Newsletter February 2014

RadioNet3 Newsletter

February 2014

Two noteworthy RadioNet3 meetings this February

Two coordination meetings were organized for this February. A RadioNet3 workshop "Outreach for the general public" was held at the Max-Planck-Institut für Radioastronomie in Bonn on 12 February, with the participations of outreach officers of many RadioNet3 partner institutes. Representative of the EU Universe Awareness (UNAWE), EU Hands-On-Universe (EuHOU), SKA Africa, SKA Organisation, and IAU Office of Astronomy for Development, joined the workshop.

A Transnational Access (TNA) face-to-face meeting was held at the Max-Planck-Gesellschaft Office in Brussels on 14 February, with the participation of the RadioNet3 Coordinator, Project Manager and TNA Leaders. Dr. Sebastian Jester, new RadioNet3 Scientific Officer, took part to the meeting.

XII EVN Symposium in Cagliari, Italy

The XII European VLBI Network (EVN) Symposium will be hosted by the National Insitute of Astrophysics (INAF) in Italy and organized jointly by the Istituto di Radioastronomia and the Osservatorio di Cagliari. The symposium will be held in Cagliari, Sardinia (Italy), in the week of October 7 - 10, 2014. The latest scientific results and technical development from VLBI, space VLBI, and e-VLBI will be reported at the conference. The program will also include a visit to the Sardinia Radio Telescope. All individuals who have interests in the various research fields of VLBI and in related fields are encouraged to attend the symposium and make an oral or poster presentation. At present, different alternatives for the venue are still being explored. One possibility is the new building of the Osservatorio di Cagliari, located in Selargius in the suburb of Cagliari. Alternatively, the symposium could be held in a hotel in Cagliari.

Luigina Feretti, IRA, Bologna

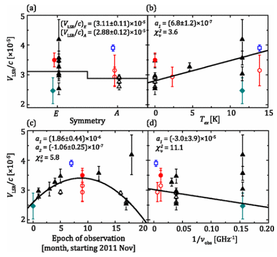
The XII EVN Symposium is financially supported by the Science Working Group, a RadioNet3 Networking Activity.

Robust Constraint on a Drifting Proton-to-Electron Mass Ratio at z= 0.89 from Methanol Observation at Three Radio Telescopes

A limit on a possible cosmological variation of the proton-to-electron mass ratio was derived frommethanol (CH3OH) absorption lines in the benchmark PKS1830-21

1 lensing galaxy at redshiftz= 0.89 observed with the Effelsberg 100-m radio telescope, the Institute de Radio AstronomieMillimetrique 30-m telescope, and the Atacama Large Millimeter/submillimeter Array. The Effelsberg observations are based on ongoing RadioNet3 Transnational Access eligible projects 19-11, 86-12.

Ten different absorption lines of CH3OH covering a wide range of sensitivity coefficients Kμ are used to derive a purely statistical 1-σ constraint of Δμ/μ = (1.5 ± 1.5) 107 for a look-back time of 7.5 billion years.

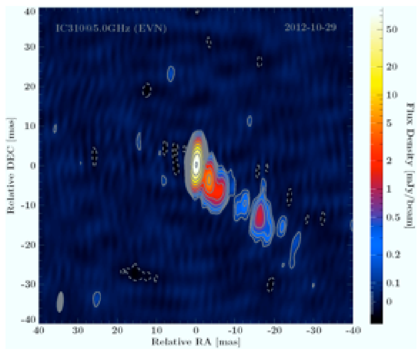


Systematic effects of chemical segregation, excitation temperature, frequency dependence and time variability of the background source are quantified. A multi-dimensional linear regression analysis leads to a robust constraint of Δμ/μ = (1.0 ± 0.8stat ± 1.0sys) 107.

To read the full paper: Bagdonaite et al., Ph.Rev. Letters 111, issue 23, 231101 (2013)

No evidence for a counter-jet in the TeV-emitting radio galaxy IC 310

The nearby active galaxy IC 310 (z = 0.019) is one of only four radio galaxies detected at very high gamma-ray energies above 100 GeV so far. In contrast to its previous classification as a head-tail radio galaxy, its variability at X-ray and gamma-ray energies and its compact one-sided parsec-scale radio jet suggest a blazar-like nature. The EVN observations (based on the RadioNet3 Transnational Access eligible project EE009, led by Dorrit Eisenacher, University of Würzburg) have thus helped to estimate a key parameter relevant for the understanding of the enigmatic high-energy source in IC 310.



The nearby active galaxy IC 310 (z = 0.019), located in the Perseus cluster of galaxies is one of only four radio galaxies detected at very high gamma-ray energies above 100 GeV so far. In contrast to its previous classification as a head-tail radio galaxy, its variability at X-ray and gamma-ray energies and its compact one-sided parsec-scale radio jet suggest a blazar-like nature (Kadler et al. 2012, A&A 538, L1; Aleksić et al. 2013, A&A, in press, arXiv: 1305.5147; Eisenacher et al. 2013, arXiv: 1308.0433). The unusual hard gamma-ray spectrum and variable TeV emission shorter than one day raises questions about the role of the jet orientation angle for the interpretation of the gamma-rays.

The figure shows VLBI jet of IC 310 at 5.0 GHz obtained with EVN on 2012-10-29. Contours start at three times the noise level and increase logarithmically by factors of two. The restoring beam is 5.3 × 1.7 mas2 with a position angle of -5 deg.

From October 2012 to February 2013, the first successful simultaneous multiwavelength program for IC 310 has been organized yielding the detection of an exceptionally bright TeV are of the object on 12-13 Nov. 2012 reaching a flux level of up to > 0.5 Crab units above 1TeV measured with the MAGIC telescopes (ATel #4583, #4581). Further instruments participating in the campaign were: EVN, VLBA (MOJAVE), Effelsberg 100 m, Kungliga Vetenskapsakademien telescope on La Palma, the telescopes at the Observatoire de Haute Provence (France), Swift, INTEGRAL and, Fermi-LAT. The first high sensitive multi-frequency VLBI observations were carried out with the EVN shortly before the bright TeV are at 18 cm, 6 cm, 3.6/13 cm, and 1.3 cm. Fig. 2 shows a preliminary image of IC 310 at 6 cm (5.0 GHz) with no evidence of a counter-jet down to a threshold of three times the noise level in the image. Following the analysis by Kadler et al. 2012, the jet-to-counter-jet ratio was estimated by taking the ratio of the peak flux density to the aforementioned threshold. An upper limit of the jet angle to the line of sight was estimated assuming a flat spectrum of the compact emission and a jet velocity β → 1. In comparison to previous (short) VLBA observations the jet-to-counter-jet ratio was significantly better constrained in our EVN observations, due to a higher signal-to-noise ratio. This yields an upper limit of ≤20 degrees, which is substantially lower than the value reported by Kadler et al. 2012 (31 degrees). In combination with jet size-scale deprojection arguments (see Aleksić et al. 2013), the IC 310 jet inclination angle can thus be constrained to 10-20 degrees. The EVN observations have thus helped to estimate a key parameter relevant for the understanding of the enigmatic high-energy source in IC 310.

Robert Schulz (Univ. Würzburg, Univ. Erlangen-Nürnberg), Dorit Eisenacher, Matthias Kadler, Dominik Elsässer, Karl Mannheim (Univ. Würzburg), Eduardo Ros (MPIfR Bonn)

The New K-band receiver for the Effelsberg telescope

by Gundolf Wieching on behalf of the K-band Rx project team

Within the update process of the Effelsberg receivers high priority had been given to a new K-Band receiver. At the end of 2013 the new K-Band receiver saw first light in the lab and will be deployed to the secondary focus at Effelsberg within January 2014. After a comprehensive commissioning the receiver will be available to the community in autumn this year. Users can apply for observing time at the Effelsberg 100-m telescope equipped with the enhanced K-Band receiver taking advantage of the RadioNet3 Transnational Access programme.

The superb sensitivity of the 100m-telescope, in particular at higher frequencies, is reflected by the fact that the telescope is highly overbooked especially at the high frequencies. The most requested higher frequencies are within the K-Band, covering the transitions of water vapour, ammonia, and many more molecules. Thus it was evident that within the update process of the Effelsberg receivers high priority had been given to a new K-Band receiver. At the end of 2013 the new K-Band receiver saw first light in the lab and will be deployed to the secondary focus at Effelsberg within January 2014. After a comprehensive commissioning the receiver will be available to the community in autumn this year. In the following some technical details of the new system will be presented to explain the potential of this exceptional machine.
The K-Band receiver is setup as a double feed system, providing two beams at a distance of five times the beam width (HPBW @ 22 GHz: 39.4"). In addition each feed resolves circular left and right hand polarized (LCP, RCP) signals. Combined with the huge instantaneous detection bandwidth of 8 GHz (within the range of 18 - 26.5 GHz), the IF- (Intermediate Frequency) and backend system converts and resolves up to 32 GHz bandwidth.

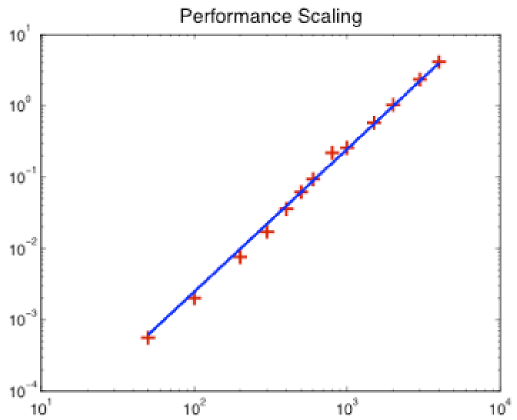
The frequency resolution is adjustable to the scientific needs. For this purpose a highly complex IF double mixing is implemented providing three different observing modes:
➢ Mode 1 ("polarisation"):
Both beams and both polarisations (LCP, RCP) each with the full 8 GHz bandwidth and a frequency resolution of 44 kHz (0.5 km/s @ 26.5 GHz)
➢ Mode 2 ("resolution"):
LCP at one feed and 8 GHz bandwidth with at least 10 kHz (0.12 km/s @ 26.5 GHz) resolution.
➢ Mode 3 ("zoom"):
Four times 300 MHz bandwidth at both feeds and polarisation with at least 10 kHz (0.12km/s @ 26.5 GHz) resolution.
➢ Mode 4 ("polarisation / zoom"):
Mode 1 and in addition up to four times 300 MHz LCP at one feed with at least 10 kHz (0.12 km/s @ 26.5 GHz) resolution. As the first new generation receiver the supporting "infrastructure" such as the control system, data transmission and data reduction is being updated as well. To handle the integrated data rates of contiguous 240 MBit/s special effort is made to provide automated data calibration and reduction pipelines (see Article on page 6). The amount of raw and calibrated data also requires adapted tools to analyse the data. This still leaves some challenges ahead even if the

hardware is close to its completion. The new K-Band receiver is providing unique performance and it will be very exciting to explore its full potential and follow its discoveries to come.

StEFCal: reliable and fast calibration for radio telescopes

Stefan Wijnholds (Netherlands Institute for Radio Astronomy (ASTRON), The Netherlands), Stefano Salvini (Oxford e-Research Centre, UK)

The Statistically Efficient and Fast Calibration (StEFCal) algorithm provides a computationally efficient and reliable way to calibrate the direction independent electronic gains of the individual receptors in a radio astronomical array. Those receptors can either be dishes in an array like the Westerbork Synthesis Radio Telescope, stations in an array like LOFAR or antennas / tiles in a LOFAR station.



The Statistically Efficient and Fast Calibration (StEFCal) algorithm provides a computationally efficient and reliable way to calibrate the direction independent electronic gains of the individual receptors in a radio astronomical array. Those receptors can either be dishes in an array like the Westerbork Synthesis Radio Telescope, stations in an array like LOFAR or antennas / tiles in a LOFAR station. In the context of Hilado, a joint research activity of RadioNet3 , we have done a rigorous analysis of this algorithm with the following conclusions:

1. The number of operations required by StEFCal scales with the square of the number of receptors in the array (see Figure 1). For generic algorithms, this number typically scales with the cube of the number of receptors. This is very important in view of the Square Kilometre Array (SKA), which will have one to two orders of magnitude more receptors than current telescopes. Since the number of data values generated by a correlator also scales with the square of the number of receptors, this implies that StEFCal scales linearly with the number of data points. This is a real game changer for calibration, which has now become an I/O intensive instead of a compute intensive operation.
2. StEFCal converges fast to the optimal solution in any reasonable scenario. In this context "reasonable" means that it is mathematically possible to construct cases in which the algorithm does not converge, but that these cases are not realistic. An example is calibration on an empty image, which one would never do in practice.
3. StEFCal is statistically efficient in the low SNR regime common to radio astronomy. Statistically efficient means that the algorithm produces solutions with minimal uncertainty given the noise on the data.

With the proper foundations in place, we have started to incorporate StEFCal in commonly used pipelines. StEFCal is currently part of the LOFAR station calibration software and the AARTFAAC real-time calibration pipeline. Figure 2 shows a calibrated all-sky image produced with the 288-element AARTFAAC system, for which the use of StEFCal reduced the computational burden due to calibration by a factor 30. Oleg Smirnov (Rhodes University, South-Africa) is already using StEFCal instead of a generalized solver in the differential gain estimation method he uses to deal with direction dependent gains. In the near future, we hope to make StEFCal and its polarized version an integral part of the LOFAR standard pre-processing and imaging pipelines.