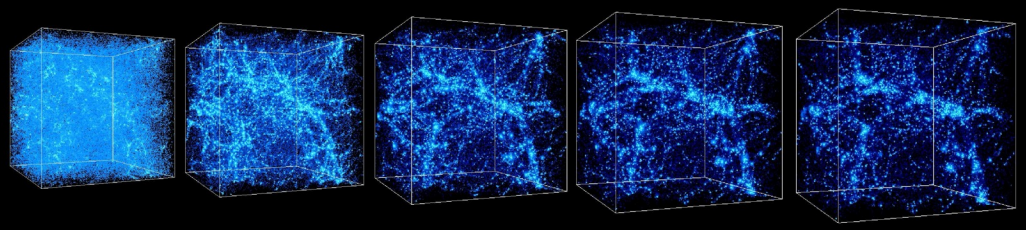
# THE CALIBRATION OF MISTRAL AT THE SRT

*E.S. Battistelli*
*Experimental Cosmology group*
*Physics department*
*Sapienza, University of Rome*

*Image credits: cosmic web (http://cosmicweb.kimalbrecht.com/)*

# TALK OUTLINE



- The need of high angular resolution mm observations and resolved measurements of the SZ effect

- MISTRAL

  - Sardinia Radio Telescope
  - Cryostat
  - Optics
  - Detectors and Read-out
  - Laboratory calibration
  - Transportation and mount
  - On-site calibration→**Isopi's poster**

- Conclusions

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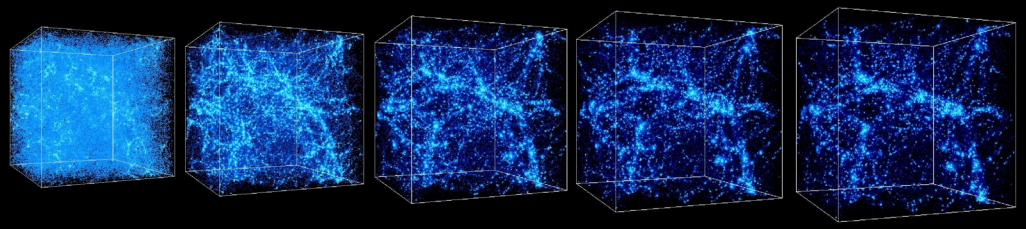

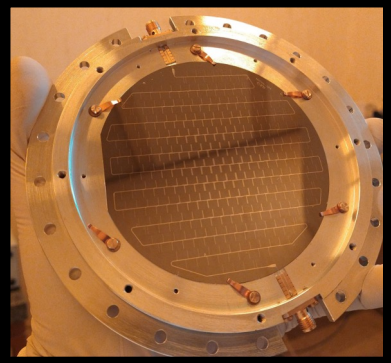

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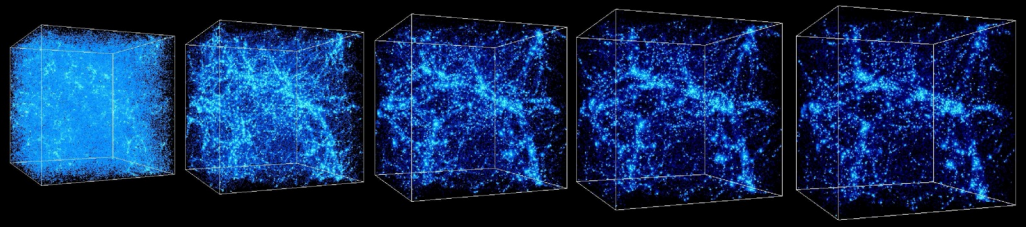

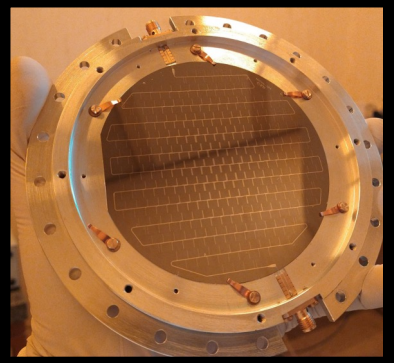

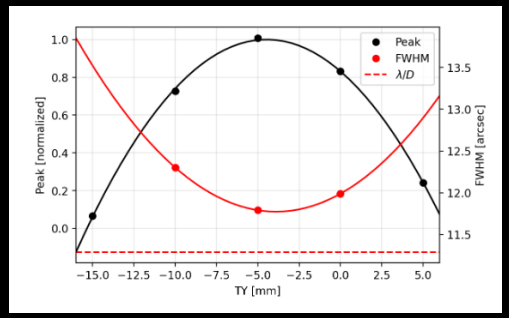


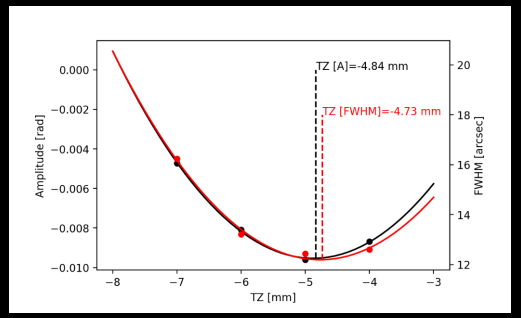


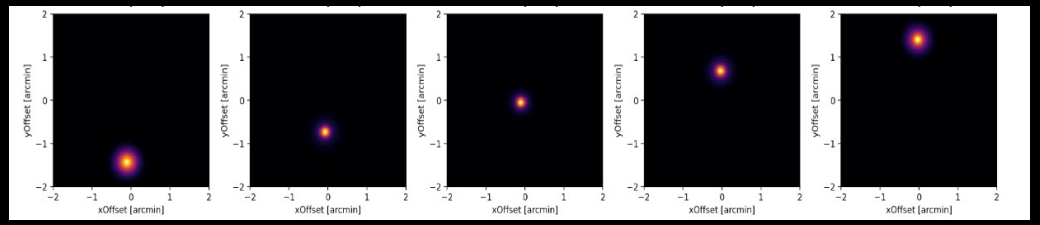


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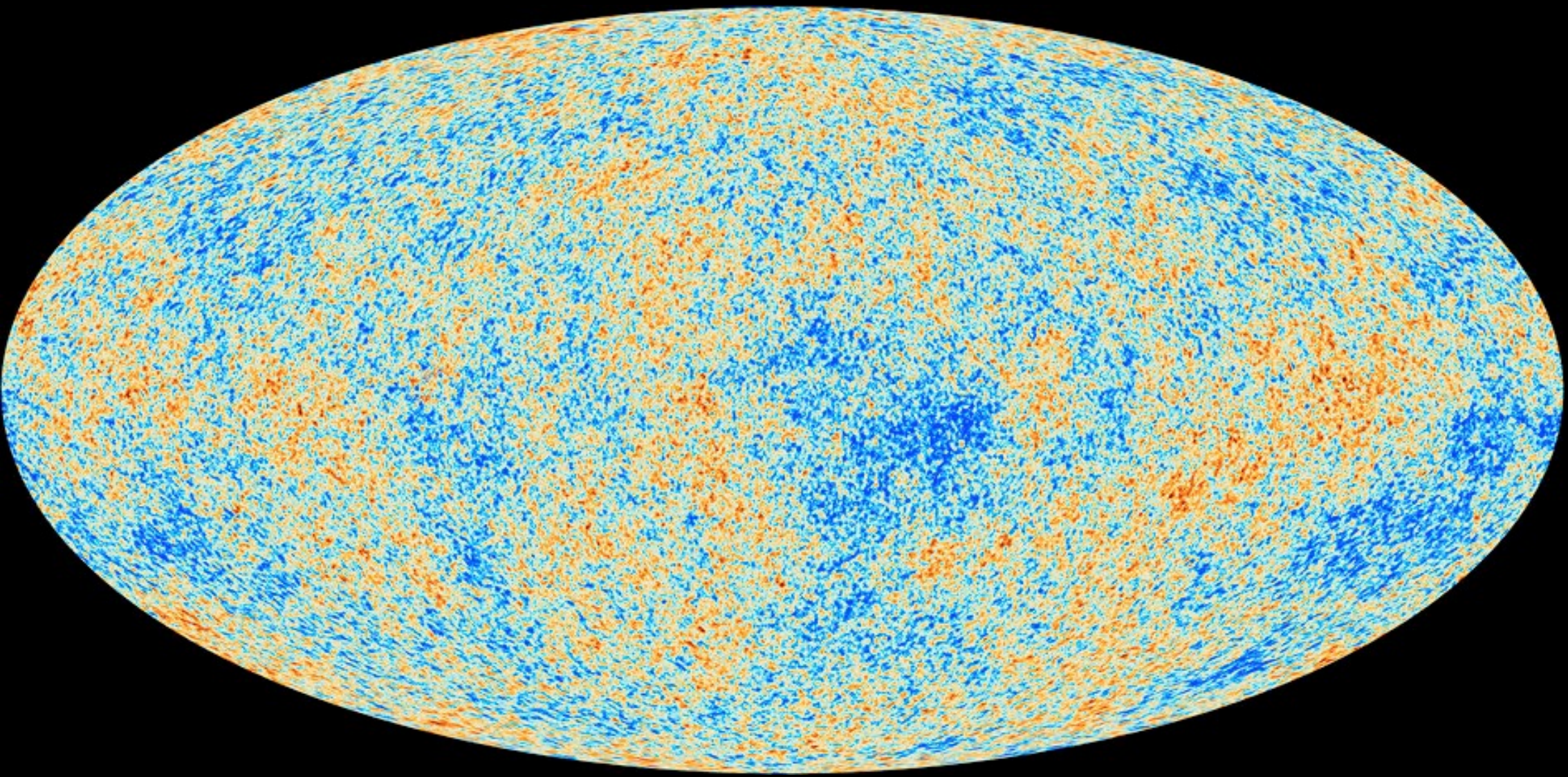
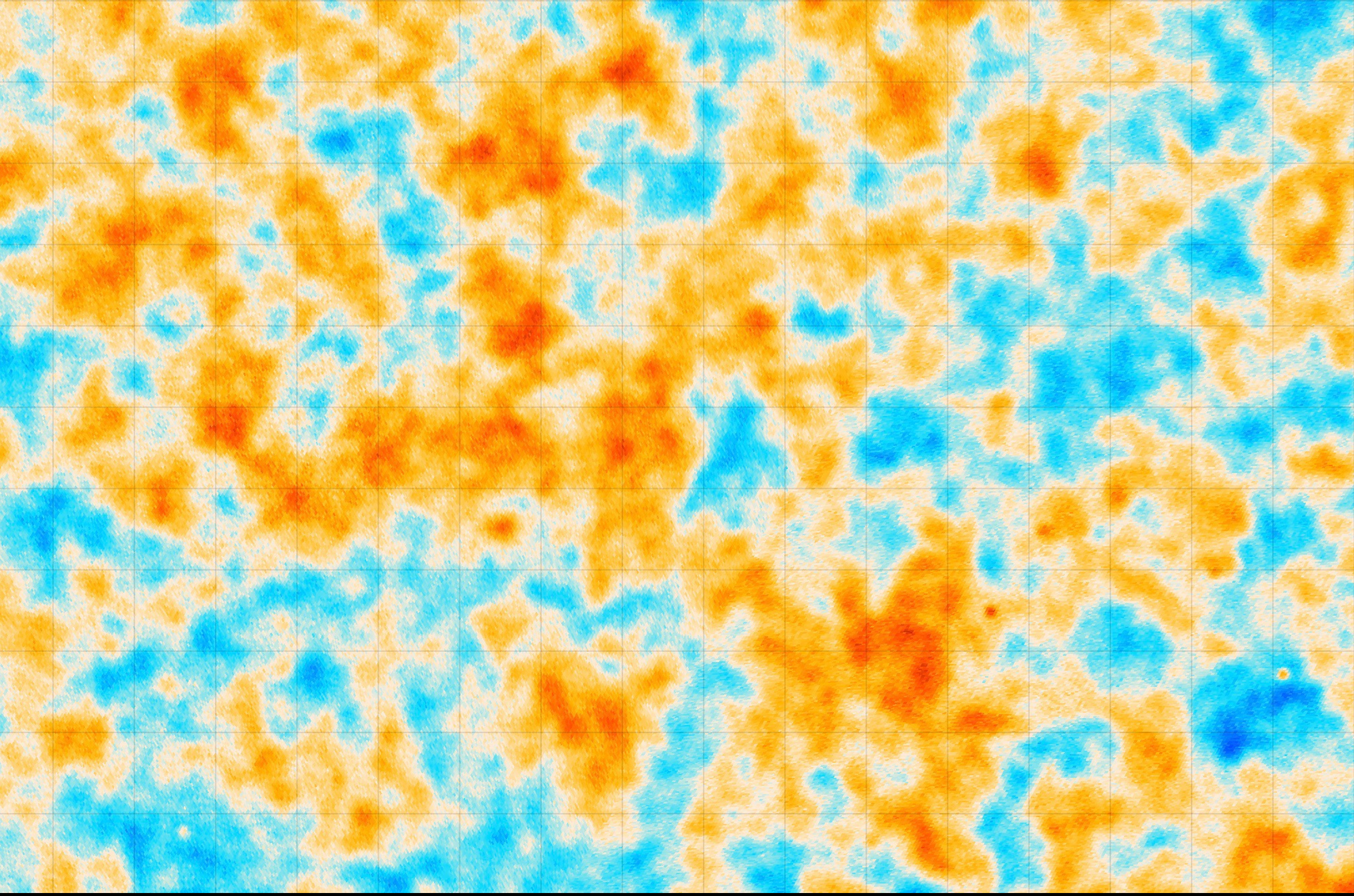
# COSMIC MICROWAVE BACKGROUND



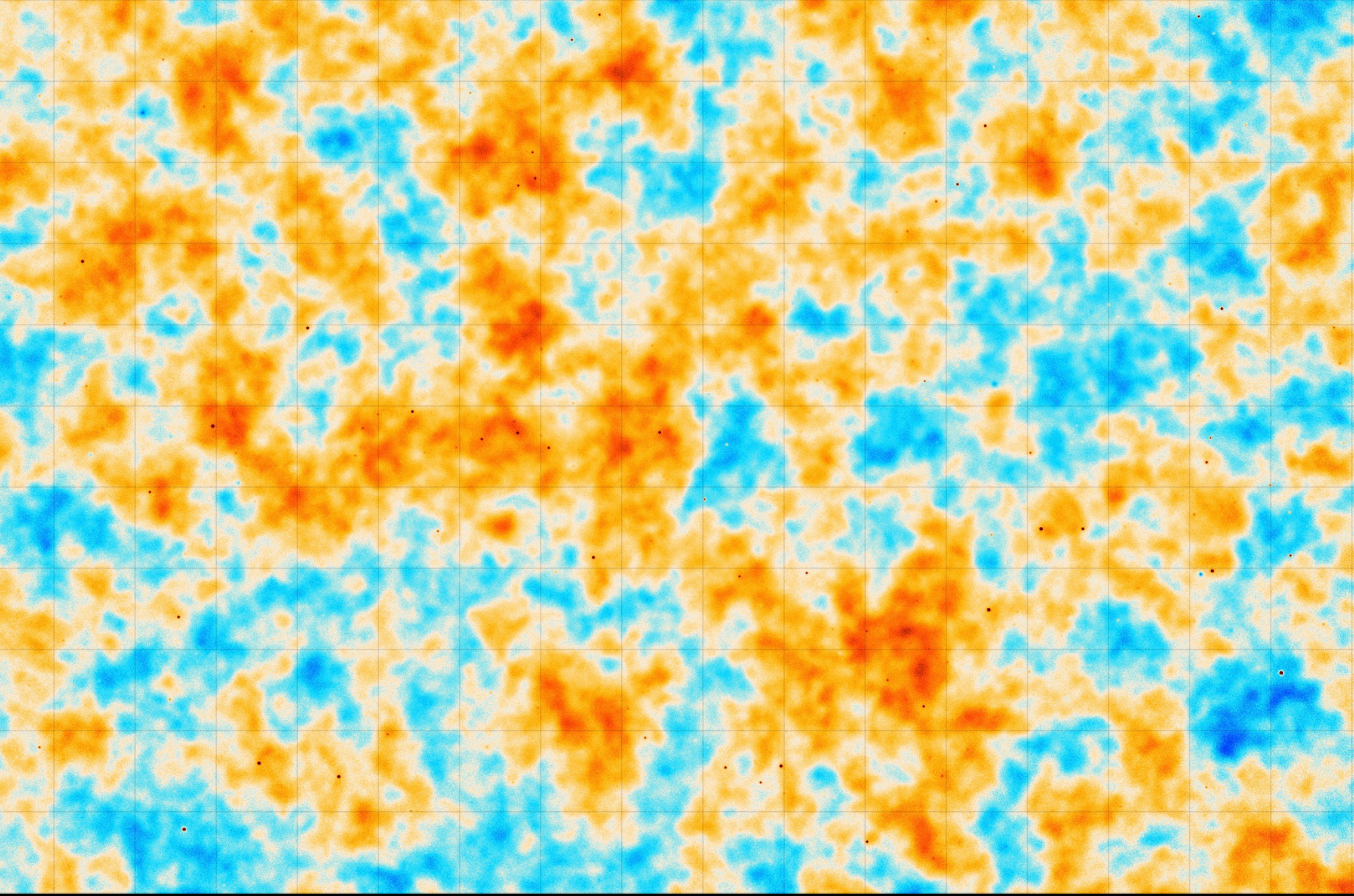
PLANCK

ESA/Planck Collaboration



30x22 deg$^2$ CMB map as seen from Planck (150GHz)

Naess et al. 2020



30x22 deg$^2$ CMB map as seen from Planck+ACT-DR4 (150GHz)

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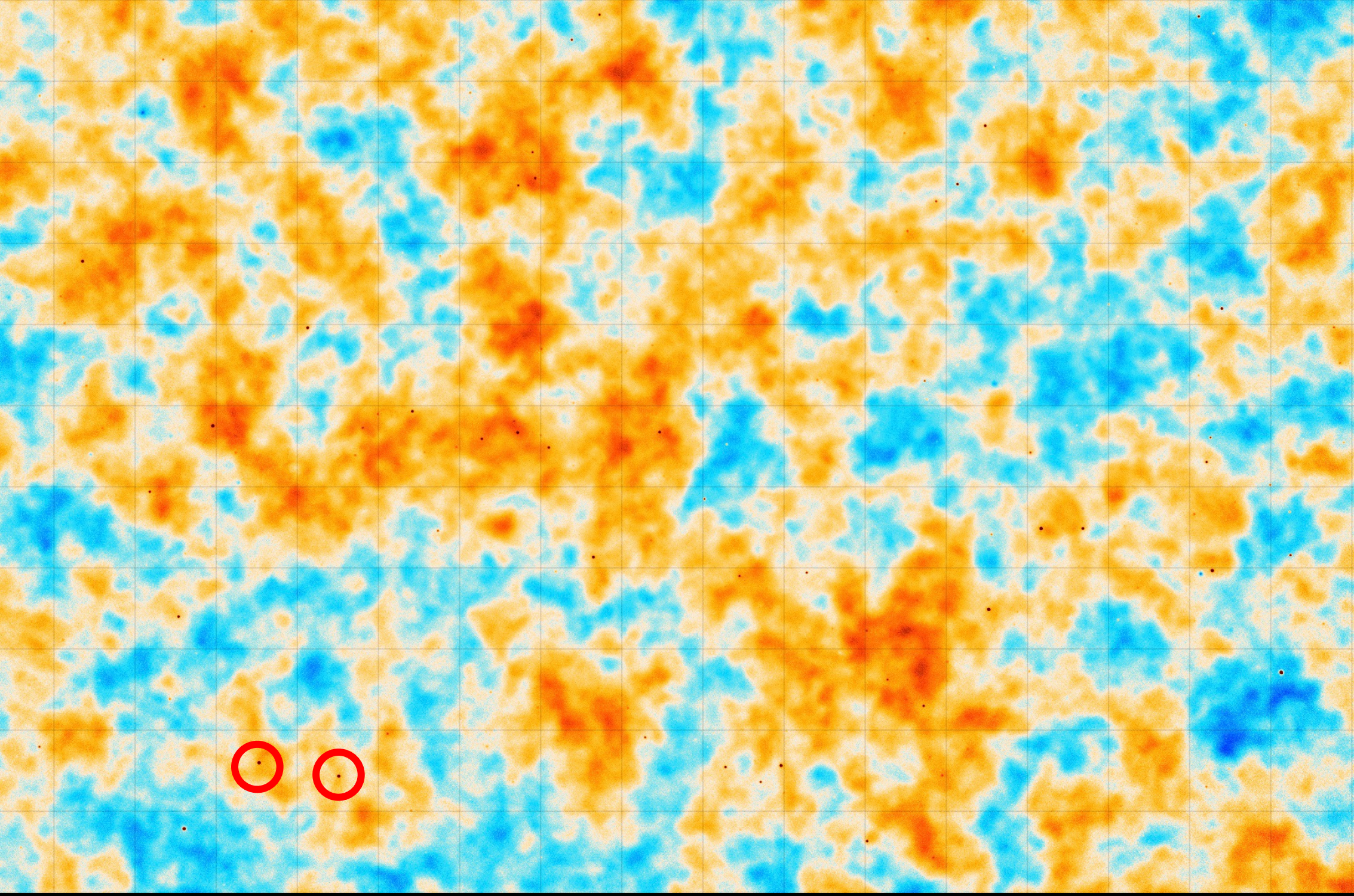

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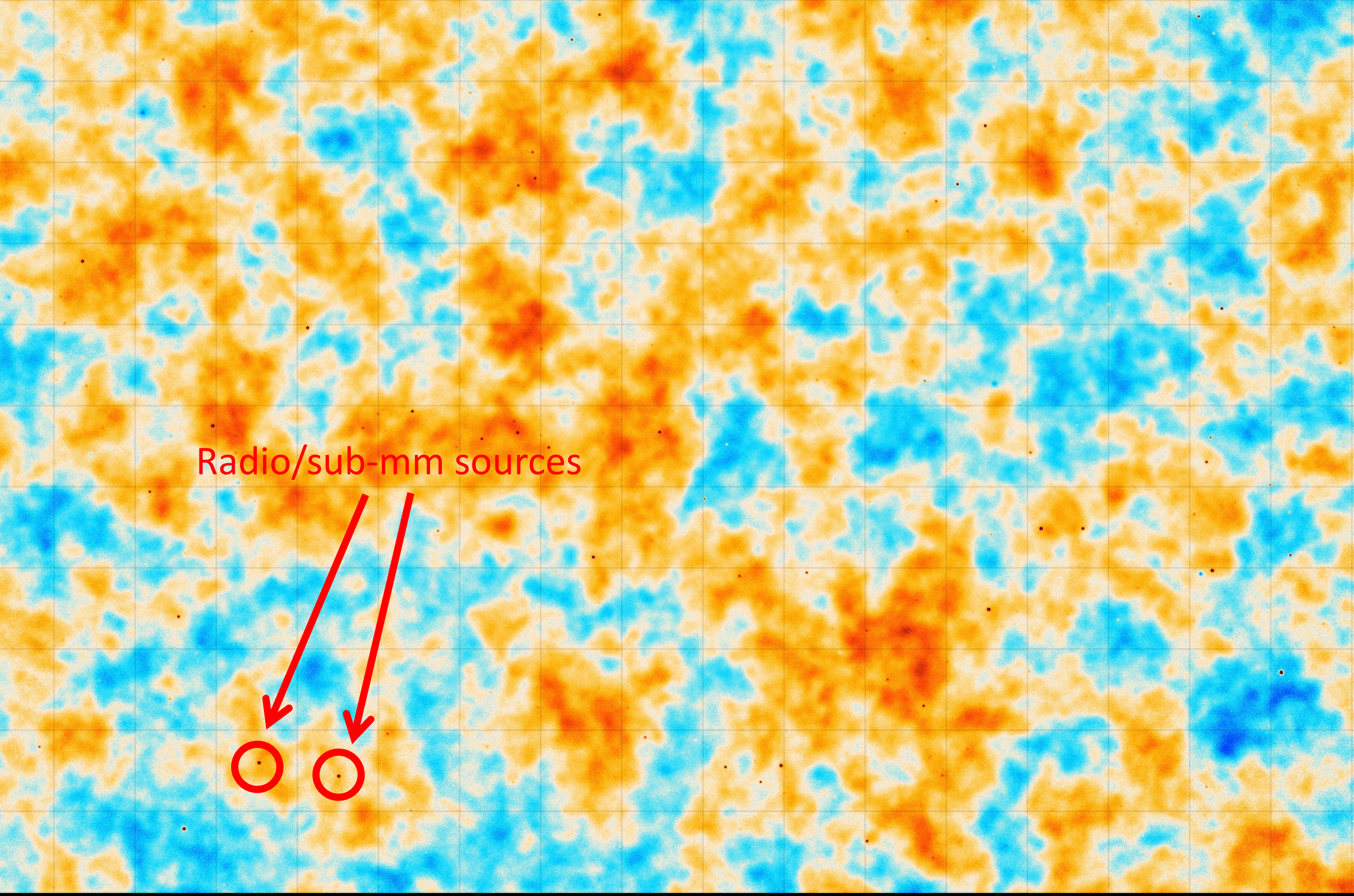


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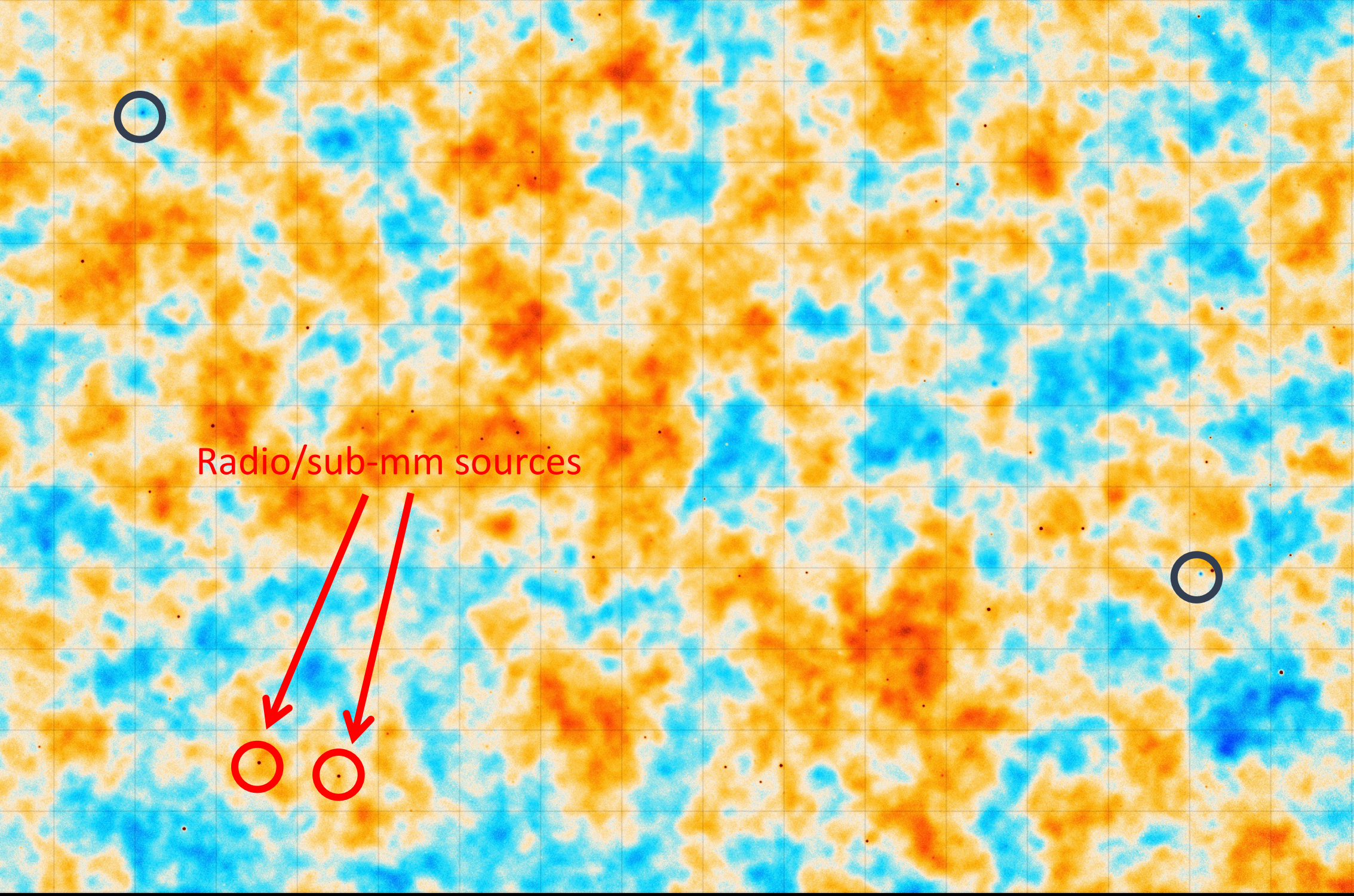


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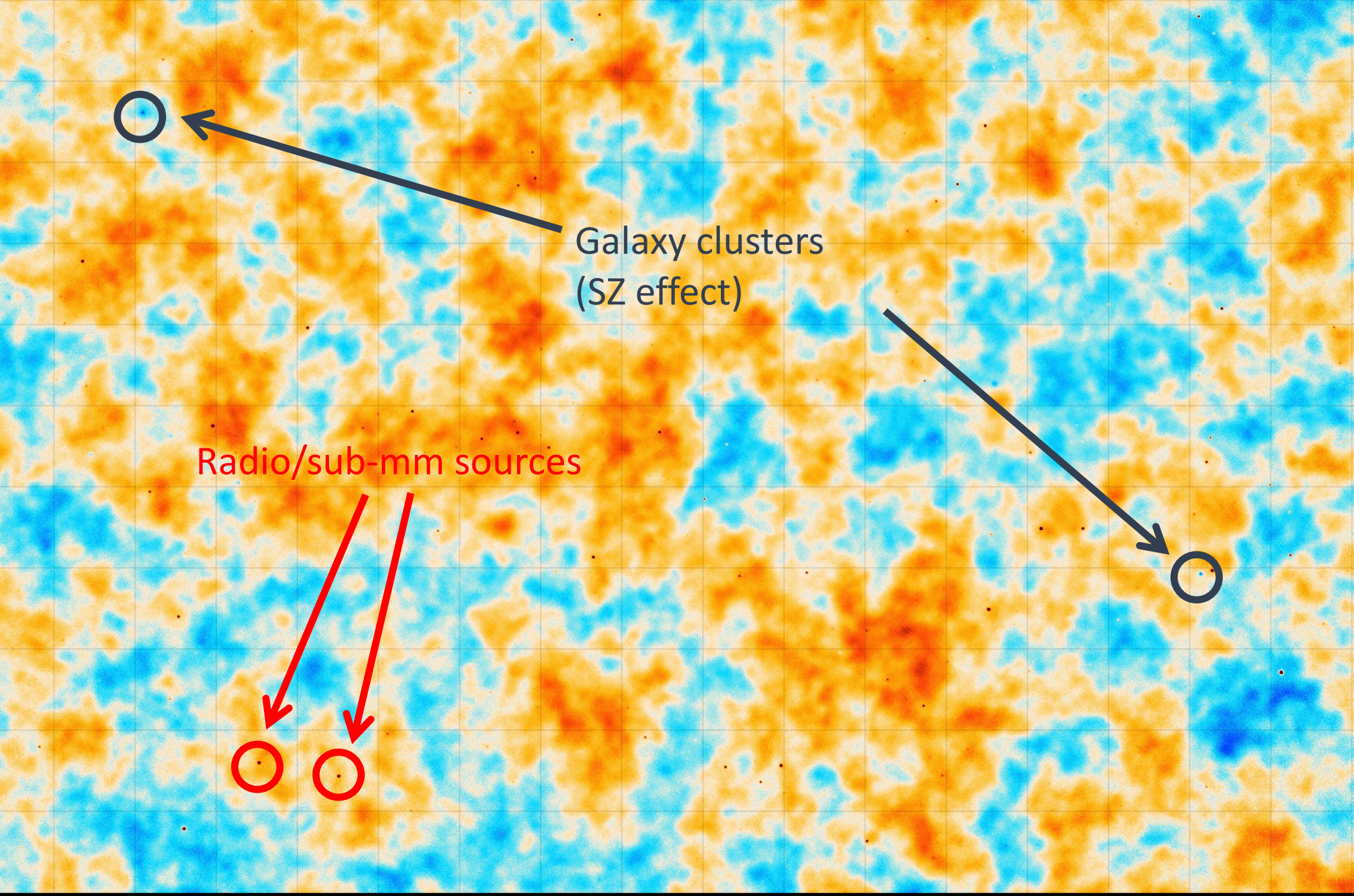


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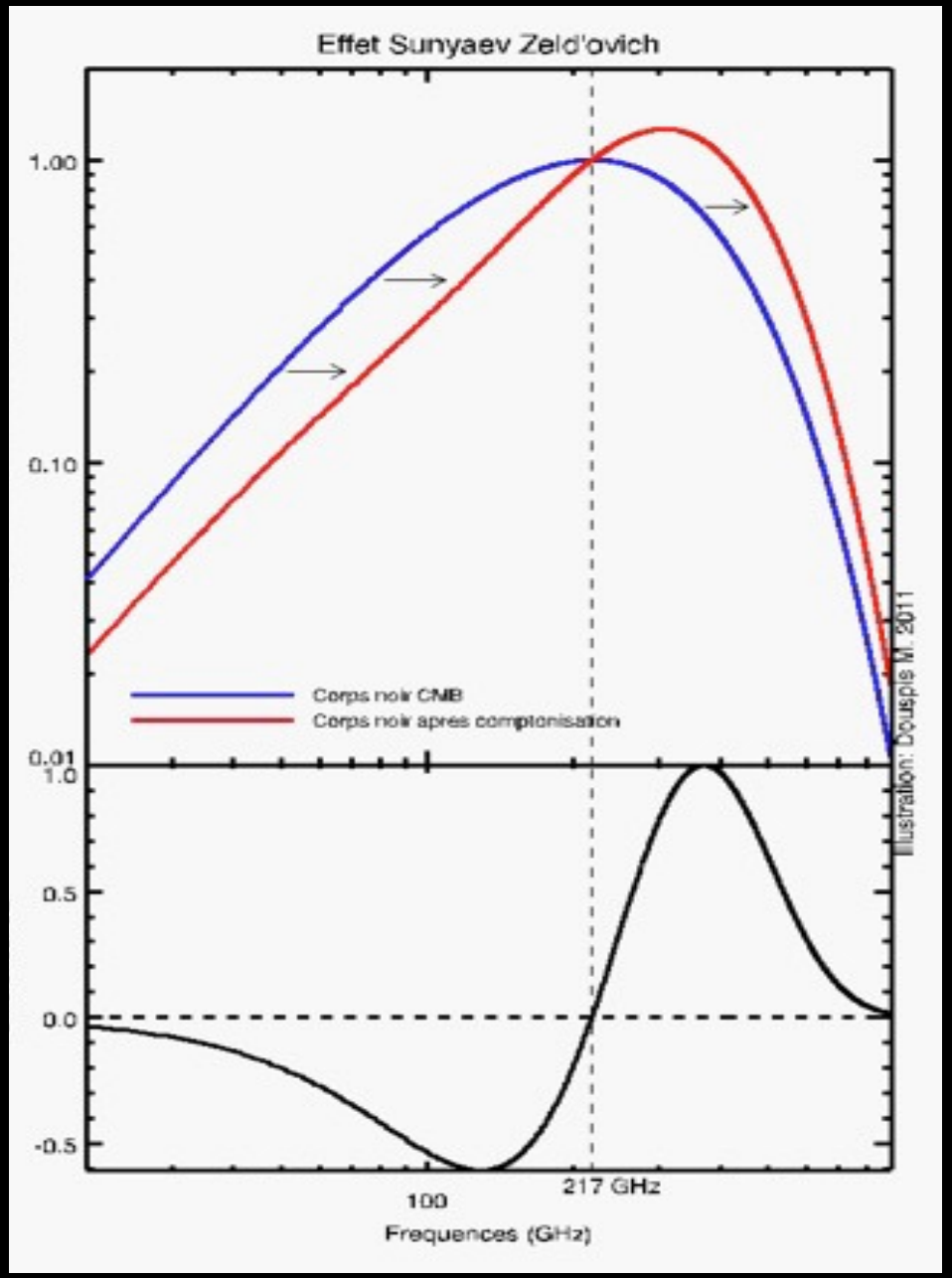
# THE SUNYAEV ZEL'DOVICH EFFECT

- When CMB interacts with hot ionized medium, its photons undergo inverse Compton scattering
- SZ: spectral distortion of the CMB due to inverse Compton scattering by a hot (T~$10^8$K) electron gas typically in galaxy clusters is quantified by:

$$y = \int n_e \sigma_T \frac{k_B T_e}{m_e c^2} dl = \tau \theta_e$$




*(Sunyaev & Zel'dovich, Comm.A.S.P., 1972)*

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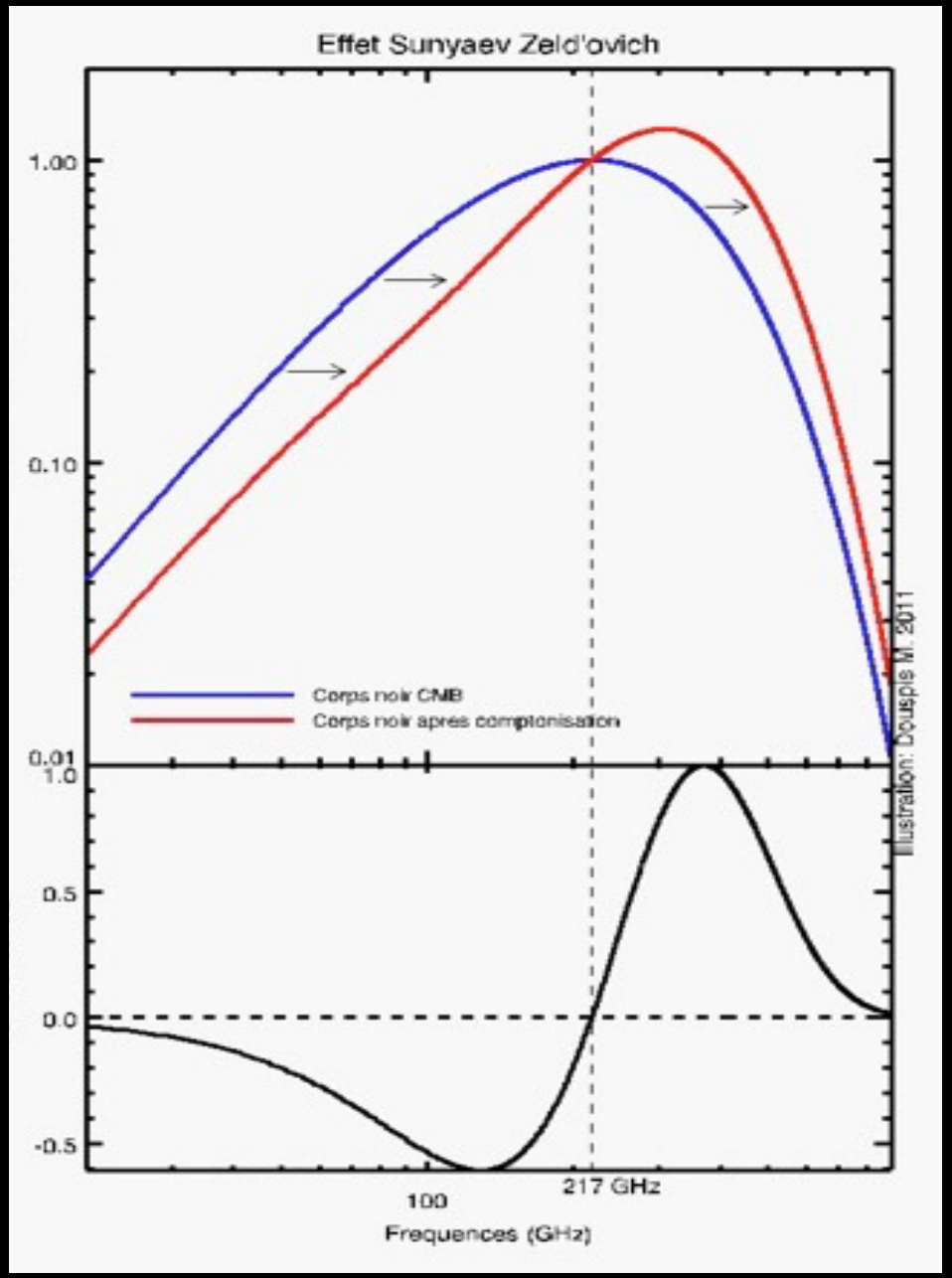
$$X_{br} \propto ne^2 \cdot \sqrt{T_e} \cdot l$$

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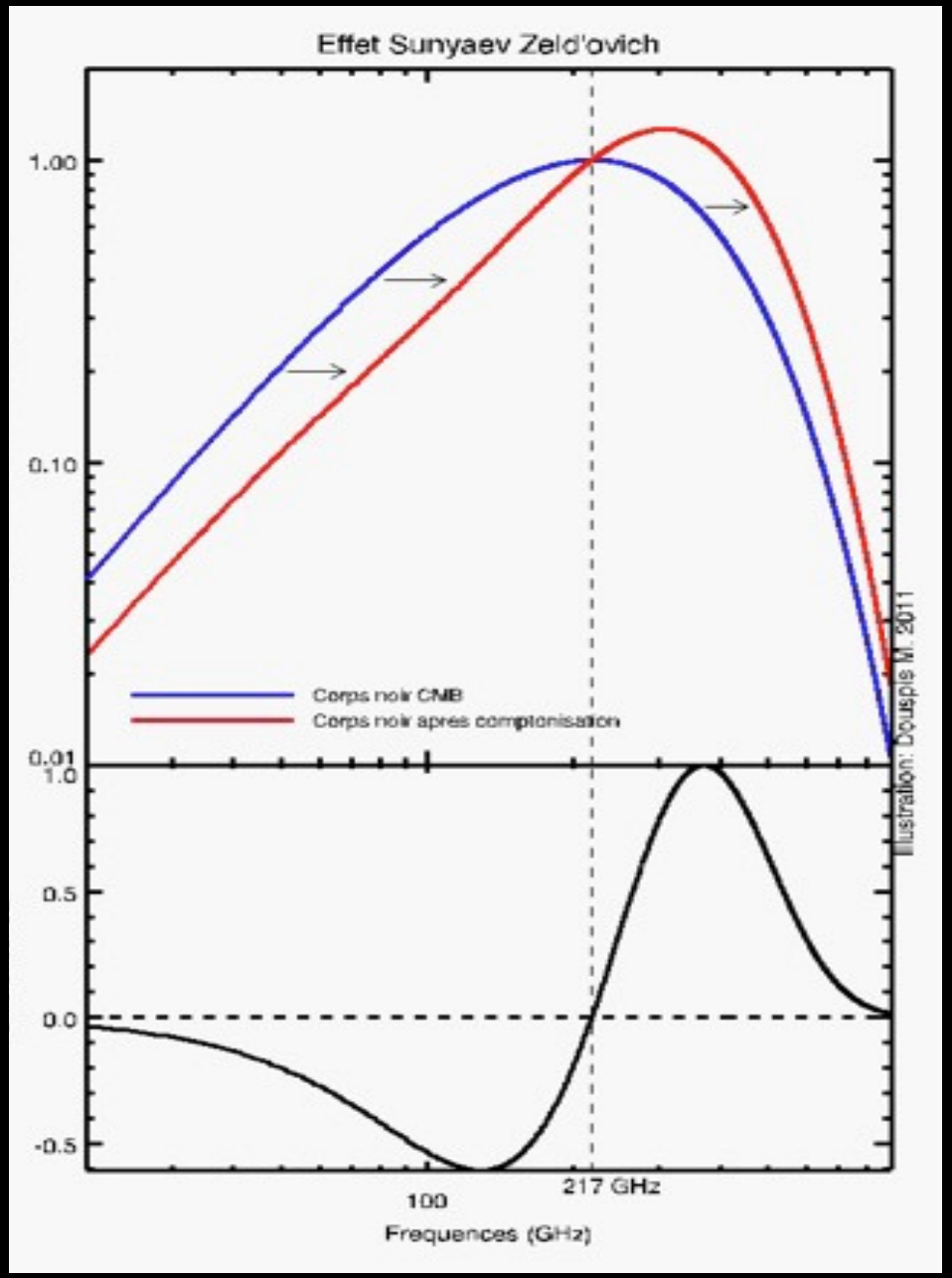


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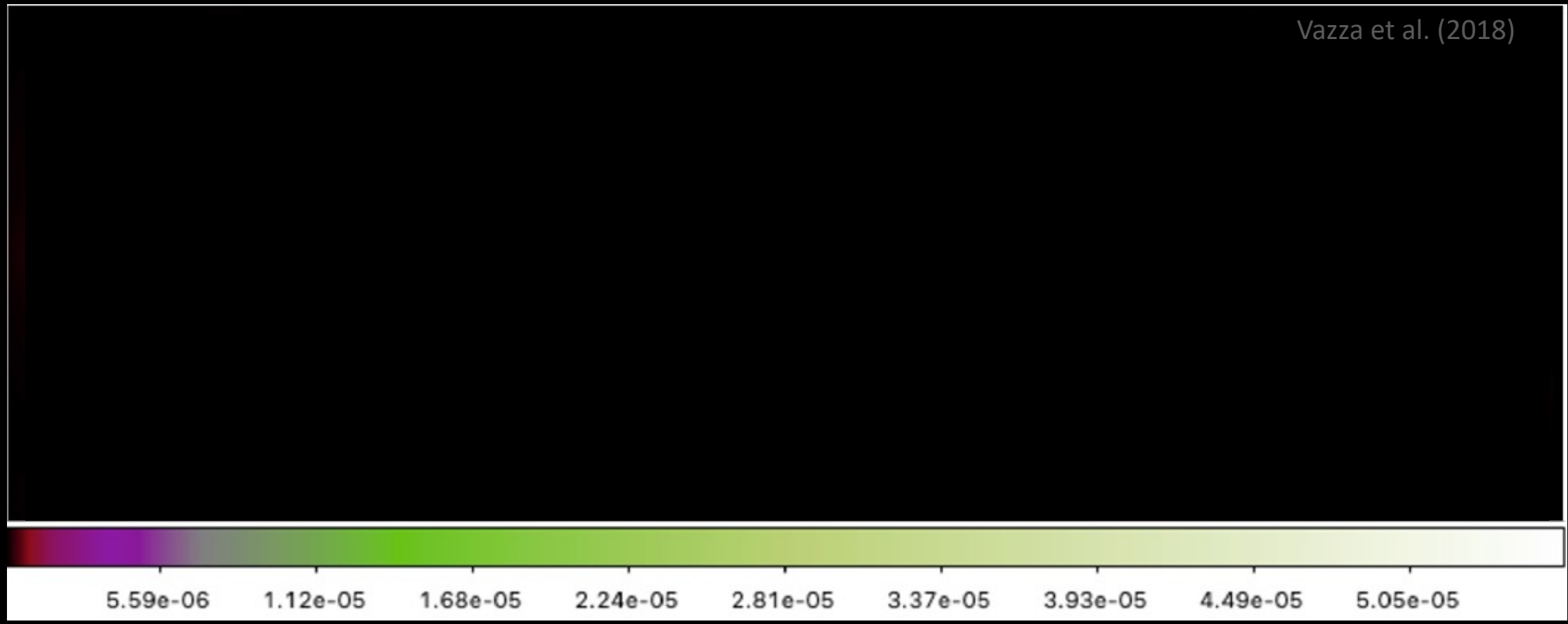
# NEED FOR HIGH RESOLUTION OBS.

- Non relaxed galaxy clusters can benefit from high angular resolution SZ observation: turbulence predicted by hydrodynamical simulations of the order of $y \lessapprox 10^{-5}$ at the few hundreds of kpc
- Galaxy clusters sit at the knots of the Cosmic Web and they are connected by bridges and filaments
- In bridges, predictions of the scale at which baryons depart from DM distribution: 0.7-7Mpc scales is key and show a specific signature  illustrisTNG simulation (Galarraga-Espinosa et al. 2022)



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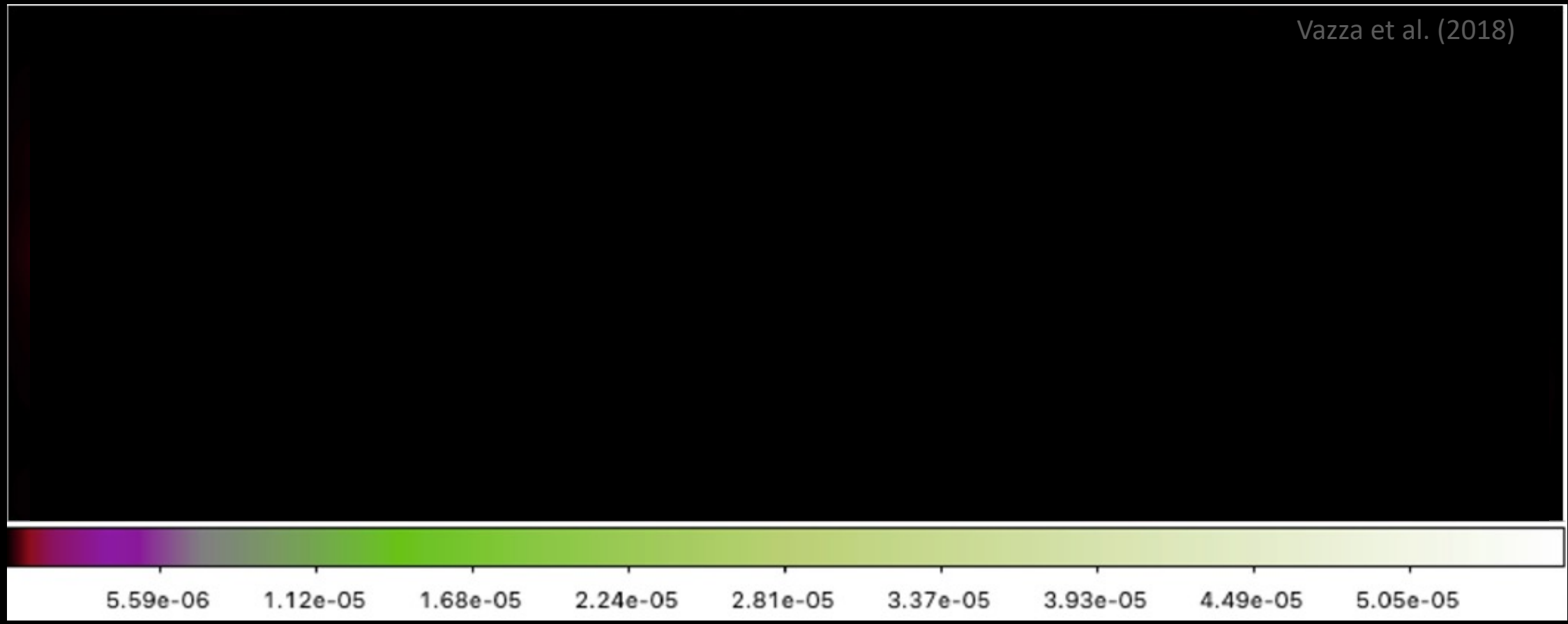

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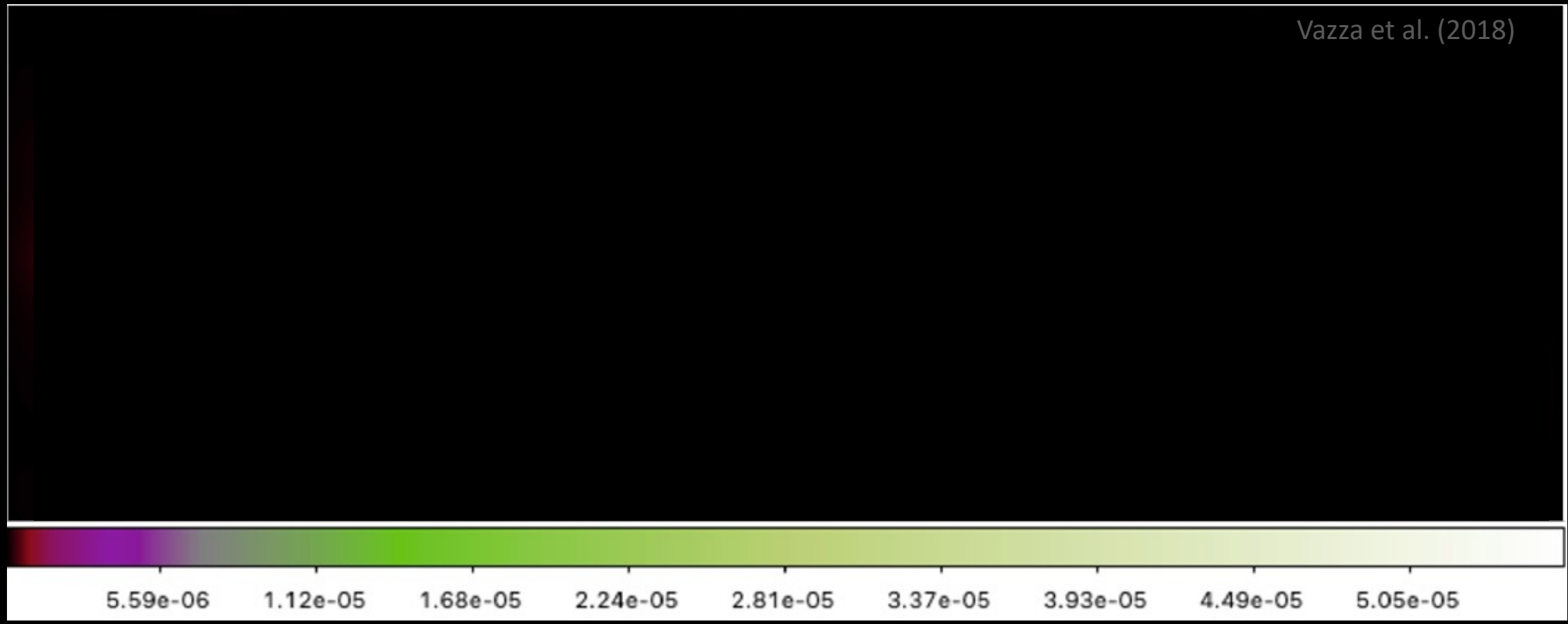

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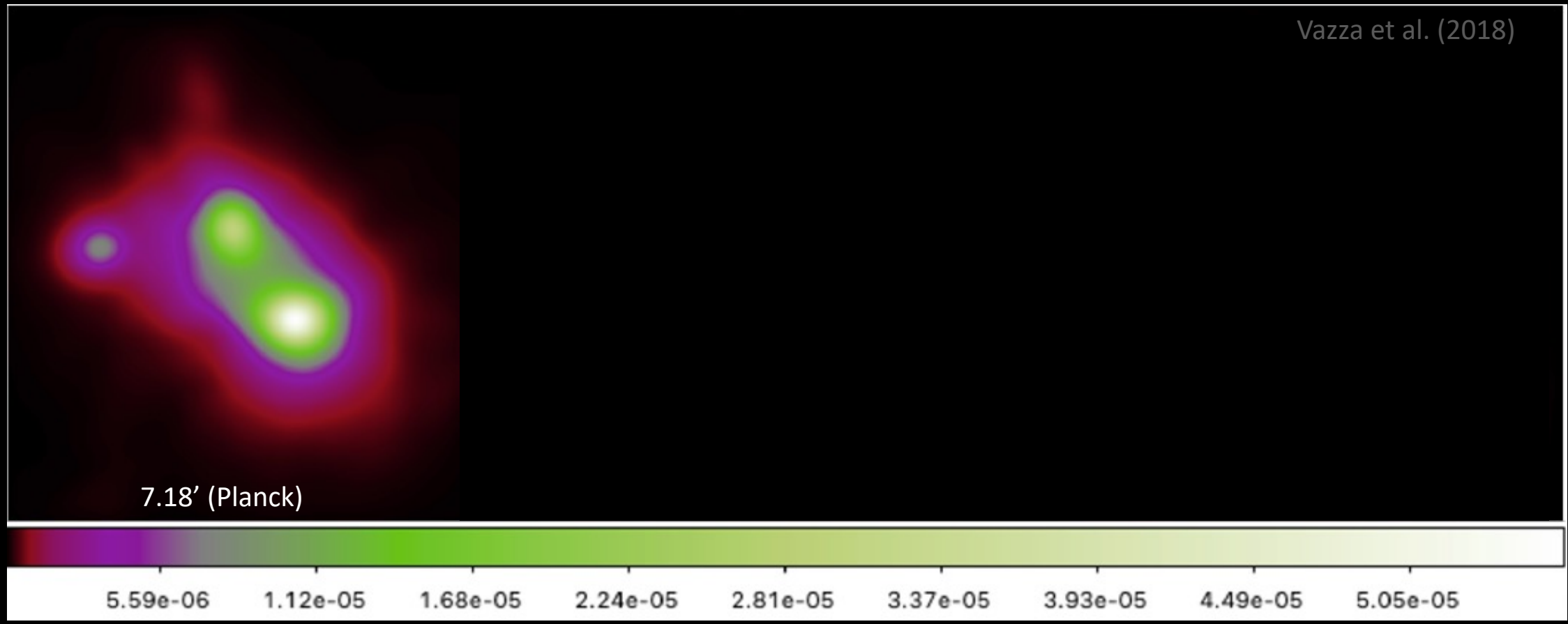

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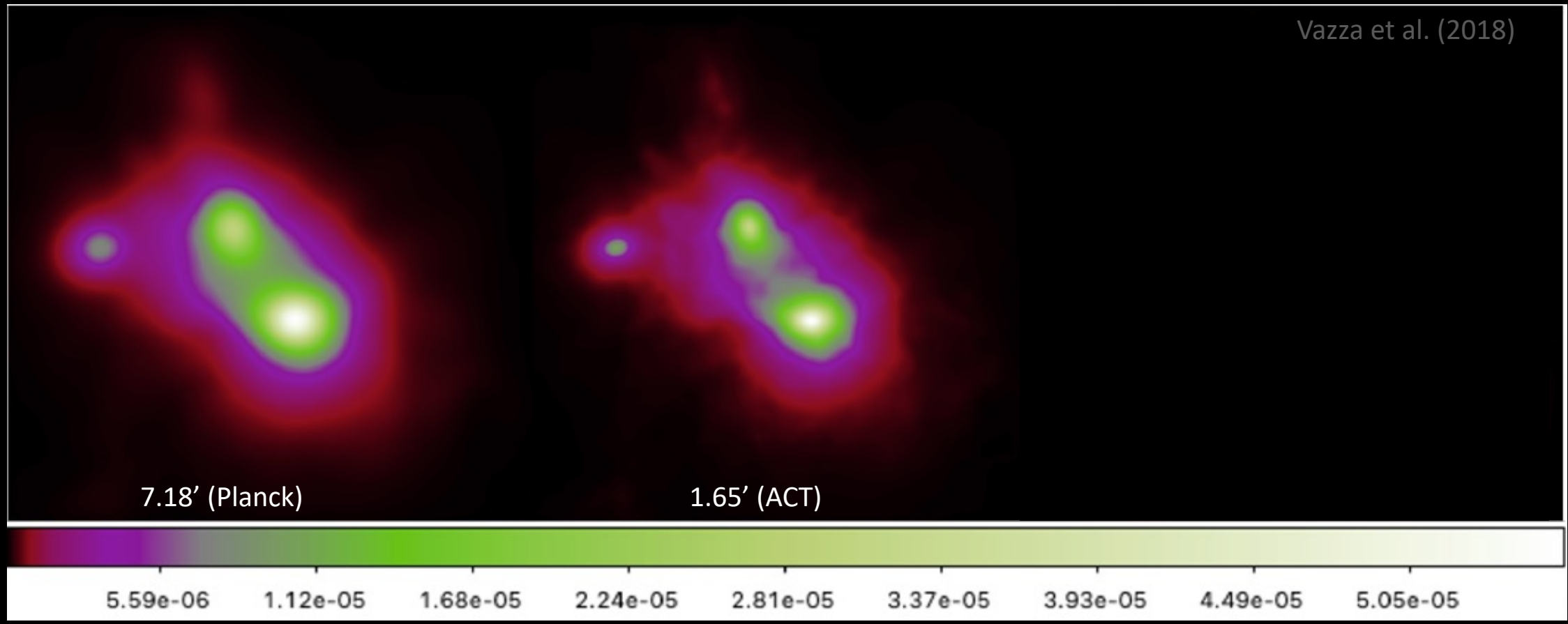

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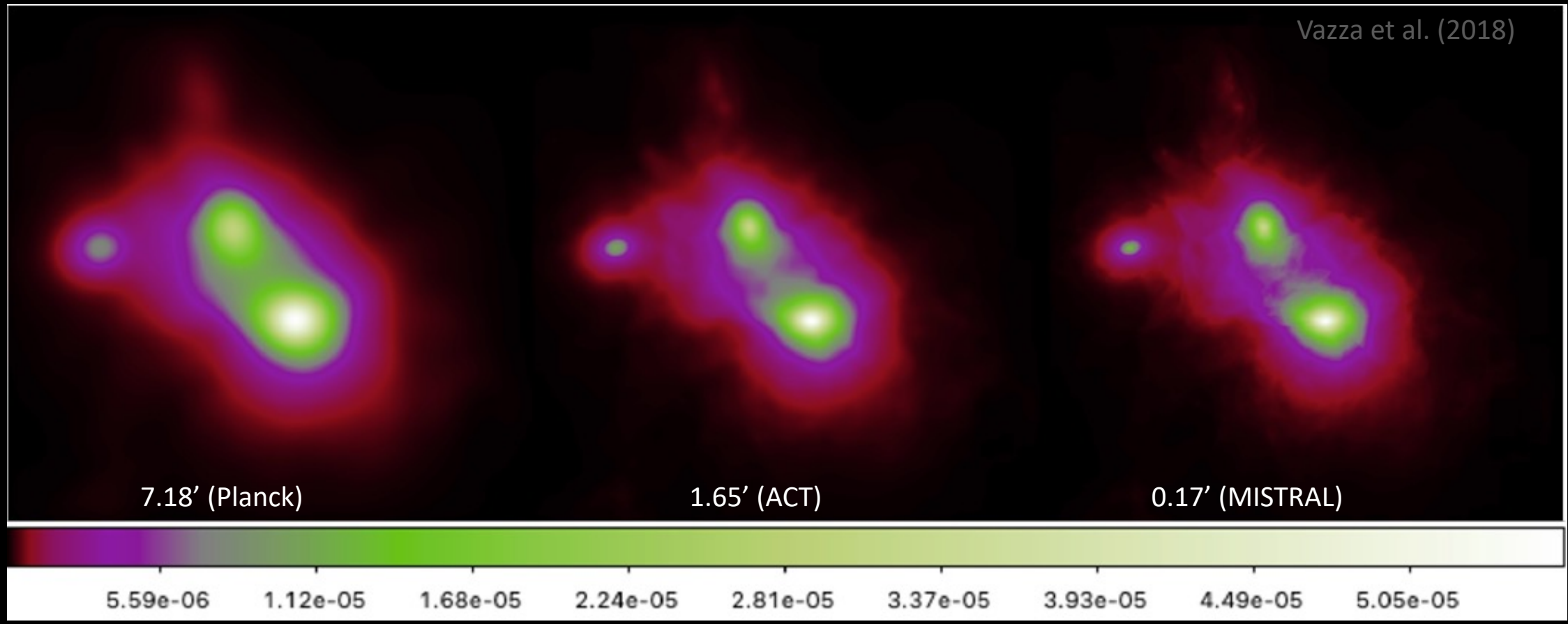
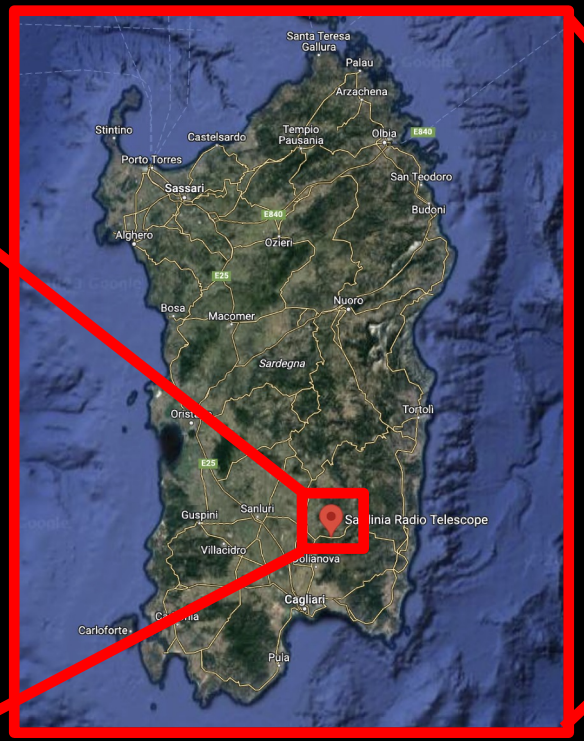


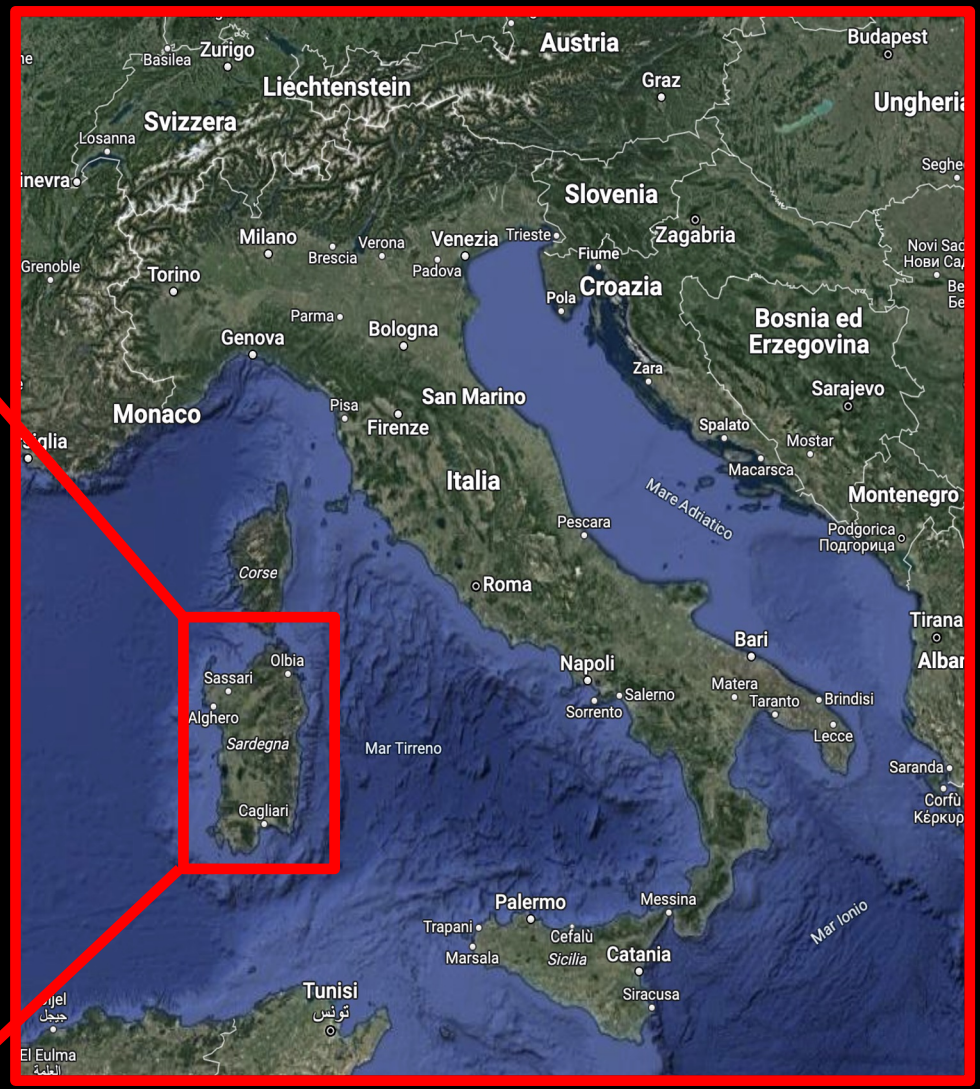


# MISTRAL

# SARDINIA RADIO TELESCOPE

- 64m radio telescope located in Sardinia, at 600m a.s.l. at 50km from Cagliari in a radio quiet zone
- Suited for observations up to 116GHz: current surface rms ~200$\mu$m (to be further improved)
- Estimation of sky opacity based on recorded dedicated radiometer data:
  - $\tau$<0.15Np (50th percentile) at 93GHz during winter nights;
  - the PWV in the same conditions is mainly 8mm

# SRT: ANTENNA

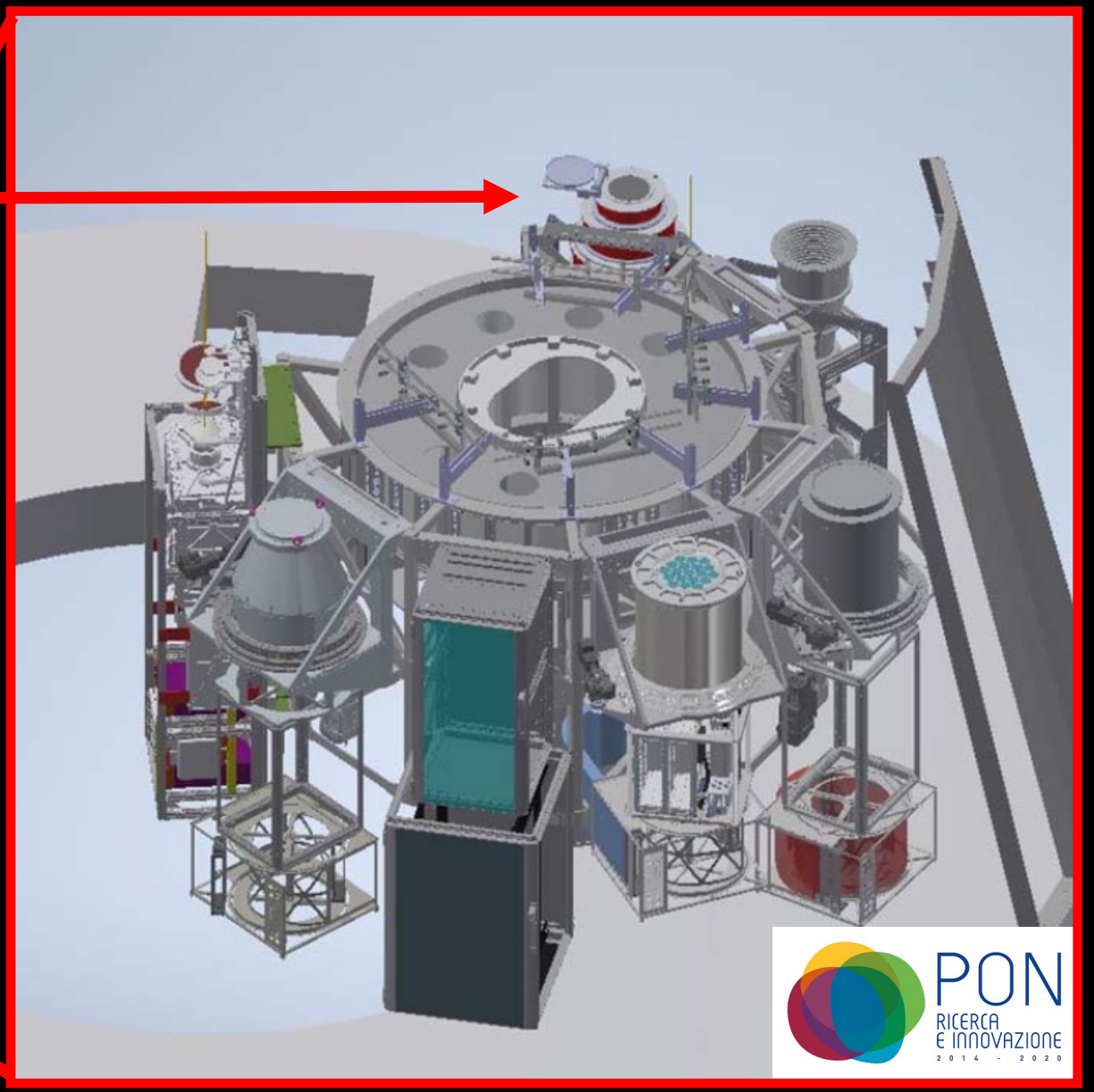
- Fully steerable antenna of (M1) 64m in diameter
- f/2.34 Gregorian room focus
- Active M1 composed of 1008 electromechanically controlled aluminum elements by actuators
- M2 is composed of 49 aluminum elements
- Alidade (compressor) room 120m apart
- Timeline:
  - 2016: early science;
  - 2018- : normal operations;
  - 2020- : PON to upgrade the receiver fleet and the SRT performance

*Bolli at al. Journal of Astronomical Instrumentation, Vol. 4, Nos. 3 & 4 (2015)*

# MISTRAL

A. Attoli, E. Barbavara, **E. S. Battistelli**, P. de Bernardis, F. Cacciotti, G. Carboni, E. Carretti, D. Ciccalotti, F. Columbro, A. Coppolecchia, A. Cruciani, G. D'Alessandro, M. De Petris, F. Govoni, G. Isopi, A. Ladu, L. Lamagna, P. Marongiu, S. Masi, **M. Murgia**, A. Navarrini, A. Novelli, A. Occhiuzzi, A. Orlati, A. Paiella, G. Pettinari, F. Piacentini, M. Pili, T. Pisanu, S. Poppi, M. R. Schirru, G. Vargiu

MILLIMETER
SARDINIA RADIO
TELESCOPE
RECEIVER BASED ON
ARRAY OF
LUMPED ELEMENTS
KIDS

PON RICERCA E INNOVAZIONE 2014 - 2020

*Picture acknowledgment: Sergio Poppi. INAF-SRT: http://www.srt.inaf.it/*

*Bolli et al. 2021*

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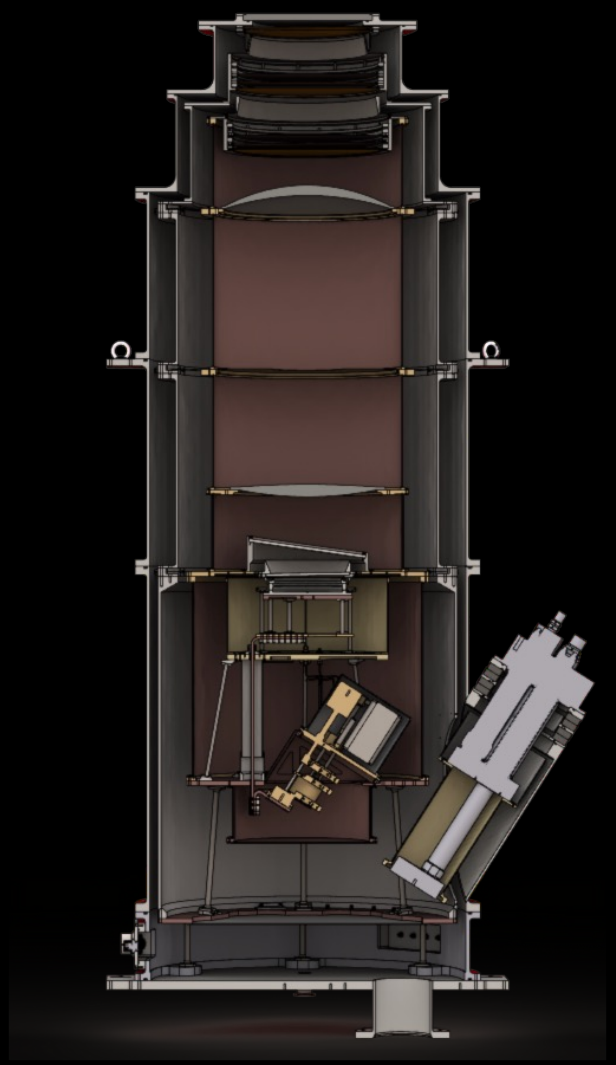
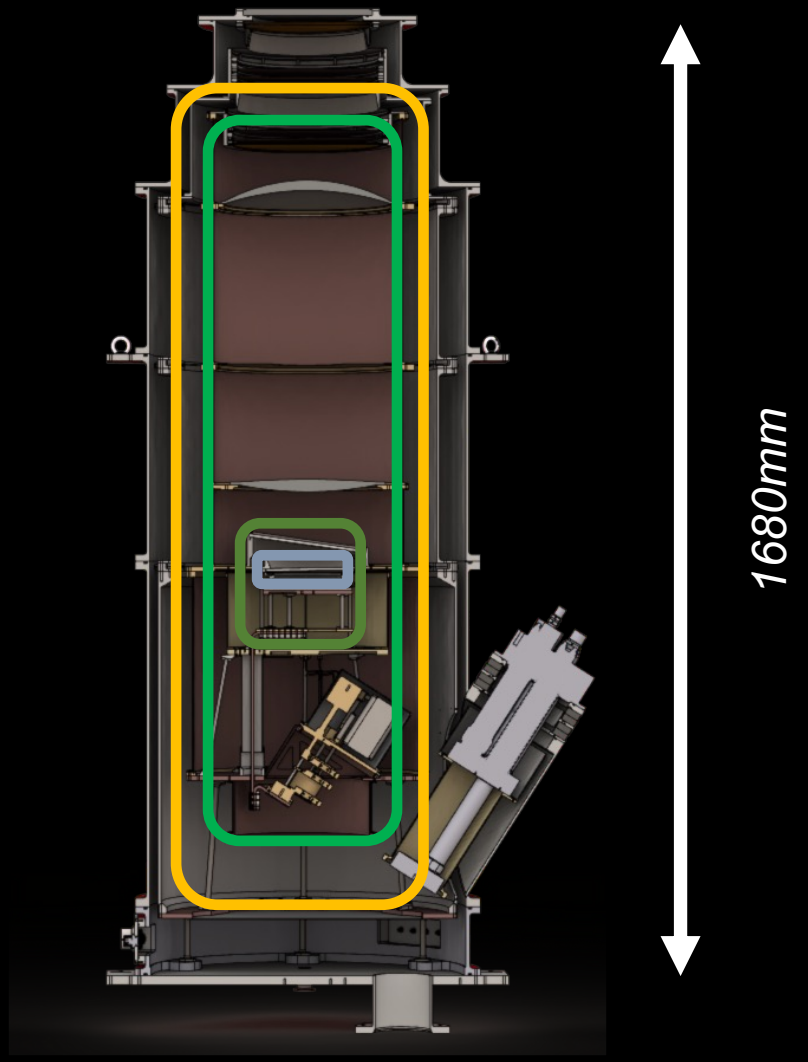


- MISTRAL is a facility instrument. Strong limitations in the Gregorian room:
  - ~250kg maximum
  - 700x700x2400mm
  - RF shielded and quite
  - Should work also when SRT is parked
  - Long (~120m) cryocooler lines
  - Remote PT compressor (~120m)
  - Not accessible
- *Cryostat built by QMC*
- *Composed of 40K, 4K radiation shields cooled by a 1.5W PT cryocooler*
- *Plus ~0.8K – 300mK – 200mK He-10 sorption fridge provided by Chase Research Cryogenics*

# MISTRAL: CRYOSTAT

*~250Kg ; ~1m³*

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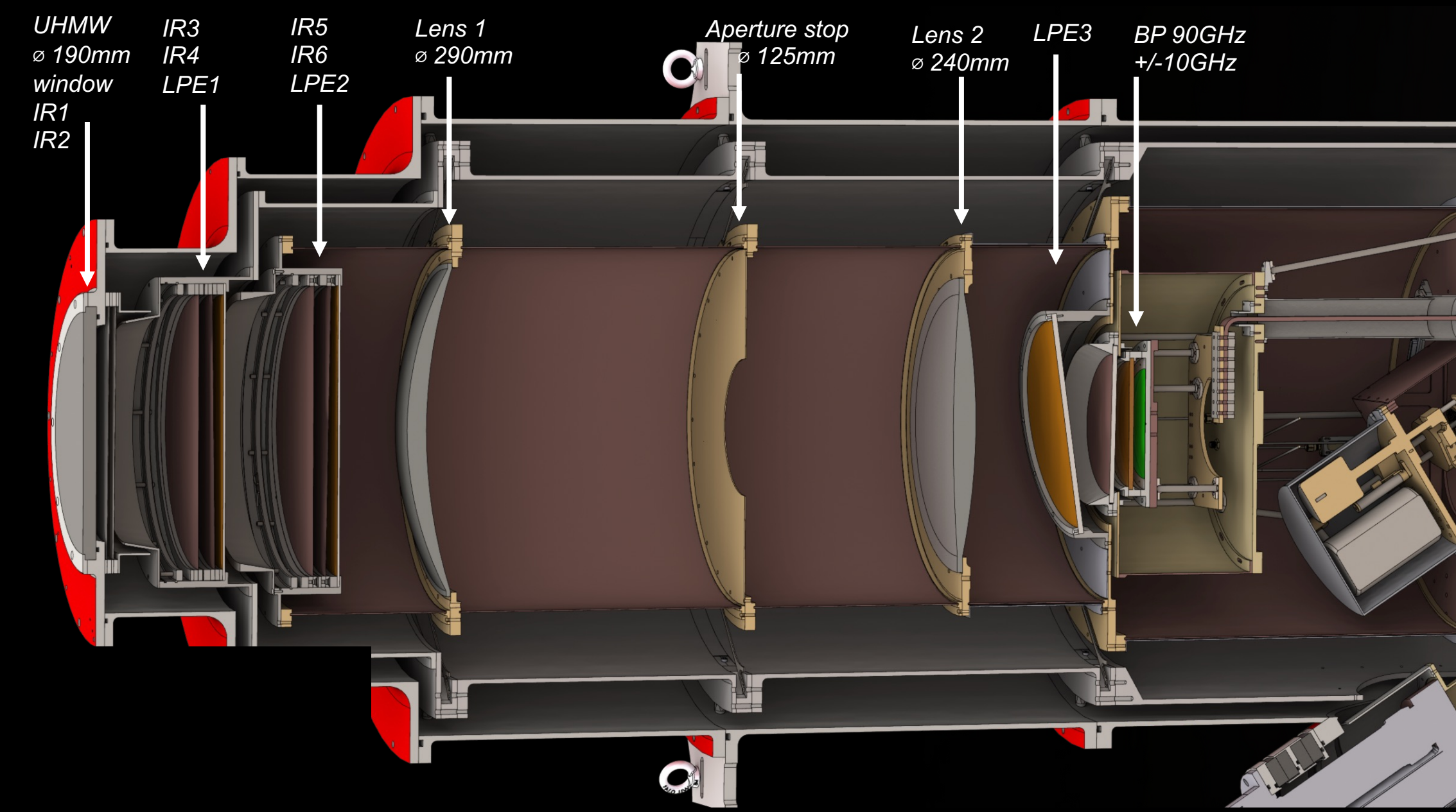
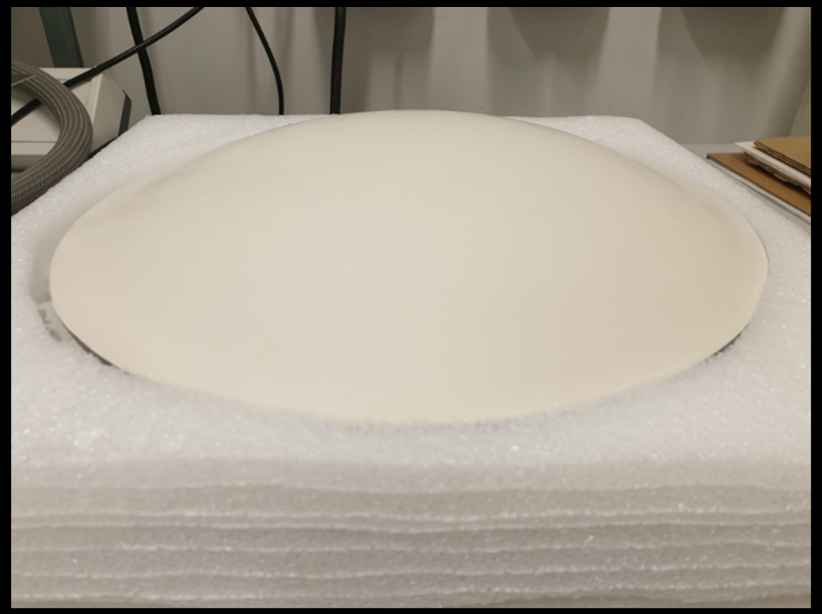
# MISTRAL: (QUASI-)OPTICS

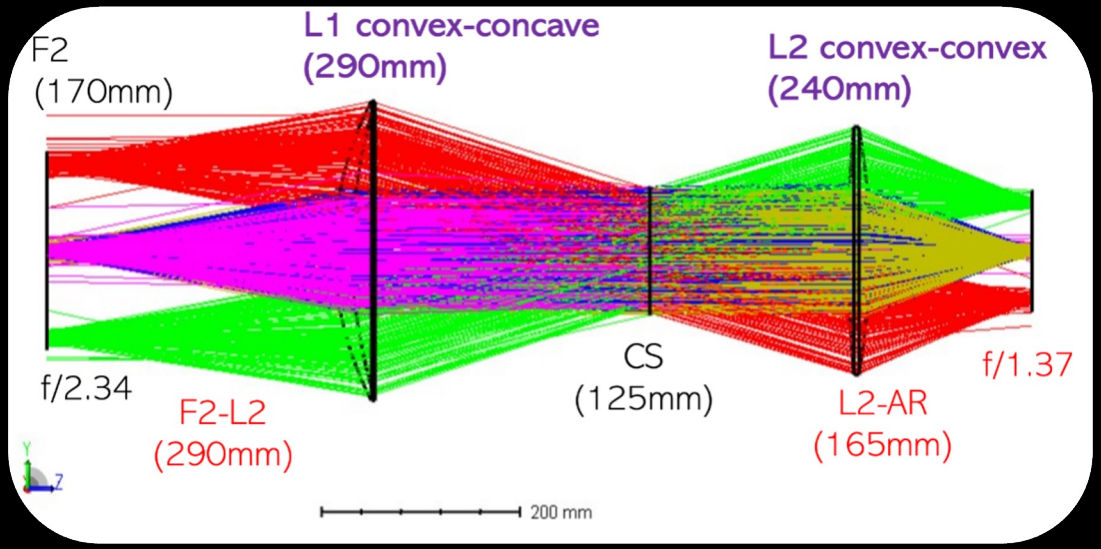


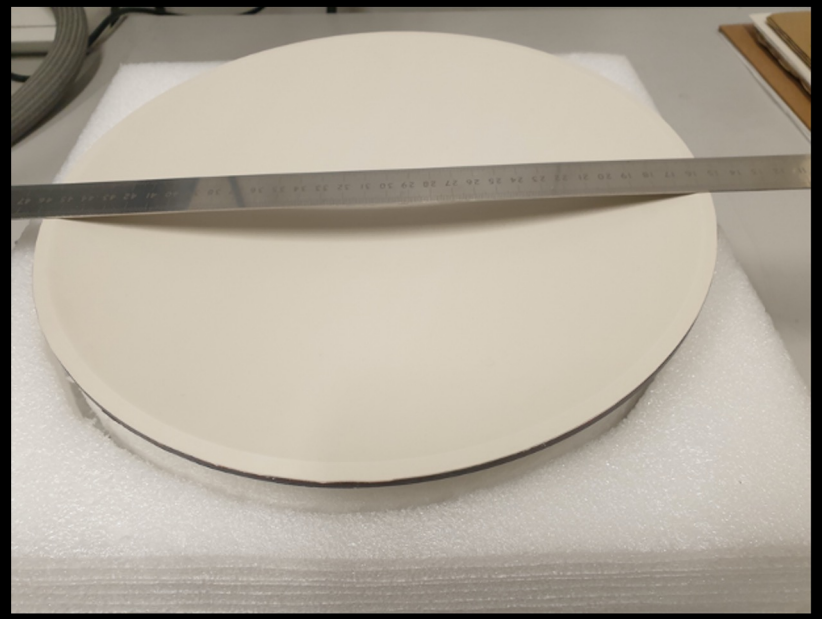

*Combination of: Metal mesh filters, thin IR filters, sub-mm low pass filters (LPE), a final 77-103GHz Band pass filter*

# MISTRAL: OPTICS

- Filled (naked) array of KIDs
- Cold stop at 4K to avoid extra-load on KIDs
- Rogers R30003 ARC silicon lenses: a biconvex and a meniscus ones *(0.91<SR<0.97)*
- angular resolution = 12 arcsec
- F.O.V. = 4 arcmin
- Pixel separation = 10.6 arcsec





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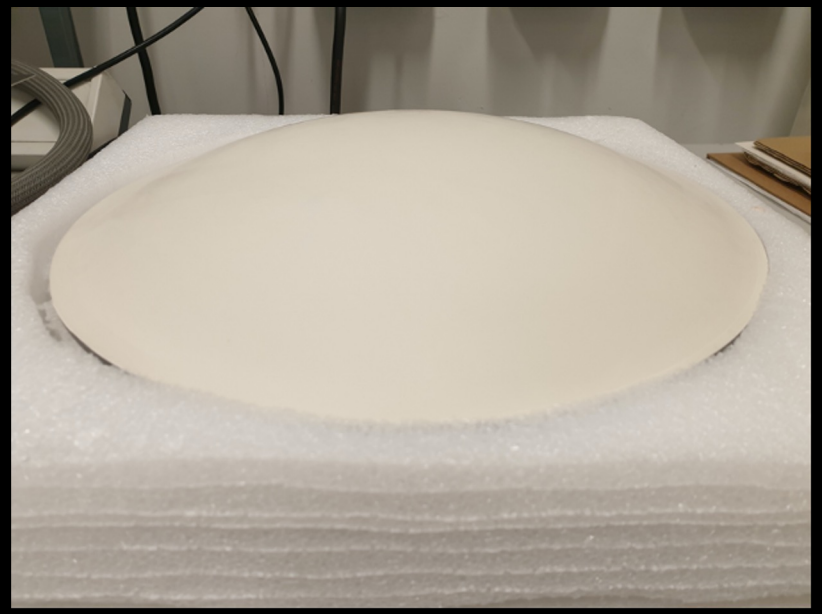

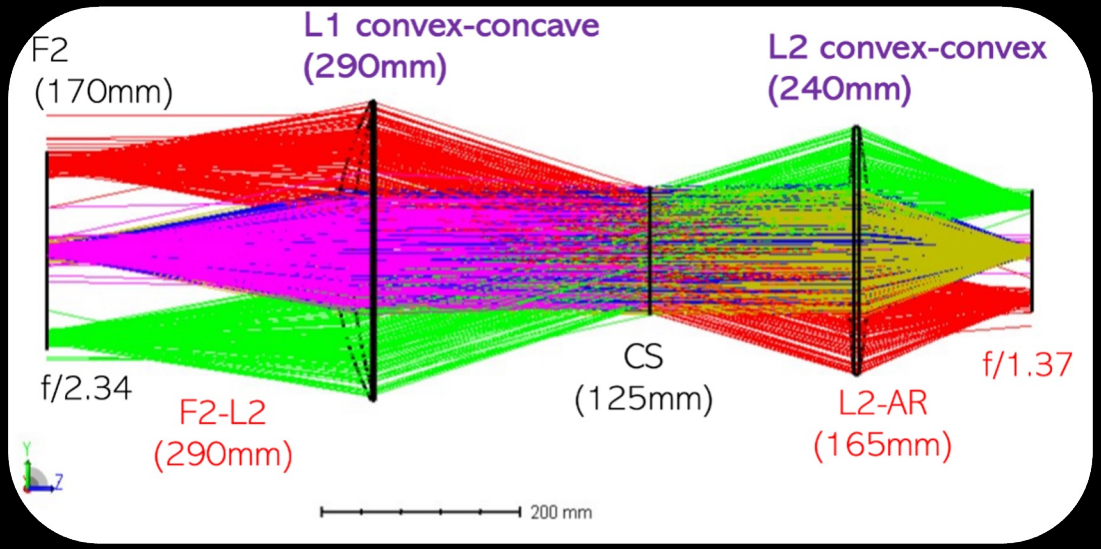


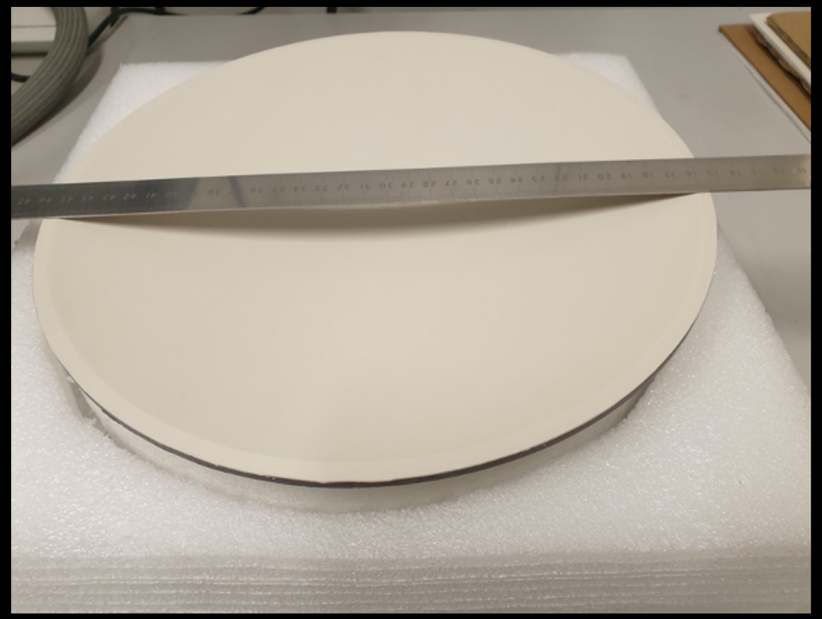

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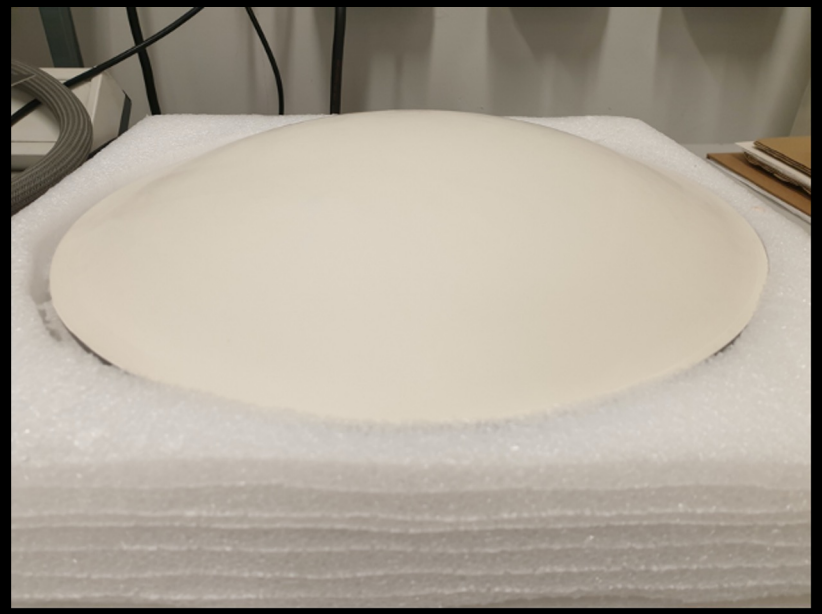
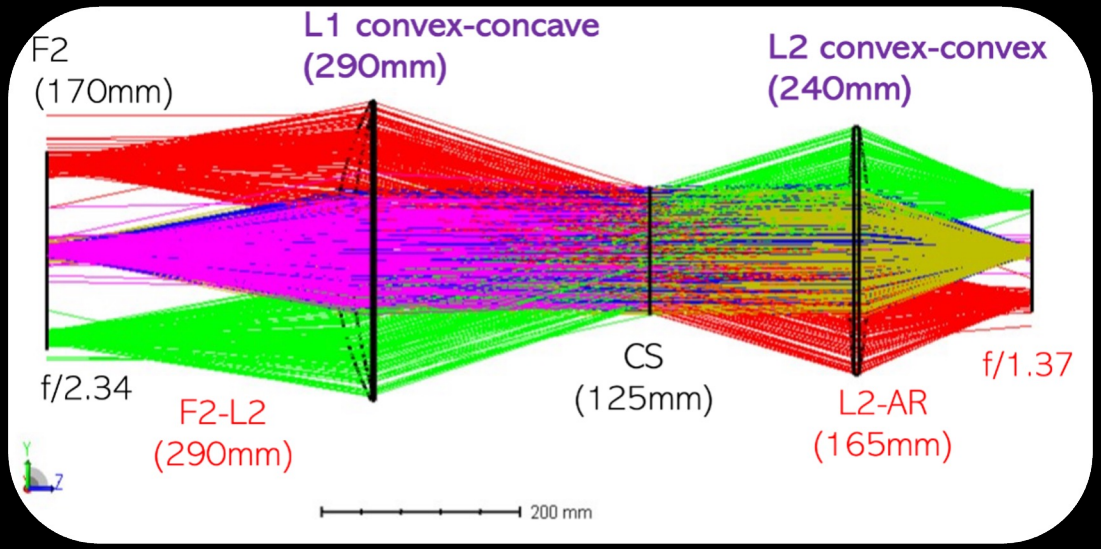
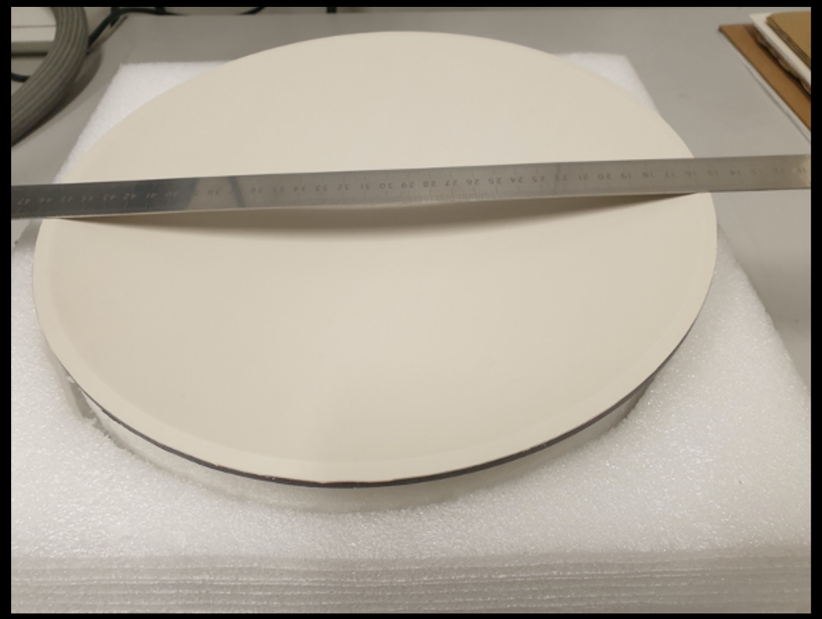
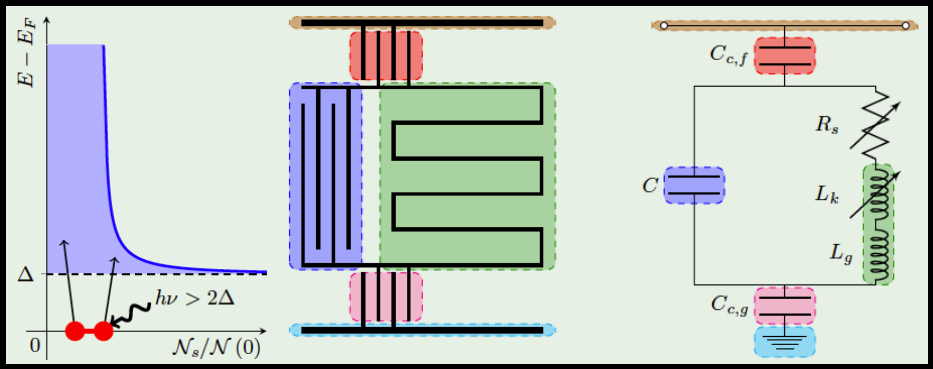




# MISTRAL: KID DETECTORS

- KIDs are fast, superconductive detectors
- Lumped element configuration, KIDs act as adsorbers/inductors coupled to a capacitor to form: high-Q LC resonators




- Cooper pair change and kinetic inductance produce a change in the resonant frequency
- They can be sensed by measuring the change in the amplitude and phase of the bias signal

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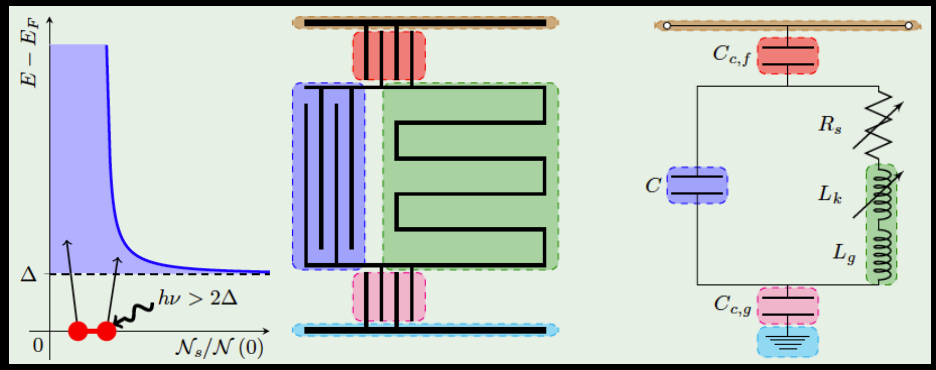


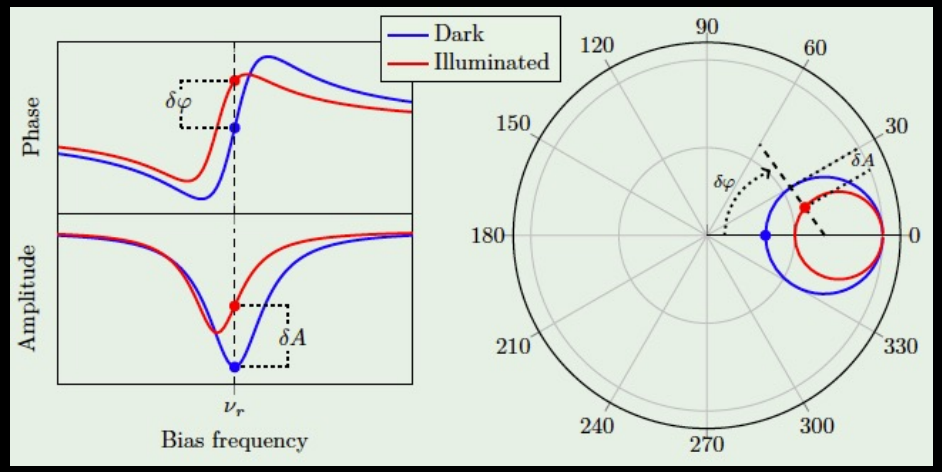


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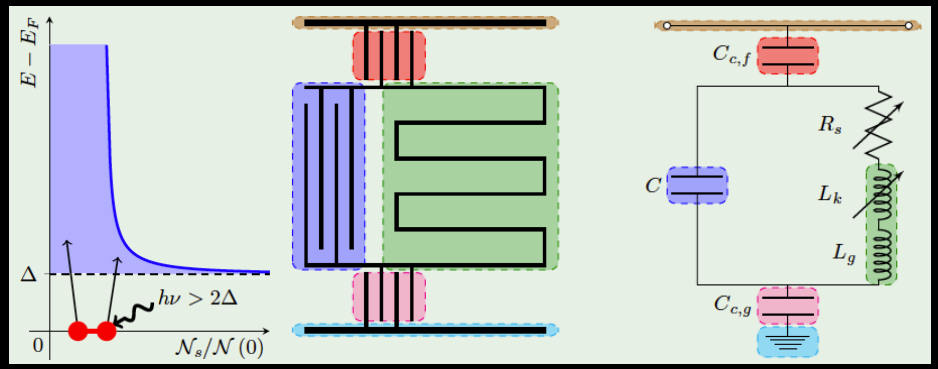


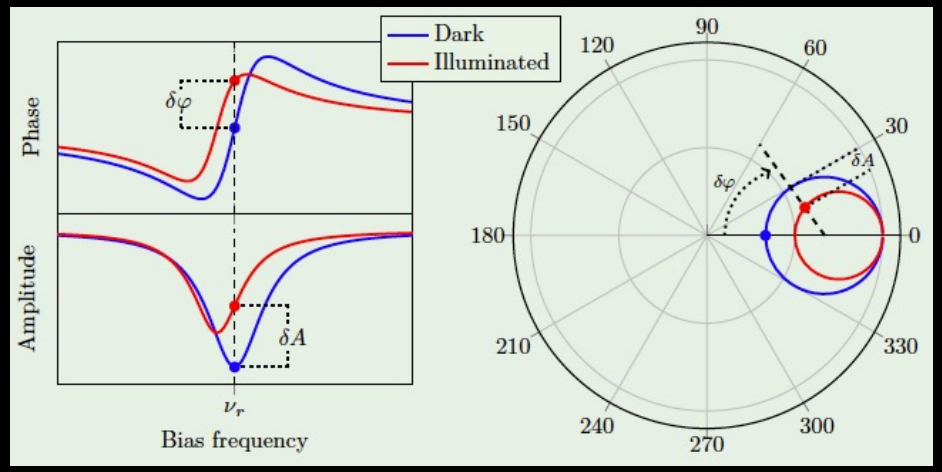


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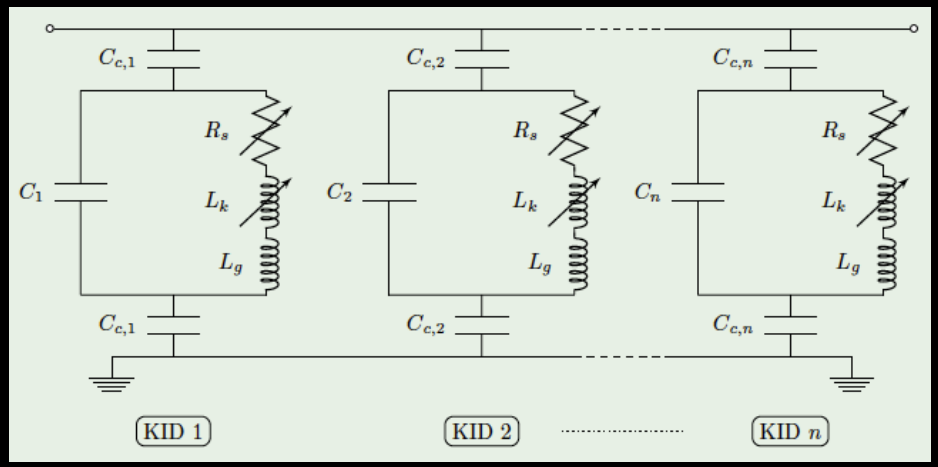

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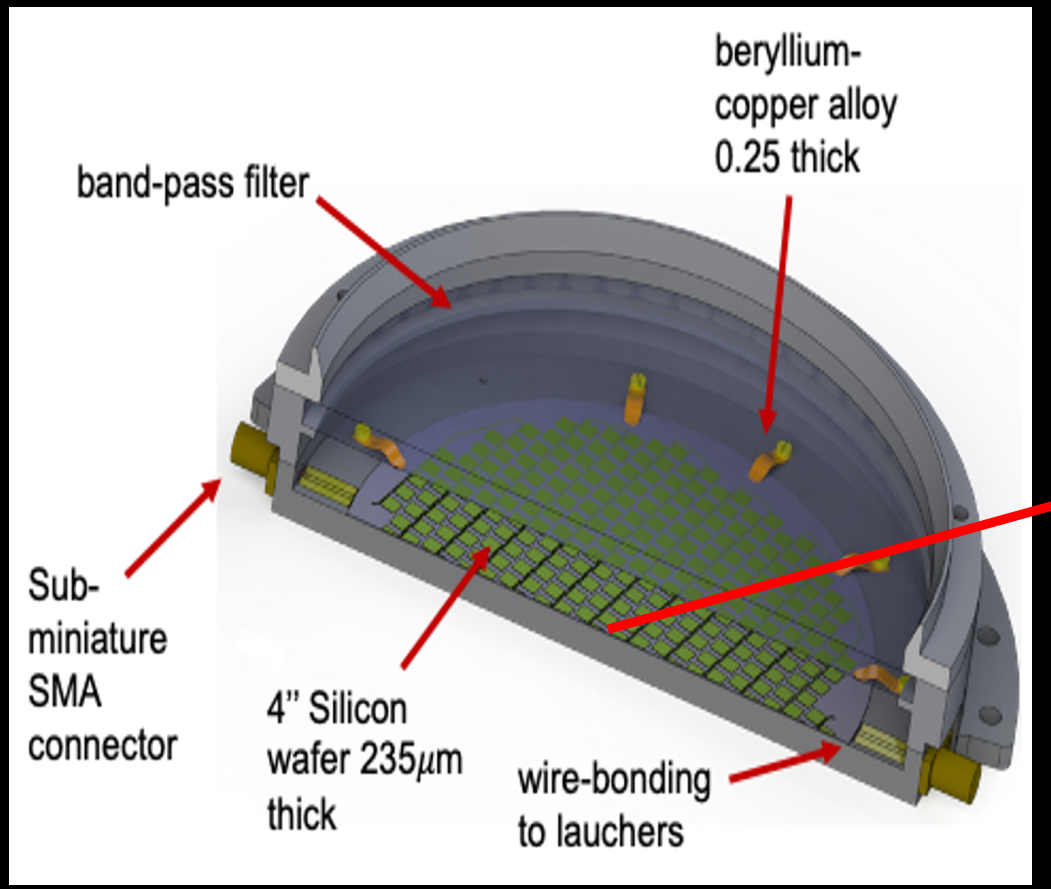


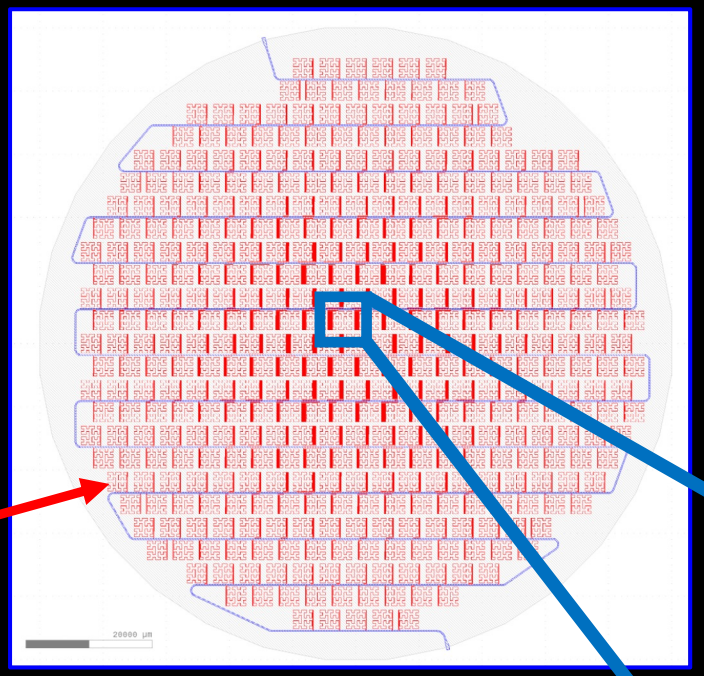

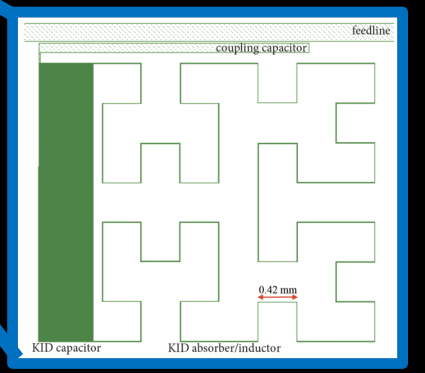

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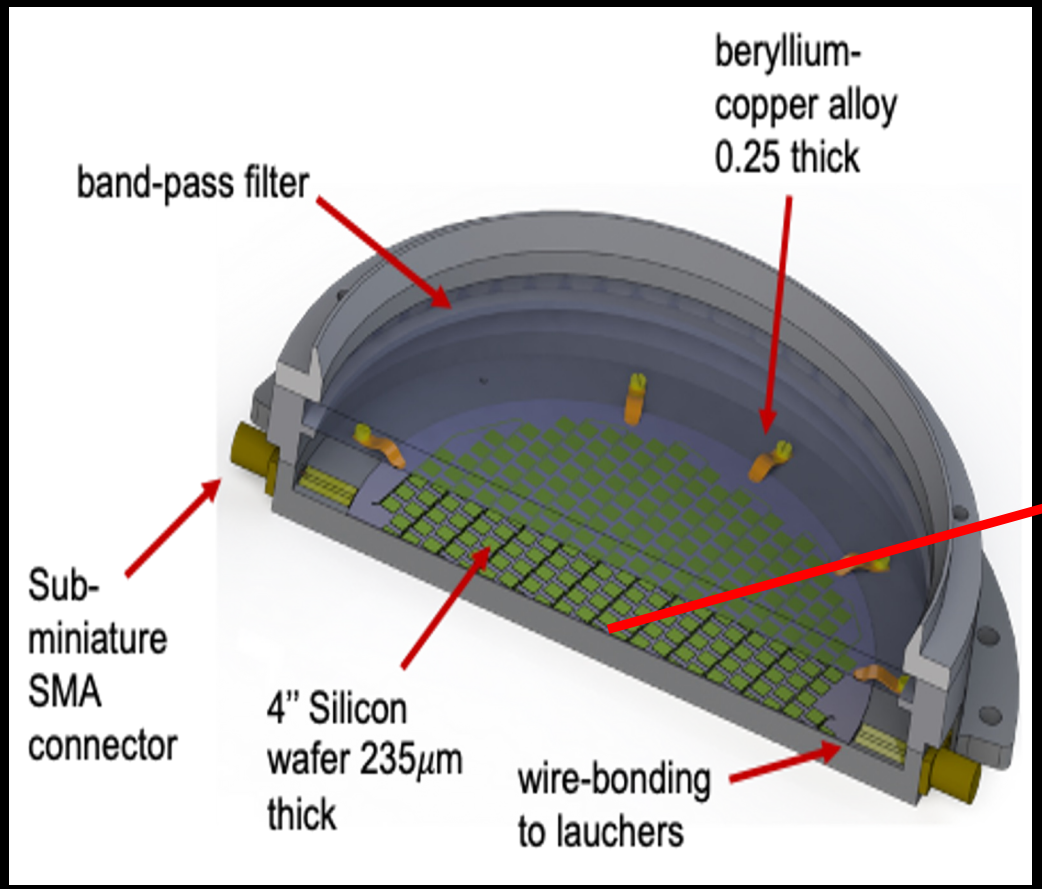


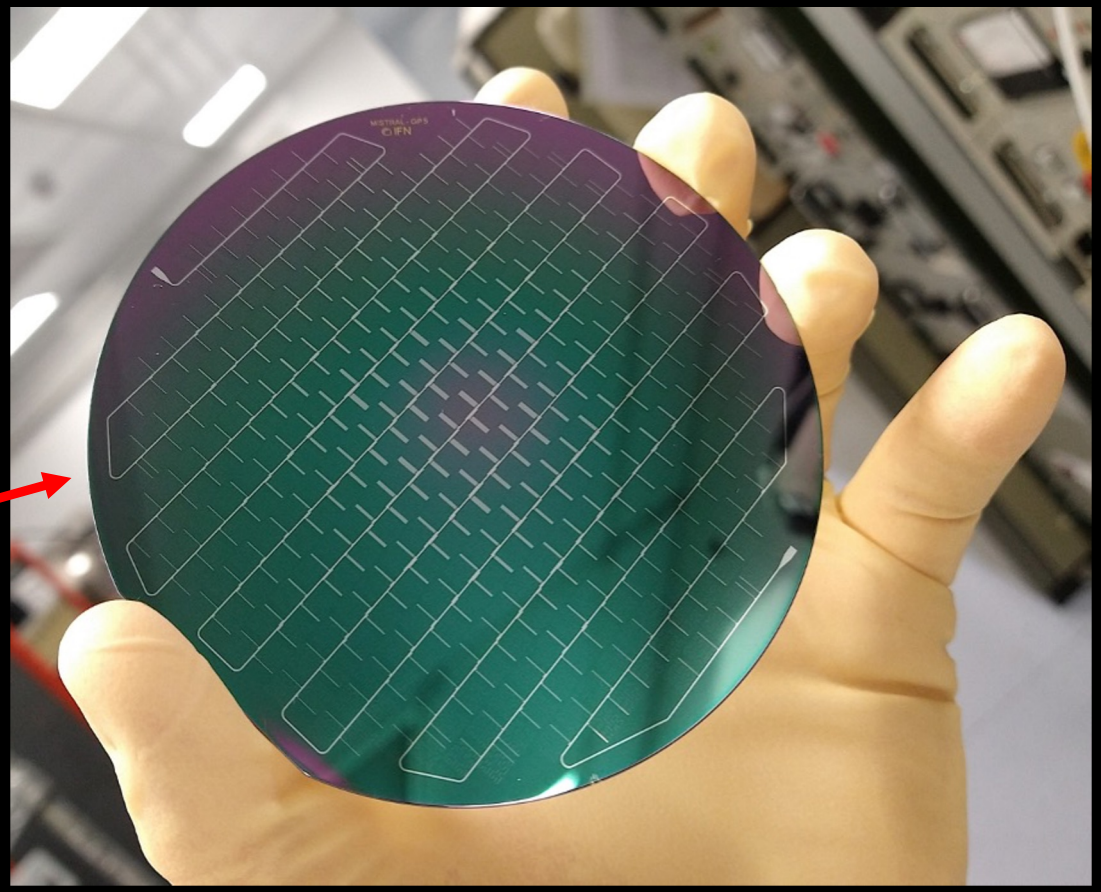

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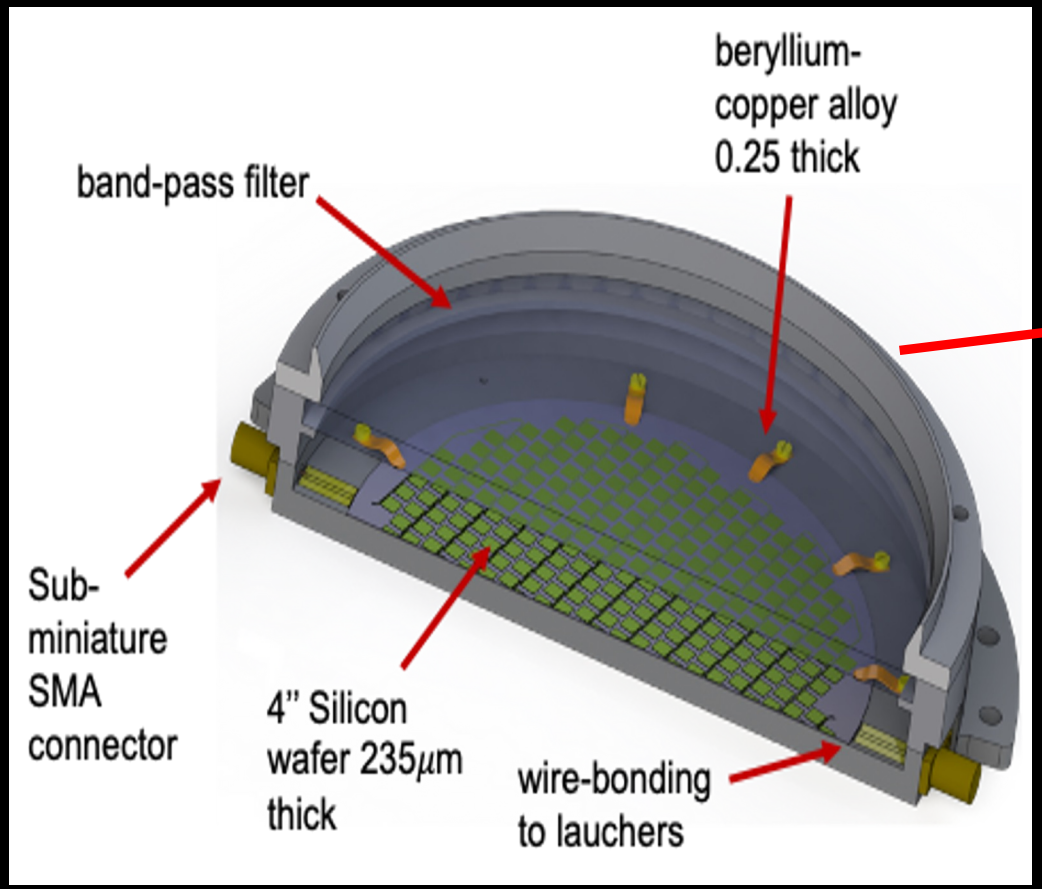


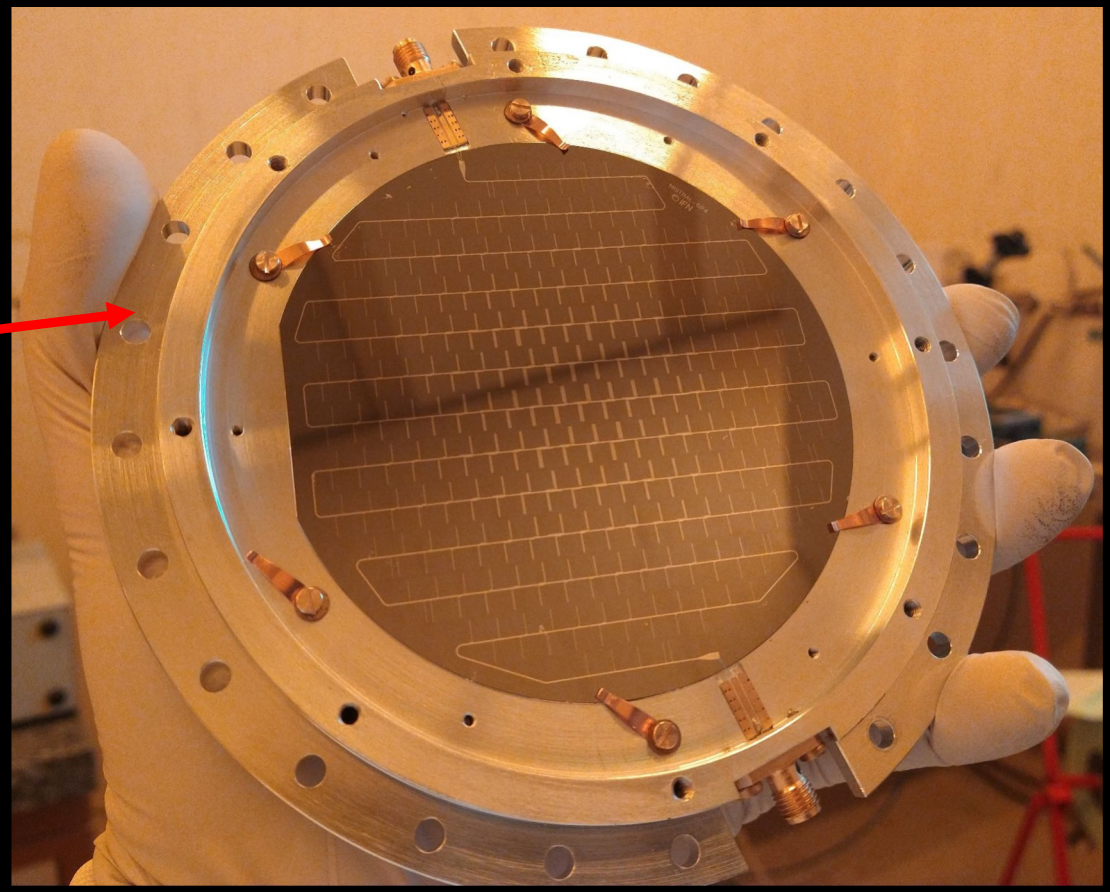

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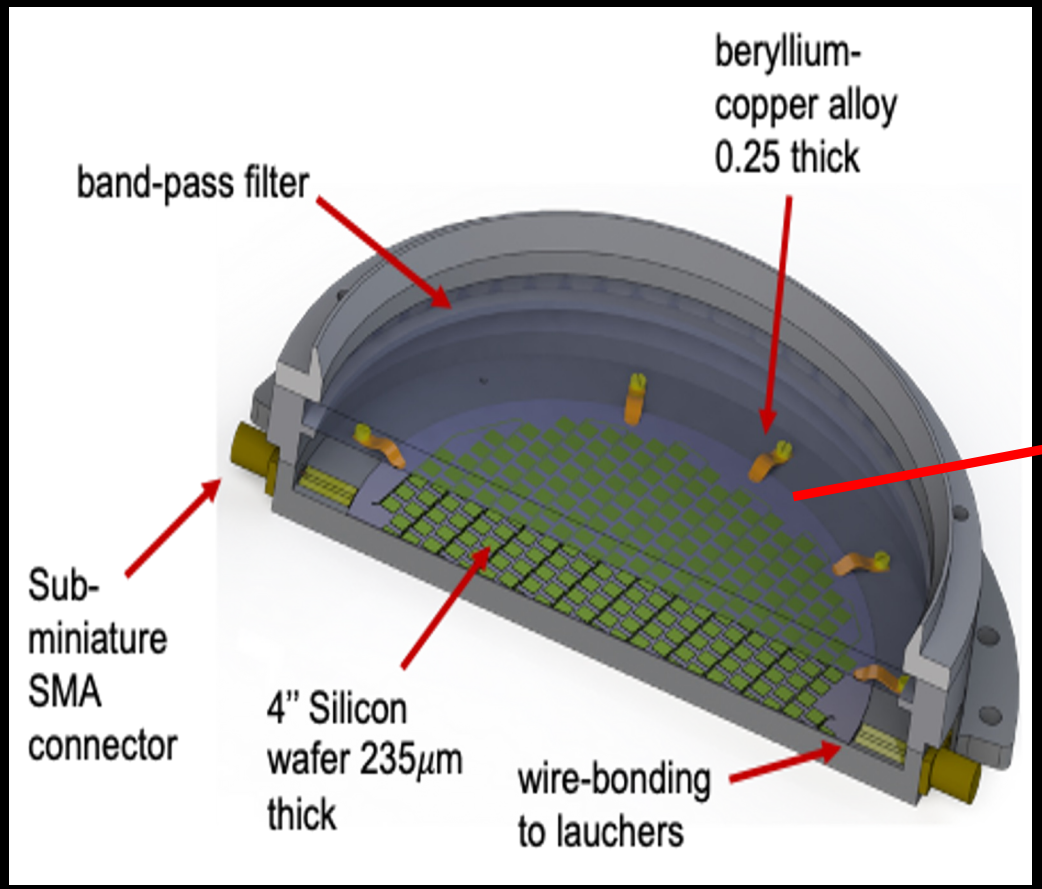


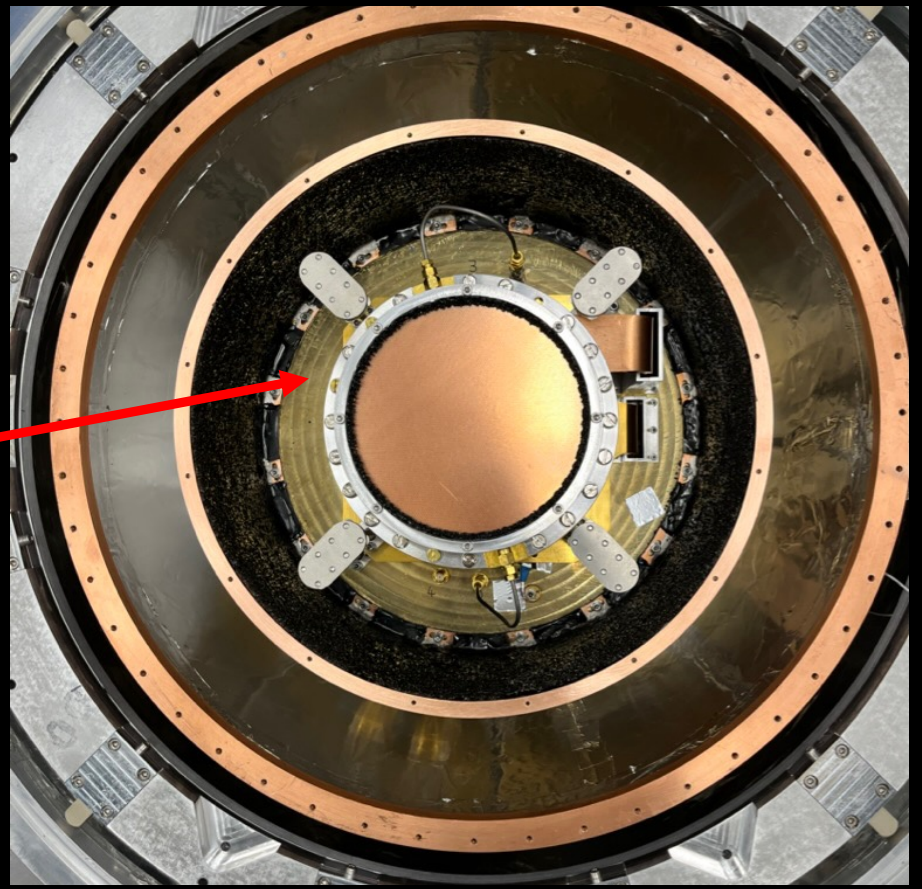

# MISTRAL: READ-OUT

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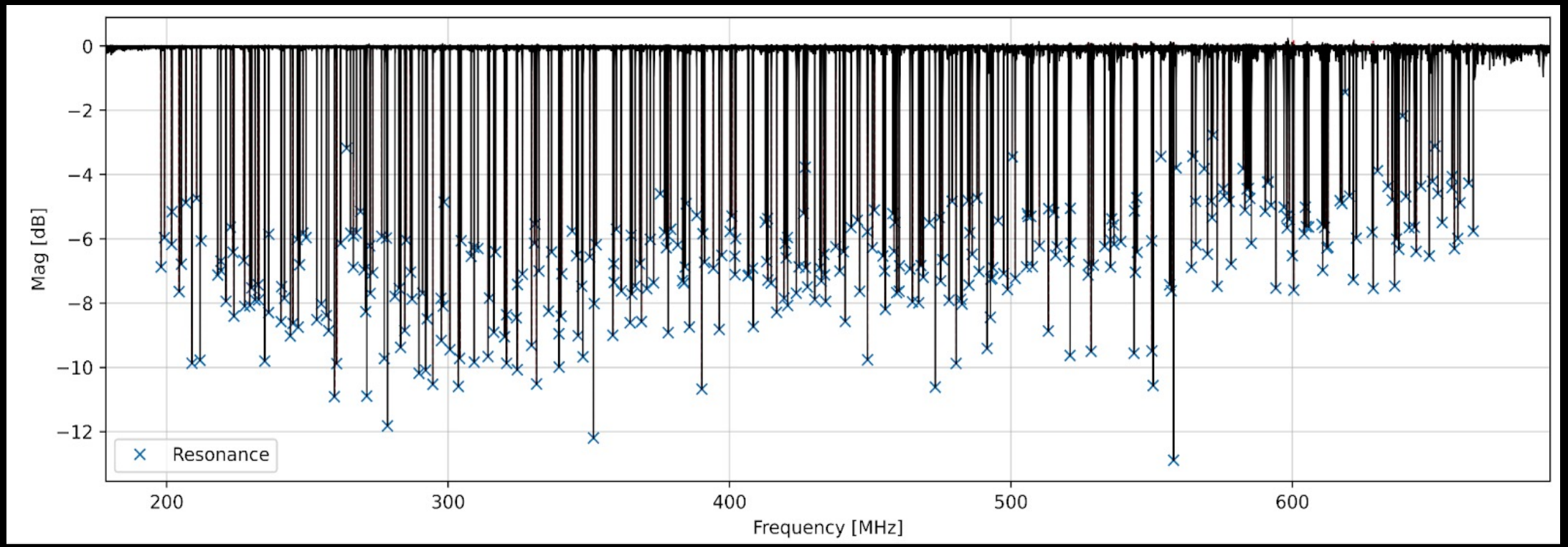
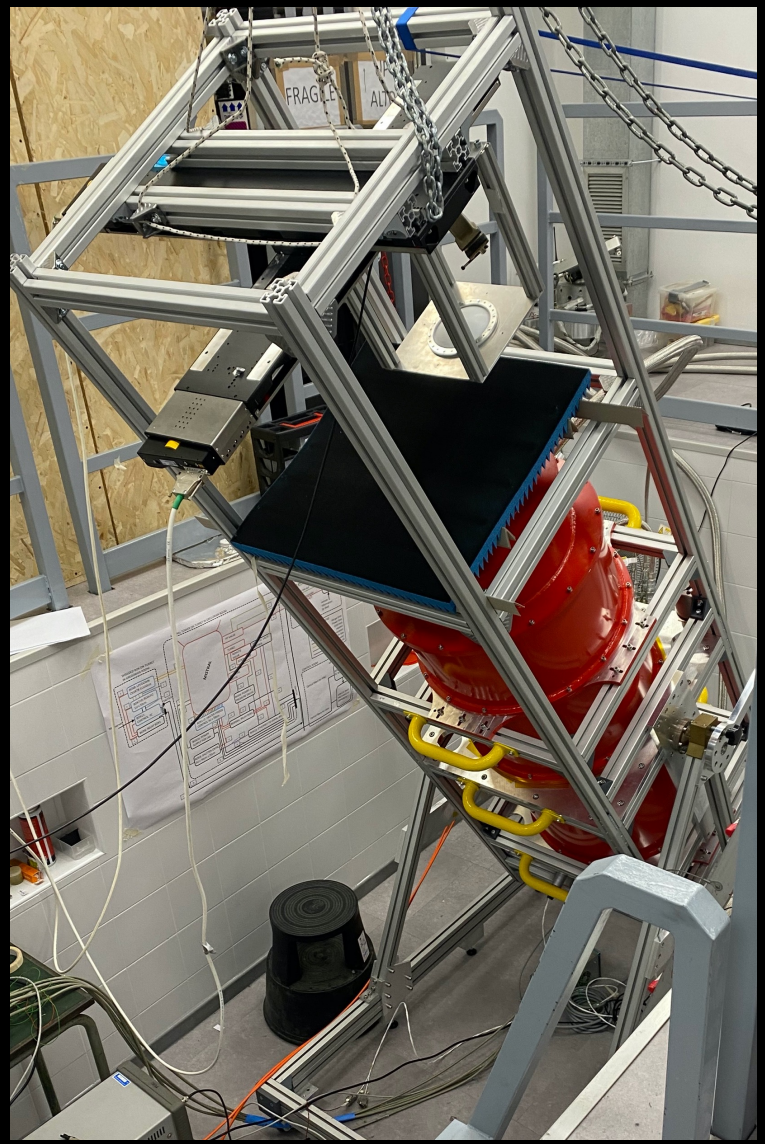
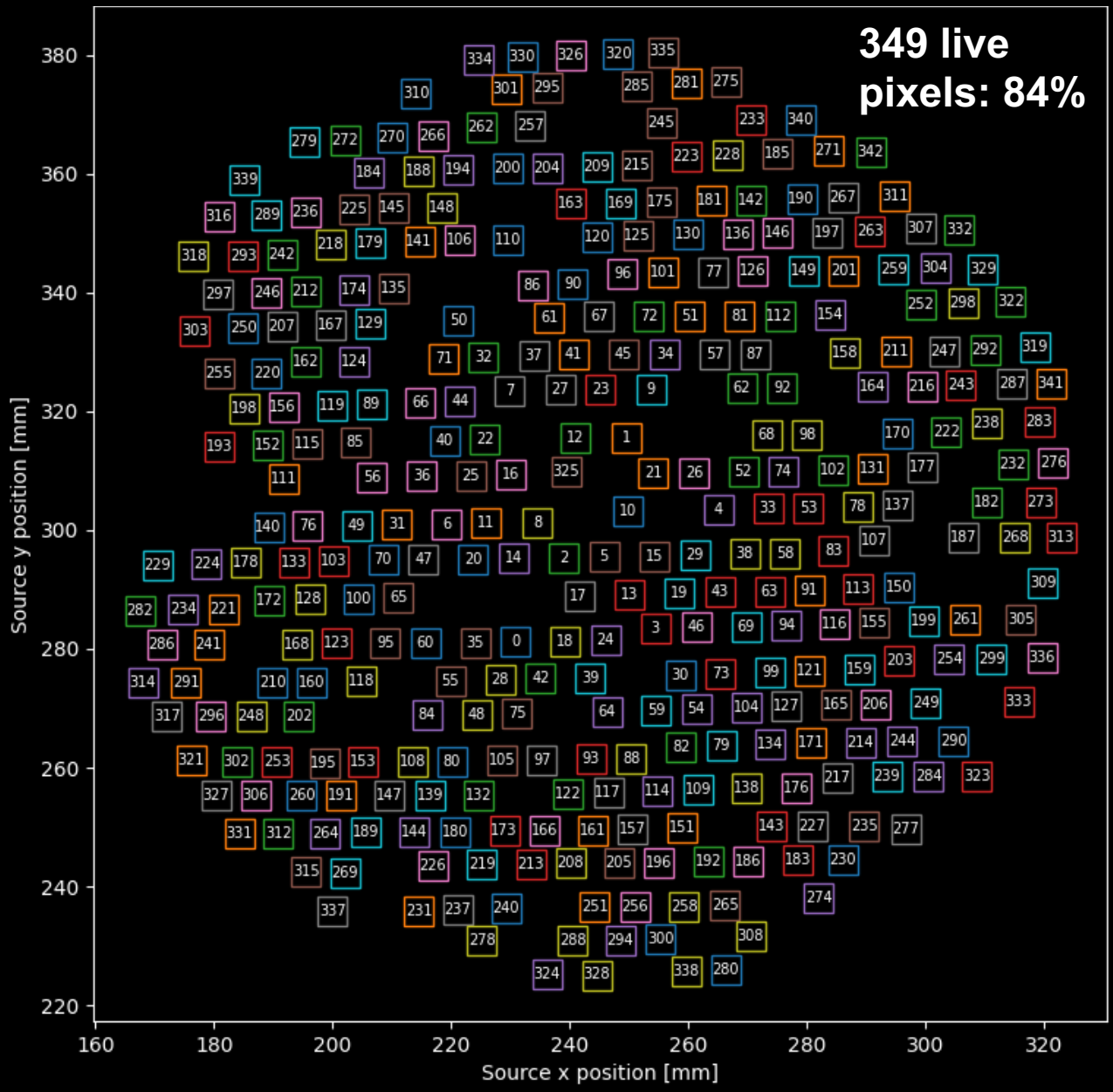
- 0.96MHz (median) pixel separation



# MISTRAL CALIBRATION: LAB TESTING





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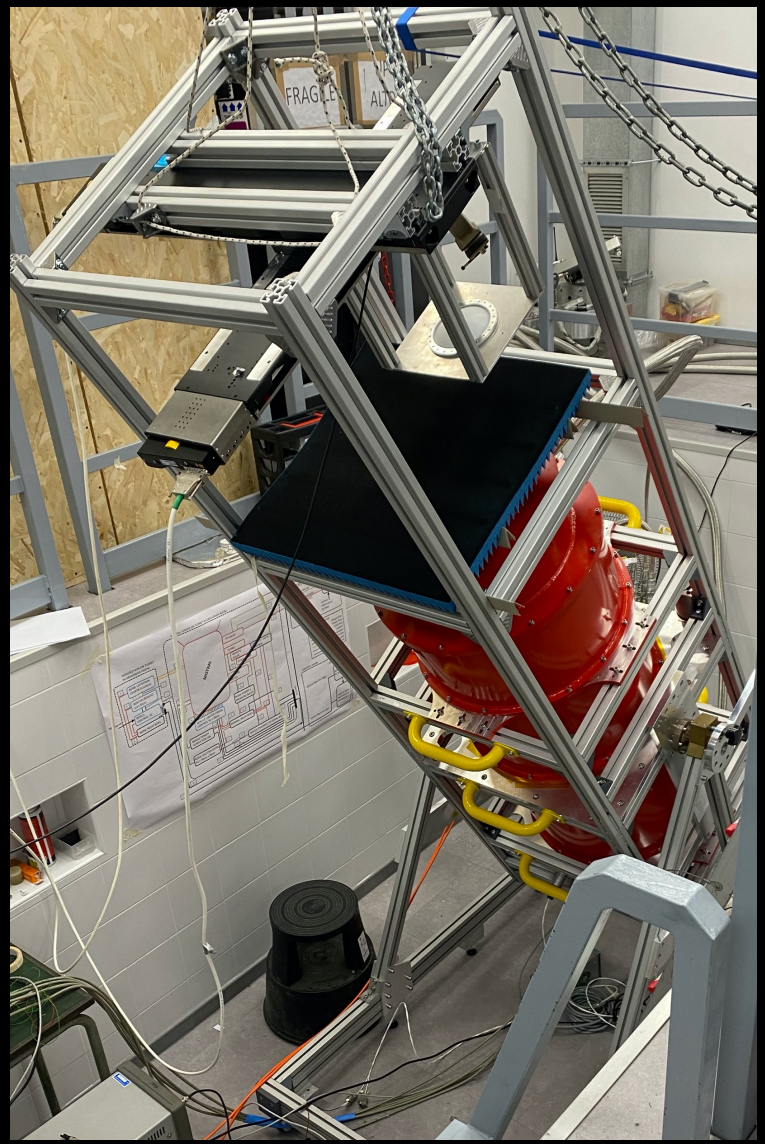

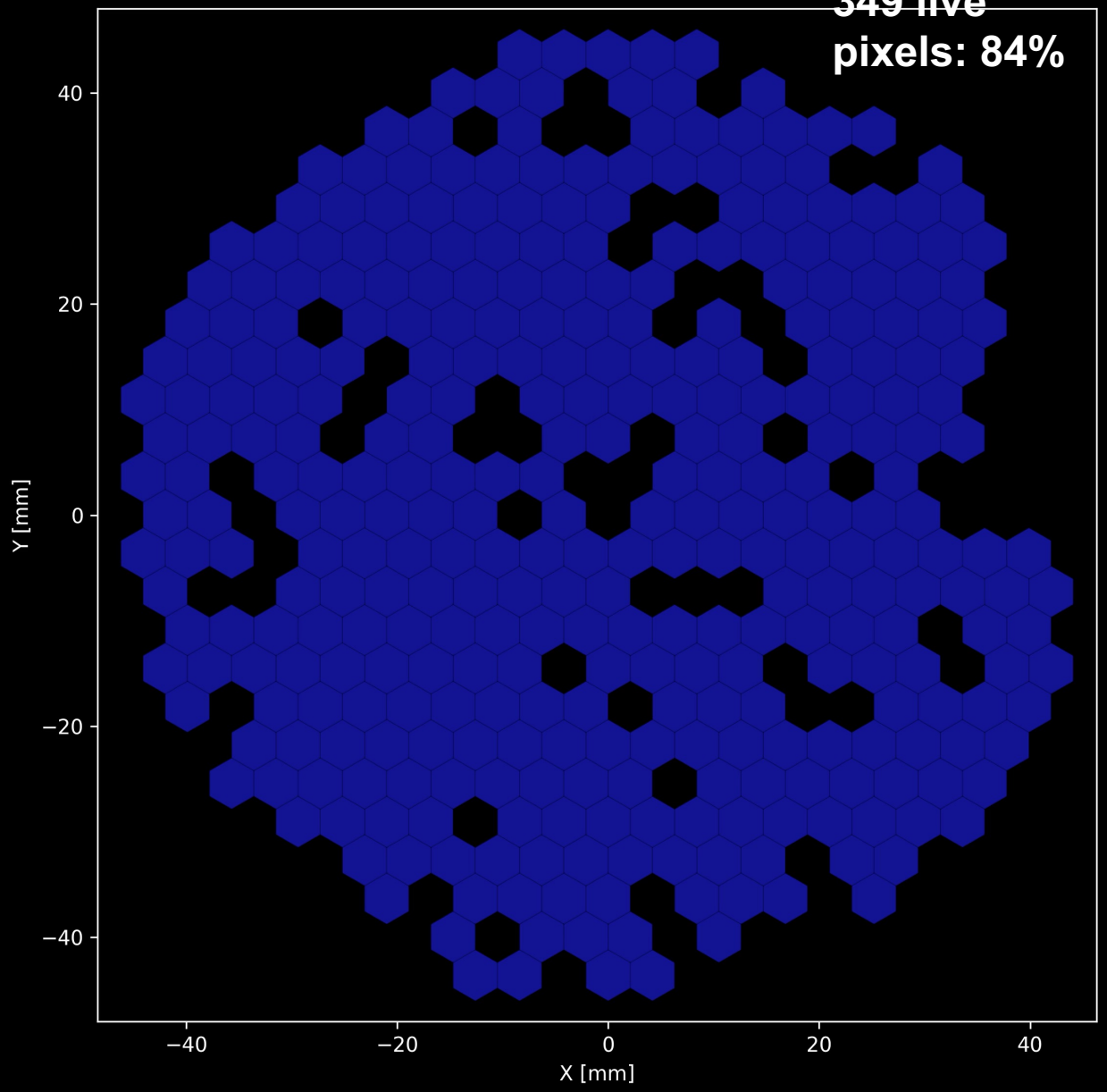

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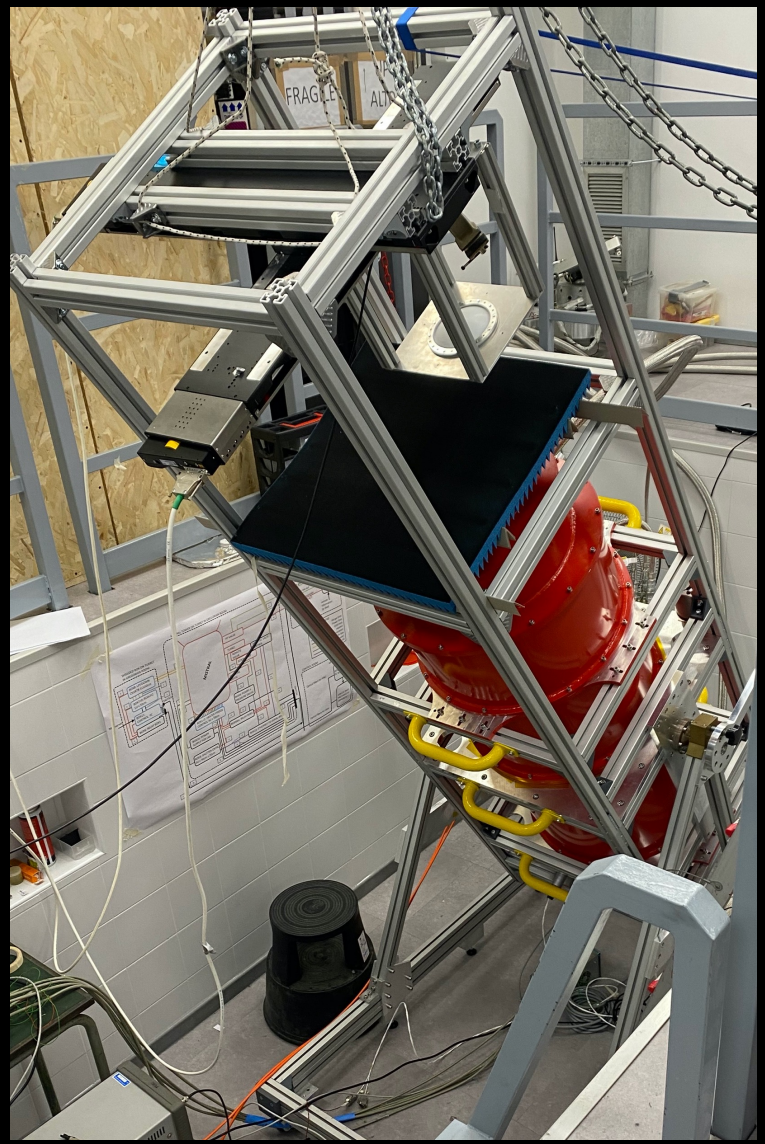

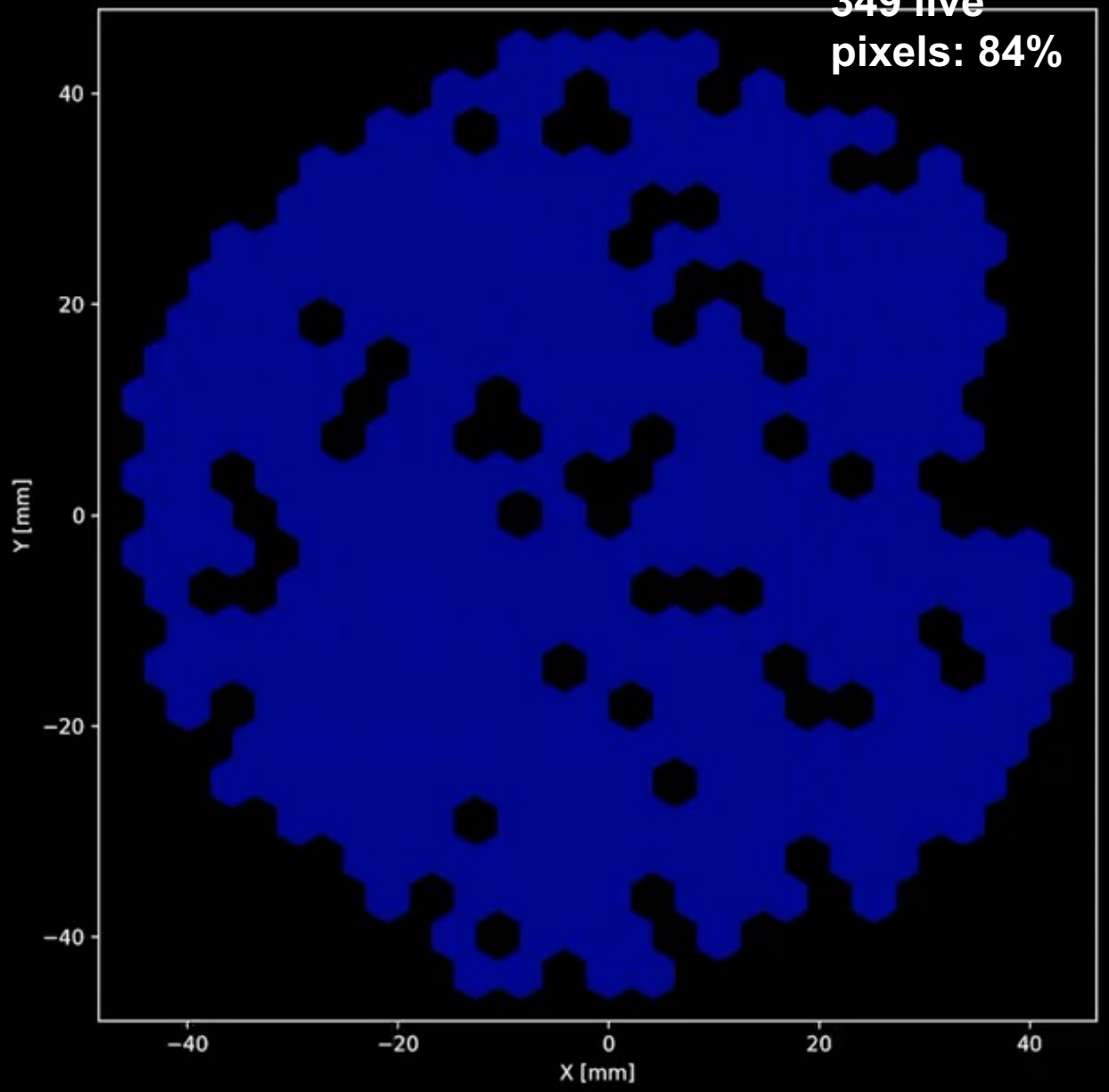

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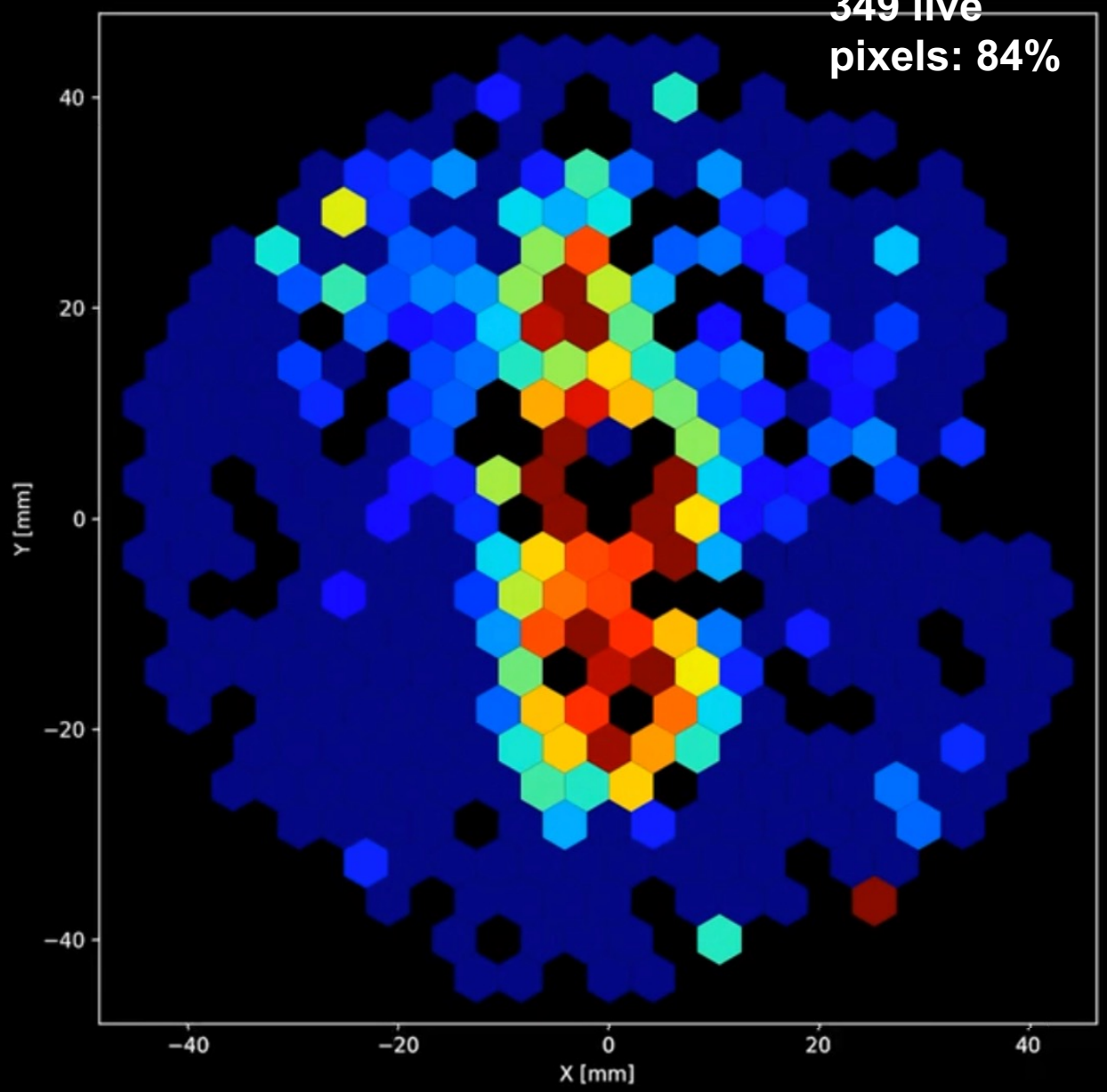

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- MISTRAL calibration:
  - Pulse Tube operations (120m apart) and cryogenic performance
  - Mechanical and optical alignment
  - Pixel recognition
  - Pixel performance
  - Mitigation of PT and mount noise;
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  - Telescope efficiency and panels rms reduction;
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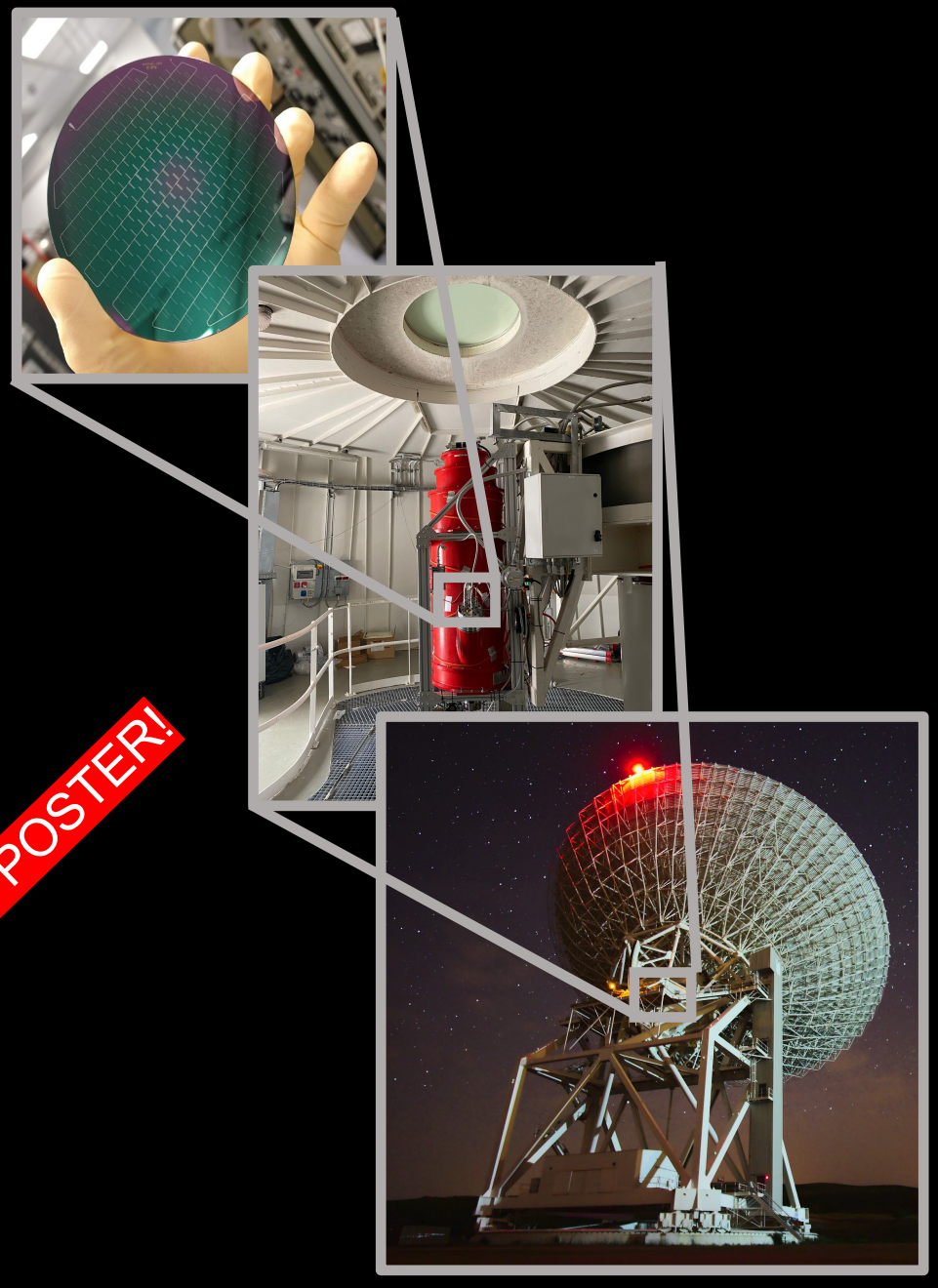

SEE ISOPI'S POSTER!

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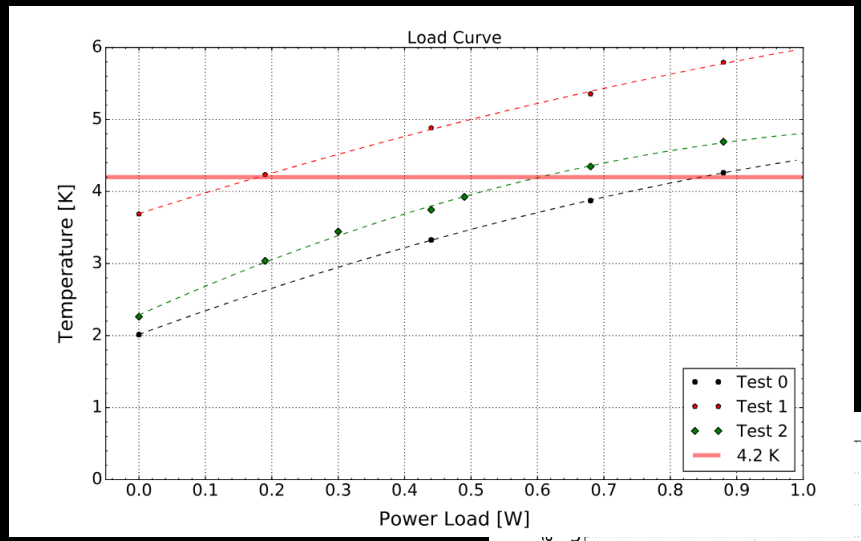


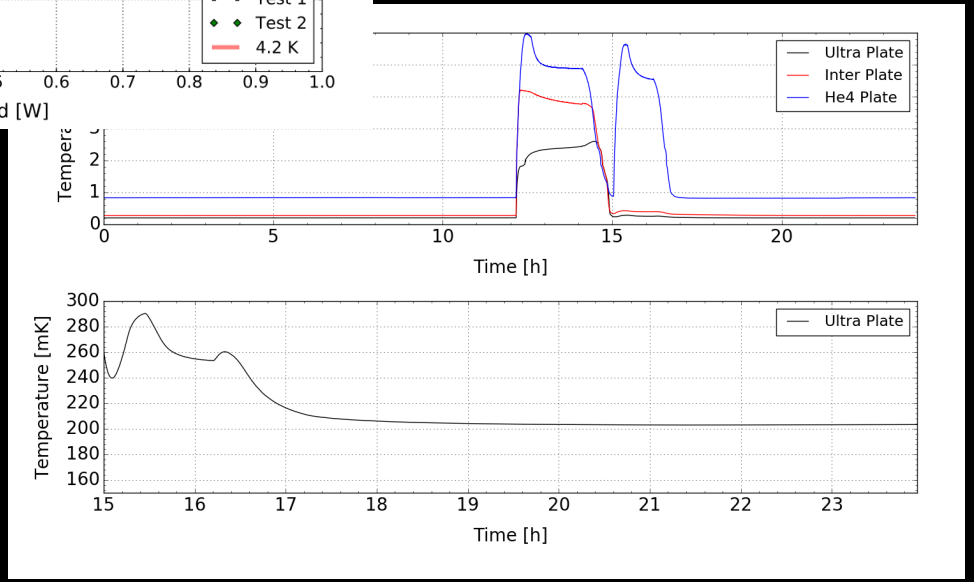


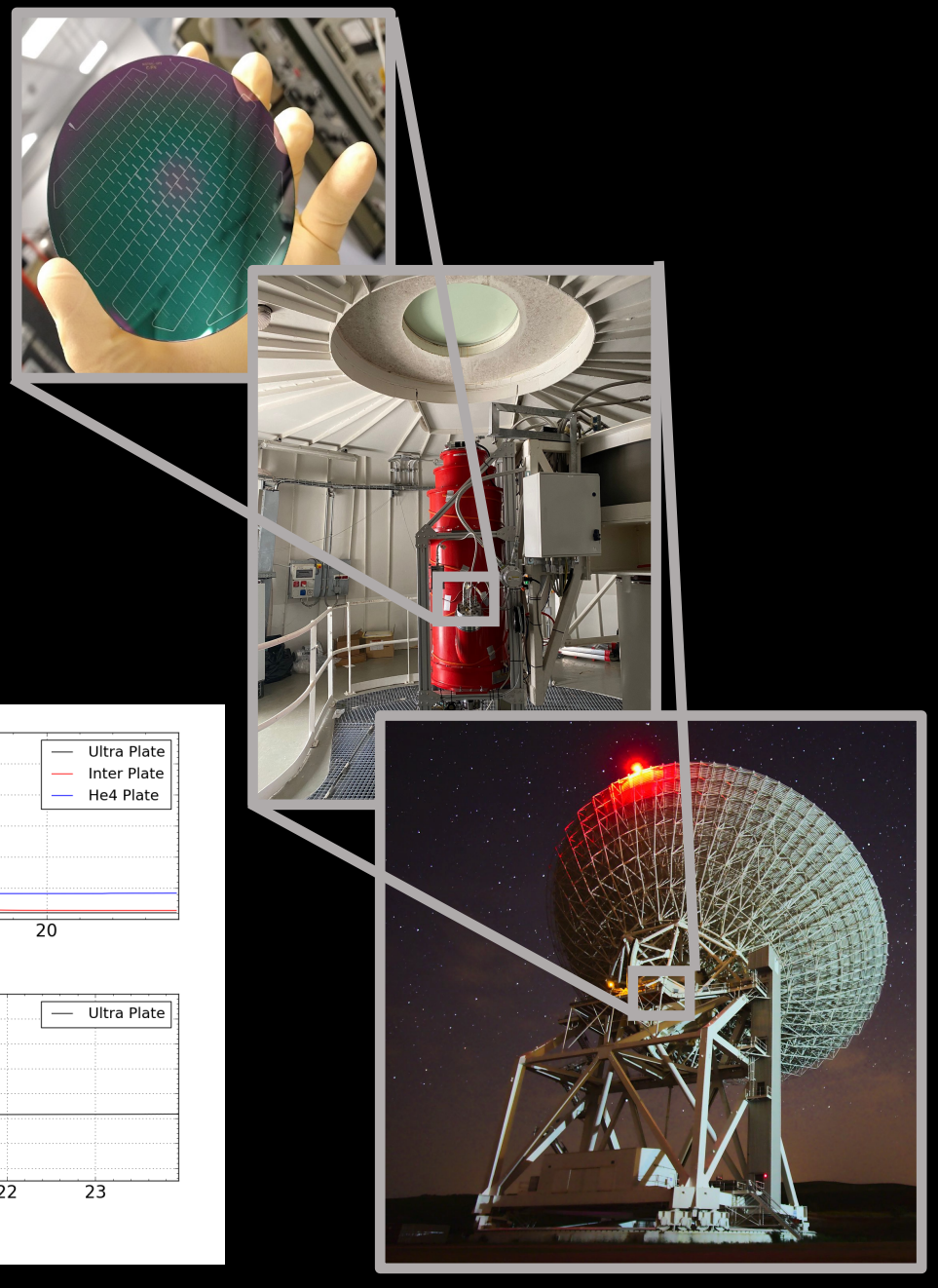

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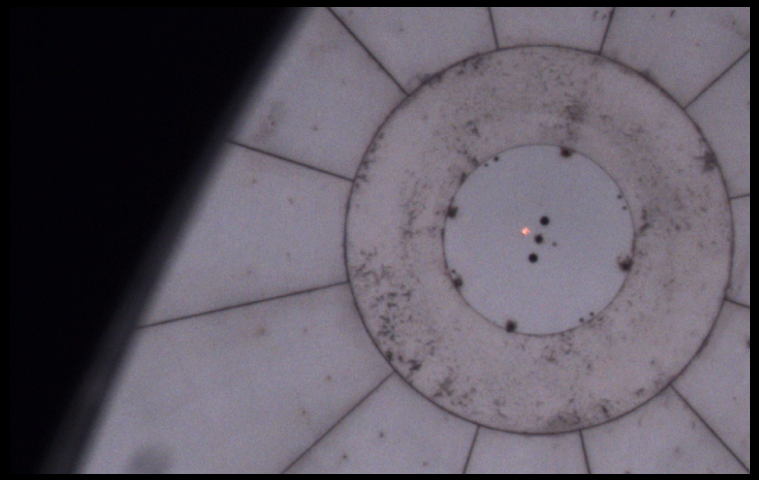

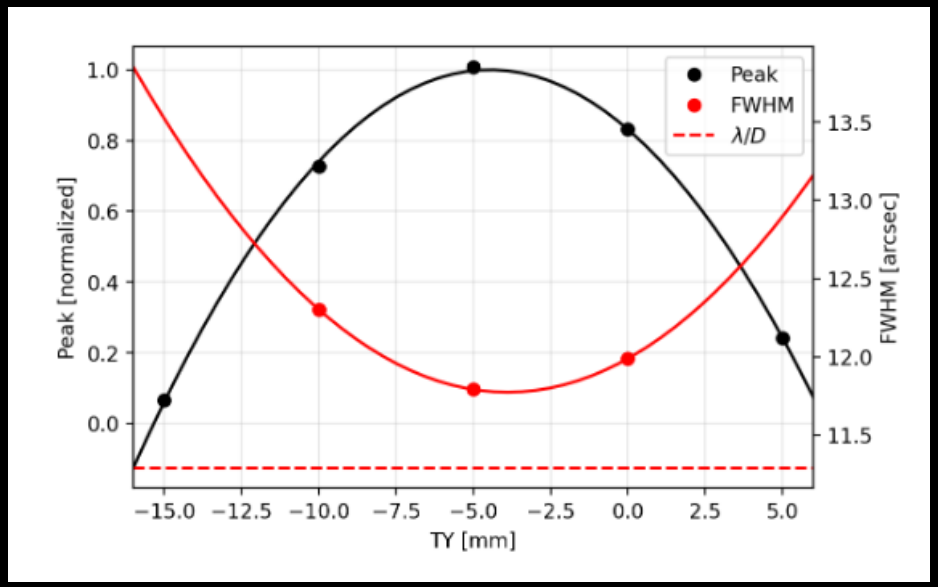


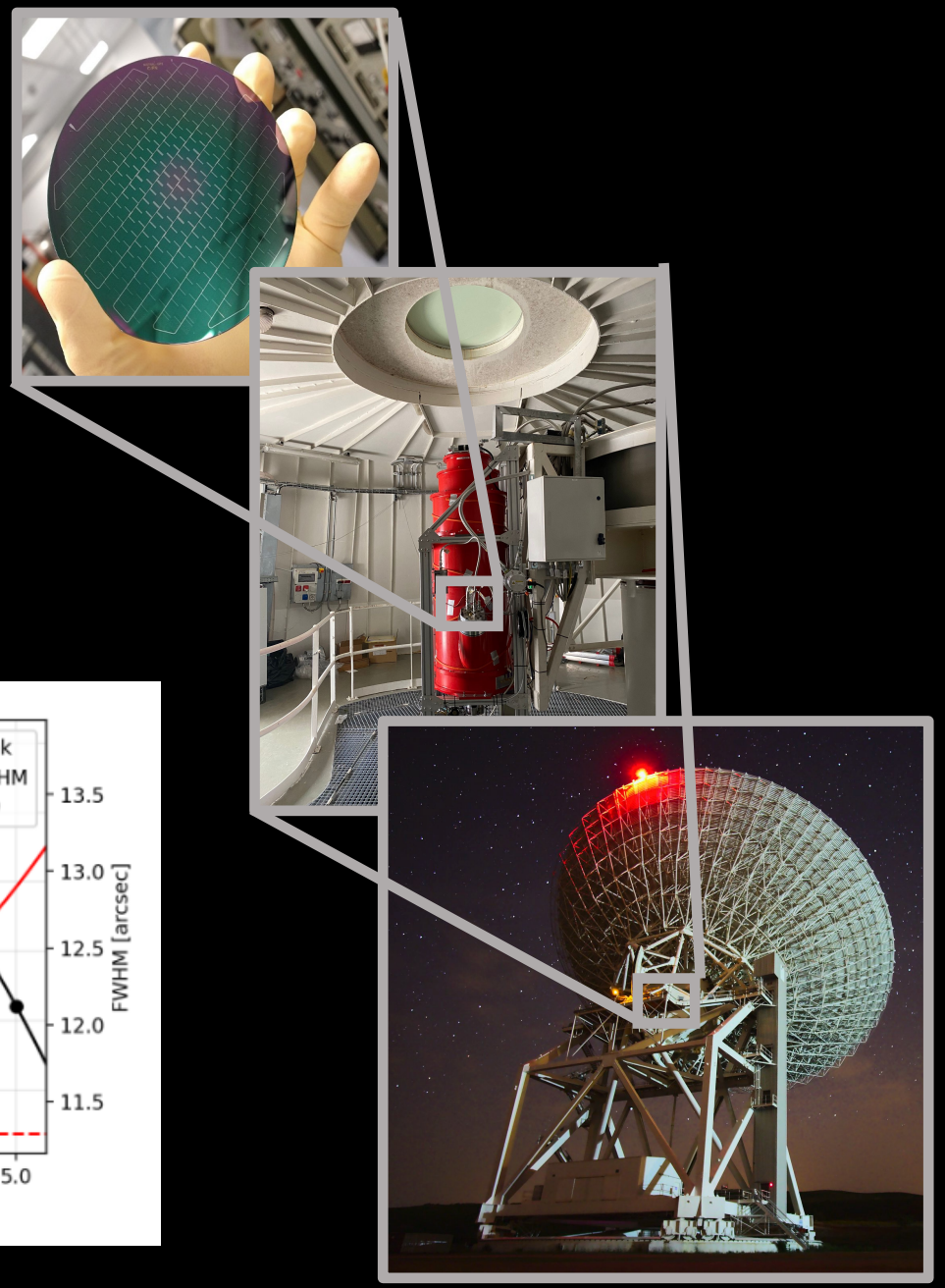

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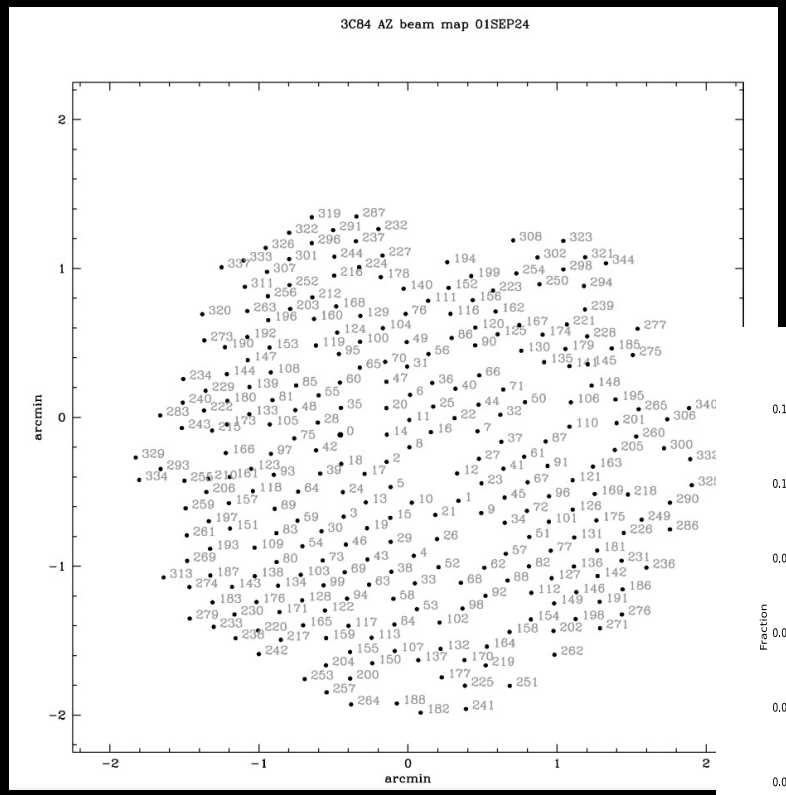


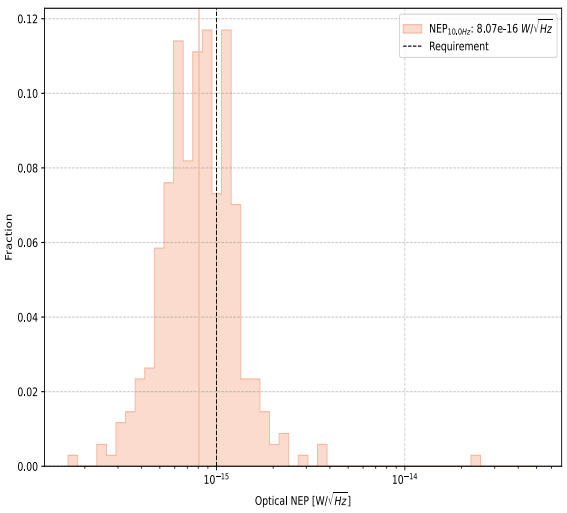


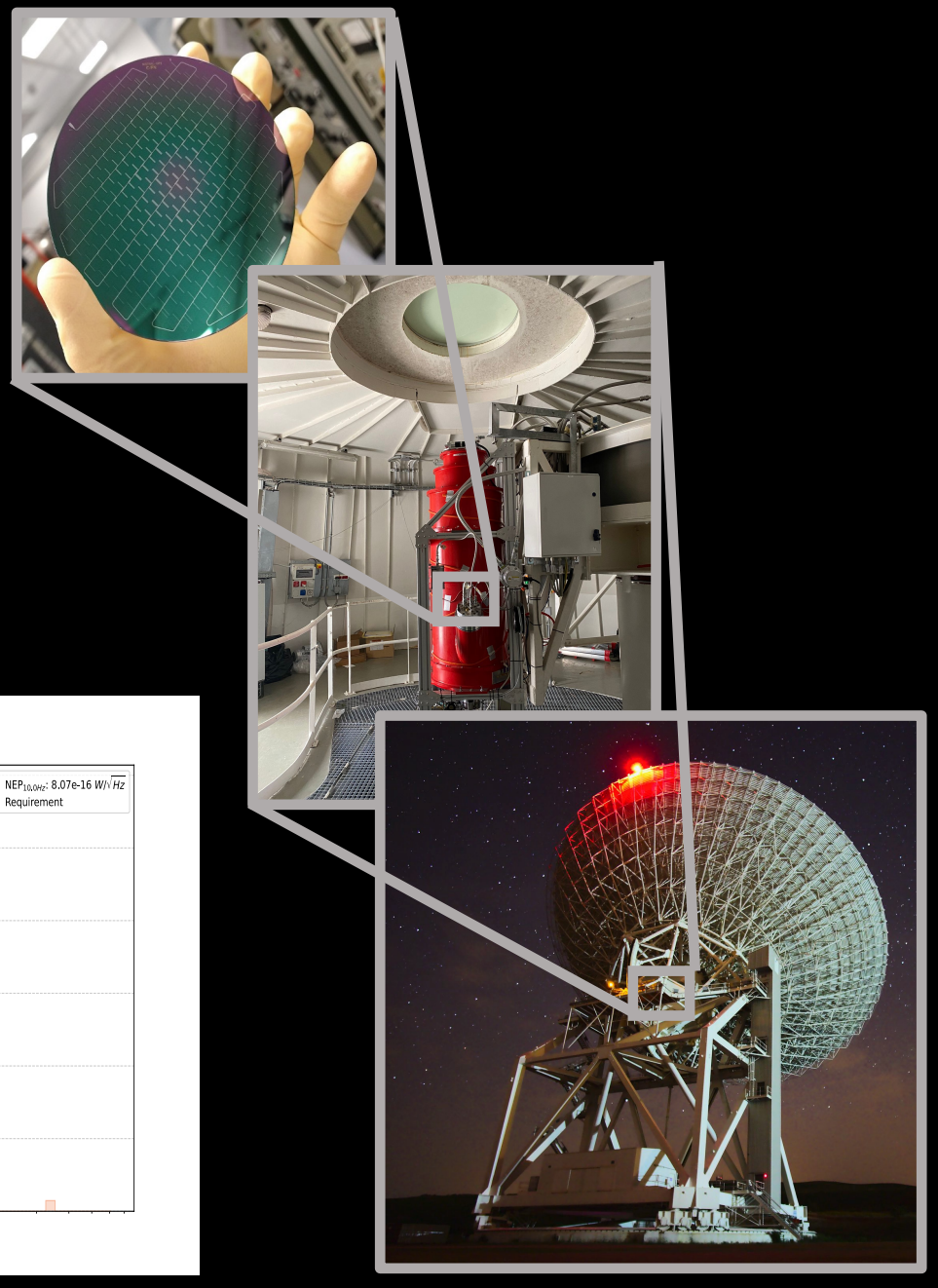

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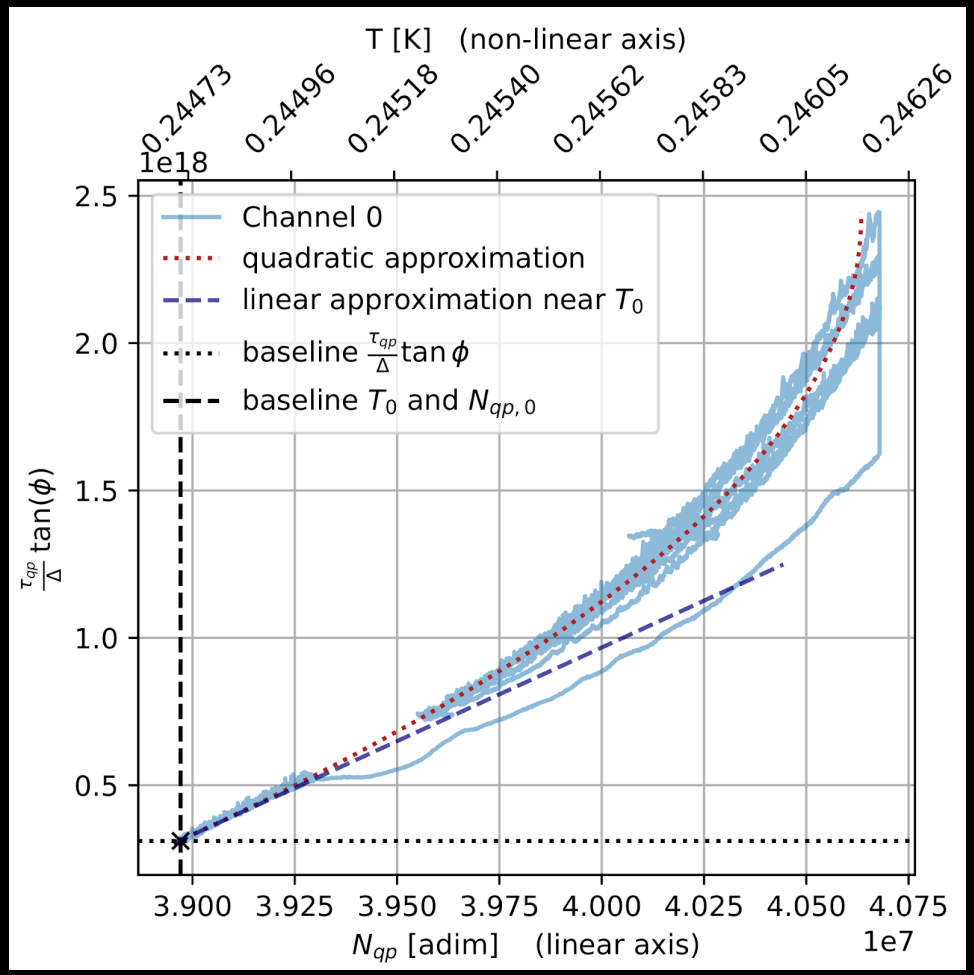


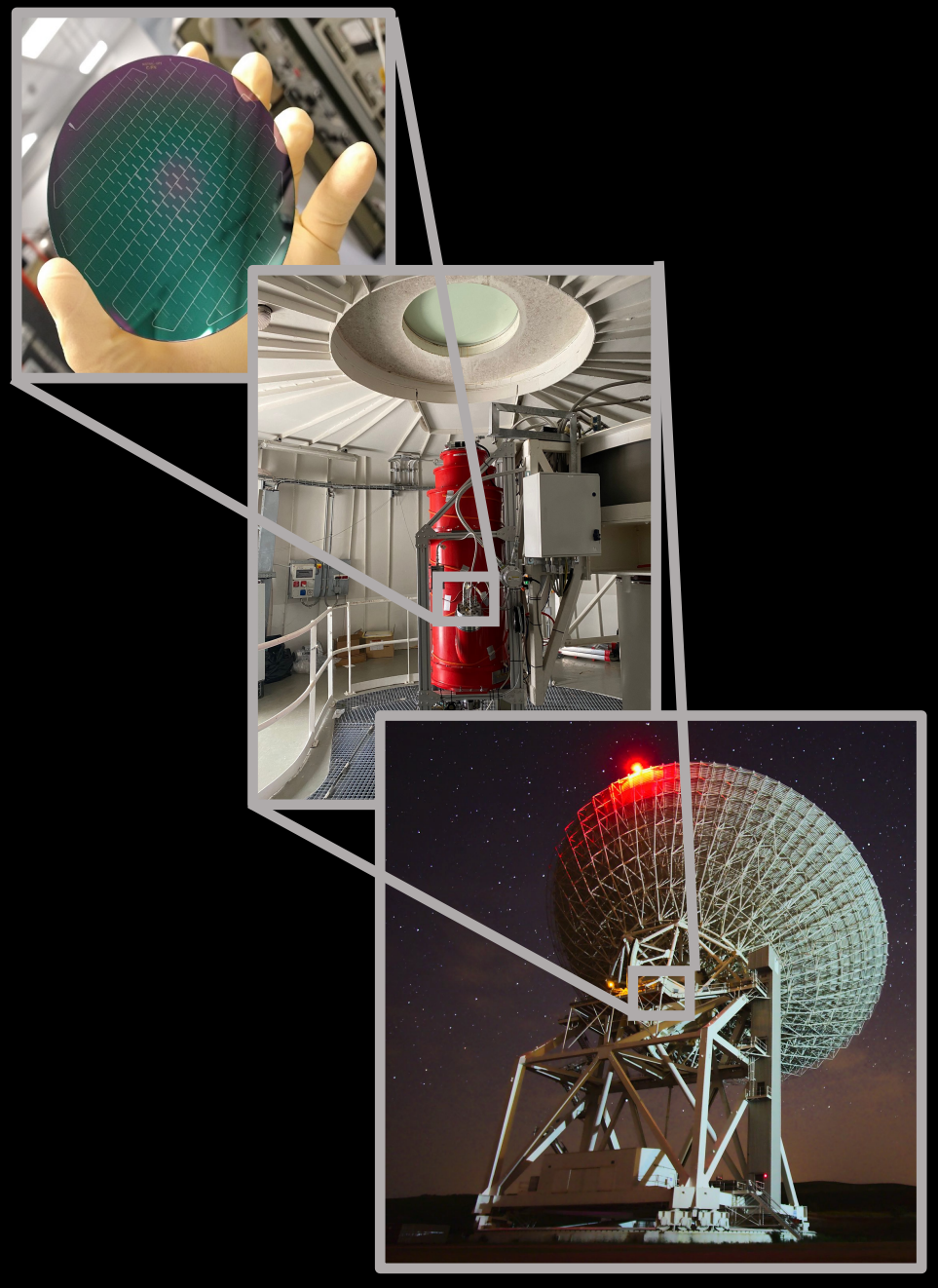

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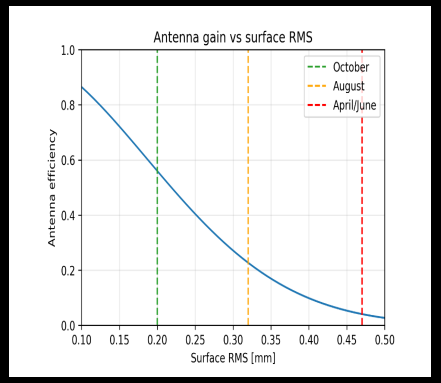
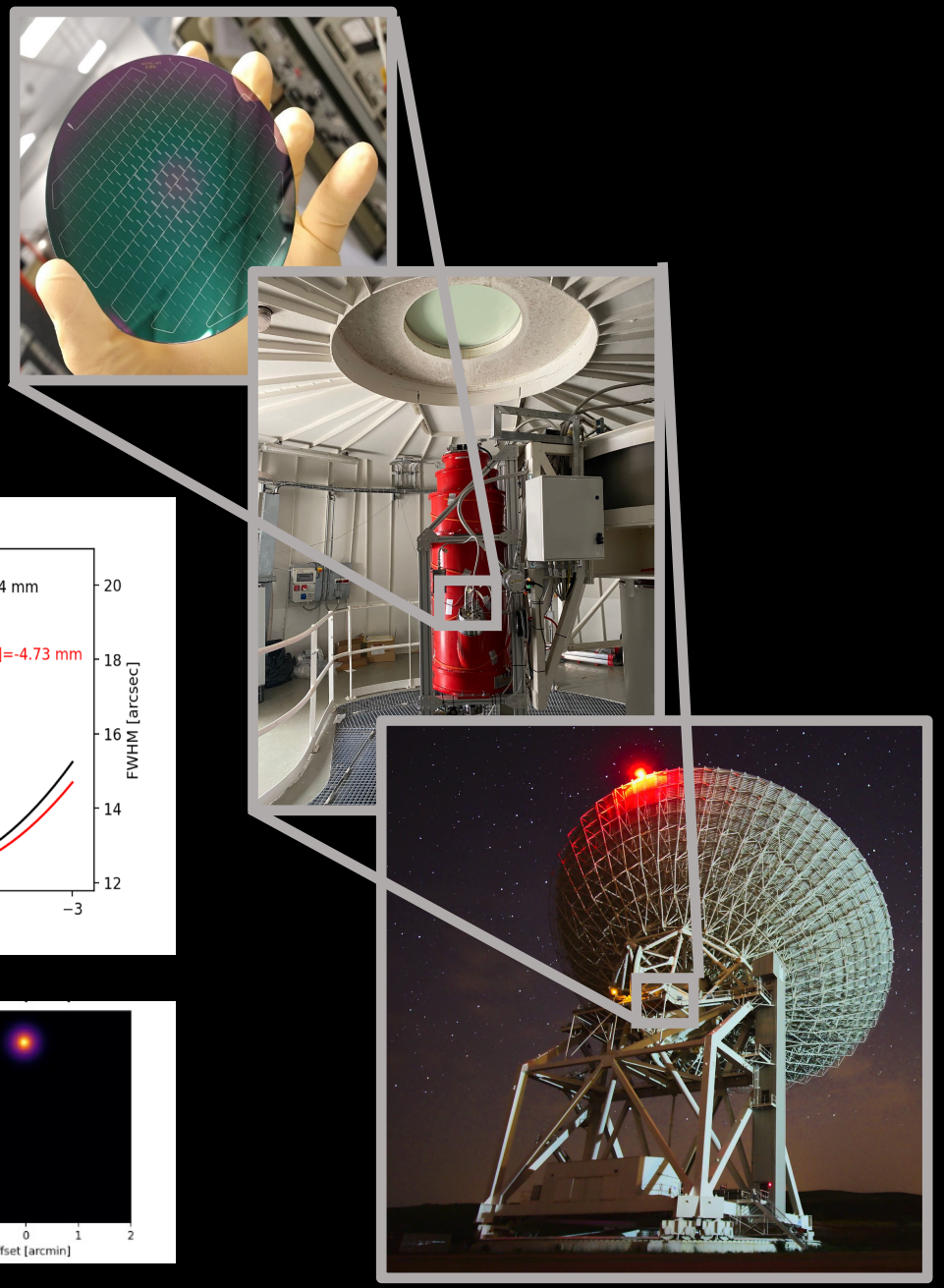
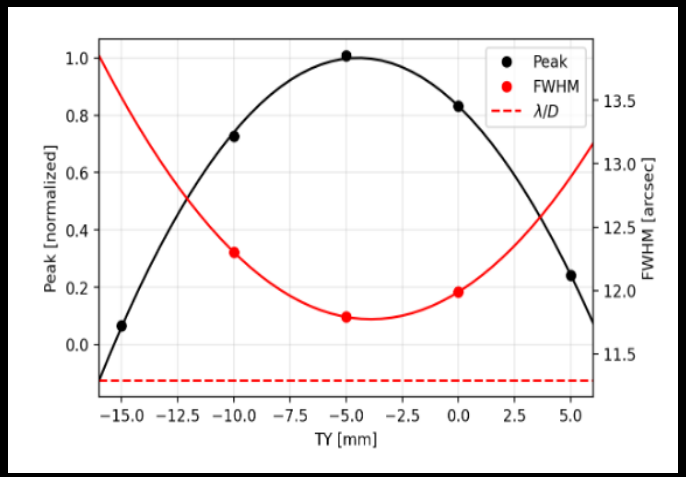
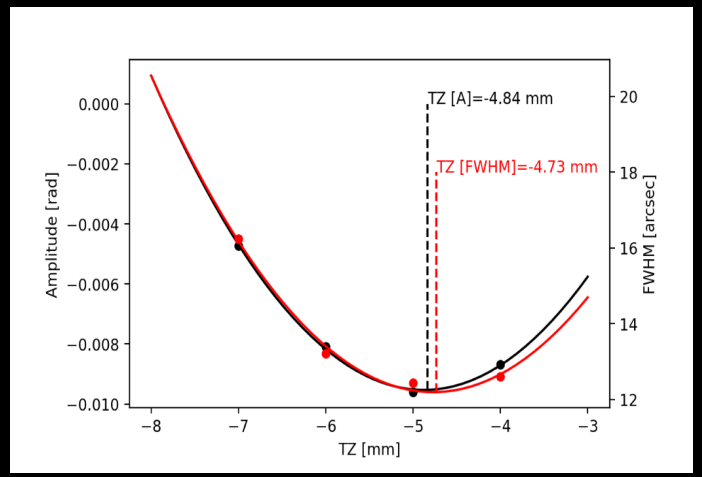
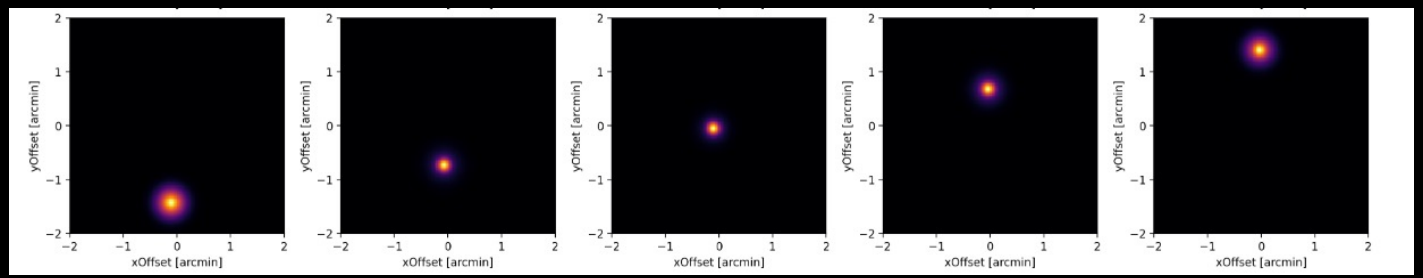




# MISTRAL: FACILITY INSTRUMENT


## Observing with the Italian radio telescopes

Welcome to the Italian radio telescopes users' page

Here you can access all of the resources needed to achieve successful single-dish and extra-EVN interferometric observations

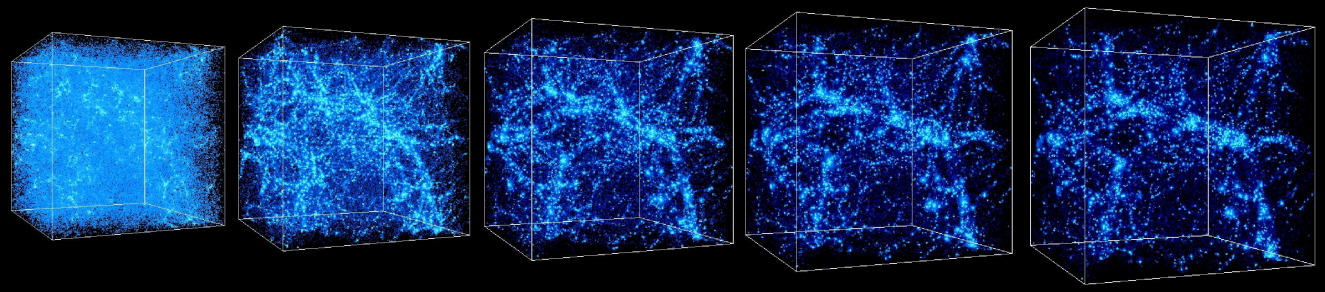
### Contact us

***Regular call is closed. Next call will be in March 2025.***

***Proposals for ToOs and DDT can be submitted anytime.***

***The offered instrumentation is listed here.***

# CONCLUSIONS



•High angular resolution mm observations needed: SZ is a unique tool to study the Cosmic web

•MISTRAL is a new (agile) millimetric camera

•Calibration and commissioning just started

•MISTRAL will be a facility instrument…ready for observations soon

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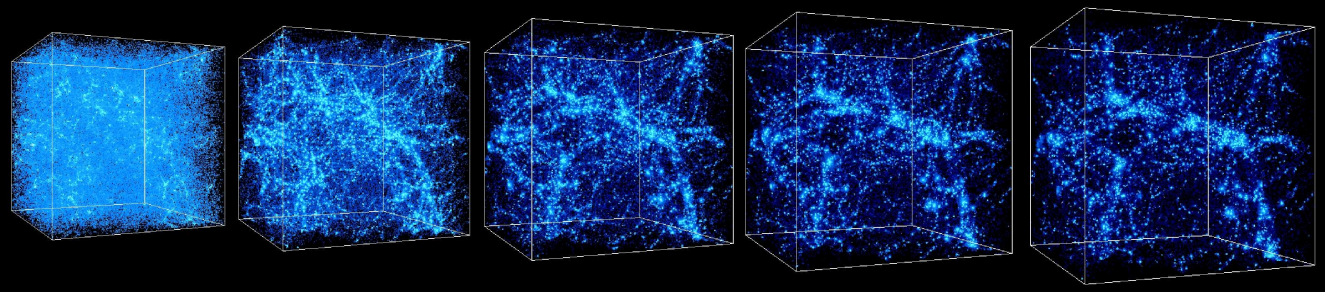

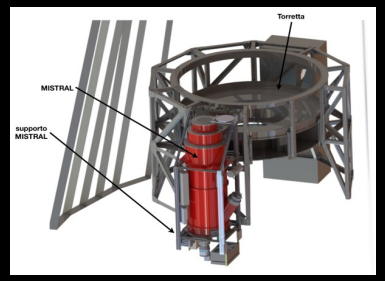


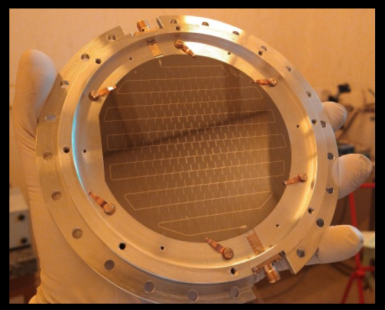

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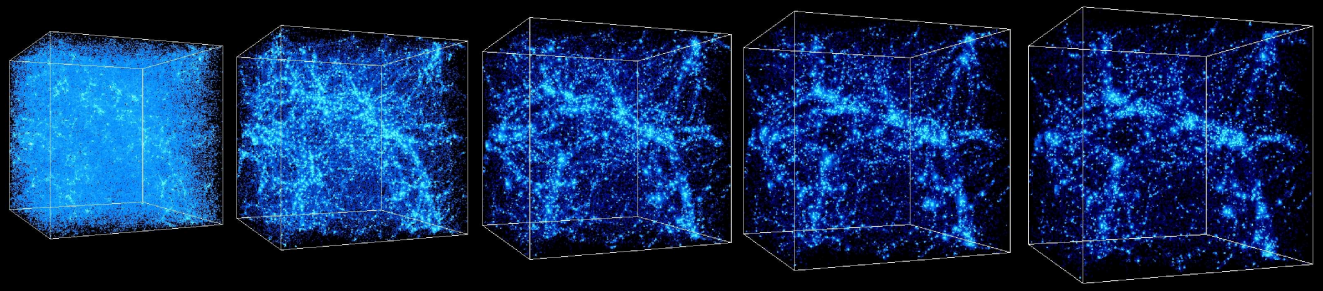

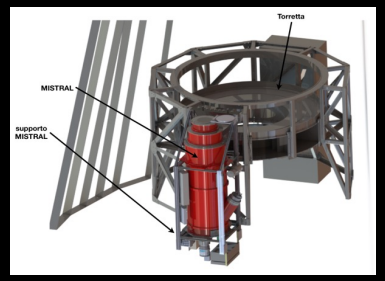


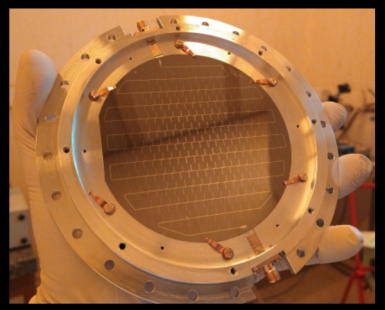


PON RICERCA E INNOVAZIONE 2014 - 2020

SAPIENZA UNIVERSITÀ DI ROMA

ISTITUTO NAZIONALE DI ASTROFISICA
INAF
NATIONAL INSTITUTE FOR ASTROPHYSICS

- High angular resolution mm observations needed: SZ is a unique tool to study the Cosmic web
- MISTRAL is a new (agile) millimetric camera
- Calibration and commissioning just started
- MISTRAL will be a facility instrument…ready for observations soon

# THANK YOU!