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Ministero dell'Università e della Ricerca

Italiadomani
PIANO NAZIONALE DI RIPRESA E RESILIENZA

INAF
ISTITUTO NAZIONALE DI ASTROFISICA

FRB observations: past, current and future perspectives

Gianni Bernardi

INAF-IRA

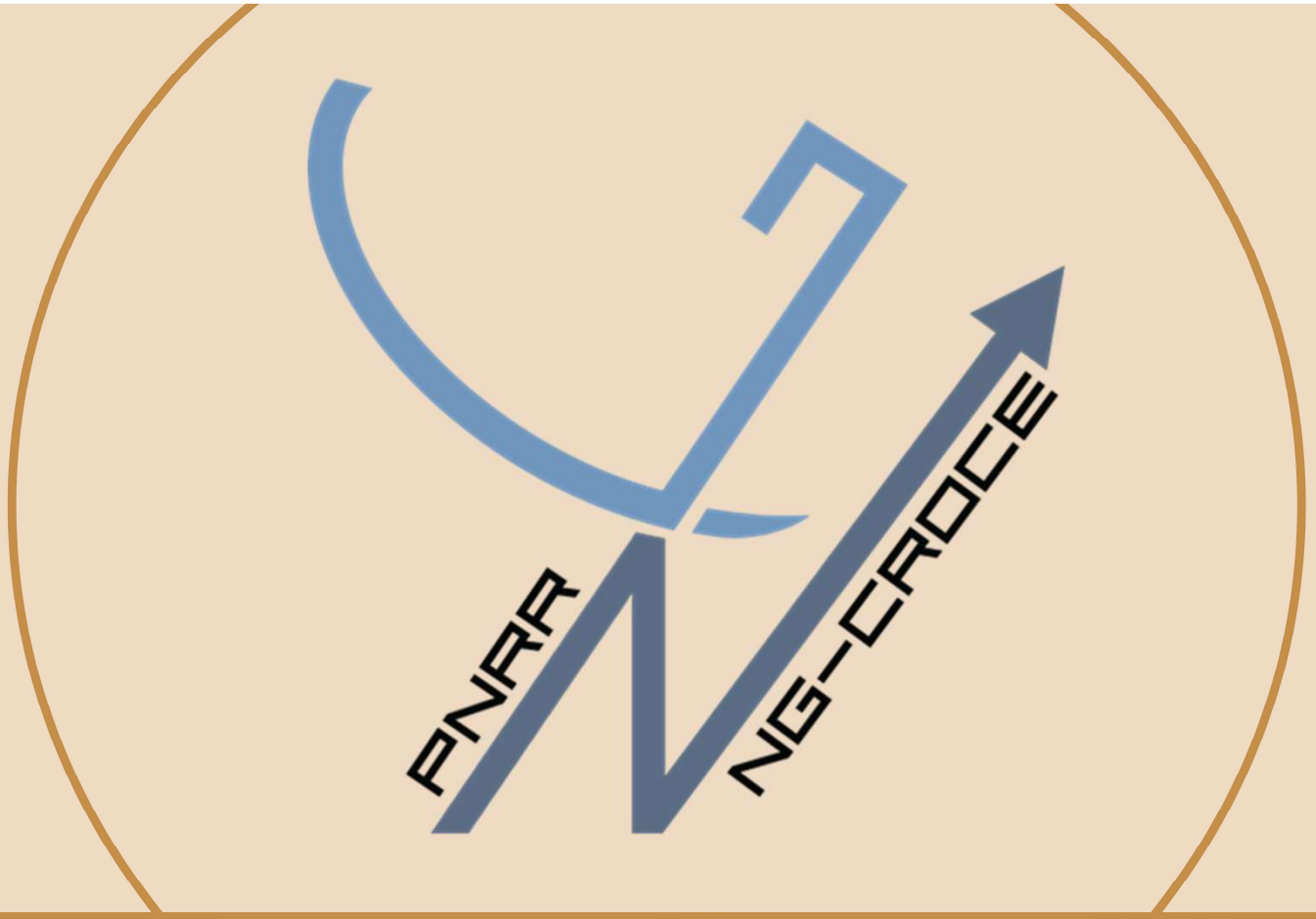
Training Meeting

NG-Croce

Lunedì 12 Maggio - Giovedì 15 Maggio

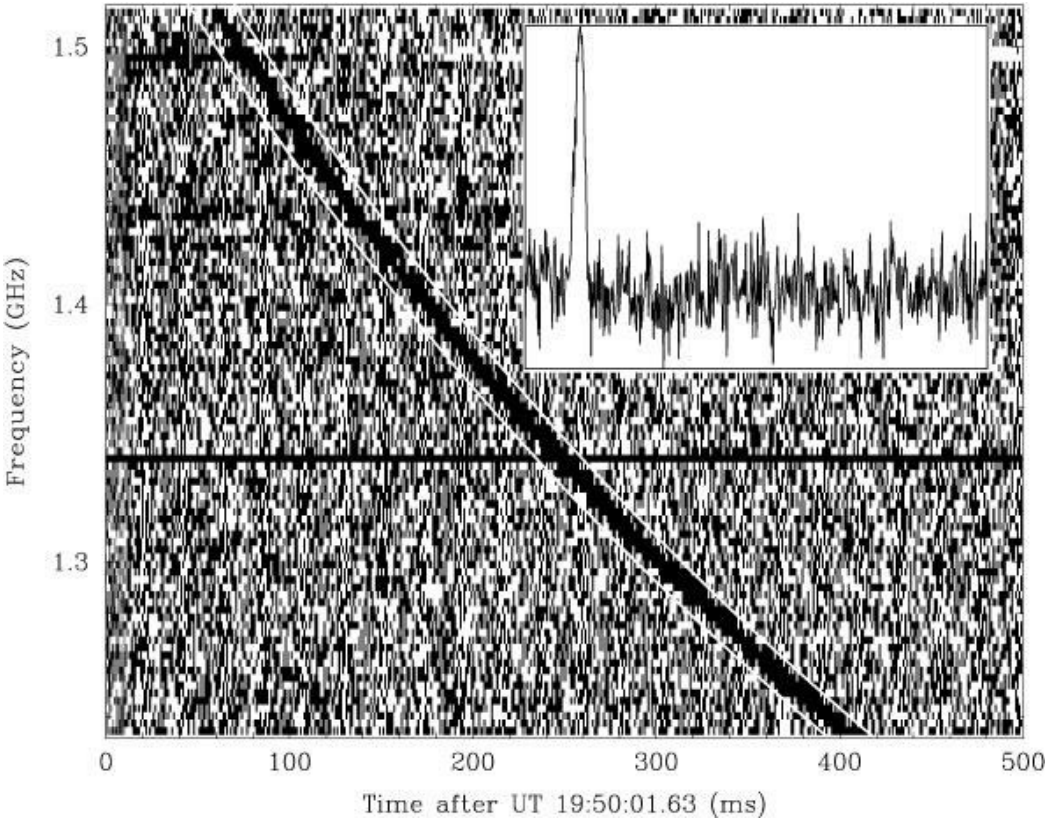
Radiotelescopi di Medicina

IRA - Bologna



Nome Cognome Relatore

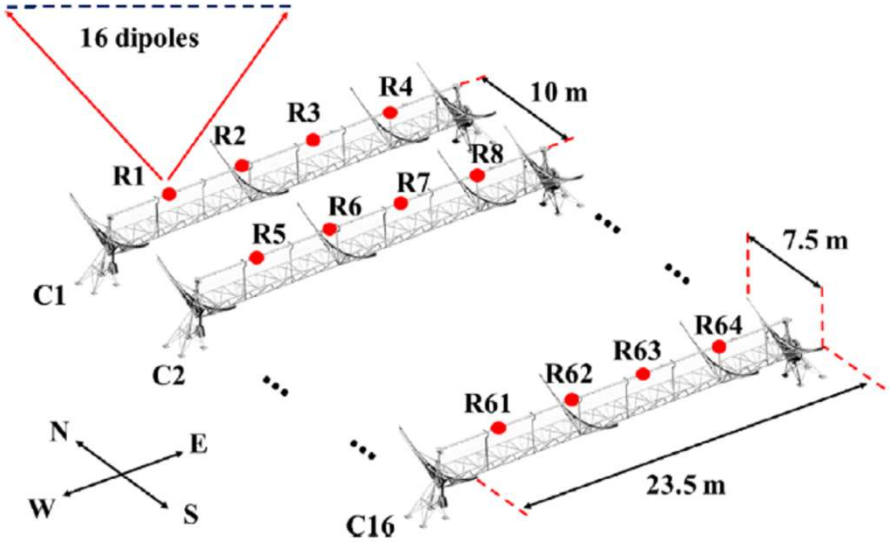
Single-slide FRB summary



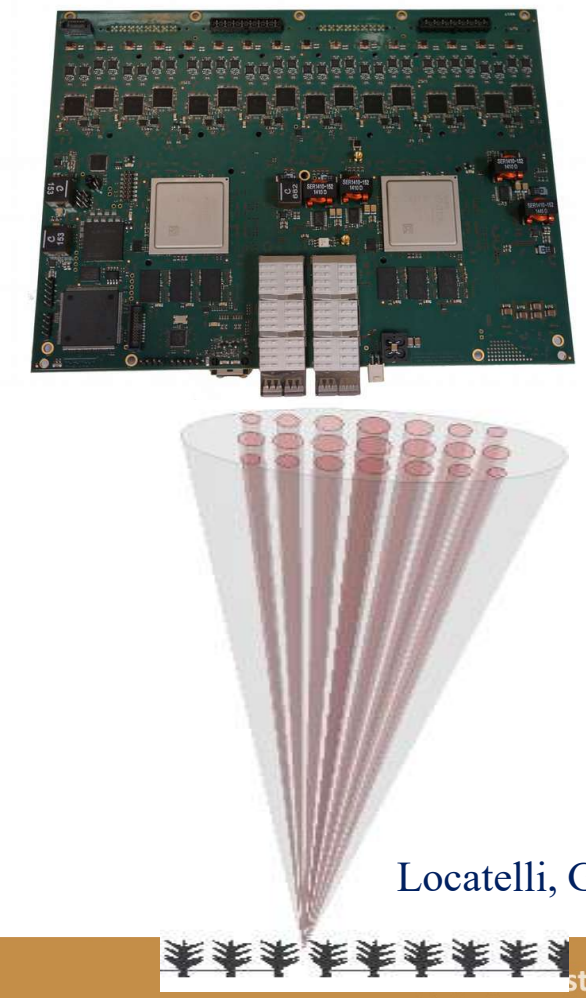
the Adam of FRBs (Lorimer et al. 2008)

- Hundreds of bursts every day in the sky (along unpredictable directions);
- What do we want/need to study them?
  - as much instantaneous sky coverage as possible;
  - as much sensitivity as possible;
  - sub-ms time resolution;
  - full-polarization capabilities;
  - arcsec angular resolution;
  - multifrequency coverage (with high frequency resolution), up to multiwalength coverage.

the Adam of FRBs (Lorimer et al. 2008)

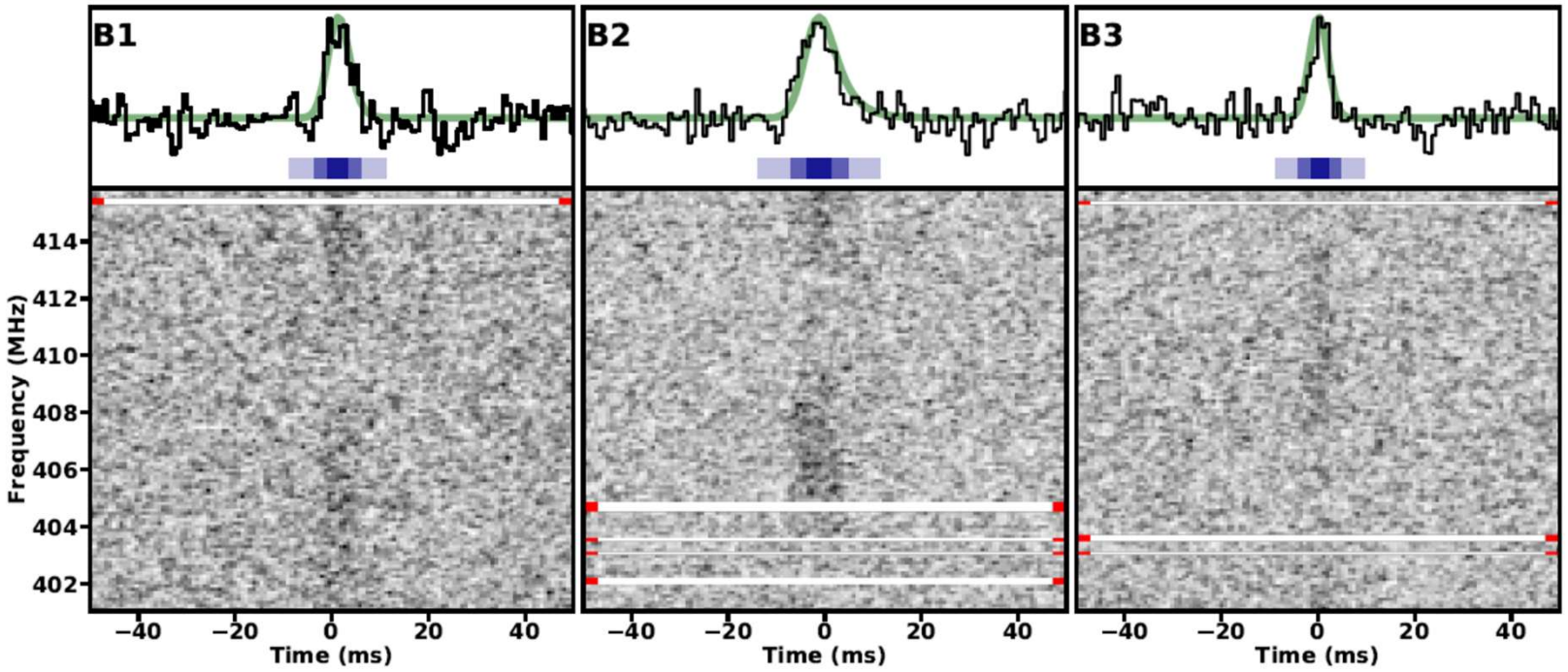

16 dipoles
10 m
R1
R2
R3
R4
R5
R6
R7
R8
C1
C2
7.5 m
R61
R62
R63
R64
C16
23.5 m
N
E
W
S

- Analogue beam former → 16 dipoles (one receiver) are grouped together within each cylinder. 4 beams per cylinder;
- New LNAs installed on the focal line, signals sent RF over fibre to an acquisition board (digitisation and channelization);
- Calibration is by cross-correlating the signals from all the receivers and form the corresponding visibilities (i.e. interferometrically);
- FPGA channelization: 16 MHz bandwidth, 781.25 kHz channel width, 1 digital beam. Second channelization stage for a final: 134 μs time resolution, 14 kHz channel resolution.
- 8 cylinders till 2022, 16 cylinders now: one 0.2°×1.6° beam; 1σ sensitivity: ~ 1 Jy ms.



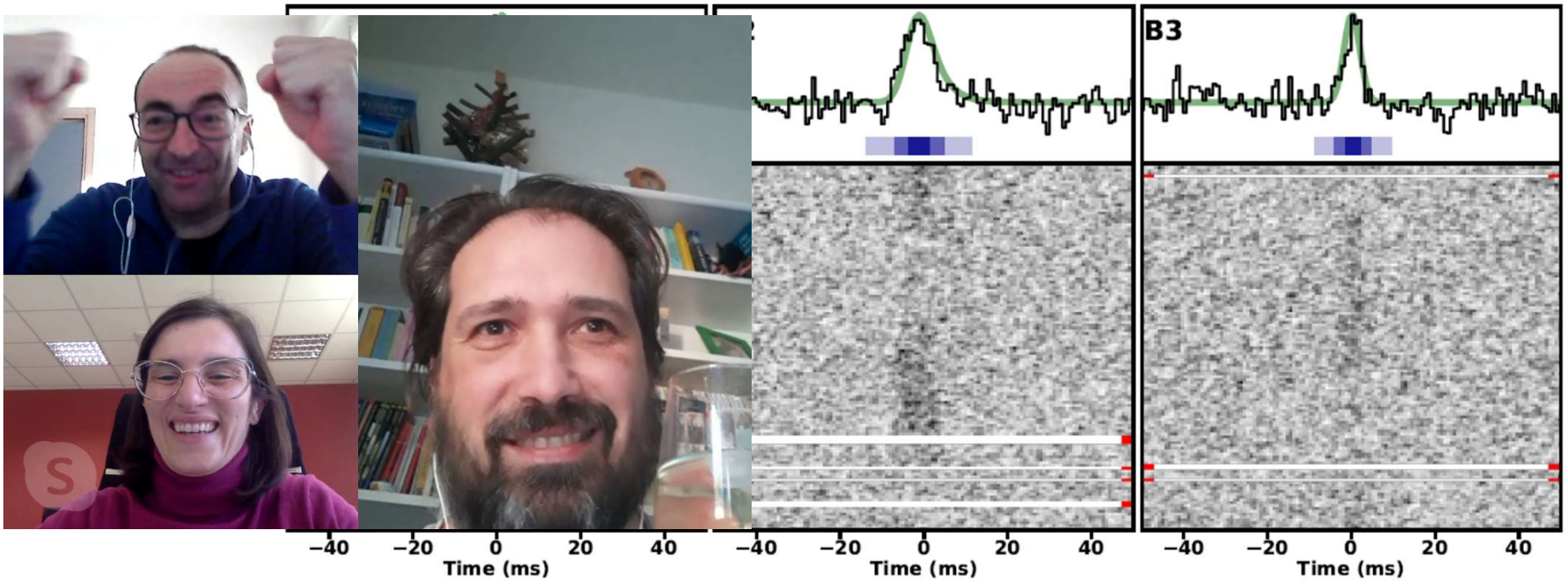
Locatelli, GB et al. (2020)

First FRB light in 2020



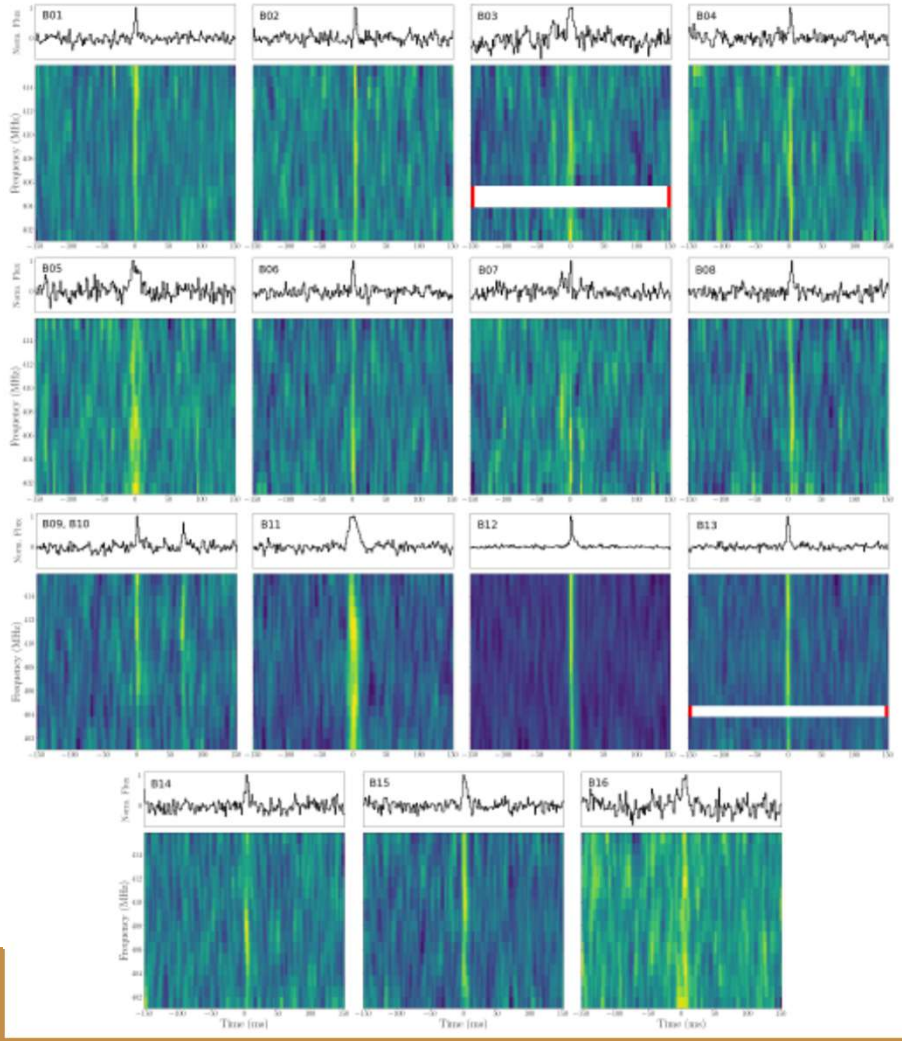
Trudu, Pilia, GB et al. (2022)

First FRB light in 2020



Trudu, Pilia, GB et al. (2022)

- 17 papers so far included NC data;
- > 2000 h on sky;
- 3 PhD these completed at UniBo (Locatelli & Pellicciari UniBo; Trudu, Cagliar University) and 2 ongoing (Geminardi, IUSS Pavia; Beduzzi, UniBo)



FRB 20200912A

Pelliciari, GB et al. (2024)

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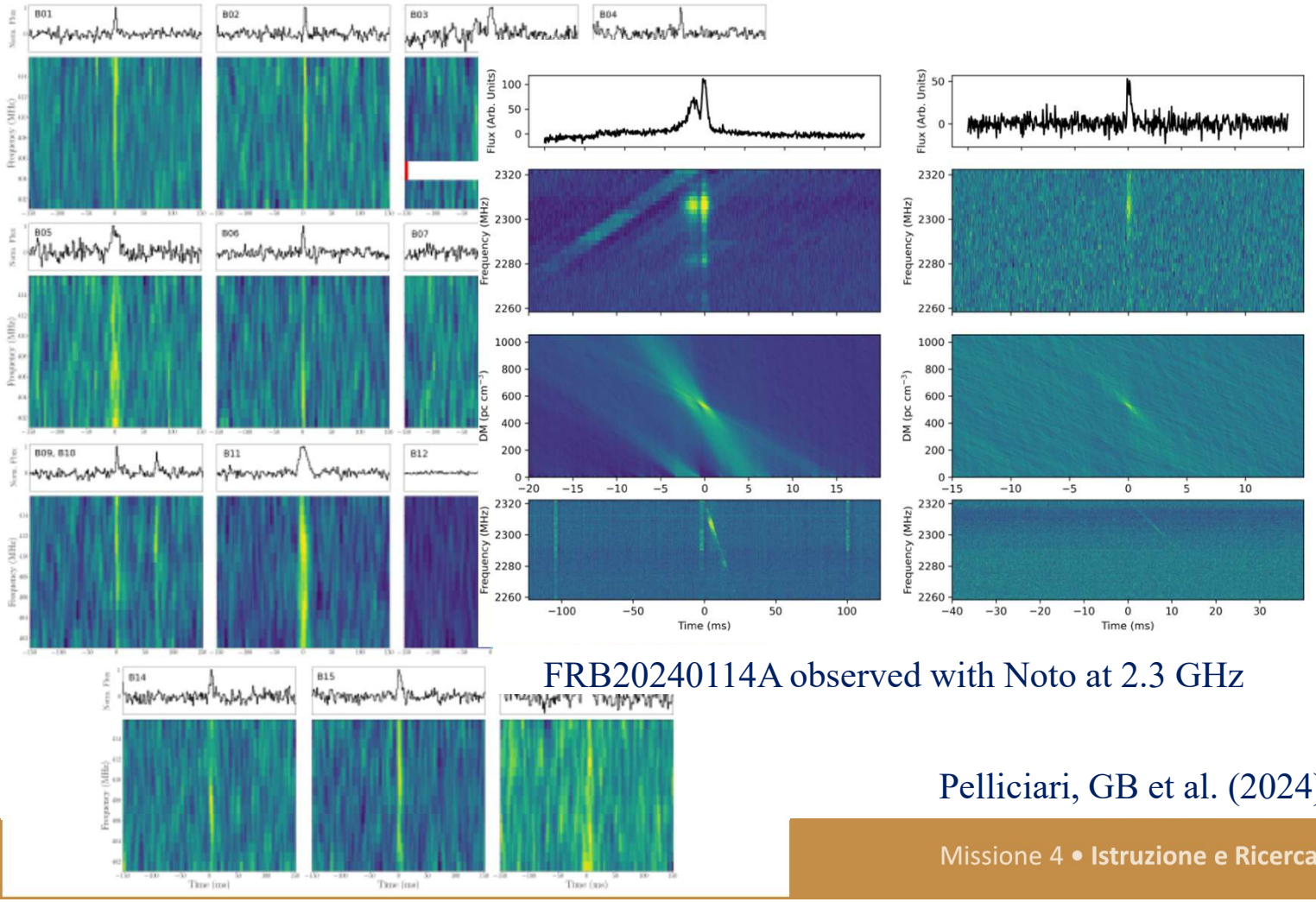

FRB20240114A observed with Noto at 2.3 GHz

Pelliciari, GB et al. (2024)

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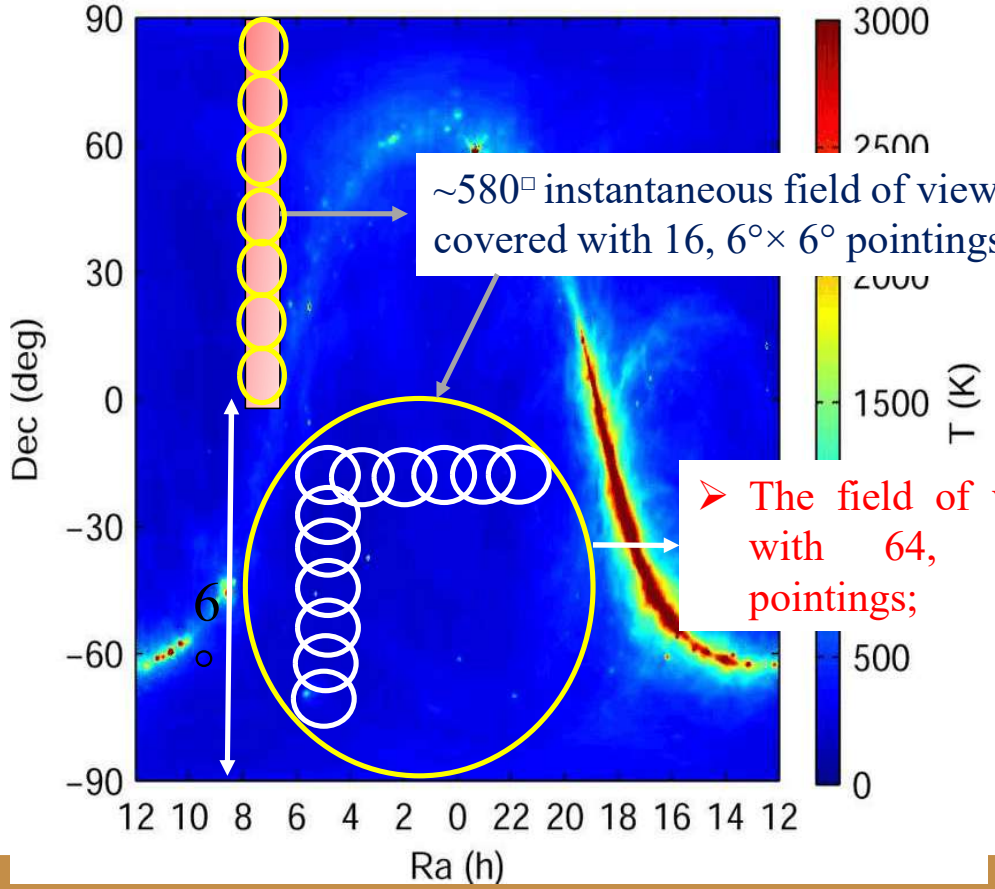
Future observing modes and capabilities

Large area case:

- Beamform 4 cylinders;
- Mechanically shift block of 4-cylinders
- 1σ sensitivity: ~ 4 Jy ms;
- 160 μs time resolution,
- 7.8 kHz frequency resolution;

→ ~1 burst every two days > 10 Jy ms

- Limited localization: ~arcmin for ~100 Jy ms bursts



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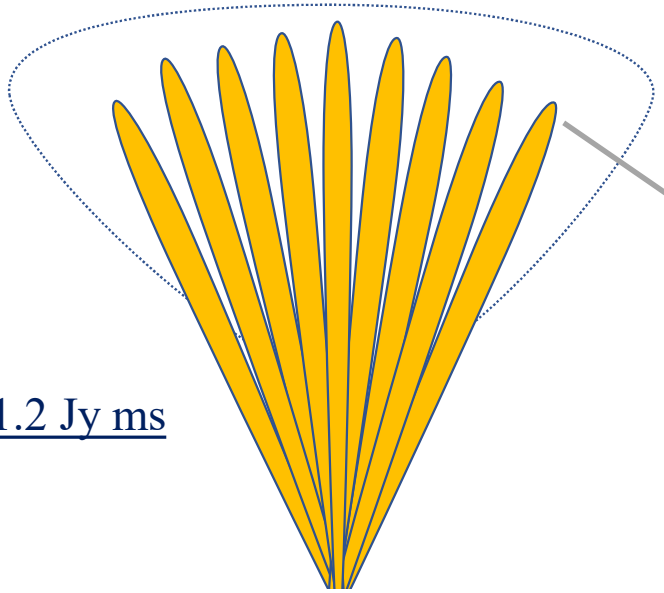
Future observing modes and capabilities: NS + EW

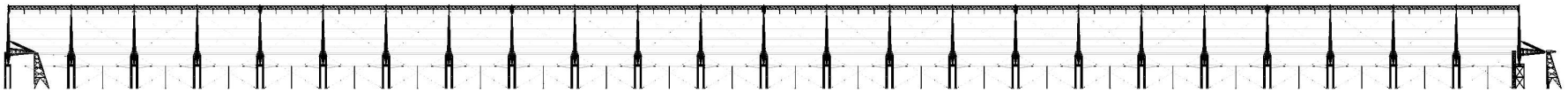
Large area case:

- EW doubles the NS collecting area
- 1σ sensitivity: ~ 120 mJy ms;
- 160 μs time resolution,
- 7.8 kHz frequency resolution;

EW→ ~1 burst every three days > 1.2 Jy ms

NS + EW → ~300 burst yr^{-1}





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Conclusions

- We made the Northern Cross telescope capable of observing FRBs. The Northern Cross is the only INAF-owned radio array. We built an enthusiastic research group (includes promising young researchers, technologists, collaborators from four different institutes);

- We can run long observing campaigns (> 1500 h on the sky so far); still limited instantaneous sky coverage; ~30 bursts detected so far;

- Simultaneous multifrequency observations 0.408 - 2.3 GHz (Northern Cross, Medicina, Noto) of well-localized bursts – unique in today's world landscape and extending down to 190 MHz when the LOFAR station will become operational in Medicina;

- The combo of the new NS backend and the EW will allow to detect ~300 burst yr^{-1}… the NC-Croce will into a CHIME-like telescope… looking forward to our own 500 burst catalogue;

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THANK YOU