COSMOCal **CO**smic **S**urvey of **M**illimeter wavelengths **O**bjects for CMB experiments **Cal**ibration

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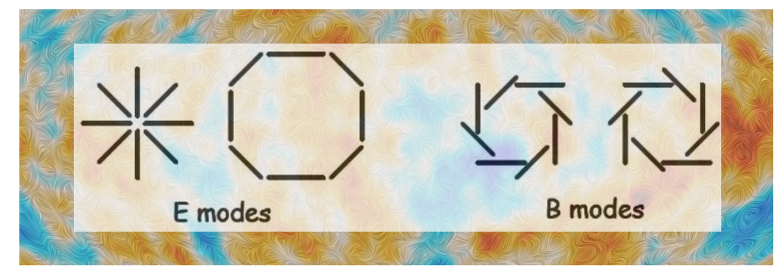
SCIENCE CASE

Cosmic Microwave Background (CMB) polarization detection provides unique insights into primordial Universe physics. Specifically, the **CMB *B*-modes** encode the imprint of predicted **primordial gravitational waves** as predicted by the Inflation theory (*Polnarev 1985*). These waves are remnants of the rapid post-Big Bang Universe expansion. Detecting this faint signal and probe this **early epoch of the Universe** drives the development of high-sensitivity experiments, like Simons Observatory and CMB-S4 on the ground, and LiteBIRD in space.

CMB Polarization

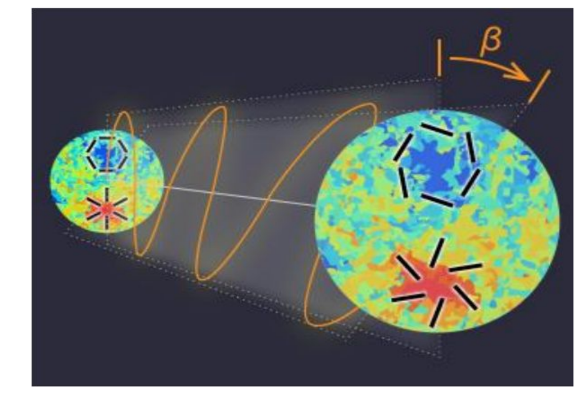


***E*-modes** due to density fluctuations in the early Universe.

***B*-modes** exhibit a curl-like pattern imprinted by primordial gravitational waves (Hu & White 1997).

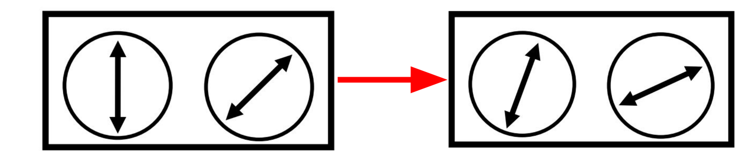
Cosmic birefringence naturally convert *E*<->*B*

$$\begin{pmatrix} E_{\ell m} \\ B_{\ell m} \end{pmatrix}^{obs} = \begin{pmatrix} \cos(2\beta) & -\sin(2\beta) \\ \sin(2\beta) & \cos(2\beta) \end{pmatrix} \begin{pmatrix} E_{\ell m} \\ B_{\ell m} \end{pmatrix}$$



Minami, Yuto et al. 2018

But **miscalibration** introduces a rotation *angle* as well



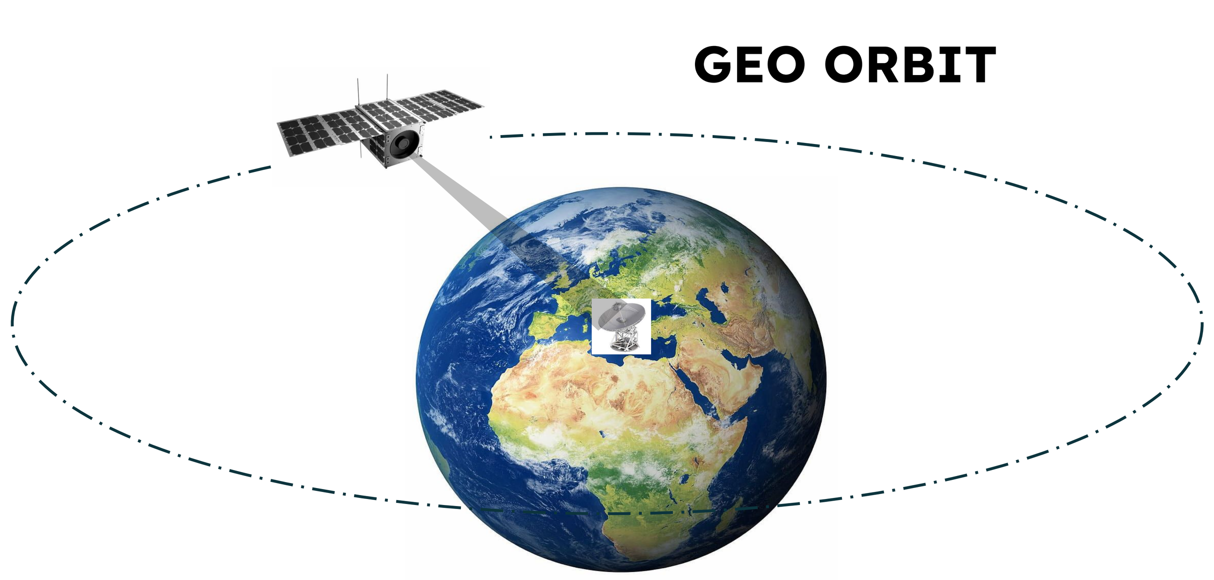
Krachmalnicoff et al. 2022

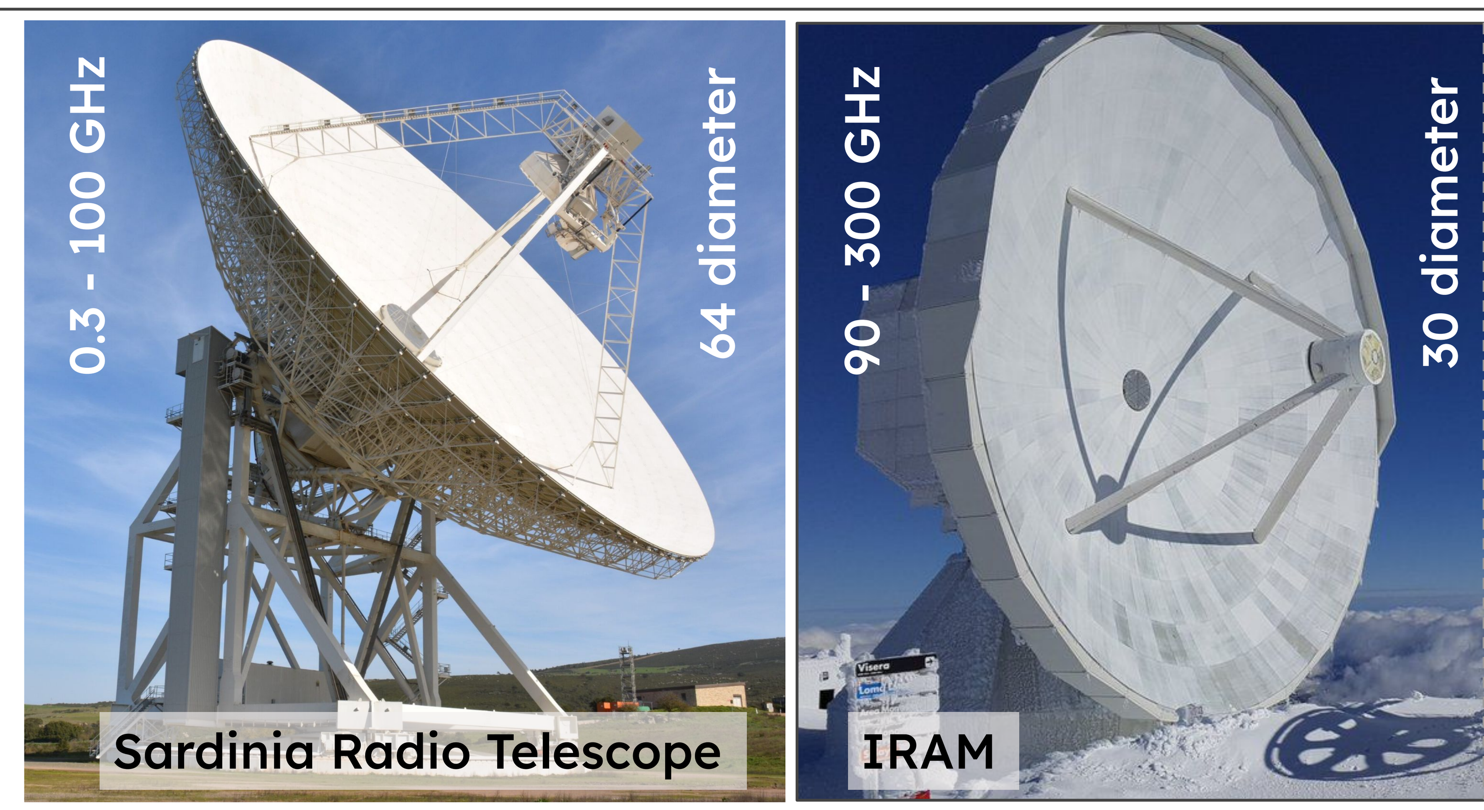
Creating a spurious CMB *B*-modes signal mixing *E* and *B*-modes

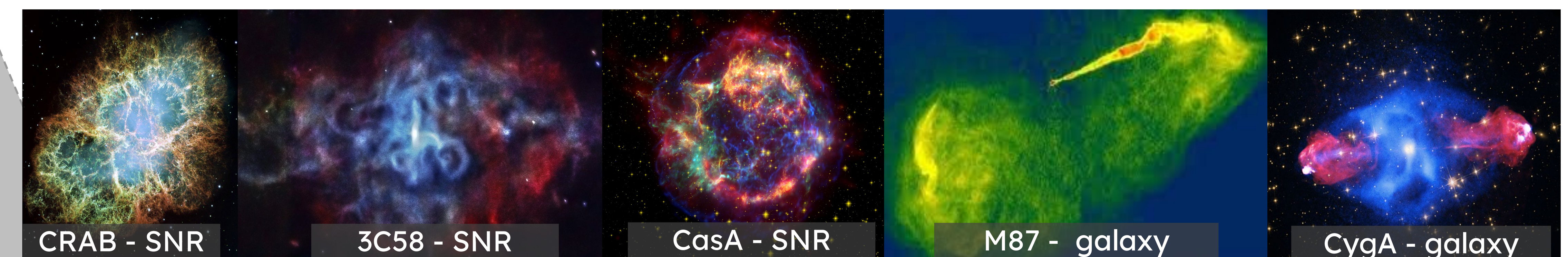
$$\Delta C_\ell^{BB} \simeq (2\Delta\psi_{\rm Gal})^2 C_\ell^{EE}$$

Aumont et al. 2020

THE PROJECT IDEA







GOAL

Absolute calibration of the polarization angle < 6 arcmin in the range: 20-400 GHz.

IDEA

Making use of ground based telescopes as baseline to build a reference set of sky sources measured at the accuracy required for CMB studies.

REQUIREMENTS

- **Multi-frequency artificial source** in the **far-field** => In space.
- Large ground based telescopes cannot track LEO => **geostationary orbit**.
- Visible from different places on Earth: **Europe and Chile** is good (Atlantic).
- Developing technology and data analysis to ensure the stringent constraint and link ground-based observations on astrophysical sources with LiteBIRD.

PROTOTYPE DEVELOPMENT

2022-2023

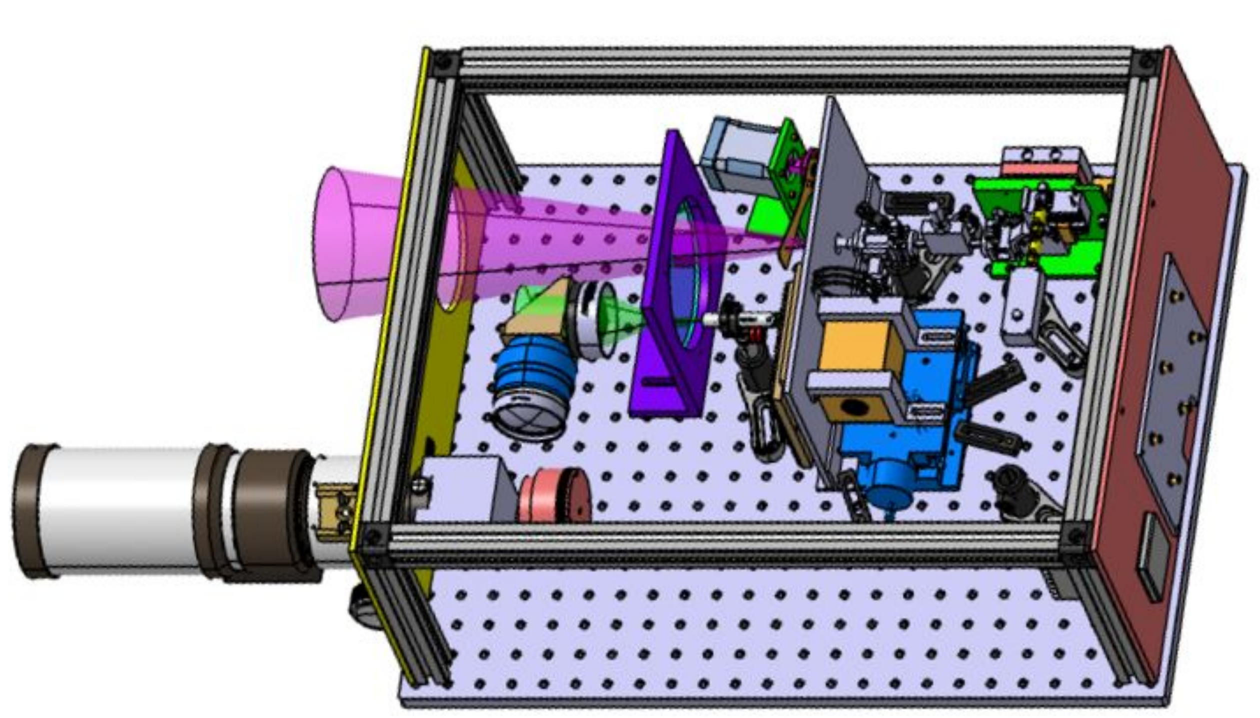
- Project supported by **CENSUS** (*CEntre pour les Nanosatellites en Sciences de l'UniverS*).
- Development of a **prototype** emitting in the mm wavelength range (**200-300 GHz**).

2023-2024

- Ground **tests** of the whole system **to be performed** in laboratory and then at Pico Veleta in front of the **IRAM 30m telescope**.

2024- Prototype for the low frequencies and project study for a space payload.

BOX DRAWING

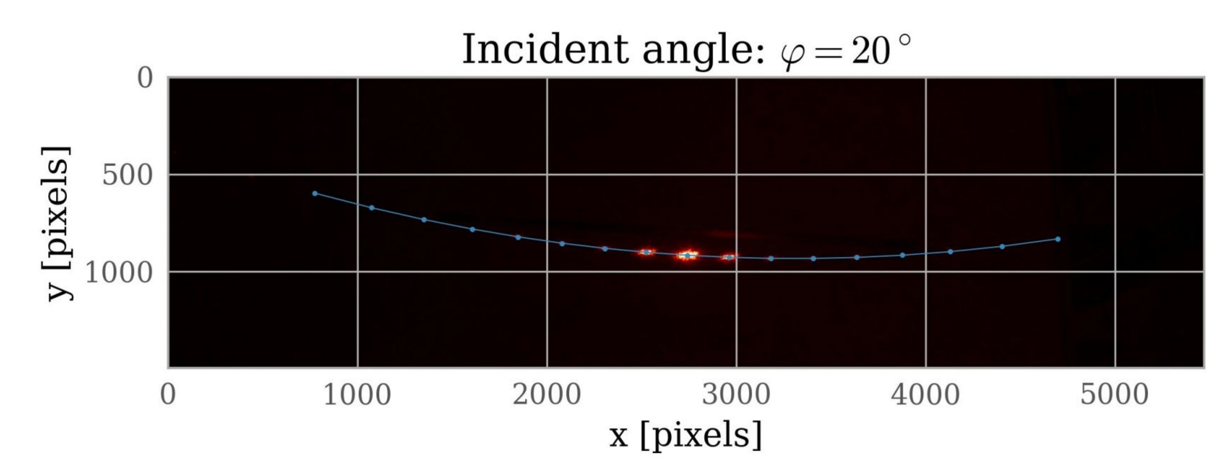


Monochromatic millimeter source:

Electronic chain developed and characterized at LERMA institute.

Optical system and mechanics (LPENS):

- A laser is employed to project the diffraction pattern of a polarizer, which is used to ensure the purity of the polarization signal.
- To capture this pattern and reference points in the sky or on the ground, a CDD camera is utilized, facilitated by a flip mirror.



Preliminary results on laboratory measurements gives an accuracy on the polarization angle of $\Delta\psi \leq 0.05°$.

Need to be verified with the whole system assembled.