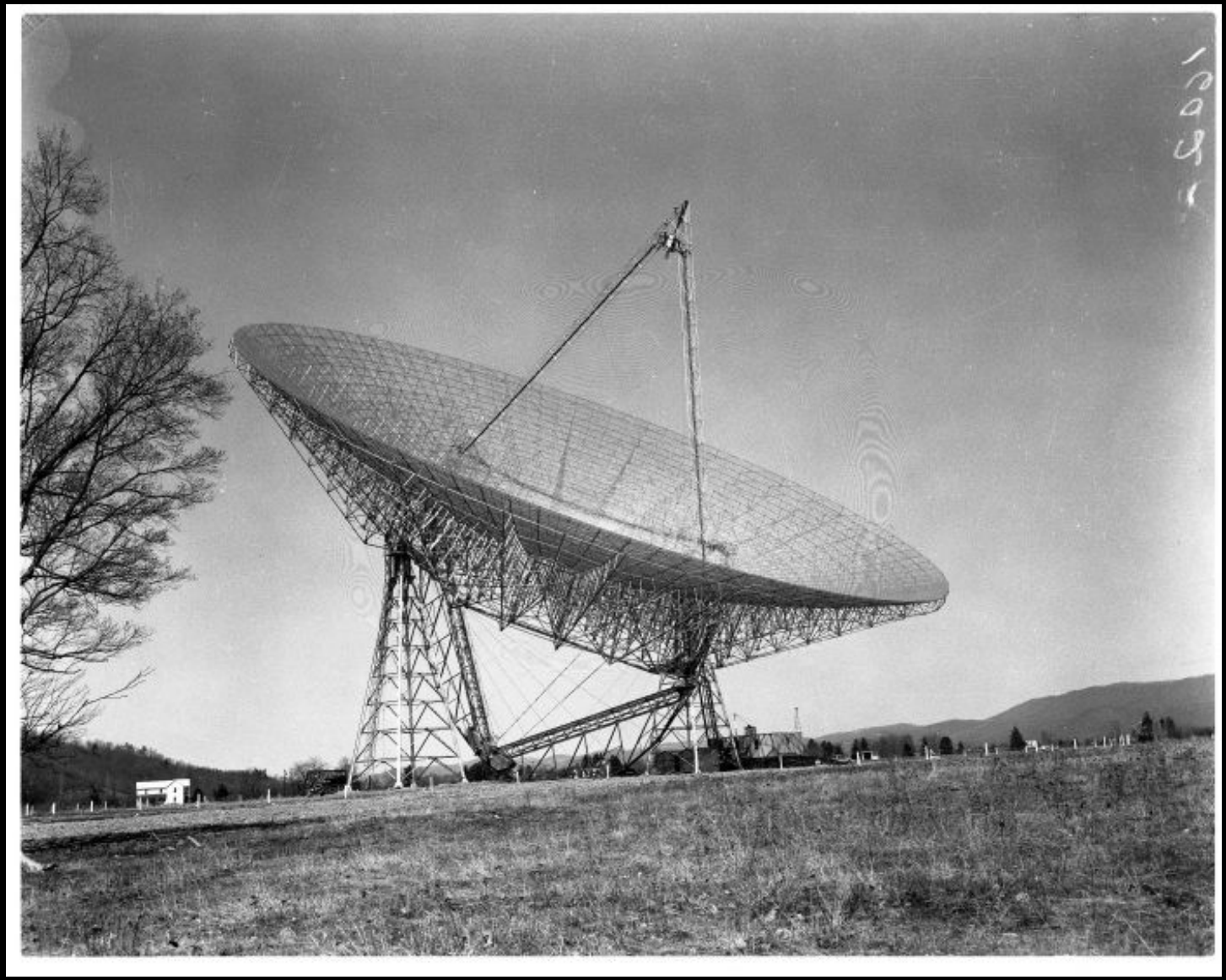
Green Bank's role in Pulsars and Transients

Duncan Lorimer, Dept. of Physics and Astronomy, West Virginia University



Credit: GBO

Some landmark GB pulsar surveys

- Staelin & Reifenstein
  - Giant pulses from the Crab nebula
- 300 ft surveys
  - B1931+24 (emphasis on patience!)
- Some memorable GBT targets
  - Terzan 5 (Ransom et al.; Prager et al. 2017)
  - 3C58 PSR/SNR (Camilo et al. 2002)
- GBT Drift
  - Missing link pulsar!
  - Triple system
  - Pulsar Search Collaboratory
- GBNCC
  - 156 and counting (20 MSPs)

Future GB pulsar surveys

- Galactic Center
  - Keep on pushing (VEGAS...)
- Other targeted searches
  - Globular clusters
  - High-energy point sources
- 300-400 MHz (P-band) surveys
  - Done by 2020?
- Focal Plane Array
  - Deep Galactic plane L-band surveys
    - e.g. GBT sky 1 hr dwells $|b|<5$
    - >3000 new normal PSRs; >300 new MSPs
    - See http://psrpop.phys.wvu.edu

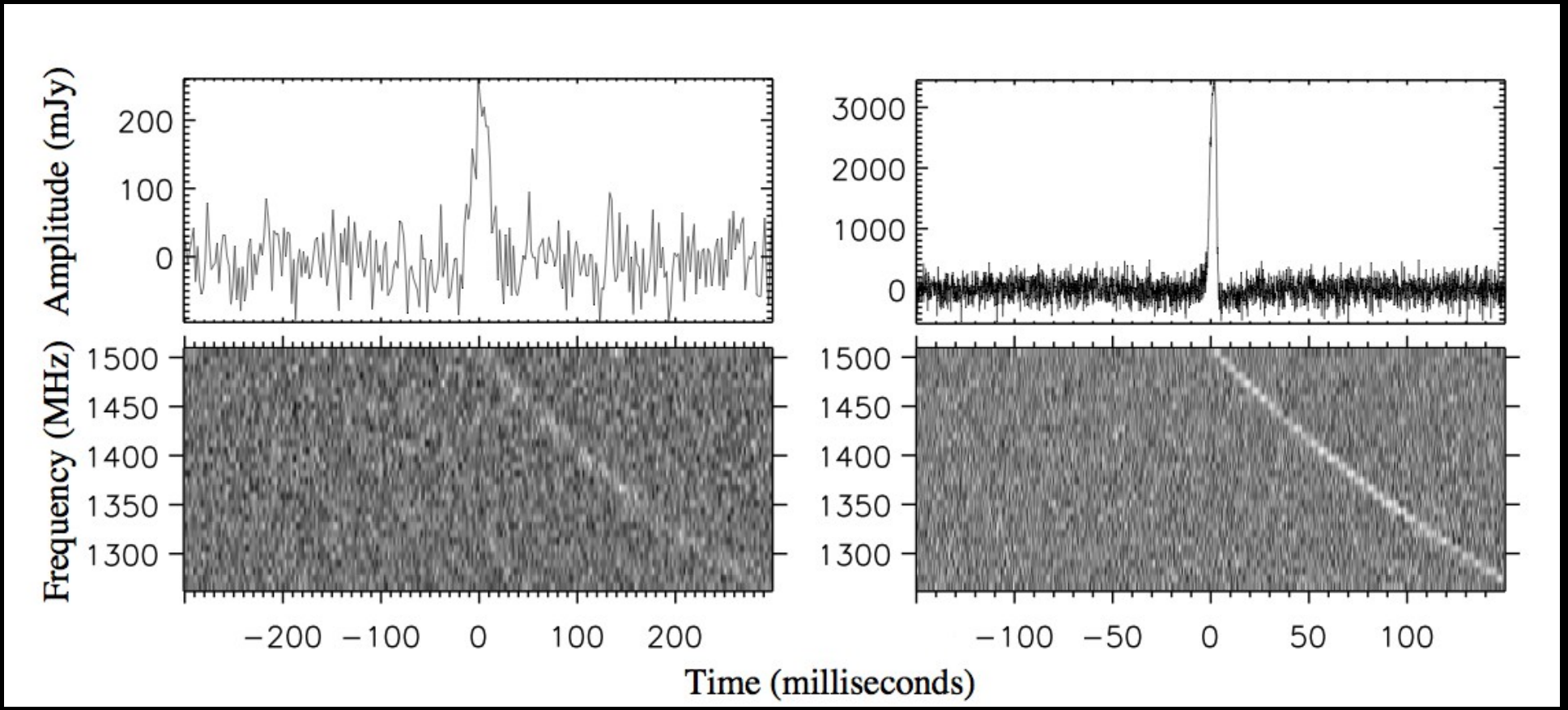
Ongoing non-timing projects

- Interstellar medium
  - DM / RM
  - Flux modulations ▫ scintillation
  - Scattering
  - Parallaxes

- Single-pulse studies with higher fidelity
  - Fine structure in normal pulsars
  - Millisecond pulsars

- Pulsar intermittency/state switching
  - Resurgence in last decade

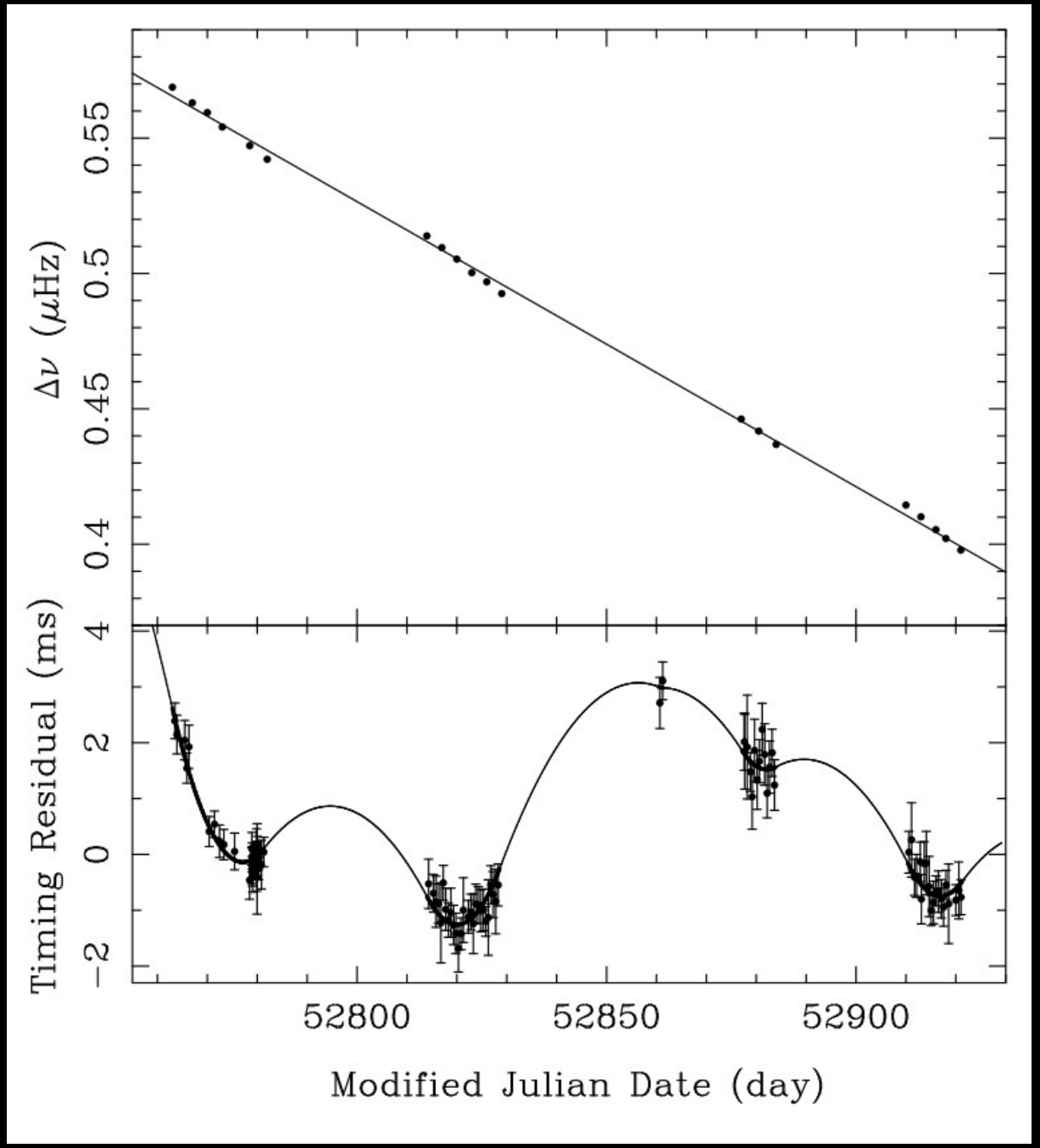
Rotating Radio Transients (RRATs)



McLaughlin et al. (2006)

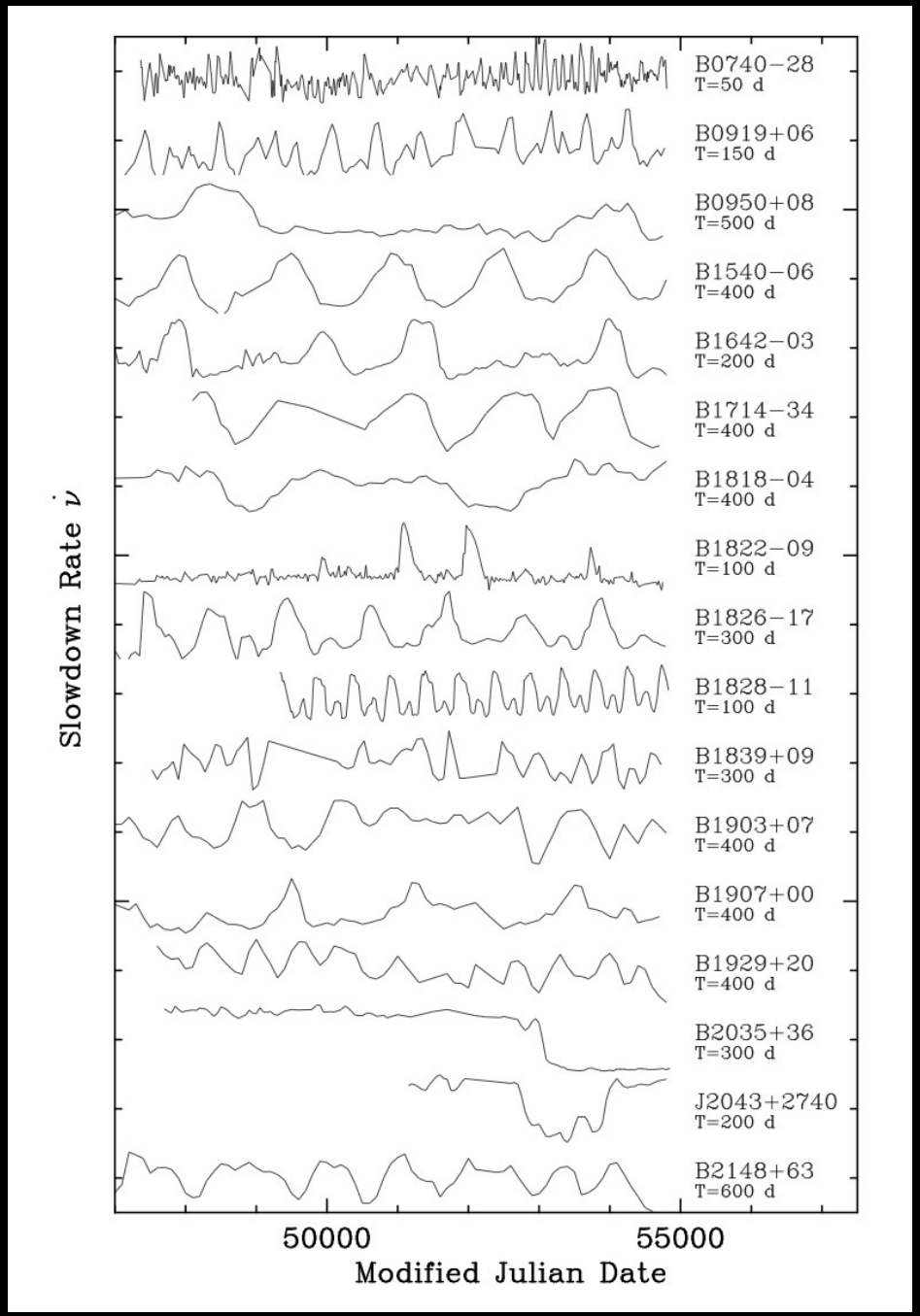
http://astro.phys.wvu.edu/rratalog – currently over 100 known

Pulsar intermittency

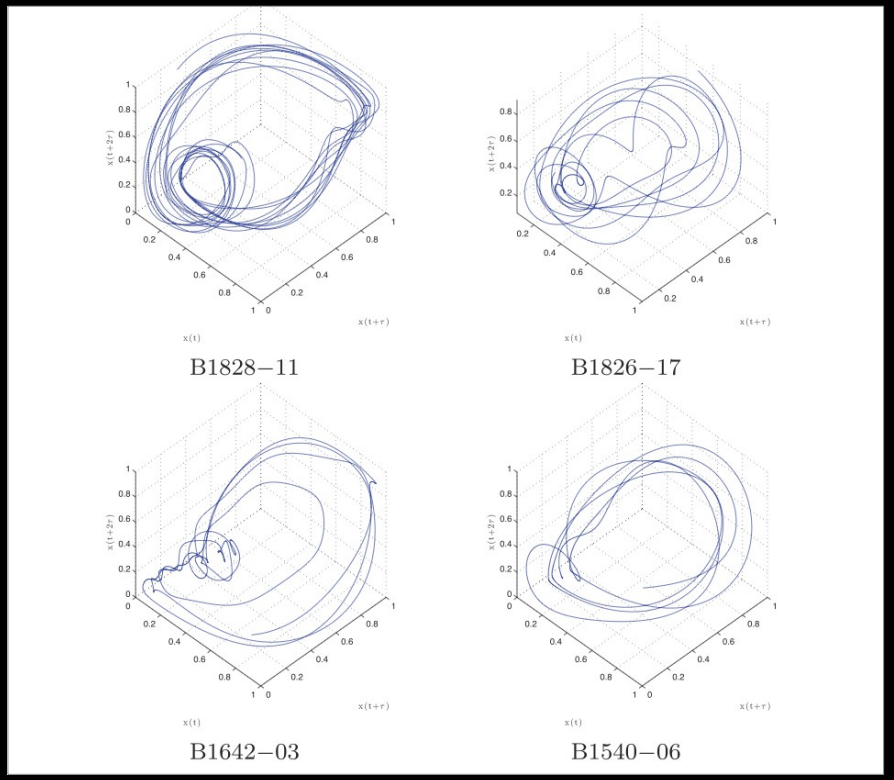


Credit: Kramer et al. 2006

Spin-state changing



Credit: Lyne et al. 2010

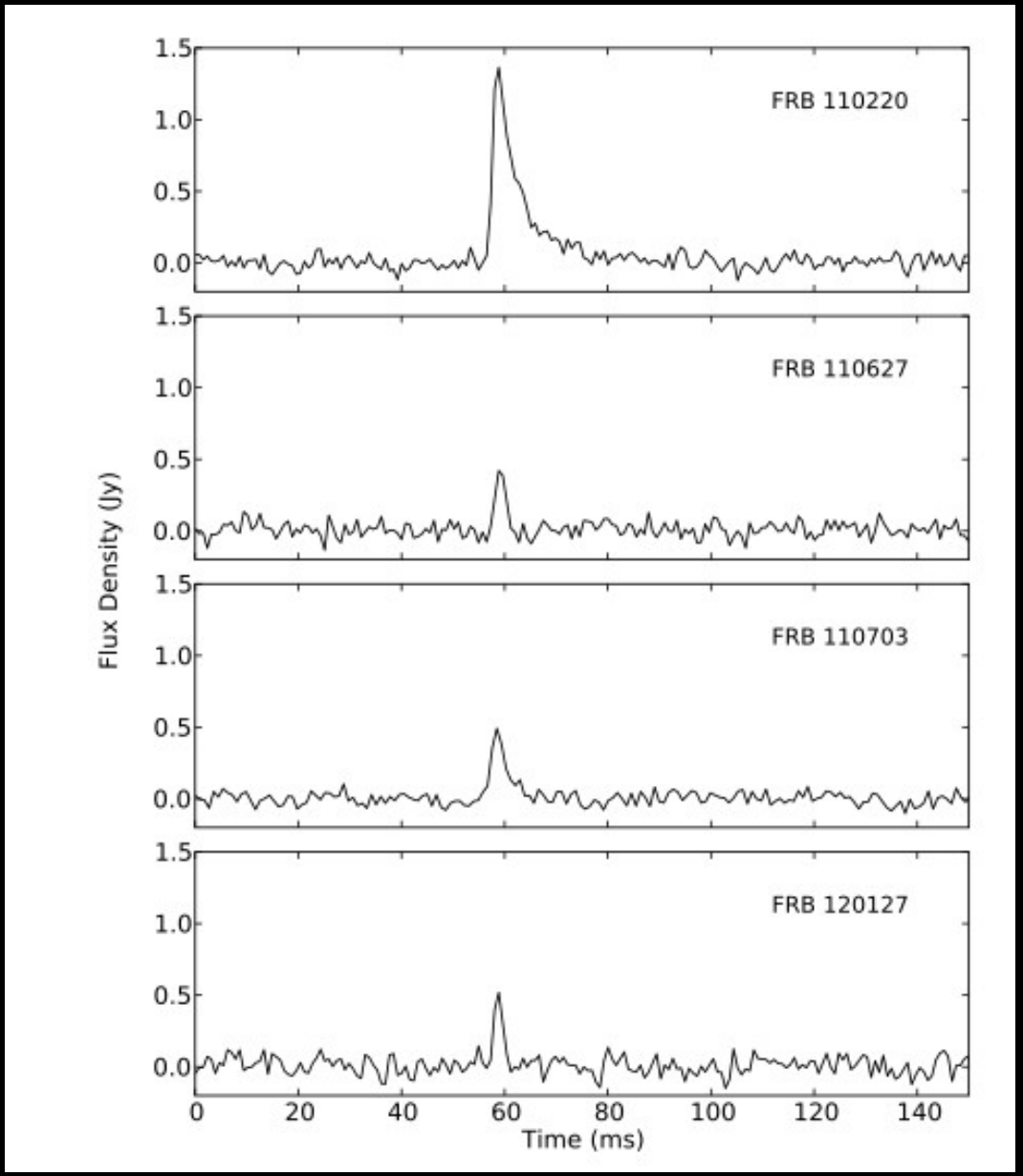


Seymour+DL (2013)

- Low-D attractors?

FRB lowdown

- Two dozen known so far
- Flux > 0.5 Jy @ 1.4 GHz
- Pulse widths > few ms
- Highly dispersed
- Weakly scattered
- One FRB so far repeats!
- Few arcmin localization
- One counterpart so far
- ~few x 1000/day/sky



Credit: Thornton et al. (2013)

A Bright Millisecond Radio Burst of Extragalactic Origin

D. R. Lorimer,[1,2]* M. Bailes,[3] M. A. McLaughlin,[1,2] D. J. Narkevic,[1] F. Crawford[4]

Pulsar surveys offer a rare opportunity to monitor the radio sky for impulsive burst-like events with millisecond durations. We analyzed archival survey data and found a 30-jansky dispersed burst, less than 5 milliseconds in duration, located 3° from the Small Magellanic Cloud. The burst properties argue against a physical association with our Galaxy or the Small Magellanic Cloud. Current models for the free electron content in the universe imply that the burst is less than 1 gigaparsec distant. No further bursts were seen in 90 hours of additional observations, which implies that it was a singular event such as a supernova or coalescence of relativistic objects. Hundreds of similar events could occur every day and, if detected, could serve as cosmological probes.

Lorimer bursts are real!

Matthew Bailes Dec 12 (3 days ago)

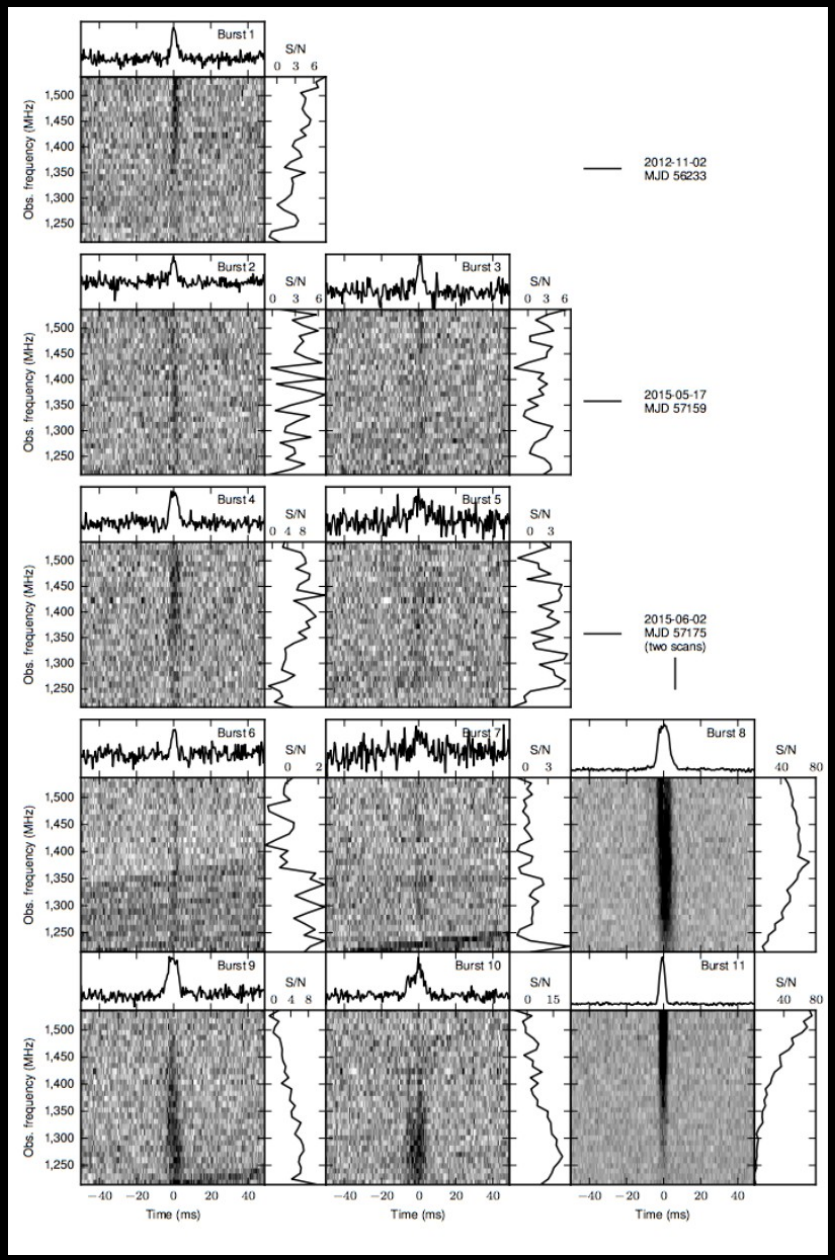
to me

Hey Dunc - spectacular news about the repeating Arecibo FRB/Lorimer burst!

Looks like Lorimer bursts are real after all!

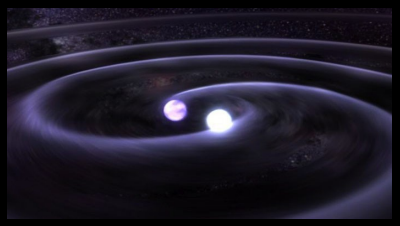
Cheers - Matthew

2016: FRB 121102 repeats!

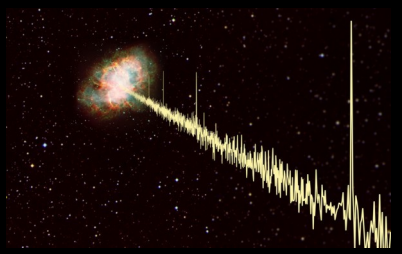


Credit: Spitler et al. and Scholz et al. (2016)

- No!



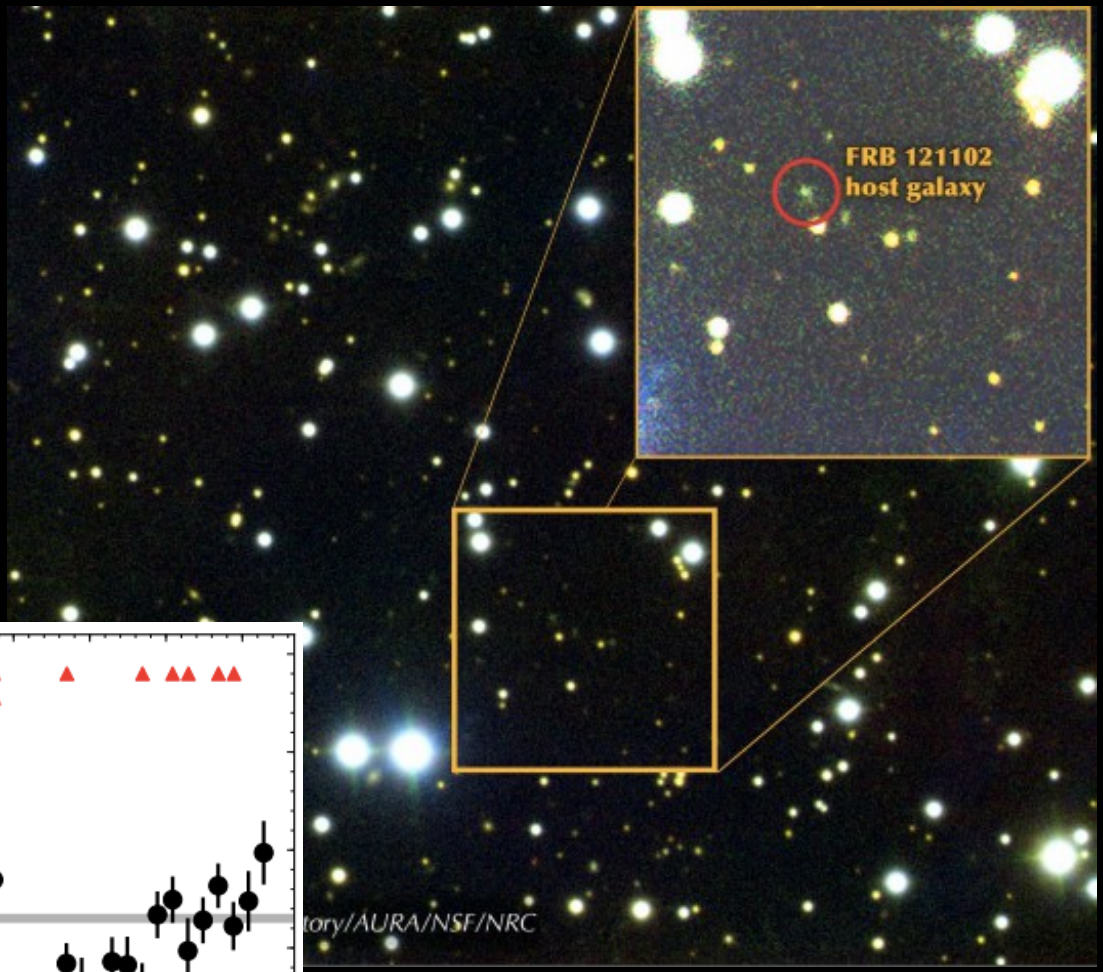
- No!

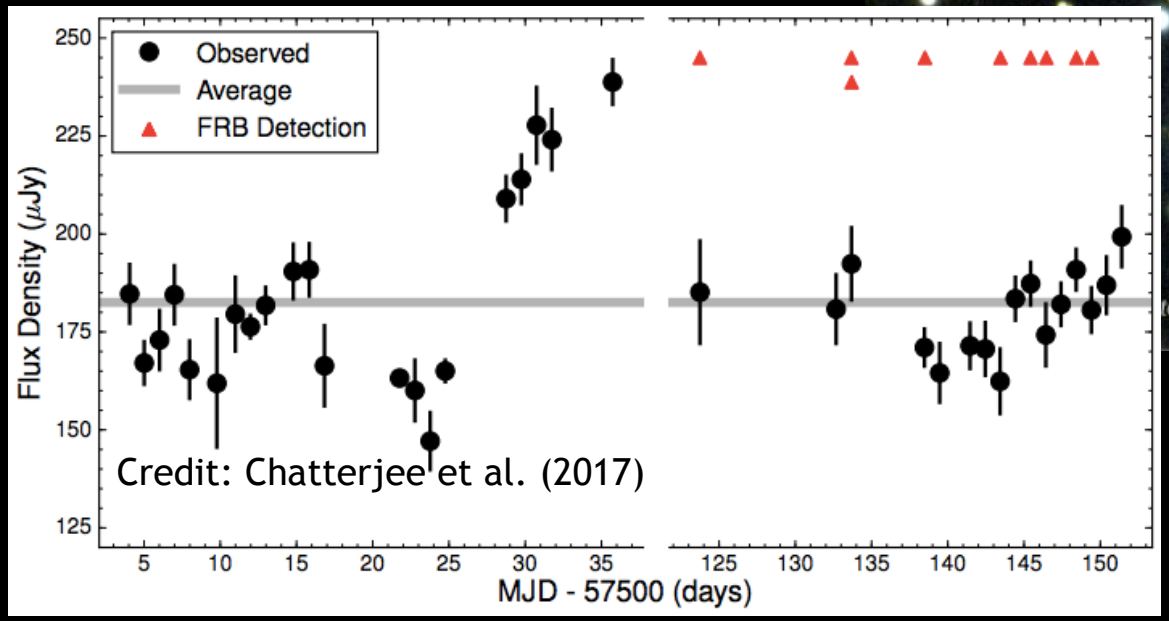


- Maybe?

… or maybe something else?

2017: FRB 121102 localized!





z = 0.19
(2.3 billion yr)

We're not sure what FRBs are!

- What is the source of FRB 121102?
  - Are the radio sources related?
  - Magnetar/AGN interaction?
- Is FRB 121102 representative?
  - Do all FRBs repeat?
  - Are there multiple classes?
- What are best strategies going forward?
  - Positional localization crucial
  - Large area coverage also needed

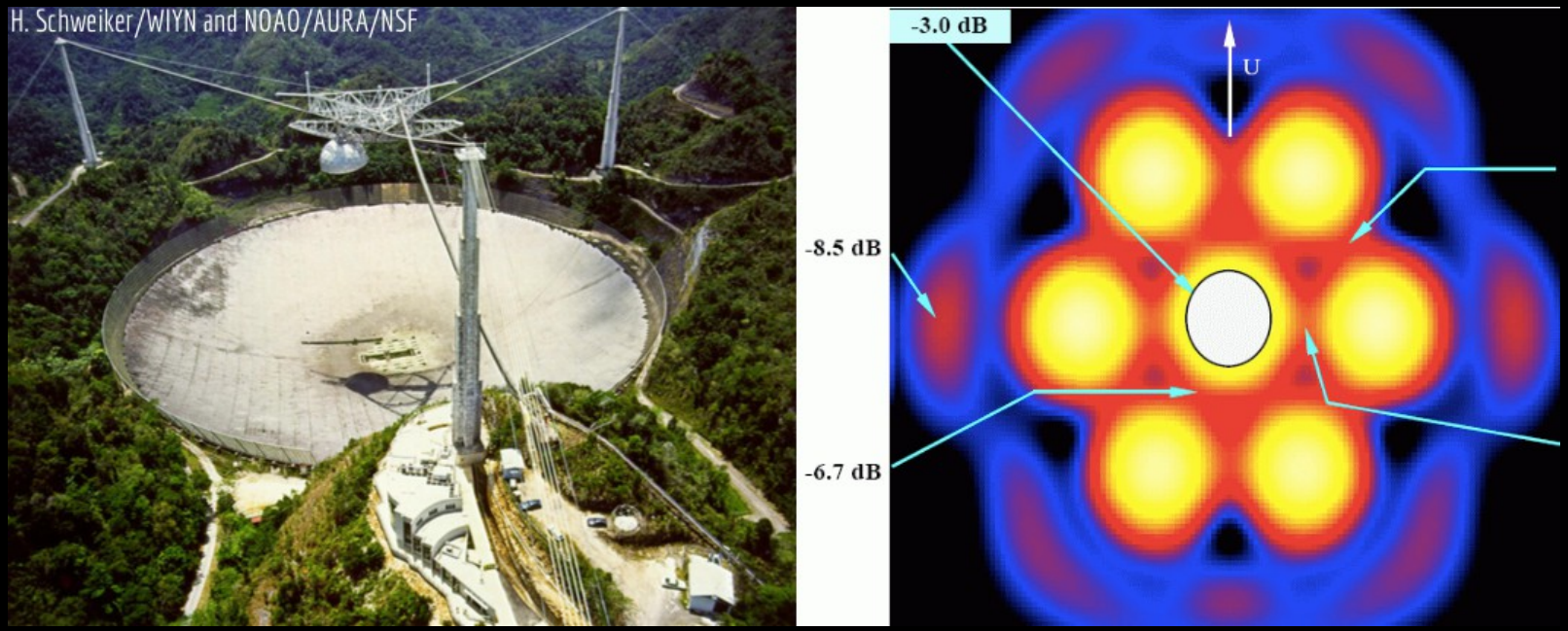
What might FRBs probe?

- New/exciting physics
  - Cosmological NS census?
  - Non-stellar origin?
  - Fundamental tests?
- The intergalactic medium
  - Electron content ▫ missing baryons?
  - Magnetic field || to line of sight
- Cosmology
  - Rulers
  - DM halos, DM/DE parameterization

GBTrans [Ellingson et al.]

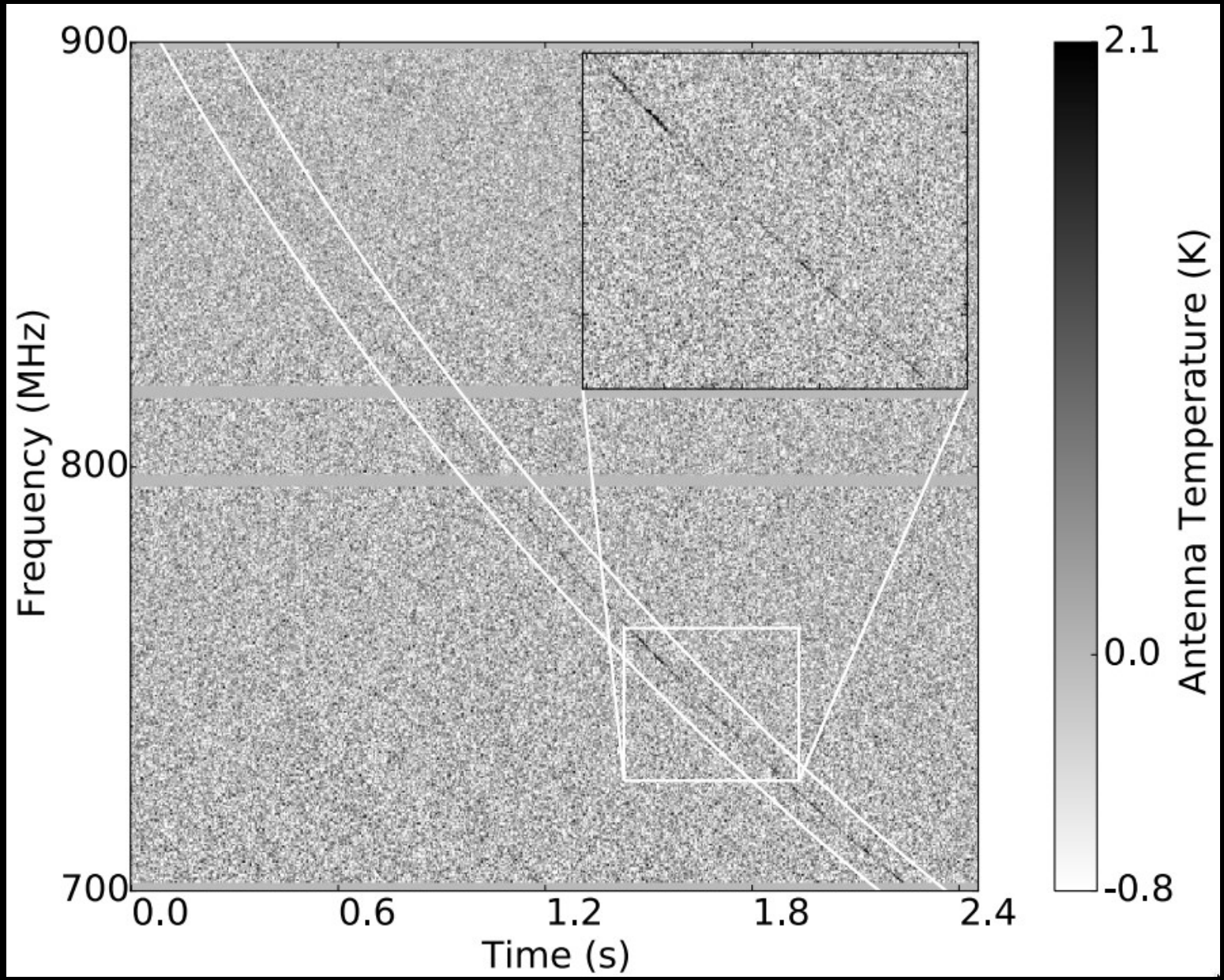
- 1.4 GHz / 50 MHz
- Realtime processing
- FRB rate ~1/month?
- Target nearby clusters
- Beginning “shadowing”
  - Swift
  - LIGO
  - Fermi
  - CHIMERA

FRBs at Arecibo - ALFABURST



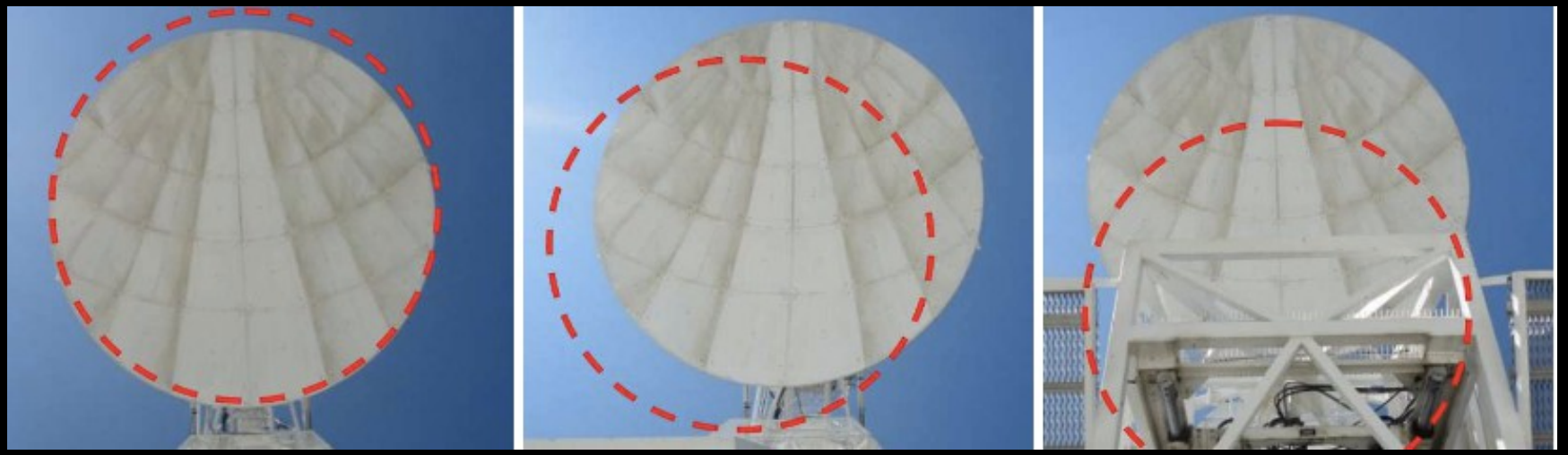
- 7 beams – commensal observing
- 56 MHz current bandwidth
- DM range out to 10,000 pc/cc
- Realtime pipeline (similar to Parkes)

2015: FRB 110523 at GBT



Credit: Masui et al. (2015)

FRBs at GBT - GREENBURST



- 1 beam – commensal observing
- Even when other feeds in use!
- 800 MHz current bandwidth
- DM range out to 10,000 pc/cc
- Realtime pipeline

Strategies going forward

- Single dish surveys
  - FAST
  - FLAG ▫ FLAG++??
  - ALFABURST ▫ ALPACA ▫ ++?
- Broadband single-dish follow-up
  - High sensitivity
  - FRB spectra?
- Shadowing by other arrays?
  - Build something at GB?
  - Make use of RQZ
  - Potential for a PSR telescope?

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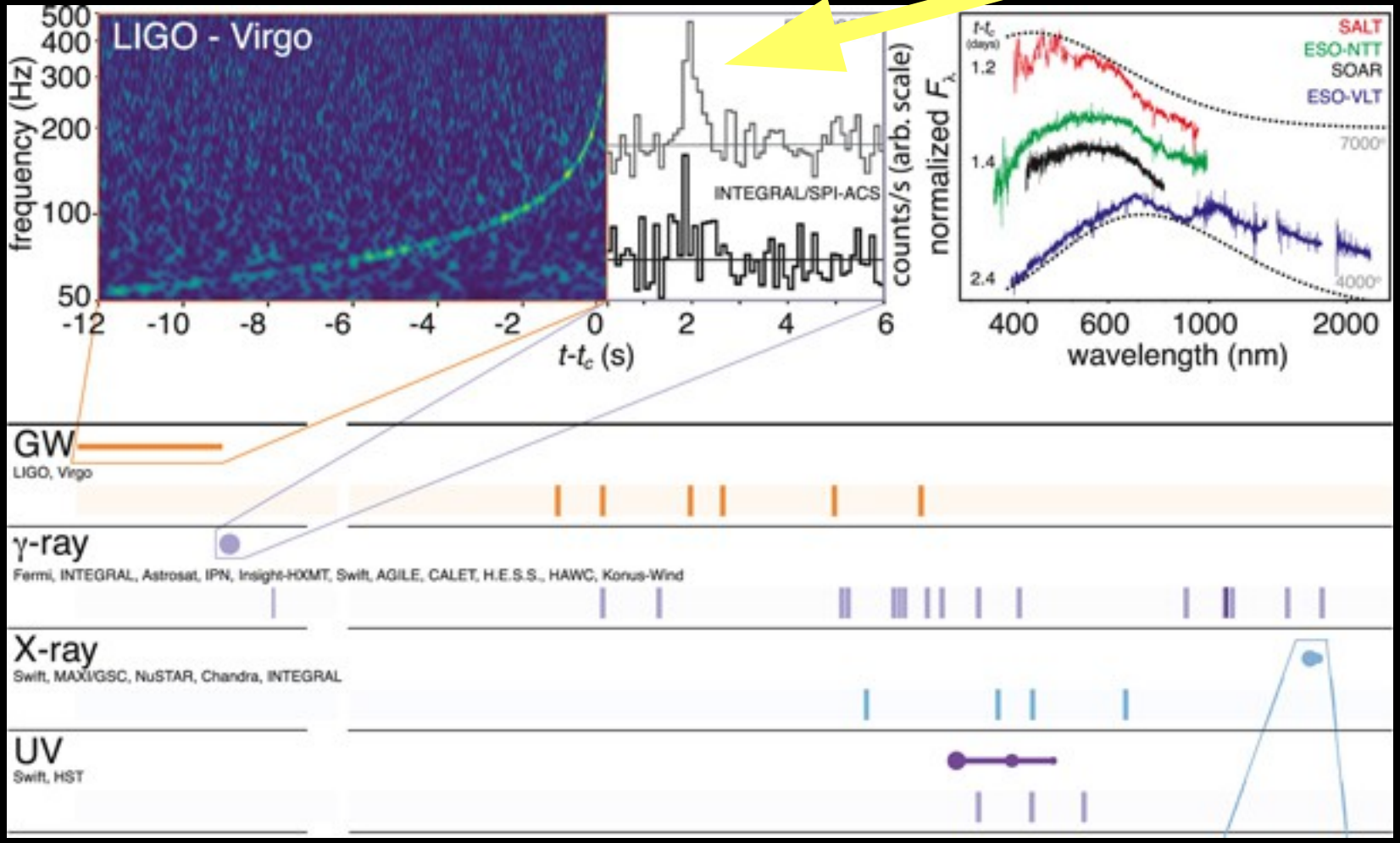
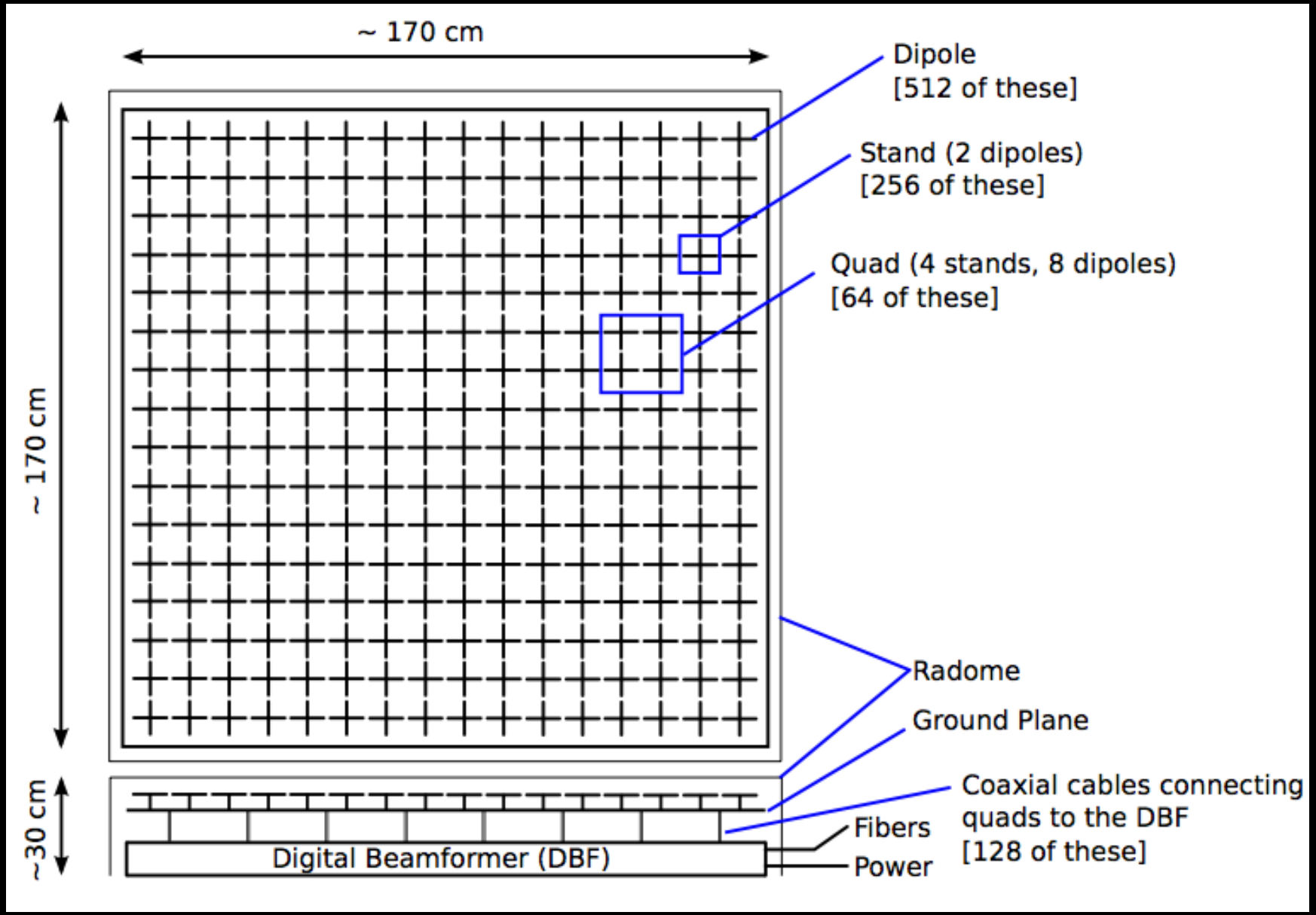
We would like to be here...



L-band Array of Small Arrays (LASA)



Credit: Steve Ellingson

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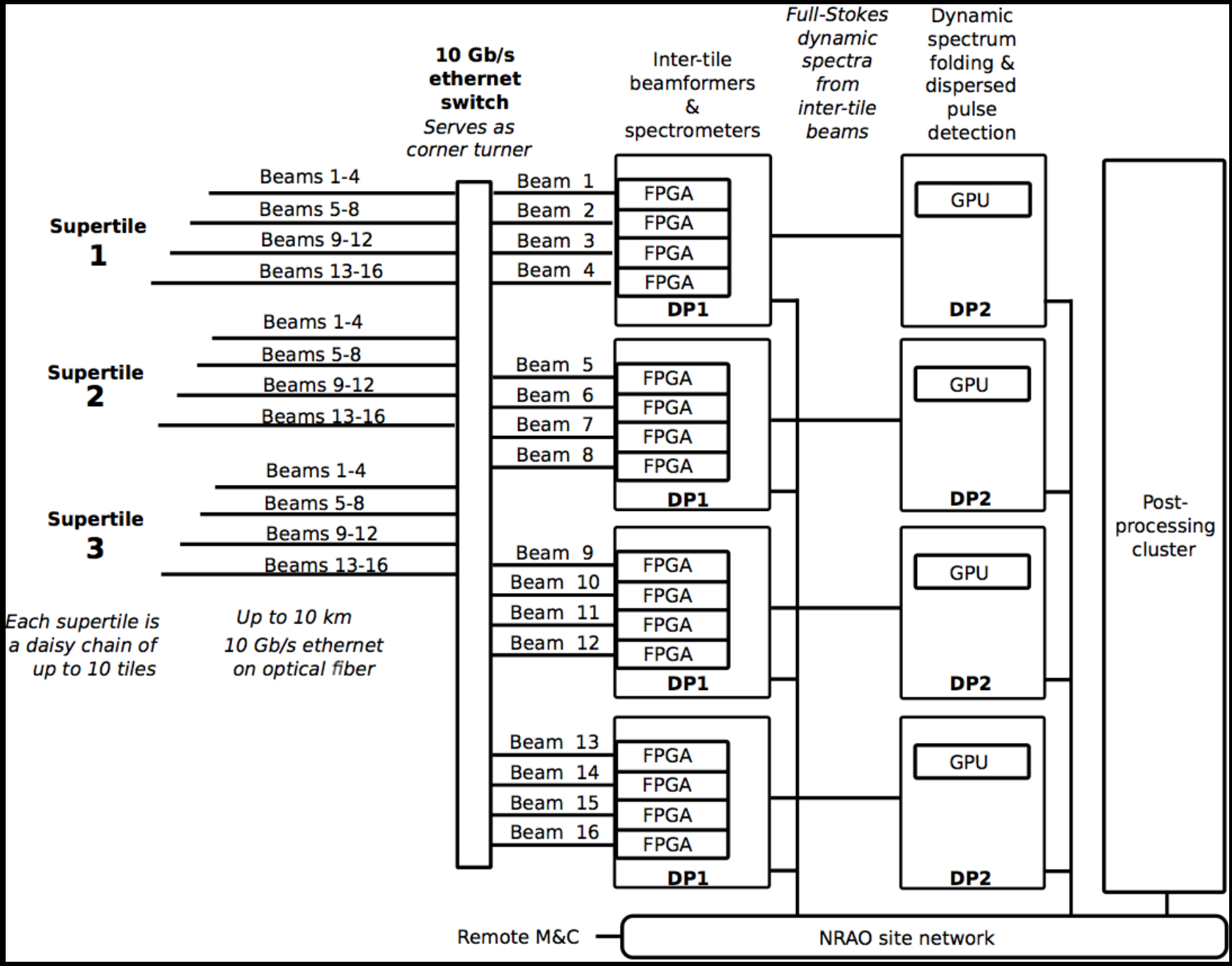

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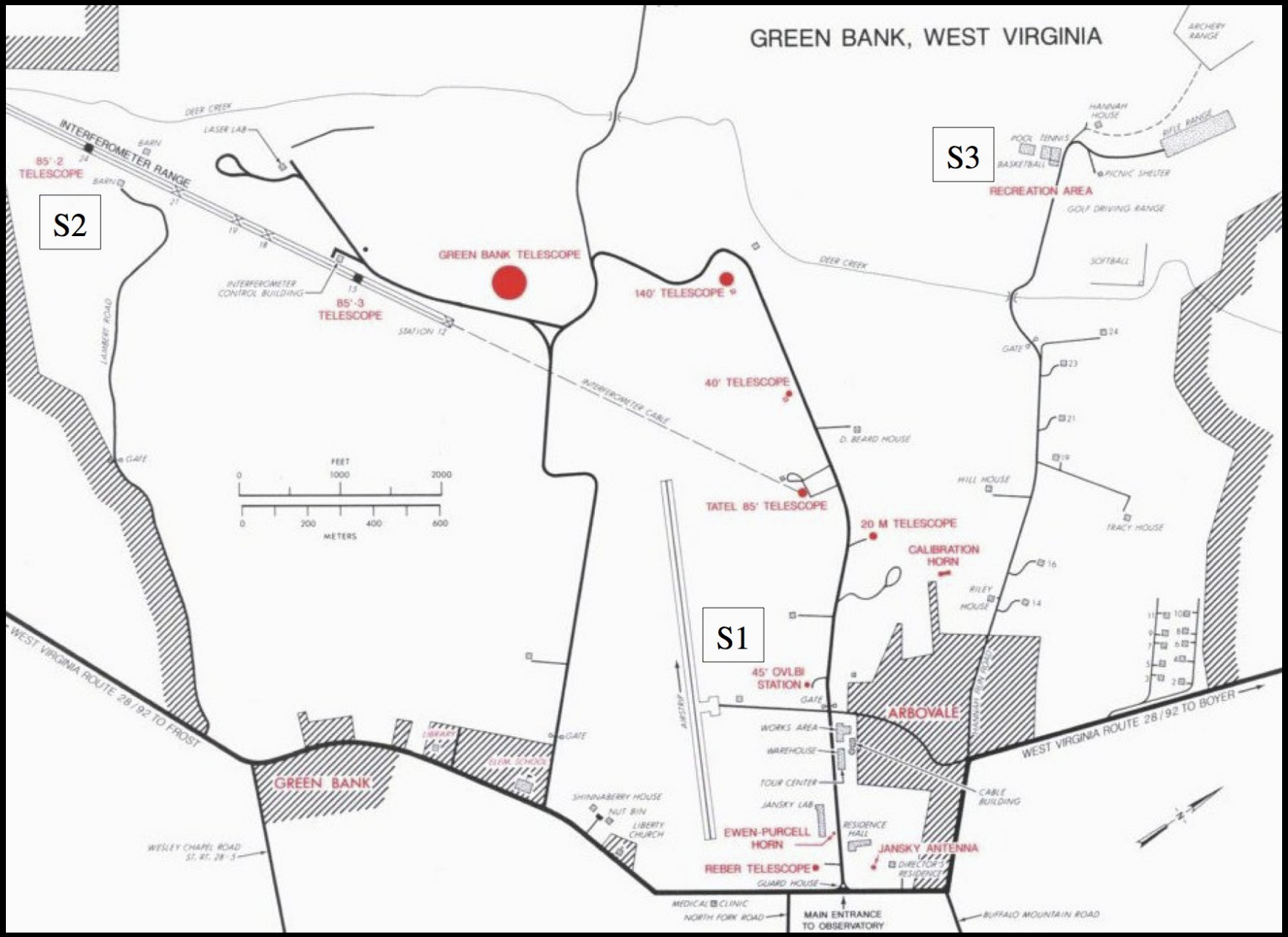
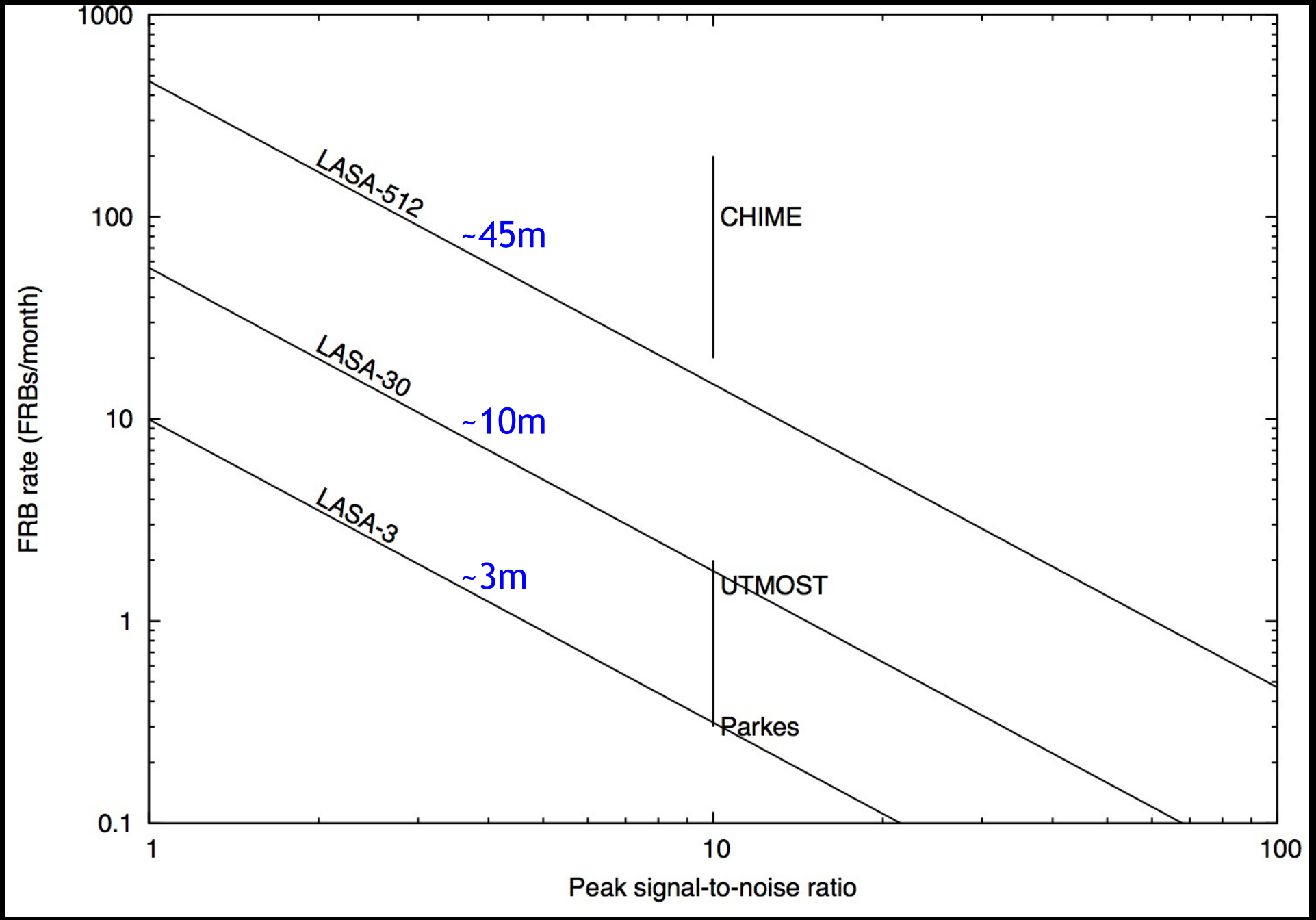


Credit: NRAO

L-band Array of Small Arrays (LASA)



(My) bold predictions

- 2020: 100s FRBs found
  - CHIME
  - REALFAST
  - ASKAP
- 2025: 1000s of FRBs known
  - SKA and its pathfinders
- 2030: FRBs essential cosmological tools
  - Many papers on this already!