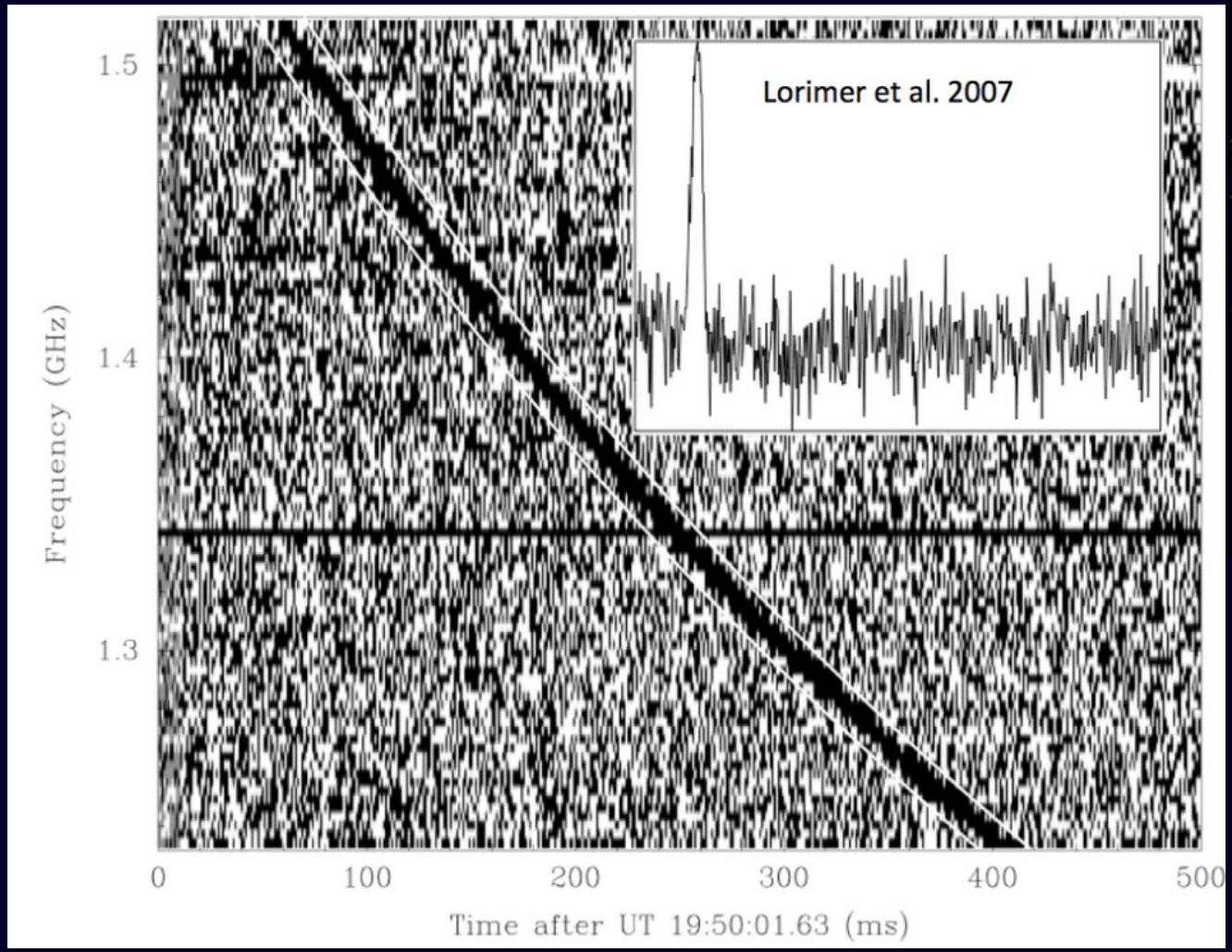
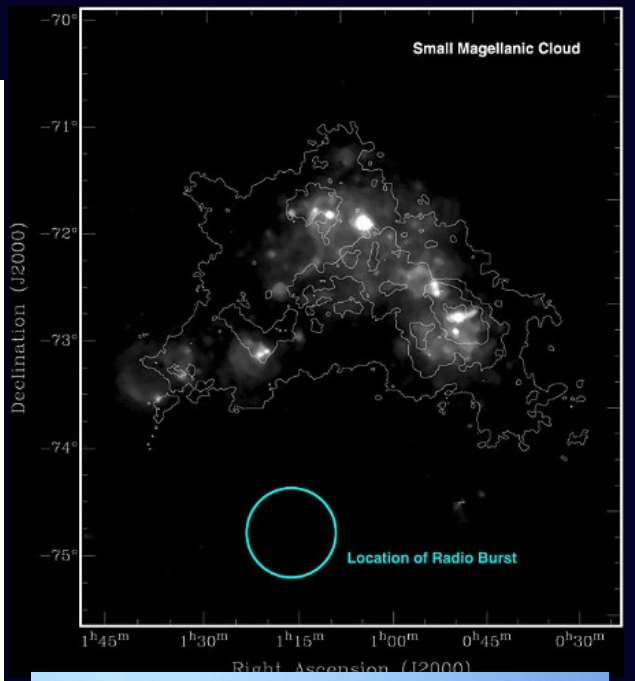
Digging in noise and interferences – FRB observations in Piwnice

Indiana Jones - RotLA

The Lorimer Burst – 24.07.2001





64-m Parkes Radio Telescope

FRB 20010724 – 3° from SMC, burst with a large dispersion measure, max ~30Jy, fluence ~200 Jy·ms (1 Jy= 10^{-26} W·Hz^{-1}·m^{-2}).

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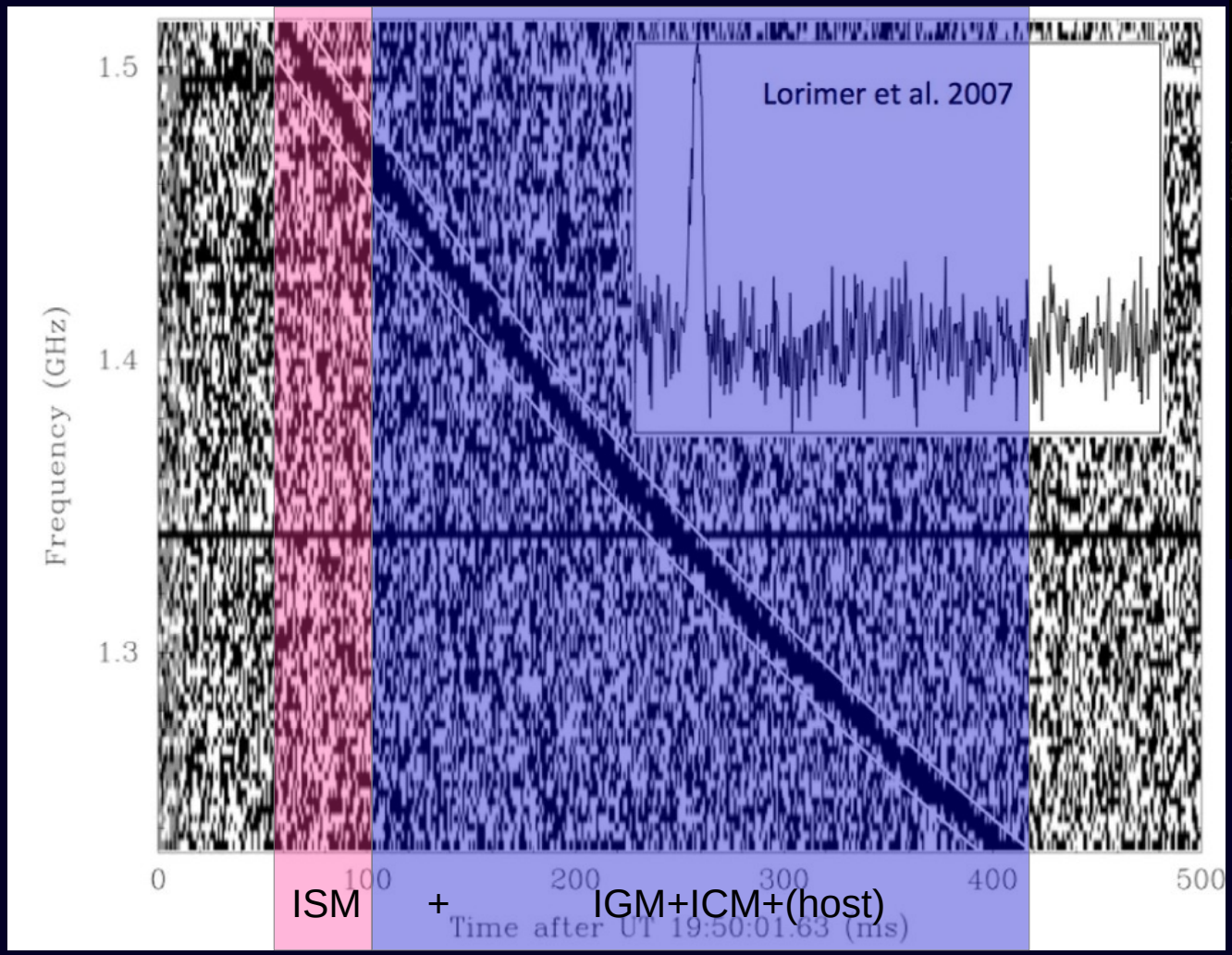

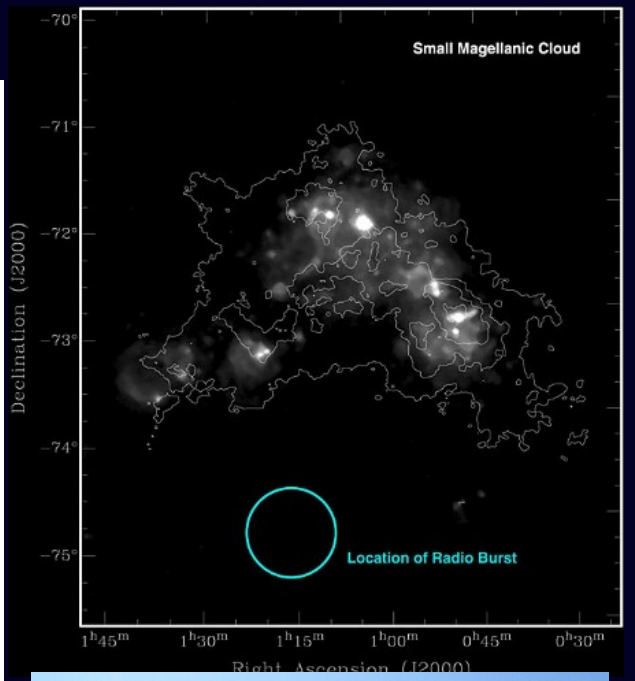

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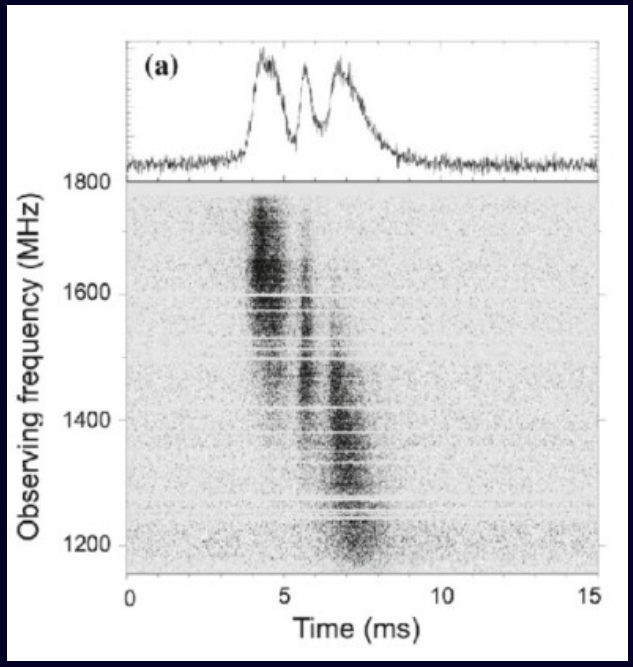
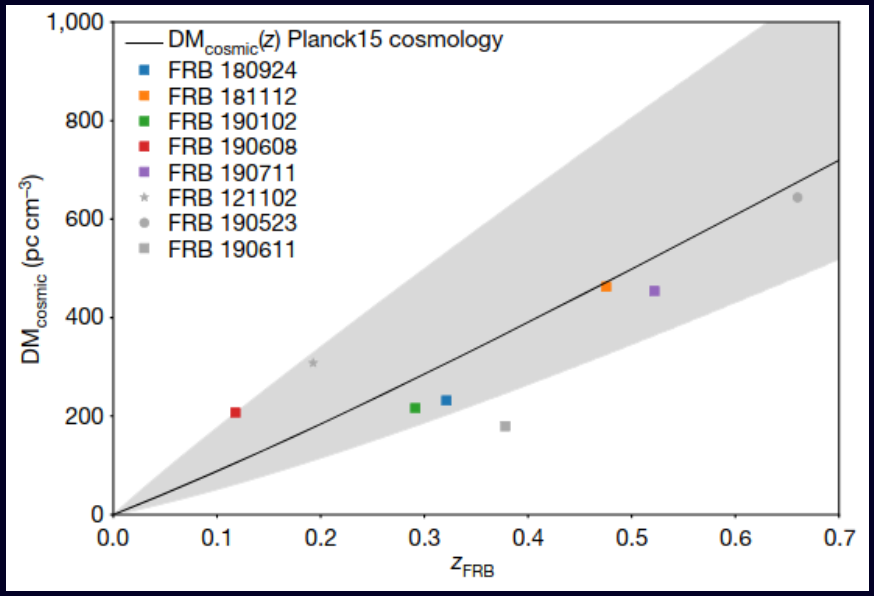
Fast Radio Bursts (FRB):

- extremely bright (~10^{42} erg/s)
- duration time msec – subsec
- extragalactic origin (dispersion measure)
- two classes, *one-offs* and *repeaters*
- statistical differences between both groups
- unknown type(s) of central engine and physical process(es)
- ~600 FRB/day (CHIME+21, >5 Jy·ms)
- probable cosmological evolution (James+21)
- the Macquart relation between DM – z (Macquart+20), the missing baryons problem



FRB from R3 (CHIME+21)



CHIME FRB statistic (Pleunis+21)

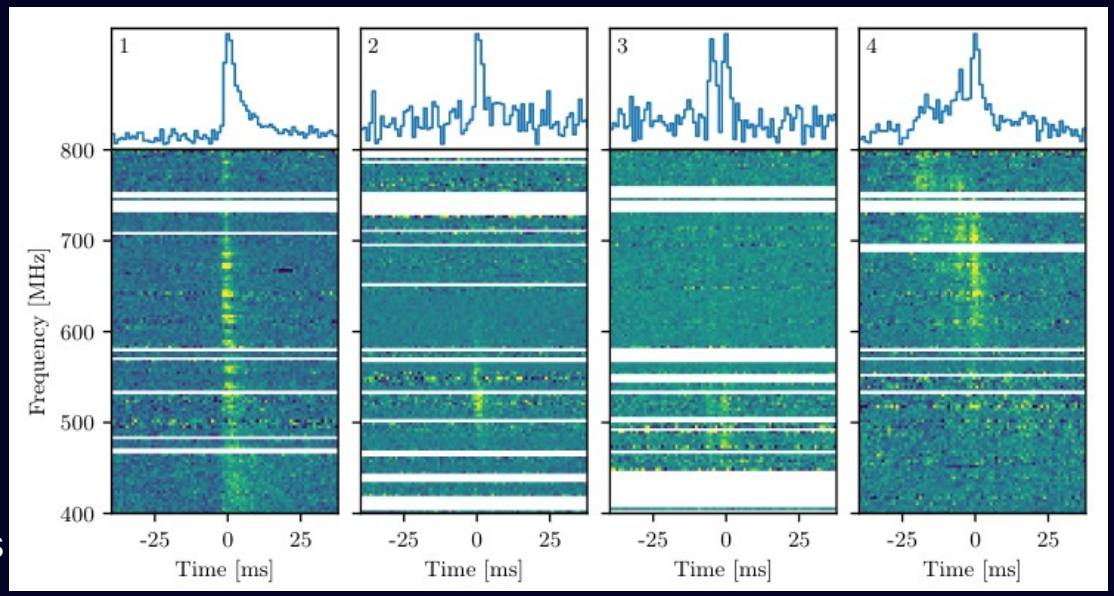
The Canadian Hydrogen Intensity Mapping Experiment (CHIME) – four main types of bursts:

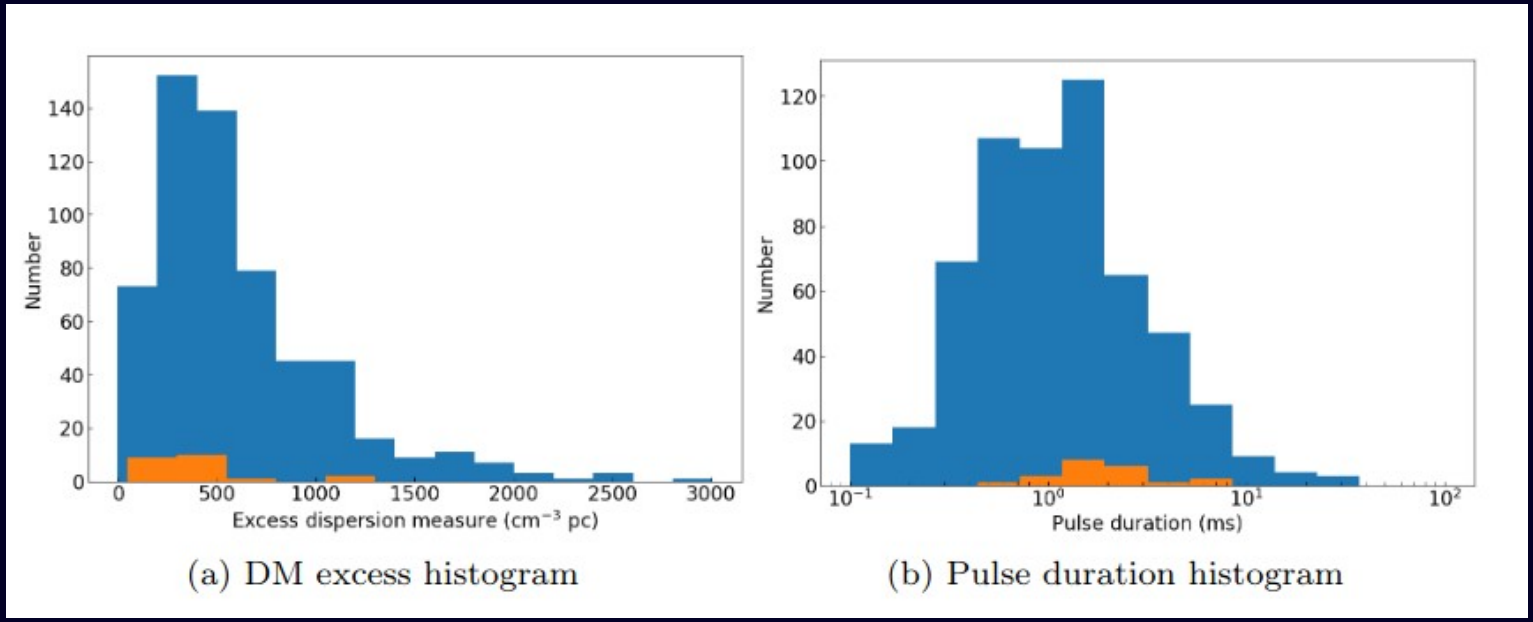
I) wide-band bursts, the scattering tail is a frequent feature

II) narrow-band burst with with gaussian spectra

III) complex bursts composed of multiple peaks with similar frequency extent

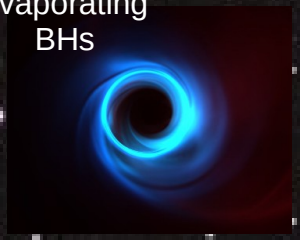
IV) complex bursts composed of multiple sub-bursts that drift downward in frequency as time progresses

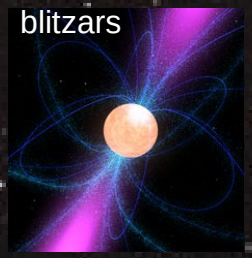


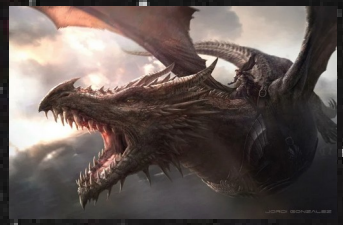


FRB statistics (Hassels 21)

FRB zoo

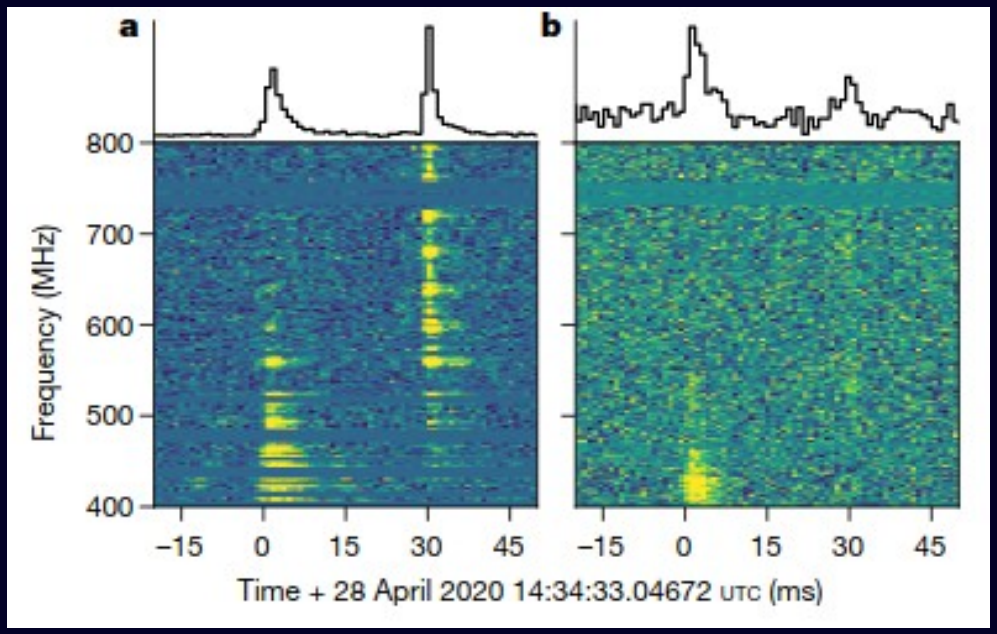




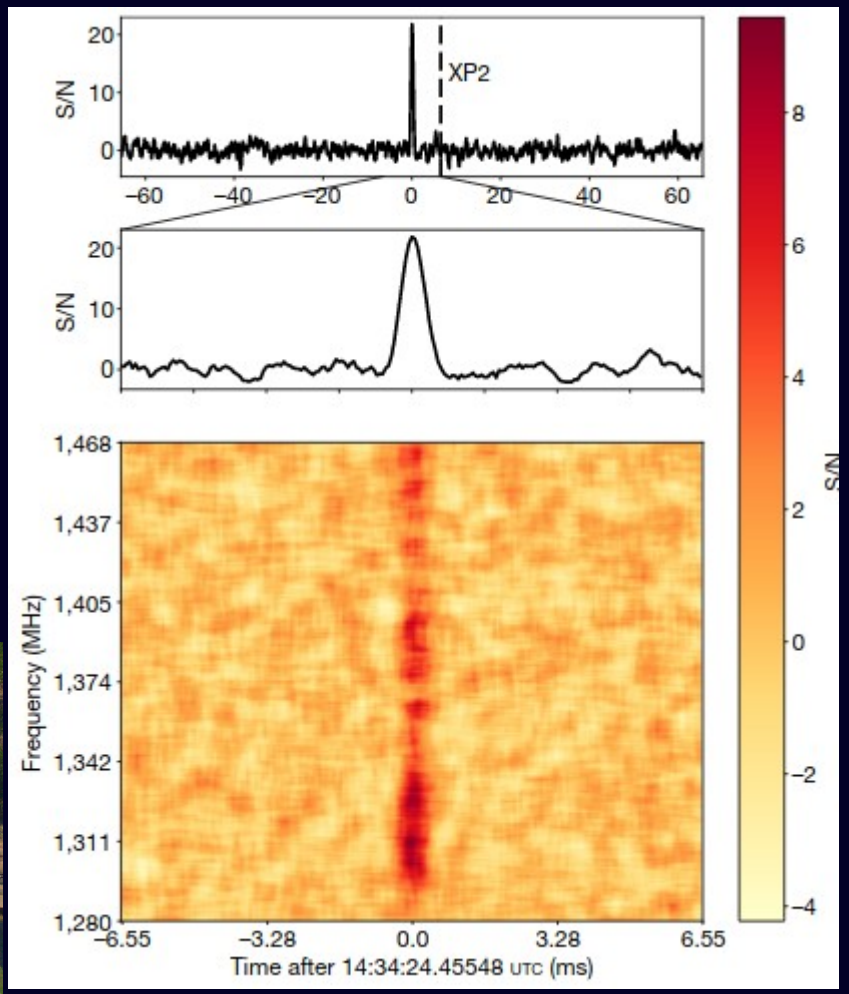


frbtheorycat.org

The Galactic FRB (SGR 1935+2154)



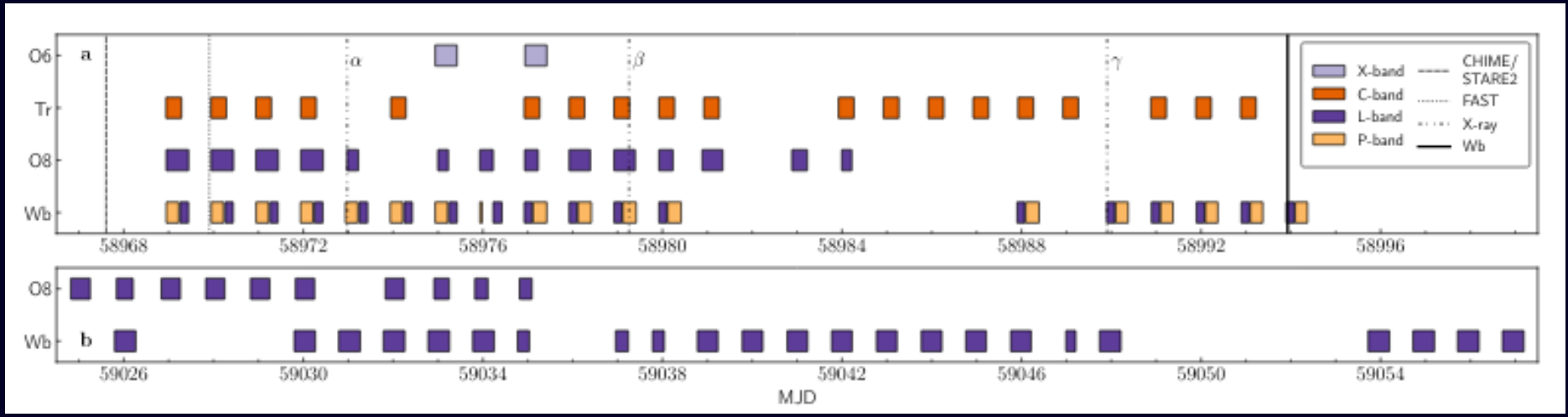
CHIME+20, ~700 kJy·ms



STARE2, Bochenek+20, ~1.5 MJy·ms

The monitoring of SGR 1935+2154

– from 30.04.20 coordinated observations of SGR1935 using three dishes, 25-m Onsala (Sweden), 25-m Westerbork (the Netherlands) and 32-m Toruń (Poland), contemporaneous observations to cover different radio bands (Kirsten+21, Nature Astronomy)



Onsala 25-m

Westerbork 25-m

Toruń 32-m

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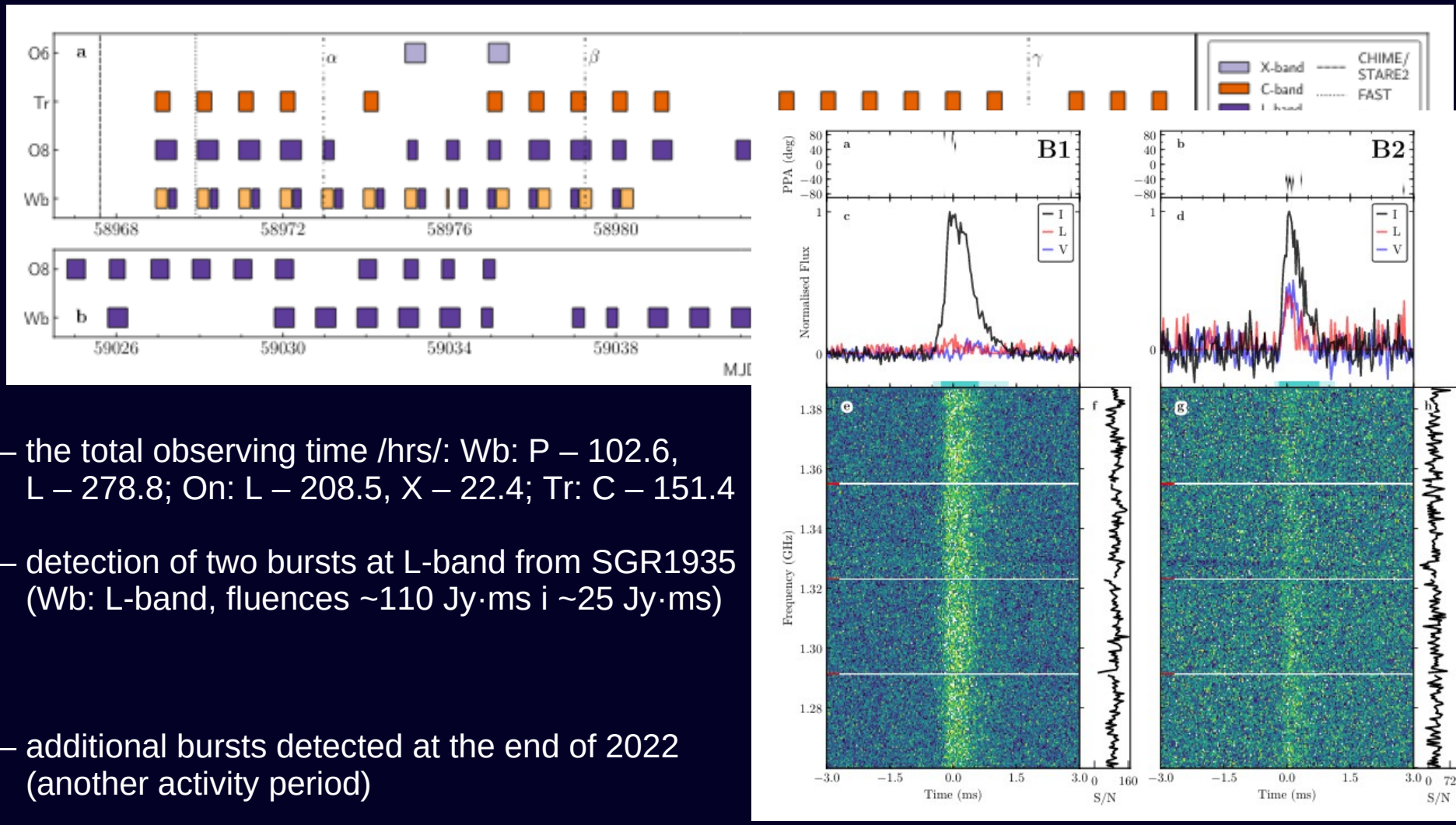


– the total observing time /hrs/: Wb: P – 102.6, L – 278.8; On: L – 208.5, X – 22.4; Tr: C – 151.4

– detection of two bursts at L-band from SGR1935 (Wb: L-band, fluences ~110 Jy·ms i ~25 Jy·ms)

– additional bursts detected at the end of 2022 (another activity period)

PRECISE

(Pinpointing REpeating ChIme Sources with EVN dishes)

– localization of FRBs @ ~1" is crucial to understand cosmological evolution, types and the host properties

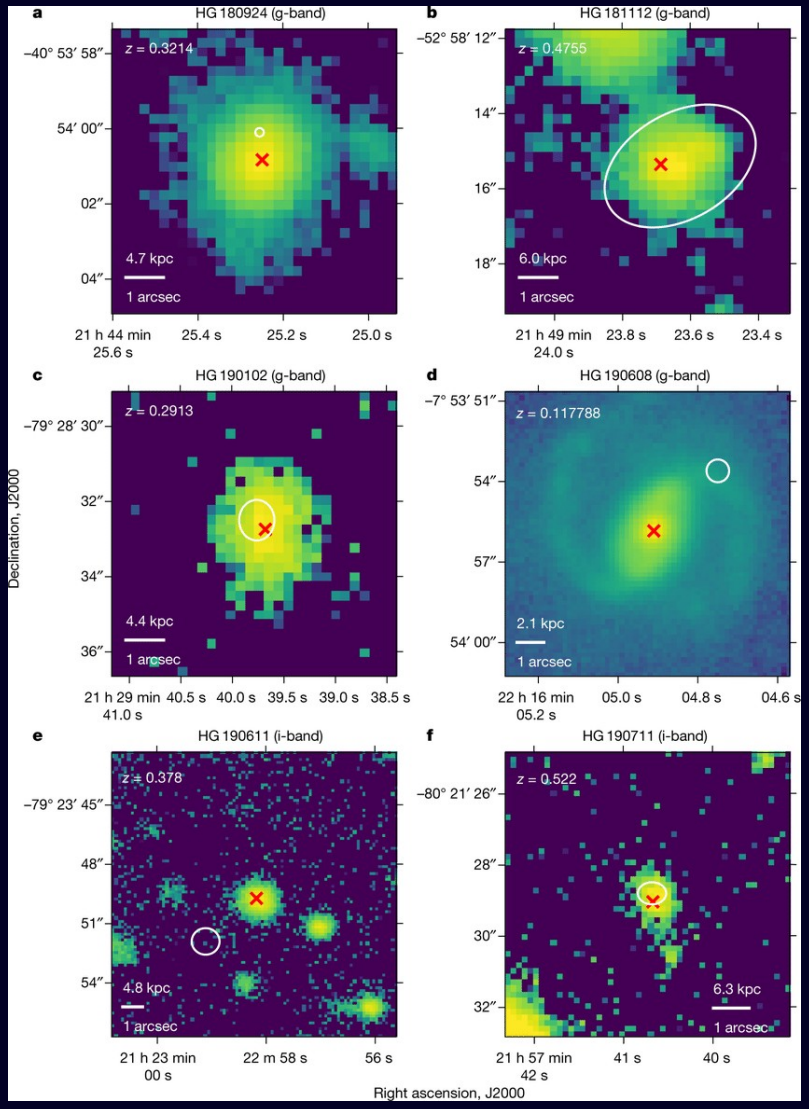
– localization of FRBs @ ~mas is crucial to describe local properties, the origins of engine etc

– most FRBs in galaxy outskirts, no AGN or cosmic strings, incompatible with SLSNe, likely mix of prompt and delayed channels (Bhandari+20)

– FRBs host have diverse properties that do not track diagrams, green valley excess, host do not track stellar mass, FRBs incompatible with LGRBs (Heintz+20)

– FRBs track stellar mas within hosts, different spatial distribution from any known transients, (Mannings+21)

– one-offs and repeaters host have similar properties, moderately star forming, incompatible with Galactic NS & GC, compatible with LMXBs (Bhandari+21)



FRB hosts and FRBS positions (Bhandari+21)

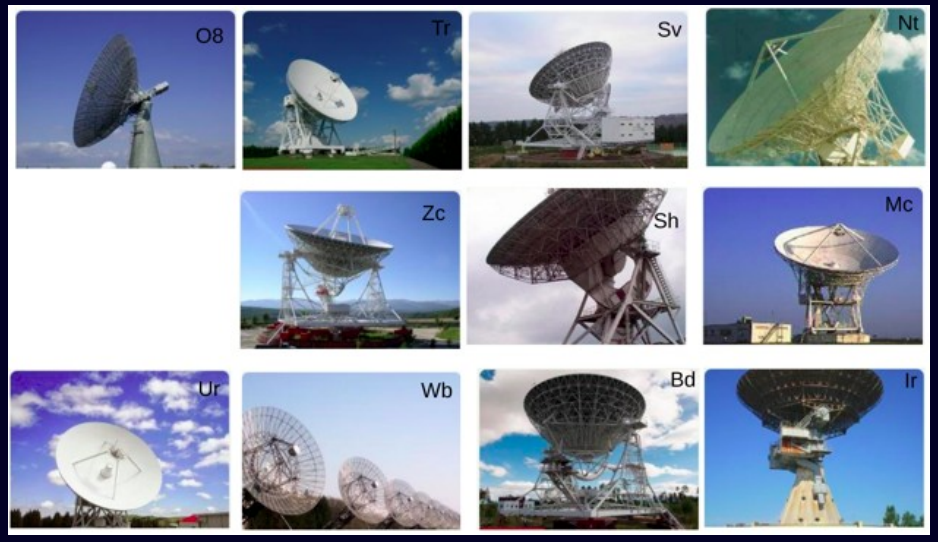
PRECISE
(Pinpointing REpeating ChIme Sources with EVN dishes)

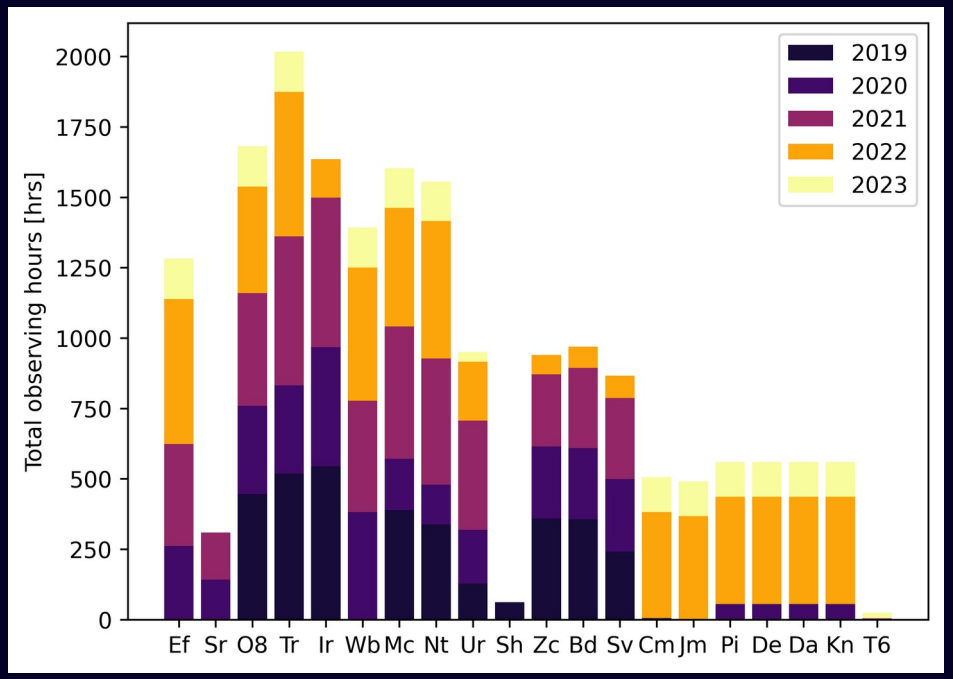
– sub-EVN network dedicated to precise localization of CHIME repeaters

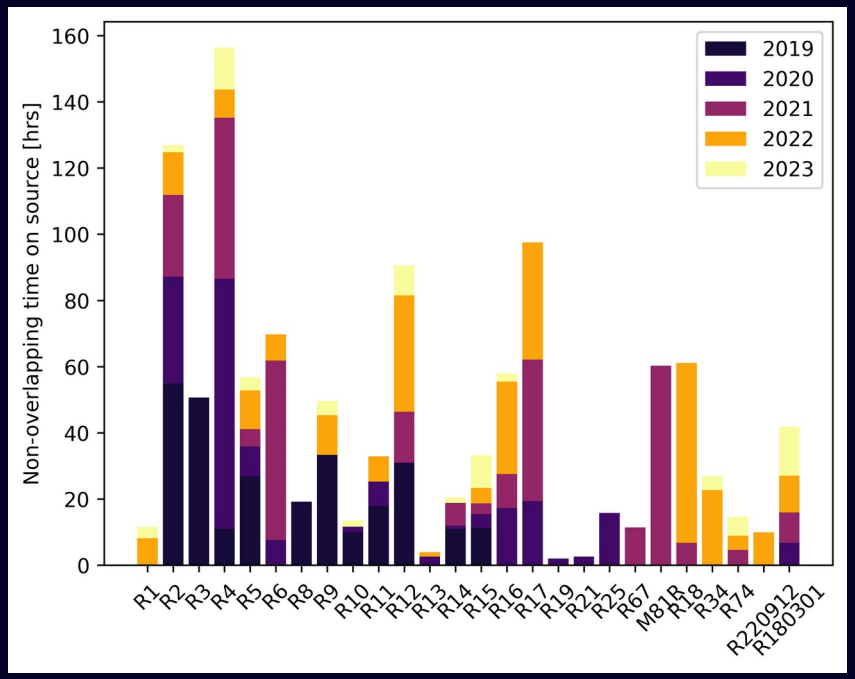
– dynamic scheduling based on CHIME observations (detection of repeaters bursts)

– 6 detected CHIME repeaters, two sources already published (Nature & ApJL), more to follow soon

– Tr is an important member of the project







FRB in M81 (M81R)

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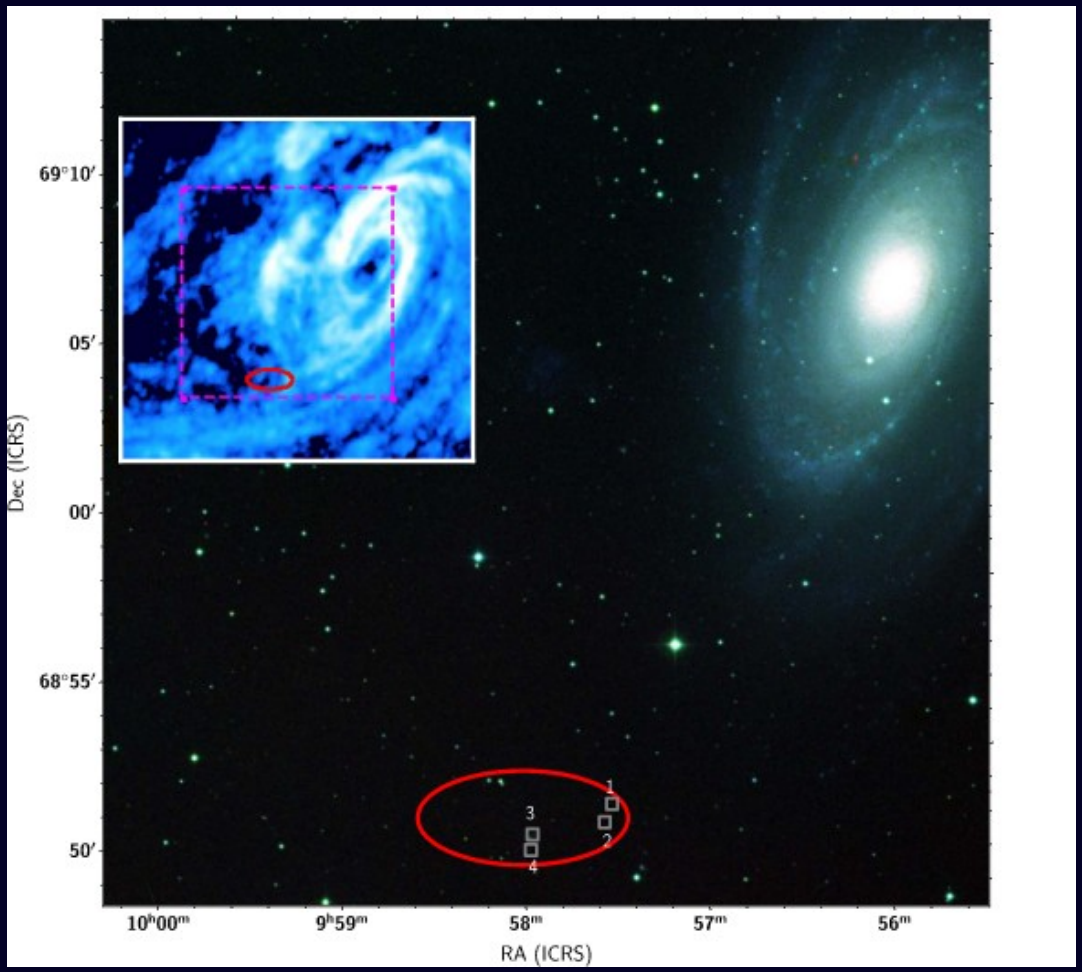
– the Boode Galaxy (1974), a grand design spiral galaxy 12 mln ly from MW, circumpolar object for Poland

– object visible through binoculars

– in 2020 CHIME reported the discovery of FRB repeater from ~M81 direction, DM suggests a nearby objects (FRB 20200120E, Bhardwaj+21)

– a big chance for the first optical identification of the FRB engine!!

FRB in M81 (M81R)



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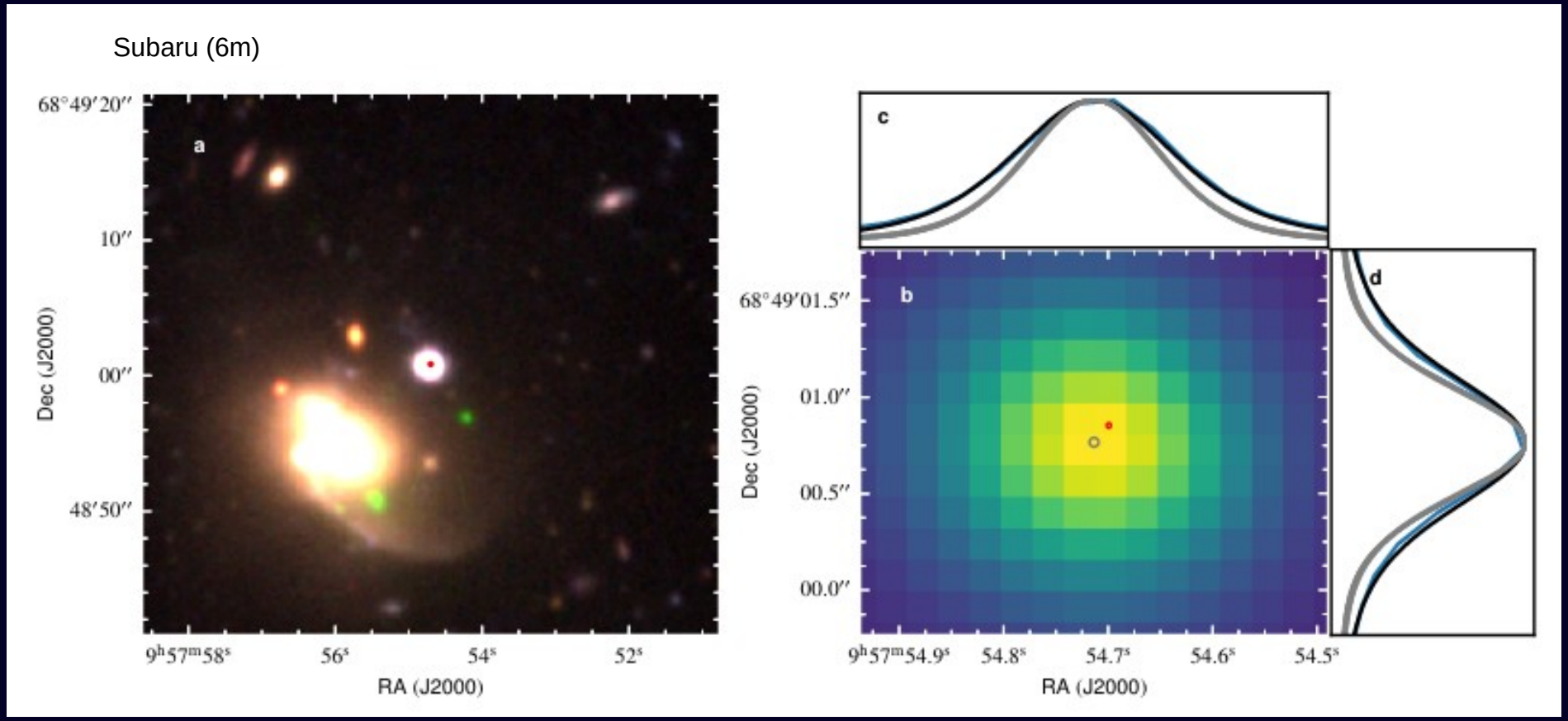
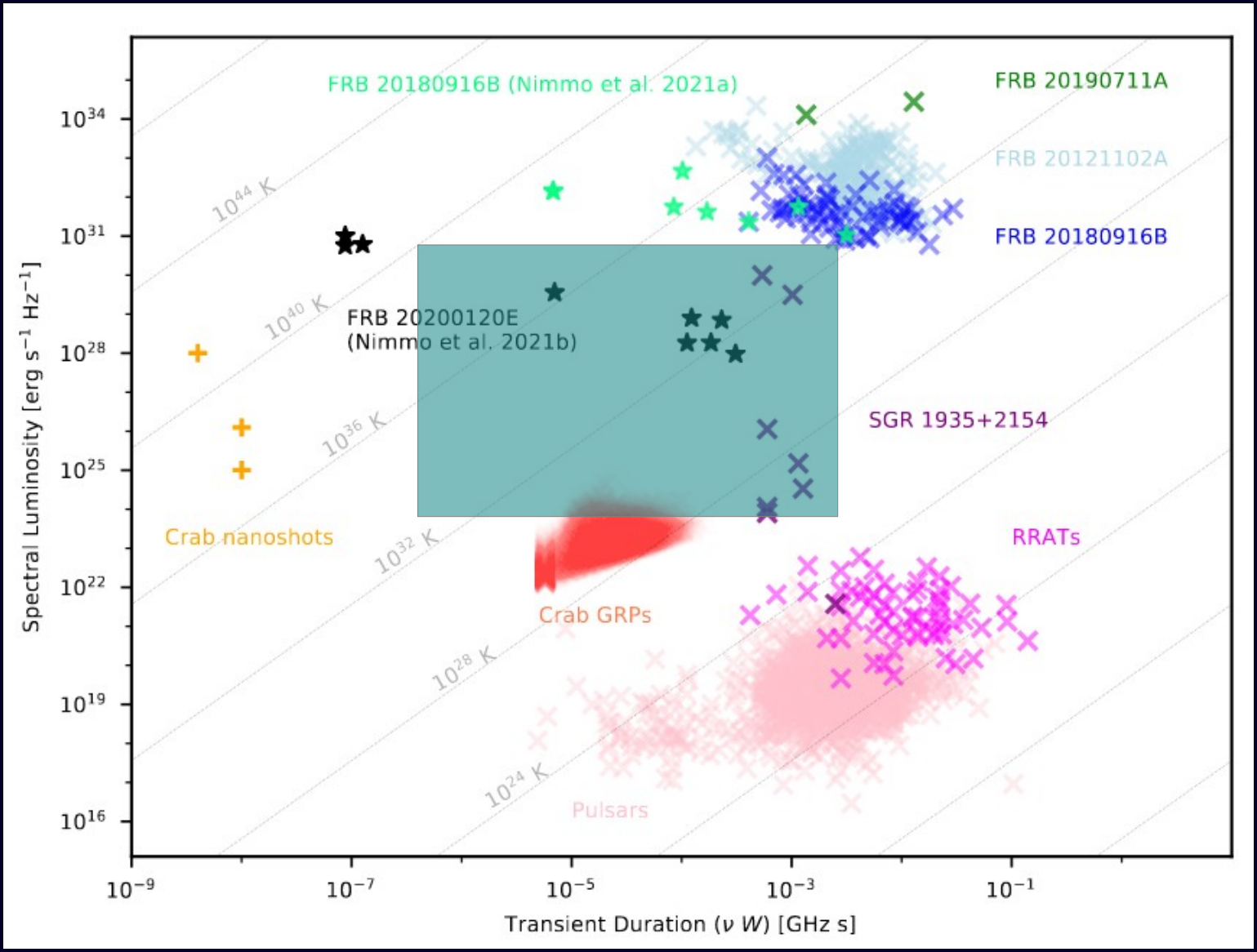


- observations 20.02/7.03/28.04 (2021), sub-EVN+China, 5 bursts detected
- M81R position agrees with an old globular cluster from the M81 system [PR95] 30244 (!!!)
- FRB engine not located at the centre of GC (~2pc from the core)
- bursts energy comparable or smaller than FRB from SGR 1935+2154 (Kirsten+22, Nature)

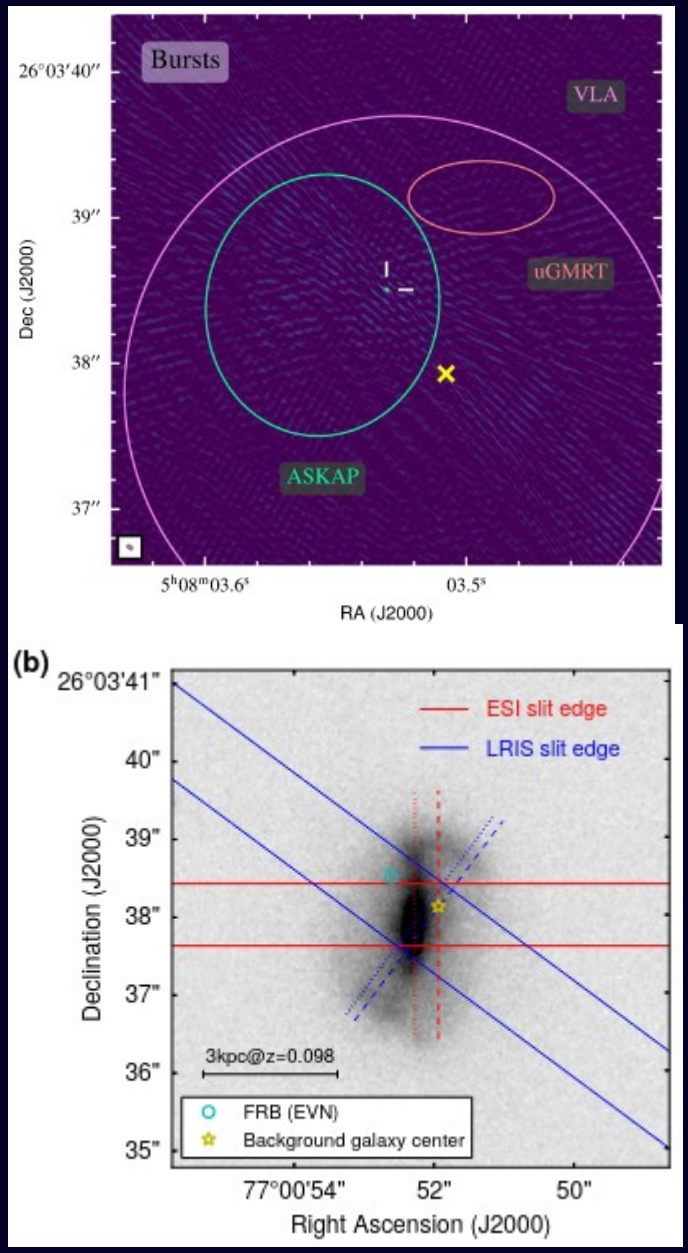
FRB in M81 (M81R)



– M81R fills the gap between Galactic pulsars and extragalactic FRBs (Nimmo+22)

R67 – FRB 20201124A

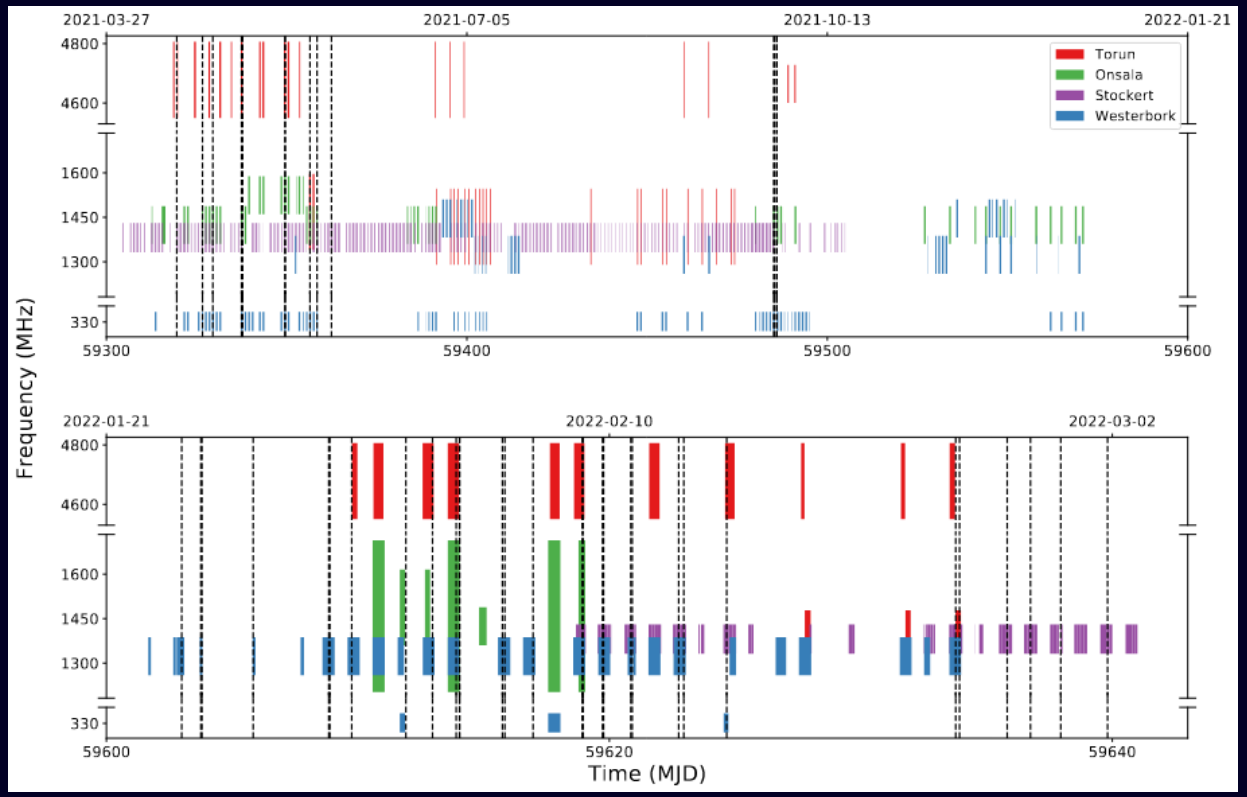
- repeater discovered by CHIME(21), very active source (AstTel)
- PRECISE localization of FRB position (Nimmo+22, ApJL)
- the host has similar properties to MW z=0.098, source located in a large star forming region (Xu+22)
- FAST recorded ~5000 bursts from R67, no periodicity found
- the maximum activity ~45 bursts/hr (~10.IV.21, Xu+22)
- two activity periods (III-V.21 i I-III.22)
- FRB engine is located in a complicated, dynamically evolving, magnetized immediate environment of the size ~1 au, (Xu+22)
- 20201124A originates from a magnetar/Be star binary with a decretion disk (fast changes of RM values, magnetic field reversal, Wang+23)



The host galaxy of R67 (Xu+22)

R67 – FRB 20201124A

- coordinated observations on three radio bands (P,L & C) using four telescopes (Tr, On, Wb and 25-m Stockert in Germany)
- total amount of 3557.5 hrs observing time (2663.9 hrs not simultaneous)
- the unique database of observations probing high-end of bursts energy distribution
- in total 46 bursts detected by all dishes
- new campaign is ongoing



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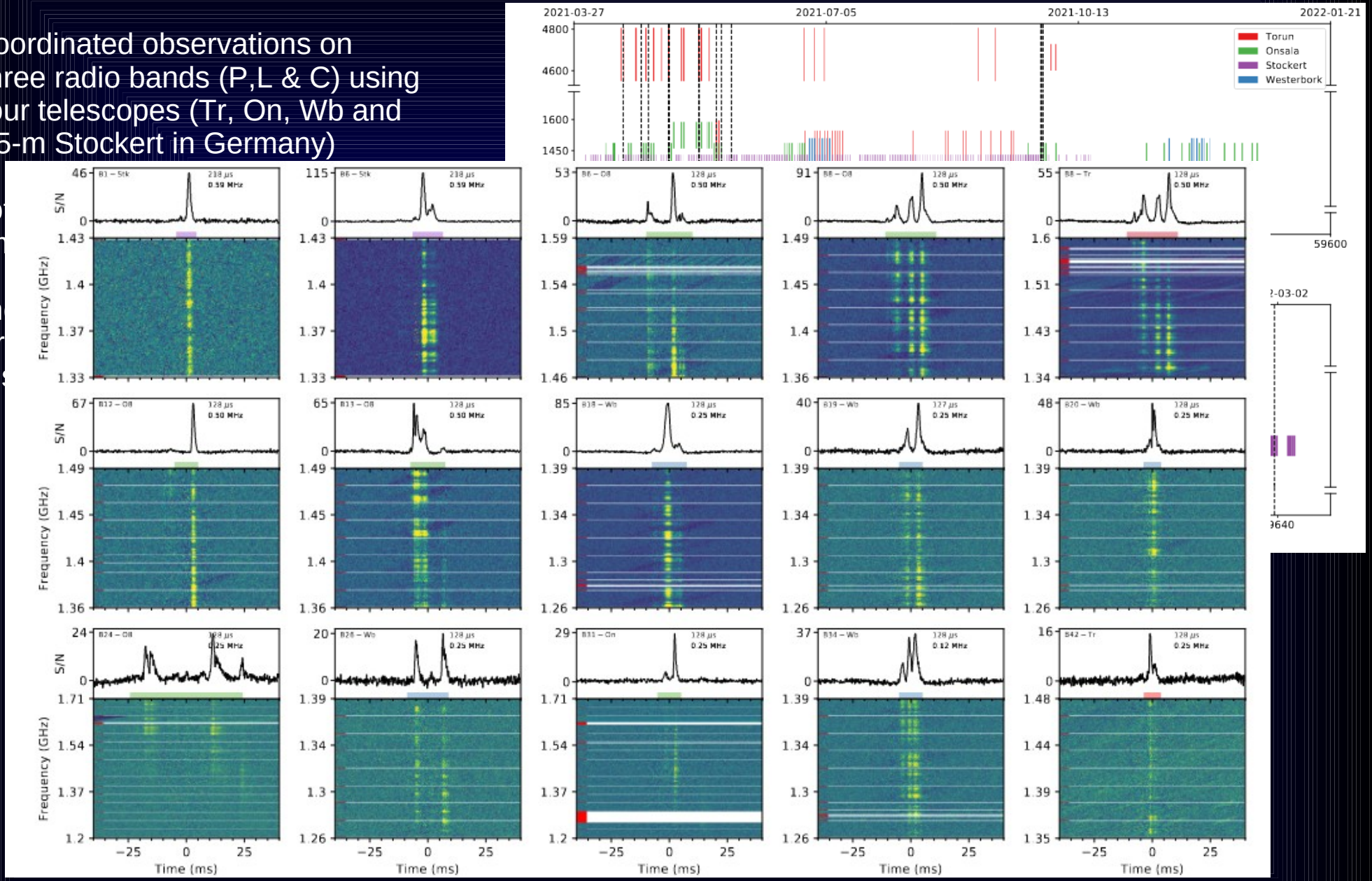
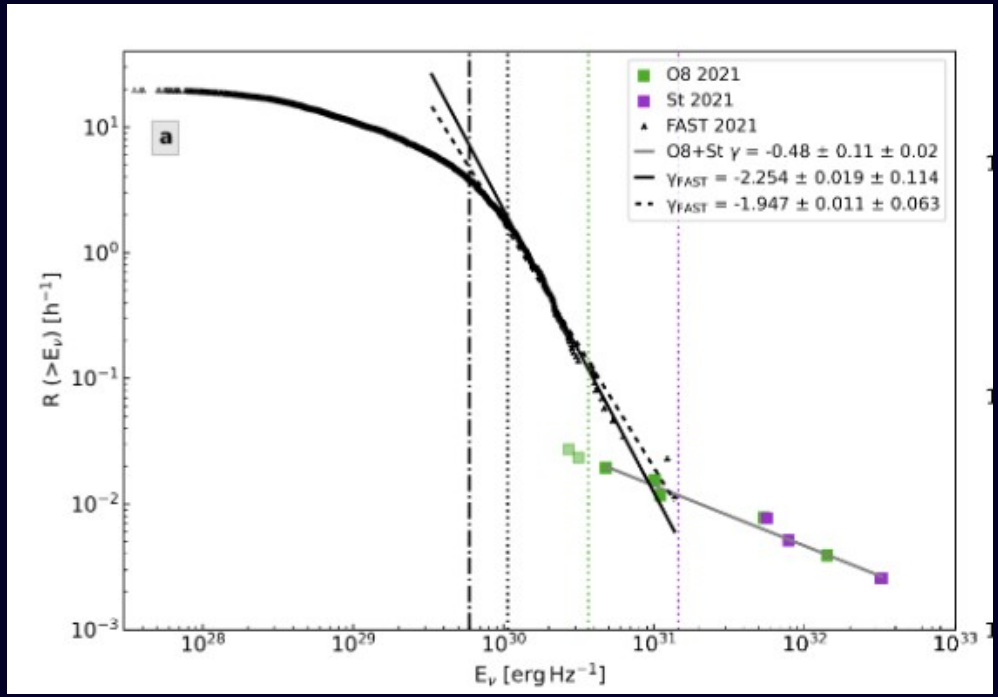
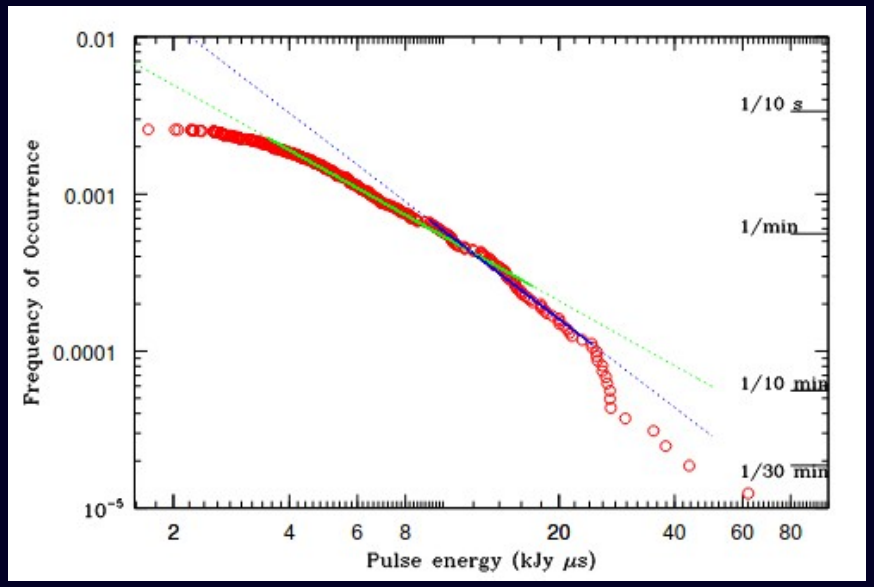


R67 – FRB 20201124A

- ultra-high-energy ($E_\nu \gtrsim 10^{31}$ erg Hz^{-1}) bursts occur much more frequently than would have been expected based on lower energy bursts statistic
- the highest-energy bursts may originate from a separate emission mechanism or emission region at the progenitor source
- R67 generates bursts spanning at least six orders-of-magnitude in spectral energy density, a similar span to SGR 1935+2154
- spectral energy distribution resembles distribution of the Crab pulsar GPs



R67 spectral energy distribution (Kirsten+23, NatAst)



The GPs Crab statistic (1.3 GHz, Bhat+18)

The future is bright (and the lost ark is waiting..)

Radio activity of the magnetar XTE J1810−197 in the 21 cm radio band.

Weronika Puchalska

Marcin Gawroński, Marta Cholewa, Roman Feiler

Faculty of Physics, Astronomy and Informatics
Nicolaus Copernicus University in Toruń

Radio activity of magnetar XTE J1810-197 during a glitch in early June 2023

Marta Cholewa

Marcin Gawroński, Weronika Puchalska, Roman Feiler

Faculty of Physics, Astronomy and Informatics
Nicolaus Copernicus University in Toruń

- Nat, NatAst(2+1), 2ApJL, 1MNRAS..
- PRECISE observations
- monitoring of known repeaters – tracking high-energy distribution of FRBs
- searching for “low-energy” FRBs in the Local Universe
- tracking the activity of Galactic magnetars
- **new FRB machine dedicated to searching FRB on µs time scales in real-time, founding via ERC Advanced Grants, PI: Jason Hessels (ASTRON)**

… but we are all afraid of the truth ...