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Wide-field imaging including direction-dependent corrections

The framework for wide-field imaging with direction-dependent corrections is well understood at this point. Most of the effort in this 18 month reporting period has been devoted to improving the code infrastructure to support interoperation of a number of different, modular components, such as wide-field (w-term) corrections, primary beam correction, and wide-band corrections. This refactoring work is begin done on a branch of the CASA source tree to isolate development efforts from the needs of CASA users. The effort to merge the changes back into the CASA main development tree will be made in 2012.

Prior to re-factoring of the software framework, the implementation of the A-Projection algorithm supported only EVLA primary beams (PBs). Code required to include PBs for other telescopes, in particular ALMA, was re-factored to allow inclusion of other PBs such that only a single telescope-specific specialization of a software component needs to be written. This component for the EVLA was implement and the software framework was regressively tested against existing data from the EVLA. The ALMA-specific component has also been written by Dirk at ESO and is pending software testing. Some more work on this front for the extra bookkeeping for heterogeneous arrays might still be required to fully integrate this into the framework.

Dirk Petry (ESO) visited Socorro to discuss adaptations of primary beam calculations for ALMA antennas where there is expected t be antenna-to-antenna differences in antenna beams due to ability to accurately machine small parts that will impact imaging at high dynamic range.

Most of the past six months was spent rewriting parts of the imaging framework to allow flexibility in combining major-cycle and minor-cycle algorithms. This is required for the joint A-Projection and MS-MFS algorithm for wide-band wide-field imaging were one needs to account for the instrumental frequency dependence (the antenna Primary Beam; see figure) as well as the frequency dependence of the sky emission (source spectral index variations). We have begun testing various approaches to wide-band wide-field imaging and their numerical performance as a function for field-of-view (FoV) and bandwidth and found that a single algorithm does not optimally work for all cases. We find that the optimal solution depends on the required FoV, imaging dynamic range and the computing platform used. We are now testing the limits of various approaches, which either limit the the FoV, or band-width or requires larger number of Taylor terms as part of the MS-MFS algorithm. We have also done some initial tests for an algorithm which corrects for frequency dependence of the primary beam prior to invoking the minor cycle and which might limit the number of required Taylor terms. Note that memory footprint of the minor cycle algorithm strongly scales with the number of Taylor terms, particularly for complex fields, as will be the case for many mosaicking applications.

At this moment generation of images using the new infrastructure is not yet possible. Very shortly (within 2012 Q1) the first tests will be possible There will very likely be images produced from these new capabilities to showcase in the ALBiUS final report.

Parallelization efforts

Multi-process imaging for continuum and spectral cube was first achieved early in this reporting period. The work during 2011 was focussed on dealing with data-parallel optimization for problems that require minimal inter-process communication. The new infrastructure has lead to an easy path for implementing parallelization of different modules of a data reduction pipeline (e.g., flagging, calibration application or continuum subtraction) by distributing the work on different dataset subsets across different processors.

CASA release 3.3 was made publicly available during this reporting period and is the first release to include useful parallelized imaging algorithms. With this release, Multi-Scale clean and Multi-Scale-Multi-Frequency-Synthesis now use OpenMP-based multithreading. At the toolkit level, parallel imaging for both continuum and spectral-line cube cases is available. Additionally, a framework for making parallel tasks (such split, applycal, ...) is in place.

Advanced global fringe fitting

NRAO has retained only a facilitory role in the fringe fitting development after handing this deliverable over to JIVE. NRAO hosted the visit of Stephen Bourke and Ian Stewart in Socorro in February 2011. In addition to advising development at JIVE, NRAO has been playing a large indirect effort toward realizing CASA fringe fitting by developing and implementing the new "CalTable" infrastructure which will provide the infrastructure needed to store and apply fringe fitting results to visibility data. The prior version of CalTable could handle fringe fitting results, but had numerous shortcomings. A description of the new CalTable effort can be found at: http://www.aoc.nrao.edu/~gmoellen/CASADOC/caltable_refactor.txt

Figure caption:

The blue curve shows the spectrum (covering the frequency range of 1.0 to 2.0 GHz) of a unit point source located at the ~33% point of the PB at the low frequency. The image was made using the classical imaging algorithm. The red curve shows the spectrum of the same source, but when imaged using the wide-band A-Projection (WB A-Projection) algorithm. The gain variation as a function of frequency is markedly reduced. The residual frequency variation correspond to about 5% flux variation across the frequency range.