5000 pixels LEKID Array for Antarctic Terahertz Telescope at 850-GHz

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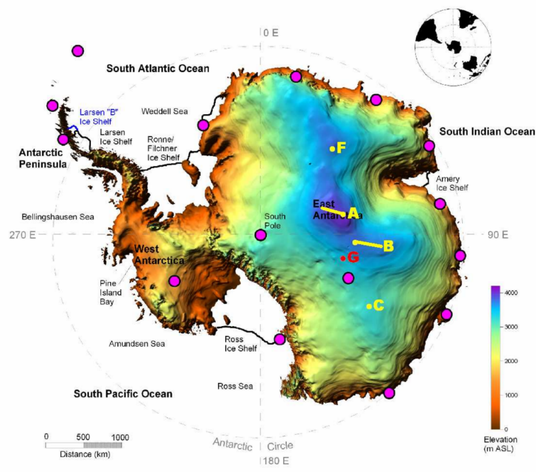
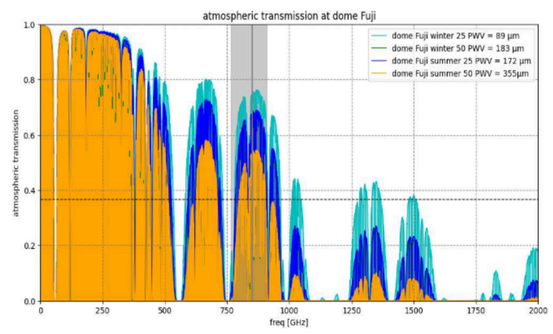
Science case

The Antarctic Terahertz Telescope project aims to build a 12m diameter single dish telescope on Dome Fuji (3810m). Spectroscopic observation would be conducted by an heterodyne instrument, and imaging done by superconducting Kinetic Inductance Detectors.



Will Saunders et al.(2009), Where is the best site on Earth?

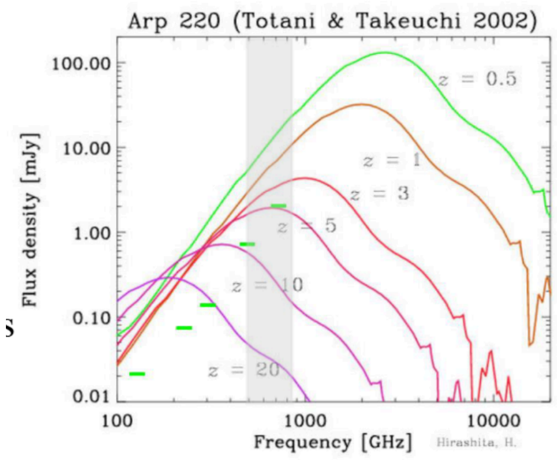


Atmospheric Transmittance at Dome Fuji

Dome Fuji is an exceptional site for southern hemisphere observations thanks to the high altitude and low PWV, which allow from ground based observations at high frequencies (from 200 GHz to 1 THz). Atmospheric transmission is around 60% at Dome Fuji for the 850 GHz band, which is really good compared to many observation sites in the world.

Science case : Survey the emission of dusty galaxies in submillimeter and THz band (850 GHz). Precise measure of dust temperature, and redshift for distant galaxies (z=5-7), because the band is near the SED peak.

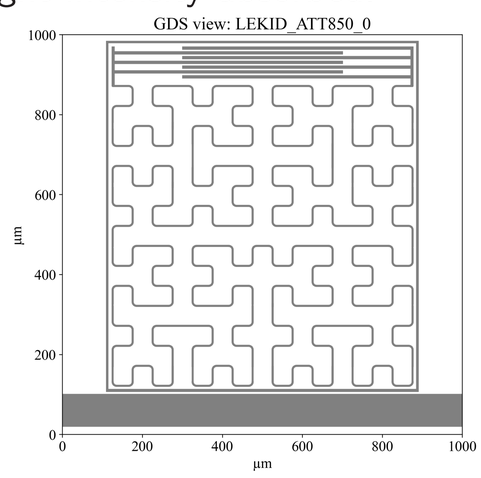
Goal : Design, fabrication and test of a dual-polarization, photonoise-limited array of Superconducting Kinetic Inductance Detectors (KIDs), with highest angular resolution possible.



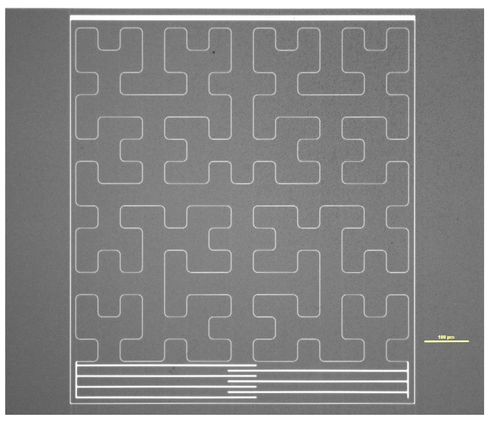
Spectral Energy Distribution (SED)
$T_{dust} = 42K$, $L_{IR} = 1.4 \times 10^{12} L_{\odot}$

LEKID pixel Design and characterization

Pixels are designed as Lumped Element Kinetic Inductance Detectors (LEKID). A Superconducting resonator (LC), absorbs photons that break cooper pairs, and increase the Kinetic inductance. The resonance frequency shifts, and can be accurately measured to recall the light intensity absorbed.

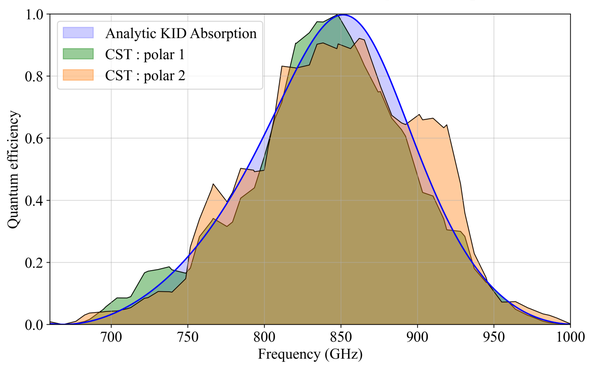


Design of a single 1mm pitch pixel : Hilbert pattern LEKID



A single pixel seen under the optical Microscope

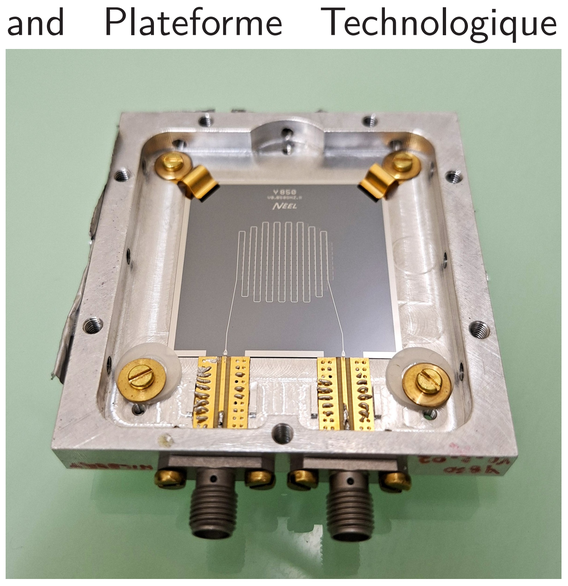
Inductance of the LEKID is shaped as Hilbert pattern to allow for dual-polarization absorption. The interdigital capacitor is tunable to change the base resonance frequency of each pixel.



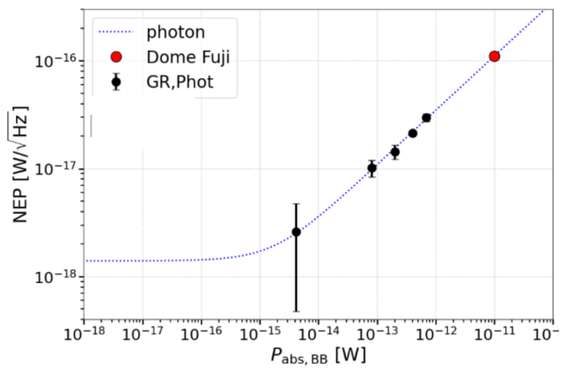
CST Studio Simulations :
Quantum efficiency of the detector is optimized to aborb more than 60% of the incomming light on the whole band, and reaching 90% efficiency at 850 GHz.

First Detector prototype

First array built in 2024 to test the pixels sensitivity, in Néel and Plateforme Technologique Amont (PTA Grenoble) facility.



First iteration of the ATT850 Array



Measured NEP on the v0 array, compared to Fuji Dome NEP

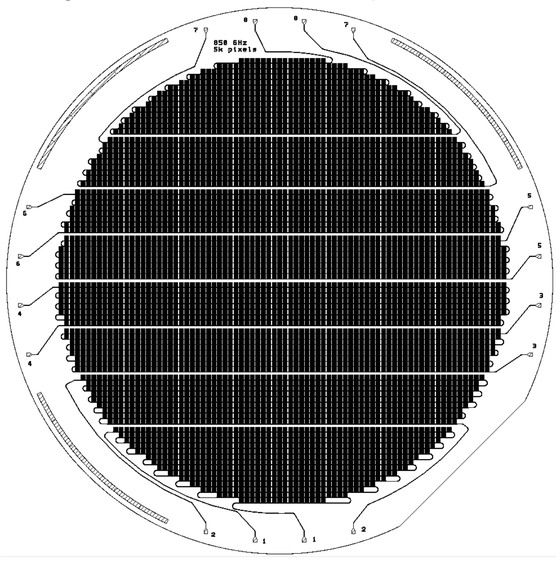
The first detector Array has 224 pixels, made on 130μm silicon, in 25nm Aluminum.

Yuma Sato measured and studied this array in a 100mK dilution fridge, providing sensitivity measures of the detectors.

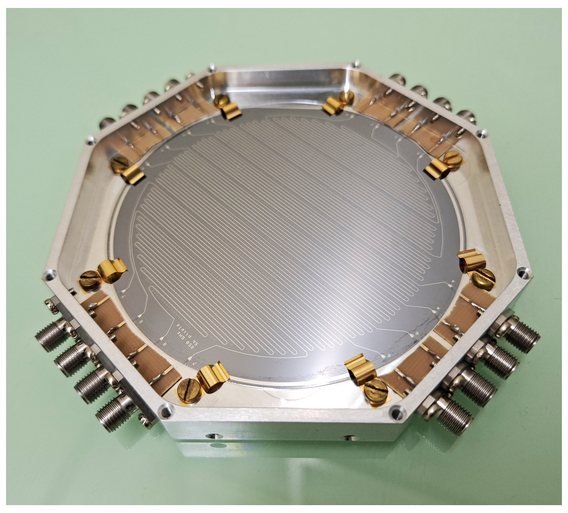
The LEKID pixel sensitivity is photo-noise limited, and therefore capable to measure the expected background at Dome Fuji ($\approx 10^{-11}$ W/pixel).

5000 pixels design

Based on the v0 sensitivity measurements, the goal is to scale up the array to thousands of pixels to reach maximal angular resolution.

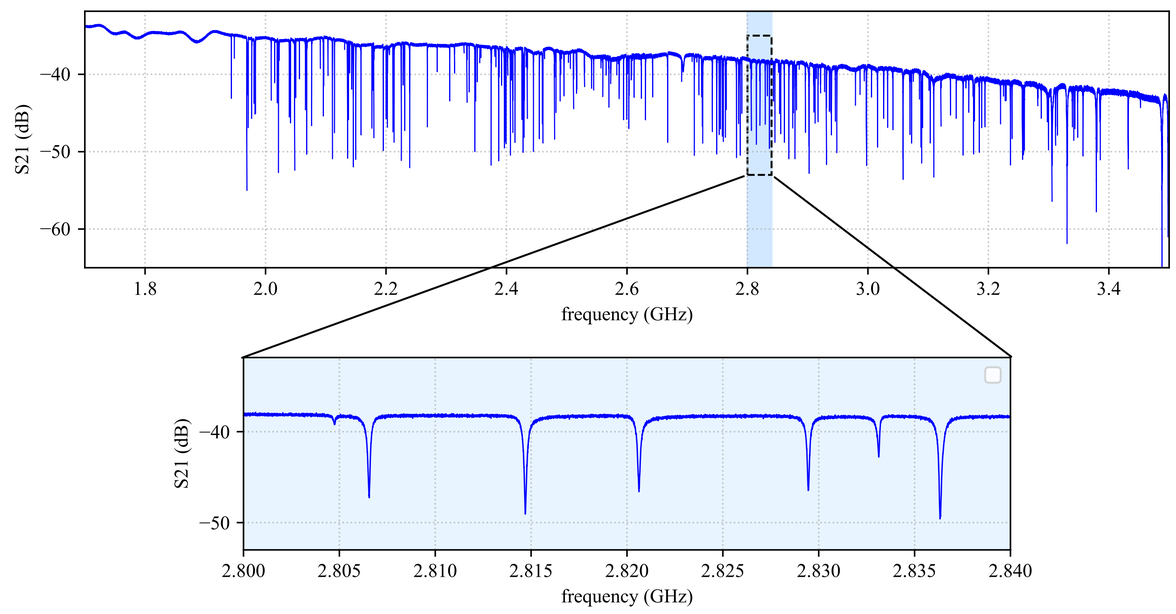


New design of 5028 pixels array on a 4" silicon wafer.



New 5028 pixels array assembled in device holder.

A 5028 pixels design has been fabricated and is currently being tested. The pixels are distributed on 8 feedlines (≈ 800 pixels/feedline) with a resonance frequency between $1.7\ GHz$ and $3.5\ GHz$. Frequency distribution still needs to be optimized on array (cross-talk, coupling).



VNA scan of feedline 1 for sensor in dark environment.

Conclusion

A new 5000 LEKID pixels sensor has been designed and tested for the ATT850 telescope project. Sensitivity and angular resolution goals have been validated. However, Quantum efficiency measurements and design optimization are still to be done.