Monitoring and Control of EMBRACE,

a 4608 Elements Phased Array for Radio Astronomy

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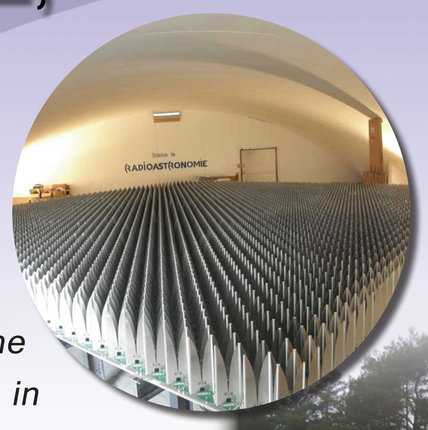
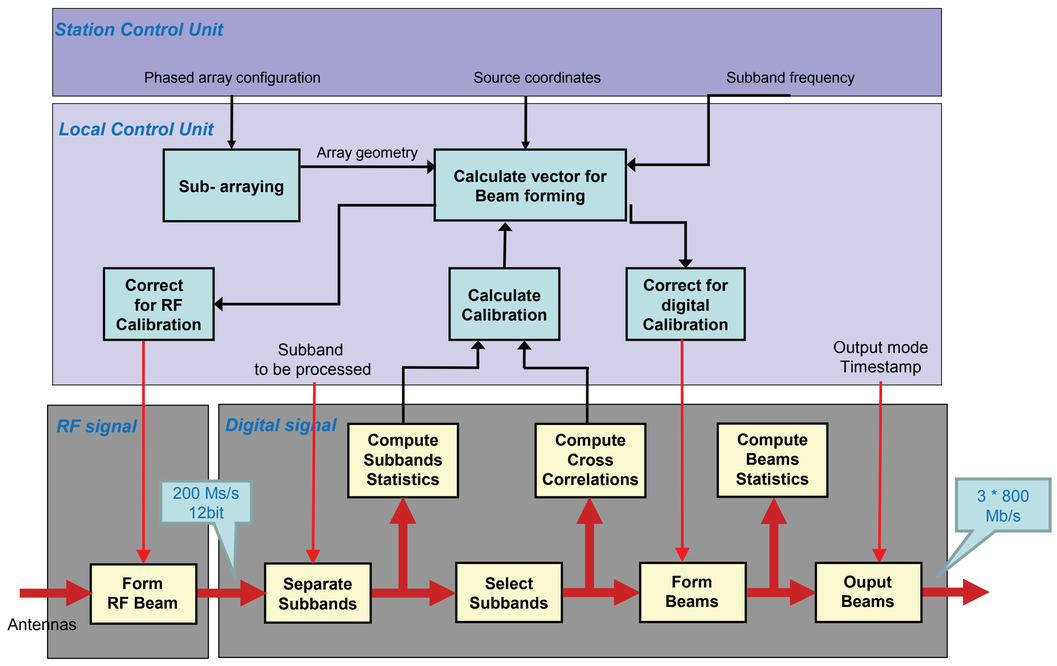


EMBRACE is a technology demonstrator for the decimetre wavelength range of the Square Kilometre Array. Two arrays have been built with one at Westerbork in the Netherlands, and the other at Nancay. The array at Nancay currently has 64 tiles each with 72 antenna elements, making a phased array of 4608 elements. EMBRACE is capable of real-time analog beamforming in two independant directions using a LOFAR backend. Multiple digital beams can be formed inside each RF beam. As a demonstrator instrument, the primary goal is to test and verify its merits as an SKA candidate design. We have developped the control software for EMBRACE including both the real-time control software and the observation setup system.



EMBRACE Processing

- RF signal comes from 16 tilesets (each tileset has 288 antenna elements).
- RF beamforming of 4 elements is done by beamformer chips developped at Nançay.
- The output of tilesets is fed into LOFAR-type RCU and RSP boards for digital beamforming.
- Local Control Unit (LCU) computer calculates coefficients for RF and digital beamforming.
- 1 second integrated data (statistics) are calculated by Backend firmware for calibration.
- 3 X 1Gbps spectral data (beamlets) output.
- Observation setup is provided by Station Control Unit.

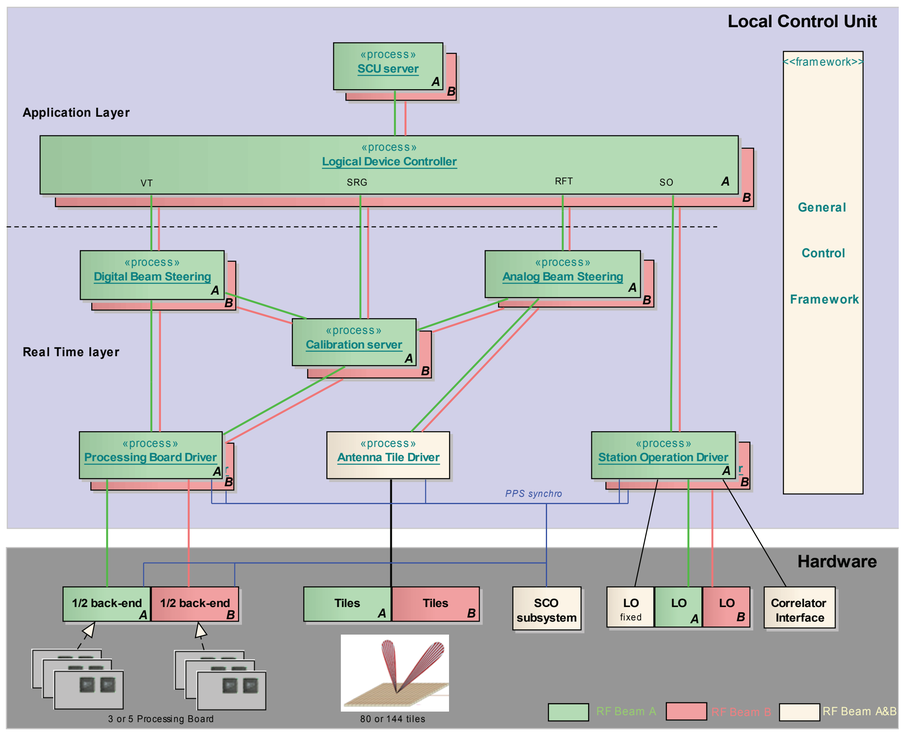
Local Control Unit (LCU) Software

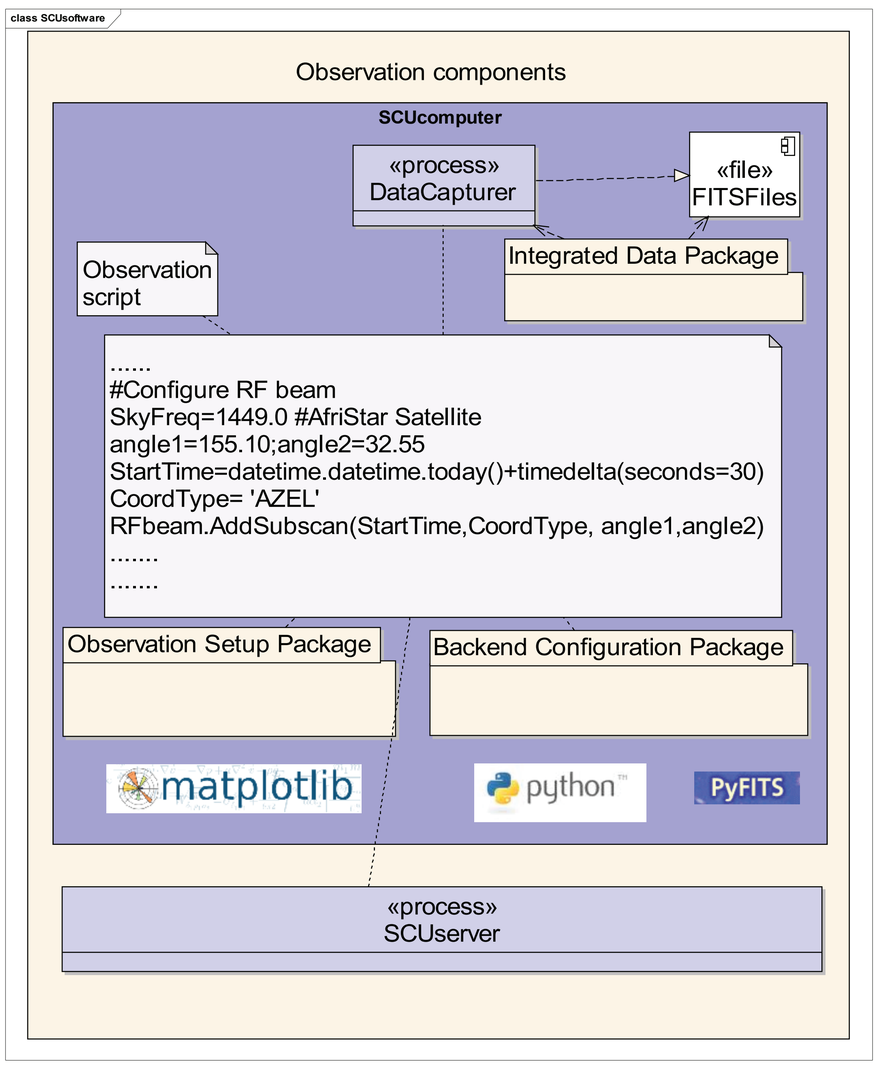
Architecture:

- Framework ⇨ Event driven system (processes communication, task, port, state machine mechanisms).
- Real time layer ⇨ Beam steering computation - Beam calibration - Link with hardware device.
- Application layer ⇨ schedule (start/stop observation, beam handle and instrumentation configuration) - Interface with SCU.

Specificities:

- Reuse the LOFAR C++ control software and adapt to architecture for Embrace features.
- Split back-end : each RF beam is handled by an independent hardware and software, excepted for antenna driver (one hardware address per tile).



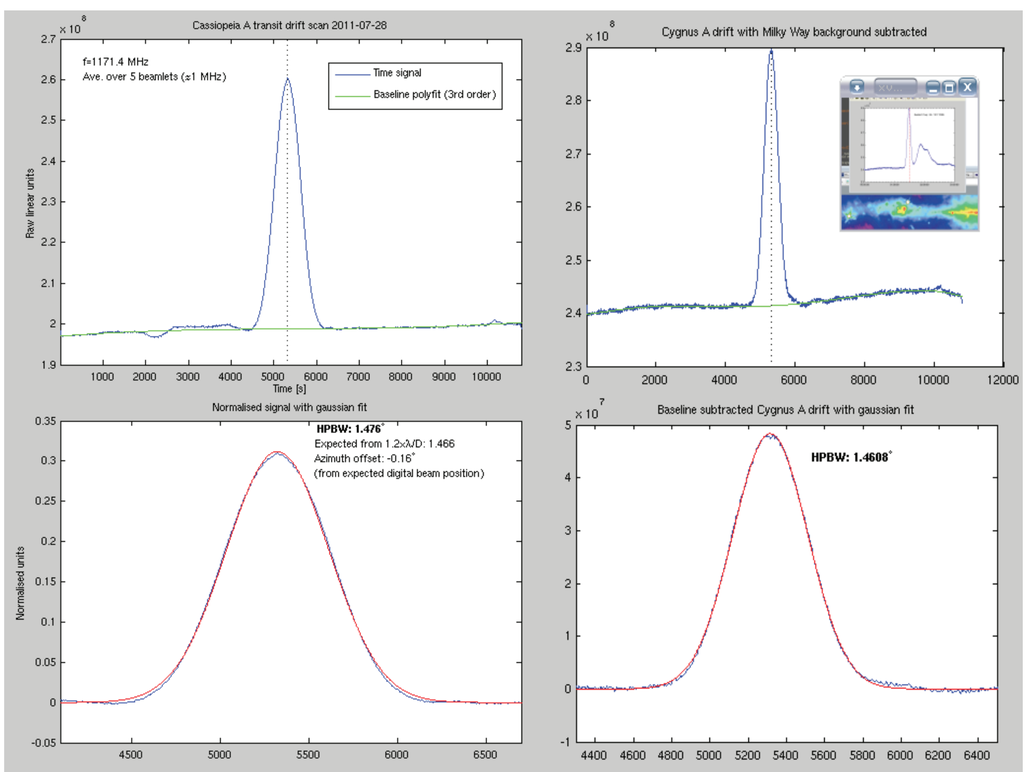


Station Control Unit (SCU) Software

- SCU software provides interface between user and real-time LCU software.
- An extensive Python package library gives scripting functionality for users to easily setup observation scripts for various targets and type of observation.
- A Data Capturer process captures observation meta-data and integrated data.
- Integrated statistics data are saved into FITS files.
- Raw data (beamlets) are captured from Ethernet 1Gbps output and saved into binary files.

Observation Results

EMBRACE@Nançay does routine observations of strong radio sources Cassiopeia-A (a super nova remnant) and Cygnus-A (a radio galaxy). The figure shows a drift scan of the continuum source Cas-A, and Cygnus-A observed in the HI-Line (21cm). The drift scans are used to measure the main lobe profile of EMBRACE. The main lobe is Gaussian to a high degree, and the beam width matches the expected value. (images by Henrik Olofsson).



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