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

BINGO

An overview of the BINGO radio telescope

Carlos Alexandre Wuensche, Alessandro Marins

And the BINGO Collaboration

ca.wuensche@inpe.br

August 24, 2022

22-26 AUGUST 2022
RIO DE JANEIRO, BRAZIL

photo - © Thierry Cohen

Plan of the talk

- ☑ Motivation: 21 cm cosmology
- ☑ Methodology: intensity mapping
- ☑ The instrument
- ☑ Current results and status

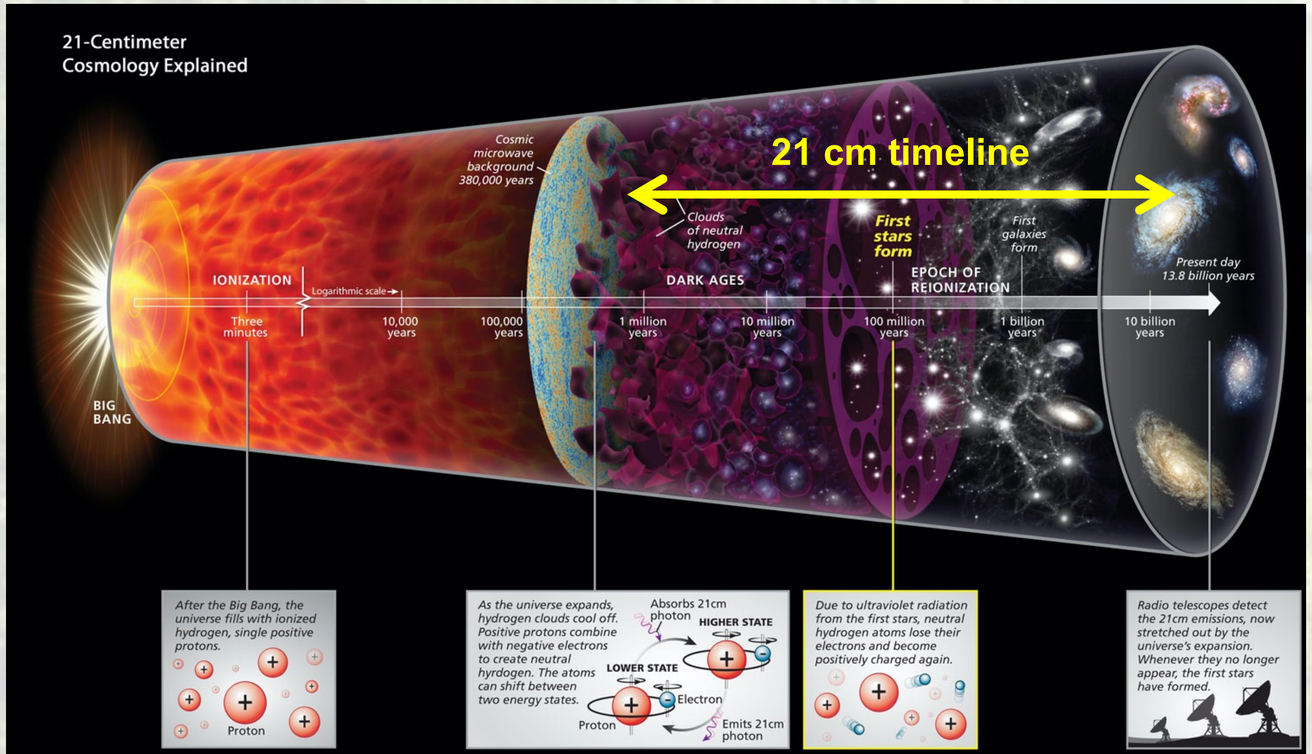
BAO from Integrated Neutral Gas Observations

21 cm cosmology

- ☑ Information between CMB and local Universe
- ☑ Probe hydrogen ionization states across the Universe history
- ☑ Traces the matter distribution and its evolution in large cosmological volumes
- ☑ Provides information about the dynamics of the Universe
- ☑ Can be used to trace BAOs in the radio band

$$\delta T_b(\nu) \approx 9 X_{HI}(1+\delta_b)\left[1-\frac{T_\gamma(z)}{T_s}\right] \times$$

$$\times\ (1+z)^{1/2}\left[\frac{H(z)/(1+z)}{dv_{||}/dr_{||}}\right](mK)$$



$$\boxed{T_S^{-1} = \frac{T_\gamma^{-1} + x_\alpha T_\alpha^{-1} + x_c T_K^{-1}}{1 + x_\alpha + x_c}}$$

α => coupling constants
T_γ => CMB
T_α => WF coupling
T_K => scattering
x_i => coupling constants

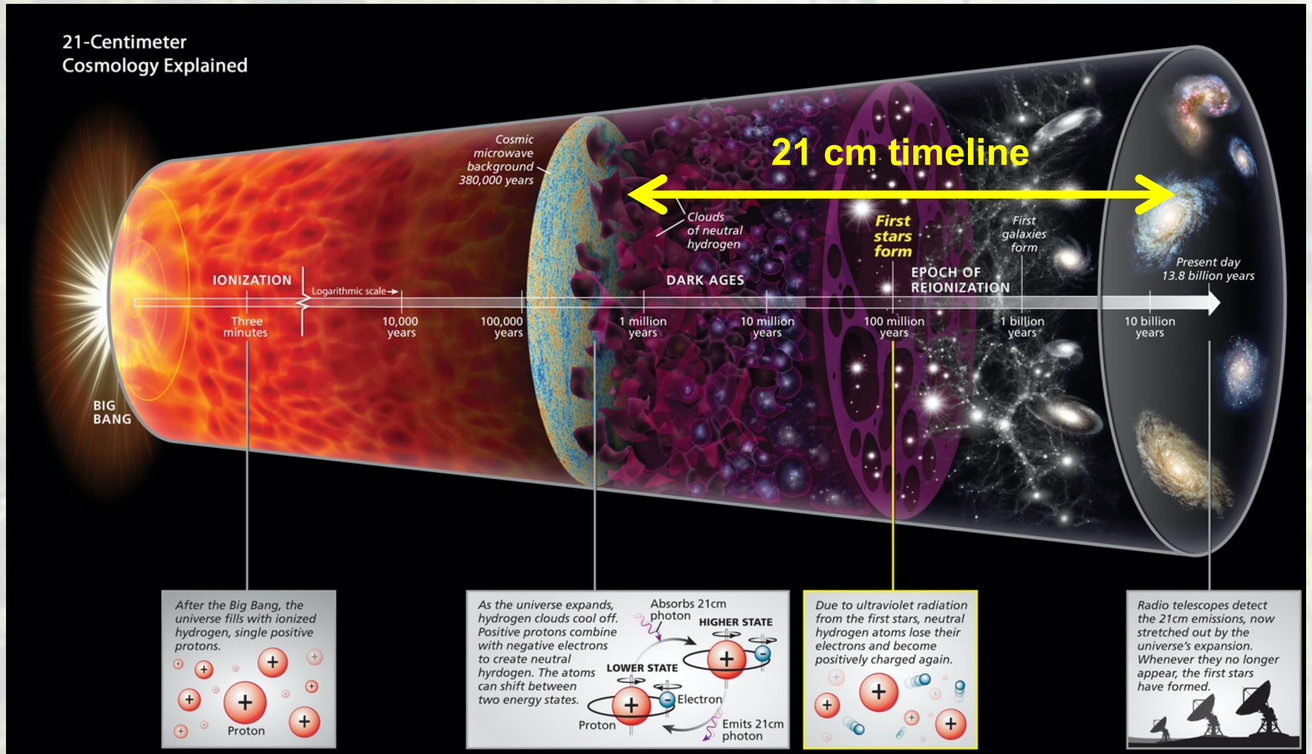
21 cm cosmology

- ☑ Information between CMB and local Universe
- ☑ Probe hydrogen ionization states across the Universe history
- ☑ Traces the matter distribution and its evolution in large cosmological volumes
- ☑ Provides information about the dynamics of the Universe
- ☑ Can be used to trace BAOs in the radio band

Fraction of HI

$$\delta T_b(\nu) \approx 9 X_{HI}(1+\delta_b)\left[1-\frac{T_\gamma(z)}{T_s}\right] \times$$

$$\times\ (1+z)^{1/2}\left[\frac{H(z)/(1+z)}{dv_{||}/dr_{||}}\right](mK)$$



$$\boxed{T_S^{-1} = \frac{T_\gamma^{-1} + x_\alpha T_\alpha^{-1} + x_c T_K^{-1}}{1 + x_\alpha + x_c}}$$

α => coupling constants
T_γ => CMB
T_α => WF coupling
T_K => scattering
x_i => coupling constants

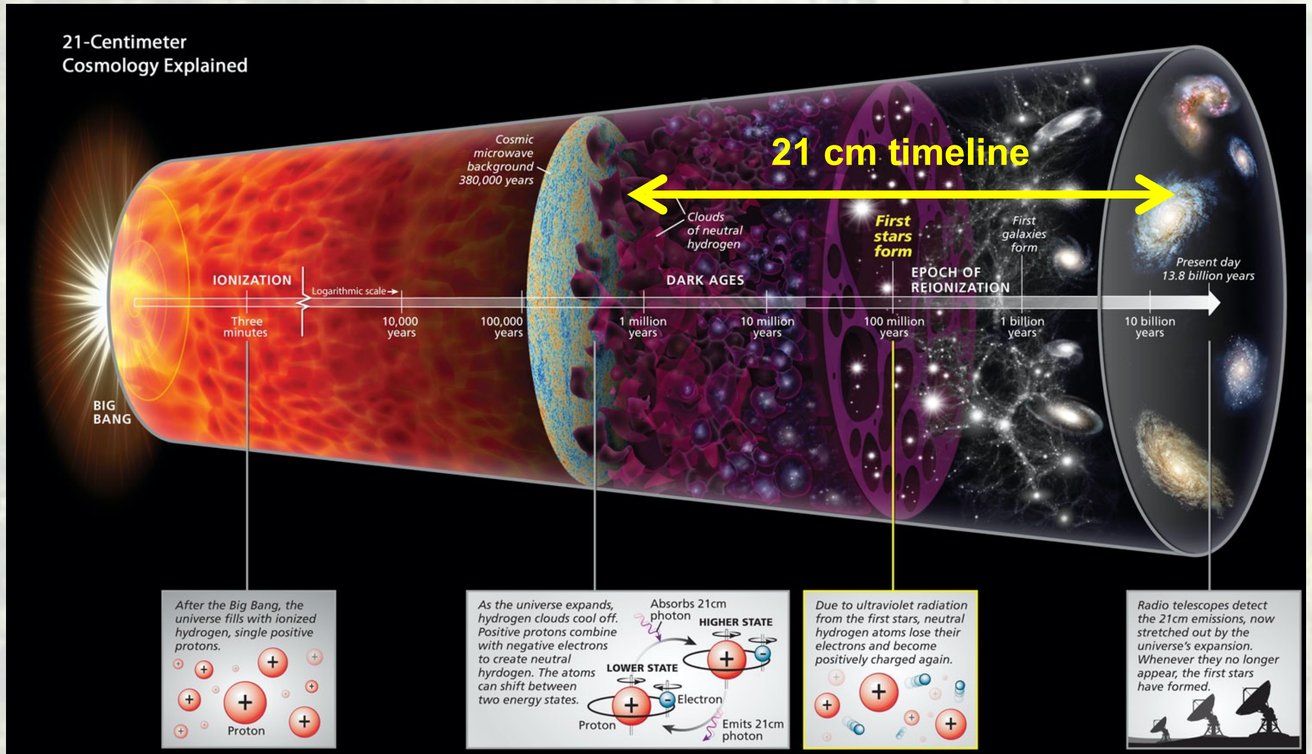
21 cm cosmology

- ☑ Information between CMB and local Universe
- ☑ Probe hydrogen ionization states across the Universe history
- ☑ Traces the matter distribution and its evolution in large cosmological volumes
- ☑ Provides information about the dynamics of the Universe
- ☑ Can be used to trace BAOs in the radio band

Fraction of HI — Baryon fractional overdensity

$$\delta T_b(\nu) \approx 9 X_{HI}(1+\delta_b)\left[1-\frac{T_\gamma(z)}{T_s}\right] \times$$

$$\times\ (1+z)^{1/2}\left[\frac{H(z)/(1+z)}{dv_{||}/dr_{||}}\right](mK)$$



$$\boxed{T_S^{-1} = \frac{T_\gamma^{-1} + x_\alpha T_\alpha^{-1} + x_c T_K^{-1}}{1 + x_\alpha + x_c}}$$

α => coupling constants
T_γ => CMB
T_α => WF coupling
T_K => scattering
x_i => coupling constants

21 cm cosmology

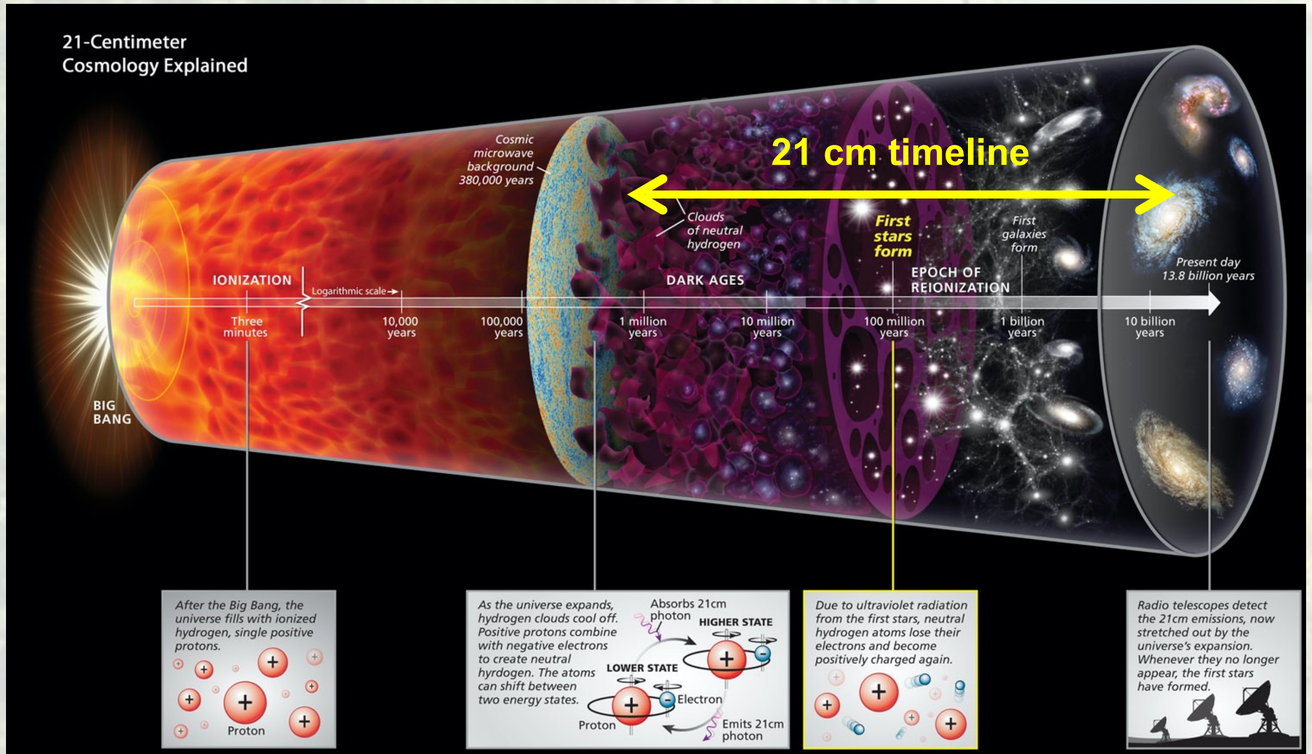
- ☑ Information between CMB and local Universe
- ☑ Probe hydrogen ionization states across the Universe history
- ☑ Traces the matter distribution and its evolution in large cosmological volumes
- ☑ Provides information about the dynamics of the Universe
- ☑ Can be used to trace BAOs in the radio band

Fraction of HI — Baryon fractional overdensity

$$\delta T_b(\nu) \approx 9 X_{HI}(1+\delta_b)\left[1-\frac{T_\gamma(z)}{T_s}\right] \times$$

$$\times\ (1+z)^{1/2}\left[\frac{H(z)/(1+z)}{dv_{||}/dr_{||}}\right](mK)$$

Spin temperature

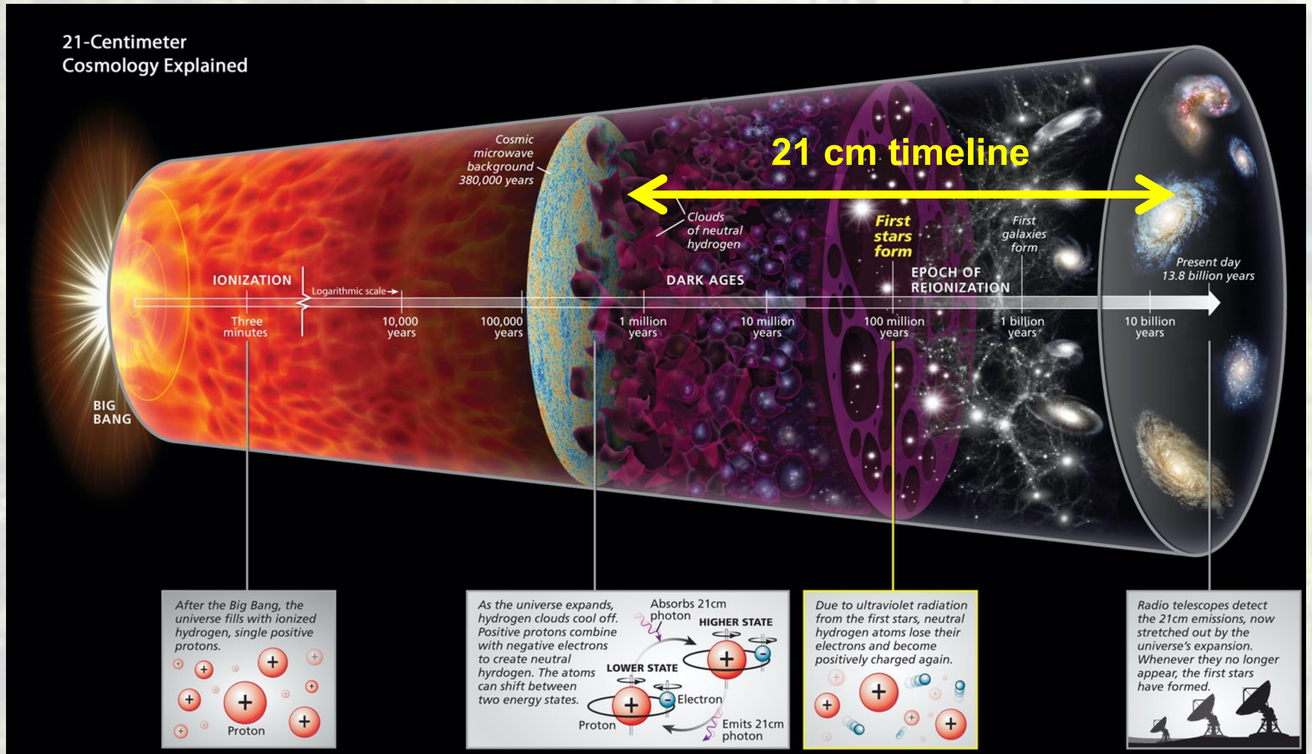


$$T_S^{-1} = \frac{T_\gamma^{-1} + x_\alpha T_\alpha^{-1} + x_c T_K^{-1}}{1 + x_\alpha + x_c}$$

α => coupling constants
T_γ => CMB
T_α => WF coupling
T_K => scattering
x_i => coupling constants

21 cm cosmology

- ☑ Information between CMB and local Universe
- ☑ Probe hydrogen ionization states across the Universe history
- ☑ Traces the matter distribution and its evolution in large cosmological volumes
- ☑ Provides information about the dynamics of the Universe
- ☑ Can be used to trace BAOs in the radio band



Fraction of HI — Baryon fractional overdensity

$$\delta T_b(\nu) \approx 9 X_{HI}(1+\delta_b)\left[1-\frac{T_\gamma(z)}{T_s}\right] \times$$

$$\times\ (1+z)^{1/2}\left[\frac{H(z)/(1+z)}{dv_{||}/dr_{||}}\right](mK)$$

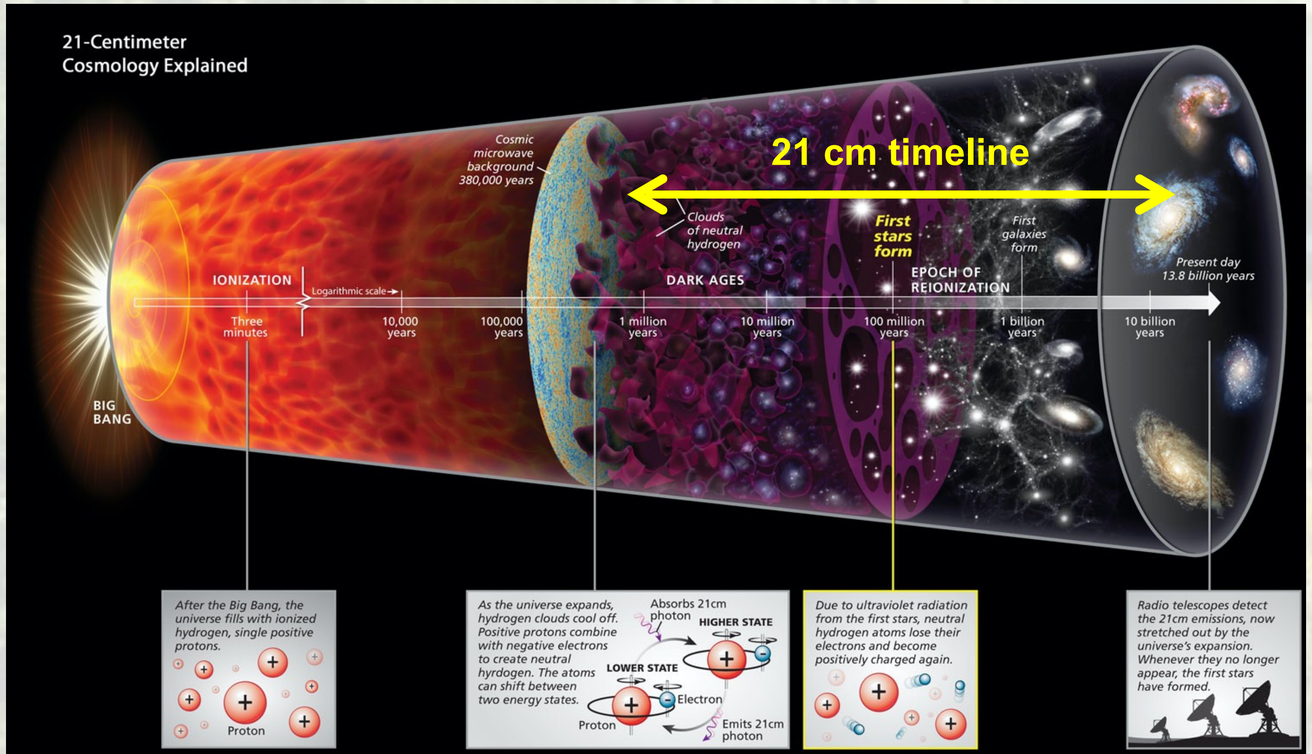
LoS velocity gradient — Spin temperature

$$T_S^{-1} = \frac{T_\gamma^{-1} + x_\alpha T_\alpha^{-1} + x_c T_K^{-1}}{1 + x_\alpha + x_c}$$

α => coupling constants
T_γ => CMB
T_α => WF coupling
T_K => scattering
x_i => coupling constants

21 cm cosmology

- ☑ Information between CMB and local Universe
- ☑ Probe hydrogen ionization states across the Universe history
- ☑ Traces the matter distribution and its evolution in large cosmological volumes
- ☑ Provides information about the dynamics of the Universe
- ☑ Can be used to trace BAOs in the radio band



Fraction of HI — Baryon fractional overdensity — **Astrophysics**

$$\delta T_b(\nu) \approx 9 X_{HI}(1+\delta_b)\left[1-\frac{T_\gamma(z)}{T_s}\right] \times (1+z)^{1/2}\left[\frac{H(z)/(1+z)}{dv_{||}/dr_{||}}\right](mK)$$

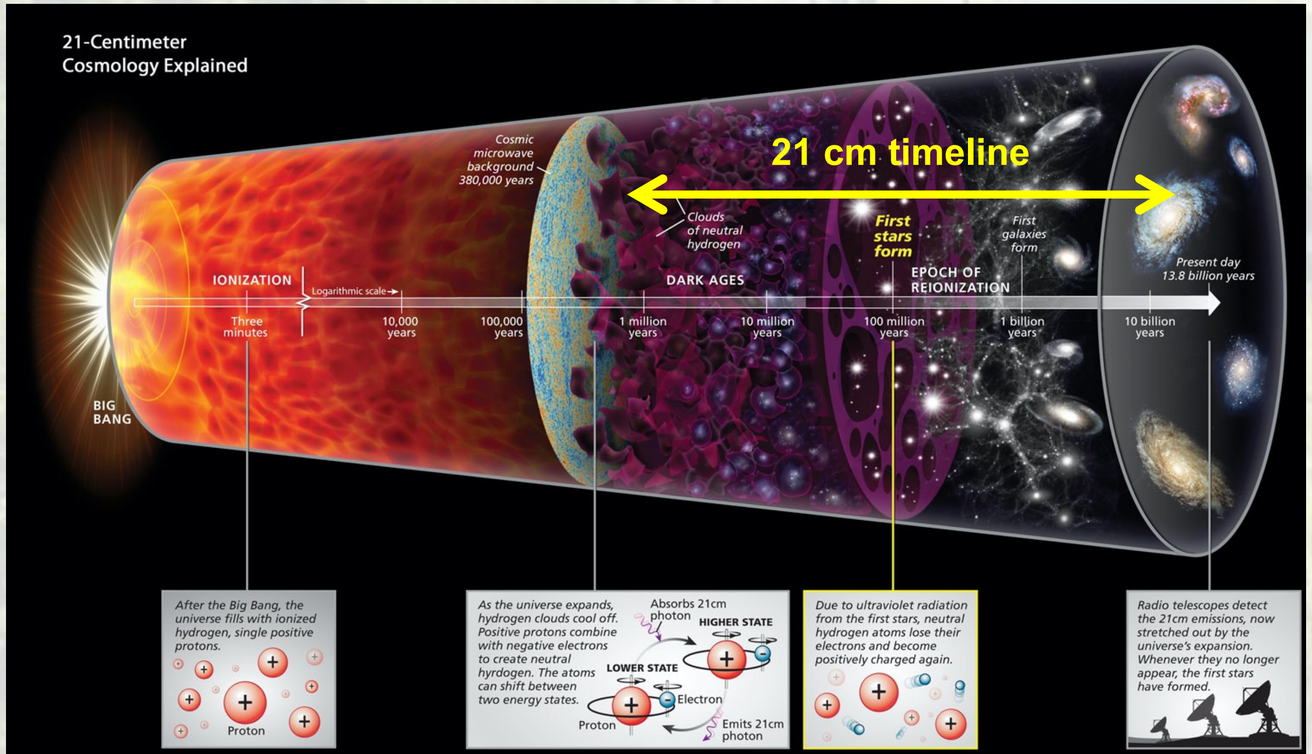
LoS velocity gradient — Spin temperature

$$T_S^{-1} = \frac{T_\gamma^{-1} + x_\alpha T_\alpha^{-1} + x_c T_K^{-1}}{1 + x_\alpha + x_c}$$

α => coupling constants
T_γ => CMB
T_α => WF coupling
T_K => scattering
x_i => coupling constants

21 cm cosmology

- ☑ Information between CMB and local Universe
- ☑ Probe hydrogen ionization states across the Universe history
- ☑ Traces the matter distribution and its evolution in large cosmological volumes
- ☑ Provides information about the dynamics of the Universe
- ☑ Can be used to trace BAOs in the radio band



Fraction of HI — Baryon fractional overdensity — **Astrophysics**

$$\delta T_b(\nu) \approx 9 X_{HI}(1+\delta_b)\left[1-\frac{T_\gamma(z)}{T_s}\right] \times$$

$$\times\ (1+z)^{1/2}\left[\frac{H(z)/(1+z)}{dv_{||}/dr_{||}}\right](mK)$$

Cosmology

LoS velocity gradient

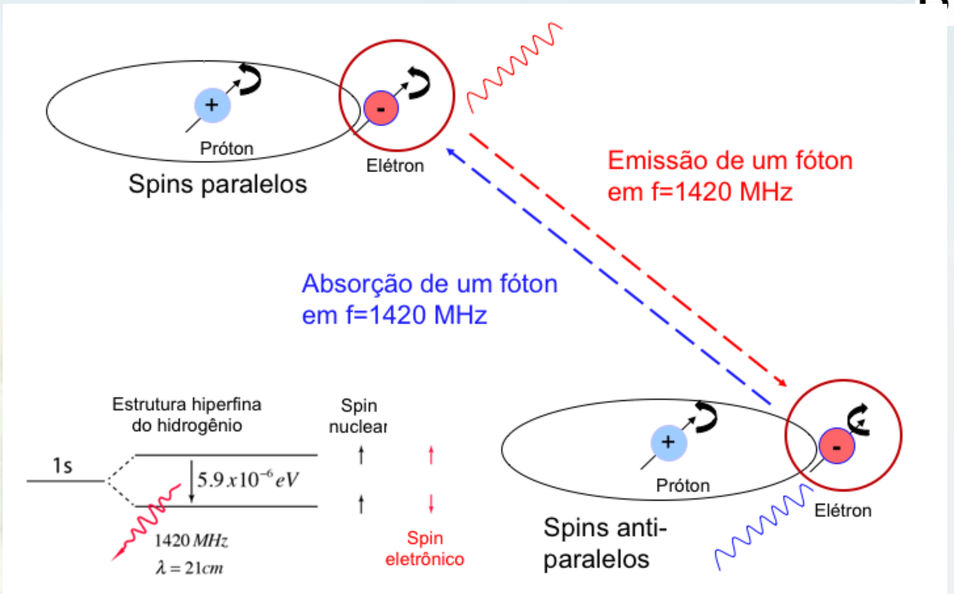
Spin temperature

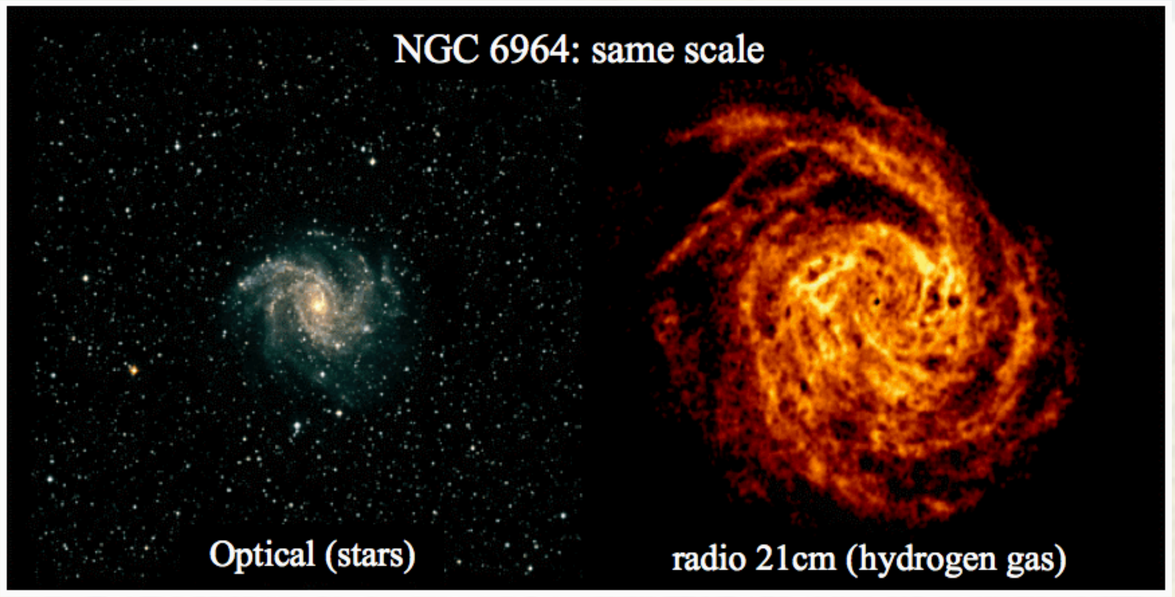
$$T_S^{-1} = \frac{T_\gamma^{-1} + x_\alpha T_\alpha^{-1} + x_c T_K^{-1}}{1 + x_\alpha + x_c}$$

α => coupling constants
T_γ => CMB
T_α => WF coupling
T_K => scattering
x_i => coupling constants

Atomic Hydrogen 21 cm line

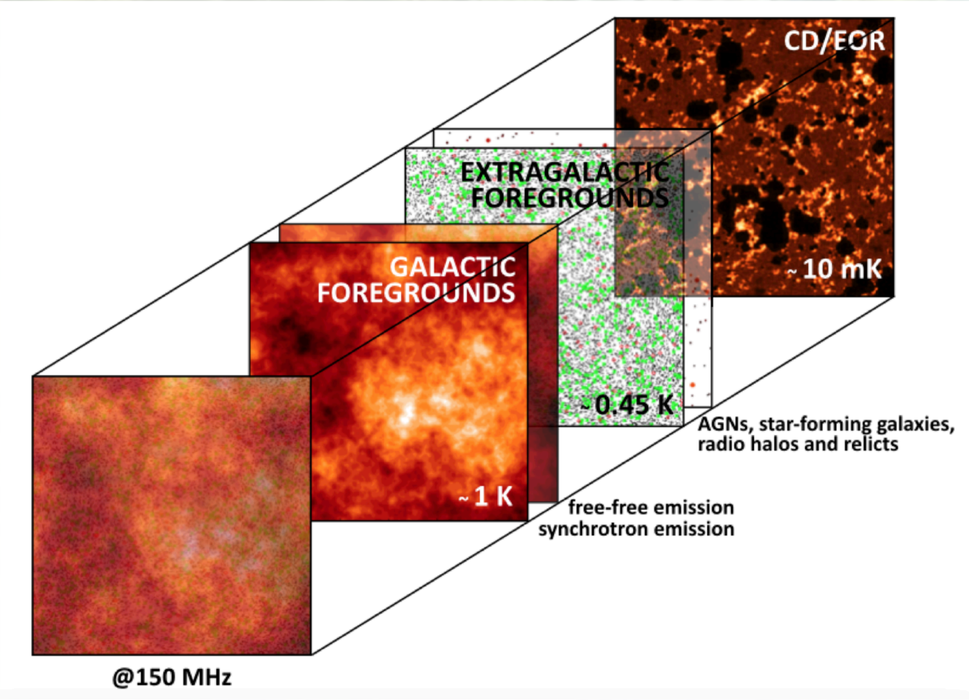
- ☑ H is the most abundant element in the Universe
- ☑ Neutral H (HI) is most important, BUT:
  - ✓ Very hard to detect in cosmological distances
- ☑ 21 cm “forbidden” transition line
  - ✓ 1 atom emits a photon every 10^{15} s
  - ✓ Weak signal
  - ✓ Frequency: 1420.406 MHz (~ 21 cm waveleght – radio)
- ☑ Observed since 1950s’ but only restricted to the Galaxy and neighbor galaxies (z < 0.1)
- ☑ Doppler shift of HI line gives direct information of velocity and distance





The Intensity Mapping (IM) concept

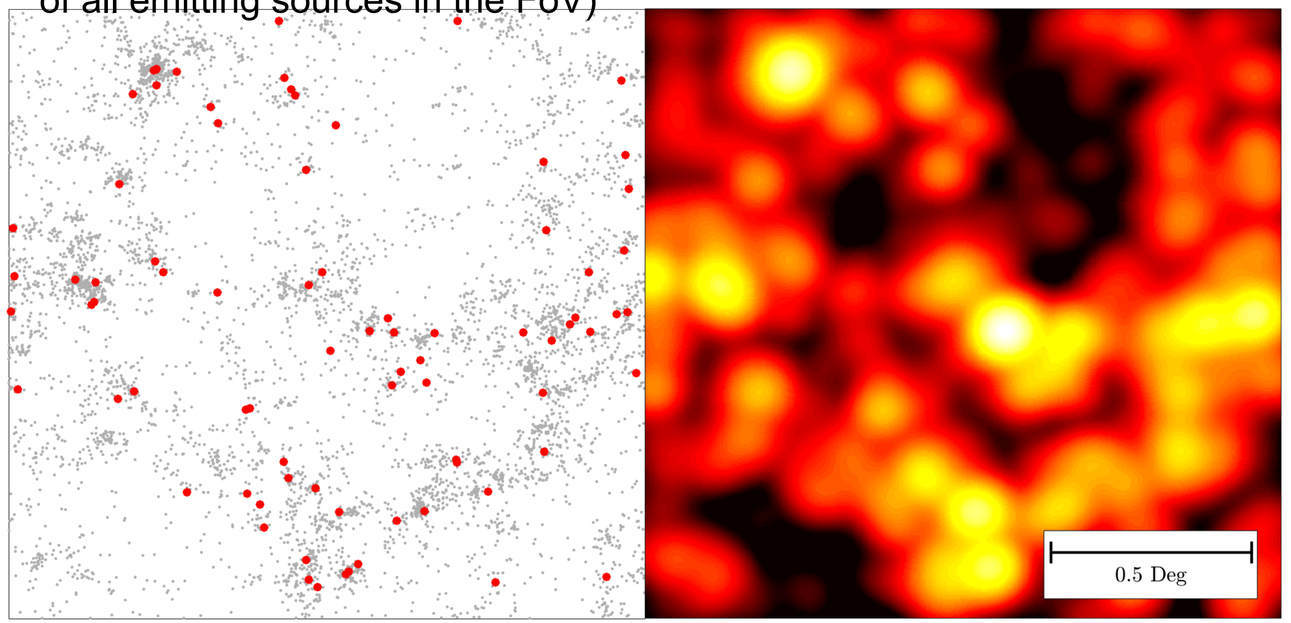
- ☑ Measure the large scale features from the integrated emission of galaxies + IGM
- ☑ Can collect info from spectral line of different elements (H, C, O, …)
- ☑ Does not worry about individual objects
- ☑ Large z coverage in a tmogropaphical fashion
- ☑ Allows for 3D imaging (data cubes)
- ☑ **Collects a lot of foreground emission in the same frequency band**



C. A. Wuensche (2022)

VLA (simulated, 4500h, detects 1% of all emitting sources in the FoV)

COMAP (simulated, 1500h, sensitive to all sources emitting in the FoV)

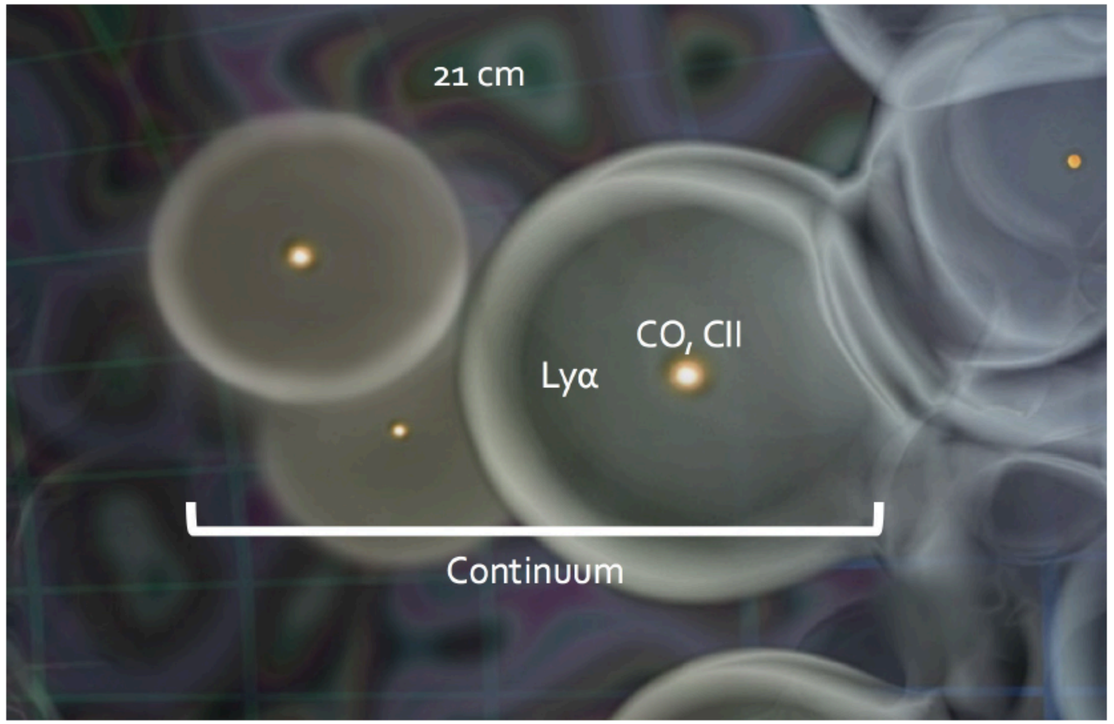


CO emission

Kovetz et al, (arXiv:1709.09066)

CO, CII – star formation regions
Ly-alpha – galaxy halos
HI – neutral gas from outside bubbles
Continuum - CIB

Different environments, different physics, deeper understanding of the star formation process at high-z



Kovetz et al, (arXiv:1709.09066)

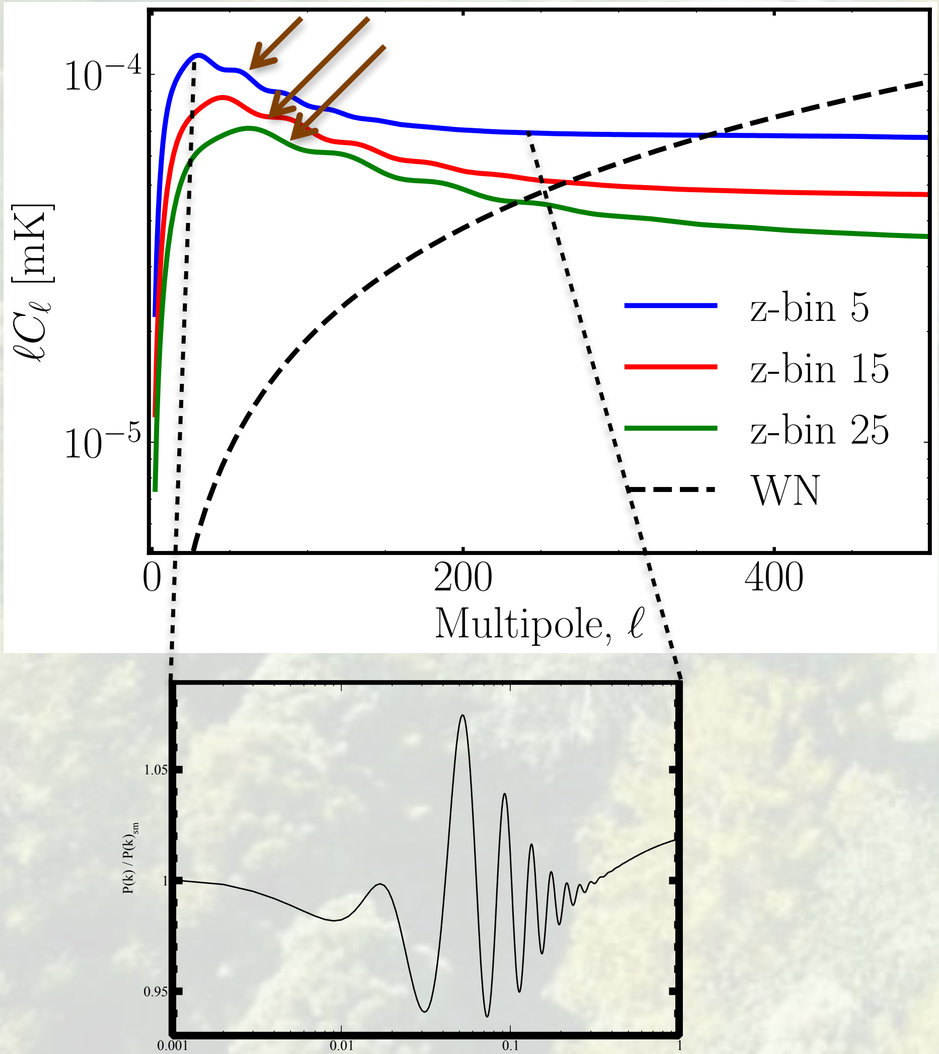
- ☑ Use relatively large beam on the sky
  - ✓ Measure HI *fluctuations*
- ☑ HI intensity mapping can be used as mass tracer, probing distortions in redshift space
- ☑ No competition in the radio
- ☑ Complementary to large optical surveys
- ☑ Similar to CMB, using: $\Delta T_{CMB} = \Delta T_{CMB}(\theta, \phi, z = 1100)$

$$\Delta T_{HI} = \Delta T_{HI}(\theta, \phi, z)$$

C. A. Wuensche (2022)

21 cm science using intensity mapping

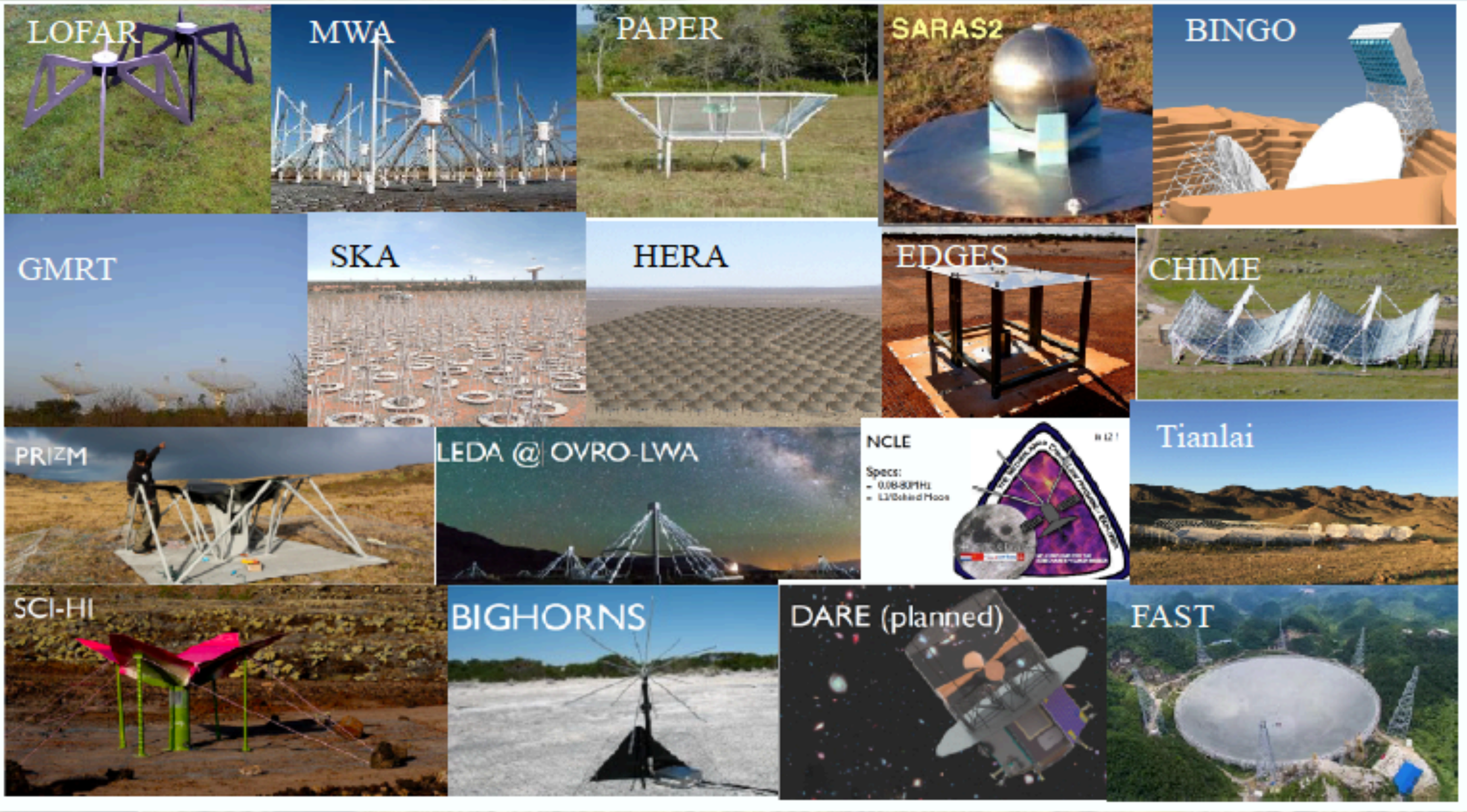
BAOs (superimposed on top of HI signal)



- HI traces matter distribution and can be used to measure BAO
- Powerful probe of Dark Energy
- Can be also used as a cosmological standard ruler
- BAO size: ~ 150 Mpc

(Novaes et al. arXiv:2207.12125)

21 cm science is a very hot topic in 21 century astrophysics



Assembly: Marta Bruno Silva (Univ of Oslo)

C. A. Wuensche (2022)

The BINGO Telescope- BAOs in Integrated Neutral Gas Observations

Visit us at https://bingotelescope.org

The BINGO main science case

- ☑ Measure BAOs on top of the 21 cm Hydrogen spectrum
- ☑ HI intensity mapping can be used as mass tracer, probing distortions in redshift space
- ☑ ADDITIONAL SCIENCE
  - ☑ Life history of hydrogen
  - ☑ Radio recombination lines
  - ☑ Galactic continuum
- ☑ Time domain analysis
  - ✓ FRB
  - ✓ Pulsar timing analysis
  - ✓ Other radio transients.

Project status (August 2022)

- ☑ Almost of needed funding (> 85%) is already granted
  - ✓ FAPESP: main state funding agency
  - ✓ Paraiba government: funding for mirror construction and structure
  - ✓ FINEP: funding for civil engineering work
  - ✓ Other funding sources from China, MCTI, CNPq, INPE
- ☑ BINGO civil construction is ongoing…
  - ✓ Road work to site ongoing
  - ✓ Terrain preparation for foundations ongoing
  - ✓ All antenna parts (horns + front end) successfully tested (2018 – 2021)
  - ✓ Main receiver components qualified, assembled & tested (2020 – 2022)
  - ✓ Integration to the digital backend at INPE completed - migration to SKARAB boards completed
  - ✓ Optical design completed (2021) and mirror + supporting structure contract in production
  - ✓ First horn prototype coupled to a simple radiometer currently looking at the sky in Paraíba

Estimated first light (one horn): May 2023

Estimated total costs: ~ US$ 7M

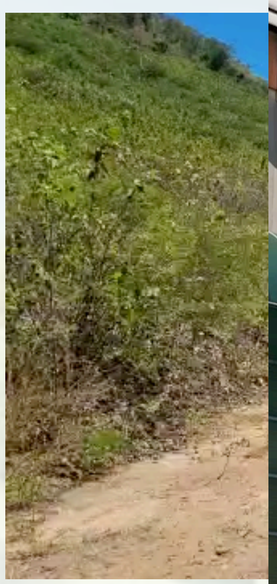
Project status (August 2022)

- ☑ Almost of needed funding (> 85%) is already granted
  - ✓ FAPESP: main state funding agency
  - ✓ Paraiba government: funding for mirror construction and structure
  - ✓ FINEP: funding for civil engineering work
  - ✓ Other funding sources from China, MCTI, CNPq, INPE
- ☑ BINGO civil construction is ongoing…
  - ✓ Road work to site ongoing
  - ✓ Terrain preparation for foundations ongoing
  - ✓ All antenna parts (horns + front end) successfully tested (2018 – 2021)
  - ✓ Main receiver components qualified, assembled & tested (2020 – 2022)
  - ✓ Integration to the digital backend at INPE completed - migration to SKARAB boards completed
  - ✓ Optical design completed (2021) and mirror + supporting structure contract in production
  - ✓ First horn prototype coupled to a simple radiometer currently looking at the sky in Paraíba

Estimated first light (one horn): May 2023

Estimated total costs: ~ US$ 7M

Project status (August 2022)

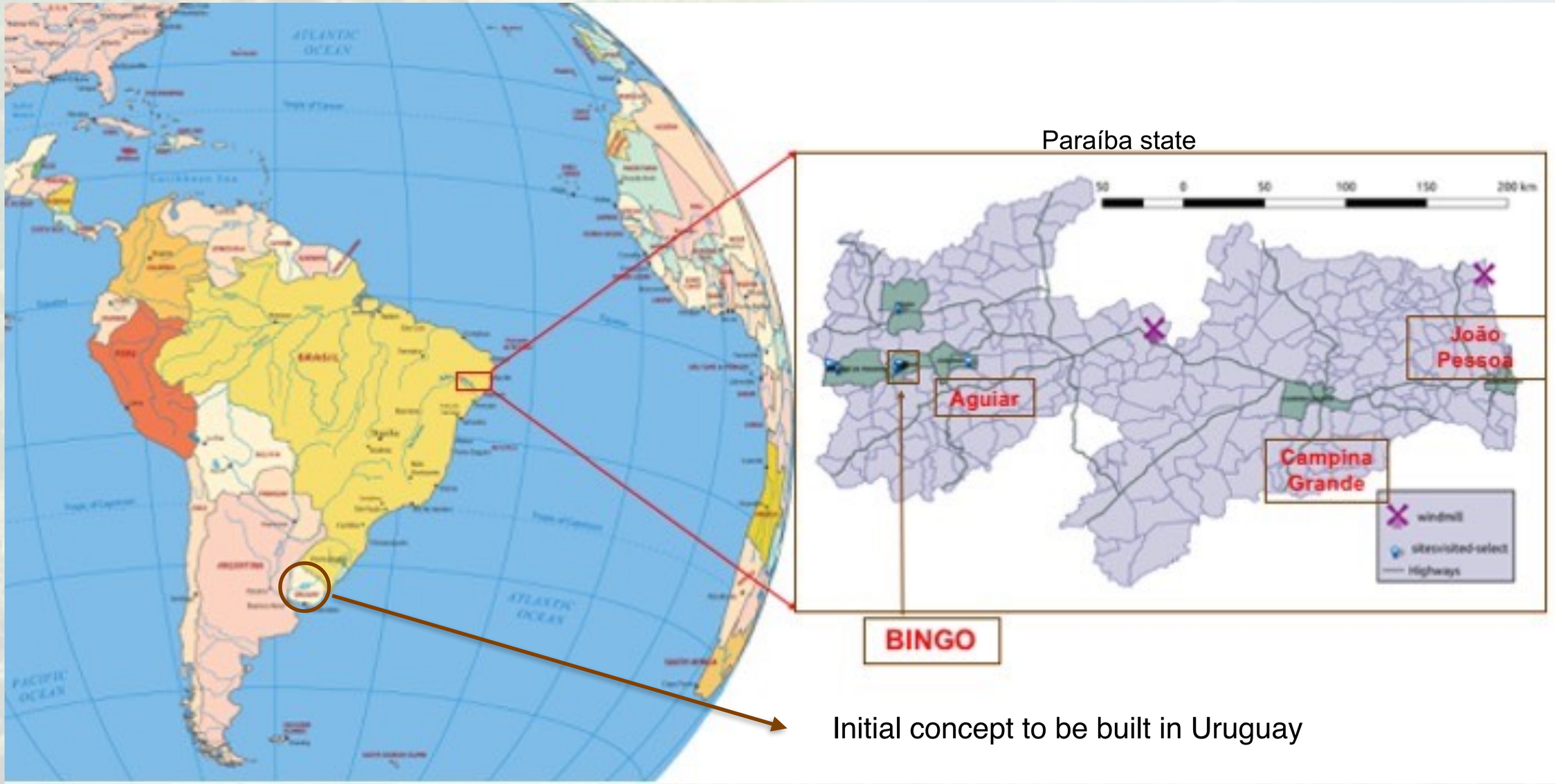


- ☑ Almost of needed funding (> 85%) is already granted
  - ✓ FAPESP: main state funding agency
  - ✓ Paraiba government: funding for mirror construction and structure
  - ✓ FINEP: funding for civil engineering work
  - ✓ Other funding sources from China, MCTI, CNPq, INPE
- ☑ BINGO civil construction is ongoing…
  - ✓ Road work to site ongoing
  - ✓ Terrain preparation for foundations ongoing
  - ✓ All antenna parts (horns + front end) successfully tested (2018 – 2021)
  - ✓ Main receiver components qualified, assembled & tested (2020 – 2022
  - ✓ Integration to the digital backend at INPE completed - migration to SKA
  - ✓ Optical design completed (2021) and mirror + supporting structure con
  - ✓ First horn prototype coupled to a simple radiometer currently looking a

Estimated first light (one horn): May 2023

Estir

The BINGO location: Coords: 7° 2' 27.6” S; 38° 16' 4.8" W



Serra da Catarina, Vale do Piancó (PB)

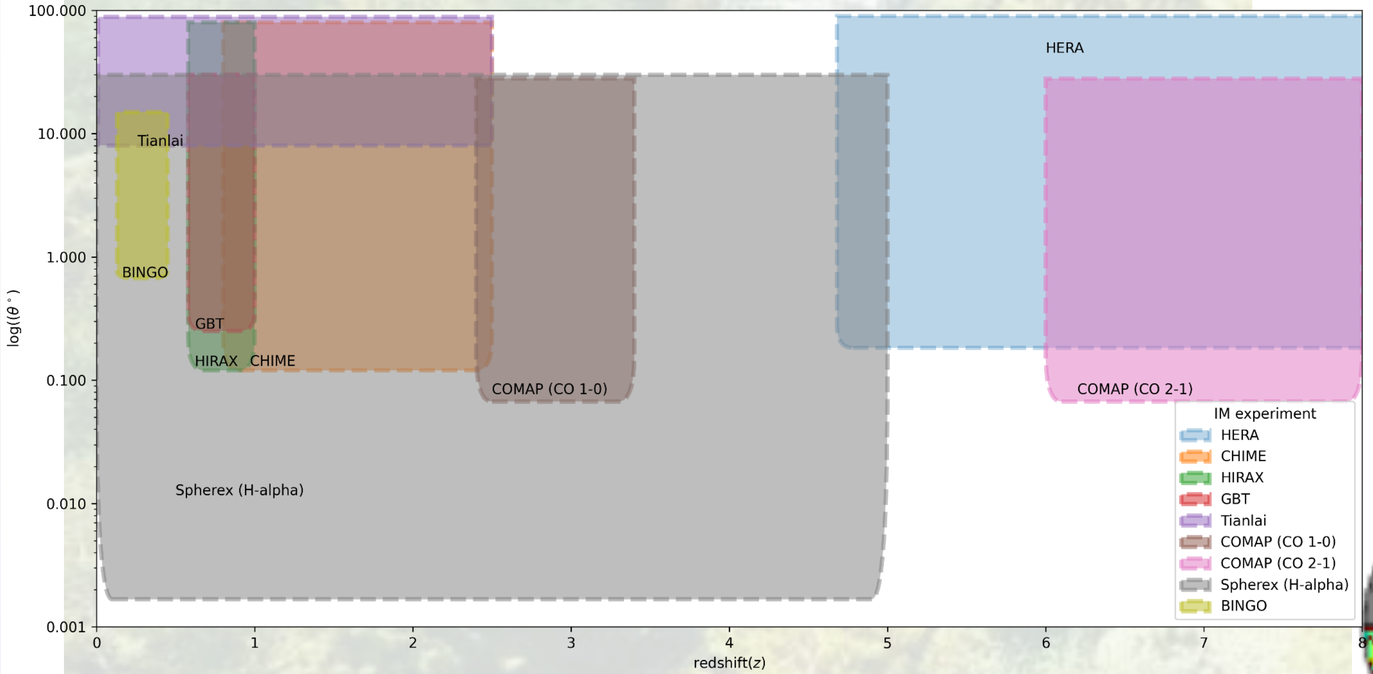
Photos: A. Queiroz

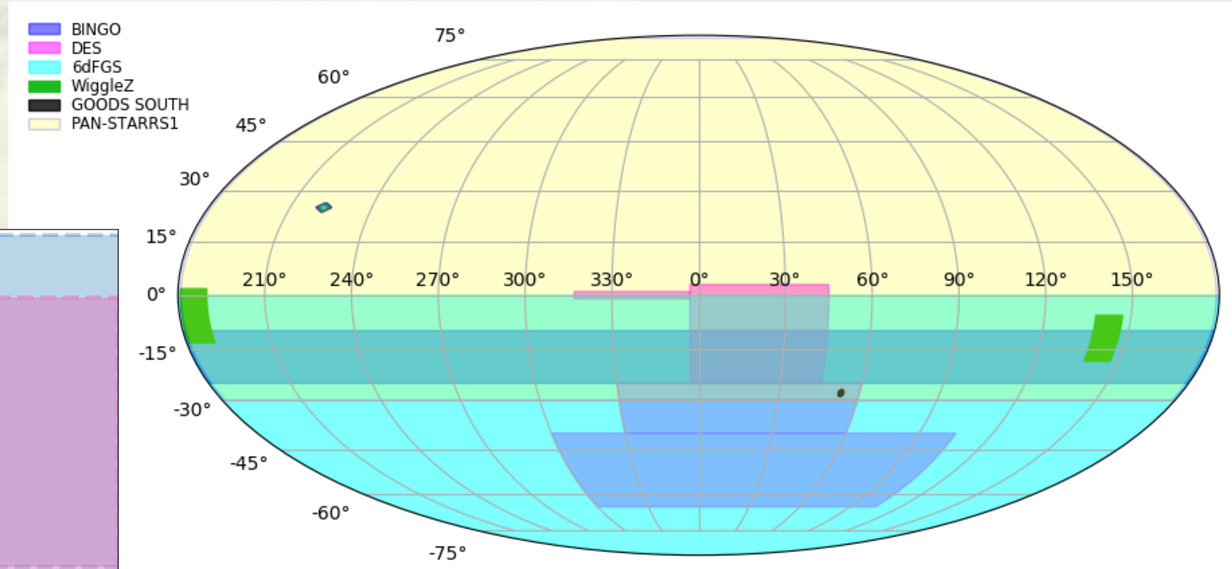
C. A. Wuensche (2022)

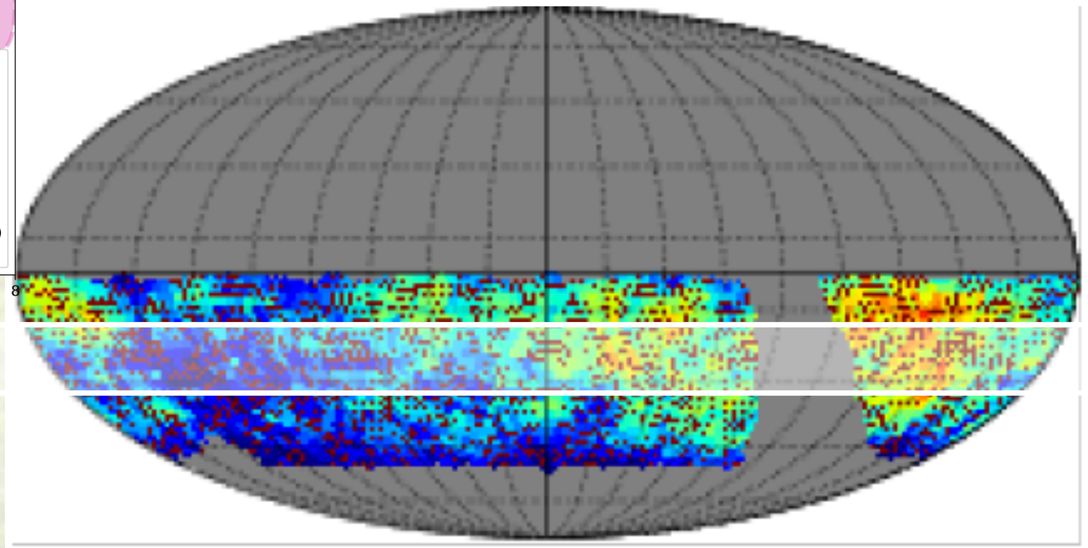
Artistic view – May 2021

C. A. Wuensche (2022)

BINGO superpositions with other surveys







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

The “FIDUCIAL” BINGO – Phase 1 (June 2022)

TELESCOPE INFORMATION	
Site coordinates (vertex of the area)	
7° 2' 27,6" S	38° 16' 4.8" W
Site denomination: Serra da Catarina, Aguiar (PB)	
Focal length (m)	63.2
Primary major semi-axis (m)	25.7
Primary minor semi-axis (m)	20.0
Secondary major semi-axis (m)	18.3
Secondary minor semi-axis (m)	18.0
Primary area (m^2)	1620
Effective area (average, m^2)	600
Number of horns	28
Telescope orientation	N-S
Central declination (deg.)	-15

RECEIVER INFORMATION	
T_sys (K)	70
Minimum frequency (MHz)	980
Maximum frequency (MHz)	1260
Frequency band (for 30 channels, MHz)	9.33
Instrument noise (mK, 1 second)	26.5
Instrument noise (mK, 1 second)	26.5
Digital backend FFT channels	2048
Sampling time (s)	0.1
Beam resolution (FWHM, deg.)	0.67
Total survey area (sqr. deg.)	5300

Wuensche et al. A&A (2022)

The “FIDUCIAL” BINGO – Phase 1 (June 2022)

TELESCOPE INFORMATION	
Site coordinates (vertex of the area)	
7° 2' 27,6" S	38° 16' 4.8" W
Site denomination: Serra da Catarina, Aguiar (PB)	
Focal length (m)	63.2
Primary major semi-axis (m)	25.7
Primary minor semi-axis (m)	20.0
Secondary major semi-axis (m)	18.3
Secondary minor semi-axis (m)	18.0
Primary area (m^2)	1620
Effective area (average, m^2)	600
Number of horns	28
Telescope orientation	N-S
Central declination (deg.)	-15

RECEIVER INFORMATION	
T_sys (K)	70
Minimum frequency (MHz)	980
Maximum frequency (MHz)	1260
Frequency band (for 30 channels, MHz)	9.33
Instrument noise (mK, 1 second)	26.5
Instrument noise (mK, 1 second)	26.5
Digital backend FFT channels	2048
Sampling time (s)	0.1
Beam resolution (FWHM, deg.)	0.67
Total survey area (sqr. deg.)	5300

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

Wuensche et al. A&A (2022)

The “FIDUCIAL” BINGO – Phase 1 (June 2022)

TELESCOPE INFORMATION	
Number of horns	28
Telescope orientation	N-S
Central declination (deg.)	-15

RECEIVER INFORMATION	
Beam resolution (FWHM, deg.)	0.07
Total survey area (sqr. deg.)	5300

Table 4: BINGO estimated sensitivity for a 60 (90) % duty cycle (one polarization).

	$\Delta T_{\rm min}$ (μK)		
Number of horns	1 year	2 years	5 years
1	542 (442)	383 (313)	242 (198)
28	102 (84)	72 (59)	46 (37)

Wuensche et al. A&A (2022)

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

Current status

- ☑ **A The BINGO project — I. Baryon acoustic oscillations from integrated neutral gas observations.** Elcio Abdalla et al. A&A 664, A14 (2022)
- ☑ **The BINGO project — II. Instrument description.** Carlos A. Wuensche et al. A&A 664, A15 (2022)
- ☑ **The BINGO Project — III. Optical design and optimization of the focal plane.** Filipe B. Abdalla, Alessandro Marins, Pablo Motta, João A. M. Barreto et al. A&A 664, A16 (2022)
- ☑ **The BINGO project — IV. Simulations for mission performance assessment and preliminary component separation steps.** Vincenzo Liccardo et al. A&A 664, A17 (2022)
- ☑ **The BINGO project — V. Further steps in component separation and bispectrum analysis.** Karin S. F. Fornazier et al. A&A 664, A18 (2022)
- ☑ **The BINGO project — VI. H I halo occupation distribution and mock building.** Jiajun Zhang, Pablo Motta et al. A&A 664, A19 (2022)
- ☑ **The BINGO project — VII. Cosmological forecasts from 21 cm intensity mapping.** Andre A. Costa et al. A&A 664, A20 (2022)
- ☑ **The BINGO project - VIII. Recovering the BAO signal in Hi intensity mapping simulations.** C. P. Novaes et al. Accepted for publication on A&A (arXiv:2207.12125)
- ☑ **Testing synchrotron models and frequency resolution in BINGO 21 cm simulated maps using GNILC.** Eduardo J. de Mericia, Larissa Santos et al. Accepted for publication on A&A (arXiv:2204.08112)

Current status

website, you agree that EDP Sciences may store web audience measurement cookies and, on some pages, cookies from social networks. More information and setup OK

Home › All issues › Volume 664 (August 2022)

Previous issue | Table of Contents

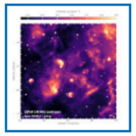
Free Access to the whole issue

Astronomy & Astrophysics articles are available online as soon as the production process is complete.
The currently opened issue will be updated regularly until it is complete. To keep abreast of new articles, you may either visit this page regularly or subscribe to our E-mail alert

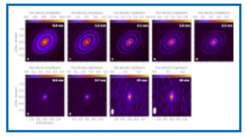
Astronomy & Astrophysics

Volume 664 (August 2022) (in progress)

Artist's view of the BINGO telescope site (Abdalla, E., et al., 2022, A&A, 664, A14)



LOFAR view of ionized gas structures in Cygnus X (Emig, K. L., et al., 2022, A&A, 664, A88)



The Herbig star HD 163296 observed by ALMA and VLA (Guidi, G., et al., 2022, A&A, 664, A137)

Sort by Section | Sort by article number

Export the citation of the selected articles Export

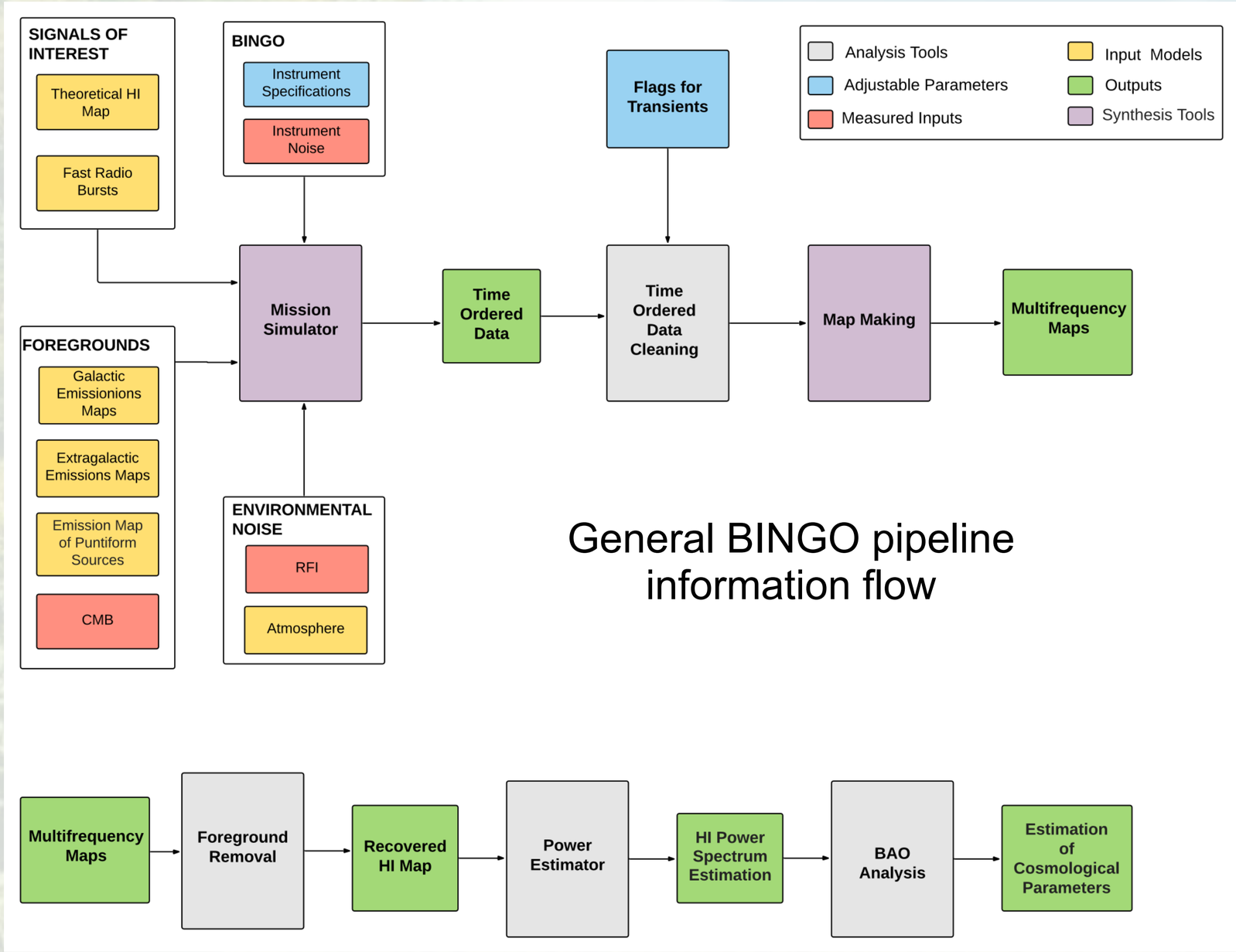
Select all

C. A. Wuensche (2022)

Thank you!

Visit us at http://www.bingotelescope.org

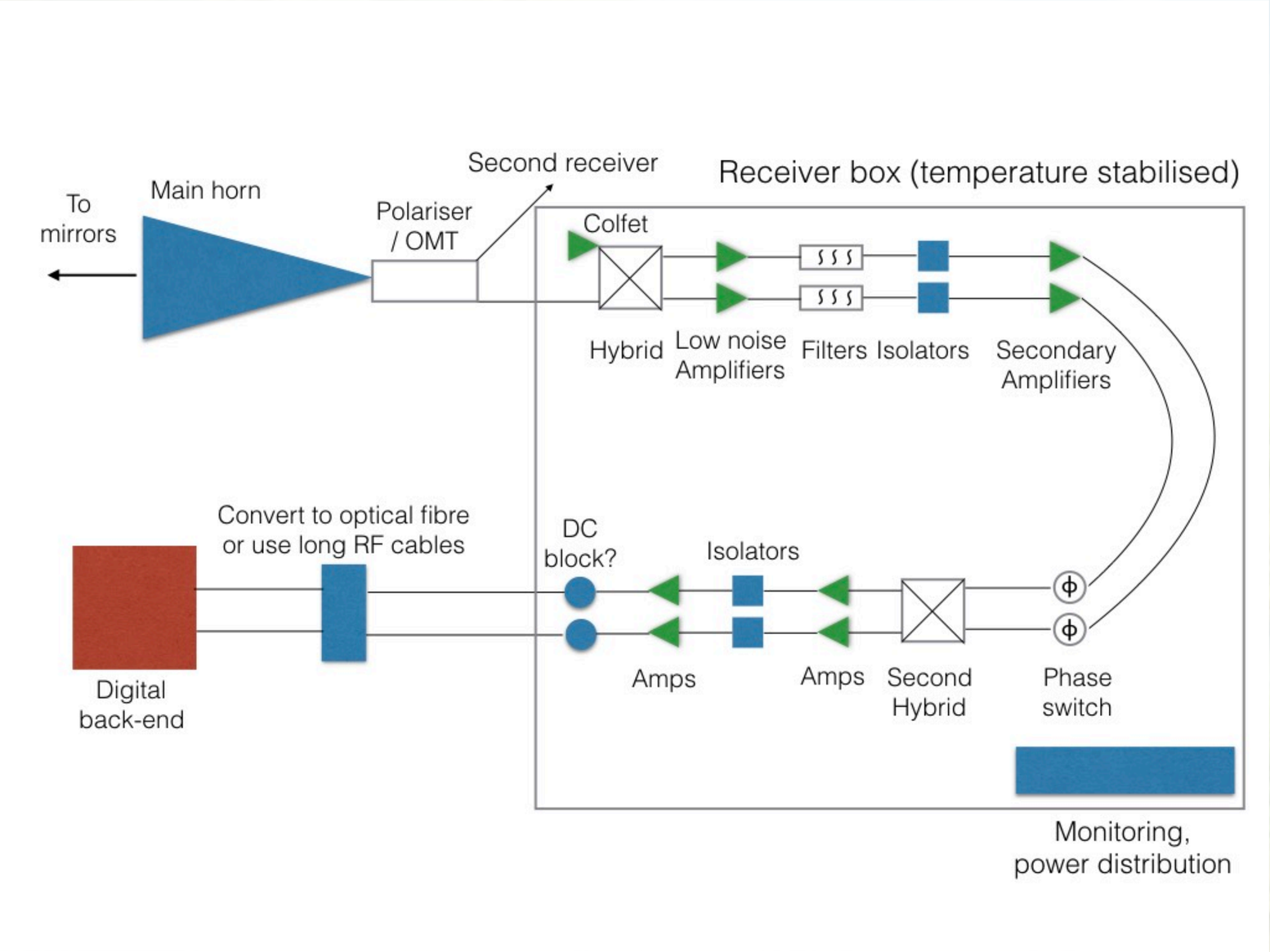
The BINGO subsystems

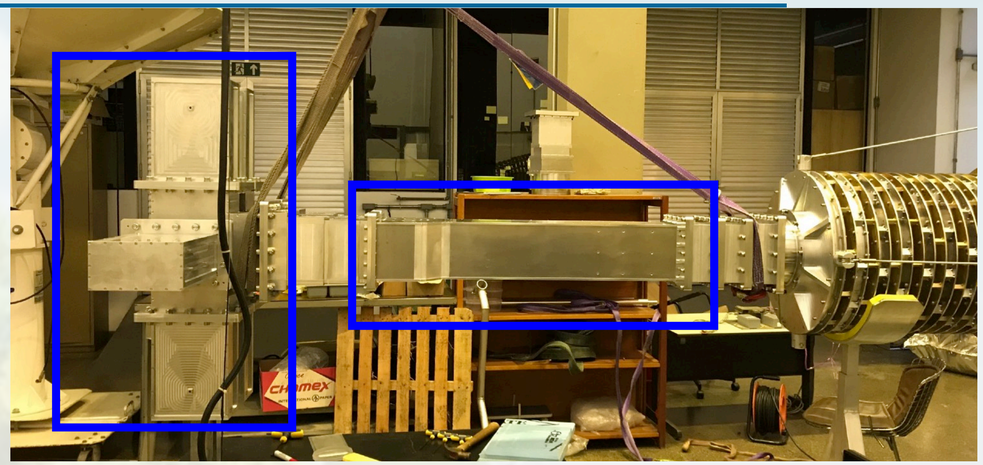


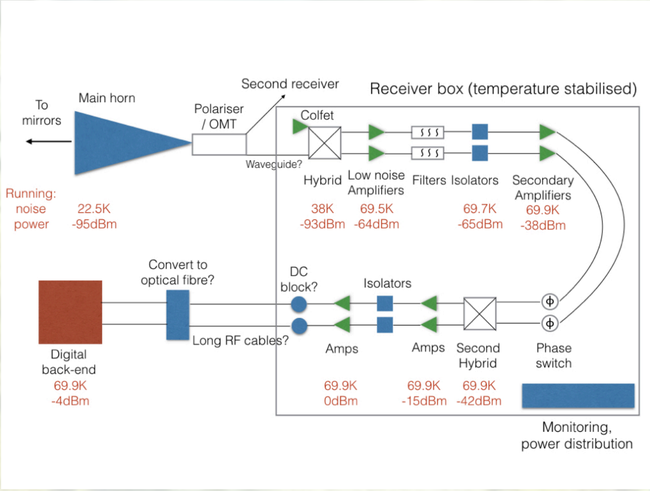
From E. Merícia

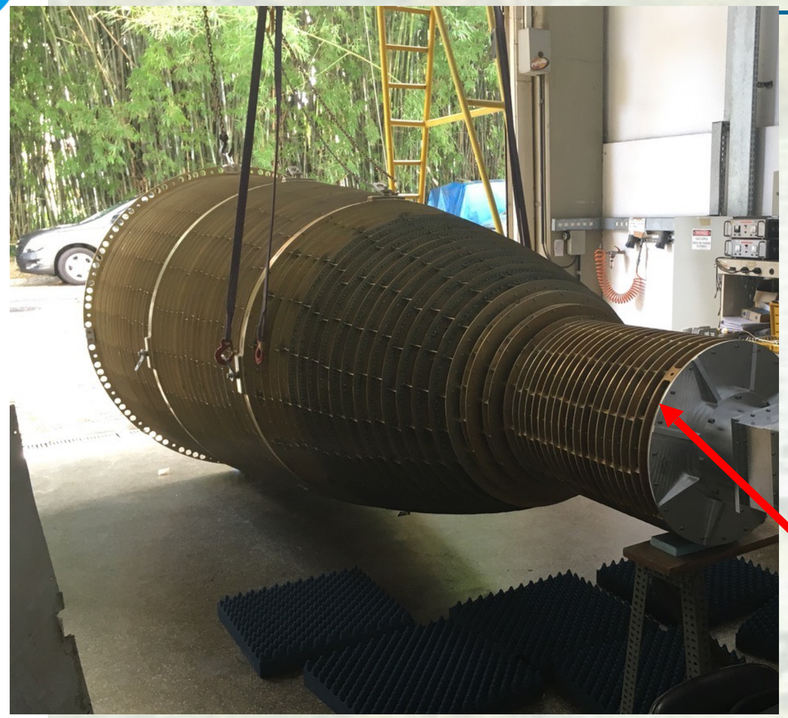
C. A. Wuensche (2022)

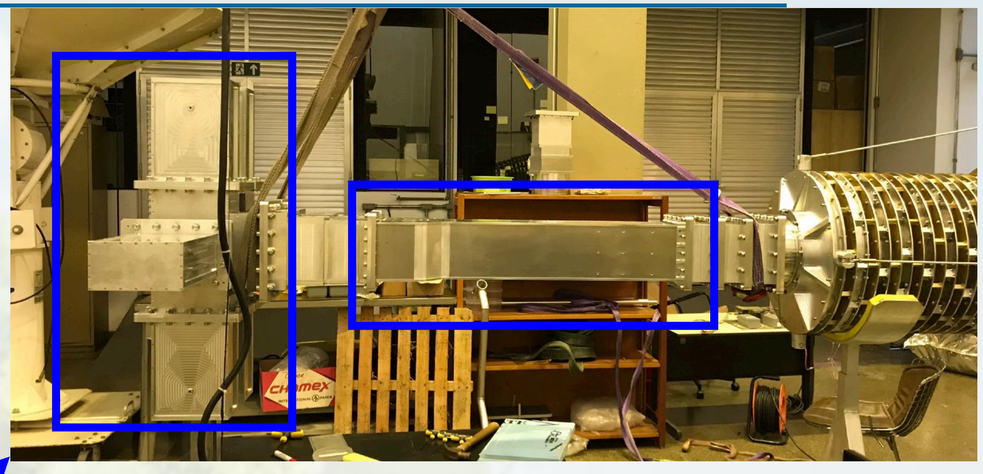
BINGO receiver schematics

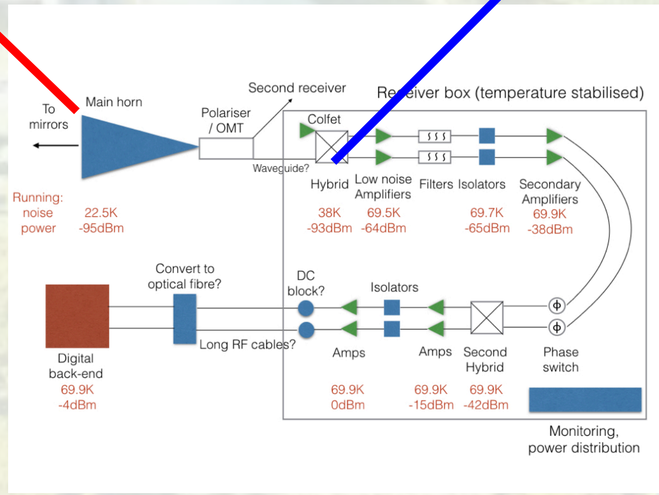


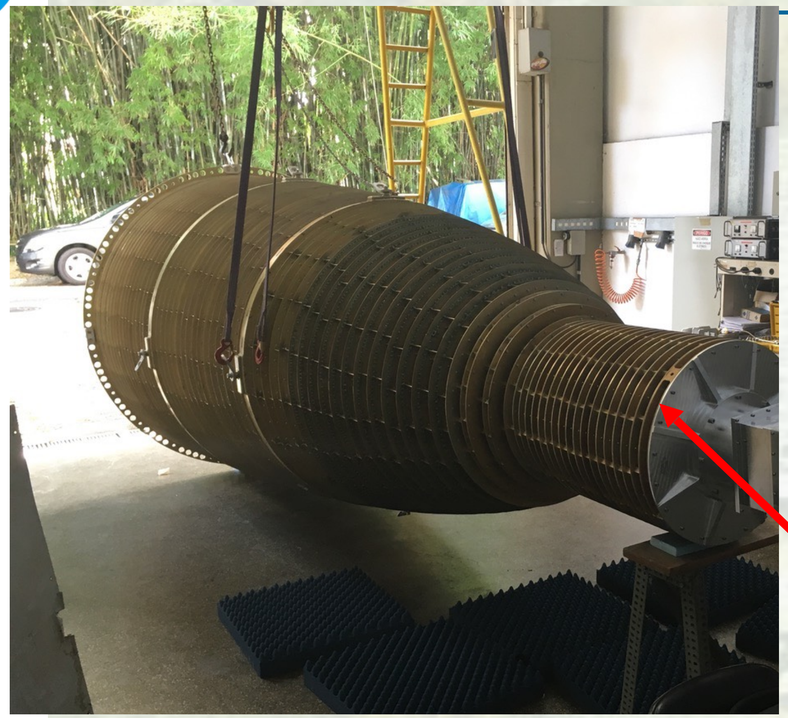


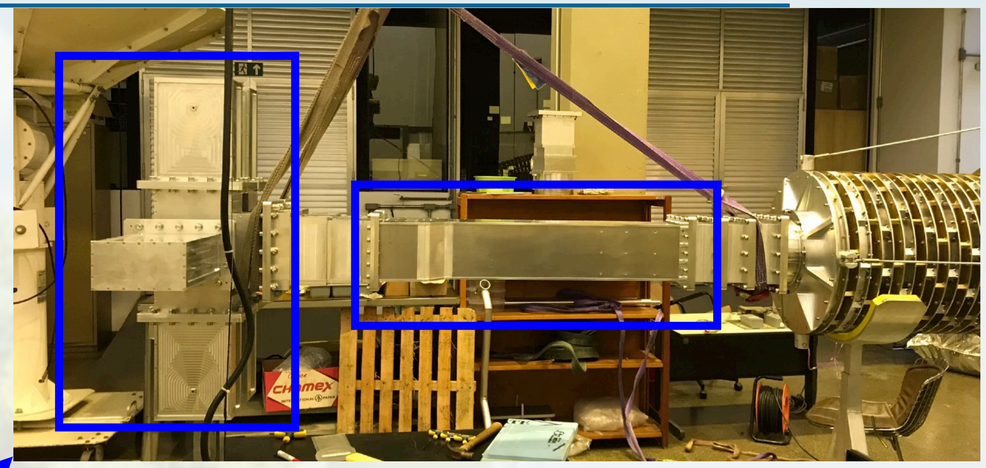

Receiver box (temperature stabilised)
To mirrors
Main horn
Polariser / OMT
Second receiver
Waveguide?
Colfet
Hybrid
Low noise Amplifiers
Filters
Isolators
Secondary Amplifiers
Running: noise power
22.5K -95dBm
38K -93dBm
69.5K -64dBm
69.7K -65dBm
69.9K -38dBm
Convert to optical fibre?
DC block?
Isolators
Digital back-end
69.9K -4dBm
Long RF cables?
Amps
Amps
Second Hybrid
Phase switch
69.9K 0dBm
69.9K -15dBm
69.9K -42dBm
Monitoring, power distribution

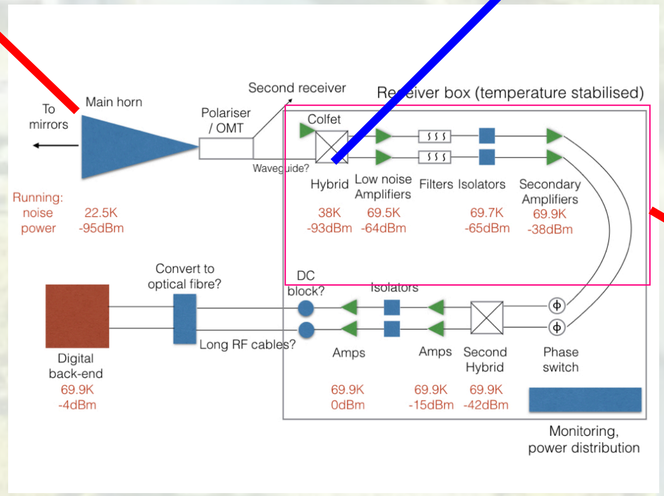


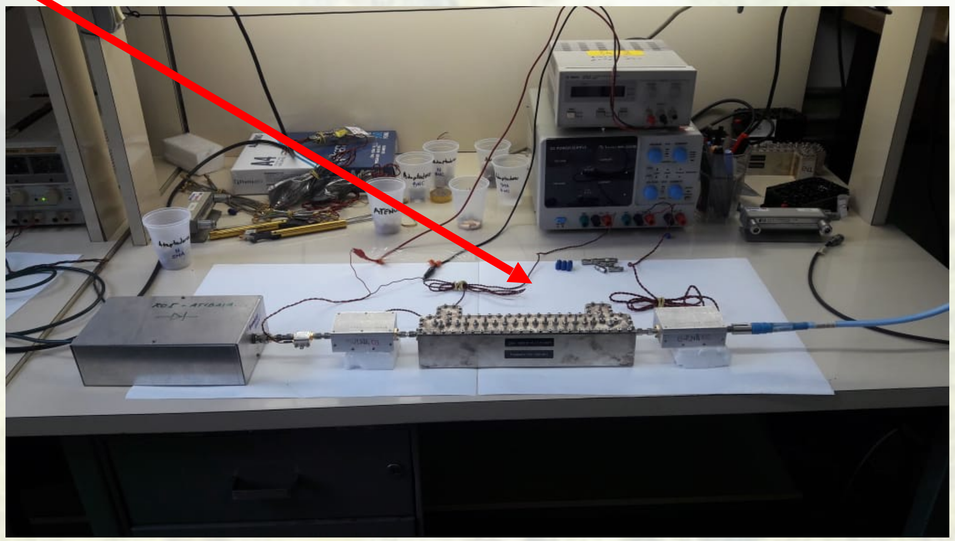


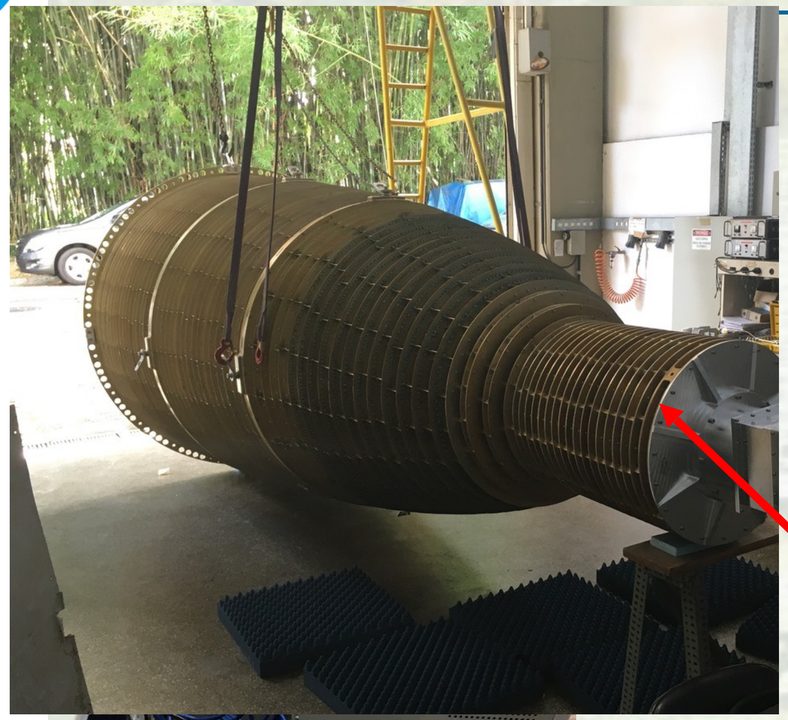

To mirrors
Main horn
Polariser / OMT
Second receiver
Waveguide?
Receiver box (temperature stabilised)
Colfet
Hybrid
Low noise Amplifiers
Filters
Isolators
Secondary Amplifiers
Running: noise power
22.5K -95dBm
38K -93dBm
69.5K -64dBm
69.7K -65dBm
69.9K -38dBm
Convert to optical fibre?
DC block?
Isolators
Digital back-end
69.9K -4dBm
Long RF cables?
Amps
Amps
Second Hybrid
Phase switch
69.9K 0dBm
69.9K -15dBm
69.9K -42dBm
Monitoring, power distribution

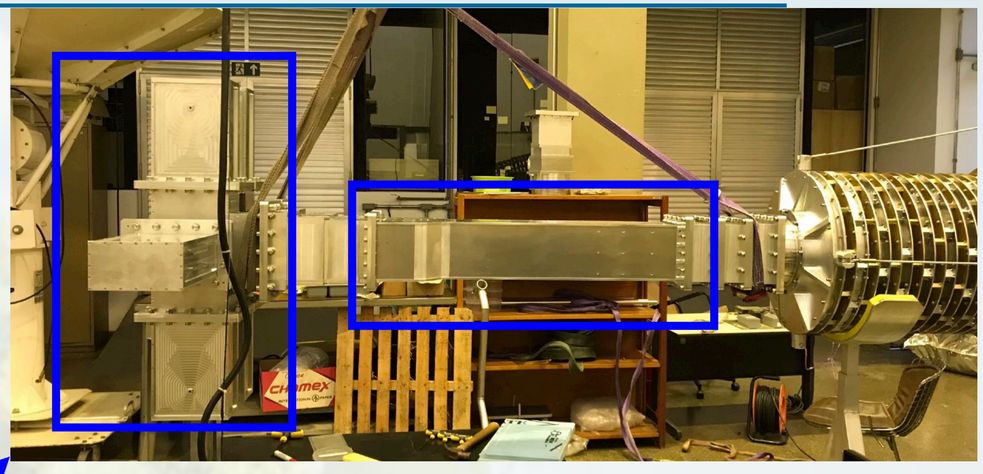


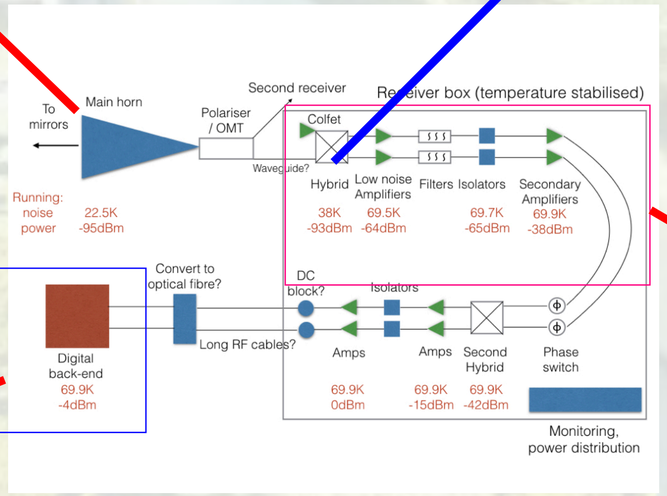


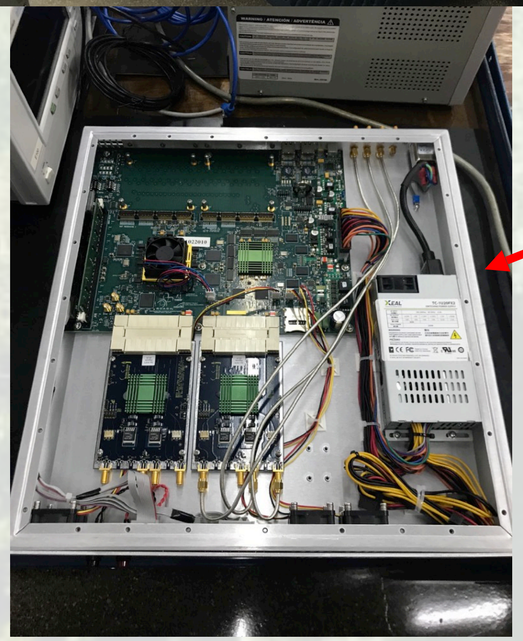

To mirrors
Main horn
Polariser / OMT
Second receiver
Receiver box (temperature stabilised)
Colfet
Waveguide?
Hybrid
Low noise Amplifiers
Filters
Isolators
Secondary Amplifiers
Running: noise power
22.5K -95dBm
38K -93dBm
69.5K -64dBm
69.7K -65dBm
69.9K -38dBm
Convert to optical fibre?
DC block?
Isolators
Digital back-end
69.9K -4dBm
Long RF cables?
Amps
Amps
Second Hybrid
Phase switch
69.9K 0dBm
69.9K -15dBm
69.9K -42dBm
Monitoring, power distribution

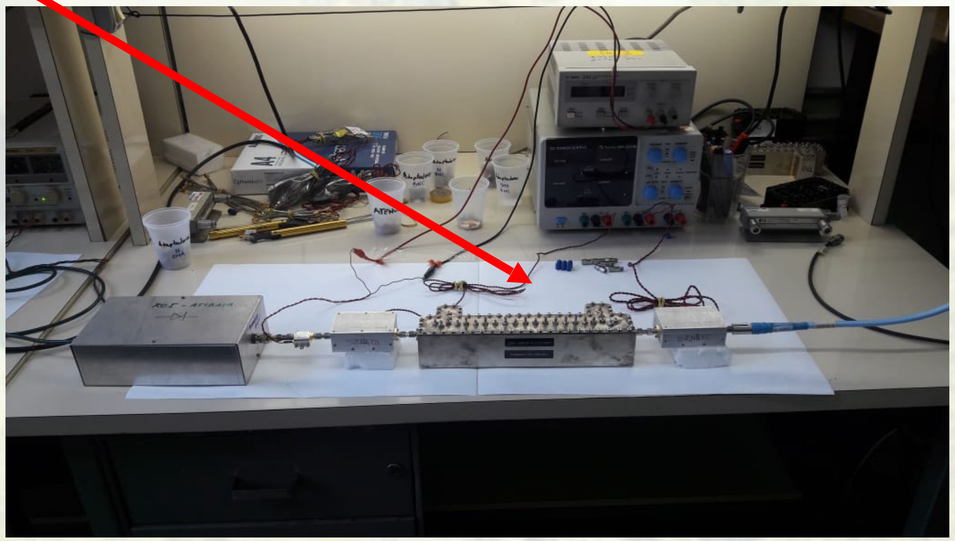







To mirrors
Main horn
Polariser / OMT
Second receiver
Receiver box (temperature stabilised)
Colfet
Waveguide?
Hybrid
Low noise Amplifiers
Filters
Isolators
Secondary Amplifiers
Running: noise power
22.5K -95dBm
38K -93dBm
69.5K -64dBm
69.7K -65dBm
69.9K -38dBm
Convert to optical fibre?
DC block?
Isolators
Digital back-end
69.9K -4dBm
Long RF cables?
Amps
Amps
Second Hybrid
Phase switch
69.9K 0dBm
69.9K -15dBm
69.9K -42dBm
Monitoring, power distribution





Horn & polarimeter status

- Aluminum horns
  - 6060 T4 alloy
  - Mass: ~ 400 kg
  - Number of rings (sectors): 127
  - Length: 4318 mm
  - Mouth: 1900 mm
  - Throat: 250 mm
- Prototype construction
  - Calfer (Brazil)

- Polarimeters transitions and magic tees (aluminum)
  - Mass: ~ 90kg,
- Prototype construction
  - Metalcard (Brazil)

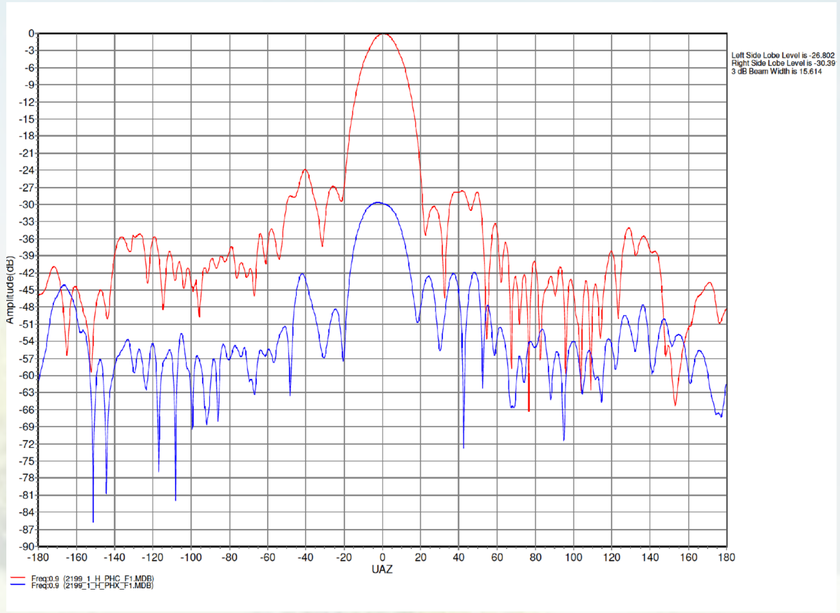
- EM project: Bruno Maffei (IAP, France)
  - Contributions from Chris Radcliffe (Phase 2 Microwave, UK)
- Mechanical project : Luiz Reitano (INPE, Brazil)

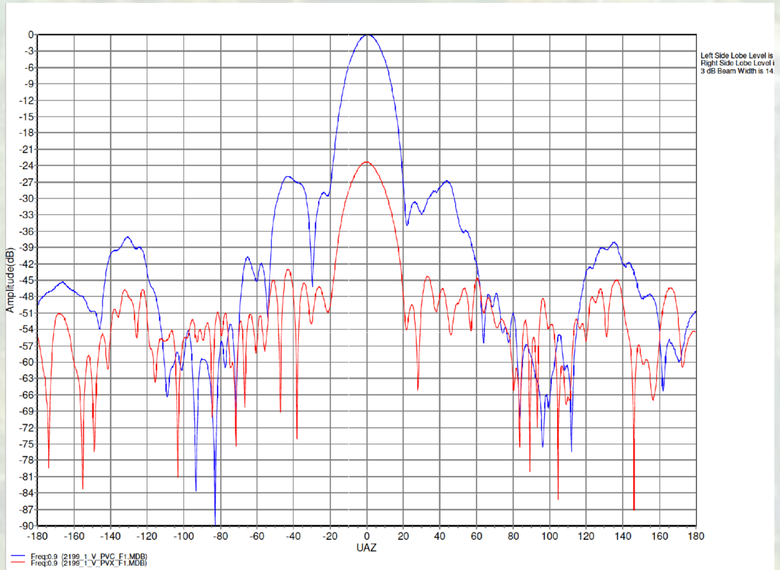
Horn testing results –polarization

HORIZONTAL

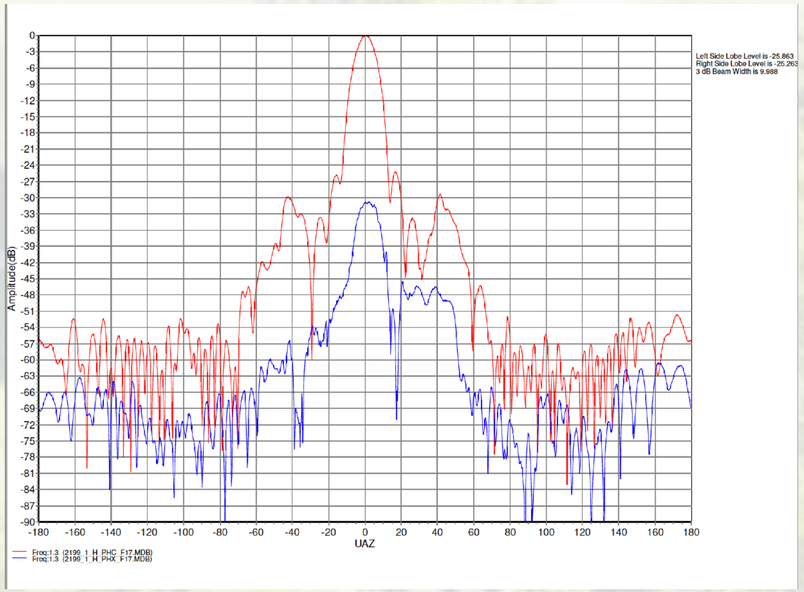
VERTICAL

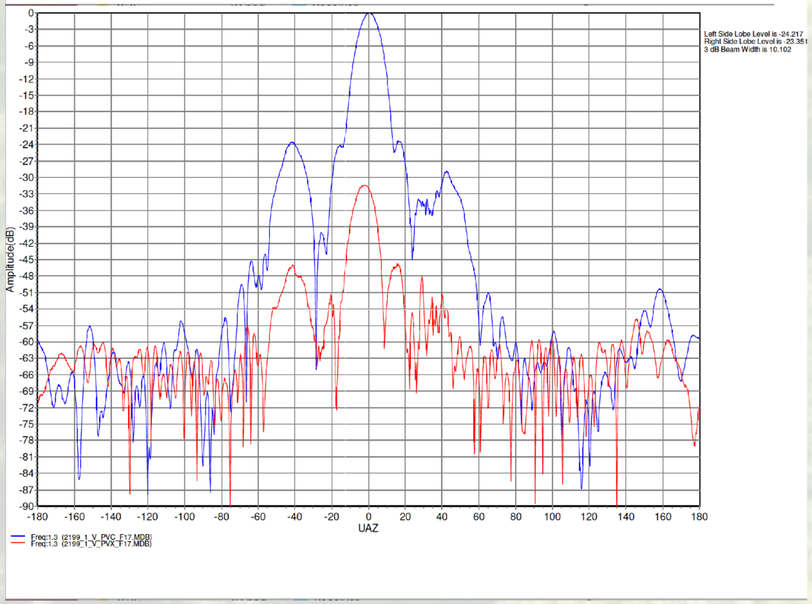
900 MHz





1300 MHz

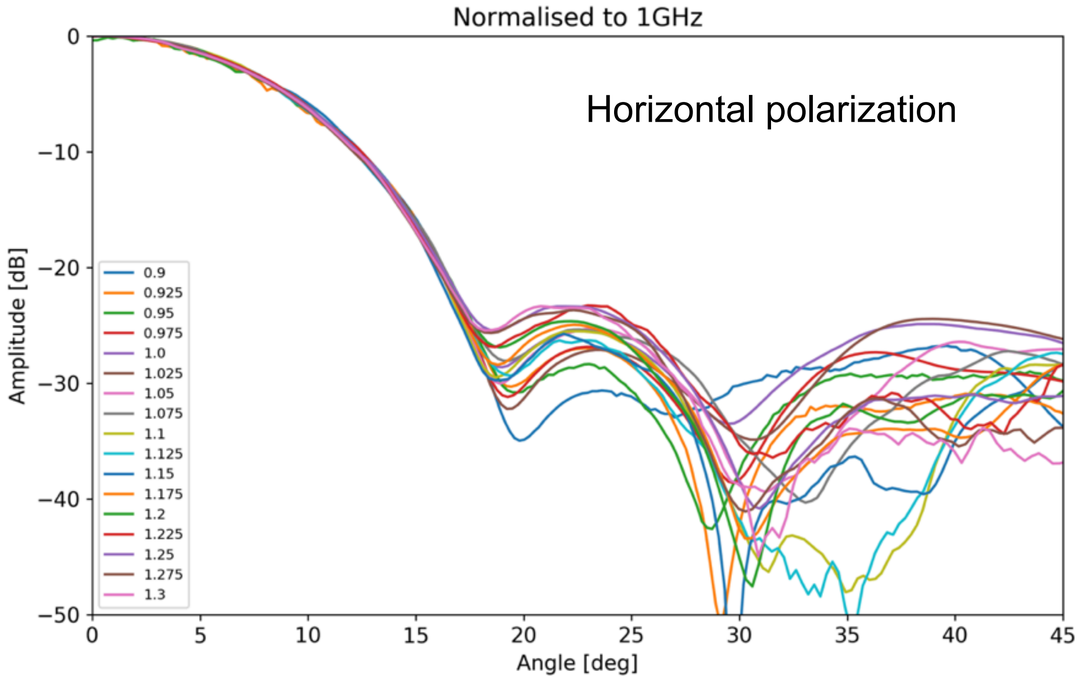




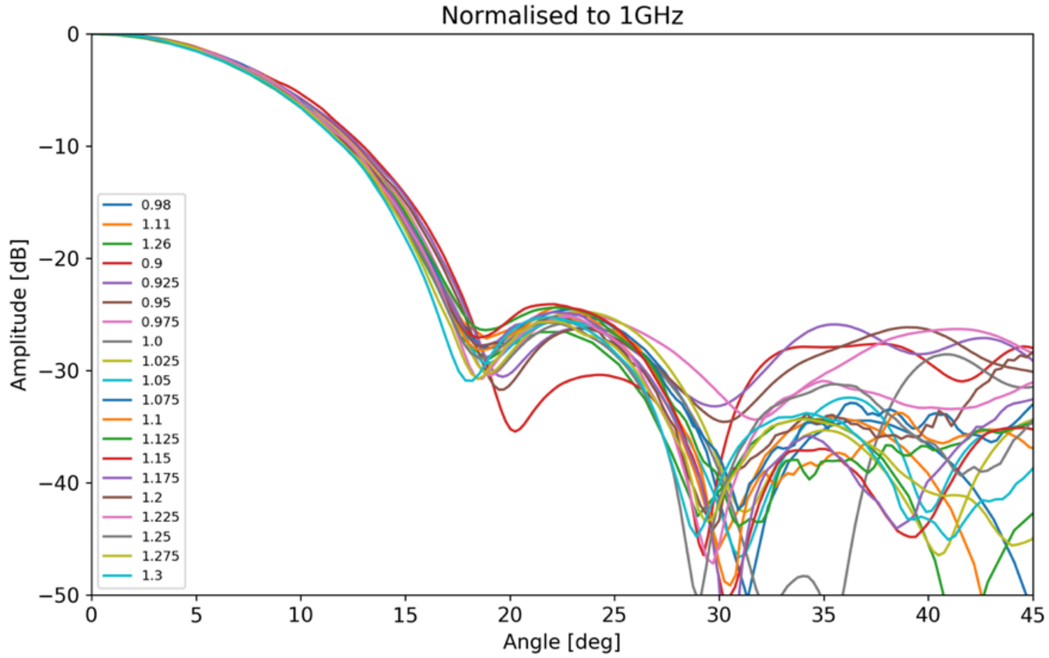
C. A. Wuensche (2022)

Wuensche et al. Exp. Astronomy 2020 (arXiv:1911.13188)

Horn testing results – Combination of all freqs.

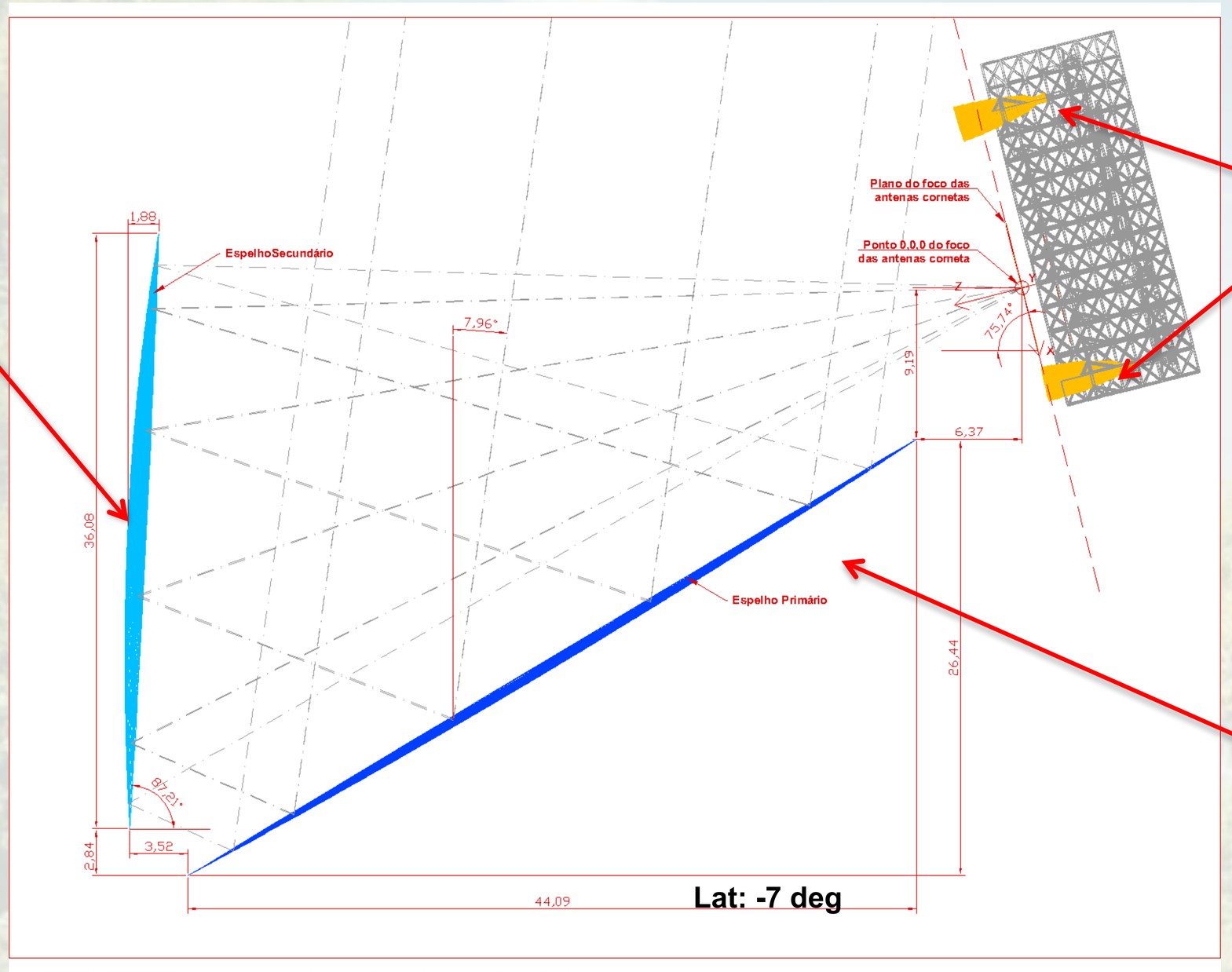


Vertical polarization



Wuensche et al. Exp. Astronomy 2020 (arXiv:1911.13188)

Secondary mirror

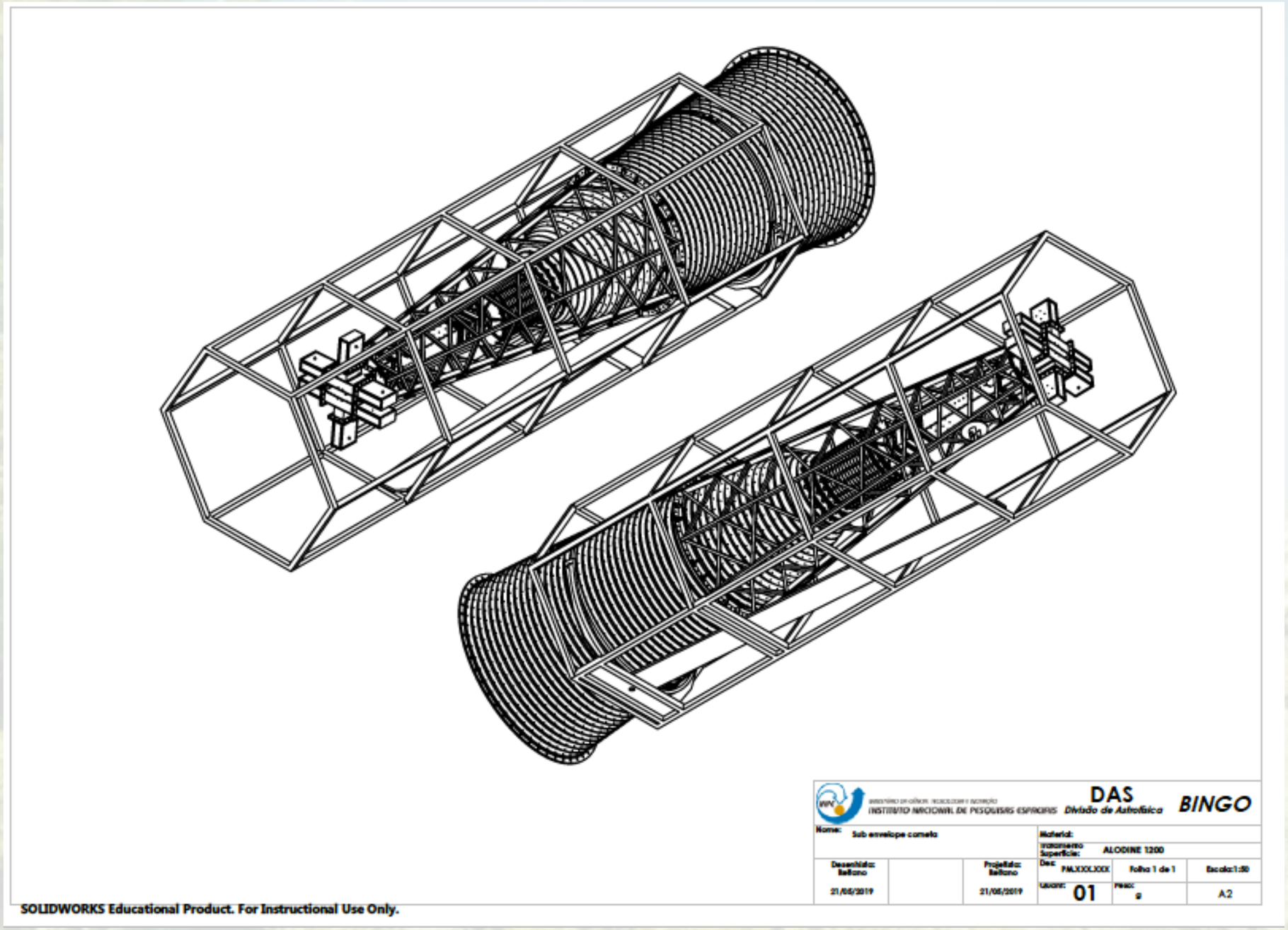


Horn array (detectors)

Primary mirror

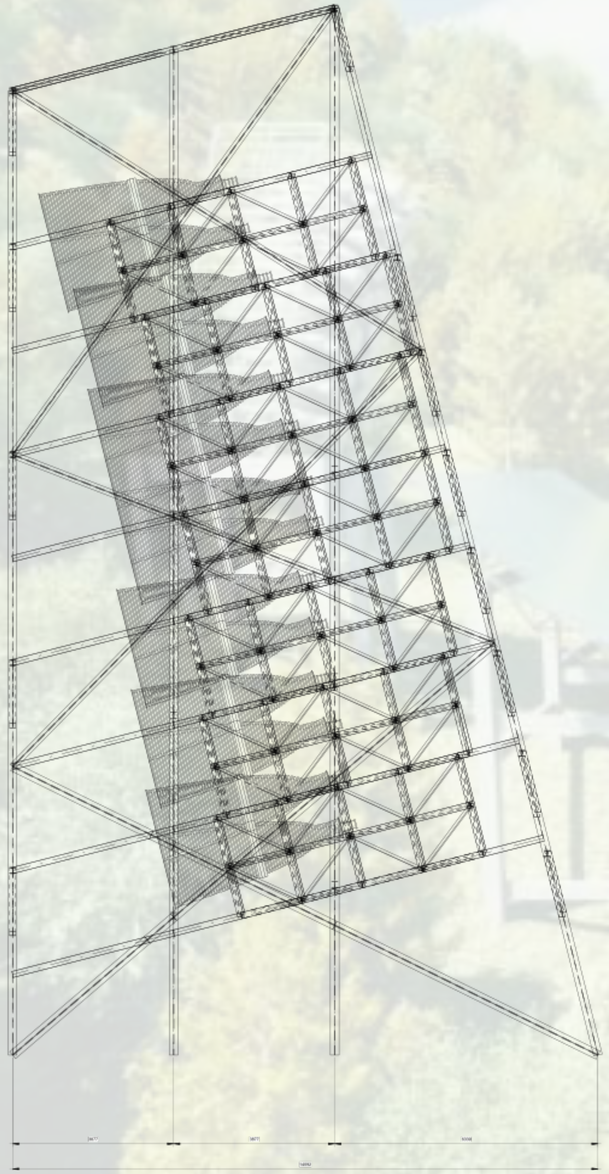
Source: BINGO Collaboration

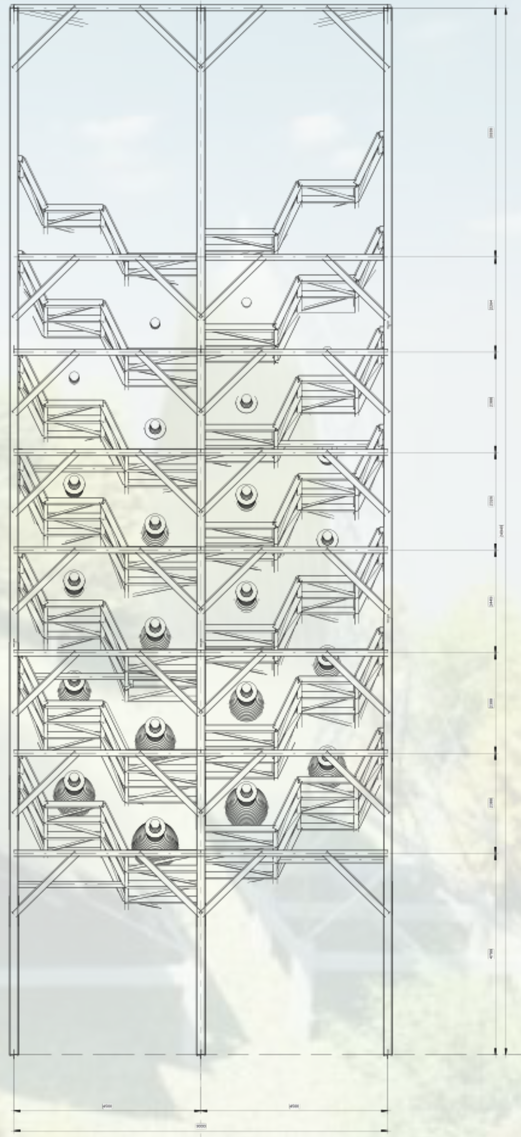
C. A. Wuensche (2022)



Source: BINGO Collaboration (L. A. Reitano)

C. A. Wuensche (2022)



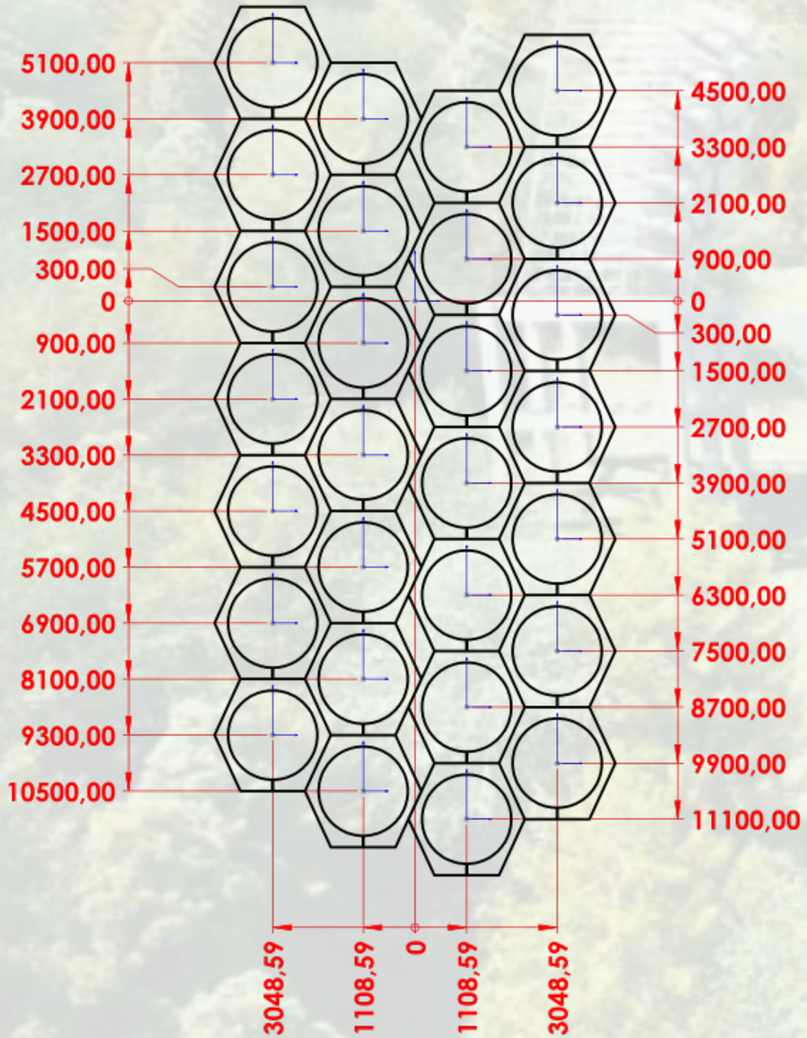


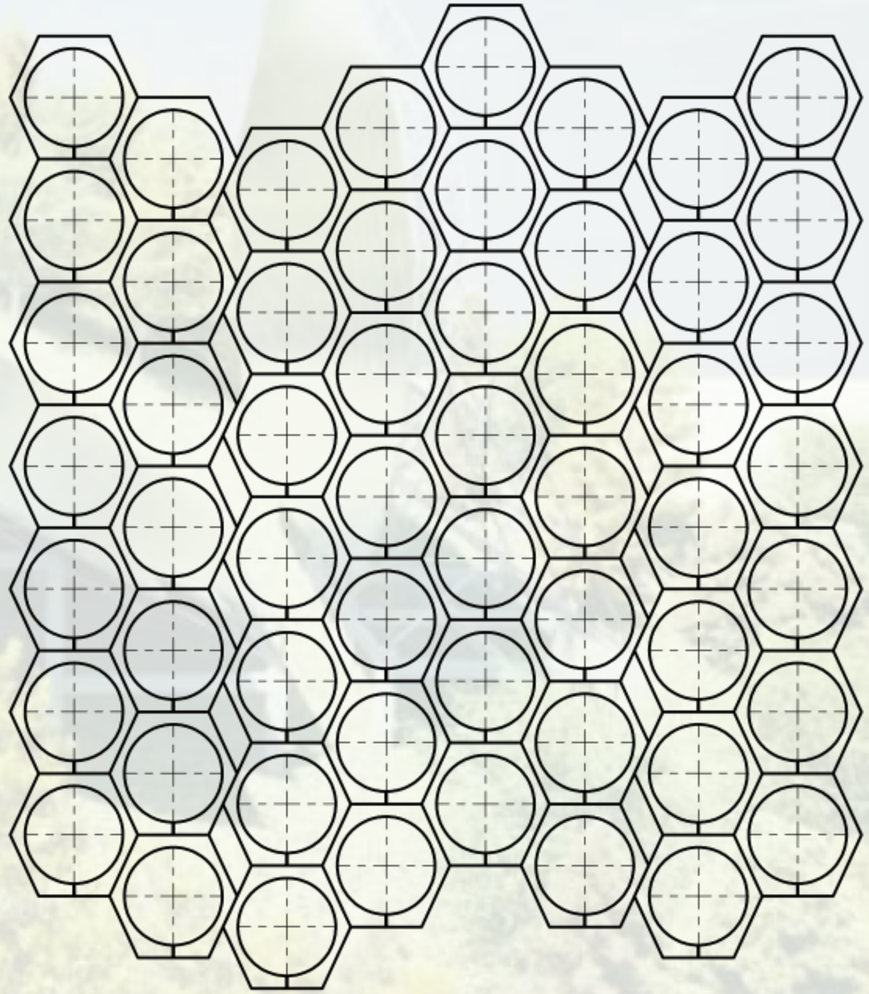
Source: Ponto de Apoio Engenharia

Focal plane – 28 horns

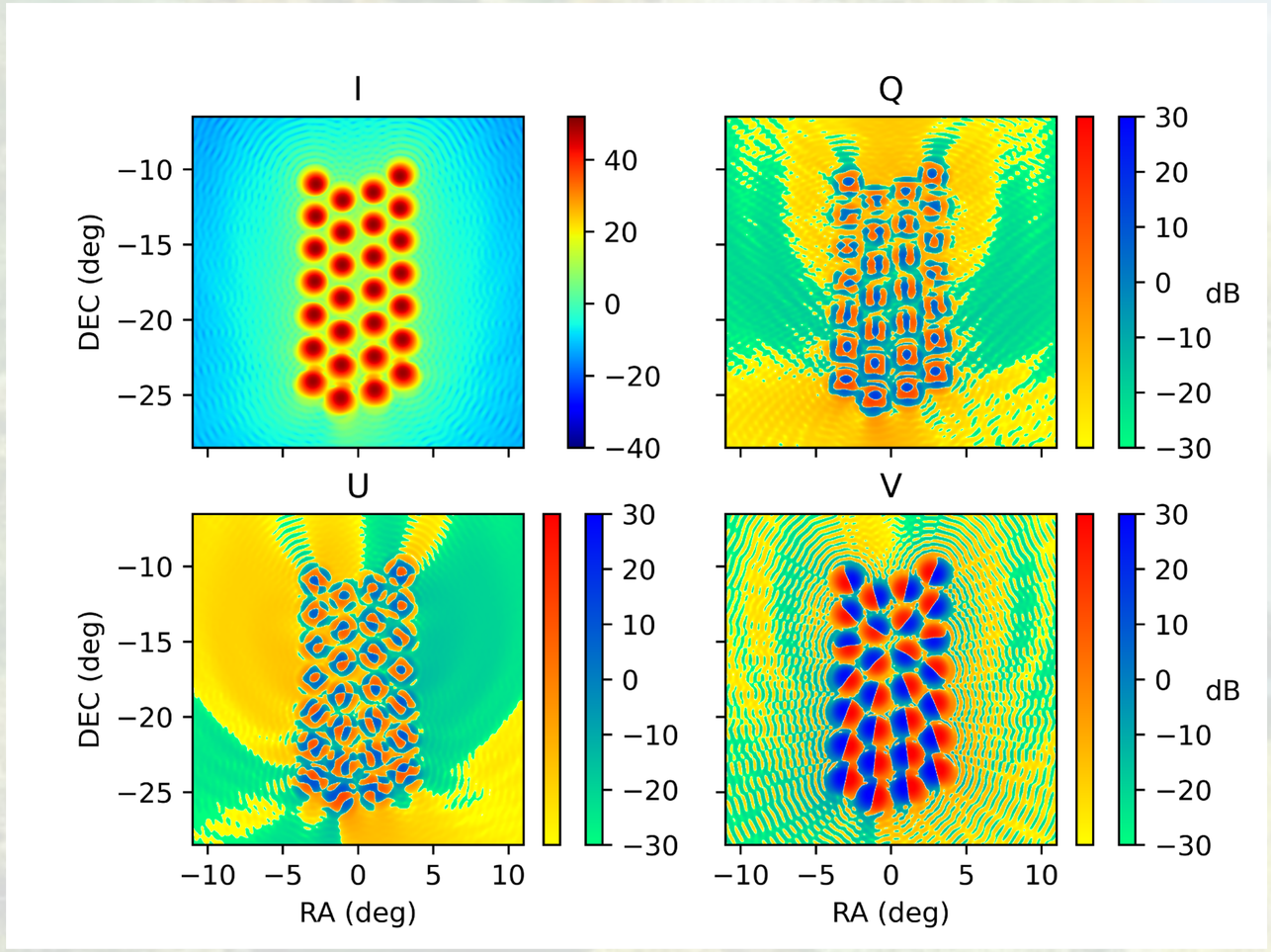
Declination coverage: ~ 15.4 deg

Future upgrade to 56 horns

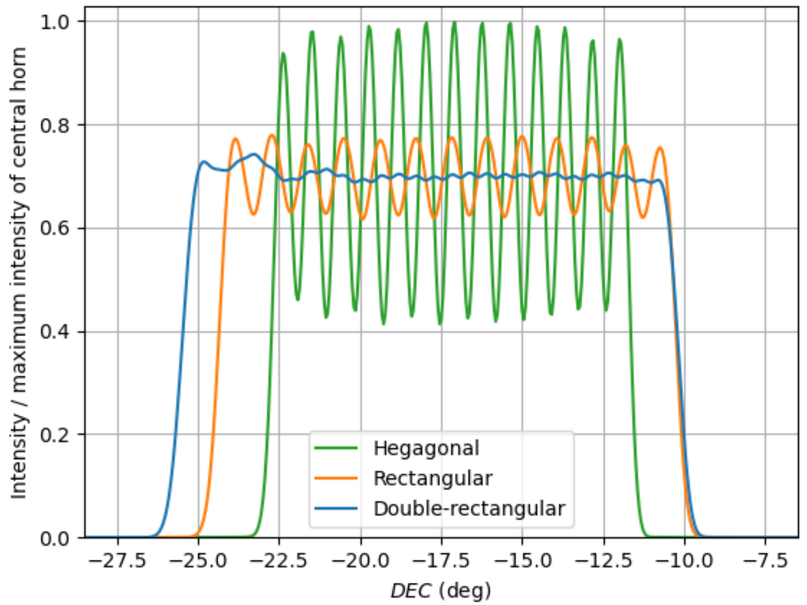


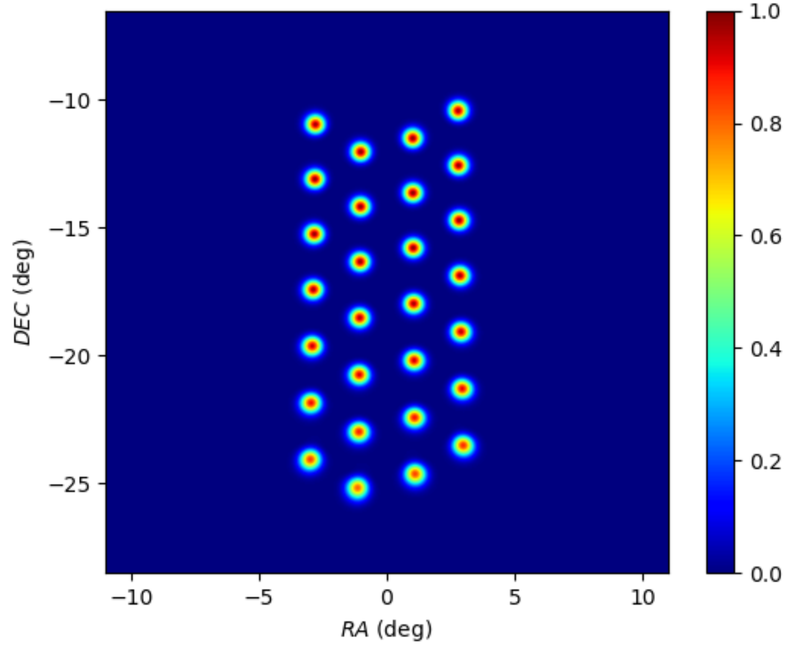


C. A. Wuensche (2022)

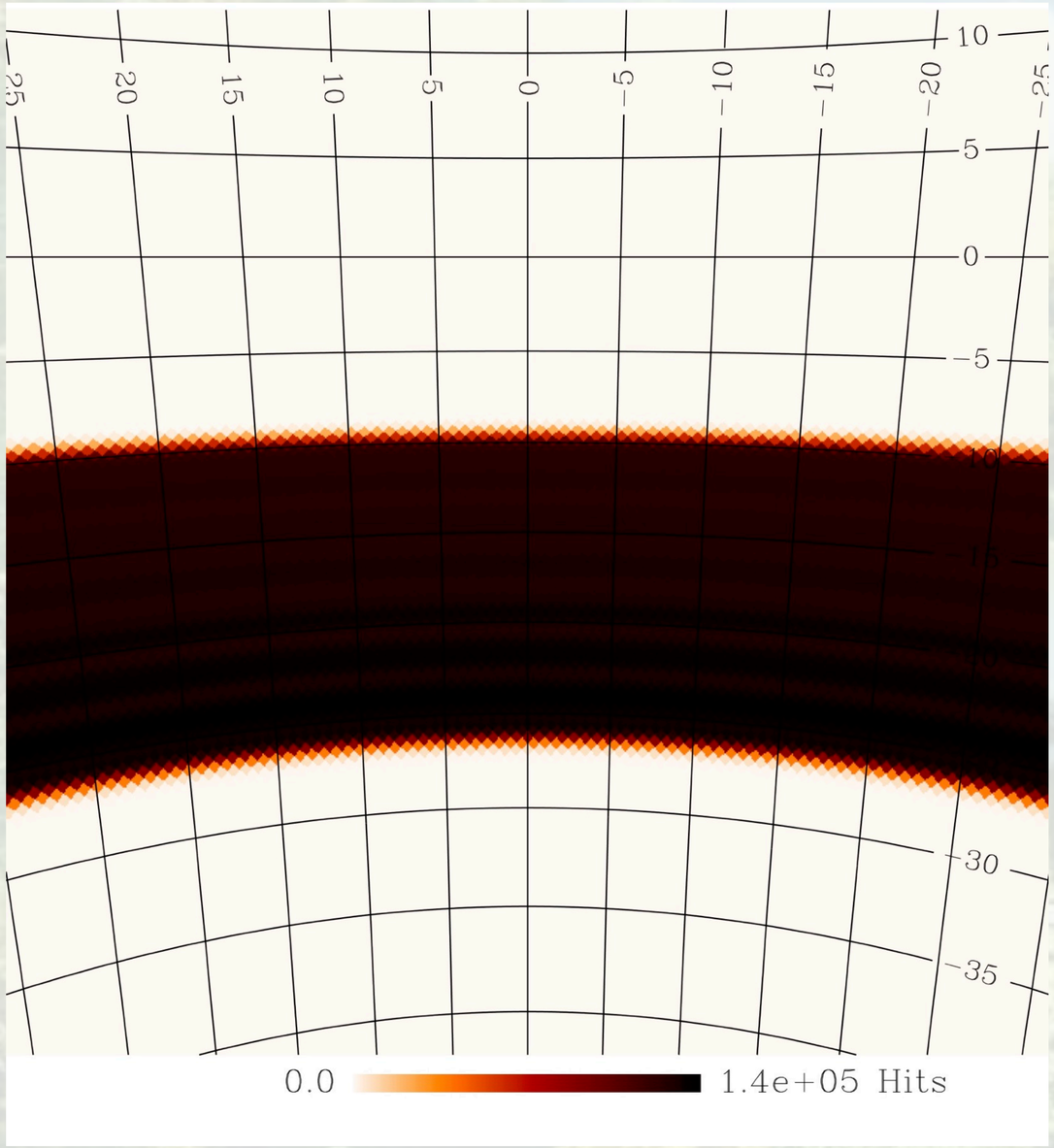


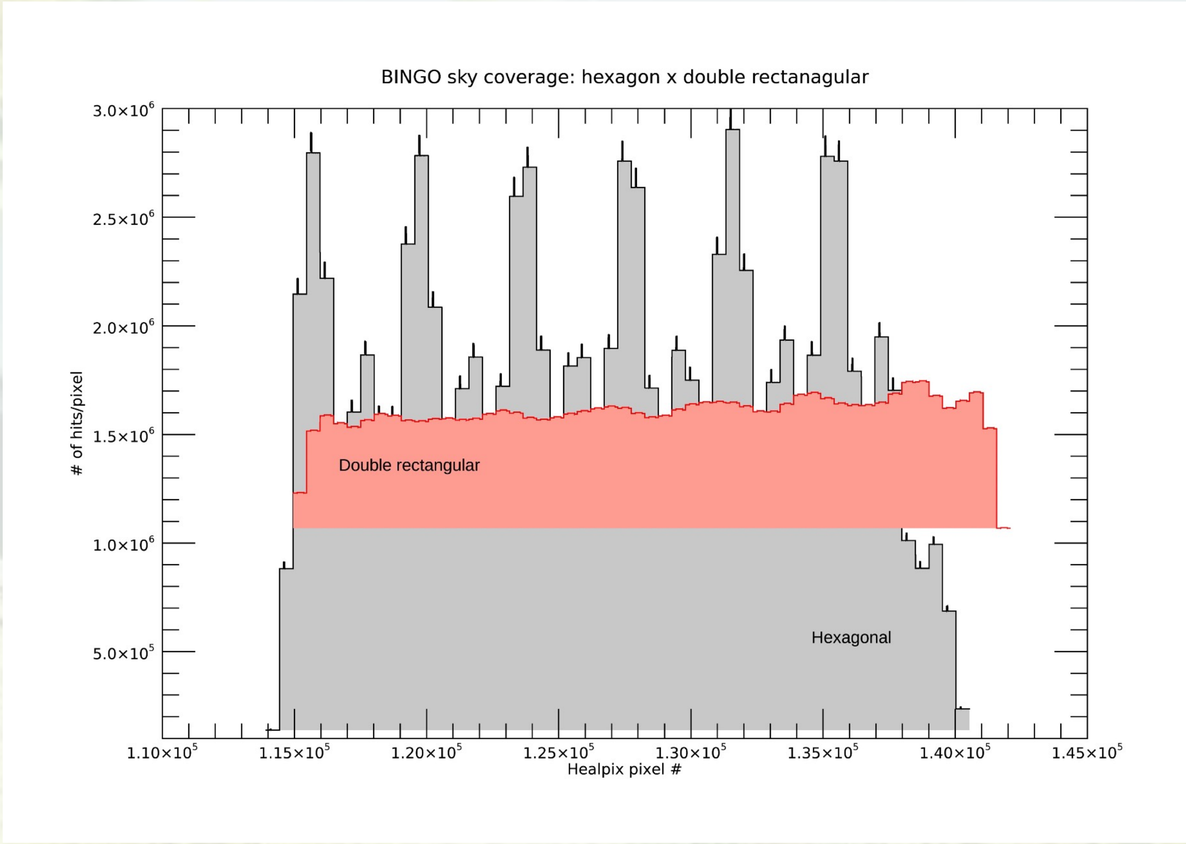
Abdalla, Marins, Mota et al. A&A (2022)





C. A. Wuensche (2022)





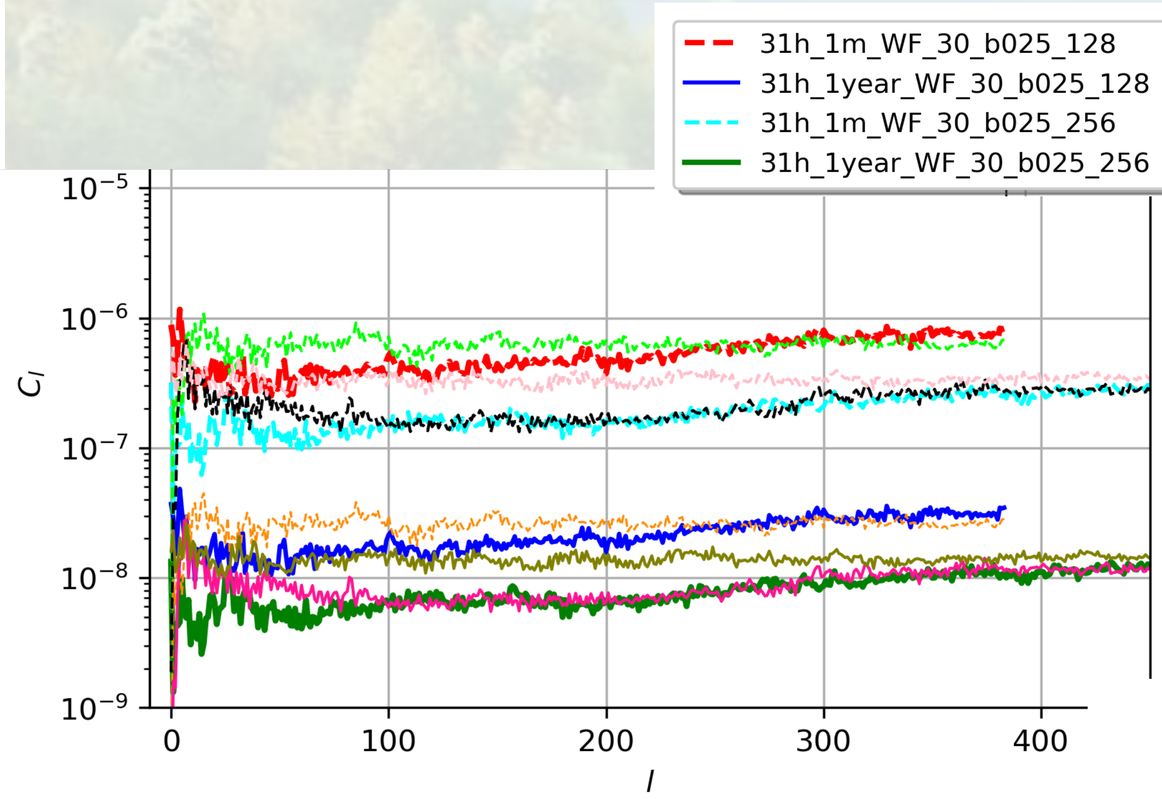
Liccardo et al. A&A (2022)

Foreground budget

Table 2. Summary of foregrounds for HI intensity mapping at 1 GHz for an angular scale of $\sim 1^\circ$ ($\ell \sim 200$). The estimates are for a 10°-wide strip at declination $\delta = +45^\circ$ and for Galactic latitudes $|b| > 30^\circ$.

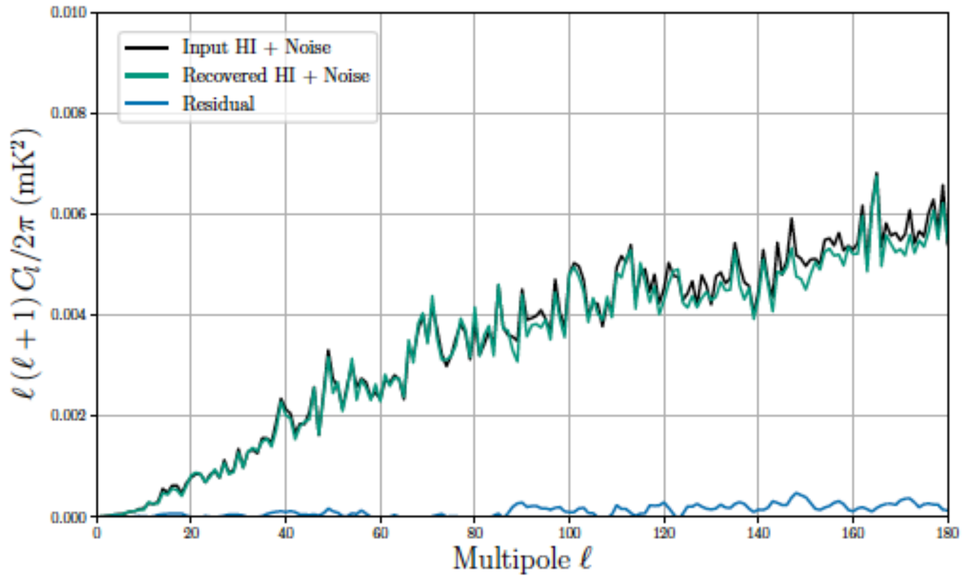
Foreground	$\bar{T}$ [mK]	δT [mK]	Notes
Synchrotron	1700	67	Power-law spectrum with $\beta \approx -2.7$.
Free-free	5.0	0.25	Power-law spectrum with $\beta \approx -2.1$.
Radio sources (Poisson)	–	5.5	Assuming removal of sources at $S > 10$ mJy.
Radio sources (clustered)	–	47.6	Assuming removal of sources at $S > 10$ mJy.
Extragalactic sources (total)	205	48	Combination of Poisson and clustered radio sources.
CMB	2726	0.07	Black-body spectrum, ($\beta = 0$).
Thermal dust	–	$\sim 2 \times 10^{-6}$	Model of Finkbeiner et al. (1999).
Spinning dust	–	$\sim 2 \times 10^{-3}$	Davies et al. (2006) and CNM model of Draine & Lazarian (1998).
RRL	0.05	3×10^{-3}	Hydrogen RRLs with $\Delta n = 1$.
Total foregrounds	~ 4600	~ 82	Total contribution assuming the components are uncorrelated.
HI	~ 0.1	~ 0.1	Cosmological HI signal we are intending to detect.

- ☑ From Battye et al. (2013), still valid for the current BINGO configuration



Fornazier et al. A&A (2022)

Liccardo et al. A&A (2022)

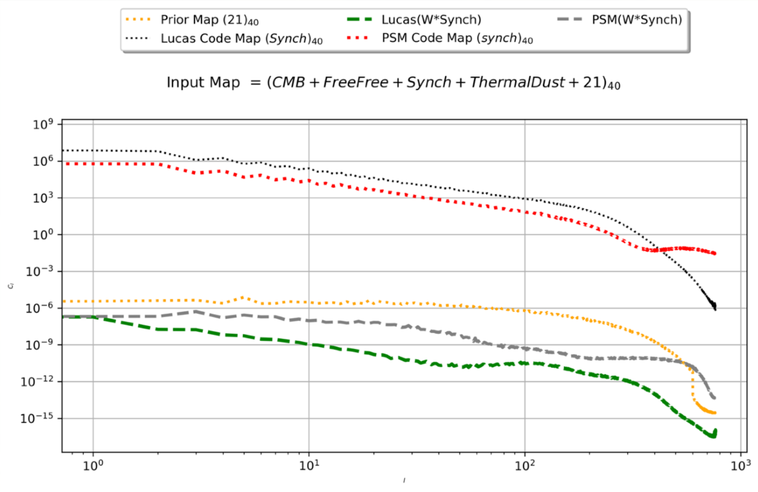


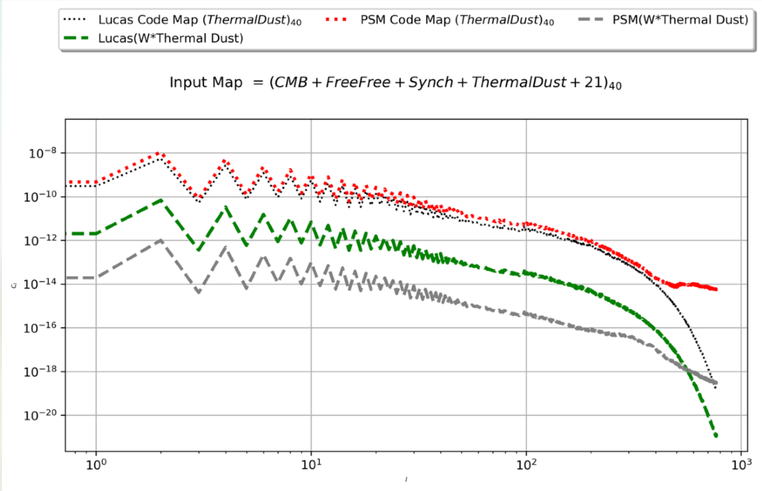
Range ℓ	N_{GNILC}
1 - 180	0.051
1 - 15	0.423
15 - 30	0.056
30 - 45	0.0412
45 - 60	0.0378
60 - 75	0.042
75 - 90	0.041
90 - 105	0.042
105 - 120	0.0437
120 - 135	0.046
135 - 150	0.05
150 - 165	0.05
165 - 180	0.042

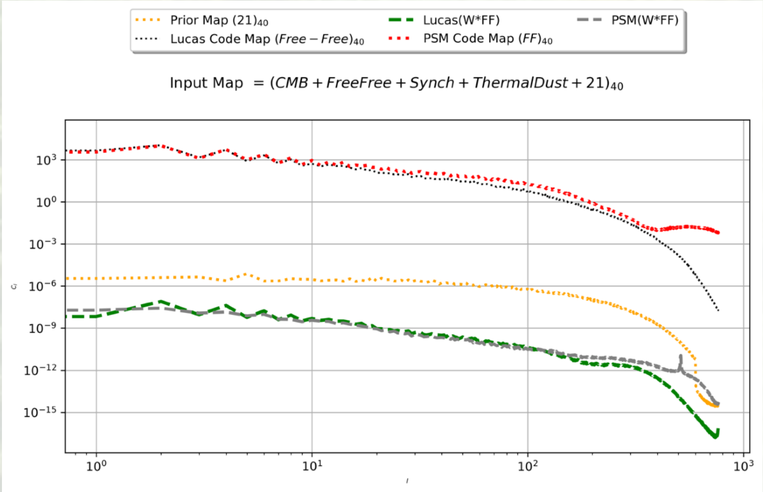
C. A. Wuensche (2022)

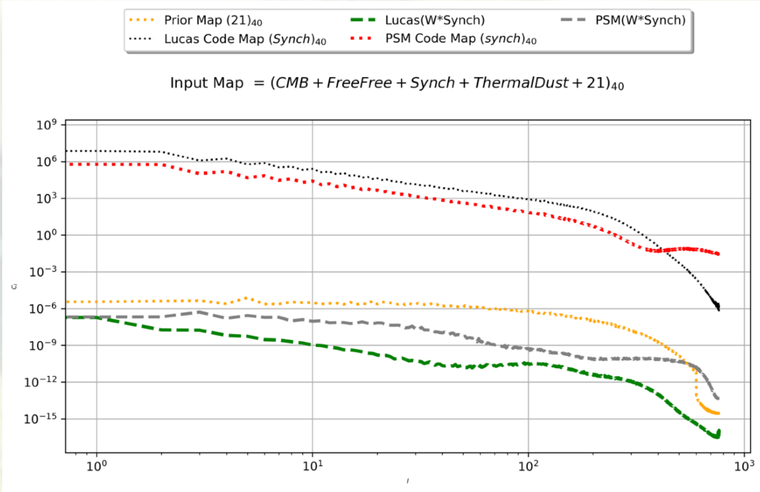
Component separation

Fornazier et al. A&A (2022)





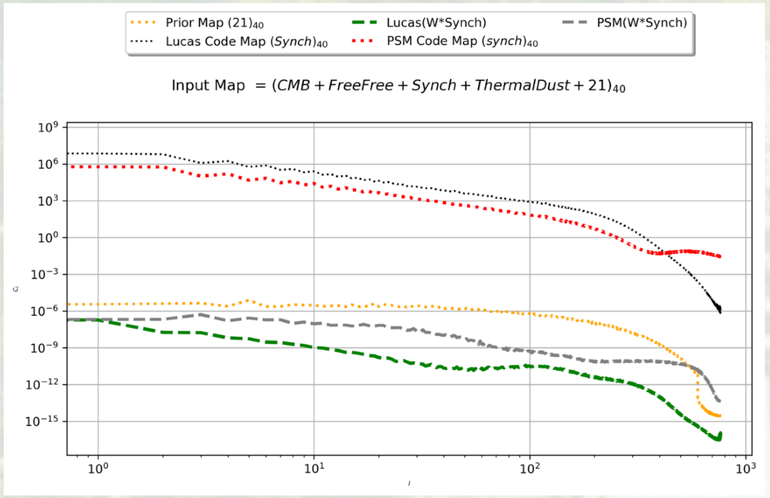


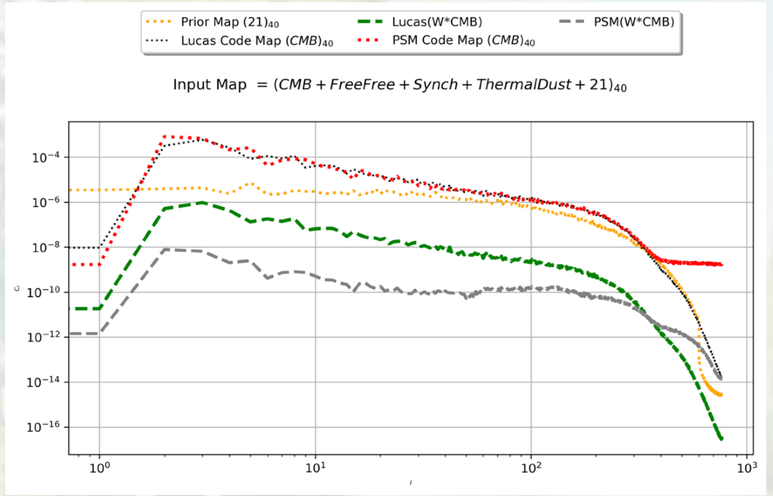


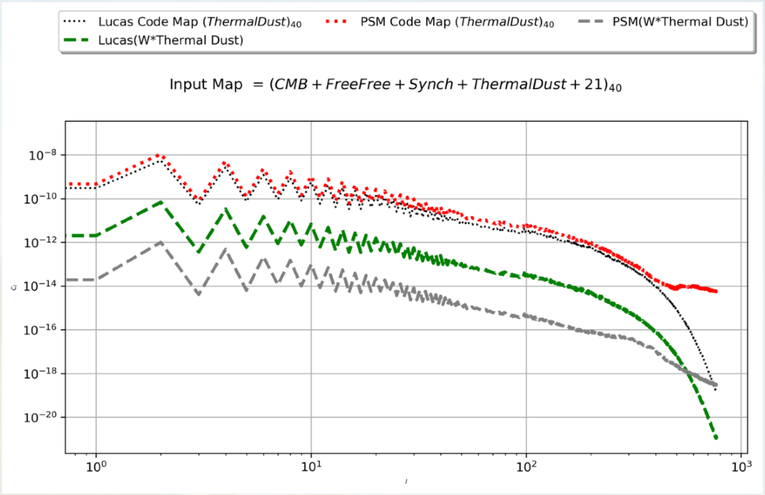
C. A. Wuensche (2022)

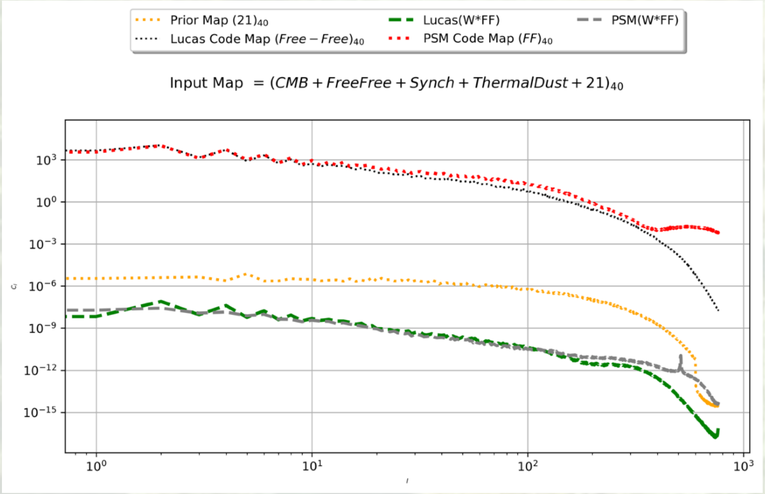
Component separation

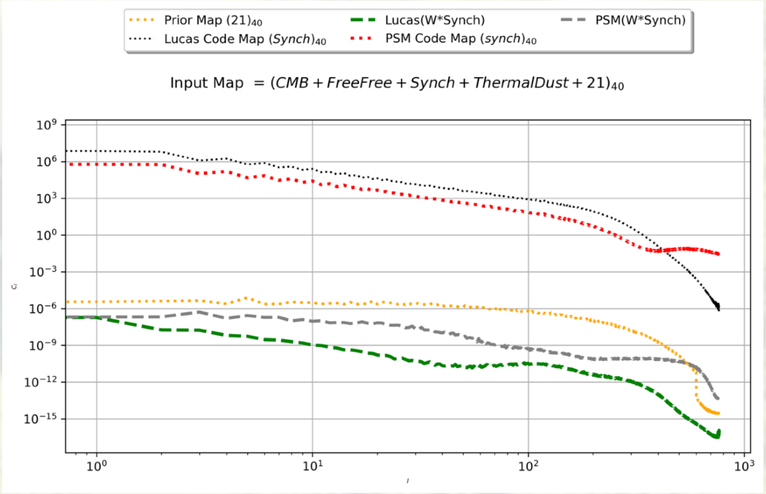
Fornazier et al. A&A (2022)



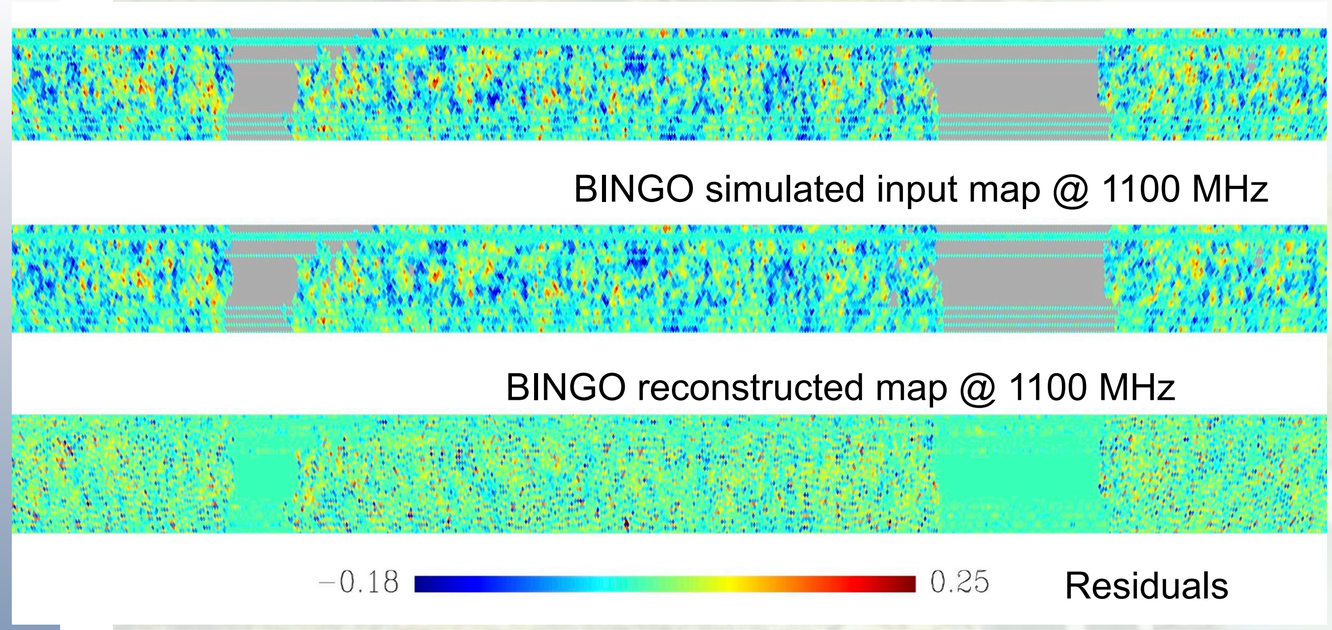




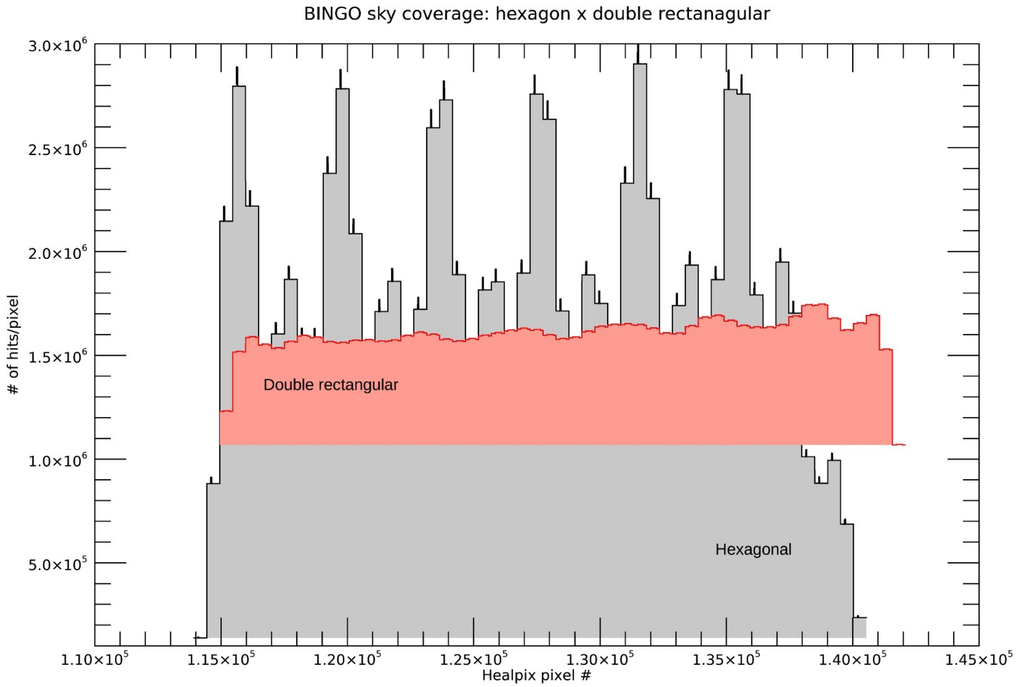




C. A. Wuensche (2022)



Liccardo et al. A&A (2022)



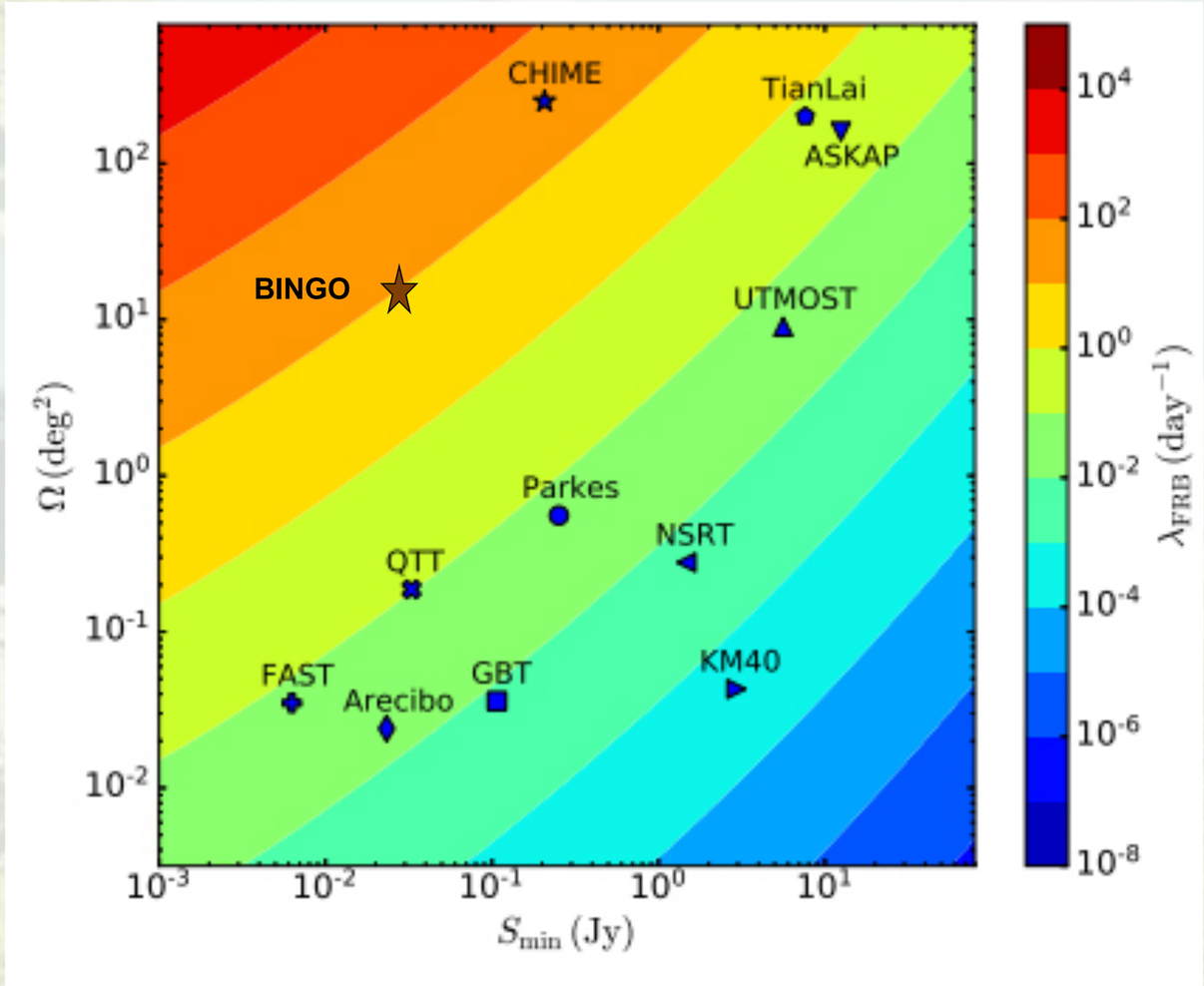
C. A. Wuensche (2022)

Fast Radio Bursts detection

- ☑ FRB is not BINGO main science, but serendipitous detections are expected
- ☑ Outriggers for interferometric pinpoint of the progenitor are being planned
- ☑ Need 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…



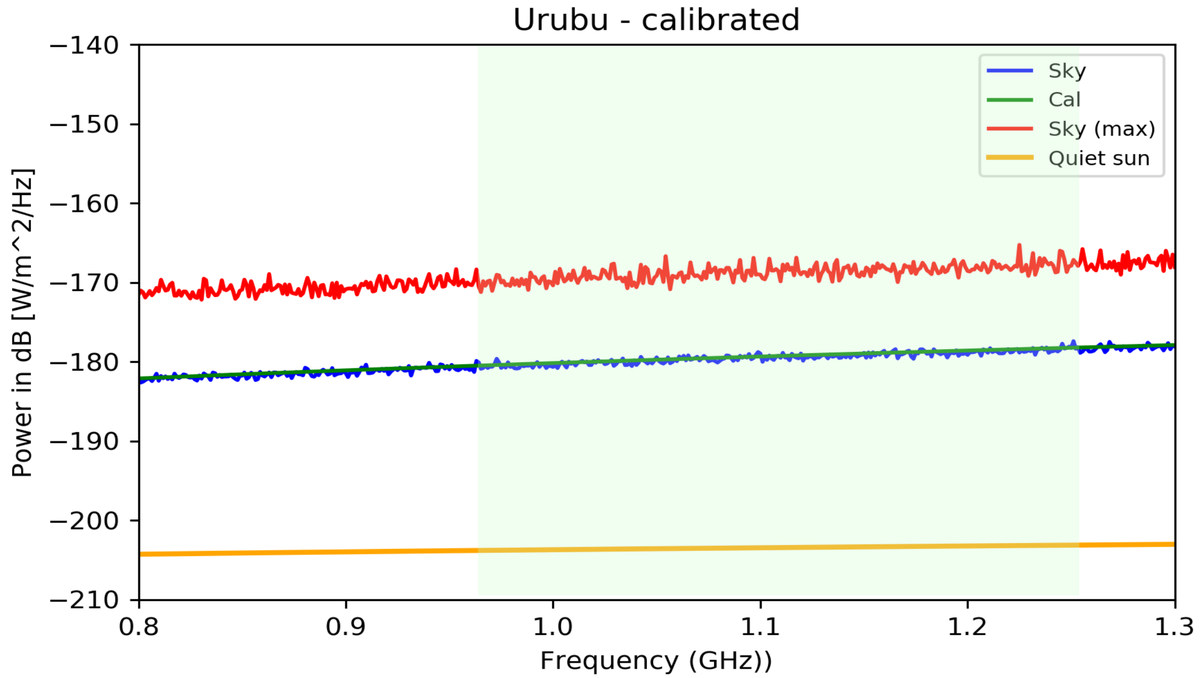
Luo et al., arXiv:2003.04848

F. Vieira: estimates for BINGO

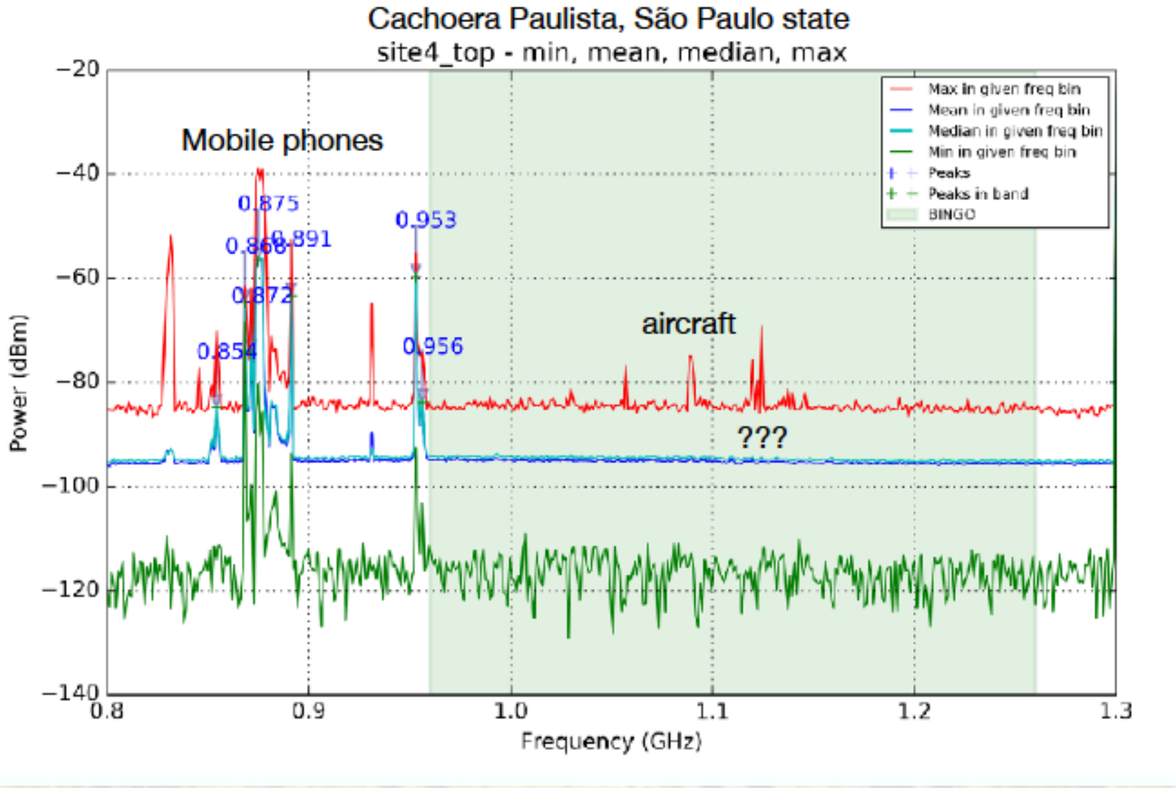
Vargas et al. In preparation

C. A. Wuensche (2022)

The BINGO site in Paraíba is CLEAN in the radio band

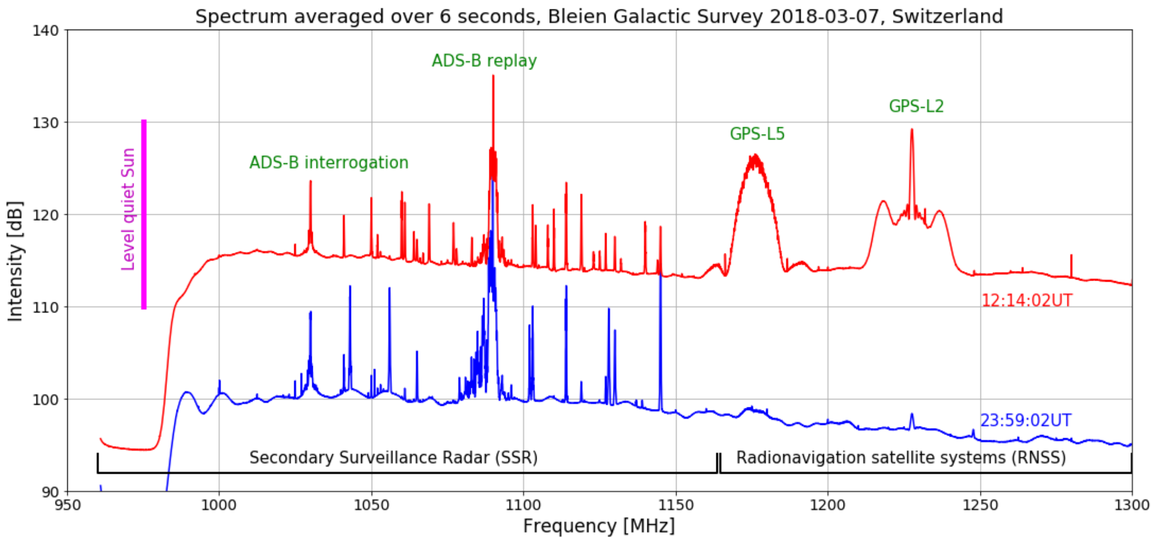


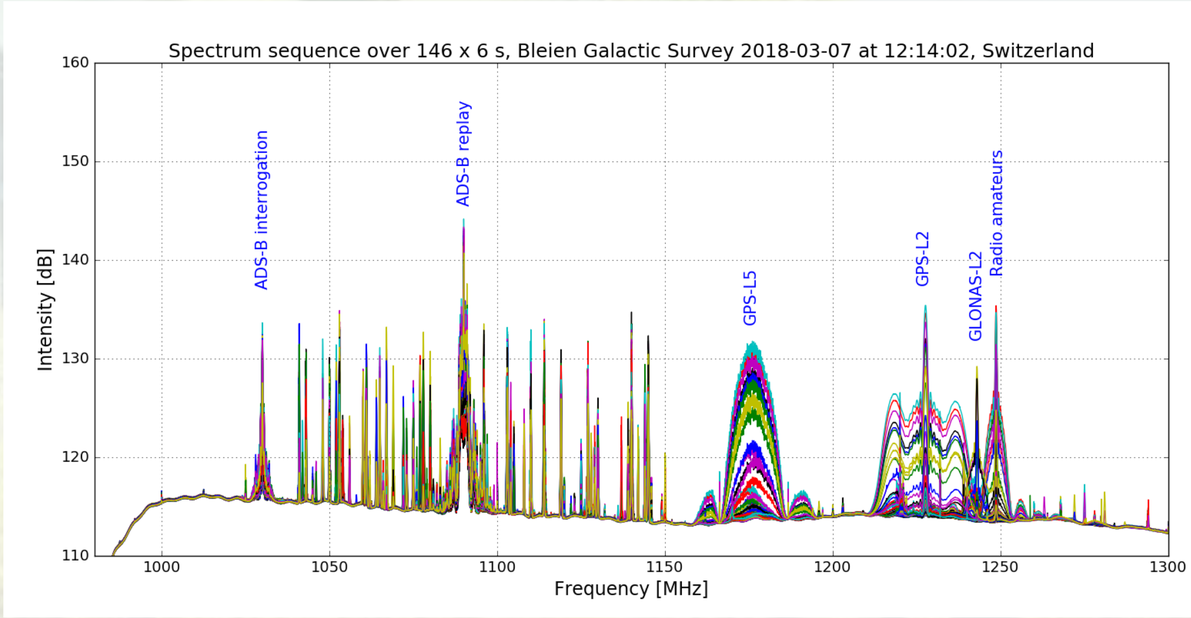
Peel et al. Journal of Astr. Instrumentation (2019)



C. A. Wuensche (2022)

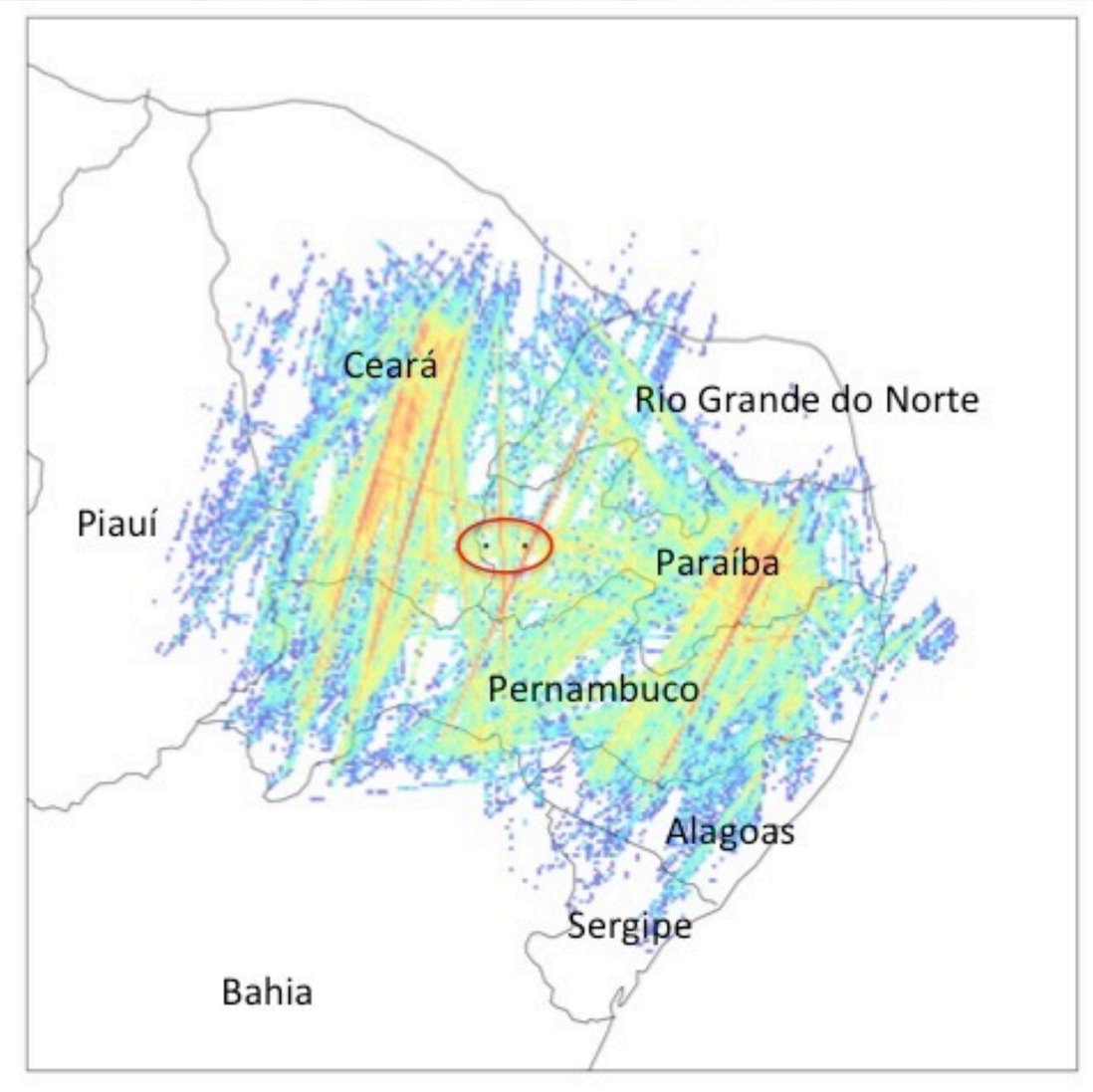
For comparison, the spectrum in the same band in Bleien Observatory (Switzerland)…





C. A. Wuensche (2022)

Still, there are concerns about airplane coverage and geostationary satellites…



Peel, Wuensche et al (J. Astr. Instrumentation 2019)

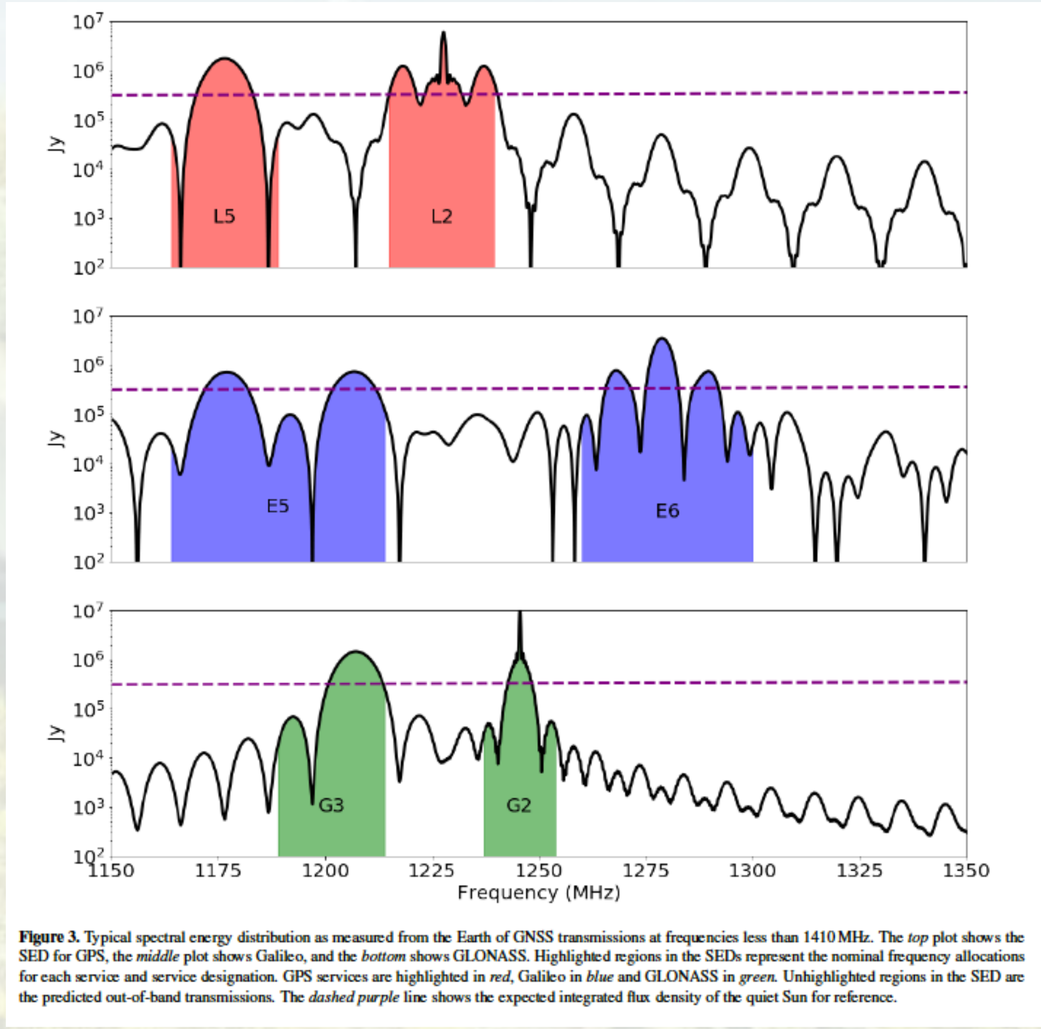


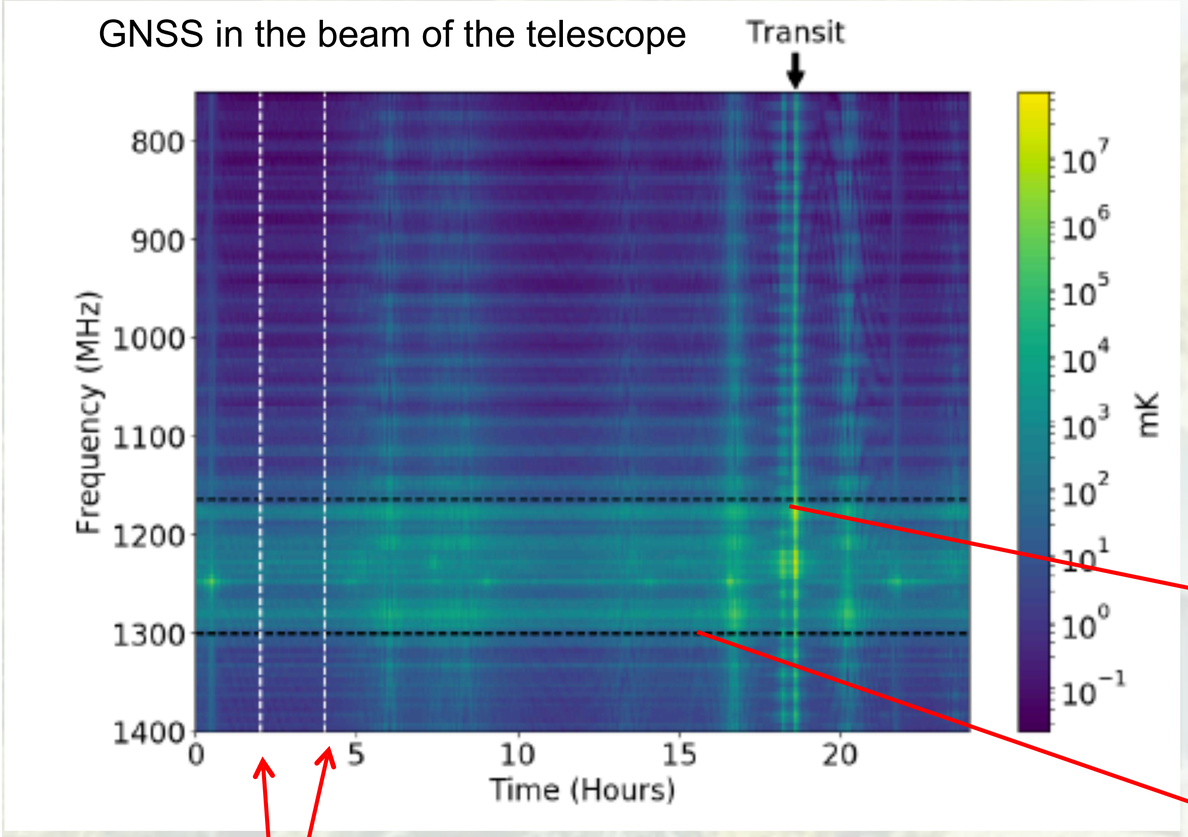
Figure 3. Typical spectral energy distribution as measured from the Earth of GNSS transmissions at frequencies less than 1410 MHz. The *top* plot shows the SED for GPS, the *middle* plot shows Galileo, and the *bottom* shows GLONASS. Highlighted regions in the SEDs represent the nominal frequency allocations for each service and service designation. GPS services are highlighted in *red*, Galileo in *blue* and GLONASS in *green*. Unhighlighted regions in the SED are the predicted out-of-band transmissions. The *dashed purple* line shows the expected integrated flux density of the quiet Sun for reference.

C. A. Wuensche (2022)

Harper & Dickinson, arXiv:1803.06314v2

And GNSS...

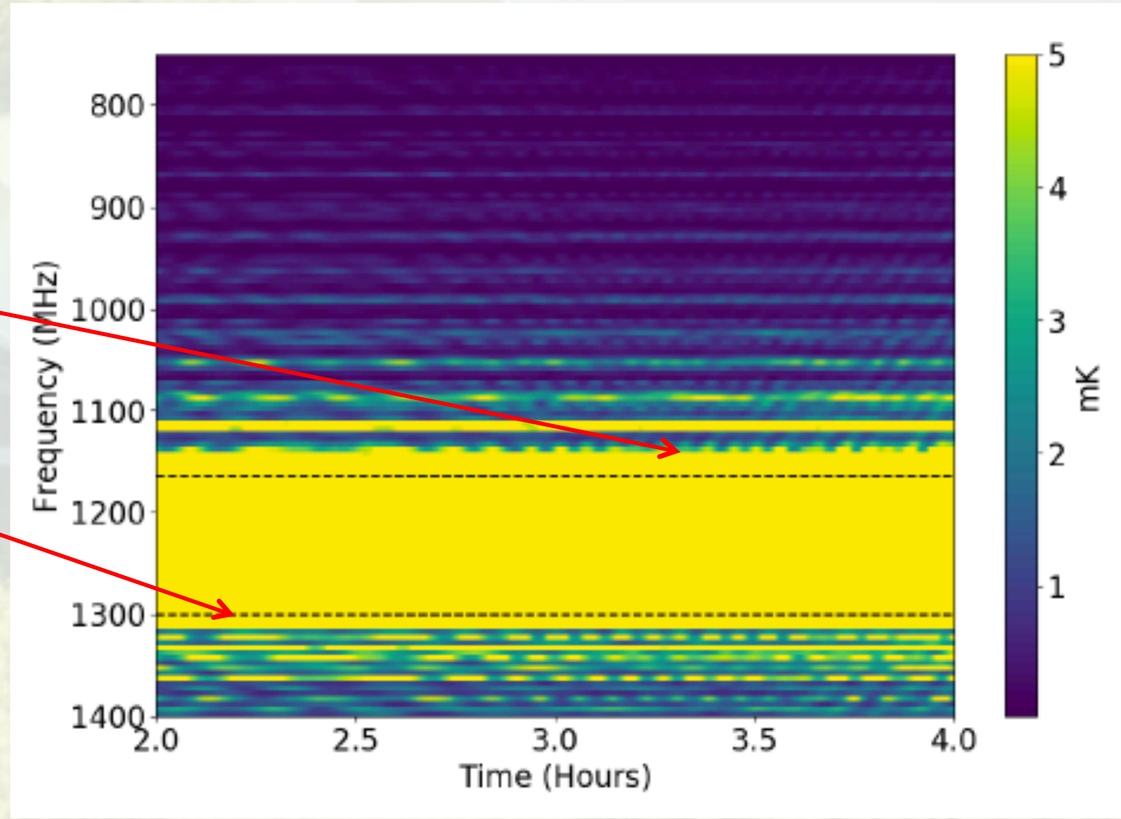
GNSS in the beam of the telescope



White lines: no GNSS closer than 29 deg. of the main be beam axis

Harper & Dickinson, arXiv:1803.06314v2

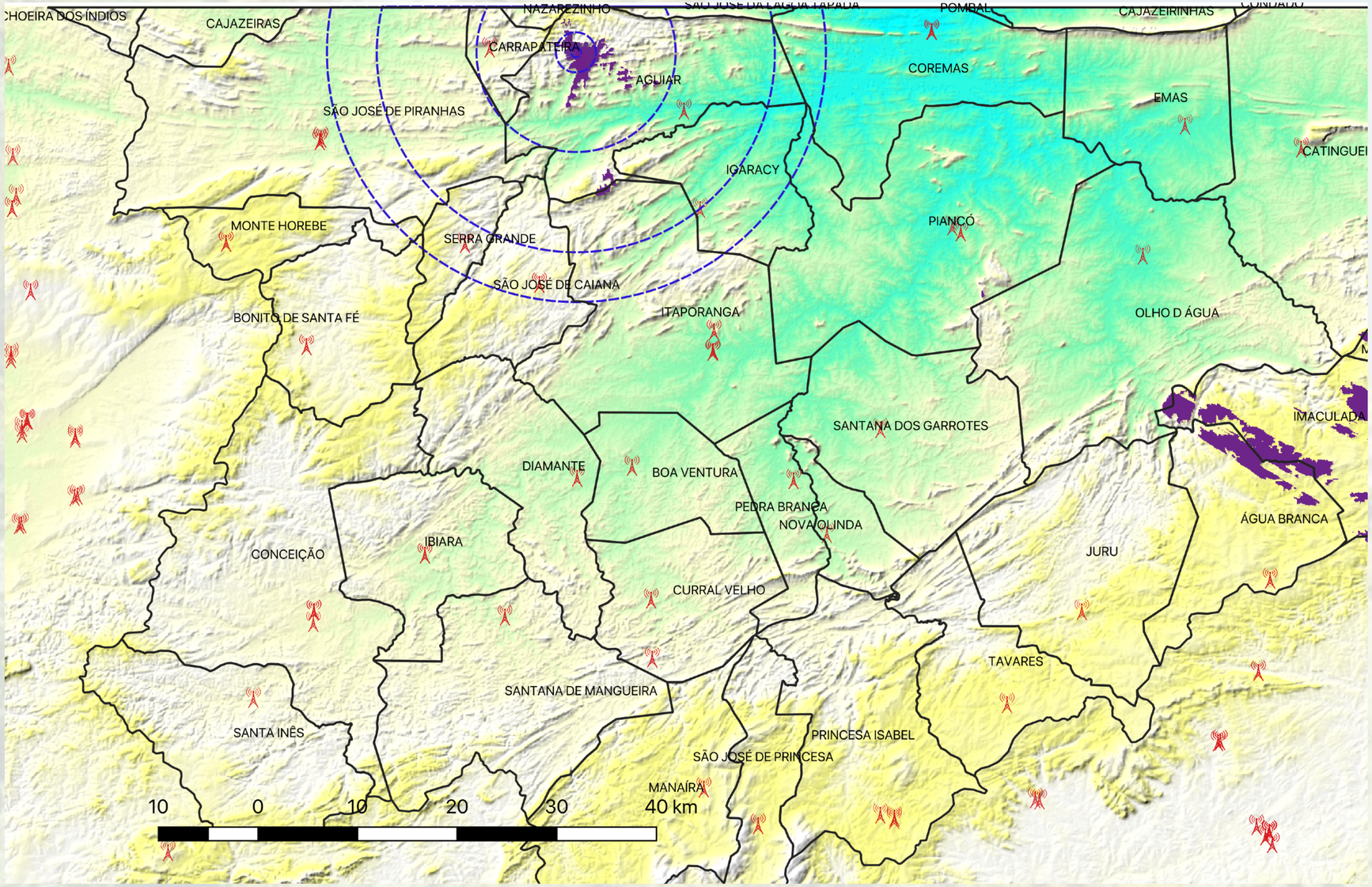
Black dashed lines: L5 (1164 MHz) and L2 bands (1260 MHz)



Yellow band (zoom and scale) to show the off-band leakage of GNNS into the band

C. A. Wuensche (2022)

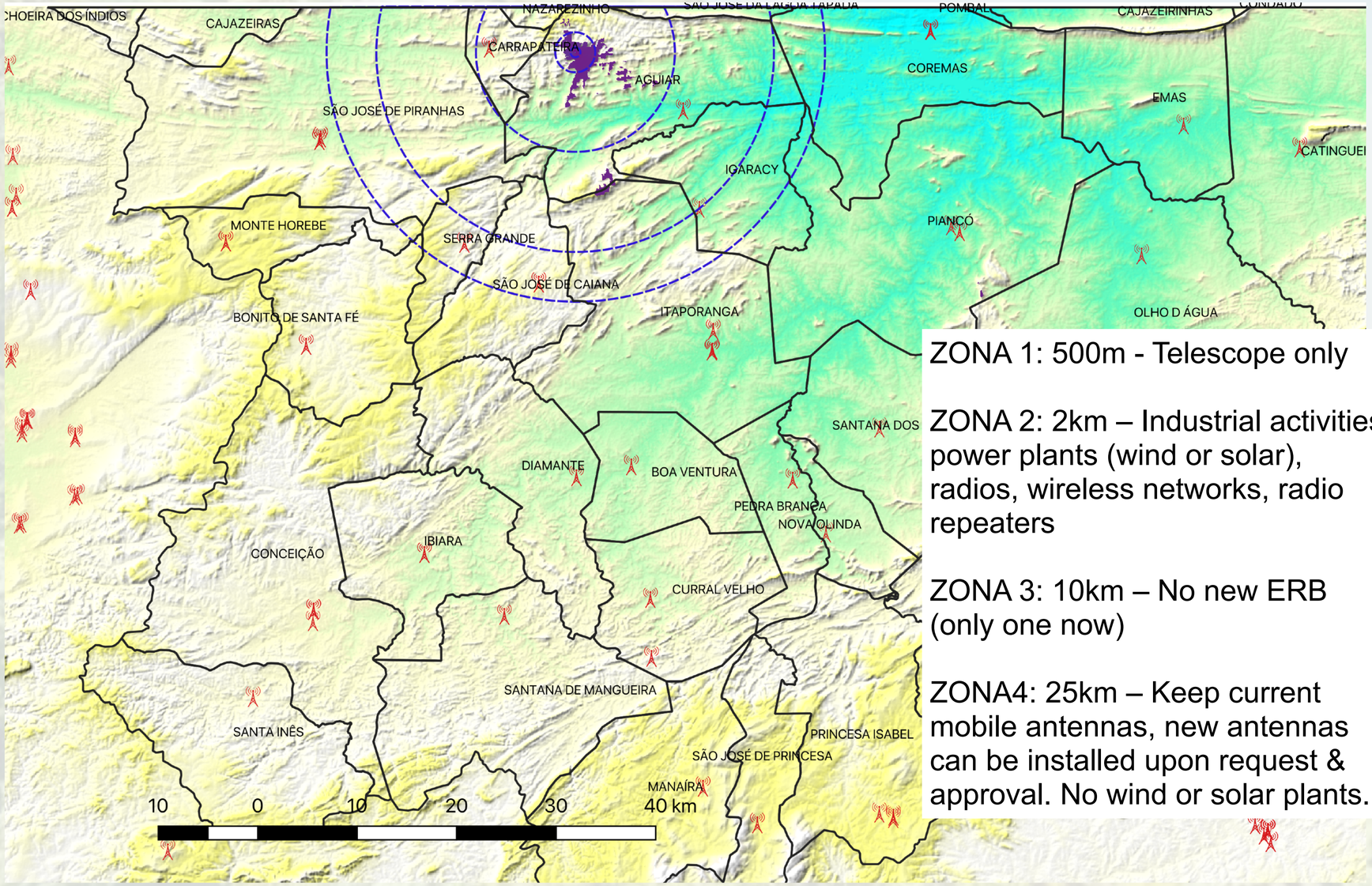
Silence zone proposal (discussions with Anatel started October 2018)



Source: L. Barosi

C. A. Wuensche (2022)

Silence zone proposal (discussions with Anatel started October 2018)



ZONA 1: 500m - Telescope only

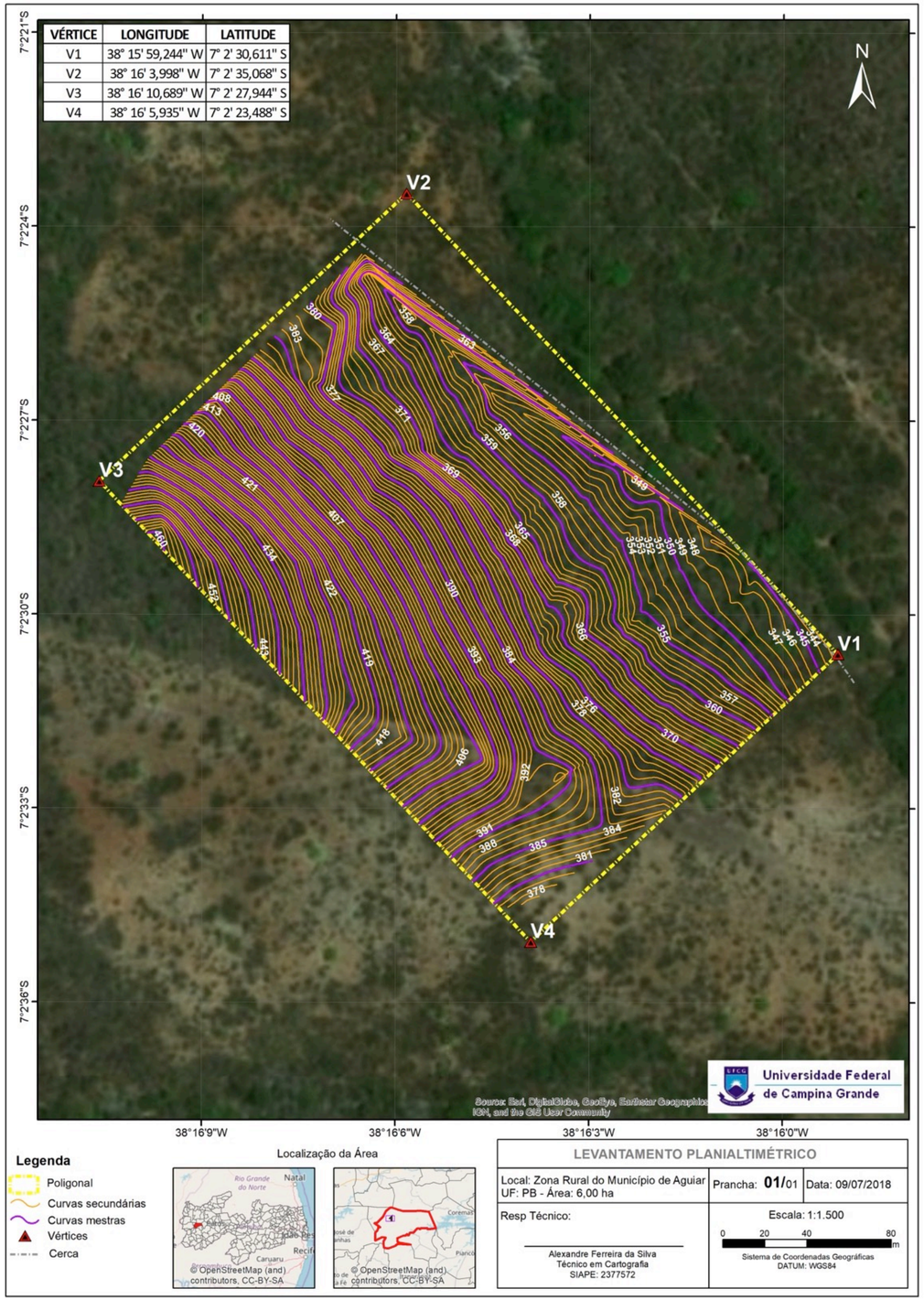
ZONA 2: 2km – Industrial activities, power plants (wind or solar), radios, wireless networks, radio repeaters

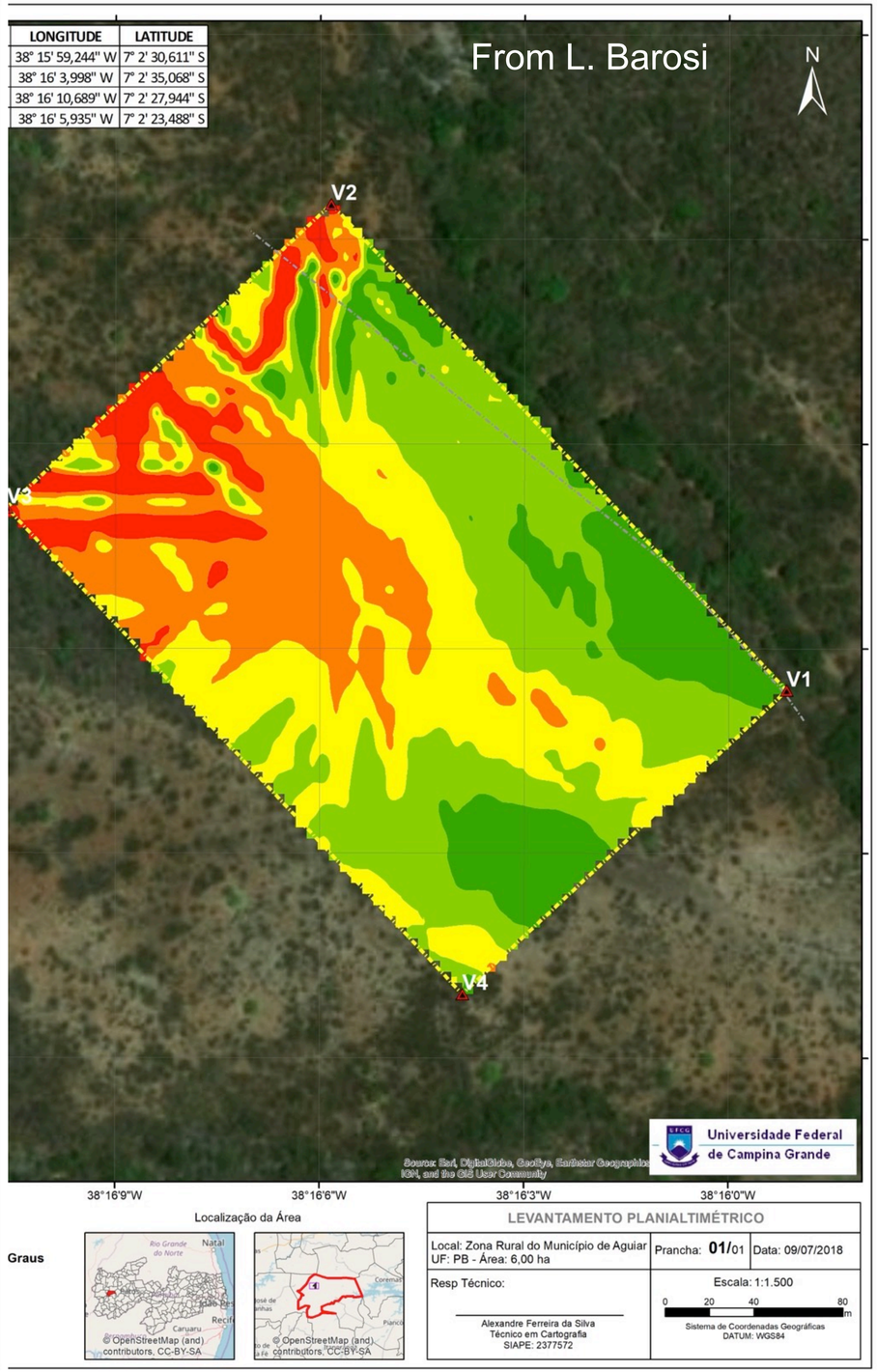
ZONA 3: 10km – No new ERB (only one now)

ZONA4: 25km – Keep current mobile antennas, new antennas can be installed upon request & approval. No wind or solar plants.

Source: L. Barosi

C. A. Wuensche (2022)


VÉRTICE | LONGITUDE | LATITUDE
V1 | 38° 15' 59,244" W | 7° 2' 30,611" S
V2 | 38° 16' 3,998" W | 7° 2' 35,068" S
V3 | 38° 16' 10,689" W | 7° 2' 27,944" S
V4 | 38° 16' 5,935" W | 7° 2' 23,488" S
N
V1
V2
V3
V4
7°2'21"S
7°2'24"S
7°2'27"S
7°2'30"S
7°2'33"S
7°2'36"S
38°16'9"W
38°16'6"W
38°16'3"W
38°16'0"W
Universidade Federal de Campina Grande
Legenda
Poligonal
Curvas secundárias
Curvas mestras
Vértices
Cerca
Localização da Área
LEVANTAMENTO PLANIALTIMÉTRICO
Local: Zona Rural do Município de Aguiar
UF: PB - Área: 6,00 ha
Prancha: 01/01
Data: 09/07/2018
Resp Técnico:
Alexandre Ferreira da Silva
Técnico em Cartografia
SIAPE: 2377572
Escala: 1:1.500
0 20 40 80 m
Sistema de Coordenadas Geográficas
DATUM: WGS84


From L. Barosi
LONGITUDE | LATITUDE
38° 15' 59,244" W | 7° 2' 30,611" S
38° 16' 3,998" W | 7° 2' 35,068" S
38° 16' 10,689" W | 7° 2' 27,944" S
38° 16' 5,935" W | 7° 2' 23,488" S
N
V1
V2
V3
V4
38°16'9"W
38°16'6"W
38°16'3"W
38°16'0"W
Universidade Federal de Campina Grande
Graus
Localização da Área
LEVANTAMENTO PLANIALTIMÉTRICO
Local: Zona Rural do Município de Aguiar
UF: PB - Área: 6,00 ha
Prancha: 01/01
Data: 09/07/2018
Resp Técnico:
Alexandre Ferreira da Silva
Técnico em Cartografia
SIAPE: 2377572
Escala: 1:1.500
0 20 40 80 m
Sistema de Coordenadas Geográficas
DATUM: WGS84