Hunting for fast radio transients at low frequencies with LOFAR

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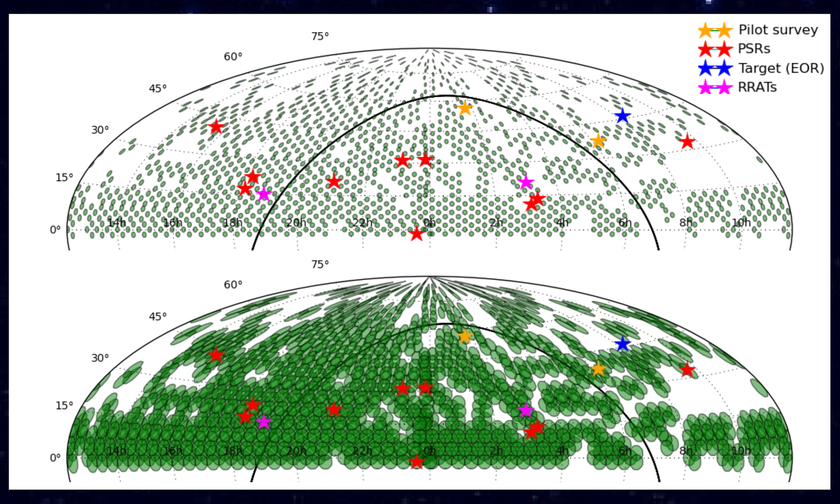
LOTAAS is an all-sky survey for pulsars and fast transients

LOTAAS is the LOFAR Tied-Array All-Sky Survey, an ongoing LOFAR all-Northern-sky survey (Coenen et al. 2014). It uses the 12 HBA sub-stations on the LOFAR Superterp. Each LOTAAS survey pointing is comprised of three incoherent array beams, and together these cover ~30 square degrees of sky. Within the FoV of each incoherent beam we also form a Nyquist-sampled, hexagonal grid of 61 tied-array beams. Together, this set of 3×61 tied-array beams cover a survey area of ~10 square degrees at a sensitivity roughly twice that of the ongoing GBNCC survey. Lastly, for each incoherent beam an additional 12 tied-array pointings are generated and pointed towards any other cataloged pulsars that fall within the incoherent FoV. These additional beams provide valuable data on known sources, simultaneous with the survey observations. All together, there are 3×61+3×12+3 = 222 beams per survey pointing. In other words, this is a survey approach unlike any other and a unique stepping stone on the path to surveying with SKA-Low. With a bandwidth of 32 MHz, a spectral resolution of 12 kHz, and a sampling time of 492 μs, LOTAAS generates data at an astounding rate of 35 Gbps. Each 1-hour pointing produces 16 TB of raw data.

Fast transient: a sub-second radio burst

15% of LOTAAS processed



Survey coverage to date:

Coherent beams

Incoherent beams

Single pointing out of 1953 total

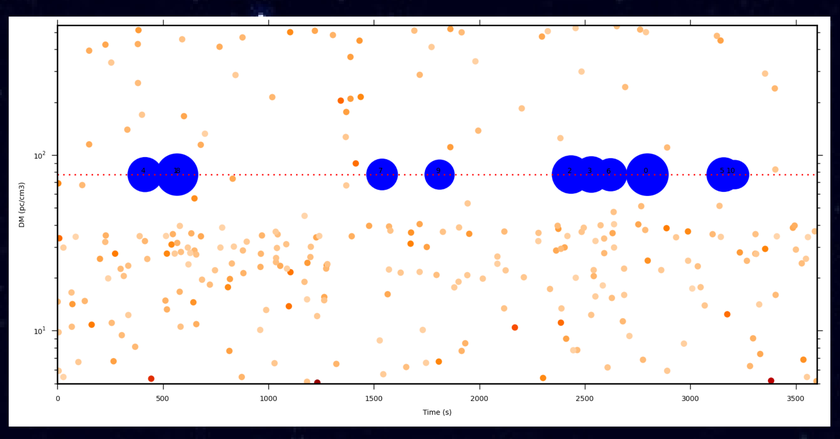
3 incoherent beams
FoV ~ 30 sq deg

Brightness proportional to detected flux

Localization of LOFAR's first RRAT discovery

183 coherent beams
High sensitivity
FoV ~ 10 sq deg

16 new pulsars discovered
2 Rotating Radio Transients



Rotating Radio Transients (RRATs) are pulsars whose pulses are only sporadically detectable. This characteristic makes them difficult to find through "classical" periodicity searches and they are rather detected through the bright single pulses they emit (McLaughlin et al. 2006).

The plot shows the first LOFAR RRAT discovery I have made. The figure has been made with the signal detected in a single coherent beam where the source was present. The RRAT has emitted 10 bright pulses during the one-hour observation, highlighted with the blue circles. The quantity reported in the vertical axis is called Dispersion Measure and represents the amount of free electrons between us and the source. It is linked to the distance of the source.

The small orange dots represent terrestrial interference signals. They are a growing problem in radio astronomy. For each astrophysical pulse, we may also detect billions of interference signals in the same data set. A large part of my project is dedicated to mitigate such interference and pull out the interesting astrophysical signals.

12 sub-stations used

Superterp: LOFAR's core

LOFAR telescope: 1000s of radio antennas connected to a central super-computer
Operates at the longest wavelengths detectable from Earth (~1-30 m)

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www.astron.nl/lotaas

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