

First Batch of Discoveries from the LOFAR High-Time-Resolution LOTAAS Survey

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API / ASTRON

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LOTAAS: survey for radio pulsars and fast transients

- **LOFAR**: Next generation radio telescope
- **Tied-Array**: Beam-forming mode
- **All-Sky**: The entire Northern Hemisphere will be mapped

Scientific goals

- Complete census of local population of pulsars
Neutron-star Galactic population and supernova rate
- Discovery of exotic pulsar systems
Testing GR, physics of dense matter and pulsar emission mechanism
- Discovery of pulsars well-suited for timing arrays
GW detection
- **Characterization of the low-frequency transient sky**
Discovery of RRATs, FRBs, intermittent pulsars and new transient phenomena

Fast Radio Bursts [Lorimer et al. 2006]

Non-repeating extragalactic radio bursts

Possible uses:

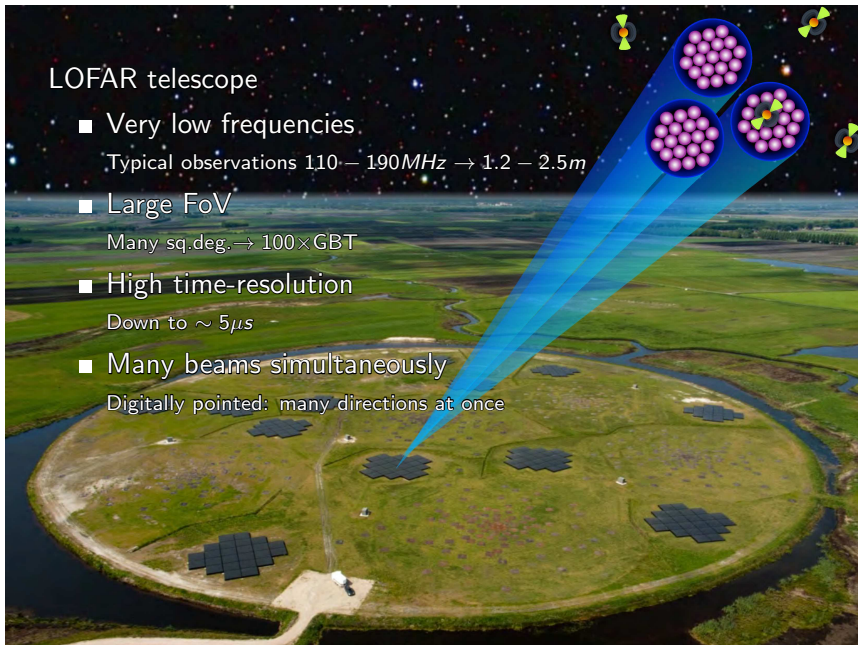
- “Missing baryons” weight
- Dark energy equation of state
- Intergalactic medium
- Intergalactic magnetic field

LOTAAS can detect 1 FRB / 10hrs

- Long dwelling time
- Large FoV

LOFAR telescope

- Very low frequencies
Typical observations $110 - 190 \text{ MHz} \rightarrow 1.2 - 2.5 \text{ m}$
- Large FoV
Many sq.deg. $\rightarrow 100 \times \text{GBT}$
- High time-resolution
Down to $\sim 5 \mu\text{s}$
- Many beams simultaneously
Digitally pointed: many directions at once

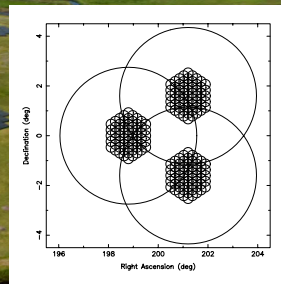


LOTAAS survey

- $t_{obs} = 1$ hour
- $\nu_{obs} \sim 120 - 150\text{MHz}$
- 3 incoherent beams:
 - Total FoV ~ 60 sq deg
 - Single-beam Fov ~ 5 deg
- 3×61 coherent beams:
 - ~ 3.5 times higher sensitivity
 - Total FoV ~ 10 sq deg
 - Single-beam Fov ~ 0.5 deg
- Beams nyquist sampled

~ 4 TB/hour

www.astron.nl/lotaas





LOFAR Superterp
- Signal acquisition

Cobalt
- Beam forming



Cartesius
- Data processing



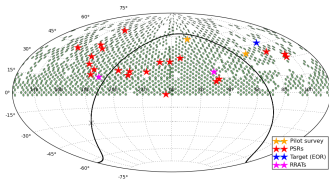
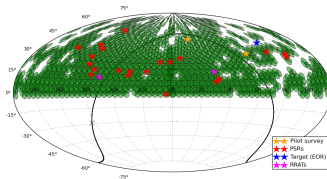
LOTAAS survey

- $\sim 25\%$ observed and $\sim 20\%$ processed (Sep 1st)
- 26 new pulsars discovered (1 every 16hrs!)
- Expected ~ 200 new pulsars in total

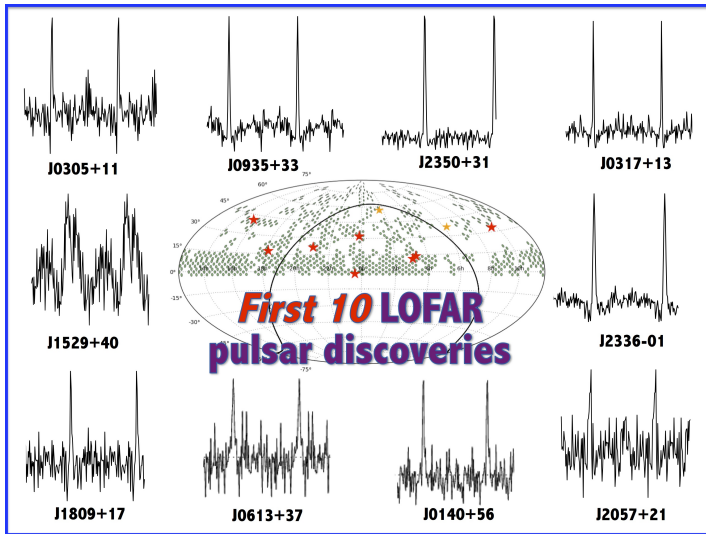
First pulsars discovered with a next-generation telescope!

Already the most succesful very-low-frequency survey since 70s

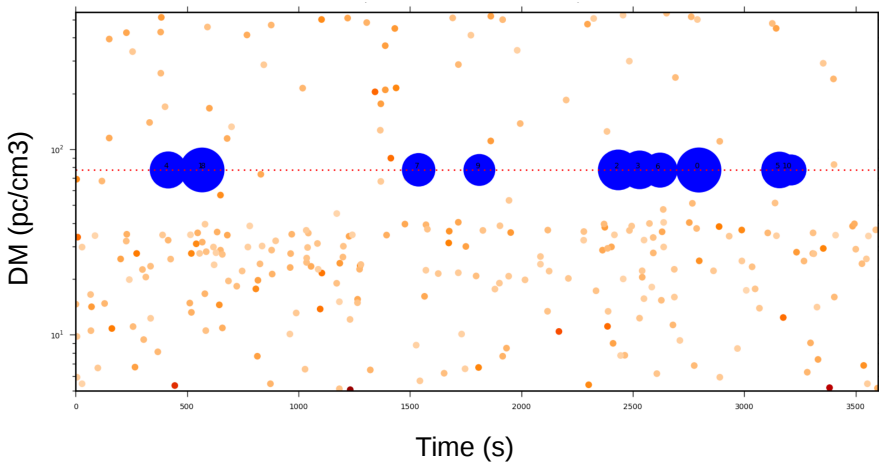
Essential precursor for SKA-low



Periodicity search: 24 new “normal” pulsars discovered
(among the nearest and lowest luminosity pulsars known)



Single-pulse search: 2 RRATs discovered



■ Pipeline Version 2.0

- Acceleration search (for binary pulsars)
- Improved data digital processing
- Refined candidate selection scheme
- Drastically improved single-pulse search
 - Better discrimination of astrophysical events
 - New selection algorithms for candidates

■ DRAGNET

DRAGNET

GPU cluster for high-speed analysis
Backend system connected to COBALT

- 92 GeForce TitanX GPUs
- 368 TB of disk storage
- 2.9 TB of memory

Piggyback mode



The background of the slide is an aerial photograph of a large, circular, grassy field, likely a radio telescope array site, with a winding river or canal. Overlaid on the top half is a dark space background with stars. The word "DRAGNET" is written in large, white, bold, sans-serif capital letters. The letter "G" is replaced by a stylized, glowing orange and yellow sun or star with a blue circular halo. A blue beam of light originates from the bottom left of the "G" and points towards the bottom left of the slide.

DRAGNET

Main scientific goals

- Real time searching for Fast Transients
- Simultaneous observation and timing of pulsars
- Off-line search for millisecond pulsars
- Expansion of LOTAAS characteristics (e.g. time resolution)

