A multi-wavelength campaign on FRB 20180916B to unravel the nature of Fast Radio Bursts

by

Matteo Trudu

Congresso Nazionale Oggetti Compatti XII

29 September 2022

On behalf of

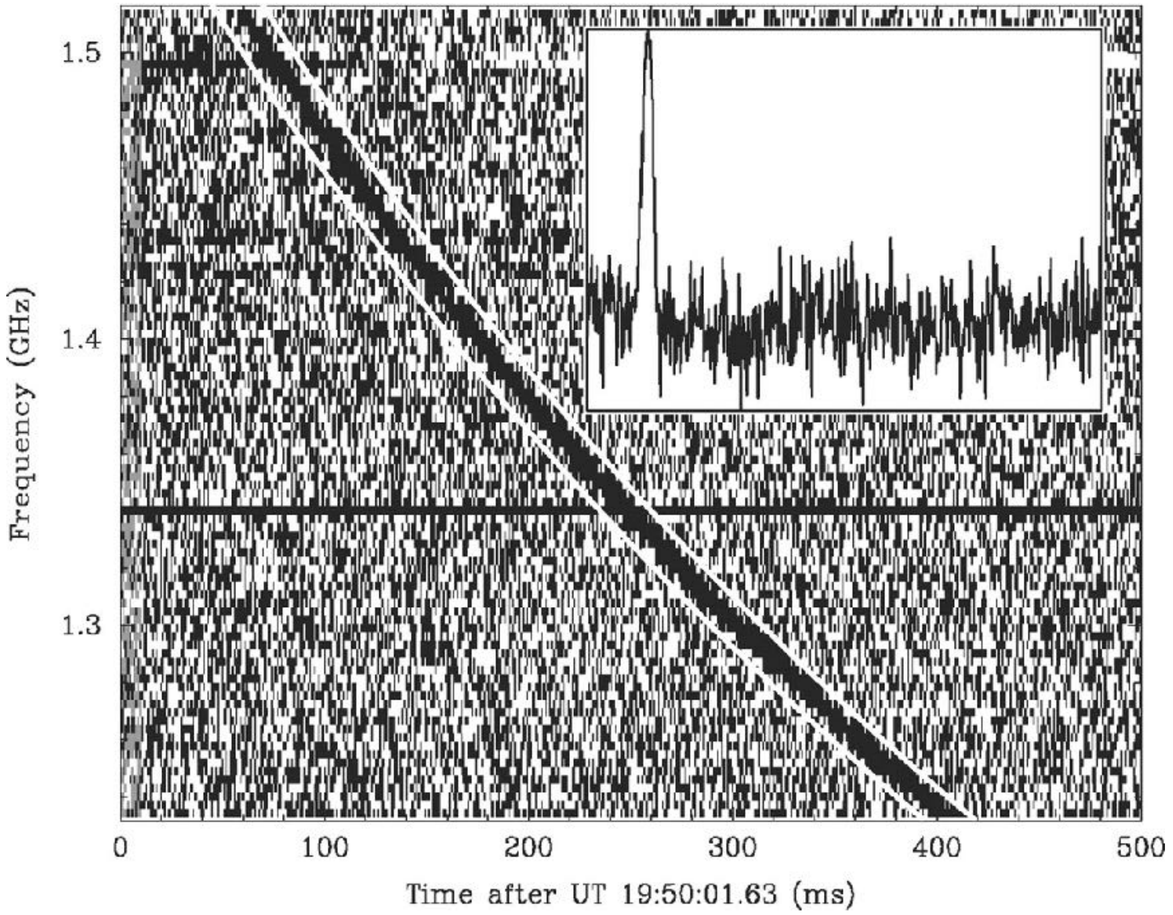
M. Pilia, L. Nicastro, C. Guidorzi, L. Zampieri, V.R. Marthi, A. Possenti, F. Ambrosino, M. Burgay, C. Casentini, I. A. Mereminsky, E. Palazzi, F. Panessa, F. Verrecchia, M. Anedda, G. Bernardi, M. Bachetti, A. Burtovoi, P. Casella, M. Fiori, F. Frontera, V. Gajjar, A. Gardini, A. Ghedina, G. Naletto, P. Ochener, M. Orlandini, A. Papitto, M. Perri, C. Pittori, A. Ridolfi, V. Savchenko, M. Tavanti, A. Ursi

Fast Radio Bursts (FRBs)

- Jy-ish intense radio transients of ms duration
- “Highly dispersed signals” (extragalactic)

$$\Delta t \propto \mathrm{DM}\left(\frac{1}{f_1^2}-\frac{1}{f_2^2}\right) \qquad \mathrm{DM}=\int_0^d n_e(s)ds$$

- Luminosities of 10^{43} erg s^{-1}
- Energetics of 10^{40} erg
- Huge brightness temperature (T_B ~ 10^{34} - 10^{37} K)
- Magnetars are good candidates (at least for some)



Lorimer + 2007 (Science)

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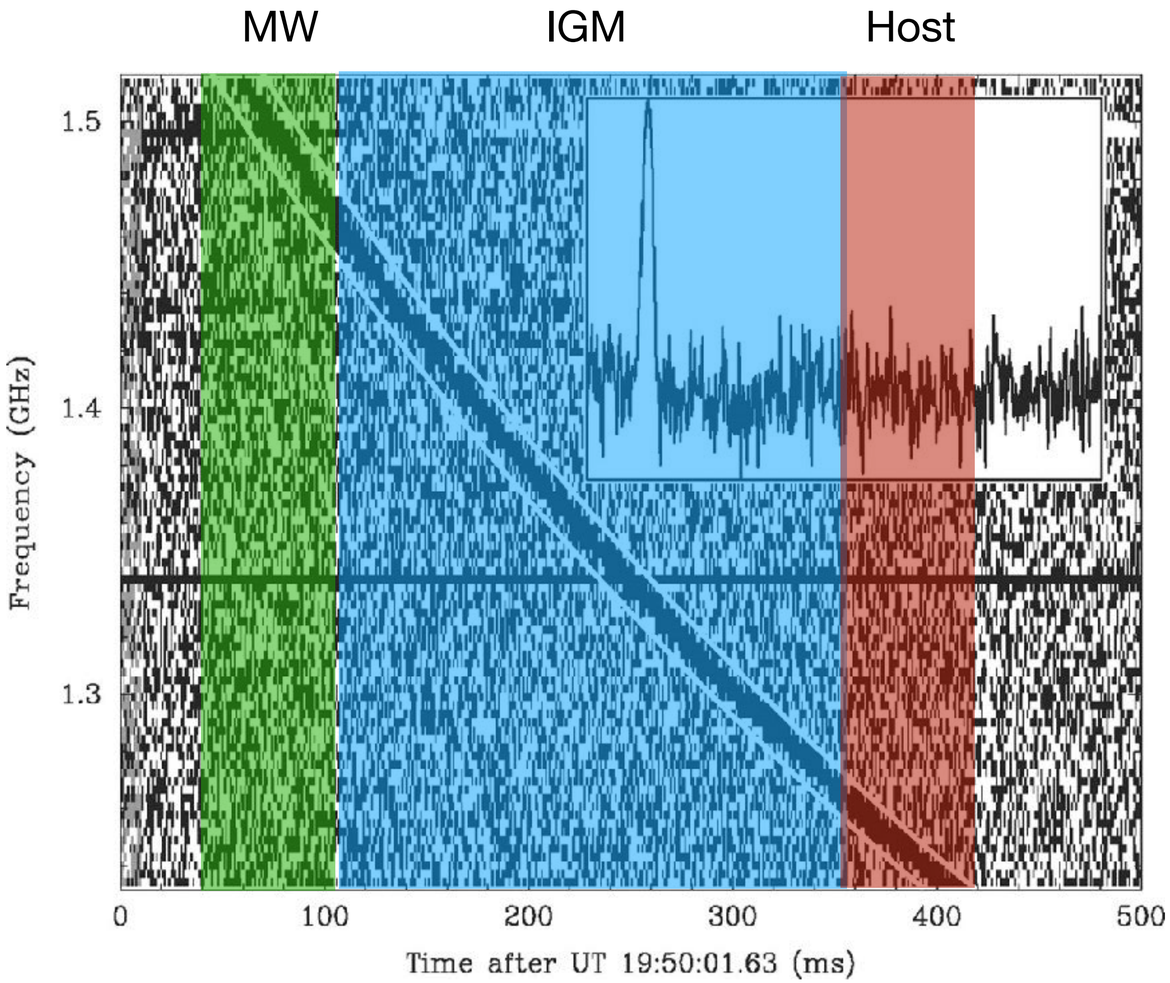

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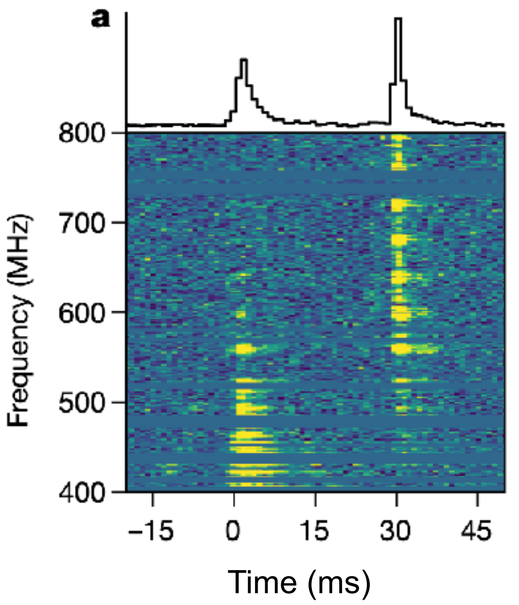
SGR 1935+2154

- Discovered by Swift in 2014
- P = 3.24 s, B ~ 2.2 × 10^{14} G [Israel+16]
- A forest of X-ray bursts started on the 24th of April 2020
- On the 28th CHIME detected a double burst in radio with fluence 700 kJy ms at P-band
- A single burst independently seen by STARE2 at L-band with fluence 1.5 MJy ms
- Simultaneous detection at higher-energies!

assuming a distance of 4.4 kpc [Mereghetti+20]

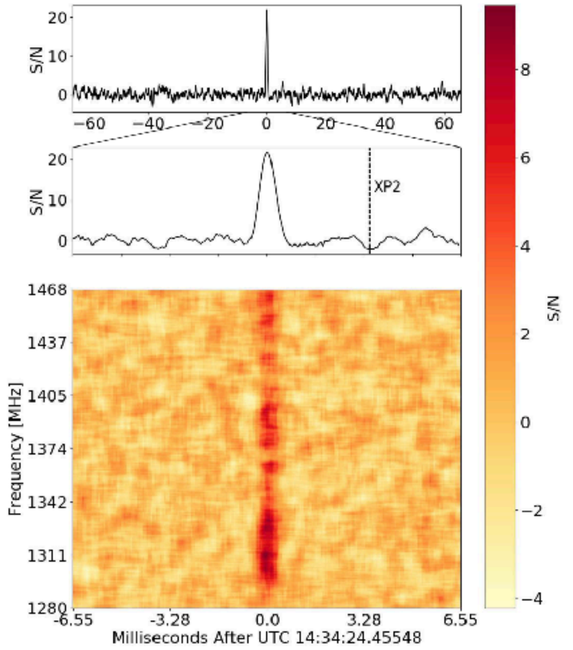
$$E_{HE}/E_{radio} = 3 \times 10^{6}$$

CHIME



Chime/FRB Collaboration + 2020 (Nature)

STARE2



Bochenek + 2020 (Nature)

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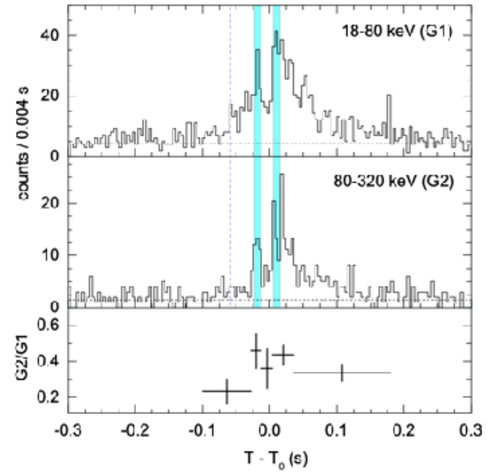
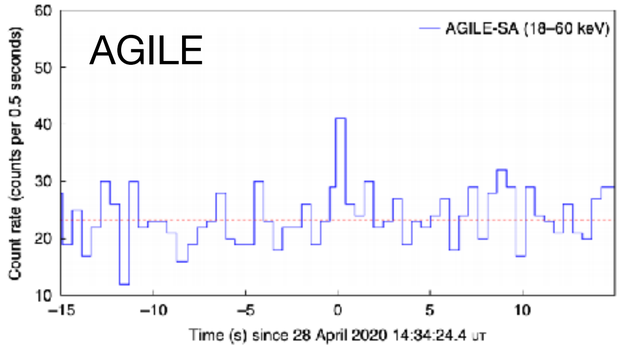
$$E_{HE}/E_{radio} \sim 10^{6}$$

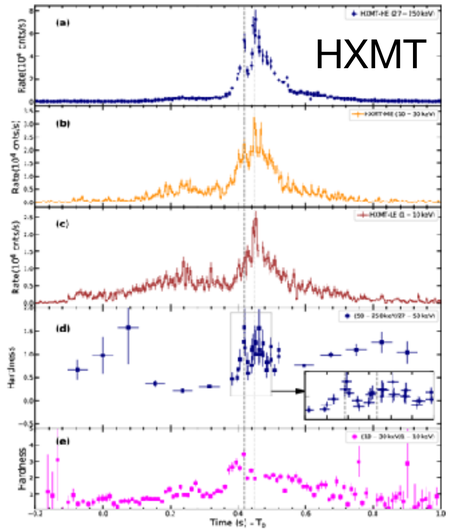
KONUS-WIND

Ridnaia + 2020 (NatAstro)

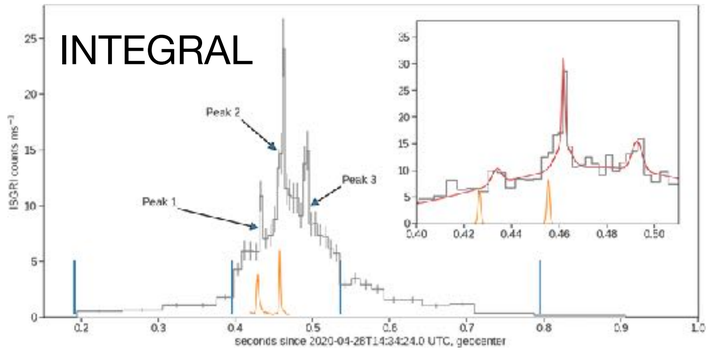


Tavani + 2020 (NatAstro)





HXMT Coll + 2020 (NatAstro)



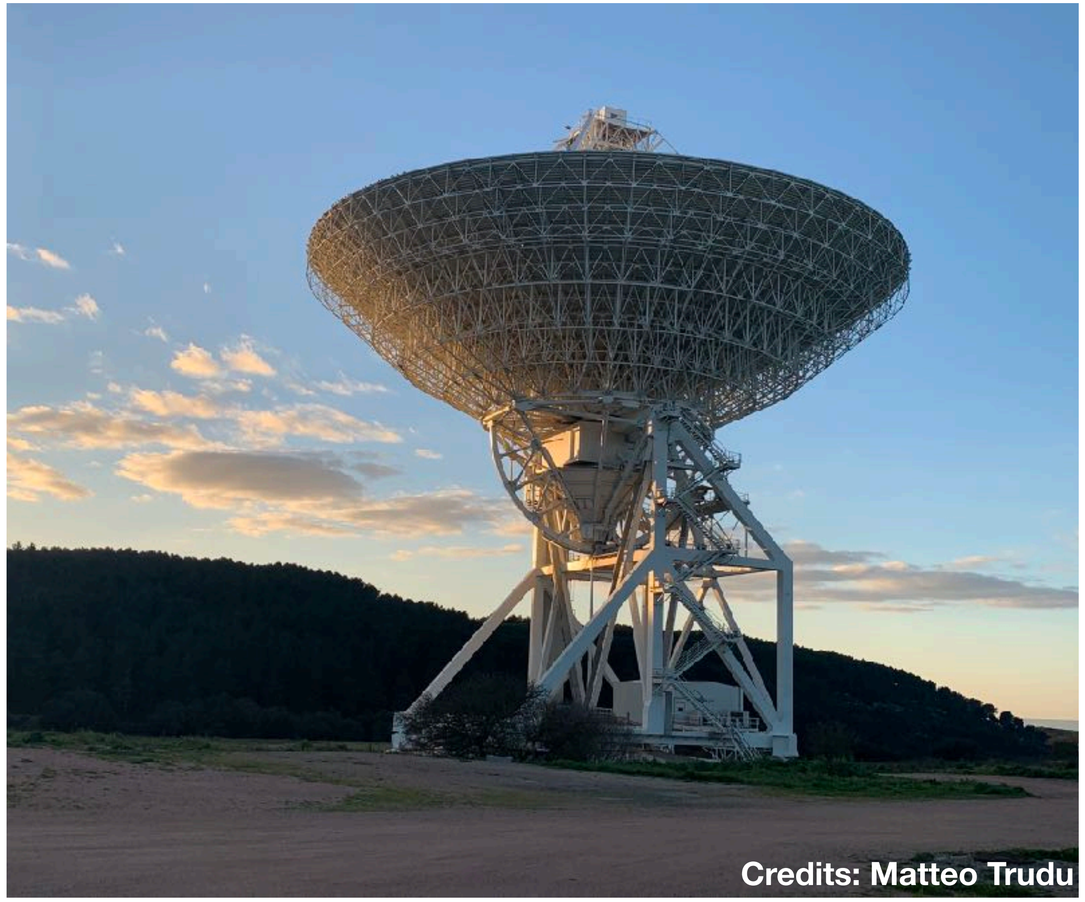
Mereghetti + 2020 (ApJL)

Sardinia Radio Telescope (SRT)

- Located in Sardinia (Italy) distant 50 km from Cagliari
- 64 m single dish radio telescope
- Dual band receiver

  P-Band 296-376 MHz

  L-Band 1000-2000 MHz
- Ideal instrument for multi-band searches



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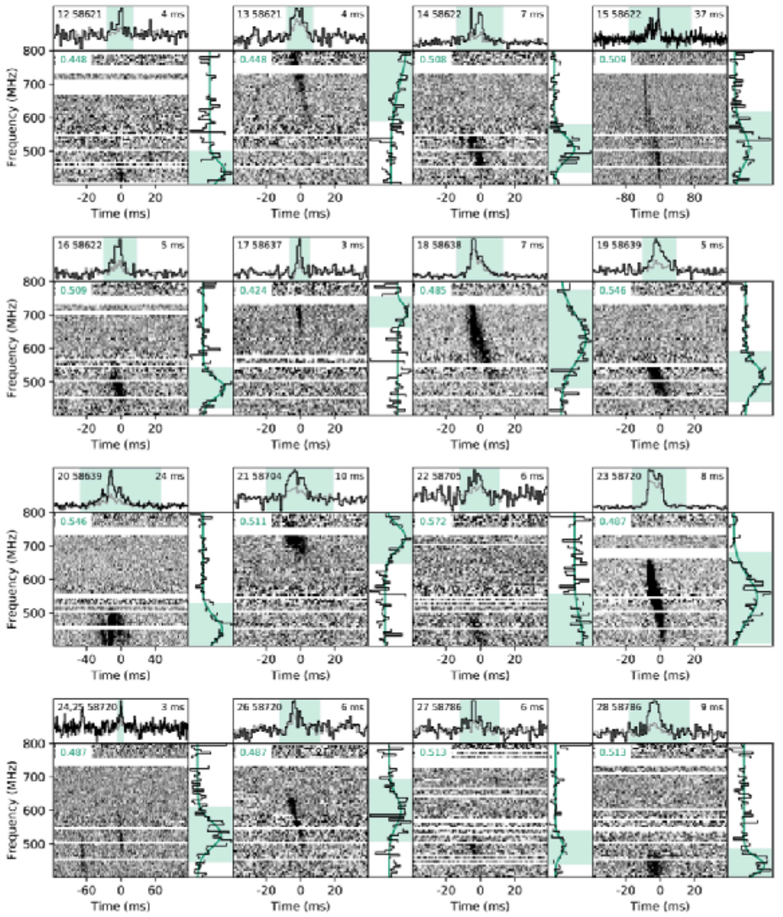
FRB 20180916B (R3)

- Discovered by CHIME [CHIME/FRB+19]
- The first one in which a periodic activity has been confirmed (16 days in a window of 5 days) [CHIME/FRB+20 Nat]
- Reasonably “close” (149 Mpc) [Marcote+20]
- Ideal source for our hunt



Chime/FRB Collaboration + 2020 (Nature)

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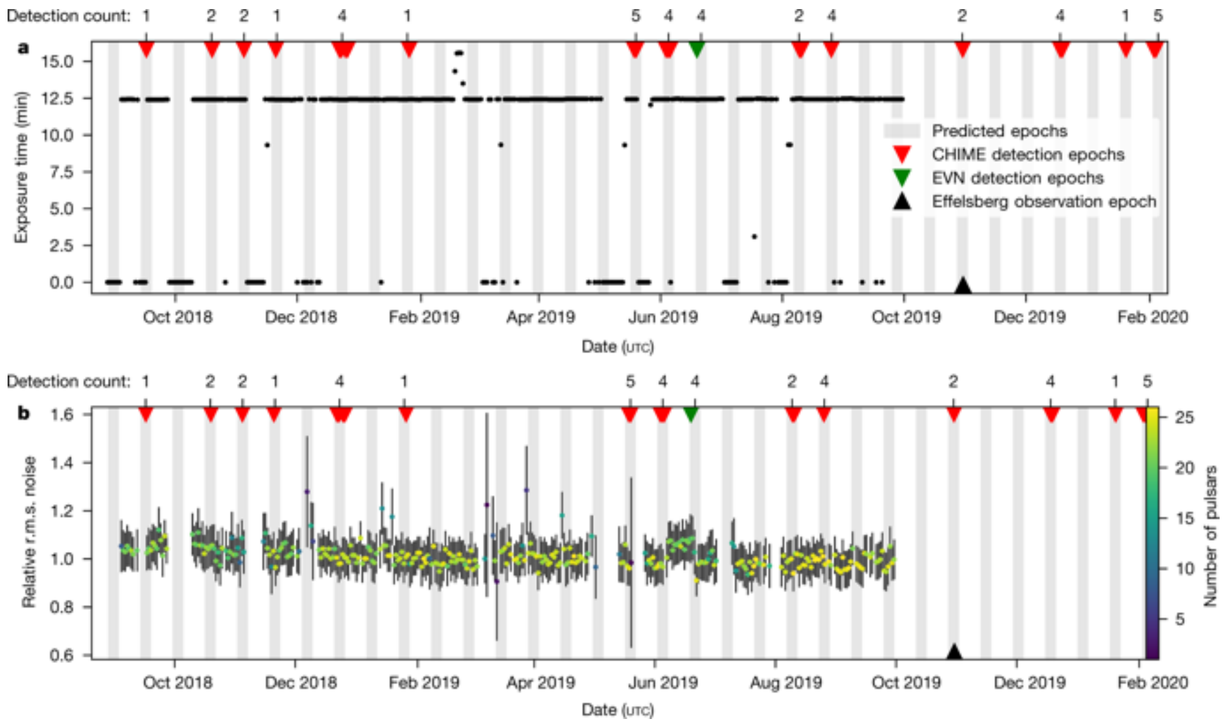

Chime/FRB Collaboration + 2020 (Nature)

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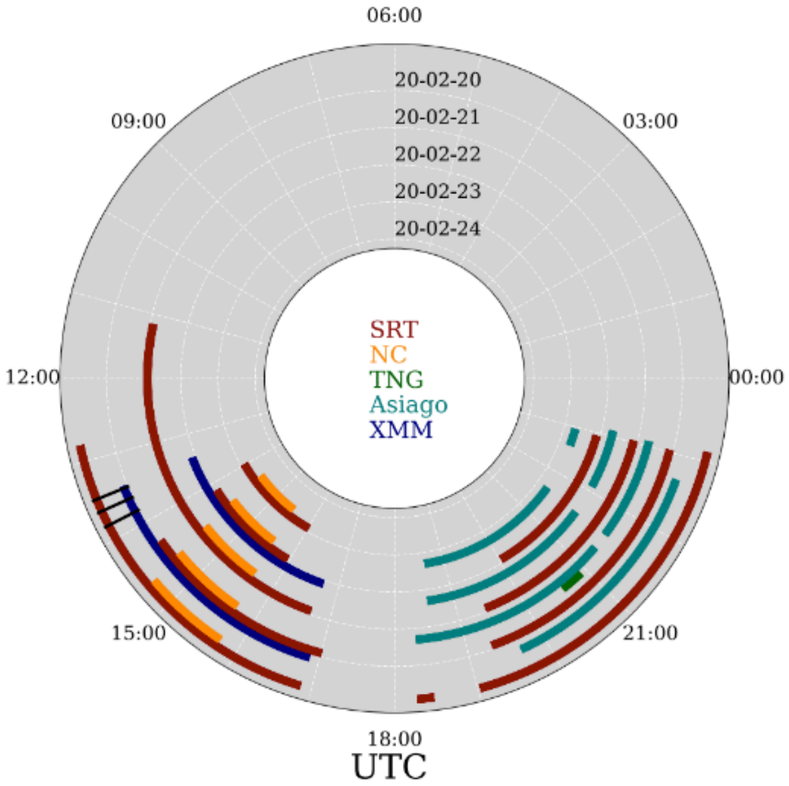
Winter 2020 Campaign

SRT and NC

Asiago and TNG

AGILE, INTEGRAL, NICER, XMM-Newton



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Winter 2020 Campaign

3 bursts at P-band

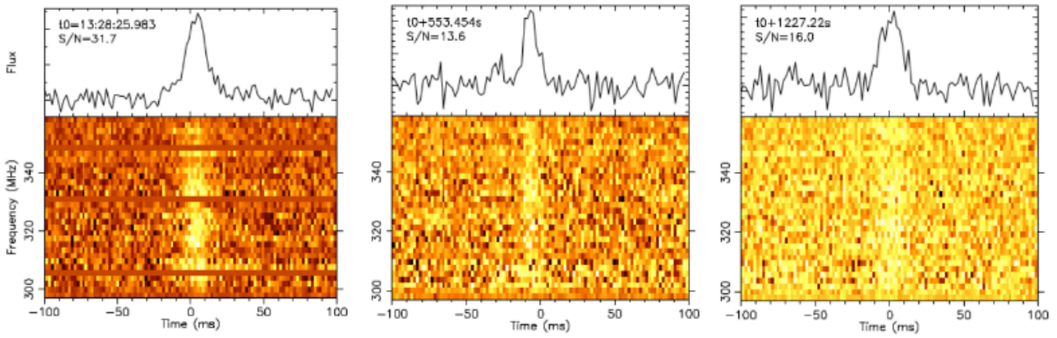
Radio detections happened around 1PM :(

UL from AGILE for Burst 1

$$E_{HE}/E_{radio} < 5 \times 10^{8}$$

HE UL close to SGR 1806-20 2004 giant burst

[Palmer+04 Nat]



Time (UT)	Time (MJD)	Width (ms)	S/N (-)	Peak flux (Jy)	Fluence (Jy ms)	DM (pc cm^{-3})
13:28:25.983(8)	58899.56141184	13(4)	31.7	2.8(9)	37(16)	349.8(1)
13:37:39.437(7)	58899.56781756	9(4)	13.6	1.5(7)	13(8)	349.4(1)
13:48:53.20(1)	58899.57561573	14(4)	16.0	1.4(4)	19(8)	350.1(1)

Pilia + 20 (ApJL)

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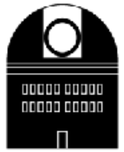
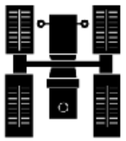
Fall 2020-Summer 2021 Campaign

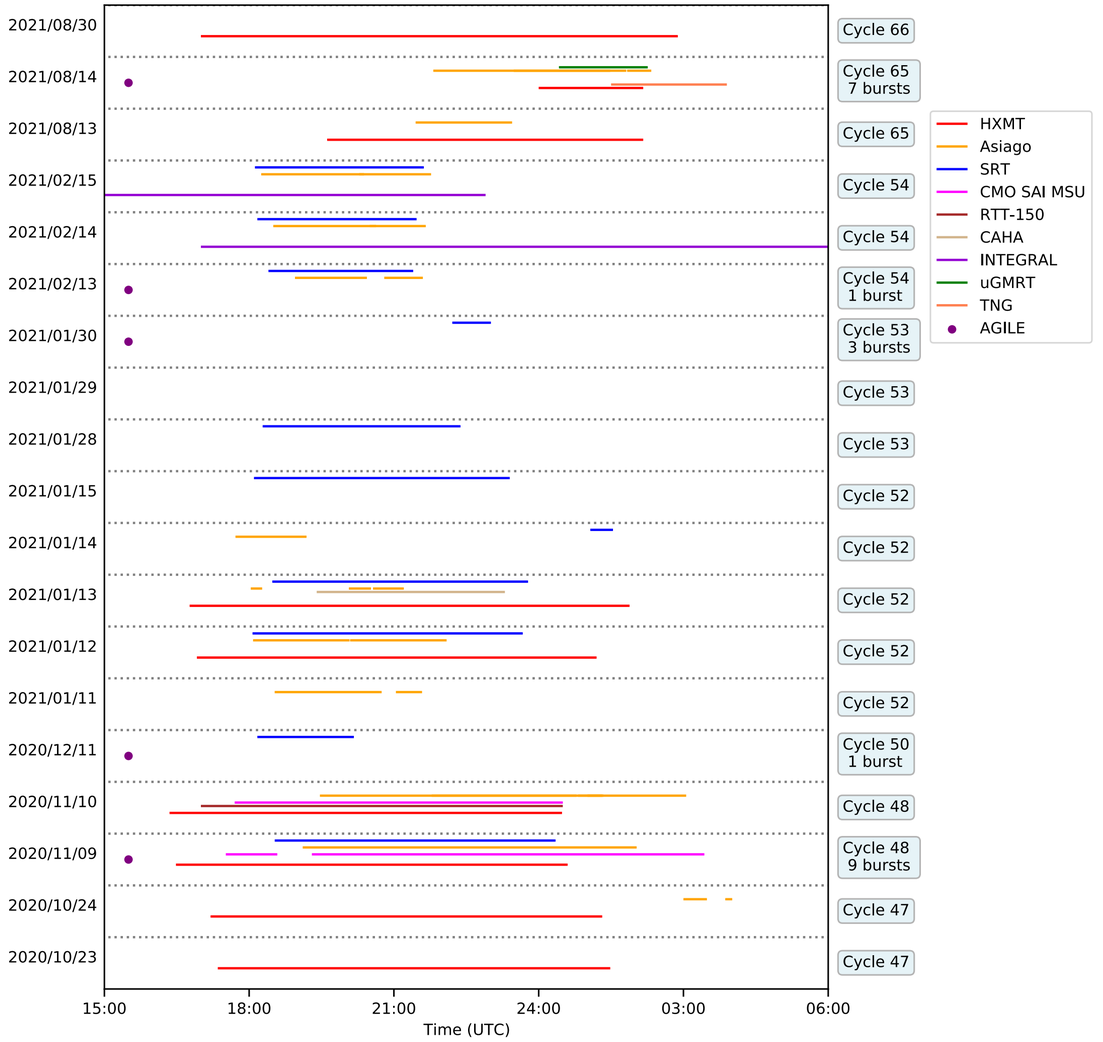
SRT and uGMRT



Asiago, CMO SAI MSU, CAHA, RTT-150 and TNG



AGILE, HXMT, INTEGRAL



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Fall 2020-Summer 2021 Campaign

14 bursts with SRT-P
7 bursts with uGMRT

Asiago

Optical excess close to SRT-P-02 (not statistically significant enough) [See Zampieri's talk]

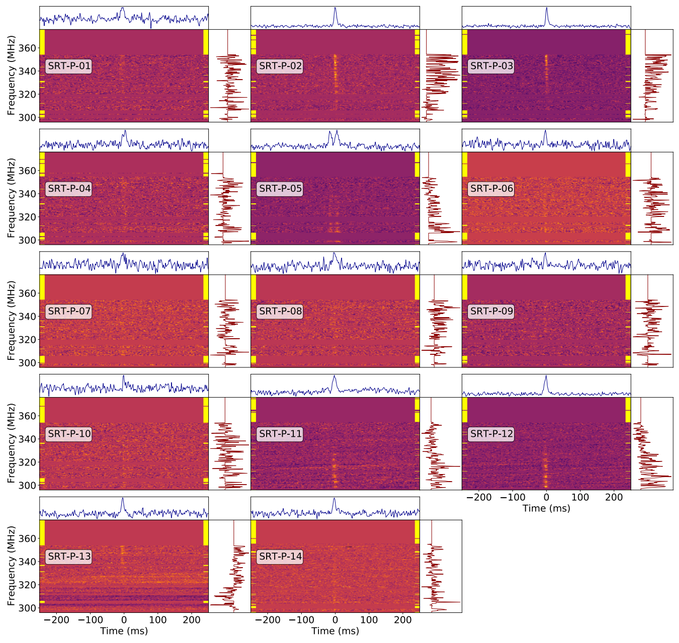
Punctual UL for SRT-P-02 of ~ 3 x 10^{41} erg (V band) from Aqueye+

$$E_{Opt}/E_{radio} < 10^{3}$$

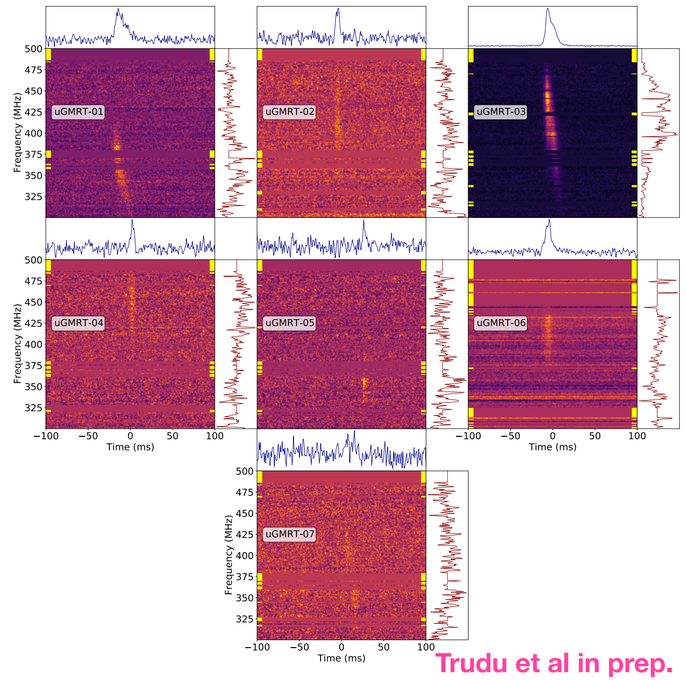
HXMT

Punctual UL for SRT-P-02 of ~3 x 10^{45} erg (1-30 keV range)

$$E_{HE}/E_{radio} < 2 \times 10^{7}$$



Trudu et al in prep.



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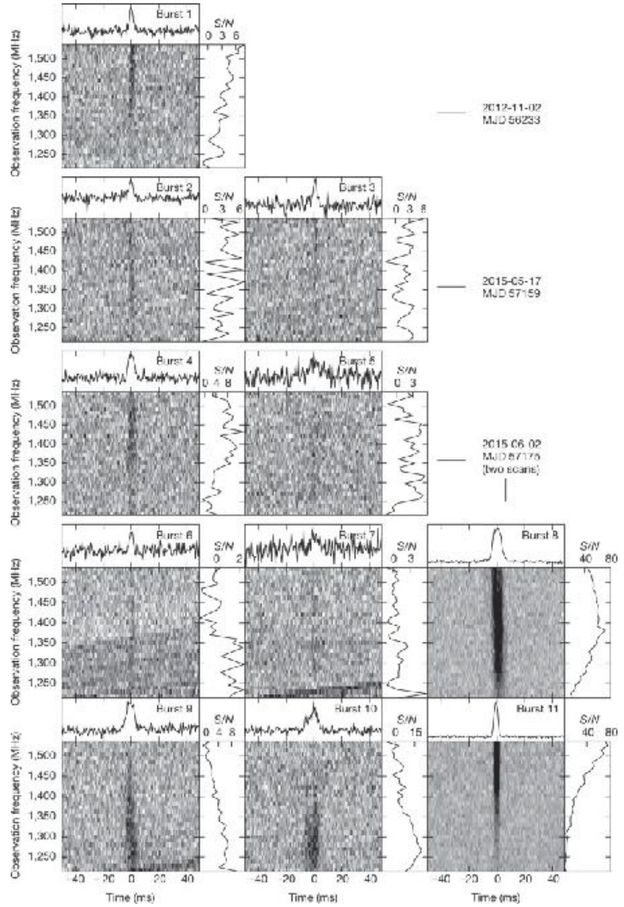
Chromaticity of R3 vs R1

- FRB 20121102A (R1) discovered by Arecibo [Spitler+14]
- First FRB Repeater [Spitler+16]
- Activity period of 160 days with 90 days of activity [Rajwade+20, Cruces+21]
- More likely to emit at L-band
- Located in a dwarf-galaxy (1 Gpc) [Chatterjee+17, Tendulkar+17,Marcote+17]
- Significant variations of DM and RM [Michilli+18]
- Young compact object surrounded by a dense medium?



Spitler + 2016 (Nature)

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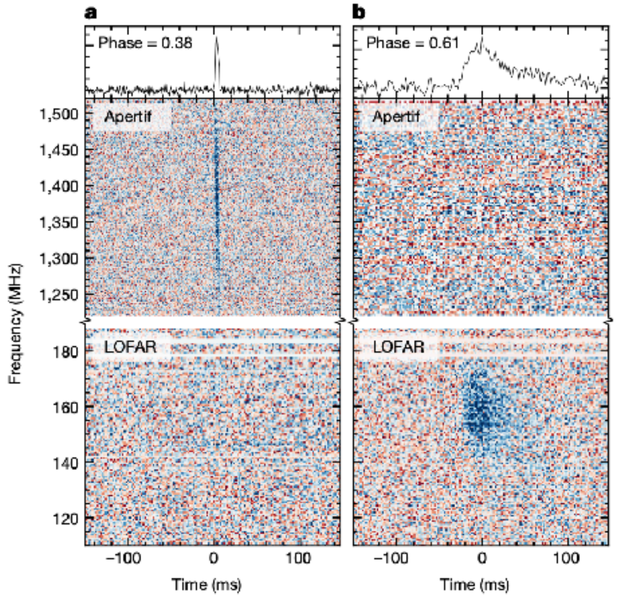
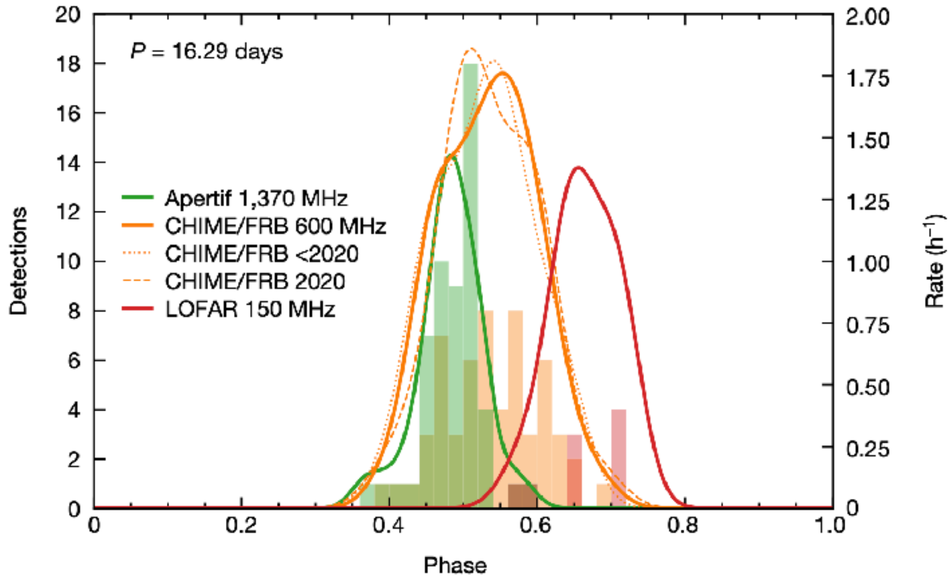
Chromaticity of R3 vs R1

- Burst at higher frequencies arrive (statistically) at earlier activity phases



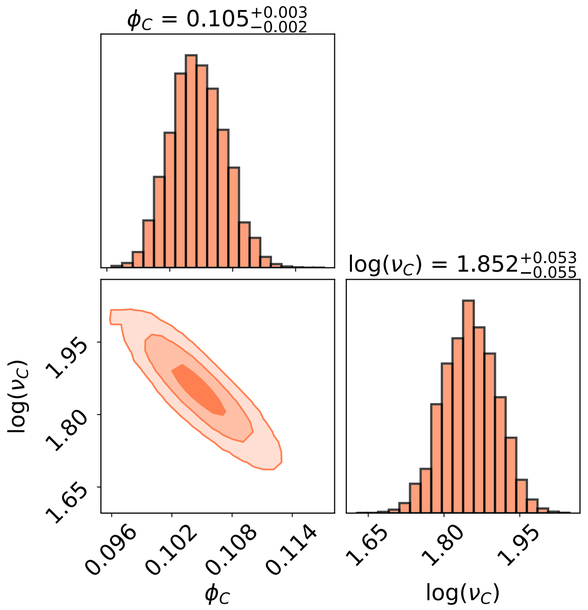


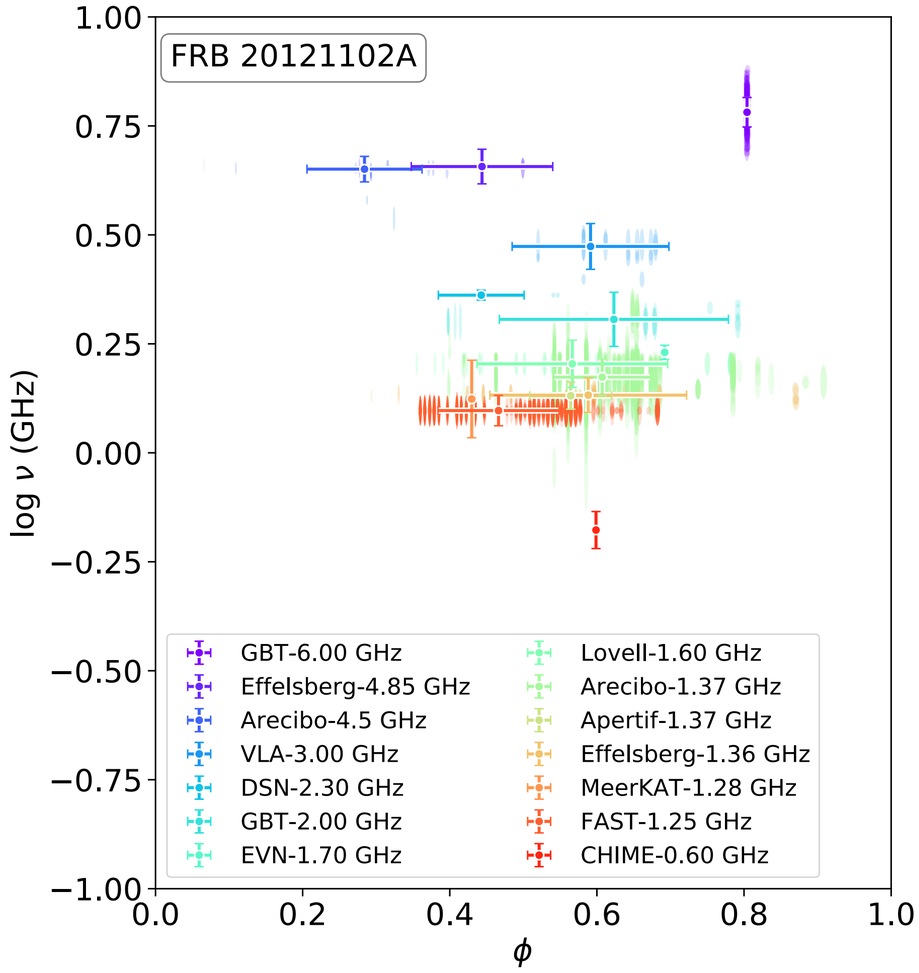
Pastor-Marazuela + 2021 (Nature)

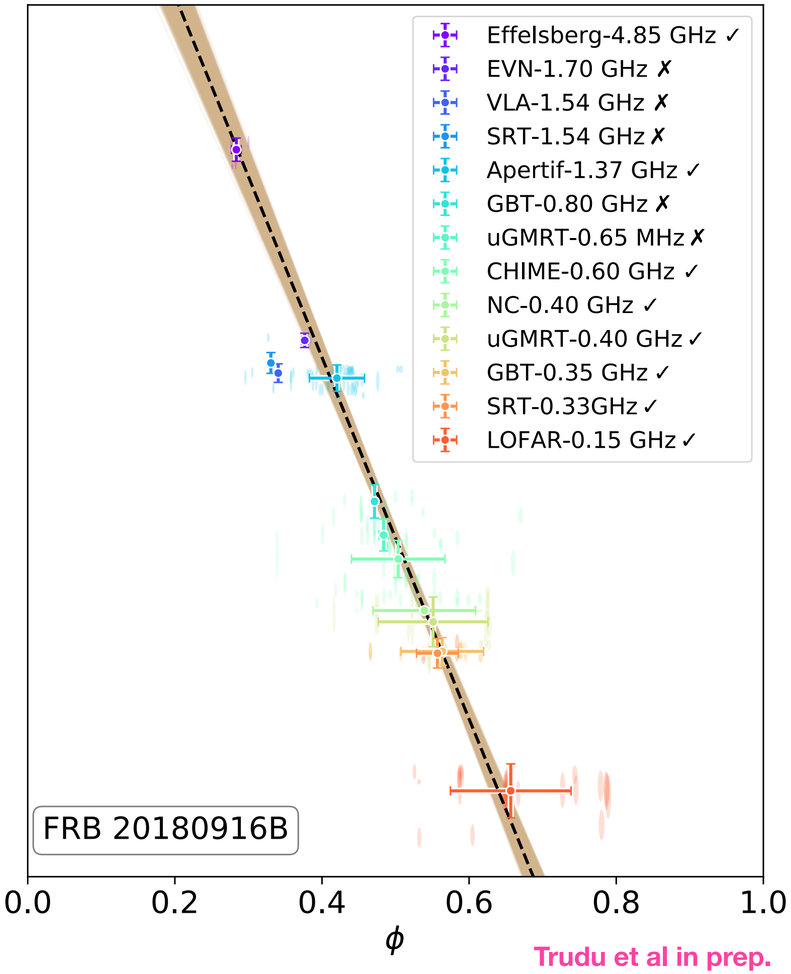
Chromaticity of R3 vs R1

- R3 chromaticity template

$$\nu = \nu_C \exp\left(-\frac{\phi}{\phi_C}\right)$$







Trudu et al in prep.

Chromaticity of R3 vs R1

Emission Properties of Periodic Fast Radio Bursts from the Motion of Magnetars: Testing Dynamical Models

Dongzi Li[1,2,3] and J. J. Zanazzi[1]

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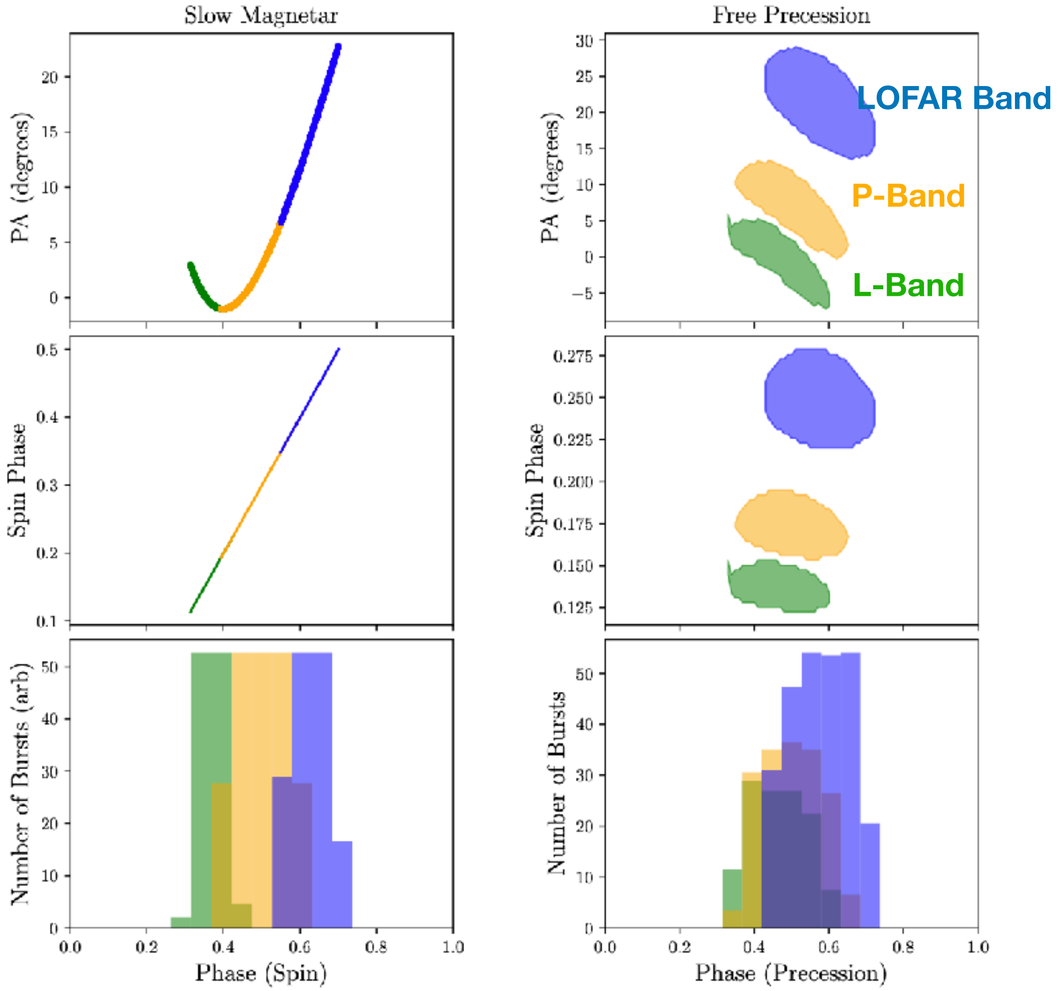
[2] *Department of Physics, University of Toronto, 60 St. George Street, Toronto, ON M5S 1A7, Canada*
[3] *Cahill Center for Astronomy and Astrophysics, California Institute of Technology, 1216 E California Blvd, Pasadena, CA 91125, US*



Summary and Conclusion

- Tighter constraints on the emission energetics at optical and high energy band
- From the whole dataset for R1 and R3 we showed that a chromatic activity seems unlikely for R1and R3 clearly shows an exponential trend
- We are currently performing a new MWL campaign (lead by HE instruments this time)
- We are planning to diversify our strategy (observational windows in line with the chromaticity model, different sources like FRB 20200220E, FRB 20201124A) stay tuned!

Thanks!

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