International MUON Collider Collaboration

# Perspective from the magnet point of view

**Marco Statera, Jonathan Pavan, Lucio Rossi, Stefano Sorti,**
UMIL & INFN, LASA Milano, MuCol-WP8
IMCC annual meeting
Orsay ,21 June 2023

# Outline

- Motivation
- Configurations
- A first draft design and considerations
- Technologies R&D
- Potential time schedule
- Conclusions

# Motivation

Room temperature RF testing

- High fields 7 T – 10 T range
- 500 mm diameter bore at room temperature
- Horizontal and/or radial access

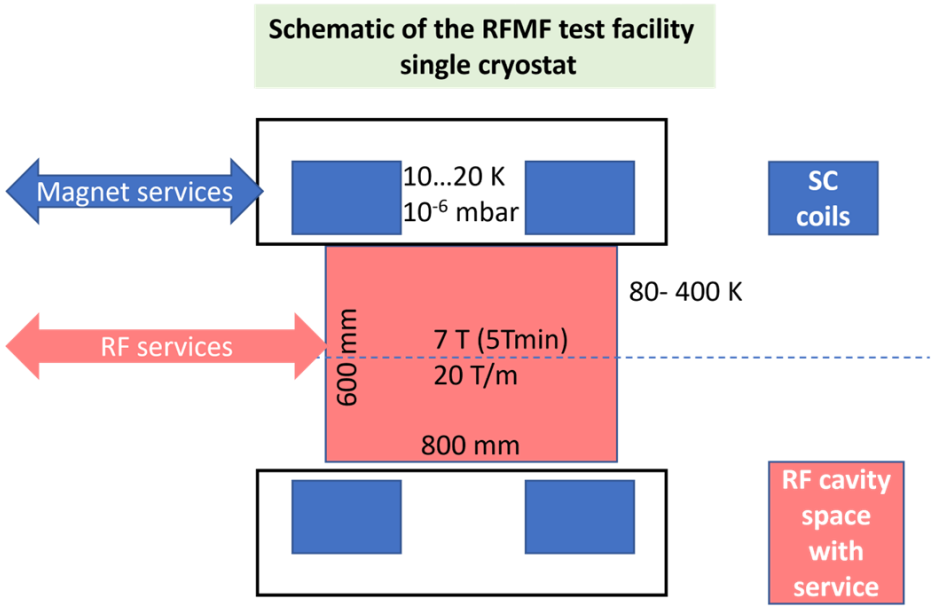
Magnetic system similar to a cooling cell

- Commisisonig of selected technologies (conductor, mechanics and cryogenics) -> improvement of TRL

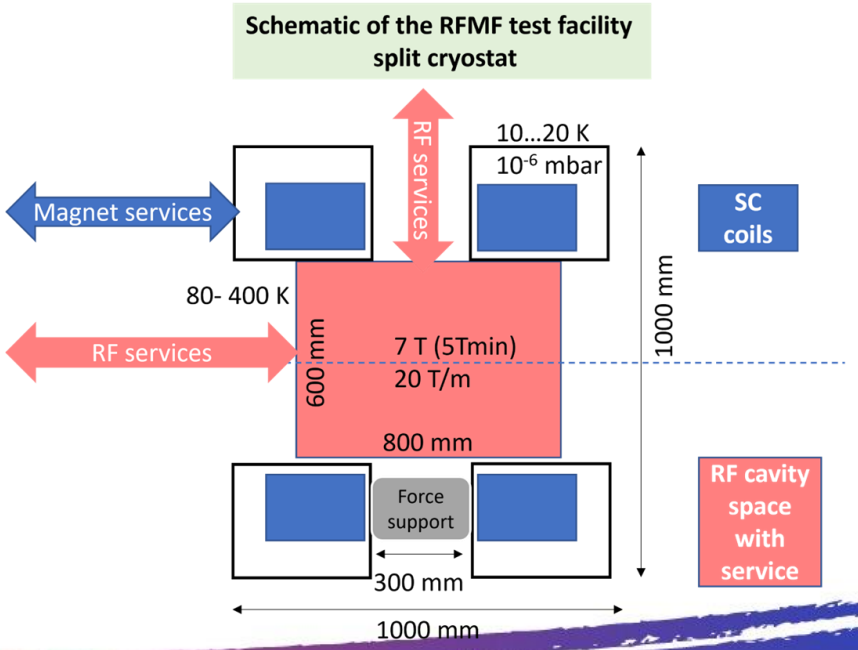
# General layout of the RFMF test station

- Preliminary design is aimed at fitting a cavity of the size up **to a 700 MHz system**
- Minimum bore of the split coil
  - → ∅600 RT free bore for RF → ∅700 mm minimum SC coil diameter

## Scheme 1: single cryostat



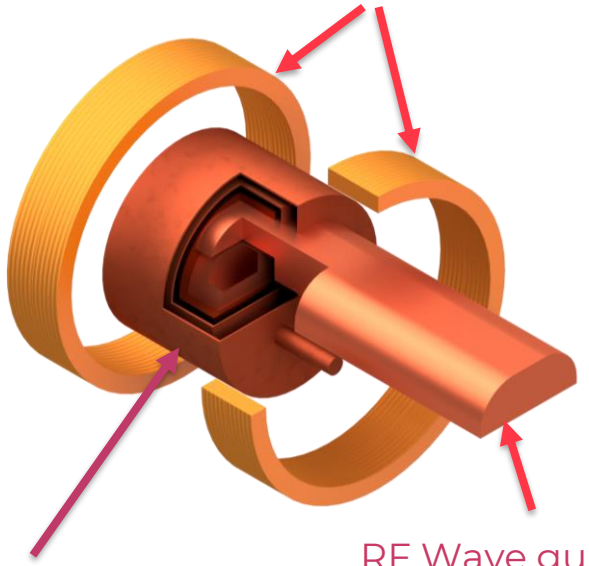

## Scheme 2: split cryostat



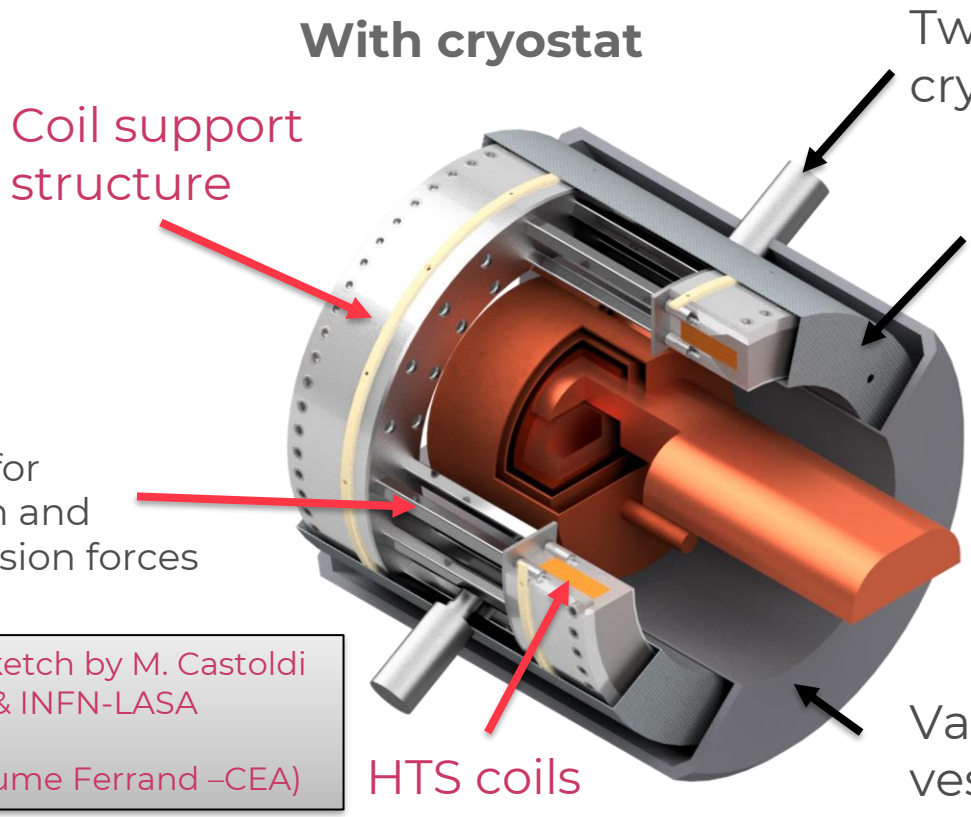
# First sketch (scheme split coils in single cryostat )



## Bare coils and RF cavity




## With cryostat




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

(RF drawing by Guillaume Ferrand –CEA)

B1 as aspect ratio of the cross section
B3 and A2 similar inner diameter
A4 similar field 6T, but smaller diameter

The construction of a test bed is an important push toward the definition of a baseline technology.
An intermediate construction can be the commisisonig of first design choices

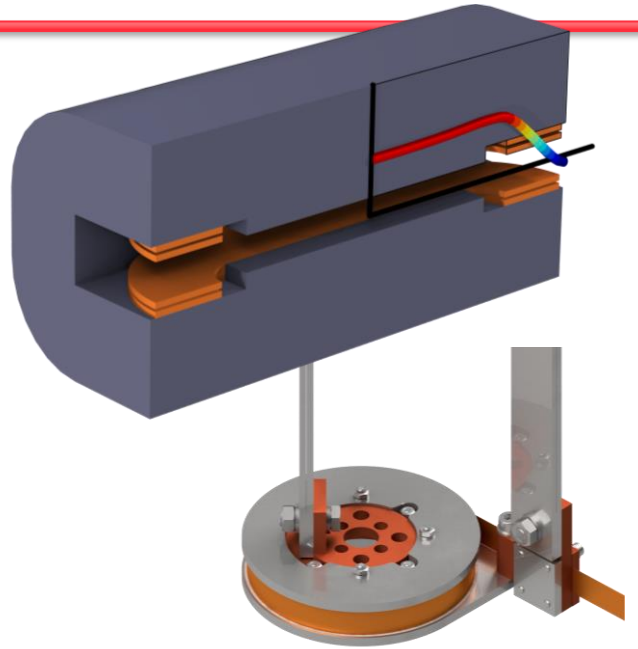
# A few considerations

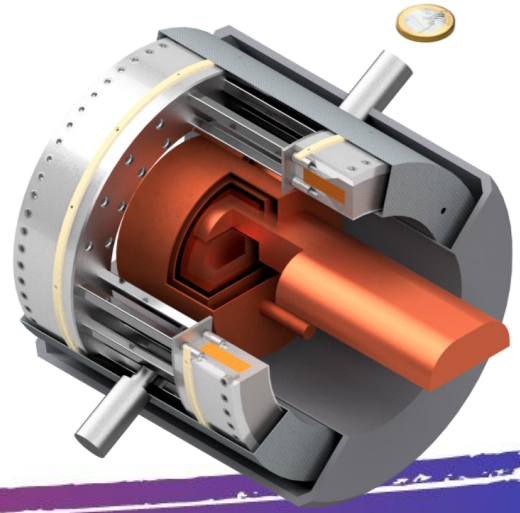
- The work on magnet design just started (discussion inside WG11/WP8)
- Many assumptions can be refined (space for thermal insulation etc…)
- At present only scheme 1 (single cryostat) has bene studied;
  - scheme 2 (split cryostat) will follow
  - Compressive/repulsive forces between coils: about 5 MN (500 tons!)
- The bottom line that the HTS magnet **is expensive:**
  - 45 km of REBCO tapes 12 mm cost about 3 MEur (plus taxes)!!!
  - The coil manufacturing 1 MEur;  the cryostat and services about 1 MEur
  - 5 MEur total cost (crude evaluation)
  - HTS remains our basic choice in view of then MC design
- The option to build also a smaller size/energy/force demonstrator has to be taken into account
- Higher frequency test bench needs smaller coils, i.e. less expensive

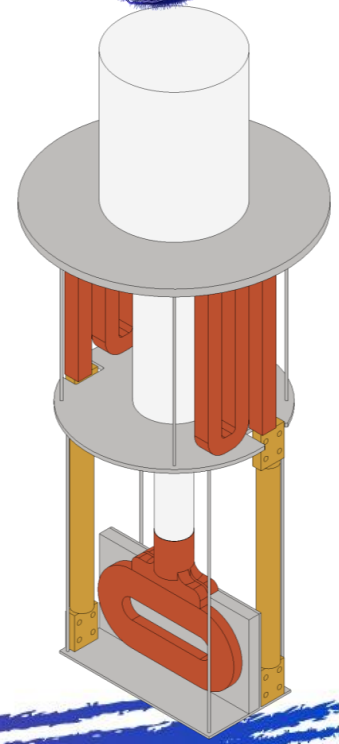
# Ongoing activities from 7.2

## Synergies with WP 7 task 2 solenoids and IRIS

- 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** (WP7 and WP8)
- Coil design for the cells
  - Field and forces
  - Integration of cooling system
  - Field quality definition and optimization



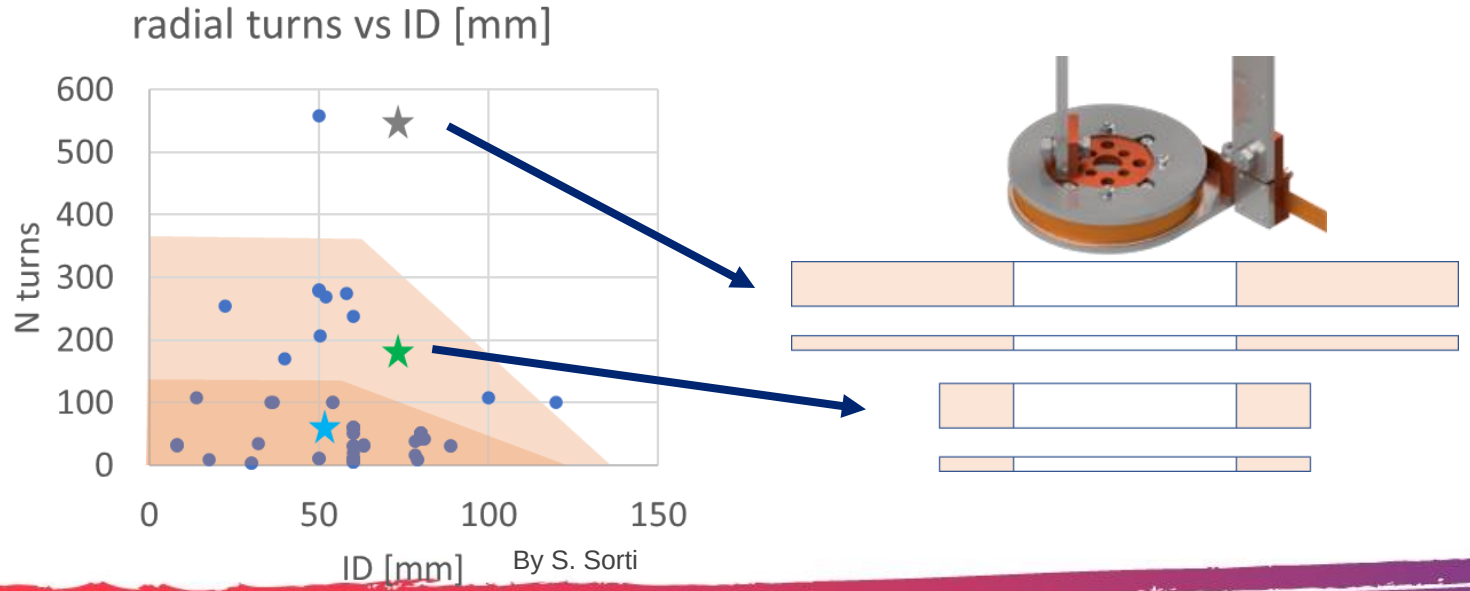


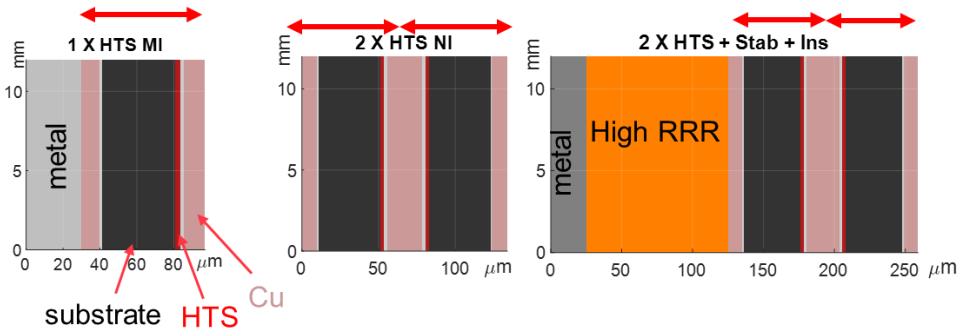


# Test coils

- 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



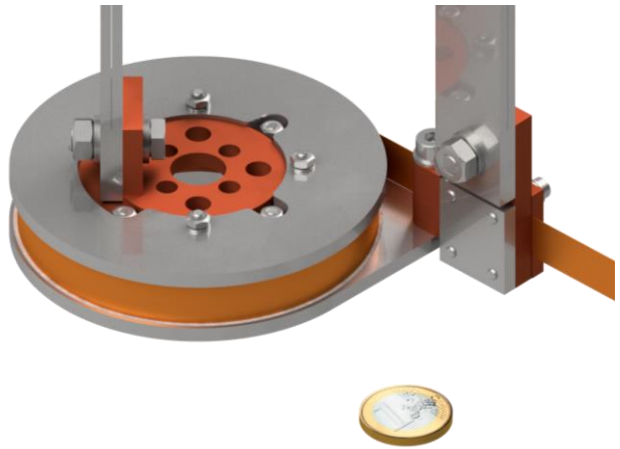




Examples of configurations

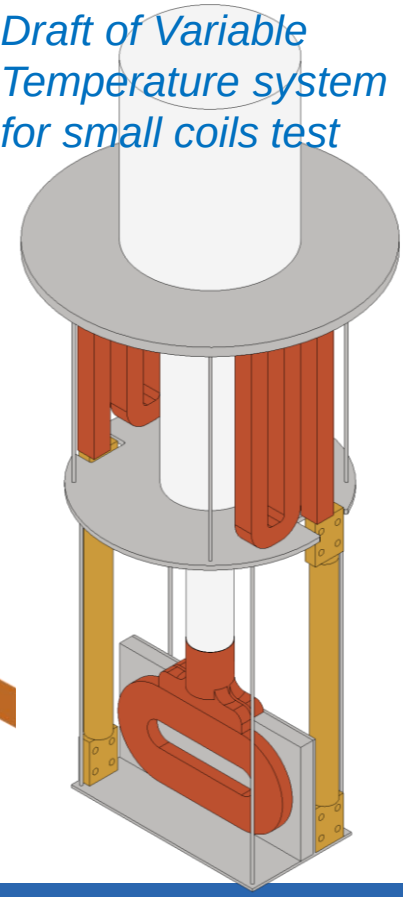
# Test of small coils

- 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

*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

# Schedule for discussion

Tentative schedule with no contingency and assuming the task is approved and financed today

By now, no funding and no dedicated manpower for the executive design and construction

| | |
|---|---|
| ▪ Design studies for single cryostat and double cryostat scheme | Nov 2023 |
| ▪ Design evaluations for higher frequencies RF and smaller diameters | Dec 2023 |
| ▪ Design choices (conductor configuration, mechanics, cryogenics) | May 2024 |
| ▪ Coil demonstrator (about half size) design | Jun 2024 |
| ▪ Demo coil production and test | Apr 2025 |
| ▪ Production of the test bench (coils, mechanics, cryostat) | May 2025 |
| ▪ Commissioning of the test bech | Oct 2025 |

# Conclusion

- A test bench for room temperature RF cavities is a interesting device both for RT-RF development and for the HTS solenoids R&D
- The magnetic system is a demonstrator for technologies for conductor, mechanics and thermal insulation. It may provide the commissionig of the selected technologies before the final coices for a demonstrator and the series production.
- Many challenges in different fields
  - Cost
  - Cryogenics & Force management
  - Quench protection
- An extensive program of modeling and R&D started the framework of MC

International
MUON Collider
Collaboration

# THANKS