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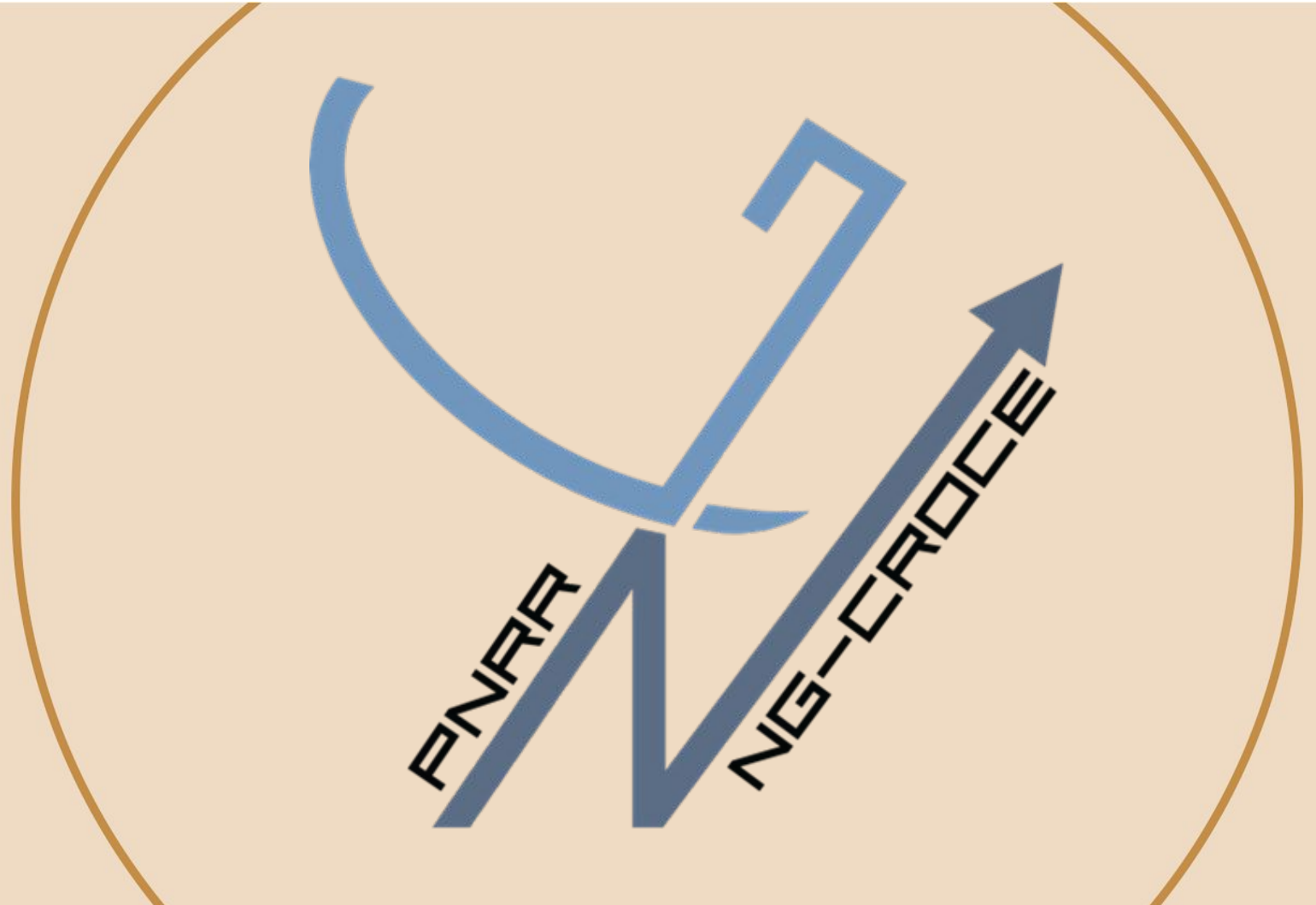
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The *NC-FRB* data products

Final Meeting

Martedì 30 Giugno – Giovedì 02 Luglio

OAA - Osservatorio Astrofisico di Arcetri



Luca Bruno (INAF-IRA)



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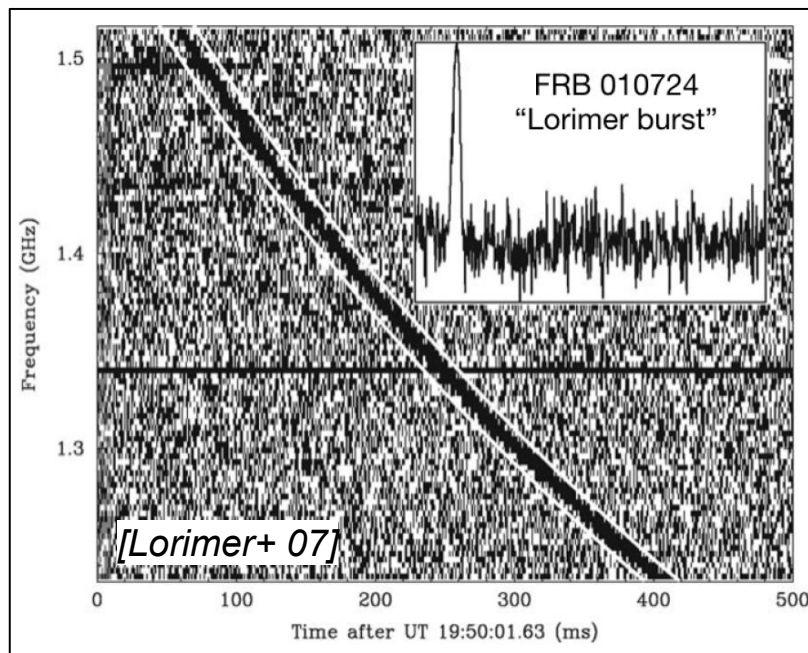
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Fast radio bursts

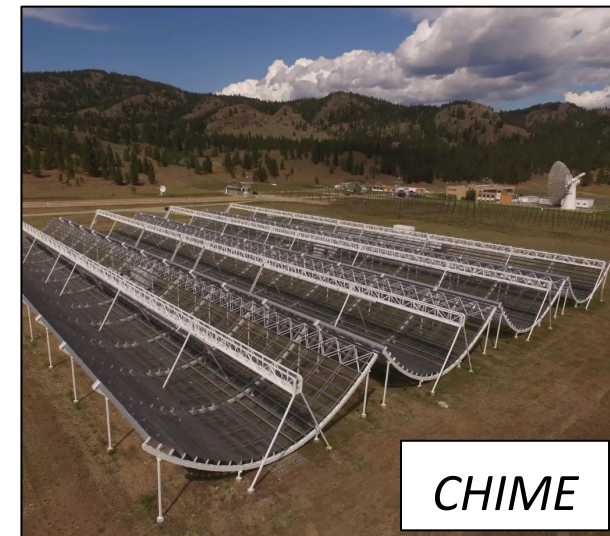
Bright (Jansky-level) and short-duration
(~1 ms) extragalactic radio flashes



[Reviews: Petroff+ 22; Zhang 23]

~5000 FRBs known to date → ~2% are repeaters

[Chime/FRB Collaboration 26]





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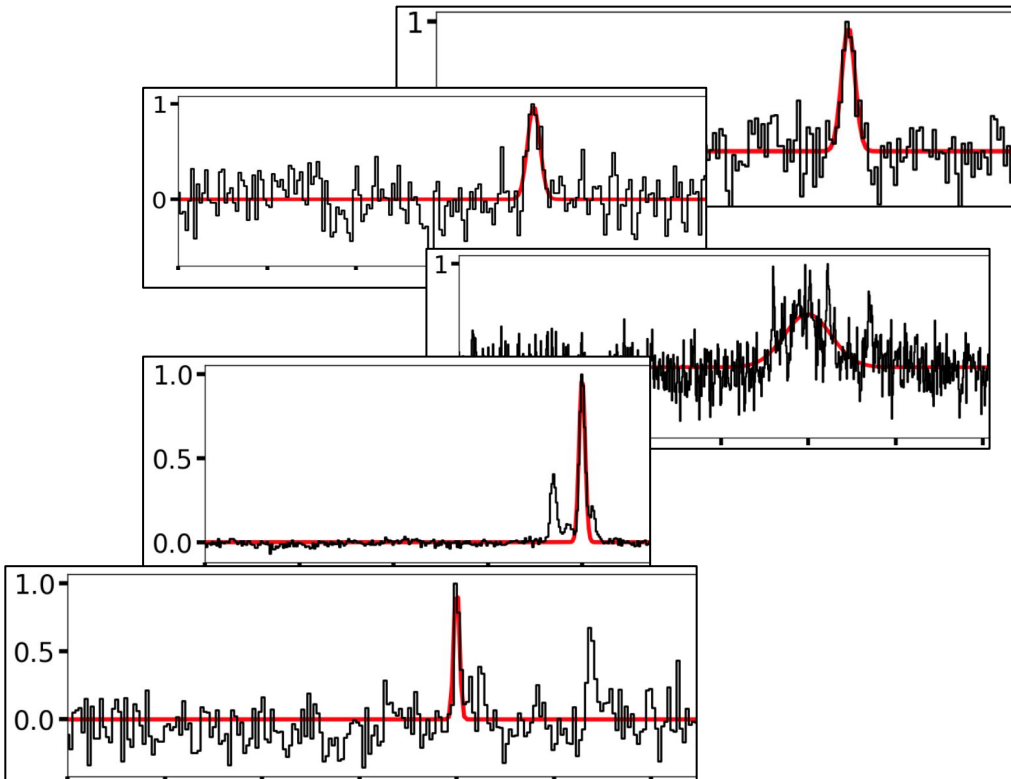


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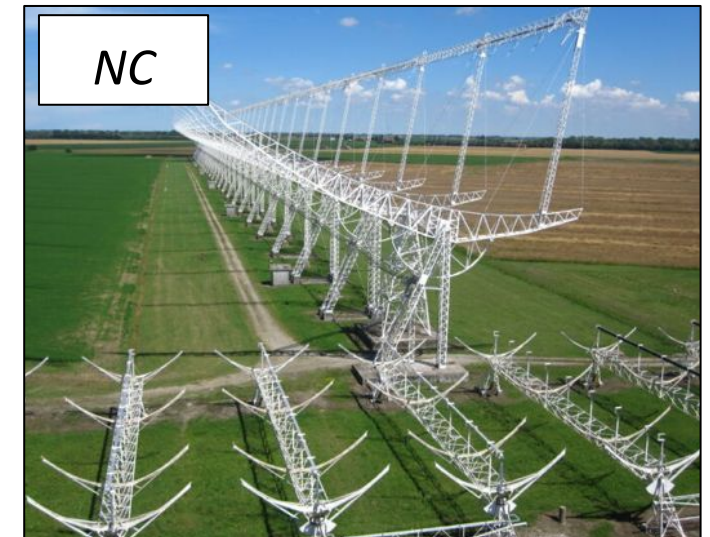
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NC-FRB data



NC detections →

35 FRBs from 7 sources





NC-FRB data

1. signal acquisition → digitisation → calibration → beam-forming

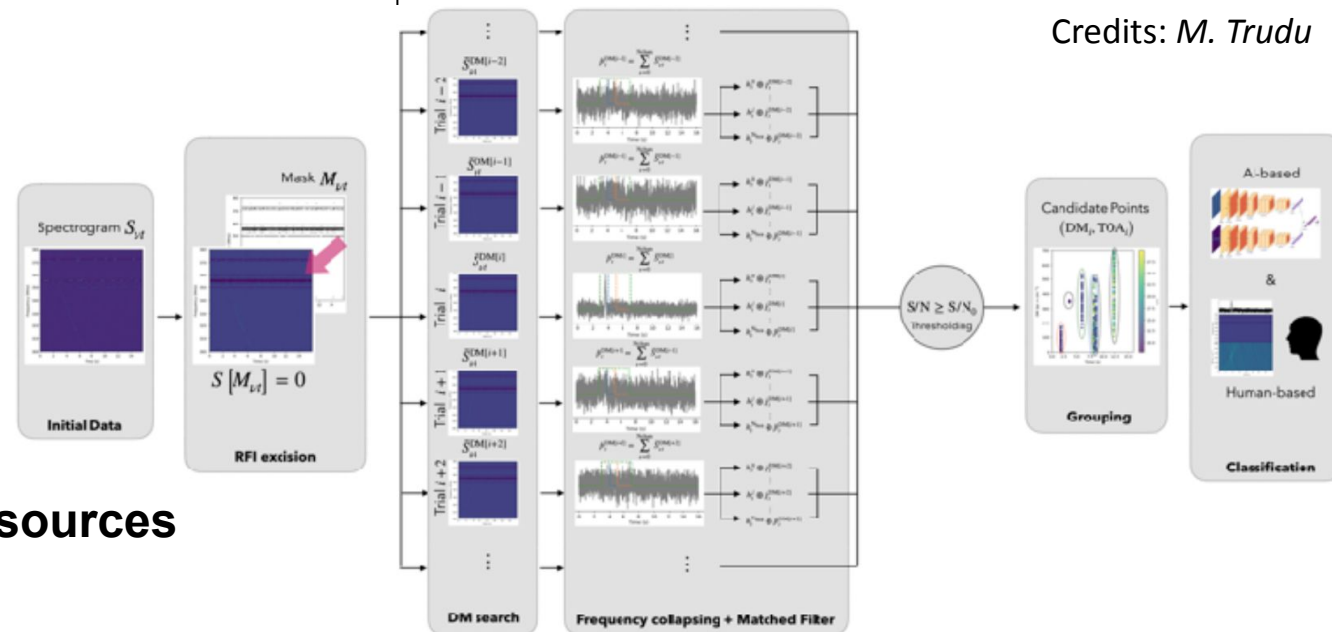
beam-formed data (custom Δt - $\Delta \nu$ format): 250 GB/h

2. equalisation and rescaling

processed data (filterbank format): 50 GB/h

3. transient event search and classification

large computing and storage resources





NC-FRB data

Beam-formed data ~250 GB/h + Processed data ~50 GB/h



4 hours x 20 days x 10 months → **~250 TB/yr**
(lower limit pre-upgrade!!)



- A large fraction of non-detections
- A small fraction of FRB detections

PROBLEMS

1. Short-term storage capacity
2. Long-term storage capacity
3. Data and metadata distribution
4. FRB analysis products
5. Policy



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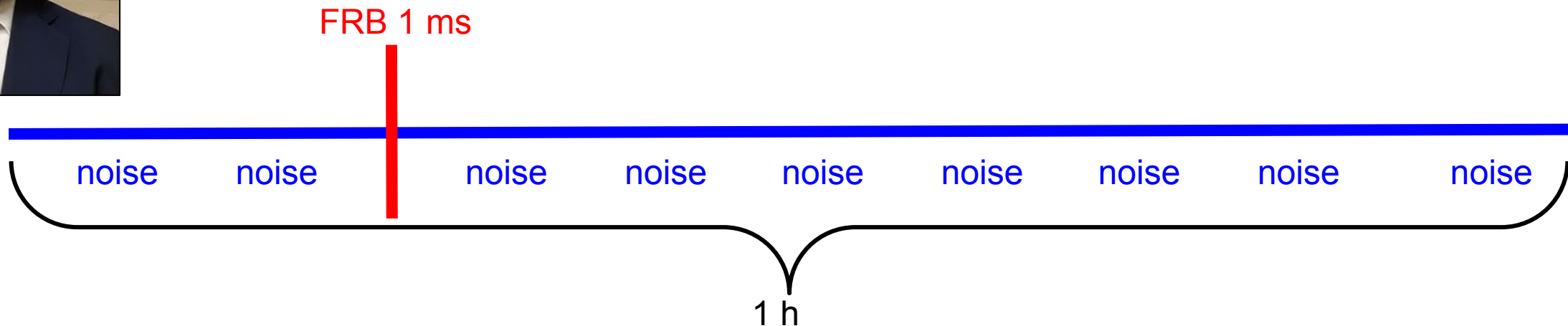


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What should we keep ?

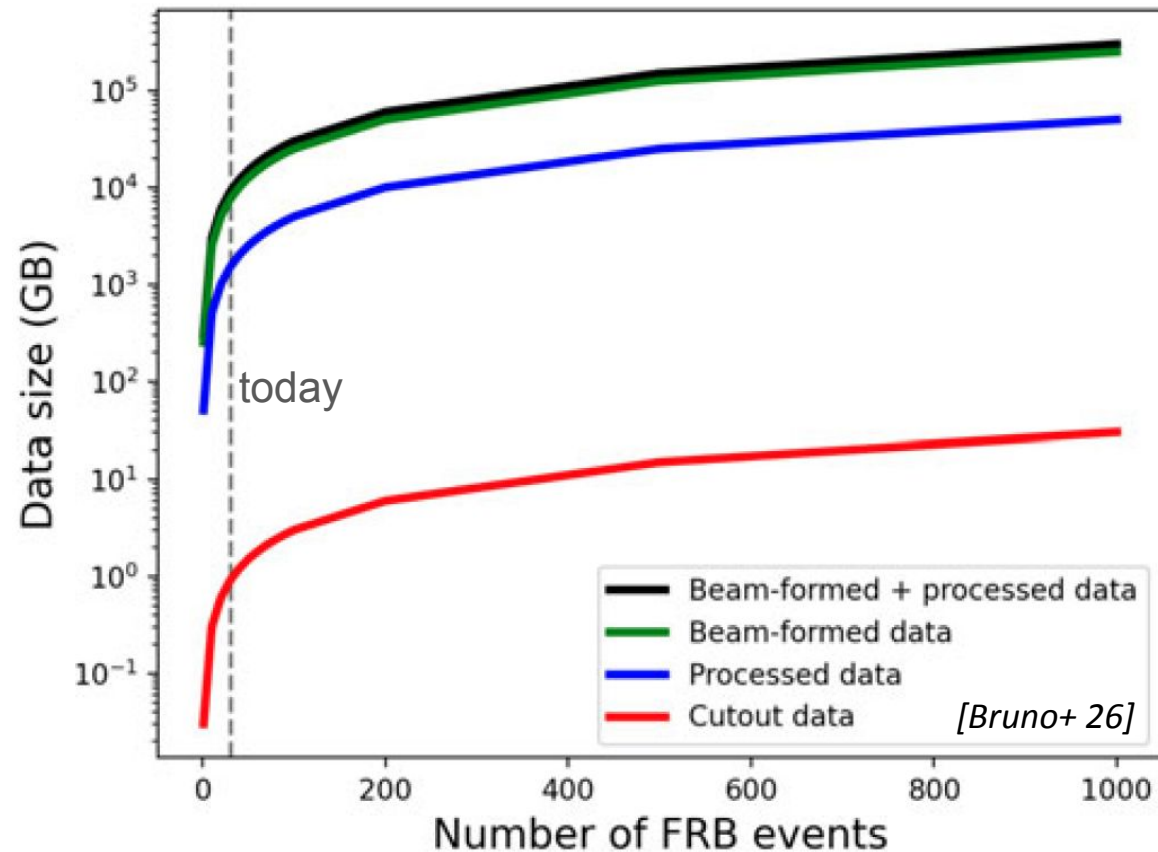
"If you had a giant fridge, would you keep apple peels just because you have free space?"
G. Bernardi



Extraction: cut out a few seconds around FRB → **from 50 GB to 30 MB**



Storage sustainability



- Beam-formed data → short-term → 
- Processed data → short-term → 
- Cutout data → long-term → 

data size reduced by factor 10.000
→ **long-term storage sustainability!**

+ real-time FRB search [Naldi+ 25; Camilleri+ 26]

- Non-detections → 
- Candidate detections → extraction

→ **short-term storage further reduced!**



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A CHIME-like database for the NC

CHIME/FRB

Fast Radio Bursts in realtime

tns_name	repeater_name	ra_1	ra_2	dec_1	dec_2	snr_fitb	dm_fitb	bc_width	fluence	fluence_err
FRB20180909A	FRB20180909A	120.04	-9999	57.004	-9999	13.86	408.647	0.01573	0.9	0.5
FRB20180910A	FRB20180910A	354.83	-9999	89.014	-9999	50.38	684.4081	0.00098	5.6	3
FRB20181201D	FRB20181201D	266.9	-9999	89.125	-9999	16.8	448.266	0.00197	1.4	1.1
FRB20181226F	FRB20181226F	95.87	-9999	83.8	-9999	38.22	236.42	0.00492	11.3	6.1
FRB20190107B	FRB20190107B	49.31	22.37	83.4	83.37	26.84	166.0939	0.00098	4.3	2.5
FRB20190110C	FRB20190110C	249.325	-9999	41.445	-9999	27.76	221.921	0.00295	1.4	0.76

CHIME: public catalogues of FRB physical properties

FRBs at the Northern Cross							
File Modifica Visualizza Inserisci Formato Dati Strumenti Estensioni Guida							
	A	B	C	D	E	F	G
1	Source Name	Burst Time (UTC)	Burst Width (ms)	DM (pc cm ⁻³)	S/N	Flux (Jy)	Fluence (Jy ms)
2	FRB20180916B (R3)	59276.5954859605	4.76	349.28	14.5	20	96
3	FRB20180916B (R3)	59307.5148011862	5.95	349.57	21.7	22	135
4	FRB20180916B (R3)	59408.2528584486	4.37	349.64	12.5	16	71
5	FRB20180916B (R3)	59699.52604	6.35	349.8	15	15	96
6	FRB20180916B (R3)	59800.25185	5.7	350.7	20	19	108
7	FRB20220320	59658.05142	1.8	303	11	32	58
8	FRB20220912A	59868.88599	4.1	219.6	15	18	74
9	FRB20220912A	60125.1603	3.1	220.2	12	7.4	23
10	FRB20220912A	60133.14275	9.4	220.1	10	4.3	40
11	FRB20220912A	60136.13248	4.1	219.6	14	6.8	28
12	FRB20220912A	60138.12095	16	219.7	15	4.8	77
13							

NC: private google sheet + publications/Atel
[e.g. Trudu+ 22, Pelliciar+ 24; Geminardi+ 25]

→ The community needs a public database of
science-ready products!



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INCART

Italian Northern Cross Atlas of Radio Transients



Welcome to **INCART**! This repository collects advanced data products from observations of **FRBs** detected by the **NC** radio telescope in Medicina (Bologna, Italy). Browse the NC-FRB catalogue online or download it [catalogue.fits](#). For support with the FRB data analysis, please contact the [NC team](#) and we will be happy to share our pipeline. Feedback and suggestions are welcome!

ACKNOWLEDGEMENTS. These data are provided by the NC team and are owned by **INAF**. The filterbank-format data are also available in the [INAF Radio Data Archive](#) service. If you use the FRB-NC data for your research, please include the following acknowledgements and references:
This research used data products from the INCART database ([Bruno et al. 2026](#)). This research used the facilities of the Italian Center for Astronomical Archive (IA2) operated by INAF at the Astronomical Observatory of Trieste.



Northern Cross radio inteferometer. **Image credits:** Lesia Vasylichenko



Public access to the **NC-FRB**
advanced data products

Search by

☐ Complete catalogue

☒ FRB Name

FRB20220912A

☐ Date of observation

from gg/mm/aaaa to gg/mm/aaaa

Submit Reset

The **NG-Croce** project is funded by the **EU** under the **PNRR**, Mission 4 - Education and Research, Component 2 - From Research to Business (MAC2), Investment Line 3.1 - Strengthening and creation of Research Infrastructures, Project IR0000026.



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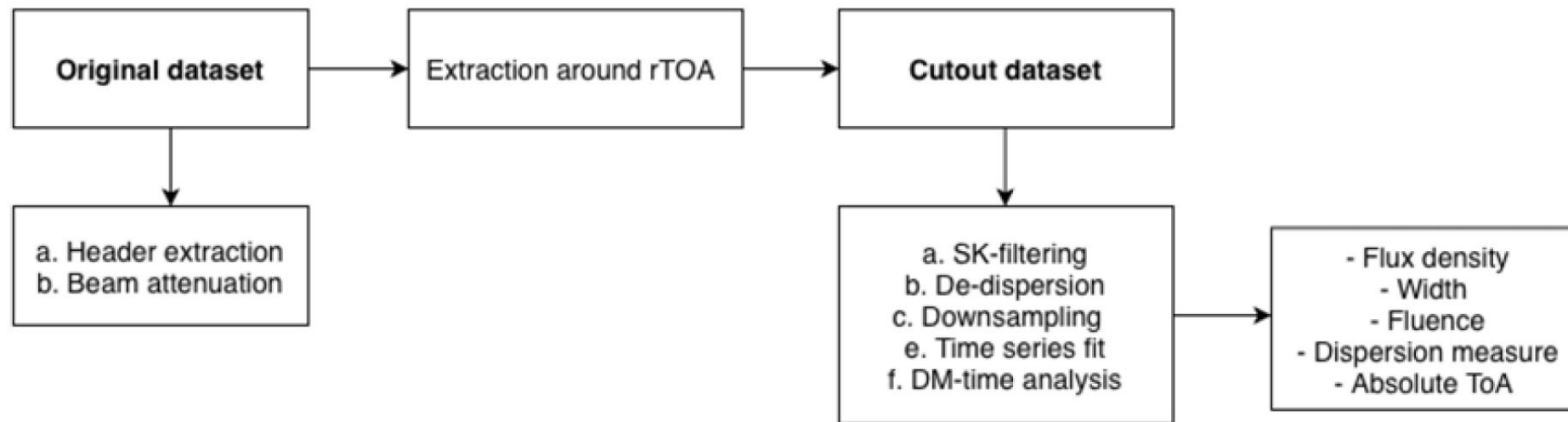
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[ARCHIVIST.py](#) pipeline* [Bruno+ 26] → **standard and homogeneous procedures for FRB analysis**



*[miniARCHIVIST.py](#) publicly available under request!



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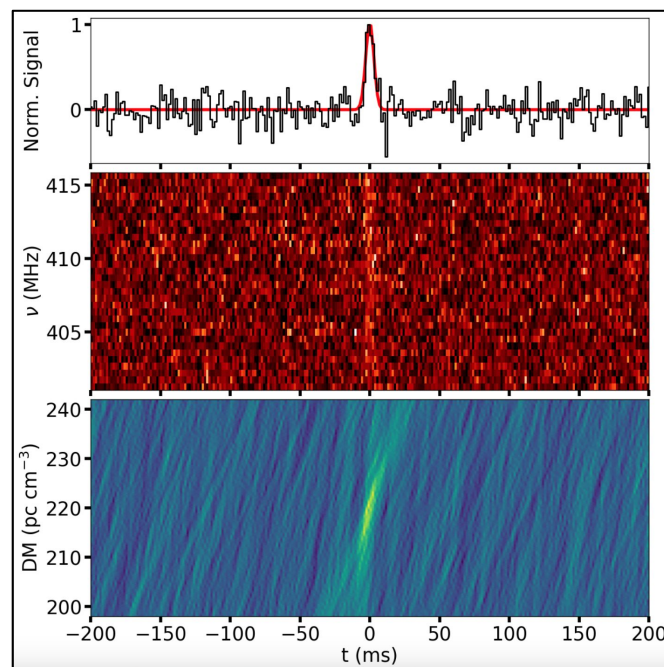
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ID ▼	Name ▼	RA ▼	DEC ▼	Obs. Date ▼	ToA _∞ ▼	SN _p	SN _{int}	DM	FWHM	S _p ▼	F _{rect}	F _{gauss} ▼	χ ² _{red}	Plot	Log	Data
		deg	deg	yyyy-mm-dd	MJD (TOPO)			pc cm ⁻³	ms	Jy	Jy ms	Jy ms				
1	FRB20220912A	347.270417	48.707056	2023-07-13	60138.20319312	5	17	217 ± 2	15.6 ± 1.9	5.1 ± 0.5	80 ± 13	81 ± 13	1.6	img	log	data
2	FRB20240209A	289.890417	86.065833	2024-07-11	60502.0177407	3	26	180 ± 9	31.5 ± 2.2	9.3 ± 0.6	294 ± 27	299 ± 28	1.21	img	log	data
3	FRB20240209A	289.8875	86.051389	2024-07-02	60493.97523088	5	14	177 ± 4	13.2 ± 1.7	5.3 ± 0.6	70 ± 12	71 ± 12	1.09	img	log	data



timeseries

dynamic
spectrum

Dispersion measure
vs time

Diagnostic plots



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2	FRB20240209A	289.890417	86.065833	2024-07-11	60502.0177407	3	26	180 ± 9	31.5 ± 2.2	9.3 ± 0.6	294 ± 27	299 ± 28	1.21	img	log	data
3	FRB20240209A	289.8875	86.051389	2024-07-02	60493.97523088	5	14	177 ± 4	13.2 ± 1.7	5.3 ± 0.6	70 ± 12	71 ± 12	1.09	img	log	data

Data file: beam_1695936734.972585_processed.fil
Data type: filterbank (topocentric)
Telescope: NC
Datataking Machine: ADU
Source Name: FRB20220912A
Source RA (J2000): 23:09:04.9
Source DEC (J2000): +48:42:25.4
Frequency of channel 1 (MHz): 415.854456
Channel bandwidth (MHz): -0.014468
Number of channels: 1024
Number of beams: 1
Beam number: 1
Time stamp of first sample (MJD): 60215.980728849361
Sample time (us): 138.24000
Observation length (minutes): 39.1
Number of bits per sample: 16
Number of IFs: 1
Original relative TOA (s): 1397.9725
Beam correction factor: 1.024662430059169
Cutout observation length (s): 2
Cutout relative TOA (s): 1.0
Time stamp of first sample cutout (MJD): 60215.99689751255
Cutout filename: FRB20220912A_beam_1695936734.972585_processed
SK masking fraction: 0.00390625
Downsampled bins: 256
Temporal window (ms): 400

Norm. Gauss Amp.: 1.0232988934069585
Err. Norm. Gauss Amp.: 0.10014162735761556
Fit Width (ms): 6.875544905289506
Err. Fit Width (ms): 0.7770098382955651
Fit gauss center (ms wrt TOA): 0.018784241393665437
Downsampled time (us): 1562.5
SNR peak: 6.793591725258797
SNR integrated: 14.478312538834178
Gauss fit Chi2red: 0.9721393011606779
Number of cylinders: 16
Flux density peak (Jy): 5.872060499345407
Err. Flux density peak (Jy): 0.57464900835475
Rectangular Fluence (Jy ms): 40.37361564982607
Err. Rectangular Fluence (Jy ms): 6.035591347946397
Gaussian Fluence (Jy ms): 41.01782234374011
Err. Gaussian Fluence (Jy ms): 6.131896033209172
Fit DM (pc cm⁻³): 219.0
Err. Fit DM (pc cm⁻³): 4.0
Topocentric TOA at chan1 (UTC): 2023-09-28 23:55:32.945
Topocentric TOA at infinite frequency (UTC): 2023-09-28 23:55:27.691
Topocentric TOA at infinite frequency (MJD): 60215.996848277195
Project ID: NC-01-21
Observer:
BMAJ (deg): 1.6
BMIN (deg): 0.25
BPA (deg): 90.0
Central frequency (MHz): 408.44684
Run: --f beam_1695936734.972585_processed.fil --DM 220 --TOA 1397.972

Logfile with metadata and
FRB analysis results



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ID ▼	Name ▼	RA ▼	DEC ▼	Obs. Date ▼	ToA _∞ ▼	SN _p	SN _{int}	DM	FWHM	S _p ▼	F _{rect}	F _{gauss} ▼	χ ² _{red}	Plot	Log	Data
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Cutout dataset in filterbank format
→ users can perform independent FRB analysis



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Coordination with the *INAF Radio Data Archive*

Storage for all Italian radio facilities →
cutout data stored both in *INCART* and *Archive*

- metadata → standard convention
- redundancy → backup
- coordination → project-based & national infrastructures

The screenshot shows the INAF Radio Data Archive search interface. At the top, there are four search tabs: 'Simple search' (selected), 'VLBI-IT search', 'SD search', and 'Pulsar and transients search'. Below the tabs is a 'File name' input field. The main search area is divided into two sections. The top section is for 'Name resolver' and includes an 'Object name' input field, a 'Resolve' button, and two radio button options: 'RA (J2000)' and 'Dec (J2000)'. The 'RA (J2000)' option is selected, and it has two input fields for 'hh:mm:ss.ss' and 'dd:mm:ss.ss'. The 'Dec (J2000)' option is unselected. To the right of these fields is a 'Radius (arcmin)' input field with the value '14'. The bottom section is for 'Toggle all' and includes three checkboxes: 'Observation date' (unselected), 'Project id' (selected), and 'Toggle all' (unselected). The 'Observation date' checkbox has two date input fields labeled 'From:' and 'To:', both with the placeholder 'yyyy-MM-dd' and a calendar icon. The 'Project id' checkbox has a single input field. At the bottom right, there are 'Search' and 'Reset' buttons. The background of the interface shows a large radio telescope dish.



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Summary & conclusions

- **Sustainable storage** → short-term: real-time search; long-term: extraction
- **Science-ready data products** → free access via *INCART* & *INAF Radio Data Archive*
- **Analysis pipelines** → definition of strategies; scalability for *NG-Croce*, *Medicina-Grueff*, *Noto*
- **Documentation** → publications (*Bruno+ 26*), user guides, policy (*Data Management Plan*)

Thanks for your attention

... Questions?