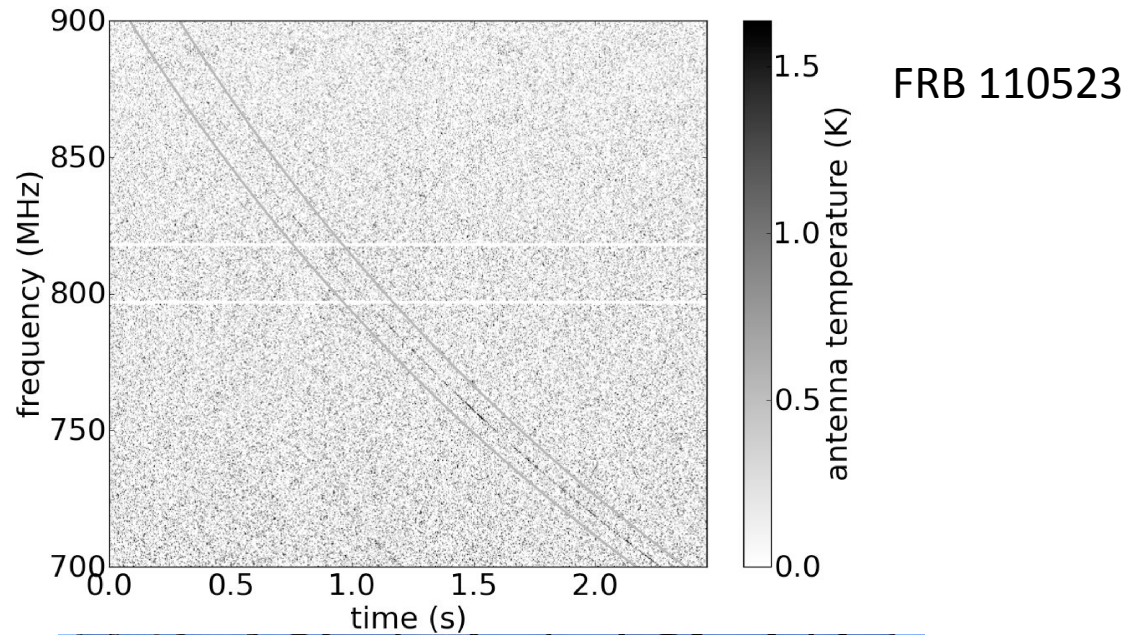


Fast Radio Bursts with HIRAX

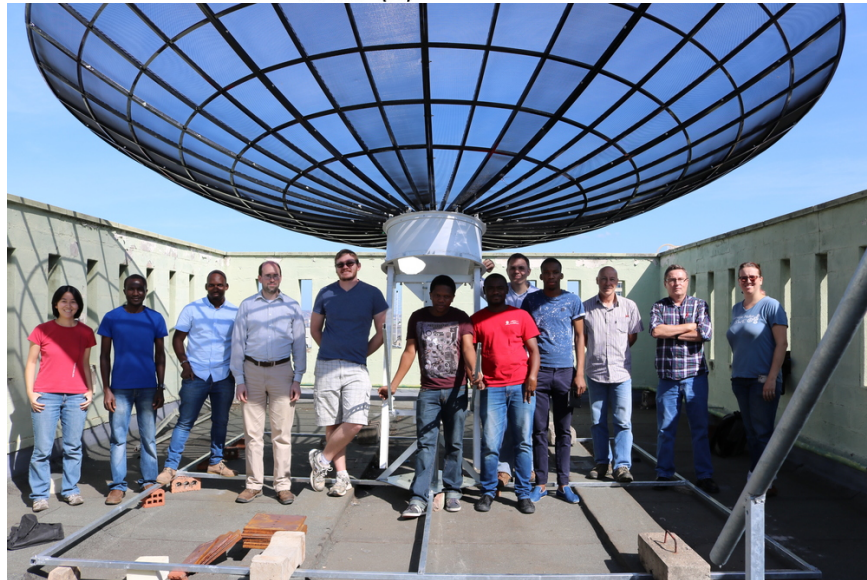
Jeff Peterson

McWilliams Center for
Cosmology

Carnegie Mellon
University,
Pittsburgh PA USA

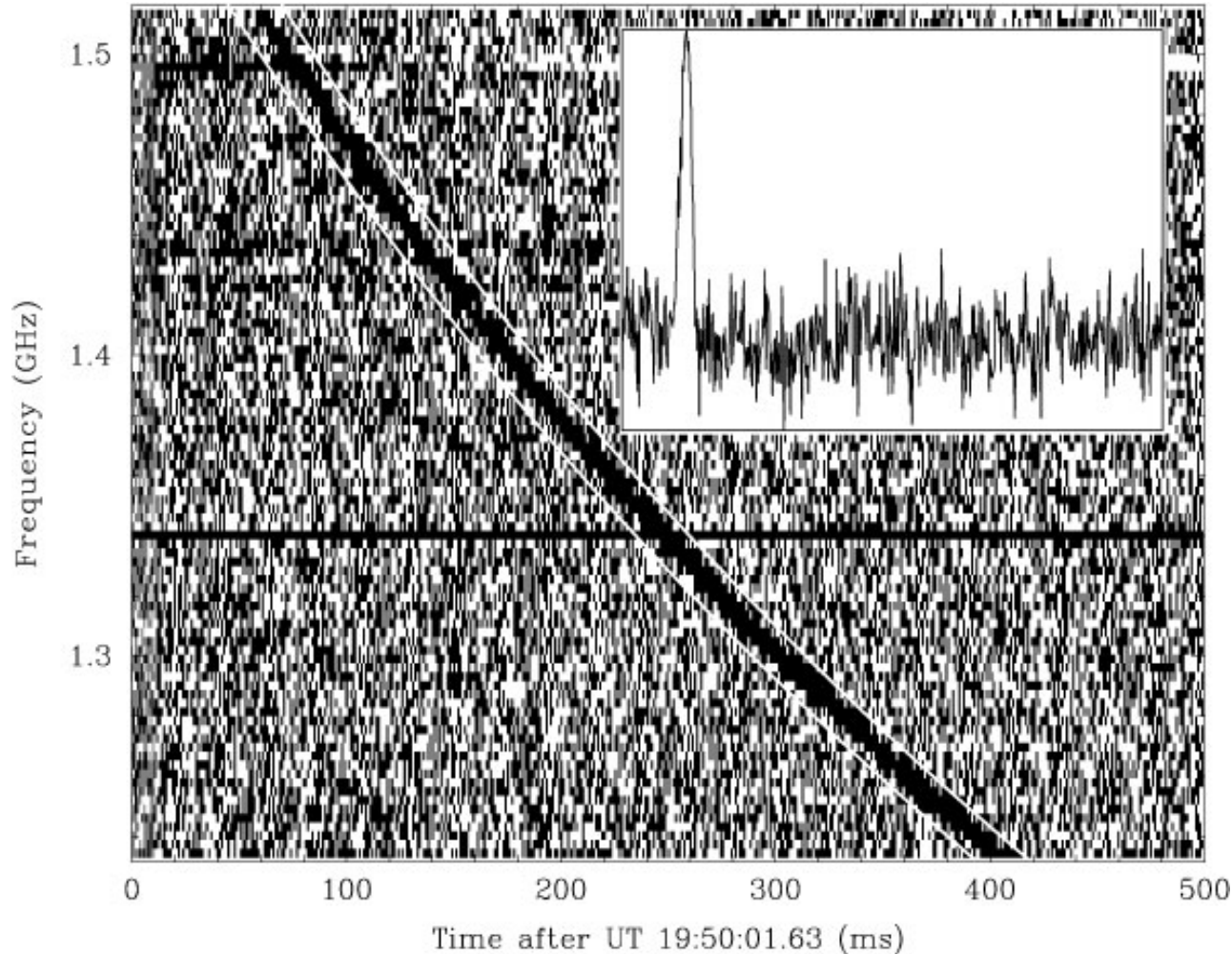


First HIRAX
Six-Meter Dish
Built at CMU, tested at
Durban SA



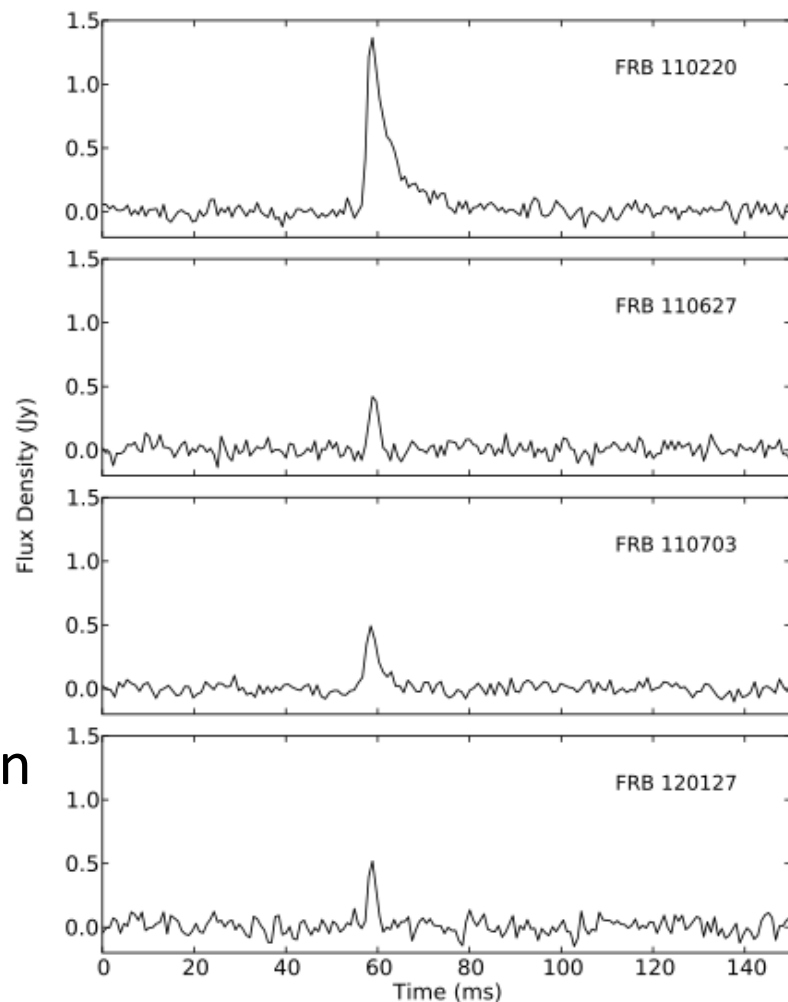
The Lorimer Burst (2006)

- Found in a pulsar search of archived data from Parkes

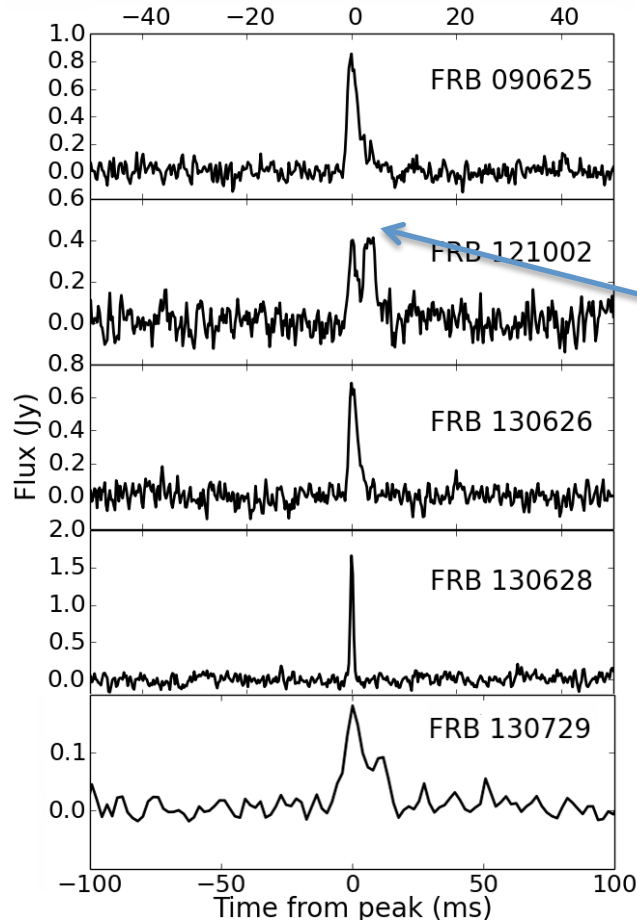


Characteristics of Previous Bursts (11)

- Peak Flux ~ 1 Jansky
- Highly dispersed
- Pulse width few ms
- Three FRB have scattering tail
- Location precision: 15 arcmin.
- Not concentrated in Galactic plane
- Rate $\sim 2500 \text{ sky}^{-1} \text{ day}^{-1}$
- All but one detected with Parkes
- Two events found at same pointing
- These events have different dispersion
- No counterparts identified at other wavelengths

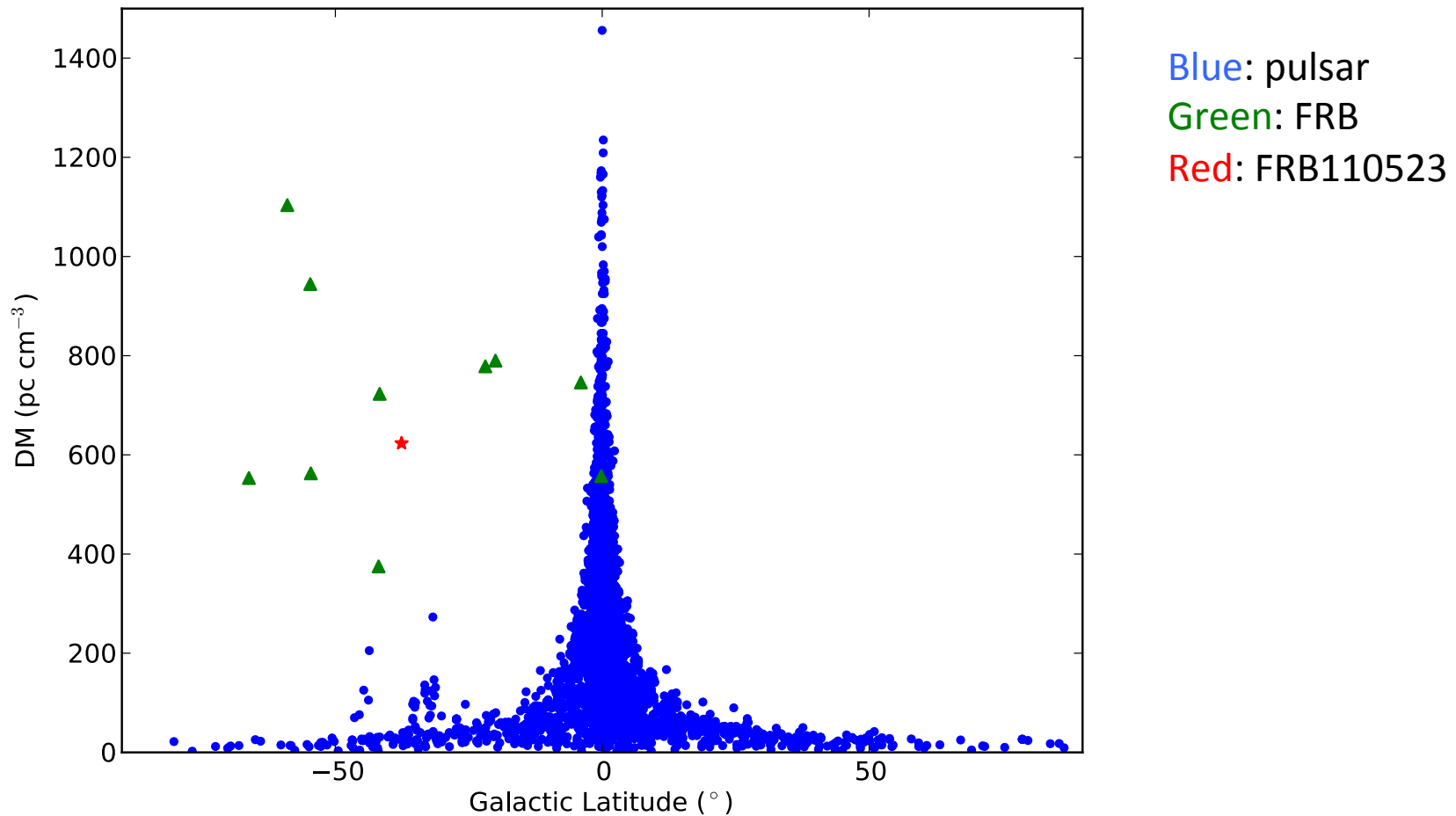


Recent news: Five new bursts at Parkes, Arecibo burst repeats

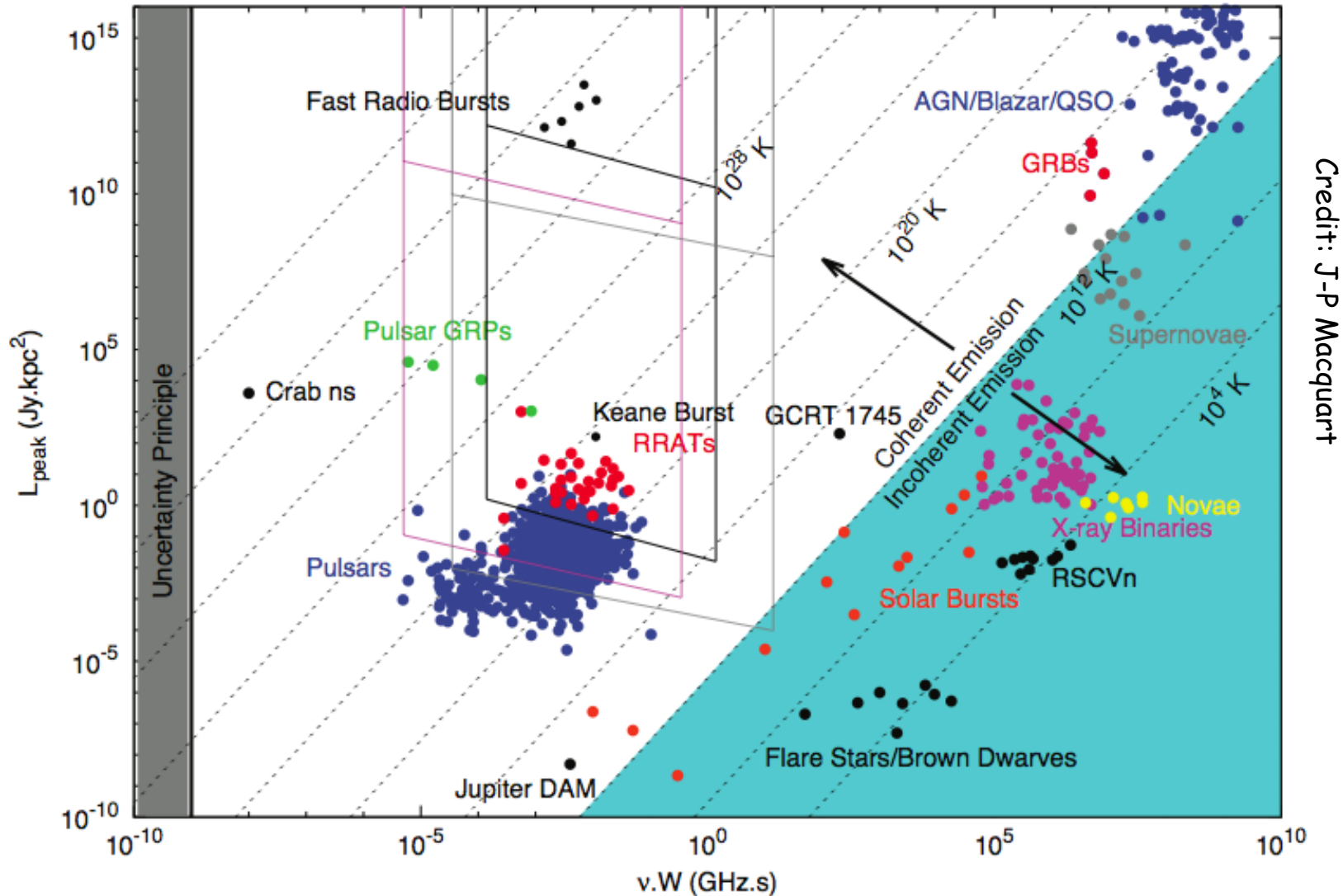


Coming soon:
several Bursts found
with MOST

FRB sources are very likely outside of the Milky Way

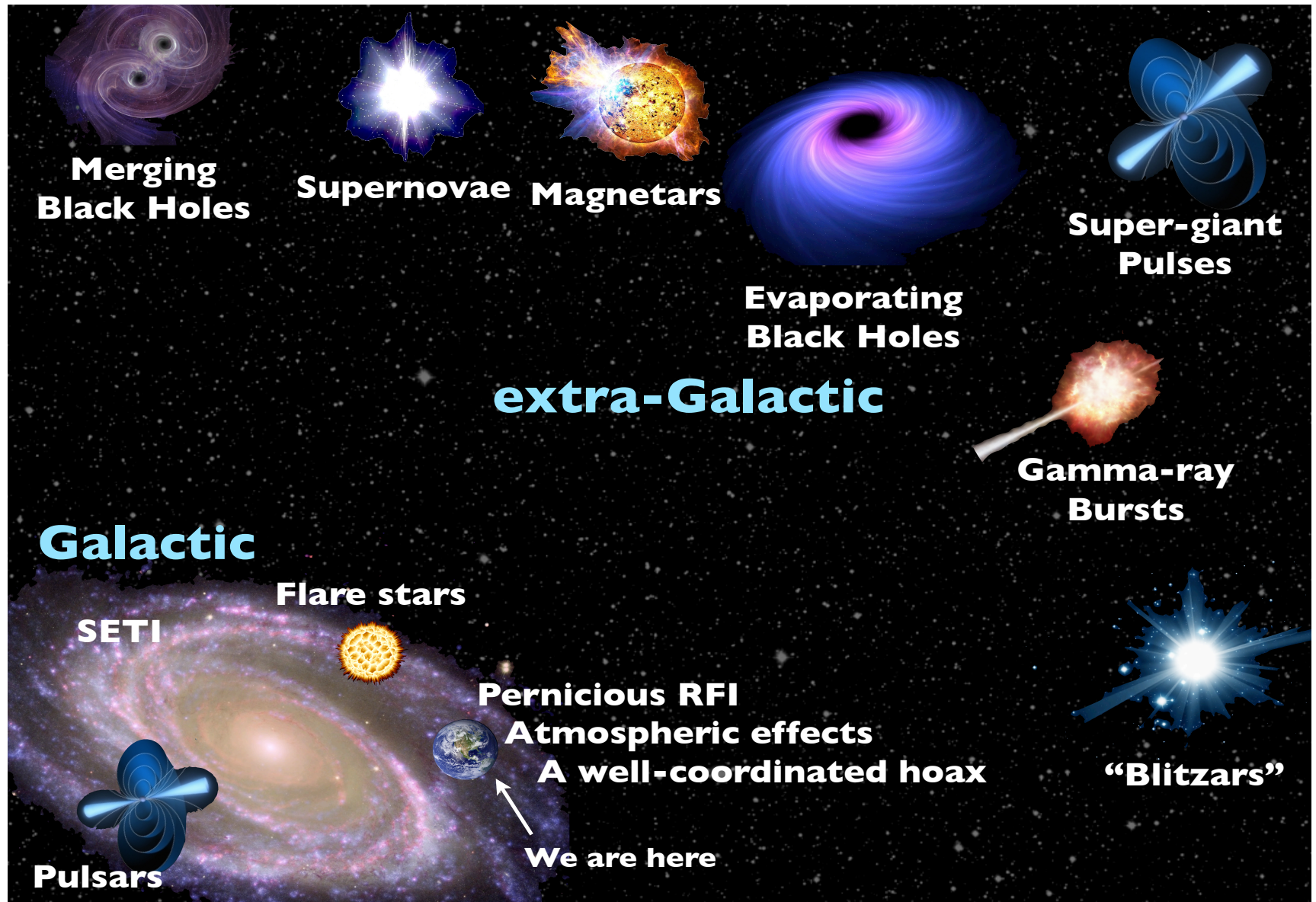


If FRB are at $z \sim 1$ they have exceptional brightness temperature



Black: Parkes; Pink: SKA1-lo; Grey: SKA1-mid

FRB proposed models



HIRAX: The Hydrogen Intensity and Real-time Analysis eXperiment

- Primary Science Goal: Probe Dark Energy models using a 21-cm Intensity Mapping BAO test
- Sec Goal:
 - Find and sharply localize
 - Hundreds of FRBs



Also a
Thrash
Metal
Band



Collaborators

- UKZN: Sievers, Moodley, Chiang, Hilton, Poole
- Stellenbosch: Brink
- UCT: Woudt, Taylor
- Rhodes: Smirnov
- UWC: Santos, Maartens, Dave
- AIMS: Basset
- DUT: Van Vuuran, Macpherson
- Carnegie-Mellon: Peterson, Lin, Kung
- U Wisconsin: Timbie Gayley
- ASIAA: Chang
- IUCAA: Gupta, Srianand
- APC Paris: Ganga, Bucher
- NRAO: Ransom
- Oxford: Karastergiou
- HDU (China): Zhi-Ping Chen
- Yale: Newburgh
- Toronto: Lokhorst
- Various CHIME Canadians

Current HIRAX Plan



- 1024 close-packed 6m dishes at Karoo site.
- KIS--No tracking, no cryogenics, commodity dishes.
- Dishes tilt N/S by hand: when “deep enough” on a strip, tilt over to increase f_{sky} .
- Operate between 400-800 MHz
- Channelizing on FPGA ICE boards (Matt Dobbs)
- Correlation on GPUs.
- Plan to do beamforming in correlator, distribute beams for FRB processing.
- Outrigger arrays in Botswana and Namibia to localize FRBs

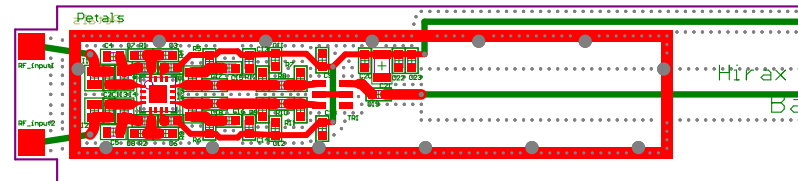
Status

- Funded to build 128 element at Klerfontein
- Proposal in SA under review to expand to 512
- Plan to submit NSF MRI proposal for the final 512 elements
- 4 Element pathfinder in place at HartRAO
- Ten dishes in transit
- Use to verify performance of RF system, RFOF, Channelizer, beamformer, correlator, Realtime FRB search.

Tests at HartRAO



Newer design: LNA at feed antenna terminals →



10 six-meter dishes on the boat to Durban

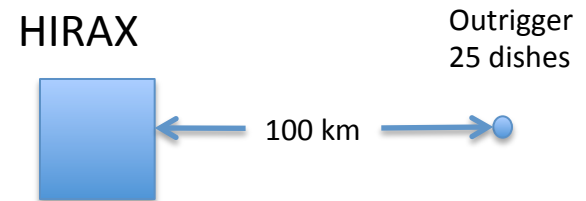


Laser-cut dish ribs at Durban




Outriggers

- Central array makes initial FRB detection
- Central array and outriggers streaming amplitudes to disk... but deleting after few hours
- On candidate alert: amplitudes files are saved for all arrays
- Carry out aperture synthesis imaging using known DM, time and formed-beam
- Provides a sub arc second error ellipse for most FRBs



Outrigger
25 dishes



Small Outriggers
allow arcsecond
localization
of each FRB

Science Possible with HIRAX-FRB

- Fast Radio Bursts: 30,000 m² collecting area w/ 1000 beams allows detection of >10 FRB/day.
- Pulsar search: Pulsars spend 20 min in beam each day--12 μ Jy/scan
- Site allows pulsar search in Galactic Center.
- Neutral hydrogen and OH absorbers: Req's Higher frequency resolution in beam-formed data (with a few FFTs on GPUs).
- Diffuse polarization of galaxy.
- Other ideas?

Thinking BIG: Specs and FRB event rate for a future array

- 4028 elements, 10 m aperture on-axis close packed. Plus two outrigger arrays...\$30M
- 4028 instantaneous dual-pol beams
- Effective area 150,000 m²...40 x GBT, 62 x CHIME. 4 x FAST (but twice T_{sys} of GBT or FAST)
- Gain 80 K/Jy
- FRB rate: 19,000 /day -> one every 5 sec
- Multi-octave feed? Wider correlator bandwidth?
- What other science does this enable?