Probing the low frequency transient sky with the OVRO-LWA

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Caltech

Science at Low Frequencies IV

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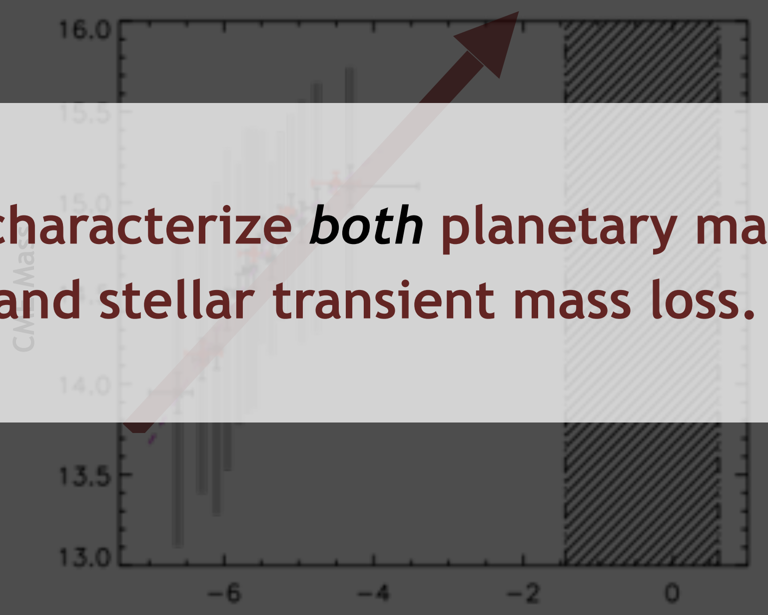
Understanding how CMEs scale with flare energy and frequency is critical to diagnosing habitable environments around magnetically active stars.

Relationship between CME mass and flare flux for the Sun



Aarnio et al. 2010

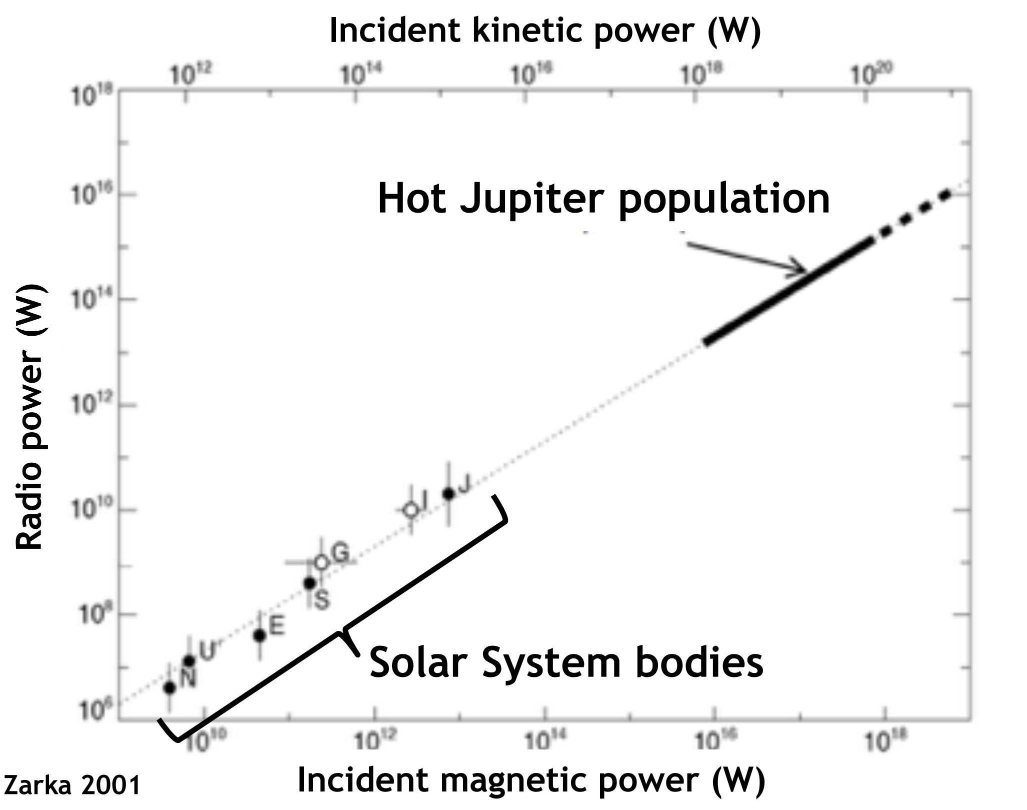
We need to characterize *both* planetary magnetic fields and stellar transient mass loss.

Characterizing stellar magnetic activity, planetary magnetic fields, and their interaction for a wide range of host mass and age.

- How can we optimize the search for extrasolar space weather, and begin detecting and characterizing systems en masse?
  - Low frequency (< 100 MHz)
  - Large-FoV instruments
  - Capitalize on characteristics of emission mechanisms (Stokes V)

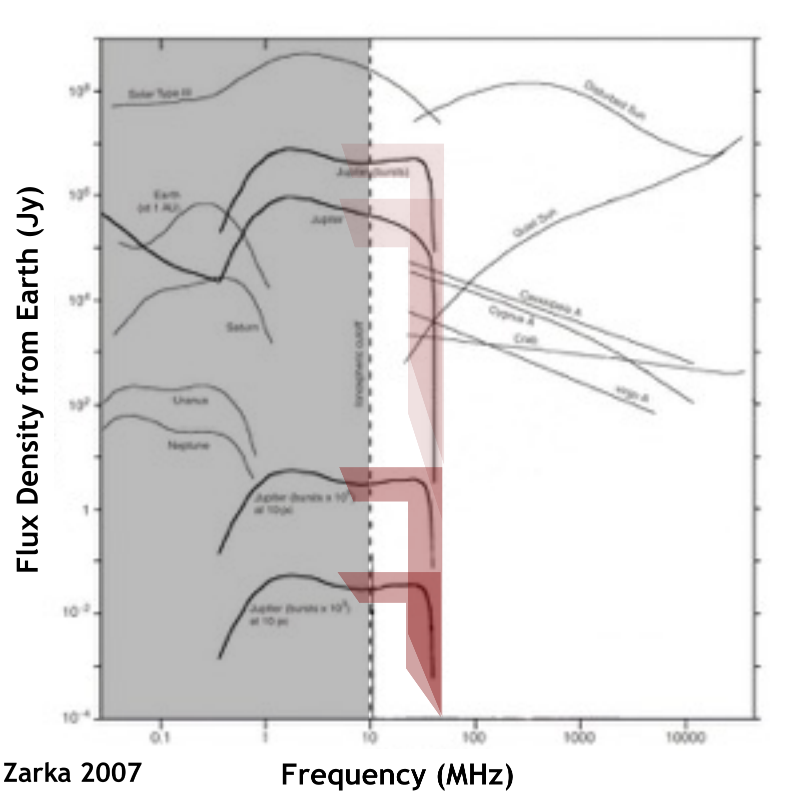
Image credit: **C. Carter & G. Hallinan**

Low frequency (< 100 MHz)



Low frequency (< 100 MHz)

- Extrapolation from our own SS suggests it is necessary to go below 100 MHz to directly detect exoplanetary radio emission.



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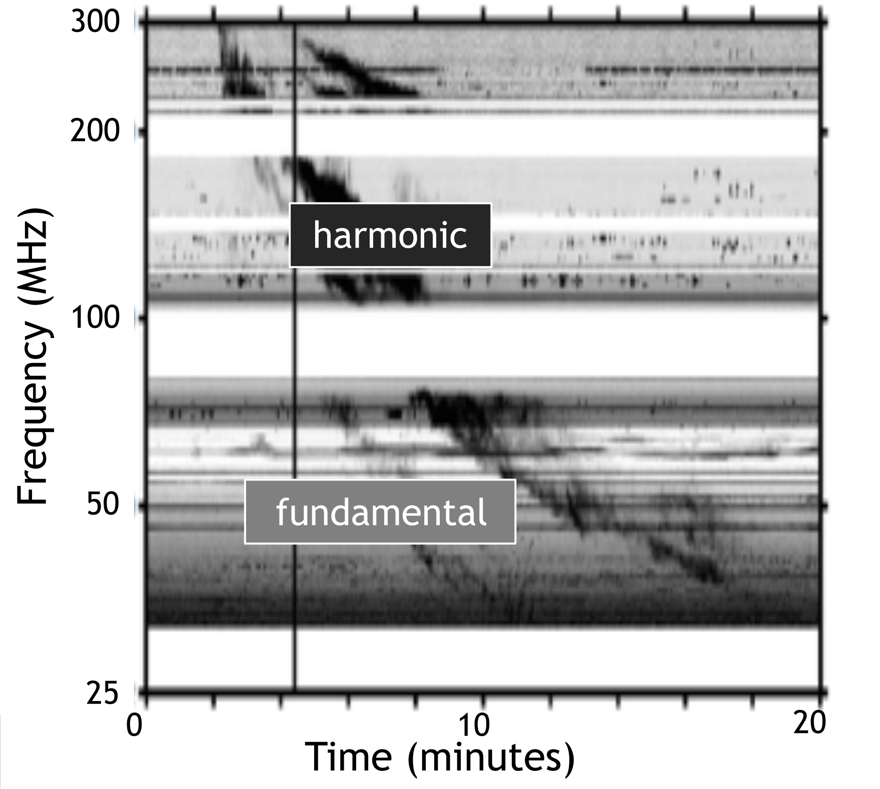
- Solar Type II radio bursts are associated with CMEs, and frequently occur in the sub-100 MHz regime.



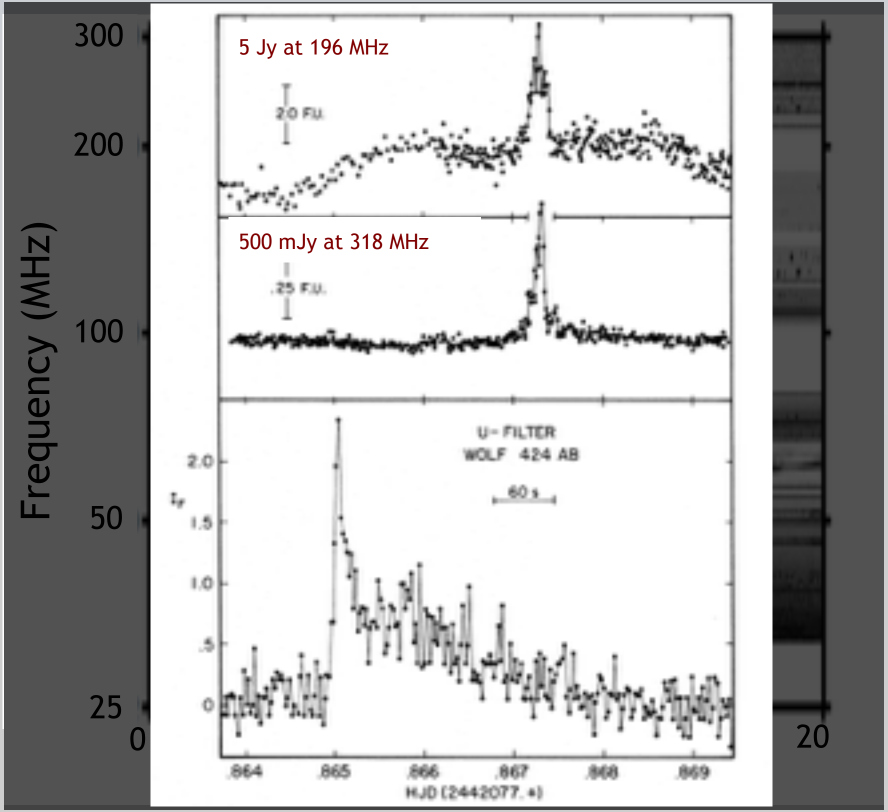
Kouloumvakos et al. 2014
Figure c/o J. Villadsen

Low frequency (< 100 MHz)

- Extrapolation from our own SS suggests it is necessary to go below 100 MHz to directly detect exoplanetary radio emission.

- Solar Type II radio bursts are frequently associated with CMEs, and peak in the sub-100 MHz regime.

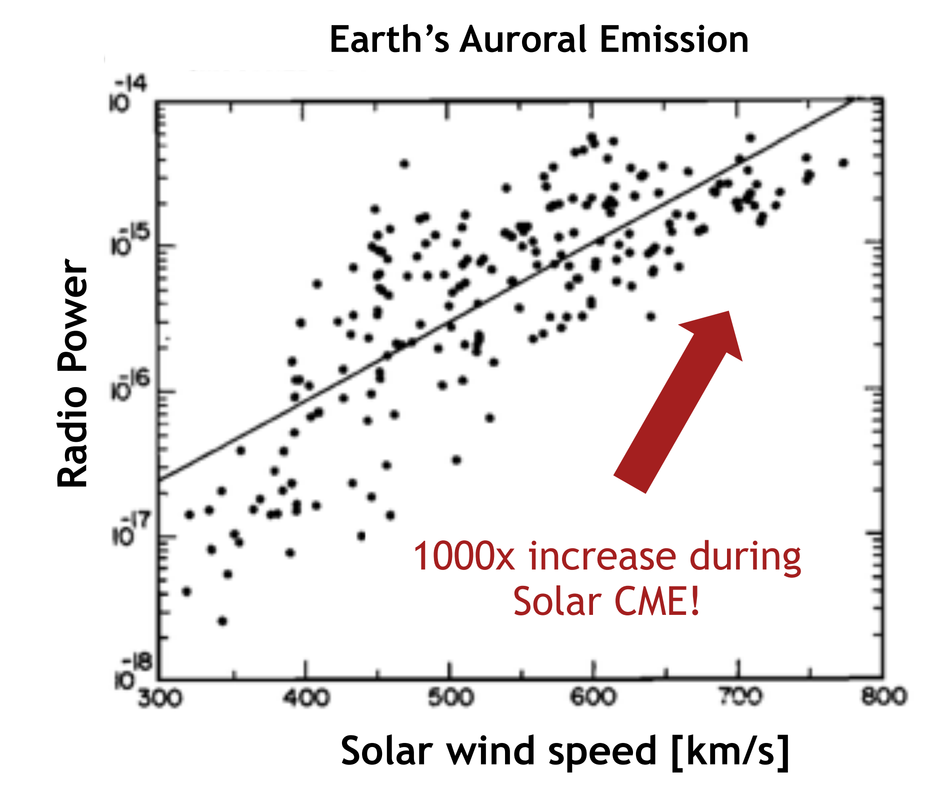
- Previous detections of flare star radio emission indicate flux increases at low frequencies.



Spangler & Moffett 1976

Large-FoV Instruments

- Capture a large fraction of sky in order to monitor a large sample of objects.
- Sensitive to rare events associated with extreme flares / CMEs that may induce significant increase in exoplanetary radio power.

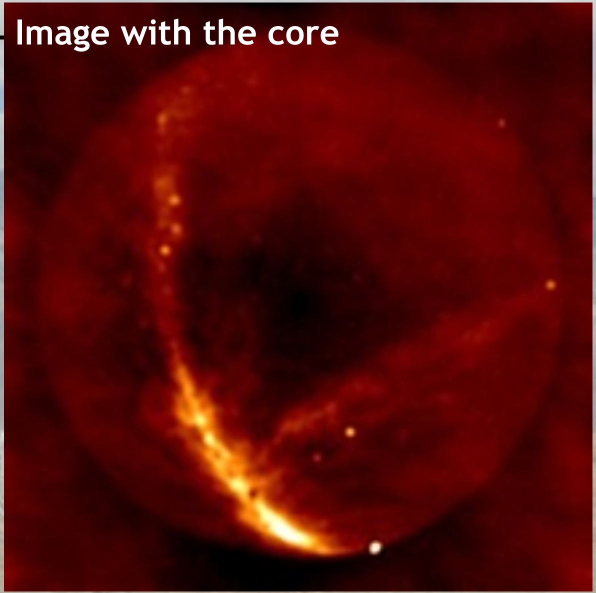


Gallagher and D'Angelo 1981

OVRO-LWA: Stage I of the array was completed in 2014

1

- 256 crossed-dipoles
- Spread out across 200-m diameter core



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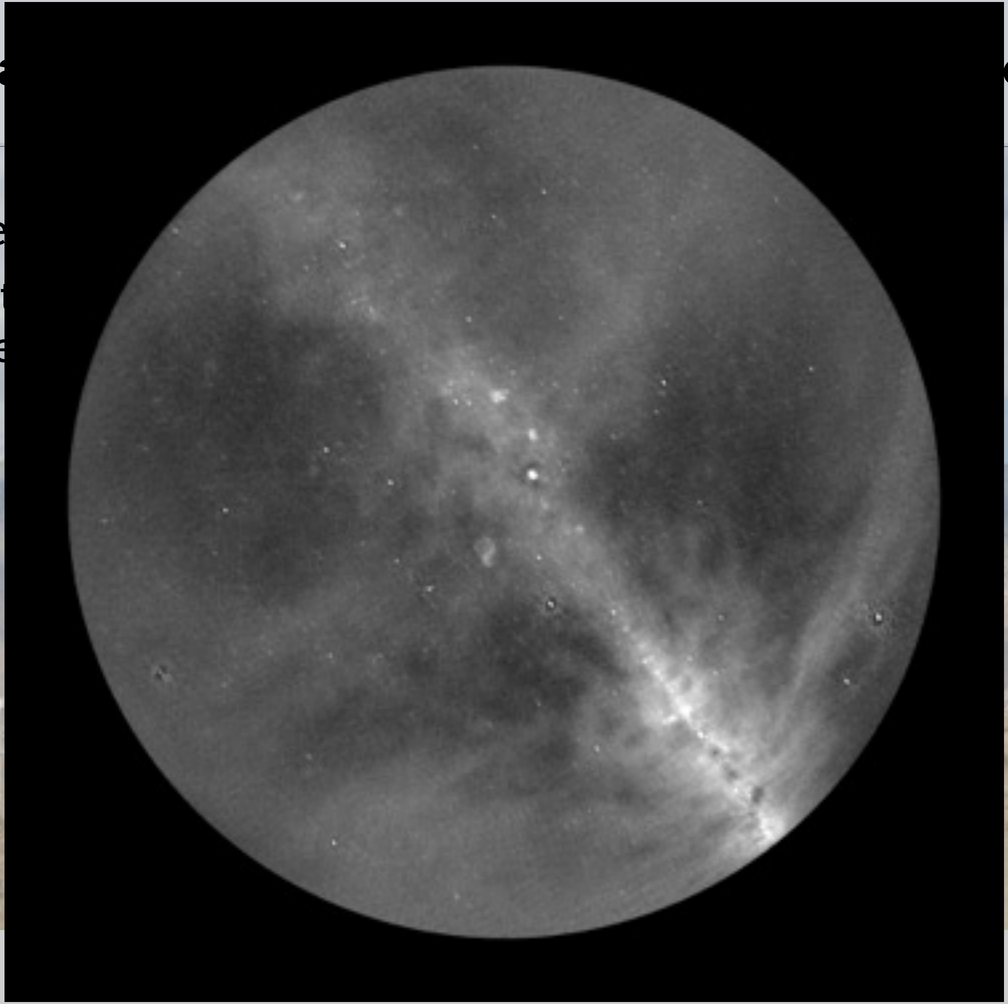
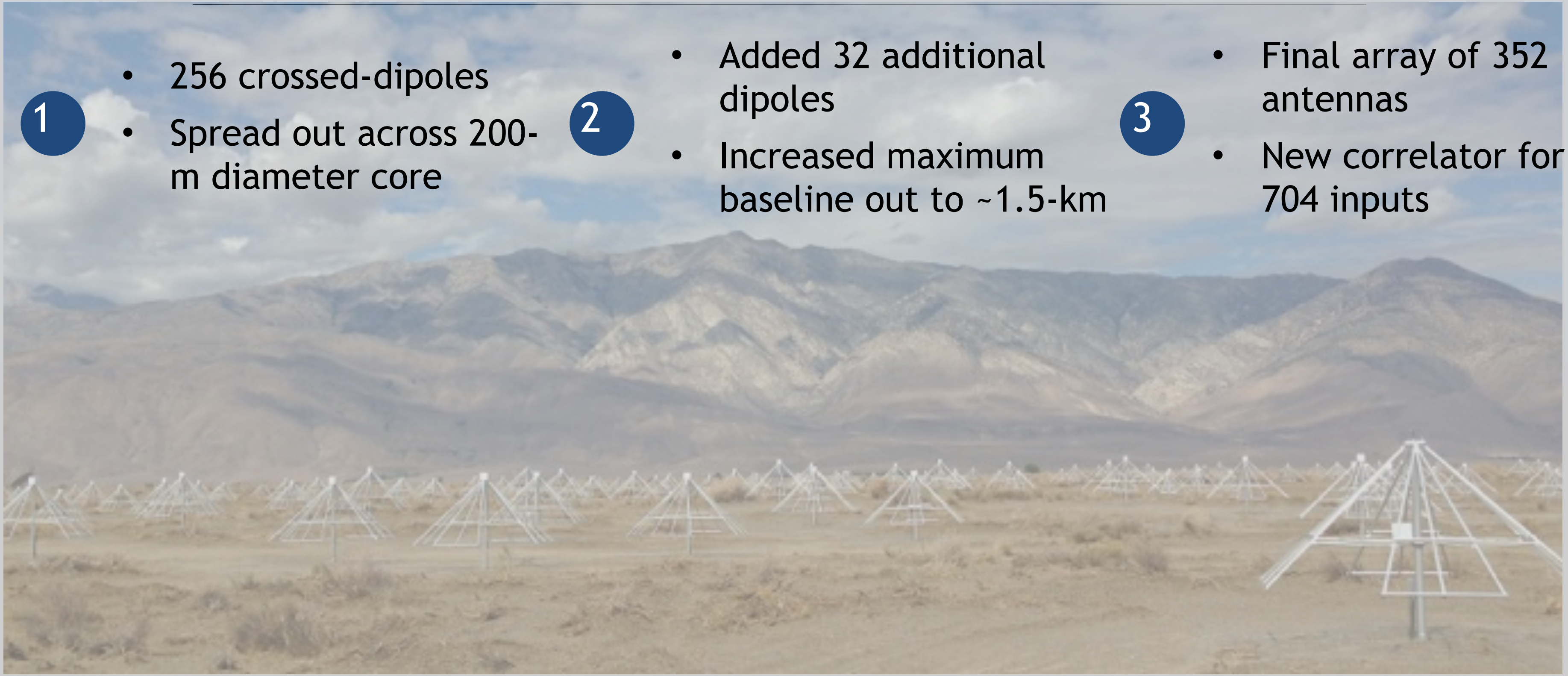


(The final) Stage III of the array will add an additional 64 antennas on long baselines, and vastly increase the capabilities of the existing OVRO-LWA.



1
- 256 crossed-dipoles
- Spread out across 200-m diameter core

2
- Added 32 additional dipoles
- Increased maximum baseline out to ~1.5-km

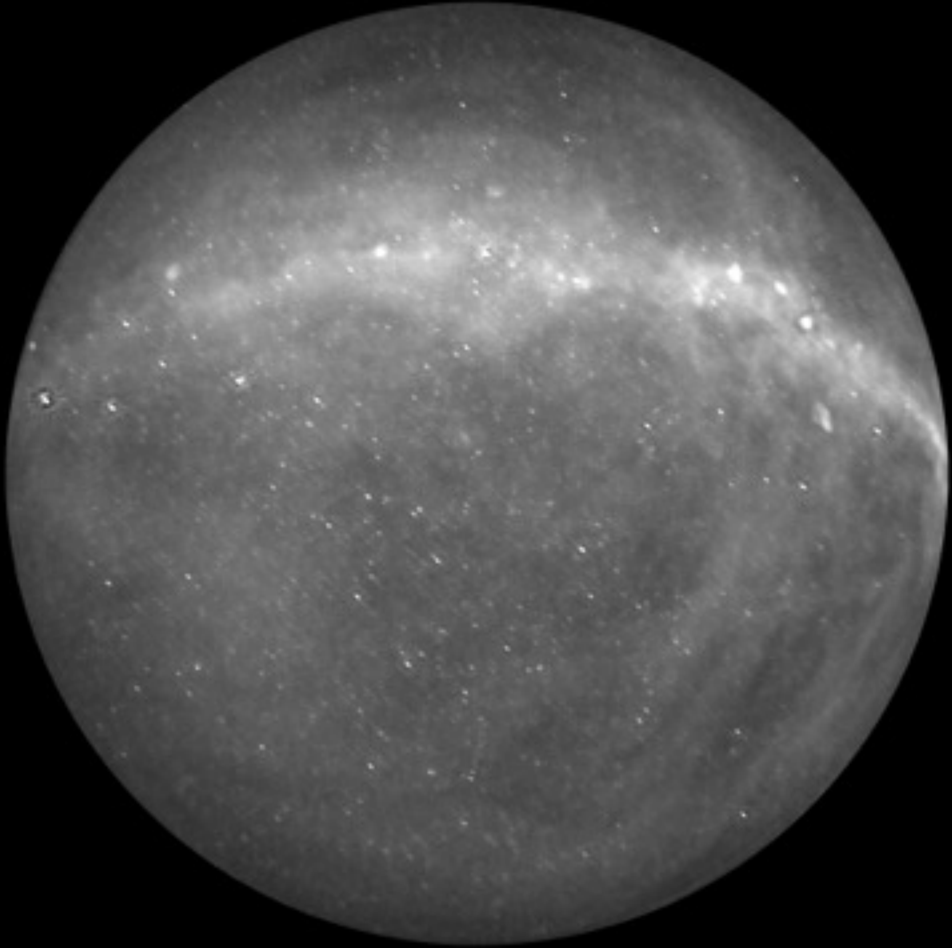
3
- Final array of 352 antennas
- New correlator for 704 inputs

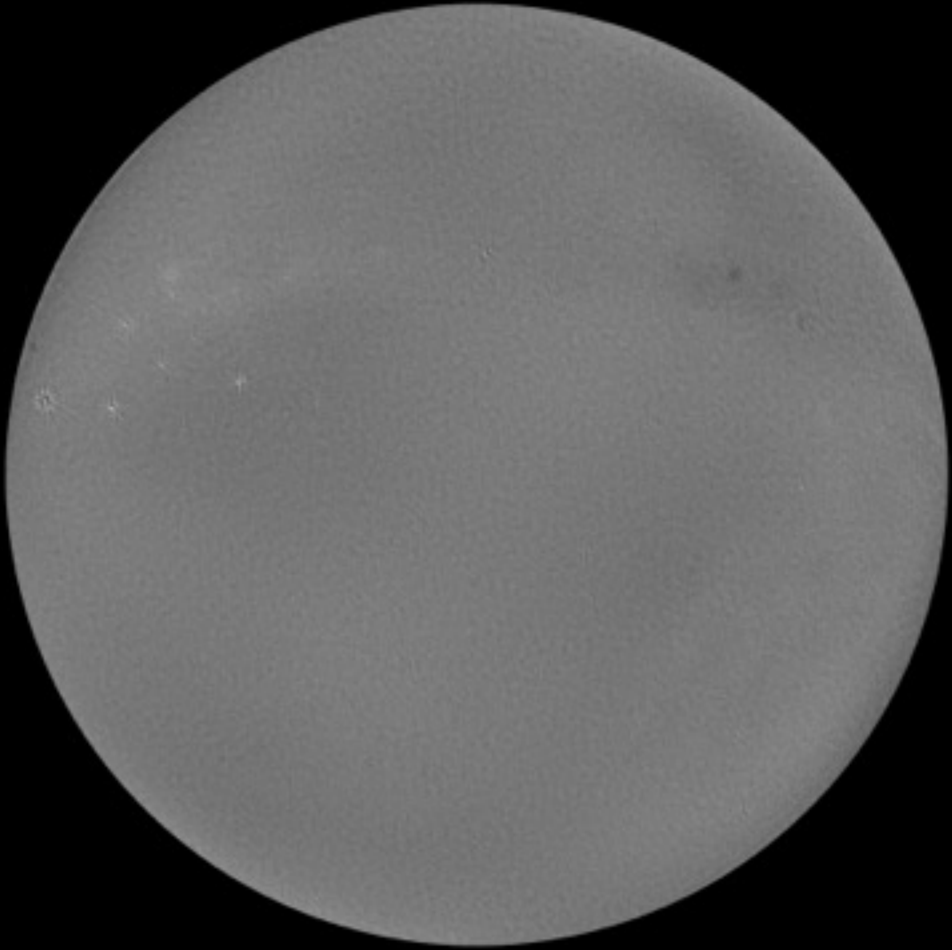
Current mode of operation with the Stage 2 OVRO-LWA

- Continuously observing as of November 2016, in order to respond to external event triggers (including GW events from aLIGO, X-ray flares from *Swift*).

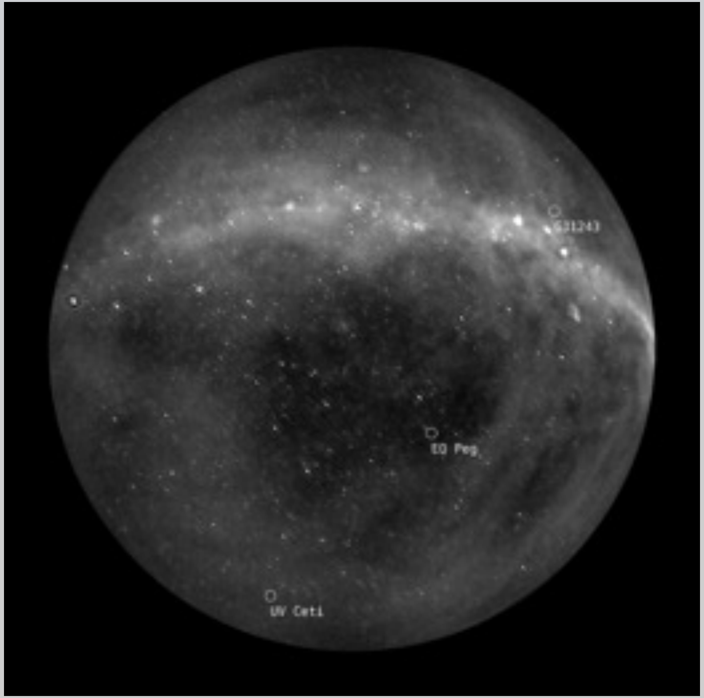
Image credit: **G. Hallinan**

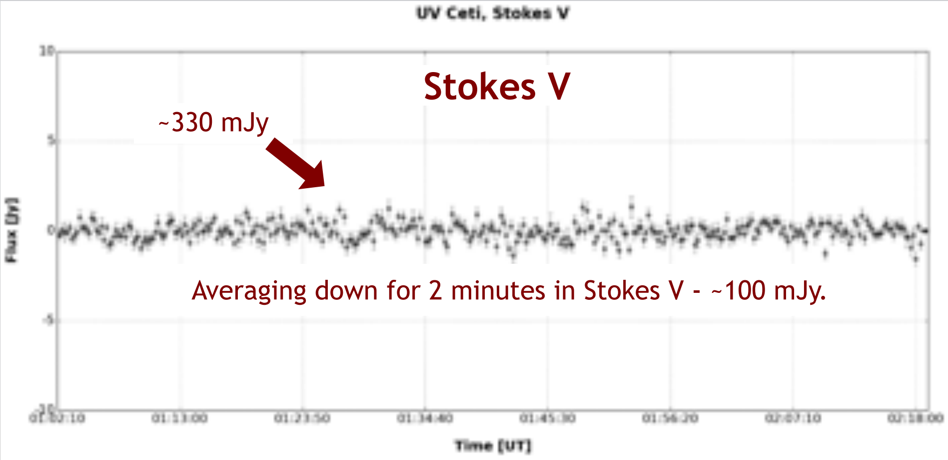
- Initial 31-hour dataset monitoring 4000 objects out to 25 pc.
- 27-84 MHz with 24 kHz resolution
- 13-second integrations



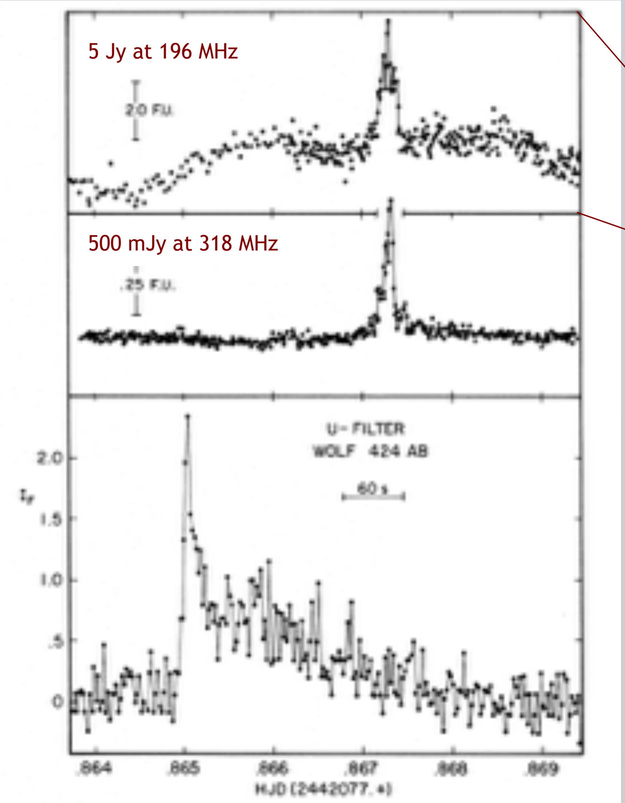


Initial results from a sample subset of flare stars.

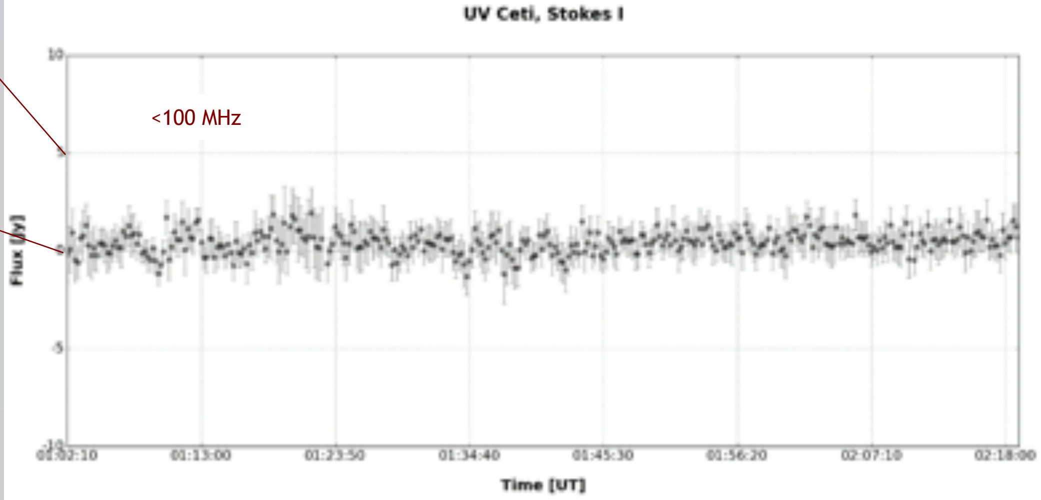




OVRO-LWA light curves for the usual flare star suspects.

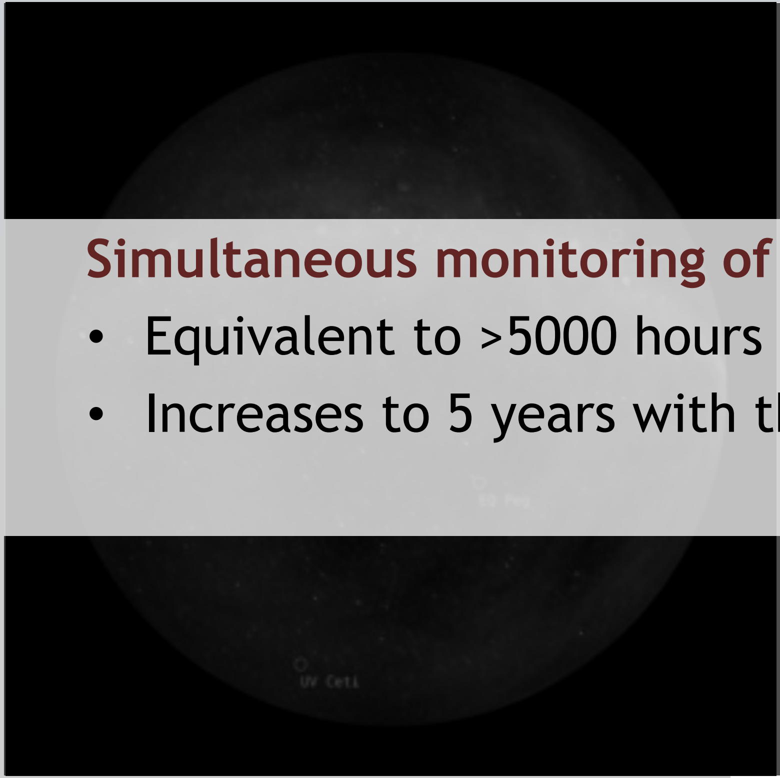


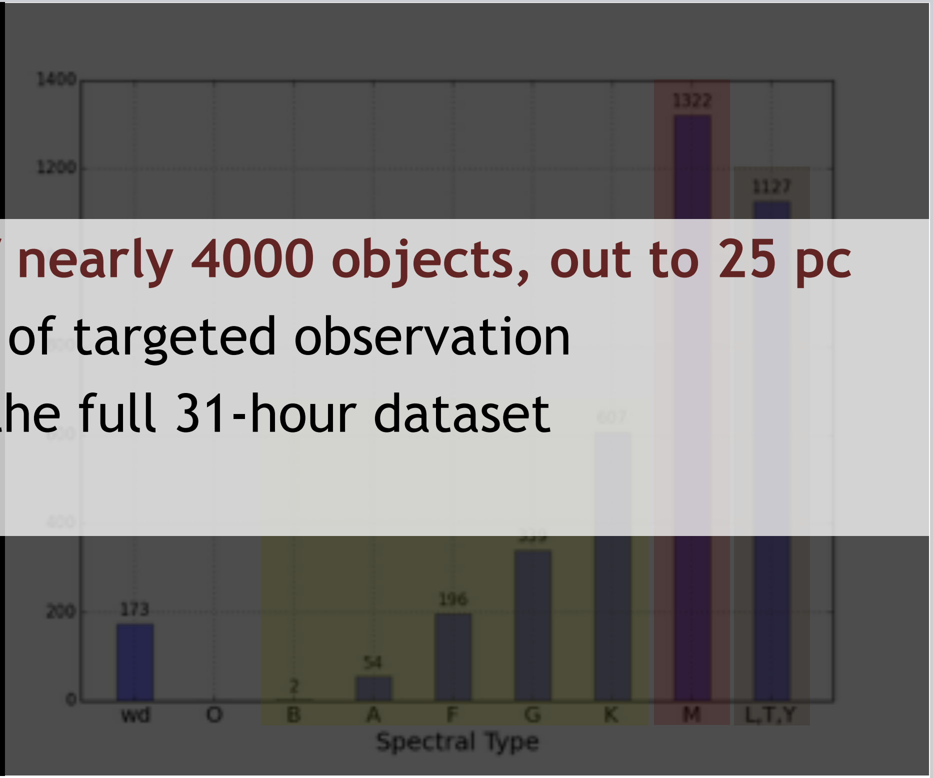
Spangler & Moffett 1976



- A Wolf 424-like flare would be >10 σ detection!

Searching for signatures of magnetic activity in a volume-limited sample of systems.

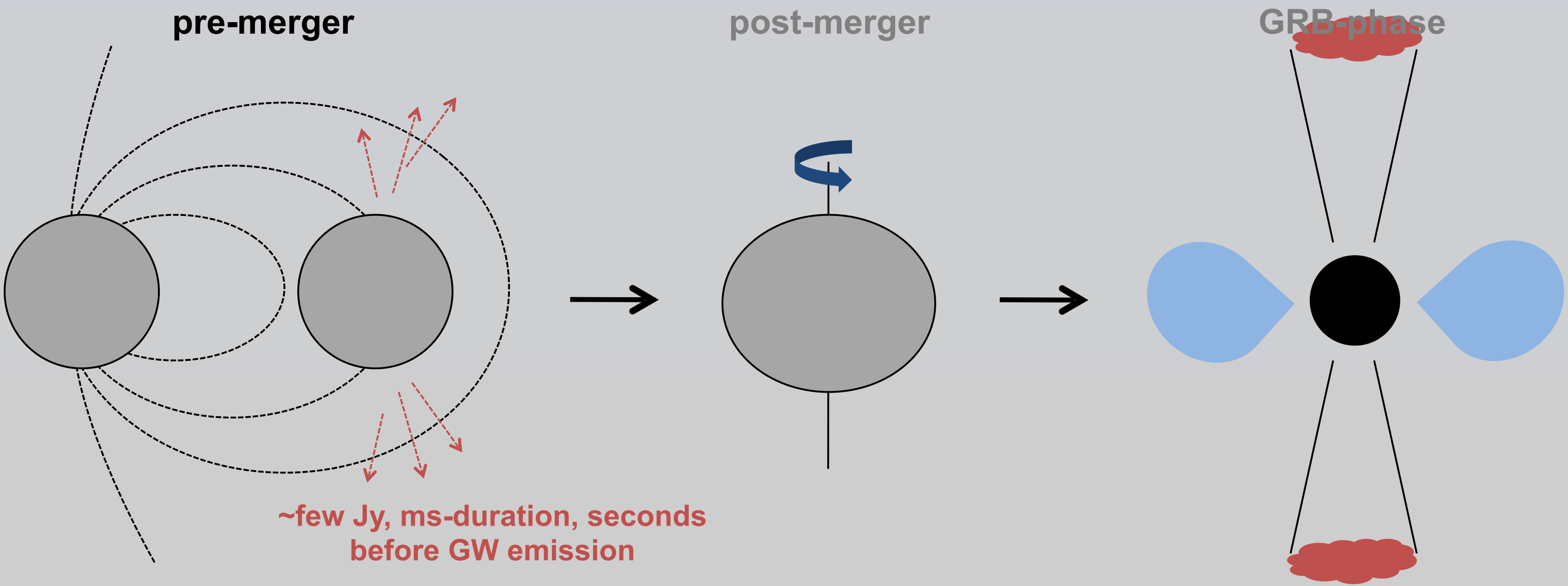




Simultaneous monitoring of nearly 4000 objects, out to 25 pc

- Equivalent to >5000 hours of targeted observation
- Increases to 5 years with the full 31-hour dataset

A number of models predict a (highly speculative) counterpart to SGRBs and NS-NS mergers in the form of prompt, low frequency radio emission.



e.g. Hansen & Lyutikov 2001

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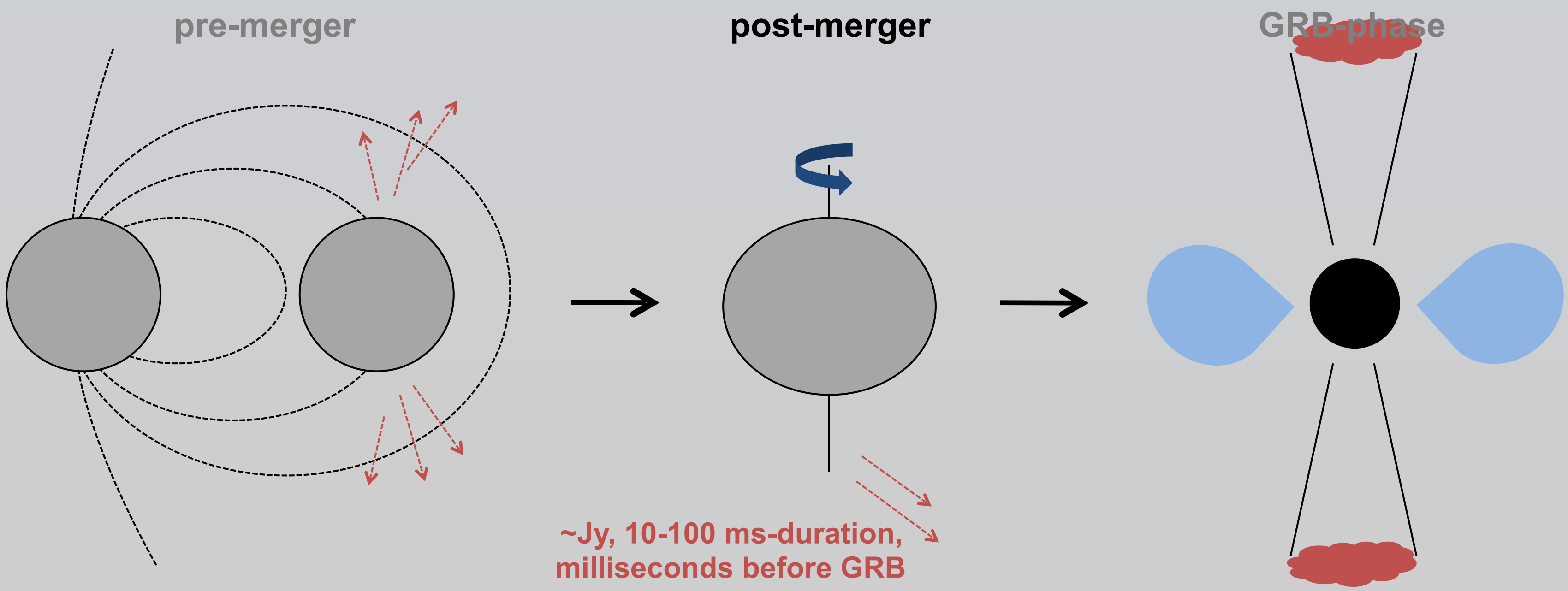

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e.g. Pshirkov & Postnov 2010

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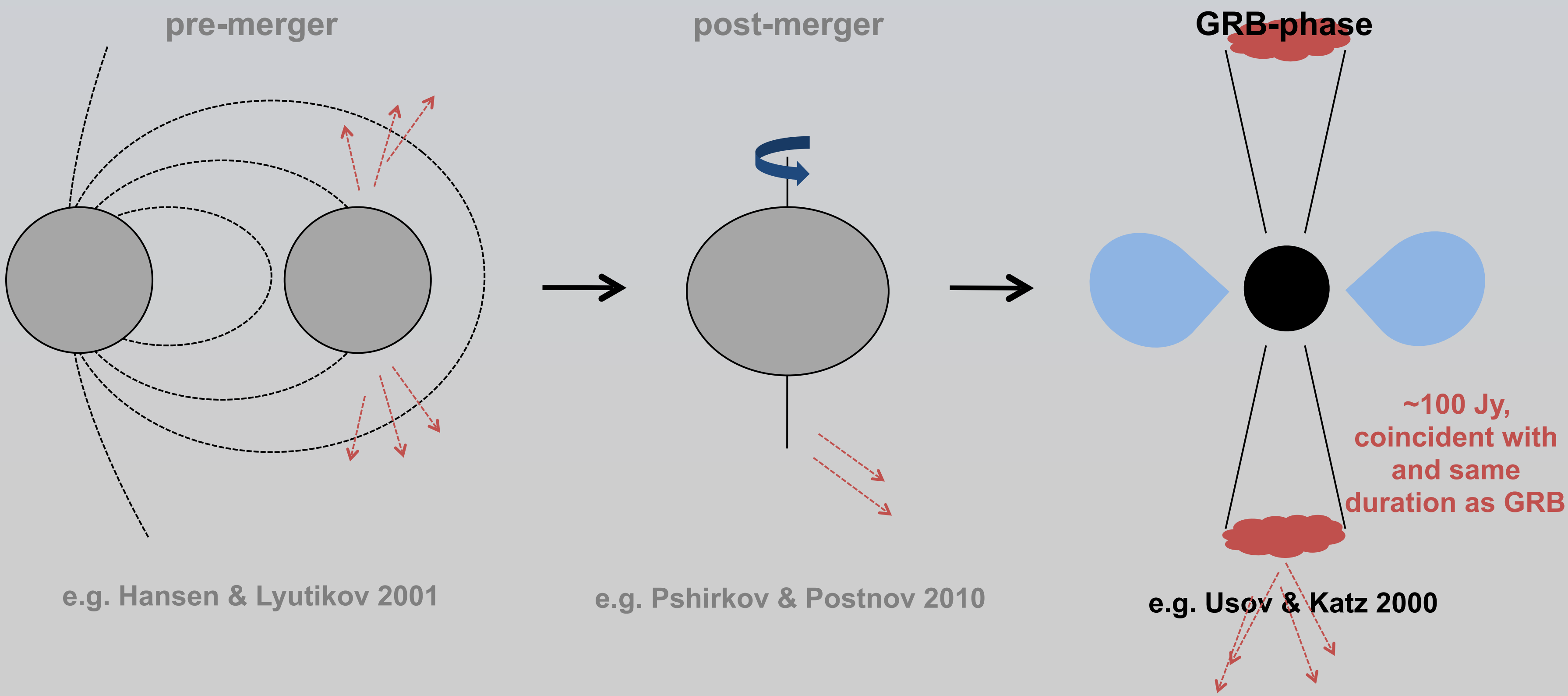

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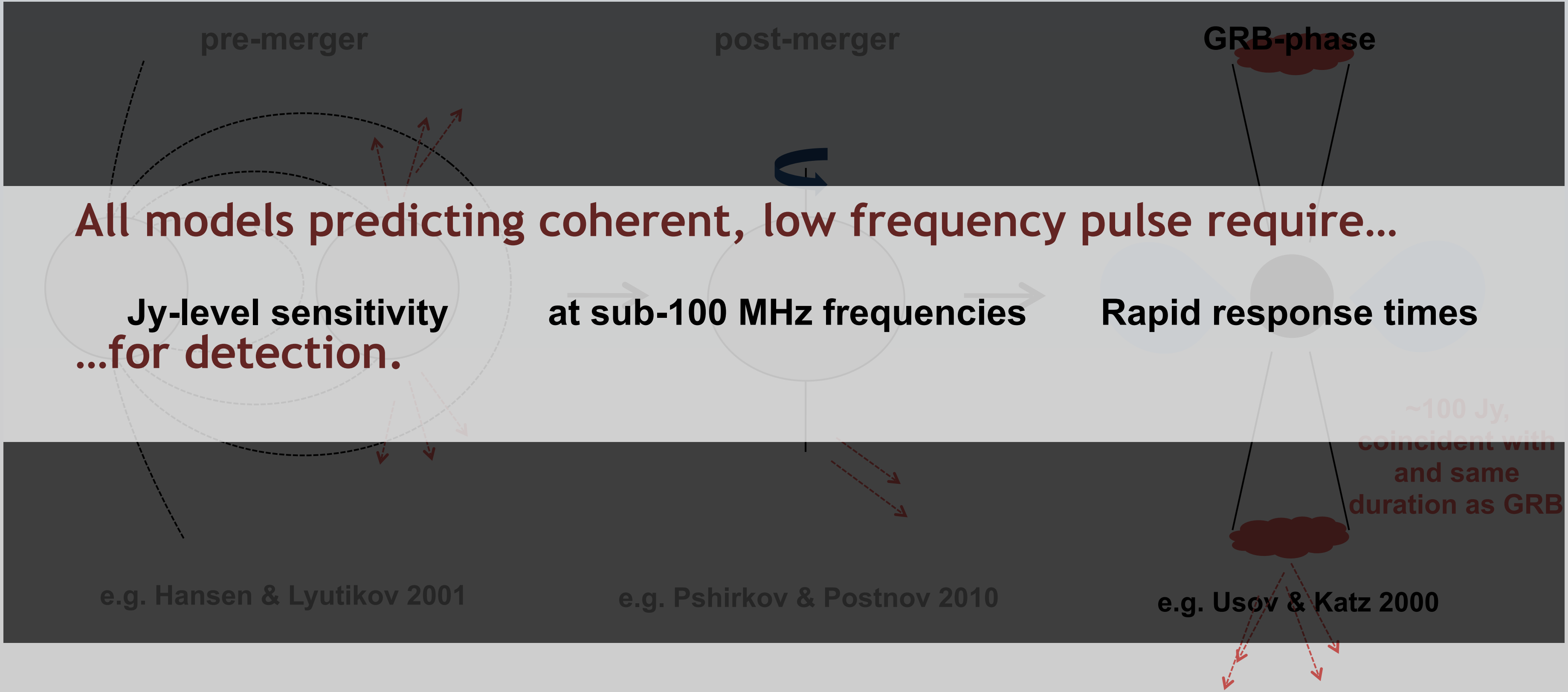
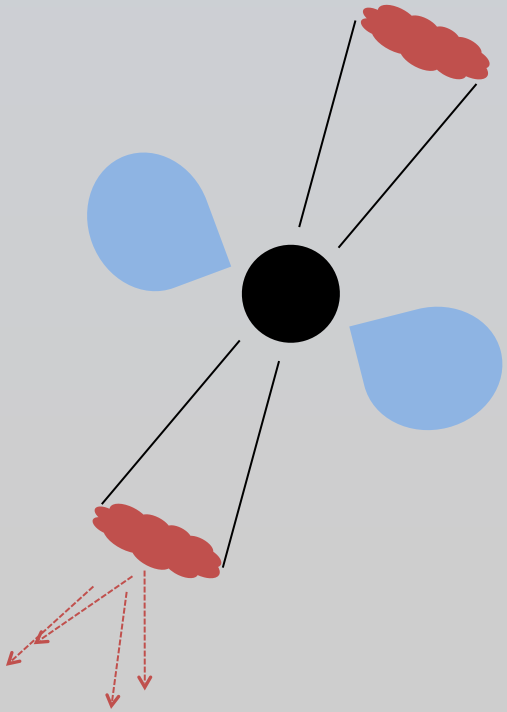


All models predicting coherent, low frequency pulse require…

Jy-level sensitivity **at sub-100 MHz frequencies** **Rapid response times**

…for detection.

Why is prompt pulse of low frequency radio emission accompanying GRB valuable?

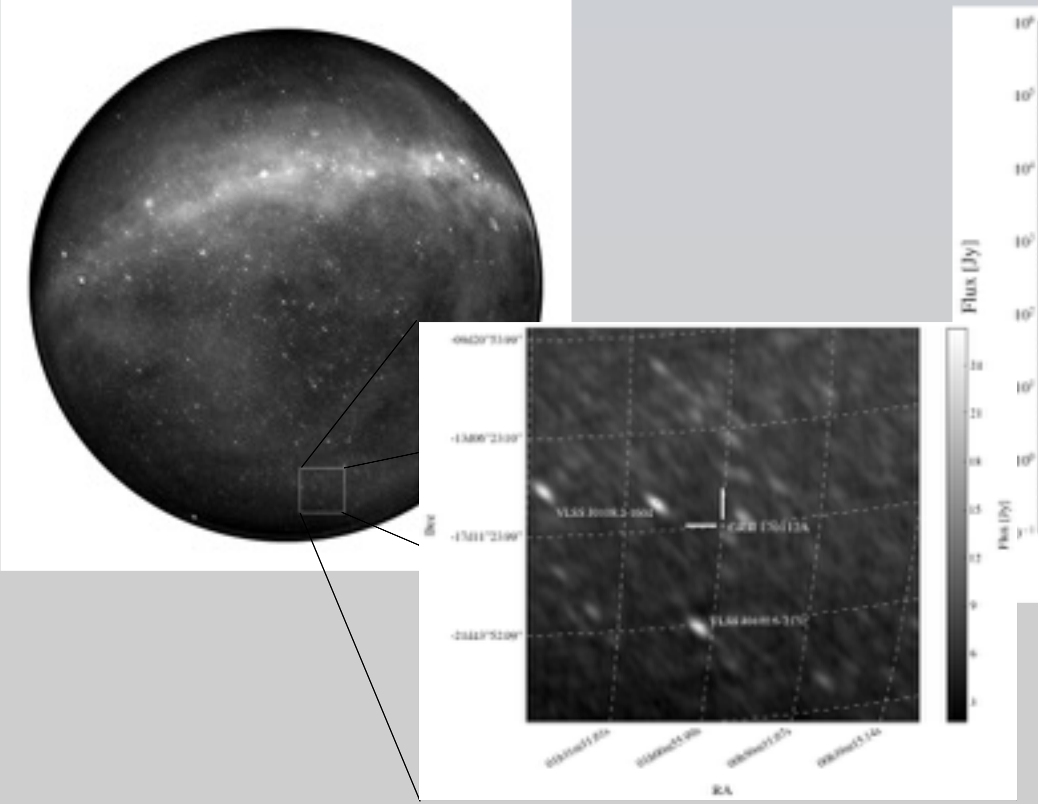


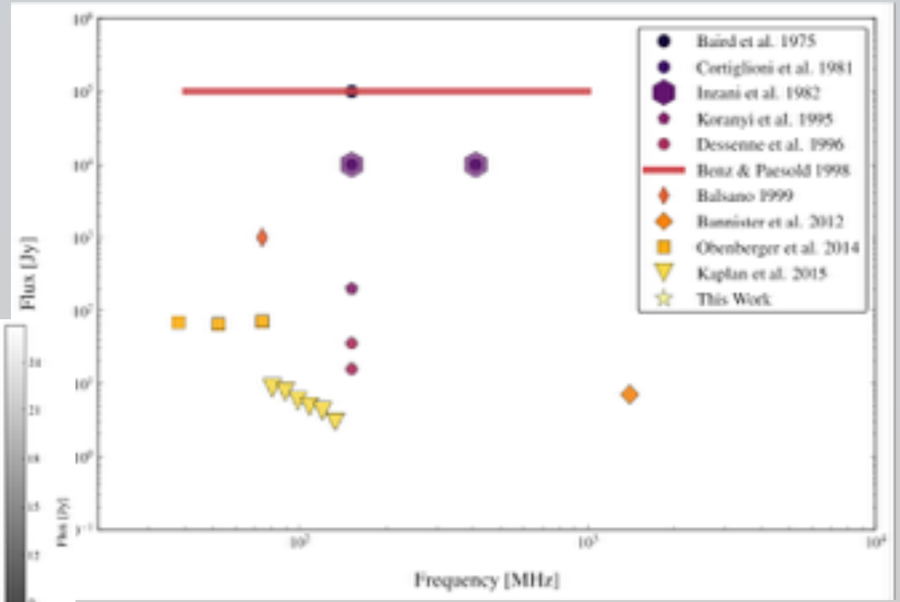
Serves as probe of **IGM density and turbulence**.

Provides constraints on explosion physics in GRBs, including **Lorentz factor** and **jet opening angle**.

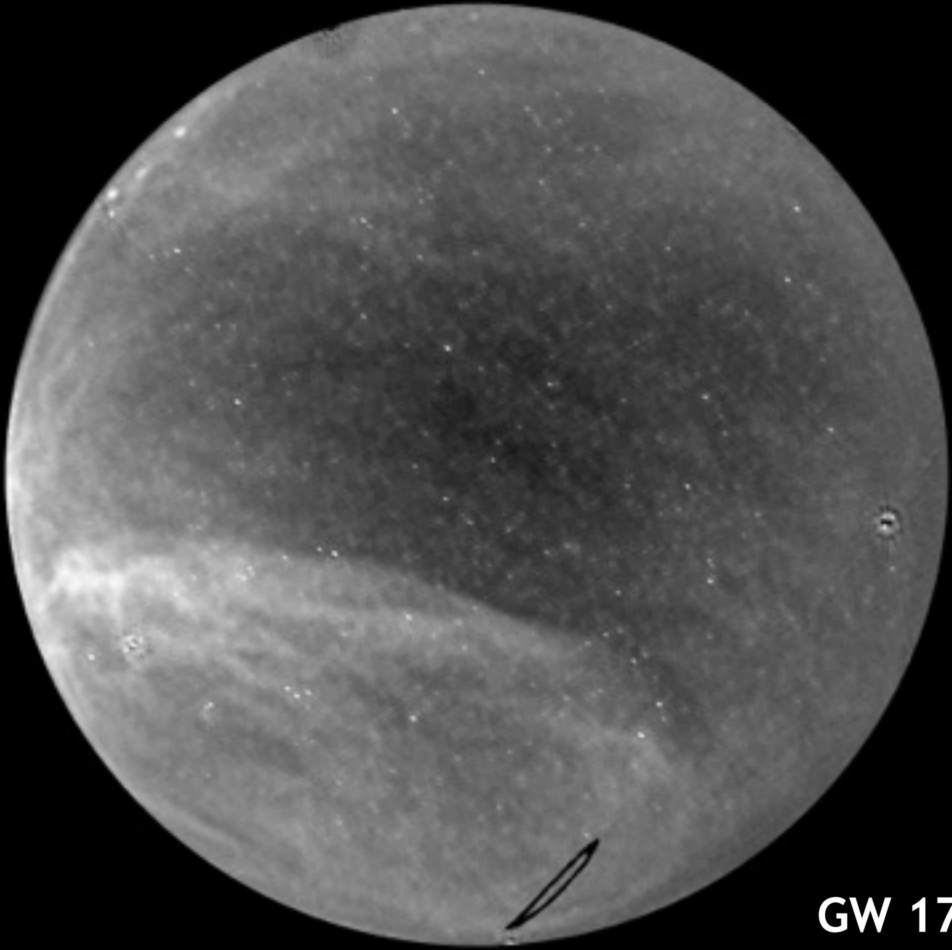
Provides **EM-counterpart** to **GW source**!

Deepest search for prompt, coherent emission associated with a short GRB.





Anderson et al. 2017



GW 170817

From the known knowns, to the known unknowns…

Stewart et al. 2016

Questions?