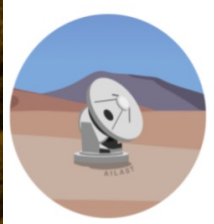




CMB research at the IAC. Science and Technology Synergies for AtLAST



J.A. Rubiño-Martín (IAC)
on behalf of the CMB group at IAC

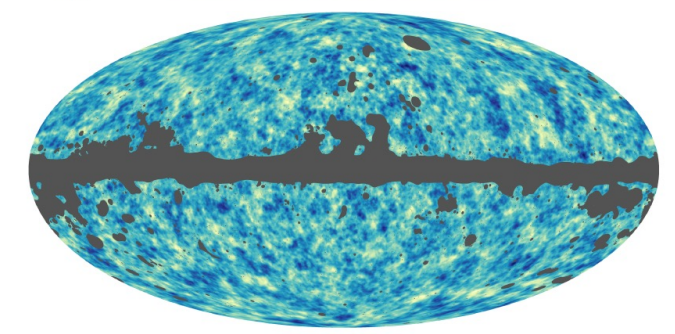
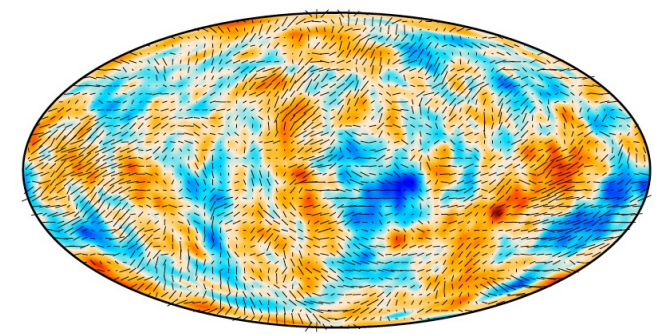
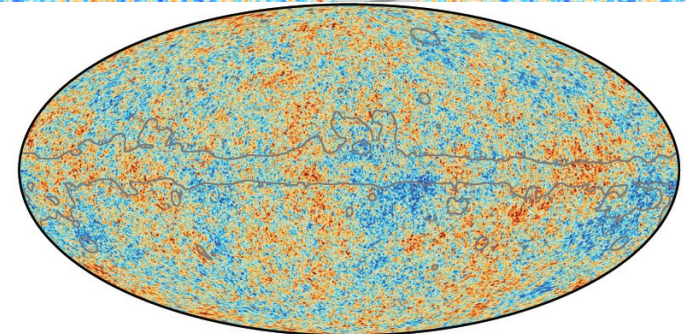
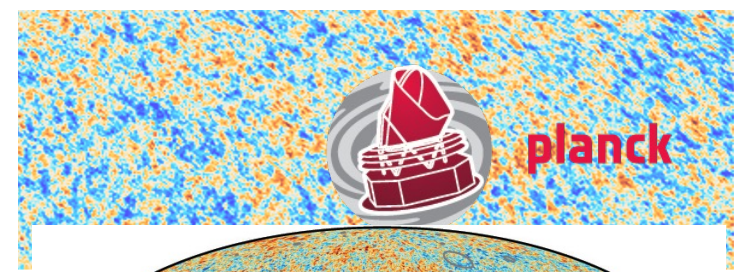
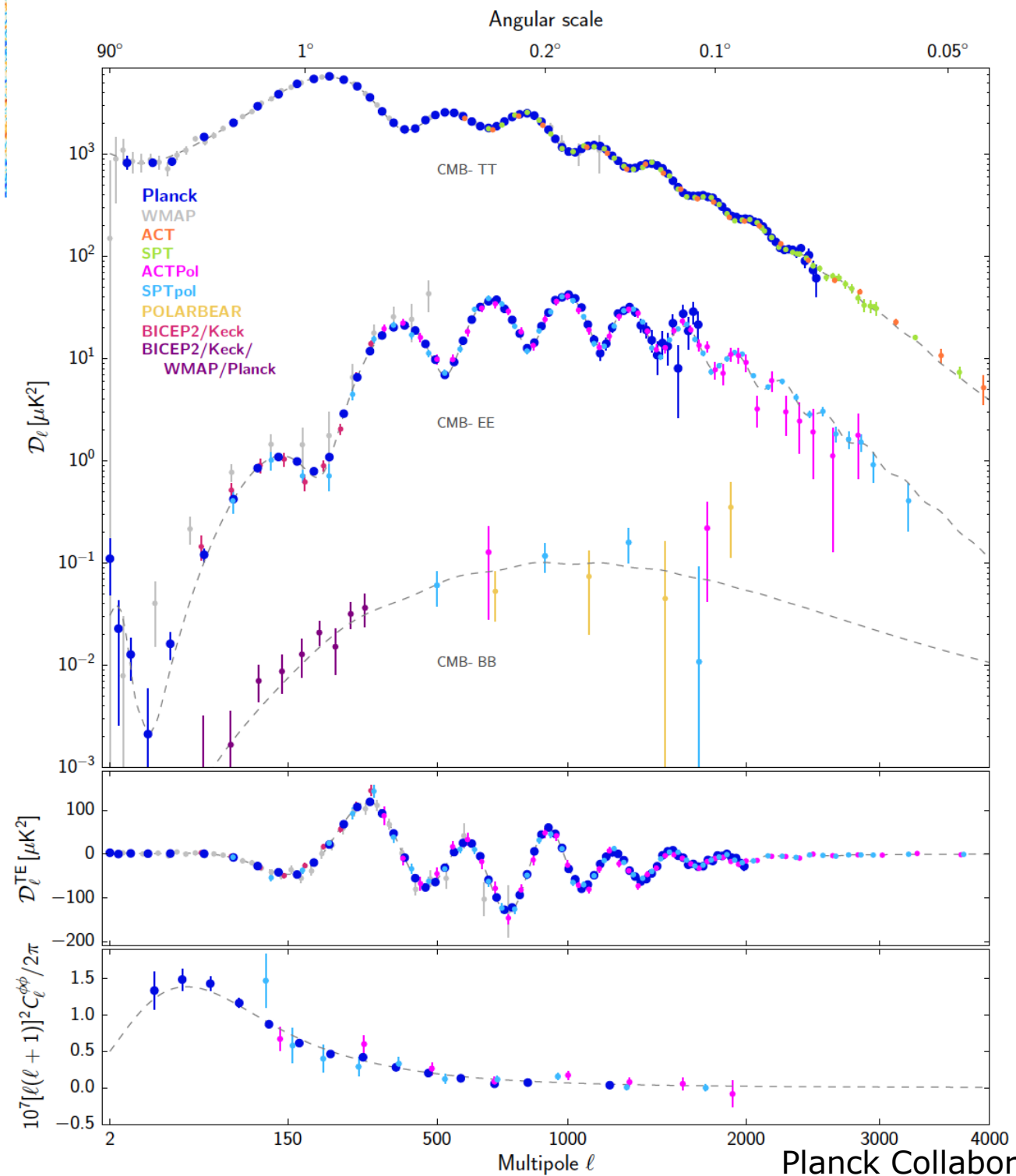


IBERIAN
AtLAST DAYS
2026



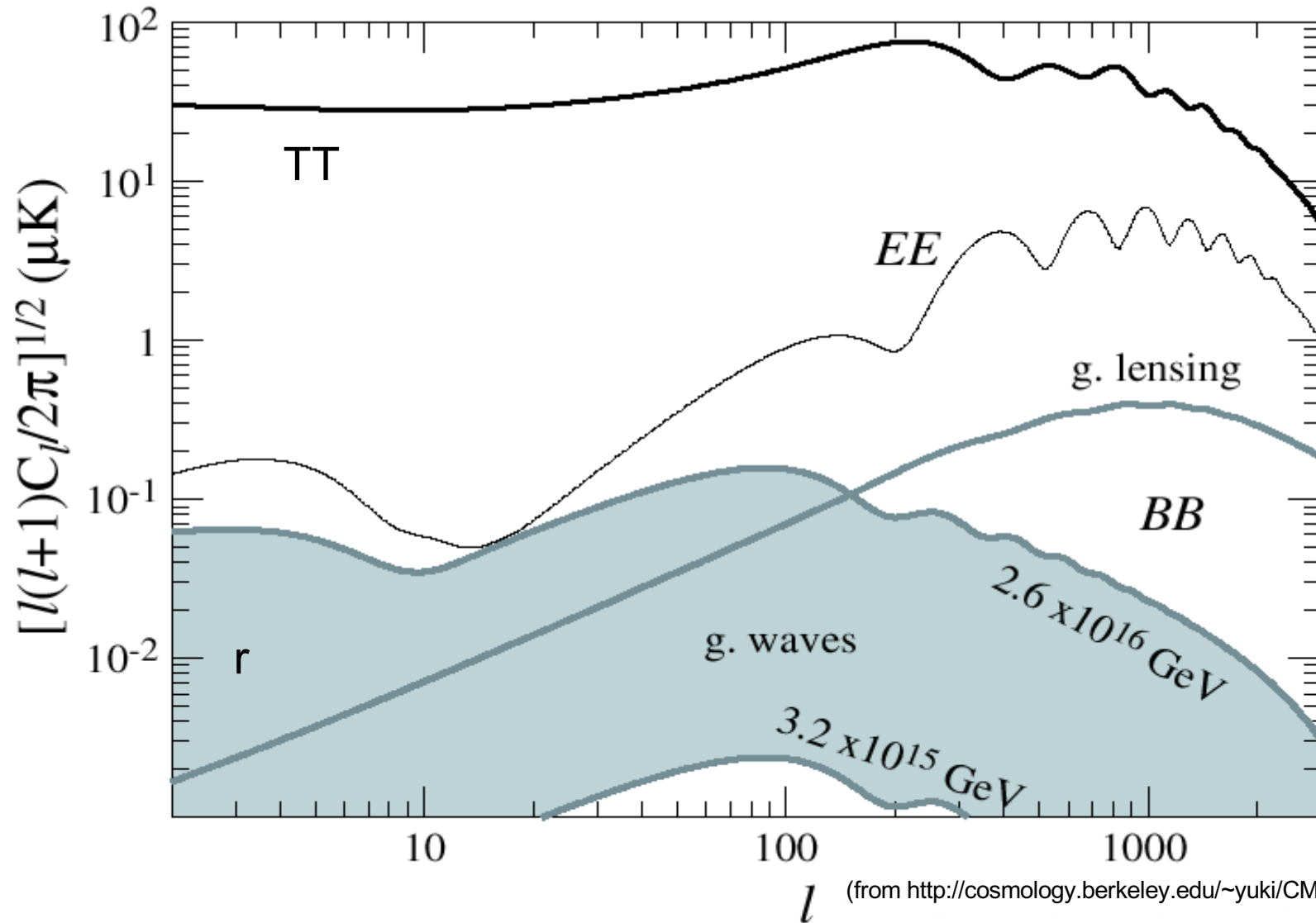
UNIVERSIDAD COMPLUTENSE DE MADRID, 4-5 JUNE 2026





Planck Collaboration I (2020)

Primordial gravitational waves and B-modes



Current upper limits: $r < 0.032$ at 95% C.L.
(BICEP2/Keck + Planck PR4. Tristram et al. 2022)

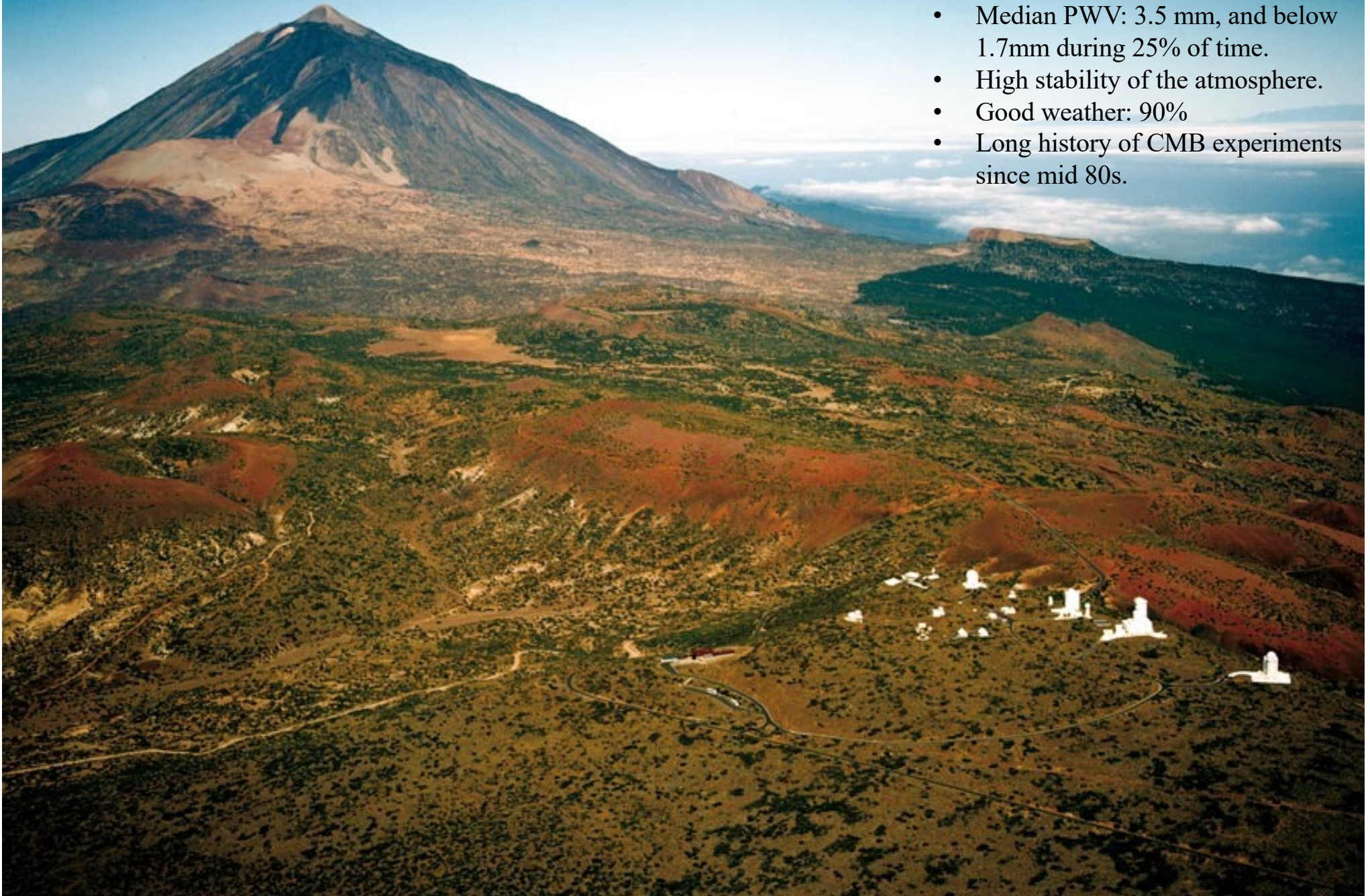
$$V^{1/4} = 1.04 \times 10^{16} \text{ GeV} \left(\frac{r}{0.01} \right)^{1/4}$$



Teide Observatory (Tenerife, Canary Islands)

(<https://www.iac.es/en/observatorios-de-canarias/teide-observatory>)

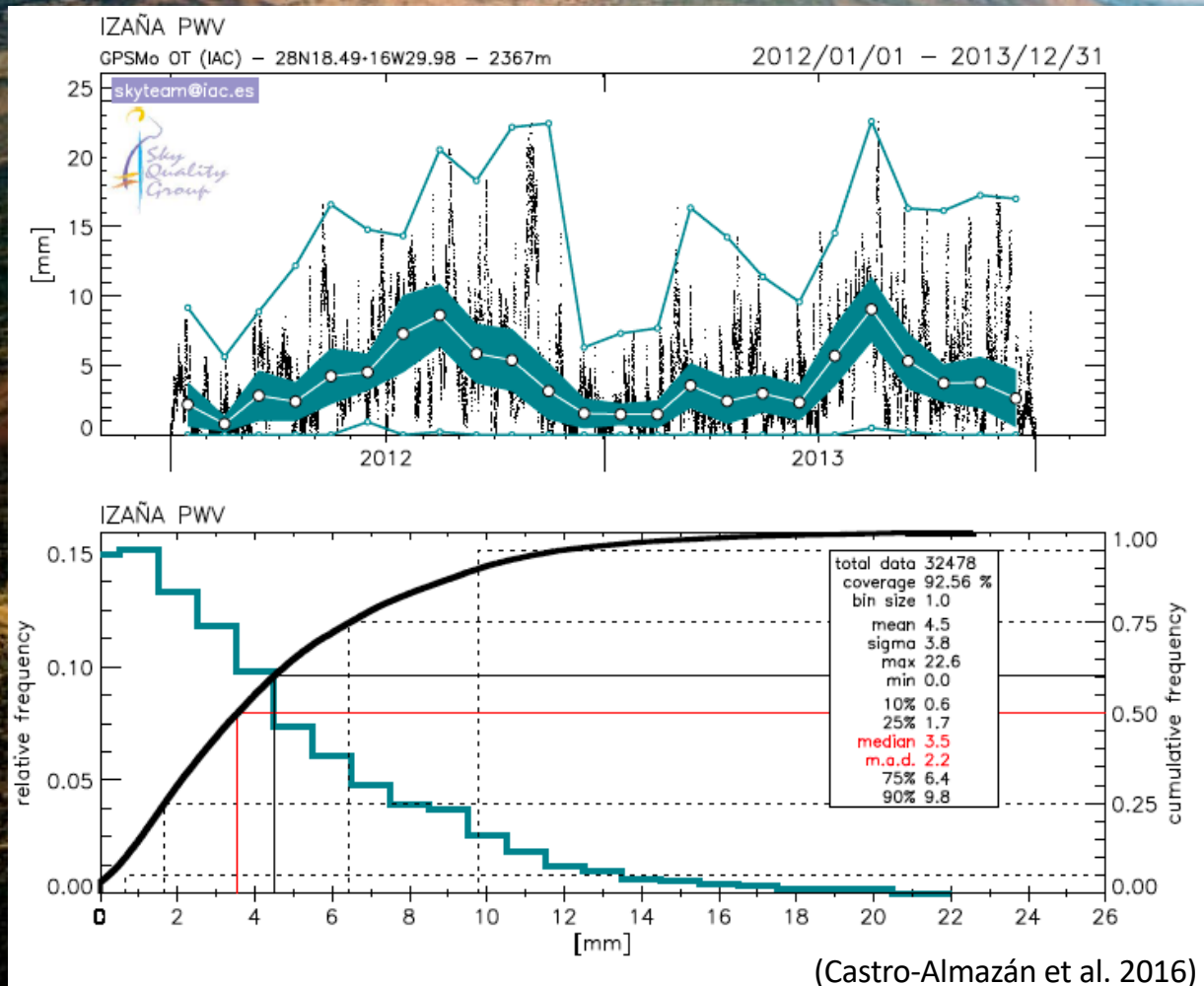
- Altitude: 2.400 m
- Longitude: 16° 30' W
- Latitude: 28° 17' N
- Median PWV: 3.5 mm, and below 1.7mm during 25% of time.
- High stability of the atmosphere.
- Good weather: 90%
- Long history of CMB experiments since mid 80s.



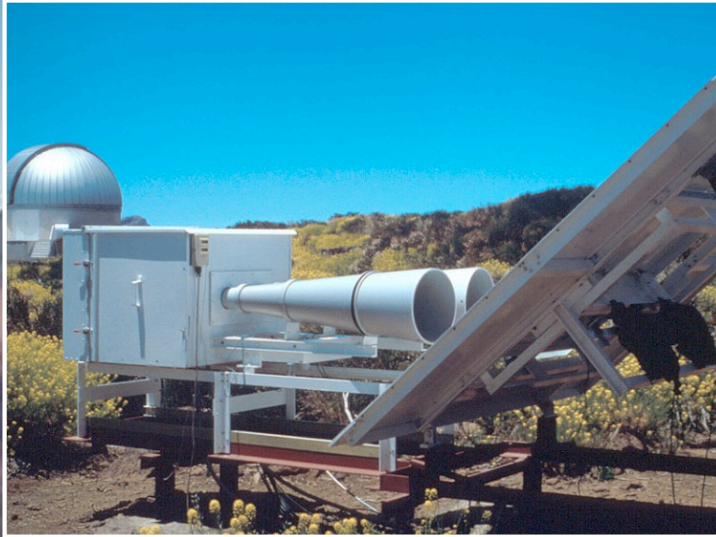
Teide Observatory (Tenerife, Canary Islands)

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- Long history of CMB experiments since mid 80s.



**Teide Observatory
CMBLab
(past)**



Tenerife Experiment (1984-2000)
10, 15, 33 GHz



COSMOSOMAS (1998-2007)
11, 13, 15, 17 GHz



JBO-IAC int (1997-2002)
33 GHz

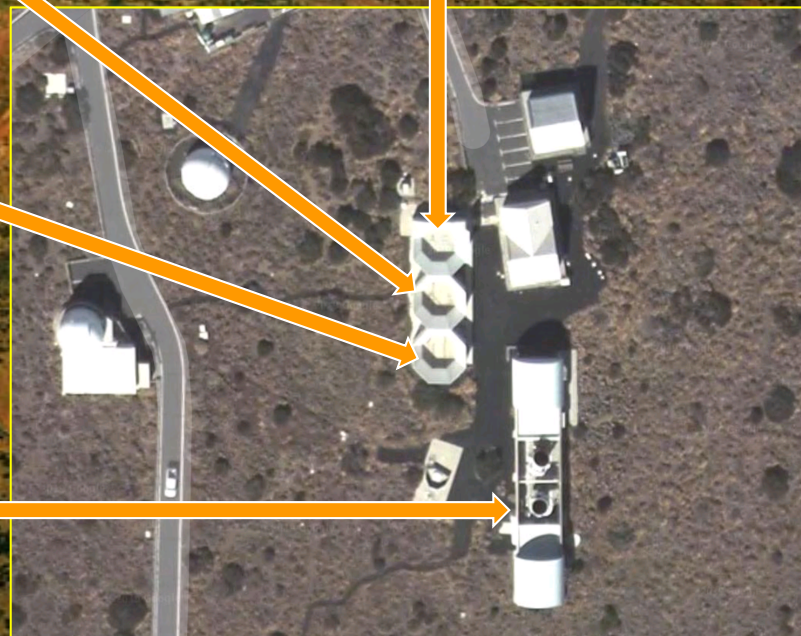
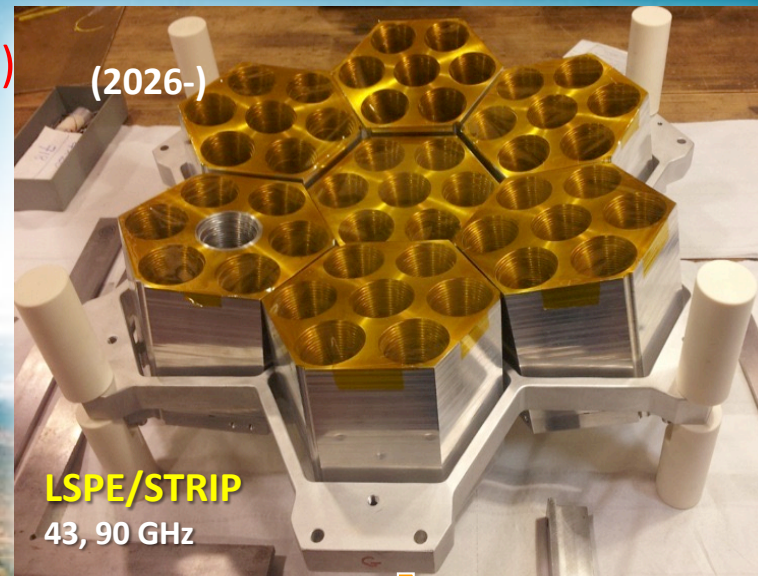


IAC-Bartol (1994-1997)
90, 143, 230, 270 GHz



The Very Small Array (2000-2008)
30 GHz

**Teide Observatory
CMBLab today
(CMB-Teide Collaboration)**



The QUIJOTE experiment

(Q-U-I JOint Tenerife Experiment, <http://research.iac.es/project/quijote>)

QT-1 and QT-2: Crossed-Dragone telescopes, 2.25m primary, 1.9m secondary.

QT-1. Instruments: MFI, MFI2.

11, 13, 17, 19 GHz. $\Delta\nu=2\text{GHz}$.

FWHM=0.93°-0.62°

MFI: 2012-18.

MFI2: 2023-

QT-2. Instruments: TGI & FGI

30 and 40 GHz. $\Delta\nu = 10\text{GHz}$

FWHM=0.37°-0.28°

Commissioning 2018.

Observations re-started 2021.

NGI: 90GHz camera.

500 detectors (KIDs).



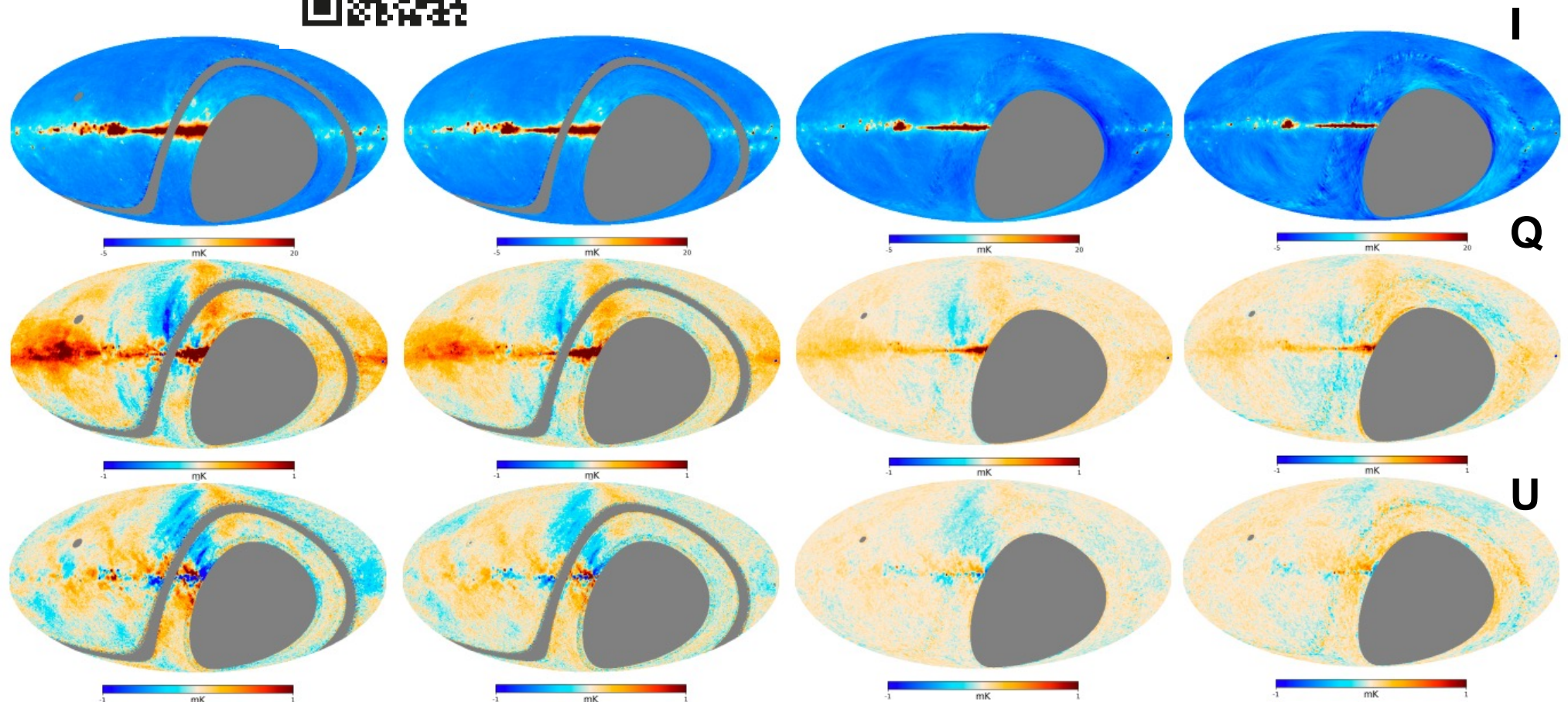
Wide survey with the QUIJOTE MFI (10-20 GHz)



DOI: doi.org/10.26698/quijote-mfi-dr1

(DR1: Jan 2023)

(Rubino-Martin et al. 2023)



QUIJOTE 11GHz

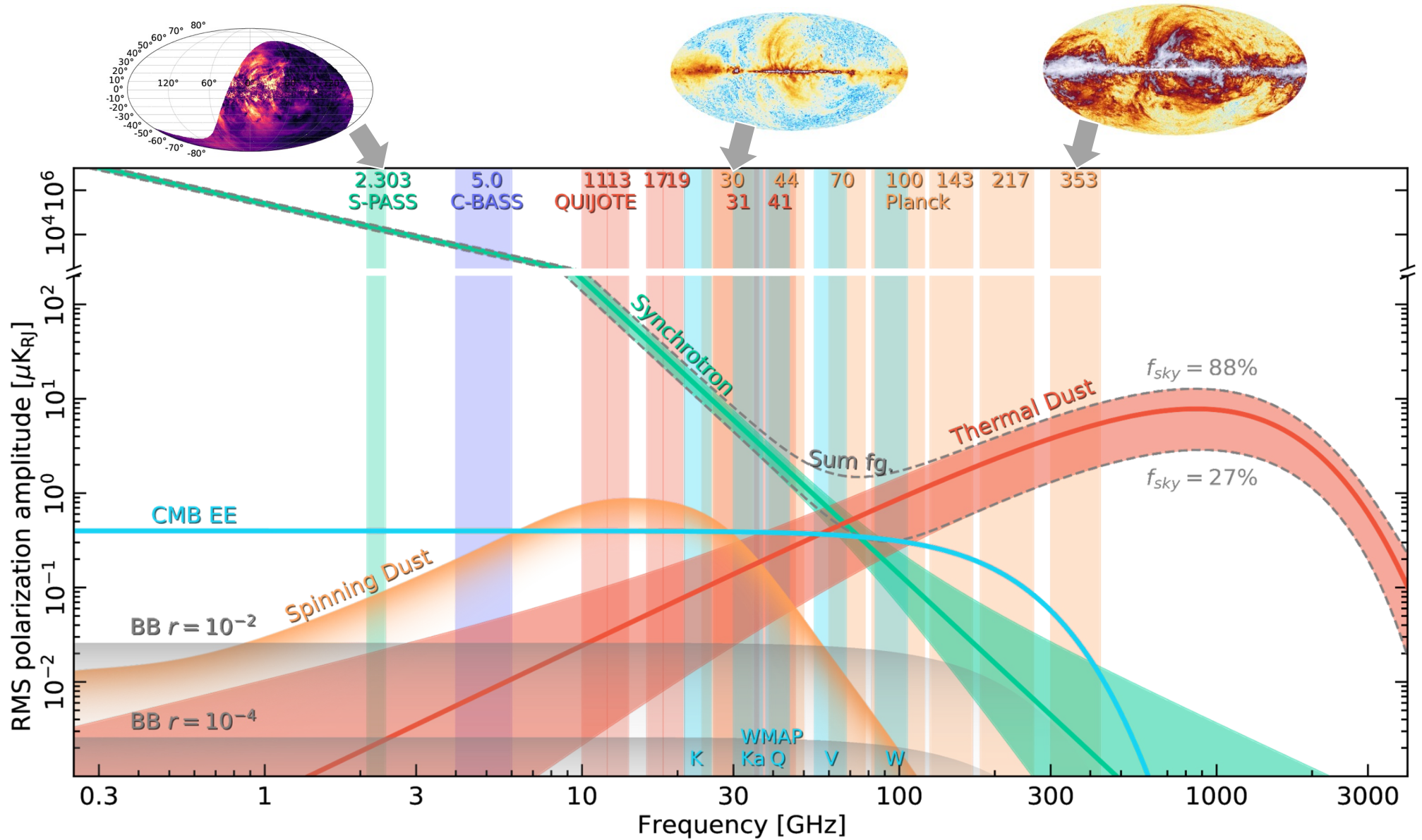
QUIJOTE 13GHz

QUIJOTE 17GHz

QUIJOTE 19GHz

Approx. 30,000 deg². About 10,000 h of observations. Sensitivities in polarization (Q,U):
 $\sim 35\text{-}40 \mu\text{K/deg} \rightarrow$ equivalent to $2.4 \mu\text{K.arcmin}$ @ 100GHz with $\beta=-3$.

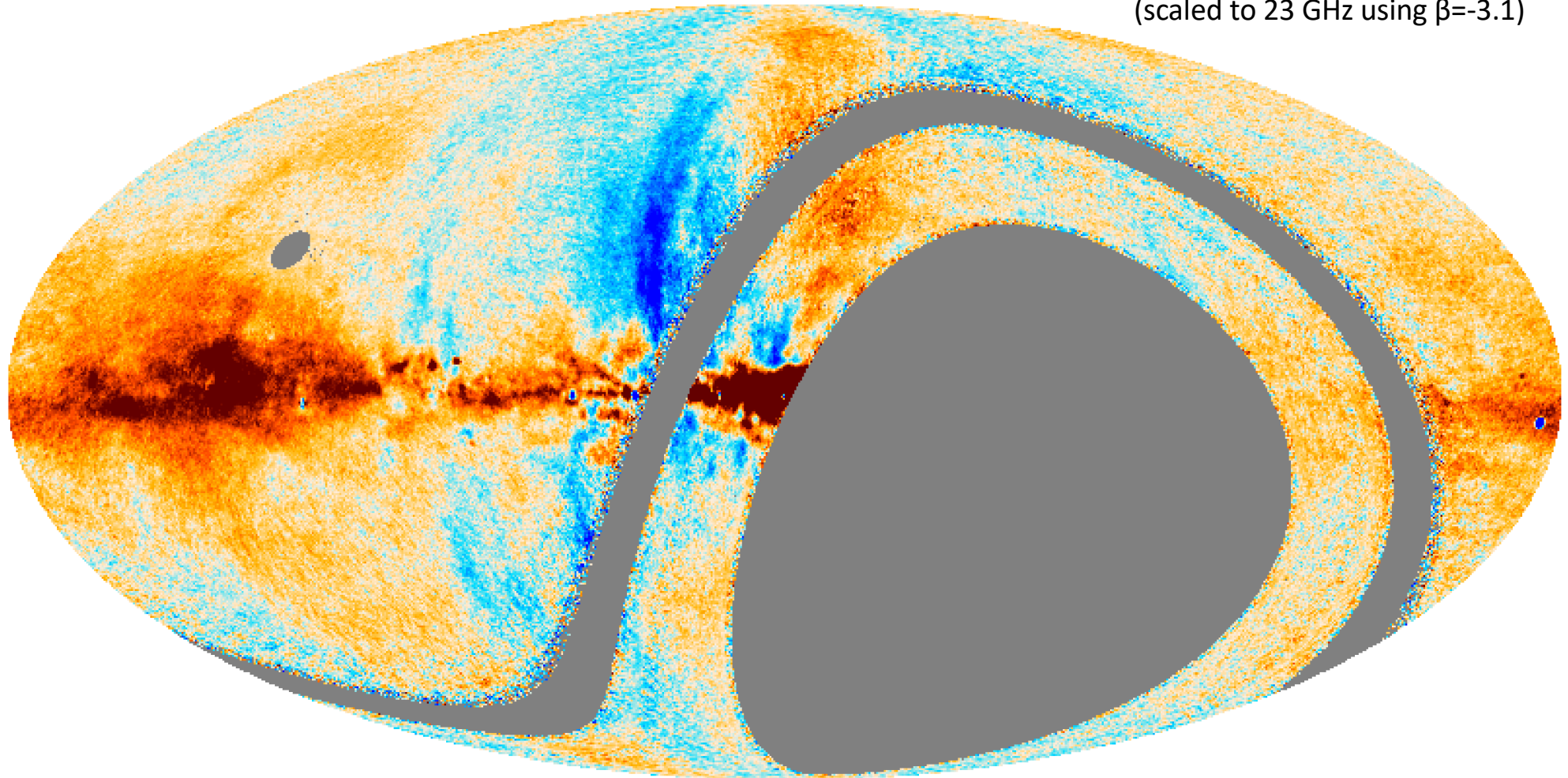
Sky emission in polarization at degree scales



Wide survey with the QUIJOTE MFI (10-20 GHz)

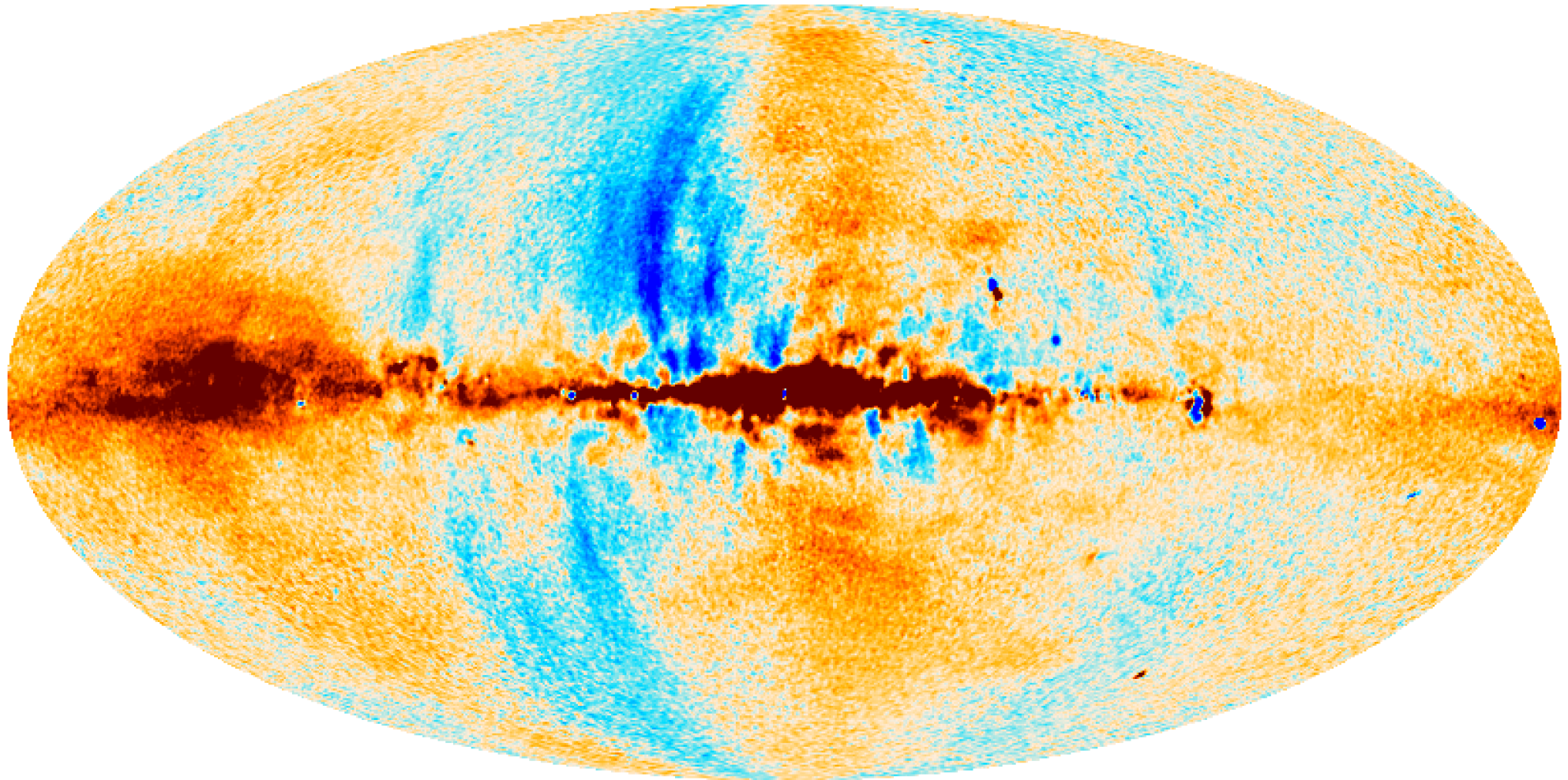
QUIJOTE Q H3_11GHz (1deg)

Final 1 deg maps
(scaled to 23 GHz using $\beta=-3.1$)



Wide survey with the QUIJOTE MFI (10-20 GHz)

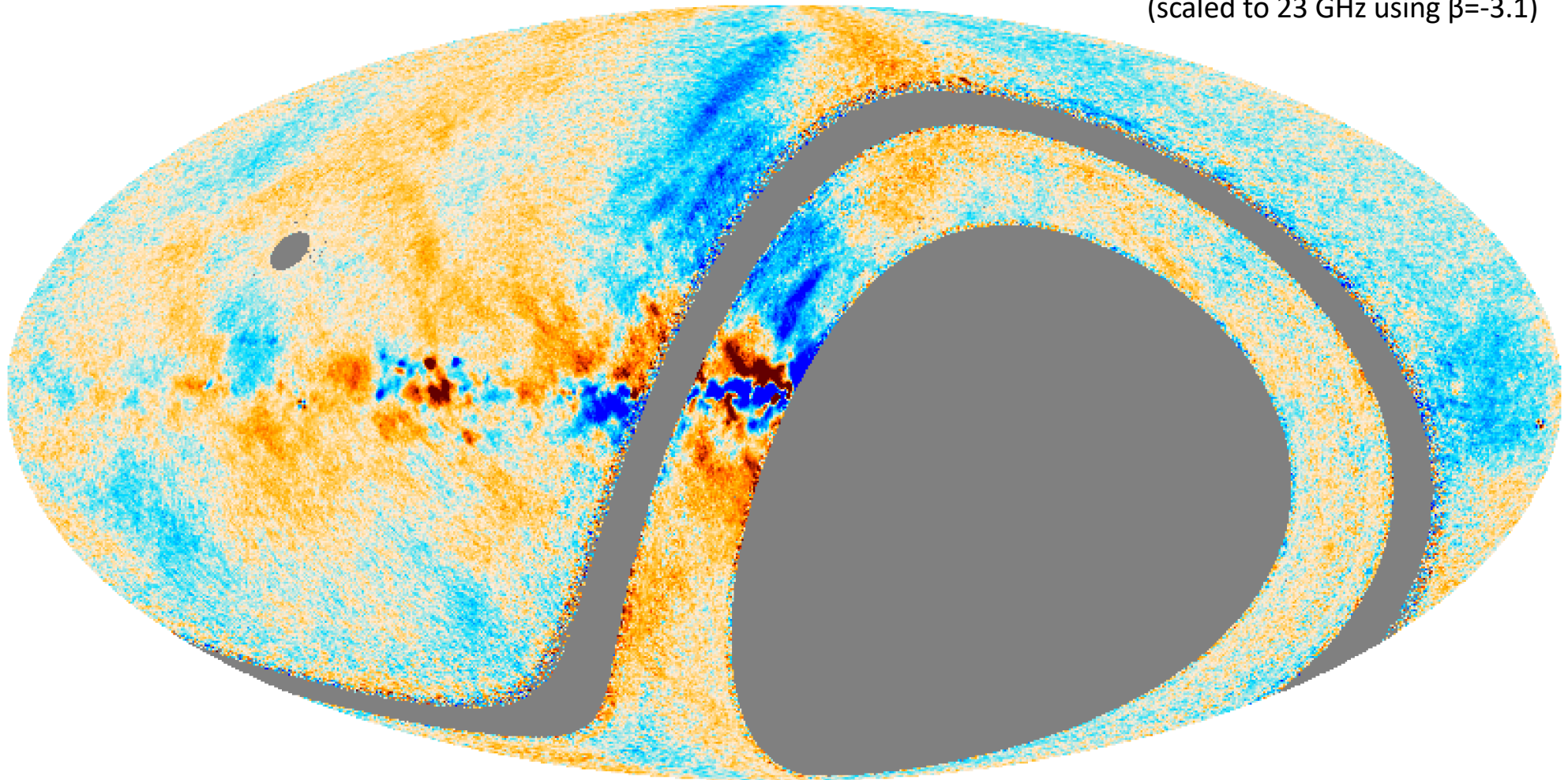
WMAP 23GHz Q (1deg)



Wide survey with the QUIJOTE MFI (10-20 GHz)

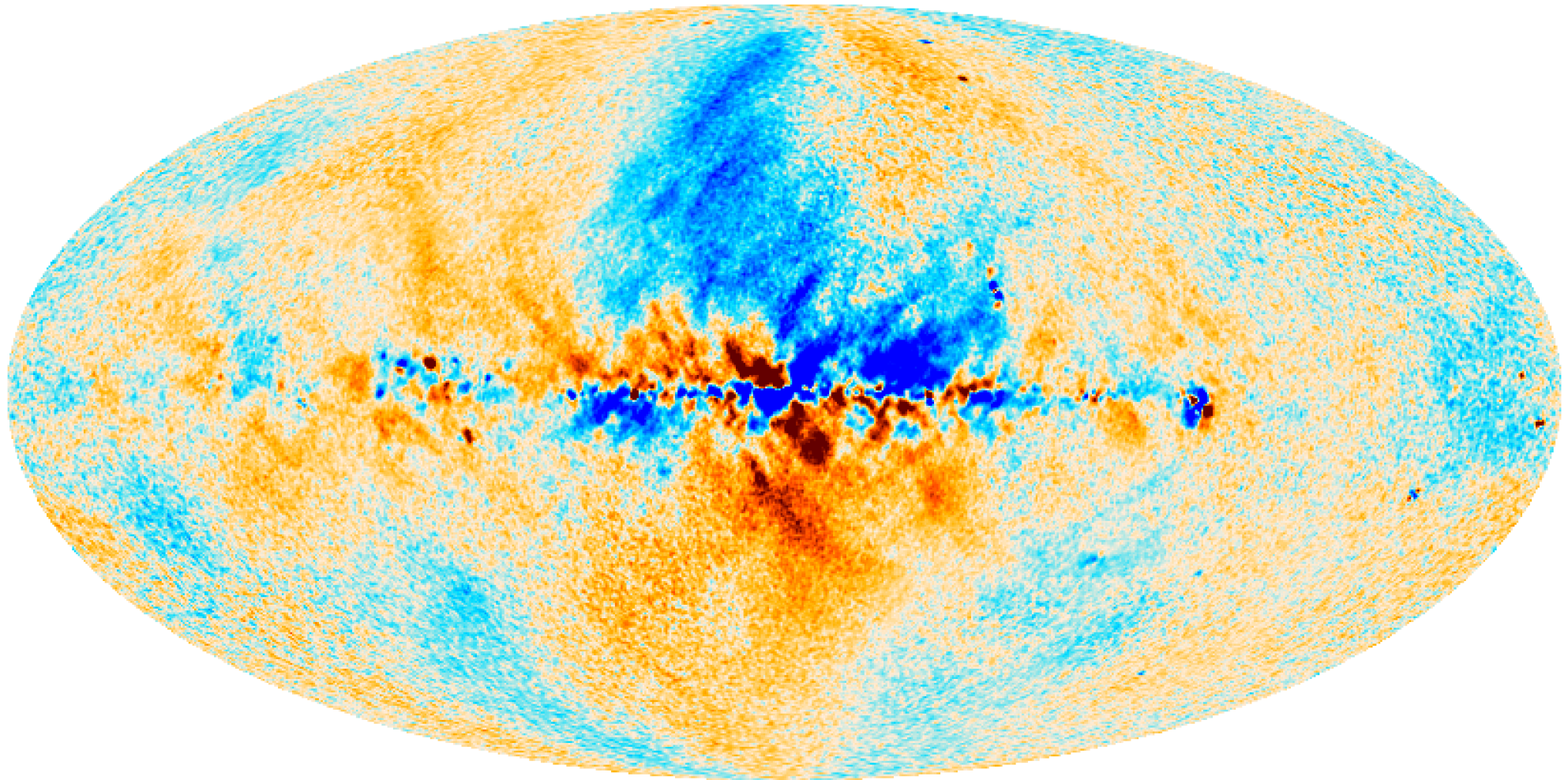
QUIJOTE U H3_11GHz (1deg)

Final 1 deg maps
(scaled to 23 GHz using $\beta=-3.1$)



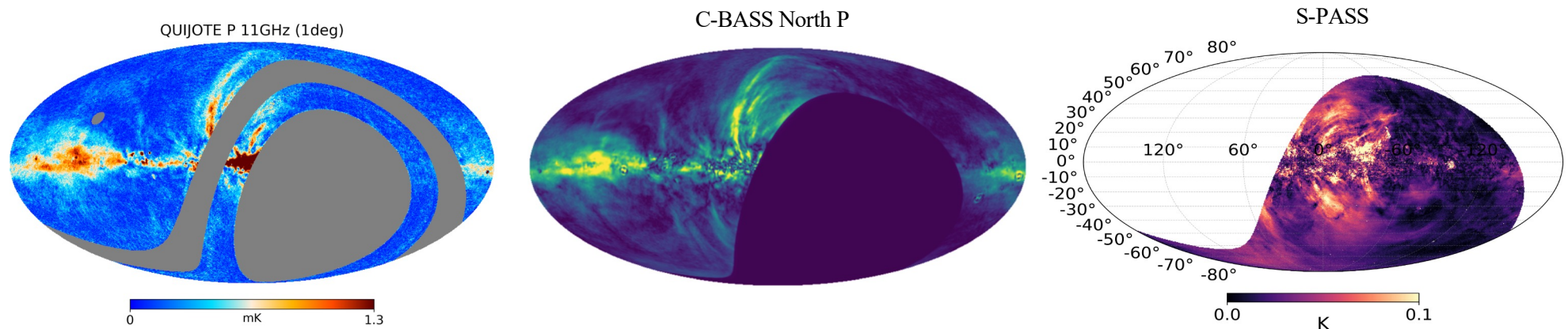
Wide survey with the QUIJOTE MFI (10-20 GHz)

WMAP 23GHz U (1deg)



To provide the best possible characterization of the physical properties of the polarized emissions in the microwave range, by combining Planck (30-857GHz) with **QUIJOTE** (10-40 GHz), **C-BASS** (at 5 GHz) and **S-PASS** (at 2.3 GHz). The resulting analyses will play a key role in preparing and supporting future international CMB experiments.

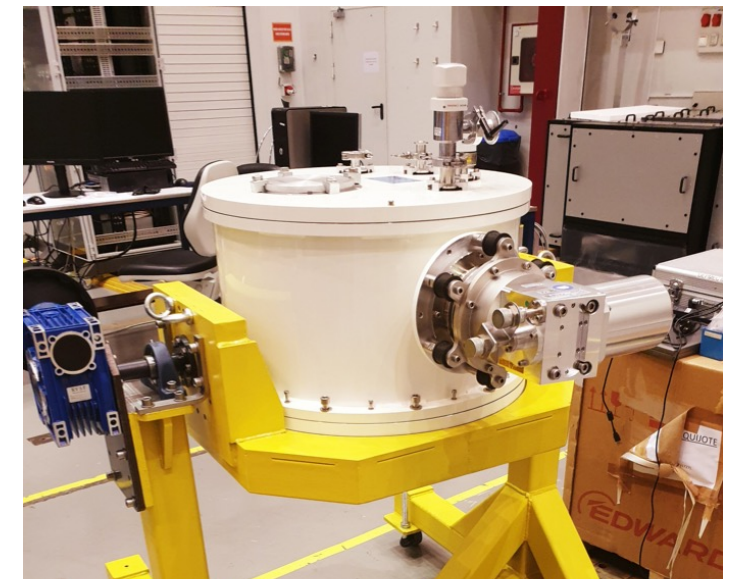
Period: 2024-2026



Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Health and Digital Executive Agency (HaDEA). Neither the European Union nor the granting authority can be held responsible for them.

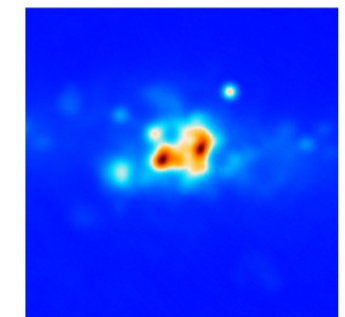
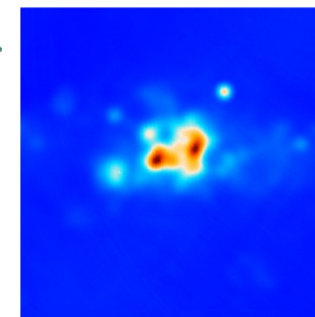
MFI2 Instrument (10-20 GHz)

- ❖ **MFI upgrade (MFI2 @ QT-1)**. Aim: to increase the integration speed of the MFI by a factor 3.
- ❖ **5 horns**. Three covering the 10-14GHz band, and two covering 16-20GHz.
- ❖ **Full digital back-end (FPGAs), heterodyne** → RFI removal (TV sats, Megaconstellations Starlink, OneWeb, Kuiper).
- ❖ **Status**: Installed at QT1. Commissioning with old MFI DAS started March 2024. Sensitivity confirmed! New DAS (FPGA based) ready in lab.
- ❖ **Operations**: 3 effective years.



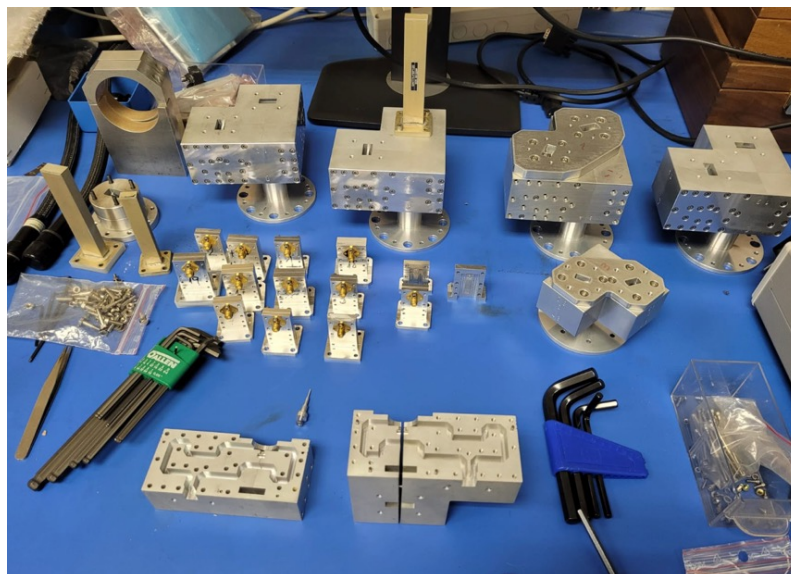
MFI2 11GHz (1000h, horns 1+3)

MFI 11GHz (wide survey, 8500h)

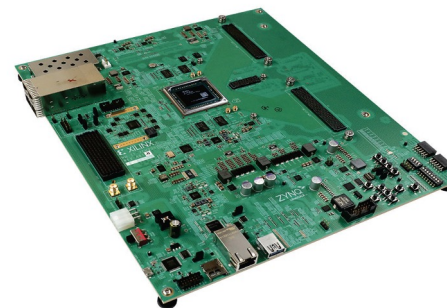


-0 240
00.0, 0.01 μ Jackie

-0 240
00.0, 0.01 μ Jackie



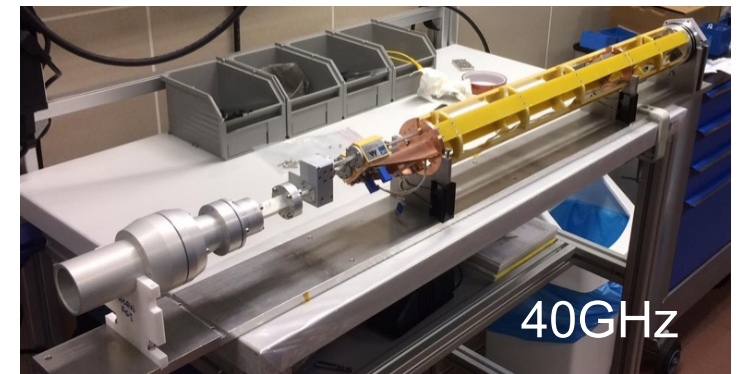
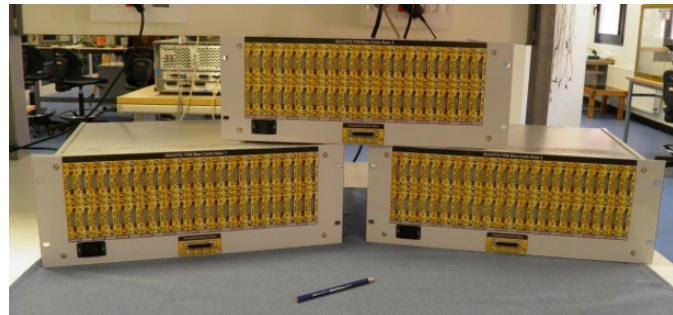
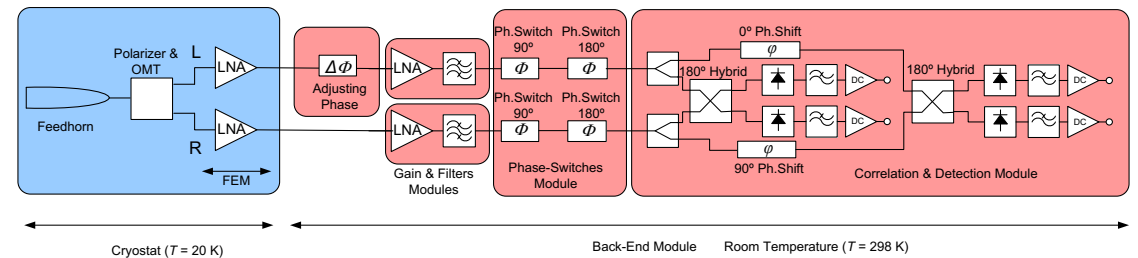
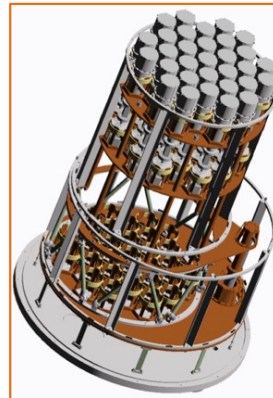
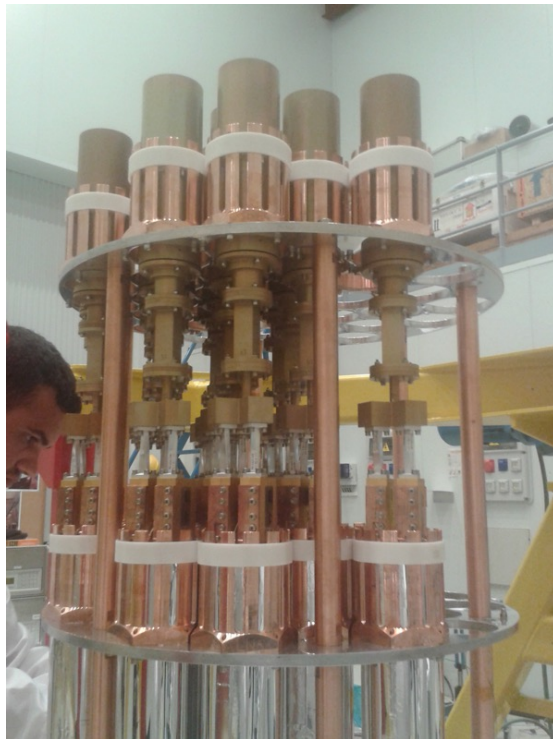
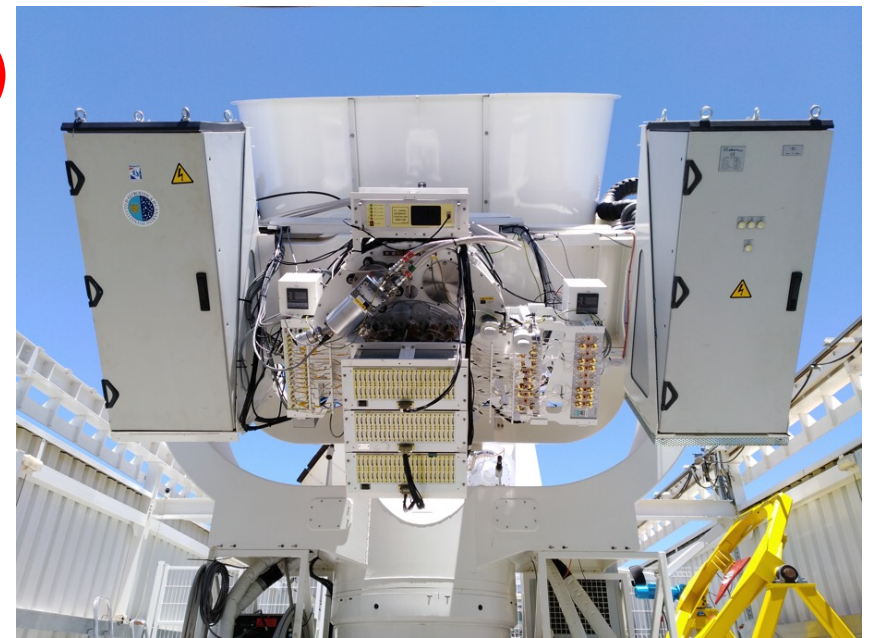
(Hoyland et al. 2022, SPIE)





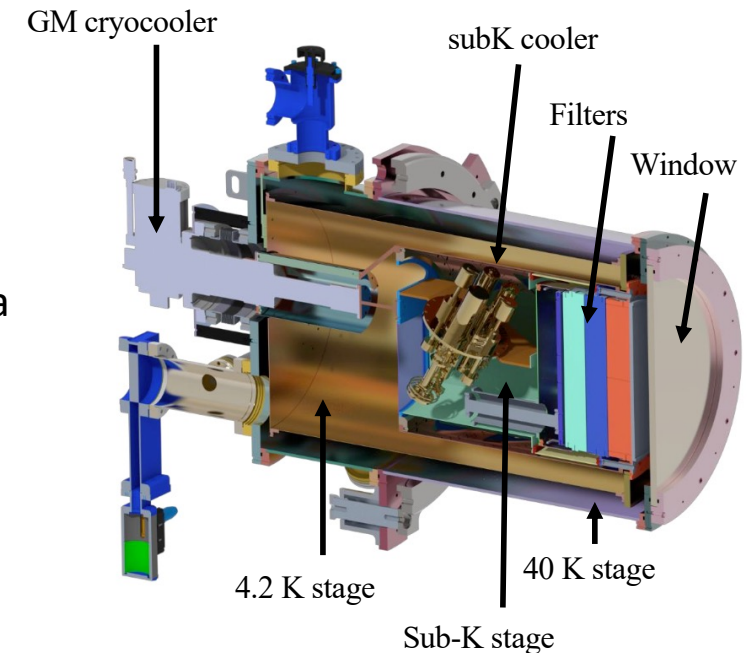
TGI (30 GHz) and FGI (40GHz) instruments @ QT2

- ❖ **TGI:** 31 pixels at 30GHz (20'). Measured sensitivity: $50 \mu\text{K s}^{1/2}$ for the full array. First light May 12th 2016.
- ❖ **FGI:** 31 pixels at 40GHz (18'). Sensitivity: $60 \mu\text{K s}^{1/2}$ for the full array. First observations in 2018-19 (with 14 pixels).
- ❖ **Joint TGI/FGI (TFGI) observations started in 2018.** Stopped during 2020. Problem with the cryostat fixed → Nov2021-Oct2022 with 7 pixels. Now 19 detectors to start observations.



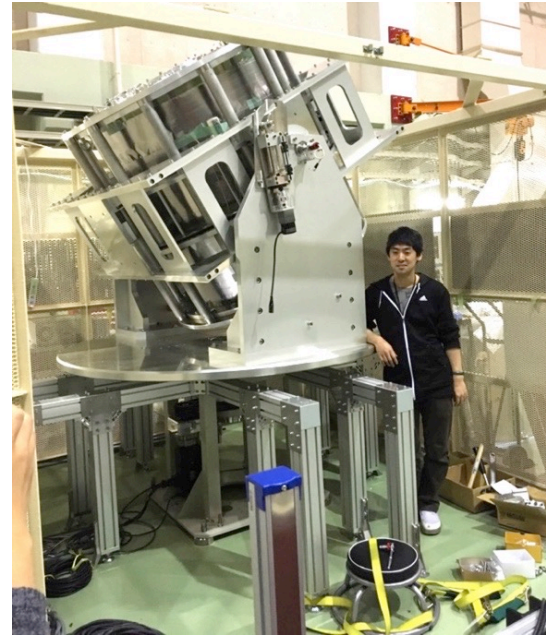
The Ninety GHz Instrument (NGI) for the second QUIJOTE telescope (QT2)

- **90-GHz instrument** for the second QUIJOTE telescope (QT2).
- **Scientific collaboration:** two QUIJOTE nodes (IAC, IFCA), the University of Rome La Sapienza and Kavli IPMU (Tokyo).
- **Baseline design** based on **MISTRAL@SRT** (Paiella et al. 2022)
 - Cryostat: GM cryocooler combined with a multiple stage (He3 and He4) sorption-cooler refrigerator to reach a final temperature of **150 mK**.
 - Polarization modulation unit: \varnothing 60-cm HWP coupled to a rotation unit based on magnetic levitation.
 - Detectors: 703 KIDs with dual polarization at 150 mK, FOV \varnothing 5.2°
 - DAS: room-temperature electronics based on FPGAs.
- **Scientific goals:**
 - Survey of 3,000 deg² down to a sensitivity of 8 μ K·arcmin
 - $\sigma(r) = 0.01$ after combination with QUIJOTE MFI2+TFGI and Planck
- **Status:**
 - Conceptual design finished.
 - Tenders and providers identified for the cryostat and cold structure.

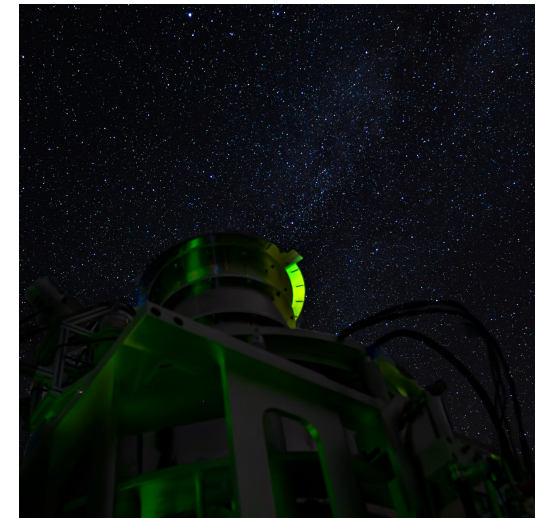
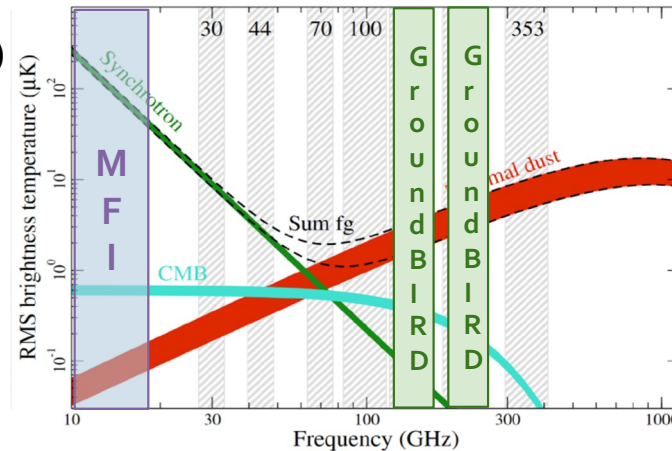


GroundBIRD

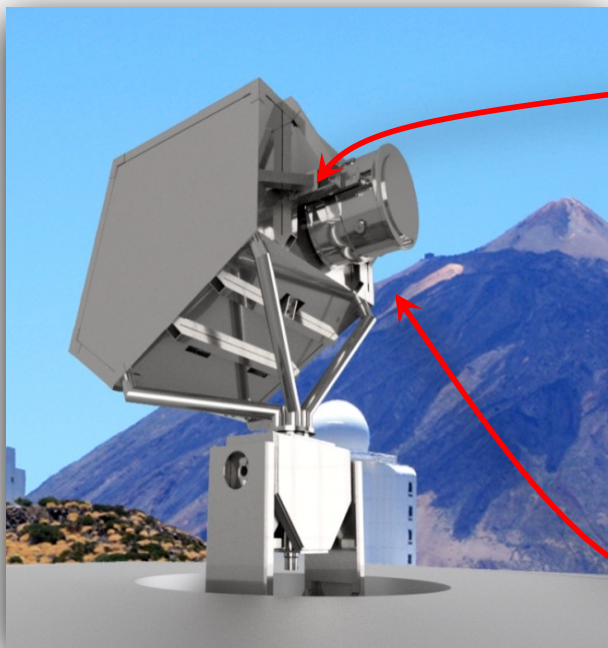
- Installation completed in 2019.
- New set of detectors installed in 2023.
- Location: Teide Observatory
- **Operation plan: 3 years.**
- **Full array: 145 GHz (660 KIDs) and 220 GHz (224 KIDs)**
- **Current array: 145 GHz (144 KIDs) and 220 GHz (24 KIDs).**
- Expected sensitivity: $300 \mu\text{K} \cdot \sqrt{s}/\text{detector}$.



- High-speed rotation scans (20 rpm)
- 20-deg FOV with angular resolution of 0.6 deg @ 145 GHz
- Aims: reionisation and recombination bumps
- Final goal: $r=0.01$.

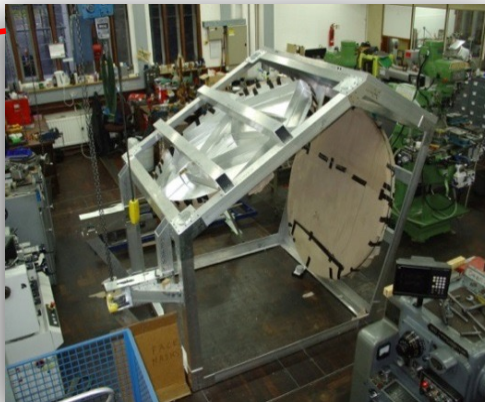


Deployment at Teide Observatory (Tenerife): Spring 2027



LSPE/STRIP

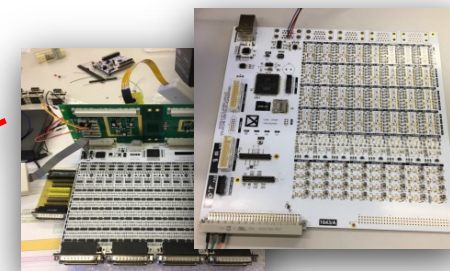
1.5m cross-Dragone telescope



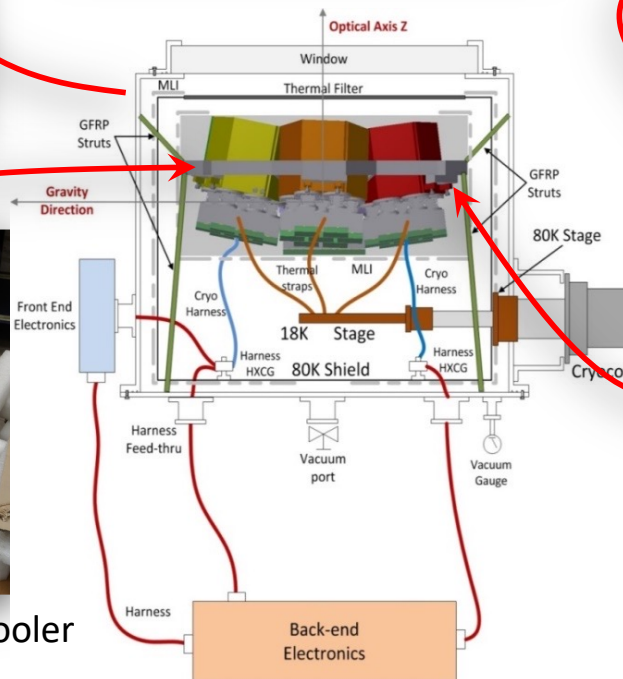
Direct measurement of Q & U, low systematics

Q band: 49-element array, resolution 20', sensitivity 1.5 μ K/deg

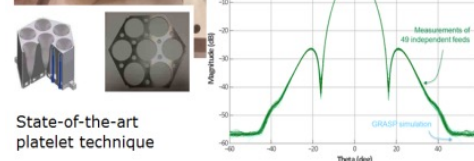
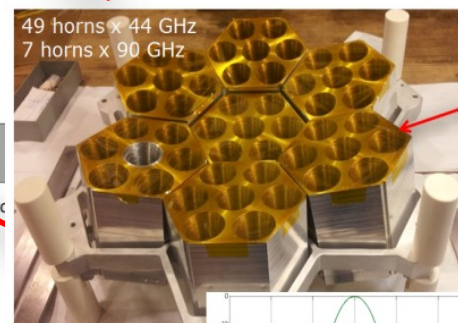
W-band: 6 elements, atmospheric monitor, calibration channel



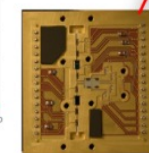
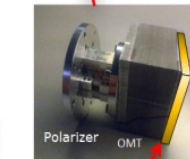
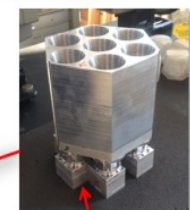
• STRIP Electronics



- High efficiency 2-stage 18-20K cooler
- Intermediate 80-100K shield



State-of-the-art platelet technique



Polarimeter

- STRIP focal plane



Tenerife Microwave Spectrometer

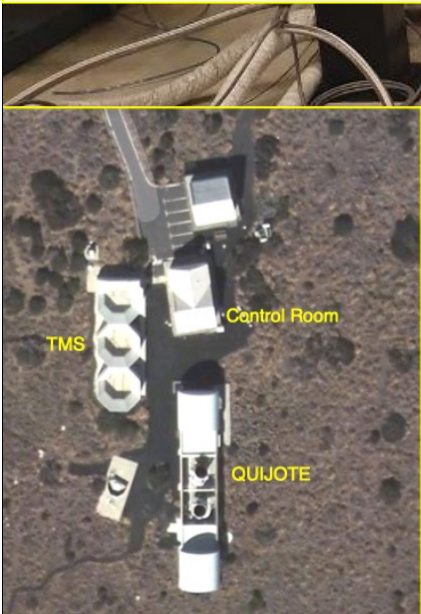
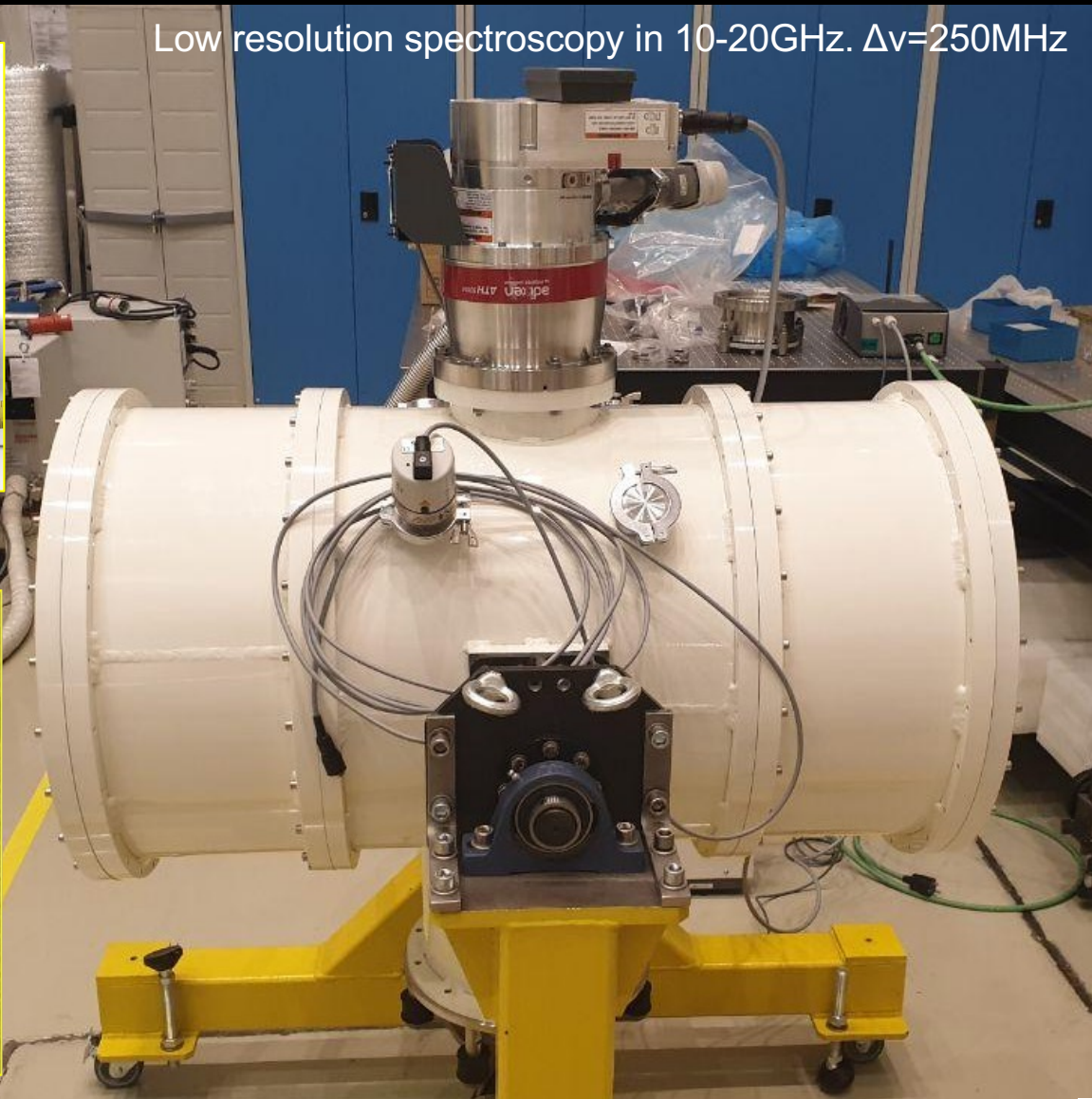
<https://research.iac.es/proyecto/tms/>



Low resolution spectroscopy in 10-20GHz. $\Delta\nu=250\text{MHz}$



Ref. de la ayuda: ICTS-2019-03-IAE-12



Instrumental participation from:



UNIVERSITÀ DEGLI STUDI DI MILANO



Universidad Politécnica de Cartagena

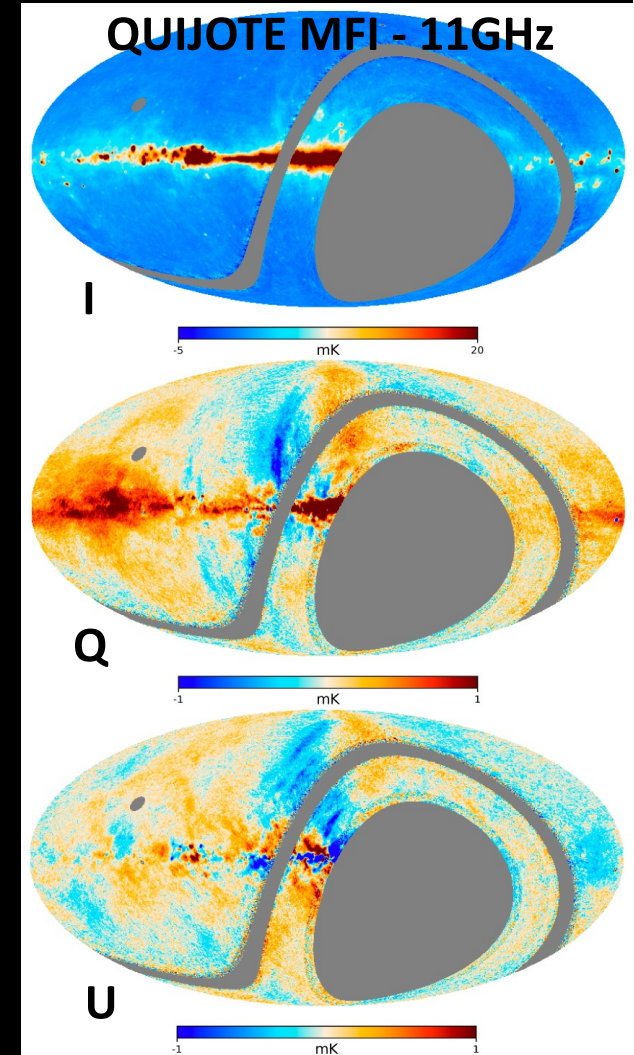




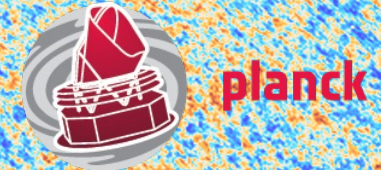
TMS in a nutshell

<https://research.iac.es/proyecto/tms>

- **TMS description:** Ground-based (Teide Observatory), low resolution spectroscopic observations in the 10-20GHz range. Coherent detectors cooled at 4-10K. Internal reference load at ~6K. Digital backend using FPGAs. Starting late 2026.
- **Science drivers:**
 - to characterize foregrounds / CMB spectral distortions down to 10Jy/sr in the 10-20GHz range;
 - to provide absolute calibration for QUIJOTE-MFI.
 - **Radio background** → high discovery potential, with implications for dark matter physics.
- **Prototype for future instruments.** Technology demonstration for FOSSIL (Voyage 2050). Cutting-edge technology:
 - FPGAs
 - Cold load (BB): thermal control & calibration
- **Legacy value.** Complementing future space missions (FOSSIL) in the range 10-20GHz, which is not covered from space.

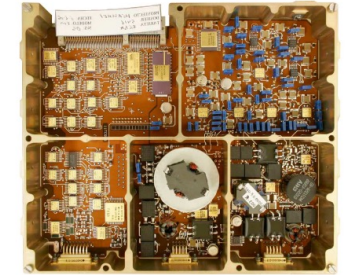


Spain's role within PLANCK (2009-2013)



Instrumental responsibilities

- Radiometer Electronics Box Assembly (REBA) of the LFI, REBA SW and REBA data compression SW: IAC (R. Rebolo, CoI LFI)
- Back end modules for the LFI 30GHz and LFI 44GHz receivers: IFCA, DICOM and Universitat Politècnica de Catalunya. (E. Martinez, CoI LFI; E. Artal technical resp.)
- Pre-charge regulator for the HFI cooler: Univ. de Granada (E. Battaner, CoI HFI).



Scientific responsibilities

- Coordination of the **Non-gaussianity** working group (E. Martínez-Gonzalez)
- Coordination of the **Cluster Science** working group (J.A.Rubiño)
- Coordination of the **Primordial Magnetic Fields** science (E. Battaner)
- Coordination of the **ISW** science (P. Vielva, C. Hernández-Monteagudo)
- Coordination of the **KSZ** group (C. Hernandez-Monteagudo)
- Production of the **point-source catalogues** (Gonzalez-Nuevo, D. Herranz, Lopez-Caniego / Toffolatti)
- Production of the official **CMB maps** (B. Barreiro)
- Management of **PLA** at ESAC (Lopez-Caniego)

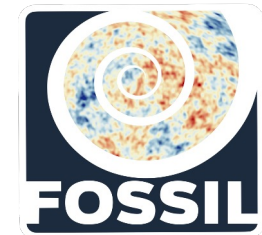


Planck Researchers in: Barcelona, Granada, Madrid, Oviedo, Salamanca, Santander, Tenerife, Teruel, Valencia.



Current IAC technological contributions to space missions

- **LiteBIRD**. Lite (Light) satellite for the study of *B*-mode polarization and Inflation from cosmic background Radiation Detection. JAXA mission, L class, selected May 2019. Now in MDR, to enter JAXA phase A. Launch 2030s.
- **FOSSIL**. Proposal in response to ESA-M8 call (PI: Nabila Aghanim). Now in phase 2 of selection process.



In both cases: **Temperature Monitoring and Control System (TMCS)**.

In connection to FOSSIL: readout electronics for low-frequency KIDs (collaboration with Grenoble & CAB) \leftrightarrow KIDsNET (see presentation by Victor Rollano).



The FPGA group at the IAC

Established in 2023 (within the Electronics Department at IAC).

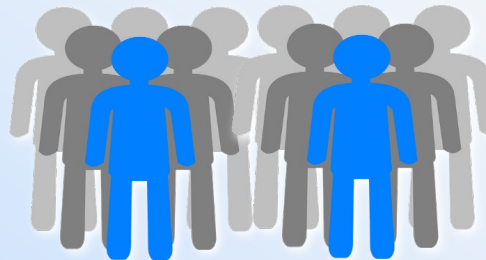
Activities: design, implementation, and validation of embedded real-time signal acquisition and processing systems, primarily applied to radio astronomy (coherent detectors) and high-speed scientific detectors (KIDs).

Readout platforms based on AMD **RFSoc devices**, leveraging the monolithic integration of high-speed ADC/DAC converters, FPGA programmable logic, and multicore ARM subsystems within a single heterogeneous platform.

Roger Hoyland
QUIJOTE Project
System design

David Díaz
QUIJOTE/TMS projects
MKID Readout thesis
supervision

Alberto Hernández
MKID readout thesis
- photon detection
- CMB radiation 100GHz



FPGA GROUP

David Hernández
Space Project
FPGA:Vigil PMI
Stratospheric Balloon:
Sunrise

José Javier Díaz
LiteBIRD. FOSSIL.
MKIDS laboratory

IACTEC
Commercial
applications





FPGA technology (ZCU111 + ZCU208, RFSoc4x2)

5 x

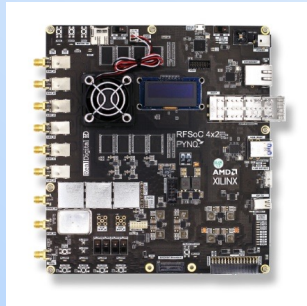


(177.5k€)

7 x



1 x



Zynq UltraScale+ RFSocZCU111

- Onboard ADC Sample rate: 4GSPS (máximo: 2GHz bandwidth)
- Channels: 8 x 12 bits ADC
- FPGA: Gen 1 with Arm® Cortex®-A53 supporting ZYNC interface

Zynq UltraScale+ RFSocZCU208

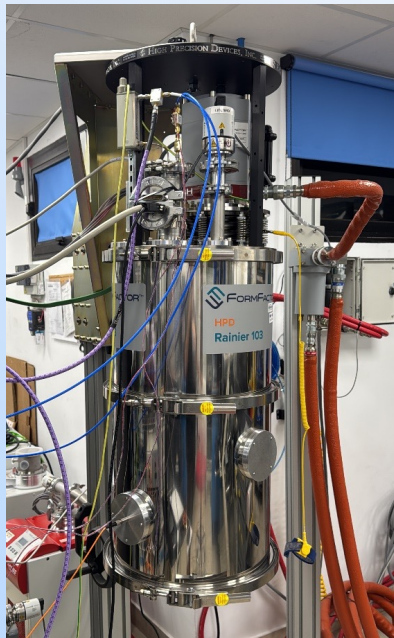
- Onboard ADC Sample rate: 5GSPS (máximo: 2.5GHz bandwidth)
- Channels: 8 x 14 bits ADC
- FPGA: Gen 3 with Arm® Cortex®-A53 supporting ZYNC interface

Zynq UltraScale+ RFSoc 4x2

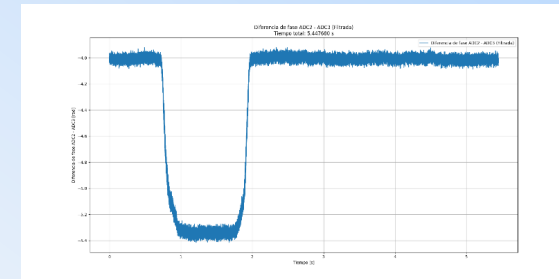
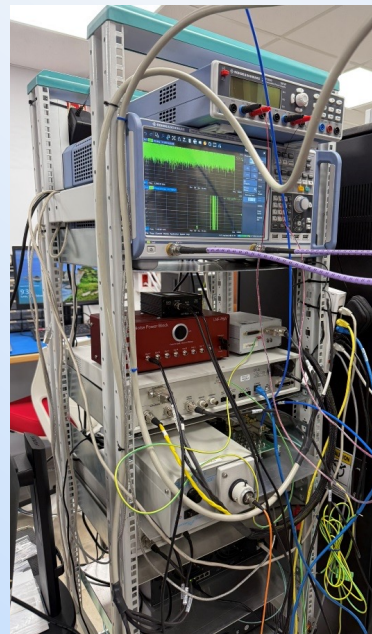
- Onboard ADC Sample rate: 5GSPS (máximo: 2.5GHz bandwidth)
- Channels: 4 x 14 bits ADC
- FPGA: Gen 3 with Arm® Cortex®-A53 supporting ZYNC interface



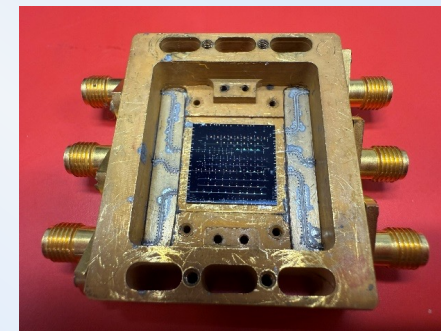
Equipment: ADR cooler, MKIDs Laboratory



100mK ADR cooler



FPGA phase measurement

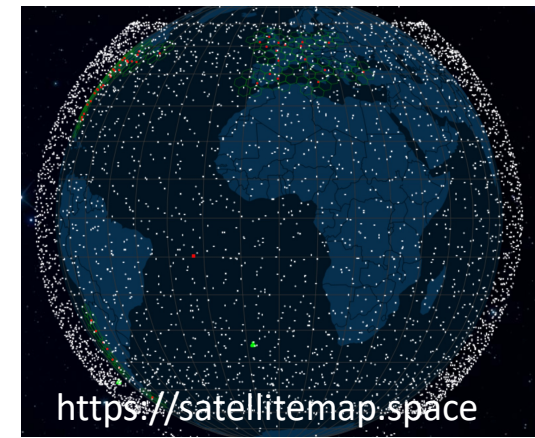


<100 array Optical MKIDs for Photon detection (Dublin Institute for Advanced Studies)

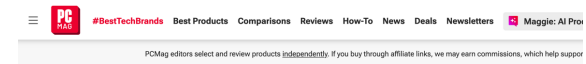


QUIJOTE MFI2 instrument – RFI

- ❖ **RFI contamination:** Significant impact of NGSO megaconstellations at 10.7-12.7GHz (Starlink, OneWeb). New geostationary satellites in the high frequency bands (17GHz).
- ❖ **RFI its getting worse** (19GHz; Terawave: 37.5–42 GHz; W band for automotive radars; Starlink plans 71-76 and 81-86GHz). Thermal emission (e.g. Foster+25 SPT).
- ❖ **Digital DAS are needed at these MFI2 frequencies!**

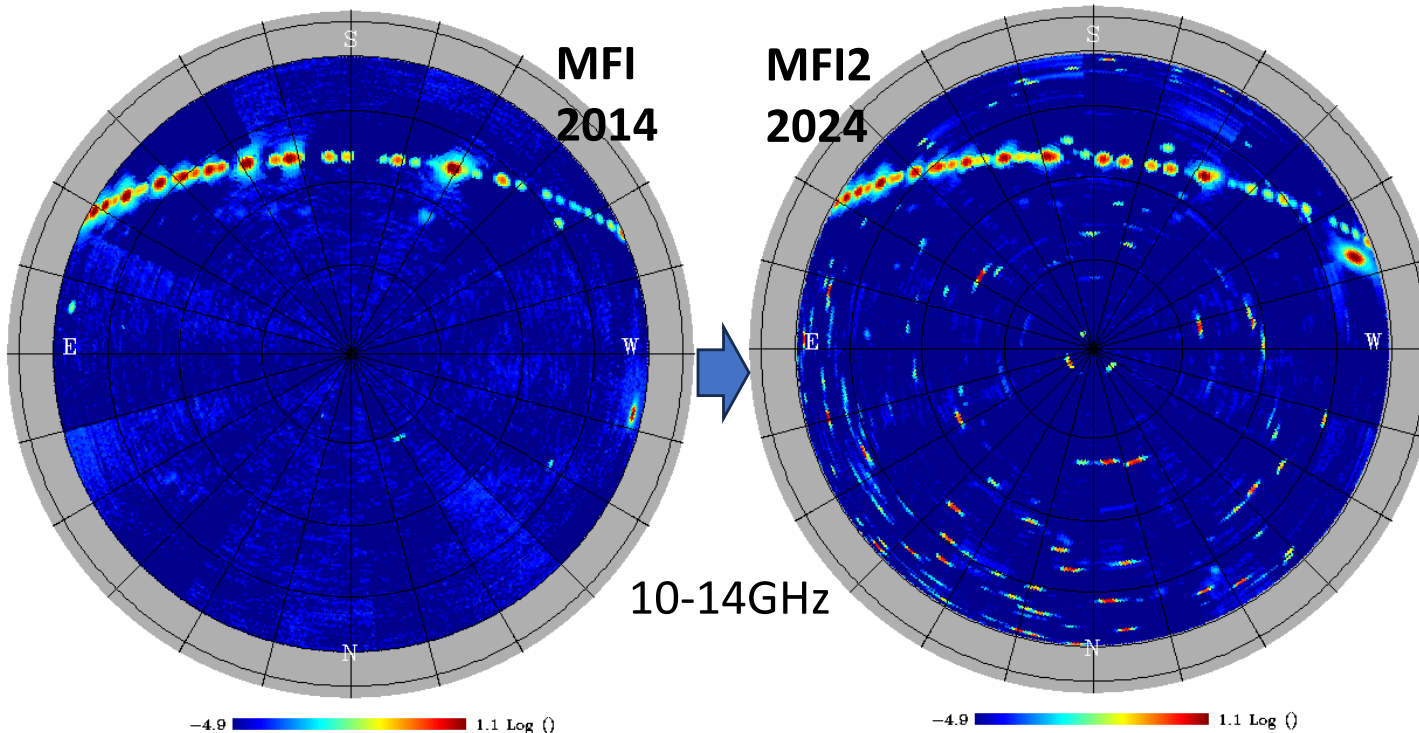


17.3-17.7 GHz



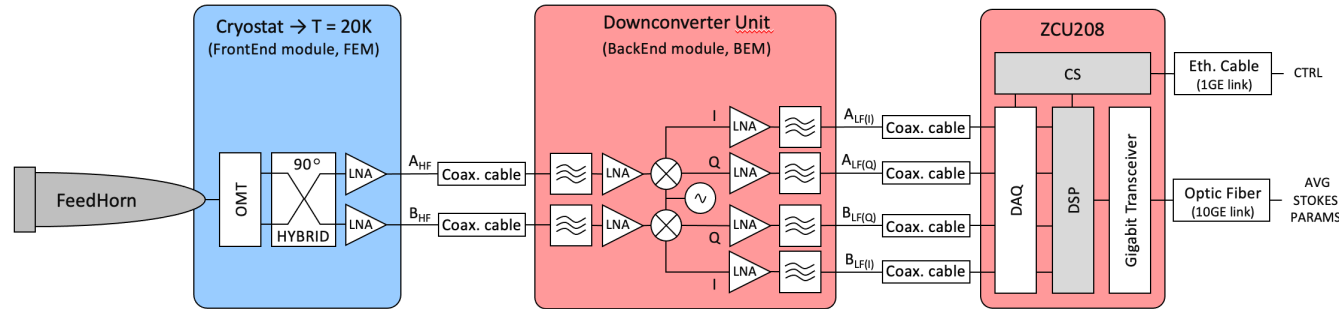
18.8-19.3 GHz

(Peel et al. 2025)

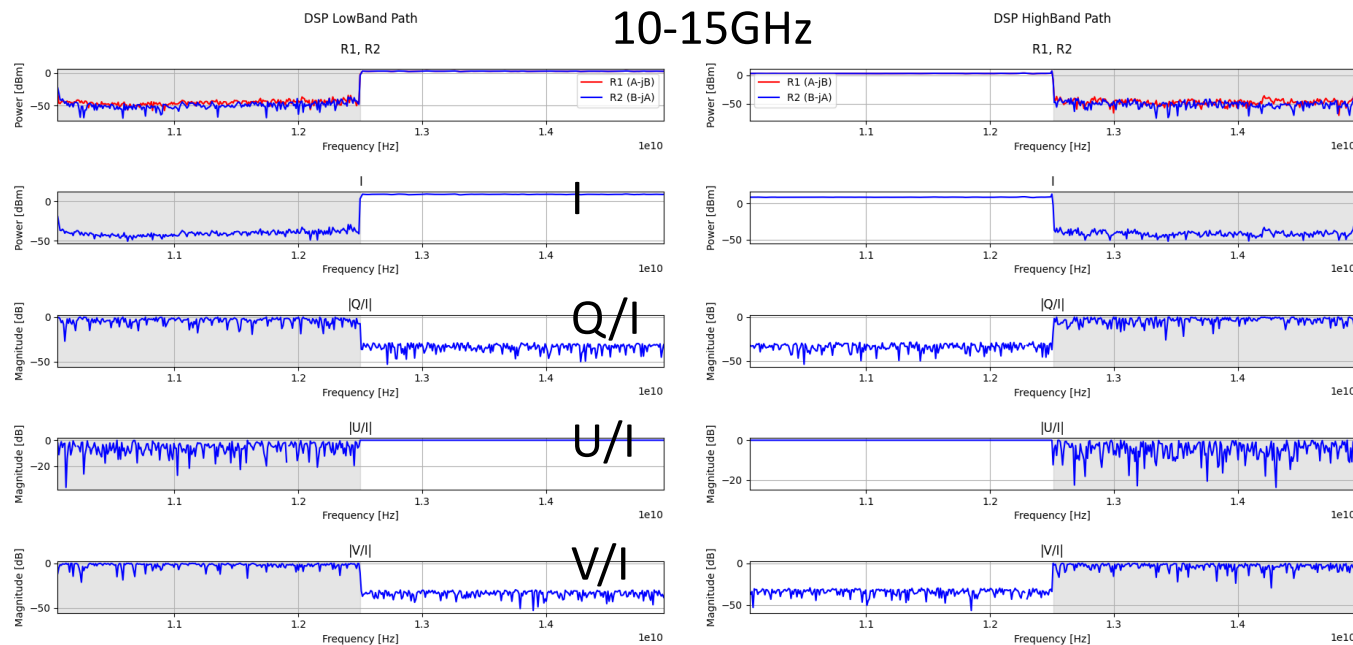


Satellites	Use	Frequencies
Starlink	DTC downlink	1.190–1.995 GHz
	User downlink	10.7–12.7 GHz
	Gateway downlink	17.8–18.6 GHz
	Gateway downlink	18.8–19.3 GHz
	Gateway downlink	19.7–20.2 GHz
	User downlink	37.5–42.5 GHz
OneWeb	Gateway downlink	37.5–37.75 GHz
	User downlink	10.7–12.7 GHz
	Gateway downlink	17.8–18.6 GHz
Amazon Kuiper	Gateway downlink	18.8–19.3 GHz
	User/GW downlink	17.7–18.6 GHz
	User/GW downlink	18.8–19.3 GHz
	User/GW downlink	19.3–19.4 GHz
	User/GW downlink	19.7–20.2 GHz
	User/GW downlink	19.7–20.2 GHz

QUIJOTE MFI2 instrument – digital DAS (FPGAs)



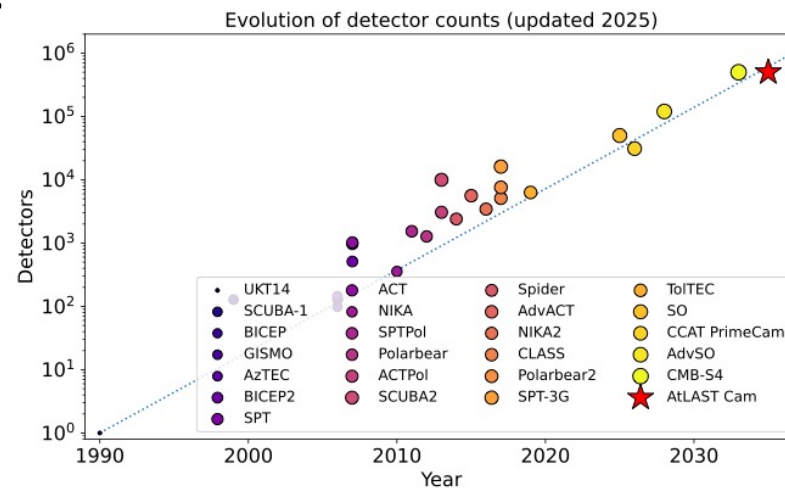
- MFI2 electronic box fully integrated (Xilinx ZCU208). Now testing.
- Calibration (amplitude and phase). Removal of “systematics”.



Science cases & synergies with AtLAST.

Themes of interest (IAC CMB group).

- **LIM** signal and cosmic reionization (**CO** \leftrightarrow **TMS**)
- **SZ effect.**
 - SZ diffuse: cosmic web. Blind searches of high-redshift clusters. Galaxy cluster science.
 - kSZ: reionization, velocity reconstruction.
 - **bSZ: blurring SZ effect.**
- **Anomalous microwave emission (AME).**
 - High angular resolution in our galaxy. Carriers.
 - AME in other galaxies.
- Mapping synchrotron at low frequencies with comparable resolution to SO LATs at 150GHz.





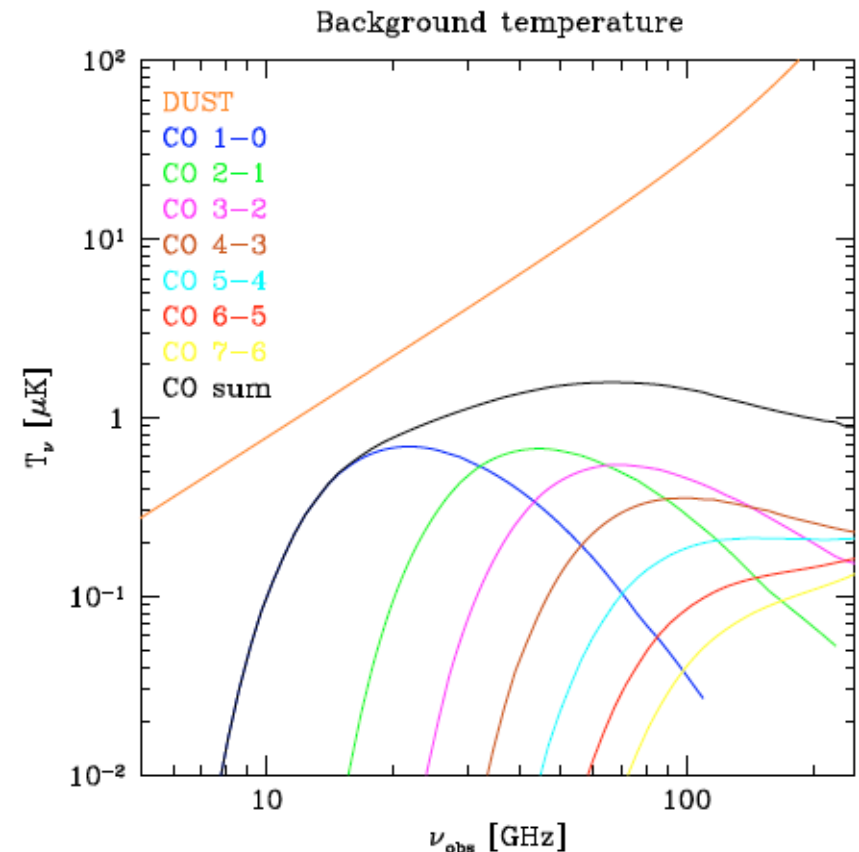
TMS science goals.

CO line at high redshifts. Collisionally induced emission of the carbon monoxide molecule. Main transition is $J=1 \rightarrow J=0$ at 115 GHz. **Extending COMAP science case at 26-36GHz.**

Righi et al. (2008) provided the first estimates of the average intensity and angular fluctuations associated to these rotational transitions of the CO molecule across cosmological history.

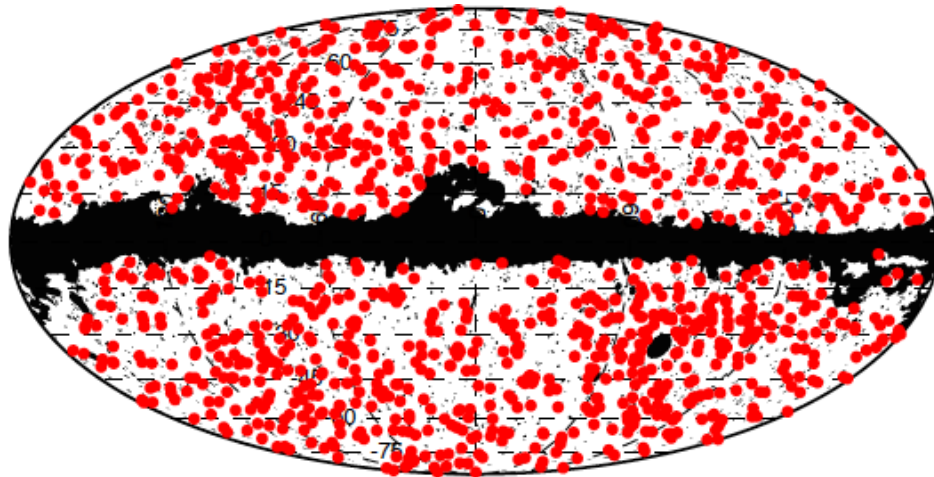
CO radio emission creates an average intensity just below the average brightness of the CMB. The corresponding anisotropies associated to CO transitions (and to any other line) should have a strong bandwidth dependence.

The combination of broad band data from other experiments (**QUIJOTE**) and the narrow-band observations from **TMS** opens the way to **constrain the presence of CO during the end of the epoch of cosmic reionization ($z \sim 9$).**

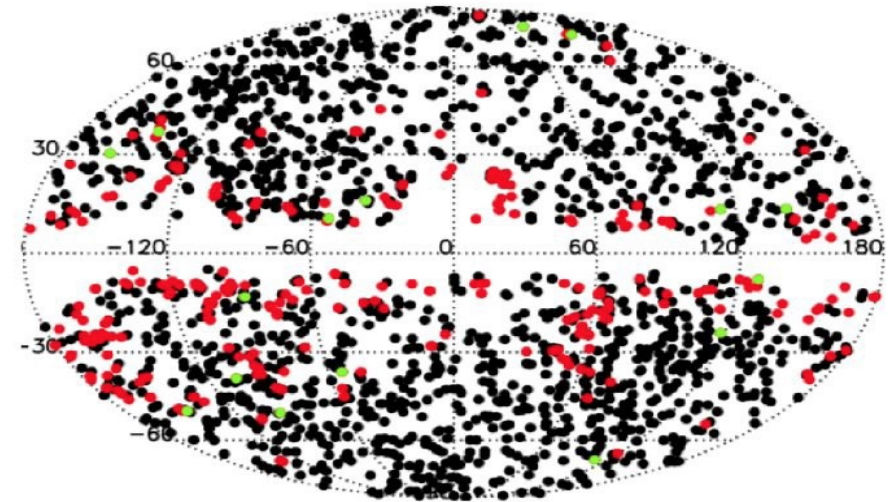


Righi, Hernández-Monteagudo & Sunyaev (2008)

Planck cluster catalogues (PSZ1 & PSZ2)



PSZ1 (Planck Collaboration XXIX 2014)



PSZ2 (Planck Collaboration XXVII 2016)

Sample	PSZ1 2013	PSZ1 2015	PSZ2	Common	New PSZ2
Union	1227	1227	1653	937	716
Intersection	546	546	827	502	325
Confirmed	861	947	1203	820	383
Candidates	366	292	546	99	447
Low reliability	142	131	143	39	104

Optical follow-up @IAC (Planck Collaboration XXXVI 2016; Aguado+2019, 2022; Barrena+2018, 2020; Streblyanska+2019; Ferragamo+2020, 2021). → WEAVE Cluster survey.

- ITP 13B-15A: **>80 nights** observing time at GTC, INT, TNG and WHT.
- LP 15B-17A. **>40 nights** with INT, TNG and GTC telescopes.

221 confirmed. Spectroscopy for 182 targets (>10,000 individual spectra). 180 non-detections.

SZ effect.

tSZ – Cluster physics.

rtSZ – temperatures.

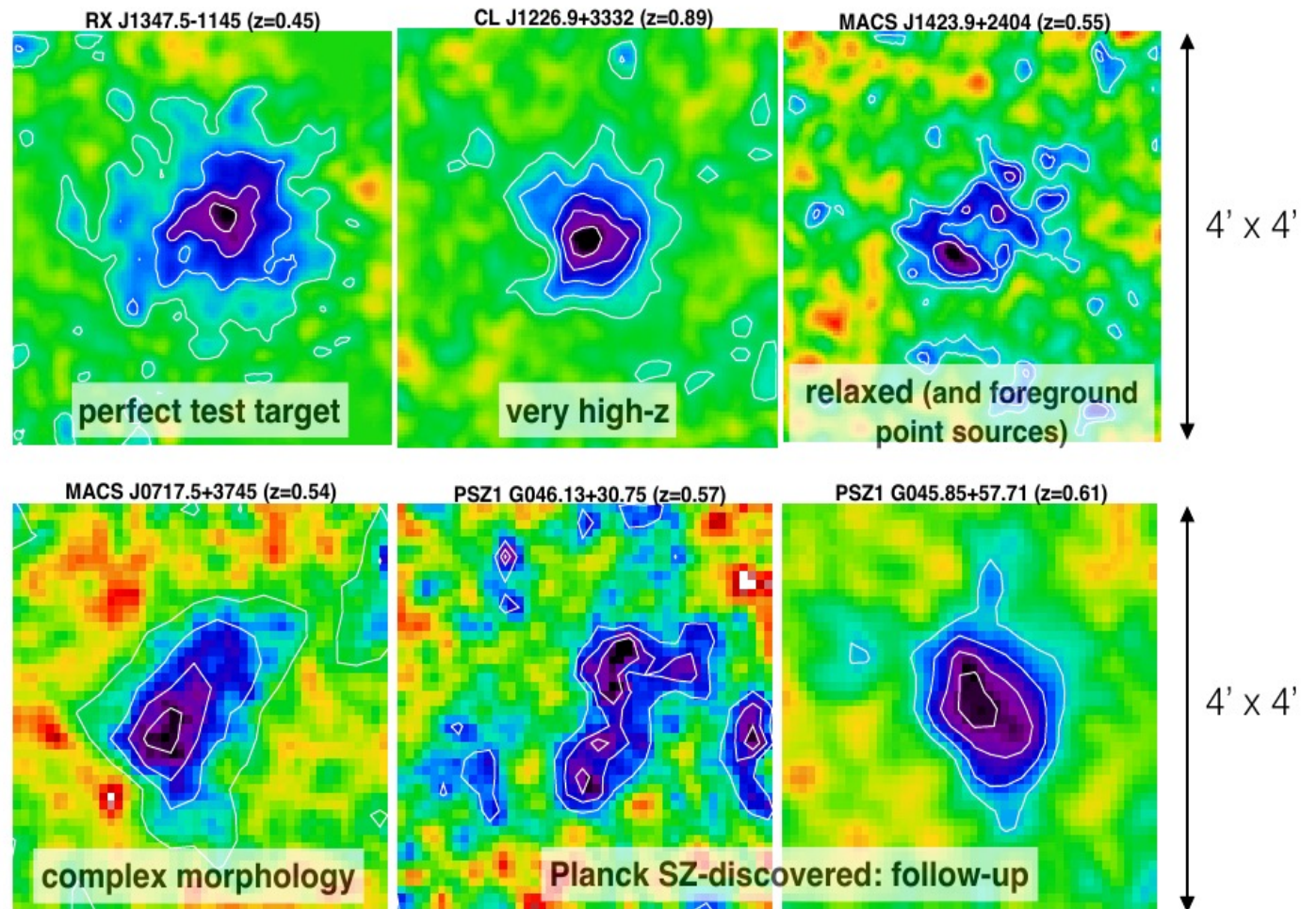
kSZ – velocities

bSZ

Synergies with:

NIKA, NIKA2 @ IRAM

CONCERTO @ APEX

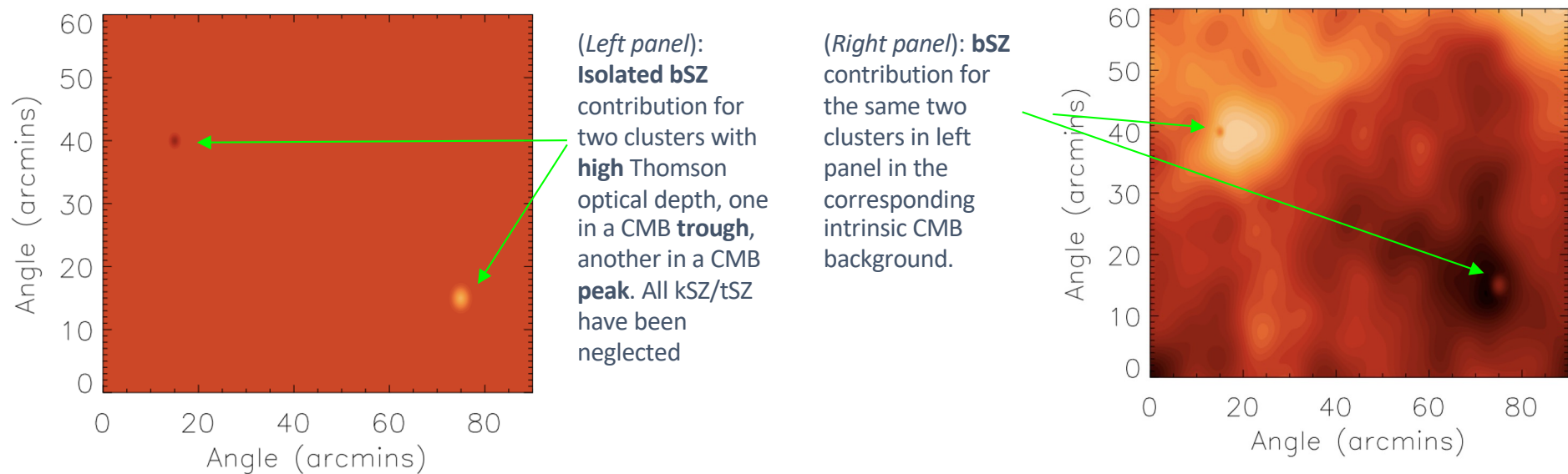


[Adam & NIKA collaboration, 2014, 2015, 2016, 2017

Ruppin & NIKA collaboration 2017, Romero & NIKA collaboration 2017]

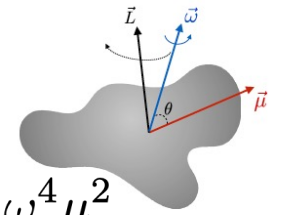
Detecting the blurring Sunyaev-Zeldovich effect (bSZ)

- The **blurring SZ effect (bSZ)** describes the **smearing/blurring** of intrinsic CMB anisotropies via **Thomson scattering** in **intervening free electron screens**, that could be present in **galaxy groups and clusters** (Hernández-Monteagudo & Sunyaev, 2010). The bSZ has the **opposite sign** of the intrinsic CMB: $-\tau_T \delta T_{\text{CMB}}$
- While it has been detected **statistically** at $\sim 4.1\sigma$ (Hadzhiyska, Sailer & Ferraro 2025), it has not yet been detected individually, in an object by object basis.
- **AtLasT** would count with the **required angular resolution** to detect this effect, and map the electron density of the groups and clusters against the intrinsic CMB foreground



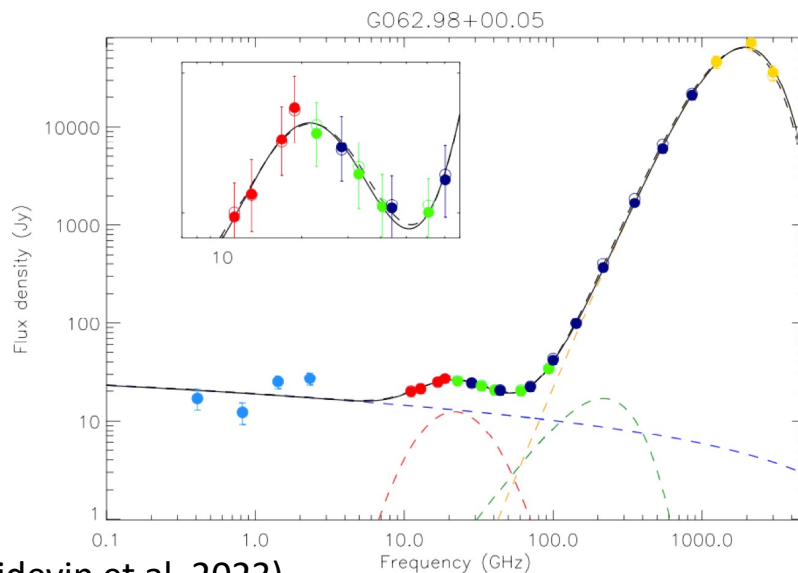
Figures from Hernández-Monteagudo & Sunyaev 2010

QUIJOTE results: modelling the Anomalous Microwave Emission

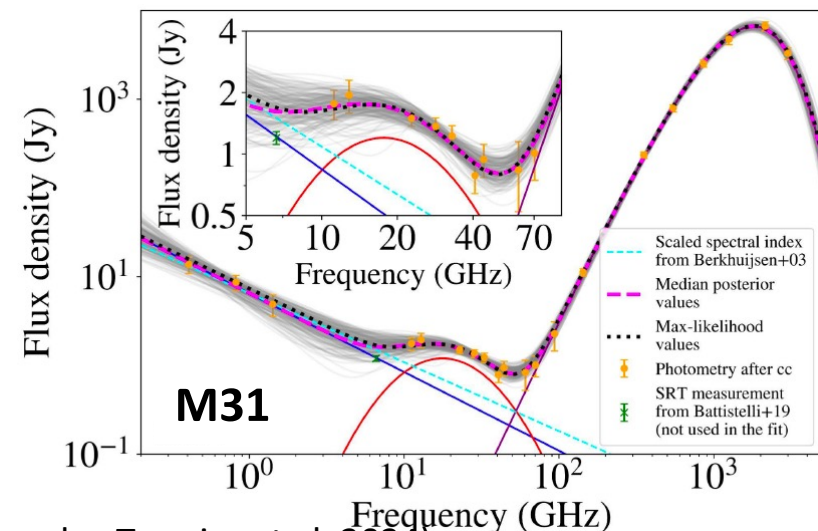


$$P \propto \omega^4 \mu^2$$

- **AME:** excess emission over free-free, dust and synchrotron in microwaves; spatially correlated with thermal dust. Origin unknown. Probably spinning dust VSG (PAHs, ...). Polarization information is key.
- **QUIJOTE results in Galactic compact regions.**
 - **Genova-Santos+2015,2017:** Perseus, W43, W44, W47. **Poidevin+2019:** TMC.
 - **Poidevin+2023:** Study of 56 compact AME sources (PIR XV 2014).
 - **Tramonte+2023; López-Caraballo+2024:** W49, W51, CTB80, HB21, Cygnus Loop, CTA1, Tycho, HB9.
 - **Cepeda-Arroita+2026.** 144 regions. Most complete study (QUIJOTE+CBASS+SPASS).
- **QUIJOTE results for AME diffuse emission in the Galactic plane ($|b| < 10^\circ$).**
 - **Fernández-Torreiro+2023.** Spatial variability v_{AME} . Correlation AME emissivity vs ISRF.
- **M31.** **Fernández-Torreiro+2024.** AME detected at 3.5σ . Consistent with SRT (Battistelli+19).
- **Polarization constraints at 1 deg scales:**
 - Apparently unpolarized. Best upper limits in W44 ($< 0.4\%$ at 17GHz from QUIJOTE, and $< 0.22\%$ at 41GHz from WMAP). **Génova-Santos+2017; González-González+2025.**



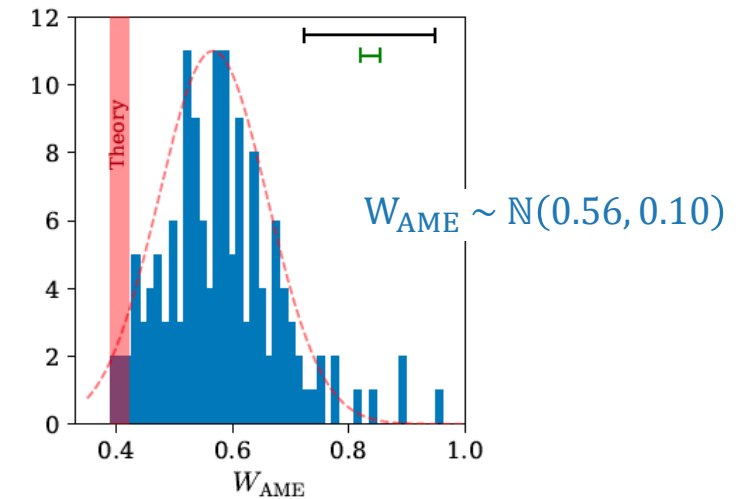
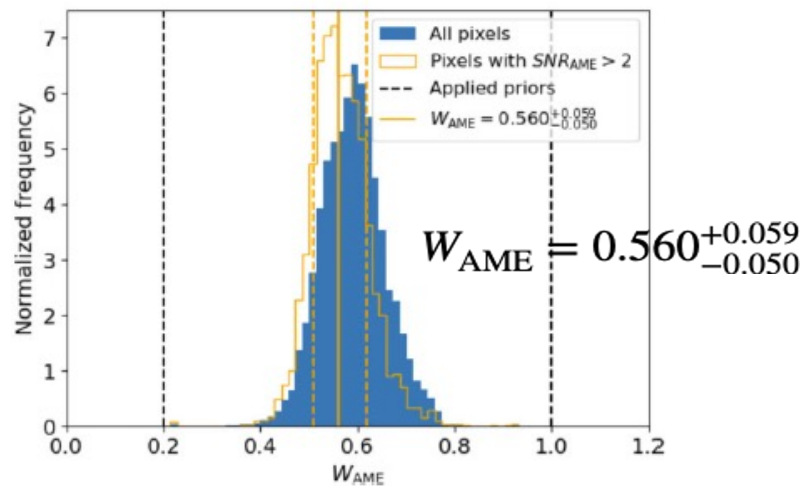
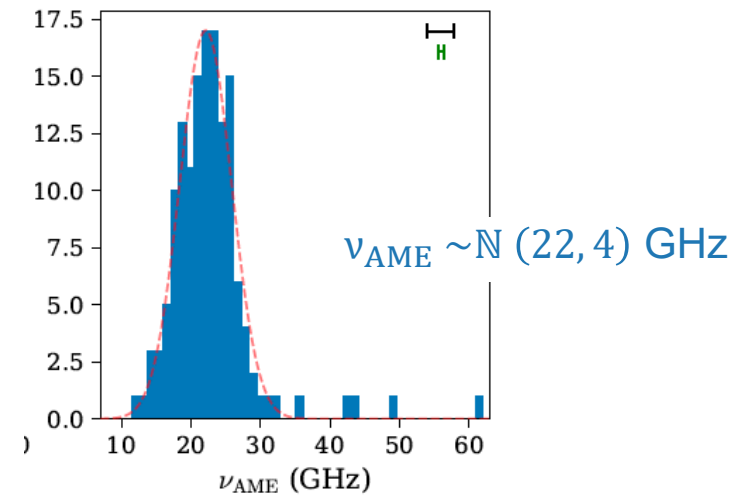
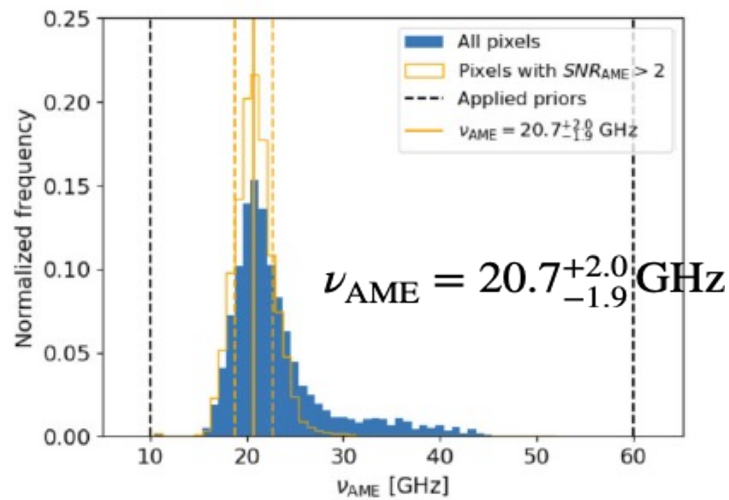
(Poidevin et al. 2023)



(Fernandez-Torreiro et al. 2024)

AME SED parameters

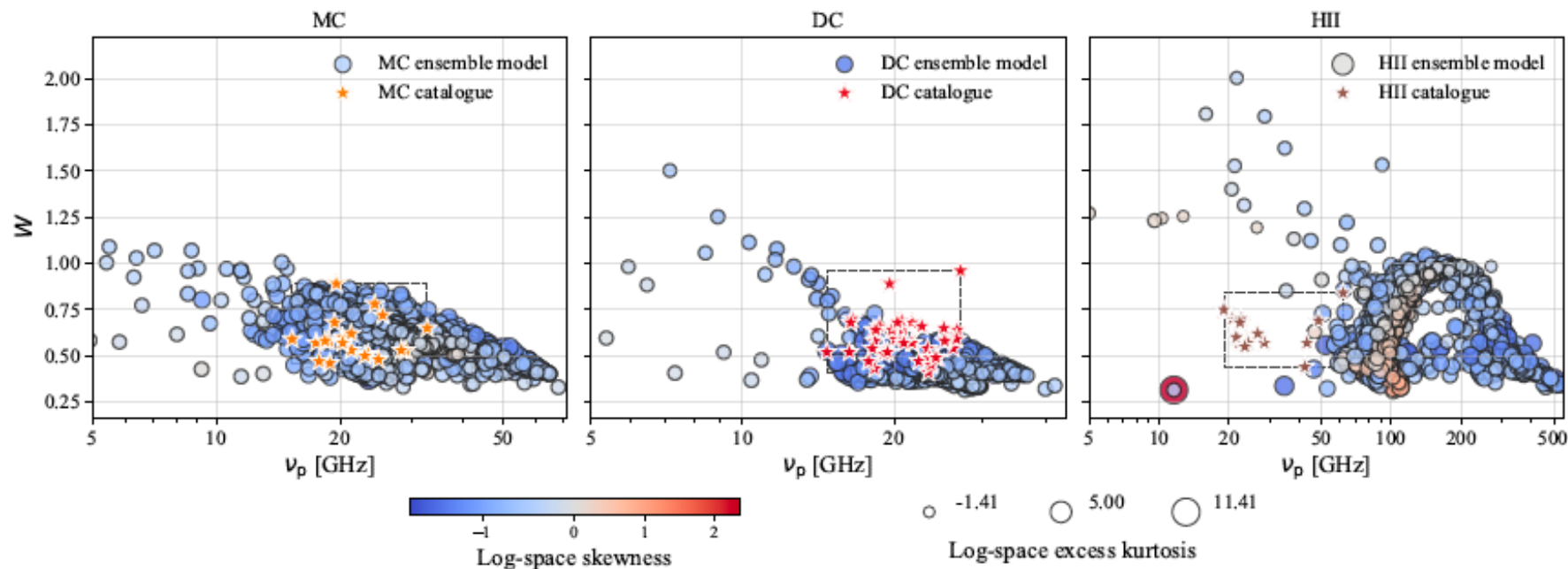
$$S_{\text{AME}} = A_{\text{AME}} \cdot \exp\left(-\frac{1}{2} \cdot \left(\frac{\ln(\nu/\nu_{\text{AME}})}{W_{\text{AME}}}\right)^2\right)$$



Diffuse AME in galactic plane
(Fernandez-Torreiro et al. 2023).

AME in Galactic compact regions
(Cepeda-Arroita et al. 2026)

$$S_{AME} = A_{AME} \cdot \exp\left(-\frac{1}{2} \cdot \left(\frac{\ln(\nu/\nu_{AME})}{W_{AME}}\right)^2\right)$$



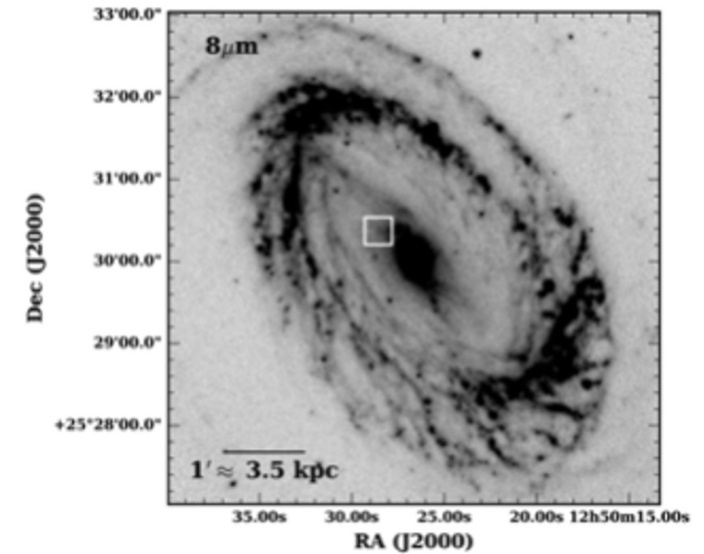
- **Single-Phase ISM SpyDust models can not reproduce the observed AME widths.**
- 3 key parameters in SpyDust.
 - Grain size $\rightarrow \nu_{AME}$
 - Grain shape $\rightarrow W_{AME}$
 - Carbon/hydrogen abundance (region dependent)
- **Ensemble models** can capture the observed widths for MC and DC. Discrepancy in HII regions \rightarrow high-angular resolution observations needed. Range 10-20GHz. (Zhang, Chluba, Cepeda-Arroita & RM 2026).

Extragalactic AME.

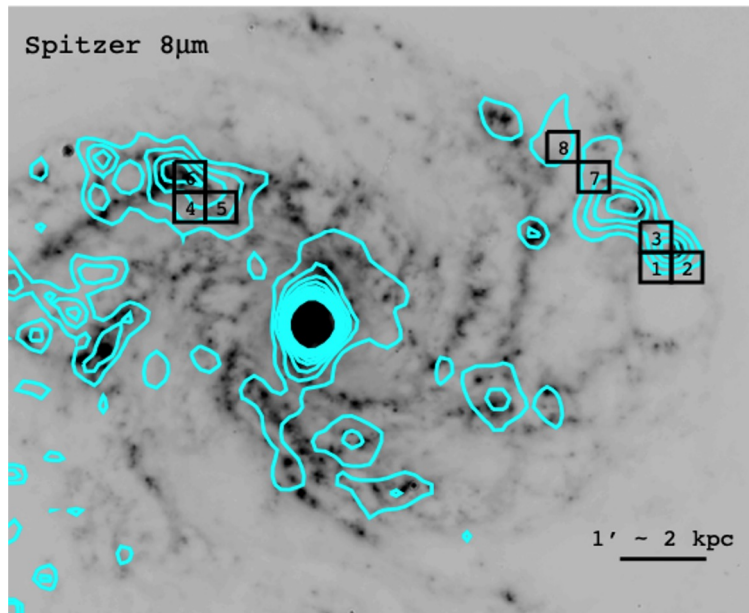
Linden et al. (2020, ApJS, 248, 25).

3, 15, 33GHz - spectrum modelling, found 33 regions with increasing 15-33GHz emission, in 9 galaxies (2403, 3627, 4254, 4631, 4725, 5194, 5457, 6946, 7793)

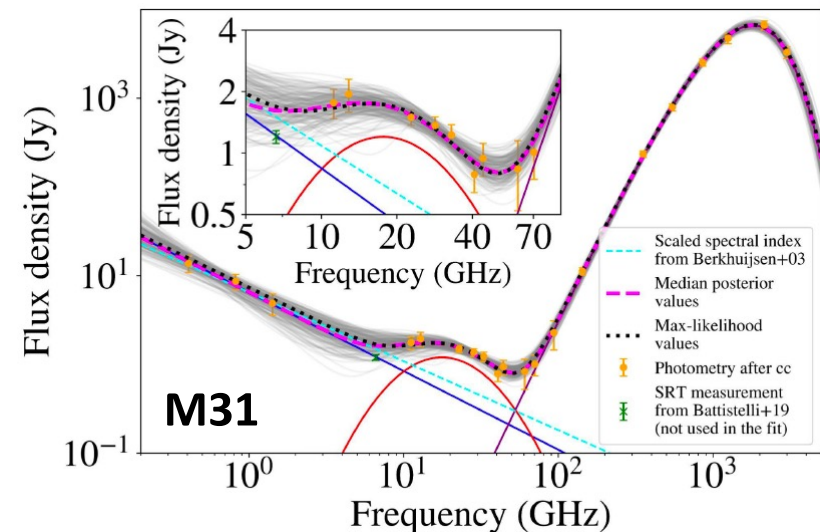
Bot et al. (2010) found submm excess in SMC, followed up with Planck Collaboration Early results XVII (2011)



Murphy et al. (2018, ApJ, 862, 20). NGC 4725.



Murphy et al. (2010, ApJL, 709, L108) used GBT @ 33GHz to observe 10 star-forming regions in NGC 6946.



Planck Collaboration XXV (2015), A&A, 582, A28.
Battistelli et al. (2019, ApJL, 877, L31)
Fernández-Torreiro et al. 2024.
Harper et al 2024.

Summary & Outlook



QUIJOTE:

- QT1 + MFI (10-20 GHz): 2012-2018. De-commissioned.
- QT1 + MFI2 (10-20 GHz): 2024-2029.
- QT2 + TGI (30 GHz) and FGI (40 GHz): 2018-2028.
- QT2 + NGI (90GHz): 2028-. Now in construction phase.

TMS:

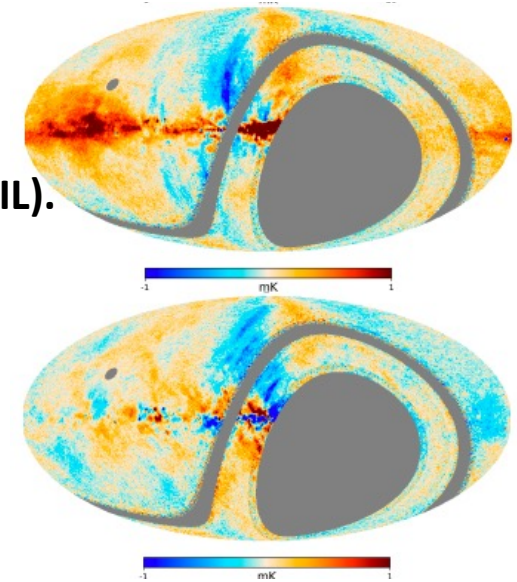
- Radio Synchrotron Background (ARCADE2) excess. CO.
- Instrument design, data analysis pipelines for SD experiments (FOSSIL).

Others:

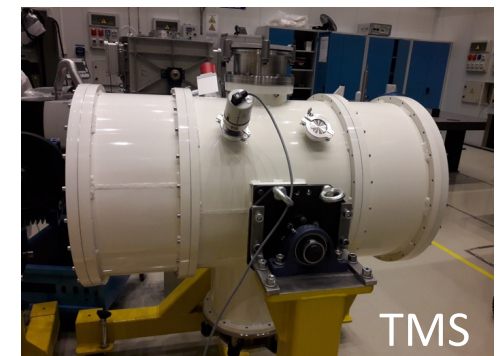
- Groundbird (150, 220GHz), LSPE-STRIP (43, 90GHz).
- Contributions to LiteBIRD and FOSSIL (thermometry).
- Expertise in FPGAs.

CMB group. Science cases & synergies with AtLAST.

- SZ: cluster science. bSZ effect.
- LIM signal (CO, and synergy with TMS).
- Galactic foregrounds (AME). Extragalactic AME.



Funded by
the European Union





Galactic Science & CMB foregrounds

Tenerife. Spain. October 26-29 2026



<https://meetings.iac.es/cmbforegrounds2026>

