



WP3: Nb₃Sn on Cu films for 4.2K cavity operation

INFN, CEA, HZB, UKRI

Convener: Cristian Pira (INFN), Deputy O. Malyshev (UKRI)

Main contacts with other partners:

T. Proslier (CEA), O.Kugeler (HZB), O. Malyshev (UKRI), R. Valizadeh (UKRI)

Task 3.1: Coordination of R&D on SC Cavities – M1-M48

- General coordination by INFN.

Task 3.2: Flux Trapping – M1-M32

- Explore new coating parameters for planar samples and small resonators to minimize flux trapping in SC A15 films.
- Upgrade the STFC choke cavity and the HZB QPR to support detailed flux trapping analyses of coated SC films.
- Characterize trapped flux, flux viscosity and the interaction with the RF field with SC A15 films in small resonators and planar samples with the upgraded systems.

Task 3.3: RF Tunability – M1-M32

- Explore new coating parameters on planar samples and resonators to enhance the mechanical strength in SC A15 films.
- Mechanical film-stability tests with planar samples.
- Build cavity tuning system and perform vertical cryo-tests of coated cavities to explore RF performance limits and acceptable tuning without incurring film damage.
- Devise cavity tuning schemes for Nb₃Sn cavities fulfilling the required tuning parameters while taking into account the constraints of Nb₃Sn. The implementation of FE-FRT to assist will be considered.

Task 3.4: Adaptive layers – M1-M40

- Develop adaptive layers by atomic layer deposition on Cu that are stable up to 650 °C.
- Compare performance Nb₃Sn on Cu with and without adaptive layers on planar samples and QPR.

Task 3.5: Working Cavity @4.2 K – M1-M48

- Improve I.FAST 1.3-GHz superconducting coating recipe based on Tasks 3.2-3.4 results.
- Prepare 1.3-GHz thin film cavities with an optimized coating recipe.



WP3 – SRF: status/evolution of Task 3.1

Coordination (INFN, CEA, HZB, UKRI) – *Cristian Pira*

Status:

WP3 Meeting 01 - Task leaders Pre-Kick-Off remote meeting on 21/02/2024

<https://agenda.infn.it/event/40107/>

WP3 Meeting 02 - Kick-Off meeting in Paris (hybrid) on 16/04/2024 (in collaboration with I.FAST WP9)

<https://indico.cern.ch/event/1357302/sessions/528505/#20240416>

WP3 Meeting 03 - Task Leaders remote meeting on 17/07/2024 (in collaboration with I.FAST WP9)

<https://indico.cern.ch/event/1437516/>

WP3 Meeting 04 – Hybrid meeting in Berlin on 02-03/12/2024 (in collaboration with I.FAST WP9)

<https://events.hifis.net/event/1875/>

Flux Trapping (INFN, CEA, HZB, UKRI) – Oleg Malyshev

Deliverable 3.2 Flux trapping Report on flux dynamics study in Nb₃Sn on Cu samples - *HZB - Report M30*

Milestone 3.1 Modification of choke cavity for flux trapping study - *Engineering report M12*

Status:

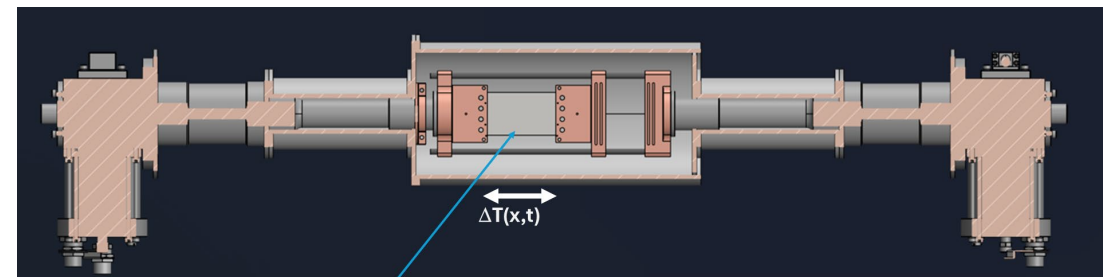
ON TRACK FOR Milestone 3.1

At UKRI:

- A measurement facility is being moved to a new bunker to enable the measurements at higher RF power.
- New magnet shield procured and delivered to UKRI
- New set of Hall probes and a 4-channel controller procured. All items arrived to UKRI. A design of a new sample holder that will accommodate Hall probes is ongoing
- **New sample holder in the commissioning phase**

At HZB:

- Production and procurement of apparatus to measure temperature-gradient driven flux trapping ongoing. Commissioning expected in October 2024 → **November 2024 (delayed by 1 month due to manufacturing issues)**



Cryocooler

Sample and magnetic mapping

Cryocooler

Temperature gradient system @HZB

Tunability (INFN, CEA, **HZB**, UKRI) – *Oliver Kugeler*

Deliverable 3.1 Cavity tuning Report on implementation of cavity Q vs F tuning tool - *HZB - Report M24*

Milestone 3.3 Report on mechanical strength test of SC coatings - *Test report M30*

Status:

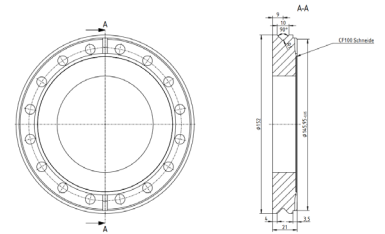
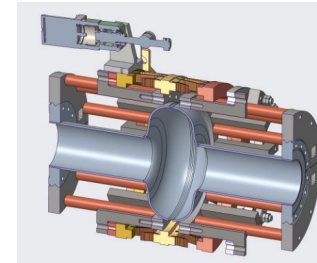
CEA: Preparing protocol for mechanical properties test on Nb₃Sn coatings

UKRI and INFN: Coating systems ready for first planar samples deposition

HZB: Design of adapter for blade tuner

Agreement between INFN Legnaro, INFN Milano and HZB on cavity end flange design:

- CF type blade, Cu gasket
- Stainless steel
- Circumferential groove for interface to adapter
- **Procurement ongoing**
- **Hiring planned: Felix Kramer will occupy postdoc position by 2025**
- **Flange testing in progress @INFN**



New cavity flange design test



WP3 – SRF: status/evolution of Task 3.4

Adaptive Layers (INFN, CEA, HZB, UKRI) – *Thomas Proslie*

Deliverable 3.3 Adapt. Layer Report on QPR study of Nb₃Sn on Cu & adaptive layers - CEA - *Report M38*

Milestone 3.2 Developed ALD adaptive layers on Cu - *Test report M24*

Status:

UKRI and INFN: Coating systems ready for first planar sample deposition. Substrate polishing in progress

CEA:

- Al₂O₃ coatings on EP Cu substrate and subsequent low T Nb deposition by HIPIMS(100-200°C) successful
- ALD coating of a 1.3 GHz Cu cavity with Al₂O₃ for future HIPIMS deposition of Nb at CERN.
- Tunneling spectroscopy measurements on Nb/Cu and Nb/Al₂O₃/Cu coupons in progress.
- Crystalline ALD oxide layer by ALD for high temperature Nb₃Sn HIPIMS growth. Layer Stable up to 750°C.
 - **Need more Cu coupons and A15 deposition attempts to confirm the trend (UKRI, INFN)**
- **Tunneling spectroscopy measurements completed on Nb₃Sn/Ta/Cu and Nb₃Sn/ALD layer/Cu**
- **New insulating oxide layer deposited on electropolished Cu coupons for High temperature Nb₃Sn deposition. MEB show cracks after annealing in vacuum at 750°C for 2hrs. Other layer thicknesses and composition will be investigated.**

Two 1.3 GHz machined cavities has been ordered from CERN.
The PVCVD for deposition of Nb₃Sn is been set up and is going through its commissioning phase.
Three 1.3 GHz cavities sent to CEA for surface preparation for future deposition



WP3 – SRF: status/evolution of Task 3.5

Working Cavity (INFN, CEA, HZB, **UKRI**) – *Reza Valizadeh*

Deliverable 3.4 4.5-K Cavity Report on 4.5-K Cavity performance & tunability tests - *INFN - Report M46*

Milestone 3.4 Characterization of Nb₃Sn reference cavity - *Test report M34*

Status:

UKRI:

Two potential target manufacturing companies Osaka Asahi Metal and Photon Export has been identified and enquiry for NbTi, Nb₃Sn target made as tubes is been made.

Received several halfshell 1.3 GHz copper cavity

Deposition from cylindrical mixed Nb rod and Ti mesh.

Two 1.3 GHz machined cavities has been ordered from CERN

The PVCVD for Nb₃Sn coating is been set up and is going through its commissioning phase

Three 1.3 GHz cavities sent to CEA for surface preparation for future deposition

INFN:

1.3 GHz Coating systems in the commissioning phase (part of the I.FAST program)

PEP Succesfully tested on full 1.3 GHz cavity (new synergy ongoing with CERN and KEK)

1.3 GHz seamless cavity Cu substrate in preparation (Cu annealing phase)



First 1.3 GHz successfully polished by PEP



WP3 – SRF: points of attention

- **Synergy with I.FAST partners** at least until 31/04/2025
- Nb₃Sn R&D on I.FAST showed the need for an adaptive layer on top of the copper substrate to optimize the lattice parameter of the superconductive Nb₃Sn film that is growing on the substrate in order to maximize the T_c value. Currently, an Nb layer thicker than 30 microns is used for this purpose.
- **ISAS Task 3.4 gains more importance** because, in addition to looking for an adaptive layer via ALD that optimizes the mechanical properties, we will also look for the possibility of replacing the thick Nb layer with an ALD layer that optimizes the lattice parameter of the Nb₃Sn coating and thus maximizes the T_c.
- **In the grant agreement encountered an error in assigning deliverables** (probably occurred during the task numbering change):
 - ***Deliverable 3.4 is in charge of CEA and not UKRI***
- ***No New Point of Attention***

WP3 – SRF: plans to achieve milestones & deliverables

D3.1 Cavity tuning Report on implementation of cavity Q vs F tuning tool - *Report M24- HZB*

D3.2 Flux trapping Report on flux dynamics study in Nb₃Sn on Cu samples - *Report M30 – HZB*

D3.3 Adapt. Layer Report on QPR study of Nb₃Sn on Cu & adaptive layers - *Report M38 – CEA*

D3.4 4.5-K Cavity Report on 4.5-K Cavity performance & tunability tests - *Report M46 - INFN*

M3.1 Modification of choke cavity for flux trapping study - *Engineering report M12*

M3.2 Developed ALD adaptive layers on Cu - *Engineering report M24*

M3.3 Report on mechanical strength test of SC coatings - *Test report M30*

M3.4 Characterization of Nb₃Sn reference cavity - *Test report M34*

