Searching for Low Frequency Radio Transients with LOFAR CS1

Casey Law and the Transients Key Project (Amsterdam)

Outline:

- What are these transients?
- Searching with CS1
- Future searches with LOFAR

If we find one of these, you will be the first to know…

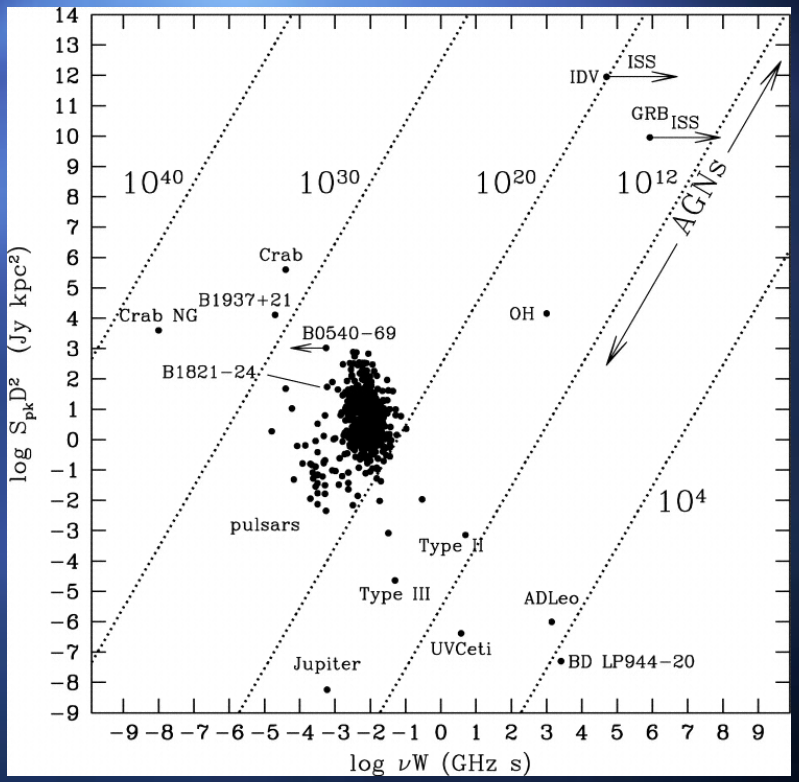
1. What are low frequency radio transients?

At low frequencies, coherent, synchrotron and cyclotron processes dominate.

Where do we find strong magnetic fields?

- AGN
- Pulsars
- GRBs
- X-Ray binaries
- (exo)Planets
- Flare stars
- ?

- Also scattering and scintillation



Luminosity vs. frequency*duration of transients from Cordes & McLaughlin (2003)

2. Searching for transients with LOFAR CS1

A few previous surveys:

Non-imaging:

- MOTER (Amy et al. 1989)
- STARE (Katz et al. 2003)
- Nasu 1.4 GHz (talk by N. Matsumura)

Imaging:

- Green Bank 300ft (Gregory & Taylor 1986)
- FIRST/NVSS (Levinson et al. 2002)
- VLA calibration field (talk by G. Bower)

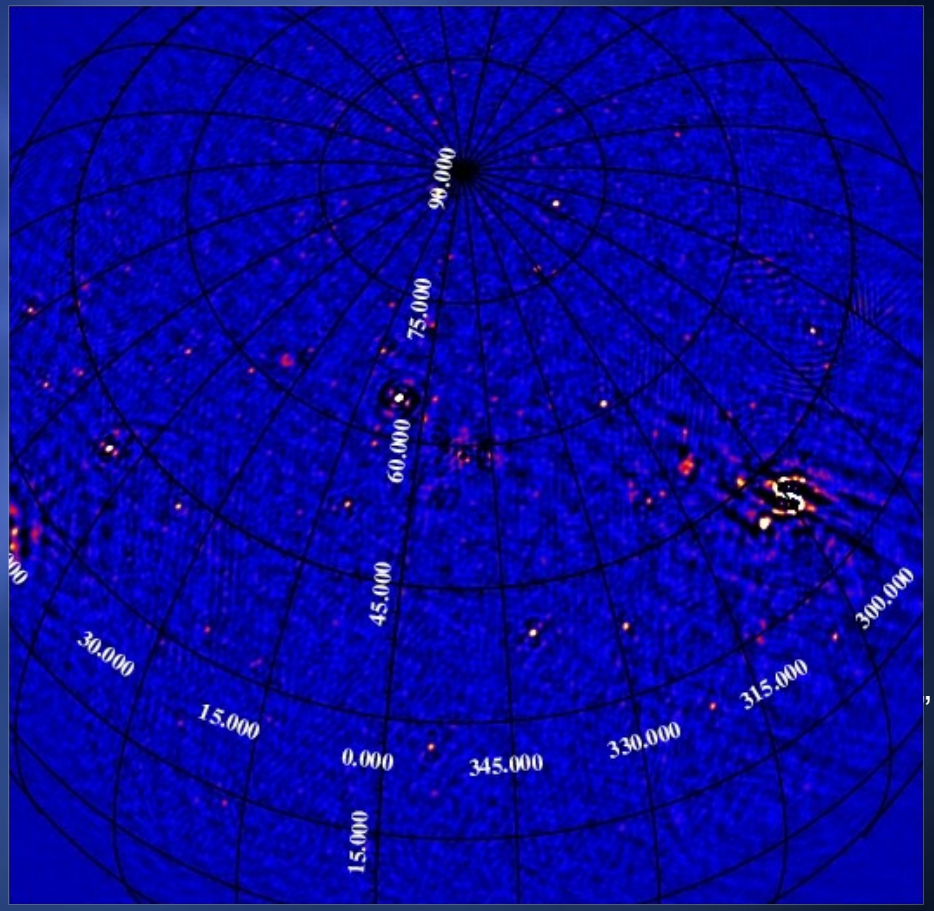
Our ultimate goal: The Radio Sky Monitor

The RSM combines the best of imaging and non-imaging techniques!

2. Searching for transients with LOFAR CS1

Step 1: Core Station 1 survey

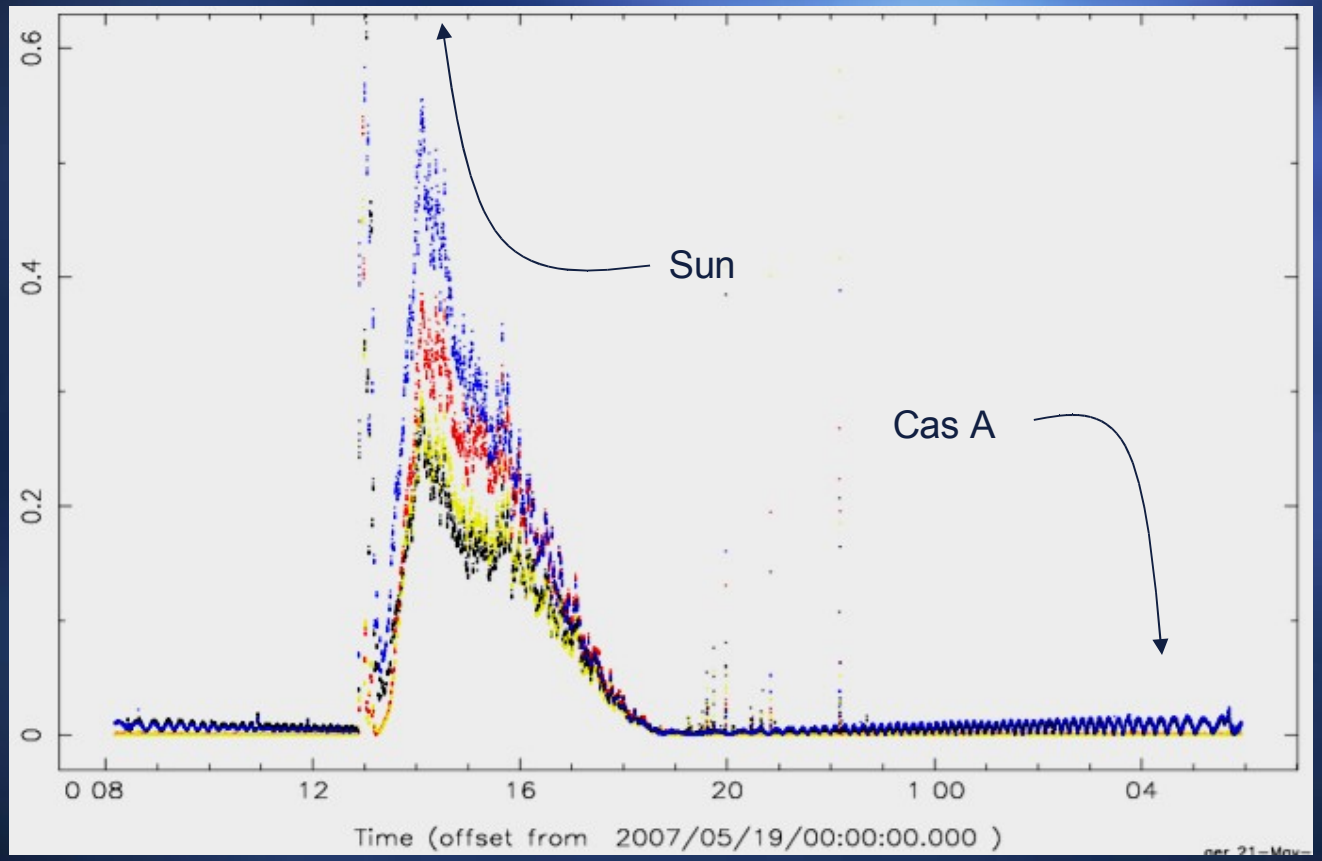
Goals:
- test calibration and imaging pipelines
- test transient search methods
- find bright transients!



Current best, all-sky CS1 image near 60 MHz

CS1 Survey Characteristics:
- center in Cygnus region
- four 12-hour observations
- ν range = 50-70 MHz, 4 MHz bandwidth
- calibration removes Cas A and Cyg A to <1%

Our first transient: the Sun!



Cross-correlated power vs. time for one baseline and four polarizations near 60 MHz

Survey Data Reduction: (see talk by J. Swinbank)

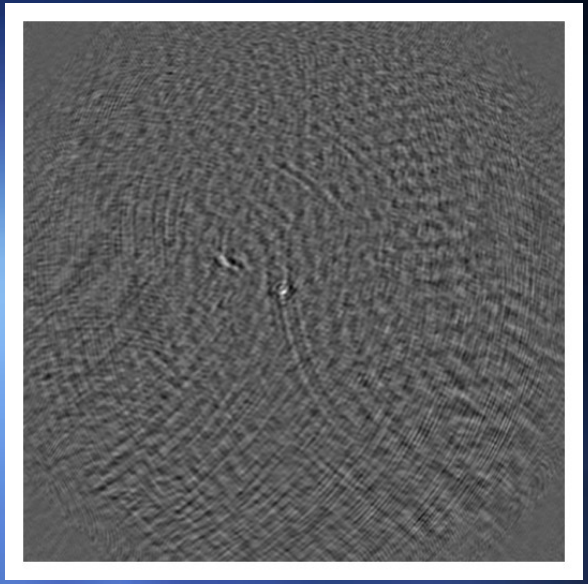
- Flag data (aips++)
- Calibrate assuming simple sky model (MeqTrees)
- Run Transient detection pipeline:

- image short intervals, Δt = 0.5, 1, 2, 4, 8 hours

- difference neighboring images with same Δt

- run source detection on all images

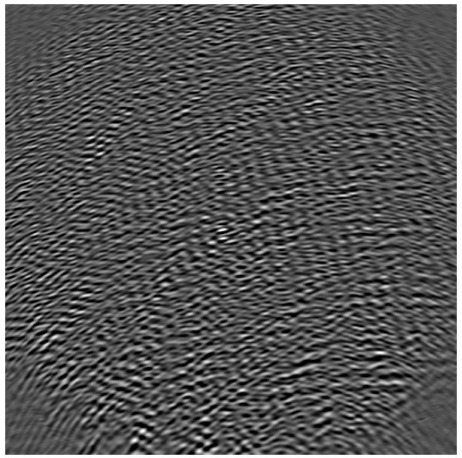
4. Inspect output catalogs and images

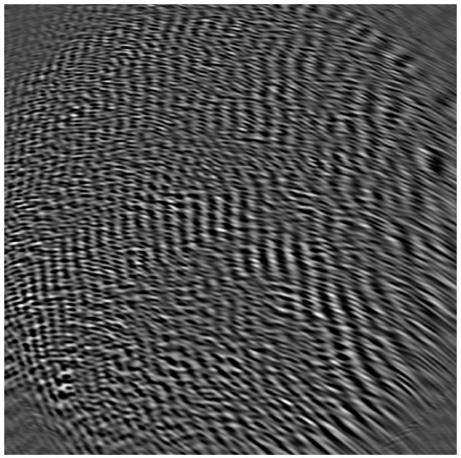


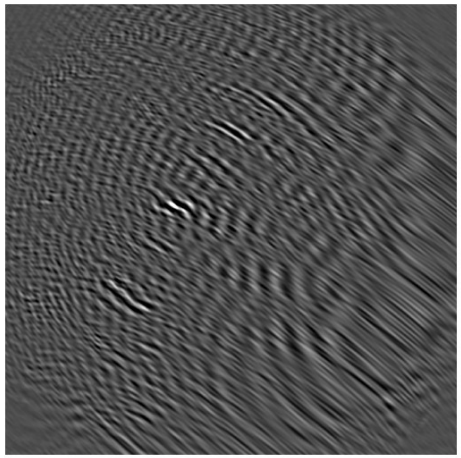
8-hour image

t1 t2 t3

Whole sky







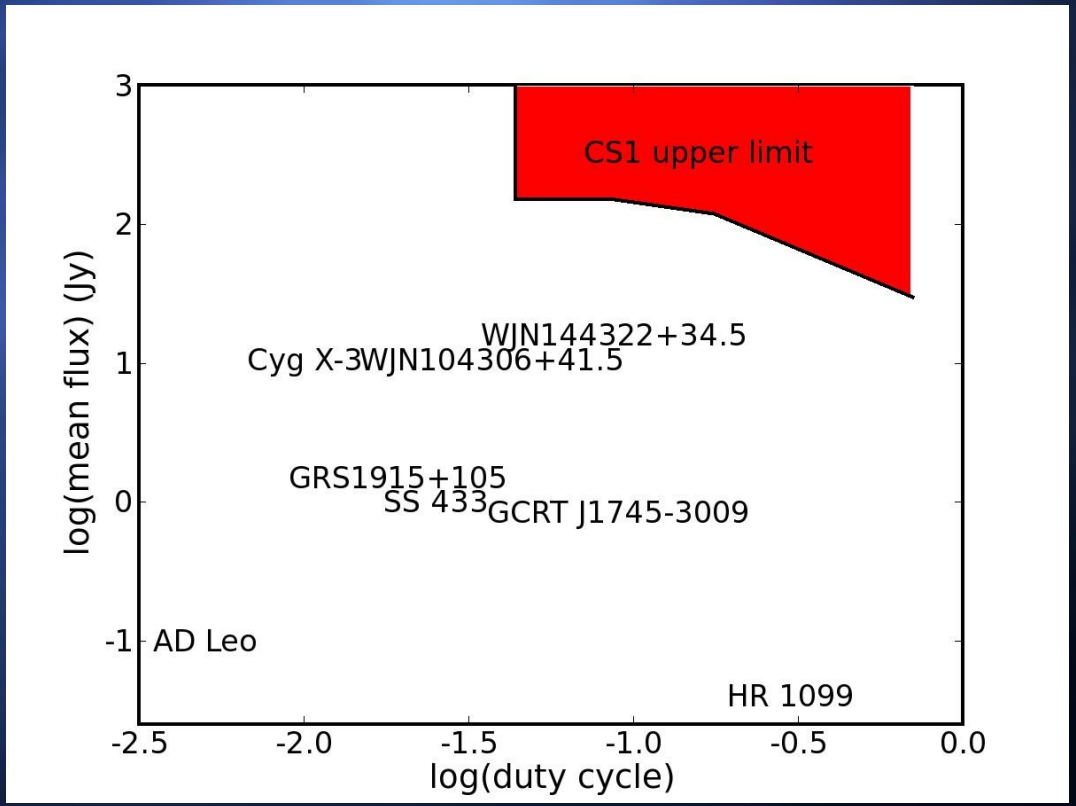
Results:

Good time = 34 hours; analysis most reliable within ~30° of Cygnus A (20h,+40°).

No transients detected.

Number of detections follows Poisson distribution:
$P(N_{det} = 0) = e^{-f*N}$, where f is duty cycle and N is number of observations.

With 95% confidence:
$f_{max}*N = 3$, or
$f < 3/N$



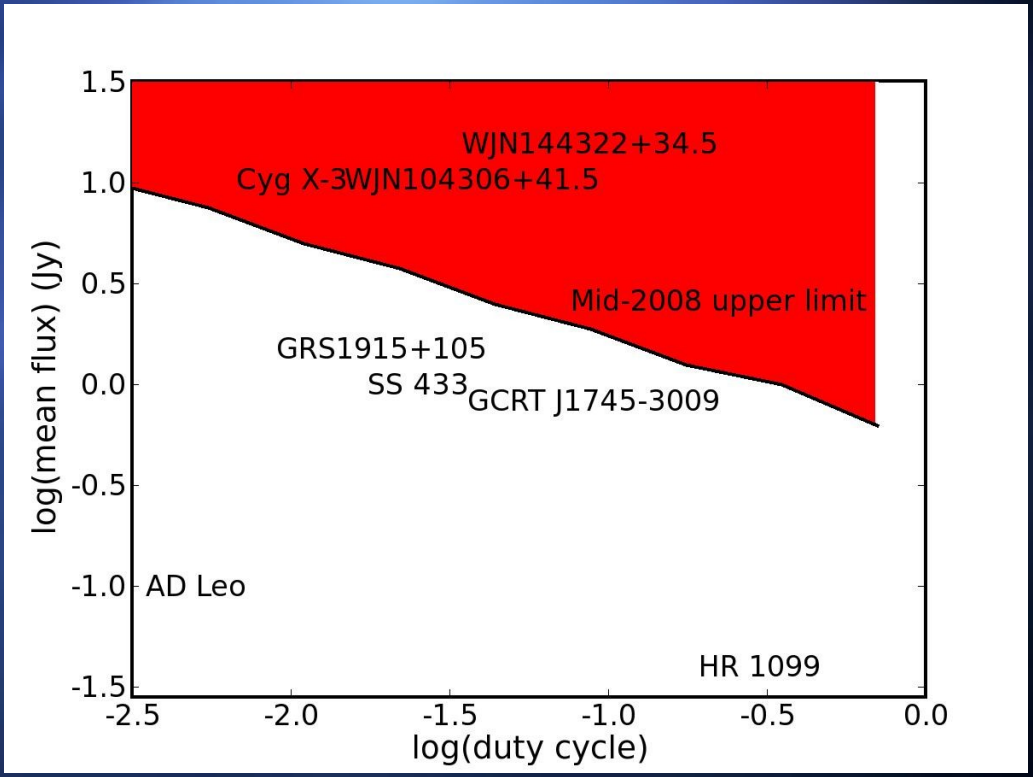
Limit accurate for rare events with durations from min-days.

Limit on known 60 MHz transients CS1 survey in flux-duty cycle space

1. Future Searches with LOFAR

In 2008 we plan to have 20 stations built.
Automated calibration and search pipelines will also improve our constraints considerably.

Note that this only shows limits on known sources. Many more likely exist!



Projected limits of similar survey in 2008

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Schematic of full LOFAR