Fast Radio Bursts and multi-wavelength campaigns of FRB121102

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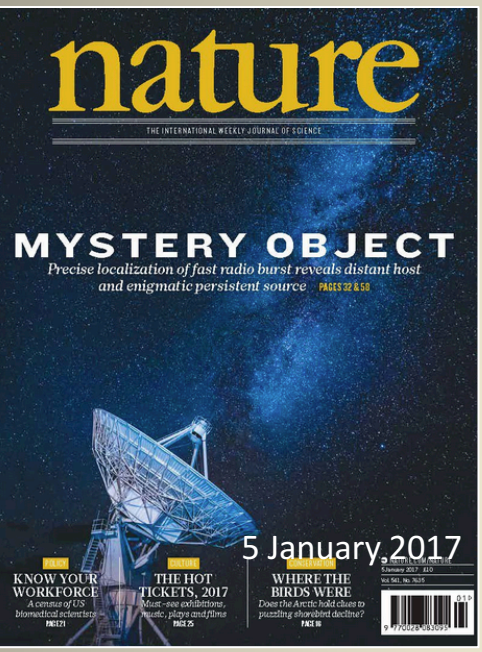
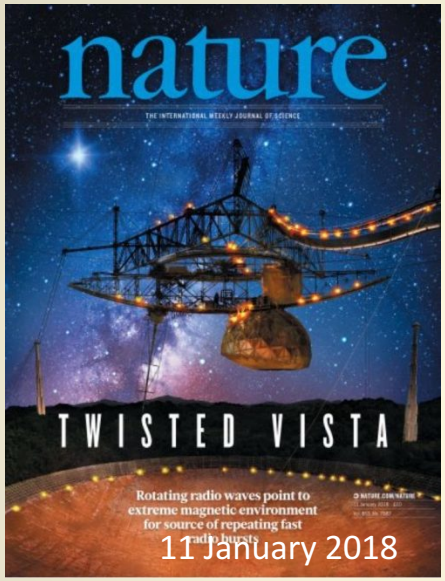
Christian Gouiffès, CPPM , 30 Sept.2019

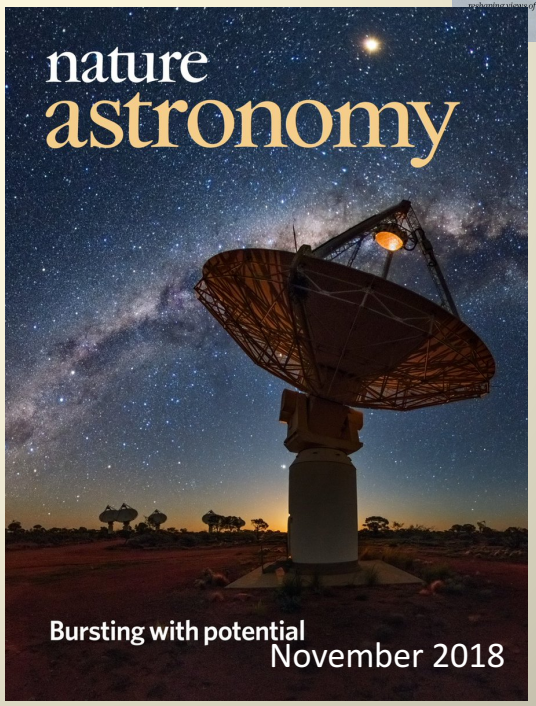
Une pensée
pour
Pierre Mandrou

FRBs: Many recent publications

(and the best cover of the year is…)







FRBs develop imagination, creation of artists

And also suggest sometimes more exotic ideas/interpretations/illustrations

Daily express, August 2019
Radio signals from life: Mysterious radio signals have been detected on Earth (Image: GETTY)

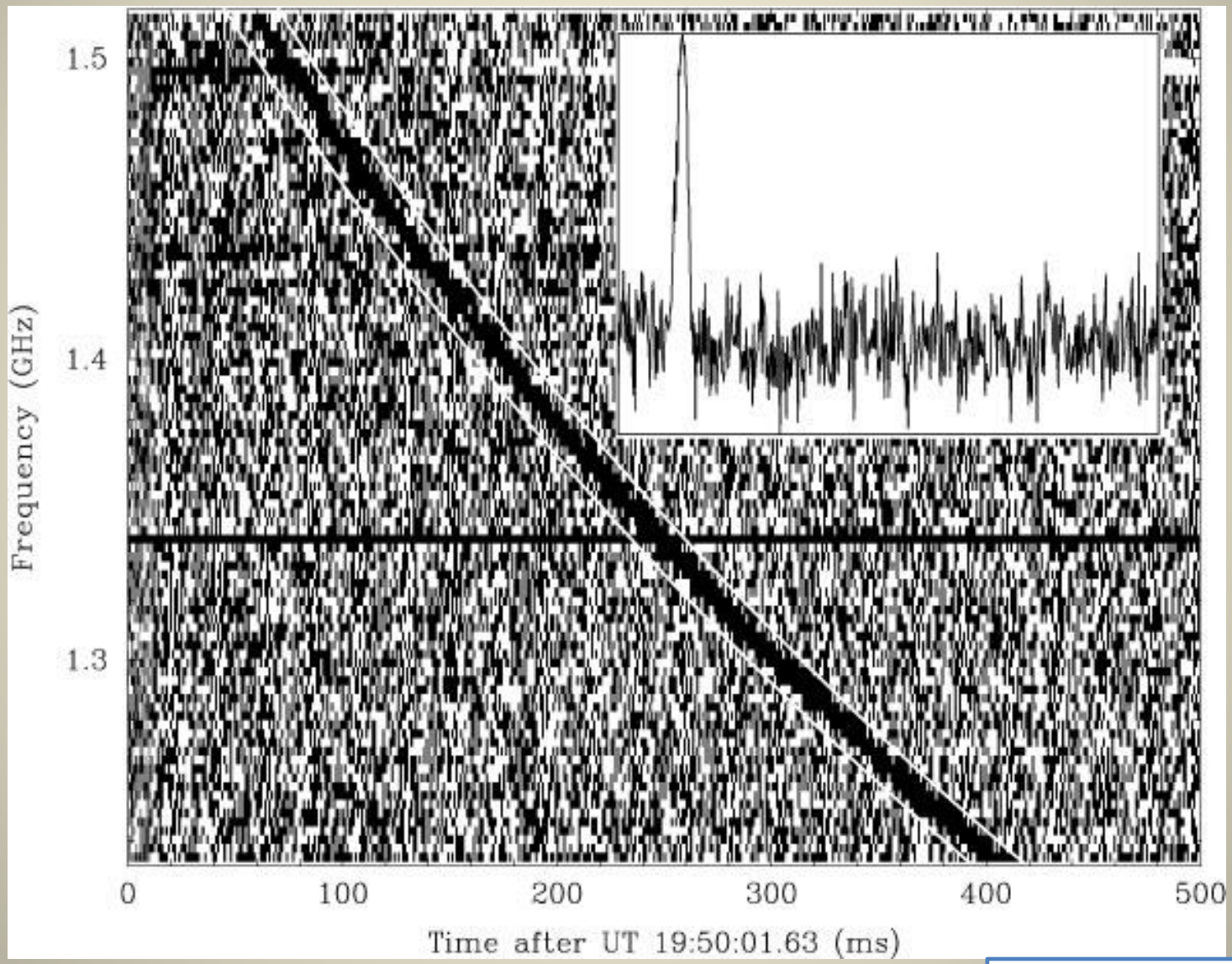
« Radio signals from space just reached Earth: Proof of alien life or is it something else? »

Outline :

- ✓ Introduction to Fast Radio Bursts
- ✓ FRB121102, a special and unique target for years
- ✓ Search for a counterpart to FRB121102 , the INTEGRAL programme
- ✓ Prospective

Suggestion for a reference :
E. Petroff, J.W. Hessels and D. R. Lorimer
The Astronomy and Astrophysics Review, 2019
(part of the material used in this presentation is extracted from this publication)

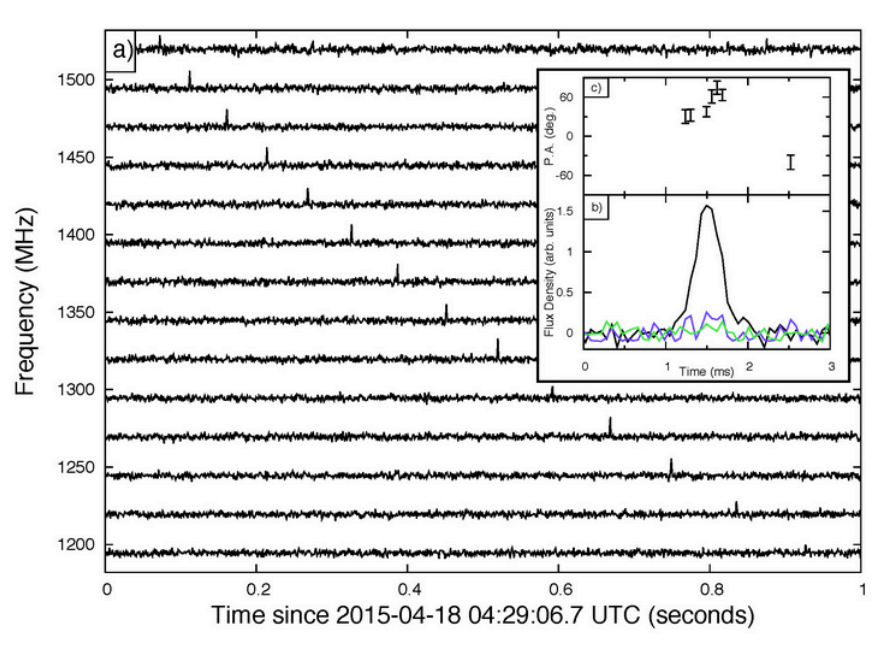
Fast Radio burst was discovered in 2007 by Duncan Lorimer during a Parkes LMC archive search – 2001 - programme forlooking to fast/very fast variable objects :
Remarks : D. L. expert in radio pulsars science

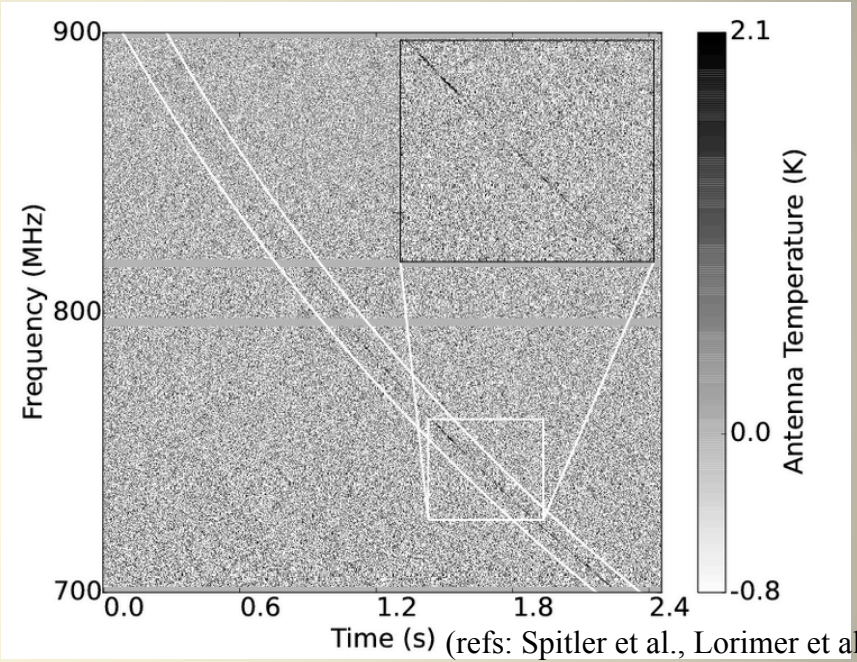


The « Lorimer » burst

Fast Radio Bursts:

- Discovered in 2007 (Lorimer burst)
- Bright, short radio pulses
- High dispersion measure (DM) -> Extragalactic origin
- Cataclysmic event ?



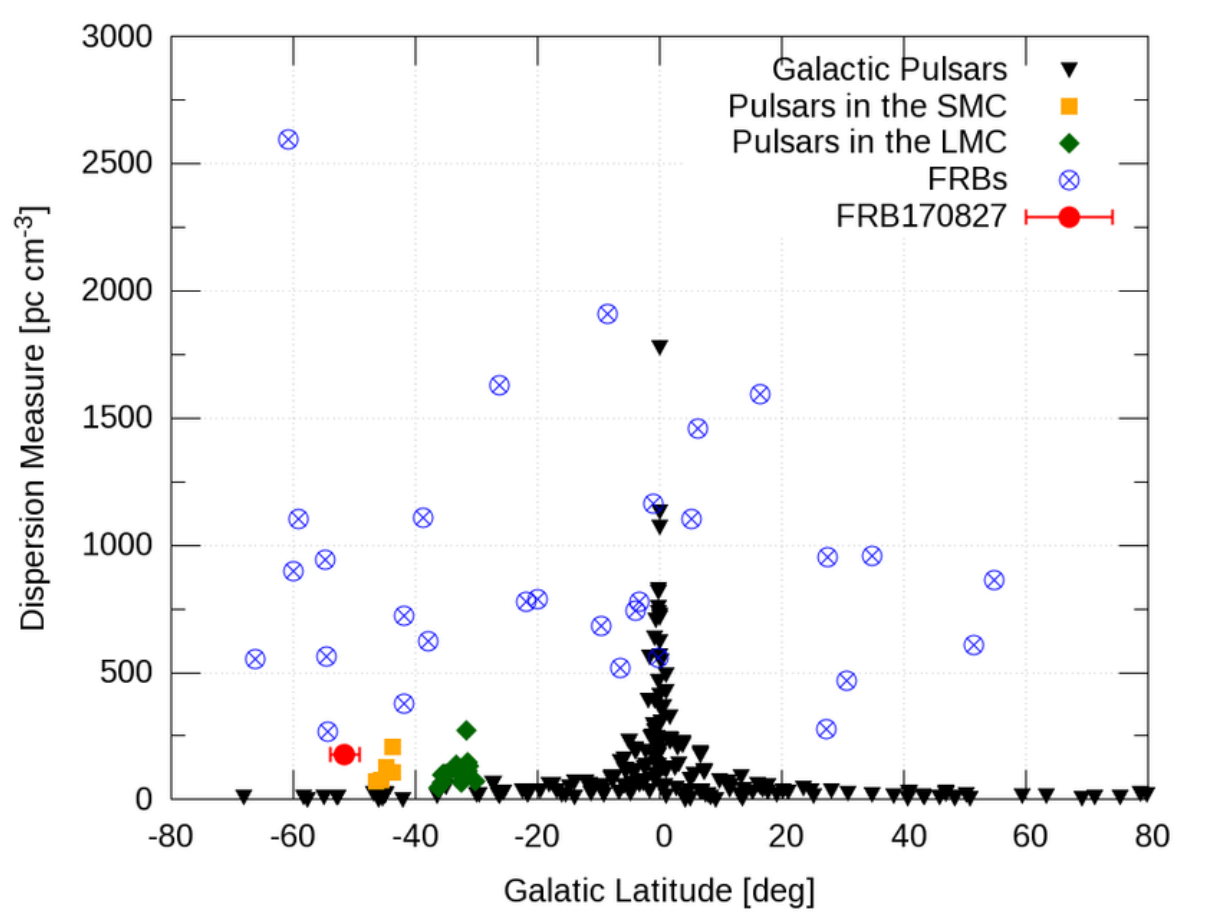


(refs: Spitler et al., Lorimer et al.)

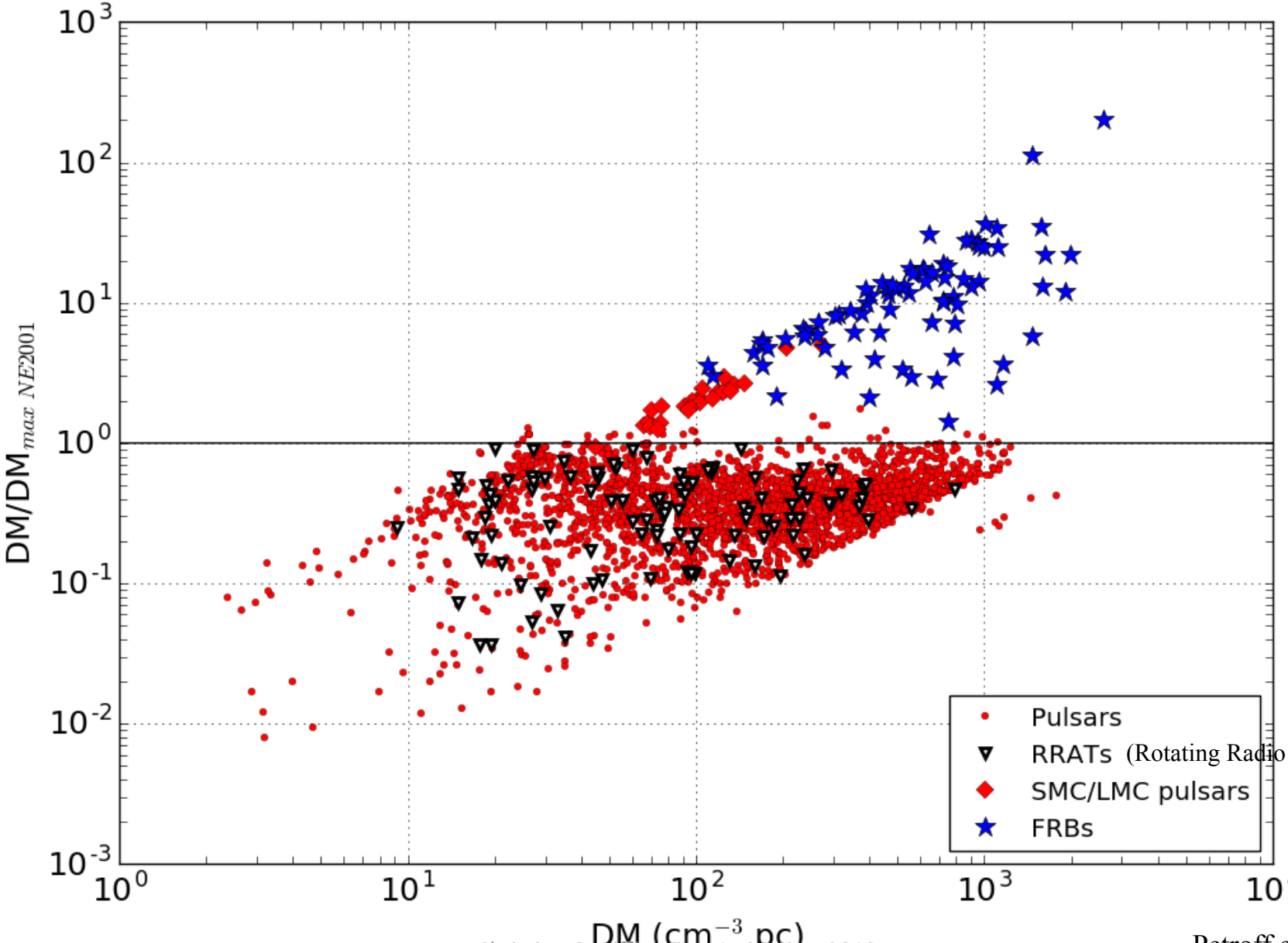
- Radiations propagating through an ionized medium disperse FRB pulses and delay the arrival time

$$\mathrm{DM} = \int_0^D n_e dl$$

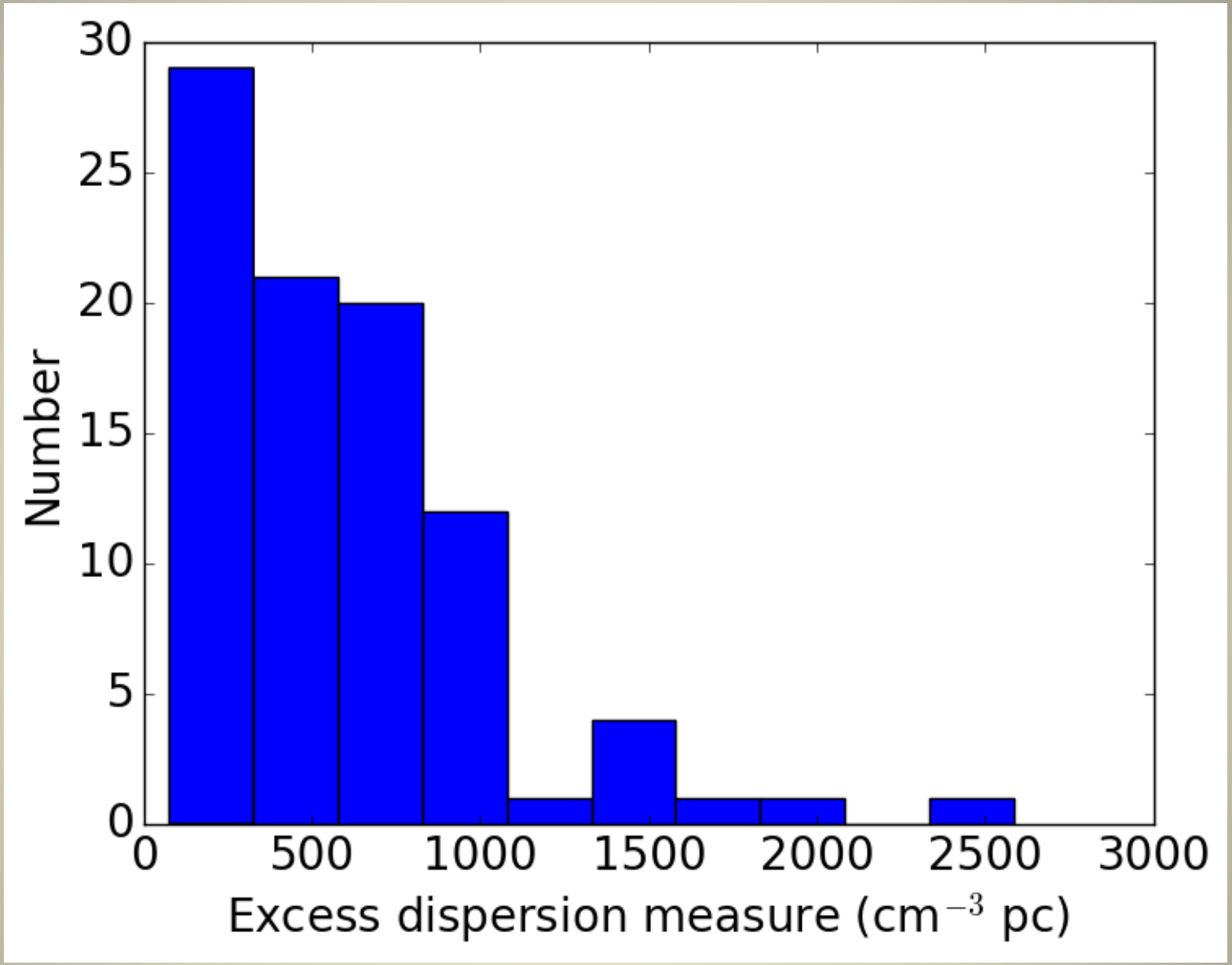
$$t_1 - t_2 = 4.16 \times 10^6 \ \mathrm{DM} \left[\frac{1}{\nu^2_{1,\mathrm{GHz}}} - \frac{1}{\nu^2_{2,\mathrm{GHz}}} \right] \mathrm{ms}$$



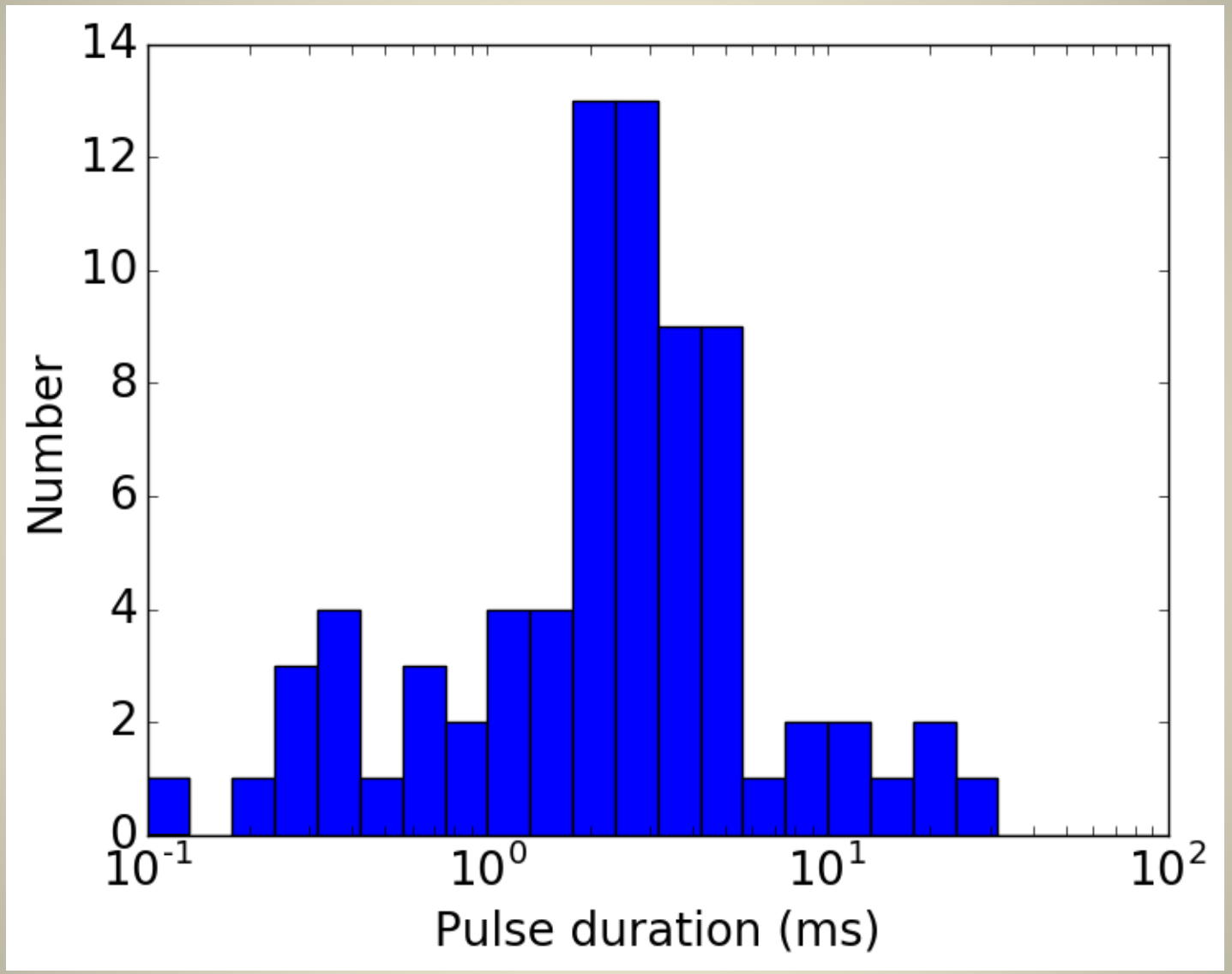
DM versus Galactic latitude plot for published FRBs and Milky Way, LMC and SMC pulsars Farah et al, (2018)



Petroff et al, 2019



Petroff et al, 2019



Petroff et al, 2019

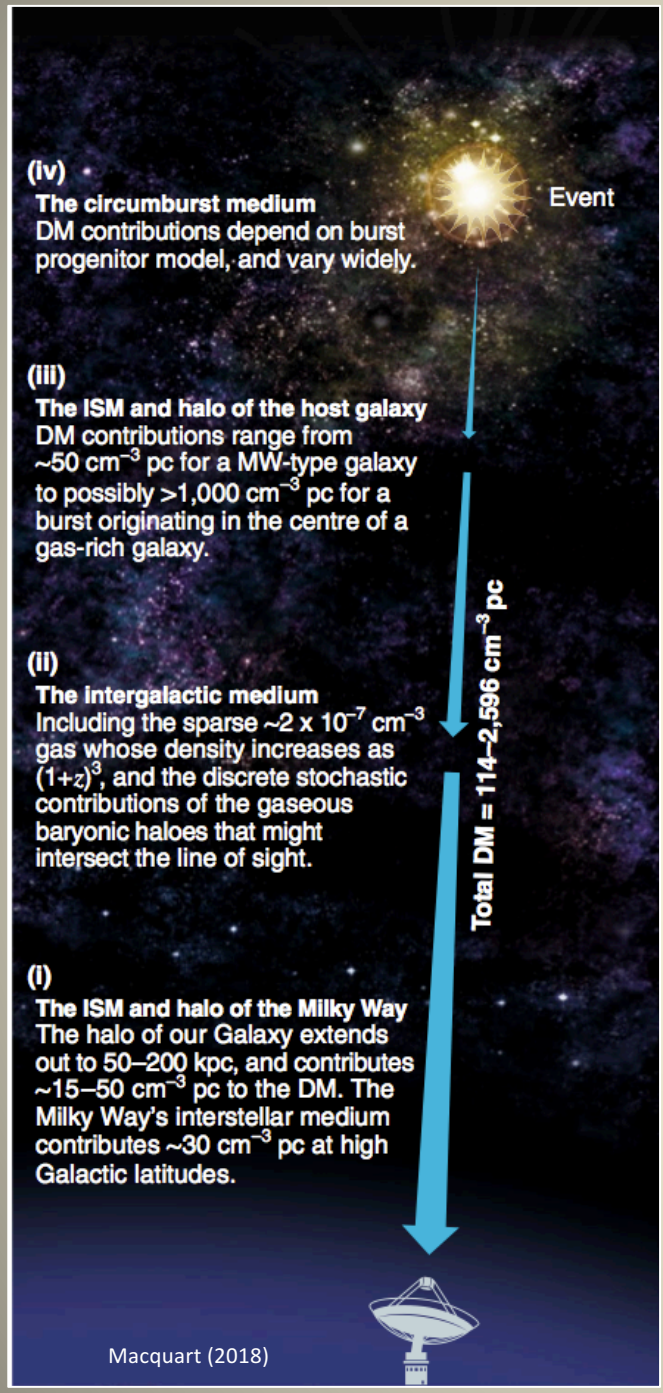
Dispersion Measure DM (cm^{-3} pc)

$$\mathrm{DM} = \int_0^D n_e dl$$

$$t_1 - t_2 = 4.16 \times 10^6 \ \mathrm{DM} \left[\frac{1}{\nu^2_{1,\mathrm{GHz}}} - \frac{1}{\nu^2_{2,\mathrm{GHz}}} \right] \mathrm{ms}$$

Remarks :

DM = 500 cm^{-3} pc, ν_1 = 45Mhz, ν_2 = 1.4Ghz → Δt = 20 min !



$$DM_{tot} = DM_{MW} + DM_{IGM} + DM_{HG} + DM_{circum}$$

- DM_{MW} ~ 30 cm^{-3} pc at Galactic latitudes |b| > 30deg

  (possible extra contribution of ~15-50 cm^{-3} pc from the Galactic Halo)

- DM_{HG} : ~ 50 cm^{-3} pc from the ISM of the host galaxy, possibly up to ~1000 cm^{-3} pc if occurring in dense gaseous regions from the inner parsecs of the host

- DM_{circum} : very hard to constrain (progenitor dependent)

DM_{tot} ~ 100 – 2500 cm^{-3} pc

→ DM_{IGM} is largely dominant
→ DM_{IGM} indicates distance (assuming homogeneous IGM distribution)
→ If known z, DM_{IGM} constrains IGM baryons

Major progress recently thanks to new networks/telescopes

Deep Synoptic Array 10 dish, Owens Valley Radio Observatory (OVRO,near Bishop, California)


Effelsberg telescope

Without forgetting other very active facilities


Arecibo telescope


FAST


GBT


NRT : Nançay Radio Telescope

FRB Catalogue

92 FRBs on 2019, Sept, 30th

This catalogue contains up to date information for the published population of Fast Radio Bursts (FRBs). This site is maintained by the FRBCAT team and is updated as new sources are published or refined numbers become available. Sources can now be added to the FRBCAT automatically via the VOEvent Network, details of this process are given in Petroff et al., 2017. FRBs confirmed via publication, received with a high importance score (>0.95) over the VOEvent Network, or with a high confidence value defined explicitly in an Astronomer's Telegram are given 'Verified' status and are shown on the default homepage; to see all events (including unverified candidates received via the VOEvent Network or ATel system) toggle the "Verified events/All events" button below. As refined and peer-reviewed confirmation of FRB detections are received they will be moved to the Verified category.

Information for each burst is divided into two categories: observed parameters from the available data, and derived parameters produced using a model. Cosmological values are obtained using the Cosmology Calculator (Wright, 2006). The observed parameters are sometimes either lower or upper limits, due to the limitations of the data acquisition systems. Where multiple fits or measurements of a burst have been made each one is provided as a separate sub-entry for the FRB.

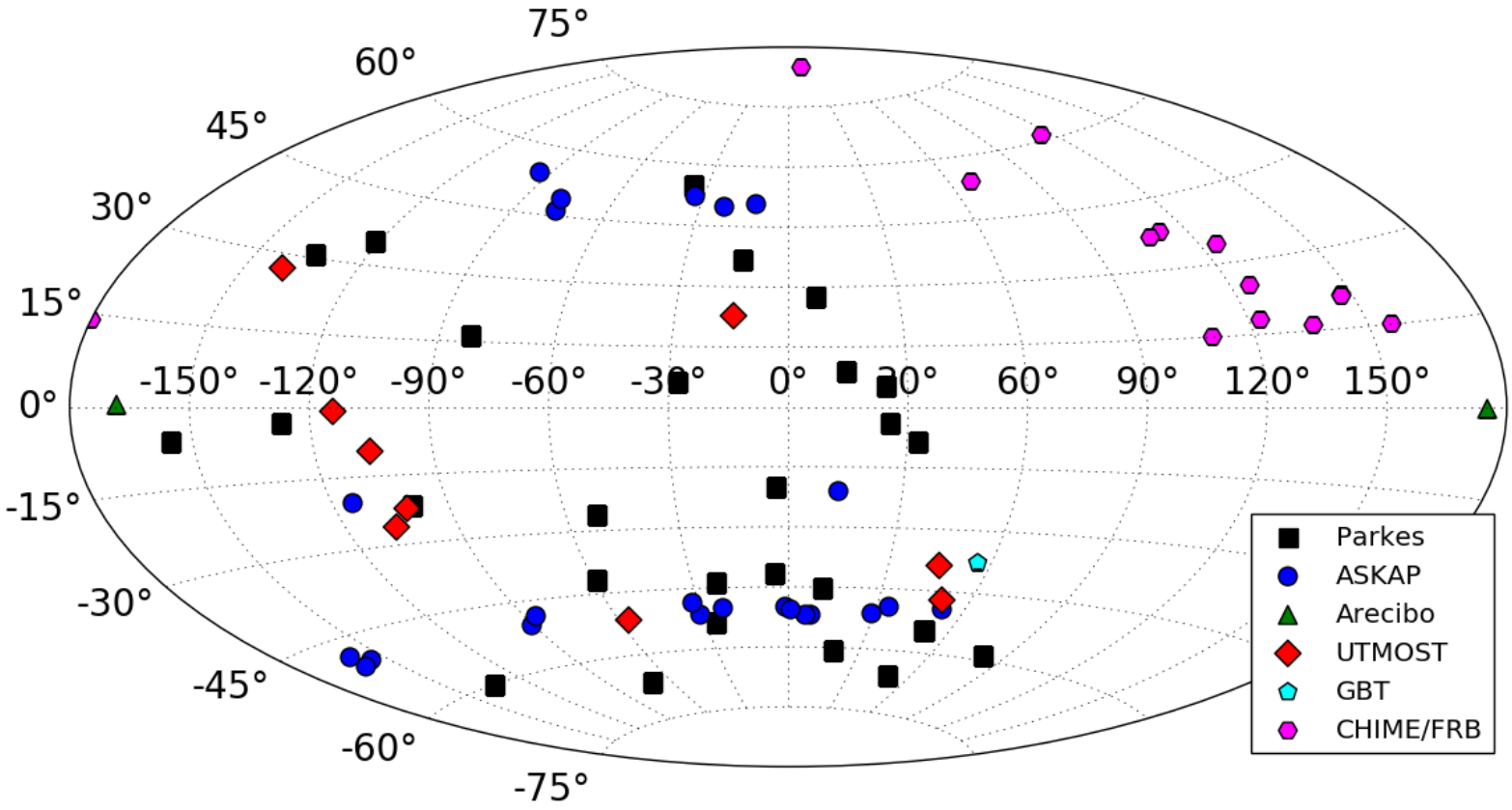
You may use the data presented in this catalogue for publications; however, we ask that you cite the paper (Petroff et al., 2016) and provide the url (http://www.frbcat.org). Any issues relating to the use of the catalogue should be addressed to FRBCAT team (primary contact: Emily Petroff).

The most recent version of the catalogue database and previous versions are available in CSV format on Zenodo at the DOI: http://www.frbcat.org/frbcat.csv

Visible columns | Verified events | Export to CSV | Search | Clear

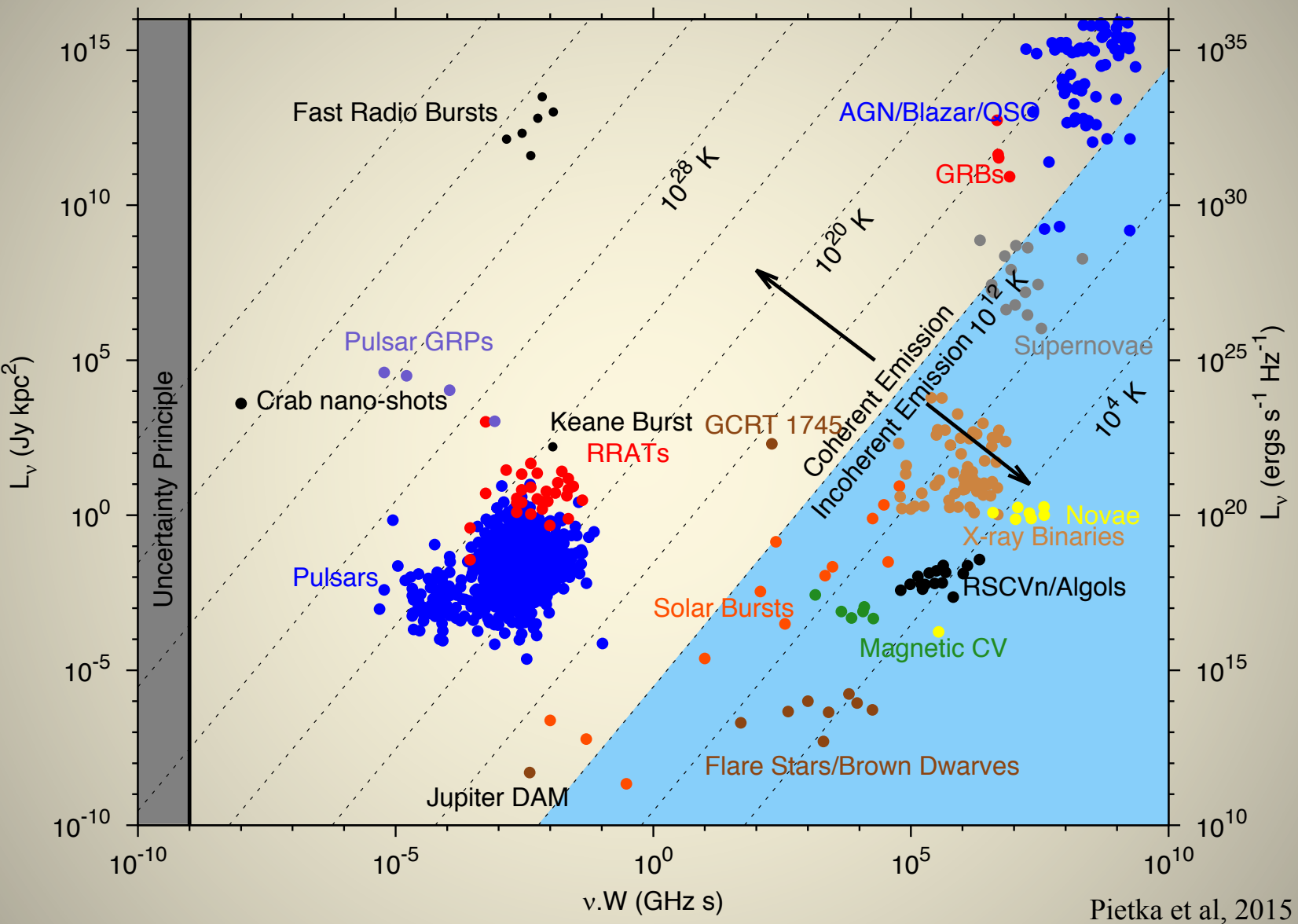
	FRB	UTC	Telescope	RAJ	DECJ	gl	gb	DM	Width	S/N
+	FRB190523	2019/05/23 06:05:55.815	DSA-10	13:48:15.6	+72:28:11	117.03	44	760.8±0.6	0.42	11.5
+	FRB190222.J...	2019/02/22 18:46:01.367	CHIME/FRB	20:52	69:50	104.9	15.9	460.6±0.1	2.97	0
+	FRB190209.J...	2019/02/09 08:20:20.977	CHIME/FRB	09:37	77:40	134.2	34.8	424.6±0.6	3.7	0
+	FRB190116.J...	2019/01/16 13:07:33.833	CHIME/FRB	12:49	27:09	210.5	89.5	444±0.6	4	0
+	FRB181228	2018/12/28 13:48:50.100	UTMOST	06:09:23.64	-45:58:02.4	253.3915	-26.0633	354.2±0.9	1.24	12
+	FRB181128.J...	2018/11/28	CHIME/FRB	04:56	63:23	146.6				

http://www.frbcat.org (Petroff et al, 2016)

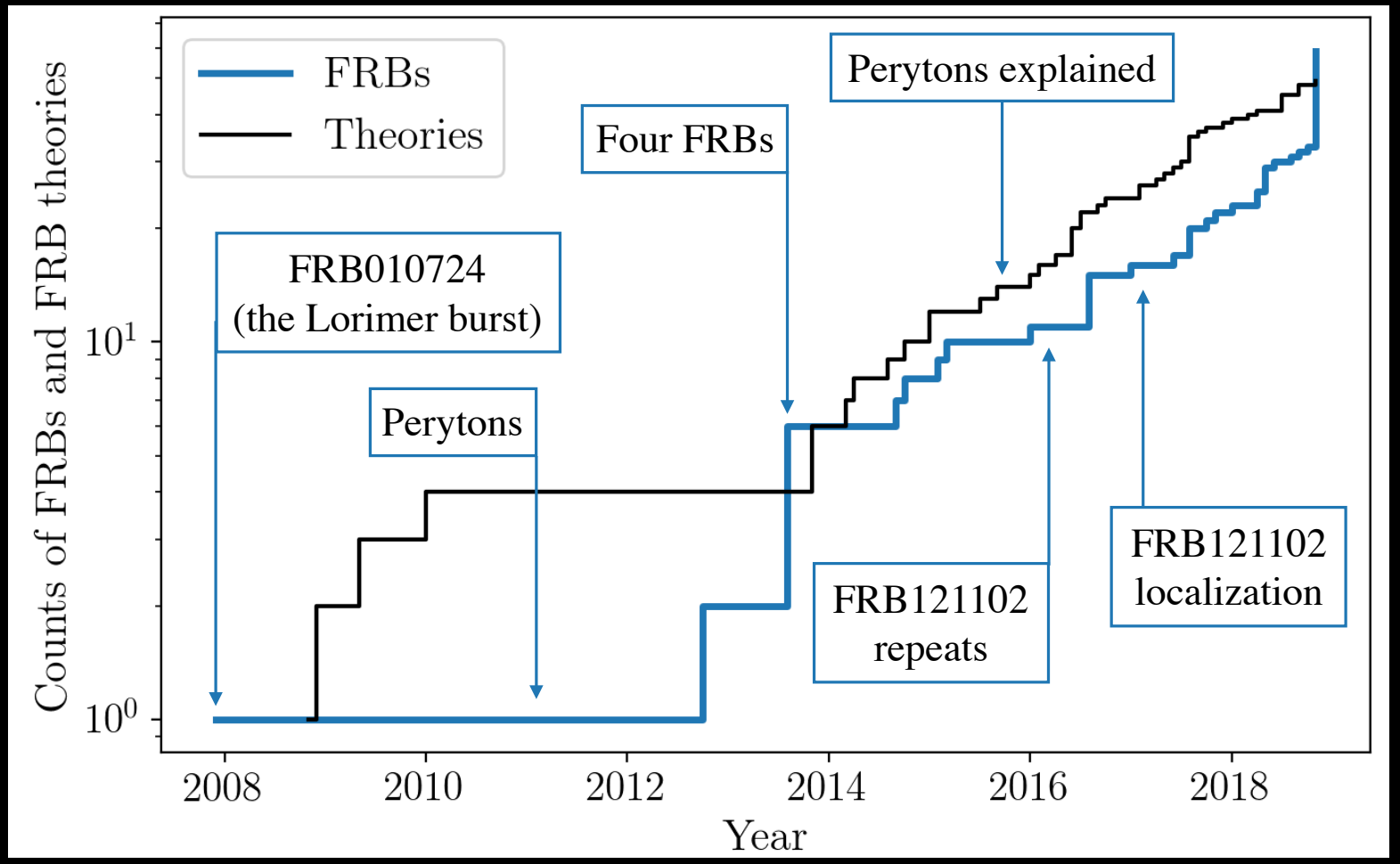


Petroff et al, 2019

2 class of FRB's : repeating and not repeating (these latest often referred as cataclysmic event)


Fast Radio Bursts
AGN/Blazar/QSO
GRBs
Supernovae
Pulsar GRPs
Crab nano-shots
Keane Burst
GCRT 1745
RRATs
Pulsars
Solar Bursts
Novae
X-ray Binaries
RSCVn/Algols
Magnetic CV
Flare Stars/Brown Dwarves
Jupiter DAM
Uncertainty Principle
Coherent Emission
Incoherent Emission
10^{28} K
10^{20} K
10^{12} K
10^{4} K
L_ν (Jy kpc^2)
L_ν (ergs s^{-1} Hz^{-1})
ν.W (GHz s)
Pietka et al, 2015

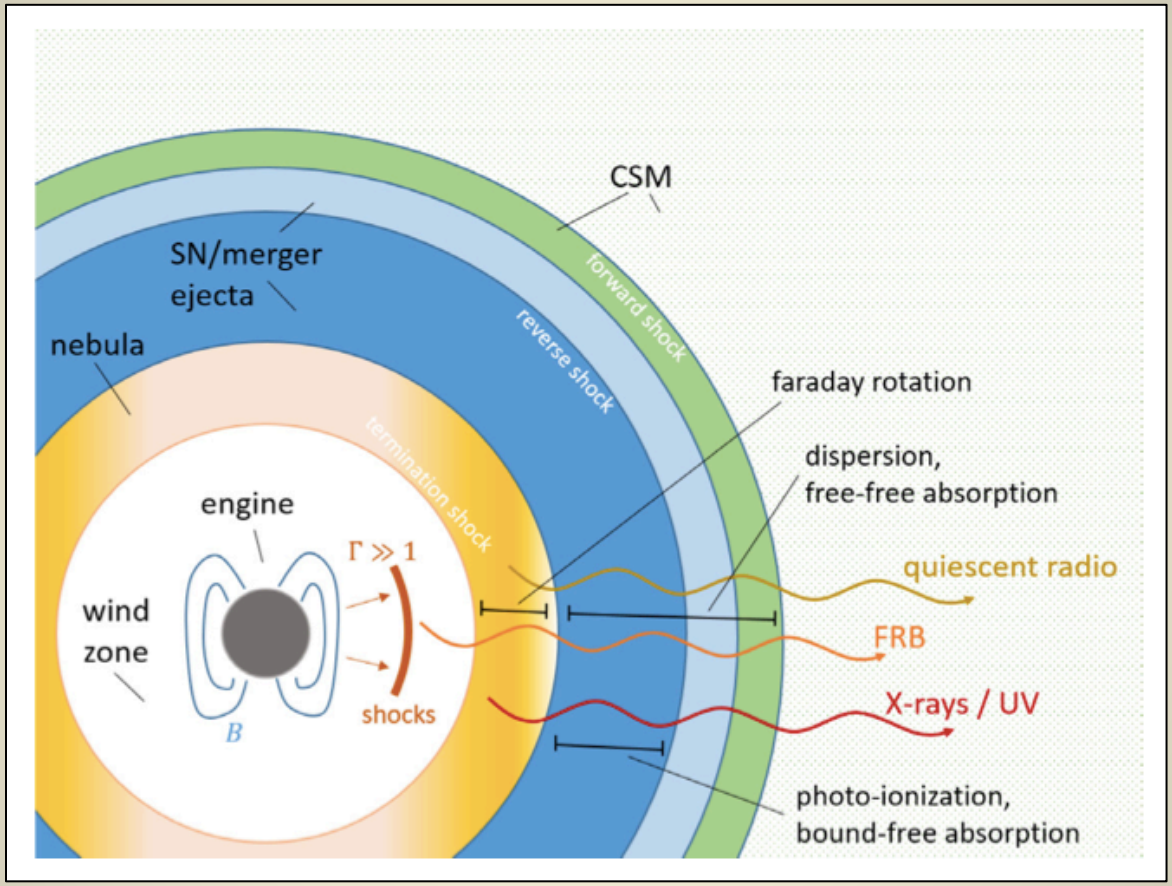
FRBs and their possible progenitors



From Ravi, Amsterdam workshop, 20

Many theoretical models proposed for FRB's

- Collapses of supra-massive neutron star into black hole (Falcke et al, 2014, Zhang et al, 2014)
- Magnetar pulse-wind interactions (Lyubarsky, 2014)
- Charged black hole binary mergers (Zhang et al, 2016)
- Giant pulse emissions from pulsars (Cordes et al, 2016)
- Giant flares from magnetars (Katz at al, 2014, Kulkarni et al, 2014, Pen et al, 2015)
- Unipolar inductor model (Wang et al, 2016)
- Double neutron stars mergers (Totani et al, 2013)
- Encontering of many asteroids with a highly magnetised pulsar (Dai et al, 2016)
- Radio emissions from pulsar companions (Mottez et al, 2014)
- Magnetic energy release in magnetar magnetosphere (Katz J.I, 2016)
- Extreme environment : "An extreme magneto-ionic environment associated with fast radio burst source FRB121102.', Michilli et al, *Nature*, January 11th, 2018 : Polarization (nearly 100%) → emission close to a massive black hole or within a very powerful nebula
- …



Schematic representation of an expanding material ejecta produced by a core-collapse Supernova or a Binary Neutron Star merger, enveloping a magnetar at the origin of the Fast Radio Burst emission (Margalit et al. 2018)

Fast Radio Bursts and multi-wavelength campaigns of FRB121102

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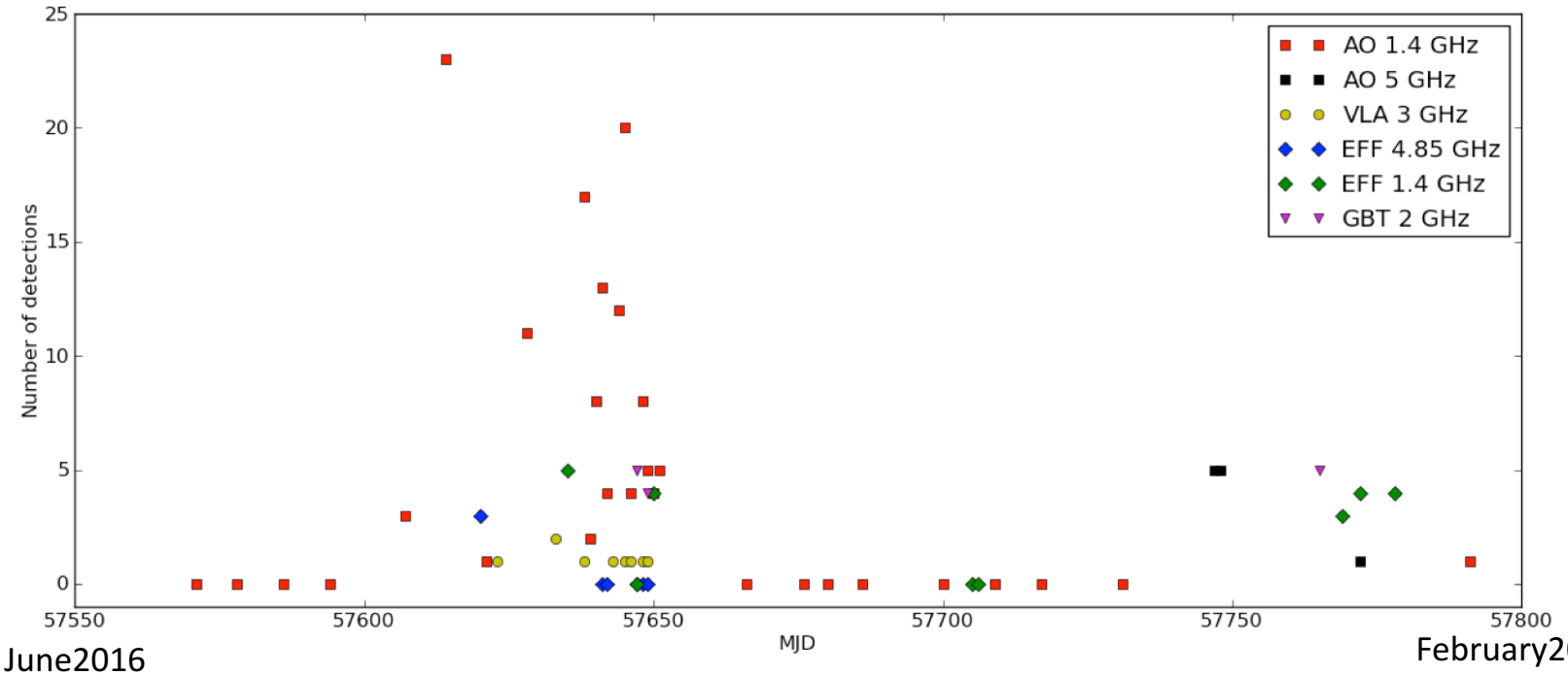
Repeating Fast Radio Bursts

The case of FRB121102

FRB121102, the first repeating FRB



June2016

February2017

(Spitler, private com.)

A very brief history of the Fast Radio Burst FRB121102

- ✓ Discovery at Arecibo /PALFA survey, 2012 November 2 (Spitzer et al, 2014)
- ✓ Follow-up Arecibo 10 new bursts detected —> **FRB121102 is a repeating burst** (Spitler et al, 2016)
- ✓ Follow-up: Arecibo, Effelsberg, Green Bank telescope, Lowell telescope, VLA
  ➔ 6 more bursts (Scholz et al, 2016)

N=17 bursts

- ✓ VLA follow up: 83h distributed over 6 months ➔ 9 bursts detected in 2016
  + Optical identification of the host galaxy (Chatterjee et al, 2017)
  - accurate localization <100 mas
  - persistent radio and optical counterpart

N=26 bursts

✓ European VLBI networks + 305m-Arecibo telescope : detects both the bursts (4) and persistent radio emission at millisecond angular scale, persistent radio source less than 0.7 pc (Marcote at al, 2017)

N=30 bursts

✓ Gemini + GMOS Optical observation : low-metalicity dwarf galaxy at z=0.192, Persitent radio source offset by 200 mas from the galaxy's center
No optical signatures for AGN activity (Tendulkar et al, 2017)

Many theoretical models proposed for FRB121102

- Collapses of supra-massive neutron star into black hole (Falcke et al, 2014, Zhang et al, 2014)
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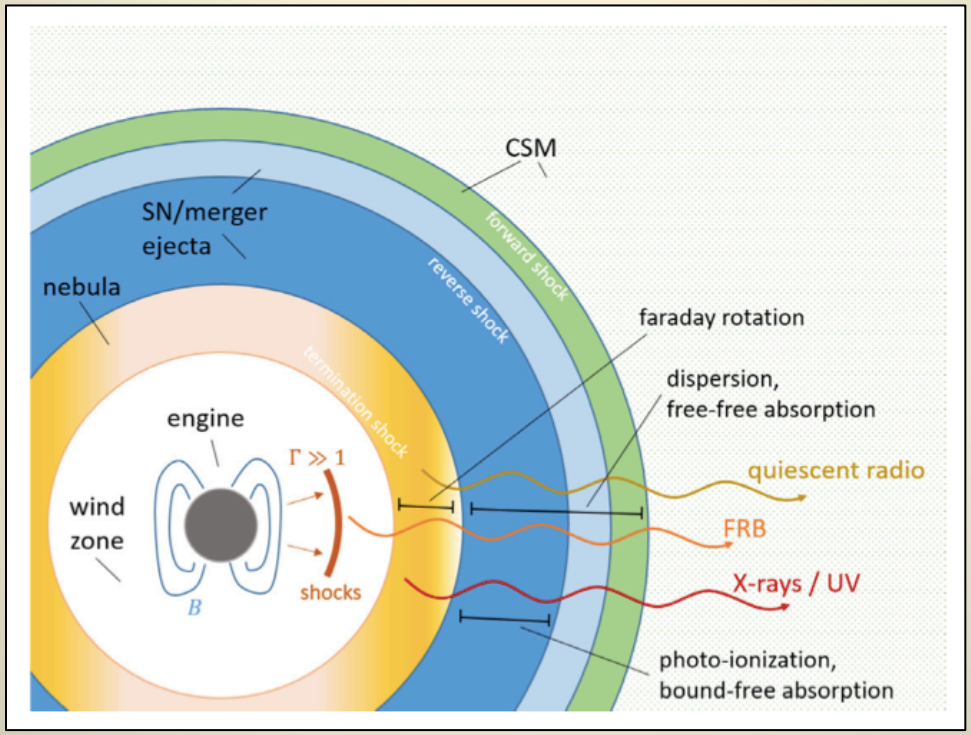
- …

« Preferred » model for FRB121102

- ✓ Star-forming galaxy at redshift z=0.19
- ✓ FRB is coincident with a compact region with prominent emission lines characteristic of intense star formation
- ✓ very high Faraday rotation
- ✓ the ~100% linearly polarized emission



➔ support to scenarios linking FRBs to compact sources of stellar origin embedded in extreme magnetic environments

Several arguments to search for a counterpart/afterglow of FRB's in lambda ≠ radio

- Important to look for afterglow
- Several models predict extended gamma-ray emission (Murase et al, 2017)
- Search for the host galaxy when possible (precision of the localization)
- A possible afterglow detected by Swift/BAT from FRB131104 (Delaunay et al, 2016)

The 2017 Campaign

Two orbits allocated late September 2017, multi-lamda campaign organized

Several facilities involved
BUT….


Effelsberg telescope


OHP


Hurricane Maria

Arecibo telescope


FAST


Major failure of the hydraulic system
(used for the receiver motion along its track)

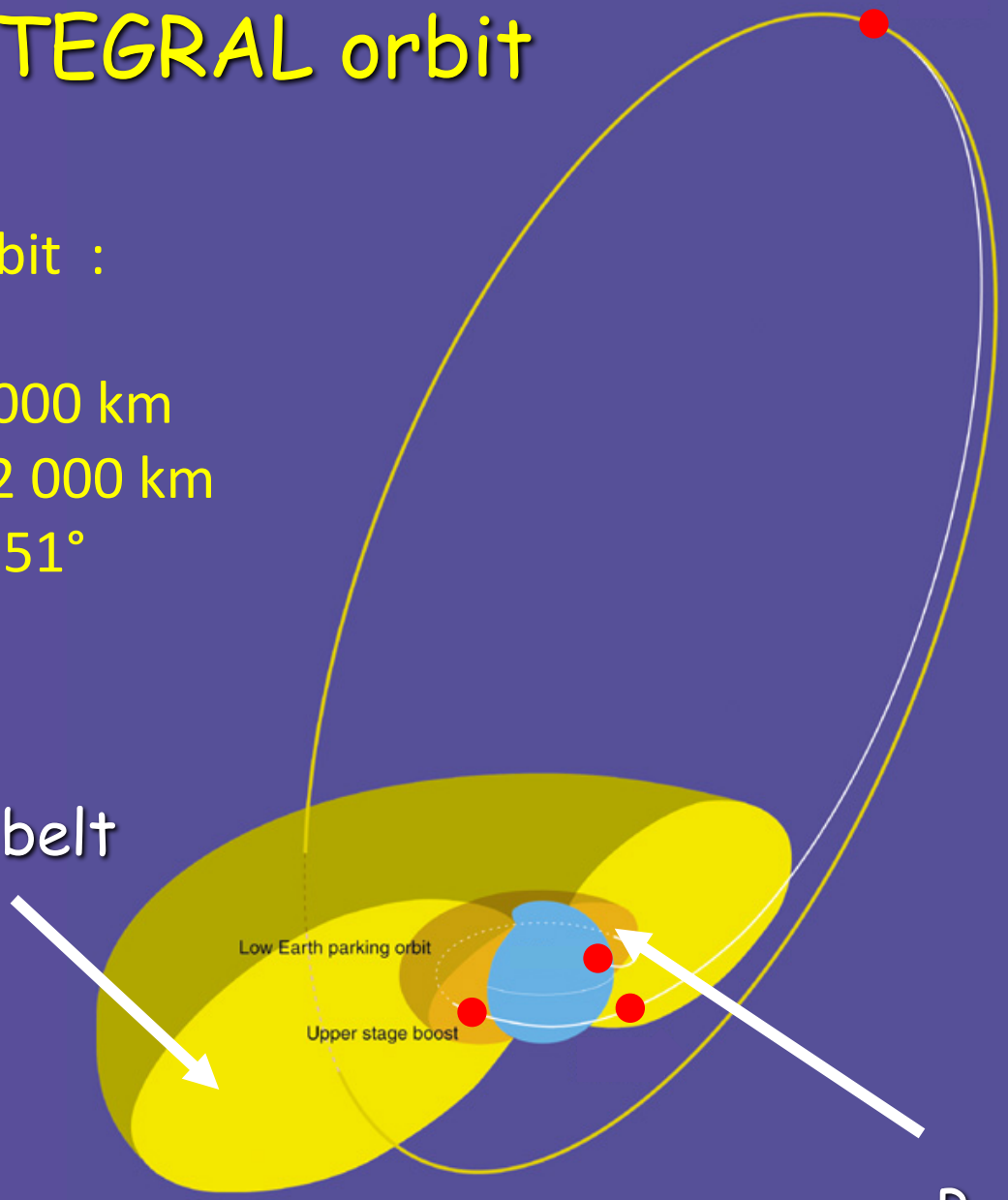
NRT : Nançay Radio Telescope

INTEGRAL
Launch : 2002, October 17

The INTEGRAL orbit

Eccentric Orbit :

Apogée: 13 000 km
Périgée : 152 000 km
Inclinaison : 51°
Durée : 72h



INTEGRAL Scientific payload

Satellite
4.1 tons
5 m height
3.7 m diameter
16 m solar pannels

OMC (optical)

JEM-X

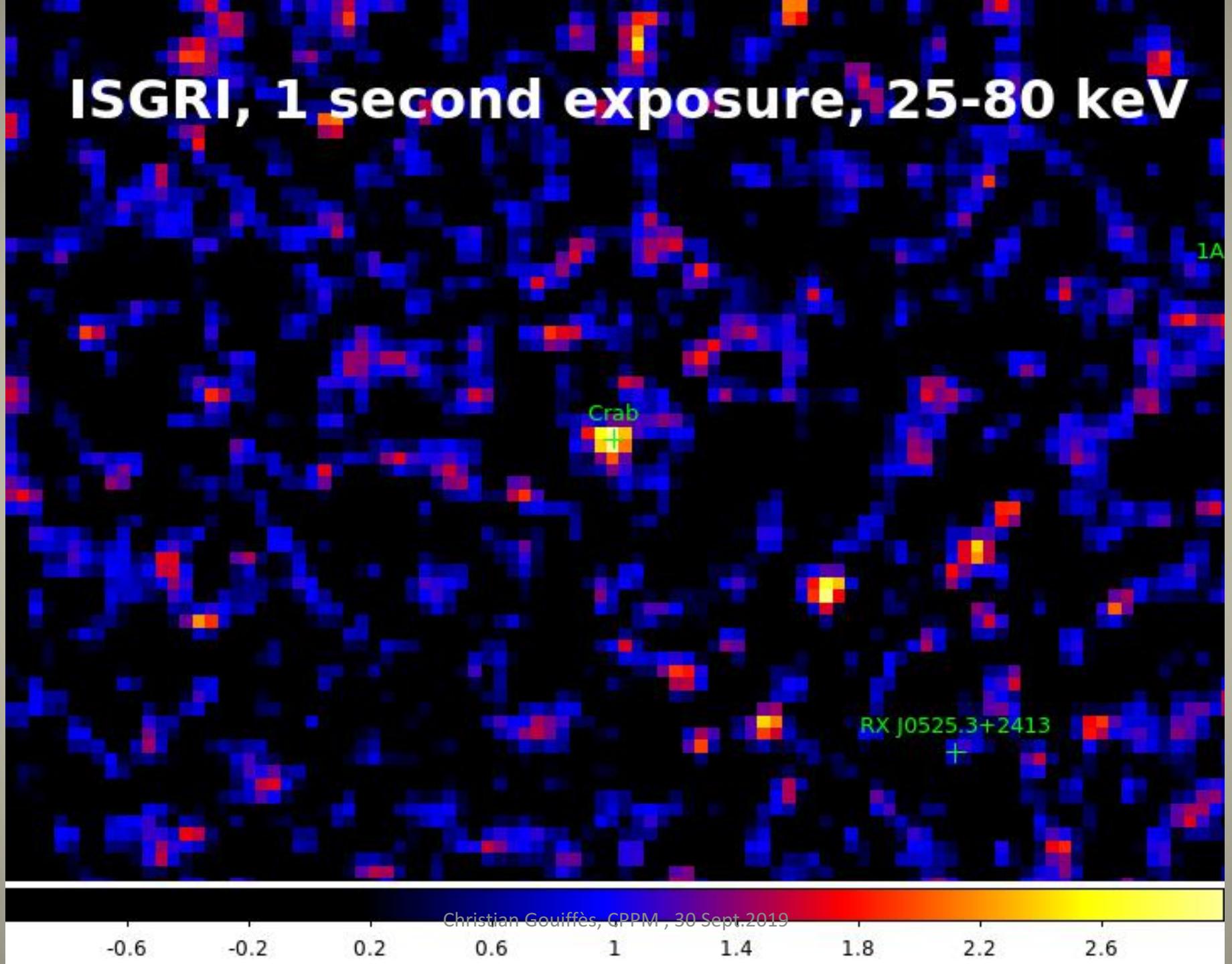
IBIS

15 keV – 10 MeV
12′ FWHM imaging
<1′ source location
19°x19° FOV

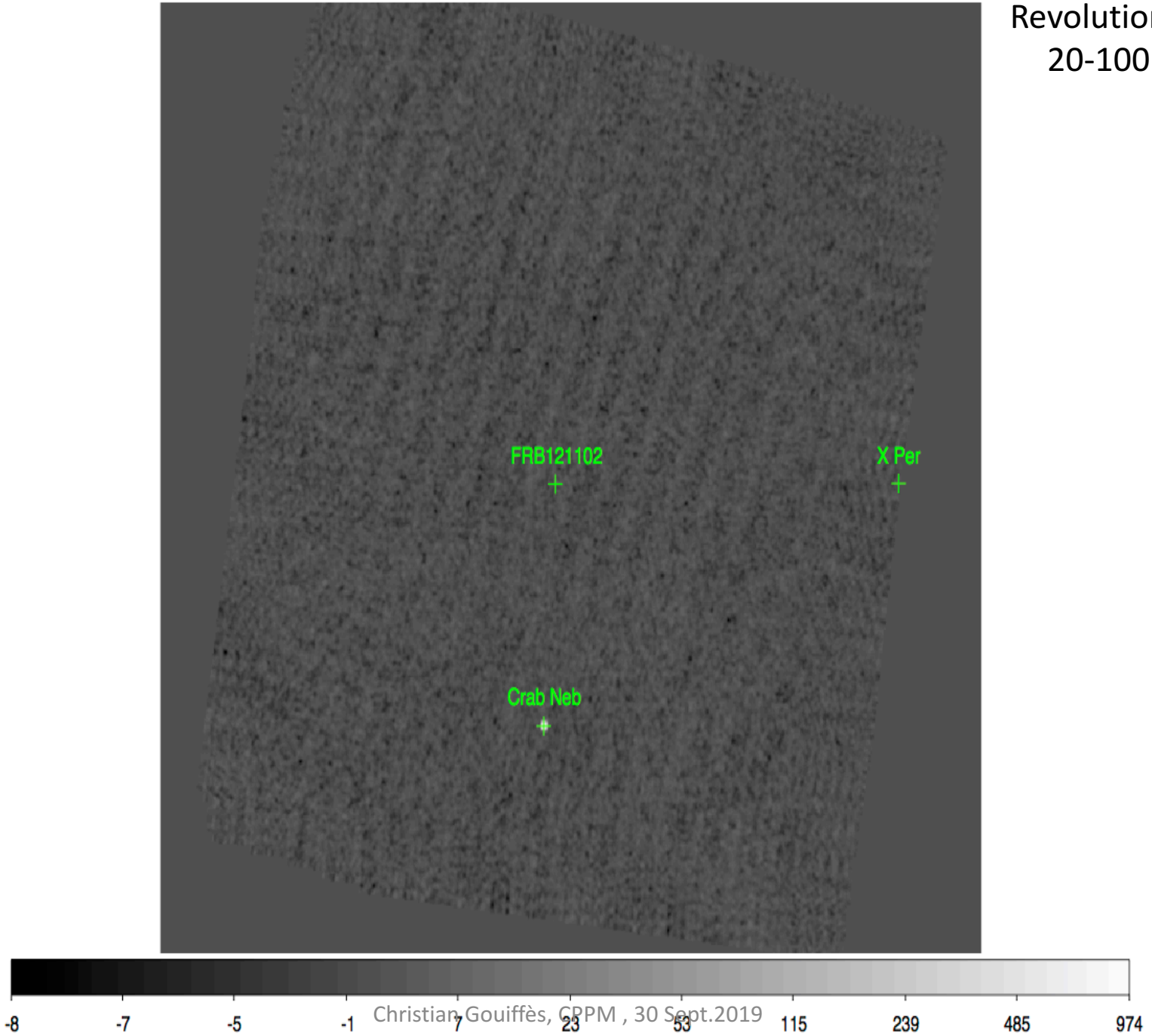
ISDC

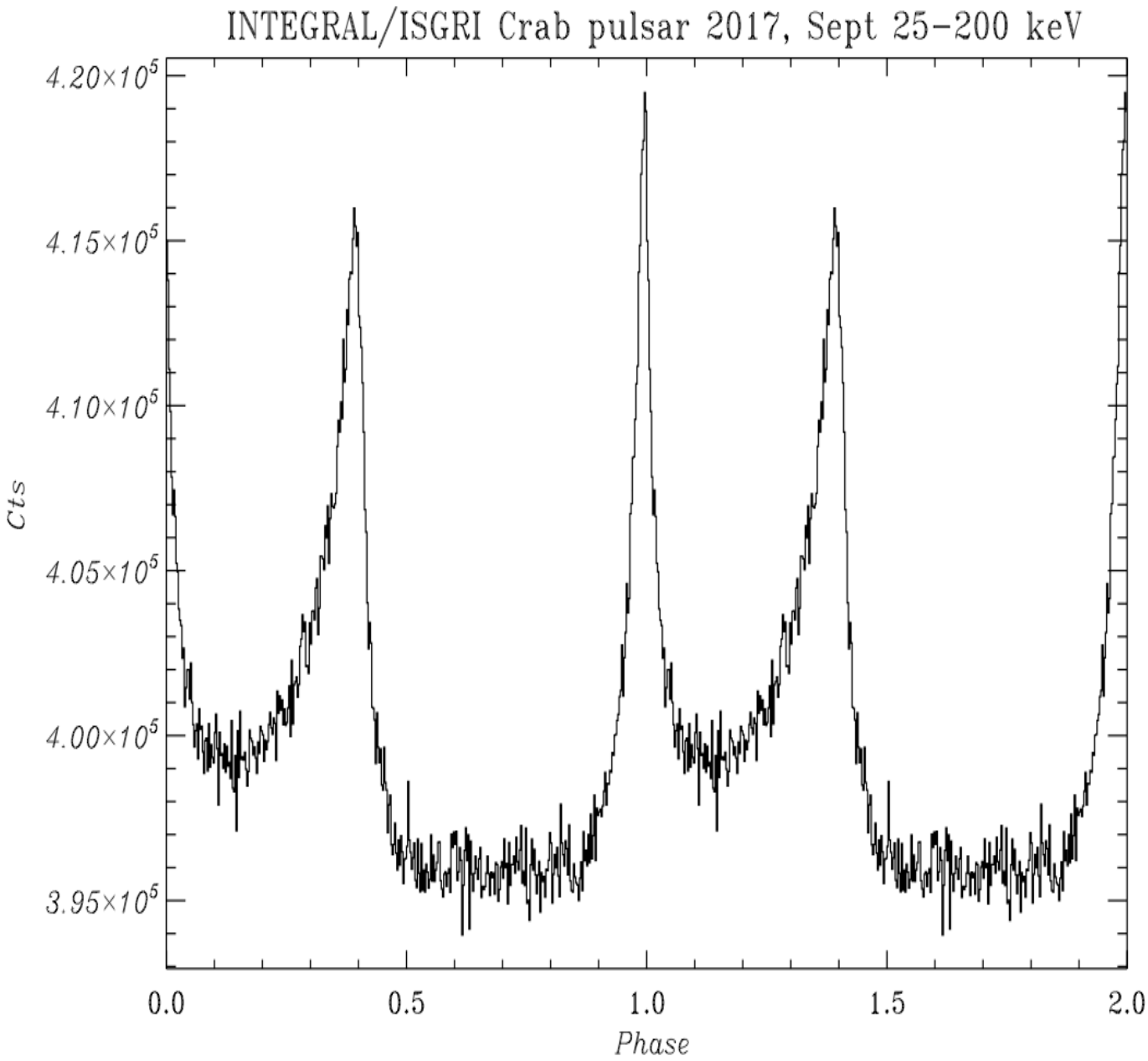
SPI

20 keV – 8 MeV
2 keV FWHM
26° Ø FOV


ISGRI, 1 second exposure, 25-80 keV
1A
Crab
RX J0525.3+2413
-0.6
-0.2
0.2
0.6
1
1.4
1.8
2.2
2.6

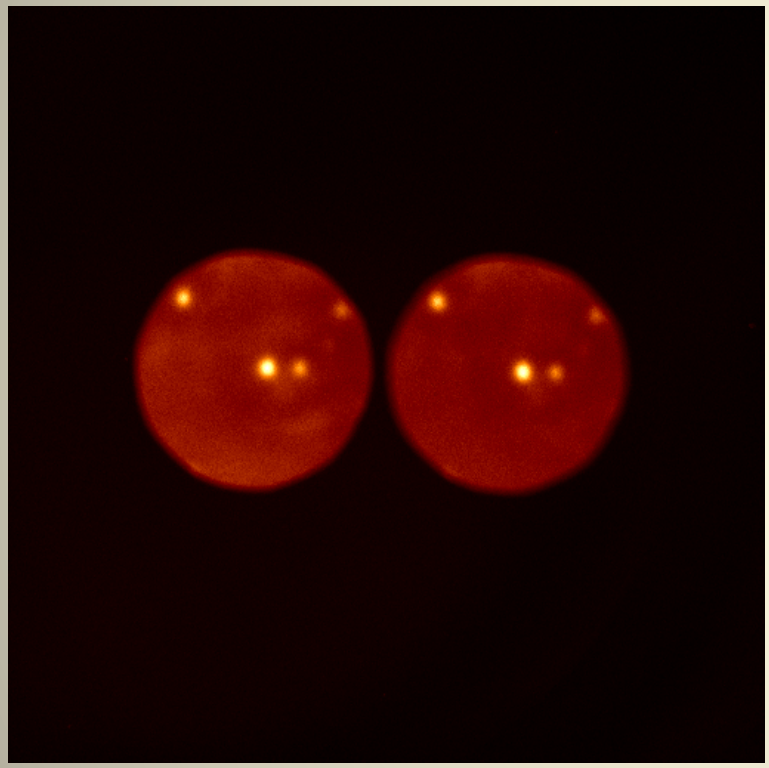
Revolution 1867
20-100 keV

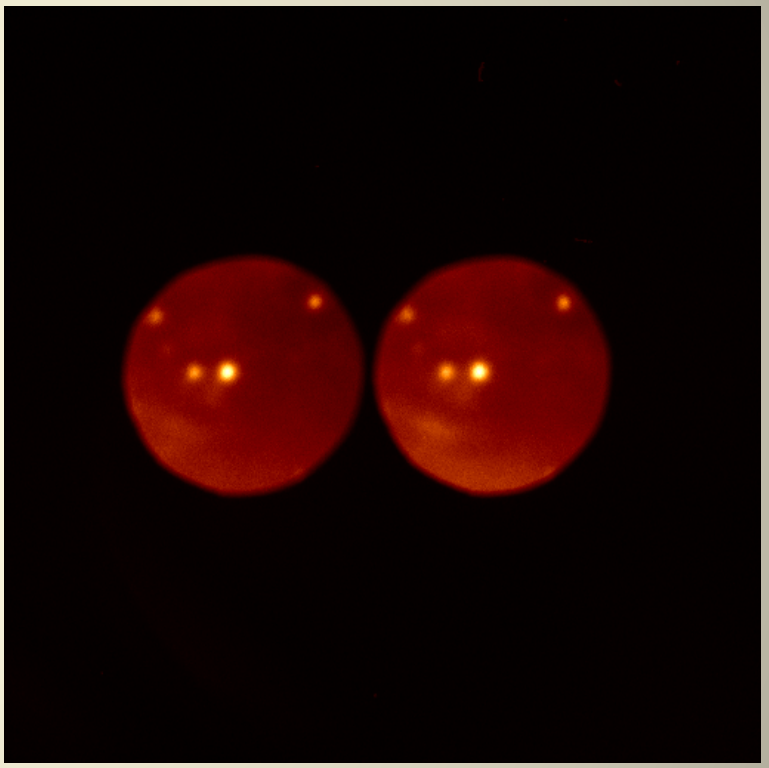


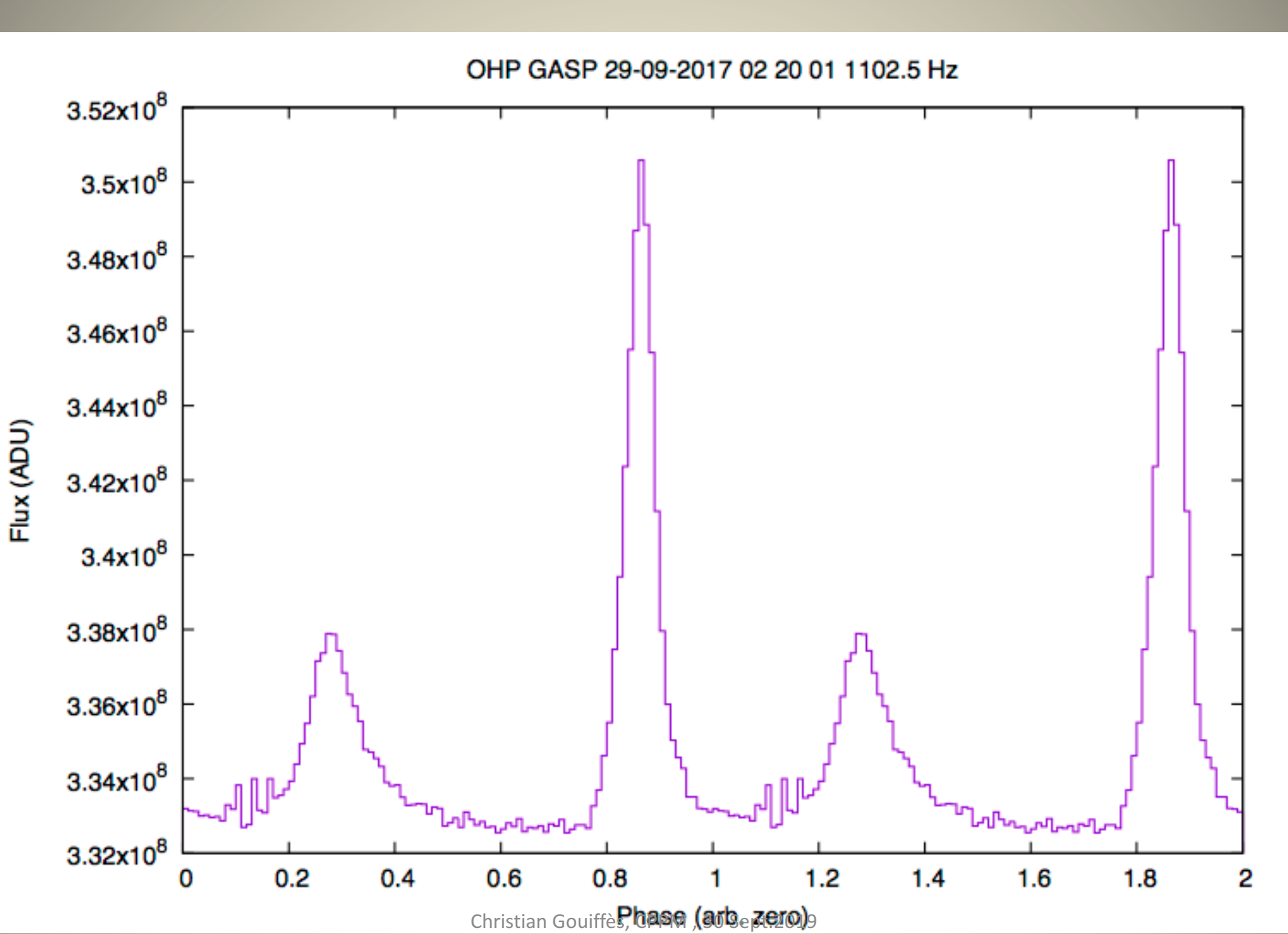

INTEGRAL/ISGRI Crab pulsar 2017, Sept 25-200 keV
4.20×10^5
4.15×10^5
4.10×10^5
4.05×10^5
4.00×10^5
3.95×10^5
Cts
0.0
0.5
1.0
1.5
2.0
Phase

Optical campaign : Instrument GASP (Galway Astronomical Stokes Polarimeter) @ OHP T193cm

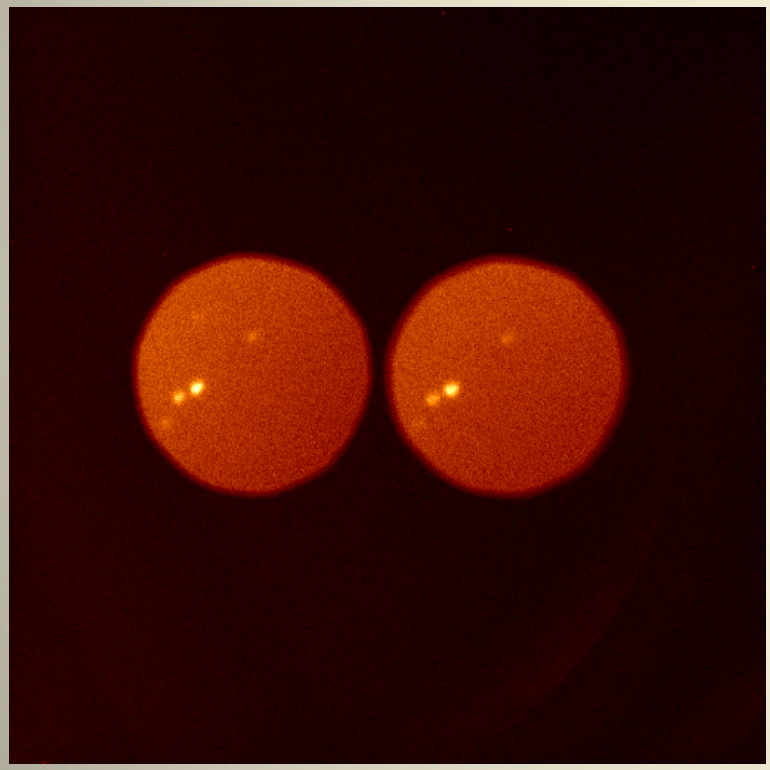
Crab @ OHP193cm+GASP
2017, September

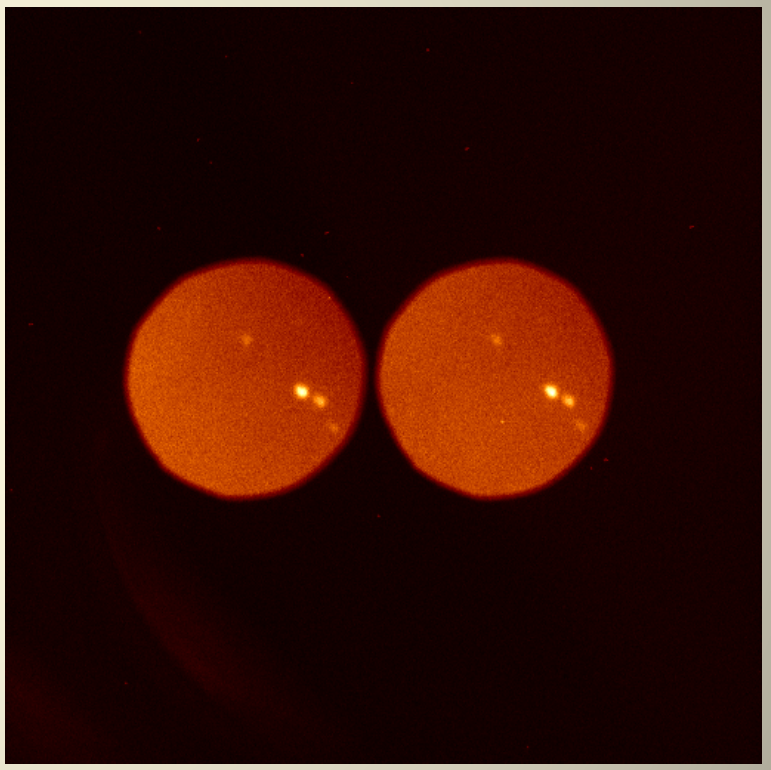





OHP GASP 29-09-2017 02 20 01 1102.5 Hz
Flux (ADU)
3.52x10^8
3.5x10^8
3.48x10^8
3.46x10^8
3.44x10^8
3.42x10^8
3.4x10^8
3.38x10^8
3.36x10^8
3.34x10^8
3.32x10^8
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Phase (arb. zero)

FRB121102 field at OHP193cm+GASP
10x1 sec expo, R filter



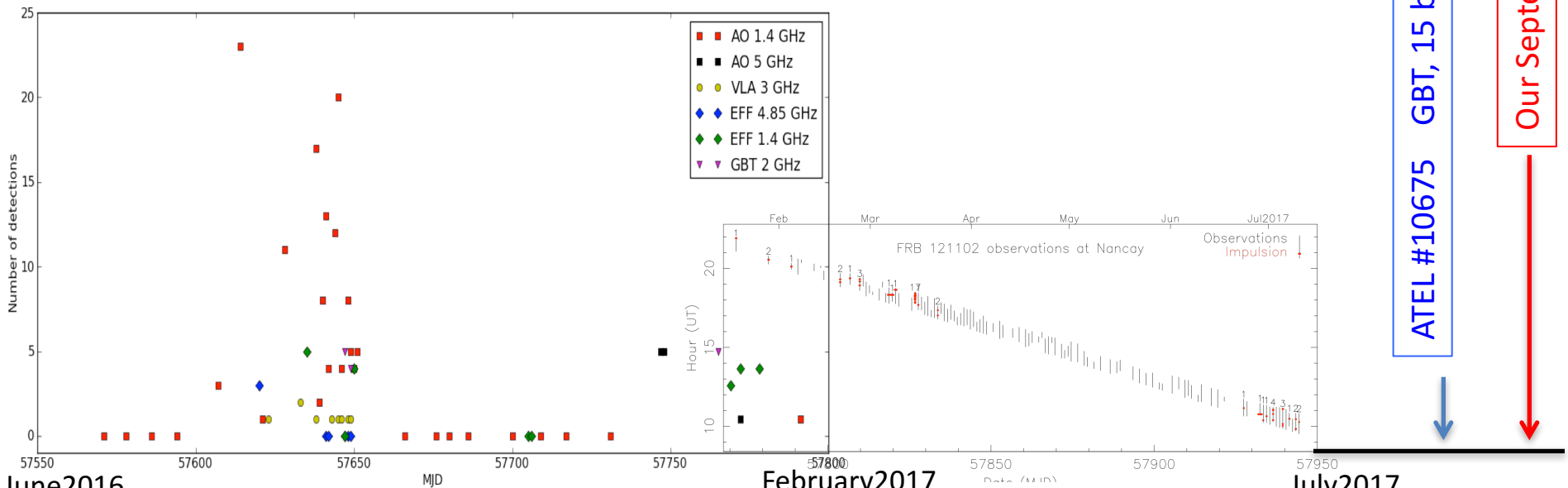


The campaign of September 2017

- ✓ INTEGRAL OK
- ✓ Good radio coverage (even if Arecibo and Nançay not part of the campaign)
- ✓ Some extra VHE observations
- ✓ OHP+T193cm + GASP excellent run

BUT No radio bursts detected in 60 hours from Effelsberg + GBT (means no trigger for INTEGRAL/OHP analysis)

No burst detected → periods of quiescence of the source ?

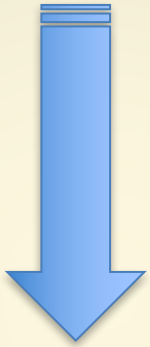


Date (MJD)

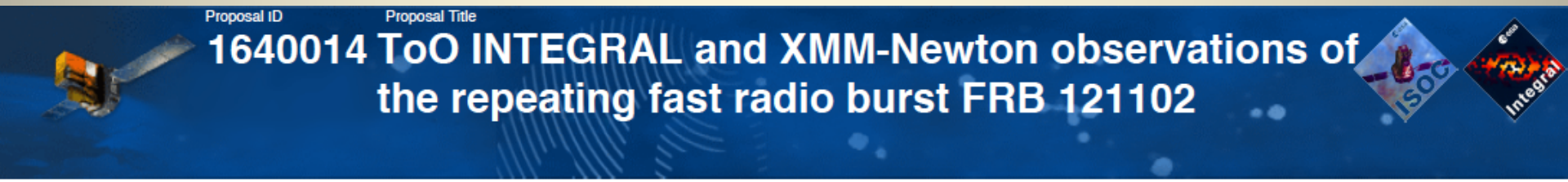
Active — Quiet — Active — Quiet — ?

Change of strategy

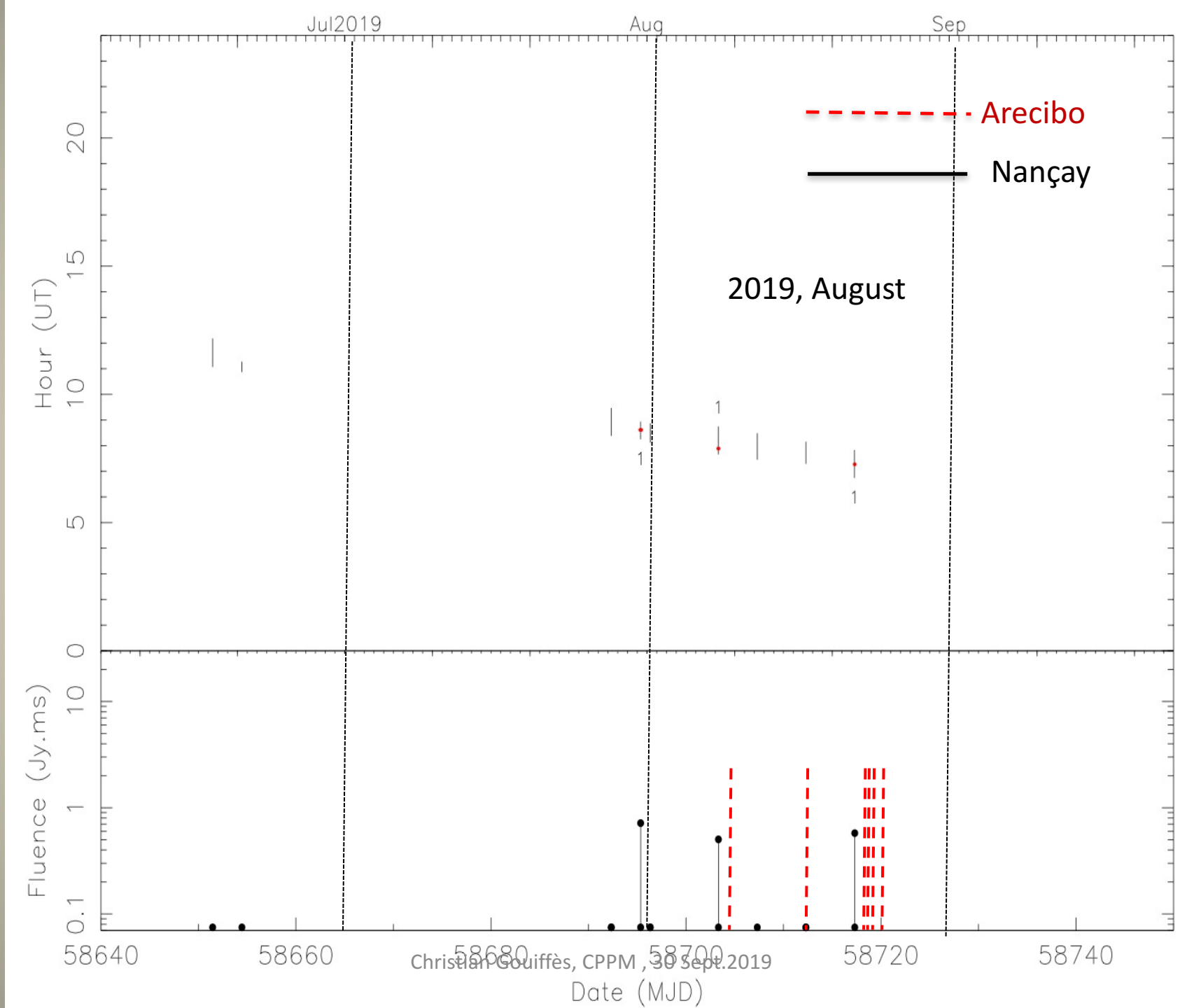
Daily monitoring of FRB121102 with the Nançay Radio Telescope



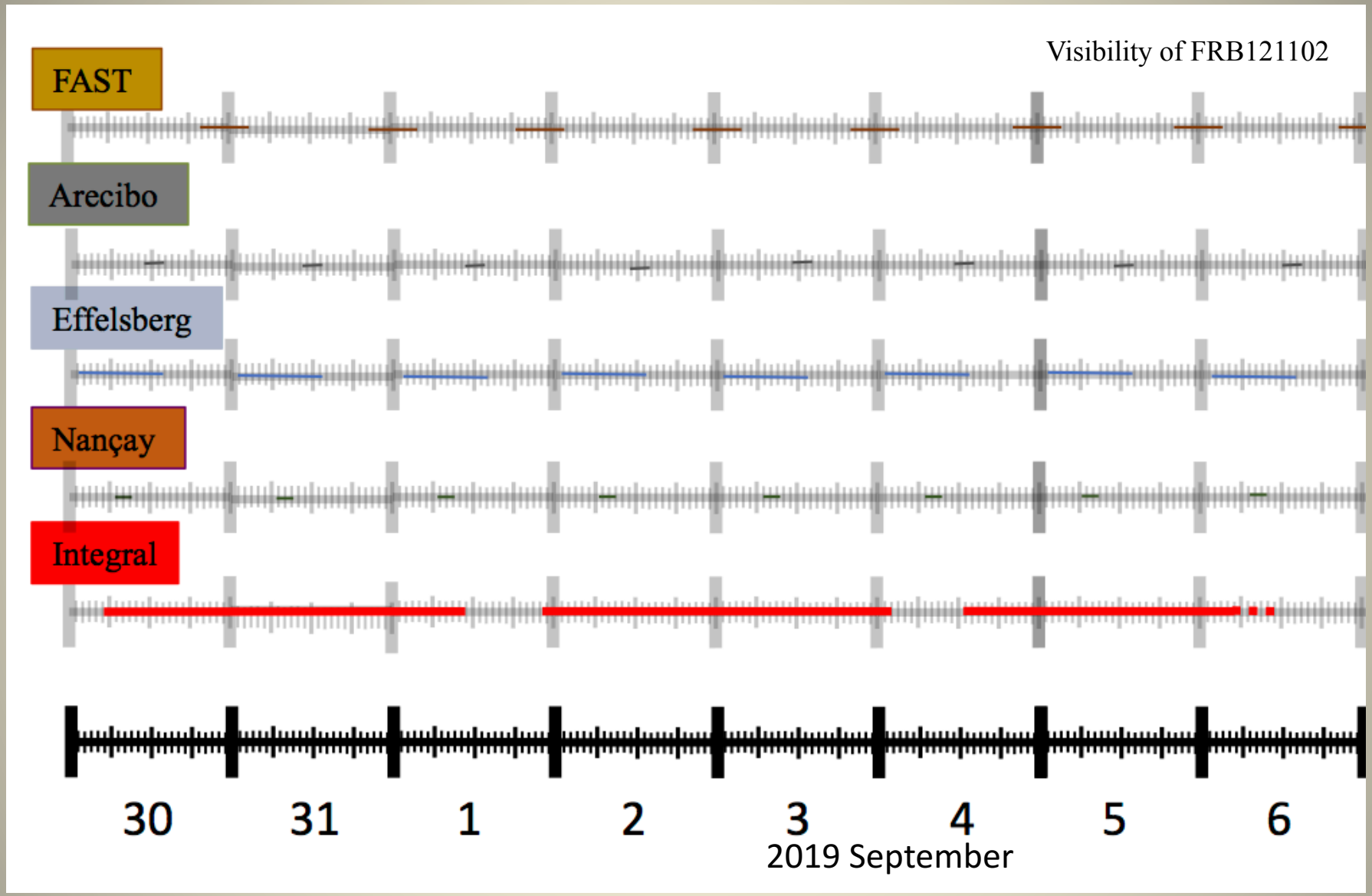
ToO programme



Criteria : Trigger the INTEGRAL ToO (+others) when radio bursts detected in at least in 2 over 3 one hour long successive observations with NRT (Nançay Radio Telescope) (+supporting observations with Arecibo and Effelsberg)

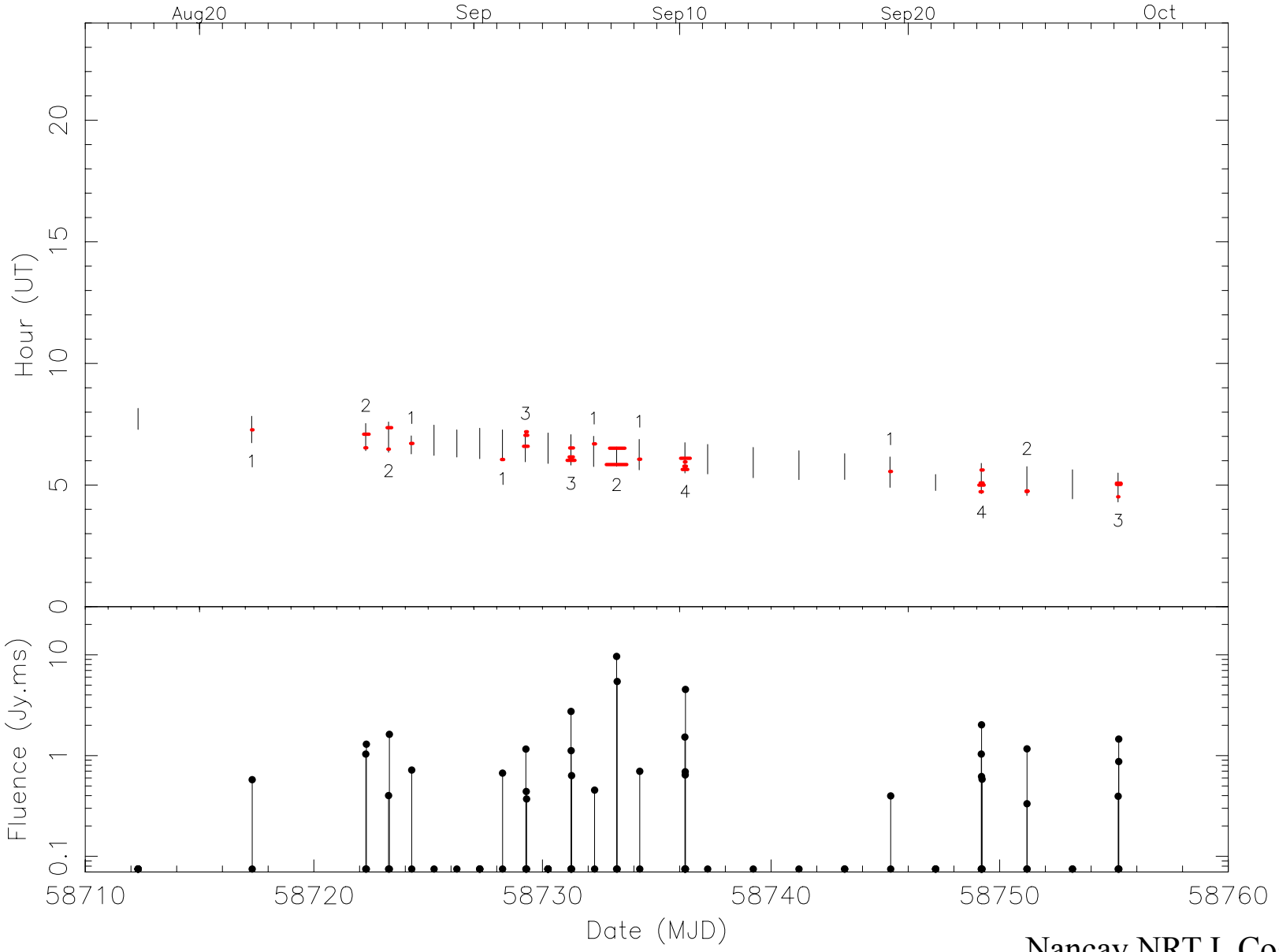

Jul2019
Aug
Sep
Arecibo
Nançay
2019, August
Hour (UT)
0
5
10
15
20
Fluence (Jy.ms)
0.1
1
10
58640
58660
58680
58700
58720
58740
Date (MJD)

INTEGRAL + friends triggered

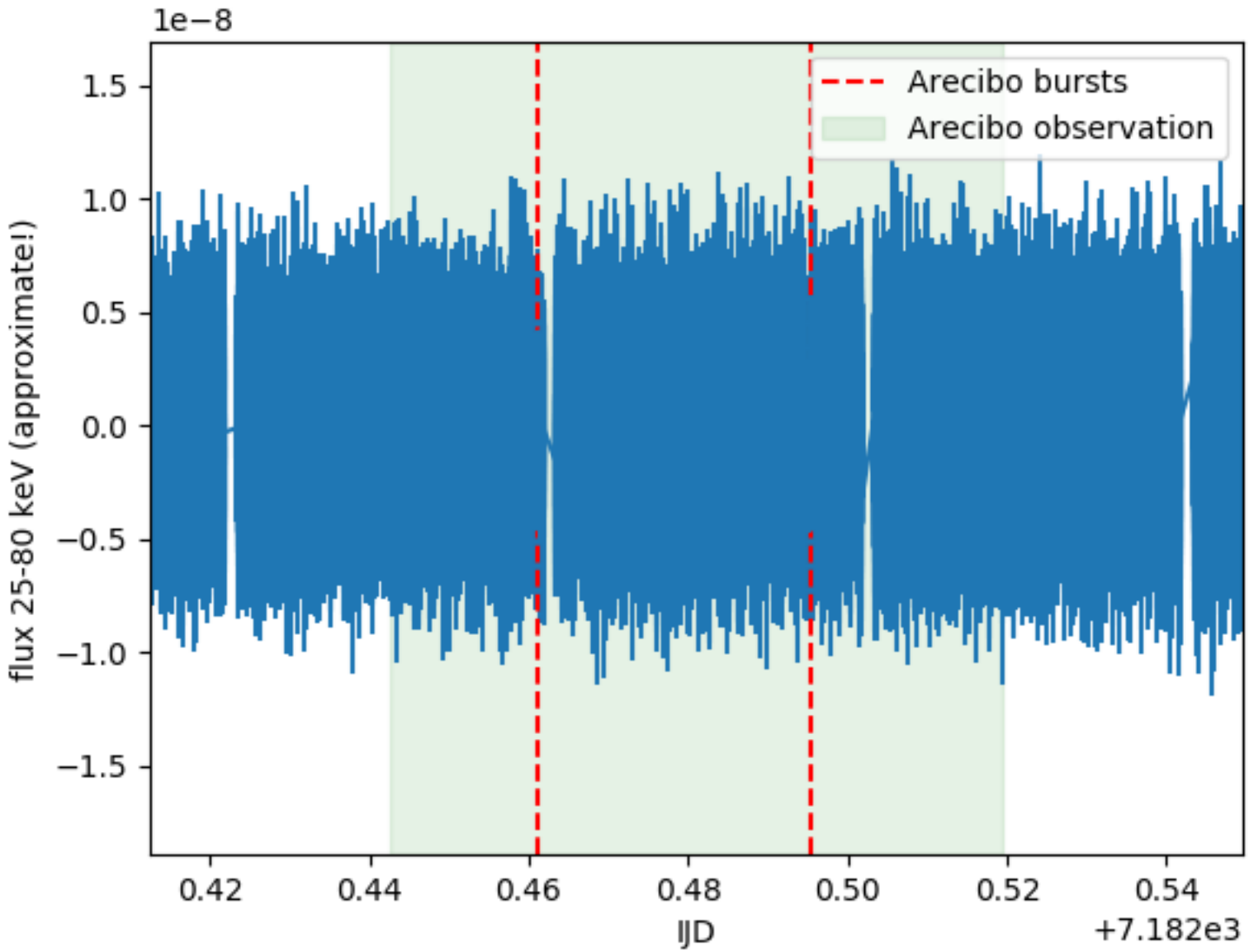


+ Nenuphar at Nançay joint observations with the NRT $\Delta t = 20$ min

+ Swift, Alma, SRT, GTC/Hypercam, Magic


Aug20
Sep
Sep10
Sep20
Oct
Hour (UT)
0
5
10
15
20
Fluence (Jy.ms)
0.1
1
10
58710
58720
58730
58740
58750
58760
Date (MJD)
Nançay NRT I. Cognard

INTEGRAL/ISGRI/preliminary



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INTEGRAL and radio joint programme of FRB121102 during a renewed activity

ATel #13073; *Christian Gouiffes (CEA Saclay), Laura Spitler (MPIfR), Ismael Cognard (CNRS OrlÃ©ans), Anaelle Maury (CEA Saclay), Jason Hessels (University of Amsterdam), Andrew Seymour (Obs. Arecibo), DI Li (NAOC), Philippe Laurent (CEA Saclay), Emeric Le Floc'h (CEA Saclay), Eoin O'Connor (NUI Galway), StÃ©phane Corbel (CEA Saclay), Mary Cruces (MPIfR), Michel Dennefeld (IAP), Diego GÃ¶tz (CEA Saclay), Lei Qian (NAOC), Volodymyr Savchenko (ISDC Geneva), Andy Shearer (NUI Galway), Jerome Rodriguez (CEA Saclay), Philippe Zarka (Observatoire de Paris)*
*on **3 Sep 2019; 19:28 UT***
Credential Certification: Jerome Rodriguez (jrodriguez@cea.fr)

Subjects: Radio, X-ray, Gamma Ray, Transient, Fast Radio Burst

Referred to by ATel #: 13098

Tweet

Here we report on a renewed activity of the repeating fast radio burst FRB121102. During an on-going programme involving the INTEGRAL satellite in hard X-rays, the Arecibo, Effelsberg, and the Nançay radio telescopes, several radio bursts were detected in the last days. Previous activity of the source has also been reported using the FAST telescope (ATel #13064).

Our last observation on September, 3rd indicates that FRB121102 is still active and our monitoring of the source will continue in the coming days according to the following schedules :

- INTEGRAL observations will continue till 2019, September 6 05:00 UTC (revolution 2132 and 2133, see detailed scheduling information at https://www.cosmos.esa.int/web/integral/schedule-information)

- Nançay will observe on:

04.09.2019 05h59 -> 06h59 UT

05.09.2019 05h55 -> 06h55 UT

06.09.2019 05h51 -> 06h51 UT

- Effelsberg will observe on:

4.9 from 0:15 to 7:00 UTC

[Previous | Next | ADS]

FAST Detects Multiple Bursts in L-band from FRB 121102

ATel #13064; *Di Li (NAOC), Xinxin Zhang (NAOC), Lei Qian (NAOC), Weiwei Zhu (NAOC), Ran Duan (NAOC), Dan Werthimer (Berkeley), Vishal Gajjar (Berkeley), Yan Zhu (NAOC), Jeff Cobb (Berkeley), Youling Yue (NAOC), Chengjin Jin (NAOC), Bing Zhang (UNLV), Christian Gouiffes (CEA), Shen Wang (NAOC), Laura Spitler (MPIfR), Mary Cruces (MPIfR), Jason Hessels (University of Amsterdam), Andrew Seymour (Arecibo), Eric Korpela (Berkeley), Jingtao Luo, HengQian Gan (NAOC), Peng Jiang (NAOC), Hui Li (NAOC), Qi Li (NAOC), HongFei Liu (NAOC), Chenchen Miao (NAOC), Chenhui Niu (NAOC), GaoFeng Pan (NAOC), Zhichen Pan (NAOC), Bo Peng (NAOC), JingHai Sun (NAOC), Ningyu Tang (NAOC), QiMing Wang (NAOC), Pei Wang (NAOC), Xin Pei (XAO), Jun Yan (NAOC), Rui Yao(NAOC), DongJun Yu (NAOC), Mao Yuan (NAOC), Haiyan Zhang (NAOC), Lei Zhang (NAOC), ShuXin Zhang (NAOC), and and FAST Collaboration (NAOC)*
*on **2 Sep 2019; 01:32 UT***
Credential Certification: Di Li (dili@nao.cas.cn)

Subjects: Radio, Fast Radio Burst

Referred to by ATel #: 13073, 13075, 13090, 13098

Tweet

Tracking observations of FRB 121102 were carried out with the newly commissioned Five-hundred-meter Aperture Spherical radio Telescope (FAST). We used the FAST L-band Array of 19-beams (FLAN), which has a FWHM of ~2.95' for individual beams and a ~26' footprint. The source was placed in the central beam, while all 19 beams were recorded. The bursts were firstly identified by the FRB backend on August 29th (UT), whichÂ performs real time signal processing of 19-beams data and automatic candidate selection/triggering. The subsequent single pulse search using multiple pipelines have turned up many tens of pulses with significant SNR in observations carried out so far, on the 29th, 30th, and 31st (UT). While careful cross-check are being carried out, the majority of these detections are expected to be credible. FAST has been targeting FRB 121102 since April of this year. In addition to the regular on-going FRB follow-up programs, the current observations was also motivated by timely and valuable alerts from our colleagues in the INTEGRAL team, Arecibo team, Max-Plank Institute for Radio Astronomy, Berkeley, and Cornell University. Given the significance of this source and its now apparent active state, FAST is executing more observations under the auspice of engineering testing time and multiple approved PI-led programs, which targeted FRB 121102. We encourage more ToO observations with other facilities.

FAST pulsar survey results

[Previous | Next | ADS]

MeerKAT detections of FRB 121102 at L-band

ATel #13098; *Manisha Caleb (University of Manchester), Benjamin Stappers (University of Manchester), Ewan Barr (MPIfR), Mechiel Christiaan Bezuidenhout (University of Manchester), Laura Driessen (University of Manchester), Fabian Jankowski (University of Manchester), Michael Kramer (MPIfR), Mateusz Malenta (University of Manchester), Vincent Morello (University of Manchester), Kaustubh Rajwade (University of Manchester), Sotiris Sanidas (University of Manchester), Weiwei Chen (MPIfR), Jason Wu (MPIfR), Sarah Buchner (SARAO), Rob Fender (University of Oxford), Lauren Rhodes (University of Oxford), Maciej rylak (SARAO), Lee Townsend (UCT), Patrick Woudt (UCT), Julio Andrianjafy (University of uritius/DARA), Nalini Heeralall-Issur (University of Mauritius), Divya Hurwanth (University of Mauritius/DARA)*
*on **11 Sep 2019; 13:24 UT***
Credential Certification: Manisha Caleb (manishacaleb@gmail.com)

jects: Radio, Transient, Fast Radio Burst

Tweet

MeerKAT telescope carried out observations of the FRB 121102 on 10 September 2019 at 00 UT, motivated by the source's recent activity as reported by various facilities (ATels #13064, 073, #13090). MeerKAT performed the observations centred on 1284 MHz in the range of about -1670 MHz, as part of a Director's Discretionary Time Proposal. 384 coherent beams centred on location of the burst were formed using the Max Planck Institute for Radio Astronomy beam mer. Using the MeerTRAP real-time single pulse detection pipeline and backend, in our liminary analysis we identified 12 repeat bursts in 3 hours of observing time. Further data lysis is ongoing. An example pulse can be seen in the link below. FRB 121102 is still active and encourage multifrequency observations.

MeerKAT telescope is operated by the South African Radio Astronomy Observatory (SARAO), ich is a facility of the National Research Foundation, an agency of the Department of Science Innovation. MeerTRAP acknowledges funding from the European Research Council (ERC) ler the European Union's Horizon 2020 research and innovation programme (grant agreement . 694745). We would like to thank the Director, the operators and SARAO for scheduling these ervations.

MeerKAT FRB 121102

中国科学院
CHINESE ACADEMY OF SCIENCES

FAST Detects Multiple Bursts from Fast Radio Burst 121102

Sep 09, 2019

Five-hundred-meter Aperture Spherical Radio Telescope (FAST), the world largest single dish radio telescope, began commissioning on 25th September, 2016. In February 2019, it announced call for proposal publicly to Chinese astronomers. More than 133 proposals from 21 institutions including the University of Hong Kong were received. Granted proposals started to arrange observations on 18th April, 2019.

In its recent tracking observation of the Fast Radio Burst (FRB) FRB121102 using FAST L-band 19-beam receiver (with FWHM of ~2.95' for individual beam), FAST detected multiple bursts.

The bursts were firstly identified by the FAST FRB backend on August 29th (UT), which performs real time signal processing of 19-beam data and automatic candidate selection/triggering. The subsequent single pulse search using multiple pipelines have turned up many tens of pulses with significant SNR in observations carried out so far, from 29th August to 3rd September (UT).

The total number of bursts detected from FRB121102 this time is known to be the highest by far. Careful cross-check and further processing are being carried out.

FAST FRB backend was developed by researchers from the National Astronomical Observatories of the Chinese Academy of Sciences (NAOC), and the collaborators from UC Berkeley, Beijing Normal University and Xinjiang Astronomical Observatory of the Chinese Academy of Sciences. It passed technical review and final project review in November 2018 and was rated as excellent NAOC project.

The FAST FRB backend system has high-efficiency real-time pulse capture capability, and can observe in parallel with most observation tasks. It will play an important role in the discovery of new FRBs, improving the position accuracy and capturing the high-resolution absorption lines generated by FRB in real time.

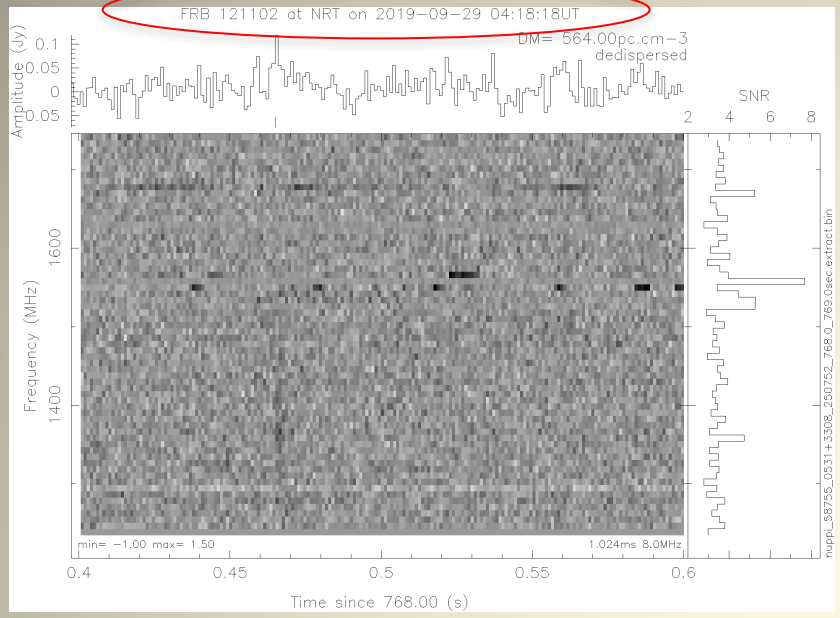
FRB are the brightest burst in radio band currently known in the universe, but there is no reasonable explanation for their origin. The repeated bursts detection of FAST will promote the research on understanding the origin and physical mechanism of FRB.

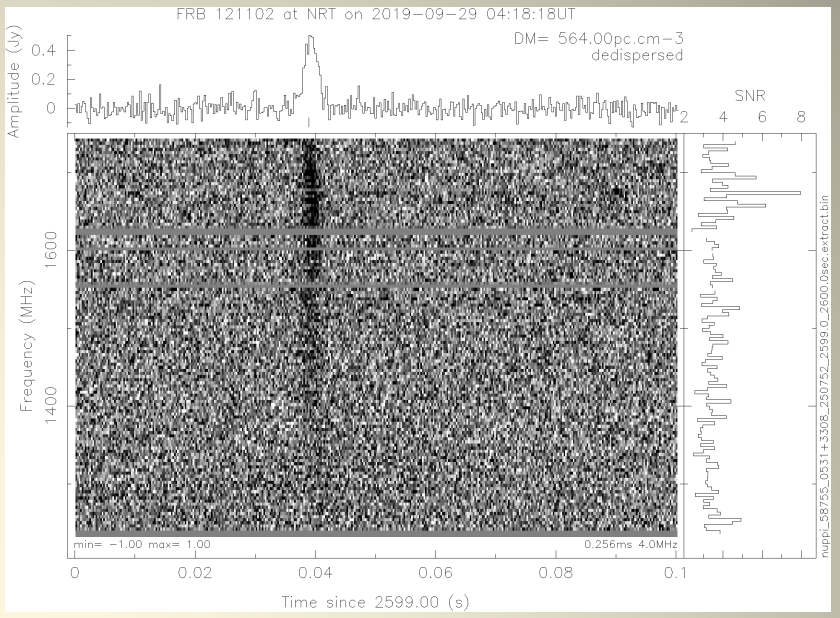
FAST has been targeting FRB 121102 since April 2019, and is executing more observations under the auspice of engineering testing time and multiple approved PI-led programs. In addition to the regular on-going FRB follow-up programs, the current observation was also motivated by timely and valuable alerts from the colleagues in the INTEGRAL team, Arecibo team, Max-Plank Institute for Radio Astronomy, Berkeley, and Cornell University.

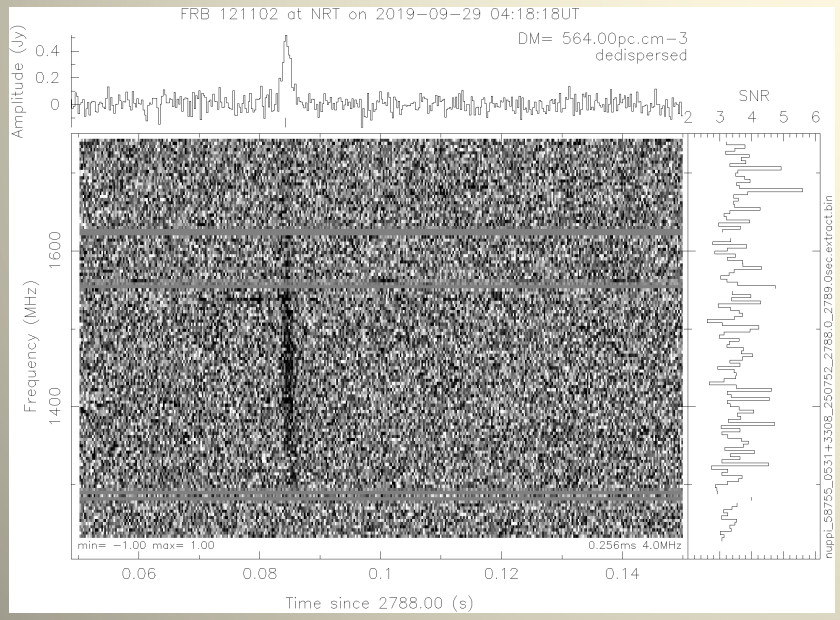
Address: http://english.cas.cn/

Communication OK

FAST has been targeting FRB 121102 since April 2019, and is executing more observations under the auspice of engineering testing time and multiple approved PI-led programs. In addition to the regular on-going FRB follow-up programs, the current observation was also motivated by timely and valuable alerts from the colleagues in the INTEGRAL team, Arecibo team, Max-Plank Institute for Radio Astronomy, Berkeley, and Cornell University.







FRB121102 still active on 2019, September 29 Nançay NRT

The « Cognard » bursts

Conclusion/prospective

- ✓ Hundreds, Thousends FRB's expected/year in a near future
- ✓ More repeating FRB's will help population analysis (are all FRB repeating but not detected?)
- ✓ Better localization required → follow-up studies
- ✓ Host galaxies : active star forming environment required ?
- ✓ More low DM FRB's (in tha Halo) will be detecetd
- ✓ Can the Miky Way habours FRB's?

- ✓ NRT extremely useful especially for regular monitoring (need of these telescopes, programme possibly difficult with SKA)
- ✓ Good communication : programme lead by non-radioastromers might have help
- ✓ Interaction with FAST encouraging (future collaborations, SVOM context, etc)
- ✓ Trigger extragalactic programmes and proposals
- ✓ Need better localisation of FRB's for follow-up
- ✓ Host galaxies studies just started
- ✓ Better communication to the « better localisation of FRB's for follow-up »
- ✓ New ToO INTEGRAL campaign in 2020 (3 orbits)

- ✓ Can we take advantage of GRB's studies/history to improve strategies, etc