The MSC-CMI Section:
Cryostats & Machine Integration

V. Parma,
CERN, TE-MSC

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Mandate

The CMI Section (Cryostats & Machine Integration) is responsible for:

- Design & construction of cryostats for accelerator SC devices and integration of technical systems;
- LHC layout and machine integration studies; management of system interfaces;
- Technical coordination of LHC superconducting magnets;
- Maintenance of the LHC SC magnet cryostats and construction of spares (SMI2 facility, 189 storage);
- Participation to LHC cryo-magnets interventions during long shut downs (LS); study of magnet handling and interventions in activated areas;
- Development of supporting technologies and key technical competencies;
- Support to LHC operation (MP3).
Evolution of personnel in the Section

Staff:
Cat.E/F
- V.Parma
- J.Ph.Tock
- L.R.Williams
- D.Duarte Ramos (starts on 1st May)
- New cat. E: open recruitment end 2012

Cat.C/D:
- A.Musso
- A.Vande Creaen
- J.B.Deschamps (joined on 1st February)
- G.Barlow (starts on 1st May)
- New cat. D: open recruitment mid 2012

Cat.A/B:
- M.Souchet
- A.Bastard

Fell/PhD students/VIA
- Y.Leclercq (FELL)
- P.Azevedo (FELL)
- R.Bonomi (FELL)
- R.Ortwein (PhD student)
- J.A. Boursquet (VIA)

Collaborators from other institutes
- A.Chrul (Polish institute) (joined in March)
HIGH-LIGHTS
LS1 related activities in CMI

- CMI involvement in LS1 consolidation activities:
  - SMACC management (J.Ph.Tock)
  - Preparation of spare cryo-magnets cryostats and cryo-magnets technical coordination (M.Souchet+A.Musso)
  - Open/Close IC and DN200 installation (A.Musso)
  - Installation of redesigned interconnect thermal shields (A.Musso)
  - Participation to special team activity (J.B.Deschamps, cutting of M sleeves)
  - Inspections and repair of Connection Cryostats (A.Vande Craen)

At peak : 6.1 pers. – 6/8 staff involved

- Involvement in QA related activities:
  - WISH: development of web-based communication platform for QA and consolidation work follow-up from the tunnel (A.Musso)
  - Implementation of QA in Open/Close IC (A.Musso,A.Chrul)
Assembly of spare LHC cryo-magnet spares (SMI2 facility)

- Assembly of 5 dipoles and 2 SSS (+4 in test cryostat) in 2011;
- Construction/modification of small components for LHC cryostats (cryogenic tubing, ph.separators, etc.);
- Major work foreseen for 2012:
  - Assembly of remaining cryo-magnets for LS1
  - Assembly of LHC ondulator spare
Procurement of spare cryostat components

- Procurement of 3 spare vacuum vessels (through French in-kind);
- Recovery of 6 dipole vacuum vessels; ~500 kCHF saving!
- Procurement of magnet end caps (under DS collimator project);
- Procurement of cryostat parts for undulator spare launched
- Construction/modification of small components for LHC cryostats (cryogenic tubing, ph. separators, etc.);

Recovered LHC dipole vessels

Magnet end cap (Metso, Finland)

Modification of ph. separator

New spare vacuum vessel (CMI, France)

LHC undulator
Support to LHC operation (MP3)

- Re-commissioning performed in shifts beginning 2011
- Piquet service members: Z Charifouline, M Koratzinos, J Steckert, A Verweij, M Zerlauth (TE-MPE)
  S Le Naour, M Modena, A Musso, JPh Tock (TE-MSC)
- 82 interventions (On 16.11.2011), called at least once more than 80% of the weeks, > 2 interventions per week in average

- X ray tomography (partnership with EN/MME)
Technical coordination of LHC superconducting magnets

- Preparation of LHC spare SC magnets;
- Knowledge of SC magnets and cryostat spares and of their main components;
- LS1 preparation activity (magnets to be replaced);
- Application of QAP (including NCR, ECR) and Manufacturing & Test File (MTF);
- Support to test analysis & evaluation, and presents magnets to the Magnets Evaluation Board (MEB);

Web interface from LHC tunnel during LS1 allows:

- Real-time tasks advancement recording (easier coordination)
- Team and tooling traceability for each single task
- Fast reaction in case of NCR’s
- MTF traceability when needed

Requires:

- 3G data connection (checked with IT experts, this is the best in terms of speed, cost, installation time)
- Tablets (or laptop) for team leaders
- Website specification (work already started)

Project schedule

- Database design and performance study: APRIL 2012
- Web setup and programming: July 2012
- Test and debugging: August
- Code revision and training: September 2012
- Production: November 2012

Note: Foresee access to all points during technical stops to test connection

Presentation movie available
W Bellows: New thermal shield design

Thermal connection by mechanical clamping

**Why?:**
- Avoid Welds to be done in the tunnel (Fire hazard)
- Grind-free removal during next LS’ (RP issue)

The shield will be fixed to the cryo-magnet thermal shield with a screwed clamp. Thermal calculations and test are in progress. ECR will be written.
Design & construction of cryostats for accelerators superconducting devices and integration of technical systems

• LHC machine upgrades
  – Short Connection Cryostat, → conceptual design reviewed. Project postponed.
  – improved design of new spare Connection Cryostats → in progress, construction delayed to after LS1.
  – New SC links and surface feedboxes, for R2E in IR1,5 and 7, (LS2, 2018, LS3, 2022), → study yet to start.
  – New IT (and D1) cryostats (LS3, 2022), → study not started.

• Cryogenic devices for other machine :
  – Cryomodule prototype for HIE Isolde, → conceptual design done.

• Testing cryostats:
  – MQXC horizontal test cryostat
  – 11 T magnet horizontal test cryostat
  – HFM vertical test cryostat, → conceptual design done.
  – SPL Short Cryomodule, → conceptual design done.

Use existing concepts, could be a « universal » test cryostat.
Connection Cryostats

**Short Connection Cryostat** (DS collimator project):
- Design improvements (BB routing and supports)
- Design reviewed, project stopped, drawings being archived.

**Spare Connection Cryostat**
- Same design improvements of SCC
- Components to be procured in 2012
- 2 spares to be constructed after LS1
- Need for shielding to be assessed again
HFM vertical test station

- General dimensions fixed
- Integration ongoing (10kA, cold buffer,...)
- General concept finished
- Detailed design started
- Final design of vacuum vessel started

Parameter description

<table>
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<tr>
<th>Parameter description</th>
<th>Value</th>
<th>Unit</th>
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<tr>
<td>Nominal magnetic field @ 4.2 K</td>
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<td>T</td>
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<tr>
<td>Ultimate magnetic field @ 1.9 K</td>
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<td>T</td>
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<td>Maximum current</td>
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<td>Maximum heat dissipation when ramping</td>
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DS collimator studies: moving to compact integration solutions

Design of a Short Connection Cryostat (SCC)

By-pass cryostat+warm collimator (EN-MME)

Warm Option

Q8 MB

LTC

SCC Q11 MB

Warm Option

• 11T dipole magnet + collimator (warm or cold): compact 2-in-1 solutions
  – Feasibility study in progress

Possible options (cold or warm)
HIE-ISOLDE High Beta Cryomodule as it is today

- Helium vessel
- RF cavities
- SC solenoid
- Beam line
HIE-ISOLDE High Beta Cryomodule Recent Changes and Work Underway

• Vacuum Tank
  – Two top seals with inter-seal pumping
  – Rounded bottom to reduce stresses and deformations
  – 316L for a stricter control of permeability
  – Electro-polished to ease cleaning
  – Tech Spec is written for procurement in May

• Helium Tank
  – Operational volume and pressure defined
  – Internal piping under design now
  – Chimney is dimensioned, thermalisation under study
  – Electrical and cryogenic services to the chimney are being studied

• Support System
  – Operational pressure reduced now to ~4 bar with helium exhaust line at dia 150 mm
  – Support structure and cryo connections (bellows) less rigid - helps alignment
  – First modes and natural frequencies of the suspended active part have been calculated
  – Electrical and cryogenic services to the chimney are being studied

• Alignment
  – Call for tender underway via CATE for the design and construction of 2 positional adjusters for the active part
  – The B-CAM position determining system is under test on the mockup in SM12
  – Targets may be changed from active (illuminated) to passive (reflectors)

• Cavity and Solenoid Support
  – Concept unchanged but details modified to allow late assembly and easy access to the cavities and the solenoid

• Thermal Shield and MLI
  – Construction methods have been examined
  – Thermalisation needs to be re-examined once the location of all sources of heat input is known
  – Space has been left for some form of FLI (Few Layer Insulation) system based on stretched mylar films. This will not be installed in the first cryomodule

• Instrumentation
  – Inventory is defined (except for RF)
  – First contacts with industrial suppliers, may buy connectors and cable looms together

• Clean Room
  – Tech Spec is written
  – Call for tender out by end April
  – The staff to manage the clean room and carry out the first module assembly needs to be identified and maybe trained

• Cryomodule Assembly
  – Assembly sequences defined
  – Procedures for tasks are being written
  – Special tooling concepts are under study

• Safety File
  – Needs have been clarified with HSE
  – Construction according to EN-13458-2 with CE certification only for the helium vessel and the solenoid helium vessel

• Risk Analysis
  – Strategy has been defined with HSE; Process based risk analysis
  – Study group has been formed with Delio as our representative

• Design Review
  – Will be held on 26 and 27 April 2012
  – Procurement will start after the review and subject to recommendations
SPL Short Cryomodule
(CERN/CNRS/CEA collaboration effort)

- Conceptual design finalized (reviewed in Nov.11)
- Main choices frozen
SPL Short Cryomodule: developing innovative solutions

Original cavity supporting concept:
- RF coupler tube as main cavity support
- efficient He vapor-cooled tube support

Vacuum vessel optimisation design:
- elasto-plastic buckling stability

Vacuum vessel with top lid
- vertical insertion of cavities (for compactness)
Development of supporting technologies and competencies

**Design & Computational competencies:**
- Design methodology for low heat load/precise alignment cryostats
- Mechanical and thermo-mechanical calculation
- Thermal performance @ cryogenic temperatures (thermal shielding with MLI system, low-emissivity surfaces…)

**Construction technologies:**
- Mechanical assembly techniques and benches for LHC-type cryostats
- Leak-tight welding methodology and He mass spectrometry leak check techniques (sniffing, clamshell, accumulation methods)
- Cryostat leak-tight feed-throughs solutions for instrumentation routing
- Expertise in compound material leak-tight assemblies (ex. ITER plugs)
- Mockups for mechanical testing and leak-tight checks

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*Images:*
- Isolde cryomodule Vacuum vessel
- Mechanical testing of LHC vacuum barrier
- Mechanical testing of LHC supports
- ITER plug prototype
- SPL cryomodule cavity supporting
- Test tank
- SPL cryomodule cavity supporting
SMI2, LHC cryostat assembly facility

Bd189, storage of cryostat components

Point 18, future facilities for cryo-module assembly
GOALS AND ACHIEVEMENTS
Main achievements in 2011

**LHC cryo-magnet cryostats:**
- Assembly to need of spare dipoles and SSS cryostats → all year long
- Procurement of spare vacuum vessels (critical spare components) for SSS MS and CC → Jan.-Nov. 2011
- Recovery of 6 dipole vacuum vessels; ~500 kCHF saving! → Jan.-Dec. 2011
- Re-start of tech. coordination activity and associated committees (MEB) → Sept. 2011

**Support to LHC operation:**
- > 2 MP3 interventions/week → all year long, and shift work

**Design accomplishments on new devices:**
- Review of DS collimator cryostats → June 2011
- Conceptual review of the SPL Short Cryomodule → November 2011
- Design improvements for the Connection Cryostats → Jan.-Sept. 2011
- Critical advances in the design of the HIE-Isolde cryomodule → Jan.-Sept. 2011
Status in April 2012 w.r.t. main goals set end 2011

• Preparation for LS1:
  – Finalize preparation of spare cryo-magnets by October → in progress, on track:
    3/15 cryo-dipoles in final preparation in SMI2; 21 cryo-dipoles, available for MEB choice;
    4 SSS: 230 ready, 233 @ 80%, cold masses Q5 & Q7 foreseen in June (on critical path)
  – Prepare section work package for LS1 work (opening/closing IC, DN200 installation); → in progress, on track
  – Prepare QA coordination role of the section and associated tools and methodology (needs resources detached from other sections);
    → Goal suppressed, QA coordination not anymore centralized in the section, but limited to section activity in LS1 (opening/closing IC, DN200 installation)

• Preparation of spares:
  – Construction of 2 spare Connection Cryostats; → in progress, delayed:
    – Not a priority, delayed to 2013-2014 (after LS1 engagements)
    – Only design and procurement of long-lead-time this year (bus bars, vacuum vessels)
  – Procurement of additional LHC spare vacuum vessels;
    – 6 dipole prototype vessels upgraded to LHC spares
    – 2 vessels procured (1 special SSS + 1 connection cryostat), 1 more in progress (amendment of French in-kind)
    – Decision not to procure additional dipole vessels agreed within MSC
  – Procurement of spare ondulator components; → in progress:
    – All components ordered (but for MLI blankets)
    – Study of cryostat assembly started;
**Status in April 2012 w.r.t. main goals set end 2011**

- **Design studies:**
  - Start of conceptual design & integration studies for SC links and surface feedboxes: **in progress,**
    - definition of strategy and concepts
    - work will gain momentum in May, when D.Ramos will join
  - HIE Isolde Cryomodule: **in progress, on track:**
    - Detailed design review (March 2012) → fixed on 26-27 April
    - Procurement of cryostat parts by end 2012
  - SPL Short Cryomodule: **in progress, on track:**
    - Detailed design review (October 2012):
    - Launch of procurement of long lead items
Newly added goals for 2012 (revised w.r.t. 2011)

- HFM Vertical Test Cryostat:
  - Priority set for launching procurement by mid 2012,
  - Major cryostat components available to start installation in the beginning of 2013

- Development of WISH tool for LS1

- Enlarged participation in LS1 (J.B. Deschamps joins “special team”)

- Redesign of Interconnect thermal shields (ECR in preparation)

- Activated magnets removal study: preparatory study phase before LS1 starts (identify additional workload for LS1)