

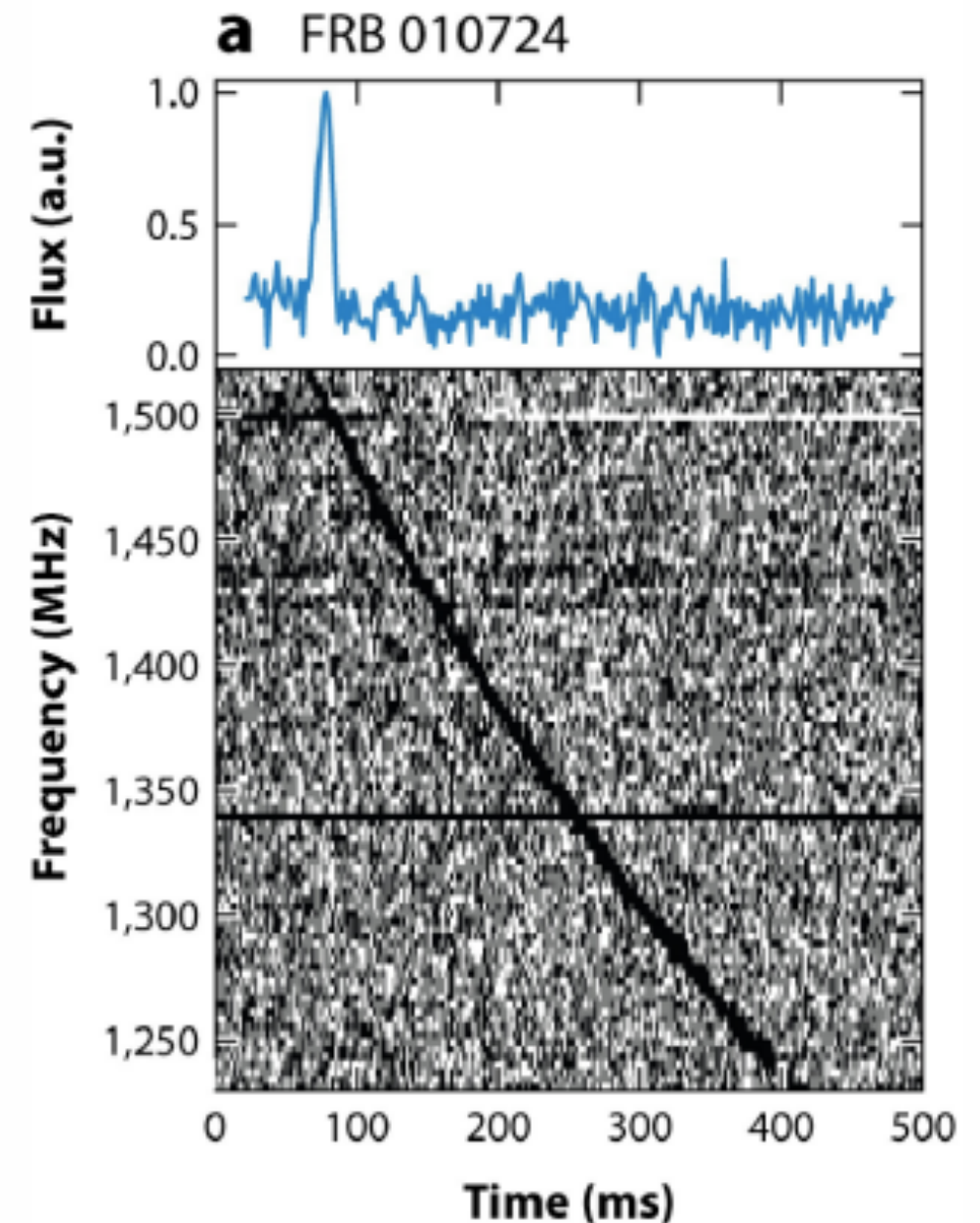


Search for Fast Radio Burst repeater counterparts with **INTEGRAL**

Martin Topinka (OAC-INAF)

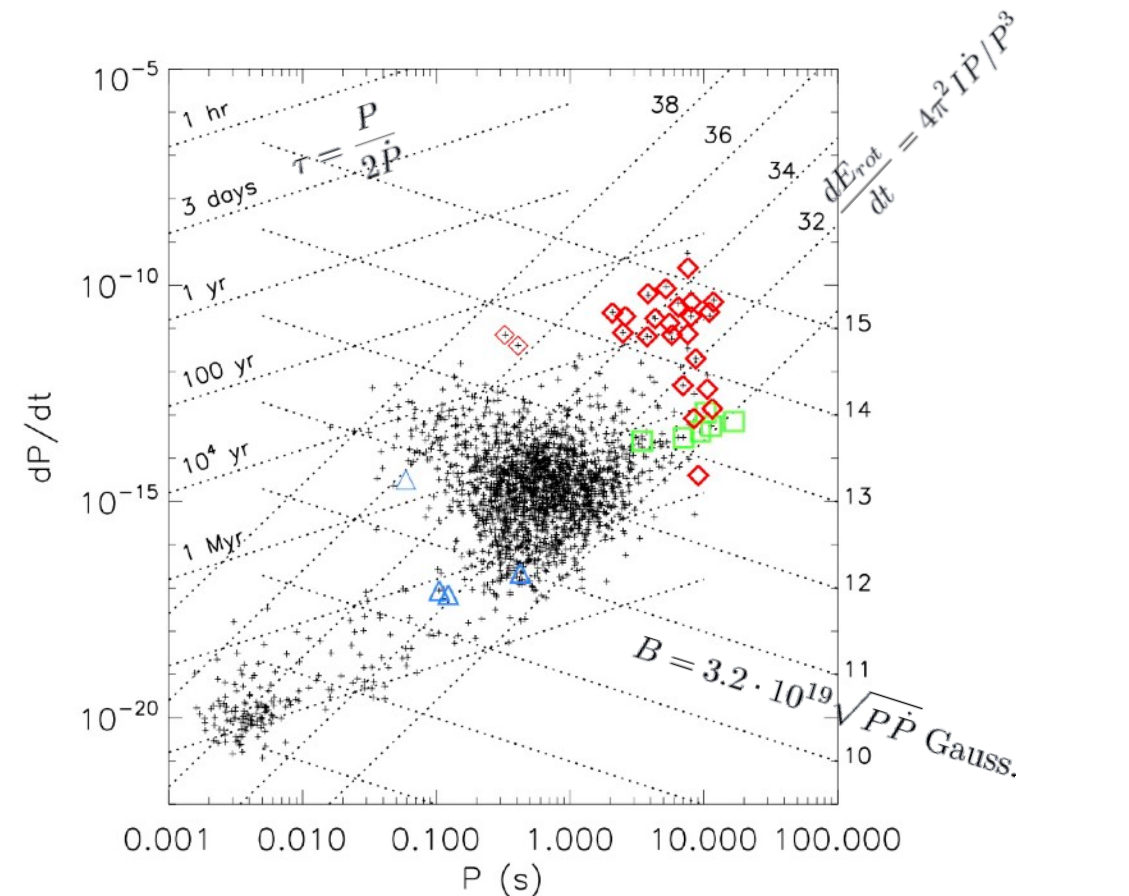
FRB Italy 2025, Bologna

- **Fast** $\sim$ ms
Radio $\sim$ 400 MHz - 8 GHz
Bursts $\sim$ 0.01 Jy - 100 Jy
- $>1000/\text{day}$
- high DM, host galaxies $z \sim < 1$
 $E_{\text{iso}} \sim 10^{37}$ to 10^{40} ergs
- **unknown origin**
(www.frbtheorycat.org)
coherent emission, $c\Delta t \Rightarrow \sim 100\text{km}$
- a few repeats

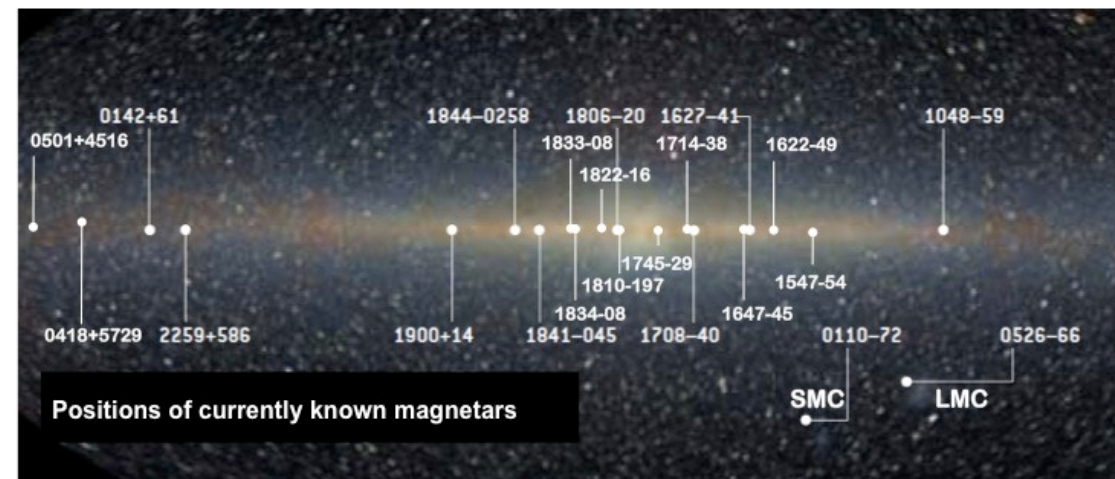


Magnetars

- (Isolated) neutron stars powered by magnetic energy
- Slowly rotating ($P \sim 1\text{-}12\text{ s}$)
fast spin-down ($dP/dt \sim 10^{-10} - 10^{-11}\text{ s/s}$)
- $L_x \approx 10^{34} - 10^{36}\text{ erg/s} > dE_{\text{rot}}/dt$
- Giant flares 10^{47} erg/s



$$\frac{dE}{dt} = \frac{1}{6c^3} B^2 R^6 \omega^4 \sin^2 \alpha$$



Magnetar activity

persistent

bursts

giant
flares

10^{35}

10^{41}

10^{47}

L [erg/s]

hot surface +
magnetospheric
 e^+e^- discharge

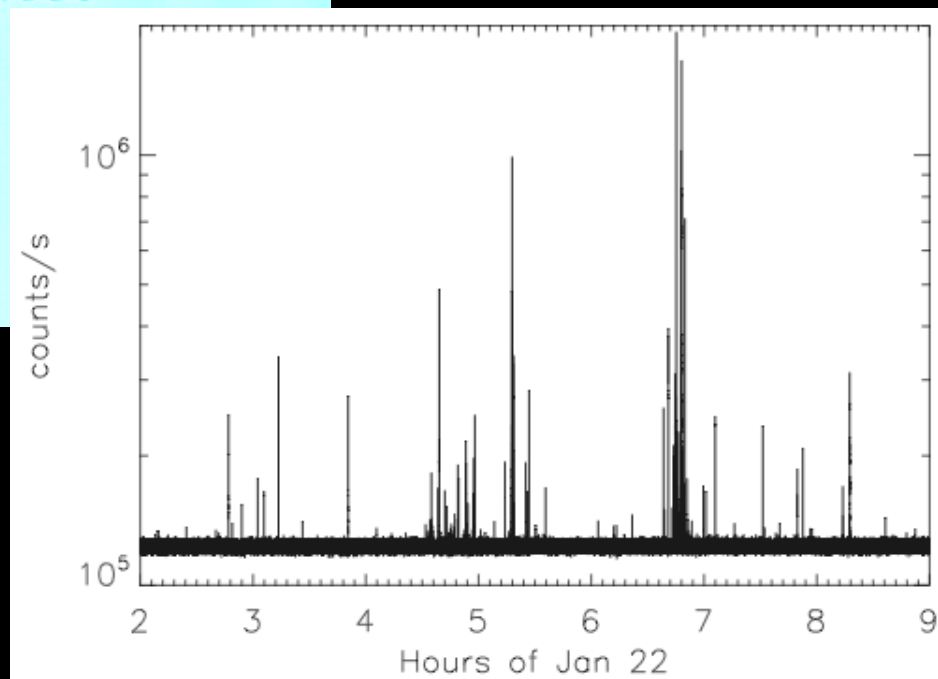
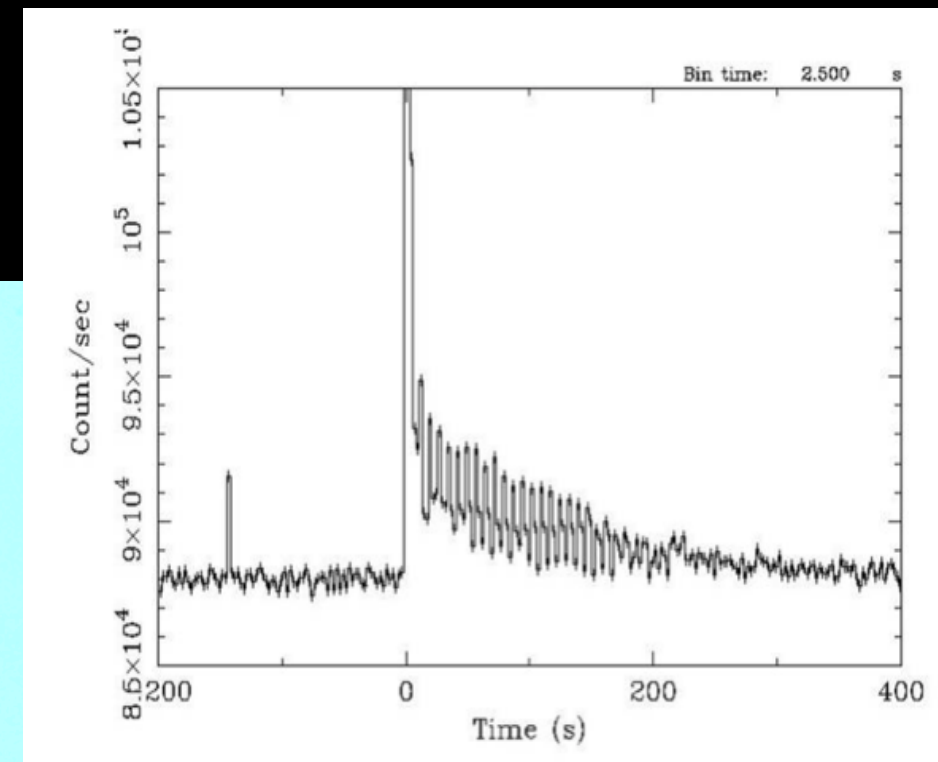
?

thermalized
 e^+e^- fireball

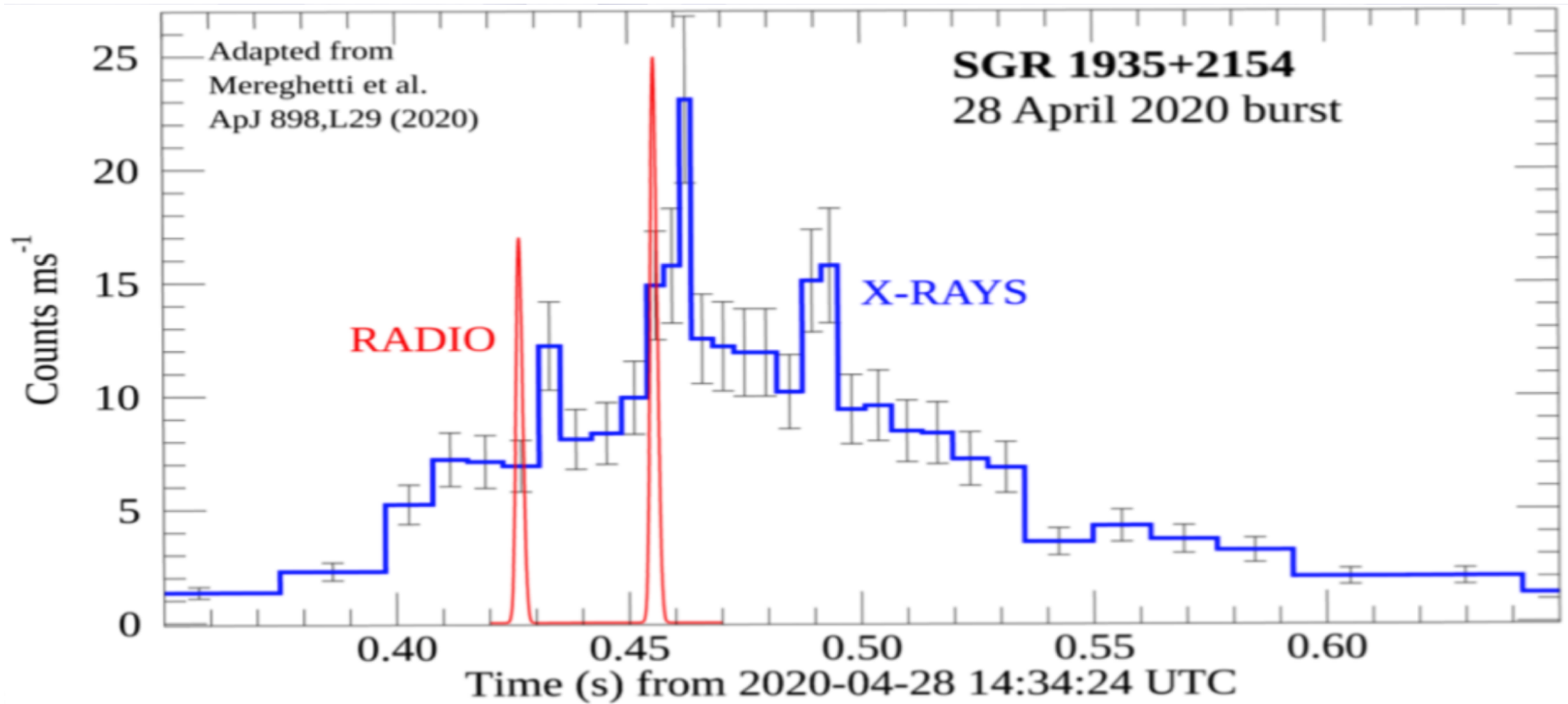
Thompson et al. 2022
AB 2013

Thompson, Duncan 1996

hard X-rays => magnetospheric emission

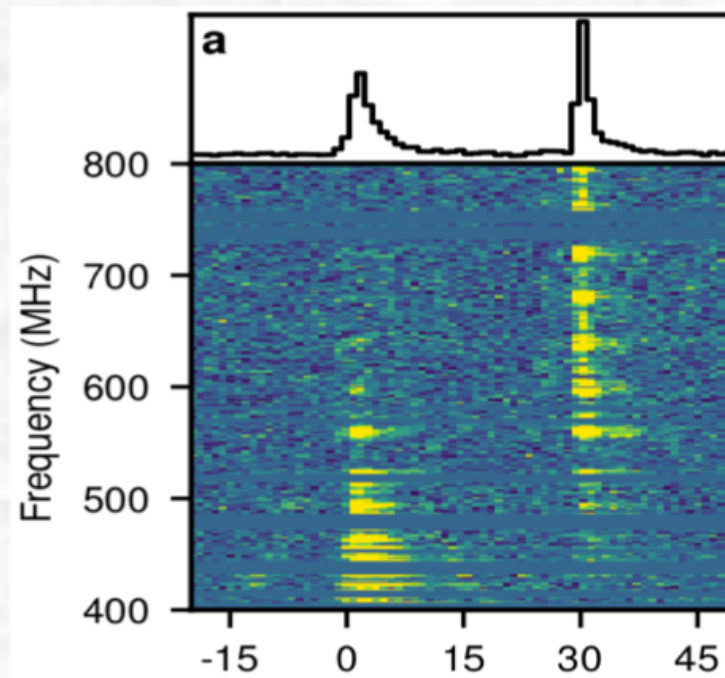


Andrei Beloborodov

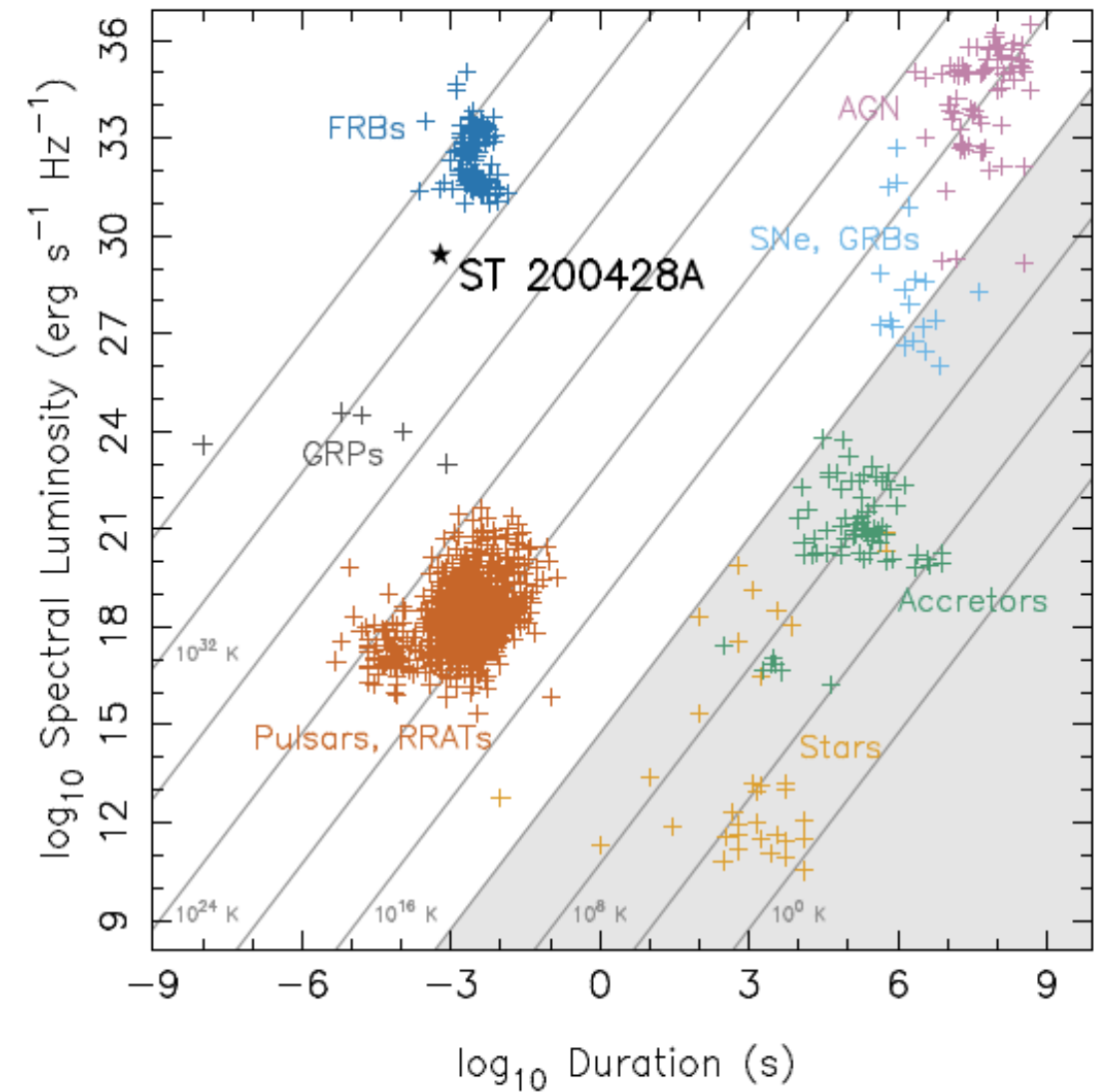
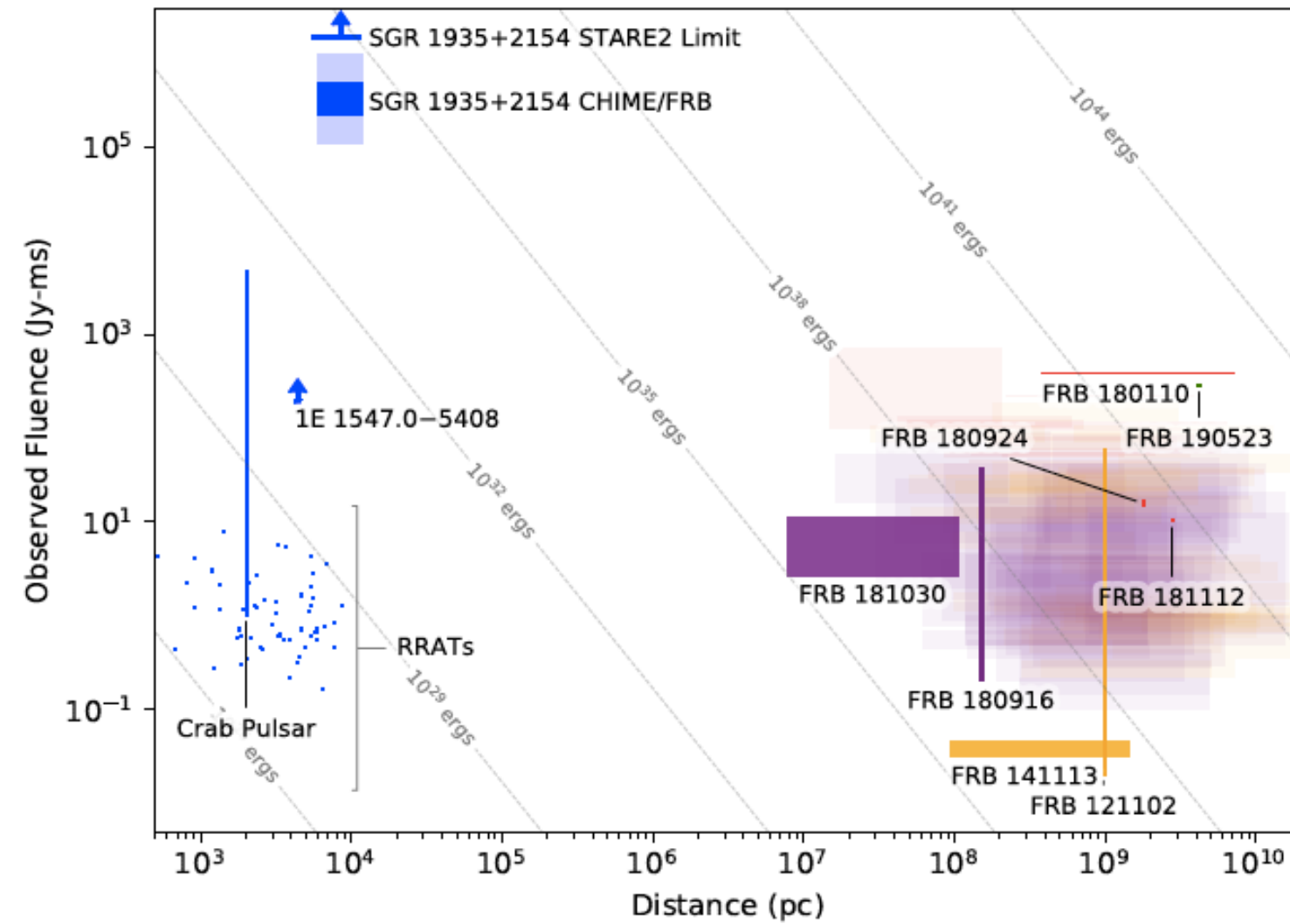


Flux, ergs/s/cm² (hard)

[CHIME/FRB+2020]



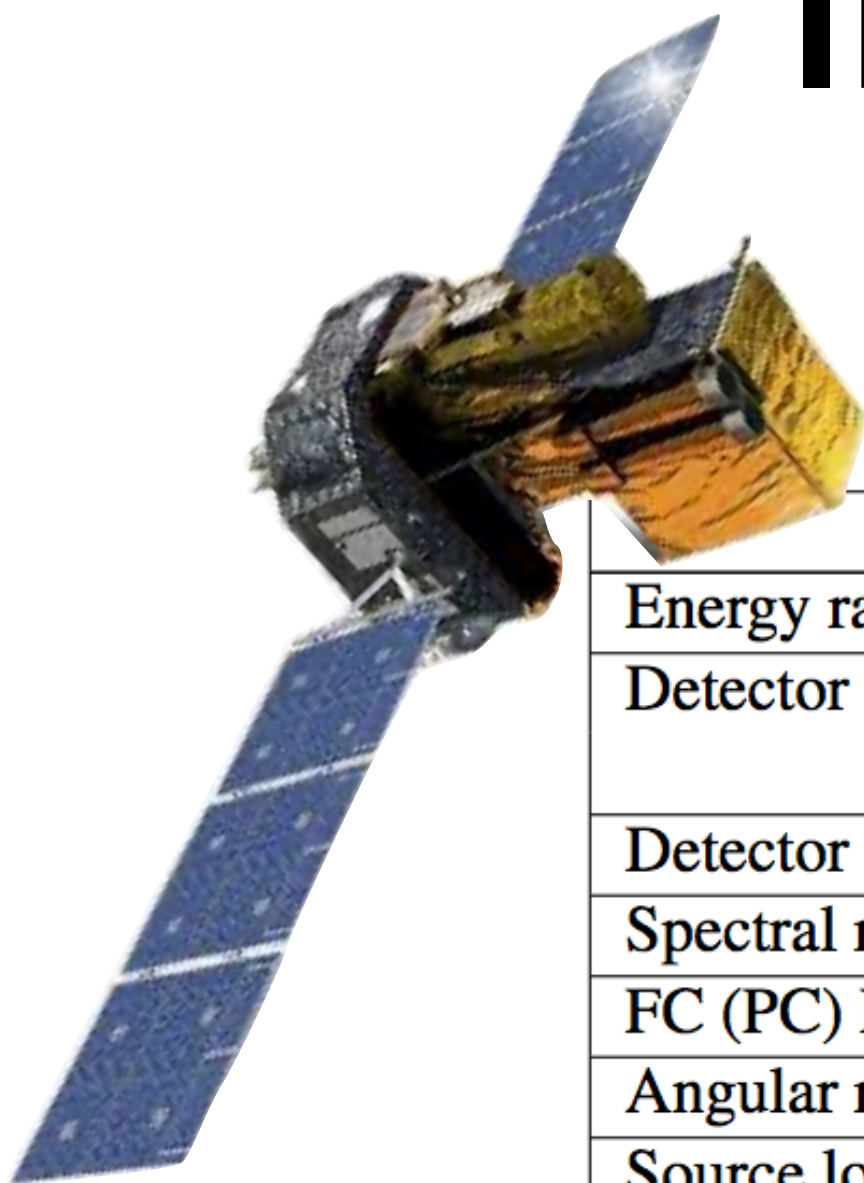
**CHIME detections in
far side lobes with a
combined fluence of
 ≈ 0.7 MJy ms at 400-
800 MHz band**



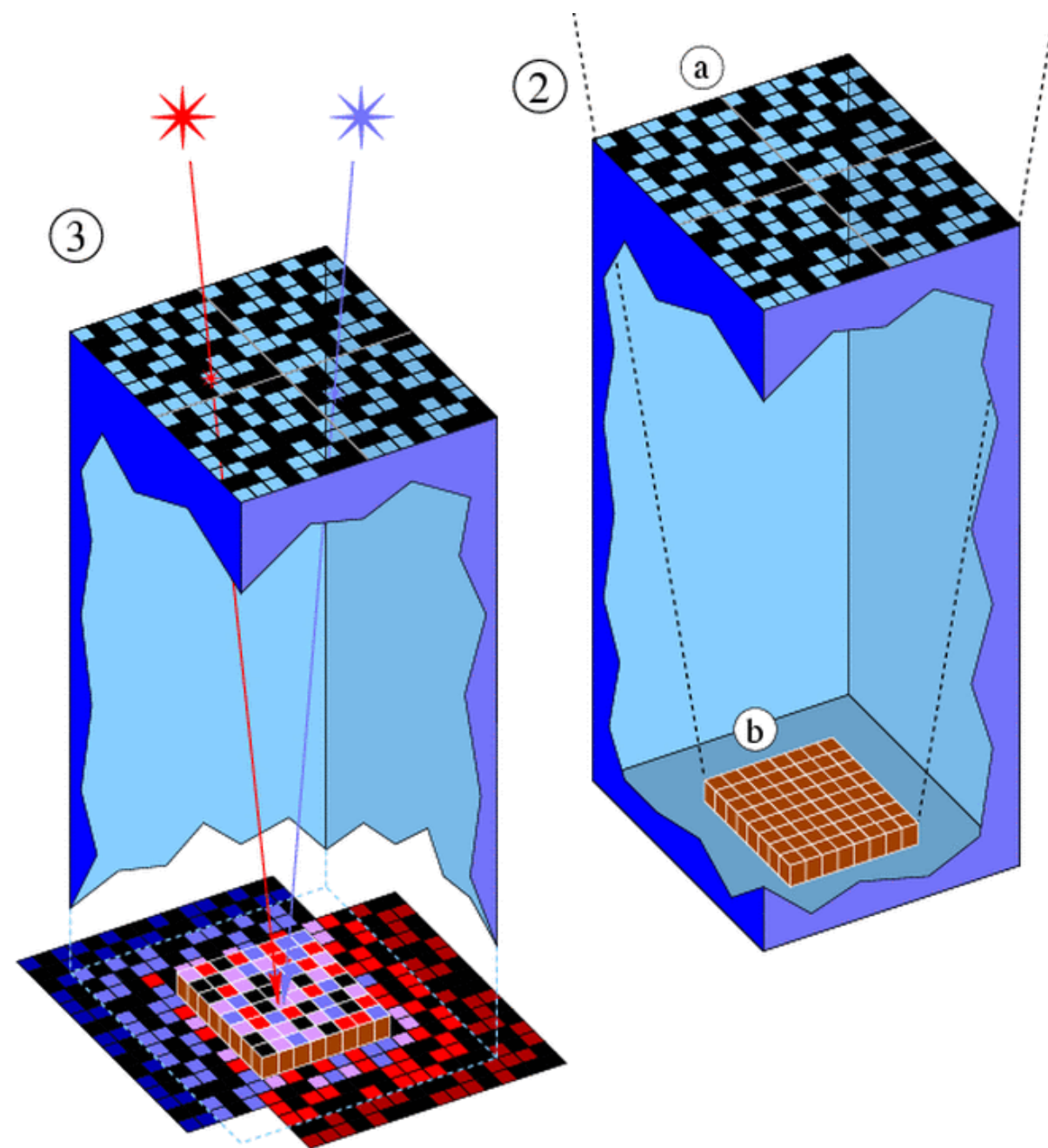
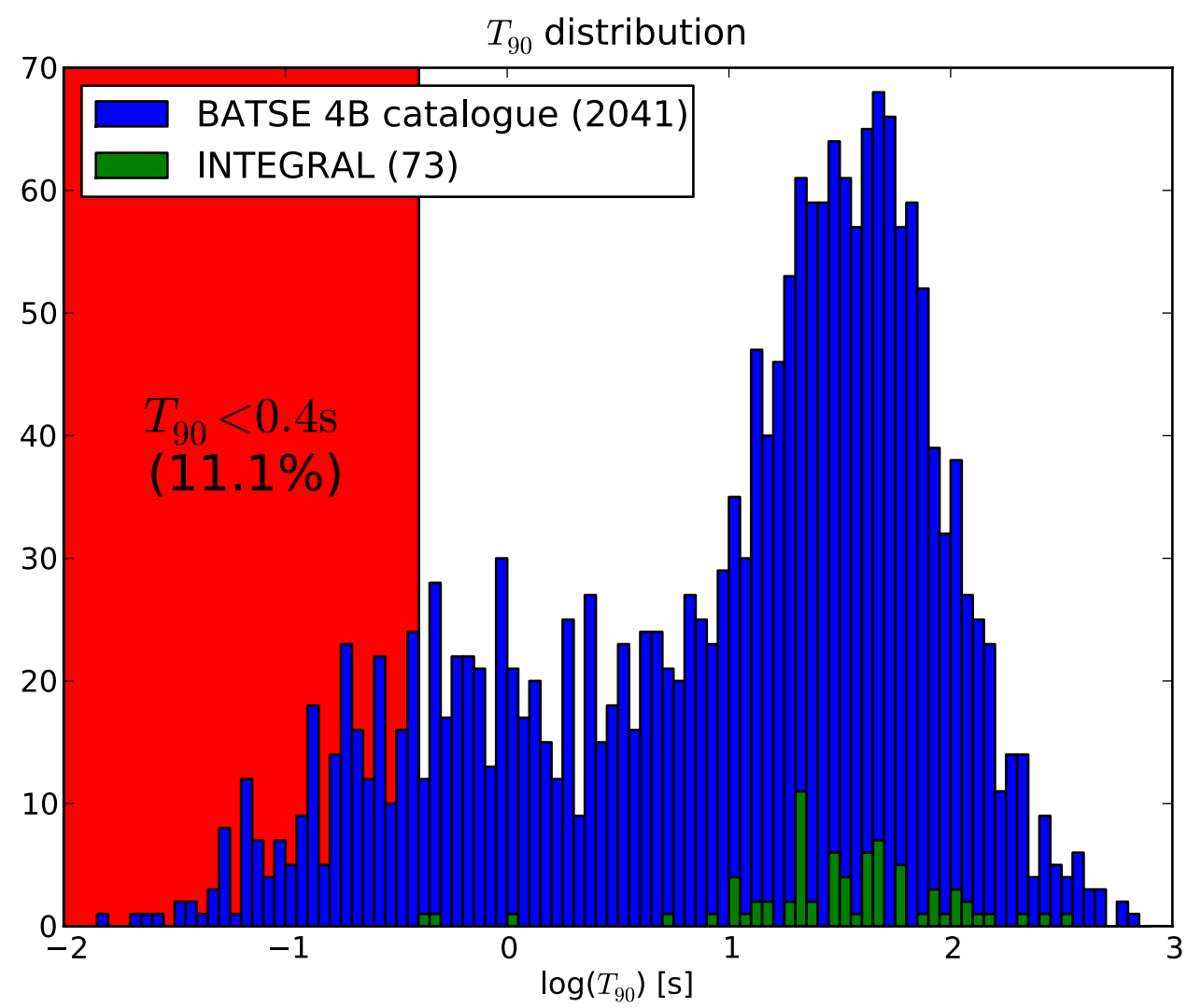
- PRS, Linear Polarisation, Faraday rotation, host environment, physics...

INTEGRAL

October 2002 ... 2025 †



	SPI	IBIS
Energy range	20 keV - 8 MeV	15 keV - 500 keV (10 MeV)
Detector	19 Ge dets	16384 CdTe dets (ISGRI) 4096 CsI dets (PICsIT)
Detector area (cm ²)	500	2600 (CdTe), 3100 (CsI)
Spectral resolution	2.3 keV @ 1.3 MeV	9 keV @ 100 keV
FC (PC) FoV	16° × 16° (35° × 35°)	9° × 9° (19° × 19°)
Angular resolution	2.5°	12'
Source location	< 1.3° (depending on the source strength)	< 1' (for 10σ source)
Usage	poor image good spectrum poor lightcurve (1 s)	good image average spectrum good lightcurve (0.1 s)



FRB Repeaters

FRB	RA [deg]	DEC [deg]	(avg)DM	INTEGRAL coverage [Ms]	#flares in CHIME
FRB 20200120E	149.2	+68.8	87.8	18.1	67
FRB 20220912A	347.27	+48.70	222.1	19.8	443
FRB 20240209A	289.9	+86.1	176.4	1.8	57
FRB 20200223B	8.25	+28.8	201.5	1.5	14



Cross-checks

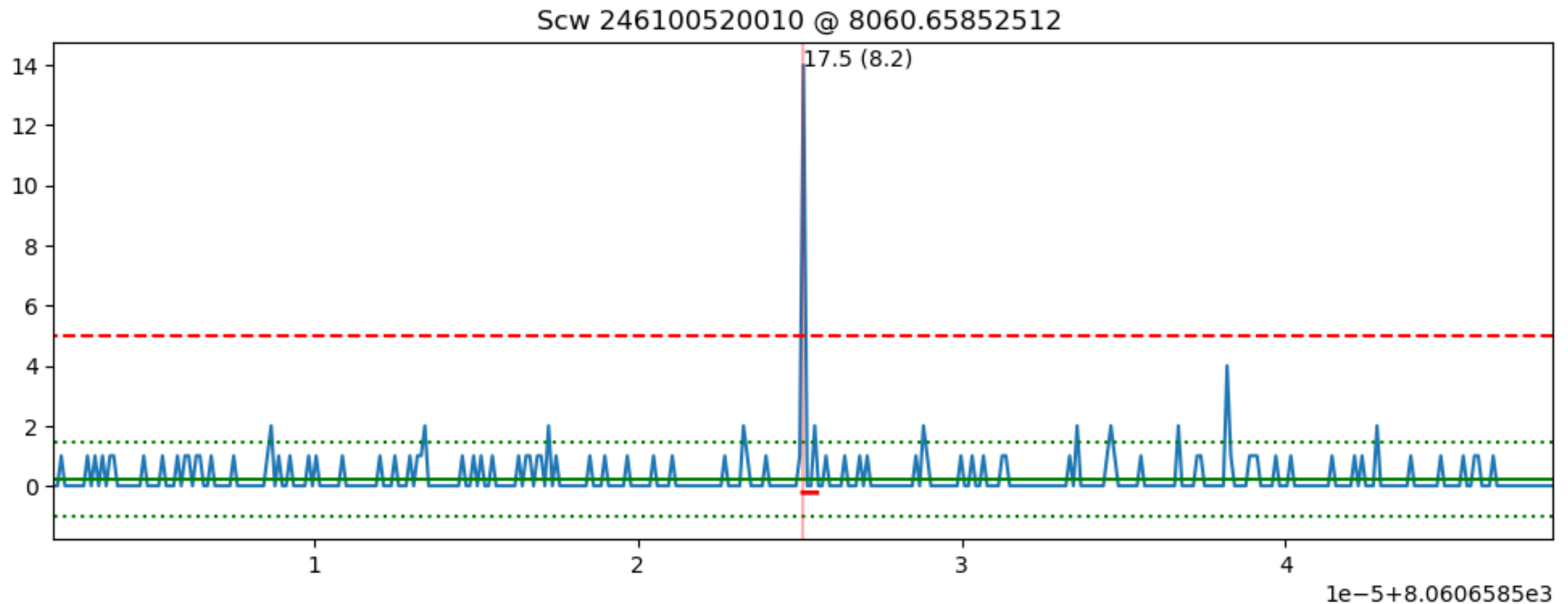
Cosmic ray 3 sigma-clipping

Anti-PIF

Pixel Illuminating Fraction Bayes factor
Likelihood ratio of $N_{\text{cts}} = N_{\text{cts}}(\text{PIF})$ for
(source + background)
vs
background only

Image reconstruction

Nothing found

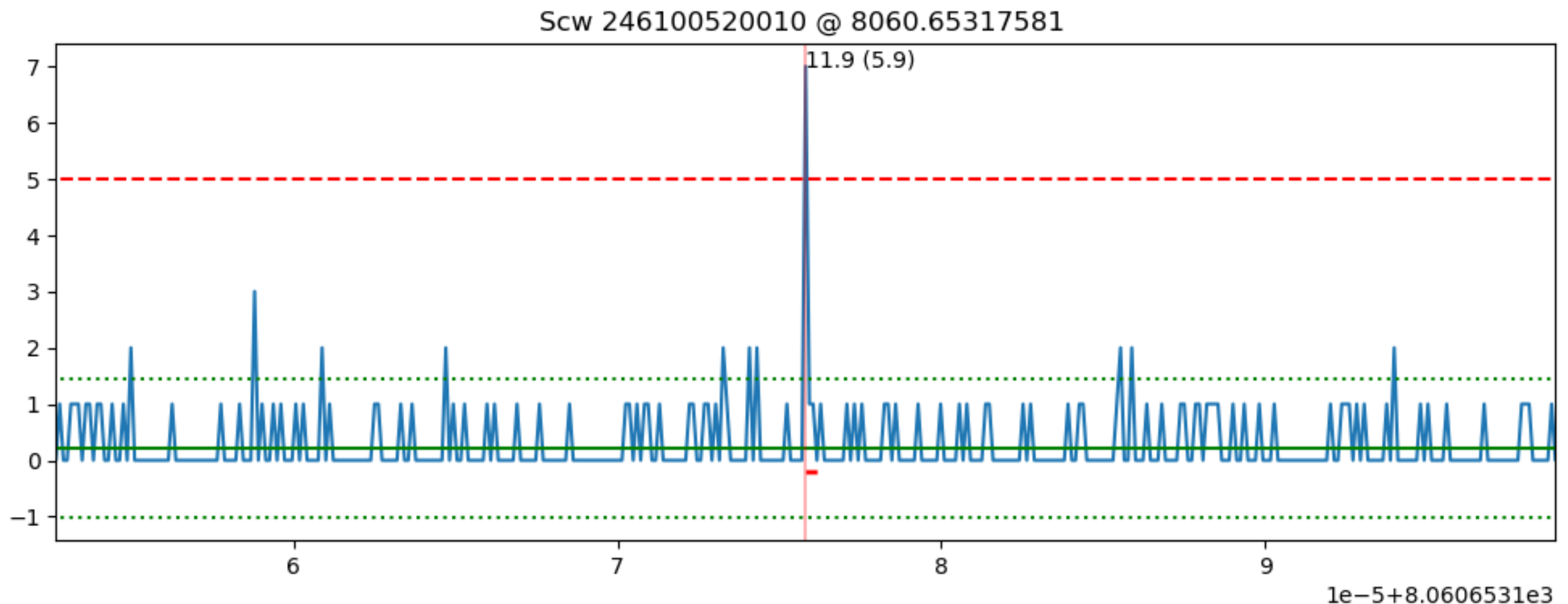


- 2022-01-25 15:37:59
- CR **ok**
- $1-\exp(N_p) \sim 1e-6$
- Anti-PIF **ok**
- Image **no way!** ~ 20 counts
- Bayes factor $\rightarrow 2.6$ sigma

Time coincidence with CHIME?

CR **ok**, Anti-PIF **ok**, spurious **0.04**, BF ~ 1.7 sigma, image **no way**

FRB	Burst ID	Time	Delta T [s]
FRB 20220912A	220912	2022-09-12 07:45:50.57	0.57



Bye-bye Notes

FRB	> 8 sigma	Coinc w/CHIME
FRB 20200120E	0	0
FRB 20220912A	1	1 ?
FRB 20240209A	TBD	TBD
FRB 20200223B	0	0

- More FRB repeaters out there to check in INTEGRAL
- More CHIME/FAST etc FRB bursts for temporal cross-check (what is the time window?)
- Never the less, hard X-ray counterparts are rare and faint in terms of radio to X-ray

limit of fluence $< 10^{-8}$ erg cm $^{-2}$ in 20–150 keV

- Up to what distance we would see SGR1935-like bursts?