Fast radio bursts: ASKAP and beyond

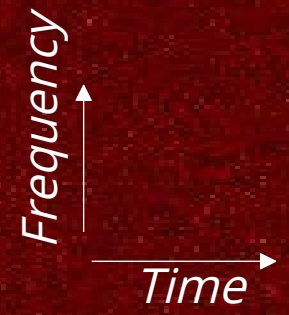
Ryan Shannon (Swinburne)

Image: CSIRO/Alex Cherney

Fast Radio Bursts (FRBs)

- Dispersed radio pulses that arise at cosmological distances
  - Frequent: emission at other wavelengths must be faint or unusual, rate inconsistent with known cataclysmic progenitors
  - Greater than 10^5 per day over the sky at FAST sensitivity

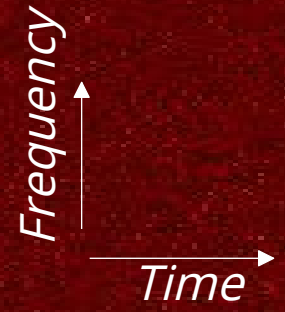
- Rapid progress is being made in the field
  - Wide-field telescopes
  - Capability to localize bursts to arcsec precision (hosts, *z*)
  - **Detailed study of repeating sources: concordance model (is the model correct?)**



Parkes FRB 150807: Ravi, Shannon et al. *Science* **2016**

Fast Radio Bursts (FRBs)

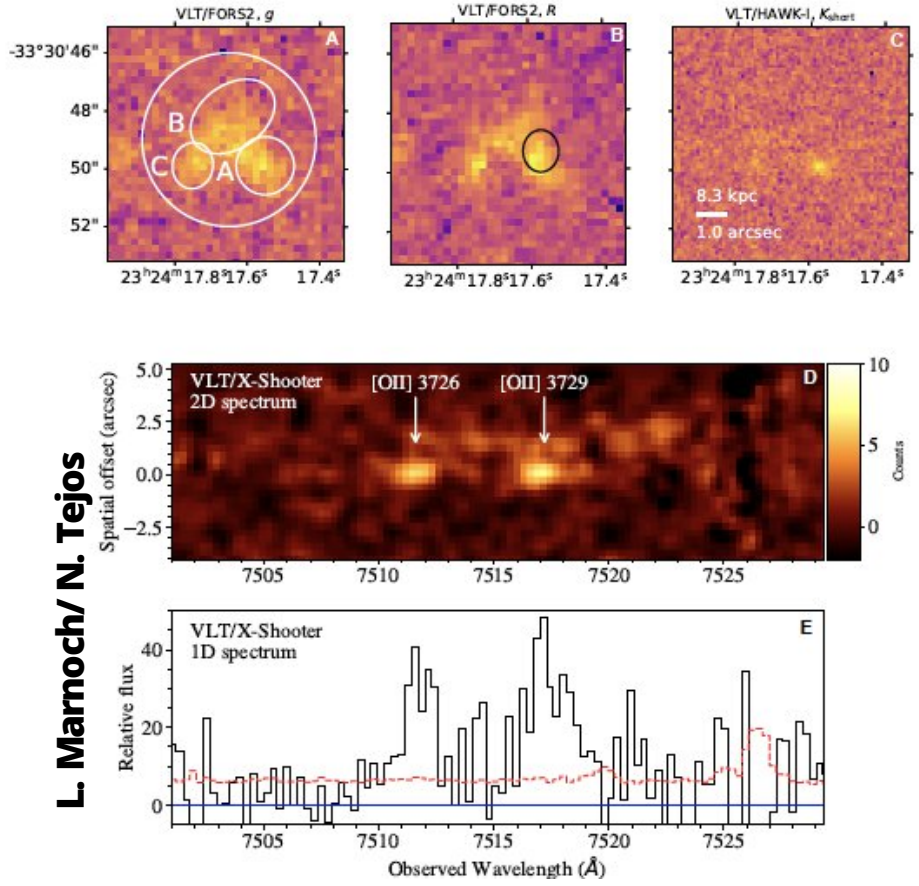
- **What produces them?**
  - Magnetars, black holes, shocks?
  - Is there more than one source
- **What causes the FRB emission?**
  - Motivation for theory
- **How can we use them as tools?**
  - Almost perfect impulses
  - Reverse engineer the Universe
- As astronomers we want to do everything, but recognize there isn't a a budget for everything.

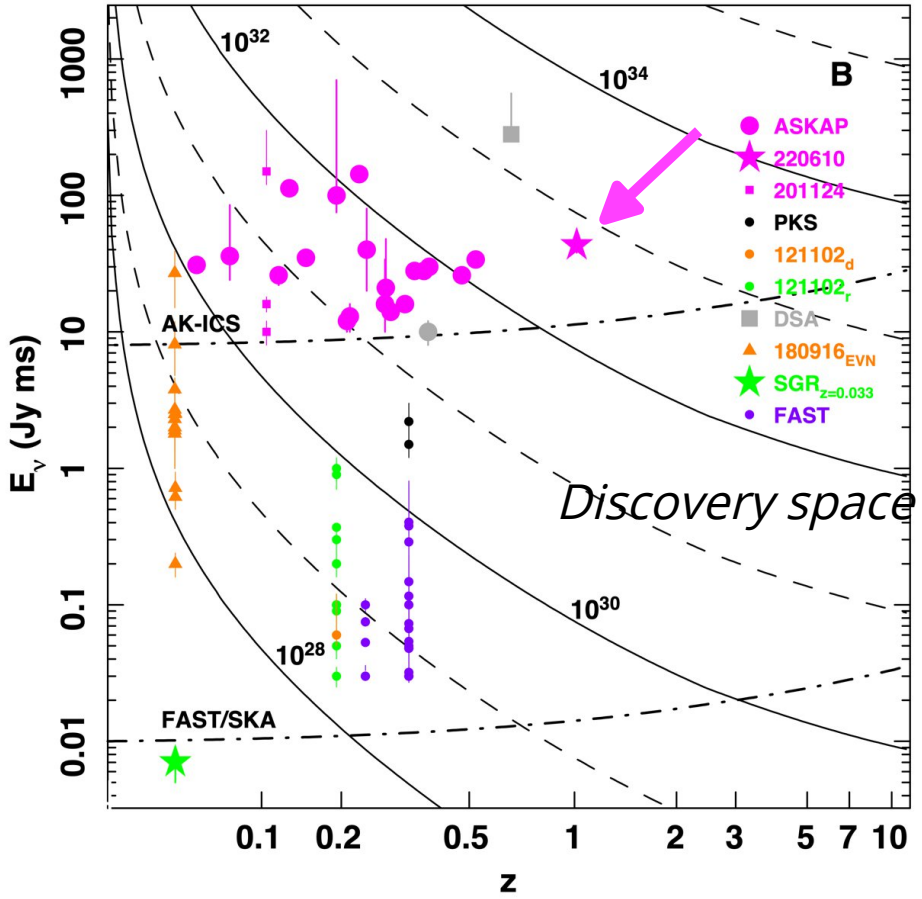


Parkes FRB 150807: Ravi, Shannon et al. *Science* **2016**

A “High”-z FRB

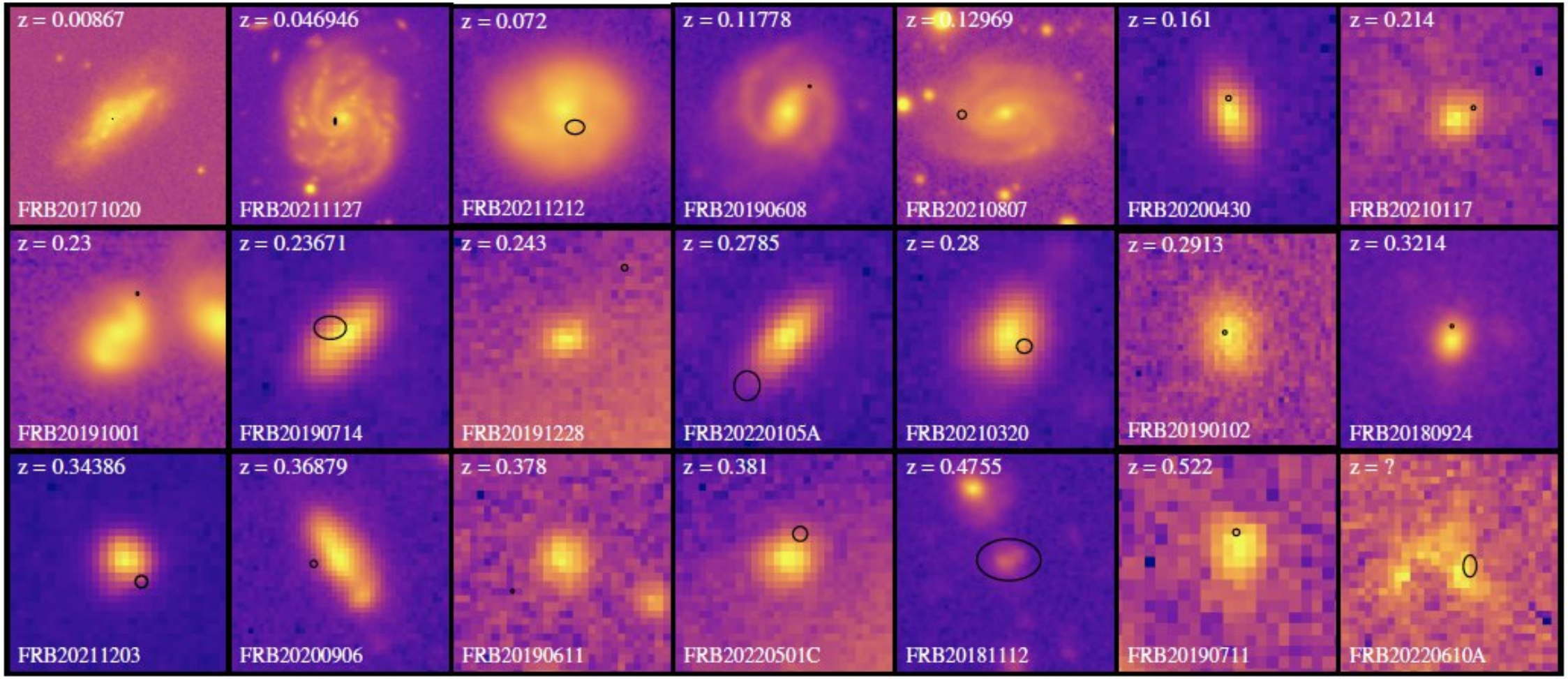
ASKAP FRB 20220610A
DM ~ 1450 pc cm^{-3} and z = 1.0016





Luminous FRBs exist at z >1!
Burst properties in contrast to repeating FRB sources!
Ryder et al., submitted to *Science*
(no twitter)

FRB host galaxies

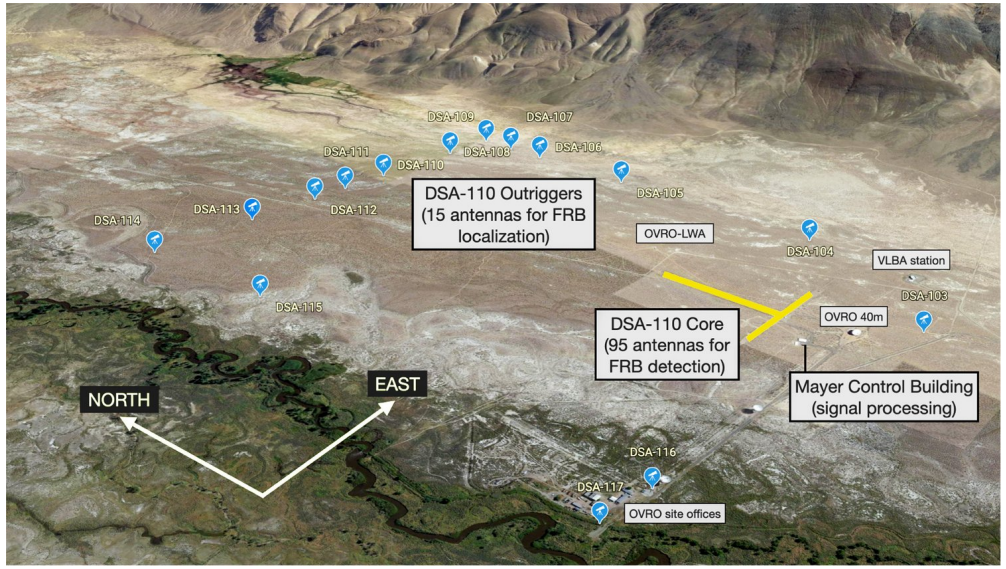


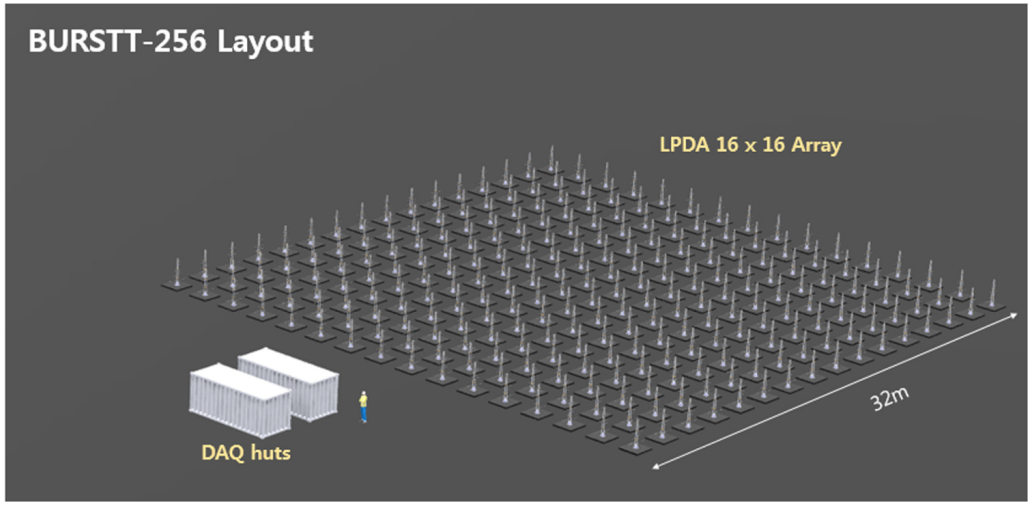
Credit: Lachlan Marnoch

FRB landscape

- Hundreds of millions of dollars being invested in FRB (or FRB++) experiments
- Facilities Capable of detecting and localizing FRBs at high rates under construction/funded/proposed:
  - CHIME/CHORD: (McGill/DRAO)
  - DSA-110/2000: (Caltech)
  - BURSTT: All sky dense aperture array: (ASIAA)
- Most investment in the Northern Hemisphere

DSA-110





Lin et al. (2022)

Expected FRB rates

System	Sensitivity (Jy ms)	Rate (FRB day-1)
ASKAP Fly's Eye	24	0.13
ASKAP ICS-24	5	0.16
CRACO-24	1	1.6
CHIME-predicted	0.6	28.9
CHIME-reported	5*	1.4
DSA-110	0.9	0.66
CHORD		3-20
DSA-2000		3-10
BURSTT		30-70

Extrapolated from ASKAP fly's eye rate

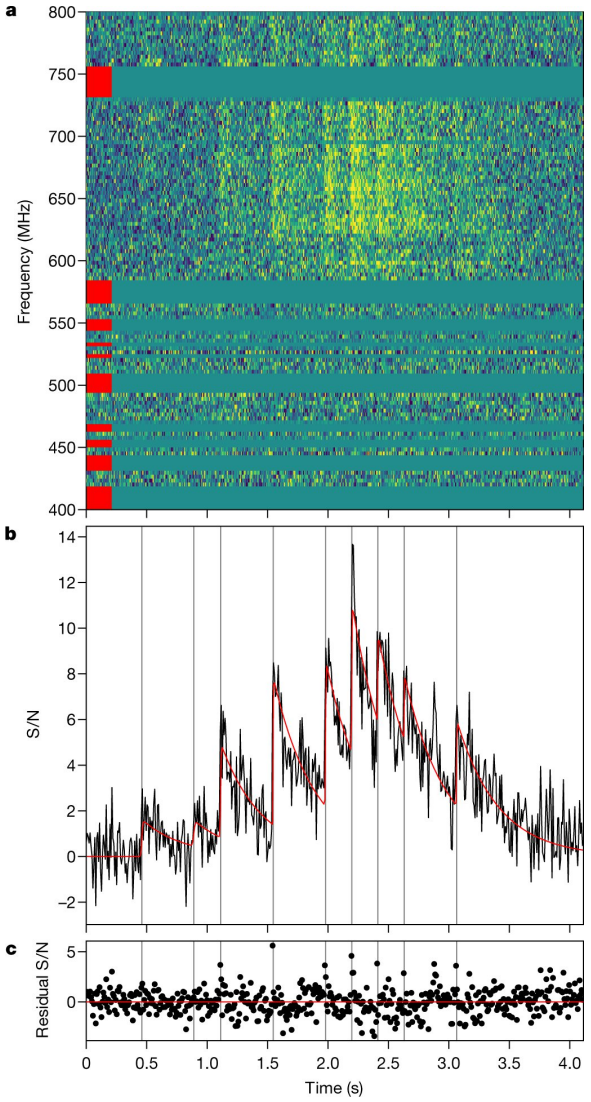
Connor & Ravi (2022) population modelling

What are possible discovery axes to investigate?
Where can Australia have a niche?

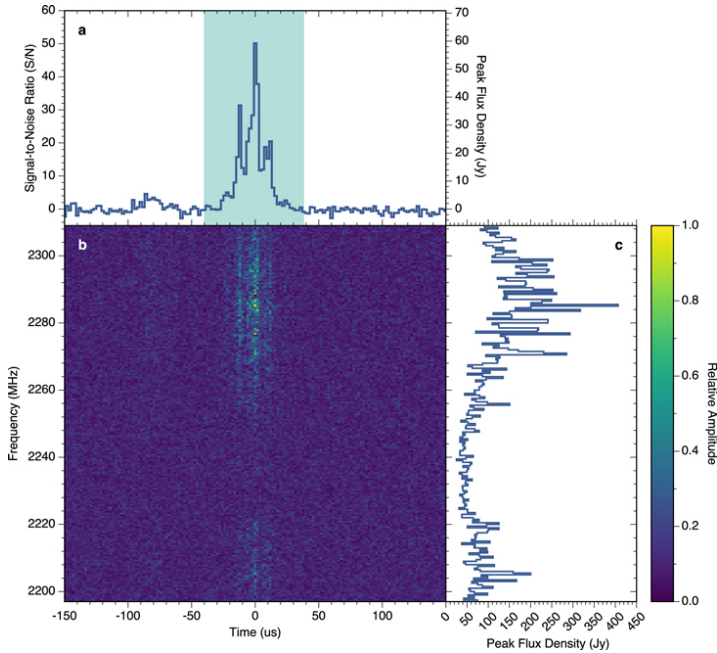
Time resolution

- High time resolution
  - How narrow can FRBs be
  - Scatter broadening
  - Pre-dedispersion?

- Lower time resolution:
  - CHIME pulse trains
  - Long period magnetars (see Natasha's talk)
  - "Easier" (except RFI)



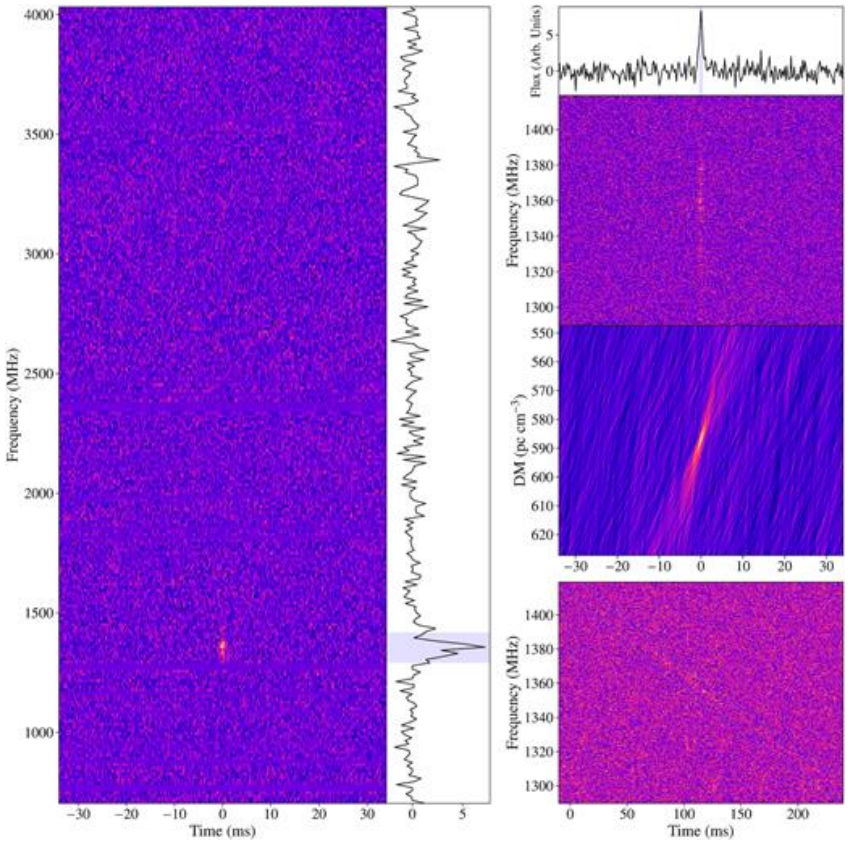
CHIME/FRB et al. (2022)



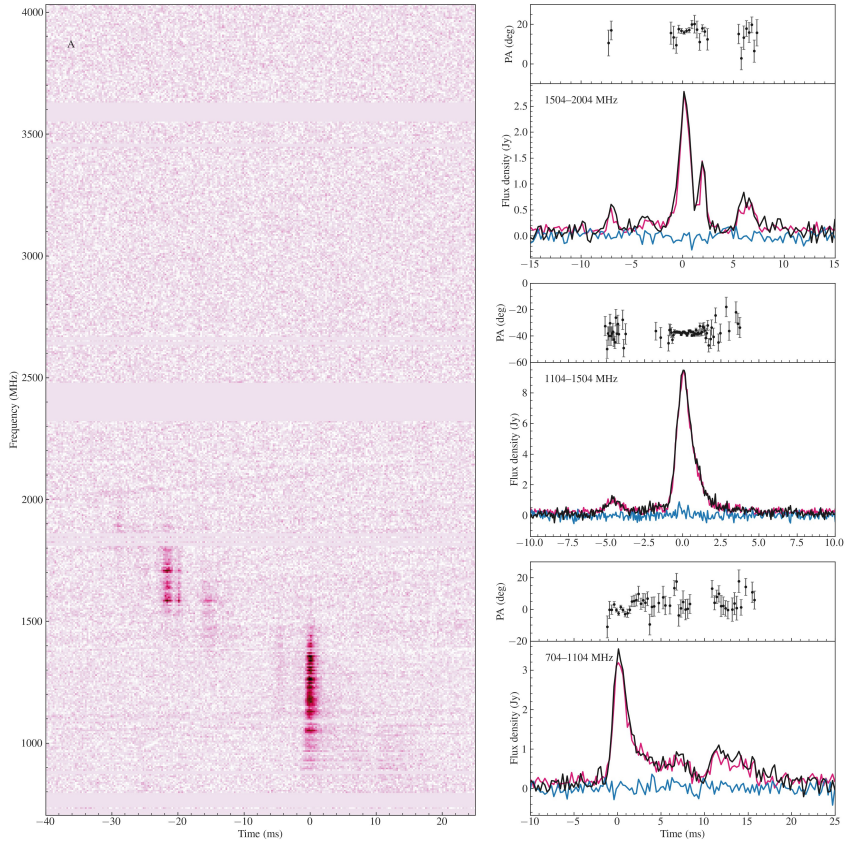
Majid et al. (2021)

Frequency and bandwidth

- Higher frequency
  - Propagation effects weaker
  - Dedispersion becomes cheaper
  - Unexplored domain
  - Spectral index/activity?
- Lower frequency
  - Easier to get field of view
  - Stronger propagation effects
- Ultrawide band systems
  - If FRBs are band limited (are they?) run multiple searches for free
  - Study of pulsar emission mechanism



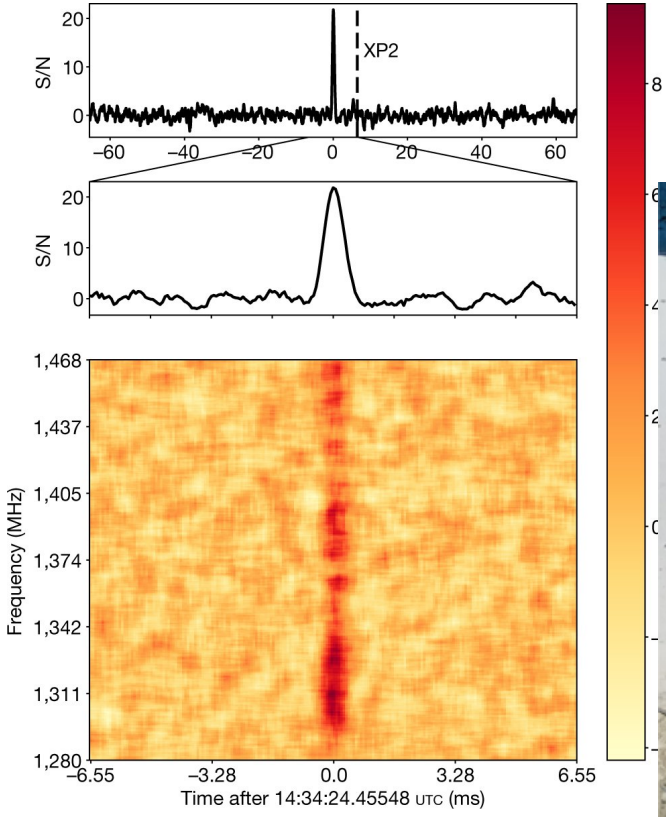
Kumar et al. (2021)
UWL repetition of ASKAP localized FRB



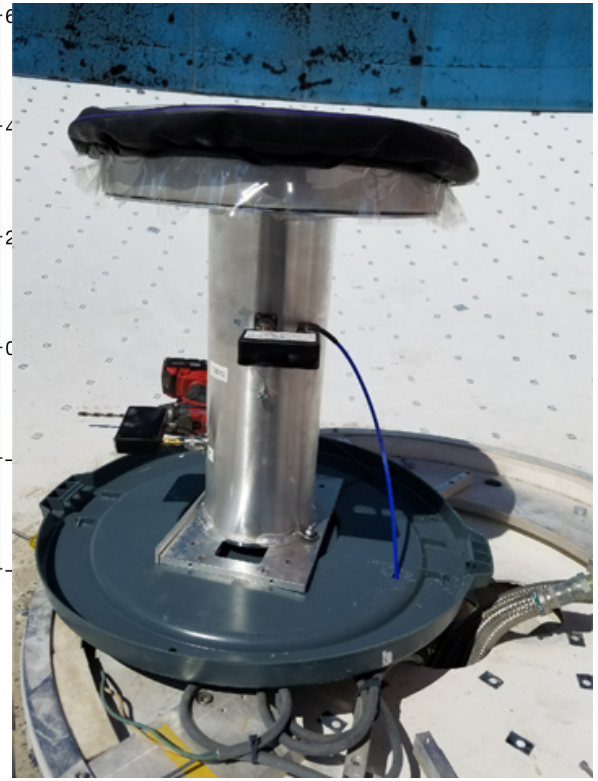
Kumar et al. in prep: UWL repetition of CHIME repeating FRB
“Sad orchestra”

Field view and sensitivity

- Wider field of view
  - Rare, bright events
  - SGR 1935 (Milky Way ”FRB”) is in the Northern Hemisphere because that is where the wide field of view instruments were discovered
- Sensitivity
  - More distant events: explore in detail the Macquart relation
  - HEII reionisation



Bochenek et al. 2020a,b



Commensal versus targeted

- Commensal
  - FRBs can come from anywhere
  - Ride along for free

- Targeted
  - Specific science questions may benefit from deep follow up
    - “IGM tomography”
    - Lensed FRBs
  - Depends on field of view of instrument
    - 30 deg^2 is Virgo size but not much else

- Multimessenger/prompt emission
  - Account for large event rate

Possible future instrumentation

- Upgrades to ASKAP
  - More sensitive PAFs
  - New FRBs backends and digital signal processing
- Dedicated FRB facilities
  - Complement other facilities
  - Budget constraints/SKA
- International collaboration
  - BURSTT outriggers
- SKA

Australia's role

- Novel instrumentation to open up new parameter spaces
- Risky and ambitious projects
- Flexible systems
  - Upgrade paths for for $\$10^8$-$\$10^9$ facilities long and expensive
  - Systems that can be reconfigured to search different parts of parameter space
- Dense L-band aperture arrays at MRO
  - Aperture arrays vs phased array feeds

Conclusions

- Lead times to develop facilities/capabilities long
- Need to start thinking now even though CRACO isn't yet commissioned

- "Australia offers a culture of academic freedom, openness to ideas, and an amazing willingness to pursue goals that are ambitious. And the results speak for themselves – we have achieved tremendous success in our endeavour, largely because **we gave things a go that the rest of the world didn't dare to try**, …."
  - Michelle Simmons Australia Day Address (2017)