CERN

SRF thin films @ CERN

TE/VSC/SCC
Alban Sublet

23.06.2015 - CERN-LNL-STFC collaboration kickoff meeting

Technical challenges

→ “Thin films & new ideas for SRF” workshop LNL’14

Miguel:

- 2018 end of run 2, start of LS2

  → run 2 physics results will define what’s needed for the future
- Cavities: bulk Nb not in-line with optimization, cost, raw material availability, need alternative for large scale projects (FCC)

→ THIN FILM technology must be mature for 2018

→ **2.5 years** to get to this level: get closer to bulk Nb RF-properties (Q0 + high accelerating gradients)

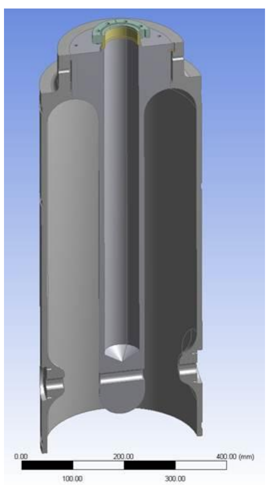
Erk:

- FCC: “The design study shall be organised on a world-wide international collaboration basis under the auspices of the European Committee for Future Accelerators (ECFA) and shall be available in time for the next update of the European Strategy for Particle Physics, foreseen by 2018.”

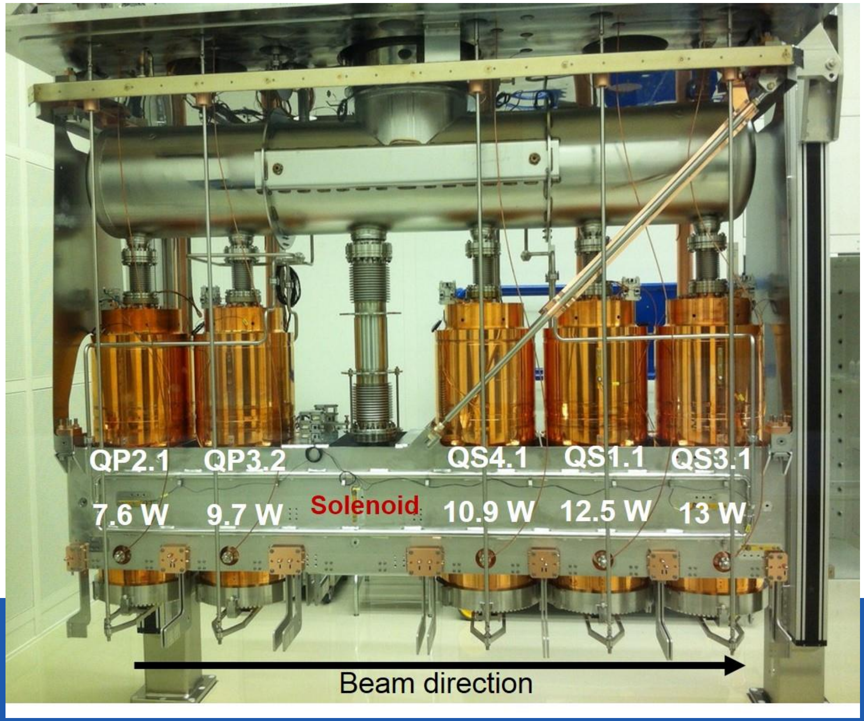
→ Must start studying now to be ready for 2035/2040

SRF thin films production activities I/II

- HIE-ISOLDE QWR 100 MHz
  - 1 test cavity with sample holder + QPR sample
  - 20 “high-β” cavities (phase 1 + 2) → on going
  - 12 “low-β” cavities (phase 3) → to be approved

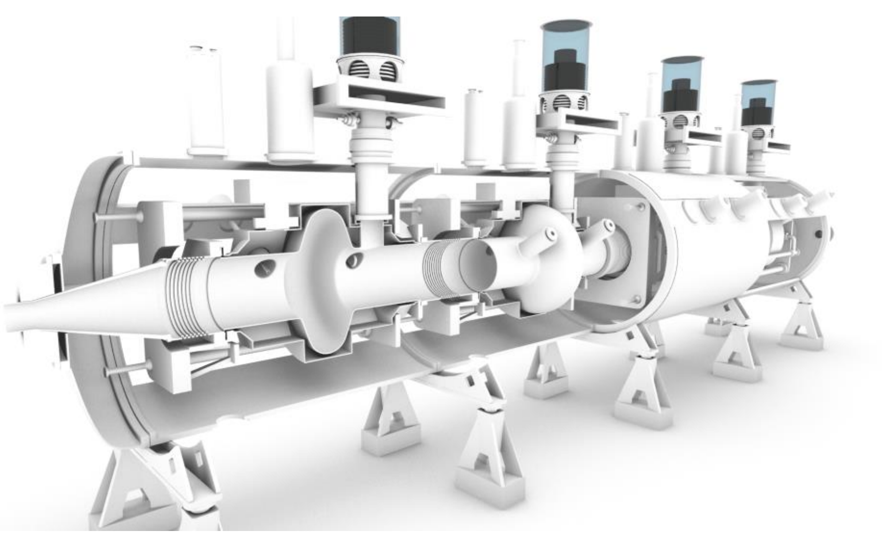


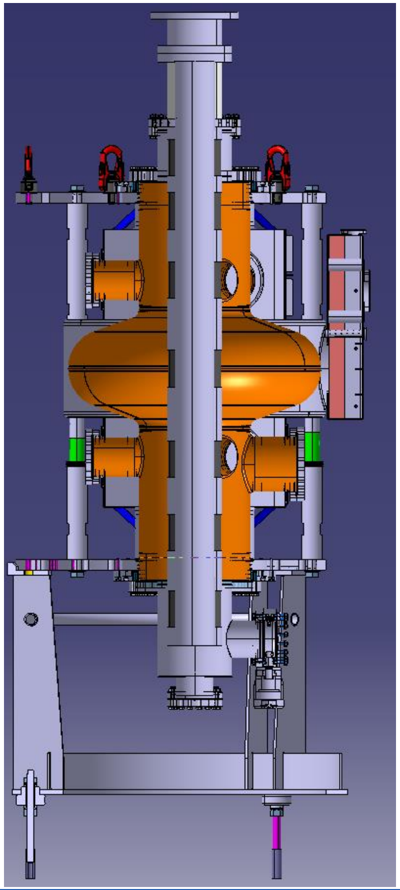
→ First cryomodule under commissioning
→ Coating of cavities for second cryomodule on the way
→ R&D continuing



SRF thin films production activities II/II

- LHC single cell 400 MHz spare cavities
  - Test tube to asses coating setup
  - 2 prototypes → fabrication on going
  - 1 full cryomodule + spares

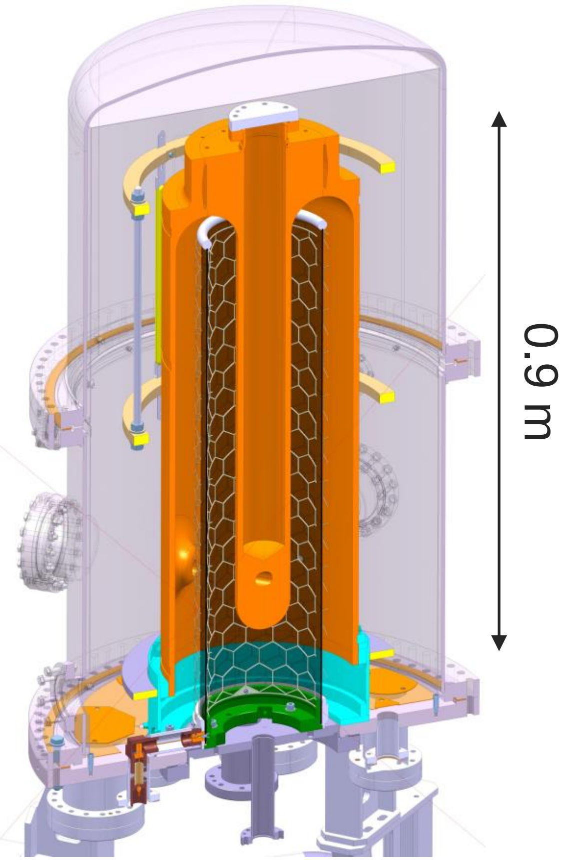




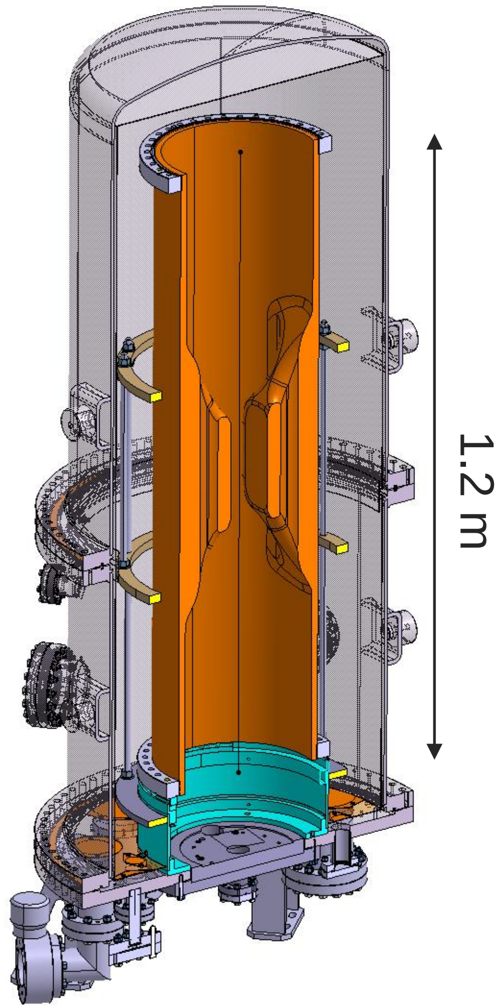
SRF thin films R&D: drivers I/II

- HIE-ISOLDE high/low-β (100 MHz)
- HL-LHC Crab Nb/Cu (400 MHz)
- LHC upgrade/ERL/FCC (800 MHz)
- FCC (400/800 MHz)

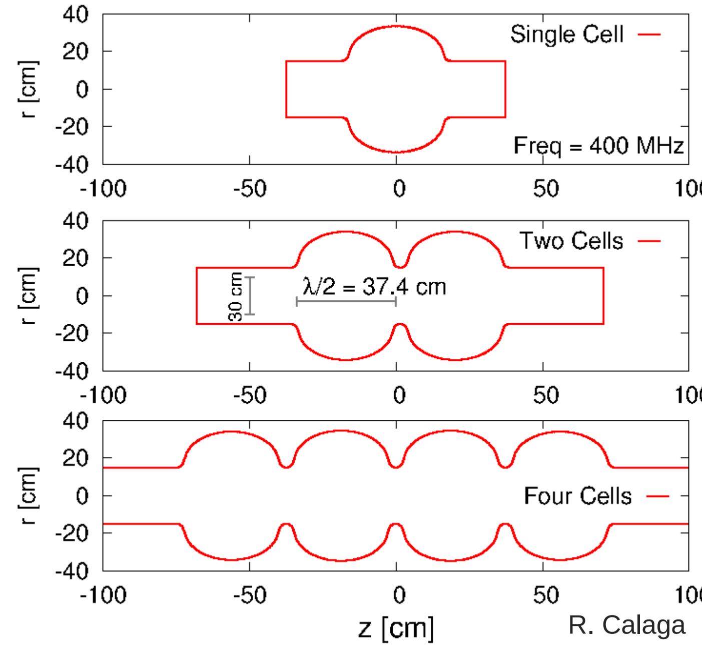
SRF thin films R&D: drivers II/II



QWR (HIE-ISOLDE)

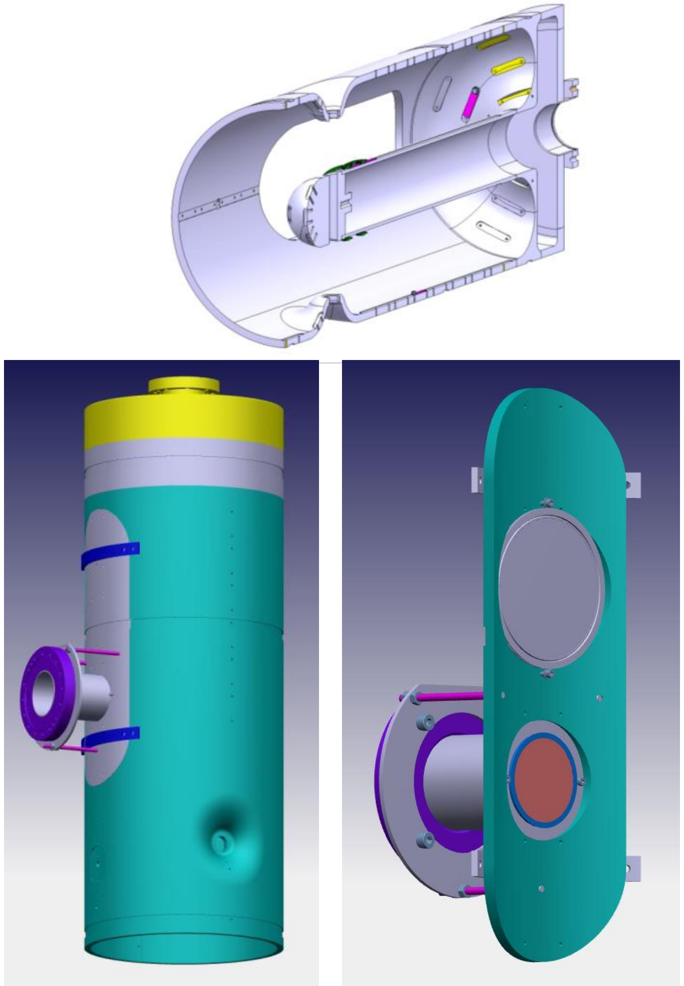


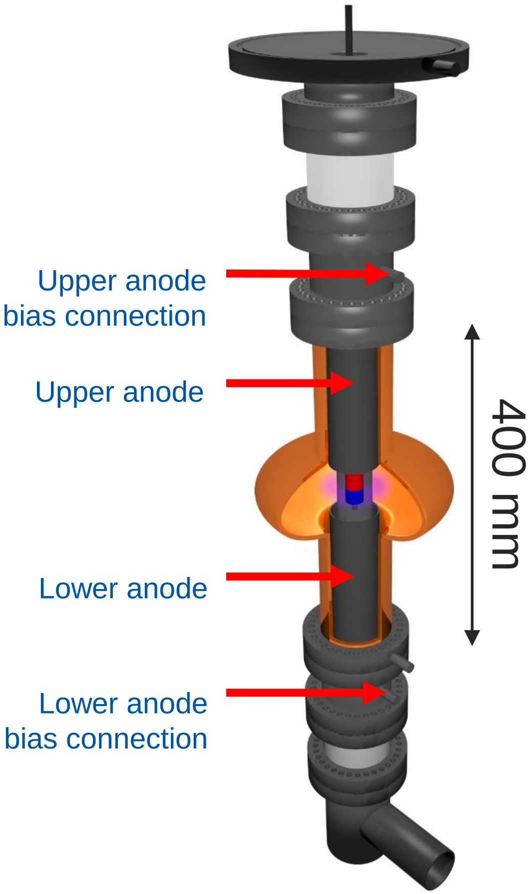
WOW Crab Nb/Cu (HL-LHC)



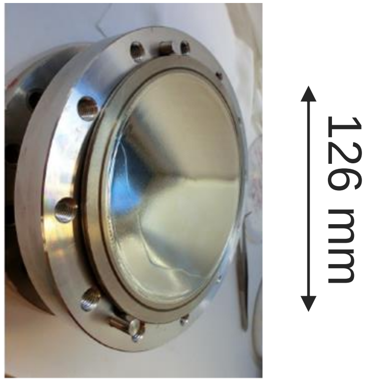
elliptical x-cell(s) (FCC)

SRF thin films R&D: test substrates

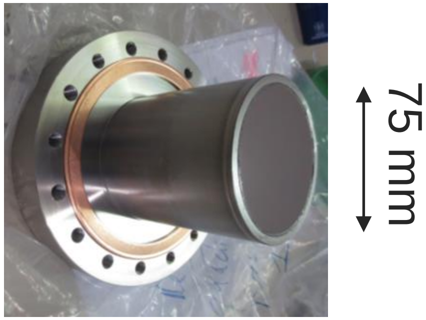

Q4 sample cavity (HIE-ISOLDE)



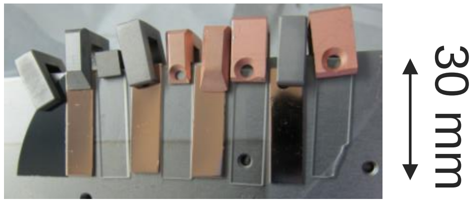
elliptical 1.3 GHz



Orsay Cu-disk



QPR-sample



Si-wafer/quartz/Cu coupons

SRF thin films R&D: functionality characterization

Basic studies:

- RRR on quartz sample → CERN
- Point Contact Tunneling (PCT) → ANL
- Muon Spin rotation (μ-SR) → PSI/TRIUMF
- Third harmonic magnetometer → Saclay

RF characterization:

- TE011 test cavity for Cu-disk → Orsay
- RF Quadrupole Resonator test → CERN
- RF test on 1.3 GHz cavity (cryolab) → CERN
- RF test on cavities (SM18) → CERN

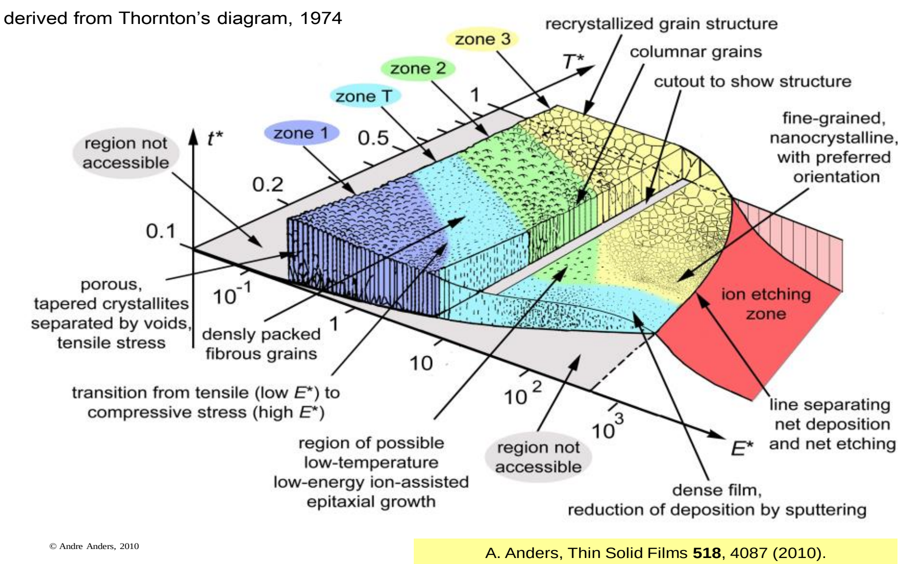
SRF thin films R&D: topics

- Coating technics
- SC Material
- Material/thin film analysis
- Plasma diagnostics and plasma simulation

SRF thin films R&D: coating technics

- → DC bias diode sputtering, production level
- → DC magnetron Sputtering, production level
- → HiPIMS (+bias), development level

- → Cathode design/shape
- → Biasing, grid design
- → Heat treatment
- → substrate temperature
- → Nitrogen treatments

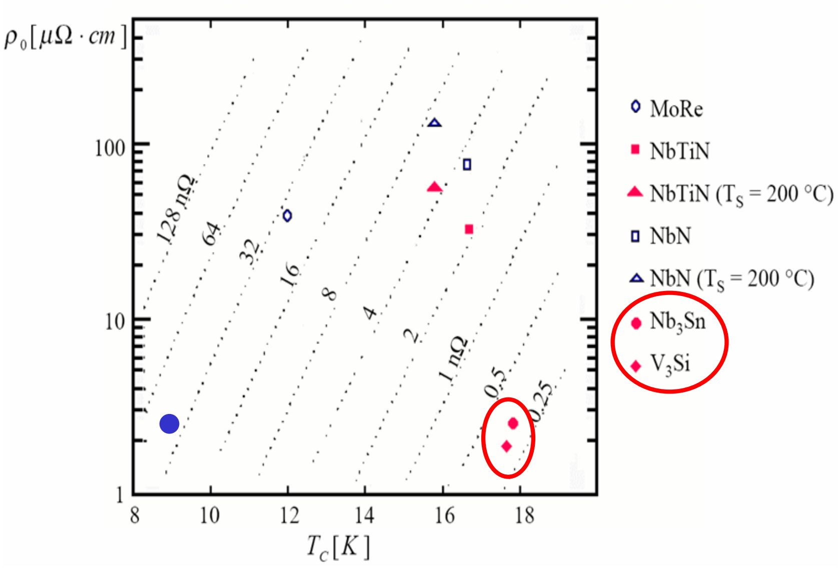


A. Anders, Thin Solid Films **518**, 4087 (2010).

SRF thin films R&D: SC material

→ Niobium

→ A15 compounds: Nb3Sn (and V3Si)



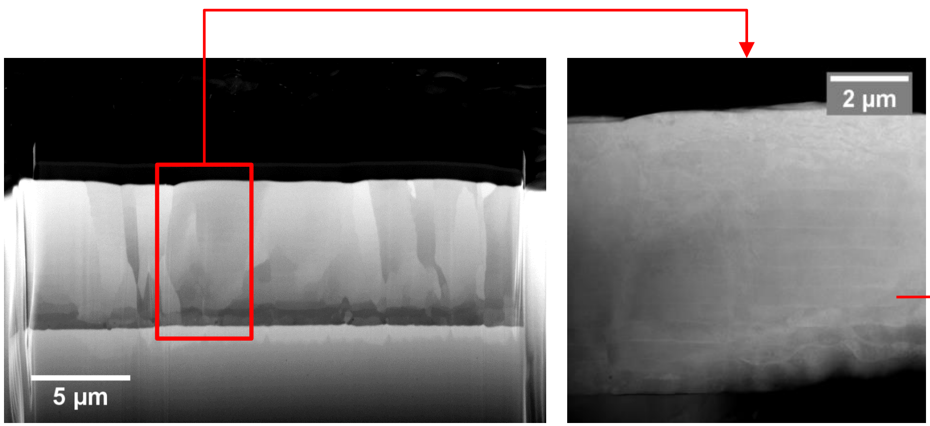
BCS surface resistance at 4.2 K
and 500 MHz for films (● Nb ~ 45 nΩ)

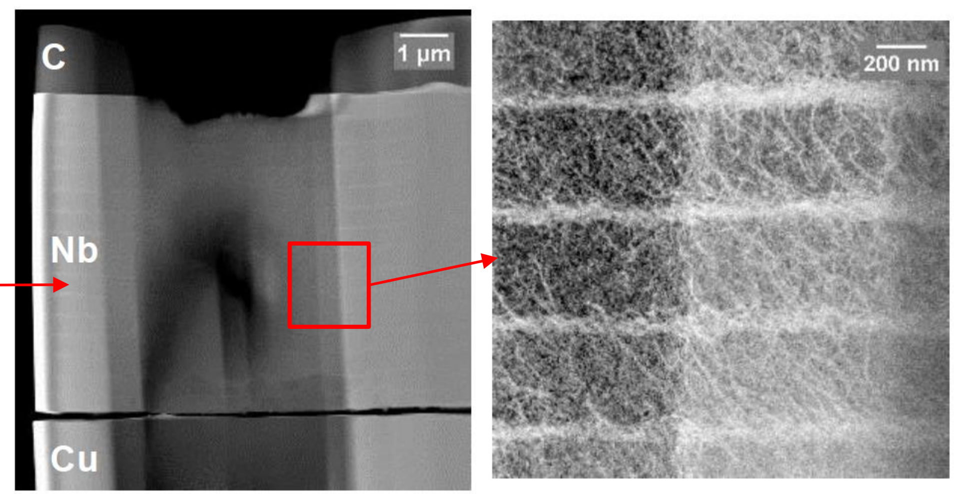
Planar magnetron Nb3Sn target sputtering

SRF thin films R&D: material/thin film analysis

→ XRF, XPS, XRD (CERN), SIMS, …

→ SEM/EDS – FIB/SEM, STEM/TEM (CERN/EPFL)



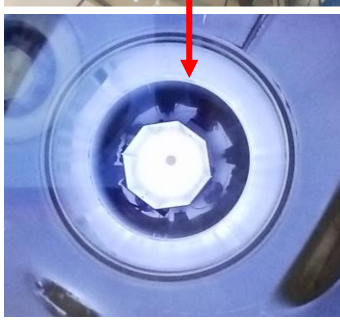


HIE-ISOLDE
Q4 sample from middle antenna
Nb/Cu, 14 runs coating

Courtesy B. Bartova and EPFL-CIME

SRF thin films R&D topics: plasma diagnostics

Plasma test bench



Bottom view of plasma

→current/voltage probes
→Retarding Field Analyzer (RFA)
→Quartz balance
→OES
→Langmuir probe

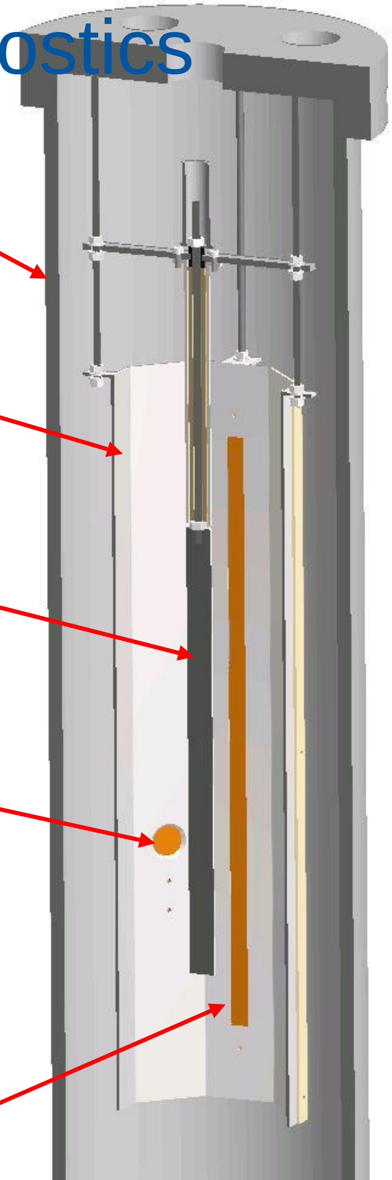
UHV vacuum chamber

anode tube (+bias)

Nb cathode
- DC bias diode
- DCMS
- (HIPIMS)

diagnostic port: RFA, Qz-balance

Cu strip for thickness profile 400 mm height

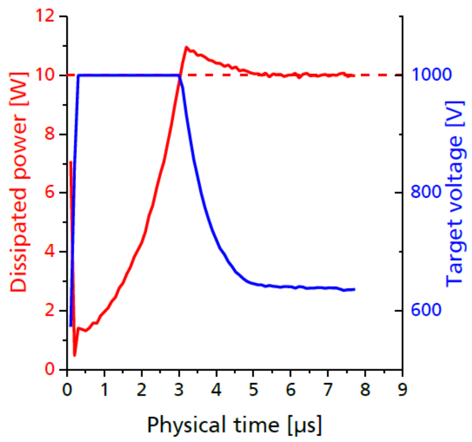


SRF thin films R&D: plasma simulation

DSMC/PIC-MC code

- P = 0.32 mbar (diode discharge)
- Constant wall temperature
- Initial charged particles density = 10^{13} m^{-3}
- Power = 10 W
- Maximum voltage = 1000 V

→ benchmarking with plasma test bench



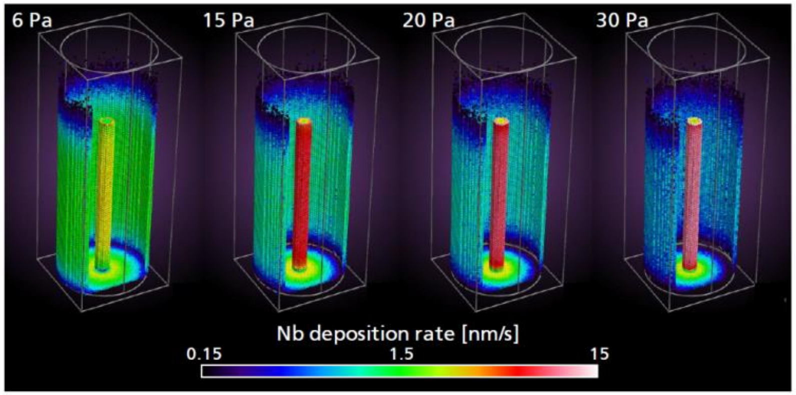
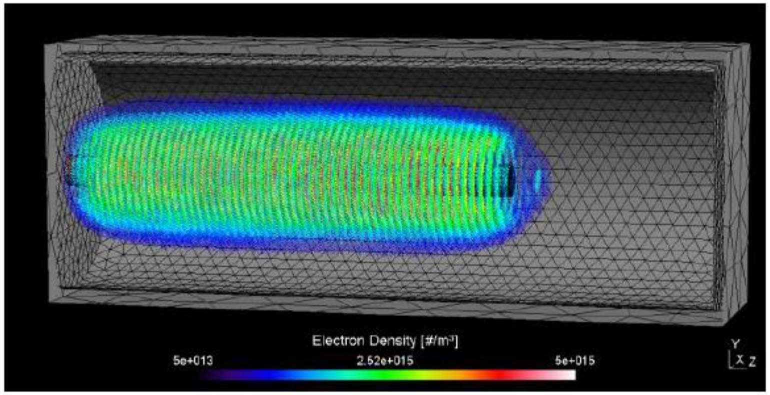


Figure 2: Simulated deposition rate on tube surface and re-deposition on target after 30 ms for different total pressures.



a) Electron density (scaled view) [1/m³]

Thank you for your attention

TE-VSC group