News on SGR 1935+2154

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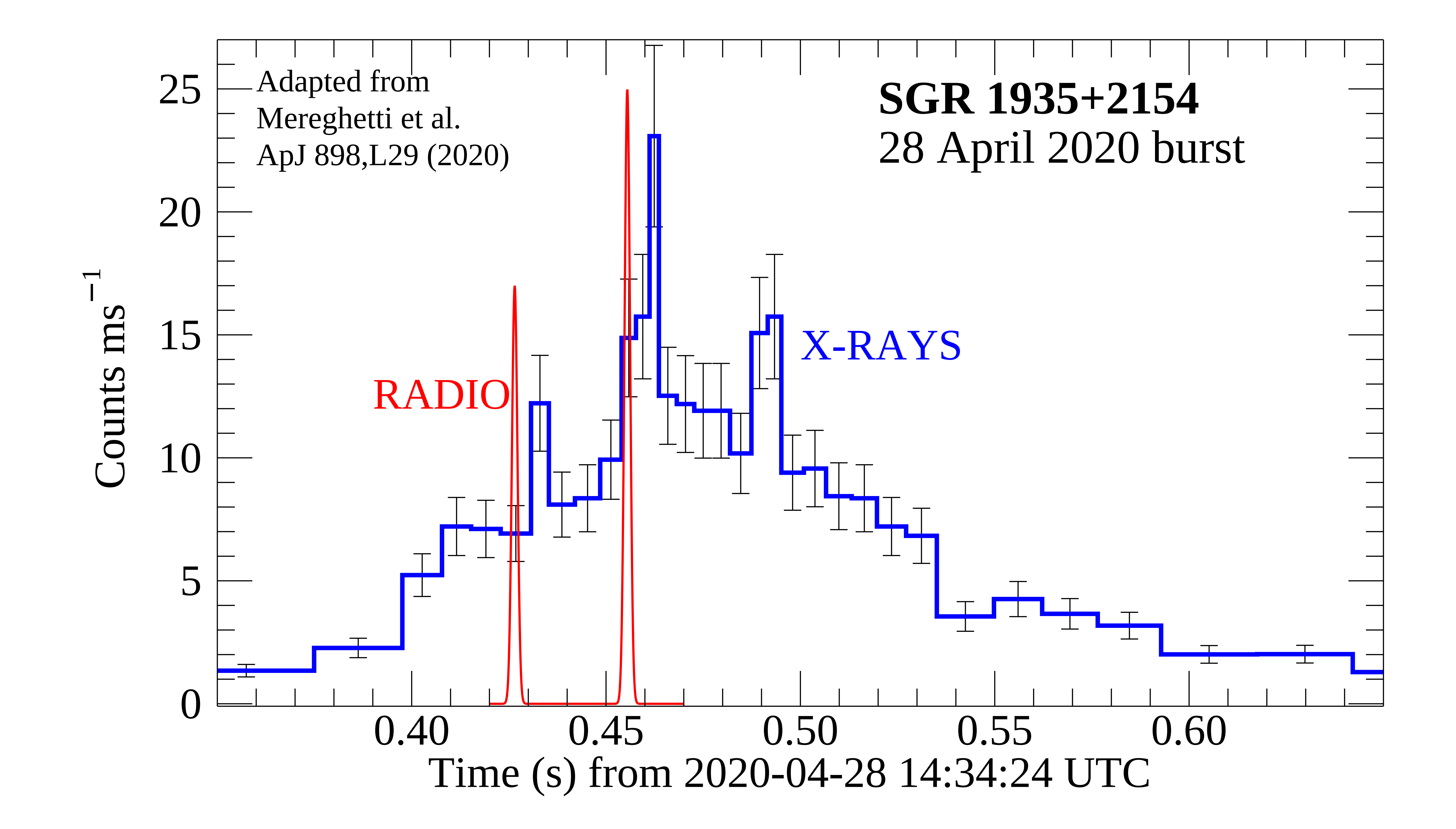
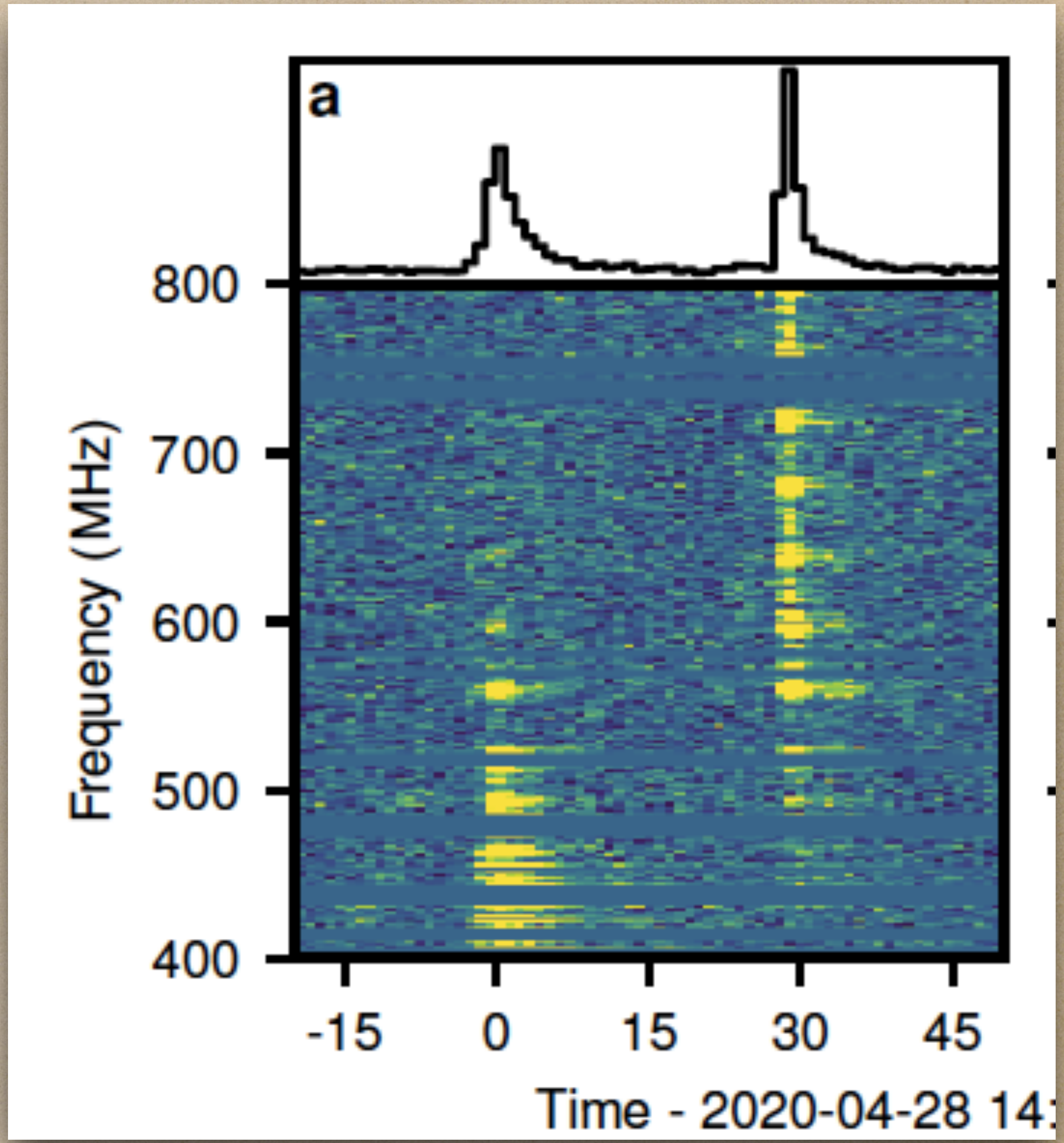
SGR 1935+54 X-ray / radio burst



CHIME Coll 2020



Broad X-ray pulse starts before the radio

Narrow X-ray peaks with 6.5± 1 ms lag wrt the radio

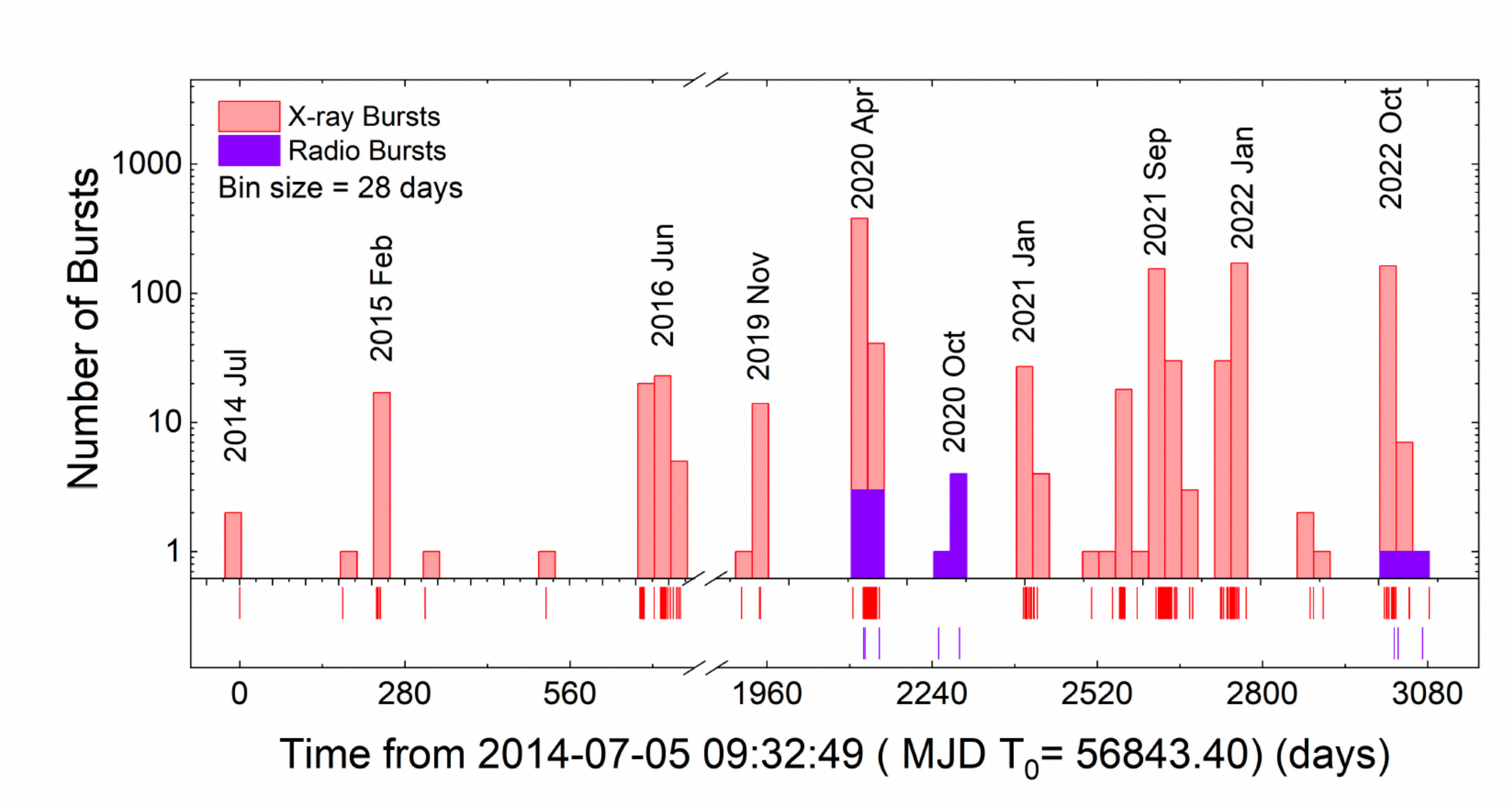
Fluence 480 + 220 kJy ms [600 MHz]

1.5 MJy ms [1.4 GHz]

DM = 332.7 pc/cm^3

Radio energy 2 10^{35} erg

Peak luminosity = 7 10^{36} erg/s



2014 July : Discovery

2020 Apr 27-28 : Storm

2020 Apr 28 : FRB-X

2020 Apr 30 : high pol. FRB

2020 Oct ~5: glitch ?

2020 Oct 8 : 3 FRBs

2020 Oct 9-20 : Radio PSR phase

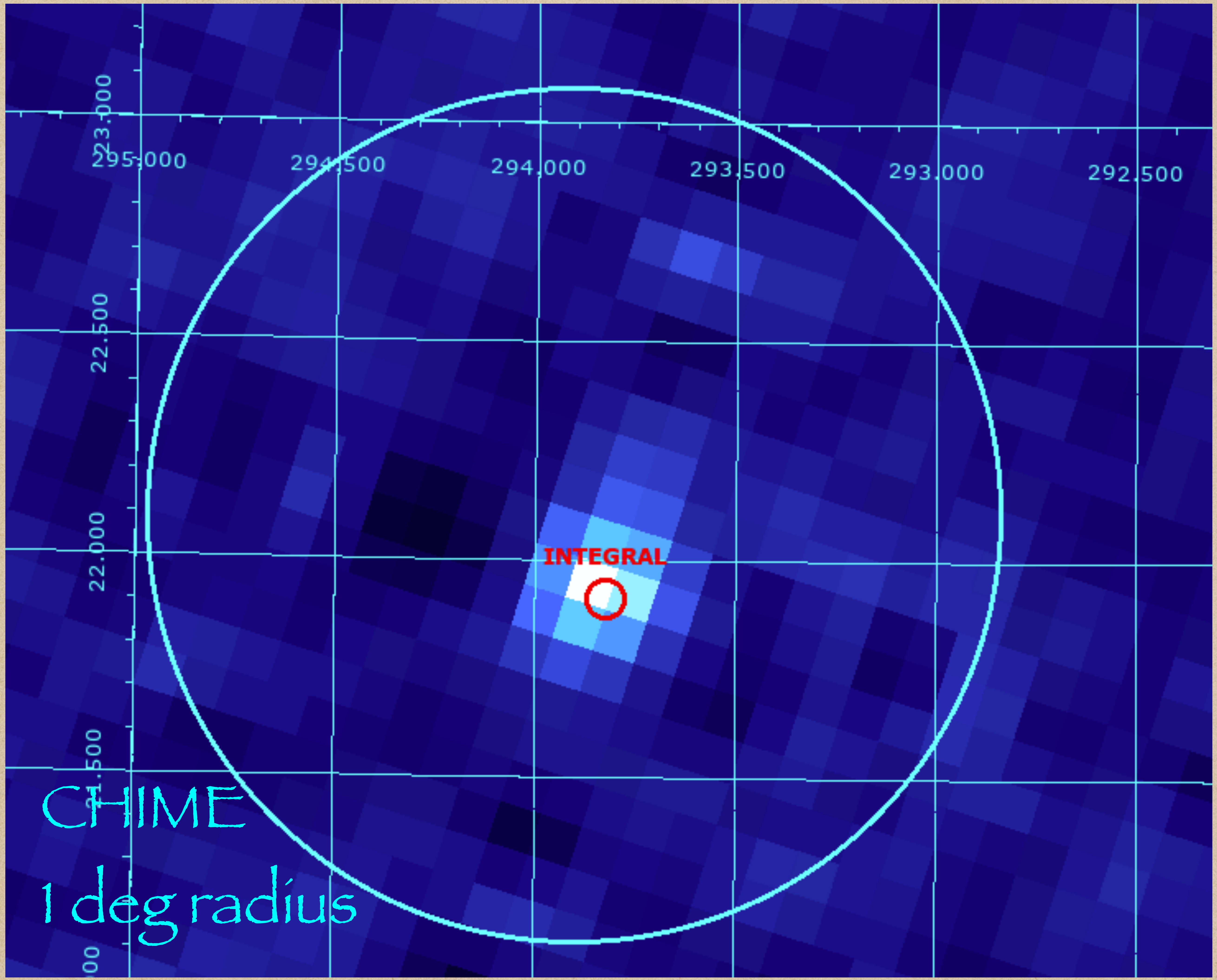
2022 Oct 10 : reactivation

2022 Oct 14 : 5 FRBs + storm + IF

2022 Oct 14 : 2 spin-up glitches

2022 Dec 1 - FRB

Importance of localisation wrt Multiwave

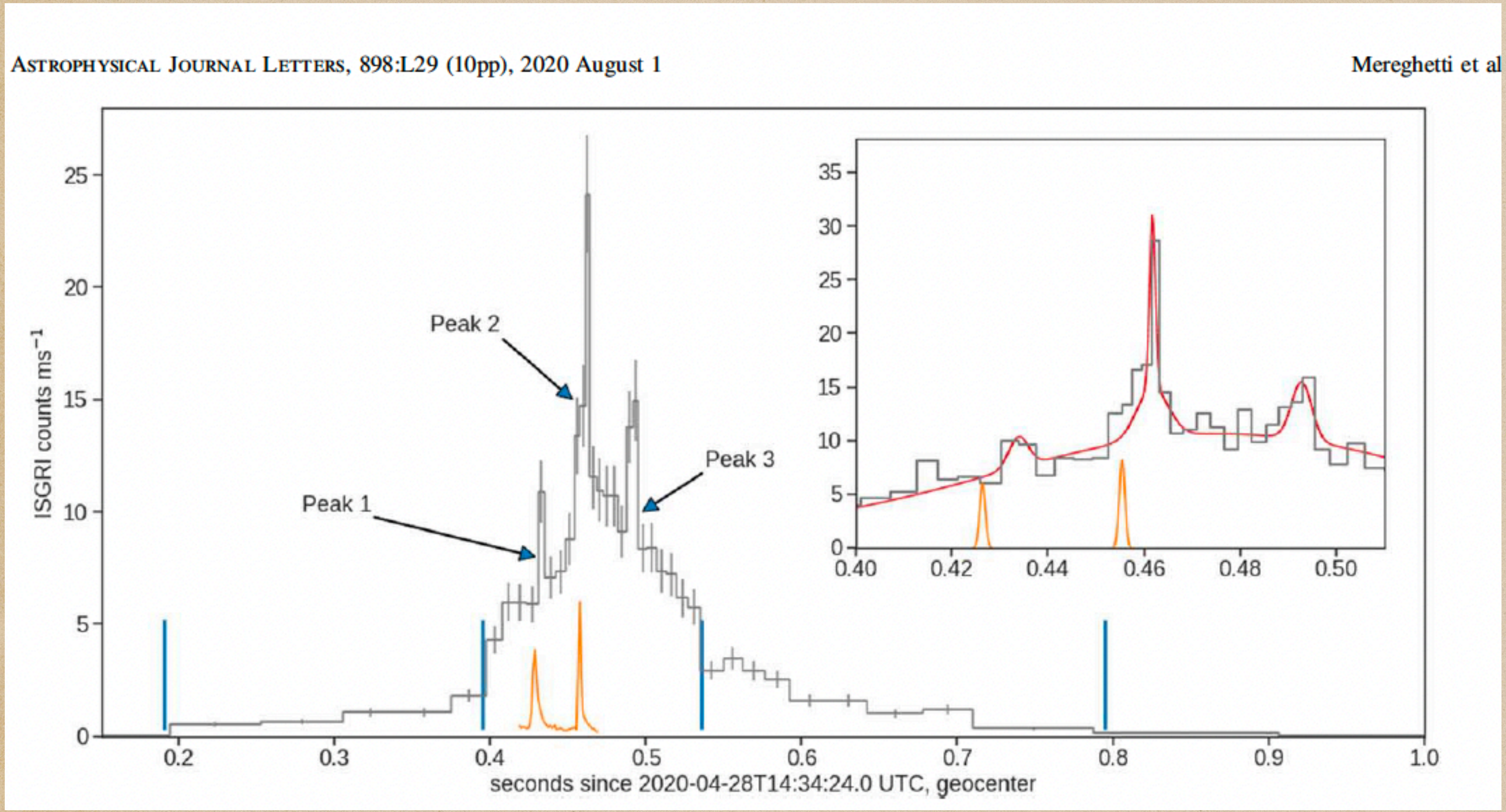


INTEGRAL localisation

2.7 arcmin after 5 sec

(6 hr before CHIME Atel)

TIMING



ΔT RADIO = 28.97 ± 0.02 ms

INTEGRAL

ΔT P2-P1 = 28 ± 3 ms

ΔT P3-P2 = 31 ± 3 ms

(Mereghetti+20)

Konus-Wind

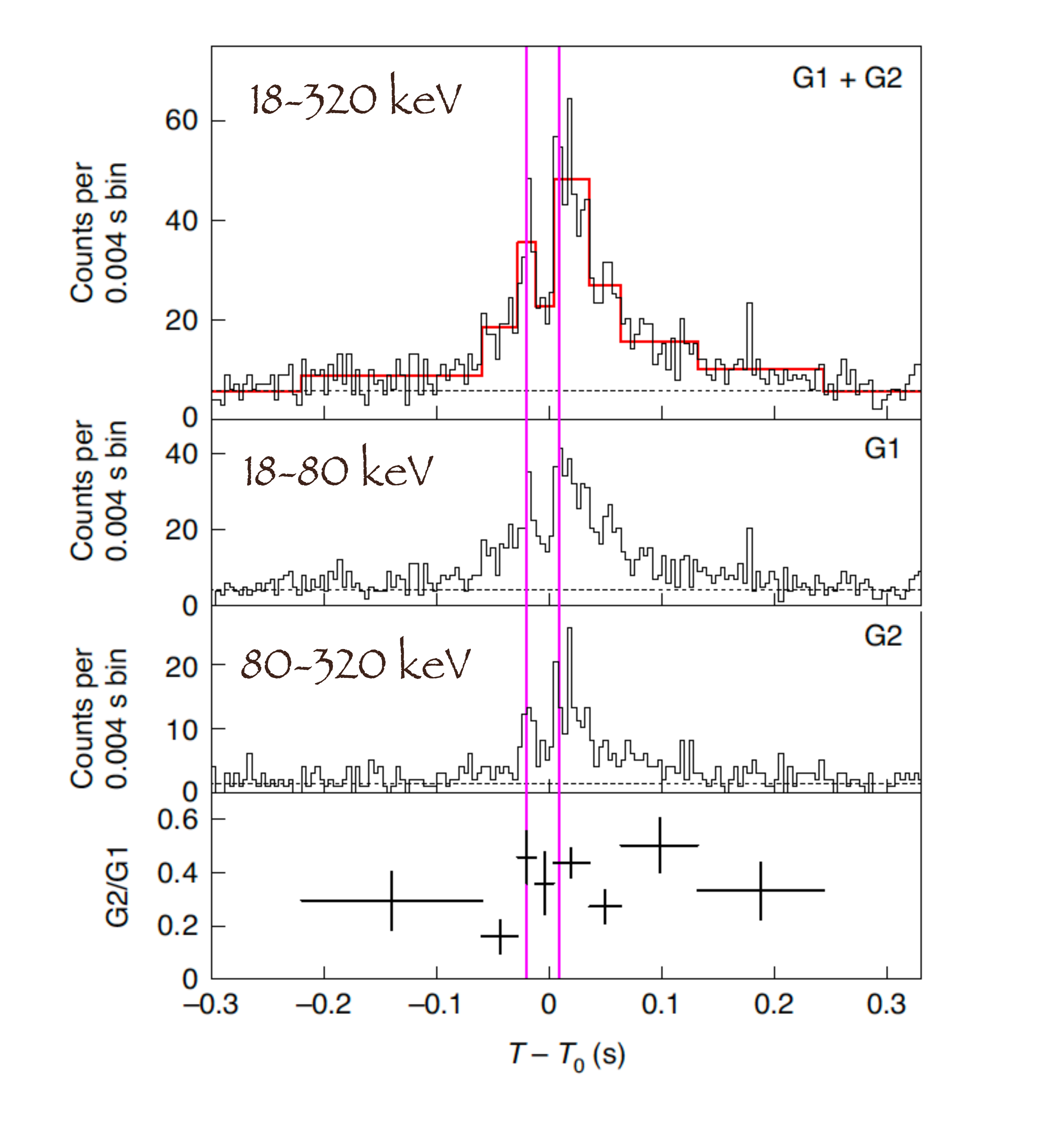
ΔT P2-P1 ≈ 28 ms

(Ridnaia+21)

HXMT

ΔT P2-P1 ≈ 34 ms

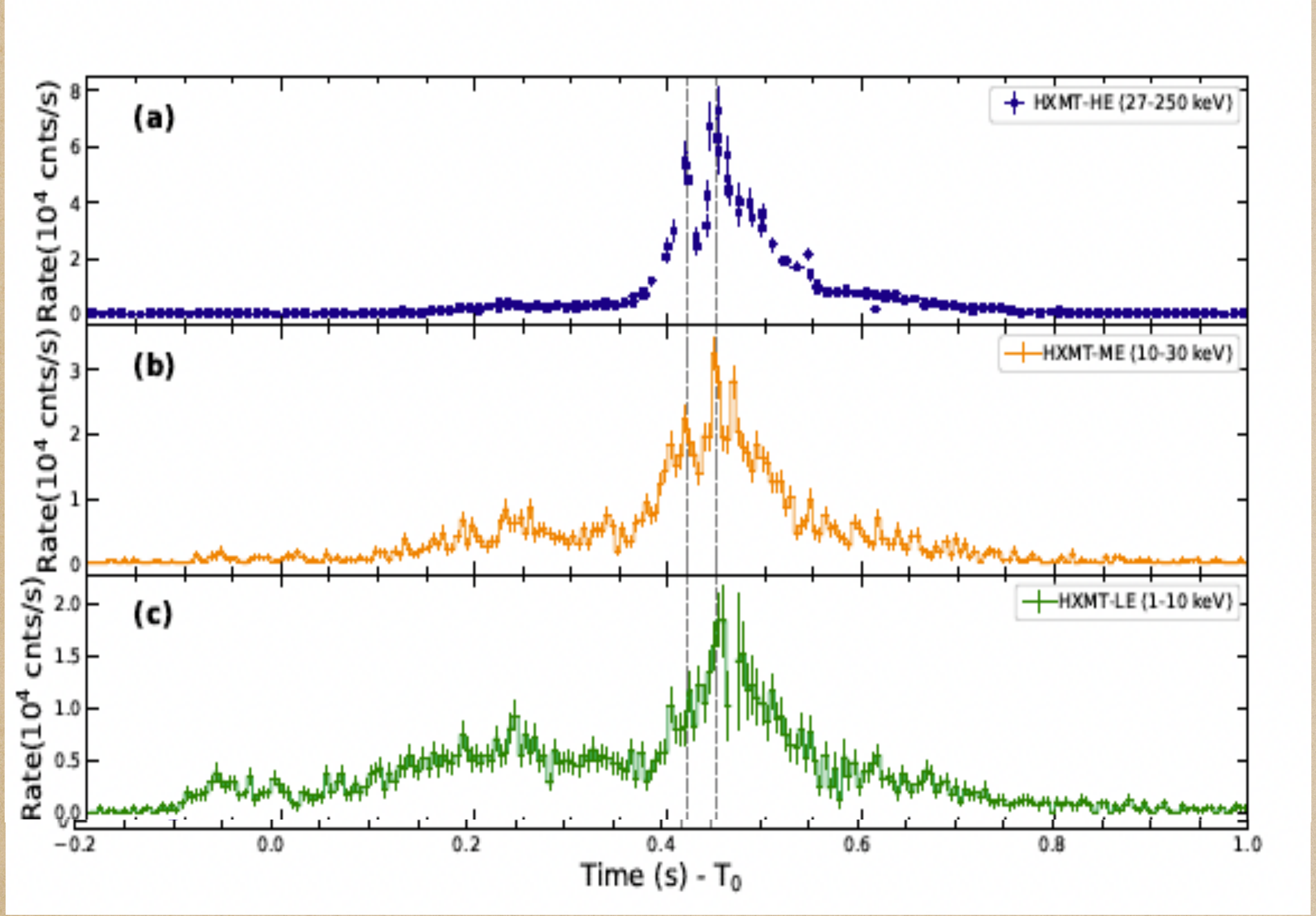
(Li+21)



Konus-Wind

ΔT P2-P1 ≈ 28 ms

(Ridnaia+21)



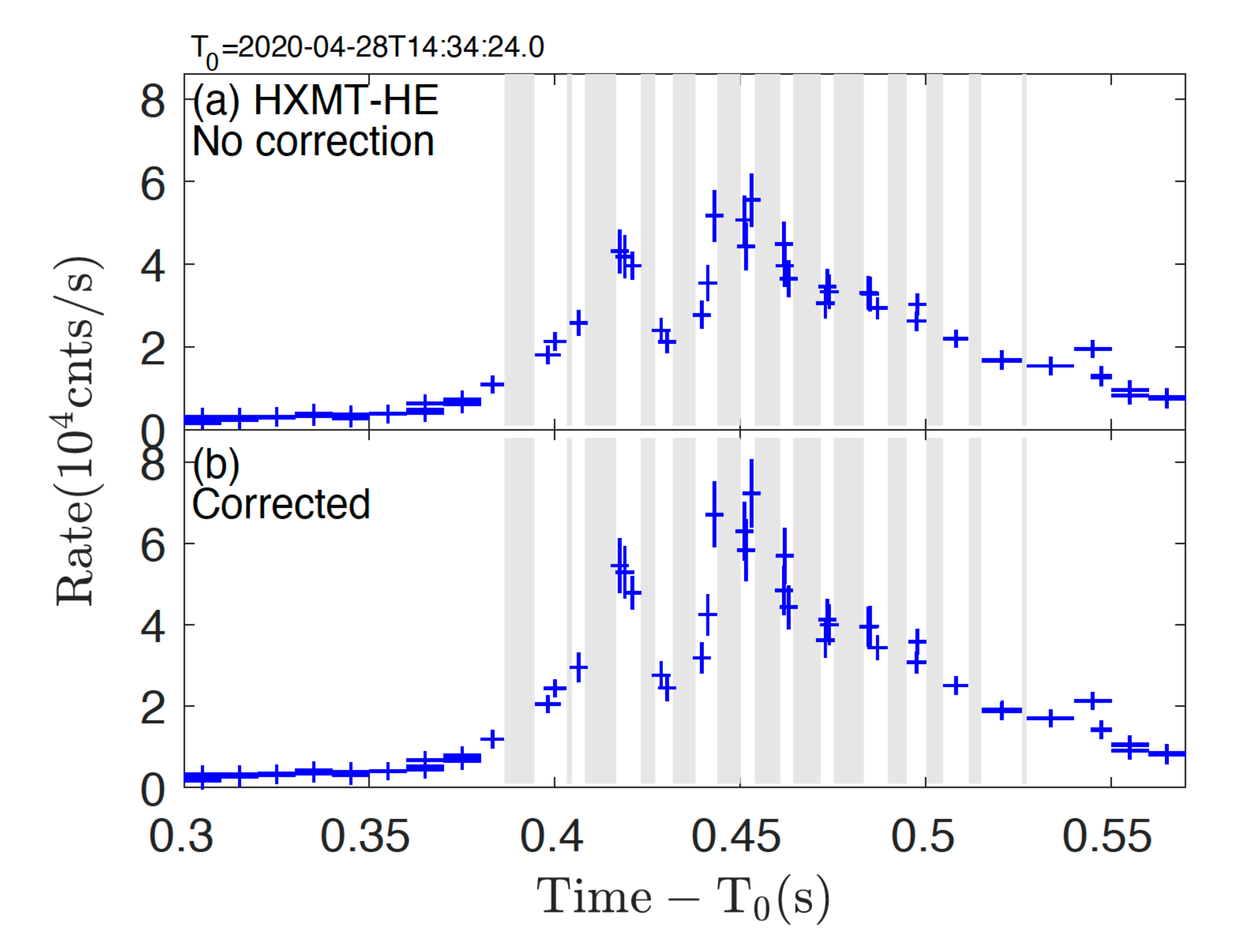
ΔT RADIO ≈ 28.97 ± 0.02

HXMT

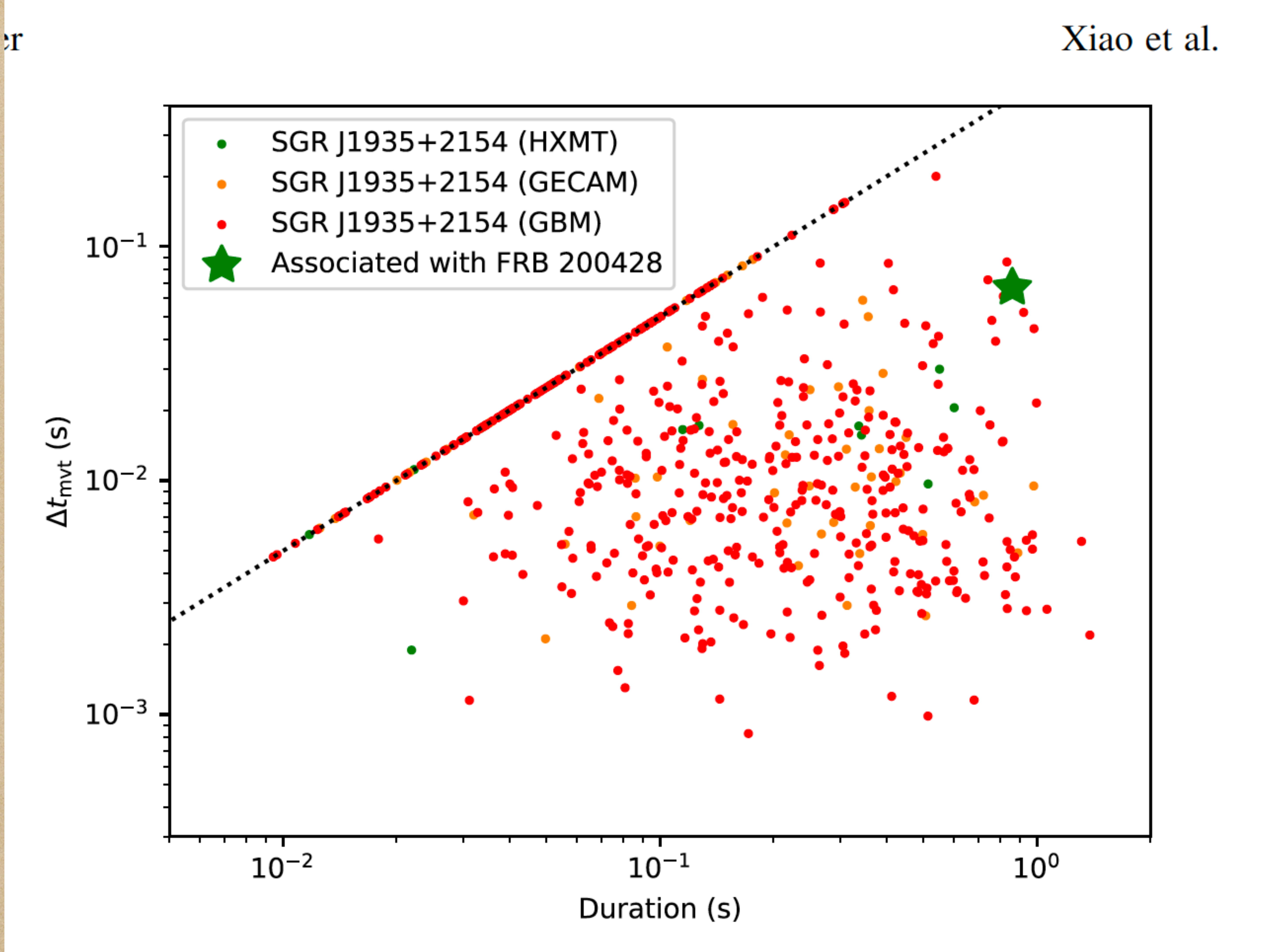
ΔT P2-P1 ≈ 34 (Li+21)

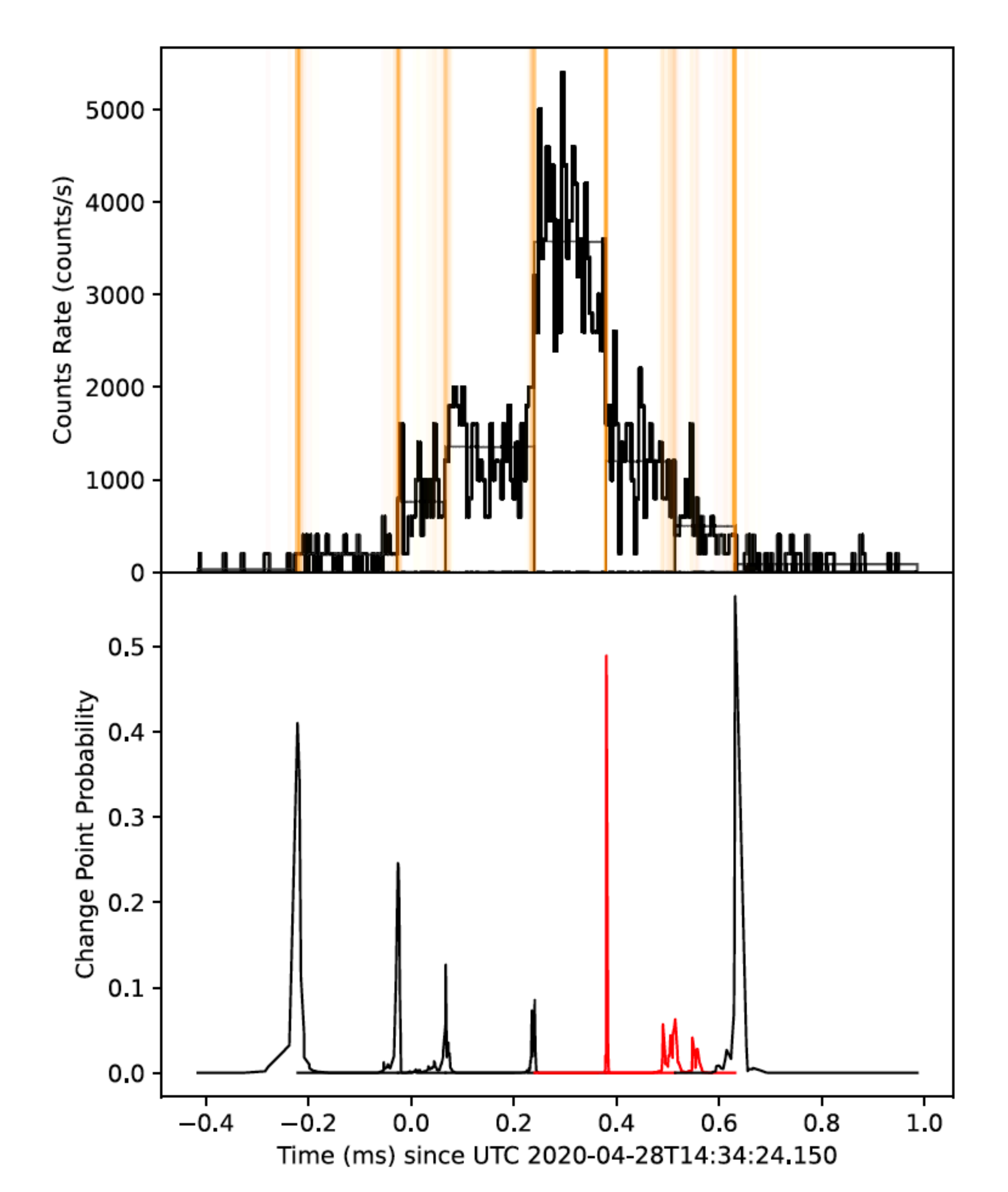
ΔT_{HE} P2-P1 ≈ 31.5±0.7 (Ge+23)

ΔT_{ME} P2-P1 ≈ 30.0±2.8 (Ge+23)


T0=2020-04-28T14:34:24.0
(a) HXMT-HE
No correction
(b)
Corrected
Rate(10^4cnts/s)
Time − T0(s)
0
2
4
6
8
0.3
0.35
0.4
0.45
0.5
0.55

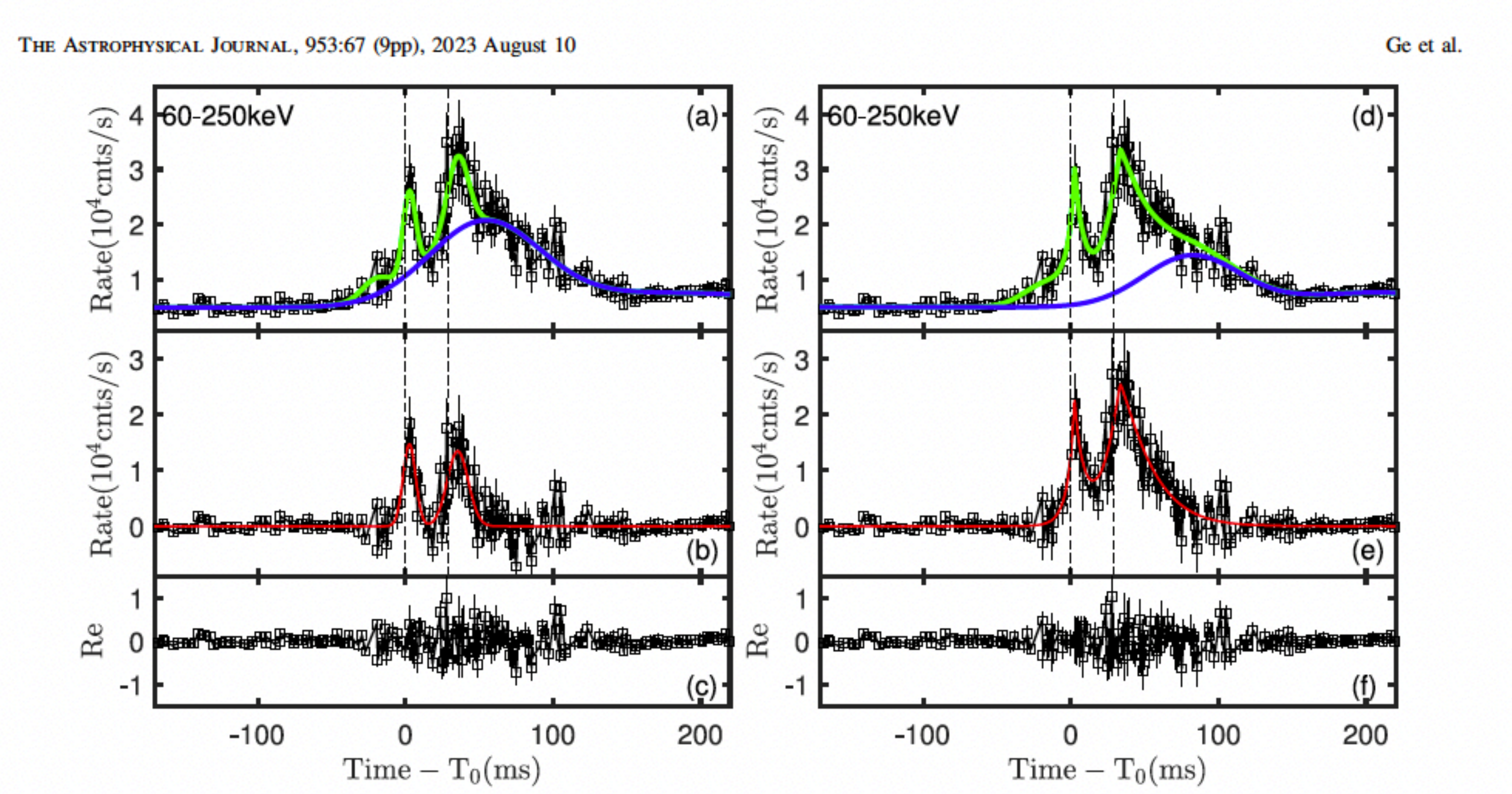
FRB 200428 Minimum variability timescale is 70 ms





HXMT/ME Xiao+23

Gauss FRED



Δ X-R

2.8+/-0.5 ms 1st peak

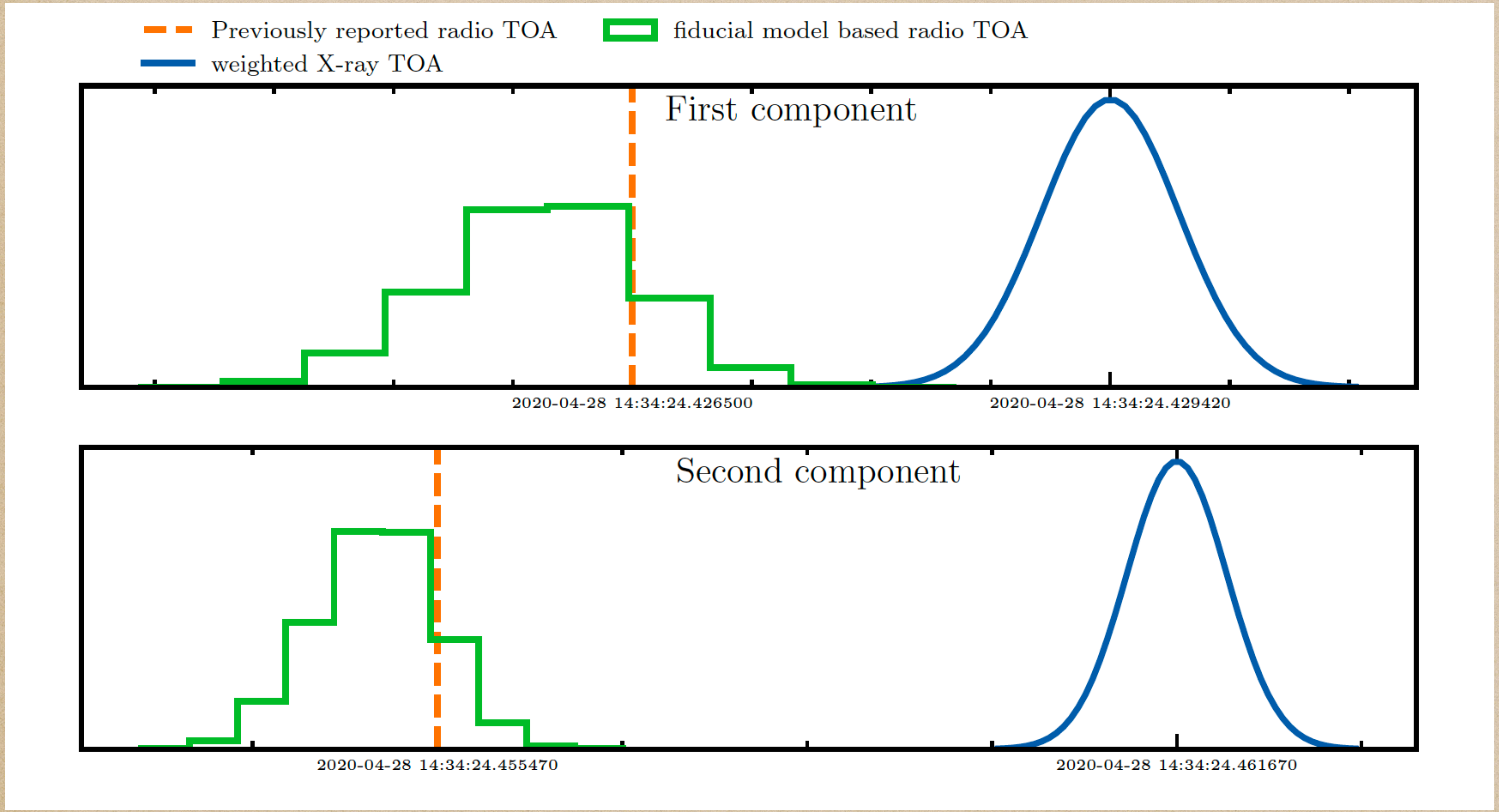
5.3+/-0.6 ms 2nd peak

Δ X-R

2.6+/-0.5 ms 1st peak

3.5+/-1.4 ms 2nd peak

Re-analysis of CHIME data FRB200428D [Giri+23]



Δ X1-R1

3.47 +/- 0.73 ms 1st peak

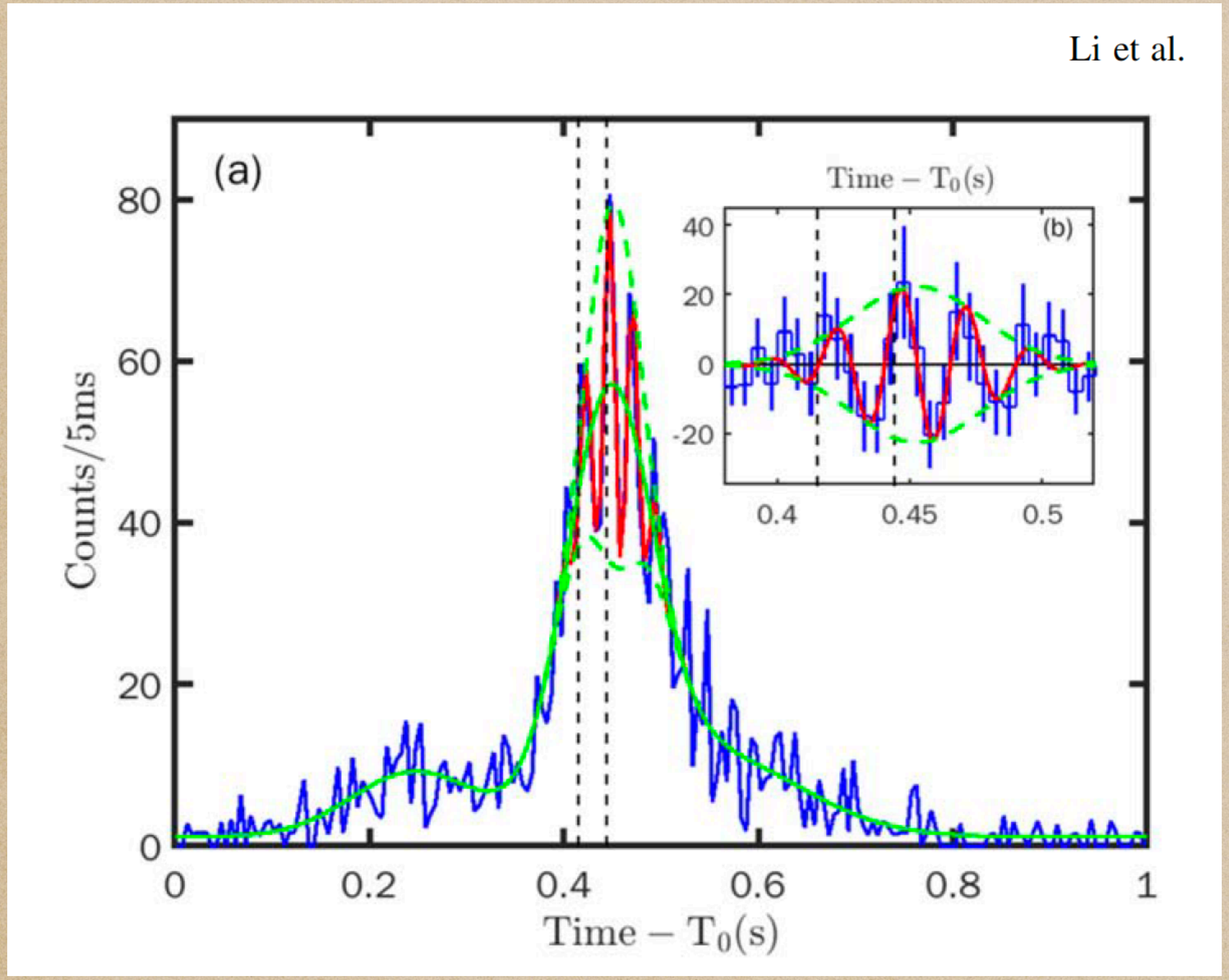
Δ X2-R2

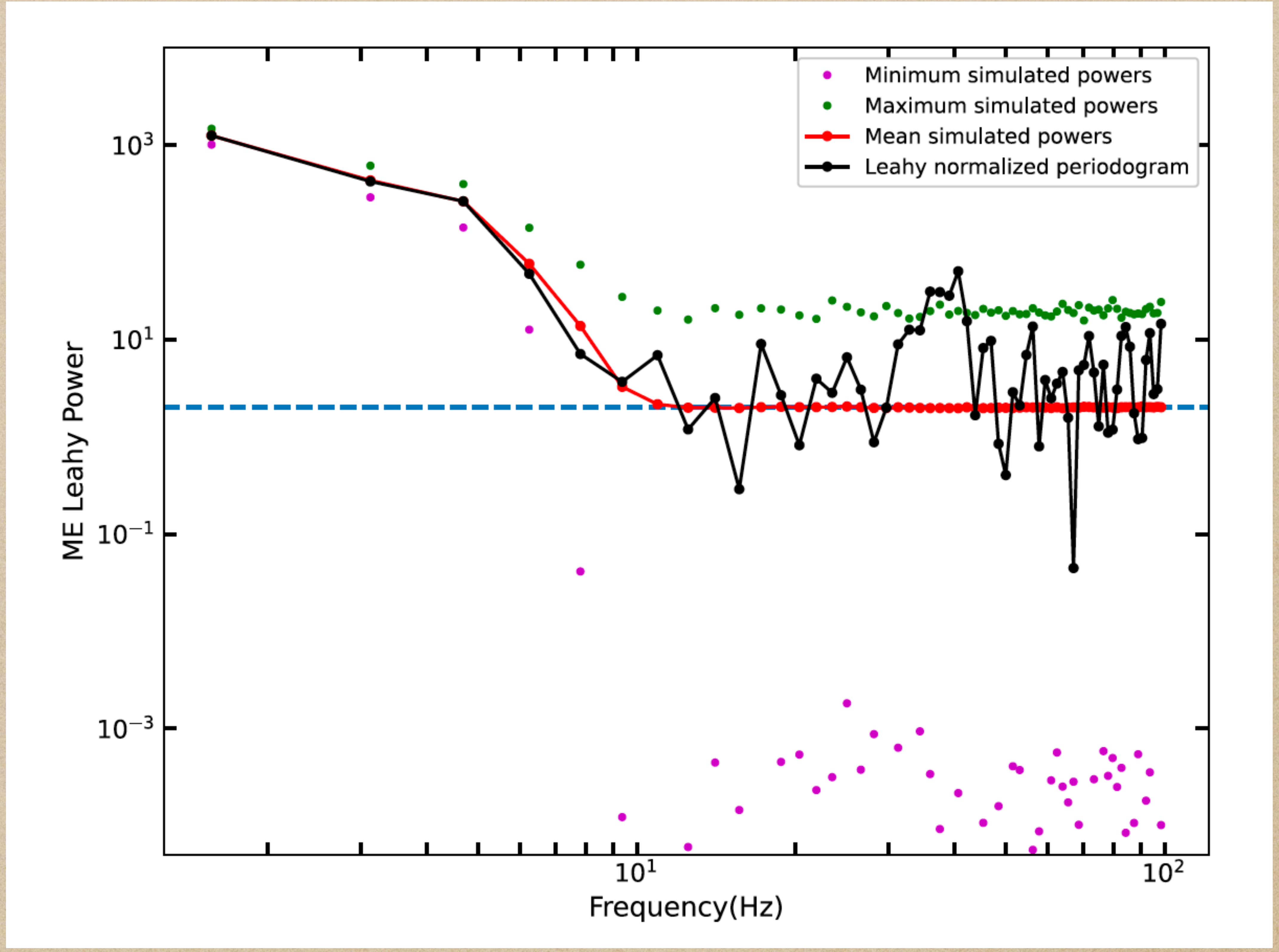
6.7 +/- 0.67 ms 2nd peak

40 Hz QPOs ?

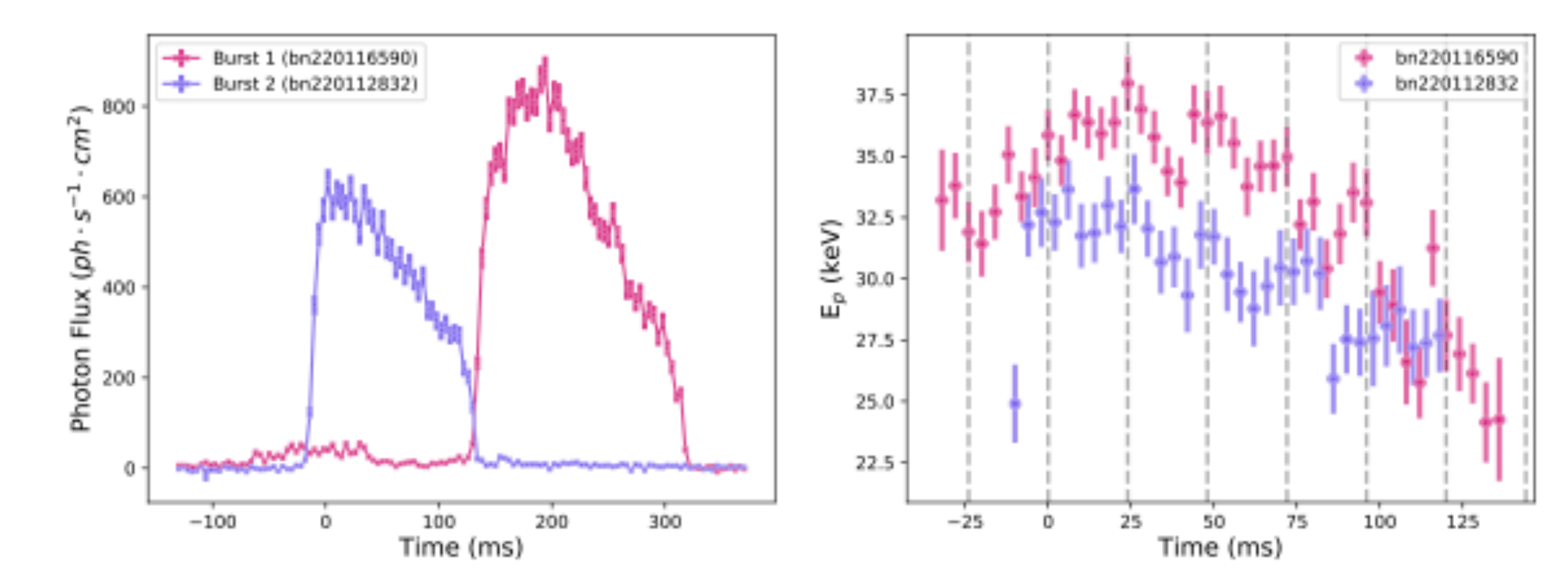
HXMT/ME

Li+22





42 Hz QPOs of Epeak during burst(s) ?! Roberts+ 23

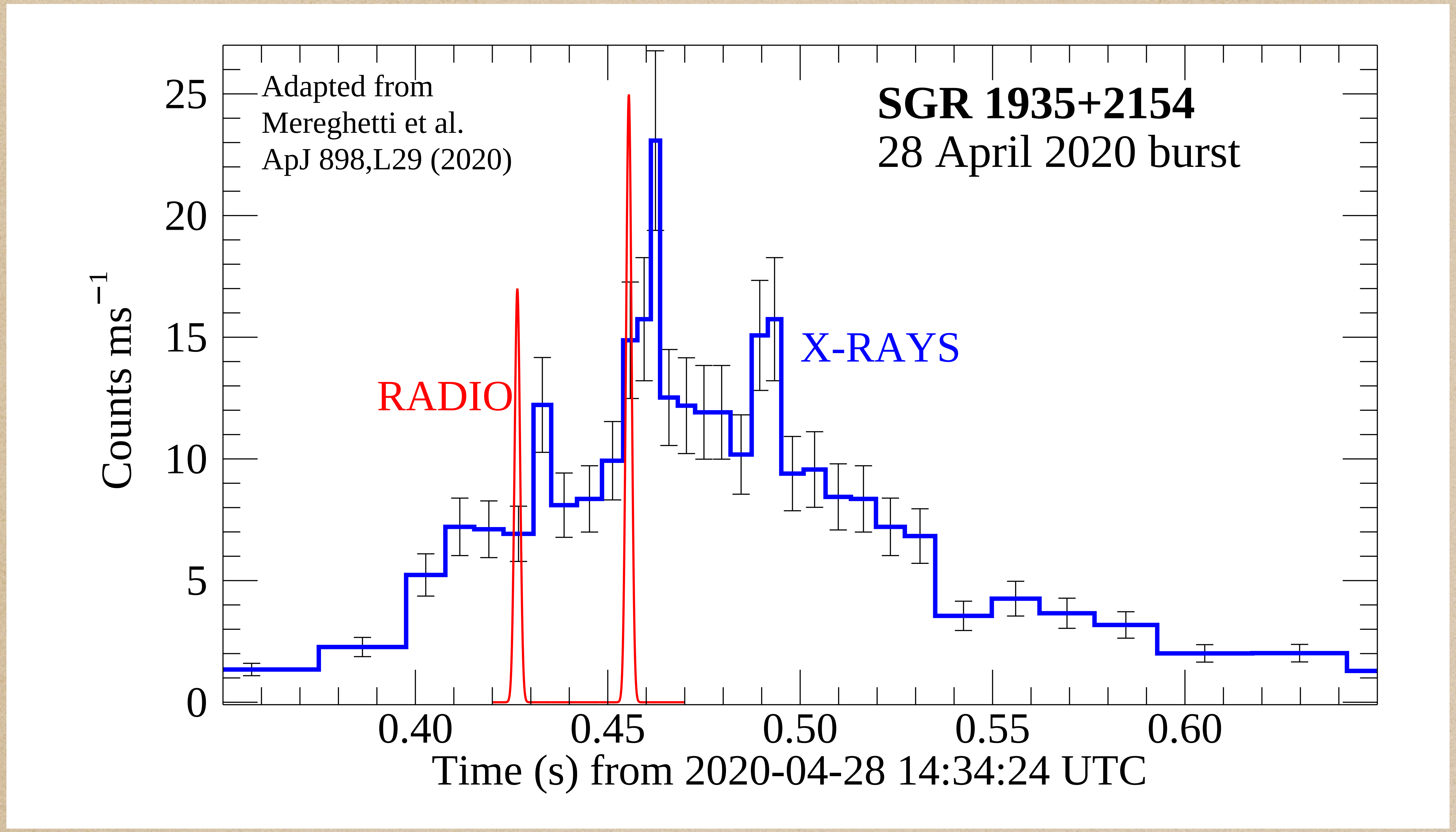


- Narrow X-ray peaks associated to the two radio pulses

- Safe to conclude that X and R coincide within 10 ms

- Delayed by few ms (~ 2 to 7 ?). Precise value affected by low statistics, instrumental effects, spectral variability

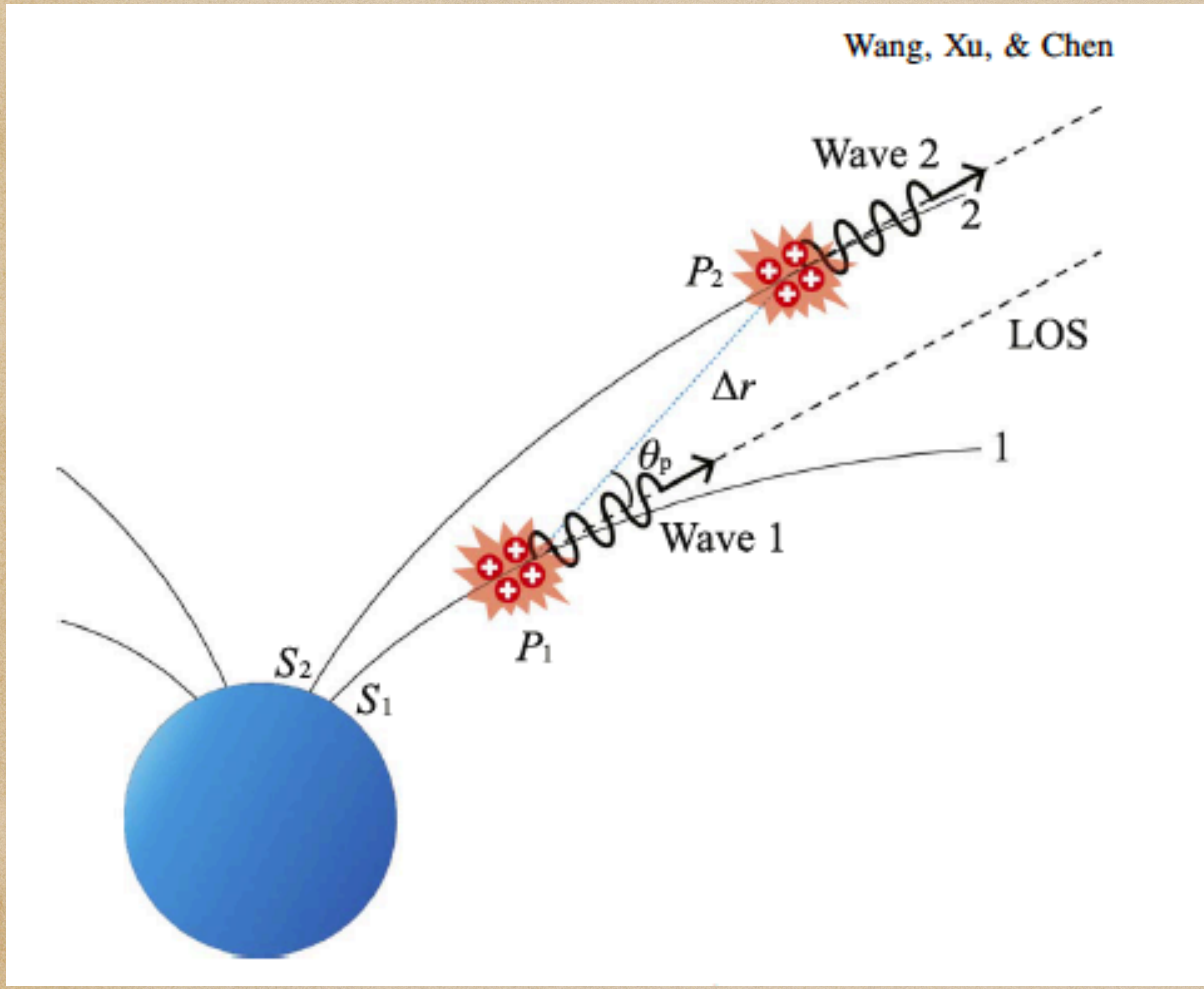
- Two or three X-ray peaks ?



Broad X-ray pulse starts before the radio

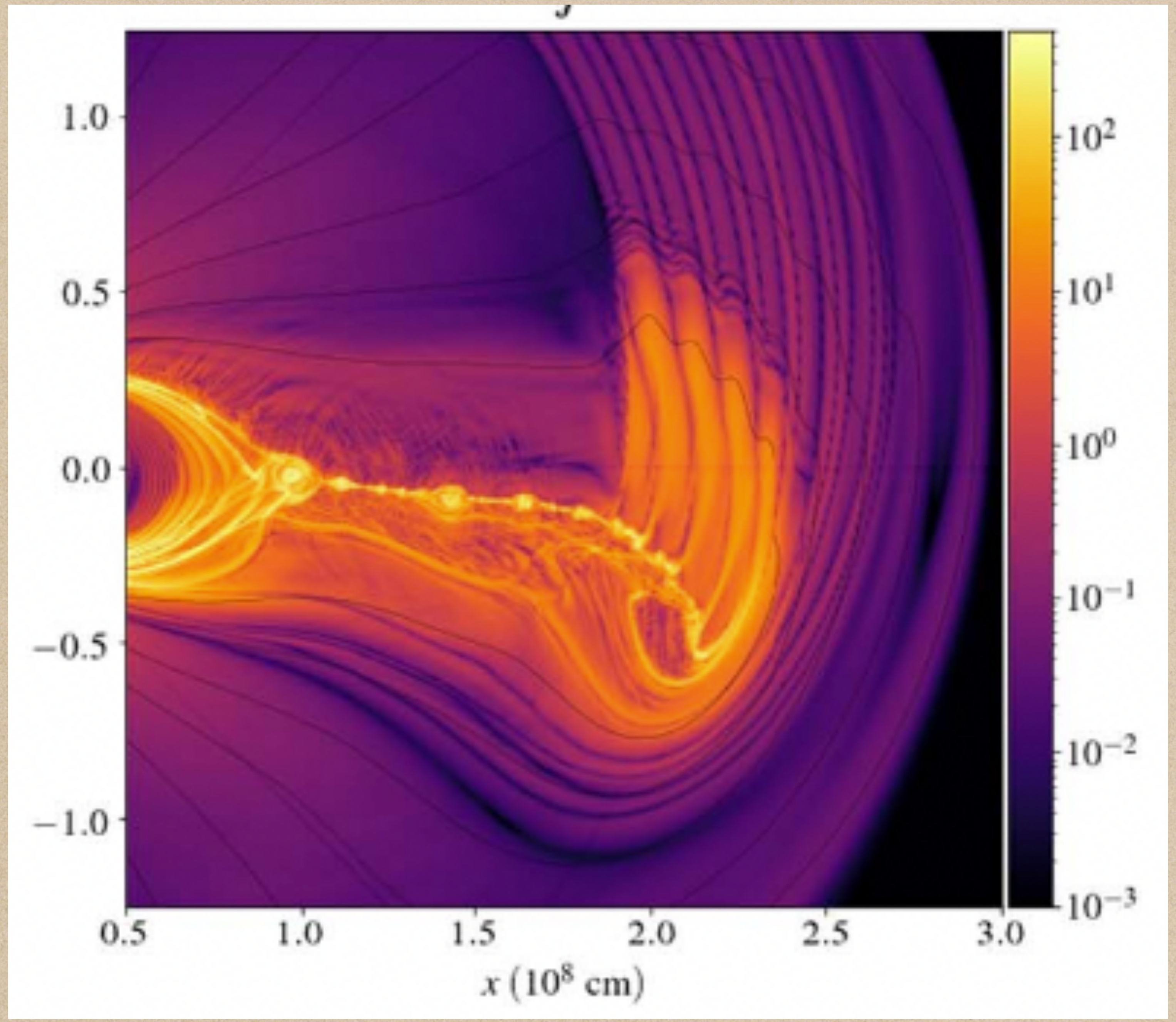
Yamasaki+ 22 : magnetically trapped FB (long thermal pulse) + relativ.outflow (non-thermal spikes & radio) ;

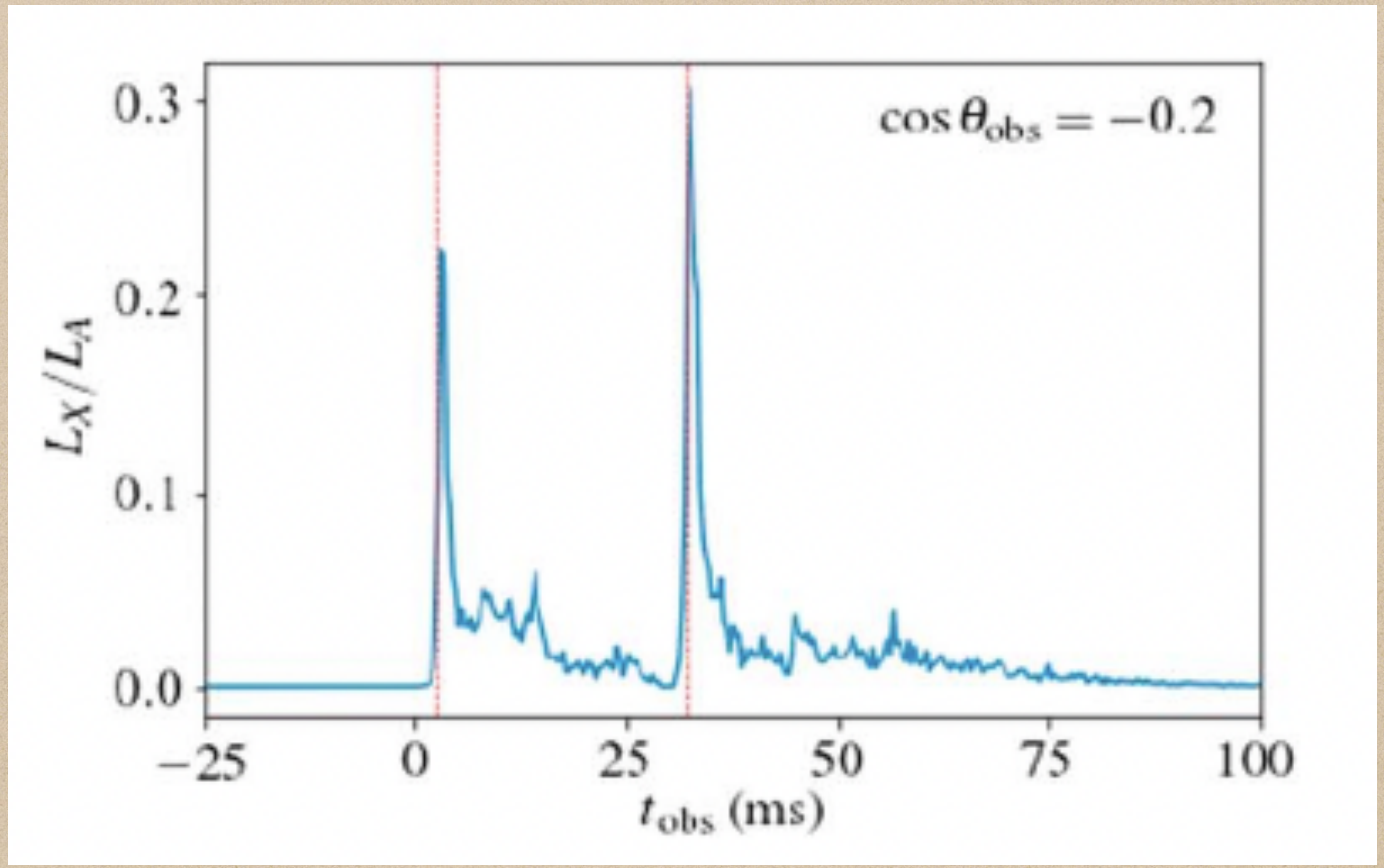
Δxr < 10ms → limits on baryon mass <10^{14} g , Γ~100

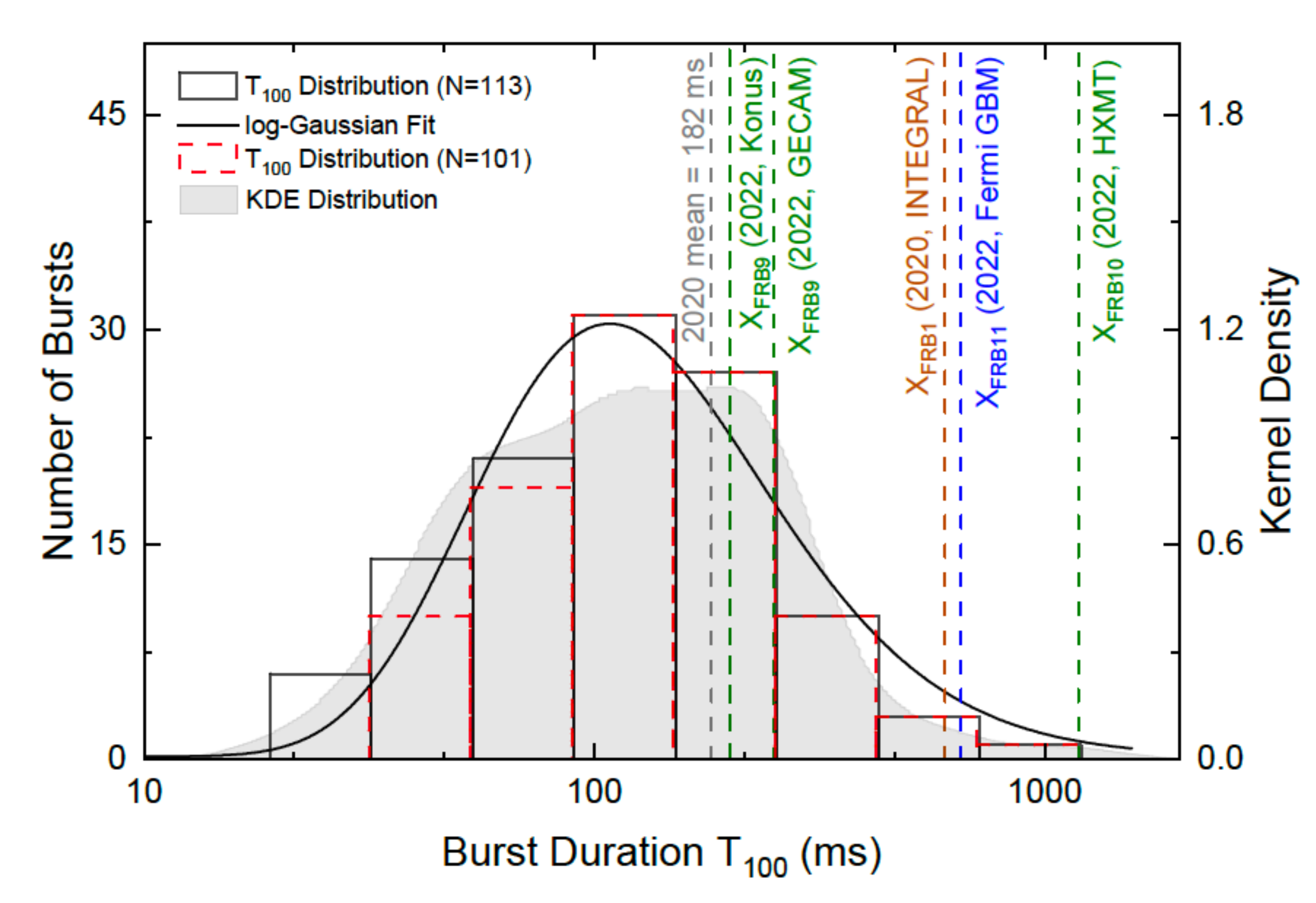


Wang, Xu & Chen 20 : coherent curvature radiation from particle bunches in magnetosphere;
Timing →constraints on field geometry

Yuan, Beloborodov +20 : repeated ejections of relativistic "pancake" plasmoids from Alfvén waves in outer magnetosphere



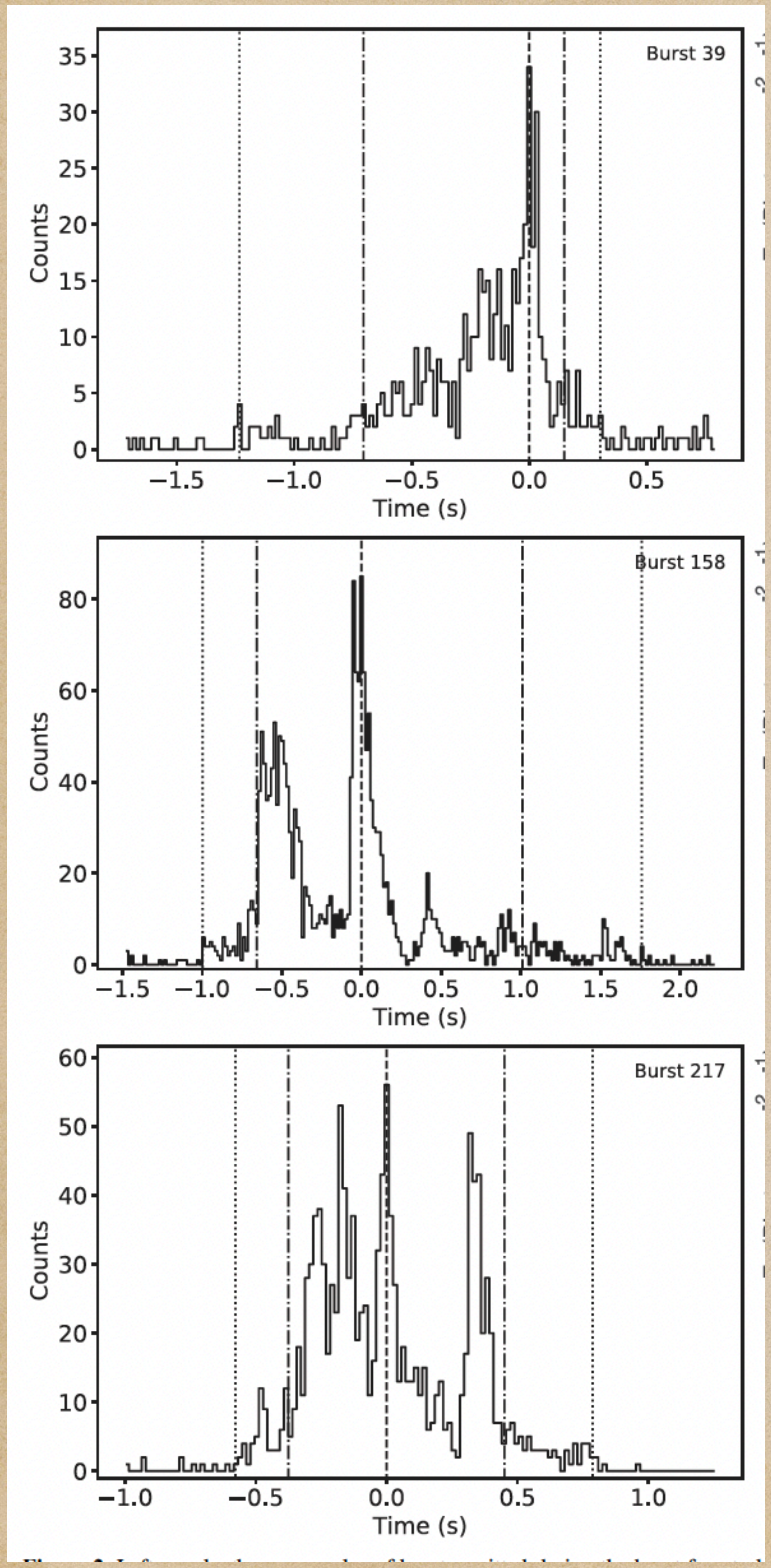




Burst duration distribution

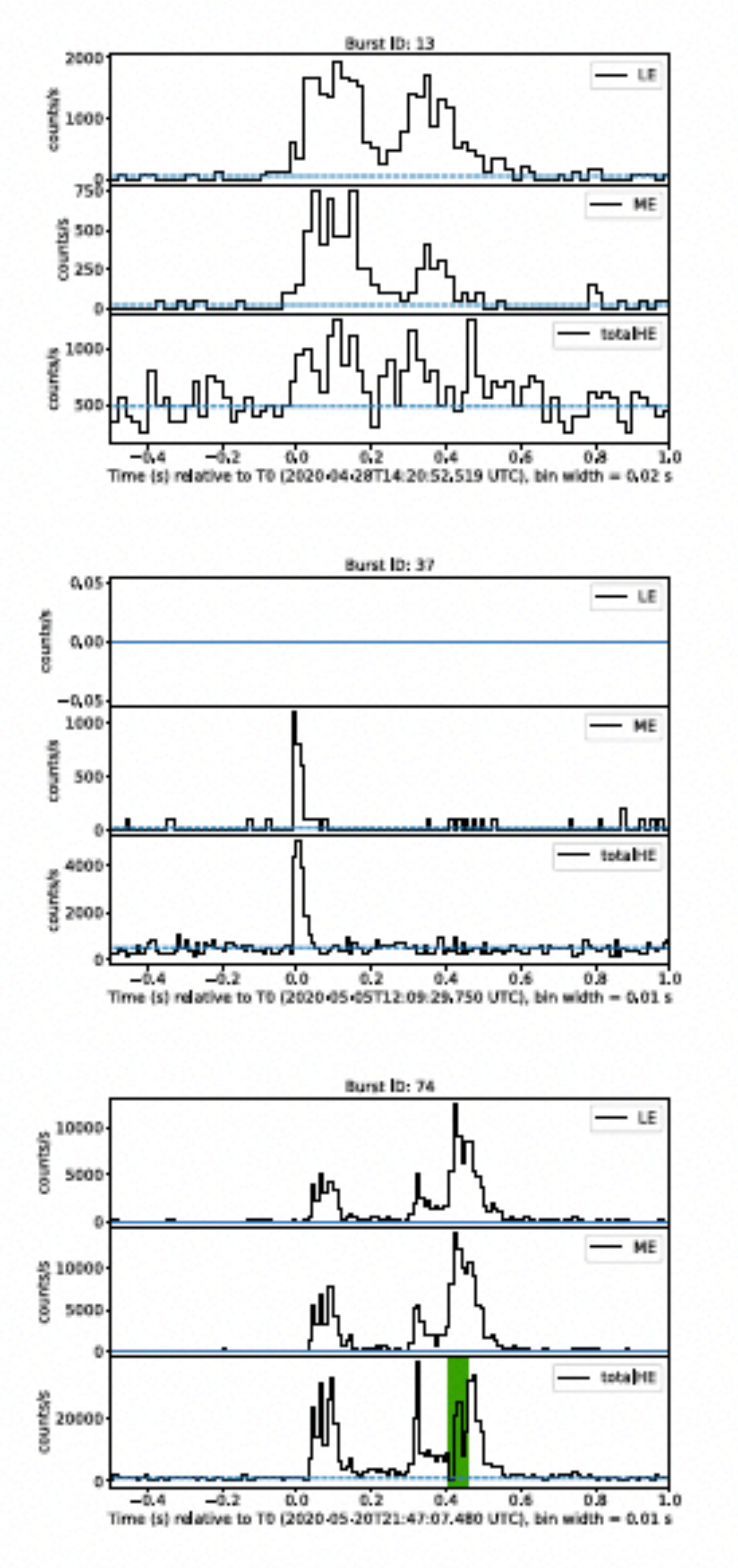
Fermi/GBM

Rehan & Ibrahim 24



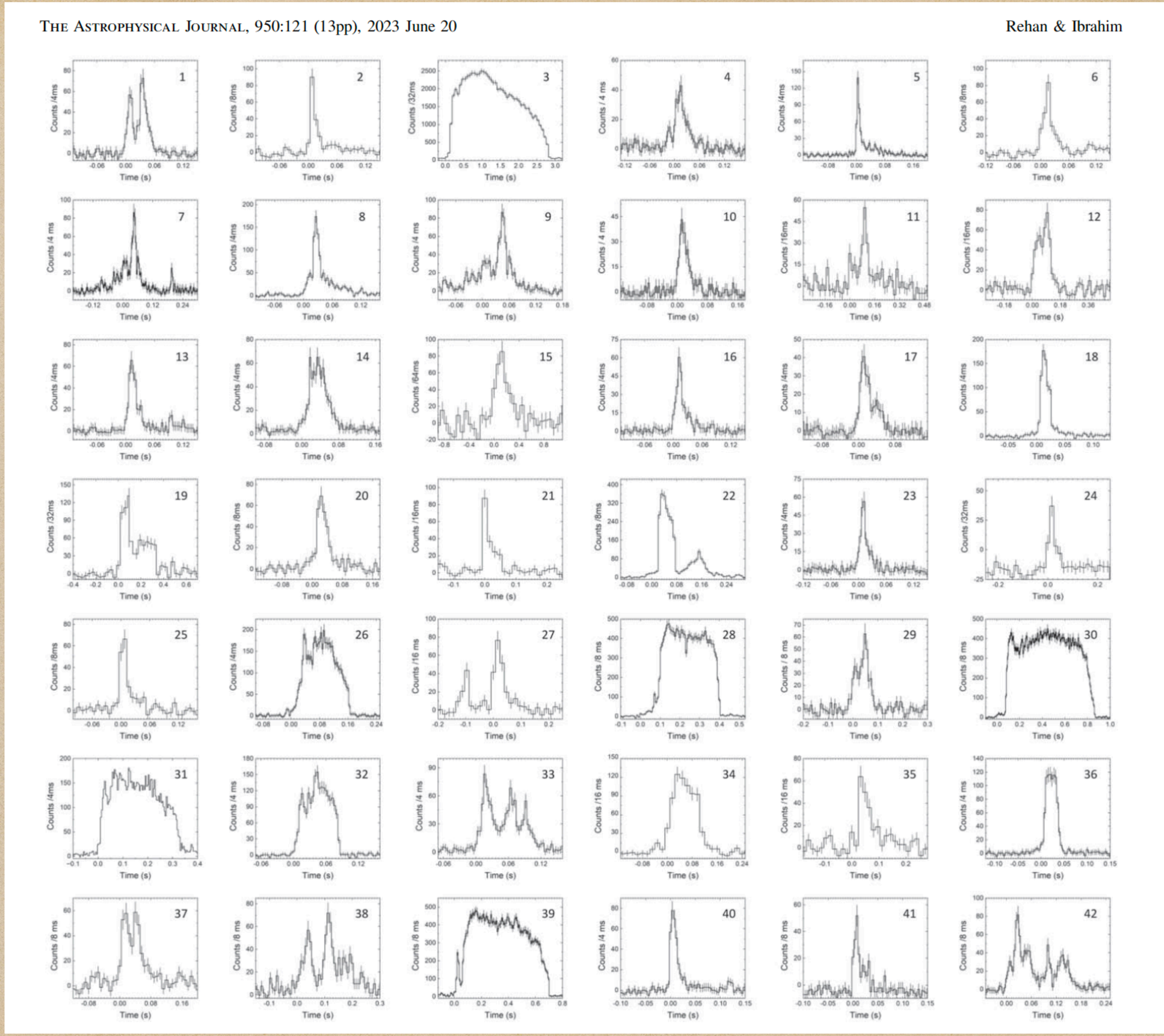
NICER,
1-10 keV

Younes+20



HXMT

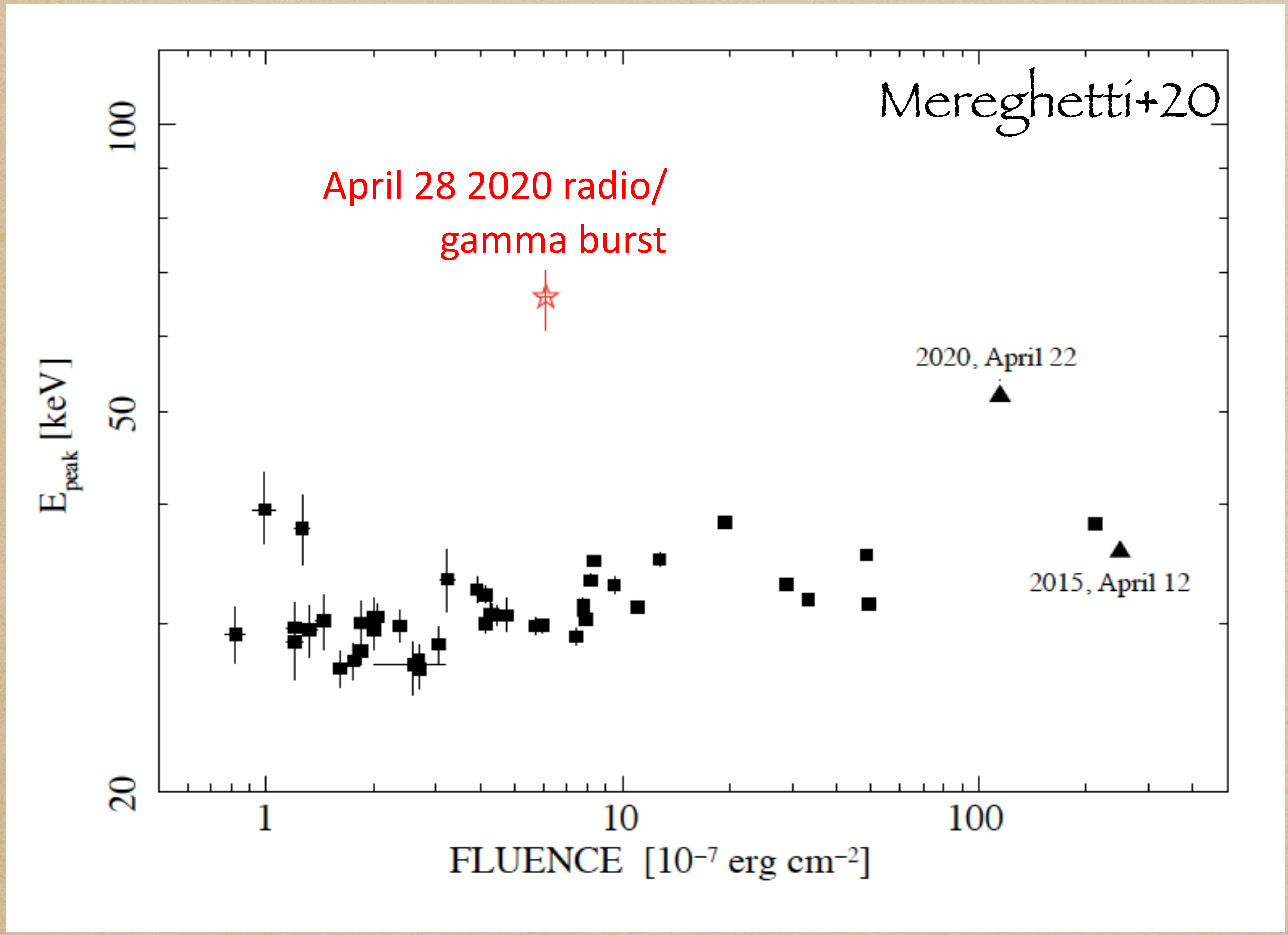
1-10 keV
10-30 keV
28-250 keV
Cai+22

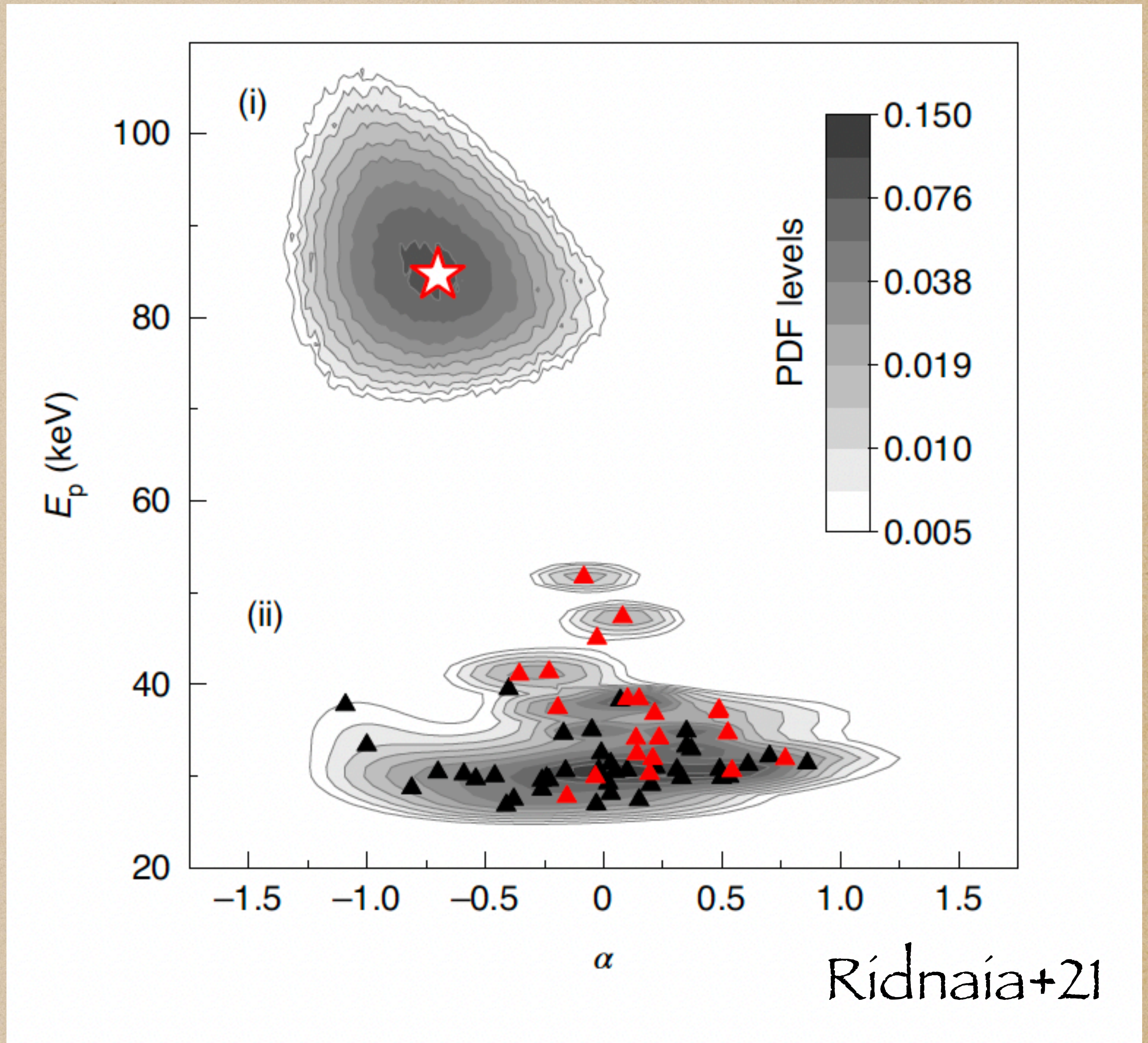


Fermi GBM
8-200 keV
Rehan & Ibrahim +23

Spectroscopy

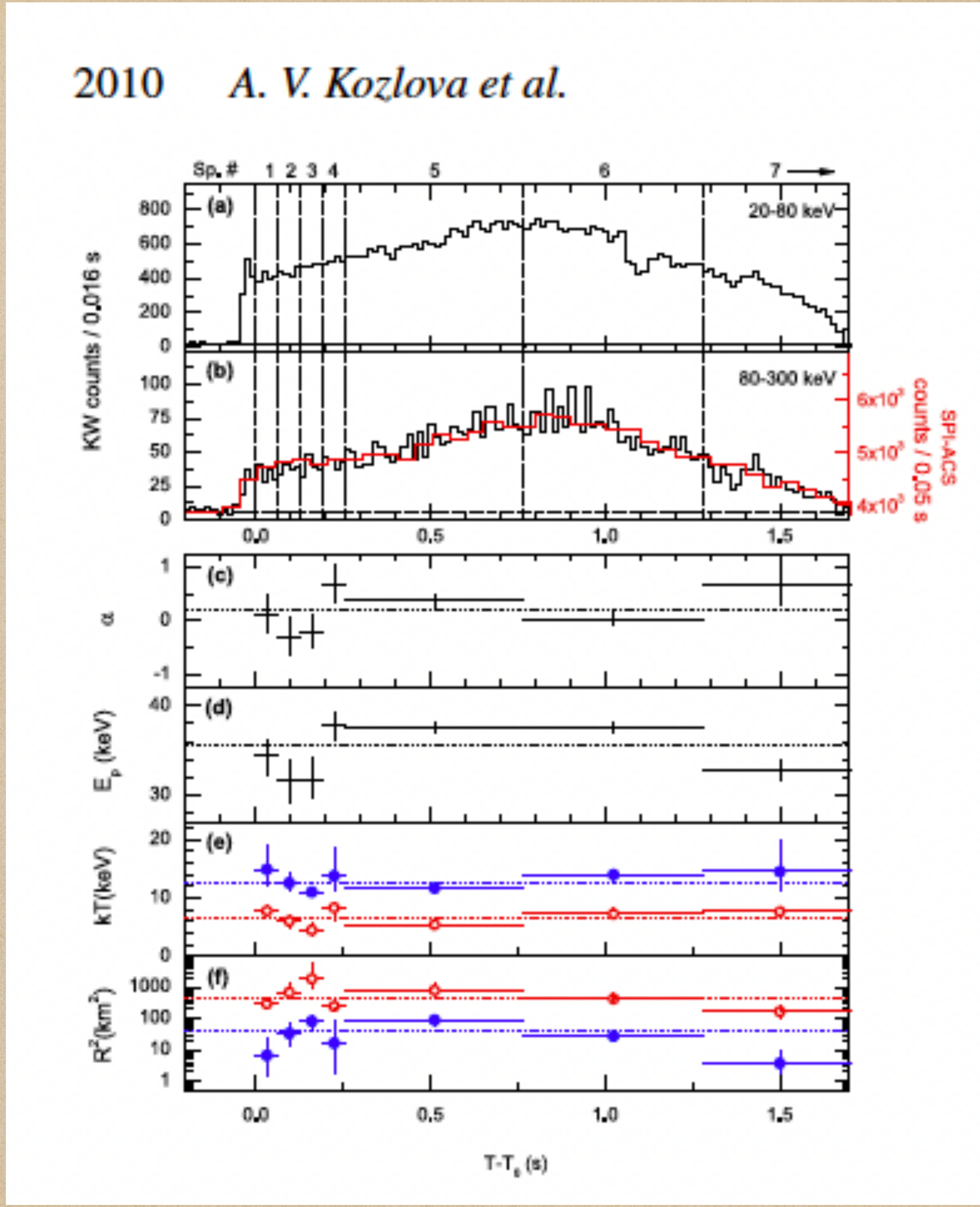
Not particularly energetic but significantly harder than 'normal' bursts from SGR 1935+2154 (and other magnetars)

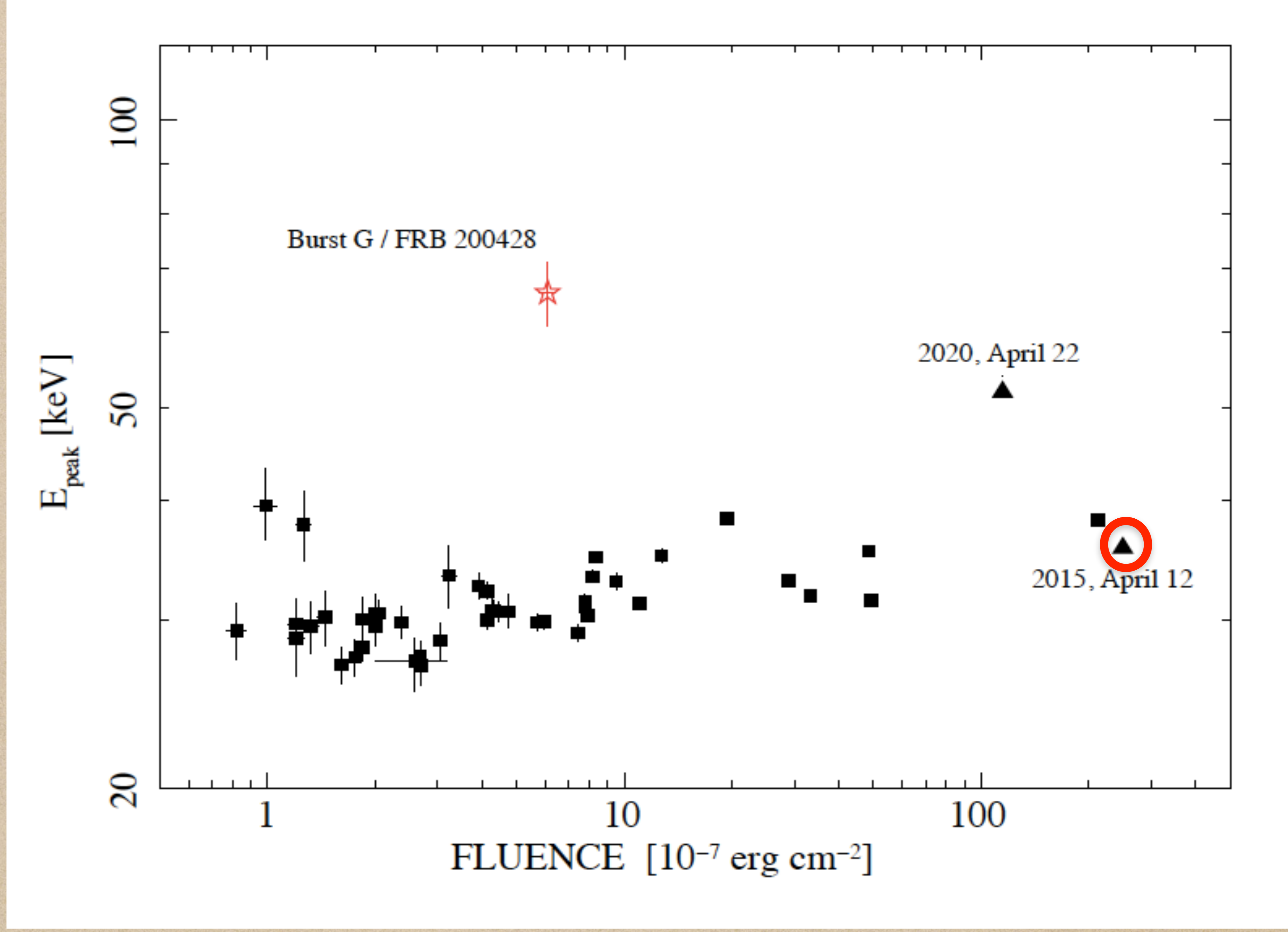


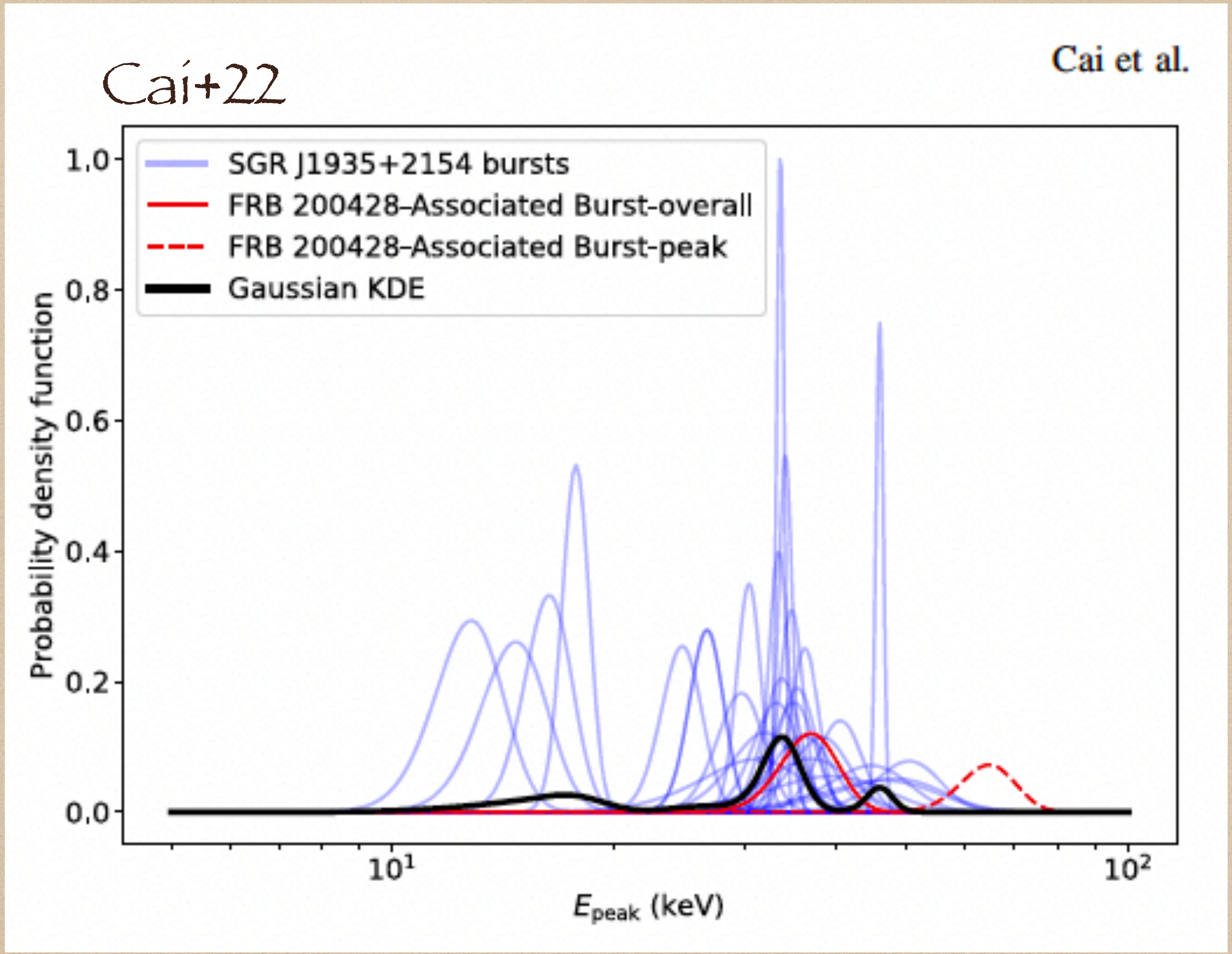


Intermediate flare of Apr 12, 2015

~ 10^{41} erg (for d=5 kpc)

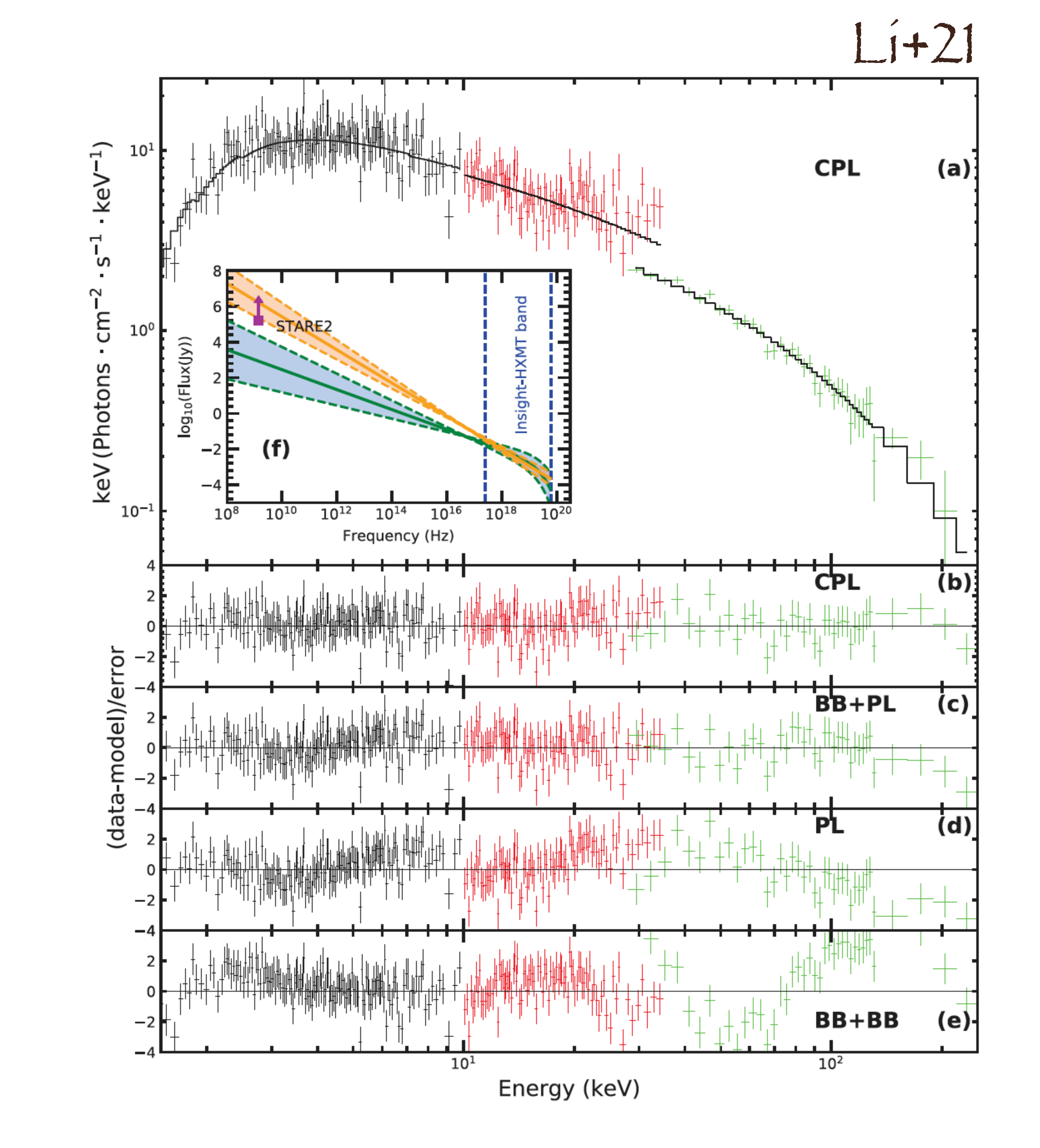


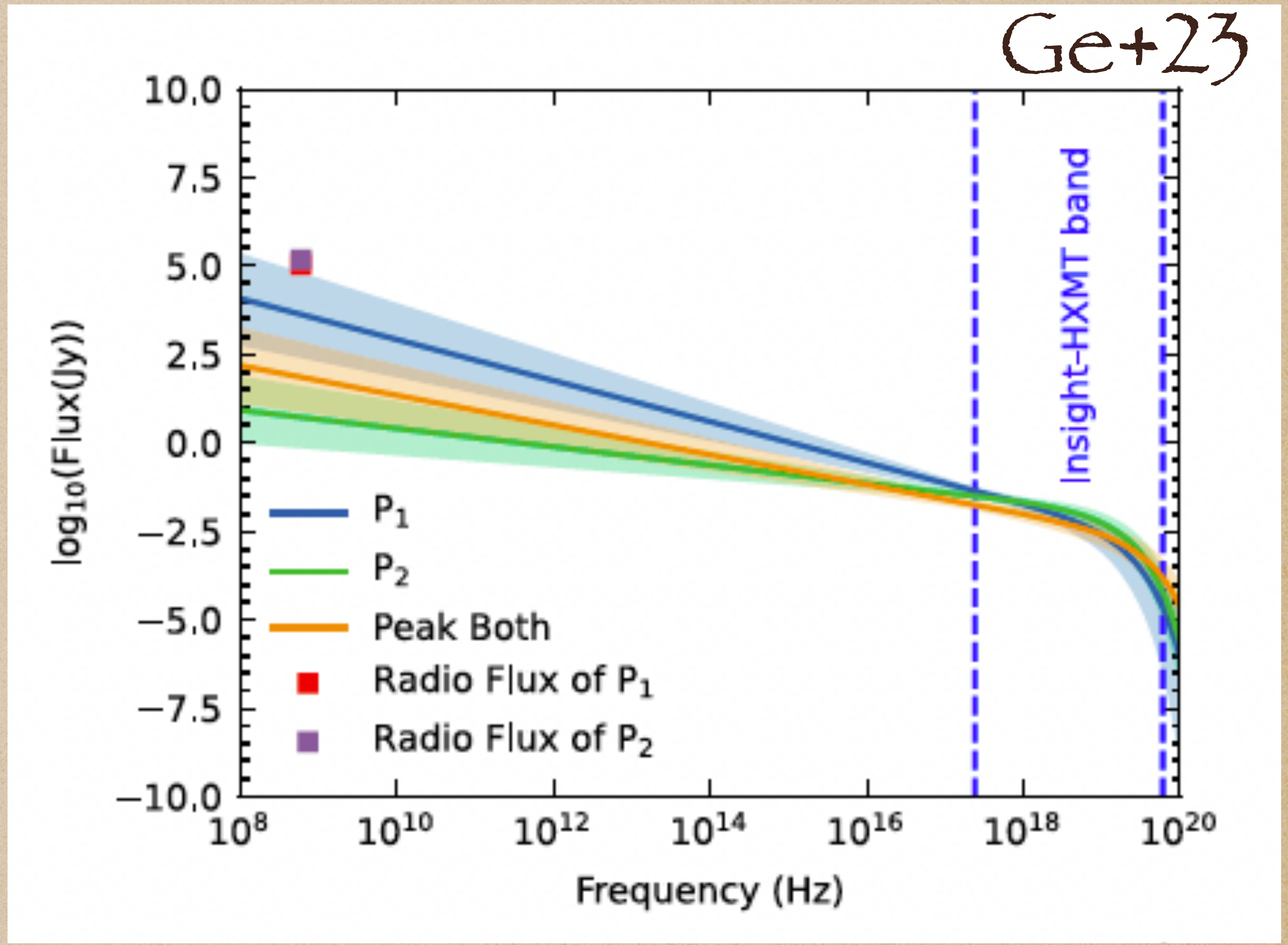




Importance of time resolved spectra

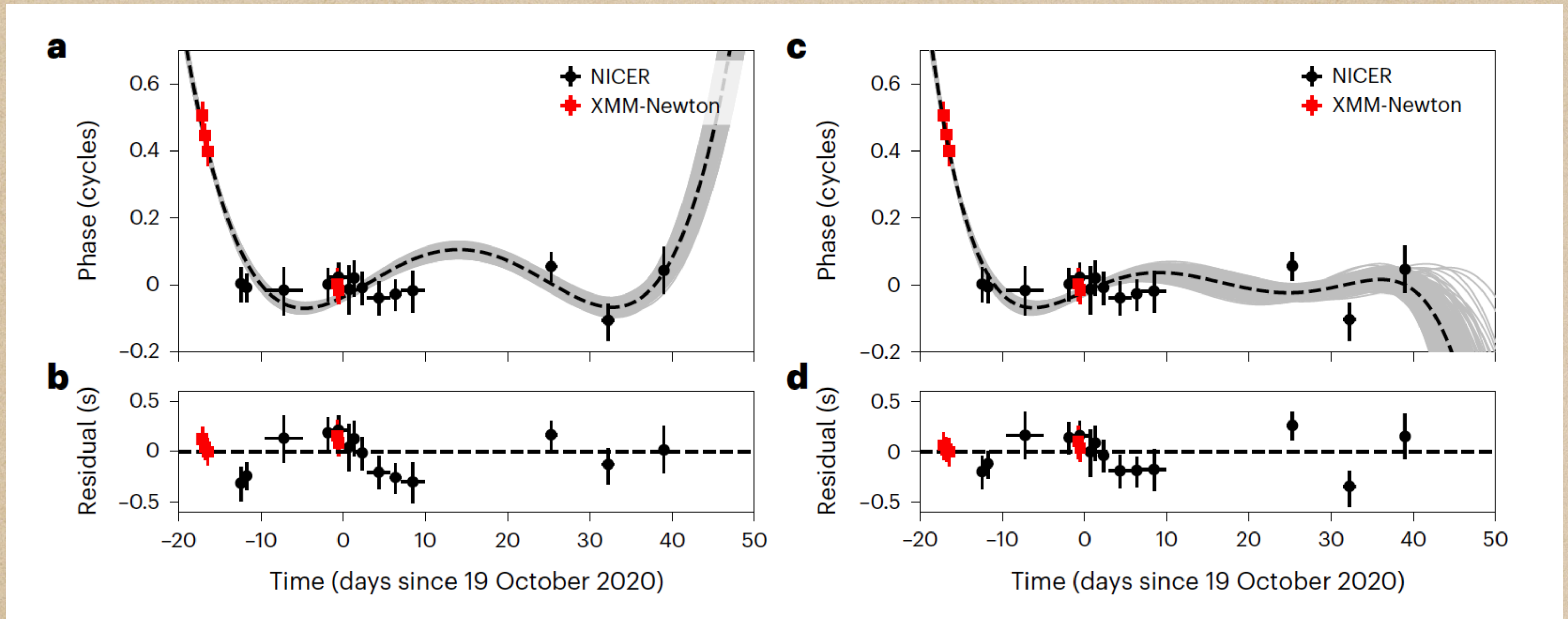
HXMT spectra



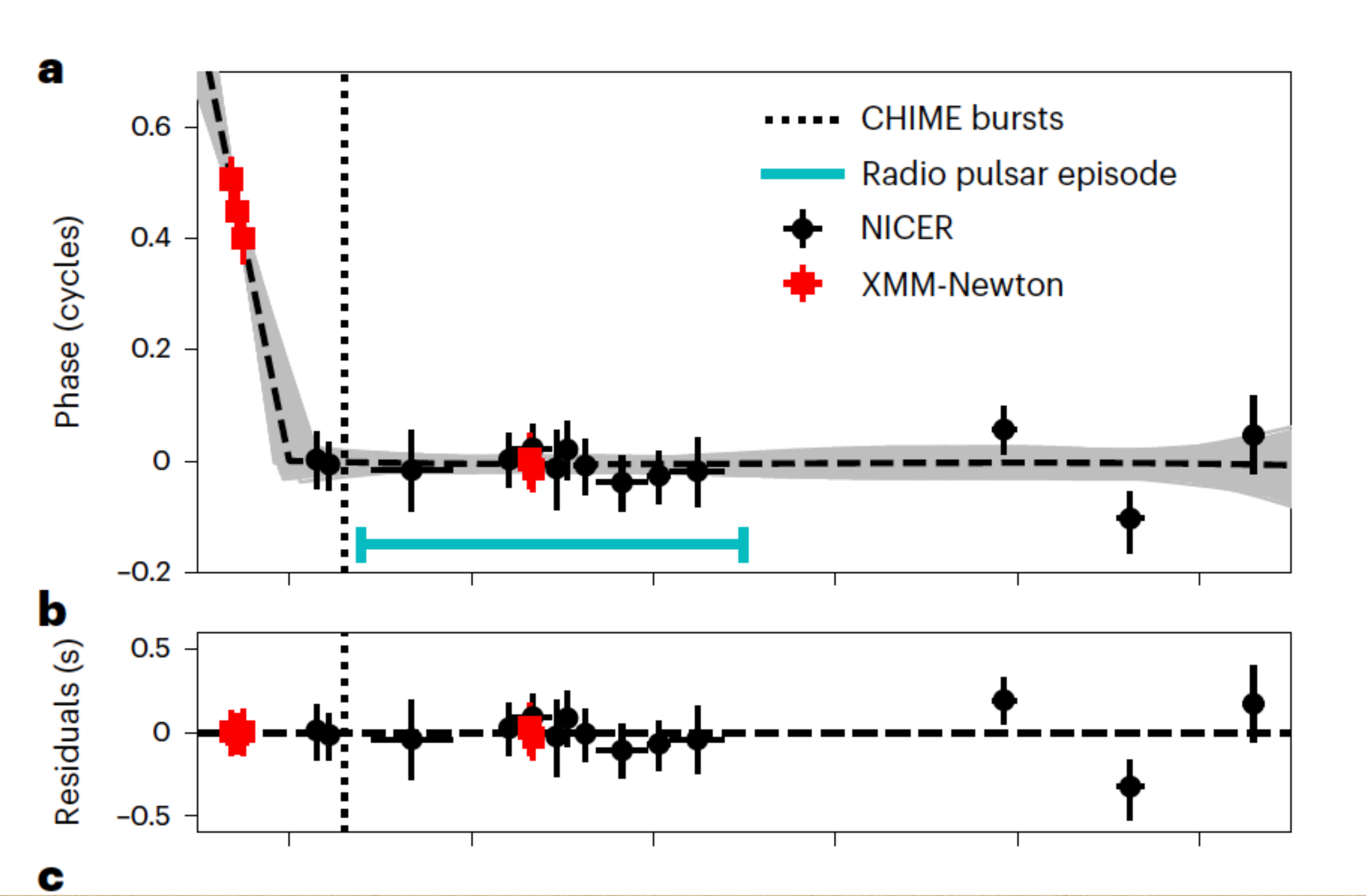


Outbursts / Glitches

2020 October 5 - Glitch (?) before radio PSR phase [Younes+23]

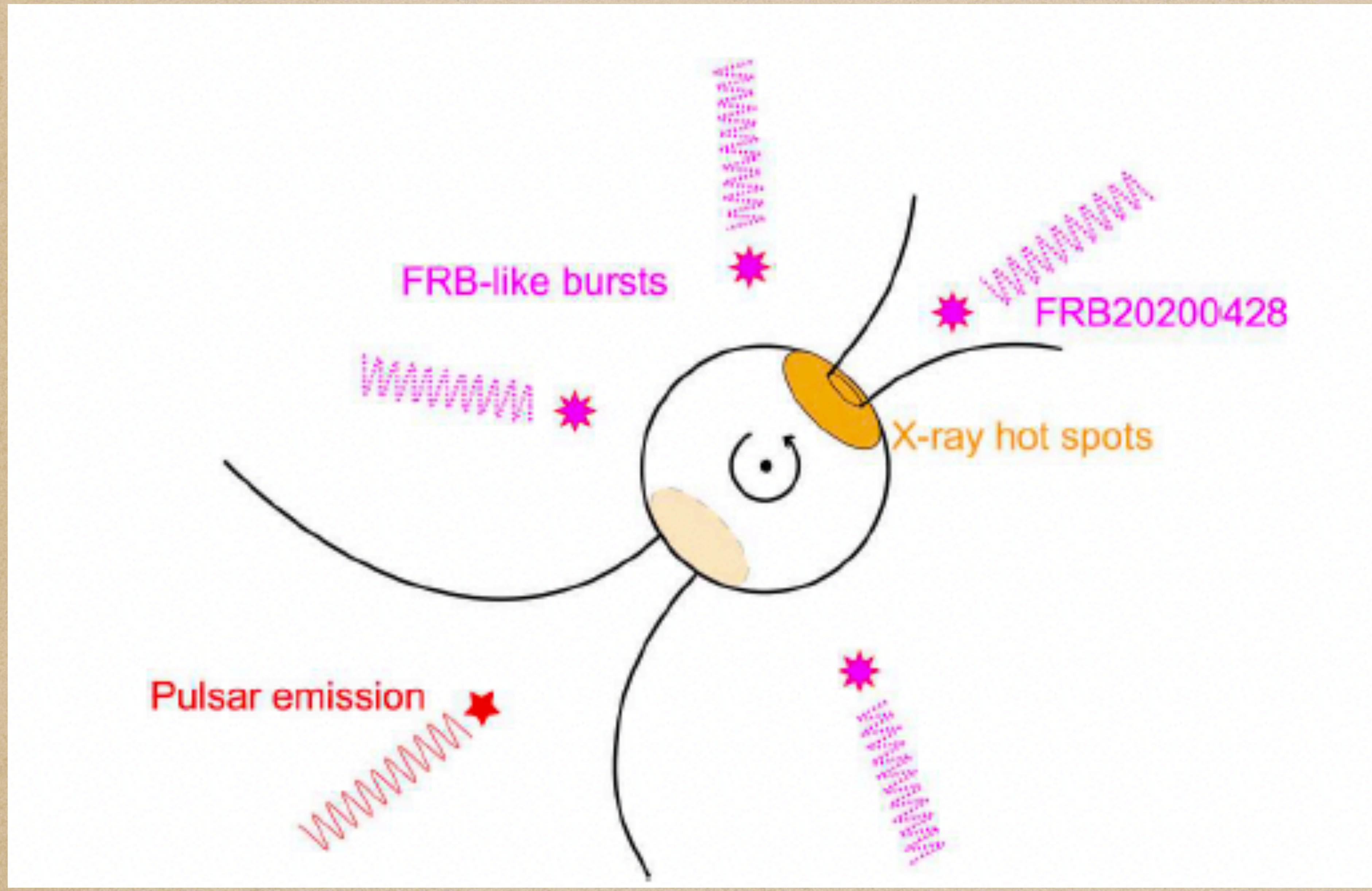


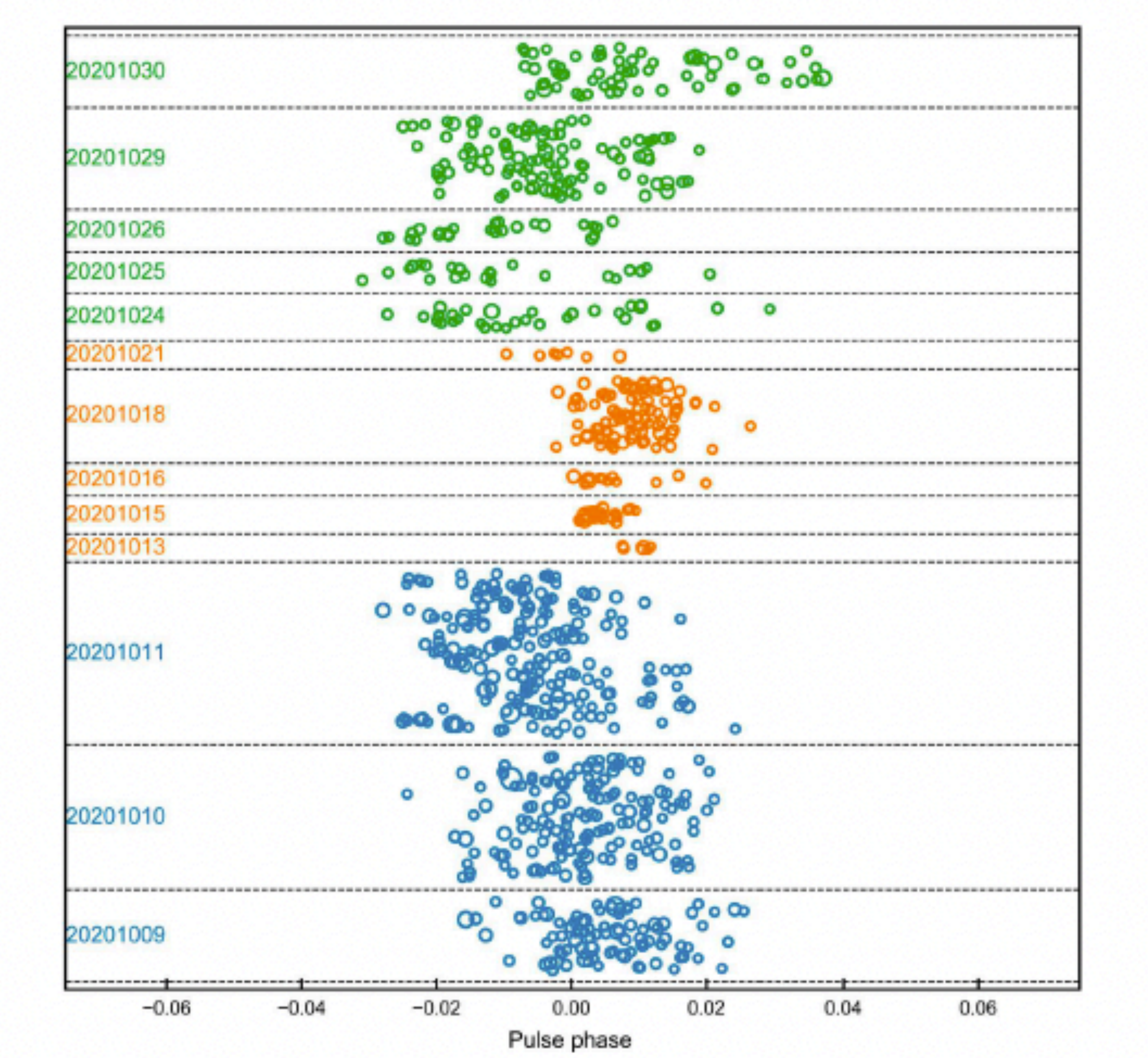
TOA Phase fits with 3 or freq. derivatives



TOA Phase fits with glitch

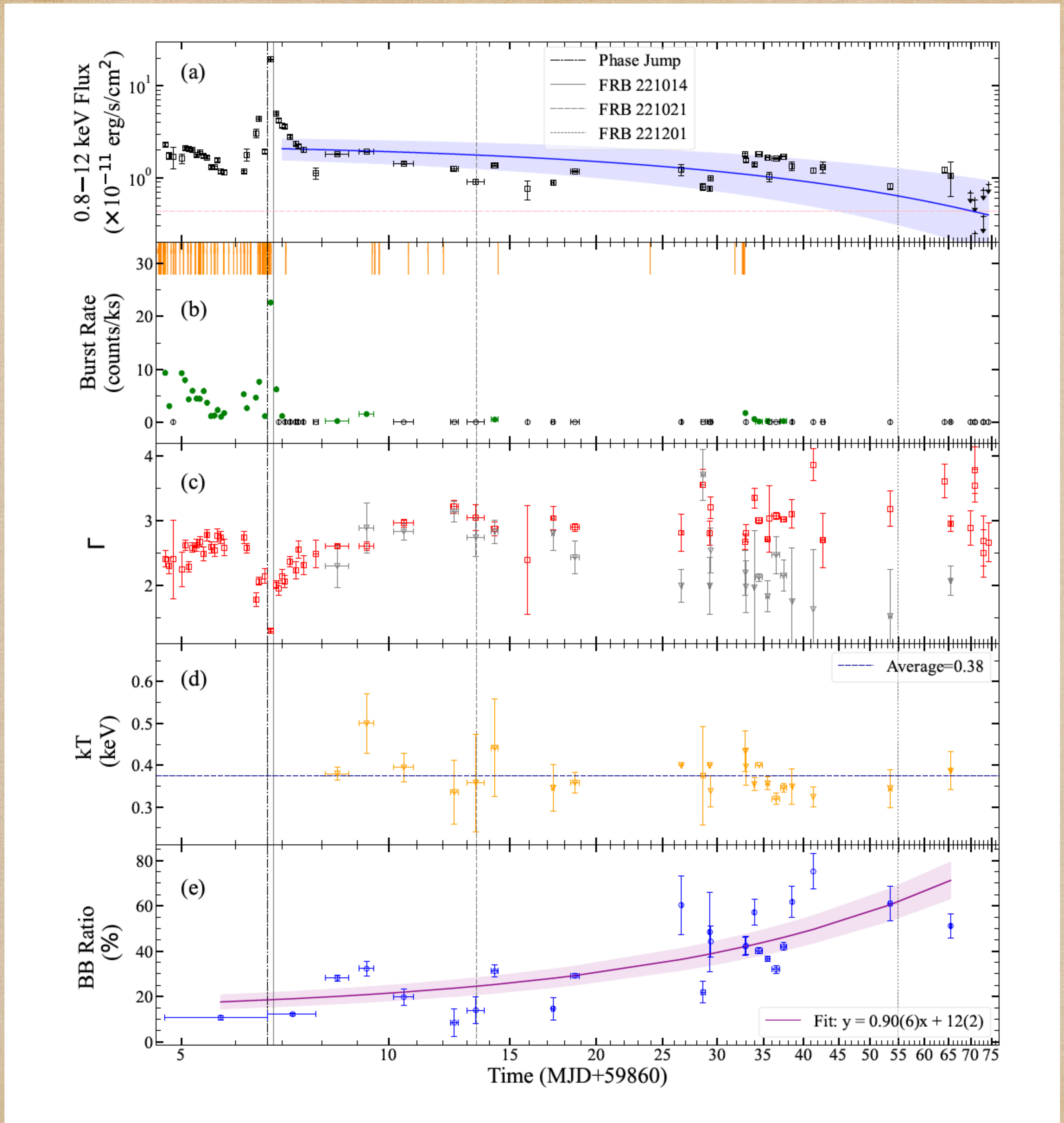
Radio PSR phase - transient: only 16 hr over 13 days
- 8 decades lower flux than burst - pulse in anti phase wrt X-rays
(as also for the polarised pulse of Apr 30, 2020)





Bursts (magnetosph disturbances) / Pulses ('Normal PSR emission, in open field lines)

Zhu+ 2023



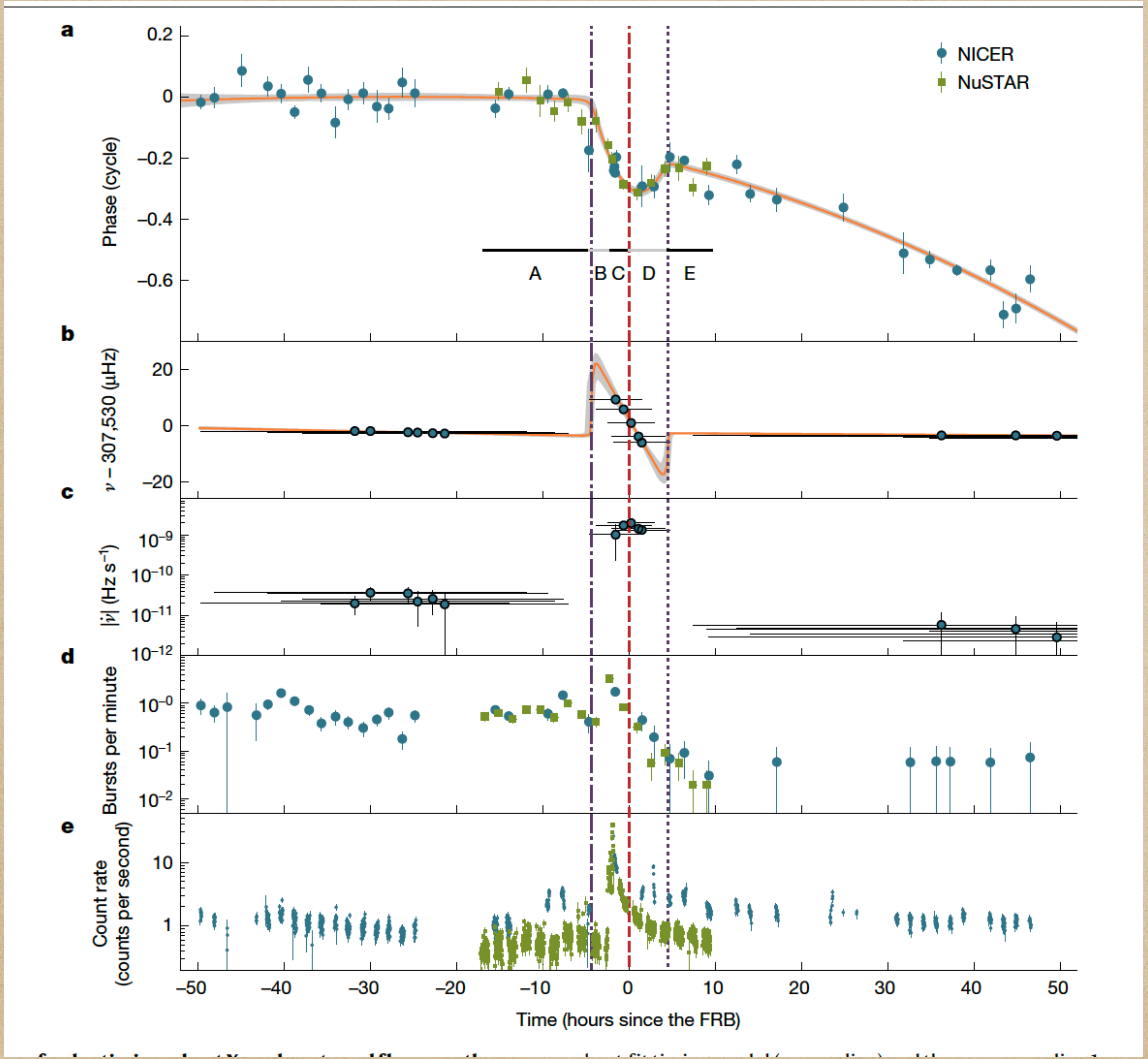
2022 October outburst

NICER

Yu-Cong+24

Flux decay dominated by hard component decrease

2022 Oct 14 - FRB and glitches (Hu+23)



Two spin-up glitches bracket a rapid spin-down phase around the radio burst.

"We postulate that a strong, ephemeral, magnetospheric wind11 provides the torque that rapidly slows the star's rotation. Thetrigger for the first glitch couples the star's crust to its magnetosphere, enhances the various X-ray signals and spawns the wind that alters magnetospheric conditions that might produce the FRB"

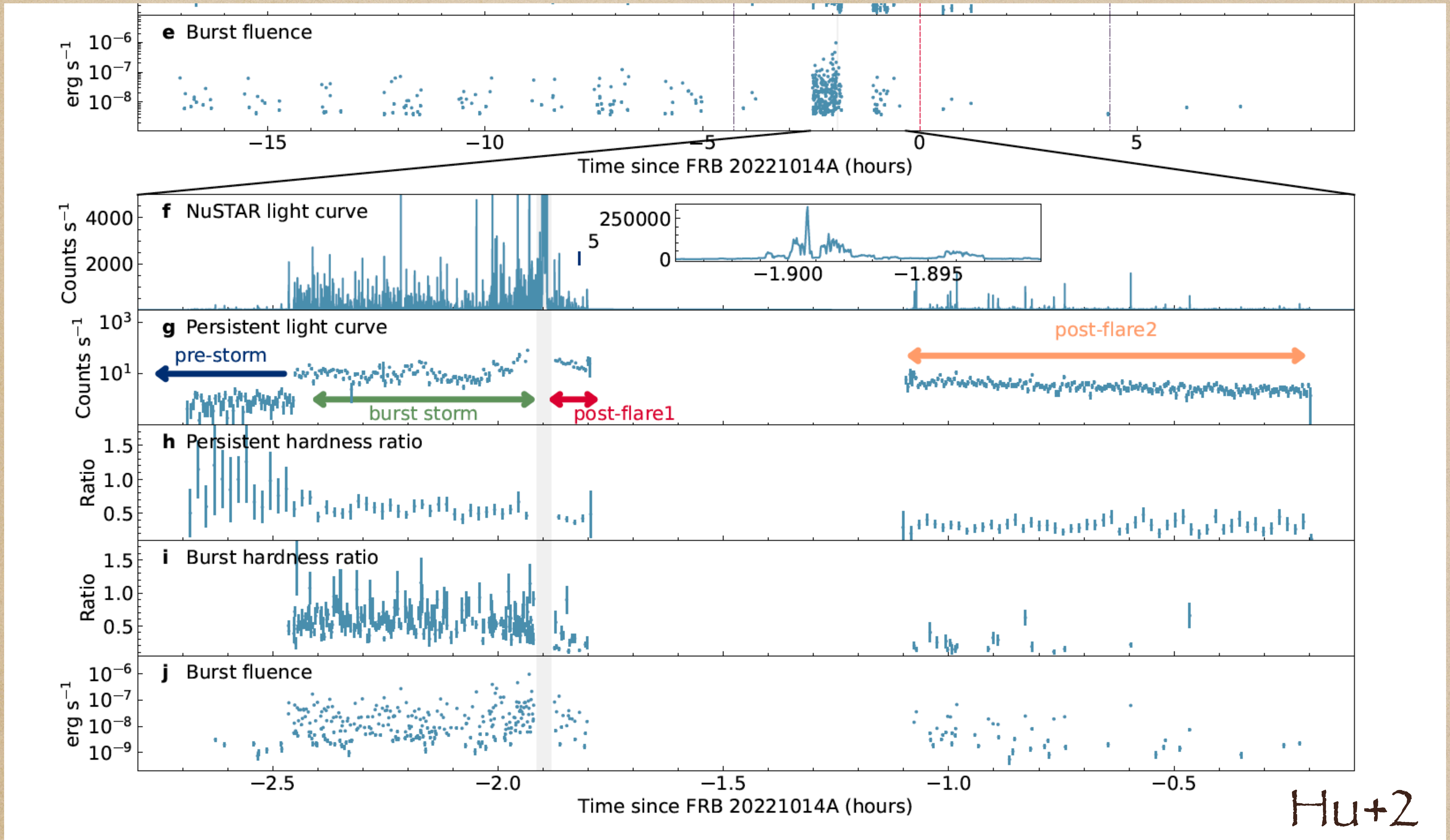
CHIME bursts from SGR 1935 [Giri+23]

Table 3. MCMC based estimates of model parameters for the radio bursts from SGR 1935+2154. The estimates correspond to the median of converged MCMC samples. The uncertainty on time, flux, fluence and *DI* are 1σ standard deviation of the samples. For DM, width, scattering and *SI* we report the 68% highest density interval.

Properties	FRB 20200428D [a]		FRB 20201008B	FRB 20201008D	FRB 20201008C [b]	FRB 20221014A	FRB 20221201A
UTC Date	2020-04-28		2020-10-08	2020-10-08	2020-10-08	2022-10-14	2022-12-01
Time [c]	14:34:24.4080(6)	14:34:24.4370(5)	02:23:33.3578(8)	02:23:35.307(1)	02:23:36.261(3)	19:21:39.130(2)	22:06:59.0762(6)
DM [pc cm^{-3}] [d]	$332.77^{+0.08}_{-0.08}$		$332.50^{+0.13}_{-0.11}$	$332.09^{+0.19}_{-0.20}$	$332.67^{+0.12}_{-0.13}$	$332.72^{+0.26}_{-0.30}$	$333.11^{+0.09}_{-0.08}$
Width [ms]	$0.66^{+0.05}_{-0.05}$	$0.33^{+0.07}_{-0.08}$	$0.23^{+0.02}_{-0.04}$	$0.29^{+0.08}_{-0.11}$	$1.03^{+0.92}_{-0.97}$	$1.48^{-0.25}_{-0.25}$	$2.02^{+0.05}_{-0.04}$
Peak Flux	110 kJy	150 kJy	266 ± 64 Jy	16.3 ± 3.9 Jy	1.8 ± 0.7 Jy	2.1 ± 1.4 kJy	3.8 ± 3.0 kJy
Fluence	420 kJy ms	220 kJy ms	966 ± 239 Jy ms	34.1 ± 8.1 Jy ms	5.9 ± 1.7 Jy ms	9.7 ± 6.7 kJy ms	23.7 ± 18.0 kJy ms
Hour Angle [deg]	22°		-0.5°	-0.5°	-0.5°	-99.8°	-11.1°
Beam ID [e]	2068		0062	0059	0059	0181	3061
Scattering [ms] [f]	$0.76^{+0.09}_{-0.10}$		$0.72^{+0.08}_{-0.09}$	$0.52^{+0.08}_{-0.09}$	$1.13^{+0.5}_{-0.8}$	$0.93^{+0.35}_{-0.45}$	$0.92^{+0.11}_{-0.12}$
Dispersion index	−1.9998(2)		−2.0004(3)	−2.0014(5)	−2	−2.000(1)	−1.99934(23)
Scattering Index	$-3.96^{+0.35}_{-0.37}$		$-3.70^{+0.46}_{-0.34}$	$-4.27^{+0.45}_{-0.45}$	−4	$-3.92^{+0.45}_{-0.54}$	$-2.62^{+0.32}_{0.30}$

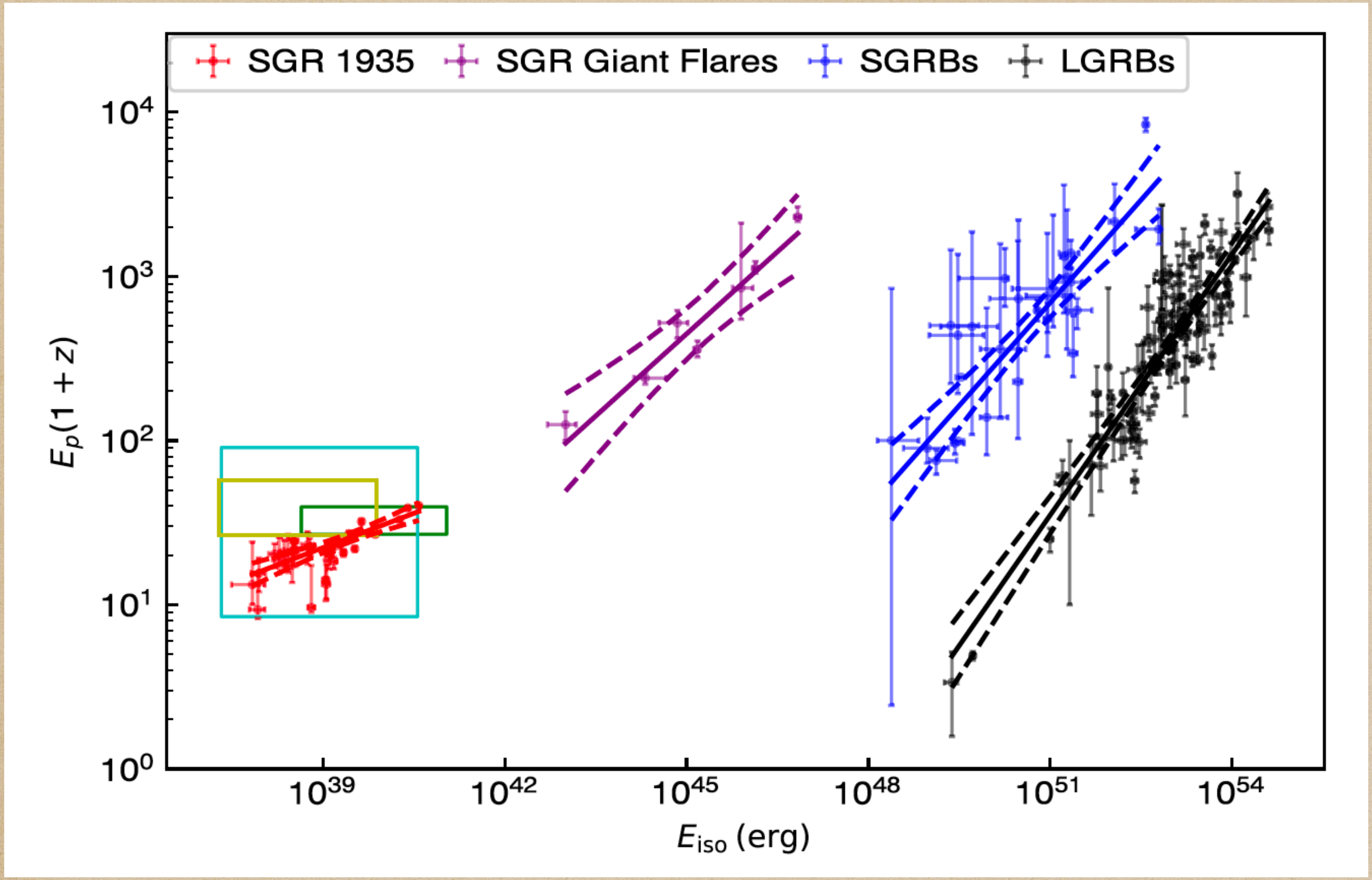
Three within one rotation period

Oct 10 with X-rays (KW, Gecam)



Hu+2

Spectral softening (burst and persistent em.) induced by IF ?



E_peak - E_iso
(Amati Relation)

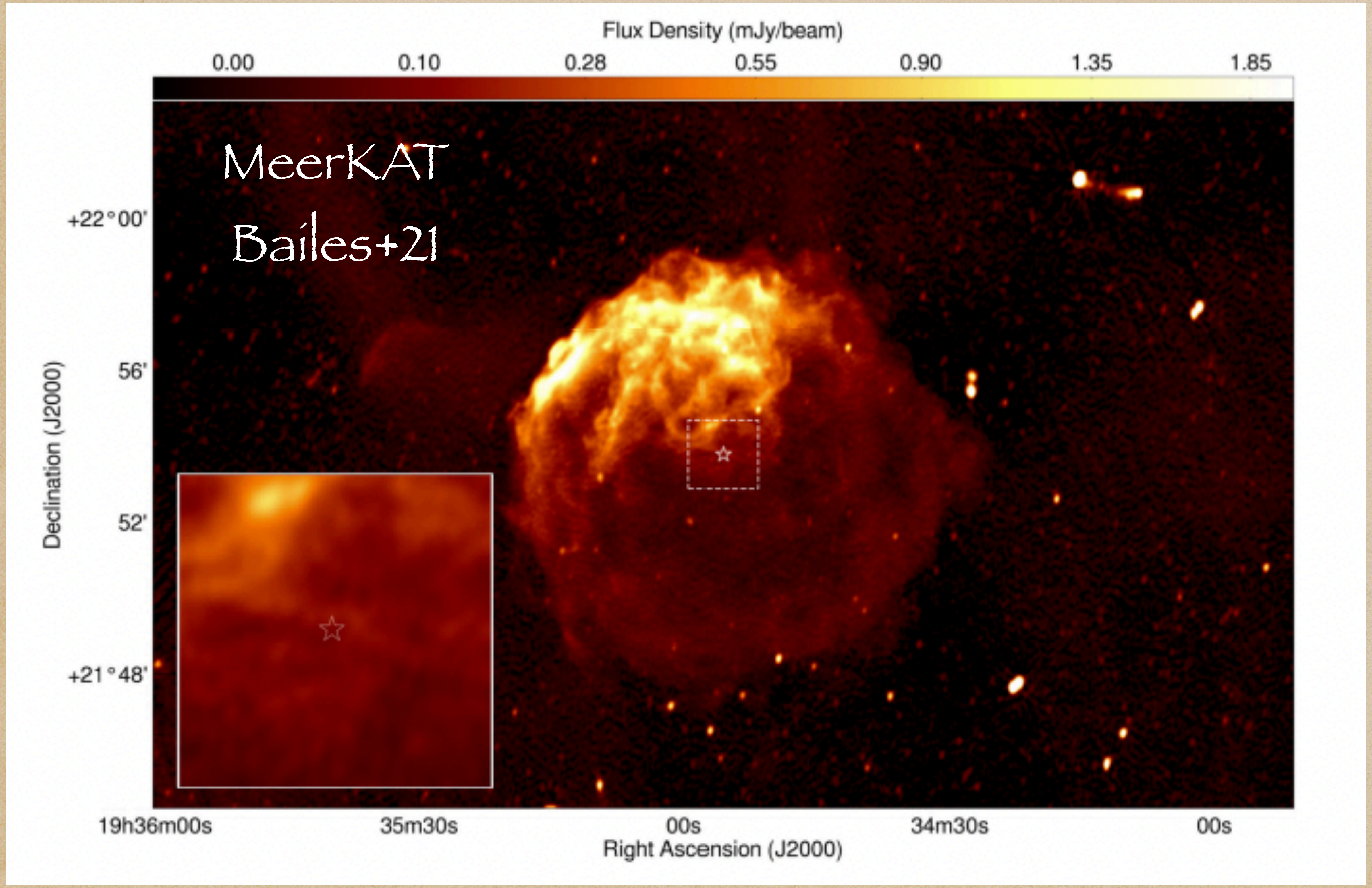
Yang+21

Distance

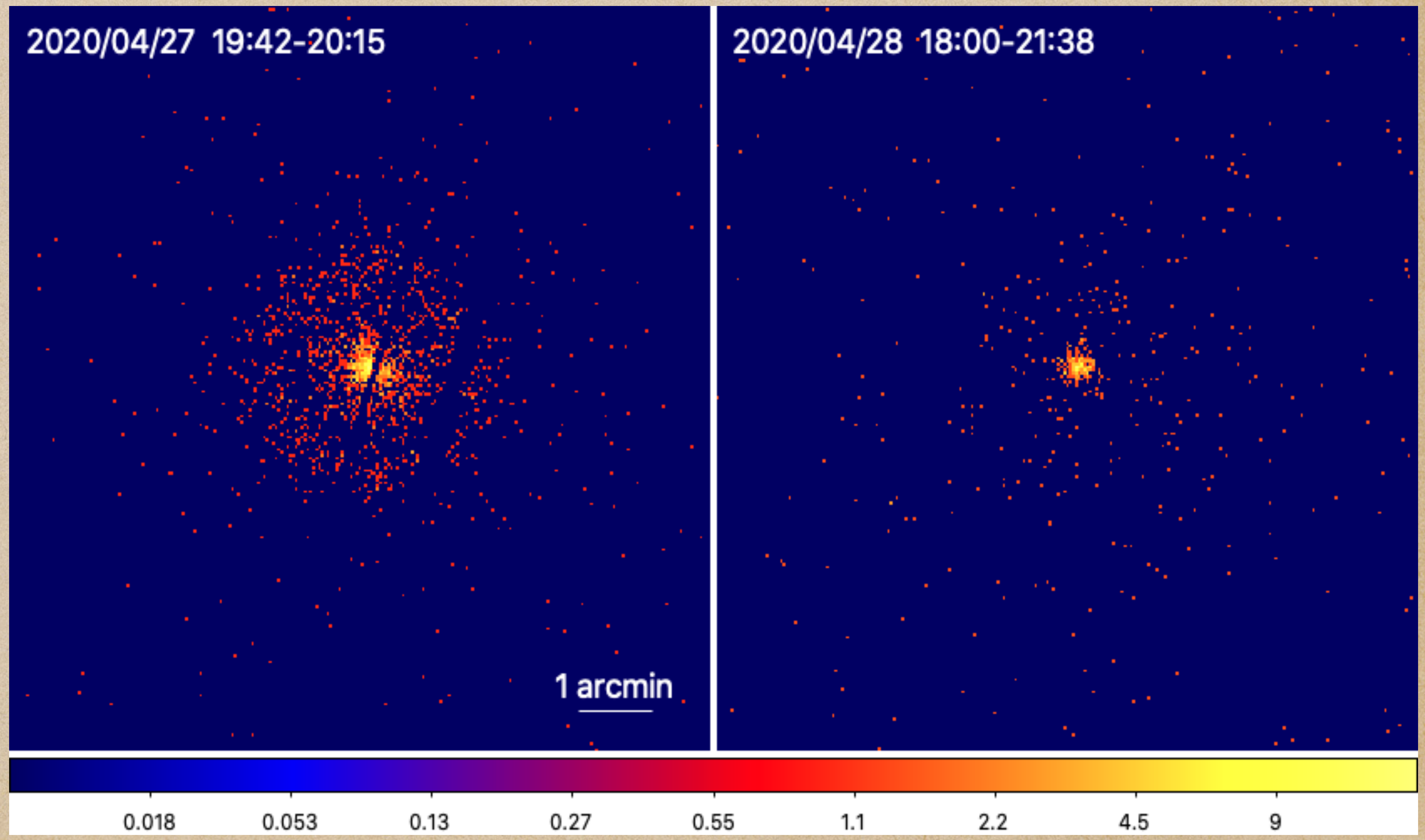
Zhou+20 CO lines —> 6.6 kpc (SNR)

Bailes+21 —> 1.5 to 6.5 kpc (SNR)

Mereghetti+20, dust rings —> 2.2 to 7.1 kpc (Magnetar)

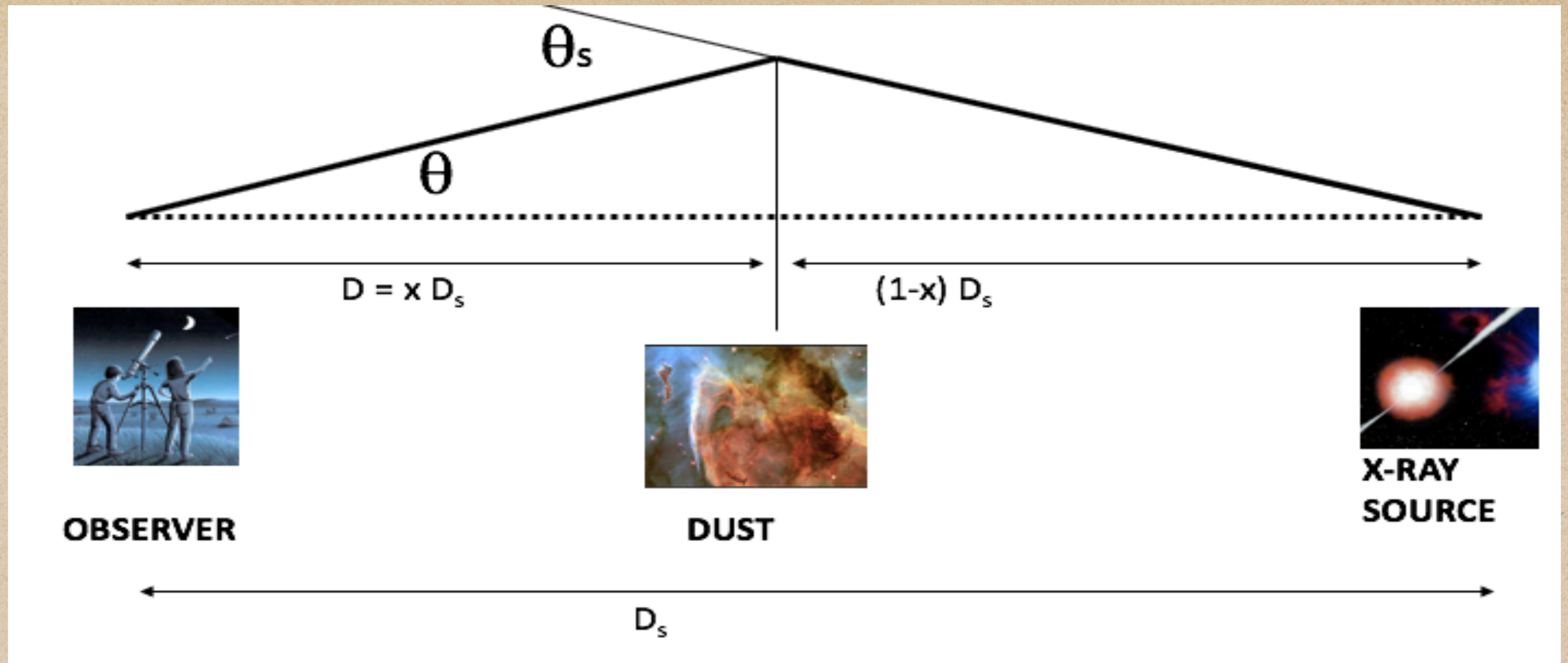


Mereghetti+ 2020



$$TIME\ DELAY = t - t_B = \frac{x}{1-x}\,\frac{D_{SOURCE}\,\theta^2}{2\,c}$$

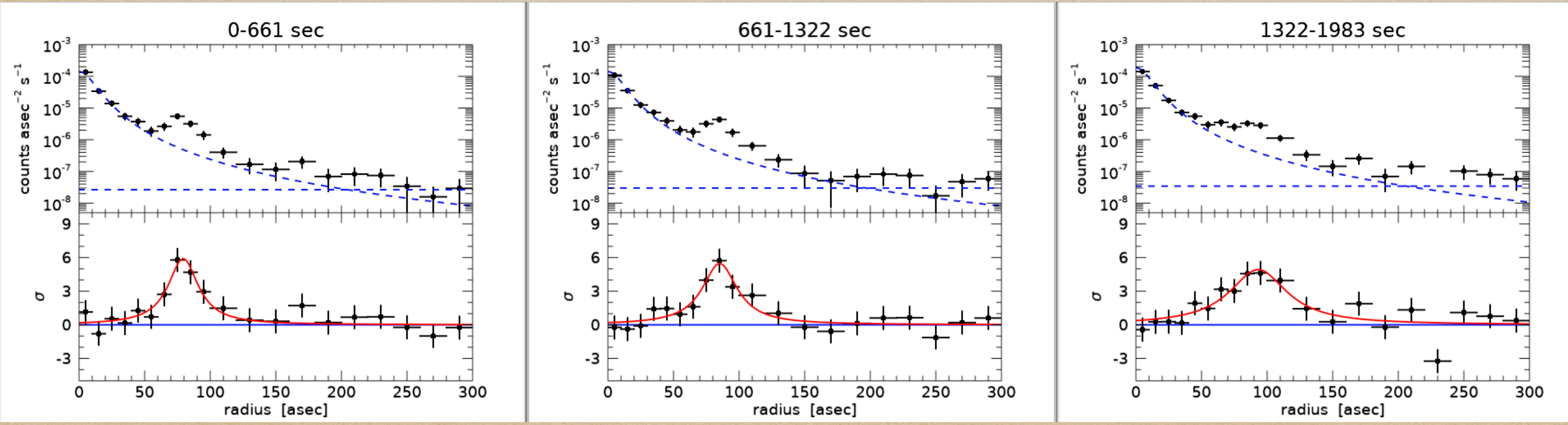
$$x \equiv \frac{D_{DUST}}{D_{SOURCE}}$$



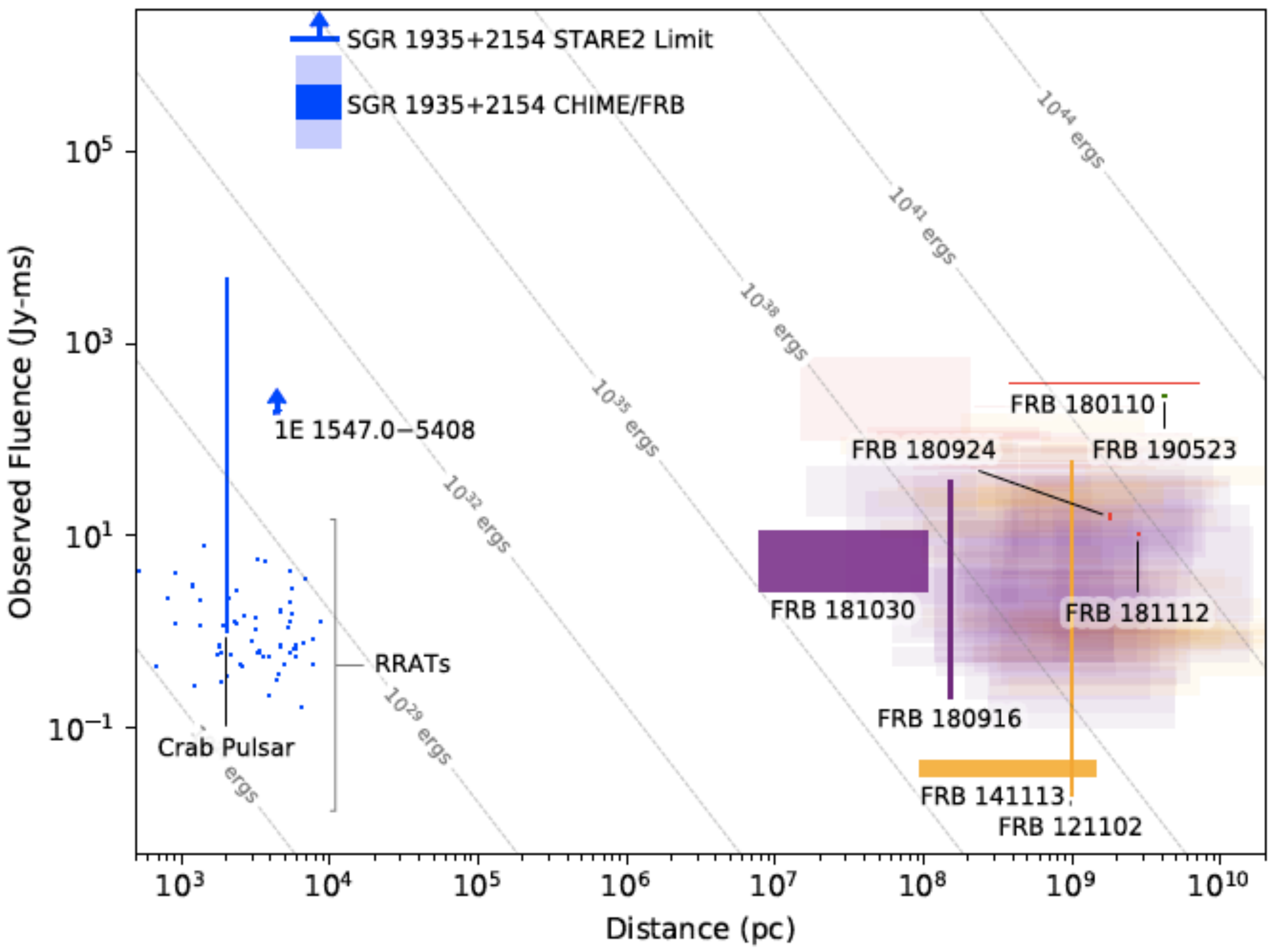
D_{DUST} from 3D distrib. optical extinction (Green+ 2019) = 512+/-16 pc

t_B = April 27 18:33:10 ''burst forest'' (Palmer+ 2020, Ursi+ 2020)

$$\boxed{D_{SOURCE} = 4.4\,^{+2.8}_{-1.3}\ kpc}$$

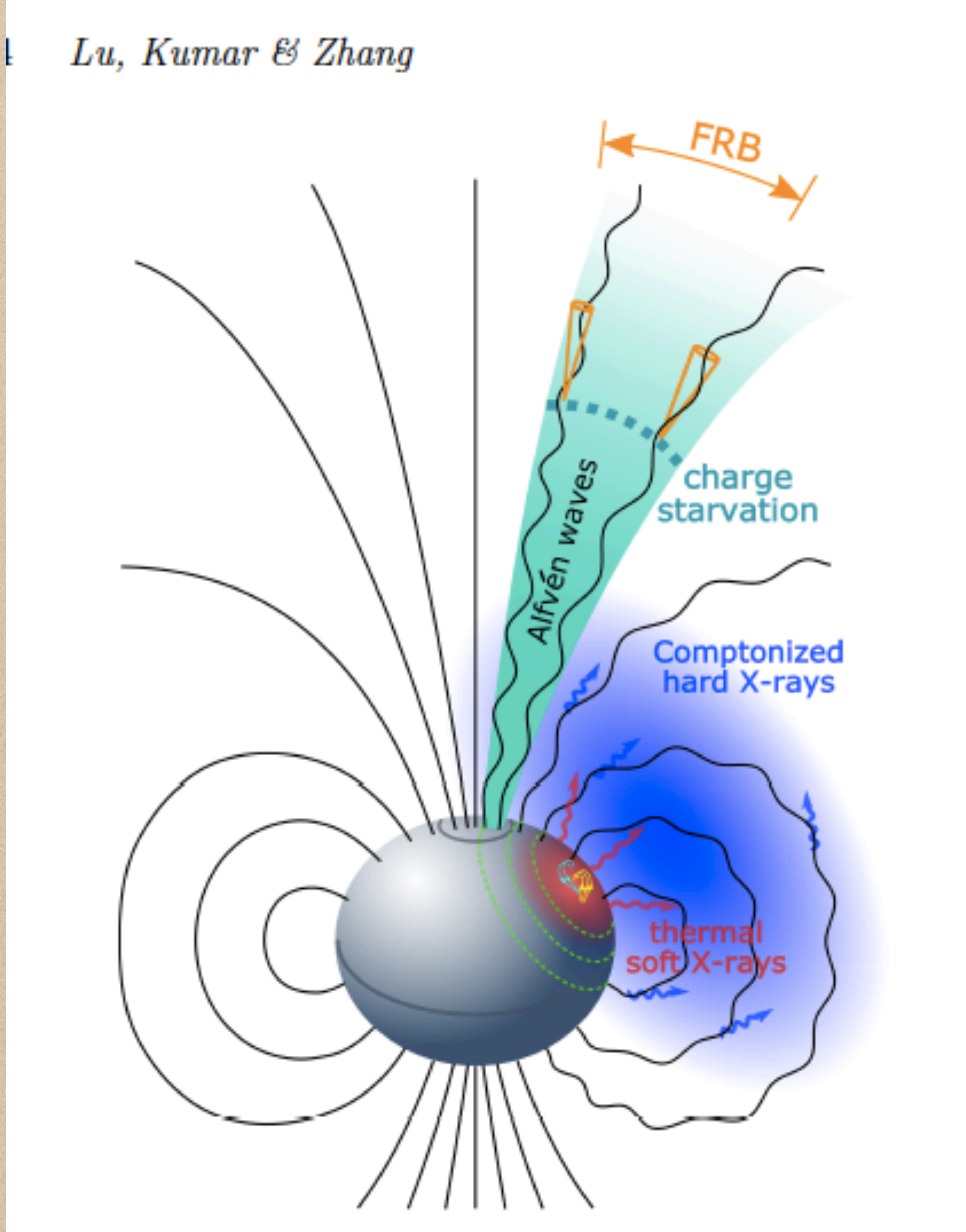


CHIME/FRB Coll. 2020

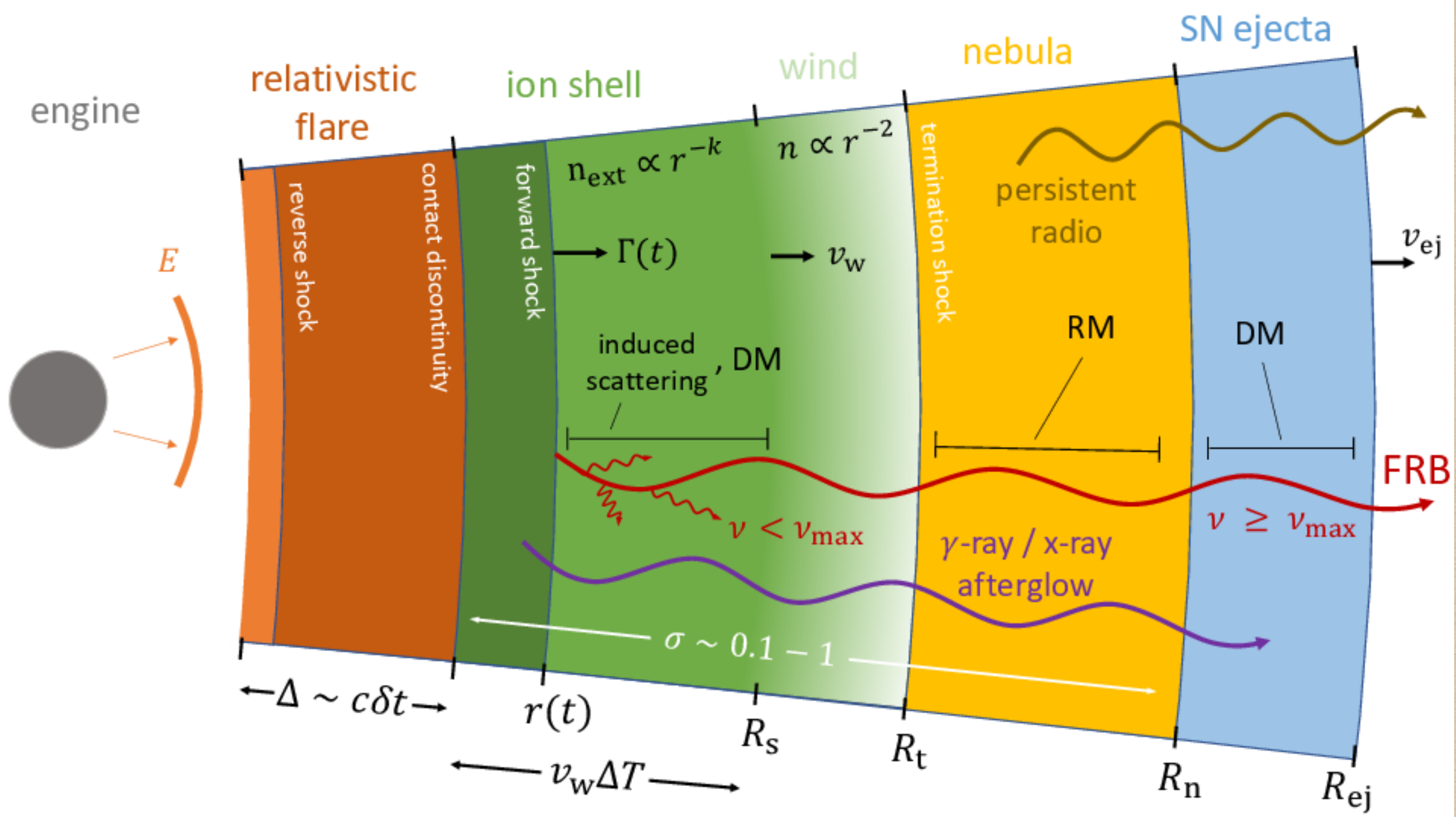


TWO MAIN CLASSES OF FRB MODELS INVOLVING MAGNETARS

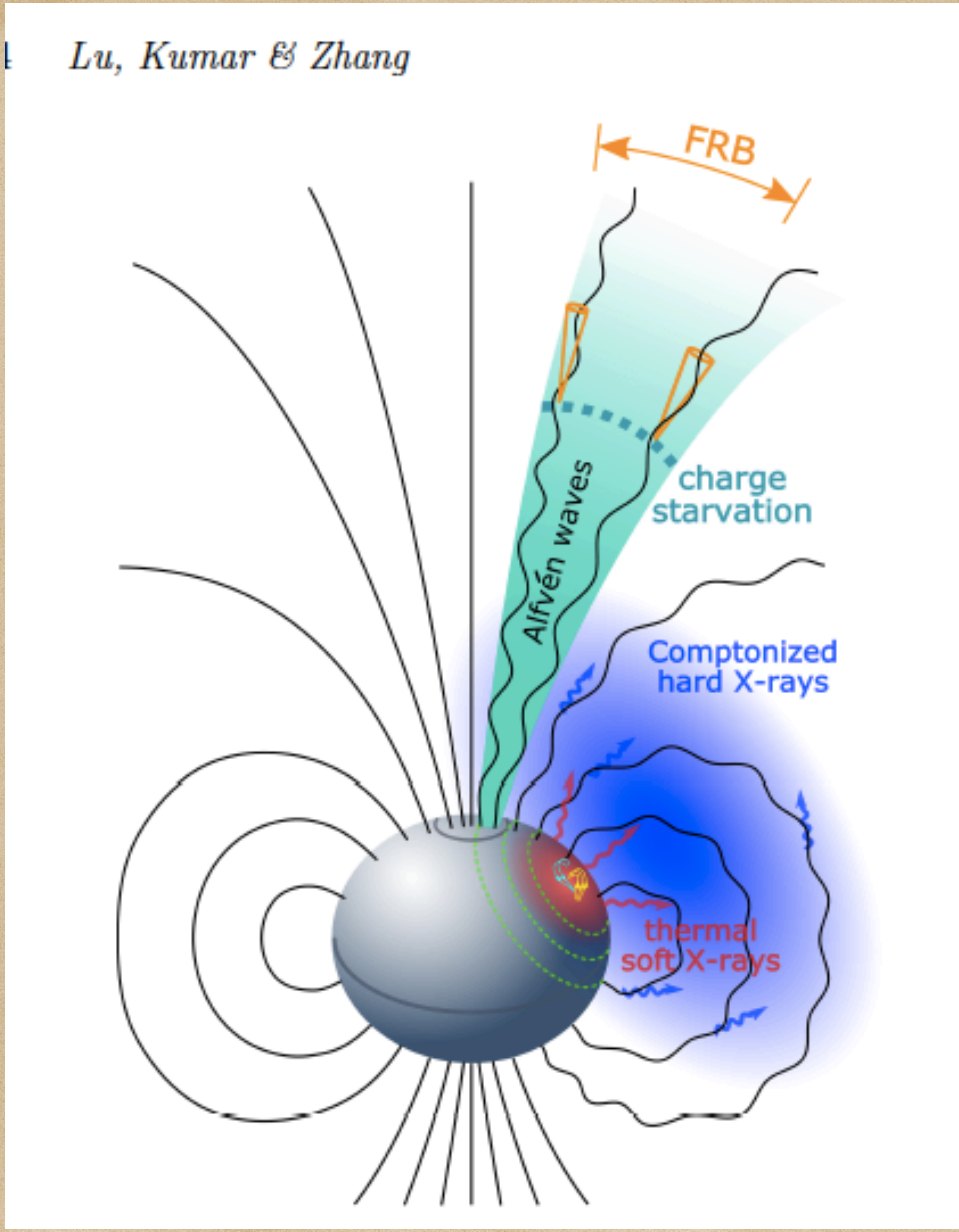
``PULSAR-LIKE''



``GRB-LIKE''



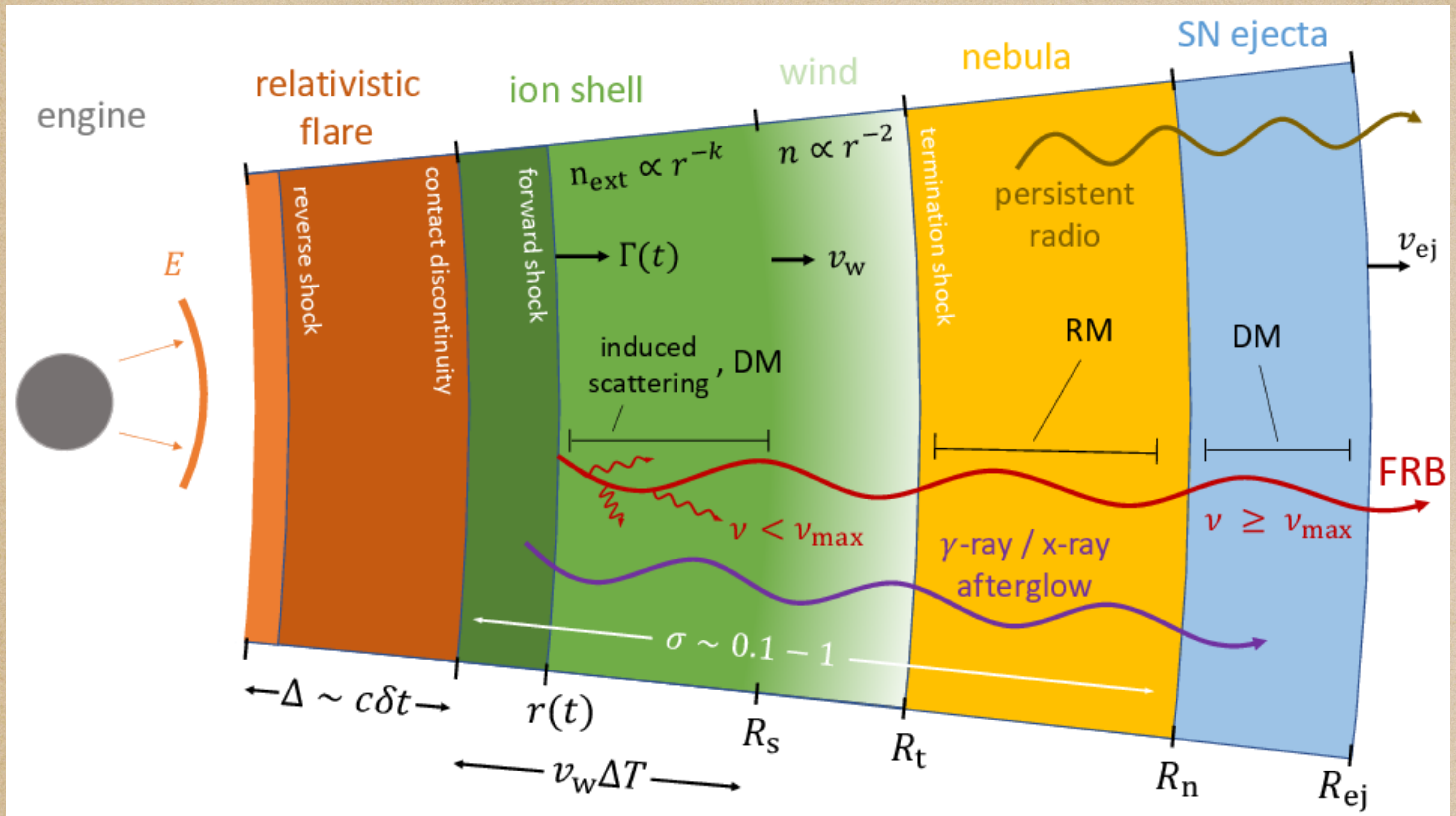
Most models originally developed considering Giant Flares, not 'normal' bursts



$R < R_{LC}$ - Inside NS magnetosphere

$R_{LC} = 1.5\ 10^{10}$ cm for SGR1935

[e.g., Pen & Connor 2015; Cordes & Wasserman 2016; Lyutikov + 2016; Kumar+ 2017; Zhang 2017; Lu & Kumar 2018; Yang & Zhang 2018; Kumar & Bosnjak 2020]



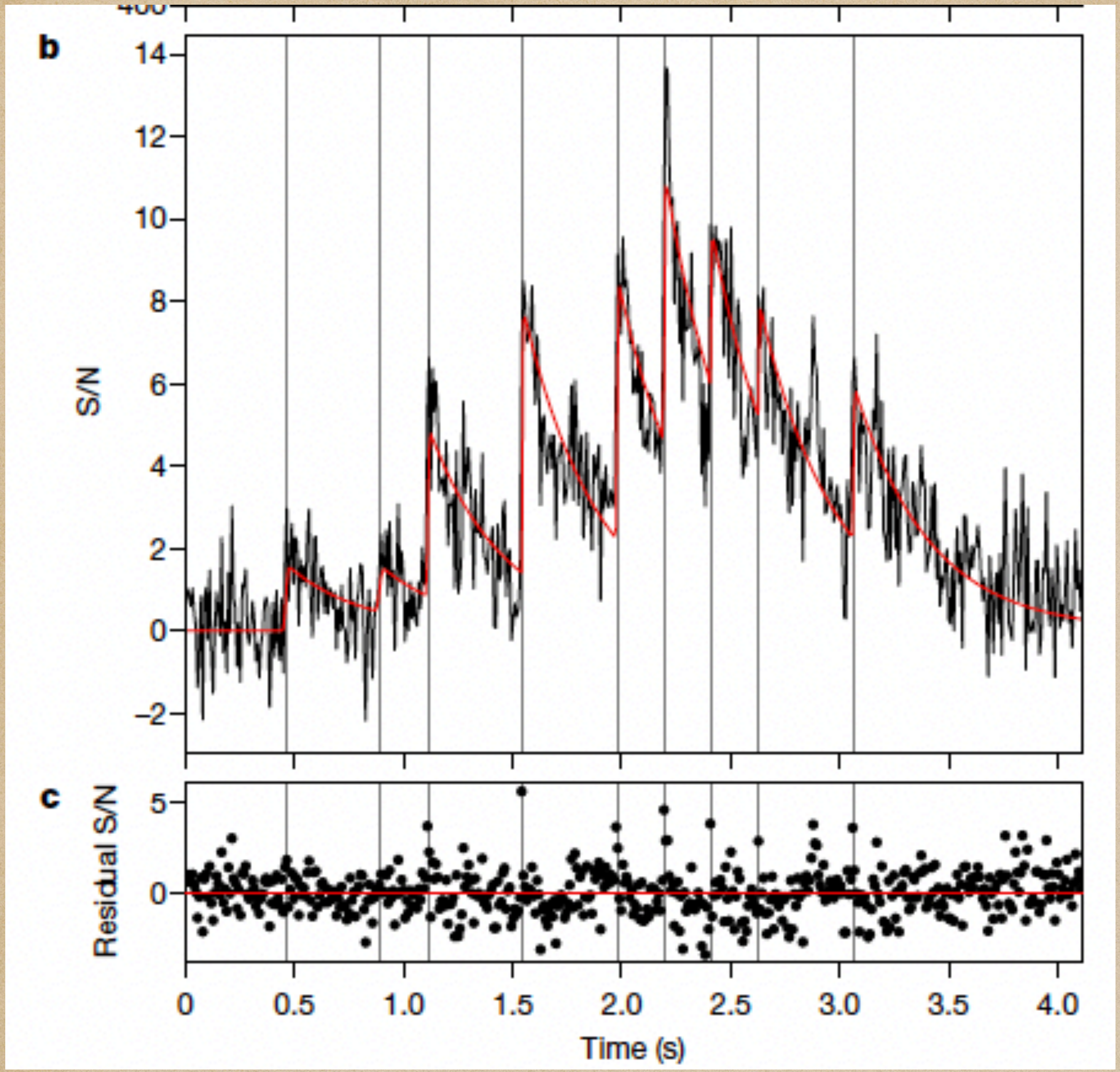
Metzger, Magalit & Sironi 2019

R >> R_{LC} - Relativistic outflow interacting with surrounding medium - R ~$10^{13\text{-}15}$ cm

Requires ultrarelativistic ejection.

Collisionless shock in pre-existing pairs wind or slow barionic ejecta

[e.g. Lyubarsky 2014; Waxman 2017; Beloborodov 2017, 2019; Metzger+ 2019; Margalit+ 2020]



CHIME/FRB Coll+22

FRB 20191221A

3 s duration and 9 pulses.

Prob 7e-11

Not repeating,

HXMT Cai+22

The Astrophysical Journal Supplement Series, 260:24 (12pp), 2022 June Cai et al.

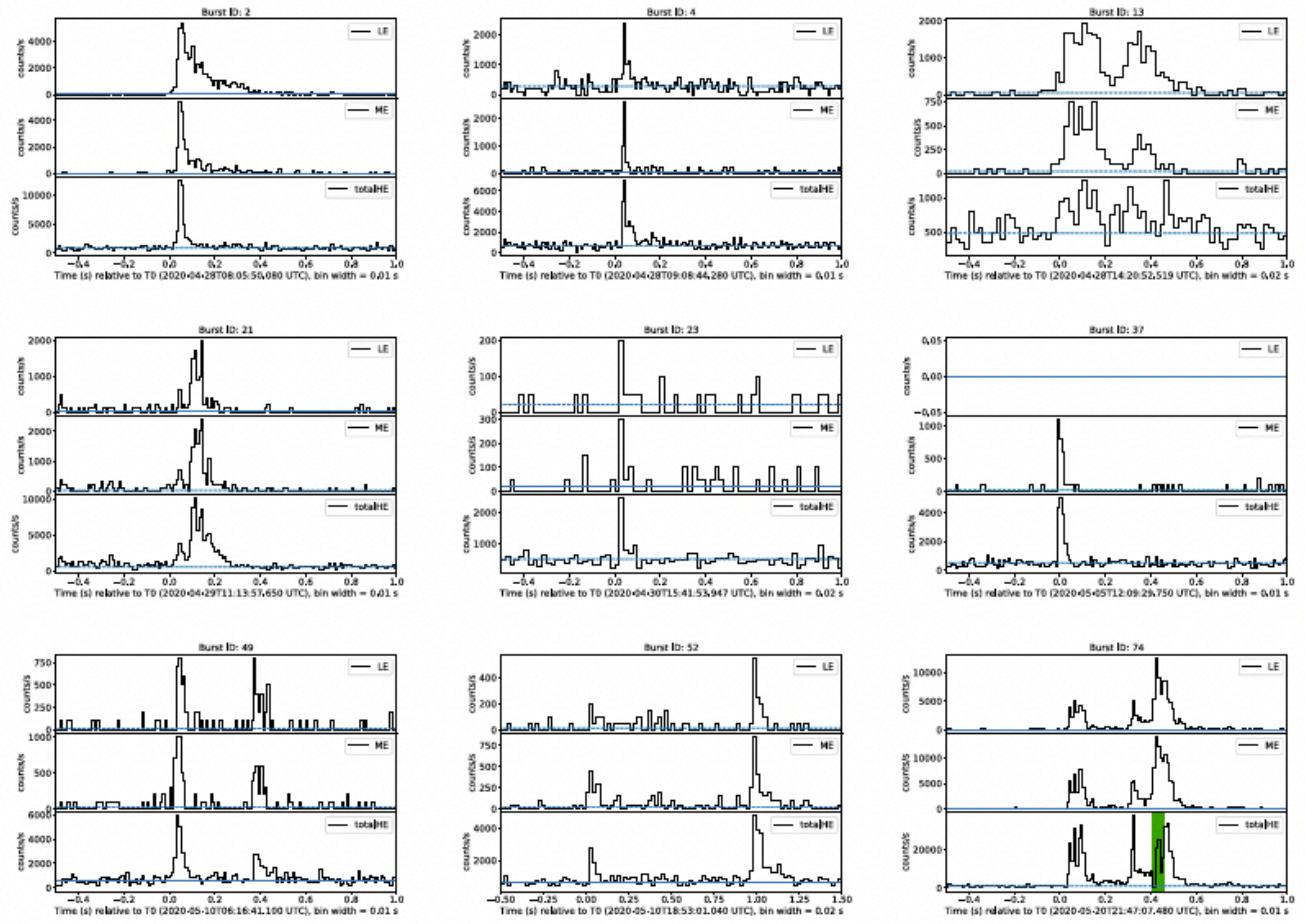


Figure 4. Examples of Insight-HXMT-detected bursts of SGR J1935+2154. For each burst, light curves are shown for LE (1−10 keV; top panels), ME (10−30 keV; middle panels), and HE (28−250 keV; bottom panels). The background of each burst is shown by the blue dotted line. The events of LE data of burst #37 are lost owing to instrumental effects (e.g., bright Earth, bad events with higher grade). The HE data of burst #74 suffered from data saturation in the time interval marked as green shading. Burst #23 represents weak bursts in our sample with a trigger timescale of 0.01 s and trigger threshold of $\sim 5\sigma$.

Duration of multipeak is overestimated (see n.49) ?

DURATA 1.2 s in HXMT

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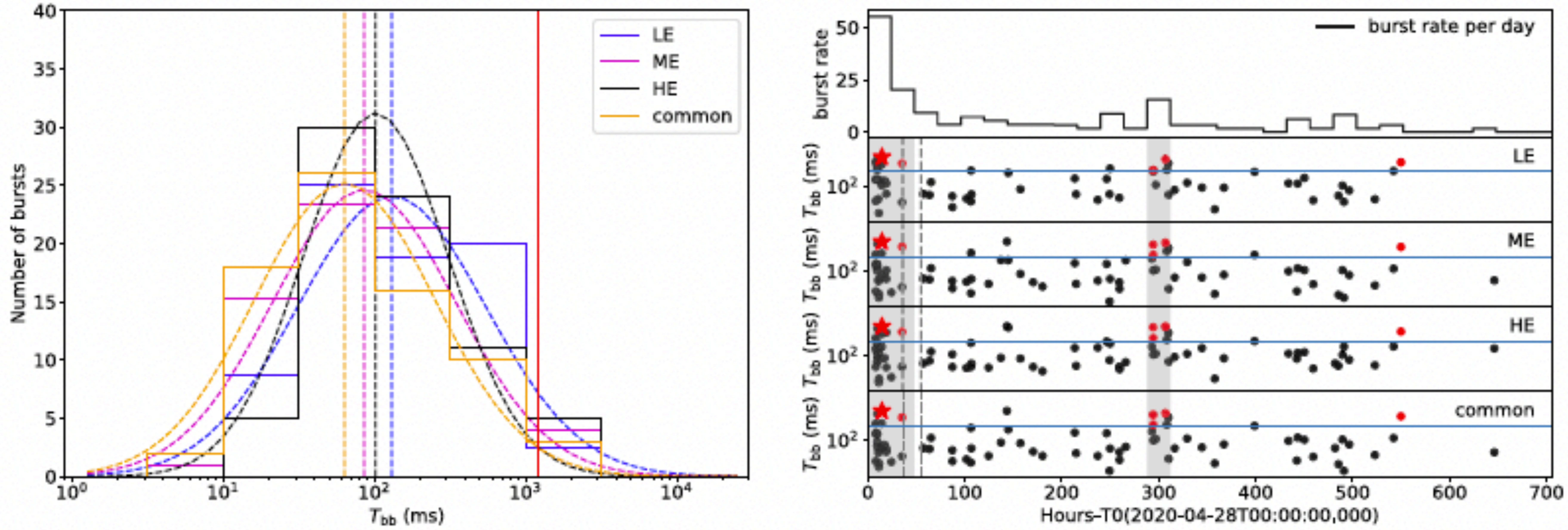

Figure 7. Left: the burst distribution of the whole burst sample. The best-fit log-Gaussian functions and corresponding mean values are shown by dotted lines. The blue, purple, black, and orange lines represent the duration of LE, ME, HE, and common, respectively. The red line is FRB 200428–Associated Burst. Right: the burst history of SGR J1935+2154 is shown in the top panel. Other captions of the top panel are the same as in Figure 5. The scatter of duration vs. their trigger time since 2020-04-28T00:00:00 is shown in the four lower panels. The gray dotted lines represent the time interval of no observation of Insight-HXMT (see also Table 1). The red star is FRB 200428–Associated Burst. Multipulse bursts are shown in red. The bursts with longer duration (larger than 350 ms, as marked by horizontal blue lines) are mostly found in the gray shaded regions.