

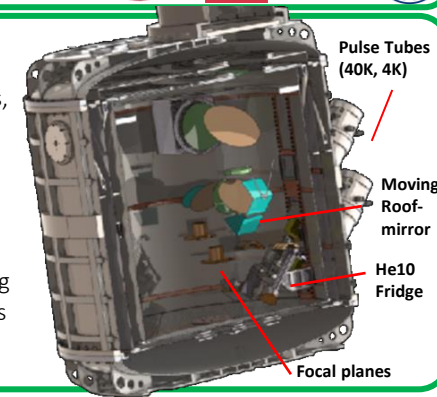
COSMO: Measuring CMB spectral distortions from Antarctica

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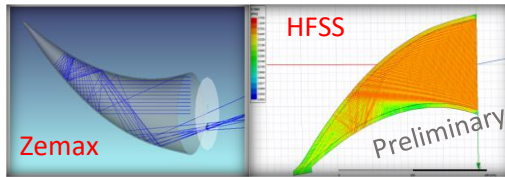
Abstract

The COSmic Monopole Observer (COSMO) is a ground-based experiment aimed at detecting the *Spectral Distortions* of the Cosmic Microwave Background (CMB) from Dome-C, Antarctica. CMB spectral distortions are produced by physical processes related to energy exchange with CMB photons, opening a window to a variety of physical processes along the thermal history of the Universe [1]. To date only upper limits have been set on the distortion parameters, $|y| < 1.5 \cdot 10^{-5}$ and $|\mu| < 9 \cdot 10^{-5}$ (95% c.l.) from COBE-FIRAS (1990) [2]. COSMO exploits a cryogenic differential Martin-Puplett interferometer to measure the difference between the absolute brightness of the sky in the 130-280 GHz range and a reference blackbody calibrator. The intrinsic differential nature of the instrument allows for good control over systematic effects, providing high Common-Mode Rejection Ratio (CMRR) levels, >50dB as has been measured for the 300K spectrometer exploited in the OLIMPO experiment [3]. A larger CMRR is required for the extraction of the isotropic CMB distortion spectrum: this is achievable with a cryogenic instrument. The atmospheric emission is measured and removed by performing fast sky-dips while scanning the interferogram, greatly reducing the residual signal from its fluctuations and requiring relatively fast detectors. Two arrays of multi-mode Kinetic Inductance Detectors (KIDs) are used at the two focal planes of the interferometer ($\tau < 50\mu s$) covering the 150GHz and 220GHz frequency bands.



Blackbody Calibrator

- Emissivity as close as possible to unity (limiting spurious distortion signal)
- Low thermal gradients (single compact element)
- Ray Tracing approach (RT): Maximization of the # of reflections with the absorbing coating (cr-110, Emerson & Cuming)



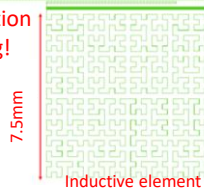
$$r_{RT} < -60dB \quad r_{HFSS} < -50dB$$

$$[100,300]GHz \quad @ 100GHz$$

Multi-mode KIDs Arrays

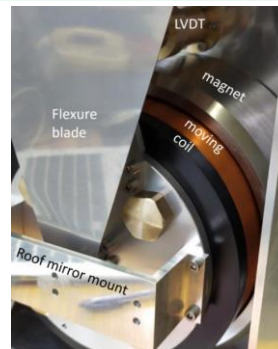
- Less pixels, each achieving photon noise limited performance more easily as the sensitivity scales as $N_{modes}^{1/2}$
- Well adapted to CMB measurements with coarse angular resolution and large detector units

Optical Optimization (HFSS) on going!



Roof-Mirror Voice Coil Actuator

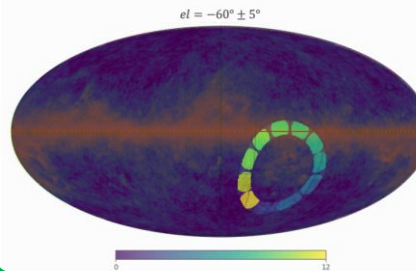
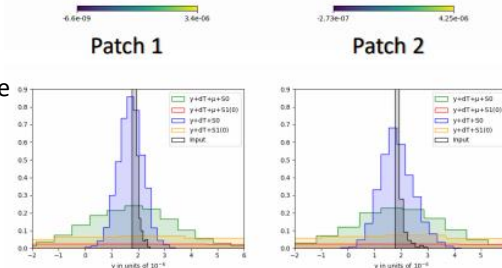
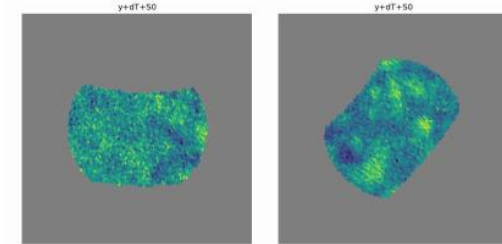
- Frictionless device minimizing the heat load during cryogenic operations (4K)
- Based on a powerful voice coil with steel flexure blades support, providing smooth and fast motion
- An inherently frictionless Linear Variable Displacement Transducer (LVDT) provides the absolute linear displacement
- Cryogenic tests coming soon!



Performance Forecast

ILC-based simulations show that COSMO can extract the isotropic comptonization parameter (assumed $y = 1.77 \cdot 10^{-6}$) as $y = (1.76 \pm 0.26) \cdot 10^{-6}$ in the presence of the main Galactic foreground (thermal dust) and of CMB anisotropy, and assuming perfect atmospheric emission removal.

Photon noise limited performance is assumed, dominated by the atmospheric emission (AM atmospheric model) and the cryostat window ($\epsilon = 1\%$)



$$\langle y \rangle_w = (1.76 \pm 0.26) \cdot 10^{-6}$$

References

- [1] J. Chluba, M.H. Abitbol, N. Aghanim et al. *Exp. Astron.* (2021)
- [2] D. J. Fixsen et al., *The Astrophysical Journal*, 473, 576 (1996)
- [3] G. D'Alessandro, P. de Bernardis, S. Masi, A. Schillaci. *Applied Optics*, 54 (2015)