LHC Status Report

Emmanuel Tsesmelis / CERN
LHCC Open Session
21 March 2007
Main Magnets
Dipole Cold Masses

Updated 28 Feb 2007

Data provided by G. de Rijk AT-MCS

E. Tsesmelis – LHCC Open Session 21 March 2007
Cryodipole Overview

LHC Progress Dashboard

Cryodipole overview

Updated 28 Feb 2007

Data provided by D. Tommasini AT-MCS, L. Bottura AT-MTM

E. Tsesmelis - LHCC Open Session 21 March 2007 4
Dipole Installation Progress
# Installed Magnets

<table>
<thead>
<tr>
<th></th>
<th>Right</th>
<th>Left</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cryo-magnets</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In Arc</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dipoles</td>
<td>SSS (arc + D5)</td>
<td>LSS</td>
</tr>
<tr>
<td></td>
<td>Dipoles</td>
<td>SSS (arc + D5)</td>
<td>LSS</td>
</tr>
<tr>
<td>Secteur 1-2</td>
<td>70</td>
<td>27</td>
<td>4</td>
</tr>
<tr>
<td>Secteur 2-3</td>
<td>77</td>
<td>28</td>
<td>8</td>
</tr>
<tr>
<td>Secteur 3-4</td>
<td>77</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>Secteur 4-5</td>
<td>77</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>Secteur 5-6</td>
<td>77</td>
<td>28</td>
<td>7</td>
</tr>
<tr>
<td>Secteur 6-7</td>
<td>77</td>
<td>27</td>
<td>2</td>
</tr>
<tr>
<td>Secteur 7-8</td>
<td>77</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>Secteur 8-1</td>
<td>77</td>
<td>28</td>
<td>8</td>
</tr>
</tbody>
</table>

LHC | 1212 | 429 | 64 | 94 | 1799 |
Cryo magnets | 1705 |

Prepared by Pascal Ponsot TS-IC 19/03/2007 15:01
Cryogenics
Infrastructure & 4.5 K Refrigerators
1.8 K Refrigerators

Air Liquide

Il l Linde
Cryogenic Distribution Infrastructure
QRL Installation

• 3.3 km of QRL / sector
  – 2100 internal welds made with automatic orbital welding machines
  – 700 external manual welds
QRL Special Regions
Progress Report – Cryogenic Plants

LHC Progress Dashboard

Cryogenics overview

Legend:
- Green: Commissioned & accepted
- Red: Delivered / Under installation
- Blue: Under fabrication
- Pink: Under commissioning
- Tan: Ordered (Contract placed)
- Yellow: Under definition

Updated 28 Feb 2007

Data provided by L. Tavian, AT-ACR

E. Tsesmelis – LHCC Open Session 21 March 2007
Electrical Feedboxes
Design

Connection to magnets

Shuffling module

Vacuum equipment VAA

Current lead chimneys

13kA leads

6kA leads

Removable door

HCM/LCM interconnect

Jumper cryo connection to QRL

Supporting beam

6kA leads

600A leads

Low current module 6kA & 600A leads

High current module 13kA & 6kA leads

DFBA

DFBL

DFBM

DFBX

1.9K

4.5K

E. Tsesmelis – LHCC Open Session 21 March 2007
DFBA Installation

DFBAO-HCM Leaving Assembly Hall 183

DFBAO-HCM Lowered at Point 2
DFB Interconnection

DFBAO in Sector 7-8

DFBMA in Sector 7-8
DFB Progress

DFB Electrical Feed Boxes

- Nominal component delivery
- Components delivered
- DFB ready for installation

Updated 28 Feb 2007

Data provided by A. Pailin AT-ACR

E. Tsesmelis – LHCC Open Session 21 March 2007
Interconnections
Identification of Lines
Dipole Interconnections
General Progress
General Progress

General Advancement of Interconnects per Sector 03-Mar-2007

- Close W & Jumper
- Weld Package I & VAC tests
- N-Line Package
- Cryo-Lines Welding & Testing
- Electrical Interconnects & QA per halfcell
- IC preparation

E. Tsesmelis – LHCC Open Session 21 March 2007
Electrical Quality Assurance
Inner Triplets
Cryo-magnet Assembly

External Heat Exchanger
Pressure Test of Sector 8-1

- During the pressure test of Sector 8-1 (25 November 2006) the heat exchanger tube in the inner triplet failed at 9 bar differential pressure.
- The inner triplet was isolated and the pressure test of the whole sector was successfully carried out to the maximum pressure of 27.5 bar.
Inner Triplets at LSS5L

New Design

Vacuum Brazing  EB Welding
Inner Triplet Repair

• New high quality heat exchanger tubes are being installed in all 24 inner triplets (starting with Sector 4-5)
• Production of new tubes has been completed
  – Acceptance tests give a buckling pressure of 84 bar.
• Repair schedule for inner triplets has been consolidated.
  – Work is advancing according faster than plan.
Collimation System
The Lay-out
Non-conformities

• Quality problems at production company reported in August 2006
  – Resulted in immediate suspension of production

• Considerable involvement of CERN personnel (AB, AT, TS) deployed to address situation
  – Resulted in all technical problems being overcome by early 2007

Instrumentation feedthrough brazings

Contamination of components exposed to beam
Collimators are an intensity-driven system.

LHC can be started at low intensities without any collimators. However, once intensity or energy is increased a high number is quickly needed!

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Primary collimation (TCP) and scraper (TCHS)</th>
<th>Secondary collimation (TCS)</th>
<th>Absorbers for collimation debris (TCLA)</th>
<th>IR (exp) collimators (TCT, TCLP, TCLI)</th>
<th>Dump protection (TCDQ + TCS)</th>
<th>Total number (two beams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&lt; 5 \times 10^{11}$</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>$&lt; 1 \times 10^{13}$</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>$&lt; 3 \times 10^{13}$</td>
<td>8</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>Full system</td>
<td>14</td>
<td>30</td>
<td>18</td>
<td>28</td>
<td>2</td>
<td>92</td>
</tr>
</tbody>
</table>

TCT not required if triplet is not aperture bottle-neck (as foreseen) → No squeeze below 11m!
Production Progress

• Minimal system of 28 collimators to be delivered by beginning May 2007
  – Installation during LSS campaign up to July 2007

• The 58 additional collimators needed for $10^{33}$ cm$^{-2}$ s$^{-1}$ to be delivered by end 2007
  – Installation during 2007/2008 shutdown
Power Converters
Installation and Tests

- All main magnet power converters installed (968 units).
  - Short-circuit tests approaching completion.
- Installation of orbit corrector power converters well underway.

Infrared Tests
Cool-down of Sector 7-8
Progress
Magnet Temperature Profile

Magnet temperature profile along sector 78 at 17:29 20 Mar

Move cursor to yellow square to identify magnet
### Activities in Progress

**Ongoing Hardware Commissioning Activities in SECTOR 78**

<table>
<thead>
<tr>
<th>REGION</th>
<th>ACTIVITY TYPE</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECTOR 78</td>
<td>Cooldown to 4.5K, 1.9K</td>
<td>Cooldown continues, some magnets below 4K</td>
</tr>
<tr>
<td></td>
<td>Preparation for Powering</td>
<td>Calibration of 50A converters</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>TS-EL installs and tests AC network control equipment in the alcoves.</td>
</tr>
</tbody>
</table>

**Future Hardware Commissioning Activities in SECTOR 78**

<table>
<thead>
<tr>
<th>REGION</th>
<th>ACTIVITY TYPE</th>
<th>ACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECTOR 78</td>
<td>Elia at Cold</td>
<td>to start after CRYO OK</td>
</tr>
</tbody>
</table>

Target remains to be ready for Sector 7-8 Powering Tests in Week 13

Preparation for Cool-down of Sectors 4-5, 8-1, 3-4 underway
LHC Construction and Installation Schedule
LHC Master Schedule

Point 2

Point 4

Point 6

Point 8
Engineering Run
Objectives

• Commission essential safety systems
• Commission essential beam instrumentation
• Commission essential hardware systems
• Perform beam based measurements to check:
  - Polarities
  - Aperture
  - Field characteristics
• Establish collisions
• Provide stable two beam operation at 450 GeV
• Interleave collisions with further machine development, in particular the ramp.

• Optics:
  - $\beta^* = 11$ m in IR 1 & 5
  - $\beta^* = 10$ m in IR 2 & 8
  - Limited by triplet aperture
• Crossing angles off
  - 1, 12, 43, 156 bunches per beam
• Separation bumps - two beam operation
• Shift bunches for LHCb
  - 4 out of 43 bunches, or 24 bunches out of 156
• Solenoids & Experimental Dipoles etc. off (to start with)

Provide a firm platform for the commissioning to 7 TeV and provide adequate lead time for problem resolution.
## Phases of Beam Commissioning

<table>
<thead>
<tr>
<th>Phase</th>
<th>Main Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 First turn</strong></td>
<td>End TI2, TI8, injection region, BPMs, BLMs, thread first turn, polarity checks</td>
</tr>
<tr>
<td><strong>2 Establish circulating beam</strong></td>
<td>Closed orbit, chromaticity, energy matching, tune, RF capture</td>
</tr>
<tr>
<td><strong>3 Initial commissioning</strong></td>
<td>RF, control &amp; correction, transverse diagnostics, linear optics checks, BLMs, beam dump, machine protection</td>
</tr>
<tr>
<td><strong>4 System commissioning</strong></td>
<td><strong>4 a Measurements</strong> Beta beating, aperture, field quality checks, transfer functions</td>
</tr>
<tr>
<td></td>
<td><strong>4 b</strong> RF, transverse feedback, BLMs to MPS, tune PLL, collimators and absorbers</td>
</tr>
<tr>
<td><strong>5 Two beam operations</strong></td>
<td><strong>5 a</strong> Parallel injection, separation bumps, instrumentation and control</td>
</tr>
<tr>
<td></td>
<td><strong>5 b</strong> Establish collisions, luminosity monitors, collimation, solenoids</td>
</tr>
<tr>
<td><strong>6 Increase intensity</strong></td>
<td>Collimators, LFB, multi-batch injection</td>
</tr>
</tbody>
</table>
Beyond 2007

<table>
<thead>
<tr>
<th>Year</th>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>Stage I</td>
<td>Hardware commissioning 7TeV, Machine checkout 7TeV, Beam commissioning 7TeV, 43 bunch operation, 75ns ops, 25ns ops l, Shutdown</td>
</tr>
<tr>
<td>2009</td>
<td>I</td>
<td>No beam</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>Beam</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Beam setup, 25ns ops l, Shutdown</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>No beam, 25ns ops l, Shutdown</td>
</tr>
</tbody>
</table>
Conclusions

- Solid progress in construction, transport, installation and interconnection (+ QA).
- CERN’s ability to solve various production problems, e.g. Inner Triplets & Collimators, is evident.
- Cool-down of Sector 7-8 is well-underway.
- The Engineering Run at 450 GeV for the end of 2007 remains the top priority.

<table>
<thead>
<tr>
<th>Event</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last magnet delivered</td>
<td>November 2006</td>
</tr>
<tr>
<td>Last magnet tested</td>
<td>January 2007</td>
</tr>
<tr>
<td>Last magnet installed</td>
<td>March 2007</td>
</tr>
<tr>
<td>Machine ring closed</td>
<td>August 2007</td>
</tr>
<tr>
<td>First collisions at 450 GeV</td>
<td>November 2007</td>
</tr>
<tr>
<td>First collisions at 7 TeV</td>
<td>June 2008</td>
</tr>
</tbody>
</table>