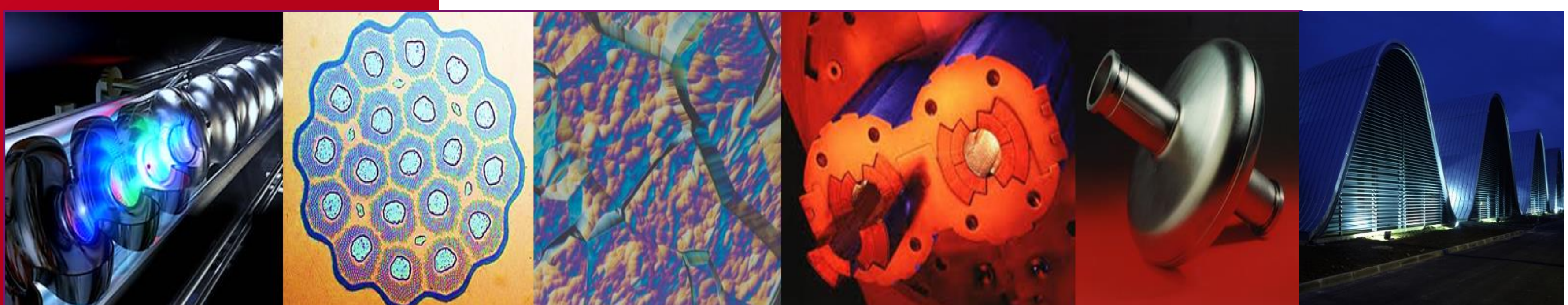
DE LA RECHERCHE À L'INDUSTRIE

Research Program for improving SRF cavity performances at CEA



Thomas Proslier

www.cea.fr

ARIES PoC report – Nov. 2019

Team:

Technician: C. Boulch, P. Carbonnier, E. Fayet, A. Four, G. Jullien, C. Servouin
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Ph.D.: Sarra Bira (IPNO/CEA), Y. Kalboussi (CEA)
Future Post-doctorant.
Internship: R. Dubroeucq, S. Habhab

Collaborations:

KEK: T. Saeki, T. kubo, Marui. (thin films, theory, electropolishing)
IPNO: D. Longuevergne, M. Fouaidy, T. Pépin-donat
LAL: G. Sattonnay (characterization)
DESY: M. Wenskat (characterization, thin films)
CERN: G. Rosaz, S. Calatroni (thin films)
STFC: R. Valizadeh (thin films, Nb3Sn)
INFN: C. Pira (thin films)
JLAB: A-M. Valente, G. Ciovati, D. Patshupati (Bulk Nb, thin films)
FNAL: S. Posen, A. Romanenko, A. Grassellino (Bulk Nb, Nb3Sn)
ANL: A. Glatz – Theory (theory simulations)
IIT: J. Zasadzinski
TRIUMPH: T. Junginger (characterization)
Cornell: M. Liepe (Nb3Sn)

Research Program for improving SRF cavity performances at CEA

- Unique Characterizations tools
  - Point Contact Tunneling spectroscopy
  - Magnetometry
  - Predictive power for RF tests
- Thin films developements
- Bulk Nb infusion
- Plasma Processing
- Summary and future

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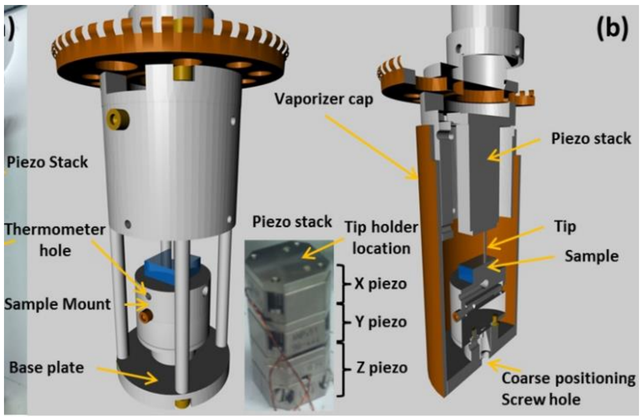
Unique characterization tools at CEA

PCTS

Measure surface superconductivity

Parameters: Δ, T_C, Γ

Cavity: Q0, Q-slope, *Emax*



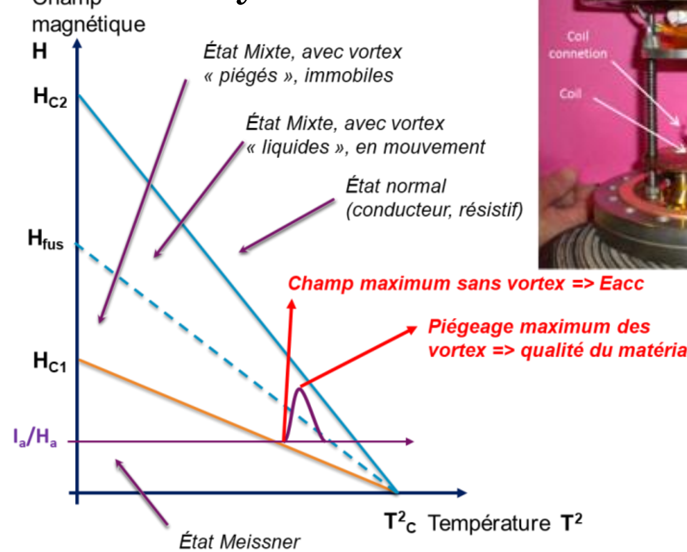
- Temp: 1,4 K – Magnetic field: 6 T
- Cartography: 10 µm – 1 mm
- Fast measurements: 100-300 jonctions/5hrs
- Sample size: 10x10 mm

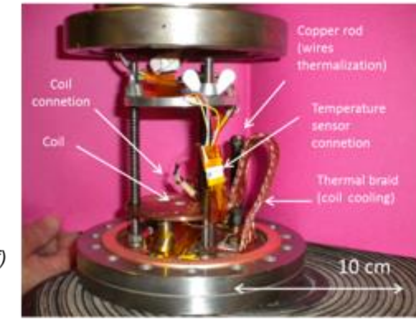
Magnetometry

Measure critical penetration field

Parameters: H_{SH}

Cavity: Emax





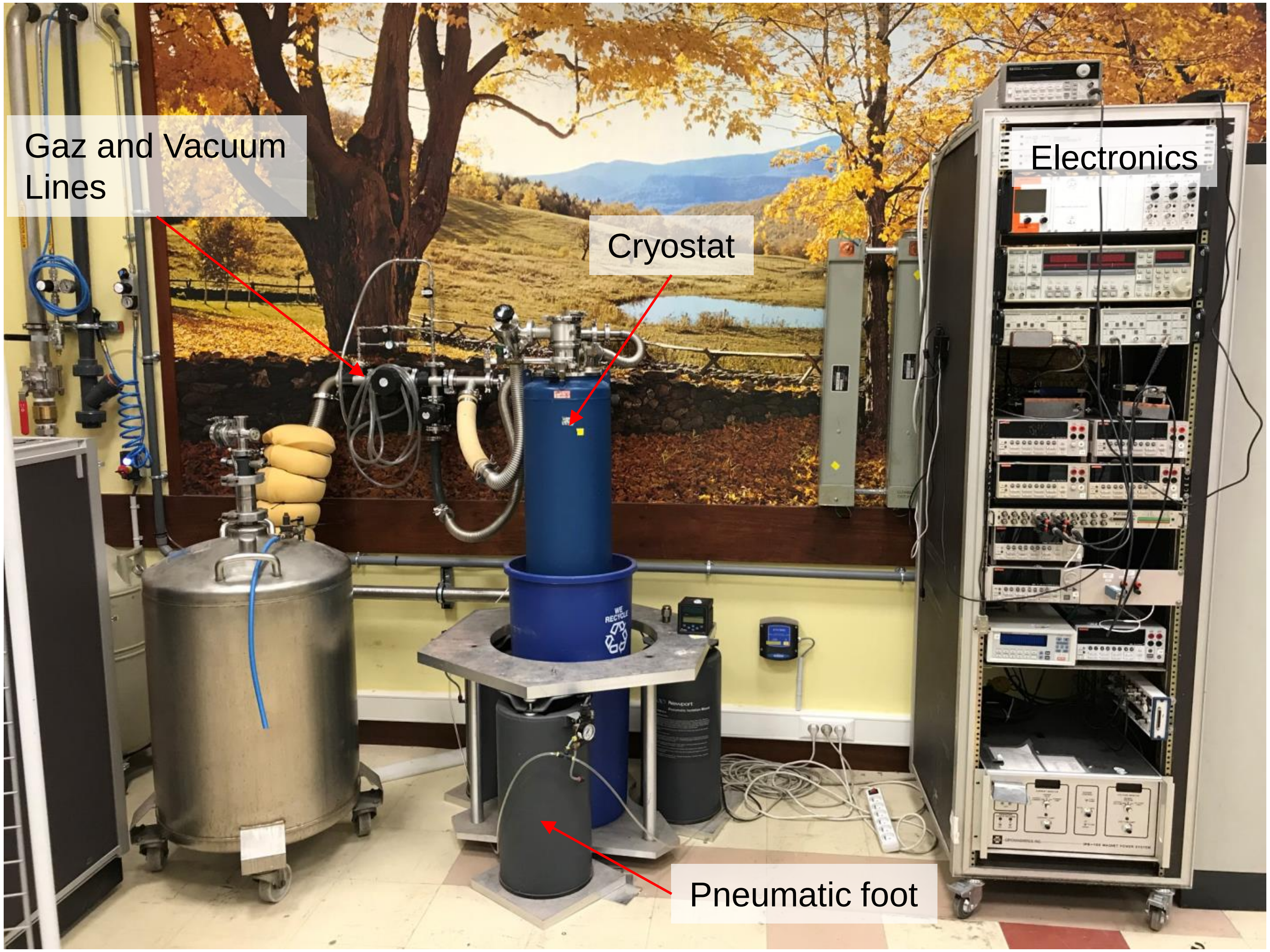
- Temp: from 4,2 to 300K
- External magnetic field: up to 130 mT
- Sample size: Ø ≥ 30 mm

Used for thin films: Nb/Cu, Nb_3Sn, mutlilayers, bulk Nb surface treatments (doping, infusion…)

Future: Improve noise - Faraday Cage

Future: higher magnetic field 200 mT

The Point Contact system at CEA



- Temp: 1,4 K
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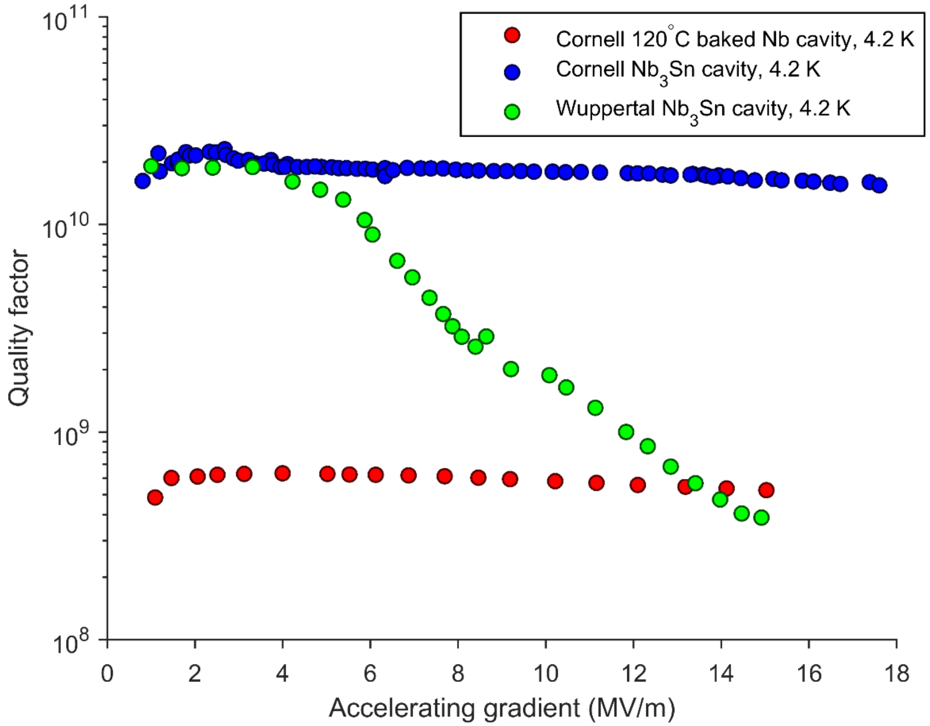
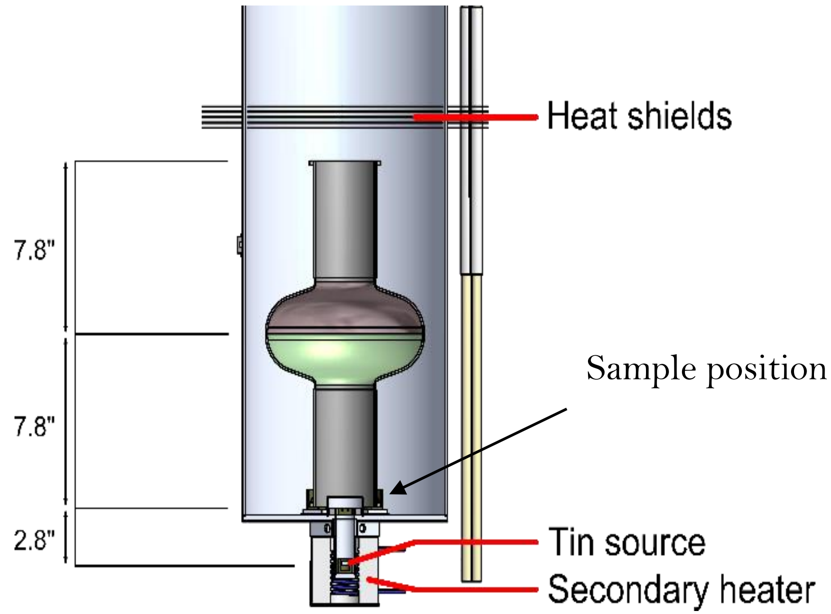
Nb_3Sn/Nb (Cornell-FNAL)





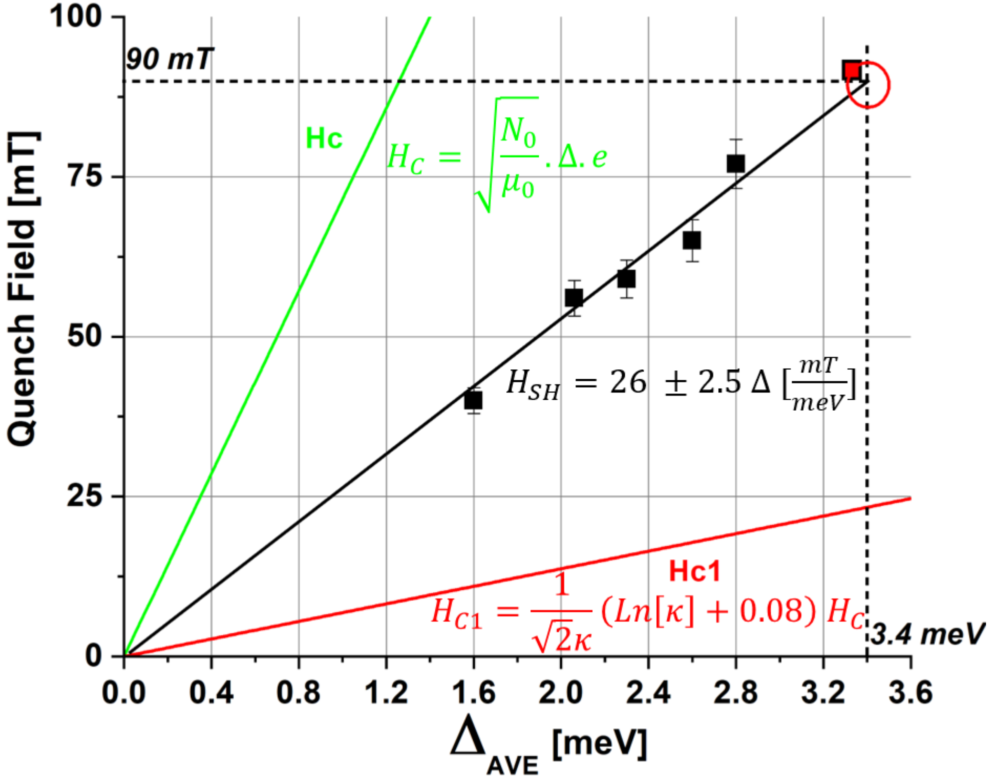
- Wupperthal method: diffusion of Sn in a Nb cavity
- Nb_3Sn Q_0 at 4,2K ~ Nb Q_0 at 2K
- Moderate increase of Q_0 between 4K to 2K -> Non-BCS
- Q_0 decrease at ~ 6K

Have we reached the limits of Nb_3Sn ?

Nb_3Sn/Nb (Cornell - FNAL) – PCT

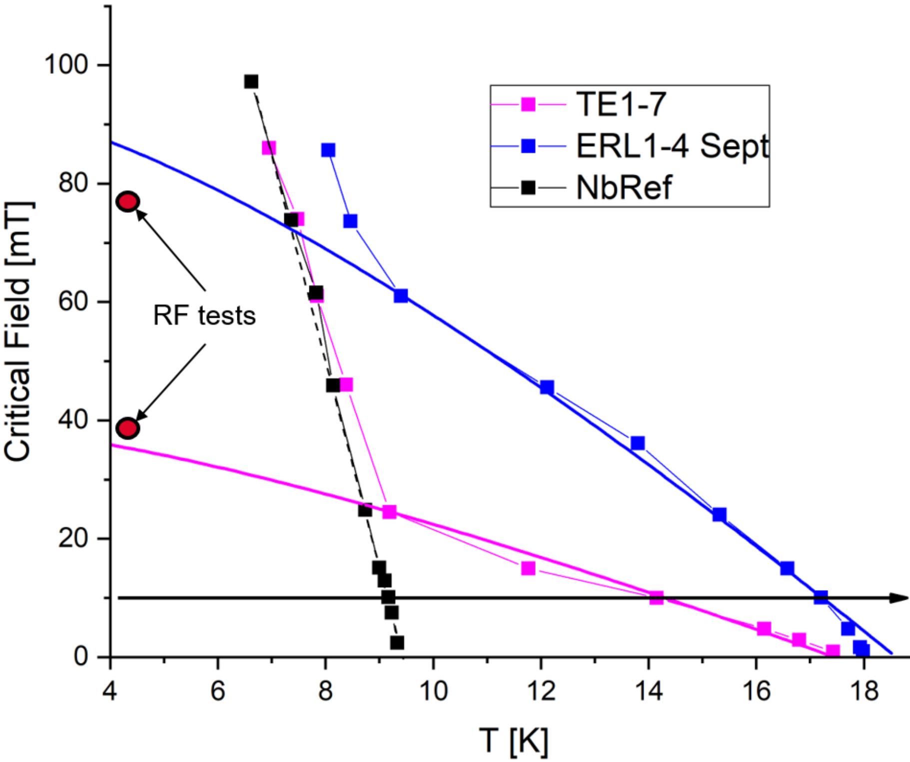
PCTS

Quench field vs Average Gap



Magnetometry

Measured critical field



- Linear dependence of Emax on the average surface gap (~300x300 µm)
- A15 compounds (V_3Si, Nb_3Sn, Nb_3Al…) are good for Q_0 and higher operation temp. (4,2 K)
- But what about E_{MAX} ? How to increase E_{MAX} ?

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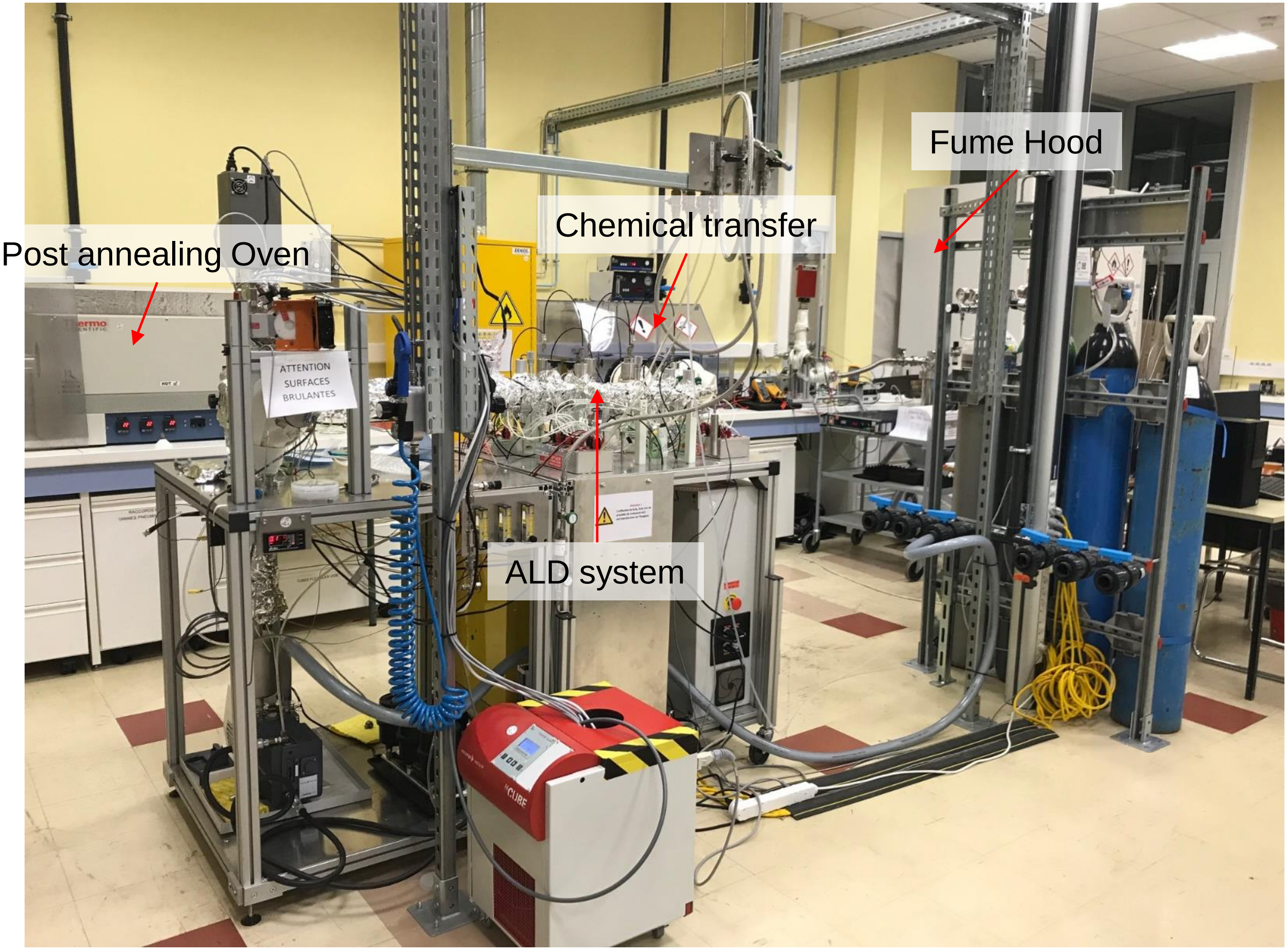
Thin films developements at CEA

Set up of the ALD laboratory

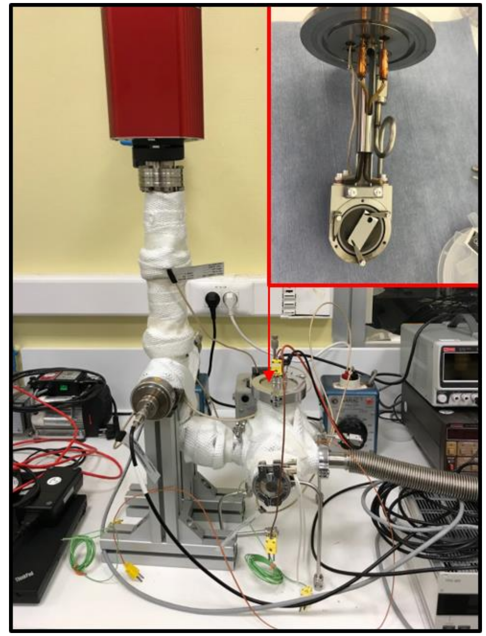


- 7 chemical precursors
- Temperature up to 500°C
- RGA and QCM in-situ monitoring
- Design to fit 3 and 1,3 GHz cavities
- Fully automated
- Deposition homogeneity < 1%

Thin films developements at CEA

- Deposition on BCP, EP bulk Nb samples + Post annealing treatment in High Vacuum

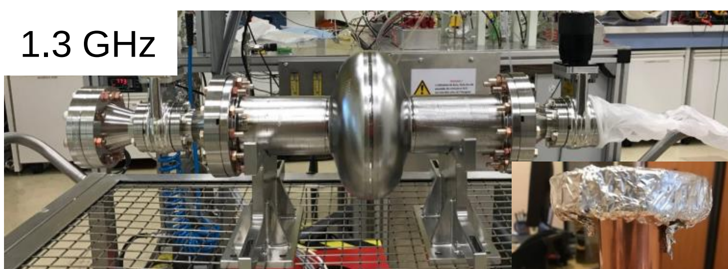
Annealing



- Up 1000°C
- 1 inch samples
- 5.10^{-6} mbar at 800°C
- RGA and gaz feedthroughs
- Set for Insitu X-ray studies

- Soon on 3GHz and 1,3 GHz cavities

1.3 GHz

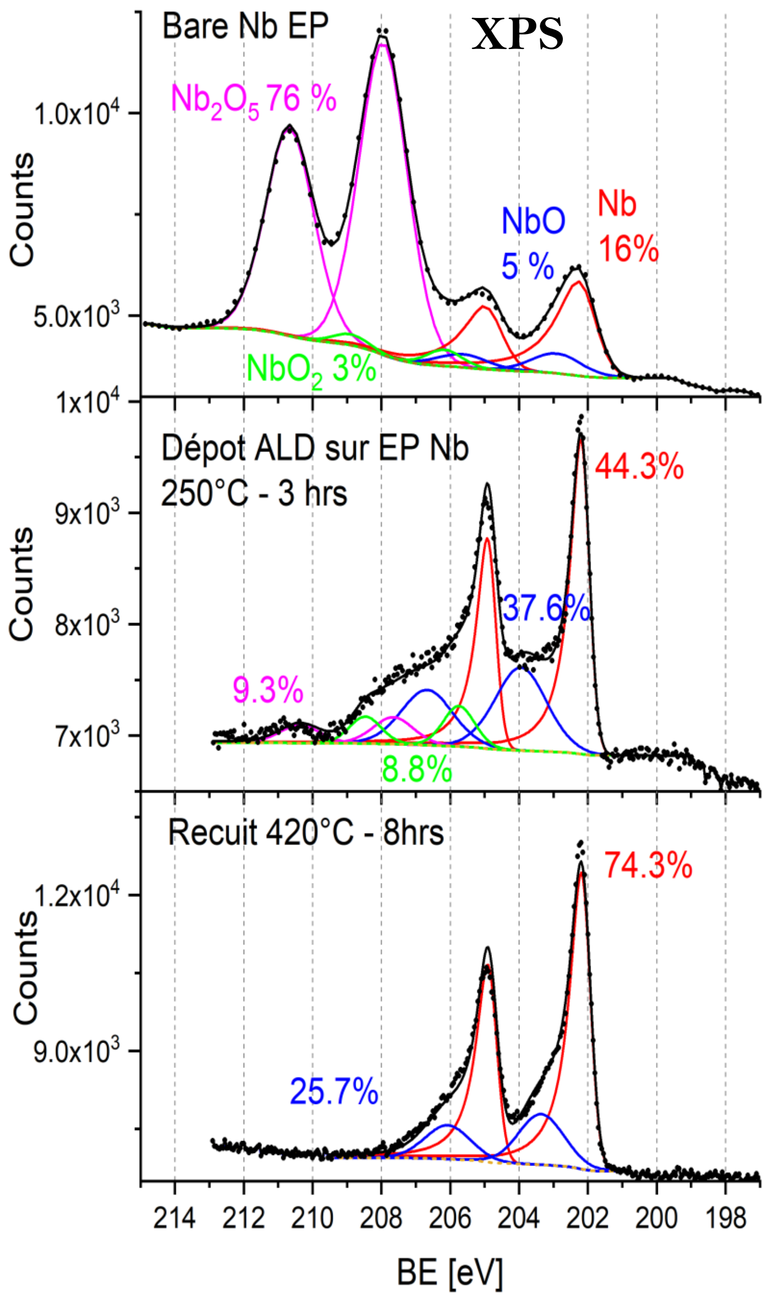


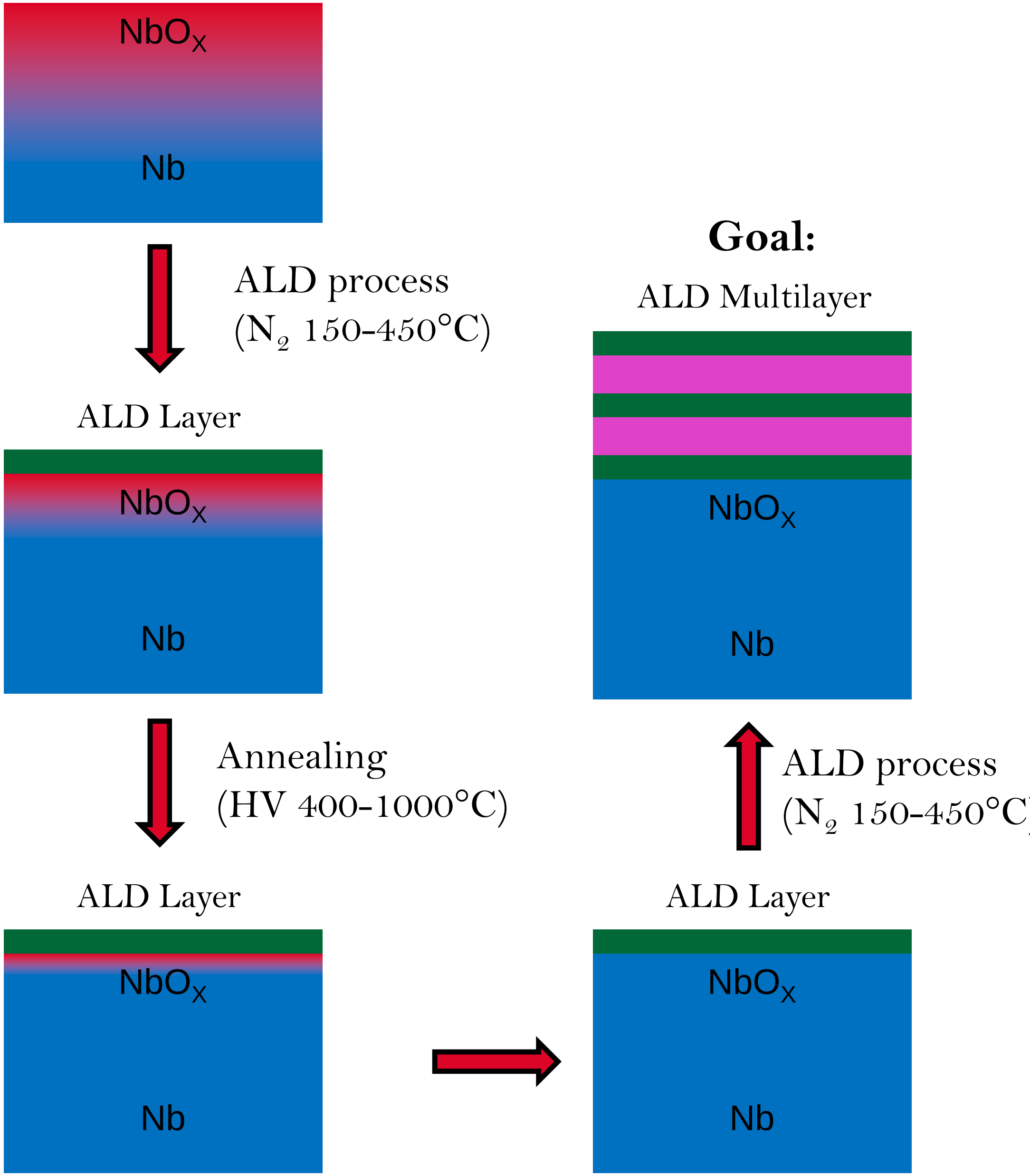
3 GHz

Annealing

- Up 1000°C
- Up 1,3 GHz cavities
- 10^{-6} mbar at 800°C
- RGA and gaz feedthourghs

Thin films developements at CEA





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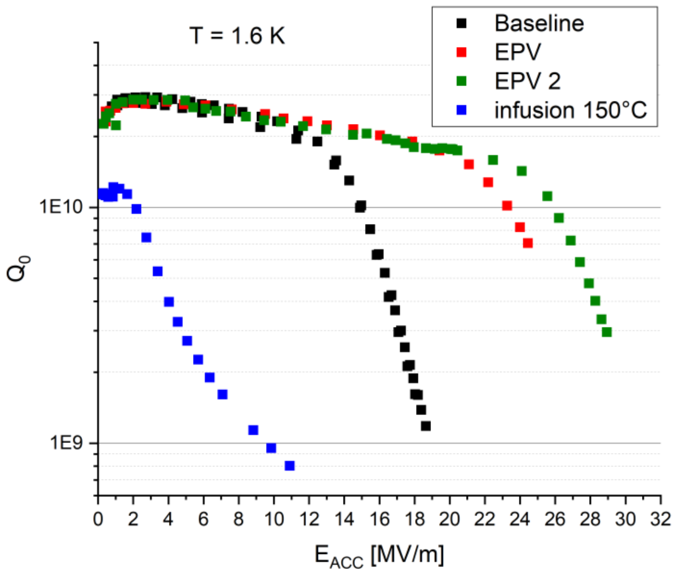
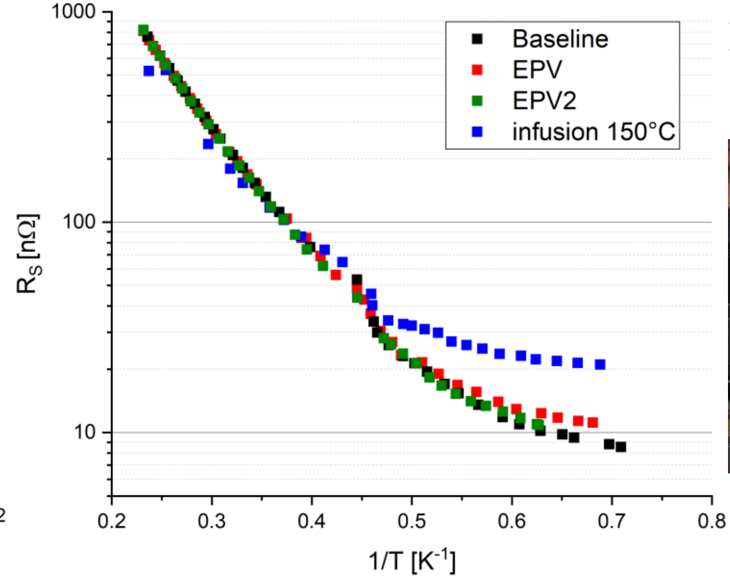
Bulk Nb Infusion – (IPNO/CEA)

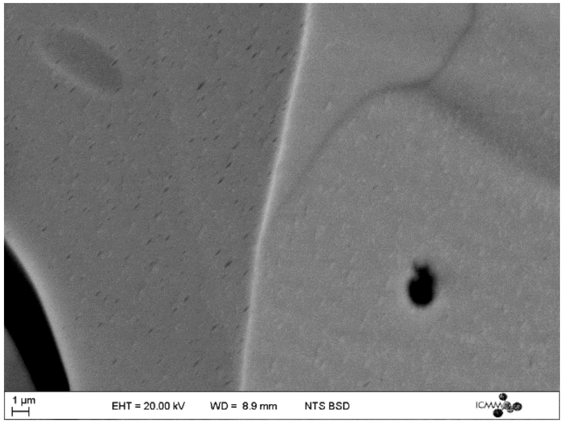
- Diffusion of N in the first nm's of bulk Nb cavities.

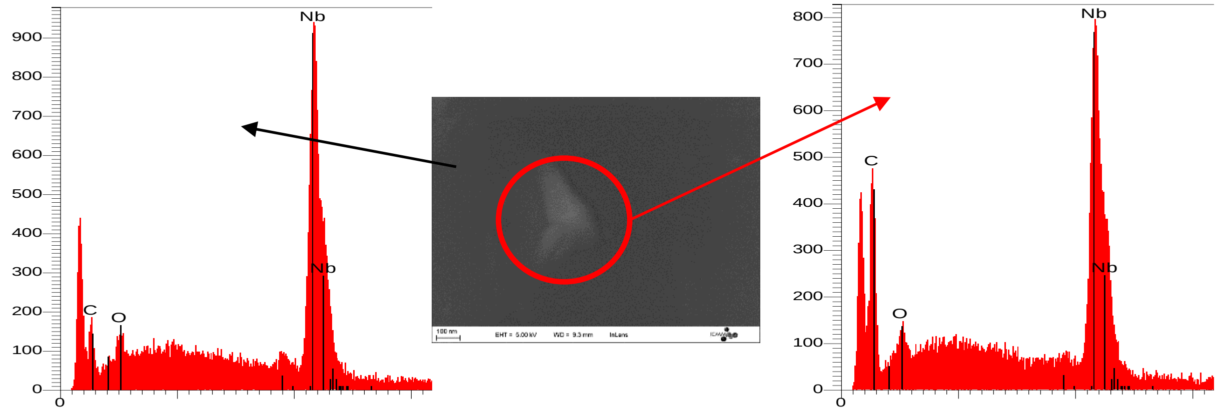




Process: 150°C – 48hr
under 0,025 mbar N_2

- Treated Samples





- Carbon pollution -> improve process

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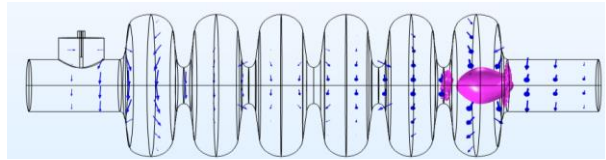
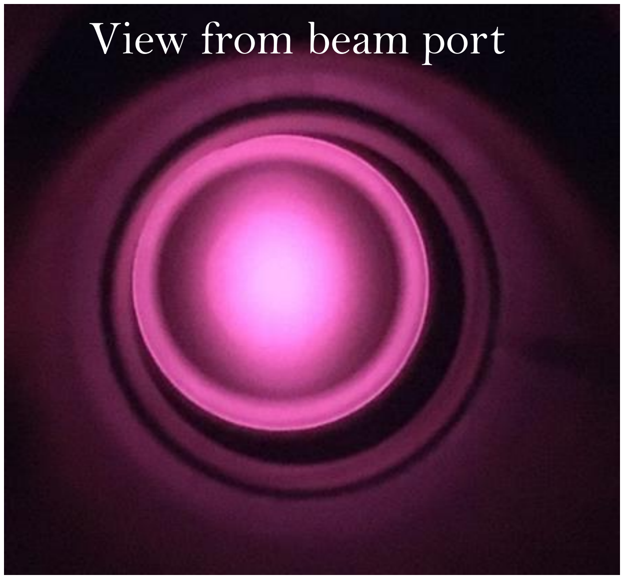
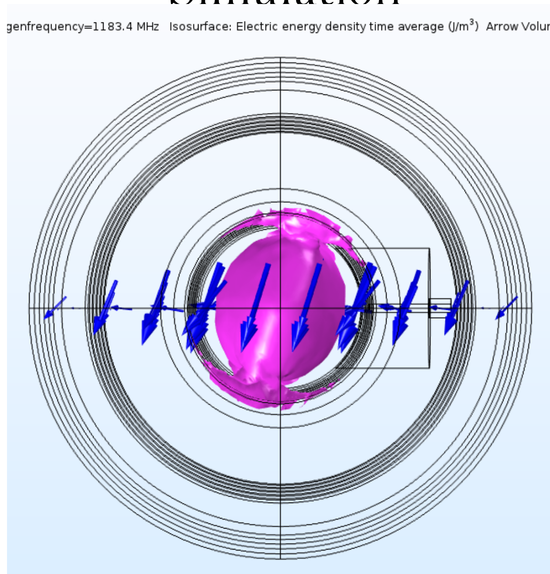
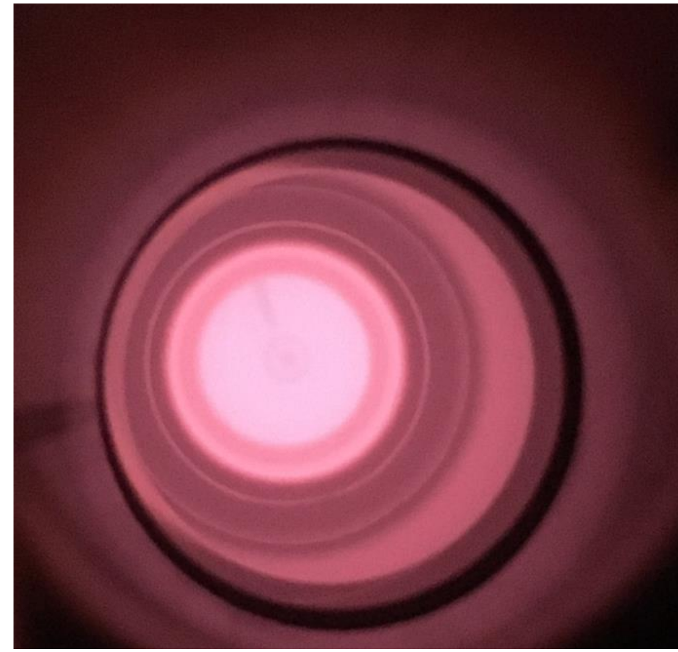


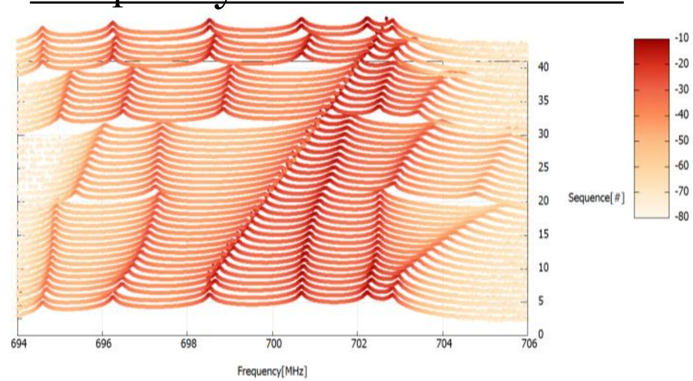
Simulation







Frequency shift due to Plasma



R&D

Research

Niobium oxide manipulation?

Sub-micron particle removal?

Development

Cavity recovery: VT, cryomodule….

Effect on Multipactor and Field emission

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Summary

Characterization:

- Two unique set of characterization tools with predict power for RF cavity tests

- Enable testing recipes/surface treatments/heterostructure on coupons prior to cavity tests
- Faster turner over and phase space exploration of growth parameters etc…
- Measurement of Nb3Sn sample from FNAL

Thin film growth:

- Set up ready to deposit on coupons, 3 and 1,3 GHz cavities

- Study influence of thin dielectric films on Nb oxide/Nb interface
- Post annealing capalities for samples and cavities

Plasma Processing:

- Successful Ar and air plasma lightning in ESS cavity and controled location in cells.

Characterization:

- Faraday Cage to improve noise (ordered).
- Measure of infusion in bulk Nb and Nb_3Sn thin films from DESY, Jlab, STFC.

Thin film growth:

- Pursue ALD deposition on cavities and coupons of dielectrics layer/optimize performances.
- Optimization of Nitrides electronic properties on Coupons.
- Construction of the Oven ALD system for high temperature deposition (Oven call fro tender Issued and offer received).
- Deposition of multilayers on cavities.

Plasma Processing:

- Optimize plasma homogeneity in multicells and mono-cell.
- Oxide engineering (H_2-N_2 etc…)
- Future synergy with vapor phase deposition techniques

Funding Sources

Région Île-de-France ⟹ Faraday Cage, SRF cavities, MEB

ARIES ⟹ Building ALD deposition system

CEA ⟹
- Building ALD deposition system for cavities
- RF tests
- Technical support
- Cobotization

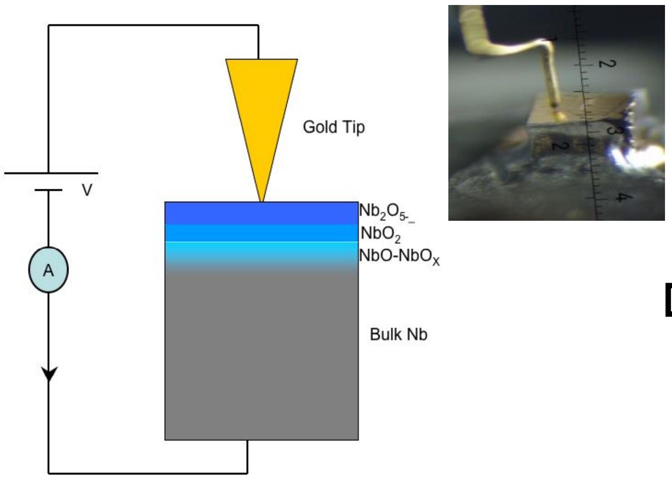
Irfu ⟹ Support for Ph.D. Student and Postdoctorant

Toshiko Yuasa Laboratory (France-Japan Particle Physics) ⟹ Support travels, shipping (3 GHz)

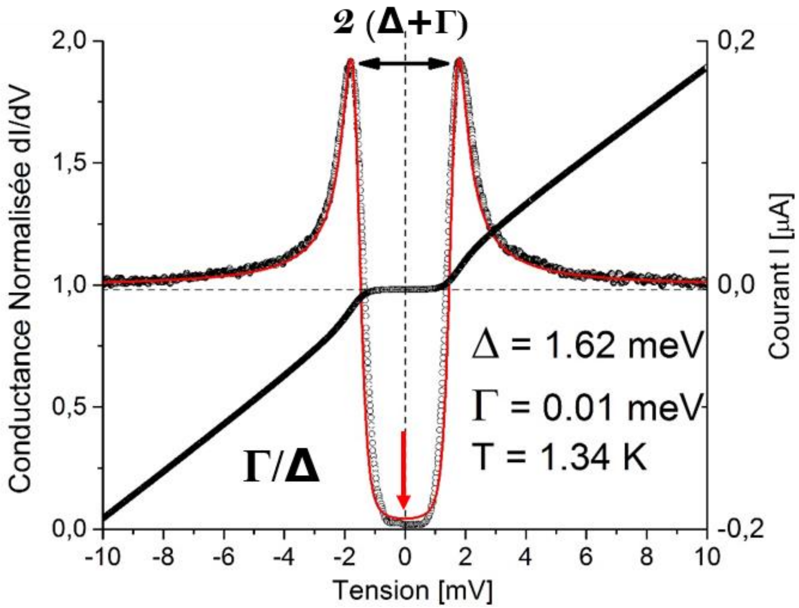
Thanks you

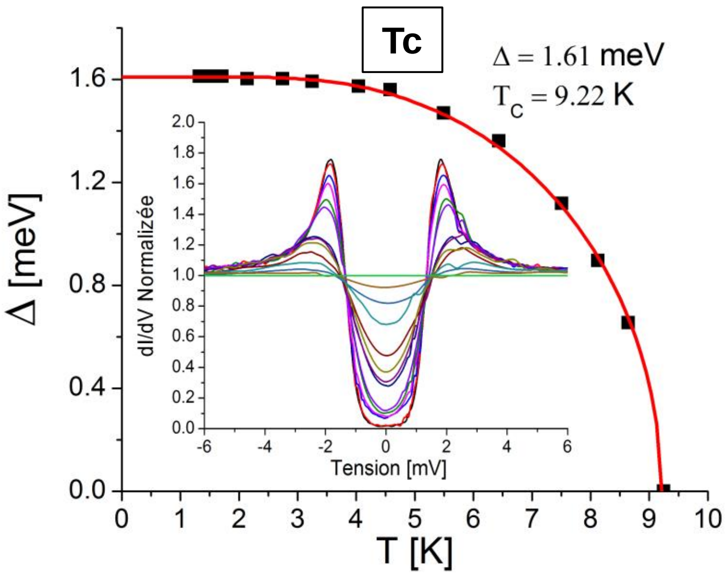
The END

principle



measure





- Measure the fundamental superconducting parameters: Δ, T_C, H_{C2}
- Measure non-ideal signature: Γ.
- All of these are directly correlated to SRF cavity performances
- Cartography