The quest for radio continuum counterparts of FRBs

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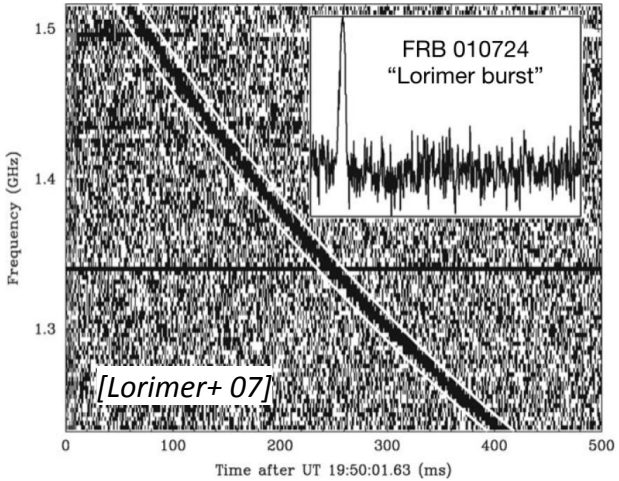
FRB-Italy 2025 - 9th May 2025

The nature of FRBs

Bright (~10^{-2} – 10^{2} Jy) and short-duration (~1 ms) extragalactic radio flashes



One-off VS **Repeater** (~10%) FRBs

- Real or apparent dichotomy?
- Distinct features?
- Different physical mechanisms?
- Different progenitors?

[Reviews: Petroff+ 22; Zhang 23]

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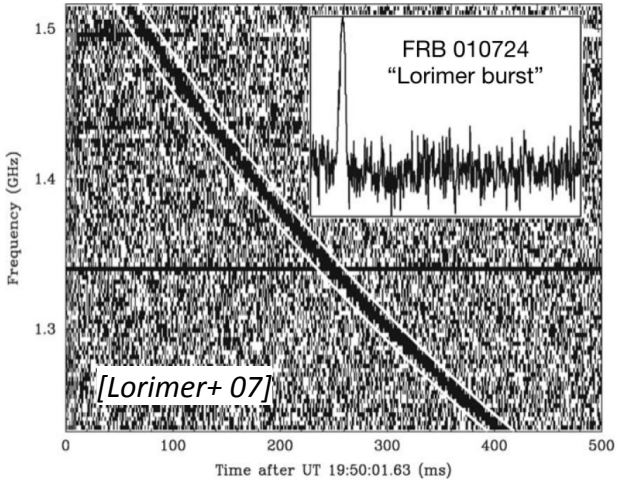

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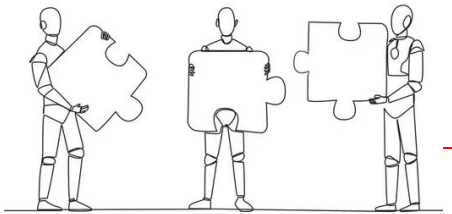


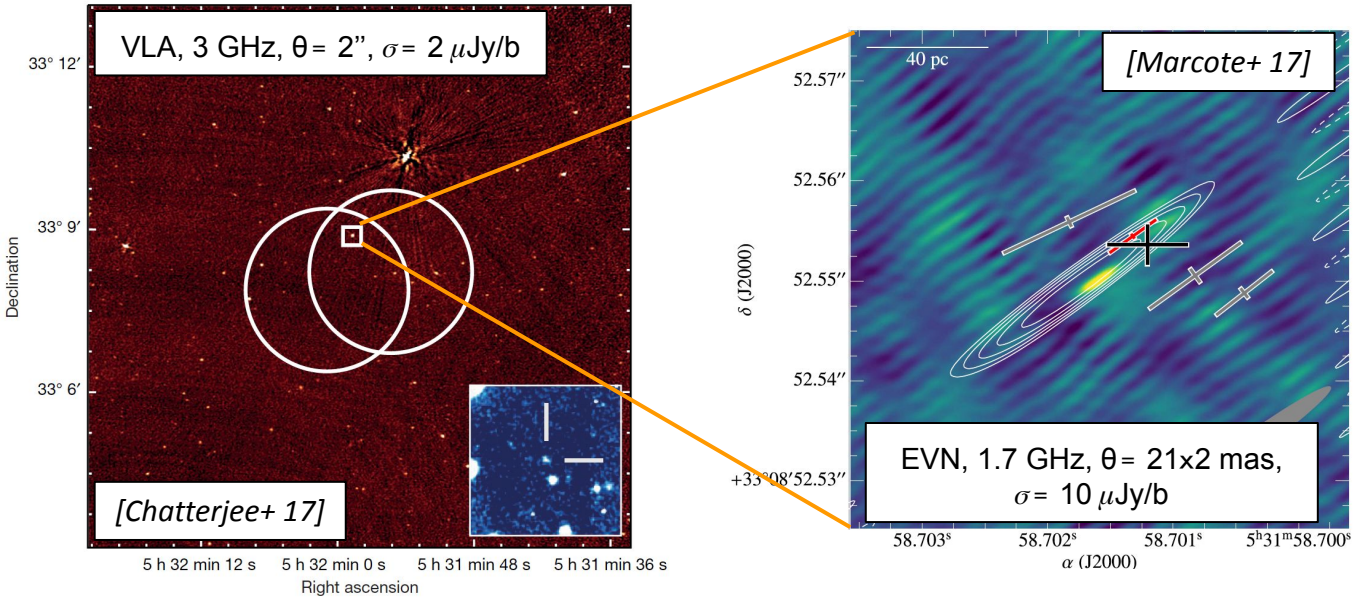
Long-monitoring programs
(*CHIME*, *NG-Croce*, *FAST*, *CRAFT*, *MeerTRAP, DSA*…)
& multi-wavelength information are vital!

[Reviews: Petroff+ 22; Zhang 23]

Transient and persistent emission

Key discovery of PRS: radio continuum compact source co-spatial with rFRB

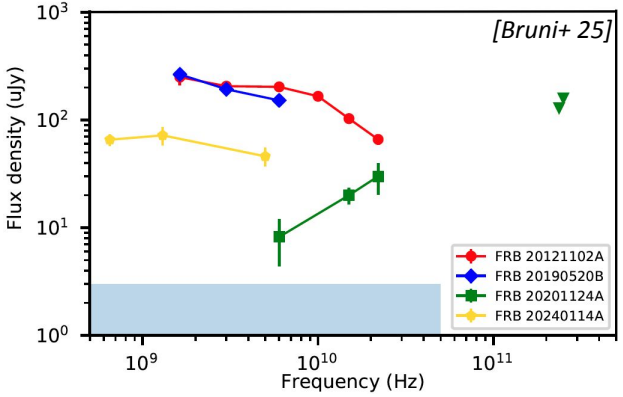
FRB 20121102A



Transient and persistent emission

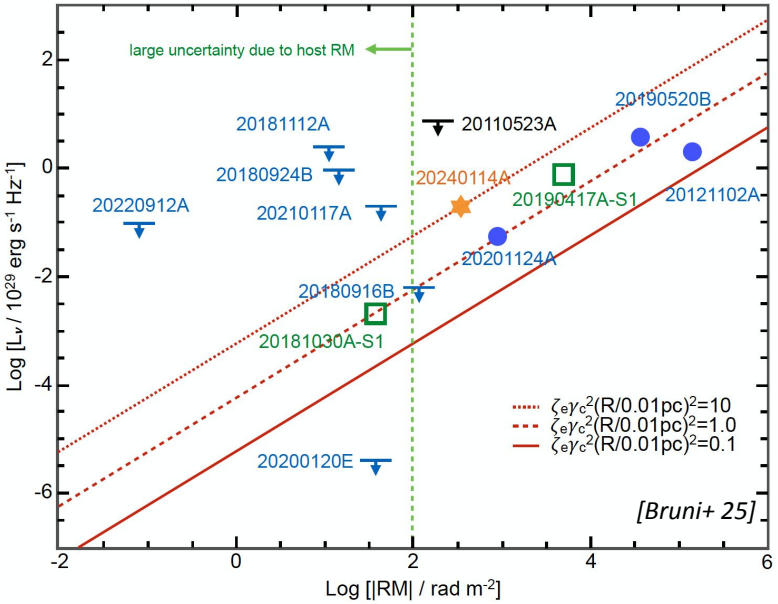
Known PRSs (+ candidates)

1. FRB 20121102A *[Chatterjee+ 17]*
2. FRB 20190520B *[Niu+ 22]*
3. FRB 20201124A *[Bruni+ 24]*
4. FRB 20181030A *[Ibik+ 24]*
5. FRB 20190417A *[Ibik+ 24]*
6. FRB 20240114A *[Bruni+ 25]*



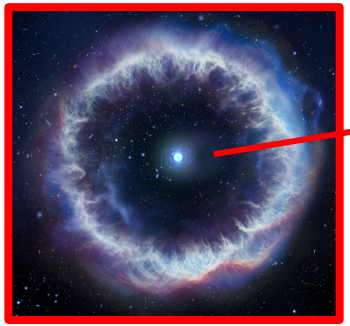
Properties

- rFRB only
- Compact on pc-scales
- No AGN/SF
- Spectrum: $S_\nu \propto \nu^{\pm|\alpha|}$
- $L_{\nu,\mathrm{PRS}} \propto |RM_{\mathrm{FRB}}|$



The magnetar-nebula model

Credit: S. Dagnello, NSF/AUI/NRAO



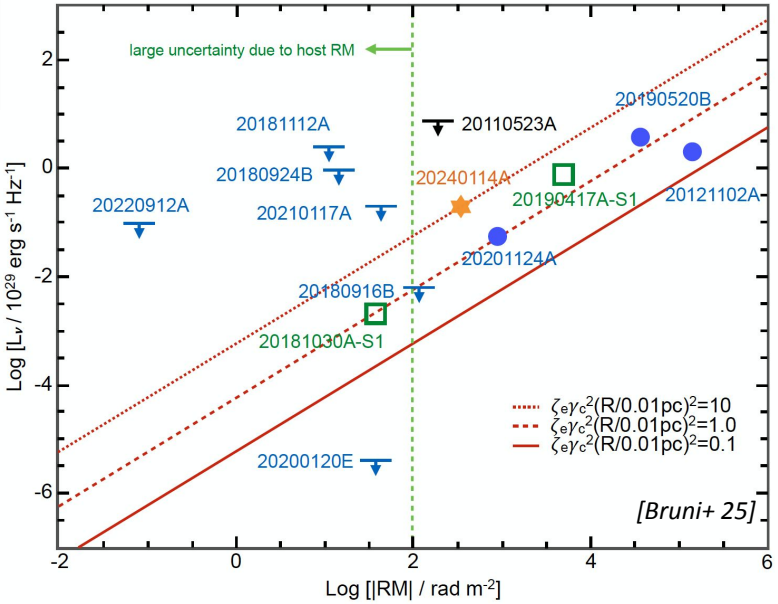
- Magnetar emits FRBs
- Circumstellar magneto-ionic nebula emits via synchrotron

$$L_{\nu,\mathrm{PRS}} \propto B^2_{\mathrm{PRS}} \gamma^2_{\mathrm{PRS}}$$

$$|RM_{\mathrm{FRB}}| \propto \int n_{e,\mathrm{PRS}} B_{\mathrm{PRS}} dl$$

Nebula includes electrons powering PRS and causing Faraday rotation of FRB

[Margalit & Metzger+ 18; Yang+ 20]

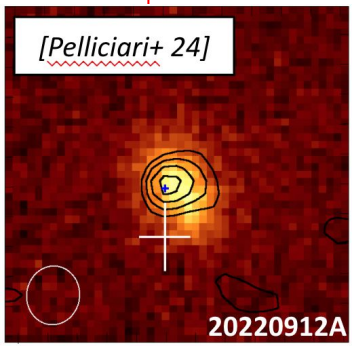


Searching for PRSs with uGMRT

PRSs are preferential probes of FRB progenitor and origin!

uGMRT search campaign
(PIs: G. Bernardi; D. Pelliciari)

- $\Delta\nu$ = 1050-1450 MHz
- θ ~ 2''
- σ ~ 10-30 μJy/b

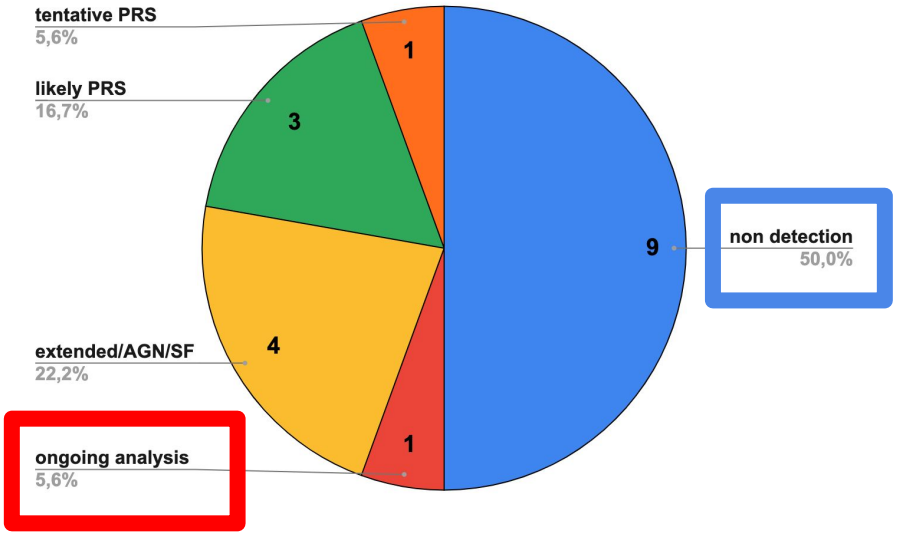


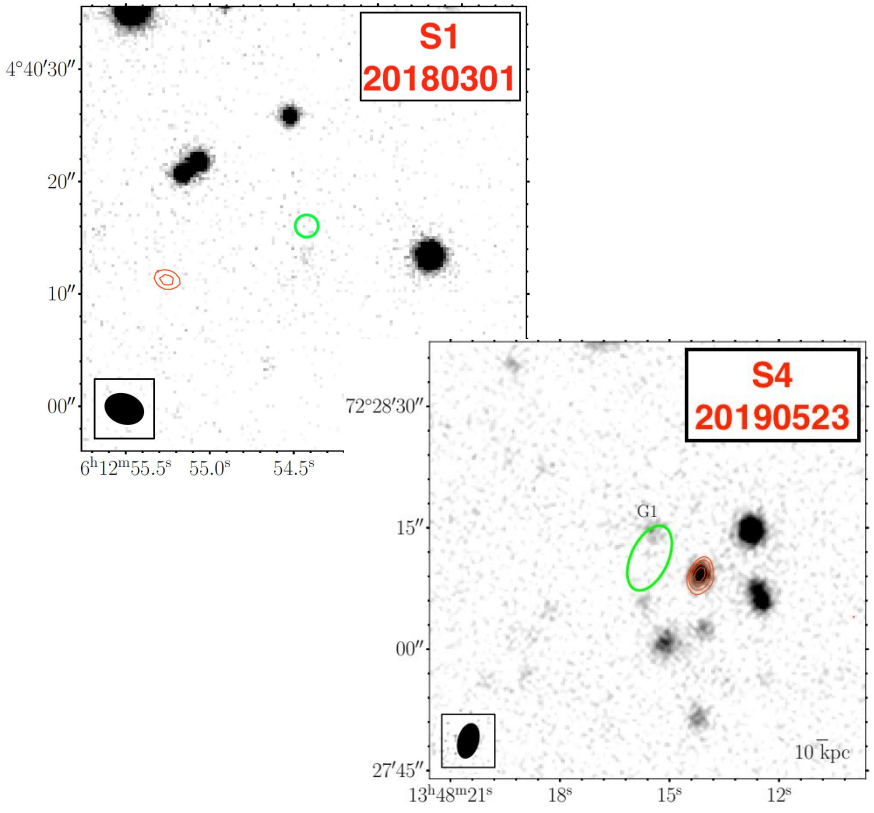
18 targets → 9 rFRB + 9 FRB
localisation region of ~1''- 1'

AIMS:

- occurrence of PRSs
- search for PRSs in one-off FRBs
- deep ULs for non-detections

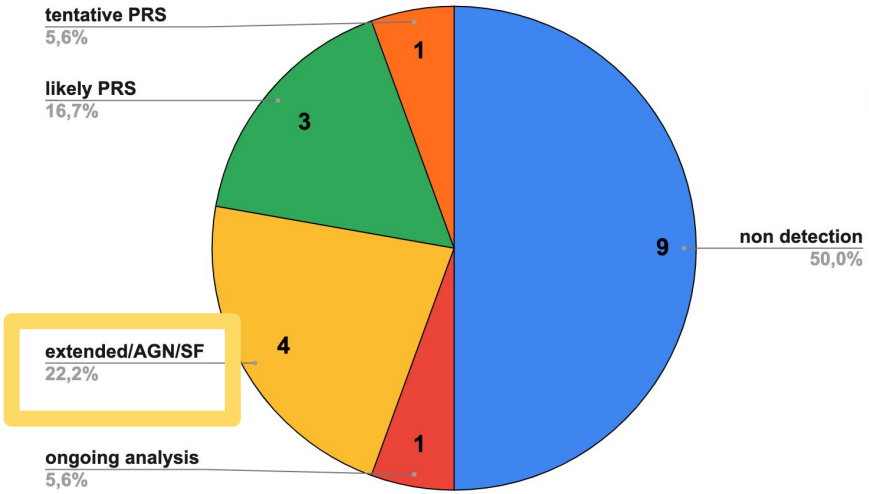
Detections and upper limits

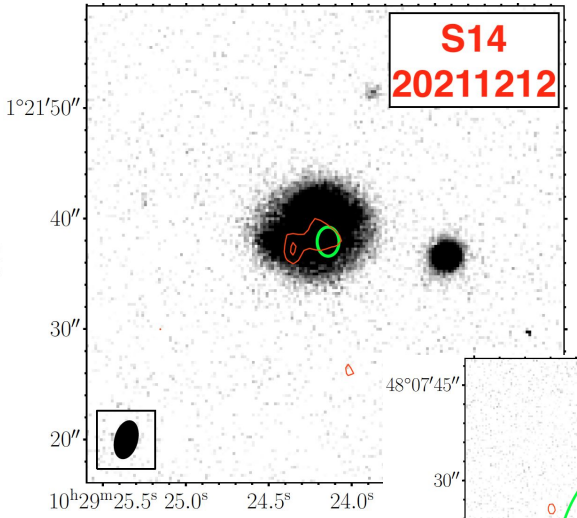


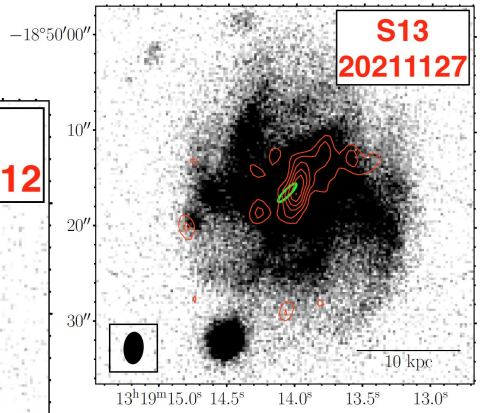


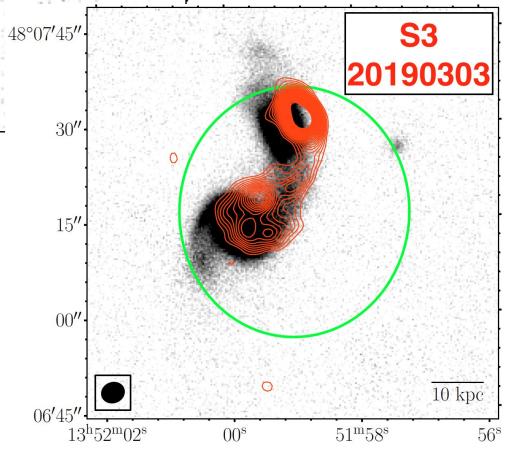
Preliminary results *[Pelliciari+ LB+, in prep.]*

Detections and upper limits









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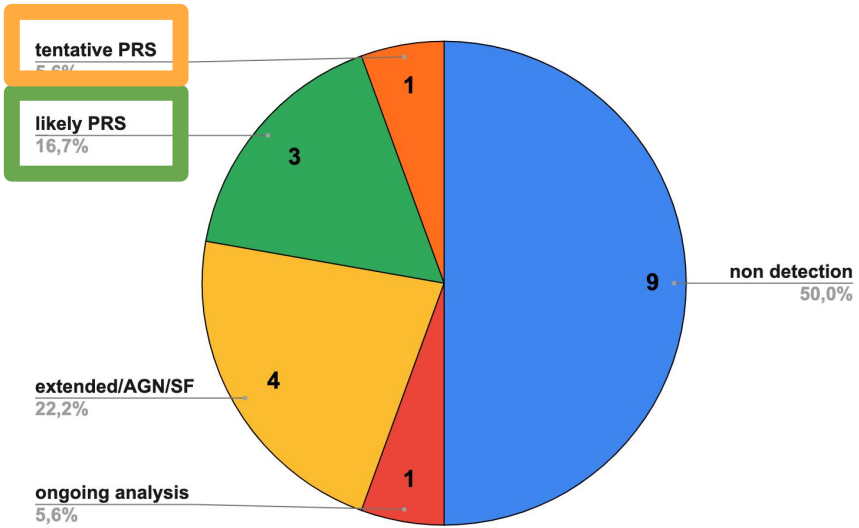
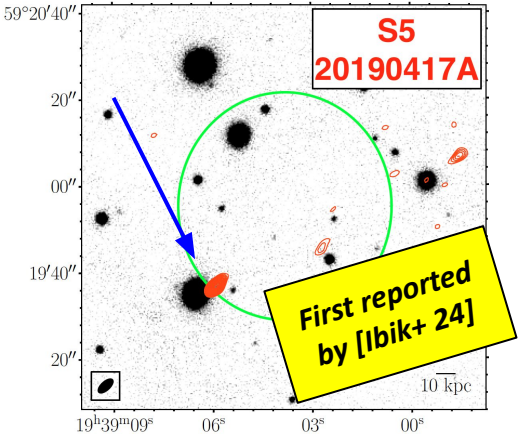
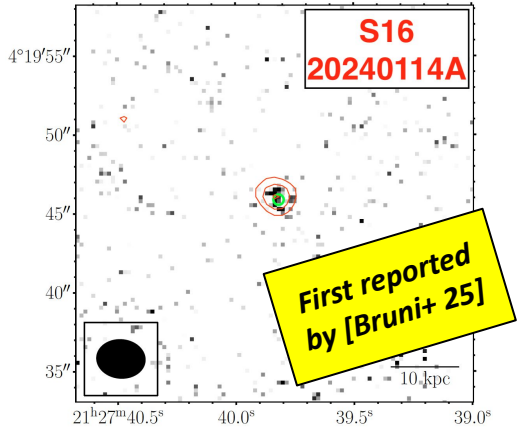
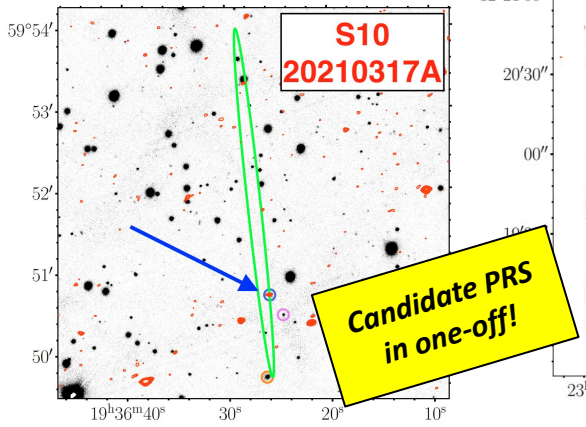
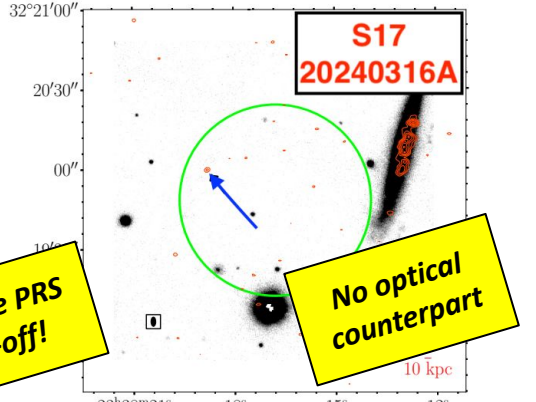




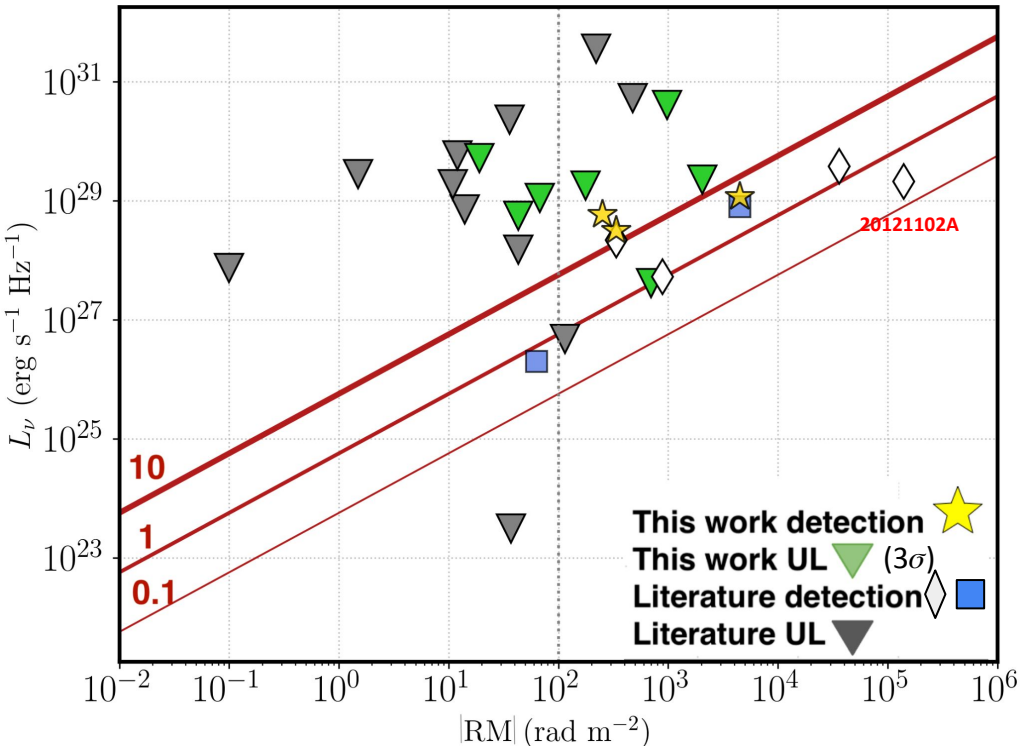






Preliminary results *[Pelliciari+ LB+, in prep.]*

Radio power VS rotation measure



Detections in line with correlation

Number of ULs increased by x2

ULs consistent with or deeper than PRS in FRB 20121102A

PRS absent or fainter?

Preliminary results *[Pelliciari+ LB+, in prep.]*

Summary and conclusions

Summary

- search of PRSs in 18 targets
- 4 candidate PRSs
- x2 increase of number of ULs
- deep ULs wrt to known PRSs

What's next ?

- Further analysis of candidate PRSs
- Sub-arcsec follow-up
- Additional targets coming… stay tuned!

Thanks for your attention

… Questions?

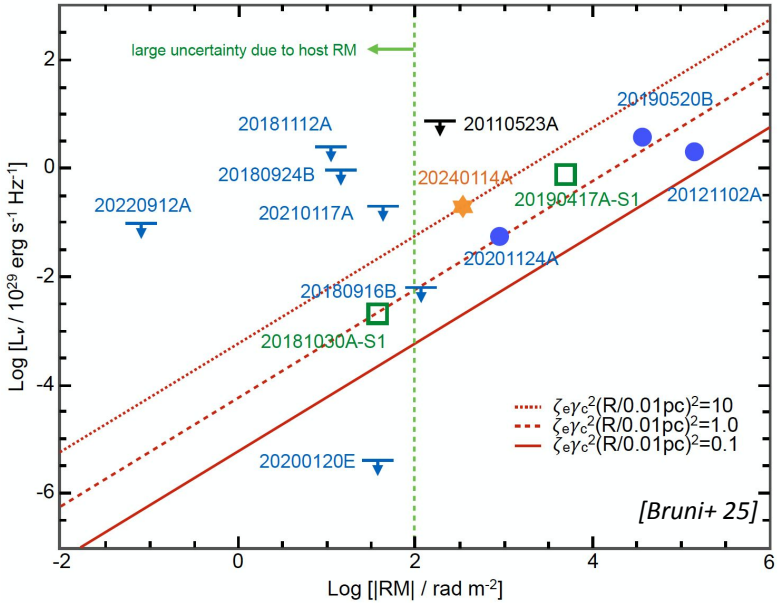
The magnetar-nebula model

Nebula radius

Lorentz factor

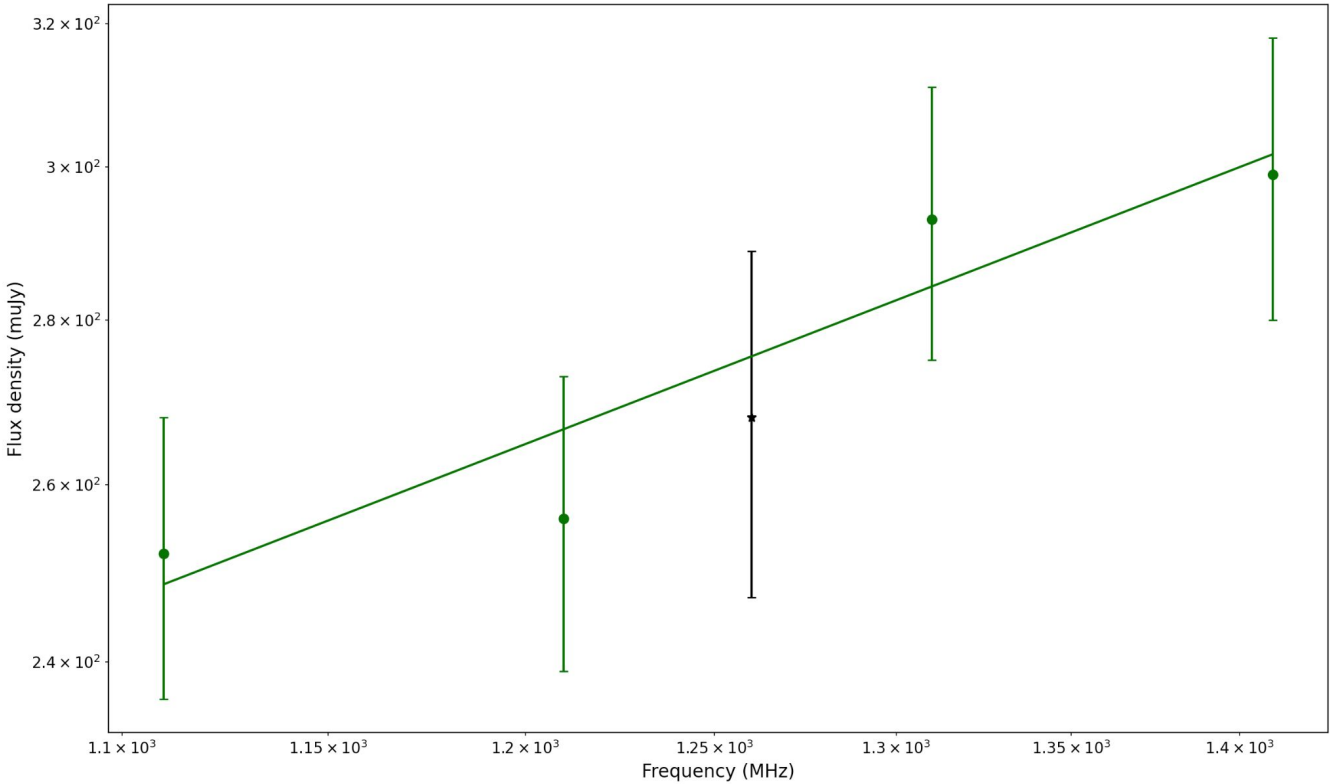
$$L_\nu \simeq 5.7 \times 10^{28}\ \mathrm{erg\ s^{-1}\ Hz^{-1}} \zeta_e \gamma_c^2 \left(\frac{|\mathrm{RM}|}{10^4\ \mathrm{rad\ m^{-2}}}\right)\left(\frac{R}{10^{-2}\ \mathrm{pc}}\right)^2$$

Fraction of non-thermal to thermal electrons



[Yang+ 20]

Spectrum of S5



In-band spectrum

α = -0.8 ± 0.2