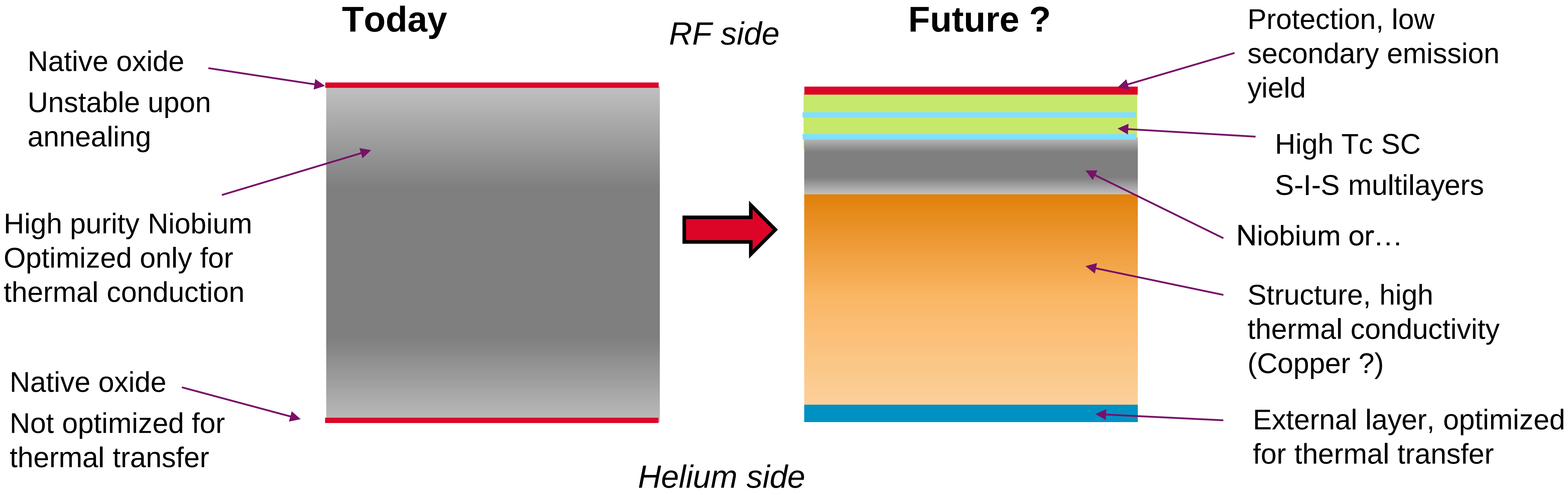
2nd I.FAST Annual Meeting
18-21 April 2023

Oleg B. Malyshev (UKRI) / Claire Antoine (CEA)

WP9 coordinators

Desired: Tailored material for RF cavities



Today

RF side

Future ?

Native oxide

Unstable upon annealing

High purity Niobium
Optimized only for thermal conduction

Native oxide

Not optimized for thermal transfer

Protection, low secondary emission yield

High Tc SC

S-I-S multilayers

Niobium or…

Structure, high thermal conductivity (Copper ?)

External layer, optimized for thermal transfer

Helium side

At stakes : COST REDUCTION !!!

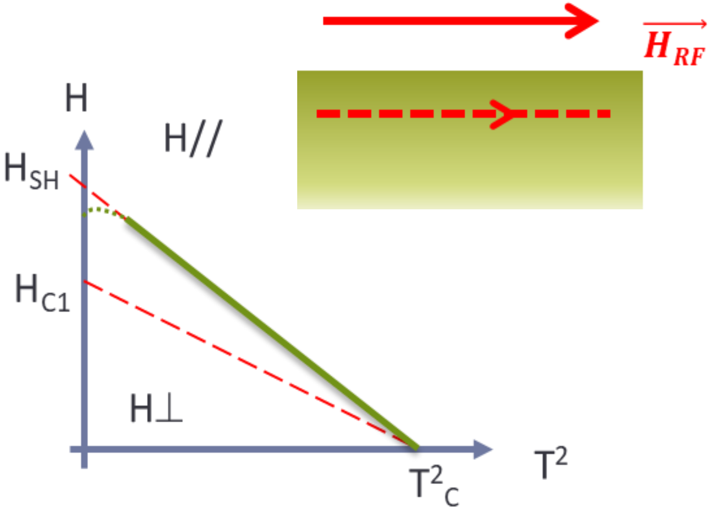
- **Cooling power (any application); can we go to cryocooling ?**
- **High accelerating fields; shorter machines ?**

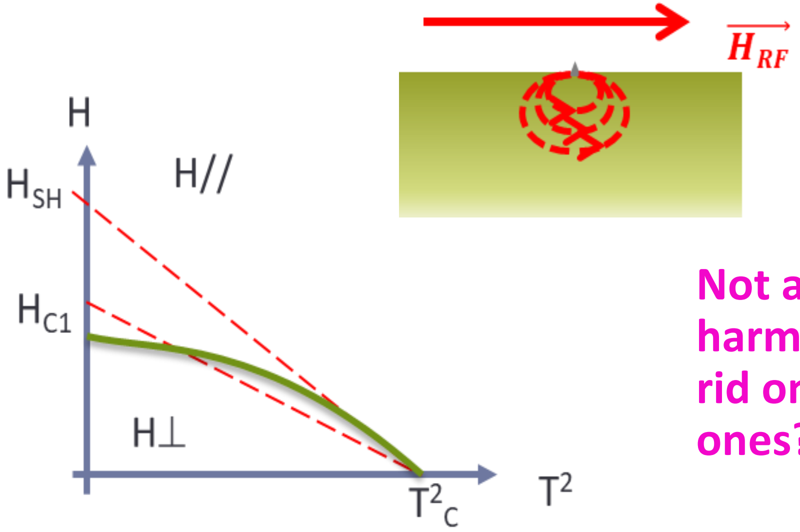
Today's technological limitation

- **Lower dissipation (high Q_0) => goes w. higher T_c**
- **Shorter machine (high E_{acc}=> goes with higher transition field (H_{SH} or H_{C1} ?)**

Physics vs Real life : today we are limited by defects

SRF: no vortex (flux line) inside SC



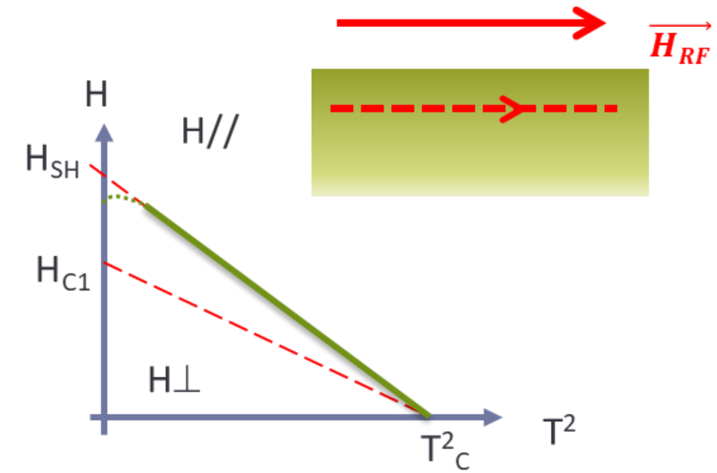


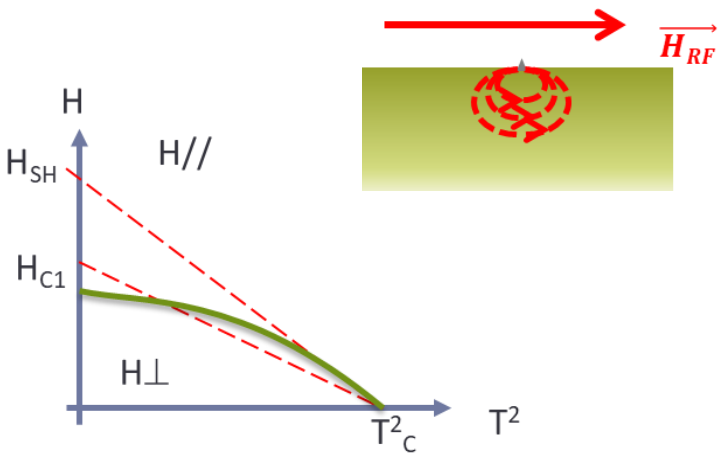
Not all defect are harmfull, how to get rid only of the bad ones?

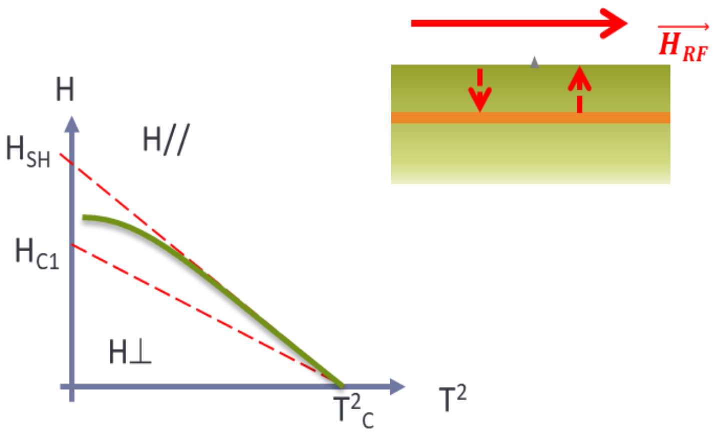
At stakes : reproducible large scale production

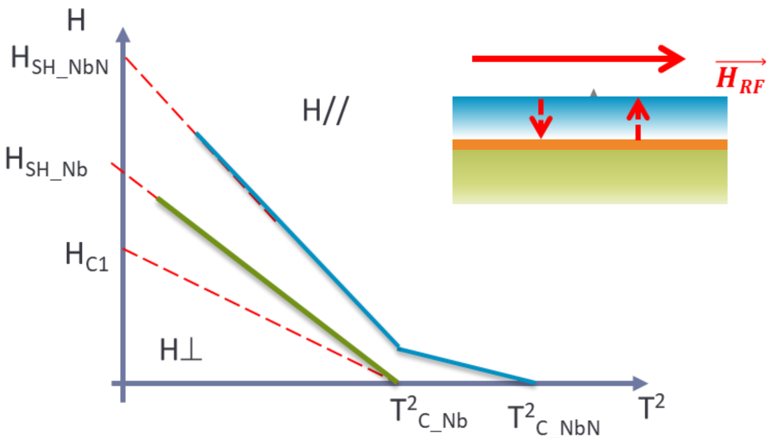
(Accelerators are big machines!)

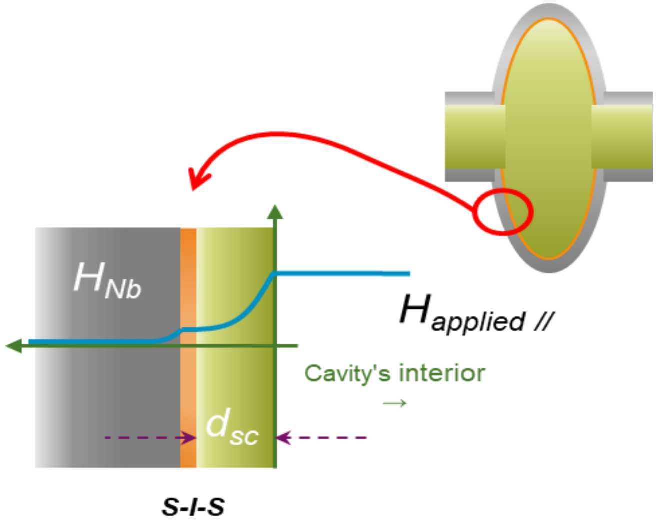
Multilayers (SIS) concept, or how to make theory face reality

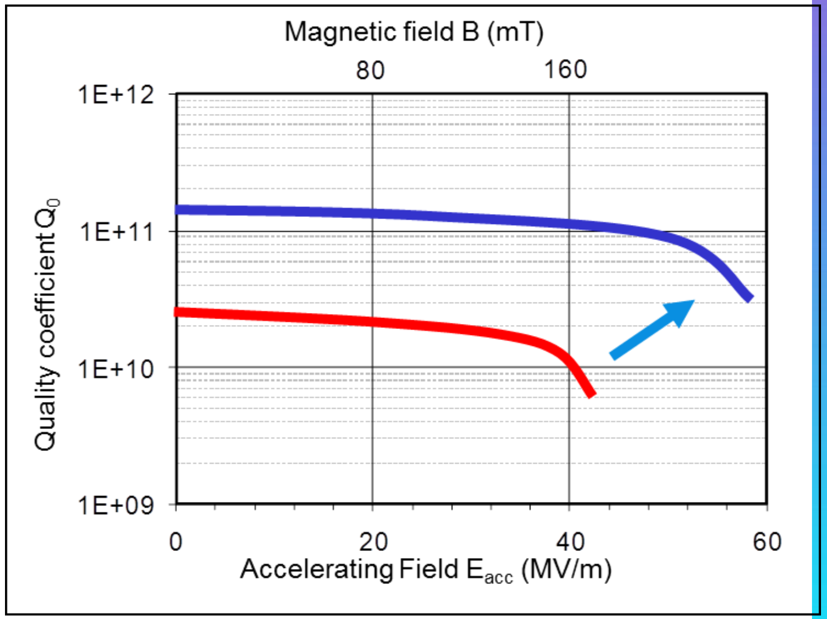












Objectives for WP9
Innovative superconducting cavities

To improve performance and reduce cost of SRF acceleration systems

Small community

- **We built together a global strategy to be able to produce Superconducting RF (SRF) cavities coated with a superconducting film. Not only IFAST, (informal) WW collaboration**
- **It includes pursuing the optimisation and the industrialisation:**
  - **Substrates preparation (Nb, Cu), e.g. PEP, metallographic polishing**
    - **Pre-and post treatment (laser)**
    - **The production of seamless copper cavities**
  - **The optimization deposition techniques: MS, PVD, ALD… to get Nb, NbN, Nb_3Sn, V_3Si… thick films (µm) and/or SIS Multilayers (nm)**
- **Produce and RF test prototypes of SRF cavities at 6 & 1.3 GHz Easier to handle, fabricate, dissect to provide fast feedback**
- **Produce accelerator type 1.3 GHz cavities (feasibility assessment).**

I.FAST WP9

The main emphasis is on applying
the result to the RF cavity deposition and testing

Surface preparation

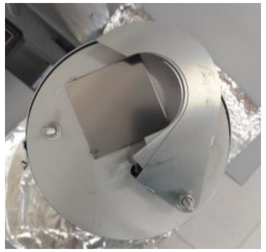
- Cleaning, etching,
- Polishing, passivating

Cu sample polishing

Thin film deposition

- **PVD**: DC, pulsed, HIPIMS…
- (PE)CVD, (PE)ALD
- **Nb, NbN, NbTiN, Nb_3Sn, V_3Si**, MgB_2, etc.
- Laser treatment of Nb films

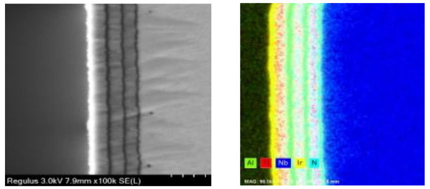
Film deposition



Film characterisation

- SEM, FIB, AFM,
- XPS, XRD, RBS, TEM…

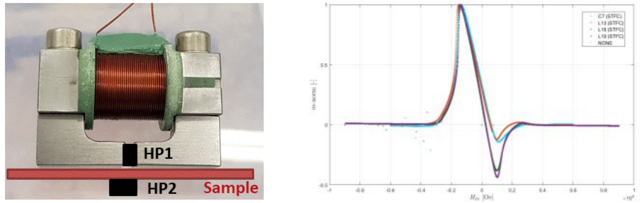
SEM and EDS images of SIS film



Superconducting DC properties measurement

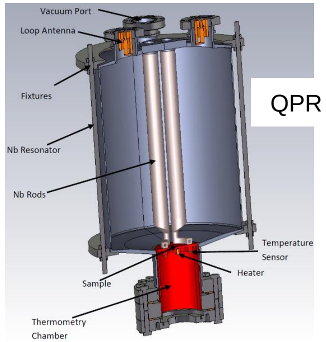
DC magnetic susceptibility,
RRR, H_c, H_{fp}, H_{sh},
Field penetration

DC magnetisation



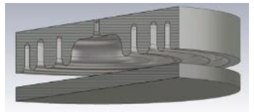
Superconducting RF properties evaluation

- QPR at HZF
- HW cavity at ASTeC

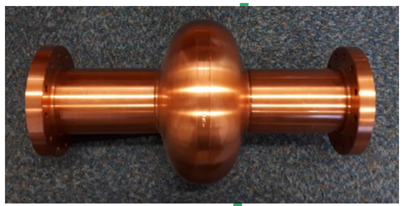


QPR

HW test cavity



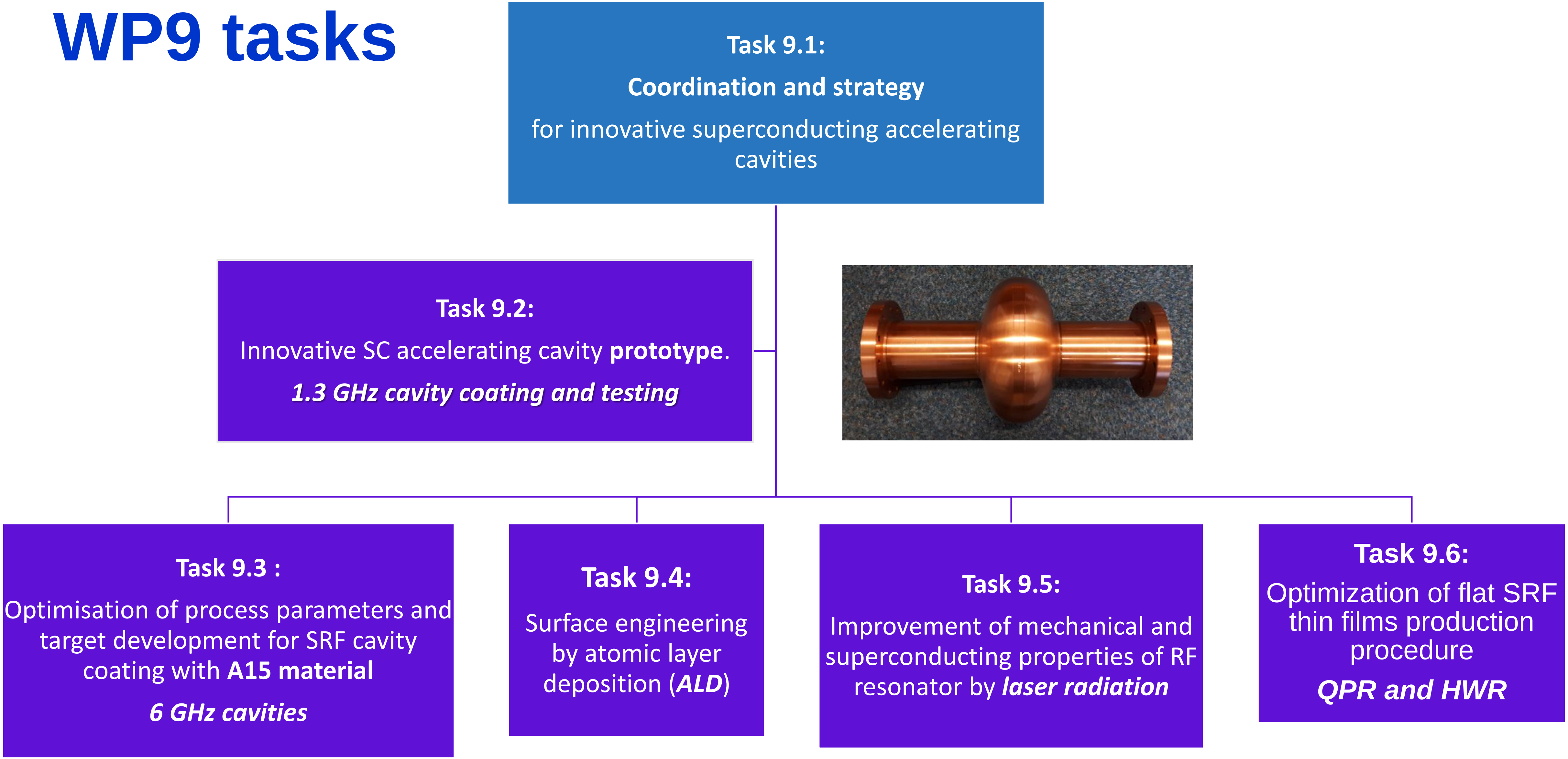
1.3 GHz cavity for STF deposition



Real cavity measurement

- Cavity deposition and testing

WP9 tasks



Task 9.1:

Coordination and strategy

for innovative superconducting accelerating cavities

Task 9.2:

Innovative SC accelerating cavity **prototype**.

1.3 GHz cavity coating and testing

Task 9.3 :

Optimisation of process parameters and target development for SRF cavity coating with **A15 material**

6 GHz cavities

Task 9.4:

Surface engineering by atomic layer deposition (***ALD***)

Task 9.5:

Improvement of mechanical and superconducting properties of RF resonator by ***laser radiation***

Task 9.6:

Optimization of flat SRF thin films production procedure

QPR and HWR

Task 9.1:

Coordinators : Oleg B. Malyshev (UKRI) / Claire Antoine (CEA)

- **Coordination and strategy for innovative SC accelerating cavities**

WP9 Meetings every 3 months

On scopes:

- **Preparation of the ESPP R&D roadmap report:** *done*
  - **implement our expertise in the organisation of future Int^l thin film R&D**
- **Leading Implementation of TF SRF theme as a part RF Coordination Panel** **ongoing**
  - **aiming to gather all European TF activities together in a common project/collaboration**
- **Coordinating with DESY/CERN** **ongoing**
- **Coordinating with Thin films TTC group** **ongoing**
- **Snowmass letter of interest** **ongoing**
- **Participating in Organising Committees**
  - **2022 Thin Films SRF workshop** *done*
  - **SRF 2023 conference** *ongoing*
    - **Several members of WP9 are also implied in those initiatives**

Future:

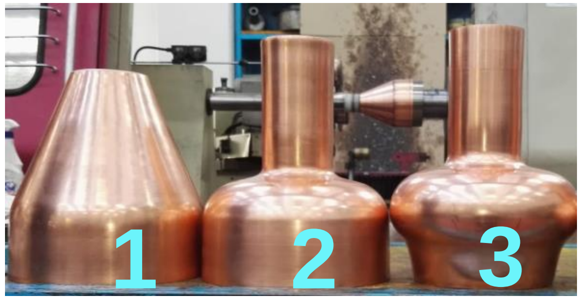
- **Organising the 2024 Thin Film SRF workshop (scientific committee + local organisation)**
  - **Will be held @ Paris-Saclay**
  - **Officially sponsored by IFAST**

Task 9.2:Seamless elliptical copper cavities

GOALS:

Task Leader: Cristian Pira (INFN)

- **Move cavity forming process from semi-automatic to fully automatic using CNC machine**
- **Study annealing temperature effect on formability**
- **Test reproducibility**
- **6 GHz for task 9.3 and 1.3 GHz cavities for prototype**



Why ?

- **Need a lot of cavities for destructible tests**
- **Welding on copper definitively bad for films**
- **18 cavities realized 6 GHz**
- **No intermediate annealing necessary**

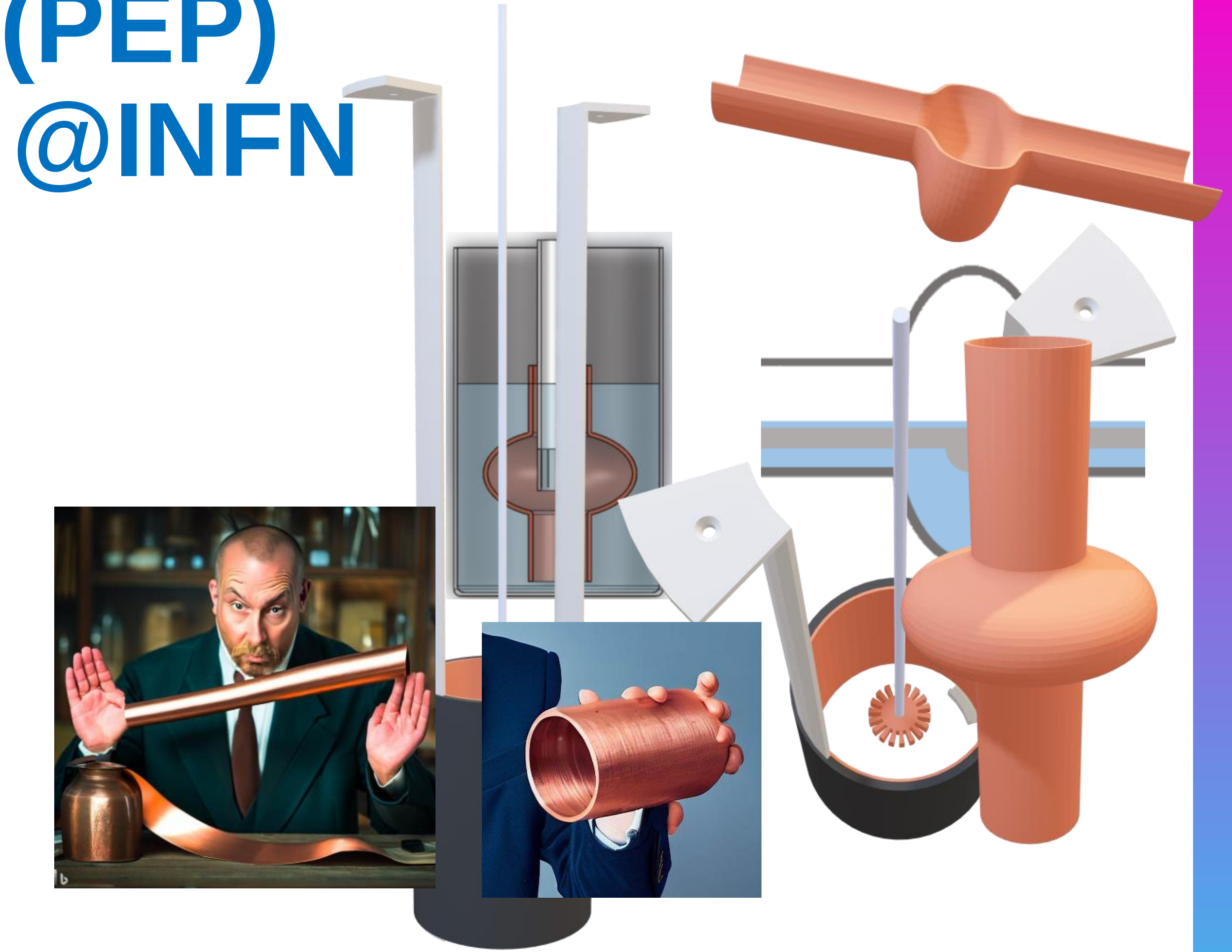
Plasma electropolishing (PEP) of 1.3 GHz copper cavity @INFN

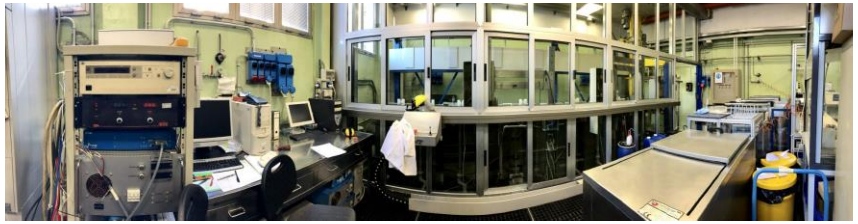
Workflow in the framework of a master degree student Roberta Caforio.

System
- Vertical
- Horizontal

Substrates
- Cu sheets
- Tubes
- 1.3 GHz cavity

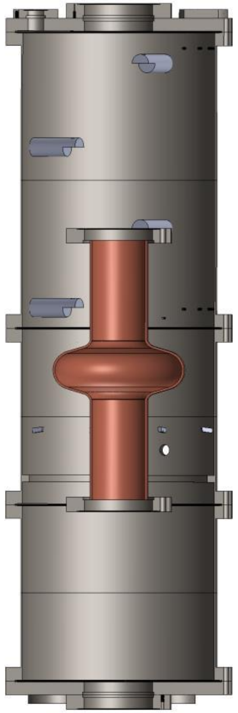
Engineering
- Semi-automatic pre-build chemical plant
- Supports, isolation, connection





1.3 GHz cavities coating facility at INFN

Main chamber parts produced and ready to be assembled



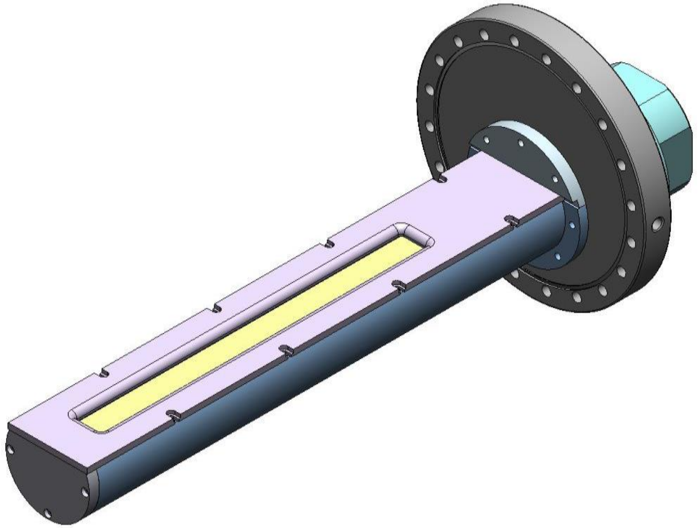
- Features:
  - ‘Hybrid’ coating system
  - Rectangular magnetron &rotating cavity
  - Post magnetron configuration with Nb_3Sn cylindircal target produced via dipping

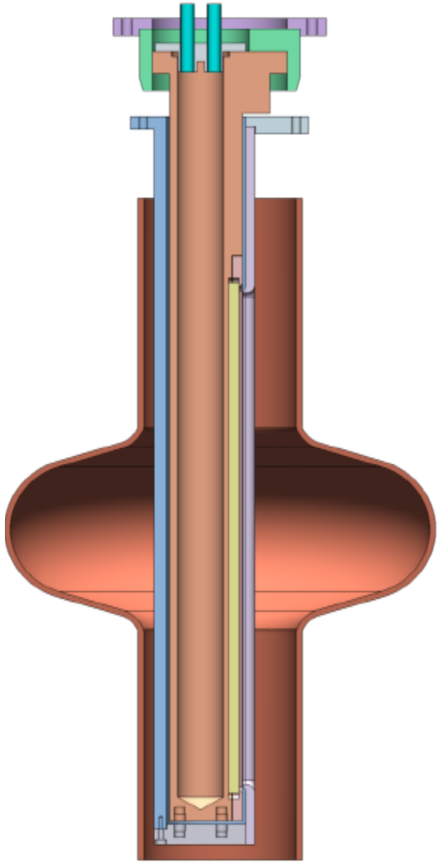
Courtesy by Alessandro Salmaso, INFN

1.3 GHz cavities coating facility at INFN

Heating system:

- IR lamps
  - Uniform heat
  - Fragile
  - >800 °C
- Resistive
  - Non-uniform heat
  - Rigit
  - <600 °C

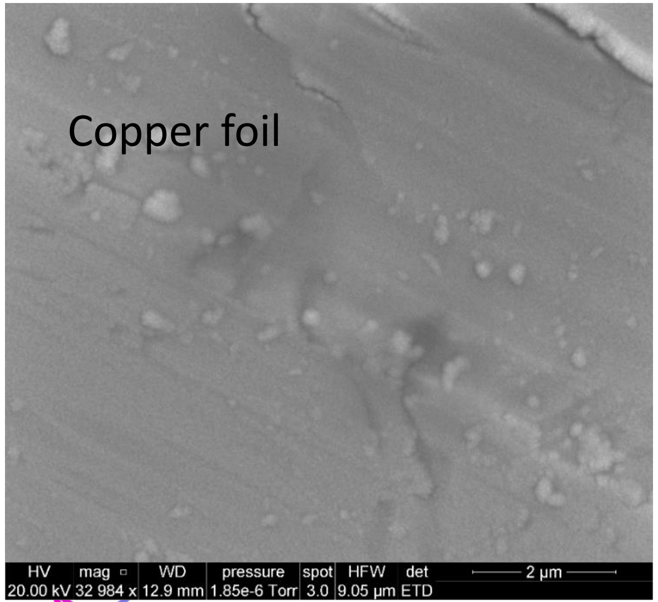


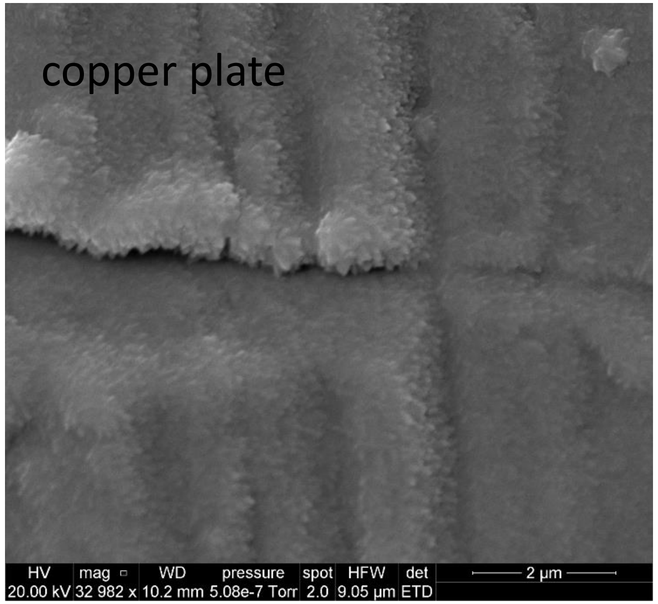


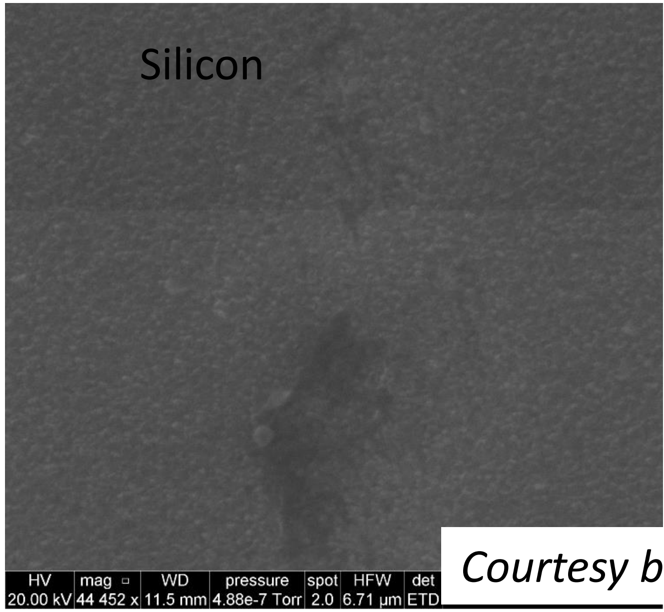
- Rectangular magnetron:
  - Design still ongoing, based on existing project
  - Limiting factor: cut-off diameter (78 mm)
  - Goal for end of 2023: first runs on samples with a mock-up cavity

Courtesy by Alessandro Salmaso, INFN

HIPIMS dep of Nb on half cell 1.3 GHz cavity RT at UKRI

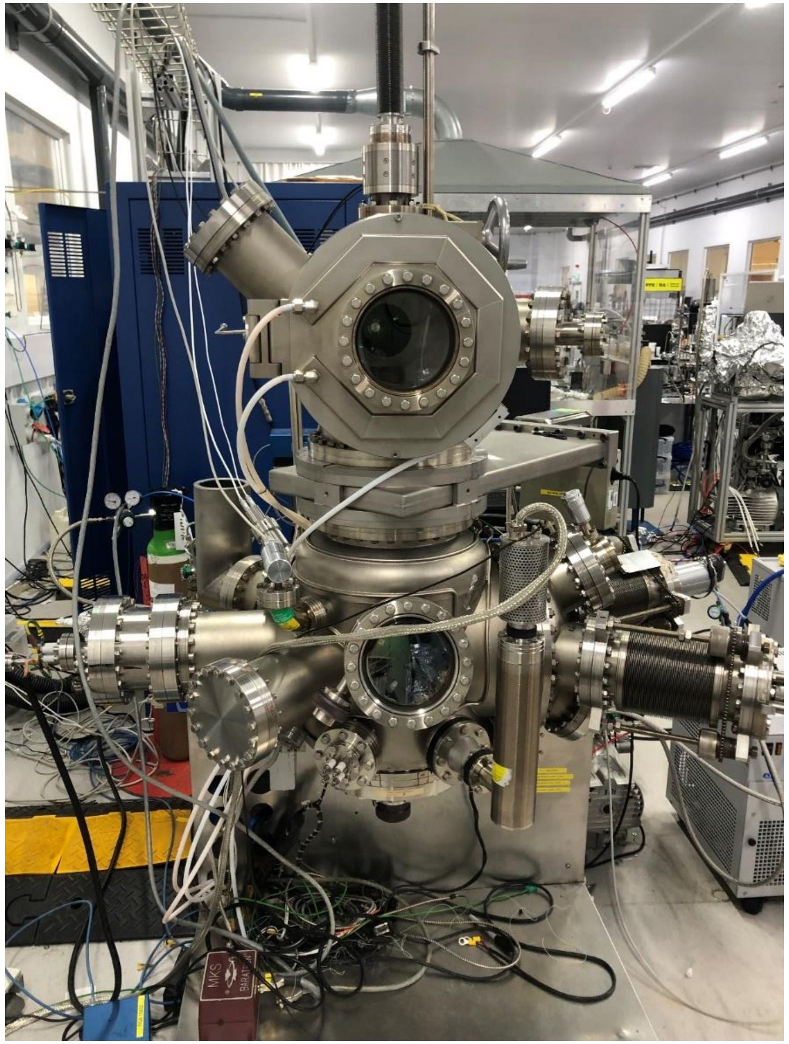

Copper foil


copper plate


Silicon

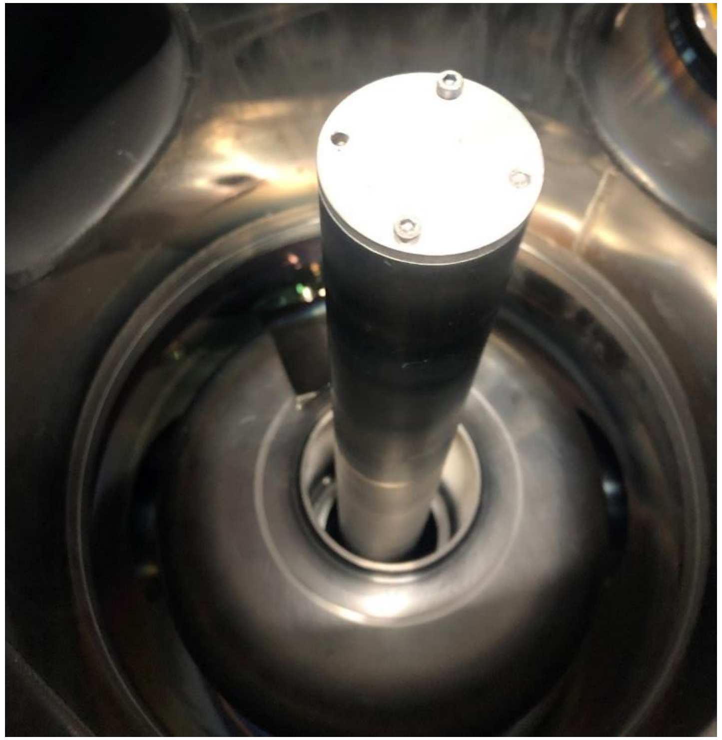
Courtesy by Reza Valizadeh, UKRI

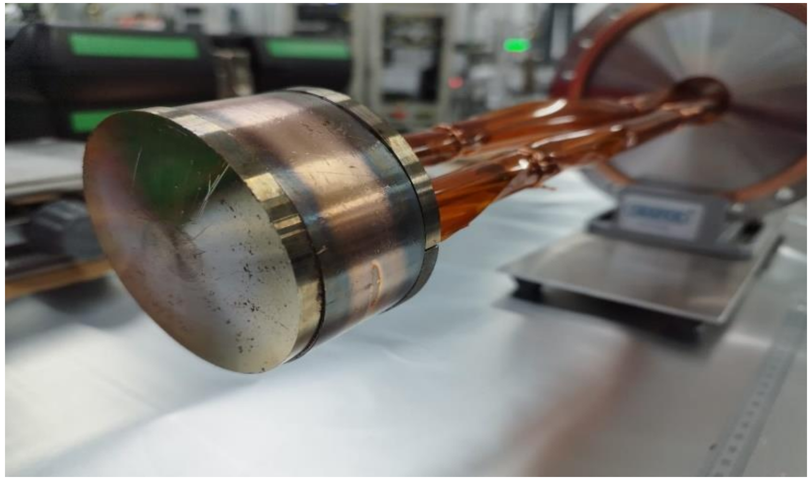
1.3 GHz Cavity deposition system at UKRI



The system is equipped with load lock chamber, rotating arm that can turn and move up and down, the chamber wall is water cooled, fixed magnetron in the centre.

It will be positioned in an ISO 6 clean room with ISO 4 cabinet for final cavity preparation.





Courtesy by Reza Valizadeh, UKRI

Nb_3Sn Cylindrical target production

by tin liquid diffusion (dipping)

Nb target

Dipping
in Liquid Tin
+ Annealing

Nb_3Sn on Nb target

Magnetron Sputtering

New system for Nb_3Sn Cylindrical target production by tin liquid diffusion (dipping)

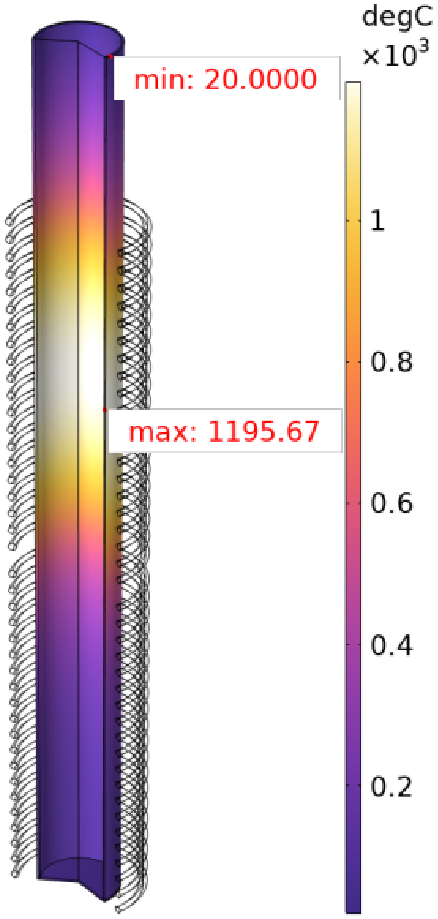
New custom vacuum chamber system that contains the Nb chamber and new inductive heating system

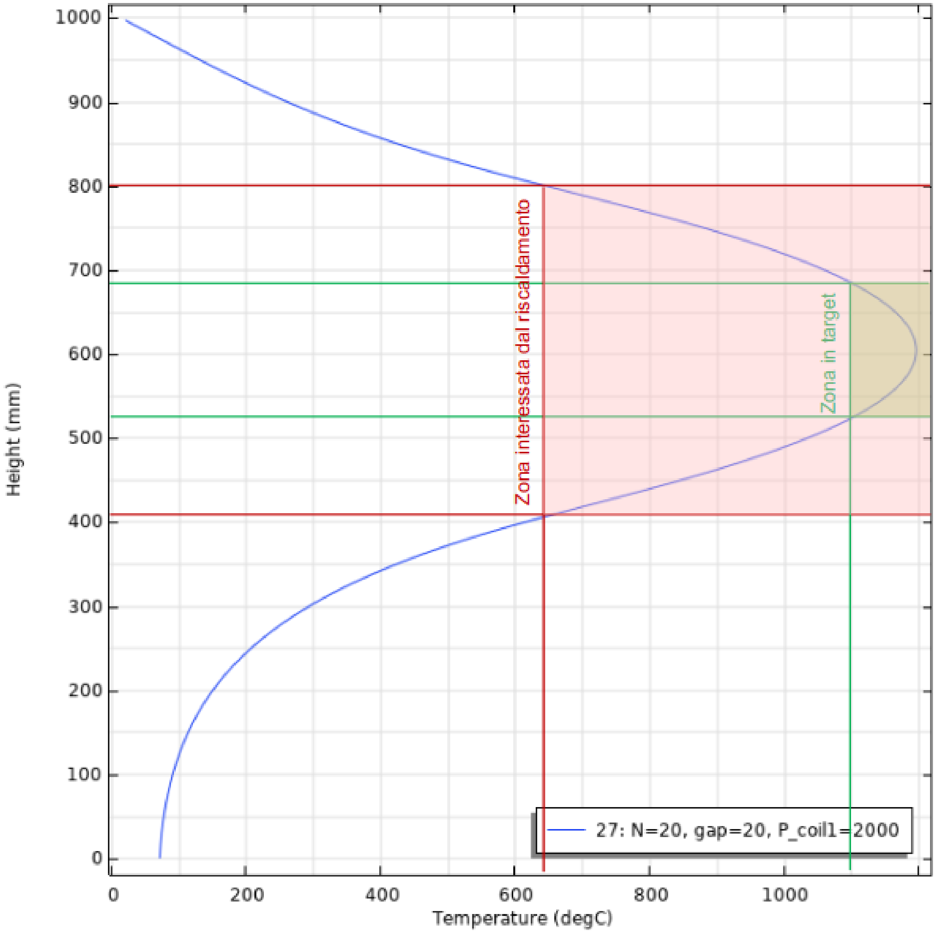
- Integral chamber cooling;
- 2 viewports for monitoring;
- Single vacuum pump solution for the entire system
- 3 kW total power
- Process entirely automated and remotely controlled
- More reliable system and more accurate temperature control

System already commissioned and will be delivered by the end of May

Inductive heating system simulations

Single inductor maximum temperature test





Power on Nb	1463 W
Losses	564 W
Yeld	73 %
I2 (RMS)	167 A

Single inductor heating meets target temperature of >1000°C

In coparison with the old resistive heating, target temperatures are easily reached even with single inductor heating

Courtesy by Davide Ford, INFN

Task 9.3 Part 1: Cavity Coating and Evaluation

Task Leader: Reza Valizadeh (UKRI)

Aim:

- **Quick deposition, quick testing, low cost (6 GHz)**
- **Optimization of process parameters with A15 material**
- **Evaluation of SRF performance by deposition of high T_c superconductor inside a 6-GHz copper cavity.**

Nb_3Sn, V_3Si, NbTiN, NbN, MgB_2

Why?

- **Higher T_c SC are complex (compound) materials**
- **Composition needs to be adjusted to get best SRF performance**
- **Optimised recipes need then to be adapted for complex geometries**

6 GHz copper cavity at UKRI

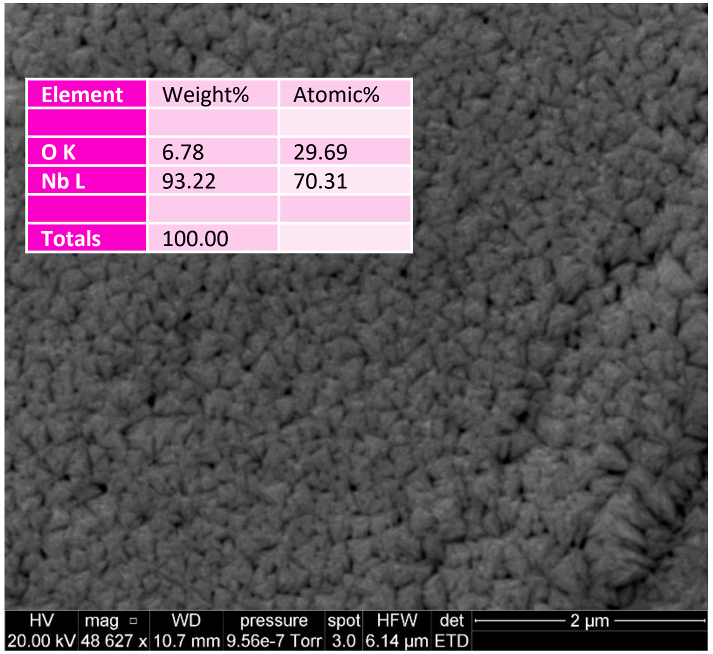
- Two type of cavity is going to be explored at UKRI/STFC/DL

INFN seamless standard
elliptical copper cavity

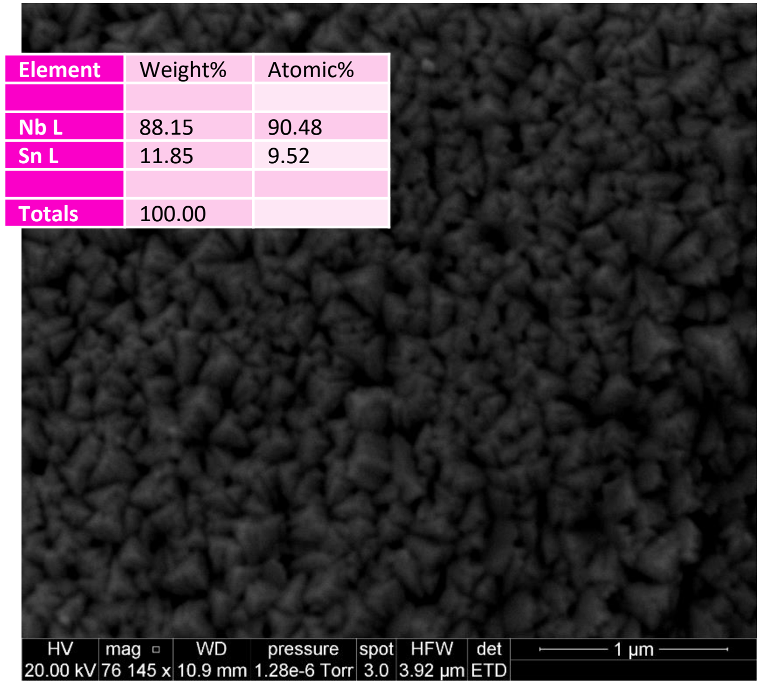
Lancaster University /
STFC
spilt cavity design

Courtesy by Reza Valizadeh, UKRI

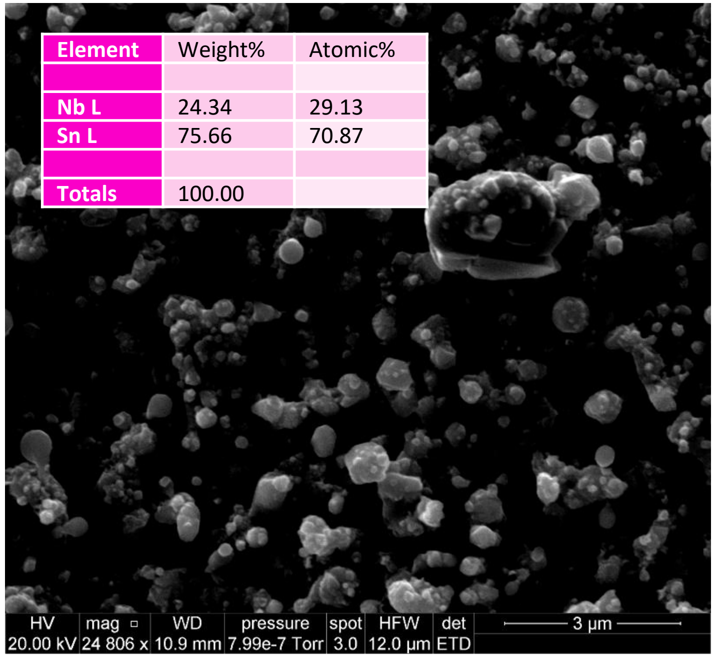
Nb_3Sn deposition with Nb tube and Sn wire inside



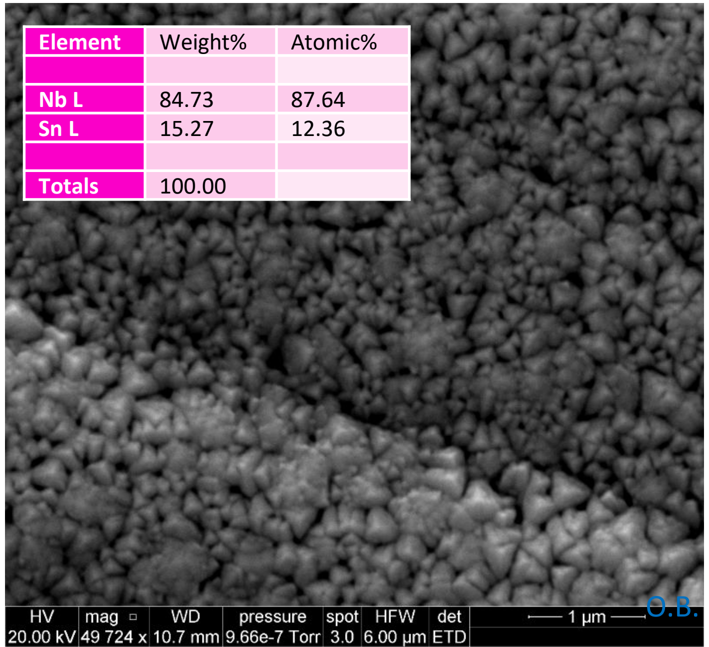
Element	Weight%	Atomic%
O K	6.78	29.69
Nb L	93.22	70.31
Totals	100.00	



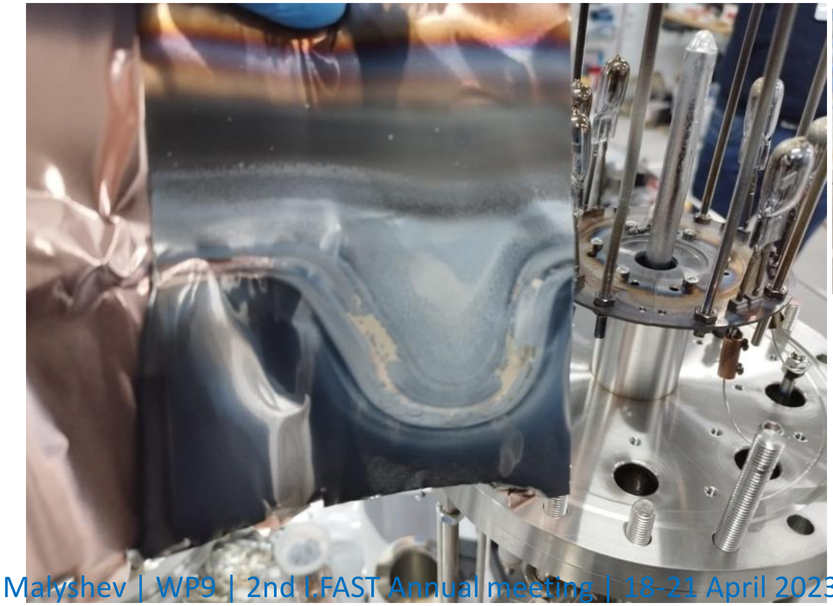
Element	Weight%	Atomic%
Nb L	88.15	90.48
Sn L	11.85	9.52
Totals	100.00	

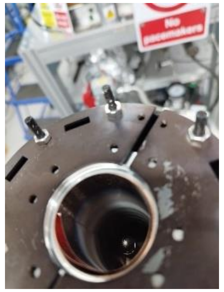


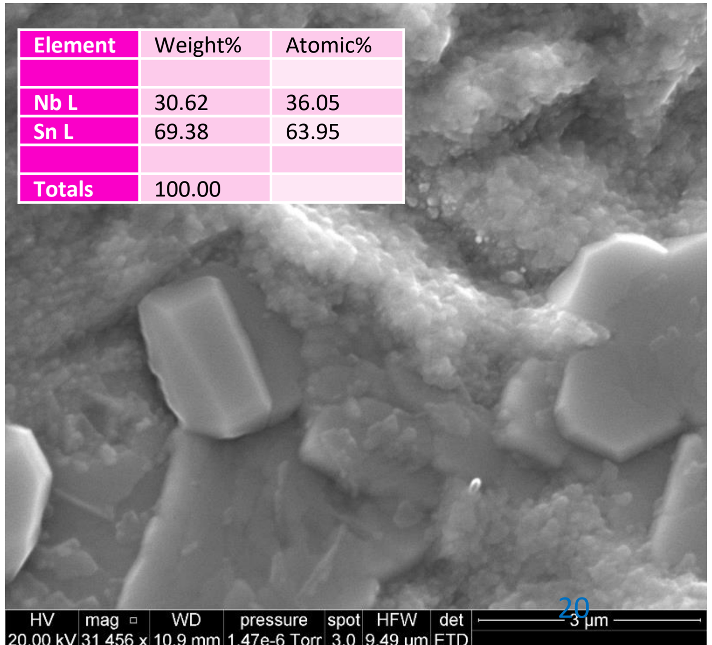
Element	Weight%	Atomic%
Nb L	24.34	29.13
Sn L	75.66	70.87
Totals	100.00	



Element	Weight%	Atomic%
Nb L	84.73	87.64
Sn L	15.27	12.36
Totals	100.00	

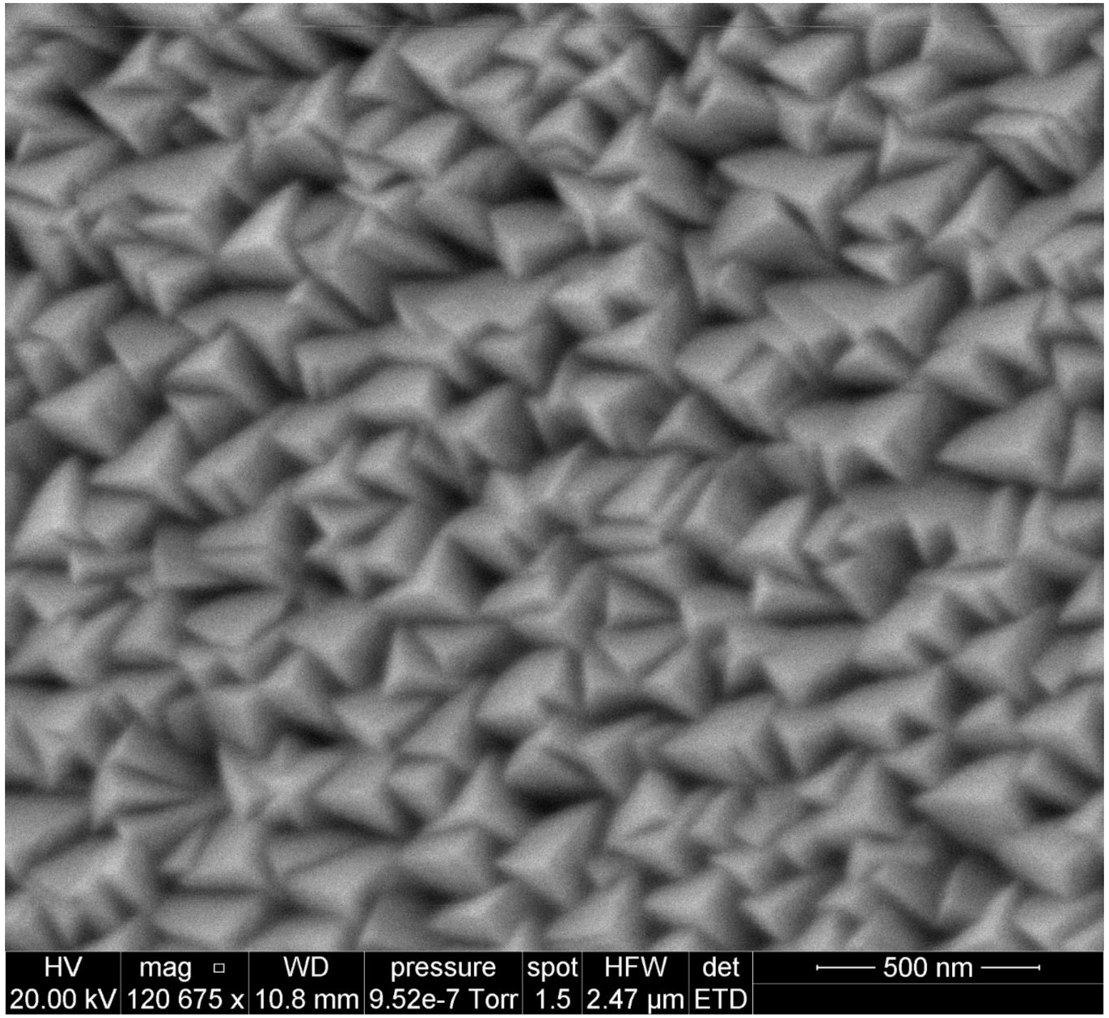


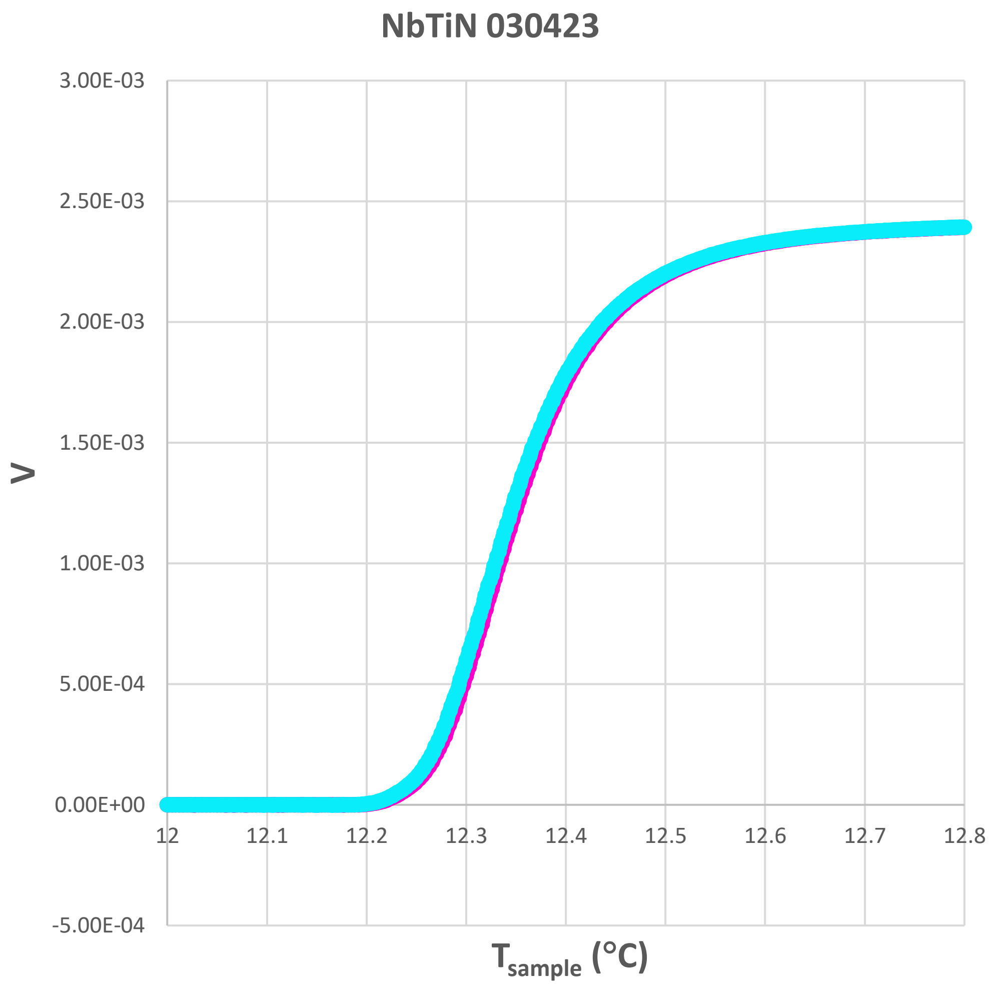




Element	Weight%	Atomic%
Nb L	30.62	36.05
Sn L	69.38	63.95
Totals	100.00	

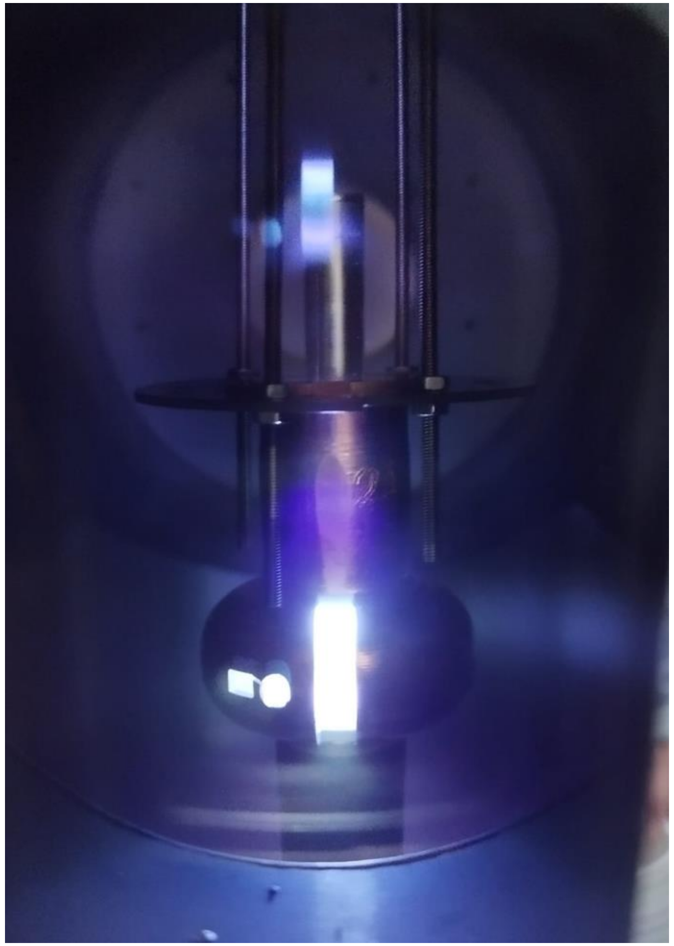
NbTiN deposition using $Nb_{37}Ti_{63}$ rod



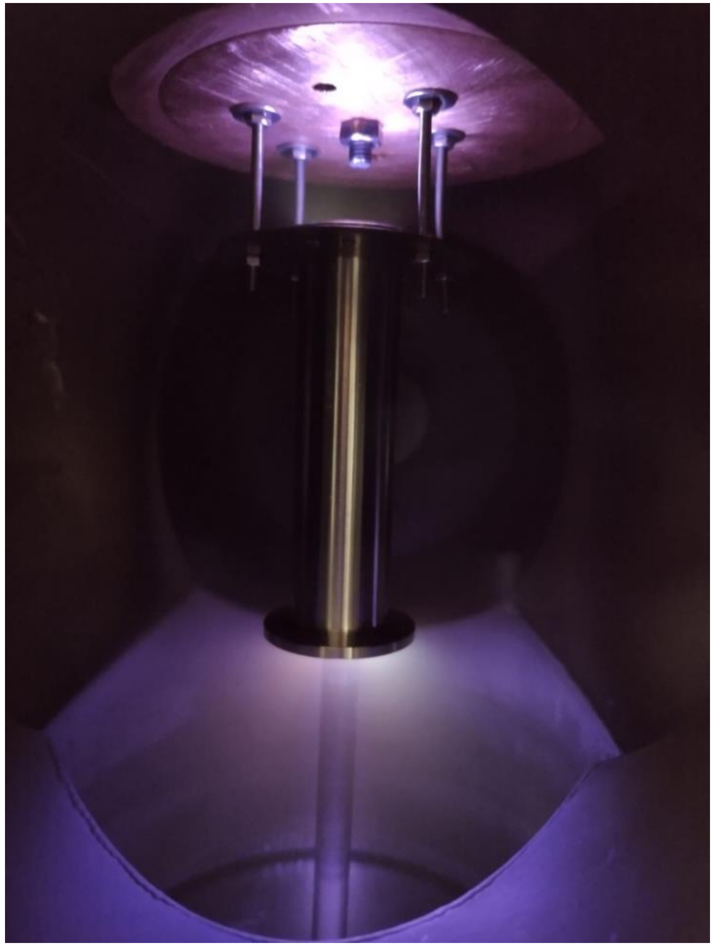

NbTiN 030423

Courtesy by Reza Valizadeh and Liam Smith, UKRI

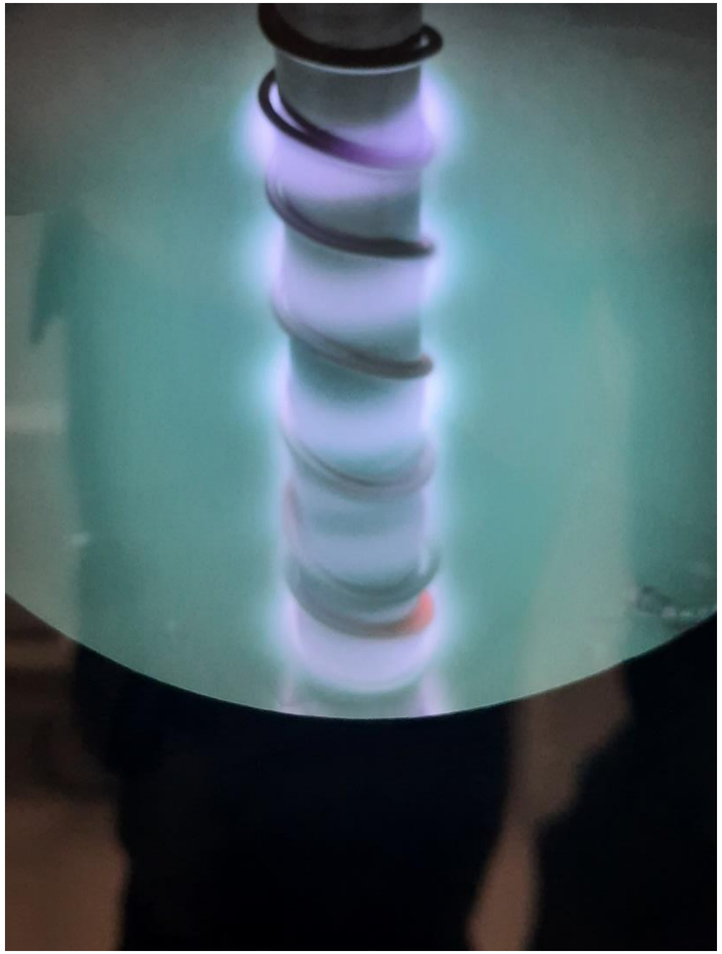
Nb/NbTiN using permanent magnet magnetron



Close cavity



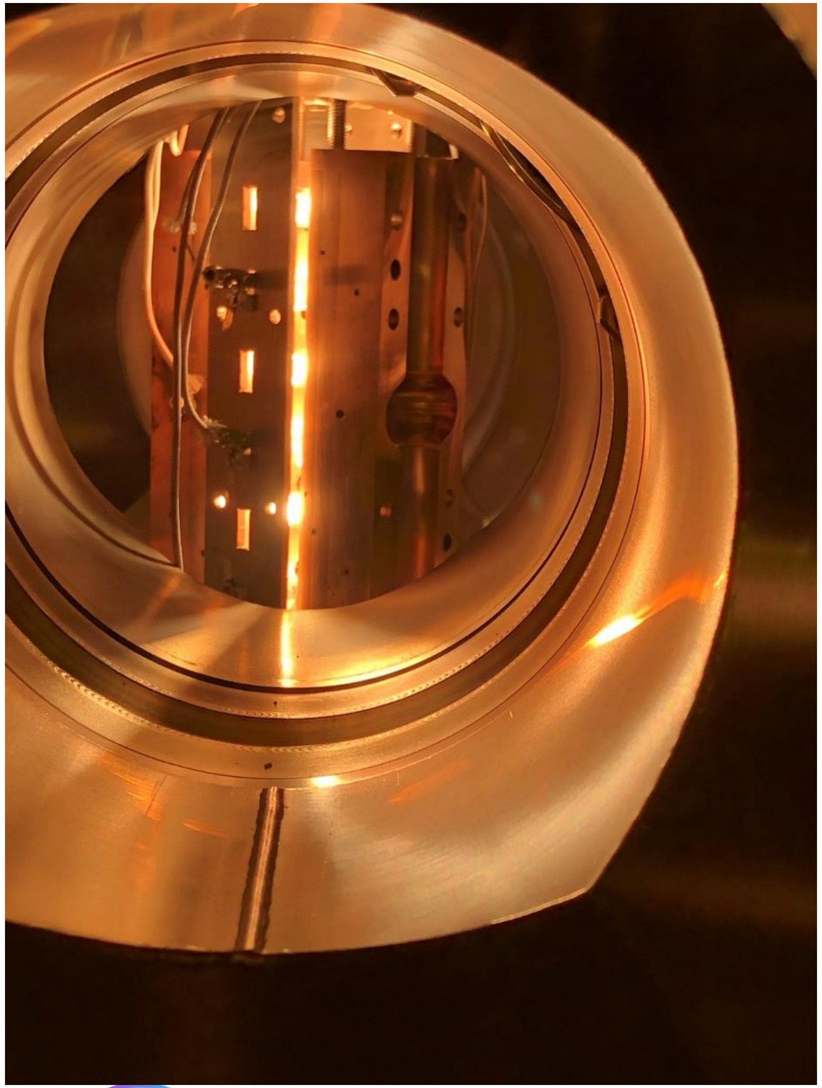
Tube

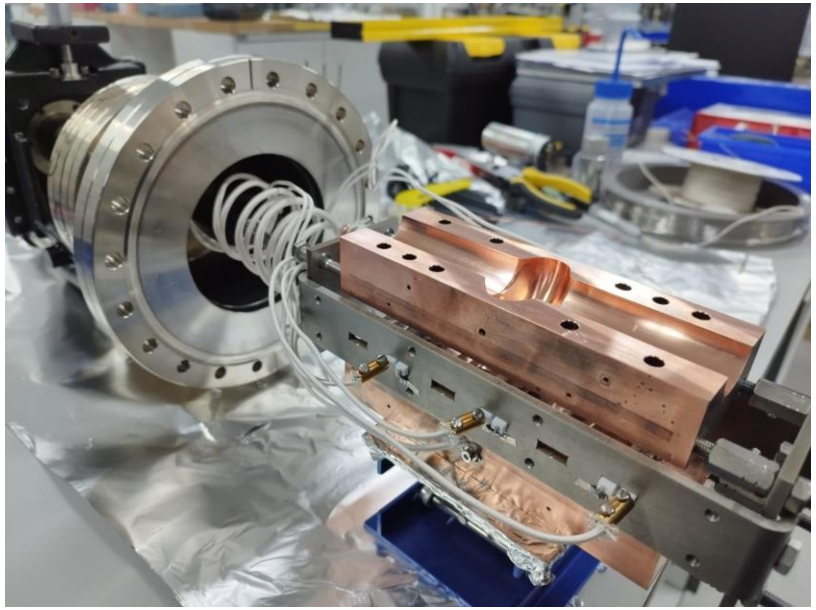


For A15 and B1 superconducting deposition

Courtesy by Reza Valizadeh, UKRI

6 GHz split cavity heating stage



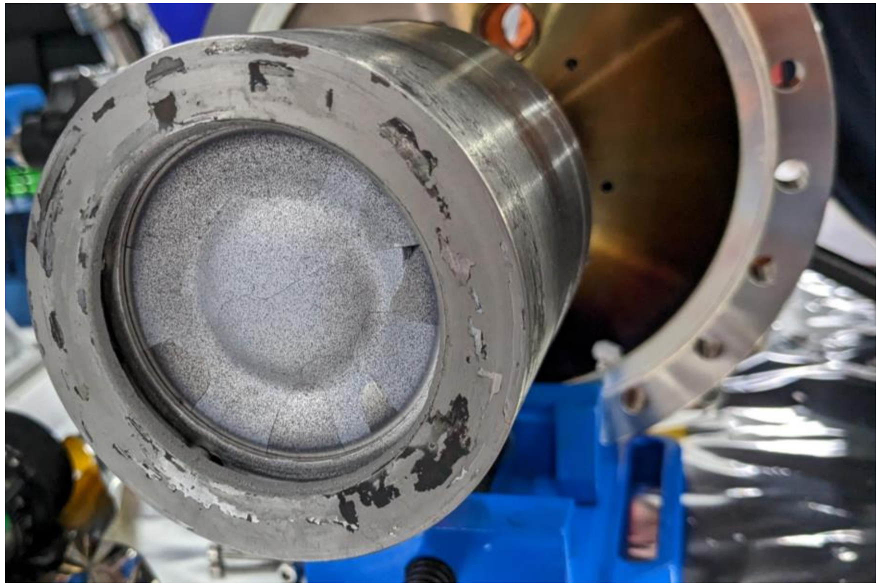


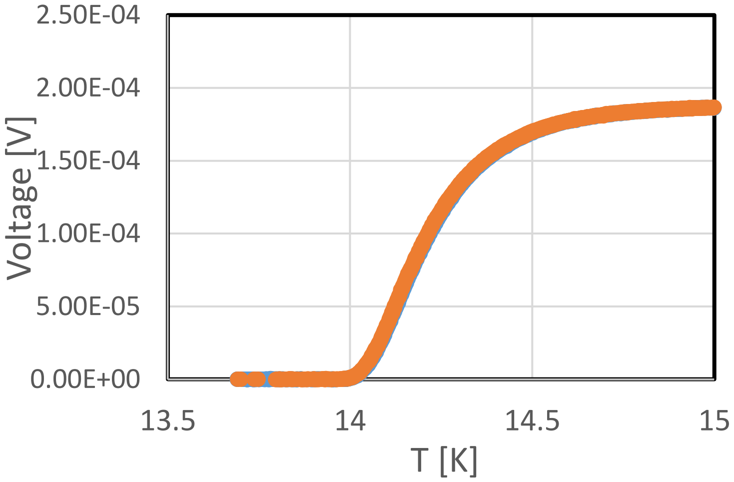
Without any heat shield the cavity temperature reaches to 600 °C

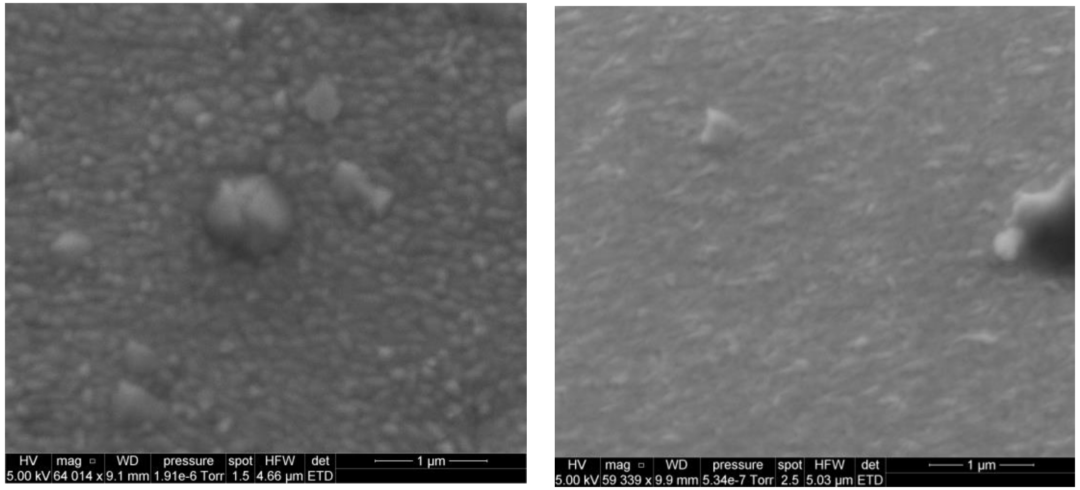
Courtesy by Reza Valizadeh, UKRI

V_3Si deposition at UKRI

- **Deposition system**
  - System is equipped with a single planar magnetron source (V_3Si alloy target).
  - Sample holder capable of heating to 800 °C.
  - Kr as the process gas.
  - Base pressure 5×10^{-9} mbar







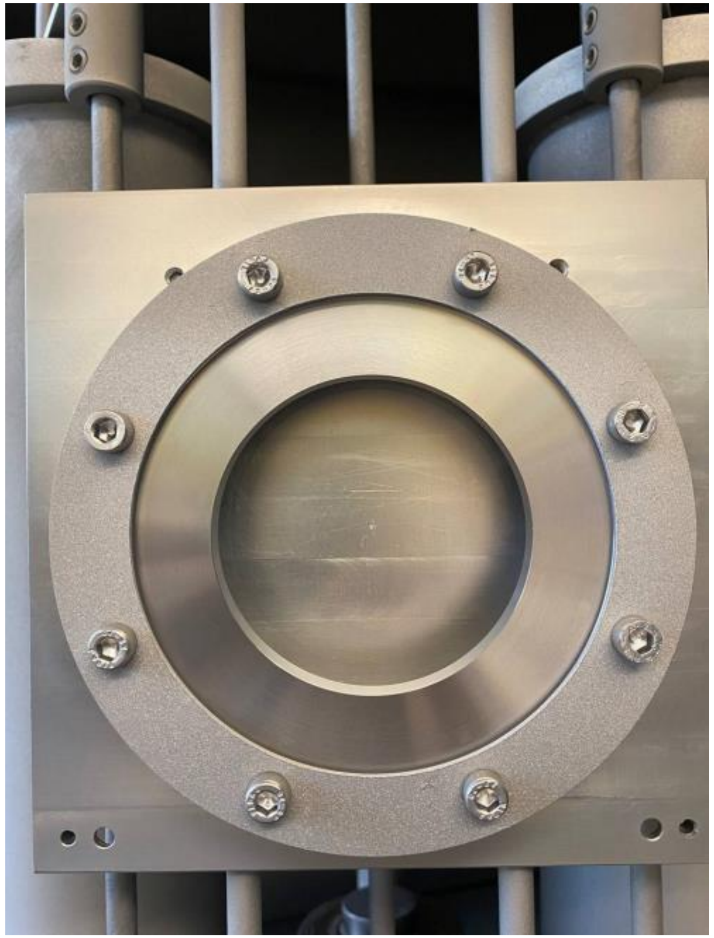
V_3Si on Cu morphology

Courtesy by Chris Benjamin and Liam Smith, UKRI

Deposition facility at USI

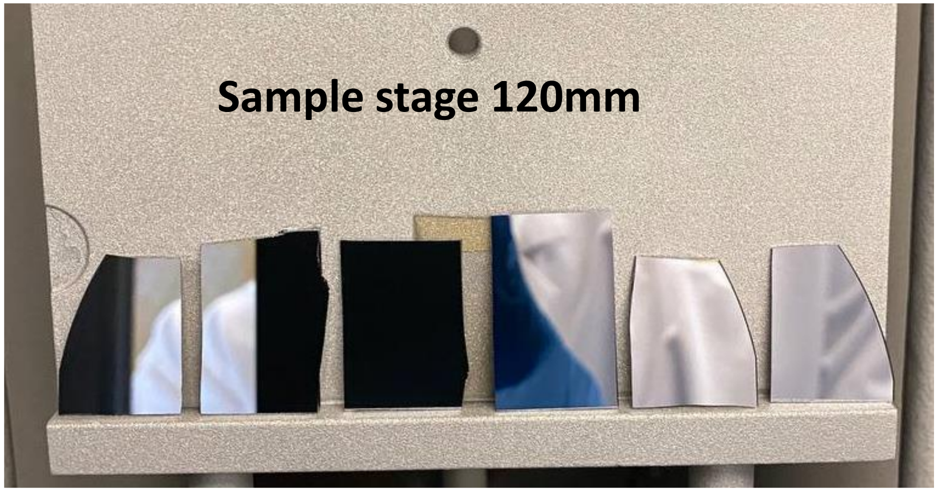
Various adapters designed and produced

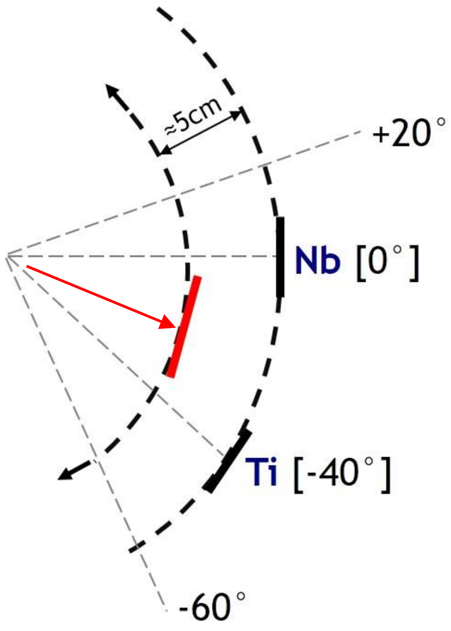
- QPR sample adapter
- Adapter CF125 to CF100

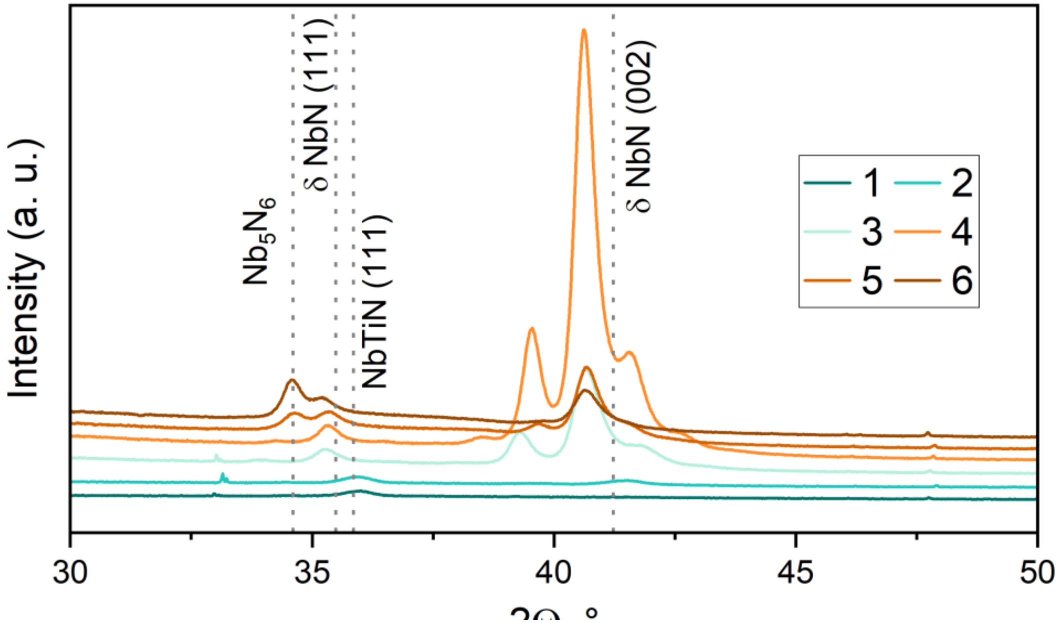


Courtesy by Alexander Zubtsovskii, USI

Co-sputtering of NbTiN: rocking angle at USI



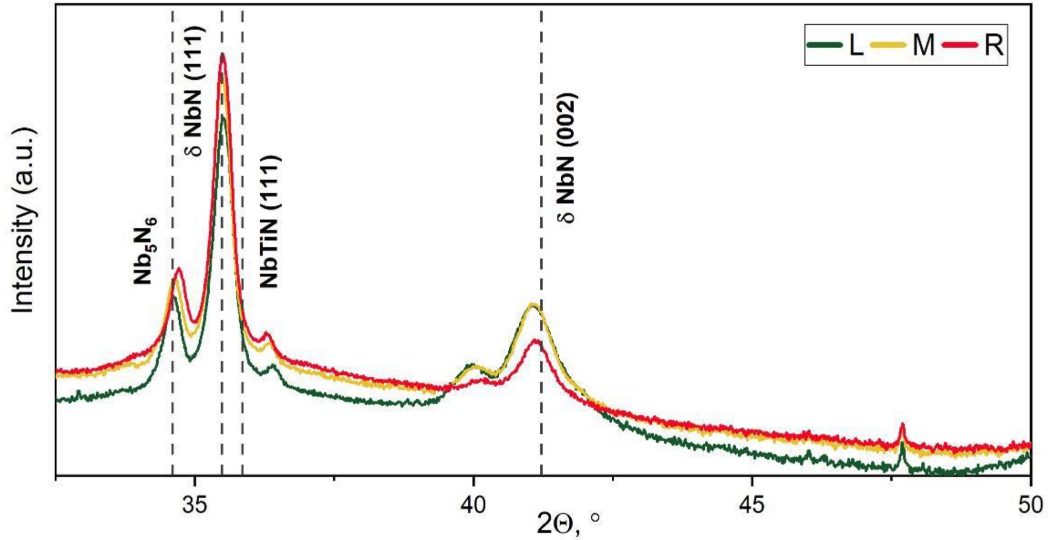




Rocking	angle
-40	0
-45	+5
-50	+10
-55	+15
-60	+20
-65	+25

Change the Ti/Nb power ratio:

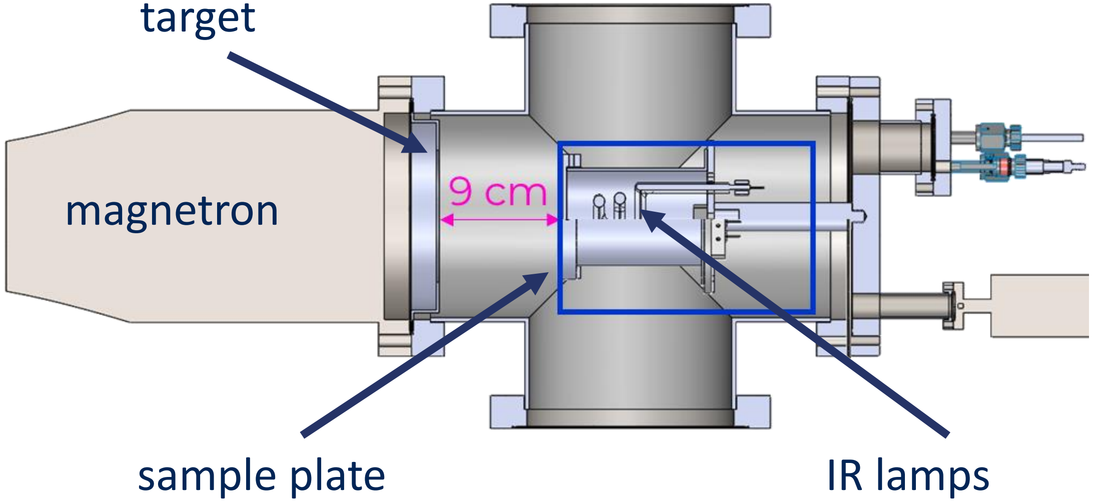
- Optimum around 500W/300W
- Rocking angle
  - -60° ↔ +20°
- Needs to vary other parameters: p, Ar/N_2, bias

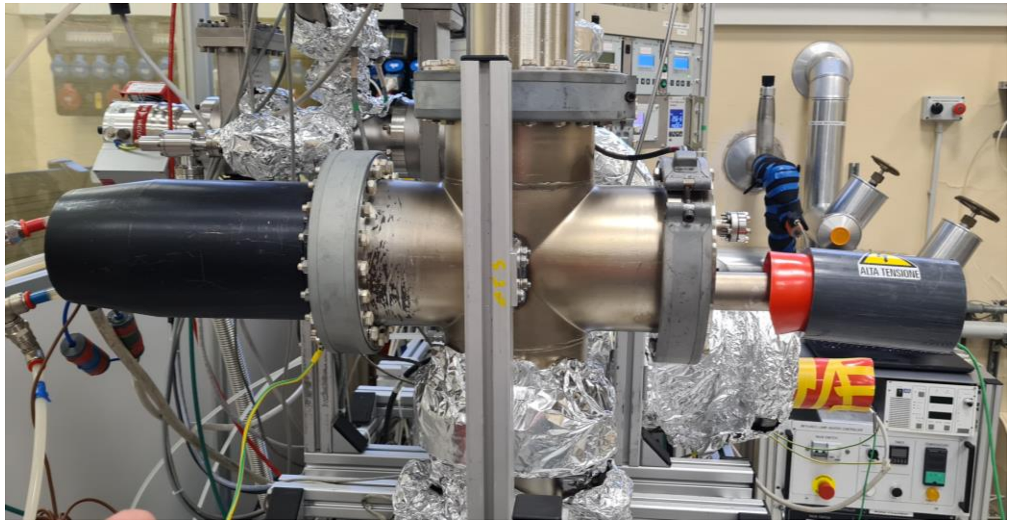


Courtesy by Alexander Zubtsovskii, USI

Nb_3Sn samples coated at INFN

- Commercial Nb_3Sn stoichiometric planar target (4” diameter)
- System base pressure: 5x10^{-9} mbar
- Heated sample holder: up to 950 °C via IR lamps





Courtesy by Dorothea Fonnesu, INFN

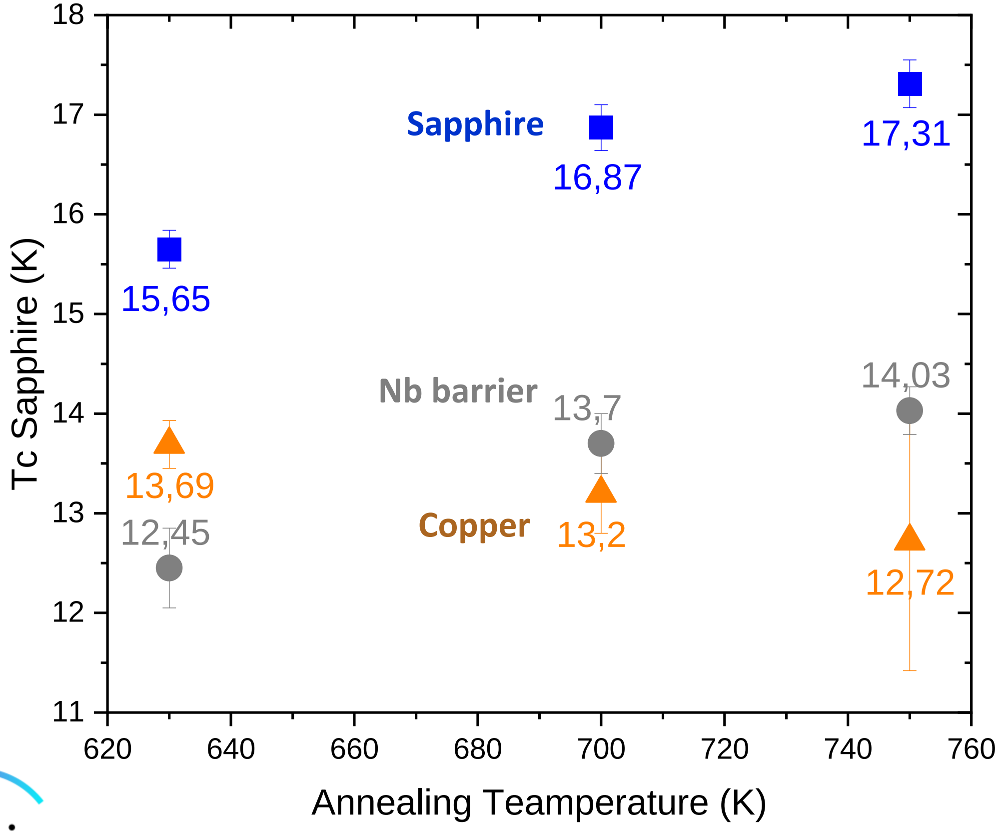
Main results for Nb_3Sn samples coated at INFN

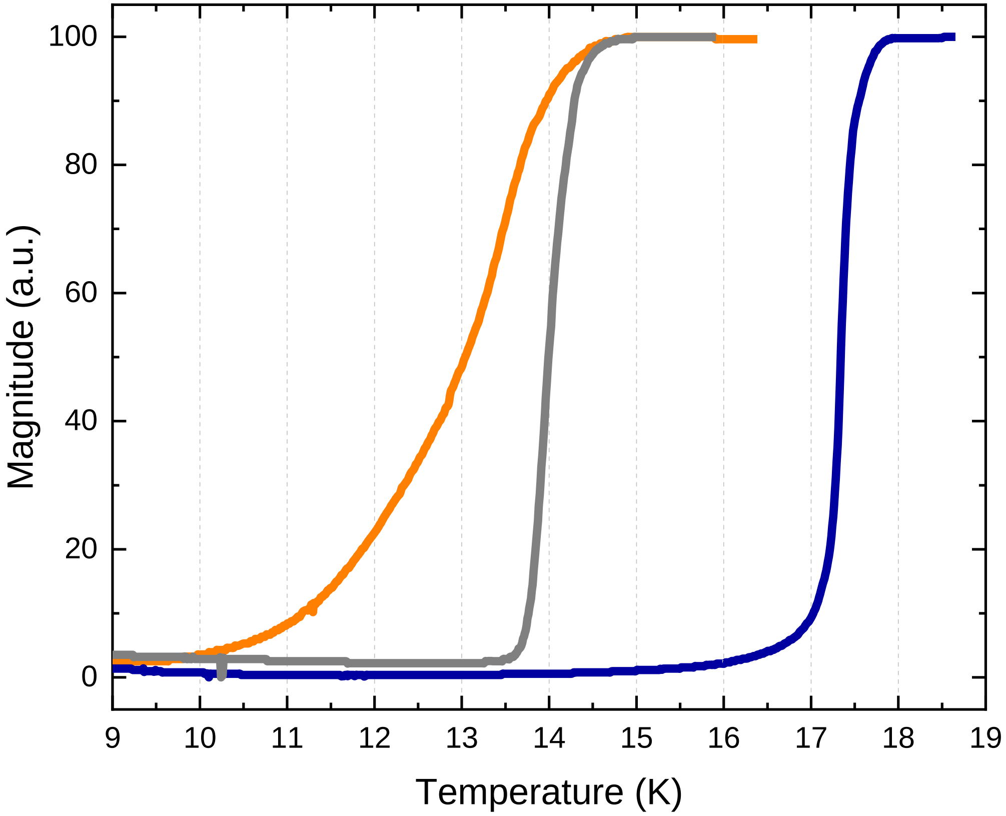
Tc vs. Temperature

Low weakening/melting point of Cu is a limitation

650 °C can be considered a limit in a Cu cavity

Diffusion of Cu into Nb_3Sn and Sn migration into Cu

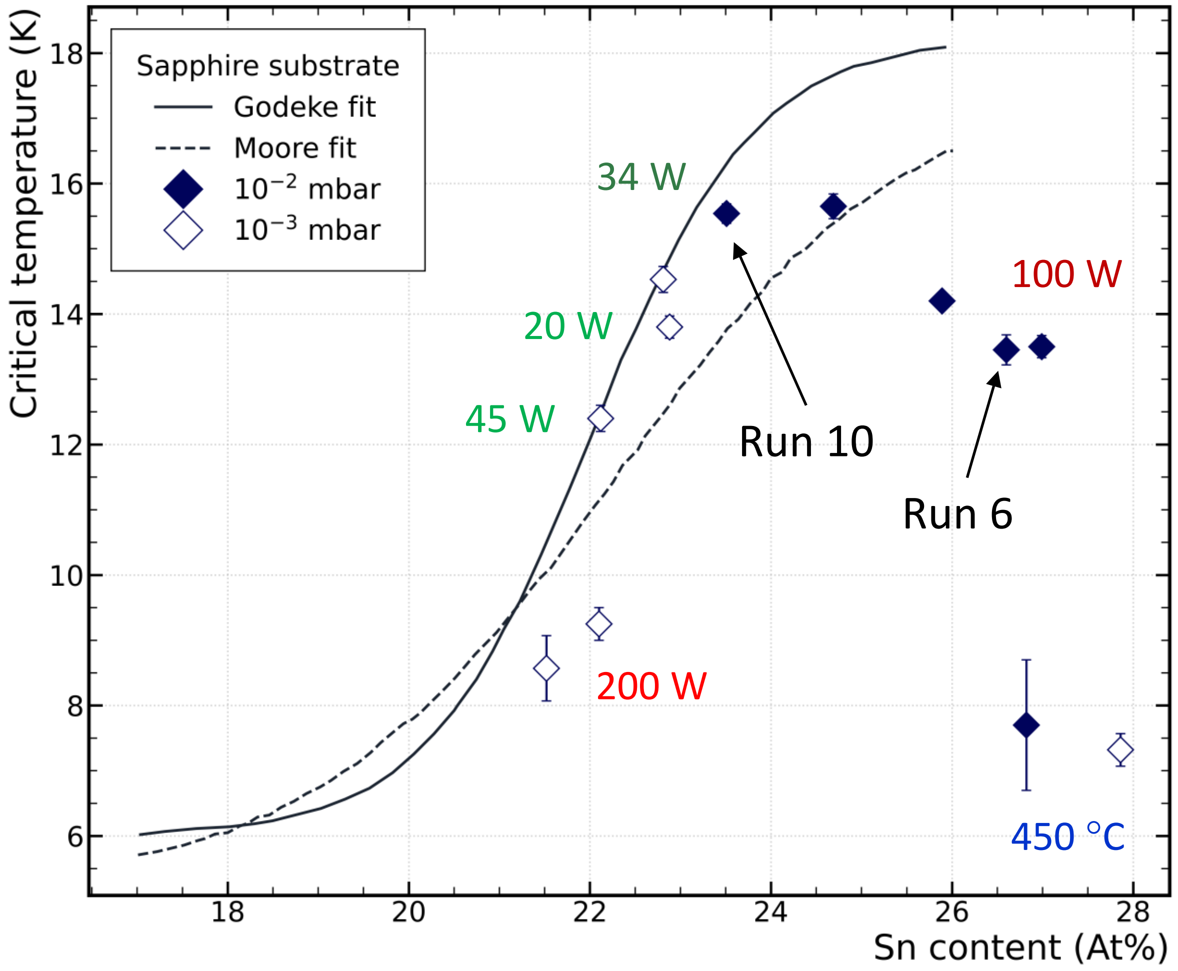




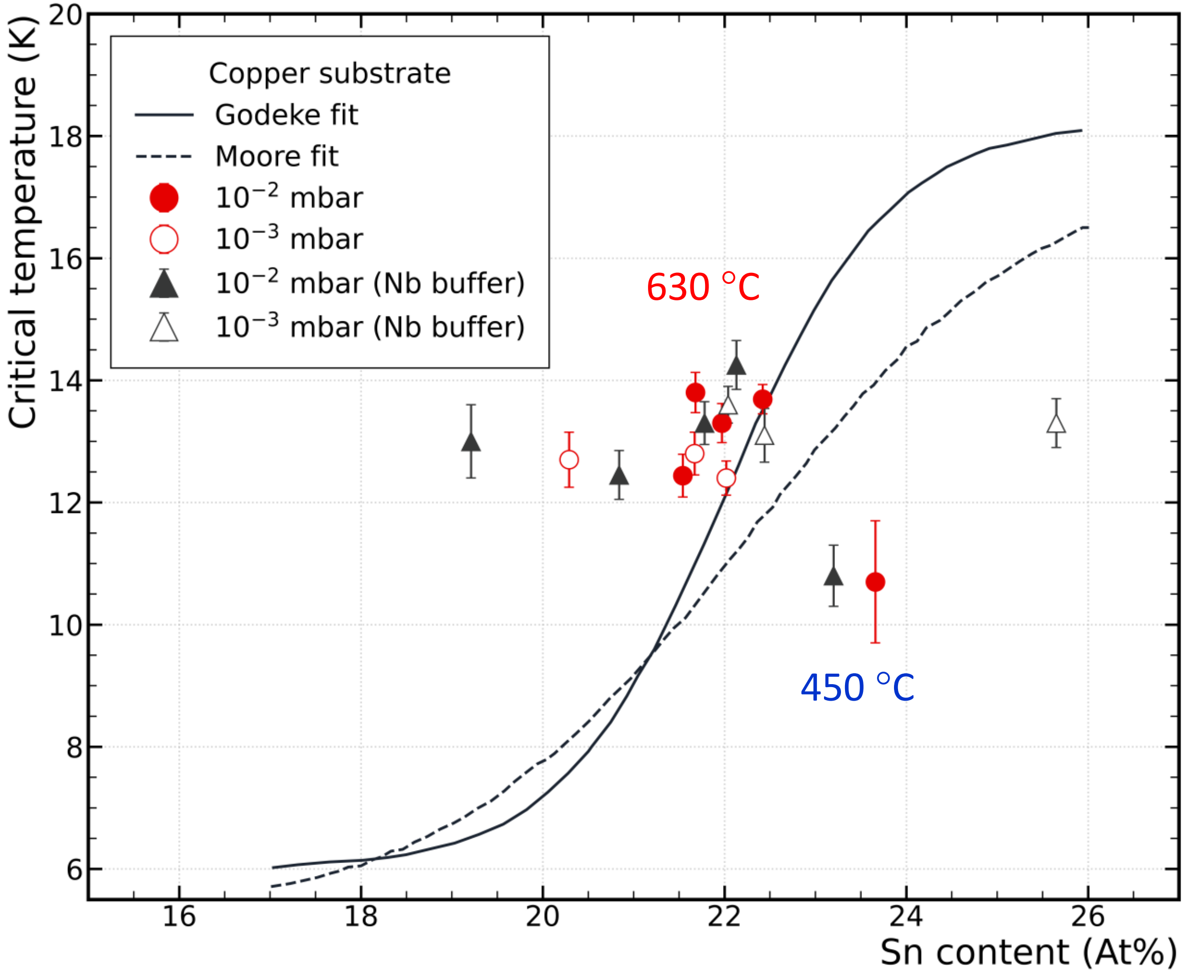
Courtesy by Dorothea Fonnesu, INFN

Main results for Nb_3Sn samples coated at INFN

High power increases tin content



Low T reduce Sn migration?



Courtesy by Dorothea Fonnesu, INFN

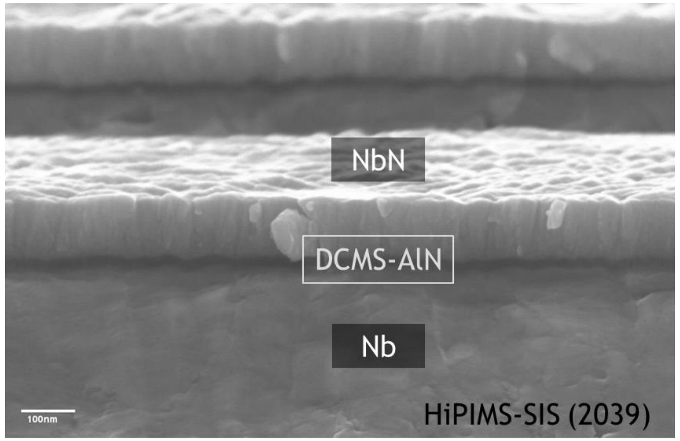
Task 9.3 Part Two:
Planar Samples & QPR deposition

Aim:

- **Optimise deposition parameters for other high T_c superconductor and provide sample for other partners for SRF evaluation of the SRF thin Films**

Why ?

- **Optimisation of films still on going**
- **Alternative surface treatments**
- **Need to assess RF properties (see Task 9.6)**
- **Going from flat sample to complex shaped cavities is not straightforward => intermediate step**



HiPIMS-coated SIS structure on Si

Task 9.3 Part Two:
Planar Samples & QPR deposition

GOAL: Evaluate the effect of planar substrate Cu polishing on RF performance of QPR

Lathe machining

Chemical or Electrochemical Polishing

Nb, NbN and SIS by HiPIMS

Nb, Nb3SN, SIS by DCMS or HiPIMS

Nb thick film by DCMS

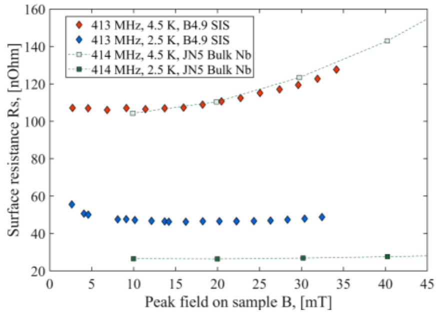
, other partners...

MECHANICAL MACHINING

POLISHING

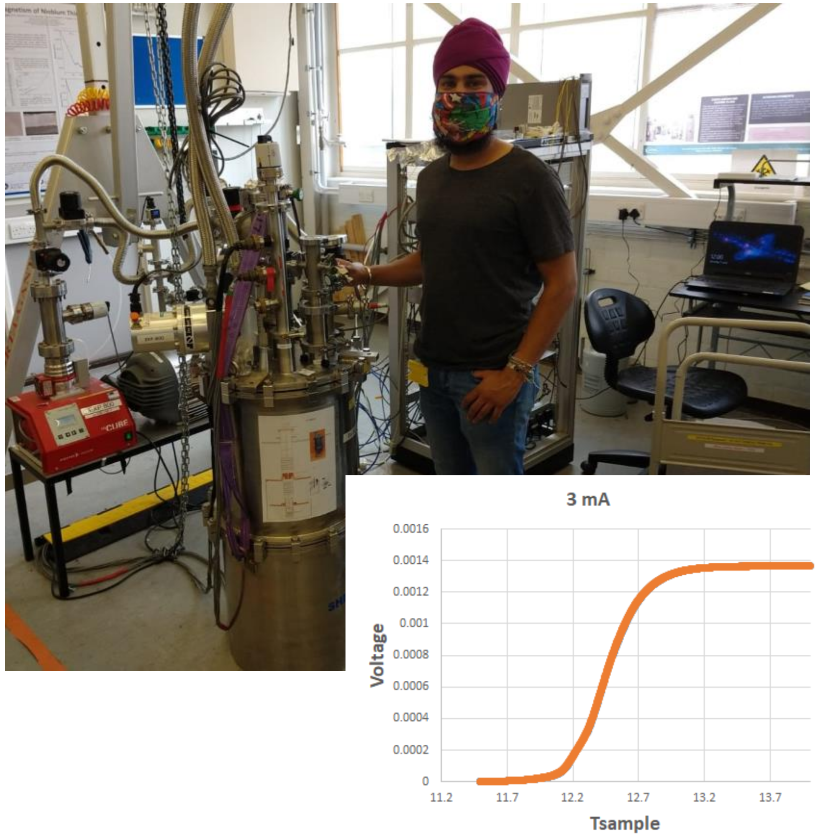
COATING

RF TEST

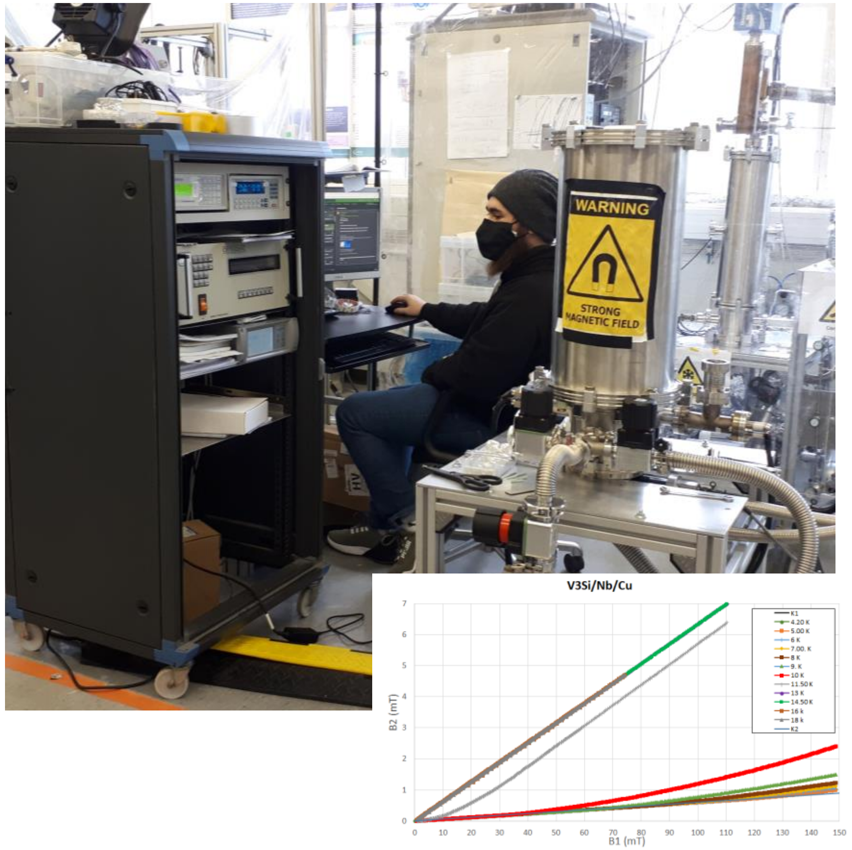


Courtesy of C. Pira (INFN) and E. Chyhyrynets

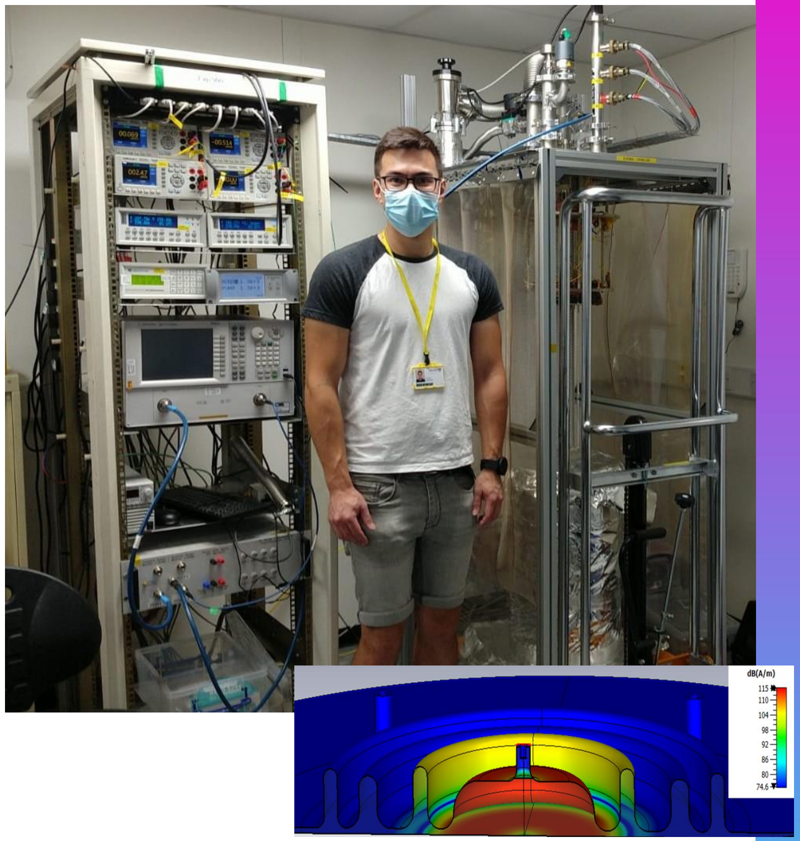
Superconducting Properties Evaluation at UKRI/STFC/CI



EXP800: RRR, Magnetic field penetration
+ 2 other experiments (in-He-gas)



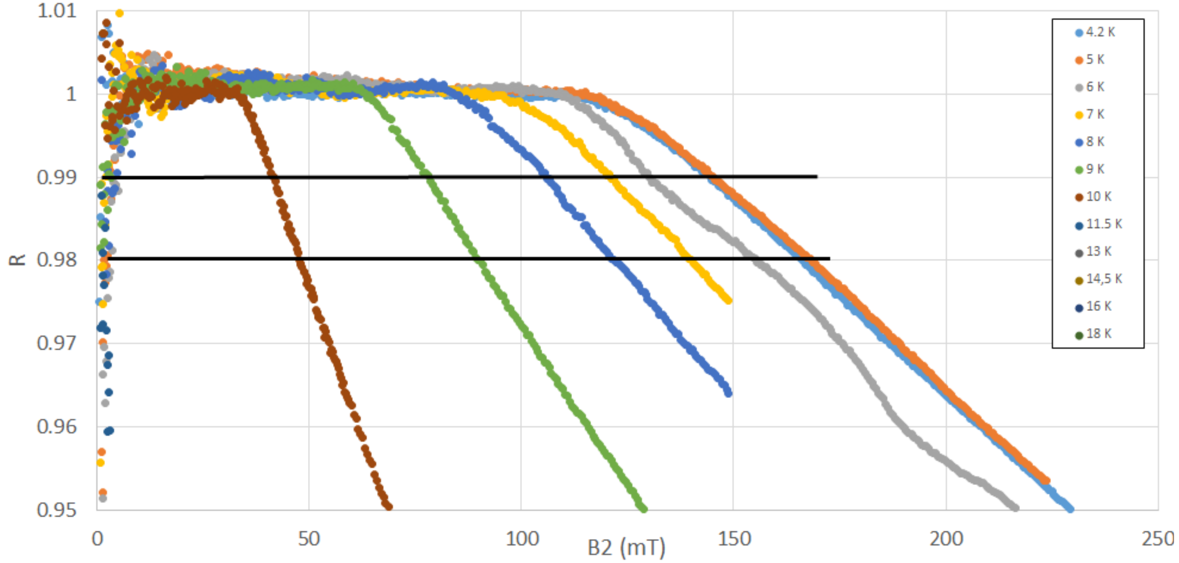
EXP700: Magnetic field penetration facility (in-vacua)



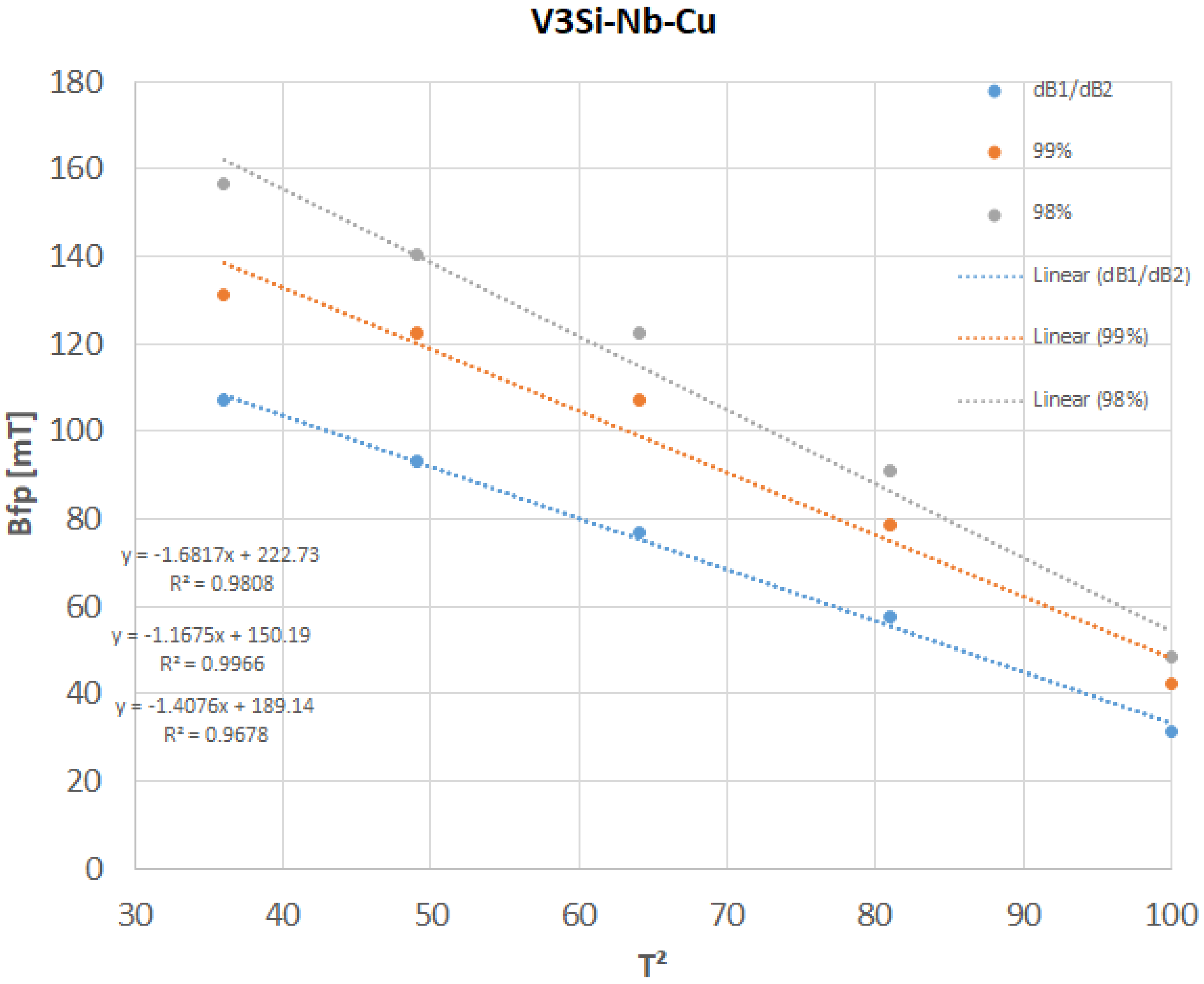
EXP900: R_S measurements with 7.8 GHz cavity

Courtesy of Taaj Sian, UKRI

Typical results for magnetic field penetration for $V_3Si/Nb/Cu$

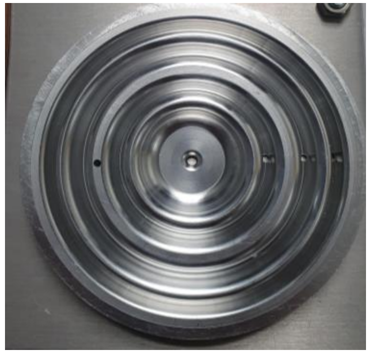


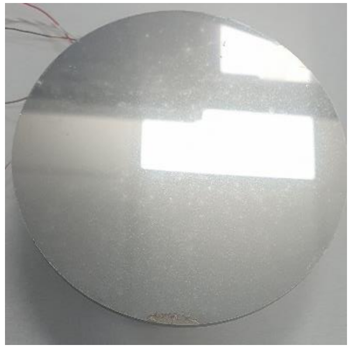
Courtesy of Liam Smith, UKRI

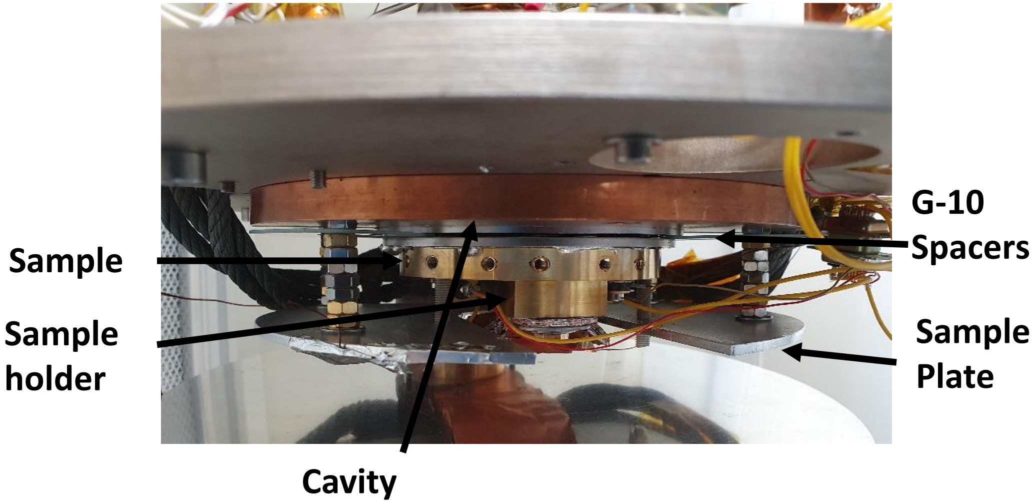


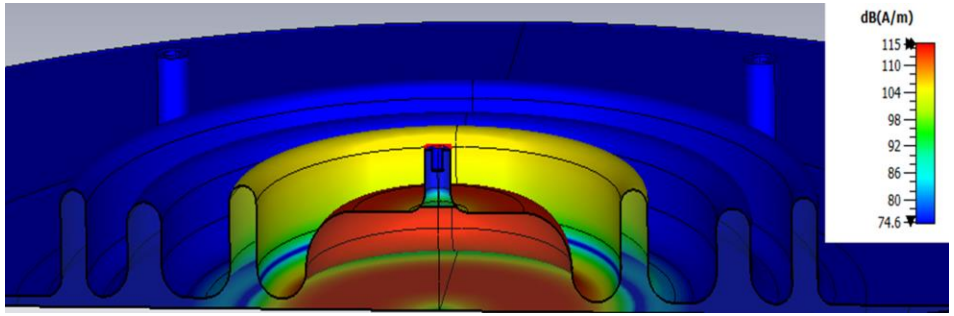
The Choke Cavity Facility

- **Two part test cavity in LHe-free cryostat:**
  - Bulk Nb choke cavity
  - Planar disk - **90 - 130 mm** diameter, **1 – 10 mm** thickness
- **RF-DC compensation →** $R_S\,(T, B)$
- **VNA measurements →** $\Delta f \rightarrow \Delta\lambda$
- **Parameters:**
  - f_0 = 7.8 GHz
  - $T_{\text{Sample}} \geq 4$ K
  - RF Power up to 1 W (for now!)
  - $B_{\text{sample, pk}} \leq 1$ mT









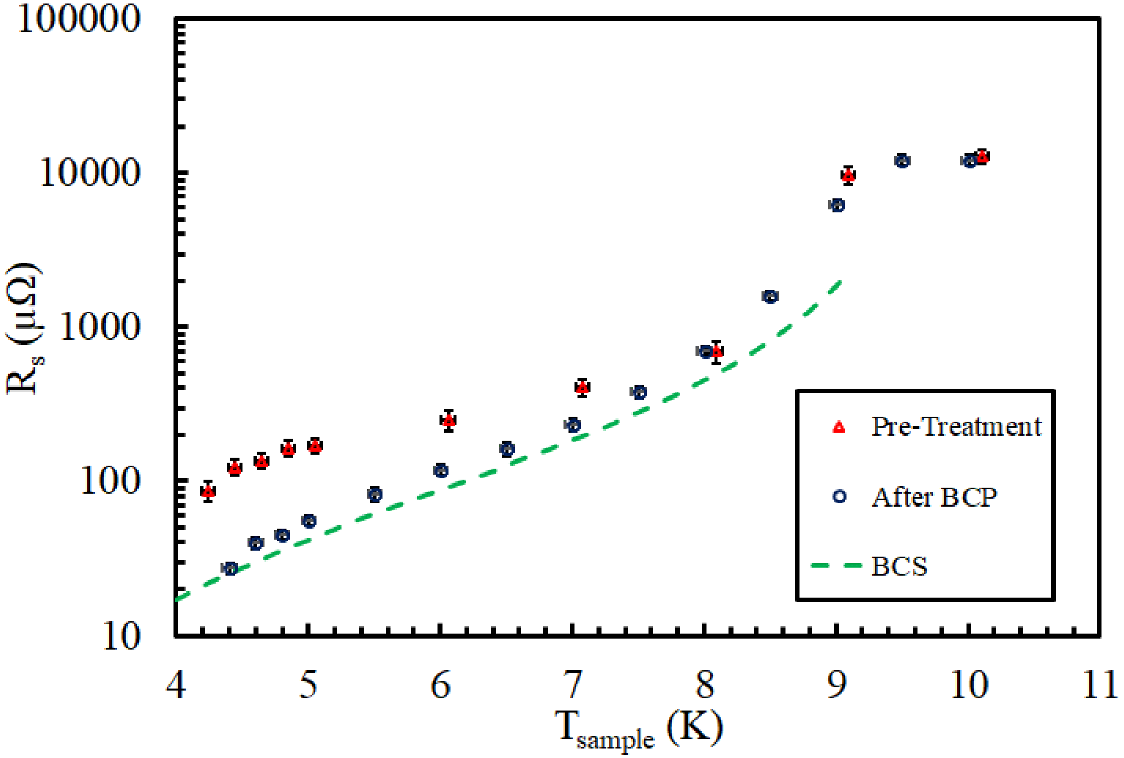
1 sample test $R_s(T)$in 2 days

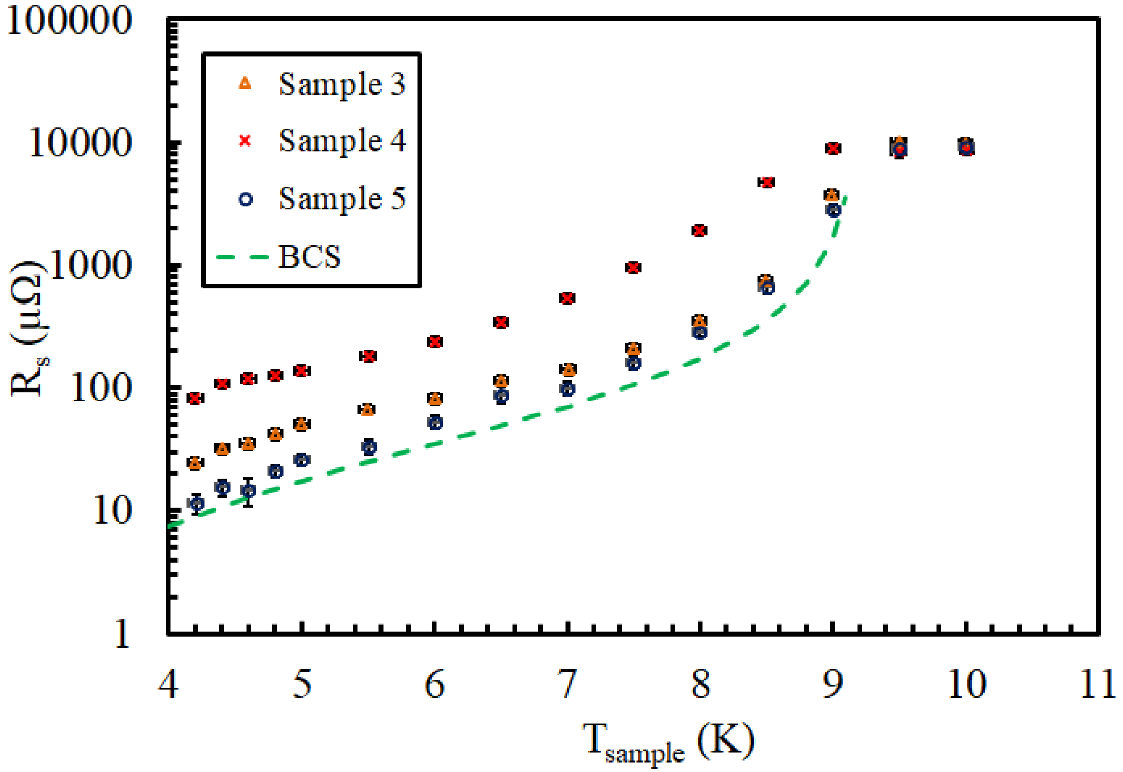
Courtesy by Daniel Seal, Lancaster University

Results with choked cavity

Bulk Nb: : RRR = 300, BCP with 60-100 µm removed
courtesy of E. Chyhyrynets

Nb films: **Sample 3:** 400-450 °C, ~ 3 µm
Sample 4: RT, ~ 3 µm
Sample 5: 300-350 °C, ~ 3 µm

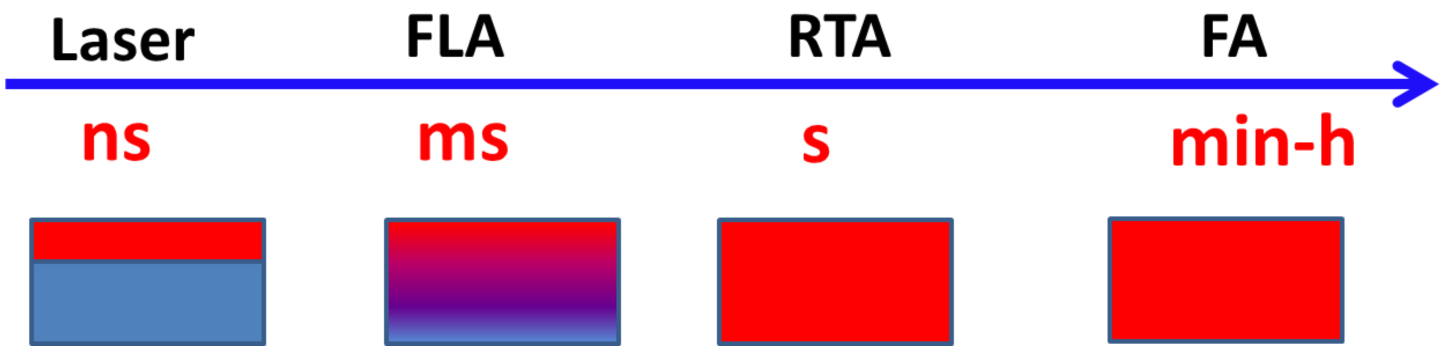


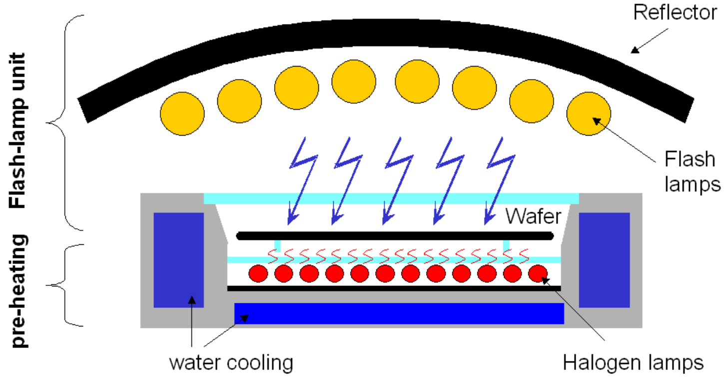


Courtesy by Daniel Seal, Lancaster University

FLA processing of Nb-alloys at HZDR

Issued from semiconductor industry





Samples:

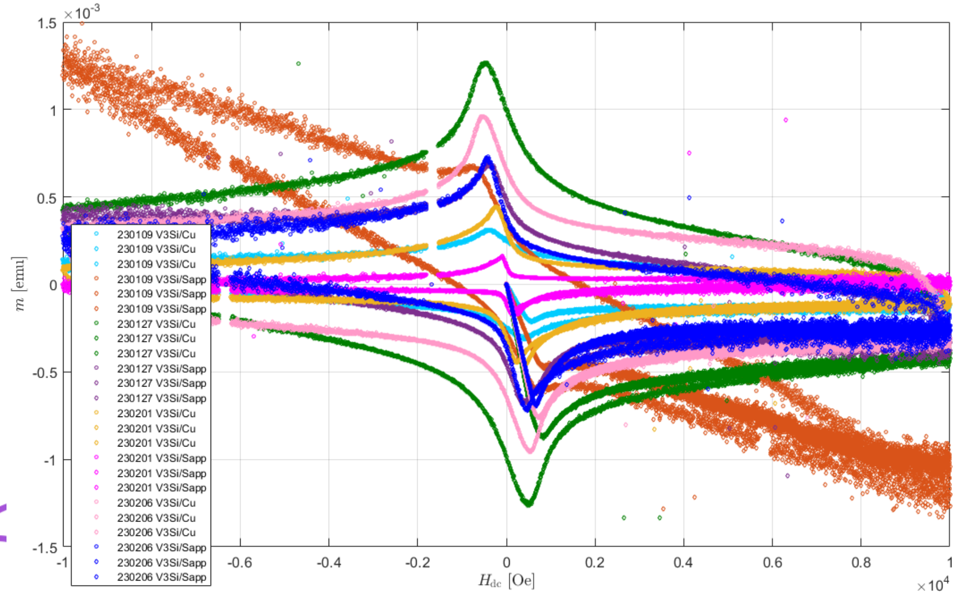
- **Nb, Nb/NbTiN from UKRI: FLA 3.2 ms at 4.0 kV**
  - ➢ -10 to 40% increase in B_{c1}
- **Si/AlN/NbTiN from CEA: FLA 3, 6 and 23 ms**
  - ➢ T_c increase from 5 to 14.5 K
- **Cu/Nb_3Sn from INFN $\Rightarrow$**
  - ➢ results to be reported soon

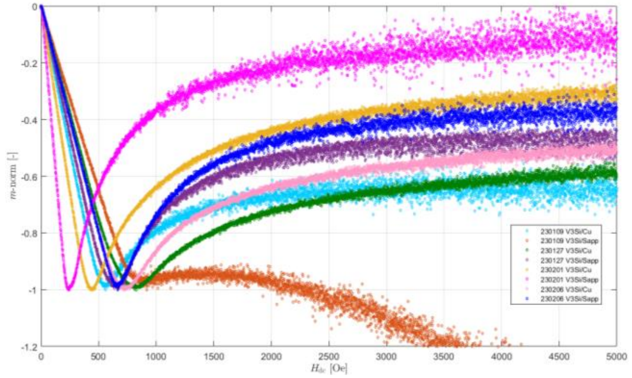
Superconducting Properties Evaluation at IEE

Samples from UKRI:

- **Nb:**
  - **laser treated at RTU:**
    - **in N_2**
    - **in Ar**
- **V_3Si films on Cu and Sapphire substrates**

	Sample	Ben [Oe] (2% crit. at 4.22 K) Perpend	 Parallel	Tc [K]
Nb / Cu	0_Non_irr		240	9.25
	1_Atm_Laser_max		90	9.15
Arturs RTU	2_Atm_Laser_min		310	9.1
3.2.2023 series	3_Argon_Laser_max		-	7 ?
	4_Argon_Laser_min		-	7 ?
V3Si	230109_Cu		190	12.8
Substrates: Cu, Sapphire	230109_Sapp		610	14
	230127_Cu		510	13
STFC	230127_Sapp		470	11.5
16-03-23	230201_Cu		330	10.5
	230201_Sapp		200	8.2
	230206_Cu		530	12.5
	230206_Sapp		580	11.5





Courtesy of Eugen Seiler, IEE

Task 9.4:Surface engineering by atomic layer deposition (ALD)

Task Leader: Thomas Proslier(CEA)

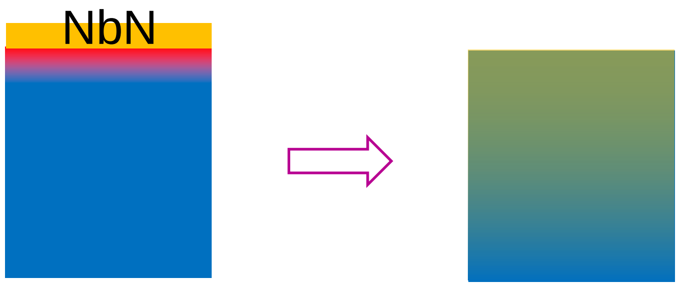
Aim:

- **Deposition of functionalized layers :**
  - **Low secondary yield cap layer (↓ multipacting)**
  - **SIS multilayers**
  - **Dielectric surface engineering and doping**
- **Development of a 1.3 GHz deposition set-up**

Why ?

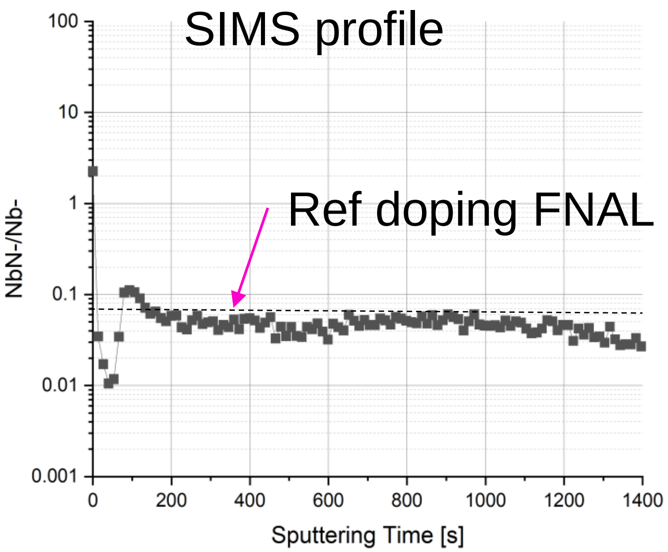
- **ALD = highly conformational => adapted to complex shapes**
- **Chemical technique => wide range of compounds manageable in the same deposition set-up**
- **Can be used to upgrade Bulk Nb cavities**

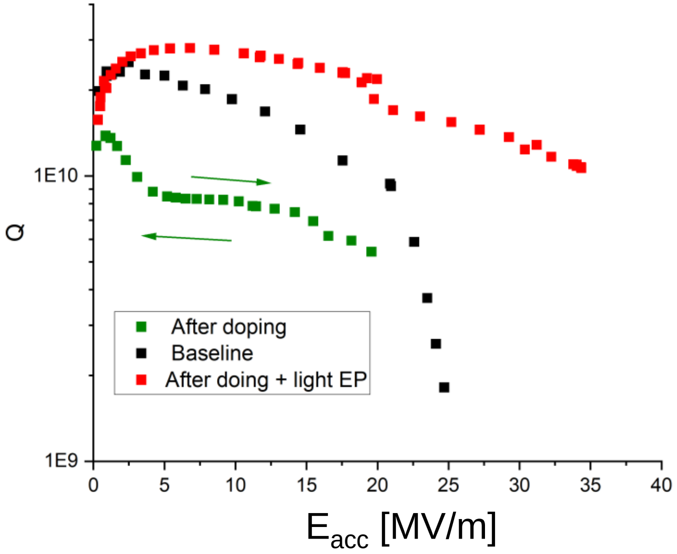
Doping by ALD

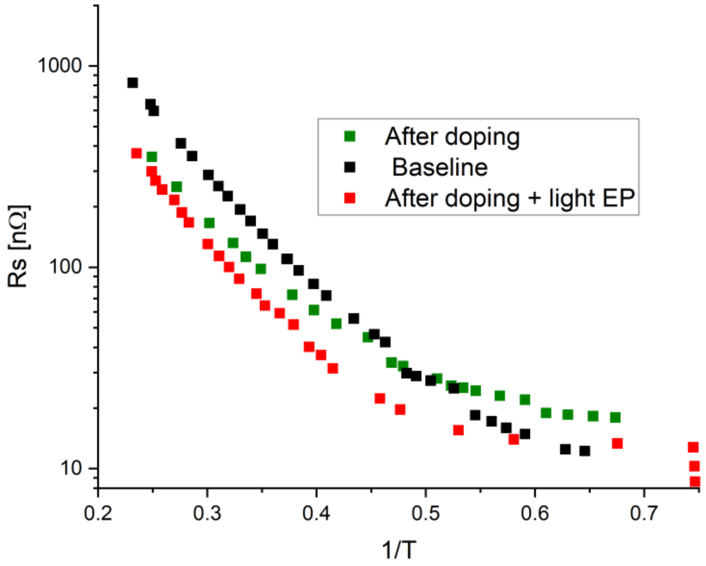


Doping Nb with N:

- ALD of NbN 5 nm + post annealing at 900°C for 3hrs

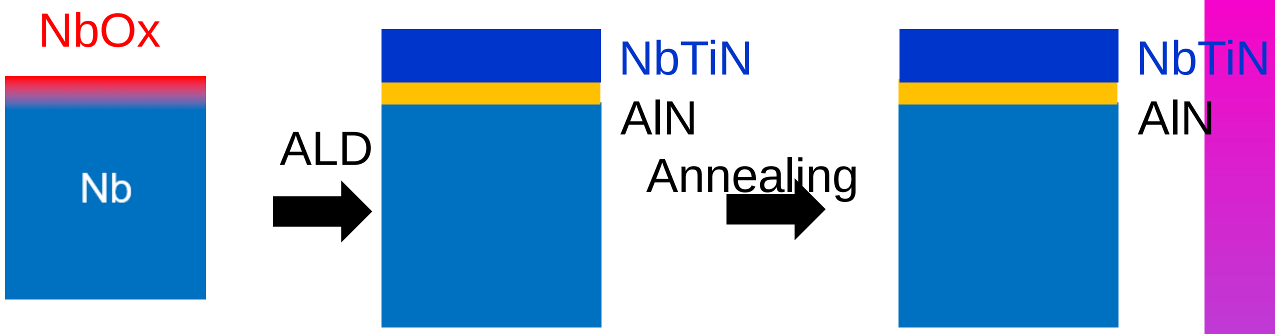




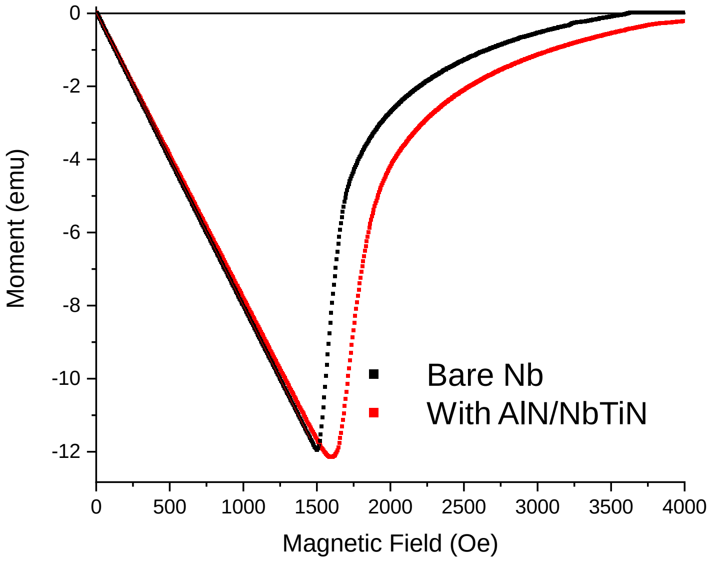


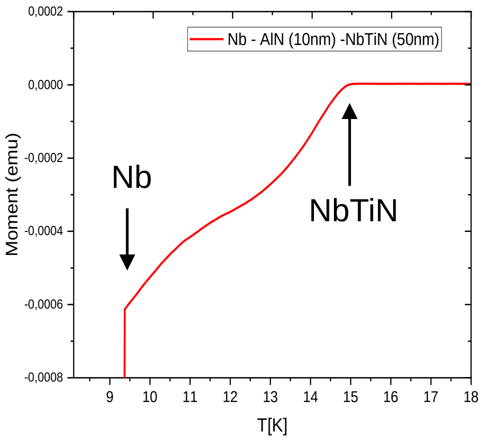
- N Doping profile by SIMS similar to reference recipe from FNAL.
  - Better quality factor at 4,2K but reduced performance at 2K as compare to baseline.
  - Possibility to tune surface dopant and oxide protective layer by trying other ALD layers: TiN etc…

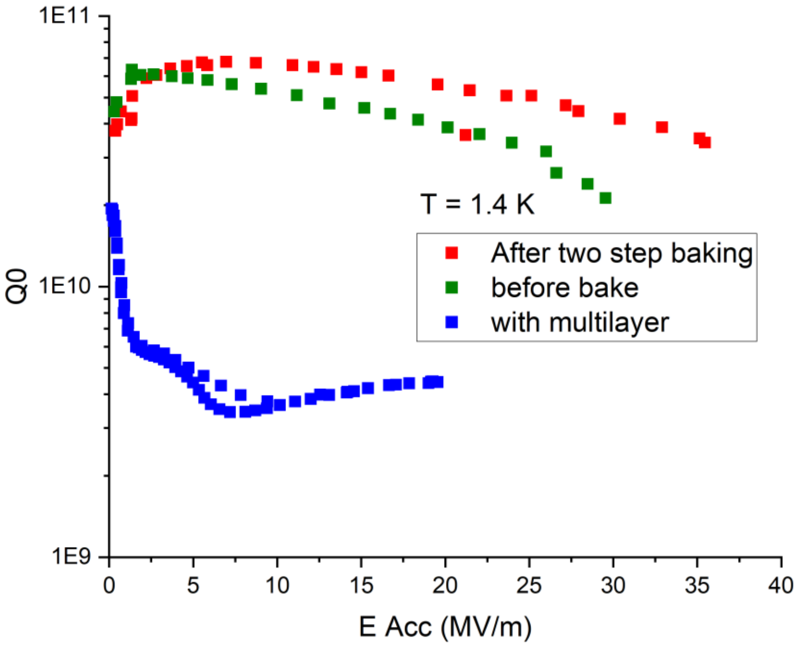
Multilayers

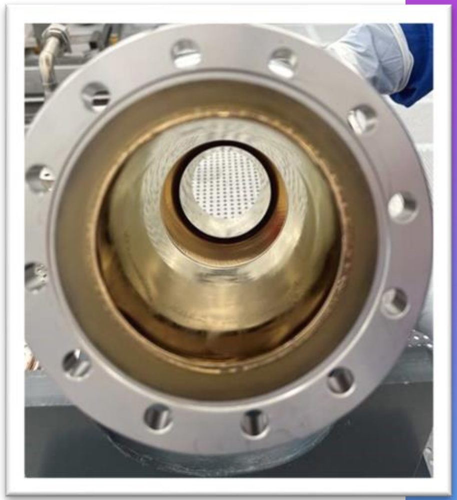


VSM on Nb Ellipsoid with ALD of AlN(10nm)/NbTiN(50nm)









- Increased penetration field with AlN/NbTiN multilayer on Nb.
- First deposition on a cavity – coating successfull (but unexpected delamination in the beamtubes during the post annealing).
- Recovery of good performances after EP and HPR.
- Work in progress: currently limited HR ressources in clean rooms and LHe for RF test.

Task 9.4 results summary

- Atomic Layer deposition strength is its scalable capability: from bench to industrial scale (coupons to cavities and much more high aspect ratio and large surface objects).

Achievement within IFAST Task 9.4:

- Control and reduction by ALD of the secondary electron yield and the resulting multipacting mitigation.
- Control and optimisation of the superconducting multilayer properties by ALD (Tc =15 K).
- Homogeneous deposition and multilayer properties on Nb and Cu 1.3 GHz cavities.
- Compatible with cavity surface treatments (stability after HPR, thermal treatments…)
- New doping approach and dielectric layer engineering by ALD.

Task 9.5: Improvement of mechanical and superconducting properties of RF resonator by laser radiation

Task Leader: Arturs Medvids (RTU)

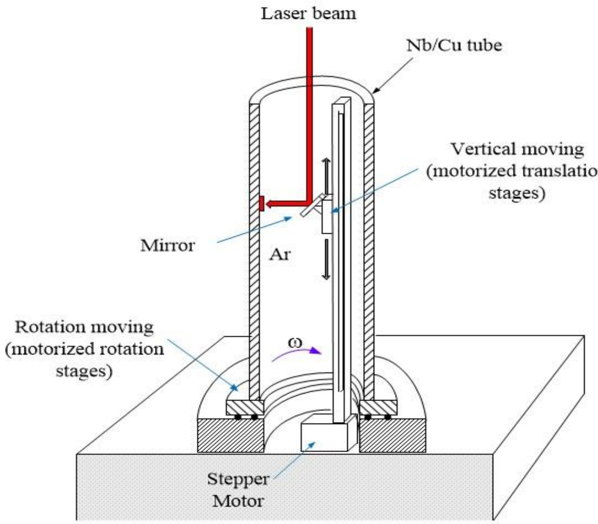
Aim:

- **Pre-and Post-surface Laser treatment**
  - **On copper, to improve film deposition**
  - **On deposited films, to improve their crystalline quality**

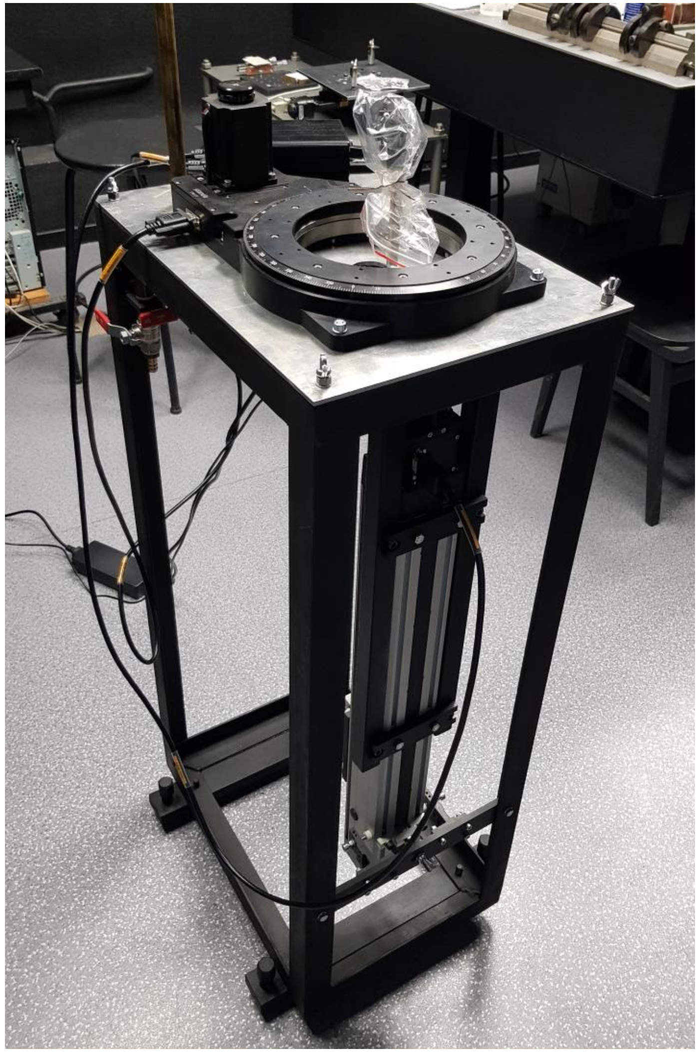
Why ?

- **Smoothing of surfaces**
- **Recrystallization**
- **Decreasing porosities**

The laser facility for irradiation inner surface of RF cavity



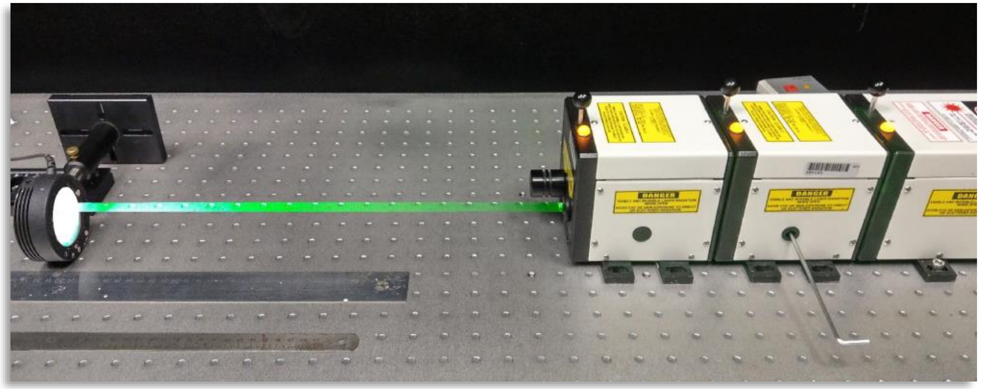
Laser facility:
L=450mm, D=250mm,
Ar gas atmosphere
1.5 atm pressure.



Scanning system for cylindrical copper tubes Nd:YAG laser.

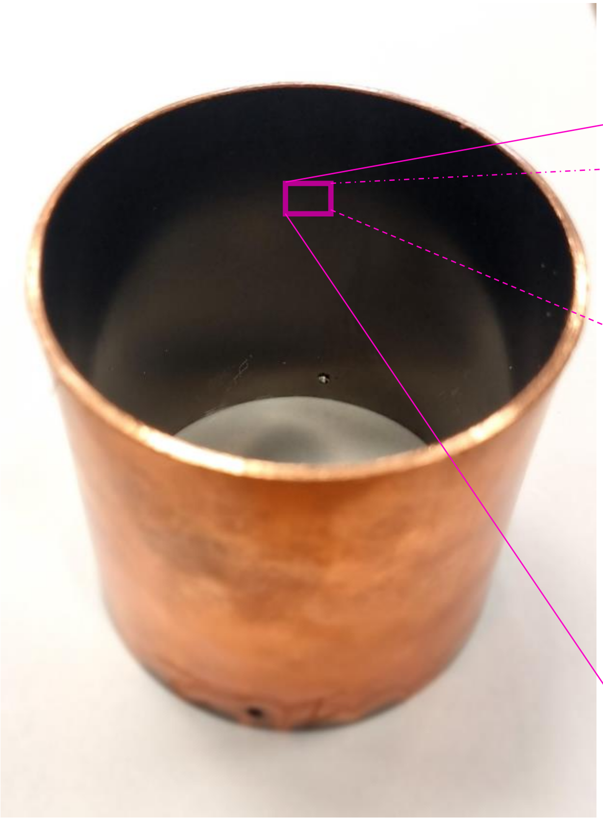
Nanosecond Nd:YAG laser,

- wavelength 1064 nm,
- pulse duration 6 ns,
- repetition rate of 10 Hz
- beam diameter of 0.5 mm.
- Scanning of the laser beam was performed normally to the surface with a speed of 1.2 mm/s and hatch of 0.4 mm.
- The irradiation of the samples was carried out at room temperature in Ar chamber to prevent oxidation.

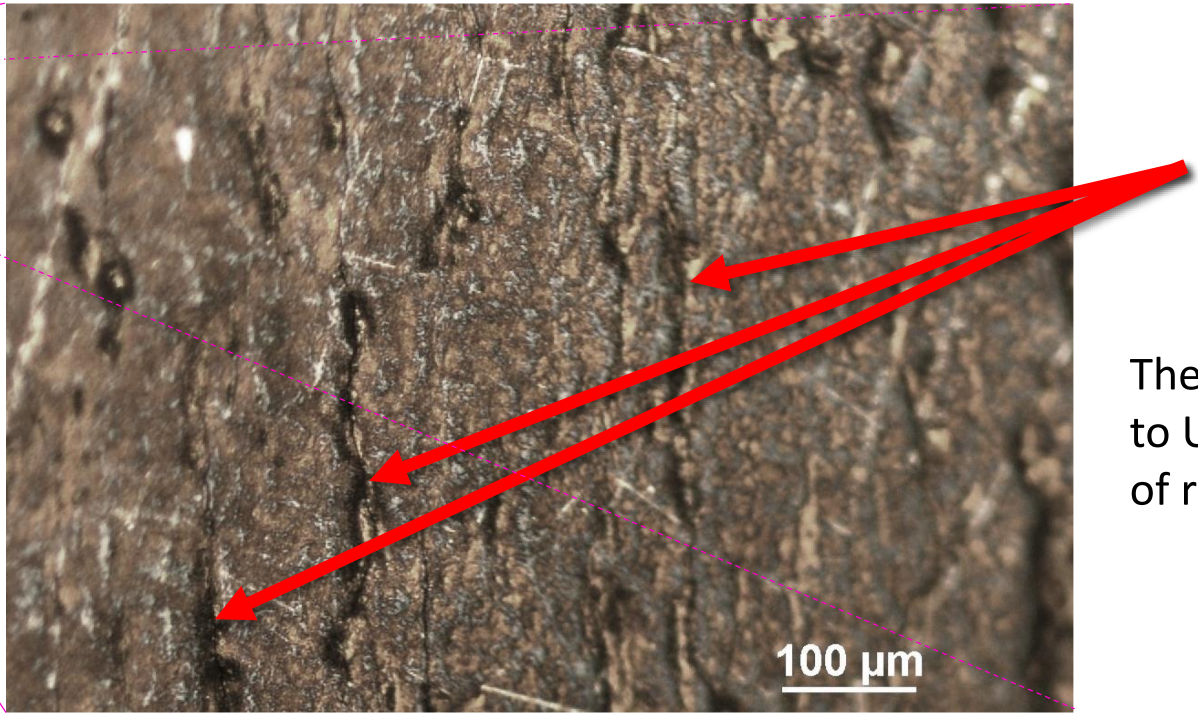


Applying laser on Nb coated tube

Optical microscope image

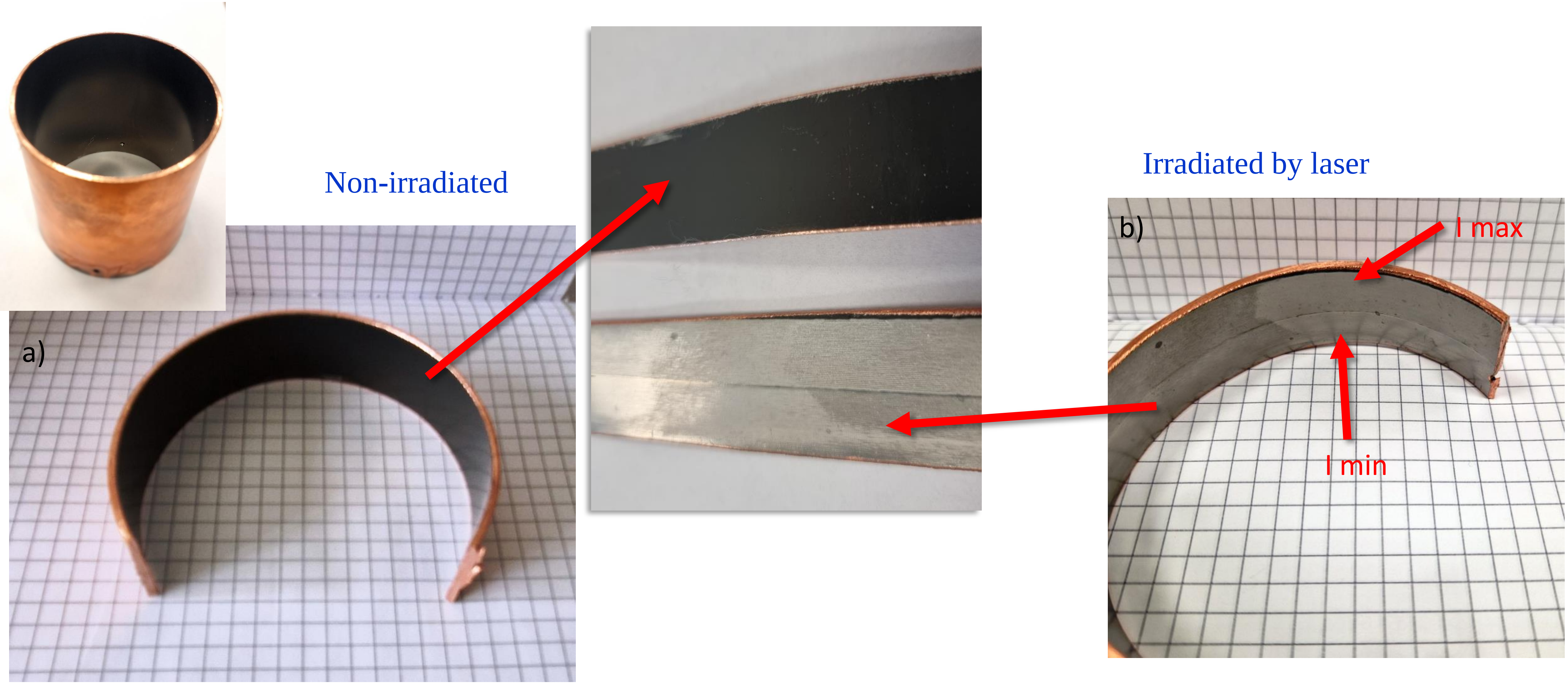


Nb coated OFHC copper tube



Optical microscope image of the surface of a cylindrical copper tube with a thin film of niobium (Nb) before laser processing.

The samples were sent back to UKRI for determination of reasons of cracks.



Non-irradiated

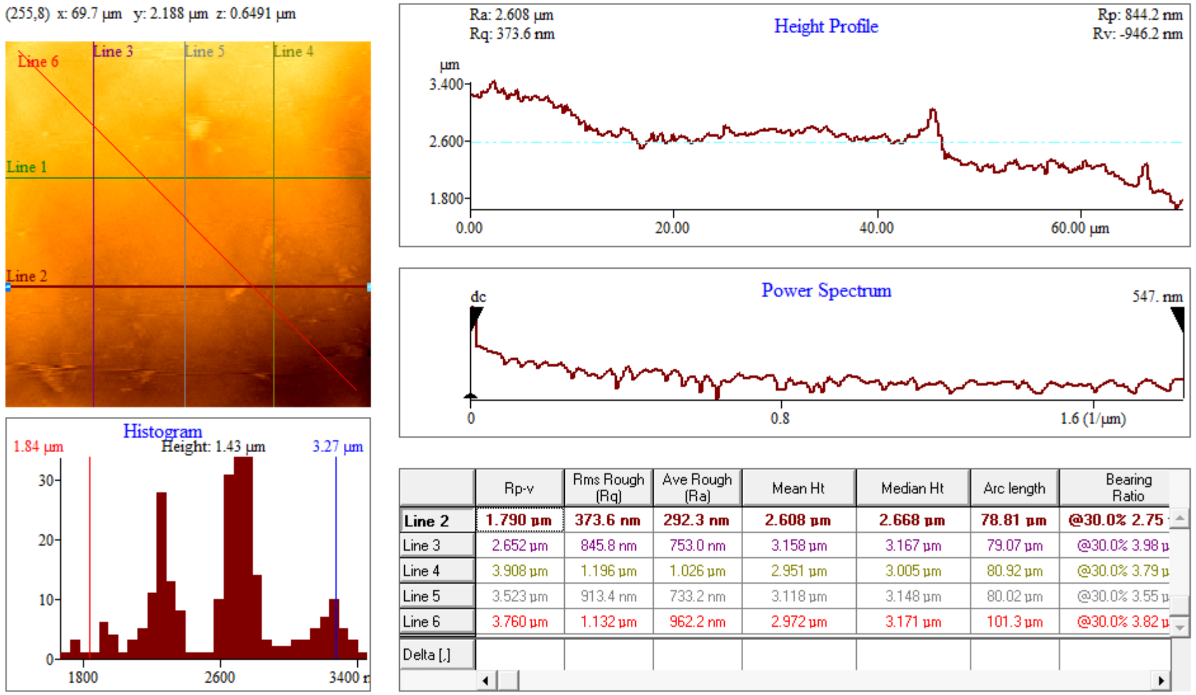
Irradiated by laser

Fig.5. Samples formed from cylindrical copper tube with Nb film: (a) non-irradiated; (b) irradiated in Ar chamber by ns laser radiation.

References:

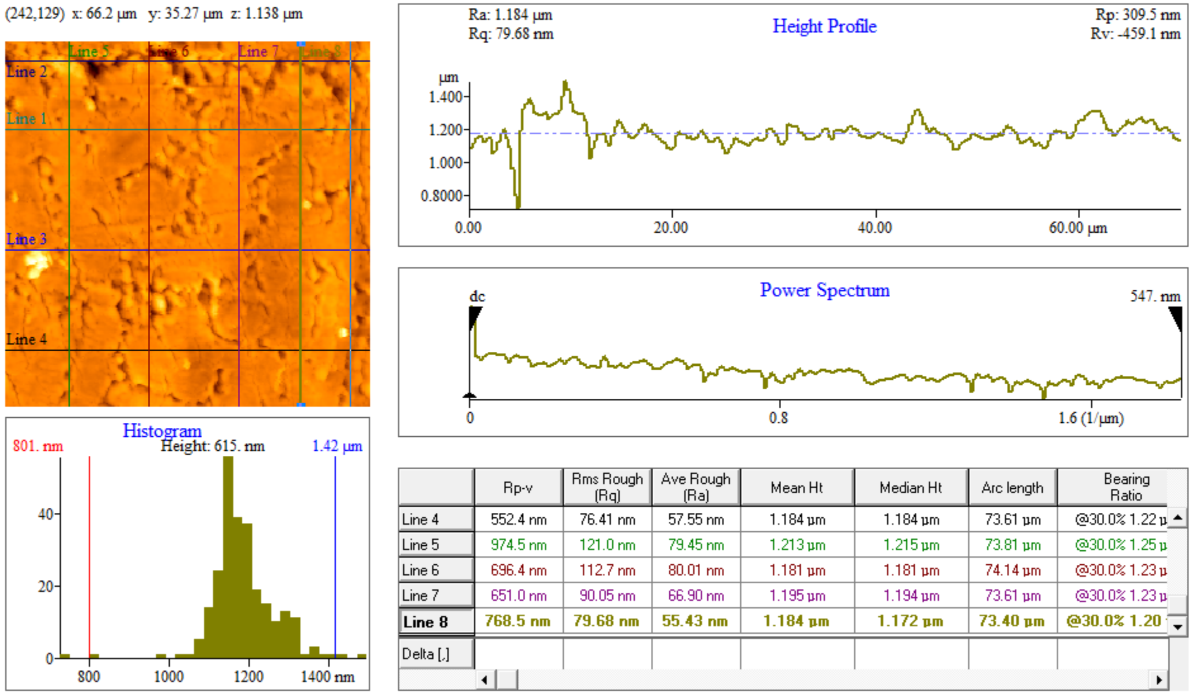
1. C. K. Gupta, A. K. Suri, S Gupta, K Gupta (1994), *Extractive Metallurgy of Niobium*, CRC Press, ISBN 0-8493-6071-4

Non irradiated surface texture parameters



	Rp-v	Rms Rough (Rq)	Ave Rough (Ra)	Mean Ht	Median Ht	Arc length	Bearing Ratio
Line 2	**1.790 µm**	**373.6 nm**	**292.3 nm**	**2.608 µm**	**2.668 µm**	**78.81 µm**	**@30.0% 2.75**
Line 3	2.652 µm	845.8 nm	753.0 nm	3.158 µm	3.167 µm	79.07 µm	@30.0% 3.98
Line 4	3.908 µm	1.196 µm	1.026 µm	2.951 µm	3.005 µm	80.92 µm	@30.0% 3.79
Line 5	3.523 µm	913.4 nm	733.2 nm	3.118 µm	3.148 µm	80.02 µm	@30.0% 3.55
Line 6	3.760 µm	1.132 µm	962.2 nm	2.972 µm	3.171 µm	101.3 µm	@30.0% 3.82
Delta [,]							

Irradiated surface texture parameters



	Rp-v	Rms Rough (Rq)	Ave Rough (Ra)	Mean Ht	Median Ht	Arc length	Bearing Ratio
Line 4	552.4 nm	76.41 nm	57.55 nm	1.184 µm	1.184 µm	73.61 µm	@30.0% 1.22
Line 5	974.5 nm	121.0 nm	79.45 nm	1.213 µm	1.215 µm	73.81 µm	@30.0% 1.25
Line 6	696.4 nm	112.7 nm	80.01 nm	1.181 µm	1.181 µm	74.14 µm	@30.0% 1.23
Line 7	651.0 nm	90.05 nm	66.90 nm	1.195 µm	1.194 µm	73.61 µm	@30.0% 1.23
Line 8	**768.5 nm**	**79.68 nm**	**55.43 nm**	**1.184 µm**	**1.172 µm**	**73.40 µm**	**@30.0% 1.20**
Delta [,]							

1. The cylindrical copper tubes with Nb were effectively scanned using laser radiation in an Ar chamber.
2. X-ray diffraction (XRD) analysis showed that there were no traces of niobium oxide present in either the non-irradiated or irradiated samples treated with the Nd:YAG laser.
3. The irradiated samples' surface roughness (Ra) decreased by more than ten times compared to the non-irradiated samples.
4. The number of cracks on the irradiated samples increased, they became smaller in size after laser processing.

Task 9.6:Optimization of flat SRF thin films production procedure

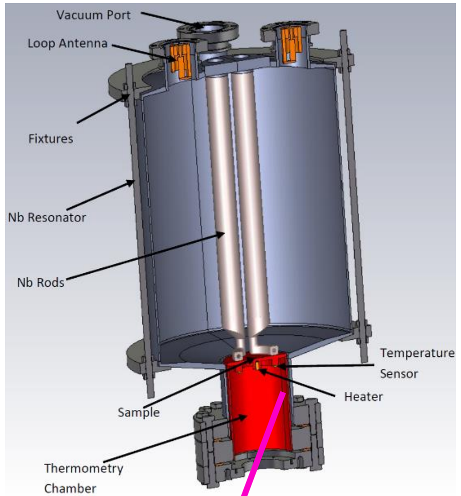
Task Leader: Oliver Kugeler (HZB)

Aim:

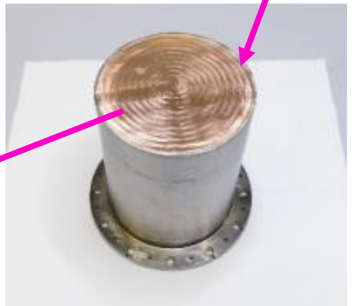
- **RF testing of the films developped throughout the WP9**
  - **Sample is small enough for easy handling**
  - **Smaple is flat (one problem less in the way)**
  - **3 ≠ frequencies available : large exploration (R_{BCS} vs R_{res}**

Why ?

- **Material characterization, even advanced are still not predictive of future RF behavior**



QPR



Flat sample for RF testing

Task 9.6: Optimization of flat SRF thin films production procedure

Lathe machining

Chemical or Electrochemical Polishing

Nb, NbN and SIS by HiPIMS

Nb, Nb3SN, SIS by DCMS or HiPIMS

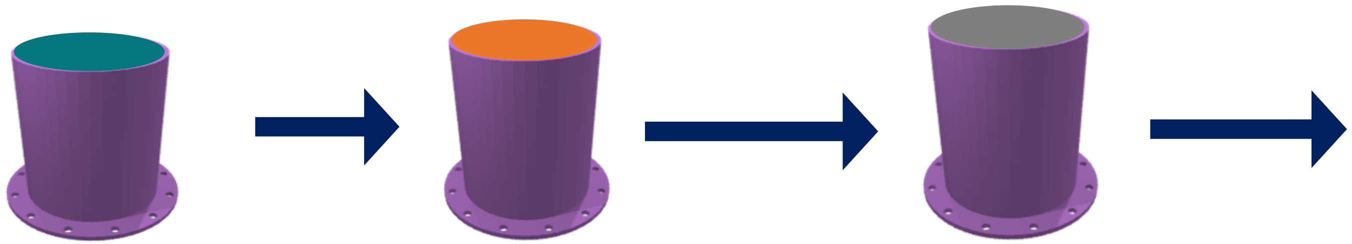
Nb thick film by DCMS

, , other partners...

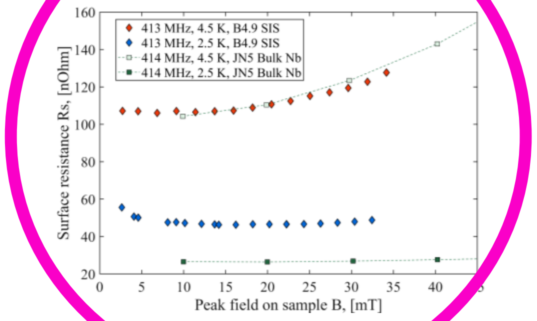
MECHANICAL MACHINING

POLISHING

COATING

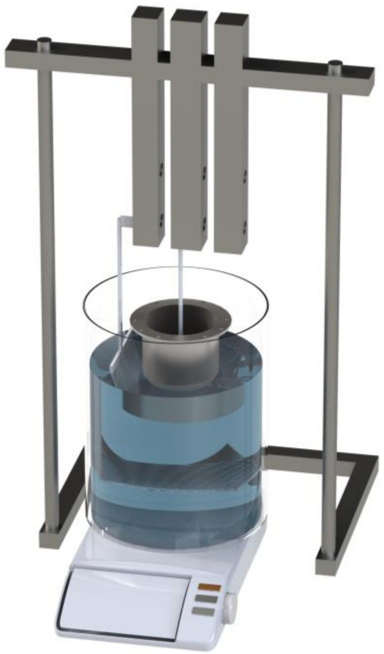


RF TEST

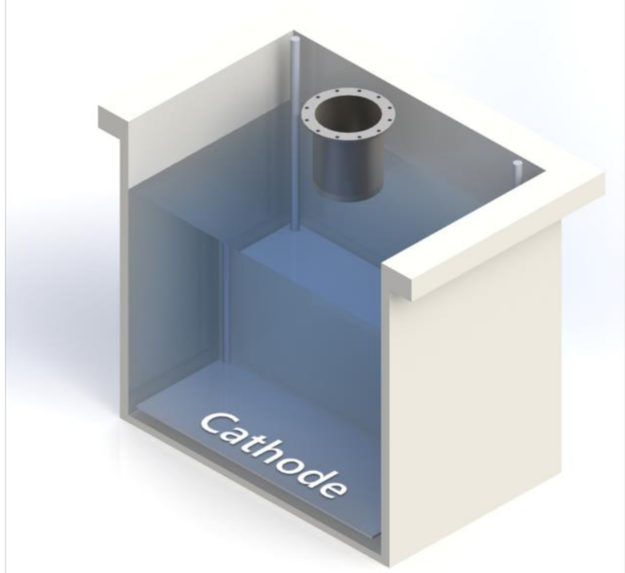


Courtesy of C. Pira (INFN) and E. Chyhyrynets

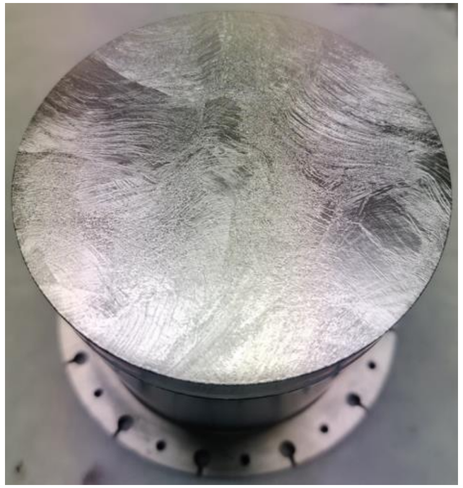
Plasma electropolishing on QPR samples @ INFN



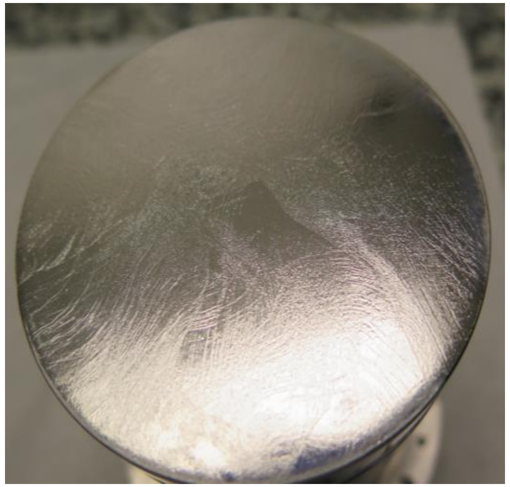
Old system



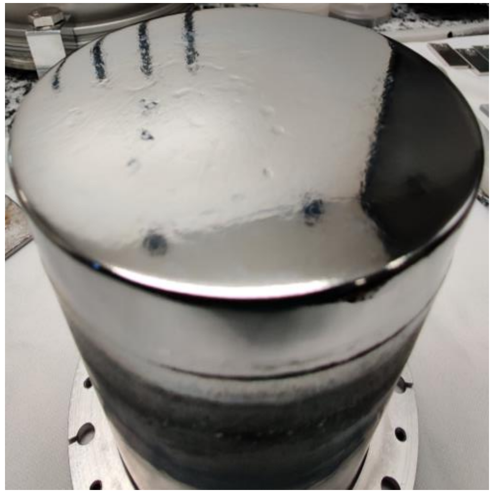
Upgraded system
- Larger volume
- More stable temperature
- More stable current



Initial Nb QPR sample



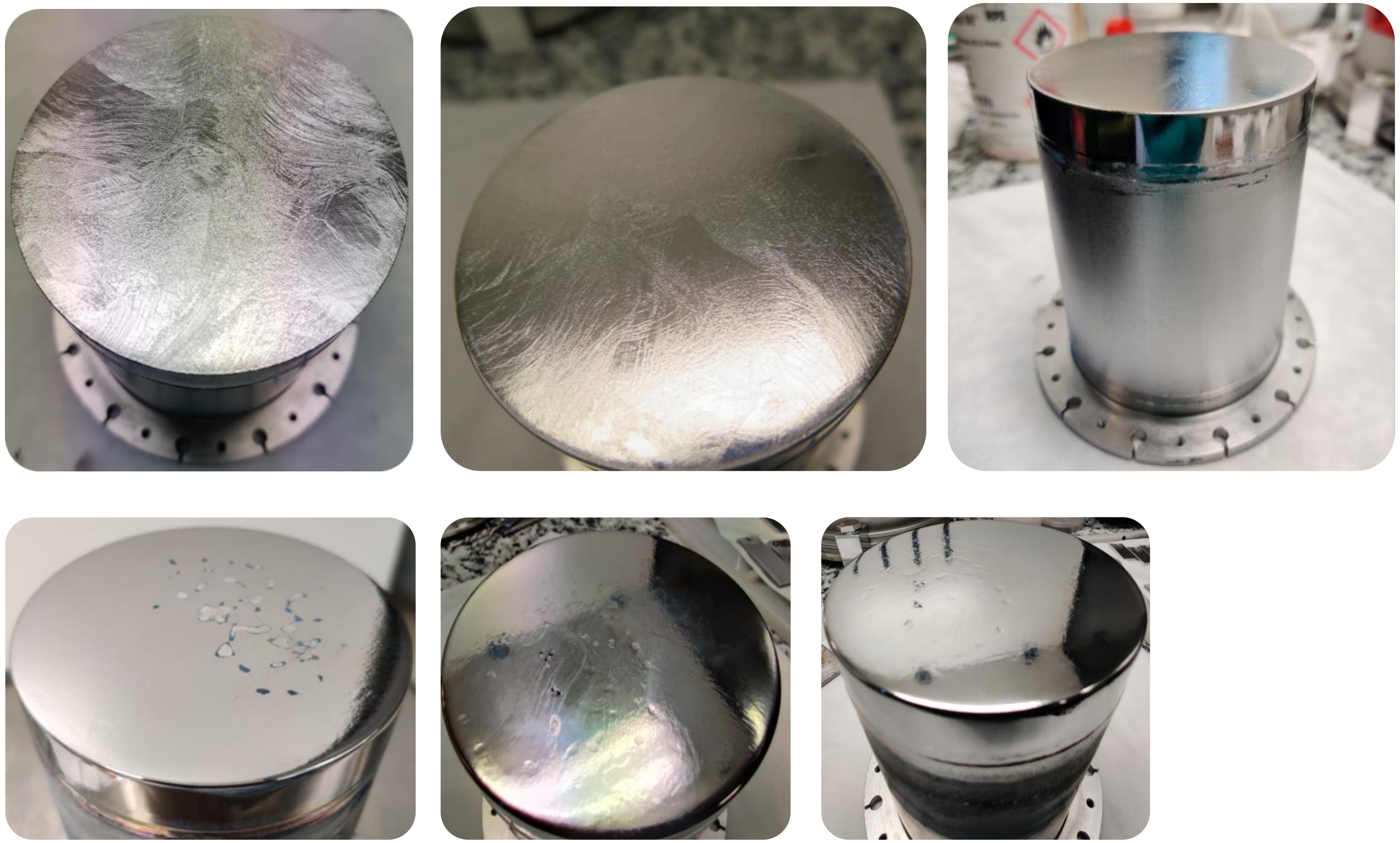
Surface improvement after 10 min



100-µm removal in 60 min.
Mirror finish

Polishing QPR samples @ INFN

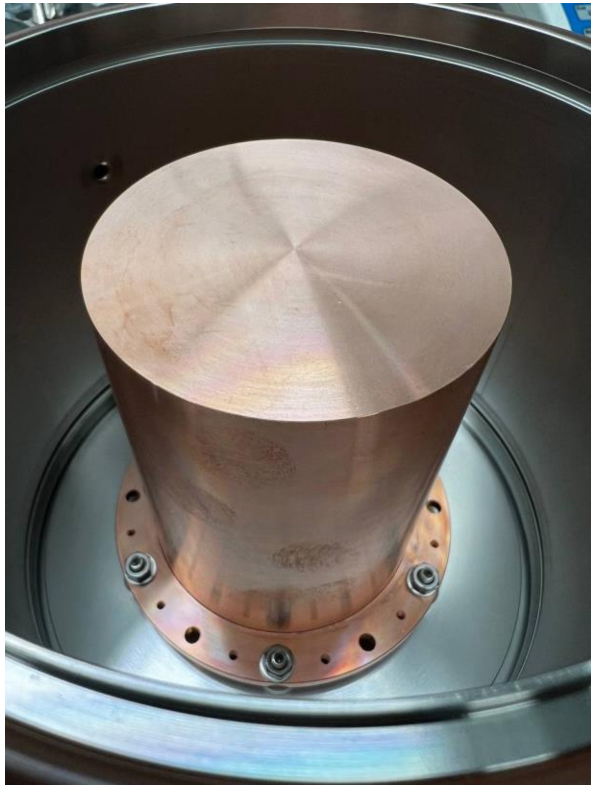
A1 Nb



C1 Cu

Cleaning

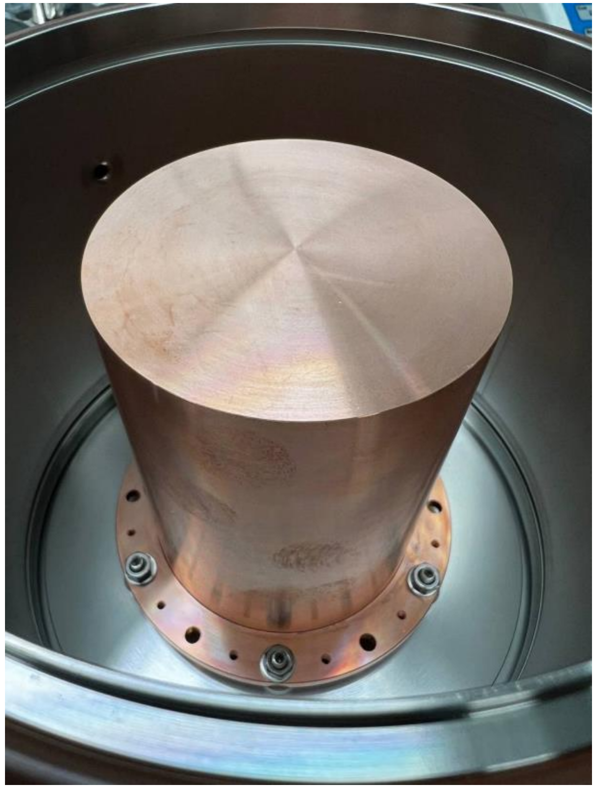
1. PEP disk + 3 cm
2. Bulk QPR SUBU



Courtesy of Eduard Chyhyrynets, INFN

RF-performance measurements of films with QPR

- Decision to use **bulk copper QPR sample** instead of brazed Cu/Nb samples as used in ARIES
- First Copper Sample C1 manufactured at HZB and shipped to INFN Legnaro for cleaning.
- Next step will be: Nb coating at Siegen University (for minimisation of unwanted sample RF-heating) and subsequent coating with SIS structure.



Courtesy of Oliver Kugeler, HZB

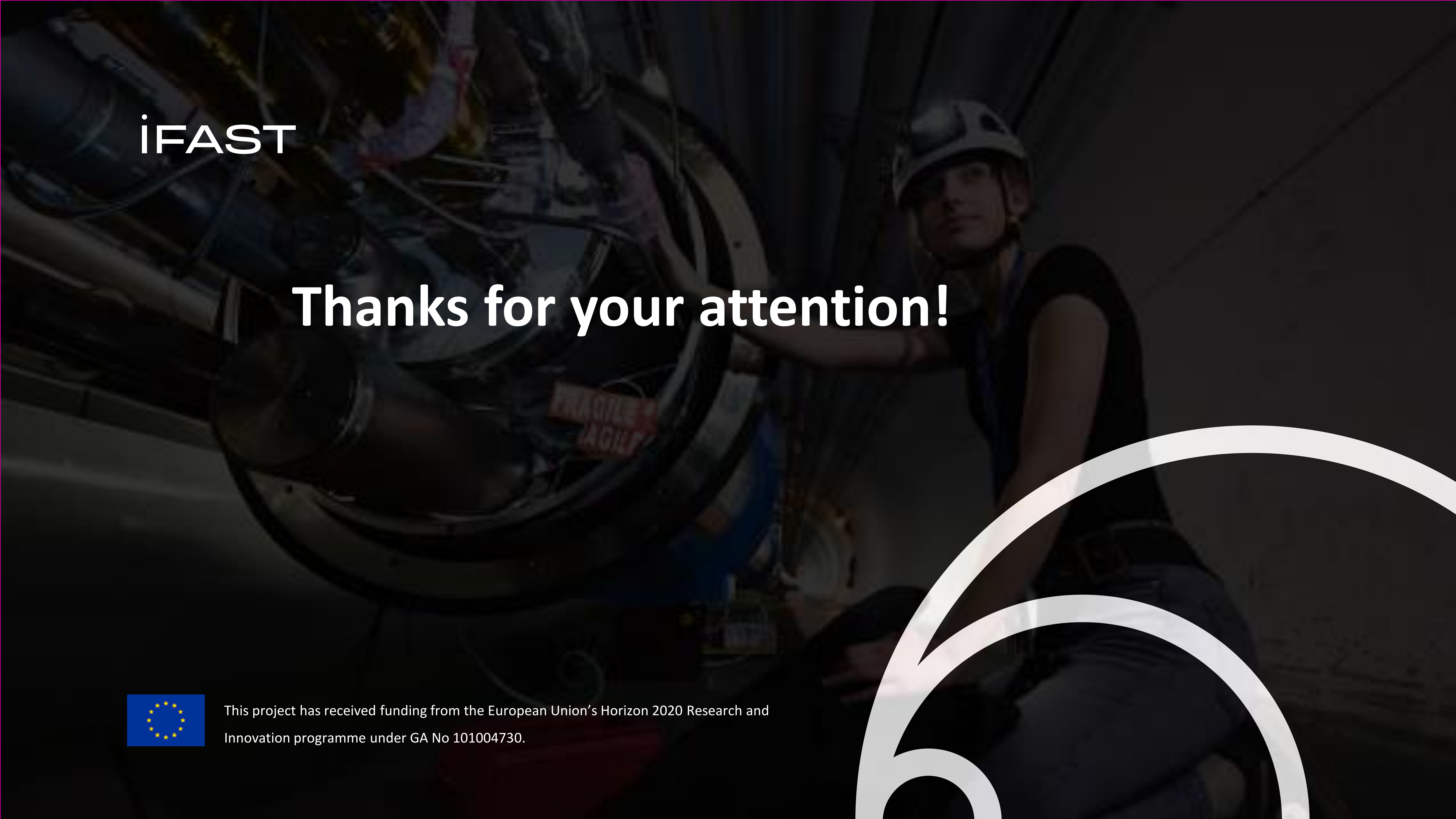
Bulk Nb QPR samples – scheduled for future

- One Nb bulk QPR sample was cleaned at Saclay and is currently scheduled for baseline testing in the QPR in CW 20.
  - This sample will then be shipped to Daresbury for coating with suitable SIS structure and subsequent RF characterisation with QPR at HZB
- Two more Nb samples are currently scheduled for baseline surface preparation at Saclay for further processing (tbd)
- One Nb bulk sample was baseline-tested in the QPR at HZB and then shipped back to Saclay for coating with an insulator layer by ALD. The impact of the passivation coating on the baseline performance will be measured in the QPR at HZB

Courtesy of Oliver Kugeler, HZB

CONCLUSIONs

- → Things are going according to IFAST WP9 plan
- →4 milestones already achieved.



iFAST

Thanks for your attention!

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