MUCOL WP8
Cooling Cell Integration

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SCOPE

- **The first objective** of this workpackage is **to select** the technologies that are more suitable for a **construction of a cooling cell that will demonstrate** the feasibility of the concept including:
  - ***Superconducting solenoids***, to limit the transverse blow-up of the beam.
  - ***RadioFrequency Cavities***, that will accelerate the beam providing back longitudinal momentum
  - ***absorbers*** that will decrease the emittance in both the longitudinal and transvers plane
- **The second objective** is **to design** each component of **a cooling cell** and integrate them in a single assembly **to demonstrate** that there is no showstopper for such systems. The work will be concentrated on a cooling cell that is fully representative of the entire CC of the MC (probably not the most difficult not the easiest…). Aim: 3D Add Manufacturing real model.

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Interactions

- WP8 is strongly interlinked with
  - WP4 – Muon Production and Cooling
  - WP6 – RadioFrequency
  - WP7 – Magnets

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Deliverables & Milestones

- D8.1 Concept design M15
- D8.2 Consolidated report M42

- M8.3 3D design completed M33

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Roadmap based on D & M

- **15 Months** to
  - Select the candidate cooling cell
  - Sketch a conceptual design
  - Write a report to justify choices.
  - ***Supported by an International Workshop with all experts***
- Then, **18 Months** to complete the mechanical design
  - To be presented to the community for feedback
- Another **9 Months** to collect feedback and write a final report.
  - Eventually, apply modifications and produce a final design if necessary

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Institutes in WP8 (and activity)

- UMIL
  - Integration
  - Magnets
- CERN
  - Integration
  - Absorber
- INFN
  - MI-LASA
    - RF
    - Magnets
  - LNS (Catania) : RF
- UKRI : Performance

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Workplan

- **WP8** counts on a mix of experienced researchers, and young people, e.g., a new researcher and technician by UNIMI on the project.
- These people will need training and will stay at CERN for a period to work in the design/integration team (and agree on common tooling and software exchange)
- The work will start (**has started actually!**) by designing a **RFMF-TF** – Radio Frequency in Magnetic Field Test Facility – (WP6 and WP7)
- The **RFMF-TF** will be also a training exercise for integration
- → **construction of the RFMF-TF is outside HE-MuCol**

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Solenoids for RFMF-TF

- A couple of meetings already took place, we agreed on reasonable parameters for a solenoid that could be built immediately:
  - Free bore 500÷600 mm:
    - Considered as a safe parameter to design our first SC solenoid, allowing at the same time a good freedom to select the RF frequency within a reasonable range (hopefully down to 700 MHz)
  - Configuration with two solenoids in order to have maximum flexibility in defining the magnetic field profile on the RF cavities (uniform or variable)
    - The two solenoids configuration will allow to test also the forces among solenoids pairs, fringing fields decoupling (if required) and maximum input loads that will be useful to validate the whole magnetic system of the cell.
    - The two solenoid may allow RF feeders coming form the gap between solenoid, if required

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RadioFrequency fro RFMF-TF

- The first critical choice is the frequency of the cavity to be designed:
  - Has to fit in a cylinder of 500÷600 mm, including all ancillaries (couplers, cooling, supports etc…)
  - Compatible with RF test stand being discussed in WP6
  - Compatible with one of the existing RF sources available in the various Institutes
  - Previous studies (CLIC, LC) investigated scaling with frequency of breakdown characteristics and found they are constant, no effect from frequency.

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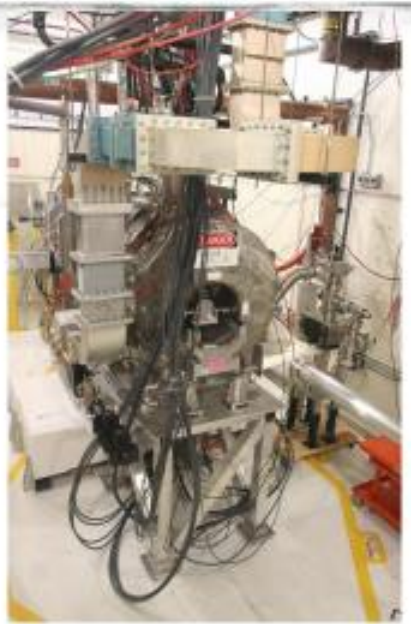

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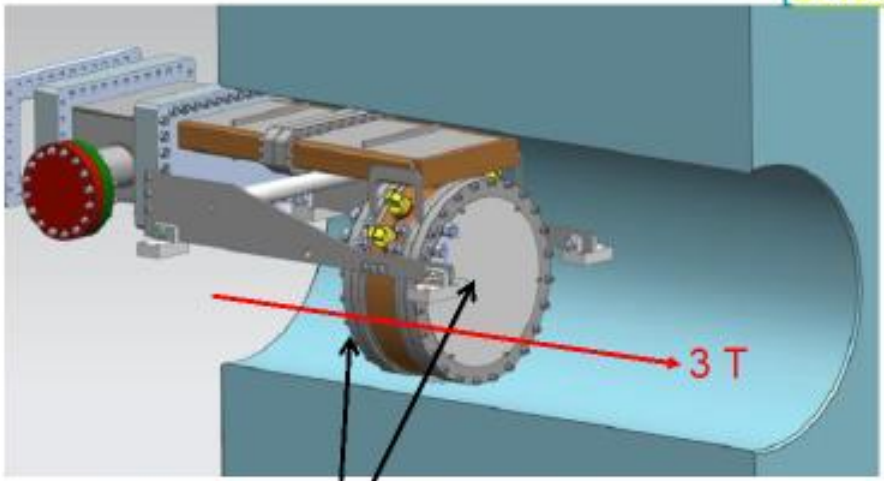


removable plates (Cu, Al, Be)

PHYSICAL REVIEW ACCELERATORS AND BEAMS **23,** 072001 (2020)

Operation of normal-conducting rf cavities in multi-Tesla magnetic fields for muon ionization cooling: A feasibility demonstration

D. Bowring, A. Bross, P. Lane, M. Leonova, A. Moretti, D. Neuffer, R. Pasquinelli, D. Peterson, M. Popovic, D. Stratakis, and K. Yonehara
Fermi National Accelerator Laboratory, Batavia, Illinois 60510, USA

Material	B-field (T)	SOG (MV/m)	BDP ($\times 10^{-5}$)
Cu	0	24.4 ± 0.7	1.8 ± 0.4
Cu	3	12.9 ± 0.4	0.8 ± 0.2
Be	0	41.1 ± 2.1	1.1 ± 0.3
Be	3	$> 49.8 \pm 2.5$	0.2 ± 0.07
Be/Cu	0	43.9 ± 0.5	1.18 ± 1.18
Be/Cu	3	10.1 ± 0.1	0.48 ± 0.14

- A Beryllium based cavity sustained a high gradient in the presence of multi-tesla B-fields!

International MUON Collider Collaboration

805 MHz

440 mm bore diameter

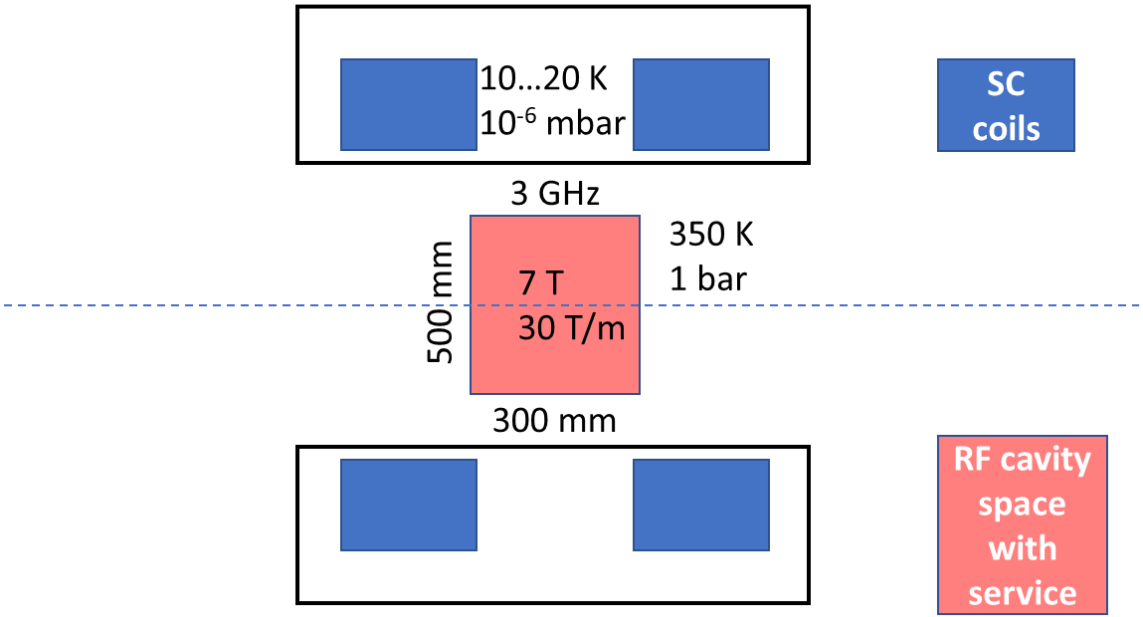
custom designed power coupler

10 Hz rep rate

32 microsec pulse

Conceptual Layout of the RFMF-TF

Schematic of the RFMF test facility



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Final cell to be integrated
Exercise for the MC and demo preparation

- Will be designed once WP4, with WP8 identifies the most suitable candidate
- Has to take into account experience built in the first 15 Months on the RFMF.TF design
- Frequency of RF shall be the one of the final implementation (700÷800 MHz)
- Free bore will be derived from this choice

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Absorbers

- To be discussed in coordination with WP4
- For the first implementation, it seems wise to consider a solid absorber.
- Material will depend on the kind of test that we can envisage (Muon or Proton beam?)
- HiRadMat test could be envisaged (for candidate materials). Only proton beams can be obtained
- However also fluid based absorbers will be studied in WP4 and therefore we will extend the study to provide a full integration of most promising candidates if possible.

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Next Steps

- RF studies (WP6) need to confirm what frequency we can choose for RFMF-TF:
  - 3 GHz
  - 1.3 GHz
  - ~700 MHz (if feasible, will need a creative development to match it to power couplers within a 600 mm bore)
- HTS cable to be used needs to be discussed soon (WP7) to be ready for the design of the solenoid

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Next Steps

- Outside of MuCol, will have to take into account as well the (Cooling Cell) Demonstrator programme:
  - A demonstrator at CERN should be launched asap
  - Will need a cooling cell ASAP.
  - It makes sense to prepare a test programme:
    - What can we learn from a test with proton beams?
    - Or from a test at low muon intensity ($10^5 \div 10^6$)

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Conclusions

- Work has started and first choices need to be made quite rapidly
- Need confirmation from WP6, WP7 about what is feasible.
- Needs guidance from WP4 on the cell to implement
- WP8 meetings will continue every first Monday of every month at h11.00 (or h16.00)
- Egroup: MuCol-WP8-members@cern.ch

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A pre-announcement

International MUON Collider Collaboration

INFN ACCELERATORI ERICE Accelerator School

ETTORE MAJORANA FOUNDATION AND CENTRE FOR SCIENTIFIC CULTURE

TO PAY A PERMANENT TRIBUTE TO ARCHIMEDES AND GALILEO GALILEI, FOUNDERS OF MODERN SCIENCE AND TO ENRICO FERMI, THE "ITALIAN NAVIGATOR", FATHER OF THE WEAK FORCES

27 July – 2 August 2023

Title : ***Novel acceleration schemes and enabling technologies***

Topics: **Muon-C**, plasma, dielectrics and ERL