

Thin Film SRF programme in ASTeC

Oleg Malyshev and Reza Valizadeh

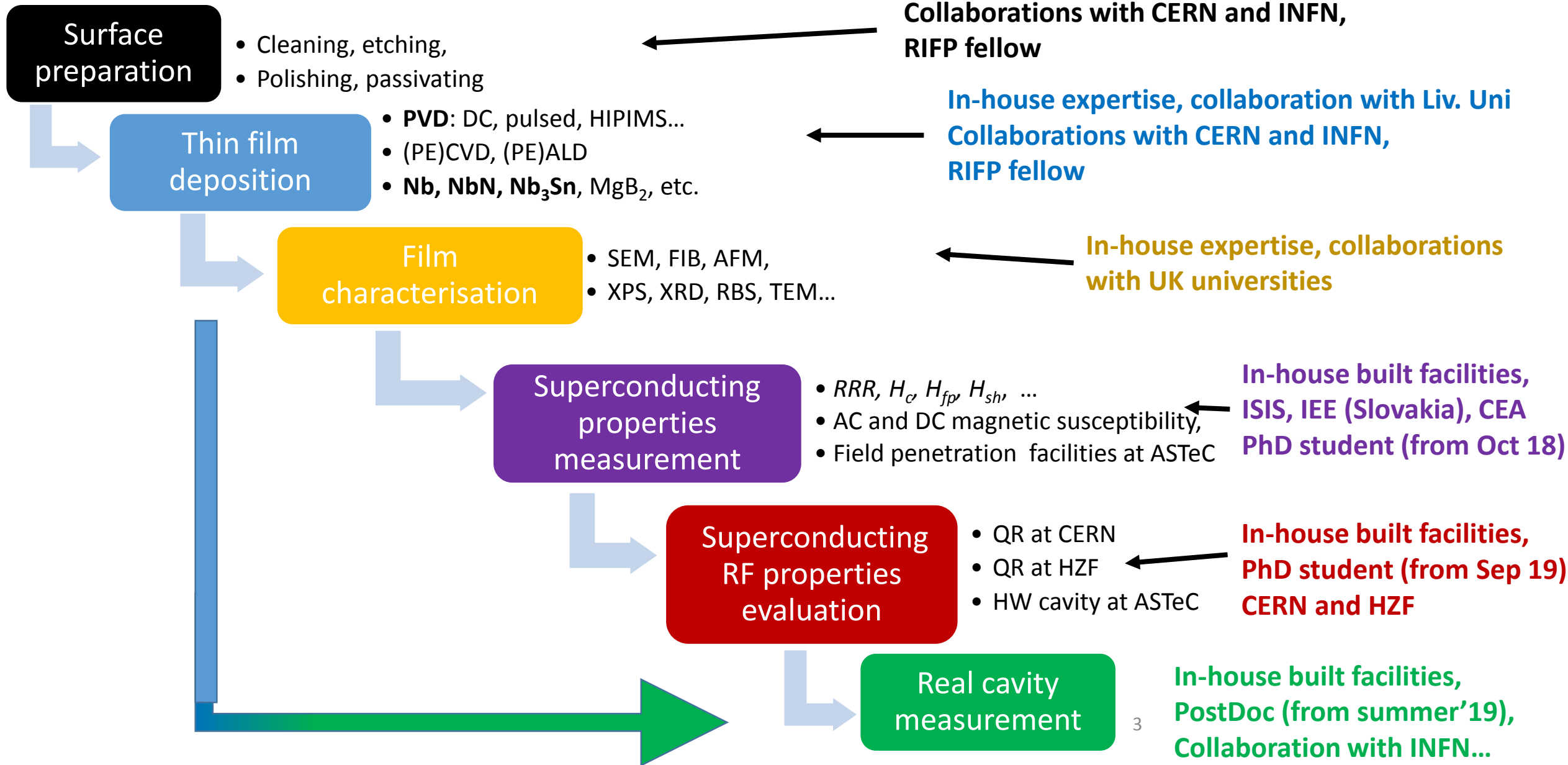
The aim of TF SRF programme

SRF programme at ASTeC started six years ago from no infrastructure and it aims from beginning was to establish know how for depositing SRF thin film in RF (Nb or Copper) and train future engineer and scientist in the SRF discipline.

As part of this program PhD studies were set to:

- Systematic study and develop coating technology of superconducting materials to enable the deposition of superconducting coated RF cavities with characteristics required for future ASTeC accelerator projects.
- The main emphasis was set on a systematic study of **correlation** between
 - surface preparation,
 - deposition parameters,
 - film structure, morphology, chemistry
 - as well as AC and DC superconductivity parameters
 - such as T_c , H_c , H_{fp} , H_{st} , RRR
 - of superconducting material Nb, NbN, Nb₃Sn, NbTiN, MgB₂, etc.
 - deposited on Cu and bulk Nb,
 - and the behaviour at radiofrequency with the test cavities in ASTeC and QPR at CERN and HZB,
 - And, finally, depositing real cavities made of Cu or Nb

The main components of the ASTeC programme + ARIES



Surface preparation

Thin film whether deposited in PVD or CVD will mimic the surface topography of the substrate and further more the crystal size and orientation of substrate has large influence on how the growth morphology of the film. For this reason a special study was set to control the substrate surface and bulk chemistry, surface topography and surface damage.



Glove box Facility to handle safely CVD/ALD Precursor chemical



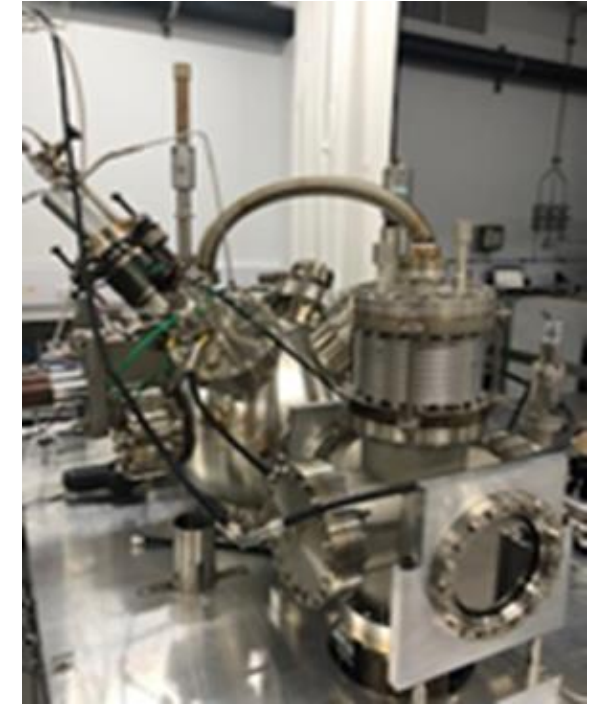
Mechanical polishing for substrate before chemical preparation/cleaning



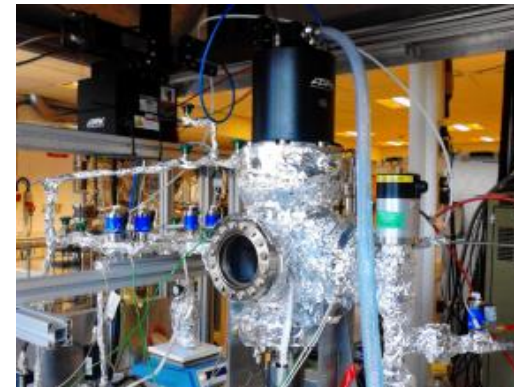
Electro chemical (EP) and SUBU polishing

Thin FILM Deposition

- ❑ Two UHV physical vapour deposition chambers with multiple UHV magnetrons are designed and built in house. Both systems are capable to control full range of deposition parameters from
 - Deposition temperature;
 - Reactive and non reactive atmosphere,
 - Sample Bias (DC and RF)
 - In-situ Plasma characterisation during deposition,
 - DC, Pulse DC, RF, HiPIMS and positive Kicked HiPIMS,
- Two Chemical vapour deposition (CVD) system designed and built in house. Capable to depositing pure single and alloy metallic thin film on flat and 3D geometry substrates



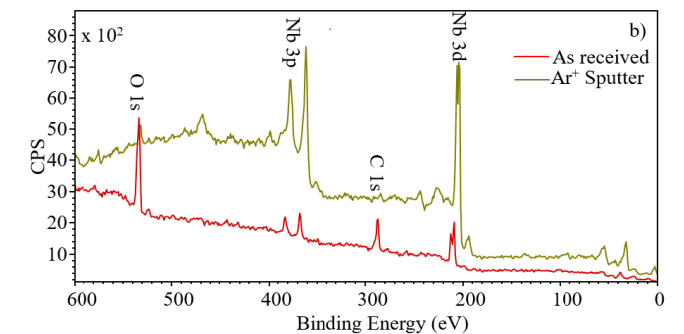
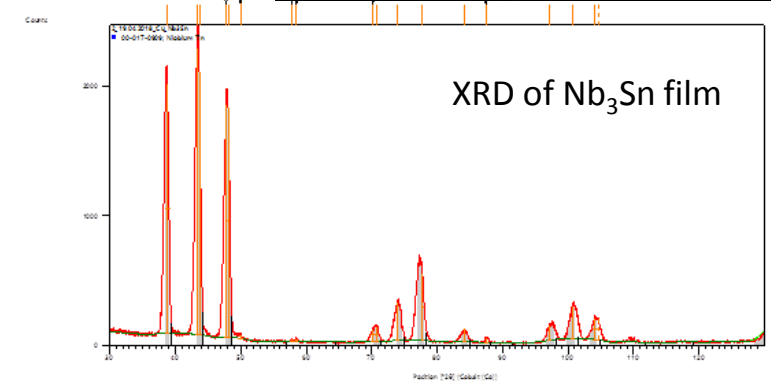
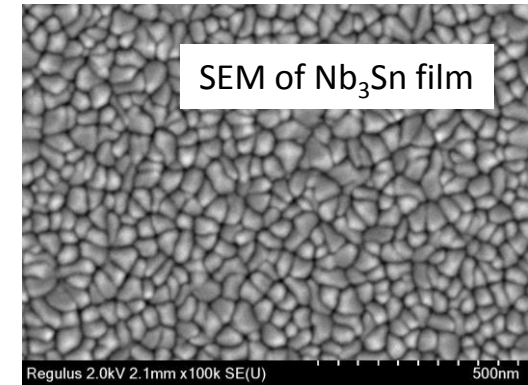
UHV Physical deposition (PVD) facilities system



Chemical vapour deposition (CVD) and plasma enhanced(PECVD) systems

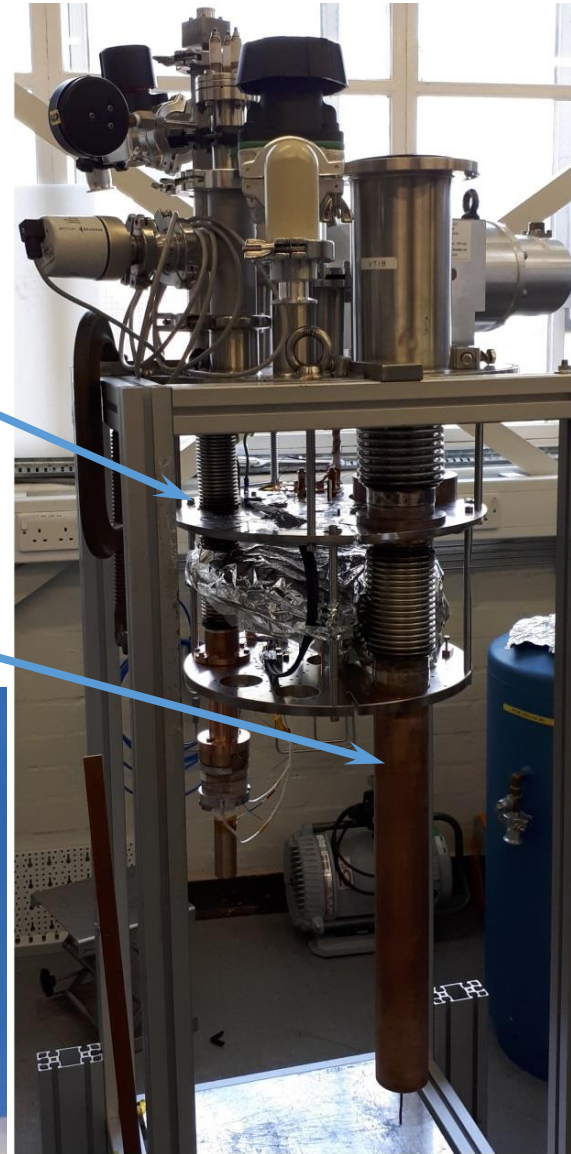
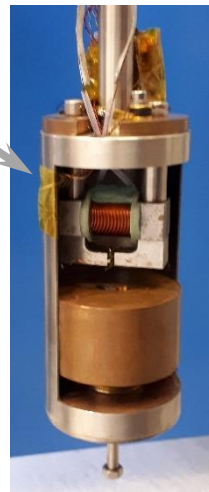
Thin film characterisation

- Sample are being cut and will be analysed at VISTA or at the collaborator's sites with
 - SEM (planar and X-section) - surface and cross-sectional investigation
 - GIXRD – structure and morphology
 - EDX - elemental analysis
 - RBS- Rutherford backscattering spectroscopy
 - XPS- X-Ray photoelectron spectroscopy
 - AFM – Surface morphology and roughness

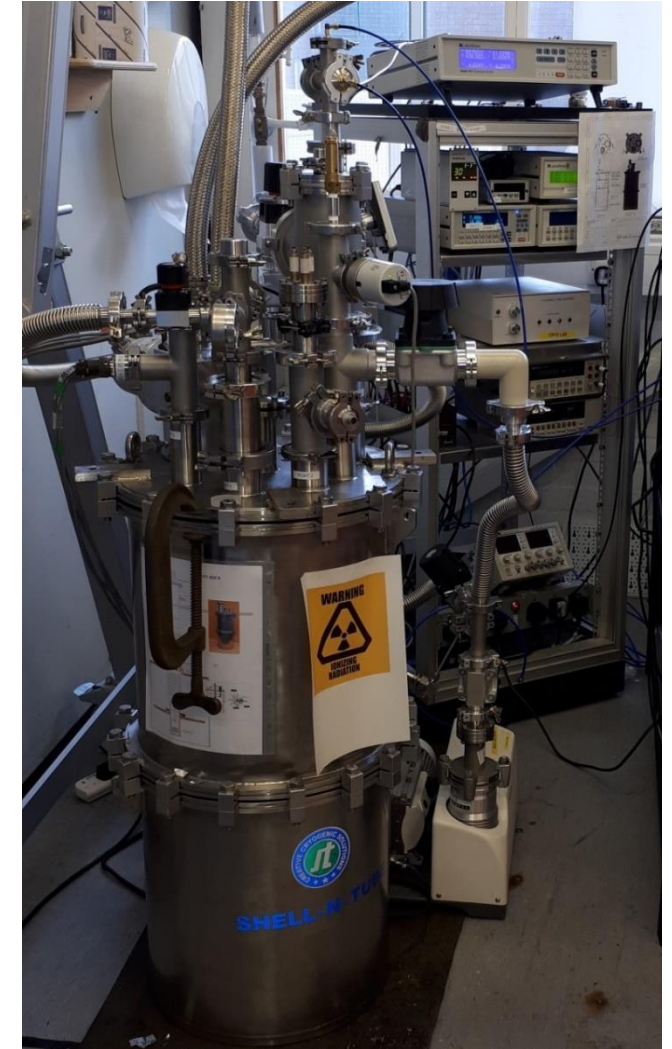


AC/DC Superconductivity evaluation SRF characterisation

- VTI-A
 - RRR
 - RRR in magnetic field
 - Magnetic field penetration measurements on tubes
- VTI-B
 - Tubular resonator
 - Magnetic field penetration measurements on flat samples
- Cryostat is operational
 - $T \sim 3.5$ K reached at stage 2
 - Has been used for ESS tests
 - but only $T \sim 7.5$ K at the sample
 - Problem is under investigation

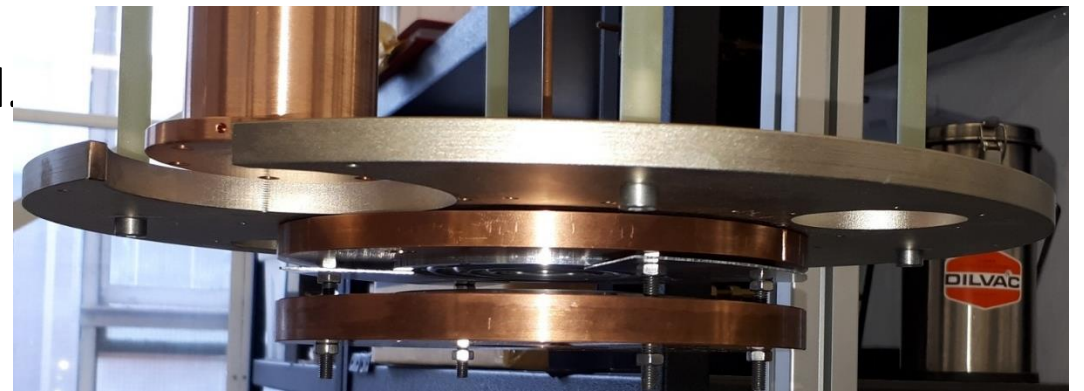
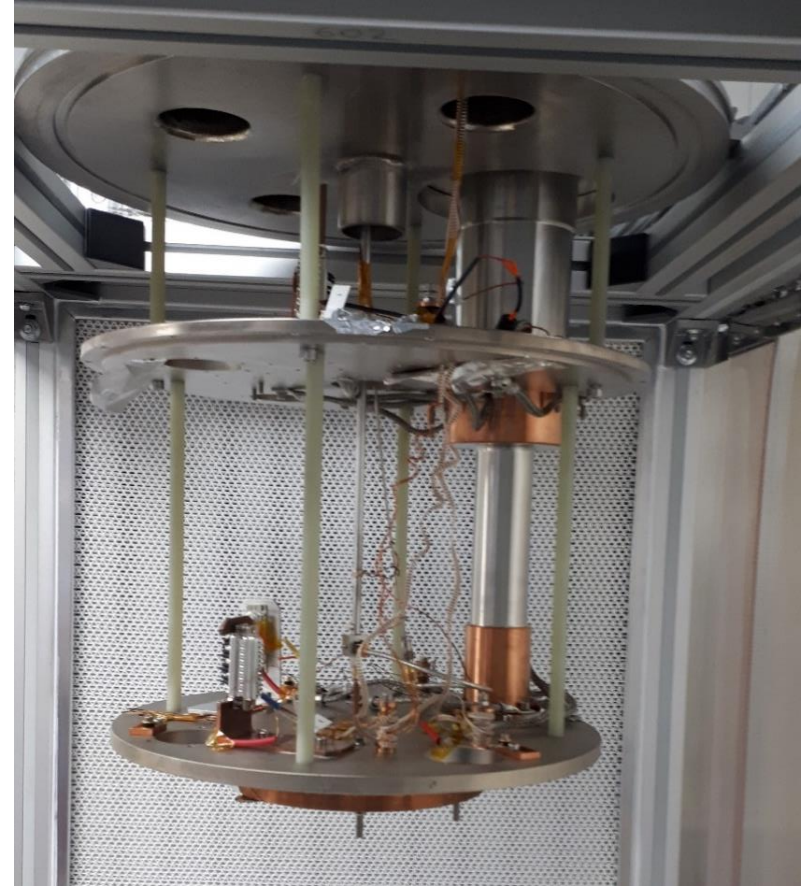


Facility in operation



Pill-box cavity in a new facility with a closed-cycle refrigerator in CrabLab

- At **ASTeC** a radiofrequency (RF) cavity and cryostat dedicated to the measurement of superconducting coatings at 7.8 GHz has been rebuilt for operation with a closed-cycle refrigerator.
- Low power measurements with an emphasis on fast turn-around time.
- No LHe required (lower operation cost and eliminated risk of cold burns)
- A trial cooldown demonstrated $T_{cavity} = 5$ K while $T_{sample} = 8$ K. Sample cooling has been redesigned, all parts received and being installed.
- New test is planned by end of April 2019.



Main achievements

- ❑ Three PhD student has successfully graduated in the past five years and currently two PDRA and another two PhD student participating on the SRF program.
- ❑ Thin SRF film of Nb, NbN, NbTiN and Nb₃Sn with excellent superconducting properties has been synthesised by PVD and CVD on flat and 3D substrates
- ❑ We are now depositing Quadro-pole resonator (QPR) samples based on deposition parameters identified in the PhD investigation studies.
- ❑ Setting up facility to deposit 6 GHz cavity provided by the INFN.
- ❑ All these has been achieved within the last five years starting from scratch and be able to participate in international thin film SRF programs with collaborators which have decades of experience.

Collaborations on TF SRF

CI and UK universities

- Liverpool University (HiPIMS: J. Bradley and F. walks PhD student)
- Lancaster University (SRF: G. Burt, Tobi, 2-3 PhD students and a PostDoc)
- **STFC**: ISIS – material science and SQUID

International

- ARIES WP15:
 - CEA (France), CERN Switzerland, IEE (Slovakia), INFN/LNL (Italy), HZB and University Siegen (Germany), RTU (Latvia)
- CERN-INFN-STFC collaboration
- JLab, SLAC