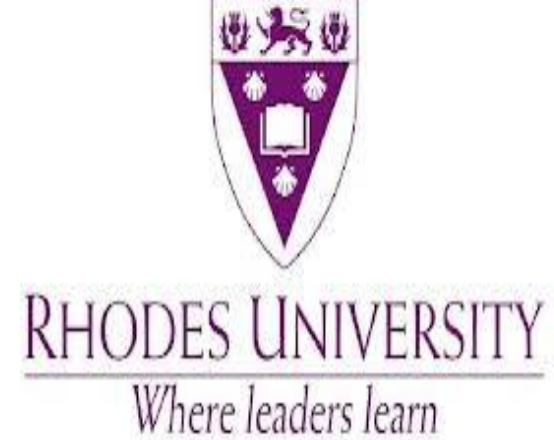


# **The Northern Cross Fast Radio Burst project**

**Gianni Bernardi**

**INAF-IRA & Rhodes University**

**with N. Locatelli, G. Bianchi, A. Magro, G. Naldi, M. Pilia, G.  
Pupillo, A. Ridolfi, & G. Setti**



# The Epoch of Reionization

Gianni Bernardi

SKA SA & Rhodes University

(thanks to the HERA, LEDA and PAPER collaborations)

“The first Pietro Baracchi conference: Italo-Australian Radio Astronomy in era of the SKA”,  
Perth, November 1-4, 2016

# Once upon a time...



“We should do something with the Northern Cross”

# Once upon a time...



“We should do something with the Northern Cross”



“Can we do something with the Northern Cross?”

# “Remember to look beyond your horizon line everyday”

PILLARS OF SELF AWARENESS



Patrizio Paoletti

## OMM<sup>®</sup>

the One Minute Meditation



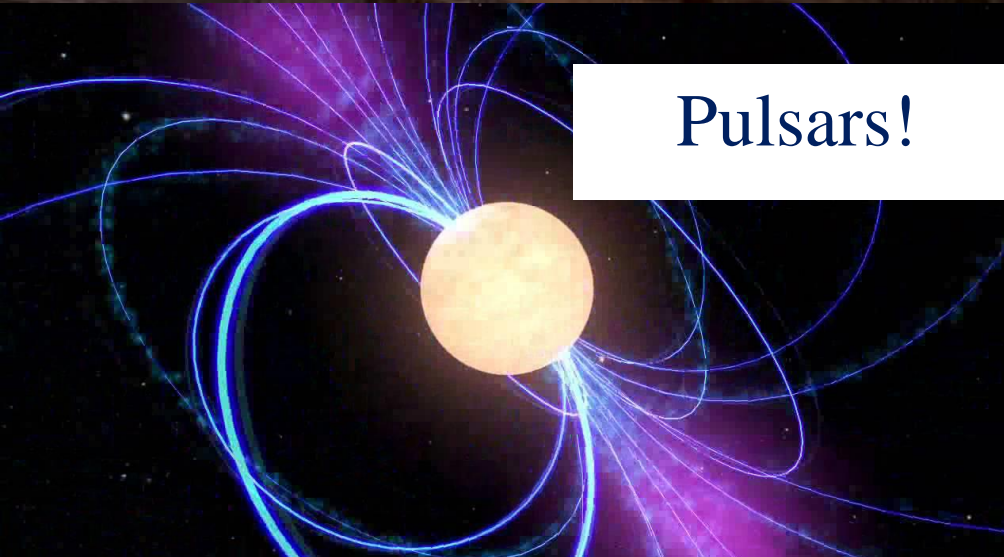
A practical guide  
to know yourself  
and live a happy life

**medidea**  
INSPIRING PEOPLE



# “Remember to look beyond your horizon line everyday”

PILLARS OF SELF AWARENESS



Pulsars!

Patrizio Paoletti

**OMM**<sup>®</sup>  
the One Minute Meditation

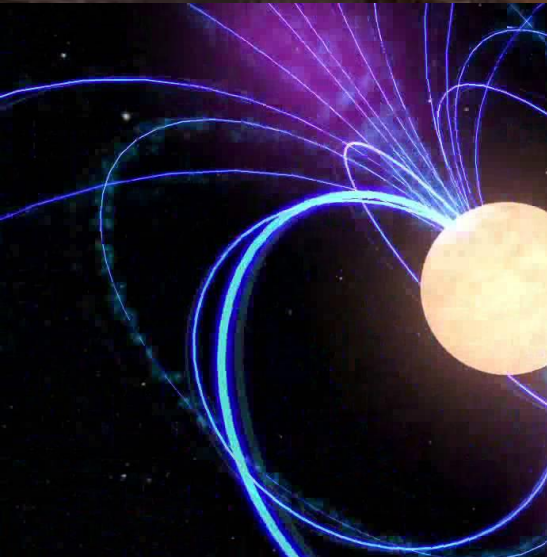


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Rizio Paoletti

**MM**<sup>®</sup>  
Minute Meditation

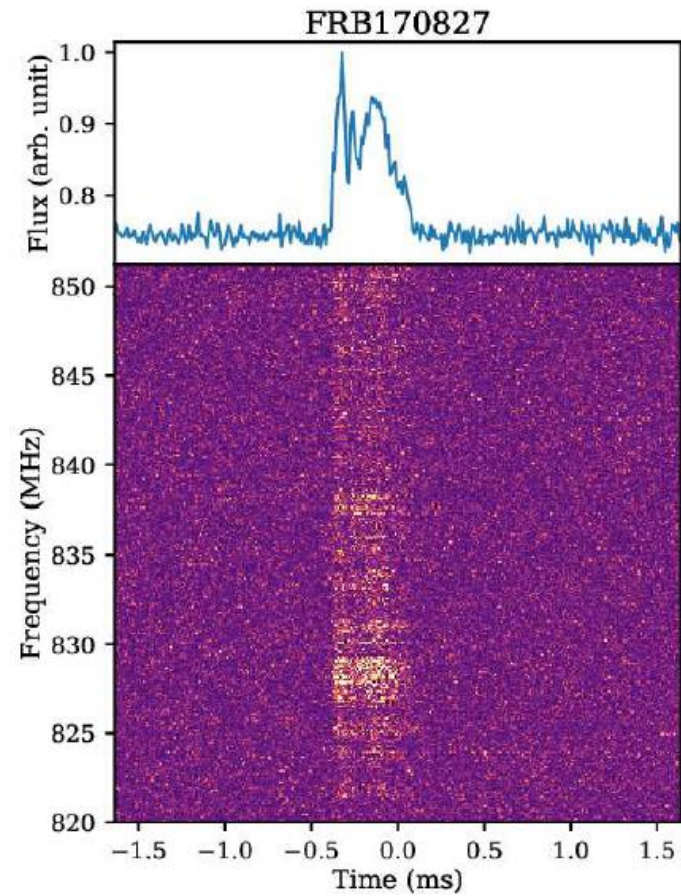
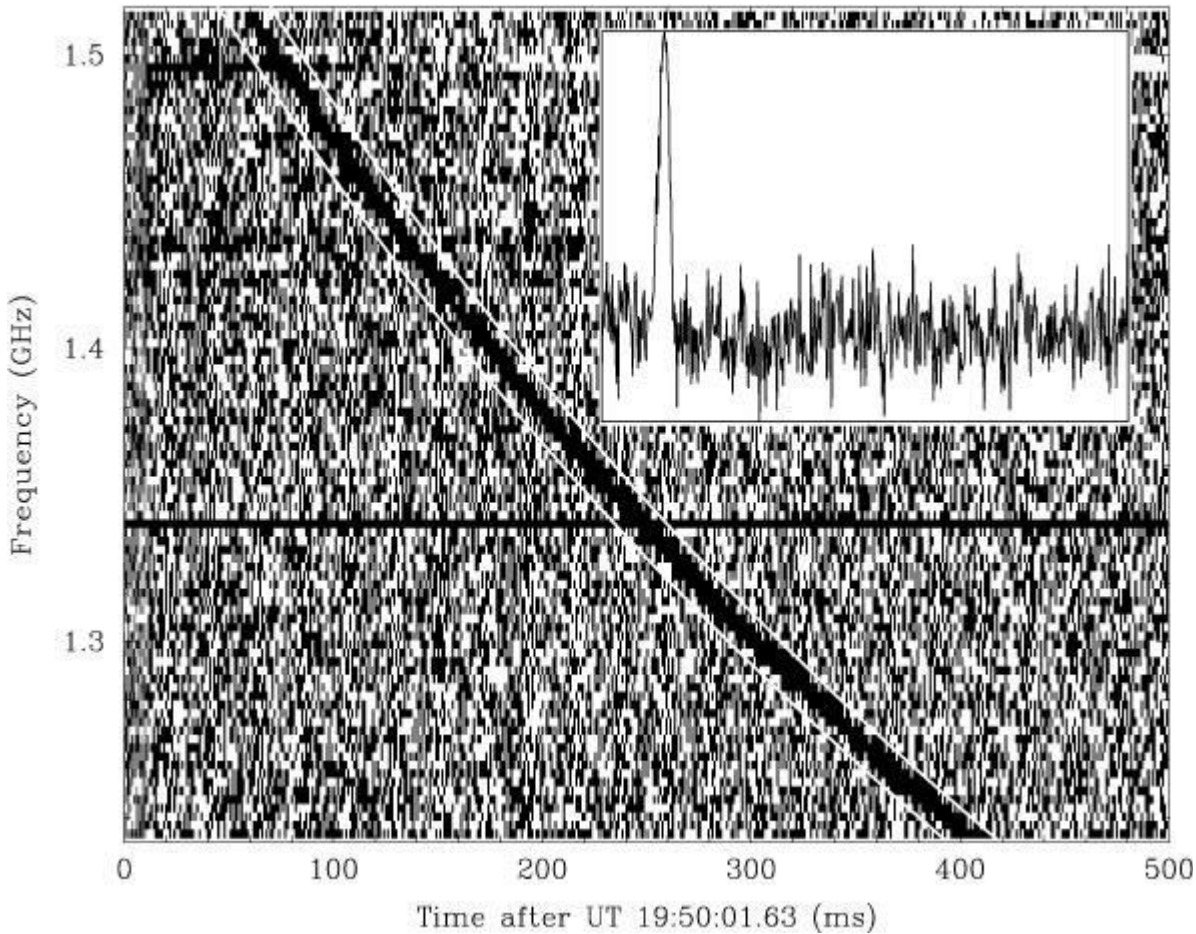


practical guide  
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# Fast Radio Bursts



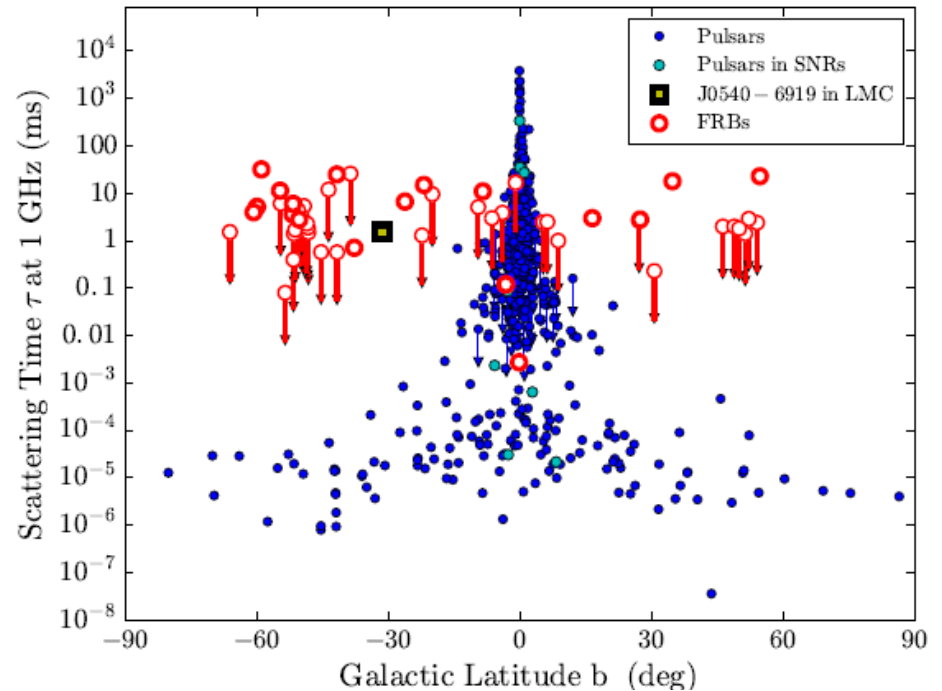
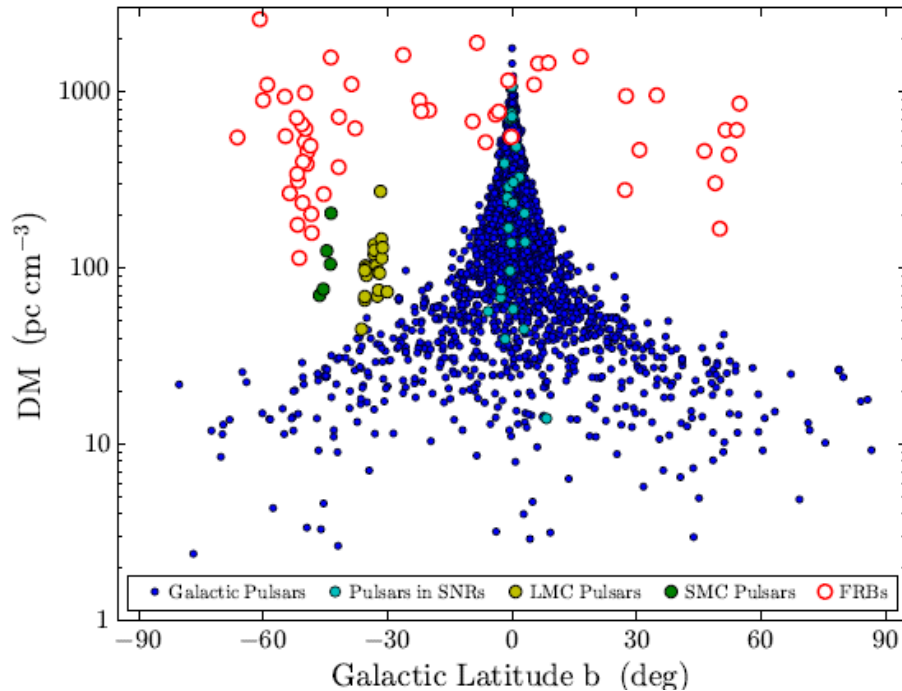
(Farah et al. 2018)

the Adam of FRBs (Lorimer et al. 2008)

See talks by Bhandari's and Ryder's talks

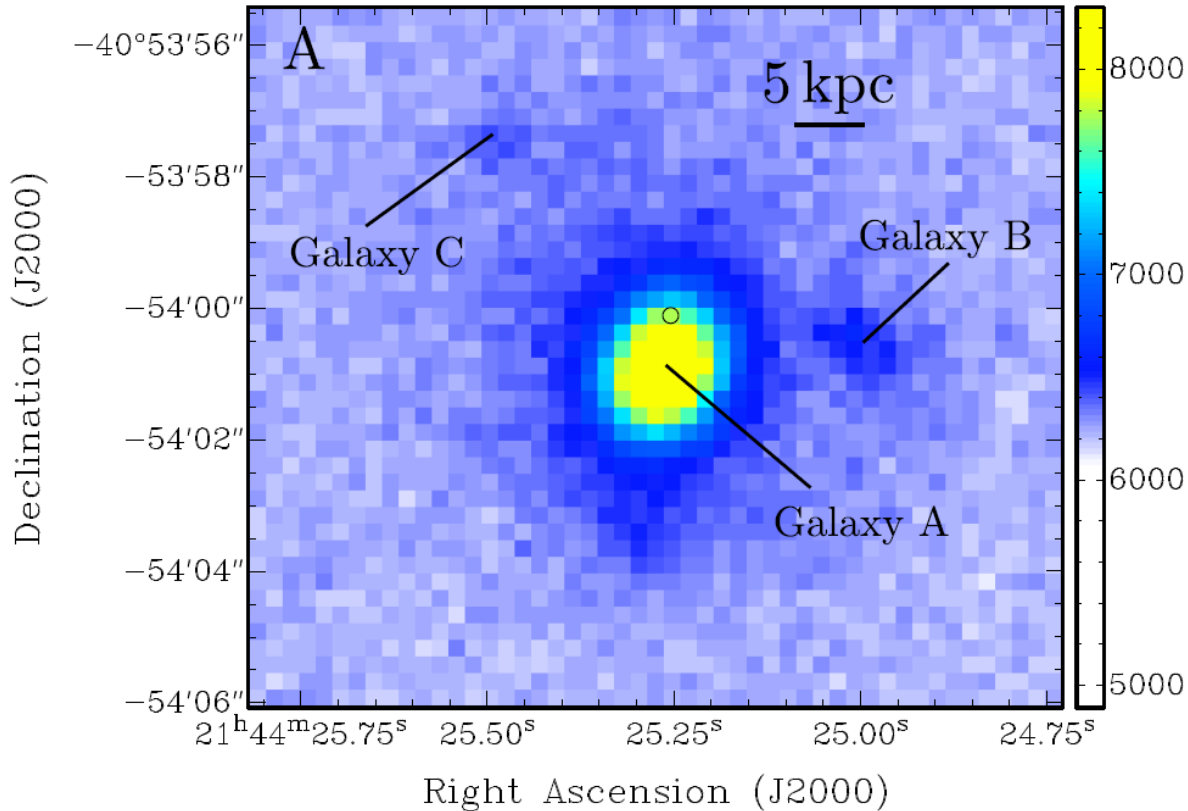
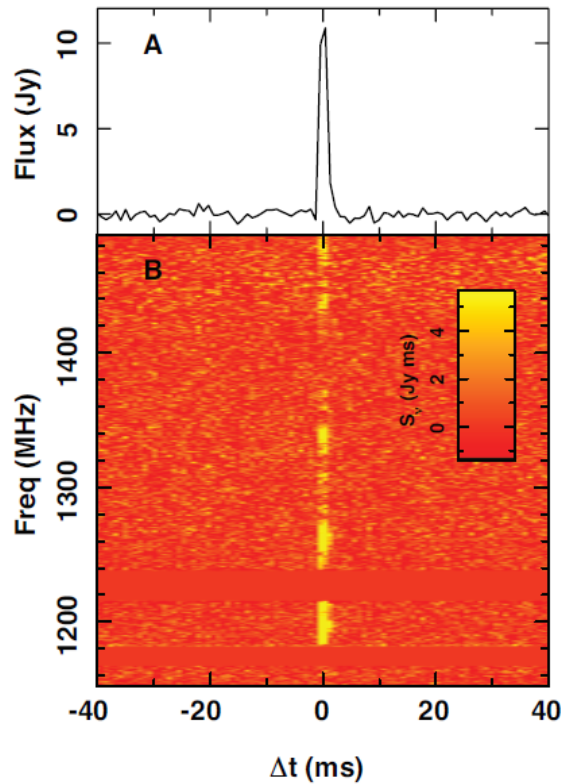


# Fast Radio Bursts



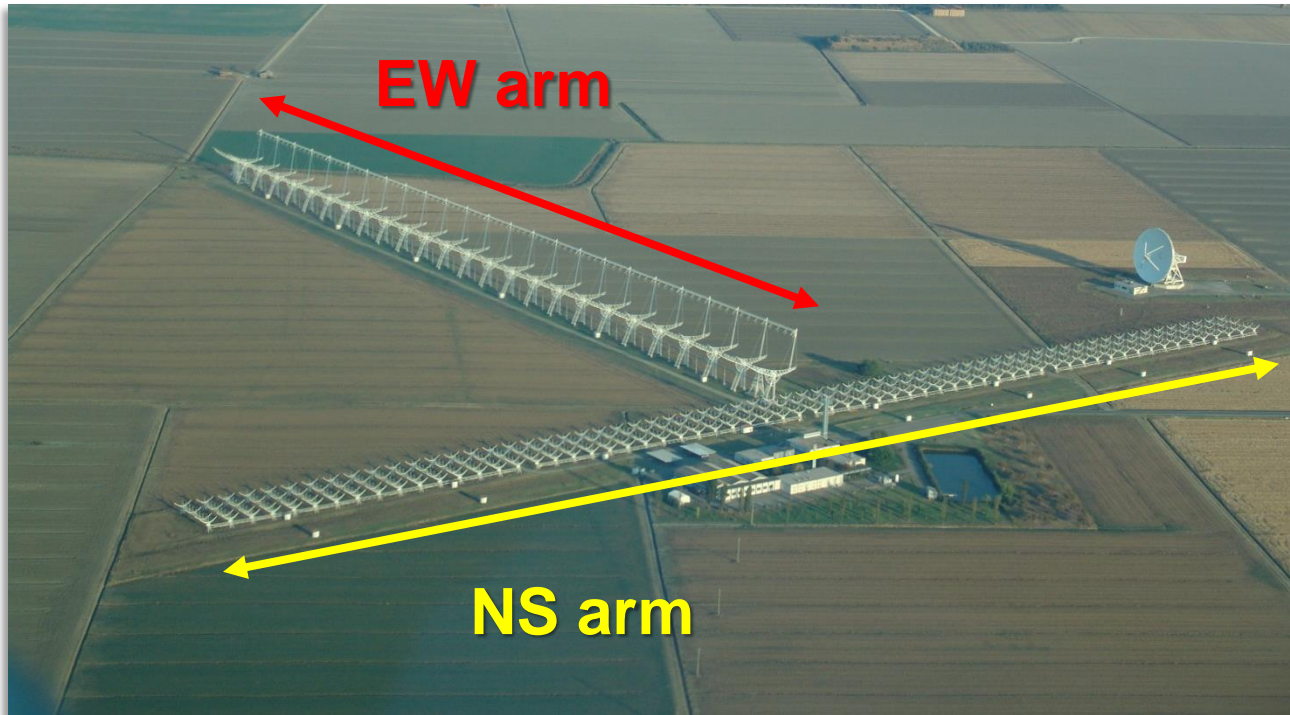
$$DM = \int_0^z n_e dl > 10^2 \text{ pc cm}^{-3} \quad \text{well in excess of the Galactic contribution}$$

**Most are unique events... some repeats... some are localized!**



$z = 0.32$

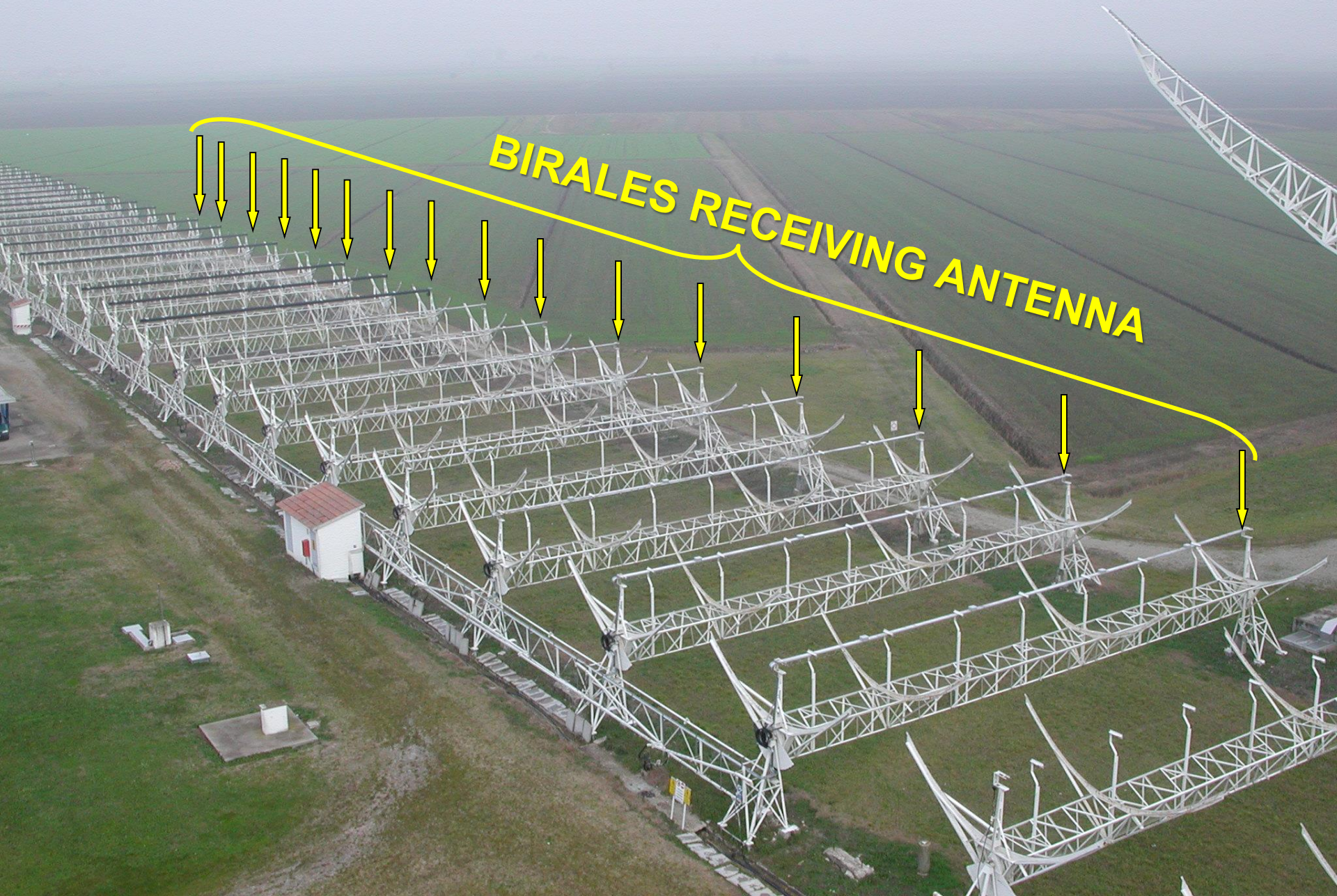
# The Northern Cross Telescope



- T-shape array operating at 408 MHz;
- NS arm: array of 64 cylinders, 640 m  $\times$  23.5 m (11200 m<sup>2</sup> vs 8000 m<sup>2</sup> for CHIME), 64 dipoles per cylinder;
- EW arm: array of single dipoles, 564 m  $\times$  35 m;
- used for continuum observations: the Bologna catalogue (>13000 sources > 100 mJy; Ficarra et al., 1985)

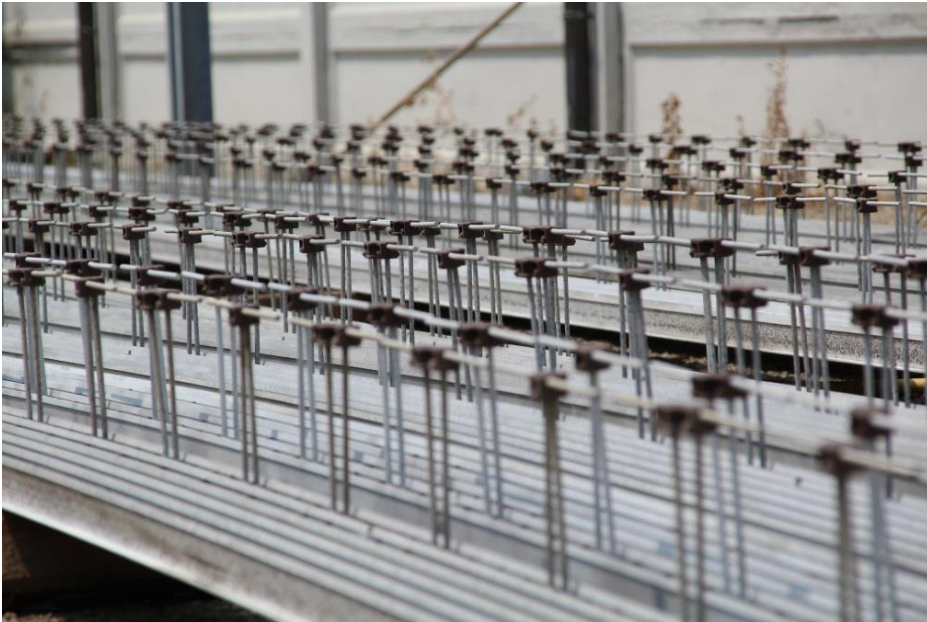


# The Northern Cross FRB project: hardware upgrade





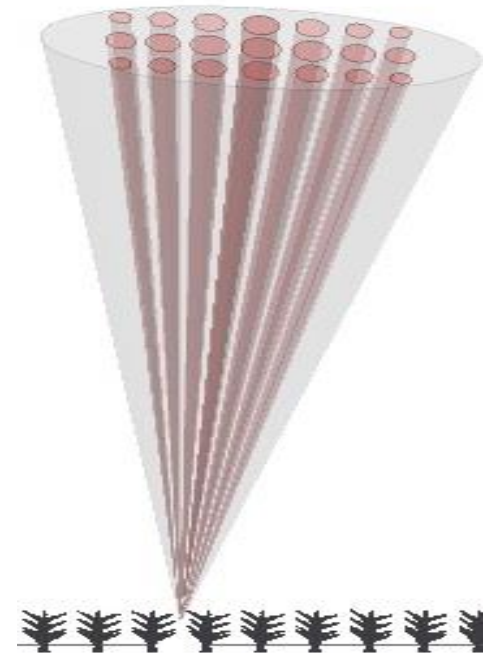
# The Northern Cross FRB project: hardware upgrade



- Analogue beam former → 16 dipoles (one receiver) are grouped together within each cylinder;
- New LNAs installed on the focal line, signals sent RF over fibre to an acquisition board (digitisation and channelization);

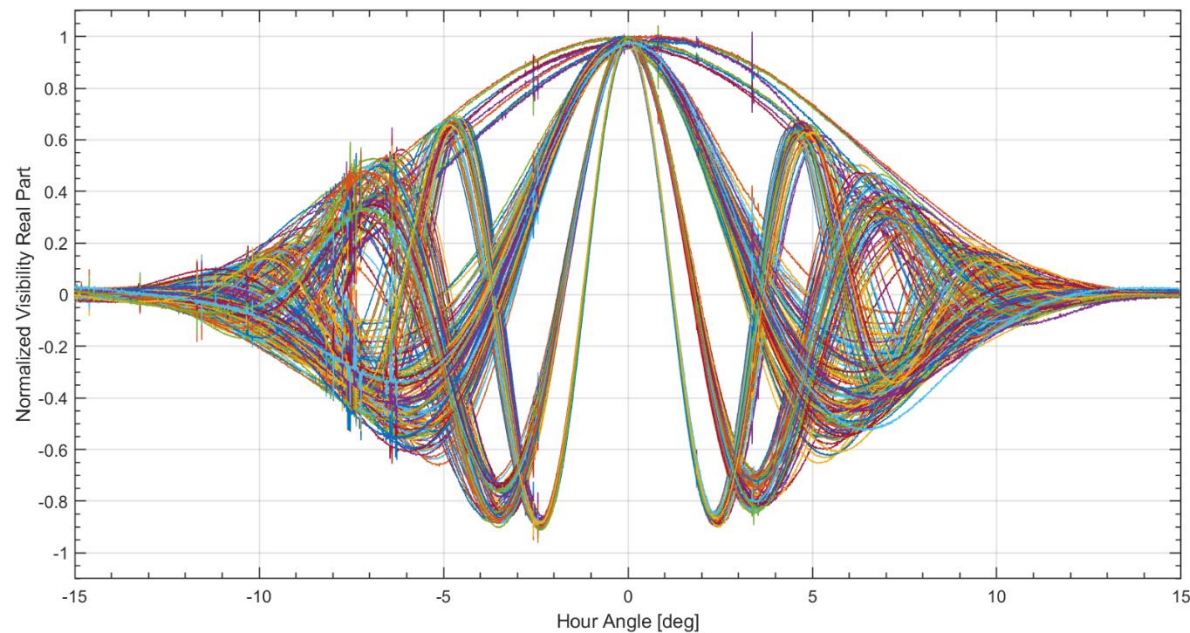
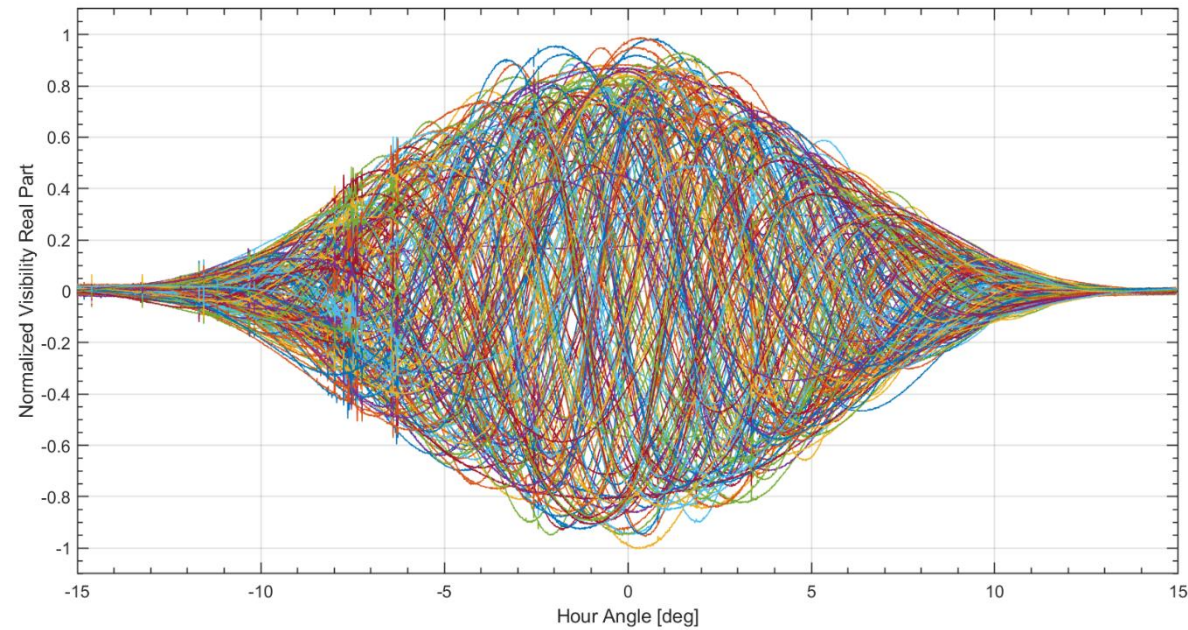
# The Northern Cross FRB project: hardware upgrade

- FPGA channelization: 16 MHz bandwidth, 781.25 kHz channel width;
- Digital beam forming:
  - 6 cylinders, 1 beam:  $0.75^\circ \times 1.5^\circ$ ;  $1.08 \mu\text{s}$  time resolution;
  - 6 cylinders, 4 simultaneous beams:  $0.75^\circ \times 1.5^\circ$  resolution,  $124 \mu\text{s}$  time resolution;
  - 4 cylinders,  $6^\circ \times 6^\circ$  FoV, 20 simultaneous beams:  $(1^\circ \times 1.5^\circ)$ ;  $276 \mu\text{s}$  time resolution; 3 kHz channel width;





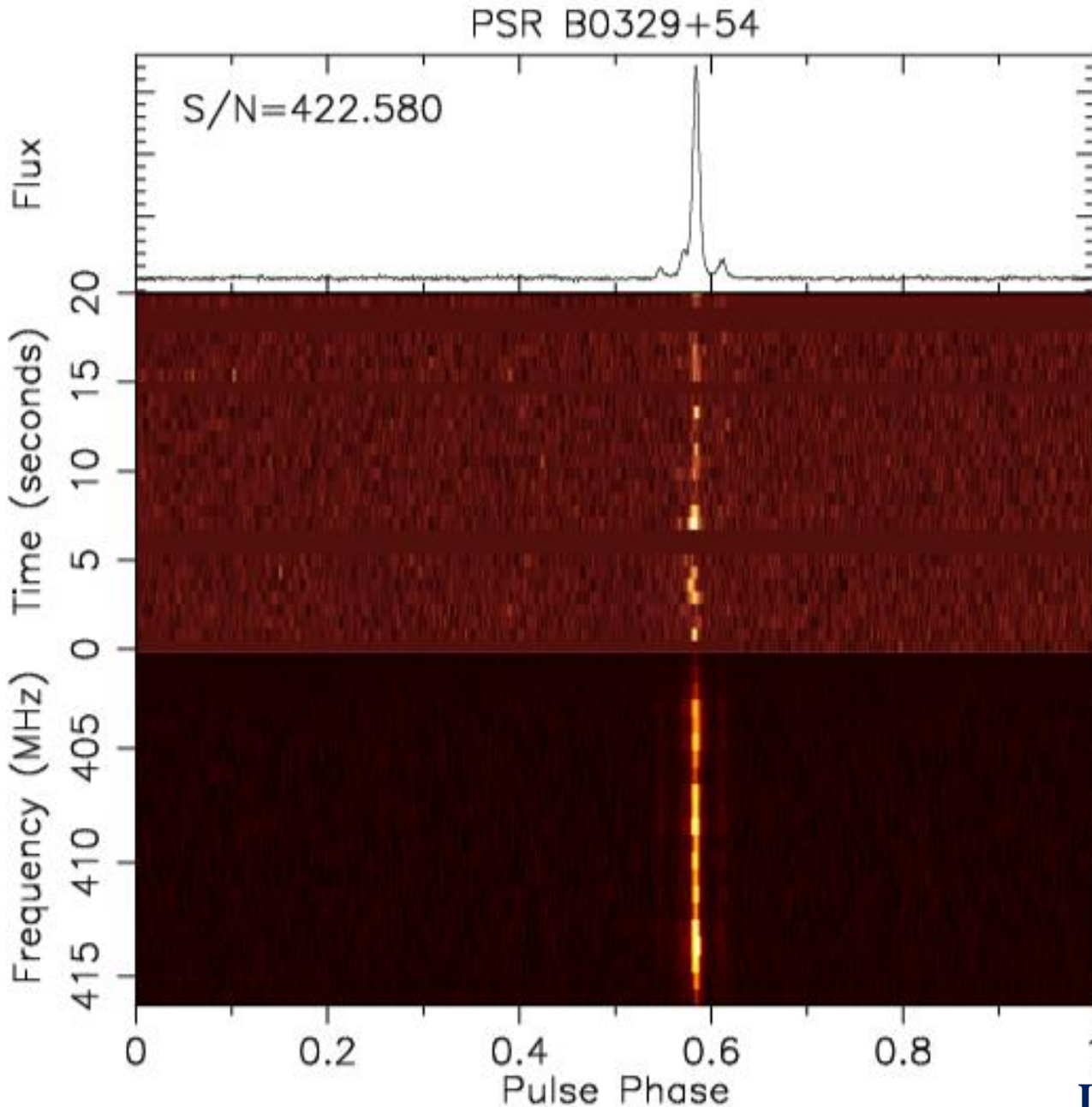
# System calibration



**Instrumental amplitudes  
and phases are calibrated  
via interferometric  
observations of a  
calibration source (Cas A)**

**Locatelli, GB et al. (in prep.)**

# System characterization



**B0329+54:**

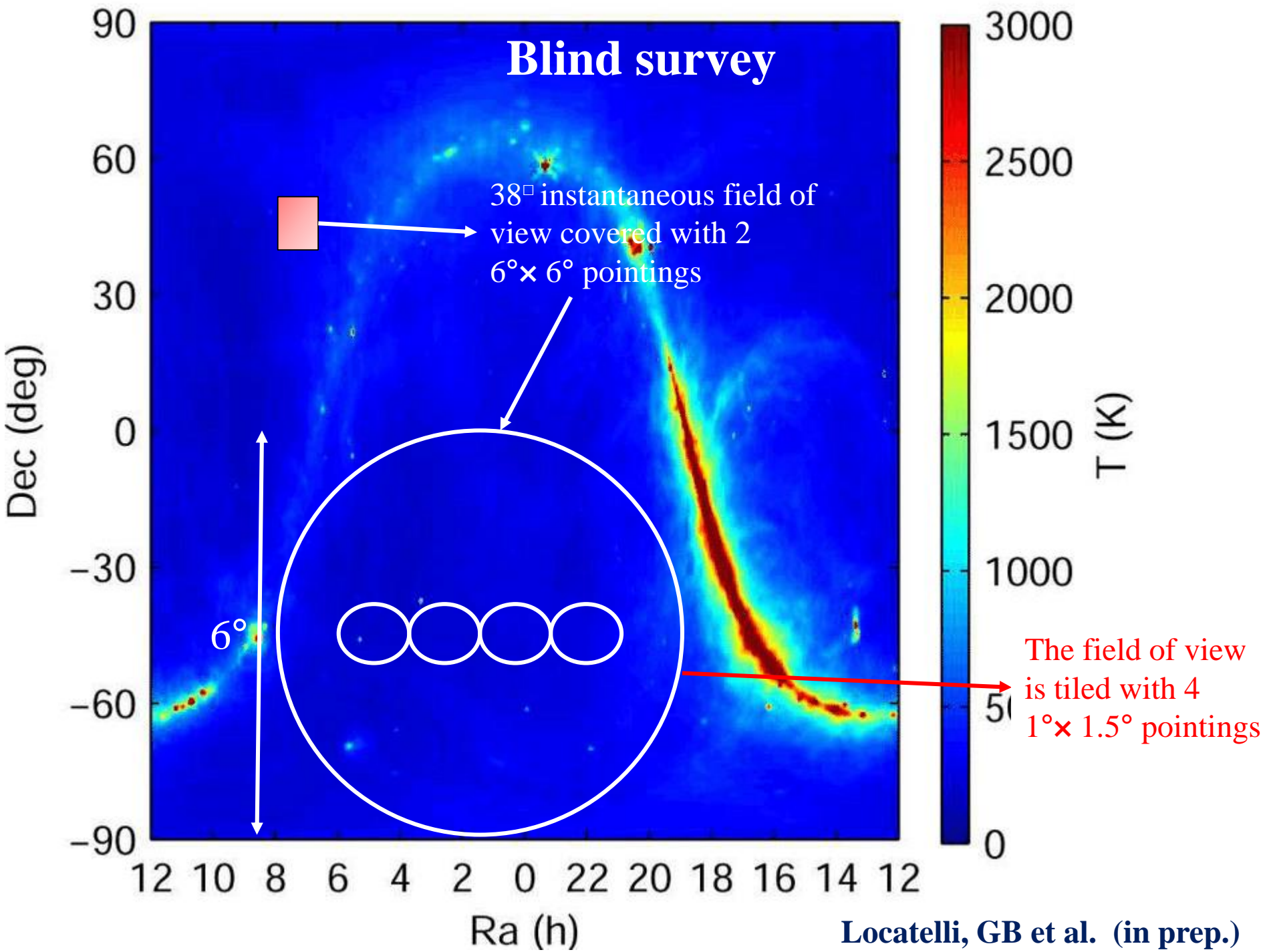
- 1.5 Jy @ 400 MHz;
- 714 ms period;
- DM ~ 27 pc cm<sup>-3</sup>

$$SEFD = \frac{S_v \sqrt{B\tau}}{S/N} = 426.5 \text{ Jy}$$

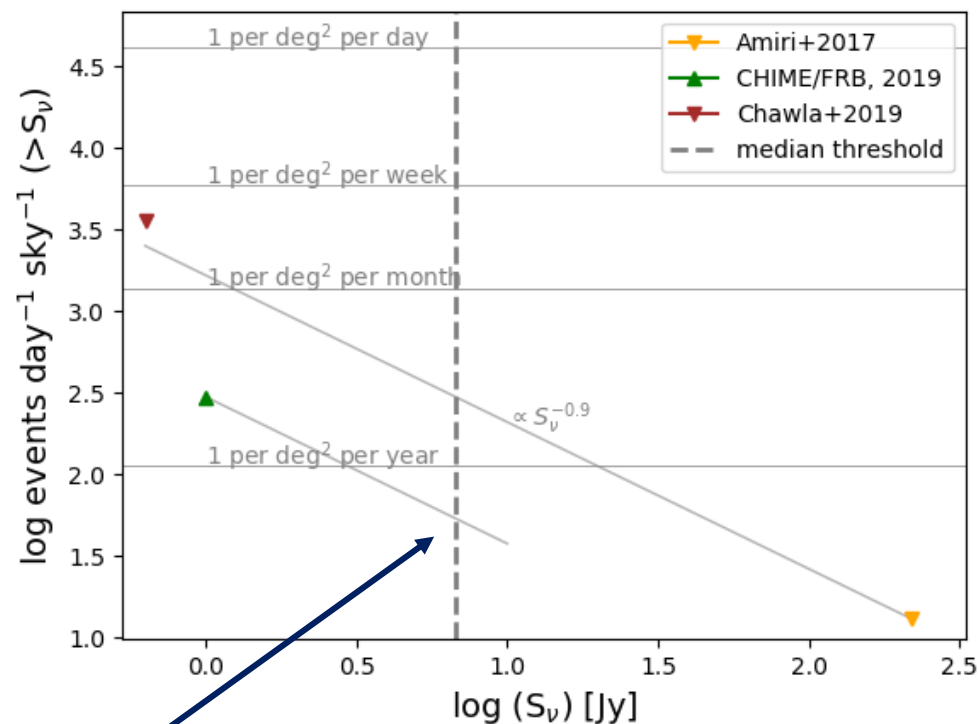
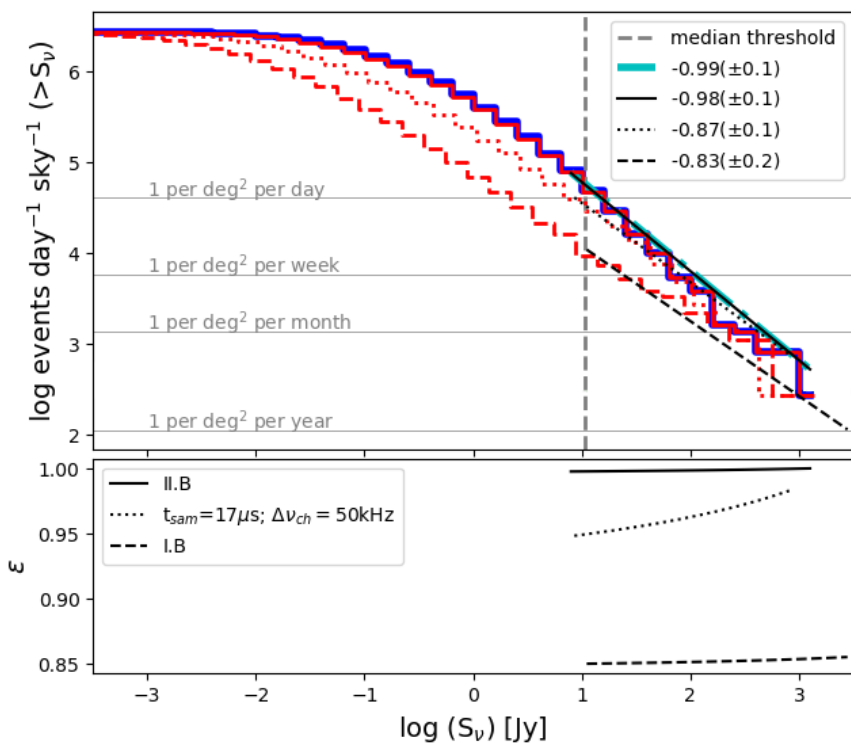
# The Northern Cross Fast Radio Burst project roadmap

- Blind survey:
  - $2 \times 4$  cylinders;
  - $6^\circ \times 6^\circ$  (element) FoV, 4 simultaneous ( $1^\circ \times 1.5^\circ$ ) beams;
  - 127  $\mu\text{s}$  time resolution; 781.25 kHz channel width;
- Targeted follow up of known repeating FRBs:
  - 8 cylinders,
  - 1 beam:  $0.6^\circ \times 1.5^\circ$ ;
  - 1.08  $\mu\text{s}$  time resolution; 781.25 kHz channel width;
- Blind survey (2.0):
  - $N \times 4$  cylinders;
  - $6^\circ \times 6^\circ$  (element) FoV, 20 simultaneous ( $1^\circ \times 1.5^\circ$ ) beams;
  - 276  $\mu\text{s}$  time resolution; 3 kHz channel width;
- Localization;





# Blind survey forecasts



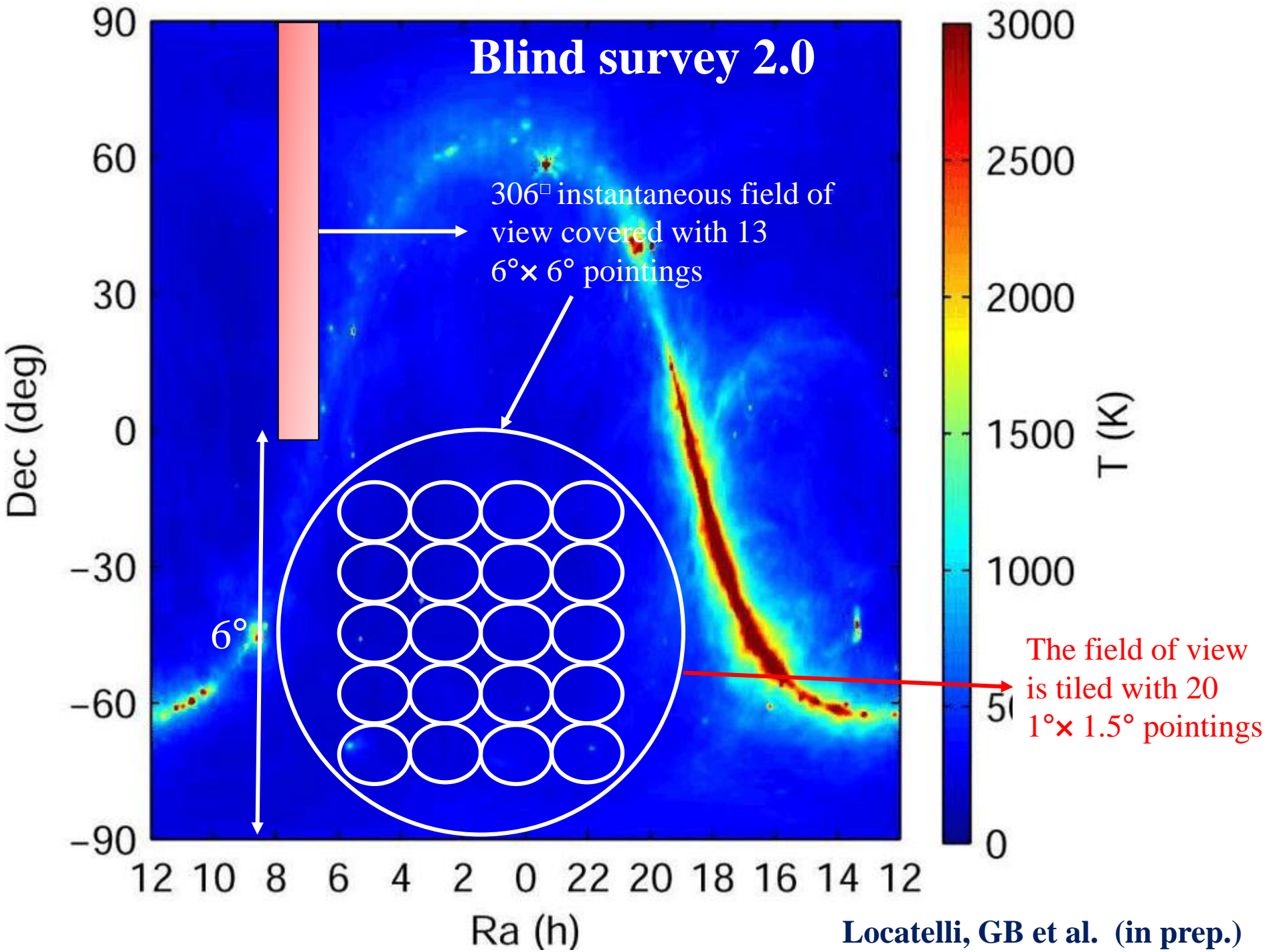
CHIME FRB rate equalized in ~1500 hours

# Moving forward: blind survey 2.0 & localization

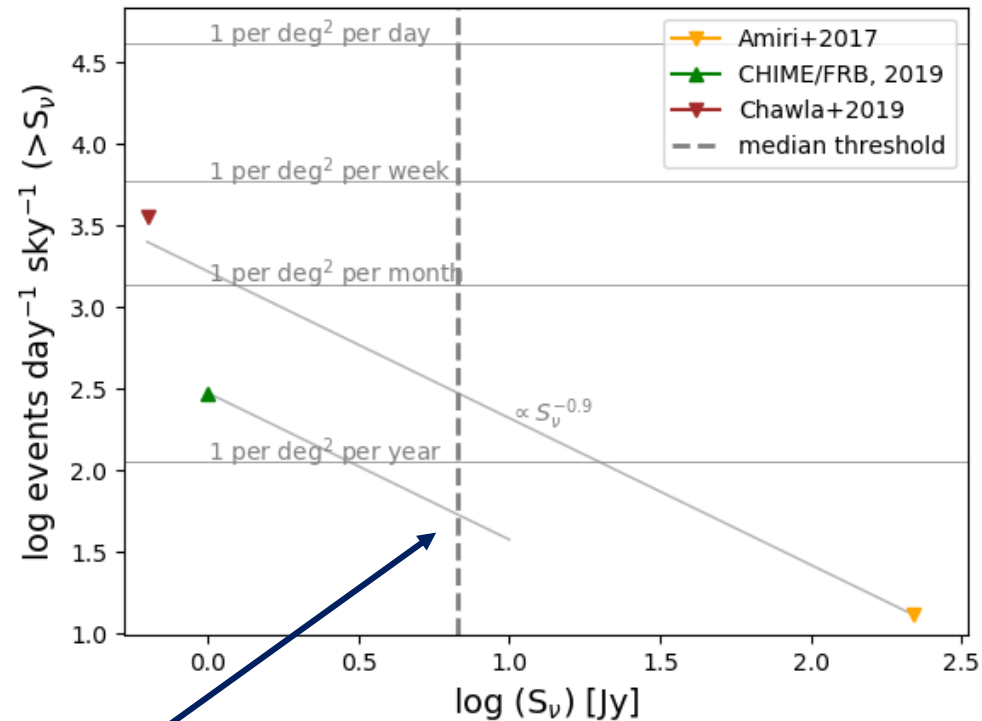
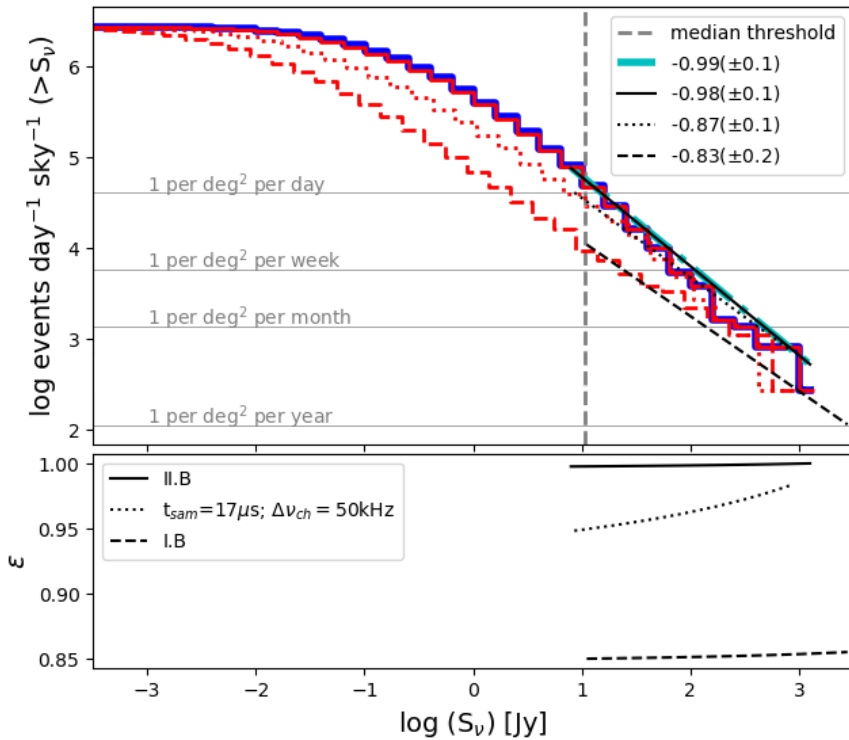
- New acquisition system → 3 kHz channel width;
- New digital beamformer → 20 simultaneous beams;
- Full restoration of the NS arm;
- Simultaneous observation at 150 MHz with the upcoming LOFAR station in Medicina (?);
- Localization: leveraging on the Italian VLBI network infrastructure?







# Blind survey 2.0 forecasts



**CHIME FRB rate equalized in ~34 hours**

# Conclusions and future outlook

- 1) FRBs are cool, exciting, the biggest surprise of the last decade (they are as old as my eldest daughter)... you name it!
- 2) The field changes on turkey life time scales (ASKAP, CHIME, UTMOST, MeerKAT + ...);
- 3) Our goal is to add the Northern Cross to the FRB world map;
- 4) Did we spark the interest of our “Australian FRB colleagues”?

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THANK YOU