A High Frequency SAT for SO: The Kairos Project

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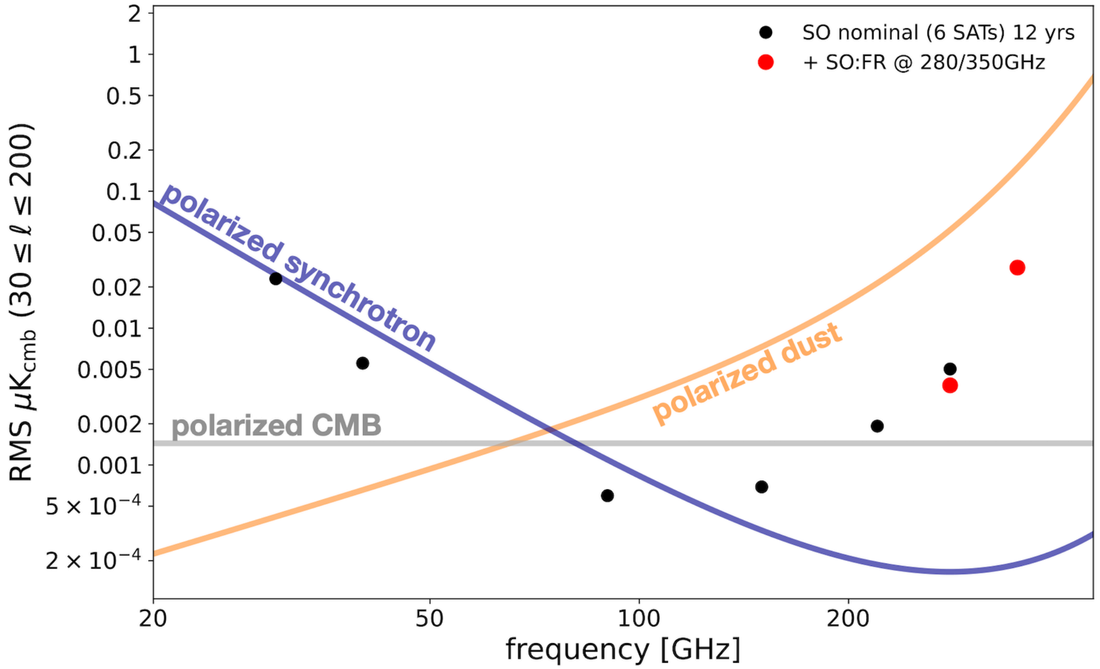
The French SAT for SO : *Kairos*

In early 2024 we proposed to add a high frequency Small Aperture Telescope (SAT) to Simons Observatory existing telescope

More precise measurement of the contamination of galactic dust emissions



- **Increase the lever arm on the dust SED fit**
- **Lower the noise on the dust template**

Status

In France:

Participation to the CNRS M.I.P.N RI^2

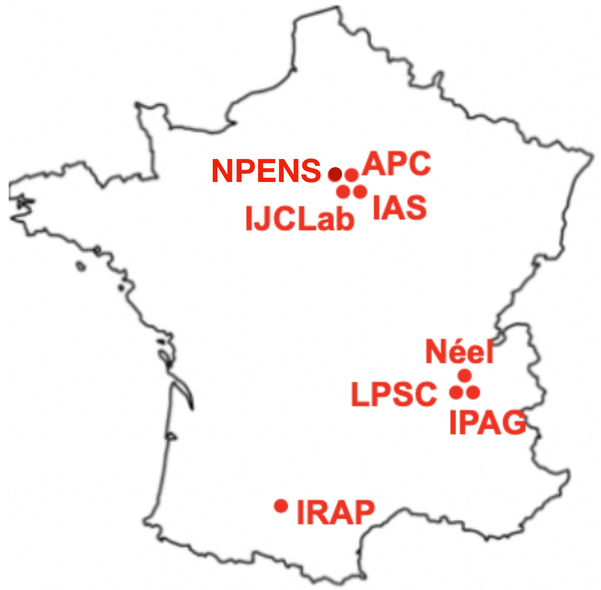
3.5 M€

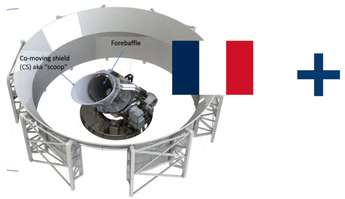
Final decision Summer 2025

With Simons:

Common consensus between the OEO and Kairos Consortium

Consortium





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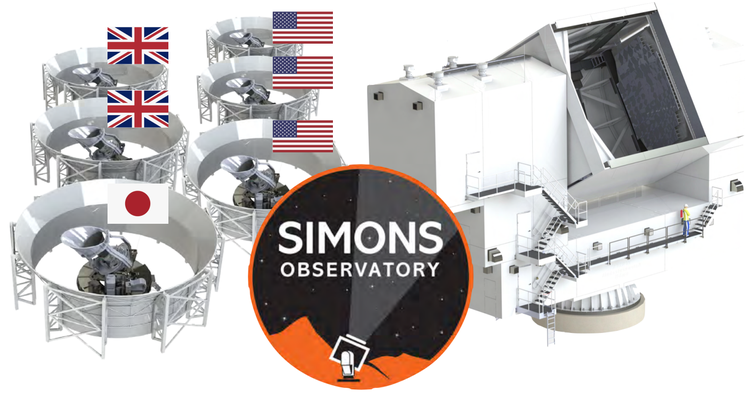

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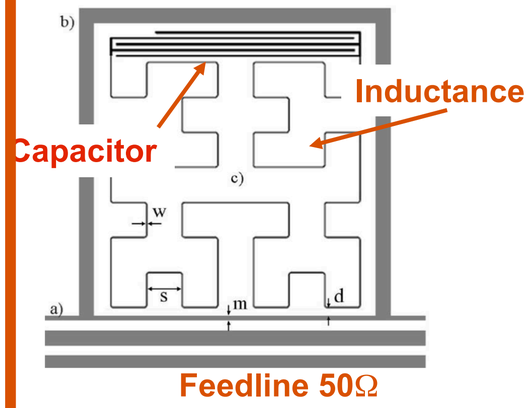
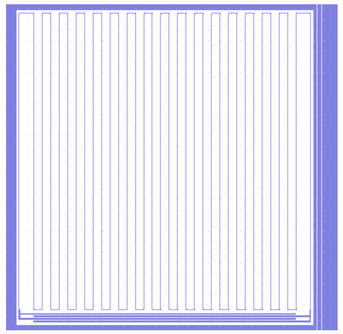
Our approach on KID development for Polarimeters

Lumped Element KID

Dual Polarisation
(3rd-order Hilbert pattern)

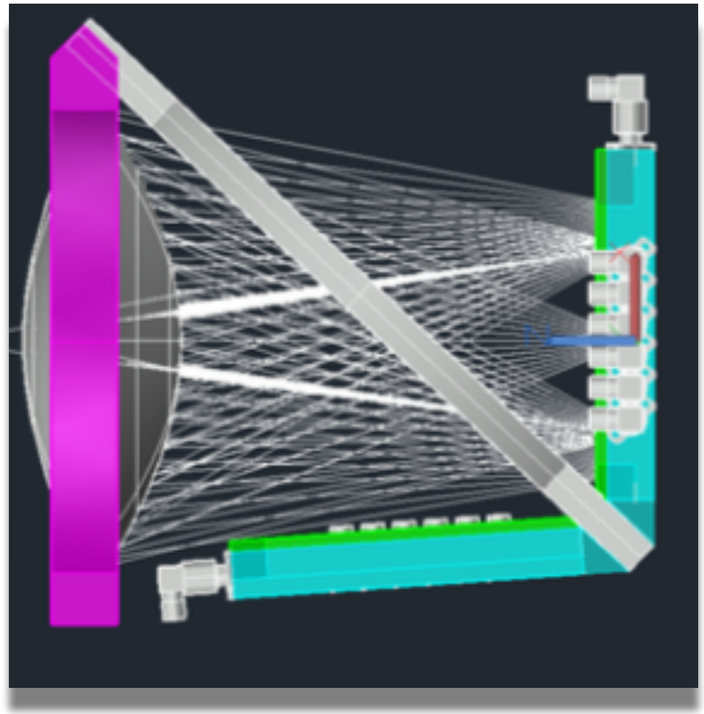


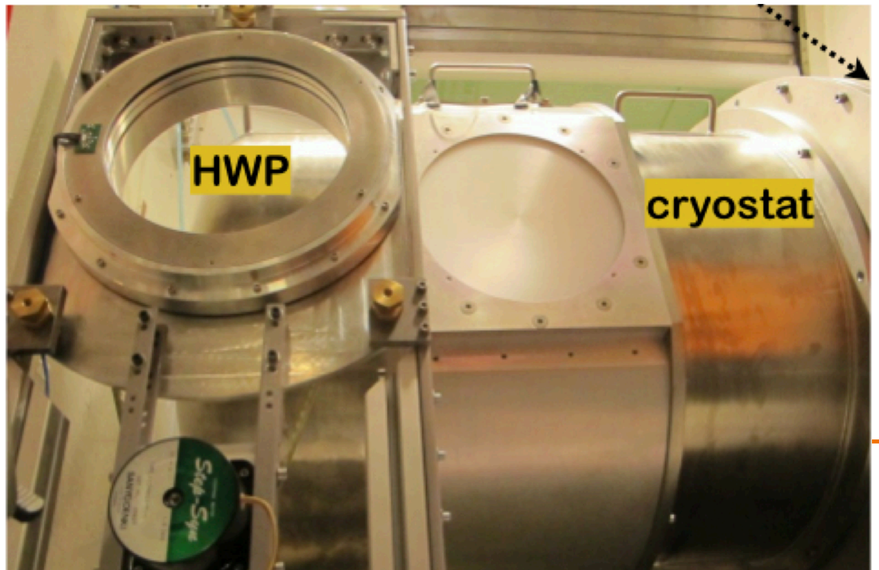
Single Polarisation

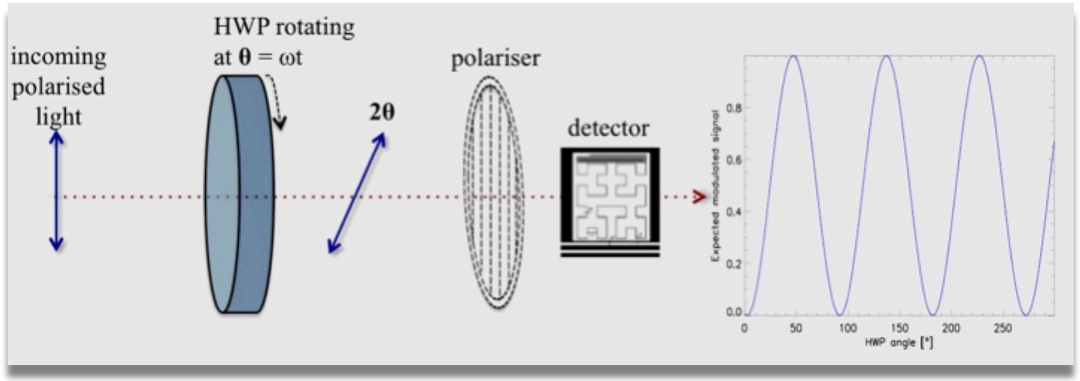


Filled arrays LEKID:

- Large filling factor
- Very high quantum efficiency in a 30% mm-band
- Fast Detectors (τ = 10 - 100 μs)
- Easy to fabricate







Continuous Rotation of an HWP permits quasi-simultaneous Observations of I,Q,U Stokes parameters

LPSC GRENOBLE | MODANE

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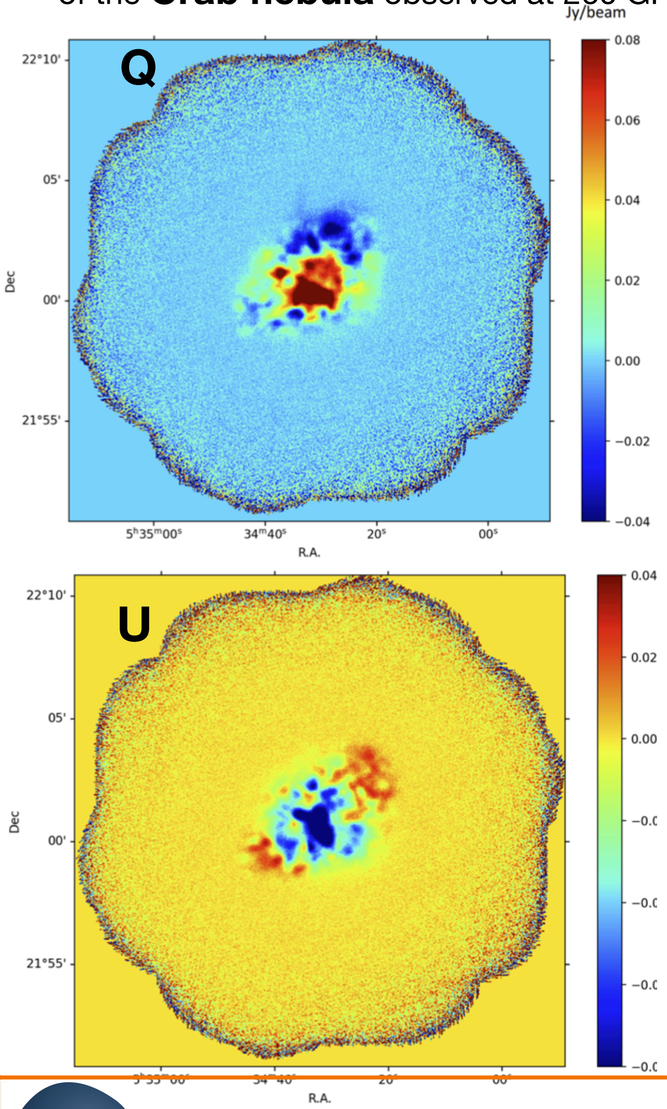
State of the Arts: Polarisation with NIKA2 & Lab Charact.

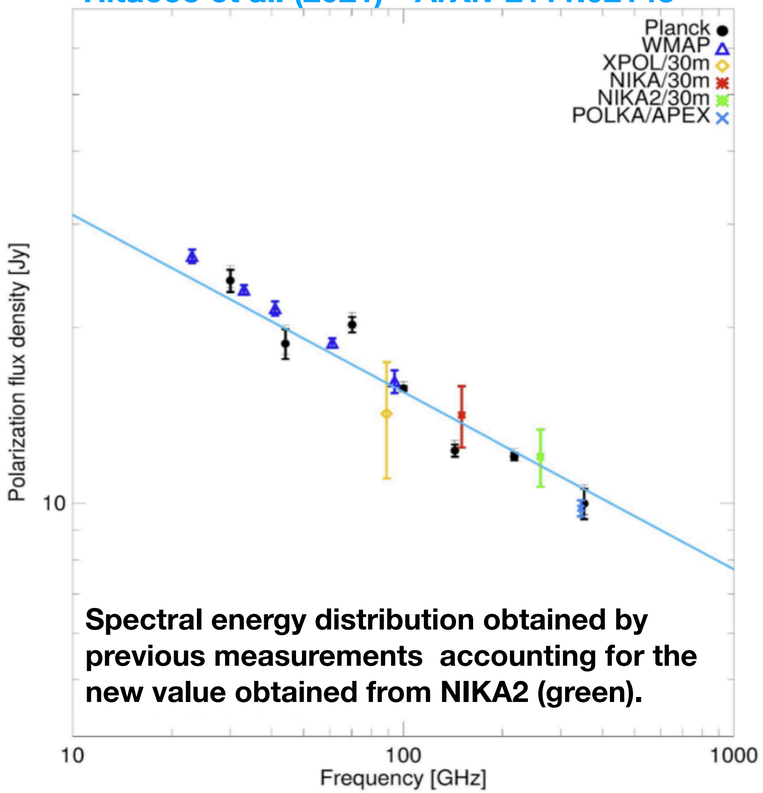
Stokes Q and U maps
of the **Crab nebula** observed at 260 GHz



NIKA2

- **Final Sensitivity:~20mJy*sqrt*(s)**
  Polarization Leakage : < 1%
  Error on the pol. angle rec : ~ +/- 0.5 Deg.

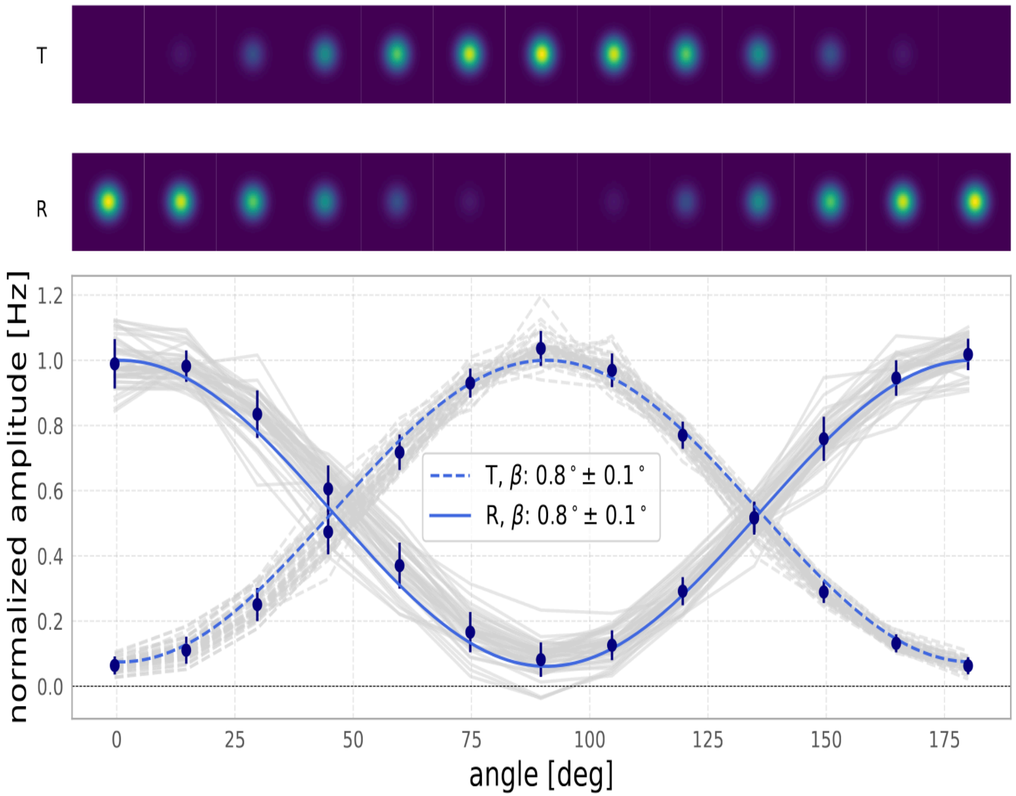
Ritacco et al. (2021) - ArXiv 2111.02143



Spectral energy distribution obtained by previous measurements accounting for the new value obtained from NIKA2 (green).

Lab. Charcterisations

Savorgnano et al. (2025) - accepted for pub. A&A



We can achieve polarization angle reconstruction with a precision of 0.1 degrees.

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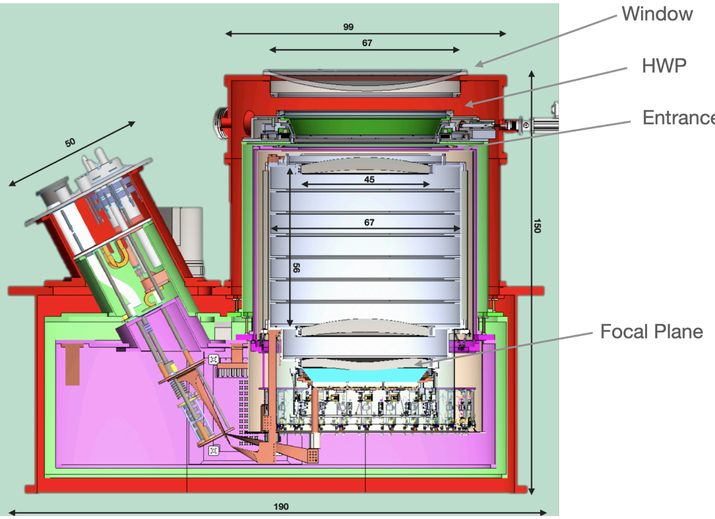
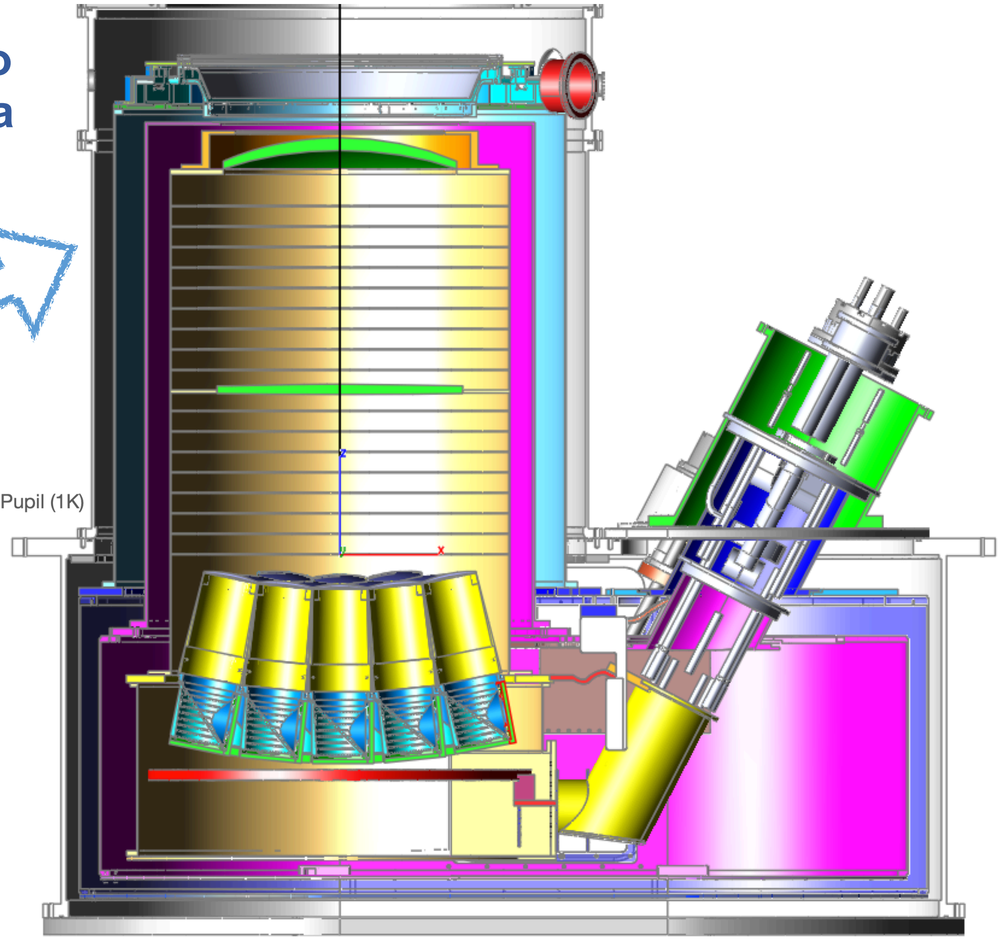
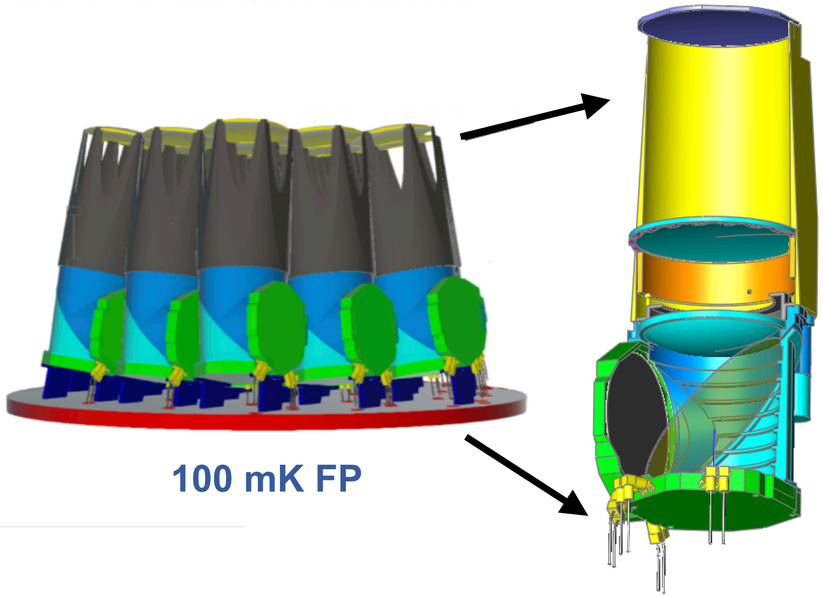
Perspectives : Polarimeters → The French SAT for SO

Starting from the constraints imposed by SO, we propose to adapt the French SAT to host a 30k-KID focal plane with adapted optics





Entrance Pupil = 420 mm
Total F.o.V. = 35 Deg.
# of channels = 2
BandPass = 200-400 GHz
# of Optical Tubes = 19
F.o.V per Tube = 6 Deg
Total # of Si lenses per Tube = 5
Total # of Det. ~ 30k
# of LEKID array = 38 (4-inches wafer)
# of Readout Boards = 50-70
(multiplex. Factor~ 600-800)
Total Data Rate ~ 100 MBytes/s



100 mK FP

from US SAT …

…. to French SAT

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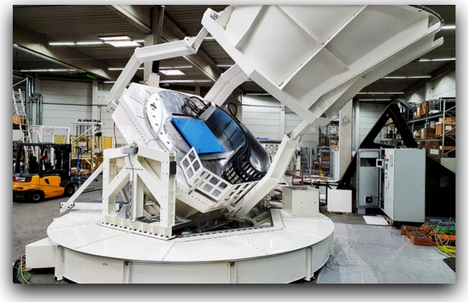
Technological Effort

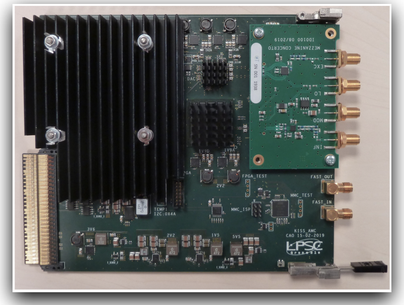
Big Challenge, big effort, two sub-systemes identified as criticals.

Pointing Platform



Same Platform and ground shield
Fabricated in Germany (Vertex)

READOUT+ Acquisition

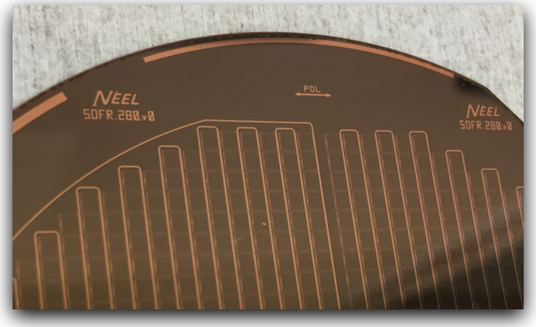


About 70 Boards (Concerto Version)
Lead: LPSC

Cryostat

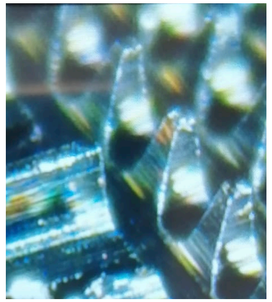
Modified US Cryostat adapted for filled arrays
LEKID optics
Lead: IN

Detectors



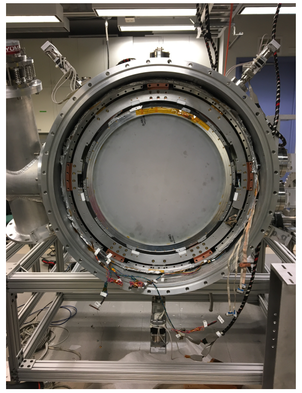
30k-pixel in 38 k-pixel arrays
Lead: IN

Optics



Design, Filters, Polarisers
….but critical point Si
Lenses with AR
Lead: LPSC

MHWP + CHWP



Sapphire HWP
+
Rotation system by magnetic levitation
Lead: IJCLab (with GIS)

- Not Critical
- Challenging
- Critical

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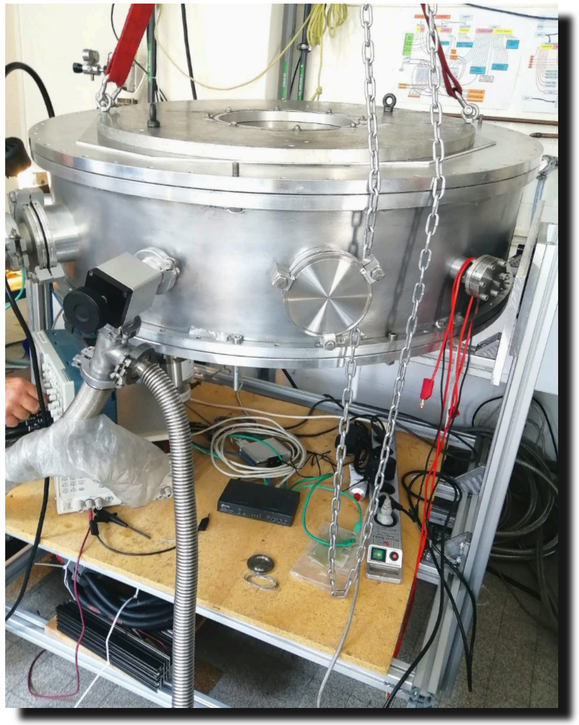
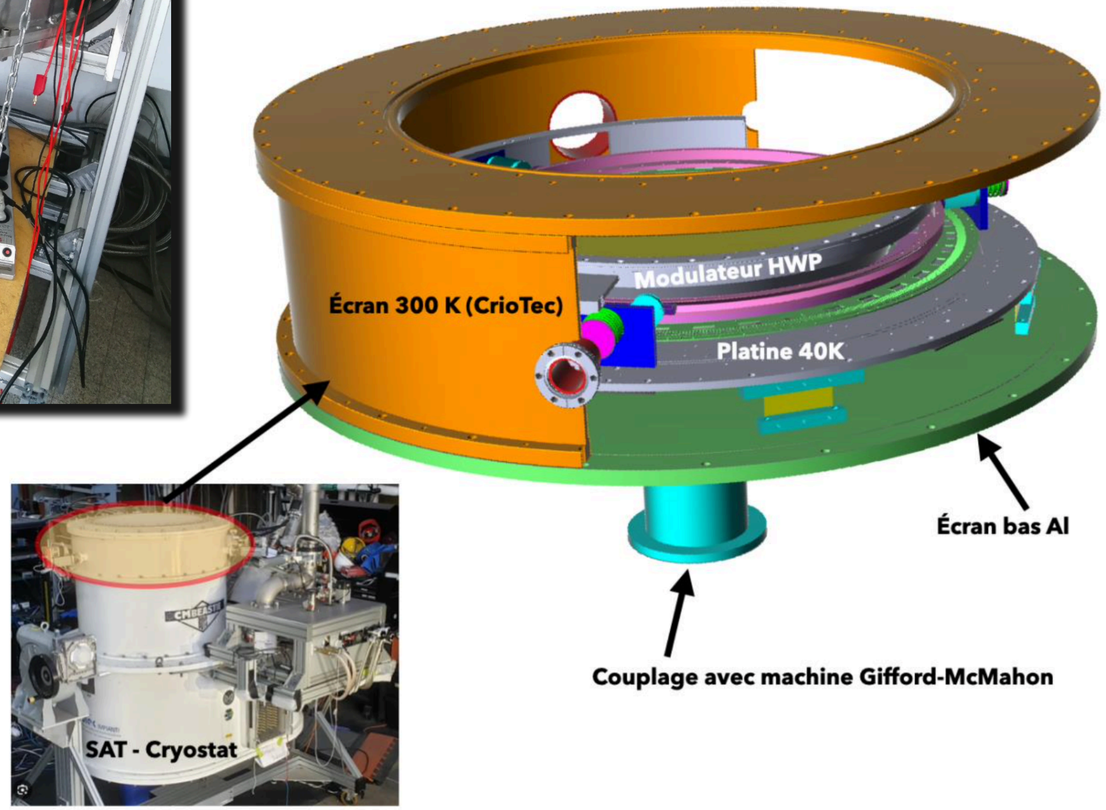
Exemple #1: HWP modulation Systeme

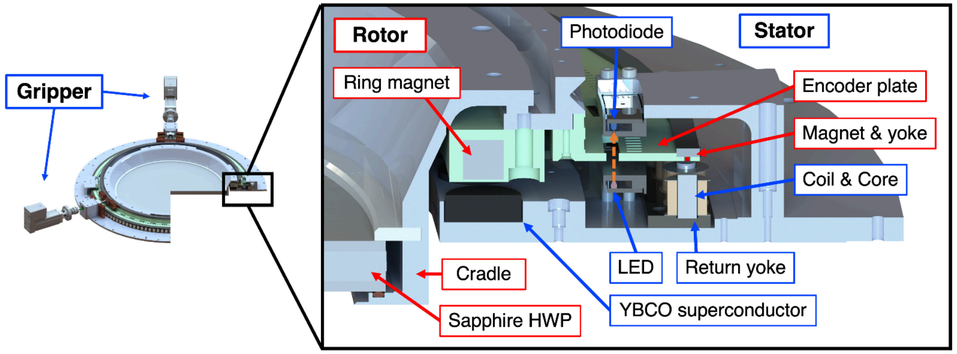
Changing some key element of the design

- **Angle encoding & control Electronics**
- **Grippers?** (from warm step motor to passive Nitrogen)
- **Magnet?** (from Neodymium to Samarium Cobalt)
- **Few parts of the mechanical design.**



Fabrication of a test cryostat in progress.





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Exemple #2: Silicon Lenses

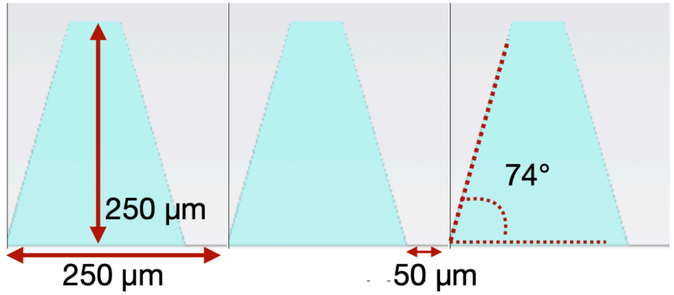
Up to now we have used for mm-wave instruments plastic lenses (HDPE or Polypropylene). Skills at LPSC

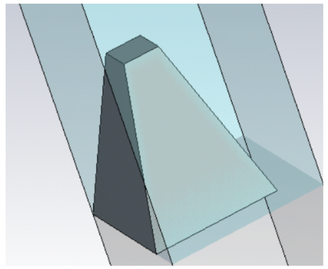
Bigger FoV → Bigger Lenses → Thicker Lenses

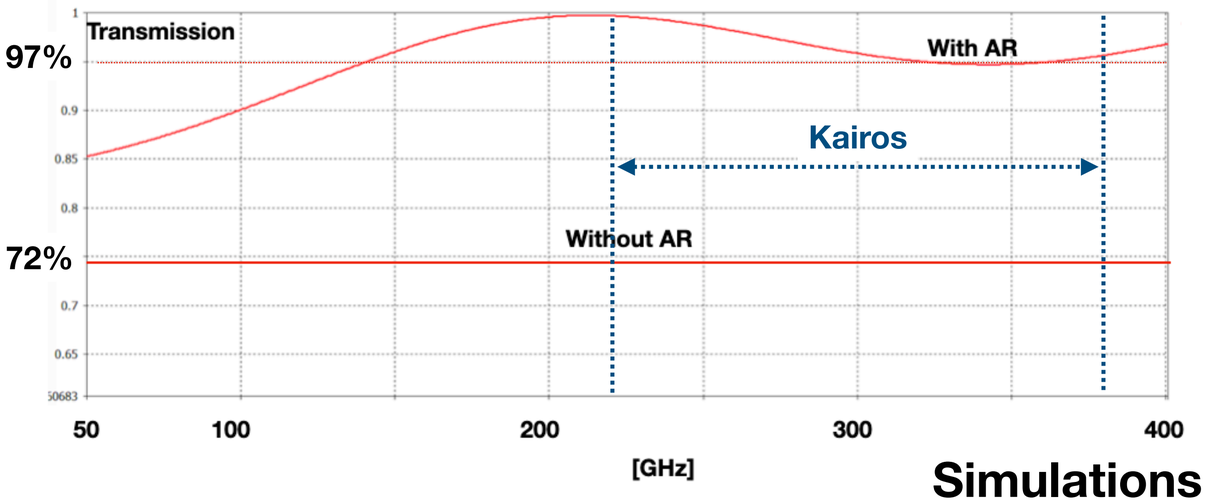
Plastic — low refr. index, higher absorption

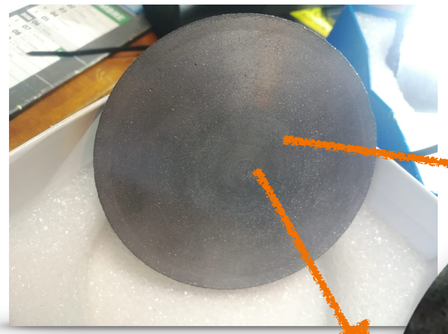
Silicon — high refr. Index, lower absorption

Anti-Reflection coating needed!









Simulations → **Prototype fabricated in December 2024**

Conclusion & Perspectives

- **Potential Funding**
  Participation to the CNRS *(RI)*^{2} program to design, install and commissioning the KID French SAT. Support of the three CNRS institutes (IN2P3,INSU and INP).

- **Interface with the SO Observatory Execution Office**
  Close contacte with S. Staggs, M. Devlin and A. Lee. Preparation of a first Collaboration agreement between OEO and Kairos Consortium. Once funded, the OEO will discuss directly with CNRS institutions.

- **Planning is very hard to keep, Kairos has to happen now or never……**