

Fast Radio Bursts, CHIME, and CHORD

Paul Scholz
York University



YORK **U**

Fast Radio Bursts

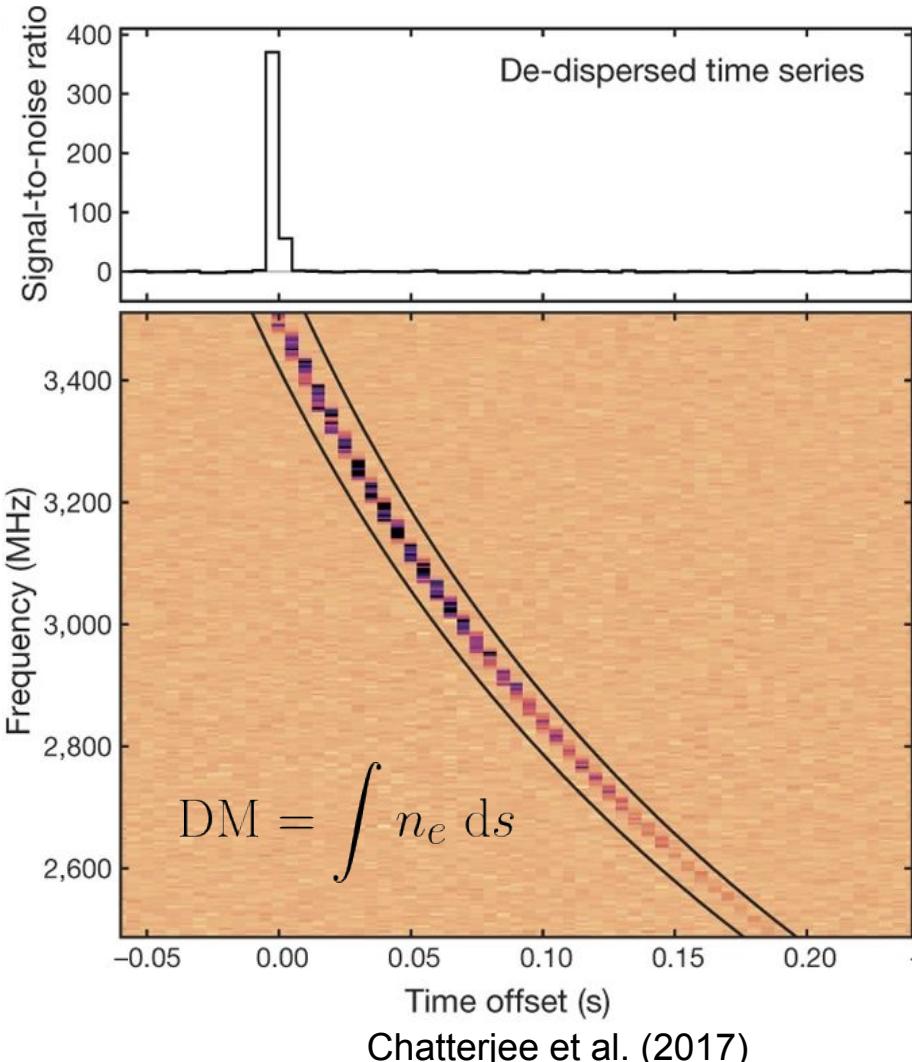
First discovered in 2007

Nanosecond - Millisecond duration
(Fast!!)

Large dispersion measure (DM)
→ Extragalactic (up to $z=3$ so far)

Intrinsically energetic (10^{37} - 10^{42} erg)

Origin unknown!

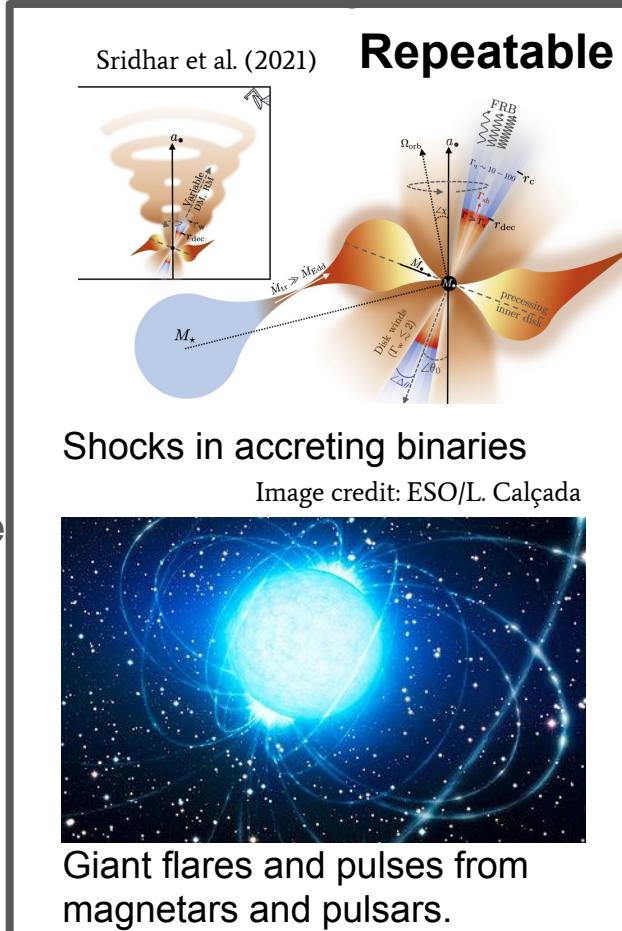


Magnetic and relativistic explosions across the universe

$$c \times 1 \text{ ms} = 300 \text{ km} > R$$

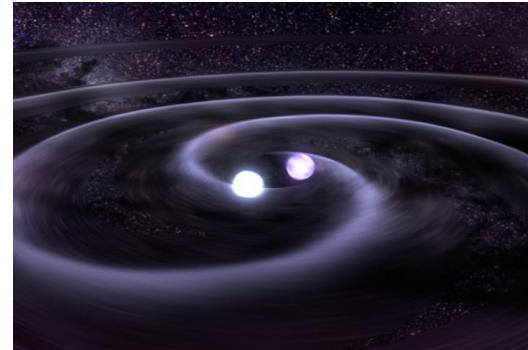
Extreme energetics →
Magnetic fields and/or
relativistic shocks

FRBs will reveal extreme
physics throughout the
universe.



Cataclysmic

Image credit: NASA/Goddard Space Flight Center



Compact object mergers



Collapse of compact object

An FRB-like burst from a Galactic Magnetar

CHIME/FRB Collaboration (2020)

See also codetection by Bockenek et al. (2020)

Magnetar: Neutron stars with highest magnetic fields in nature ($B \sim 10^{14}$ G).

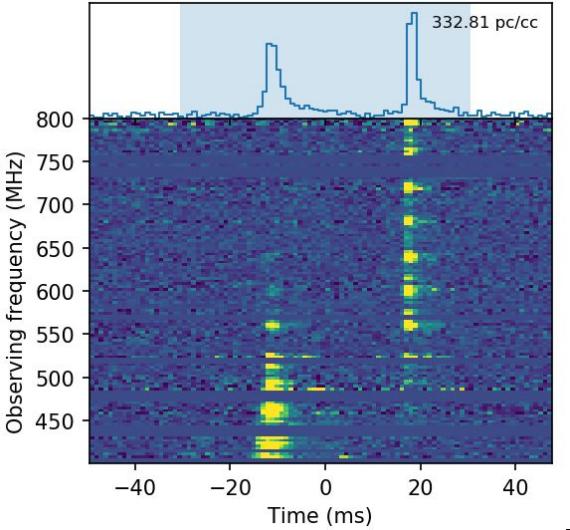
In April 2020: An extremely bright fast radio burst detected from a source within our galaxy: magnetar SGR 1935+2154

Would have been detectable from nearby galaxies.

Some FRBs are magnetars!

Follow-up question: Are all FRBs magnetars?

Problems: Energetics and environment.



(Artist's Impression) Credit: ESO/L. Calçada

FRBs as probes

$$DM = \int$$

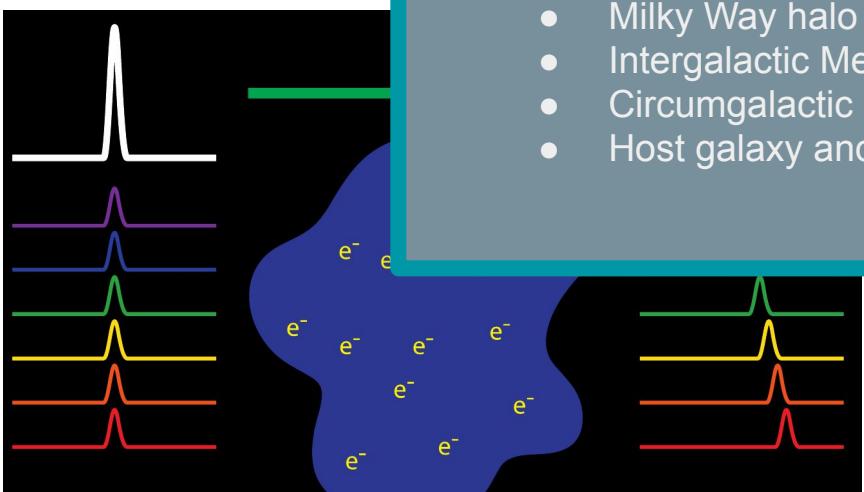
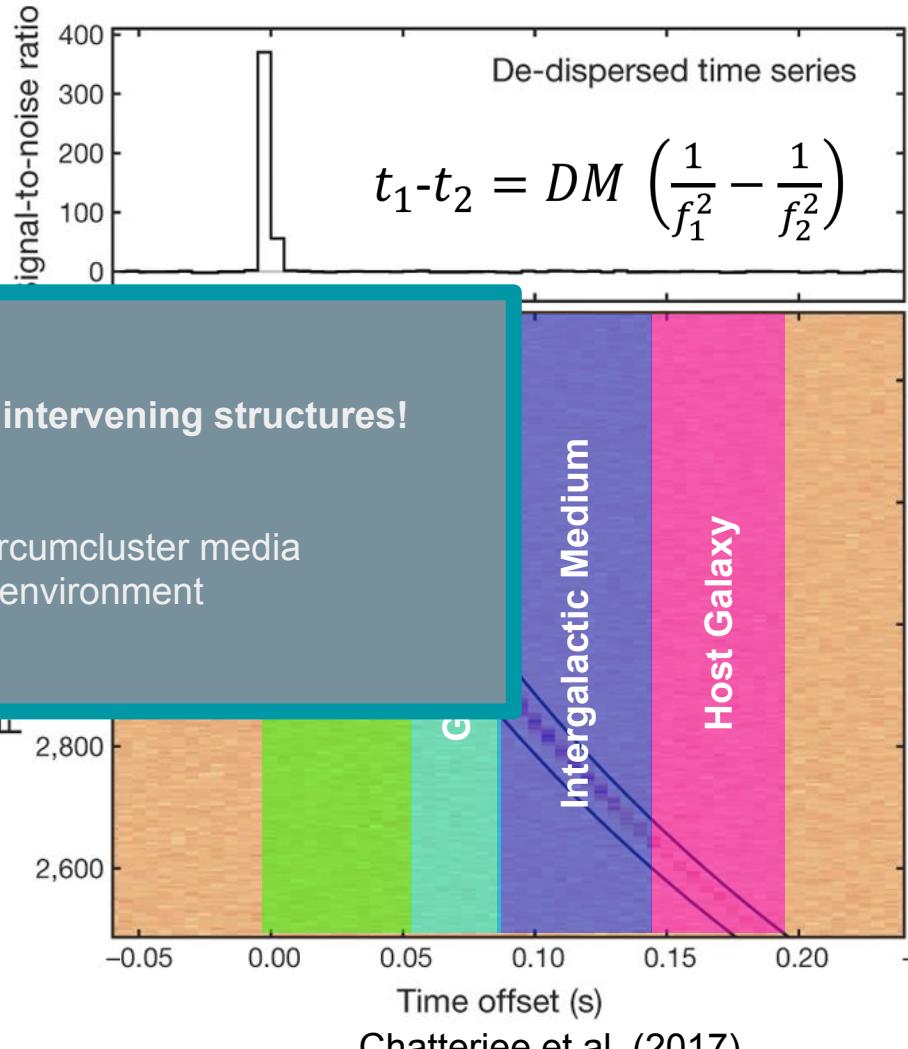


Image Credit: Erik Madsen



Chatterjee et al. (2017)

Canadian Hydrogen Intensity Mapping Experiment



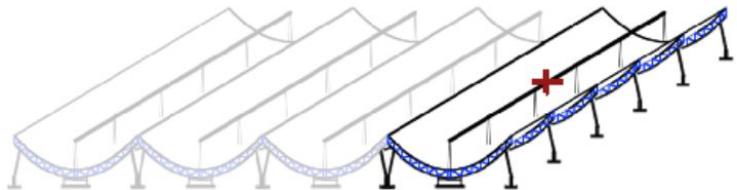
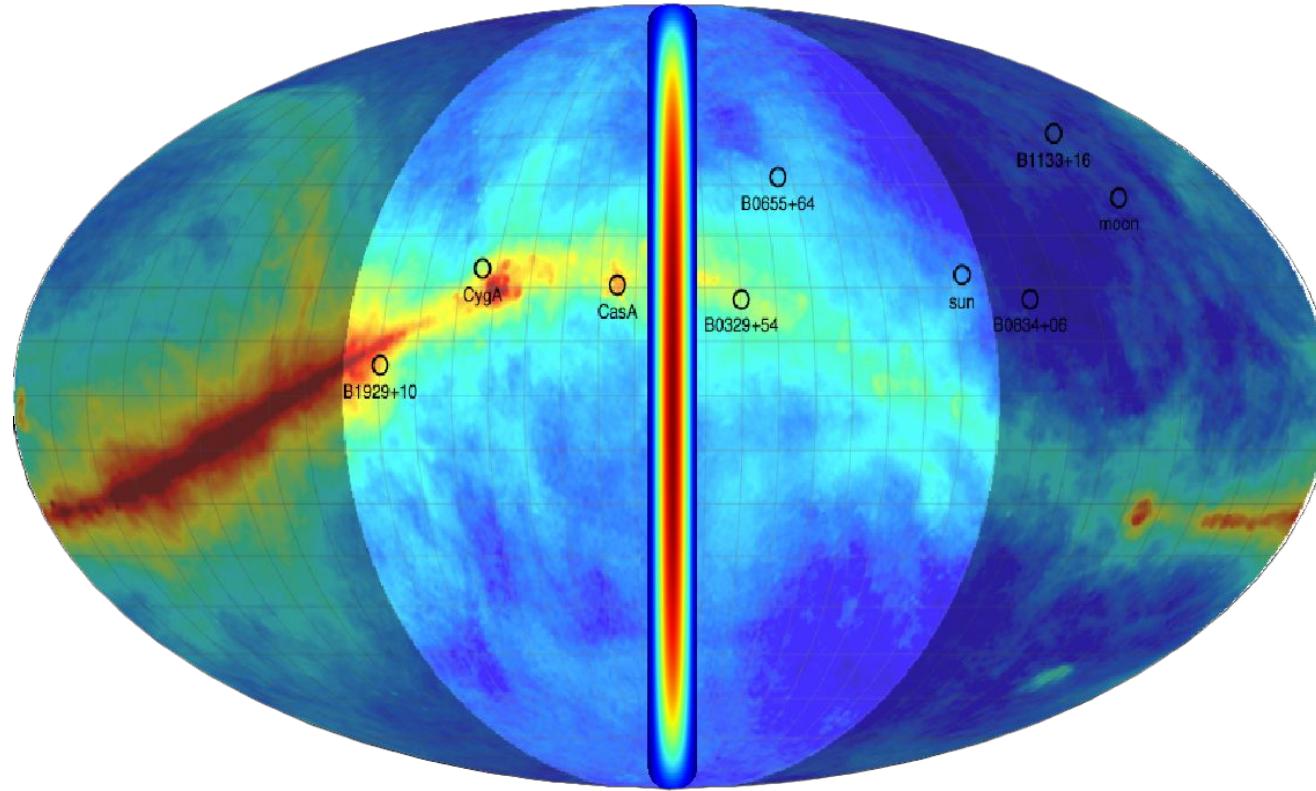
Image credit:
J. R. Shaw/
CHIME Collab.

CHIME/FRB F2F meeting Jan 2025

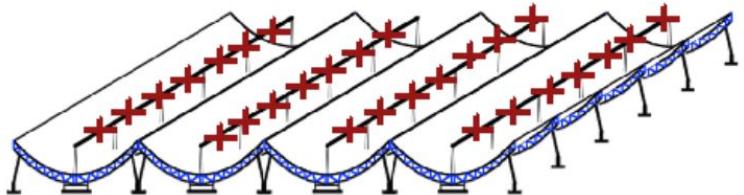
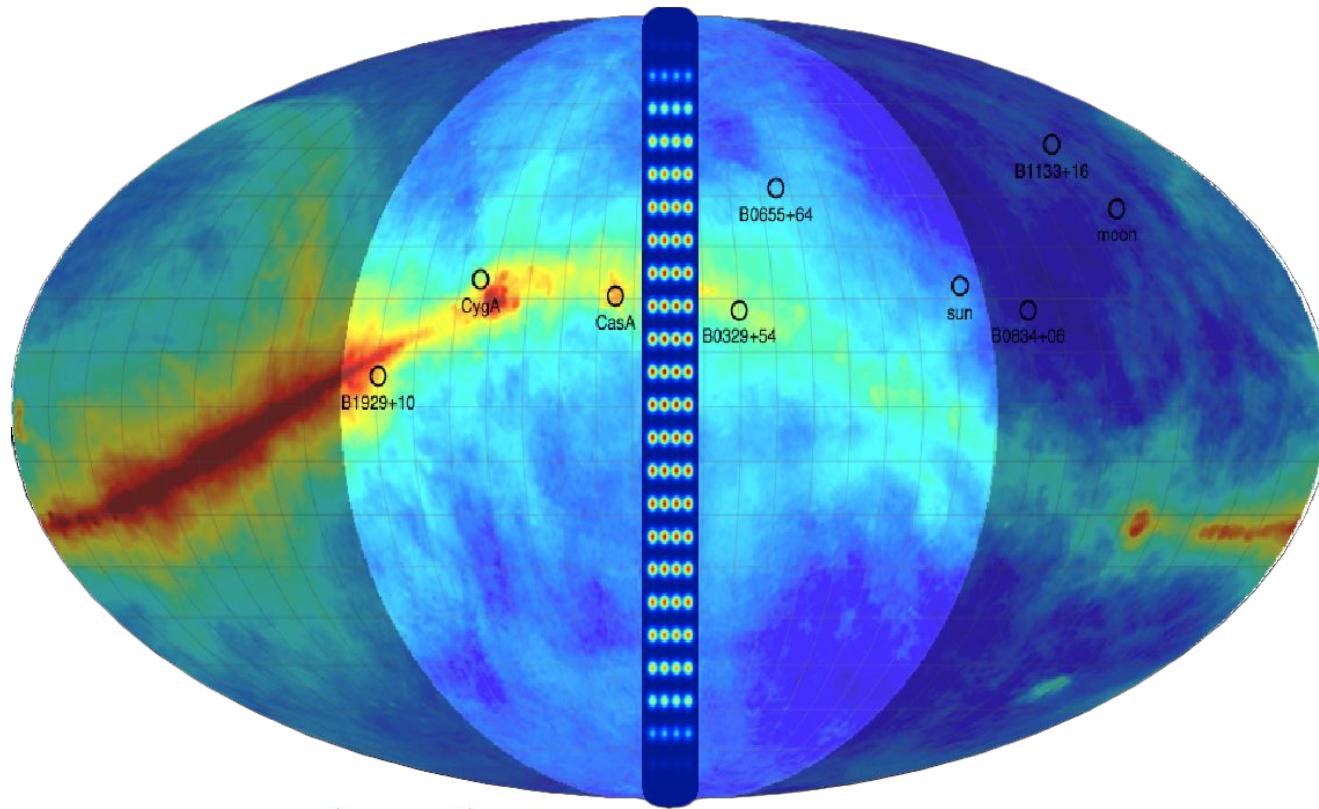


TORONTO

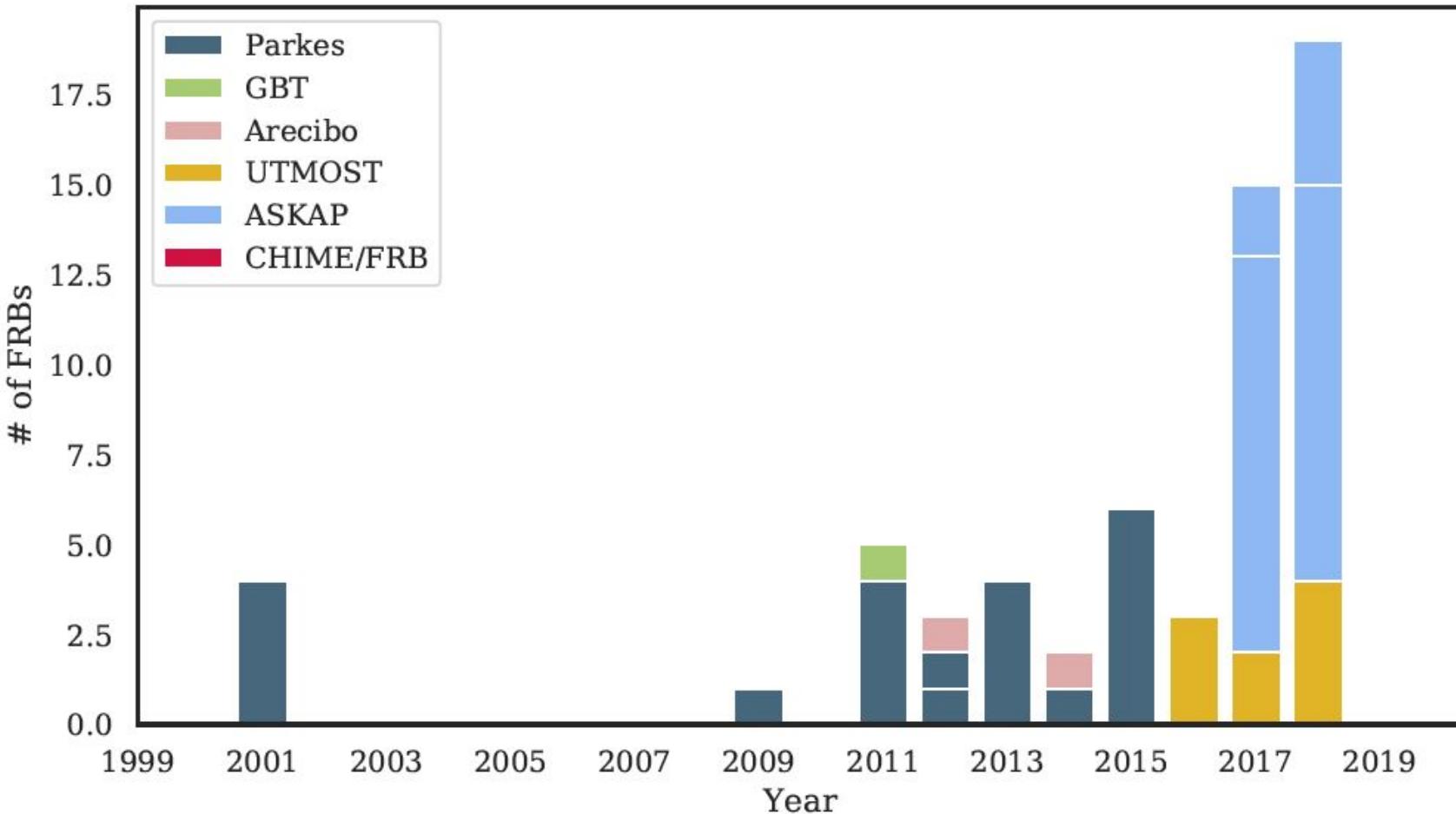


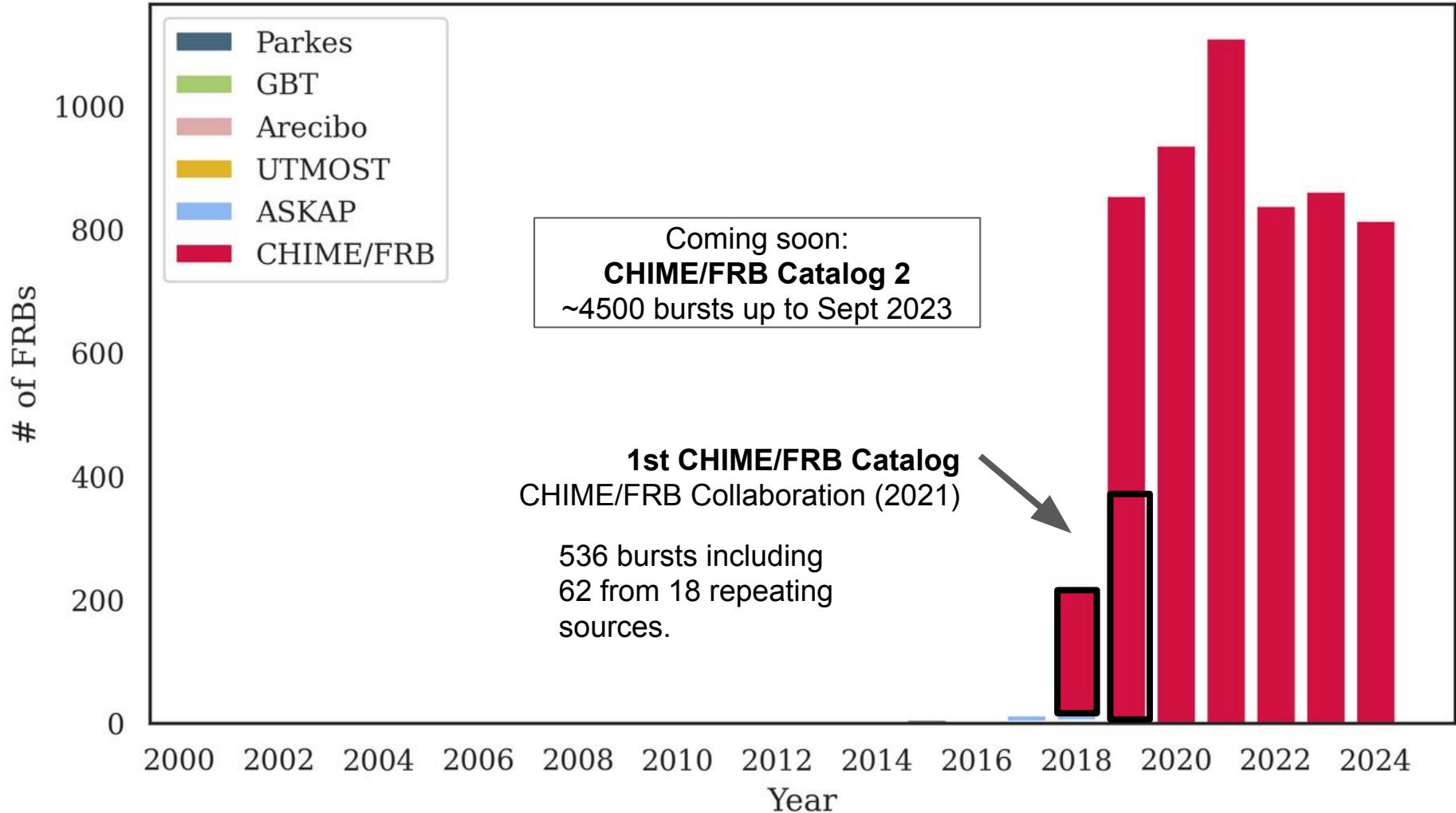


Cylinder focuses light only in E-W direction.
Leads to large field-of-view.

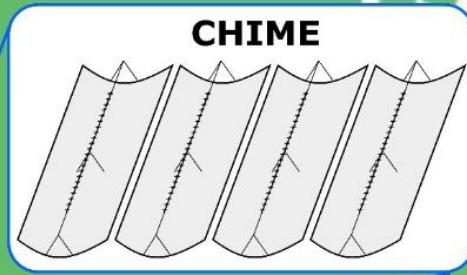


Form 1024 beams using signals from feeds on all 4 cylinders.





CHIME Outriggers

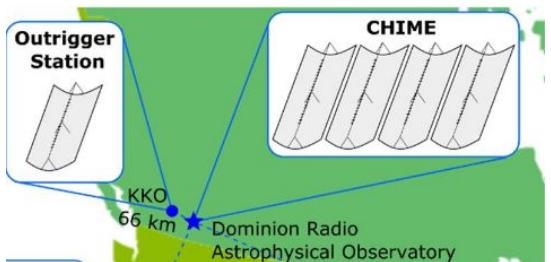


3300 km

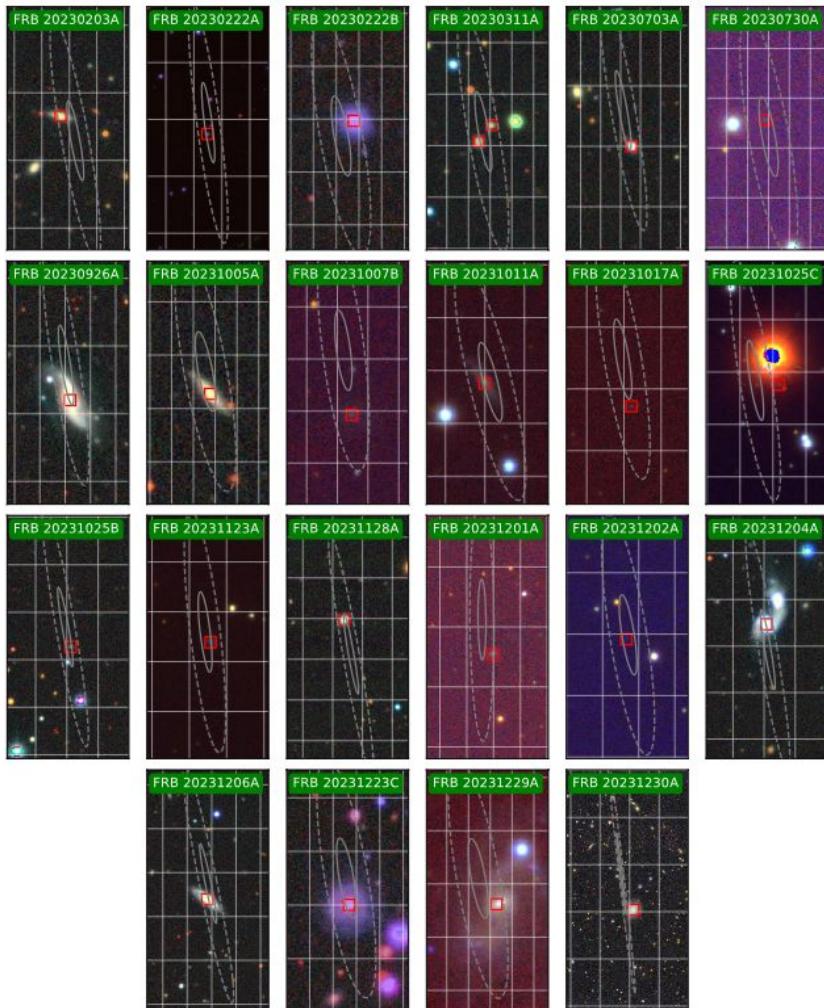


Outrigger localizations

First sample of CHIME/FRB
Outrigger localizations.

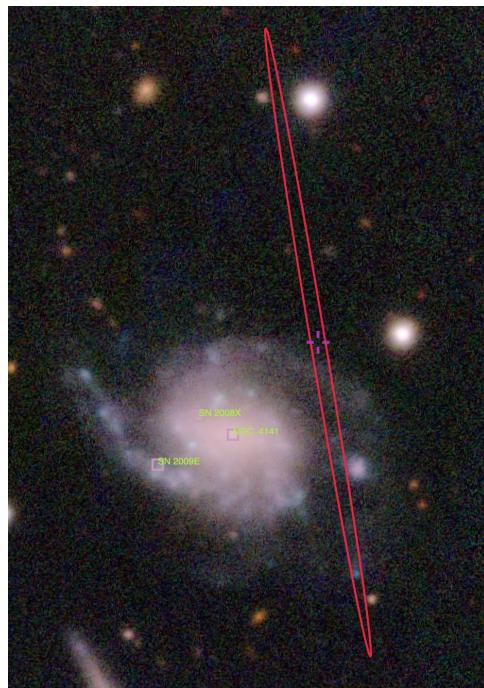
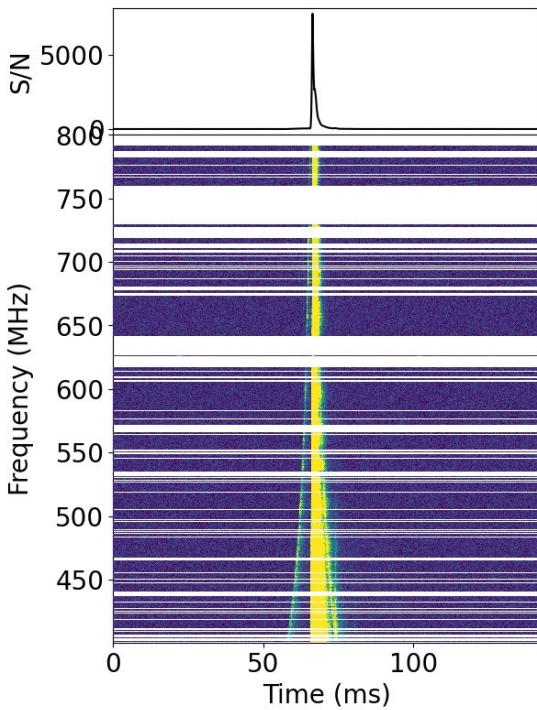


Identified new host galaxies for 21
FRB sources.



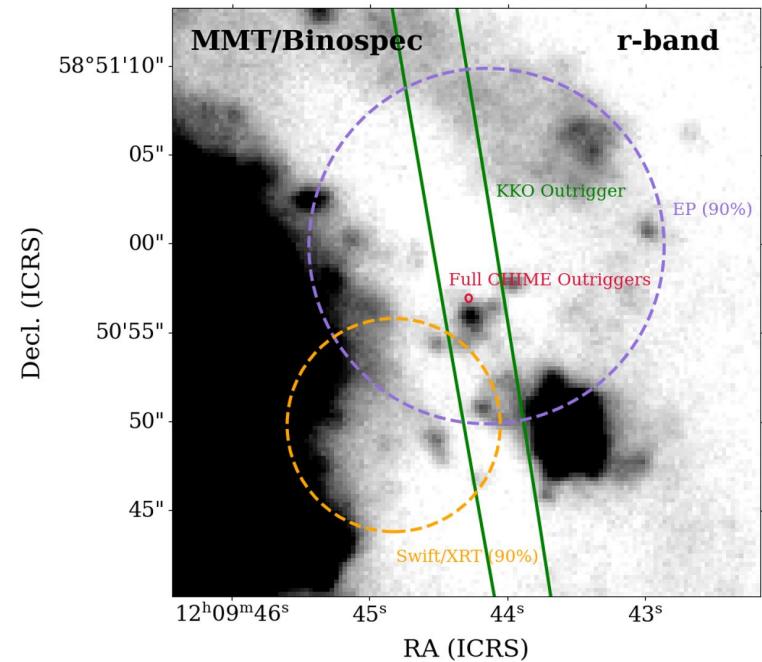
CHIME/FRB Collaboration (2025)

CHIME Outriggers: First full array localization!



Ng and CHIME/FRB (2025),
ATel #17081

Leung and CHIME/FRB (2025),
ATel #17086



Andrew and CHIME/FRB (2025),
ATel #17114

The Canadian Hydrogen Observatory and Radio-transient Detector

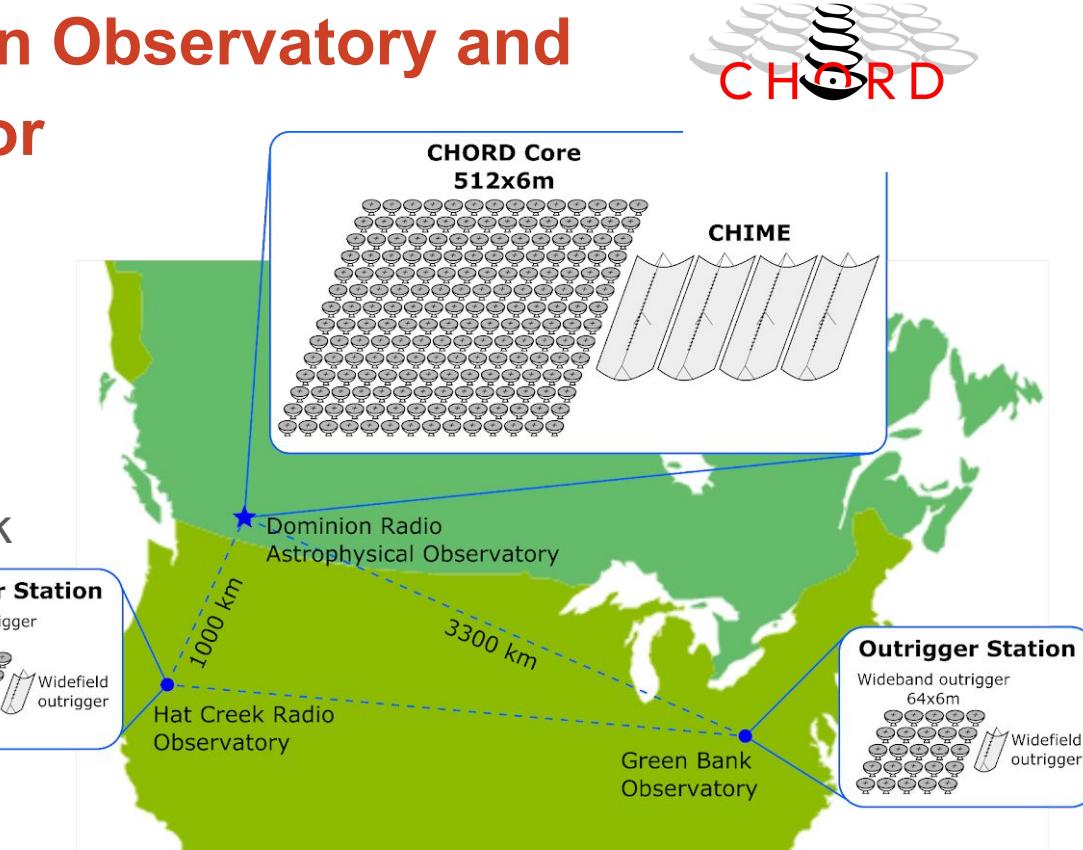
A highly sensitive core:

- 512 6-m dishes

VLBI Outrigger stations:

- At Green Bank and Hat Creek observatories.
- 64 6-m dishes

Construction ongoing!



The Canadian Hydrogen Observatory and Radio

A highly

- 512

VLBI Out

- At G
- obse
- 64 6

Construction



CHORD F2F meeting April 2024

CHORD

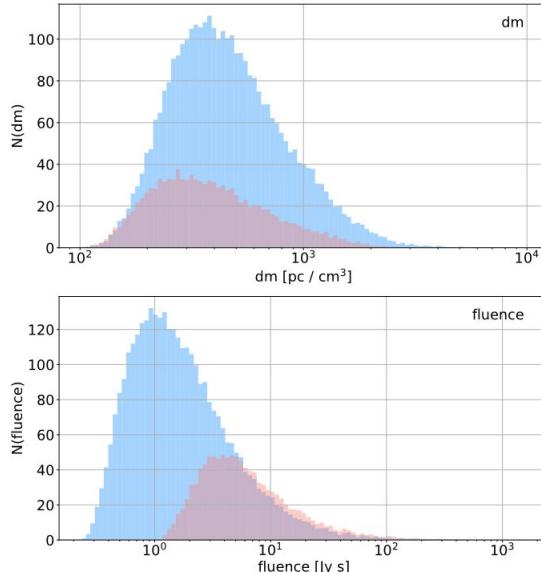
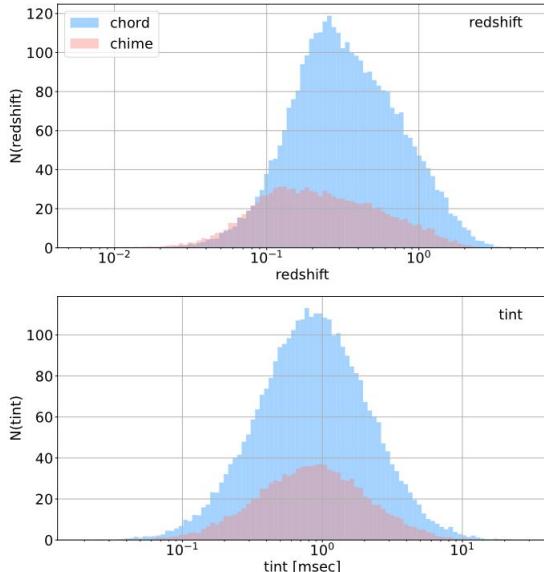


CHORD Forecasts

- 10-20 FRBs per day
- Better than 50 milli-arcsecond localization (hosts!)
- Detect FRBs in smaller field of view to much greater depth.
- Detect FRBs out to redshift 3-4.



Seth Siegel
(Perimeter Institute)



Siegel et al. in prep

Some FRB Stats Questions

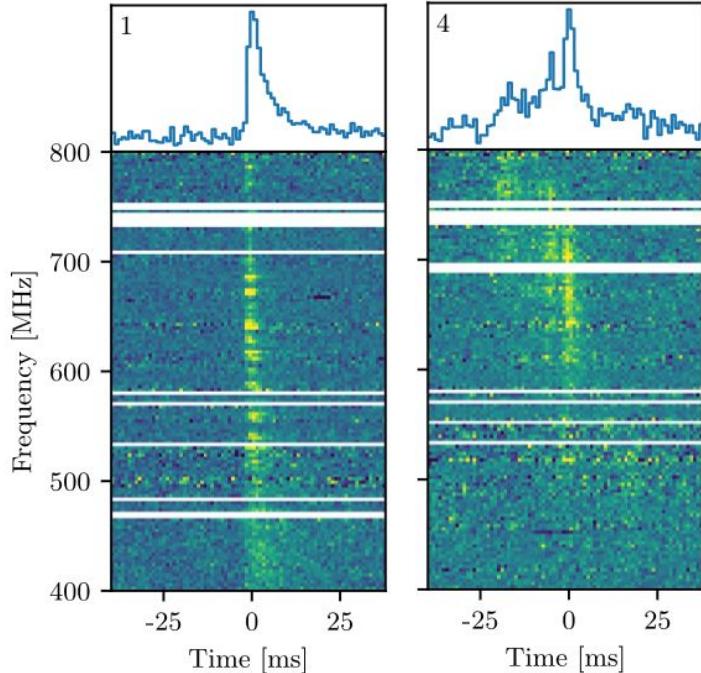
- **Do all FRBs repeat?**
 - If they are all able to repeat we can rule out cataclysmic models
- Where do FRBs live?
 - Do they prefer environments with recent star formation?
 - This would point to models like magnetars that require recent formation.
- Can we use FRBs as precise probes of matter in the Universe?
 - Or does astrophysics get in the way?

Do All FRBs repeat?

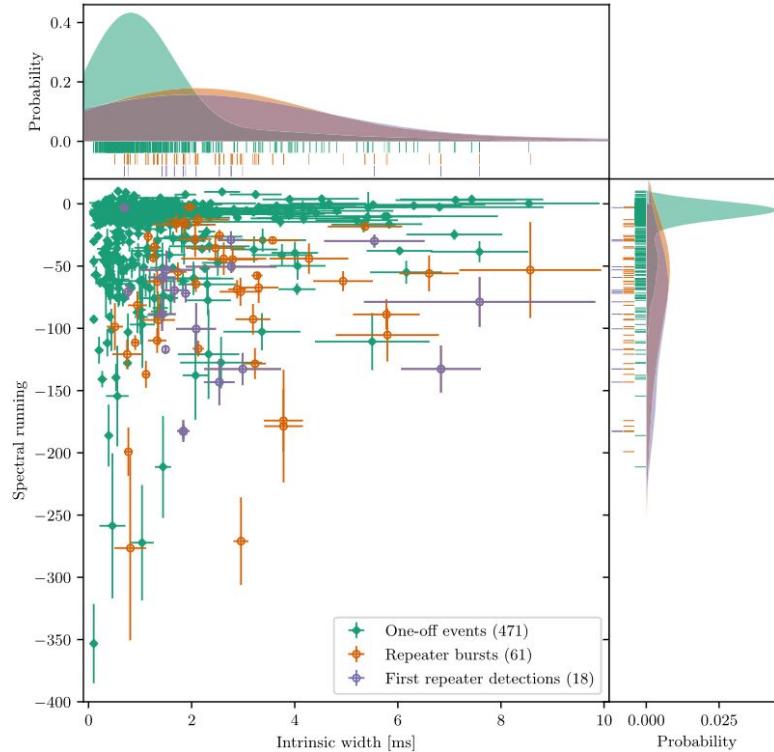


Ziggy Pleunis
(University of Amsterdam)

- Are repeaters and non-repeaters separate populations?



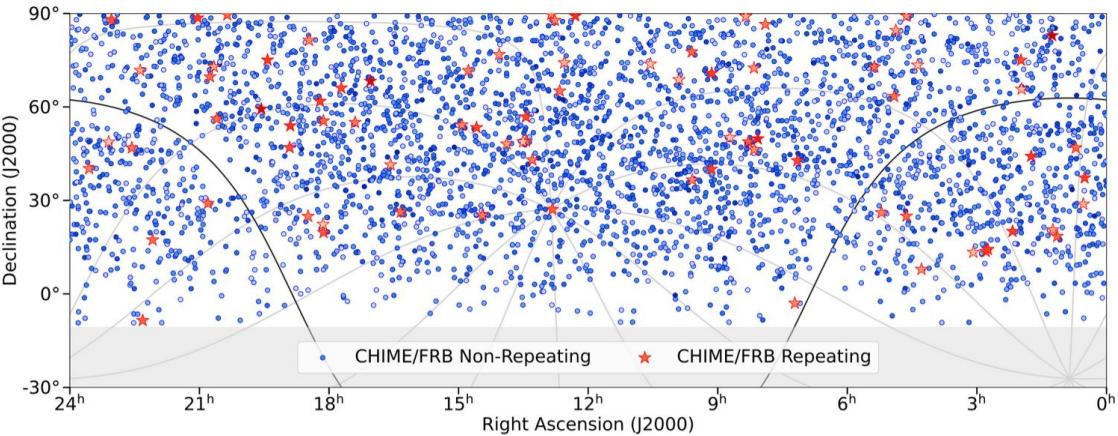
Pleunis et al. (2021)



Do All FRBs repeat?

- What even is a repeater?

Sky density of FRBs is high enough that chance alignment of sources in RA, Dec, DM is non-negligible!



CHIME/FRB Collaboration, submitted

K-CONTACT DISTANCE FOR NOISY NONHOMOGENEOUS SPATIAL POINT DATA WITH APPLICATION TO REPEATING FAST RADIO BURST SOURCES

BY A. M. COOK^{1,2,a}, DAYI LI^{3,d}, GWENDOLYN M. EADIE^{1,3,4,e}, DAVID C. STENNING^{5,g}, PAUL SCHOLZ^{6,2,i}, DEREK BINGHAM^{5,h}, RADU CRAIU^{3,f}, B. M. GAENSLER^{7,2,1,j}, KIYOSHI W. MASUI^{8,9,l}, ZIGGY PLEUNIS^{10,11,m}, ANTONIO HERRERA-MARTIN^{1,3,b}, RONNIY C. JOSEPH^{12,13,n}, AYUSH PANDHI^{1,2,c}, AARON B. PEARLMAN^{12,13,o}, AND J. XAVIER PROCHASKA^{7,k}

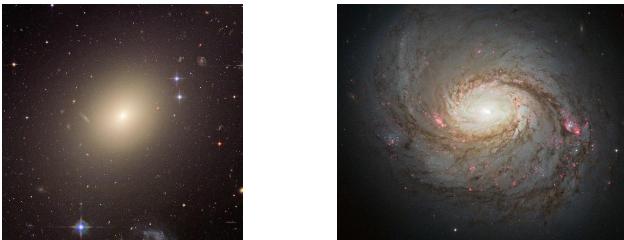
(submitted to the Annals of Applied Statistics)



Amanda Cook
(Banting Fellow at McGill)

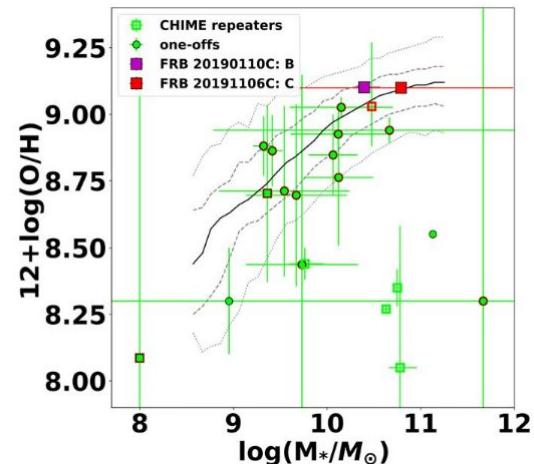
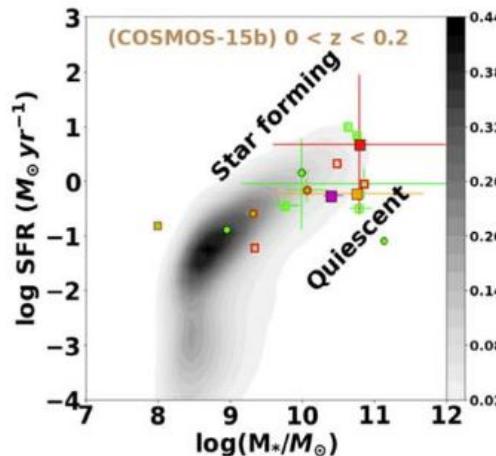
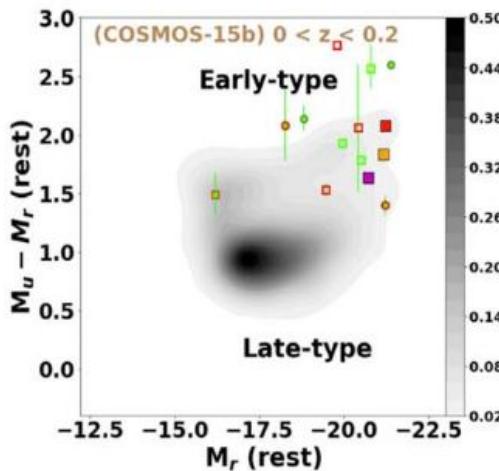
Fourth repeating FRB sample
in prep using this method!

Do All FRBs repeat?



Adaeeze Ibik
(UofT PhD graduate)

- Do repeater and non-repeater host galaxies look different?



Squares: Repeaters

Circles: One-off FRBs

Ibik et al. (2024)

But small samples so far!
Large host galaxy samples: **Outriggers!**

Summary

- CHIME and CHORD is providing/will provide large samples of FRBs and their host environments.
- These large samples can help address science questions:
 - What are FRBs?
 - Are they all repeaters?
 - What environment do they come from?
 - What an FRBs tell us about matter in the Universe?