Sub-gap
Kinetic Inductance Detectors
(SKID)

$h\nu << 2\Delta_g$

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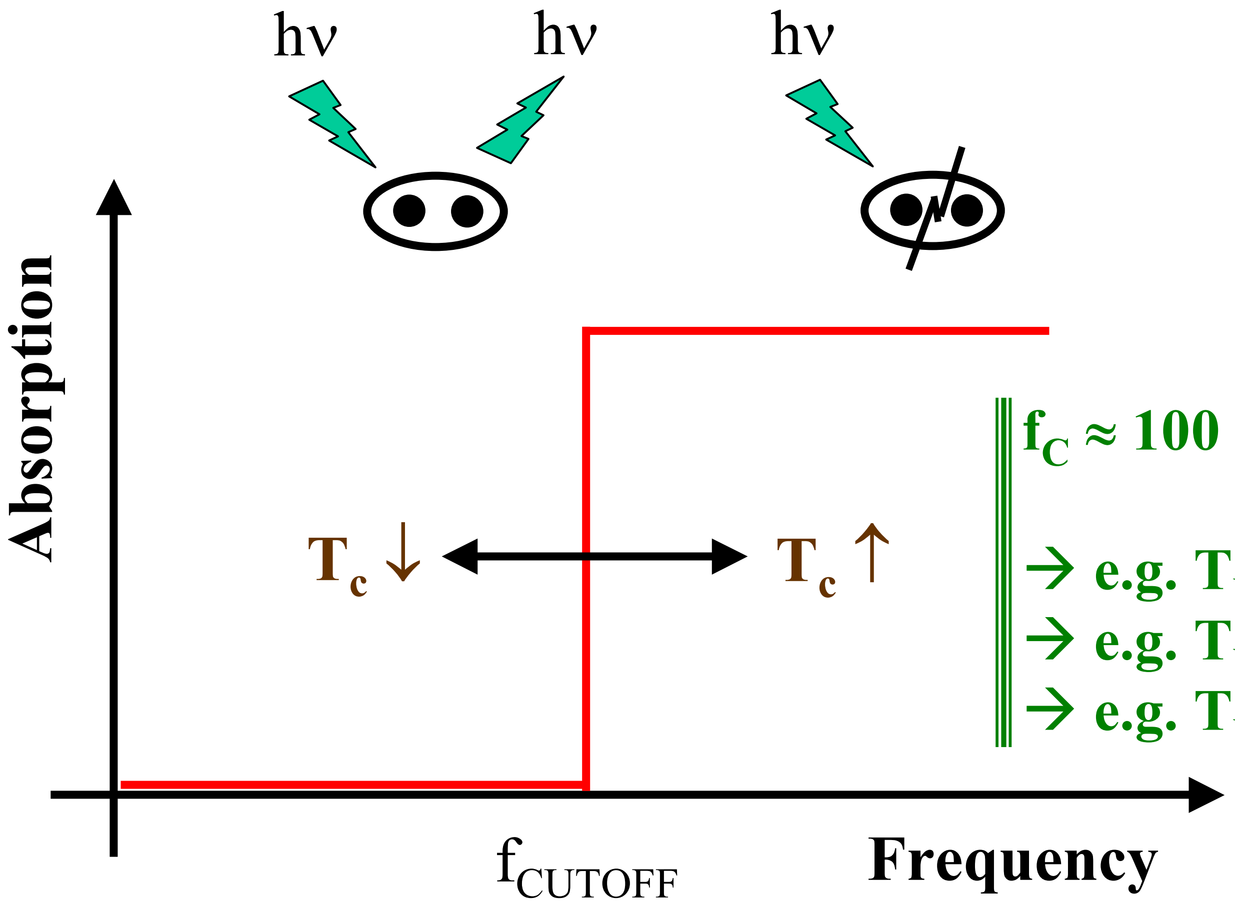
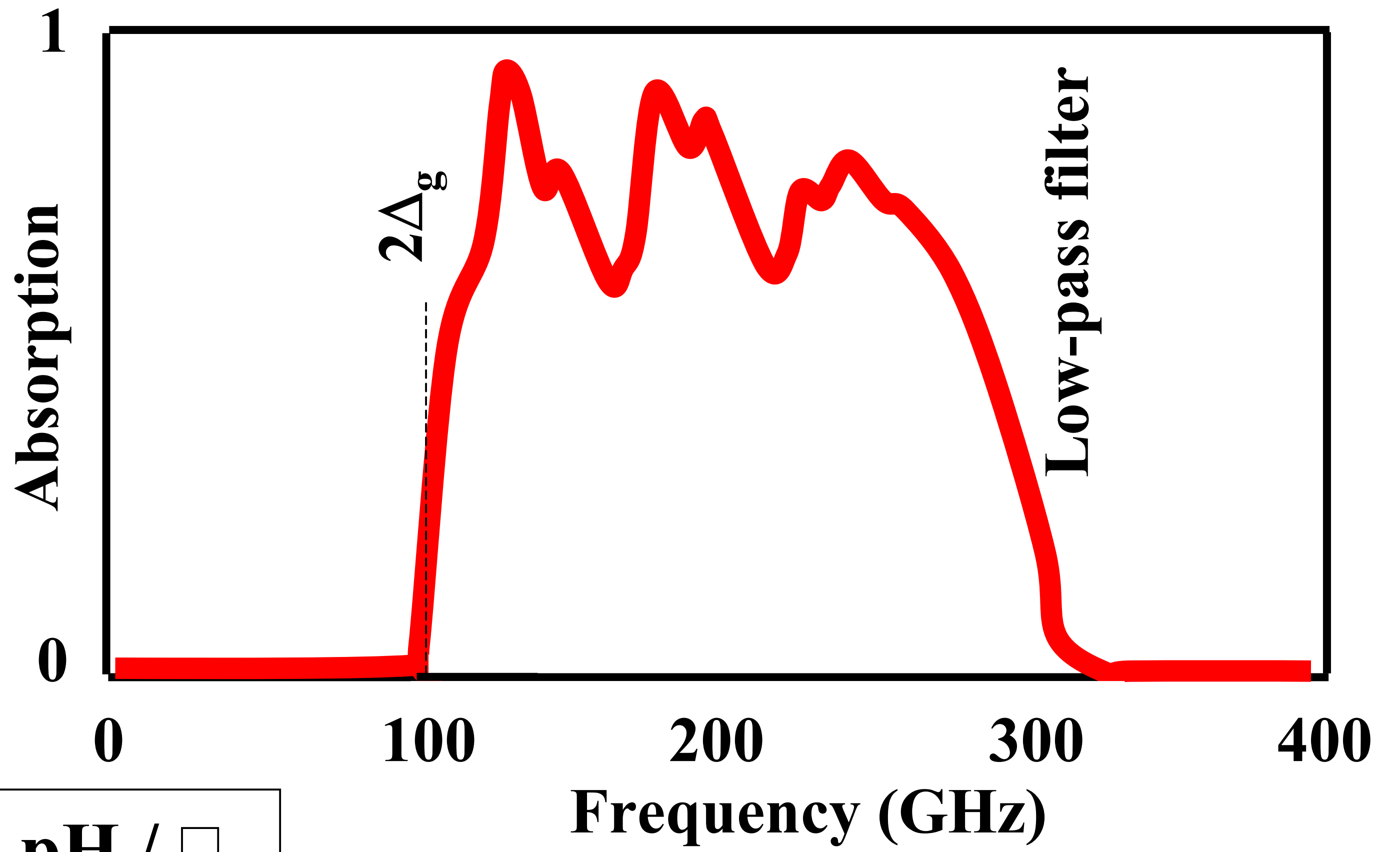
The KID



$f_C \approx 100$ GHz $\cdot$ $(T_c / 1.3)$

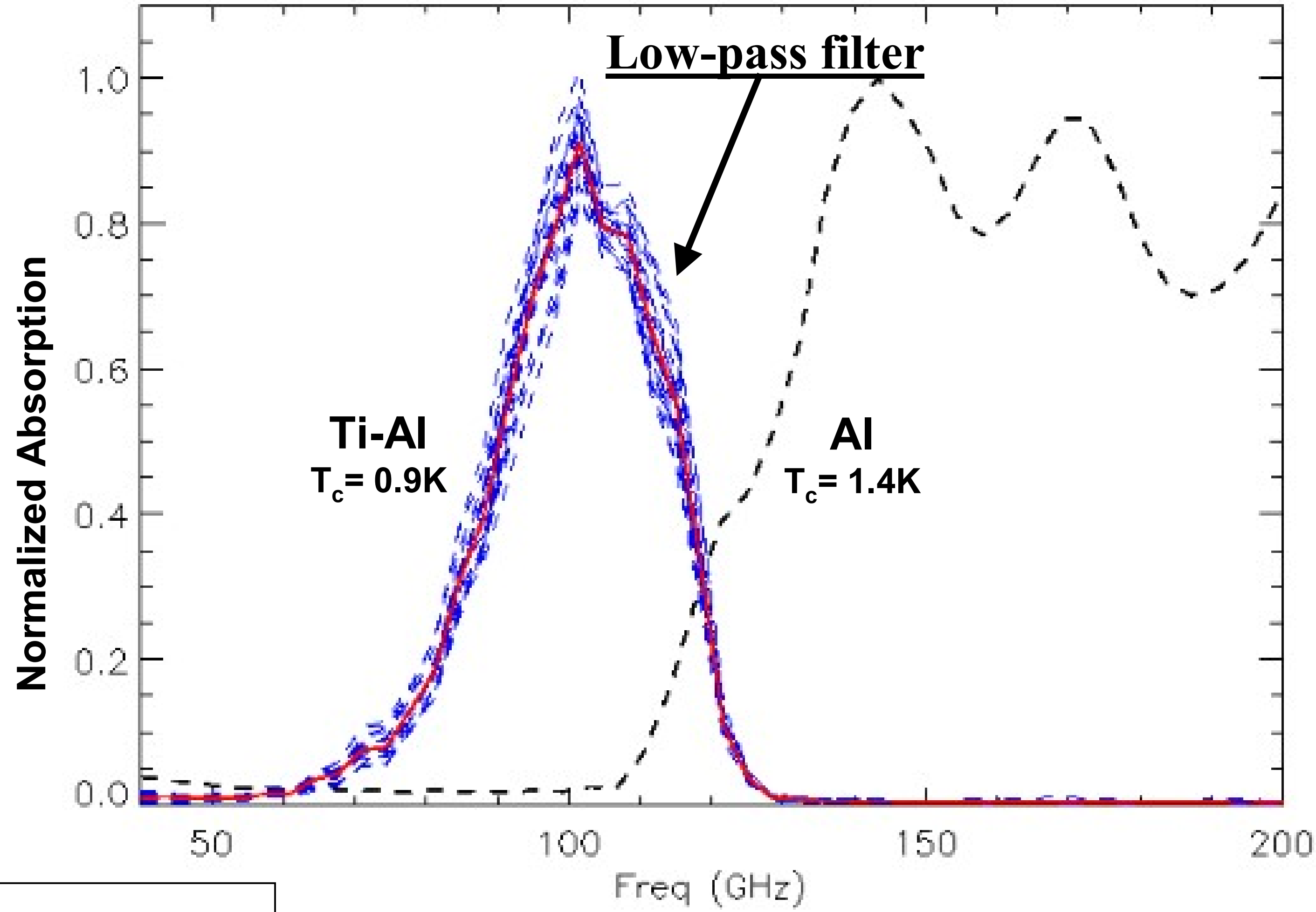
→ e.g. $T_{base} < 0.2$K @ 100GHz
→ e.g. $T_{base} < 0.02$K @ 10GHz
→ e.g. $T_{base} < 0.002$K @ 1GHz

Aluminium KID



$L_k \approx 2$ pH / □

Multilayers KID

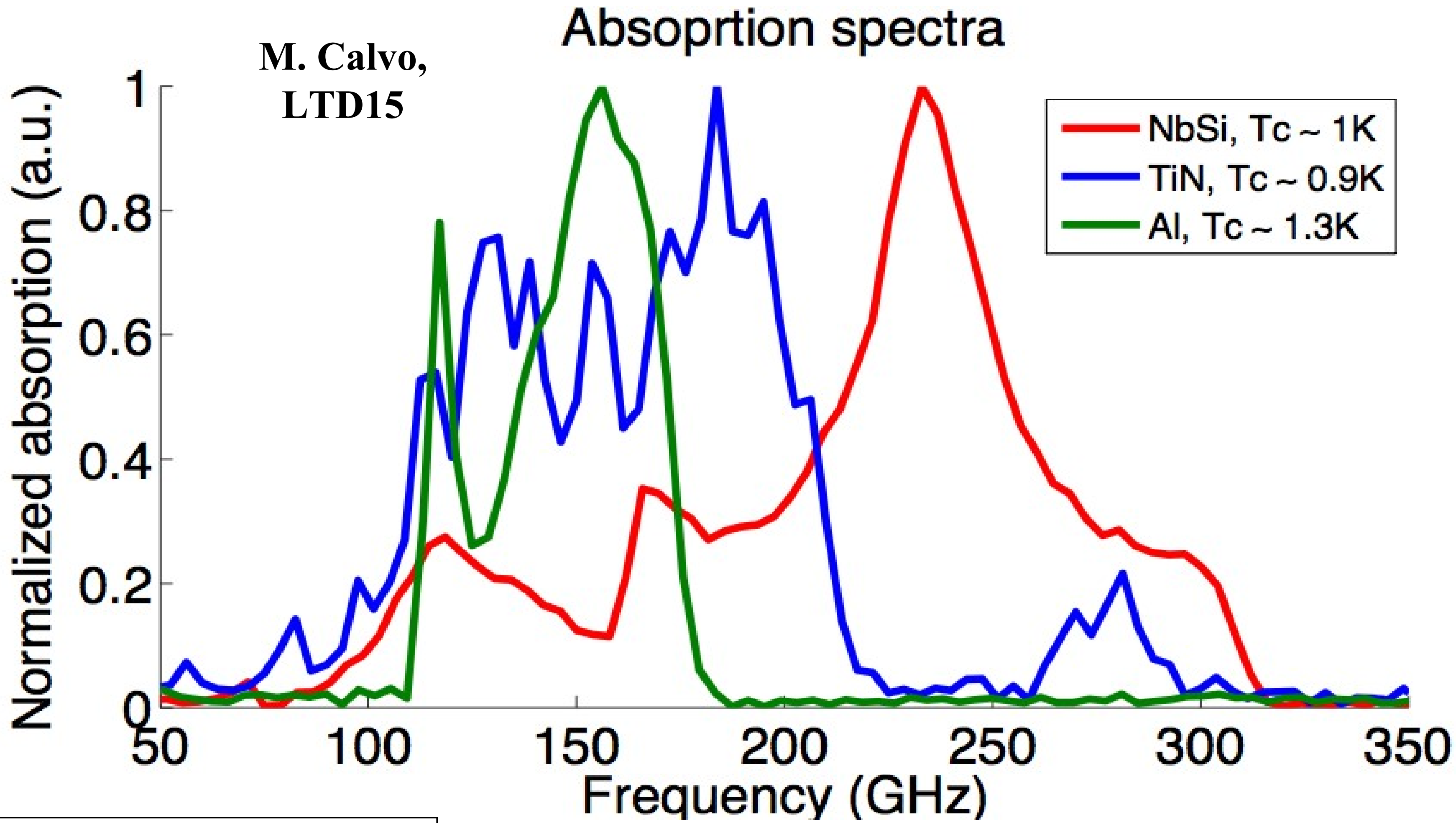


$L_k \approx 5$ pH / □

Credits: H. Le Sueur (CSNSM)

TiN_x and Nb_xSi KID

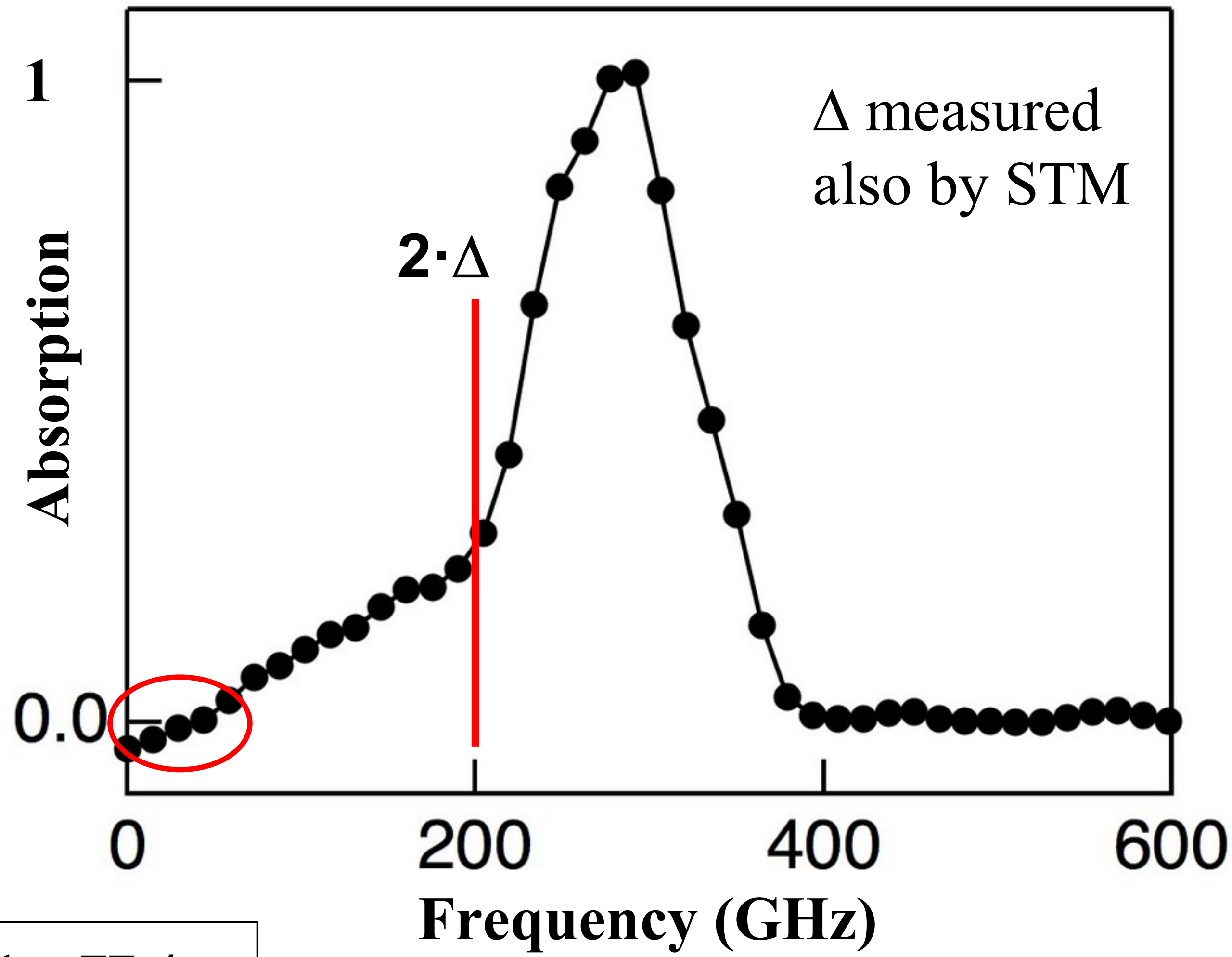
M. Calvo, LTD15



$L_k \approx 250$ pH / □

Credits: S. Marnieros, L. Dumoulin (CSNSM), H. Leduc (JPL)

InO_x KID (T_c = 2.8 K)



$L_k \approx 1$ nH / □

Collaborations: F. Levy-Bertrand, B. Sacepe (Institut Néel)

Experimental limitations

All these were spectra acquired by a Fourier-transform Martin-Puplett interferometer, using black-body sources.

Limitations:

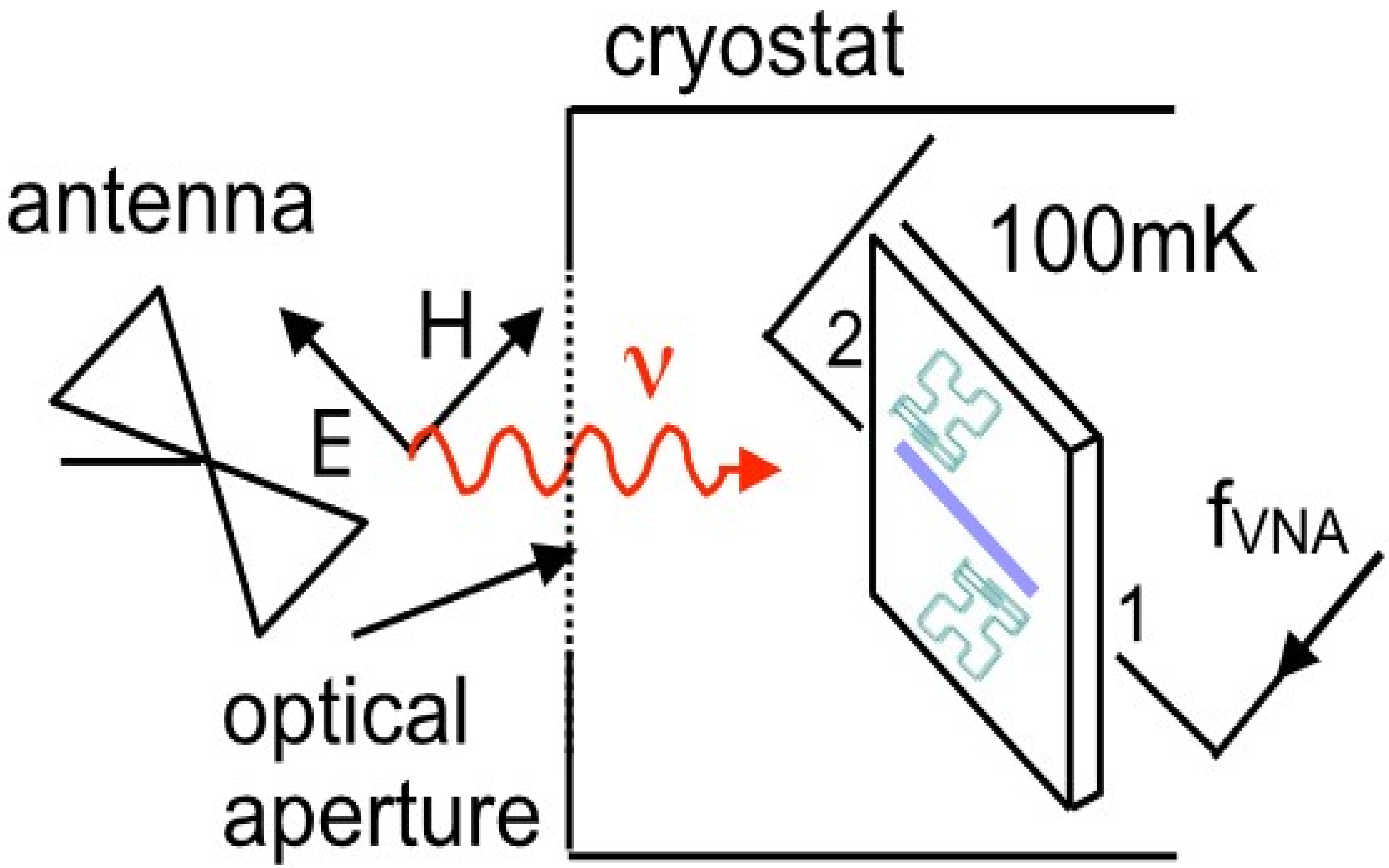
→ Low energy (e.g. f < 50 GHz) part limited by:

- Diffraction
- Faint black body emission

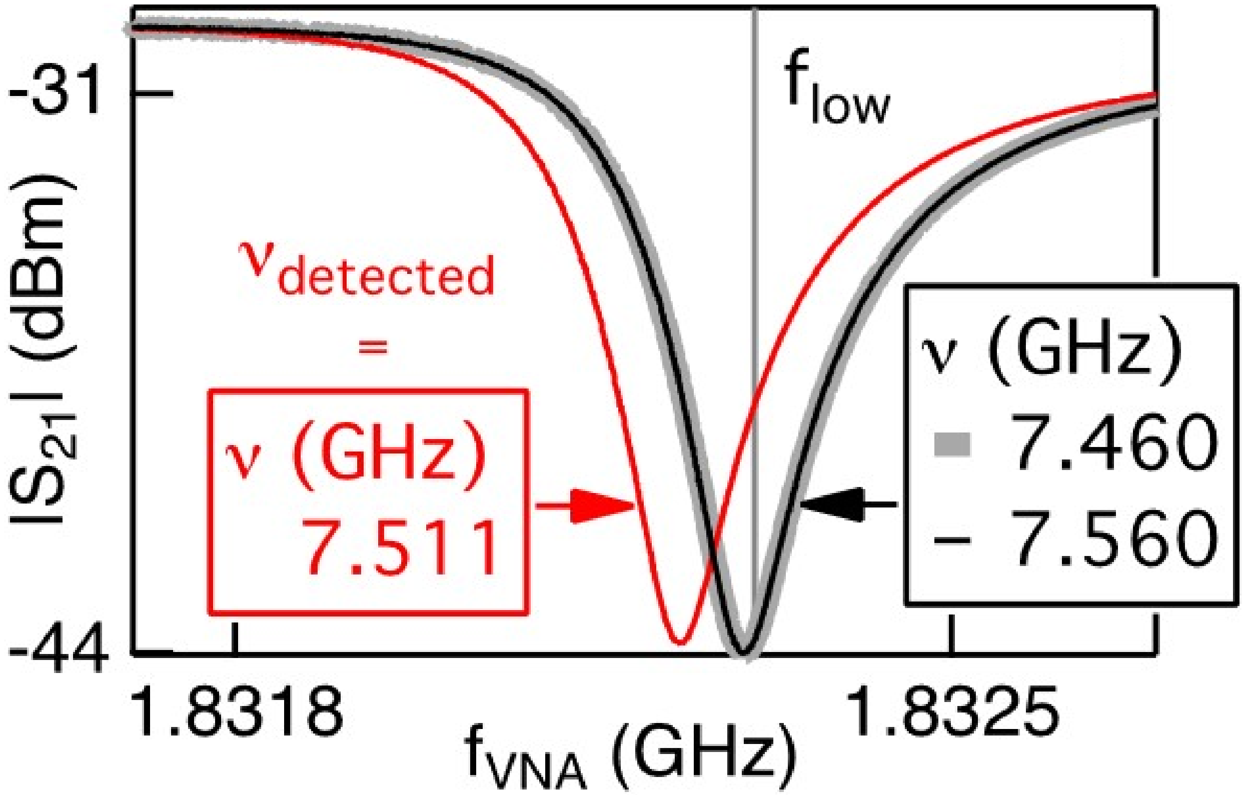
→ Spectral resolution limited to ~ 1 GHz

NEED NEW METHODS

New setup

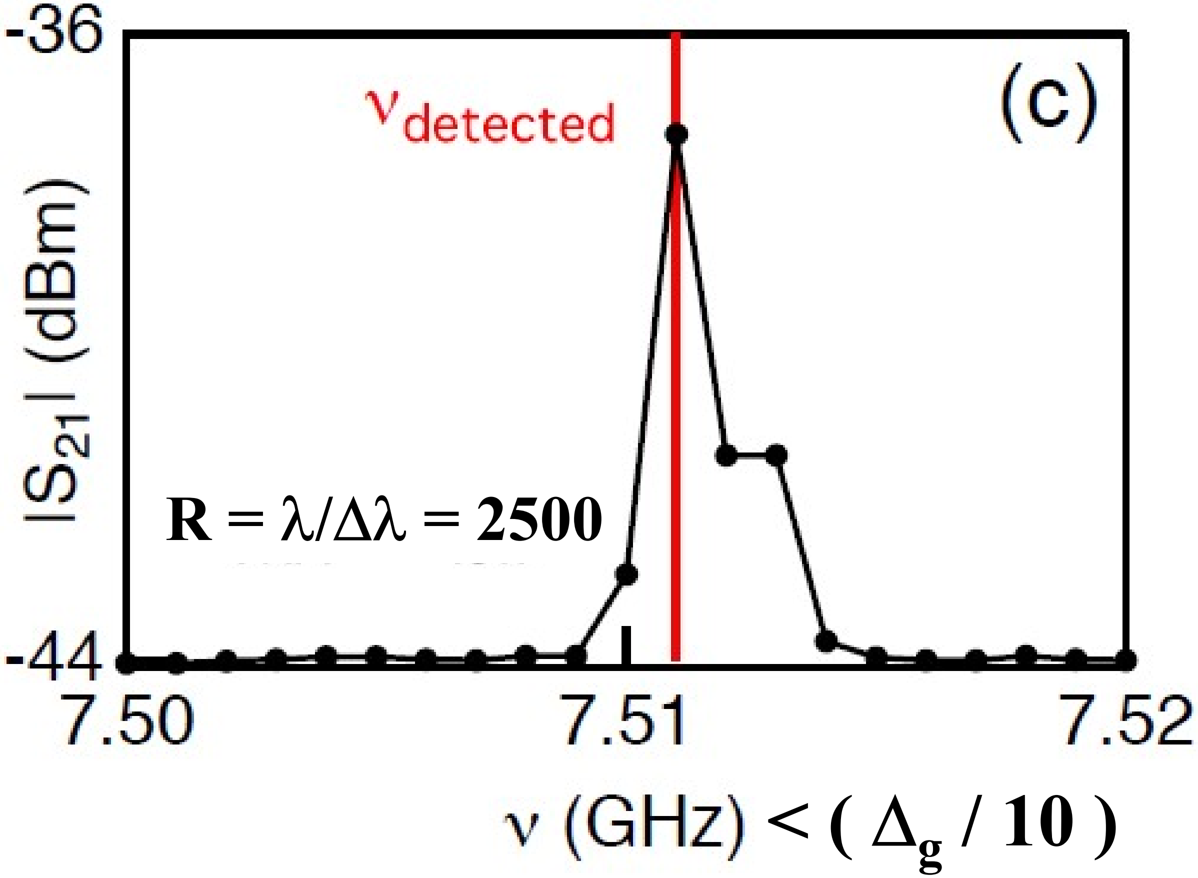


First result: surprise



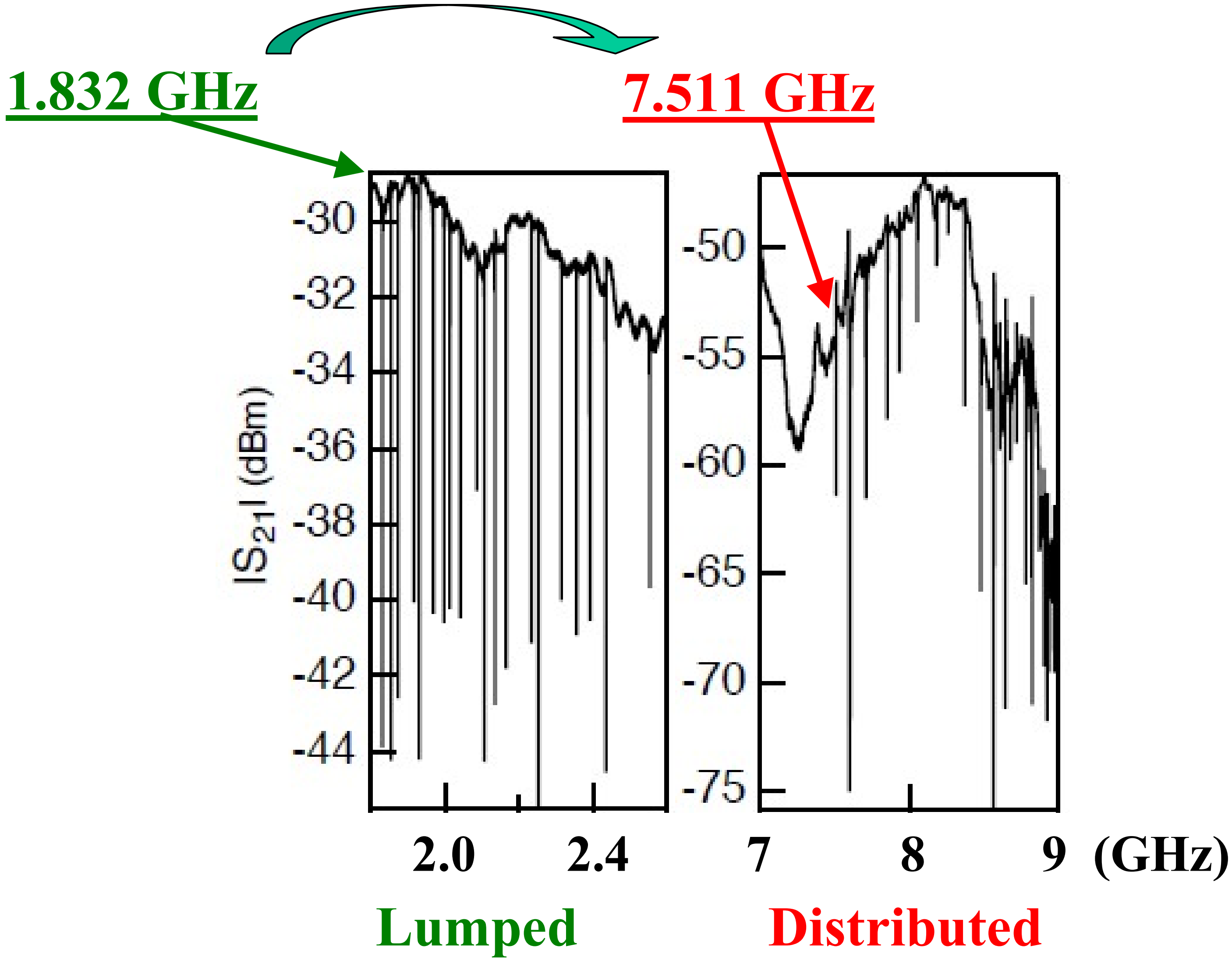
O. Dupré, A. Benoît, M. Calvo, A. Catalano, J. Goupy, C. Hoarau, T. Klein, K. Le Calvez, B. Sacépé, A. Monfardini, F. Levy-Bertrand, Supercond. Science and Technol. 30 045007 (2017)

Frequency selectivity

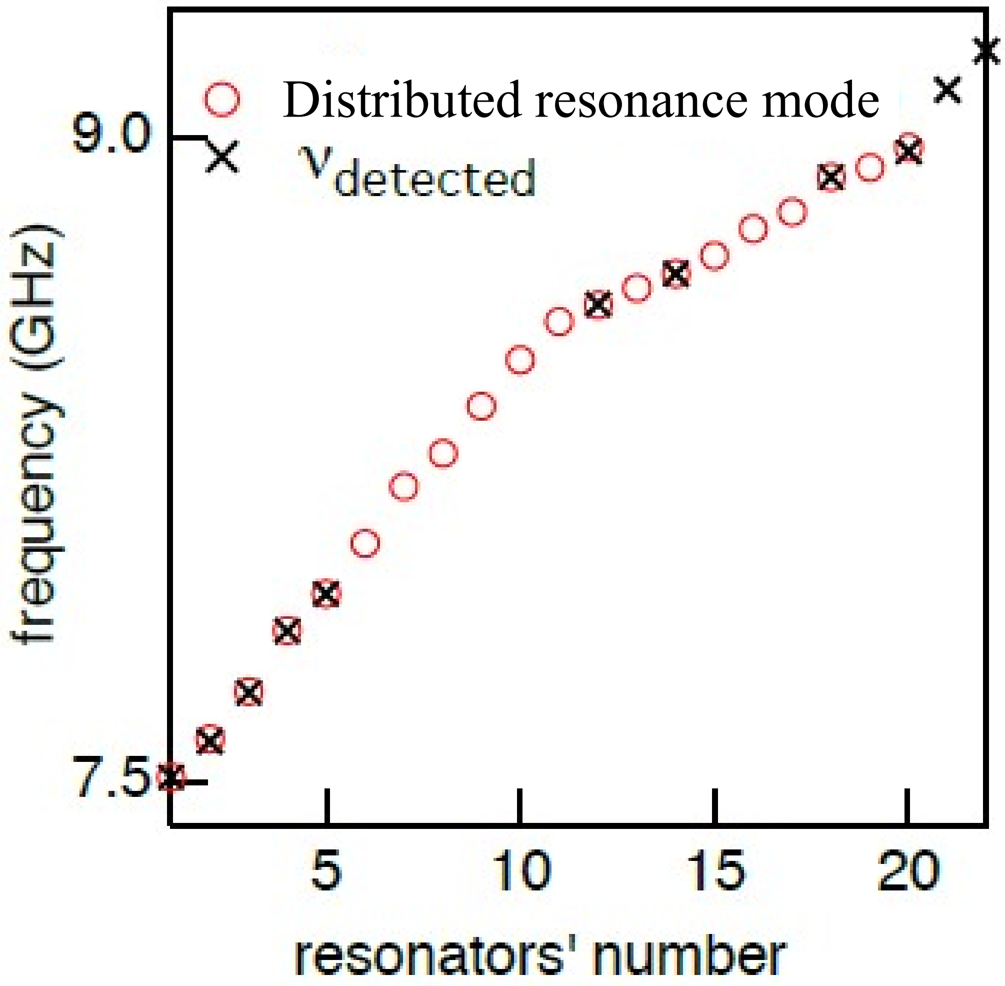


O. Dupré et al., Supercond. Sci. Technol. 30 045007 (2017)

Higher order resonance



All resonators



Physics explanation

→ If the system was **perfectly harmonic** no effect would be expected

HOWEVER, this is not the case:

$$L(J) = L(0)[1 + J^2/J_*^2 + ..]$$

L. Swenson et al., J. Appl. Physics 113, 104501 (2013)

$J_*\,(InO) \approx 4\cdot 10^9\ A/m^2$

$J_*\,(Al) \approx 10^{12}\ A/m^2$

→ **J = J_{LE} + J_d . L_k thus increases, « dragging » the LE (readout) f_{LE}**

→ Well-known effect in the qubit community … « cross-Kerr »

→ Used in the « Kinetic Inductance parametric amplifier »

Open question: dissipative mechanism ?

SKID vs. KID

a) KID are **wideband (imaging)** , SKID are **selective in energy (spectroscopy)**

b) SKID **break the « T < 0.2 · (frequency / 100 GHz) » rule** that KID **must obey**

c) For SKID, **highly-anarmonic materials (low J_c)** are most adapted. In KID the **highest J_c results in better S/N**

d) KID **have already natural applications** in low-resolution visible-NIR spectroscopy and for mm and sub-mm continuum Astronomy. SKID **applications and competitivity** with respect to other technologies are still to be investigated.

Potential applications

1) On-chip **centimeter-wave spectroscopy** (R ≈ 1,000 ÷ 10,000)

→ the EM design requires some art

- Astronomy (single dishes) at intermediate resolutions
- Atmospheric studies
- Others ?

2) For-free **low-frequency extension** of focal planes based on KID

Possible extensions of SKID: mm-wave and/or wider band ?

THANKS