

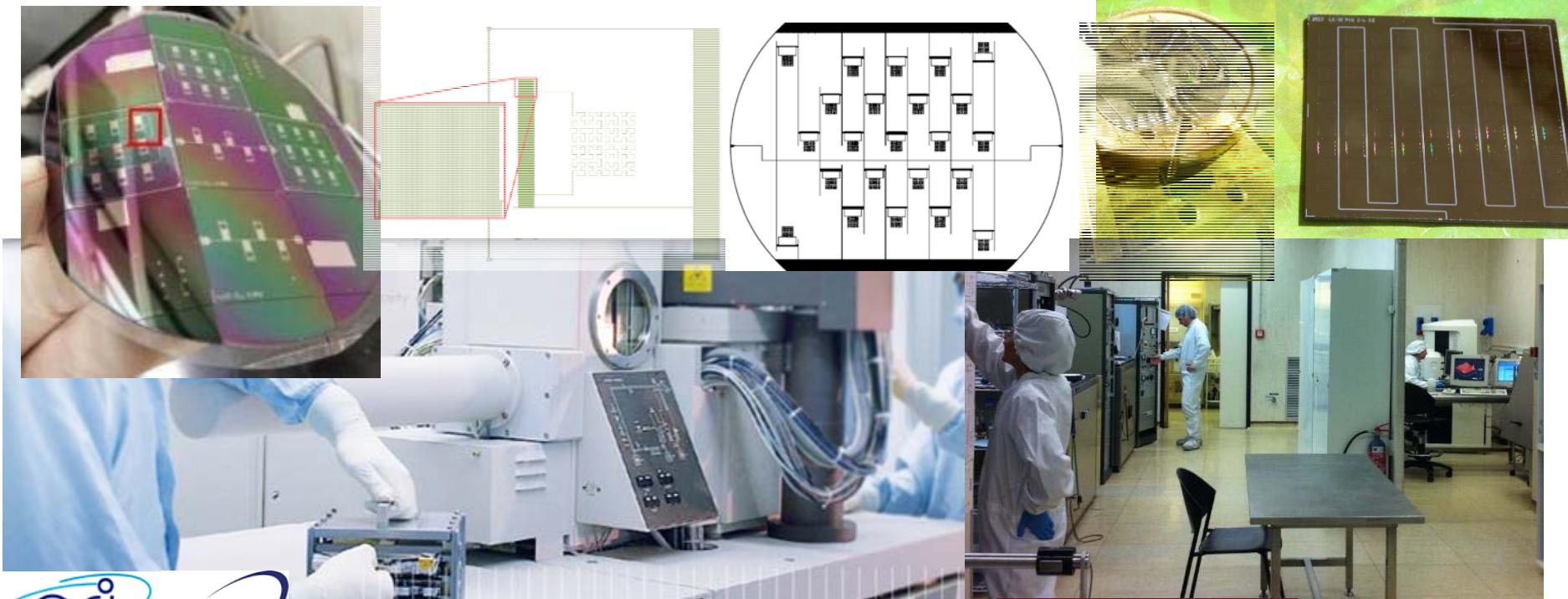
Development of Kinetic Inductance Detectors for CMB observations in Italy

Maria Gabriella Castellano⁰, I. Colantoni⁰, A. Coppolecchia^{1,2}, A. Cruciani^{1,2},
A. D'Addabbo³, P. de Bernardis^{1,2}, L. Lamagna^{1,2}, S. Masi^{1,2}, A. Paiella^{1,2}, G. Presta¹

⁰Istituto di Fotonica e Nanotecnologie – CNR Roma

¹Sapienza Università di Roma, Dip. Fisica, ²INFN, Sezione di Roma1

³LNGS-INFN, Assergi (AQ)



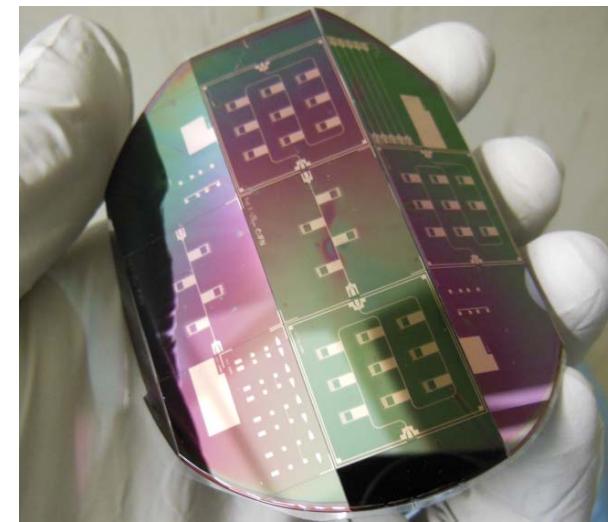
FABRICATION REQUIREMENTS

Choose material:

- superconducting gap $\Delta \sim 1.75 K T_c$ such that $h\nu > 2e\Delta$ in the frequency range of interest
- resistivity must be suitable for impedance matching with feedline

Choose thickness:

- small thickness gives high inductance responsivity
- but changes film properties and T_c



W-band 75-110 GHz

Example of films fabricated at CNR and tested at Sapienza

Materials	Thick (nm)	T_c (K)	v_c (GHz)	Band (GHz)
Al	20	1,43	104,0	150
Al	40	1,31	95,5	90
Al	80	1,28	93,2	90
Ti/Al (bilayer)	10/25	0,85	65,0	90
Ti/Al (bilayer)	10/30	0,96	In measure	90
TiN_x			under investigation	

FABRICATION STEPS

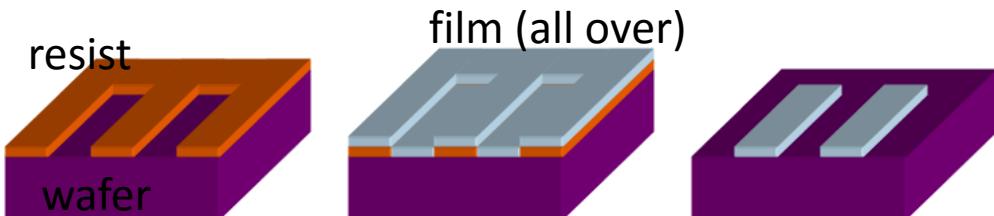
Substrate: high resistivity silicon wafer (up to 4 inches diameter)

Thin film deposition (by evaporation/sputtering/reactive sputtering)

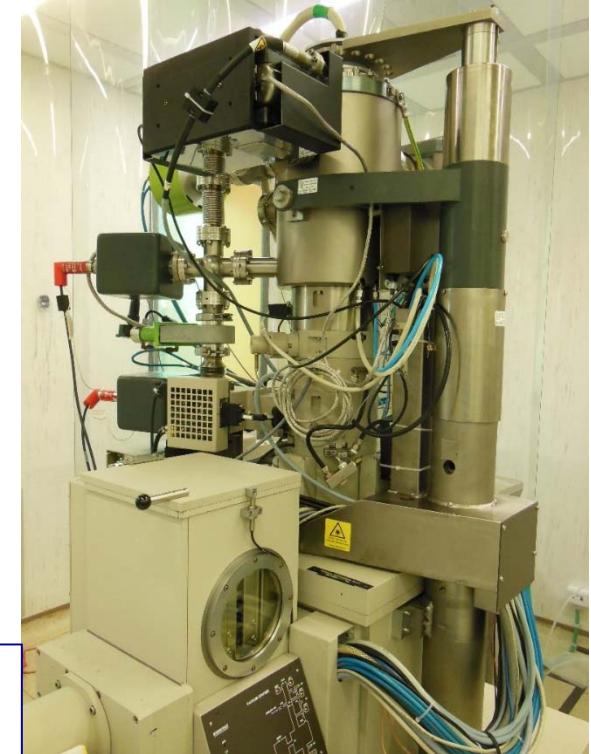
Pattern transfer: through resist mask and electron-beam lithography (100 keV e-gun)

Selected removal of the film: two techniques

1) Lift-off (additive process)

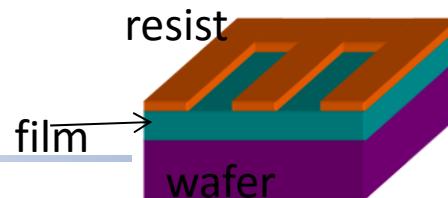


after resist removal,
film remains only on selected areas.



EBL Leica/Vistec EBPG 5000

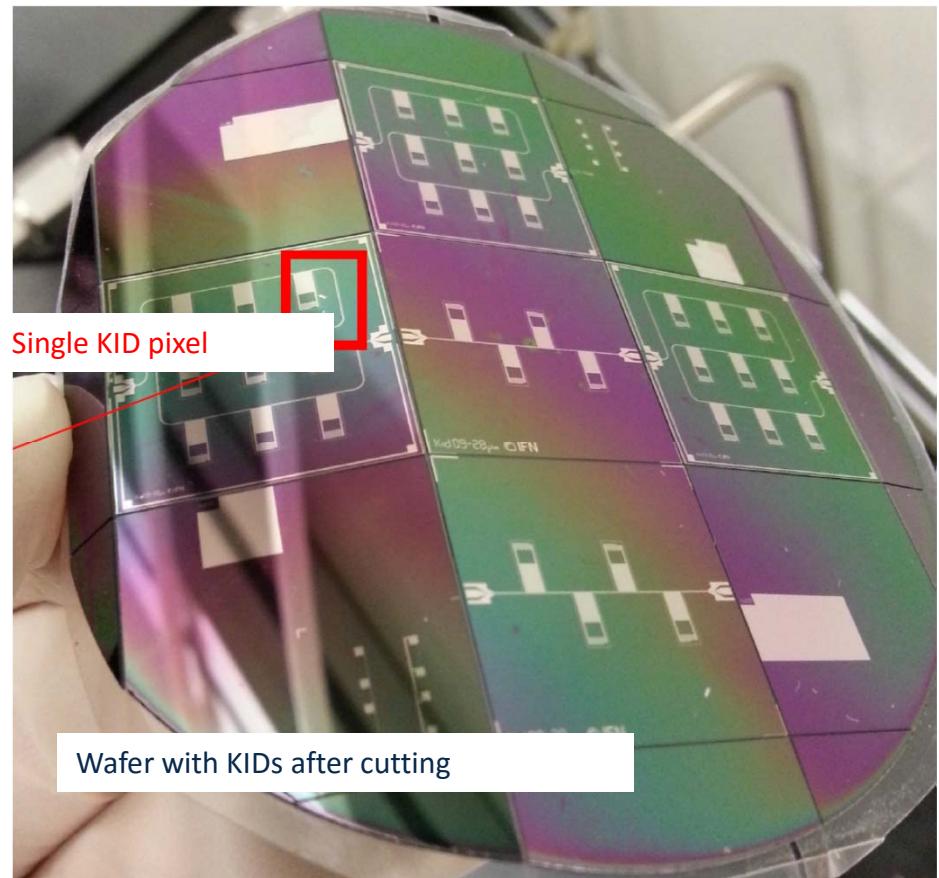
2) Etching (subtractive process)



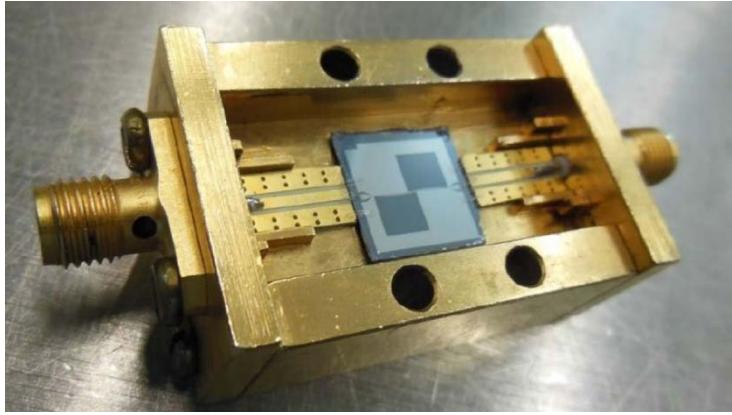
plasma removes unprotected film.

FABRICATION STEPS

Wafer dicing



Ultrasonic bonding in chip carrier



THE FABRICATION FACILITY AT IFN-CNR ROMA

Cleanroom 300 m², class 100-1000 (ISO 5-6)

Thin-film deposition

Lithography
[electron-beam]

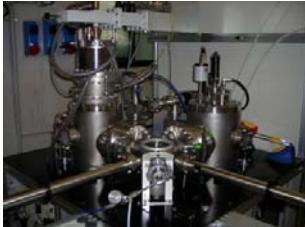
Etching

Diagnostics

evaporazione,
sputtering, CVD

optical UV 365 nm, RIE Cl, F, Deep RIE
electronic 100 kV

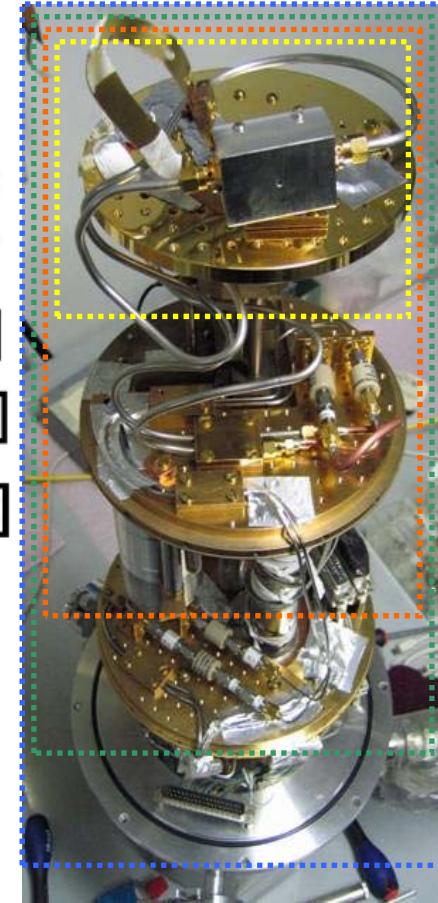
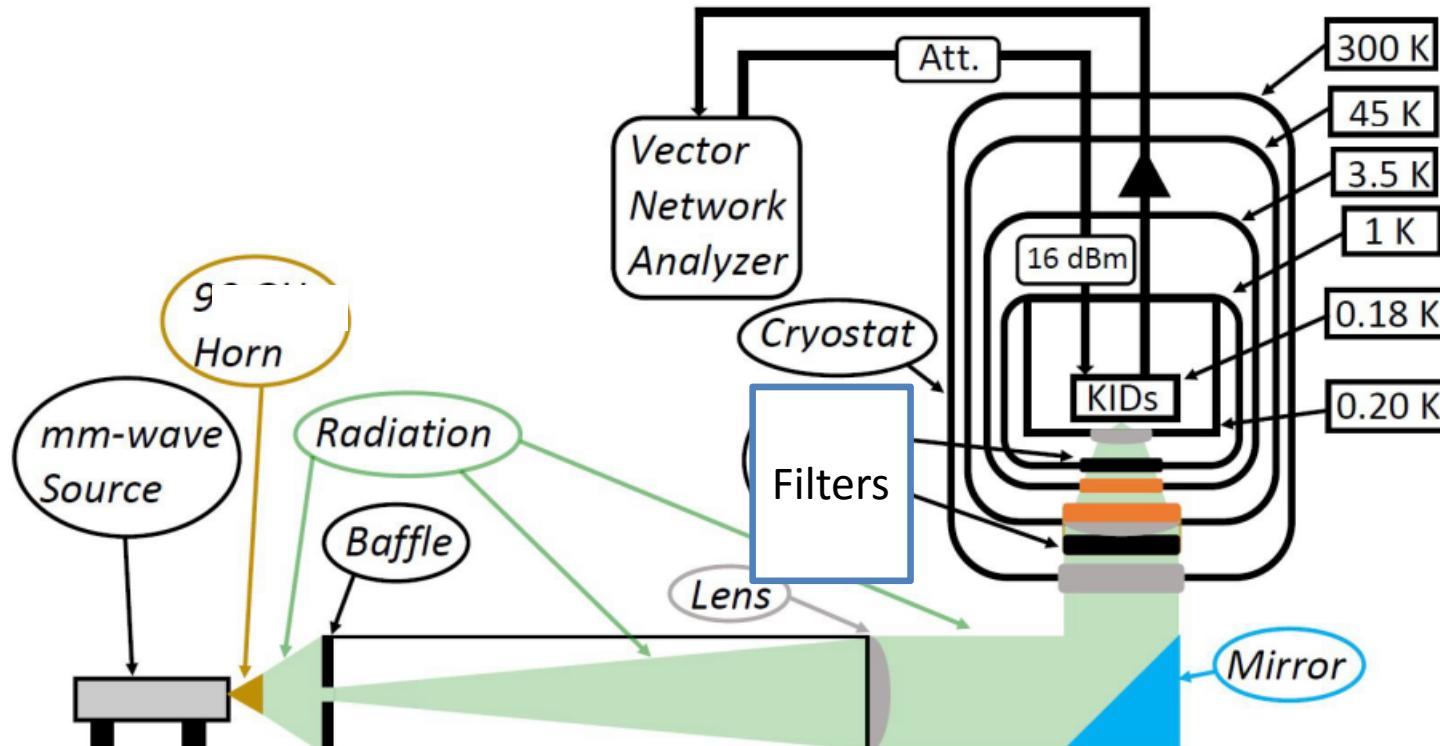
AFM, SEM

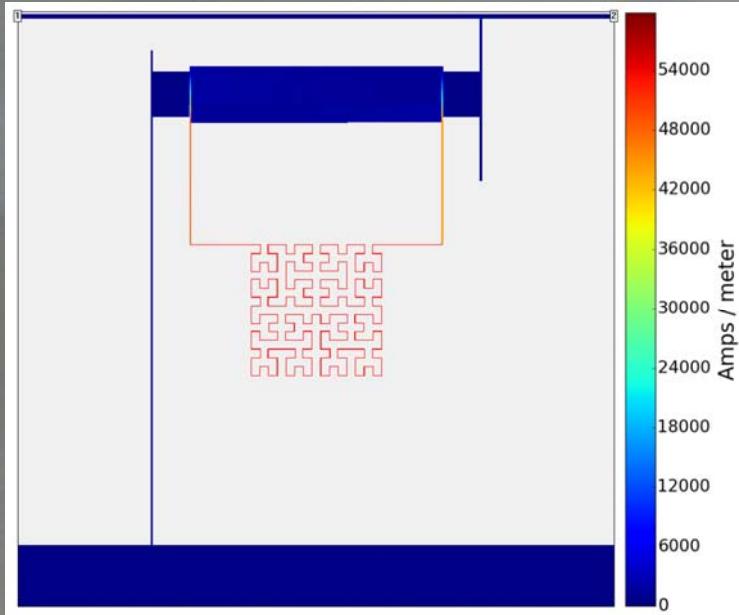


- devices, MEMS, nanostructures,
- metals, Si, Si₃N₄, III-V, polymers....

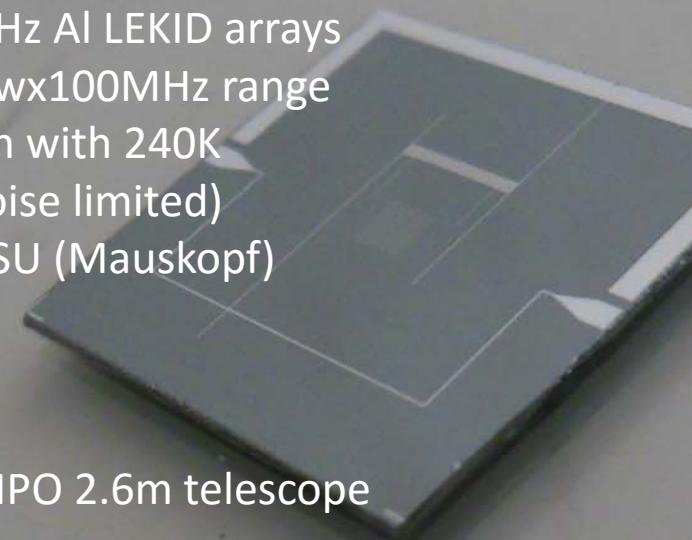
THE TEST FACILITY AT DIPARTIMENTO DI FISICA - SAPIENZA

- 0.1K dilution fridge /pulse tube, with filters set for 90, 140, 240, 340 GHz bands
- 20GHz & W band VNAs
- Set of sources & choppers (thermal, coherent)

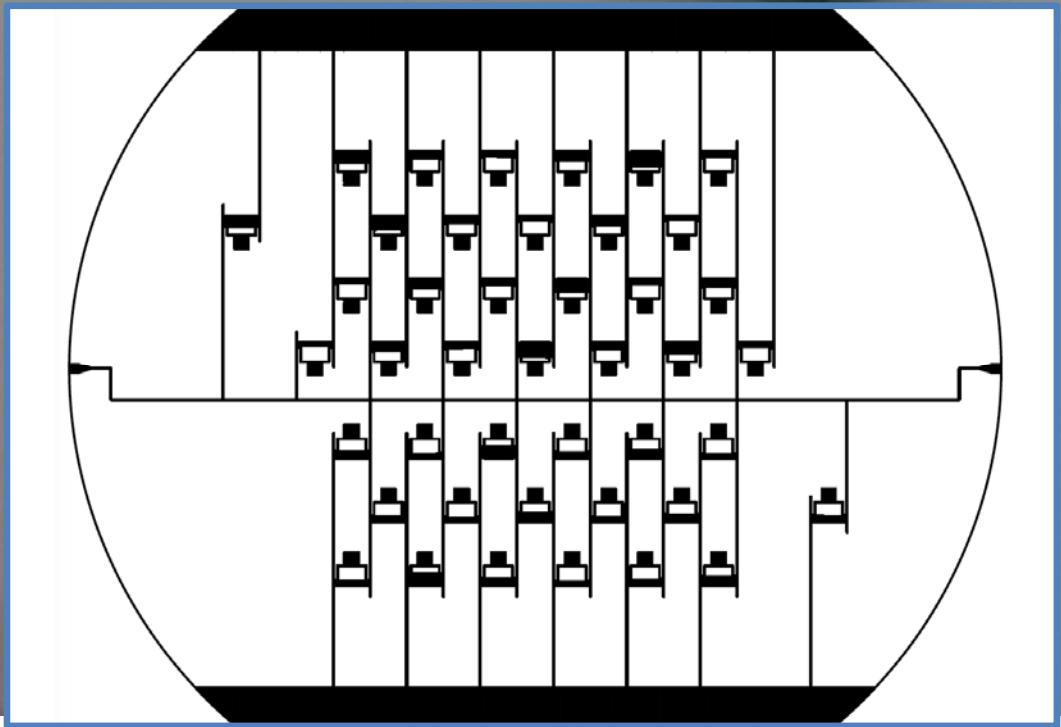




140, 220, 340, 480 GHz Al LEKID arrays
Resonances in the fewx100MHz range
Optimized for balloon with 240K telescope (photon noise limited)
Collaboration with ASU (Mauskopf)



To be tested on OLIMPO 2.6m telescope



TOWARDS THE W-BAND

Tests done at Sapienza on different CNR films

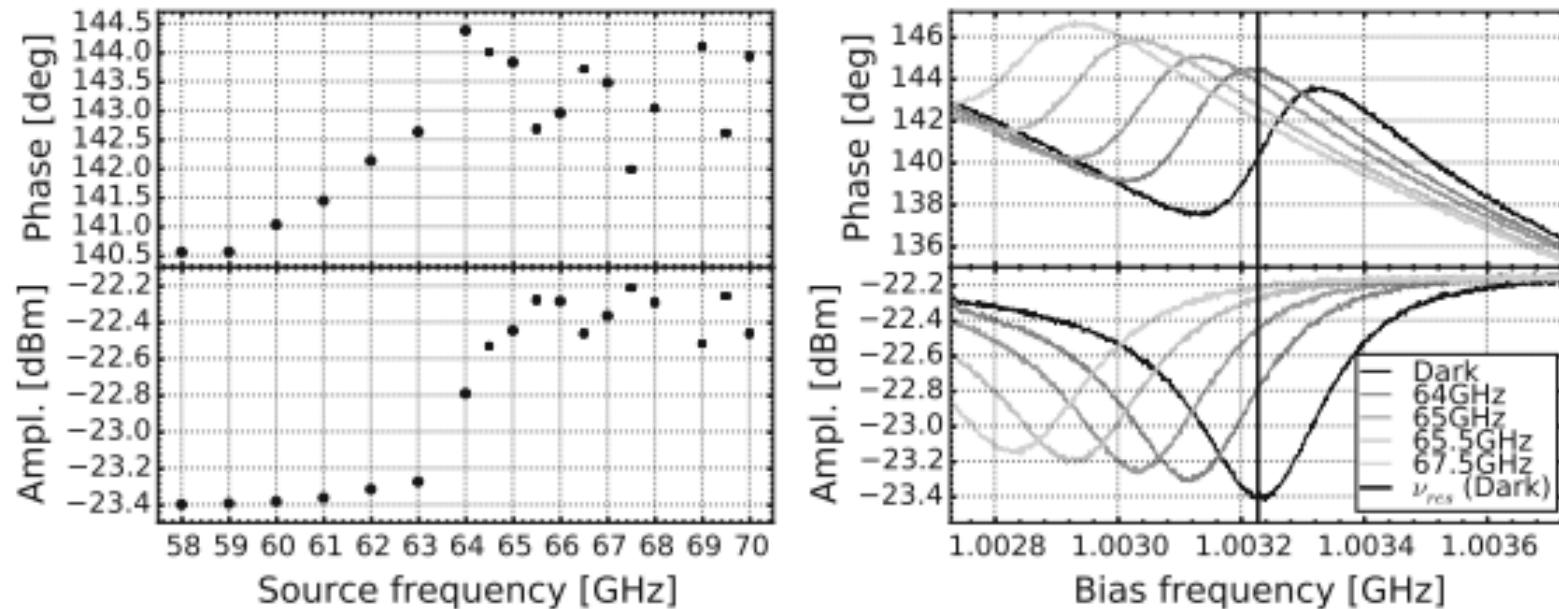


Fig. 8 *Left panel* measurement of the cut-on frequency with a millimeter-wave source (VNA). *Right panel* resonance responses over 1 MHz span around the dark resonance frequency (ν_{res}), for different source frequencies. ν_{res} (Dark) is our operation point

See Paiella et al. 2016.

Al/Ti LEKID : $f > 60$ GHz (W-band)

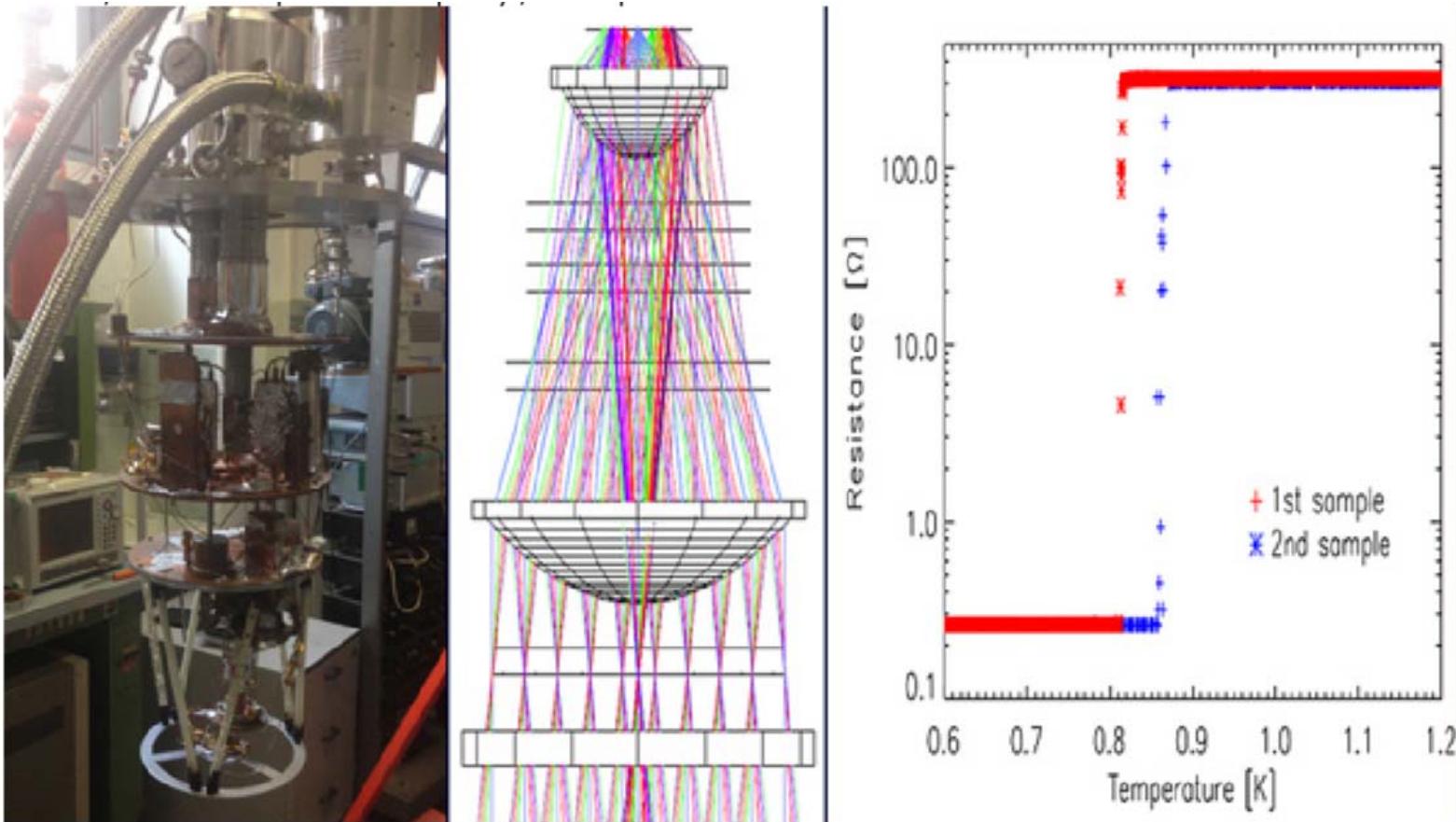


Fig. B2-5 – Testbed dilution cryostat (left) with optical system (center). right: superconductive transition measured with this system.

For M5

- Ready and willing to contribute to KIDs focal optimization and to produce a share of it if selected.
- Existing collaborations with Grenoble and ASU
- High quality mass production facilities exist in Italy (FBK Trento etc.)
- Recently funded by ASI for deep study (Sapienza, CNR-IFN, Mi-Bicocca, Mi-Statale)
- Interest of INFN in joining/supporting.