# FRBs - a short review

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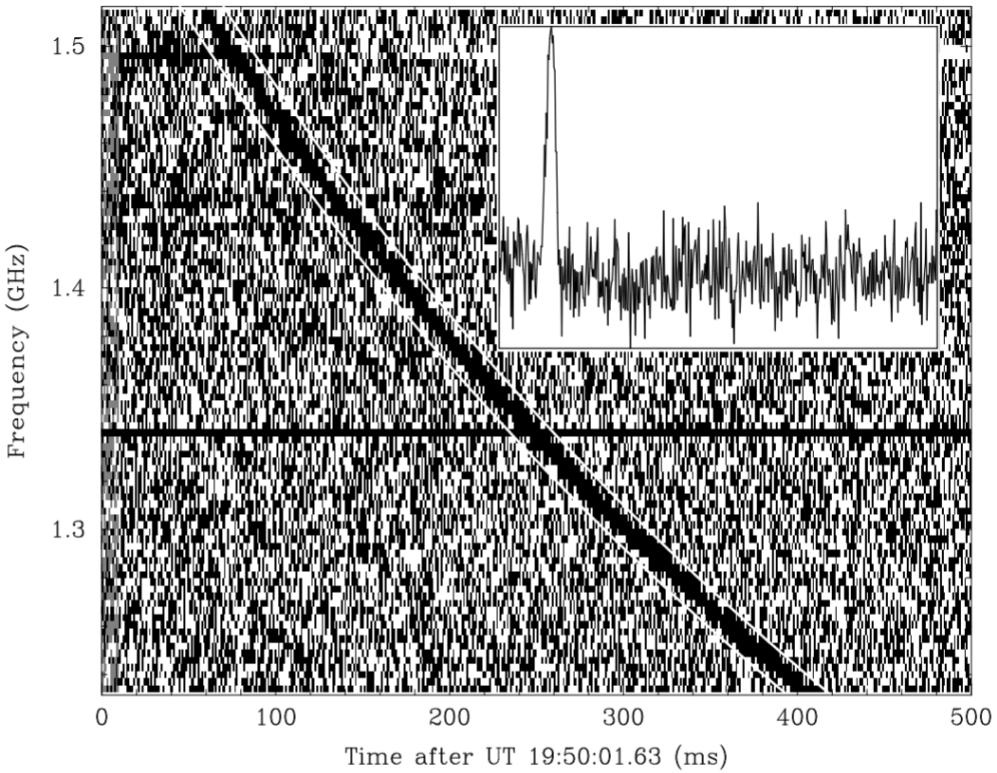
# The Discovery

FRB 010724 the "Lorimer" burst




Frequency evolution and integrated pulse shape of the radio burst (Lorimer et al. 2007).

Observed in archival data from a pulsar survey of the Magellanic Clouds taken with the Parkes telescope in 2001.

Extremely bright (**30 Jy**), short-lived ($<$ **5 ms**) and observed across the whole radio bandwidth (**288 MHz**).

$$\mathrm{DM} = \int_0^d n_e(l)dl = 375\ \mathrm{cm}^{-3}\mathrm{pc}$$

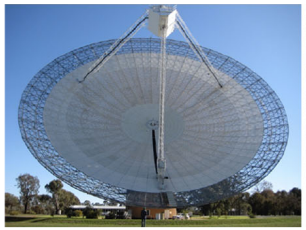
$$d < 1\ \mathrm{Gpc}$$

Assuming distance 500 Mpc ($z \sim 0.12$, host galaxy $\mathrm{DM} = 200\mathrm{cm}^{-3}\ \mathrm{pc}$)

$$T_\mathrm{b} \sim 10^{34}(D_{500}/W_5)^2\ \mathrm{K}$$

$$E \sim 10^{40} W_5 D_{500}^2\ \mathrm{erg}$$

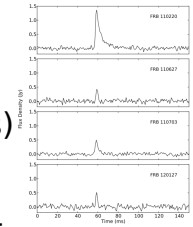
# Timeline of discoveries





**2007** — **FRB 010724 the "Lorimer" burst**

"Radio Bursts with Extragalactic Spectral Characteristics Show Terrestrial Origins" (16 bursts in 13 beams, Burke-Spolaor et al. 2011)



From "Lorimer Bursts" to Fast Radio Bursts (FRBs) (Thornton et al. 2013)

E(erg): 10^{40}, 10^{38}, 10^{39}, 10^{38}

**2011** — Arecibo: FRB 121102 (Spitler et al. 2014, Spitler et al. 2016)

**2013** — GBT: FRB110523 (Masui et al. 2015)

**2015**

**2017** — ASKAP: FRB170107 (Bannister et al.2017)

ASKAP: 34 bursts (Shannon et al. 2018)

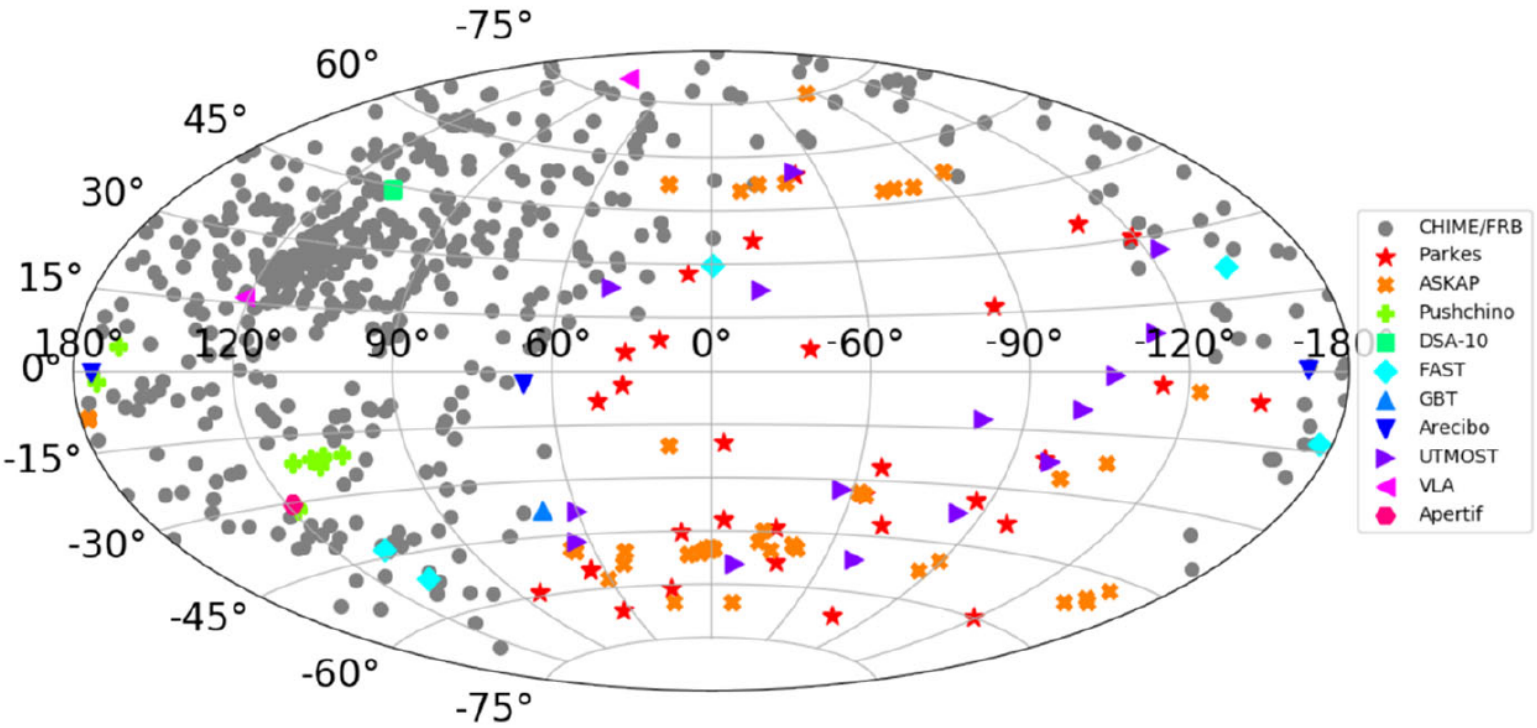
**2019** — CHIME: FRB180725A (Boyle and CHIME/FRB Collaboration 2018)

CHIME: 8 bursts, FRB 180814.J0422+73 (CHIME/FRB Collaboration 2019)

~60 FRBs (2 repeaters)

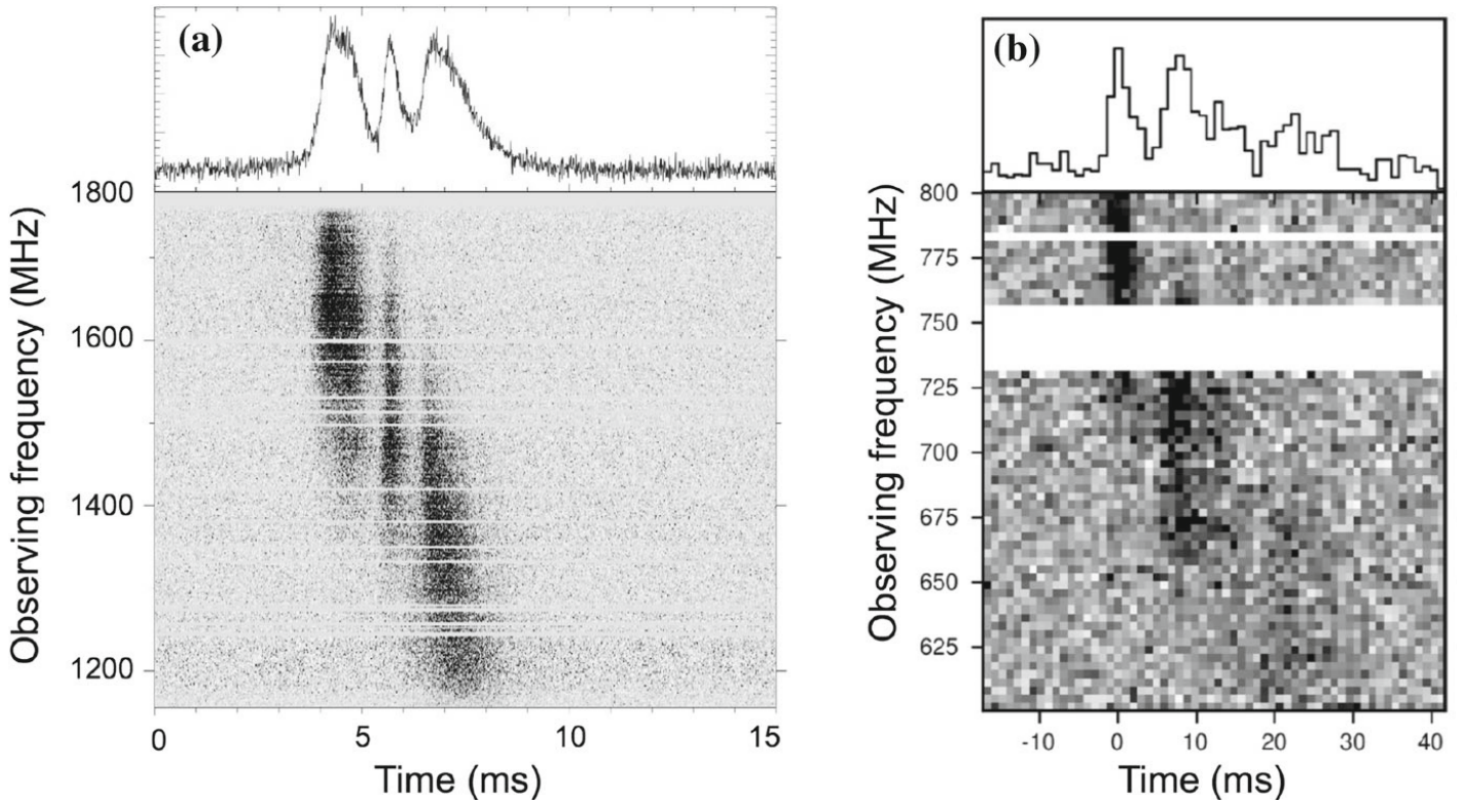
# 600 FRBs at the end of 2021

## The Canadian Hydrogen Intensity Mapping Experiment (CHIME) Catalog 1 (536 FRBs)




Sample of FRBs in Galactic coordinates (Petroff et al. 2022). The underlying distribution is isotropic (when corrected for non-uniform sky coverage).

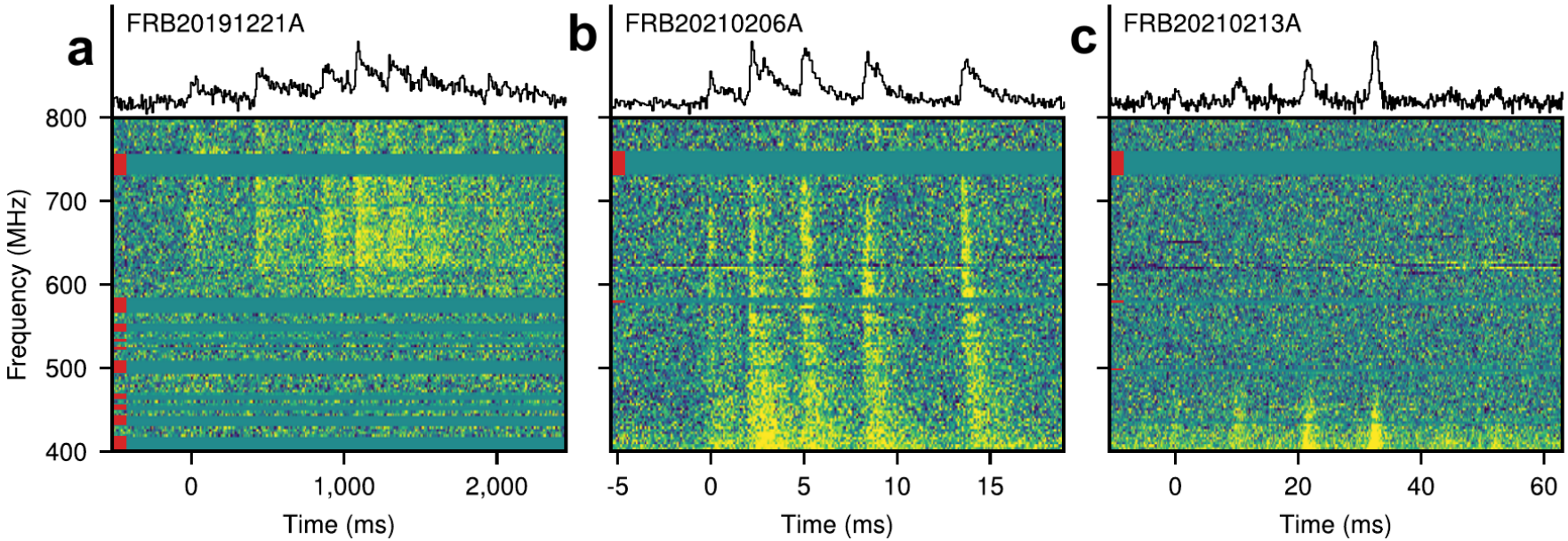
# Repeating FRBs (24 sources)




Dedispersed spectra of individual bursts from the repeating FRB 121102 (Arecibo) and FRB 180814.J0422+73 (CHIME).

- sub-burst structure with descending centre frequencies
- $\sim$ 100% (75, 50) linear polarisation and negligible (25, 47) circular polarisation
- many repeaters observed only twice
- typically wider in time but narrower in bandwidth

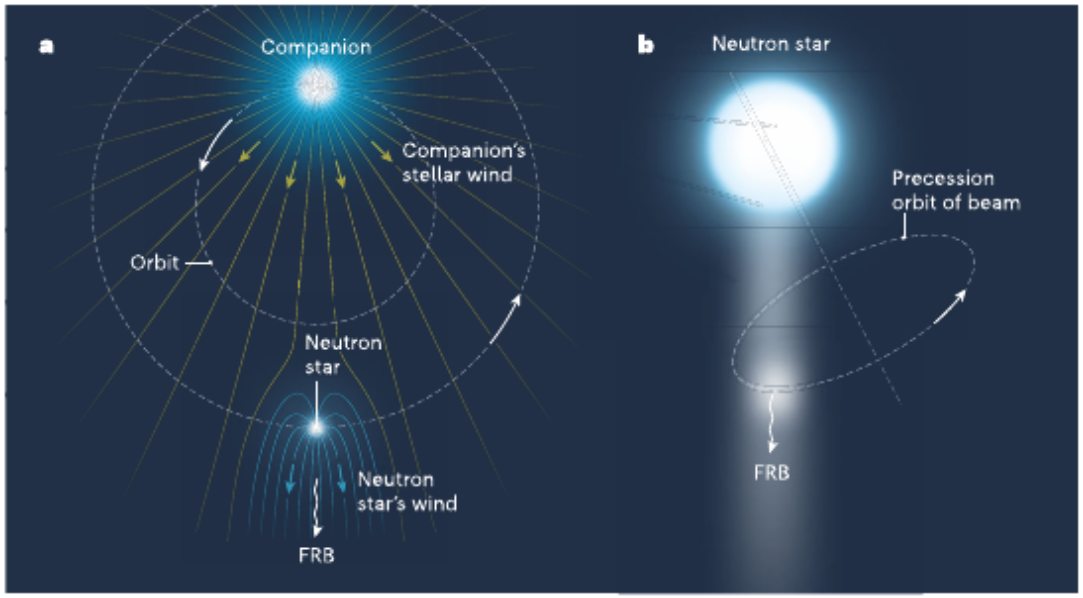
# Periodic behaviour in FRBs (I)




Periodic and quasi-periodic bursts detected with CHIME (CHIME/FRB Collaboration et al. 2021, Petroff et al. 2022).

- FRB 20191221A
- 9 peaks with a strict period of 216.8 ms
- strongly suggest neutron star link (only one source)
- FRB 20210206A, quasi-periodic at 2.8 ms
- FRB 20210213A, quasi-periodic at 10.7 ms

# Periodic behaviour in FRBs (II)

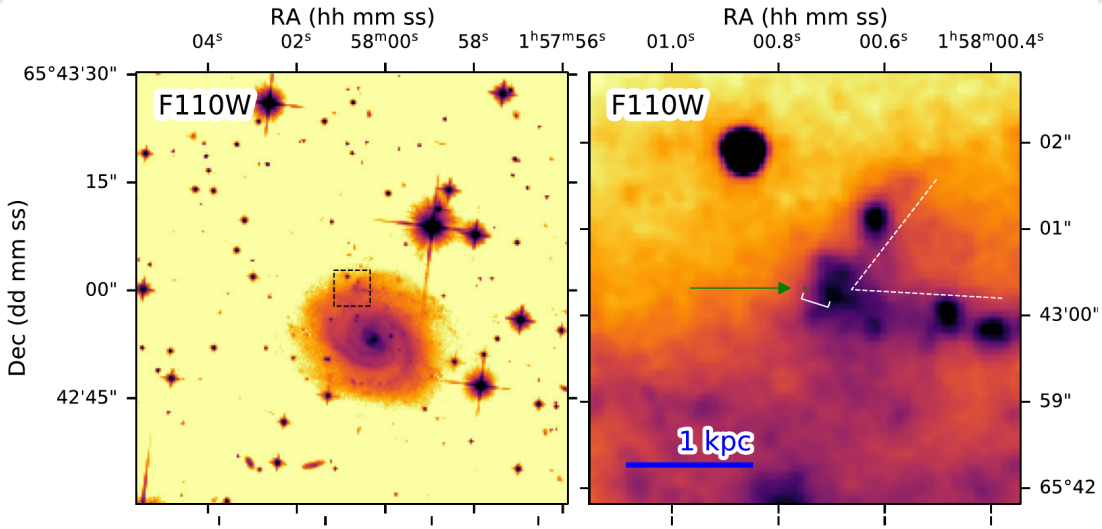



Two systems that could produce periodic emission from FRBs: (a) a neutron star and a binary companion, (b) a processing isolated neutron star (Zhang 2020).

- FRB 20180916B
- Periodic activity $P = 16.33 \pm 0.12$ days
- ruling out cataclysmic engines

- FRB 20121102A
- $P \sim 160$ days
- the longest lived active source
- estimates of total energy budget $10^{47} - 10^{49}$ erg (consistent with magnetar source)

# Localisation of FRBs

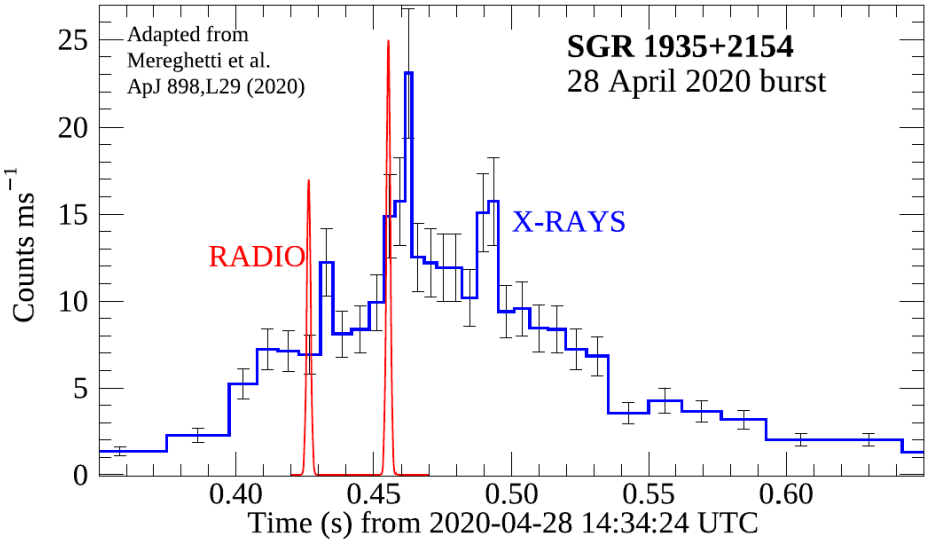



Hubble Space Telescope images of the host galaxy of FRB 20180916B. The FRB position as determined by EVN (Tendulkar et al. 2021).

- two dozen FRBs have been localised to (sub-)arcsecond precision
- hosted in a wide range of galaxy types and environments
- Star-forming region in their host galaxies: FRB 121102, FRB 180916.J0158+65, FRB 20201124A
- Offset of $\sim 200 - 250$ pc from the closest peak of star formation: FRB 20121102A, **FRB 20180916B**
- some non-repeaters found in galactic hosts with very low star-formation rates or in the outskirts (Heintz et al. 2020; Mannings et al. 2021; Bhandari et al. 2022)

# Multiwavelength observations

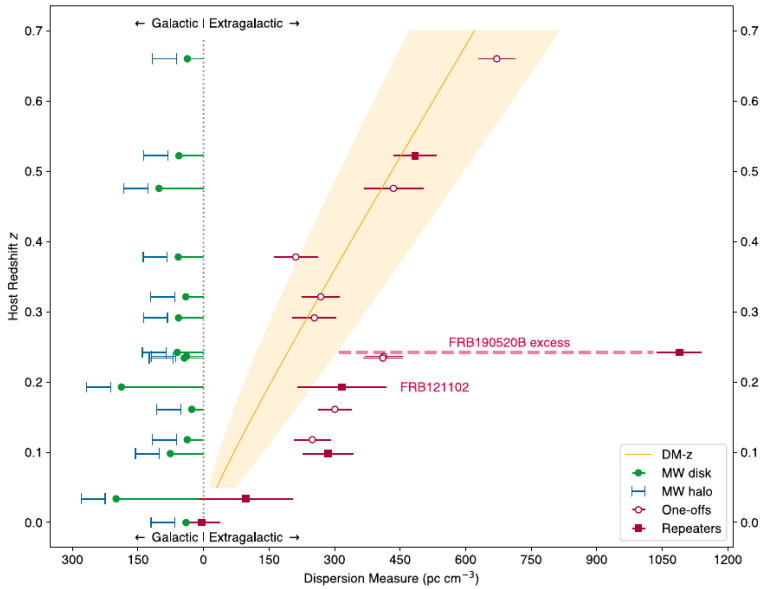
## SGR 1935+2154 - a putative FRB in Milky Way galaxy



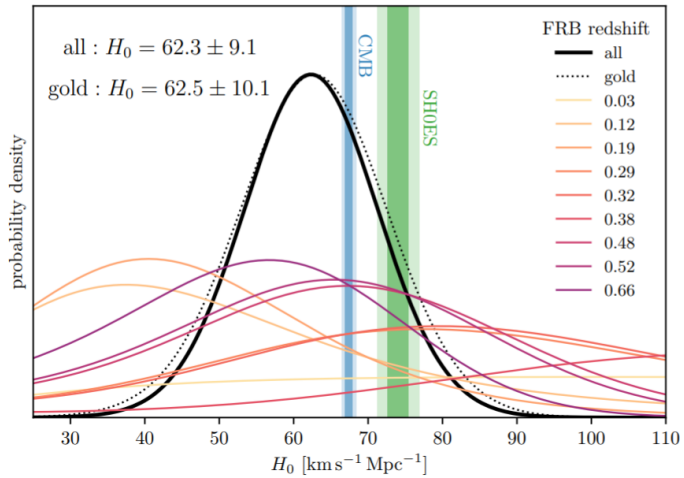

Hard X-ray burst detected from SGR 1935+2154 (INTEGRAL) and two radio peaks. CHIME detection with delay of 6.5 $\pm$ 1.0 ms (Mereghetti et al. 2020).

- An exceptionally bright (1.5 MJy ms at 1.4 GHz) detected with CHIME/FRB
- The nearby FRB 20200120E - no multifrequency obs. (in M81 galaxy at 3.6 Mpc)
- Spectral luminosity only a factor of 30 less compared to the weakest known burst (FRB 20180916B)
- GBT detection of bright 5 GHz radio bursts coincident with X-ray and 600 MHz bursts (**ATel#15697** - Maan at al.)

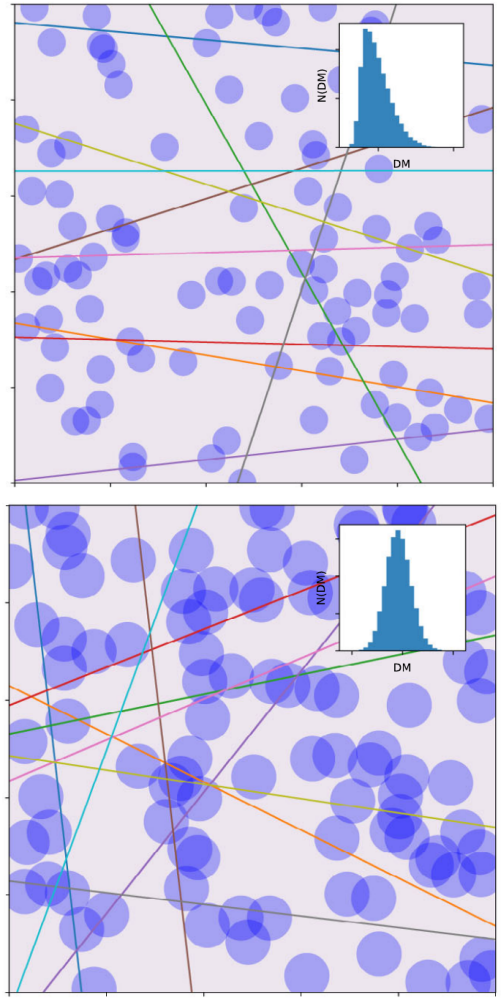
# FRBs as cosmological probes




Host redshift as a function of dispersion measure (Niu et al. 2021)




The Hubble constant $H_0$ from 9 individual FRBs (Hagstotz et al. 2022).




The dependence of the observed DM distribution on galaxy halo extent (Bhandari and Flynn 2021).

Thank you!