BAUMIER.C[1,2,3], ANTOINE.C.Z.[3], FORTUNA.F[2], MARTINET.G[1], VILLEGIER J.C. [4].

MULTILAYERS ACTIVITIES AT ORSAY/SACLAY

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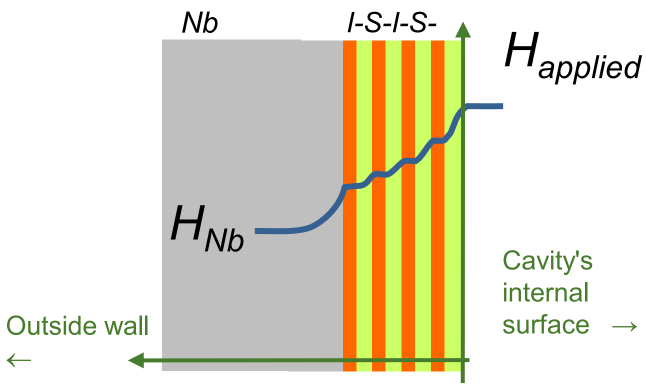
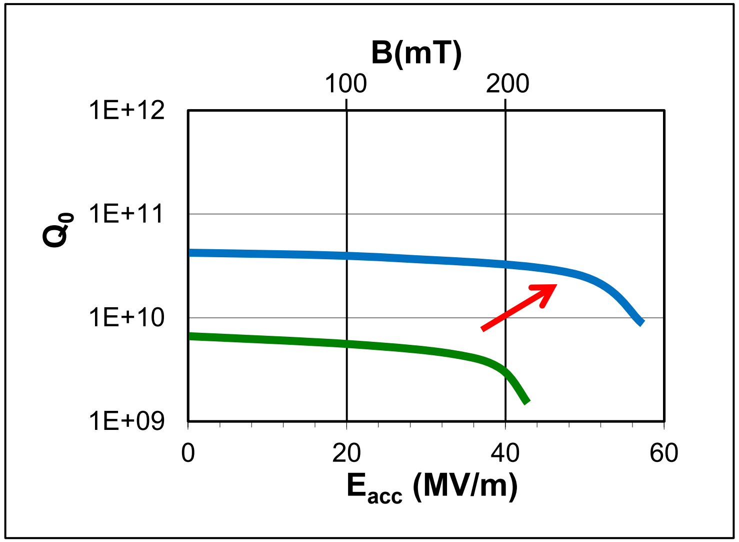
Outlook

- Introduction to ML
- H_{C1} measurement / magnetometer
- R_S measurement / TE011 cavity
- Multilayers deposition / MBE
- Conclusion and perspectives

Multilayers / theory

Multilayers: Nb / insulator/ superconductor / insulator /superconductor… *In principle :*





- **Artificial enhancement of H_{C1} → Thin SC films. d< λ (1)**
- Applied field is reduce by each layer.
- Niobium surface screening: allows higher field in the cavity
- **NbN thin film : higher T_C => higher Q_0**
- Insulating layer prevents Josephson coupling between layers
- **The accelerating field can be increased without high field dissipation**
- **High H_{C1} → no transition, no vortex in the layer**

Overcoming niobium limits (A.Gurevich, 2006) :

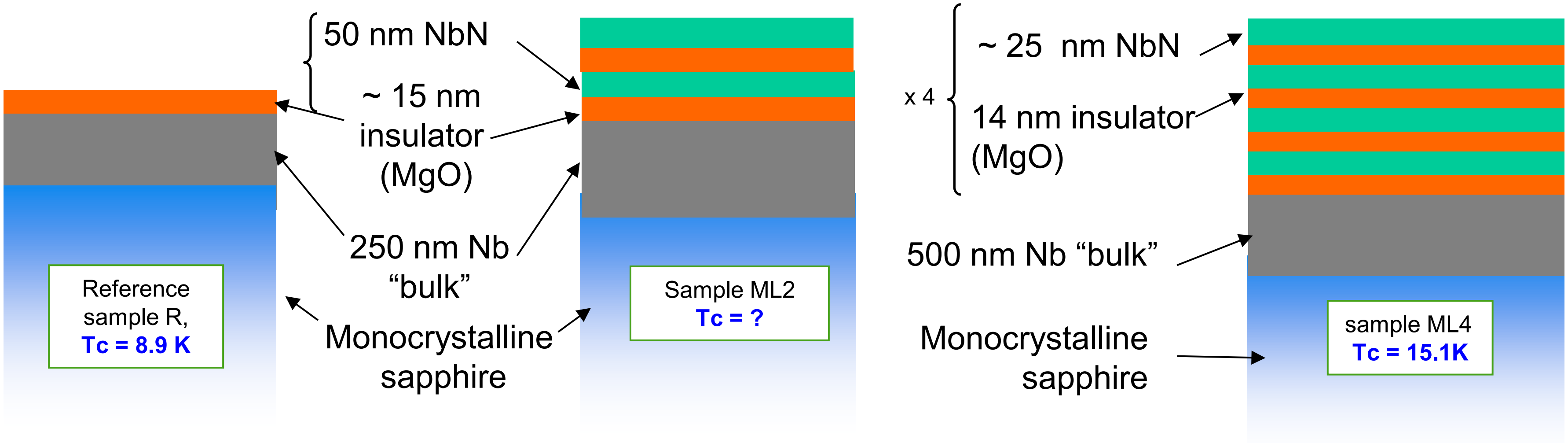
(1) *In theory 20 nm NbN : H_{C1} x ~200*

$$R_S^{NbN} \approx \frac{1}{10} R_S^{Nb} \Rightarrow Q_0^{\text{multi}} >> Q_0^{\text{Nb}}$$

(similar improvement expected with MgB_2 or Nb_3Sn)

Samples description

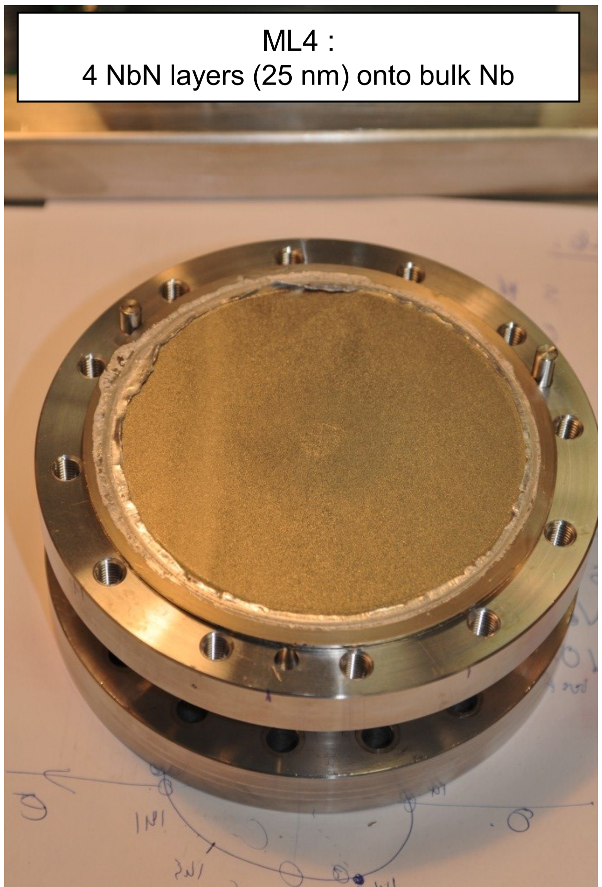
- Model samples: magnetron sputtered* on monocrystalline sapphire
- RF Samples: magnetron sputtered* on Nb **disks** (similar conditions)

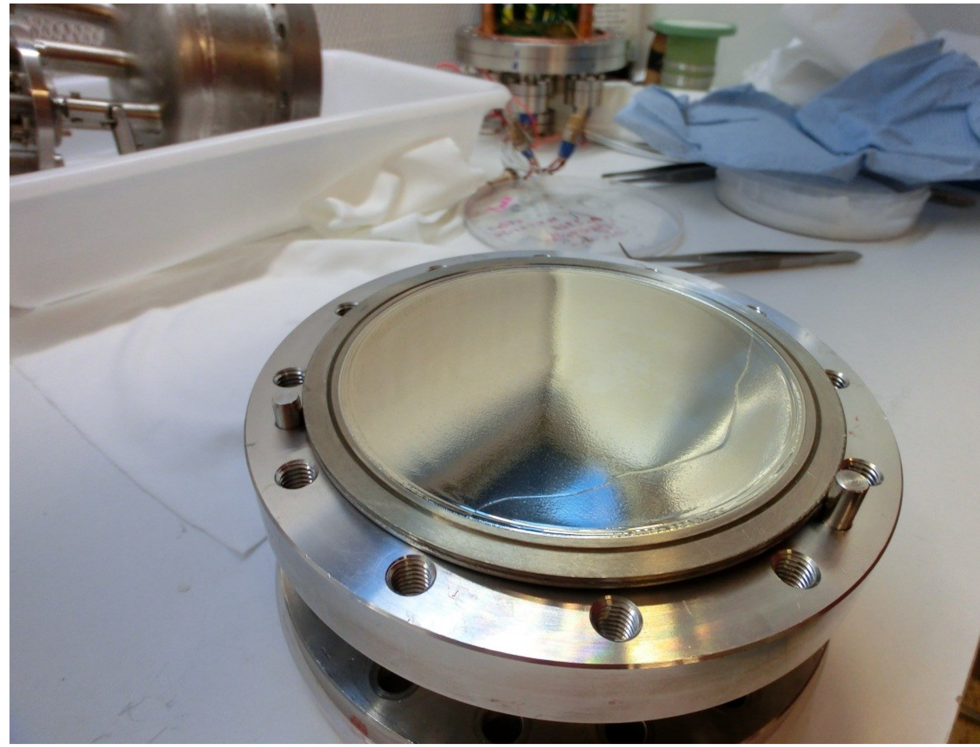


Samples	Nb thickness	NbN thickness	Number of NbN/MgO[a] sequences	Tc (K)
R	250 nm	NA	0	8.9 [b]
SL	250 nm	25 nm	1	16.38 [b]
ML4a	500 nm	25 nm	4	15.1 [c]
rf-ML4	Bulk, polycrystalline	25 nm	4	
rf-ML2	Bulk, large grain	50 nm	2	Not directly known
Rf-Nb	Bulk, polycristalline	NA	0	

** Collaboration with CEA Inac*

Magnetometry experiment done
On ML4 sample



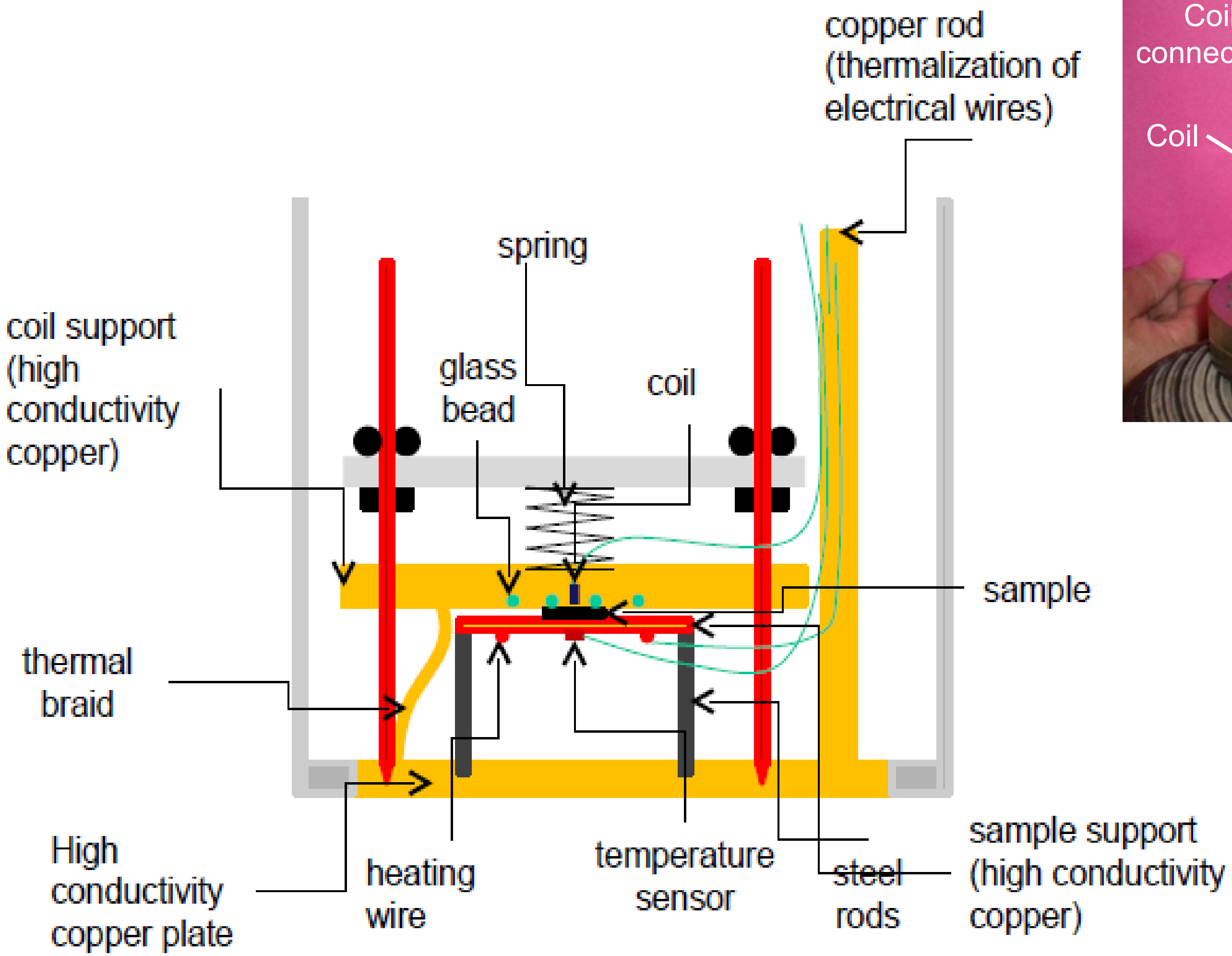


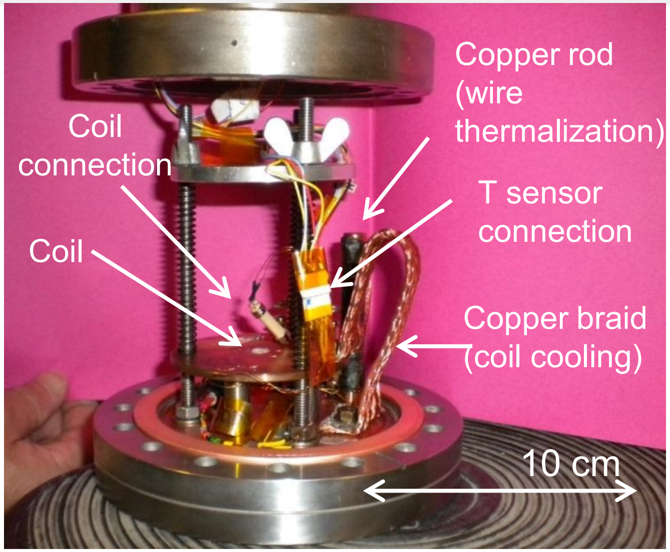
RF experiment done, waiting for the magnetometer measurement.

Sample Magnetron sputtered @ CEA Inac

Magnetometer

CEA IRFU



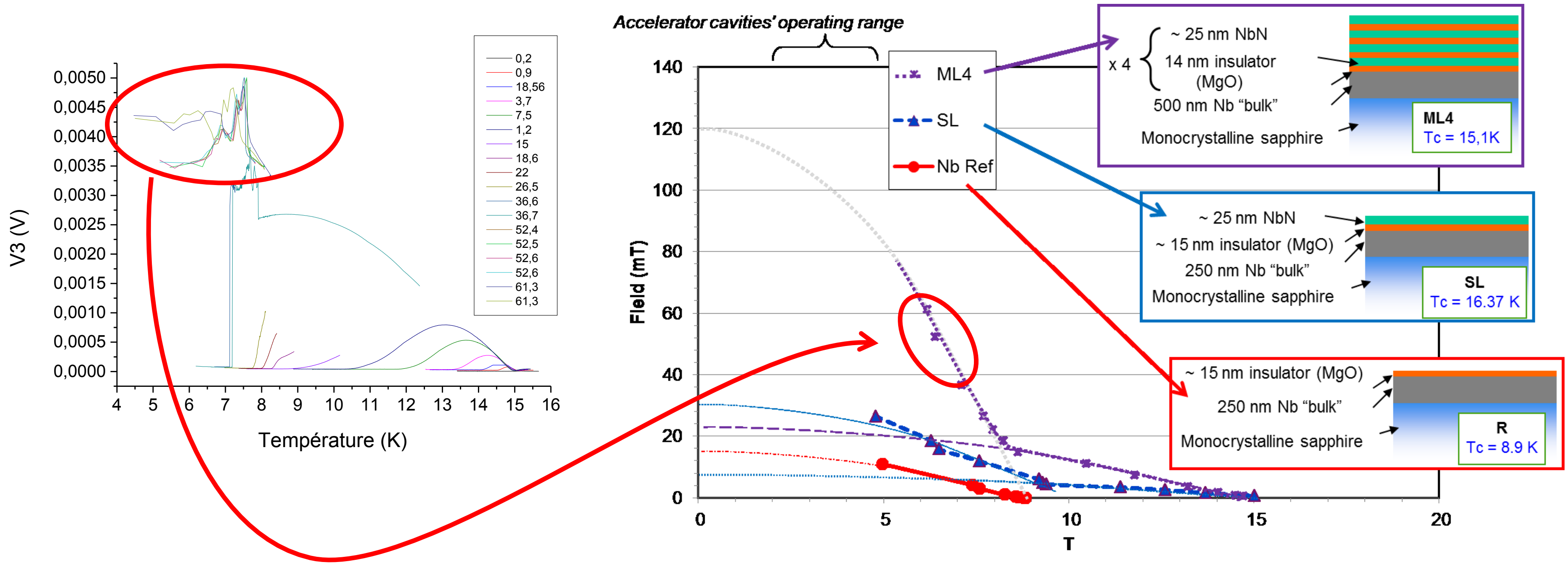


The measurement :

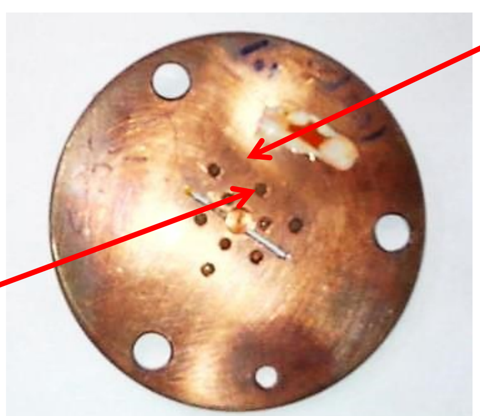
- Hc1 direct Value
- Perpendicular
- Local
- No border effect

Early results

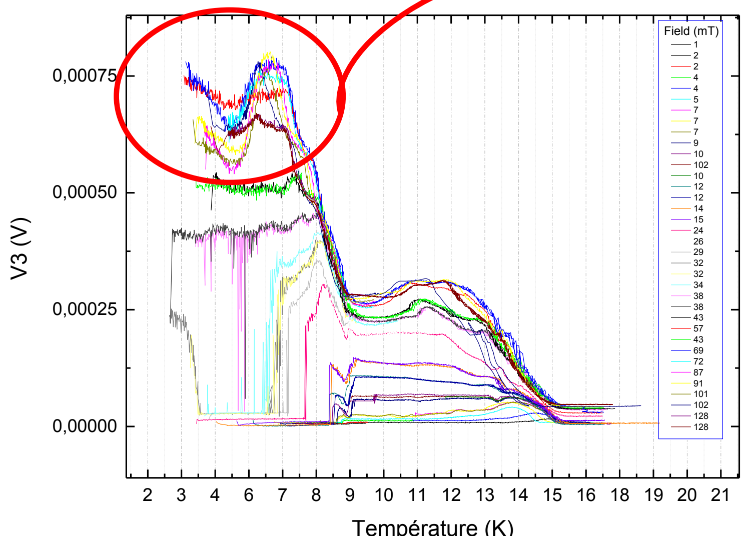
CZ Antoine, JC Villegier, G Martinet, Applied Physics Letters 102 (10), 102603-102603-4

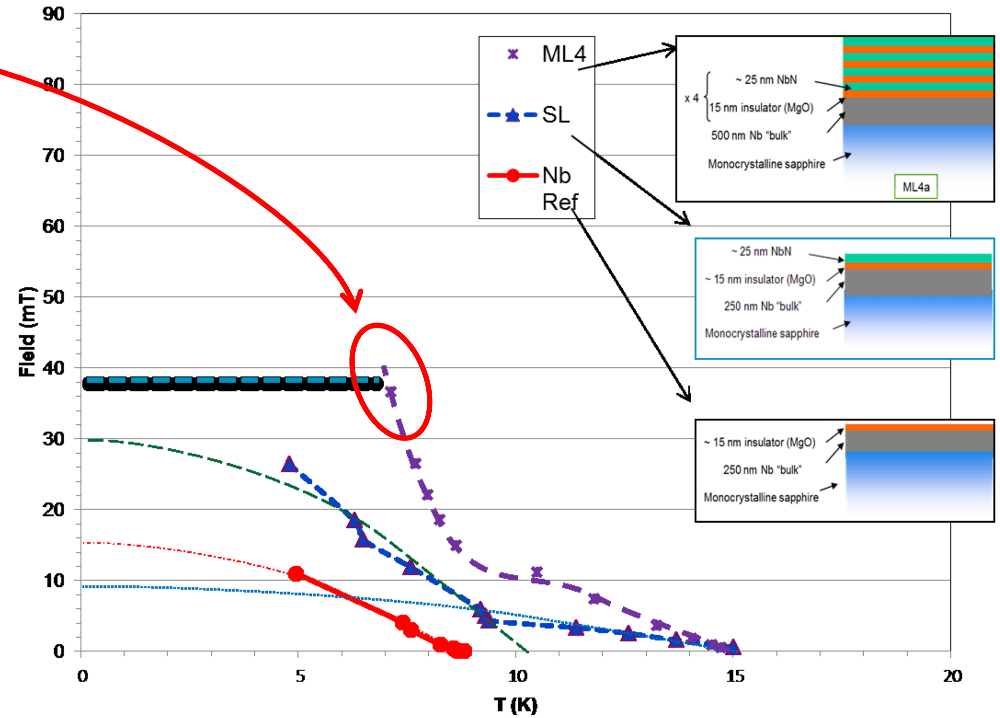


- High field exp. measurements limited (~60 mT) by unexpected heating of the system
- Interference between the various films of the multilayer
- Recently diagnosed as Foucault losses in coil holder.
- A slit was added in the coil holder.

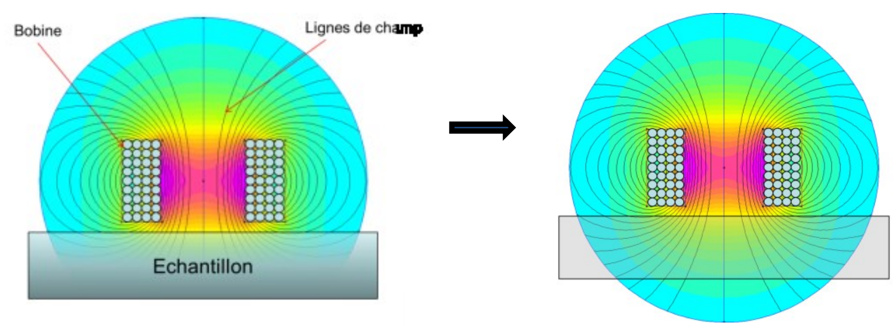


Magnetometry (continued)

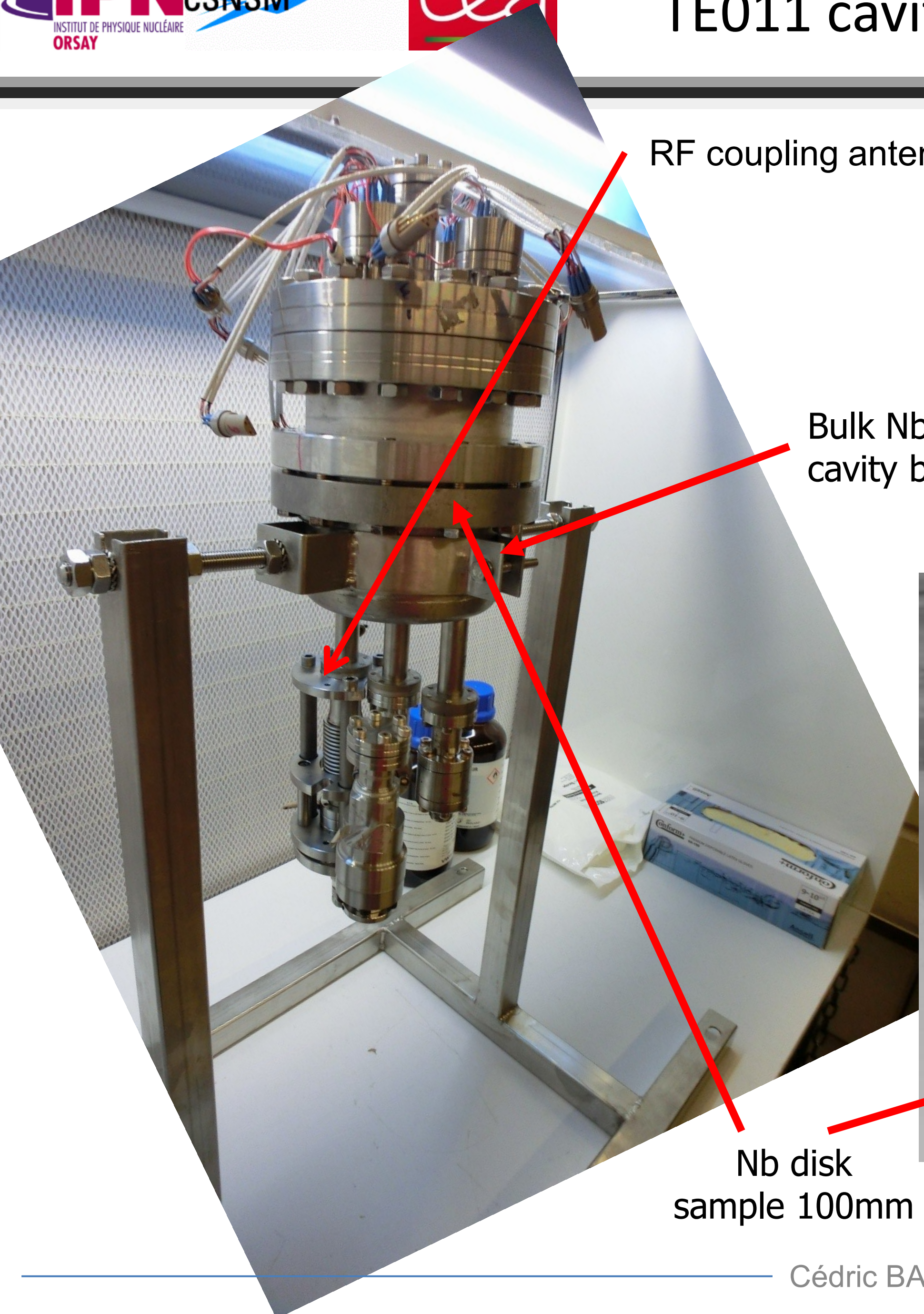




- Magnetic screening evidenced for ML4 up to 38 mT, at T~7K
- Dramatic transition around 38 mT => $r_{coil} << r_{sample}$ not valid anymore ?
- Magnetometer is effective up to 1500 mA (equivalent field 150 mT) Tp° 2-40 K
- Use of larger samples is mandatory



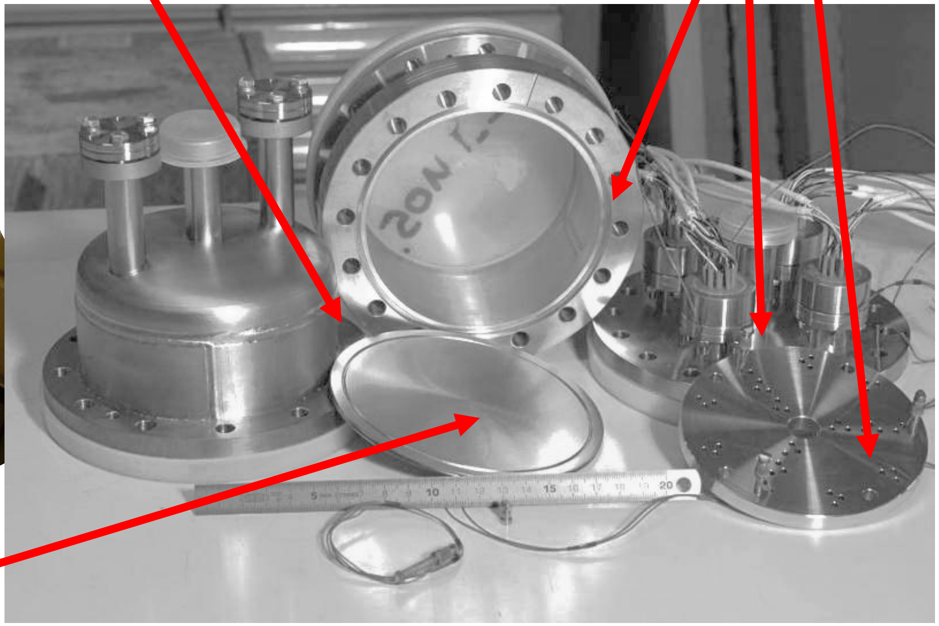
TE011 cavity developed @ IPNO



RF coupling antenna adapt for experimental conditions

Bulk Nb TE011
cavity body

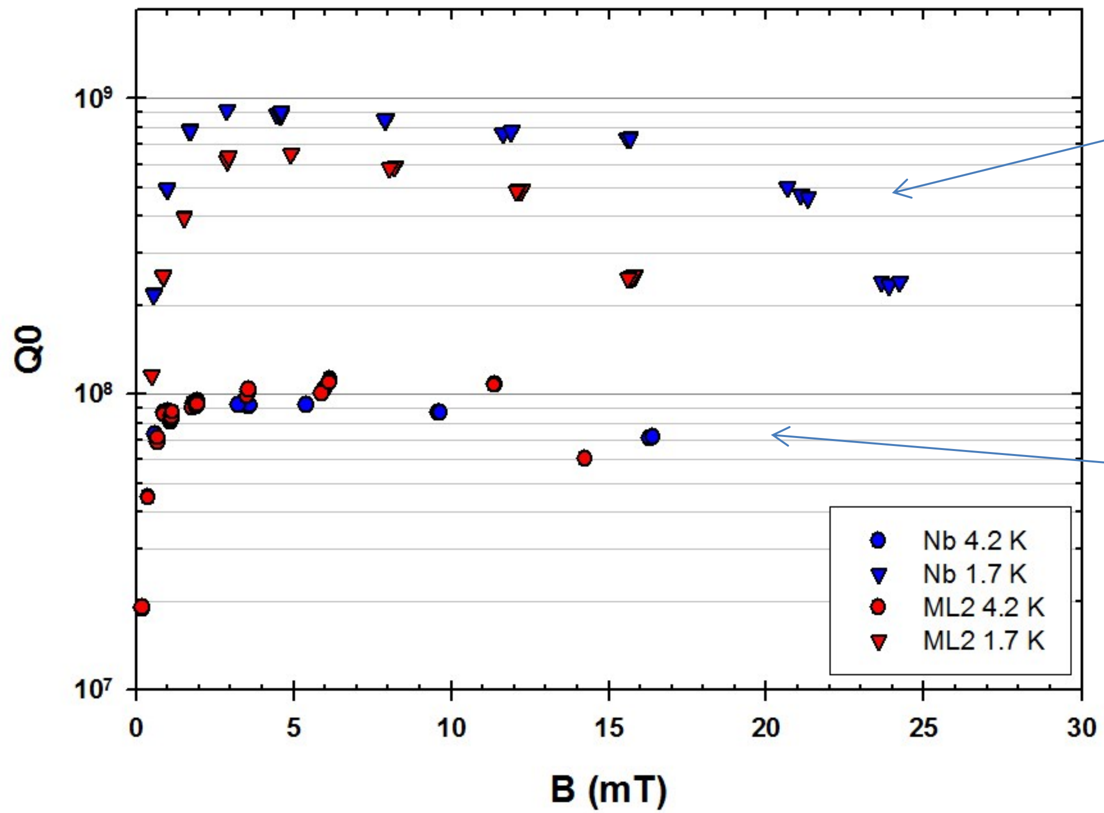
Themometric set-up



Nb disk
sample 100mm

results for rf-ML2 & Nb @ 4,2 K and 1,7 K

RF measurement @ 3,88 GHz:



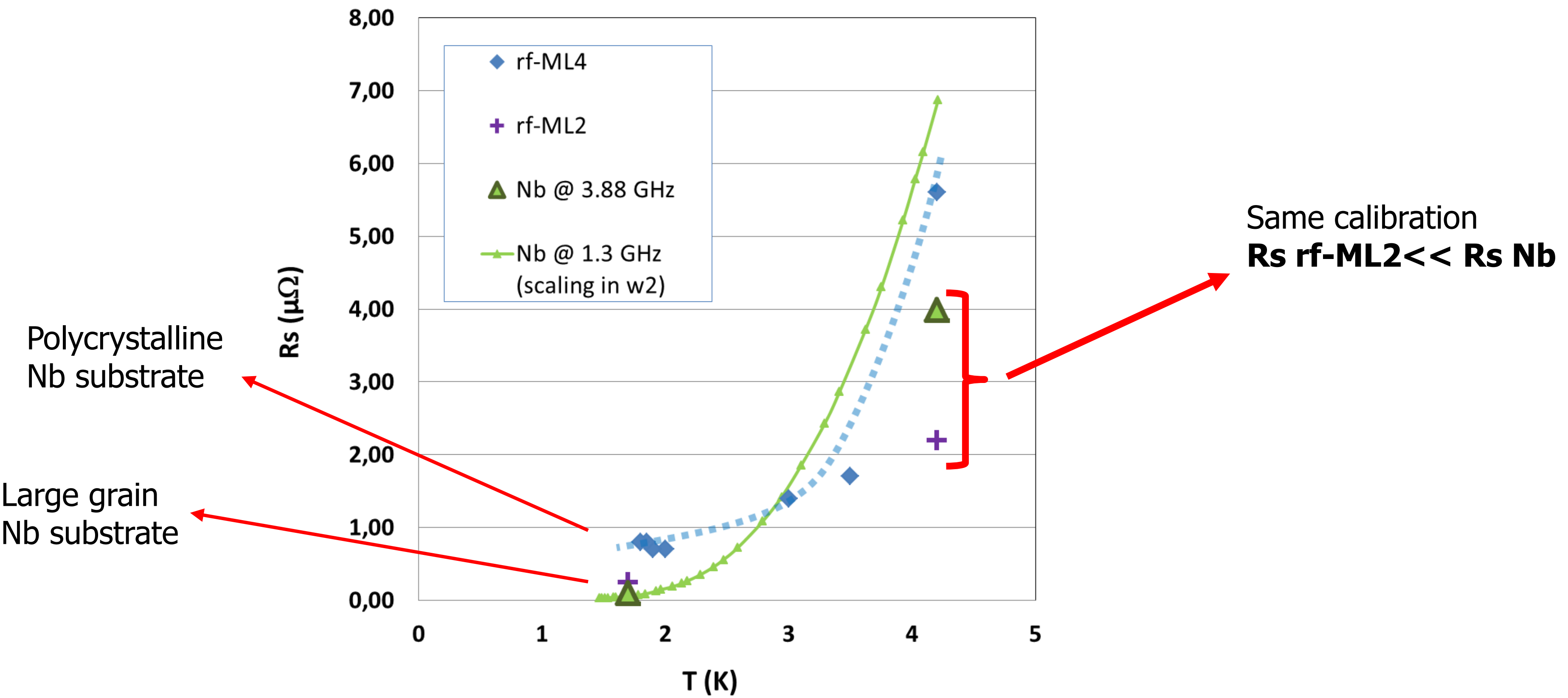
RF-ML2 a little less good than Nb @ 1,7 K because of the Rres

Nb/RF-ML2: similar results @ 4,2 K

- **Residual resistance (the only non predictable part of Rs) is not "that" bad**

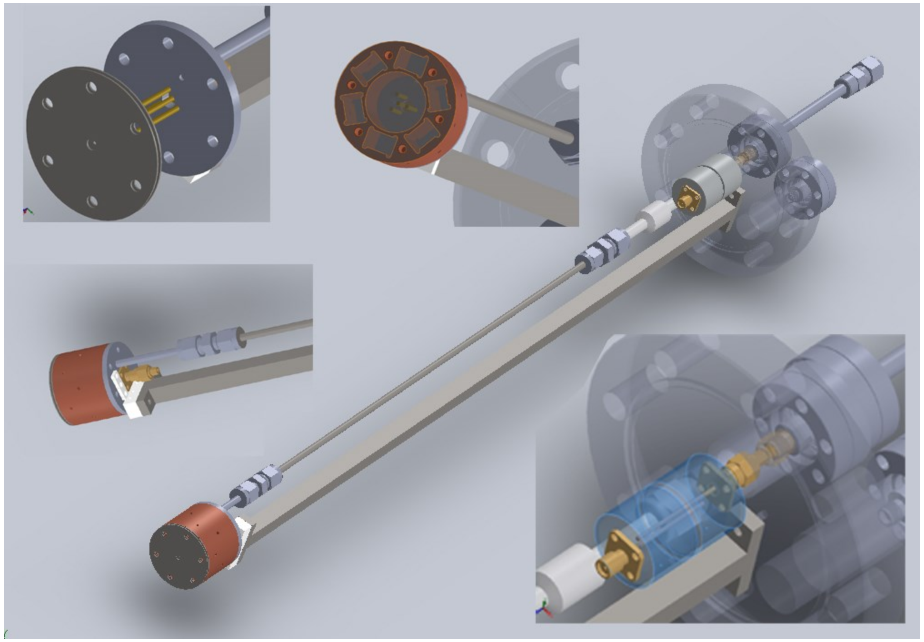
Sample quality can be improve .

Thermal analysis



- Strong indication that R_{BCS} is improved with ML
- Could probably be improved with the use of thicker layers (complete screening)
- **Very promising preliminary results**

COMICS Source



P. Sortais
S. Bouat

H. Ringuenet
P. Leroy
B. Pilette

- News series of samples
- A new tool under commissioning

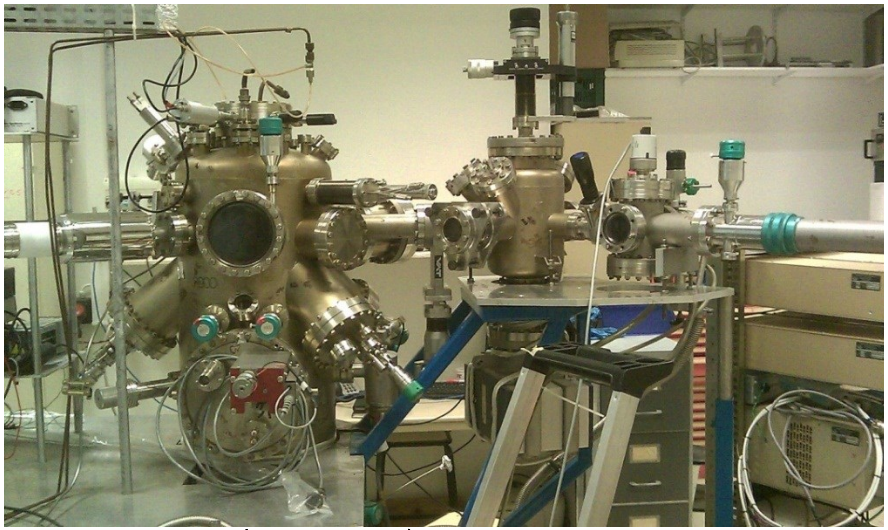
Molecular Beam Epitaxy (MBE)

High purity base from ultra high vaccum : 1.10^{-10} mBar
1.10^{-8} and 1.10^{-7}mBar for working vaccum conditions.
Better control of parameters

The Team : P2IO collaboration

C. Baumier (IPNO/IRFU/CSNSM)
G.Martinet (IPNO)
C.Antoine (IRFU)
F.Fortuna (CSNSM)

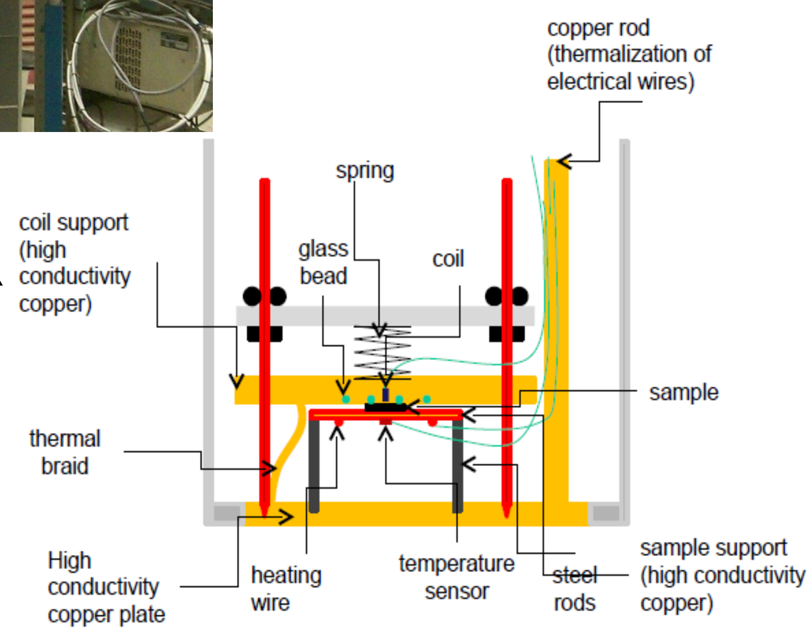
MBE @ CSNSM



Samples for fundamental studies

RF @ IPNO :
Required New & adapted cavity.

Magnetometer @ IRFU



Conclusions and perspectives

- ML structures seem to be a promising way to go beyond Nb for accelerator cavities
  - Effective screening of the surface, prevents early vortex penetration
  - **R_{BCS} is improved with the use of higher T_C SC**
  - R_{res} is not dramatically degraded compared to Nb
  - Room for improvement: better understanding of interaction with substrate needed
- 2 strategies need to be developed in parallel:
  - Deposition method for cavities / *see poster TUP081*
  - **Understanding the physics of ML and optimization of their structures**
- Adequate tools for the testing of many samples are now effective
- Effort must be now carried on the production of ML on samples and cavities

Thanks to P2IO Financial Support

Thank you for your attention