ANTON PANNEKOEK INSTITUTE

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Extreme Radio Astronomy: Hunting 20,000 sq.deg/s

Going after Nature's weirdos with LOFAR and

AARTFAAC

UNIVERSITY OF AMSTERDAM

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Former key members:

Evert Rol, John Swinbank, Alexander van der Horst, Michael Wise, Hanno Spreeuw, Bart Scheers, …

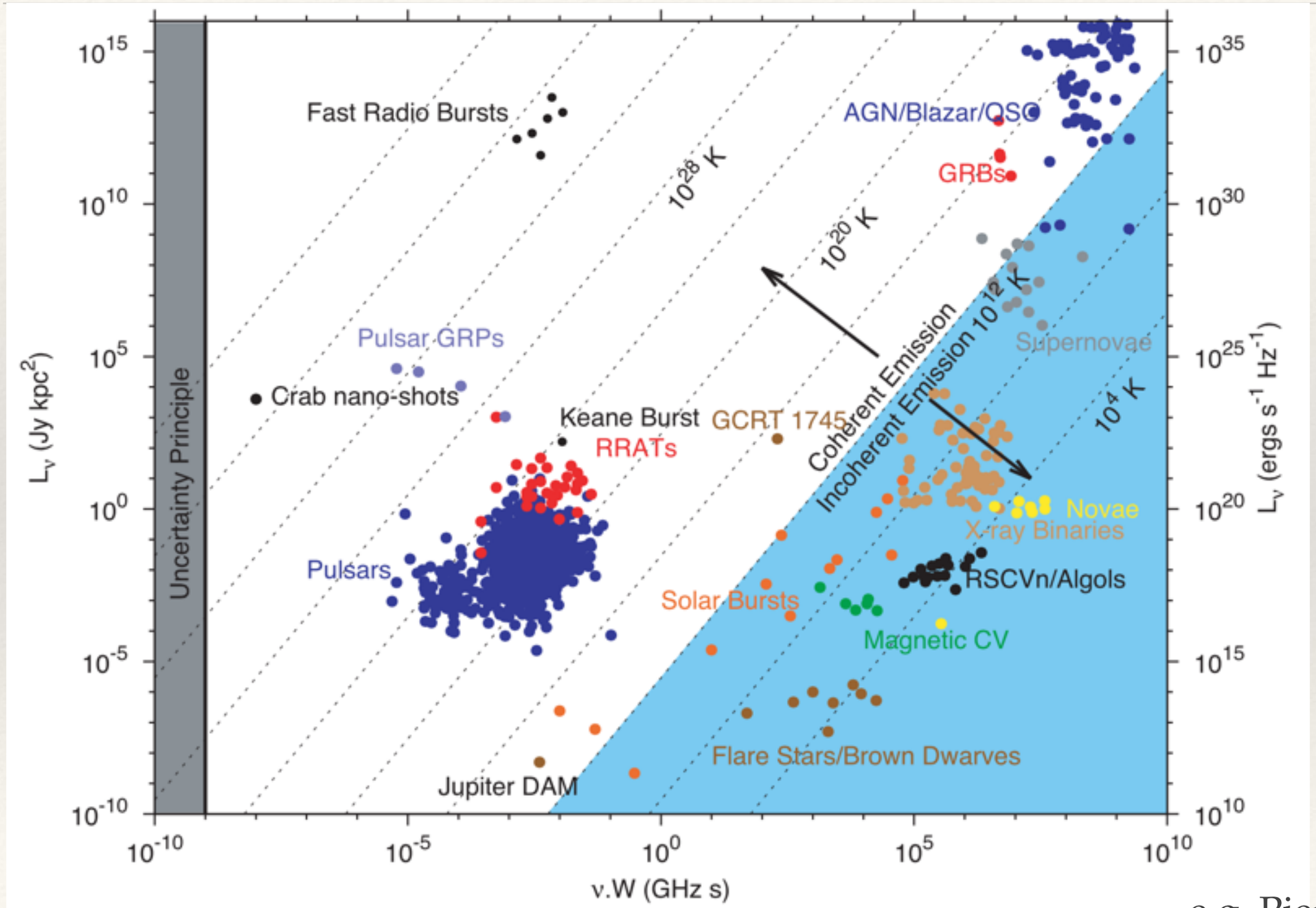
Outline

- A small but coherent rant: Low is not (always) slow
- The AARTFAAC all-sky imager in LOFAR
- Fast automatic triggering of LOFAR
- What is next?

Why low (freq.) transients are slow transients

- peak BB frequency at 2.7K is 300 GHz —> all radio astronomy is in Rayleigh-Jeans limit: $S_\nu = 2kT\nu^2/c^2$
- So $L_\nu \propto R^2\ \nu^2 T$
- Furthermore, for a flare from a transient: $R < cW$, where W is flare duration
- So $L_\nu \propto W^2\ \nu^2 T \propto T\ (W\nu)^2$ —> indeed, low is slow
- With coefficients: $L_\nu = 3$ Jy kpc^2 $(W\nu/\text{GHz.s})^2\ T_{b,12}$
- $T_b < 10^{12}$ K (e.g. Sincell & Krolik 1994)
- So: no fast, bright LOFAR transients (Metzger et al 2015)

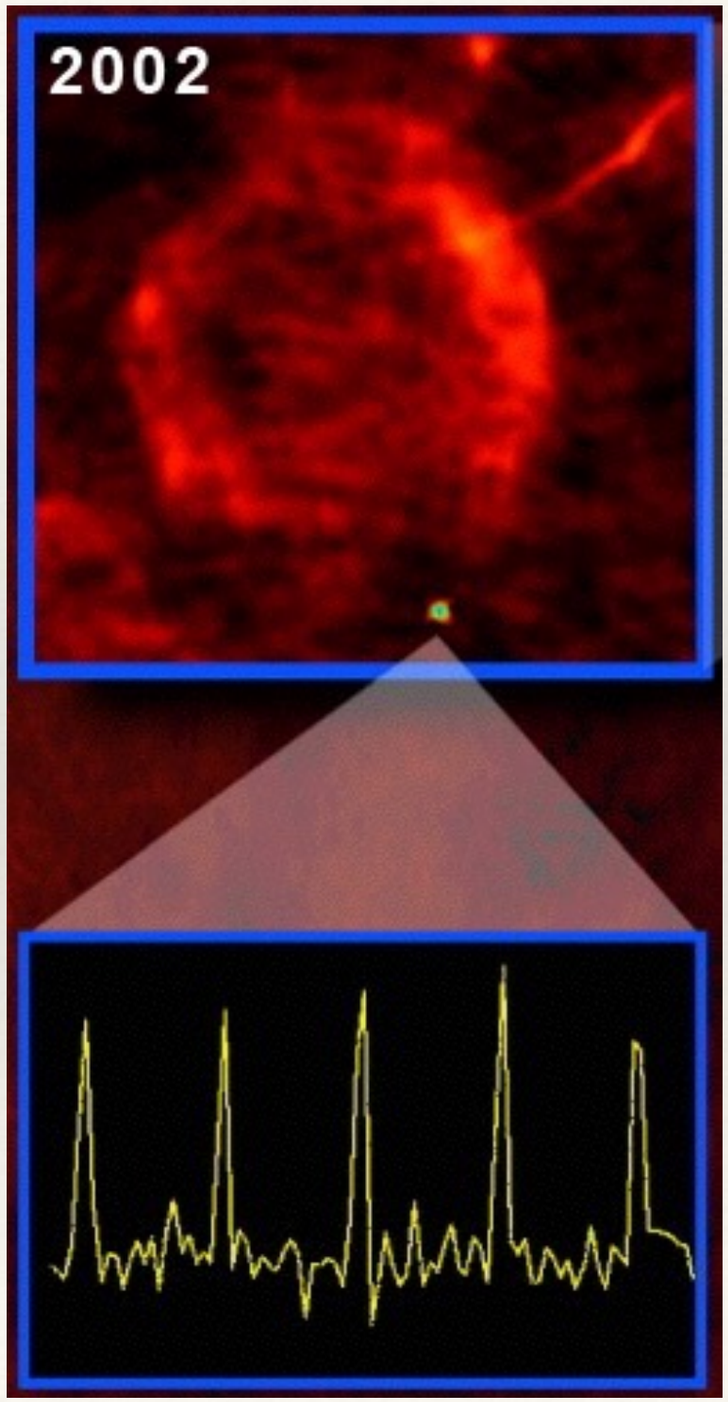
Mother Nature's Verdict



e.g. Pietka et al. 2015

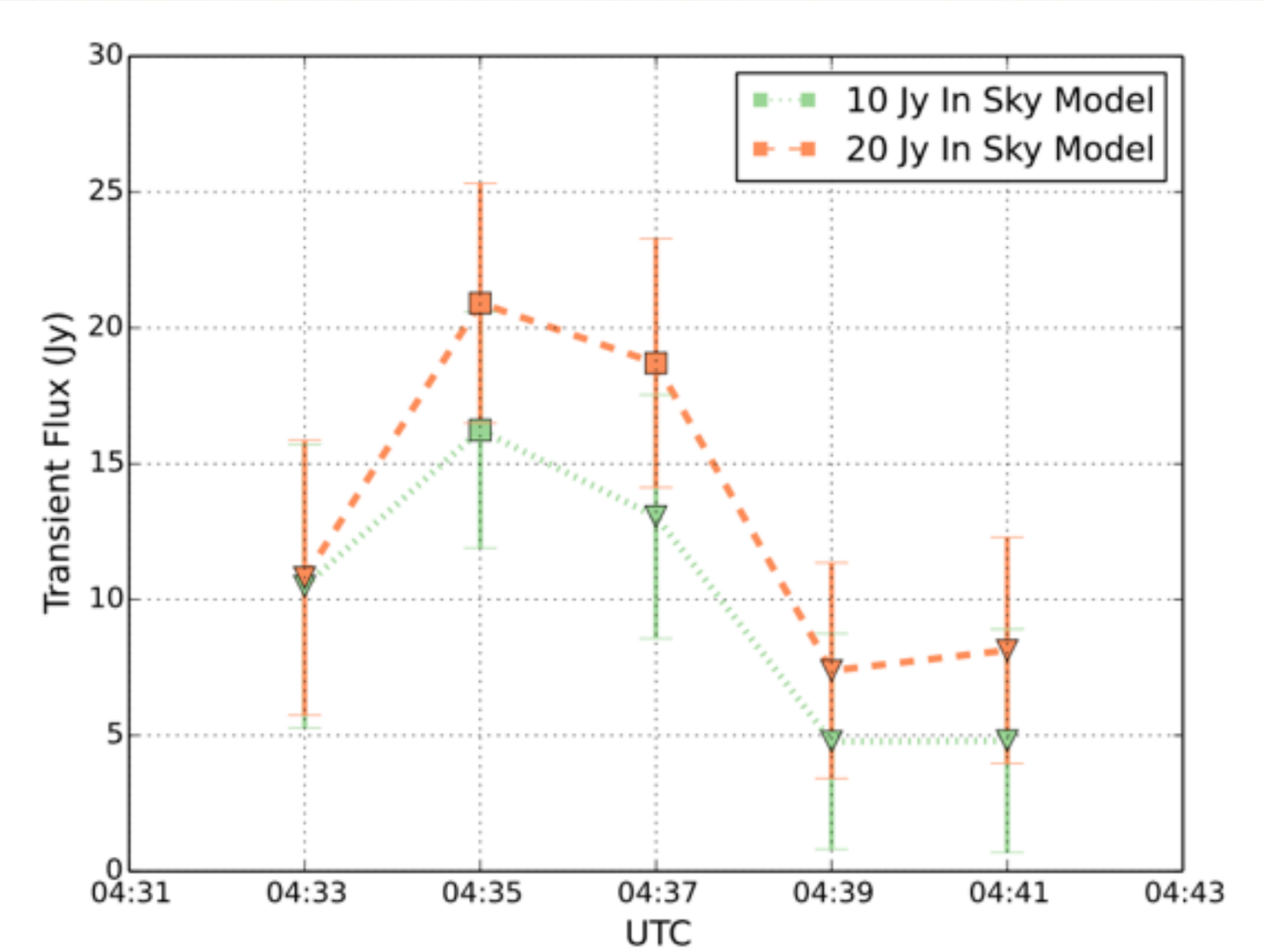
Example:
The Galactic Centre Burper (GCRT J1745-3009)

- 11-min outbursts every 77.102 min at 325 MHz, highest flux 1 Jy
- In direction GC, so let's assume d=8 kpc
- Then it follows that $T_b=10^{16}$ K!



The NCP transient

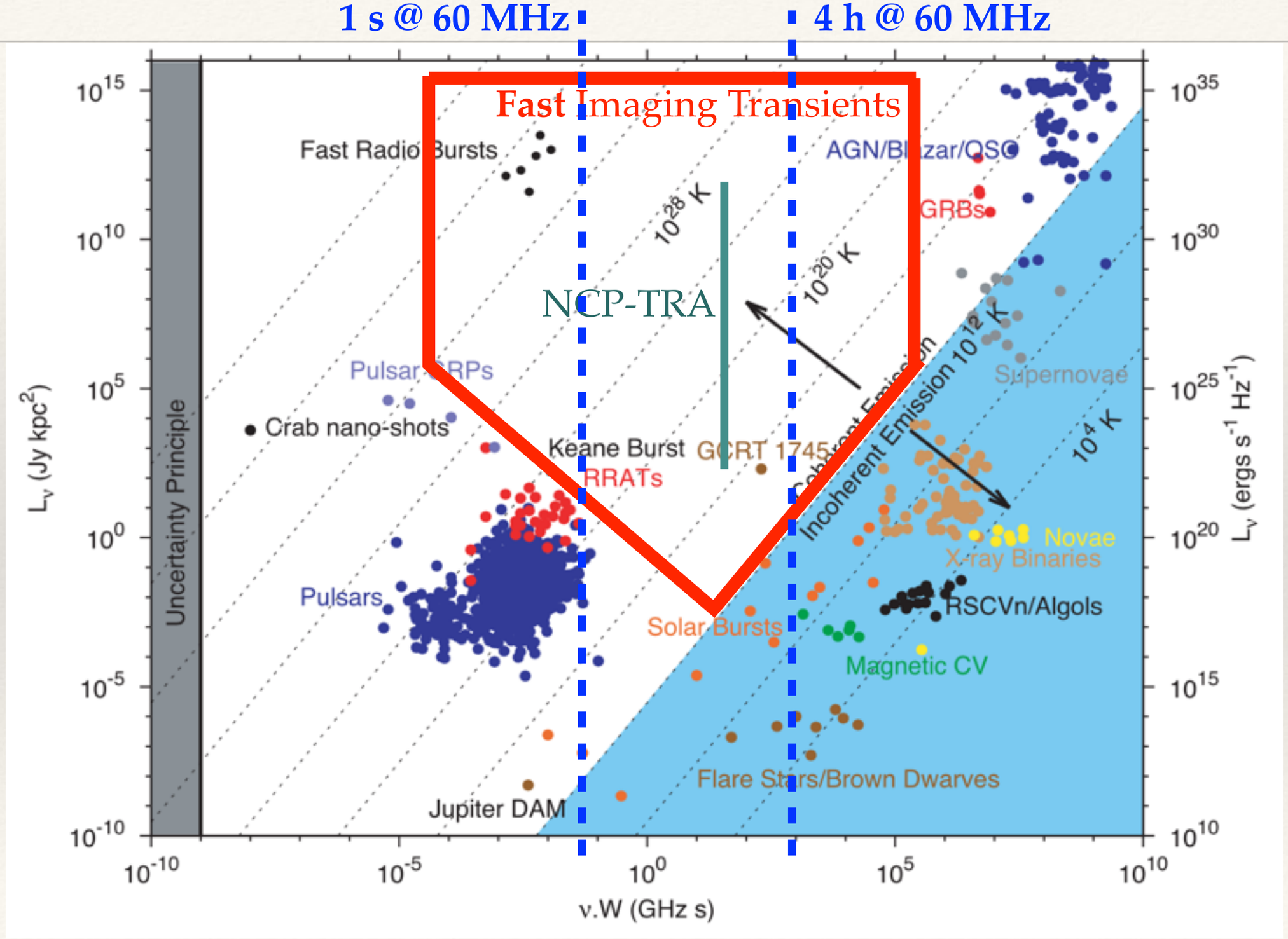
- A strange, bright, fast transient
- If incoherent synchrotron, d < 14 pc (flare star?)



NCP field survey, 2000 times 11min, 0.2 MHz bandwidth

Stewart et al. 2016

What more to find?

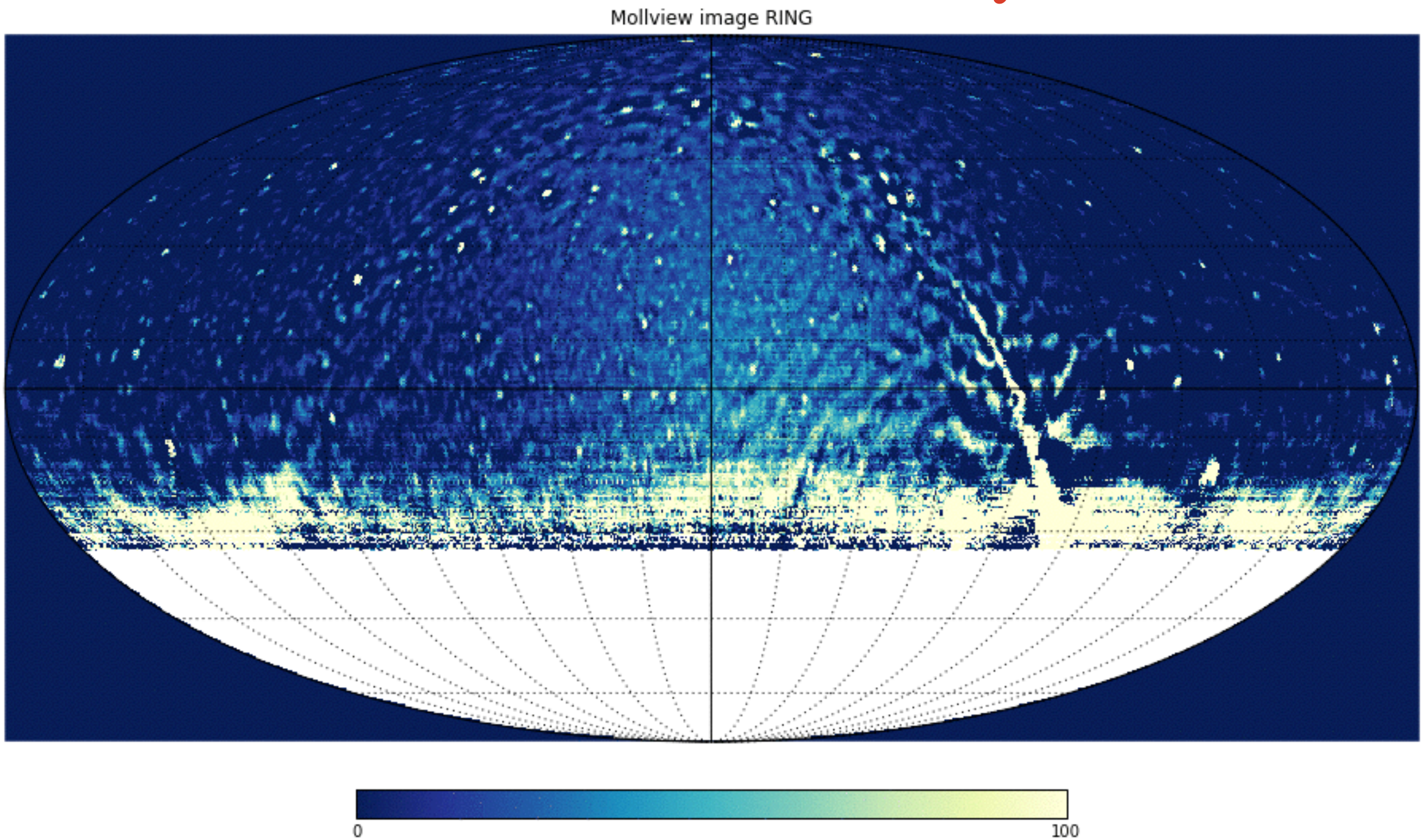


The extreme end: AARTFAAC

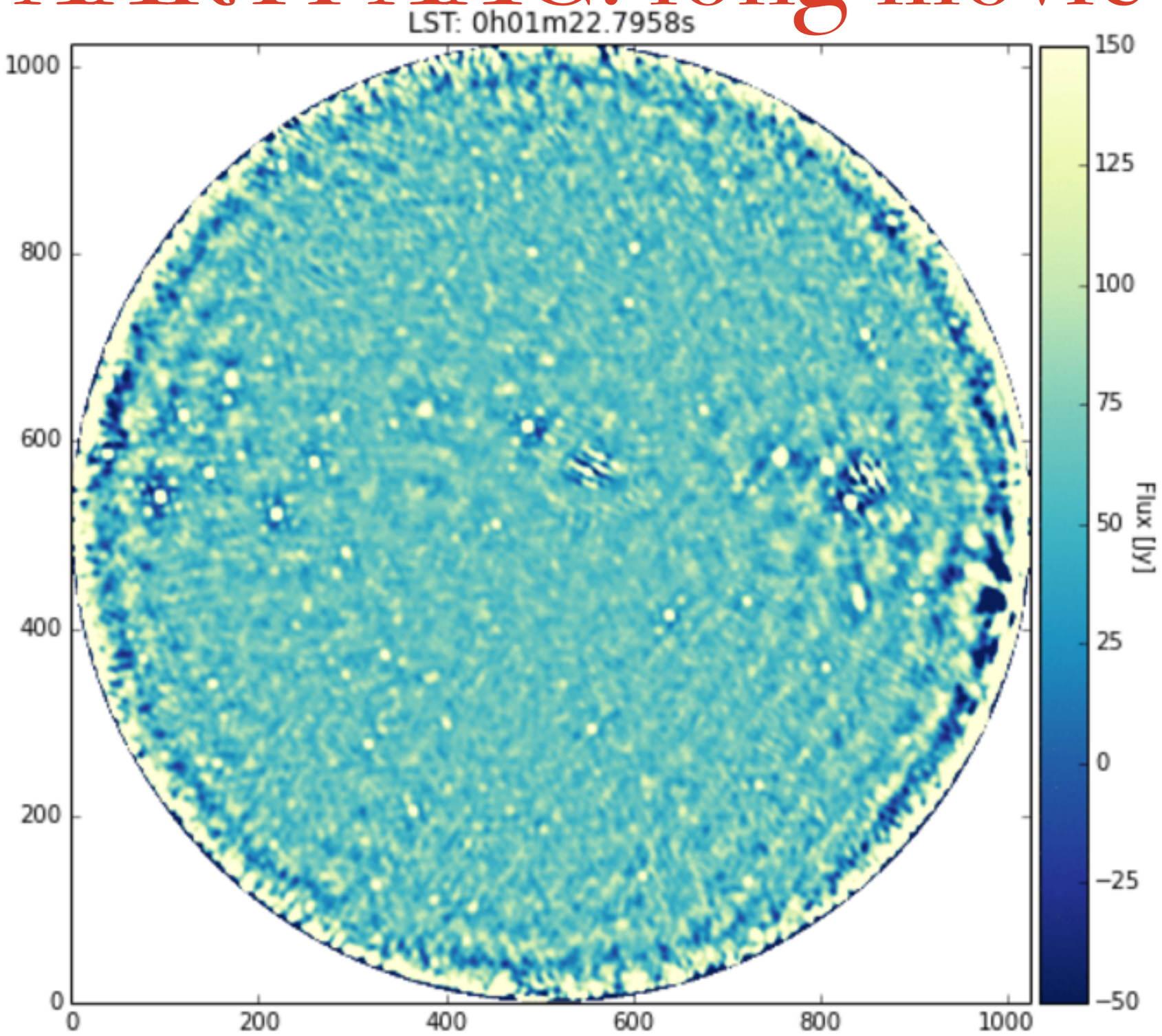
- All-sky (10,000-20,000 sq.deg)
- 1-sec images, BW 3.2 MHz, ~6 Jy rms
- Can do NCP transients, high end of FRBs, …..
- Real-time system now in place, shakeout in progress

- Workshop January 2017: Many other science cases!
- Future: 12 stations, BW 6.4 MHz, baseline 1000 m

AARTFAAC: all-sky view

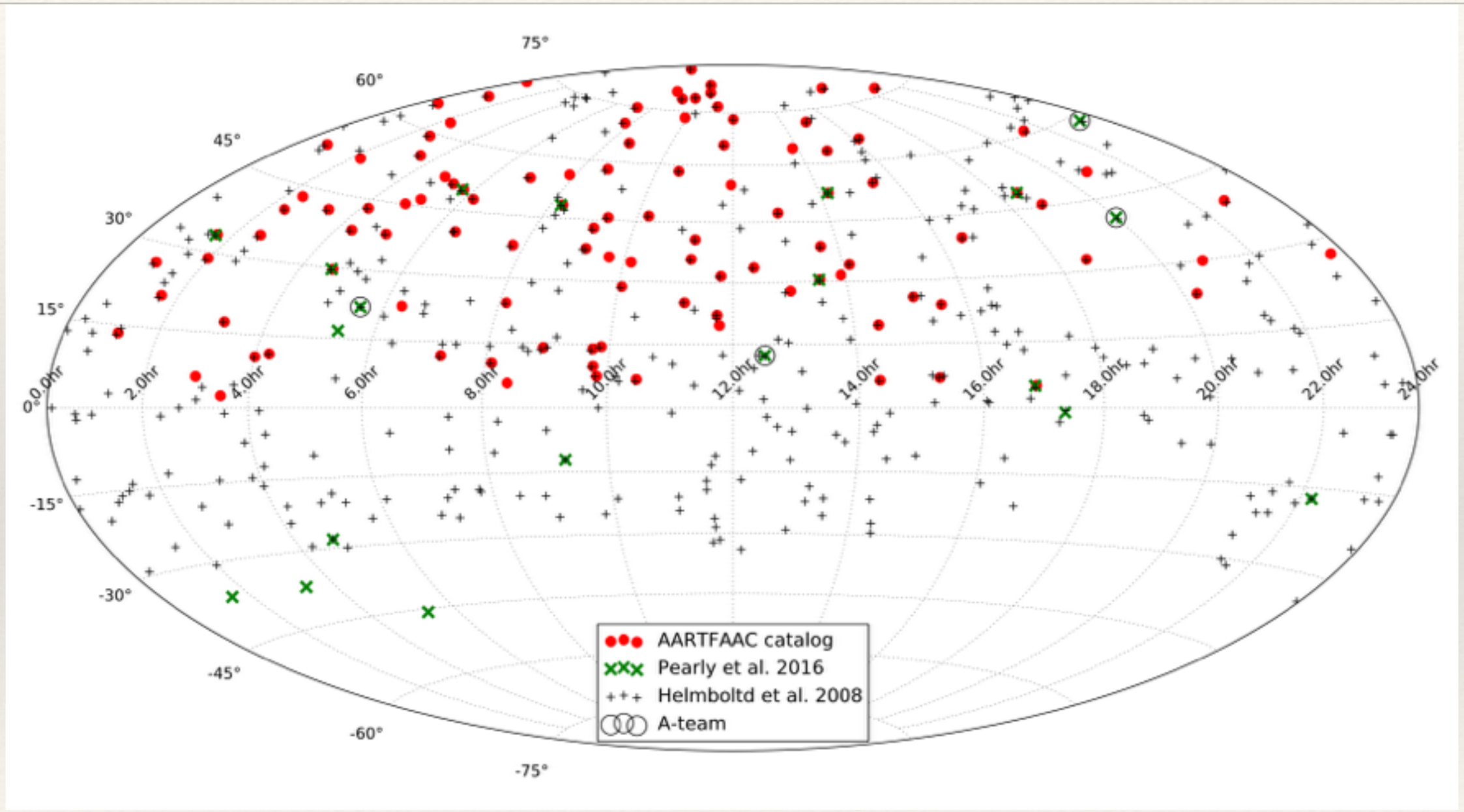


AARTFAAC: long movie



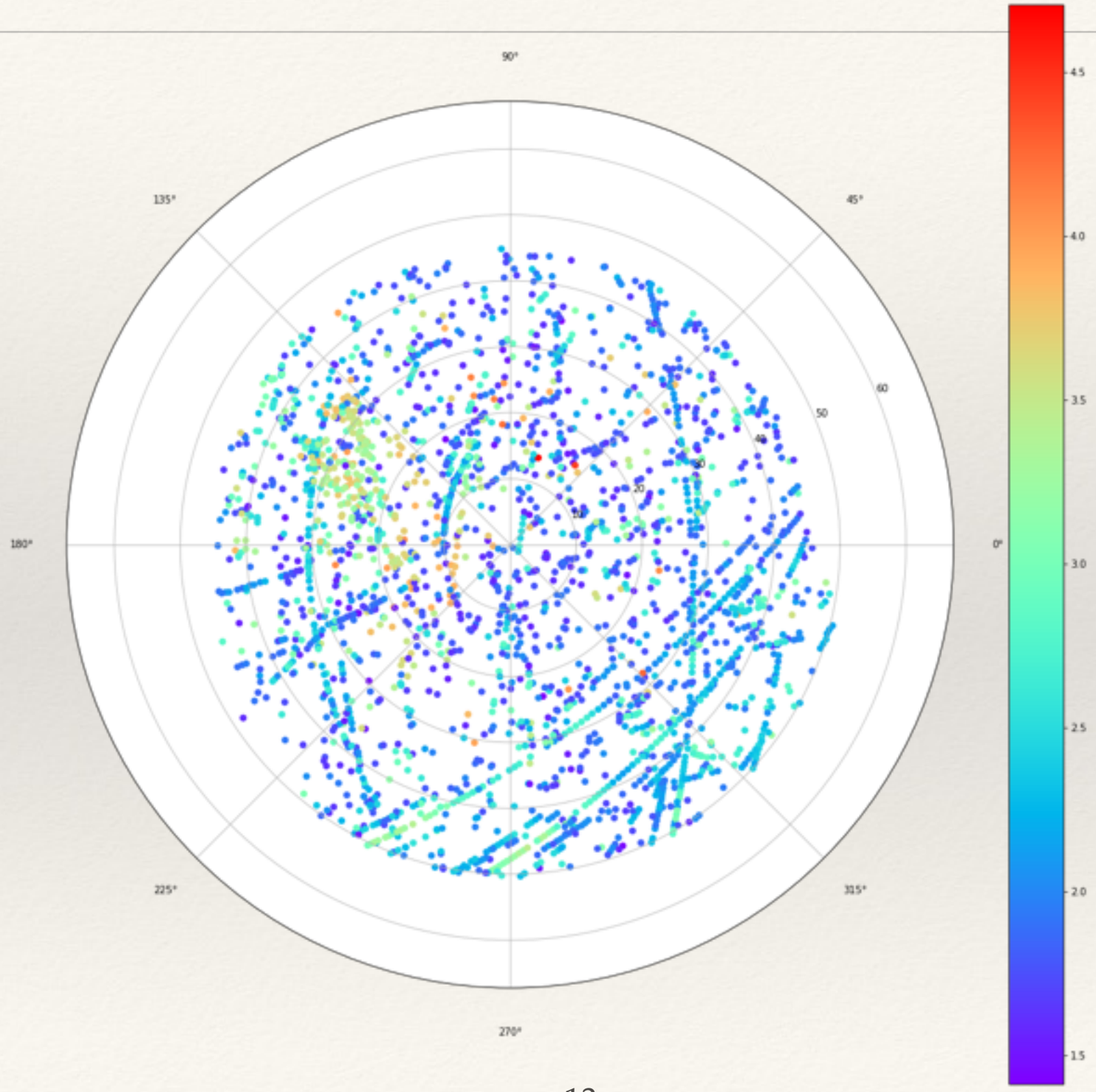
- Watching the radio sky go by, but only bright sources

AARTFAAC flux calibration

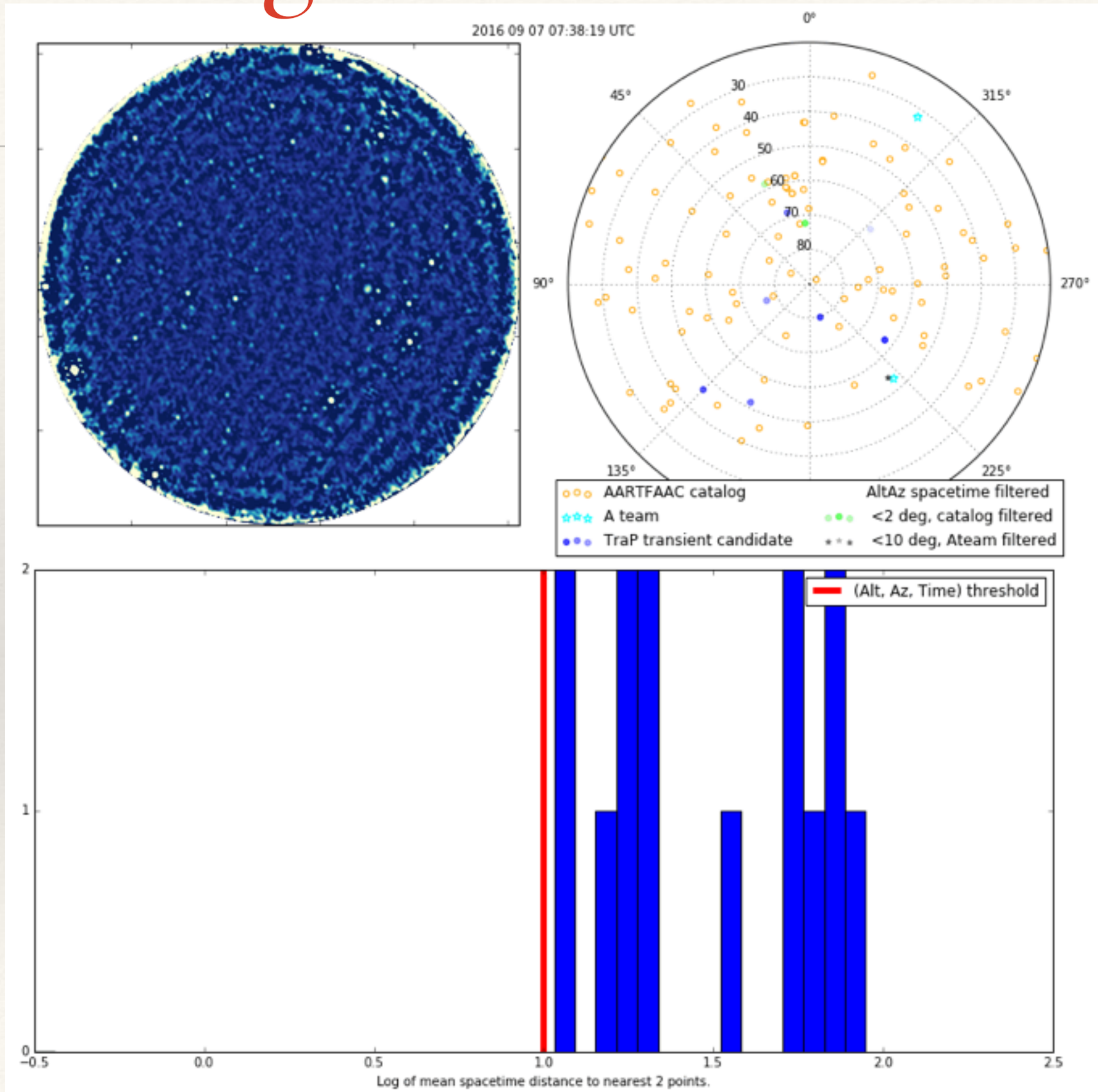


- Bootstrap off A team, earlier catalogues

Training: What is a transient?

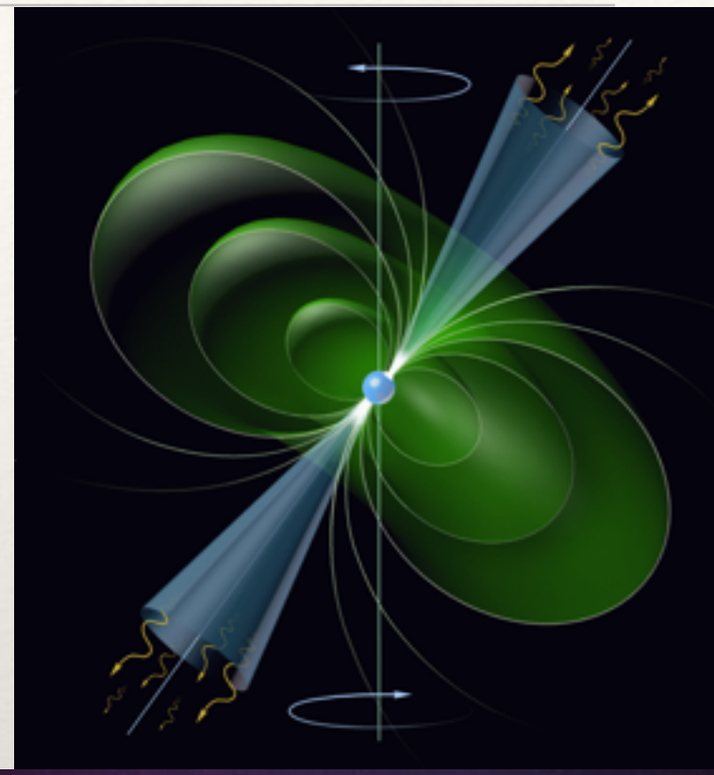


Training: What is a transient?

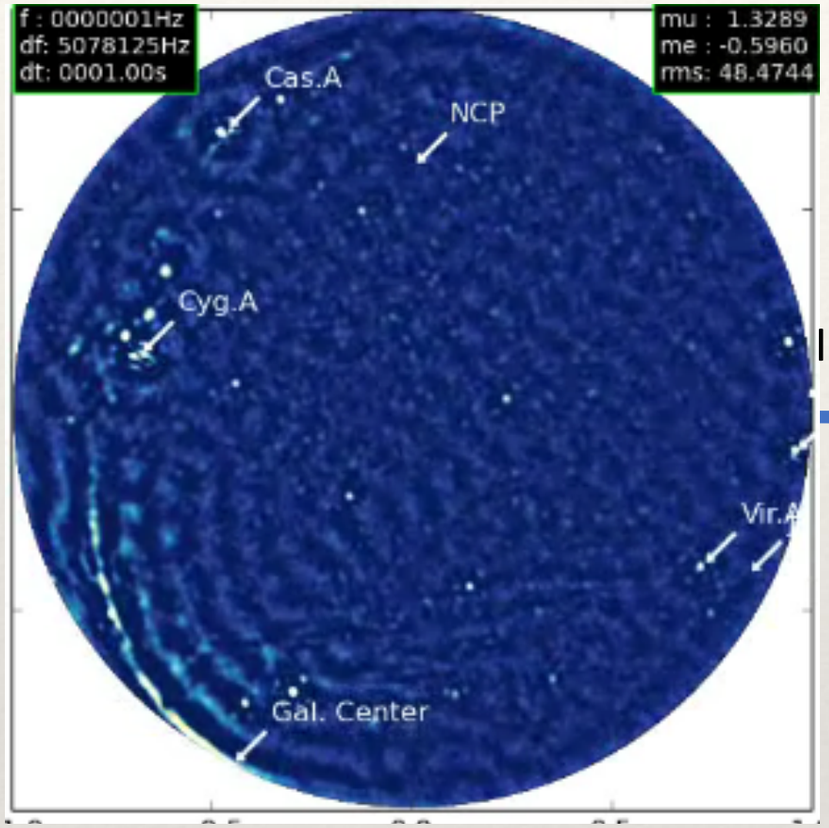


So, what ARE we looking for?

- Pulsars, fast radio bursts (but: dispersion)
- Stewart et al. transients
- Cataclysmic outbursts (GRBs, SGRs, CVs)
- Solar system: Sun, meteors
- …. ?? …



LOFAR as a Responsive Telescope

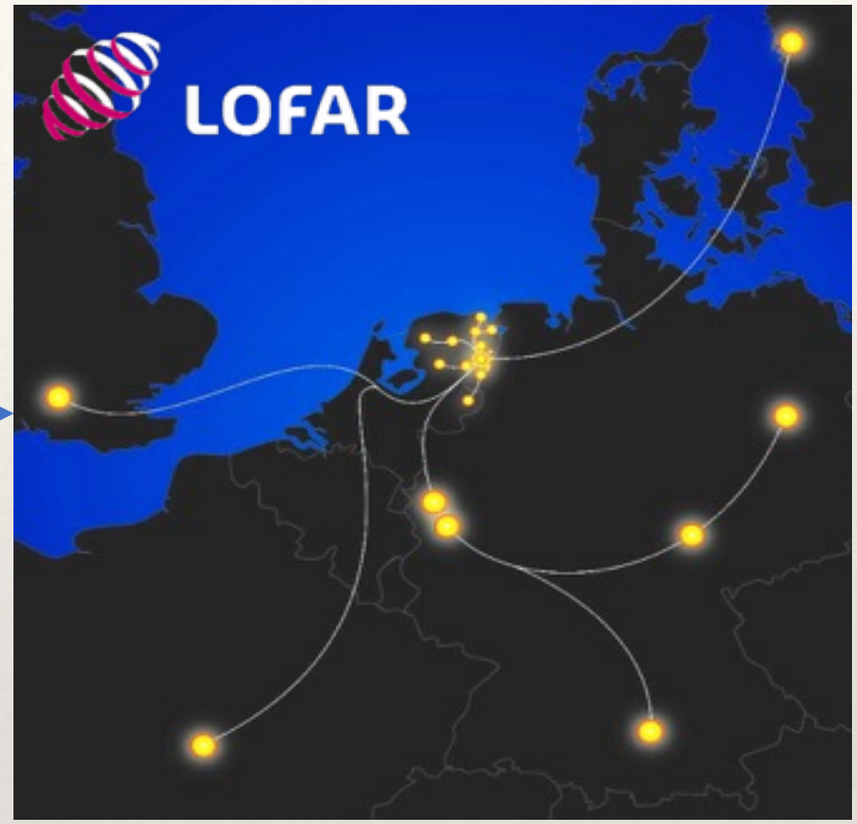


AARTFAAC observations of transient source

Images

Transients Pipeline (Swinbank et al. 2015)

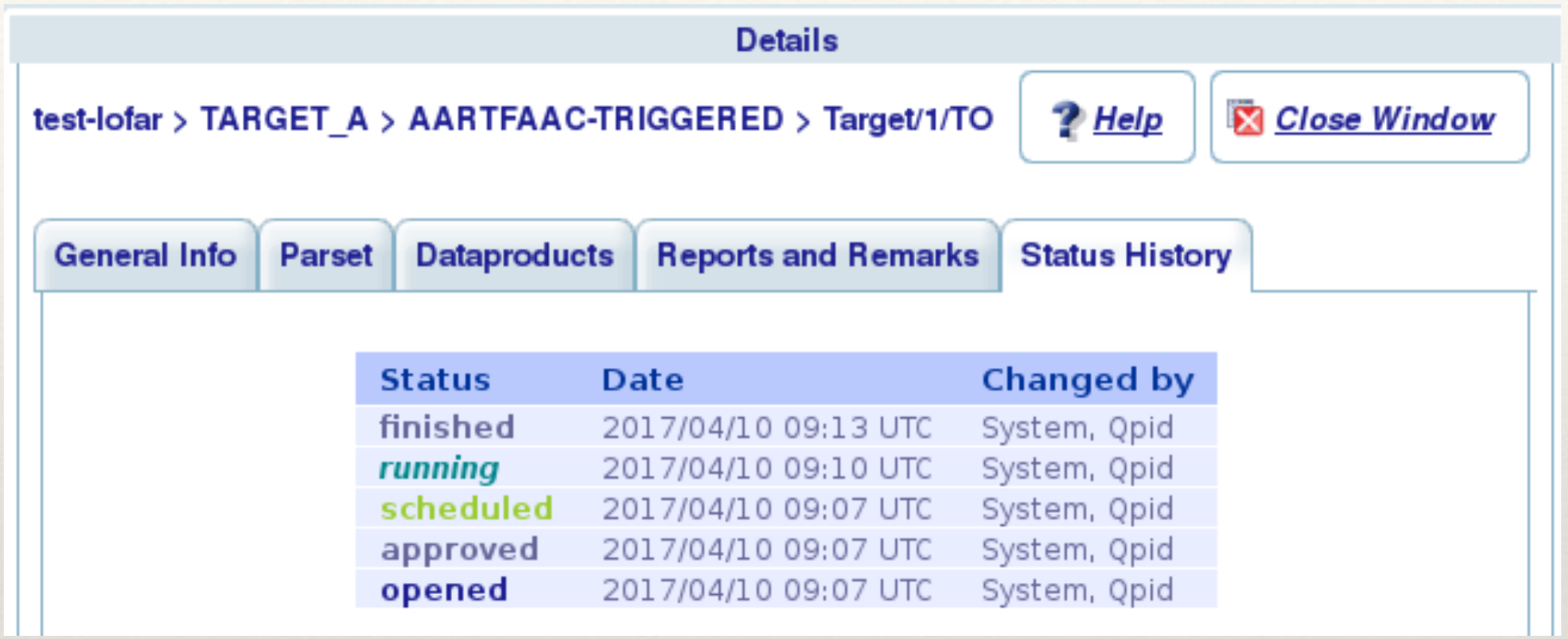
Alert



Triggered LOFAR observations (within 5 mins of alert)

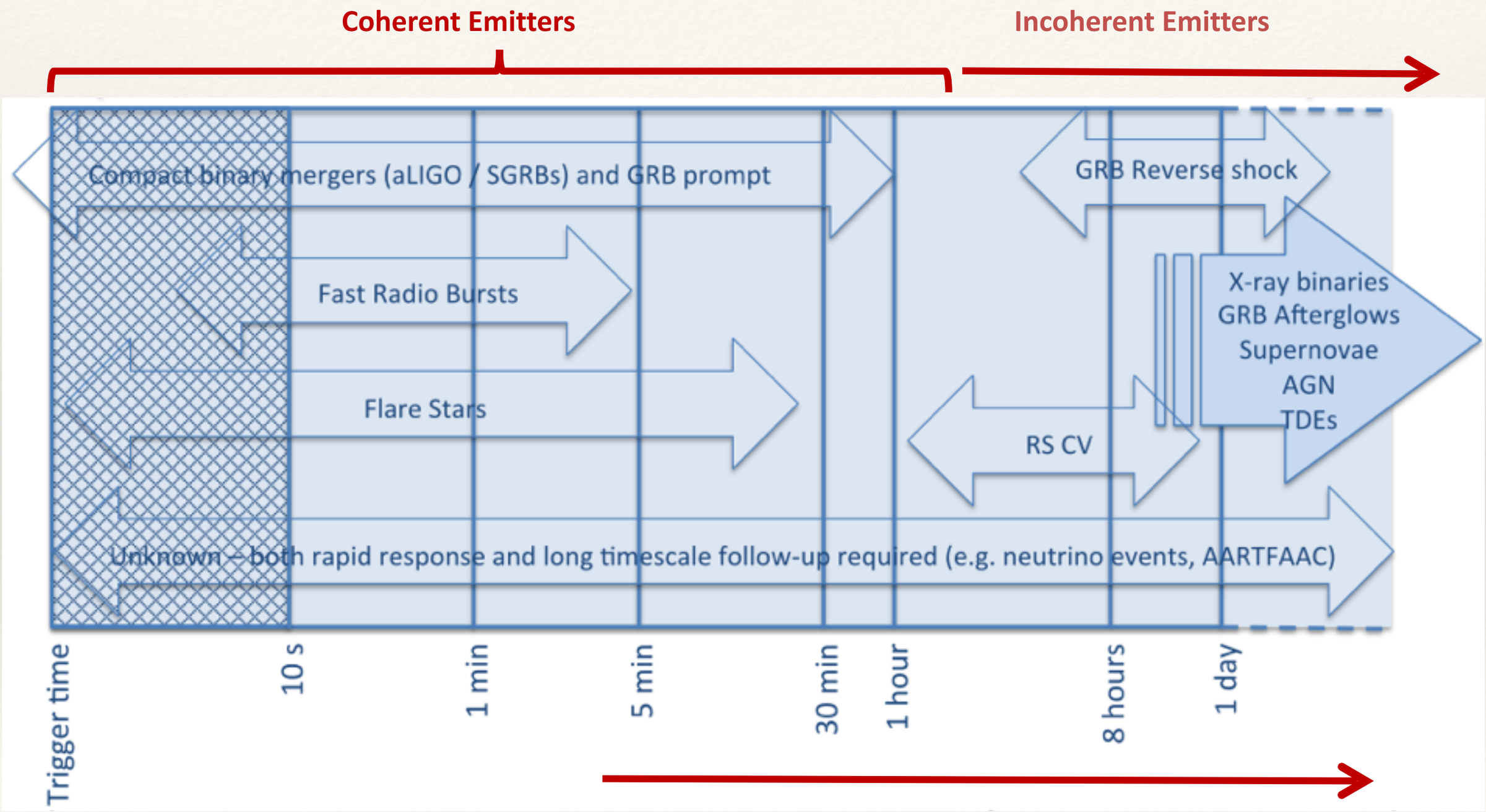
Project owners: Antonia Rowlinson and Sander ter Veen

LOFAR as a Responsive Telescope



- New observing mode for all transient sources requiring a rapid response (minutes to hours)
- Currently being implemented within LOFAR systems
  - Demonstrated 3 minute response time on test system
  - Expected completion: end September 2017
- Predetermined templates with entries for e.g. RA & Dec

Rapid triggering of LOFAR



Shameless Advertising

- We have one two-year postdoc position available immediately: Science with AARTFAAC
- We may have at least one more PhD position in the coming year
- Talk to Antonia, Mark, myself if interested

Conclusions

- AARTFAAC will explore the “brightest & rarest” end, is now ready for science
- Plenty of detections, but filter out many ‘foregrounds’ and artefacts
- LOFAR is nearly ready to trigger followup studies of fast transients
- Imagine a mJy-level AARTFAAC in SKA-LO core!

www.aartfaac.org