Millimeter wave detection using On-Chip LEKID based spectrometer

Usasi Chowdhury

Supervisors: Alessandro Monfardini, Florence Levy-Bertrand, Martino Calvo

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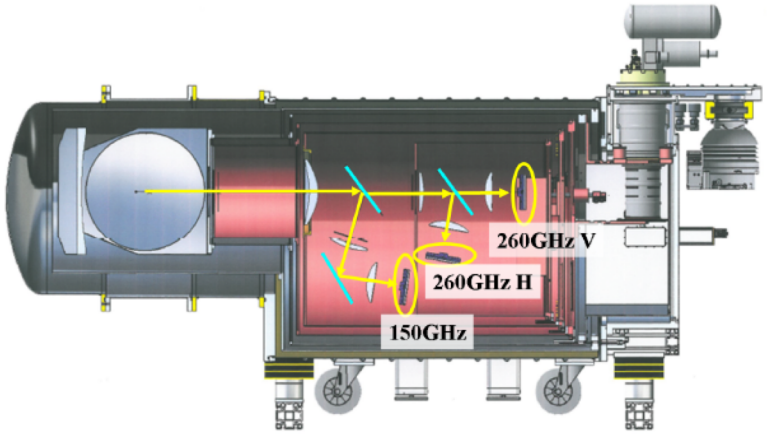
Outline:

- Scientific Motivation
- Goal of the thesis
- Concept of on chip spectrometer, *OMKID*
- Results

Motivation:



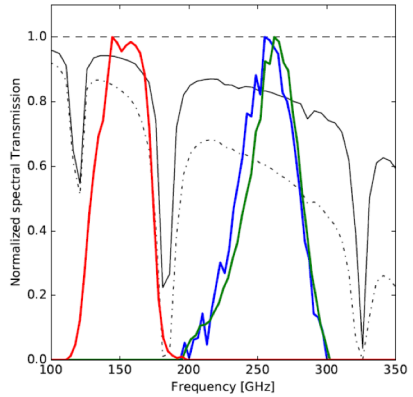
NIKA2 Camera
Imaging
$R = 3 - 5$

MISSING Part!!!

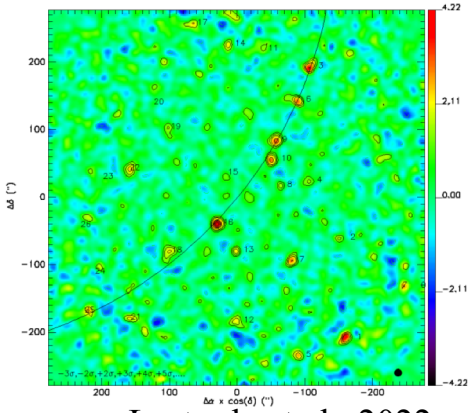
Mapping speed of intermediate spectra resolution

NOEMA
High Resolution Spectroscopy
$R = 10^5$

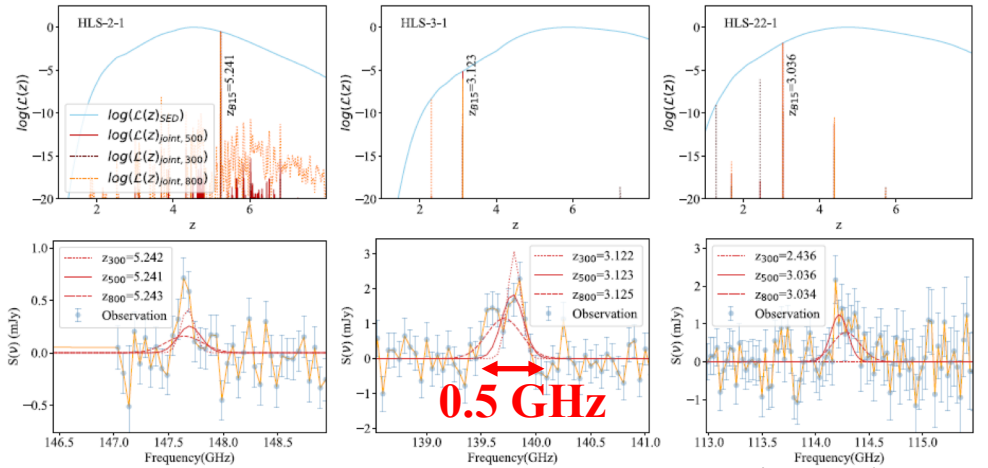
NIKA2 spectral characterisation



Adam et al, 2022

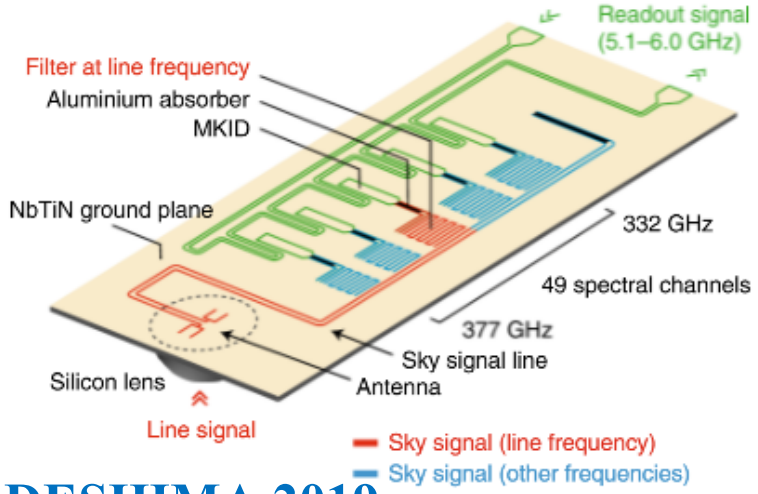


Lestrade et al., 2022

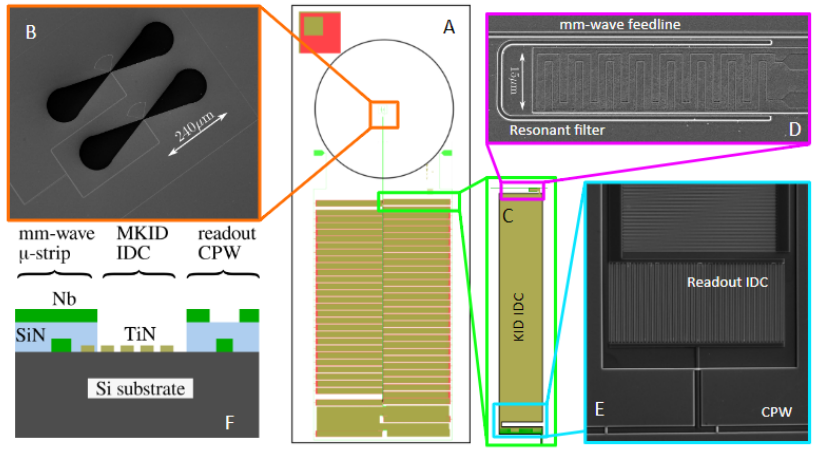


Bing et al, 2022

Goal: On-Chip Spectrometer based on Kinetic Inductance Detectors (KIDs)



DESHIMA,2019 330-380 GHz



SuperSpec, 2019 180-300 GHz

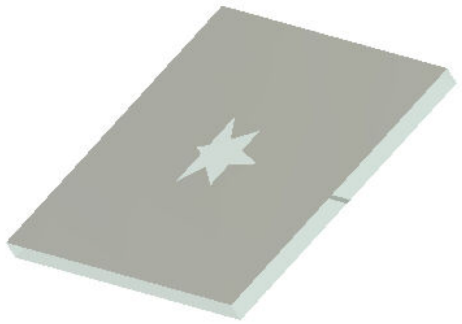
OMKID, 2021 75-110 GHz

- ✓ **Minimized design**
- ✓ **Monocrystalline dielectric material**
  Sapphire(100 µm, 150 µm)
- ✓ **Ground with Slot**
- ✓ **Simplified lithography process**

- **Concept of on-chip spectrometer:**

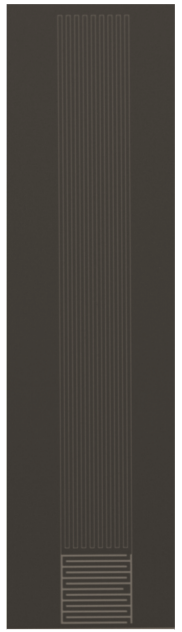
  ✓ **Spectrum Analyzer**

Antenna/ Selection of source frequency → Filtering the frequency → Detection of each of the frequency → Power Spectrum for the range ofsource frequency

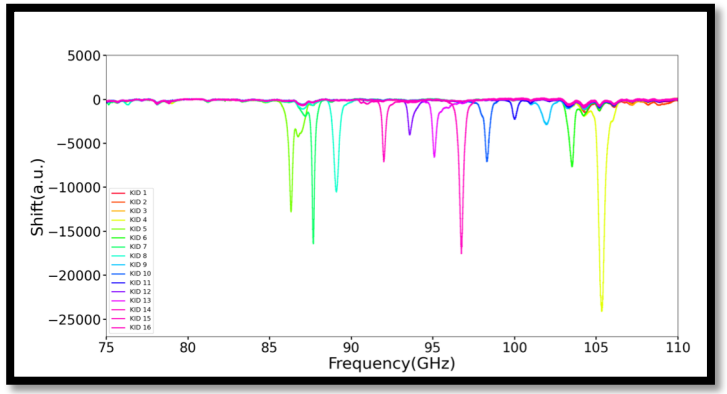


Microstrip slot antenna

Planar Bandpass filter

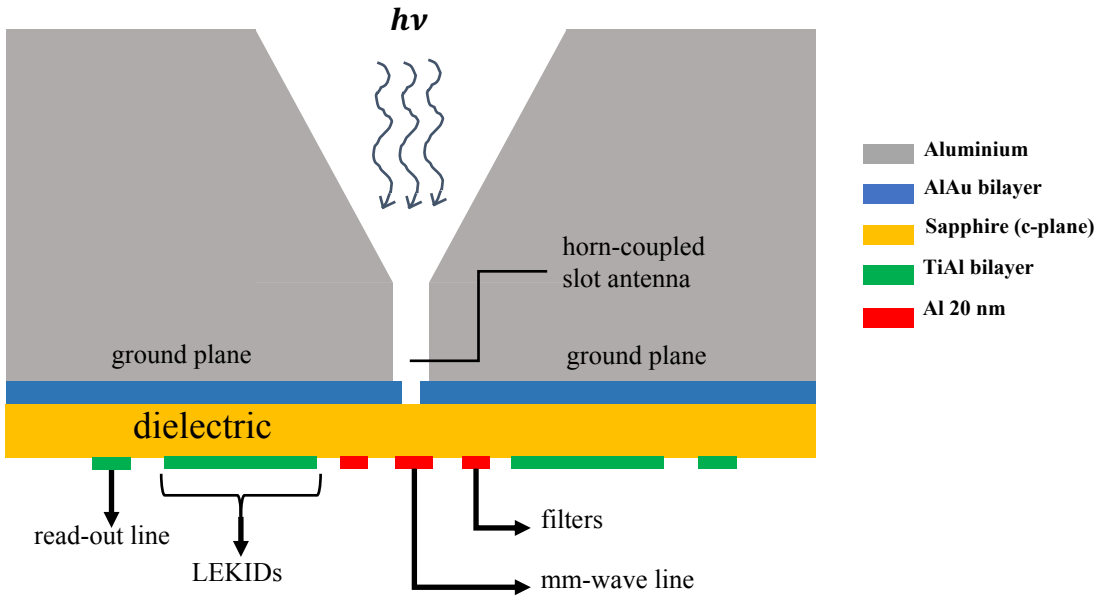


LEKIDs



Spectrum Data

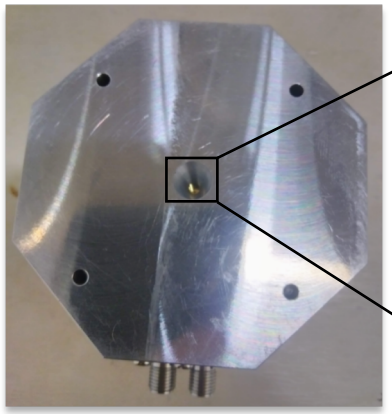
OMKID: *the onchip spectrometer*



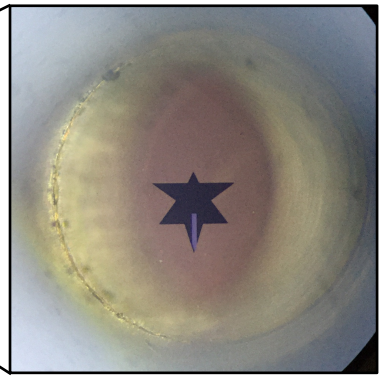
Schematic side section

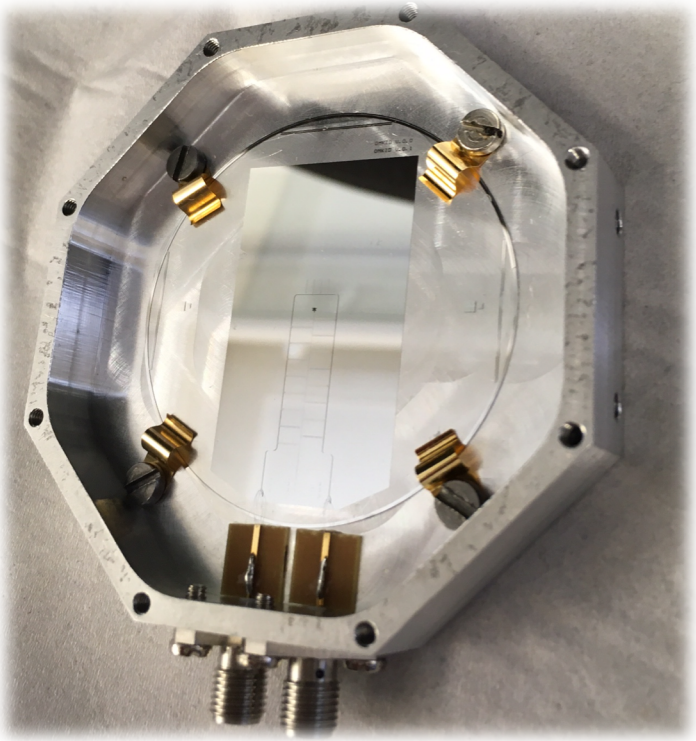
Side infront of the source

Side with horn and slot: Infront of Source



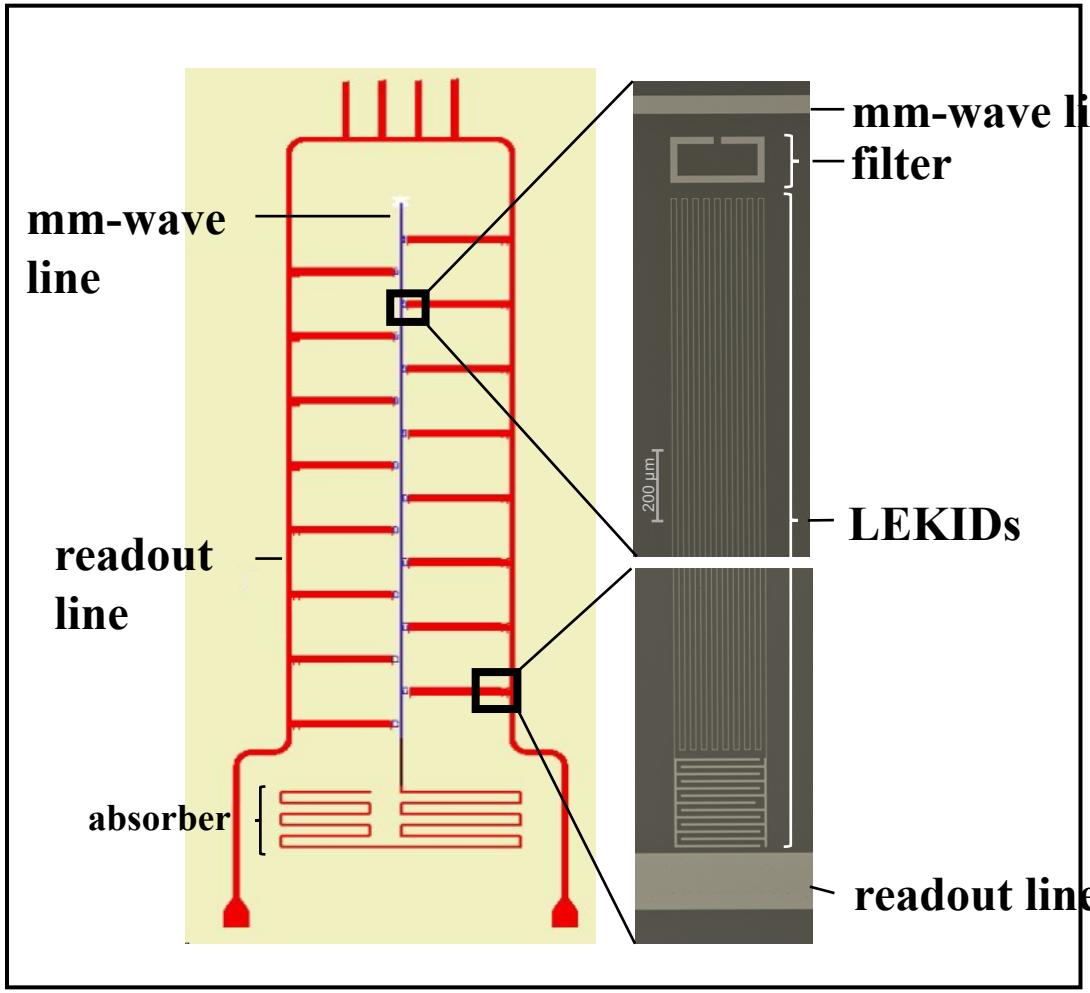
Star-slot antenna with microstrip feed (mm wave line)



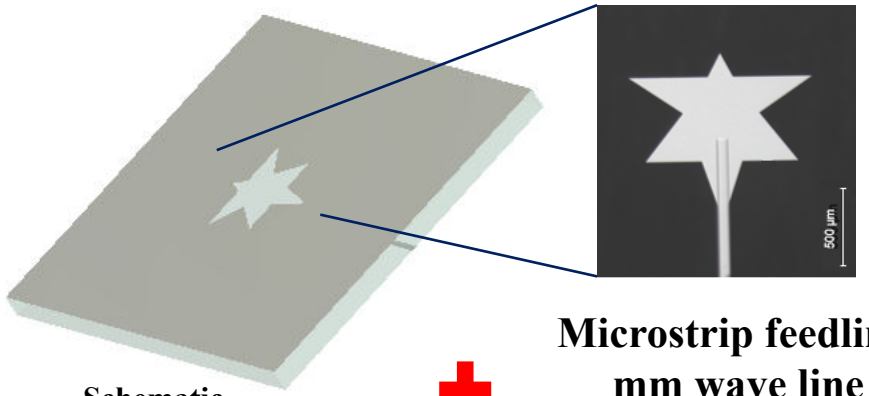


Back side of sample holder

16 pixels

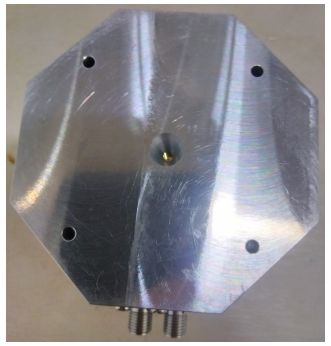


Star-shaped slot in continuous ground plane

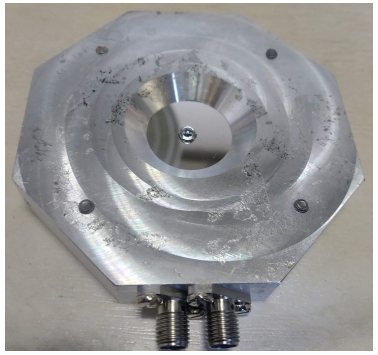


Schematic

Microstrip feedline/
mm wave line

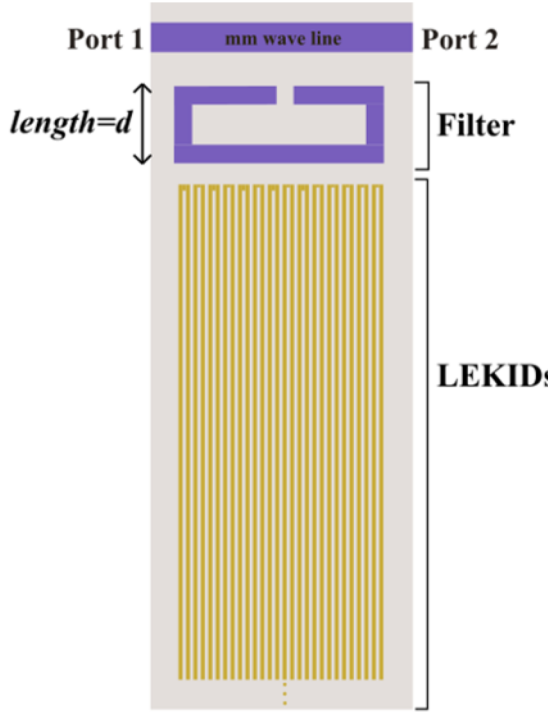


Horn

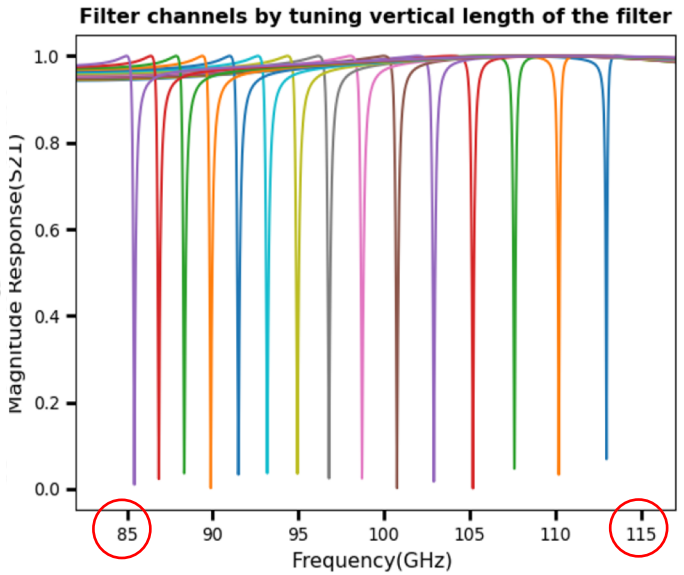


Si lens

Resonant bandpass filter: Selecting subband (80-120 GHz)

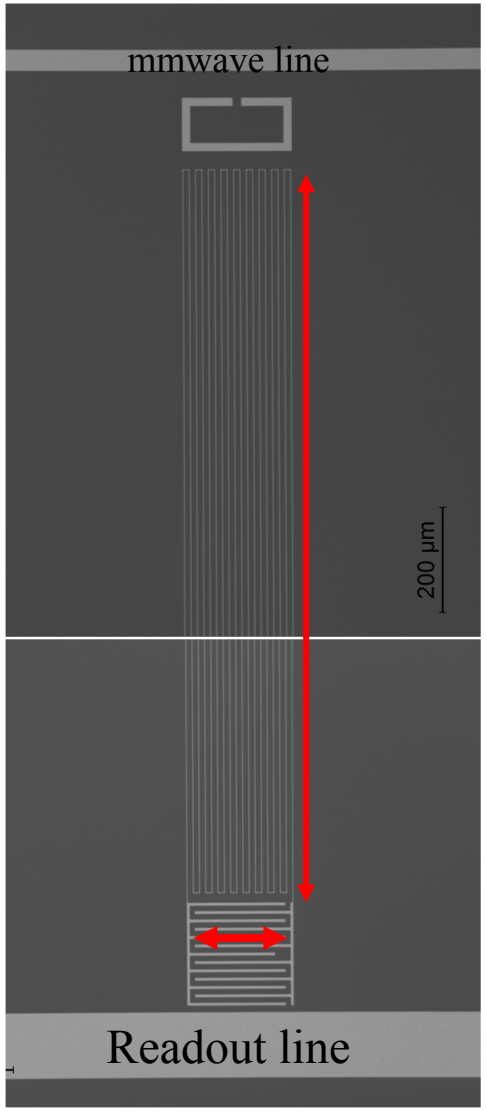


Change resonant
frequency: Adjust *d*



Spectral bandwidth: 0.5 GHz
Q factor = 220

Using different components for different element:



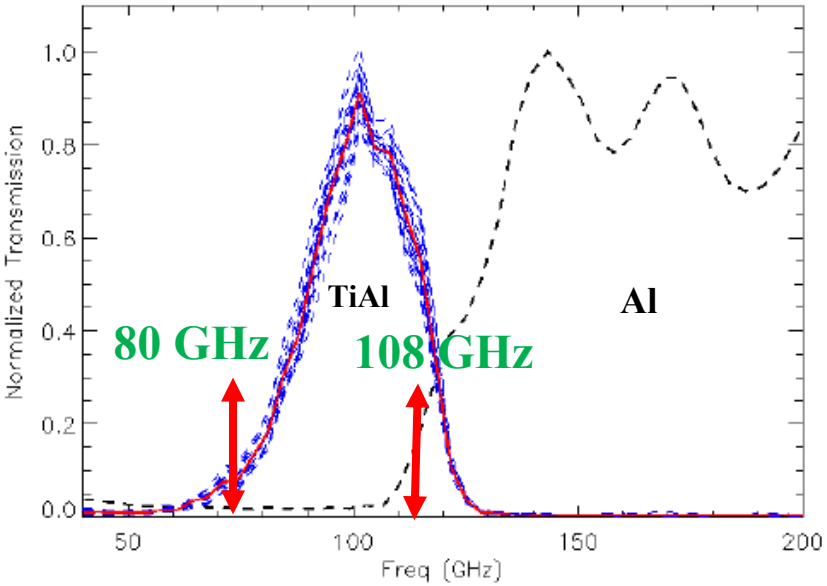
Probe tones: 1-2 GHz

Q factor: 10^5

mm wave Transmission line, Band pass filter:
Al 20 nm: T_c=1.4 K, Cut off frequency ~ 108 GHz

Resonator, Readout line:
TiAl Bilayer (10+15 nm), T_c~1 K
Cut off frequency ~ 80 GHz

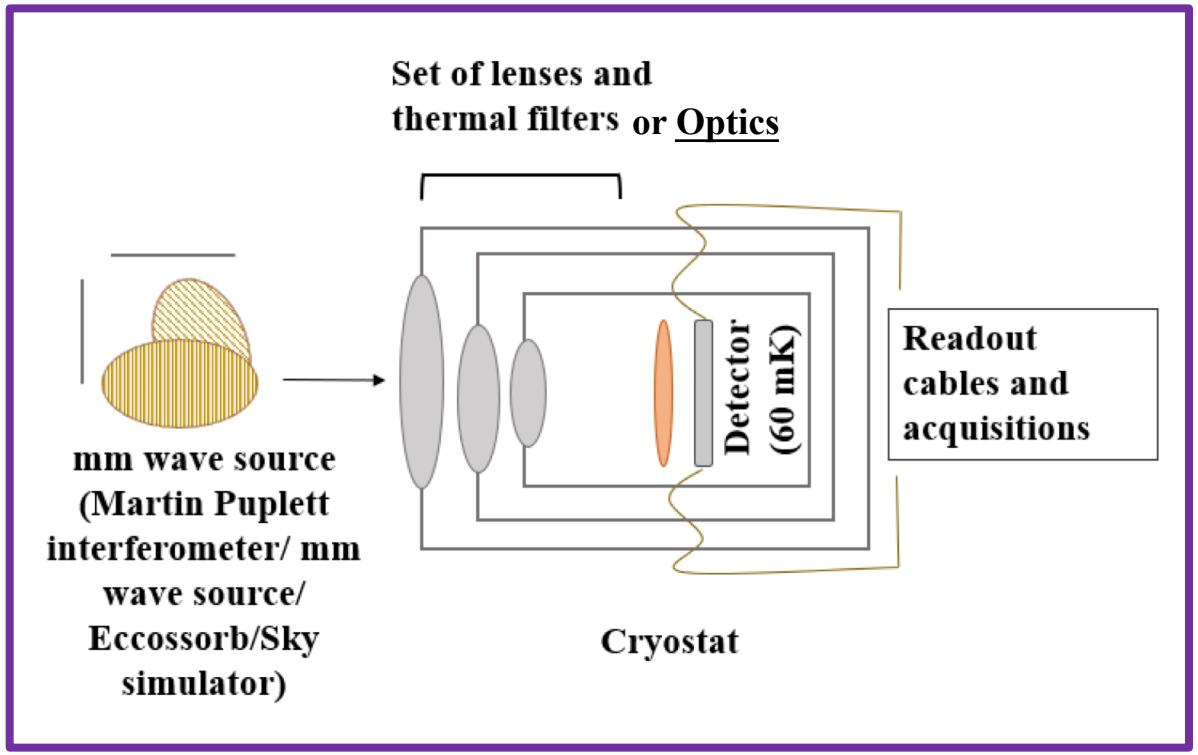
Proximity effect: TiAl bilayer

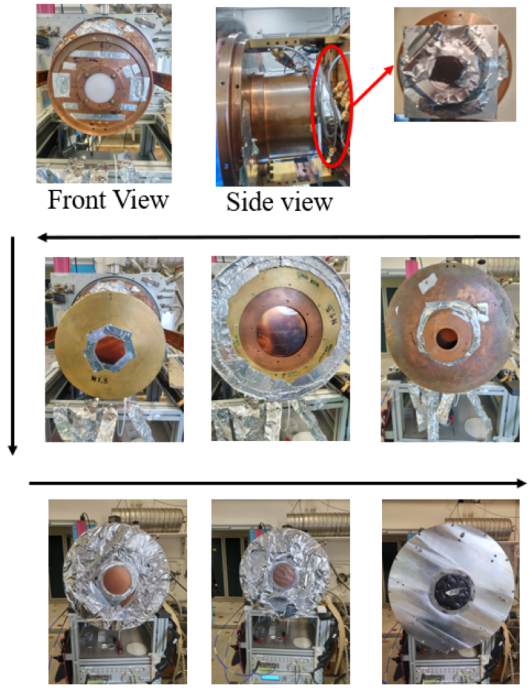


Superconducting Cut off frequency,

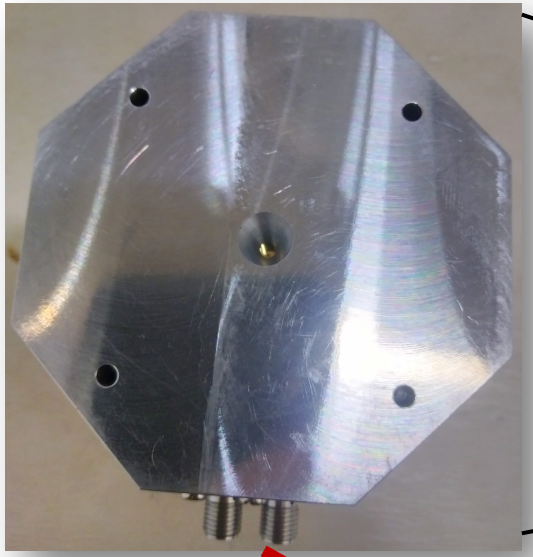
$$\nu_g = (74 \times T_C)\ GHz$$

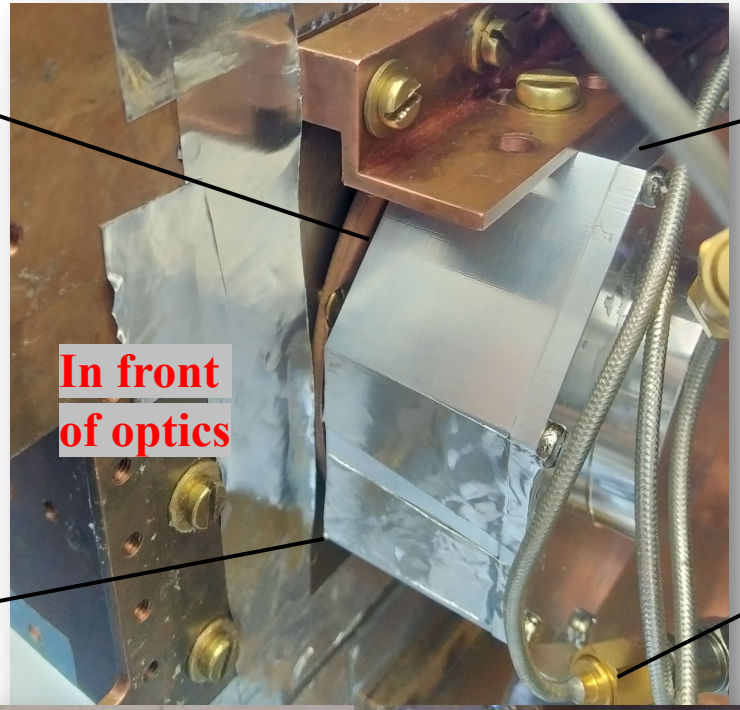
- **Measurements of OMKID spectrometer:**



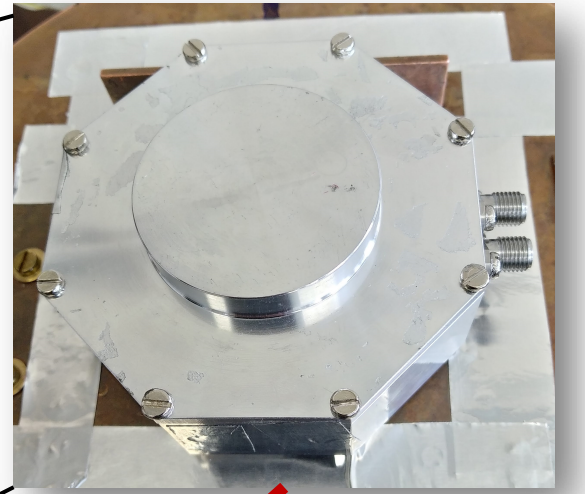


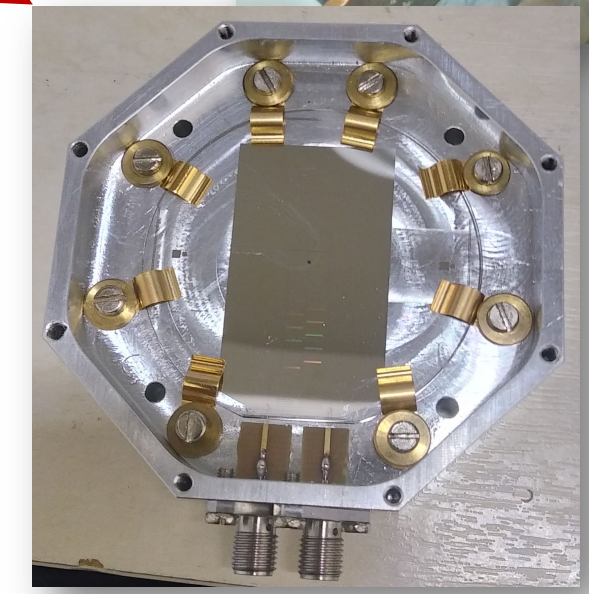
Horn antenna with slot



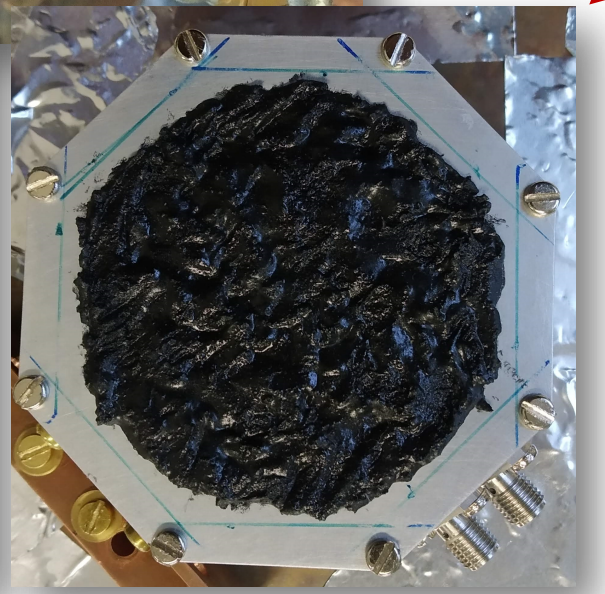


In front of optics





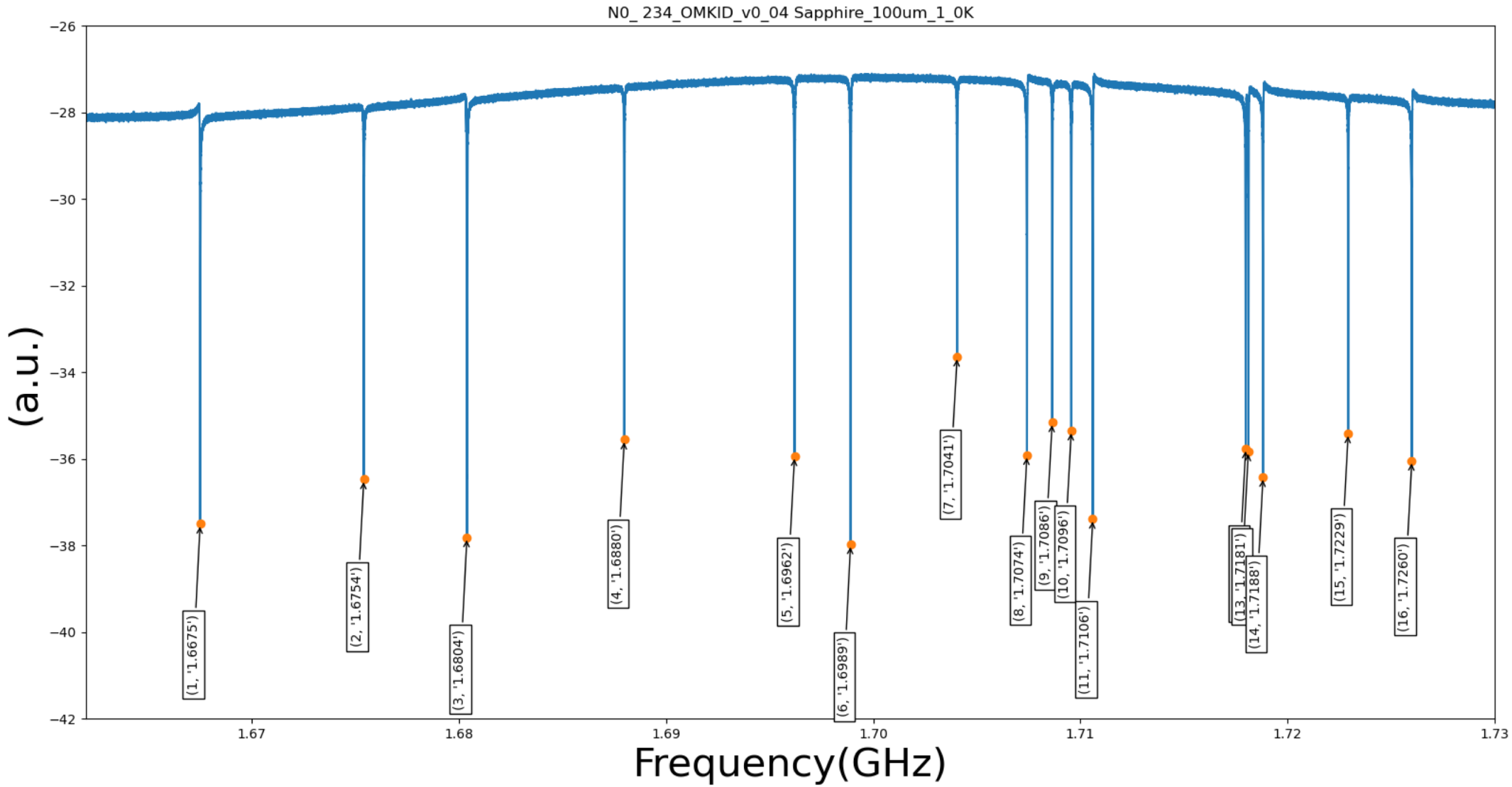
Detectors



Eccossorb

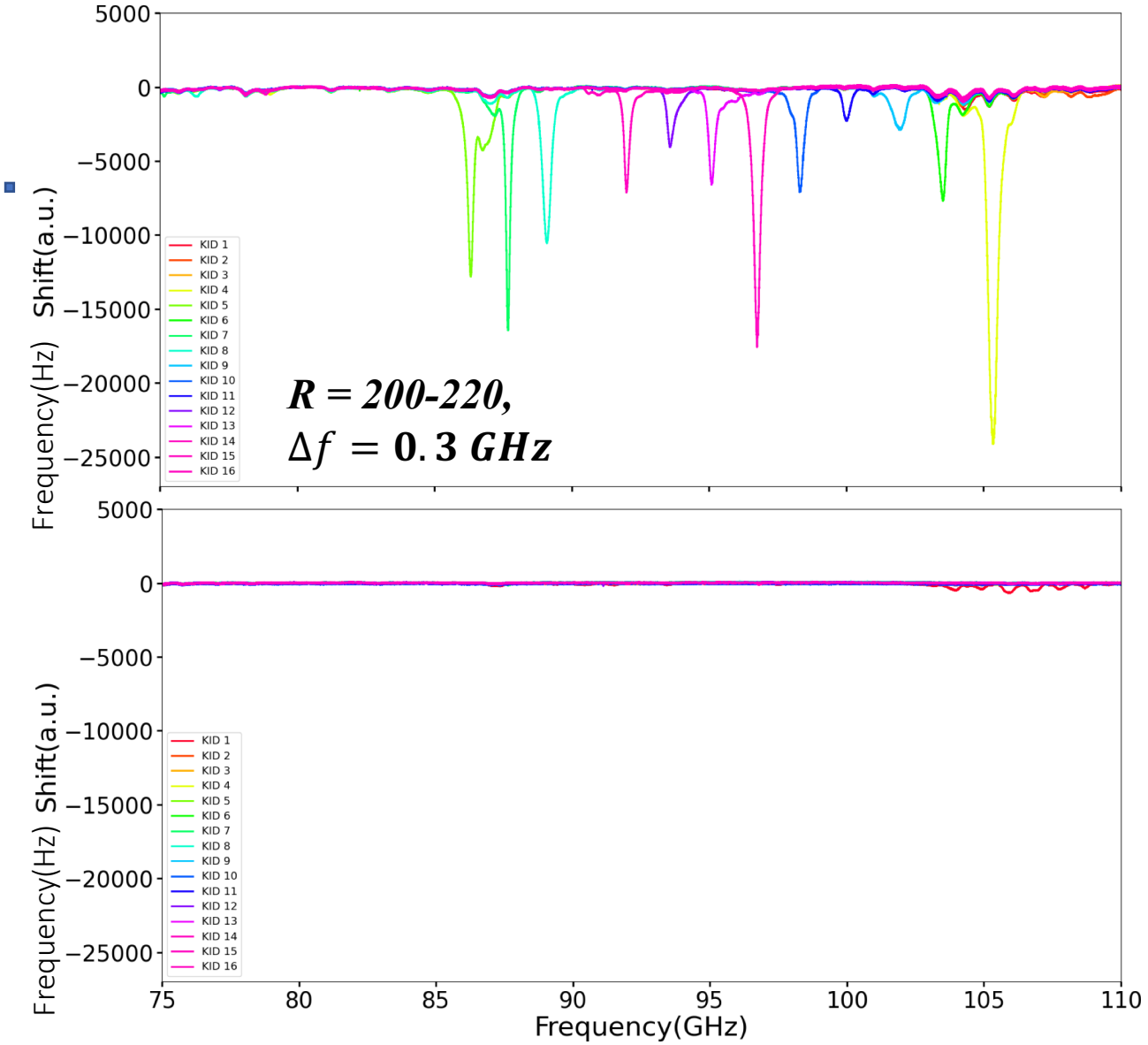
On the other side

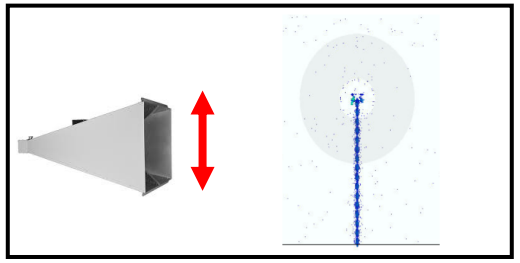
VNA response of the LEKIDs:



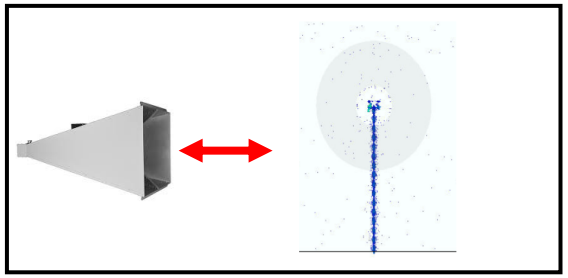
Results:

Illumination through horn and slot antenna





Horizontal polarization w.r.t mmwave line



Vertical polarization w.r.t mmwave line

Conclusion:

- ✓ The device is working with promising results.
- ✓ Strong polarization dependency is observed with the currenct device configuration.
- ✓ More optimization is needed for each component.
- ✓ Upcoming with higher channels(64+64 channels)

Thank you very much for your attention.