Searching for primordial gravitational waves in the Cosmic Microwave Background (CMB)

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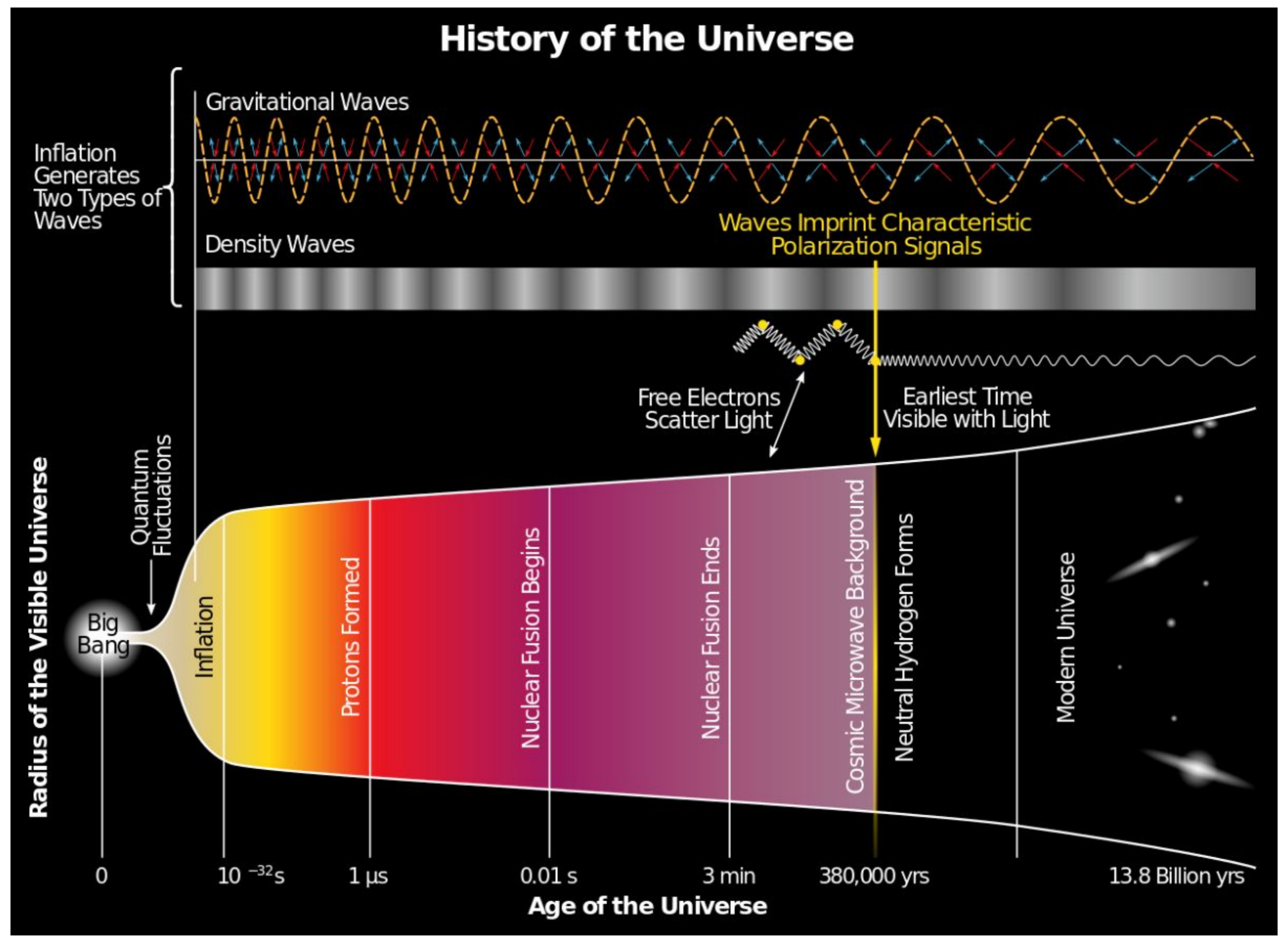
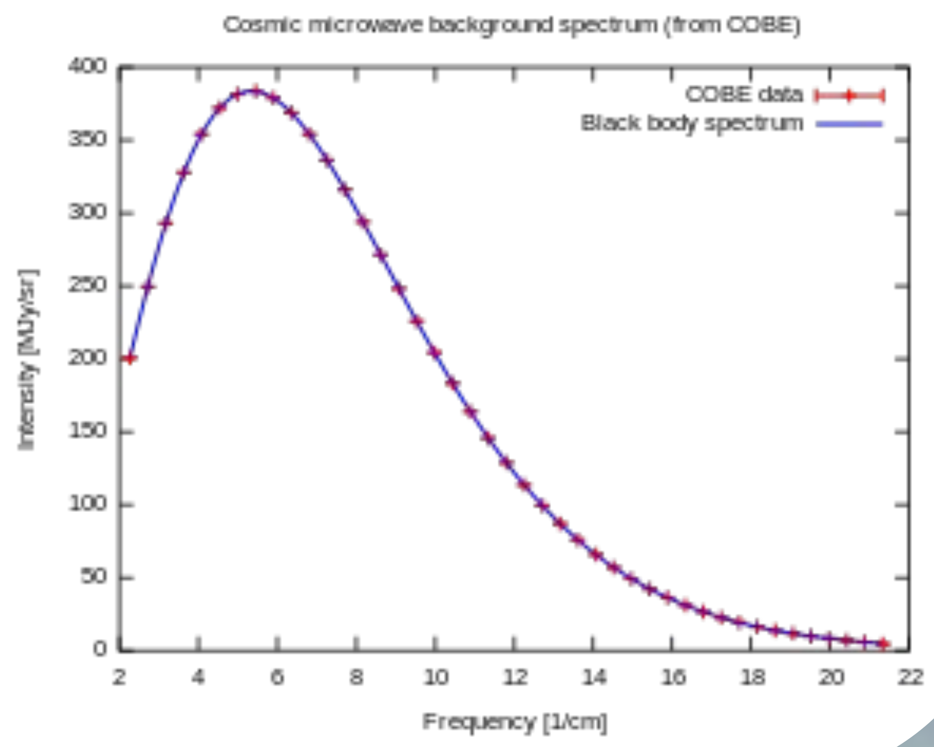
The search for primordial gravitational waves, through the detection of polarization B-modes in the CMB, would confirm the theory of Inflation which is a pillar of modern Cosmology.

QUBIC

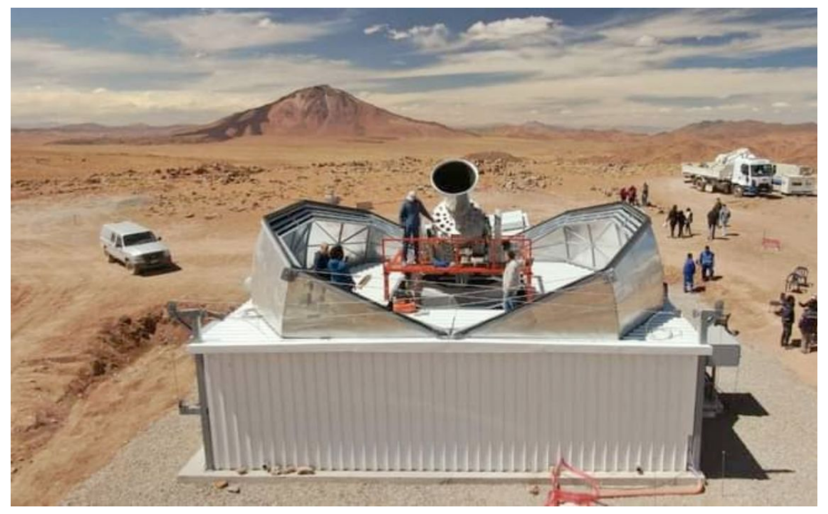
The Q & U Bolometric Interferometer for Cosmology (QUBIC) is an experiment dedicated to the measurement of the CMB B-mode polarization using a unique feature called ***spectral-imaging***.[1]



Inflation is a theory introduced to solve major problems in cosmology. This model supposes the existence of an extremely brief expansion phase during which the Universe's size increased by a factor of 10^{26}. This amplified quantum fluctuations into macroscopic perturbations which evolved into the Large Scale Structures in the Universe.

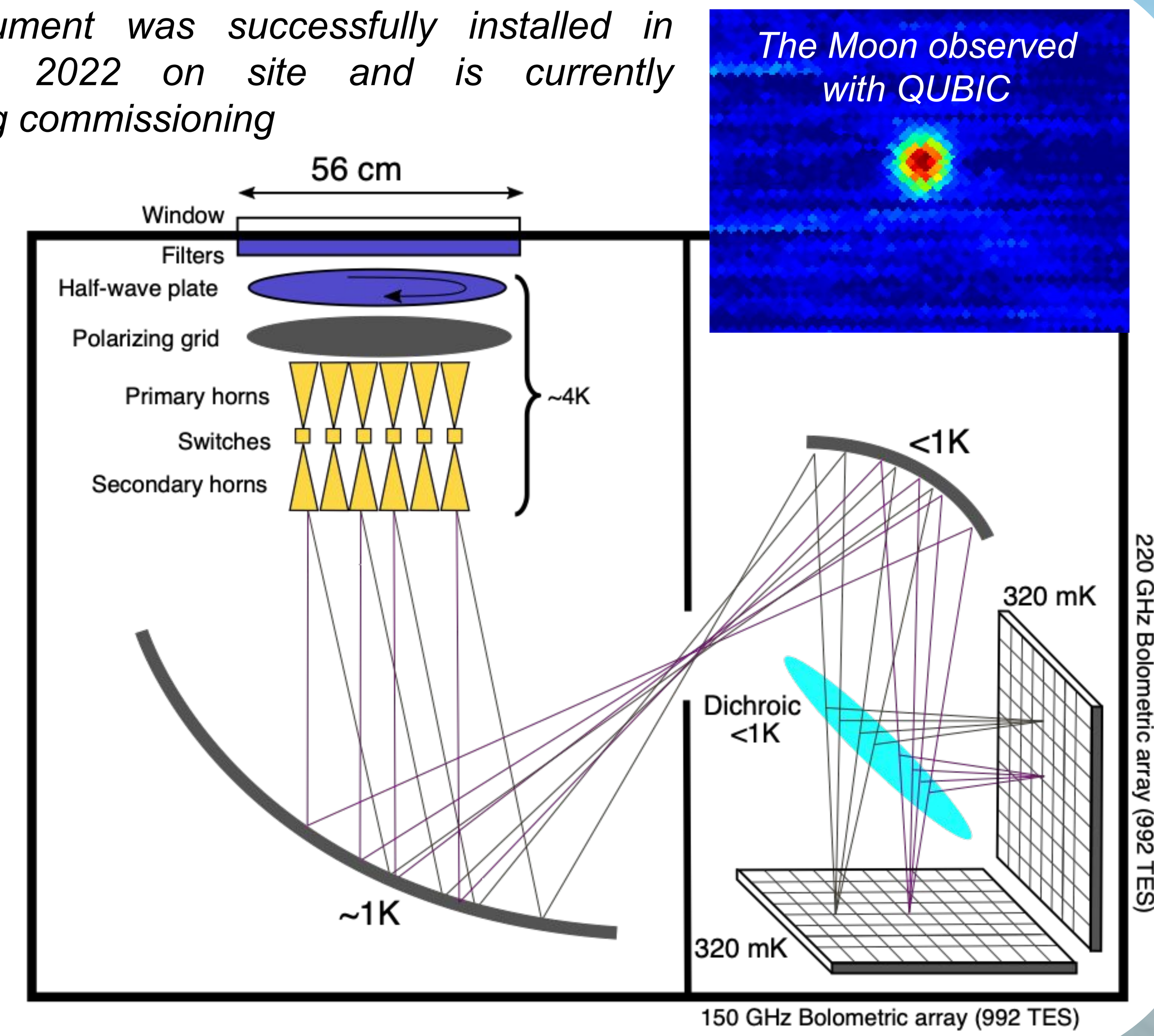


Photons scattered off electrons before being captured by nuclei. After that epoch of the last scattering, the photons are free to travel and are detected today as the CMB blackbody radiation.

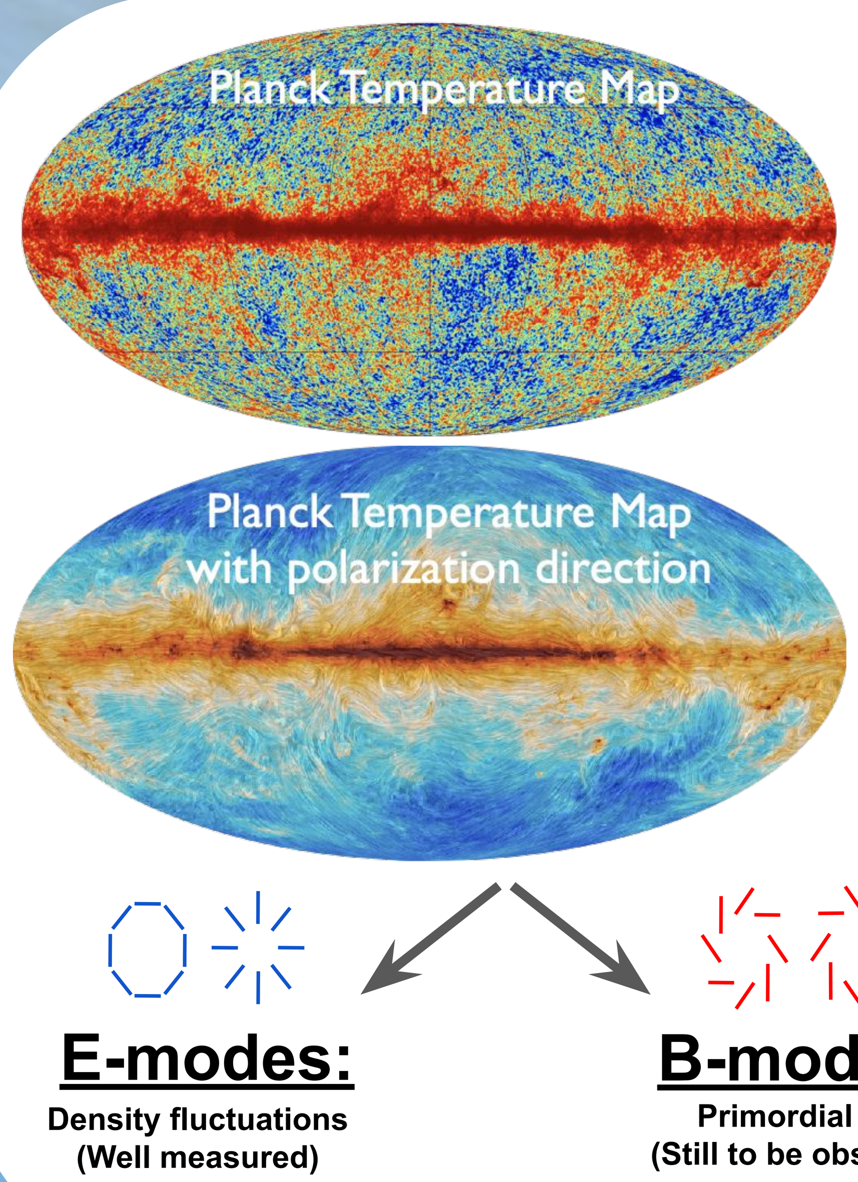


The instrument was successfully installed in November 2022 on site and is currently undergoing commissioning

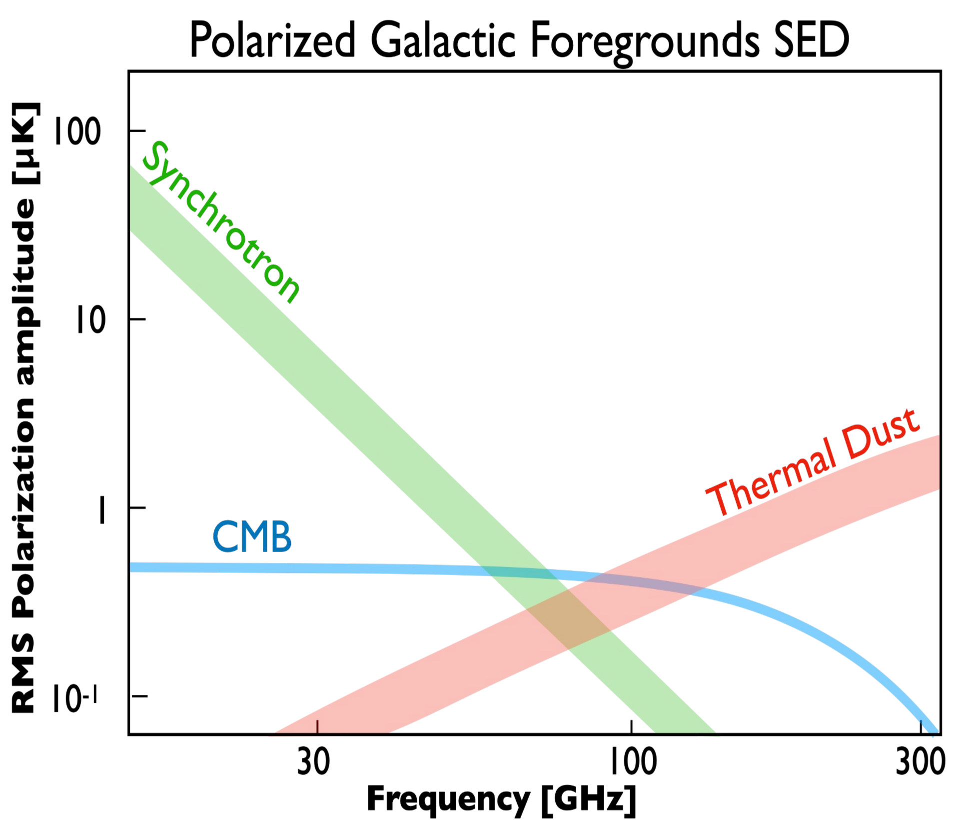
All optics are inside the cryostat minimizing thermal noise on the detectors.[2]

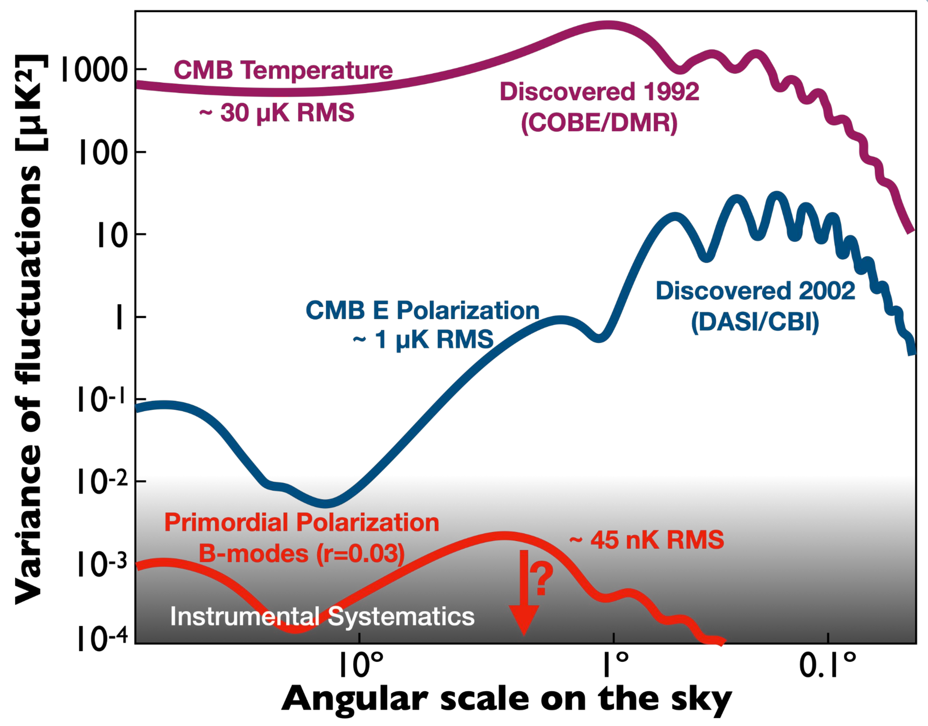


Several optical elements are used to filter, modulate the polarization and limit the cross-polarization of the signal. Following this, an array of horns produces a multitude of beams that are focused by two concave mirrors at a focal plane populated with highly sensitive bolometers.

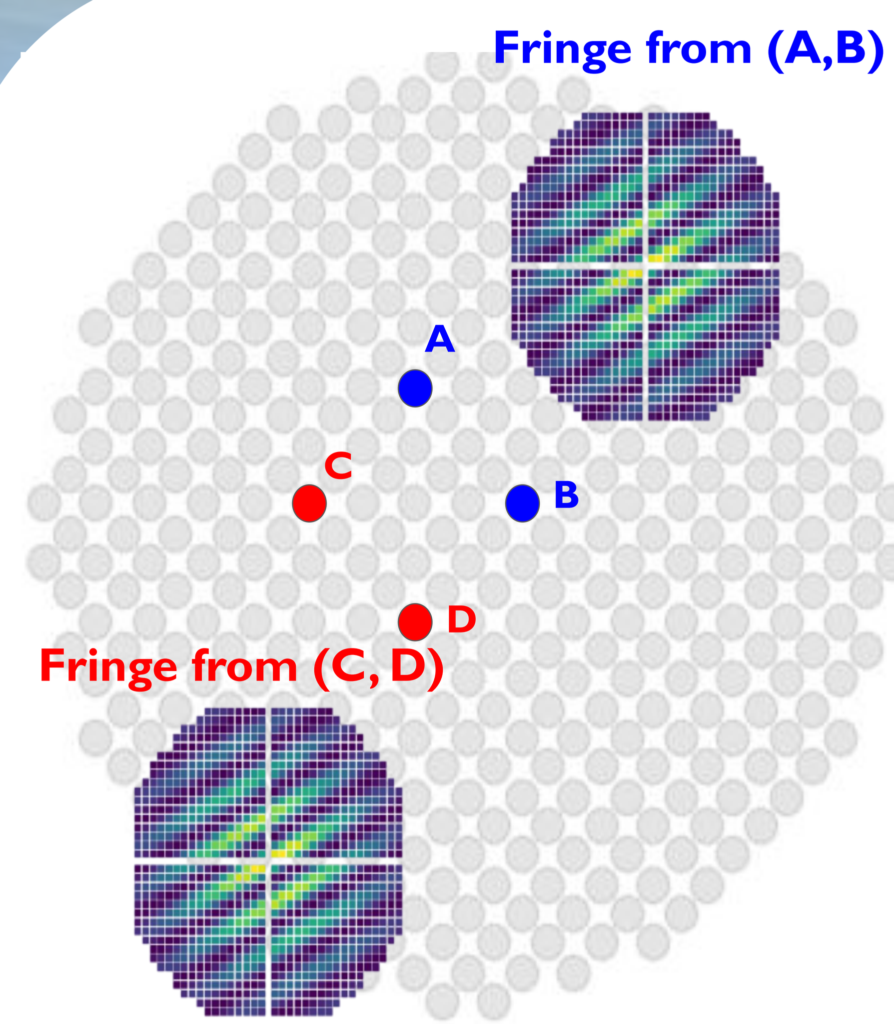


We use the slight temperature and polarization fluctuations, caused by density inhomogeneities, to understand the primordial Universe. We want to observe polarization B-modes arising from primordial gravitational waves to confirm and constrain the Inflation model.

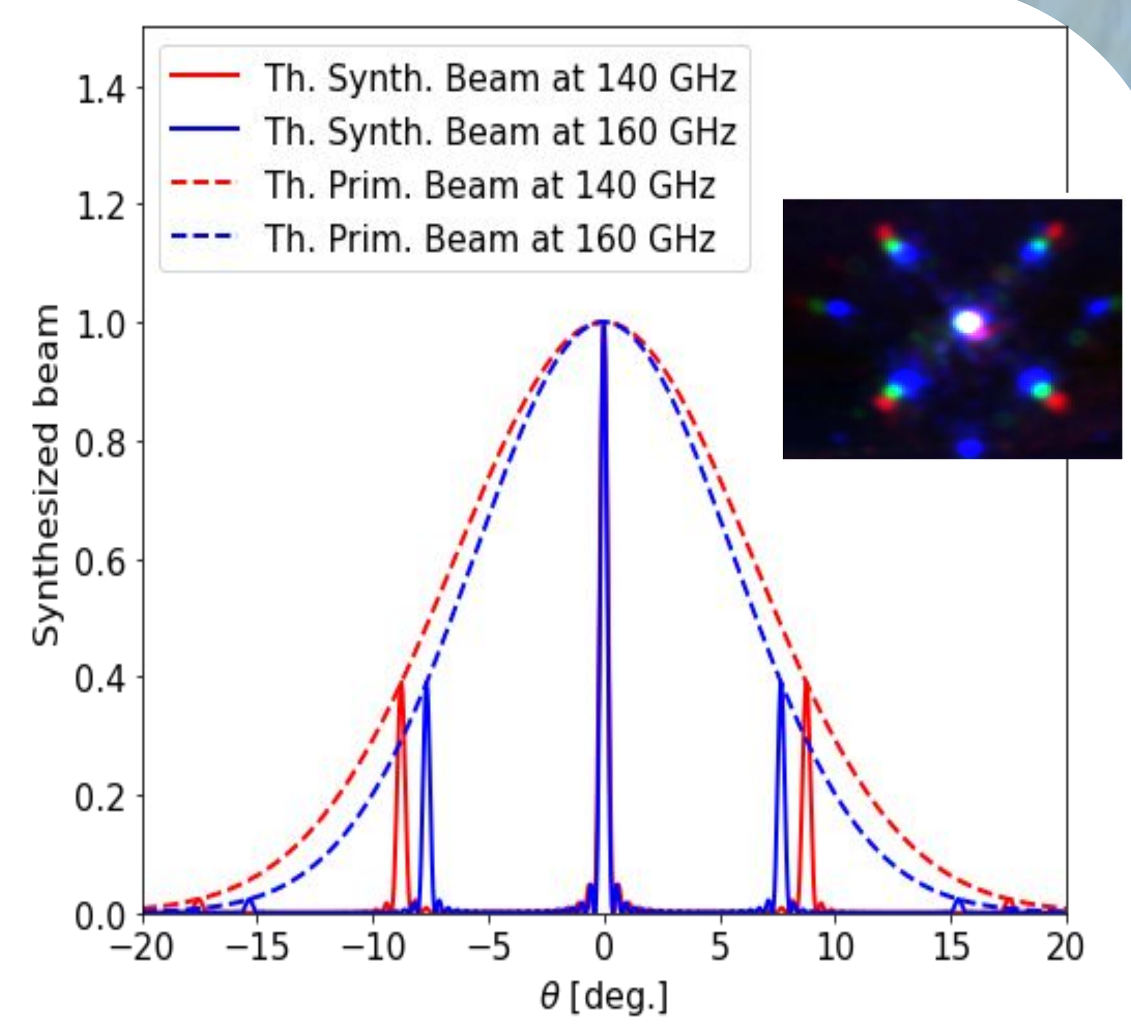




However, this detection is difficult: the signal is extremely weak and several astrophysical phenomena (synchrotron, dust and gravitational lensing) also produce polarization that masks the primordial B modes.



Self-calibration consists of comparing the interference patterns produced by opening different pairs of horns, allowing us to precisely estimate different systematic instrumental effects.[3]



The interference pattern produced consists of a central peak and several secondary peaks, the positions of which depend on the frequency of the incident signal. This property allows us to reconstruct the sky map in frequency sub-bands during post-processing.[4]

References :

1. Hamilton et al. : *QUBIC I : Overview and science program* 2. Torchinsky et al. : *QUBIC III : Laboratory characterization*, 3. M. A. Bigot-Sazy et al. : *Self-calibration: an efficient method to control systematic effects in bolometric interferometry*, 4. L. Mousset, M. M. Gamboa Lerena, et al. : *QUBIC II: Spectro-Polarimetry with Bolometric Interferometry*

Picture Credit :

BICEP Collaboration : *History of the Universe*, COBE Collaboration : *CMB Spectrum,* Planck Collaboration : *Temperature & polarisation CMB maps*