

# DRAGNET

**Jason Hessels**  
(ASTRON/UvA)

LOFAR Status Meeting - Dwingeloo - 150819

# DRAGNET & LOTAAAS Teams

- Jason Hessels (PI)
- Alexander van Amesfoort
- Cees Bassa
- Vlad Kondratiev
- Sotiris Sanidas
- Daniele Michilli
- Sally Cooper
- Ben Stappers
- Joeri van Leeuwen
- Aris Karastergiou
- LOFAR Pulsar Working Group

# LOTAAS

LOFAR Tied-Array All-Sky Survey

A high-time-resolution, all-sky survey using LOFAR's Superterp and "Coherent Stokes" (tied-array) mode.

<http://www.astron.nl/lotaas/>

# DRAGNET

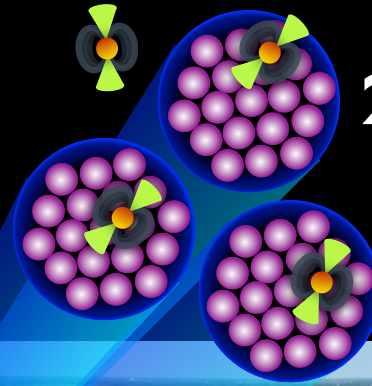
Dynamic Radio Astronomy of Galactic Neutron Stars and Extragalactic Transients

A substantial hardware and software extension to LOFAR's ability to search for pulsars and fast transients.

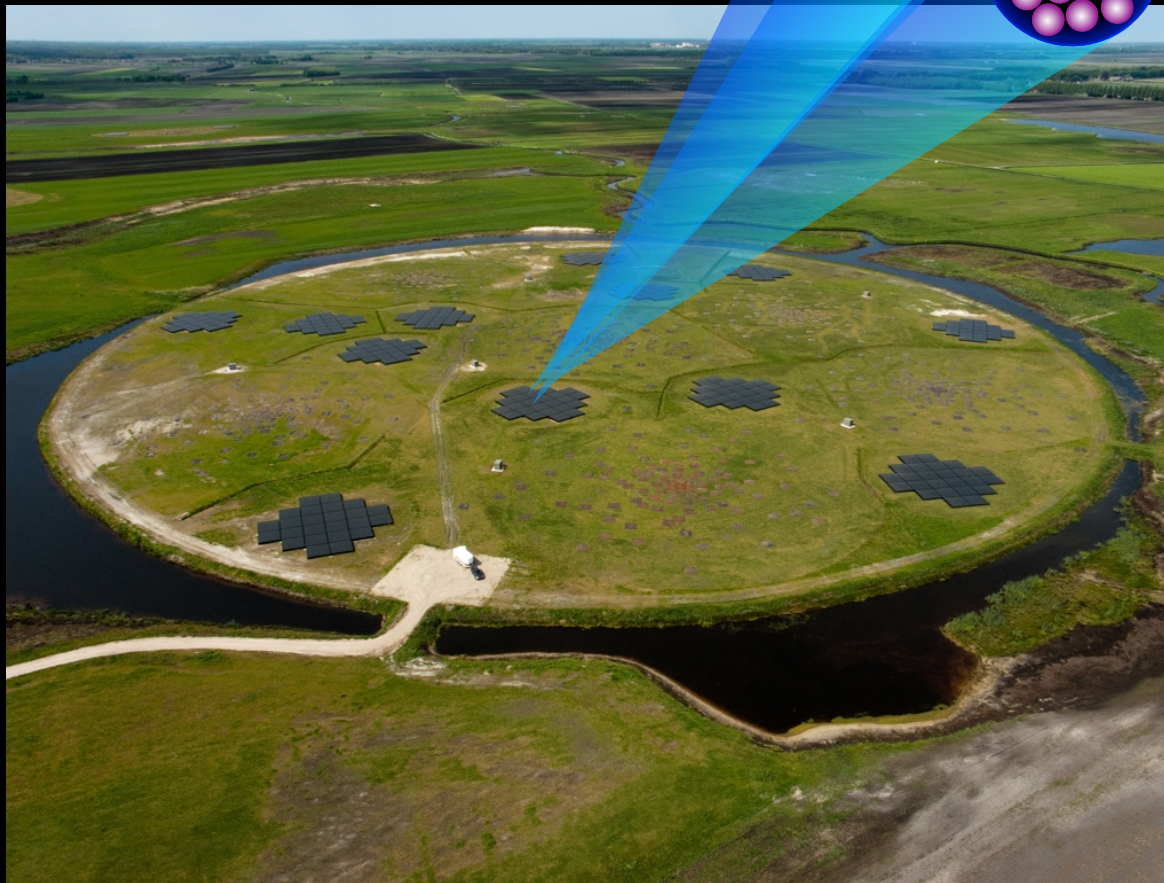
# LOTAAS

## LOFAR Tied-Array All-Sky Survey

**Great field-of-view**  
**Great sensitivity**



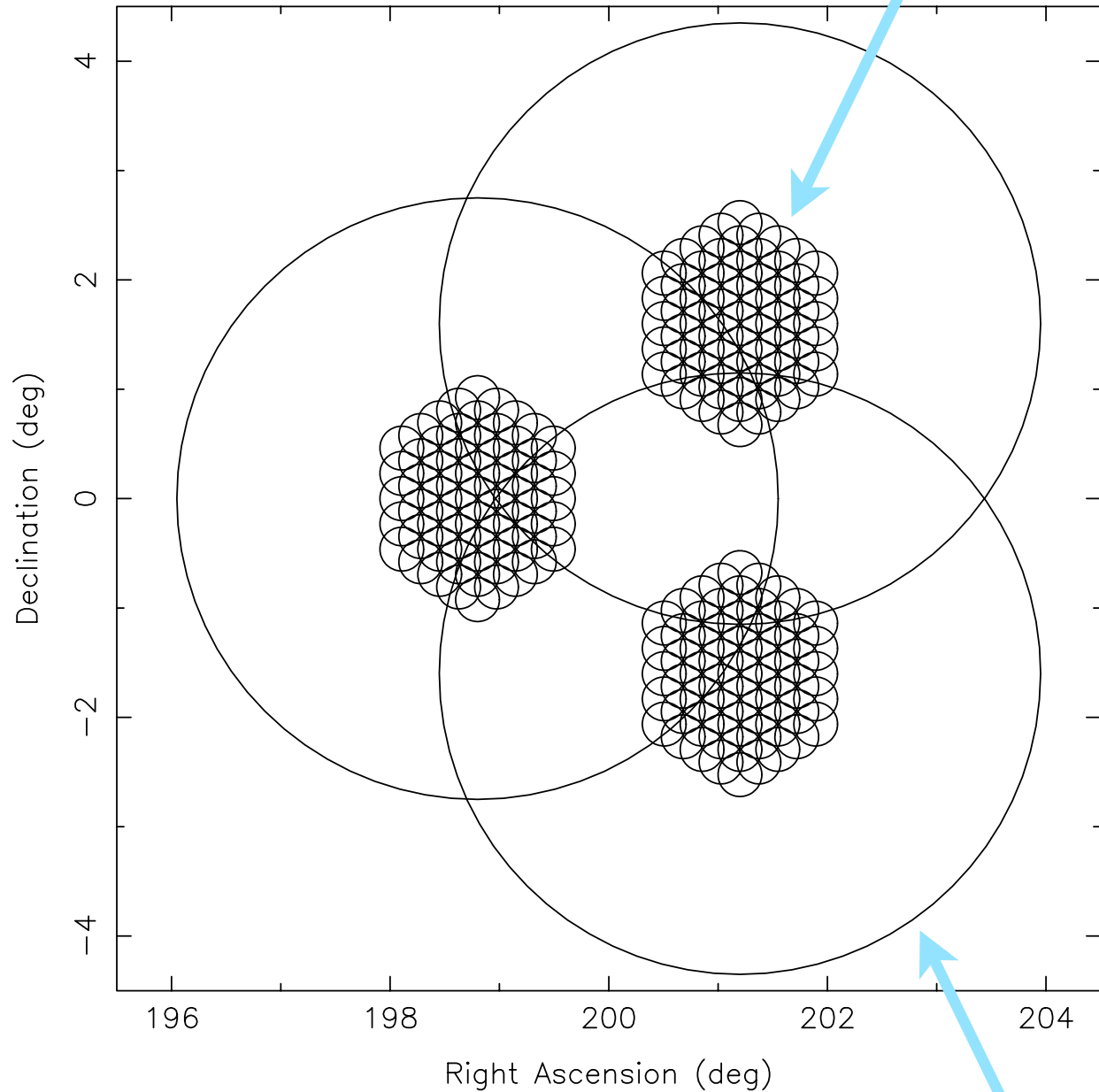
**219 coh. beams**  
**3 incoh. beams**



← LOFAR “Superterp”  
(innermost 12 HBA  
sub-stations)



**Coherent “tied-array” beams**



**LOTAAS  
Single  
Pointing**

**222 beams  
(FoVs) at once**

**First SKA-like  
pulsar survey**

**Incoherent “station” beam**

# LOTAAS

## LOFAR Tied-Array All-Sky Survey

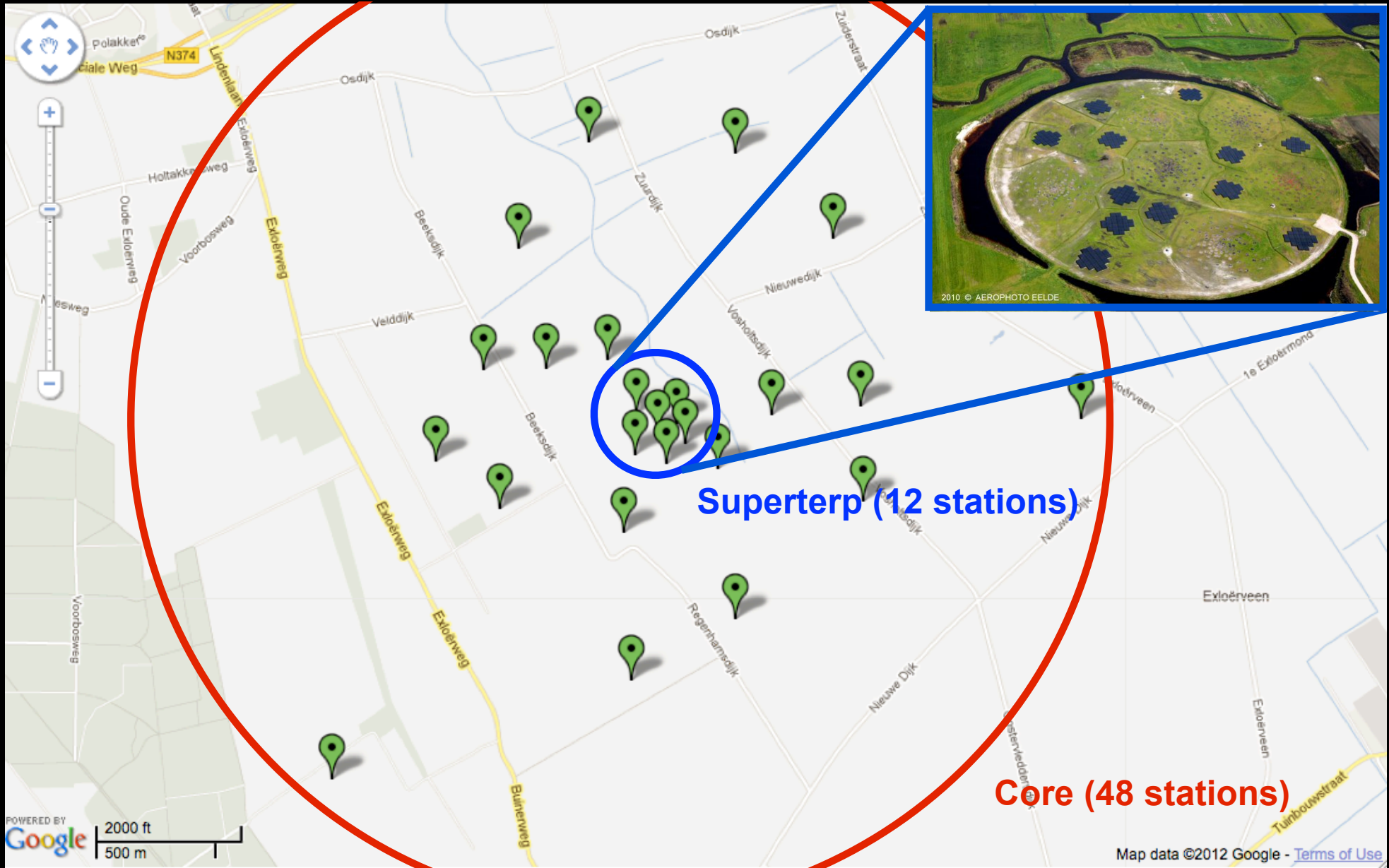
### Survey Specs

- 3 SAPs (incoh. beams) of 32MHz each (119-151MHz).
- 1hr per pointing (1.5hr all-sky by end... new param. space).
- 0.49ms time resolution, 12kHz frequency channels.
- Find millisecond pulsars out to DM  $\sim 50 \text{ pc cm}^{-3}$ .
- **219 tied-array beams**, 3 incoherent beams.
- $\sim 9$  sq. deg. total per ptg. from tied-array beams.
- $\sim 30$  sq. deg. total per ptg. from incoherent beams.
- $S_{\text{min}} \sim 3 \text{ mJy}$  at 135MHz.

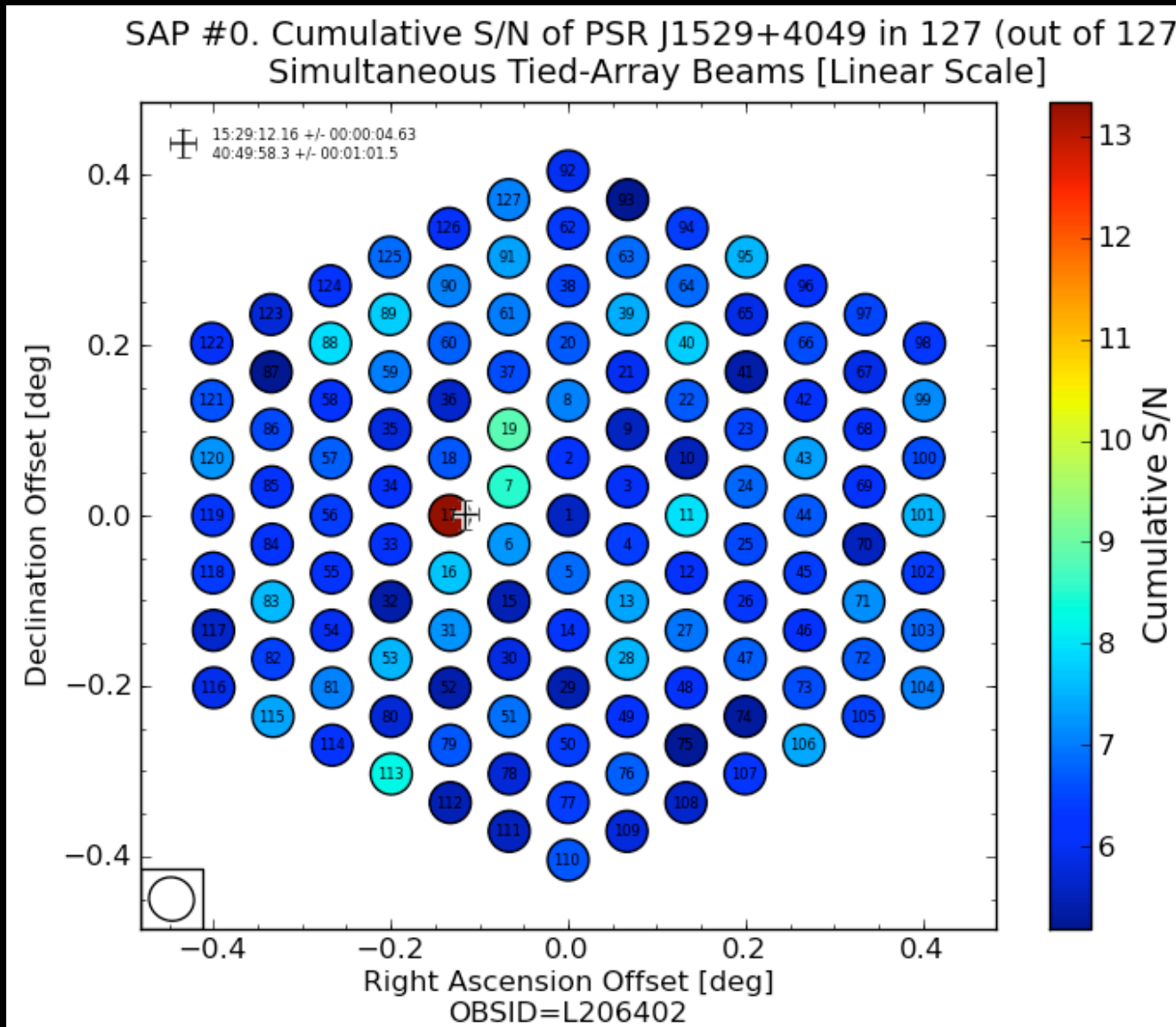
**High-time-resolution version of MSSS**

**The SKA-Low precursor survey**

# The LOFAR Core



# Localizing LOTAAAS Sources



**Also localize transients**



# Extragalactic



Merging Black Holes



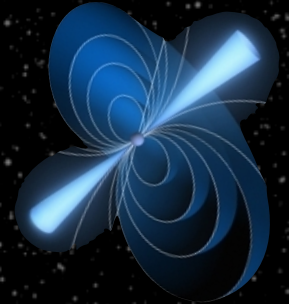
Supernovae



Magnetar Giant Flares



Evaporating Black Holes



Super-giant Pulses



Gamma-ray Bursts

# Sensitivity

and

# Dwell time

## Galactic

ETI



Flare stars



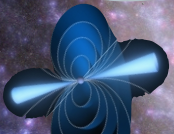
## Terrestrial

Pernicious RFI  
Atmospheric effects

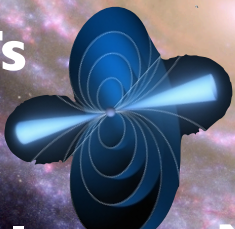


"Blitzars"

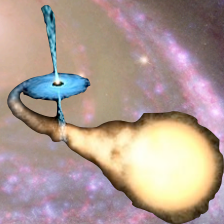
RRATs



Magnetars



Pulsars



Micro-quasars



We are here

# LOTAAS vs. GBNCC

(GBNCC = GBT Northern Celestial Cap Survey at 350MHz)

## Compare with state-of-the-art

- LOTAAS at 135MHz vs. GBNCC at 350MHz.
- LOTAAS ~25x the data rate vs. GBNCC
- LOTAAS > 30x the field-of view of GBNCC.
- LOTAAS 30x the dwell time of GBNCC.
- LOTAAS ~2x the cumulative sensitivity of GBNCC.
- LOTAAS lower time resolution: significantly worse at finding (high-DM) millisecond pulsars.
- LOTAAS likely better at finding intermittent srcs though instantaneous sensitivity is ~2.5x lower than GBNCC.



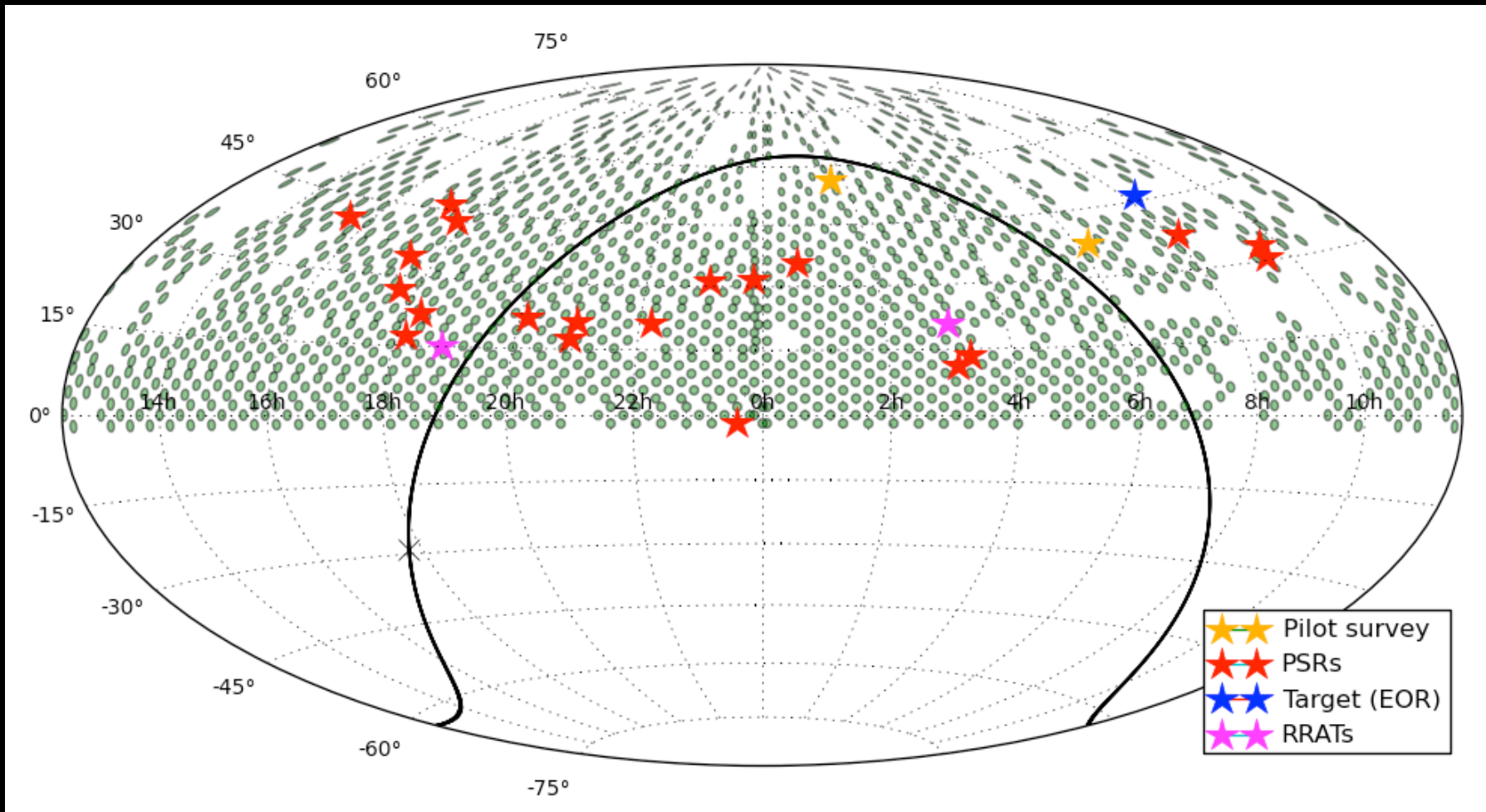
# Observing/Processing Status



- 492 pointings observed so far; 380 processed.
- 651 pointings needed for sparse pass of Northern Hemisphere.
- Processing on Cartesius: 3hrs/pointing/24-core node.
- ~2PB of data collected and archived.

# Discovery Status

<http://www.astron.nl/lotaas/>

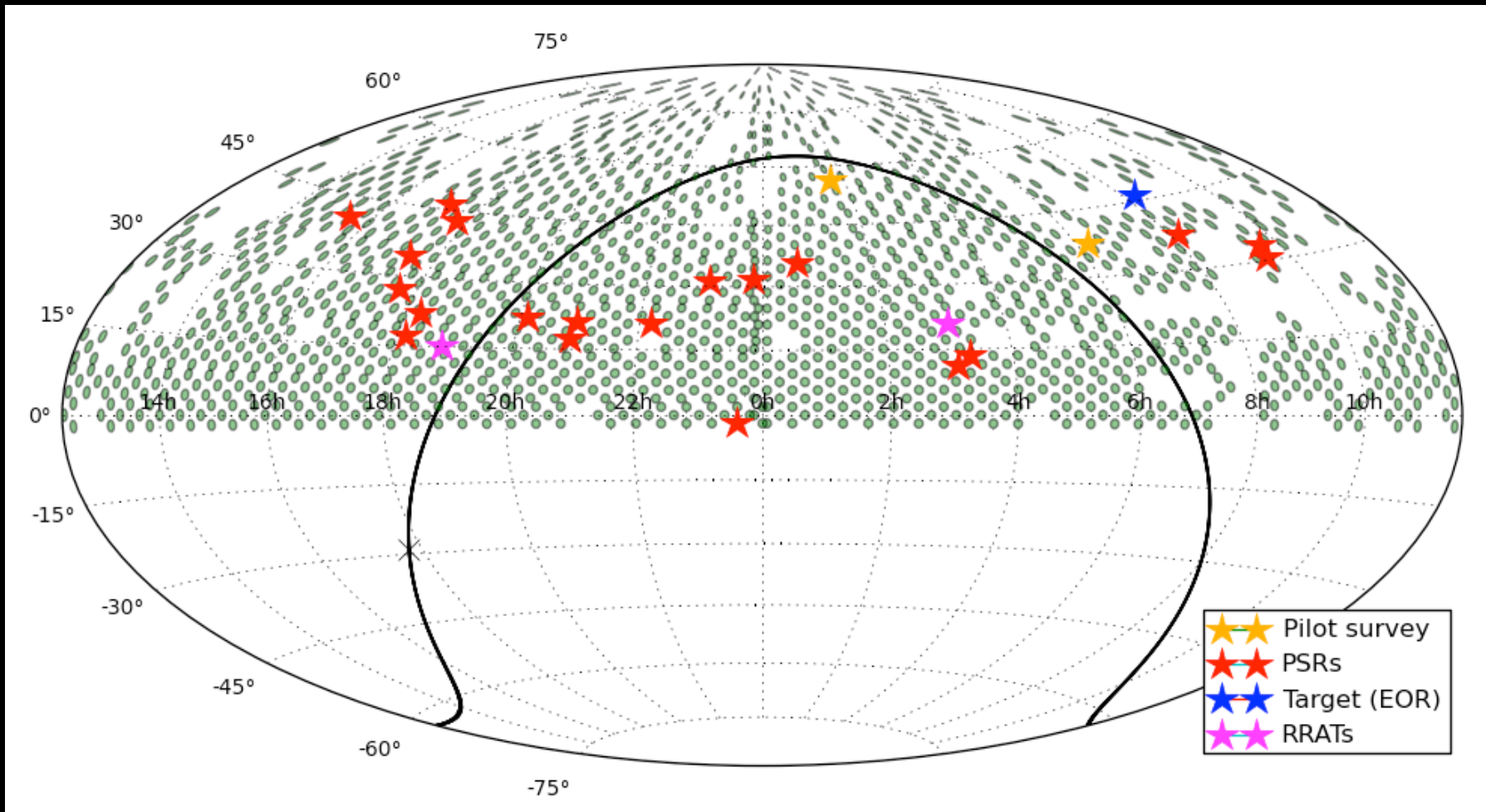


Kondratiev

- LOFAR has discovered 25 pulsars so far!
- 10 pulsars found in last 2 months thanks to a big push by Sotiris Sanidas & Sally Cooper.

# Discovery Status

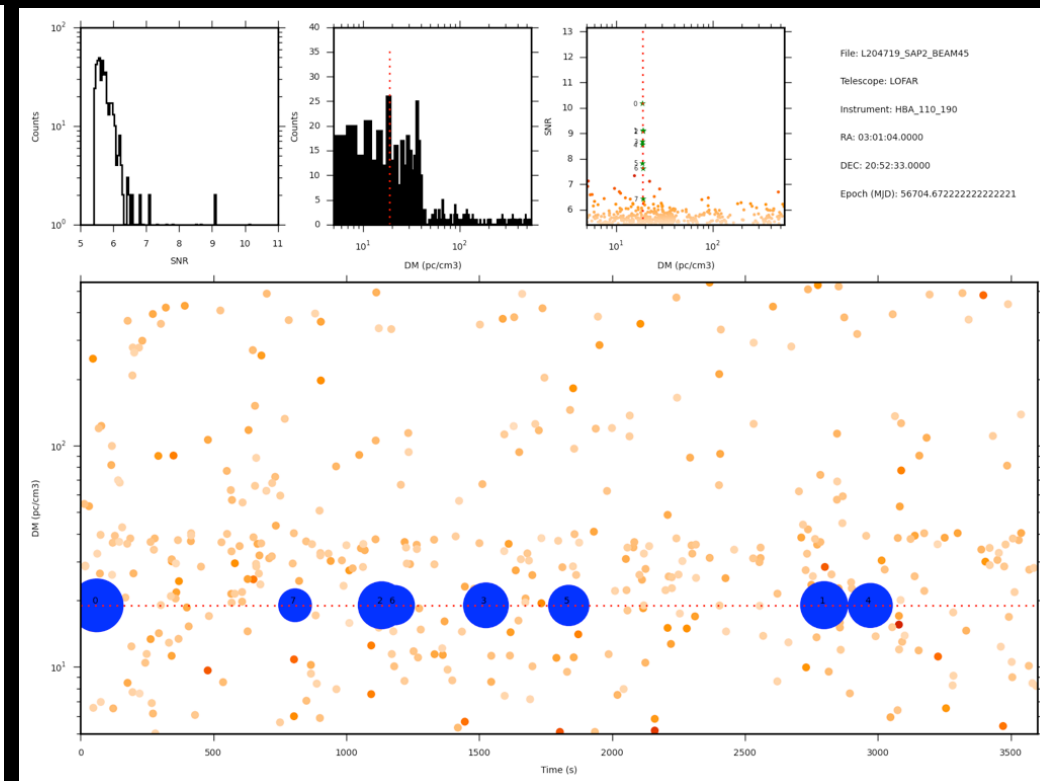
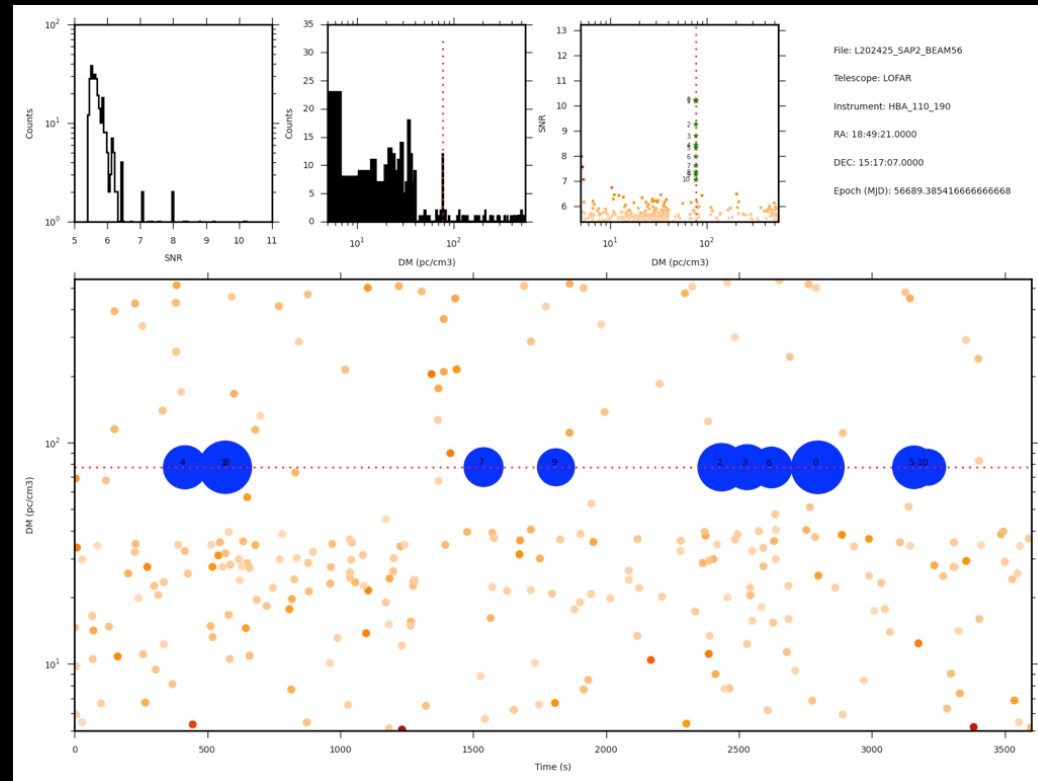
<http://www.astron.nl/lotaas/>



Kondratiev

- Currently at  $\sim 1$  discovery per 100 sq. deg. - as predicted.
- One new pulsar per 13hrs of observing time - very good.
- Single-pulse searches still ramping up (2 discoveries so far).

# First LOTAAAS RRAT Discoveries



Blue circles show astrophysical pulses as a function of dispersion measure and time

Michilli

Same pipeline is looking for fast radio bursts



# DRAGNET GPU Cluster

Delivered and installed at CIT Groningen  
by ClusterVision on July 9th-10th, 2015

Cees

Alexander

Jason

Vlad

Sotiris





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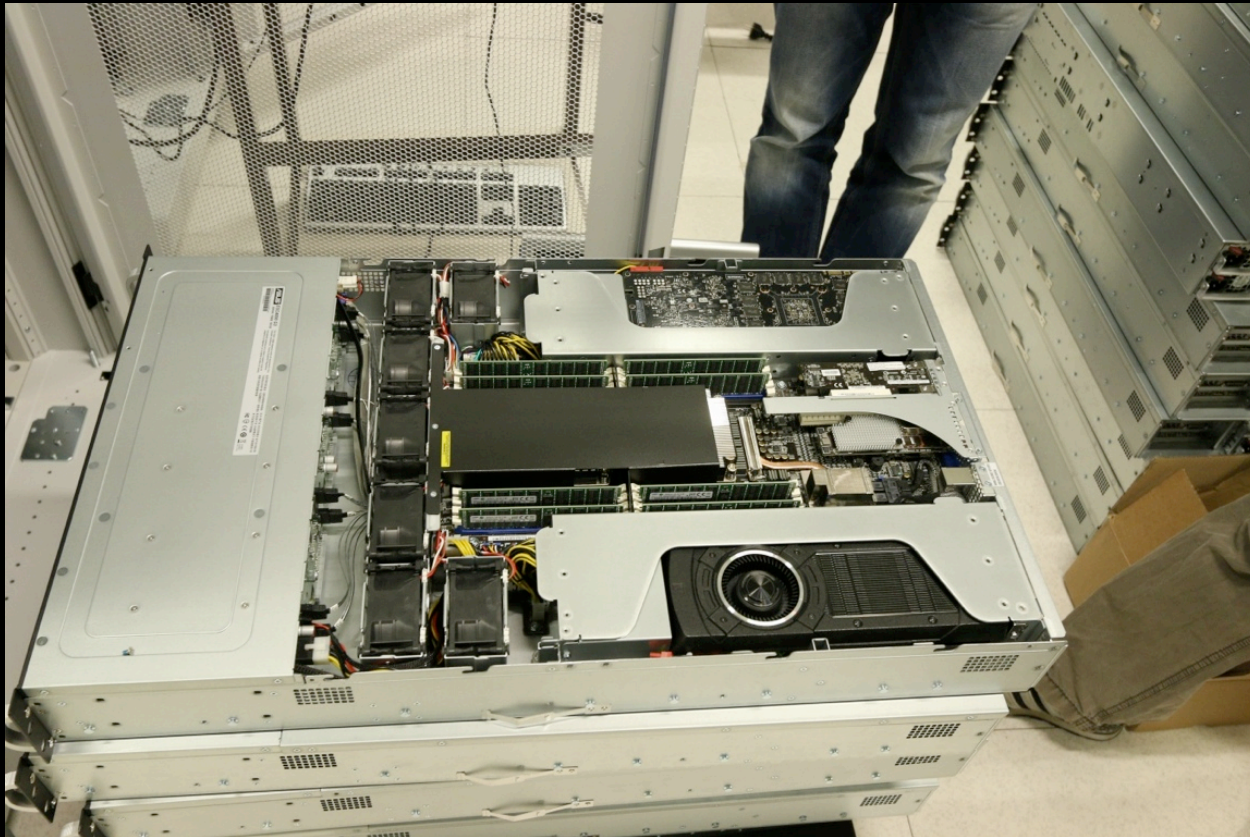
Vlad

Sotiris

Special thanks to:  
Edwin Stuut  
Henk Jonkers  
Arjen Koers  
Hopko Meijering  
Mike Sipior  
Teun Grit



# DRAGNET Worker Nodes (23x)

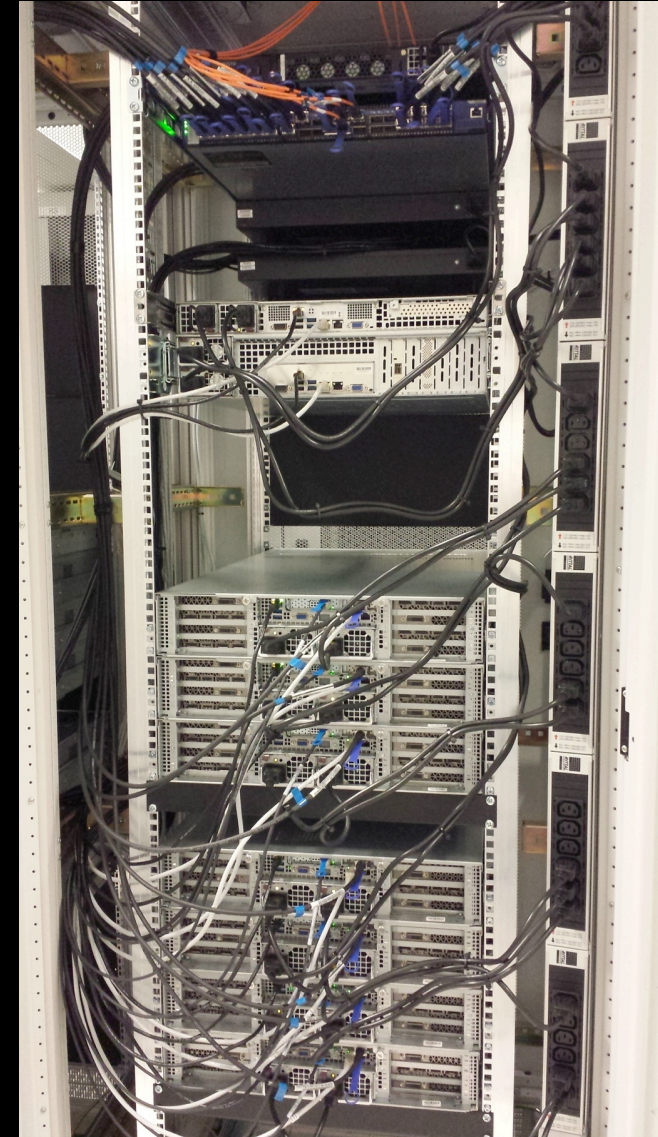
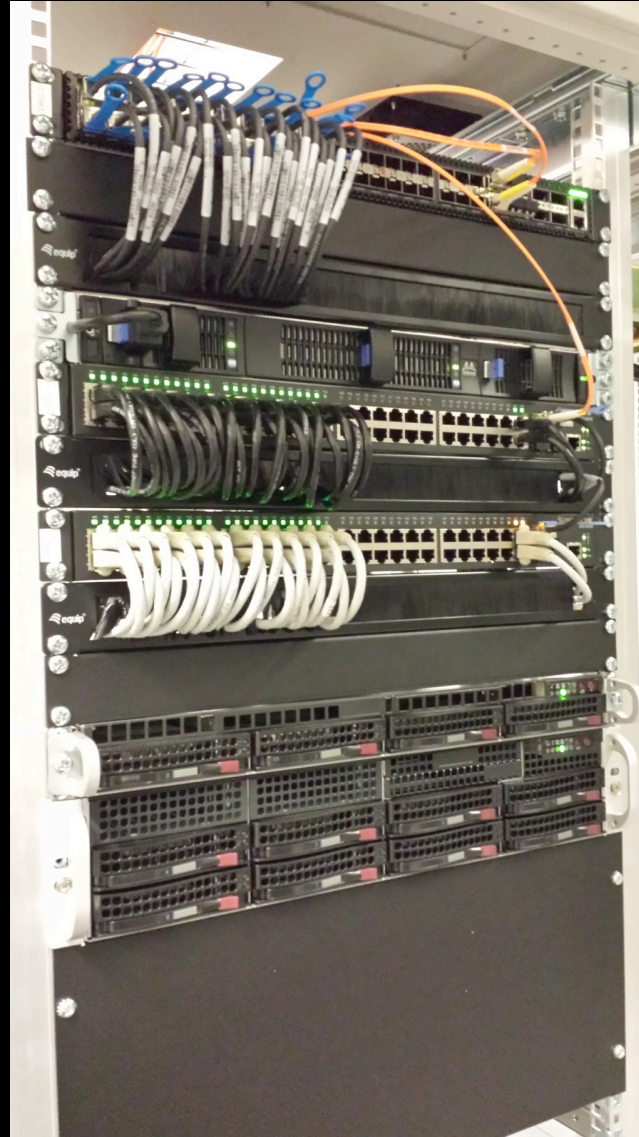


- 4x TitanX GPUs
- 2x 8-core CPUs
- 14TB disk space
- 128GB RAM
- 10Gb Eth
- 1Gb Eth
- Infiniband

Aggregate single precision compute  
power ~0.5 Petaflop

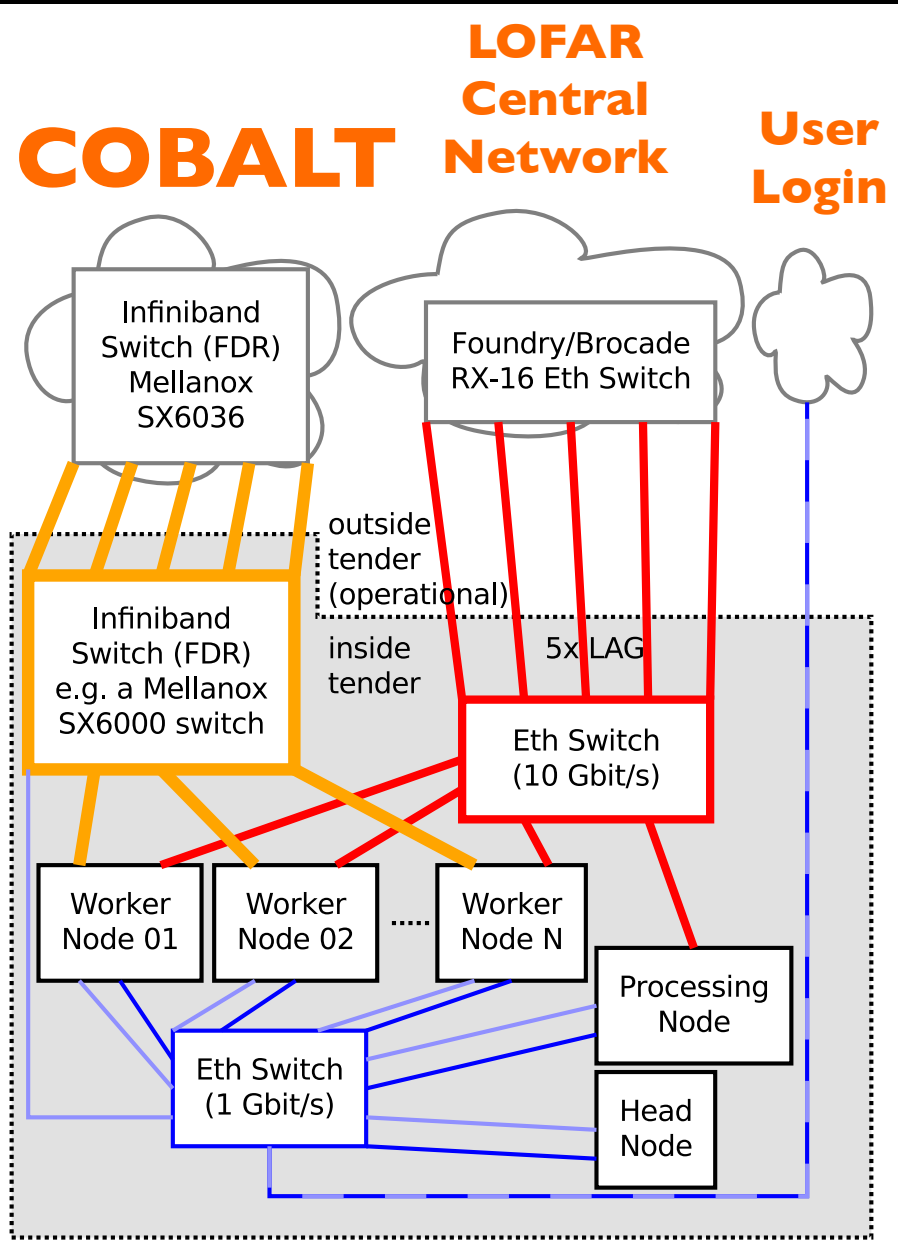


# DRAGNET GPU Cluster



... even more powerful when plugged in!

# DRAGNET GPU Cluster



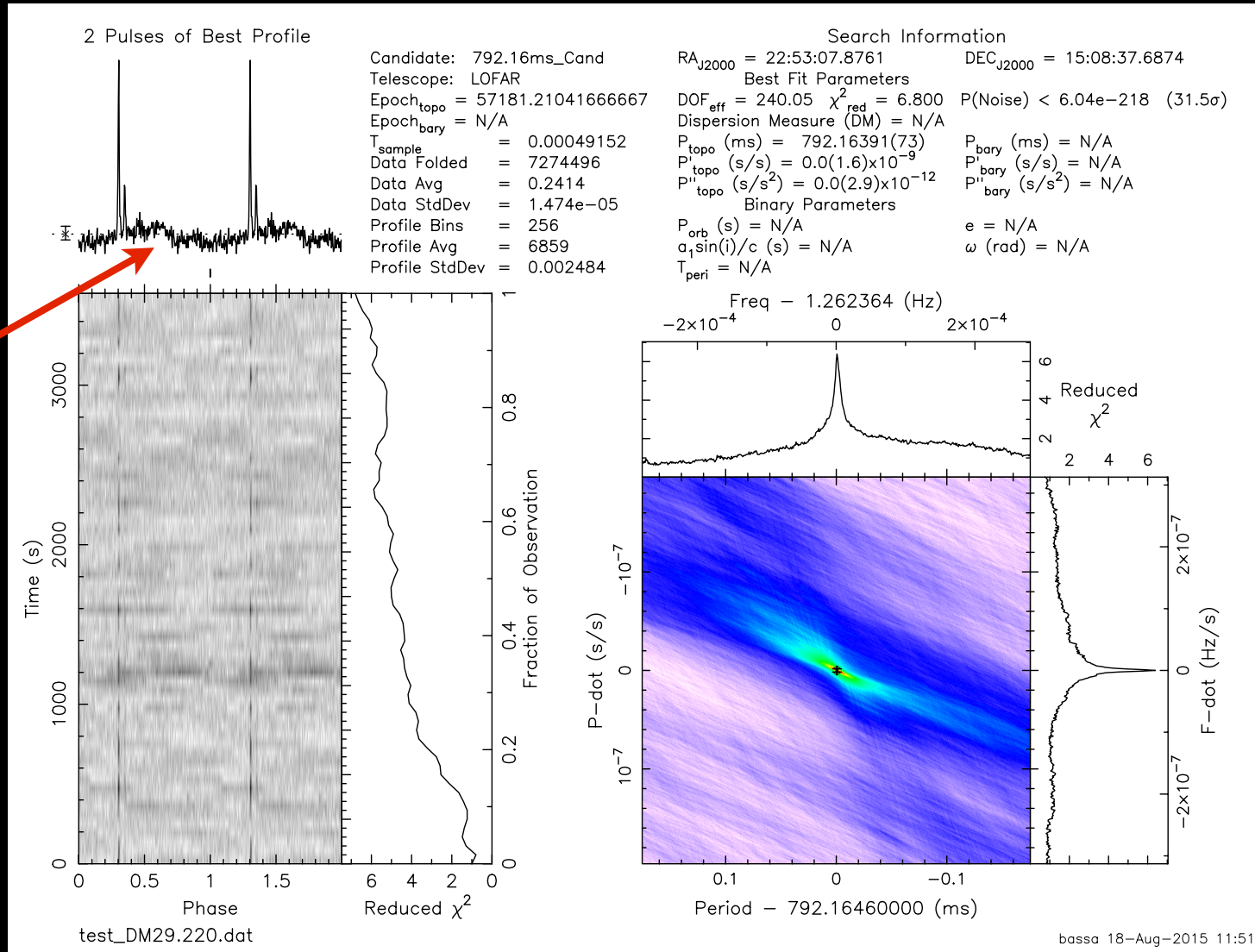
DRAGNET & COBALT are next-door neighbors

- Raw Data Network: Infiniband (54 Gbit/s)
- Batch Data Network: Ethernet (10 Gbit/s)
- User Access Network (Login/NFS/PXE, OoBM/IPMI/MGT): Ethernet (1 Gbit/s)

van Amesfoort



# DRAGNET “First Light” (One of many to come...)



RFI excision  
to be  
improved

Bassa & Kondratiev

4000 trial DMs from 3600s of LOTAAS data,  
calculated in only 25 minutes on 1 TitanX GPU

# DRAGNET “Next Lights”

- Full Cartesius pipeline processing on DRAGNET.
- Write data from COBALT to DRAGNET.
- 2-3x higher time resolution (for milliseconds pulsars).
- Write data commensally to DRAGNET.
- Process incoming data in real-time.
- Parallel observing of many pulsars.
- Online RFI excision on COBALT.
- Online re-bitting on COBALT.
- Online coherent dedispersion step(s).
- Beam-forming on DRAGNET.