MINISTÉRIO DA CIÊNCIA, TECNOLOGIA, INOVAÇÕES E COMUNICAÇÕES
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

The BINGO Telescope

an instrument to investigate the Universe through the 21 cm neutral hydrogen line

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on behalf of the BINGO Collaboration

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BINGO

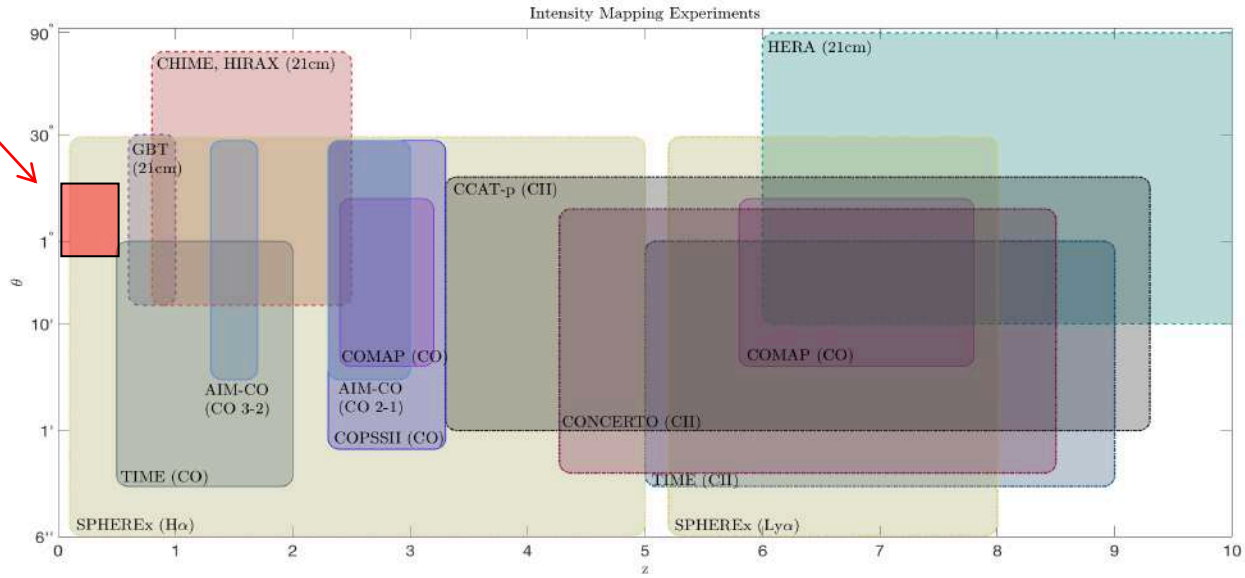
BAOs from Integrated Neutral Gas Observations

Visit us at http://portal.if.usp.br/bingotelescope/

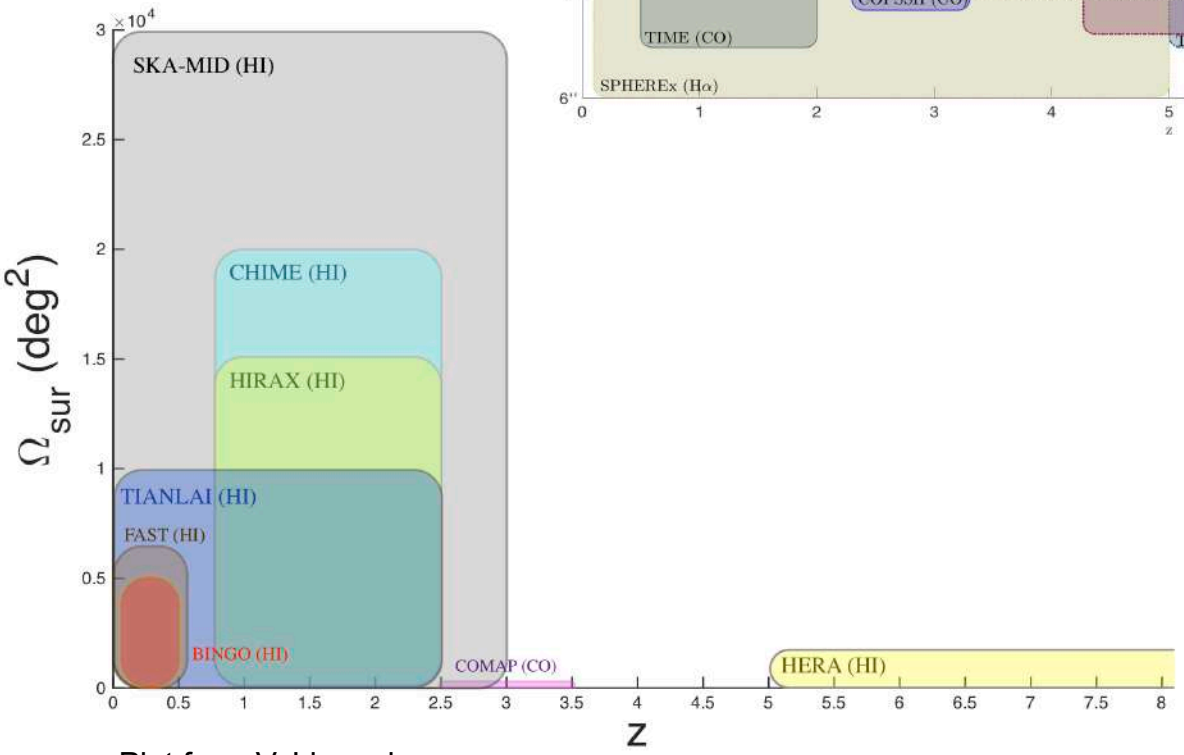
BINGO Science goals

- Measure BAO on top of the 21 cm HI spectrum
- HI intensity mapping can be used as mass tracer, probing distortions in redshift space and checking BAO anisotropy
- **Additional science**
  - Life history of hydrogen
  - Radio recombination lines
  - Galactic continuum
- And, of course, **FRBs**, which will be delivered for free due to the nature of BINGO observational strategy

BINGO fits here (our update of pag. 44 of Kovetz et al (2017)



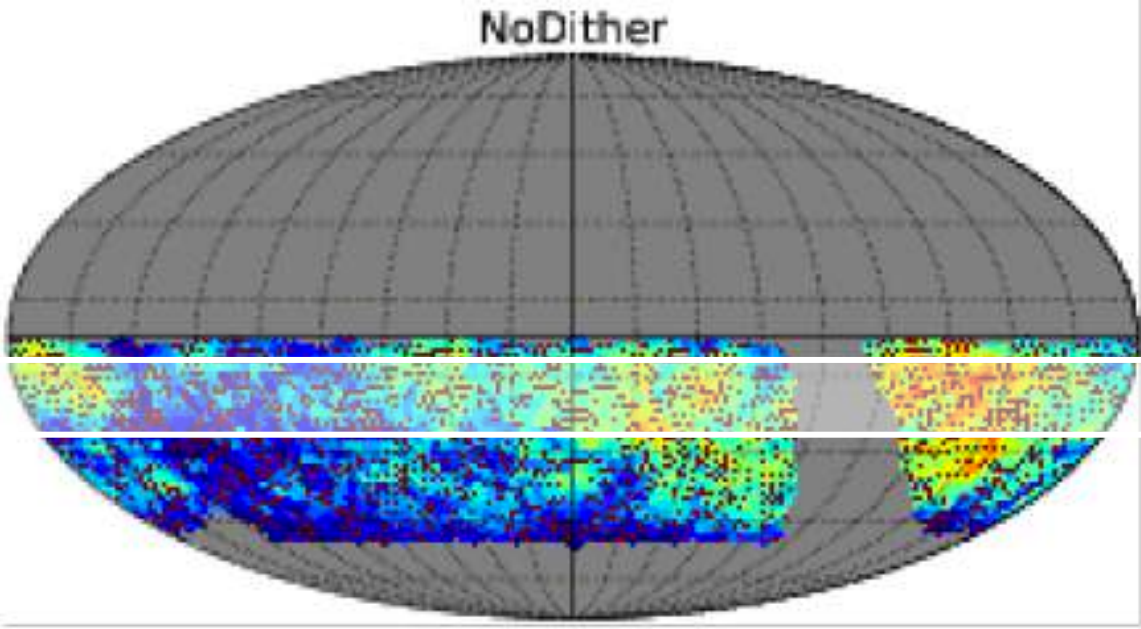
Kovetz et al, (arXiv:1709.09066)

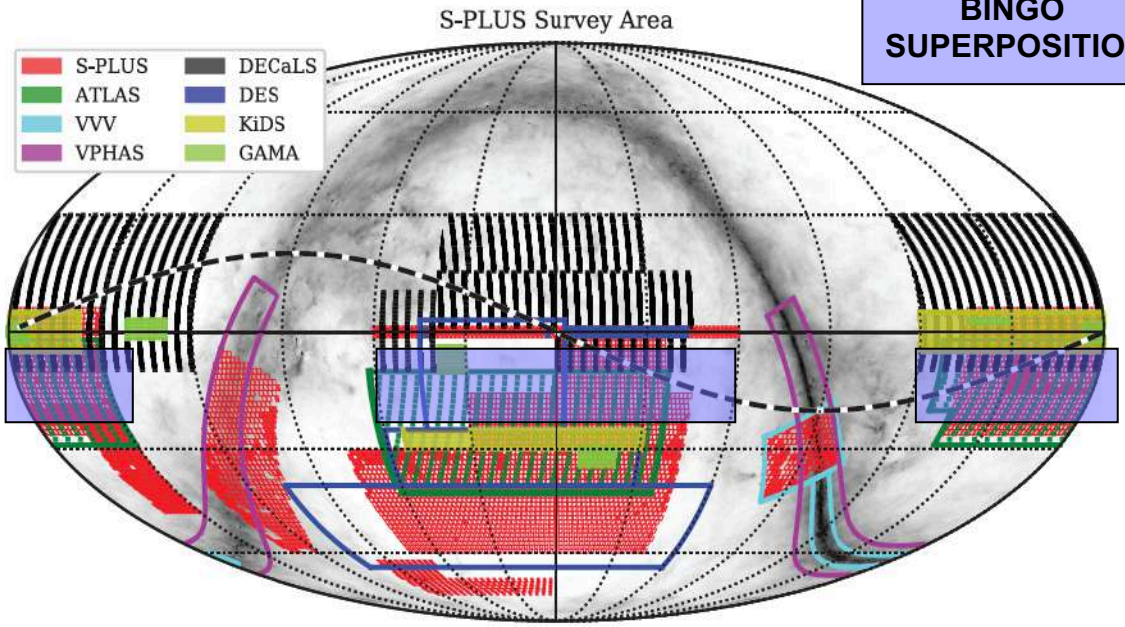


Plot from V. Liccardo

C. A. Wuensche (2020)

LSST Cosmology map (simulated).
arXiv:1708.04058, chap. 9, fig. 9.3.
BINGO coverage area in white





BINGO SUPERPOSITION

The “FIDUCIAL” BINGO (May 2020)

FIDUCIAL BINGO	
T_sys (K)	70
Frequency band (MHz)	280
#channels	40
Channel resolution (MHz)	7.5
Sampling time (Hz)	10
Min frequency (MHz) / Redshift	980 / 0,45
Max frequency (MHz) / Redshift	1260 / 0.13
Redshift band (for 40 channels)	0.008
Instrument noise (mK, 1 second)	26.5

FIDUCIAL BINGO	
Focal length (m)	63.2
Primary mirror: off-axis paraboloid	
Major/minor semi-axis (m)	25.7 / 20.0
Secondary mirror: off-axis hyperboloid	
Major/minor semi-axis (m)	18.3 / 18.0
Pixel solid angle (sr)	0.35
Optics FWHM (deg)	0.67
Survey area (square deg)	5359.75
Horns	30

Site coordinates (Aguiar, PB)	
7° 2’ 27.6" S	38° 16' 4.8" W

Fixed wire-mesh parabolas
No moving parts
Transit telescope
Most components “off-the-shelf”
Guiding principle : simplicity !

Project management status

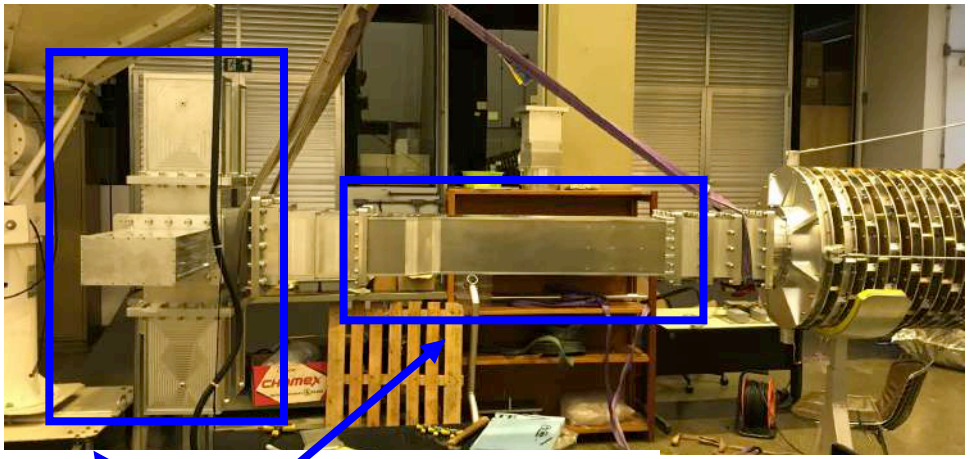
- Most of the funding (> 80%) is already granted
  - FAPESP: main funding agency.
  - General coordination: Elcio Abdalla (IF/USP)

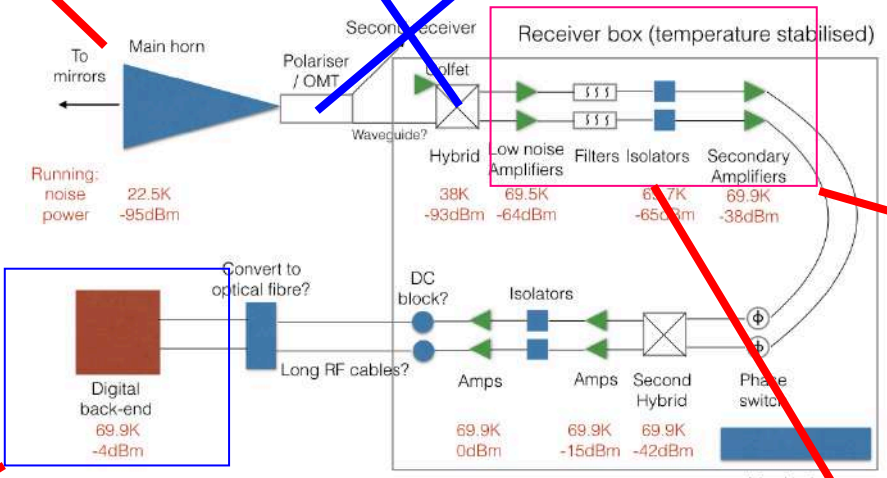
- BINGO construction proceeds…
  - Site defined => RFI initial measurements on site completed
  - Site waiting for return to normal conditions to start road work and cleaning
  - Horn, transitions, polarizer, and magic tee prototypes completed and successfully tested
  - main receiver components (first stage LNAs and filters, secondary LNAs and filters) successfully tested
  - Major Project Review 2019 → **green light to proceed to Phase 2.**
  - "Antenna" to be integrated and tested at INPE (no sky measurements)
  - "Antenna" to be integrated and tested in Paraíba (sky measurements)
  - Optical design almost completed
  - Engineering projects in discussion
  - Dish fabrication in discussion

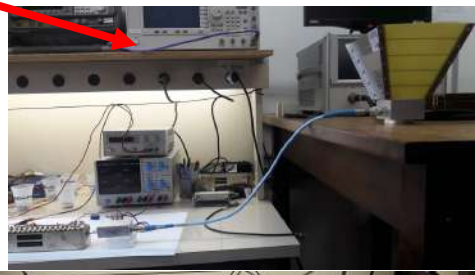
Challenges (June 2020)

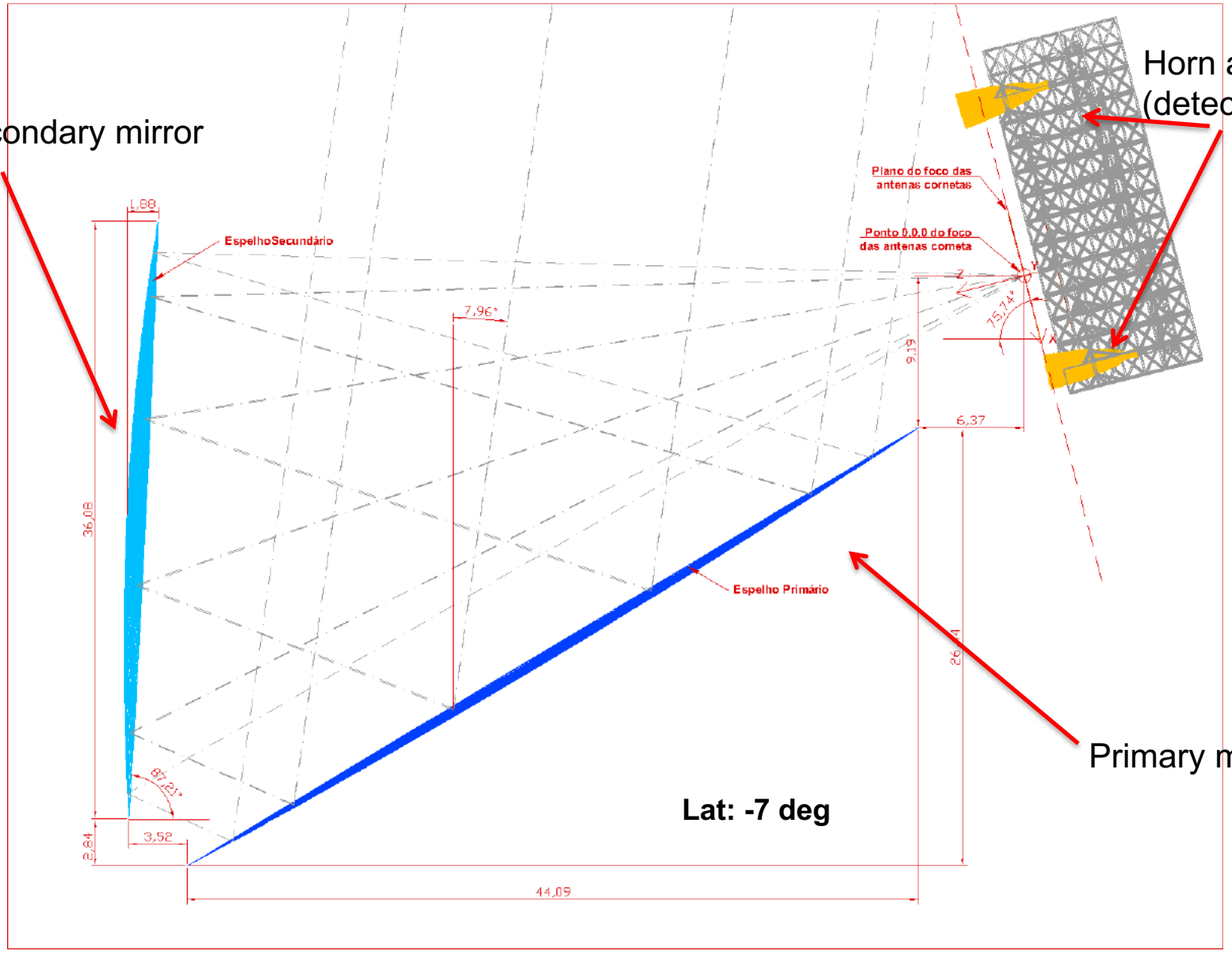
- Large telescope: **discussions ongoing with the company to produce the dishes**
- Large horns: **fabrication process understood, discussions ongoing with the company to produce the horns**
- Calibration and stability: **use colfets and a CW source as internal calibration. Noise and stability for both are under investigation**
- Receiver stability: **has to be tested with internal cooling and later, under the hot environment temperature in Paraíba**
- Digital backend: **SKARAB boards are the choice. Learning curve for their programming is not known yet, need to be integrated to the system in the lab**
- Optical design: **optics simulations indicate very small distortions of the beams for the current horn array. Final horn positioning still to be determined. TBC during commissioning**
- Radio Frequency Interference → **Mobile quiet zone has been already requested to the state authorities (both to State agencies and to ANATEL)**

THANK YOU




To mirrors
Main horn
Polariser / OMT
Waveguide?
Receiver box (temperature stabilised)
Hybrid
Low noise Amplifiers
Filters
Isolators
Secondary Amplifiers
Running:
noise 22.5K
power -95dBm
38K
-93dBm
69.5K
-64dBm
69.9K
-38dBm
Convert to optical fibre?
Digital back-end
69.9K
-4dBm
Long RF cables?
DC block?
Isolators
Amps
Amps
Second Hybrid
69.9K
0dBm
69.9K
-15dBm
69.9K
-42dBm

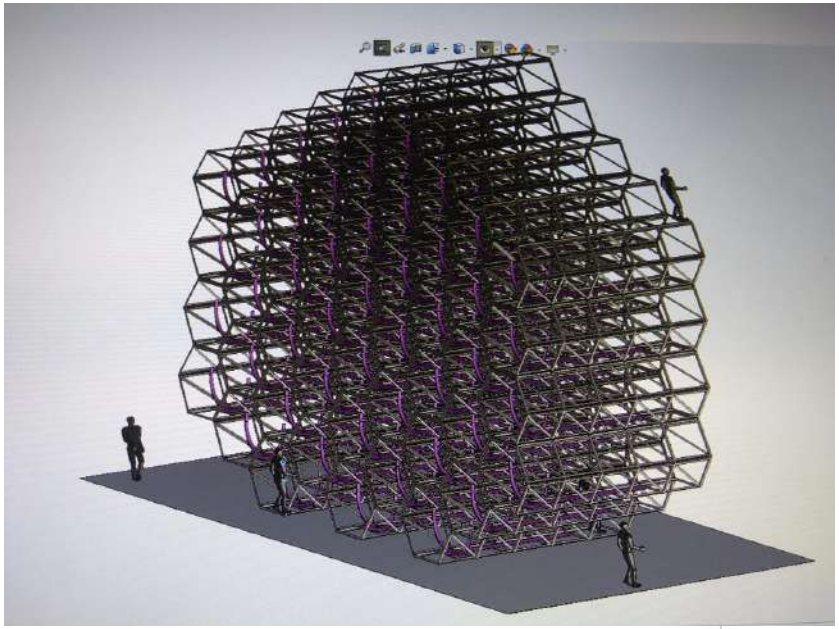




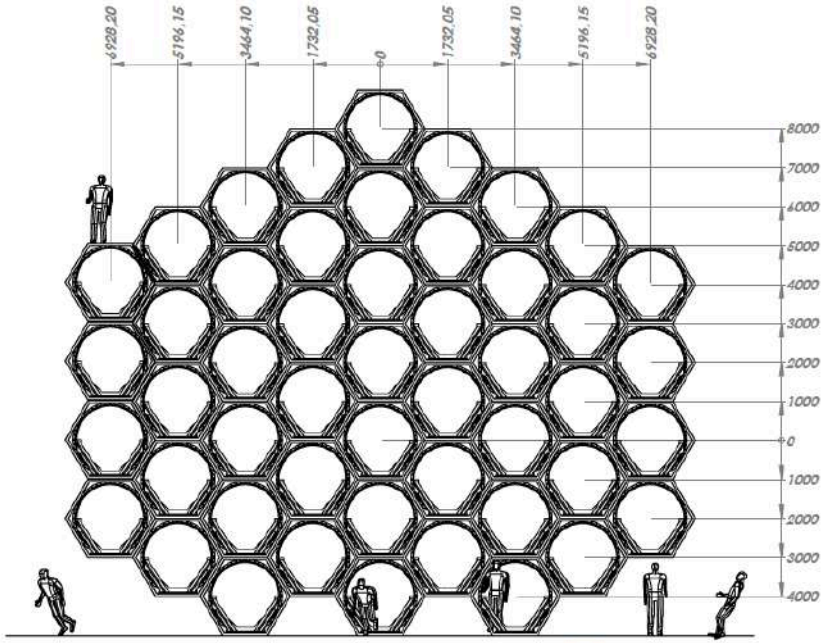
Contributions of Maffei, Ferreira, Abdalla, Souza

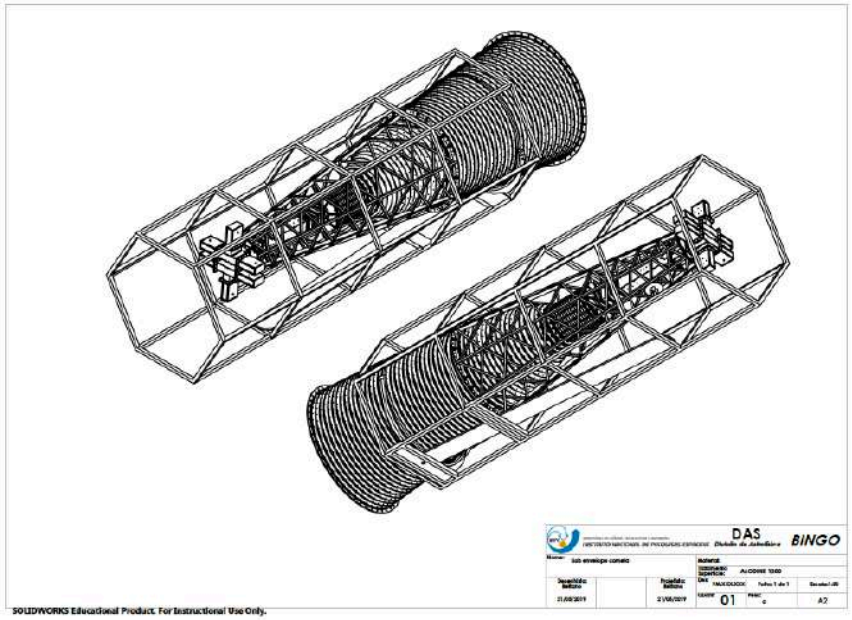
C. A. Wuensche (2020)

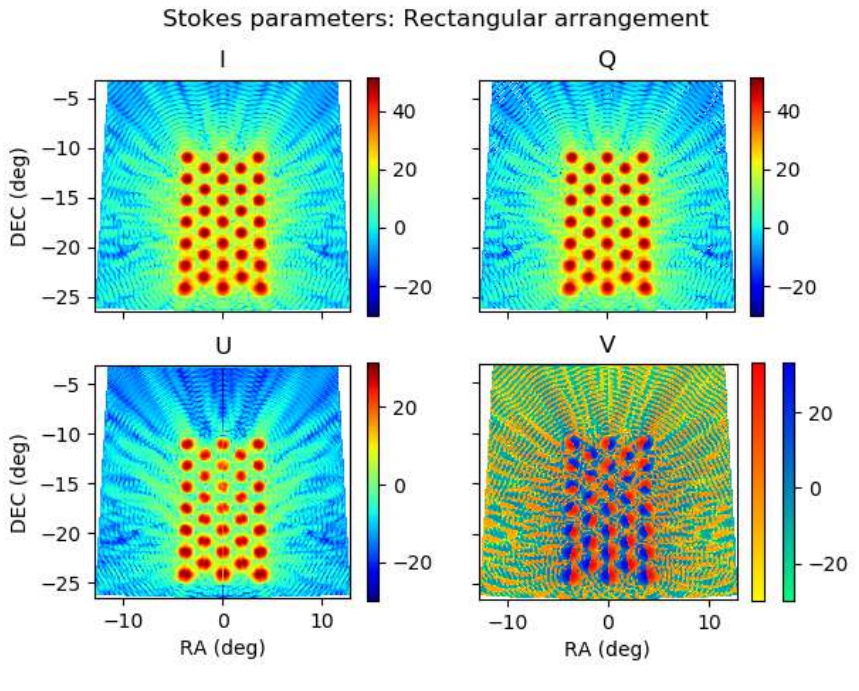
BINGO

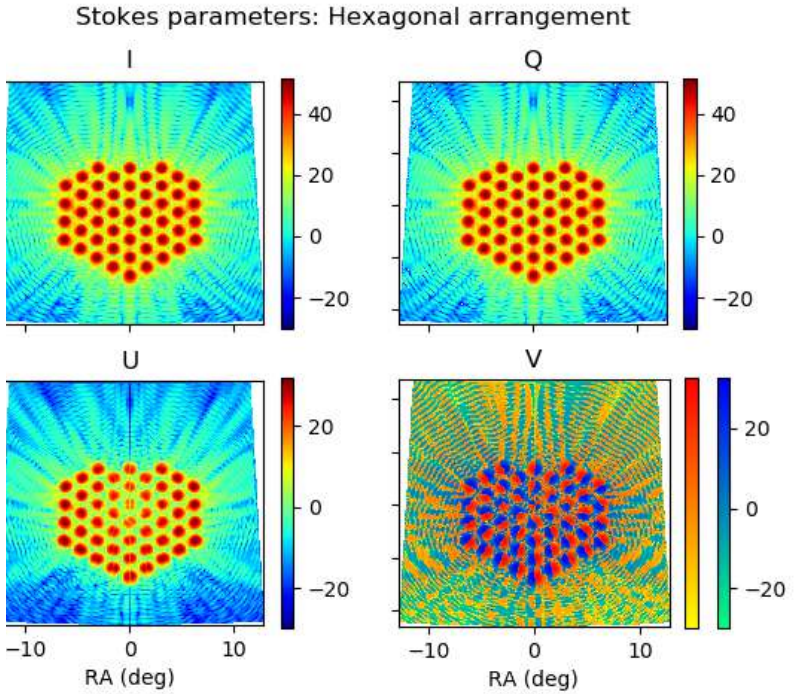


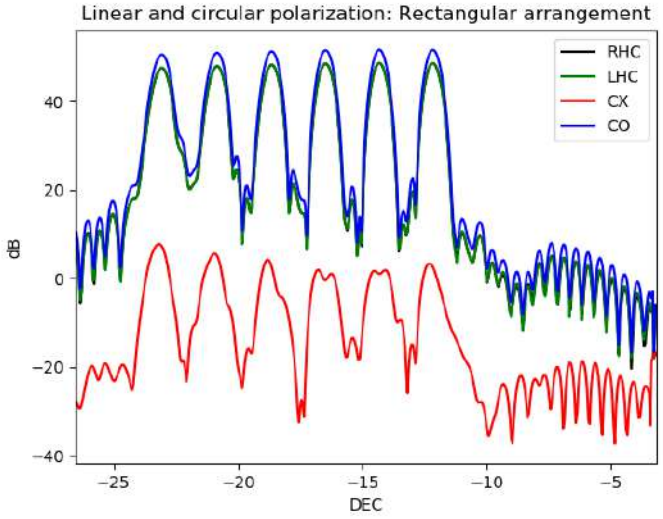
From L. A. Reitano

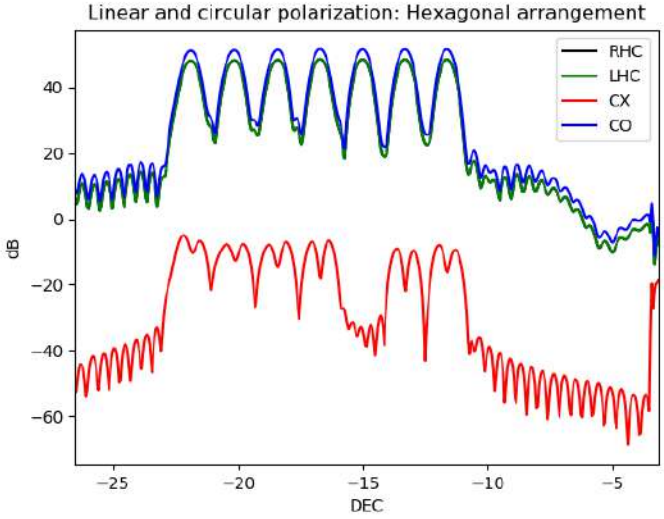






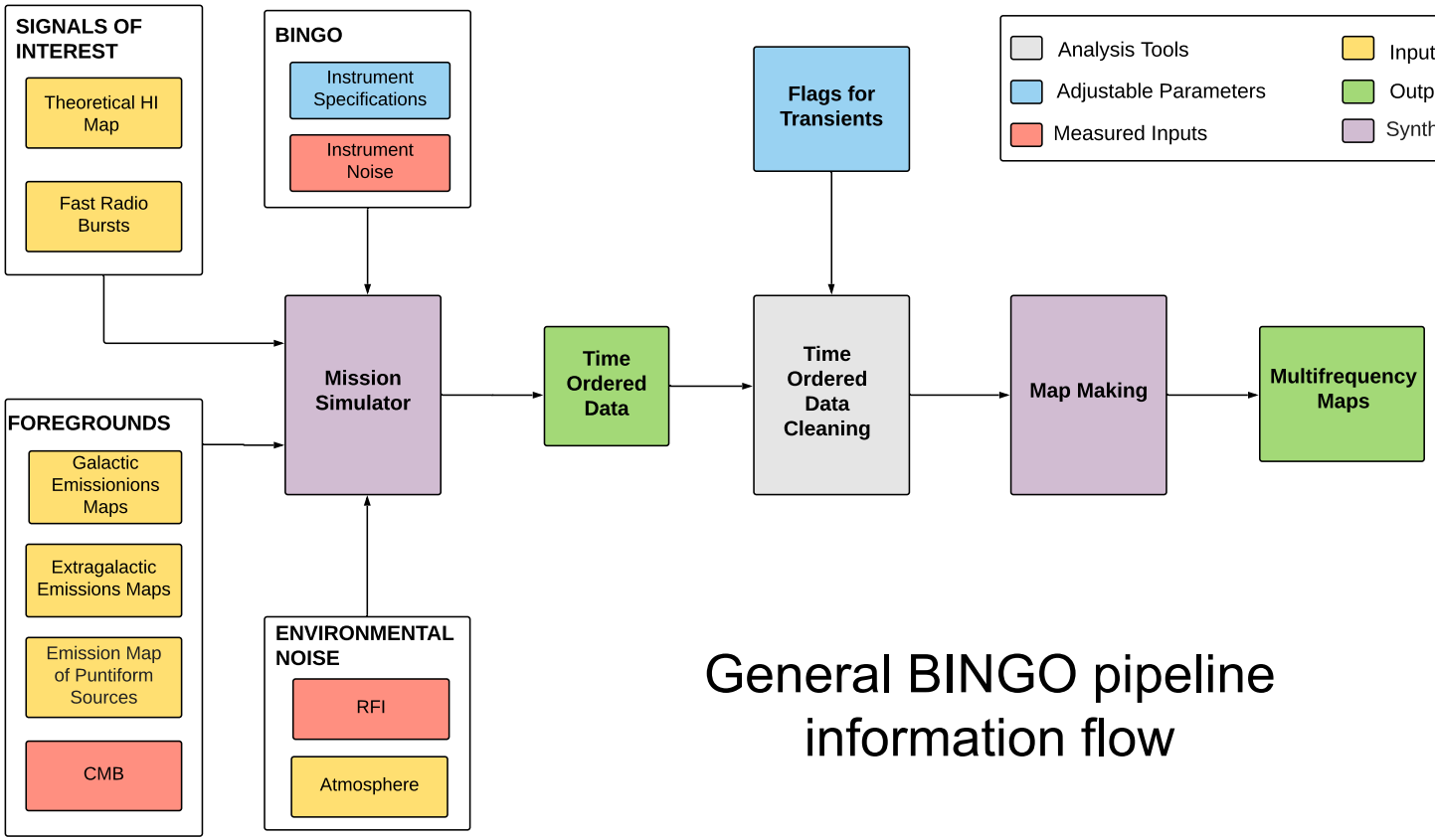




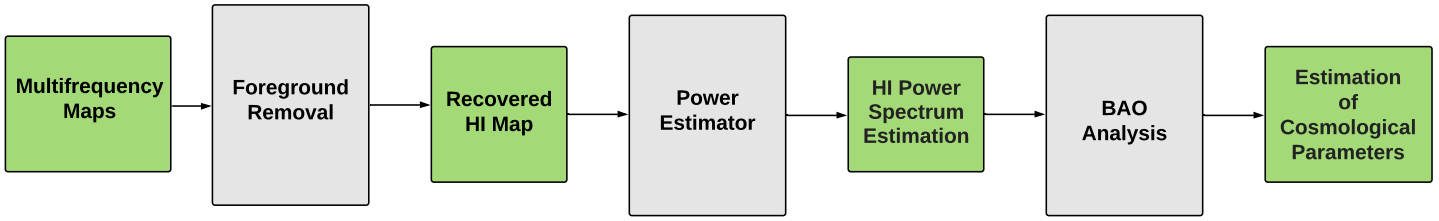


Abdalla, Marins, Mota et al., in preparation

C. A. Wuensche (2020)

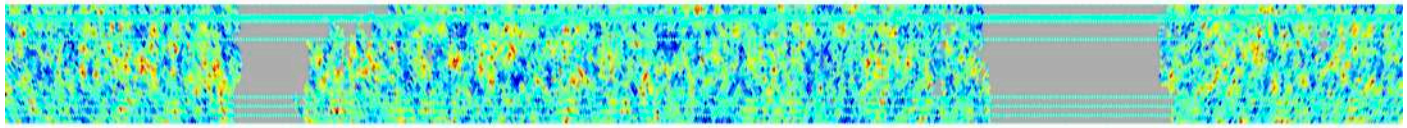


General BINGO pipeline information flow

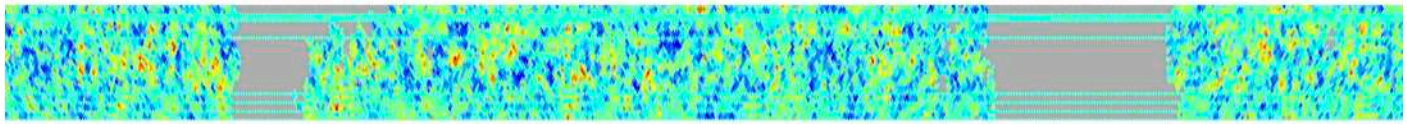


From E. Merícia

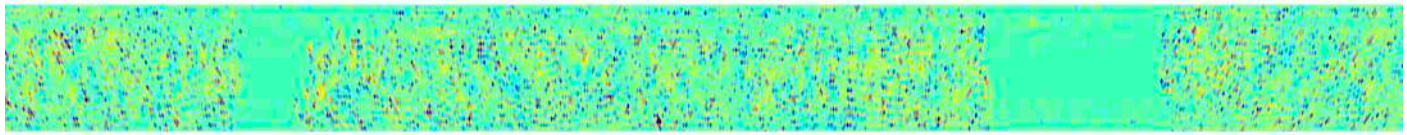
C. A. Wuensche (2020)



BINGO simulated input map @ 1100 MHz

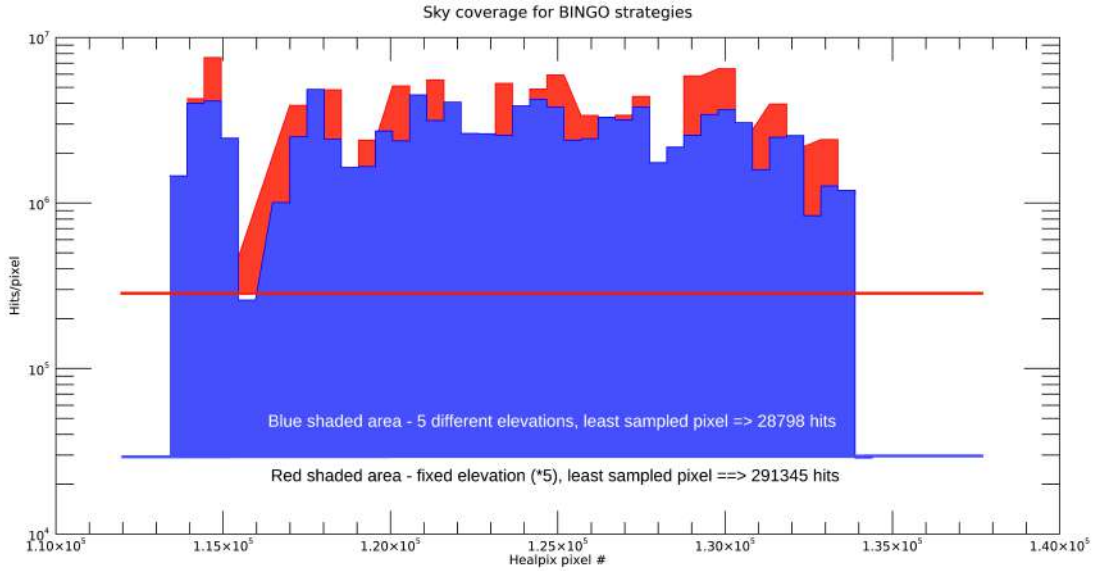


BINGO reconstructed map @ 1100 MHz



Residuals −0.18 0.25 mK

From V. Liccardo



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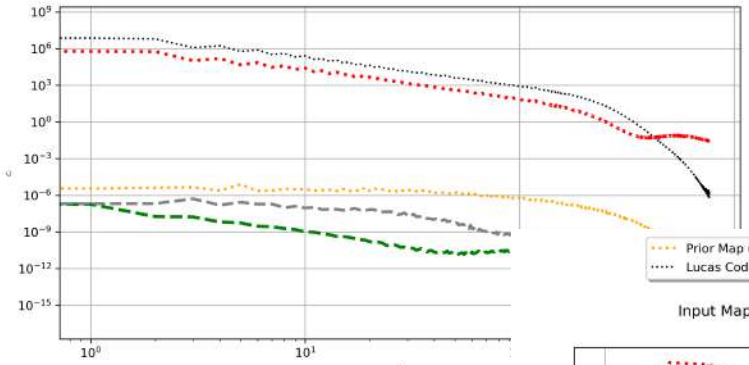
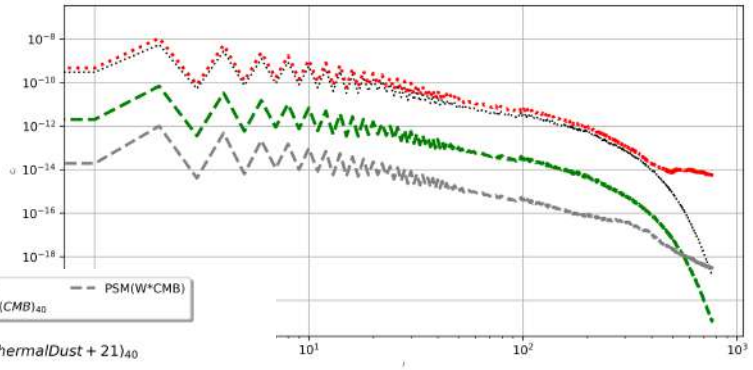
From K. Fornazier

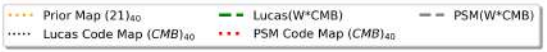
Component separation

Input Map $= (CMB + FreeFree + Synch + ThermalDust + 21)_{40}$

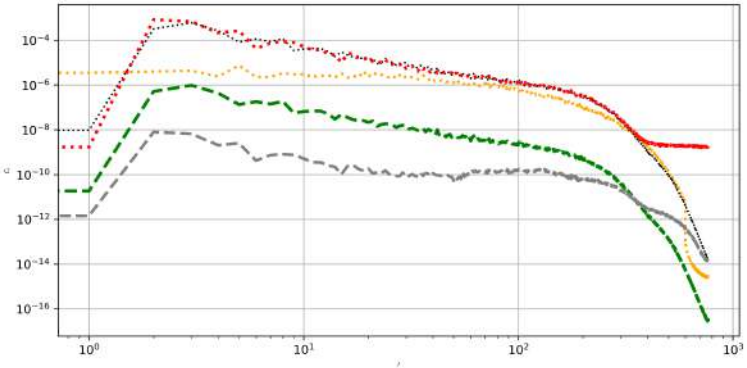


Input Map $= (CMB + FreeFree + Synch + ThermalDust + 21)_{40}$

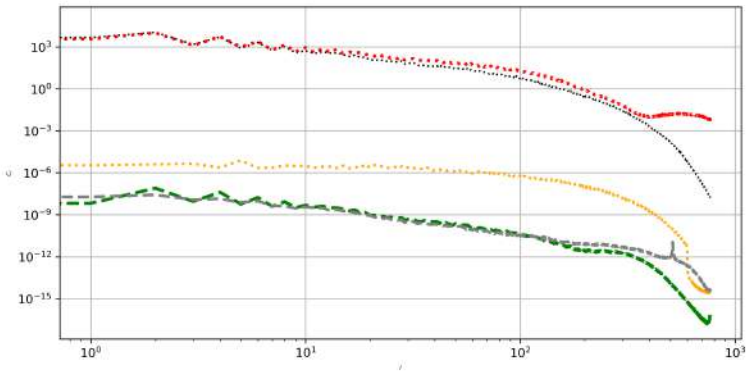




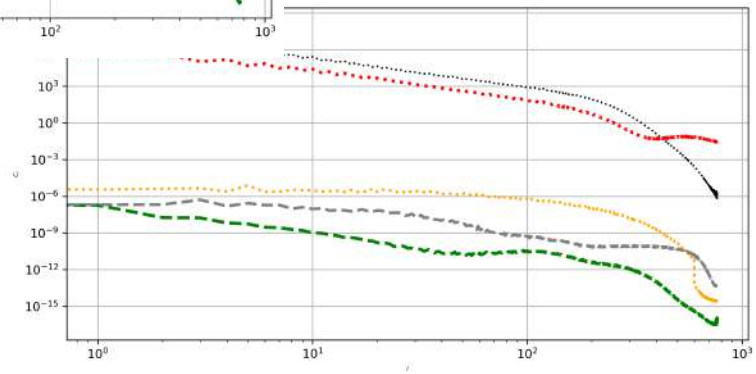
Input Map $= (CMB + FreeFree + Synch + ThermalDust + 21)_{40}$



Input Map $= (CMB + FreeFree + Synch + Therm$



$MB + FreeFree + Synch + ThermalDust + 21)_{40}$

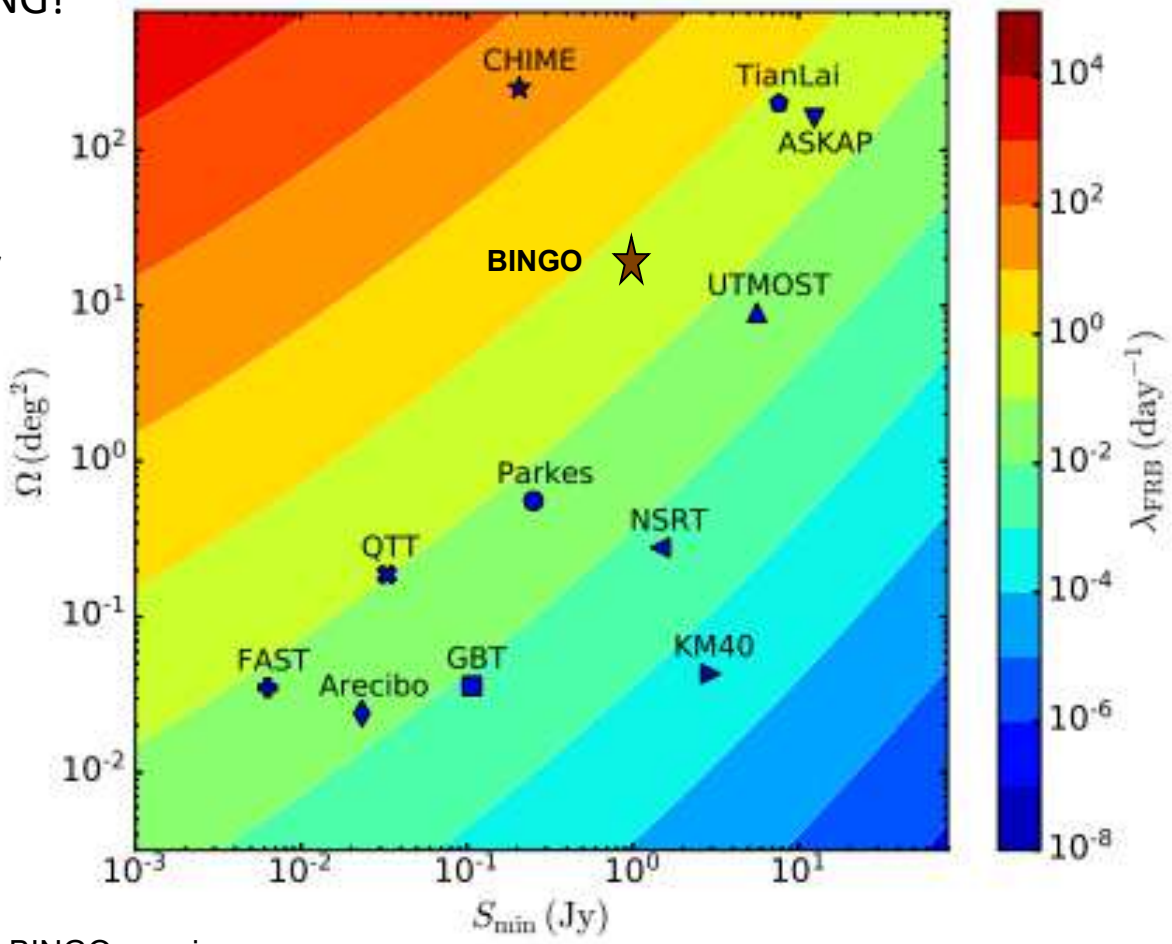


C. A. Wuensche (2020)

- FRB is not BINGO main science, but serendipitous detections are expected
- Outriggers for interferometric pinpoint of the progenitor are being planned
- Needs ADDITIONAL FUNDING!

M.Sc. thesis from F. Vieira (2020) presented a preliminary analysis performance regarding FRB detections

For ~ 3 Jy (max flux density) BINGO will likely see about 1 event every 2.84 days…



Luo et al., arXiv:2003.04848

Landim, Vieira, Vargas et al.: estimates for BINGO ongoing