Muon Collider R&D magneti SC

Marco Statera, INFN LASA
B. Caiffi, INFN Genova, S. Mariotto e S. Sorti, UNIMI e INFN LASA
LNF ,13-11-2023

Outline

- Where in muon collider
- Magnet zoo
- Technology drivers and options
- objectives, schedule and team: what who and when are we doing

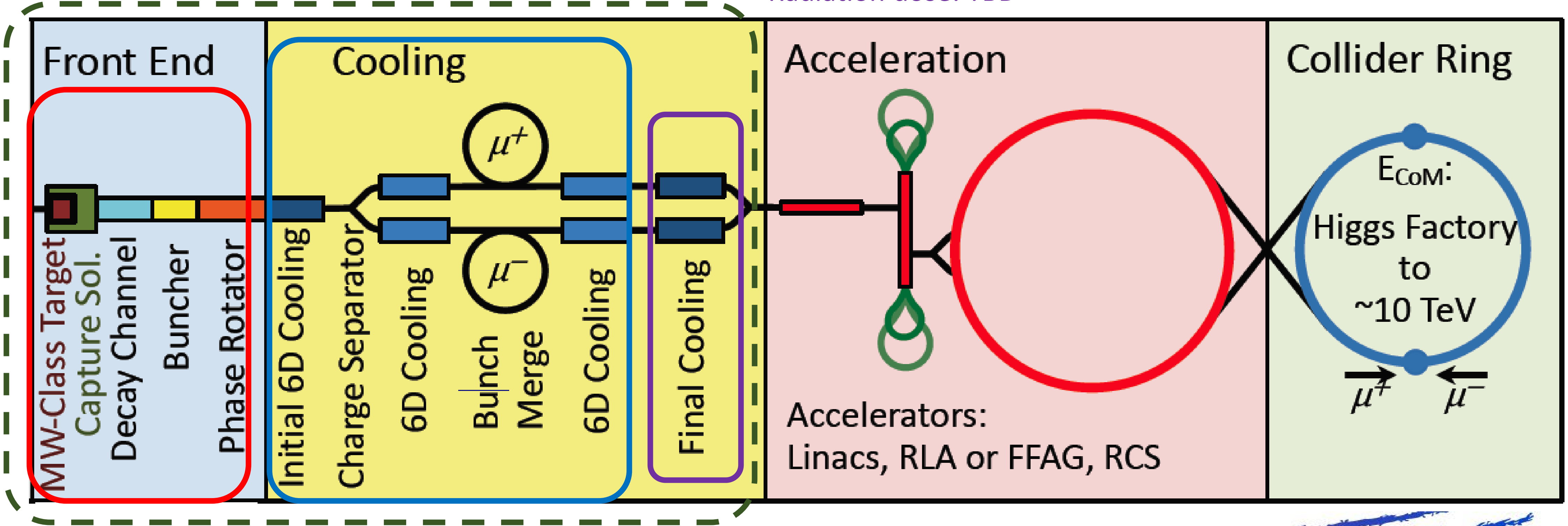
Muon Collider magnet "specs"

Target solenoids
Field: 20 T… 2T
Bore: 1200 mm
Length: 18 m
Radiation heat: ≈ 4.1 kW
Radiation dose: 80 MGy

6D Cooling solenoids
Field: 4 T … 19 T
Bore: 90 mm … 600 mm
Length: 500 mm (x 17)
Radiation heat: TBD
Radiation dose: TBD

Final Cooling solenoids
Field: > 40 T (ideally 60 T)
Bore: 50 mm
Length: ≈ 1 km (x 2)
Radiation heat: TBD
Radiation dose: TBD

TASK 7.2



Muon Collider Magnet team

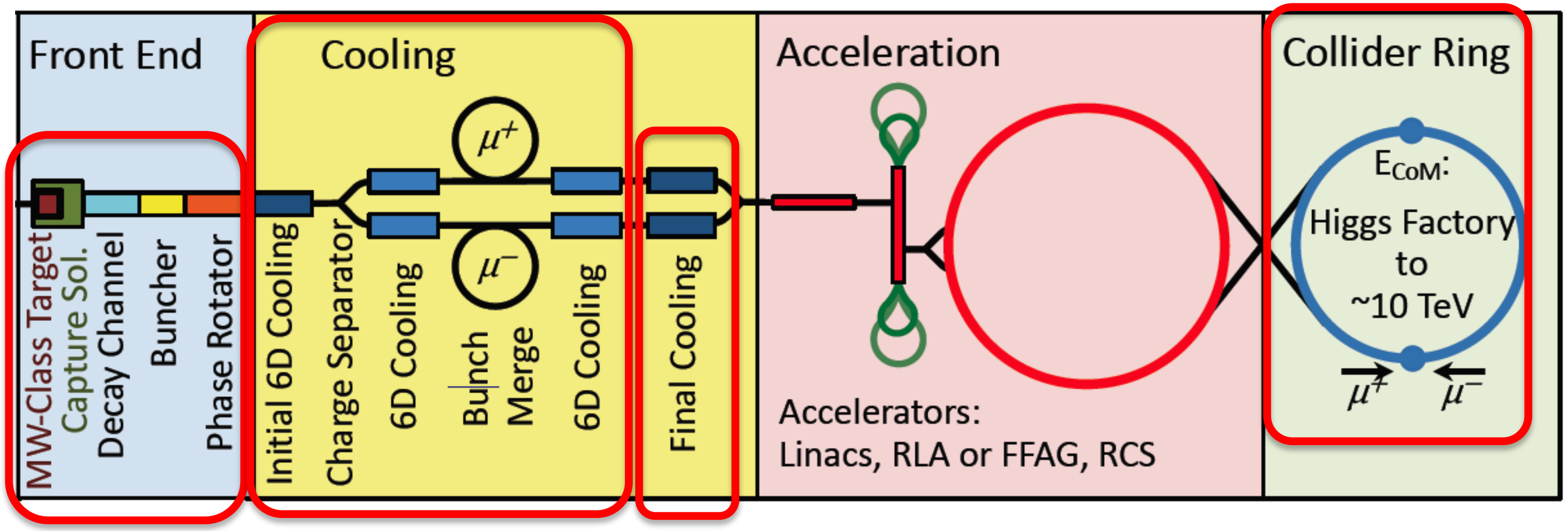
CERN
F4E (Barcelona)
F4E (Garching)

INFN
CERN
UniMI
KIT

CERN
INFN
CEA
CNRS
PSI
UniGE
SO'TON
uniTwente

INFN
UniMI
CERN
TUT

The SC magnets are coordinated by INFN



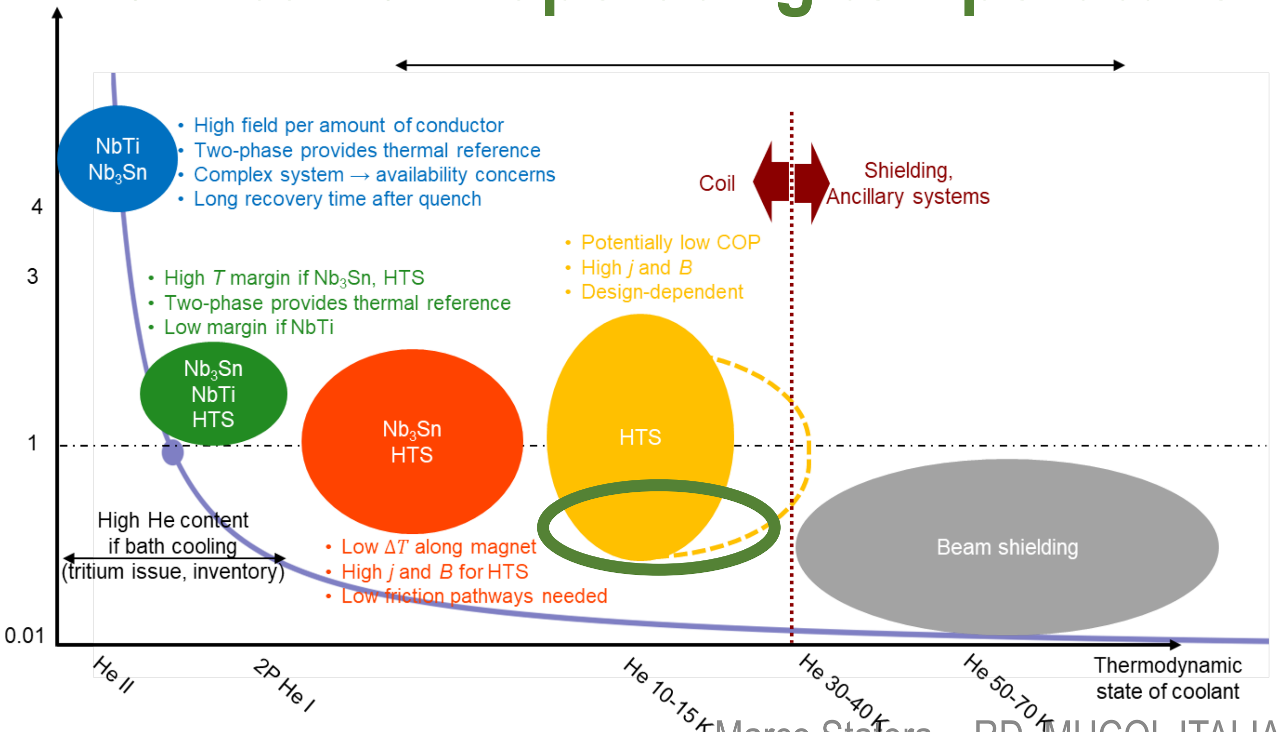
Shared R&D on conductor properties ⟷ Task 7.2 | Task 7.3 | Task 7.4

Motivation and conductor characterization

3 pillas of design:

Performance (field and field quality), Cost and Sustainability

10 K to 20 K operating temperature

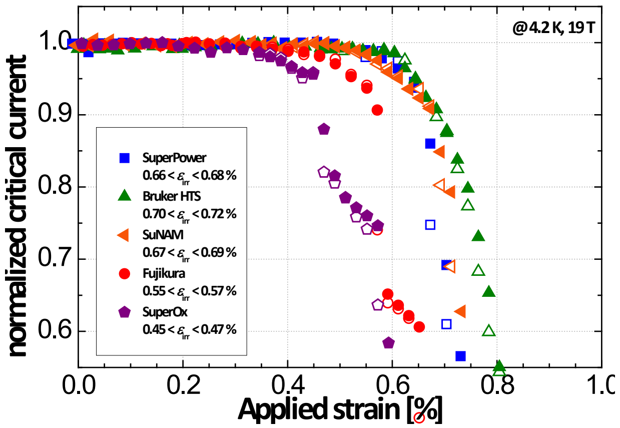


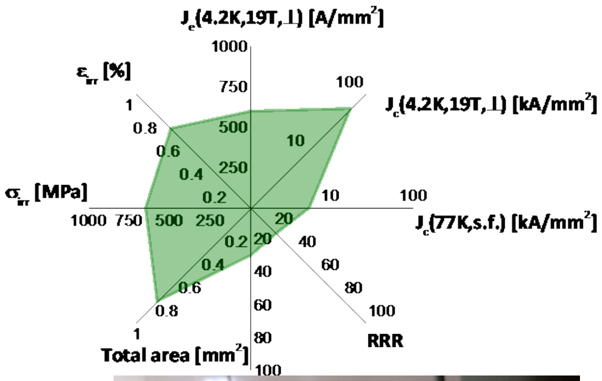
P. Borges de Sousa, 2022

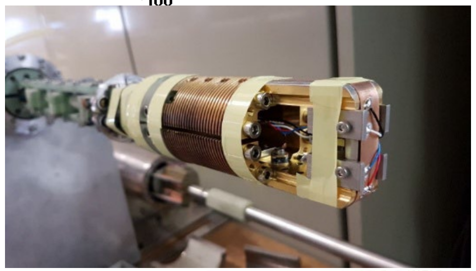
Ongoing conductor characterization and modeling

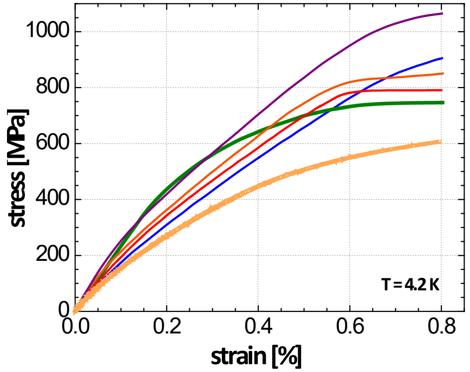
HTS inventory for IMCC

SuperPower Inc. 上海超导 SHANGHAI SUPERCONDUCTOR Fujikura FARADAY FACTORY JAPAN







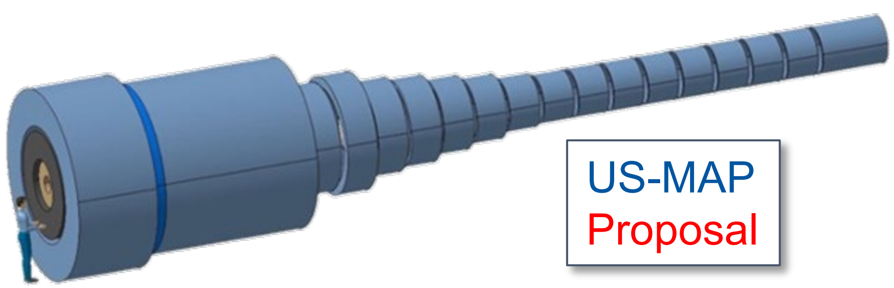


Electromechanical properties

Courtesy of C. Senatore, UniGE

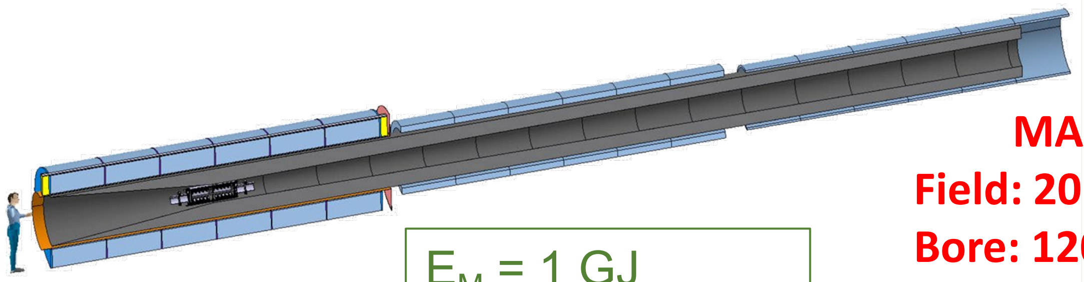
Target solenoid

New conceptual design finalized



E_M = 2.9 GJ
T_{op} = 4.2 K
M_{coils} = 200 tons
M_{shield} = 300 tons
P = 12 MW

- Remove resistive insert (10 MW), HTS to achieve field of 20 T
- Reduce shield thicknes, accepting higher heat load at 20 K



A. Portone, F4E

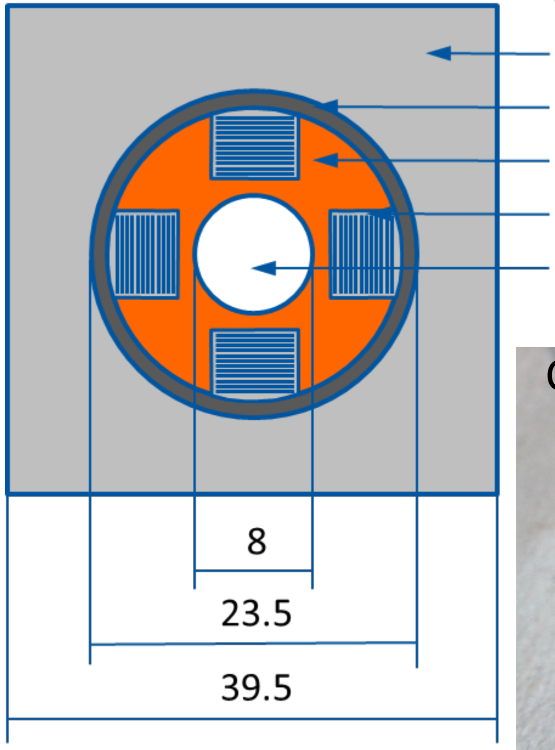
E_M = 1 GJ
T_{op} = 10…20 K
M_{coils} = 110 tons
M_{shield} = 196 tons
P = 1MW

MAGNET SPECS

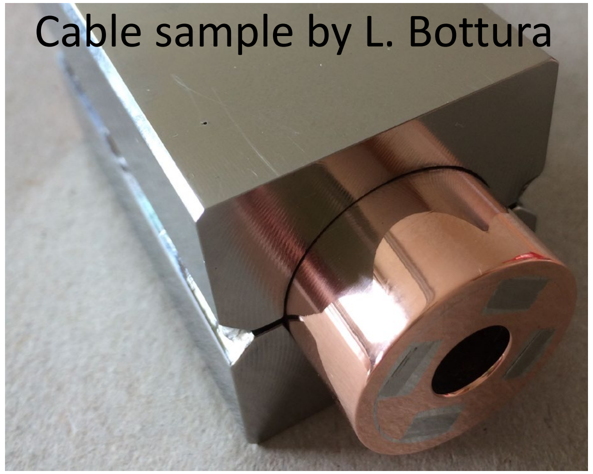
Field: 20 T… 2T
Bore: 1200 mm
Length: 18 m
Radiation heat: ≈ 4.1 kW
Radiation dose: 80 MGy

HTS conductor design
Based on viper by MIT

Operating current: 58 kA
Operating field: 20 T
Operating temperature: 20 K

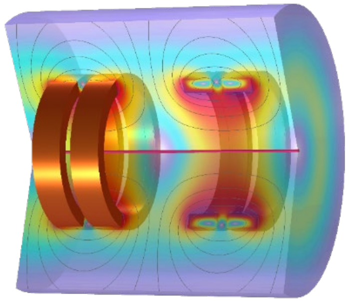


STAINLESS STEEL JACKET
STAINLESS STEEL WRAP
COPPER FORMER
SOLDERED HTS STACK
COOLING CHANNEL



6D cooling

We consider a four-stage (A1–A4) tapered channel, where each stage consists of a sequence of identical cells and some of the main lattice parameters are summarized in Table I.
After bunch merging, both longitudinal and transverse emittances of the now
single muon bunch increase by a factor ~4 and thus are comparable to their initial values. It can thus be taken again
through the same cooling system but with one important difference. While only a modest transverse cooling to
~1.5 mm was required before the bunch-merging system, the new single muon bunch needs to be cooled by an
additional order of magnitude before it can be sent to the accelerator systems. We consider eight tapered stages (B1–B8) to achieve this goal



e view.

Technology options

Full study based on US-MAP proposal

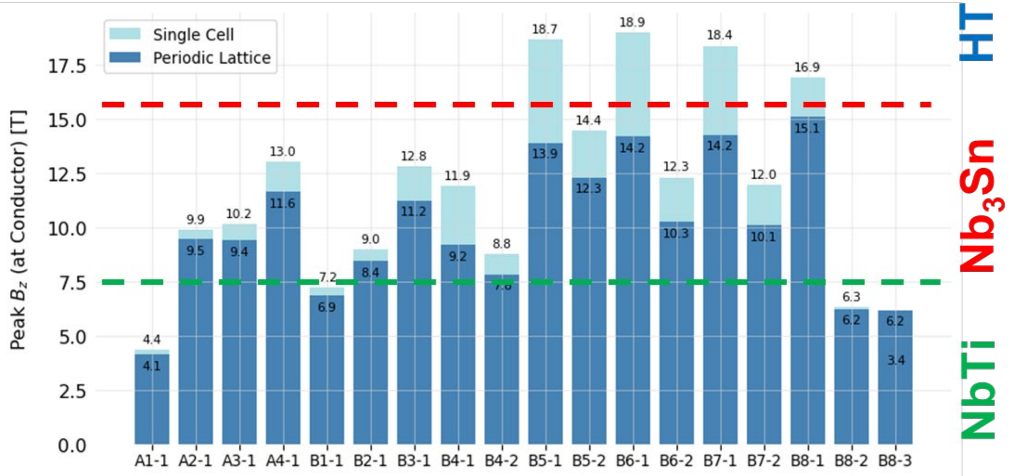
Some stats:

Fields on axis: 2 to 14 T

Cell Lengths: 0.8 to 2.7 m

Total length of all Stages: ~ **1 km**

Total number of solenoids: 2432



Stage	[1] Cell Length [m]	[1] Solenoids/Cell	[2] Peak Bz field on axis [T]	[2] Stored Magnetic Energy [MJ]	Coil	Technology Options: NbTi (4 K)	Nb3Sn (4 K)	HTS (4 K)	HTS (20 K)
A1	2	4	2,4	5,38	A1-1	X	X	X	X
A2	1,32	2	3,5	15,35	A2-1		X	X	X
A3	1	4	4,8	7,23	A3-1		X	X	X
A4	0,8	4	6,1	8,39	A4-1		X	X	X
B1	2,75	2	2,6	44,54	B1-1	X	X	X	X
B2	2	2	3,7	24,1	B2-1		X	X	X
B3	1,5	2	4,9	29,83	B3-1		X	X	X
B4	1,27	4	6	24,4	B4-1		X	X	X
					B4-2		X	X	X
B5	0,806	4	9,8	12,03	B5-1			X	X
					B5-2		X	X	X
B6	0,806	4	10,8	8,19	B6-1			X	X
					B6-2		X	X	X
B7	0,806	4	12,5	5,65	B7-1			X	X
					B7-2		X	X	X
B8	0,806	6	13,6	1,42	B8-1			X	X
					B8-2	X	X	X	X
					B8-3	X	X	X	X

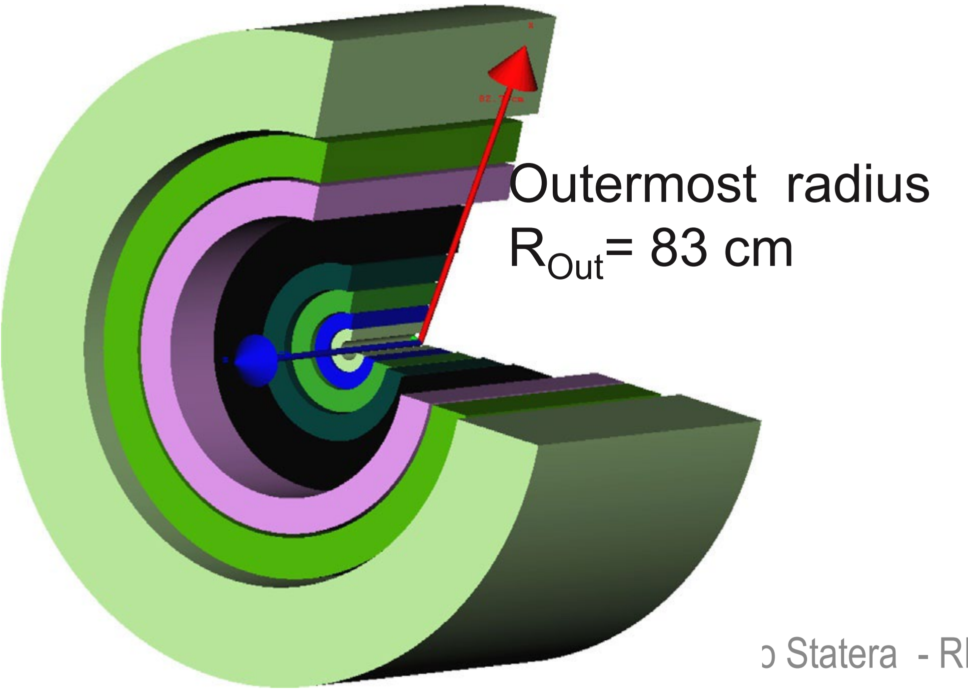
S. Fabbri, CERN and J. Pavan, INFN

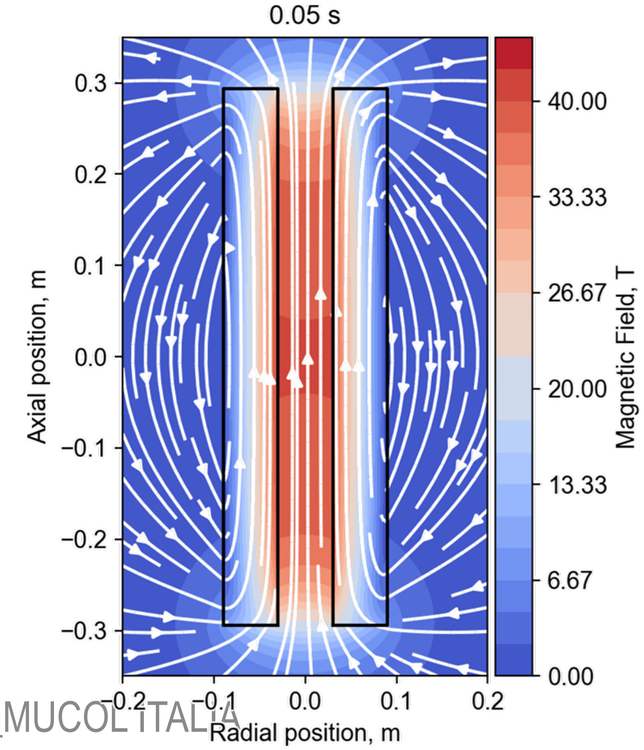
Final cooling solenoids

Conceptual design finalized (electromagnetic and mechanics)

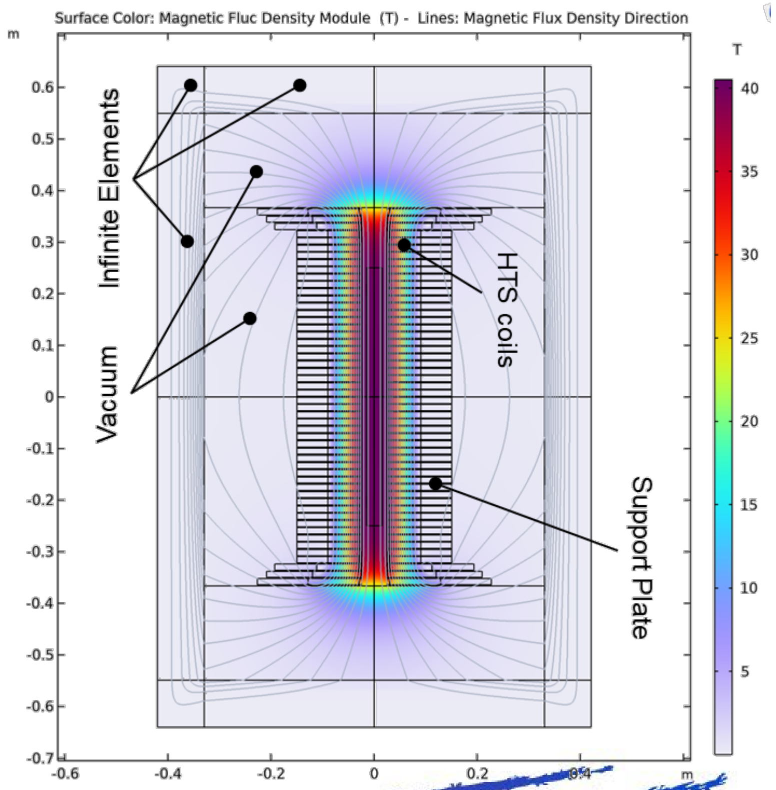
Main specs used for the CERN conceptual design

- Based on HTS pancake non insulated coils
- **B ≥ 40 T**, aperture **ϕ ≥ 50 mm**, field **homogeneity 1 % over ˜ 0.5 m**
- **Energizing** time **6 hrs** and **persistency 0.1 Units/s**





T. Mulder, CERN



B. Bordin, CERN

To be investigated

We are defining technologies
- Conductor
- Operation condition, i.e. temperature an cooling method

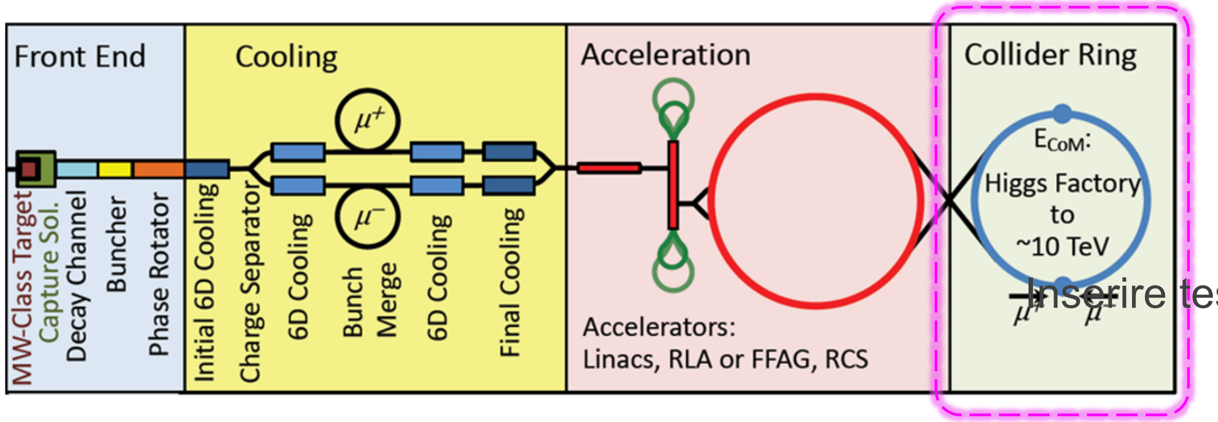
To be investigated
- Conductor performance
- Conductor configuration
- Field quality
- Thermal/mechanical configuration

Technologies 6D cooling solenoids

Technology	Pro's	Con's
LTS	Known technology (TRL 9)	Operating temperature
HTS ReBCCO Insulated	More compact than LTS/HTS Allows for operation at higher temperature Batch above 100 m demonstrated	R&D at low readiness (TRL 4/5) Quench detection protection Production of km batches to be demostrated
HTS ReBCCO Non-insulated	Most compact magnet winding Synergies with other fields of science and societal applications Batch above 100 m demonstrated Can profit from development by others (e.g. NHMFL)	R&D at low readiness (TRL 3/4/5) Ramping time and field stability need to be demonstrated Quench detection and protection Production of km batches to be demostrated
HTS BiSSCO/IBS	Round wire demonstrated for BiSSCO	R&D at low readiness (TRL 3/4) for IBS Production lengths (?)

Collider Magnets Requirements

D. Novelli, B. Caiffi e S. Mariotto

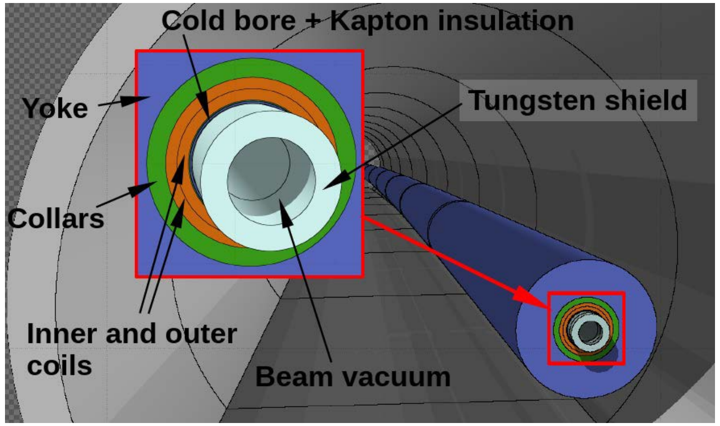


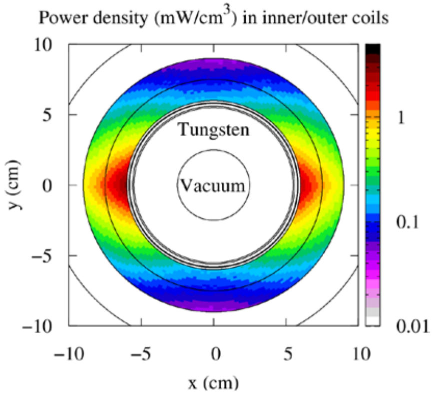
Field: 16 T peak (IR 20 T)

Length: 10…15 m (x 700)
Space between magnets: 300 mm
Radiation heat load: 5 W/m
Cumulative dose: 20…40 MGy

Aperture

Courtesy of Patricia Borges de Sousa
https://indico.cern.ch/event/1250075/contributions/5357594/

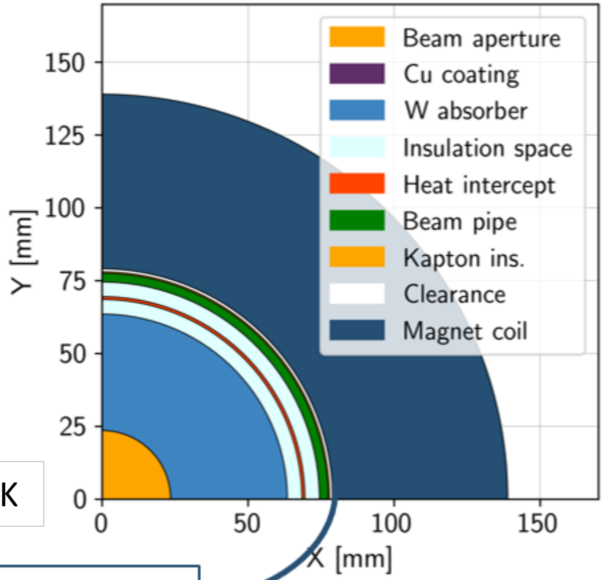




Beam aperture (5σ)	23.5 mm radius
Cu layer beam screen	0.01 mm thick
Tungsten absorber	40 mm thick
Insulation space	5 mm thick
Heat intercept	1 mm thick
Insulation space	5 mm thick
Beam pipe	3 mm thick
Kapton insulation	0.5 mm thick
Clearance	1 mm thick
Coil pack*	(60 mm thick)

*thickness TBD, placeholder

Assuming 10 TeV machine and coil at 4.5 K

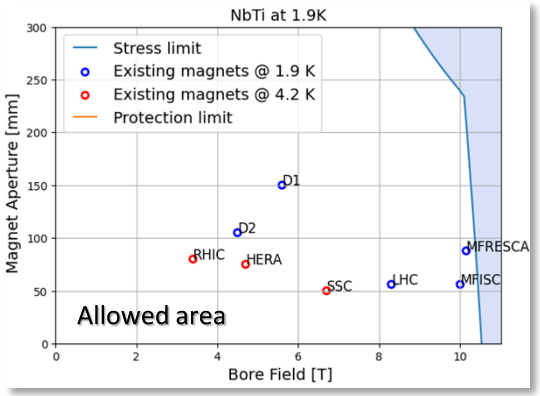


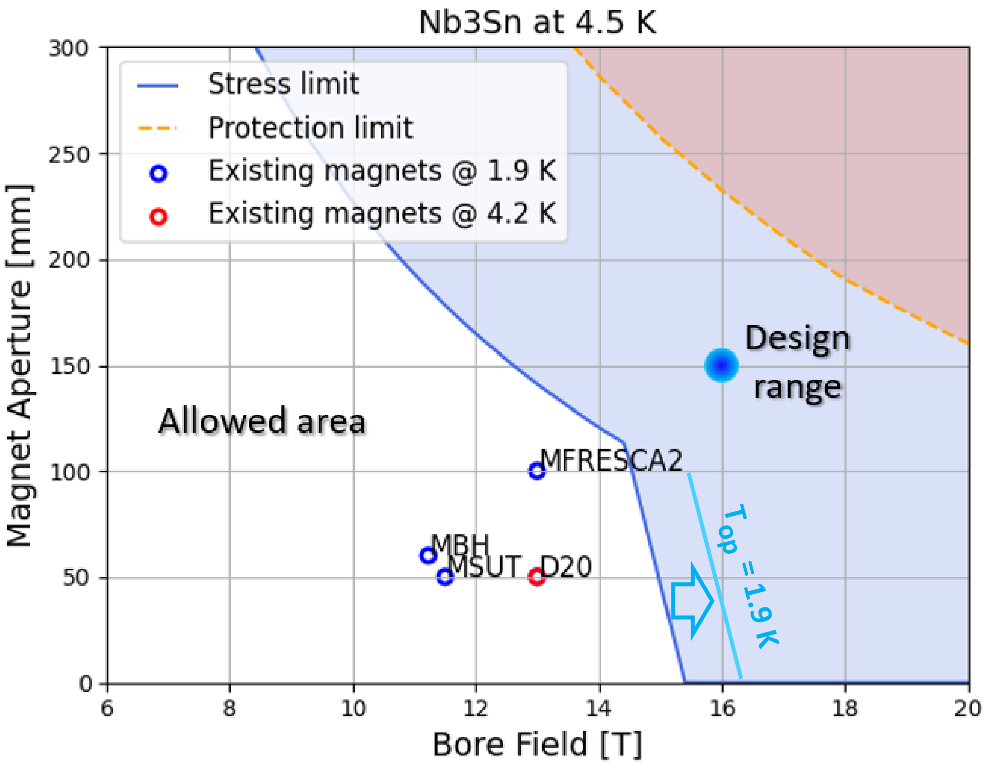
Coil aperture 158 mm

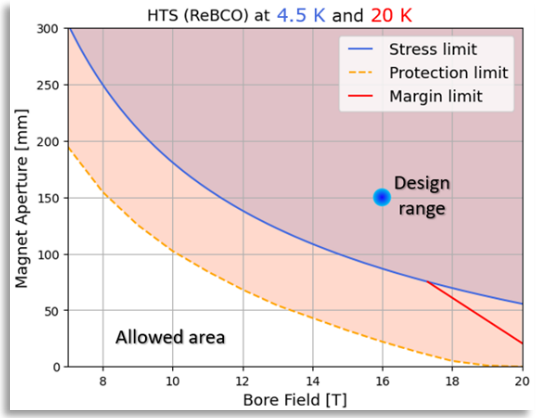
! Need for large fields in large apertures → discussion on parameter limits

A-B PLOTS Nb_3Sn

D. Novelli, B. Caiffi e S. Mariotto





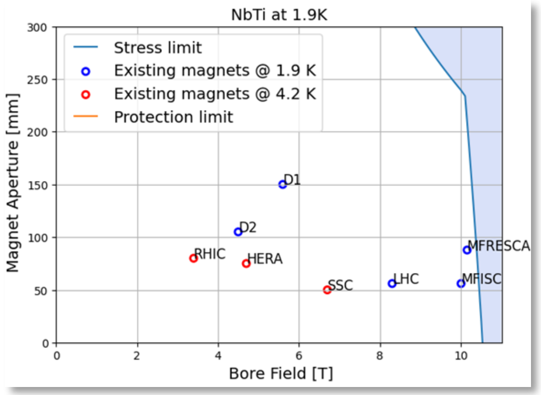


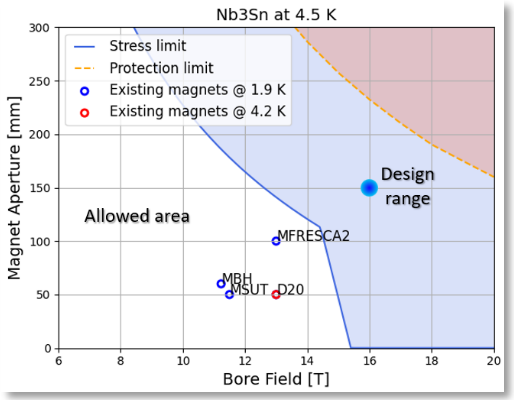
We are using the aspirational value for the SC cost (700 EUR/kg).

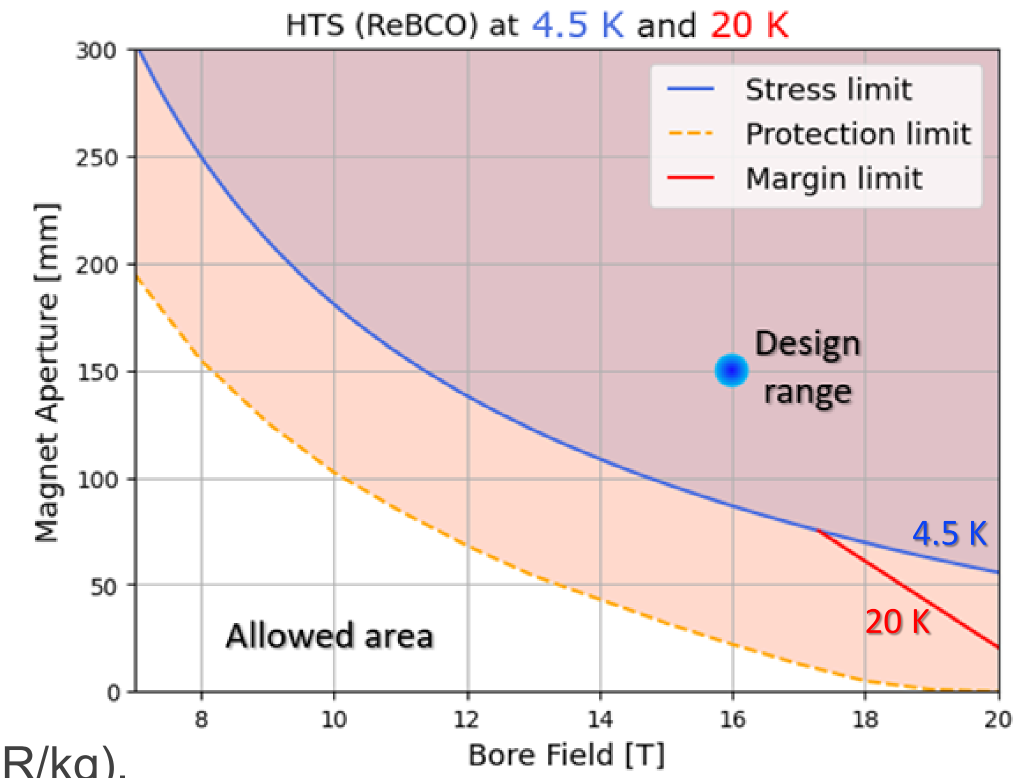
- Nb_3Sn falls short of required performance because of operating margin and peak stress.
- Reducing the operating temperature at 1.9 K, the change in the slope occur at higher field.

A-B PLOTS *HTS*

D. Novelli, B. Caiffi e S. Mariotto





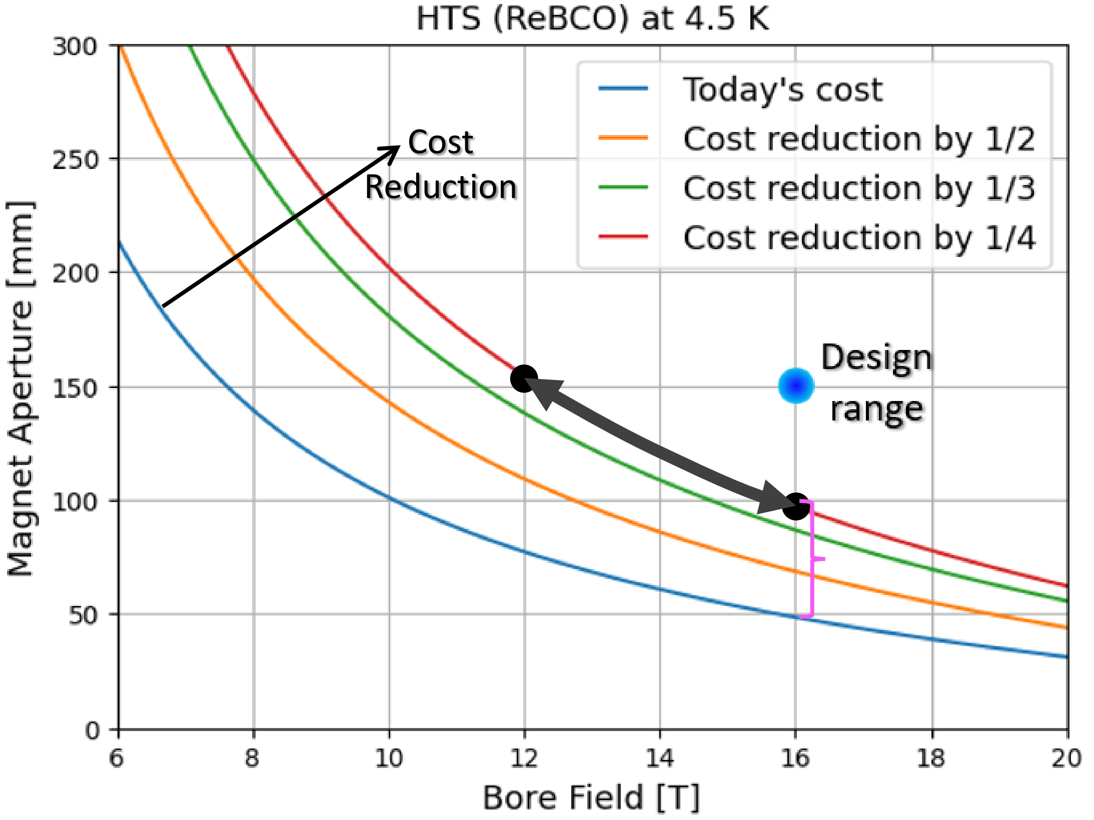


We are using the aspirational value for the SC cost (2500 EUR/kg).

- HTS falls short of required performance because of peak stress and protection.
- **Need to devise alternative protection schemes.**
- **Up to 17 T working with a cold mass operating temperature of 20 K.**

A-B PLOTS

D. Novelli, B. Caiffi e S. Mariotto



- Reducing the cost of HTS will result in a bigger allowed area.
  - Reducing the unit cost by a factor 1/4 doubles the maximum magnet aperture at 16 T.
- The reduction in the cost of the HTS is obviously does not depend on us.
  - Is it possible to spend more on the collider?
  - (It is not 100 km long like the FCC).
- Operation in the range of temperature 10 K…20 K (above liquid helium) will reduce magnet aperture requirements.
  - Acceptable heat loads is increased by a factor 2…4, thus reducing the need for shielding.

Typical A-B range can be (12 T, 160 mm) to (16 T, 100 mm) for the SC dipoles, using the HTS at a cost reduction of 1/4.

Muon Collider magnet "team"

- CERN-EP
  - Contribution to development of HTS technology for UHF solenoids
  - Contact person: A. Dudarev

  Baseline studies for HF solenoids

  Engineering design

  R&D pancakes
- PSI
  - Contribution to target and cooling solenoids design and technology R&D
    - Instrumentation and analysis of NI coils (in synergy with other projects that provide the coils)
    - Powered samples to test mechanical limitations (NOTE: need to brainstorm)
    - Integrated conceptual target-magnet design, in close iteration loops with particle-shower simulations
  - Contact person: Dr. B. Auchmann

  Instrumentation for test coils (vtap, protection schemes and devices)

  R&D pancakes
- University of Geneva
  - Measurements in support to R&D on HTS
    - Electro-Mechanical characterization and limits at high field (NOTE: need to brainstorm)
  - Contact person: Prof. C. Senatore

  Characterization measurements and conductor review
- INFN LASA
  - Critical current measurement
  - Contact person: Dr. Marco Statera

  Coordination

  Define reference geometries fo r small coils (L. Bottura)

  Design of test coils devices (together with CERN, CEA…)

  R&D pancakes

  Test of small coils
- University of Southampton
  - Design of solenoids and measurement of HTS properties
  - Test in background field (10 T, 110 mm)
  - Contact person: Prof. Y. Yang

  Review of material options REBCO, Bi-2212, Bi-2223, IBS

  Evaluate current distribution in multi tape windings

  Mechanical and electro-mechanical properties

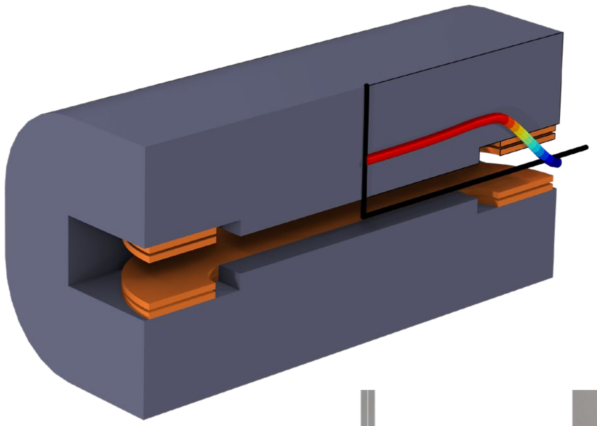
  R&D pancakes

  Test of small coils
- University of Twente
  - Contribute to the design and conductor effort
    - HTS conductor design (both ReBCO and B2223) at the level of basic strand/tape, shape optimization and reinforcements
    - HTS smart innovative cabling to allow for higher current, current sharing redundancy and quench protection
    - HTS conductor characterization/review for limiting strain and cycling degradation
    - HTS coil windings with controlled resistance to smartly balance conflicting requirements of ramp loss and quench stability
  - Contact person: Prof. A. Kario

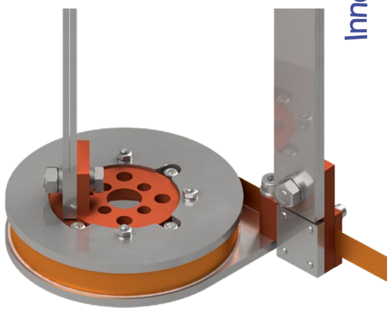
  Mechanical and electro-mechanical properties
- KIT
  - R&D on coils and tests
  - Contact person: Dr T. Arndt

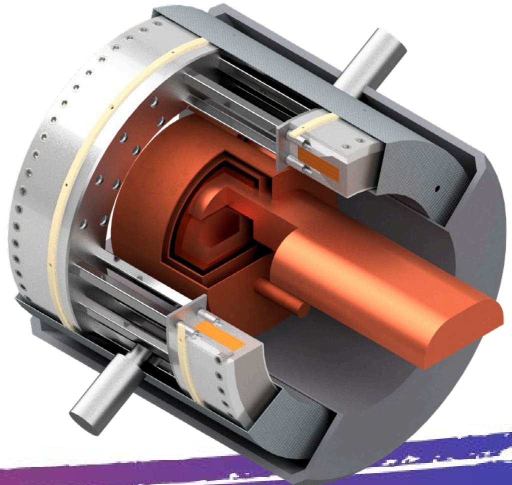
  Test coils winding and test, model development

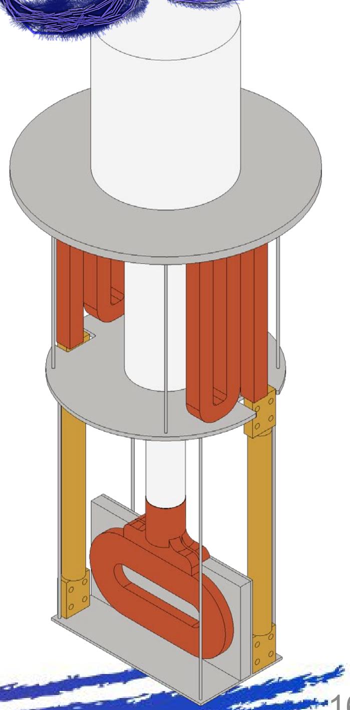
Ongoing activities



- Tape characterization
- Preliminary design of coils and cell
  - Design of a HTS dipole for IRIS, Next Gen EU
  - Winding tests of small pancakes
  - Test of small pancakes (also in field)
  - Design of the RF test station (in collaboration with WP8)
- Coil design for the cells
  - Field and forces
  - Integration of cooling system
  - Field quality definition and optimization



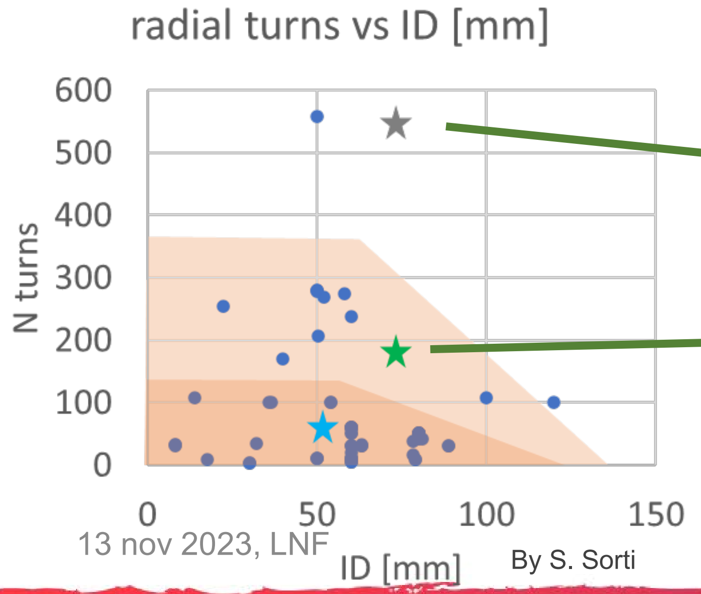




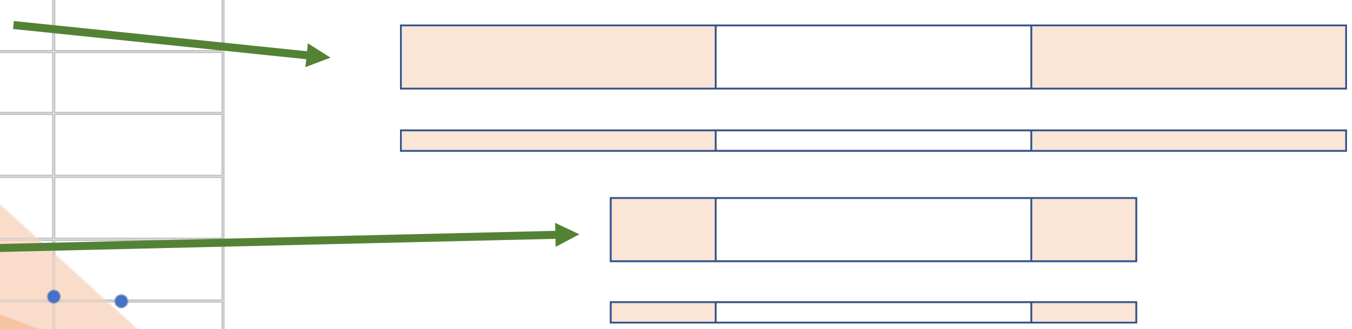
Test coils

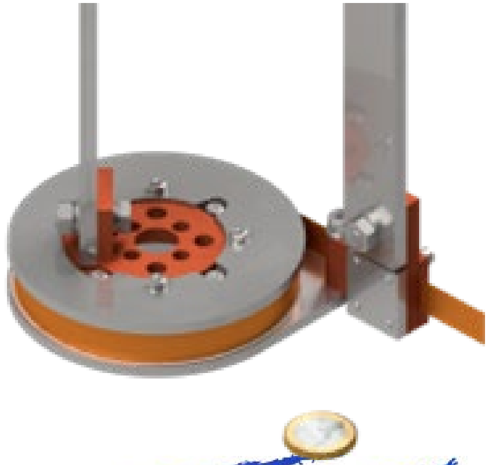
- Test coils Identical/similar configurations used at CERN, INFN, PSI
- Geometry
- Configuration
- Tests self field and in field
- Validate handling procedures and models

60 mm inner diameter
20 mm and 60 mm thickness
4 mm and 12 mm tape width
Single and double pancakes winding
One- and two-in-hand winding
Pancakes can be stacked in mini-coils



By S. Sorti

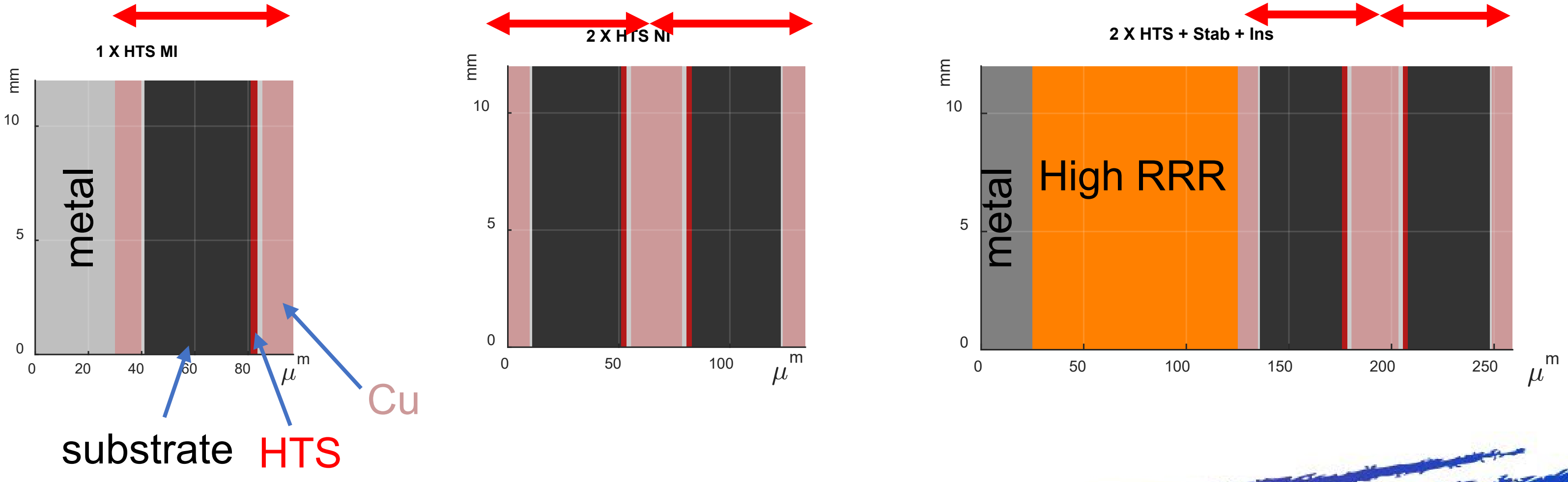




Conductor configurations

- Explore the Controlled-Insulation vs non-insulation solutions.
- Multi-tape winding is foreseen, including different materials and technologies to impact the inter-turn resistance.
- The goal of this campaign is to asses and improve the TRL of such technologies in magnet-like conditions.

Examples of target technologies: Metal-Insulated (MI), multi-tape NI, multi-tape resistive layer + stabilizer.



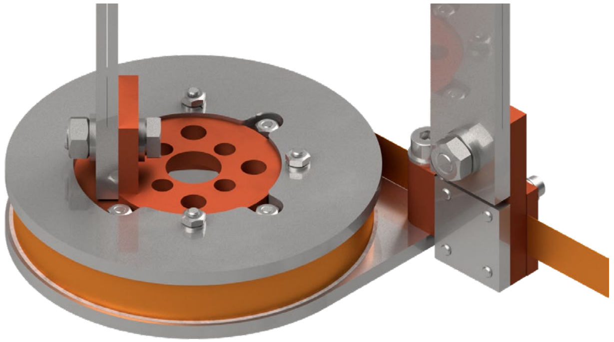
Test of small coils

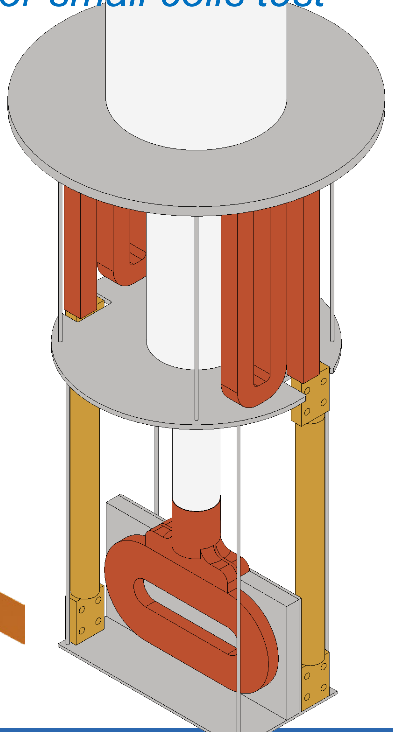
- Synergies with IRIS (NextGenerationEU)
  1. Operation at T in the range 10 K – 30 K;
  2. Induction of flux densities in the tesla range
  3. Test in field up to 20+ T
  4. Non-round geometries (PNRR-IRIS project)
- The goal is to test magnet-like conditions for NI coils and further validate models.
- Target time: begin 2024

Coils are tested in **CERN, INFN LASA, PSI, LNCMI, CEA**

Innovative Research Infrastructure on applied Superconductivity IRIS

Draft of Variable Temperature system for small coils test



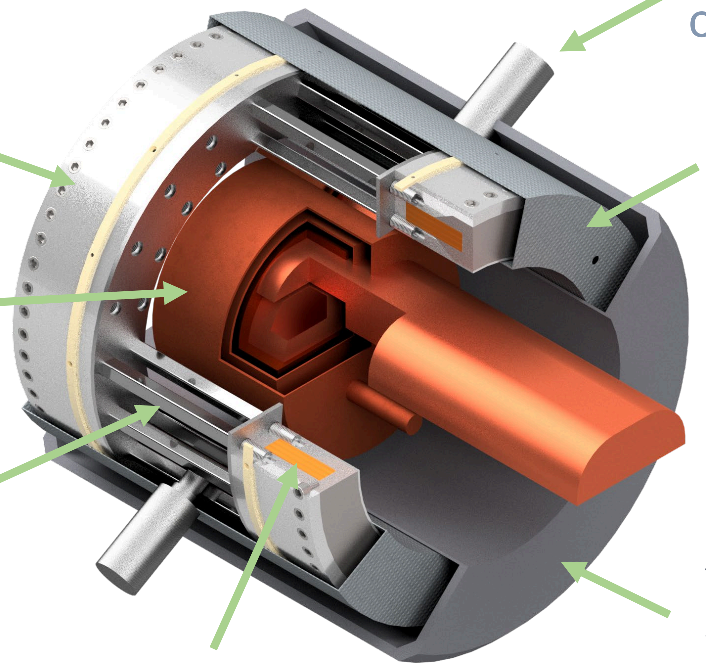


Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

RF test station

- Select and validate a technology and design options
- Design and commission a real size cell-like magnetic system
- Synergy between two WPs

600 mm RT bore for RF
7 T (to 10 T)
+- 5 MN range forces



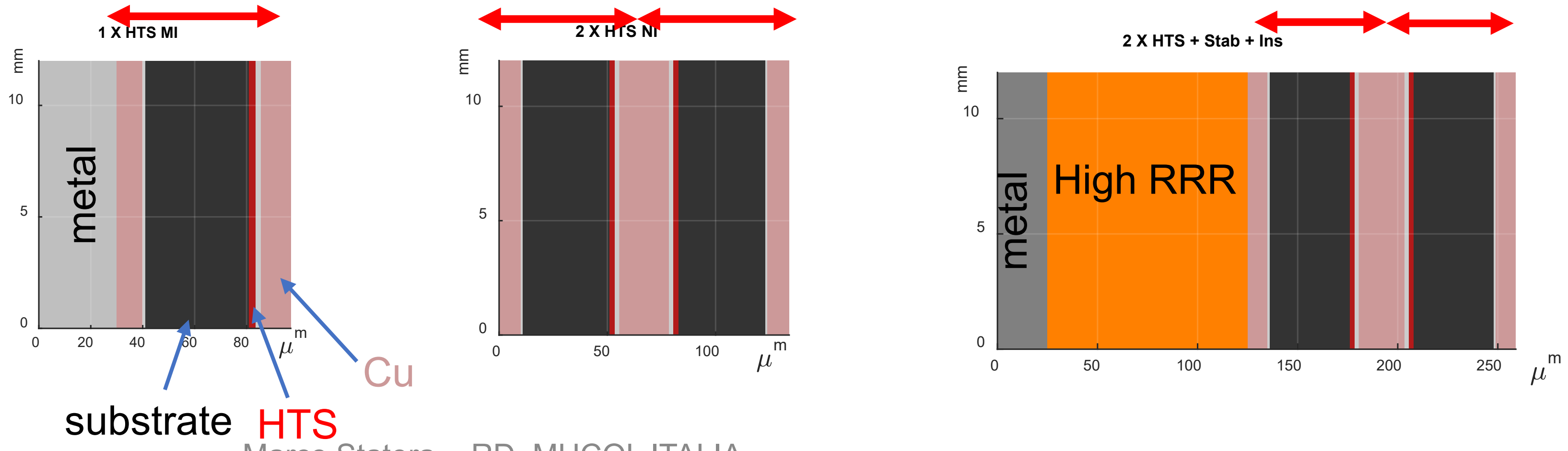
Sc magnet/cryostat sketch by M. Castoldi & Stefano Sorti, UMIL & INFN-LASA

(RF drawing by Guillaume Ferrand –CEA

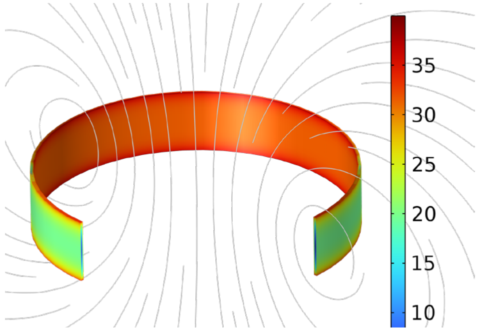
Conductor configurations

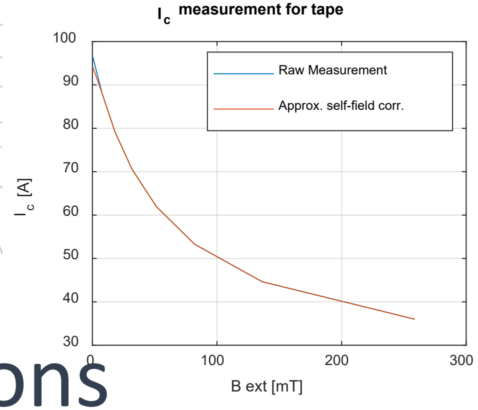
- Explore the Controlled-Insulation vs non-insulation solutions
- Multi-tape winding is foreseen, including different materials and technologies to impact the inter-turn resistance
- Both easy to bend cables and Mechanically stable conductors i.e. Roebel, tapestar/CORC and Viper like cable
- The goal of this study is to asses and improve the TRL in magnet-like conditions
- Internal splices
  - Development of technology
  - Configuration optimization for multi tape windings

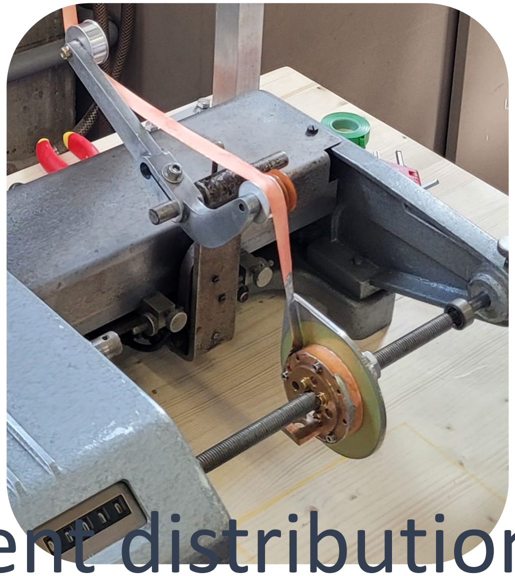
Examples of target technologies: Metal-Insulated (MI), multi-tape NI, multi-tape resistive layer + stabilizer.



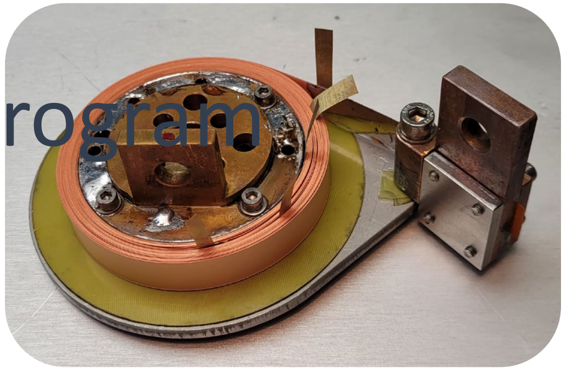
Modeling and Simulation

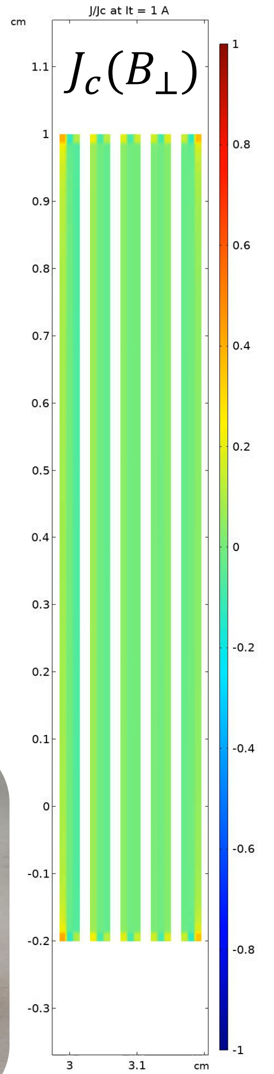


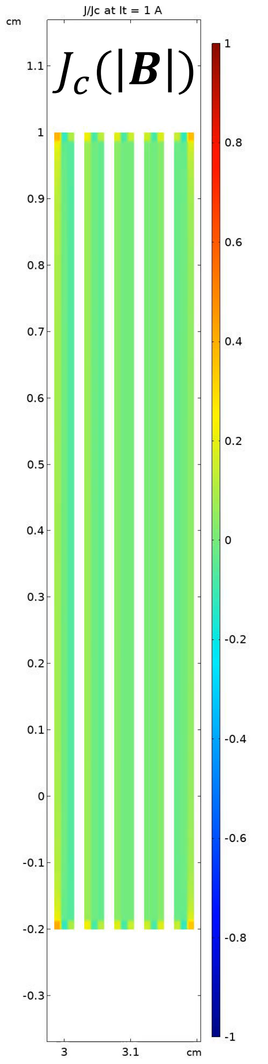




- Field calculations
- In tape critical current and current distribution
- Testing critical current and potential degradation
- 3D calculation of margin
- Probing modeling by small coils program
- Quench modeling





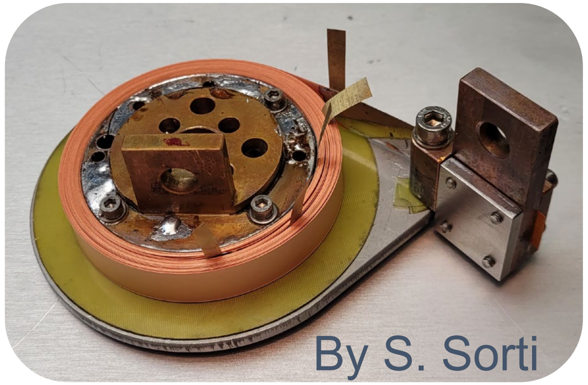


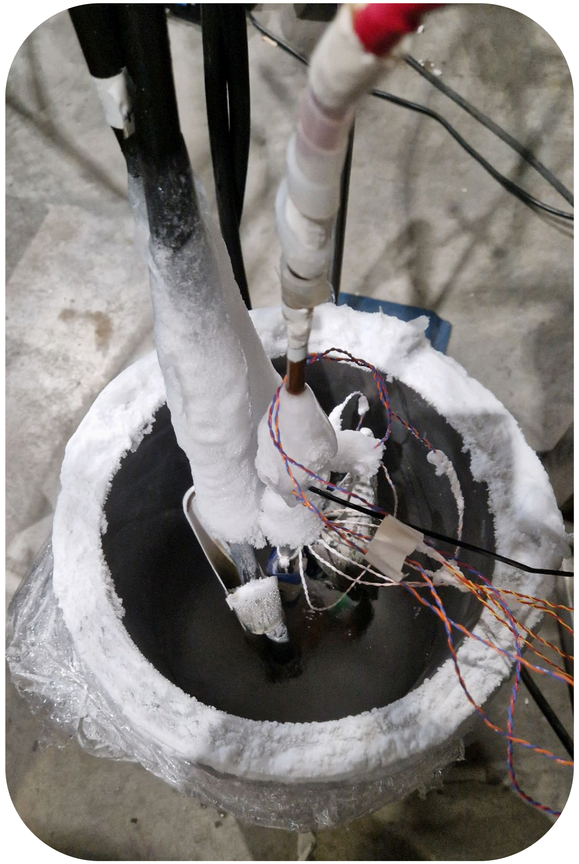
Test of small coils

- Synergies with IRIS (NextGenerationEU)
  1. Operation at T in the range 20 K – 30 K;
  2. Induction of flux densities in the tesla range
  3. Test in field up to 20+ T
  4. Non-round geometries (PNRR-IRIS project)
- The goal is to test magnet-like conditions for NI/controlled insulation coils and further validate models.
- Target time: begin 2024

Coils are tested in

CERN, INFN LASA, PSI, CEA, SOUTHAMPTON



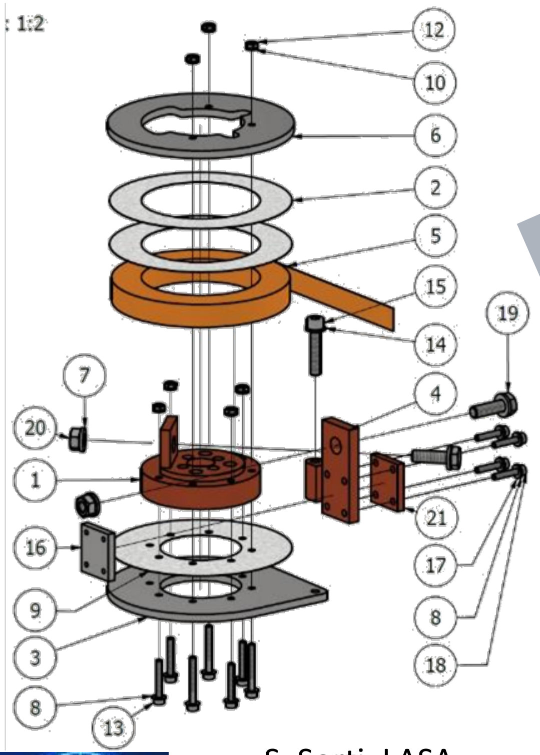


Preliminary winding and test al LASA

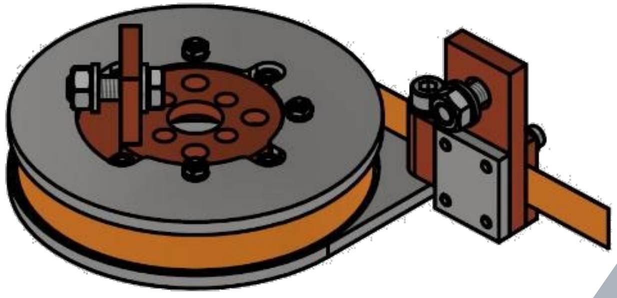
Test of small coils at LASA

R&D testing small coils (in self field or up to 8T)

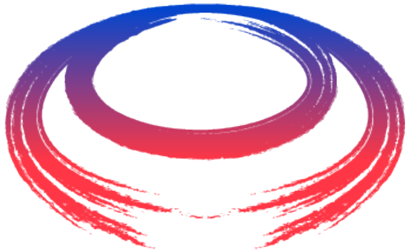
NI-partial insulated – impregnated



S, Sorti, LASA

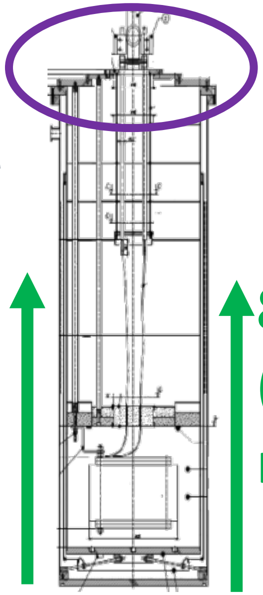


NI-partial insulated – impregnated

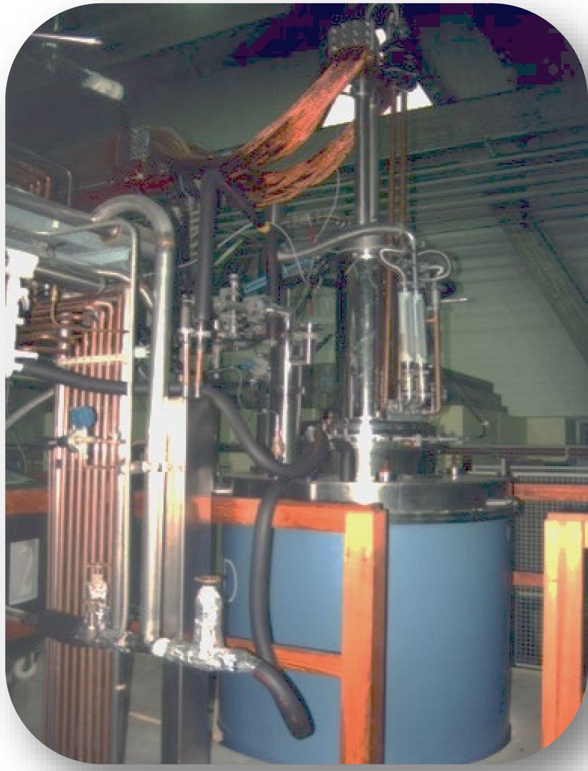


SOLEMI Insert
D 480 mm
h 1200 mm
4.2 K and 2.17 K
500 A

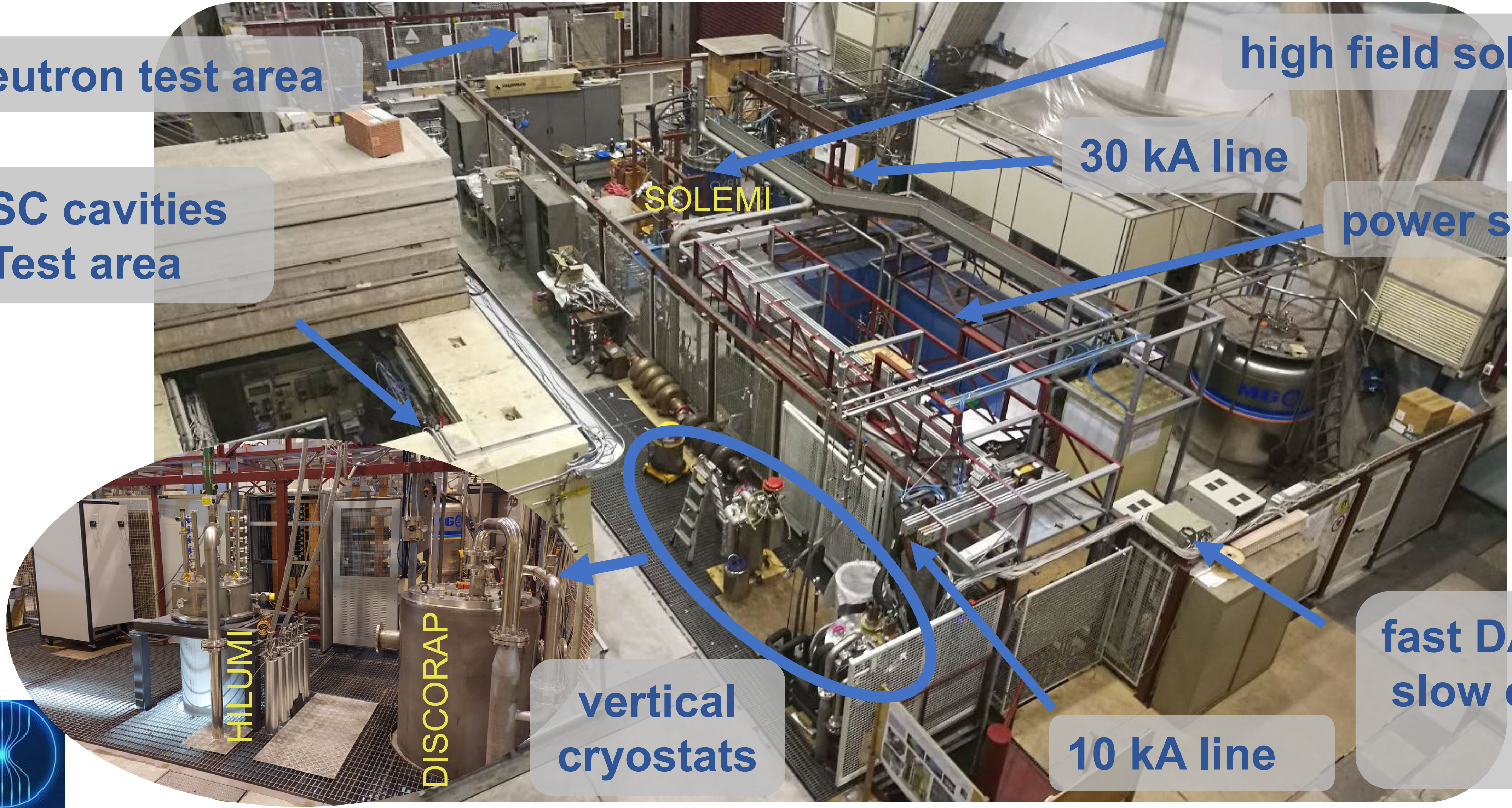
New cooling system 20-50K Closed loop G-He (IRIS)



8 T field by solemi (refurbished and recommisisoned by IRIS)



LASA overview

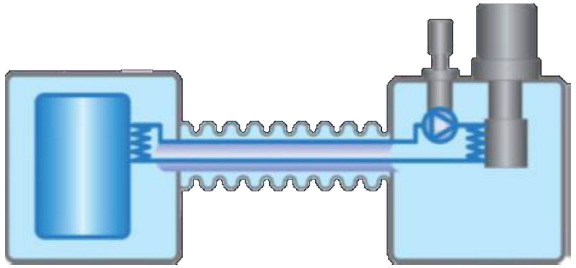


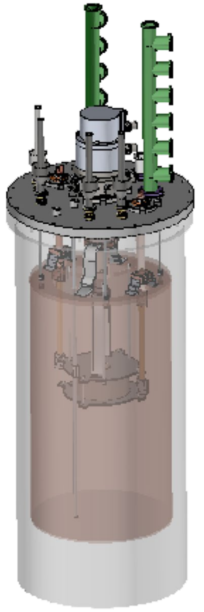
LASA test facility upgrade

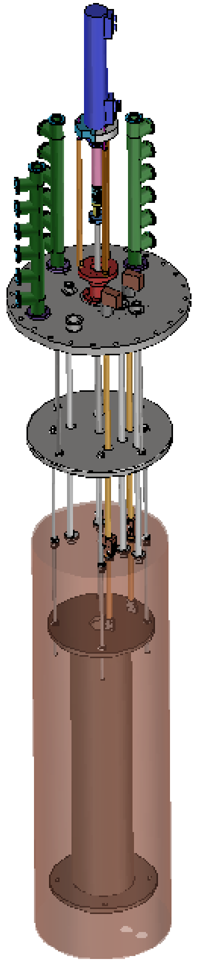
- Two new cold masses to test HTS magnets
  - Solemi insert
  - Hilumi
- Conduction cooled (cryocooler or closed loop He gas)
- New closed loop G-He cooling
  - Cooling power by cryocooler
  - Gas Helium circulation
  - Easy to move, no liquid helium required
  - 20 W at 20 K – 200 W at 55 K

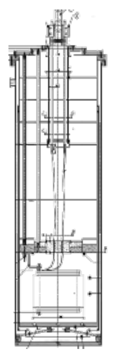
IRIS – Innovative Research Infrastructure on applied Superconductivity

2024

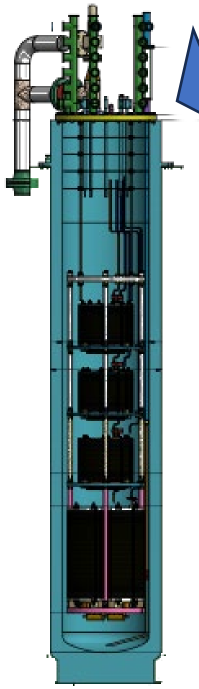








SOLEMI insert
D 480 mm
h 1200 mm
4.2 K and 2.17 K
500 A



HiLumi
D 515 mm
H 2950 mm
4.2 K
500 A

Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani Piano Nazionale di Ripresa e Resilienza

Schedule general task 7.2

International MUON Collider Collaboration

Review of conductor requirements and of material options started

			Today:	15/6/2023		
	OBJECTIVES (can be in Parallel)	COLLABORATORS	PROGRESS	MONTHS	START	END
	General tasks related to this workpackage	Institutes: INFN, CERN, Utwente, Ugeneva, Usouthampton Persons: M. Statera, L. Bottura, H. Ten Kate, A. Kario, C. Senatore, Y. Yang, S. Fabbri, L. Quettier				
1	Review and define broad conductor requirements (operating temperature, materials, electrical, mechanical, etc.) for various types of solenoids (target, 6D cooling, final cooling): tapes, wires, and cables.	M. Statera, L. Bottura, H. Ten Kate, A. Kario, C. Senatore, Y. Yang	0%	6,0	1-Jan-23	30-May-23
2	Review material options for HF and UHF HTS solenoids (REBCO, Bi-2212, Bi-2223, IBS), providing broad evaluation of potential of each material for high field and temperature higher than liquid He, with Pro's and Con's	Y. Yang (SO'TON)	0%	15,0	1-Jan-23	30-Mar-24
3	Cost and power estimate	M. Statera, L. Bottura, S. Fabbri, L. Quettier		54,0		
	Draft version June 2025		0%	30,0	1-Jan-23	30-Jun-25
	Final version June 2027		0%	24,0	1-Jul-25	1-Jun-27
4	**Milestone (M7.1)**: Report on solenoids and TPL experiments - by Mar. 1 2024				1-Mar-24	1-Mar-24
5	**Milestone (M7.3)**: Workshop on ultra-high-field solenoids - by Aug. 30 2025				30-Aug-25	30-Aug-25
6	**Milestone (M7.6)**: Report on solenoid conceptual design - by Jan. 1 2026				1-Jan-26	1-Jan-26

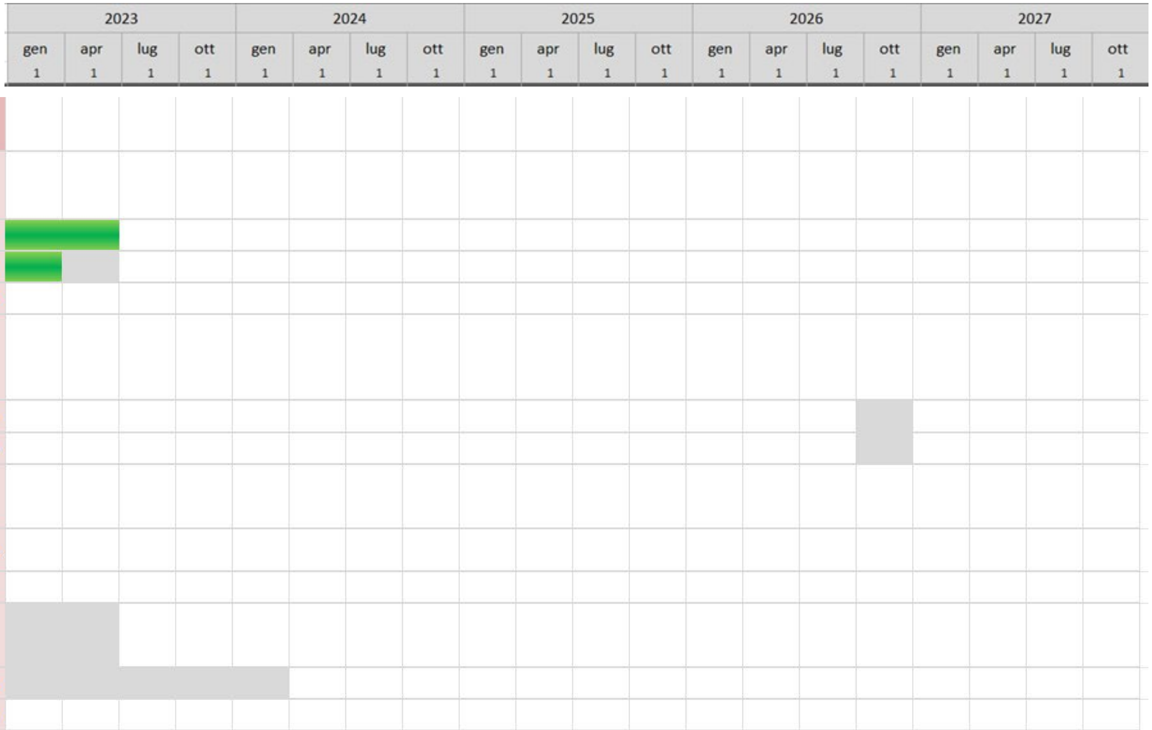
2023				2024				2025				2026				2027			
gen	apr	lug	ott	gen	apr	lug	ott	gen	apr	lug	ott	gen	apr	lug	ott	gen	apr	lug	ott
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d	d

Milestones preparation started: workshop in UHF Solenoids, technology and design reviews

Schedule conductor R&D

Conductor characterization: Ic vs stress/strain, angle, field…
Procurement of updated tapes available in engineering lengths ongoing
Meaurements in UniGE UniTwente SO'TON

2.1 – HTS Conductors for solenoids		Institutes: INFN, CERN, Utwente, Ugeneva, Usouthampton Persons: M. Statera, L. Bottura, H. Ten Kate, A. Kario, C. Senatore, Y. Yang				
1	onductor Specification (performance and quantity) and procurement of relevant materials for testing and small-scale demos	L. Bottura (procurement), C. Senatore (material sotrage)		20,0		
	Short samples from leading manufacturers by April 2023		0%	6,0	1-Jan-23	30-Apr-23
	6 - 8 km procurement launched end of June 2023		0%	2,0	1-May-23	30-Jun-23
	Additional 10 km procurement launched mid 2024		0%	12,0	1-Jul-23	30-Jun-24
2	Standard characterization measurements, review and establish present Ic(B,T,angle) database, perform minimal characterization (e.g. Ic at reference points for procured material), critical surface mapping (additional angles) and UHF data. Material: tape samples and short witness lengths from procurement.	C. Senatore		36,0		
	First update to database and scaling		0%	12,0	1-Jan-23	31-Dec-23
	Final results		0%	24,0	1-Jan-24	31-Dec-26
3	PROPOSAL: Mechanical and electro-mechanical properties, measure Ic degradation and limits under stress and strain in tapes, stacks and conductors (bending, twisting, pressure) TBD and tim	A. Kario (TWENTE), Y. Yang (SO'TON)				
4	Novel experiment #1: delamination under I x B force (First tests autumn 2023, tape sample tests end of 2024	C. Senatore (UNIGE)	0%	18,0	1-Jul-23	31-Dec-24
5	PROPOSAL: Novel experiment #2: internal joint technology (TBD)	A. Kario (TWENTE)				
6	Evaluate current distribution and time dependencies in multi-tape and NI windings, integrate results in magnet design (field ramping and field persistence), benchmark against small scale experiments			36,0		
	Intermediate report Spring 2024		0%	16,0	1-Jan-23	30-Apr-24
	Final report		0%	20,0	1-May-24	31-Dec-25



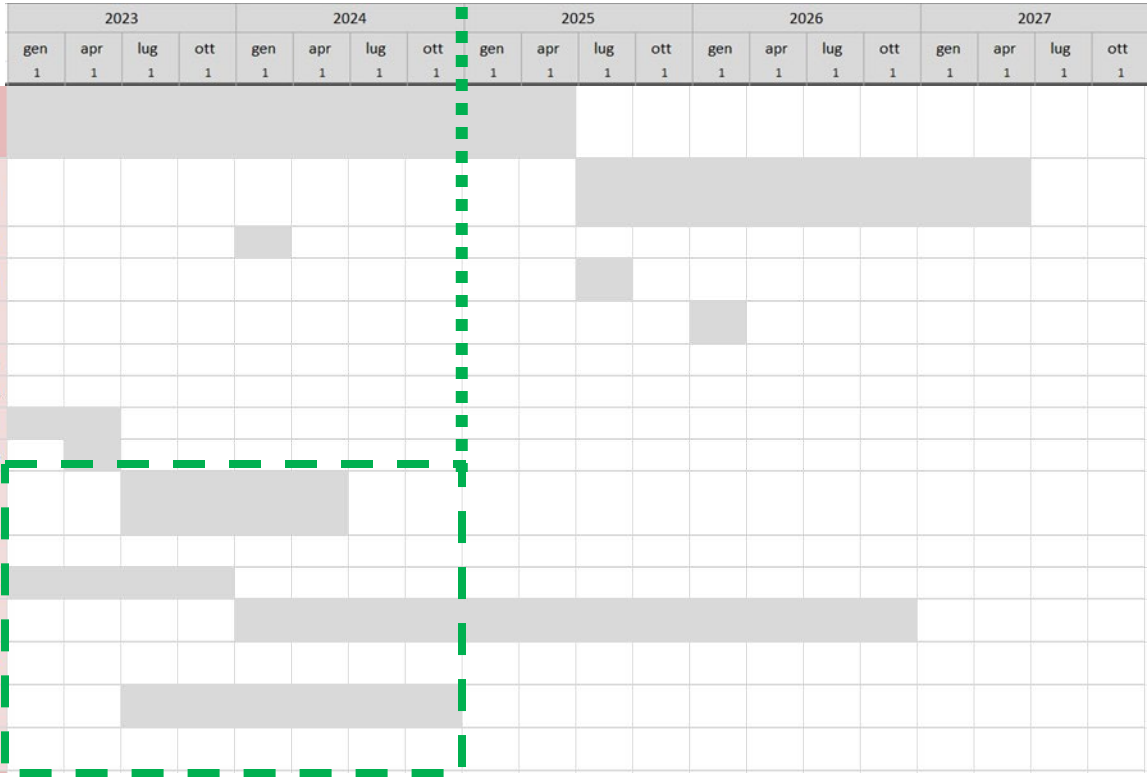
Modeling and measurements of magnetization and current distribution in stacks and joints

Schedule 6D solenoids

International MUON Collider Collaboration

Specification of parameters and reference geometries for the solenoids (1 km)
Performance, Cost, Sustainability and series production compatibility

#	2.2 – Design and demonstrate UHF HTS solenoids using NI/PI technique for final cooling	Institutes: INFN, CERN, PSI, CEA, LNSMI, Utwente, Usouthampton, SO'TON Persons: A. Dudarev, B. Bordini, T. Mulder, A. Bertarelli, C. Accettura, M. Statera, S. Fabbri, L. Bottura, Y. Tang				
1	Define performance specifications (beam physics), and initiate meetings with beam/shield/absorber/cryo/vacuum/ on these specs (First draft - 2023, final draft - 2025)	S. Fabbri, L. Bottura, M. Statera	0%	9,0	1-Jan-23	30-Sep-23
2	Define reference geometries and estimate material needs for technology R&D	M. Statera, L. Bottura	0%	4,0	1-Jan-23	30-Apr-23
3	CERN - Engineering design of final cooling solenoid, 40 T (or higher), 50 mm bore, 500 mm length, stand-alone (First concept 2023, Final Concept 2025)	A. Dudarev, B. Bordini, T. Mulder, A. Bertarelli, C. Accettura	0%	9,0	1-Jan-23	30-Sep-23
4	CERN - R&D pancakes manufacturing and test at CERN, geometry and loading alternatives, resistance control, mechanical testing, powering test	A. Dudarev, B. Bordini, T. Mulder, A. Bertarelli, C. Accettura		36,0		
	Design and tooling		0%	12,0	1-Jan-23	31-Dec-23
	Mechanical tests		0%	18,0	1-Jan-24	31-Dec-24
	Manufacturing start		0%	18,0	1-Jun-24	1-Jun-25
	Testing		0%	24,0	1-Jan-25	31-Dec-26
5	INFN - R&D pancakes manufacturing and test at INFN, small coils having different configurations and characteristics (insulated, non-insulated, dimensions,...). Proposal: Provide test windings for characterization and test at collaborators	M. Statera, S. Sorti		36,0		
	Start construction		0%	12,0	1-Jul-23	1-Jul-24
	Start testing		0%	24,0	1-Jan-24	31-Dec-25
6	(SO'TON) – R&D pancakes manufacturing with insulation/potting technology as tested in EuCARD2 (timeline TBD)	Y. Tang				
7	Testing of small R&D pancakes in background field (10 T, 100 mm maximum) at variable temperature in gaseous helium, for currents up to 1500 A - first tests mid 2024	Y. Tang	0%	12,0	1-Jun-23	30-Jun-24
8	PROPOSAL: PSI - R&D pancakes manufacturing and test at PSI. Share advances and make available small windings for characterization and test at collaborators	J. Kosse (PSI), B. Auchmann (PSI)				
9	PROPOSAL: CEA/LNCMI – Testing of small R&D pancakes in background field (20 T, 120 mm maximum)	X. Chaud (LNCMI), L. Quettier (CEA)				



R&D on smal coils and cabling options
Test in self field and in field – CERN, INFN LASA, PSI, LNCMI, CEA

Higher TRL allows civil application

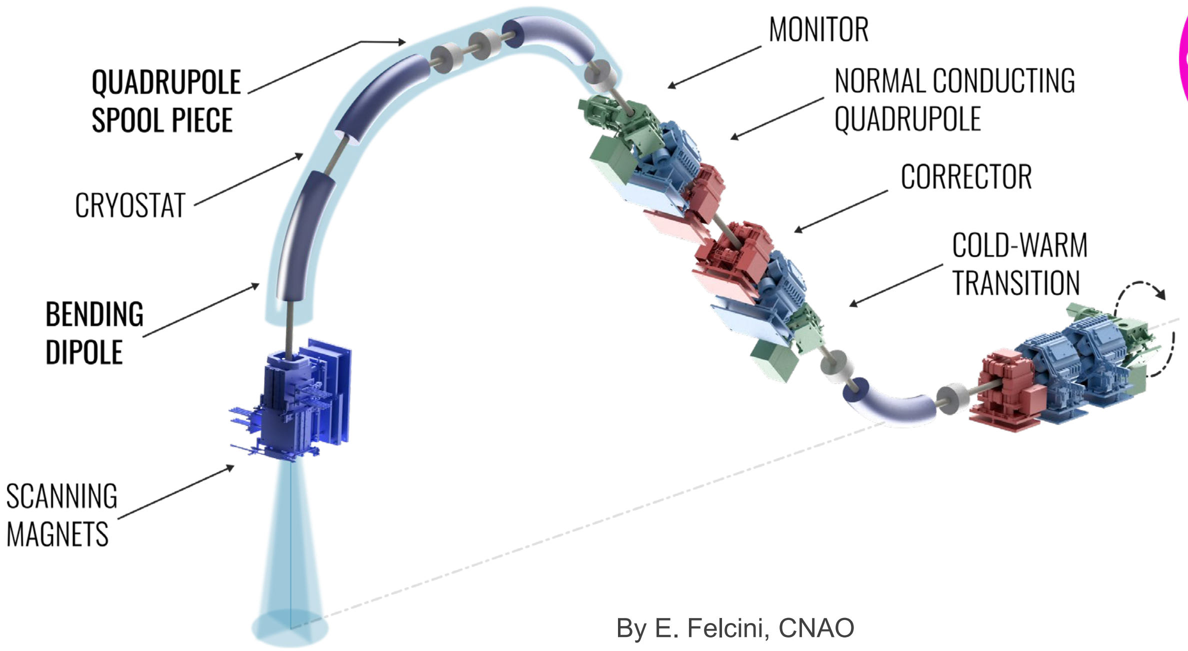
Example of an application having the same pillars : Performance, Cost, Sustainability

hadron therapy

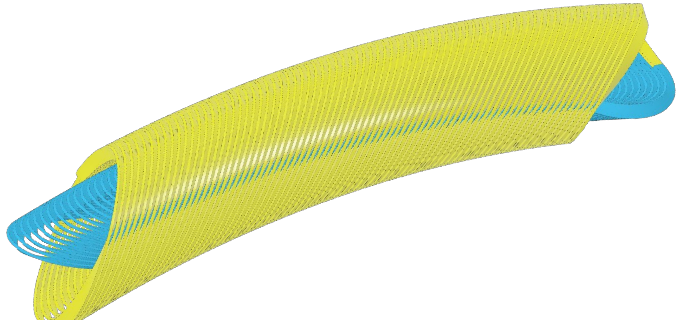
HITRI plus
Heavy Ion Therapy Research Integration

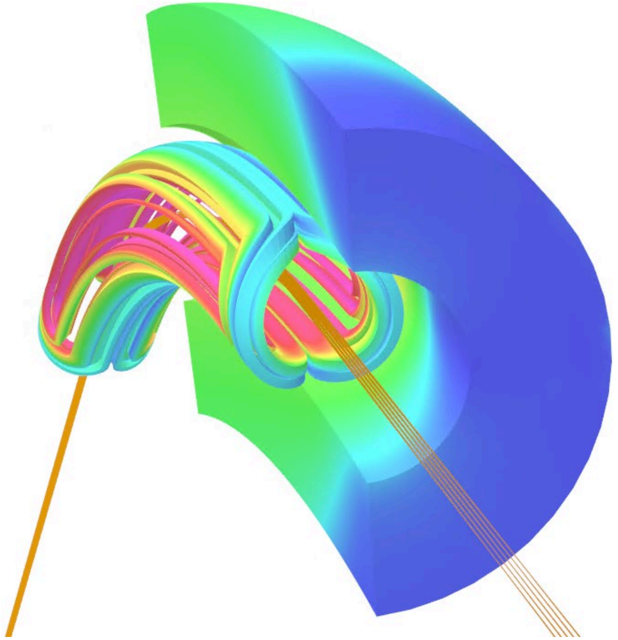
iFAST

Superconducting Ion Gantry



By E. Felcini, CNAO



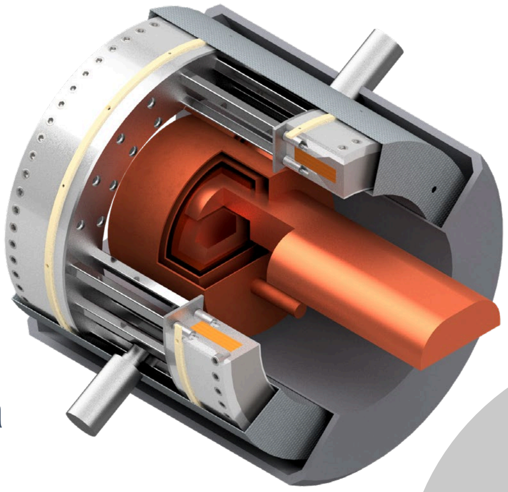


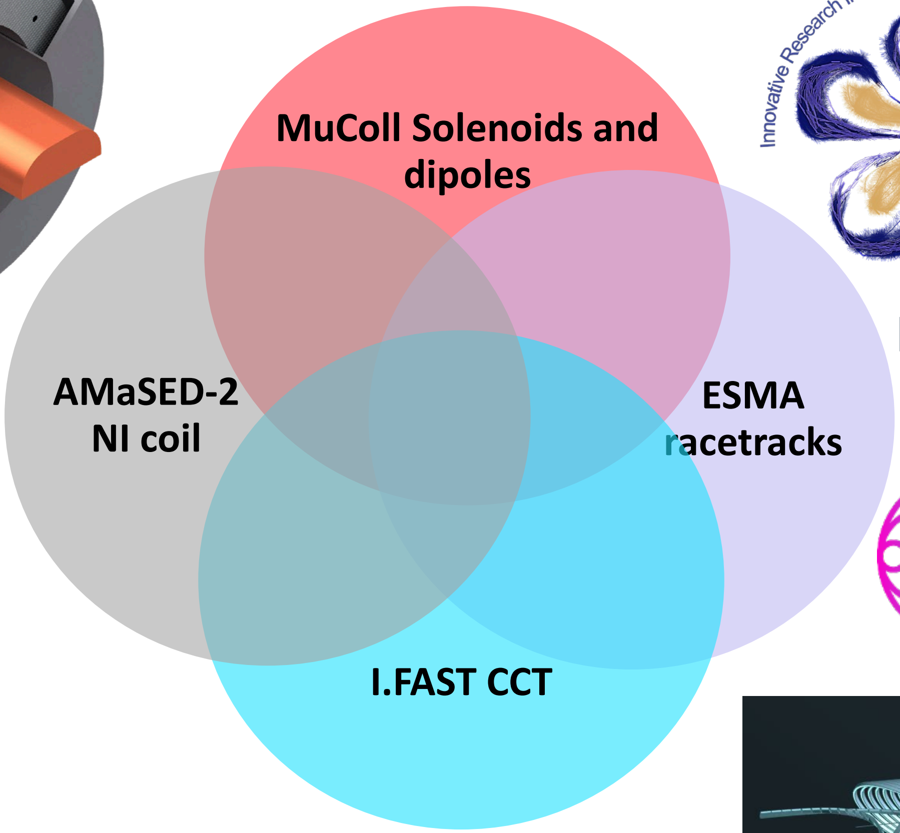
Magnetic configurations – framework and background

Finanziato dall'Unione europea NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

International MUON Collider Collaboration

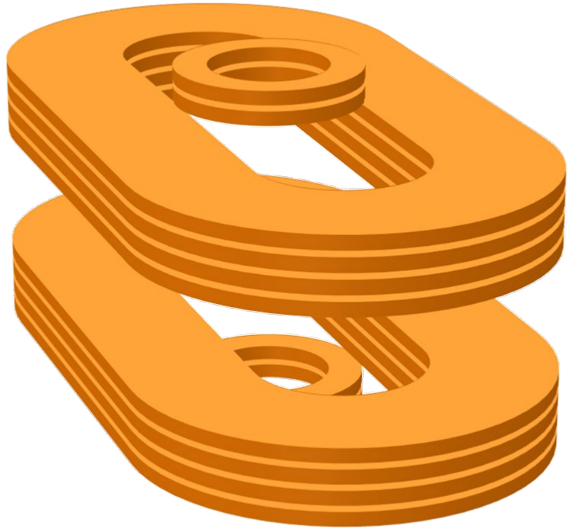
Test stand L. Rossi
Solenoids M. Statera





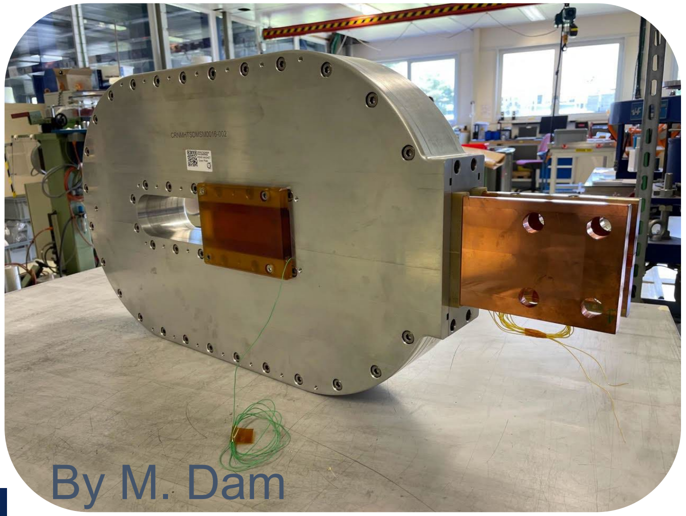
Innovative Research Infrastructure on applied Superconductivity IRIS

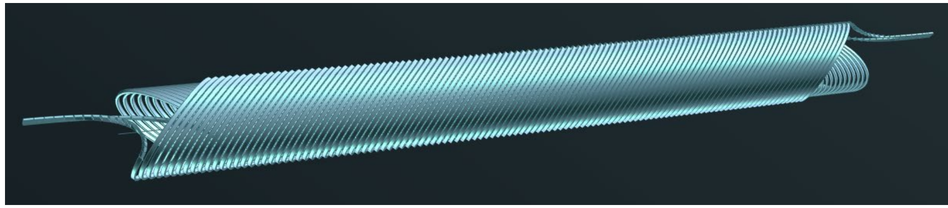
L. Rossi



iFAST

E. De Matteis





T. Lecrevisse, "**Conceptual Design of HTS Magnet**", IFAST WP8.3 Milestone 33, Zenodo, https://doi.org/10.5281/zenodo.6979877

HFM High Field Magnets

MUR

ASTROTOR
Variable T test M. Prioli

Conclusion

- An overview of the required coils and dipoles
  - 12 cells
  - 18 different coils
  - 1 km of 6D cooling
  - >12 T dipoles
- We set the driving parameters and the technology we are aiming to
- A full R&D program for tape characterization and conductor development
- Focus on modeling (magnetization, current distribution…)
- Many synergies in the project and in other applications
- Performance-Cost-Sustainability togheter with compatibility with series production

THANKS