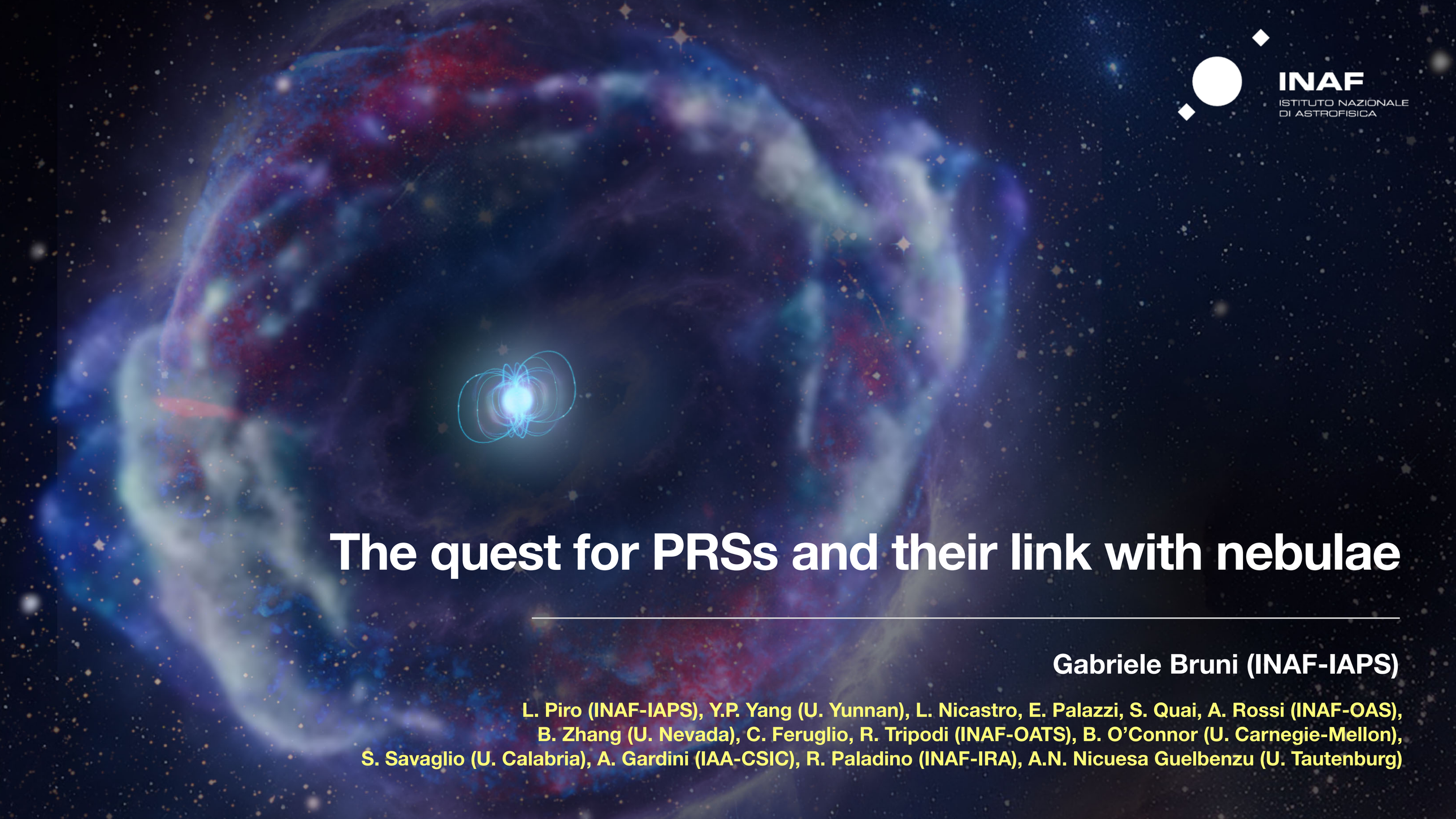

INAF
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DI ASTROFISICA

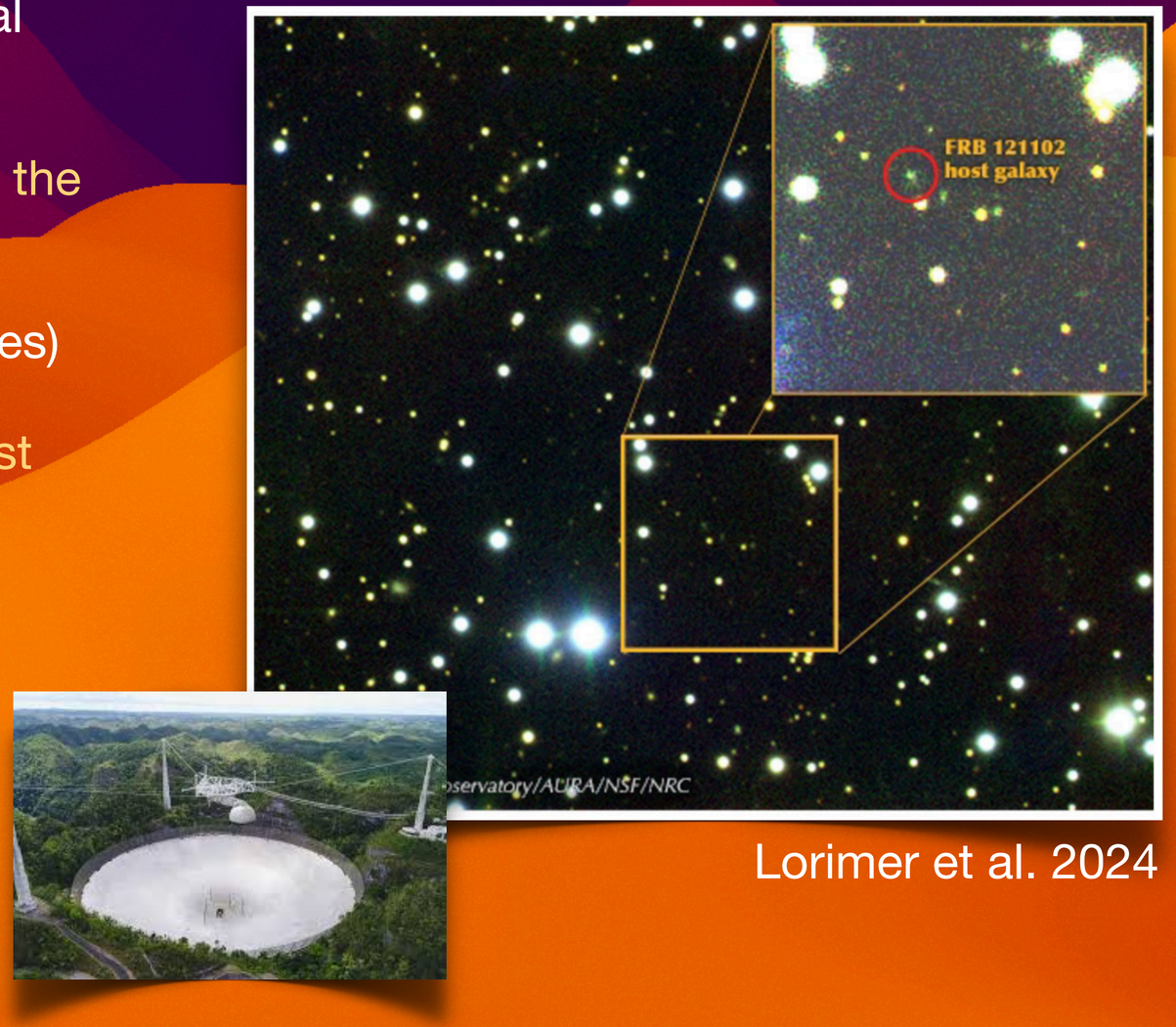
The quest for PRSs and their link with nebulae

Gabriele Bruni (INAF-IAPS)

L. Piro (INAF-IAPS), Y.P. Yang (U. Yunnan), L. Nicastro, E. Palazzi, S. Quai, A. Rossi (INAF-OAS),
B. Zhang (U. Nevada), C. Feruglio, R. Tripodi (INAF-OATS), B. O'Connor (U. Carnegie-Mellon),
S. Savaglio (U. Calabria), A. Gardini (IAA-CSIC), R. Paladino (INAF-IRA), A.N. Nicuesa Guelbenzu (U. Tautenburg)

Repeating FRB

- In 2014, FRB121102 was found in Arecibo archival data from 2012 (Spitler burst)
- In 2015 it reactivated, producing 11 bursts: it was the first repeating FRB
- Non-catastrophic nature (at least for repeating ones)
- Most importantly, first direct localization in the host galaxy with the VLA



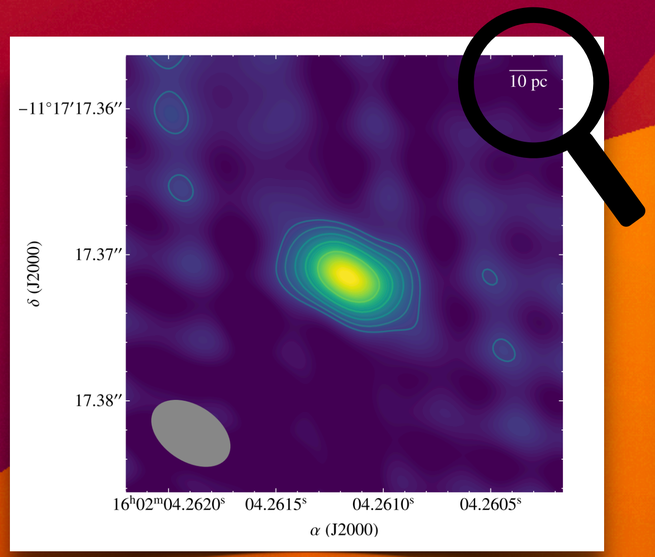
Lorimer et al. 2024

Persistent radio emission

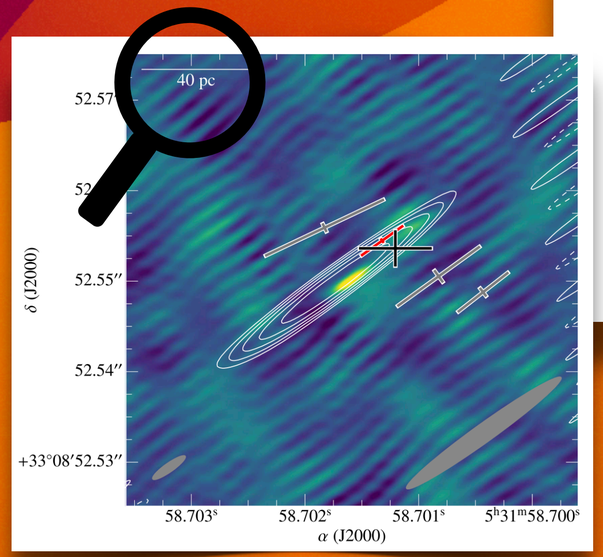
PRS were initially detected only in two repeating FRB:

- FRB20121102A (Chatterjee et al 2017; Marcote et al. 2017)
- FRB 20190520B (Niu et al. 2022, Bhandari et al. 2023)

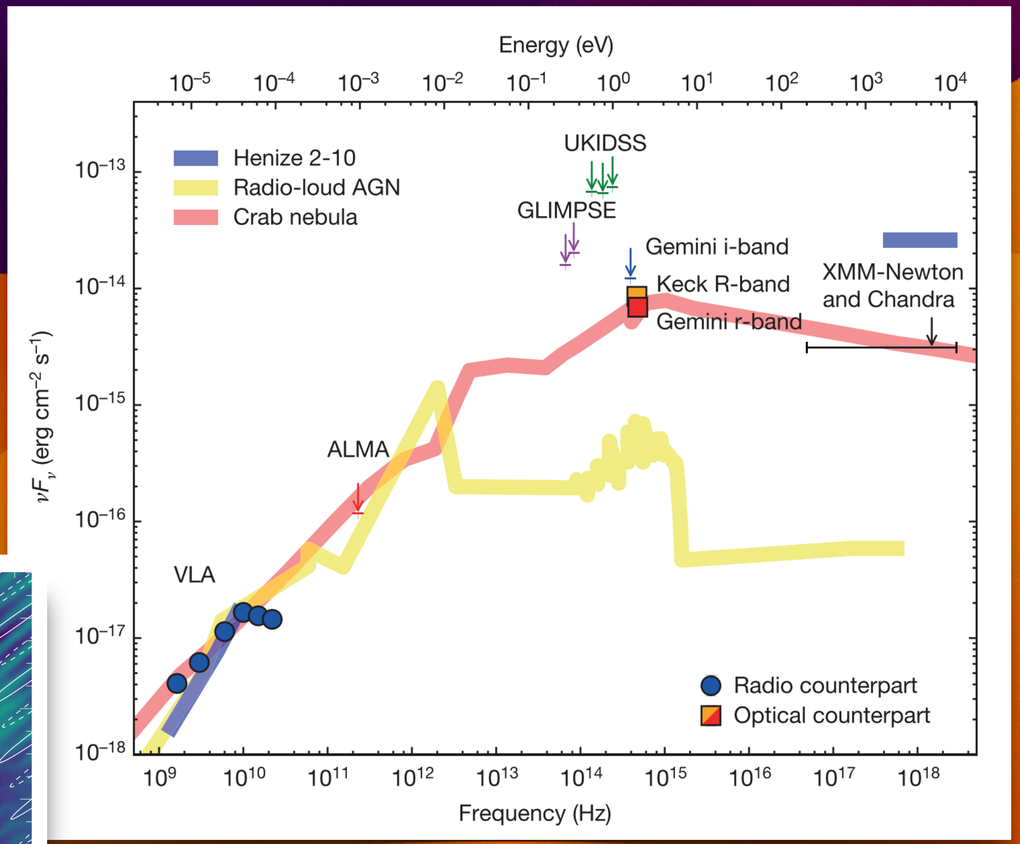
pc scale



Bhandari et al. 2023



Marcote et al. 2017



Chatterjee et al 2017

The PRS associated with FRB 20201124A

First hints of a persistent emission

HOME Information Catalog1 CHIME/FRB Collaboration (2023) Catalog Baseband Catalog 1 VOEvents Repeating FRBs Galactic Sources Transit Calcu

CHIME/FRB

Fast Radio Bursts in realtime

Last Updated:

This data is provided to you by the CHIME/FRB collaboration. If you use this data, please use the following acknowledgement:

We acknowledge use of the CHIME/FRB Public Database, provided at https://www.chime-frb.ca/ by the CHIME/FRB Collaboration.

Note that is page is manually updated by a human and so can have a significant delay. Repeat bursts are also sent automatically by our VOEvent stream as "subsequent" events. See he

CHIME/FRB VOEvents Overview Page.

Repeating FRBs (Total: 60 sources)

Repeaters that have a burst in the past 10 days are highlighted in red

Per page 10 « ‹ 1 2 3 4 … › » Download Repeaters Filter: Type to Search

ID	Previous Name	Latest Event	DM (pc cm^{-3})	RA	Dec	Events	Arxiv Link	H
FRB20180916B	180916.J0158+65	2023-11-23 05:55:27.065436	349.4 (1.6)	01:58	+65:44	114	1908.03507	s
FRB20220912A		2023-11-21 03:07:05.524242	222.1 (0.9)	347.27	+48.70	439		
FRB20190303A	190303.J1353+48	2023-10-11 20:30:26.829565	223.3 (2.1)	13:53	+48:15	31	2001.03595	
FRB20181128A	181128.J0456+63	2023-10-06 12:03:01.165552	449.3 (2.2)	04:56	+63:23	10	1908.03507	
FRB20200120E		2023-10-01 17:25:53.106130	88.2 (0.8)	09:57	+68:49	9	2103.01295	
FRB20181119A	181119.J12+65	2023-09-25 20:24:21.759966	365.6 (2.3)	12:42	+65:08	15	1908.03507	
FRB20190117A	190117.J2207+17	2023-09-12 06:44:26.481705	396.4 (0.9)	22:07	+17:23	14	2001.03595	
FRB20200926A		2023-08-04 06:00:38.187632	758.7 (1.0)	18:53	+53:57	6	2301.08762	

Recent high activity from a repeating Fast Radio Burst discovered by CHIME/FRB

ATel #14497; ***CHIME/FRB Collaboration***

*on **31 Mar 2021; 02:11 UT***

[Previous I Next I ADS]

uGMRT detection of a persistent radio source coincident with FRB20201124A

ATel #14529; ***Robert Wharton (MPIfR), Suryarao Bethapudi (MPIfR), Tasha Gautam (MPIfR), Dongzi Li (Caltech), Hsiu-Hsien Lin (CITA), Robert Main (MPIfR), Viswesh Marthi (NCRA), Laura Spitler (MPIfR), Ue-Li Pen (CITA)***

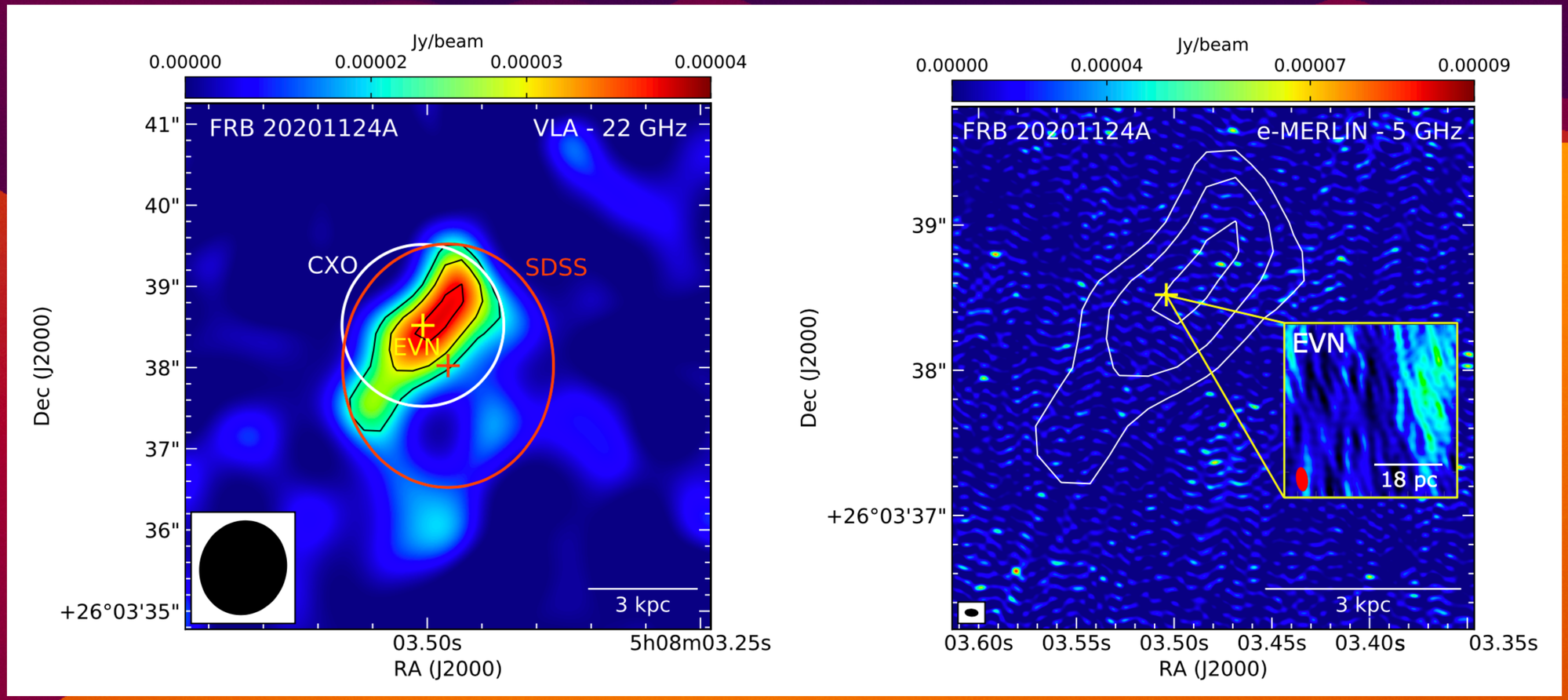
*on **8 Apr 2021; 14:39 UT***

Detection of a persistent radio source at the location of FRB20201124A with VLA

ATel #14549; ***Roberto Ricci (INAF/IRA), Luigi Piro (INAF/IAPS), Francesca Panessa (INAF/IAPS), Brendan O'Connor (George Washington University), Simone Lotti (INAF/IAPS), Gabriele Bruni(INAF/IAPS) , Bing Zhang (University of Nevada)***

The case of FRB 20201124A

Piro et al. 2021



Extended (5 kpc) region in VLA observations, no compact emission on sub-kpc scales

The case of FRB 20201124A

A&A 656, L15 (2021)
https://doi.org/10.1051/0004-6361/202141903

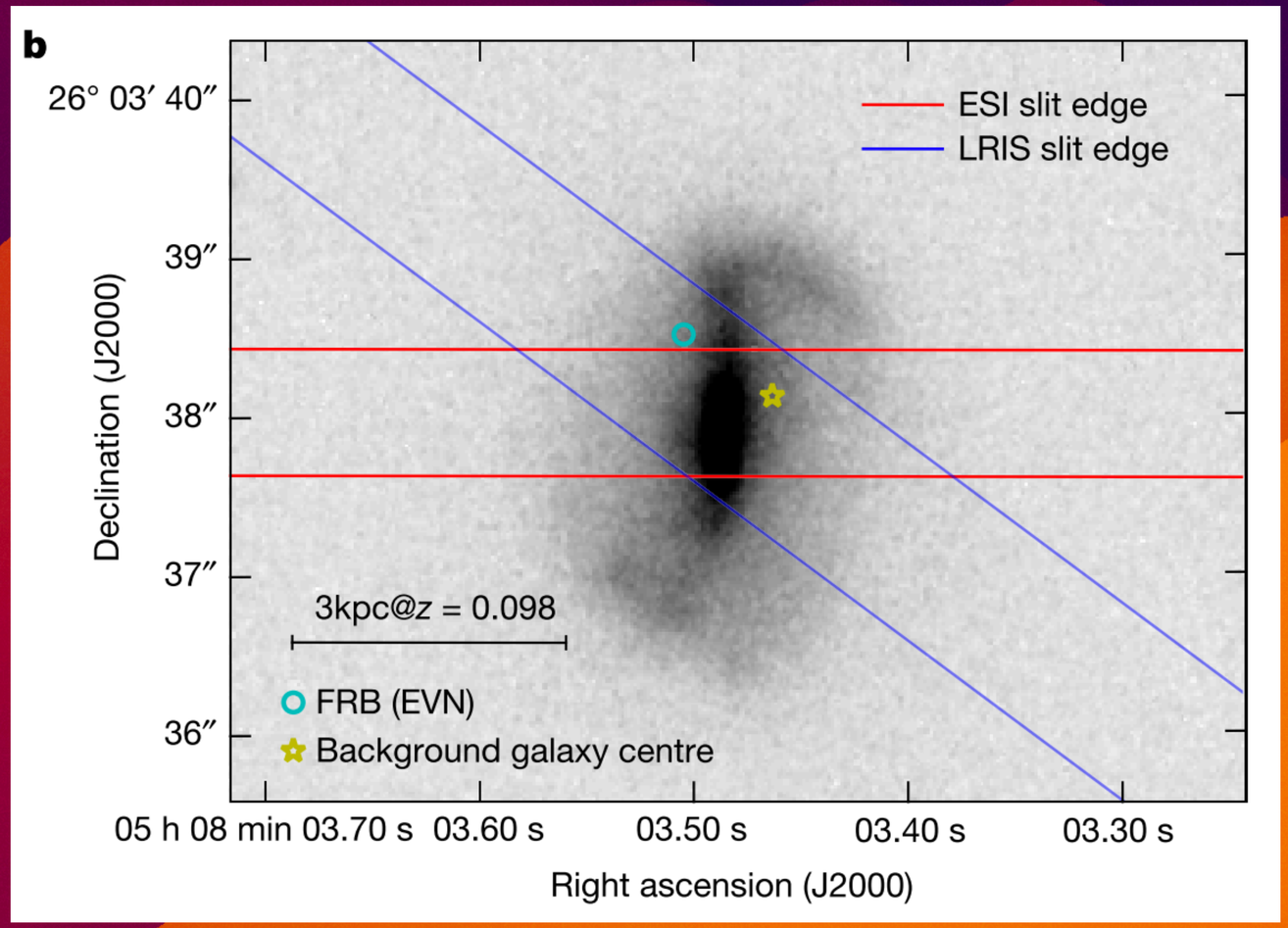
Astronomy & Astrophysics

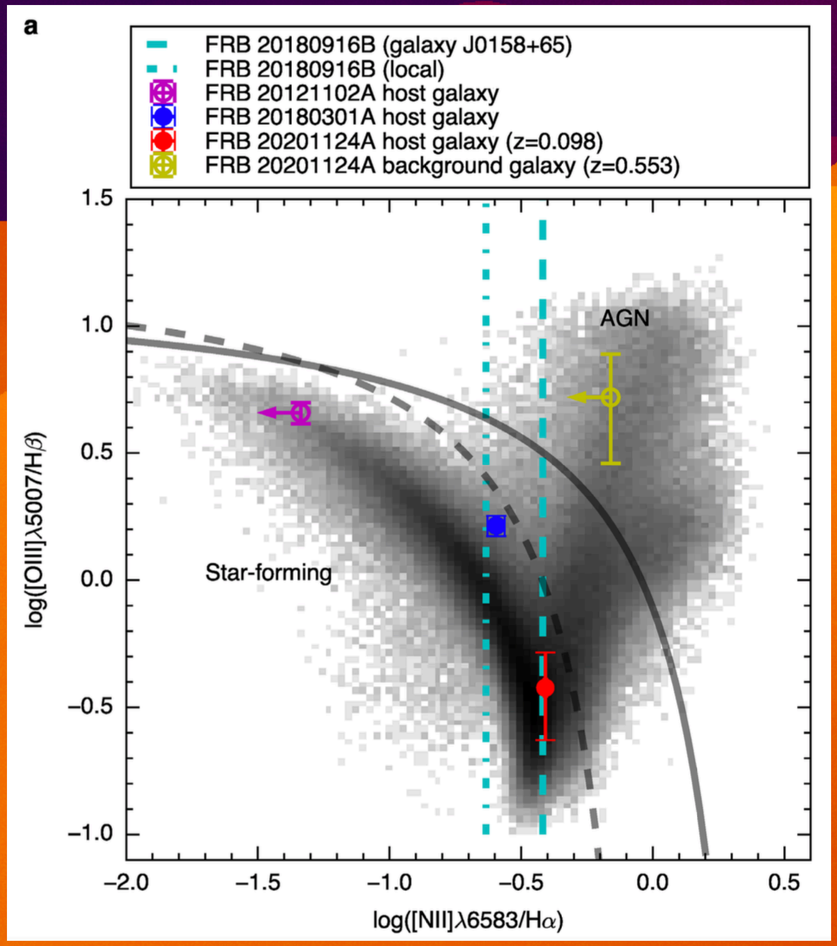
LETTER TO THE EDITOR

The fast radio burst FRB 20201124A in a star-forming region: Constraints to the progenitor and multiwavelength counterparts

L. Piro[1], G. Bruni[1], E. Troja[2,3], B. O'Connor[2,3,4,5], F. Panessa[1], R. Ricci[6,7], B. Zhang[8], M. Burgay[9], S. Dichiara[2,3], K. J. Lee[10], S. Lotti[1], J. R. Niu[11], M. Pilia[9], A. Possenti[9,12], M. Trudu[9,12], H. Xu[10], W. W. Zhu[11], A. S. Kutyrev[2,3], and S. Veilleux[2]

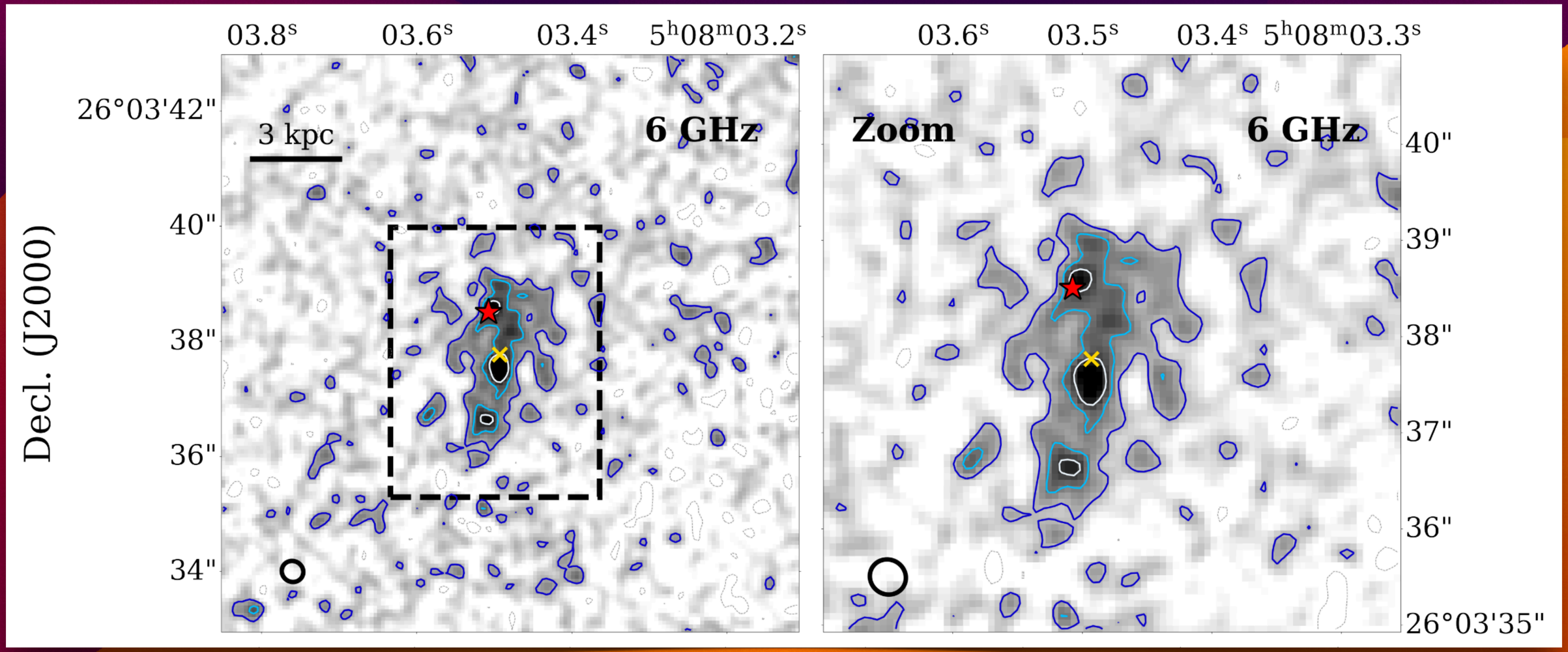
The case of FRB 20201124A





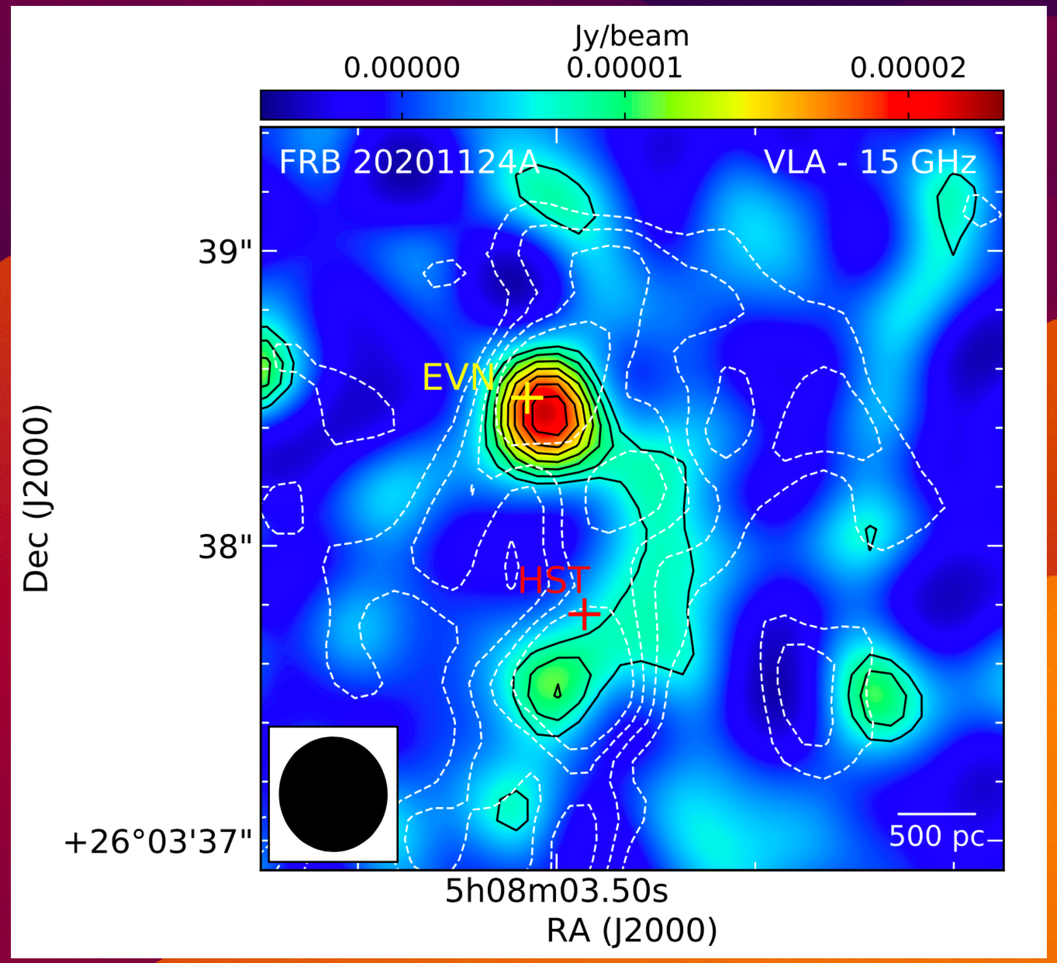
Xu et al. 2022

Obscured star forming regions unveiled by the VLA

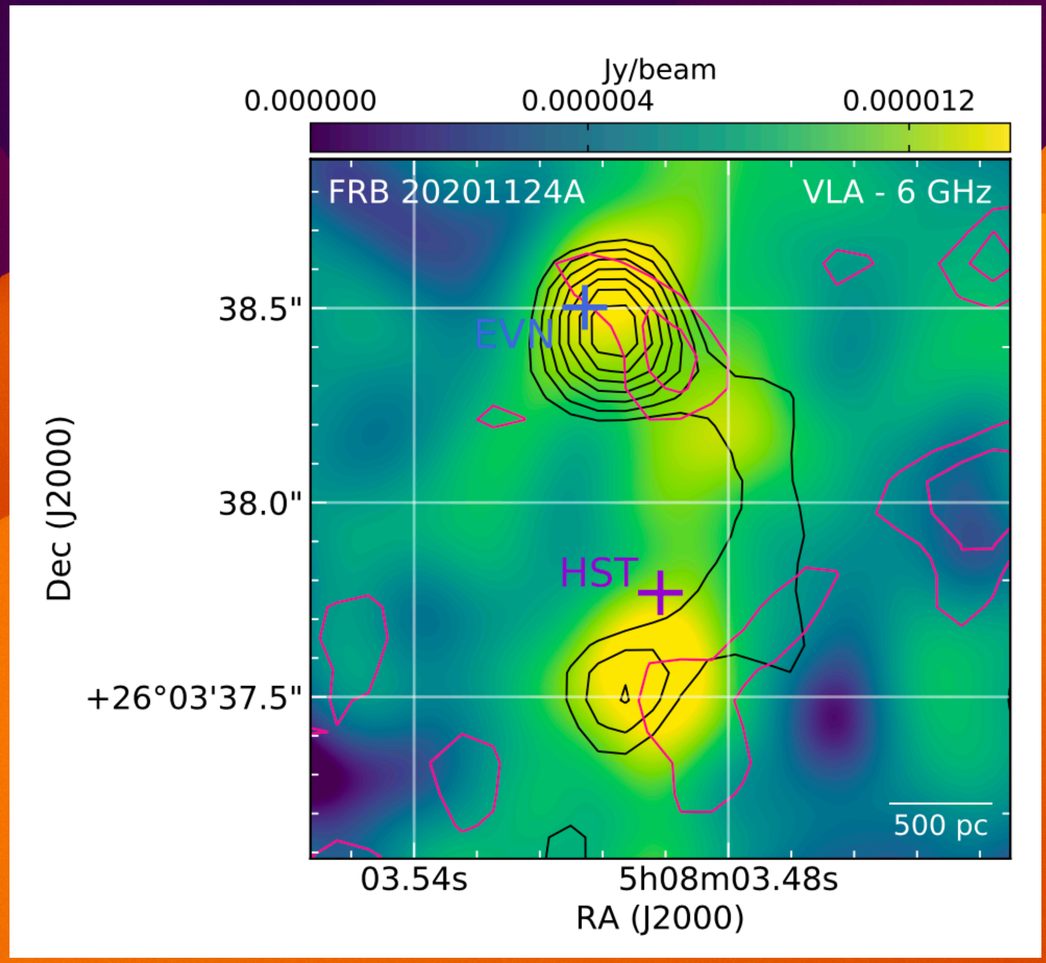


Dong et al. 2023

The discovery of a compact PRS



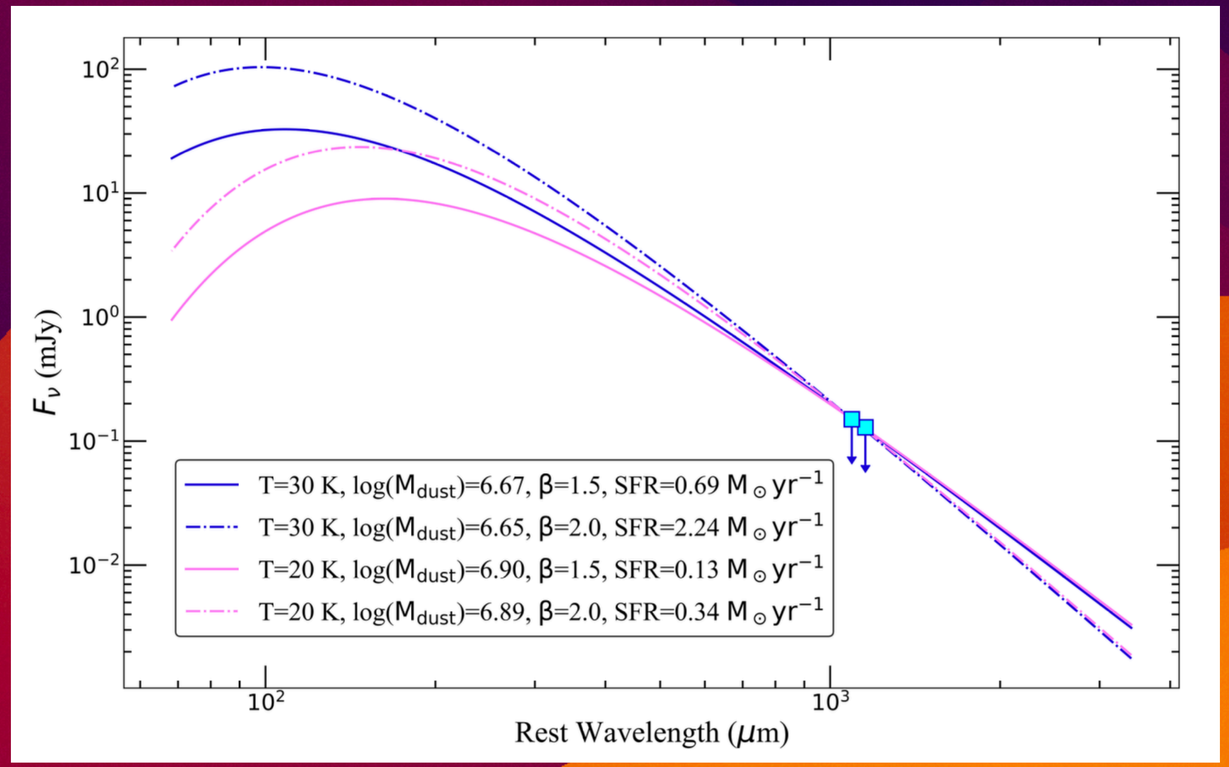
VLA (6+15 GHz)

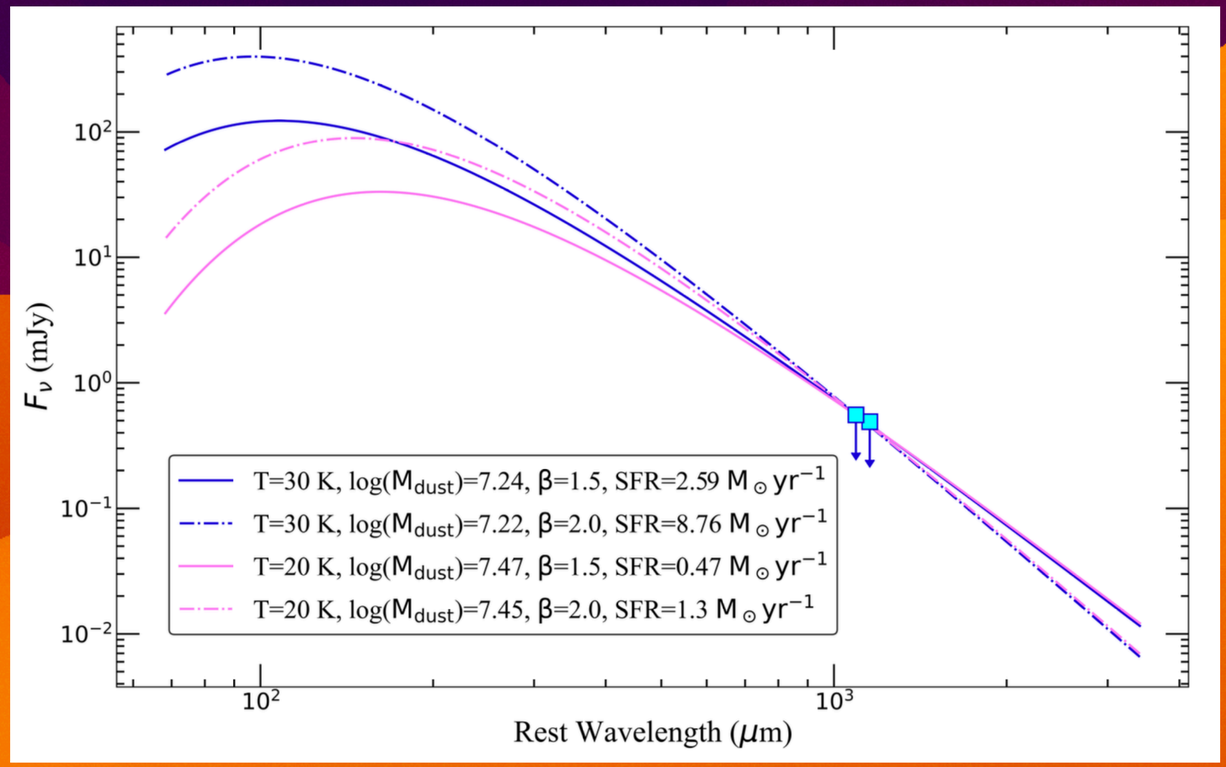


VLA (6+15+22 GHz)

Bruni et al. 2024, Nature

The dust component: NOEMA observations





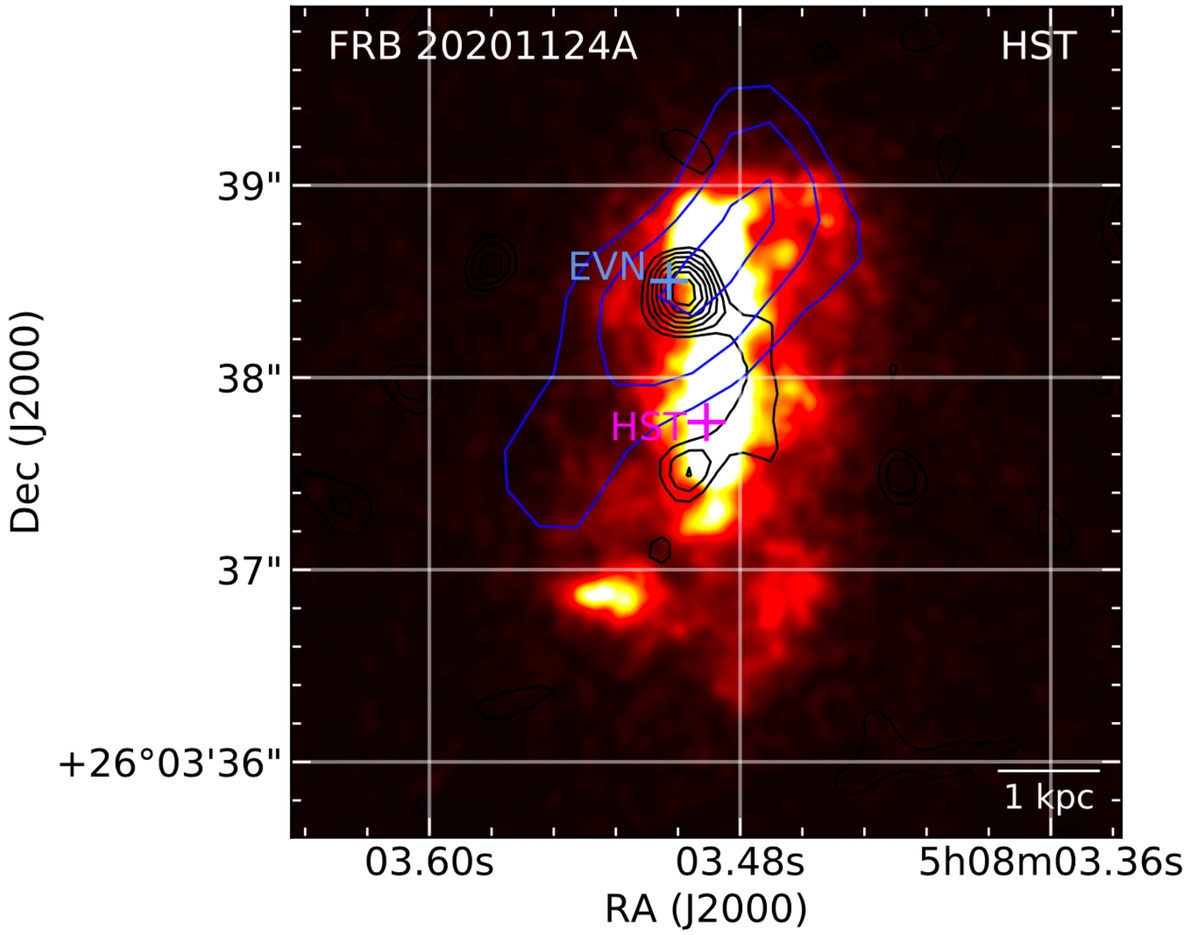
FRB region
(SFR<2.2 M/yr)

Host galaxy
(SFR<8.8 M/yr)

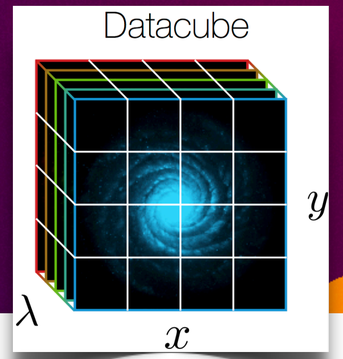
Bruni et al. 2024, Nature

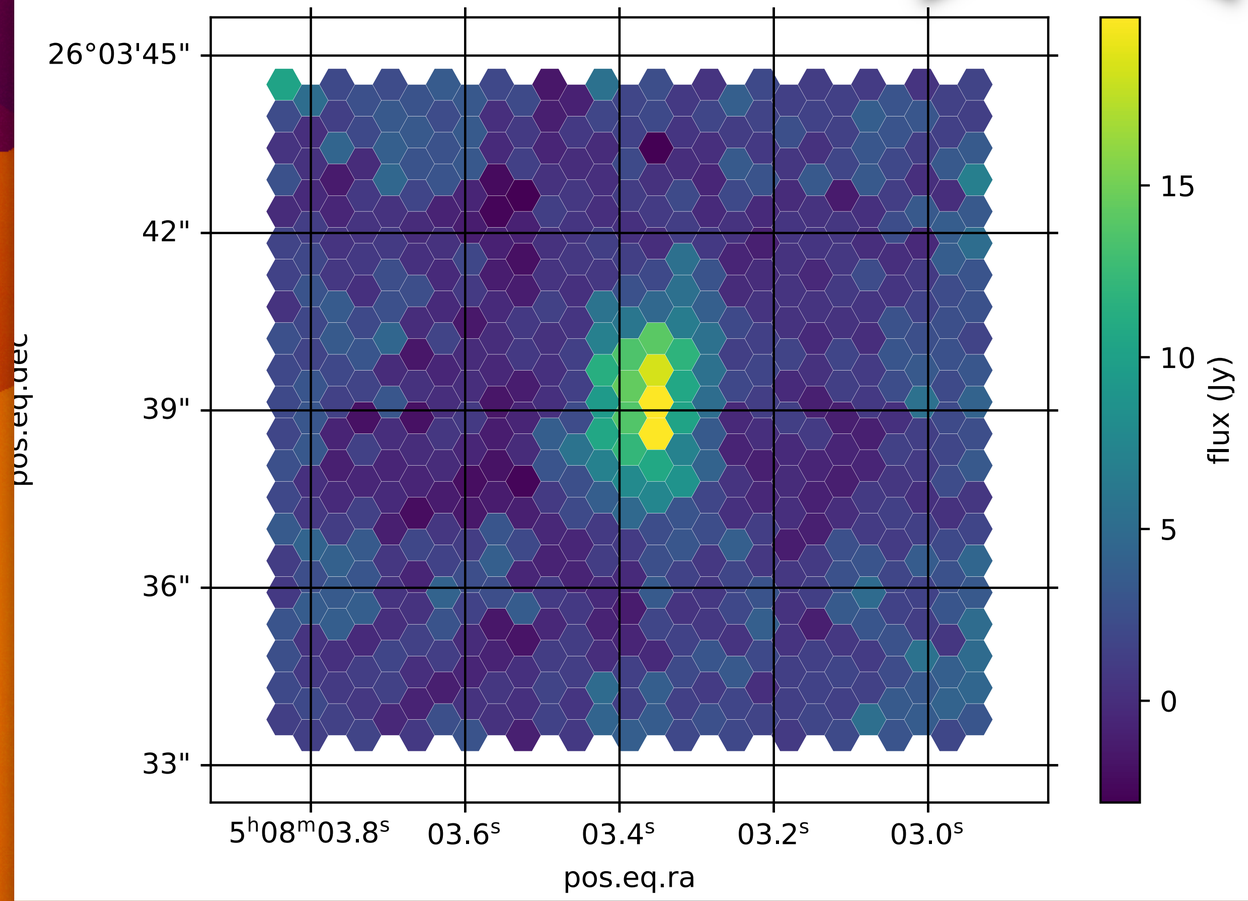
The host galaxy

Hubble



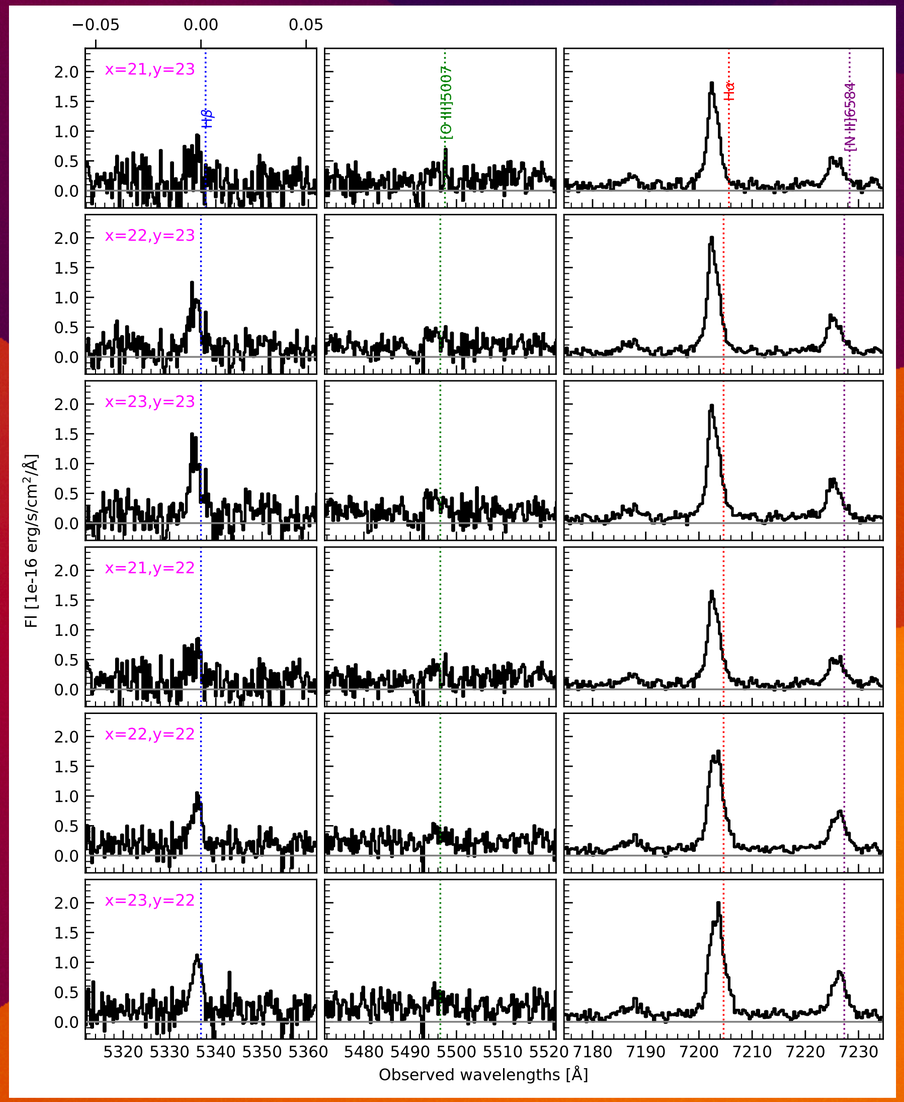
GTC/MEGARA

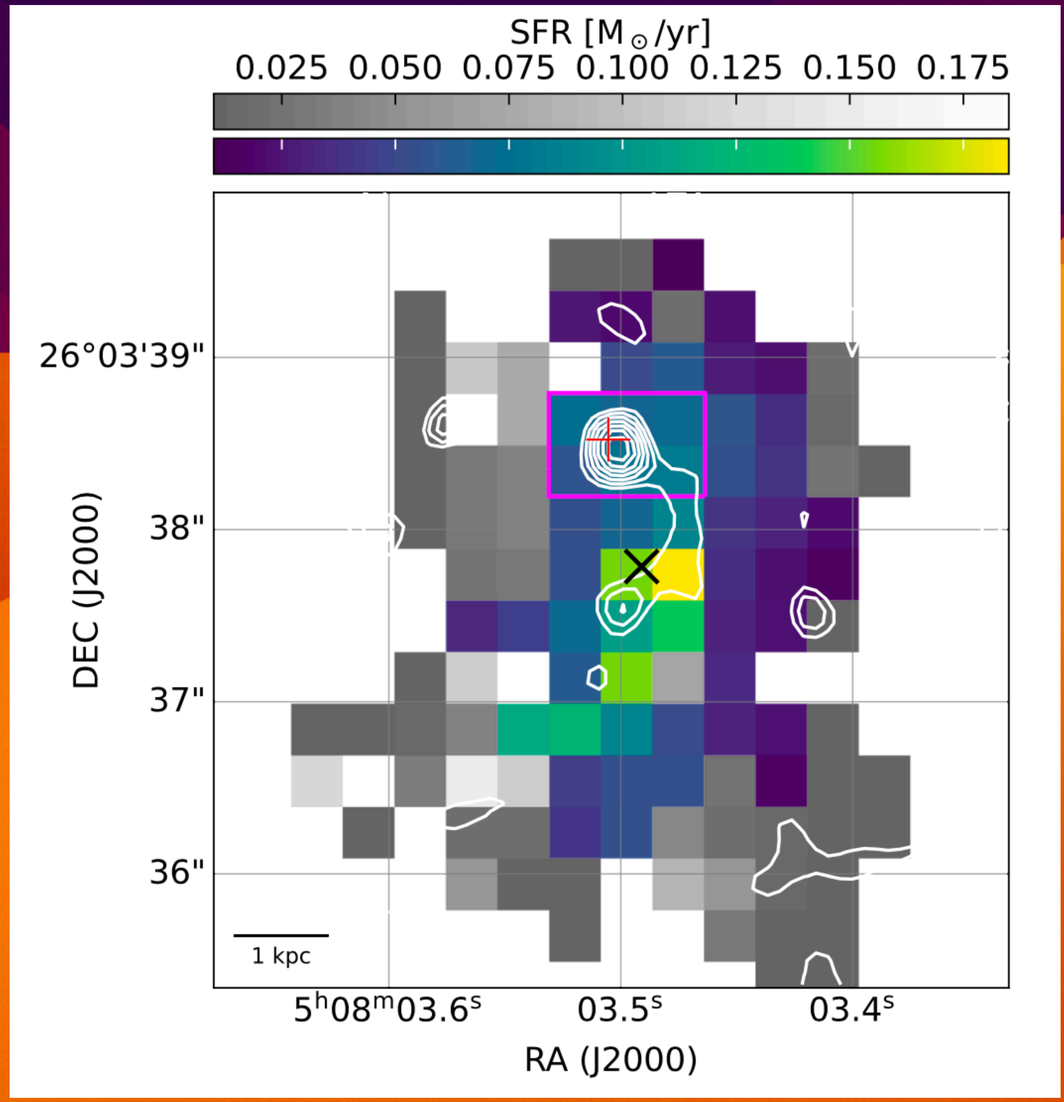




Bruni et al. 2024, Nature

The host galaxy

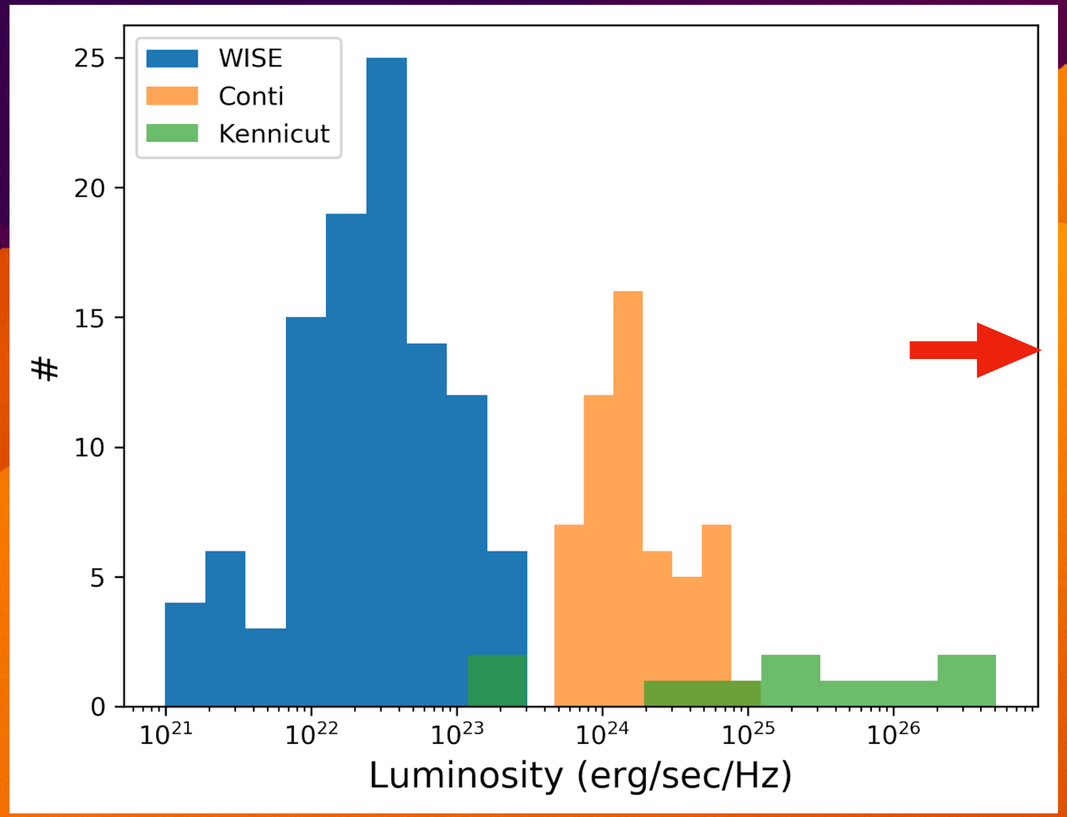




Bruni et al. 2024, Nature

Is it really a PRS?

- Size → < 700 pc (to be improved with HSA)
- NOEMA upper limit → Obscured SFR < 2.2 M/yr
- VLA detection → SFR > 3 M/yr
- GTC/MEGARA Halpha → SFR=0.4 M/yr
- Radio luminosity (4.9 x 10^27 erg/s/Hz) more than x10 higher than the largest, brightest SF regions



Where the PRS comes from?

The Astrophysical Journal, 895:7 (6pp), 2020 May 20 https://doi.org/10.3847/1538-4357/ab88ab

Are Persistent Emission Luminosity and Rotation Measure of Fast Radio Bursts Related?

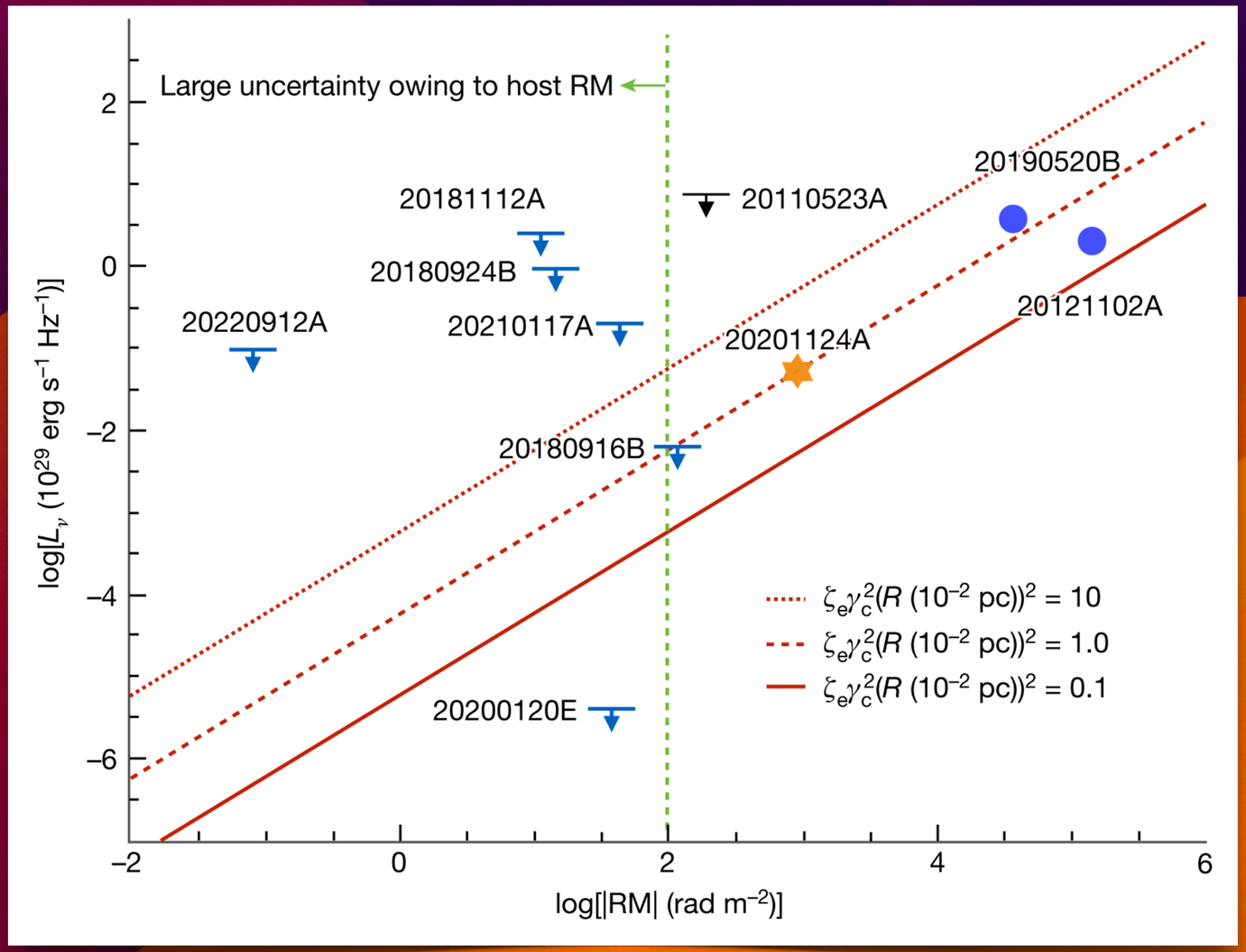
Yuan-Pei Yang[1], Qiao-Chu Li[2,3], and Bing Zhang[4]
[1] South-Western Institute for Astronomy Research, Yunnan University, Kunming, Yunnan, People's Republic of China; ypyang@ynu.edu.cn
[2] School of Astronomy and Space Science, Nanjing University, Nanjing 210093, People's Republic of China
[3] Key laboratory of Modern Astronomy and Astrophysics (Nanjing University), Ministry of Education, Nanjing 210093, People's Republic of China
[4] Department of Physics and Astronomy, University of Nevada, Las Vegas, NV 89154, USA; zhang@physics.unlv.edu
Received 2020 January 29; revised 2020 March 27; accepted 2020 April 11; published 2020 May 19

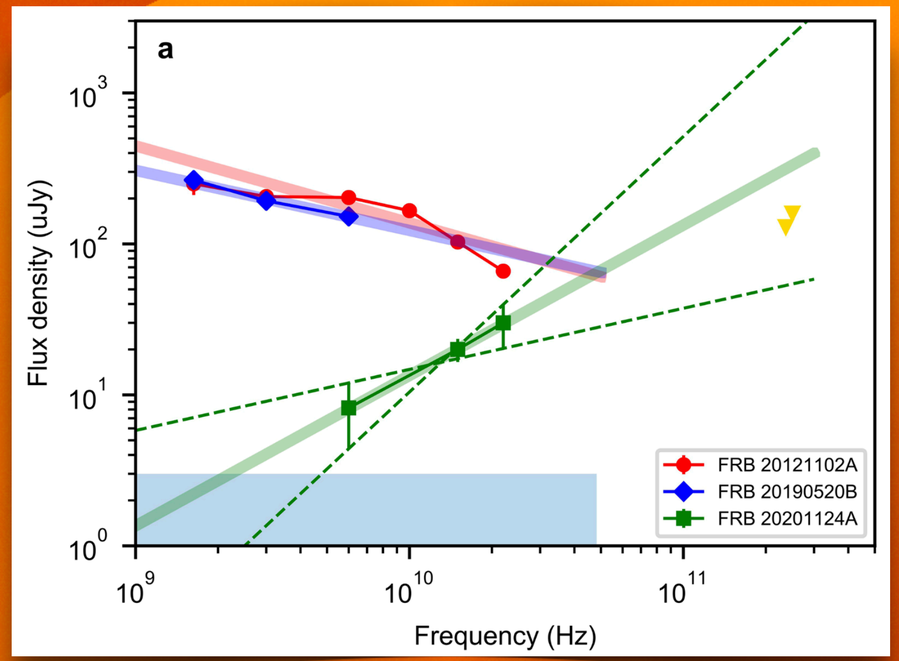
The Astrophysical Journal, 937:5 (22pp), 2022 September 20 https://doi.org/10.3847/1538-4357/ac8a4a

Radio Nebulae from Hyperaccreting X-Ray Binaries as Common-envelope Precursors and Persistent Counterparts of Fast Radio Bursts

Navin Sridhar[1,2] and Brian D. Metzger[2,3,4]
[1] Department of Astronomy, Columbia University, New York, NY 10027, USA
[2] Theoretical High Energy Astrophysics (THEA) Group, Columbia University, New York, NY 10027, USA
[3] Department of Physics, Columbia University, New York, NY 10027, USA
[4] Center for Computational Astrophysics, Flatiron Institute, 162 5th Avenue, New York, NY 10010, USA
Received 2022 June 28; revised 2022 August 14; accepted 2022 August 15; published 2022 September 15

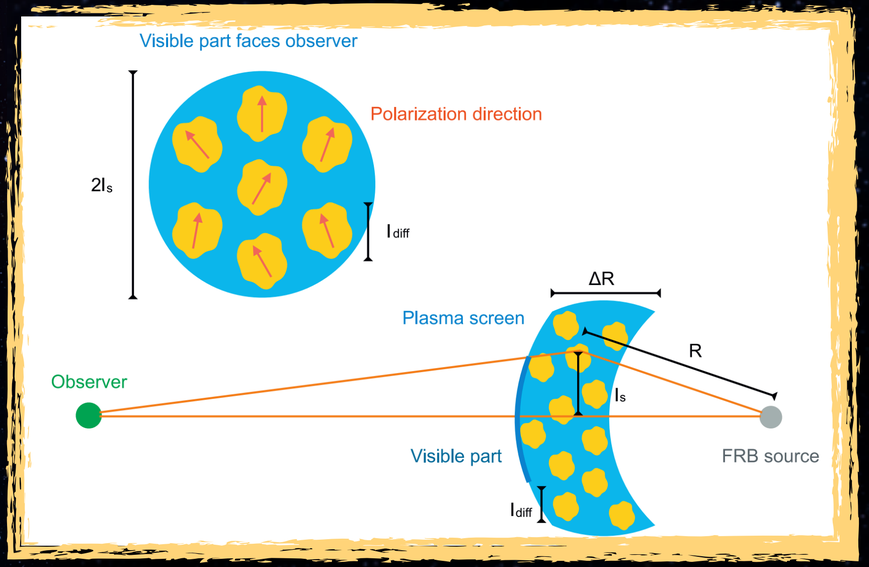
$$L_\nu \propto (\zeta_e \gamma_{\rm th}^2 R^2) \times |{\rm RM}|.$$





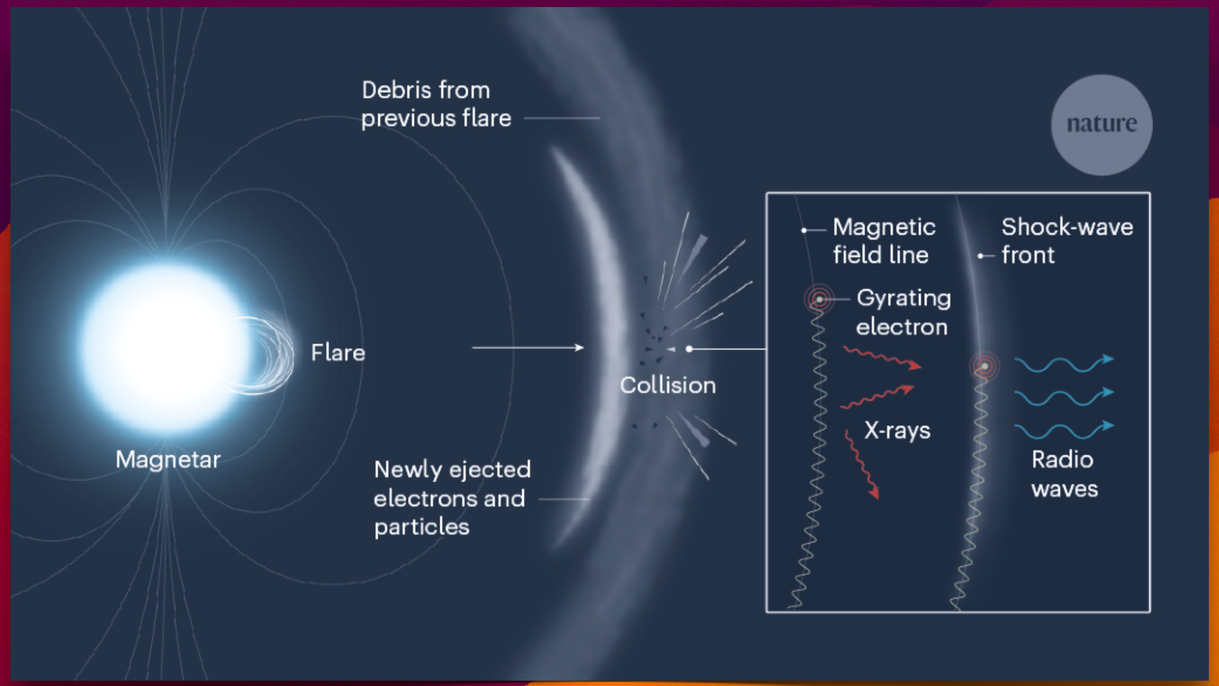
Bruni et al. 2024, Nature

Yang et al. 2022

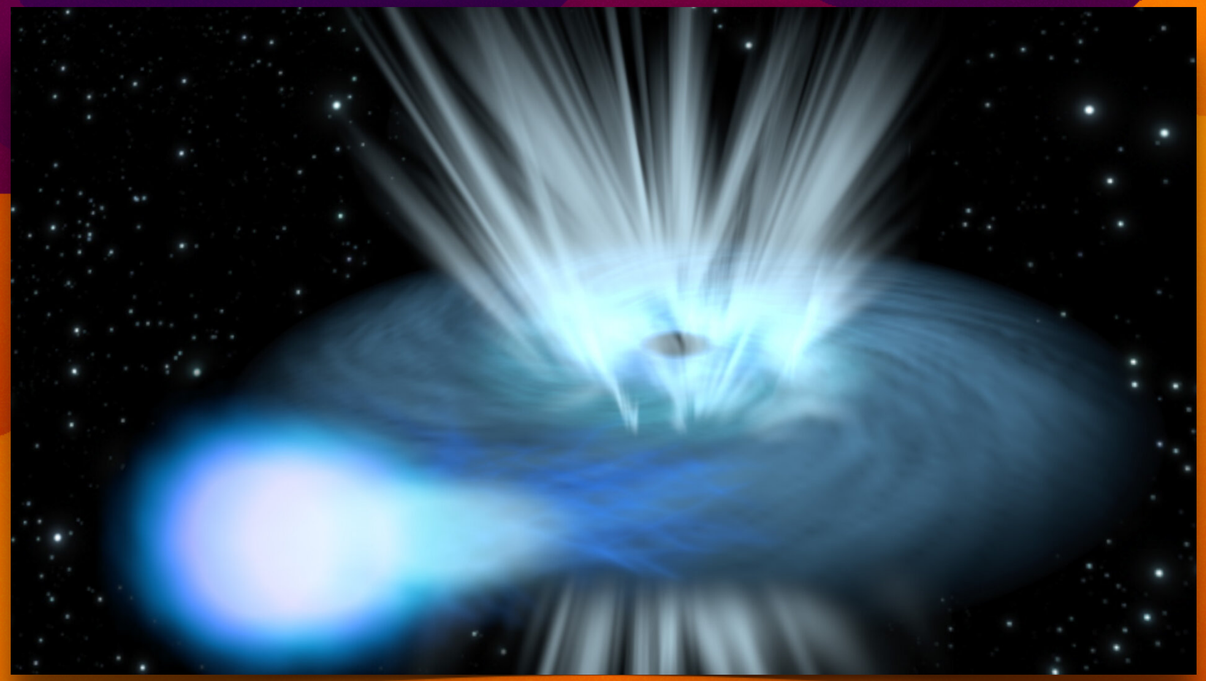


Possible central engines

Magnetar

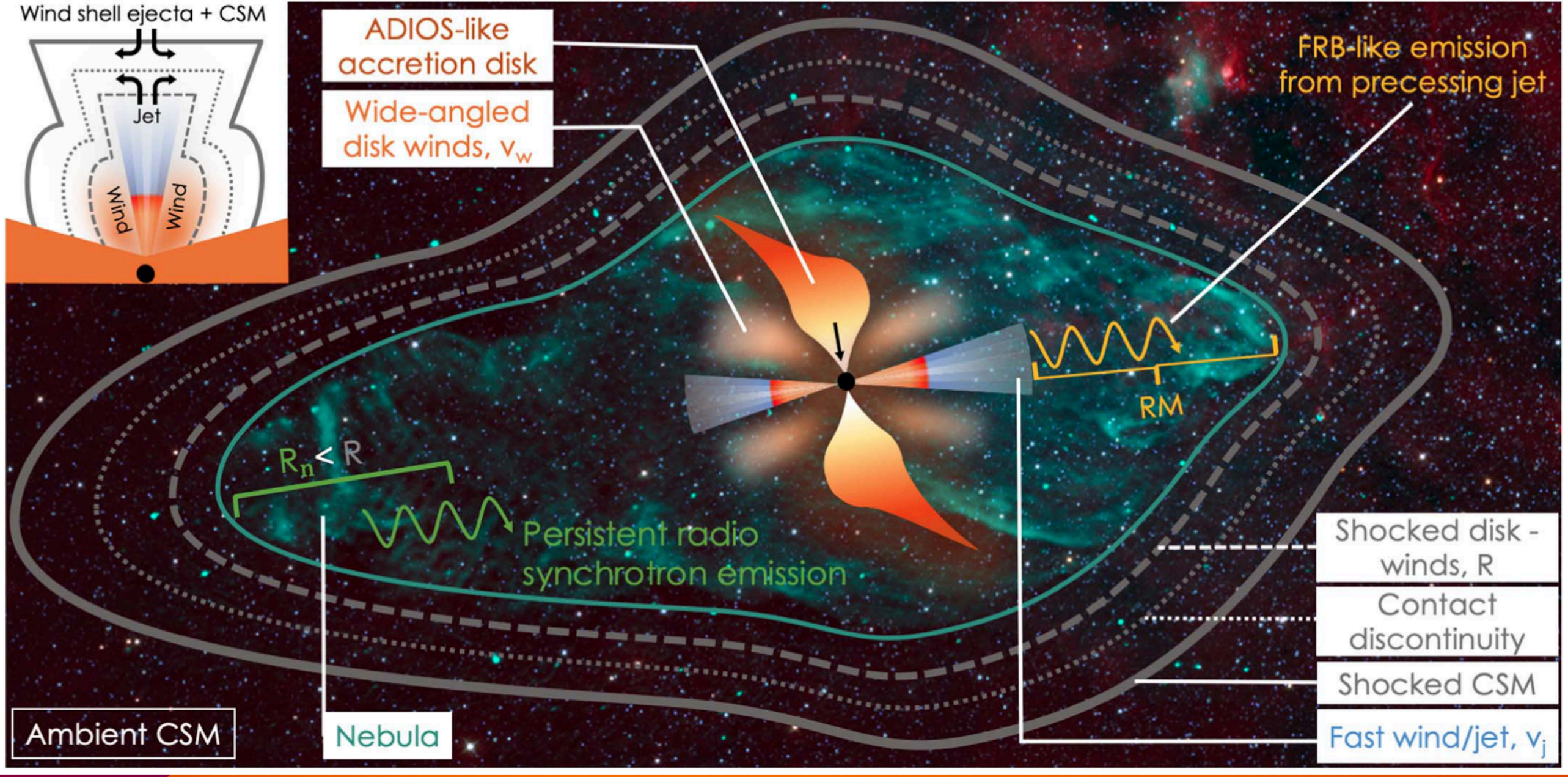


Hyper-accreting XRB



Sridhar et al. 2022

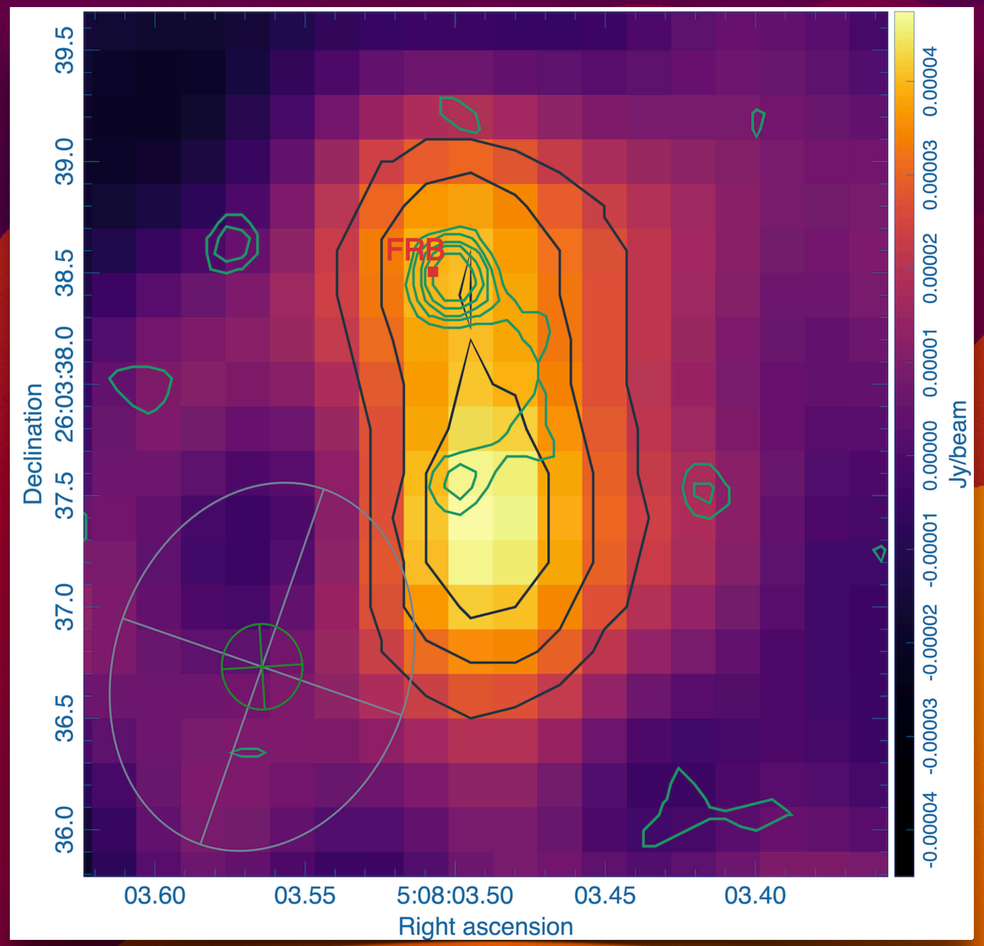
Both scenarios are consistent with the nebula model



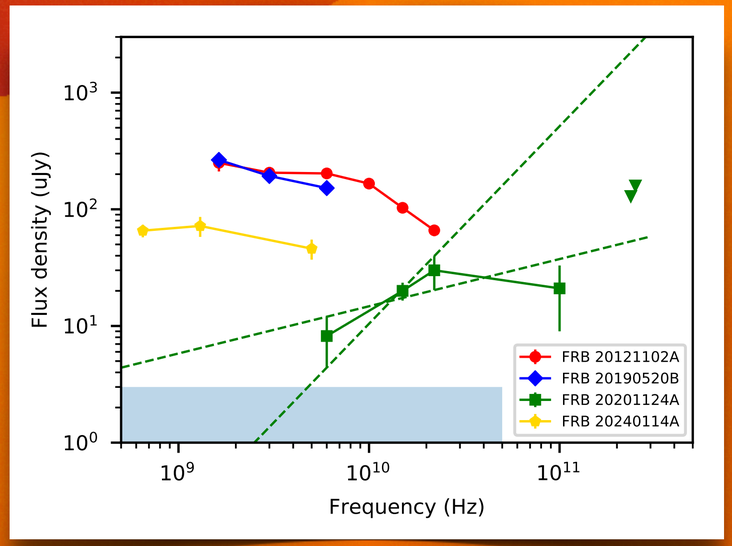
Sridhar et al. 2022

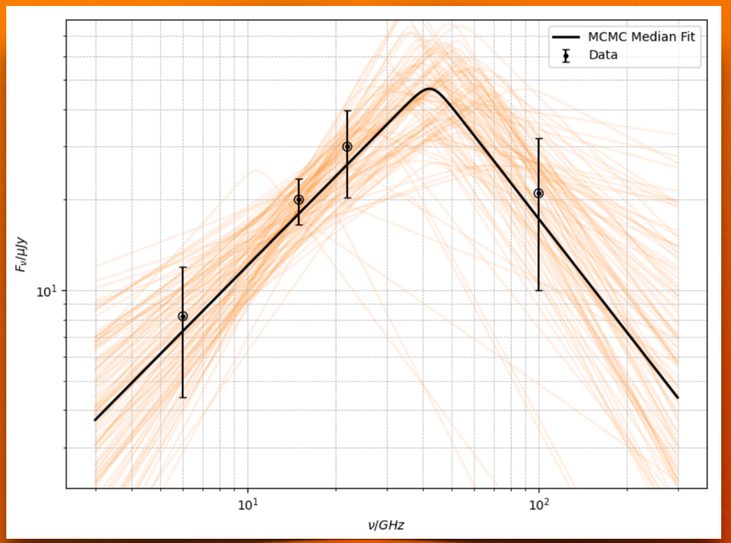
New constraints from ALMA

VLA (15 GHz) ⊕ ALMA (100 GHz)



- ALMA flux at 100 GHz suggest a spectral curvature
- ALMA+VLA proposal just submitted





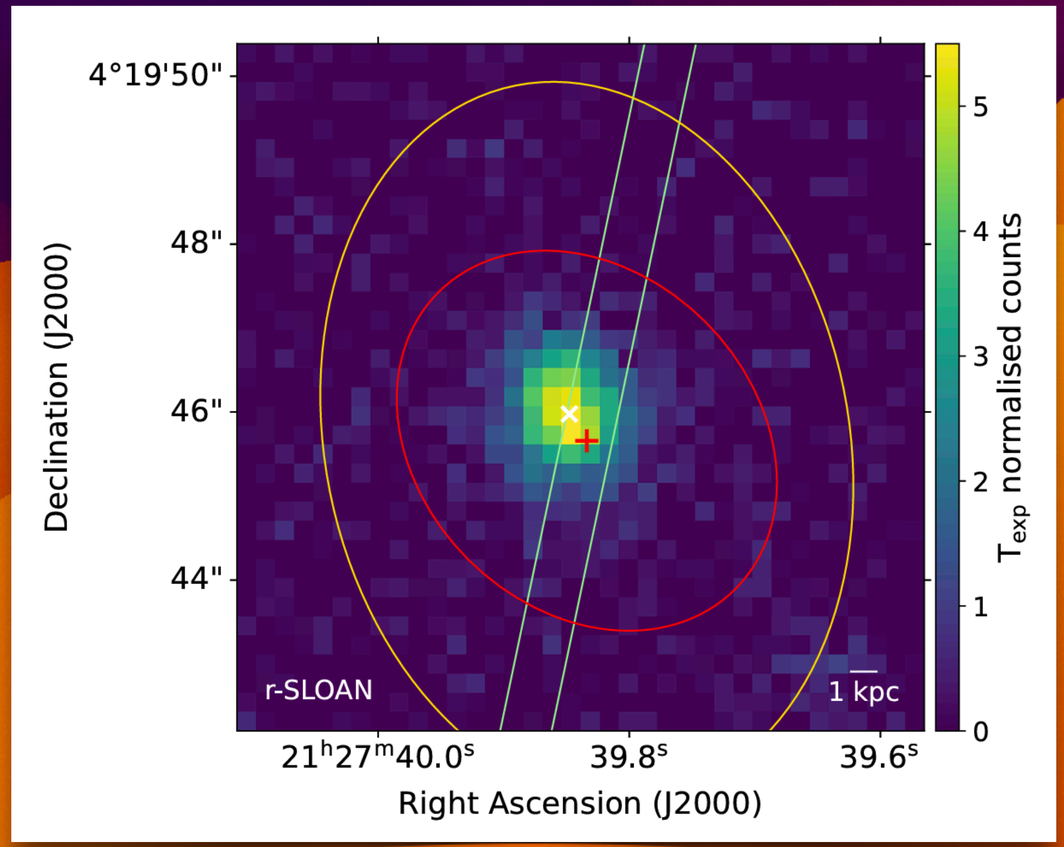
Ongoing observations…

- ALMA+VLA proposal to build the SED from 10 to 100 GHz
- HSA (VLBA+Effelsberg+VLA) to detect the PRS and constrain the physical size on the mas scale

A new case: the PRS associated with FRB 20240114A

A new case: PRS 20240114A

- First identified as possible counterpart with MeerKAT (Zhang+24, red circle) and uGMRT (Bhusare+24, yellow circle)
- Arcsec-resolution included the entire host, not allowing to exclude a star-forming origin
- VLBI observations at pc-scale can solve the issue…

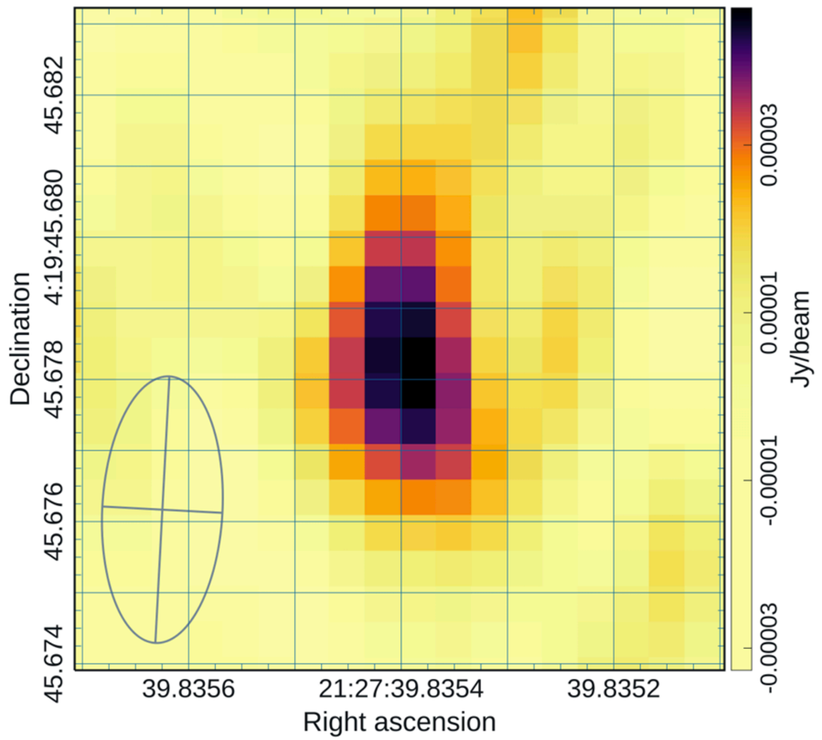


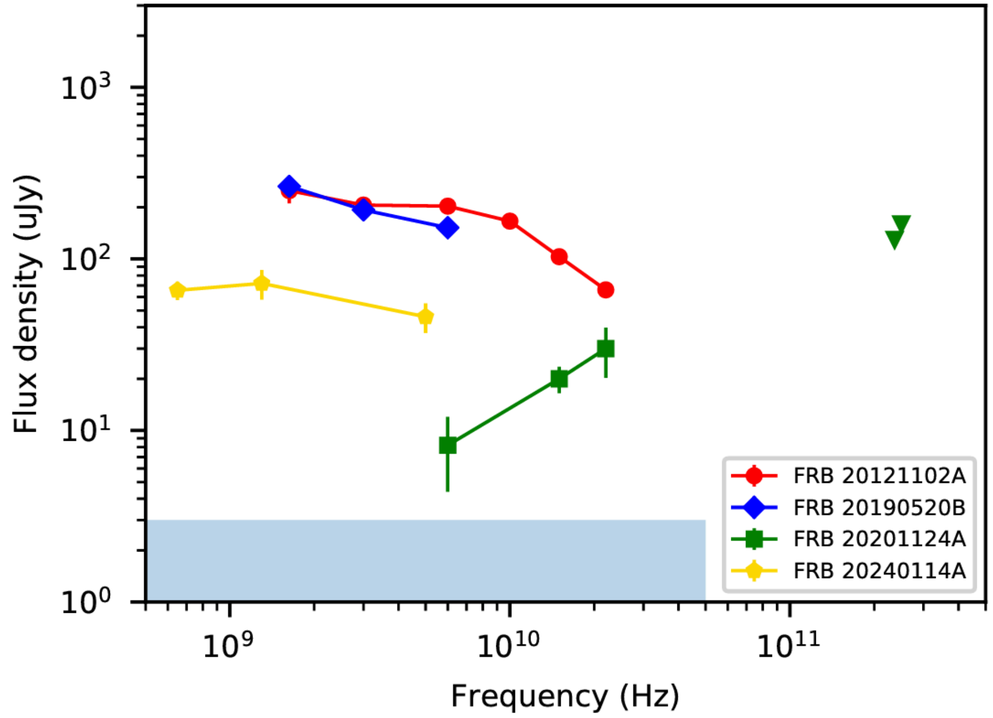
Bruni et al. 2025

A new case: PRS 20240114A

…We observed with the VLBA at 5 GHz, finding a compact source within the PRECISE error region

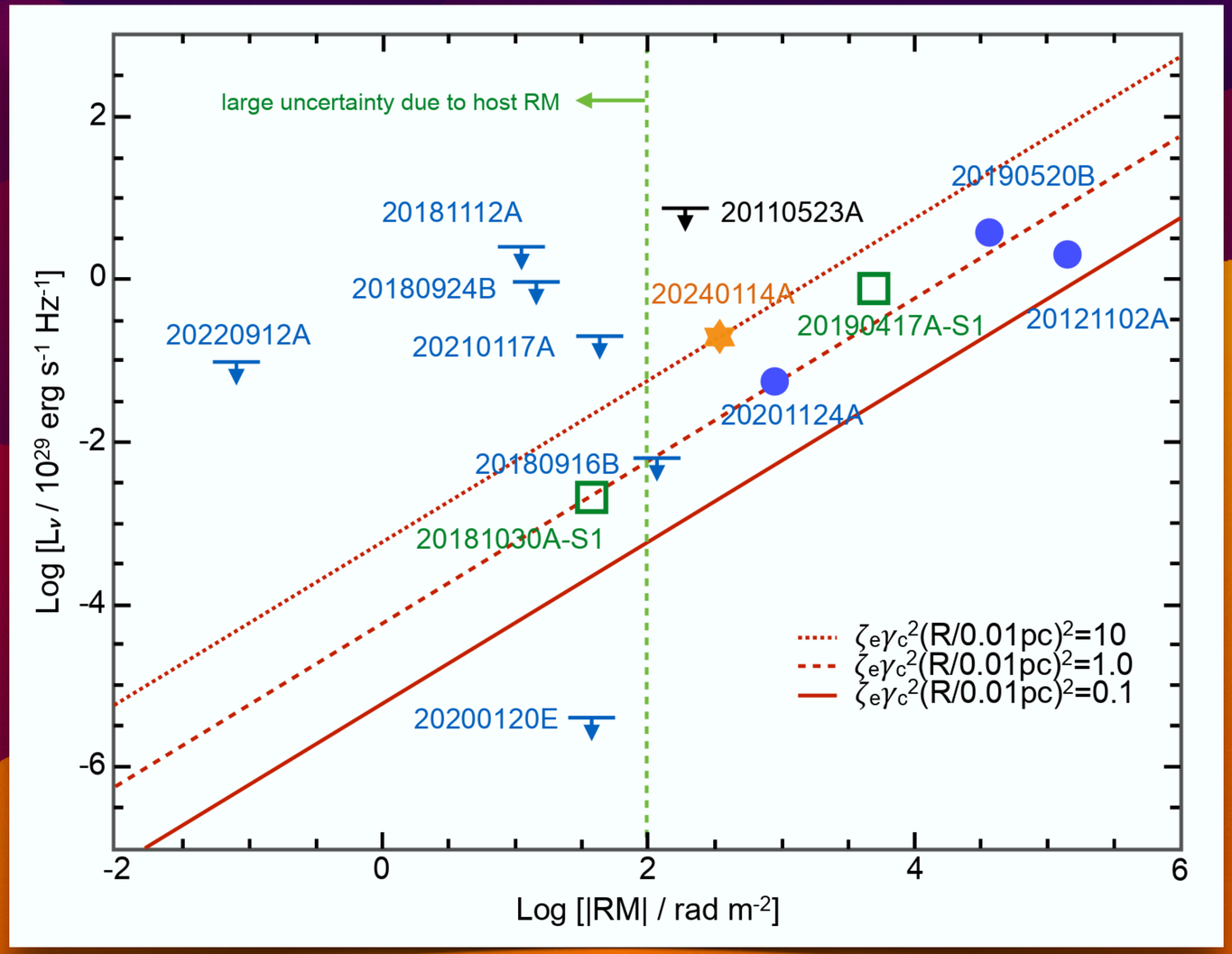
First indication of a peaked spectrum, to be verified through further VLBI observations





Bruni et al. 2025

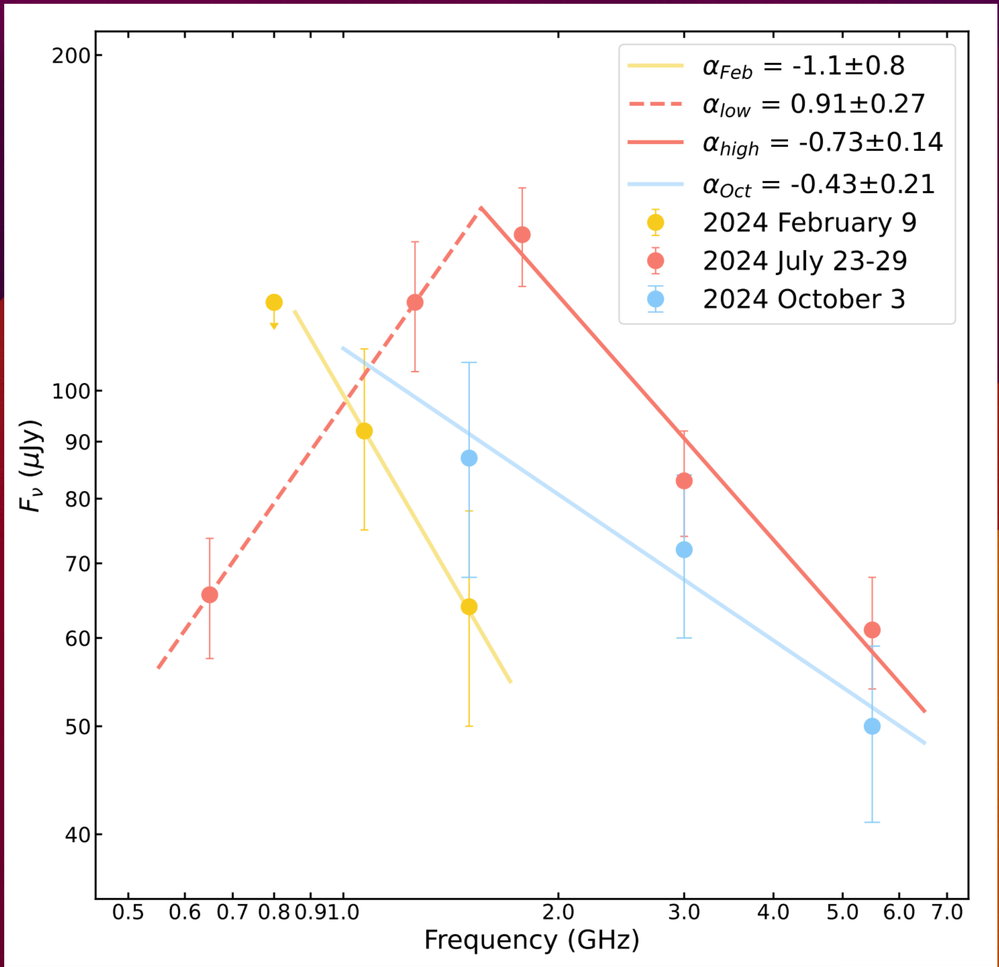
A new case: PRS 20240114A



Bruni et al. 2025

The radio luminosity and RM (340 rad/m^2) further supporting the nebular model

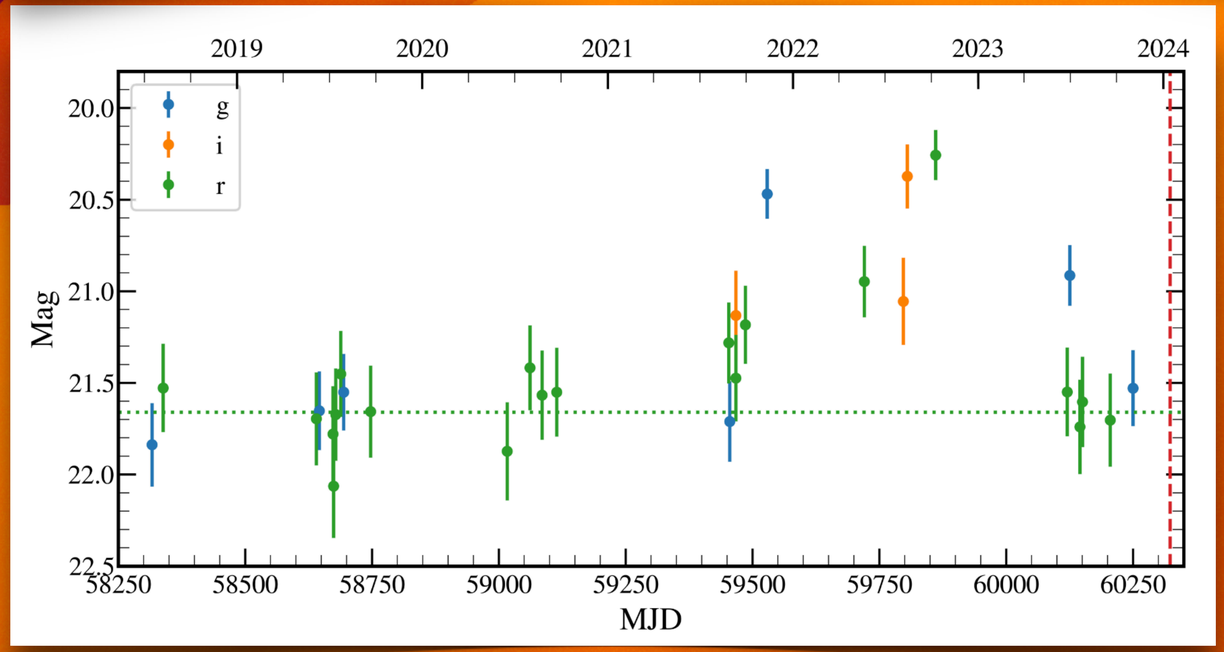
A new case: PRS 20240114A



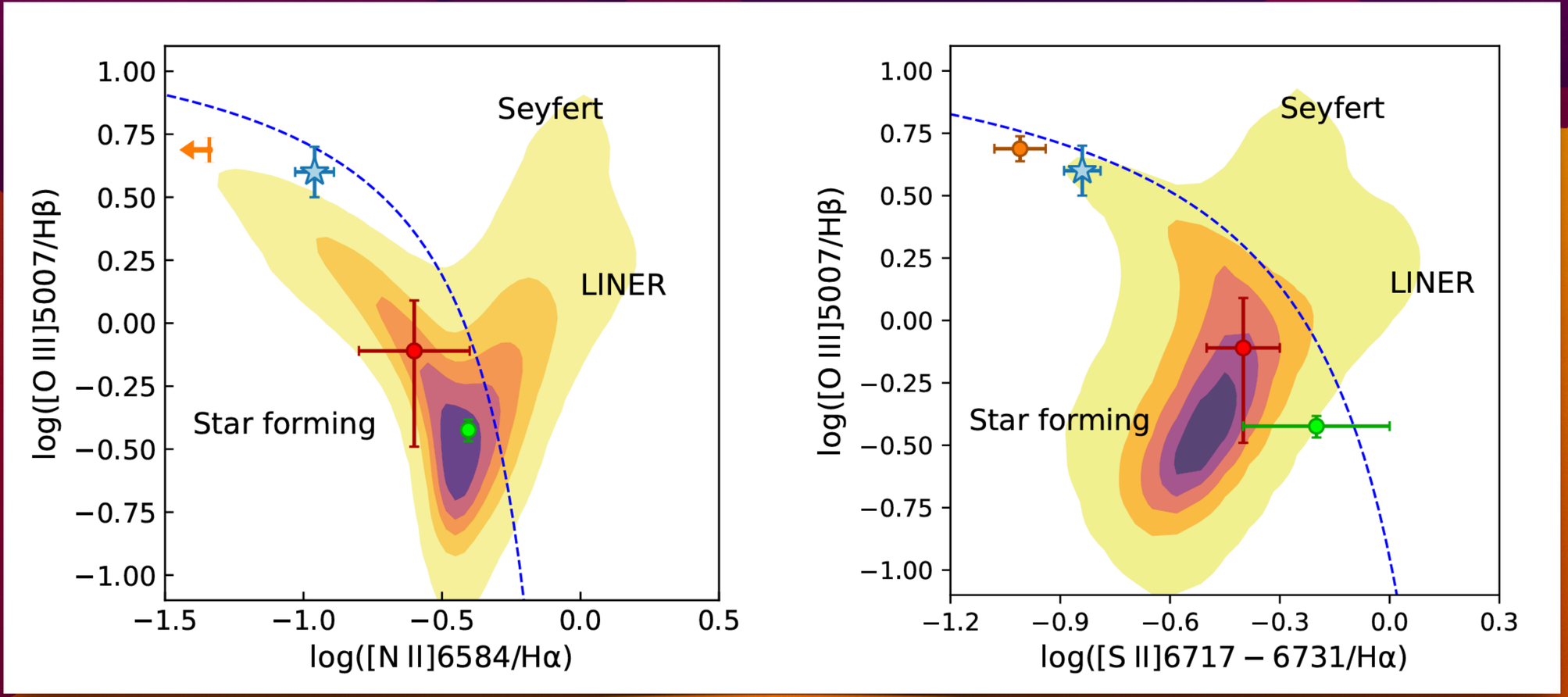
A flaring radio counterpart to a fast radio burst reveals a newborn magnetized engine

Xian Zhang [1], Wenfei Yu [1], Zhen Yan [1], Yi Xing [1], and Bing Zhang [2,3]

[1] *Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai 200030, China*
[2] *The Nevada Center for Astrophysics, University of Nevada, Las Vegas, Las Vegas, NV 89154, USA*
[3] *Department of Physics and Astronomy, University of Nevada, Las Vegas, Las Vegas, NV 89154, USA*



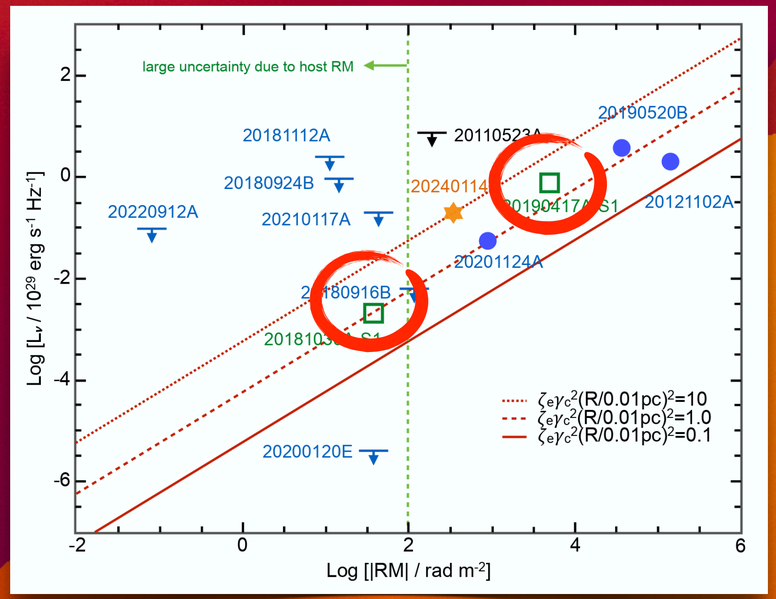
A new case: PRS 20240114A

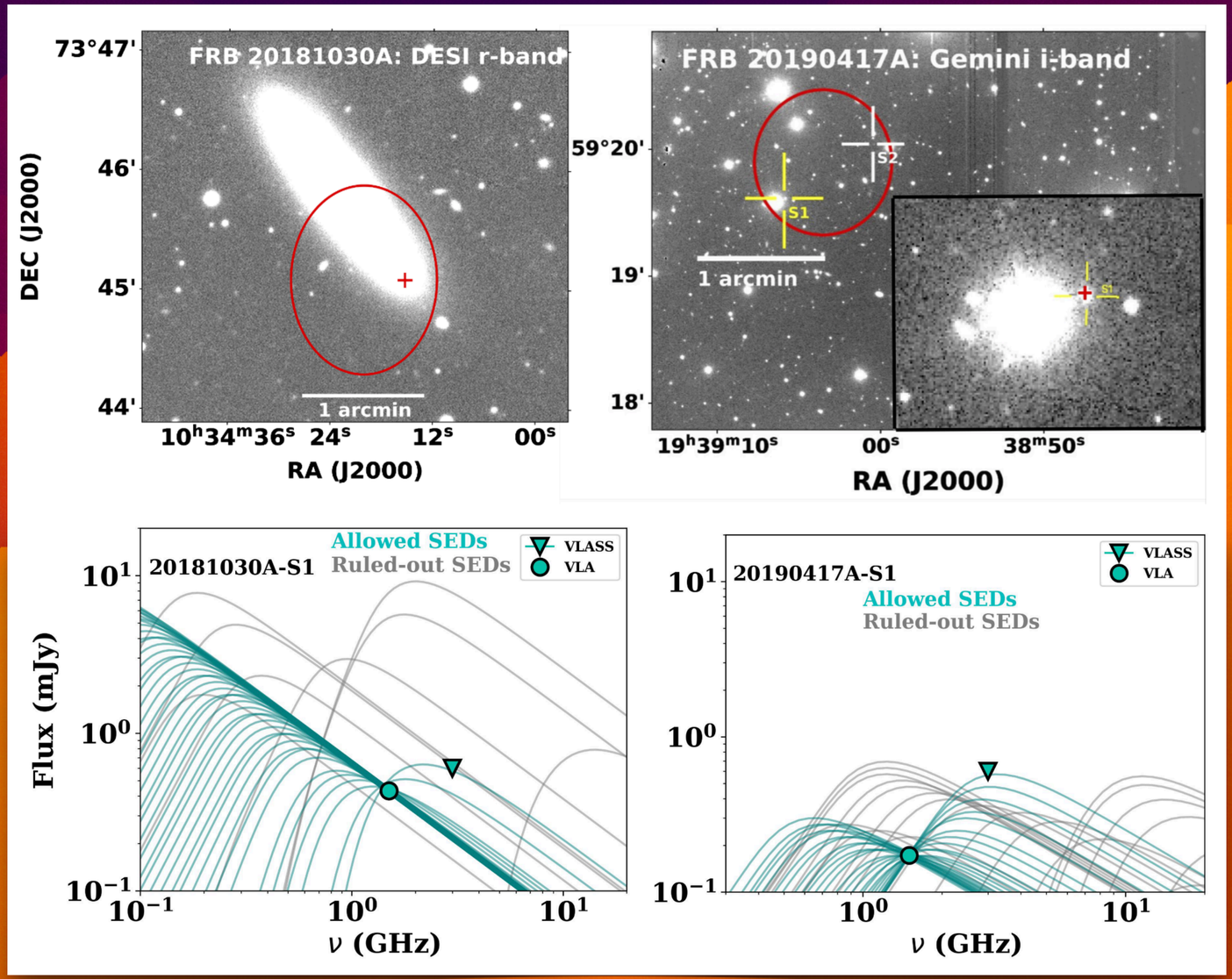


Bruni et al. 2025

More candidates…

- Another two candidate PRSs found with the VLA also fall in the expected regions (FRB 20181030A and FRB 20190417A)
- Ongoing EVN observations to test the compactness
- Additional candidate in the latest CHIME catalogue (FRB 20231128A)





Ibik et al. 2024

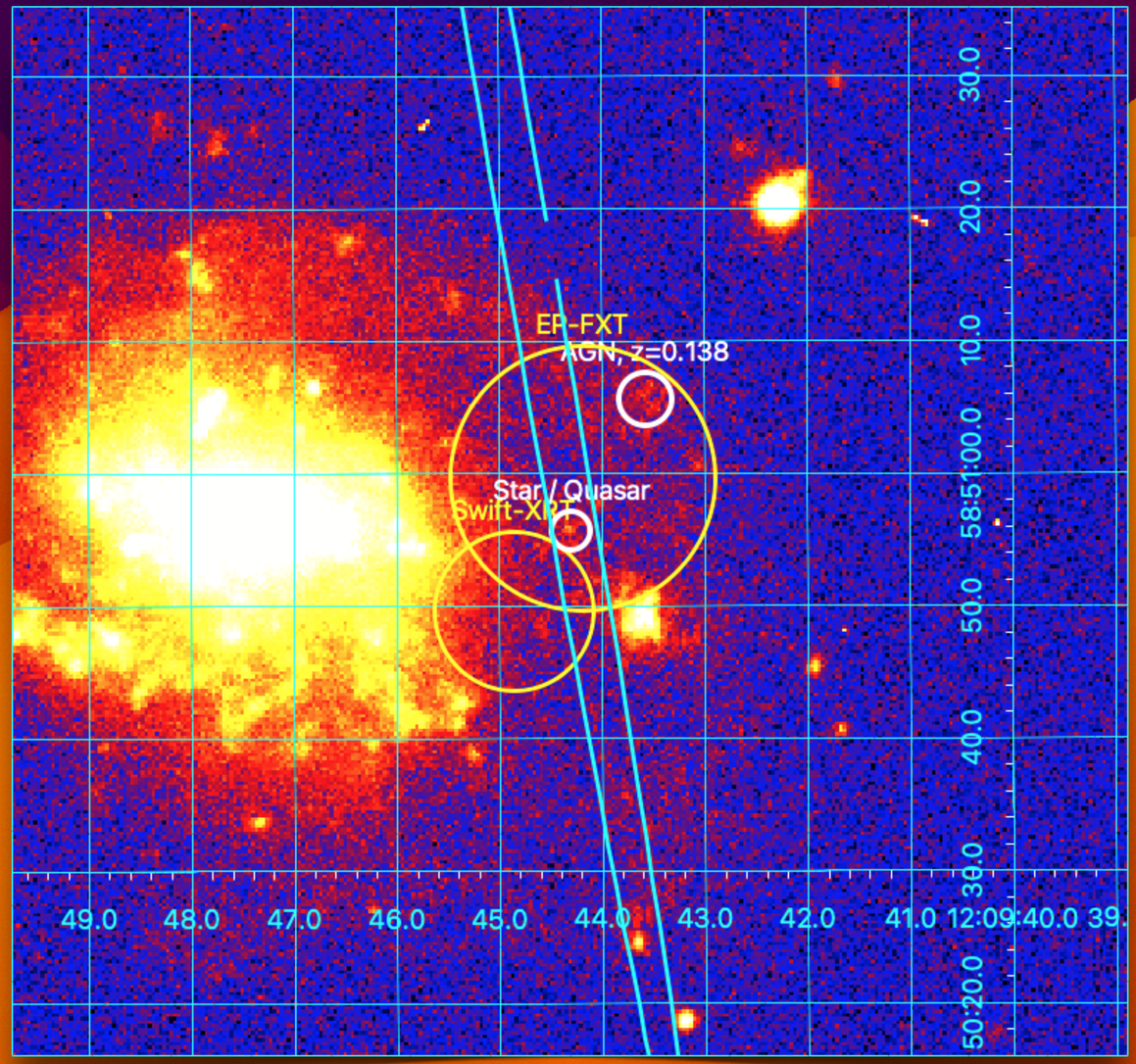
A growing census of repeating (and well localised) FRB

- Almost 60 known so far
- A link between rFRB and FRB (FRB 20201124A, Kirsten+24)
- 4 rFRB with PRS known so far, in agreement with the nebular model
- 3 more PRS candidates (Ibik+24, CHIME/FRB+25)
- Many more with future facilities

A nearby FRB in NGC 4141

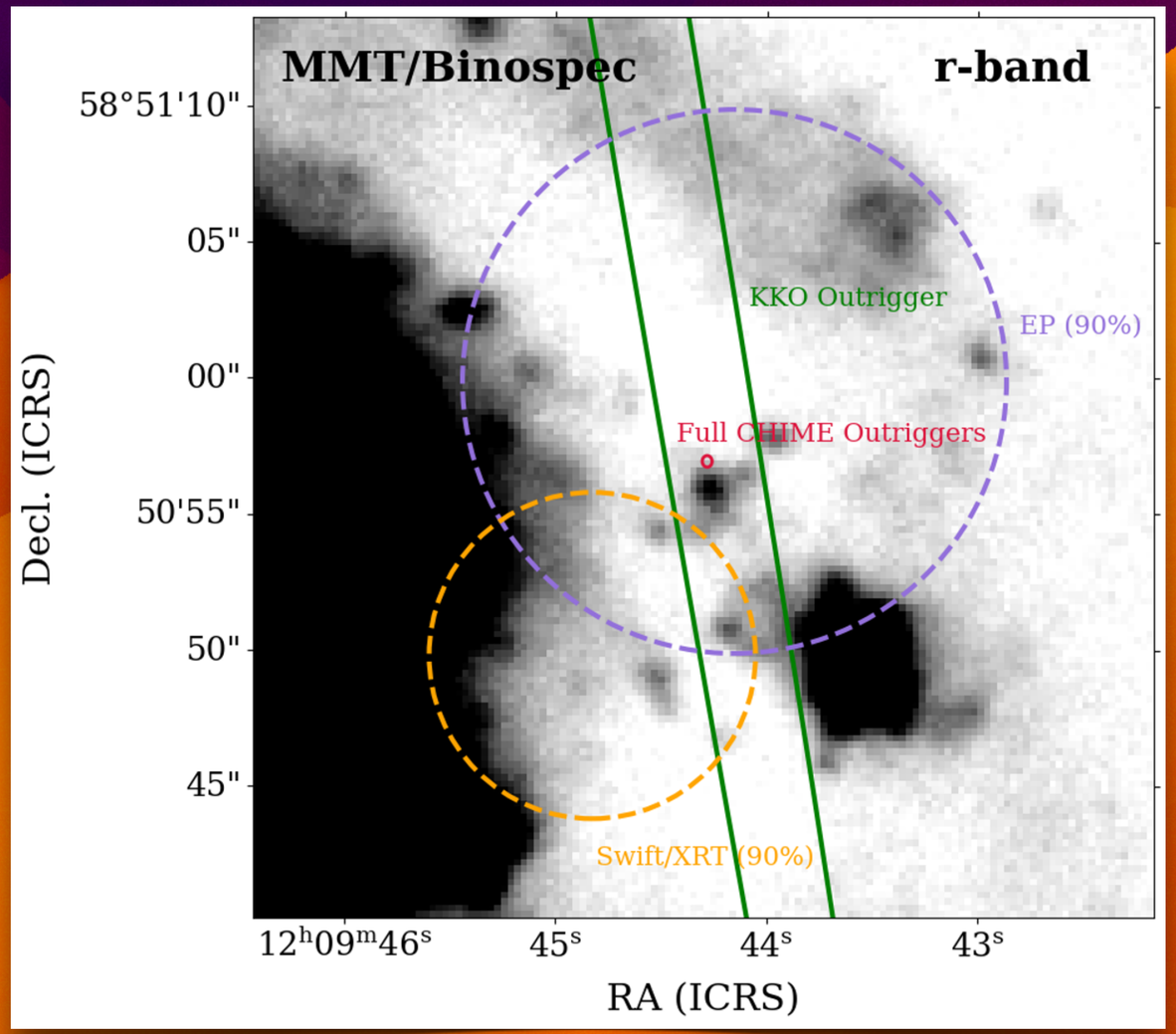
The FRB 20250316A in NGC 4141

- A nearby (40 Mpc) FRB was found past in March in NGC 4141
- The close distance allows to easily reach high spatial resolution and probe the nebular model
- An candidate X-ray counterpart (continuum) was initially claimed by the Einstein Probe team
- Later discarded by Chandra, probably linked to star formation



The FRB 20250316A in NGC 4141

- CHIME was able to use the commissioning data from the Outrigger stations to localize the FRB with a 150 milli-arcsec uncertainty
- Our e-Merlin (VLBI) observations were able to exclude the presence of a PRS down to a luminosity <10^26 erg/s/Hz
- This is x100 lower than other known PRSs
- The FRB is non-repeating, allowing to constrain the nebular model in such objects



Future prospects

- The 4 PRS discovered so far were associated to repeating FRB, and suggest a magnetar/X-ray binary nature for the central engine
- They were detected thanks to deep observations, by pushing the instrumental sensitivity at its limit. Both resolution and sensitivity are key to identify these faint counterparts
- A more statistical meaningful census can be build only with next generation instruments like SKA and ngVLA, working in the uJy regime,
- The enhanced VLBI sensitivity will also allow to study them on the pc scale, further constraining the model