International MUON Collider Collaboration

CERN

μCol WP7 Magnets

L. Bottura, F. Boattini, B. Caiffi, S. Mariotto, L. Quettier and M. Statera
for μCol WP7

Description of WP7

- Main objectives:
  - Assess feasibility and technology limits of the magnet and powering systems of the muon collider complex
  - Evaluate the technology readiness
  - Provide a R&D timeline
- Leading topics:
  - Value of the maximum field and free bore of the solenoids for the target, capture and cooling complex
  - Concept, performance and feasibility of the magnets and powering systems for the fast accelerator chain
  - Design options, LTS and HTS, for the magnets of the collider complex
- Address the above topics through a combination of:
  - Conceptual design work (design and simulation)
  - Targeted tests and specific characterization measurements (Technology Performance Limits experiments)
  - Synergies with on-going developments in other fields (high magnetic field science, NMR, fusion) and programs (EU High-Field Magnets R&D, US-MDP)

WP7.1 – Coordination and Integration

- Establish a *magnet catalogue*, including:
  - Target specifications
  - Baseline concepts and technology options
  - Estimates of power consumption and system cost
- Interface for magnet energy deposition and radiation studies, magnet cooling studies, as well as safety and environmental aspects of the magnet system

- Participants: CERN (task leader) and CEA
- Interface to: WP2, WP3, WP4, WP5 for physics input

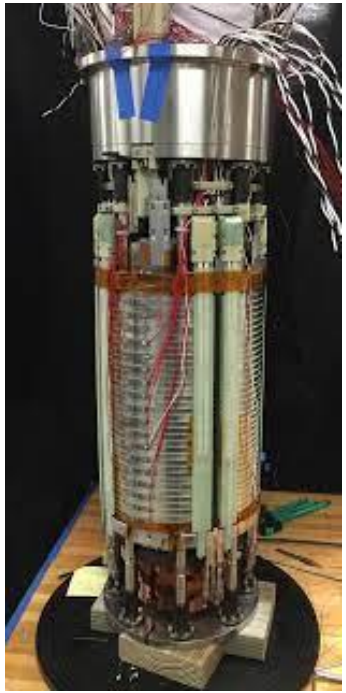
WP7.2 – Target, Capture and Cooling Magnets

- Conceptual design work on the target, capture and final cooling solenoids, as required to:
  - Establish performance limits
  - Assess feasibility
  - Identify outstanding R&D
- Specific focus on:
  - Target solenoid: high field (20 T) in a large bore (150 mm), energy deposition (100 kW) and radiation
  - Final cooling solenoid: required field (40 T minimum to 60 T target) in a small bore (50 mm), well beyond the present state of the art

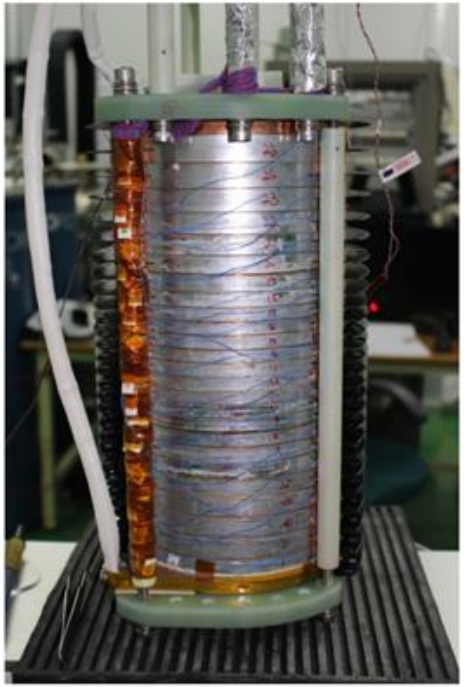
- Participants: INFN (Task Leader), CEA, CERN, CNRS, KIT, PSI, SOTON, UNIGE and TWENTE, in collaboration with KEK and US-MDP
- Interface to: WP4 for physics input, WP8 for technology selection and integration

Ultra-high field solenoids

NOTE: all magnets are installed **vertically** (mechanics, helium bubble)



NHMFL 32 T, 40 mm
HTS insert



SuNAM 26.4 T, 35 mm
all HTS

ITER Central Solenoid, 13.6 T, 2 m
Nb_3Sn

WP7.3 – Fast Cycled Accelerators

- Propose concepts and evaluate realistic performance targets for the fast-cycled accelerators magnets and powering systems:
- Specific focus on:
  - Management of the large energy stored in the magnet system (of the order of 100 MJ),
  - Power flow required for ramping (in excess of 50 GW reactive power)
  - Quality of the fast field ramp (0.5 ms for the shortest cycle time)

- Participants: CERN (Task Leader), CNRS, TUDa, UNIBO and TWENTE, in collaboration with KYOTO
- Interface to: WP5 for physics input

Energy storage

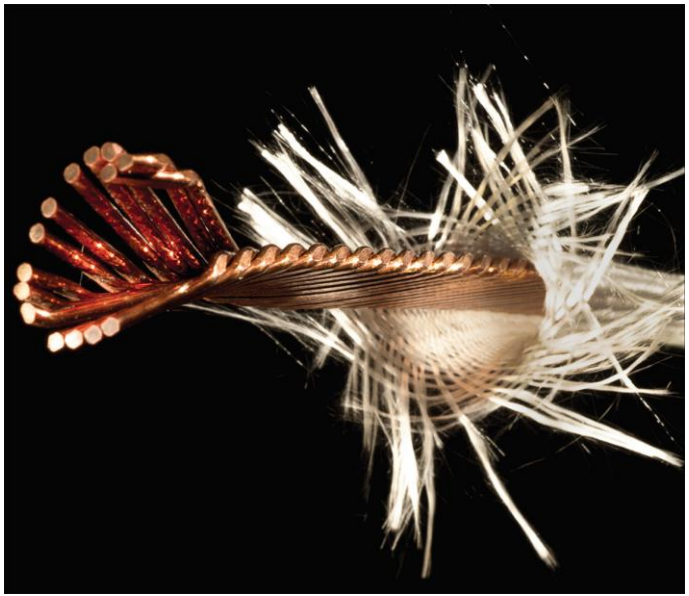
Capacitor banks for the 60 MW CERN-POPS power converter

WP7.4 – Collider Ring Magnets

- Propose concepts and evaluate realistic performance targets for the collider magnets:
- Specific focus on:
  - Combined functions arc dipoles, requiring high-field (10 to 16 T) on large aperture (150 mm)
  - LTS and HTS materials
  - Adopt a *stress management* mechanical system

- Participants: INFN (Task Leader) and UNIMI, in collaboration with PSI and US-MDP
- Interface to: WP2 and WP5 for physics input

Conductors for collider magnets



Nb_3Sn cable for high-field accelerator dipole and quadrupole magnets

HTS Roebel cable for high-field accelerator dipole and quadrupole magnets

Table 3.1b

Work package number	7		**Lead beneficiary**		CERN		
Work package title	Muon Collider Magnetic Systems						
Participant number	2	1	10	20	5	28	11
Short name of participant	CEA	CERN	INFN	SOTON	TUDa	TWENTE	UMIL
Person months per participant:	18	0 (45.6)	32	42	15	14	8
Start month	1			**End month**	48		

NOTE: CH institutes PSI (36 pm) and UNIGE (24 pm) are associate funds will be matched in case the proposal is successful

Deliverables

Deliverable (number)	Deliverable name	Work package number	Short name of lead participant	Type	Dissemination level	Delivery date (in months)
7.1	Intermediate report on muon collider magnets	7.1	CERN	R	PU	36
7.2	Final report on muon collider magnets	7.1	CERN	R	PU	46

Milestones

Milestone number	Milestone name	Related work package(s)	Due date (in month)	Means of verification
7.1	Report on solenoids and TPL experiments	7.2 (4, 8)	12	Report
7.2	Workshop on fast-cycled magnets	7.3 and 5	18	Proceedings
7.3	Report on RCS and HCS configurations	7.3 (5)	24	Report
7.4	Workshop on ultra-high-field solenoids	7.2	30	Proceedings
7.5	Report on HTS fast-cycled magnets	7.3	32	Report
7.6	Report on solenoid conceptual design	7.2 (8)	36	Report
7.7	Report on high-field collider magnet design	7.4 (2, 5)	36	Report
7.8	Workshop on high-field collider magnets	7.4	42	Proceedings
7.9	Report on footprint, power and cost model	7.1 (1)	44	Report
7.10	Report on R&D and impact	7.1 (1)	44	Report

Table 3.1e: Critical risks for implementation

Description of risk (indicate level of (i) likelihood, and (ii) severity: Low/Medium/High)	Work package(s) involved	Proposed risk-mitigation measures
Late decision of magnet performance targets for the muon collider complex. Likely for at least parts of the collider complex. Medium severity (potential delay on beginning of magnet design study)	WP3, WP4, WP5, WP7	Use the results of the US-MAP as baseline for feasibility and readiness study, and to define required R&D
Complexity or cost of Technology Performance Limits (TPL) experiments beyond the scope of the work planned	WP7	Resort to basic electro-mechanical characterization measurements to identify design limits, postponing full TPL experiments to the R&D phase

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Thank you
for attention