Consiglio di Sezione 11th July 25

Laboratorio **A**cceleratori e **S**uperconduttività **A**pplicata

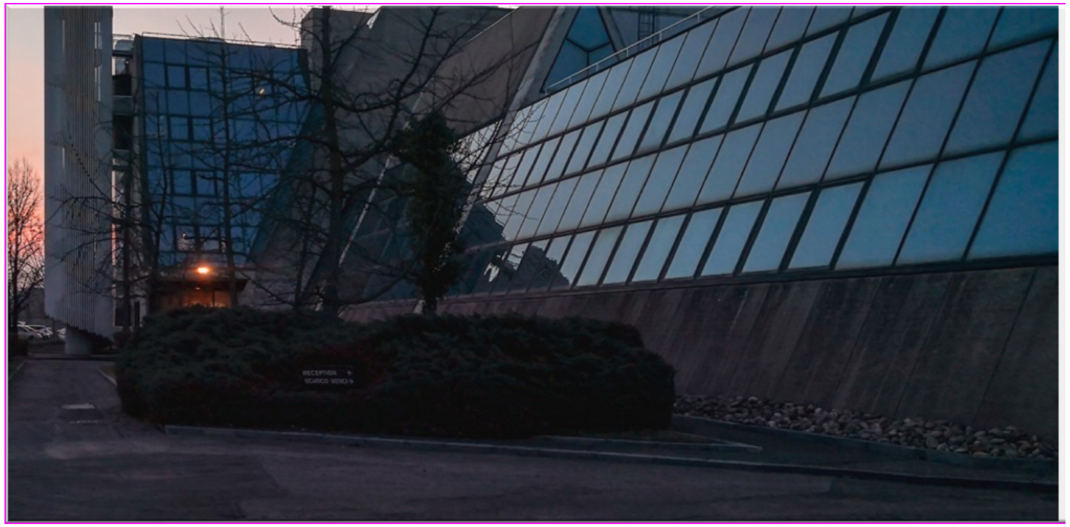
Dario Giove

11th July 2025

What is LASA ?

The INFN laboratory LASA (short for Laboratorio Acceleratori e Superconduttività Applicata, i.e. Laboratory for Accelerators and Applied Superconductivity), in Segrate, at the outskirts of Milano, is an internationally Excellence Particle Accelerator technology center since nearly thirty years.

The LASA develops advanced technologies for superconductivity, cryogenics and the productions of high intensity DC and RF electromagnetic fields.



As the name suggests, the LASA laboratory is dedicated to the study and development of innovative acceleration schemes and applications of advanced superconductivity both to accelerators and to other fields of physics.
The activities carried out since the early 90s in different sectors of accelerator physics and cryogenics applied to both magnets and RF cavities, have allowed the establishment of unique skills, which result in the possibility for INFN to play an important rule in support of international projects of particle physics.

Main Experimental Hall

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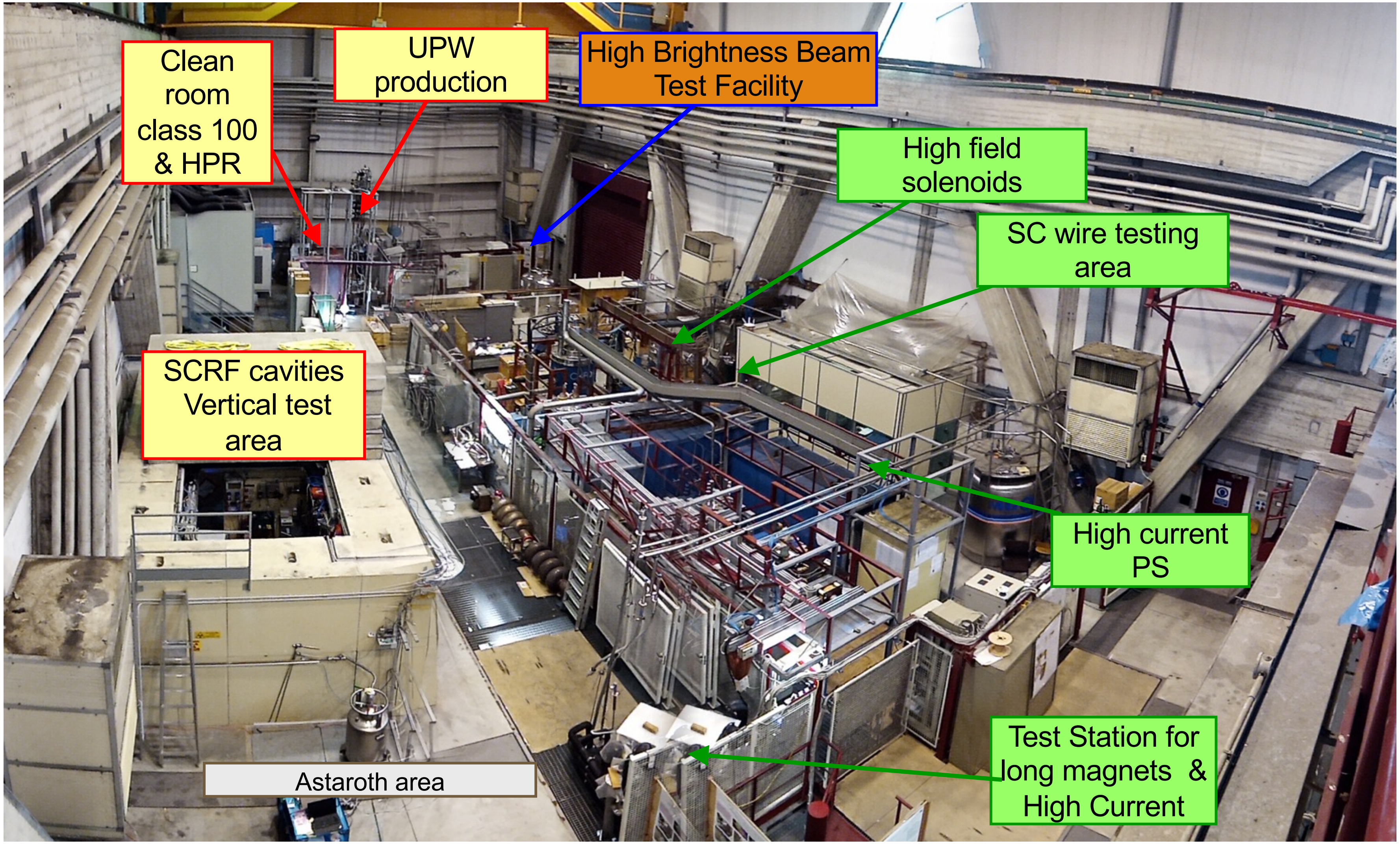


Per fine 2025 dovrebbe essere ratificato il passaggio di proprietà dell'edificio LASA da UNIMI ad INFN !

Grande impatto sul laboratorio e sulla Sezione di Milano …

Una situazione nuova da gestire con risvolti da valutare con attenzione …

A new strategy for the Laboratory ?

- upgrading of laboratories and organizational structures (even if not immediately declinable as services) ?

- request for new staff, taking advantage of the different possibilities available, aimed at strengthening the structure of the laboratory as a whole both in terms of researchers, technologists and technical collaborators (the latter particularly necessary) ?

- training of young people hired on a fixed-term basis

- general staff training with regard to workplace safety issues and use of specific equipment (mechanical, electronic and laser)

- opening of the laboratory to local relations

Clear Identification of Research Areas

The research areas already funded at LASA and on which the laboratory has focused in recent years, cover the following topics:

- Superconducting magnets
- superconducting cavities
- design of an ERL-type linear accelerator with 2 experimental stations to generate coherent X radiation, THz radiation and a beam line for applications in the medical field (BriXsino project)
- normal conducting cavities developments
- sustainable approach in the design of elements for accelerators
- advanced optics applications
- radioisotope study.

Finanziato dall'Unione europea
NextGenerationEU

Ministero dell'Università e della Ricerca

Italiadomani
PIANO NAZIONALE DI RIPRESA E RESILIENZA

INFN

WP1 – Milano LASA
Project Management and Technical coordination

WP2 - Frascati
Magnetic Measurement Laboratory

WP3 - Genova
Superconducting Cables and Material Laboratory

WP4 – Milano LASA
Superconducting Magnet Laboratory

WP5 - Napoli
Advanced Instrumentation Laboratory

WP6 - Salento
Laboratory for Superconductivity and Magnetism

WP7 - Salerno
Test Facility for Large Magnets and Superconducting line

Innovative Distributed Research Infrastructures

WP8
Green Superconducting Line at Zero Emissions

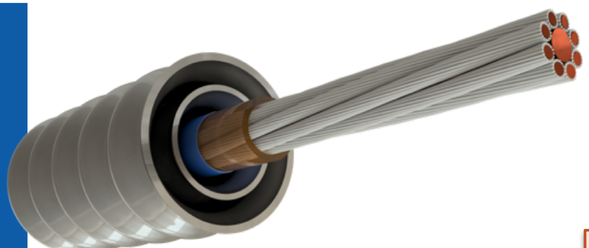
WP9
Energy Saving HTS Magnets for Sustainable Accelerators

Demonstrators for Green Energy

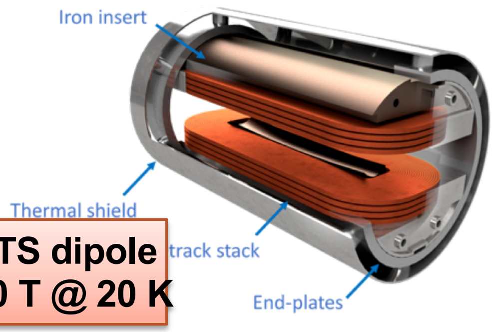
Innovative Research Infrastructure on applied Superconductivity

IRIS

Consigli



Green SC Line 1 GW
25 kV-40 kA in MgB2



HTS dipole
10 T @ 20 K

Infrastructure

Green Sc Line

HTS R&D and construction

See specific presentation

Strengthening of International and National Collaborations

iFAST

HITRI plus
Heavy Ion Therapy Research Integration

Superconducting
Ion
Gantry

International
MUON Collider
Collaboration

PIP-II

iSAS

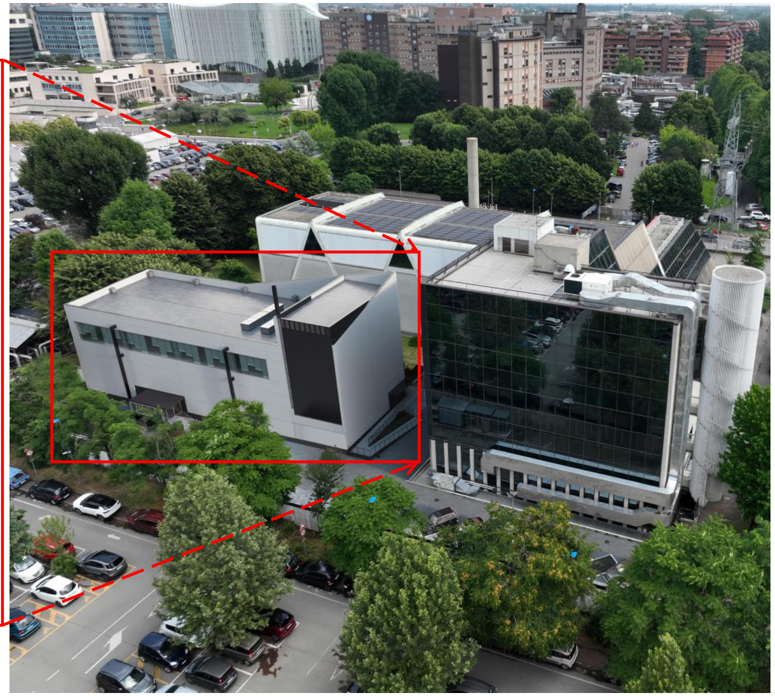
EURO-LABS
EUROPEAN LABORATORIES
FOR ACCELERATOR
BASED SCIENCES

HB²TF

A new layout for LASA

IRIS - SML
2 floors
Superconducting Magnet Laboratory

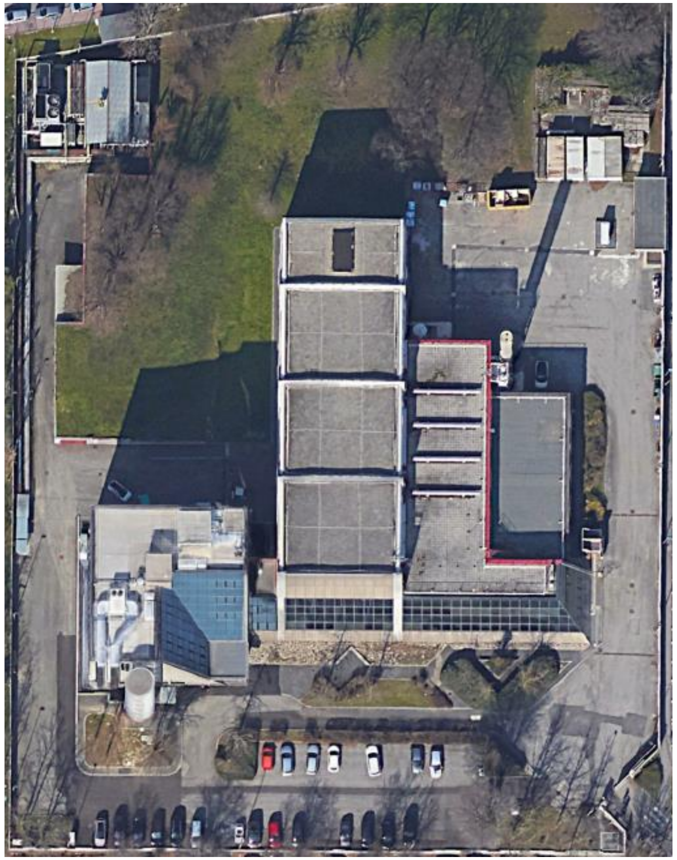
AATF
1 underground floor
Advanced Accelerator Test Facility



As part of the PNRR-IRIS program and with a significant specific contribution provided by the INFN in 2023, the construction of **an extension based on two laboratories** will begin within the LASA premises: one called **SML (Superconducting Magnet Laboratory)** and the other **AATF (Advanced Accelerator Test Facility)** for a total of 2100 m^2 spread over an underground bunker and two external floors.

These new laboratories will be available in 2026.

A new layout for LASA



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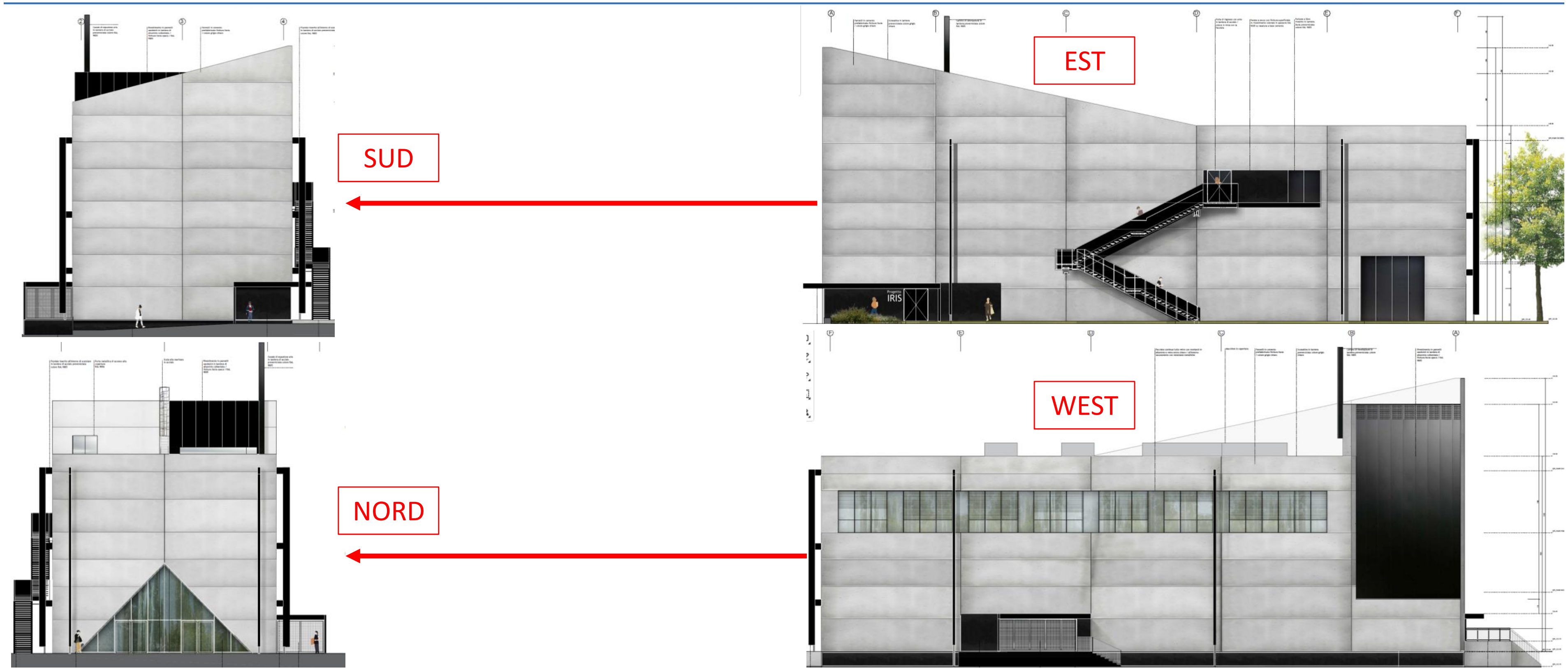
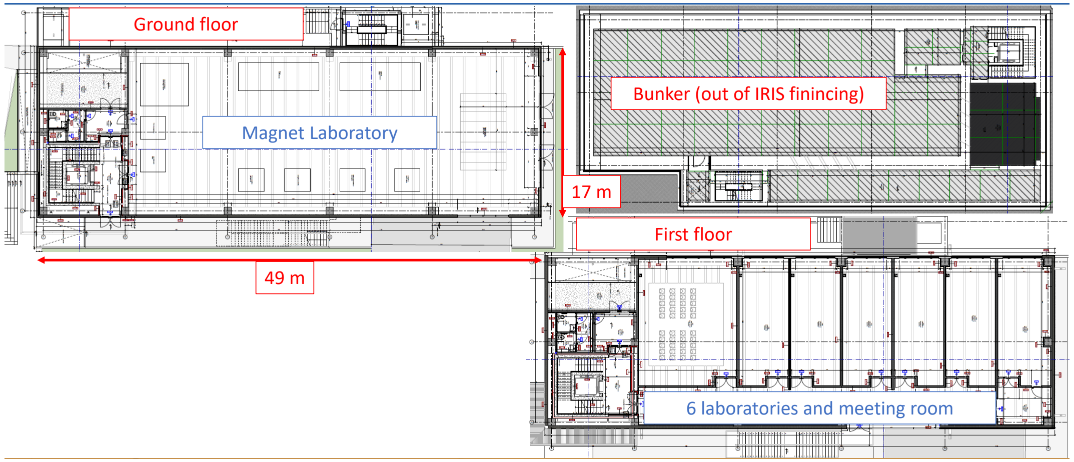
A new layout for LASA



A new layout for LASA



LASA Main Infrastructures

INFN has guaranteed specific funding for LASA of approximately 150 kEuro in 2025, which has been used up to now for:

- the 4-month rental of a refrigeration unit for cold water,
- the replacement of an electrical power supply line
- a new small electrical panel
- the dismantling of faulty equipment that has been unused for 20 years, the technical design of a new cooling system.

Main Infrastructures

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The construction of the new building involved some particularly critical decisions regarding the laboratory's overall functionality.
The main one was the demolition of the cooling towers of the water system used both for experiments and for managing the offices and infrastructure.
This required the acquisition of new, more compact cooling units and the opportunity to redo the related system.

The bad news is that when this decision was made, UNIMI had guaranteed to cover 50% of the related costs.
To date, this option is no longer viable, and even the INFN is having serious difficulties covering the costs within a reasonable timeframe.

This means that from September 2025, we will no longer be able to conduct experiments that require the use of cooling systems.

Main Infrastructures

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In April 2025, the good old compressor at LASA's helium liquefaction plant suffered a major failure, the repair of which would have cost over 150 thousand euros and taken an estimated period of six months.
This led to the decision to immediately decommission the plant (considering the arrival time of the new system, as we will see shortly) and therefore to cease all repetitive activities related to liquid helium testing.

This resulted in the inability to secure the collaborations being defined within the EuroLabs project and in a general review of the laboratory's measurement policies.

Delays in building completion also forced a review of all available spaces at LASA to accommodate the equipment acquired under the PNRR, which needed to be at least tested.

Main Infrastructures

A new liquefier is in advanced realization phase. The installation is foreseen in the 2026 summer period.

This has been a 4 MEuros investment from INFN.

L140 liquefaction performance at ≤ 4.4 K

without LN_2 pre-cooling	with LN_2 pre-cooling	compressor/power rating
45 l/h	90 l/h	CSDX165/90 kW
60 l/h	120 l/h	DSD205/110 kW
70 l/h	140 l/h	DSD240/132 kW

LR140 refrigeration performance at ≤ 4.4 K

without LN_2 pre-cooling	with LN_2 pre-cooling	compressor/power rating
210 Watt	225 Watt	CSDX165/90 kW
250 Watt	325 Watt	DSD205/110 kW
290 Watt	400 Watt	DSD240/132 kW

L140/LR140 main dimensions

Description	L x W x H [m]	Weight [kg]
Coldbox	1.6 x 1.3 x 2.6	1700
Control cabinet	0.8 x 0.4 x 1.9	110
Compressor CSDX type	2.2 x 1.3 x 2.0	2000
Compressor DSD type	2.7 x 1.7 x 2.4	3400
Oil removal system and gas management panel	0.9 x 1.2 x 2.6	500 (including filling)

LASA Main Infrastructures

A significant amount of money is requested to complete the installation of the new liquefier and to reduce the power demand at start-up.
At the same time we need to use the new water cooling system (at least a reduced part of it) as a refrigeration tools for the liquefier.

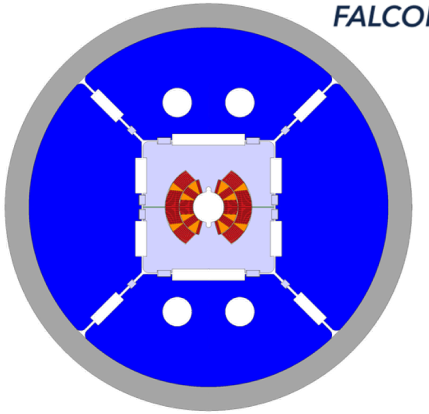
WE ARE WAITING …..

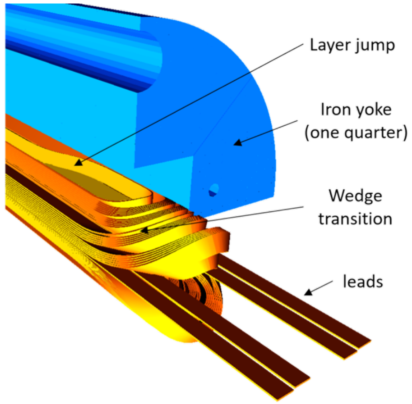
LASA based activities on SC Magnets & Superconductors

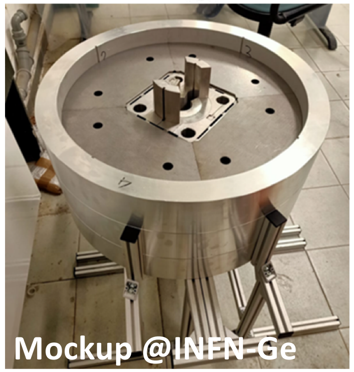
HFM (R&D per FCChh) :
1 step Falcon D

- Falcon D : inizio 2018-19
- Dopo vari cambi di design conduttore fissato nel 2023
- Ora in fase di inizio avvolgimento in Industria (ASG Superconductors, Genova)
- Mockup meccanico INFN-Genova
- **Assemblaggio bobine e magnete presso LASA** (team Ge-Mi)
- 12 T@1.9 K
  test a 4.2 K al LASA 2026-27

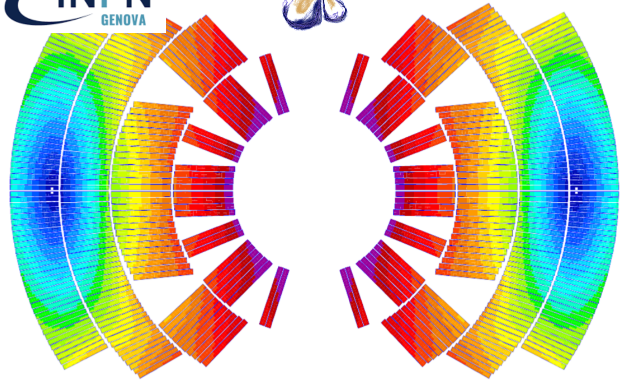
FALCOND



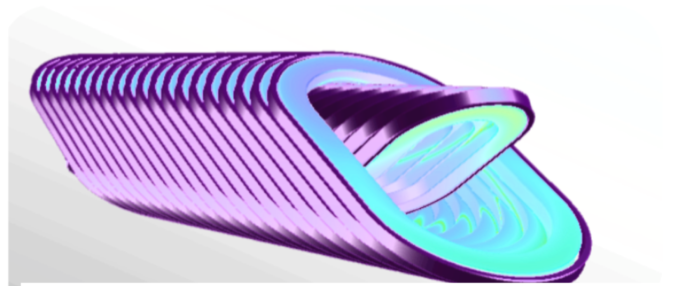




HFM-Italia: contratto di R&D mirato a FCChh con CERN



- INFN (e Unimi) si si impegnano fortemente nell'R&D per FCChh
- CERN riconosce la competenza assegnado un grande contratto R&D a INFN:
  →3.8 MCHF cash + 1.01 M mat. da CERN per INFN.
  →2.4 M€ cash + 36 FTEy (+PhDs) risorse INFN per progetto.
- **1 dipolo 14 T (full Xsect.1m) cosTheta (classico)**
- **Studio HTS vari layout e 1 dipolo 10T@20K (step verso 20@20)**
- Design, construction (in-house) e test @4-60K !



Dipolo HTS per FCC-hh – Design "Flat CCT"

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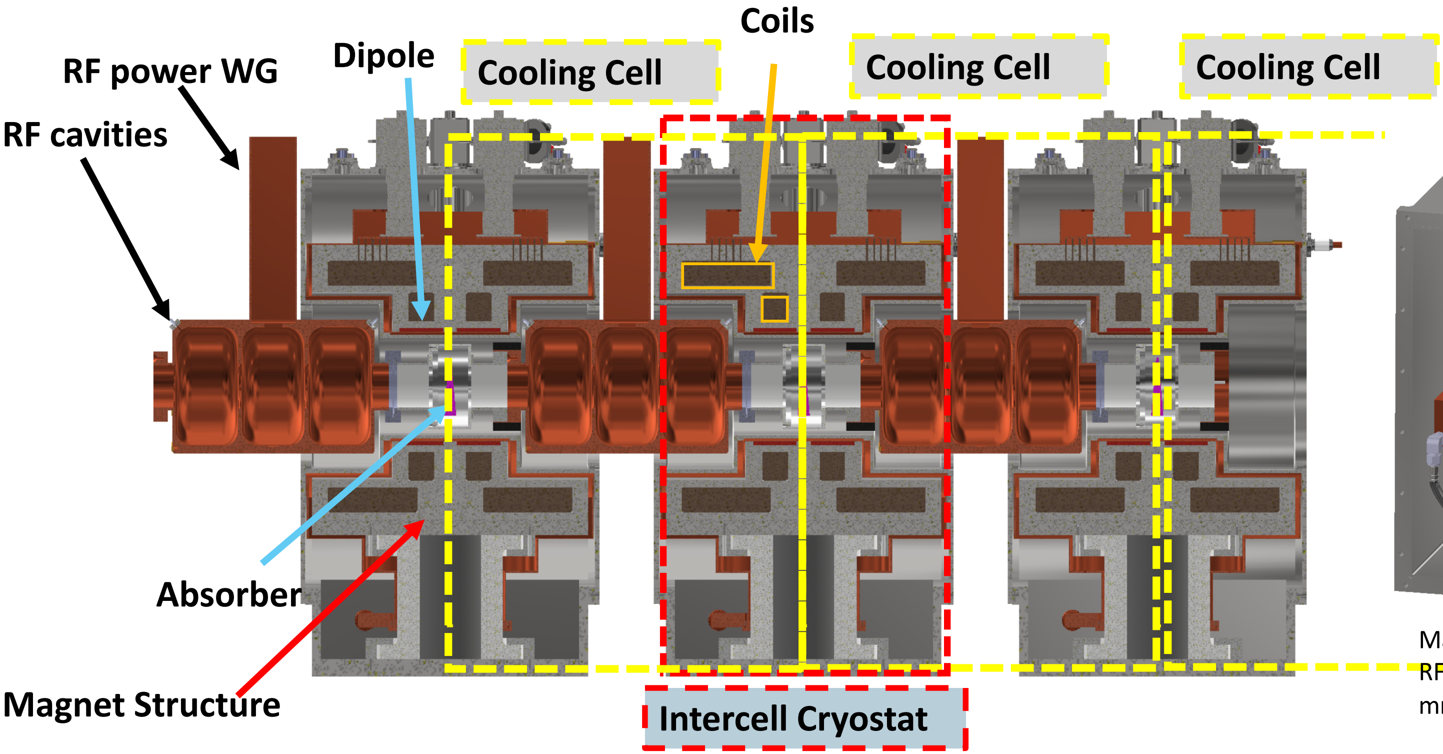
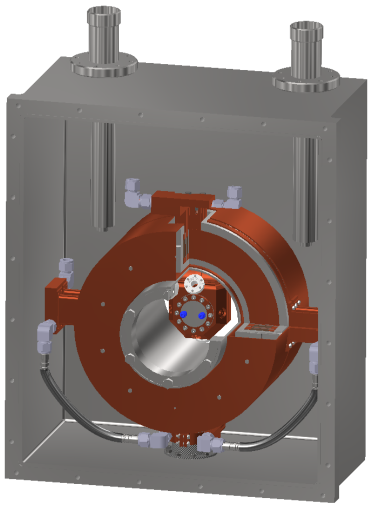
Muon Collider: Cooling Cell Integration study: new concept of inter-cell cryostat to be studied in detail





Magnet facilty for 3 GHz RF tests (RFMFTF.3 7 T 200 mm diameter)

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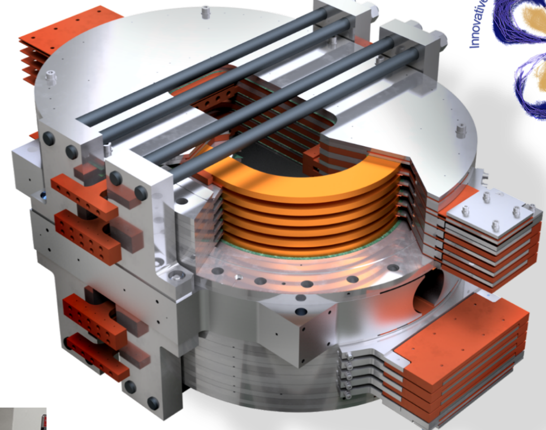
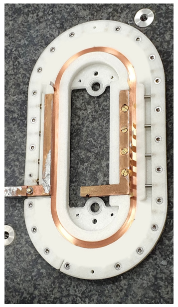
The IRIS 10 T **E**nergy **S**aving HTS **M**agnet for sustainable **A**ccelerator **ESMA**

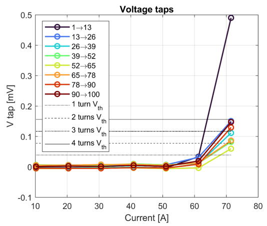
- Test *cryogen-free* technology
- Test (non)-insulation technology
- Installed in INFN Genoa facility
- Fulfilling the following performances:

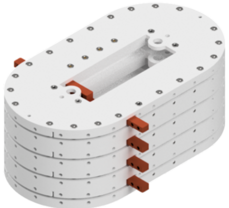
Central field B_0 (min. accept)	T	8-10 T
Free/Coil aperture	mm	Ø70/104
Good field region uniformity	N/A	±1.5%
Good field region	mm	H50×V30×L350
Operating temperature	K	20
Critical current margin	N/A	>20%

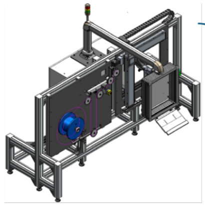


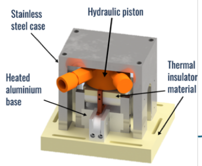
The internal HTS coil development program: **modular and repeatable**

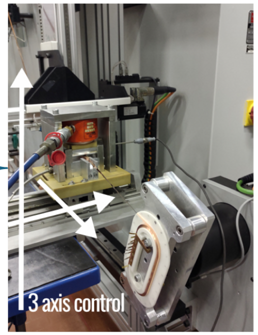












Design & Technology

Engineering & Construction

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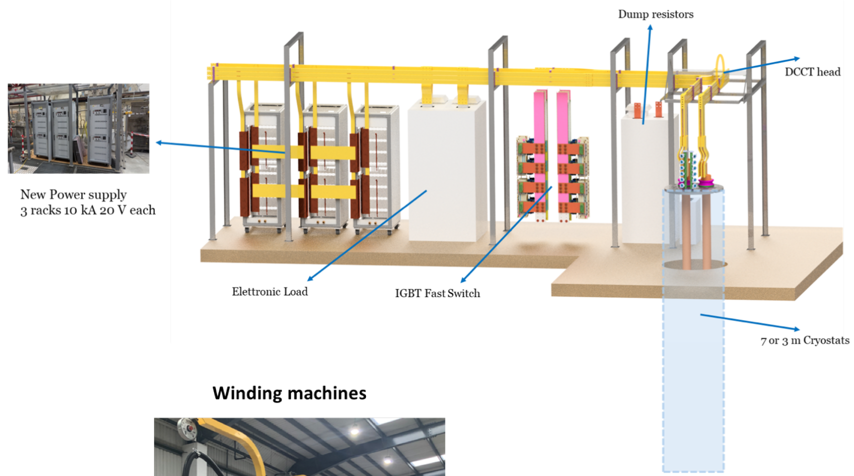
Large Equipment for SML (IRIS)

Scope of the tender:

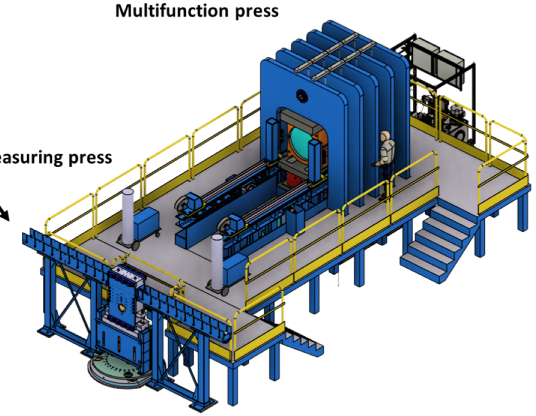
- Large equipment for construction of superconducting magnets:
  - Combined press (Curing, collaring and cold mass welding);
  - Winding machines (horizontal and vertical axes, tender, spooling and unspooling system);
  - Measurement press (E – Young modulus measurement);

30kA upgrade for Lhe Magnets Test Facility



Multifunction press

Young's modulus measuring press



Winding machines

- •Supports continuous currents up to 30 kA DC
- •Connection to a fast IGBT switch for rapid discharge
- •Installation in 10/2025

HITRIplus WP8 – Superconducting magnet design

Heavy Ion Therapy for Research Infrastructure (HITRIplus) project:

European project focused on the medical aspects (50%) and technology development (50%) for heavy Ion therapy.

WP8 objective: **Construction and test of a small demonstrator** for feedback useful for accelerator as well as gantry final magnet design.

- Explore a **curved Canted Cosine Theta layout magnet based on NbTi** (Low losses strand) and conductor (rope 6+1 strands)

HITRI plus — Heavy Ion Therapy Research Integration

Magnet parameters

Parameters	Values
Dipole field	4 T
Physical length	1 m
Curvature radius	1.65 m
Aperture	80 mm
Ramp rate	0.4 T/s
Magnet current	1670 A
Operational Temp.	4.5 K
Loadline margin	>20 %
Rope diameter	3.15 mm
Number of turns	40

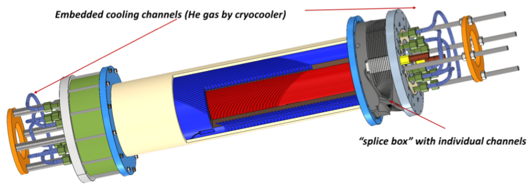
WP8 - Partners

I.FAST WP8 – Innovative superconducting magnets

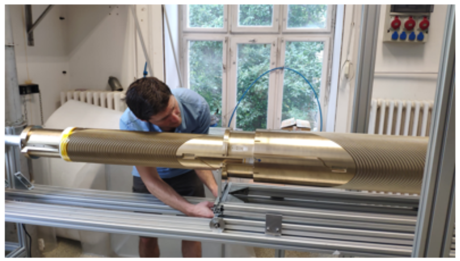
WP8 - Partners

Parameters	Values
Dipole field	4 T
Physical length	1 m
Aperture	80 mm
Ramp rate	0.4 T/s
Operational Temp.	20 K
Loadline margin	>20 %

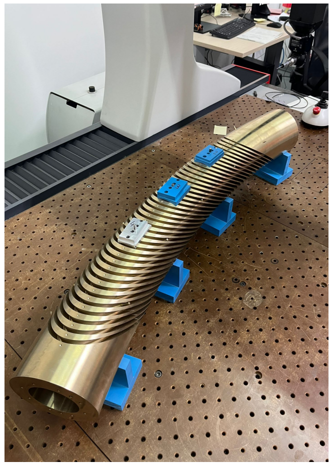
Final magnet with impregnation tooling and cooling channels



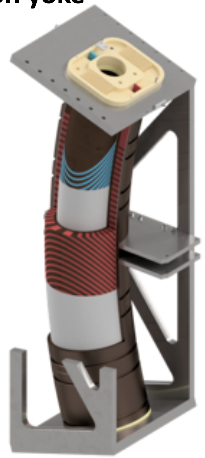
iFAST



Inner curved former



Assembly without iron yoke



Superconducting RF cavities

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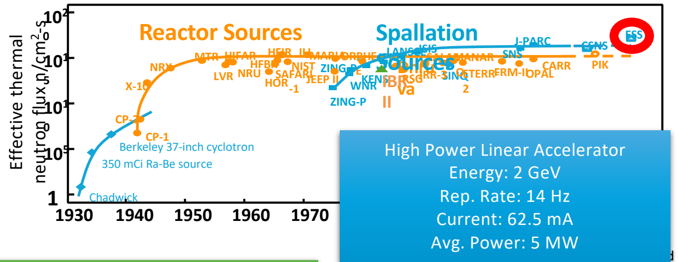
European Spallation Source

- **The most intense neutron source in the world**
  - **INFN LASA** contributes **In-Kind** for the **36 Superconducting Cavities** of the Medium Beta Section
    - All SRF Cavities delivered and **all above specifications**
    - All Medium Beta Cryomodules **installed in linac**
    - **4 spare cavities to be delivered in 2026**
- **May 16, 2025 Beam on Dump** with:
    - 860 MeV
    - 4.5 mA (5 us pulse)
- Energy upgrade in Summer 2025 (up to 3 MW)
- First **beam on target** expected in **Spring 2026**
- **Full beam on target in 2028**



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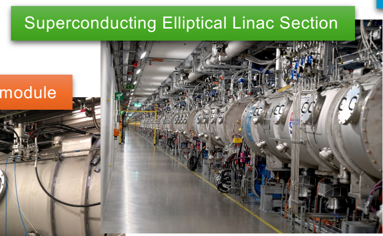
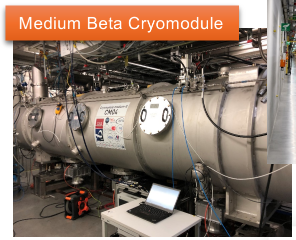
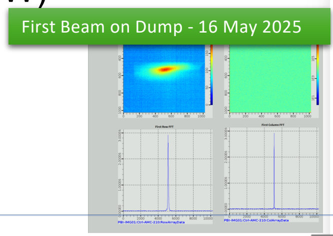
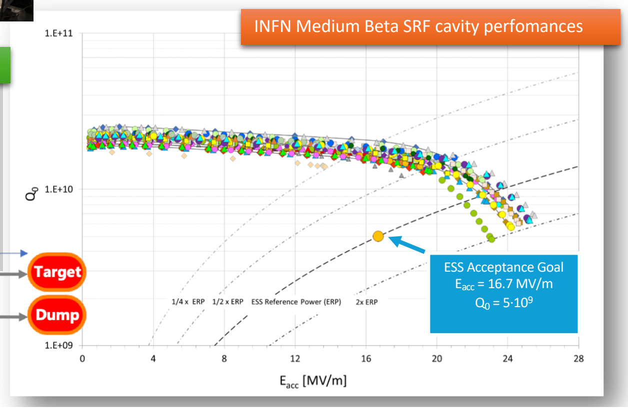
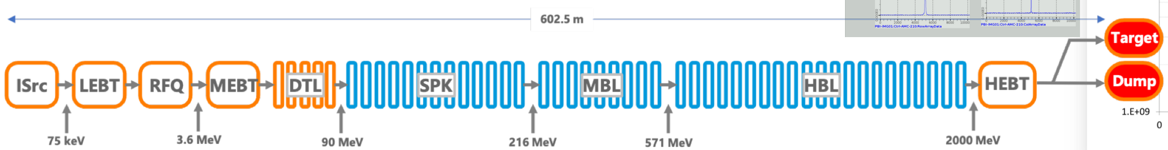




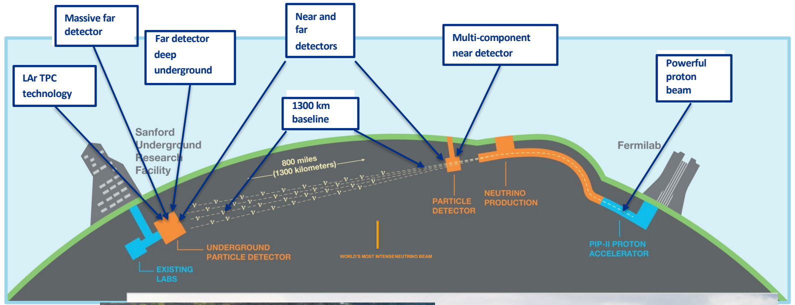




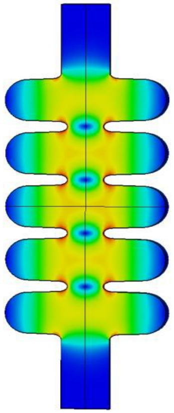


PIP-II/LBNF/DUNE

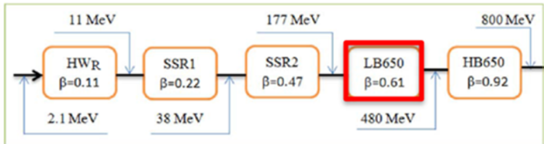
- Powerful proton beams (**PIP-II**)
  - 1.2 MW upgradable to multi-MW in energy range of 60-120 GeV to enable world's most intense neutrino beam
- Dual-site detector facilities (**LBNF**)
  - Deep underground caverns (1.5 km) to support 4x17 kt liquid Ar detectors
  - A short baseline (SBN) and a long baseline (1300 km) neutrino beam, with wideband capability
- Deep Underground Neutrino Experiment (**DUNE**)
  - The next-generation neutrino experiment
  - Precision beam and cosmic neutrino physics



Novel RF design for the LB650 cavities from INFN

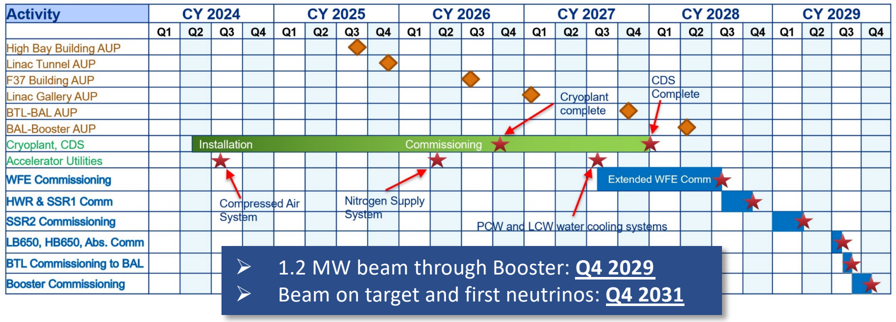


INFN LB650 cavity for PIP-II, TM010 pi-mode E-field profile



INFN contribution covers the LB650 section:

- **38 cavities** to equip 9 cryomodules with 2 spares
- Delivered as ready for string assembly.
- Qualification via **vertical cold-test** at a qualified cold-testing infrastructure
- Compliance to the **PIP-II management system**: Engineering, Review, QA/QC, and Risk Management.



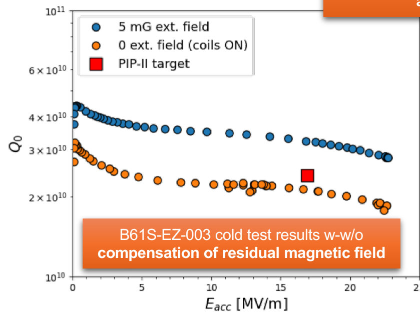
Status of INFN in-kind contribution to PIP-II

PIP-II project requirements are above SRF state-of-the art and LB650 cavities are among the **key scientifical challenges of the project**:

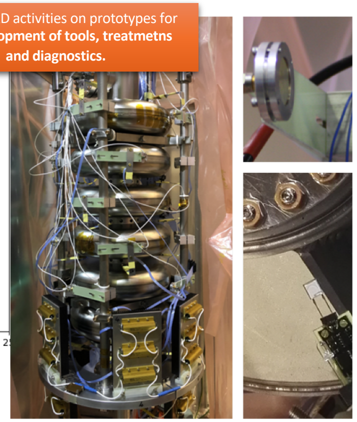
- INFN LASA integrate these requirements into an industrial production, after thorough R&D experience with single- and multi-cell prototypes.

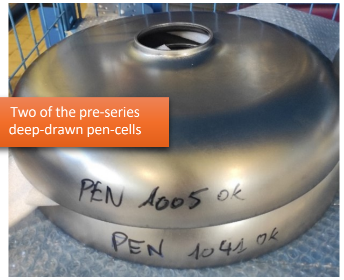
Cavity **series production activities started** and **all key contracts** with partner companies and labs are **running**.

- Production specifications, quality control documents and procedures discussed and agreed with the awarded vendor, Zanon R&I.
- Cavity manufacturing started, **half-cells** subcomponents have been realized and are now being inspected (RF, dimensional, shape).
- **Agreement with DESY** as qualified lab has been **achieved**
  - **high throughput** of the AMTF test facility necessary to manage the **tight schedule**

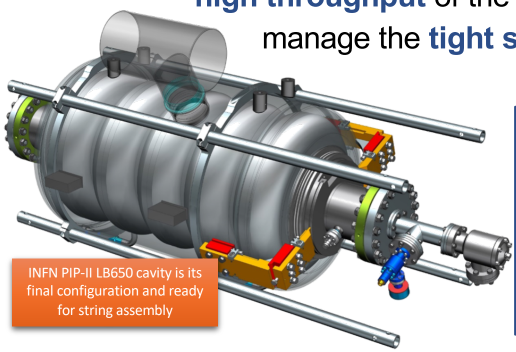


B61S-EZ-003 cold test results w-w/o **compensation of residual magnetic field**


Several R&D activities on prototypes for the **development of tools, treatmetns and diagnostics.**



Two of the pre-series deep-drawn pen-cells


INFN PIP-II LB650 cavity is its final configuration and ready for string assembly

Delivery is scheduled to **begin in summer 2026**

- rate of **4 cavities per month,** qualification and hand-over to PIP-II planned to **conclude by 2027.**
- The **follow-up** on the operation is expected in the **next years to address cryomodule installation.**

INFN PIP-II LB650 cavity design and operational parameters
Requirements are above state-of-the-art for low-beta cavities

Parameter	Value
$\beta_{geometric}$	0.61
Frequency	650 MHz
Number of cells	5
Cell-to-cell coupling, k_{cc}	0.95 %
Optimum beta β_{opt}	0.65
E_{peak}/E_{acc} @ β_{opt}	2.40
B_{peak}/E_{acc} @ β_{opt}	4.48 mT/(MV/m)
R/Q @ β_{opt}	340 Ω
G @ β_{opt}	193 Ω
Target acc. Gradient in CM	16.9 MV/m
Target Quality factor in CM	> 2.4 10^{10}
Qualification gradient in VT*	19.4 MV/m
Target Q0 in VT – naked	2.9 10^{10}
Target Q0 in VT – jacketed	2.6 10^{10}
Max. admissible radiation	1 mSv/h
Multipacting-free range	15.2 -18.6 MV/m

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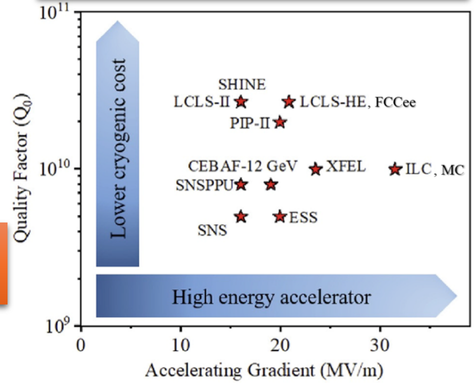
SRF towards future machines HighQ/HighG R&D activities

Cost reduction & sustainability for future machine



Since 2022, **INFN promoted initiatives** for developing **R&D for future particle accelerators** that can **significantly contribute to the ESPP.**

- **Future machines** will require **higher performances**, but also **cost reduction** and **sustainability**

- **HighQ -> power saving**
- **HighG -> shorter machine**

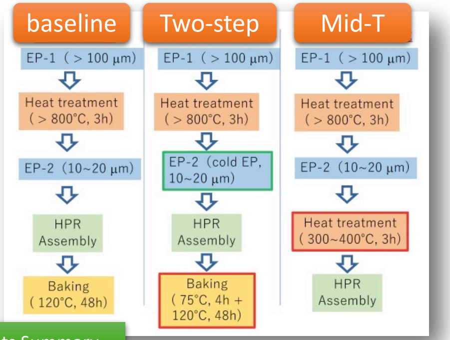
For **SRF Nb bulk cavities**, a **program has been funded by INFN** on **HighQ/HighG SRF R&D** for new surface treatments to reach higher cavity performances.

- The activity will be done on **1.3 GHz** single-cell and 9-cell **cavities**, taking profit on the LASA group experience gained both on **R&D** and on the **large-scale productions** (E-XFEL, ESS and the future PIP-II).

- This **INFN activity is clearly synergic and adaptable** to the requirements of future colliders as **ILC**, **Muon Collider**, **FCC**, **CEPC…**
- Part of this activity is done also in the frame of the **ILC Technology Network (ITN)**, that collects the participation on labs/institutes in Asia, EU and Americas to foster and improve the TESLA technology.
- These activities are also supported and benefits from the **EAJADE staff exchange EU program** that promotes the **exchange of EU researchers** with Japan/Americas laboratories in view on the future Higgs factory projects.

On-going activities

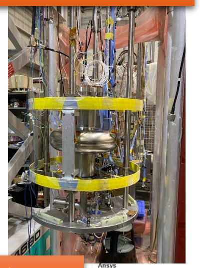
- **1.3 GHz Nb bulk single and multi-cell cavities**
  - **2 Single-Cell** -> research and development of **surface and thermal treatment** (at LASA, at industry and possibly in collaborating laboratory)
    - Mechanical Fabrication at industry **on-going (expected in Sep. 2025)**
    - Baseline treatment (optimized E-XFEL process with EP cold and 900 °C)
    - Advanced processes (Two-step baking, Mid-T baking, etc.)
    - Cryogenic Test at 2 K at LASA; cross-check with other labs (e.g. CEA) for process validation
  - **Multicell** -> **export** best single-cell **treatment to multicell** in preparation of **industrialization**
    - Treatment reproducibility and process robustness verification



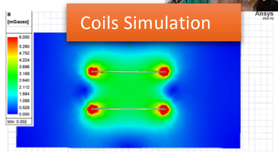
Treatments Summary

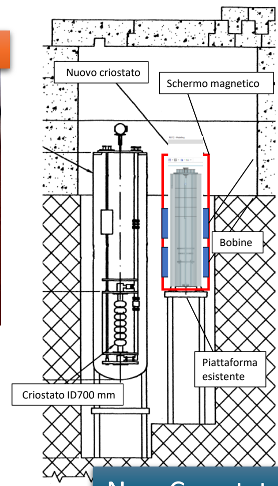
- **SRF cold VT infrastructure upgrade At LASA**:
  - **New Cryostat for 2 K vertical test** of single cell **(install. by July 2025, then commissioning)**:
    - Reduced lHe consumption, shorter test time, fast transition through Tc
    - Active cancellation of remanent magnetic field to improve Q_0 **(Helmholtz coils and coils frame under construction)**
    - Advanced diagnostic for quench and FE spot identification
  - **New dedicated RF and acquisition system**:
    - New 1.3 GHz amplifier **delivered**
    - Migration of RF control system from **analog to digital (test on-going)**

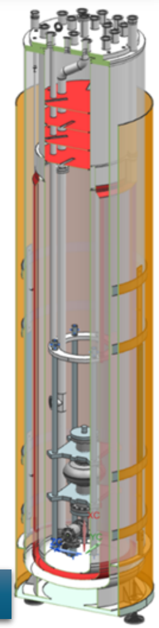
PIP-II Coils Prototypes



Coils Simulation





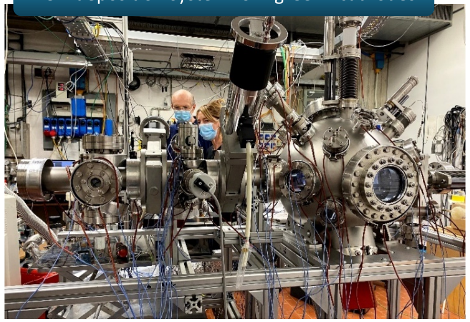


New Cryostat

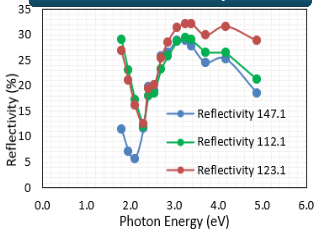
The "Green" Photocathodes (INFN – DESY)

- From the successful Cs2Te experience, we are now developing "Green" photocathodes
- **CW machine** operation requires photocathode:
  - sensitive to visible light to relax requests on lasers.
  - smaller thermal emittances $\epsilon_{th} \approx$ 0.3 mm mrad to improve machine performance
- **Requires XUHV** (≈ 10^{-11} mbar) since more sensitive than Cs_2Te
- **New LASA deposition system** for "green" (Alkali Antimonide) films
  - collaboration with DESY-PITZ

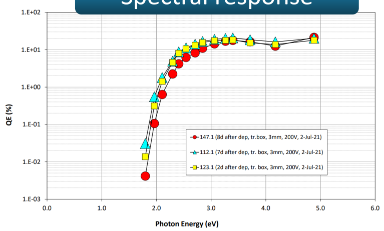
New deposition system for «green» cathodes



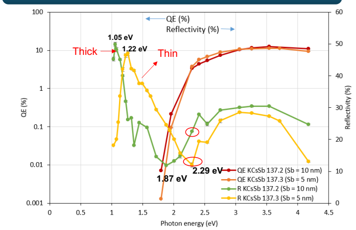
Reflectivity

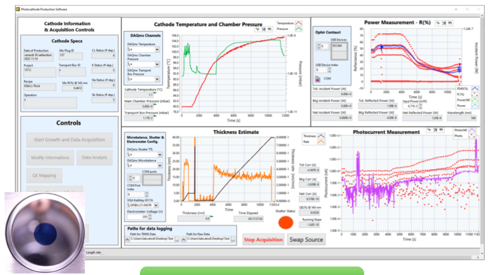


Spectral response



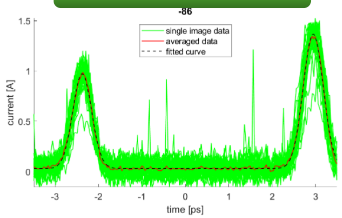
thin & thick films studies



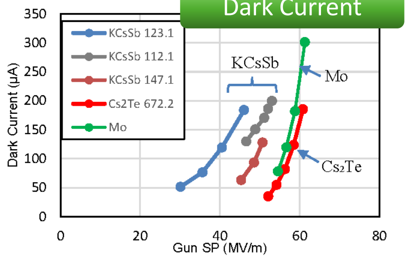


✓ **Photocathodes delivered and tested in PITZ RF gun**

Response time



Dark Current



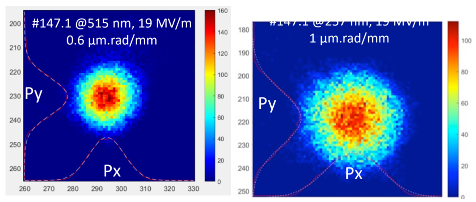
#123.1 QE@2.4 eV

~8% (At INFN)

~4% (In PITZ loadlock)

~5.6% (In PITZ gun)

Emittance

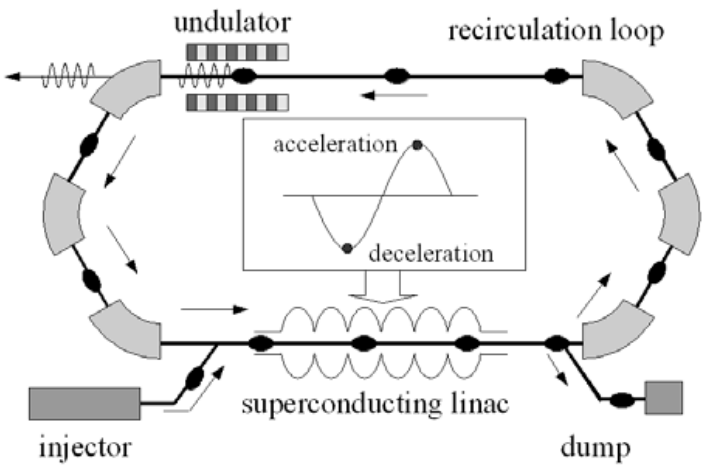


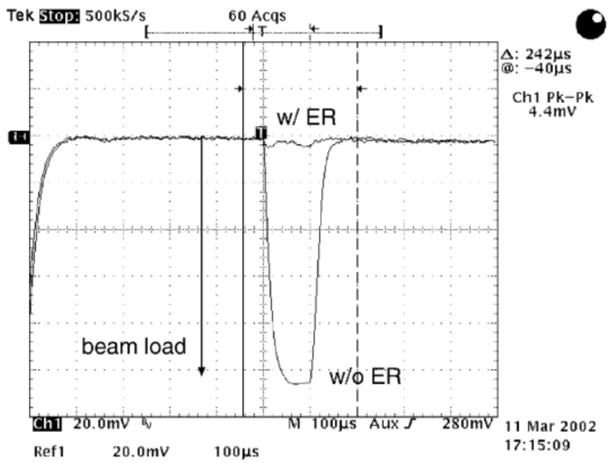
2D distribution of photoemission transverse momentum

ERL

Energy Recovery Linac Basic Principle

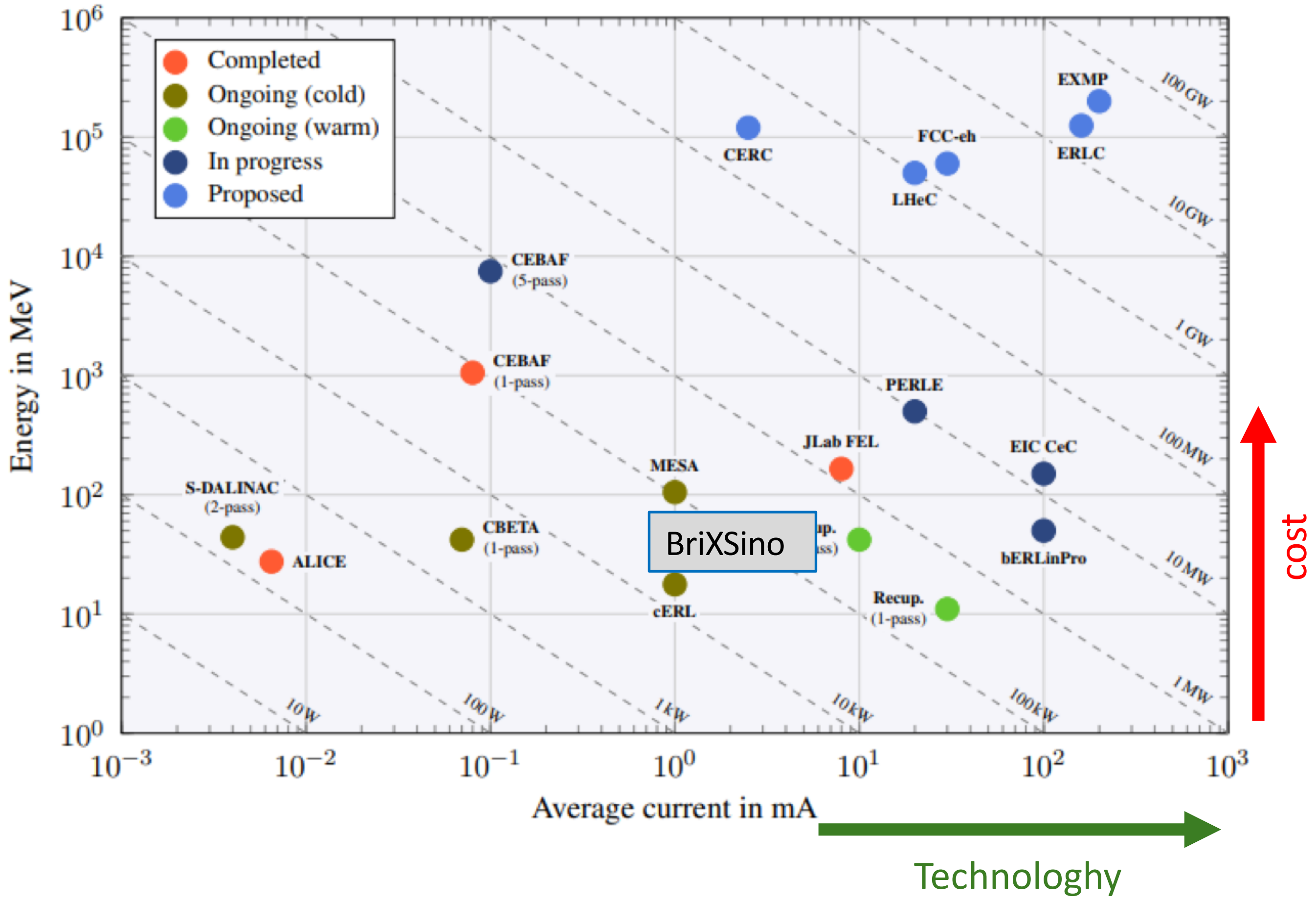
Energy-recovery linac (ERL) is a new class of electron accelerators used for generating an electron beam of high-average current and small emittance achieving the highest average beam brightness. In an energy- recovery linac, an electron beam from an injector is accelerated in a superconducting linear accelerator; the beam is then transported to a recirculation loop. In the recirculation loop, the beam is utilized for particular applications such as X-ray generation. After the recirculation, the spent electron beam is injected again into the superconducting accelerator so that the electrons are decelerated. This deceleration can be accomplished by putting the electrons in the phase opposite to the acceleration. Therefore, the energy of the accelerated electrons is converted back into the rf energy and recycled to accelerate the succeeding electrons.
The energy recovery technology has a significant impact on modern accelerator applications because the ERL can accelerate a high-power electron beam with small-capacity rf generators.
In addition to this excellent conversion efficiency, the ERL has an advantage essential to the generation of high-brightness electron beams. Since an electron bunch in an ERL goes to a beam dump after deceleration and another fresh electron bunch is accelerated at every turn, the electron beam in the ERL maintains a small emittance.





Overview of ERL Facilities

- Several **ERLs** are currently in operation, with more under development or planned.
- To date, only **one ERL** has exceeded **1 MW beam power**: the **JLab FEL (3 orders of magnitude below** the beam power anticipated for the **LHeC**.
- Only **two superconducting ERLs** have successfully demonstrated **multi-turn operation.**



Courtesy of S. SAMSAM

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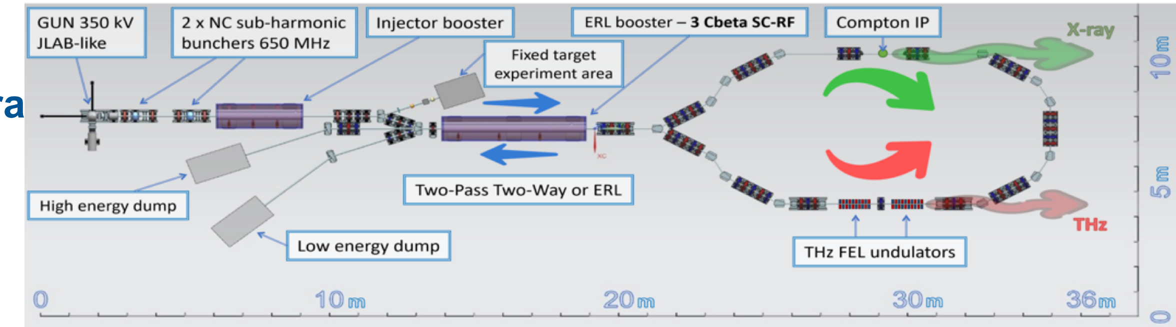
BriXSinO Principle of Operation

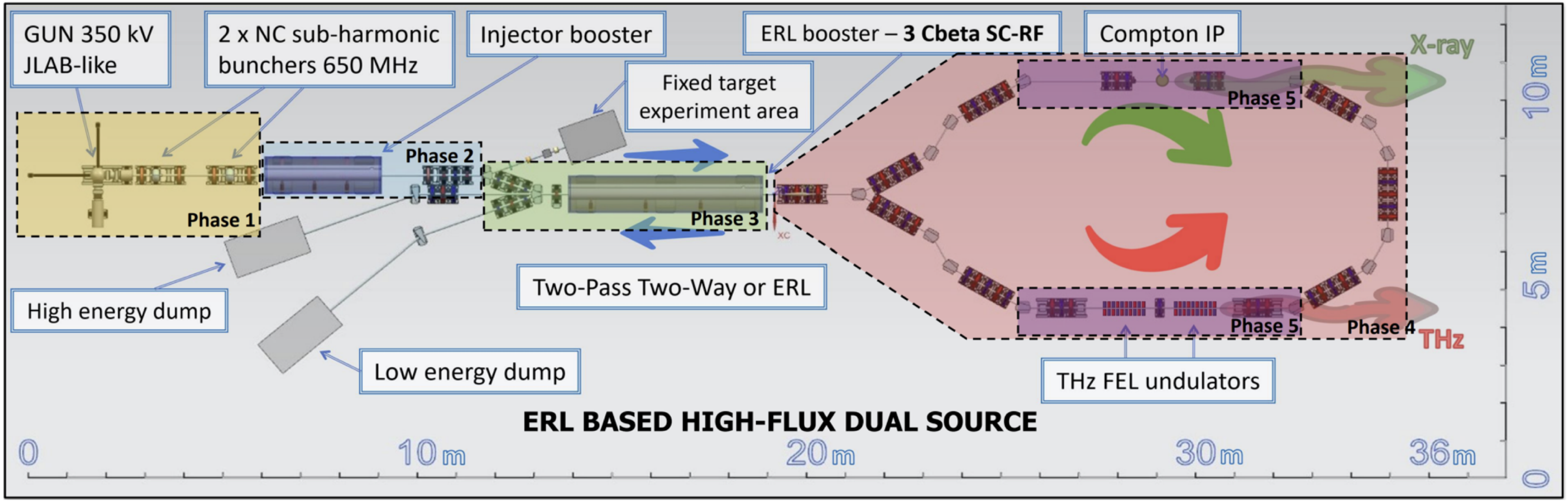
- A “**newly**” conceived scheme of ERL with **counter propagating beams** is proposed in BriXSinO.
- This **scheme allows** to explore not only the **ERL operation** but also the **two-pass opera**
where the beam is reaccelerated when reinjected in the accelerating module at reduced current.



- A further operation mode for BriXSinO is the use of its **injector for fixed target experiments** performed with maximum electron energy of 10 MeV and 5 mA average current. This high intensity beam enables both **experiments of flash therapy** (total charge in a 200 ms time interval up to 1 mC), as well as converting the electron beam into **bremsstrahlung photons with energy peaked at 7 - 8 MeV at an impressive flux of 10^{16} photons/s** (i.e. up to 30 kW X-Ray beam).
- Also experiments of **positronium generation** for fundamental studies of matter-antimatter asymmetry can be conducted at this test station.

Parameter	two-pass acc.	ERL
Energy (MeV)	80	45
Bunch charge (pC)	100	50
Repetition rate (MHz)	0.9286	92.86
Average Current (mA)	$50\ 10^{-3}$	5
Beam power @ dump (W)	$22.5\ 10^{3}$	400
$\varepsilon^{n}{}_{x,y}$ (mm – mrad)	< 1.6	< 1.6
Energy spread (%)	< 0.2	< 0.2

BriXSinO foreseen Schedule

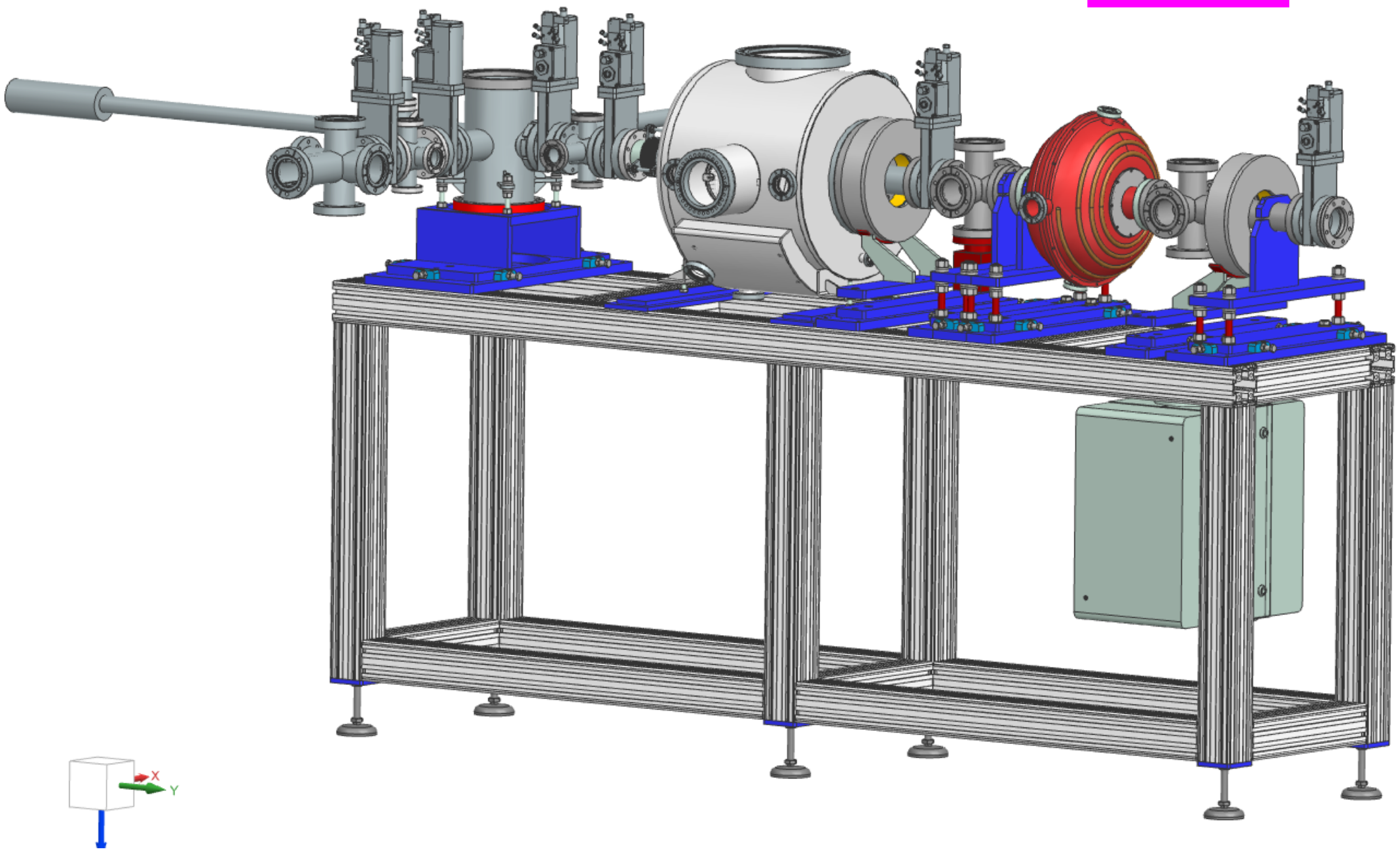


HB²TF Layout

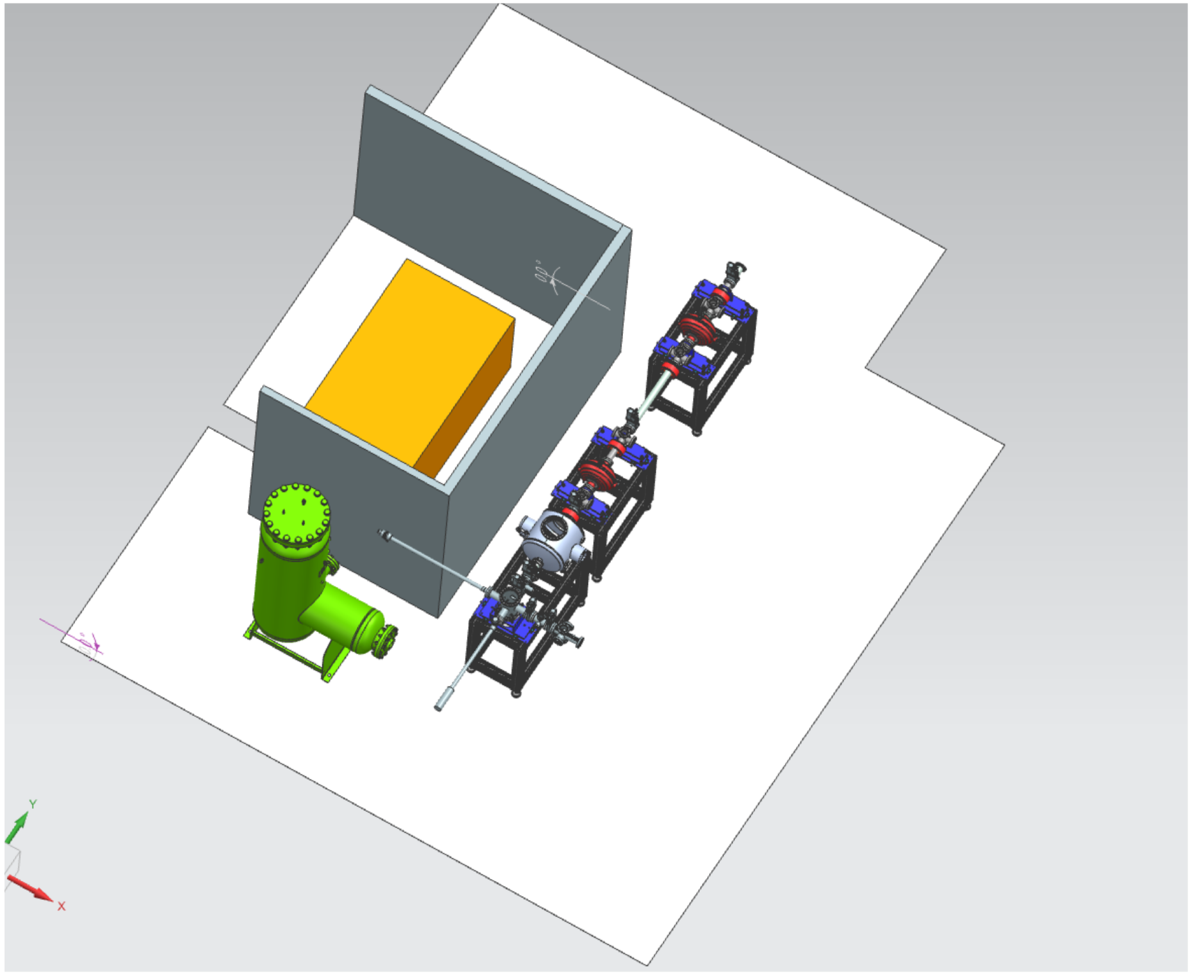
Photocathode Chamber

DC Gun

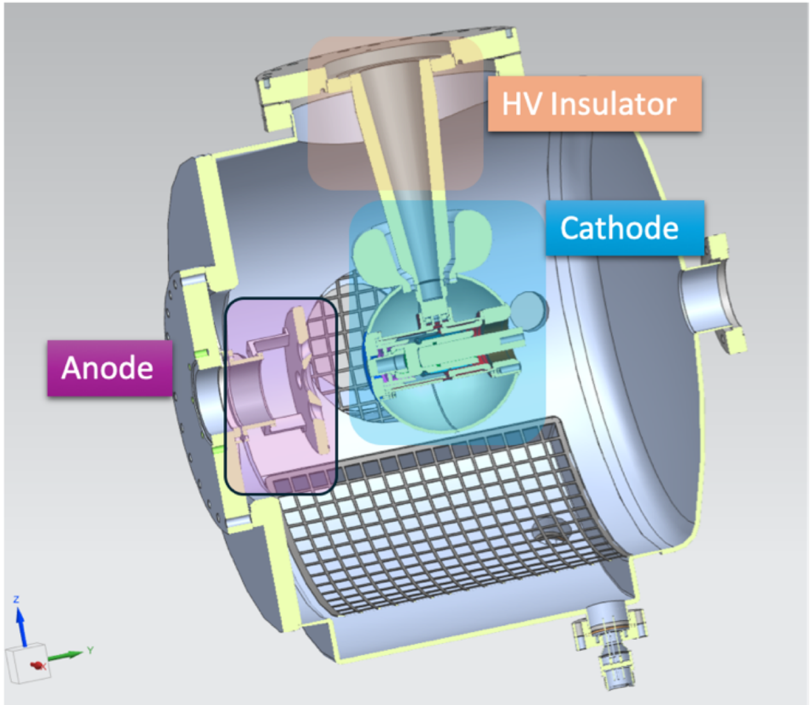
Buncher

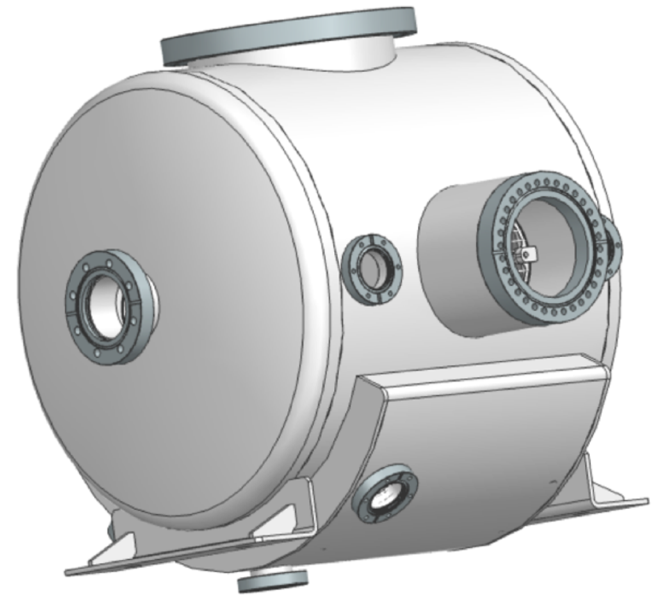


HB^{2}TF Layout

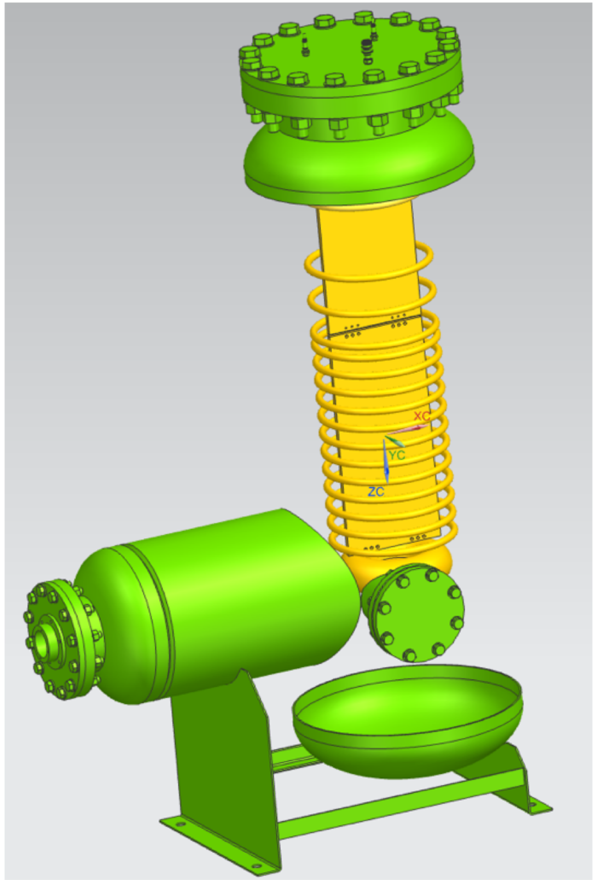


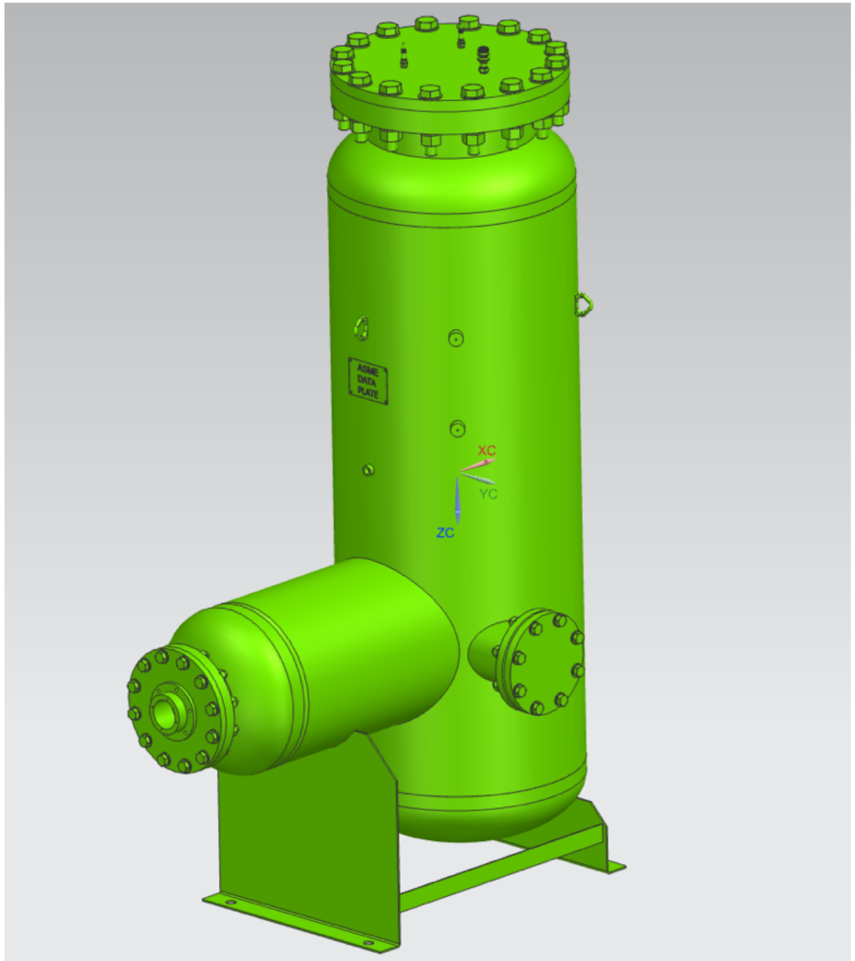
HB²TF DC Gun





HB²TF HV Tank





2025 Status

The following components have been defined:

- RF buncher power coupler: the specifications for our initial project have been written and the procedure for outsourcing its construction to an external company has begun
- chiller for buncher cavity temperature control: with the technical assistance of colleagues from LNF, a suitable model has been defined and the purchase procedures are underway
- 200 kW electrical power lines from the main LASA cabin to the experimental area: the order is being issued
- electrical panel for the experiment: designed and market survey carried out. Procurement procedures underway
- Distribution of electrical outlets in the experimental area: completed
- Optical beam diagnostics unit: designed based on existing components and outsourced to an external company for modification and updating
- Electrical cable from the power supply to the DC Gun: specifications written, supplier identified, procurement procedures underway
- various HV components: award procedures underway
- laser-RF timing and synchronization unit: specifications written and supply underway
- laser beam injection unit in the line: specifications written and construction awarded
- control system, remote instrumentation, and data acquisition: supply of components in progress
- control and data acquisition computer: units in the laboratory recovered and a remote control room set up for the experiment
- UHV valve systems: purchased
- UHV pumps: specifications written and procurement procedures underway
- optical table with laminar flow: purchased
- optical components for laser system: purchased
- RF instrumentation: purchased.

2026 Extension Request

The request to extend the HB2TF experiment to 2026 stems from the following considerations:

- significant delays in issuing orders (and therefore in delivering parts)
- difficulties in managing the logistics of the installation, both due to problems related to the expansion of LASA (lack of a cooling water system) and due to the non-participation of the UNIMI Physics Department in the related support work (promised at the time of submission of the proposal)
- objective difficulties in developing the components necessary for the experiment.

By the end of 2025, the following elements are expected to be available:

- DC Gun mounted on the line complete with valve systems and housed on the relevant supports
- Electrical power line laid
- Electrical certification panel for the experiment installed
- HV power supply installed
- Laser system, with relevant protections, installed.

The following will be present but not installed:

- Vacuum system
- Data acquisition system
- Control system
- Radiation protection system.

The following will not be present, with estimated delivery dates by March 2026:

- RF power supply and LLRF system
- Buncher cavity
- Power coupler for buncher
- RF distribution
- Chiller for cavity cooling
- electrical distribution for the experiment
- cooling water distribution.

Assuming that the components arrive by March 2026, we can assume a time of about two months for the final assembly of the experiment and then another two months for the start of high-voltage testing, both DC and RF.
At this point, in September 2026, emission, acceleration, and beam formation tests will be carried out.

Muon Collider Partecipation

LDG review - February 24-26, 2025 @ CERN

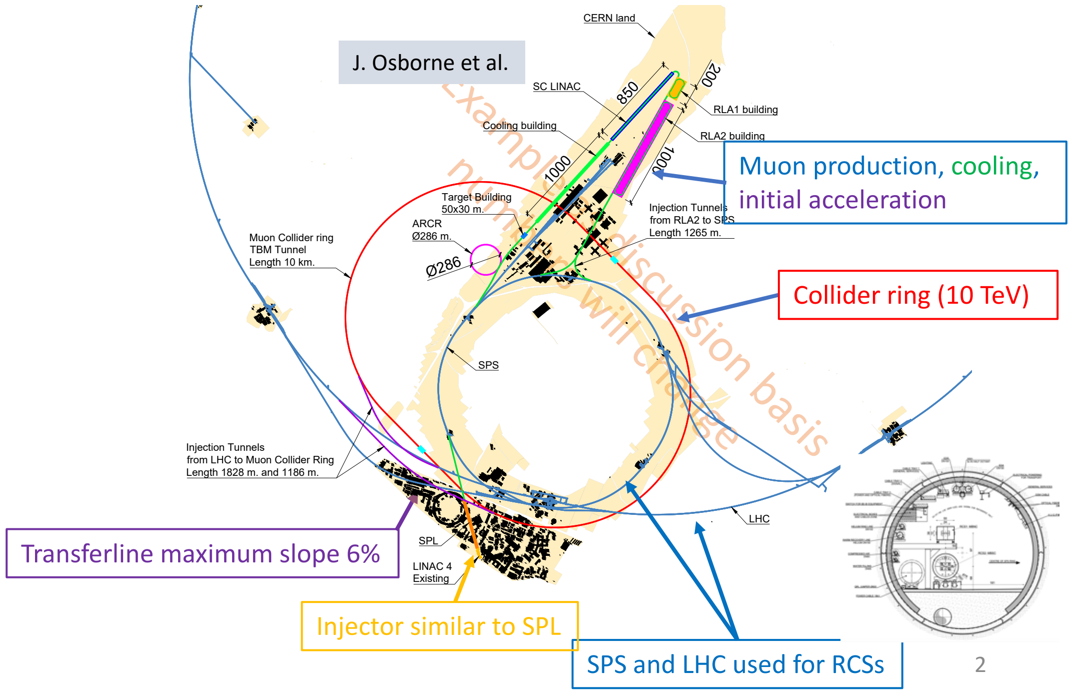
to review:

- R&D plan
- Demontrator design and proposal

10 TeV Muon Collider Beam Requirements

Parameters	Symbol	$\sqrt{s} = 10$ TeV
Particle energy [GeV]	E	5000
Luminosity [10^{34} cm^{-2} s^{-1}]	$\mathscr{L}$	20
Bunch population [10^{12}]	N_p	1.8
Transverse normalized rms emittance [μm]	ε_n	25
Longitudinal emittance ($4\pi\ \sigma_E\ \sigma_T$) [eVs]	ε_l	0.314
Rms bunch length [mm]	σ_z	1.5
Relative rms energy spread [%]	p_T	0.1
Beta function at IP [mm]	β^*	1.5
Beam power with 10 Hz repetition rate [MW]	P_{beam}	14.4

- First collider ring site identified @ CERN
- SPS and LHC tunnels reused
- All construction on CERN
- Energy stages maybe 2.5 and 8 TeV



Muon Collider Magnet team

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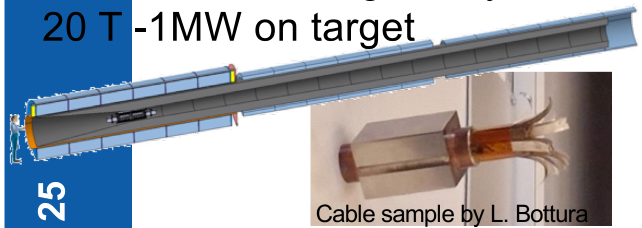
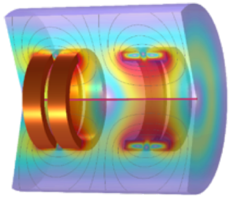
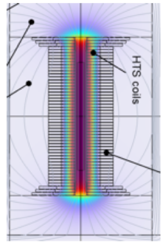
Fusion like - designed by F4E
20 T -1MW on target



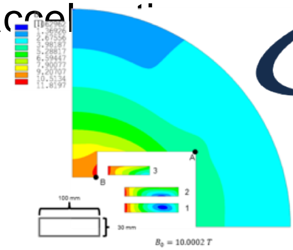


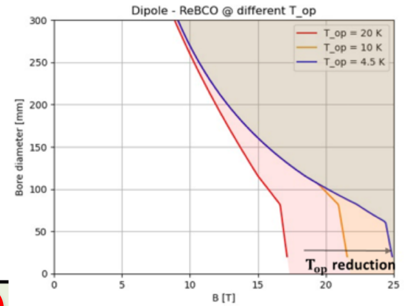
2 km
Field up to 20 T
½ m bore
About 1500 coils

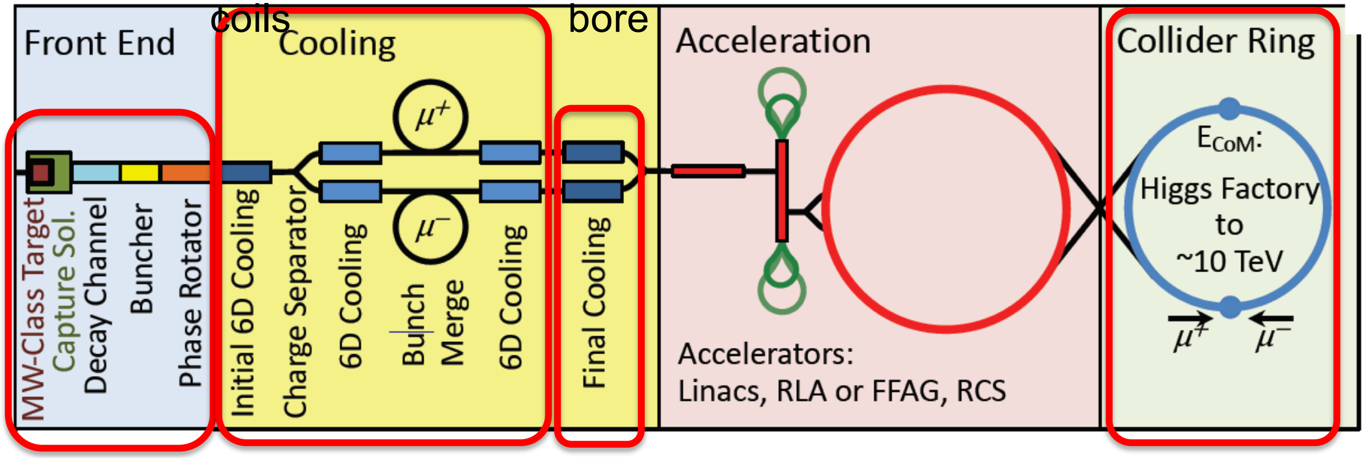


40 T
Small bore

Newcomer
10 T dipole for accel...







The SC magnets are coordinated by INFN

Dipoles
15T / 140 mm
Quadrupoles
G 300 T/m
120 mm
Nb3Sn and HTS
Producing parameters maps

Shared R&D on conductor properties

Task 7.2

Task 7.3

Task 7.4

Muon Collider Cooling Channel

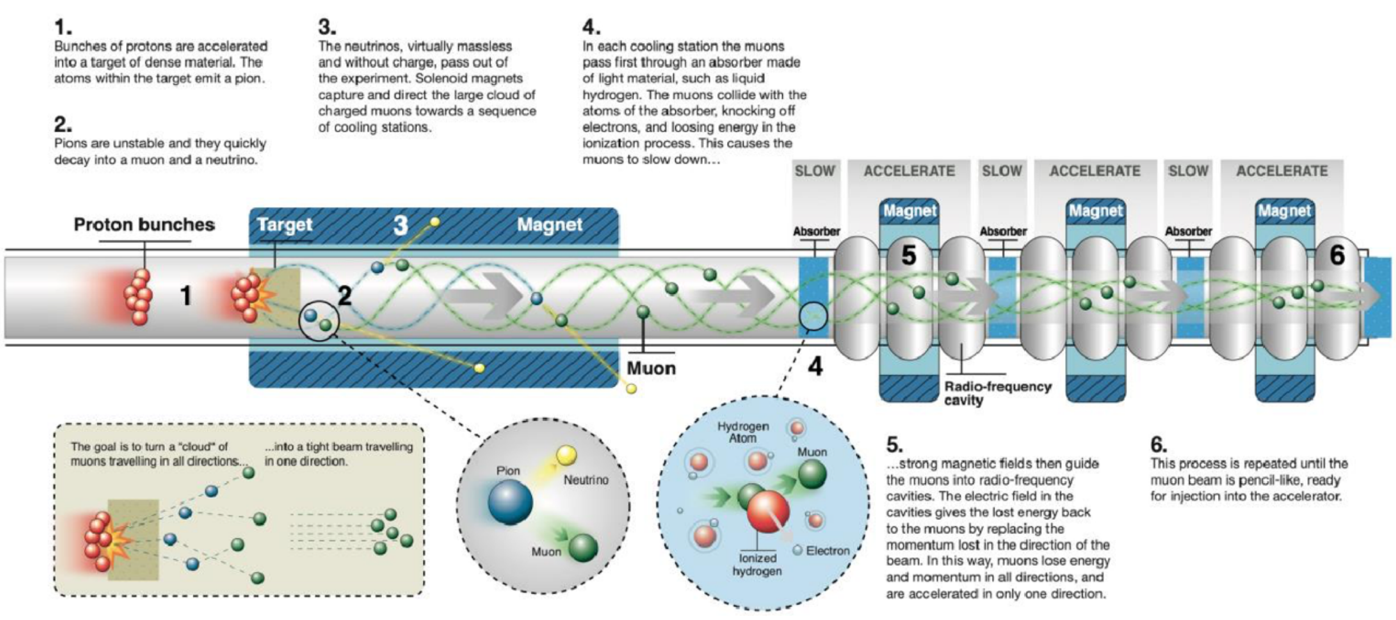
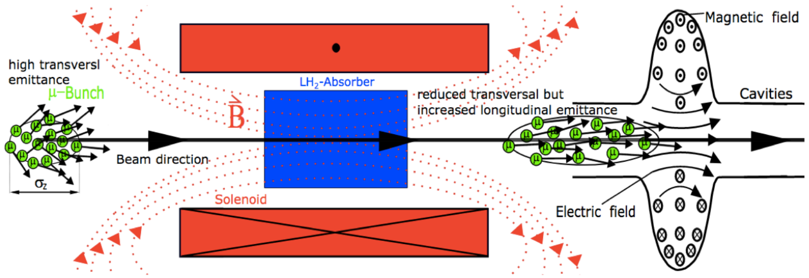


Fig. 3: Principle of the Muon Ionisation Cooling



Muon Collider Cooling Channel

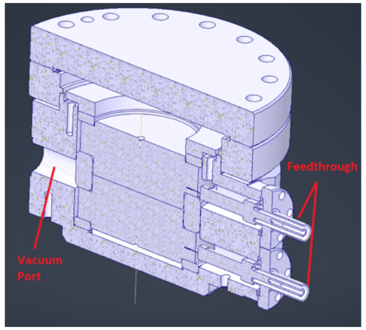
We are in an advanced phase of design related to a couple of tests stands:

- A DC HV test stand with pulsed capabilities embedded in 1 T magnetic field
- A high power (10 MW) S band RF test stand to power a 2856 MHz RF cavity installed in the bore of a SC magnet (see next slides for the magnetic part).

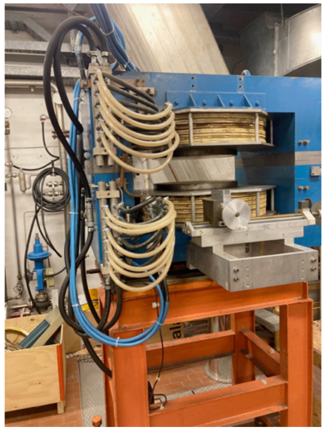
The DC Test Stand may be installed immediately in the existing experimental area @ LASA. We are discussing the design of the pulsed power supply with S. Calatroni (CERN) and the people of his group. Orders for the first components will be placed within summer 2023 and a first version will be ready for the end of this year.

The S band RF test stand may be installed in the AATF in the new building, taking advantage of all the infrastructures we will have at that time (2025) and adding a RF power equipment.

Test facilities: high electric fields in magnets and RF laminas

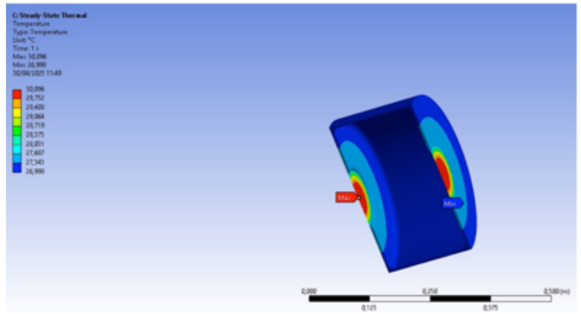


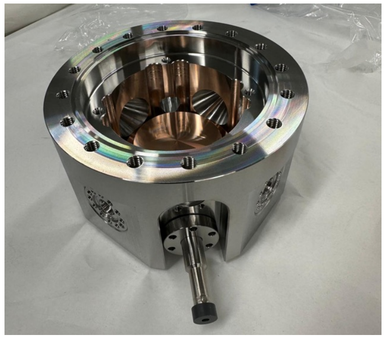
The PVX-4110 pulse generator is a direct coupled, air cooled, solid state half-bridge (totem pole) design, offering equally fast pulse rise and fall times, low power dissipation, and virtually no over-shoot, undershoot or ringing. It has overcurrent detection and shutdown circuitry to protect the pulse generator from potential damage due to arcs and shorts in the load or interconnect cable.

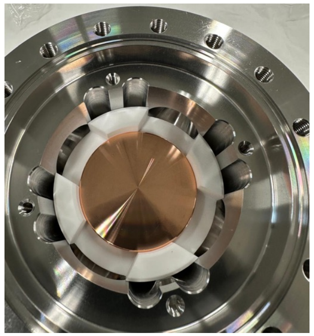


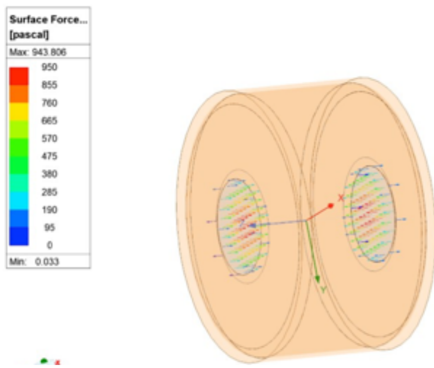
Suitable to test different materials, surface finishing and treatments up to 50 MV/m

The RF cavities design foresees the presence of thin (100 micron) metallic windows at the cells iris.
This will simplify the RF e.m. design but introduces a challenging element related to the mechanical design, the soldering procedures and the capability to sustain RF pressures and thermal stresses.



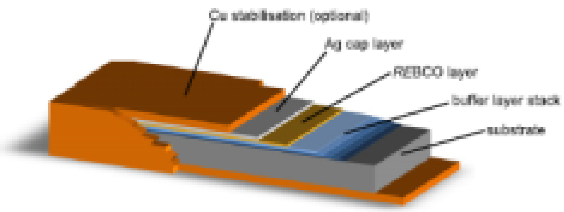


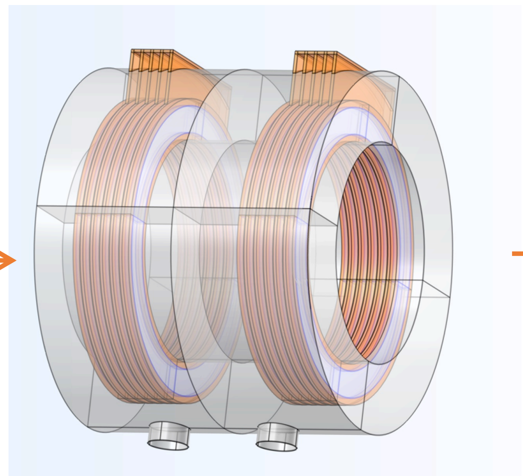


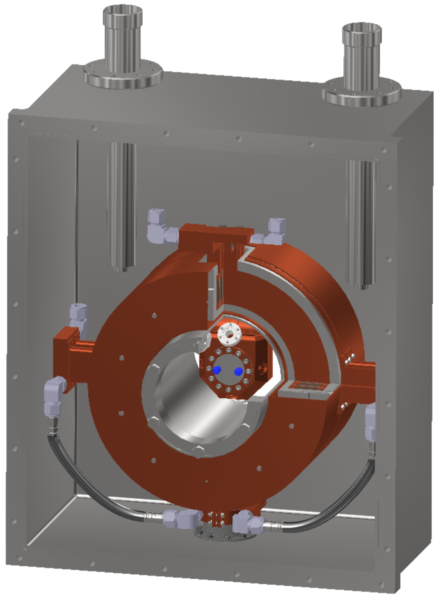


Consiglio di Se

- RFMFTF.1: free bore > 450 mm (> 5 M€) good for 700 MHz test
- RFMFTF.2: free bore ~ 320 mm (> 3 M€) good for 1.3 GHz test
- RFMFTF.3: free bore ~ 180 mm (> 1.5 M€) good for 3 GHz test

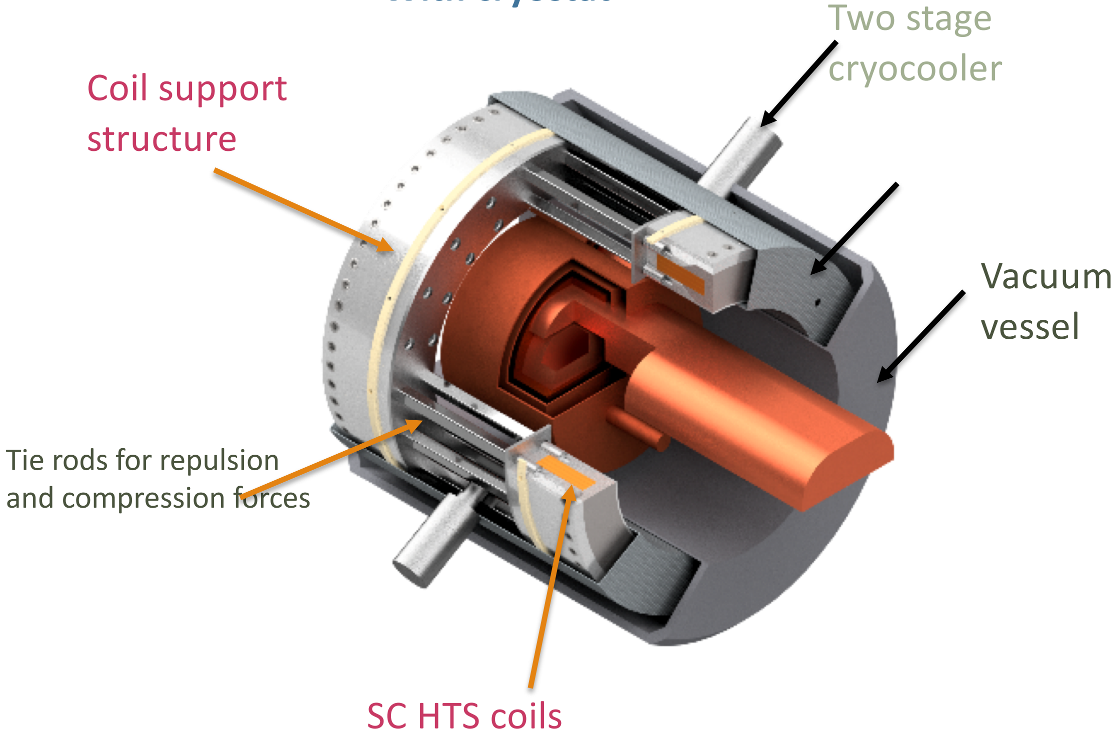


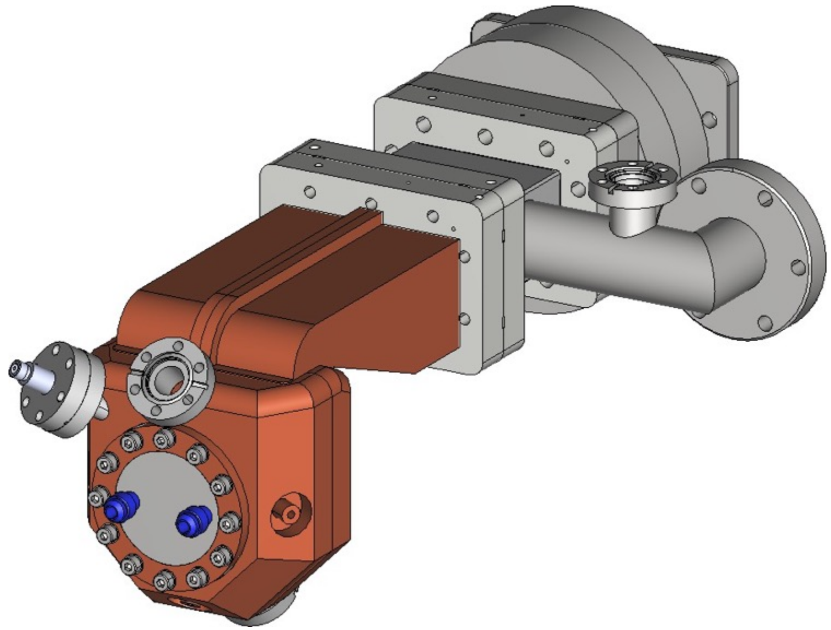




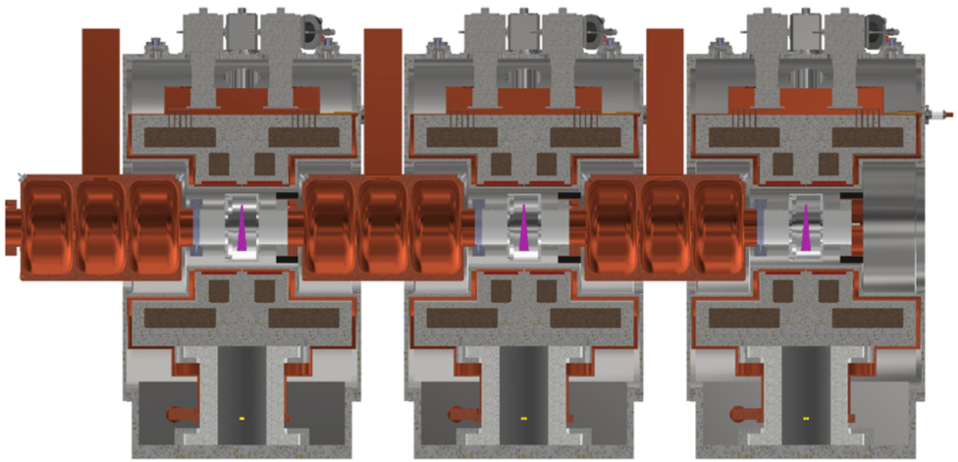
Muon Collider Cooling Channel

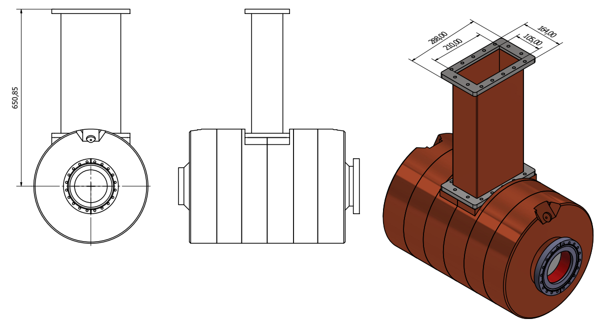
With cryostat

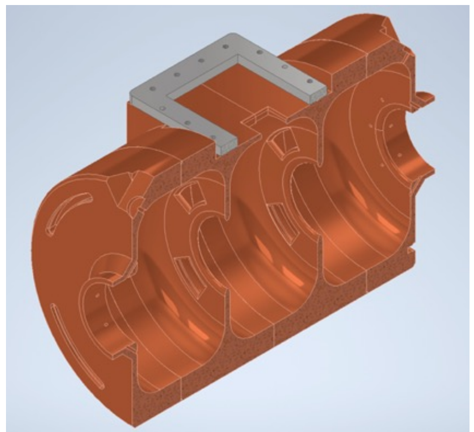




Cooling Cell Integration study: first concept







Health Physics

The double² face of the health physics group of LASA

The Four Seasons, Arcimboldo 1563-1573

Research

- Radionuclides in food and biological samples
- Trace Elements and radionuclides in air

EyeRAD – INFN-E

- Nanotoxicology
- Radiochemistry

MATHER-3D
CSN5 - INFN

- Optimization of the production of theranostic radionuclides

REMIX	CSN5 - INFN
CUPRUM_TTD	CSN5 - INFN
APHRODITE	**PRIN-PNRR**
SPES-MED	CSN3 - INFN

Environmental radioactivity

Medical applications

- Radiolab and ISOradioLAb
- Macugnaga summer school

RADIOLAB & ISOradioLAB
PARTICLE THERAPY MASTERCLASS
PLAYMO
CC3M – INFN & **PNRR Orientamento – UNIMI**

- Particle Therapy Masterclass

Education

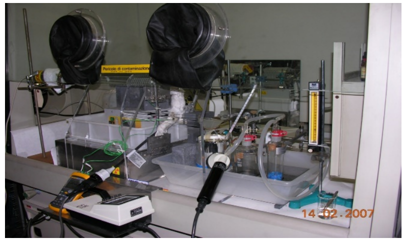
Thesis and formation periods are proposed on all the research topics

Finanziato dall'Unione europea
NextGenerationEU

Optimization Production of HSARn for Nuclear Medicine applications

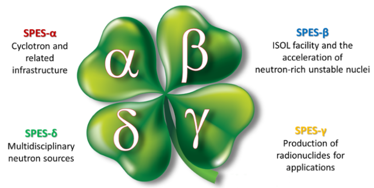
LASA

Hot Radiochemistry Laboratory
ISO Class II and UNICEN 7815 classified Controlled (Restricted) Area - Non Sealed sources of medium activities containing radionuclides of short and medium half life can be manipulated



Physics and Chemistry Measurements Laboratory

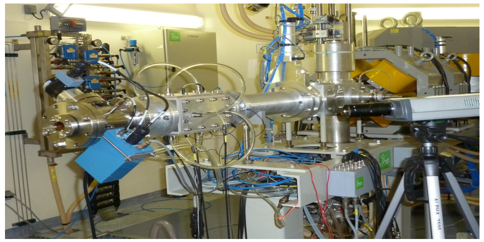
in collaboration with:



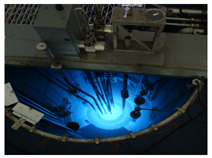
LEGNARO Laboratory - SPES-γ activities

ARRONAX Cyclotron (Nantes) Beam particles

- Protons 35 – 70 Mev **up to 750 mA**
- Deuterons 15 – 35 Mev
- Alpha 70 MeV



LENA - Pavia Nuclear Research Reactor TRIGA MARK II

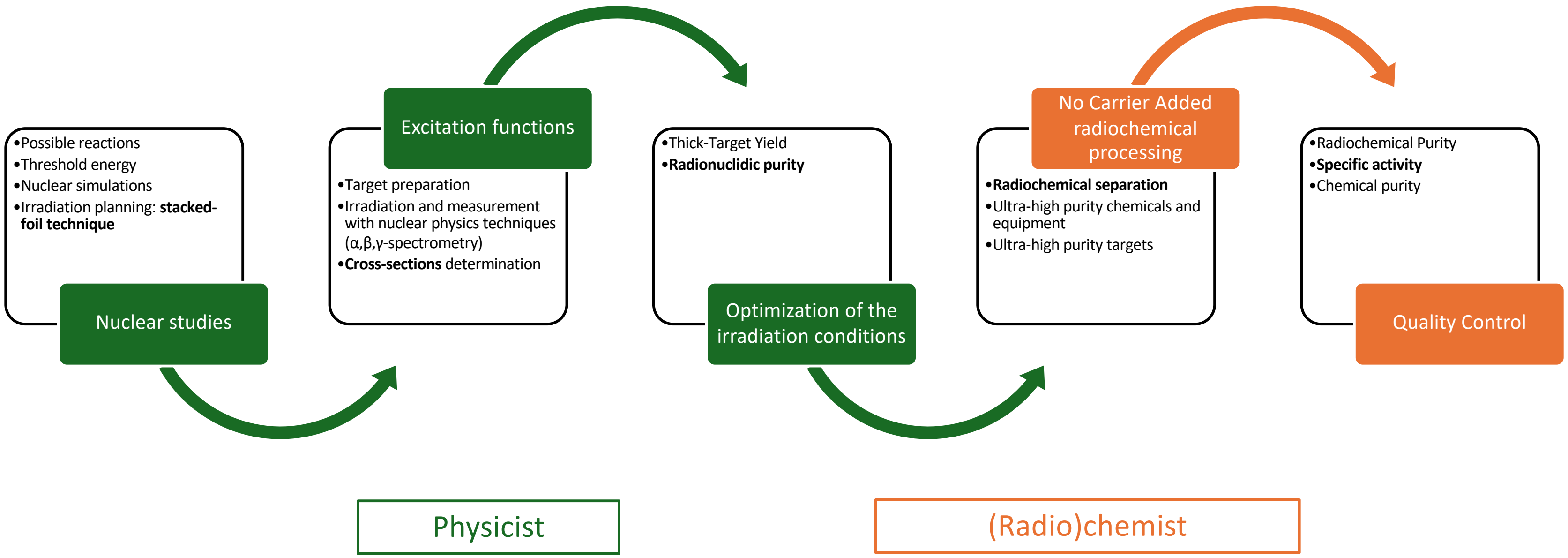


UNIVERSITÀ DEGLI STUDI DI MILANO

INFN LASA Istituto Nazionale di Fisica Nucleare Laboratorio Acceleratori e Superconduttività Applicata

RADIOLAB

Optimization of the **production** of **theranostic radionuclides**



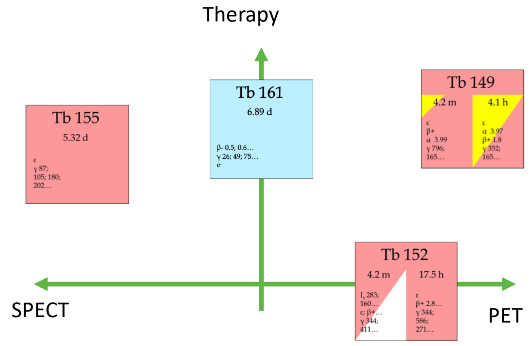
Optimization of the production of theranostic radionuclides → The example of terbium

Terbium offers a unique set of radioisotopes for both diagnostic and therapeutic applications.

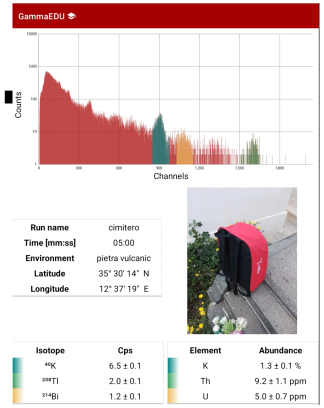
Key isotopes:

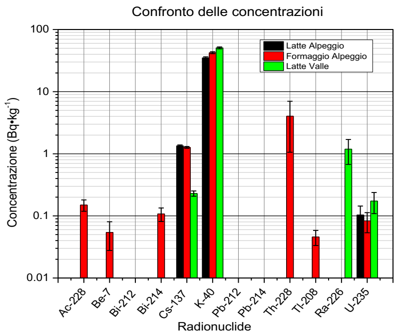
- ^{149}Tb: Targeted Alpha Therapy (TAT) and PET imaging.
- ^{152}Tb: PET imaging for extended imaging times.
- ^{155}Tb: SPECT imaging and Auger electron-based therapy.
- ^{161}Tb: β- therapy with added Auger electron benefits.

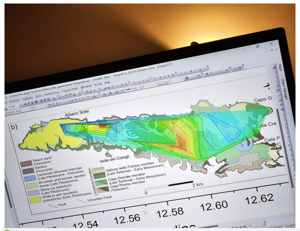
Known as the ”Swiss Army Knife of Nuclear Medicine” due to its versatility.

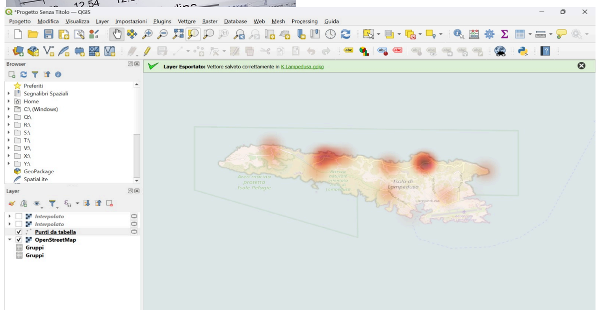


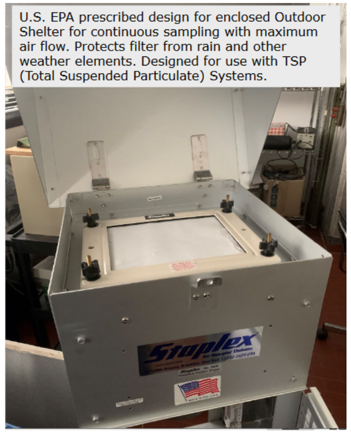
Environmental projects and EyeRAD











EyeRAD

INFN Environmental RADioactivity monitoring network

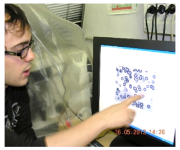
Goal

- **environmental radioactivity INFN monitoring network** focusing on measuring the **concentration of radionuclides present in atmospheric particulate matter**, in particular, in the **detection of artificial radioactivity issued following occasional anomalous events**, in parallel with the regional and national agencies and bodies that already deal with them for an institutional duty;
- inclusion of any other initiatives regarding **environmental monitoring and radiation protection**.

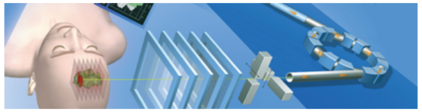
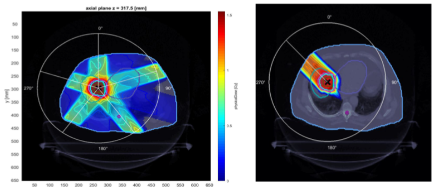
Dissemination of scientific themes for schools and public

- **High school students** are involved in the measurement of **natural radioactivity**

RADIOLAB and recently expanded in **ISOradioLAB** devoted to schools in minor Italian islands Lampedusa, Pantelleria, Eolie – involved more than **2000 students of Regione Lombardia + Albania + Ecuador + Slovakia**

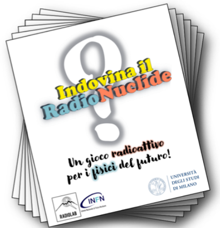



- **Particle Therapy International Master Class** – 5 editions 150 students for Milano

- **PLAYMO – table games, partecipation with "Indovina il Radionuclide"**
  INFN patent: 10.15161/oar.it/vb3r7-ezr77

Card game based on "Guess who" where you may meet Cs-137 or U-235 instead of Uncle Tom.



- **Partecipation to events:**

Summer School in Macugnaga;
Open days: UNIMI, visit at LASA Labs

- Training for the High School teachers

All activities are recognized for PCTO and by MUR (program that unites classes and internships)

Cosmic rays measurements at 3000 m s.l.m.

Manpower requests

This is an old time problem.

Our proposal for 2026 is the following:

Mechanical workshop:	add one more staff resource
General services:	add, at least, a staff resource (we are approaching the duplication of the building and at least one would be completely to be supported by INFN !)
Mechanical Design:	add one staff resource for the design and a mechanical draftman for the lab
Electronic services:	add one staff resource for the lab
Researchers:	we have valuable young researchers working with us and still more are needed. What would be their future ? How to maintain (and expand) the accelerator school at LASA ? The same applies for the PNRR IRIS resources but at least in this framework a discussion is on going.

Thanks for your attention !