STARE: Fast Radio Bursts in the Local Universe

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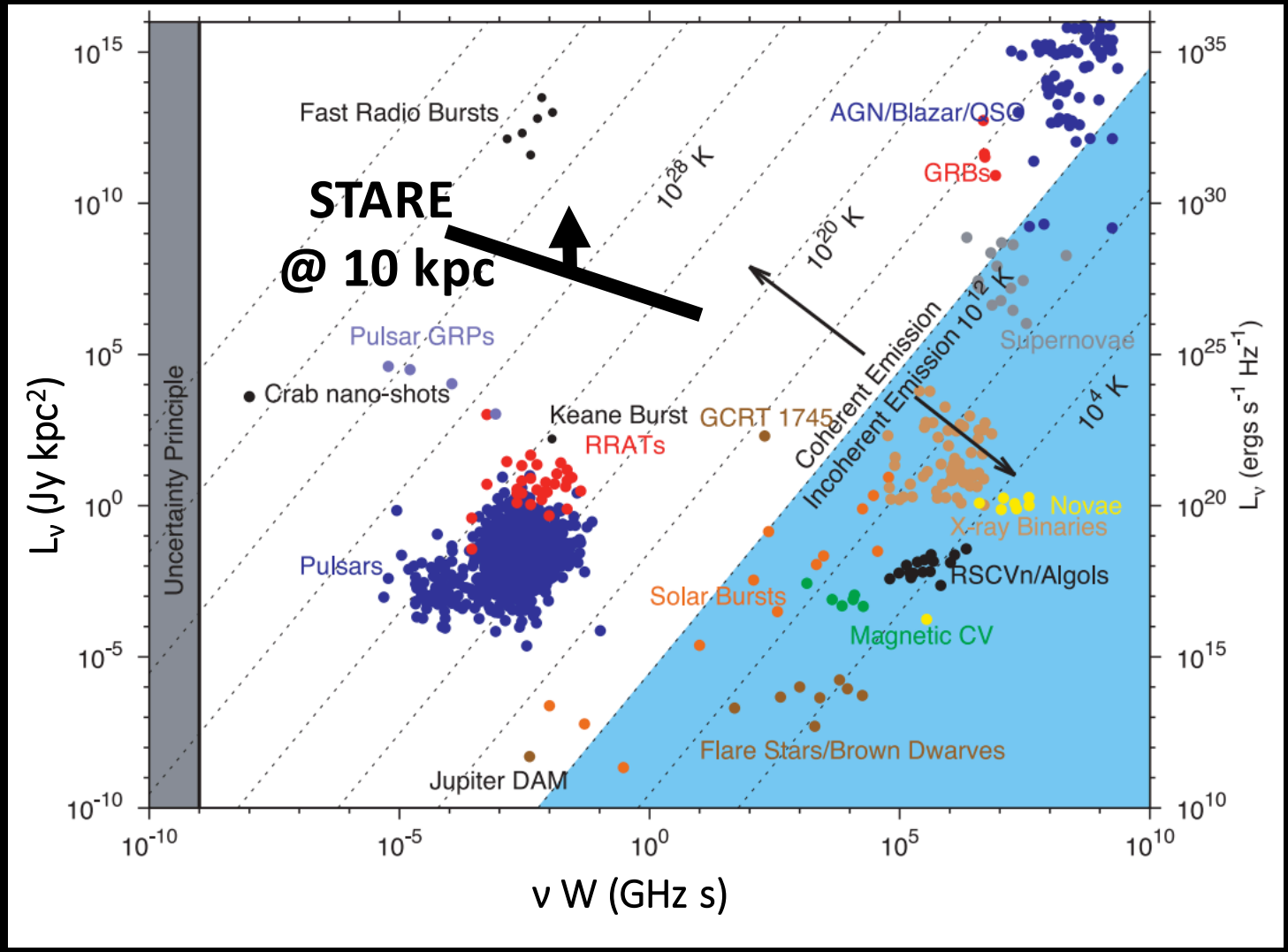
Purpose

- Search for galactic versions of fast radio bursts (FRBs)
- Investigate the luminosity function of FRBs
  - How far down does the luminosity function extend?
- Perform a census of FRB progenitors within 5 Mpc
- Probe the gap between pulsar giant pulses and FRBs

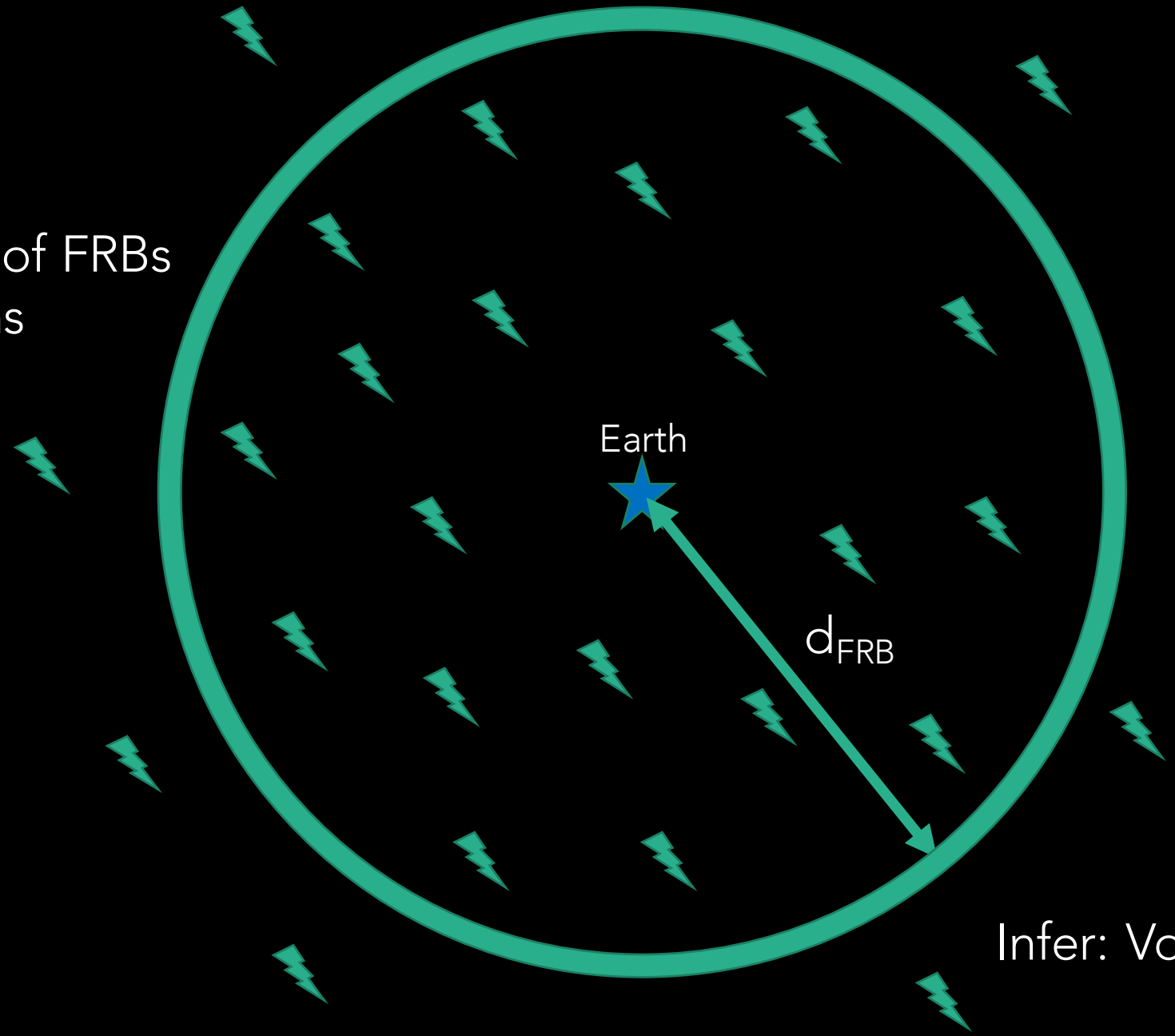
Fast Radio Bursts



Pietka et al. 2015

The Luminosity of Galactic FRBs

Fix: All-sky rate of FRBs
> 1 Jy ms



Infer: Volumetric rate of FRBs

The Luminosity of Galactic FRBs

Assume:

- FRBs track stellar mass

Volumetric Rate $\propto M_{stars}$

OR

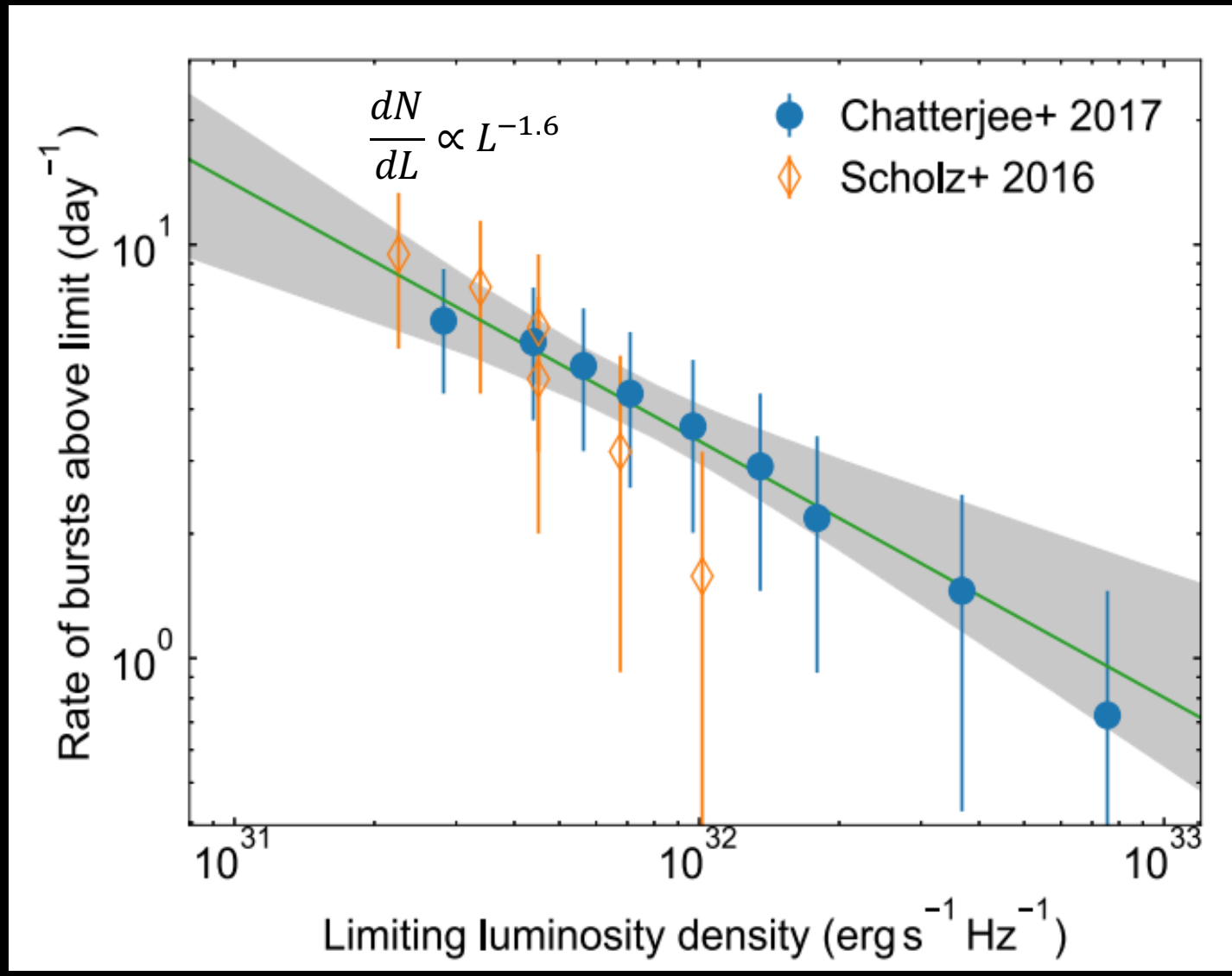
- FRBs track star formation

Volumetric Rate $\propto$ SFR

to infer an FRB rate ($L > 4\pi$ Jy ms d_{FRB}^2) for an individual galaxy

The Luminosity of Galactic FRBs

- Have: galactic rate of FRBs > 4π Jy ms d_{FRB}^2
- Want: Luminosity of FRB that happens every year
- Extrapolate down the luminosity function until the galactic rate of FRBs is > 1 FRB yr^{-1}



Nicholl et al. 2017

The Repeater

- ~5000 FRBs sky^{-1} day^{-1} (Vedantham et al. 2016)
- d_{FRB} = 817 Mpc
- Volumetric rate = 8 x 10^5 FRBs yr^{-1} Gpc^3
- FRBs track SFR: 0.02 FRBs yr^{-1} MW^{-1}
- FRBs track M_{stars}: 0.04 FRBs yr^{-1} MW^{-1}
- $\frac{dN}{dL} \propto L^{-1.6}$ (Nicholl et al. 2017)
- $L_{yearly\ FRB}$ = 0.002 Jy ms Gpc^2
- Fluence at 10 kpc: 1.5 MJy ms

What if we change the luminosity function?

The Repeater:

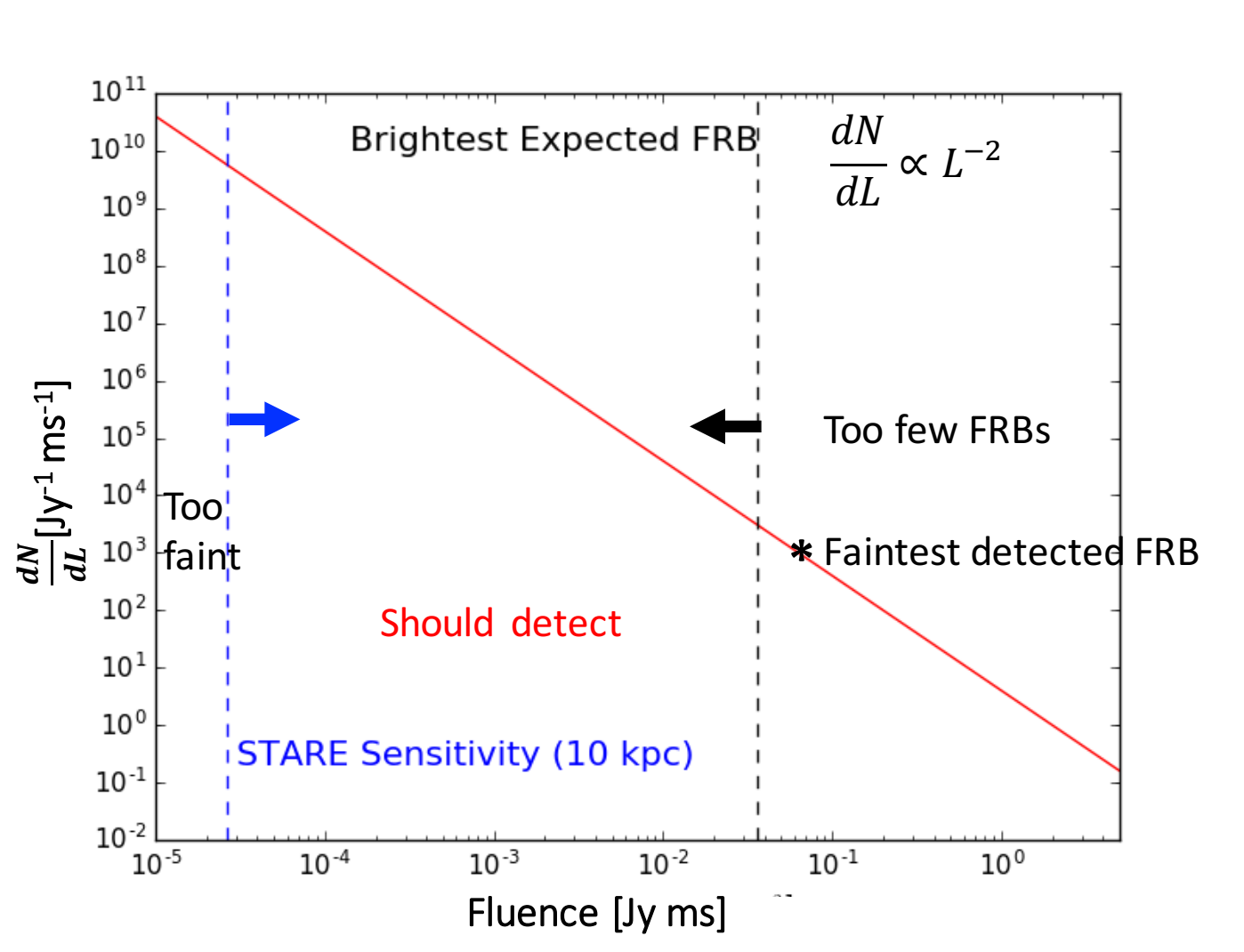
- $\frac{dN}{dL} \propto L^{-1.6}$ & d_{FRB} = 817 Mpc
- Fluence at 10 kpc: 1.5 MJy ms

Some other FRB population:

- $\frac{dN}{dL} \propto L^{-2.0}$ & d_{FRB} = 817 Mpc
- Fluence at 10 kpc: 18 MJy ms

Any detection/nondetection is a strong probe of the FRB luminosity function!

How Bright are FRBs are in the Galaxy?

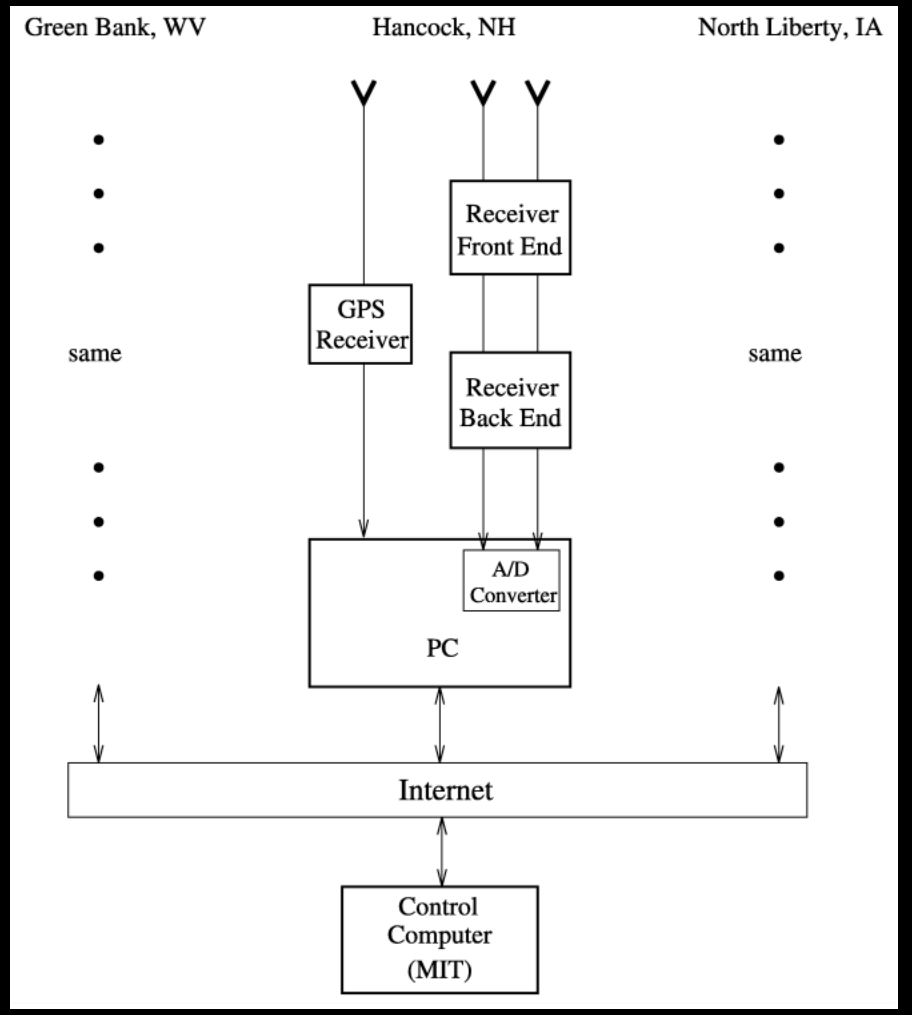


A census of nearby FRB progenitors

- We could see a typical 1 Jy ms FRB if it was < 5 Mpc away
- 5000 FRBs sky^{-1} day^{-1} = $n_{FRB}V_{olume}r_{epetition\ rate}$
- Volume ~ 30 Gpc^3 (z~0.5)
- Repetition Rate ~ 1/day (From repeater)
- Distance between FRB progenitors: ~110 Mpc
- Constrain:
  - Is the repeater unusually active?
  - What is the number density of FRB progenitors?

Previous Experiment: STARE

- Three crossed dipoles in a cavity
- Operated between 609-613 MHz
- Filtered RFI by coincidence
- Time resolution of 0.125 s
- Detection threshold of 27 kJy
- Only found solar transients

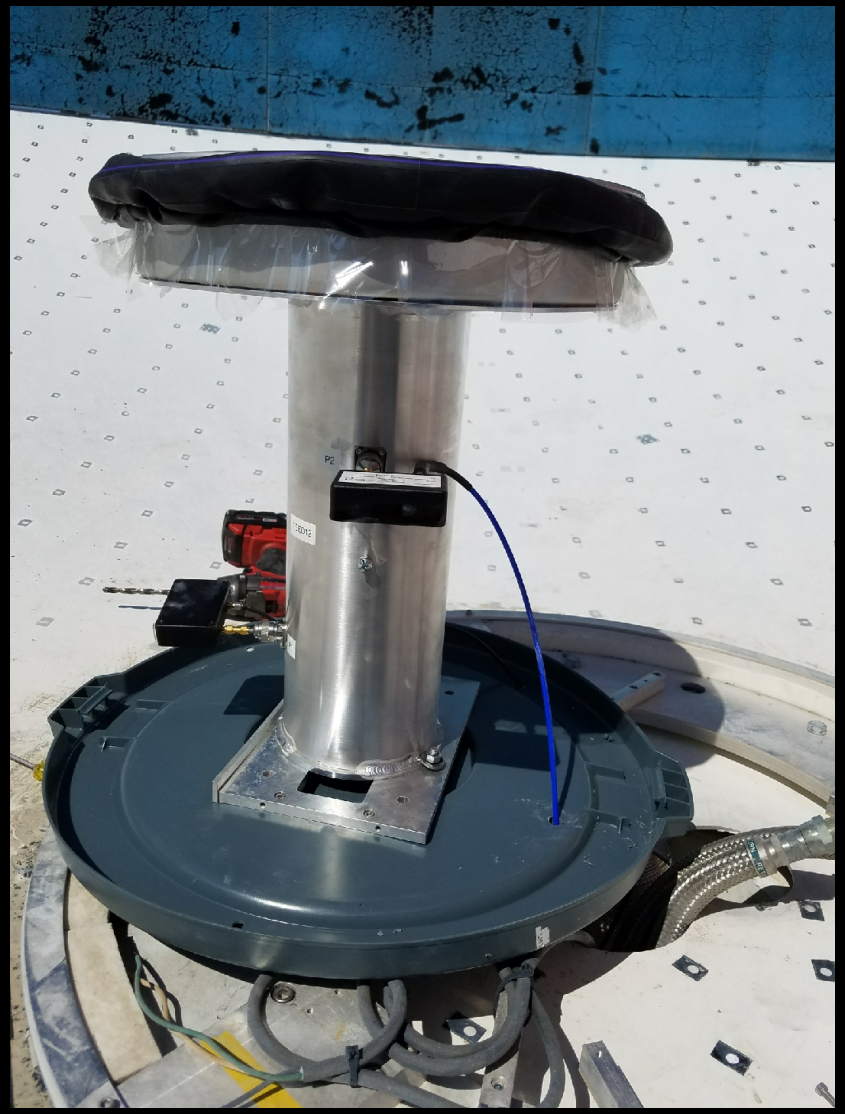


Katz et al. 2003

Implementation & Timeline

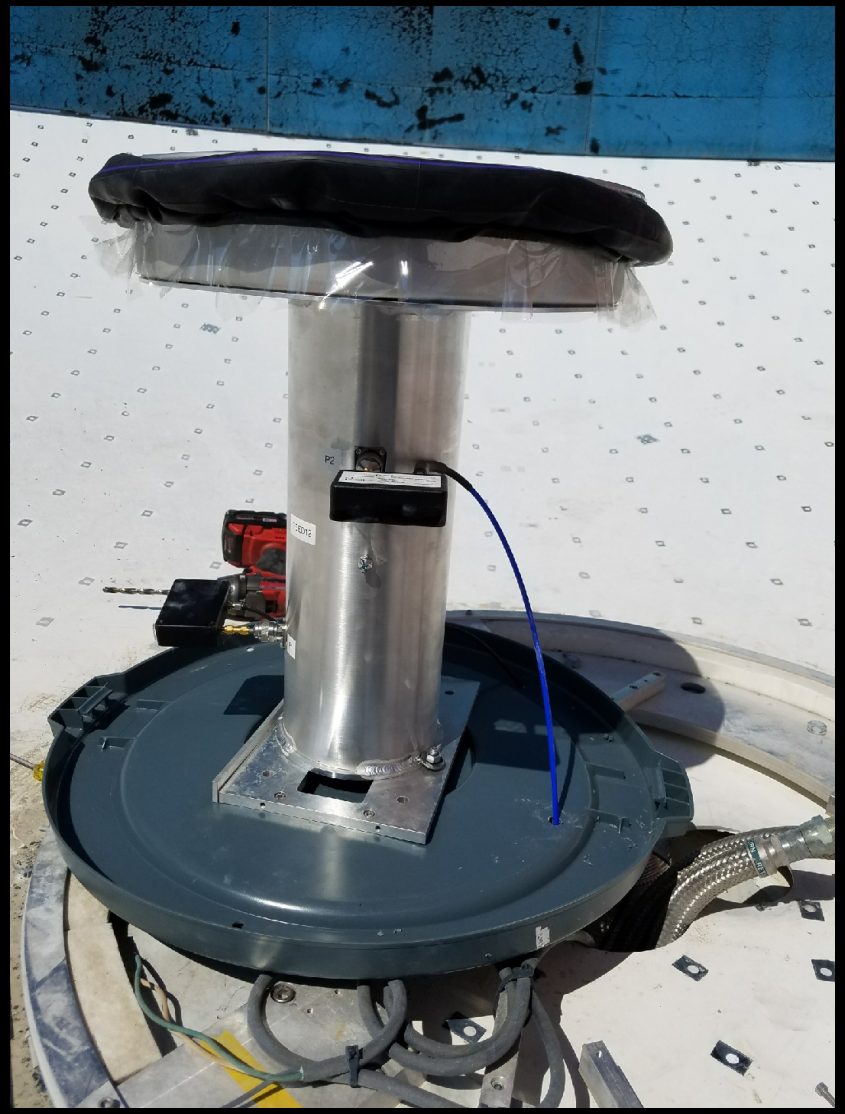
Design

- Three low gain, large field of view feeds at different locations
- Filter RFI by coincidence
- Detection criteria:
  - Same time
  - Same DM
  - Same RM in all 3 antennas
- Localization to < 30”



Design

- Operates between 1.28-1.53 GHz
- 2048 channels, 122 kHz resolution
- 131 microsecond time resolution
- Field of view: ~1.8 steradians
- SEFD ~7.4 MJy (T_{sys} = 55 K)
- S/N = 7.3 for 1 ms pulse ⇒ S > 140 kJy

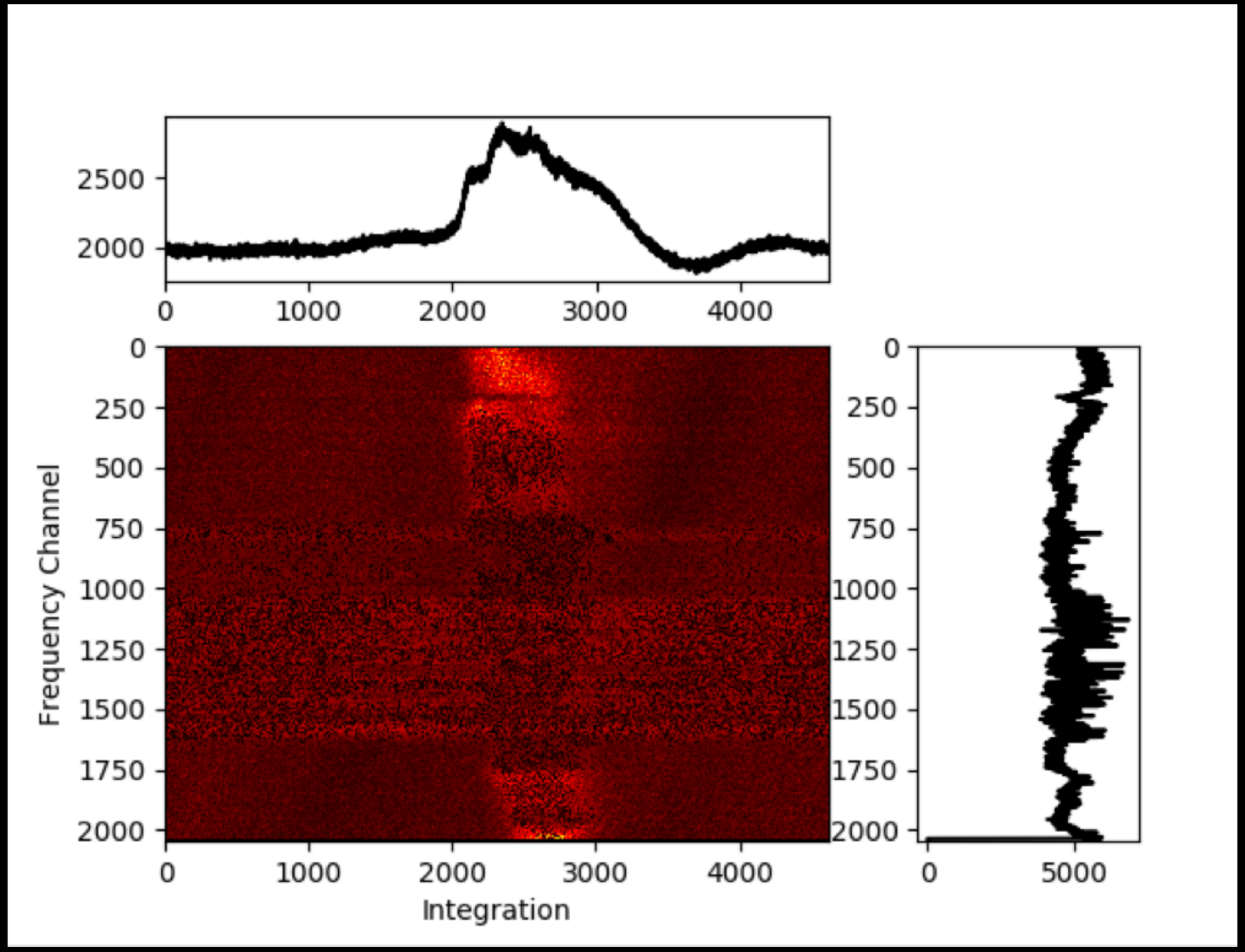



OVRO
258 km
Goldstone
450 km
218 km
Palomar
290 km
SPM
Kitt Peak
San Francisco
San Jose
Fresno
CALIFORNIA
Death Valley National Park
St George
Las Vegas
NAVAJO NATION RESERVATION
Pueblo
Santa Fe
Albuquerque
Bakersfield
Los Angeles
Anaheim
Long Beach
ARIZONA
NEW MEXICO
Phoenix
Mesa
Gila National Forest
San Diego
Tijuana
Mexicali
Tucson
Las Cruces
El Paso
Nogales
BAJA CALIFORNIA
SONORA
CHIHUAHUA

Status

OVRO	Operational	Build first system Done! Write software Done! Operate at site Done!
Palomar	First light in 2 weeks!	Build system In Progress Operate at site
Unit #3	Goal: mid-2018	Build third system Operate at site

Peryton Detected!



Conclusion

- STARE will:
  - Search for FRBs in the Milky Way
  - Investigate the luminosity function of FRBs
  - Catch FRB progenitors in the Local Group
  - Probe the gap between pulsar giant pulses and FRBs
- There may be more FRBs in the galaxy than we think!
- Operational by mid-2018