Next Generation of NIKA2 Pixels

Shibo Shu, S. Leclercq, A. Monfardini, M. Calvo, J. Goupy and E. Driessen

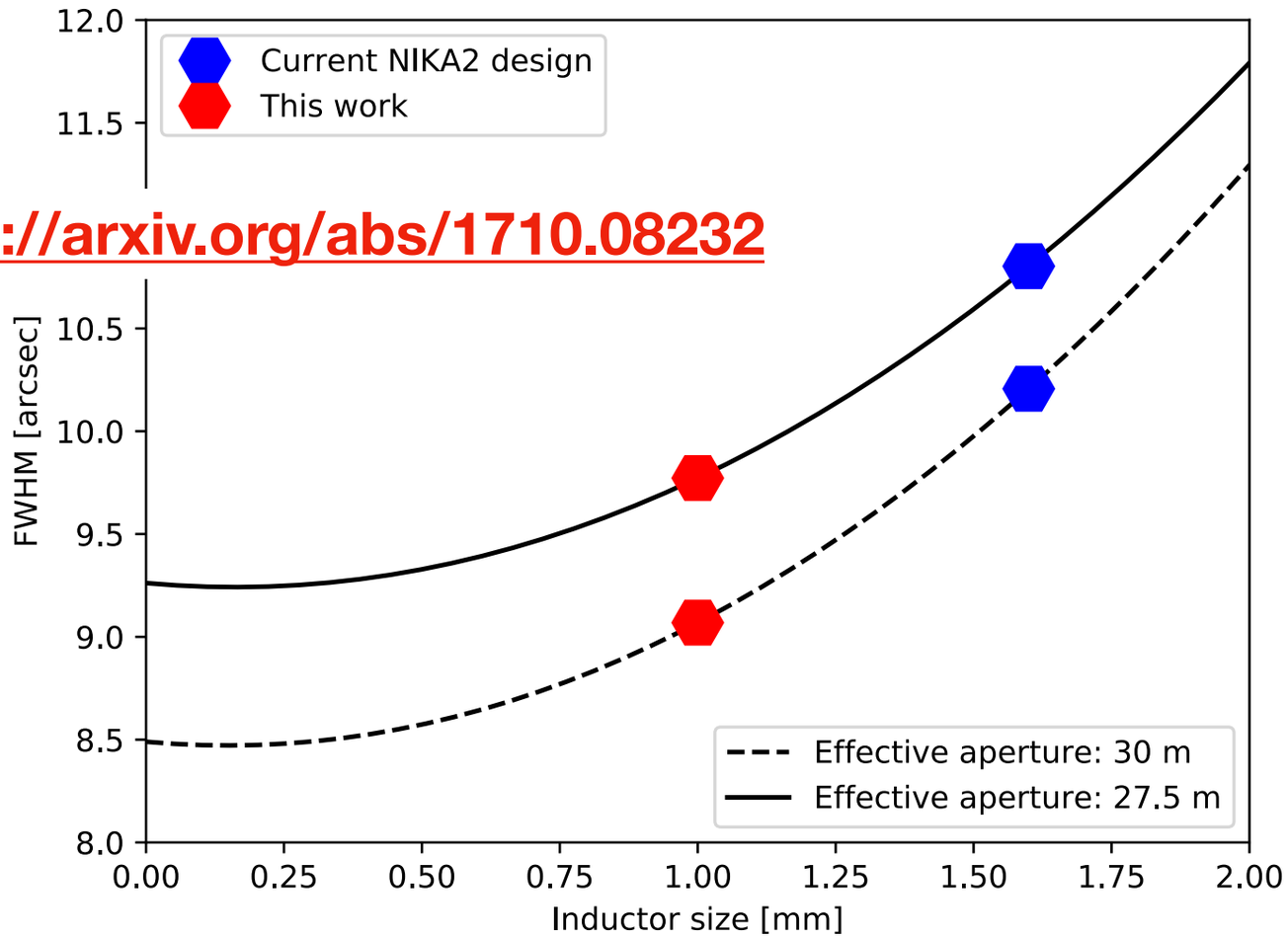
Future Development for NIKA2

- Higher angular resolution:
  10.8” -> 9.8” @1mm

Updated results: https://arxiv.org/abs/1710.08232

- Larger band coverage:
  230-290 GHz -> 200-310 GHz

- More sensitive:
  current 1mm array has 25 mJy·s$^{1/2}$



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Prototype High Angular Resolution LEKIDs for NIKA2

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Optical Response Analysis of LEKIDs Array

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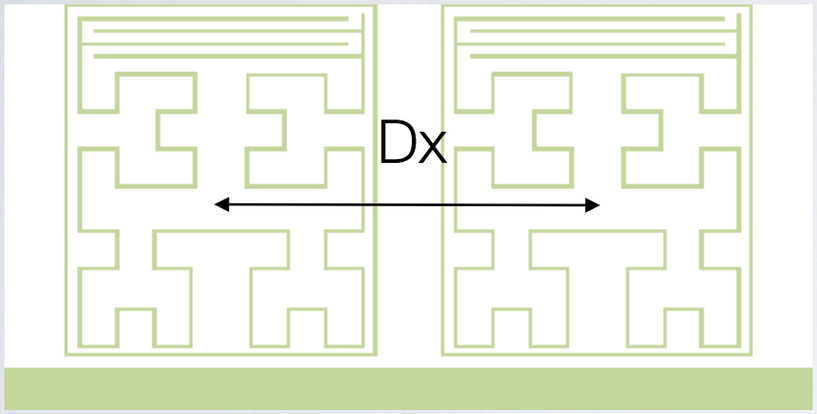
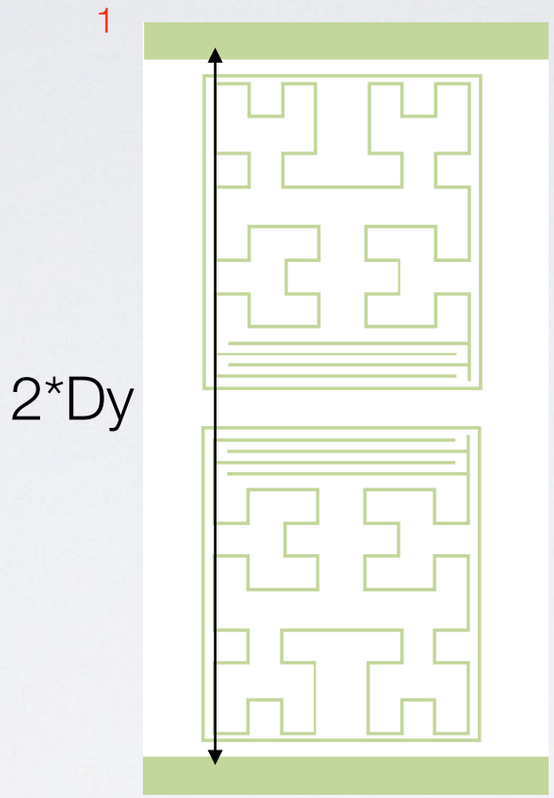
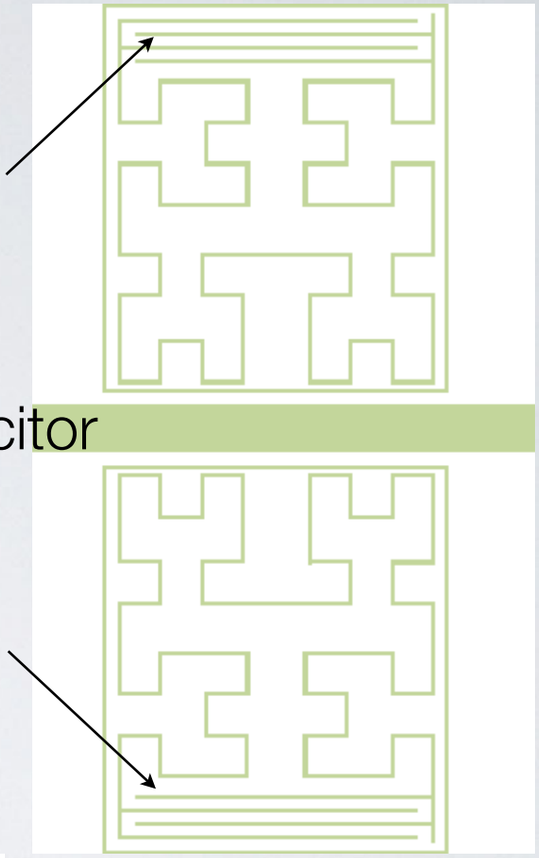
  mJy·$s^{1/2}$

Prototype high resolution LEKIDs







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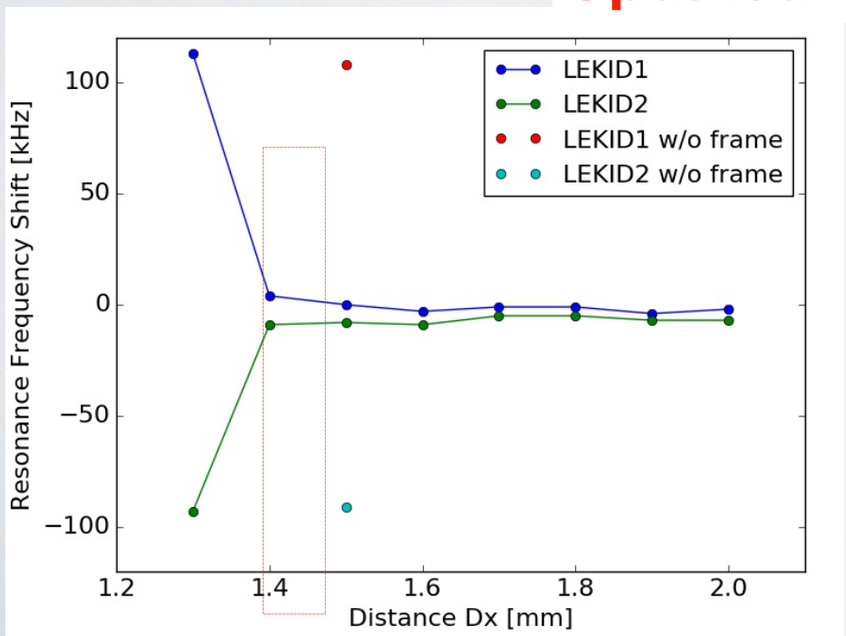

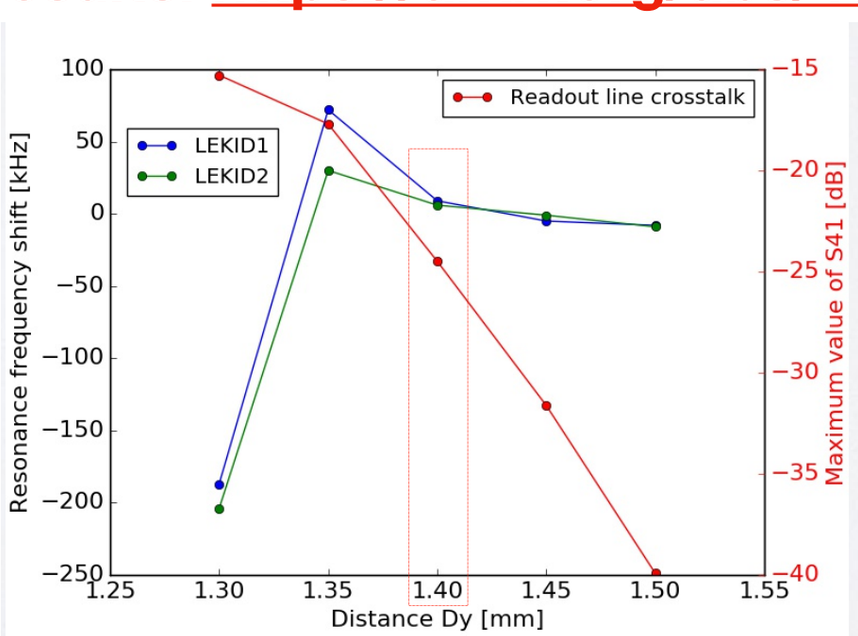

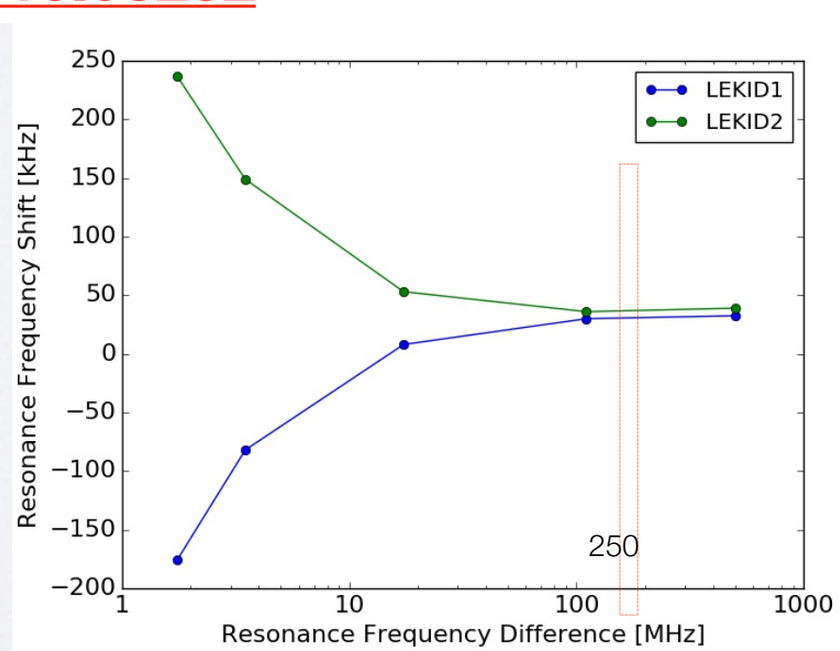

Prototype high resolution LEKIDs

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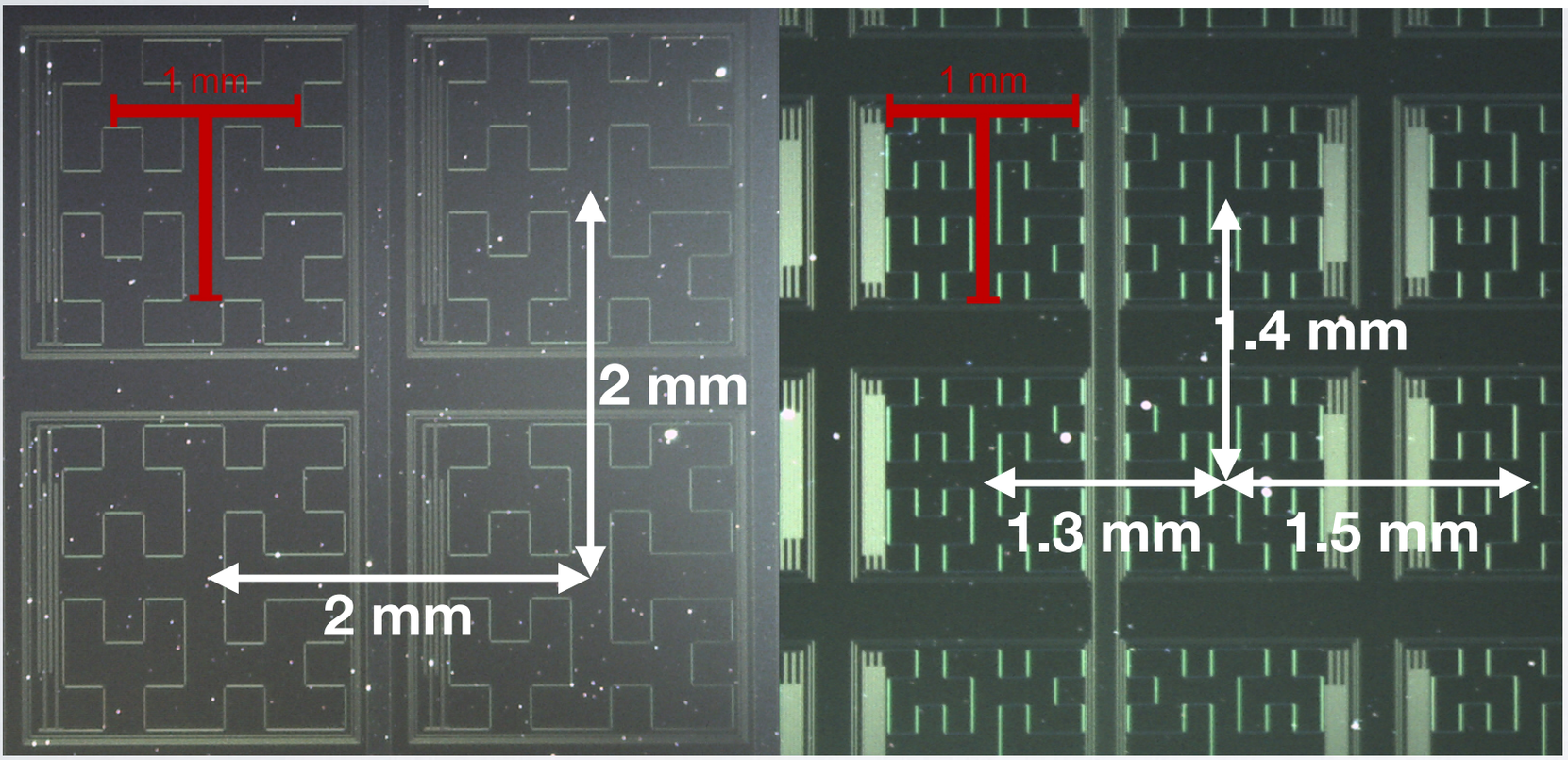
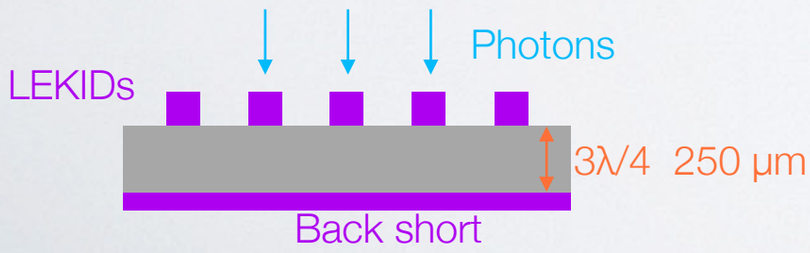


NIKA2 1mm Array | This work

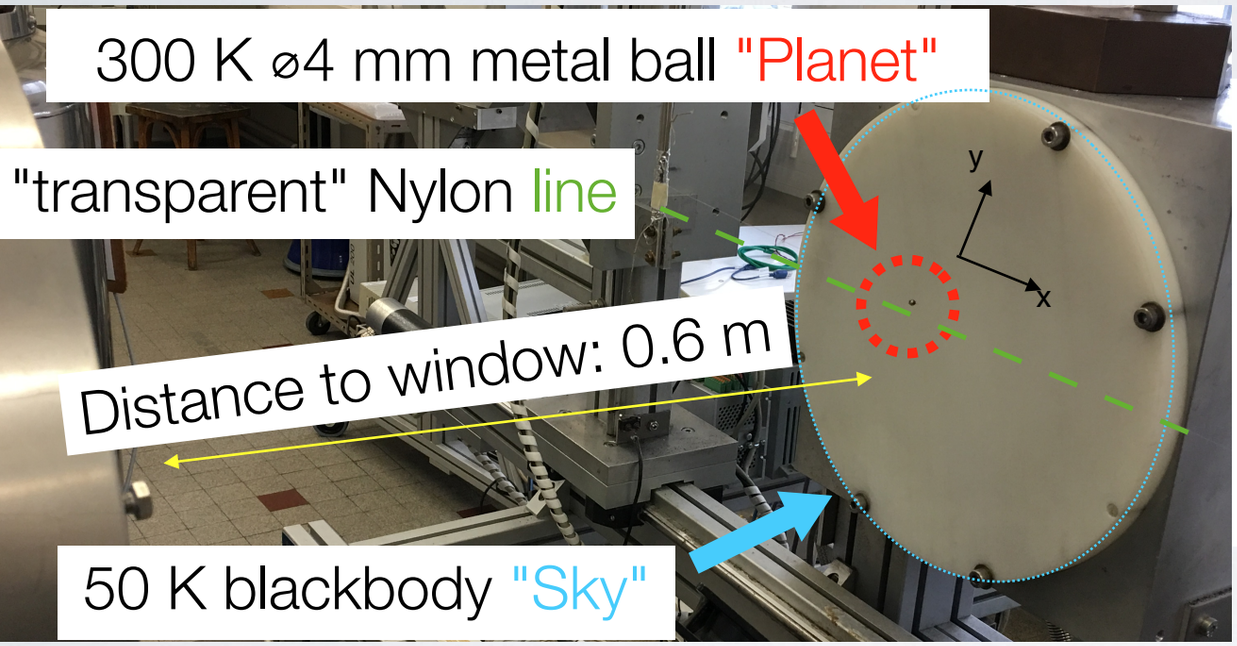
	NIKA2 1 mm Array	This work
Inductor size	1.5*1.6 mm^2	1*1 mm^2
Pixel size	2*2 mm^2	1.4*1.4 mm^2
Resonance frequency	1.9-2.4 GHz	2.1-2.6 GHz
Inductor width	4 μm	2.5 μm
Resolution [FWHM]	10.80"	9.77"



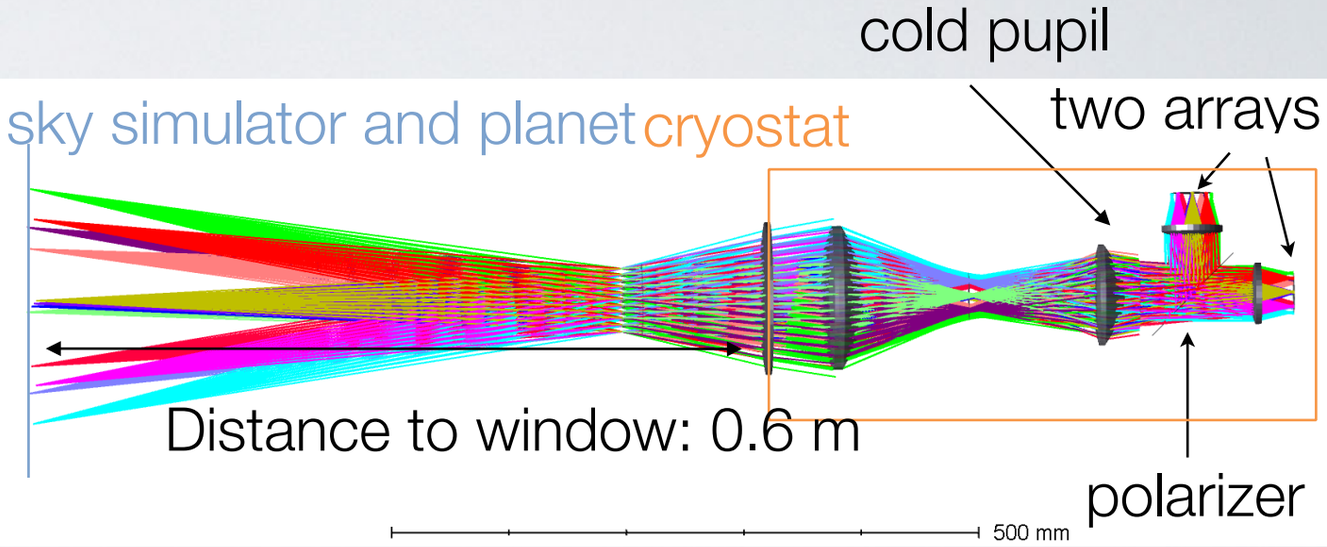
- **20 nm Al**
- **200 nm Al backshort**

Measurement optics

Updated results: https://arxiv.org/abs/1710.08232



Sky simulator setup

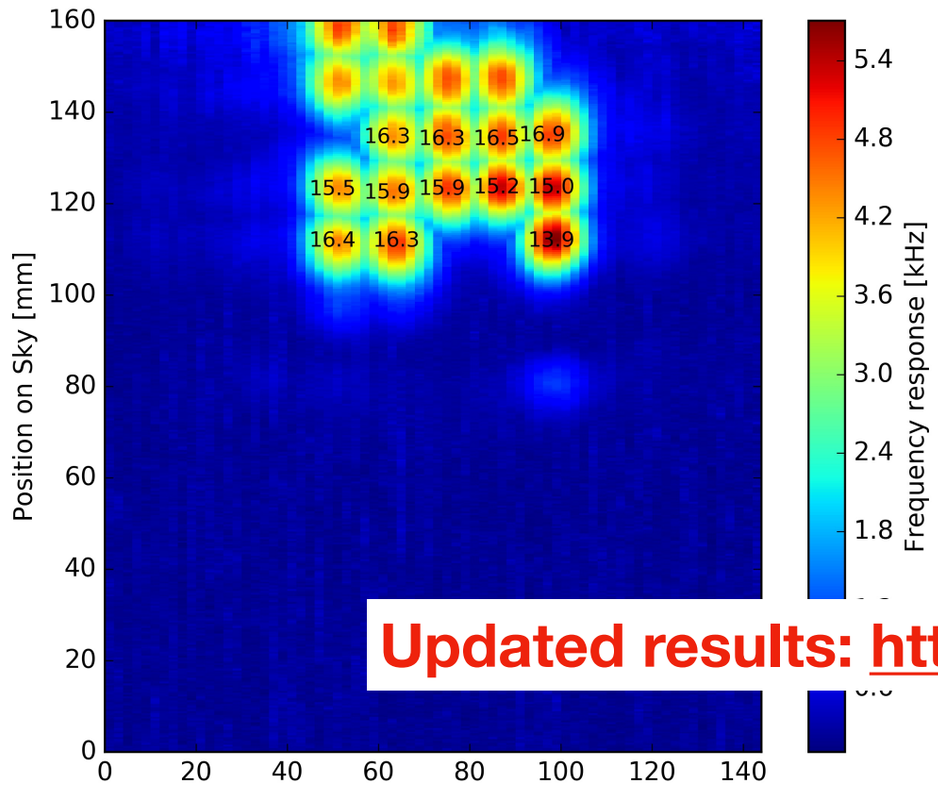


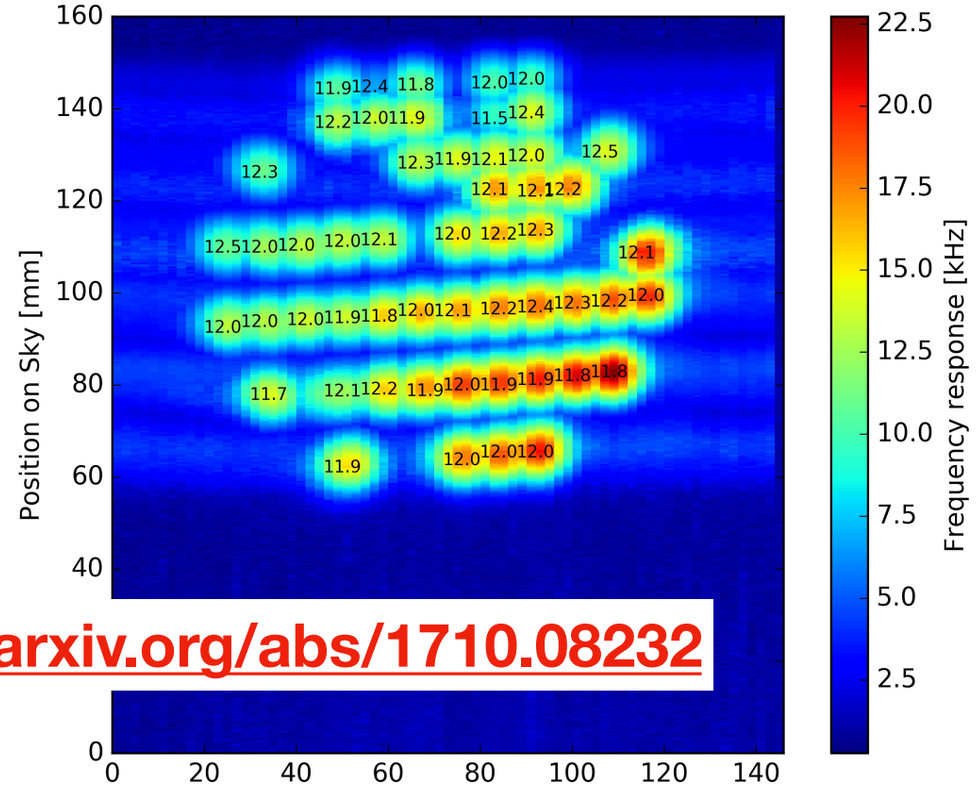
Optics of test cryostat

- **The optics and sky simulator optically behave the same as the NIKA2 at the 30-m telescope:**
  the planet image on focal plane <-> point spread function on telescope
- **This optics has a F#1.48 and a magnification factor of 0.38**

Measurement result

NIKA2 1 mm Array Numbers: FWHM [mm] This work





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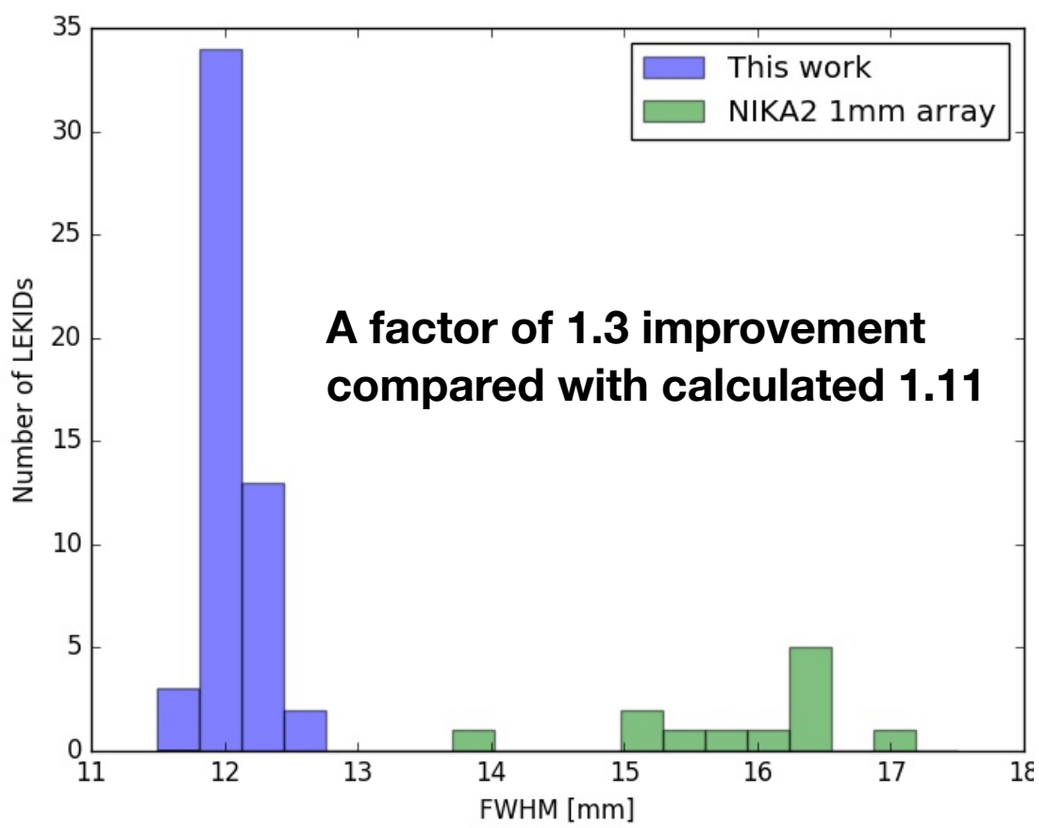
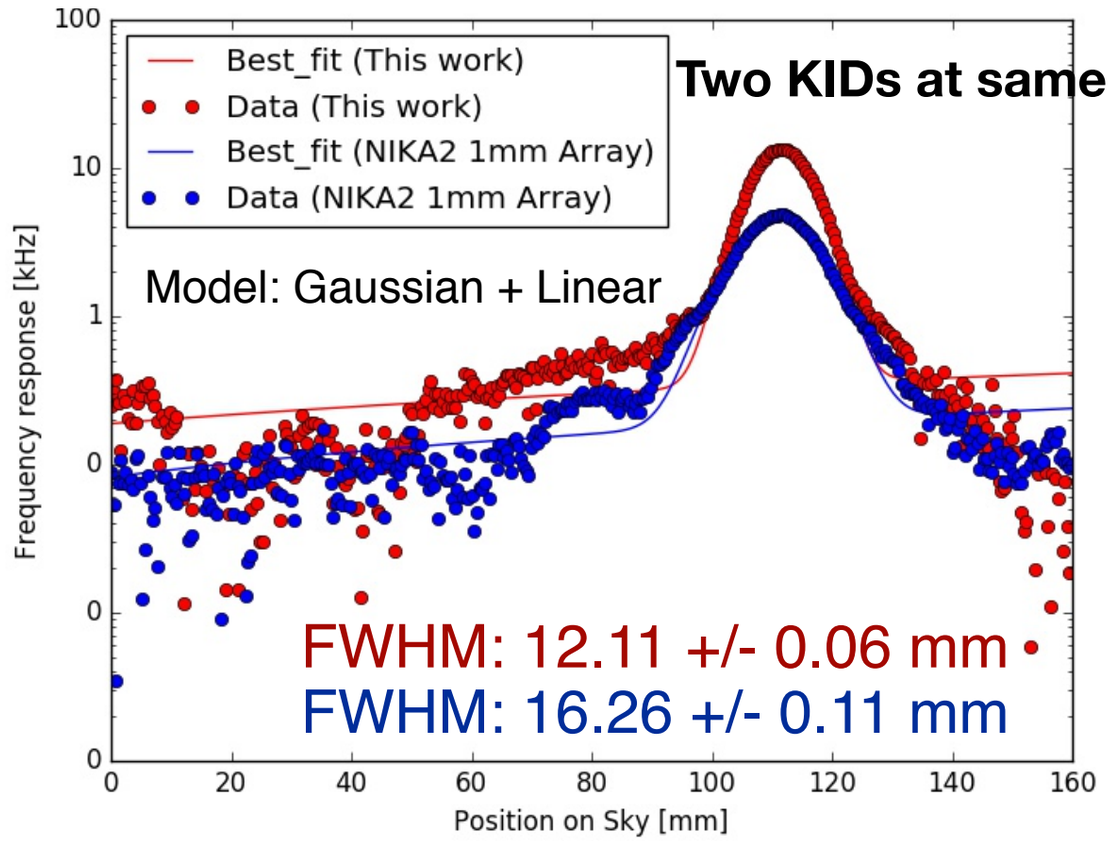
Position on Sky [mm]



Position on Sky [mm]



Optical response simulation of LEKIDs array

Optical response of LEKID

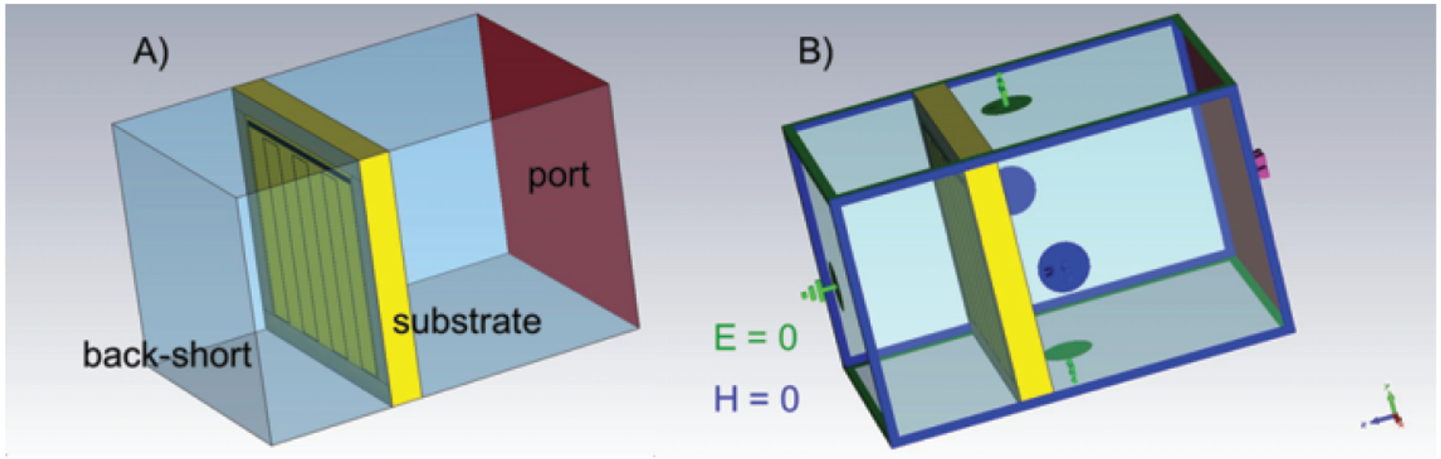
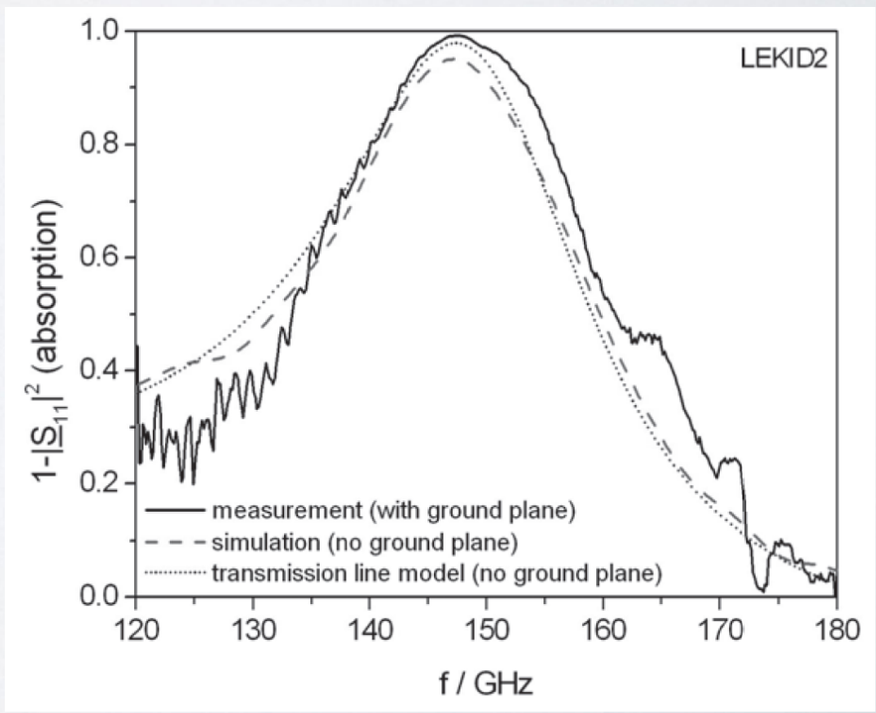
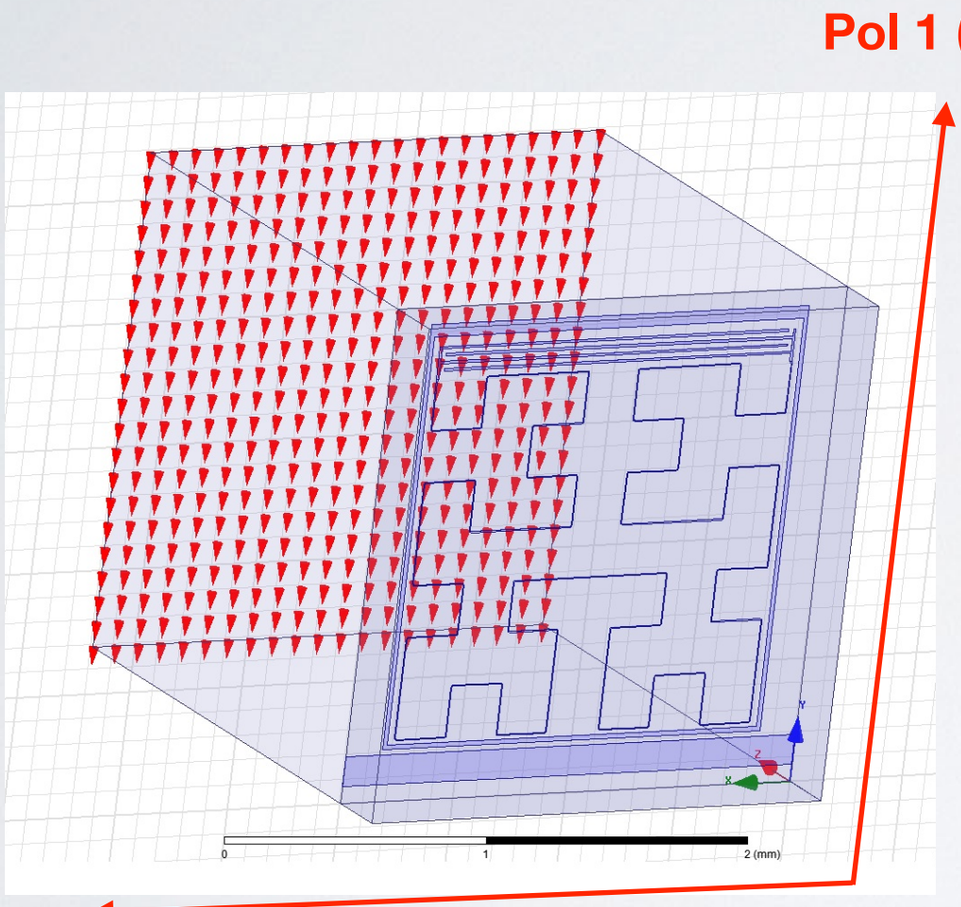


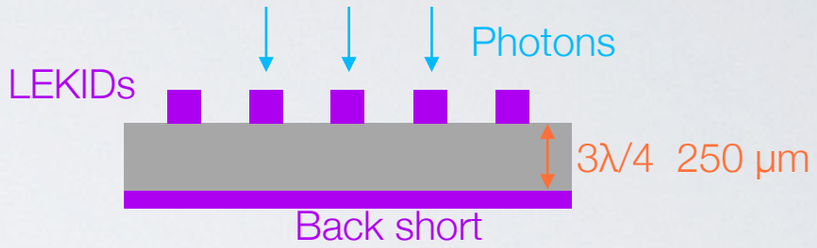
Fig. 7.21.: A) Schematic of the CST model to simulate the optical coupling of LEKIDs. B) The model is considered as a waveguide defined by the boundary conditions $H = 0$ (blue) and $E = 0$ (green). The back-short is modeled as an electrically shorted wall with $E = 0$.



Rosch, M. J.,et al. (2013). *IEEE Transactions on Antennas and Propagation*,

Simulation setup

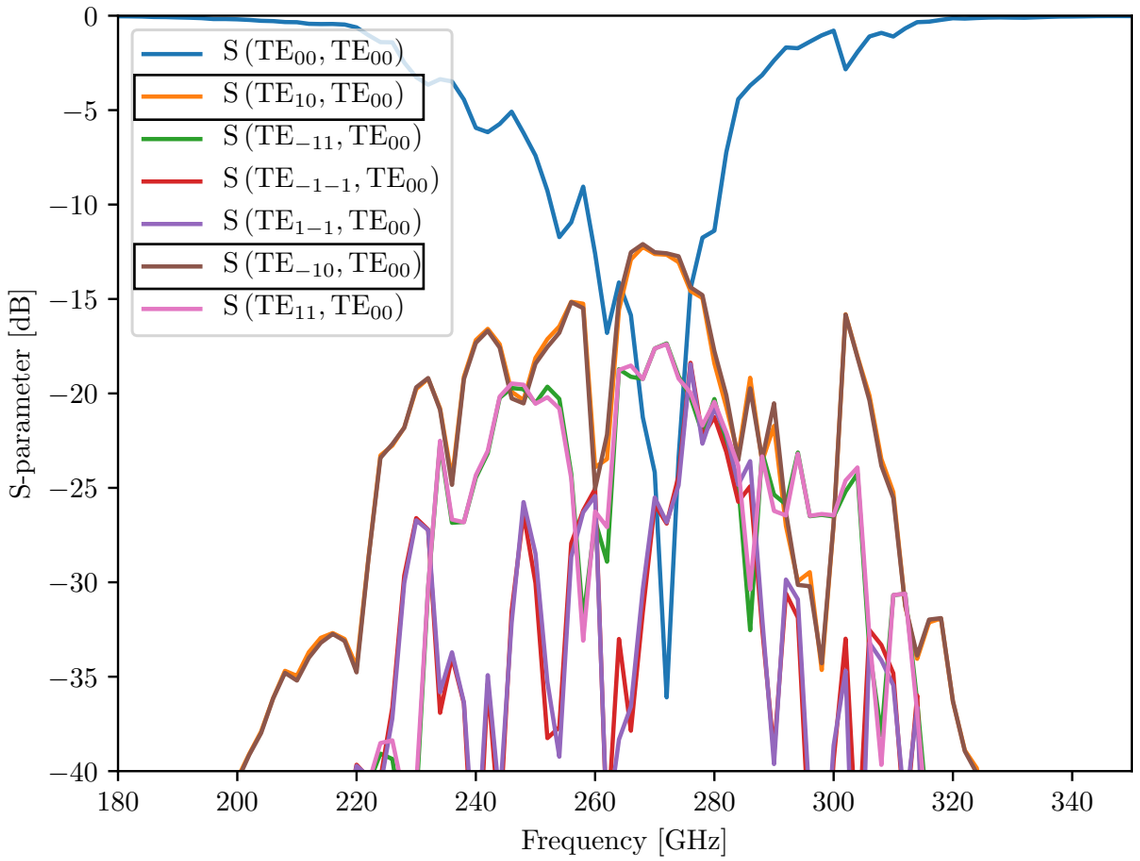




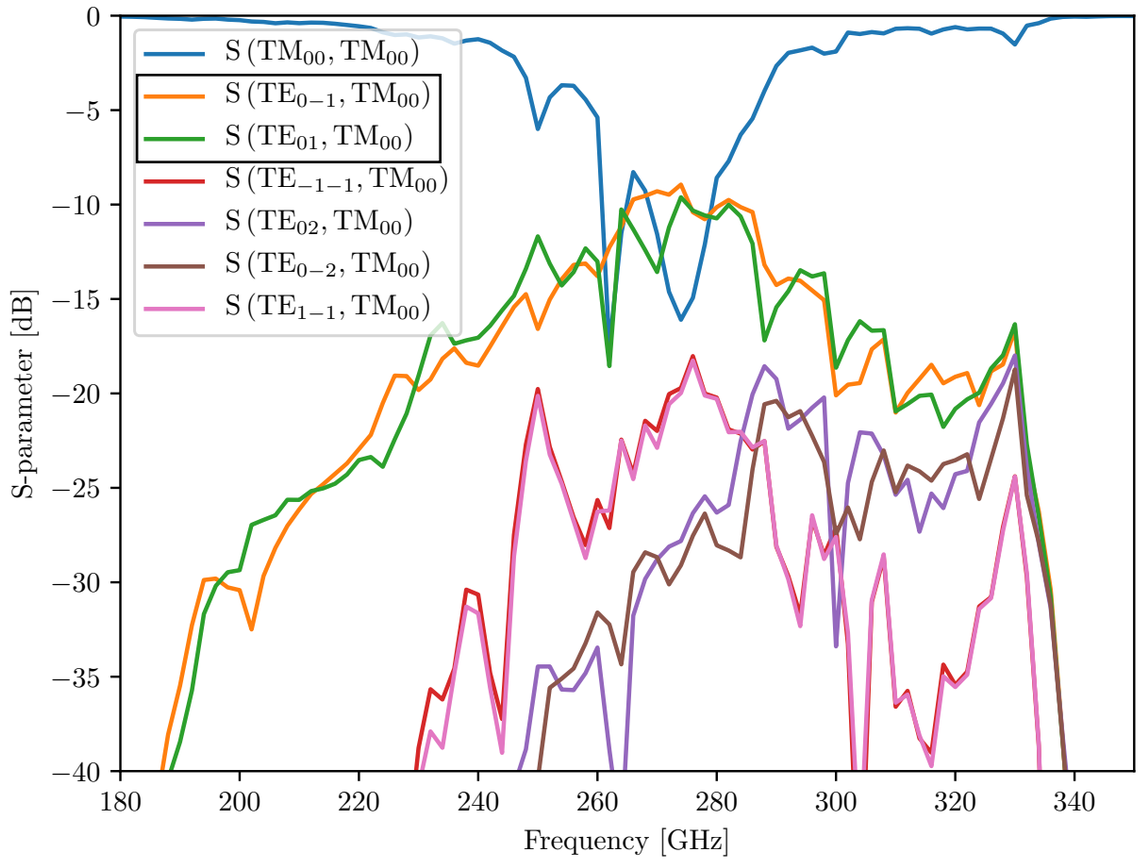
- **Floquet port with Periodic boundaries**
- **18 modes for 150 - 350 GHz**
- **Two polarizations incident**
- **1.6 Ohm/square for 20 nm Al**
- **250 μm Si substrate**

S-parameter

Pol 1



Pol 2



Modes with S-para > -20 dB are shown

Max. 12.1% absorbed by TE10 and TE-10
230-290 GHz averaged: 4.3%

Max. 23.7% absorbed by TE10 and TE-10
230-290 GHz averaged: 10.1%

Surface loss analysis

$$p_s = Re(\vec{P} \cdot \vec{n})$$

P: Poynting vector
n: normal vector to the surface S
p_s: surface loss density

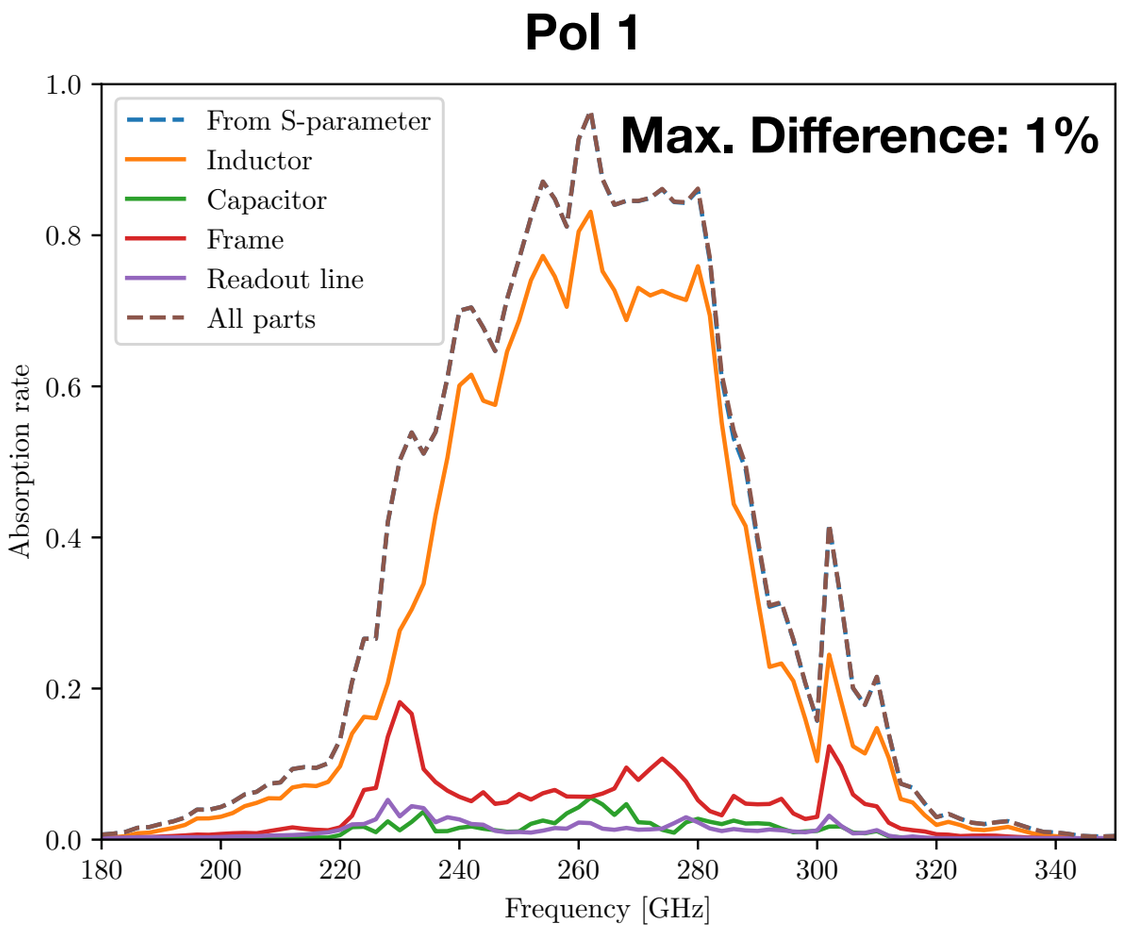
$$Loss = \int_S p_s dS$$

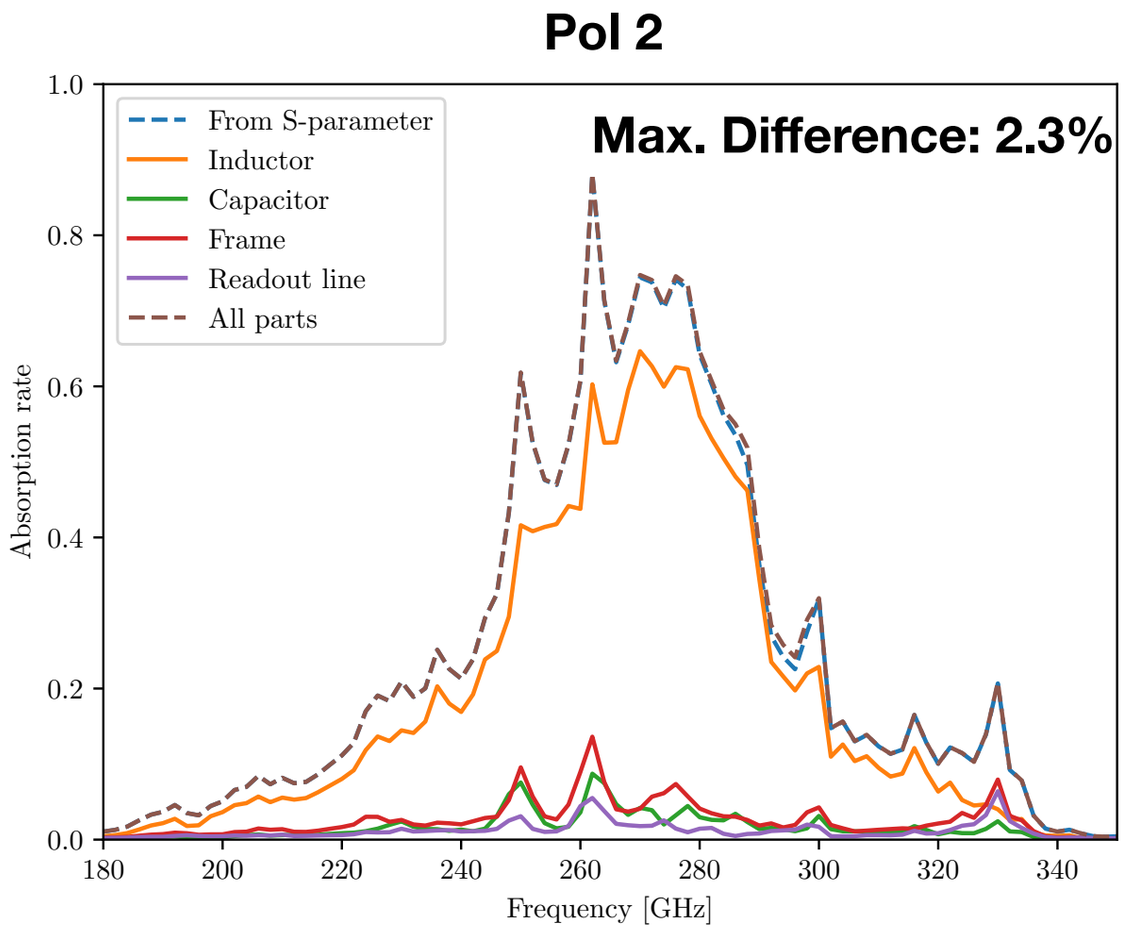
Surface loss could be estimated by integrating p_s with surface area

$$\text{Absorption rate} = \frac{\text{Loss}}{\text{Incident power}}$$

This calculation is done with “Field Calculator” in HFSS

Surface loss analysis





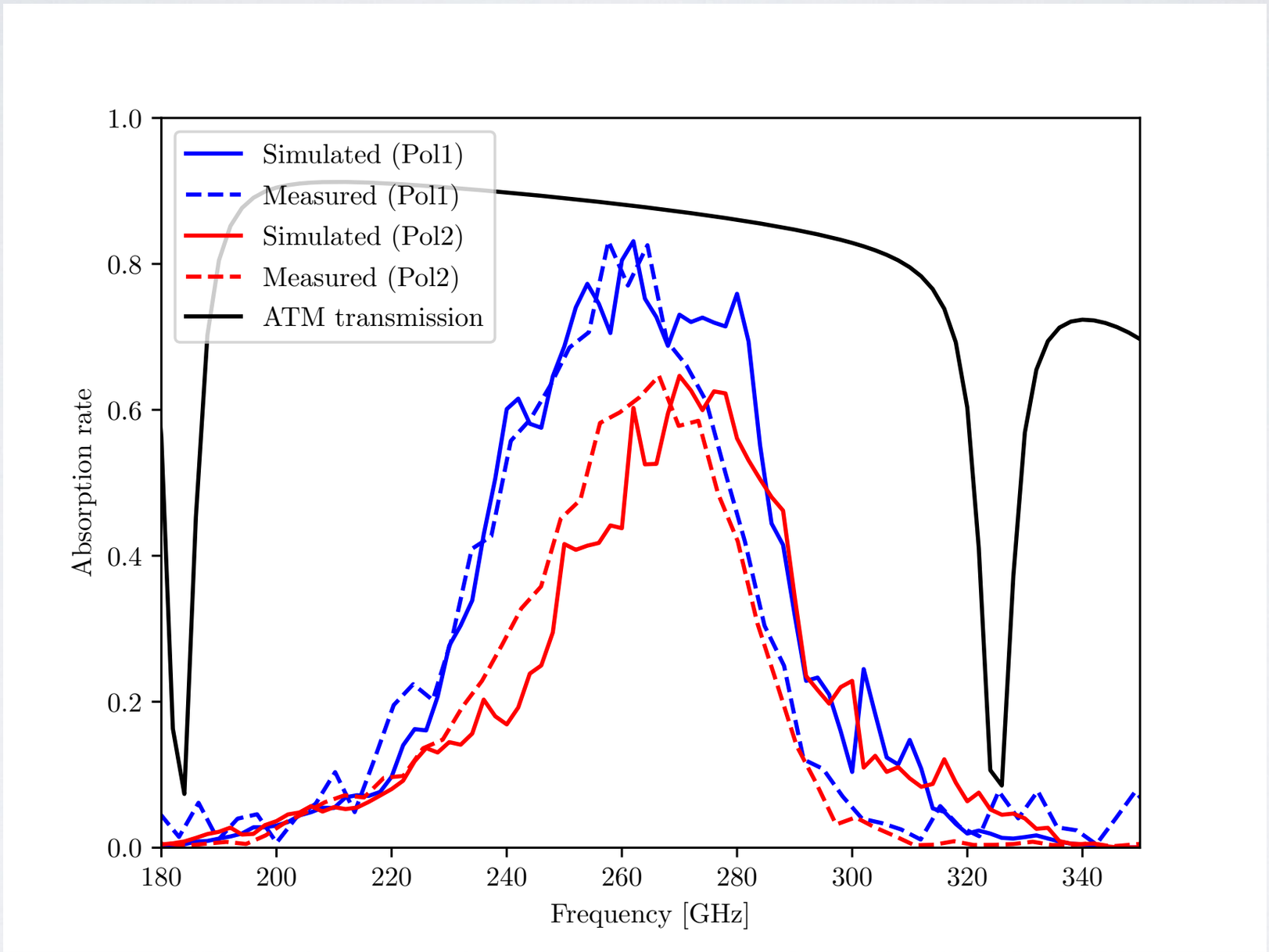
230-290 GHz averaged: 61.7%

230-290 GHz averaged: 41.2%

Absorption from S-para: $1 - \sum_{n=1}^{all} S1(n)1(1)$

$1 - \sum_{n=1}^{all} S1(n)1(2)$

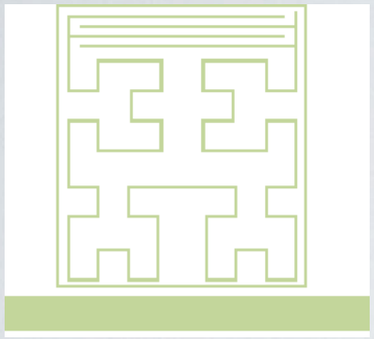
Compared with FTS results



NIKA2 1mm Array

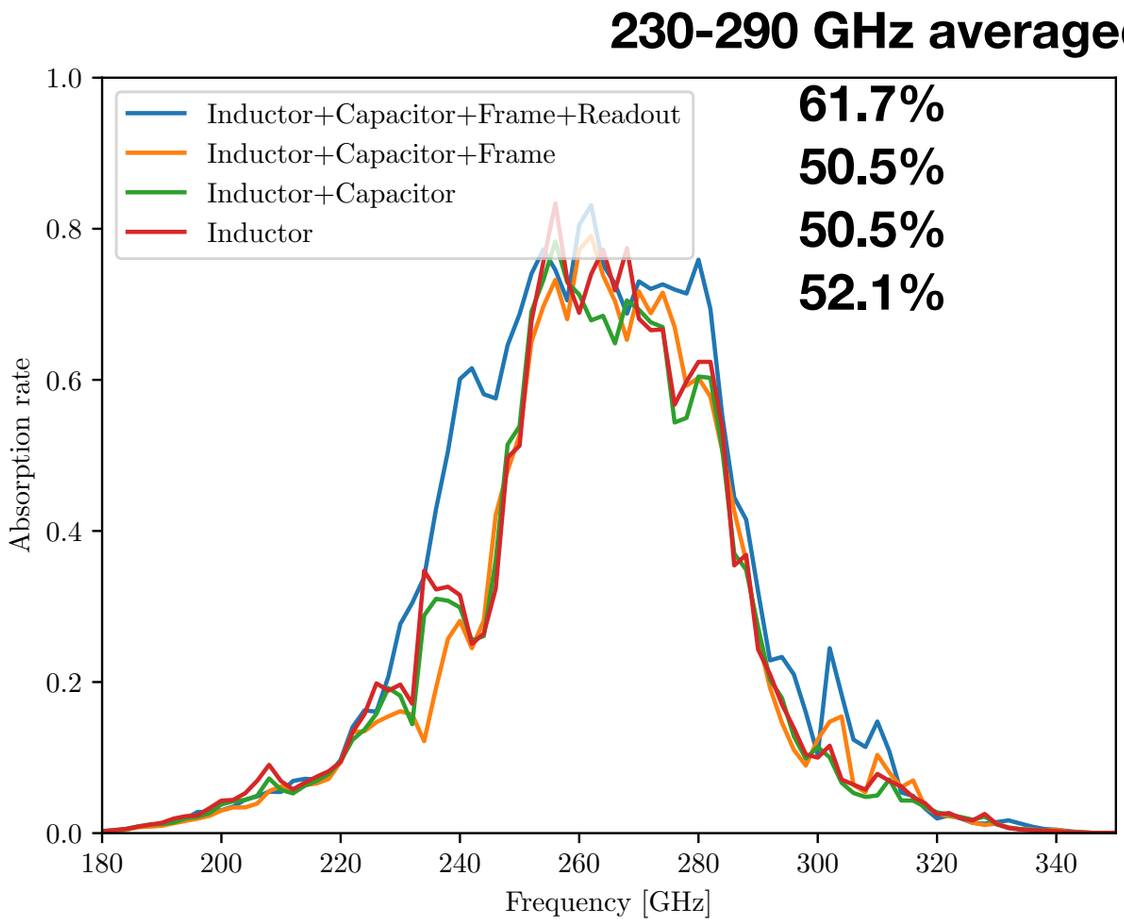
We assume that only absorption in inductor is detected

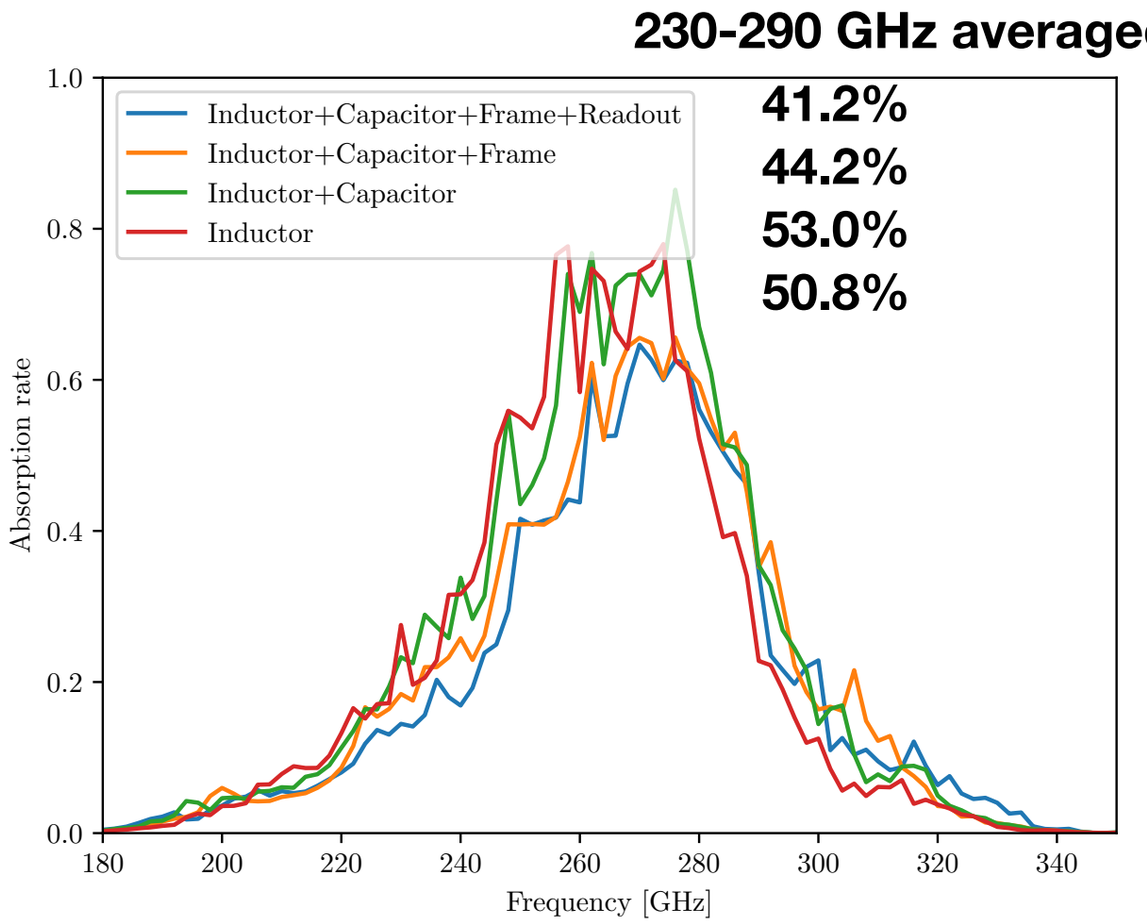
Effect of LEKID structure



Pol 1

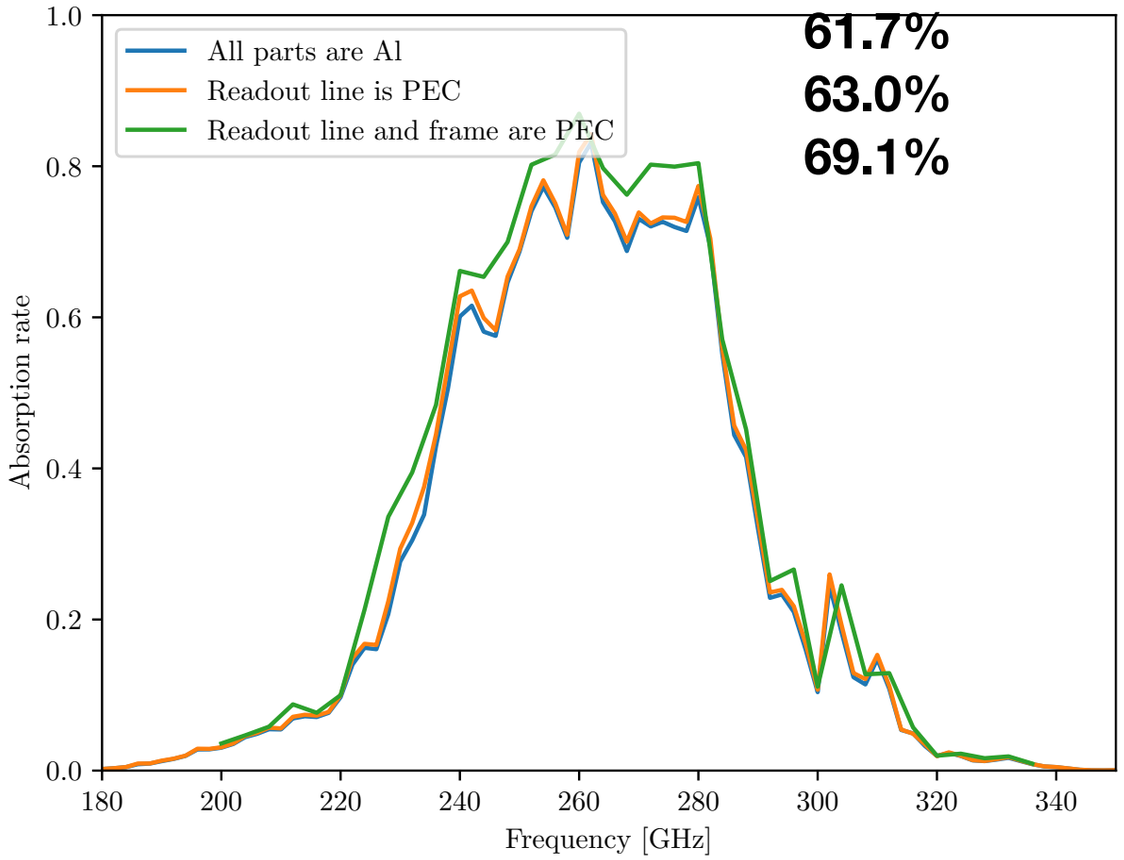
Pol 2



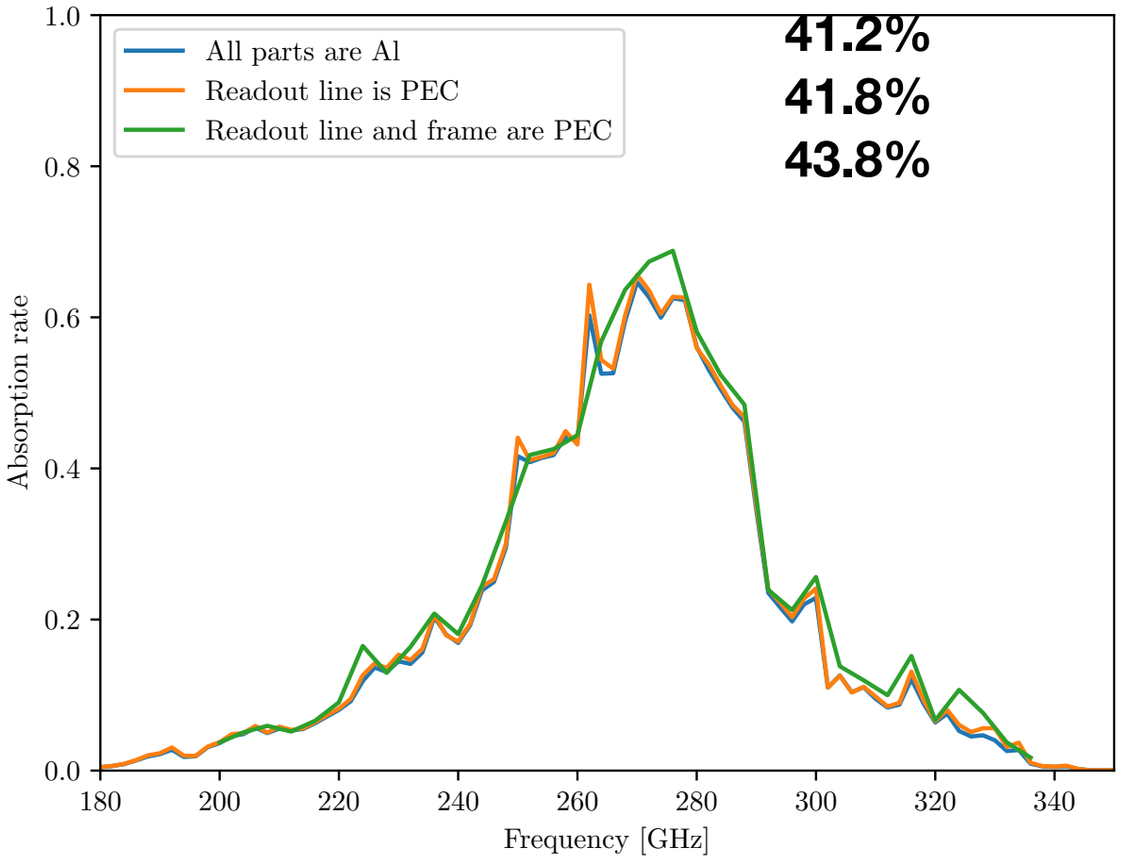


Could PEC (e.g. Nb) help?

Pol 1

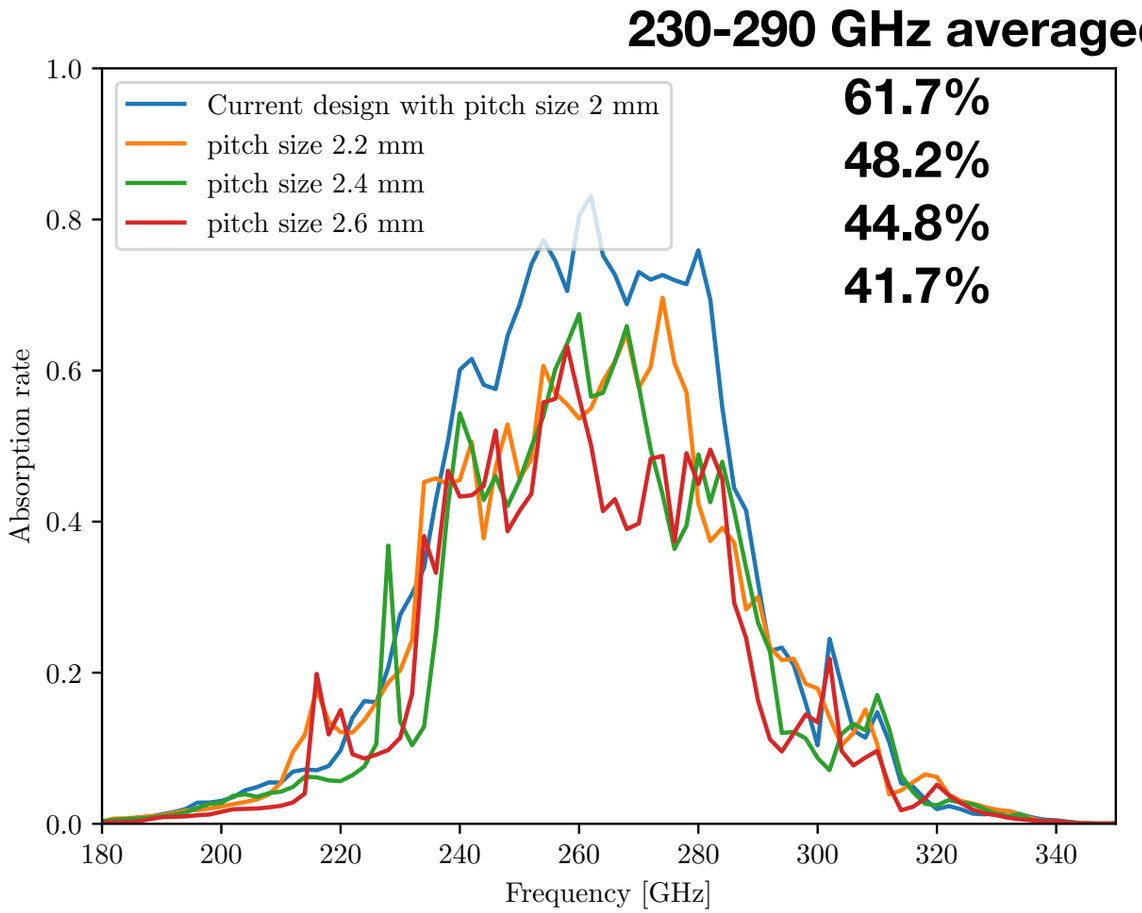


Pol 2

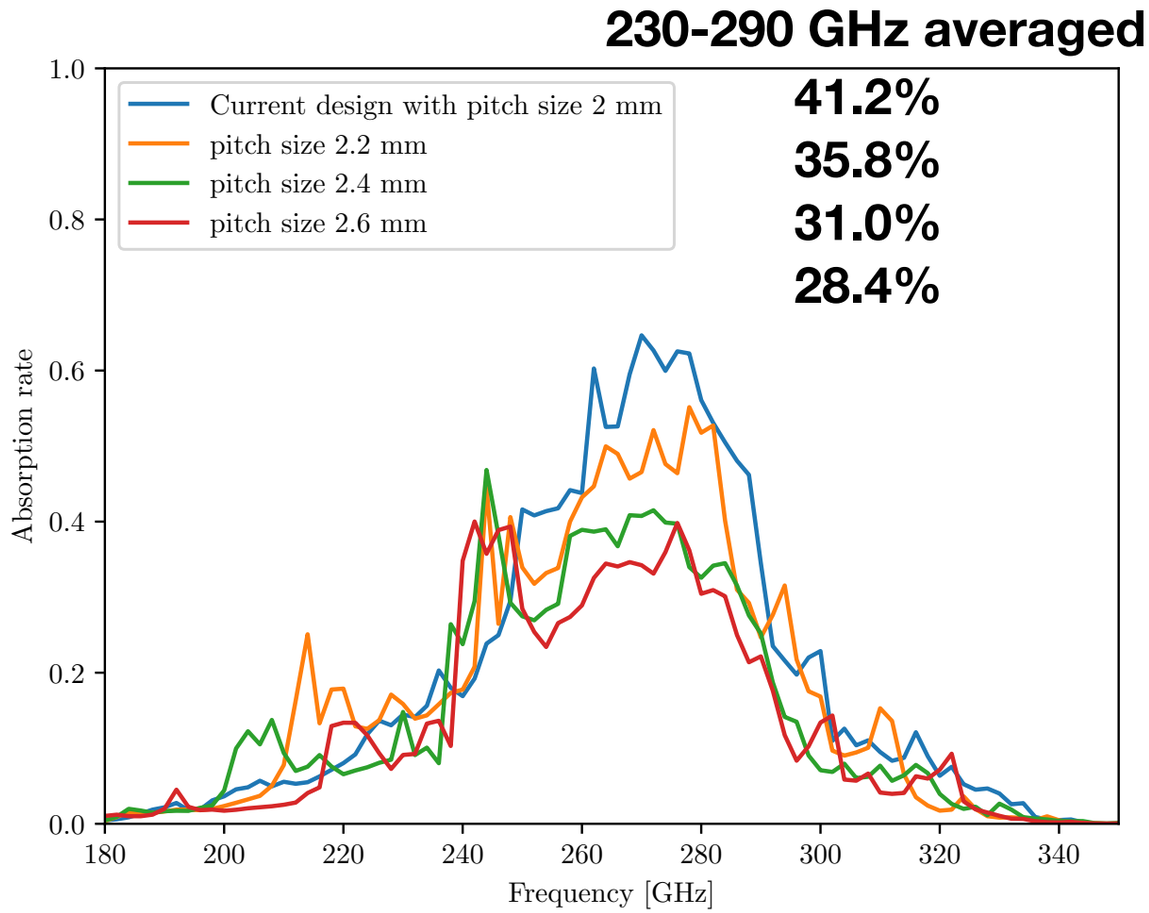


Pitch size matters?

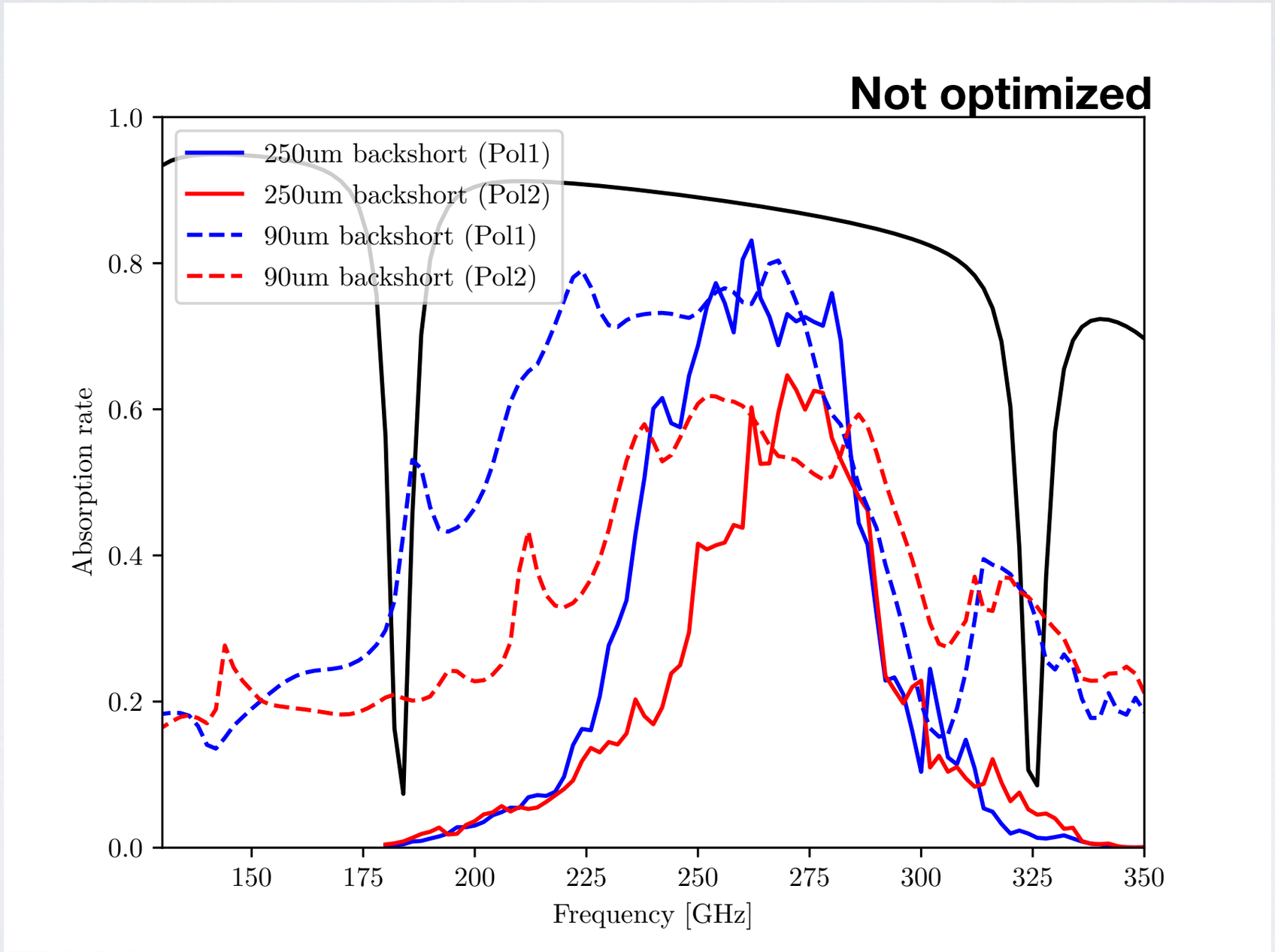
Pol 1



Pol 2



For larger band coverage



Conclusion

- A prototype high angular resolution LEKIDs array is designed and measured for NIKA2 1mm

Updated results: https://arxiv.org/abs/1710.08232

- The focal plane layout is pushed to a compact 1.4*1.4 mm^2 pixel size design

- A simulation method is demonstrated for LEKIDs array optical analysis to estimate energy absorbed in inductor

- Be careful with bi-polarization structure