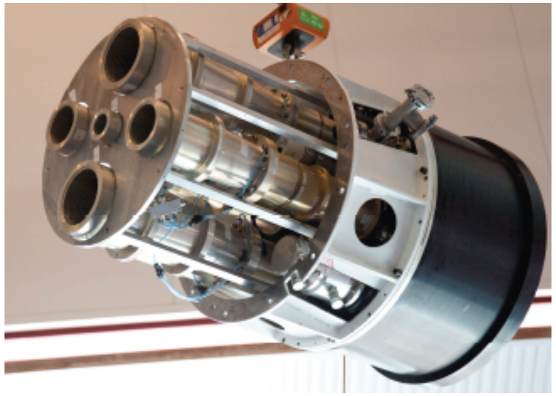

QUIJOTE: a CMB polarization experiment

José Alberto Rubiño-Martín

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IFCA Instituto de Física de Cantabria

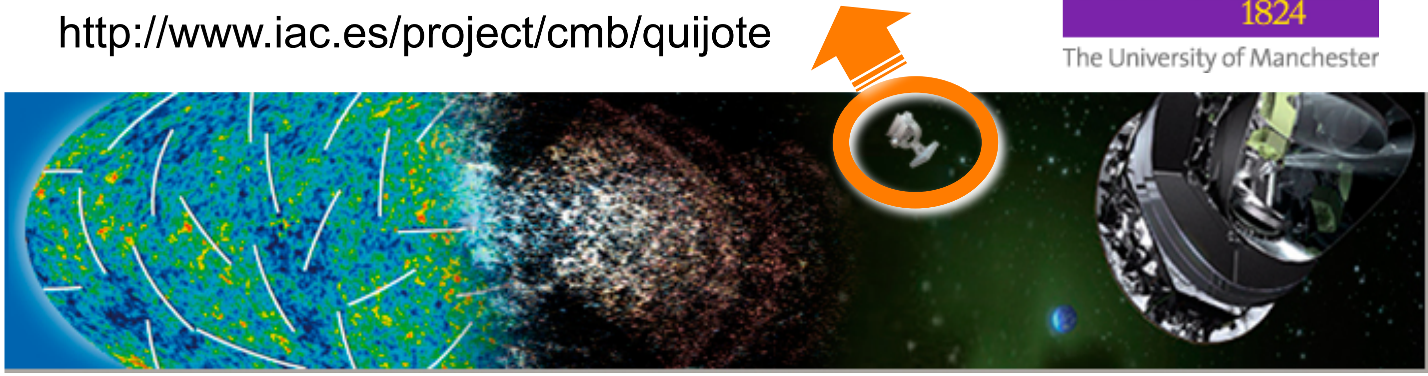
DICOM

idom

MANCHESTER 1824 The University of Manchester

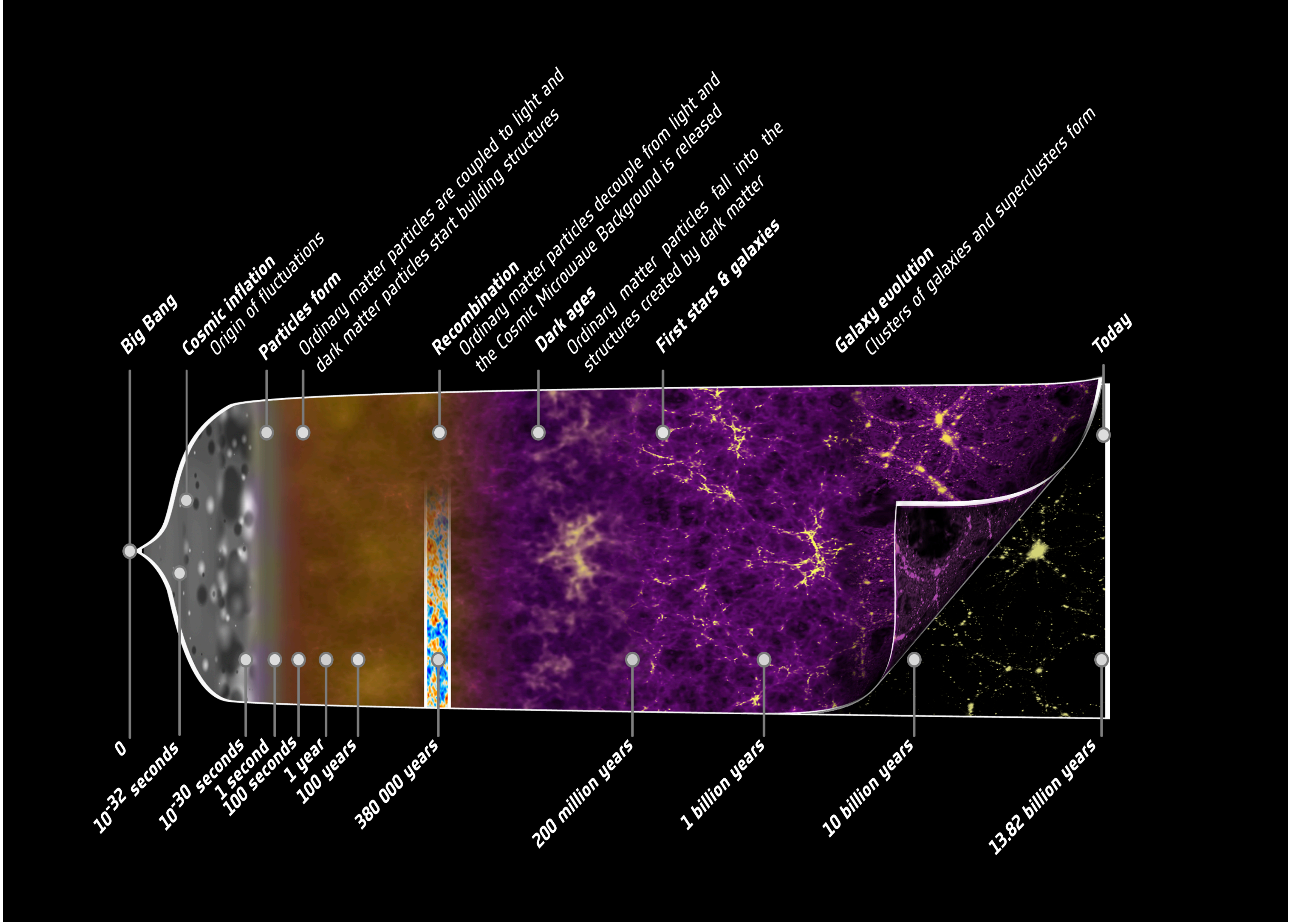
UNIVERSITY OF CAMBRIDGE

http://www.iac.es/project/cmb/quijote

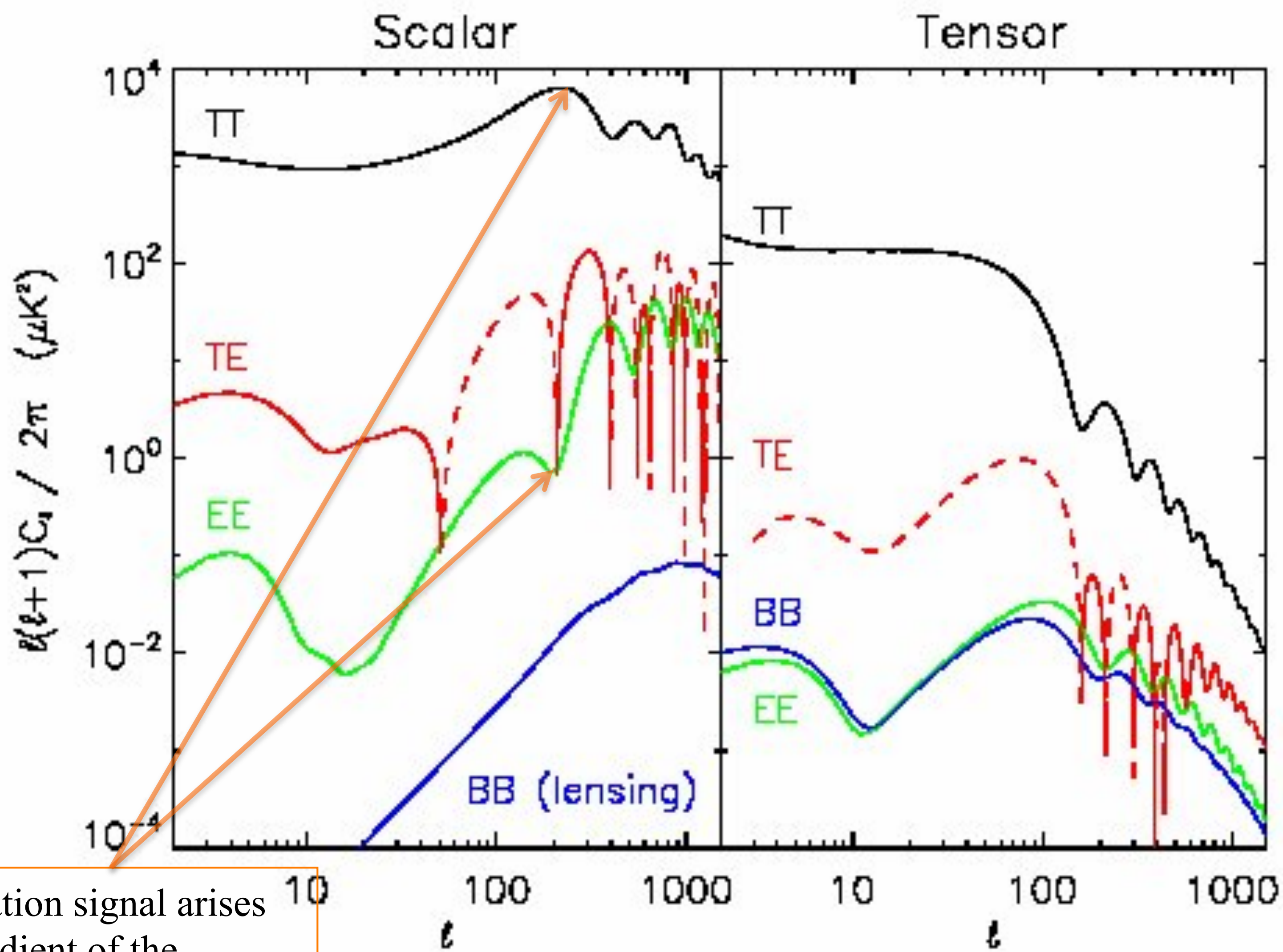


Exploring the Physics of Inflation

Santander, Spain • June 24-27, 2013


Big Bang
Cosmic inflation
Origin of fluctuations
Particles form
Ordinary matter particles are coupled to light and
dark matter particles start building structures
Recombination
Ordinary matter particles decouple from light and
the Cosmic Microwave Background is released
Dark ages
Ordinary matter particles fall into the
structures created by dark matter
First stars & galaxies
Galaxy evolution
Clusters of galaxies and superclusters form
Today
0
10^{-32} seconds
10^{-30} seconds
1 second
100 seconds
1 year
100 years
380 000 years
200 million years
1 billion years
10 billion years
13.82 billion years

CMB Power spectra - Theory



The polarization signal arises from the gradient of the peculiar velocity of the photon fluid => TT and EE peaks are out of phase.

Effects only on large scales because gravity waves damp inside horizon.

What would a detection of GW tell us?

- It would provide strong evidence that inflation happened!

- The amplitude of the power spectrum is a (model-independent) measurement of the energy scale of inflation.

$$P_{tensor} = \frac{8}{m_{Pl}^2}\left(\frac{H}{2\pi}\right)^2 \propto E_{\inf}^4$$

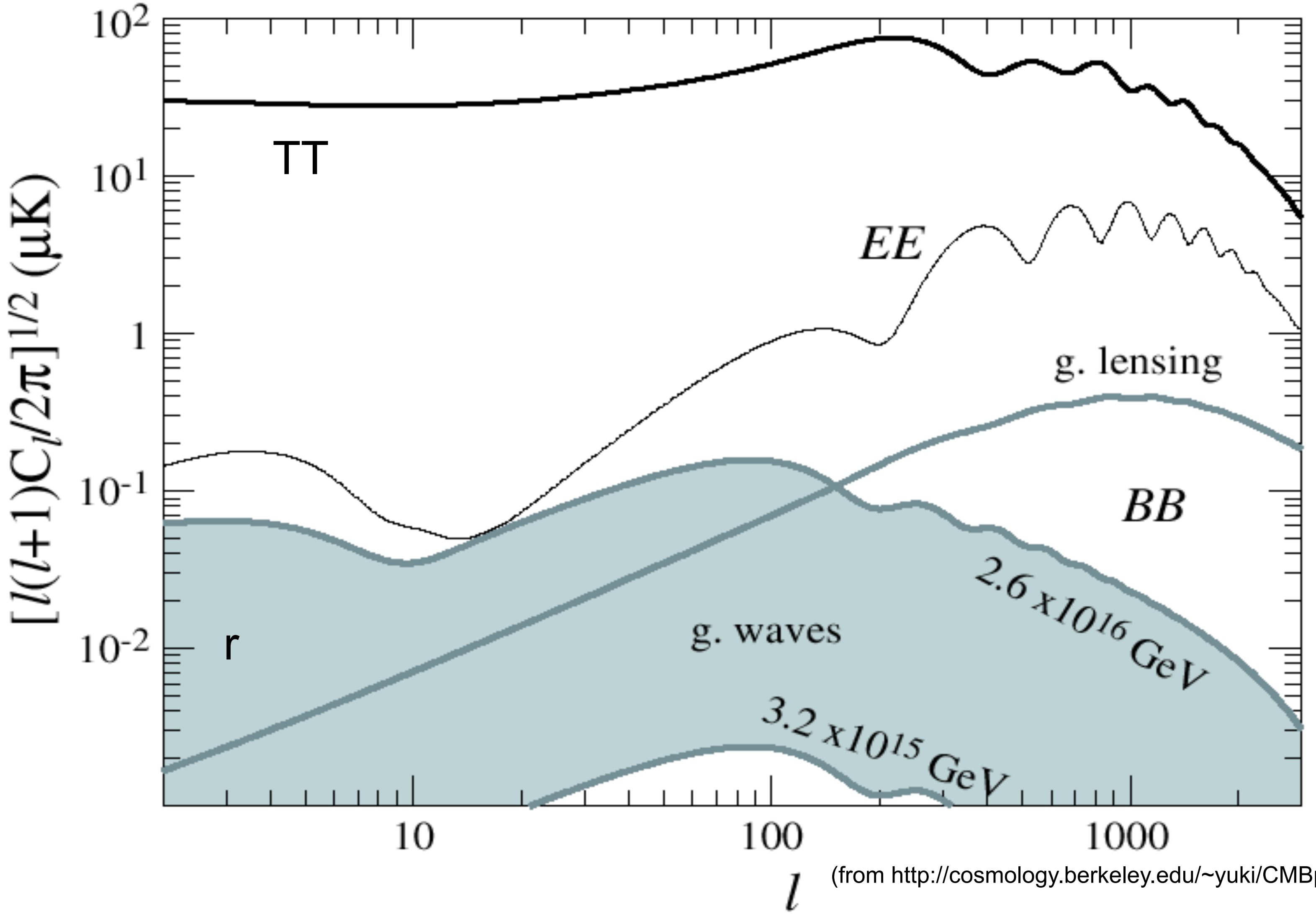
- Defining the tensor-to-scalar ratio (r) at a certain scale k_0 (e.g. at 0.001 Mpc^{-1}), we have

$$r \equiv \frac{P_{tensor}(k_0)}{P_{scalar}(k_0)} = 0.008\left(\frac{E_{\inf}}{10^{16}GeV}\right)^4$$

- Values of r of the order of 0.01 or larger would imply that inflation occurred at the GUT scale.

- These scales are 12 orders of magnitude larger than those achievable at LHC!

Primordial gravitational waves and B-modes

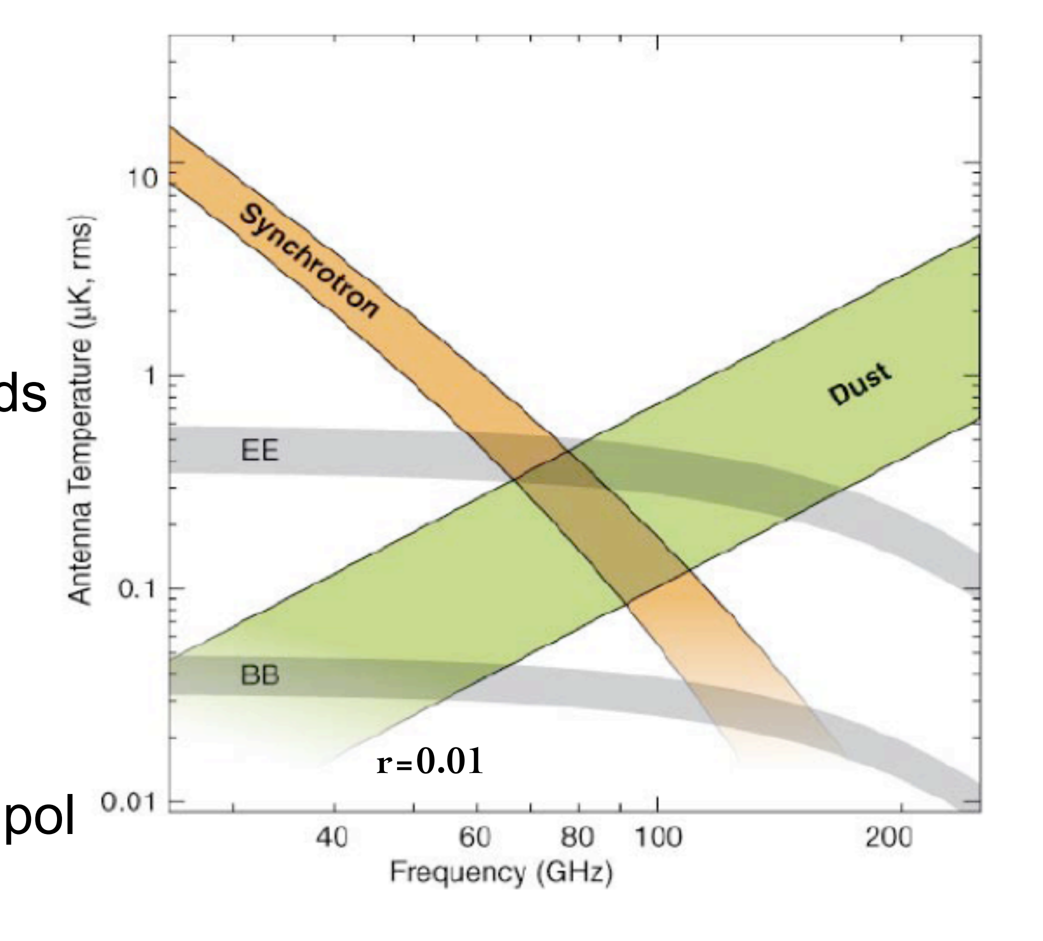


(from http://cosmology.berkeley.edu/~yuki/CMBpol/CMBpol.htm)

- r=0.1 corresponds to an energy scale of inflation around 2×10^{16} GeV.

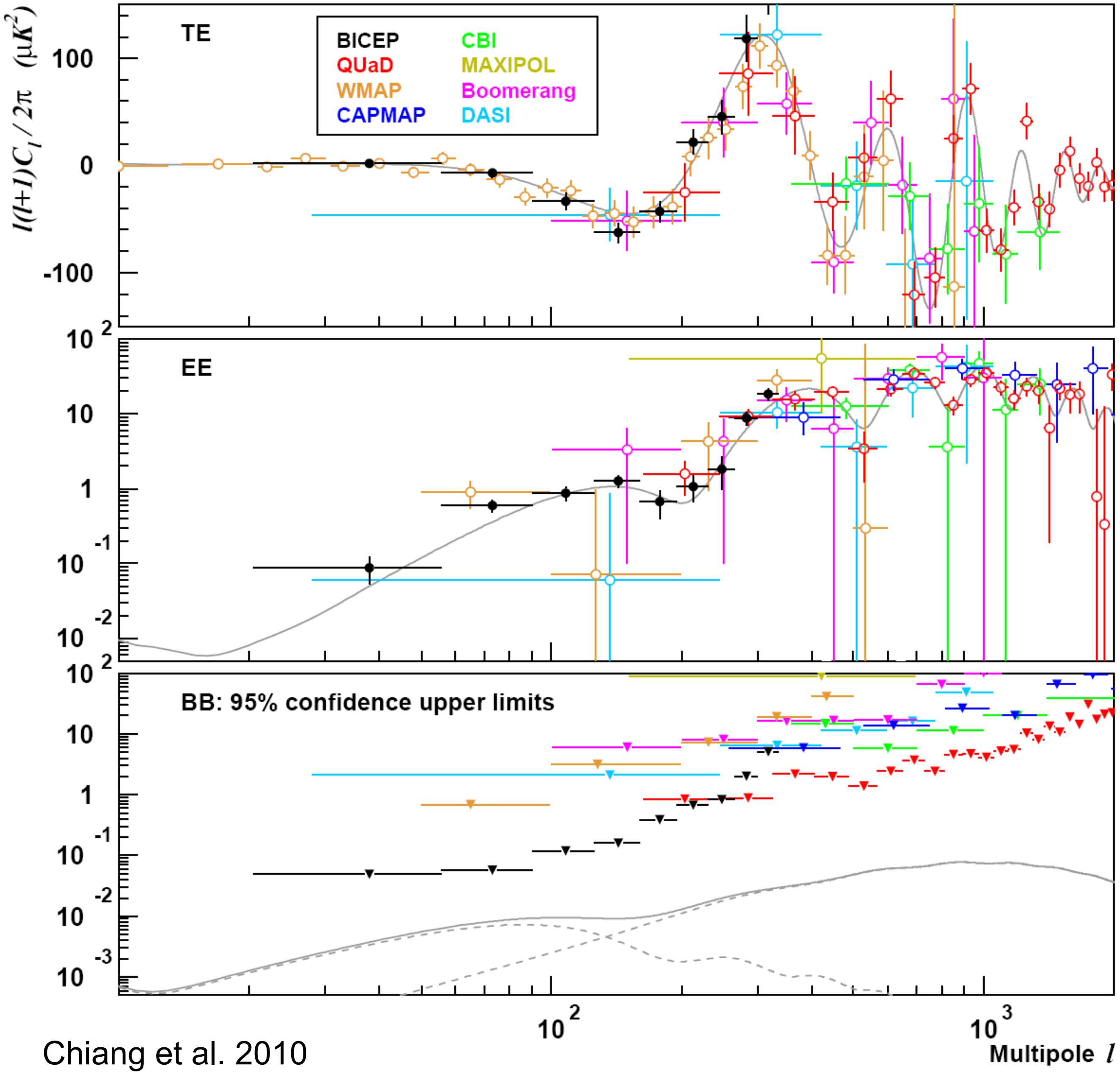
Observability of B-modes

- **Signals are extremely small** ⇒ large number of receivers with large bandwidths are required.
- Accurate **control of systematics** (cross-pol, spillover,...) is mandatory.
- **Foregrounds**. B-mode signal is subdominant over Galactic foregrounds
  - Free-free, low-freq, not polarized
  - Synchrotron, low-freq, pol ~10%
  - Thermal dust, high-freq, pol ~10%
  - Anomalous emission, 20-60 GHz, pol ~3%?
  - Point sources, low-freq, pol ~5%



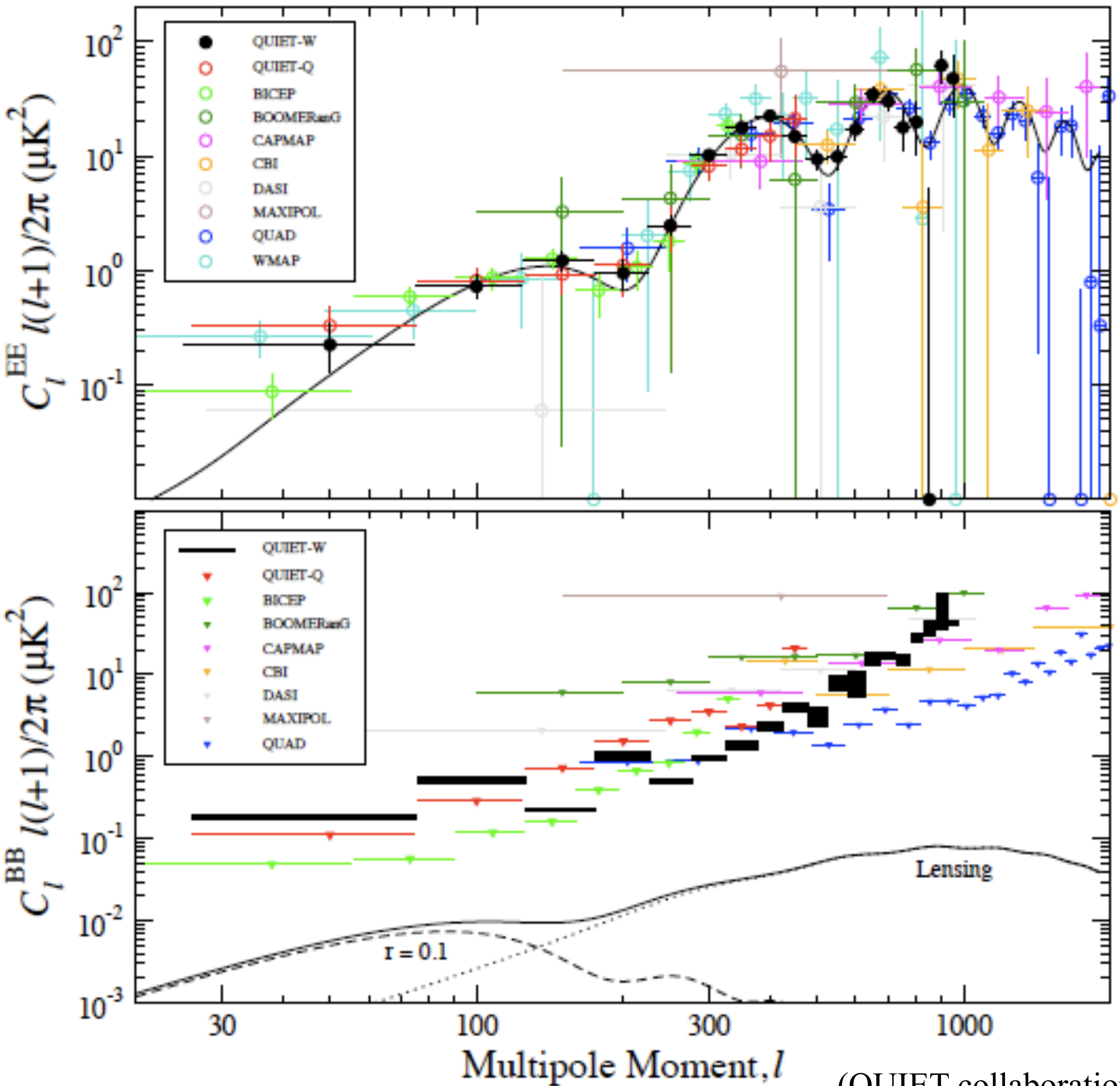
(Bock et al. 2006, arXiv:0604101)

CMB polarization: observational status



Chiang et al. 2010

- Several E-mode detections: DASI, CBI, CAPMAP, Boomerang, WMAP, QUAD, BICEP, QUIET, etc.
- WMAP7 gives r<0.93 at 95% using TE/EE/BB, and r<2.1 at 95% with BB alone.
- WMAP7+BAO+SN gives r<0.2 (Komatsu et al. 2010).
- BICEP: r<0.72 at 95% with BB only (Chiang et al. 2010).
- QUIET: $r=0.35^{+1.06}_{-0.87}$ with BB only (Bischoff et al. 2010)

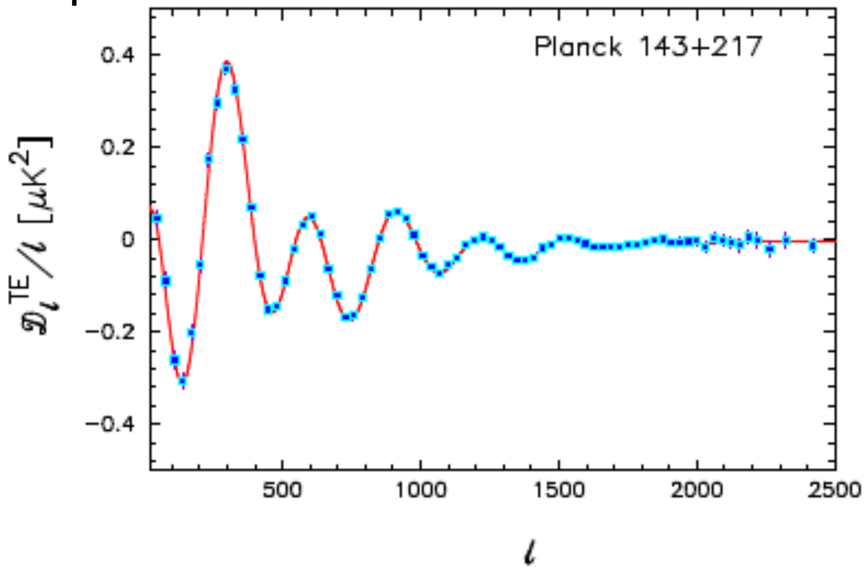


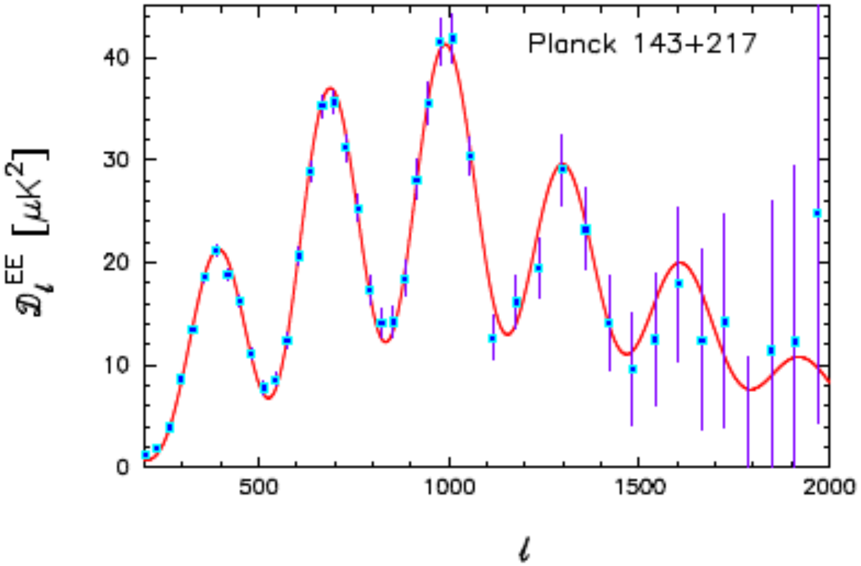
r < 2.7 at
95% C.L.

(QUIET collaboration: arXiv1207.5034)

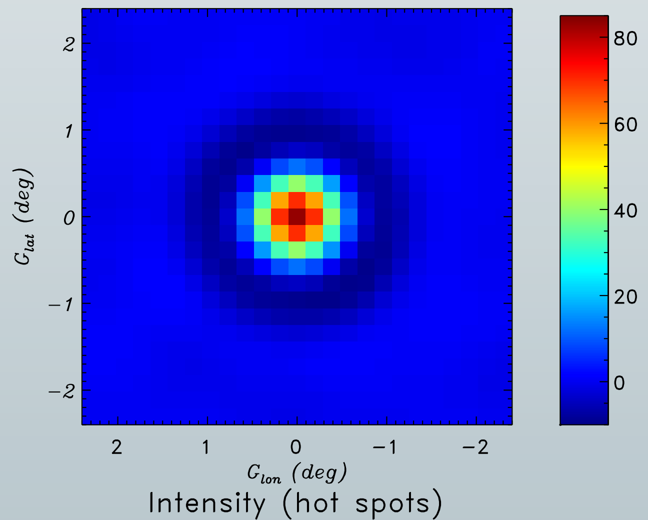
Planck preliminary polarization results

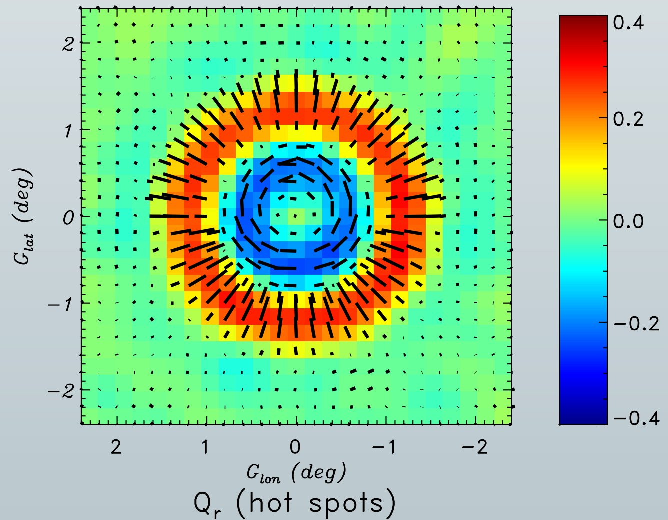
CMB polarization



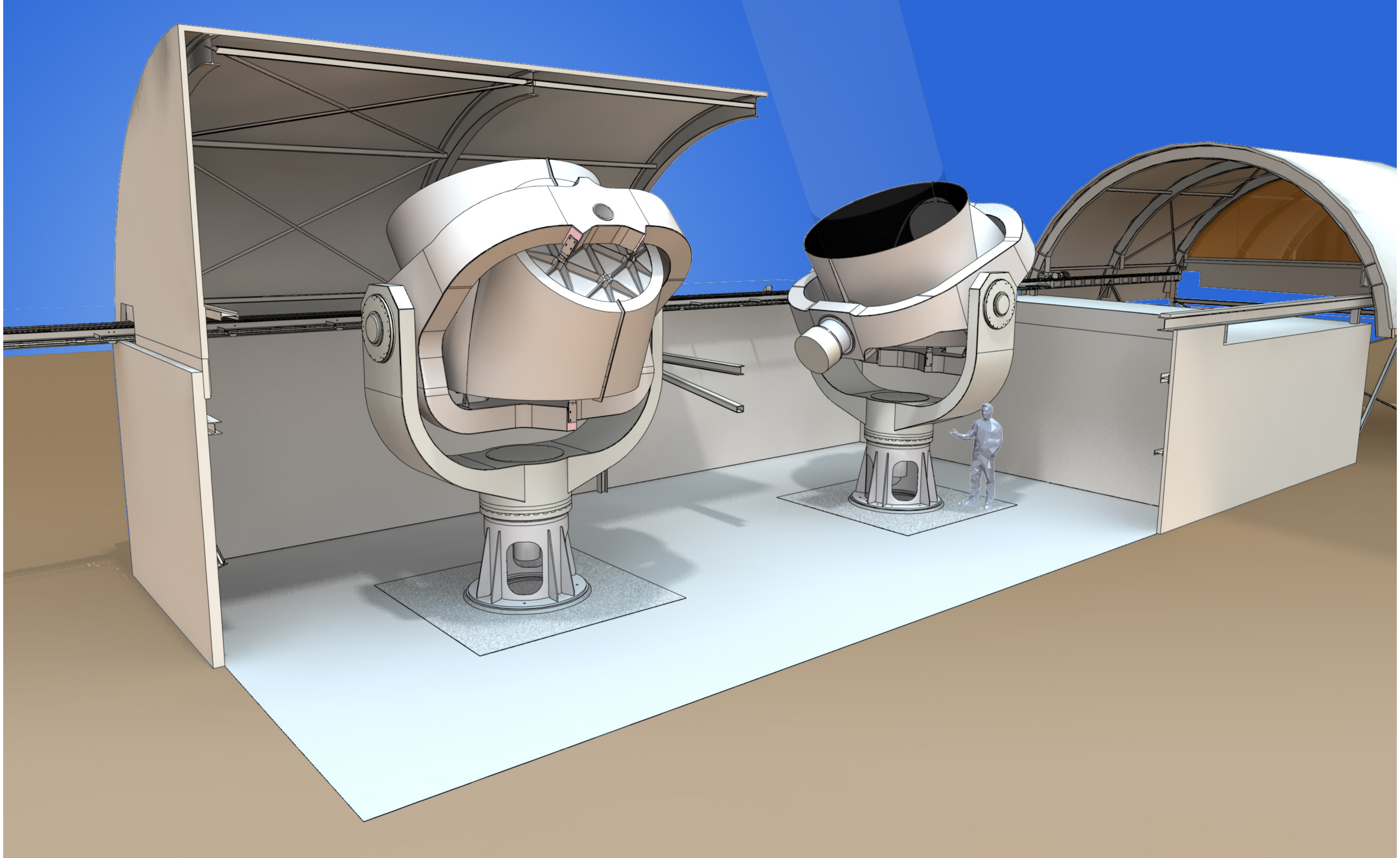


Adiabatic primordial fluctuations from inflation!





QUIJOTE CMB experiment



(Q-U-I JOint TEnerife Cosmic Microwave Background Experiment)

The QUIJOTE CMB consortium

(http://www.iac.es/project/cmb/quijote)

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M.P. Hobson, A. Challinor, A.N. Lasenby, N. Razhavi, R.D.E. Saunders, P.F. Scott, D. Titterington

IDOM

G. Murga, C. Gómez, A.Gómez, J. Ariño, R. Sanquirce, J.Pan, A. Vizcargüenaga

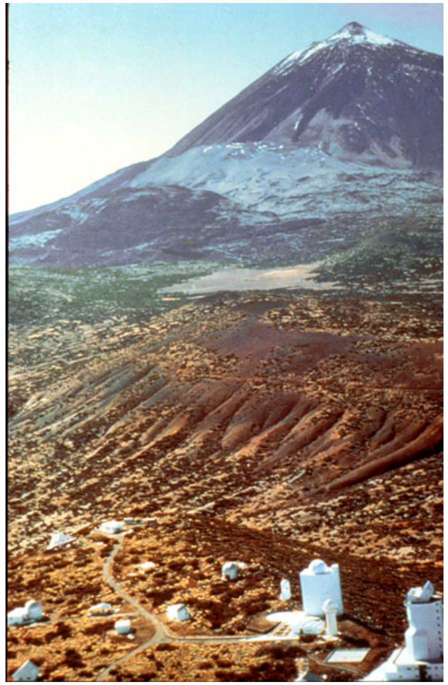
The QUIJOTE-CMB Experiment: Goals

- **Main science driver**: to constrain (or to detect) gravitational B-modes if they have an amplitude of r=0.05.

- Complement Planck at low frequencies. In combination with Planck data, push the upper limits below that value.

- Measure polarized foregrounds (synchrotron) with high sensitivity to correct them in future space missions aiming to reach r=0.001.

QUIJOTE: Project baseline



- **Site**: Teide Observatory
- **Frequencies**: 11, 13, 17, 19, 30 and 42 GHz.
- **Angular resolution**: 0.92º to 0.26º
- **Sky coverage**: 20,000 deg^2.

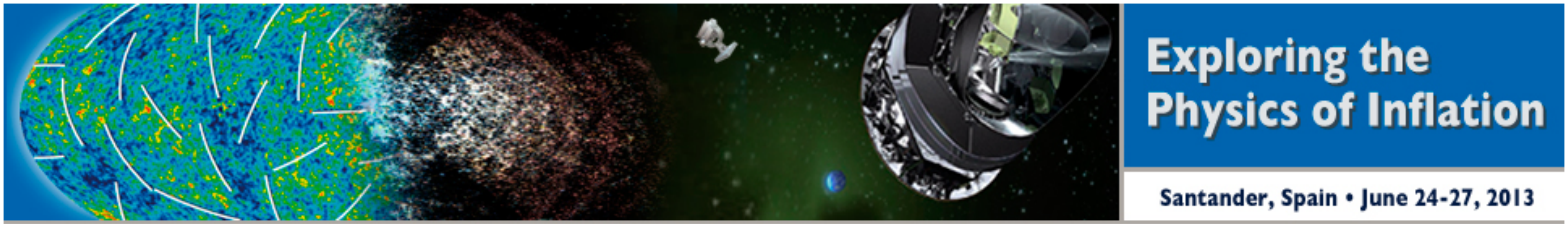
- **Telescopes and instruments: two phases, fully funded.**

  - **Phase I.**
    - First telescope (QT1). In operation.
    - Multi-Frequency Instrument (MFI) with 4 polarimeters at 10-20 GHz. In operation.
    - Second Instrument (TGI) with 31 polarimeters @ 30 GHz. Starting early 2014.
    - Polarised source subtractor facility at 30GHz. In commissiong.
  - **Phase II.**
    - Second telescope (QT2). Under construction, starting operations early 2014.
    - Third instrument (FGI) at 42 GHz (40 polarimeters). Early 2015.

- **Technology:** Coherent detectors. **Polarization detection**: modulation.
- **Observing strategy**: Deep observations in selected areas using raster scans, plus wide survey using "nominal mode".
- **Scientific operation plan**: 2012-2018.

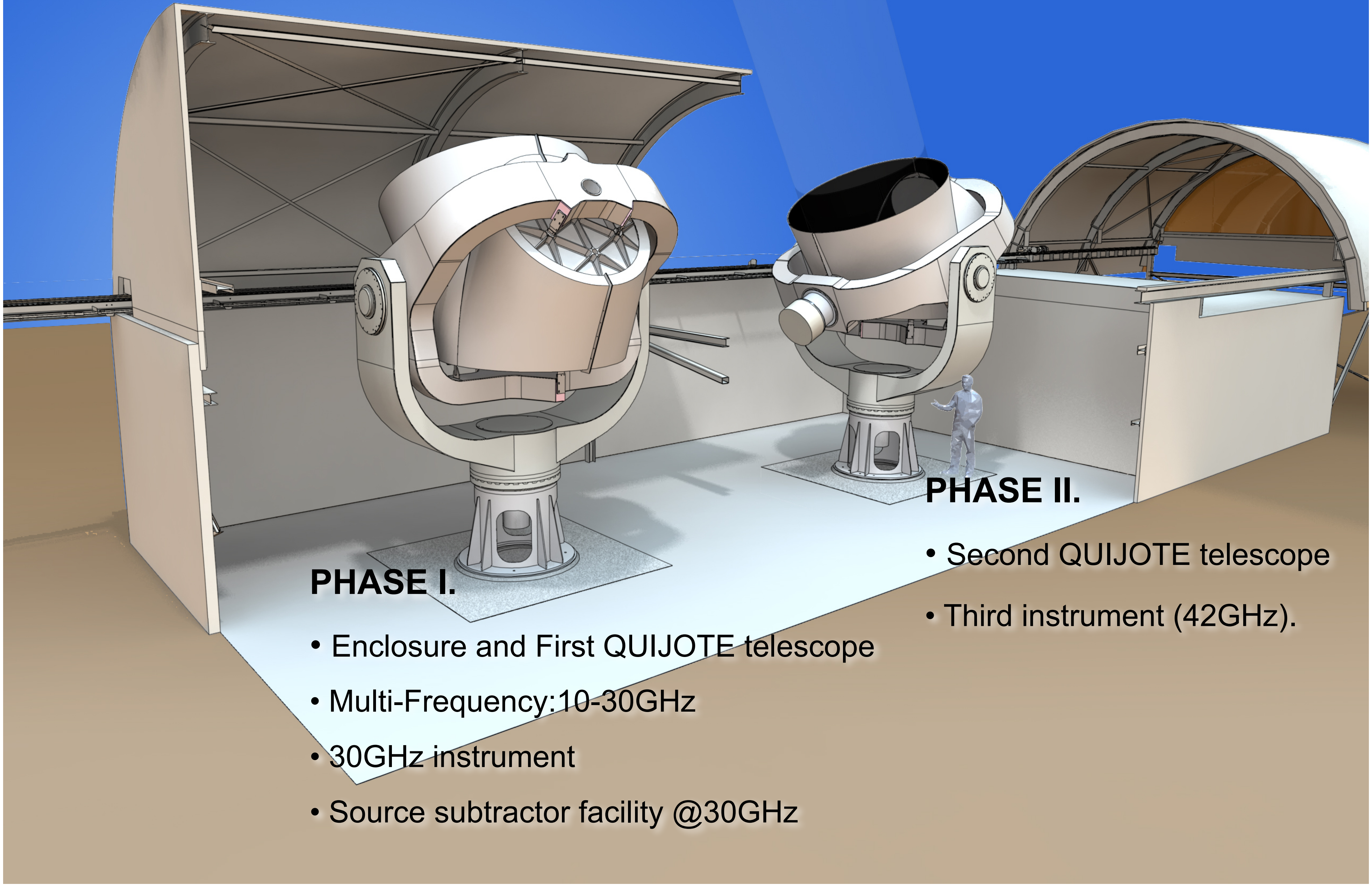
Consolider-Ingenio Program 2010: "Exploring the physics of inflation (EPI)"

- Five-year grant (2011-2016).
- Nodes: IFCA, IAC, DICOM, UGR, UPV, Univ. of Manchester, Univ. of Cambridge, Chalmers.
- Technical contributions:
  - Second QUIJOTE telescope.
  - QUIJOTE 42GHz experiment.
  - Development of technology to build 42GHz FEMs.
  - Pathfinder for a large-format interferometer.



QUIJOTE CMB Experiment

(Q-U-I JOint TEnerife Cosmic Microwave Background Experiment)



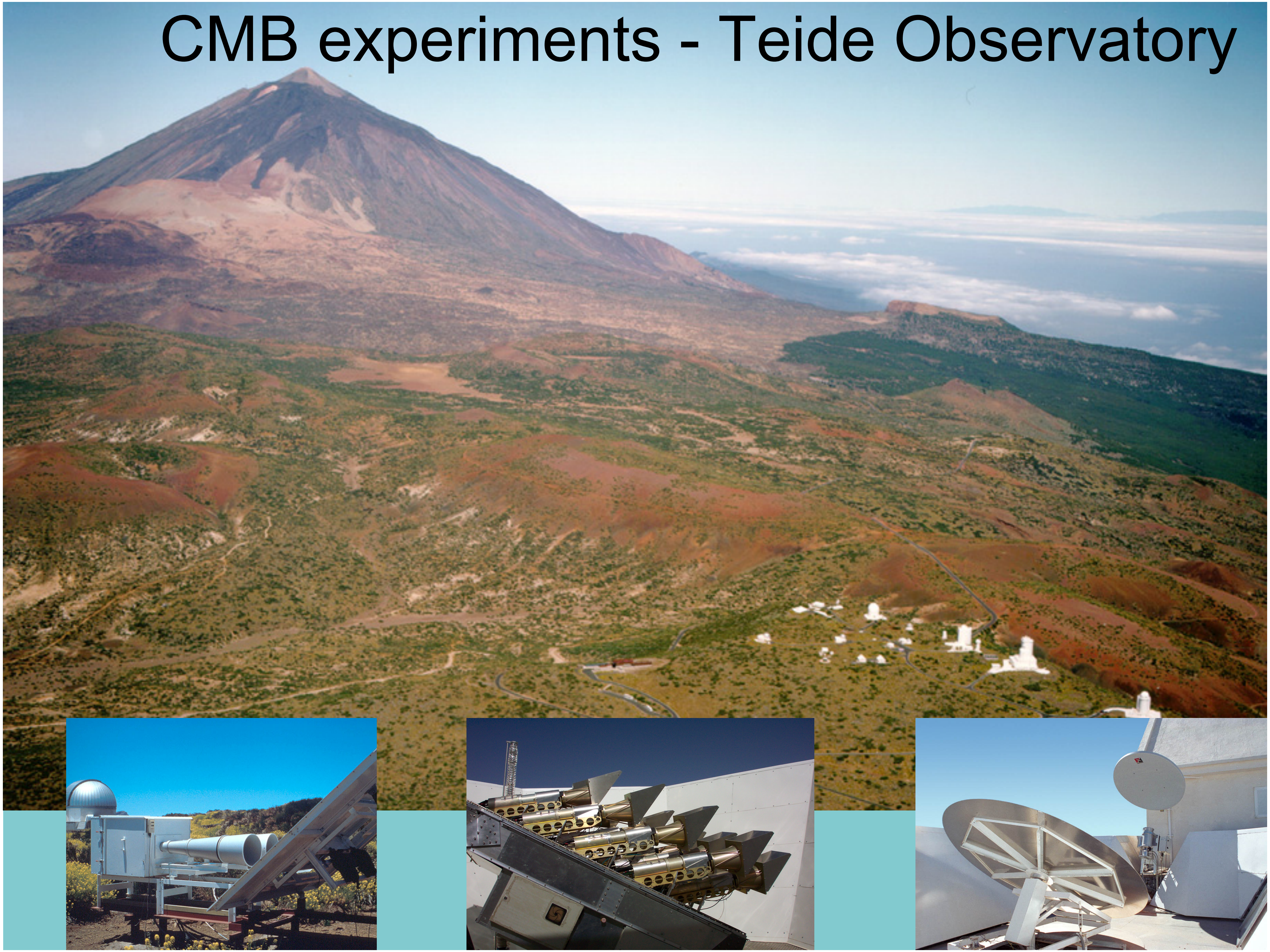
PHASE I.

- Enclosure and First QUIJOTE telescope
- Multi-Frequency:10-30GHz
- 30GHz instrument
- Source subtractor facility @30GHz

PHASE II.

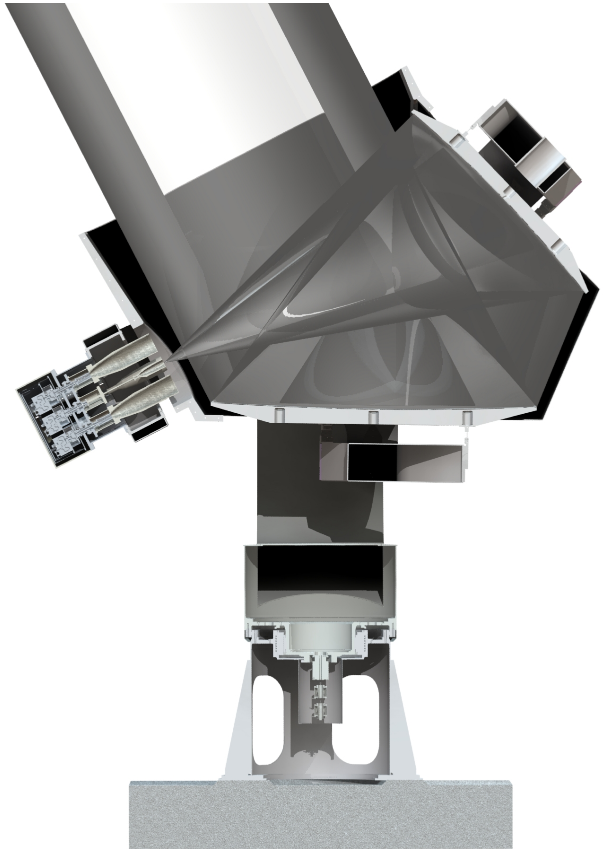
- Second QUIJOTE telescope
- Third instrument (42GHz).

CMB experiments - Teide Observatory

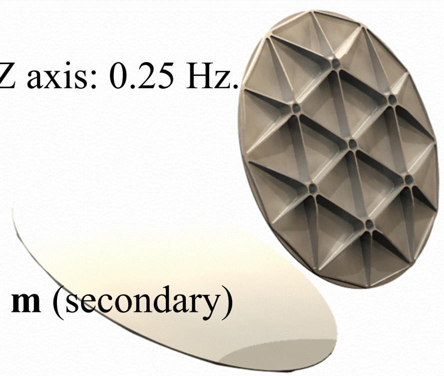


QUIJOTE. Platform

QUIJOTE. Telescope



- **Alto-azimutal mount**
- Maximum rotation speed around AZ axis: 0.25 Hz.
- Maximum zenith angle**: 60º**
- **Cross-Dragonian design.**
- Aperture: **2.25 m** (primary) and **1.9 m** (secondary)



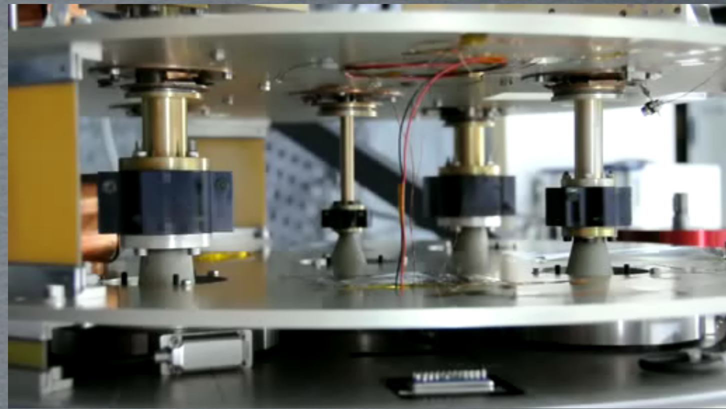
First QUIJOTE Telescope (QT1)

Installed at the Teide Observatory in May 3rd, 2012.

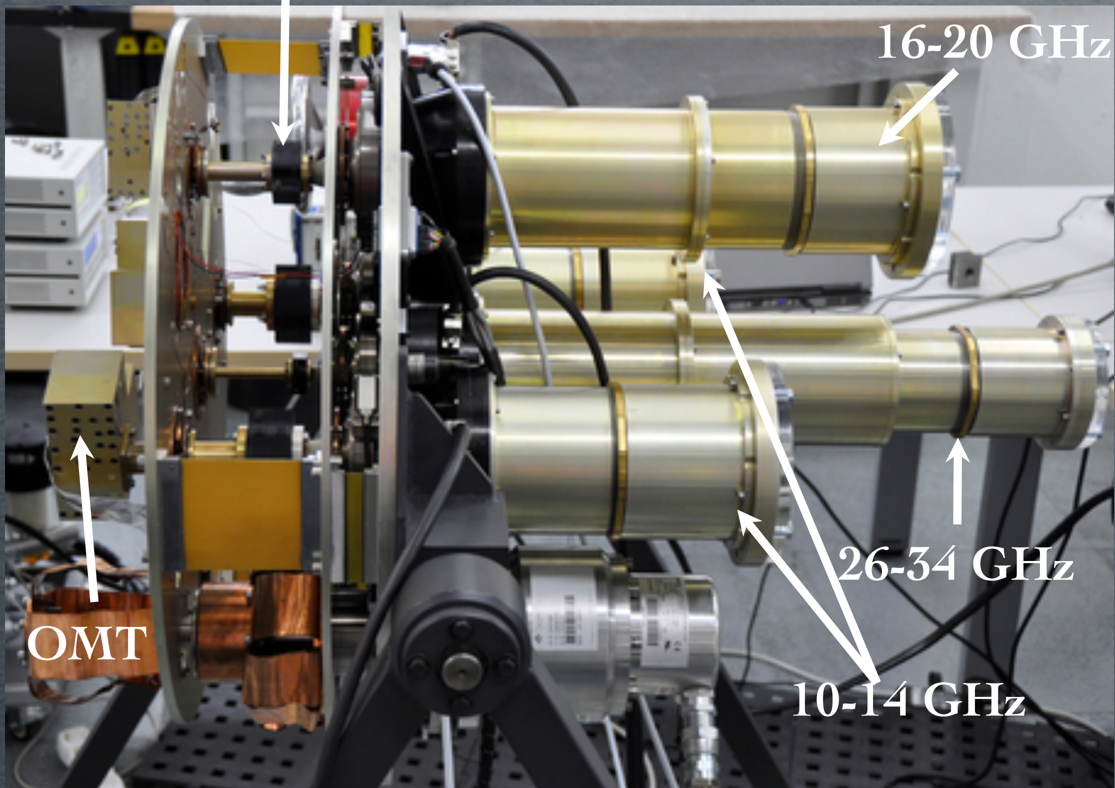
QUIJOTE first instrument: Multi-Frequency Instrument

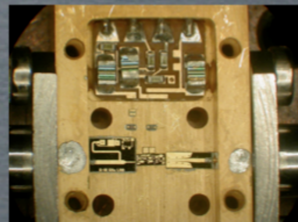
- 4 conical corrugated horns (2 at 10-14 GHz and 2 at 16-20 GHz)
- Polar modulator spinning at speeds up to 40 Hz
- Wide-band cryogenic Ortho-Mode-Transducer (OMT)
- MMIC 6-20 GHz Low Noise Amplifiers. Gain: 30dB
- Noise temperature: ~7-10 K (10-14 GHz), ~10-20 K (16-20 GHz)

Spinning polar modulators



Polar Modulators

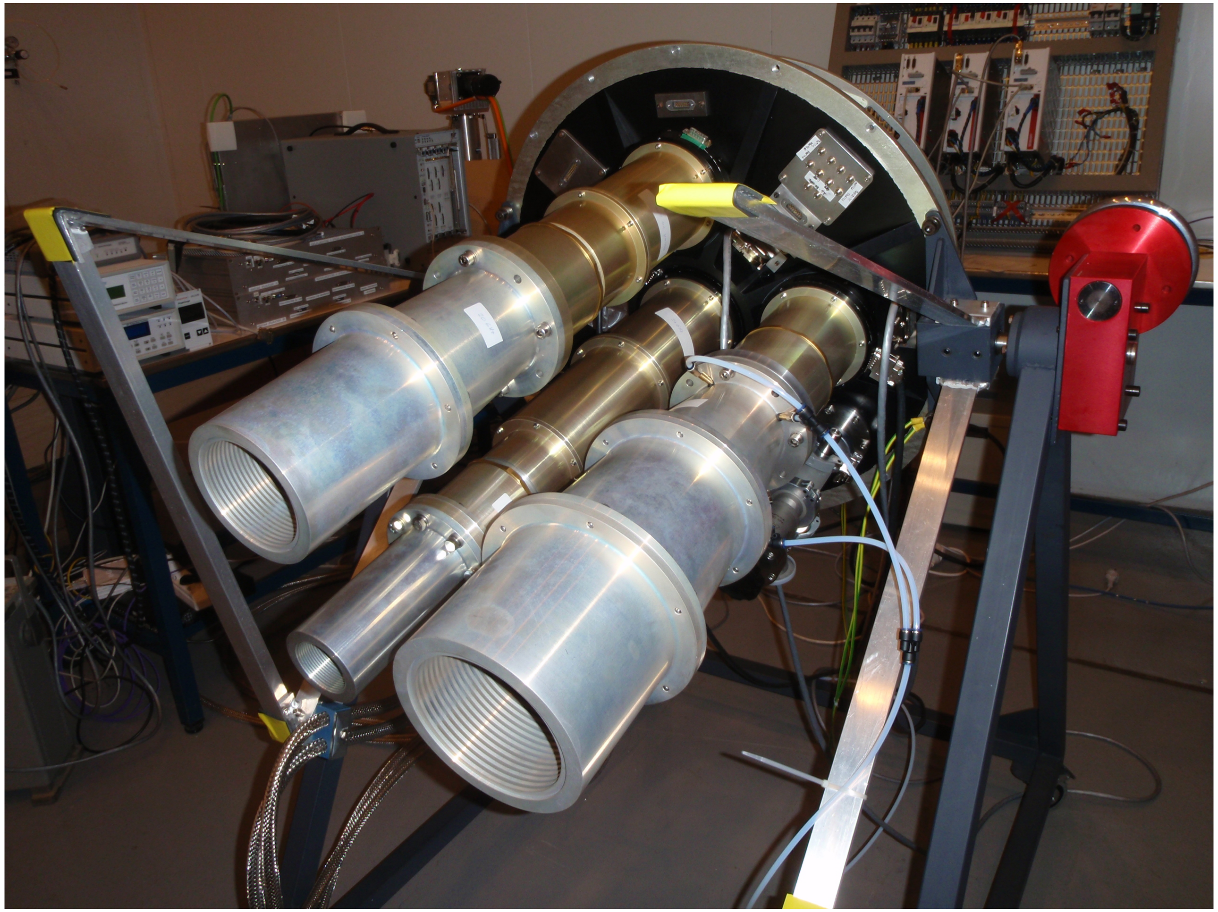




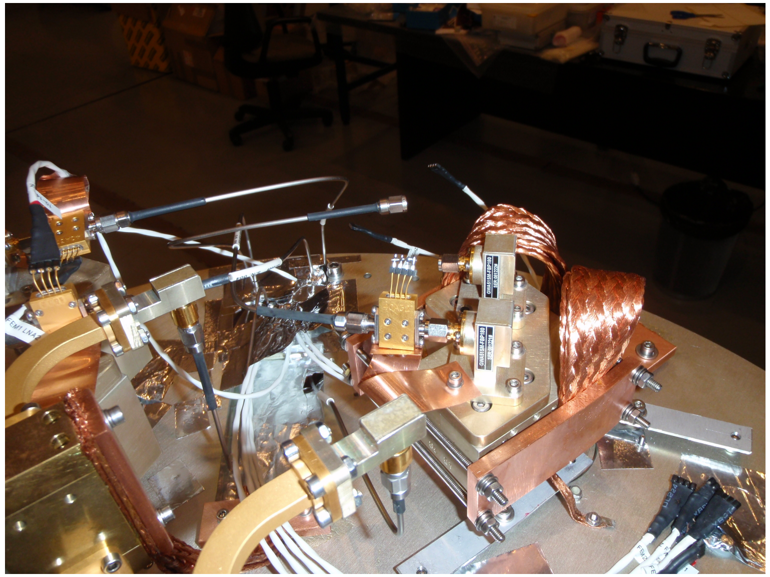
LNA

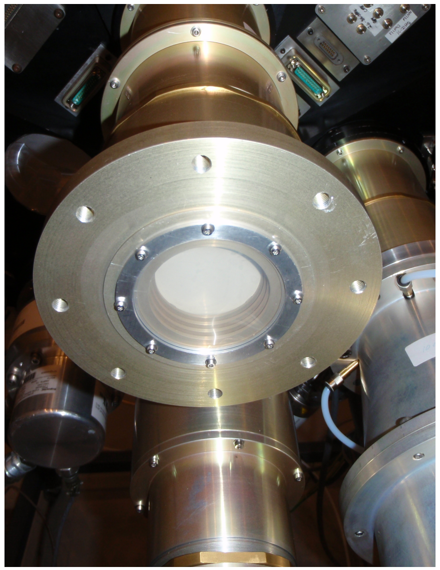
OMT and motor

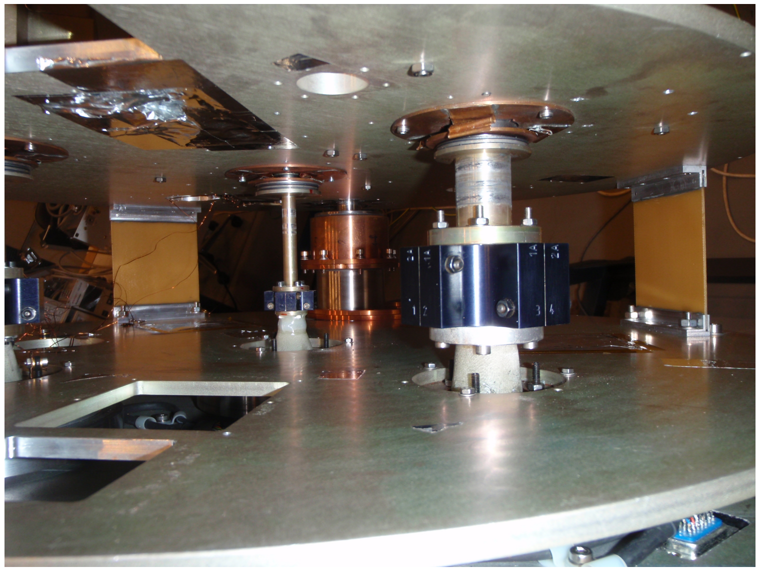
Horns

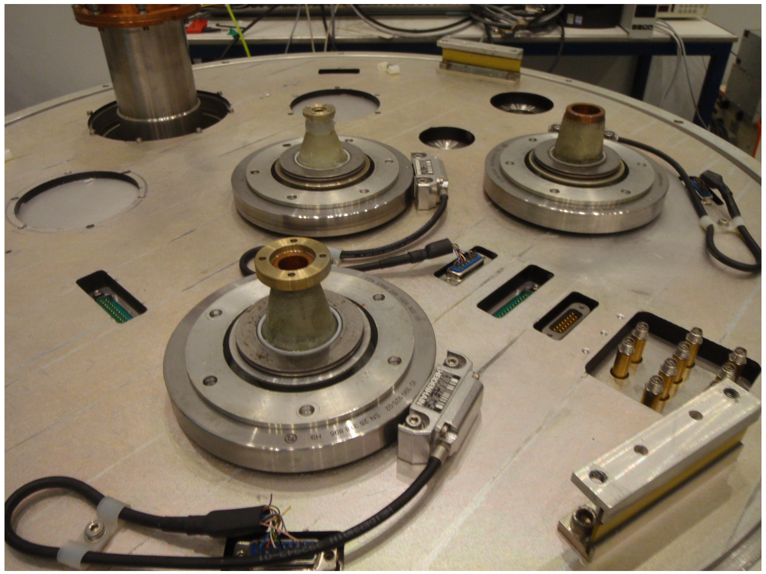


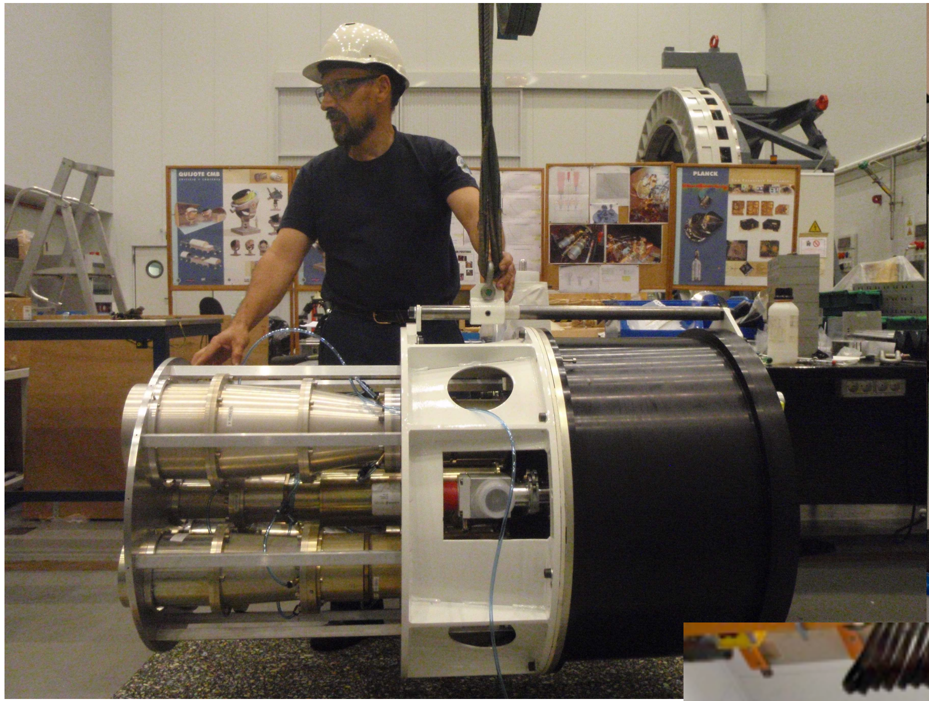
QUIJOTE MFI.
Final integration

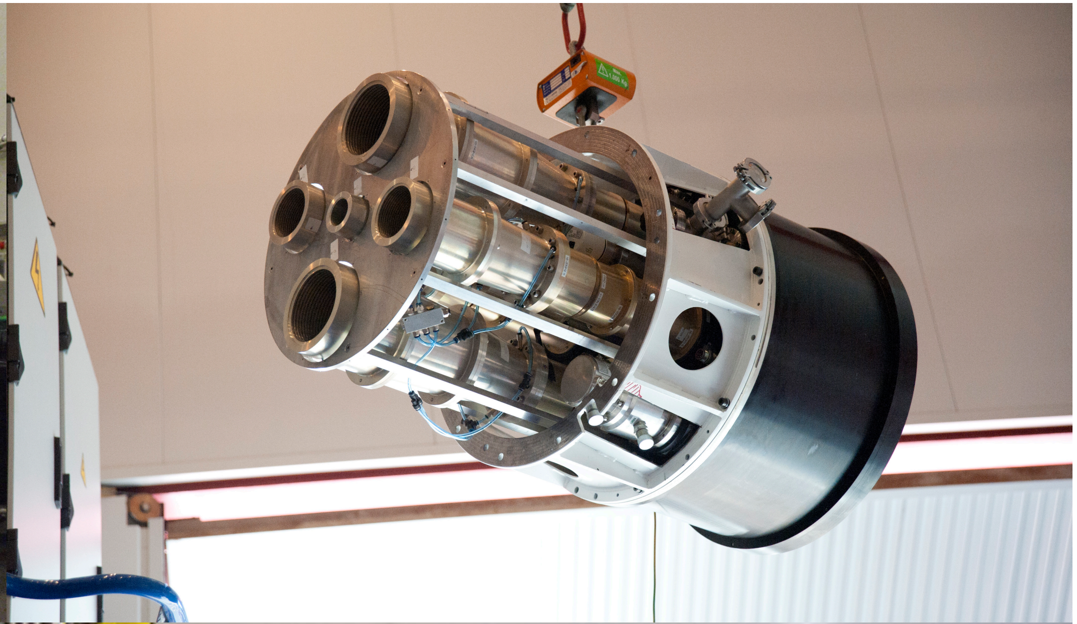


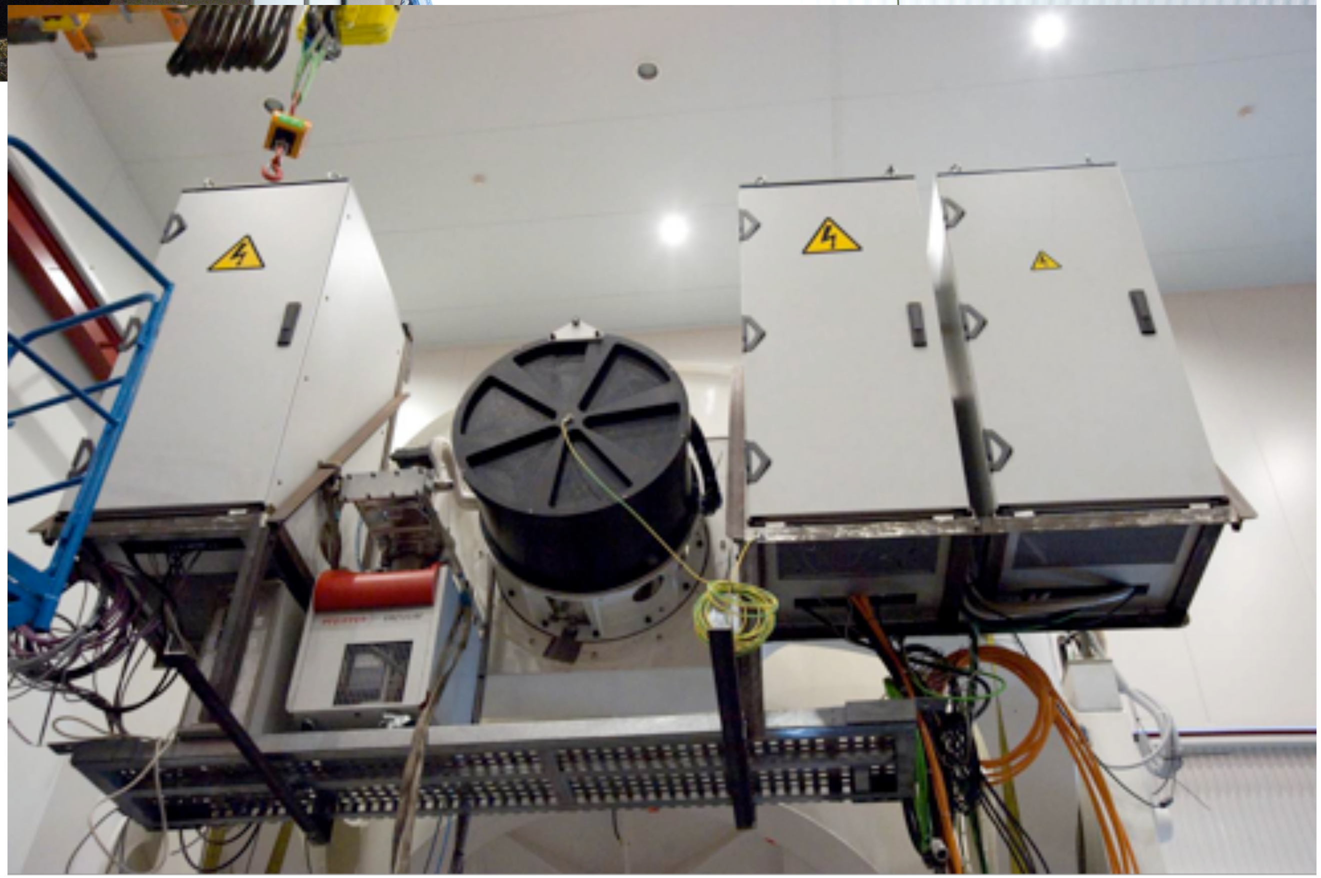










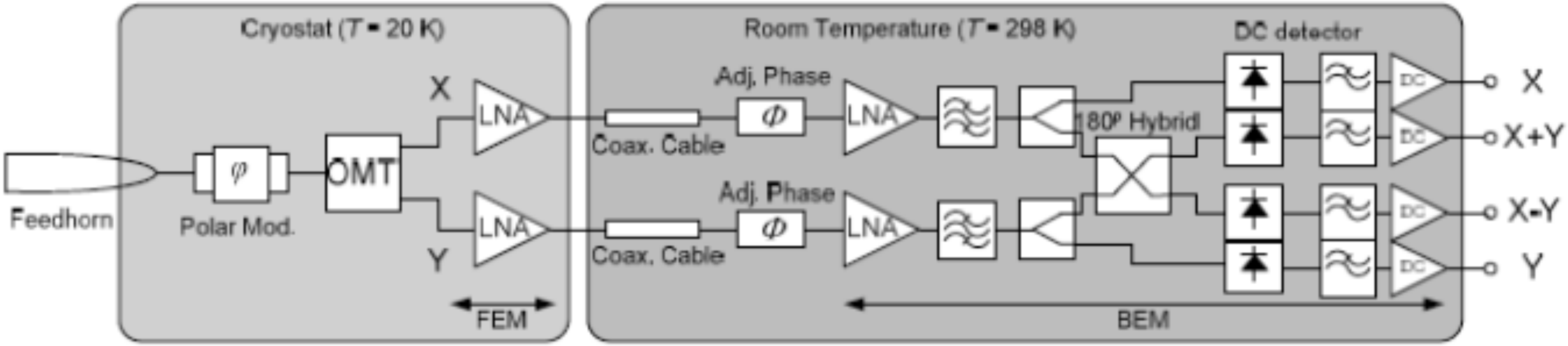


• Integration tests of the MFI and QT1 at the AIV room (February-March 2012).

• In operation since Nov. 2012.

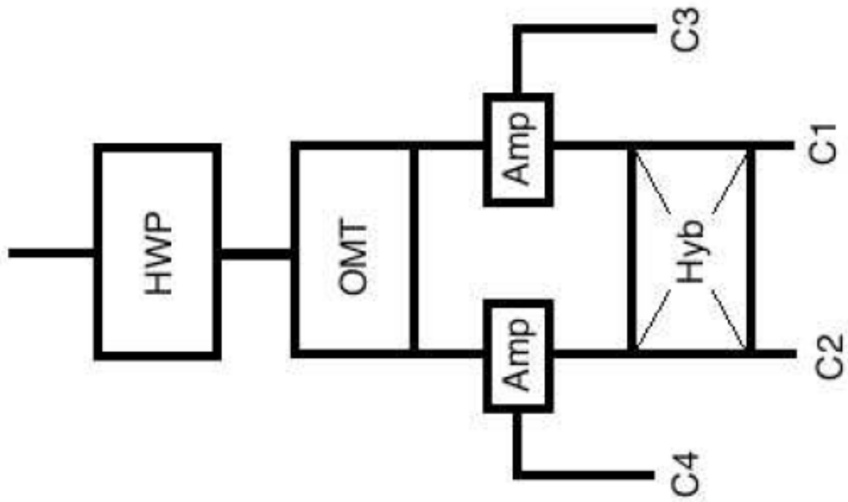
MFI polarimeter configuration

• FEM: partially-cooled feed-horn, polar modulator, OMT and LNAs
• BEM: phase adjuster, further amplification, band pass filter and correlation.
• Output: two channels (x) and (y) measuring Q (un-correlated), two channels (x+y) and (x-y) measuring U (correlated)



• Continuous spinning of the polar modulators allows independent measurement of I, Q and U for each channel, while switching out the 1/f noise.
• Each of the four outputs are divided into a lower frequency and an upper frequency band.

MFI polarimeter: polarization detection



$$C_1 = D_1^{int} = \frac{1}{2}[\,T + Q\ \sin(4\theta) - U\ \cos(4\theta)]$$

$$C_2 = D_2^{int} = \frac{1}{2}[\,T - Q\ \sin(4\theta) + U\ \cos(4\theta)]$$

$$C_3 = D_1^{ext} = \frac{1}{2}[\,T + Q\ \cos(4\theta) + U\ \sin(4\theta)]$$

$$C_4 = D_2^{ext} = \frac{1}{2}[\,T - Q\ \cos(4\theta) - U\ \sin(4\theta)]$$

Mueller matrix analysis of the MFI:

(Pessimistic values)

HWP:	$H_x = -0{,}02$ dB; $H_y = 0$ dB; $H_a = -20$ dB $\delta\theta = 0{,}5°$; $\chi_a = 0°$; $\chi_c = 1°$
OMT:	$O_x = -0{,}05$ dB; $O_y = 0$ dB; $O_a = -50$ dB $\phi_a = 0°$; $\phi_c = 0{,}5°$
LNA :	$L = -0{,}50$ dB; $\lambda = 7°$
Hyb:	$B_x = -0{,}5$ dB; $B_y = 0$ dB; $B_a = -25$ dB $\beta_a = 0°$; $\beta_x = 5°$; $\beta_y = 1°$

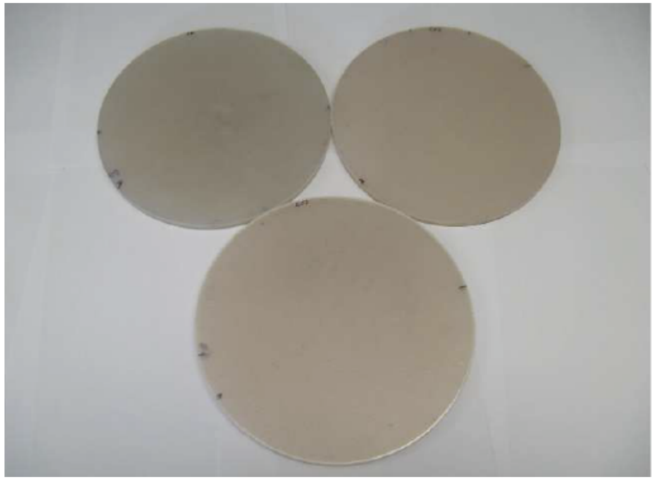
I Q U V

$$M_{r360} = \begin{pmatrix} 0{,}953 & 1{,}41\times10^{-6} & -1{,}78\times10^{-6} & 1{,}63\times10^{-3} \\ 0 & 0{,}951 & 1{,}65\times10^{-2} & 0 \\ 0 & -1{,}65\times10^{-2} & 0{,}951 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

$$M_{d4pos} = \begin{pmatrix} 0{,}953 & -4{,}98\times10^{-4} & -1{,}36\times10^{-3} & 1{,}93\times10^{-3} \\ 1{,}59\times10^{-5} & 0{,}951 & 1{,}72\times10^{-2} & -1{,}17\times10^{-2} \\ -1{,}11\times10^{-3} & -1{,}71\times10^{-2} & 0{,}951 & 8{,}31\times10^{-3} \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

A QUIJOTE Source-Subtractor facility at 30GHz

- A dedicated instrument at 30 GHz to measure radiosources (an upgraded version of the VSA subtractor converted to a polarimeter).
- Uses dielectrically embedded mesh-HWP designed and produced at the University of Manchester.



Twofold subtraction strategy:

- NVSS-GB6 extrapolation. ~300 sources with Stokes-I flux > 300 mJy at 30 GHz. Flux sensitivity per source ~2-3 mJy in ~100 days.
- Identify sources in the low-frequency channels by MH wavelet filters (López-Caniego et al. 2009).

• Interferometer of two 3.7m antennae with a 9m baseline
• Primary beam: 9’
• Synthesized beam: 4’
• Dec. range: $-5^o<\delta<+60^o$

QUIJOTE CMB Experiment - Phase I and II. Sensitivities

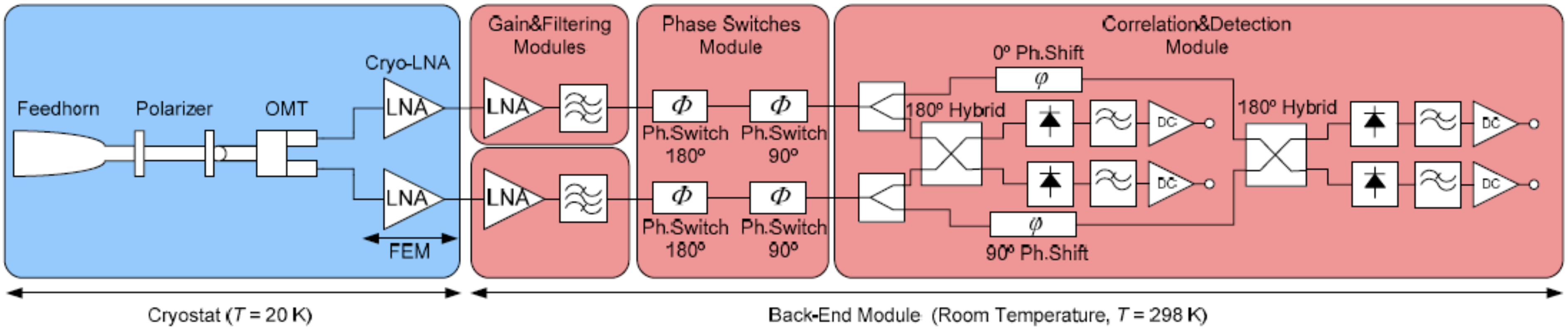
	MFI				TGI	FGI
Frequency (GHz)	11	13	17	19	30	40
Bandwidth (GHz)	2	2	2	2	8	10
Number of horns	2		2		31	40
Channels per horn	2	2	2	2	4	4
Beam FWHM (deg)	0.92	0.92	0.60	0.60	0.37	0.28
T_{sys} (K)	25	25	25	25	35	45
NEP per channel ($\mu K\ s^{1/2}$)	456	370	663	1019	557	632
Sensitivity per channel ($Jy\ s^{1/2}$)	0.49	0.55	0.73	1.40	0.66	0.76

- Measured sensitivities for MFI, and nominal sensitivities for TGI and FGI.
- Temperature sensitivity per beam, given by

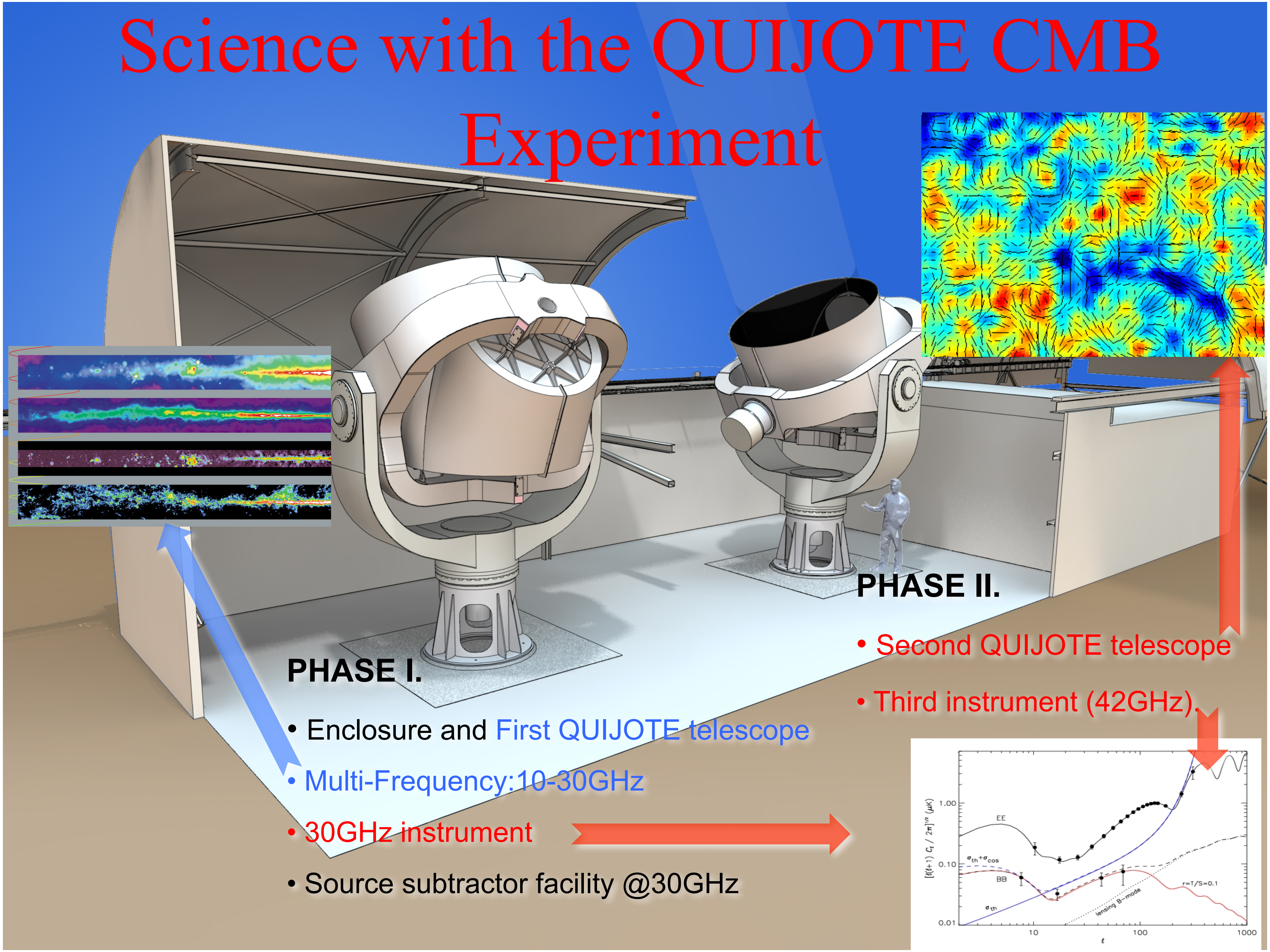
$$\Delta Q = \Delta U = \sqrt{2}\frac{T_{sys}}{\sqrt{\Delta\nu \times t_{int} \times N_{chan}}}$$

Thirty-GHz Instrument (TGI)

- 31 polarimeters at 30 GHz (4 channels each).
- Nominal sensitivity: 50 μK $s^{1/2}$



- MFI not appropriate for long-term operations required for TGI.
- New design: We have modified the receiver configuration by replacing the rotating polar modulator with a fixed polarizer
- It includes a fixed polarizer and 90 and 180 phase switches to generate four polarisation states to minimize the different systematics in the receiver.


Science with the QUIJOTE CMB Experiment
PHASE I.
• Enclosure and First QUIJOTE telescope
• Multi-Frequency:10-30GHz
• 30GHz instrument
• Source subtractor facility @30GHz
PHASE II.
• Second QUIJOTE telescope
• Third instrument (42GHz).
EE
BB
r=T/S=0.1
lensing B-mode
1.00
0.10
0.01
10
100
1000

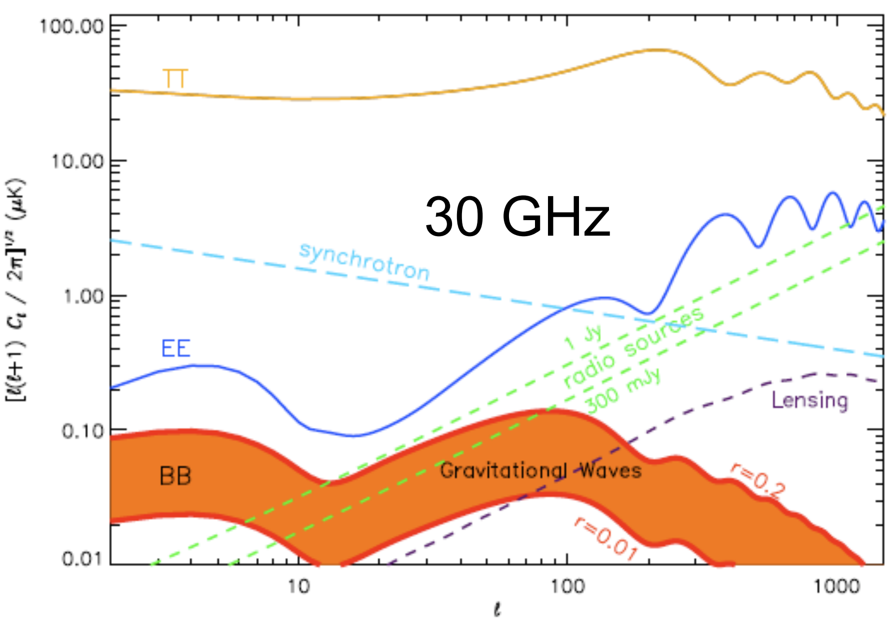
Science with QUIJOTE first instrument (MFI)

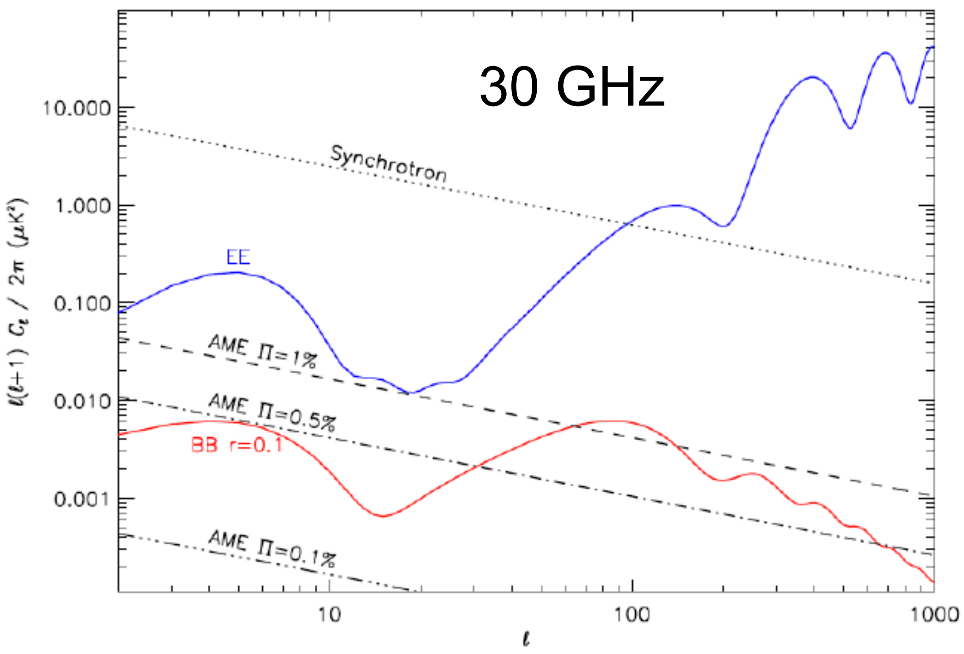
Two large surveys in polarization:

- Wide Galactic survey. **It will cover 20,000 deg^2, and will be finished after 3 months of** observations with each instrument (half-way through with the MFI). Expected sensitivities:
  - **~14 μK/(beam 1^o) with the MFI @ 11, 13, 17 and 19 GHz, in both Q and U**
  - **≤ 3 μK/(beam 1^o) with the TGI @ 30 GHz and with the FGI @ 40 GHz**
- Deep cosmological survey. **It will cover around 3,000 deg^2. Expected sensitivities after 1** year:
  - **≈ 5 μK/(beam 1^o) with the MFI @ 11, 13, 17 and 19 GHz**
  - **≤ 1 μK/(beam 1^o) with the TGI @ 30 GHz and with the FGI @ 40 GHz**

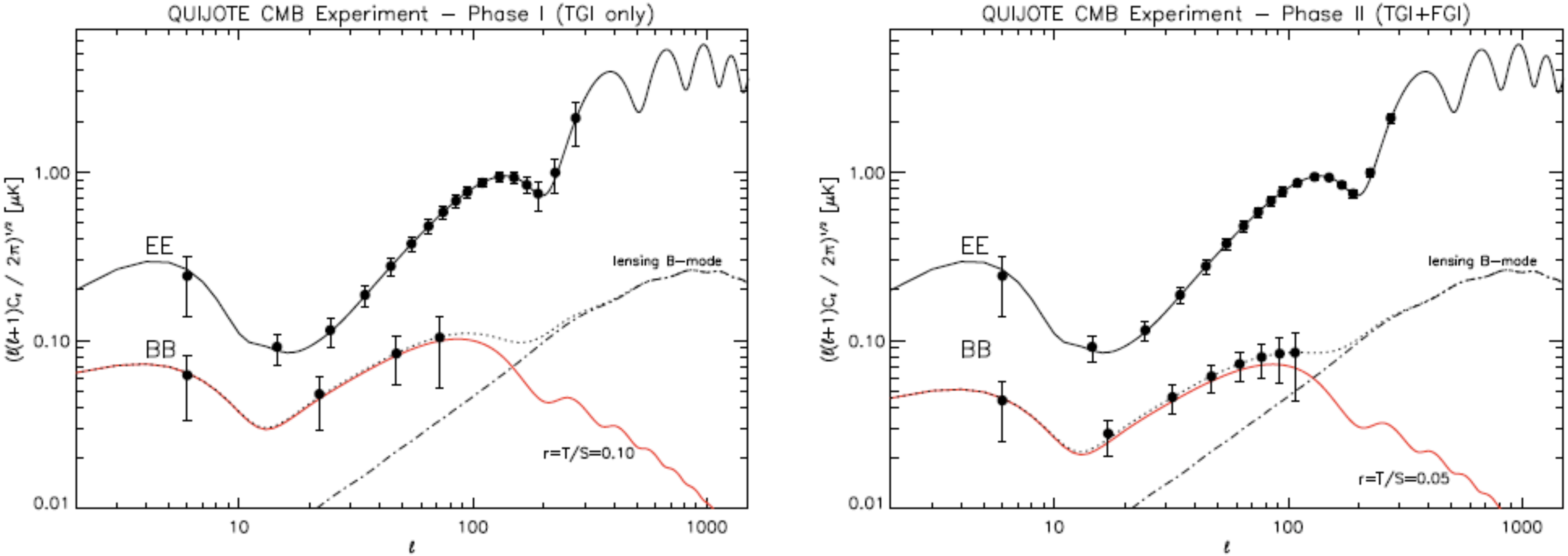
Science with QUIJOTE first instrument (MFI)

- These maps will provide valuable information about the **polarization** properties of:
  - Synchrotron emission: it should dominate the emission at our frequencies
  - Anomalous microwave emission (spinning dust? little known about its polarization).
  - Radio-sources: low contribution at degree scales, but relevant for B-modes science.
- Maps used to clean the 30 GHz and 40 GHz maps of the 2nd and 3rd QUIJOTE instruments (TGI and FGI).
- Excellent complement to Planck at low frequencies.





Science with QUIJOTE second (TGI) and third (FGI) instruments



Left: Example of the QUIJOTE-CMB scientific goal after the Phase I. It is shown the case for 1 year (effective) observing time, and a sky coverage of 3, 000 deg2. The red line corresponds to the primordial B-mode contribution in the case of r = 0.1.

Right: QUIJOTE-CMB Phase II. Here we consider 3 years of effective operations with the TGI, and that during the last 2 years, the FGI will be also operative. The red line now corresponds to r = 0.05.

Commissioning phase

(November 2012 – March 2013)

- Calibrators (>100 hrs observing CRAB, CASS-A, Moon, Jupiter).
- Polarization tests.
- Local interference map (~10 hrs)
- Tsys calibration (~10hrs).
- Science demonstration cases:
    - Cygnus loop (~1hr)
    - Fan region (> 135 hrs)
    - Perseus molecular cloud (>170hrs)

Science phase

(April 2013 - now)

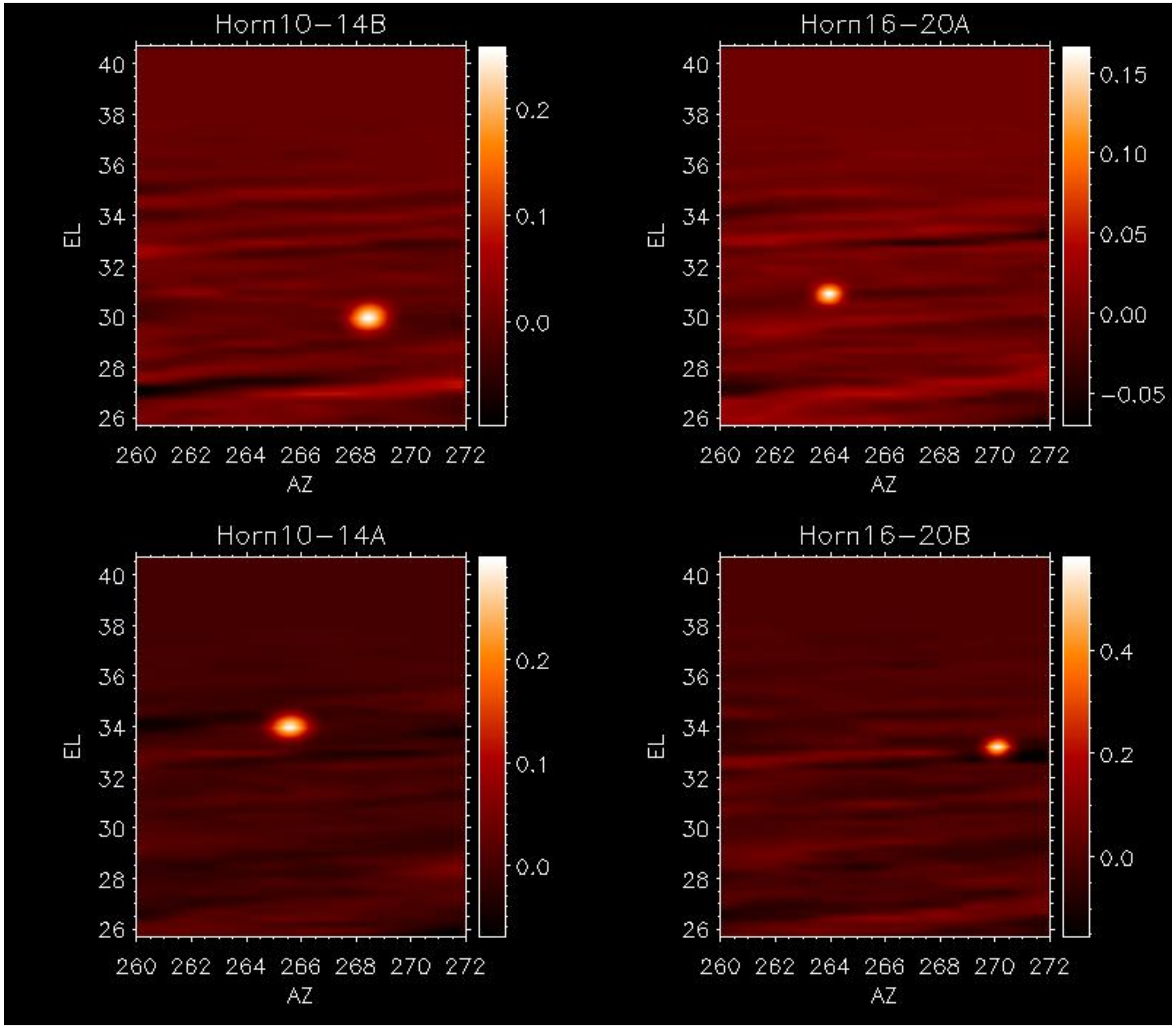
- Wide survey (almost completed)
- Daily calibrators.
- Fan region.

Observing efficiency **~ 85%** (including bad weather & technical problems).

Observing modes:

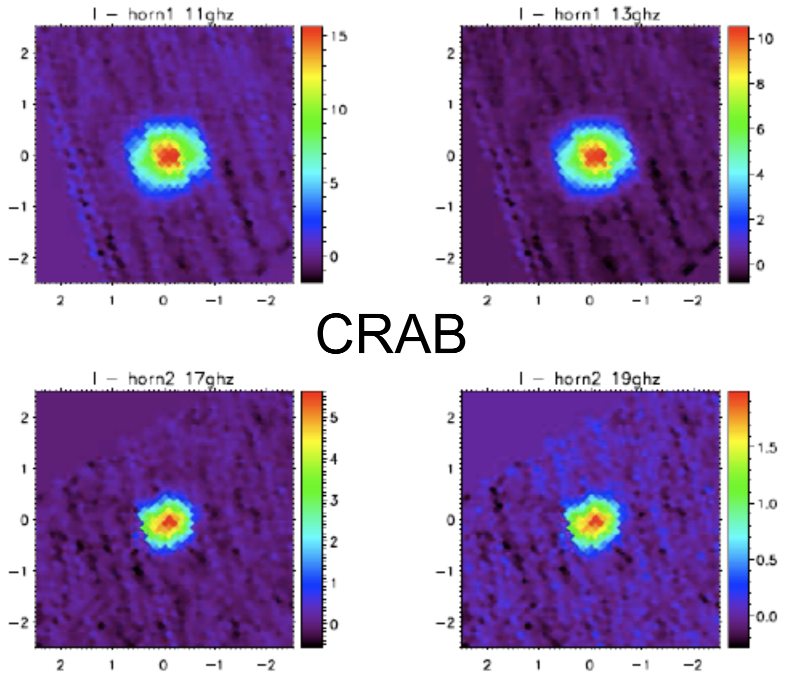
1. Nominal: fast spinning at fixed elevation. Earth rotation provides daily sky coverage of several thousand sq degrees. (→Wide survey)
1. Raster and Tracking observations are also possible (→Cosmological fields, calibrators, galactic fields).

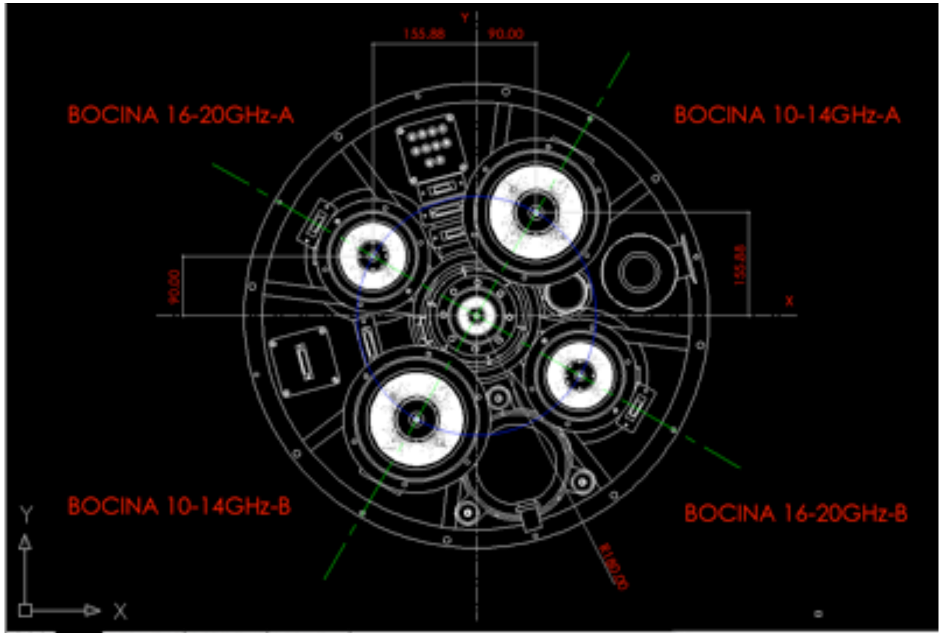
Technical First Light: the Moon seen through clouds



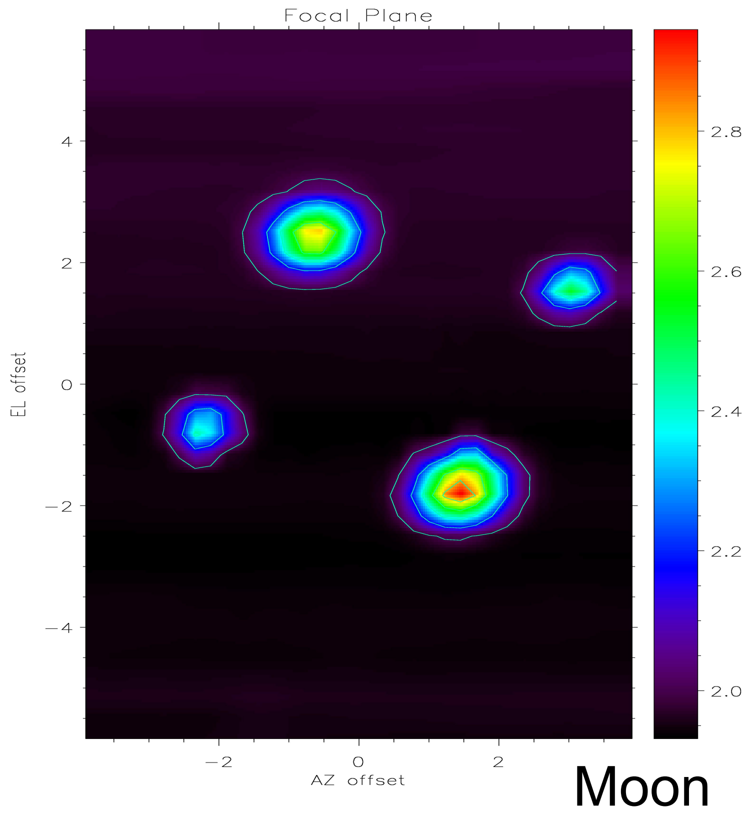
Nov 6th, 2012

Focal plane and beams



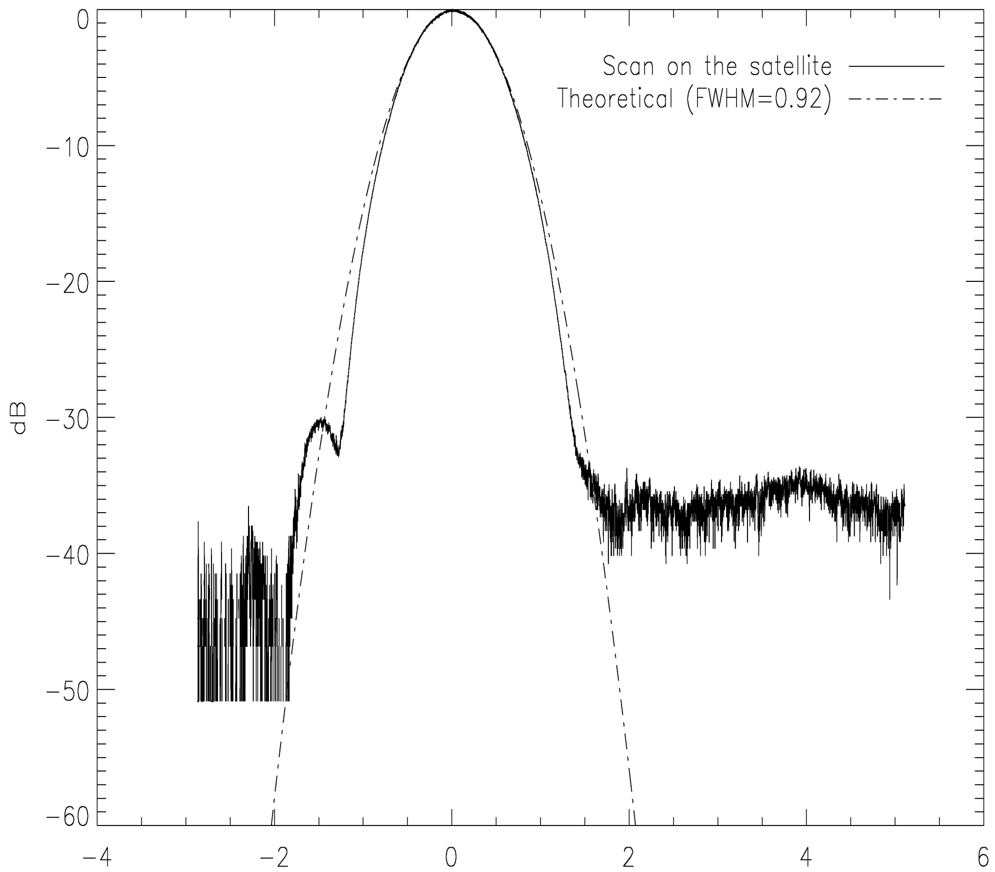


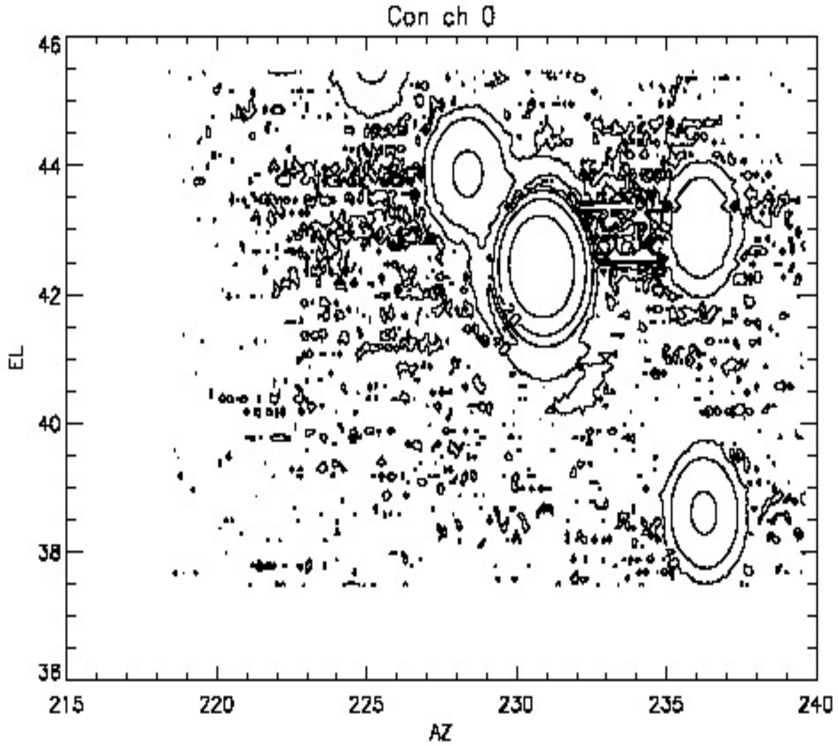
Horn	FWHM AZ (deg)	FWHM EL (deg)
1 - 11 GHz	0.89	0.88
1 - 13 GHz	0.89	0.89
2 - 19 GHz	0.66	0.67
3 - 11 GHz	0.81	0.85
3 - 13 GHz	0.82	0.88
4 - 19 GHz	0.63	0.66

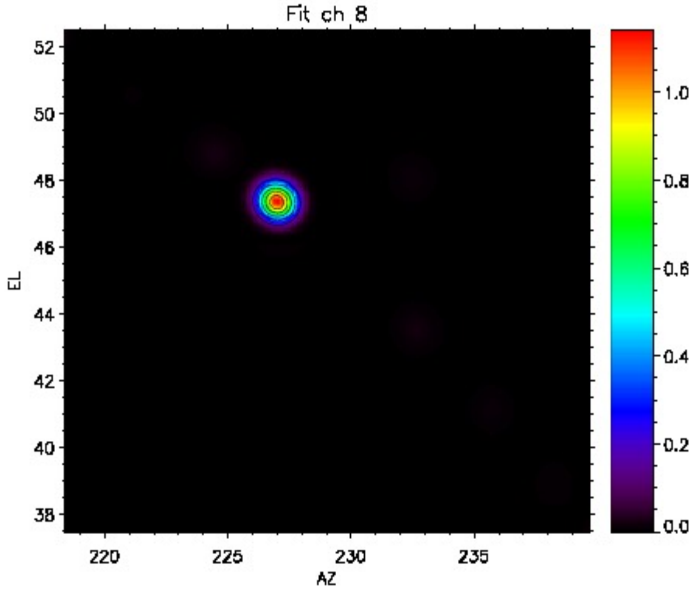


Focal plane and beams

- Geo-stationary satellites can be used in the low frequency channels.
- First side lobes below -30dB.







MFI - Noise properties

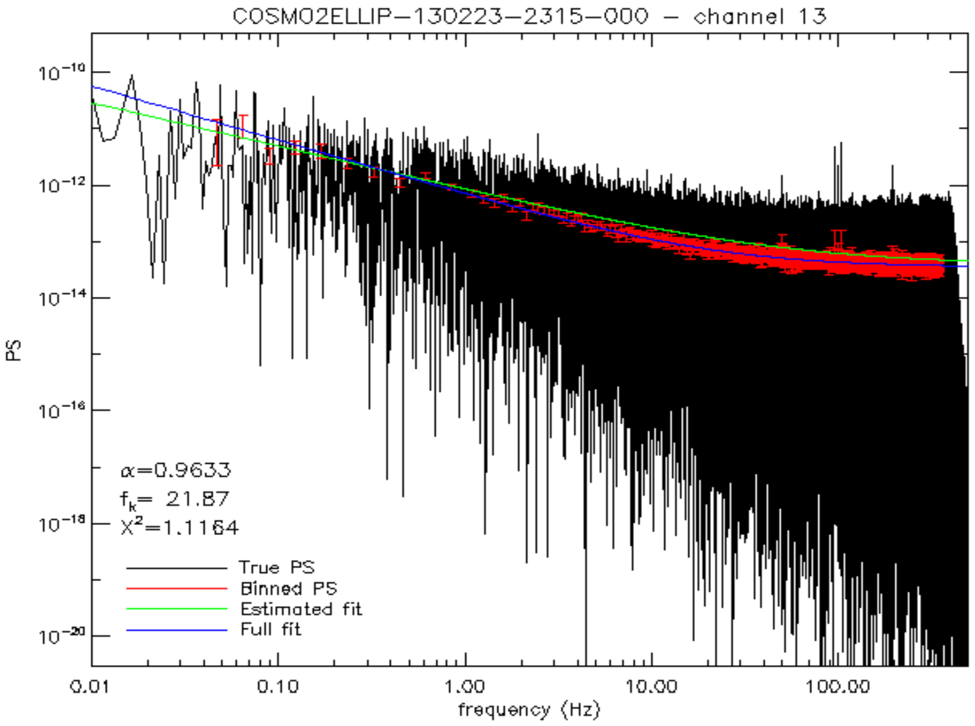
○ Noise power spectrum is measured using long observations of blanck fields.

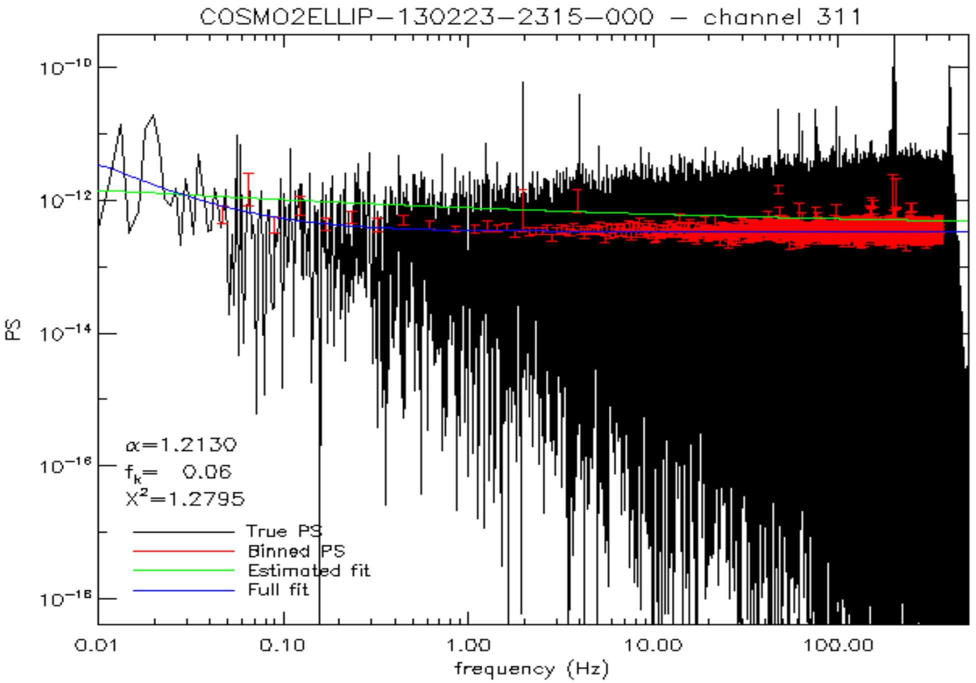
○ There is a 2Hz signal + harmonics which suggests the cooler frequency. It is also visible a 50Hz signal.

○ The anti-aliasing filter cuts off at >400Hz.

○ The 1/f noise knee frequency (in intensity) is generally < 10-20Hz.

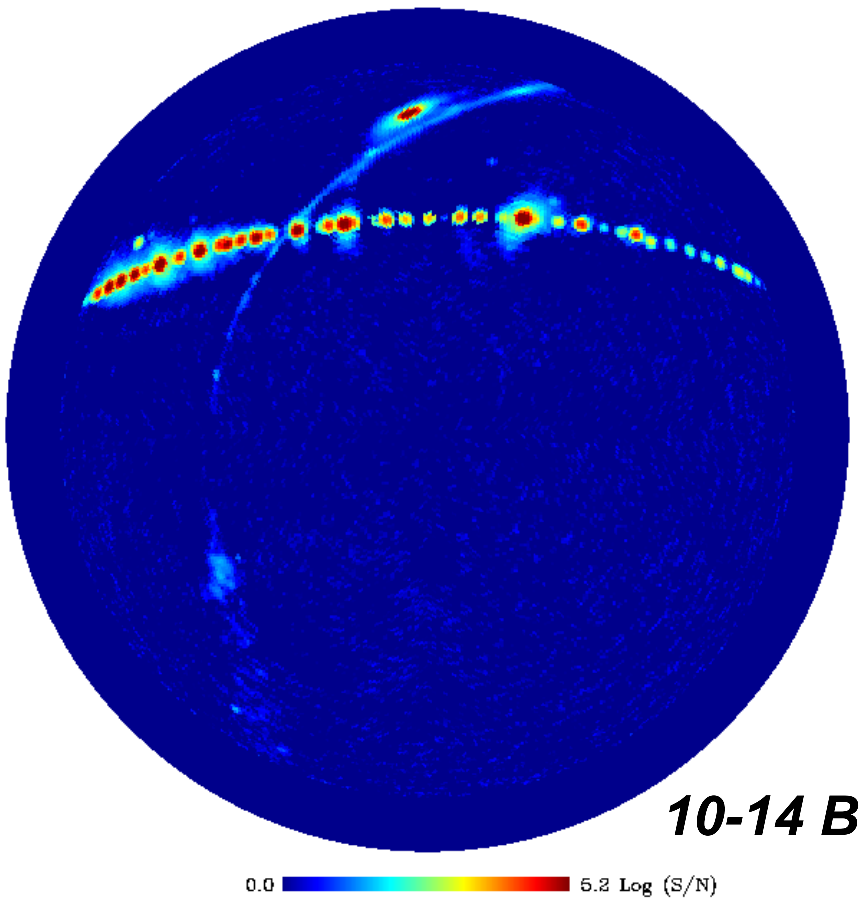
○ When subtracting correlated channels instantaneously, the knee frequency is effectively reduced.

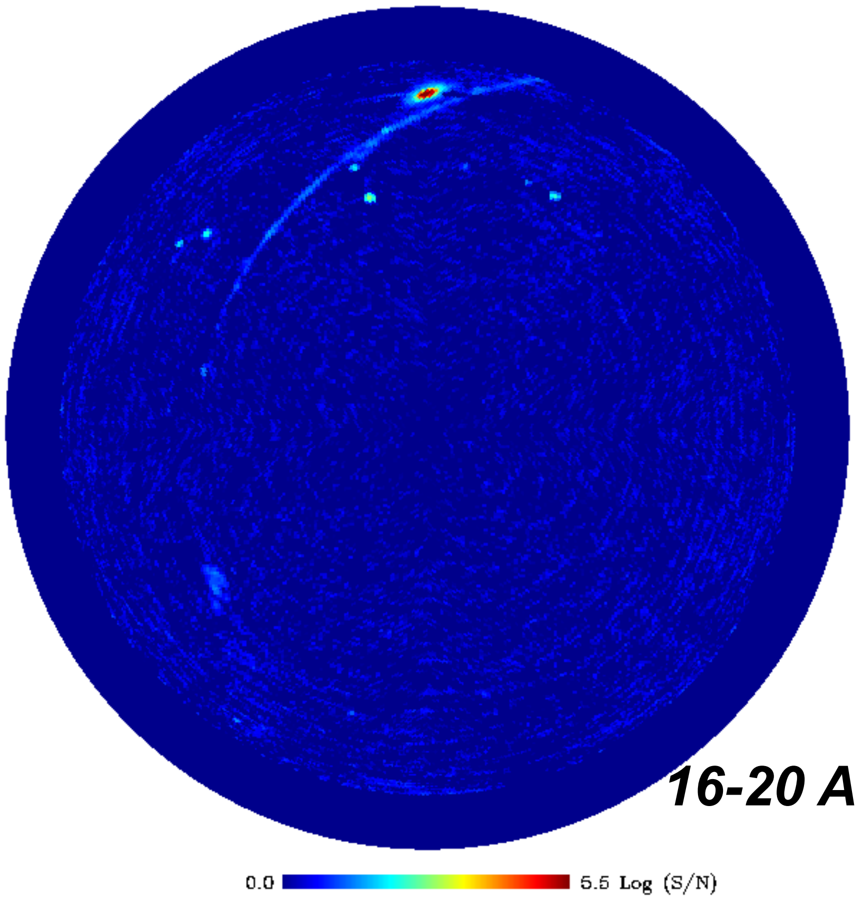




LOCAL interference maps – Radio contamination

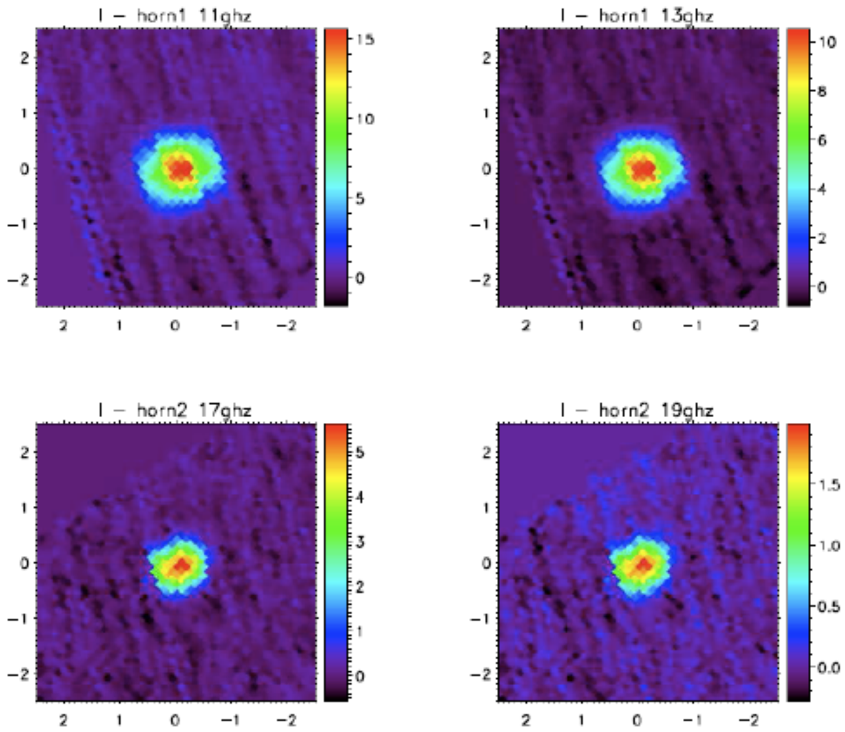
• Uses nominal mode, and it represents local coordinates centred at zenith (N is bottom, E is left). A full map is produced in 3hrs, covering from EL=30º to 90º with steps of 0.2º, and telescope velocity of 4deg/s.
• This example was taken on Dec 27th 2012, during the morning (the Sun is visible).
• Stripe of geo-stationary satellites at declination 0º is seen in the 10-12GHz band.



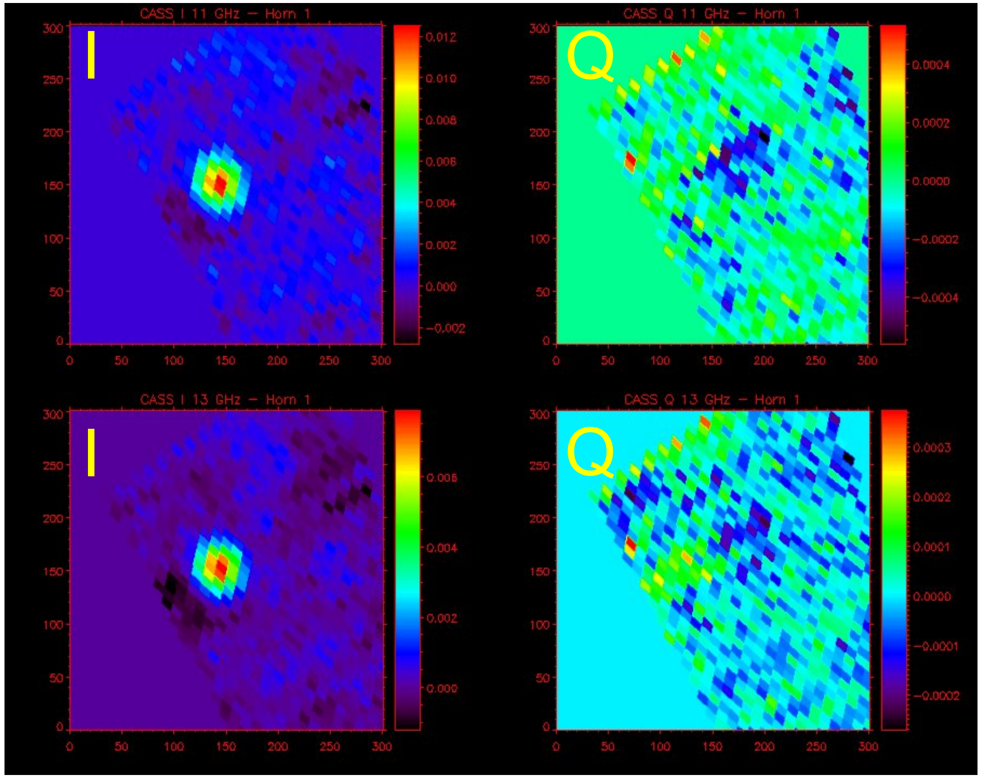


Photometric calibrators

CRAB (TauA)



Cass-A



Typical integration on source: 10 s

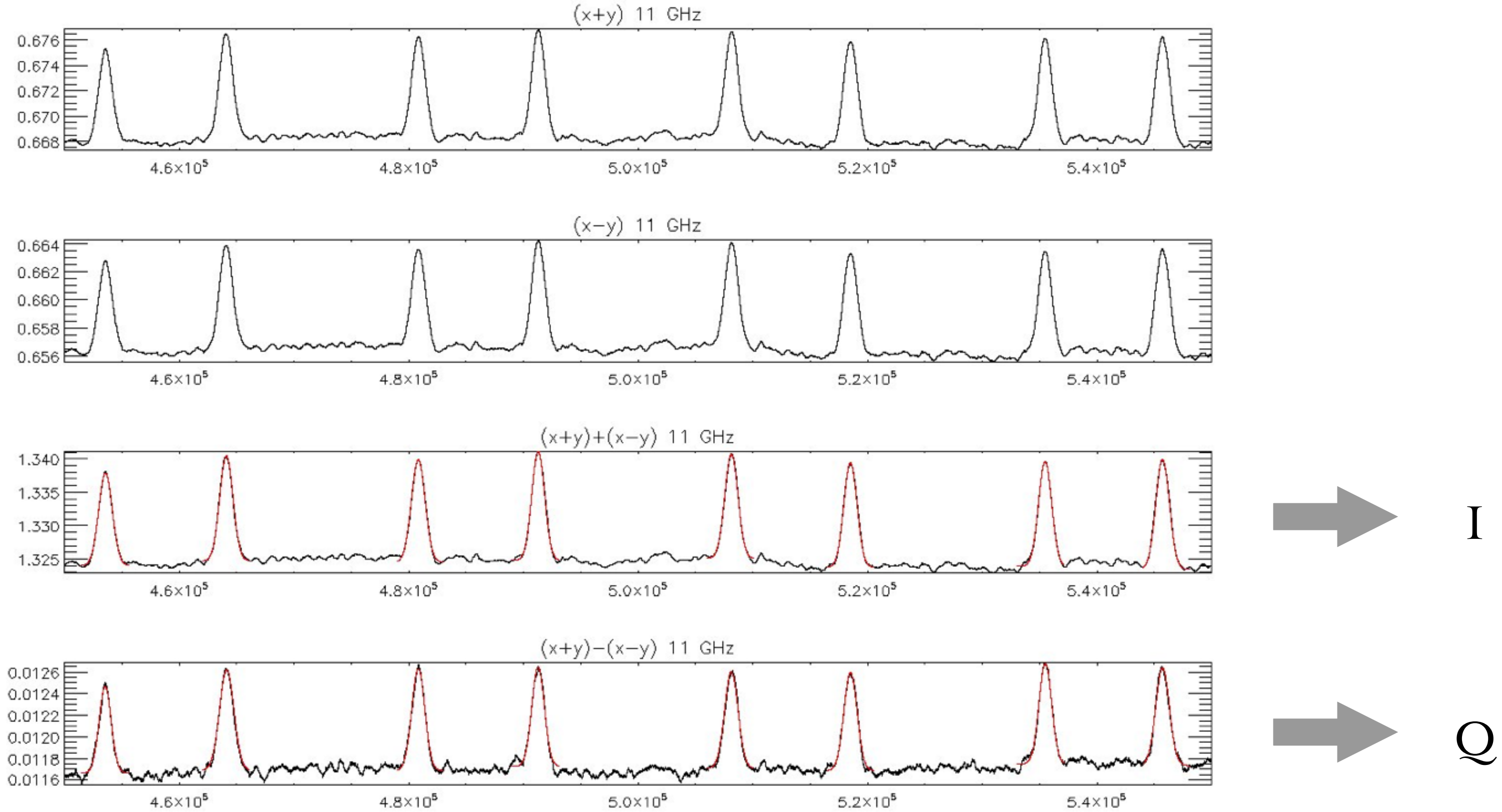
Crab P=7%

Cass A   P=0.7%

Cass-A - null polarization calibrator to adjust the gain mismatch between pairs of channels

Polarization calibrators: CRAB

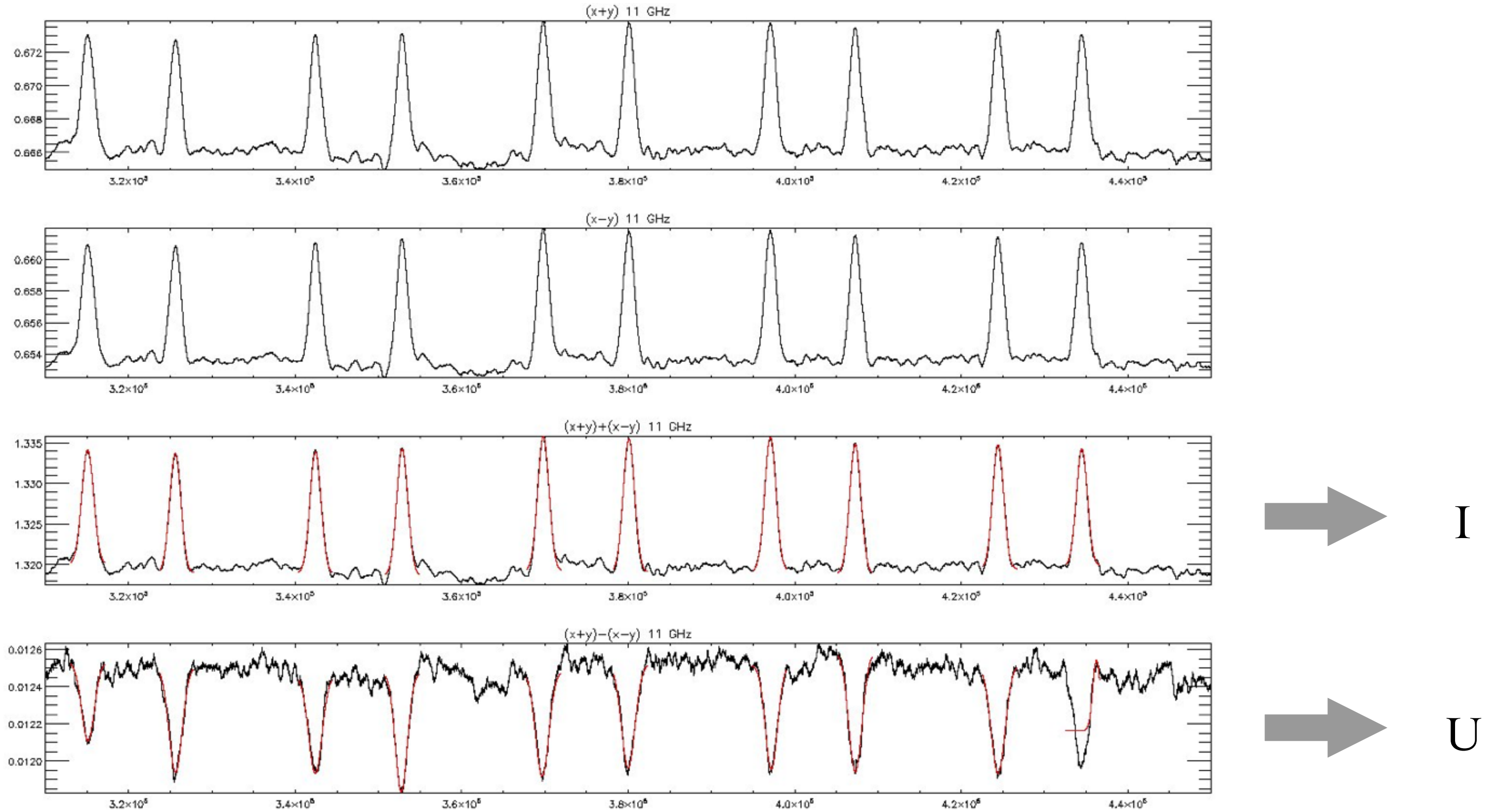
Crab observations on 15/11/2012: Modulators fixed at 0º



$\langle Q/I \rangle = 0.0579 \pm 0.002$

Polarization calibrators: CRAB

- Crab observations on 15/11/2012: Modulators fixed at 22.5º

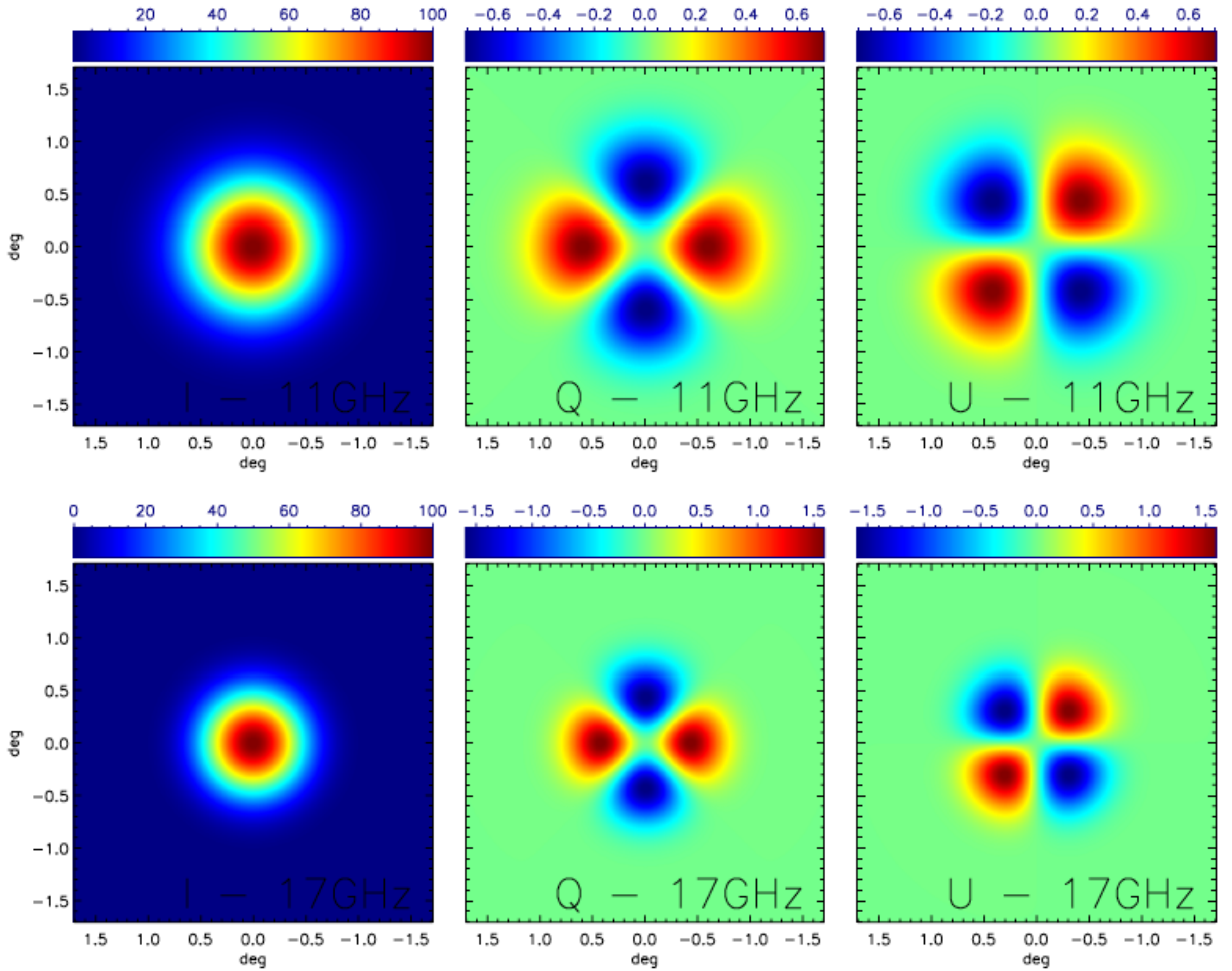


<U/I> = -0.0360±0.004

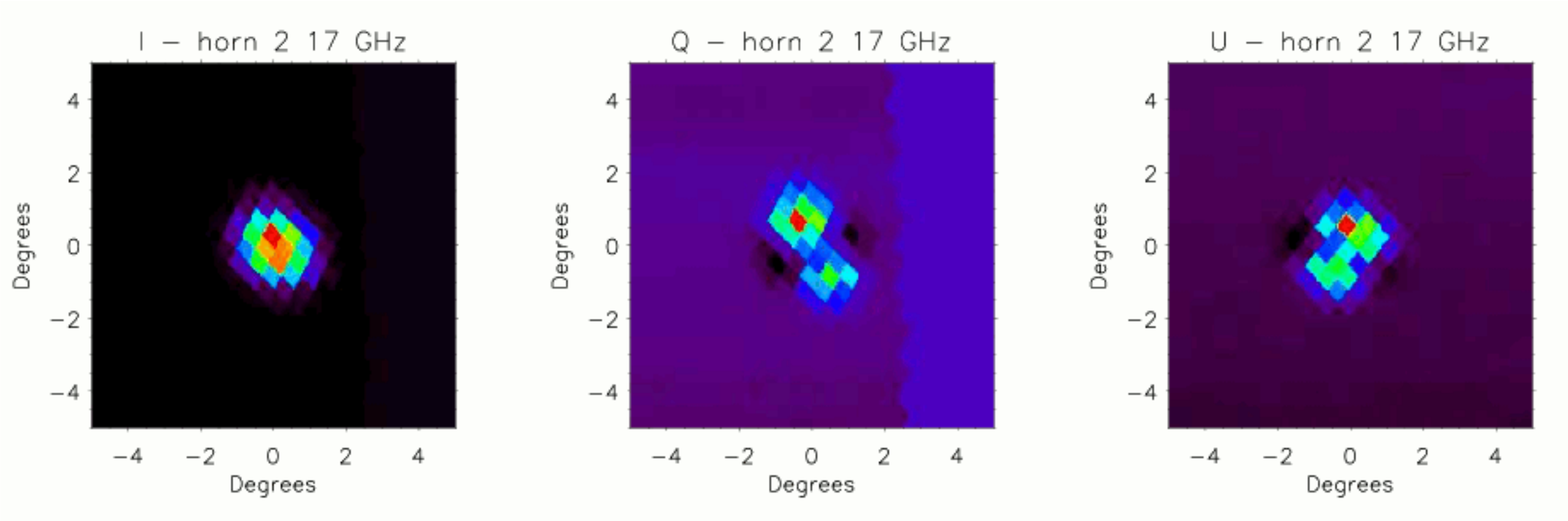
<P/I> = 6.8±0.8 % at 11 GHz (Consistent with WMAP 23 GHz, *7.08±0.25%*)

Moon model

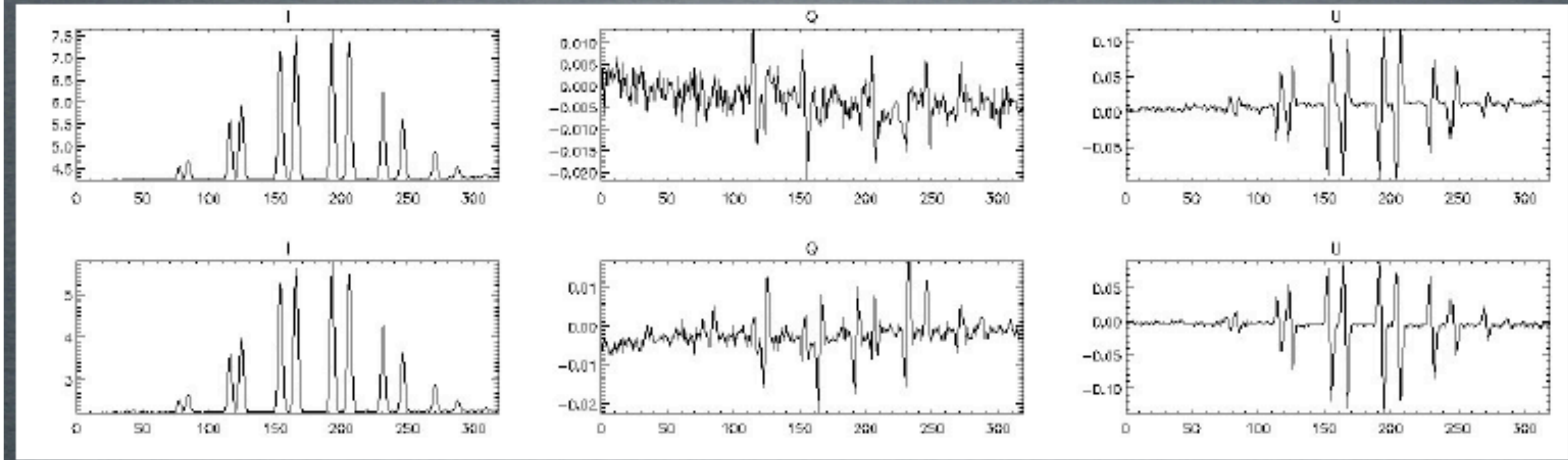
- Dielectric sphere of refractive index n_i=1.8 at uniform temperature (see Davies & Gardner 1966; Bischoff 2010).



Moon Maps at 17 GHz of Stokes I, Q and U (integration time of 1 min on source)

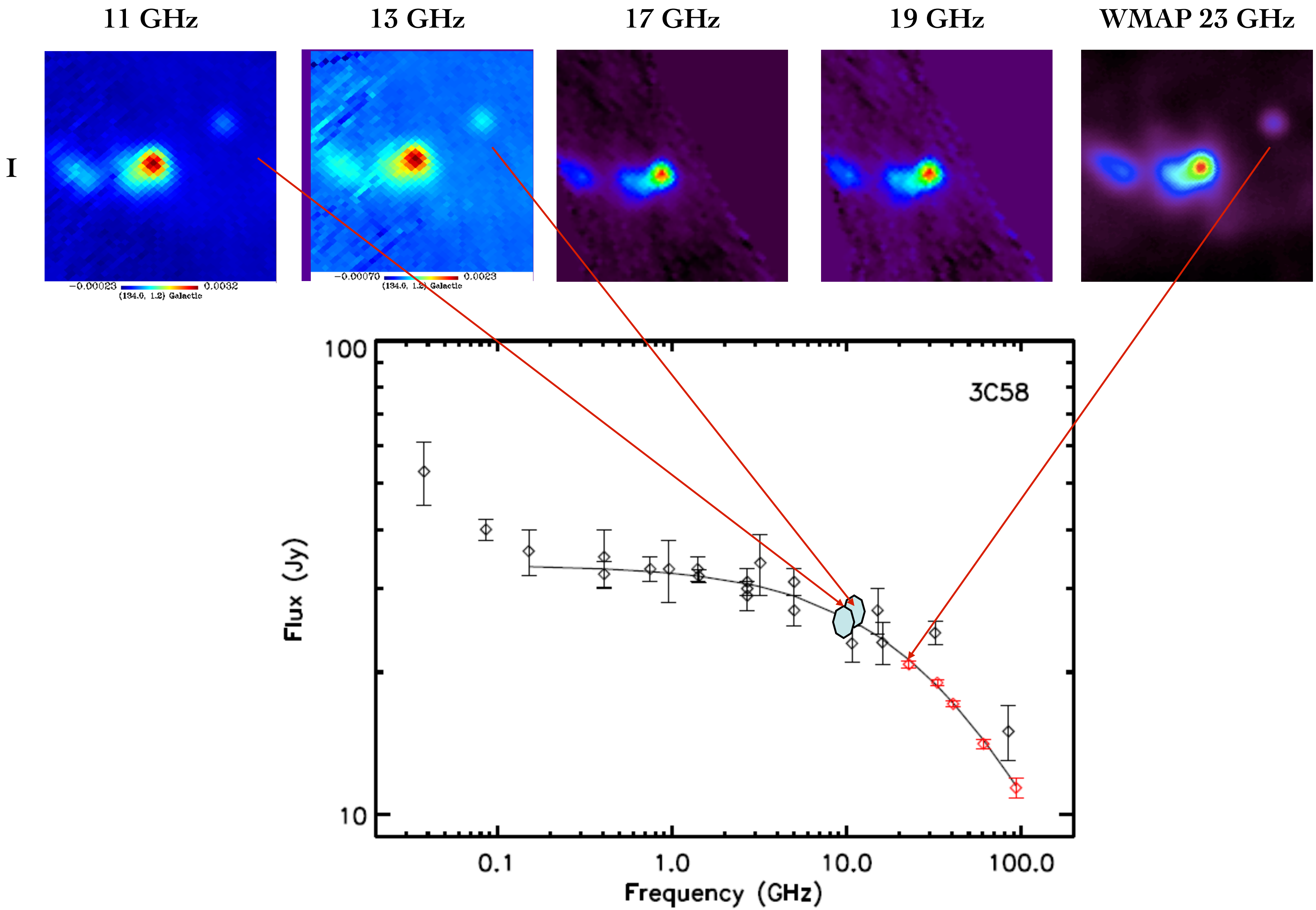


• Moon observations on 22/11/2012 (continuous movement of the modulators):



Fan maps

QUIJOTE Observations of 3C 58

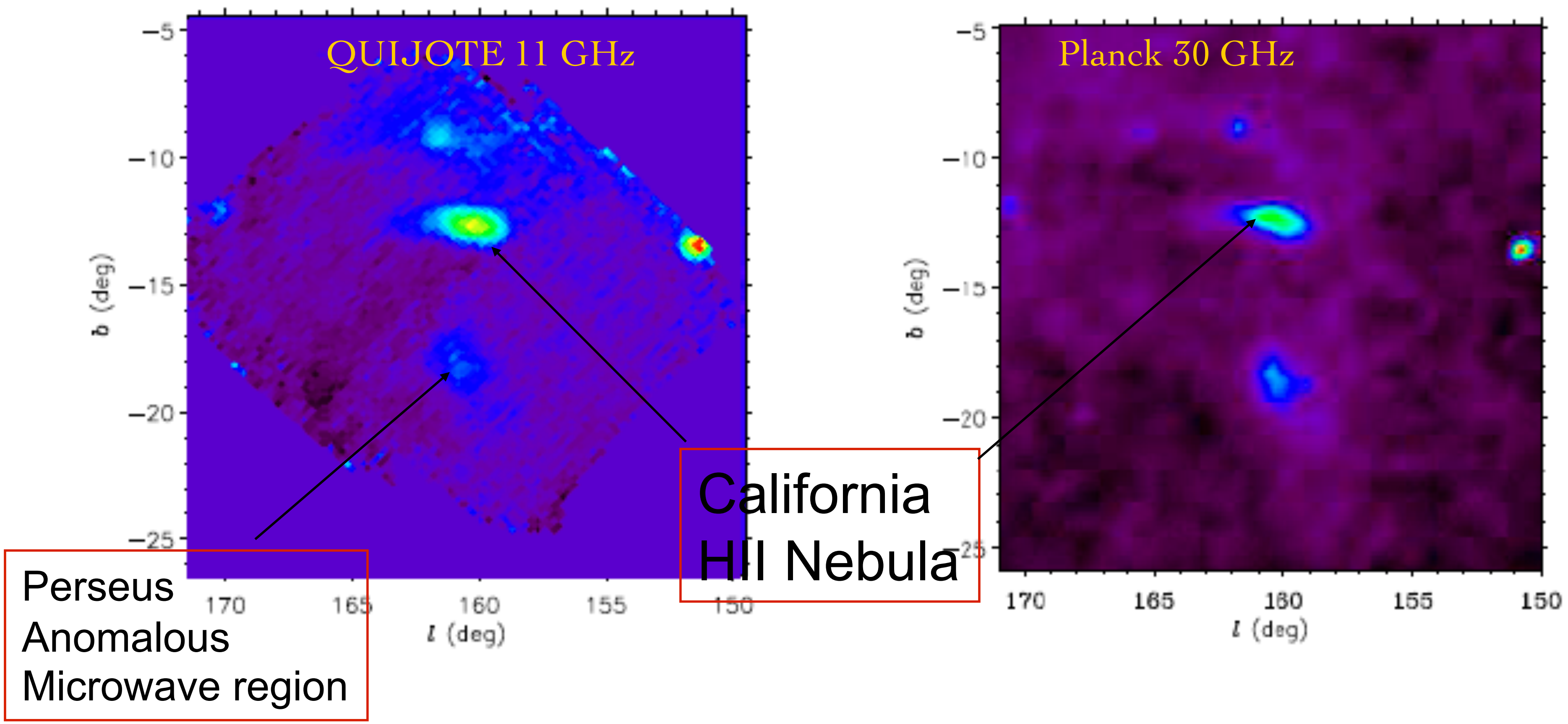


Perseus molecular complex

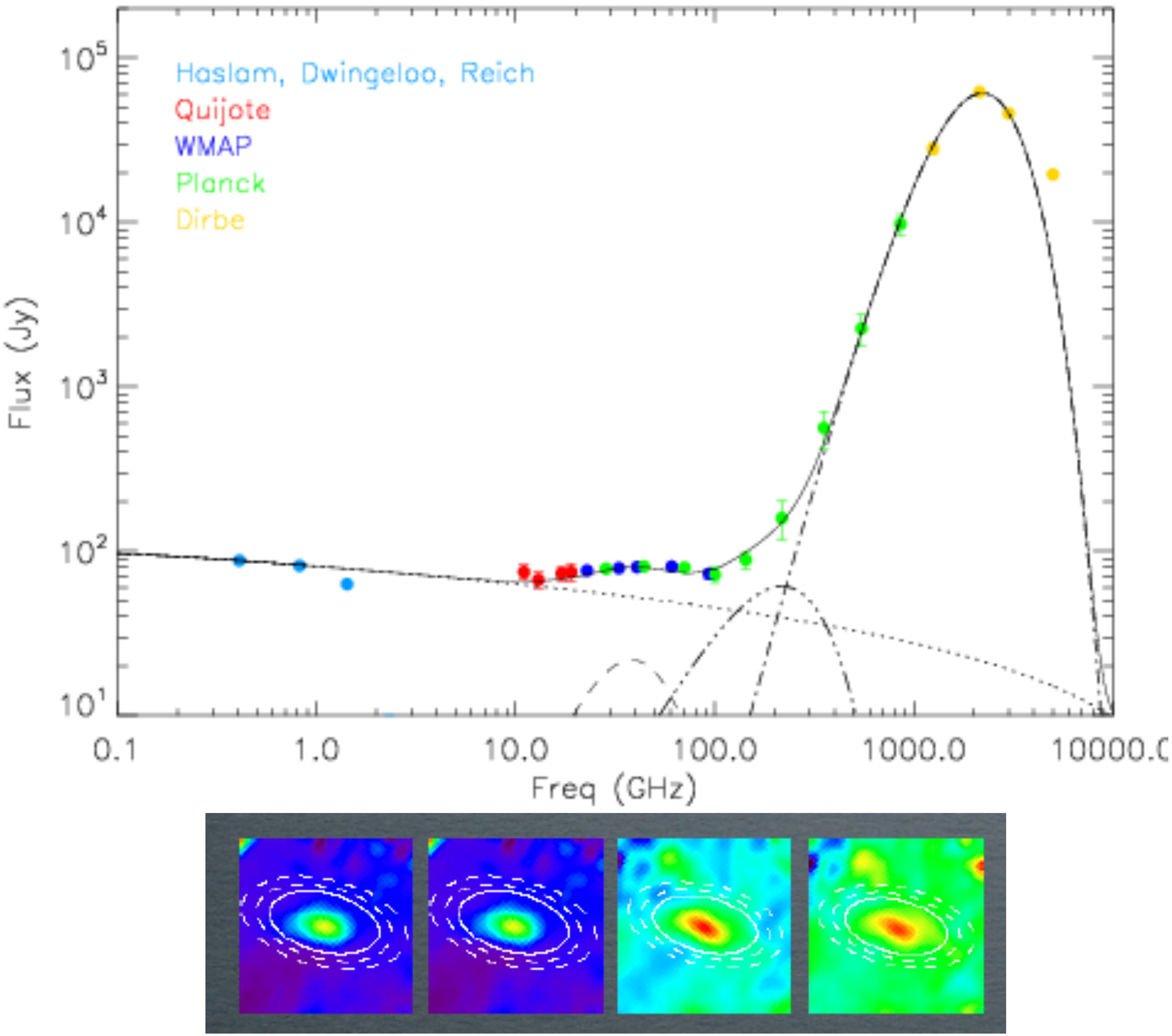
★ Large observation programme (~150 hours, from December 2012, still ongoing), on an area covering ~200 deg^2 around the Perseus molecular complex. One of the brightest AME regions on the sky (Watson et al. 2005; Planck collaboration 2011)

★ Also covering the California nebula (HII region - null polarization control region)

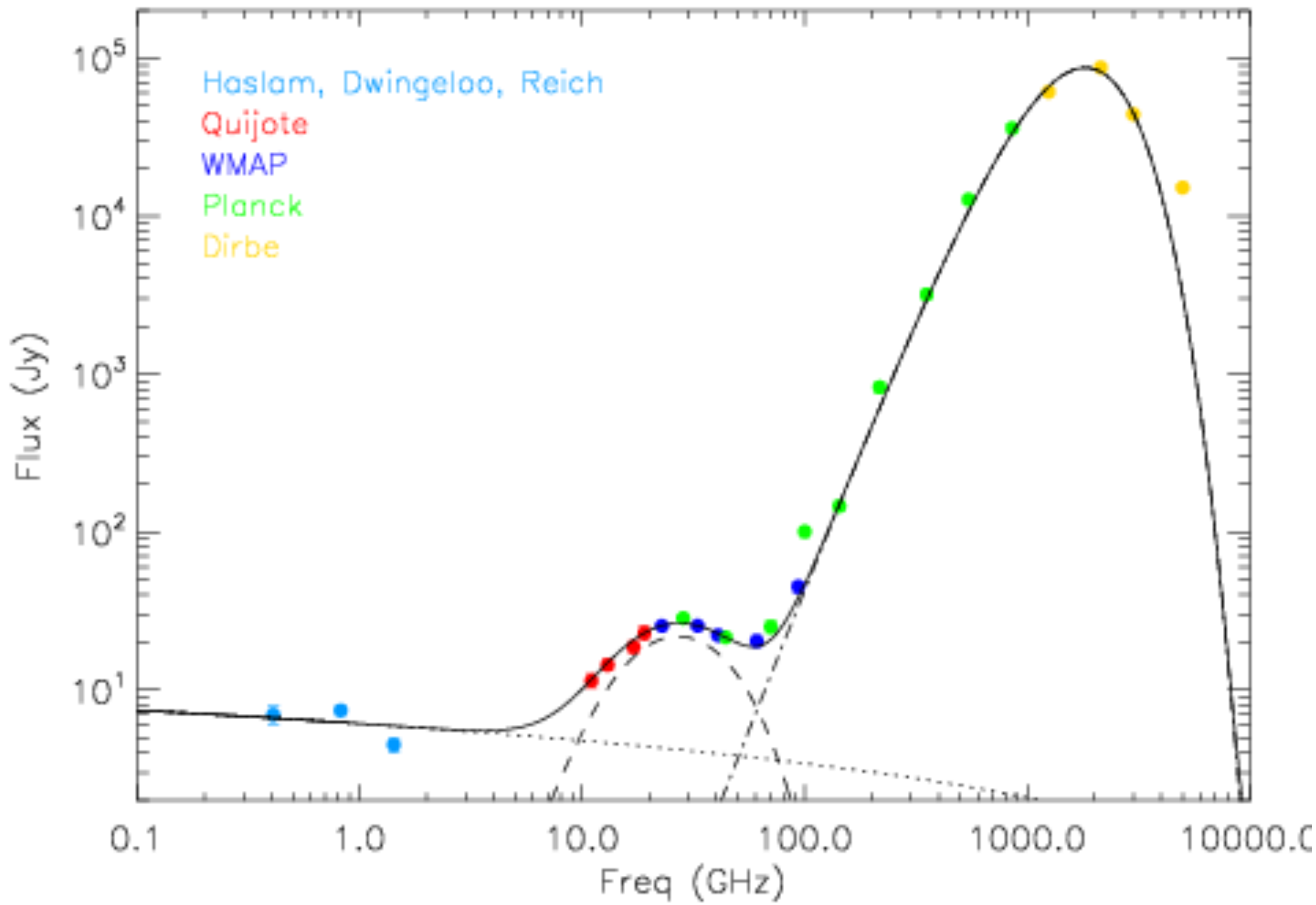
Final integration time of ~ 2500 s/beam, yielding a sensitivity of ~ 40 mJy/beam in Q and U

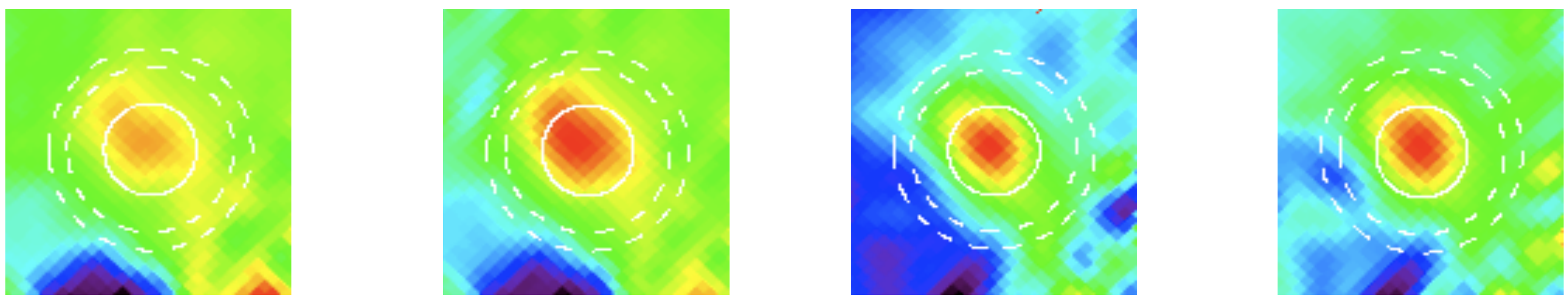


California HII region



Perseus G160.26-18.62





Polarization of the Anomalous Microwave Emission

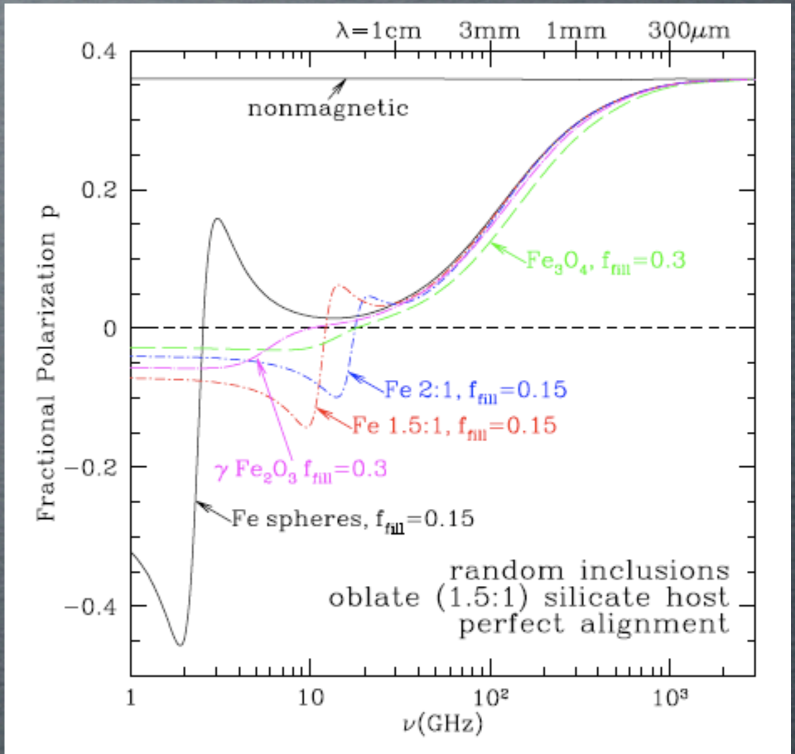
★ Forecasts of the level of contamination for B-mode experiments

★ Probing the electric and magnetic dipole emission models:

• Electric and dipole emissions present different polarization spectra

• Magnetic dipole emission, in the case of single-domain grains (no Fe inclusions) is expected to be strongly polarized (up to ~30% for ν> 40 GHz; Draine & Lazarian 1999). However, magnetic inclusions produce lower polarizations (<10% at ν ~ 30 GHz; Draine & Hensley 2012)

• Electric dipole emission (spinning dust) is weakly polarized (under ~2% above 20 GHz; Lazarian & Draine 2000)



Draine & Hensley 2012

Current status of AME polarization measurements

Name	Experiment	Resolution	Π [%] 9-11 GHz	22 GHz	30-33 GHz	44 GHz	Reference
Galactic AME regions							
Perseus	COSMOSOMAS	1°	$3.4^{+1.5}_{-1.9}$				Battistelli et al. (2006)
"	WMAP7	1°		< 1.01	< 1.79	< 2.69	López-Caraballo et al. (2011)
"	WMAP7	1°		< 1.4	< 1.9	< 4.7	Dickinson et al. (2011)
ρ-Ophiuchi	CBI	$\sim 9'$			< 3.2		Casassus et al. (2008)
"	WMAP7	1°		< 1.7	< 1.6	< 2.6	Dickinson et al. (2011)
LDN1622	GBT	$\sim 6'$	< 2.7				Mason et al. (2009)
"	WMAP7	1°		< 2.6	< 4.8	< 8.3	Rubiño-Martín et al. (2012)
Pleiades	WMAP7	1°		< 12.2	< 32.0	< 95.8	Rubiño-Martín et al. (2012)
LPH96	CBI	$\sim 9'$			< 10		Dickinson et al. (2006)
"	WMAP7	1°		< 1.3	< 2.5	< 7.4	Rubiño-Martín et al. (2012)
Helix	CBI	$\sim 9'$			< 8		Casassus et al. (2007)
Diffuse Galactic AME							
Full-Sky	WMAP3	1°		< 1	< 1	< 1	Kogut et al. (2003)
Full-Sky	WMAP5	1°		< 5			Macellari et al. (2011)

Table from Rubiño-Martin et al. (2012).

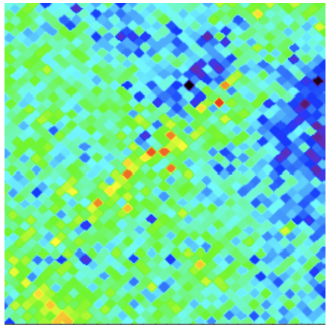
QUIJOTE Polarization maps in Perseus

No sources in the field with flux > 0.6 Jy

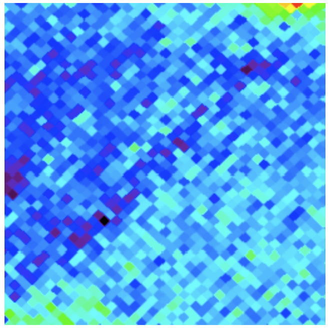
PRELIMINARY

Q maps

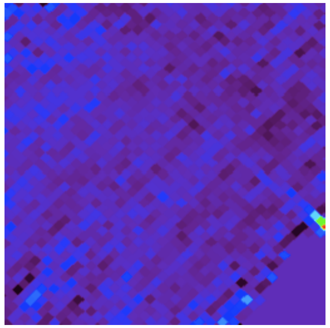
11 GHz



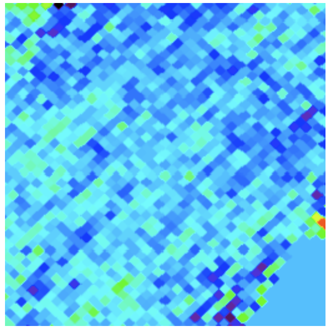
13 GHz



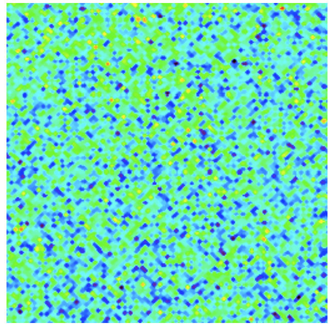
17 GHz



19 GHz

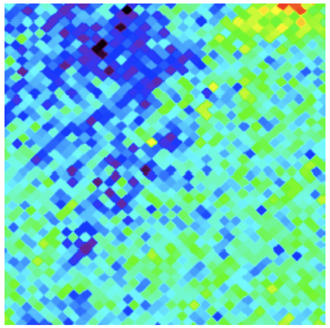


WMAP 23 GHz

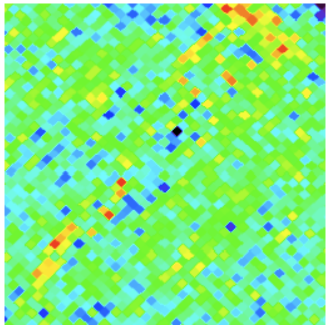


U maps

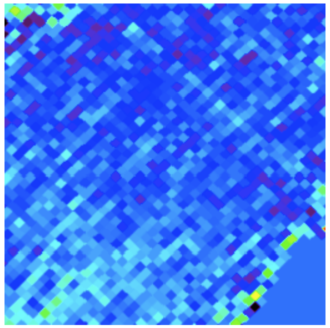
11 GHz



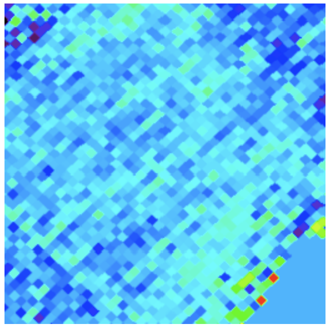
13 GHz



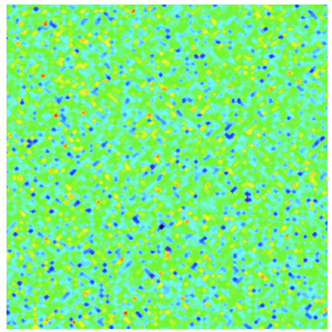
17 GHz



19 GHz

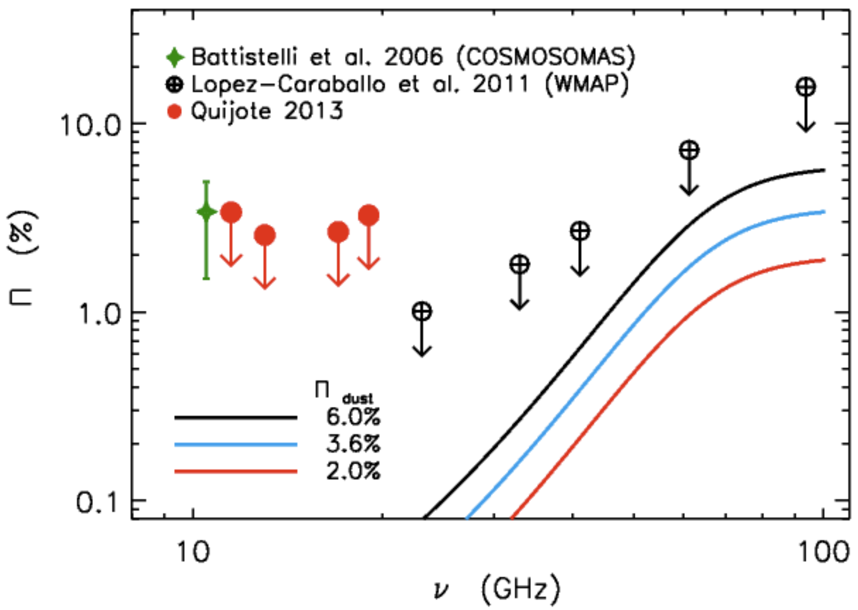


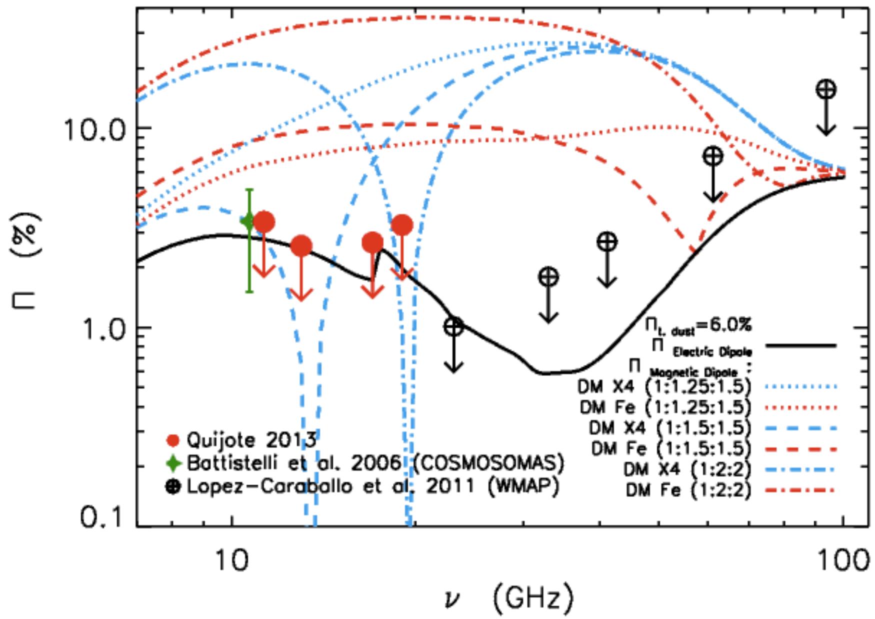
WMAP 23 GHz



Perseus: Polarization upper limits

ν (GHz)	I (Jy)	Q (Jy)	U (Jy)	P (Jy)	P_{db} (Jy)	Π (%)	Π_{db} (%)
11	11.4 ± 1.1	0.07 ± 0.35	0.30 ± 0.27	0.30 ± 0.27	< 0.39	2.66 ± 2.39	< 3.385
13	14.4 ± 1.1	0.12 ± 0.29	0.22 ± 0.33	0.26 ± 0.32	< 0.37	1.78 ± 2.24	< 2.557
17	18.7 ± 1.6	-0.25 ± 0.40	0.28 ± 0.39	0.38 ± 0.40	< 0.50	2.02 ± 2.12	< 2.664
19	22.9 ± 2.4	-0.30 ± 0.70	0.35 ± 0.61	0.46 ± 0.65	< 0.74	2.00 ± 2.83	< 3.260

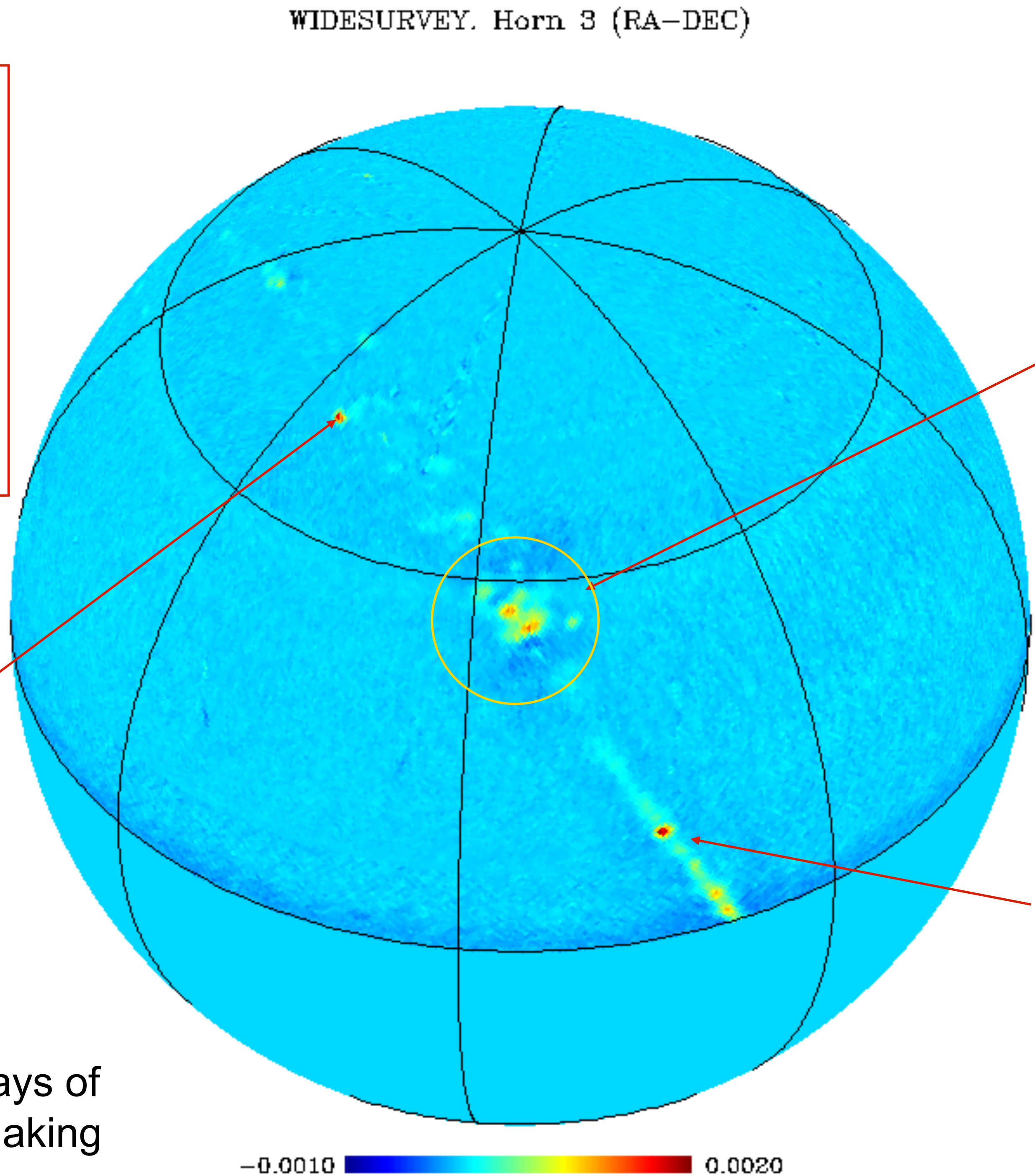




QUIJOTE Northern Hemisphere Survey

(20000 sq deg)

On-going



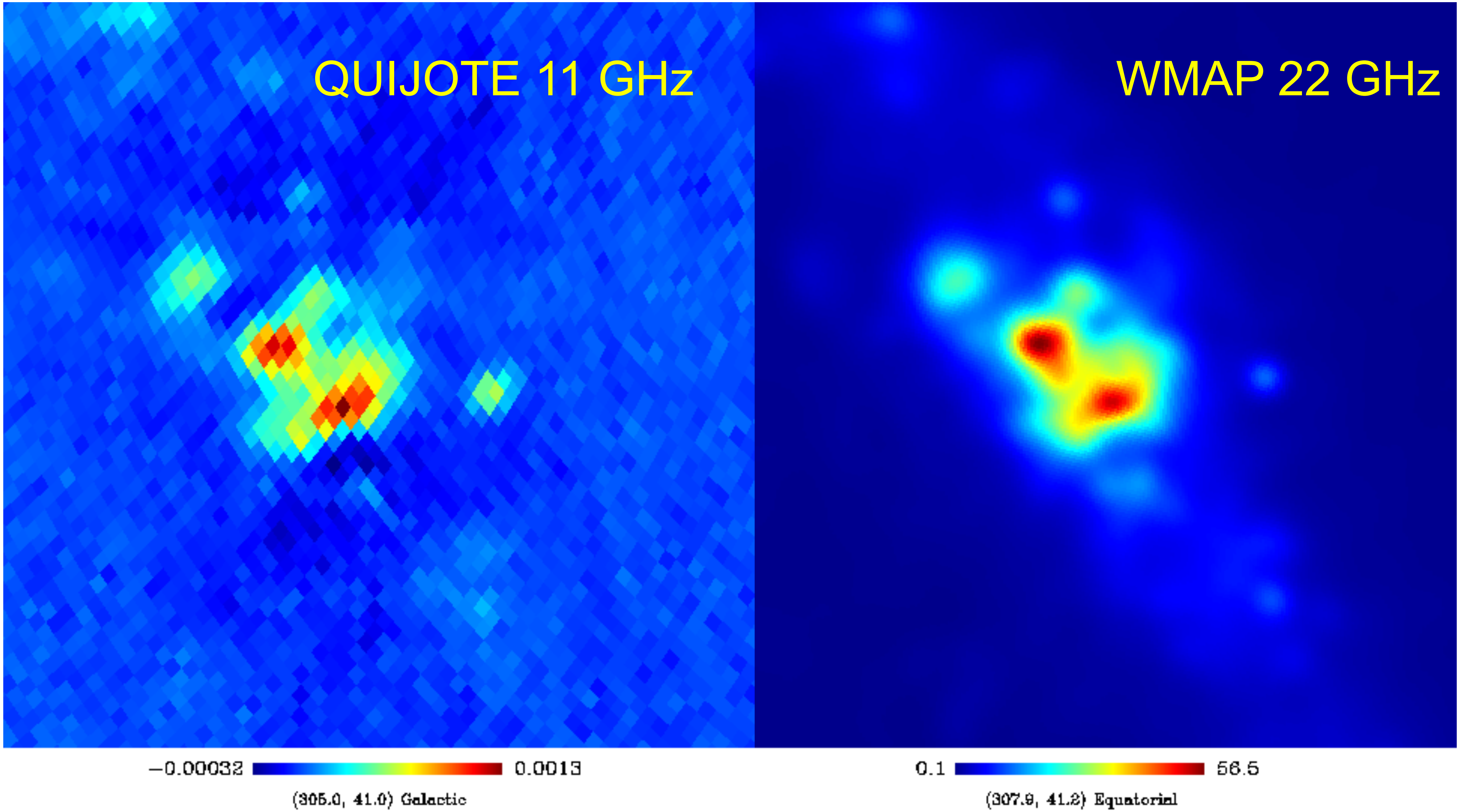
Cygnus complex

Cass A
SN remnant

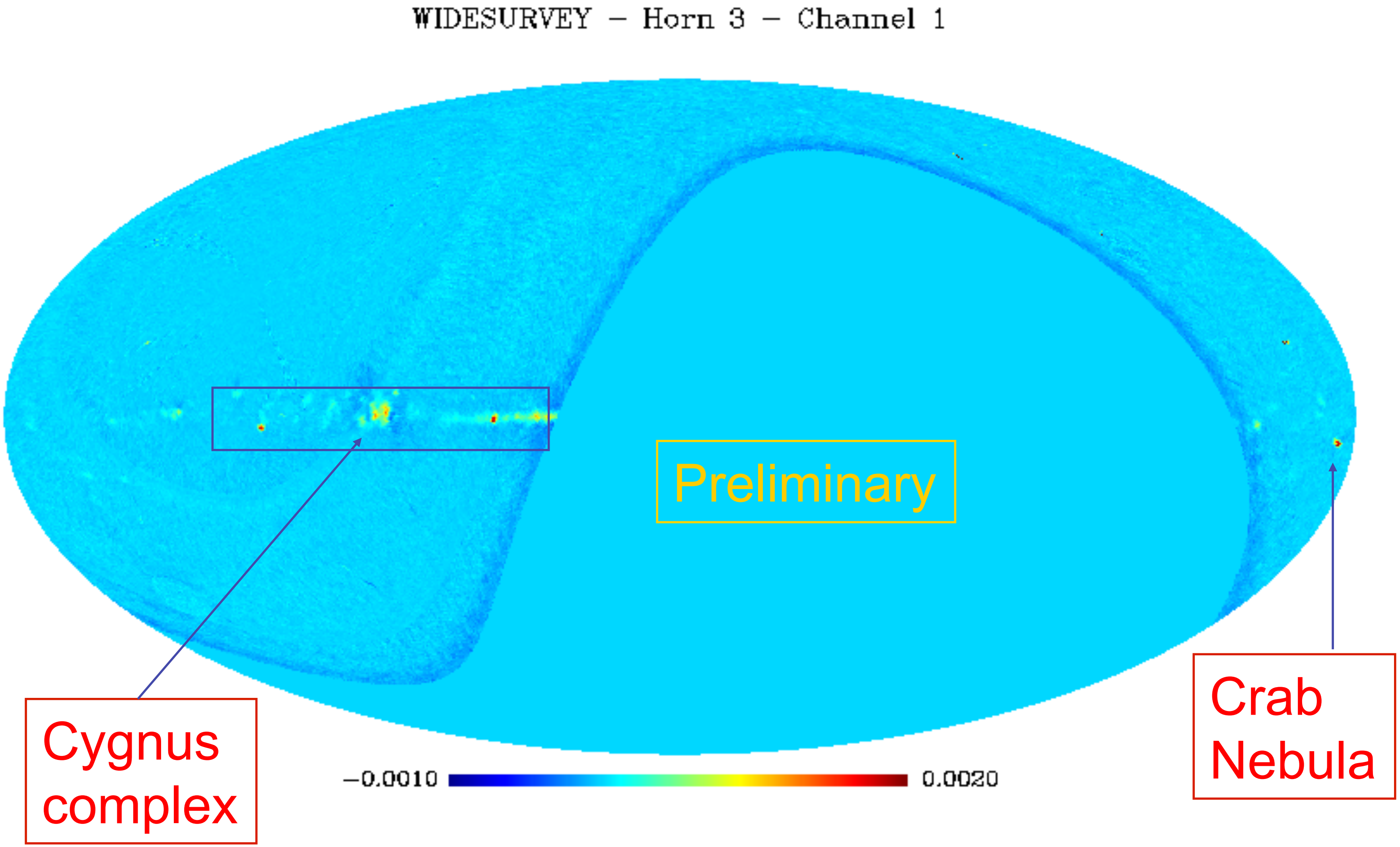
W51
SN remnant complex

Co-adding 10 days of data. No map-making applied.

Cygnux complex

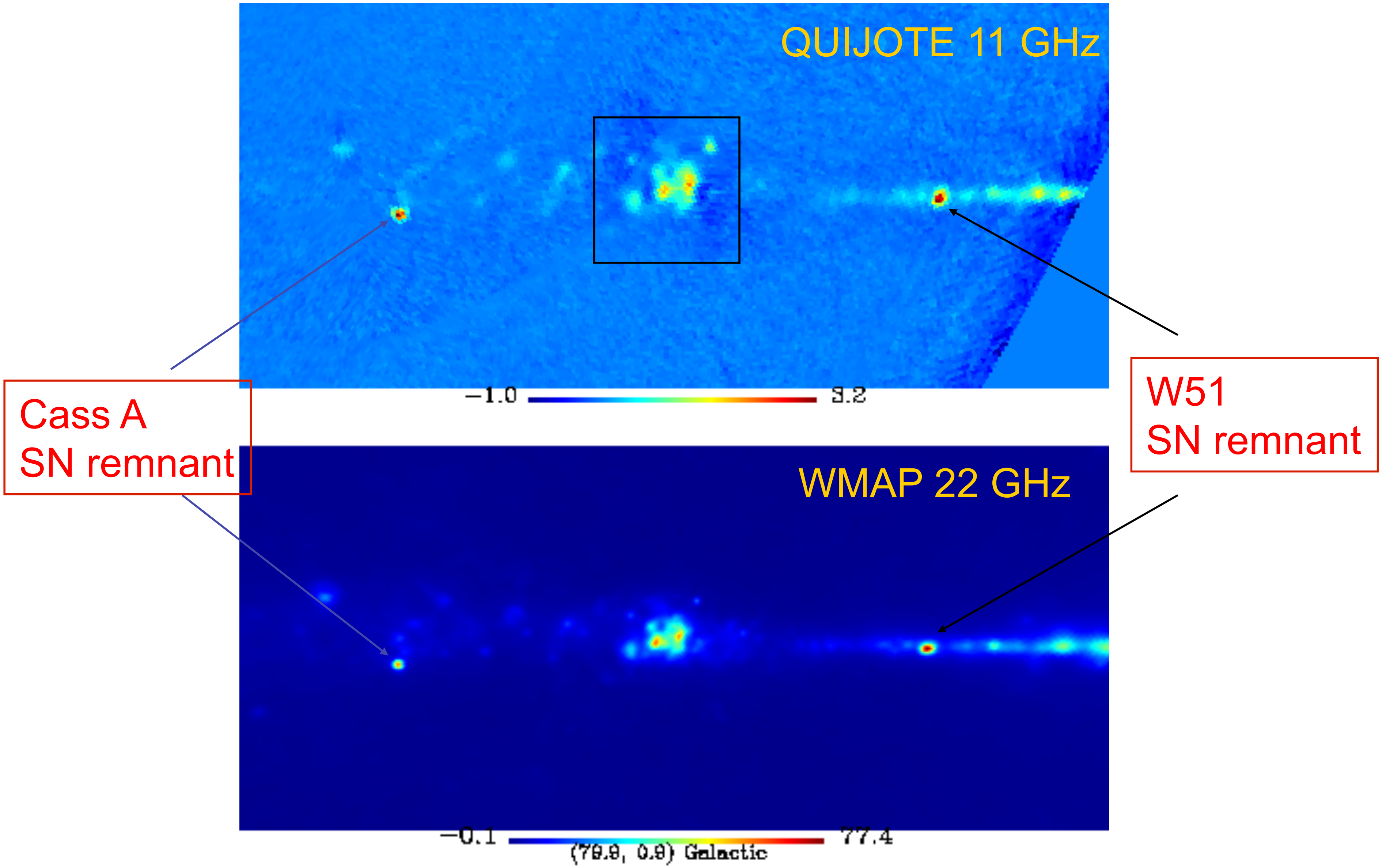


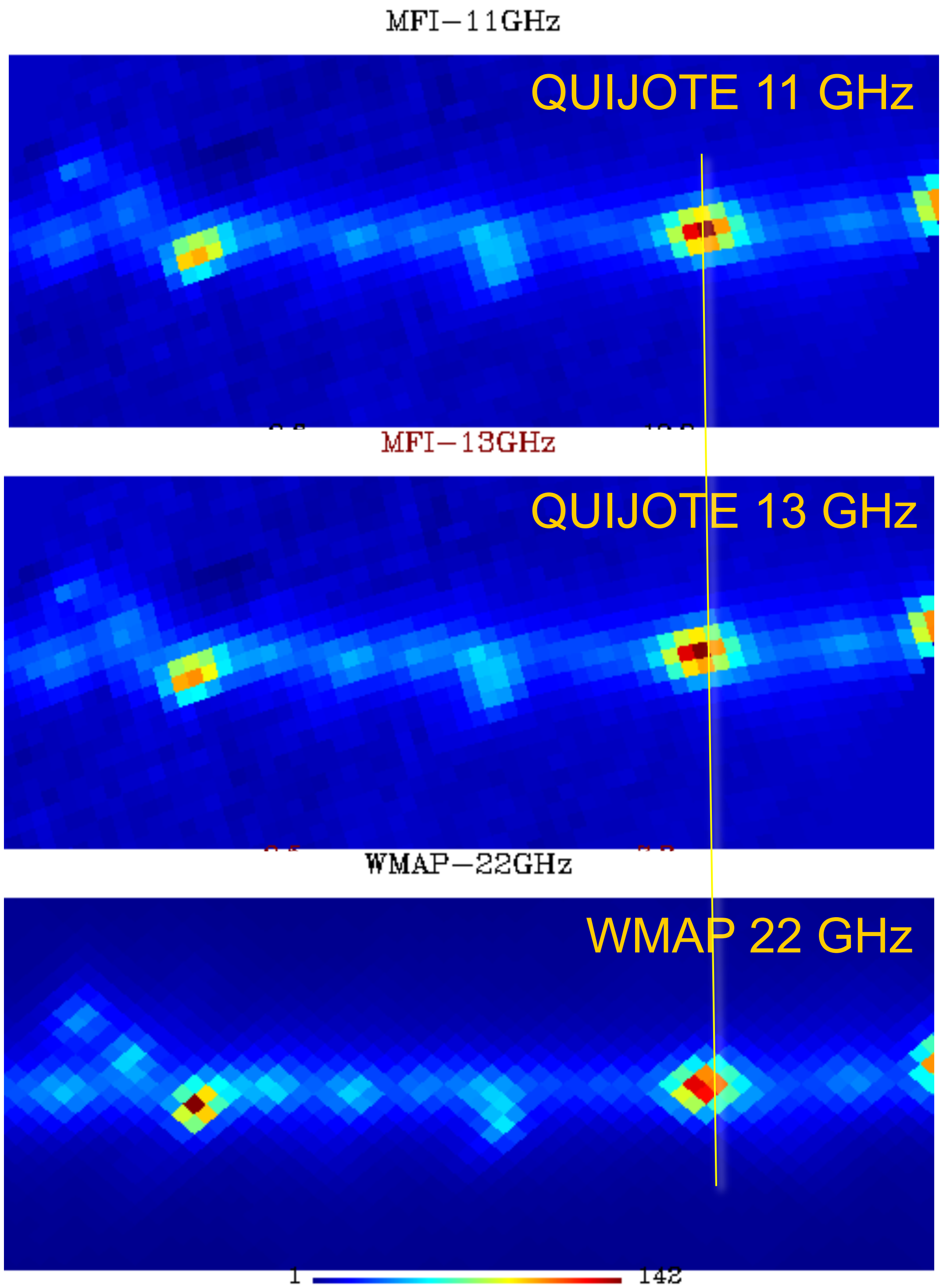
QUIJOTE Northern Hermisphere Survey



Observations conducted in May 2013

Galactic plane (centered at l=80º)



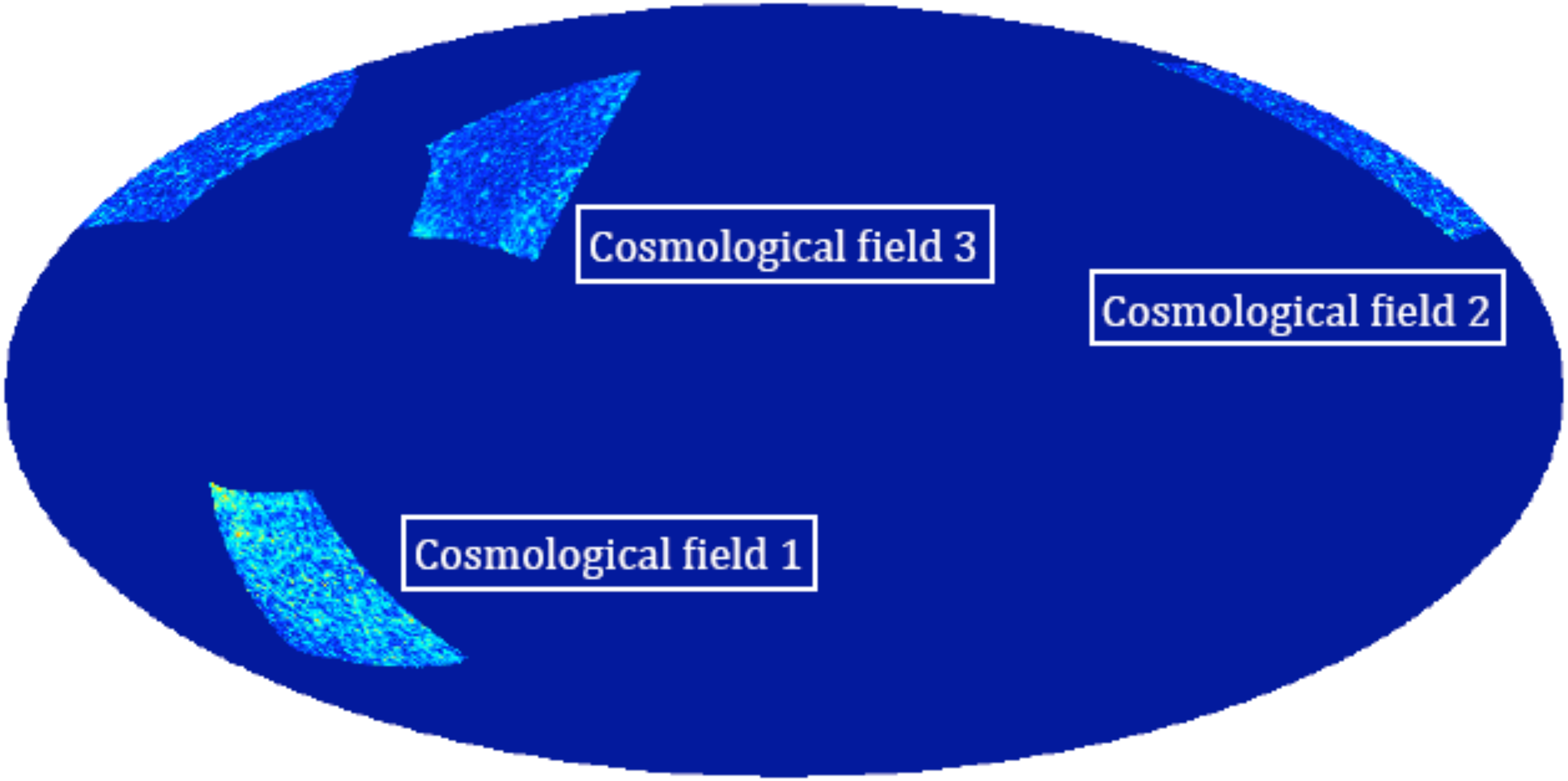


Galactic plane (centred at l=7º)

- Map of 27º x 11º a side.

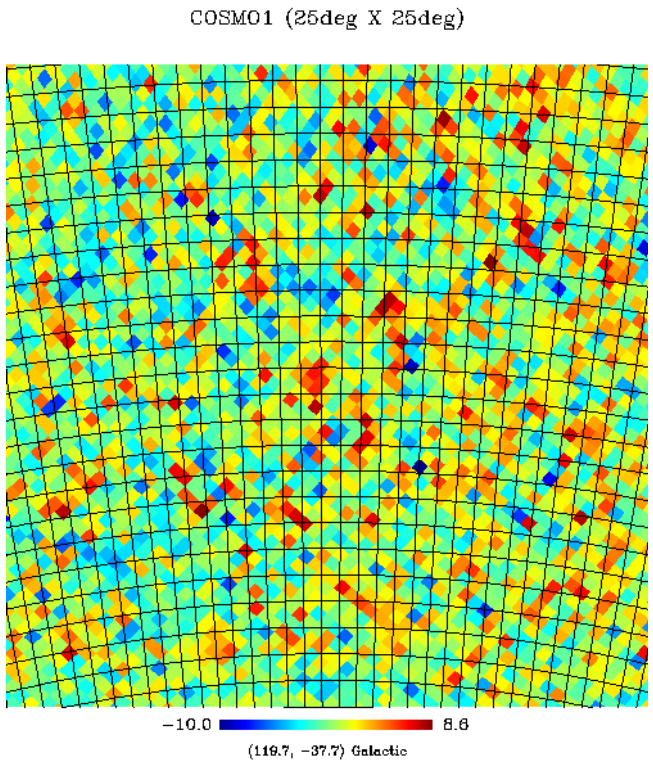
- QUIJOTE maps are extracted from one day nominal map at EL=30 deg (taken on June 21st).

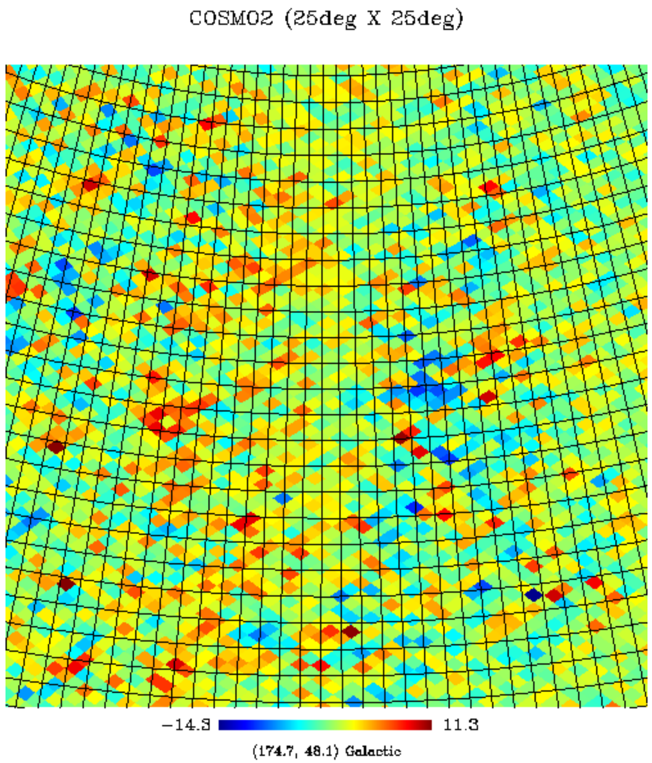
Cosmological fields

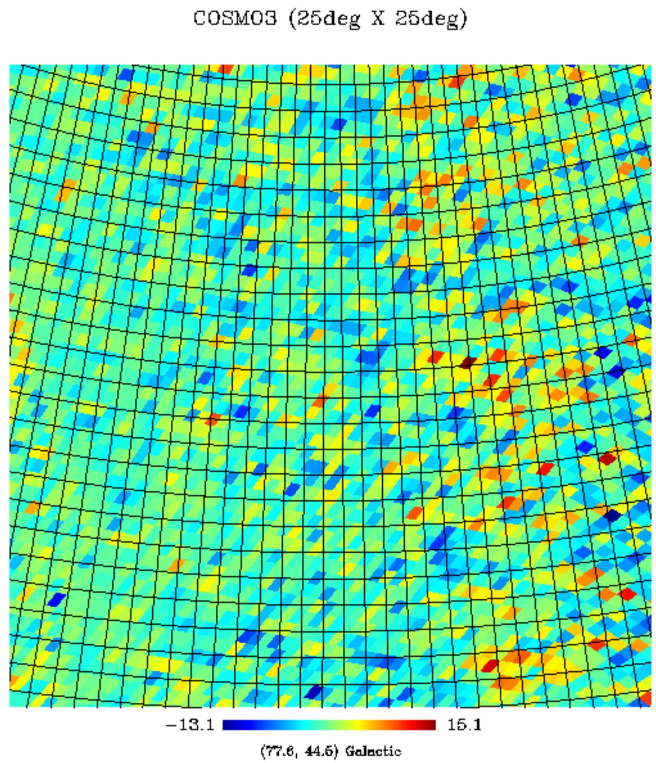


Three (non-overlapping) areas of ~1200 square degrees each, with low galactic emission.

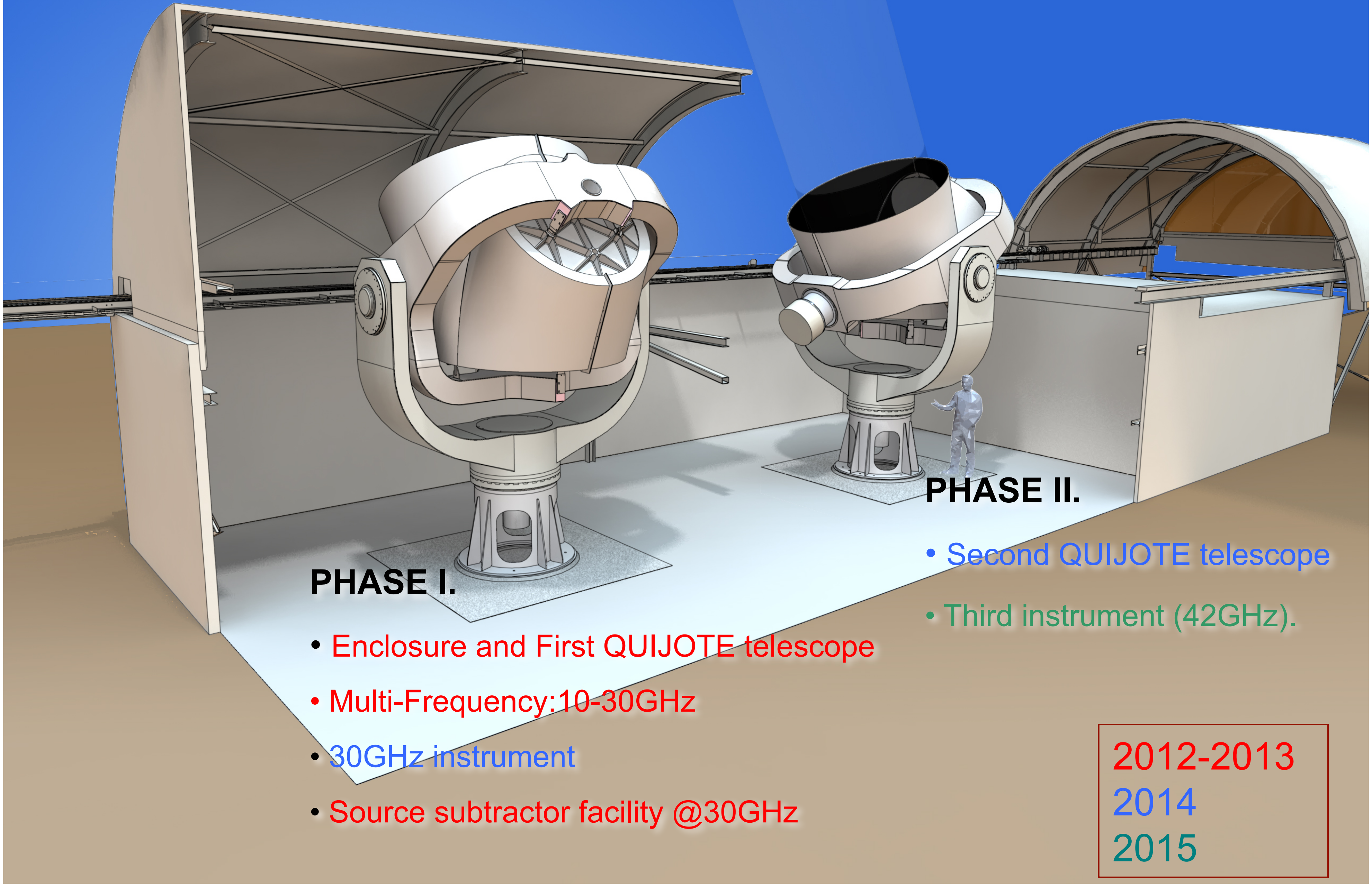
Status of observations of cosmological fields







QUIJOTE CMB Experiment: Schedule



PHASE I.

- Enclosure and First QUIJOTE telescope
- Multi-Frequency:10-30GHz
- 30GHz instrument
- Source subtractor facility @30GHz

PHASE II.

- Second QUIJOTE telescope
- Third instrument (42GHz).

2012-2013
2014
2015

Summary


EL INGENIOSO
HIDALGO DON QVI-
XOTE DE LA MANCHA.
Compuesto por Miguel de Ceruantes
Saauedra.
DIRIGIDO AL DVQVE DE BEIAR,
Marques de Gibraleon, Conde de Benalcaçar, y Bañares, Vizconde de la Puebla de Alcozer, Señor de las villas de Capilla, Curiel, y Burgillos.
Año 1608.
Con priuilegio de Castilla, Aragon, y Portugal.
EN MADRID, Por Iuan de la Cuesta.
Vendese en casa de Francisco de Robles, librero del Rey nro señor.

QUIJOTE: a new CMB Polarization experiment is currently in scientific operation.
The first telescope and instrument are performing well.
Intensity and polarization maps are produced at four frequencies.
The second telescope and instrument are under construction.
Our long ride to search for B-modes has just started.