Enabling ground-breaking transient astronomy with a responsive LOFAR

Antonia Rowlinson

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ANTON PANNEKOEK INSTITUTE

UNIVERSITEIT VAN AMSTERDAM

ASTRON
Netherlands Institute for Radio Astronomy

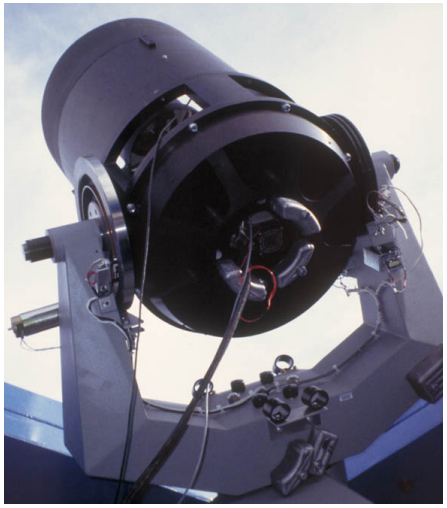
LOFAR

Transient astronomy and rapid response modes

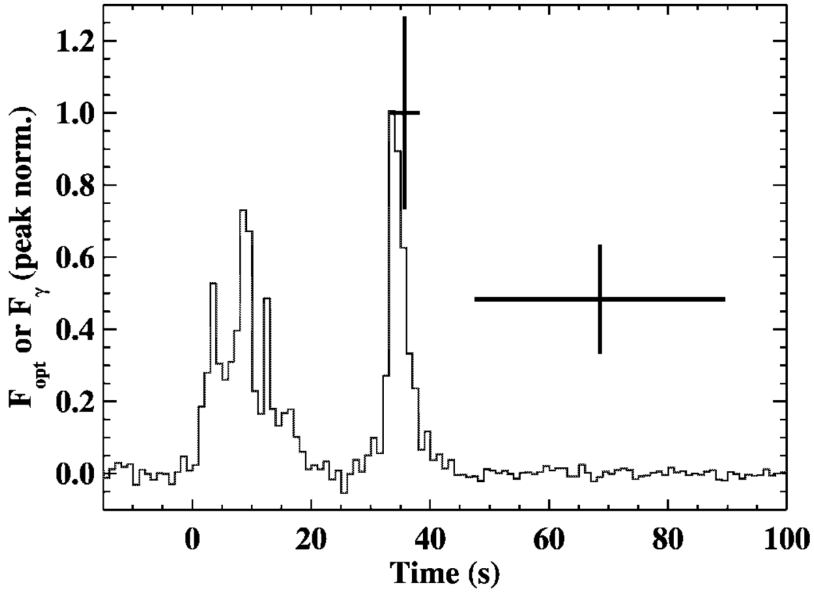
- A faster response often leads to increased understanding of the sources and new discoveries
- Precedence set in the field of Gamma-Ray Bursts (GRBs)
  - crucial in identifying afterglows, host galaxies, and determining the likely progenitors
- Methods are now being applied to other sources, such as Fast Radio Bursts (FRBs)

Rapid response at optical wavelengths

- Fully automated optical telescopes, e.g.:
  - MASTER – response **~100s**
  - ROTSE – response **<100s**
- **Limiting factor on speed is the slew time**



- Optical counterpart of GRB 050401 was detected **33s** after the GRB trigger by ROTSE (Rykoff et al. 2005)

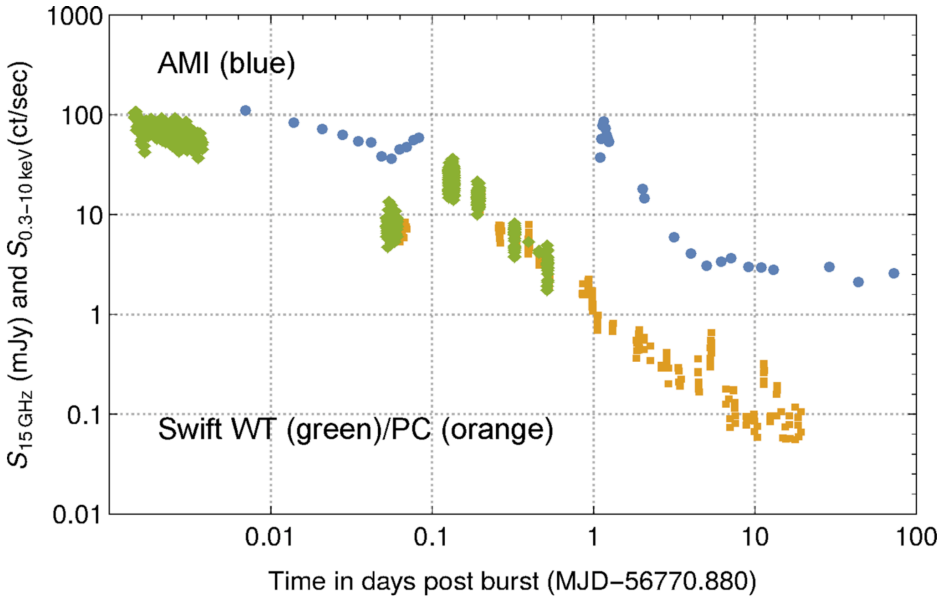


Rapid response at 15 GHz

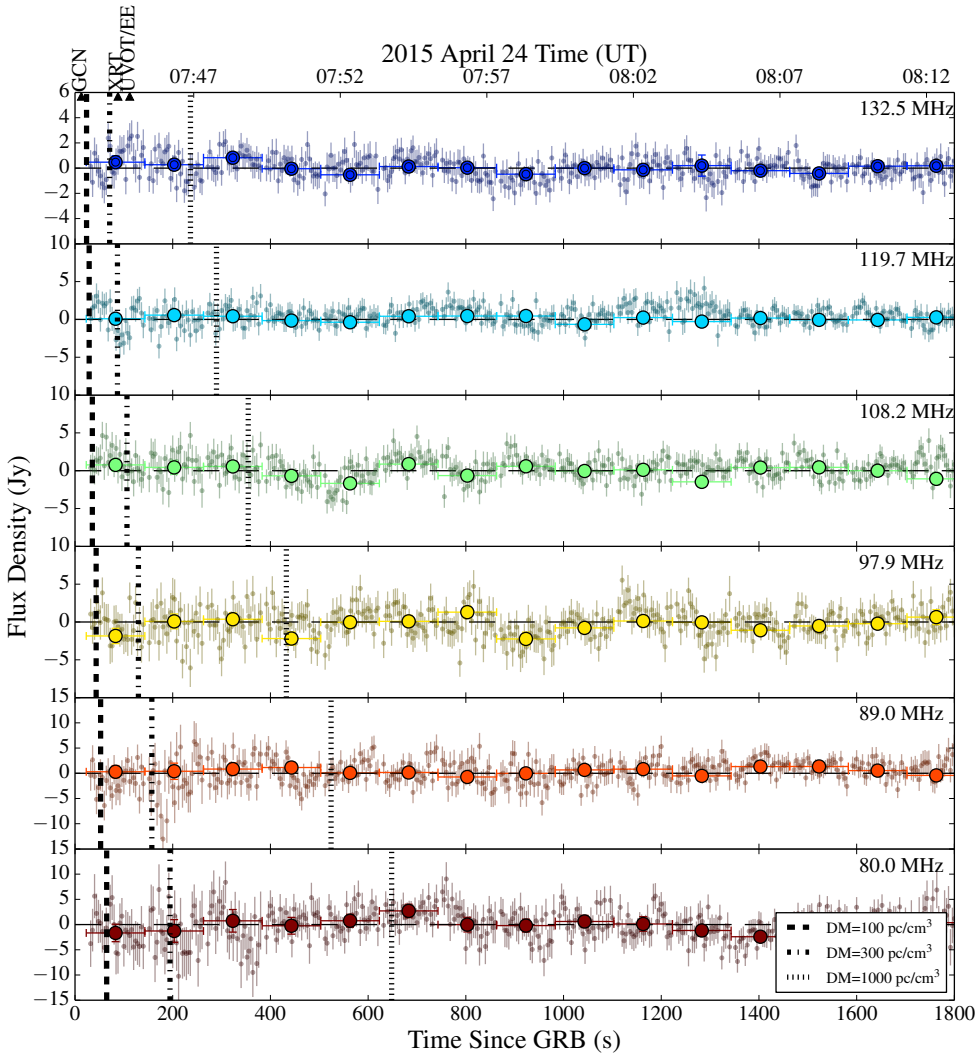
- Arcminute Micro Kelvin Imager (AMI)
- **Limiting factor on speed is the slew time**

- Young M dwarf binary DG CVn - Gamma-ray superflare
- Observations started at **6mins** post flare

Staley et al. (2013), Fender et al. (2015)



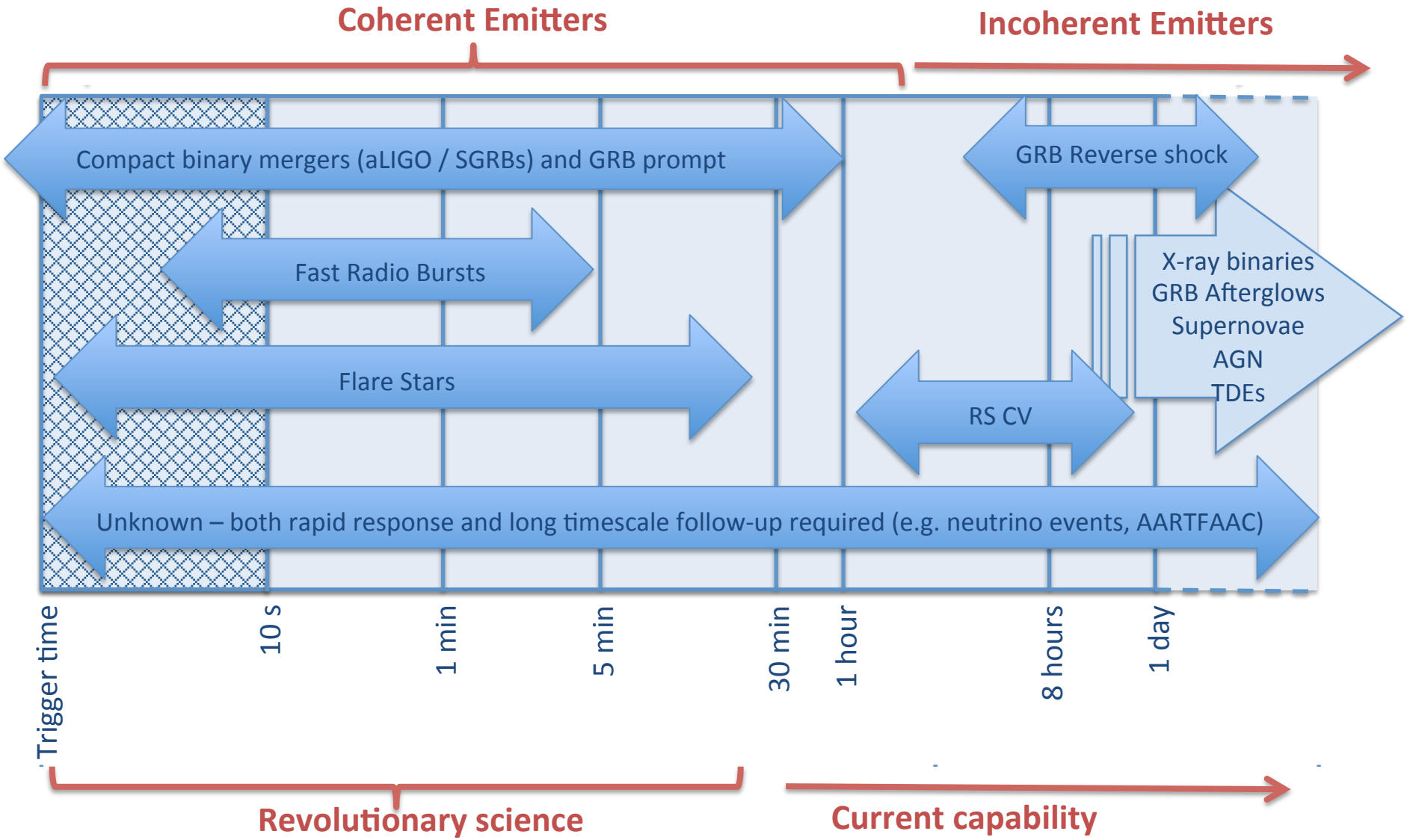
Rapid response at 100 MHz



- Limits on prompt radio emission from Short GRB 150424A
- Observations started **26s** after the GRB occurred (**10s** after the alert was received)
- A telescope with no moving parts → **no slew time limitations**

Kaplan, Rowlinson et al. (2015)

Target transients at low frequencies



Current rapid response capabilities at low frequencies

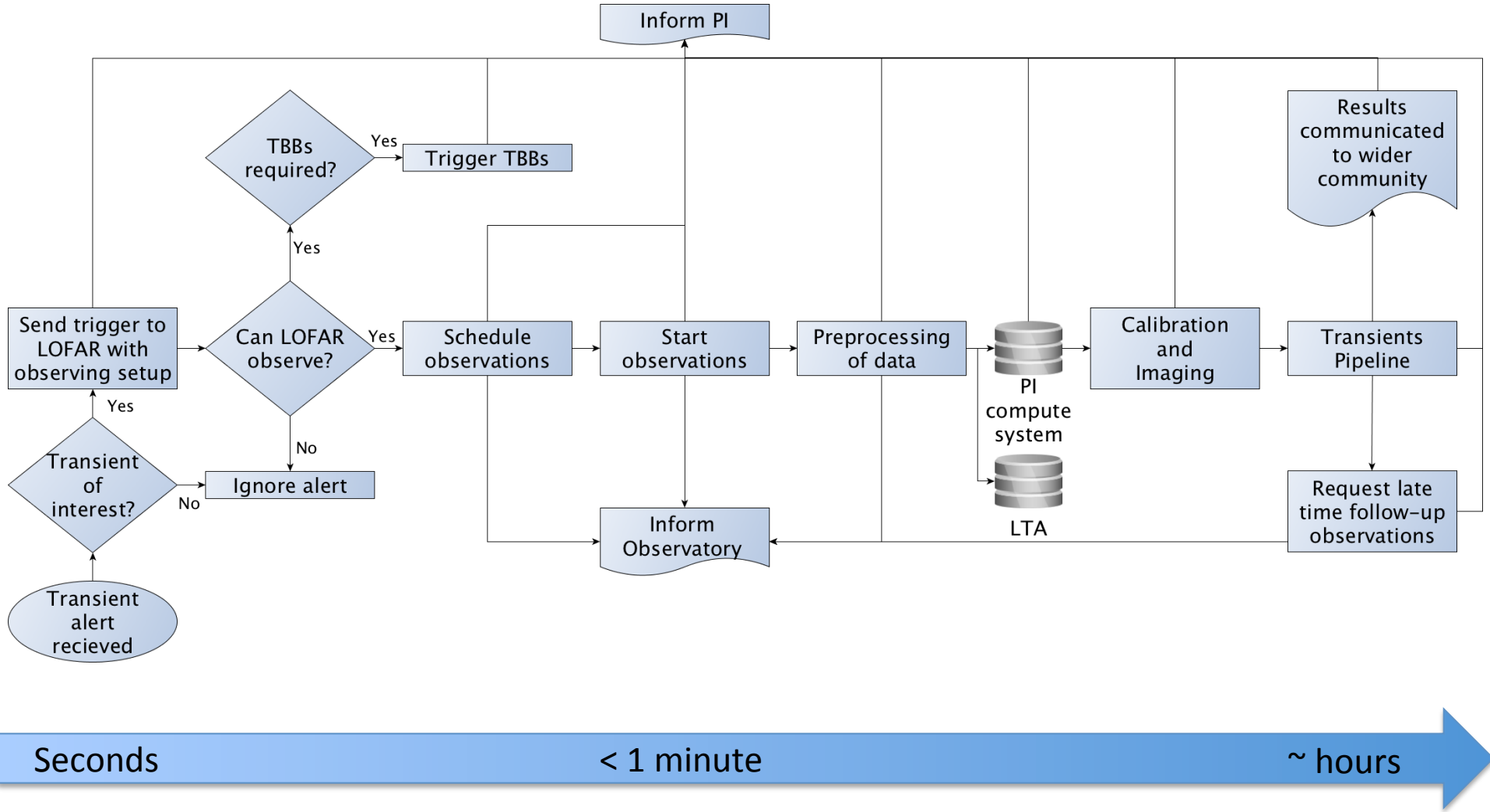
LOFAR

- ~30 minutes
- High spatial resolution
- Capability:
  - Imaging and/or beam formed
  - Transient Buffer Boards

MWA

- ~10 seconds
- Low spatial resolution
- Capability:
  - Imaging

Planned response



Development Outline

- Phase 1
  - Achieve response in 2-3 minutes to selected transients using standard, pre-determined observation set-ups
- Phase 2
  - Achieve fast turn around of observations, data processed and communication of key results
- Phase 3
  - Improved speed of response and integration of TBBs
- Phase 4
  - More complex observation set-ups determined “on the fly”
  - Live streaming of data to processing pipelines

Phase 1

Radio Observatory

- Automation of current observation strategy
- Agreement on format and content of observation trigger
- Determine trigger priorities and plans for interrupted observations

Transients Key Science Project

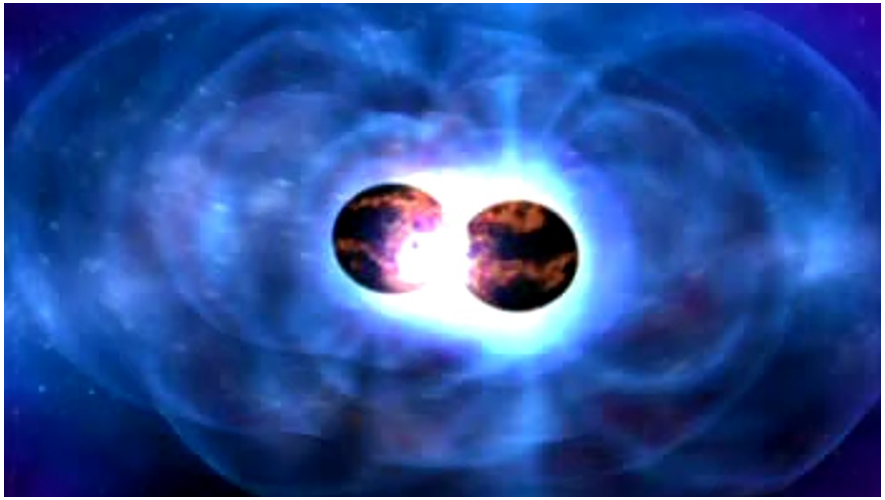
- Set up simple VOEvent broker to filter messages from top priority transients
- Automation of production of observation trigger

Aiming to start development of phase 1 in second half of this year

Initial targets

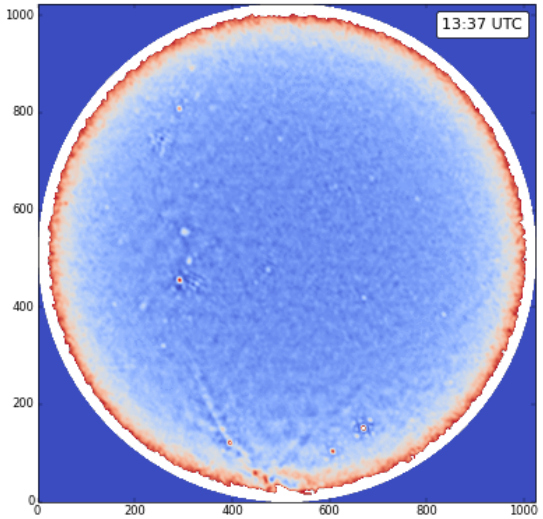
Gravitational Wave Alerts

- Search for coherent radio emission from compact binary mergers
- See talk on Wednesday



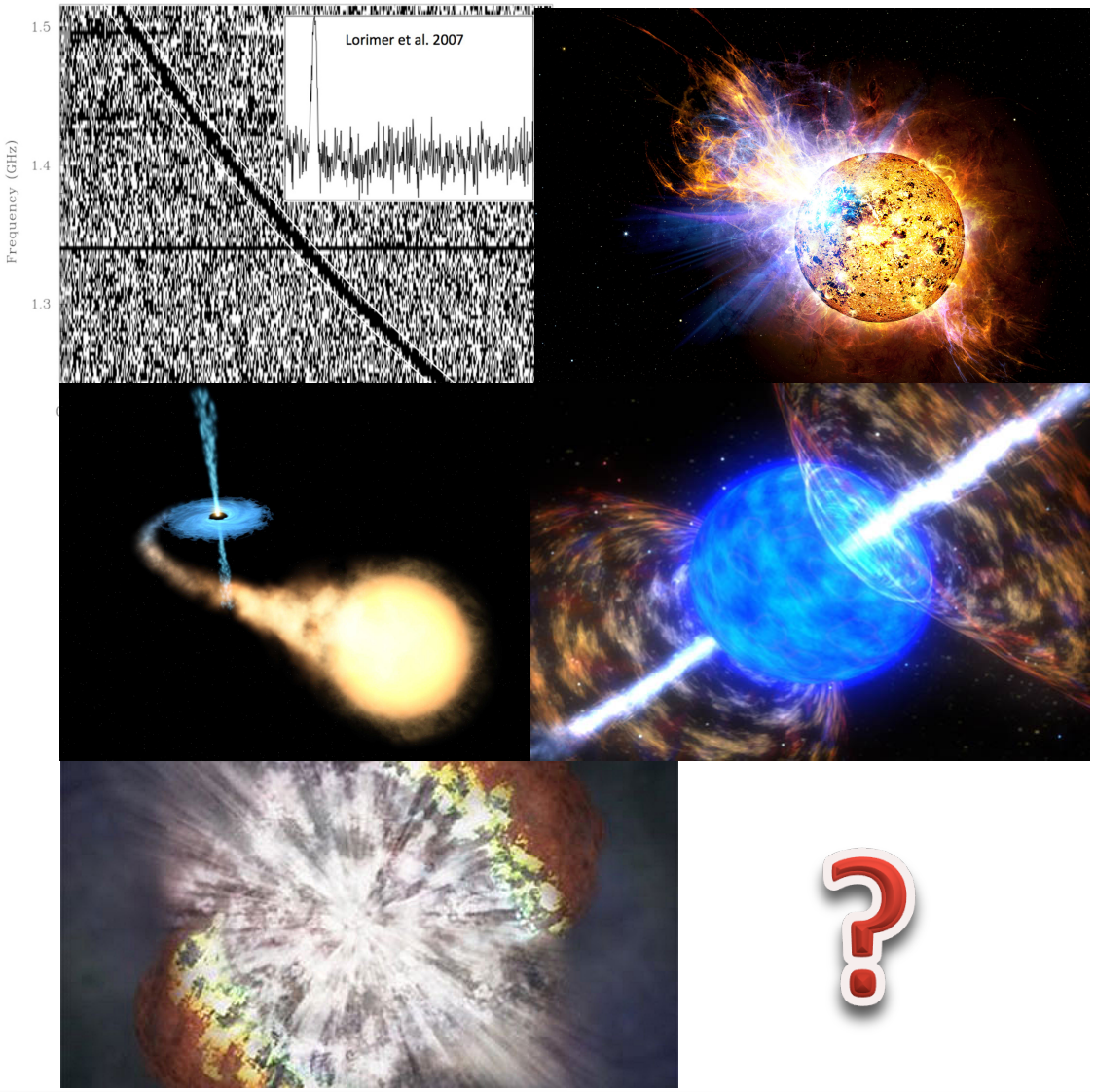
AARTFAAC triggers

- Detection of rare, bright radio transients in real time
- See talks on Wednesday (P. Prasad, Y. Cendes)



Future Targets

- Fast Radio Bursts
- Flare stars
- X-Ray Binary outbursts
- Gamma-ray bursts
- Supernovae
- Neutrino triggers
- Unknown
- …



Summary

- A fully automated, rapid response for LOFAR

- Response aims to include:
  - Imaging mode observations
  - Beam formed mode observations
  - Transient Buffer Boards
  - Fast access and processing of observed data

- Initial targets include gravitational wave sources and unidentified radio transients