1st Periodic Report – Core of the report

Reporting Period: from 01/01/2009 to 30/06/2010

Integrating activity – Combination of Collaborative Project and Coordination and Support Action

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1 Project objectives for the period

RadioNet FP7 is the successor of the highly successful FP6 Integrating Activity RadioNet and is funded by the FP7 program of the European Commission. RadioNet has its roots in the EVN, an organization that was formed by European VLBI institutes in 1980. This cooperation resulted in the FP5 RadioNet Infrastructure Cooperation Network, followed by RadioNet FP6 that brought all of Europe's leading radio astronomy facilities together. RadioNet FP7 is building on this success and gradually widening its scope towards the new radio astronomy instruments that become available on the short term like LOFAR, and SRT thereby keeping in mind that a new generation of astronomers and engineers is required to play a leading role in large global projects such as ALMA and SKA. The global future of radio astronomy is also noticeable in the evolution of the RadioNet consortium of 27 partners with new FP7 partners in US (NRAO) and South Korea (KASI) and the recent joining of the Shanghai Radio Observatory.

The primary objective of RadioNet FP7 is o enable optimal use and development of the European radio astronomy. The TNA program gives researchers access to radio astronomical facilities for their scientific objectives. Another objective is to encourage and ensure that knowledge and expertise are shared in Europe and that technological developments are supported on a European scale.

The principal and specific objectives of RadioNet as mentioned in the DoW are:

- To provide an integrated radio astronomy network which will ensure that European scientists have access to world-class facilities
- To provide an integrated research and development program which will support and enhance European radio astronomy facilities
- To develop a program of networking activities which will ensure close European collaboration in engineering and science, sharing their knowledge and expertise, expanding the use for the community
- To foster the development of the next generation of astronomers in the use of the current state-of-the-art and future radio astronomy facilities
- To foster the development of the next generation of engineers who will lead the design and construction of the instruments of the future
- To prepare for the next generation of world-class radio astronomy facilities through a wide discussion of their scientific motivation, through integrated research and development initiatives and through the planning of the future structure of European radio astronomy
- To promote public knowledge of radio astronomy and public understanding of science.

These objectives are realized in an integrated nature:

1. Trans National Access (TNA); RadioNet FP7 involves 10 radio astronomy facilities on 9 different institutes, including 2 of the newest generation: SRT and LOFAR. The RadioNet FP7 EC funding ensures that the access is provided on a transparent process and that researchers are offered an integrated, professional and consistent level of support.
2. The Joint Research Activities are inter-dependent as they all address the effectiveness of the existing (and future) radio telescopes in the next decade. AMSTAR+ for mm/sub-mm and APRICOT for cm/mm telescopes contribute to the development of multi-pixel arrays. The large volume of data produced by these arrays will require a flexible and powerful backend developed in UniBoard. A digital processing board that will enhance the signal processing of existing and future telescopes offering a wide range of functionality: spectroscopy, pulsar search, high resolution interferometry. The ALBiUS software program will develop software tools that are needed to fully use the capabilities of new and upgraded telescopes.
3. The Networking Activities are linking the RadioNet work packages. The Science Working Group organizes workshops on the science goals of the facilities but als taking into account different techniques maintaining strong connections with the Training Working Group, giving input to the Joint Research Activities and giving guidance to the specification and capabilities of instrumentation R&D. The Engineering forum aims at enhanced communication, train and enables scientific interactions amongst engineers and in keeping strong links with all RadioNet facilities and JRA's. Other important goal of the Engineering forum is building a knowledge base for radio astronomy engineering. The Training Working group will educate astronomers with the latest techniques and prepare them for the new instrumentation. Finally the Spectrum Management Working Group will provide a European voice within the regulatory bodies to protect the radio astronomy bands in an increasingly commercialized RFI environment.

The RadioNet FP7 program started officially at 1st January 2009 but really gained momentum after the distribution of the pre-payment. Given this constraint the progress towards the milestones in the program has been impressive. The procedures installed by the management are running smoothly and the management structure with a compact management team at ASTRON/JIVE quarterly meeting with the main work packages and a good interaction with the board is functioning well. This 1st Periodic Report covering the first 18 month describes the progress in all of the work packages.

2 Work progress and achievements during the period

2.1 Networking Activities

The RadioNet networking activities (NA) are designed to enhance the coordination and co-operation of the RadioNet partners and of the European radio astronomers as a whole. They also promote the science performed with the facilities, help develop the next generation of astronomers and engineers and provide essential fora for engineering and technical aspects. All of the NAs have had a significant impact on radio astronomy over the first 18 months of the programme.

There are four Networking Activities defined each focusing on a different interest group thereby maintaining and encouraging interaction between these groups. The main focus on the Science Working Group (WP2) is organising a series of workshops focusing on further development of strong links between RadioNet and the wider astronomical community, and to ensure that the results of RadioNet activities, in particular gained through access to the TNA radio telescope facilities, are presented to the widest possible audience. The Engineering Forum (WP3) focuses on enhancing the communication, training and scientific interactions amongst engineers mainly but not exclusively from RadioNet facilities and Joint Research Activities, ensuring information exchange on a wide variety of subjects. A third networking activity concentrates on the Training for Radio Astronomers (WP4). It educates astronomers in the latest techniques and instrumentation developed and used at the RadioNet facilities and beyond by supporting schools and workshops on a variety of subjects. As the radio facilities operate in an increasingly commercialized RFI environment, the Spectrum Management (WP5) networking activity continued the work done to provide a European voice within the regulatory bodies to protect the radio astronomy bands.

2.1.1 WP1: Project Management

Project management will be discussed in section 3: *Project Management during the reporting period*.

2.1.2 WP2: Science Working Group

2.1.2.1 Activity Progress

Introduction - Goals of the networking activity

The main aims of the Science Working group are to further develop strong links between RadioNet and the wider astronomical community, and to ensure that the results of RadioNet activities, in particular those associated with access to the TNA radio telescope facilities, are presented to the widest possible audience. This networking activity makes an effort to ensure a broad range of science topics to be dealt with, and to support initiatives over as many countries as possible within Europe. The approach taken to fulfill these goals is to organize and sponsor topic orientated meetings throughout the duration of the contract, with particular emphasis on the support of young and motivated European participants.

The meetings that are being sponsored under this work package scale the full range of possibilities. They range from small, well-focused workshops and meetings, to large international conferences. Moreover, WP2 encourages (and in some cases support) the publication of papers associated with these meetings either in the form of conference proceedings or via web pages.

Beyond these general guidelines, WP2 supports the coordination of the scientific activity and the link between science and new frontier technology (new generation of radio telescopes and other technological developments) such as:

- Astrophysics at centimeter and meter wavelengths
- Early Science with ALMA
- Science with LOFAR
- European Pulsar Timing Array (EPTA) initiatives.

Overview of the activity in the period 1st January 2009 – 30th June 2010

Over the last 18 months, a total of 16 meetings were sponsored and partly organized within WP2. They covered a wide range of scientific topics, and were held all across Europe. They can be divided as follows:

3 Very large conferences
5 Topic oriented workshops dealing with different science cases
5 ALMA related initiatives (3 CASA Tutorials and 2 ALMA early science)
2 LOFAR related initiatives (1 Workshop and 1 LOFAR busy week)
1 EPTA (European Pulsar Timing Array) meeting

In order to allow an equal distribution of the financial resources among the different events, it was decided that ALMA and LOFAR related initiatives have a fixed yearly budget each. Furthermore, in each case there is only one contact (Martin Zwaan and Corina Vogt, respectively), who ensure that the allocated budget is distributed among the many initiatives. This turned out to be necessary in the light of the many funding requests received from the growing ALMA and LOFAR community. This solution seems satisfactory, as it provides a continuous support to ALMA and LOFAR science, and at the same time it ensures that financial resources are available for further requests for other events.

The complete list of supported events is provided in the table below. In each case, the larger fraction of the RadioNet allocation was used to support participants. A more detailed summary on the content is given in the following paragraphs.

*Table wp2.1 Complete list of WP2 activity - * On line conference proceedings (PoS); + Proceedings published in the form of book; # Presentations available on line*

Quarter	Event	Place and Date	Type of event	Initial Allocation (€)
Q2-2009	Tutorial on CASA	Garching (D) 11-13 May 2009	# ALMA related	5000
Q2-2009	Workshop "Panoramic Radio Astronomy"	Groningen (NL) 2-5 June 2009	* Topic oriented workshop	9000
Q2-2009	LOFAR Surveys meeting	Edimburgh (UK) 17-19 June 2009	LOFAR related	3500
Q3-2009	ALMA Workshop "From data cubes to science"	Koln (D) 5-7 October 2009	# ALMA related	7000
Q3-2009	30-50 GHz Science Workshop	Manchester (UK) 14-15 Sep 2009	# Topic oriented workshop	3500
Q4-2009	Tutorial on CASA	Bonn (D) 5-7 Oct 2009	ALMA related	2500
Q4-2009	EPTA Meeting	Besancon (FR) 19-23 Oct 2009	EPTA event	5000
Q4-2009	.Astronomy 2009	Leiden (NL) 30Nov-4Dec 2009	+Very large conference	2000
Q1-2010	ALMA Science in Galaxies	Manchester (UK) 29-30 March 2010	# ALMA related	3500
Q1-2010	Tutorial on CASA	Bologna (IT) 27-29 April 2010	ALMA related	5100
Q1-2010	Science with LOFAR surveys	Leiden (NL) 8-12 March 2010	# LOFAR related	5000
Q2-2010	Workshop "Steady jets and transient jets"	Bonn (D) 7-8 April 2010	+ Topic oriented workshop	5000
Q2-2010	Workshop "Magnetic fields"	Riccione (IT) 10-14 May 2010	# Topic oriented workshop	7000
Q2-2010	Workshop "Astronomy in Megastructures"	Crete (GR) 10-14 May 2010	+ Very large conference	15000
Q2-2010	Workshop "Fermi meets Jansky"	Bonn (DE) 21-23 June 2010	* Topic oriented workshop	5000
Q2-2010	Workshop "A new golden age for radio astronomy: first results from the new generation of radio telescopes"	Assen (NL) 10-14 June 2010	* # Very large conference	9000

General comments
This WP is a constant "work in progress", since a large number of the supported events is the result of last minute requests of support. As a matter of fact, the financial support provided to each initiative is an indicator to discriminate between those activities that were planned well in advance (support is larger than 5000 €) and the last minute ones, which are additions to the original implementation plan. These additions ensure that a wide area of topics can be covered by reacting to the needs of the community and the latest developments at any given time.

There are no failures to be reported for the first 18 months, quite the opposite; an increasing request of support has to be reported.

The original list of milestones and deliverables (see page 11 on the final DoW dated 04/12/2008) includes 5 sponsored events each year, for a total of 15 events over the whole period 2009-2011. WP2 already sponsored 16 events in 18 months. There are no problems foreseen for the successful completion of this networking activity.

Due to the nature of this activity, i.e. financial support for the organization of conferences, the milestones and deliverables are the events themselves and a summary is presented in table wp2.1.

2.1.2.2 Meetings and workshops

The following small summaries from the organizers detail the main goals and outcomes of the meeting supported within WP2.

Large Conferences

.Astronomy 2009 – Networked astronomy and the New Media

Leiden (NL), November 30 – December 4, 2009

Between Nov 31 and Dec 4, 2009, 40 to 50 participants gathered at the Lorentz Center in Leiden to explore, exchange and learn about networking technologies and the new media used for astronomy research and outreach.

The following themes were explored: citizen science, web-based research, visualization and new media for outreach and education. During the mornings, keynote speakers gave talks that were streamed on the Internet and recorded. The online followers trebled the audience of the morning sessions with peaks at 140 viewers.

Sessions in the afternoons were user-generated and organized organically during the week. The Lorentz Center set-up with well-equipped meeting rooms was particularly suitable for this format. These sessions were dedicated to hands-on group discussions on the impact of new technologies on research (Open Science, Virtual Worlds, Podcasting) and '101s': introduction sessions to new technologies (Android phone programming, Remote telescope controllers, Lego NXT), etc.The final program can be browsed at http://www.dotastronomy.com/programme/.

One day mid-week was left for a 'Hack day', a day devoted to making things, giving new projects a head start and testing new ideas. Participants spontaneously formed groups and started working on new projects, of which some were achieved during the day and some are work in progress. At the end of the meeting prizes were given to participants, which were donated by O'Reilly Media. The meeting was sponsored by the Lorentz Center, NWO, ASTRON, the European program RadioNet, the British Council/Platform Beta Techniek's Partnership in Science program and the Royal Astronomical Society.

What characterized this meeting was a dynamic and notably young group of participants. The collaborations were intensive and resulted in a number of concrete outcomes. What was particularly notable was the diversity and complementary of skills present. Everyone present contributed significantly to the meeting, demonstrating the collaborative nature of networked astronomy projects.

It is clear from this meeting that the .Astronomy series will continue. This was the second of its kind and a large number of expressions of interest to host the third edition have been received from the participants.

Conference proceedings will be made available online and appear in the form of a self-publishing book on lulu.com (print-on-demand service), they are in the process of being collected.
The website of the .Astronomy community is http://www.dotastronomy.com/

Astronomy with Megastructures: Joint science with E-ELT and SKA

Crete (GR), 10-14 May 2010

A new era is dawning in Astronomy with the advent of extremely sensitive new facilities to probe the universe across the electromagnetic spectrum. We brought together the radio and optical communities for a workshop aimed at developing linked science cases for the giant, next generation telescopes including the E-ELT and SKA and other key ground- and space-based facilities.

The meeting hosted representatives from a large number of next generation instruments, including LOFAR, ALMA, JWST, LSST, IXO and GAIA. To cover the broad spectrum of science planned with these instruments, the workshop split up into five thematic areas:

- *Exo-Planets and Astrobiology*, which discussed exoplanets, stellar disks, the search for bio-markers and techno-markers;
- *Local Universe*, which discussed local star formation, nearby galaxies, resolved stellar populations, magnetism and baryonic tracers of Dark Matter;

- *Extreme Physics*, which discussed black holes, neutron stars & pulsars, high-energy cosmic rays and transients;
- *Galaxy Formation and the Young Universe*, which discussed distant galaxies, reionisation, first stars, SF/AGN feedback and distant clusters;
- *Cosmology and Fundamental Physics*, which discussed cosmological parameters, dark energy, neutrino masses, gravitational waves and new theories of gravity.

From the perspective of radio astronomy and the SKA, one of the highlights of the workshop was that there were presentations based on the chosen design for phase I and phase II SKA, demonstrating through simulations the enormous advances both in Pulsar science and in Cosmology.

From the 97 participants, 22 were women. There were a total of 15 non-EU participants, mainly from the USA, Australia and South Africa.
The conference website is http://www.physics.ox.ac.uk/users/Karastergiou/Greece2010. The conference proceedings will be published later this year by Crete University Press, (http://www.cup.gr)

A new golden age for radio astronomy: first results from the new generation of radio telescopes
Assen (NL), 10-14 June 2010

The conference *"A new golden age for radio astronomy"* has been part of a series of events organized around the opening of LOw Frequency ARray (LOFAR) and the International SKA Forum 2010. The meeting took, in fact, its inspiration from the opening of the LOFAR telescope but, at the same time, by the many other (new or recently upgraded) radio telescopes that are now coming online. These include the E-VLA, e-MERLIN, e-VLBI, MWA, PAPER, ATA, eSMA, SCUBA-2, APEX, and ATCA (CABB) and many others. Some of these facilities are now beginning to produce their first results and this meeting wanted to give the opportunity to present them. The program of the meeting was focused on the main science topics covered by these new facilities and it was organized such to provide an overview of the first successes of these projects but also the struggles (!) that the radio community is going through because of the use of innovative technology solutions (including new software approaches and calibration algorithms). Many of the results presented have given a first taste of the science (and the challenges) that we will enjoy (and face) with the SKA.

Several major elements of new telescopes like MeerKAT, ALMA, ASKAP, APERTIF, LWA, SRT and FAST are also producing some initial technical results. These facilities were also included in the programme of the meeting with particular emphasis at the on-going science preparation.

The programme included six sessions: "*Setting the Scene*" where Ron Ekers and George Miley gave their perspective of the past "gold ages" of radio astronomy and of the ideas behind the starting of LOFAR; "*A new era for the transient Universe*" where a number of speakers discussed the great possibilities that open up in the study of the transient Universe going from planetary lightning to pulsar (including the effort for the detection of gravitational waves) up to the far away AGN; "*EoR and Cosmology*" where the efforts and different approaches of the various EoR experiments were described as well as the other cosmological possibilities (e.g. the detection of Barionic Acustic Oscillation); "*Gas at high and low redshift*" where a number of speakers discussed new results of atomic neutral as well as molecular gas from deep observations that uses the available telescopes at the limit together with "staking" techniques; "*Deep view of the radio sky: imaging and polarisation*" where the challenges in this field were discussed, in particular those related to the large field of view, low frequencies. The importance of the synergy between radio surveys and surveys in other wavebands was also discussed. Finally, in "*The Future is bright*" session the status of new radio facilities as well as a presentation on optical surveys emphasising how important they will for the success of many of the projects. Both in the pulsar/transient and in the imaging session, some new results from LOFAR observations were shown.

The invited speakers were chosen to be a mix of senior and experienced radio astronomers, leading some of the major projects that are going on around the world and many young radio astronomers that are now fully embedded in the commissioning of these facilities or in the preparation of the science that the new facilities will do. The same mix was reached for all the speakers throughout the conference. We had many female astronomers among the speakers although we were hoping to have a larger number. Some of the female invited speaker we approached had to decline the invitation due to other commitment.

The audience reached the 190 registered participants. ASTRON encouraged all the junior members and postDoc to attend and present at least a poster. Furthermore, we gave the possibility to the international summer students ASTRON hosts every summer to attend the conference and to get the chance to learn about all these new projects and interact with other senior astronomers, certainly beneficial for their carrier. We got very positive feedback about this experience from the students.

Most of the participants stayed at the resort Hof van Saksen were the meeting was also held and this ensured (despite the very busy program!) the possibility of lively discussions in the evening and in the weekend (the meeting started on Thursday and finished on Monday).

All the participants of the science conference were also invited to the LOFAR opening on Saturday 12 June. The telescope was officially opened by Queen Beatrix during a special ceremony that was attended by more than 700 people.

More details about the LOC, SOC, invited speakers and programme are given in the web page of the conference: http://www.astron.nl/iskaf2010/astronomy-meeting/astronomy-meeting

All the presentations are now available on-line: (http://www.astron.nl/iskaf2010/astronomy-meeting/programme/programme). Given the many timely results, we are aiming for rapid publication in the digital Proceedings of Science series with J. van Leeuwen, P. Serra & R. Morganti as editors.

Topic Oriented Workshops

Panoramic Radio Astronomy
Groningen (NL), 2-5 June 2009

In the coming few years, a series of new radio telescope facilities will be built or significantly upgraded. (The conference focused on APERTIF, ASKAP, ATA, EVLA, and MeerKAT.) Although these will all be powerful instruments with significant impact on our understanding of the Universe, the scientific plans are still in their formative phases, and in particular little thought has been given to the combined strength of the next generation of radio telescopes. The overarching goal of this conference was to address the scientific application of these new instruments to questions regarding the evolution of galaxies (in particular the aspects related to their gas content and star formation) over the past few billion years.

It quickly became clear that in the next decade, there will be a remarkable similarity in observational capabilities in the Northern and Southern hemispheres. Each hemisphere will boast one radio facility able to perform relatively rapid, moderately deep all-sky surveys in the 1-2 GHz regime; and one radio facility able to perform deep, but narrower-field observations at the same (and higher) frequencies. In the North this complementary pair is APERTIF (a focal plane array upgrade to the Westerbork Synthesis Radio Telescope) and the EVLA (a significant upgrade to the Very Large Array); in the South we will have ASKAP (a brand-new focal plane array-based SKA precursor) and MeerKAT (a brand-new single receiver-based SKA precursor). These two pairs are extremely similar in terms of their angular resolution, sensitivity, and field of view – making truly full-sky surveys of the sky, and crucial deep follow-up and narrower surveys, accessible in the radio. The types of scientific programs that can be carried out, and were discussed at length during the conference, include:

- large and deep HI and OH surveys to redshifts of z~1 and 1.6, respectively
- determination of the variation of the HI mass function, especially at the faint end, with z
- a much more complete picture of the faint radio continuum source population
- studies of the gas content in galaxies and their environment at redshifts up to about z~0.1
- clarification of the magnetic field (and cosmic ray) properties in galaxies, both nearby and at cosmological distances

In the slightly more distant future, the radio community is looking forward to the full Square Kilometre Array (SKA). Several talks during the conference focused on how the programs carried out by the next generation of telescopes will further motivate the SKA science case. We also had one talk devoted to the scientific mission of the SKA itself.

The conference begun and ended by two discussion sessions, which first motivated, and later summarized, the science questions addressed throughout the conference. In particular the second discussion session was quite lively, and it became clear that a more pro-actively cooperative participation (both between and within the two Hemispheres) has been motivated by the conference.
The conference participants (in total, 79) came from a large range of countries, as expected based on the geographical distribution of the telescopes under discussion and indeed the global nature of the SKA project, a longer-term goal of the community that drives much of the current development. The exact distribution: Europe

59%; Asia 1%; Australia 14%; Africa 14%; North America 11%. The fraction of students and young researchers was 58%. The fraction of female participants was 15%.

Conference proceedings were published with the Proceedings of Science (PoS), which is organized by SISSA in Trieste, Italy. The deadline for submission of articles to the proceedings is 15 September 2009; we expect (online) publication to take place before the end of the year. We have also made pdf versions of as many presentations as possible available on our conference website:
http://www.astron.nl/pra2009.

Science at Q band
Manchester (UK), 14-15 September 2009

The workshop was organised to discuss the current instrumentation available for observations in the 30-50 GHz frequency range, the science drivers for this frequency range and to provide input into the science requirements for future large format array receivers. Another goal of the workshop was to look at synergies between single dish interferometer observations in this frequency band. There was a range of presentations covering those areas.

The workshop attracted a wide range of international interest. There were participants and speakers from four EU countries, ESO, the USA (NRAO) and Australia (ATNF). A mixture of senior and junior researchers including also PhD students gave a total of 19 presentations. Two of the eleven invited presentations were given by senior women and 8 out of 50 registered participants were women.

The presentations are archived on the UK ALMA Regional Centre Node website at
http://www.alma.ac.uk/documents/science-at-q-band.

Steady Jets and Transient Jets. Characteristics and Relationship
Bonn (D), 7-8 April 2010

The aim of the workshop was to review the current status of the knowledge about steady and transient jets around accreting compact objects. An important goal was to identify the physical mechanism triggering the change from one kind of jet to the other one.

In the meeting we developed cross-disciplinary collaborations among astrophysicists, both theoreticians and observers, working on the same physical process of the ejection in different astronomical objects, as micro-quasars, AGN, gamma-ray bursts, jets around young stellar objects and the Sun with coronal mass ejection. The interaction has been very fruitful and one of the most interesting new results is the indication of magnetic reconnection as possible physical mechanism responsible for the switch from a steady to a transient jet. In the meeting new collaborations originated from working on this topic and on the relationship between transient jet and gamma-ray emission. This last was observed with Fermi LAT, AGILE and Cherenkov telescopes.

The 50 participants came from Belgium, Croatia, Finland, France, Germany, England, Italy, Poland, Spain, Switzerland and USA. The fraction of women was ~25%. The essential aspects of jets were highlighted in 9 invited review talks (30 minutes each) held by experts in the fields. The topics were further explored in 25 contributed talks, several presented by young researchers and students. Each talk was accompanied by a poster. Ample time was also assigned to discussions and poster sessions. The positive feedbacks we received, we saw that this combination of several reviews and posters plus short oral presentations was successful and we suggest this combination for future similar joint conferences.

Conference proceedings will be published on Memorie della Societa' Astronomica Italiana, 2011, Vol. 82 n.1. Conference Web page:
http://www.mpifr-bonn.mpg.de/staff/mmassi/conference/jets2010/

Rotation Measure Analysis of Magnetic Fields in and around Radio Galaxies
Riccione (IT), 10-14 May 2010

Magnetic fields in groups and clusters of galaxies regulate thermal conduction and influence the dynamics of bubbles and cavities. In radio galaxies, they are essential to the production of synchrotron radiation and to most models for the collimation and acceleration of relativistic jets. Multifrequency radio polarization observations have recently led to important new results on foreground magnetic fields on parsec and kiloparsec scales. This area of research is about to take a major step forward with the commissioning of a new generation of instruments operating at centimetre and metre wavelengths: EVLA, e-MERLIN and LOFAR. This specialised Workshop focused on the analysis of multifrequency radio polarization imaging to derive magnetic fields in thermal plasmas along the line-of-sight to radio galaxies and quasars from observations of Faraday rotation measure (RM). Its aims were to take stock of the current state of the field, to compare different methods of analysis, to provide a forum for theorists and observers to interact and to prepare for observations with the new generation of arrays. The meeting divided naturally into three main topics: magnetic fields in galaxies, groups, clusters and large-scale structure; Faraday rotation on parsec scales and its implications for jet formation and collimation and new techniques for analysis of polarization.

There is considerable interest in magnetic fields on scales larger than galaxy clusters (Kronberg, Giovannini) and the evidence for them was debated. The ubiquity of Galactic foreground RM makes analysis of large-scale effects very hard, however (Brentjens). Several groups described recent analyses of cluster and group magnetic fields using background and embedded radio galaxies as probes. Models in which the magnetic field is a Gaussian random variable described by a single power spectrum whose amplitude scales with density have been applied successfully in several cases (Bonafede, Vacca, Laing, Ensslin). There are still some discrepancies between forward modelling (e.g. using structure functions) and Bayesian maximum likelihood methods, and the meeting debated the best way to estimate the power spectrum of the field and its errors. Magnetic fields around radio sources are not always random and isotropic, however, and the persuasive evidence for foreground ordered field structures aligned with the radio lobes in several sources (Guidetti) was a highlight of the meeting. The RM analysis of sources behind Centaurus A by Feain et al. (presented by Macquart) is an observational tour de force, which led to more debate on the evidence for a thin layer of magnetoionic material around the radio lobes.

The second main theme of the meeting concerned parsec-scale jets. There was an occasionally heated debate on the reliability of VLBI Faraday-rotation data, leading to the conclusion that cooperation between groups with different datasets on the same object was essential, both as a cross-check and to search for time variability. One beautiful result from multi-epoch monitoring was the conclusion that the moving components in the jet of 3C120 are observed through a static Faraday screen (Gomez), but this may not generally be true: the screen in 3C273 may instead be moving (Asada). Rotation measures on parsec scales can potentially probe the geometry of the field around the jets, and the implications were explored from observational and theoretical perspectives (Gabuzda, Mahmud, Broderick, Clausen-Brown).

Finally, new techniques for imaging polarization were presented in the context of LOFAR (Anderson) and EVLA (Cotton), while the perils of interpreting multifrequency data (with and without RM synthesis) were enthusiastically discussed (Rudnick, Brentjens).

The meeting proved to be extremely effective in promoting discussion and identifying new projects: the combination of a well-defined topic, a small meeting and ample opportunity for discussion were very successful.
There were 43 registered participants, (14 female). The majority (33) came from European Institutes, the rest from the USA, Australia and Taiwan. Roughly 15 were early-career researchers (students or junior post-docs), depending on the exact definition. Of these, 6 were supported directly by RadioNet .

Workshop web page: http://www.ira.inaf.it/meetings/rm2010/. Programme with links to PDF-Files of talks and posters published on http://www.ira.inaf.it/meetings/rm2010/program.php

Fermi meets Jansky – AGN in Radio and Gamma-rays
Bonn, 21-23 June 2010

The goal of the “Fermi meets Jansky" workshop was to bring together experts from both the radio and gamma-ray communities to discuss our understanding of high energy physics in AGN. One of the central themes was the location of the gamma-ray emitting region. How close is it to the central black hole? This issue was vigorously discussed at the workshop and observations needed to settle the long-standing debate were outlined. Other addressed topics were e.g., testing various gamma-ray production models, constraining the basic intrinsic jet properties, understanding the duty cycle of the flares, and identifying the currently unassociated Fermi point sources. In addition to invited and contributed presentations, there were three working groups formed by the workshop participants focusing on localization of the gamma-ray emission site, spectral energy distribution modelling, as well as population properties of gamma-ray bright AGN.

Highlights of the meeting included the summaries from several large VLBI and single dish monitoring programs addressing the radio properties of the gamma-ray blazar population. It was shown how the gamma-ray brightness of a given source depends on a complicated combination of its Lorentz factor, preferred viewing angle, location of SED peak frequency, and its activity state. Also, several detailed case studies of the multi-wavelength behaviour of blazars were presented with results pointing towards distributed gamma-ray production along the jet. The most interesting advances in the theoretical understanding were presented by the groups doing state-of-the-art GRM and relativistic particle-in-cell simulations (Blandford; Hardee).

There were 72 registered participants from 13 countries (Australia, China, Finland, France, Germany, Hungary, Italy, Japan, Poland, Russia, South Africa, Spain, USA). The largest number of participants came from Germany (23), followed by the USA (21), and Italy (9). The fraction of post docs and students participating in the workshop was 35% and the fraction of women was 21%.

The proceedings were edited by Tuomas Savolainen, Eduardo Ros, Richard W. Porcas and J.Anton Zensus and published by the MPIfR. They appeared before the meeting as a printed book with 243 pages and they will be available at the MPIfR web site and at the ADS database. The proceedings contain 50 out of 55 papers presented at the workshop. Slides from the talks given at the workshop will be posted to the meeting website. (http://www.mpifr-bonn.mpg.de/div/vlbi/agn2010/).

ALMA related events

CASA Tutorials

Garching (D), 11-13 May 2009
The goal of this workshop was to introduce the CASA data reduction package to the European user community. The Common Astronomy Software Applications (CASA) package will be the primary data reduction software for all ALMA data, as well as data coming from other future radio astronomical telescopes. Overall, the ratio between time spent on presentations and time spent on exercises was approximately one-third to two-thirds. Experience with previous tutorials showed that this is a good ratio, leaving enough time for participants to practice their data reduction skills. The tutors were available for questions during these exercise sessions and offered their help.

A total of 39 participants attended the tutorial. Of these, 6 were from ESO, 1 from Denmark, 2 from Finland, 1 from France, 2 from Germany, 5 from Italy, 8 form Spain, 3 from Sweden, 4 from Switzerland, 4 from the Netherlands and 3 from the UK. 15 of the participants were students, the rest being equally split between postdoc and young staff. 14 were female.

The tutors at this tutorial were the four European CASA User Support Specialists: Silvia Leurini (ESO), Alessandra Rossetti (Bologna), Frederic Gueth (IRAM) and Martin Zwaan (ESO), with help from Kumar Golap (NRAO), Wouter Vlemmings (Bonn), Anita Richards (Manchester), and local CASA developers Dirk Petry and Jonas Larsen.

The participants were asked to fill out a questionnaire at the end of the tutorial. The main results of this are that 80% of the participants did learn what they expected to learn, 75% are confident that they can reduce a standard spectral line data set with CASA now (with the remaining 25% saying “probably”). Most participants (92%) attended the tutorial in order to prepare for ALMA (early science) and to learn to use CASA for existing instruments (75%). Only 27% indicated they were interested in using CASA for other future facilities.

The website of the tutorial is available here: http://www.eso.org/sci/facilities/alma/arc/meetings/casa09/index.html. All presentations, as well as exercises, example scripts, and test data are available from this web site.

Bonn (D), 5-7 October 2009
This tutorial served as an introduction to CASA (Common Astronomy Software Applications package). The introduction was given by European CASA support specialists and used the latest version of the CASA release. The CASA package is a set of C++ tools bundled together under an iPython interface as a set of data reduction tasks. CASA is being developed by a collaboration led by NRAO with the primary goal of supporting the data post-processing needs of the next generation of radio astronomical telescopes such as the ALMA and EVLA projects. The tutorial in Bonn was the third such tutorial organized by the European ALMA regional centre (ARC) nodes. The tutorial consisted of introductory talks on most aspects of basic data reduction and allowed ample time for participants practicing their data reduction skills, either on test data or on their own data.

The tutorial was attended by 19 participants and the lectures and tutorial sessions were given by Martin Zwaan and Dirk Petry (from the ESO ARC), Anita Richards (from the UK ARC node) and Wouter Vlemmings (from the German ARC node). Six of the participants were PhD students, six were young postdocs, four were experienced postdocs and three were at the level of staff scientist. Half of the participants were women. Of particular interest was the participation by a member of the Solar Astronomy community, leading to valuable input from an often underrepresented science topic.

The participants were asked to fill in an (anonymous) feedback form. Aside from several suggestions, the tutorial was well received. 60% indicated that they now intended to use CASA for some of their data reduction, while another 35% indicated that they would possibly start using CASA. The tutorial dinner provided by the RadioNet support was also very much appreciated.

Information on the tutorial is given at: http://www.astro.uni-bonn.de/ARC/casa09.shtml

Bologna (IT), 27-29 April 2010
CASA stands for Common Astronomy Software Applications, and is the software package of choice for the reduction and analysis of observational data from the next generation of radio/mm telescopes such as EVLA and ALMA: the Atacama Large Millimeter/submillimeter Array. ALMA is presently under construction in Chile, and will be fully operational in 2013. However, the first Call for Proposals will be issued at the end of 2010, albeit for a limited array (in number of antennas, receivers, and available configurations). The first science data are thus expected in 2011. However, CASA can also be used on data from other, already functioning antenna arrays (e.g., NRAO, SMA, PdBI), and is therefore quickly gaining in importance.

The aim of the tutorial was to prepare future users of ALMA, and users of other interferometric arrays, by providing an introduction to most aspects of basic data reduction and analysis. In addition, the participants had ample opportunity to practice their data reduction skills, either on their own data or on test data, provided at the tutorial. The tutorial was presented by 4 tutors and also guided the participants individually in the performance of the practical exercises.

The number of participants was limited to 20. The participants (12 women and 8 men) were from Italy (15), Spain (2), Portugal (1), Germany (1), and France (1). The professional status of the 20 participants was as follows: 10 young post-docs, 7 PhD students, one undergraduate student, and two astronomers.

Further information on the tutorial (including the original announcement, the list of participants, the program, data reduction scripts, presentations, and the questionnaire) can be found on the Italian ARC's web pages: http://www.alma.inaf.it (and following the link "CASA tutorial").

We have recorded the tutorial (presentations + audio) on a computer; an edited version will appear on DVD – for the moment only for local use, but possibly available on request in the future.

ALMA Science Workshops

From Data Cubes to Science: ancillary data and advanced tools for ALMA
Köln, October 5 - 7, 2009

ALMA will revolutionize many scientific areas by providing an unprecedented quantity and quality of high spatial and spectral resolution line data. This will allow detailed tests of astronomical models of star formation, galaxy formation and many others much more stringently than possible with data from current instruments. To do this, the models (e.g. radiative transfer programs) need to be of similar quality. Additionally, easy ways of comparing and visualizing models and data must exist. The models need to have access to fundamental physical data, such as molecular and atomic line frequencies and strengths, collision rates, dust properties etc. While producing the models themselves is a science activity, adapting them for use with ALMA data, and making them available to a larger community (including testing, documentation etc.) is not, particularly if the community aimed for is the larger astronomical community, and not only millimeter experts.

In order to optimize the science output from ALMA, there is therefore a need to produce and gather ancillary data and make them available to ALMA users, as well as adapting and making available scientific models for use by the ALMA community at large. While some efforts along these lines exist (CDMS, Splatalogue, BASECOL, LAMDA databases, RATRAN radiative transfer programs), there is a lot of duplicate effort, and the ease of use for both data and models is not at the level desired. This workshop brought together laboratory physicists, chemists and astronomers as providers of data and models together with astronomers as customers to discuss data and modeling needs and strategies of developing common databases both of physical data and models, usable with ALMA data.

The workshop was attended by ~50 people as planned, with wide attendance from European countries, North America and East Asia. 33% of the speakers at the workshop were female, this is slightly larger than the ratio of female participants to the workshop (~25%).

The workshop was very successful, we discussed how to proper recognize the work of theorists and experimentalists that provide essential data for catalogues and advanced scientific analysis, but are not sufficiently recognized and cited in the literature. Two possible ideas to improve the situation were presented and will be further discussed in the coming months. We also discussed possible schemes to support laboratory measurements, catalogues maintenance and theoretical calculations in a more structured fashion. The conclusion

was that projects (like ALMA) cannot provide stable and long term support to this work, but we agreed that this work is essential to achieve the best exploitation of the ALMA data and in the coming months we will probably present a white paper that could be the basis of future funding requests to agencies in the various ALMA regions. Finally, the status and availability of advanced modeling software was discussed and was agreed to create a single repository or link page for all publicly available software.
The webpage on which also presentation are available for the meeting is at:
https://www.astro.uni-koeln.de/projects/schilke/DataNeedsForALMA

ALMA science in galaxies
Manchester (UK), 29-30 March 2010

The first call for ALMA proposals is expected towards the end of 2010, for observations in 2011 (see http://www.alma.ac.uk/about-alma for links). ALMA's unprecedented capabilities mean that observations will initially be challenging but with very great rewards. The community needs to prepare to take advantage of this, and the UK ARC's role is to support prospective users and make sure that the science potential is fully understood. This workshop was for communities working on the more detailed astrophysics within galaxies (following the workshop on the high redshift universe in Oxford on 30 March 2009), with a mixture of keynote and contributed talks.

The sessions covered ALMA capabilities, star formation locally and in nearby galaxies, the relationship between nearby AGNs and their hosts (including in the Milky Way), discs and planets and evolved stars including eruptive binaries. There were nine invited speakers and the same number of contributed talks (everyone who applied for a talk was able to give one). Many of the talks specifically addressed models for interpreting ALMA observations or simulating ALMA observables. The discussion sessions were mostly very practical, addressing the potential for observing with ALMA, whether projects were suited to early science, and how they would be complemented by other instruments such as Herschel, e-MERLIN etc. The meeting has led to enhanced collaboration as well as an improved understanding of the capabilities of ALMA.

The meeting was aimed at the UK ARC catchments area (but not exclusively), since the other regional ARC nodes are holding similar events. The attendance from outside the UK was France(1), Russia (1), Poland (2), Ireland(2), Germany (1), Sweden(3) including invited speakers from Ireland, Sweden and Germany. About 50 people attended of whom 40% were women and 30% are graduate students or early-career postdocs.

The agenda can be seen at http://www.alma.ac.uk/events/past-events/agenda, including links to the talks giving details of ALMA early science capabilities and developments.

LOFAR related events

LOFAR Busy Week
Leiden (NL), 25-29 January 2010

LOFAR, the Low Frequency Array, is a next-generation radio telescope that is being build in the Netherlands and neighboring countries. It will carry out a broad range of fundamental astrophysical studies. An important goal of LOFAR is to explore the low-frequency radio sky by means of a series of unique surveys. The main aim of these surveys is to advance our understanding of the formation of galaxies, clusters and active galactic nuclei. These surveys will be carried out and scientifically exploited by a large international science team.

Currently LOFAR is in the role-out phase. At the end of November 2009, 12 stations were operational, and with the current projected rate of building, the complete LOFAR facility with 36 Dutch stations should be ready at the end of 2010. Also the main software pipeline that is capable of delivering maps of the radio sky from the basic data is advancing rapidly. The main challenge for the survey project is to ensure that high dynamic range thermal noise limited images with a stable pint-spread function can be made over the entire accessible sky and over LOFAR full frequency range. The serious issues that need to be tackled before deep and scientifically useful maps can be made include: (i) an efficient usage of the computational resources; (ii) an effective removal of radio frequency interference (RFI); (iii) dealing with the corrupting influence of the ionosphere; (iv) properly correcting for the station beams.

To deal with all these issues, the survey team has been organizing a series of “busy weeks”. The idea is that a team of astronomers from the survey team attempts to tackle a number of issues related to the challenges just mentioned.

With 28 participants, recent LOFAR data were carefully scrutinized. For the complete list of participants see http://www.lc.leidenuniv.nl/lc/web/2010/393/participants.php3?wsid=393).

Various existing (AIPS, CASA, miriad) and new (BBS) radio data reduction packages were used to reduce the new LOFAR data. As there was a constant interaction between software developers and astronomers, significant progress could be made. A highlight was the production of a deep image of 3C61.1 (http://www.lofar.org/high-resolution-lofar-image-3c611)

Surveying the low frequency sky with LOFAR
Leiden (NL), March, 8-12 2010

LOFAR, the Low Frequency Array, is a next-generation radio telescope that is being built in the Netherlands and neighboring countries, and will be fully operational by the end of the present decade. It will operate at frequencies between 15 and 240 MHz (corresponding to wavelengths of 20 to 1.2 m). Its superb sensitivity, high angular resolution, large field of view and flexible spectroscopic capabilities will represent a dramatic improvement over previous facilities at such wavelengths.

As such, LOFAR will carry out a broad range of fundamental astrophysical studies, and will be an important vehicle for astronomical research. An important goal that has driven the development of LOFAR since its inception is to explore the low-frequency radio sky by means of a series of unique surveys. We are planning to exploit the unprecedented sensitivity and wide instantaneous field of view of LOFAR to conduct large sky surveys at 15, 30 60, 120 and 200 MHz.

At the end of 2009 the LOFAR telescope consisted of 20 stations. With such array, first observations on important extragalactic fields are being carried out. This system will map out the entire sky at 60 and 150 MHz. The workshop at the Lorentz Centre in Leiden focused on: (i) updating the entire Dutch community on the LOFAR projects and key programs; (ii) discussing the first data from the 20 LOFAR stations; (iii) updating the survey plans for the full LOFAR in the light of the experience from both the 36 LOFAR stations and the first outer station; (iv) exploring synergies with surveys in other wavebands.

At the conference web page information can be found on the program, participants and organizers. Posters and presentations have also been posted. The link is: http://www.lc.leidenuniv.nl/lc/web/2010/394/info.php3?wsid=394

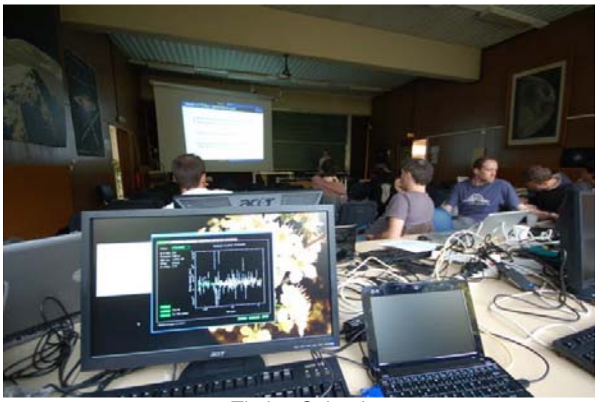
EPTA Meeting

VIth EPTA Workshop and Pulsar Timing School
Besançon (F), 19–23 October 2009

The EPTA consortium gathers researchers from five radio astronomy Institutes in Europe, all involved in pulsar timing and with a common goal: the use of most stable pulsars as astronomical clocks to detect directly a gravitational wave background. Besides this long-term aim, the collaboration exchanges know-how and radio data for a variety of topics. It coordinates thesis and post-doc projects among the different institutes and organizes worldwide collaborations with other partners such as Nanograv (US), PPTA (AU), or the VIRGO-LIGO consortium.

The EPTA meetings are the opportunity to present the status of student and post-doc projects, to organize the data sharing, to show the instrumental updates, to discuss publication policy and future prospects. This year, we added a Timing School, to train new members and new students in data analysis.

EPTA workshop group picture



Timing School

Conference proceedings and web page at http://lpc2e.cnrs-orleans.fr/~pulsar/

2.1.3 WP3: European Radio Astronomy Engineering Forum

2.1.3.1 Activity Progress

The European Radio Astronomy Engineering Forum focuses on enhancing the communication, training and scientific interaction amongst engineers and technicians. This networking activity follows a successful suite of workshops started already with the RadioNet FP6 program. The primary goal is to bring together engineers working in European radio astronomy institutions, where many engineering activities are taking place to equip and refurbish the various facilities in Europe with state of the art instrumentation. New telescopes are being built with a tremendous need of equipment, and the developments for the future main radio astronomy project Square Kilometre Array (SKA) are taking more and more over the daily workload of the technical and scientific staff. Therefore the engineers at the institutes are faced with increasing demands while at the same time manpower is decreasing at many facilities. However it has been established that a considerable overlap exists between the various instrumentation projects at the different observatories.

The main activity of the RadioNet FP7 Engineering Forum is to organize and support meetings and workshops of European radio astronomy engineers and other partners in related academic and industrial environments. This Work Package is divided into 3 tasks:

- Organize/Support Engineering Forum Workshops – to bring together radio astronomy engineers to exchange results and expertise and to convey cooperation,
- Organize/Support Technical Operation Group (TOG) Meetings – to enhance collaboration and performance amongst EVN stations via information exchange, training, development of standards and planning of technical improvements,
- Database – to collect information and describe relevant technical facilities and engineering capabilities.

Engineering Database

Another goal of the WP3 is to build up a database of technical facilities and engineering capabilities. The aim of this task is to maximize the technical interaction among the participating institutes, the knowledge of the capabilities, expertise and methodologies adopted by the various partners. Therefore, it is not a data collection, organized in the form of a searchable database, but the investigation of technical capabilities and facilities distributed over the radio astronomy Institutes of RadioNet. Such knowledge will be accessed and presented in the form of a series of web pages, cross-linked and commented.

For a useful formation of the knowledge base in fact, a two-step approach is preferred, consisting of a direct face-to-face visit to the major Institutes, equipped with complex facilities, and of a simple questionnaire compilation for the remaining partner institutes. As a result of the activities started, such a questionnaire was generated for distribution to the institutes being part of RadioNet-FP7 but not directly visited. The appropriate radio-astronomy institutes₀ representatives will fill in the questionnaire, detailing their relevant technical facilities. The questionnaire will be distributed during the incoming Engineering Forum meetings planned in September (Aveiro, PT). At this occasion it can also explained to the community appropriately.

As a second step, face-to-face visits were organized to the major radio astronomy laboratories to collect detailed information on available instruments, production facilities and technical know-how. The following radio astronomy technical laboratories were visited:

- ASTRON, The Netherlands, on August 24th 2009
- OAN - Yebes, Spain, on July 10th 2009
- IRA-INAF, Italy, on October 9th 2009
- IRAM, France, on May 31st 2010
- JBCA, United Kingdom, on June 4th 2010

For each face-to-face meeting, a detailed report is being generated. A further visit to MPIfR is scheduled on August 9th 2010, to complete the necessary face-to-face meetings.
Once those visits will be finalized, the key material for the database will have been collected. The description of the facility and the methodologies adopted for characterization and testing will be addressed. The database will therefore include not only the hardware facilities, but also the methodologies and procedures at the participating institution.

Unfortunately, a delay of eight months is currently incurred in the delivery of the database, related mainly to the difficulties in coordinating and planning the face-to-face meetings at the various institutes. Late arrival of the financial resources for travels and its re-allocation to JIVE was also an issue contributing to the delay. However, the delay in the preliminary release of the database is actually being partly recovered in the coming months (the last visit is scheduled for August 2010). No impact on other tasks is expected.

Available resources are not affected by the experienced delay, and the current planning is to bring the engineering forum database activities at its proper completion with six months delays as compared to the original proposal.

Budget:
The responsibility of organizing the Engineering Forum workshops & EVN-TOG meetings lies with personnel of the MPIfR in Bonn (chair and vice-chair of the engineering networking activity, plus part-time manager). Some aspects of the organization of the meetings still lie with the local organizers who are strongly supported by the part-time manager at MPIfR. The Engineering Database activity is lead by UROM. Both RadioNet-FP7 partners (MPIfR and UROM) have manpower expenditures as expected.

The main part of the budget of WP3 is allocated as support for local organizational costs and travel expenses of the participants. In addition a travel budget was allocated to the database task. The ratio of the financial support of the local organization cost to the travel support was 1/3 to 2/3, respectively. Additionally, the organizers that are also partners of the RadioNet-FP7 project have financially and personally supported the organization of the meetings.

The expenditures of WP3 in the first 18 months of the project are in line with the budget as planned in case of the Engineering Workshops. There is slight under spending for the TOG meetings due to a smaller number of participants who asked for travel support. The travel costs of the Database-task are less than forecasted due to the delays in some of the scheduled trips.

The under spending of the travel budget will be balanced via the WP3 meetings by stronger support of the local organizational costs and higher travel support for the participants. In addition further workshops and meetings can be scheduled. Some of the budget will be used to support organization of the meetings that play an important role in the implementation of the main goals of WP3: European Radio Astronomy Engineering Forum, such as Receivers & Array Workshop 2010 on September 19-21 in Bonn/Germany.

2.1.3.2 Meetings and workshops

Engineering Forum Workshops:
The objectives of the Engineering Forum are to facilitate and stimulate coordinated discussions, exchange of knowledge and cooperation on instrumentation issues relevant to the European radio astronomical facilities and to make full use of possible synergies. The engineering forum provides a single point of contact, and pools knowledge resources by organizing meetings and thus fostering multiple personal contacts. By talking together and keeping in contact we hope to overcome the multiple-effort problem and hopefully will avoid engineers "reinventing the wheel". The contractors involved are all partners in RadioNet-FP7, moreover the RadioNet-FP7 Engineering Workshops are meanwhile well known all over the world and more and more participants from Europe and abroad ask for participation and want to present their work. This is an indicator that the forum is well established within the community. Engineers of participating institutes suggest the workshop topics and as such the needs of the community are well met. A list of workshops that were held in the reporting period is given in table wp3.1.

EVN - Technical Operations Group (TOG)
The EVN-TOG meetings under RadioNet-FP7 – in the tradition of the previous gatherings under RadioNet-FP6 – foster the collaboration between the engineering personnel of the EVN telescopes, which are responsible for enabling and operating VLBI observations. At the same time colleagues from new partner telescopes like the Yunnan Observatory and the Institute of Applied Astronomy in Russia were welcomed at the TOG and became new members. In the reporting period, important topics of the meetings ranged from maintaining and improving the network calibration, reliability of the EVN, synchronizing the necessary upgrades of equipment to planning for future enhancements. Here contact, discussions, and strategic planning together with American colleagues are vital for the future functioning of the EVN in a global VLBI context.

During the 2nd TOG meeting in Bonn video-conferencing tools were successfully used for the first time to allow US colleagues to easily participate in an EVN-TOG meeting. In the future the TOG will try to offer this service as a means to enlarge the scope of the meetings to include engineers from the very distant observatories in the US, China, and South Africa.

The last two EVN-TOG meetings were accompanied by training workshops, the topics of which were chosen to reflect the need to introduce new hardware for VLBI (DBBC back-ends) at EVN stations and to follow the wish of the majority of the TOG members for a recapitulation of the most critical aspects of single dish amplitude calibration. Both workshops were very successful and attracted a large number of participants.

Highlights of the meetings were:
- Improving the communication between VLBI personnel at EVN telescopes.
- Welcome and integrate new members to the EVN-TOG.
- Successful use of video-conferencing tools to allow engineers from distant telescopes to participate in the TOG meetings.
- European and global planning of technical improvements and future upgrades at EVN stations.

- Successful workshop on how to install and operate the new digital back-ends (22 participants)
- Successful workshop of single dish amplitude calibration fundamentals and pitfalls (25 participants)

A list of TOG meetings that were held in the reporting period is given in table wp3.1Table.

In conclusion, three Engineering Workshops and three EVN-TOG meetings were organised in the first 18 months of the RadioNet-FP7 project (see table wp3.1). Based on the Engineering Workshop popularity and participants demand, the Engineering Workshops were scheduled earlier than was planned in the DoW. The EVN-TOG meetings were held during the intervals of the reporting period as was intended. The remaining future Engineering workshops and EVN-TOG meetings are planned as described in the DoW. The reports from the Engineering Workshop and EVN-TOG meetings are the deliverables of the WP3-RadioNet-FP7 project. They were delivered on time in case of the TOG-Meetings and even earlier in case of the Engineering Workshops.

Table wp3.1: List of workshops and operation meetings organised/supported in the reporting period.

	Topic	**Date**	**Place**	**Participants**	**Countries**
1st TOG	1st TOG	17.04. 2009	Torun / PL	27	9: (DE, ES, FI, IT, NL, PL, SE, UK, USA)
1st EW	Low Noise Figure Measurements at Cryogenic and Room Temperatures	23-24.06. 2009	Göteborg / SE	54	10: (DE, ES, FI, FR, IT, NL, SE, UK, USA, ZA)
2nd EW	Multi Pixel Camera Receivers	16-17.11. 2009	Bonn / DE	46	12: (AU, DE, DK, ES, FI, FR, IT, NL, PL, PT, UK, USA)
2nd TOG	2nd TOG	3-5.12. 2009	Bonn / DE	42	13: (AU, CN, DE, ES, FI, IT, LV, NL, PL, RU, SE, UK, USA)
3rd EW	RFI2010 - RFI Mitigation Workshop	29-31.03. 2010	Groningen / NL	72	15: (AU, BE, CN, CA, DE, FI, FR, IN, IT, NL, RU, TR, UK, USA)
3rd TOG	3rd TOG	21-22.06. 2010	Helsinki /FI	28	10: (DE, ES, FI, IT, LV, NL, PL, SE, UK, USA)

More details on the workshops and TOG meetings with all the contributions can be found on the RadioNet FP7 Engineering Forum Wiki page: http://www.radionet-eu.org/fp7wiki/doku.php?id=na:engineering

2.1.4 WP4: Training for Radio Astronomers

2.1.4.1 Activity Progress

The objective of Training for Radio Astronomers (TRA) is to improve the scientific exploitation of Radio Astronomical data with an emphasis on the products of observatories within the RadioNet consortium. Training in areas such as how to prepare experimental proposals, data reduction and interpretation and opportunities for enhanced collaboration is provided, especially for early-career radio astronomers by organizing and funding schools and meetings. The program also addresses the needs of researchers from other wavelength domains and also theorists wishing to use the suite of new and upgraded radio telescopes currently being deployed, e.g. LOFAR and ALMA.

A series of courses, workshops and schools with a significant "hands-on" approach is organized, led by radio astronomy experts. They benefit not only early-career astronomers but also more advanced researchers needing to exploit the new techniques being developed for the next generation of ultra-sensitive instruments. Such events provide "added-value" via the interaction between trainees and experienced RadioNet staff, initiating and strengthening a Europe-wide approach to research and collaboration. As forums for young researchers to discuss ideas with experts, the TRA activities stimulate the development of new techniques and promote awareness of advances throughout the community.

Progess/Highlights

One of the deliverable for this networking activity was the development of a website that is regularly updated to archive all the teaching material generated by the e.g. lecture notes, data reduction tutorials and feedback. This website was established as http://www.radionet-eu.org/fp7wiki/doku.php?id=na:training. In addition, a website archiving all historical information for one of the key conferences of this work package – the YERAC (Young European Radio Astronomer Conference) – was established: www.yerac.org. This webpage provides an historical overview of all YERACs that were held in the past and provides links to the websites where applicable.

Three annual events are planned in each of the three series, accompanied by related on-line material. Each of the three main participants (UMAN, OBSPAR & IRAM) is leading one event in each of the 3 years, according to their expertise. These three events are:

- YERAC – Young European Radio Astronomer Conference
- ERIS – European Radio Interferometry School
- Single dish summer school or a CESRA (Community of European Solar Radio Astronomers) school

In 2009, YERAC was attended by 47 early-career astronomers plus 5 LOC; ERIS was attended by 76 trainees and 21 lecturers/tutors and the IRAM (Institut de Radioastronomie Millimétrique) single dish school was attended by 42 participants and 15 lecturers/tutors. ERIS had a record attendance and the hands-on aspect of the Single Dish school was, as ever, very popular. All events produced very positive feedback (some suggestions have been incorporated into planning for future events). All meetings were well within budget. A short summary of each of this meeting is given below.

The 2010 events are all in an advanced stage of planning and set to be equally successful. Venues have been identified for all events in 2011 (ERIS in Bologna, YERAC at Jodrell Bank, Single Dish school in Spain).

The budget for 2009 was about 10k € underspent and as a result 5k funding was made available for (so far) 3 CASA training events, 3k for a LOFAR event and 2k for a cm-wave single dish school. All these events are mainly funded and organized from other sources and so they have only required a small amount of additional planning by RadioNet, whilst contributing significantly towards achieving our goal of equipping European radio astronomers to make best use of their observatories.

Spending has been within budget. It is not yet known whether there will be any underspending on the three core events (YERAC, CESRA, ERIS-IRAM) in 2010 and therefore whether or not it will be possible to offer additional support to extra events in 2011.

Table wp4.1 List of events organised in 2009

Date	Title/Subject of Meeting	Location	Number of Participants
29-31 July 2009	YERAC XXXIX	Porto (Portugal)	42
7-11 September 2009	ERIS	Oxford (UK)	97
4-11 September 2009	Single dish, 5th IRAM summer school	Pradollano (Spain)	42

2.1.4.2 Meetings and workshops

Events 2009:

YERAC XXXIX, Porto (Portugal) 2009 July 29-31

We are grateful to Sonia Anton, Dalmiro Maia and colleagues on the LOC/SOC who organized a very successful event. 42 students attended, from France, Germany, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Russia, South Africa, Spain and UK, and gave oral presentations. There were 4 local chairs and 3 additional organizers. The total cost approx. € 9200 of which 2500 was raised by the LOC from the Portuguese National Foundation for Science. The RadioNet contribution is about € 6600. The meeting was a great success. The quality of the participants' talks was very high.

The webpage of the meeting with on-line material can be found here: http://www.fc.up.pt/oa/yerac

Figure wp3.1 Participants of the YERAC 2009 in Porto

European Radio Interferometry School, Oxford (UK) 2009 September 7-11

We are grateful to the Oxford Astrophysics department for hosting this event. ERIS concentrates (but not exclusively) on cm- and mm-wave imaging in alternate years. This cm-wave school was attended by 97 people, comprising 21 lecturers and tutors and 76 'students', ranging from people about to start an MSc to senior astronomers from other domains, from Australia, Belgium, Germany, Hungary, Ireland, Italy, Latvia, Malta, Netherlands, Poland, Portugal, Russia, Spain, Sweden, Taiwan, UK and USA.

The mixture of lectures and hands-on data reduction in AIPS and CASA was very popular. Data reduction examples from MERLIN, EVLA, EVN, ATCA and other arrays were provided, along with forward looks to ALMA and LOFAR. Parallel sessions were held for the more specialized topics to allow students to work at their own pace and follow their own interests. The total cost was approx £18,200 of which 2000 was contributed by the Oxford Department of Physics and Astronomy in the form of catering. We received a grant of £2500 from the UK Royal Astronomical Society towards the expenses of early-career and non-tenured lecturers and tutors. RadioNet contributed €15,300.

Lectures and tutorials are linked from http://astrowiki.physics.ox.ac.uk/ERIS2009 (more up-to-date versions of some tutorials can be found via www.alma.ac.uk)

Single-Dish, Fifth IRAM Summer School Pradollano (Spain) 2009 September 4-11

“From Millimeter to Far-Infrared Astronomy” We are grateful to Carsten Kramer and colleagues for organising the fifth such school, for 42 participants from Austria, Chile, China, France, Germany, Greece, India, Ireland, Italy, Lithuania, Netherlands, Poland, Spain, Sweden and USA. There were 9 lecturers, including a speaker on Herschel, and 6 local teaching assistants. The school included lectures and hands-on observing sessions. The total cost was approx. 22,000 €, of which IRAM paid 12 000. Most participants’ registration and subsistence was paid by their home institutes or CNRS/INSU, leaving about 3700 € to be funded by RadioNet.

Lectures are linked from http://www.iram.es/IRAMES/events/summerschool2009/

Events 2010

In the first half of the year 2010, no meeting of the three major ones was held and they will be reported in the next period. An overview of the planned activities is given in table wp4.2 However, other training events were supported as mentioned above that took already place in the reporting period. A short summary of these meetings is provided below and in table wp4.2 an overview of the additionally planned activities is given.

CASA workshop, Manchester (UK), March 31 – April 1.
This followed a workshop on Science in Galaxies with ALMA. The CASA tutorial was attended by 27 'students' from France, Germany, Ireland, Poland, Russia, Spain, Sweden and the UK, led by 5 tutors. Feedback was mostly positive but constructive criticism included requests for such events to start with an overview of interferometry and its jargon, and diagnostics for setting up data reduction parameters, owing to the high proportion of newcomers to the subject. These events also provide vital feedback on the usability and functionality of CASA. The total cost to RadioNet was under 1000 €.

Webpage: http://www.alma.ac.uk/events/past-events/manchester-casa-2010

Multi-Wavelength Astronomy school, Amsterdam (NL), June 28 – July 9.
Radio Interferometry sessions occupied the first 4 days of this school, which was attended by 40 graduate students (selected from a more than 2x oversubscription) from Canada, Chile, China, Czech Republic, Egypt, Finland, France, Germany, India, Italy, Netherlands, Poland, Russia, Serbia, South Africa, Spain, UK, USA, Uzbekistan. Data reduction was taught in AIPS and CASA, using examples including MERLIN, EVN, ATCA, and the latest EVLA data. A problem-solving session was especially popular. The total cost to RadioNet was under 1000 €.

Webpage: http://www.black-hole.eu/index.php/schools-workshops-and-conferences/2nd-school-on-multiwavelength-astronomy

Table wp4.2: List of events in 2010 that either took place already or are planned before the end of the year.

Date	Title/Subject of the meeting	Location
31 March – 1 April 2010	CASA workshop	Manchester (UK)
28 June – 9 July 2010	Multi-Wavelength Astronomy school	Amsterdam (NL)
5-8 July 2010	YERAC XXXX	Alcala de Henares (Spain)
19-20 July 2010	CASA school	Oxford (UK)
20-24 September 2010	CESRA summer school	Nançay (F)
27 Sep – 1 Oct 2010	Single dish summer school	Bonn (D)
4-8 October 2010	ERIS	Grenoble (F)
11-15 October 2010	LOFAR data school	Dwingeloo (NL)

Note that a similar pattern of 3 major events (YERAC in Manchester, ERIS in Bologna, single dish school near IRAM Spain), plus support for events organised by other groups is planned for 2011, see RadioNet pages for links, and it is hoped to continue this in the next phase of FP7 with some changes in response to feedback.

2.1.5 WP5: Spectrum Management

2.1.5.1 Activity Progress

The objective of the Spectrum Management work package is to keep the radio astronomy frequency bands free of man-made interference in order to safe-guard this environment for fundamental astronomical research. The broad aims of the activity centre on coordinating activities designed to protect the electro-magnetic spectrum for passive radio astronomy observations. The radio astronomy community is at a significant disadvantage in pursuing this objective because it brings it into conflict with commercial and governmental and EC interests.

These objectives will be reached:

- by supporting the activities of CRAF (Committee on Radio Astronomy Frequencies). Since 1987, CRAF is mandated by all the European radio observatories to coordinate their spectrum management activities at the local, national and international level.
- by presenting the case for radio astronomy as a valuable passive service via discussions with the major public and private telecommunications agencies and the international bodies that allocate frequencies and manage standards (including the EC).
- by forming a coherent European voice acting in concert with other groups of radio astronomers around the world (e.g. CORF – the Committee on Radio Frequencies representing the interests of US scientists).
- by continuing to educate the European scientific community via a summer school that offers a comprehensive view of both regulatory and technical issues related to radio astronomers' use of the spectrum, as well as how these issues are considered by other both active and passive radio services.

Progress Report

In the following, short descriptions of the various activities supported by RadioNet are given.

Support of CRAF

CRAF has met three times (see table wp5.1) during the reporting period in accordance with the description of work and WP5 has partially supported the travel of members to these meetings and paid the expenses to local organizers hosting the CRAF meetings. Travel support was granted in thirty-six cases to participants of CRAF meetings.

Table wp5.1: List of supported meetings within WP5

Date	Title	Location
14-15 May 2009	48th CRAF meeting	Observatoire de Paris, Paris (F)
5-6 Novemeber 2009	49th CRAF meeting	Jodrell Bank Observatory in Macclesfield (UK)
27-29 April 2010	50th CRAF meeting	Chalmers/Onsala Space Observatory, Goteborg (S)

The 48th Meeting of CRAF took place at the Observatoire de Paris, in Paris (France) on 14-15 May 2009. Nineteen CRAF members and six guests participated in the meeting. Among them were representatives from EUMETNET (the network of European Meterological Services) and the EC Radio Spectrum Unit.

Summary of the meeting:

Common Spectrum Policy: CRAF and EUMETNET voice their opinion, that the EU commission should issue European guidelines for the use and protection of scientific radio frequency bands. That should help to ensure, that pressure from national interest groups or ideology driven policies does not result in the legalization of spectrum pollution in passive radio bands. Sorsaniemi (EC Radio Spectrum Unit) outlines the constraints on the EU commission's powers and asks CRAF for more detailed proposals. It is agreed to have regular consultations with the EU.

Better protection for 6.7 GHz observations: CRAF noted that the 6668.5 MHz methanol line becomes more and more important in current and future research in Europe. The current protection status given by Footnote ITU-R 5.149 is obscure and the entry in the allocation table is easily overlooked. Theoretically, it is possible to review the allocation to the 6.6 GHz allocated band. A task force is composed to specifically investigate this possibility.

Wind Power and Radio Astronomy: The specific and urgent case of Onsala is an example of how the issue of wind power shows up all around the European Observatories. The windmills can be the cause of two effects which can disturb the radio observations as RFI: one is the reflection of other signals impacting in the windmills (high frequency) and the other is the radiation coming directly from electronic power conversion and switching equipment installed in or at the wind power plant (low frequency). A recommendation from CRAF would be useful in a discussion with the local authorities. For this purpose an action item was established to define a CRAF Recommendation on the impact of wind turbines to the correct operation of radio telescopes.

The 49th Meeting of CRAF, took place at "Jodrell Bank Observatory in Macclesfield (UK), on 5-6 November 2009. Fourteen CRAF members and four guests participated in the meeting.

Summary of the meeting:
REVISION OF REC. RA.1513: It is agreed that proposing a new ITU-R recommendation is preferable than to modify the existing RA 1513 (on radio astronomical data loss). Indeed modifying the current RA.1513 may be very dangerous because it may compromise all the other ITU recommendations related to radio astronomy. This new recommendation will give an overview about how the measurements are performed at the radio telescopes.

Third Workshop on RFI Mitigation in Radio Astronomy 29-31 March, 2010: During this workshop (more information at www.astron.nl/rfi), Baan is asked to give to participants a general overview on the regulatory aspects of the spectrum management and, specifically, on the allocated bands to radio astronomy. This talk is aimed to make astronomers aware that overoptimistic claims about the effectiveness of new mitigation techniques can result in calls for the removal of spectrum protection for radio astronomy.

Wind Power: A new document entitled "Tall Structures, Wind turbines and radio astronomy stations" is now in progress. It contains an introduction, general information on Radio Astronomical Sensitivity and Interference levels and finally provides an impact assessment procedure. The document has found a favourable reception by German and Swedish administrations. It is agreed that the document will be circulated among some CRAF members for further comments before publishing in the CRAF website. Furthermore, during last CEPT Spectrum Engineering working group, following a CRAF proposal, Sweden made a proposal to study potential interference to RAS-observatories caused by Wind Turbines with the aim to develop an ECC Report with guidance on minimum separation distance between observatory and turbines. This Report could be used as a reference by radio observatories in their discussions with companies installing windturbines. The proposal was supported by Finland, Norway, the Netherlands and Switzerland. Various concerns were expressed that the issue of interference caused by Wind Turbines is not strictly a compatibility issue within the scope of WG SE. Even when this issue may be of interest of many countries, SE-WG in its function is not entitled to develop any regulations applicable to Wind Turbines, since this is a pure EMC matter, which should be subject to discussion in European Committee for Electro-technical Standardization (CENELEC). Finally, WG SE decided not to create any formal work item on this issue, but invited the interested parties to discuss on an informal basis the protection of RAS from Wind Turbines at the next SE21 meeting, based only on written contributions. Then the outcome will be reported to WG SE, which further on will decide on possible actions.

The preliminary draft Report ITU-R [ESSENTIAL ROLE OBSERVATIONS] was updated with the information about solar observations, as discussed during CRAF meeting in Paris and with results of the activities of the ITU's SG 7 correspondence group, which had been established to work develop the document. It is envisaged to finalize the work on this Draft New Report by June 2010.

Other Developments Discussed: Spectrum protection above 275 GHZ, new developments in satellite interference (IRIDIUM), UWB and Radar spurious emissions.

The 50th Meeting of CRAF at Chalmers/Onsala Space Observatory, Goteborg (Sweden) on 27-29 April 2010. Fourteen CRAF members and three guests participated in the meeting.

Summary of the meeting:
Future Organization of CRAF: An official letter has been sent to directors of the EU observatories to inform them about the precarious financial and manpower situation of CRAF. Only Jodrell Bank, Onsala and MPIfR have responded to the request to discuss the situation.

Wind power: On the afternoon of the 27th April, a wind turbine meeting was held at the Department of Radio and Space Science, Chalmers campus. As the wind turbine deployment is a hot issue for several European radio telescopes, it was decided to have such a meeting to exchange information and experience among people involved in the RFI activity. The participants of the Workshop agreed, that wind power deployment should be encouraged by radio astronomers. However it was demonstrated that wind turbines in the vicinity (<30-50 km) of radio observatories could be potential sources of interference emanating from their power electronics and telemetry as well as from the reflections of other transmitters (i.e. fixed links sharing the band with RAS) that would normally be shielded by the terrain. Wind turbines placed very close to the telescope can even function as a variable 'artificial moon' should the telescope or its sidelobes be able to point to them. The topic is new for CRAF and administrations alike. Radio astronomy should be involved in the local planning procedures of wind parks near radio telescopes and clear guidelines are to be given by CRAF on how a compatibility study is to be carried out.

The presentations given during the meeting have been uploaded to the CRAF website (http://www.craf.eu/windturb.htm).

Engaging agencies and international bodies that allocate frequencies and manage standards:
Representatives from EUMETNET and the EU Spectrum Group accepted the invitation to CRAF meetings.
Under WP5, RadioNet also supported the attendance of CRAF members at five conferences on European (CEPT) and Global (ITU) levels presenting the case for radio astronomy:

- CEPT SE40 in Biel (Switzerland) 27-29.1. 2009: mobile satellite (IRIDIUM) matters
- CEPT SE40 in Copenhagen (DK) 23.-24.11.2009: mobile satellite (IRIDIUM) matters
- CEPT SE40 in Paris (FR) 8.2.-9.2.2010: mobile satellite (IRIDIUM) matters
- ITU WP7D meeting in Geneva (Switzerland) 14-18 June 2010: on global regulatory issues: "Sharing between the radio astronomy service and active services in the frequency range 275-3 000 GHz", "spectrum usage of the 21.4-22 GHz band for the broadcasting-satellite service ","software-defined radio (SDR) and cognitive radio systems (CRS)","mobile-satellite service in the range 4 GHz to 16 GHz", "Revision of Recommendation ITU-R RA.1513","New Report on Earth observations", "Radio-Quiet Zones", "Digital TV" and "Power Line Telecommunication"
- 2009 Public Sector Spectrum Conference in Brussels, April 21-22: see below under Education and Collaboration.

Education and Global Collaboration

Two CRAF newsletters per year are sent to Institutes, administrations and agencies. They are available on the CRAF website under http://www.craf.eu/newsltr.htm and contain information about current issues in radio astronomical spectrum management and technical aspects of Radio Frequency Interference (RFI) assessment and protection.

Spectrum Policy Conference: The CRAF chairman gave a presentation titled 'Natural Limits To Flexibility' at the 2009 Public Sector Spectrum Conference in Brussels (April 21-22). The conference agenda is available at: http://www.policytracker.com/conferences/the-public-sector-spectrum-conference/public-sector-conference-agenda

The International Spectrum Management Summer school was initially planned for the summer of 2009. However the South Korean Organizer cancelled the event at short notice and the summer school was finally held in Japan (31.5.-4.6.2010). WP5 supported the attendance of two European lecturers and three students at the summer school. The presentations are available on http://www.iucaf.org/SSS2010/

RFI2010 Workshop: 29 - 31 March, 2010, Groningen (NL): Eleven CRAF members participated in the discussions or gave presentations. Details are found on http://www.astron.nl/rfi/

RadioNet Board meetings in Amsterdam and Calgari: The CRAF chair and his deputy gave presentations about Spectrum matters and CRAF at the last two RadioNet board meetings. Details are in the minutes of the RadioNet Board meetings.

Regular consultations by correspondence or teleconferences are held with representatives of IUCAF, RAFCAP and CORF on spectrum matters.

Development of Common monitoring schemes

A group of CRAF members is involved and work is in progress. The topic is an agenda item on each CRAF meeting.

A common standard and a freely accessible web-page were implemented and are available at http://laser3.ca.astro.it/rfidb/submit.php and http://laser3.ca.astro.it/rfidb/query.php) .Test measurement using simple and inexpensive monitoring equipment have been undertaken in the Czech republic. A report was finished and will be published in the next CRAF newsletter (in press).

The work package is well within budget and no problems are foreseen to finish it.

2.1.6 WP6: ALBiUS

The objectives of ALBiUS (Advanced Long Baseline interoperable User Software) are to develop key algorithms required for the successful exploitation of the upgraded and new generation of RadioNet telescope facilities (e-MERLIN, LOFAR, APERTIF, ALMA etc). These new telescopes will result in an explosion of data rates, and an expansion in the continuum spectral window of one to two orders of magnitude. ALBiUS will produce both new software systems and algorithms that are designed to meet these challenges. The focus will lie in the production of new algorithms that address issues of calibration (both in the UV and image plane) and sky modelling. The need for identifying bad data and the issue of data quality control in general, will also be addressed. In addition, ALBiUS aims to make good use of existing software packages - the goal is to make these algorithms available in a modern, distributed computing environment, and to provide transparent interoperability between the different software suites. The latter will encourage a more unified approach to software development in radio astronomy across Europe and beyond.

ALBiUS takes two distinct approaches to solving some of the software problems currently facing radio astronomy. The first approach is to improve the accessibility of existing implementations of important algorithms via interoperability and the development of standardized interfaces. The second, and more challenging part is to develop new algorithms to solve known problems in radio astronomy. Most of these are new algorithms where the main uncertainty is whether these methods can provide the computational efficiency required for use with the huge datasets provided by cutting edge radio astronomy facilities. Successful implementation of some of these methods may also impact on the data and calibration models used by the data analysis packages.

2.1.6.1 Activity progress

ALBiUS is a joint effort of experts at 10 institutes. By the start of the year 2009, one issue that has been identified is that NRAO was unable to allocate resources for the evaluation of global fringe fitting. The solution has been found in South Africa at the Hartebeesthoek Radio Astronomy Observatory (HartRAO). This required a contract change to include HartRAO, which is already part of RadioNet, into the ALBiUS JRA. The ALBiUS person in South Africa has been identified (Dr Ian Stewart), but he has not yet been formally hired.

At the end of the year 2009, the ALBiUS JRA was underspending. The reason for this has been the late start at a number of partner institutions due to difficulties to match locally the efforts. This has been particularly the case for our UK partners where the UK national funding agency has frozen the necessary matching budget. However, now the work has started at all the original ALBiUS partners and in most cases satisfactory progress has already been achieved. The collaborative and modular structure of the work in ALBiUS make possible to rearrange the time-line of the subtasks in order to deliver all the milestones and complete the planned deliverable on time. Furthermore, none of the delayed subtasks will take more than the remaining 18 months. In conclusion, the late start issue was solved by rearranging the internal ALBiUS tasks without changing the efforts of the participating institutions and without decreasing any of the original expectations. All the ALBiUS results are therefore expected to be delivered on time.

At the end of June 2010, ALBiUS was in full swing at 9 of the 10 participating institutes. Software developed within the ALBiUS activity has been already used by astronomers for both experimental and traditional data analysis. In particular, the LOFAR user community has been using the innovative ALBiUS software for cross-package (interoperable) scripting.

All the partners of the project have met twice for progress meetings. Furthermore, a number of general and subtask related teleconferences have been held. Minutes of all meetings are available on the RadioNet wiki.

2.1.6.2 Interoperability

Portable algorithms

The interoperability task is well underway at JIVE and is progressing well. Various tools have been developed to make working in a mixed AIPS / Measurement Set environment more convenient. Progress has been made on all sub-tasks, and one is completed. A collaborative effort exists between JIVE and ESO which will be strengthened in the coming months. Collaboration on the issue of flag table portability is in place with Oxford.

Framework: (Milestone 6.1.1) Interoperable calibration.

JIVE provides software infrastructure that allows the user to access both ParselTongue and CASA (the ALMA and eVLA software package) from a standard Python shell. This enables the user to make use of a wide variety of algorithms from both classic AIPS and CASA. Data transfer functions are also provided that facilitate the conversion of data between the different storage formats of the two packages. A binary distribution of ParselTongue, which includes all its dependencies, is provided. This is linked against the NRAO's CASA release and facilitates the easy installation of ParselTongue, providing the dual AIPS/Casa access discussed above. Software has been written to extract calibration information from AIPS tables and create Measurement Set (MS) calibration tables. ParselTongue is used to access AIPS calibration tables, and pyrap, a python rapper to the casacore classes, is being used to create and populate MS calibration tables. Validation of the interpretation of these data by the respective data reduction environments, AIPS and CASA, is on-going. Since CASA is missing an implementation of fringe rate corrections, alternative approaches are being developed which extrapolate phase corrections based on the fringe delay, rate values present in the AIPS calibration solutions. Furthermore additional software has been developed at JIVE to convert a priori Flag, System Temperature and Antenna Gain Curves in to Measurement Set tables.

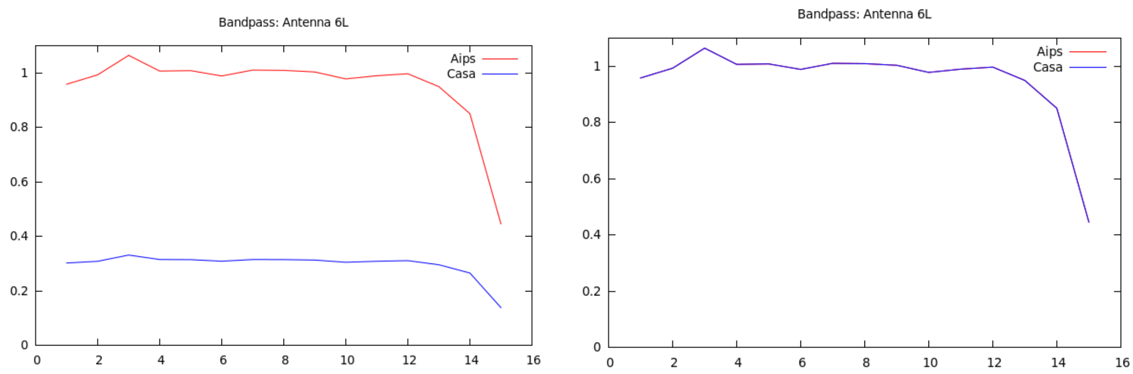


Figure wp6.1: ParselTongue and Pyrap are used to directly access and modify calibration data. The first plot shows a bandpass produced in both AIPS and CASA. The CASA bandpass was produced with a different normalisation. After transferring the Aips solutions to the MS, plot 2 shows the Aips and Casa tables to be equal.

As part of the ESO contribution to interoperability, the CASA task “importfitsidi” was developed to enable processing of VLBI data coming from networks such as the EVN and eMERLIN. The task “importfitsidi” reads the FITS IDI archive format as documented in Greisen, E.W., 2009, “The FITS Interferometry Data Interchange Convention -- Revised (AIPS Memo 114r)”, and converts it into a Measurement Set thereby enabling further processing with CASA. The design document for “importfitsidi” is attached to this report. The development is nearly completed. A preliminary version is being tested at JIVE (for EVN data) and Jodrell Bank (e-MERLIN). The staff at University of Manchester has worked also on use cases for interoperability. This has been done by testing CASA on MERLIN, EVN, NRAO, LOFAR and other data, and reducing e-MERLIN data in AIPS as well as collecting other people's reports locally. This work has indentified the issues of CASA in case of wide-field/wide-band imaging.

Data structure.
Plans for the development of a new data interchange format based on HDF5 were abandoned in favour of using the existing and well-documented FITS-IDI format (see above). University of Manchester has worked with ESO on FITS-IDI data from e-MERLIN. At the University of Manchester, a FITS-IDI writer as part of the e-MERLIN has been developed.

(6.1.2) Distributed Parseltongue.
New functionality has been added to ParselTongue. It now cooperates better with NumPy and direct access to visibilities has been implemented. ParselTongue 1.1.2 has been released and includes those new features as well as a number of bug fixes. New features have been implemented and will appear in the next release. These include:

- access to local TVs that will make possible to run multiple TVs. This will assist the parallel processing;
- random visibility access and source-based visibility access. The latter will enable processing data for multiple sources in parallel;
- integration of AIPSLite in ParselTongue. This makes possible to use ParselTongue on an HPC cluster without a pre-installed AIPS distribution, greatly lowering the barrier to parallel processing;
- possibility to add new AIPS disks "on-the-fly" to make easier data sharing between AIPS "sandboxes".

The new version of ParselTongue, which includes these features, is expected to be released early August 2010. Possible collaboration with Oxford on HPC and a ParselTongue related pipeline for GMRT data has been identified.

At University of Manchester, detailed use cases are being developed for current and new instruments: e-MERLIN, EVN, NRAO, LOFAR using CASA and AIPS (related to wide-field, wide-band imaging). Practical strategies in AIPS using real e-MERLIN data are also on study. The University of Manchester team has also investigated the A-projection algorithm and are now working on acquiring astronomical measurements for the illumination patterns using e-MERLIN as well as looking at EM simulation packages to calculate these for e-MERLIN and other antennas.

2.1.6.3 Calibration Algorithms

(6.2.1) Global Fringe Fitting.

No work has yet been done in South Africa on this work package, pending personnel acquisition details. The WP is expected to come through shortly.

2.1.6.4 Image Plane Calibrations

(6.2.2) Ionospheric/Tropospheric.

University of Manchester is working on reviewing current algorithms and implementations for Image Plane calibration. This includes work on the use of heterogeneous arrays. Detailed analysis of beam-maps for wide-field imaging is in progress.

(6.2.3) Primary Beam/Mosaicing.

Among the various direction dependent terms in the measurement equation for an interferometer, time variable antenna primary beam effects at high frequencies and ionospheric phase at low frequencies produce the dominant sources of errors limiting the imaging dynamic range.

At ESO, the team has been working on the software for mosaic imaging including primary-beam correction. This work concentrates on two issues: (a) making the existing wide-field imaging capabilities in CASA work with heterogeneous arrays and (b) enabling the CASA package to import simulated primary beam models from the GRASP format (a common simulator tool).

NRAO research has been focused on algorithms to solve for parametrized antenna primary beam and use the derived model to correct for its effects during imaging. This effort has lead to the development of the A-Projection algorithm to correct for primary beam effects during imaging and the Pointing Self Calibration algorithm to solve for antenna pointing errors. The ALBiUS goals involved applying these algorithms to real wide-band data from the EVLA. The A-Projection algorithm was used for deep imaging of the 3C147 field to correct for the effects of the rotation of the azimuthally asymmetric antenna primary beams. This produced the highest dynamic range image yet with the EVLA!

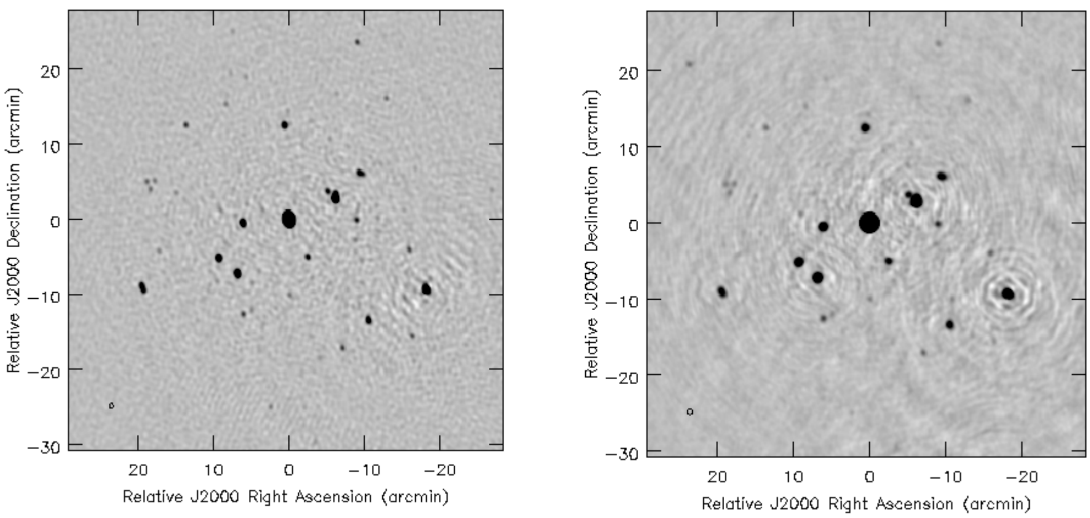


Figure wp6.2: Image on the left shows the best image without correcting for the rotation of the antenna primary beam with parallactic angle. Image on the right shows the image made using the A-Projection algorithm which corrects for such primary beam effects.

Correcting for the effects of primary beam rotation has clearly improved the imaging performance across the field of view (see figure wp6.2). However, one can still see that the compact source near the half-power point (source near -20' offset in RA and -10' in Dec.) has residual artifacts which were not fully removed. This suggests that antenna pointing errors could be the next dominant error term, after correcting for the effects of primary beam rotation.

(6.2.4) Polarization.

The subtask about polarization has started later than planned at the University of Cambridge. During the first three months of the subtask an assessment of current state of the art in the field has been completed and an analysis of the mathematical structure required to describe the problem is nearing completion. A report about polarization calibration and imaging has been completed. This report describes the theory of large interferometer telescopes and the measurement equation, which can be constructed to give an accurate description of the measurement process. It discusses the issues concerning and limiting the quality of polarimetric observations carried out by the new generation of instruments. The report studies also the suitability of software package to calibrate future data, and finally it tries to establish what future work needs to be done in order to construct calibration pipelines for the new instruments. The team at University of Cambridge has also worked on assessing CASA capability for polarization work and this work is continuing during the next quarter in collaboration with NRAO.

(6.2.5) Distributed Processing.
For the amounts of data, produced by LOFAR, ALMA, EVLA, it is as yet unclear how an optimized processing scheme would look like. In particular how the pros and cons of a facet based approach and of a convolution based approach (A-Projection) turn out in practice is still unknown. This is being investigated within this task. In general the progress is according to plan.

As a first step the CASA imager was made available in the LOFAR processing pipeline. With the conclusion of that step both the CASA imager and the Imager that is being developed by ASKAP and ASTRON, are available for comparison within the same pipeline framework. This part was successfully concluded.

One way to correct for image plane effects (primary beams, ionosphere) would be to apply an independent correction per facet. Although the current imagers are able to make facetted images, they lack the ability to apply independent corrections per facet. An initial implementation was made. Currently this implementation is further optimized. The progress is slightly behind schedule, but expectations are that this can be made up for that in the remainder of the project.

Another way to correct for image plane effects is by convolutional methods. The A-Projection algorithm is such a method for correction for Primary Beams. By implementing a dynamic gridder it was possible to import LOFAR primary beams into the CASA A-Projection method. The dynamic gridder is a general approach which would make it possible to import primary beams from other instruments too, once available. Work on this task has recently started, together with NRAO. Substantial progress has been made, but more work remains. Especially in generalizing EVLA specific parts of the code.

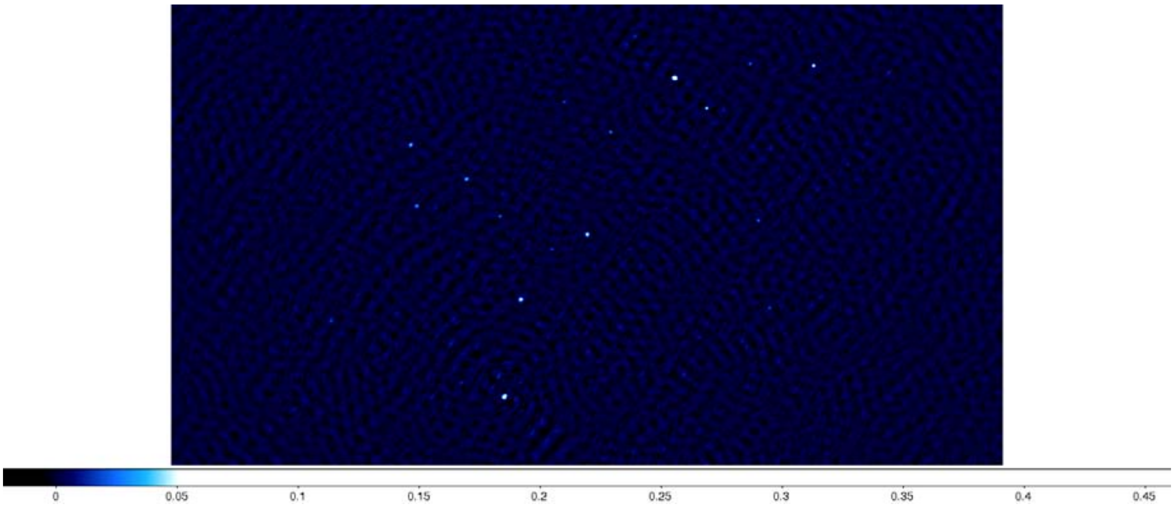


Figure wp6.3: 7°x7° field with point sources self-calibrated using LOFAR and CASA scripts. Courtesy of F. De Gasperin (MPA, Germany)

(6.2.6) Astrometric Positions.
The task on the astrometric calibration at the Bordeaux Observatory has started only on April 2010, due to delay in hiring personnel. Since then, the work has focused on understanding fundamentals of VLBI astrometry, for both the wide-angle and phase-referencing techniques, since the heart of the project is to implement algorithms that combine the two approaches. Work has also begun on reviewing capabilities of existing VLBI software packages. A poster (Chemin & Charlot, in preparation) describing the main objectives of the ALBiUS astrometric calibration task was presented at the annual meeting of the French astronomical and astrophysical society held on June 21-25, 2010, in Marseille.

A detailed bibliography about VLBI and its applications to astrometry was assembled at first with focus on finding references that provide in-depth information about the standard VLBI technique (based on total group delay measurements) as well as on the phase referencing technique (based on relative phase measurements). The software packages that we identified as possibly suitable for our work are: CALC/SOLVE (developed at NASA/GSFC, USA), MODEST (developed at the Jet Propulsion Laboratory, USA), SteelBreeze (developed at the Main Astronomical Observatory in Ukraine), QUASAR (developed at the Institute of Applied Astronomy in

Russia), GINS (developed by the CNES in France) and OCCAM (developed jointly in Europe and Australia). These are used routinely to analyze the group delay measurements that are acquired within the sessions organized by the International VLBI Service for geodesy and astrometry (IVS); it remains to be seen however whether they can also process relative phase measurements. For phase-referencing, AIPS (developed at NRAO) is the software package that has been used the most but it does not allow one to control or modify the underlying VLBI model; SPRINT (Lestrade et al. 1990) does permit such a control and may provide an interesting alternative although it is not maintained anymore.

Despite the delay in starting, it is anticipated that the work for this task is expected to be completed by the end of the project. A total of 3 person-months have been spent so far, with another 18 person-months at least to come, based on full-time employment of the hired. Overall, this corresponds to the 21 person-months, required in the description of work for Bordeaux Observatory, over the duration of the project.

2.1.6.5 Large Datasets

Quality Control
(6.3.1) RFI Mitigation.
Little activity is planned on this item until after the item Multi-Rate Filtering is complete. However, some discussions on data sources, hardware resources, and lead users have taken place.

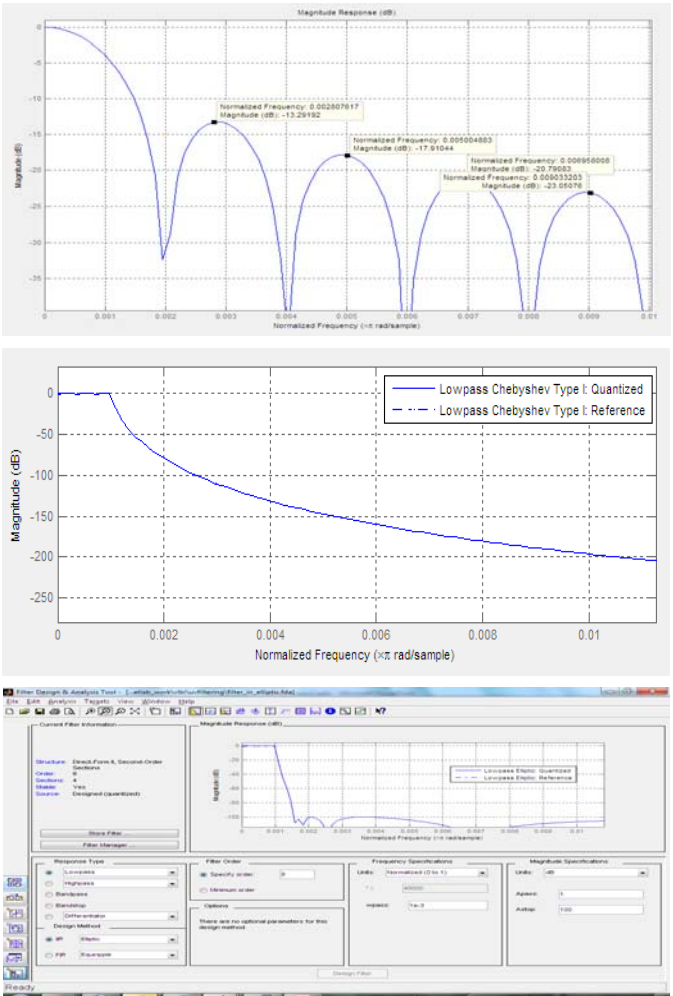


Figure wp6.4: Filter response curves for three RFI-mitigating filters considered during the multi-rate filter design showing the magnitude response vs. the normalized fringe frequency. Top: the present filter used in most existing VLBI and connected-element correlators, including DiFX (rectangular moving-window average). It shows poor rejection in the stop band (13 dB to 23 dB of rejection in the range shown) and slow dropoff. Middle: The multi-rate decimating low-pass filter (8th-order Chebyshev IIR) and bottom (8th order elliptic IIR) show 100 dB or more of stop-band rejection and very steep transition to the passband in the field of view, which is much better than the present situation and should give good rejection of RFI away from the image field centre.

The Bonn University is no longer focusing on the FPA/cross-spectra algorithm, since it has been established that the RFI is self-generated in the telescope and they want to solve this locally. New potential lead user has been identified in the Effelsberg team working on APERTIF, and sampled IF data is already available for algorithm development and testing. Actual APERTIF system delivery to Effelsberg is expected to be late 2011, after the FP7 MPIfR deliverable. Other users have shown interested (Parkes 64-m radio telescope in Australia) and wanted to provide test data sets. Current FPGA hardware at Effelsberg is not suitable for forming Kesteven cross-beam spectra (Effelsberg preferred an updated az-el mask for RFI instead). MPG is studying the capabilities of planned future hardware (Roach2) and the usability for cross-beam spectra. At the same time, they will continue with pipeline implementation of Kestevens approach for future use.

Multi rate filtering is the main area of activity at MPG since the project start. A significant result has come from the multi-rate filter design stage that yielded a filter design (elliptic IIR of order 8) that provides 100dB of rejection in the stop-band (theoretically) and is practical in terms of computing requirements. The software module to implement the filter in the DiFX software correlator has been completed and is ready for testing with real data.

(6.3.2) Data Inspection.
Data inspection is one of the most important steps in synthesis imaging processing in which only a few faulty visibilities have great influence in the image quality. University of Oxford had investigated the AIPS flagging limitations. An algorithm to bypass the flagging limitation within AIPS has been developed. Also the bottleneck of the process has been identified with the heavy disk access. Based on current GMRT datasets within an automated calibration pipeline the most meaningful diagnostic plots (see figure wp6.5) were evaluated. The pipeline itself is based on AIPS, ParselTongue and python software packages, which are all publicly available. The individual diagnostic plots are based on the python library matplotlib (http://matplotlib.sourceforge.net/). Python modules which have been developed to access raw visibilities can be used within ParselTongue. This approach assures interoperability of the developed modules and opens the opportunity that the developed modules can be used by other calibration software packages (e.g. CASA).

Quality assessment of the visibilities at all stages in the calibration scheme is crucial. Furthermore, the standard calibration is telescope-based, but errors could also occur on individual baselines (e.g. radio interference, not matching sub-bands, etc.). Therefore in order to investigate the quality of the data it is essential to evaluate the visibilities based on individual baselines and telescopes. Several plots have been created and have been tested of their practicability and usefulness within an HTML interface. In order to prepare the visibilities to be plotted in these modules additional data modules had to be development and will be made available.

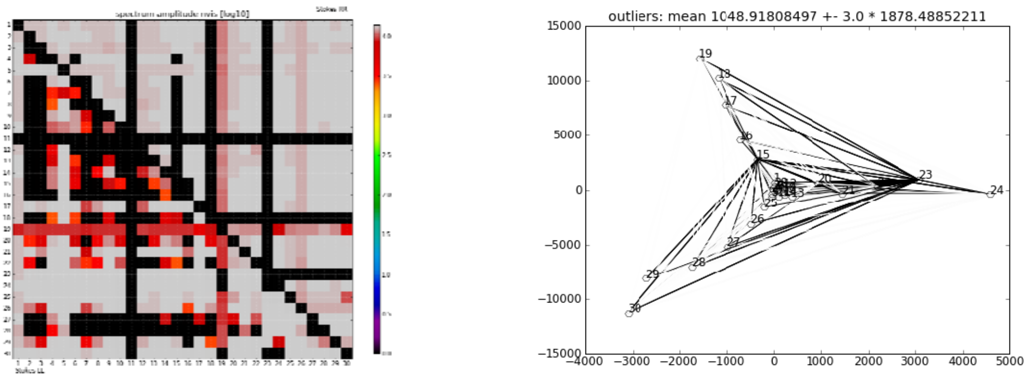


Figure 4: Developed quality control plots (visibilities). Left: Dynamic spectrum of each individual baseline displays the amplitude versus time in order to investigate RFI and faulty channels. Right: This baseline based plot shows each baseline pairs in an nxn array (n is the number of telescopes.

So far only baseline based quality assessment tools have been developed and further are planned in order to investigate band-pass problems. Plots that have been proofed to be useful within the calibration pipeline will be translated into a python-based module. The quality assessment and displaying of metadata can be based in a similar manner than the visibilities and therefore the developed baseline based and telescope based diagnostic plots can be used.

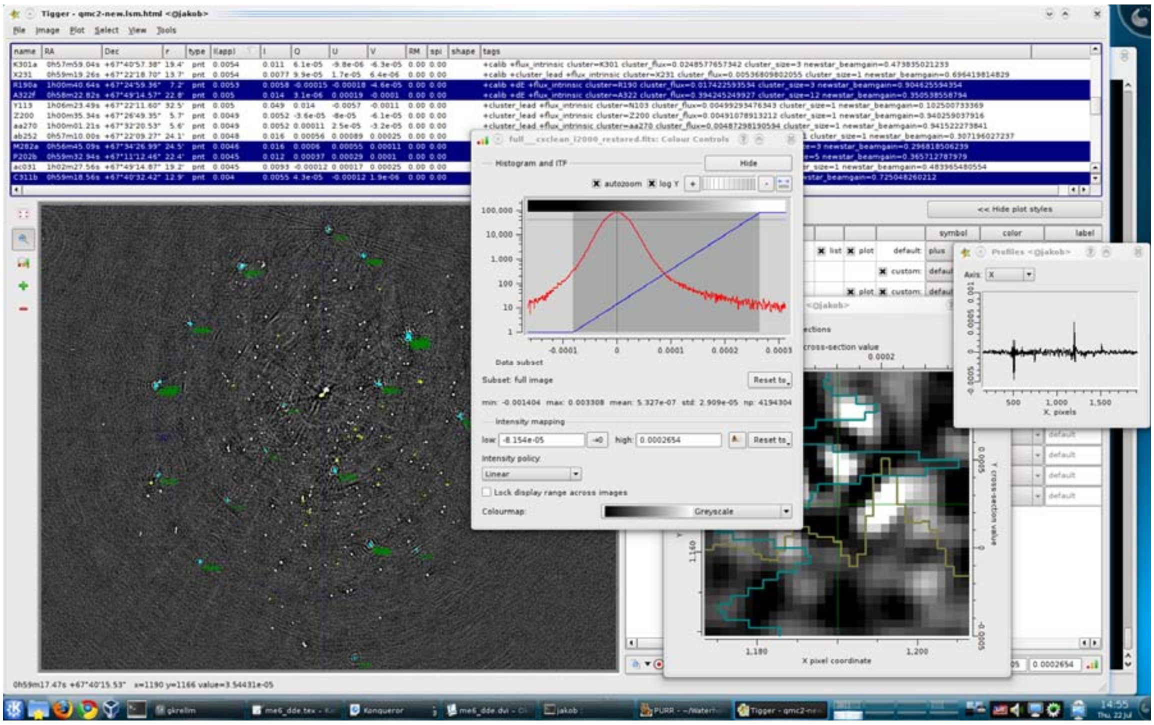


Figure wp6.6: Tool for evaluating the sky model.

(6.3.3) Source Parameterization.

The objective of this task is to make new source parameterization approaches, like shapelets, available for data processing. The task started in month 13 and is on track.

A sky model tool (see Figure wp6.6) is developed for point sources. The next step will be to extent this tool for the use of shapelets. The progress is according to schedule.

2.1.7 WP7: AMSTAR+

The AMSTAR+ JRA

The technical requirements for FPAs, especially for large, two dimensional arrays of heterodyne receivers, are much more demanding than for single-pixel receivers: in addition to *low noise and wide frequency bandwidth*, they demand *high compactness, high reliability, low fabrication cost and high reproducibility of the detector elements*. Moreover, stringent constrains exist on *LO power generation and distribution, IF amplification* and matching and cryogenic cooling. These requirements present demanding technical challenges that can be solved only by exploring novel technical solutions.

The AMSTAR+ JRA consists of 4 main tasks, or sub-packages, that explore the solutions best suited for the frequency intervals 80-120 GHz, 120-400 GHz, 400 GHz-1.2 THz and 1-2 THz. These intervals are equally important from the astronomical point of view and are accessible through the existing large European telescopes IRAM 30-m telescope, PdBI, JCMT and APEX. They are:

Task 1.*W-band array module using metamorphic HEMT technology* (partners on this task are MPIfR, IAF, IRAM, OA-Calgiari)
Task 2.*Advanced receiver pixels and LOs for large FPAs in the near mm domain* (IRAM, RAL, FG-IGN)
Task 3.*Sub-mm FPAs* (SRON, TuD, GARD, FG-IGN, KOSMA, Oxford)
Task 4.*Low noise mixers for FPAs in the THz range* (TuD, SRON, GARD, ObsParis, KOSMA)

Within the short timescale and budget of AMSTAR+/ RadioNet 2 (2009-2011, 1.2 M€), it is excluded to develop and test full prototypes for the above tasks. Deliverables are thus restricted to design studies, progress reports and, in some cases to partial devices and/or demonstrators.

AMSTAR+ Status at the end of July 2010. Summary.

Work has started at the participating institutes between January and July 2009, depending on their ability to get internal funding prior to EU funding. This is particularly true as concern hiring of new personnel for AMSTAR+ Task 4. Work reached its full span in all institutes only in Q4 2009, resulting in a few months delay for some deliverables. The total expenditures (personnel, material and consumables) are nevertheless close to predictions at the level of the JRA, thanks to the early start of some large institutes. It is foreseen to get results and terminate the program in time, i.e. by the end of Q4 2011.

2.1.7.1 Detailed description of the work per Task.

Task 1: W-band array module using metamorphic HEMT technology

Goals: The main goal of this task is to explore the potential of the metamorphic HEMT (mHEMT) process on GaAs developed by IAF to deliver a noise performance at mm-wave-length competitive to the current InP-based technology. IAF's expertise in large scale integration of solid state circuits offers the capability within Europe to build highly integrated mm-wavelength MMIC's that can be integrated into large FPAs. In comparison to the InP based technology, IAF's process could offer lower cost, especially for large area MMIC's integrating many building blocks on a single chip.

Task 1 work is split between IAF, which produces the mHEMT and MMIC devices, IGN, which tests single mHEMT devices by incorporating them inside cryogenic 4-12 GHz and 18-26 GHz amplifiers, and MPIfR and IRAM, which test the 3-mm MMIC performances at cryogenic temperatures and compare them with SIS mixer receivers. U-Cagliari concentrated on the design and fabrication of ortho mode transducers that would allow to observe two orthogonal polarizations for each pixel.

Several cryogenic mHEMT GaAs devices and MMIC were produced by IAF and tested in the course of the 18-month period. They were designed to operate at frequencies up to 26 GHz.

Subtask 1.1&1.4@MPIfR: The calibration scheme of a F50 noise probe station was developed and checked; relevant cryogenic loads and attenuators were developed. An integrated cryogenic load was designed for test of IAFs MMIC process, verification is underway. The first successful cryogenic tests of an extended S-parameter probe station were made. This station will allow for mapping of big wafer pieces, hence testing many HEMT devices in a single cool down cycle. It will help improving the statistics of cryogenic production runs. Further cryogenic noise tests were done on packaged LNAs using low-frequency (<12 GHz) MMICs from IAF's 100nm gate-length production line. Very encouraging results were obtained for 1-4GHz and 4-12GHz MMIC LNAs. 50nm tests follow.

Subtasks 1.1& 1.2@IAF: Low frequency MMIC designs were placed on IAF standard production runs of wafers in 100 and 50nm gate-length technology. After dicing and testing, devices from these runs will be distributed to the participants in Task 1 for testing. Design of new high frequency LNAs and modelling of the cryogenic devices was continued. Cryogenic S-parameters for single HEMT devices were measured and passive planar structures from the MMIC process characterized using a new IAF cryoprober.

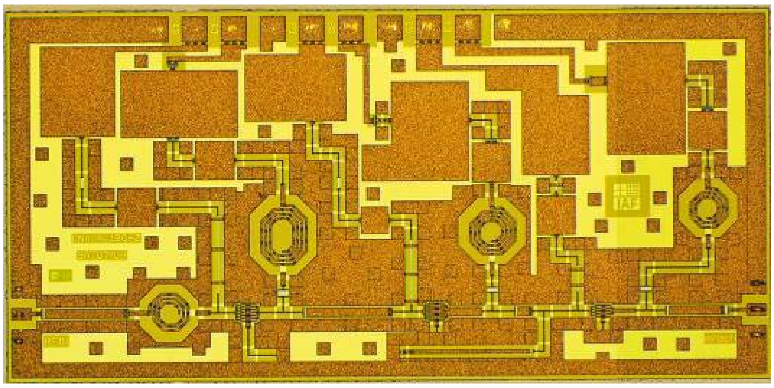


Figure wp7.1: IAF 4-12 GHz cryogenic MMIC

Subtask 1.4 @ IRAM: Cryogenic noise tests were done with the IRAM measurement set on packaged LNAs based on low-frequency MMICs from IAF's 100nm production line.

The design of a W-band heterodyne array receiver with direct amplification of the RF signal was completed. This receiver, which uses MMIC LNAs, will have 49 sky-pixels and will be used, once completed, on the IRAM 30-m telescope. A demonstrator, consisting of a dual-polarization pixel was built and tested. It uses for the time being LNAs based on InP MMICs from JPL/NGST that were bought from Umass. Receiver temperatures between 30 and 45K were achieved throughout the 84-116 GHz RF band. The IF band is 4-36 GHz. The demonstrator will soon be shipped to the IRAM 30-m telescope.

Subtask 1.3 @ FG-IGN Cryogenic noise tests were done on packaged LNAs using low-frequency MMICs from IAF's 100 nm production line. Very encouraging results from 4-12GHz MMIC LNAs were found. Noise tests on single HEMT devices from IAF used in the first stage of a packaged hybrid LNA were carried out with results that are already close to NGST devices.

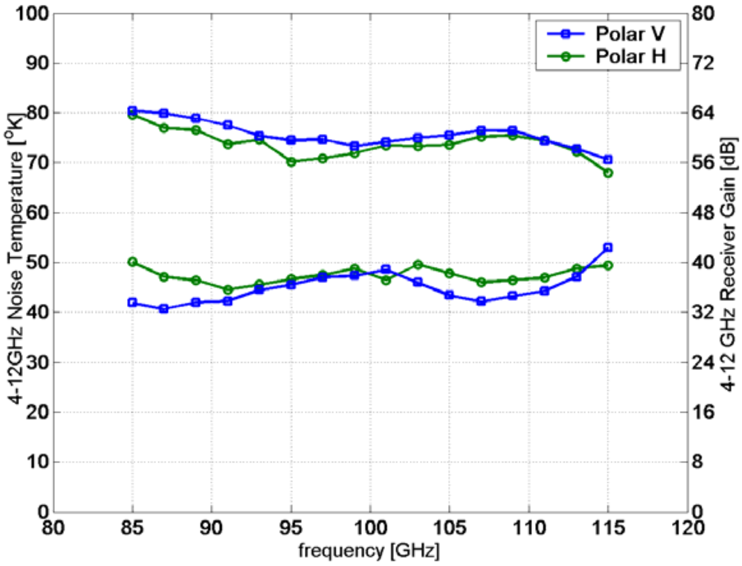


Figure wp7.2: performance of the IRAM W-band HEMT receiver

Subtask 1.3 @ INAF-Cagliari: A W-band waveguide Orthomode Transducer (OMT) based on the reverse-coupling structure designed by A. Navarrini was fabricated in the MPIfR mechanical workshop under the coordination of F. Schaefer. Waveguide transitions were sent from INAF-OAC to MPIfR that will allow test of the newly fabricated OMT. The design of a new waveguide OMT based on turnstile junction is in progress.

Task 2: Advanced receiver pixels and LOs for large FPAs in the near mm domain

Goals: To design, build, and demonstrate the following enabling components for large (two dimensional) coherent (heterodyne) mm-wave FPAs, with little or no compromise on performance with respect to single pixel receivers. Tasks 2 consist of 5 subtasks aimed at the design, fabrication and test of:

- Subtasks 2.1, .2, .3, .4: A compact pixel module with: a) small footprint suitable for 2D stacking in focal plane; b) sideband separation and wide IF band for maximum scientific throughput; c) as much as possible, integration of all signal processing from RF feedhorn to LNA output.
- Subtask 2.5: A photonic local oscillator (LO) for the near-millimeter range meeting the following conditions: a) scalable to large (~100 pixels and up) FPAs; b) spectral purity suitable for all single dish application, and, if possible, for interferometry (accuracy and linewidth of 1 kHz or less with a minimum frequency step of 100 kHz).

IRAM and IGN-CAY are in charge of sub-Task 2.1-.4 and STFC-RAL of 2.5.

Subtask 2.1&2.2@ IRAM

The design of low-noise wide-band 2SB mixer modules with a 2.5 cm footprint and, operating between 200 GHz and 280 GHz has been finalized. The Josephson effect is suppressed using micromagnets. Problems with finding a supplier for these micromagnets, caused some delay. IF bandwidth is 4-12 GHz and the input IF load 50 Ω. The modules are integrable in a 7x7 pixel array.

The first SIS junctions have been fabricated at IRAM and tested inside a DSB mixer test receiver. The receiver showed good performance over the intended RF range and the whole IF band from 4 to 12 GHz (see Figure wp7.3).

The fabrication of the 2SB mixer blocks has started in the IRAM workshop.

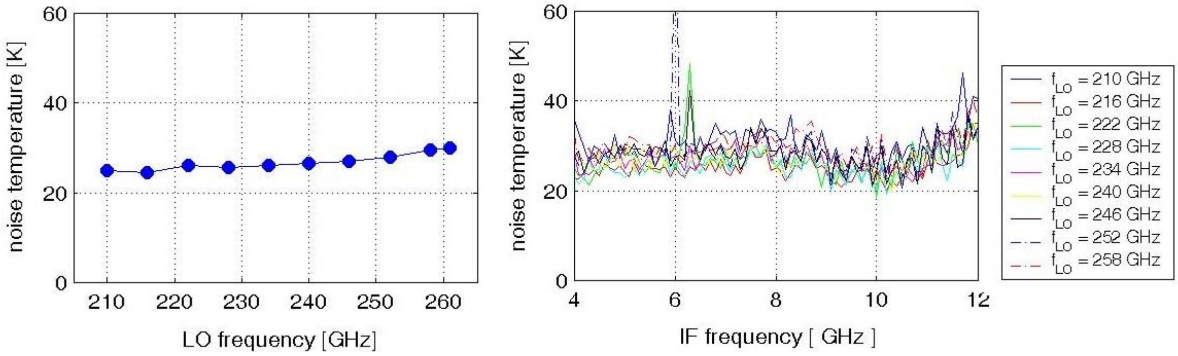


Figure wp7.3: Left: Noise measurements of the DSB receiver integrated over an IF band of 4 to 12 GHz. Right: Noise measurements in the IF band for different LO frequencies.

Subtasks 2.1&2.3 and subtask 3.3 @ FG-IGN/CAY: Progress was made in the design of a 4-12 GHz, 3-stage cryogenic LNA optimized for low input return loss (50 Ohm) and incorporating bias for the SIS mixer. Electrical simulations wire completed. Regarding the direct connection of the SIS mixer and the IF amplifier, its effect was evaluated using a model of an SIS mixer directly connected to different options of IF amplifiers The simulations shows that improving the input reflection has a drastic effect in the noise and gain ripple. This solution has been further investigated and implemented in a prototype.

An alternative approach for obtaining an excellent input reflection in a cryogenic amplifier is to use a balanced configuration. The balanced amplifier consists in two identical amplifiers combined with 3 dB hybrids in such a way that the reflected waves null (ideally) at the input port. To evaluate this option, a balanced amplifier was implemented using MIC modules (Figure wp7.4) and tested (Figure wp7.5). The scheme has proven excellent results, and resolves very effectively the mismatch problem, although it has various drawbacks, as the higher complexity and cost and the larger size and power dissipation. These make the option of the balanced amplifier not very convenient for a FPA.

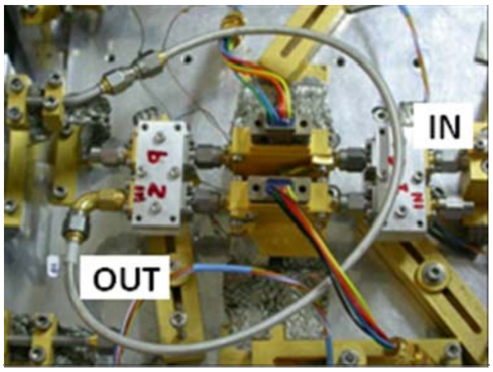


Figure.wp 7.4. Balanced Amplifier in cryostat

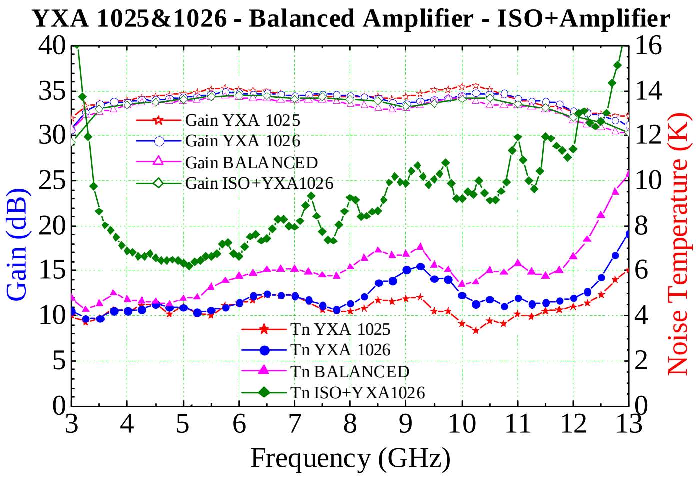


Figure wp7. 5 Balanced Amplifier measurements

Subtask 2.5:@STFC/RAL: Work has been going on for phase-locking the photonic LO. Progress has been made in setting up a photonic reference system that will allow locking of a photonic mixer. The PLL is currently being investigated and associated components performance tested, e.g. frequency reference and PLL electronics. Phase-locking test should start in Q3 2010. Main problem is a shortage of effort, but this issue is being currently addressed.

Task 3: Sub-mm FPAs

Goal: To explore solutions for the construction of large sub-mm FPAs, based on SIS junction mixers. May be used for CHAMP+ on APEX. The short wavelengths raise specific problems for large arrays: The LO power generation and injection becomes critical; The atmospheric noise is large and sideband-separating mixers reduce this noise and the required LO power; The short wavelengths make the mixer coupler and horn fabrication delicate and expensive requiring new fabrication technologies. Finally, the high frequencies require superconducting materials with high energy gap and new technologies. SRON is in charge of the mixer design, TuD and KOSMA of the junction fabrication and test. OSO develops a lithographic process for the fabrication of small, accurate mechanical parts such as RF hybrids. UOxford follows another design, based on an SSB fineline mixer.

Main results achieved in the past 18 months:

Subtask 3.1&3.2@ SRON: The design of a compact sideband separating (2SB) mixer block working in the 600-720 GHz band has been initiated and finished. It was possible to find the appropriate solutions for both hybrids, the two SIS mixers and the IF connections. The most difficult part was to design independent compact magnetic field supplies for both SIS junctions. A mechanical prototype for the mixer block is being machined and almost ready for tests. The RF hybrids was fabricated at U-Chile in a mechanical machining and at OSO-Chalmers, using lithography.

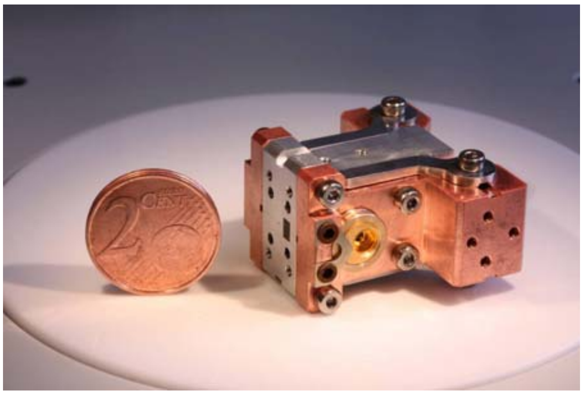


Figure wp 7.6: Mechanical prototype of compact 2SB mixer block for 602-720 GHz frequency range

Subtask 3.3@OSO: Further development of thick lithography process of defining the RF hybrids has proceeded, resulting in the fabrication of several prototype technology demonstrators. The technology has a very good potential for the production of small series of mechanical blocks.

Subtask 3.4@TuD: An AlN junction barrier technology has been developed to the level that it can be used for real detectors. Several batches of working devices have been made and delivered to SRON for further processing to be used for final mixer tests.

Subtask 3.3@FG-IGN: A cryogenic 3dB 90 degree hybrid has been successfully developed. A characterized working prototype has been delivered to SRON to be integrated in the tests system for 2SB mixer evaluation. The work carried on by FG-IGN described in subtasks 2.1 &2.3 is of equal interest for Task 3.

Subtask 3.2@UOxford: The new electromagnetic design of smooth walled feed horns have been proposed theoretically and verified experimentally. This design has a satisfactory performance but does not have small corrugation structures that are difficult to machine. A design for horn working in 602-720 GHz. This allows to produce 2SB mixers much more cost efficient.

Task 4: Low noise mixers for FPAs in the THz range

Goals: The first goal of Task 4 is to investigate materials for THz mixer devices. Two paths are followed; the first, more novel, but also more risky, seeks to develop SIS junctions based on super conducting materials with high critical temperature/energy gap, an extension of the work in Task 3 (subtask 4.1); the second, more conservative, but safer, seeks to increase the IF bandwidth and the fabrication reproducibility of HEB devices (subtasks 4.2). The second goal is to investigate mixer technology: mixer schemes more adapted to FPAs, both in quasi-optic and in waveguide technology (subtasks 4.3&4.4). Finally, LO power injection schemes will be studied.

Sub-Task 4.2: HEB Mixers The work on THz HEB mixers is carried on at GARD/Chalmers (characterisation of NbN films), at KOSMA, at ObsPM (multipixel detectors) and at SRON and TuD (NbN HEB receiver working at 5 THz).

4.2, 4.3&4.4@SRON-TUDelft: A superconducting NbN HEB mixer heterodyne receiver operating at 5.25 THz has been designed, built and tested. Terahertz radiation is quasi-optically coupled to a HEB mixer with a lens and a spiral antenna. Tests used a measurement setup with black body calibration sources and a beam splitter in vacuum, and an antireflection coated Si lens. Results were quite remarkable with a double sideband (DSB) receiver noise temperature T_{rec}^{DSB} =1150 K, only 4.5 times h□/k (the quantum limit). The measured far field beam patterns of the integrated lens antenna showed collimated beams from 2.5 THz to 5.3 THz that allow reliably measuring T_{rec}^{DSB} using the vacuum setup. The experimental results, in combination with an antenna-to-bolometer coupling simulations, suggest that the HEB mixer can work well at least up to 6 THz and may be suitable for the next generation of high-resolution spectroscopic space telescopes and, in particular, for the detection of the neutral atomic oxygen (OI) line at 4.7 THz.

4.2&4.4@ObsPM: Work at LERMA mainly concerned the developments of HEB mixers with 4 pixels configuration and mixers working at 2.5THz. This consisted in processing a matrix of 4 HEB devices working at 600 GHz and the design and fabrication of a 4 mixer block. The 4-pixel mixer demonstrated a relatively good RF coupling and a good homogeneity of the IV characteristics and the LO pumping level of the 4 pixels. Current work concerns the improvement of the mixer block and the IF circuit.

An HEB device working at 2.5 THz has been processed and incorporated in a mixer driven by a QCL made by University of Paris 7. Tests showed a good pumping level and a good IF response. Current work concerns the attempt to improve the stability and the beam quality of the QCL or to find a new QCL with better characteristics.

Sub-Task 4.2: SIS mixers @TuD, KOSMA &SRON: TuD made a new SIS junction design for the 780-950 GHz band based on AlN barriers with RnA = 3 Ω·μm² and NbTiN/Al striplines. The Figure shows that we can expect a good transmission throughout the band. The aim is to use the devices for CHAMP+ on APEX, in collaboration with SRON and the MPIfR. The next step will be to optimize the stripline configuration in collaboration with KOSMA through N. Honingh's student Marc-Peter Westig.

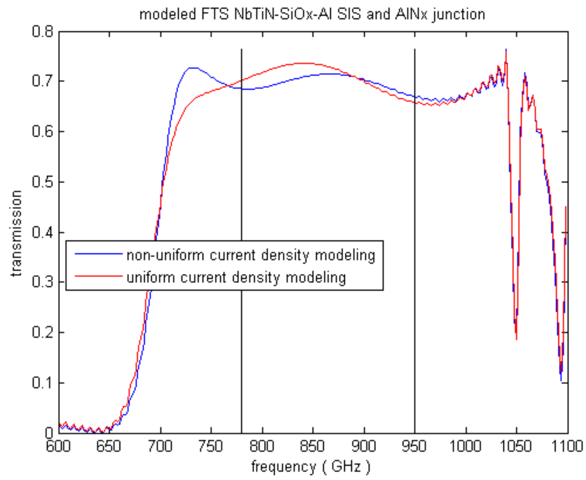


Figure wp7.7: Model of the AlN barrier SIS junction

It has been seen in ALMA Band 9 work the magnetic field applied to quench the Josephson-effect leads to unwanted glitches, most likely due to flux-jumps. The problem had become worse with high-current density AlN barriers, because of their smaller lateral areas. It has led to a redesign of the junction shape. Experimental tests are encouraging.

KOSMA fabricated in collaboration with TUD some good quality Nb-Al-AlN-Nb junctions with high barrier current. The reproductivity, however, was poor. Collaborative work started on the characterization of the process parameters and on the understanding of the device physics. The high current-density AlN barrier SIS junctions may produce more heating (electron-temperature) or generate non-equilibrum effects, which usually affect the superconducting properties in more subtle ways than just the temperature. The general understanding of these non-equilibrium effects in a device also consisting of different materials, in combination with the relevance to the performance, is a non-trivial task. The density of states will be modified in the transition region between two materials. A connection between device physics and noise is needed to estimate the fundamental limit of how good such a device can be. As an additional complication, a magnetic field is used to suppress the Cooper pair tunneling in the SIS junction. This changes the surface impedance i.e. also the characteristics of a superconducting transmission line, including the losses at THz frequencies.

Building on the work that has been done over the years at the Kavli Institute at the TU Delft a graduate student from Cologne is working on these issues in the group of Prof. Klapwijk since the middle of March 2010. This 3 months research stay is principally financed by the Bonn-Cologne Graduate School, with some contribution from the AMSTAR+ funds, because this fundamental device understanding is essential for the development of THz SIS mixers.

One postdoc, Andrey Hudchenko, has been hired as researcher at SRON to participate in the AMSTAR+ program. TuD hired a new person in the clean room, David Thoen, who also will get involved in designing and electrical evaluation. He is being trained, which takes time, but will also pay off soon.

2.1.7.2 Internal meetings

Progress report meetings:

Three face-to-face meetings were organized since Dec 2008 to present and discuss the progresses in AMSTAR+ . They were attended by 20-30 scientists and engineers. They consisted of oral presentations of progress reports (one per participating group) and of lengthy discussions. The meetings were organized in three different institutes participating to AMSTAR+. In each case, a visit of the laboratory was organized. The meetings were held successively in Freiburg at the IAF (Dec 2008), in Grenoble at IRAM (May 2009) and at Oxford University (Dec 2009). In addition, a telecon was organized on July 23rd on the status of the AMSTAR+ tasks and of a possible continuation after 2011 in the frame of RadioNet3.

The minutes of the discussions and the slides of the oral presentations are available to the AMSTAR+ community via the AMSTAR+ WIKI web pages.

Meeting on the collaboration between the teams involved in sub-task 4.1:
Members of all AMSTAR+ Task 4 have met at the International Symposium for Space Terahertz Technology (ISSTT) from 23-29 March 2010 at Oxford (UK). Concerning the cooperative work on THz HEB mixers in task4, OBSParis, GARD, SRON and KOSMA decided to carry on a joint campaign to measure the parameters of their THz HEB mixers in the same set-up. Since all groups are working on HEB mixers operating at different frequencies, SRON offers the use of its gas laser, which can generate LO power in wide range of THz frequencies. Since the laser generates much more LO power than HEB mixers require, the diplexer of the measurement set-up will be a simple dielectric foil, enabling to use SRON´s well characterized evacuated calibration load set up. For the IF, KOSMA will bring its digital spectrometer set-up, that can be used at IF frequencies from 0.5- 5 GHz.
The joint measurements will enable a more accurate breakdown of mixer parameters by comparison with the other mixers measured in the same set-upThis campaign is planned for fall 2010

International Conferences:

- 20th International Symposium on Space Terahertz Technology, Charlottesville, USA (results were reported by SRON, TuD, Chalmers.)
- Applied superconductivity conference 2009, Chicago IL
- 3rd Annual Workshop on Physics and Applications of Superconducting Microresonators, University of California, Santa Barbara, USA Jan 2010, T.M. Klapwijk
- P.J. de Visser: Lecture: Effects of readout heating in KIDs on membranes
- R. Barends: Lecture: Quality factors at the single microwave photon level in superconducting resonators
- Single Photon Counting Detectors Workshop, Keck Institute for Space Studies, Pasadena, USA
- T.M. Klapwijk: lecture: Resistive Superconducting Films for Photon-Sensing Devices
- 21st International Symposium on Space Terahertz Technology, University of Oxford and STFC Rutherford Appleton Laboratory, Oxford, U.K. Mar 2010, T.M. Klapwijk; J.R. Gao
- Brettschneider: Poster: Wideband receiver based on AlN barriers
- Y. Ren: Lecture: Gas cell measurement using a 2.9 THz heterodyne receiver based on a quantum cascade laser and a superconducting hot electron bolometer
- P.J. de Visser: Lecture: Hysteretic Thermal Switching Due to Readout Power Heating in Kinetic Inductance Detectors

Publications:

- Ronald Hesper, Gerrit Gerlofsma, Patricio Mena, Marco Spaans, and Andrey Baryshev, “A Sideband-Separating Mixer Upgrade for ALMA Band 9”, Proceedings of 20th Symposium on Space Terahertz Technology, ISSTT2009, p. 257-260, 2009
- Zhu, S.; Zijlstra, T.; Golubov, A.A., et al., “Magnetic field dependence of the coupling efficiency of a superconducting transmission line due to the proximity effect”, Applied Physics Letters, p. 253502 (3 pp.), 2009
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2.1.8 WP8: APRICOT

Objectives:

There are two main objectives of WP8 “APRICOT” (All Purpose Radio Imaging Cameras On Telescopes).

1) to develop the design and the sub-system technology for large-format focal-plane “radio cameras” for astronomical observations in the scientifically-rich range 33-50 GHz. Such cameras able to provide both polarisation-sensitive continuum or spectroscopic observations at the flick of a switch, will greatly increase the operational efficiency of the host telescope and enable users to carry out hitherto impossibly large sky surveys. The frequency range 33-50 GHz is relatively poorly-explored and lies in the gap between the frequencies which will be covered by the Square Kilometre Array (SKA) and ALMA. The scientific targets include: molecular studies of star-forming regions & circumstellar envelopes: the search for new molecules in the Interstellar Medium; the study of molecular emission (in particular CO) from high redshift galaxies; surveys for new extragalactic sources: continuum surveys of The Milky Galaxy; surveys of galaxy clusters via their Sunyaev-Zeldovich decrements.
2) to secure the availability of state-of-the-art High Electron Mobility Transistors (HEMTs) and Monolithic Microwave Integrated Circuits (MMIC) devices from within Europe. A long-standing problem for European radioastronomy is that the supply of low-noise devices is currently dominated by US companies and is subject to ITAR regulations. Establishing a European source of state-of-the-art semiconductor devices, both for low noise amplifiers and for integrating other components such as mixers, power amplifiers, phase switches etc, is crucial for the future health of European radio astronomy with spin-off potential into other arenas (e.g. space).

2.1.8.1 Meetings

Project Meetings:

1) All-project kick-off - Manchester 12 March 2009
2) Architecture and passive components (tasks 1 and 2) – Bologna 27/28 April 2009
3) MMIC procurement and performance testing (tasks 3 and 4) – Gothenburg 23 June 2009
4) All-project progress – Bonn 17 November 2009
5) Optimisation of Receiver Usage (Task 5) – Torun 13 January 2010,

Other meetings attended by P.I.

1) RadioNet Board - Amsterdam (Schiphol) 30/31 March 2009
2) Keck Institute for Space Studies: MMIC Array Spectrographs Workshop - Caltech 22 March 2009
3) AMSTAR+ JRA-kick-off - Grenoble 20 May 2009
4) AMSTAR+ JRA-progress - Oxford 8 December 2009
5) RadioNet Board - Cagliari 5 May 2010

Related workshops:

1) “Low Noise Figure Measurements at Cryogenic and Room Temperatures” – Gothenburg 23-24 June 2009 in the FP7 RadioNet Engineering Forum series.
2) “Science at Q-band” Manchester in September 2009. Supported in part by FP7 RadioNet and Presentations available at: http://www.alma.ac.uk/documents/science-at-q-band.
3) “Multi-pixel Arrays” Bonn 16-17 November 2009 – in the FP7 RadioNet Engineering Forum series.

Upcoming Meetings/Workshops

1) All-project progress– Aveiro 1 September 2010
2) “Receiver and Array Workshop” – MPIfR Bonn 19-20 September 2010 - will link the US work on radio
3) cameras and MMIC designs with the RadioNet JRA programs

2.1.8.2 Progress and Forward Look

The performance targets and science goals of APRICOT were validated by the three internationally-attended “Related Workshops” listed in Section 2. An all-purpose continuum and spectroscopic polarization receiver, covering an instantaneous band of 33-50 GHz, goes well beyond other systems and opens up many science applications

Many of the program deliverables are expected to be completed by 31/12/2011, despite the approximately 12-month delay in EC funding. However some of the hardware deliverables viz: comparative tests of passive component chains (innovative and classical) and parts of the semiconductor MIC+MMIC fabrication and performance test program may well not be delivered by that date. An additional 6 months no-cost extension would enable all these parts of the program to be delivered.

2.1.8.3 Summary by Partner

MPG: The resources as described in the DoW are well in plan. The time schedule for delivery of Task1 (strongly linked with Task 2) is delayed by about 6 months due to the late allocation of funds.

INAF-IRA: due to the late first tranche of payments, INAF spent almost nothing in 2009 and at the beginning of 2010. We are managing the bureaucracy to recruit a mechanical technician to help in Task 2. Hopefully the steps will conclude this summer. We aim to do the same for Task3-IRA, the procedure has just started

UMAN: due to recruitment delay occasioned by the late first payment the semiconductor engineer for fabrication in Task3 started work on 1 July 2010. It is not possible, therefore, to promise to complete the Manchester programme in less than the 24 months in the deliverables schedule – taking us to 6 months after the formal end of the project. We intend to accelerate the use of the manpower funding by offering a 12-month post for a device test engineer to work in parallel with the fabrication engineer.

FG-IGN (CAY): One person has been working full time for RadioNet since Jan 2009, funded 66% by AMSTAR+ and 33% by APRICOT, as initially scheduled. In principle, we are charging the first two years of this person to the AMSTAR+ budget, and the third year to APRICOT. This corresponds to the way his effort is being effectively employed. In general, expenditures are following the schedule and all the foreseen resources will have been put into use by December 2011. Probably, it will also be possible to face an extension in time of the project without extra money, but this should be decided in advance in order to plan properly. Our feeling is that, from the point of view of the expected technical results of the project, the allocated 3 years is too short. The two collaborations described under Task 3 are scheduled to finish late in 2012 and APRICOT, if extended, could better benefit from their outcomes.

INAF-IRA/UTV: The financial resources that have been transferred to UTV allowed the issue of a tender for three positions (six month research grants. The call for the positions has been issued, the respective selection has been performed and three engineers (post-docs) have been enrolled on a six-month basis, with operating periods starting from mid-year on. No financial resources have been spent therefore during the first reporting period for external personnel, but they are being spent from now on. The people that has been enrolled is actually working on the OMMIC designs regarding the MIXER and Multiplier integrated chains.

TCfA: Can deliver by the end of the project.

2.1.8.4 Summary by Task – see also Milestone and Deliverables Tables

Task 1: Receiver Architecture: specification and test:

- Deliverable 8.02: Study of receiver architectures and definition of the preferred concept – done.
- Deliverable 8.16: Comparison of passive chain performance against classical designs – ~6 month delay expected hence thus 6 month project extension required.

Task 2: Passive components: design & manufacture

- Deliverable 8.07: Report on Design of passive chain using new technology for low replication costs, low weight and suitable performance - 6 month delay expected thus 6 month project extension required.
- Deliverable 8.15: Designs for very low loss components on low loss substrates – expecting to complete within formal programme period.

Task 3: MMIC Design and Procurement

- Deliverable 8.05: € MMIC: Amplifiers and other circuits for RF & IF applications – 12 month delay expected but completion expected by mid -2011.
- Deliverable 8.08: € MIC: advanced technology devices aimed at improved noise performance – 18 month delay anticipated i.e. hence completion end Q2 2012 thus 6 month project extension required.
- Deliverable 8.14: MMICs with improved noise performance – delayed due to late start and 9 month delay anticipated; completion by end Q2 2012 thus 6 month project extension required.

Task 4: Establishing accurate performance of low-noise amplifiers:

- Deliverable 8.09: Establishment of Transfer Amplifier Standard – partially delivered; room temperature amplifier has been circulated, cryogenic amplifier now being circulated. Anticipate completion Q4 2010.

Task 5: Optimisation of Receiver Usage

- Deliverable 8.1: Atmospheric Model – done.
- Deliverable 8.10: Report on feasibility of atmospheric subtraction without spatial switching; implications for receiver architecture – some delay due to late start but anticipate completion in Q1 2011.
- Deliverable 8.12: Report on calibration procedures and queue scheduling strategies – some delay due to late start but anticipate completion Q3/4 2011.

2.1.8.5 Task Summaries

Task1: Receiver Architecture: specification and test (MPG, UMAN, INAF, FG-IGN, UMK):

The MPIfR has carried out various investigations on possible architectures for a multi-beam receiver camera at Q-band. Various block diagram options were presented and discussed within the APRICOT community. Furthermore in work for a Diploma thesis we investigated mechanical and thermal effects of a 25-beam Q-band system.

Down Conversion One of the most important decisions will be where to place the 1st mixer. This will influence many details in the electrical, cryogenic and mechanical design. A discussion on this topic showed, that a first conversion at room temperature will be most suitable for an economic receiver design.

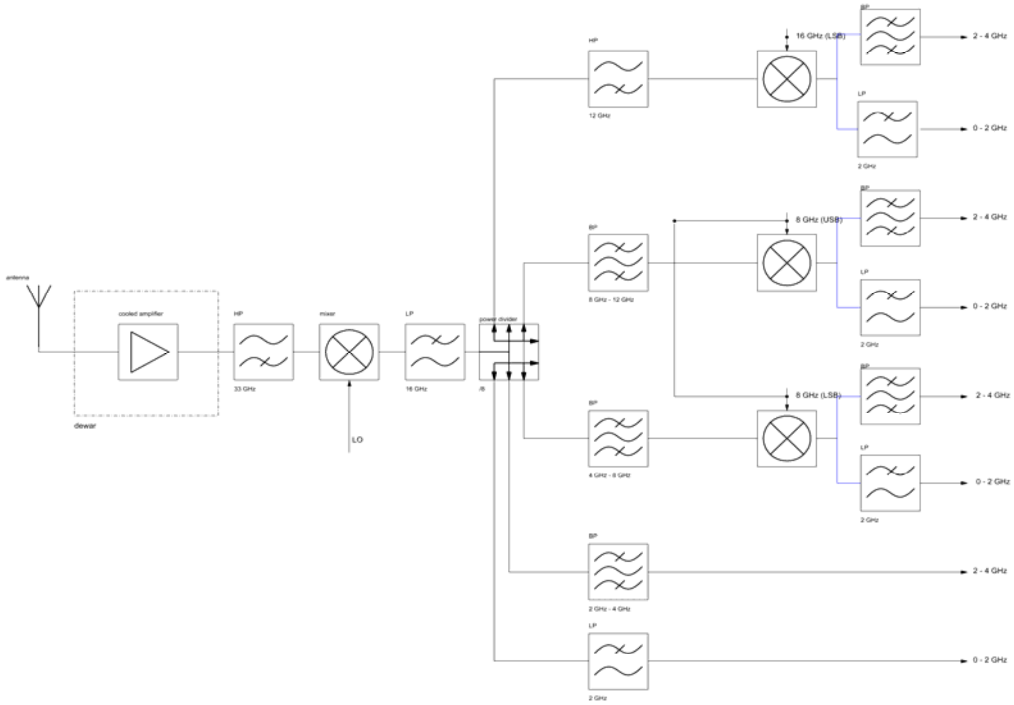


Figure wp8.1 Dual down conversion scheme with different 2nd IF and minimum mixers.

DC supply in the dewar: The usual way of DC supply for the HEMT amplifiers, supplying every amplifier stage with drain and gate voltage, seems not possible for a multi-pixel camera of 20 pixels and more. Assuming DC wires with a cross section of 0.125mm² with a thermal power flow of 16mW/m to the 70K stage and 6mW/m to the 15K stage we end up with a number of 140 wires for 3 stage LNAs. For 50cm wires and a power dissipation of 50mW of the LNA we get a thermal load on the 70K stage of 2.2W and 2.8W on the 15K stage. These numbers show that a DC network is strongly recommended on each pixel module where only the first stage gate voltage should be adjustable from outside, possibly including first stage drain voltage. One option could be to control the HEMT bias via I²C data bus. This option is currently under investigation at the MPIfR.

In a first iteration between the APRICOT partners some very basic down conversion schemes have been discussed. One basic down conversion scheme had been selected for further detailed investigation. This will be elaborated more carefully for realization; in particular intermodulation of harmonics of the different LO frequencies have to be considered.

Working proposal: First down conversion to 10-26GHz first IF with LO at 7, 9, second down conversion into different 2GHz bands for sampling in different Nyquist bands.

Pros:	***Cons***
only 1 LO in IF band	different 2nd IF 0-2GHz, 2-4GHz
3 mixers per pixels in 2nd IF	base band conversion needed
all RF filters moderate quality	different Nyquist sampling has different ADC-BP
minimum number of RF filters	two different anti-aliasing filters

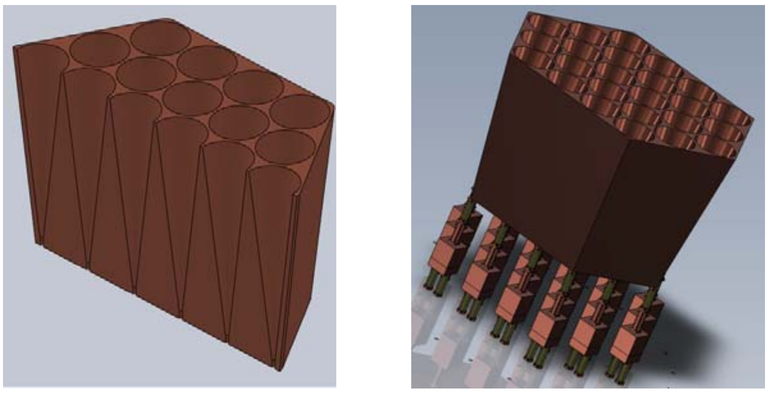


Figure wp8.2: simplified model of a 25 horn platelet array.

Mechanical and thermal design of a 25 beam cryostat: a 25-horn Q-band front end was designed to investigate the mechanical and thermal properties and boundary conditions of such a system.As a suggestion from WP 2 a platelet horn design was chosen with the actual corrugated horn dimensions from an MPIfR design

This hexagonal configuration is to be made of a stack of pre-cut metal plates enclosed in a cylindrical dewar. The horn package is mounted at its aperture plain to the dewar in order to obtain a fixed aperture in the optics of the telescope. The horns are designed to be held at 70K. The receiver components like phase shifter, OMT and LNAs at 15K temperature level have to be attached at the horn array via thermal chokes to provide thermal isolation as well as best waveguide conductivity. Figure wp8.3 shows one of the dual channel receiver units per horn.

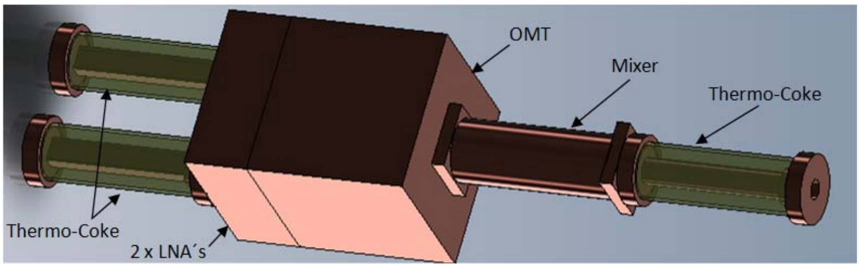


Figure wp8.3: one of the dual channel receiver units per horn

Thermal expansion and compensation. To resolve the problem of thermal expansion during cooling some solutions for compensation were investigated. Flexible waveguides, flexible vacuum tubes and a sliding waveguide feed through where considered to solve the problem of mechanical stress due to thermal expansion. The sliding waveguide feed through has been realised and is currently under investigation.

Figure wp8.4: possible solutions for thermal expansion

Thermal design of the cryostat To get a number for the cooling power needed for such a multi pixel dewar a complete cryostat was modelled mechanically and thermally in a CAD program. It could be demonstrated that two of the widely used cold heads, model CTI 350, are sufficient to cool the LNAs to a temperature of 15K and have the feed horns at 70K. Thermal radiation is reduced by an additional heat shield between the 70K and 300K temperature stages.

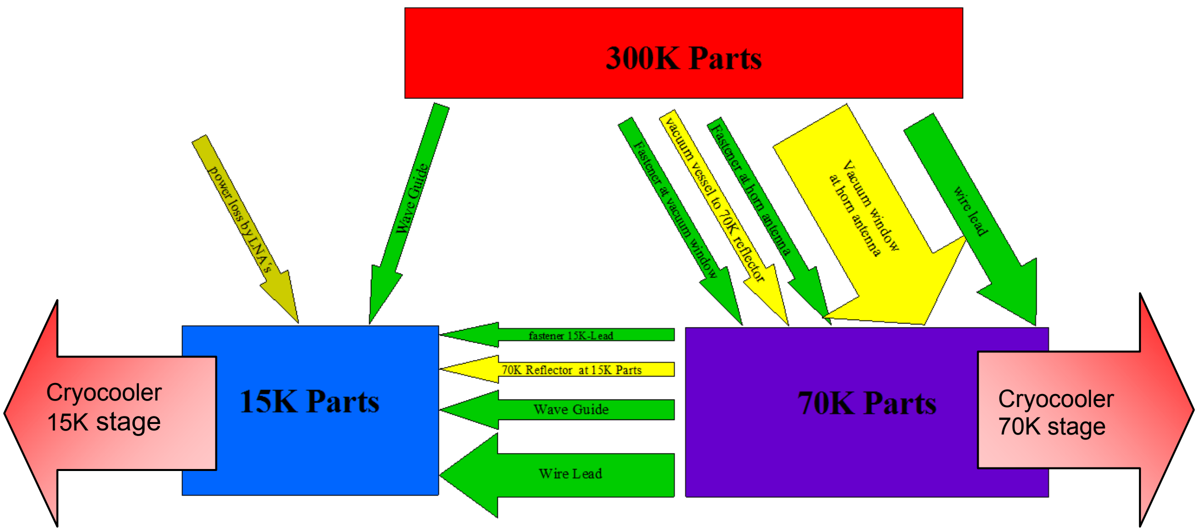


Figure wp8.5: Overview of receiver architecture

Task 2: Passive components: design & manufacture (INAF, UMAN, MPG).
Task 2 is working towards a design of all parts of the passive chain.

INAF-IRA:. The performance goals for the components of the passive chain have been agreed
Specification of horn array:

- Band: 33-50GHz
- Optics to be coupled to SRT 64-m
- Number of horns: 7
- Return loss: ≤ -25dB
- Cross-polarisation: ≤ -30dB, on axis and off-axis
- Insertion loss: ≤ 0.3dB (Note: the horn will be cooled)
- First sidelobe Level: ≤ -20dB
- The design illumination goal is the optimization of G/Tsys

Specification of polariser:

- Band: 33-50GHz
- 90^{o} phase unbalance: $\Delta\varphi \leq \pm 2^{o}$ ($\rightarrow$crosspolarisation ≤ -35dB)
- Amplitude unbalance: $S_{\perp}/S_{//} \leq 0.05$dB
- Input return loss: ≈ crosspolarisation level
- Insertion loss: ≤0.1dB (Note: the polariser will be cooled)

Specification of OMT:

- Band: 33-50GHz
- Isolation: < -50dB
- Return loss: < -20dB
- Insertion loss: ≤0.3dB (Note: the omt will be cooled)
- deliver the two outputs parallel each other, parallel to the omt axis and possibly simmetrical with respect to the common port axis

The specification for the feed system:

- Band: 33-50GHz
- Insertion loss: ≤0.7dB (Note: the feed system will be cooled)
- Return loss: < -20dB
- Crosspolarisation: ≤ -30dB on axis and off axis
- First Sidelobe Level: ≤ -20dB
- Isolation between the OMT output ports: ≈ return loss at the polariser input

.
A first step will be to produce a prototype 7-horn system by using the platelet technique (Figure wp8.6 see also Figure wp8.2). The antenna optics to be referred to is that of the 64-m Sardinia Radio Telescope. The aim is to produce the prototype horn array for October 2010 and to complete measurements of its performance in Q4 2010. Another job for 2010 is to simulate the overall feed system chain, in order to decide which and how much each component affects the whole performance, and to design the polarizer and OMT.

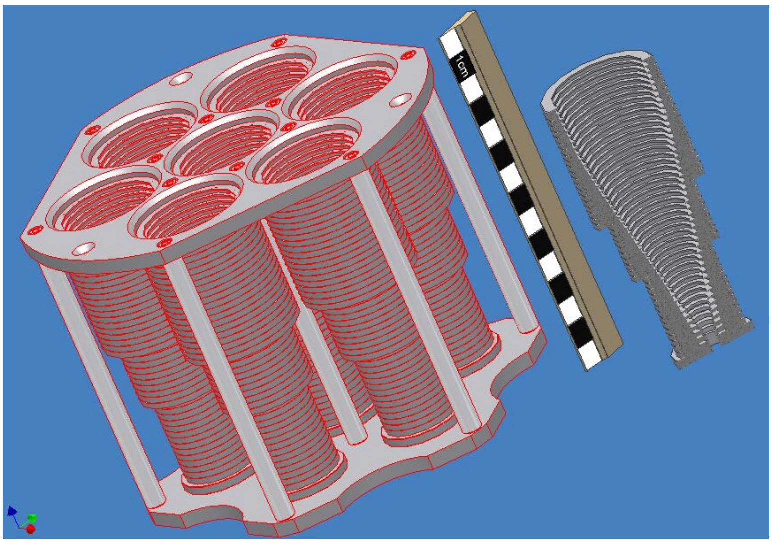


Figure wp8.6: CAD drawing of the 7–feed horn prototype to be made using the platelet technique. The scale has divisions of 1 cm.

This will build on the study "Receiver Contamination of Stokes Parameters in Radio Polarimetric Measurements" which has been made by A. Orfei. The aim is to summarize the relevant factors in a microwave receiver affecting the measurement of the Stokes Parameters of a radio source when it is used with a polarimetric back-end. The equations including representative levels of contamination are laid out and discussed with the aim of making evident which and how the feed system components corrupt the evaluation of the Stokes Parameters describing the polarization properties of the source. A major issue is of course the symmetry of the amplitude and phase performance in the E and H planes which affect the level of the "D-terms" This report will be available on the APRICOT Wiki.

UMAN: Waveguide polarisers are used to convert the polarisation of a signal from linear to circular and vice versa. These dually polarised devices can work with square or circular waveguides. An ideal polariser provides a differential phase-shift between two orthogonal polarisations equal to 90 degrees independently to the frequency, across a specified band. A new proposed waveguide polariser design, made in circular waveguide, will have the following characteristics:

- extremely limited phase-error: within +-1 degrees within a 40% bandwidth;
- extremely high polarisation purity;
- very low expected Insertion Loss (IL~0.3dB at 100GHz, will be lower at lower frequencies) and low return loss (~ -25dB).

Link with AMSTAR+: MPIfR, IAF, IRAM, INAF-Cagliari and CAY currently are also working on Task1 "Prototype W-band array module using metamorphic HEMT technology" within the AMSTAR+ project. INAF-Cagliari has developed a full-band OMT at W-band that was fabricated at MPIfR using a milling machine, tests will follow soon. IRAM has demonstrated a prototype system design at W-band based on a LHe cryostat.

***Task 3: MMIC Design and Procurement* (UMAN, MPG, INAF-IRA, UTV FG-IGN):**
This multi-faceted task involves: i) the development of discrete devices having improved noise performance over current world standards (e.g. from NGST and Hughes Research Laboratories) with which we are very familiar; ii) the procurement of MMIC circuits for both LNAs and for down-conversion and power amplifier stages, aiming to match current world standards. We are benefitting from two, non-RadioNet, programs in place between FG-IGN/IGN/U.Cantabria/IAF and MPG/IRAM/IAF, which are acting as precursors. There is exchange of information between these two independent collaborations but, under the terms of an NDA, APRICOT cannot report the results here.

Manchester: Improved pHEMT noise performance
The main basis of the performance enhancement (to better than 5 times the quantum limit) is novel epitaxial layer profiles. Manchester is producing the InP-based epitaxial wafers with its industry standard MBE facility giving it the ability to produce wafers quickly, and with different properties. Manchester also has the ability to produce physical models of transistor action focused on noise properties. There is a dual-path approach to the production of the pHEMT transistors:

pHEMT production in U. Manchester: using electron-beam lithographic facilities within the University we are developing novel techniques to produce pHEMTs with T-gate or mushroom gate architectures.
Phase 1: to reproduce industry standard pHEMT performance

- Wafer: 2-inch with a classical layer structures to known industry standard.
- Gate length: 100 nm
- Timeline: fabrication complete in Q4 2010 – Q1 2011
  testing (on wafer) in Q1-Q2 2011

Phase 2: to improve on industry standard pHEMT performance and to work towards smaller gate lengths appropriate for higher frequency applications

- Wafer: 2-inch with an improved epitaxial layer structures to Manchester design
- Gate length 50 nm – 30 nm
- Timeline: fabrication in Q2-Q3 2010
  testing (on wafer) in Q3-Q4 2010

pHEMT production in IEMN (Lille) : a collaboration has been established with the Institut d'Electronique de Microelectronique et de Nanotechnologie (IEMN) at the University of Lille to use their industry standard e-beam lithographic production techniques. The IEMN 120nm process is being used to "qualify" Manchester wafers and obtain initial results. We then intend to move to 50nm and possibly 35 nm gate lengths.

Phase 1: to reproduce industry standard pHEMT performance

- Wafer: 2-inch with a classical layer structures to known industry standard.
- Gate length: 120 nm
- timeline: fabrication complete in Q3 2010
  testing (on wafer) in Q4 2010

Phase 2: to improve on industry standard pHEMT performance and to work towards smaller gate lengths appropriate for higher frequency applications

- Wafer: 2-inch with an improved epitaxial layer structures to Manchester design
- Gate length 100 nm
- timeline: fabrication complete in Q3 2010
  testing (on wafer) in Q4 2010

Testing: this is a multi-stage process beginning "on-wafer" in Manchester. UMAN will be recruiting a test engineer for 12 months for the calendar year 2011.

- DC tests: characteristic curves; pinch-off behaviour
- RF characterisation: f_T; f_{MAX}; S-parameters and construction of equivalent circuit; frequency coverage to 40 GHz in cryogenic probe station and to 110 GHz at room temperature

This will be followed by full noise measurements of diced transistors at CAY Yebes (Task 4 Leader).

MPIfR: mHEMT device and MMIC programme with IAF. It has long been clear that a European source for low-noise HEMT devices would be highly desirable, IRAM, MPIfR and IAF therefore teamed up under a formal collaboration contract before the start of FP7 (Aug 2007 – Dec 2008). The aim of the collaboration was to have a first assessment of the potential performance of IAF's mHEMT process at cryogenic temperatures. For this purpose 4 LNAs covering 1-4GHz, 4-12GHz, 10-18GHz and 20-25GHz were designed in IAF and subsequently tested by the partners. It was agreed between the partners that CAY should also have access to devices for testing. *This program is under NDA restriction and hence cannot be reported in detail here.* However, the results strongly encourage the view that IAF's mHEMT process has all the potential to deliver very competitive performance once the planned process optimization for cryogenic devices has been done. This program therefore has been of great help to APRICOT.

An important prerequisite for designing cryogenic LNAs at IAF was extending IAF's mHEMT device model from room- to cryogenic temperatures. This was done using MPIfR's cryogenic s-parameters probe station to characterize IAF's mHEMTs at cryogenic temperature up to 50 GHz. This model is under constant improvement for subsequent designs involving cryogenic mHEMTs at IAF. So far we have very promising noise temperature results from the 1-4GHz amd 4-12GHz MMICs. Nevertheless stability issues related to the device level (that are also well known from NGST devices) are still under evaluation for some MMIC designs.

In the near future dedicated noise data of single HEMT devices will be available from MPIfR's cryogenic F50 noise prober which will significantly improve the accuracy of the croygenic noise model. Another effort is underway to improve the statistics of cryogenic performance data for HEMTs. For this purpose MPIfR is extending its cryogenic s-parameter probe station for measurements of bigger pieces of wafers which would allow testing many HEMT devices within one cooling cycle and thus wafer mapping at cryogenic temperatures becomes feasible. Experience shows that an important issue in order to get a better handle on the large scatter of cryogenic performance seen up to now (also for devices from other manufacturers).

MPIfR have agreed with INAF-IRA to share our cryogenic facilities to do cryogenic MMIC characterization of several LNA designs from outside of the APRICOT project for performance comparison purposes. So far we received 22GHz LNAs produced at NGST from IRA, testing of these chips is almost completed. At least one Q-band design (43GHz, OMMIC and/or NGST) will follow.

FG-IGN (CAY): mHEMT device and MMIC programme with IAF: A Collaboration Agreement has been in force since June 2008 between the FG-IGN and the University of Cantabria (UC) for contributing to the development of the mHEMT technology. Under this agreement IGN has been funding one researcher (B. Aja) from UC to work at IAF in MMIC designs and other activities of interest for IAF, IGN and UC In September 2009 a second Collaboration Agreement was also signed between FG-IGN and IAF for the same purpose, whereby FG-IGN gets access to space in IAF multi-project wafers. This space is being used to implement MMIC designs of interest for FG-IGN.

Within this framework two MMIC LNAs in the band 25-34 GHz have been designed, samples of which have been recently delivered for testing at cryogenic temperatures at IGN and UC. Testing will be carried out in the coming months. Also within this framework, a 31-50 GHz MMIC LNA design has been developed and this is scheduled to be manufactured in Q3. Cryogenic tests are expected to be completed in Q4 2010. If successful, this design, or evolutions thereof, could be used in future APRICOT receivers. In addition to these MMIC programs, discrete IAF transistors are being regularly tested at CAY in the bands 4-12 GHz and 20.5-24.5 GHz. A total 25 devices from 5 runs have been tested to date. Because they have been carried out under an NDA with IAF the results of these tests are not currently available to APRICOT. In general, however, promising results are being obtained.

UTV/INAF/IRA: mHEMT MMIC program with the OMMIC foundry. The 70-nm mHEMT process is available for multi-project foundry runs. September 2010 is a possible multi-project wafer run date. Smart fully-scalable passive/active linear *and non-linear models* are available hence mixers can be produced. Microstrip and coplanar and grounded coplanar architectures are all available. OMMIC does not intend to develop cryogenic models but are very interested in the results of the cryogenic performance of the existing Q-band LNAs MMICs obtained from them under the FP6 PHAROS program.

MMIC production: In a multi-project run it is unrealistic to produce an integrated conversion on a single chip but is possible to produce separately the functional circuits which build the conversion block. In the present phase of Apricot project it would also not be sensible to produce a complex MMIC which can be difficult to test; the full integration phase should be left the future. INAF-IRA and UTV therefore propose to realize examples of: i) a chip that includes a mixer and RF buffer amplifier and ii) a medium power chip able to condition the LO signal at the input of the mixer, containing amplifying and multiplying functionalities. The design of the above chips actually started at UTV during the first reporting period.
Integration and receiver architecture issues: related to the production of the first conversion module is how to provide the local oscillator signal to its input. It is worthwhile to investigate the possibility of integrating chip synthesizers in the conversion module. The existence on the market of surface mount, cheap (€100) and well-performing synthesizers should allow the use of one LO for each horn, so avoiding a potentially expensive and difficult LO distribution system at GHz frequencies. In this case it is sufficient to distribute the reference lock signal at 10 MHz.

RF chain specifications: As a reference we considered the MITEQ datasheets.

- Operating temperature: 300 K; for Apricot purposes it can operate outside the dewar or inside the dewar on the 300 K stage – the pros and cons are being investigated.
- Key specification: very low power consumption
- RF coverage: 33 -50 GHz
- IF operation: 1-18 GHz From the architectural point of view of the complete receiver chain there are some different solutions. The proposed range could trade off various constraints.
- LO coverage: 4 or 8 GHz The LO multiplication factor is an integer usually 2, 3, 4, 6, 8. As large is the multiplication factor as lower is the system tunability and as higher is the LO noise. The two coverage possibilities aim to use cheap and well-peforming LO chips available on the market now. We specify a fixed LO but a very small tunability, sufficient to tune some hundred of MHz at the mixer input, could be necessary.
- Isolations: LO to RF, LO to IF, RF to IF : 20 dB minimum
- LO Input of the module : max 5 dBm
- Mixer: Mixer architecture and/or topology will be a degree of freedom of the designer team in order to get the best tradeoff between given specifications, space occupancy on the MMIC and technology. Double or triple balanced, passive (diode mixer) or resistive (HEMT mixer where HEMT are used as resistors) . The rejection of the image is an asset but not a constraint. It can allow to eliminate an RF filter. Active mixer has to be carefully considered. Trade off among mixer pre-amplification of passive mixer, image rejection capability and LO driving request have to be evaluated. Because the conversion could be placed inside the dewar, number of bias wires must be considered.
- Mixer input power at 1 dB compression point : +5dBm
- Input IP3: +15 dBm
- Filters: they can result wide and require a too big area on chip. It could be interesting to think about a solution which keep the RF and IF filters outside the MMIC. They could be designed in LTCC or microstrip alumina and wire bonded or flipchip connected.

Link with AMSTAR+ : MPIfR, IAF, IRAM, INAF-Cagliari and CAY currently are also working on Task 1 ”Prototype W-band array module using metamorphic HEMT technology” within the FP7 AMSTAR+ project. For AMSTAR+ tests of W-band LNAs are planned in the near future.

Link with JPL: The UTV group has published paper in a well-known US conference proceedings regarding MMIC LNAs funded pre-APRICOT using the 70nm OMMIC process – the frequencies range from C-band to W-band (4 in LNAs in total). S. Weinreb (JPL) has asked if it was possible to get details of OMMIC technology and possibly to measuring some samples. Limiti suggested it would be good to link Weinreb’s group measurement capabilities into the project at no cost. This was agreed to be beneficial and some sample chips have been already shipped to Weinreb for testing. Some preliminary tests are available, further tests need to be performed at JPL (eventually also at CALTECH via Weinreb)

Task 4: Establishing accurate performance of low-noise amplifiers (FG-IGN; MPG, INAF-IRA, UMAN)
FG-IGN (at CAY, Yebes Observatory) will be the central site for the performance testing of the pHEMT discrete devices (from UMAN) and mHEMT MMICs (from IAF) procured within APRICOT. The frequency coverage of the cryogenic test system at Yebes has been expanded up to 40 GHz. The expansion (coaxial) is based on K-type connectors. The 20-40 GHz RF band is down-converted (DSB) to a 30 MHz IF and fed to an 8970B HP noise figure meter. After an initial version using standard stainless steel cables with solid teflon as dielectric for transport of RF signals inside the cryostat, a second version was developed in which the dielectric was expanded teflon. This has rendered a mechanically more stable system against deformations and ageing due to thermal cycles, with the ensuing improvement in the repeatability and reliability of electrical measurements, in particular noise. The new system (including software) has been fully built and calibrated.

Based on the same concept, components have been procured to further extend the frequency range to 50GHz (2.4 mm connectors). This is expected to be ready by Q4 2010.

Noise source calibration with a travelling cryogenic amplifier (FG-IGN) : A fully cryogenically-characterised 4-8 GHz transfer amplifier is available to help calibration systems to be cross-checked (Figure 7).

This amplifier has been sent to INAF-IRA and University of Cantabria for comparisons. Problems with the test setups or the cryostats prevented successful achievement of these tests as of now.

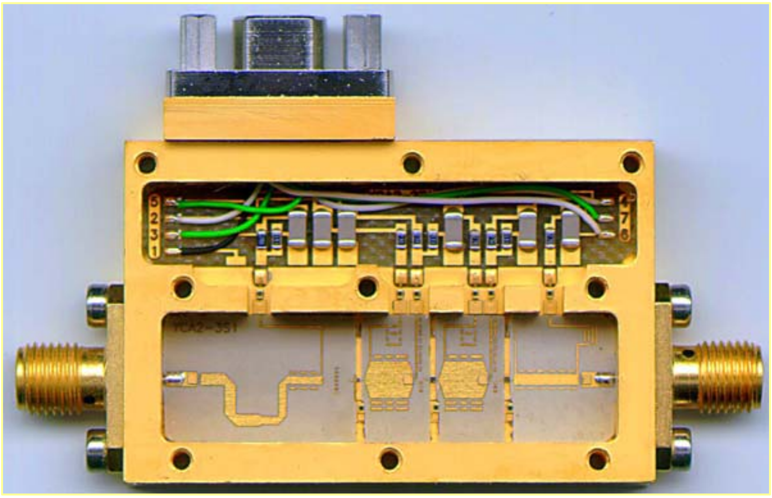


Figure wp8.7: 4-8 GHz test amplifier

Noise source calibration with a travelling room temperature amplifier (INAF-IRA): The overall uncertainty in Noise Figure measurements is dominated by the uncertainty in the amount of noise generated by the noise source (Excess Noise Ratio ENR and uncertainty of the ENR). For more than 30 years the most accurate noise generators in the market had an uncertainty +/- 0.12 dB. In 2002 work between INAF-IRA and Rome Tor Vergata (UTV) reduced the uncertainty to +/-0.06 dB at frequencies up to 26.5 GHz. A theoretical study between INAF-IRA and UTV showed that the uncertainty cannot be less than 0.05-0.06 dB. Note that an uncertainty of the ENR of +/- 0.05dB becomes an uncertainty of 0.05 dB on the noise figure i.e. ~3.5K at ambient temperature. In 2003 Agilent offered a very accurate noise generator (+/-0.05 dB up to 18 GHz). The comparison of the most accurate noise generators cannot further improve the intrinsic accuracy. But a comparison campaign will reveal if each laboratory within APRICOT is inside or outside the uncertainty boundaries. Measurements closer to the overall mean build trust for that particular noise generator and test system. Conversely measurements far from the mean indicate that corrective action may be necessary. Each contributing institute is performing the measurement of a travelling LNA using their own noise source and related instruments. The measurement is being performed in the most accurate and precise way at room temperature for simplicity in this phase of the test programme. Each Institute is sending the data file to IRA (Mariotti) for the comparison. The project will be completed in summer 2010.

PARTNERS	JOB	STATUS
IRA (S. Mariotti)	Noise Figure Measurement	Done
CAY (J.D. Gallego)	Noise Figure Measurement	Done
Uni Cantabria (E. Artal)	Noise Figure Measurement	Done
Uni. Manchester (Mo. Missous)	Noise Figure Measurement	Done
ASTRON (Wan Der Waal)	Noise Figure Measurement	Done
Fraunhofer IAF (H. Massler)	Noise Figure Measurement	Shipped to IAF
IRA (S. Mariotti)	Noise Figure Measurement. Data comparison. Web publication.	Scheduled for summer 2010

Task 5: Optimisation of Receiver Usage (UMK: MPG, INAF, UMAN)

Atmospheric Modelling: The first deliverable is an atmospheric model. This is a combination of the following complementary works:

1) Meteorological statistics for a representative European site (close to the INAF-IRA Medicina Observatory) see the document “IRA418_08.pdf” on the APRICOT wiki. There is a network of international sites.
2) A compilation of world-wide PWV and opacity data in the document “PWV_and_opacities.doc”. This shows that the statistics of PWV are consistent with median of 20mm at sea level and an exponential fall-off with a scale height of 2km. A given site exhibits PWV of half the local median for 25% of time and twice the local median for 25% of time. This is consistent with detailed statistics presented in “IRA418_08.pdf”)
3) Direct measurements of atmospheric emission using water vapour radiometry at the MPIfR Effelsberg 100-m telescope) and at the SRT site in Sardinia and GPS-derived water vapour monitoring at the SRT.
4) Numerical modeling of the fractal (power law) spectrum of spatial turbulence which can be turned into opacity variations for given wind speeds. This is described in detail in the PhD thesis of S. Lowe (2006) on the APRICOT wiki.
5) Self-consistent physical modeling of atmospheric fluctuations. This uses the SITCOM package (see http://i3rc.gsfc.nasa.gov/Presentations/S3-DiGiuseppe.pdf) which stands for “Spectral Idealised

Thermodynamically COnsistent Model". It is a solution of the 3D radiative transfer to simulate atmospheric clouds and is widely used in the atmospheric physics community. We believe that this stochastic cloud generator is directly applicable to our simulation problem. Its input data can be derived in general from aircraft or balloon flights associated with a representative site)

- Vertical temperature and pressure profiles in regions of cloud formation for dry air and dew-points
- Total water, liquid water and water-vapor mixing ratio vertical profiles
- Total water variance
- Power-law (steep) spectra of the total-water field
- Wind speed

6) Theoretical models for microwave/mm-wave opacity as a function of frequency and PWV from Prado & Cernicaro et al. (available on-line at IRAM telescopes).

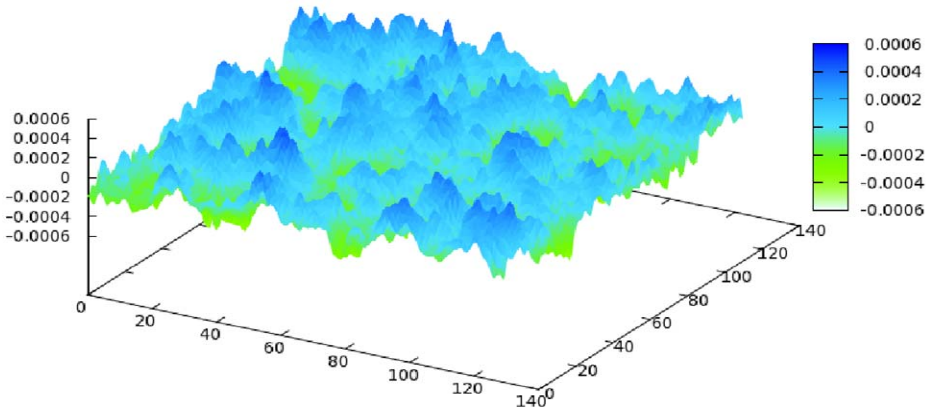


Figure wp8.8: Results of a SITCOM simulation showing representative spatial variations in water vapour.

This software and simulation task is much wider than an atmospheric model – an accessible overview of the Task can be found at http://cosmos.astro.uni.torun.pl/~blew/publications.php#talks (position 11) which is a talk given by B. Lew (TCfA) at YERAC, Yebes Observatory, on 7 July 2010. Updated information on the progress of the task can be found at: http://cosmos.astro.uni.torun.pl/~blew/scan_simulator.php#tests

In brief the APRICOT Task 5 software will consist of three principal components:

1. *Virtual telescope* (antenna and receivers basic specifications – crucial for realistic simulations of stream of TOD: 1/f noise, cross-talk, distance dependent beams patterns etc.), includes various Radio Telescope (RT) simulators and real telescope classes to operate on *(work for another few months)*
2. *Sky models* - includes realistic atmosphere model, and realistic sky model – connection with science case (to be done after scanning software works fine) *(probably end of second year studies)*
3. *Time Ordered Data (TOD) analysis* (map-making procedures and related issues, dedicated science programs) *(probably third year studies)*

The structure of and dependencies between individual components are evolving as the software package is being developed. Recent work (under point 1) has been based around the Torun 32-m telescope (RT4) and includes:

- Installation of a new real-time RT4 simulator and relevant motion control system
- Modifications of the control system to:
- test reliability of the RT4-simulator as compared to RT4
- record/learn simulated/real RT4 acceleration/deceleration motion patterns
- perform first tests of possible ways of connecting the APRICOT scanning software to RT4
- Design of a TCP socket based connection with the RT4 telescope command server with a new APRICOT control system plus planning a generic RT connectivity interface library to manage all tasks that are manageable over TCP/IP network.
- Tests of the scanning strategies using standard track command of the RT4 control system (no real-time implementation – testing purposes only)
- A prototype version of GUI for trajectory generation, visualization, analysis, scan planning, and RT4 connectivity is now available

All the documents and website URLs can be are available from the APRICOT wiki

Task 5- related programmes at INAF-IRA Medicina Observatory; A 7-pixel spectro-polarimetric receiver covering the band 18-26 GHz is in operation on the INAF-IRA 32-m telescope in Medicina and will provide invaluable information for APRICOT. The initial programme in Medicina involves surveying for discrete radio continuum sources using high scanning speeds (15 degrees per minute in azimuth) in order to eliminate the effects of 1/f receiver gain fluctuations and atmospheric opacity fluctuations. This is the proposed scheme for

APRICOT. A noise adding radiometer system, switching at 25 Hz, will also be used greatly to reduce the effect of 1/f gain fluctuations. Rapid data acquisition and accurate time tagging is a vital requirement for this technique to work. At 15 deg/min drive speed it takes <150 millisec to cross the 32-m beam at 21 GHz (108 arcsec); at the data sampling rate of 40 msec (25 Hz) one is therefore sampling the beam with >3.5 samples per beam. The Medicina telescope control and data acquisition system has proven to be capable of following a given scanning trajectory to an accuracy of <0.1 of a beamwidth at a drive speed of 15 deg/min.

An example illustrates the advantage of rapid scanning: Mrk 421 was not detected with “on-offs” with the old K-band system in Medicina – but was detected, with SNR ~10, in 12 seconds with the new system. The main change allowing this great improvement is fast scanning across the source coupled with fast data acquisition. This allows one to be dominated by thermal noise rather than other fluctuations. The K-band system noise now ~80K compared with ~140 K for the old system – but this is only a secondary reason for the improved detection performance.

2.1.9 WP9: UniBoard

Introduction
The UniBoard project, one of the JRAs in the RadioNet FP7 program, started off on January 1, 2009. Its aim is to design and develop a generic, high-performance, scalable, FPGA-based computing platform for radio-astronomical applications. The attractive, and unique, aspect of such a platform is that it will intrinsically be a multi-purpose instrument, re-programmable for a wide variety of applications, as well as be useable as a building block for larger systems. Along with the hardware a number of different VHDL applications, or board personalities were to be developed. To start with, these included a VLBI and APERTIF correlator, a digital receiver and a pulsar binning machine. As the project developed and the number of participants grew, an APERTIF beamformer and an all-station LOFAR correlator were added to the list, while more applications are being considered by the partners.

Originally 7 partner institutes were involved, all of whom were to receive one board out of the first production run. From the very start the UniBoard project drew quite a lot of attention within the community, and in the beginning of 2010 this led to Shanghai Observatory and Oxford University formally joining the project. SHAO is primarily interested in the UniBoard as a next-generation correlator for the Chinese VLBI Network; the Oxford group will investigate its use as a LOFAR all-station correlator.

The total budget is 1.8 M€, of which nearly half is contributed by the institutes in the form of matching effort. One of the original partners, KASI, did not receive any funds from the EC, and neither will the two partners that joined the project later on. To offset the higher than expected hardware expense, an MoU was signed by the partners in which an additional contribution was agreed upon. A separate agreement with SHAO ensured the financing of one extra board, while the participation of Oxford came through too late to add yet another board to the production run (due to the very long lead time of some of the components).

Project management
As this project involves quite a few international partners, efficient communication between the partners had to be insured. Bi-weekly ASTRON-JIVE meetings are held in Dwingeloo, and monthly general telecons make sure all partners have the opportunity to keep each other informed. The telecons also serve as a platform for discussions on general and technical issues. Additionally a UniBoard mail exploder was set up. A face-to-face general meeting took place in Dwingeloo in February 2009, a second meeting is planned in Bordeaux in October of this year. Several application-specific face-to-face meetings were held at Manchester and Bordeaux. To facilitate the exchange of firmware among the partners, a project-wide common SVN repository was set up. In this repository blocks of VHDL are stored, that can be re-used or adapted for different applications. An effort is underway to formalize interfaces and coding conventions, which should make the re-use and the combining of blocks of code into larger designs much easier. Following the RadioNet Consortium Agreement all code is open source.

Beside the normal coding tools, some, rather expensive, Altera IP had to be purchased. Fortunately we were offered licenses along with 2 companion licenses, which allow us to use them at three separate locations (Dwingeloo, Manchester and Arcetri). These licenses could be further shared among partners through international VPNs (Virtual Private Networks), although this has not been attempted yet. With more groups participating in the development of code this may become more pressing in the near future.

Finally, a UniBoard wiki was set up and is being used extensively as a storage area and exchange platform for documents, presentations, outreach material and minutes of meetings.

In spite of a slow start at some of the institutes, some of which was caused by local rules which make it impossible to hire personnel without the funding actually being in place, the project has progressed extremely well, with all deliverables in place at mid-term. All partners indicate that they will be able to spend the allocated funds within the three years of the project.

In the next section I will discuss the hardware development, in section 4 the different applications, section 5 will deal with documentation and outreach and in section 6 I will look at the expectations for the final 1.5 years of the project.

2.1.9.1 Common Functionality (Task 1)
Development
One of the reasons that progress has been rapid is that the ASTRON team, responsible for the actual hardware, was available from the very start of the project. Another reason was that work on the design started well before the official start of RadioNet, with the JIVE and ASTRON teams meeting regularly in order to converge to a design that would be generic enough for all applications. These discussions were of course extended to the other partners, through bi-weekly telecons.

One of the first issues to be resolved was the choice of FPGA. Both Xilinx and Altera, the major FPGA producers in the world, were at the time working on a next generation of chips based on 40 nm technology. As negotiations progressed however it became clear that only Altera would be able to deliver on the right time scale. As the architecture of the Altera product was also far more suitable for our design than Xilinx, by the end of Q2 the decision was made to use the Altera Stratix IV FPGAs. This choice did have as consequence that any interchanges with the Casper group in Berkeley (developers of among others the iBob and Roach boards) would be impossible, as their work is done exclusively on Xilinx hardware. However, this was not seen as a major issue by any of the partners.

After this decision, the design could be finalized, critical design reviews were held (internal and external) and the lay-out of the board got underway in Q3.

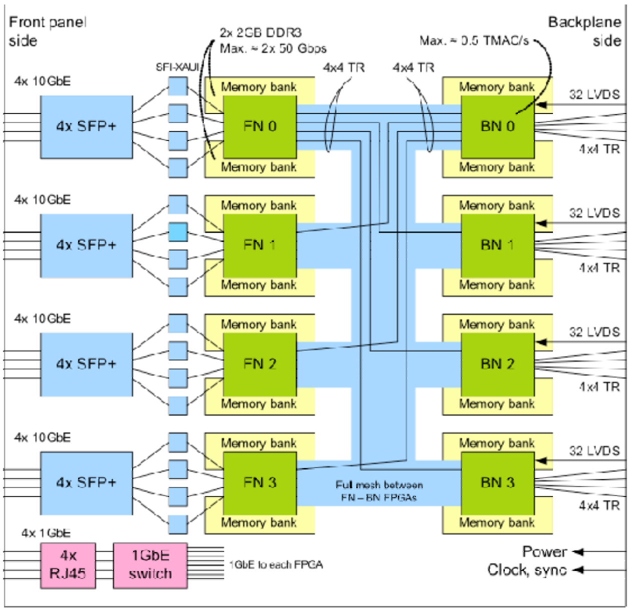


Figure wp9.1: UniBoard design

The main characteristics of the design are illustrated in Figure 1. A total of 8 FPGAs are used per board, a number arrived at by considerations of size and complexity. A high-speed mesh connects these FPGAs, one (front node) to all (back node). Every FPGA has access to two DDR3 memory modules (placed on the other side of the board). On the front-node side of the board 4 SFP+ cages are placed, giving a total of 16 * 10 Gbps connections to the outside world. The back-node side of the board has a backplane connector, allowing the connection of an ADC (on the far side of the backplane) to a UniBoard beamformer, and the combination of several UniBoard correlators on one backplane (Figures 2 and 3).

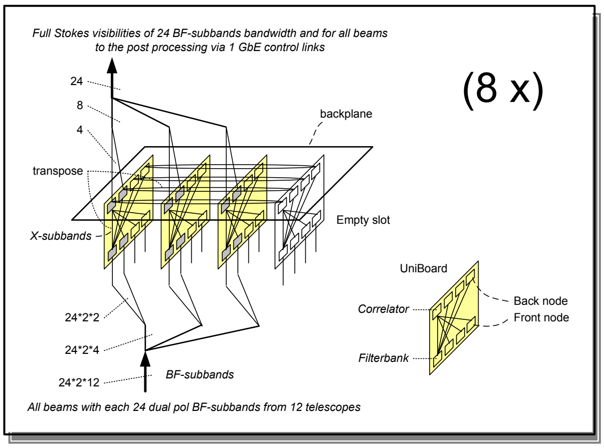


Figure wp9.2: UniBoard as APERTIF correlator

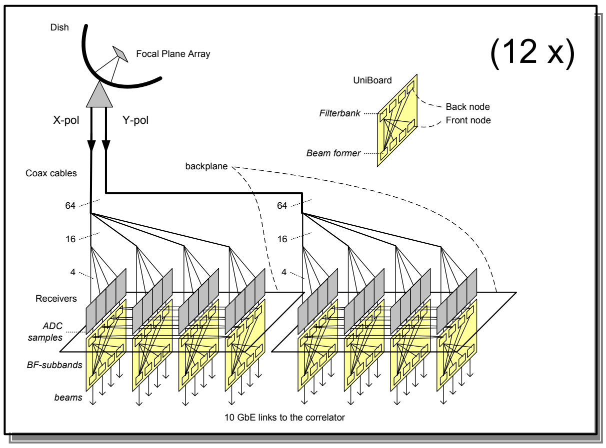


Figure wp9.3: UniBoard as APERTIF beam former

A mini backplane is currently in production (the XGB, or 10G break-out board), converting the back node outputs to 10 Gbps ethernet, making the board completely symmetrical (Figure wp9.4). This will be especially useful for stand-alone operations (Figure wp9.5). A 1 Gbps switch interconnects all FPGAs.

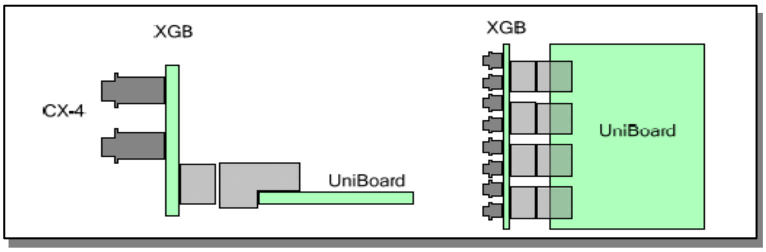


Figure wp9.4: XGB board

In Q3 a manufacturer by the name of Neways was selected out of 3 candidates. This Dutch firm has worked extensively with ASTRON in the past on LOFAR hardware. Although impressed by the complexity of the board, the Neways engineers were quite convinced it could be done (one of the other firms that were approached actually quoted a price, and then told us they could not make it). On May 17, 2010, the first complete prototype was delivered in Dwingeloo (Figure wp9.6).

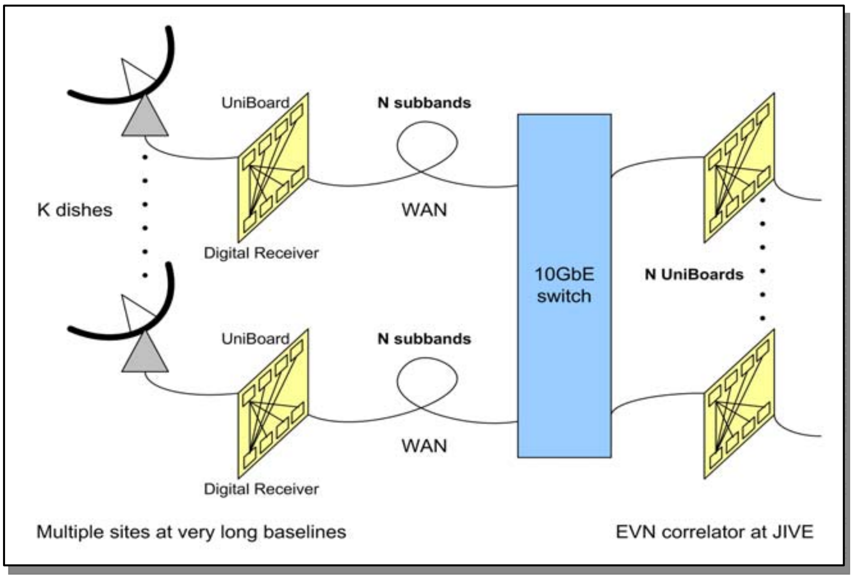


Figure wp9.5: UniBoard as digital receiver and VLBI correlator

Testing
Throughout the first phase of the project a large effort was spent by the JIVE and ASTRON teams to produce an extensive suite of test firmware, needed for validation and verification of the hardware. With the prototype in place, testing got underway, and is currently still ongoing. Many of the designs, to test for example DDR3 memory, 10 G ports and the front-node—back-node mesh will be re-used as building blocks for the larger designs, such as correlators and beam formers. At this point, some relatively minor problems have been encountered, but one of the main worries, namely whether the mesh would be able to sustain the speeds needed for, specifically, the VLBI correlator application, proved unfounded; in fact the mesh is performing flawlessly at the intended speed and will be tested at even higher speeds. As also the access speed to the DDR3 memory modules is more than adequate, we feel quite confident that it will be possible to run the applications at very high clock rates. Some issues remain with the number of 10 G ports that can be programmed into the design. Currently a number of factors limit this to 3 per FPGA, but a next version of the Altera design tools will, hopefully, correct this.

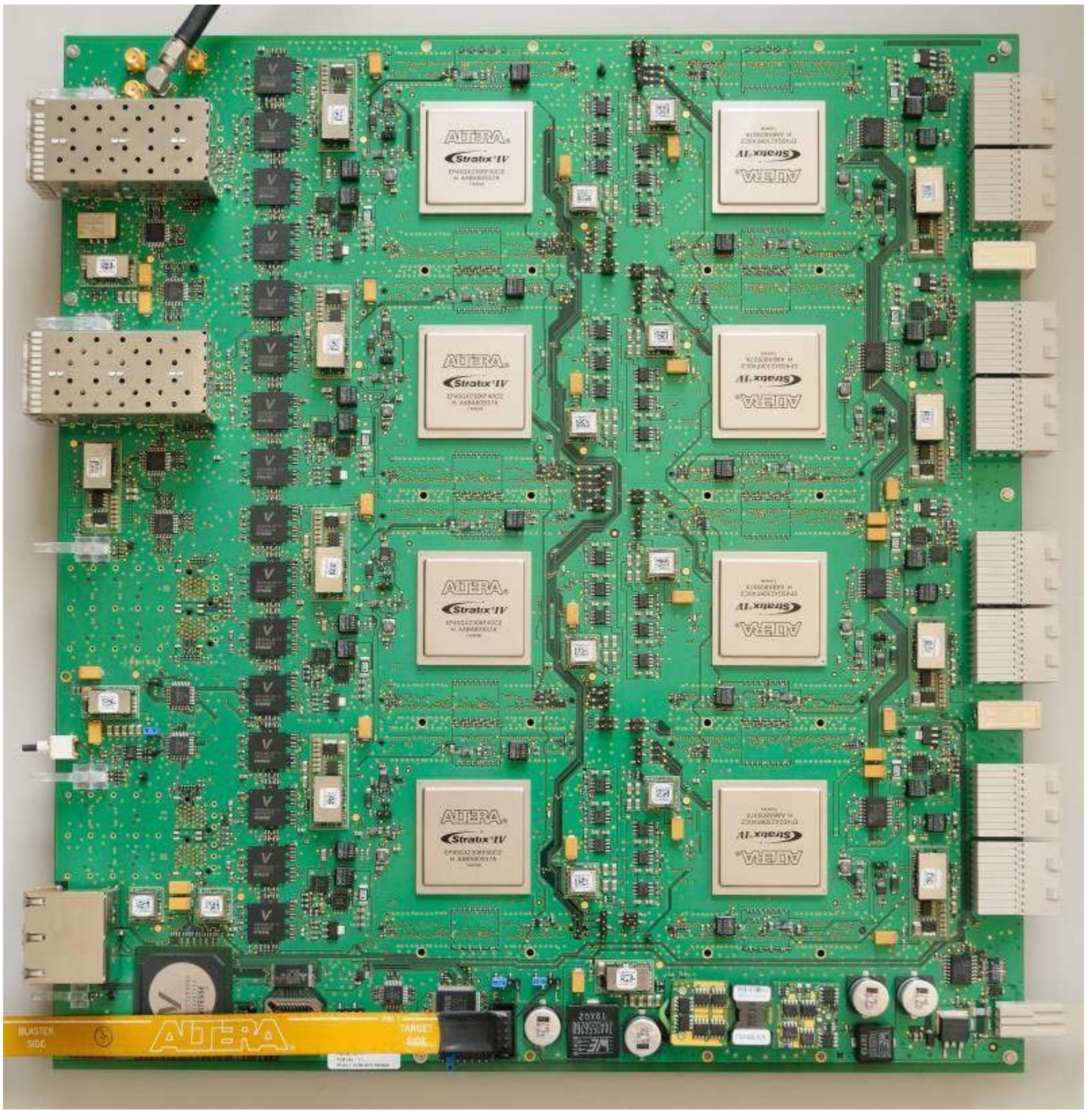


Figure wp9.6: prototype UniBoard

2.1.9.2 Applications

Correlator (Task 2)

Four of the participants in the UniBoard project have a specific interest in correlators: JIVE, ASTRON, KASI and SHAO. Until now, most of the actual work on correlator design has been done at JIVE, with input and help from ASTRON. One digital engineer from SHAO is spending one year at JIVE as visiting researcher, working on the UniBoard project, and two more SHAO engineers will spend several months in Dwingeloo towards the end of 2010. It is not decided yet when the involvement of KASI will start, or what exact form it will take.

Until a digital engineer was hired at JIVE in Q2, efforts concentrated on narrowing down the specifications for a next generation EVN correlator. To this purpose, a web-based tool was developed, called the Correlator Construction Kit (Figure 7), which proved very useful to explore the VLBI parameter space. At the same time, an investigation into the architecture and the programming language of an EVN correlator control system, as well as a more basic general UniBoard control system, was started.

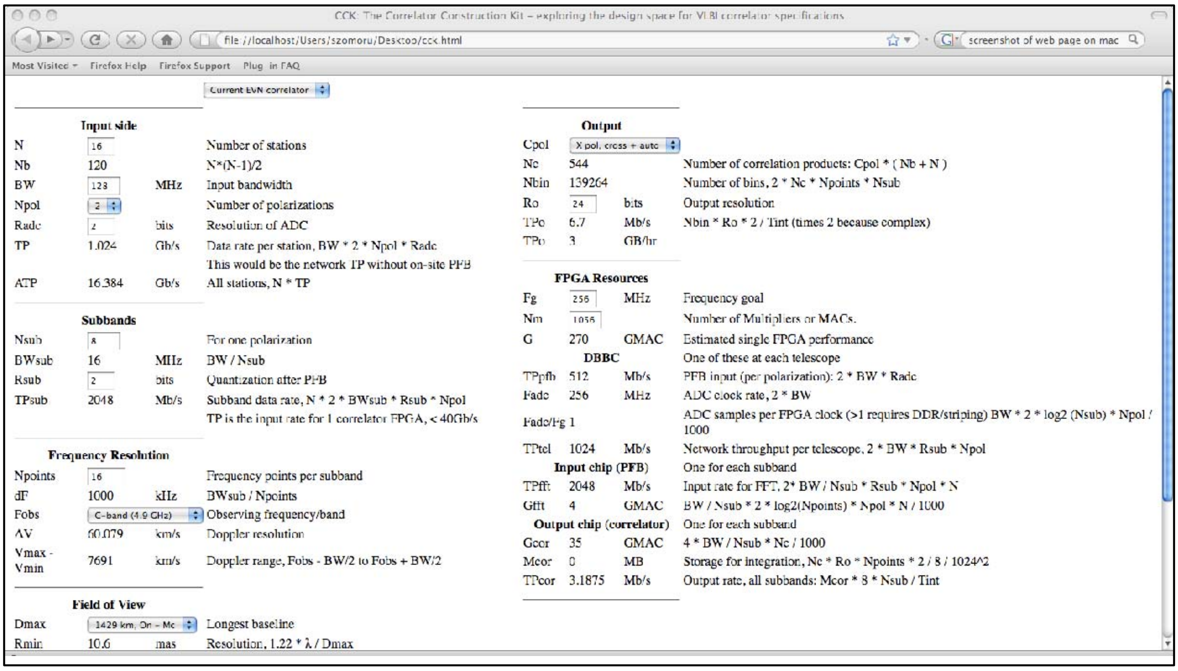


Figure wp9.7: Correlator Construction Kit

With the arrival of a digital engineer at JIVE the actual correlator design started, although, as noted before, a lot of his effort was in fact spent on writing test code. After a final internal review a correlator design document was produced in January 2010. Several parts of the design have already been implemented, and with testing all but finished the correlator VHDL implementation is now moving forward rapidly.

At the end of Q2, after extensive discussions and the creation of a number of test applications, the decision was made to implement the control system in a high-level language called Erlang. Some advantages of using this not very common programming language are its extreme robustness and its extensive built-in functionality, which makes it possible to develop highly complex applications in a very short time span. C-code was written for the NIOS embedded CPU, as was client Erlang code for FPGA control. Work also has started on an Erlang guide for test applications.

Pulsar binning machine (Task 3)
The pulsar binning application was to be developed entirely at the University of Manchester, with a RFI mitigation component being developed at Orleans. The inability to hire staff at Manchester until the EC funds were distributed, in combination with the heavy work load on their engineering group, delayed the actual start of work until Q4. Fortunately, the Orleans group was quite able to independently work on RFI mitigation algorthms and MatLab simulations with synthetic and real pulsar data.

With the effort at Manchester getting underway an engineer has been hired at Orleans to start the actual VHDL coding. An investigation in 10 G ethernet routing and use has been completed, as well as a MatLab simulation package of pulsar dispersion & dedispersion. A report was written on the first simulations and dedispersion tests, and by the end of Q6 a design document was produced.

Digital Receiver (Task 4)
The digital receiver application was divided between the INAF and Bordeaux groups. Their history of succesfull collaboration in the ALMA project shows itself through a very efficient and well-coordinated effort. Mathematical modelling, VHDL coding and code simulation and validation has been done, with the Bordeaux group concentrating on the front node, the INAF group on the back node modules. A design document was produced right on schedule, and at this time the designs for back and front node FPGAs are being integrated in a SOPC (System On Programmable Chip) processor, using the general SOPC architecture developed for the board. Work on a VLBI formatter and fast link interface has started, in which areas much exchange of code between correlator and digital receiver applications can be expected. Finally, the Bordeaux group has been working on the design and development of a fast ADC. While not directly related to UniBoard this development will certainly be relevant for the project.

2.1.9.3 Documentation and outreach

The following documents and presentations were produced during the first half of the UniBoard project (all available on the RadioNet FP7 wiki, although some parts are password protected)

Hardware

- UniBoard for EVN: Block diagram and analysis. Gijs Schoonderbeek, 13-3-2009
- UniBoard hardware design. Gijs Schoonderbeek, Sjouke Zwier, 29-01-2010
- UniBoard Schematic. Gijs Schoonderbeek, Sjouke Zwier, 29-01-2010
- PPT for Schematic Review. Gijs Schoonderbeek, Sjouke Zwier, 07-07-2009
- UniBoard PCB (preplacement) Sjouke Zwier / Gijs Schoonderbeek. 15-09-2009
- UniBoard Test Description. Sjouke Zwier / Gijs Schoonderbeek. 15-04-2010
- UniBoard Board Description. Sjouke Zwier / Gijs Schoonderbeek. 14-07-2010
- XGB hardware design document. Gijs Schoonderbeek, Sjouke Zwier, 07-04-2010
- XGB Schematic. Sjouke Zwier / Gijs Schoonderbeek 14-04-2010
- XGB PCB Overview. Sjouke Zwier / Gijs Schoonderbeek 14-04-2010
- UniBoard/XGB housing Sjouke Zwier / Gijs Schoonderbeek 07-07-2010

Functional Design

- UniBoard digital receiver design (draft 2). Gianni Comoretto, et al., 08-10-2009
- Draft for e-VLBI correlator. Paul Boven, 13-03-2009
- Evaluation of different options for the spectral domain data re-sampling for the VLBI application of the Uniboard. Sergei Pogrebenko, 19-08-2009
- VDIF specification v1.0. Ratified Madrid, 26-06-2009
- Draft EVN Correlator Design. Jonathan Hargreaves, Harro Verkouter, 13-01-2010
- UNIBOARD Pulsar Project Definition, Aziz AhmedSaid, Chris Shenton, 17-06-2010

Firmware

- Uniboard firmware development. Eric Kooistra, 05-06-2009
- Uniboard SVN draft database structure. Eric Kooistra, 24-06-2009
- Tools used for UniBoard development. 26-05-2009
- Design considerations for UniBoard's Stratix IV transceivers. Daniel van der Schuur, 25-05-2010

Software

- Draft discussion document re. Control Software Framework. Harro Verkouter, 23-03-2009
- Presentation about Erlang. Harro Verkouter, 14-04-2009
- LOFAR MAC details. Ruud Overeem, 24-04-2009
- Presentation about the PCInt. Harro Verkouter, 08-05-2009
- Python and Correlator Control Software. Des Small, 20-05-2009
- Erlang Part II: OTP mnesia and the outside world. Des Small and Harro Verkouter, 01-07-2009
- Erlang demo: developing a realtime monitoring utility. Des Small and Harro Verkouter, 27-08-2009

Pulsars

- Pulsar dedispersion simulation. Aziz Ahmedsaid, 15-04-2010

Other

- Licensing options for UniBoard. Paul Boven, 2010-01-06

Presentations

- The UniBoard, A. Szomoru, ASTRON/JIVE lunch presentation, Dwingeloo, May 7 2009
- RFI mitigation in the context of pulsar coherent de-didpersion, D.Ait-Allal et al., EUSIPCO 2009 conference paper, Glasgow, August 2009.
- RadioNet FP7: UniBoard, Eric Kooistra, Presentation at CASPER Workshop 2009, Cape Town, Sept 29, 2009.
- More on UniBoard system, Eric Kooistra, Oct 5, 2009.
- FPGA processing for Astronomy, H. Verkouter, presentation at the "High Performance Computing in observational astronomy: requirements and challenges" conference, Pune, Oct 15th 2009
- UniBoard Developments at JIVE and the SKA, Jonathan Hargreaves, presentation at the "PrepSKA WP2 Annual Meeting", Manchester, October 2009
- The UniBoard: a multipurpose scalable computing platform for radio astronomy, Arpad Szomoru, presentation at the "SKANZ 2010 conference, a pathway to SKA science in Australasia", Auckland, Februay 2010
- RFI Mitigation Implementation for Pulsar radio astronomy, D.Ait-Allal et al., submitted to EUSIPCO 2010 conference paper, August 2010.
- The UniBoard: a Multi Purpose FPGA Rich Board, Andre Gunst, presentation at "Bits and Chips Hardware Conference", Eindhoven, the Netherlands, June 17, 2010

Finally, a poster was created for use by the partners at conferences and other professional meetings. Both Altera and Neways representatives were very keen on obtaining copies for PR purposes (Figure wp9.8).

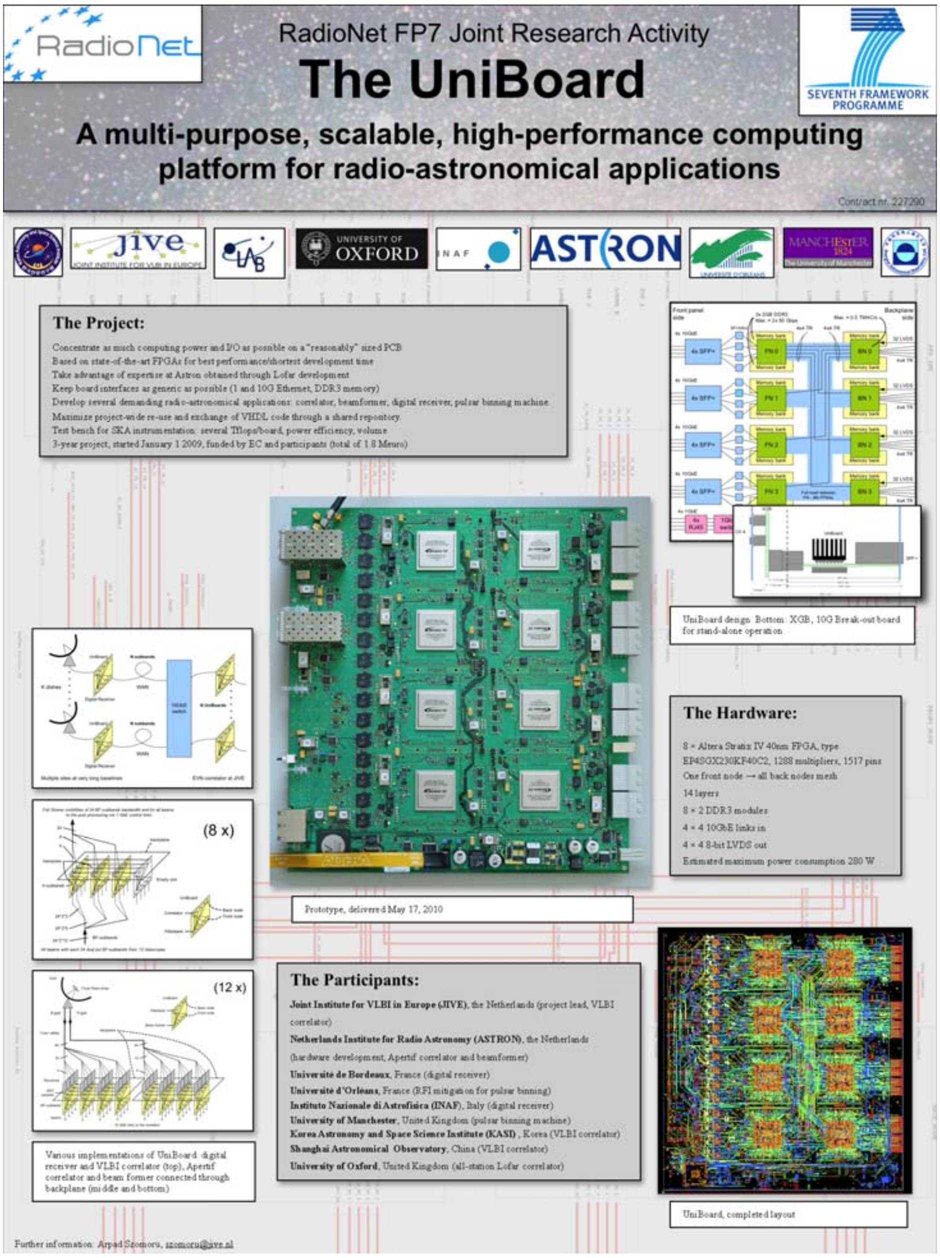


Figure wp9.8: UniBoard poster

2.1.9.4 Outlook: the next eighteen months

The UniBoard project has done quite well so far. It has gone from concept to working prototype, without any major showstoppers, on time. The hardware tests are positive and we expect the first production run and the distribution of boards to the partners to take place at the start of 2011. Having actual hardware available will considerably speed up the developments at the partner institutes. The correlator development is right on track,with first fringes expected at the end of 2010, the digital receiver effort is coming along smoothly, and after an initial slow start the pulsar binning application is headed in the right direction. ASTRON and JIVE have been quite succesfull in obtaining additional funds, which will be used among others to develop a beam former application and a backplane, both needed for the APERTIF project but potentially very useful for other projects as well. Groups in the Netherlands and the UK have obtained funding to build all-station LOFAR correlators and are now considering the UniBoard for this.

During the last 2 quarters of 2010 tests on the hardware (Task 1) will be completed, the design will be revised where needed and the production run of 8 boards will be initiated. Boards will be shipped to the partners in early 2011. Before the end of the project, all the feedback generated by the partners during the last year will be used to produce a revised hardware design document, which will be the basis for a second generation board.

The correlator development (Task 2) will aim at demonstrating first fringes before the end of 2010. This means combining the available blocks of code to connect all interfaces, filterbanks and multipliers in order to produce autocorrelations or cross correlations with pre-delayed signals. The last year of the project will be used to implement delay model corrections, extend the number of operating modes (such as spectral line observations), increase the bandwidth and clock speed and integrate the board with a full-blown correlator control system.

With the functional design of the pulsar binning machine (Task 3) in place, the implementation still has to get underway. Once the overall architecture is decided upon, the RFI mitigation algorithm implementation can get started. The definition of a data interface, MatLab modelling and tests will take place in the last quarter of 2010. VHDL coding should start towards the end of the year, and the integration with the pulsar binning application, debungging and fine tuning will follow once the hardware has arrived.

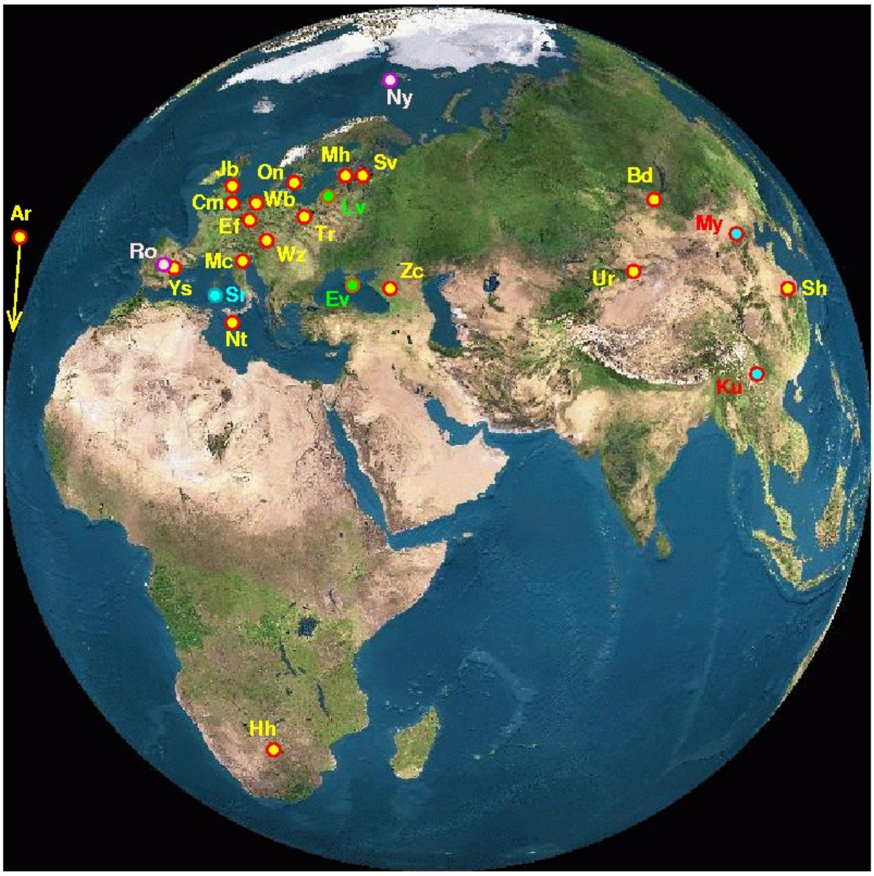
In the digital receiver development (Task 4), the VHDL coding of both front and back node FPGA cores will be completed during the last half year of 2010, as will the functional simulations. The integration of these cores in a common SOPC UniBoard structure will be started. The last year of the project will be spent integrating all parts, completing the overall board personality, debugging the code, speeding up the application, possibly adding functionality and finally interfacing the digital receiver with the correlator application to create a fully functional VLBI receiver-processor chain.

The project, as described in the DoW, will finish on time with all deliverables met. If the interest for the UniBoard within the community continues to grow, a collaborative agreement may have to be set up to run the project beyond RadioNet FP7. This however will be dealt with at a later stage.

2.1.10 WP10: EVN TNA

2.1.10.1 European VLBI Network (EVN)

In Europe, most astronomical VLBI observations are carried out by the European VLBI Network (EVN), formed in 1980 by a consortium of five of the major radio astronomy institutes in Europe (the European Consortium for VLBI). Since 1980, the EVN and the Consortium has grown to include 13 institutes with 20 telescopes in 8 EU countries, as well as institutes/telescopes in China, South Africa, Russia and the USA. Together, the EVN telescopes form a large, distributed research infrastructure: a trans-continent-wide radio telescope. The combination of simultaneous observations made by a widespread network of radio telescopes (interferometry) generates images of celestial radio sources with a detail that would otherwise only be achievable by a hypothetical single telescope of continental dimensions. The Joint Institute for VLBI in Europe (JIVE) was established in 1993 to support and coordinate network operations from a central location. JIVE operates a 16-station VLBI Data Processor (correlator) and provides extensive support to researchers affiliated with institutes and organizations of EU Members and Associate States. The EVN is an open facility and encourages proposals from the entire astronomical community. Proposals are rated on scientific merit and technical feasibility alone by the independent EVN Program Committee. A map of EVN stations is shown in figure wp10.1.



Ffigure wp10.1: The European VLBI Network (EVN) is an interferometric array of radio telescopes spread throughout Europe (and beyond) that conducts high resolution radio astronomical observations of cosmic radio sources. It is the most sensitive VLBI array in the world, thanks to the collection of extremely large telescopes that contribute to the network. The map below shows EVN and other participating stations, color-coded via:
Yellow/Red: current operational EVN stations, Cyan/Red: existing telescopes soon to be EVN stations, Cyan/Blue: new EVN stations under construction, Pink/Purple: non-EVN stations that have participated in EVN observations, Green/Brown: non-EVN stations with whom initial EVN tests have been carried out

Other MERLIN out-stations besides Cambridge can also participate in EVN observations in some situations. Global VLBI observations are also often conducted in conjunction with the VLBA, the GBT, and/or the VLA telescopes in the U.S., and sometimes with telescopes in Japan and/or Australia. The underlying map was generated from EarthView.

2.1.10.2 Description of the publicity concerning the new opportunities for access

The EVN Call for Proposals is distributed three times per year via a variety of media, 4-8 weeks prior to the proposal submission deadlines of 1 February, 1 June and 1 October. The Call for Proposals provides the dates of the upcoming sessions, focuses on special features that are available, and provides links to more detailed information, including the more detailed EVN Proposals Guidelines. The current versions of these documents can be found in the "How to Propose" item in the EVN Users' Guide on the main EVN web page. The Call for Proposals is distributed via several major international e-mail exploders reaching the main body of the professional radio astronomy community, and also promulgated via the tri-annual EVN Newsletters, which appear a few weeks before the proposal deadlines. The Proposals Guidelines specifically include a description of the opportunities for access to the EVN via the RadioNet TNA mechanism. In addition, the call for Global VLBI opportunities jointly issued by the EVN and NRAO (USA) contains clear pointers on EVN specific provisions, including RadioNet TNA opportunities. Together these methods penetrate the entire radio astronomical community in Europe and beyond.

2.1.10.3 Description of the selection procedure

The EVN selection panel (known as the EVN Program Committee or EVN PC) meets 4-6 weeks after each of the three annual deadlines mentioned above to evaluate the proposals. The EVN PC consists of twelve voting members, four of whom are affiliated to institutes that are independent of and external to the EVN. Prior to the meetings, each PC member makes written comments about each project and assigns a "pre-grade"; these are collated by the PC Chairman and further distributed to all PC members before the meeting. In the face-to-face meetings, opinions about the astronomical and technical aspects of each proposal are discussed in turn, with the aim of reaching a consensus numerical grade. Grading ranges from 0 (excellent; must be observed as soon as possible) to 4 (poor; definitely must not done). The PC also decides how much observing time a project should be awarded; due to the over-subscription of the facility, this is sometimes less than the original request. For multi-epoch proposals, a subset of the requested number of epochs may be granted, with an intermediate progress report required before granting subsequent epochs.

Proposals for e-EVN observations have been subsumed into the normal proposal cycle. There are two principal types of e-EVN observations: general, which may not need the rapid response but would benefit from the more frequent observing opportunities to obtain denser temporal sampling; and triggered, which may override scheduled observations if a specific set of conditions justified in the proposal occur. This latter type of observation is geared towards flaring or otherwise transient sources which may occur on short notice. A new proposal is not required, only a request to execute the proposed observations based on external evidence that the source has entered an "interesting state".

With the maturation of the e-EVN technique -- more stations becoming available at 1 Gbps and improvements in the reliability of data transmission over the fibre-optic networks -- target-of-opportunity proposals have proliferated owing to the faster response time. In the period January 2009 through June 2010, there have been 14 target-of-opportunity proposals (13 of which were eligible, 10 since mid-December alone), leading to 19 observations (an additional one was abandoned by the PI when a presumed state-change event turned out to be a false alarm).

Proposals submitted to the EVN PC are evaluated purely on scientific merit and technical feasibility. Extra help is, however, available to new or inexperienced users -- in particular JIVE support scientists are available to advise on the technical feasibility of proposals before they are submitted to the PC. Because the EVN is a complicated instrument with many observing modes, this help aims to prevent proposals from by new users being downgraded simply on the basis of errors or misconceptions in the technical case.

Once the proposals have been evaluated, the PC chairman contacts the group leaders. The feedback includes the consensus grade, a summary comment, and a list of all the individual-member's pre-grades and comments. It is actually extremely rare for proposals to be immediately rejected, especially those that are received from new or inexperienced users. In nearly all cases, new users are asked to re-submit, after taking into account the comments made by the PC.

The EVN scheduler will schedule experiments in the next feasible observing session. The ability to schedule a specific project is a complex mix of resource availability (time available at a given wavelength band, competition for GST ranges, antenna availability, etc.) in addition to relative grades. More highly rated proposals would naturally have priority for observation; if a proposal has not been observed within two years following its successful PC review, then it is dropped from the queue awaiting scheduling and the PI is invited to re-propose (taking into account progress in the field since the original proposal, of course). Target-of-opportunity proposals are attempted to schedule as soon as possible, without waiting for the next official observing session; this may limit participation as some telescopes may have conflicting commitments. When a project that is eligible for RadioNet TNA support appears on the block schedule for an observing session, a JIVE support scientist communicates the benefits to the group leader prior to the observation. While the RadioNet contract is running, the EVN remains committed to supporting all European users in terms of providing observing time for approved projects (even when the contracted access hours have been exceeded).

In this reporting period, there were 81 TNA-eligible proposals submitted, and of these 11 were recommended for re-submission and 4 were rejected. Of the 6 re-submissions from 2009, 3 had indeed been re-submitted by the end of the proposal period. Of course, it is quite possible that an experiment does not observe in the same year as it is proposed, and a single proposal may result in multiple epochs of observations spread over multiple years (19 of the 66 proposals with one or more observations in this reporting period stem from before 2009).

There have been five meetings of the EVN program committee in this reporting period: 3 March 2009, Bologna, IT; 24 June 2009, Madrid, ES; 10 November 2009, Cambridge, UK; 11 March 2010, Hamburg, DE; and 29 June 2010, Dwingeloo, NL. During this reporting period, there have been five personnel changes in the EVN program committee. From the EVN institutes, A. Polatidis replaced R. Strom (ASTRON). All four external members rotated: P. Charlot (Obs. Bordeaux), A. Merloni (MPA), A. Tarchi (Obs. Cagliari), and M. Ribo (U. Barcelona) departed and E. Koerding, W. Vlemmings, J.C. Guirado, and N. Vlahakis acceded. For the single meeting in March 2010, A. Cappeti (Obs. Torino) was an external member, but he became director of the observatory shortly thereafter, and had to recuse himself (leaving a vacancy, chronologically filled by N. Vlahakis).

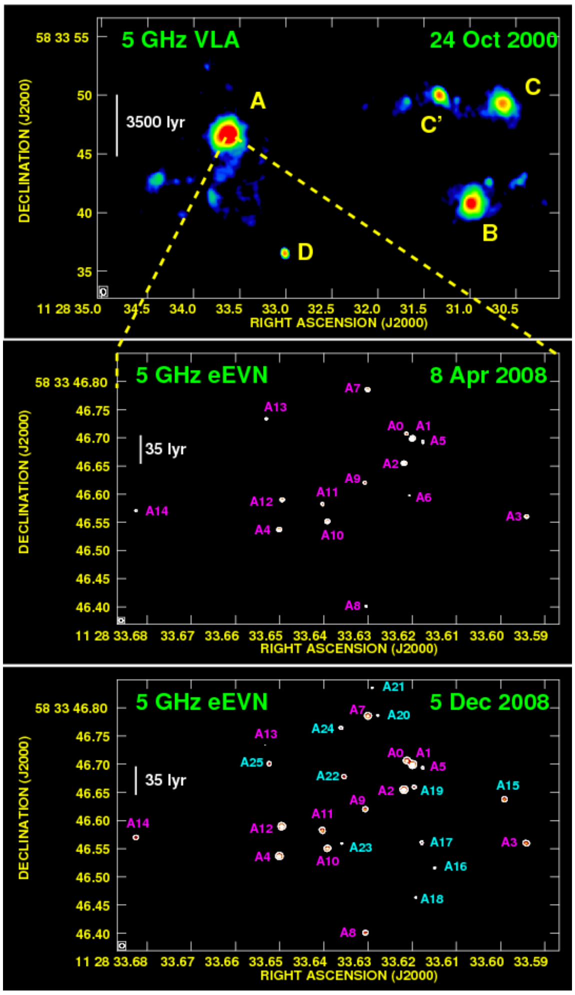


Figure wp10.2: Top: 6cm VLA archival observation of Arp299, displaying the five brightest nuclei in this merging galaxy. Middle/bottom: contour maps drawn at 5 times the rms of 6cm e-EVN observations of Arp299-A (RP009, RP014 fist epoch, respectively), revealing a large population of relatively bright, compact, non-thermally emitting sources. Sources labeled in cyan represent sources detected only in the RP014 epoch. The image sensitivity in the middle panel is 39 uJy/beam, and in the bottom panel 24 uJy/beam. There were 6 additional epochs of Arp299 observations together over 6cm & 18cm in the reporting period (RP014, EP063, EP068), with further observations anticipated. From Perez-Torres et al. 2009, A&A, 507, L17.

2.1.10.4 Transnational access activity

During this reporting period, a total of 127 different observations arising from 65 different proposals have been supported by the EVN TNA program. They were conducted by teams that included 168 individual researchers (not double-counting people involved in more than one project), of which 79% were affiliated with institutes of EU Member and Associated States (outside of the Netherlands). There were a total of 19 different PhD students involved in the research teams in the TNA-supported projects in this reporting period. The total quantity of access provided over the period is 1084.5 hr, with project-summaries on-hand for 283.5 hours worth of observations. This is considerably higher than the nominal annual amount of TNA hours required by the contract at the half-way point (168 hours). All eligible projects received support via RadioNet as described in this report.

We note that due to the specific nature of the VLBI technique, all observations and correlation processing are conducted in absentia (i.e. not requiring a presence of an investigator at the facility). Almost all PIs retrieve their correlated/pre-processed FITS files and calibration files from the EVN archive over the web, thus using a remote access mechanism. The FITS files resulting from the post-correlation review process are put onto the EVN Archive immediately once ready, and remain proprietary for a 1-year period; users may arrange a password to download their data. In addition to accessing raw correlator data, many EVN users take advantage of a pipe-line processing of the FITS files provided by the Science Operations & Support Group at JIVE. Pipelining carries out the initial calibration steps, and provides preliminary, automatically-generated images of the sources in the experiment (sources identified by the PI are also afforded the 1-year proprietary-period protection).

2.1.10.5 Scientific output of the users at the facilities

In many areas of VLBI science, EVN is the world-leading facility. To a great extent this position is achieved via scientific projects conducted by RadioNet TNA-supported groups. One of the most attractive characteristics of the

EVN for astronomers is its superb sensitivity. The large diameters of many of the EVN radio telescopes, combined with sustainable data rates of 1 Gbps, makes the EVN currently the most sensitive VLBI network in the world. The three Russian KVASAR 32-m telescopes officially joined the EVN during this reporting period, which noticeably improves the amount of medium and long baselines available.

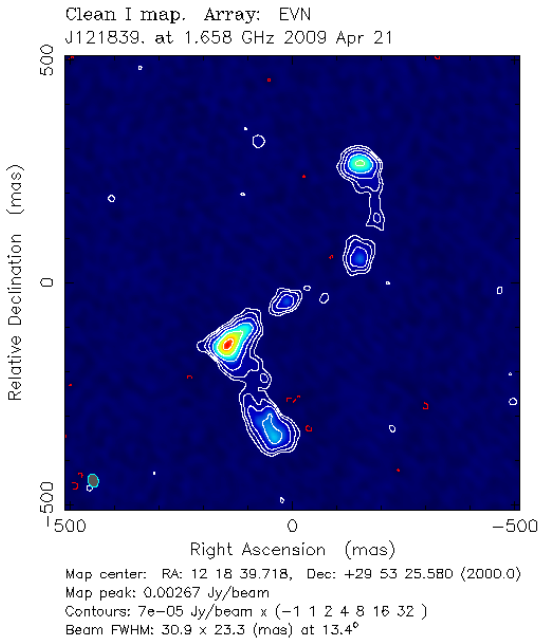


Figure wp10.3: Naturally-weighted, Gaussian tapered 18cm e-EVN image of J1218+2953 (RF006). This is the radio source at the location of a putative foreground lensing object for an optical arc, but one that would have required a very large mass-to-light ratio given non-detections in deep optical and IR imaging. The radio structure resembles a young, CSO, spanning almost 0.7". The projected linear size could be 5-6 kpc, for redshifts appropriate to a putative lens. From Frey et al. 2010, A&A, 513, 18.

The two most prevalent themes requiring the high sensitivity and high angular resolution during this reporting period have been (i) investigating the contributions of AGN and starbursts to the underlying energy source in various types of dusty active galaxies, and (ii) studying the population and evolution of supernovae and supernova remnants in specific galaxies. Targets of experiments addressing the former include distant z~2 sub-millimetre galaxies (EB041, EI010), the inner regions of ultra-luminous infra-red galaxies at D~250-350 Mpc (EP064), and the Seyfert 1 galaxy NGC7469 (EA042). Experiments addressing the latter observed the starburst galaxies Arp220 (D=78Mpc, GC031), Arp299 (D=45Mpc, EP063, RP014, EP068 – see figure wp10.2), and M82 (D=3Mpc, GF015), as well as the local-group galaxy M31 (EM082) which requires wide-field mapping techniques. Both of these topics relate to the overall issue of the evolution of the amount and efficiency of star-formation back to the early universe. M82 also saw two target-of-opportunity observations: one targeting a new supernova (RB003), and another multi-epoch global experiment following up a new transient source that happened to be detected in the course of observations of this new SN; this new transient may prove to be the first discovery of an extra-galactic X-ray binary. Other areas pertaining to AGN research seeing multiple experiments include episodic behavior in activity via evidence of jets having died and then re-started (EC030, EM078, EM079, EP067), and surveys of various phenomenological classes of AGN: pc-scale radio nuclei in nearby Seyfert galaxies (EG040), broad-absorption line QSOs (EB044), faint blazars (EM077), and faint nuclear sources in the Bologna Complete Survey (EL040). As usual, there were many experiments investigating interesting features of individual sources; a sampling includes a binary black hole hypothesis in the core of J1536+0441 (EB042), compact structure in the most-distant known radio quasar (EF022), ultra-luminous X-ray sources outside the nuclei of their host galaxy (EM072), the innermost jet/counter-jet region in Cyg A (GB065), and a putative dark lensing galaxy (RF006 – see figure wp10.3). The second stage of the multi-experiment project to detect and map candidate radio sources to use in creating an astrometric link between the current radio-defined celestial reference frame and that of the future GAIA satellite continued (GC034).

The high spectral resolution afforded by the EVN Data Processor has been used in several projects studying the maser emission of various molecular species around both young/forming stars and old/evolved stars. Typical velocity resolutions for commonly observed transitions would be 176 m/s for OH (1.6-1.7GHz), 44 m/s for methanol (6.7GHz), and 105 m/s for water (22.2GHz). During this reporting period, we also rolled-out recirculation at the EVN correlator at JIVE, which provides these velocity resolutions even when the array grows beyond 8 stations (important as the number of participating telescopes continues to grow). The EVN is uniquely capable to observe the 6.7GHz methanol maser line in the northern hemisphere, and experiments taking advantage of this dominated the spectral-line observations. The two principle areas of research using methanol masers have been (i) kinematics in massive young stellar objects, often in conjunction with observations of masers from other species, to distinguish between rotating toroids and outflow (EM062, EM064, EM069, EM071 – see figure wp10.4) and (ii) the polarization structure of the methanol masers, and what that can tell us about the underlying magnetic field structure and magnitude (EB036, EB045, ES062, ES063). There have also been experiments seeking new sources with compact methanol maser emission (EB043, ES060), and ones continuing a monitoring program of the morphology and spectral-characteristics evolution in specific regions (EB040). Three experiments observed OH masers: one aiming to use the phase-lag method to estimate distances to evolved OH/IR stars (EE005), another investigating OH maser morphology in post-AGB stars in transition to planetary nebula (EW013), and a target-of-opportunity observation catching an outburst in o Ceti (RE001). There was only one experiment looking at the kinematics of water masers in a high-mass protostar (EM059). There have been no eligible experiments on extra-galactic mega-masers so far in FP7.

Within the Galaxy, high-sensitivity continuum experiments have included trying to detect one or both components in ultra-cool dwarf binaries (GH009), following the kinematics of radio-loud compact objects (possibly ms-pulsars) in the globular cluster M15 (GV020), investigating whether it is micro-quasar jets or a non-accreting pulsar that is powering the high-energy emission of the massive X-ray binary LS 5039 (EM074). Astrometric projects/pilots have begun for pulsars (EM080, EV018A) and active red-dwarfs (EG046). Real-time e-EVN target-of-opportunity observations have targeted a nova in KT Eri (RO003) and the ejection of a jet component and its subsequent motion in the X-ray transient J1752-223 (RY001, RY002).

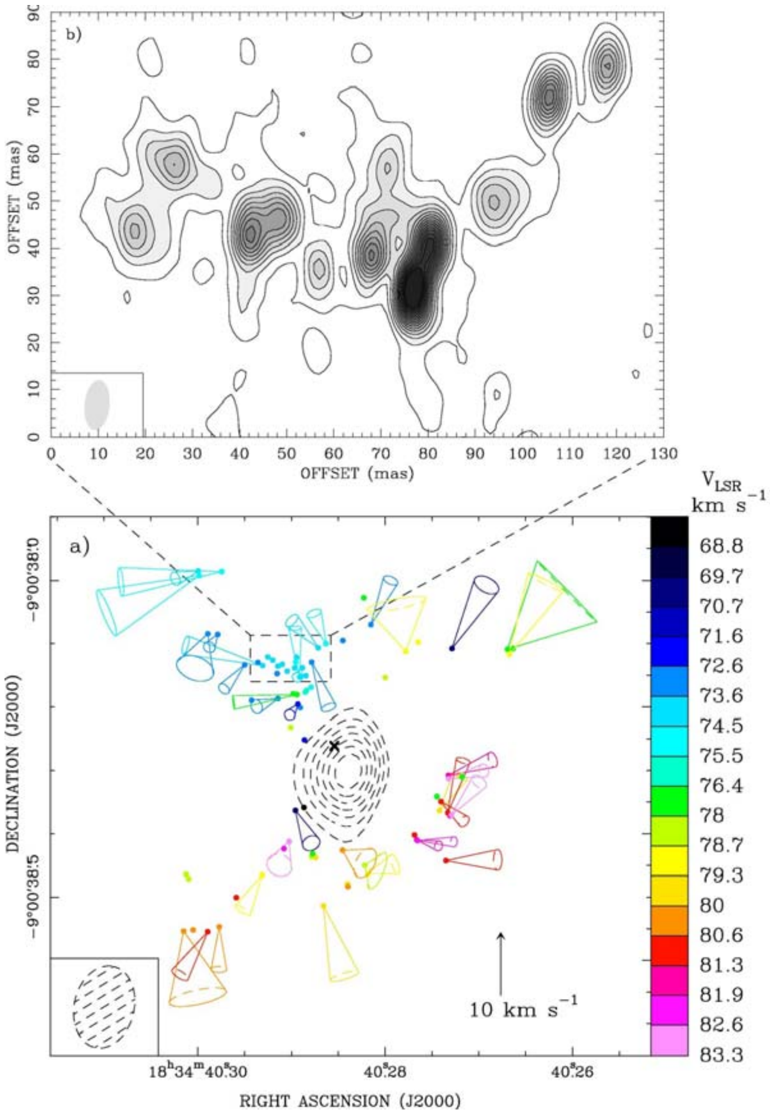


Figure wp10.4: 6.7GHz methanol masers towards G23.01-0.41 (EM069). Panel (a) shows absolute positions (dots) and proper motions (colored cones) relative to the center of motion (x). The proper-motion cones show directions, magnitude (height, scaled to the black arrow in the bottom right), and uncertainty (aperture). Color hue reflects maser LSR velocity, as per the right-hand scale (green = systematic). Dashed contours show the VLA 1.3cm continuum emission. Panel (b) shows a most crowded region of methanol-maser emission from EVN observations. From Sanna et al. 2010, A&A, in press (arXiv astro-ph:1004.5578).

This real-time e-EVN, in which data streams directly to JIVE via optical fiber from the stations rather than being recorded onto magnetic media for subsequent shipping, has continued to mature through the first half of the FP7 RadioNet period. Data rates of Gbps are now routinely reliable, and up to 9 stations can participate. Proposals for e-EVN observations have been merged into the standard proposal process since 2008. The principal advantages of e-EVN lie in more frequently spaced observing opportunities -- roughly monthly 24-hour periods -- for monitoring sources (some of the Arp299 observations discussed above were accomplished with e-EVN) and the far shorter turn-around time from observation to receipt of the resulting FITS files. Target-of-opportunity observations are also more flexible via e-EVN, since no recording media has to be in place.

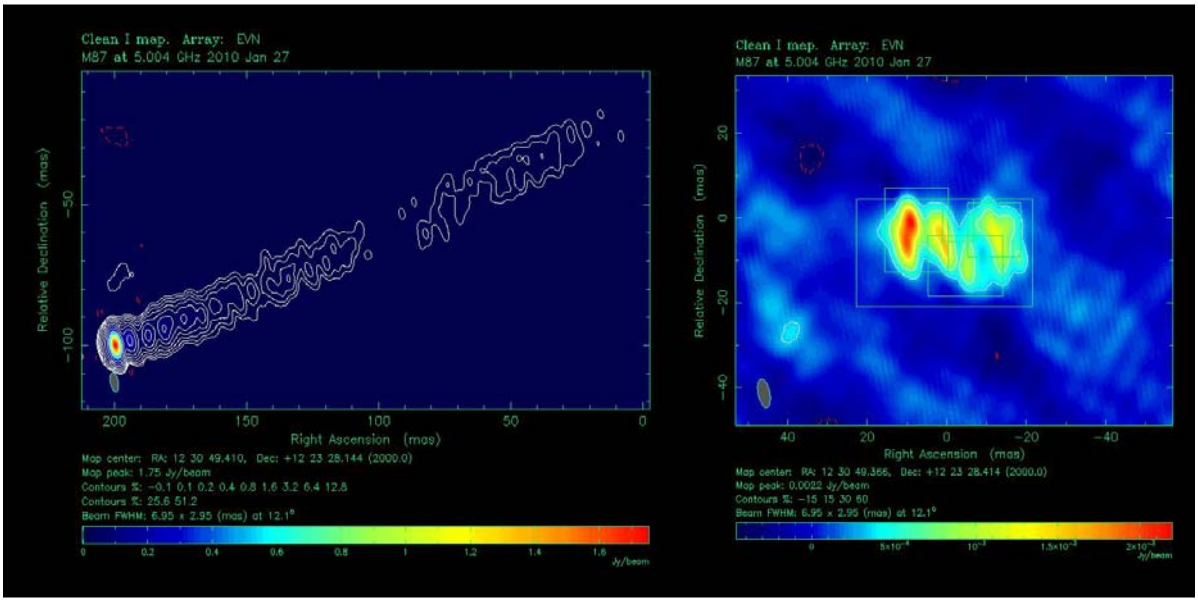


Figure wp10.5: M87 is one of the nearest AGN, and one of the few detected at TeV. One topic of intense interest is the locus(i) of the high-energy emission. The image shows the core (left-hand panel) and jet-component "HST-1" about 0.8" away (right-hand panel), as observed in the second epoch of EG043 (e-EVN). The multi-epoch EG043, RG002, and RG005 observations have revealed proper motions within the HST-1 complex.

These advantages of e-EVN enables astronomers to pursue VLBI observations coordinated with observations with other instruments more easily, a capability that has become quite relevant in light of the recent launches of advanced high-energy satellites and the development of ground-based imaging Cherenkov-radiation arrays. The fast turn-around of e-EVN observations allows for the first time milliarcsecond-scale imaging to inform the conduct of ongoing high-energy observations; appropriate e-EVN results can usually be promulgated in the form of Astronomer's Telegrams, which while unrefereed form a cornerstone of the impact of the e-EVN in such cross-disciplinary investigations. e-EVN observations of the Low-Mass X-ray Binary Cyg X-z were conducted coincident with X-ray observations from Chandra and XMM-Newton (RB002). A series of observations have targeted V407 Cyg, which FERMI observations detected as the first gamma-ray-loud nova (RG003, RG004, RG006). Joint multi-epoch e-EVN and imaging Cherenkov observations seeking to pin down the loci of gamma-ray emission and correlations between the radio and gamma-ray behavior have been made for the active galaxies 3C84 with MAGIC (EG047) and M87 with VERITAS (EG043, RG002, RG005 – see figure wp10.5). Another use of the fast turn-around of e-EVN observations has been the search for better phase-reference calibrators for future (sometimes already scheduled) observations (RM003, RSD01, RSD02, RSD03).

2.1.11 WP11: JCMT TNA

2.1.11.1 James Clerk Maxwell Telescope

The JCMT is the world's largest radio telescope working at submillimetre wavelengths (between 2mm and 0.3mm). The primary dish has a diameter of 15m and comprises 276 aluminium panels which may be adjusted to optimize the shape and accuracy of the surface. The antenna is protected from wind, dust and insolation by the world's largest piece of Gore-Tex, which is ~97% transparent to millimetre wavelengths.

JCMT is equipped with a suite of heterodyne (spectral) receivers operating in three frequency bands corresponding to transparent windows in the atmosphere: A-band at 211-276 GHz, B-band at 325-375 GHz - where we operate a 16-receptor array detector, HARP - and D-band at 620-710 GHz. This coverage includes several important CO transitions. Spectral line polarimetry can be carried out at the longer wavelengths. A new autocorrelation spectrometer, ACSIS, serves as the backend for all receivers providing spectral resolutions as fine as 30.5 kHz. Our new continuum array, SCUBA-2, was installed during 2008 with 'engineering-grade' arrays at 450um and 850um, and was operated in a 'Shared-Risks' mode in 2009/2010 with two 'science-grade' arrays. After an upgrade to 4 sub-arrays per waveband this summer, SCUBA-2 will be re-commissioned this fall, and will offer imaging in an instantaneous field of view of >50 sq.arcmin at both wavelengths, together with polarimetry and FTS capabilities.

2.1.11.2 Description of the publicity concerning the new opportunities for access

The JCMT home page contains a prominent link to RadioNet, and the Calls for Proposals each semester emphasize RadioNet funding possibilities for eligible applicants. Demand for RadioNet support continued at low levels during this reporting period, with 4, 5 and 1 eligible observing proposals received in the 09a, 09b and 10a proposal rounds, and with 2, 3 and 1 approved, respectively. As stated in previous reports, there is no reason to believe that the publicity is less effective than in previous semesters or that the program is somehow less well-known within the community. The overall numbers of requests have also declined in recent years, with much of the JCMT community waiting for the arrival of SCUBA-2.

2.1.11.3 Description of the selection procedure

The 3 funding nations of JCMT (UK, Netherlands, Canada) have independent selection panels (Time Allocation Groups, TAGs) comprising astronomers (usually users) based in the home countries. Members of the TAGs are suggested by previous members based on their experience and are confirmed by the funding agencies. The TAGs meet every 6 months (each semester), usually in May and November, in the partner countries. Proposals to the national TAGs are assessed and ranked on scientific merit and feasibility. The TAGs provisionally allocate their shares of observing time on this basis, and forward their recommendations to the 'ITAC', which comprises 2 members of the UK TAG and one each from the Dutch and Canadian TAGs. The ITAC meets by teleconference a week or two after the national TAG meetings. The ITAC assesses 'International' proposals (those submitted from beyond the 3 partner nations), resolves conflicts between competing or overlapping proposals, and formally allocates the observing time for the semester. Applicants receive notification of success or failure within a month or so of the ITAC meeting, and they receive scientific feedback from the relevant TAG by e-mail.

2.1.11.4 Transnational access activity

Semester 09A: There were 2 approved eligible projects, with some overlap in the applicant teams. One observer travelled to observe both programs, but ultimately made no claim upon RadioNet travel funds, despite reminders. The total allocation to these 2 programs was for 48 hours. They requested use of the A-band heterodyne receiver (RxA), to study the "nature of very high excitation sources and the origin of cosmic rays", and use of the B-band array receiver (HARP), to make observations of the H_2D^+ and D_2H^+ molecules in molecular clouds – a popular topic in recent semesters.

Semester 09B: There were 3 approved eligible projects: two *regular* (heterodyne) proposals (from the same PI), and one proposal to use SCUBA-2 during its *Shared-Risks* observing phase. One of the heterodyne proposals was best done flexibly throughout the semester – an arrangement approved recently by the ITAC - while the other was best done in a more classical observing mode. The PI consequently travelled and claimed RadioNet travel funding. The SCUBA-2 proposal did not require PI involvement, and, as it transpired, was not observed. The total allocation to the 2 regular, heterodyne programs was for 27 hours, and both requested use of HARP to examine the chemistry of the gas giants of the Solar System. The SCUBA-2 proposal requested 2 hours of observing time to study "*the interstellar medium in the dwarf elliptical galaxy NGC205*".

Semester 10A: There was only one eligible proposal received – an extension by the same PI of the successful 09b proposals. The program was approved by the ITAC, and the PI again travelled to observe his program, subsequently claiming RadioNet travel support. The allocation to this program was for 24 hours.

Eligible applicants continue to be based in Western Europe (France and Germany, in the period covered here). None of the applicants was a first-time JCMT user.

All 48 hours of access were delivered to the eligible 09A programs, 28.05 hours to the 09B heterodyne programs, and 33.10 hours to the eligible program in semester 10A.

A further 32.5 hours were obtained during the period for four eligible programs from previous semesters (m07bu35 10.5 hours, m08bi02 11.25, m08bn09 10.75) giving a total for the reporting period of **141.65** hours. Eligible 09A projects have been provided access at an average of 48/2 = 24 hours, while the corresponding figures for 09B and 10A are 9.3 hours and 33.1 hours, respectively.

2.1.11.5 Scientific output of the users at the facilities

We have previously (FP6) cited 18 publications that have used JCMT data taken for RadioNet-supported programs. Below, we add 5 more.

The average interval between the year of the proposal and the year of publication for these five is about 4 years, so, as always, there is a promise of more to come in the years ahead. Only two of these five publications acknowledged their RadioNet support. As noted previously, however, acknowledgements are correlated with programs that sent observers to Hawaii and who received reimbursement of their travel costs (2 of 2).

- *"Tracing high energy radiation with molecular lines near deeply embedded protostars",* P. Stäuber et al, 2007. A&A 466, 977, http://www.aanda.org/articles/aa/full/2007/18/aa5762-06/aa5762-06.html, RadioNet support of program m05bn06
- *"Probing X-ray irradiation in the nucleus of NGC 1068 with observations of high-J lines of dense gas tracers",* J-P.Beaupuits et al 2009. A&A 503, 459, http://www.aanda.org/articles/aa/full_html/2009/32/aa12350-09/aa12350-09.html, RadioNet support of program m06bn12
- *"Circumstellar molecular line emission from S-type AGB stars: mass-loss rates and SiO abundances",* Ramstedt S., 2010 et al. A&A 499, 515, http://www.aanda.org//articles/aa/full_html/2009/20/aa11730-09/aa11730-09.html, RadioNet support of program m07ai05
- *"Supersonic turbulence in the cold massive core JCMT 18354−0649S",* P. B. Carolan et al, 2009. MNRAS 400, 78, http://www3.interscience.wiley.com/cgi-bin/fulltext/122605200/HTMLSTART, RadioNet support of program m07bu20
- *"A cometary origin for CO in the stratosphere of Saturn?",* T. Cavalié et al 2010. A&A 510, A88, http://www.aanda.org/articles/aa/full_html/2010/02/aa12909-09/aa12909-09.html, RadioNet support of program m08bi02

2.1.12 WP12: e-Merlin TNA

2.1.12.1 Description of the publicity concerning the new opportunities for access

New eligible user groups were identified and sent targeted emails inviting them to consider sending personnel to Jodrell Bank Centre for Astrophysics for data analysis, indicating that travel and subsistence funding was available for such visits. Such emails were sent to all the eligible user groups. Additional updated publicity was included in the JBCA and *e*-MERLIN web pages. Many groups have indicated an interest in arranging for such a visit.

2.1.12.2 Description of the selection procedure

There are no changes to the existing selection procedures and the Selection Panel (TAG) composition has not changed during this reporting period. During the calendar year 2009, the e-MERLIN TAG met in by telecom in January. Formal e-MERLIN proposals are not being accepted at present until the early stages of commissioning have been completed. Directors discretionary time proposals are however still available, and it is envisaged that full proposal submission procedures will recommence in Q4 2010 for early e-MERLIN operations.

2.1.12.3 Transnational Access Activity

There are 9 identified eligible user groups and 11 associated e-MERLIN projects. These comprise:

MERLIN+VLBI:

EE005	PI Dieter Engels (Hamburg)	Accurate distances to OH/IR stars: the phase-lag method
EP064	PI Miguel Perez-Torres (Granada)	The dominant heating mechanism in ULIRGS
EP065	PI Willem Baan (ASTRON)	Observations of starburst dominated OH megamasers
EP067	PI Paola Parma (Bologna)	A VLBI study of dying and restarted sources
EW013	PI Pawel Wolak (Torun)	Morphology of OH masers in post-AGB stars
RG006	PI Marcello Giroletti (Bologna)	Observations of the first gamma-ray nova V407 Cyg
RR022	PI Hayden Rampadarath (JIVE)	VLBI observations of IC2497

MERLIN:

06B/13	PI Andrzej Marecki (Torun)	A survey of low-power compact steep spectrum sources
08B/09	PI Jens Zuther, (MPIfEP)	A pilot study of NLS1-BAL quasars
09A/01	PI Willem Baan (ASTRON)	Formaldehyde emission in compact IRAS sources
09B/D1	PI Nikta Amiri (JIVE)	MERLIN observations of water fountain candidates

Total access hours observed by MERLIN for all eligible projects: **441**

Access hours per eligible project:

EE005	8
EP064	93
EP065	25
EP067	16
EW013	25
RG006	12
RR022	78
MN/06B/13	49
MN/08B/09	24
MN/09A/01	96
MN/09B/D1	15

The eligible user groups contain both established workers in the field and young researchers. MERLIN is a mature instrument with a substantial international user base and observations made here are with e-MERLIN configured as traditional MERLIN. In recent years a significant effort has been made to advertise and attract new research groups from Europe and the UK. RadioNet activity has undoubtedly helped in this regard. During calendar year 2009, most of the reduction of e-MERLIN data for TNA-enabled projects was performed remotely, however 3 visits to JBCA took place for the reduction data for TNA-enabled projects. Proposals for e-MERLIN and VLBI are now handled by the NorthStar web-based proposal tool, common to a number of European telescopes. This facility was developed under the RadioNet FP6 Synergy Networking activity.

2.1.12.4 Scientific output of the users at the facilities

e-MERLIN user projects have investigated a wide range of astronomical phenomena from Galactic emission to high redshift extragalactic objects. During its commissioning, e-MERLIN continues to provide unique high-resolution imaging capability to probe the environments of star-forming regions both in the Milky Way and external galaxies. No other instrument in the world is able to provide such images – including those of Galactic Methanol maser emission associated proto-stars. e-MERLIN has also been involved in imaging several transient radio sources. The dynamic scheduling of e-MERLIN has allowed a rapid response for the instrument following any outbursts. A number of publications during 2009 have resulted from new and existing TNA-enabled projects. These are listed in the database.

2.1.13 WP13: Effelsberg TNA

2.1.13.1 Max-Planck-Institut für Radioastronomie (MPIfR)

The Max-Planck-Institut für Radioastronomie (MPIfR) was founded in 1967. The 100-m radio telescope was inaugurated in 1971 and was (for almost 30 years) the largest fully steerable single-dish radio telescope in the world. It is situated in a protected valley near Bad Münstereifel-Effelsberg. To this day, it is the largest radio telescope in Europe.

The extremely versatile and flexible instrument can be used to observe radio emission from celestial objects in a wavelength range from 73 cm (corresponding to a frequency of 408 MHz) down to 3.5 mm (86 GHz). Observations at short cm- and mm-wavelengths ($\lambda \leq 2$ cm) have become increasingly important for all kind of observing programmes during the last years. The combination of the high surface accuracy of the reflector (the mean deviation from the ideal parabolic form is ≤ 0.5 mm rms) and the construction principle of "homologous distortion" (i.e., the reflector in any tilted position has a parabolic shape with a well-defined, but shifted, focal point) enables very sensitive observations at unprecedented high frequencies for such a large telescope.

With the advent of the new subreflector in 2006, observations from the secondary (Gregorian) focus gained significantly in efficiency (more than 50 % at the high frequencies) due to the very high accuracy of the new mirror (~0.06 mm) and its active surface which is able to compensate small-scale deviations of the main dish due to imperfect homology. The new system is equipped with a hexapod focus driving system, allowing a fast and accurate positioning (better than 0.1 mm) of the receiver in the focal point. A new mechanism allows automatic receiver exchanges between the nine systems located in the secondary focus and the receiver box located in the prime focus. Thus, the telescope has strongly improved its frequency agility. Additionally, new prime focus receiver boxes were developed which contain up to four receiving systems (in contrast with the former situation where only one receiver per box was possible). The first multi-frequency receiver box (with the 18/21, 1.9, and 1.0 cm systems) is now fully functional since spring 2009. The construction of more multi-receiver boxes is going on..

The wide variety of observations with the 100 m radio telescope is made possible by the good angular resolution, the high sensitivity, and a large number of receivers which are located either in the primary or in the secondary focus. Together with a number of distinguished backends (eg., the new 16x16384 channels Array-FFT spectrometer with high dynamic range) dedicated to different observing modes they provide excellent observing conditions for spectroscopic observations (atomic and molecular transitions in a wide frequency range), and also for high time-resolution (pulsar observations), mapping of extended areas of the sky and participation in a number of interferometric networks (mm-VLBI, EVN, and Global VLBI etc.). Development, construction and maintenance of receivers and backends are supported by technical divisions in the Bonn institute as well as on site at Effelsberg.

2.1.13.2 Description of the publicity concerning the new opportunities for access

The telescope web-pages (www.mpifr-bonn.mpg.de/div/effelsberg/) are updated regularly and contain the "Call for Proposals" with all relevant information on the facility and on the opportunities for access under the RadioNet contract. The Calls are not only published on the web-pages of the Institute, but also sent out in advance of each deadline to a wide number of scientists and institutes over Europe. Since this year, the Call is accompanied by an “Effelsberg Newsletter” which contains useful information about the facility for all users.

For the support of observers and the maintenance of the web-pages a post-doc was employed at Effelsberg. In addition, one technician could be employed to support telescope operations and help administrating the observatory's computers. Additionally, since 2002, the “International Max Planck Research School for Radio and Infrared Astronomy” (IMPRS) is established in the MPIfR offering interested students scholarships and dissertation projects in radio astronomy. Many of the students attending the IMPRS in the past years used the 100 m telescope on a regular basis. Overall, we believe the opportunities for access are well known within the community of European radio astronomers. The number of incoming proposals and its worldwide origin seems to prove this.

Preparation and submission of observing proposals is easier now, since the MPIfR adopted the web-based proposal tool “North Star” which was developed by the Networking Activity 2 (Synergy) under the FP6 program.

2.1.13.3 Description of the selection procedure

RadioNet requests for access to the 100-m telescope are managed in the form of standard observing proposals in exactly the same way as done for any other observing requests. There are three deadlines for proposal submission per year (currently around February, June, October, 1st); all proposals received are subject to the same peer review procedure.
The Institute operates the Effelsberg Programme Committee (PKE) which consists of three staff scientists of the MPIfR, one scientist from the University of Bonn, and four external scientists (currently based in Italy (2), the UK and Germany).
The PKE assesses the scientific goals of the requested observations, whether the observing procedure is effective and whether the goals can be achieved with the available equipment. The PKE then either approves the scientific value of the proposals, resulting in a rating along a priority scale, or rejects the proposal. Any accepted proposal is active for one year beginning with the date of approval. The Board of Directors of the Institute are informed of any proposal submitted by external investigators that are rejected or receive a rating with low priority. In principle, the Board of Directors can override the evaluation of the PKE, but this happens extremely rarely.
The meetings of the PKE are prepared and chaired by the scheduler of the telescope (who does not have voting rights). He gives feedback in the form of a written report to the investigators. The feedback contains explanations for the rejection of a proposal or a significant cut of the requested observing time.

2.1.13.4 Transnational access activity

The opportunities for access at MPIfR are given for four main observing fields: spectroscopy, pulsars, continuum and VLBI. The observations supported by the TNA programme in 2009/2010 mostly have been performed as spectroscopy and continuum measurements. It should be mentioned that most VLBI projects are done within the framework of the European VLBI Network (EVN) and therefore are eligible for RadioNet funds outside of MPIfR.

Between January 2009 and June 2010, 14 observing projects were carried out by eligible groups. The total of number of access hours for these projects was 478. 25 users came to the Effelsberg telescope for the observations and received support from the staff at the observatory and the telescope support scientists. This support included the help in preparing, performing and analyzing the observations, accommodation at the observatory, and travel support – financially and in organization of the journey.

The PIs of the eligible groups were partly experienced observers, partly new users (including PhD students and Post-docs) of the 100-m telescope. Users came from Italy, Spain, the Netherlands, Finland, Poland, Sweden, France and Hungary.

2.1.13.5 Scientific output of the users at the facilities

The majority of researchers who came to Effelsberg for observations in 2009/2010 reports that the reduction and/or interpretation of the collected data is still going on. Our experience over the last years shows that the “publication delay” (ie., the time between observations and the completion of a referred publication) mostly is of the order of at least three years – sometimes significantly longer.
Consequently, we are now seeing more and more publications based on observations performed between 2004 and 2008; however, some observational results gained in the last 18 months are already being published. Additionally, many observing results were incorporated in diploma, master, and PhD theses.

2.1.14 WP14: SRT TNA

The construction of the Sardinia Radio Telescope suffered from some delay and is now scheduled for completion in spring 2011. TNA activities will thus start during the second half of 2011.

2.1.14.1 General Description of the facility

The Sardinia Radio Telescope (SRT) is currently being constructed by the Istituto di Radioastronomy of the National Institute for Astrophysics in collaboration with the Observatories of Cagliari and Florence. The new observatory is built in the location of San Basilio (about 35 km north of Cagliari, Sardinia). Start of operation will be in 2011, i.e. during the course of FP7.

The SRT is a parabolic dish of 64 m diameter with the following characteristics:

- Actively shaped surfaces (primary and secondary): These eliminate the multiple reflections between the secondary and the feed and optimize field-of-view and antenna efficiency.
- Continuous frequency coverage between 300 MHz and 100 GHz with (multi-beam) state-of-the art receivers: This will allow observations at hitherto rarely explored frequencies, e.g. for the search of new molecular lines or full-polarisation studies of the high-frequency continuum emission.
- Multiple focus positions and frequency agility: The combination of these two characteristics will rank the SRT among the most versatile and efficient single-dishes in Europe.
- Fibre optics link: This assures a unique interplay with the other IRA antennas for effective and flexible operations.

The site is characterized by low radio frequency interference; it is reasonably dry during the winter season and located in an orographic depression that acts as a natural wind-screen. The expertise for design and construction of the SRT is largely based on the institute's long-standing experience with its two 32-m dishes (Medicina in Emilia-Romagna and Noto in Sicily). The simultaneous operation of three observatories is facilitated by a high degree of redundancy of operational and organizational procedures and in this constellation and consequent application unique in Europe. The SRT combines various rare characteristics of the Medicina and Noto antennas and will in many aspects represent the most advanced radio single-dish telescope in Europe. It will be able to offer opportunities to the astronomical community in the course of 2011. The SRT will be among the largest five fully steerable single-dish radio telescopes in Europe and the largest one with an active primary surface (world-wide second only to the 100-m GBT). Because of the excellent precision of its primary mirror it will in particular be the high-frequency range above 20 GHz where it will show its strengths. Consequently, one of the first-light instruments will be a new 7-feed array for observations between 18 and 26 GHz, unique at this frequency in Europe.

In addition, digital backends will enormously increase the possibilities to elaborate the received signals and greatly improve the observing efficiency for continuum, spectroscopy and pulsar applications. These hardware innovations are supported by an enhanced single-dish guiding software which is currently being developed for usage at all three observatories.

The global concept of single-dish observing with the Italian radio telescopes foresees the long-term monitoring, the large-scale surveying or the rapidly scheduled observations with the smaller 32-m telescopes, while the new 64-m SRT would mainly be used for dedicated follow-up work, in particular at high frequencies at which it will be at its most impressive.

In addition to the single-dish activities, the SRT will also form a central part in an Italian VLBI sub-array which is currently being implemented (in addition to the standard VLBI configurations). In fact, being operated by the same body, the scheduling of all Italian radio telescopes can be adjusted on very short notice according to scientific requirements (essential for Target-of-Opportunity observations). In the course of FP7 we expect to provide all observatories with optical fibre connections (Medicina is already successfully participating in international e-VLBI experiments) which will allow the on-line transport of data to a local correlator. First tests with a software correlator based on GRID technology have been successfully completed.

Current status of the construction

After the spectacular lift of the entire primary mirror support structure in May 2010 (see figure wp14.1) the essential mechanical parts of the antenna have been assembled. It is expected that the final adjustment of the telescope will be completed by the manufacturer by the end of 2010.

Figure wp14.1: lift of the entire primary mirror support structure

Three receivers and a series of backends will be available for first light experiments and subsequent commissioning operations, planned to be conducted in the first half of 2011. Parallel science observations will then be scheduled as testing proceeds. The necessary telescope guiding software is being developed and tested at the 32-m Medicina dish. First results are very promising. It can thus be expected that first external observer teams can be invited to the SRT during the second half of 2011.

2.1.15 WP15: LOFAR TNA

2.1.15.1 The Low Frequency Array (LOFAR)

The Low Frequency Array (LOFAR) is a brand-new and uniquely powerful telescope for low frequencies, 10—240 MHz, which have thus far been relatively poorly available for radio astronomical studies, with a sensitivity of orders of magnitude better than previous telescopes. The advantages of its design as a phased array are optimally exploited through state-of-the-art electronics and information processing technology. The antennas have good omni-directional sensitivity; at each instant, one or more regions of the sky can be selected for detailed study in software. The full scale LOFAR will consist of more than 40 stations in the Netherlands and at least 8 stations in various countries in Europe connected to high performance central data processing and archive facilities in Groningen, The Netherlands. Dedicated LOFAR software is developed to process and analyse the data for specific astronomical applications.

LOFAR is designed to produce world-class, ground-breaking science in a number of important areas. The drive towards detecting and characterizing the Epoch-of-Reionisation will take several seasons of integration, and will yield, along the way, a host of “foreground” compact and extended sources of radio emission which will prove to be fruitful objects to study in their own right. Source surveys will open up access to a plethora of objects and astrophysical phenomena characterised by their low-frequency radio emission: high-redshift star-forming galaxies, relic radio sources, and pulsars, to name but a few. The possibilities to observe transient events in real time, and to capture buffered data spanning the instant of outburst, will revolutionise studies of variable sources. Other major research topics include magnetic fields in galaxies and clusters, ultra-high-energy cosmic rays, and our Sun.

After a phase of design, testing and hardware manufacture, construction of LOFAR stations on the ground started in earnest in the spring of 2009. Fringes between the first three new stations were detected in July 2009, and the number of operational stations increased to 5 in September, 9 in November and 14 in December 2009. 2010 show a faster increase in the number of operational stations from 16 in January to 21 in February, 23 in May and 27 in July. Construction of more than 10 stations is continuing and the number of operational stations is expected to rise to 37 by the end of 2010.

During this period, ASTRON’s Radio observatory has been operating LOFAR with the available hardware and software in a commissioning phase that is expected to continue until early 2011. LOFAR was officially dedicated by Queen Beatrice of the Netherlands on June 12, 2010 during the International SKA Forum 2010.

2.1.15.2 Description of the publicity concerning the new opportunities for access

LOFAR is operated by ASTRON as a common-user facility available to scientists from any country. Along with ASTRON, a lot of institutes both in the Netherlands and abroad have contributed to the design and realization of LOFAR.

There is tremendous interest to participate in LOFAR in many European countries, and even to contribute to its capabilities, through the building of local stations to extend the baseline lengths, and the development of software, for example. Through national consortia of typically dozens of institutes and individuals, funding has become available for stations in Germany, Britain, France, and Sweden, along with possible others in Britain, Germany, Italy, Poland, the Ukraine, and perhaps elsewhere, for which many other parties are in the process of fundraising.

In addition, members of ASTRON and other LOFAR partner institutions frequently give colloquia at other institutes and presentations at meetings in which they highlight recent scientific results and explain the capabilities of LOFAR when visiting other astronomical institutes. The personal research contacts of ASTRON staff members are also helping to foster the growth of groups at other institutes in the international community whose research is centred on the use of LOFAR.

In addition, ASTRON staff members are also regular lecturers at the summer schools on radio interferometry that are regularly held in Europe. ASTRON has a very successful international summer student program, consisting of traineeships for advanced undergraduate or beginning graduate students. Many of these students are expected to become new LOFAR users when they continue their careers elsewhere in Europe. Furthermore, support of visiting novice users is a well-proven way to broaden the user base throughout Europe.
A large body of work describing the design, capabilities and expected research opportunities with LOFAR has appeared in the astronomical literature over the last few years.

User meetings and workshops are planned at least twice yearly in the first few years, to be a forum for interaction and feedback, where users can learn about the latest scientific results and the latest technical capabilities of LOFAR. A “LOFAR Data Analysis” school was held in Dwingeloo in early 2009, and it helped introduce a large number (over 60) of astronomers to the insights of LOFAR data and analysis software.

The first “Announcement of Opportunity for Early Access Observations with LOFAR” was e-mailed to a wide distribution list of approximately 700 addresses, culled from recent proposals for the WSRT telescope, the LOFAR partners, the astrophysical literature, and lists of international astronomical institutes. The call described the most recent capabilities of LOFAR, and referred to the website for much more extensive information.

The 94 submitted proposals vividly demonstrate the high aspiration the international astronomical community has for research conducted by LOFAR.

2.1.15.3 Description of the selection procedures

LOFAR will be operated by ASTRON as a common-user observatory in the auspices of the “International LOFAR Telescope” which was formed when an Memorandum of Understanding was signed by all LOFAR partners during the LOFAR dedication ceremony.

Large investments made by parties to the development of the facility, as well as substantial contributions made during the operational phase, will lead to priority access for a restricted portion of the total observing resources. Some of the relevant groups will be based outside The Netherlands, and their access to the general infrastructure must be properly supported. In addition, it is considered vital for the overall scientific productivity to have up to a third of the observing time available right from the start as “Open Skies”, where projects are accepted from the international community strictly based on scientific merit. It is particularly important that these users, which may not have easy access to the large, well-established key-science groups, are well supported.

The LOFAR programe committee was formed in late 2009 and has an international composition, with scientists selected first and foremost for their astronomical and technical expertise in judging the merits of proposals. It consists of 15 members, of which three are from Dutch institutes and the rest are affiliated with institutes in Europe and in the USA.

The first “Announcement of Opportunity for Early access to LOFAR observations” was issued on July 10, 2010. Proposals were solicited for moderately sized- shared risk “Early access” observations relevant to commissioning the various observing modes and processing, as well as for “Long Term” large projects, which would be observed after the end of commissioning.

Proposals were submitted via the web-based tool NorthStar, a version of which was adapted for LOFAR use by ASTRON software engineers. ASTRON support scientists and software engineers were at hand in the time leading to the submission deadline to provide expert information to proposers.

94 proposals were submitted by the deadline of September 30, 2009; 59 were for “early access” proposals and 35 for “long term” proposals.

After review by the LOFAR Program Committee (PC), which met in December 8, 2010 in Dwingeloo, the approved “early access” projects have been gradually included in the long term commissioning plan that runs for 2010 and the early part of 2011. No observing time has been allocated directly to the “Long Term” proposals. Instead their evaluation will help to plan the long term resource allocation for LOFAR and feedback from the PC and ASTRON specialists will help the proposers to fine-tune their projects for the next “Call for proposals”.

2.1.15.4 Transnational access activity

ASTRON astronomers with expertise in a wide range of fields and techniques are available to advise all users at all stages of their projects, from proposal preparation, through observing specification, to data analysis. A substantial part of these interactions happens via the internet.
In addition, the observatory supports visiting scientists with office and computing facilities, as well as local accommodation. These facilities already are (and it is expected that will be extensively) used by LOFAR users, who come both to learn the ropes from observatory support scientists, and, once more experienced, to assist with assuring speedy checking and processing of the data for their particular type of observation. The most experienced users will also be regular visitors, working with observatory experts on creative projects that push LOFAR to its limits. It is particularly important that users which do not have easy access to the large, well-established key-science groups, are well supported, and, specifically, that they are not left to flounder with some possible early data imperfections or dauntingly large data volumes.
Visitors often develop new collaborations. The mixture of astronomical and technical disciplines represented in Dwingeloo, with WSRT, JIVE, and now also LOFAR users, is considered by all to be highly stimulating. Interaction is encouraged by introducing the visitors to colleagues during coffee, and by asking them to give informal lunch-time presentations about their work.

In late 2009, 50 hours of LOFAR observations were allocated to a project whose aims could be afforded with the available observing and processing resources at that time.

A further 33 hours were awarded to another project in the first half of 2010, while it is expected that the rest of the time available for TNA support will be awarded in the later half of 2010, when the observing capabilities have increased significantly so that the scientific goals of the eligible proposals are met.

2.1.15.5 Scientific output of the users at the facilities

While LOFAR is still under intense development, a lot of astronomers both from ASTRON and from the international community have been contributing to the commissioning of the array, by analyzing data from the first observations while aiming for the first scientific results.

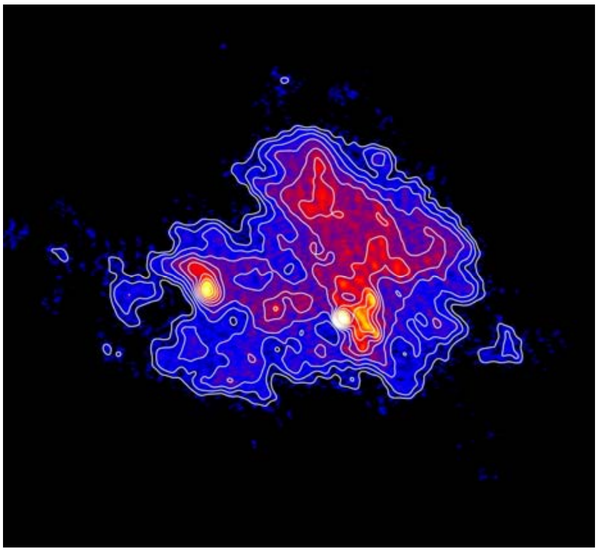


Figure 15.1 : A textbook example of a cluster hosting a radio relic and halo is Abell 2256. This cluster was observed with LOFAR in the HBA band (115-165 MHz) in May 2010 for about 8 hours. The data were taken with 10 core stations and 5 remote stations. The image was made using 18 subbands covering a total of 4 MHz of bandwidth around 135 MHz. The resolution of the image is 25 arcsec and the noise is a few mJy/beam, making it already one of the deepest images ever obtained of this cluster at low-frequencies. The yellow (brighter) regions in the image are associated with several disturbed radio galaxies. The large-scale emission in red and blue is mostly from the radio relic, although some additional faint emission in the south of the cluster (bottom of the image) comes from the radio halo.
Picture Credit: R. van Weeren, A. Bonafede, C. Ferrari, E. Orrù, R. Pizzo, A. Shulevski, S. van der Tol, and G. Macario.

While a lot of this work is still in the level of preparation and there was not time to make its way to the astronomical literature, the reality of the promise of LOFAR is vividly demonstrated by some of the first astronomical images now being produced: images of complex structures such as galaxy clusters (see Figure wp15.1),

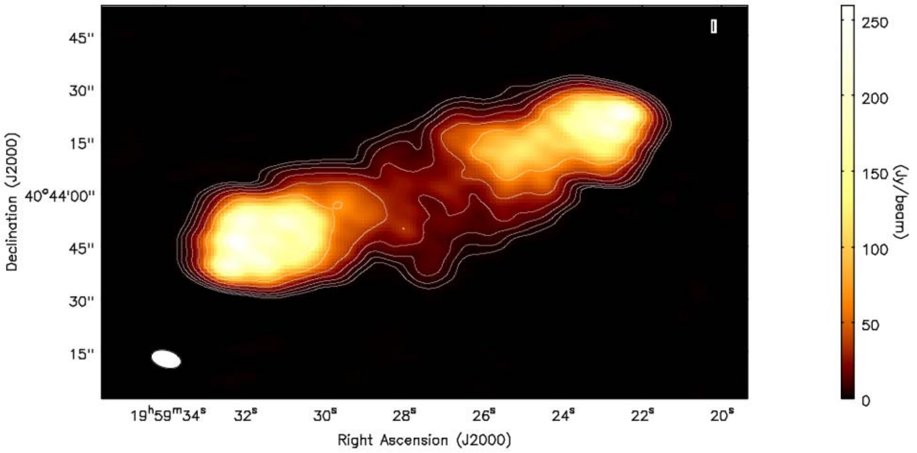


Figure wp15.2: A single sub-band (0.2 MHz bandwidth) image of Cygnus A at ~239 MHz from an observation of 6 hours in the LOFAR high band (210--240 MHz) on 2010 May 30. The array consisted of 12 core stations, 4 remote stations and 1 international station.. This image is uniformly weighted and has an elliptical restoring beam of 9 x 5 arcsec at a position angle of 79 degrees.
Picture Credit: J. McKean, L. Kerr, R. van Weeren

or the Cygnus A galaxy, one of the brightest objects in the LOFAR sky (see Figure wp15.2). Furthermore the non-imaging capabilities of LOFAR have been amply demonstrated with the abundant detections of pulsars (more than 100 currently detected) at the lowest part of their emission spectrum (see Figure 15.3).

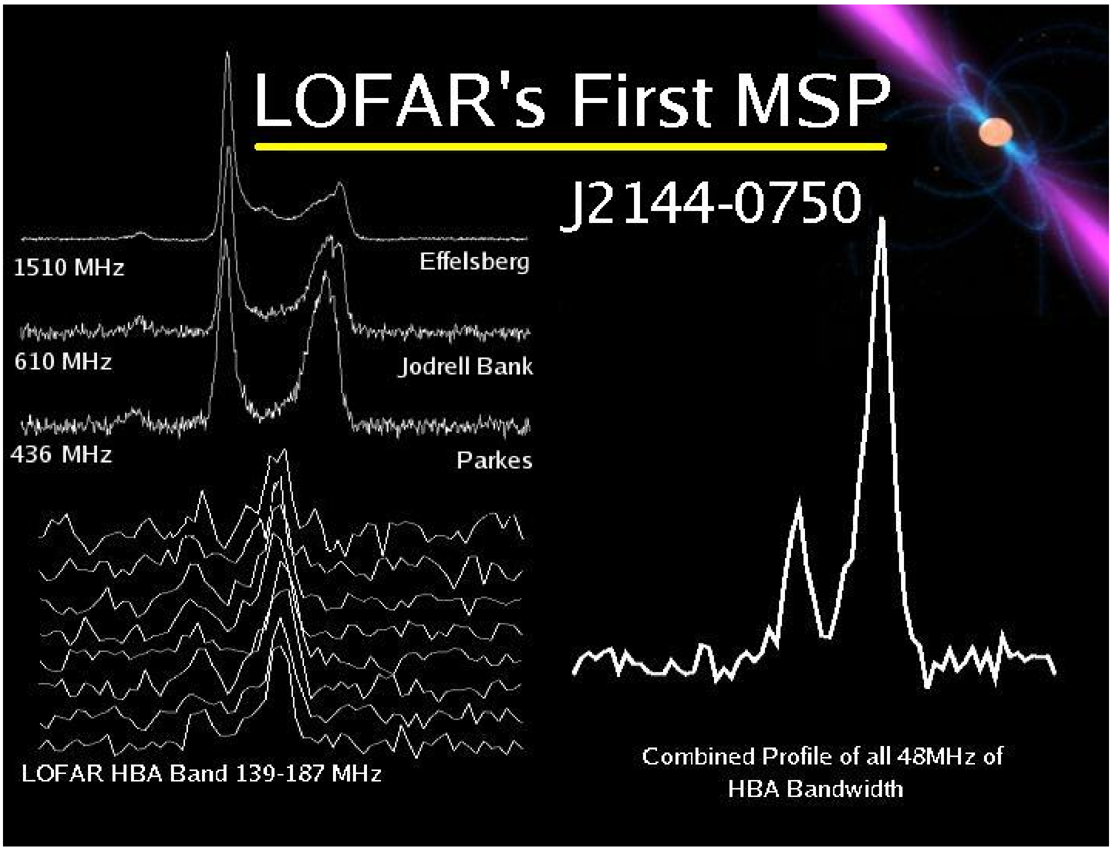
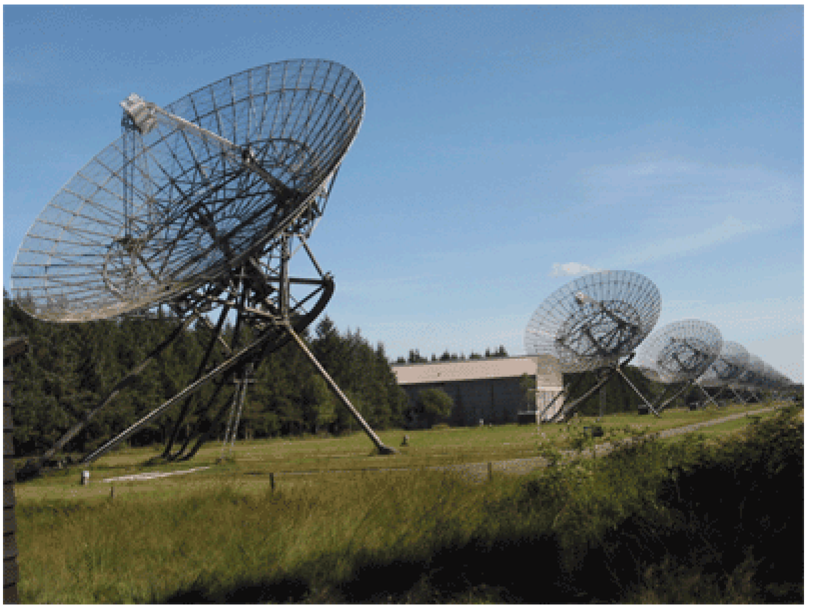


Figure15. 3: PSR J2145-0750 was the first milli-second pulsar (rotating just over 62 times per second) detected by LOFAR back in December 2009. LOFAR's frequency resolution is vital for observations like this. The plot also shows the pulse profile as a function of frequency as detected with LOFAR (163 MHz) , the Parkes Telescope (436 MHz), the Lovell telescope (610 MHz) and the Effelsberg telescope (1510 MHz). Interestingly, at low frequencies the pulse profile has evolved towards a stronger second peak, possibly signifying a different emission geometry.

2.1.16 WP16: WSRT TNA

2.1.16.1 Westerbork Synthesis Radio Telescope (WSRT)

The Westerbork Synthesis Radio Telescope (WSRT) began operation in 1970 as the most sensitive distributed array for imaging astronomical sources at radio frequencies. Now, some 40 years later, as a result of a comprehensive upgrade of the facility that was completed in 2002 and continuous improvements thereof, it has essentially regained that role with an instantaneous continuum-sensitivity equivalent to that of the Very Large Array (VLA) in the United States..



The 14 fully-steerable parabolic reflectors, distributed in an East-West configuration of 2700m length, have been given a complete mechanical overhaul. A state-of-the-art receiver package provides almost continuous coverage at decimeter and centimeter wavelengths as well as frequency agility. Furthermore, its flexible half-million channel correlator, pulsar and VLBI backends, make it a unique facility in the world even into the first years of the current decade.

WSRT's capabilities include the combination of spectral stability and high velocity resolution for deep spectral line work, particularly in neutral hydrogen gas (HI); its excellent polarisation calibratability, by virtue of the combination of the equatorial telescope mounts and cross-dipole linear polarisation feeds; its comparatively wide (80 MHz) and relatively undisturbed, and therefore sensitive 92cm band; and its unique wide-area pulsar survey capability, where the regular grid of radio telescopes is used to form multiple beams, in combination with the powerful new PuMa-II backend (so-called 8gr8 mode). Furthermore, an ambitious 21cm focal plane array receiver and digital beamformer development project, APERTIF, is currently under way at ASTRON. A prototype has been tested on one of the WSRT telescopes already, and funding has been secured so that the full WSRT could well be outfitted starting in 2012, which would enable unique wide-field surveys in a wide 21cm band.

2.1.16.2 Description of the publicity concerning the new opportunities for access

The Westerbork Synthesis Radio telescope (WSRT) of ASTRON is an open user facility available for scientists from any country, and has been in operation for four decades. As one of the most powerful radio observatories in the world, it enables astronomers to study a wide range of astrophysical problems: from pulsars to the kinematics of nearby galaxies to the physics of black holes. It is also one of the most sensitive elements of the European VLBI Network (EVN) of radio telescopes; this allows astronomers to obtain some of the most detailed images possible in astronomy. The general capabilities of the WSRT are thus widely known amongst the international astronomical community. Results making use of the improved capabilities after the upgrade completed some years ago have increasingly found their way into papers in the international astrophysical literature; this is one of the most lasting ways to convey the new opportunities.

In addition, ASTRON staff members often give presentations on recent highlights of WSRT-related research when visiting other astronomical institutes. The personal research contacts of ASTRON staff members are also helping to foster the growth of groups at other institutes in the international community whose research is centered on the use of the WSRT.

The semi-annual call for proposals is e-mailed to a wide distribution list of, at last count, approximately 600 addresses, culled from recent proposals, the astrophysical literature, and lists of international astronomical institutes. The call summarizes the most recent advances in the capabilities of the WSRT, points out the opportunities of the RadioNet TNA program, and refers to the WSRT web site (which received a thorough review in 2009) for much more elaborate information.

2.1.16.3 Description of the selection procedures

The assessment and selection procedure is aimed simply at obtaining the best possible science results with the WSRT, and is open to scientists based in any country. Proposals must be written in English. Next to some standard information, proposals must include a self-contained justification of at most 2 pages (additional figures allowed), giving some background on the general research area, and a discussion of the specific goals to be achieved with the proposed observations. A description of the setup of the observations is also needed, and the text must argue their technical feasibility.

Proposal submission and processing are done via the Worldwide Web, using NorthStar, the RadioNet web-based proposal tool that has been developed through the support of the Synergy Networking Activity of FP6 with the financial support of ASTRON. Development was carried out at and financially supported by ASTRON.
NorthStar also supports the review activities of the WSRT Program Committee (PC) which is composed of 10 members, selected on a personal basis for their knowledge of relevant research fields. They are appointed for a 3-year term.

Until the end of 2009, about half of the PC members were from Dutch astronomical institutes while the other half is affiliated with other European institutes. In 2010, the ten WSRT PC members are drawn from the larger (15 member) LOFAR program committee, selected so that their knowledge field is relevant with the research potential of WSRT. The astronomers from the Science Support Group (SSG) of the Radio Observatory Division of ASTRON advise the PC on technical issues.

The PC has been instituted by the ASTRON board and advises the WSRT Director, who would deviate only in exceptional circumstances, in the interest of scientific productivity of the WSRT, from the conclusions of the PC. It meets twice per year, following research proposal deadlines around 15 March and 15 September, to consider observing requests for the subsequent semesters, starting on June 01 and December 01, but proposers can also ask for Long-Term Status, lasting up to 4 semesters. For each proposal, the PC chairman appoints a first and second assessor from amongst the PC members, selected for their familiarity with the research field of the proposal. In order to provide some guidance to PC members who may be experts in other areas of astrophysics, the assessors provide written background reports to all PC members before ratings are due. Just before the PC meeting, all members then send in a rating of 1 (top) through 5 (bottom) for each proposal, which must reflect their personal scientific opinion on the desirability of carrying out this proposal relative to the others, given the overall aim of maximizing the science returns from the WSRT. The PC members will in general weigh their view of the potential science impact of the proposal against its required telescope resources (in particular, the amount of time requested). They may also take into account other factors, for example the continuity of a PhD program, or the track record of the proposers in obtaining and publishing results from past projects (a summary of which is requested as part of the proposal). In order to achieve maximal differentiation and ranking power, each PC member is asked to assign the grades from 1 through 5 with approximately equal frequency. This means, in particular, that some proposals may need to be assigned a low grade even though, in an absolute sense, carrying them out might still be considered potentially worthwhile.

In preparation for the PC meeting, SSG astronomers assess the technical feasibility of all proposals (will the instrumental setup be available, is the sensitivity estimated correctly, etc.), and also provide an overview of the oversubscription, which is the excess of the telescope resources requested versus those available. Oversubscription involves mainly observing time, taking account of complicating issues such as the need for day/night/weekend time and/or the use of specific telescope configurations which are labour-intensive to set up. The proposed astrophysical target fields are usually unevenly distributed over the sky, and many areas can be accessed only part of the time due to Earth rotation. These circumstances can lead to non-uniform cut-off grades due to oversubscription, which depends on the particulars of the proposals. Typical overall oversubscription factors are around 2. The best proposals are often allocated telescope resources exactly as requested, but some proposals receive modified allocations (less time, fewer fields, different technical specifications). The PC holds a 1-day face-to-face meeting, with a SSG astronomers present as technical and scheduling advisors. All proposals (typically of order 30) receive some discussion, with particular attention to those where the averaged grade is near the cut-off between allocation and rejection, and those where there was a wide dispersion of grades assigned by the PC members before the meeting. Issues such as granting some large requests versus smaller ones, or granting several partial allocations, are also carefully considered. SSG astronomers keep track of the overall oversubscription and the efficient filling of the observing queue for the semester. The first assessor of a proposal is in charge of collecting all comments made during the discussion, and composing the written (e-mail) feedback to be given to the proposers on the science case as well as other issues.

In the period covered in the report the WSRT PC met in Amsterdam on May 10 2009, on November 10, 2009 at the Leiden Observatory and in 2010 on May 18 in Dwingeloo.

2.1.16.4 Transnational access activity

The total number of access hours provided for the reporting period was 1652. These were charged in 9 projects. Details for projects observed in 2009 and the first half of 2010 are given in Annex 3 and Annex 4. The smallest project was 26 hours, the largest 600 hours, and the average 183 hours.

This is about the normal range for most WSRT projects. It should be noted that one of the projects was awarded 600 hrs allocated in three semesters, while the maximum award per project per semester was 262 hours. This is about the normal range for most WSRT projects except that some (non-'access') projects do receive up to 500 hours per semester, but such projects require a very major commitment of personnel for data processing and analysis, which is evidently more likely to be invested by groups including members tied closely to the facility, rather than more remote groups targeted by the TNA programme. Again, we saw that the qualifying TNA proposals which passed the selection on scientific excellence spanned a broad spectrum of scientific applications in the reporting period; clearly, the excellent capabilities of the WSRT continue to cater to a wide range of needs. A rather larger number of WSRT observing projects do involve foreign investigators, but fail to qualify under the strict rules for TNA support. ASTRON sees the mix in the nature of the 'access' groups as a very attractive addition to the overall WSRT user community, particularly because the number of astronomers which can be educated for the next generation in the use of a world-class radio observing facility is rather limited within the Netherlands alone. The geographic distribution of 'access' groups is probably what should be expected given small number statistics and the distribution of astronomers in Europe as a whole.

2.1.16.5 Scientific output of the users at the facilities

The programmes that have recently qualified for TNA support have spanned a broad range of scientific topics, including pulsars (e.g. R08B004, R10B013 part of it was observed in early 2010) in our Milky Way, the structure of magnetic fields in galaxies (e.g. R09A021, R10A020) and the intergalactic medium (R0), to the properties of active galactic nuclei (e.g., R08B015). Clearly, the excellent capabilities of the WSRT cater to a wide range of needs. Much of the use of the

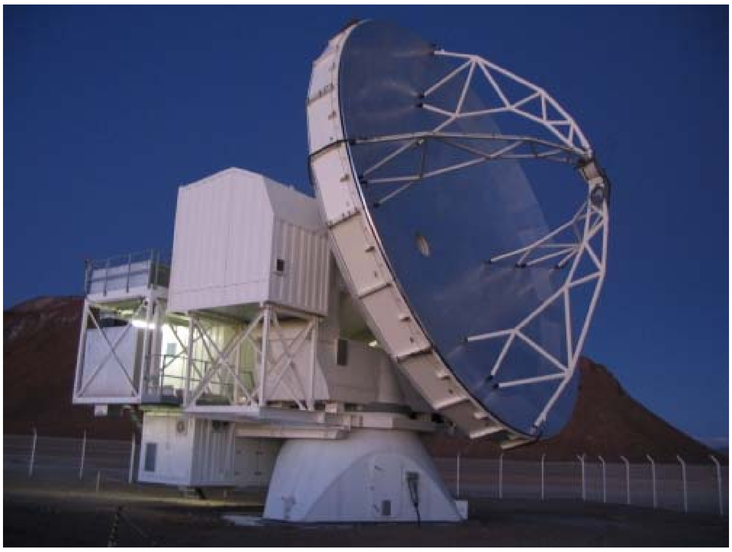
WSRT is for timing of pulsars (R08B004, R10B013) or large surveys (e.g. R09B021). The tendency that large programs are exclusively conducted by the traditional, often nationally based WSRT user community, focusing specifically on using the telescope to the limit of its abilities, has weakened (e.g. R08B004, R10B013). However, many TNA users have still conducted comparatively modestly sized WSRT observing sessions, but these are then used as one component within large multifrequency, multi-telescope projects (e.g. R08A018). As a result, the WSRT tends to make a lot of its impact in a comparatively modest number of papers, and these papers tend to appear several years after the observations initially started. Indeed, for many of the TNA projects, data are being put to good use but papers have yet to appear.

TNA projects that continued to get attention within the community was R08A018 and R10B013, parts of the European Pulsar Timing Array, conducting regular pulsar timing observations which provide a unique tool to study various questions in fundamental astrophysics, ranging from the equation of state of superdense matter to tests of strong-field gravity and the detection of a cosmological gravitation background (e.g. Jannsen et al, A&A, 514, 74).

2.1.17 WP17: APEX TNA

2.1.17.1 Atacama Pathfinder EXperiment

APEX is a 12-m sub-mm radio telescope located at 5100 m altitude on Llano Chajnantor, Chile (see http://www.apex-telescope.org/). The telescope is of excellent quality (15 micrometer rms surface accuracy) and the site is also excellent as proven by the successful operation at 1.5 THz. Observations are carried out from early April to late December (excluding the Bolivian winter). Onsala Space Observatory (OSO), Sweden, is one of three partners that operate APEX, and its share of the costs is 23%. This is also the Swedish share of the observing time, but, as the host country, Chile gets 10% of the Swedish time. Consequently, OSO distributes 21% of the observing time to the community.



APEX is equipped with a suite of bolometer cameras and single-pixel heterodyne receivers as common-user instruments, covering the range 1.3 mm to 0.2 mm. SHeFI (Swedish Heterodyne Facility Instrument) is a four-channel heterodyne receiver (230, 350, 500, and 1300 GHz), LABOCA is a 295 pixel bolometer array operating at 345 GHz, and SABOCA is a 39 pixel bolometer array operating at 850 GHz.

Additional instruments, so called PI-instruments, are available through collaborations with the groups responsible for them.

The telescope and its instruments provide a unique opportunity for European astronomers to observe southern sky objects in continuum and spectroscopic mode at sub-mm wavelengths. Astrophysical questions such as the origin of large-scale structure in the universe and the origin of stars and planetary systems are addressed.

2.1.17.2 Description of the publicity concerning the new opportunities for access

Calls for proposals are published on the web page of Onsala Space Observatory (http://www.chalmers.se/rss/oso-en/observations/proposals) about a month before the proposal deadlines (which are normally April 15 and October 15). Information about the Calls were also distributed by email to Swedish and Finnish astronomers (who very often also have collaborators in other European countries) and to previous users of Onsala telescopes and APEX. In total, information about the Calls was distributed to more than 200 European astronomers outside Sweden. The Calls included information about the RadioNet Transnational Access program.

2.1.17.3 Description of the selection procedure

Observing proposals for Swedish time on APEX are normally accepted twice per year, on April 15 and October 15, and are evaluated by a program committee (PC) with five members. The grading of a proposal is done solely on scientific merit, and takes into account whether the stated goals are likely to be reached with the observing time requested and how well the methods to reach the goals are expressed in the proposal. The principal investigator of each proposal (accepted as well as rejected) is informed by email about the outcome of the review procedure, including the recommended observing time and comments from the PC. The actual observing time scheduled on the telescope is determined by the APEX staff based on the recommendations by the PC (the scheduled time can differ slightly from the recommended time, due to, e.g., weather conditions and the availability of the requested local sidereal time interval).

In reporting period, the Selection Panel met 3 February 2009 at Lund University, Sweden, 4 June 2009 at Uppsala University, Sweden, 26 January 2010 at Onsala Space Observatory, Sweden, and 29 June 2009 at Aalto University, Espoo, Finland.

2.1.17.4 Trans-national Access Activity

There were 26 eligible TNA projects approved for observations (by the Selection Panel) during the reporting period. In addition, a Large Programme that had started earlier also fulfils the eligibility criteria. Of these, 15 projects have been selected for this report, with a total observed time of 174 h during the reporting period (the total observing time for the 26 eligible projects was 285 h).

The total number of individual users (counting all authors of the 15 selected projects) was 59, affiliated with institutions in seven European ("eligible") countries (plus Sweden and the USA).

The user-projects utilized both spectral line receivers (the Swedish Heterodyne Facility Instrument) and bolometer cameras (LABOCA, SABOCA and P-Artemis). A majority of the projects studied different aspects of star formation processes in our Galaxy, either through observations of dust with bolometer cameras, or through observations of molecular spectral lines. Both high mass and low mass star formation regions were observed. The properties of evolved stars were studied in two projects. Extragalactic objects were also observed: nearby galaxies, and active galactic nuclei detected by the Planck satellite.

2.1.17.5 Scientific output of the users at the facilities

The projects carried out with APEX under the TNA program cover a wide range of topics in galactic and extragalactic astronomy. In particular, galactic star forming regions were observed in many projects. The process of checking, reducing and analyzing data, and writing and publishing a scientific paper, often takes a substantial amount of time. Thus, there are so far very few publications from the TNA projects in this report.

In a paper accepted for publication in Astronomy and Astrophysics, O. Miettinen and J. Harju report on observations with LABOCA in April 2009 of a galactic infrared dark cloud (project 083.F-9302(A); published on the web at http://de.arxiv.org/abs/1003.3732): Infrared dark clouds (IRDCs) likely represent very early stages of high-mass star/star cluster formation. In this study, the physical properties and spatial distribution of dense clumps in the IRDC MSXDC G304.74+01.32 (G304.74) were determined and brought into relation to theories concerning the origin of IRDCs and their fragmentation into clumps and star-forming cores. G304.74 was mapped in the 870 um dust continuum with the LABOCA bolometer on APEX. The clump masses and their spatial distribution in G304.74 were compared with those in several other recently studied IRDCs. In most cases, the spatial distributions of clumps in IRDCs do not deviate significantly from random distributions. This is consistent with the idea that the origin of IRDCs, and their further sub-fragmentation down to scales of clumps is caused by supersonic turbulence in accordance with results from giant molecular clouds.

2.1.18 WP18 IRAM-PdB TNA

2.1.18.1 IRAM - Plateau de Bure

The Plateau de Bure Interferometer started in 1990 as a 3-element array. It is located at 2550m altitude in the French Alps, near Gap. Since then, 3 more 15m diameter antennas have been added, and today all 6 telescopes are equipped with low-noise heterodyne receivers for the 3mm, 2mm and 1mm atmospheric windows. The 0.8mm window is planned to become available at the end of 2010. There is at present no other interferometer on the Earth that offers the same sensitivity at these wavelengths. With its maximum baseline of 768m (in east-west direction) it allows sub-arcsecond imaging.

The signals from the 6 antennas are processed by two IRAM developed digital correlators which allow a large variety of observing modes and the possibility to phase up all 6 antennas for VLBI experiments. Global VLBI experiments at 3mm wavelength together with the American VLBA are performed twice a year. In the longer term experiments are planned that also use the ALMA antennas in Chile.

A major upgrade is currently proposed that will transform the Plateau de Bure Interferometer into a new qualitatively different and much more powerful instrument, the NOEMA Interferometer. The project consists in doubling the number of 15m antennas (from 6 to 12), increasing the total IF of the receivers from 8 to 32 GHz, and extending the East-West baseline from 0.8 to 1.6km. The proposed enhancement will transform the current Plateau de Bure interferometer into a new, sensitive, versatile and powerful facility that will provide the scientific community, together with the IRAM 30-meter telescope, full access to all of the millimetre windows, from 70 to 371 GHz, in the northern hemisphere, with a unique combination of two complementary facilities.

2.1.18.2 Description of the publicity concerning the new opportunities of access

IRAM makes publicity for RadioNet (a) electronically via the Internet, (b) in printed form via the IRAM Newsletter, and (c) informs users of the Plateau de Bure Interferometer about the possibility of TNA funding in the Calls for Proposals and in the project reports resulting from the IRAM Program Committee meetings.

2.1.18.3 Description of the selection procedure

Submission is made through letter, fax, or electronically through the EPSF (Electronic Proposal Submission Facility). The EPSF is opened about two weeks before the deadline. Submission deadlines are currently at the beginning of March and September each year for the summer (01 June – 30 November) and winter (01 December – 31 May) scheduling periods. Exact dates and all other relevant information are given in a separate Call for Proposals published on the web and in the IRAM Newsletter usually about a month ahead of the deadline.

Proposals are evaluated by the IRAM program committee and recommendations are made to the IRAM Direction. Proposals are rated A (accepted), B (backup, scheduled under certain favourable conditions), or C (rejected). In 2010, the program committee had 12 non-IRAM members (H. Beuther – MPIA, Heidelberg/Germany ; Andrew Blain – California Institute of Technology, Pasadena/USA, Sylvain Bontemps – Bordeaux University/France ; Pierre-Alain Duc – CEA Saclay/France ; Asuncion Fuente – OAN, Alcala de Henares/Spain ; Santiago Garcia-

Burillo – OAN, Madrid/Spain ; Josep-Miguel Girart – CSIC-IEEC, Bellaterra/Spain ; Michiel Hogerheijde – Leiden Observatory/The Netherlands ; Bertrand Lefloch – LAOG/France ; Eckard Sturm – MPE, Garching bei München/Germany ; Axel Weiss – MPIfR, Bonn/Germany ; Christine Wilson – McMaster University/Canada) plus the ex-officio members: IRAM direction (P.Cox, K.Schuster), and the Plateau de Bure scheduler (J.M. Winters). A complete feedback is provided to all applicants in the form of a written report, a few weeks after the Program Committee meeting. In 2010, the first meeting was held at IRAM, Grenoble, on April 20/21.

2.1.18.4 Transnational access activity

For the year 2009/2010, a total of 289 proposals (204 for the summer and winter period 2009 ; 85 for the summer 2010 period) were received for the Plateau de Bure Interferometer with a well-balanced distribution between extragalactic and galactic science. From these proposals, the Program Committee recommended 21 eligible proposals which can be supported under the RadioNet contract to be scheduled at the Plateau de Bure Interferometer. The total observing time allocated to these eligible proposals corresponds to 307 hours.

2.1.18.5 Scientific output of the users at the facilities

To illustrate the science diversity, we present in the following a RadioNet funded Plateau de Bure highlight. Selected results obtained with the Plateau de Bure interferometer are posted on the IRAM web pages.

First localisation of water in a proto-planetary disk

Water is a key ingredient for life as we know it on Earth. Most of the water in the earth's oceans likely originated in a tenuous cloud between the stars which collapsed to form our solar system. Exactly where the water was produced and how the molecules made their way from this giant cloud to tiny planets like Earth some 4.5 billion yr ago is one of the main questions in the study of our origins.

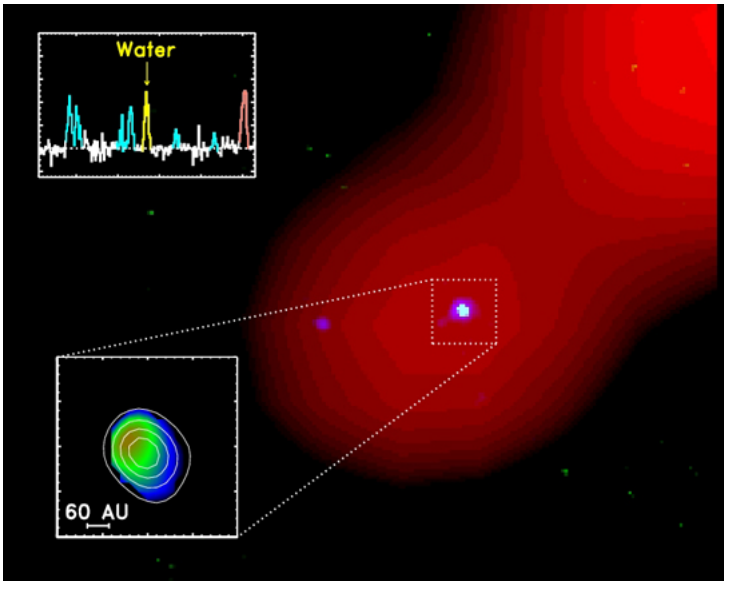


Figure wp18.1: Radio image of the star NGC 1333 IRAS4B observed with the IRAM Plateau de Bure Interferometer. The top inserted figure shows the spectral fingerprints of the water molecule. Credit Jørgensen/van Dishoeck.

While astronomers cannot turn back the clock to observe our own young solar system, they can study planetary systems in formation around other nearby young stars. The IRAM Plateau de Bure Interferometer has pinpointed for the first time the location of the bulk of the hot water vapor in the rotating disk around a very young analog of our Sun. Because of obscuration by the large amounts of water in our own atmosphere, astronomical observations of normal water ($H_2{}^{16}O$) require satellites such as the recently launched Herschel Space Observatory. However, about 1 in 500 water molecules in space contain the heavier ^{18}O isotope. Some signatures from this heavier water ($H_2{}^{18}O$) are able to penetrate the Earth's atmosphere and reach the IRAM telescopes. Since telescopes on Earth are much bigger and see a hundred times sharper than any existing satellites, this allows astronomers to zoom in on the forming stars and determine the location of water.

Jørgensen and van Dishoeck used the IRAM Plateau de Bure Interferometer to look for water around NGC 1333 IRAS4B, a young star that formed only 10,000-50,000 years ago. The astronomers found that most of this steam around the young star is located within the inner 25 AU of the rotating disk. This distance corresponds approximately to the orbit of Neptune in our own solar system. Previous observations of this protostar had suggested that water vapour is pouring down from the cloud and accretes onto the disk.

The interferometer data show that the amount of water actually in the disk is a factor of hundred larger than in any such shocks - about 100 times more than the content of Earth's oceans. Over the next 3 years, the Herschel Space Observatory will survey normal water in many star-forming clouds in our own and other galaxies. Combined with similar ground-based observations, astronomers will be able to determine exactly how much water is located where and at which stage of evolution of a young star.

2.1.19 WP18: IRAM-PV TNA

2.1.19.1 IRAM - Pico Veleta

The 30-m telescope located at an altitude of nearly 3000m on the Pico Veleta in the Spanish Sierra Nevada has a surface accuracy and a pointing capability which allow to exploit the atmospheric windows at 3, 2, 1 mm. Occasionally the telescope is even used at 0.8 mm during particularly favourable atmospheric conditions.
While other telescopes exist in Europe that can observe in the 3mm atmospheric window, e.g. the 100m telescope in Germany, the Onsala telescope in Sweden, and the Metsahovi telescope in Finland, and while European groups operate (sub-)mm-telescopes like the SEST in Chile, the HHT in Arizona, and the JCMT in Hawaii, the IRAM 30-m telescope is by far the most sensitive in its wavelength range ; it also offers unique observing capabilities through the simultaneous availability of several low-noise heterodyne receivers, a heterodyne array with 37-117-channel bolometer arrays. The heterodyne receivers can be connected to a variety of analogue and digital backends that allow spectroscopic studies at resolutions between 3.3 KHz and 4 MHz. One of the backends is capable of making cross correlations, a feature which is used for polarization observations.

The telescope is also equipped with a Mark IV VLBI terminal, and VLBI experiments at 3, 2 and 1.3mm wavelengths have successfully been carried out since several years. By combining the 30m-telescope with a 15-m diameter antenna on the Plateau de Bure Observatory, it has indeed been possible to detect for the first time fringes in a VLBI experiment at 1.3mm with a high signal/noise ratio.

The 30-m telescope is also very well suited and often used for complementing interferometer maps with short spacing information.

2.1.19.2 Description of the publicity concerning the new opportunities of access

IRAM makes publicity for RadioNet (a) electronically via the Internet, (b) in printed form via the IRAM Newsletter, and (c) informs users of the 30m telescope about the possibility of TNA funding in the Calls for Proposals and in the project reports resulting from the IRAM Program Committee meetings.

2.1.19.3 Description of the selection procedure

Submission is made through letter, fax, or electronically through the EPSF (Electronic Proposal Submission Facility). The EPSF is opened about two weeks before the deadline. Submission deadlines are currently at the beginning of March and September each year for the summer (01 June – 30 November) and winter (01 December – 31 May) scheduling periods. Exact dates and all other relevant information are given in a separate Call for Proposals published on the web and in the IRAM Newsletter usually about a month ahead of the deadline.

Proposals are evaluated by the IRAM program committee and recommendations are made to the IRAM Direction. Proposals are rated A (accepted), B (backup, scheduled under certain favourable conditions), or C (rejected). In 2010, the program committee had 12 non-IRAM members (H. Beuther – MPIA, Heidelberg/Germany ; Andrew Blain – California Institute of Technology, Pasadena/USA, Sylvain Bontemps – Bordeaux University/France ;

Pierre-Alain Duc – CEA Saclay/France ; Asuncion Fuente – OAN, Alcala de Henares/Spain ; Santiago Garcia-Burillo – OAN, Madrid/Spain ; Josep-Miguel Girart – CSIC-IEEC, Bellaterra/Spain ; Michiel Hogerheijde – Leiden Observatory/The Netherlands ; Bertrand Lefloch – LAOG/France ; Eckard Sturm – MPE, Garching bei München/Germany ; Axel Weiss – MPIfR, Bonn/Germany ; Christine Wilson – McMaster University/Canada) plus the ex-officio members: IRAM direction (P.Cox, K.Schuster), the 30-meter station manager (C.Kramer) and 30-meter scheduler (C. Thum). A complete feedback is provided to all applicants in the form of a written report, a few weeks after the Program Committee meeting. In 2010, the first meeting was held at IRAM, Grenoble, on April 20/21.

2.1.19.4 Transnational access activity

For the year 2009/2010, a total of 356 proposals (279 for the summer and winter period 2009 ; 137 for the summer 2010 period) were received for the 30-meter with a well-balanced distribution between extragalactic and galactic science. From these proposals, the Program Committee recommended 45 eligible proposals which can be supported under the RadioNet contract to be scheduled at the 30-meter. The total observing time allocated to these eligible proposals corresponds to 830.2 hours.

Related activities

IRAM organizes summer schools which are open to qualified young astronomers from all branches of astronomy. These schools alternately concentrate on interferometry and single dish observing. During the reporting period, one 30m school was held in Pradollano near Granada/Spain (04 Sep – 11 Sep 2009). This school included, apart from the usual lectures and discussions, hands-on training at the 30m telescope.

2.1.19.5 Scientific output of the users at the facilities

To illustrate the science diversity, we present in the following a RadioNet funded 30-m telescope highlight. Selected results obtained with the 30-m telescope are posted on the IRAM web pages.

Measuring the hyperfine structure of molecular lines to a precision that cannot be attained in the laboratory

Accurate knowledge of the hyperfine structure of molecular lines is useful for estimating reliable optical depths and therefore column densities, and essential for the derivation of kinematic information from line profiles. Deuterium bearing molecules are especially useful in this regard, because they are good probes of the physical and chemical structure of molecular cloud cores on the verge of star formation. However, the necessary spectroscopic data are often missing, especially for molecules which are too unstable for laboratory study.

Van der Tak and collaborators have used the IRAM 30m telescope to observe the rotational ground-state (J = 1-0) transitions of the DCO+, HN13C and DNC molecules toward the cold dark cloud LDN 1512. High-resolution spectroscopy (3.3 KHz) observations of these exceptionally narrow lines were used to derive nuclear quadrupole and spin-rotation parameters for these species. The measurements were supplemented by high-level quantum-chemical calculations using coupled-cluster techniques and large atomic-orbital basis sets. The results are consistent with, but much more accurate than previous determinations, and are in good agreement with current best theoretical estimates.

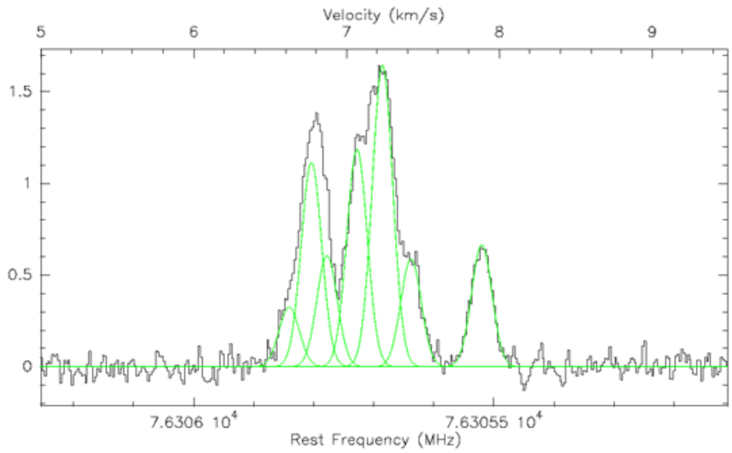


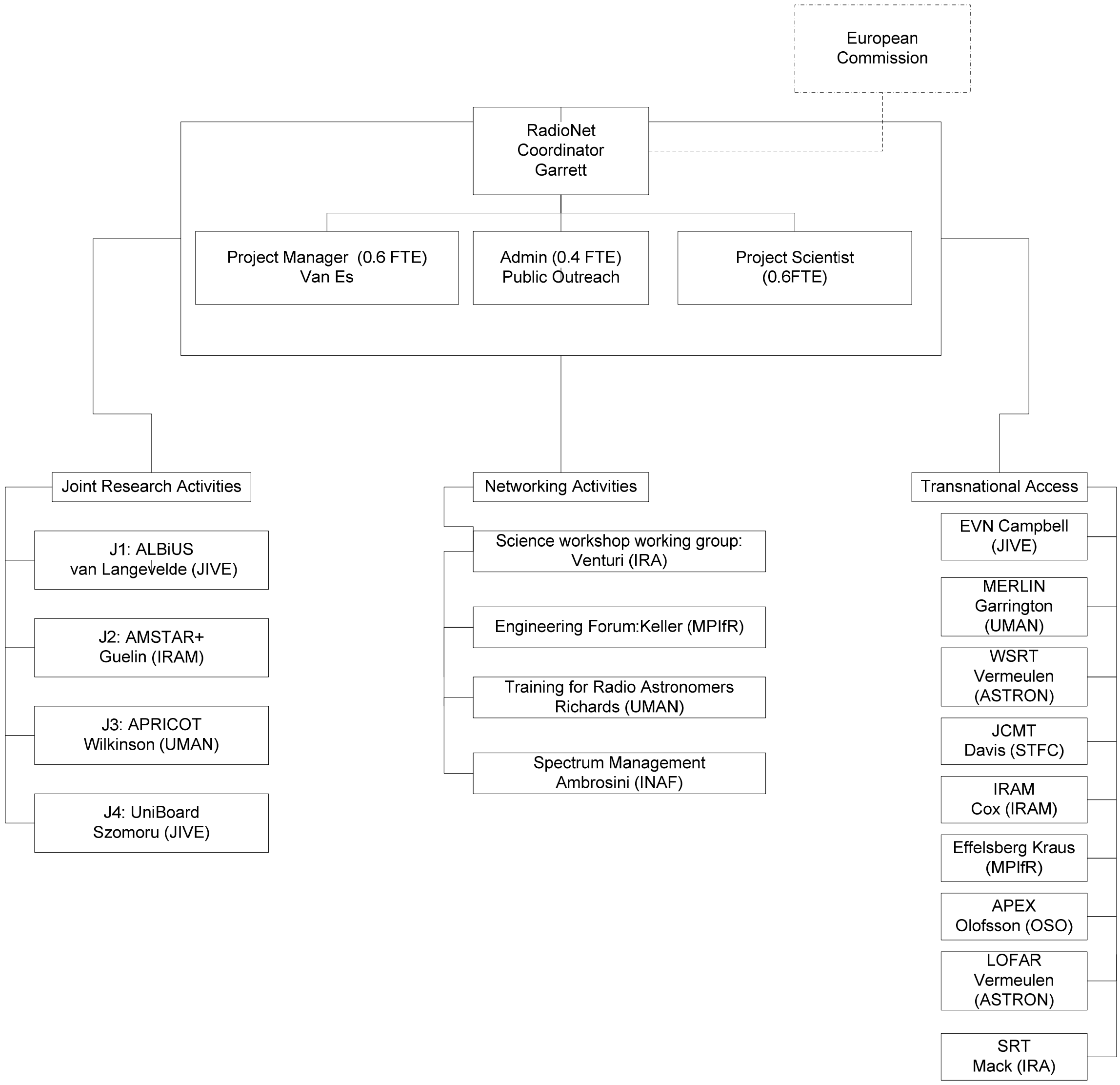
Figure wp19.1: IRAM 30m spectrum of the J=1-0 transition of DNC toward the dark cloud LDN 1512. The extremely small linewidth of this cloud allow the resolution of six hyperfine components and an accurate determination of the molecular hyperfine parameters

The measured hyperfine splitting ranges over ~1 km/s which is similar to the speed of gas motions around forming stars; the new data will thus be crucial for a better understanding of the star formation process, in particular in pre- and protostellar regions.The results are also significant from a molecular physics point of view, as the large isotopic shifts for the hyperfine parameters indicate significant non-rigidity of these molecules, particularly along the bending coordinate.

3 Project management during the period

RadioNet FP7 is an Integrated Infrastructure Initiative and is controlled by a Board. The Board consists of the Directors or representatives of all the partner institutes in the project. The RadioNet Board is the decision making body in the governance of the project, and deals with all major strategic decisions that have an impact on the DoW, the budget, the plan or changes in the consortium. The coordinator acts as an advisor to the board and is not a member.

The Executive Committee that comprises the JRA Work Package leaders, a representative of the TNA, the Management team and the Chair and vice-Chair of the board monitors on quarterly basis the progress in the project and ensures that the decisions of the board are implemented appropriately. The EC meets 4 times per year and discusses the progress report of the JRA's, new developments in the NA and monitors the TNA. The Executive Committee also prepares the Board meetings. Day to day management is performed by the RadioNet Management team, a team at ASTRON and JIVE that is headed by the Project Coordinator Prof. M.A. Garrett.



RadioNet Management Team (RMT): Project Coordinator, Project Manager, Project Scientist, JRA Work Package Leaders

Management structure of RadioNet FP7.

3.1.1 Activity Progress

The RadioNet FP7 management started directly after January 1st 2009 by setting up the website, organizing project kick off and defining procedures for project reporting and monitoring, reimbursement of travel costs, distribution of pre-financing. For internal communication and dissemination a wiki page was created (http://www.radionet-eu.org/fp7wiki/doku.php?id=start).A consortium agreement was drafted and agreed. The project kick-off was organized at 30th March 2009.

Also the NA's quickly had their plans for the first half of the project ready and started implementing these plans directly. Although some of the support especially in the Training WP was dependent on the availability of the funding.

Directly after the start of the project on January 1st 2009 all of the JRA's started their activities in the first 5 months: APRICOT-March, AMSTAR+-May, ALBiUS-March and UniBoard-February. The delay of the funding caused problems for both MMIC JRA's (AMSTAR+ and APRICOT) because staff required for essential tasks could not be hired. UniBoard was less dependent on EC funding and could start almost as planned while ALBiUS seems to have enough planning buffer to finish the work on time. It should be noted however that the delays in both AMSTAR+ and APRICOT might require an extension of the RadioNet FP7.

Management level description of resources							
Beneficiary	Personnel costs	Consulting (subcontr.)	Equipment	Direct costs	Indirect costs	Total	EC contribution
WP1 Management							
ASTRON	143,901	7,710	1,117	81,509	83,164	317,400	317,400
IRAM		7,500				7,500	7,500
INAF				0		0	0
JIVE	34,551	4,450		1,189	21,444	61,633	61,633
MPG				1,809		1,809	1,809
UMAN	0			1,469	882	2,351	2,351
OSO				0		0	0
STFC				0		0	0
Total	178,451	19,660	1,117	85,976	105,489	390,692	390,692
WP2 Science working group							
INAF	7,783			0	4,670	12,453	8,328
JIVE	0			47,382	28,429	75,811	50,698
Total	7,783	0	0	47,382	33,099	88,264	59,026
WP3 Engineering forum							
JIVE	0			36,235	21,741	57,976	38,771
MPG	19,198			0	26,434	45,632	20,542
UROM	10,426			0	6,256	16,681	11,156
Total	29,624	0	0	36,235	54,430	120,289	70,469
WP4 Training for Radio Astronomers							
JIVE	0			26,861	16,117	42,978	28,742
UMAN	11,837			0	7,102	18,939	12,666
Total	11,837	0	0	26,861	23,219	61,917	41,407
WP5 Spectrum management							
INAF				0	0	0	0
JIVE	0			23,473	14,084	37,558	25,117
Total	0	0	0	23,473	14,084	37,558	25,117
WP6 ALBiUS							
JIVE	130,561			6,208	82,062	218,831	164,123
ASTRON	73,232			0	37,810	111,042	83,282
MPG	11,646			548	16,245	28,440	21,330
UMAN	28,315			333	17,189	45,837	34,378
ESO	61,947			5,348	13,459	80,754	60,565
UCAM	12,557			22	7,547	20,126	15,095
UOXF	13,572		4,201	0	10,664	28,437	21,327
BORD	12,661			639	7,979	21,278	15,959
NRAO	43,976			0	26,386	70,362	52,771
NRF (>1/1/2010)	0			0	0	0	0
Total	388,467	0	4,201	13,098	219,340	625,106	468,830

Beneficiary	Personnel costs	Consulting (subcontr.)	Equipment	Direct costs	Indirect costs	Total	EC contribution
WP7 AMSTAR+							
IRAM	195,528			6,993	121,513	324,034	243,025
INAF				1,392	835	2,228	1,671
MPG	0			0	0	0	0
OSO	82,595		9,207	2,851	56,791	151,444	113,583
STFC	5,327		1,270	0	5,594	12,191	9,143
SRON	100,967			2,468	62,061	165,496	124,122
OBSPAR	0			7,599	4,559	12,158	9,119
KOSMA	20,835			569	12,843	34,247	25,685
FG	65,188			38,902	3,002	107,092	80,319
TUD	95,028			3,323	106,240	204,591	122,755
UOXF	0			0	0	0	0
IAF	47,922			26,113	45,024	119,059	89,294
Total	613,391	0	10,477	90,209	418,461	1,132,539	818,716
WP8 APRICOT							
INAF	61,008			1,814	37,693	100,515	75,386
MPG	126,336			3,343	173,970	303,649	227,736
UMAN	53,110		4,460	6,615	38,511	102,696	77,022
UMK	10,254			746	6,600	17,600	13,200
FG	16,551			34,427	147	51,125	38,344
UROM	9,763			2,305	7,240	19,308	14,481
Total	277,023	0	4,460	49,250	264,162	594,894	446,170
WP9 UniBoard							
JIVE	186,521			85,797	163,391	435,709	326,782
ASTRON	189,401			709	112,133	302,243	226,682
INAF	48,646			1,879	30,315	80,839	60,629
UMAN	22,931			0	13,758	36,689	27,517
KASI	16,627		17,206	42,675	13,311	89,819	0
UOXF (>1/1/2010)	0			0	0	0	0
BORD	62,492			2,311	38,882	103,685	77,763
UORL	6,531			0	3,919	10,450	7,837
SHAO (>1/1/2010)	0			0	0	0	0
Total	533,147	0	17,206	133,372	375,709	1,059,434	727,211
WP10 EVN TNA				847,112		847,112	831,243
WP11 JCMT TNA				134,800		134,800	132,693
WP12 e-Merling TNA				246,491		246,491	184,694
WP13 Effelsberg TNA				240,156		240,156	237,715
WP14 SRT TNA				0		0	0
WP15 LOFAR TNA				76,775		76,775	76,775
WP16 WSRT TNA				92,736		92,736	92,736
WP17 APEX TNA				138,852		138,852	138,852
WP18 IRAM TNA				503,195		503,195	500,310
Totals TNA	0	0	0	2,280,117	0	2,280,117	2,195,019
Total General	2,039,724	19,660	37,461	2,785,973	1,507,993	6,390,810	5,242,657

Table 1: Description of resources

The smooth transition between the FP6 RadioNet and the FP7 RadioNet allowed for a continuation of the TNA activity for the facilities also participating in RadioNet FP6. The TNA facilities continued the usual TNA procedures, taking into account the changes in FP7. The SRT had a delay in the construction so they could not provide TNA access in this reporting period. LOFAR the other new instrument was partly available and the first TNA projects in this reporting period.

With the exception of the SRT TNA and the 2 JRA's AMSTAR+ and APRICOT the project is on track. This is also indicated at both the deliverables that are ready as well is in the spending of the project until 30th June 2009. Table 1 below presents an overview:

An overview of the manpower effort is presented in table in manmonth is presented in Table 2:

Project effort per beneficiary per WP

Workpackage	WP1 Management	WP2 Science Working Group	WP3 Engineering Forum	WP4 Training for Radio Astronomers	WP5 Spectrum Management	WP6 ALBiUS	WP7 AMSTAR+	WP8 APRICOT	WP9 UniBoard	TOTAL per Beneficiary
ASTRON	24.25	0.66			1.14	8.75			26.29	61.09
IRAM		0.00		0.00	0.00		32.90			32.90
INAF		1.31			6.44		0.00	13.66	11.39	32.80
JIVE	6.99	0.00				29.95			37.56	74.50
MPG		0.70	3.34		2.00	1.86		25.26		33.16
UMAN		1.00		2.28	4.25	5.00		5.68	5.29	23.50
OSO		0.00			2.50		18.00			20.50
UMK		0.00						9.00		9.00
STFC							1.37			1.37
SRON							18.64			18.64
OBSPAR				0.00	0.00		6.00			6.00
KOSMA							2.50			2.50
FG							18.00	0.00		18.00
IGN					1.75		7.85	4.52		14.12
TUD							20.33			20.33
ESO						9.60				9.60
KASI									18.00	18.00
UROM			1.25					1.50		2.75
UCAM		0.00			0.00	6.50				6.50
UOXF		1.00				6.00	0.00		0.00	7.00
BORD						2.97			16.83	19.80
VENT		0.50								0.50
TKK										0.00
NRAO						6.00				6.00
UORL									0.97	0.97
IAF							6.75			6.75
NRF						0.00				0.00
SHAO									0.00	0.00
TOTAL	**31.24**	**5.17**	**4.59**	**2.28**	**18.08**	**76.63**	**132.34**	**59.62**	**116.33**	**446.27**

Table 2: Project effort per beneficiary per WP

3.1.1.1 Project Kick Off

The RadioNet FP7 project started formally on January 1st 2009. To set up the project and to initiate all work packages a kick off meeting was organized at Hotel vd. Valk near Schiphol. The kick-off meeting had a 2 day program, an informal kick-off where the project was presented and a board meeting to setup the project governance. Dr. Ph. Diamond former coordinator of RadioNet FP6 was elected chairman and Dr. Franco Mantovani was elected vice-chair. The project management team was proposed by the Coordinator and accepted by the Board. All work packages presented their contributions and plans.

3.1.1.2 Distribution of Funding

After the funding was received from the EC in 2 september 2009 it was immediately distributed to the participants based on a scheme that was approved by the Board during the Kick-Off meeting.

A pre-financing of €5,699,998.36 was paid to the coordinator within 45 days following the date of entry into force of this grant agreement.

On 2 September 2009 the project coordinator received on his RadioNet FP7 dedicated bank account an actual amount of €5.199.998,50. All participants received 57% of the total budgeted EC contribution, with an exception on RTD projects and excluding budget for audit costs! The RTD-work packages were funded 38% of the total budgeted EC contribution (agreed upon in the first board meeting). Audit costs will be reimbursed based on actual costs, as stated in C-forms. An amount of €832,947.60 was reserved for future distribution (RTD-projects and audit costs). The distribution of funds can be found in the following table:

Participant number in this project	Participant short name	Total requested EC contribution	5% Guarantee Fund	Total pre-payment per participant	Distributed to participant *
1	ASTRON	1.656.339,66	82.816,98	875.154,43	792.337,44
2	IRAM	578.882,00	28.944,10	289.371,52	260.427,42
3	INAF	597.088,85	29.854,44	247.147,44	217.293,00
4	JIVE	2.238.603,00	111.930,15	1.179.723,11	1.067.792,96
5	MPG	1.092.628,00	54.631,40	521.145,58	466.514,18
6	UMAN	1.117.452,22	55.872,61	527.050,39	471.177,78
7	OSO	464.997,00	23.249,85	233.941,68	210.691,83
8	UMK	118.891,00	5.944,55	50.736,27	44.791,72
9	STFC	480.632,00	24.031,60	251.411,61	227.380,01
10	SRON	146.736,00	7.336,80	55.759,68	48.422,88
11	OBSPAR	66.576,00	3.328,80	25.298,88	21.970,08
12	KOSMA	53.286,00	2.664,30	20.248,68	17.584,38
13	FG	269.535,00	13.476,75	116.316,29	102.839,54
14	TUD	146.738,40	7.336,92	55.760,59	48.423,67
15	ESO	99.000,00	4.950,00	37.620,00	32.670,00
16	KASI	0,00	0,00	0,00	0,00
17	UROM	62.926,00	3.146,30	28.229,82	25.083,52
18	UCAM	65.640,00	3.282,00	24.943,20	21.661,20
19	UOXF	95.100,00	4.755,00	36.138,00	31.383,00
20	BORD	132.950,00	6.647,50	50.521,00	43.873,50
21	VENT	29.214,00	1.460,70	16.651,98	15.191,28
22	TKK	29.248,00	1.462,40	16.671,36	15.208,96
23	NRAO	213.216,00	10.660,80	108.810,72	98.149,92
24	UORL	51.500,00	2.575,00	19.570,00	16.995,00
25	IAF	163.567,00	8.178,35	62.155,46	53.977,11
26	NRF	29.251,00	1.462,55	16.673,07	15.210,52
TOTAL		**9.999.997,13**	**499.999,86**	**4.867.050,76**	**4.367.050,90**

*** the amount mentioned in the column "distributed to participant" is corrected for the 5% Guarantee Fund.**

Table 3: Distribution of pre-financing

3.1.1.3 Contract Amendment

Shortly after the start of the project it became clear that the Shanghai Observatory was interested in joining RadioNet. Especially the development of the powerful and promising Uniboard was a reason to enter the consortium. After an email vote among the Board members it was unanimously agreed to change the contract so SHAO is now a member of RadioNet. The contract amendment was used to implement a few other board decisions:

- Implementation of a Coordinator discretionary fund. The TNA travel budgets were adjusted. A possible deficit of the budget will be compensated when it occurs.
- Because the distribution of work changed within ALBiUS so that budget had to be shifted from NRAO to NRF, for this reason NRF was added as a participant in WP6 ALBiUS in preparation of a possible budget shift when the work starts at NRF
- The University of Oxford was interested in participation in the UniBoard project, they were added as zero cost participant to this workpackage.
- All TNA and NA travel funds were moved to JIVE, identical to the FP6 construction. JIVE now handles all travel requests and travel budgets centrally, making the process more transparent.

3.1.1.4 2nd RadioNet FP7 Board Meeting Sardinia

The first part of the 2nd RadioNet Board Meeting was used to report on the progress of the project in preparation of the Mid Term Review. The Networking Activities and most of the Trans National Access presented excellent progress but the Joint Research Activities showed some delays caused by the late arrival of funding. The second part was used for exchanging information with other Astronomy projects like Opticon, ALMA and AAVP. Another major topic was the preparation of the ASTRONET Review and the future of RadioNet.

At this board meeting a new chairman was elected: Franco Mantovani and Raphael Bachiller was elected vice-chair of RadioNet. Becauses Dr. Ph. Diamond who has served RadioNet both as a coordinator and as a chairman accepted a position in Australia as leader of the CSIRO Astronomy and Space Science Division and could not complete the 3 years term.

3.1.1.5 Executive Committee

The RadioNet Executive Committee consists of the chairman, vice-chair, coordinator, management team, JRA-leaders and a representative of the TNA. The committee meets every quarter in order to monitor the progress in the project and to monitor the implementation of board decisions. The minutes of these meetings can be found at the RadioNet wiki: http://www.radionet-eu.org/fp7wiki/doku.php?id=na:management:meetings

Date	Title of Meeting	Location	Nr of Attendees
17 March 2009	1st RadioNet FP7 Exec. Comm.	Telecon	9
30 June 2009	2nd RadioNet FP7 Exec. Comm.	Telecon	8
28 September 2009	3rd RadioNet FP7 Exec. Comm.	Telecon	10
17 December 2009	4th RadioNet FP7 Exec.Comm.	Telecon	12
19 April 2010	5th RadioNet FP7 Exec. Comm.	Telecon	10

3.1.2 Outreach activities

One of the first steps was the establishment of the new RadioNet FP7 webpage: www.radionet-eu.org. A content management system was introduced, which makes it easier to change the web content and to enable more people to contribute directly.

Accompanying the RadioNet kick-off meeting in March 2009, there was a joint press release by the RadioNet partners, which got a good coverage in the general news. This made it also into the newsletter of various institutes, eg. the ASTRON newsletter.

3.1.2.1 Outreach Material

Over the last 18 months a variety of RadioNet outreach activities took place and material for the various activities was produced. This outreach material was provided to the organizers of the meetings that were supported by RadioNet in the framework of the networking activities (NA). The organized distributed the material to the participants. It proved quite popular at times. The outreach material made so far consists of a general RadioNet flyer, a RadioNet pen and postcards advertising the various RadioNet facilities (see Figure 1).

Figure 1: Produced RadioNet outreach material so far. Top left: RadioNet pen, Bottom left: Example of a RadioNet postcard here with the Effelsberg Telescope, Right: The general RadioNet flyer. This material was distributed at the numerous meetings that were supported by RadioNet.

In order to advertise the possibilities that the transnational access RadioNet program offers to radio astronomers all over Europe, we produced an informational flyer that will be distributed whenever possible. In addition, there was also an article in the June edition of the newsletter of the European Astronomy Society published explaining the opportunities that RadioNet offers.

For special meetings, we also try to organize other items. For the YERAC in July 2010, we will provide RadioNet T-Shirts. For the schools in autumn 2010, we are thinking of USB sticks containing data that the participants will use later on during the workshop. We also have writing pads with the RadioNet logo for workshops.

3.1.2.2 RadioNet at exhibitions

The management team also produced an exhibition display that was used at various exhibitions, ie. JENAM (Joint European and National Astronomers Meeting) 2009 in Hertfordshire, the IAU (International Astronomy Union) 2009 in Rio de Janeiro (see Figure 2), ECRI (European Conference on Research Infrastructures) 2010 in Barcelona and ISKAF (International Square Kilometer Array (SKA) Forum) 2010 in Assen. The outreach material mentioned above was distributed at these meetings. During these exhibitions, we had some interesting discussions with various participants that helped us understanding the needs of the community better. For instance, we were frequently asked for educational material for schools or Universities.

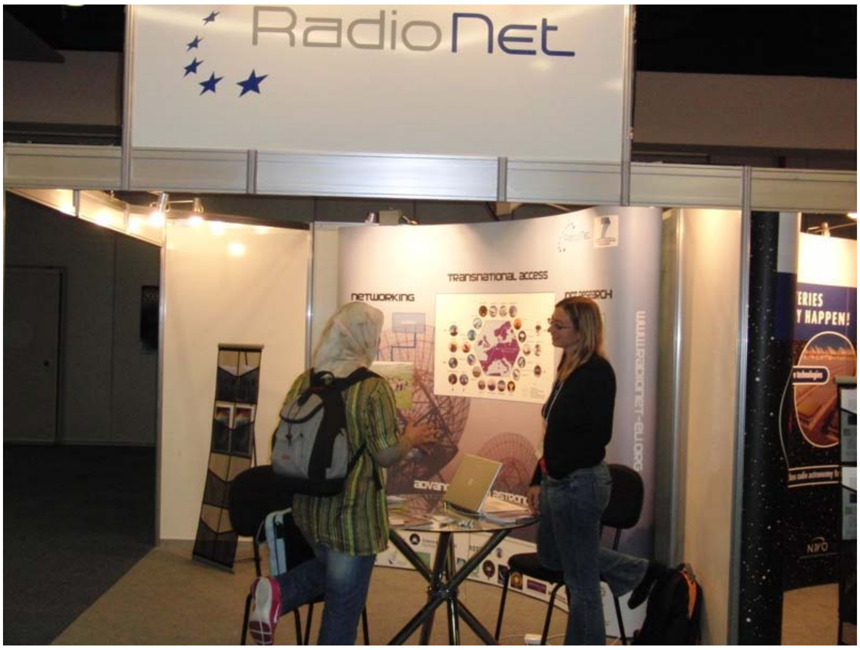


Figure2: RadioNet booth at the IAU 2009 in Rio de Janeiro.

3.1.2.3 Outlook

In the coming 18 months, we will build on the material that was produced so far and the assortment will be broadened. We will also continue to participate in exhibition, eg. the JENAM, whenever appropriate and possible.

In addition to the current activities, we are organizing a workshop on outreach activities, which will be held in Bologna from 17-19 November. This workshop will bring together the various public relation managers from the various partners. They will share their experience and discuss ways to profit from each other's material/work. There is the idea of establishing a repository for the different materials and a common webpage bringing all webcams of the facilities together - to name a few ideas.

4 List of acronyms

2SB	Sideband Separating
ACSIS	Auto-Correlation Spectrometer and Imaging System
ADC	Analog to Digital Convertor
AIPS	Astronomical Image Processing System
ALMA	Attacama Large Millimeter Array
APERTIF	APERture Tile In Focus
ARC	ALMA Regional Centre
ASKAP	Australian SKA Pathfinder
ATA	Allen Telescope Array
ATCA	Australian Telescope Compact Array
ATNF	Australian Telescope National Facility
BASECOL	numerical and bibliographical database concerning collisional ro-vibrational excitation rate coefficients of molecules
BBS	Bulletin Board System
CABB	Compact Array Broadband Backend
CALC/SOLVE	VLBI Software package
CASA	Common Astronomy Software Application
CESRA	Community of European Solar Radio Astronomers
CDMS	Cryogenic Dark Matter Search
CNES	Centre National d'Etudes Spatiales
CORF	Committee on Radio Frequencies
CPU	Central Processing Unit
CRAF	Committee on Radio Astronomy Frequencies
CSIRO	The Commonwealth Scientific and Industrial Research Organisation
DDR3	Double Data Rate Synchronous Dynamic Random Access Memory 3
DiFX	A software correlator for very long baseline interferometry
DoW	Description Of Work
DSB	Double SideBand
ENR	Excess Noise Ratio
EPSF	Electronic Proposal Submission Facility
EPTA	European Pulsar Timing Array
ERIS	European Radio Interferometry School
eSMA	a collaboration between the SMA, the JCMT, and the CSO
EUMETNET	European Meteorological Services Network
e-VLA	electronic Very Large Array
EVN	European VLBI Network
FAST	Five hundred meter Aperture Spherical Telescope
FP7	Framework Program 7
FPA	Focal Plane Array
FPGA	Field-programmable gate array
FTS	Fourier Transform Spectrometer
GAIA	Global Astrometric Interferometer for Astrophysics
GINS	Geodesie par Integrations Numeriques Simultanees
GMRT	Giant Metrewave Radio Telescope
GSFC	Goddard Space Flight Centre
HEB	Hot Electron Bolometer
HEMT	high electron mobility transistor
IGN-CAY	Instituto Geográfica National-Centro Astronómico de Yebes
ITAC	International Time Allocation Committee
IVS	International VLBI Service for geodesy and astrometry
IXO	International X-ray Observatory
JRA	Joint Research Activity
JWST	James Webb Space Telescope
LABOCA	Large Apex BOlometer CAmera
LAMDA	Leiden Atomic and Molecular Database
LNA	Low Noise Amplifier
LO	Local Oscillator
LOC	Local Organizing Committee
LSST	Large Synoptic Survey Telescope
LWA	Long Wavelength Array
mHEMT	Metamorphic High Electron Mobility Transistor
MMIC	Monolithic Microwave Integrated Circuit

MODEST	MODel and ESTimate
MWA	Murchison Widefield Array
NA	Networking Activity
NASA	National Aeronautics and Space Administration
NDA	Non Disclosure Agreement
NIOS	Nios, Alterrra Processor type
NWO	Netherlands Organization for Scientific Research
OCCAM	concurrent programming language
OMT	Orthomode Transducer
PC	Program Committee
PoS	Proceedings of Science
PPTA	Parkes Pulsar Timing Array
RATRAN	Radiative Transfer Program
RF	Radio Frequency
RFI	Radio Frequency Interference
SABOCA	Submillimetre APEX Bolometer Camera
SCUBA-2	Submillimetre Common User Bolometer Array
SISSA	La Scuola Internazionale Superiore di Studi Avanzati di Trieste
SKA	Square Kilometre Array
SOC	Science Organizing Committee
SPRINT	Software for Phase-Referenced INTerferometry
TAG	Time Allocation Group
TOG	Technical Operation Group
TRA	Training for Radio Astronomers
VHDL	Very High Speed Integrated Circuit)
LIGO	Laser Interferometer Gravitational Wave Observatory
VLBI	Very Long Baseline Interferometry
VPN	Virtual Private Networks
WP	Work package
XGB	10 Gig Breakout Board
YERAC	Young European Radio Astronomer Conference