Gamma-ray binaries as probes for Fast Radio Bursts

Benito Marcote

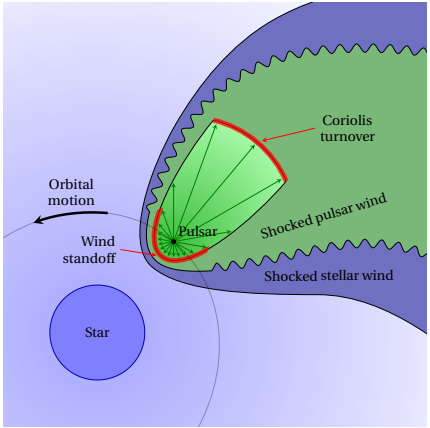
on behalf of the PRECISE and AstroFlash projects

Variable Galactic Gamma-Ray Sources VII — 7 May 2025

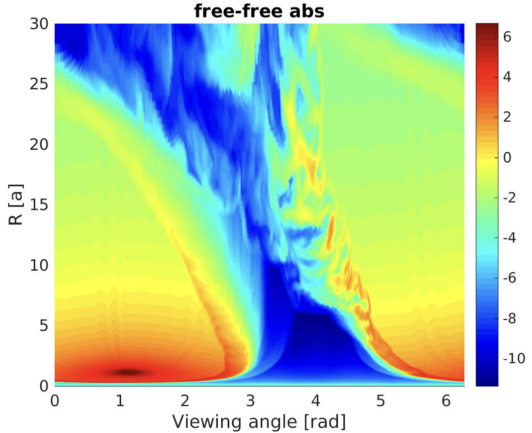
marcote@jive.eu

In this talk...

Suitable conditions for burst production



Zabalza et al. (2013)

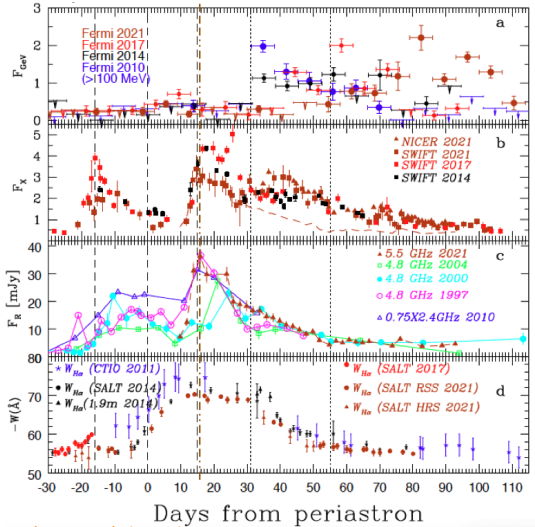


Lyutikov, Barkov & Giannios (2020)

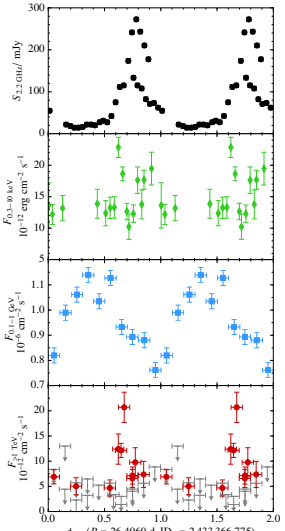
Barkov & Popov (2022)

Intra-hour variability and flaring activity

PSR B1259−63



LS I +61 303



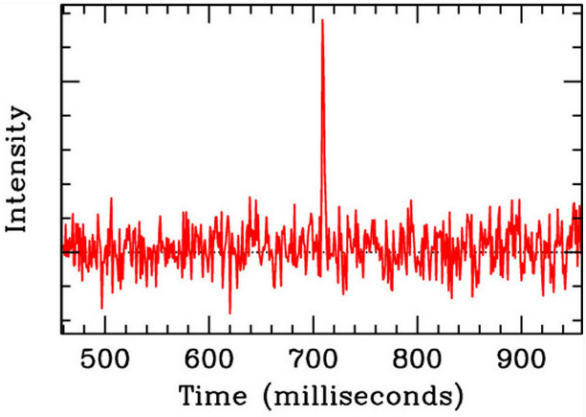
What is a Fast Radio Burst (FRB)?

Fast
Duration of $\sim$ 1 µs–10 ms

Radio
Observed at 0.2–8 GHz

Burst
Bright $\sim$ 0.1–100 Jy
($\sim 10^{40\text{–}44}$ erg s^{-1})

Narrow-band emission ($\frac{\Delta\nu}{\nu} \sim 0.1\text{–}0.5$)
Redshifts of $z \sim 0.01\text{–}1$
$\lesssim$ 4% show more than one burst



FRB 140514

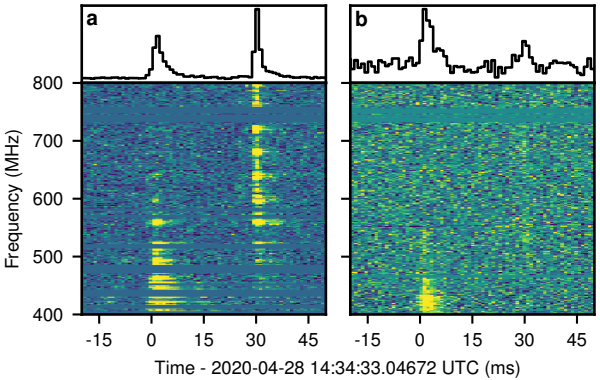
A Galactic Burst from SGR 1935+2154

SGR 1935+2154 is a Galactic magnetar

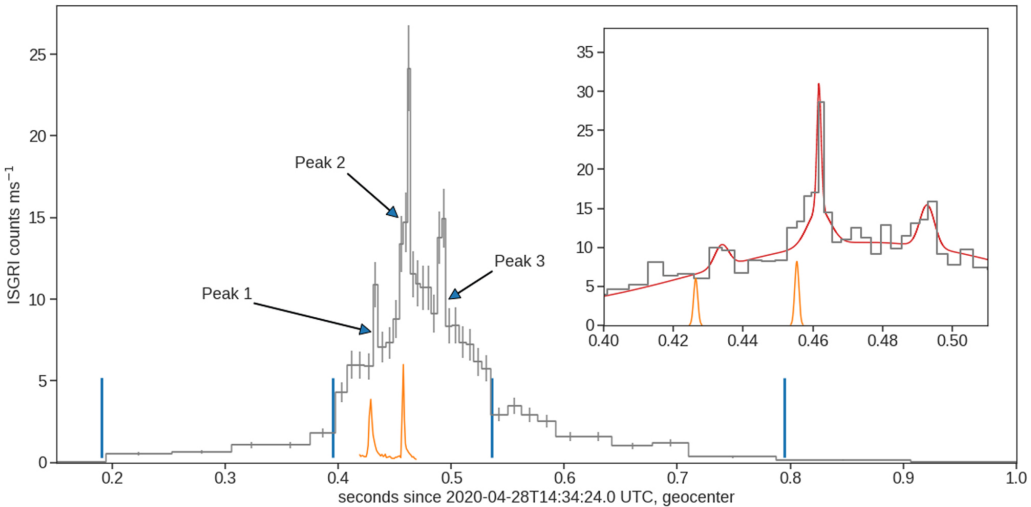
Recently entered into an active state producing high-energy bursts

On 28 April 2020...

- CHIME FRB detection: $\sim$ 1 kJy ms (CHIME/FRB Collaboration 2020)
- STARE2 FRB detection: $\sim$ 1.5 MJy ms (Bochenek et al. 2020)
- Simultaneous X-ray burst (Mereghetti et al. 2020)



A Galactic Burst from SGR 1935+2154

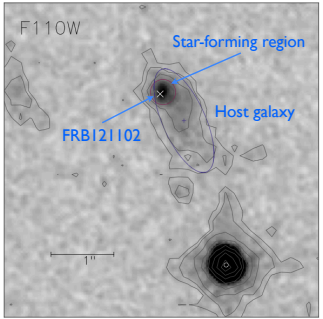


A magnetospheric emission (Mereghetti et al. 2020)


JIVE
EUROPEAN VLBI NETWORK
Onsala
Metsähovi
JIVE
WSRT
Torun
Jodrell Bank
Irbene
e-MERLIN
Wettzell
Effelsberg
Medicina
Yonsei
PyeongChang
Tamna
Urumqi
Ulsan
Arecibo
Yebes
Sardinia
Noto
Tianma
Kunming
PRECISE
Pinpointing Repeating ChIme Sources with EVN dishes
AstroFlash
astroflash-frb.github.io

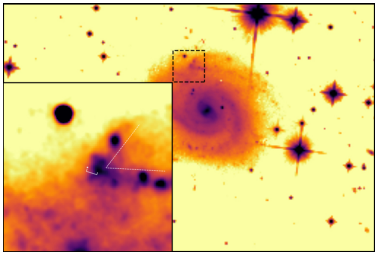
Localizing FRBs to milliarcsecond precision

FRB 20121102A



Chatterjee et al. (2017, Nat, 541, 58)
Marcote et al. (2017, ApJL, 834, 8)
Tendulkar et al. (2017, ApJL, 834, 7)
Bassa et al. (2017, ApJL, 843, 8)

FRB 20180916B



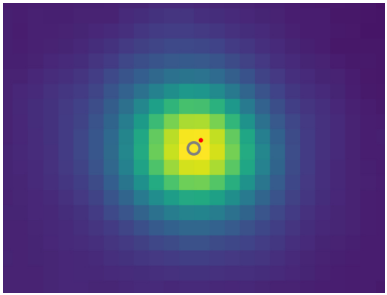
Marcote et al. (2020, Nature, 577, 190)
Tendulkar et al. (2021, ApJL, 908, L12)

Star-forming dwarf galaxy

Star-forming spiral galaxy

Globular cluster!

FRB 20200120E

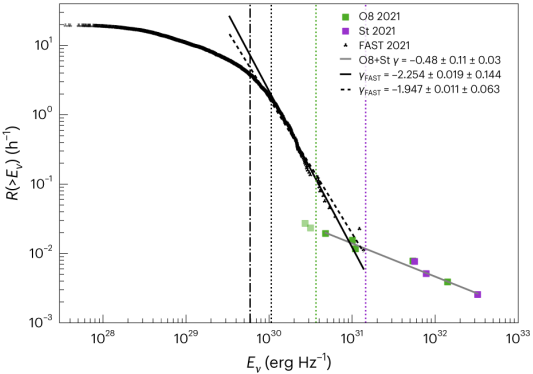


Kirsten, Marcote et al. (2022, Nat, 602, 585)
Nimmo et al. (2022, Nat Astr, 6, 393)

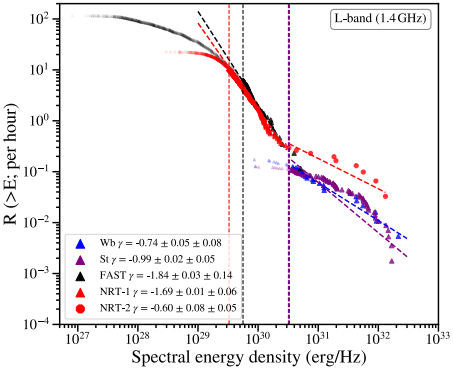
Westerbork

6,775 from 7,555 available hours (90%) in 2024

Energy distribution of the bursts



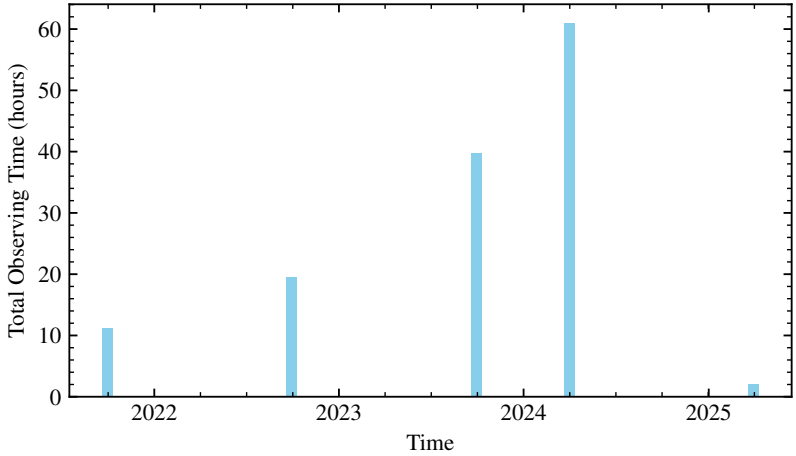
(Kirsten et al. 2024, Nature Astronomy, 8, 337)



(Ould-Boukattine et al. 2024, in press)

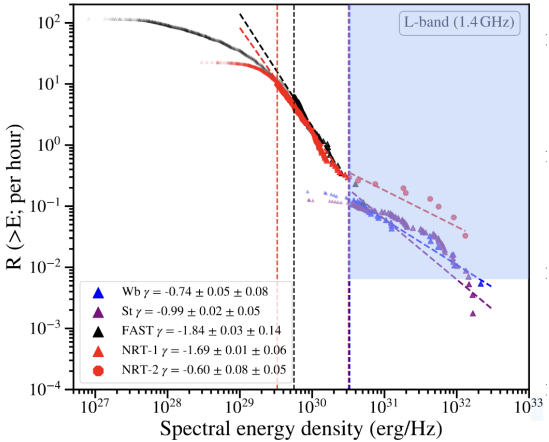
Energy distribution from FRB 20201124A bursts, but also reported in other FRBs.

Observing LS I +61 303 with the Westerbork Telescope



Totaling 133 hours at 1.6 GHz

Observing LS I +61 303 with the Westerbork Telescope



Excluded region with current observations for LS I 61 303 *(work in progress)*

(as compared to the energy distribution for FRB 20201124A)

Take home messages

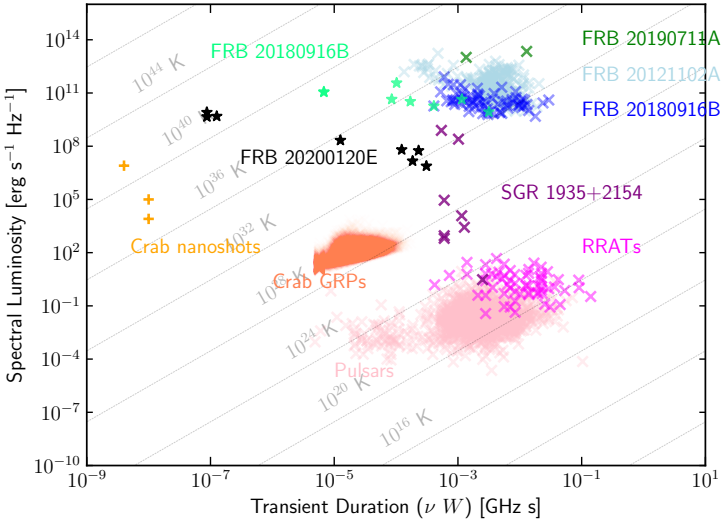
The **radio domain** allows a much higher time and angular resolution to explore high-energy systems.

It's still unclear the true **nature of Fast Radio Bursts**: likely different scenarios and some may be binary-related.

Some **gamma-ray binaries** are perfect target to search for FRBs, like LS I +61 303.

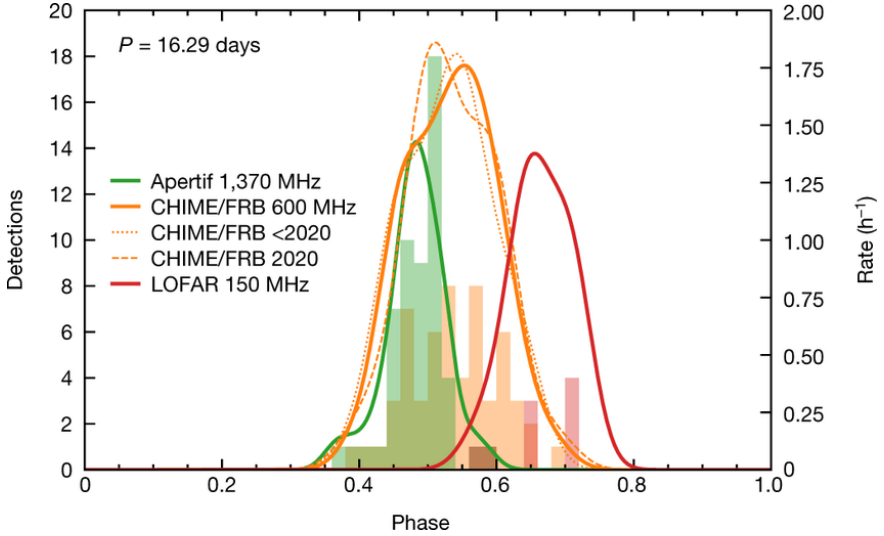
After 133 observing hours on the source, we haven't detect any burst emission.

FRBs: ultra-luminous sources on the millisecond timescales



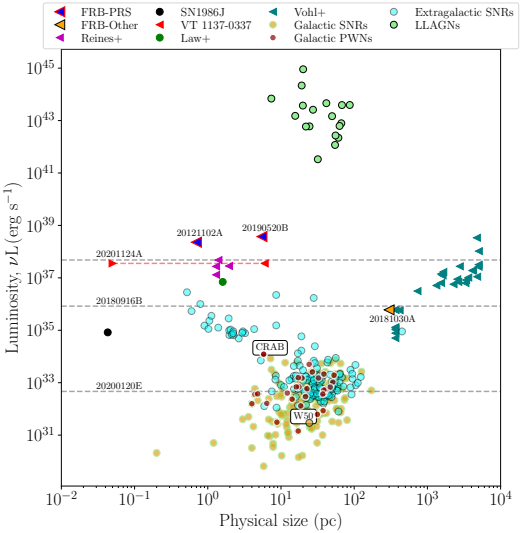
(Nimmo et al. 2022, Nature Astronomy, 6, 393)

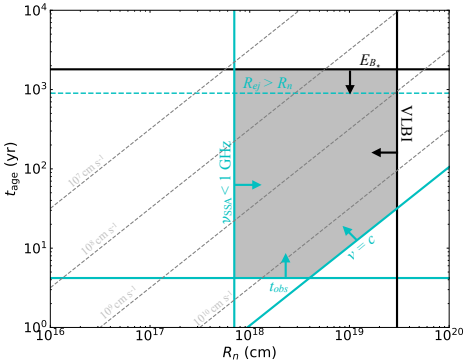
FRB 20180916B: chromatic emission



(Pastor-Marazuela et al. 2021)

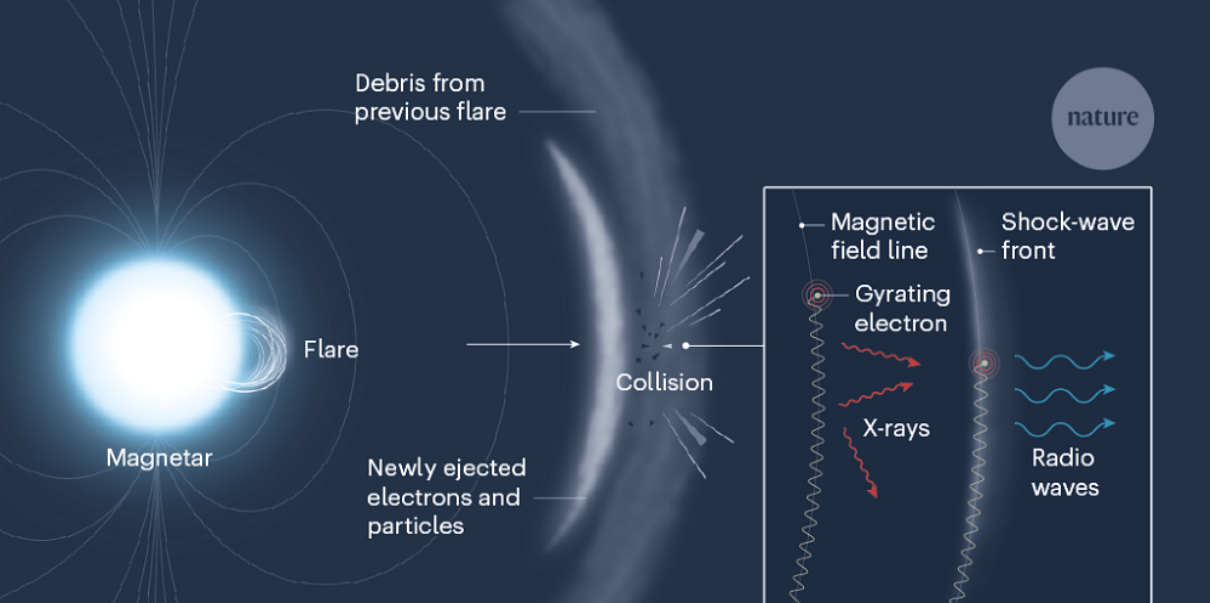
FRBs with persistent radio emission





For a magnetar wind nebula model

(Bhandari, Marcote, et al. 2023, ApJL, 958, L19)



Mereghetti et al. (2020)

The Second Localized Repeating FRB 20180916B

EVN baseband data

Highly linearly polarized ($\gtrsim$ 80%)
No circularly polarized ($\lesssim$ 15%)

Constant polarization Position Angle
but with a few deg. variations

Magnetospheric origin?

Marcote et al. (2020, Nature, 577, 190)