Single base line interferometer for mJy observations

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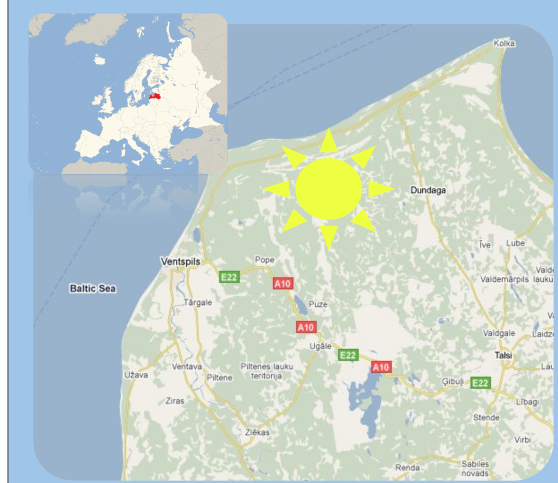
Abstract

In the the VIRAC of VeUAS has been developed a 800 m single baseline interferometer consisting of 32 m and a 16 m radio telescopes, operating at C/X-band. The correlation and calibration of the visibility data make use of the SFXC correlator and ParselTongue, developed by JIVE, enabling observations to approach the theoretical sensitivity limit of the interferometer, at about 6 mJy for a 120 s integration. The initial science themes of this new instrument will be high-cadence monitoring of blazar jet variability and both the 6.7 GHz methanol maser and radio continuum emission from high-mass protostars with associated Ultra-Compact HII regions and newly formed jets.

Irbene interferometer



Google maps screenshot of telescopes location (right)

Map of part of Latvia where telescopes is are located and map of Europe red-colored is Latvia (left)

The interferometer is a 800 m single baseline system which comprises two C-band telescopes, of 32 and 16 meters (RT-32 and RT-16).

Telescopes

RT-32

Azimuth maximum velocity
2.8 deg/sec 5 deg/sec
Elevation maximum velocity
1.8 deg/sec 5 deg/sec
Azimuth range
-328 - +328 deg
Elevation range
2.7 – 90 deg
Az/El pointing precision
~10 arcsec
Surface accuracy (RMS)
0.2 mm 0.1 mm
Working frequency range
0.3 – 22 GHz 1.4 – 40 GHz

RT-16

Broadband cryogenic receiver 4.5 – 8.8 GHz

RF sub-band	RF band (GHz)	IF Output (GHz)	Local Oscillator (GHz)	Image Band (GHz)	Main Working frequencies (GHz)
1	4.5-5.5	0.4-1.4	4.1	2.7-3.7	5.01
2	5.4-6.4	0.4-1.4	5.0	3.6-4.6	6.10
3	6.4-7.6	0.3-1.5	6.1	4.6-5.8	6.70
4	7.6-8.8	0.3-1.5	7.3	5.8-7.0	8.40 & 8.535-8580

Dever of cryogenic receiver

Antena feed

Antena backend

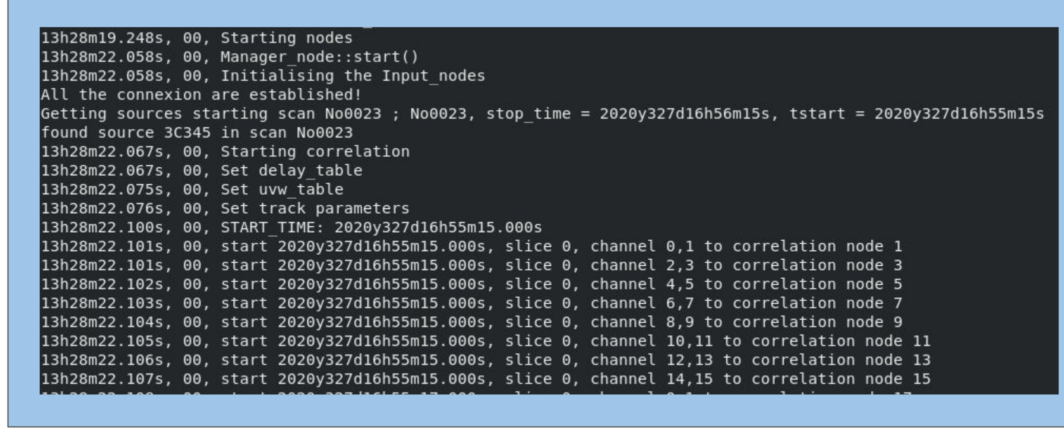
IF unit

Data processing

- SFXC correlator, installed on the VIRAC HPC.
- As output FITS file is created.
- A ParcelTongue pipeline is used for data calibration, which proceeds through the basic steps of calibration in a similar manner to VLBI data post-processing:
  - A-priori gain calibration using 'antab' files (gain curve and Tsys).
  - Bandpass, flagging and frequency definition of the 6.7 GHz methanol maser.
  - Manual phase-cal to remove delay and align polarisations and BBCs in phase.
  - Calibration files are applied to the targets.
  - Phase and rates are determined on the maser emission and applied to the continuum emission of the high-mass protostar.
  - Data are integrated in time and frequency and modelled to determine source flux.
  - Diagnostic plots are produced that allow quick inspection of the calibration quality.

VIRAC HPC

- **The second generation** - each of 9 nodes has 2 X Intel Gold 24 cores processors; RAM 384 GB per node;10Gbps and 40Gbs Infiniband networks; 240GB SSD
- **The first generation** - each of 30 nodes has 2 processors with 8 cores for each, RAM 128 GB per each, 600 GB HDD per item;10Gbps and 40Gbs Infiniband networks.



SFXC run

VIRAC HPC

Observation setup

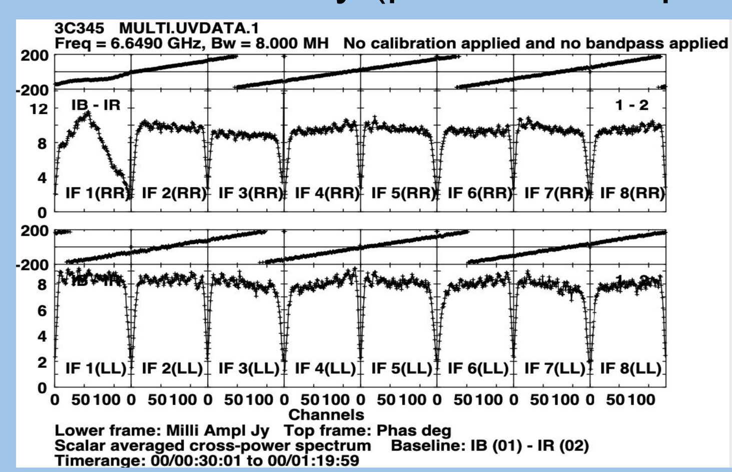
- Observation is done in a typical EVN setup: calibrator - target - calibrator.
- Currently, target source list includes about 20 sources.
- Each target source is observed twice in observation (Strong sources 5 min. scans, week sources 8 min. scans)
- Calibrators sources have 3 min. scans.
- 16 x BBCs are used, 8 x 8 MHz channels for each of LCP and RCP polarisation

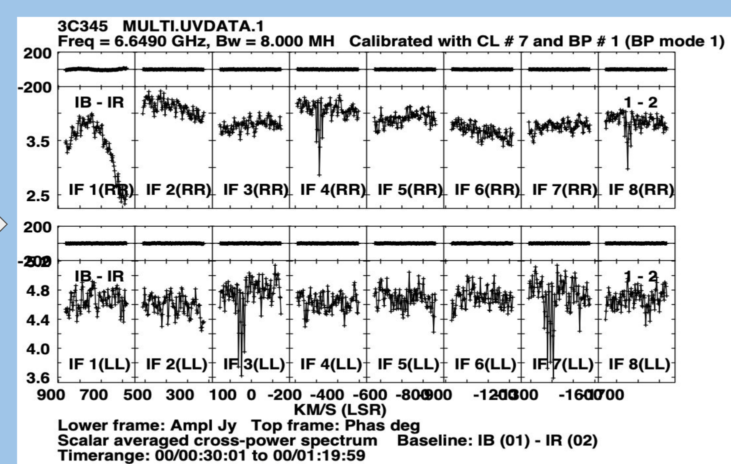
Results

Measure continuum flux towards Ultra-Compact HII (UCHII) zones associated with massive protostars with active methanol 6.7 GHz masers. Sensitivity results close to the theoretical system noise level was achieved (6 mJy for a 120 s)

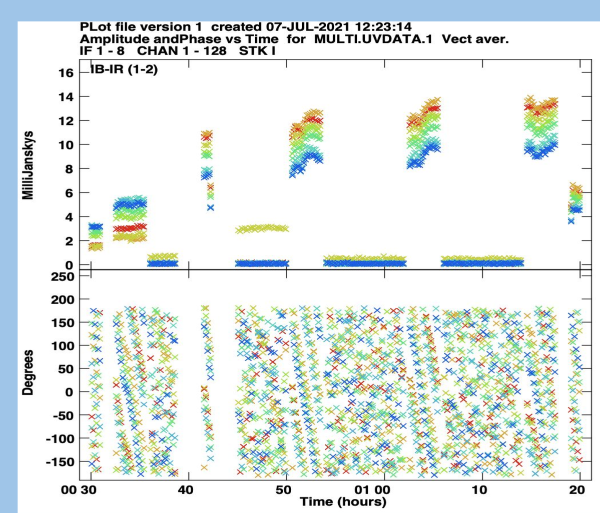
Before **After**

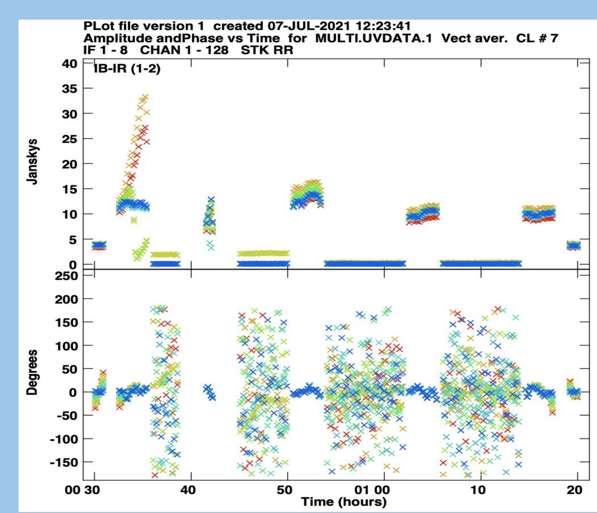
Phase and amplitude vs frequency for calibrator 3C345 which show successful calibration of delay (phase vs frequency slope) and consistency across all IFs



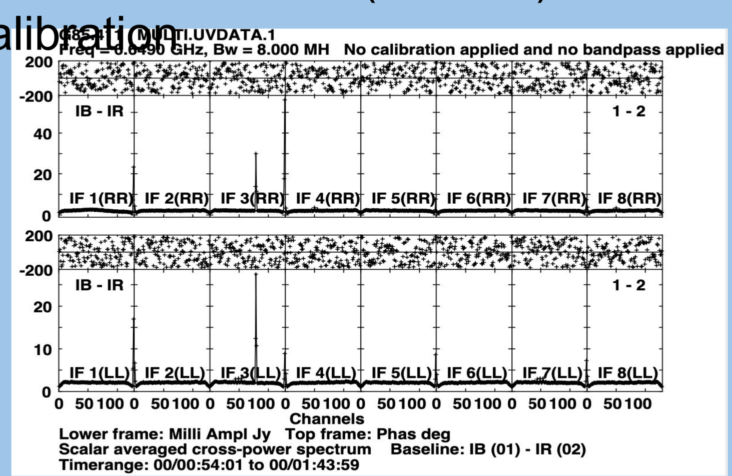


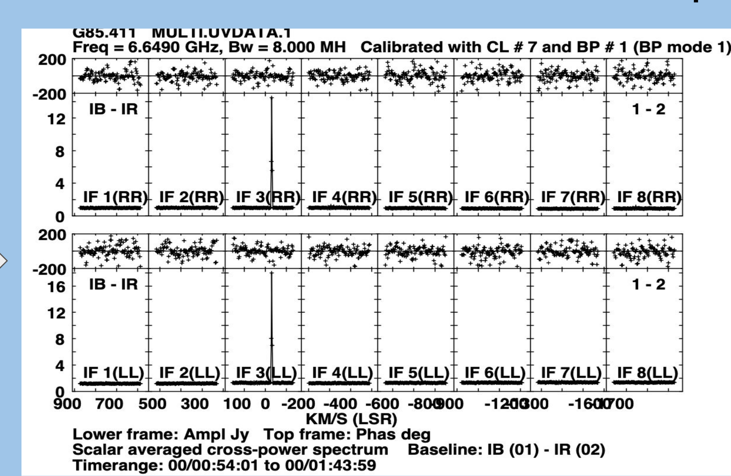
Phase and amplitude vs time for all sources showing that coherence is much improved, allowing full time integration across the scan.



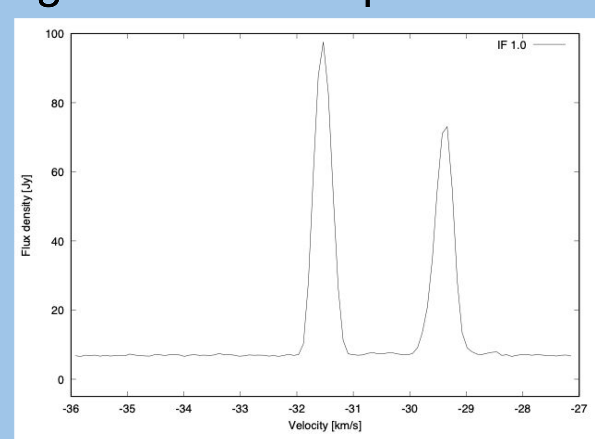


Phase and amplitude vs frequency for high-mass protostar G85.411+0.002 in which the maser (in IF 3) and radio continuum emission become clear upon calibration.

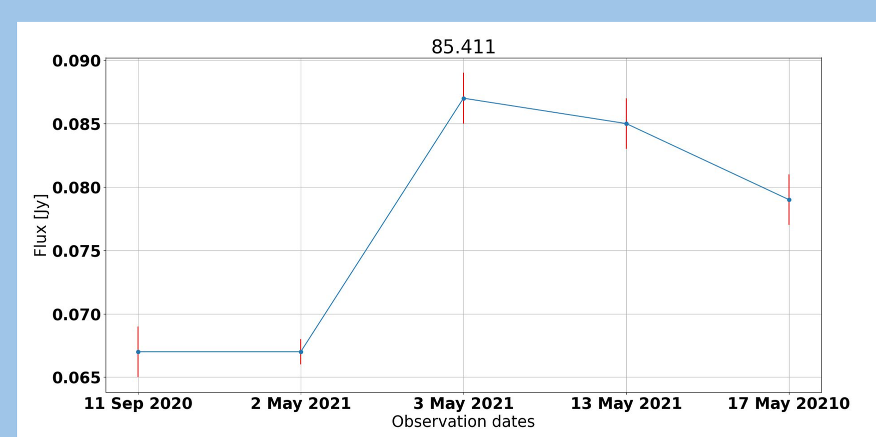




Calibrated cross-correlation spectrum of 6.7 GHz methanol maser in G85.411+0.002, Monitoring will detect flaring of individual spectral components



Initial results of the monitoring of radio continuum emission in high-mass protostar G85.411+0.002



Further improvements will be made to the pipeline and gain stability of the system and test observations of the full (25-35 target) source list are underway.

Science cases

- There are many tasks that do not require comprehensive software and can be done with a few relatively close, radio telescopes and without creating radio maps.
- The main benefits of observations with this type of array would be to increase the real sensitivity of the telescope system close to what is theoretically possible.
- The scientific goal is an observation of radio continuum emission during an accretion event in high-mass protostars with methanol maser emission, particularly to obtain more evidence of masers burst.

Acknowledgement

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