

# Fast Radio Burst Alerts

## The CHIME/FRB Virtual Observatory Event Service and frb-voe

Thomas C. Abbott on behalf of the CHIME Collaboration  
3rd Astro-COLIBRI Multimessenger Astrophysics Workshop



17/09/2024



McGill



Trottier  
Space Institute  
at McGill

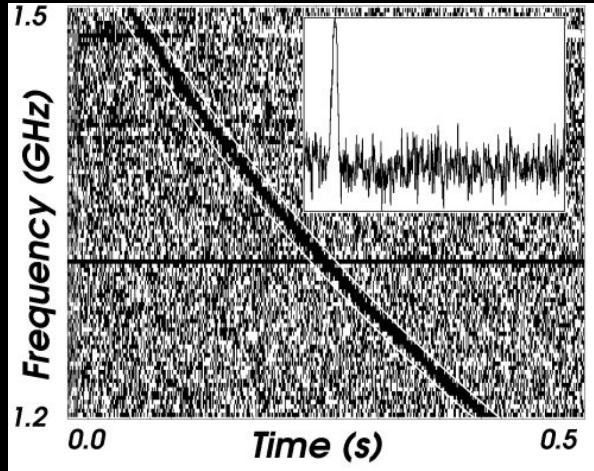
Institut spatial  
Trottier  
de McGill

Credit: CHIME Collaboration.

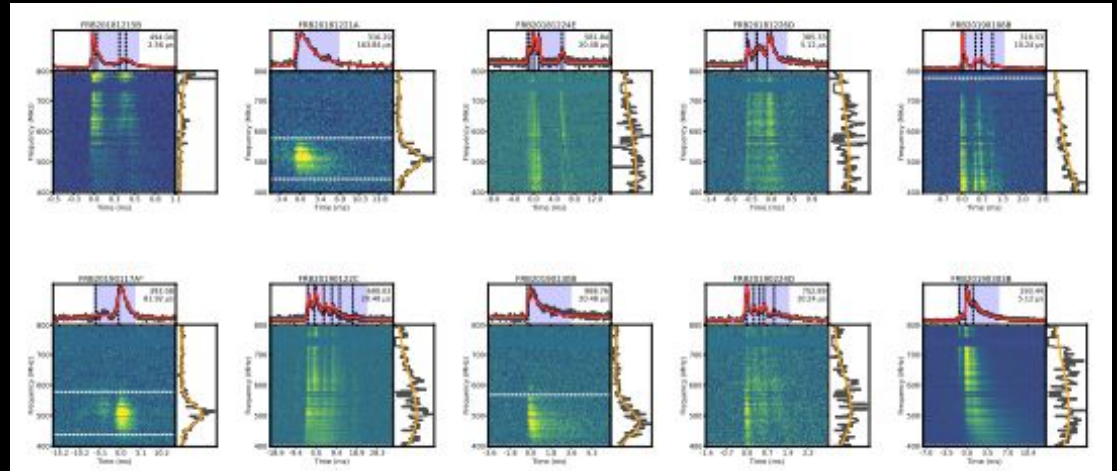
# Fast Radio Bursts

Credit: ESO/M. Kornmesser

- Fast Radio Bursts (FRBs) are luminous short duration ( $\mu\text{s}$  - ms) radio pulses
- Their dispersion measure (DM) indicates extragalactic origin.
- They exhibit a wide range of morphologies



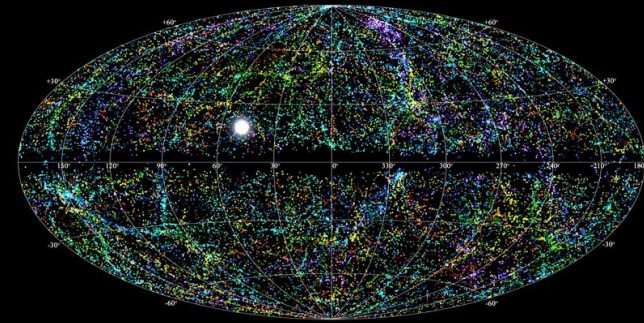
Lorimer et al. 2007



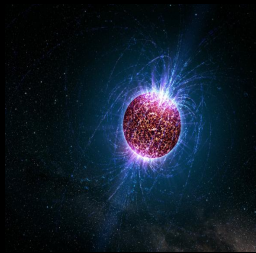
Sand et al. 2024

# Candidate FRB Progenitors

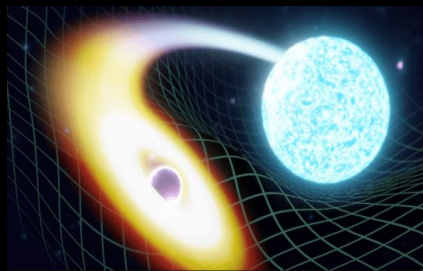
- The physical origins of FRBs are unknown
- There may be multiple FRB progenitor types
- Most FRB sources are not observed to repeat, however, a small fraction do repeat (with varying repetition rates)
- There are  $\sim 1000$  published FRBs, and the estimated all sky rate is  $\sim 10^4/\text{yr}$
- A Galactic magnetar, SGR 1935+2154, was observed to emit FRB-like bursts



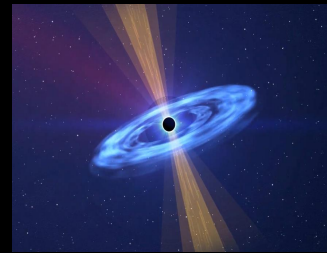
Credit: NRAO Outreach



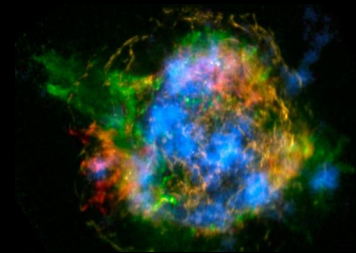
Credit: NASA



Credit: LIGO-India/ Soheb Mandhai



Credit: Dheeraj Pasham, Matteo Lucchini, and Margaret Tripe.



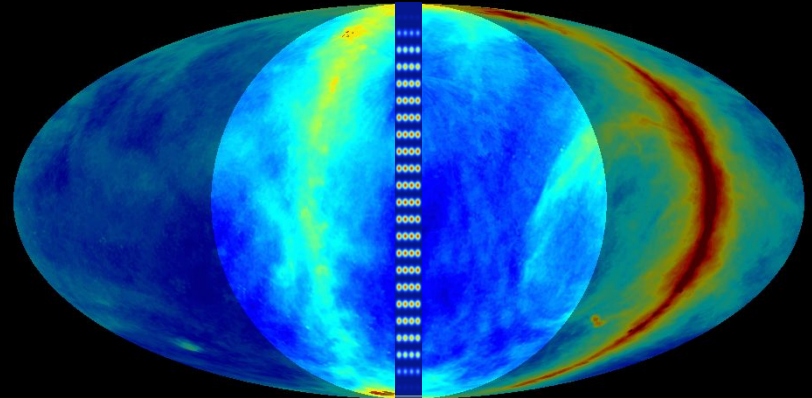
Credit: NASA/JPL Caltech/CXC/SAO

# Canadian Hydrogen Intensity Mapping Experiment (CHIME)

- CHIME is a transit radio (400 - 800 MHz) telescope in British Columbia, Canada
- CHIME has a large field of view ( $>200 \text{ deg}^2$ ) and powerful real time data processing pipeline which has allowed it to detect the majority of FRB sources



Credit: CHIME Collaboration

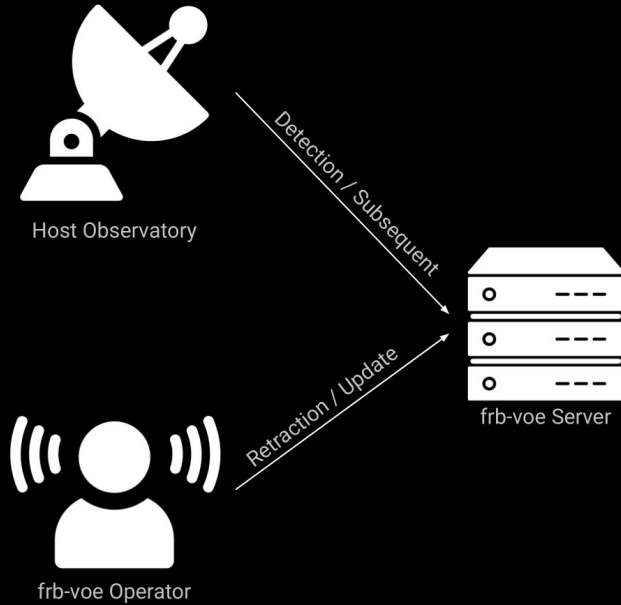


Credit: CHIME Collaboration

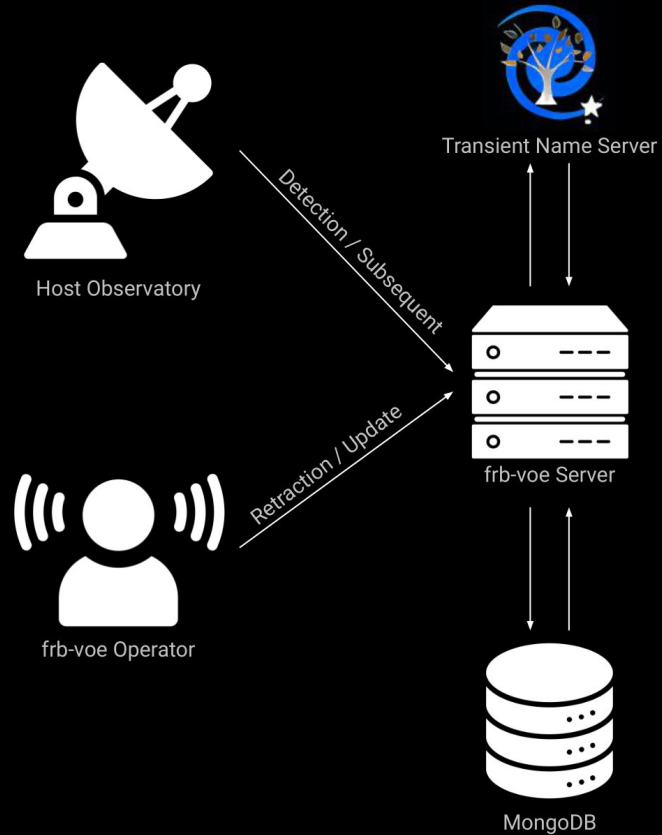
# Virtual Observatory Events (VOEvents)

- A VOEvent is a standard information packet for communicating a transient celestial event, particularly for rapid follow-up (Seaman et al. 2011).
- Petroff et al. (2017) introduced a VOEvent Standard for FRBs
  - *Detection*: a newly discovered FRB source
  - *Subsequent*: a repeat burst from a known FRB source
  - *Retraction*: a recall of a previously broadcast VOEvent
  - *Update*: an addendum to a previously broadcast VOEvent with updated parameters
- FRB VOEvents include information about the host observatory, and the burst metadata.

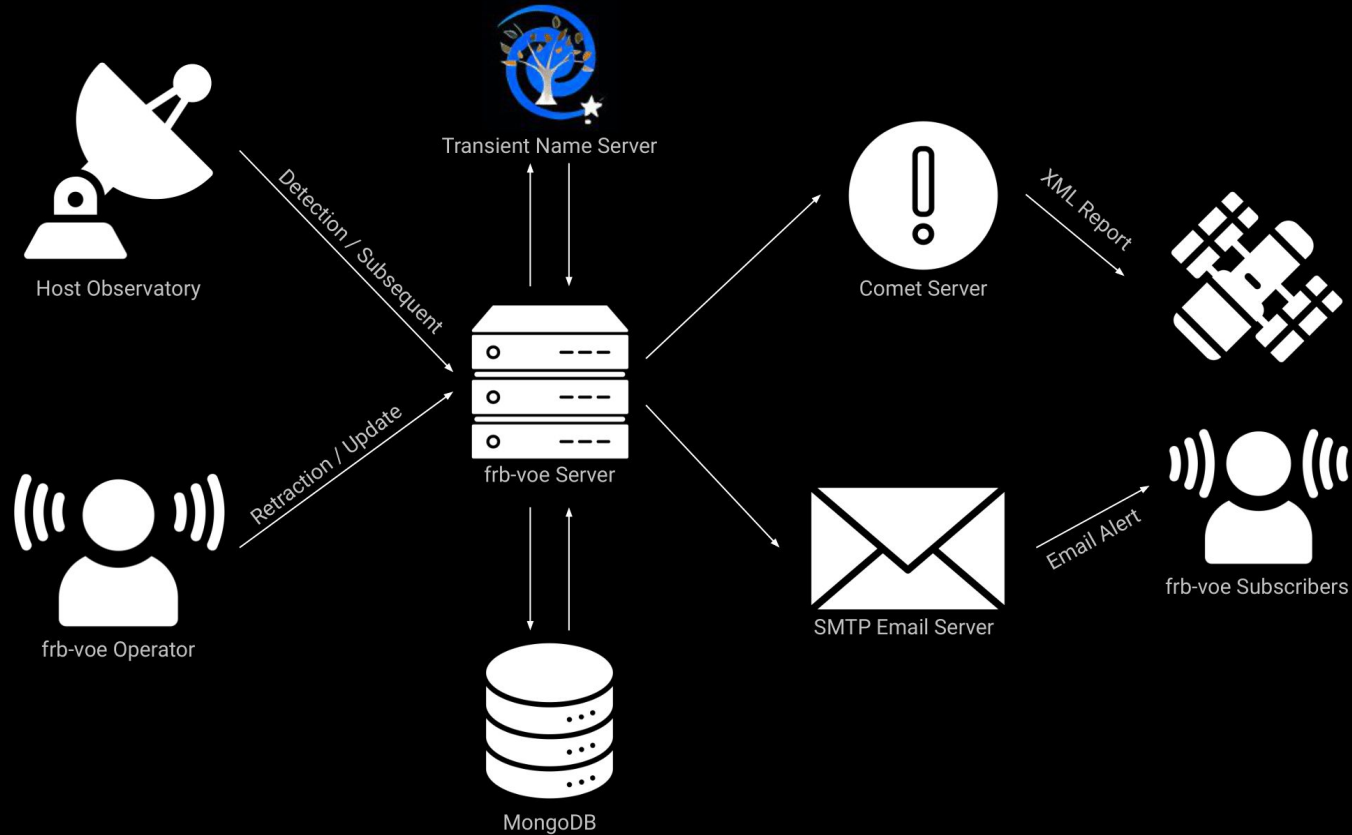
# FRB VOEvent Service Workflow



# FRB VOEvent Service Workflow



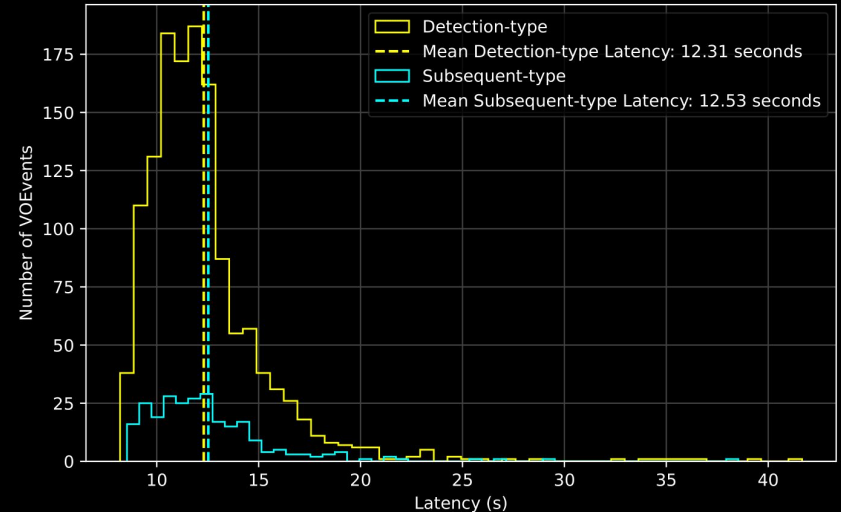
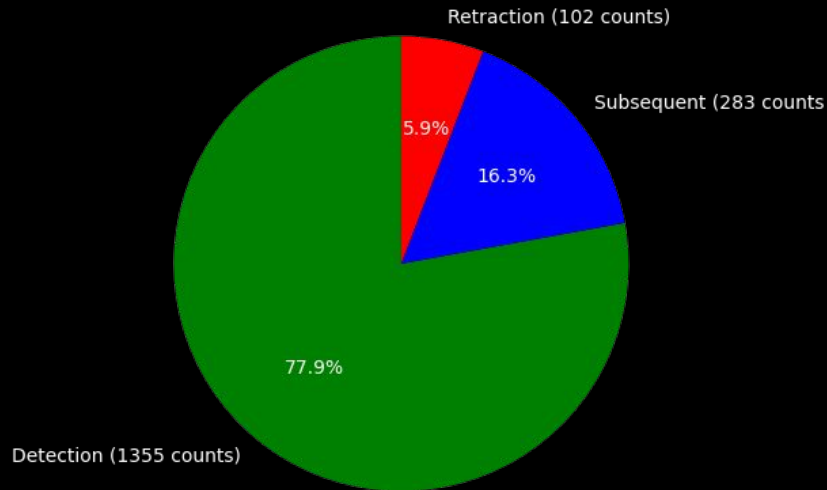
# FRB VOEvent Service Workflow





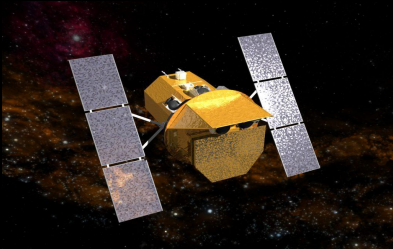
# Overview of The CHIME/FRB VOEvent Service

- Open to public subscription as of October 2021
- As of June 2024, 1752 VOEvents broadcast
- 1-3 VOEvents are typically broadcast daily
- Alerts are broadcast within 20 sec.



# CHIME/FRB VOEvent Service Engagement + Results

- 100+ subscribing groups, including faculty, postdocs, graduate students, undergraduates, and independent researchers
- Engagement from over a dozen countries across 4 continents
- CHIME/FRB VOEvents have drastically reduced the latency of coordinated FRB observations, from days/weeks to seconds
- Several instances of triggered X-ray follow-up by the Swift BAT GUANO Experiment (Tohuvavohu et al. 2021a, 2021b, 2023)
- The first triggered FRB localization (Ravi et al. 2023)



Credit: NASA



Credit: DSA/Caltech

# CHIME/FRB VOEvents Public Webpage

- Free subscription request to the Service, a database of all broadcast CHIME/FRB VOEvents, and more info: <https://www.chime-frb.ca/voevents>

CHIME/FRB  
Fast Radio Bursts in realtime

Overview  
VOEvent Database  
Subscription Request  
Citation  
Help

## CHIME/FRB VOEvent Database

This datatable contains all broadcasted CHIME/FRB VOEvents since the service started operating in October of 2021.

[Click to Download VOEvents as JSON](#)

CHIME/FRB VOEvent data

Customize Columns Type to Search... Clear

VOEvents that are retracted are highlighted in red.

Event_id	Detected	Published	Alert_Type	DM	SNR	RA	DEC	Localization_Error
395683282	2024-07-11 16:34:49.792929	2024-07-11 16:34:49	Detection	54.59053	25.953043	58.891	4.523	0.543
394807590	2024-07-08 15:04:36.316439	2024-07-08 15:04:36	Subsequent	350.18811	14.8182259	33.057	65.713	1.062
394806905	2024-07-08 14:50:54.369170	2024-07-08 14:50:54	Subsequent	348.57062	26.6956921	29.635	65.71	0.929
394416558	2024-07-05 13:46:32.983134	2024-07-05 13:46:32	Detection	380.51617	23.0411377	11.351	50.737	0.643
394377678	2024-07-05 04:56:32.480619	2024-07-05 04:56:32	Subsequent	1285.10144	12.4683905	239.313	69.574	1.38
394375171	2024-07-05 04:06:58.831803	2024-07-05 04:06:58	Detection	971.71136	21.9780712	224.595	67.552	1.048
394018406	2024-07-03 21:17:56.783055	2024-07-03 21:17:56	Detection	1146.80542	21.4127502	122.434	50.166	0.639
393801730	2024-07-02 16:54:33.912724	2024-07-02 16:54:33	Detection	559.24963	19.7615547	54.535	12.696	0.521

# frb-voe - A Telescope Agnostic FRB Alert System

- Frb-voe is a publicly available software service that enables any FRB observatory to broadcast FRB VOEvents
- Easy installation through Docker
- Data validation ensures all FRB VOEvents follow the FRB VOEvent Standard
- Offers an command line interface (CLI) to interact with the TNS.
- Available for download on Github: <https://github.com/CHIMEFRB/voe>

# frb-voe - Future Possibilities

- Co-detections of FRBs across different radio wavelengths
- Better real-time localizations, sensitivity, etc. depending on participating instruments/observatories.
- Sequentially triggered multi-wavelength and multi-messenger observations (e.g. FRB VOEvent triggers X-ray follow-up which then leads to optical follow-up)
- Integration into larger transient networks/databases

# Questions and Feedback

- CHIME/FRB VOEvent Service:  
<https://www.chime-frb.ca/voevents>



- frb-voe software:  
<https://github.com/CHIMEFRB/voe>



# CHIME/FRB Outriggers



# Real-time Localization

