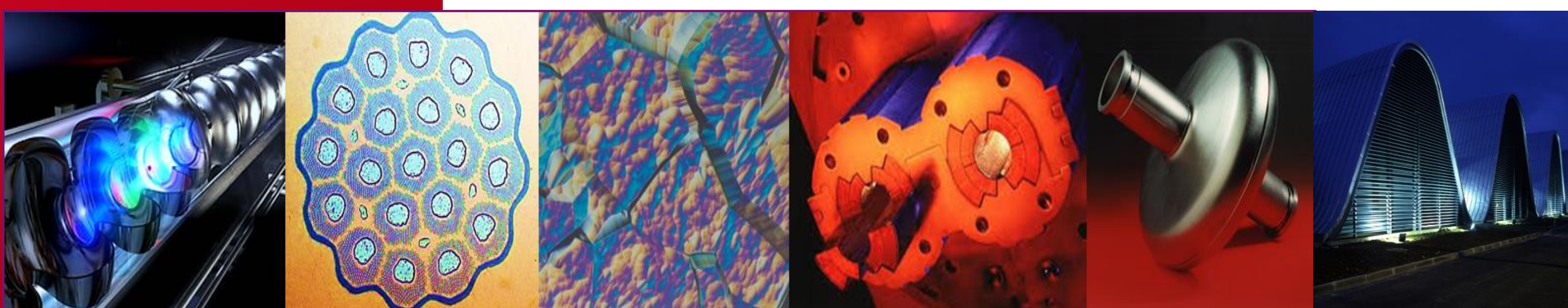
DE LA RECHERCHE À L'INDUSTRIE

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, Nb_3Sn)
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, Nb_3Sn)
ANL: A. Glatz – Theory (theory simulations)
IIT: J. Zasadzinski
TRIUMPH: T. Junginger (characterization)
Cornell: M. Liepe (Nb_3Sn)

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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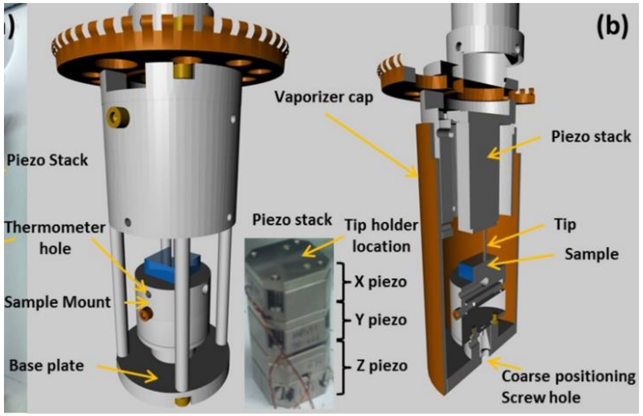
Unique characterization tools at CEA

PCTS

Measure surface superconductivity

Parameters: Δ, T_C, Γ

Cavity: Q0, Q-slope, *Emax*



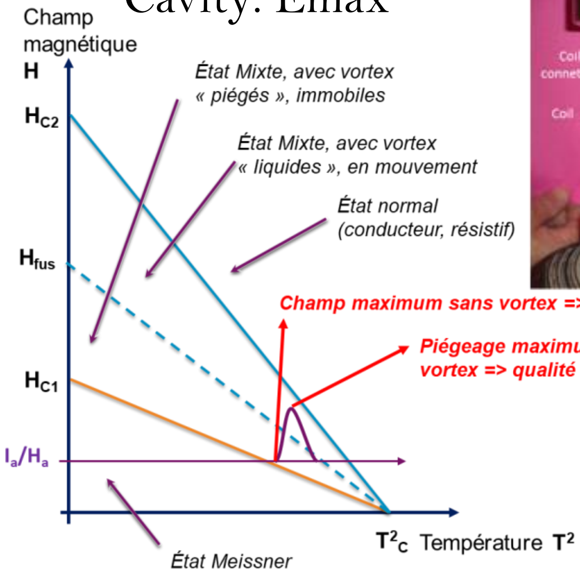
- Temp: 1,4 K – Magnetic field: 6 T
- Cartography: 10 µm – 1 mm
- Fast measurements: 100-300 jonctions/5hrs
- Sample size: 10x10 mm

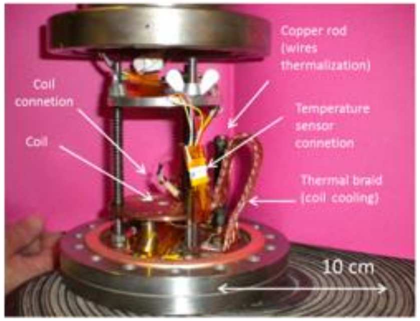
Magnetometry

Measure critical penetration field

Parameters: H_{SH}

Cavity: Emax





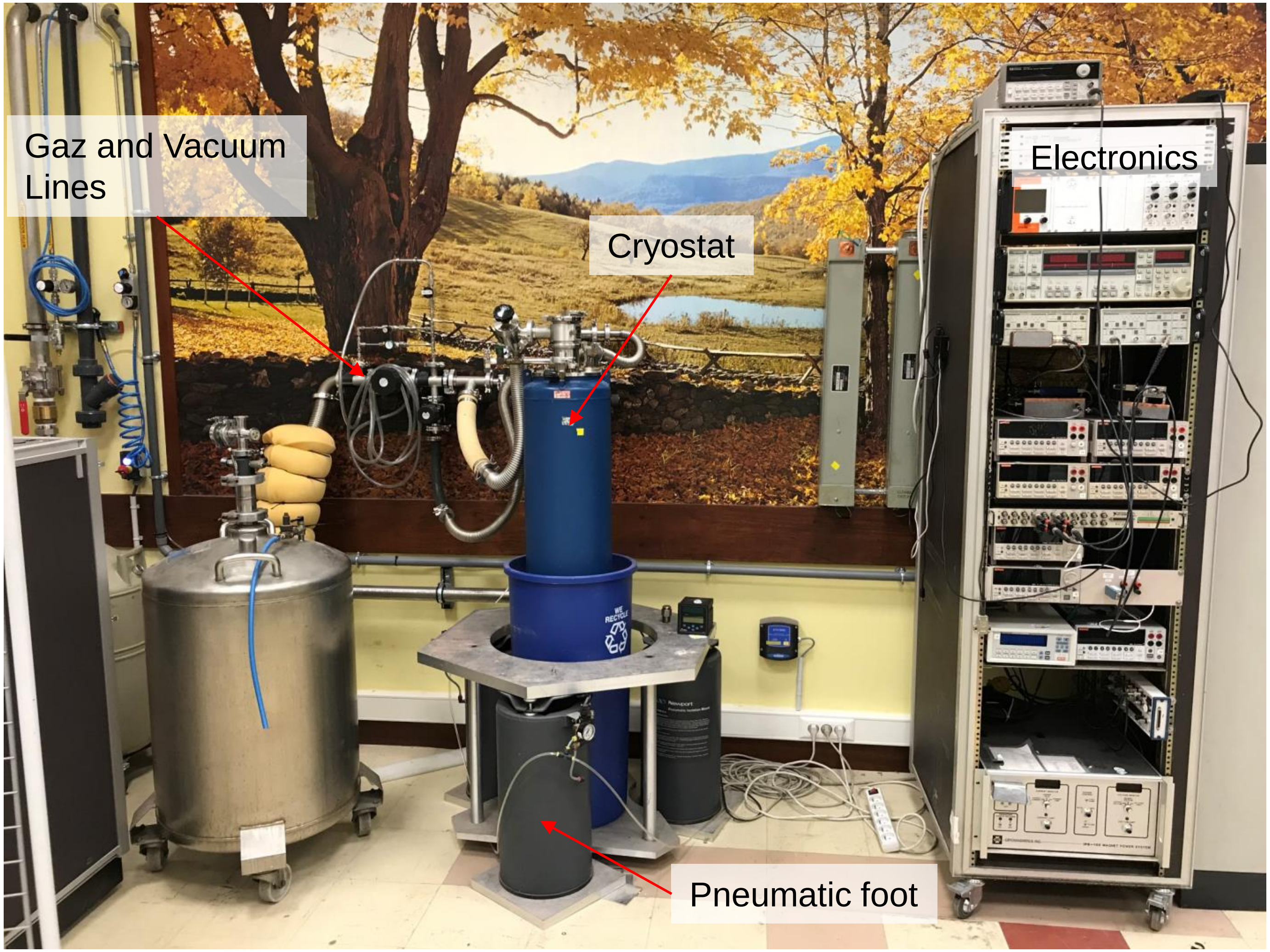
- Temp: from 4,2 to 300K
- External magnetic field: up to 130 mT
- Sample size: Ø ≥ 30 mm

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
- Magnetic field: 6 T
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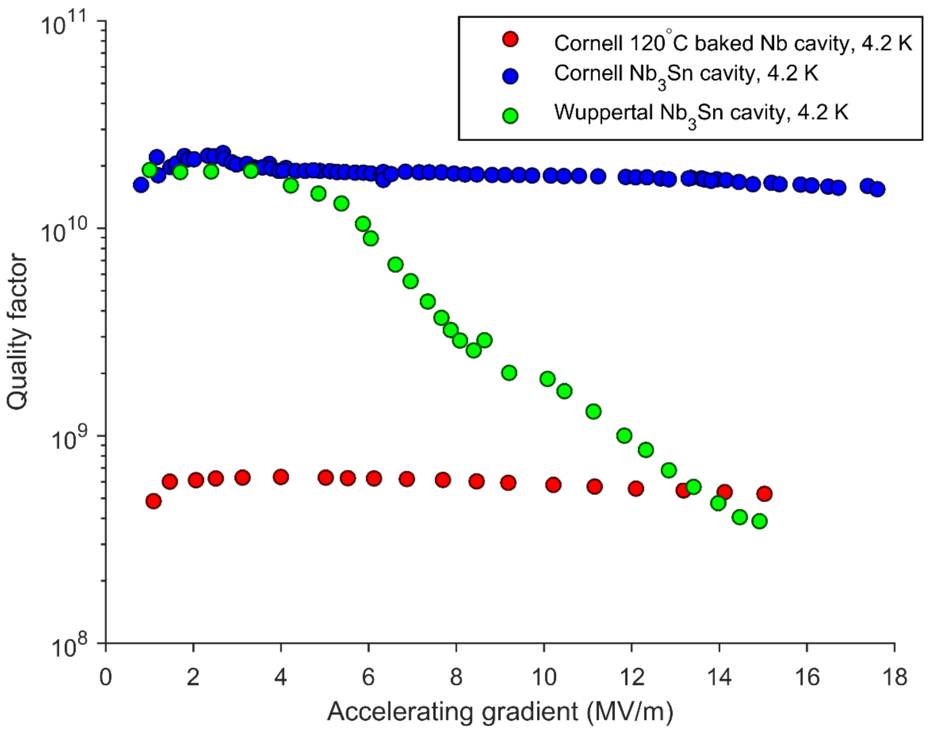
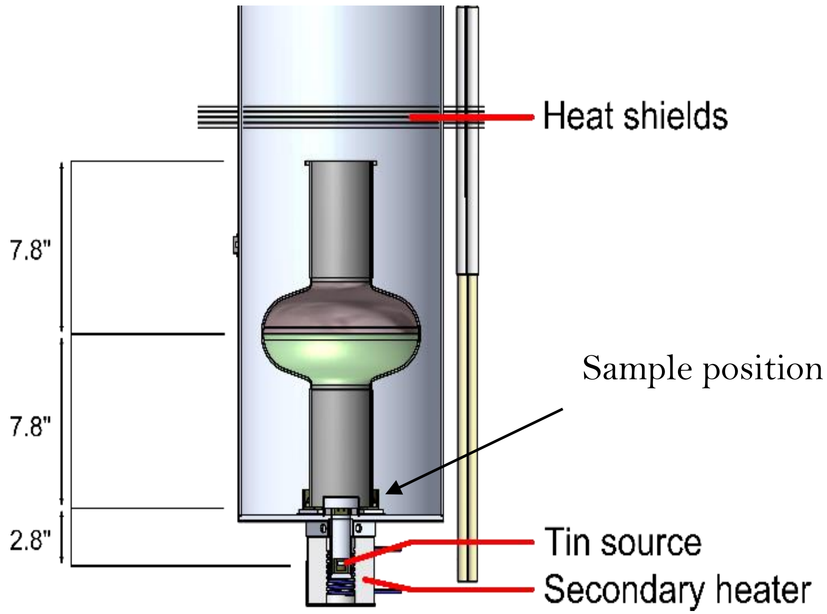
Nb_3Sn/Nb (Cornell-FNAL)



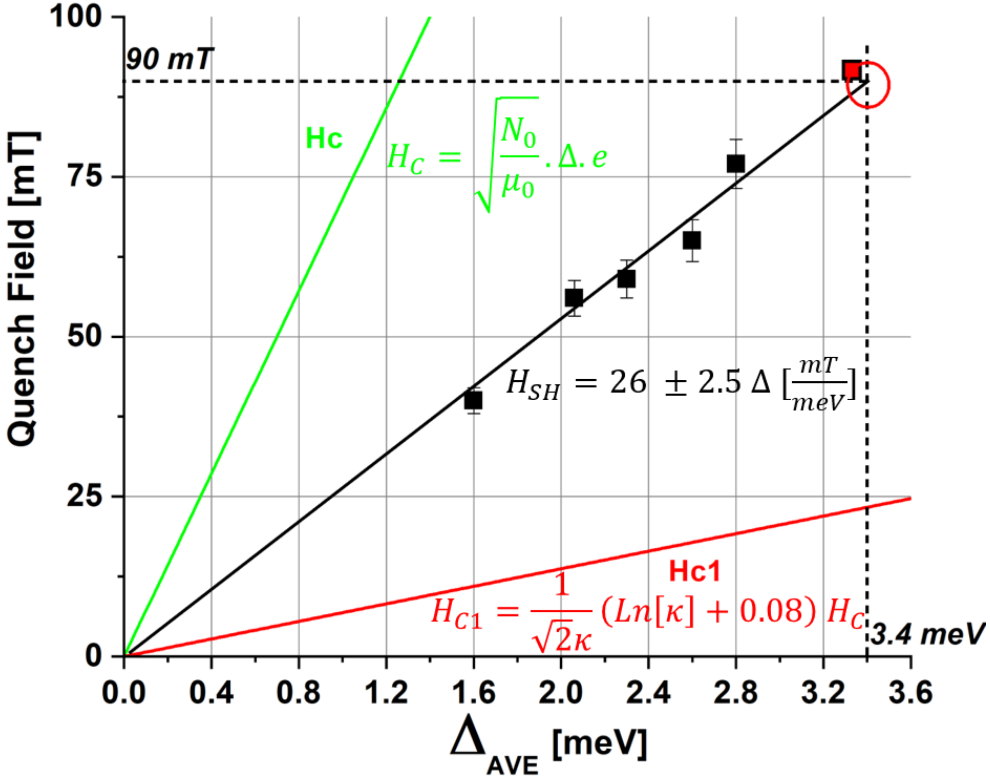


- Wupperthal method: diffusion of Sn in a Nb cavity
- Nb_3Sn Q_0 at 4,2K ~ Nb Q_0 at 2K
- Moderate increase of Q_0 between 4K to 2K -> Non-BCS
- Q_0 decrease at ~ 6K

Have we reached the limits of Nb_3Sn ?

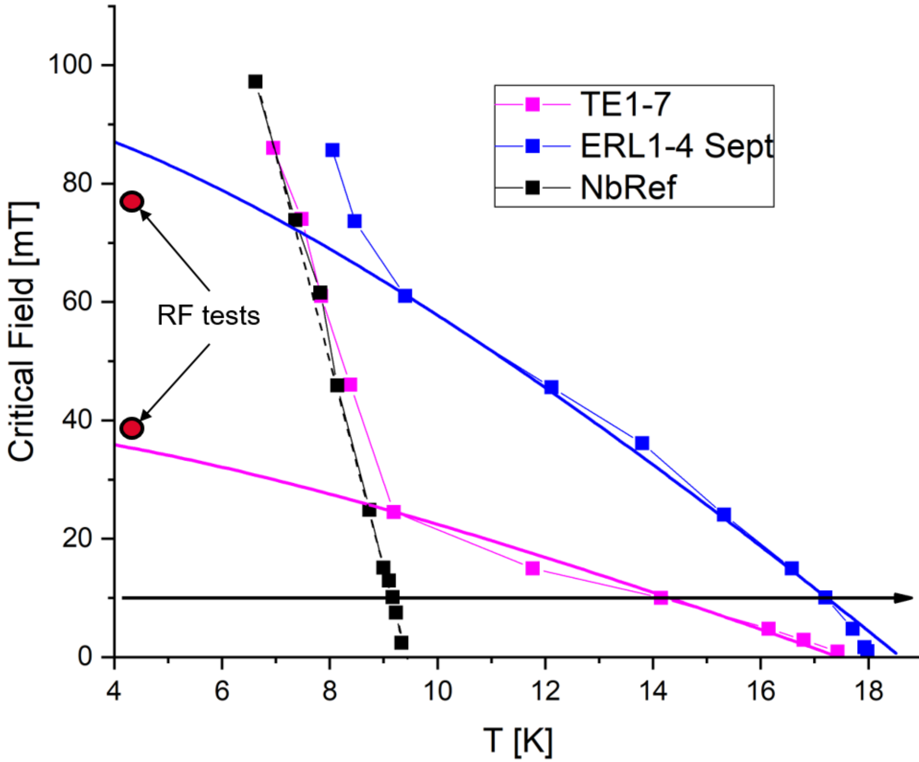
PCTS

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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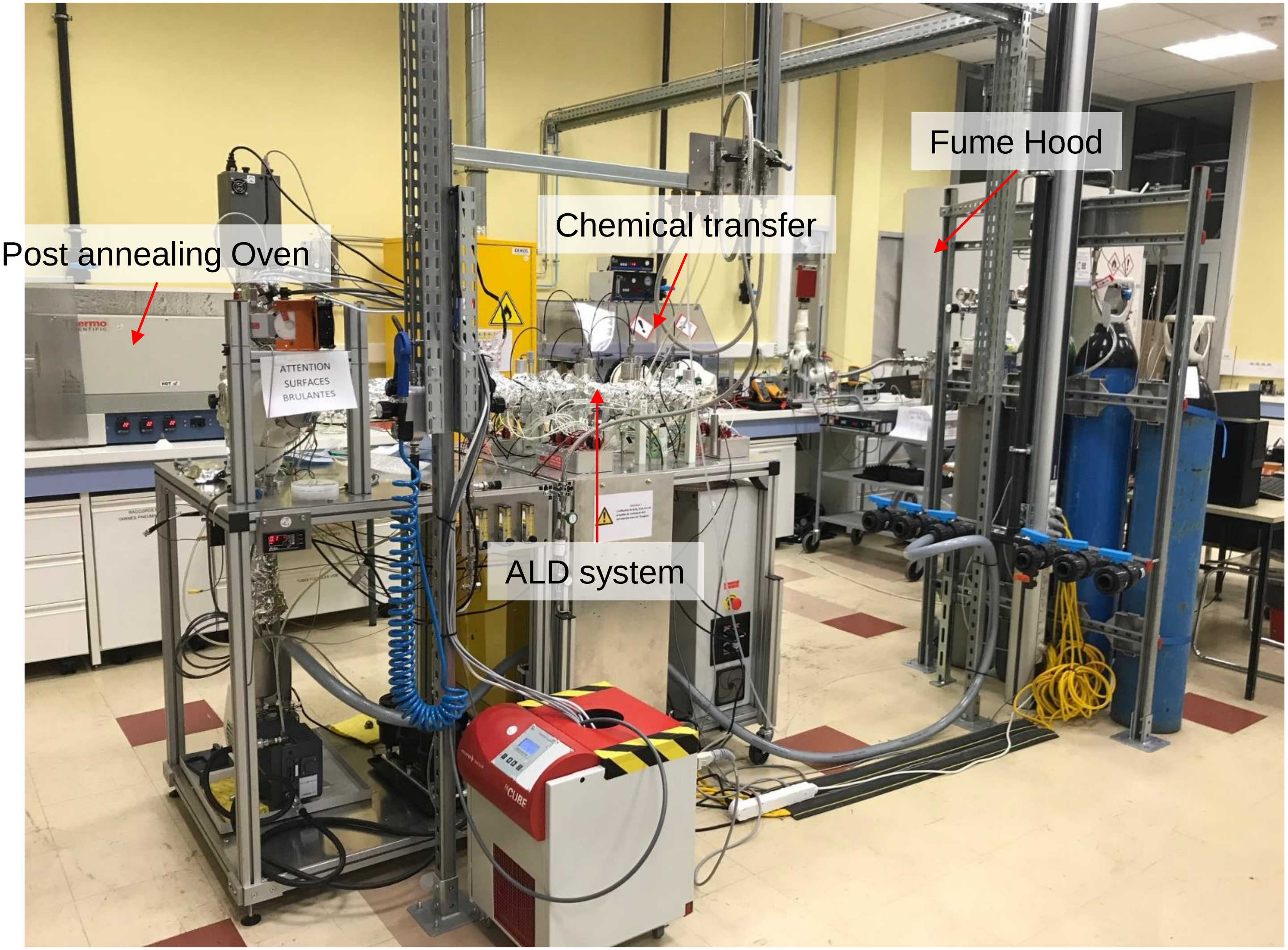
Thin films developements at CEA

Set up of the ALD laboratory

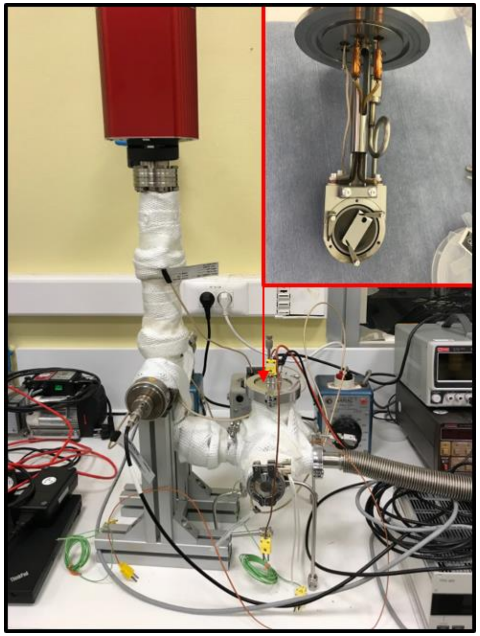


- 7 chemical precursors
- Temperature up to 500°C
- RGA and QCM in-situ monitoring
- Design to fit 3 and 1,3 GHz cavities
- Fully automated
- Deposition homogeneity < 1%

Thin films developements at CEA

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

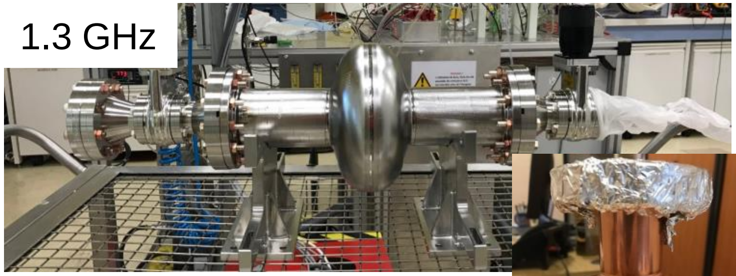
Annealing



- 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

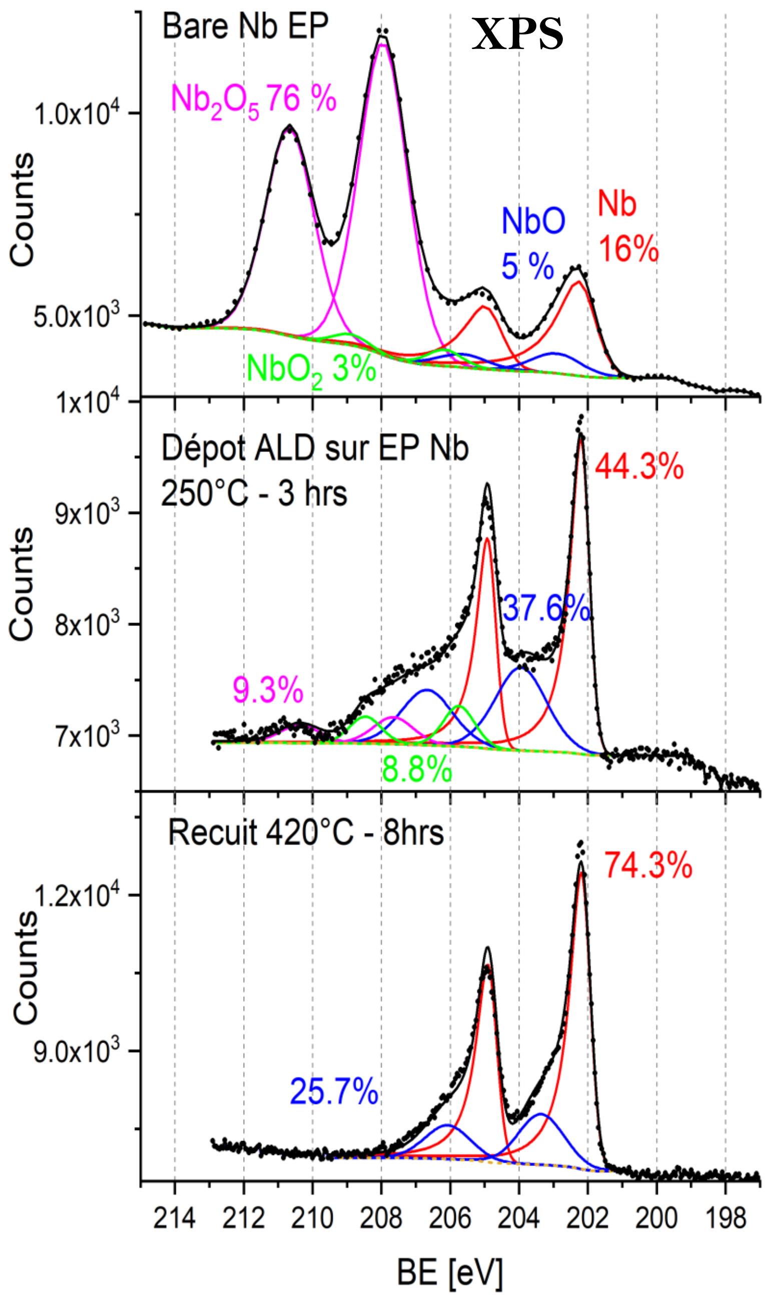


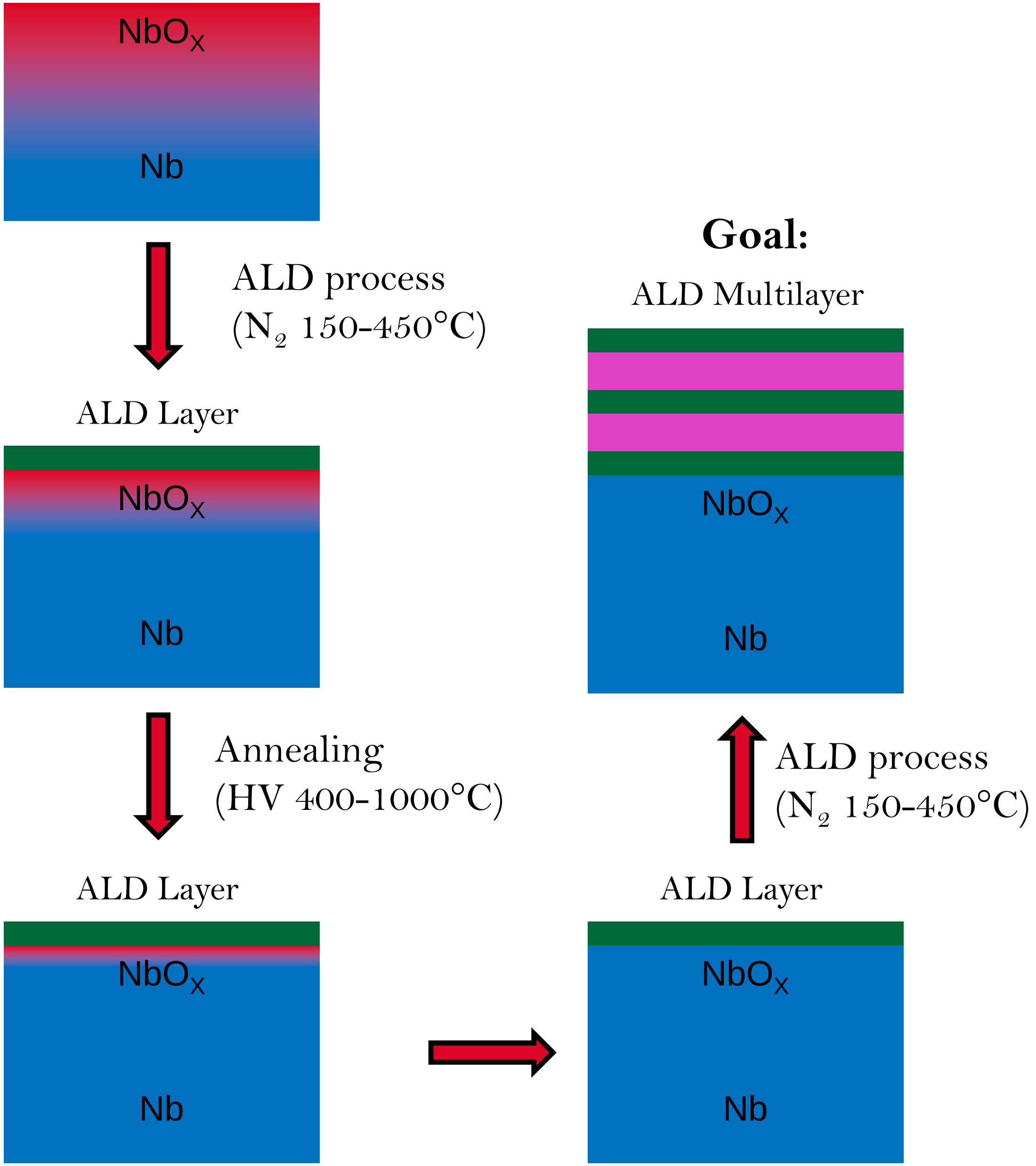
3 GHz

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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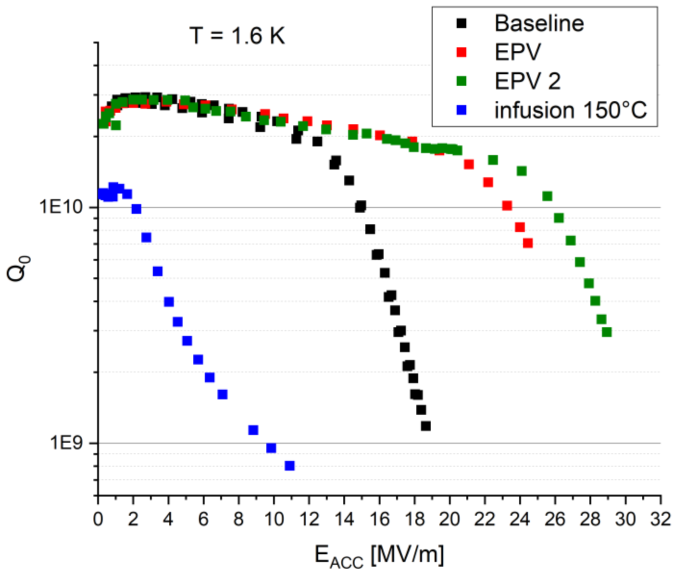
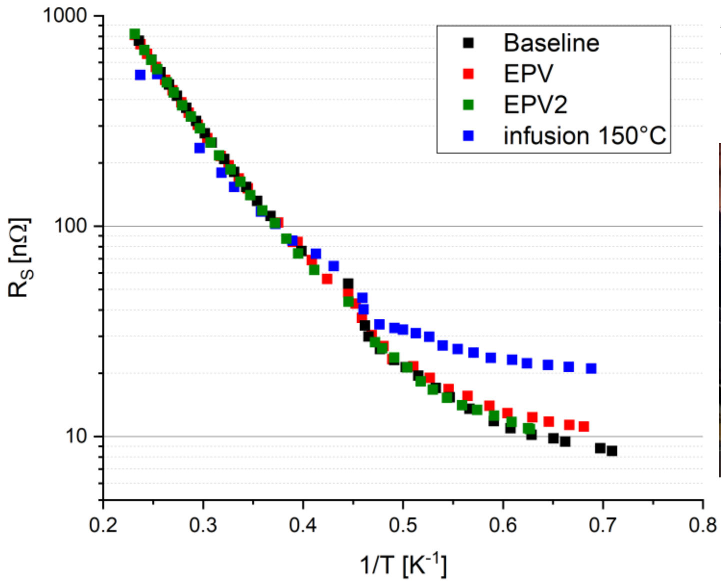
Bulk Nb Infusion – (IPNO/CEA)

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

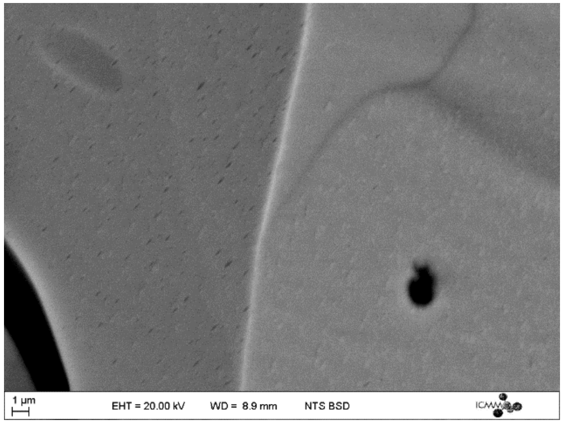


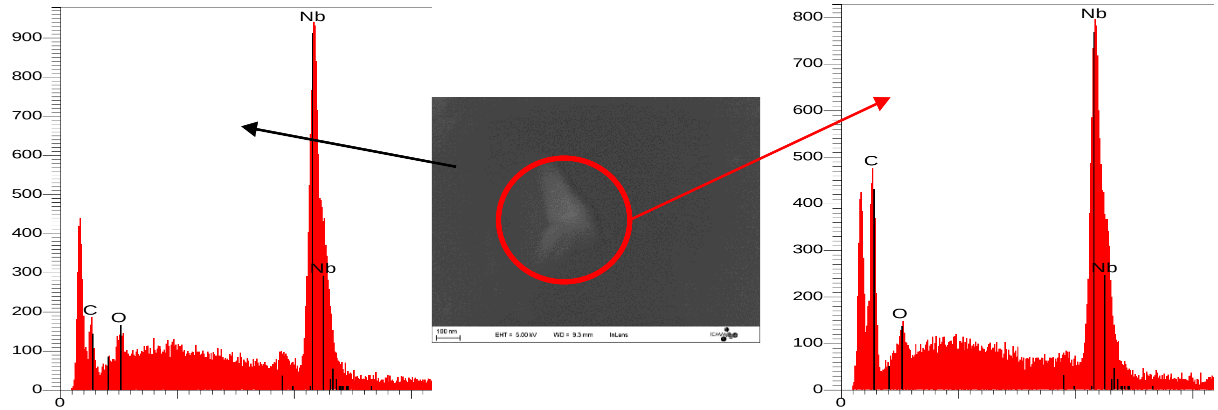


Process: 150°C – 48hr

under 0,025 mbar N_2

- Treated Samples





- Carbon pollution -> improve process

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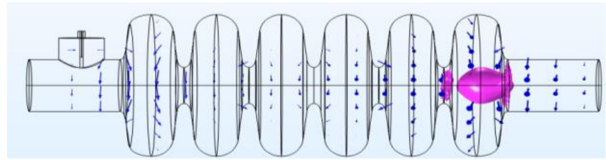
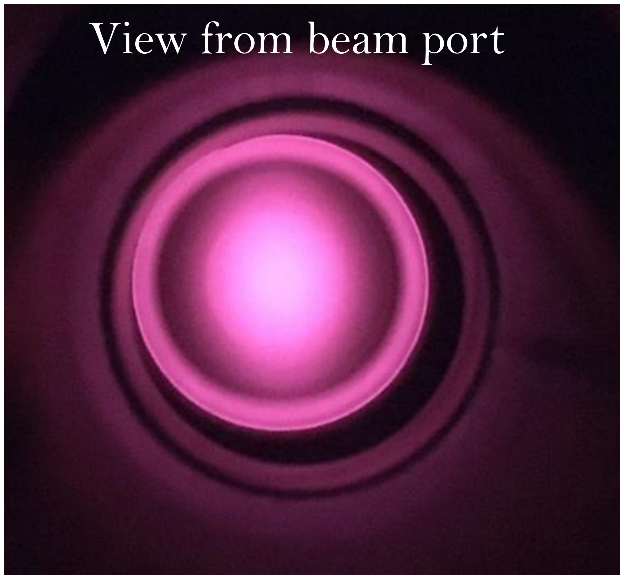
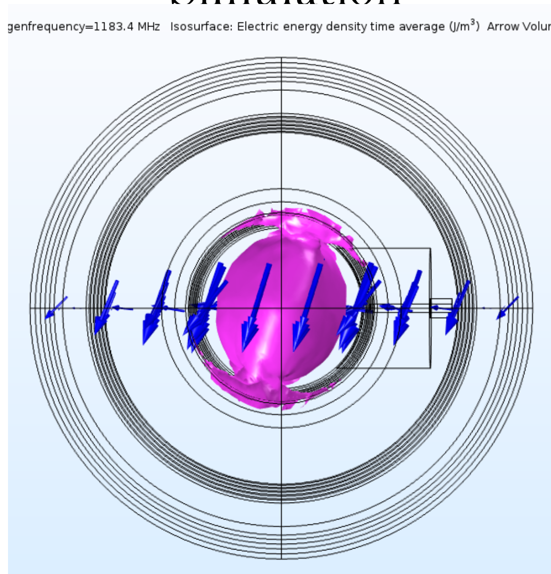
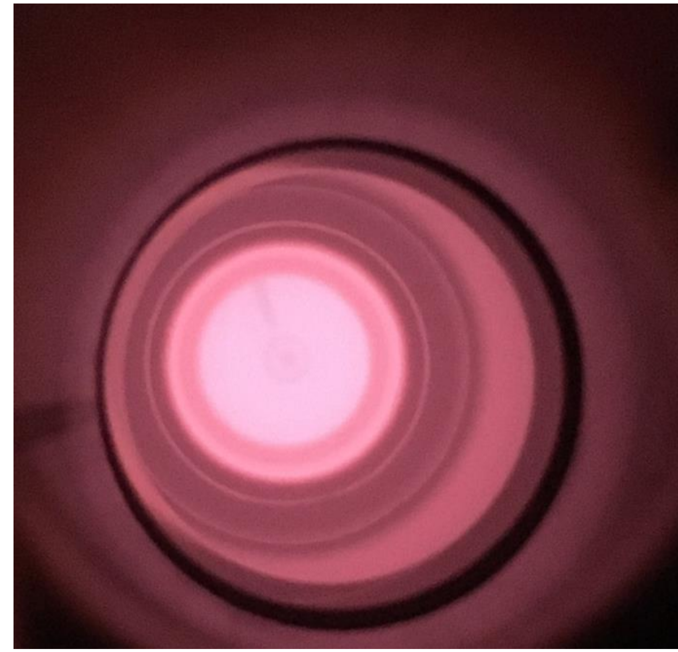
Plasma Processing



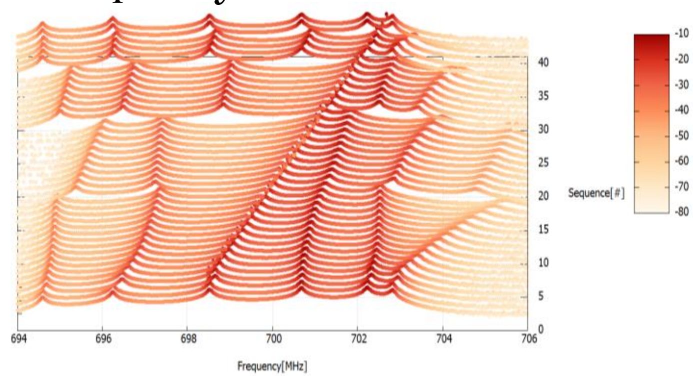
Simulation







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 Nb_3Sn 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.

Future

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

Faraday Cage, SRF cavities, MEB

Building ALD deposition system

Building ALD deposition system for cavities
RF tests
Technical support
Cobotization

Support for Ph.D. Student and Postdoctorant

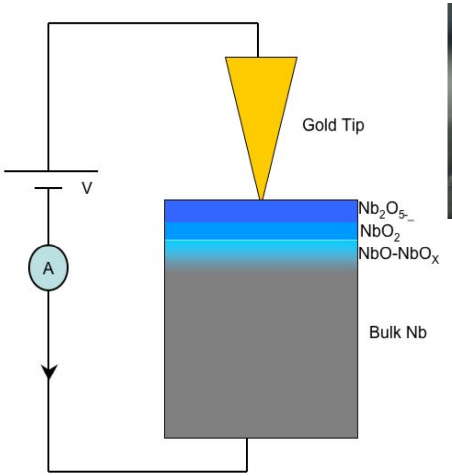
Support travels, shipping (3 GHz)

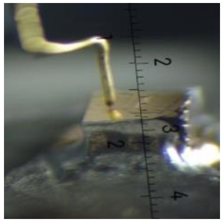
Thanks you

The END

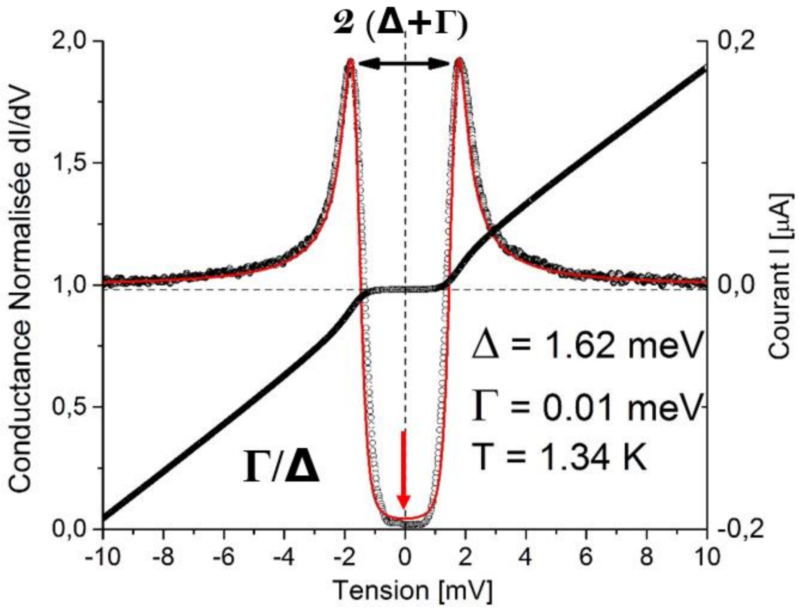
Tunneling spectroscopy: what do we measure and why?

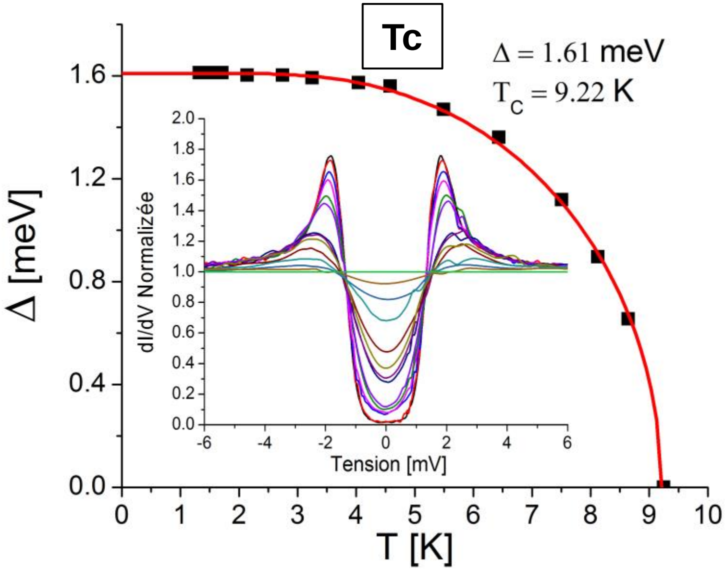
principle





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