# The AARTFAAC-12 calibration and imaging pipeline

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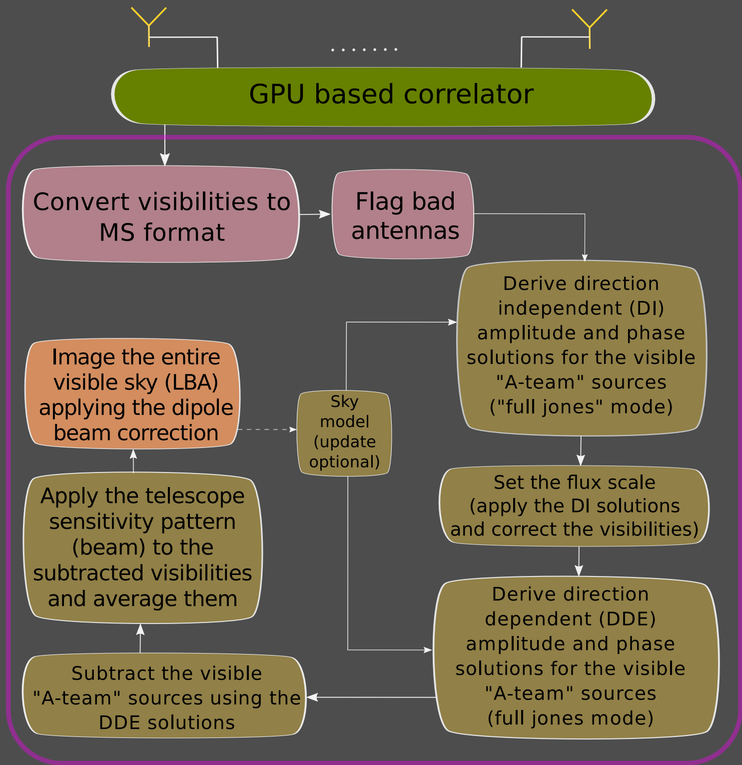
The dipole antennas belonging to the twelve LOFAR stations located in and around the super-terp at the core of the array comprise a separate instrument.

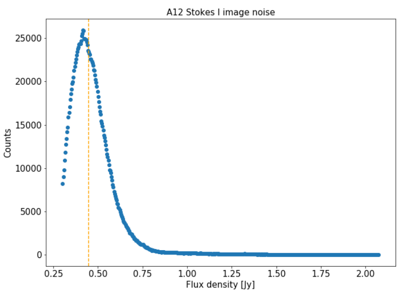
This is the Amsterdam-ASTRON Transient Facility And Analysis Center (AARTFAAC). It correlates the signals from each dipole with all the other dipoles, calibrates the produced visibilities, and images the whole sky at the lowest radio frequencies (20 MHz - 80 MHz).


We can produce all-sky images (in LBA mode) with cadence of up to 1s and PSF of 10 arcminutes.

Various research projects utilize A12 imaging products, such as: radio transient studies (including: flares from nearby stars, GRB prompt emission and gravitational wave EM counterparts, which can be FRB - like), space weather, ionosphere and Solar physics as well as Cosmic Dawn studies.

The pipeline uses Python scripting to integrate various modules (custom, as well as core LOFAR pipeline tools such as DP3). It is deployed in a Singularity container which has all the LOFAR tooling dependencies, modified to suit the AARTFAAC-12 environment requirements.

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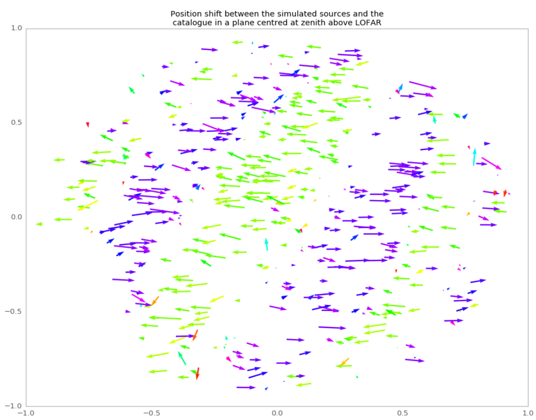
| aartfaac2ms<br>afedit<br>flagbadstations | Custom packages, aartfaac2ms is based on the Cotter pipeline (Offringa et al., 2015) |
| WSclean | Wide-field imager Offringa & Smirnov, 2017 |
| DP3 | LOFAR pre-processing software |

The figure *above* shows a histogram of pixel values from a Stokes I r.m.s. image taken at 61 MHz obtained after performing a source extraction. The image was centered on zenith and the FoV had a radius of 38 degrees. The orange dashed vertical line indicates a flux density of 0.44 Jy. The theoretical confusion noise for A12 around 60 MHz is 0.75 Jy. Analysis of Stokes V images shows that the noise scales with the observing time as expected. (Shulevski et al., in prep.)

Currently we process the data in offline mode. Expanding the array over the full LOFAR core is possible, as well as real-time operations. Computation challenges will need to be addressed and can be partially offset by adapting the calibration strategy.




The instantaneous all-sky monitoring of AARTFAAC-12 makes it an excellent tool for monitoring large scale structures in the ionosphere. Ionospheric density gradients will effectively cause a radio source to move its apparent position. By imaging these position shifts in different lines of sight one can make a direct image of the ionosphere in (near) real time. The figure *on the left* shows the reconstruction of a simulated ionospheric wave, using a realistic noise level and source model. (Mevius et al., in prep.)

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