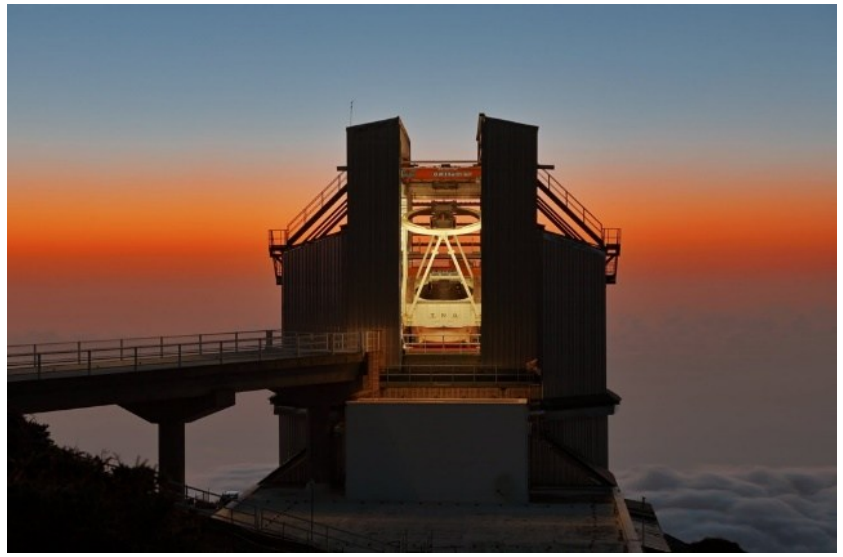
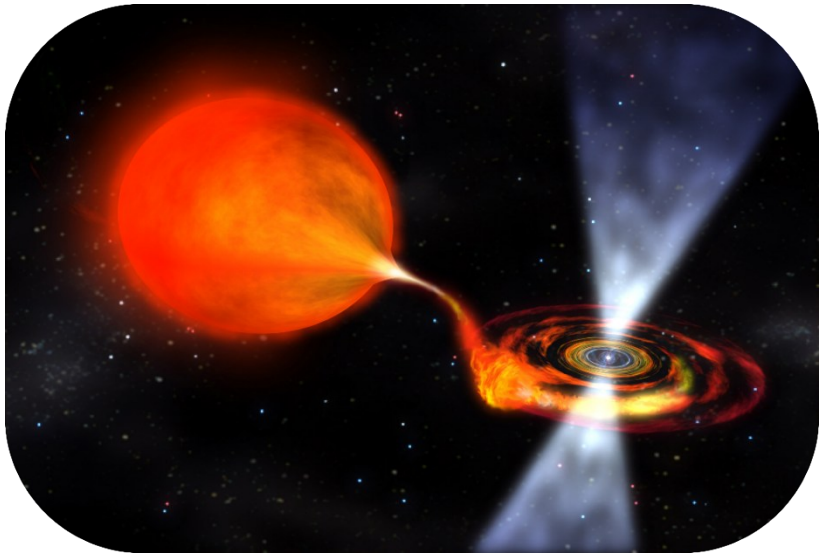
Search for optical counterparts of FRBs with SiFAP2@TNG



Filippo Ambrosino

filippo.ambrosino@inaf.it

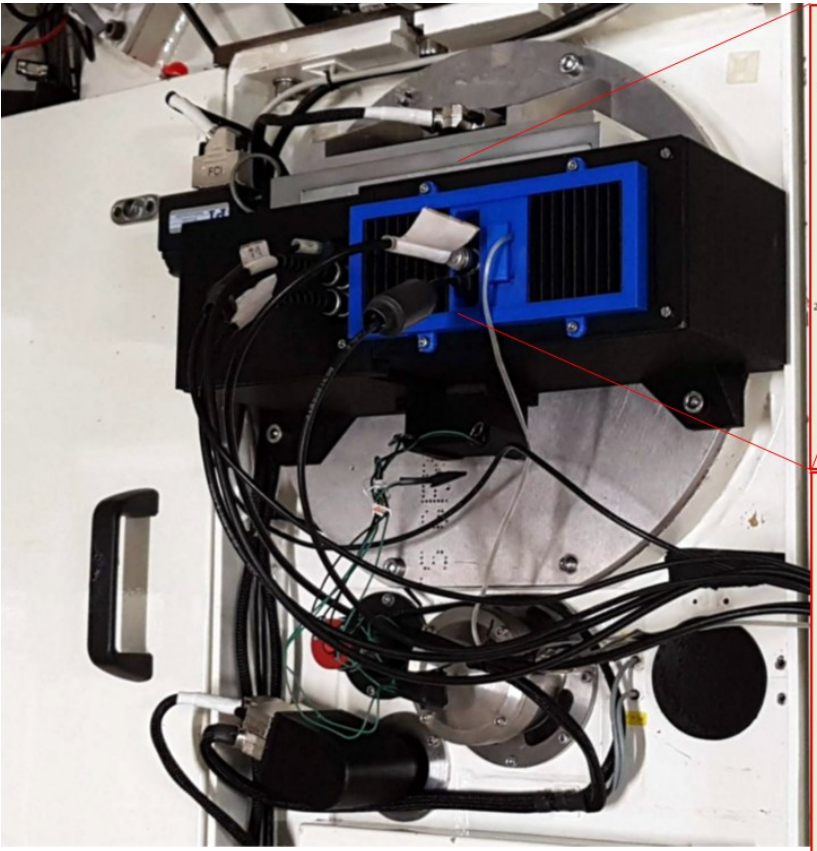


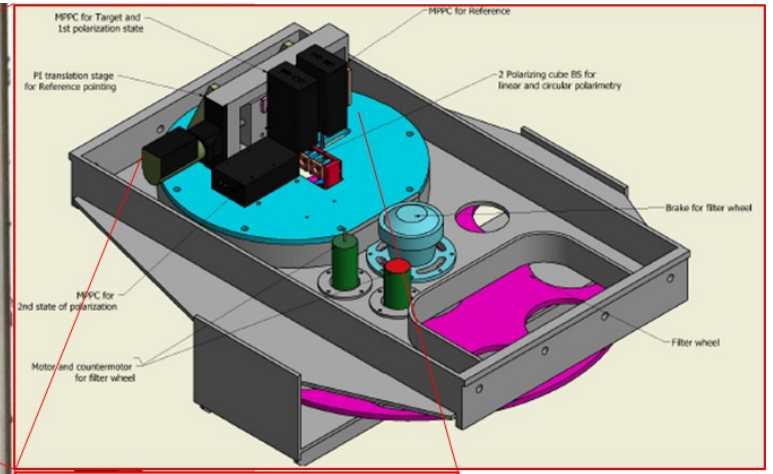
Collaborators: Piergiorgio Casella, Carlo Campa, Alessandro Papitto, Riccardo La Placa, Roberta Amato, Gianluca Israel, Luigi Stella (INAF-OAR)
Giulia Illiano (INAF-OAB), Arianna Miraval Zanon (ASI)
Franco Meddi (Sapienza Università di Roma), Franco Leone (Università di Catania)
Adriano Ghedina, Massimo Cecconi, Manuel Gonzales, Marcos Hernandez, Hector Perez Ventura (INAF-FGG)
… and many others

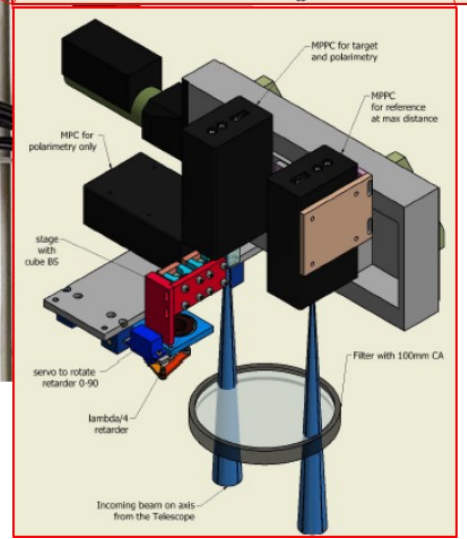
SiFAP2@TNG

http://www.tng.iac.es/instruments/sifap2/

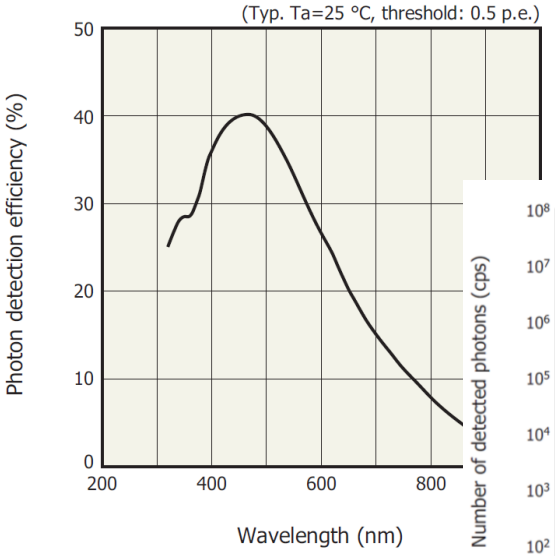
[Ghedina et al., 2018]

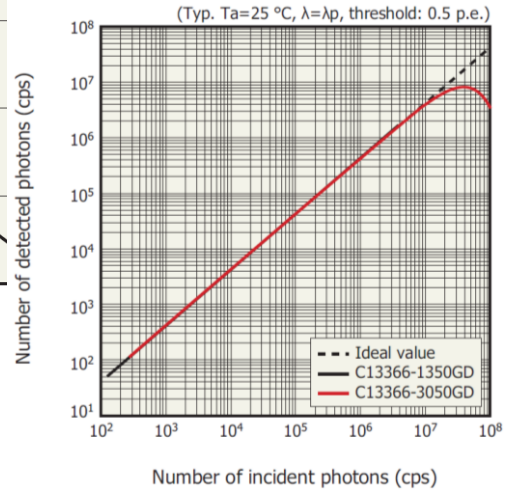






Nasmyth A focus





➔spectral range: **320 – 900 nm**

➔time resolution: **80 ps**

➔relative time accuracy: **10^{-10}**

➔absolute time accuracy: **<60 µs**

State of the art: HTRA instruments

Instrument	Detector	Group	Time res. [s]	Mode
SiFAP2	SiPM	INAF Rome/FGG	8e-11	Fast Timing/Polarimetry
Aqueye+/Iqueye	SPAD	INAF Padua	1e-10	Fast Timing
UltraCam	CCD	Sheffield/Warwick	5e-3	3-band Imaging
UltraSpec	eMCCD	Sheffield/Warwick	1e-3	Spectroscopy
GASP	eMCCD	Galway	6e-4	Polarimetry
Optima	APD	MPE	1e-9	Fast Timing/Polarimetry
Arcons	MKID	UCSB	2e-8	Imaging
Circe	HAWAII-2RG	IAC/Florida	1e-3	Photometry/Polarimetry
HiperCam	CCD	Sheffield/IAC	6e-4	5-band Imaging
AstraLux	eMCCD	MPA/CSIC	1e-3	Imaging

PSR J1023+0038 & SAX J1808.4-3658

First optical pulsations from a tMSP discovered!!!

First optical/UV pulsations from an AMXP discovered!!!

nature astronomy

LETTERS

DOI: 10.1038/s41550-017-0266-2

Optical pulsations from a transitional millisecond pulsar

F. Ambrosino[1,2], A. Papitto[3]*, L. Stella[3], F. Meddi[1], P. Cretaro[4], L. Burderi[5], T. Di Salvo[6], G. L. Israel[3], A. Ghedina[7], L. Di Fabrizio[7] and L. Riverol[7]

nature astronomy

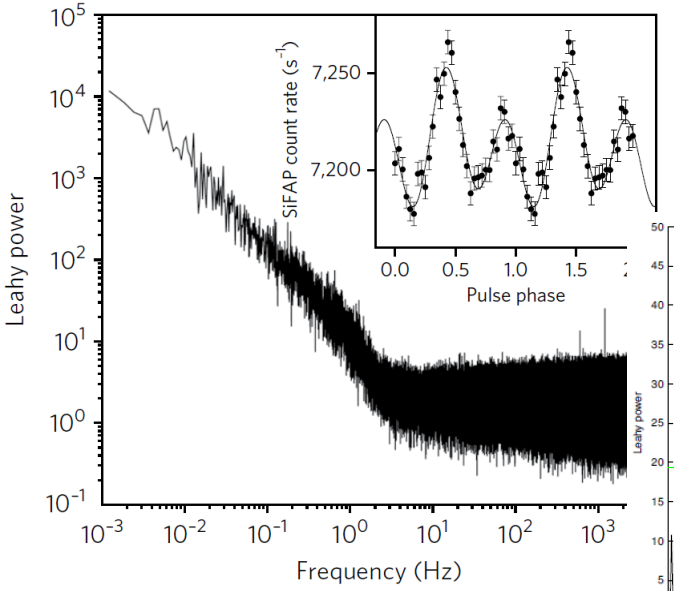
LETTERS

https://doi.org/10.1038/s41550-021-01308-0

Check for updates

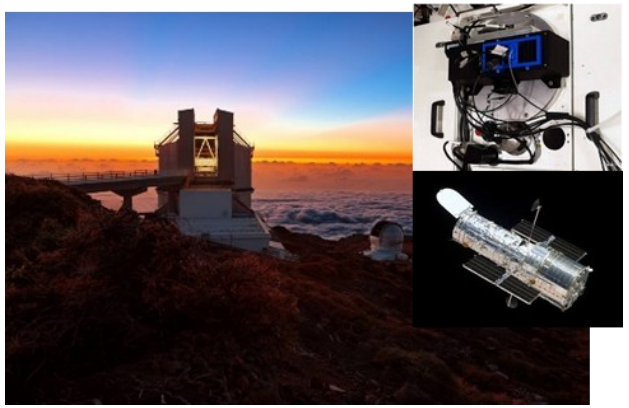
Optical and ultraviolet pulsed emission from an accreting millisecond pulsar

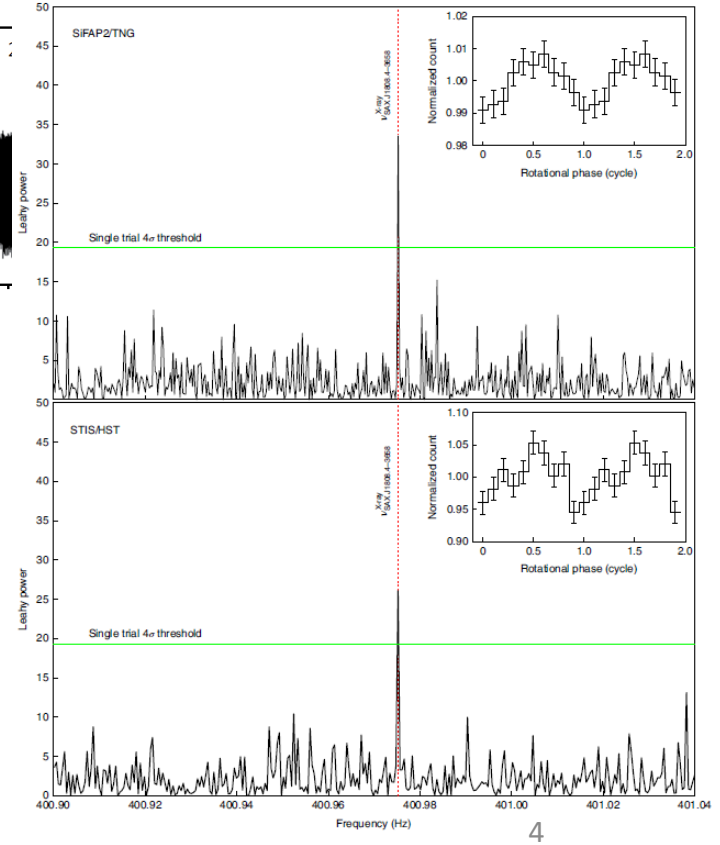
F. Ambrosino[1,2,3,22] ✉, A. Miraval Zanon[4,5,22] ✉, A. Papitto[1], F. Coti Zelati[5,6,7], S. Campana[5], P. D'Avanzo[5], L. Stella[1], T. Di Salvo[8], L. Burderi[9], P. Casella[1], A. Sanna[9], D. de Martino[10], M. Cadelano[11,12], A. Ghedina[13], F. Leone[14], F. Meddi[3], P. Cretaro[15], M. C. Baglio[5,16], E. Poretti[5,13], R. P. Mignani[17,18], D. F. Torres[6,7,19], G. L. Israel[1], M. Cecconi[13], D. M. Russell[16], M. D. Gonzalez Gomez[13], A. L. Riverol Rodriguez[13], H. Perez Ventura[13], M. Hernandez Diaz[13], J. J. San Juan[13], D. M. Bramich[16] and F. Lewis[20,21]



[Ambrosino, Papitto et al. 2017, Nature Astronomy]

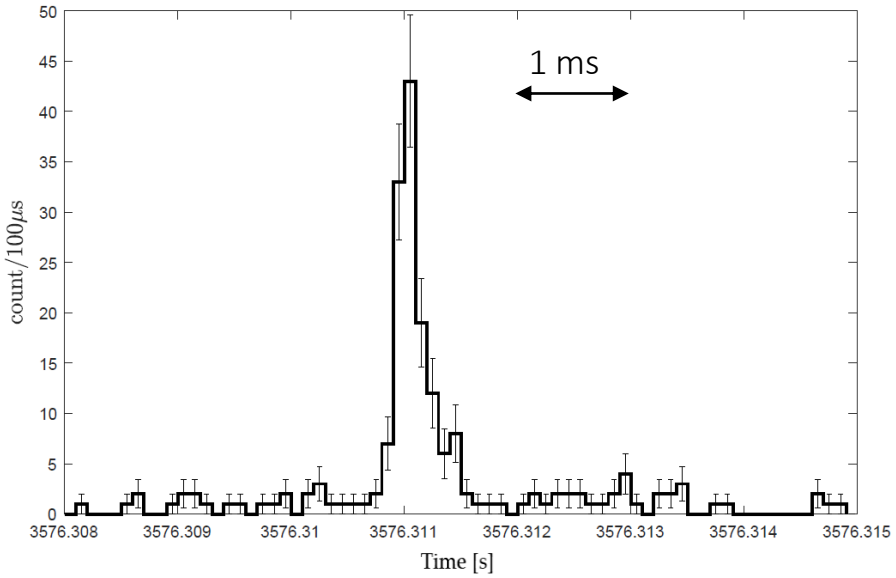
[Ambrosino, Miraval Zanon et al. 2021, Nature Astronomy]





Fast Optical Bursts (FOBs)

FRBs

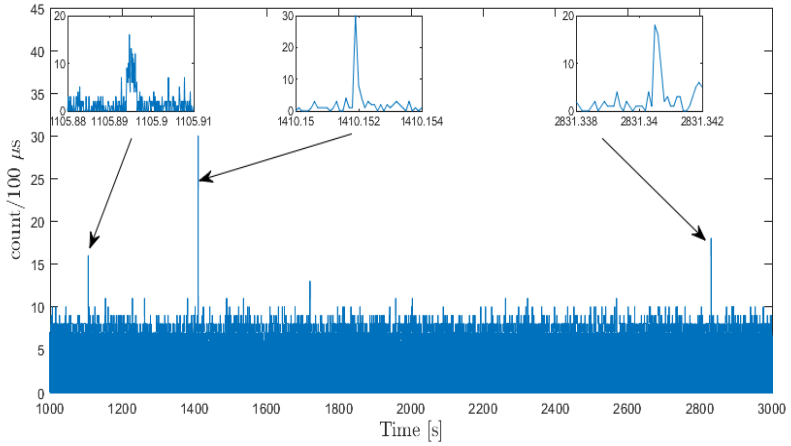


A new class of fast (ms) optical transients?

Rate of ~1.5/hr in a FoV of 7 x 7 arcsec^2!!!

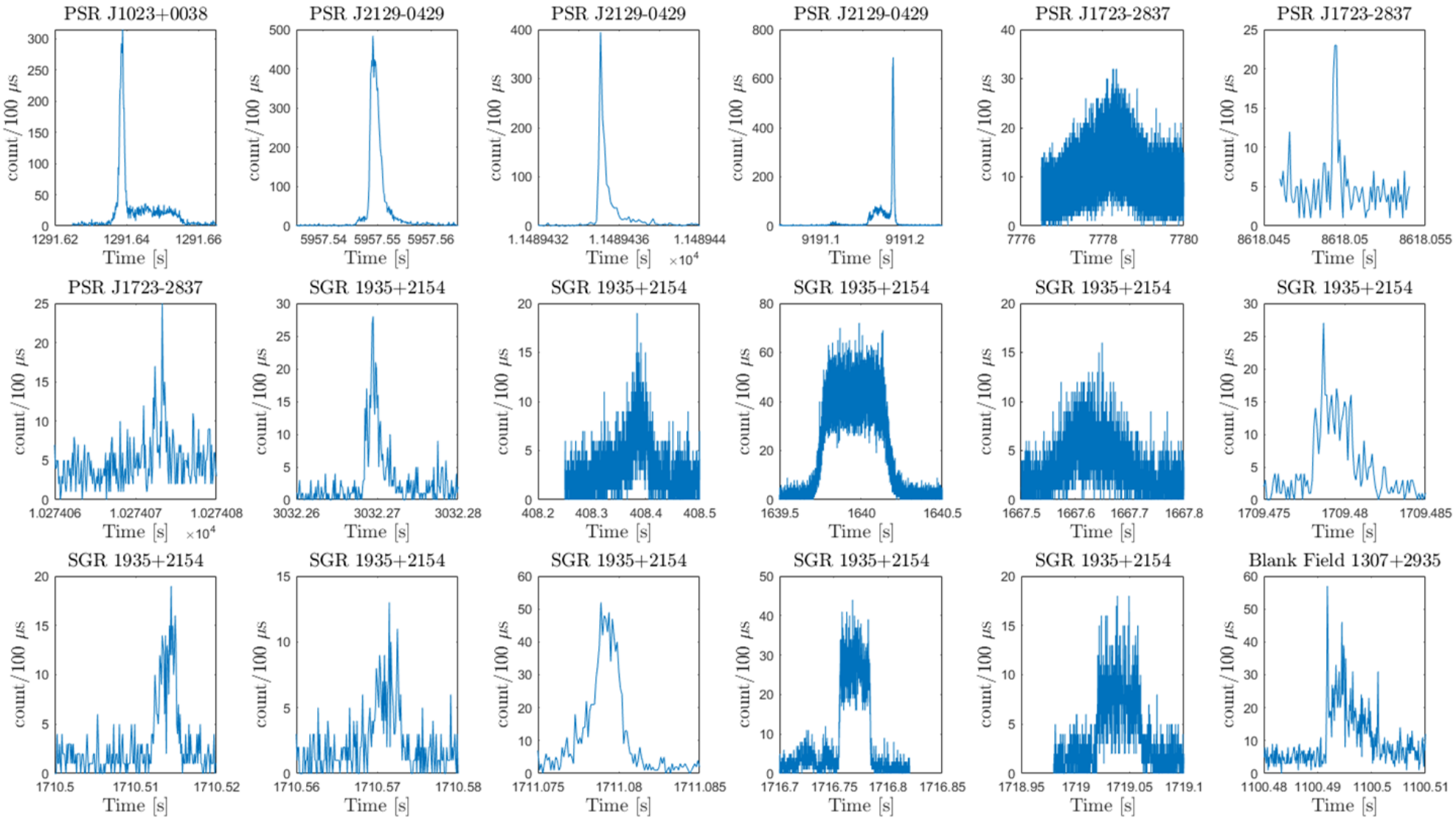
- Meteors/Fireballs? (rate of FOBs several orders of magnitude higher than that expected for meteors from MAGIC estimates)
- Space debris?
- Satellites passages?
- Atmospheric origin (optical flashes)?

Pulsars

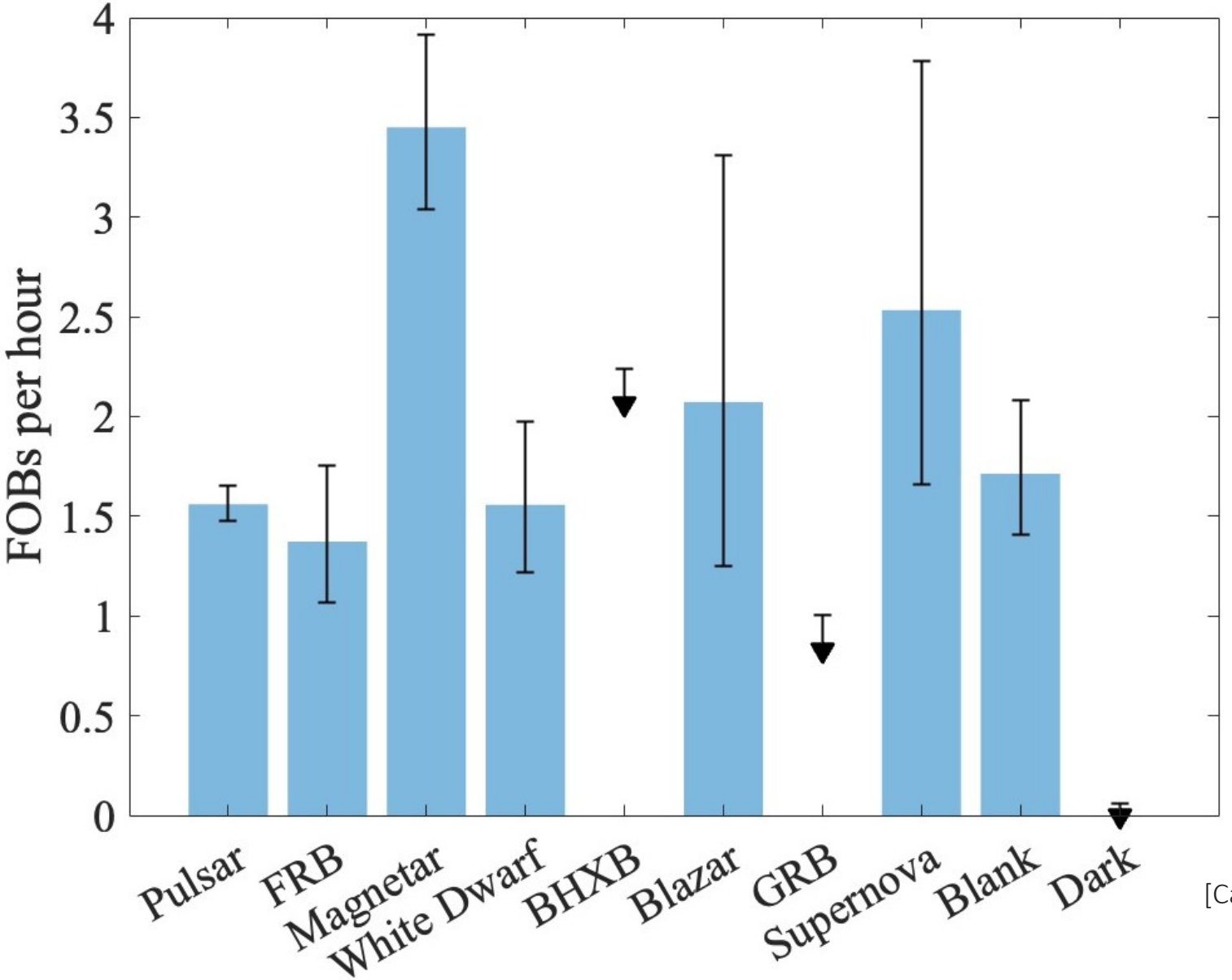


Need for more statistics to identify the optical counterpart of impulsive events with simultaneous (optical) campaigns!

FOBs morphology



FOBs statistics



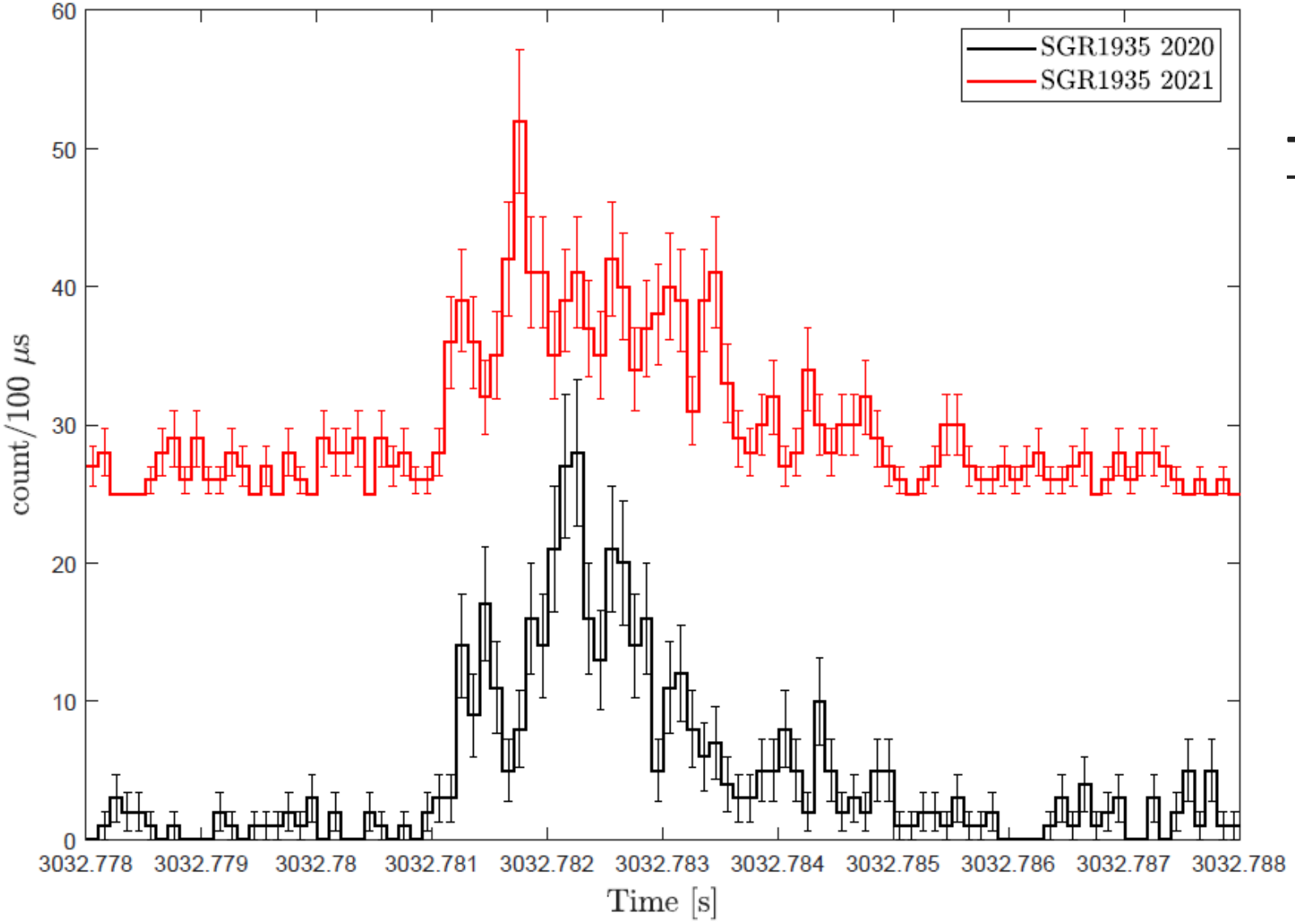
More than 300 hr of observations on different classes of objects

- more than 450 events detected
- ~1.5 events/hour on average
- most of hours spent on (ms) pulsars
- SGR1935 shows an **interesting excess**

(see Carlo Campa's presentation for details)

[Campa et al., in prep.]

SGR 1935+2154



Two bursts from SGR 1935+2154

- Very similar shape
- Very similar duration (~3 ms)
- Similar peak magnitude (V~12.6)

Likely to come from the magnetar

FRB20180916B (R3)

Ongoing MWL campaigns on the source from 2020

- Radio: SRT, NC, uGMRT, GBT, Effelsberg, Torun
- Optical: SiFAP2@TNG, Aqueye+/Iqueye@Asiago, HiperCam@GTC, AstraLux@CAHA
- X/γ-rays: NICER, Swift, HXMT, AGILE, INTEGRAL

[Pilia et al., 2020]

The Astrophysical Journal Letters, 896:L40 (11pp), 2020 June 20 https://doi.org/10.3847/2041-8213/ab96c0

The Lowest-frequency Fast Radio Bursts: Sardinia Radio Telescope Detection of the Periodic FRB 180916 at 328 MHz

M. Pilia[1], M. Burgay[1], A. Possenti[1,2], A. Ridolfi[1,3], V. Gajjar[4], A. Corongiu[1], D. Perrodin[1], G. Bernardi[5,6,7], G. Naldi[5], G. Pupillo[5], F. Ambrosino[8,9], G. Bianchi[5], A. Burtovoi[10,11], P. Casella[12], C. Casentini[8,13], M. Cecconi[14], C. Ferrigno[15], M. Fiori[16], K. C. Gendreau[17], A. Ghedina[14], G. Naletto[11,16], L. Nicastro[18], P. Ochner[11,16], E. Palazzi[18], F. Panessa[8], A. Papitto[12], C. Pittori[12,19], N. Rea[20,21], G. A. Rodriguez Castillo[12], V. Savchenko[15], G. Setti[5,22], M. Tavani[8,23], A. Trois[1], M. Trudu[1,2], M. Turatto[11], A. Ursi[8], F. Verrecchia[12,19], and L. Zampieri[11]

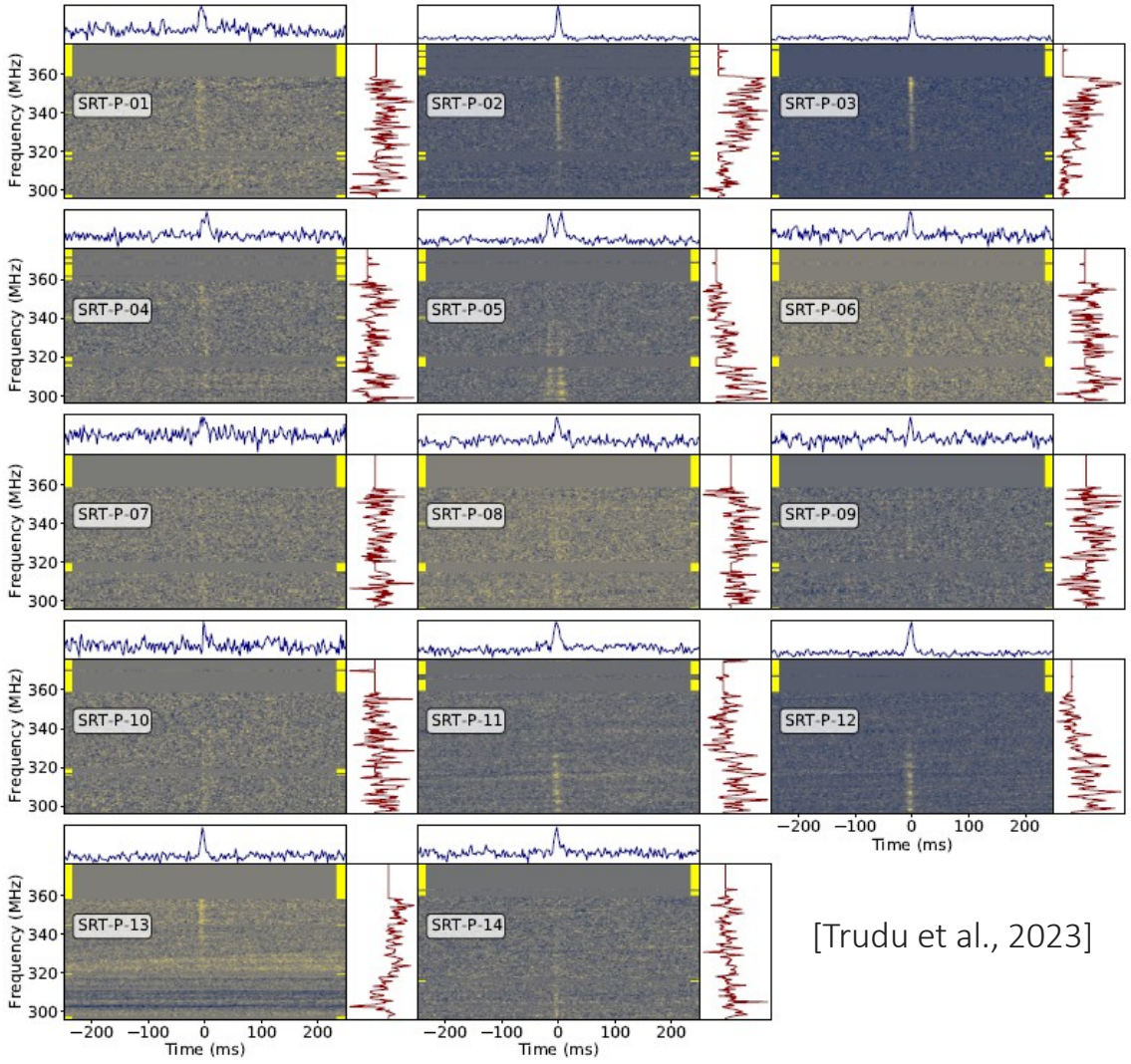
[Trudu et al., 2023]

A&A 676, A17 (2023)
https://doi.org/10.1051/0004-6361/202245303

Astronomy & Astrophysics

Simultaneous and panchromatic observations of the fast radio burst FRB 20180916B*

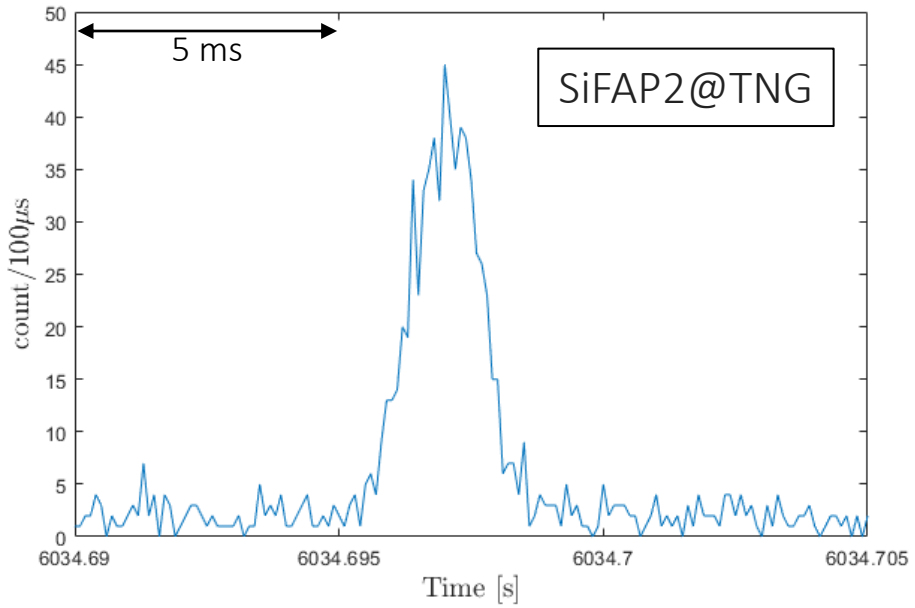
M. Trudu[1,2], M. Pilia[2], L. Nicastro[3], C. Guidorzi[4,3,5], M. Orlandini[3], L. Zampieri[6], V. R. Marthi[7], F. Ambrosino[8,9], A. Possenti[2,1], M. Burgay[2], C. Casentini[8,10], I. Mereminskiy[11], V. Savchenko[12], E. Palazzi[3], F. Panessa[8], A. Ridolfi[2], F. Verrecchia[13,14], M. Anedda[1], G. Bernardi[15,16,17], M. Bachetti[2], R. Burenin[11], A. Burtovoi[18], P. Casella[14], M. Fiori[19], F. Frontera[4], V. Gajjar[20], A. Gardini[21,22], M. Ge[23], A. Guijarro-Román[22], A. Ghedina[24], I. Hermelo[22], S. Jia[23], C. Li[23], J. Liao[23], X. Li[23], F. Lu[23], A. Lutovinov[11], G. Naletto[19,6], P. Ochner[19,6], A. Papitto[4], M. Perri[13,14], C. Pittori[13,14], B. Safonov[25], A. Semena[11], I. Strakhov[25], M. Tavani[8,26], A. Ursi[8], S. L. Xiong[23], S. N. Zhang[23,27], and S. Zheltoukhov[25]



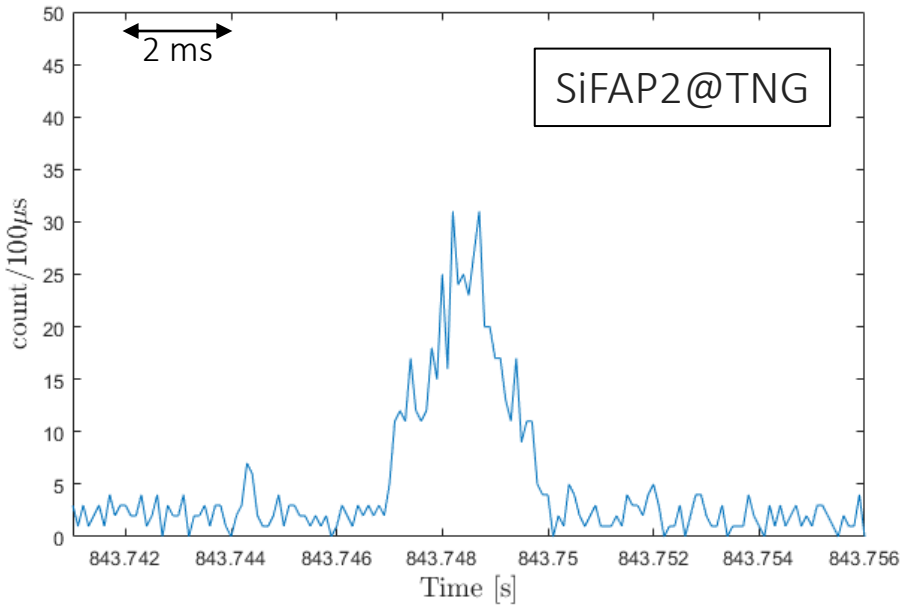
[Trudu et al., 2023]

FRB20180916B (R3) – Latest results

2025-02-01



2025-02-02



SiFAP2@TNG simultaneous observations with

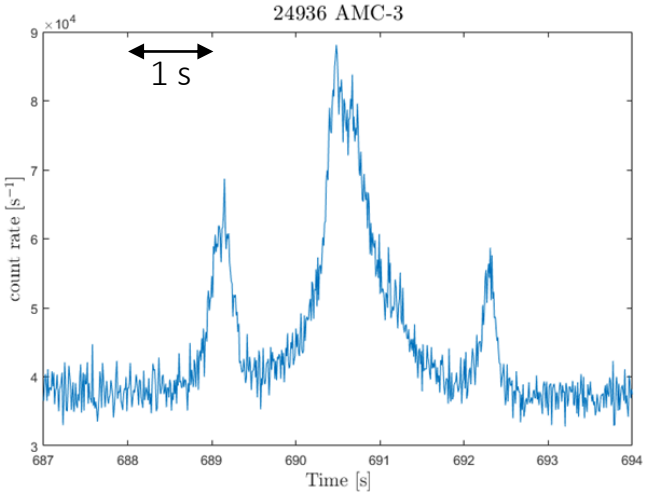
- Optical: Aqueye+@Copernicus
- Radio: SRT

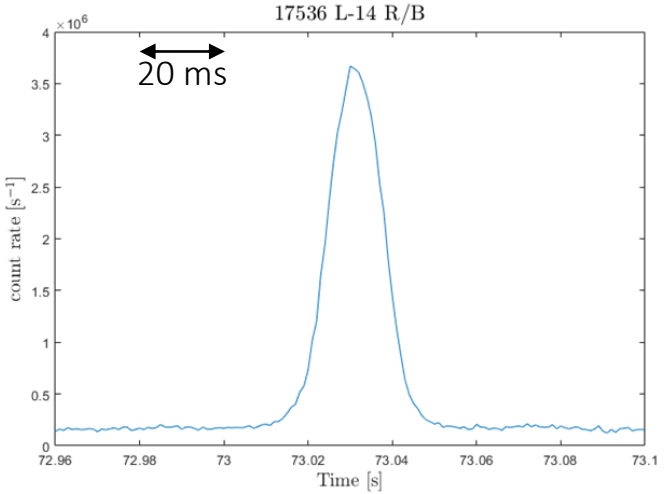
No FRB found with SRT

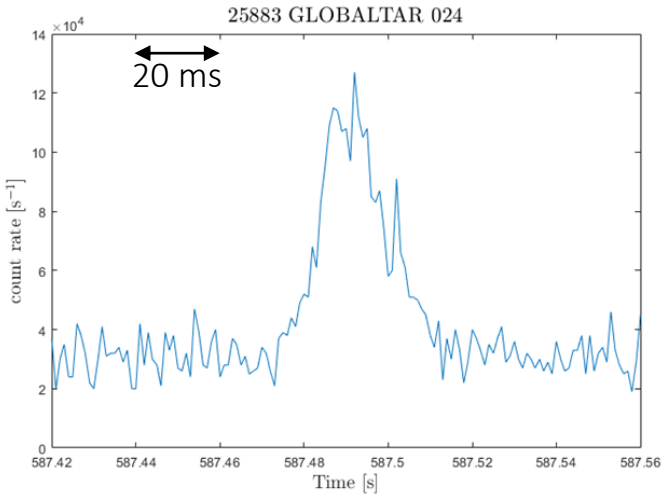
No optical simultaneous events

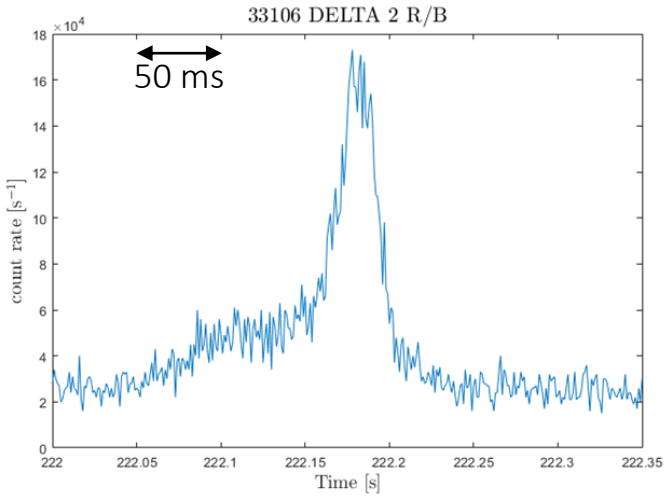
Other **active** FRB MWL campaigns on **FRB20121102A, FRB20240114A, FRB20240209A, FRB20240619D, FRB20250316A**

Space debris – Collaboration with PoliMi/Leonardo









Debris name	Type	Altitude [km]	Orbit	Dimensions [m x m]	Shape
24936 AMC-3 (GE-3)	Payload	38957	GEO	2.6 x 1.8	Box + 2 Pan
17536 L-14	Rocket Body	2606	Low-MEO	2.8 x 2.2	Cyl
25883 GLOBALTAR 024	Payload	3777	Low-MEO	1.5 x 0.6	Box + 2 Pan
33106 DELTA 2	Rocket Body	4161	Low-MEO	6.0 x 2.4	Cyl + Cone

Debris ephemeris predicted by U. Colangelo (PoliMi/Leonardo)

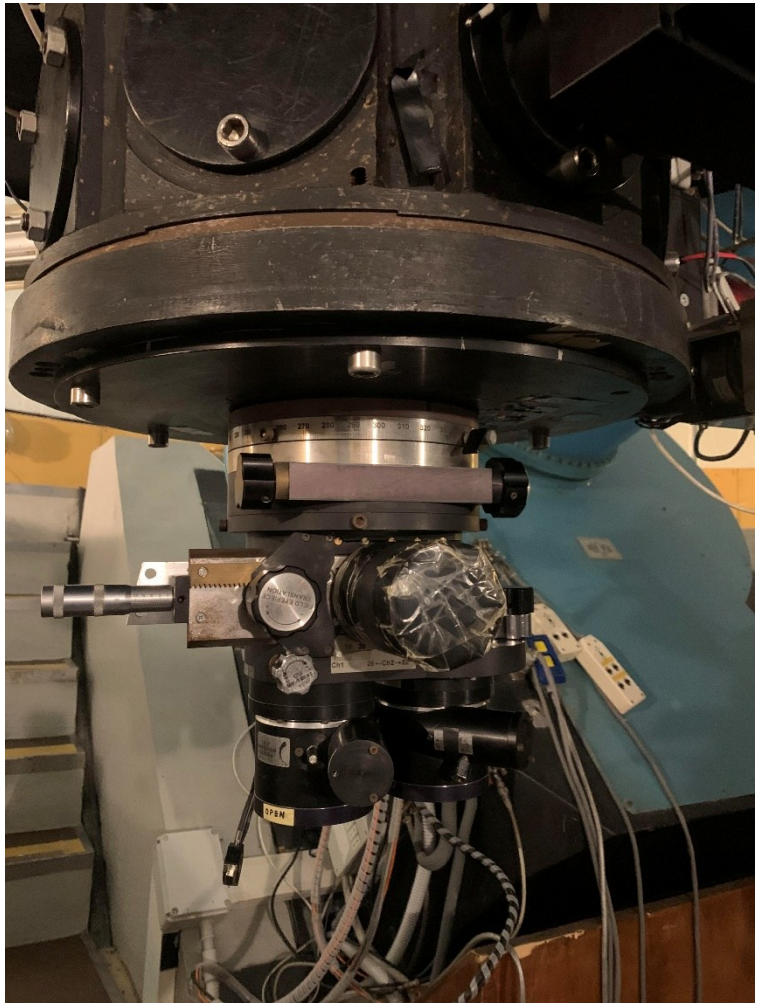
- 4 out of 22 events detected (~20%)
- mid-high object dimensions (~m)
- mid-high orbit (Low-MEO and GEO)
- time scales from tens of ms up to seconds
- quasi-simmetric shape

No LEO object detected!

➔ ephemeris not enough accurate

SiFAP-SoFT@Cassini: INAF Techno Grant (100 k€)

1.5 m Cassini



Simultaneous observations with SiFAP2@TNG and NC

- 50 – 100 hr reserved per semester
- FRBs
- Space Debris

First tests are currently ongoing

- old detectors
- old electronics

May 2025

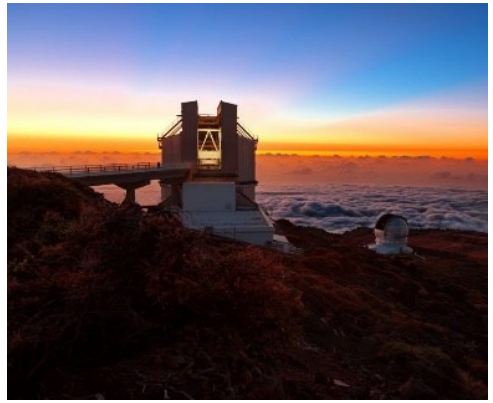
		SET	RISE		MOON	DARK	ill%	OBSERVER	INSTRUMENT
01	T	21.14	27. 9	S	24.27	2 41	23	May	
02	F	21.16	27. 7	S	25.14	1 52	33	===	
03	S	21.18	27. 4	S	25.48	1 15	43	May	
04	S	21.20	27. 2	S	26.14	0 48	54	May	
05	M	21.22	27. 0	S	26.34	0 25	63	CARBOGNANI	BVRI#4
06	T	21.24	26.58	S	26.52	0 5	73	DADINA/SST	VR#4
07	W	21.26	26.56	S		0 0	81	CUSANO	SiFAP
08	T	21.28	26.54	S		0 0	88	CUSANO	SiFAP
09	F	21.30	26.52	S		0 0	93	CUSANO	SiFAP
10	S	21.31	26.50	S		0 0	97	May	
11	S	21.33	26.48	S		0 0	99	May	
12	M	21.35	26.46	S		0 0	100	CUSANO	SiFAP
13	T	21.37	26.44	S		0 0	98	CUSANO	SiFAP

June 2025

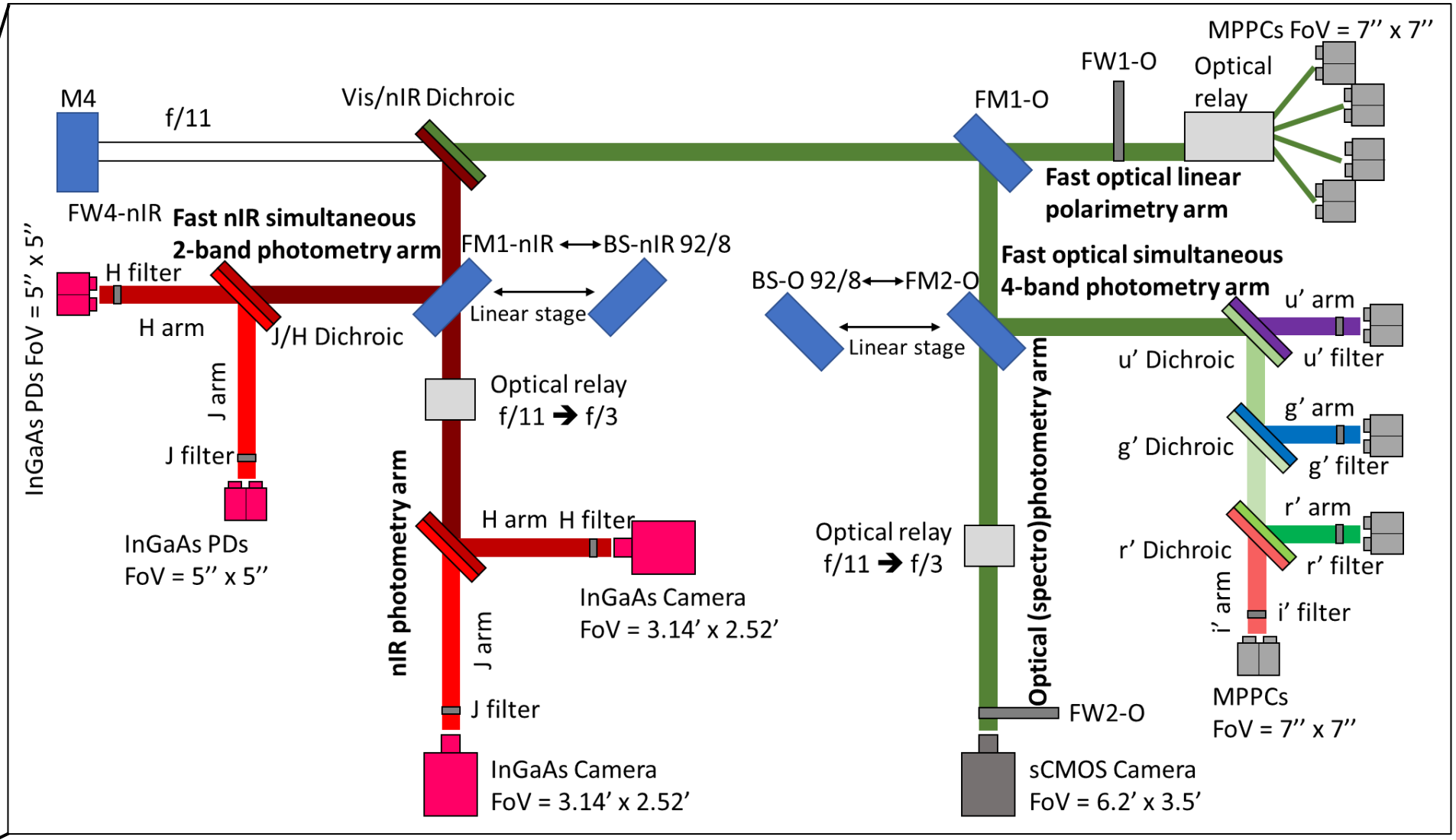
		SET	RISE		MOON	DARK	ill%	OBSERVER	INSTRUMENT
01	S	22.11	26.14	S	24.37	1 36	38	Jun	
02	M	22.13	26.13	S	24.56	1 15	48	Jun	
03	T	22.14	26.11	S	25.14	0 56	58	SST	
04	W	22.16	26.10	S	25.30	0 39	67	SST	
05	T	22.17	26. 9	S	25.46	0 22	76	SST	
06	F	22.18	26. 9	S	26. 4	0 3	83	SST	
07	S	22.20	26. 8	S		0 0	90	Jun	
08	S	22.21	26. 7	S		0 0	95	Jun	
09	M	22.22	26. 6	S		0 0	98	CUSANO	SiFAP
10	T	22.23	26. 6	S		0 0	100	CUSANO	SiFAP
11	W	22.24	26. 5	S		0 0	99	CUSANO	SiFAP
12	T	22.25	26. 5	S		0 0	97	CUSANO	SiFAP
13	F	22.26	26. 4	S		0 0	93	CUSANO	SiFAP

eSiFAP@TNG: PNRR/CTA+ project (~600 k€)

3.6m TNG



AdOpt box



Optical/nIR simultaneous fast photometry and polarimetry

Conclusions and future perspectives

- SiFAP2@TNG

  - ✓ **More than 450** impulsive events (FOBs) detected so far from different class of sources
  - ✓ **~1.5 FOBs/hr** on average
  - ✓ **Very interesting excess** from the magnetar **SGR 1935+2154**
  - ✓ Ongoing campaigns on (repeating) FRBs (expecially FRB 20180916B)
    - ➔ Optical upper limit at 1.02 mJy ms
  - ✓ Collaboration with PoliMi/Leonardo for space debris monitoring
    - ➔ 4 events detected out of 22
    - ➔ mid-high orbit (low-MEO and GEO) and dimensions (~m)

- Technological improvements

1. INAF **Techno Grant (100 k€)** to build up a new instrument (**SiFAP-SoFT**) to be mounted at **1.5 m Cassini Telecope** (Loiano)
   a. 50 – 100 hr reserved for simultaneous optical observations on FRBs and space debris
   b. possibly move the instrument to South facilities
2. PNRR/CTA+ **project fundings (~600 k€)** to build up a new instrument (**eSiFAP**) to be mounted at **3.6 m TNG** (ORM)
   a. simultaneous fast photometry in the optical/nIR bands
   b. simultaneous optical observations on CTA targets (blazars, pulsars, magnetars), FRBs, space debris


That's all Folks!