EPITA project and its advanced accelerator technologies portfolio

Superconductivity & Particle AcceleratorS 2026

Toms Torims (CERN)

20/10/2026

EPITA

Enabling Partnerships for Innovation
& accelerator Technology Advancement

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Enabling
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for
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&
accelerator
Technology
Advancement

ἐπίτα in Greek language

EPI – **ἐπί** (epi) functions as an intensifying prefix

TA – **τα** (ta) strengthens the meaning of ταχύνω (tachýno), which means *to quicken* or *to make swift*.

ἐπιταχύνω literarilly means *to really quicken* or *to accelerate*.

The Greek word "ἔπειτα" (épeita) means *then*, *afterwards*, or *next*. It's used to indicate a sequence of events or actions – thereupon.

Key objectives

EPITA aims enhance the **performance and sustainability** of **next-generation particle accelerators** through a coordinated program aligned with **RI roadmaps** and **user community strategies**.

Through **co-creation with industry** and close engagement with **end users**, EPITA will develop innovative technologies that address the **needs of accelerator communities**, maximizing their **scientific, industrial, and societal impact**.

Advance TRL of innovative accelerator technologies

- Alignment with roadmaps
- Performance
- Environmental impact

Build EU accelerator RI innovation ecosystem

- Co-creation with industry
- Long-term collaboration
- Global competitiveness
- Innovation uptake

Develop technologies for future accelerators RIs

- Cost-effective
- High performance
- Sustainable
- Knowledge transfer

EPITA Consortium

43 beneficiaries: 6 infrastructure operators, 10 research laboratories, 10 universities, 17 industries.



Key research areas

Accelerating Systems	Magnets and Beamlines	Frontier Technologies
Superconducting Thin Films for RF Cavities	**Permanent Magnets**	**Surface Treatments for Nb SRF Cavities**
Laser Drive Acceleration	**High-Temperature Superconducting Magnets**	**Additive Manufacturing**
Advanced RF Technologies	**High-Brightness Electron Injectors**	**Advanced Materials for Accelerators**

Nb_3Sn SC thin films for RF cavities

Bulk Nb SRF cavities for modern colliders operate at **2 K**.

- Performance limited by physical properties of Nb and **impurities**.
- High costs due to **Nb scarcity** and **liquid He** cryogenic systems.

Goals:

- Develop novel **Nb_3Sn** superconducting **thin films** for **Cu SRF cavities** operating with **He-free conduction cooling**.
- Test RF cavities in **horizontal cryomodule** (1.3 GHz at 4.2 K) and **cryostat** ($Q>10^{10}$, E up to 23 MV/m).
- Develop a cavity coating facility for **industrial production**.

Ambition: Develop a disruptive **SRF manufacturing technology** through advanced manufacturing, material innovation (Nb_3Sn coatings on Cu), system integration with compact **conduction-cooling**, and **industrialization**.



Copper RF cavity @INFN-LNL/Piccoli srl

Nb_3Sn SC thin films for RF cavities

Production of 1.3 GHz Cu cavity

Seamless hydroforming and equator EB welding



Yamanaka et al, Cu tubes before and after hydroforming cycles

Surface finishing and cleaning

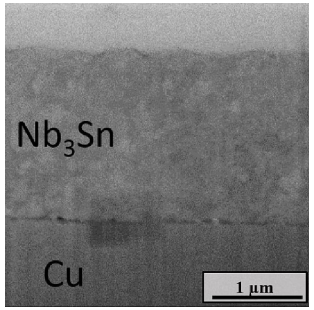
Reduce roughness and remove contaminants



Candela et al, Cu RF cavity prototype after SUBU5 surface treatment

Deposition of Nb_3Sn coating

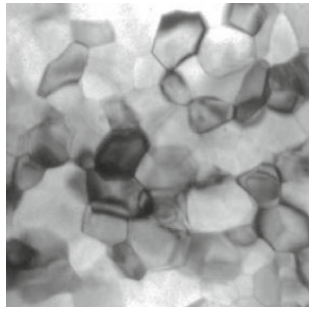
Magnetron sputtering, Sn vapor diffusion, etc.



Aliasghari et al, Nb_3Sn coating on Cu substrate

Thermal annealing

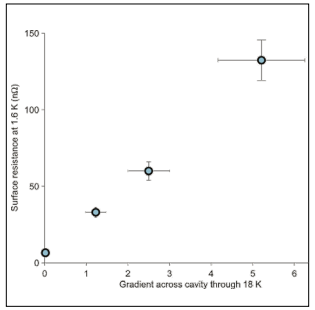
Strain relief and recrystallization



Popova et al, Nb_3Sn after thermal annealing cycles

SRF cavity qualification

Surface conductivity, quality factor Q_0, etc.



Posen & Hall, Surface resistance (1.6 K, 5 MV/m) of 1.3 GHz cavity for different thermal gradients

Surface treatments for Nb SRF cavities

Performance of 1.3 GHz **Nb SRF cavities** limited by material **defects**, **surface contaminations**, magnetic environment, and cool-down dynamics, with achievable Q factor of 3×10^{10} at 20 MV/m accelerating gradient.

Goals:

- Develop **novel surface treatments** for 1.3 GHz Nb SRF cavities, achieving **3×10^{10} Q-factor** at **30 MV/m**.
- Develop **high-pressure rinsing cobot** paths to clean complex resonator geometries.
- Develop novel techniques to **preserve and recover** cavity performance and advanced **diagnostics** to correlate treatments and cavity performance.

Ambition: Establish industrial-scale production of **Nb SRF cavities** and develop novel production process for **low-loss SRF cavities**.

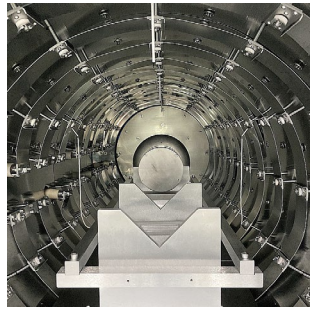


9-cell 1.3 GHz SRF cavity @DESY

Surface treatments for Nb SRF cavities

Heat treatment series

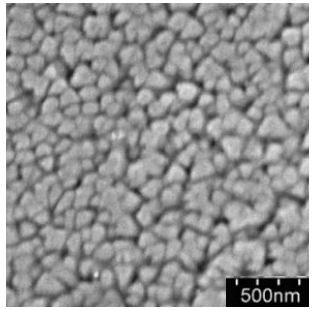
Medium and low T for high Q at high gradient



Ito et al, SRF2021 881–884 (2021)

NbN atomic layer deposition

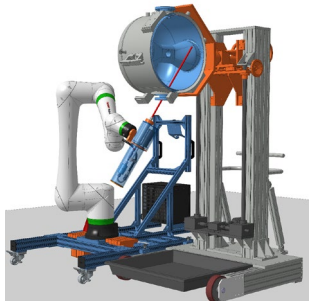
NbN films formed on 1.3 GHz Nb cavities



Zhang et al, Supercond Sci Technol 26, 045010 (2013)

Cobot-assisted cleaning

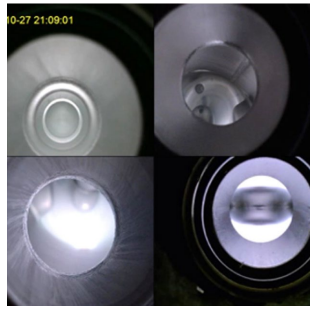
Trajectories for HPR efficiency and coverage



@CNRS

Preservation and recovery

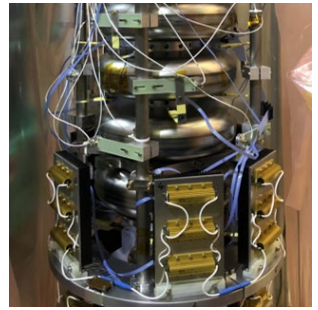
Magnetic / plasma cleaning & fast cooling



Wu et al, Nucl Instrum Methods Phys Res A, 905, 61–70 (2018)

SRF cavity tests and diagnostics

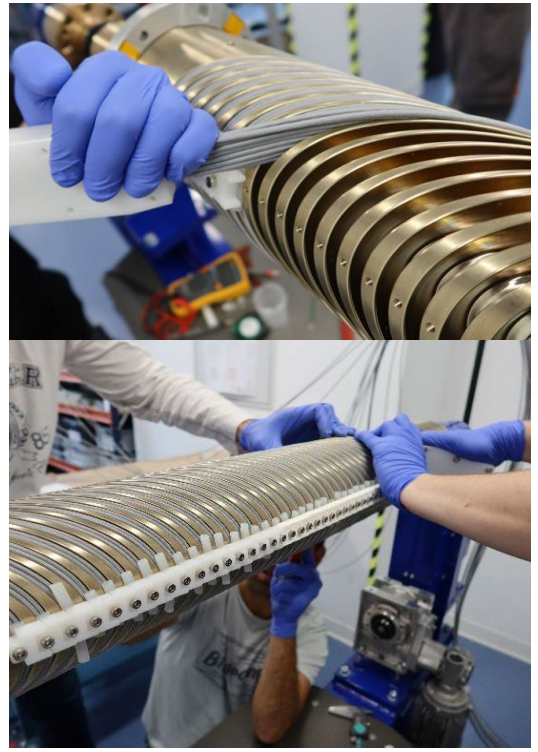
Link surface preparation and cavity performance



@INFN

HTS magnets

Nb-Ti and Nb_3Sn **superconducting magnets** have limited field strength and require operation at **2 K**.
ReBCO HTS can operate at **20 K**, but mid-field solenoids with large warm bores and fast-ramping high-current cables still need to be developed.



ReBCO magnet winding

Goals:

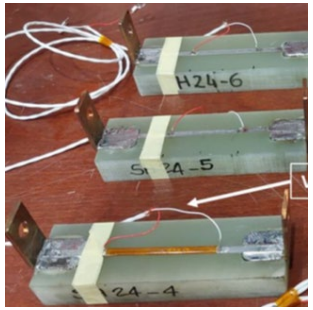
- Develop ReBCO HTS magnet components integrated with **helium-free** cooling systems, including steady-state **7 T split coils** and **10 kA-class fast-ramping cables** for dynamic applications.
- Test HTS magnets for **quench detection** and **thermal stabilization**.

Ambition: Develop compact, large-bore, cryogen-free HTS solenoids and high-current fast-ramping cables for **accelerator magnets**, enabling higher magnetic fields and **energy-efficient** systems free from **helium dependence**.

HTS magnets

HTS tapes and cables

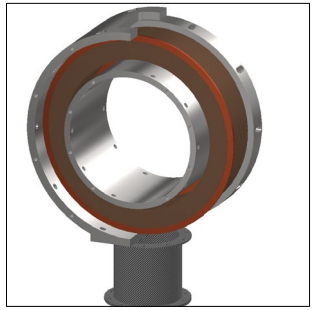
Physical properties and quench detection



SC tape and cable testing
@E De Matteis

7 T split coil HTS magnet

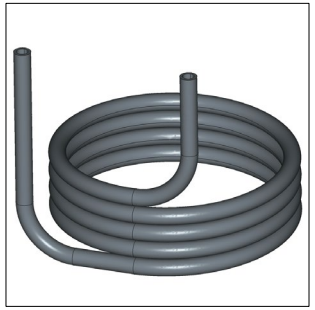
150-200 mm warm bore and ~100 mm length



Energy-saving HTS split coil
@E De Matteis

10 kA HTS cable for fast ramping

Operation in 0.5–1 T/s range at 77, 10, 4.2 K



Cable sample for fast ramping
@E De Matteis

Advanced RF technologies

HTS-coated **pulse compressors** can potentially reduce power dissipation high-gradient RF applications compared to conventional copper compressors.

Goals:

- Develop **wide HTS tapes** (up to 100 mm) for **high-gradient** RF systems.
- Characterize low-temperature field-emission, field-holding capability, and breakdown resistance of HTS.
- Develop and test joint-free **S-band RF structures** for HTS tape coating.

Ambition: Develop efficient and cost-effective **HTS low-loss** RF devices for more **sustainable and affordable accelerators**.

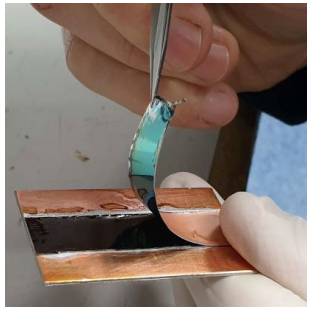


SLAC pulse compressor
@S Calatroni

Advanced RF technologies

Preparation of large HTS tapes

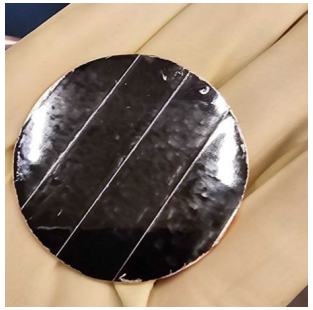
Soldering onto substrates for testing



HTS soldering @S Calatroni

Low temperature RF testing

Field emission and breakdown resistance



Soldered REBCO-CCs on copper @CSIC-ICMAB

S-band RF structure design

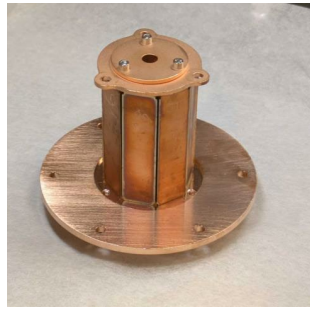
Tailored for joint-free HTS tape coating



8.05 GHz cavity resonator @S Calatroni

Cryogenic high-power testing

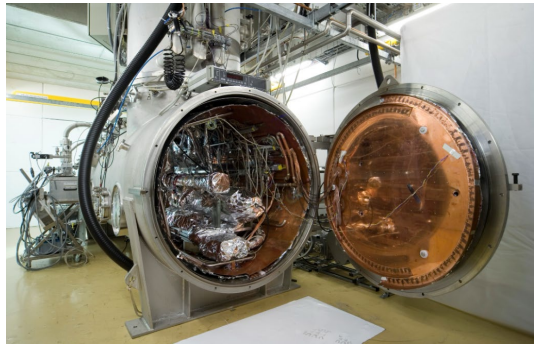
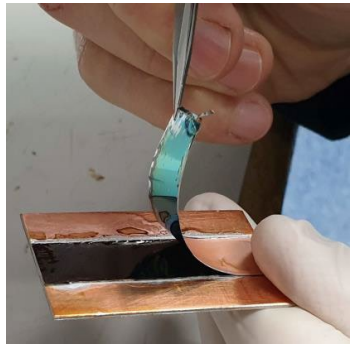
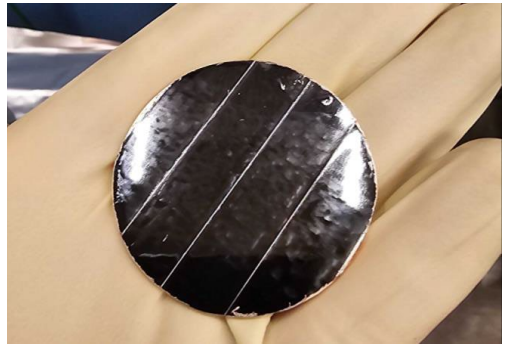
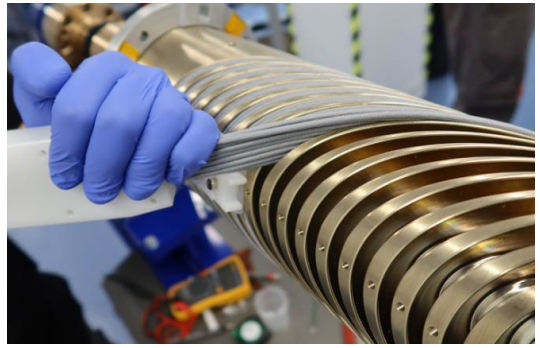
X- and S-band devices with magnetic field



Pulse compressor tests with HTS tape at SLAC @A Dhar

Prototypes for SC technologies

1. SRF cryomodule with single-cell 1.3 GHz cavity
2. Single-cell 1.3-GHz Nb_3Sn coated copper cavities
3. Disc prototype with soldered wide HTS tapes
4. HTS split coil magnet with integrated cryogen-free cooling system
5. Fast-ramping HTS cable
6. HPR set-up with cobot fully operational and qualified
7. High-Q high-G cavity prototype fully qualified


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Thank you for your attention.
Any questions?

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