LHC Status Report

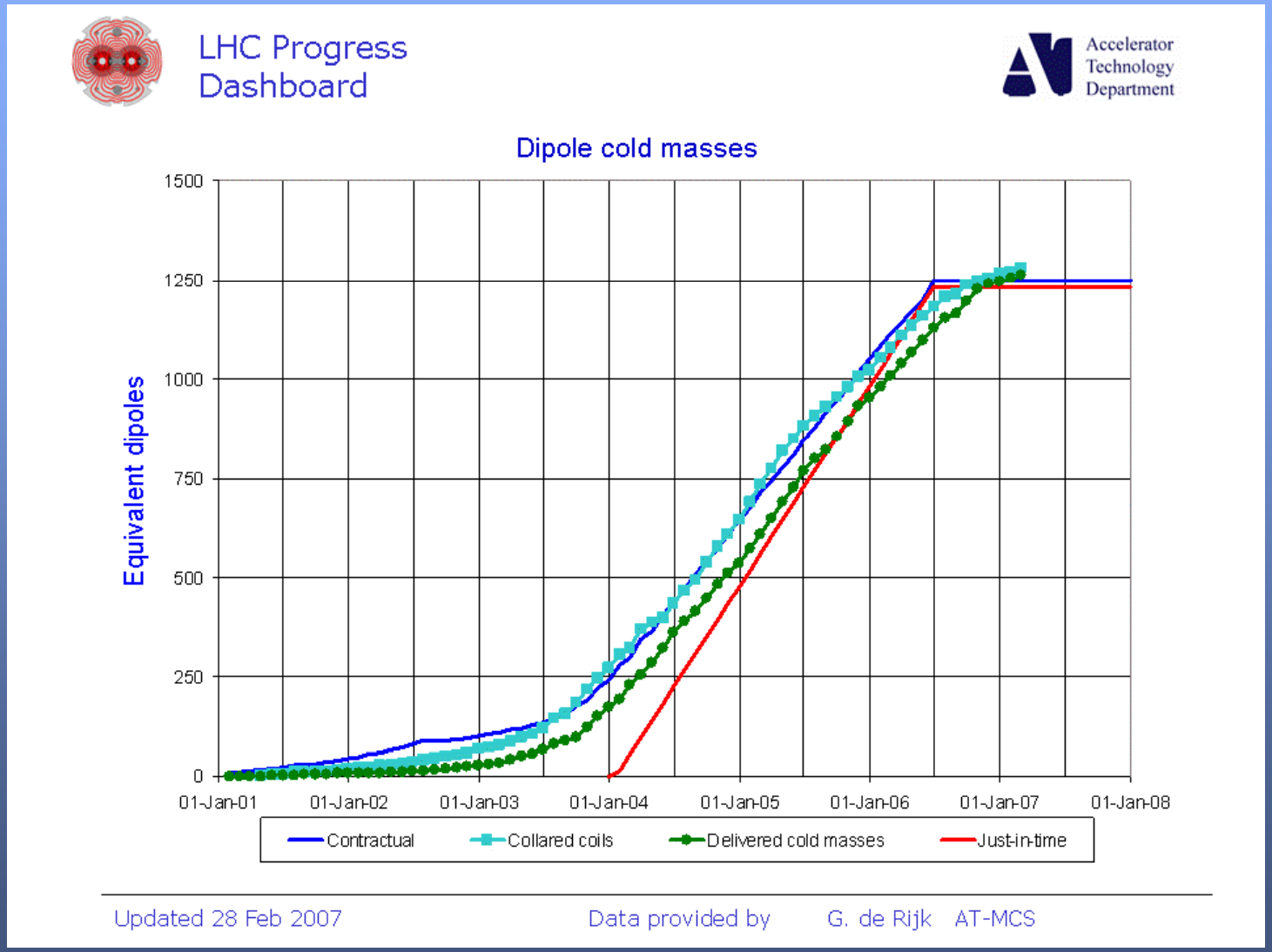
Emmanuel Tsesmelis / CERN

LHCC Open Session

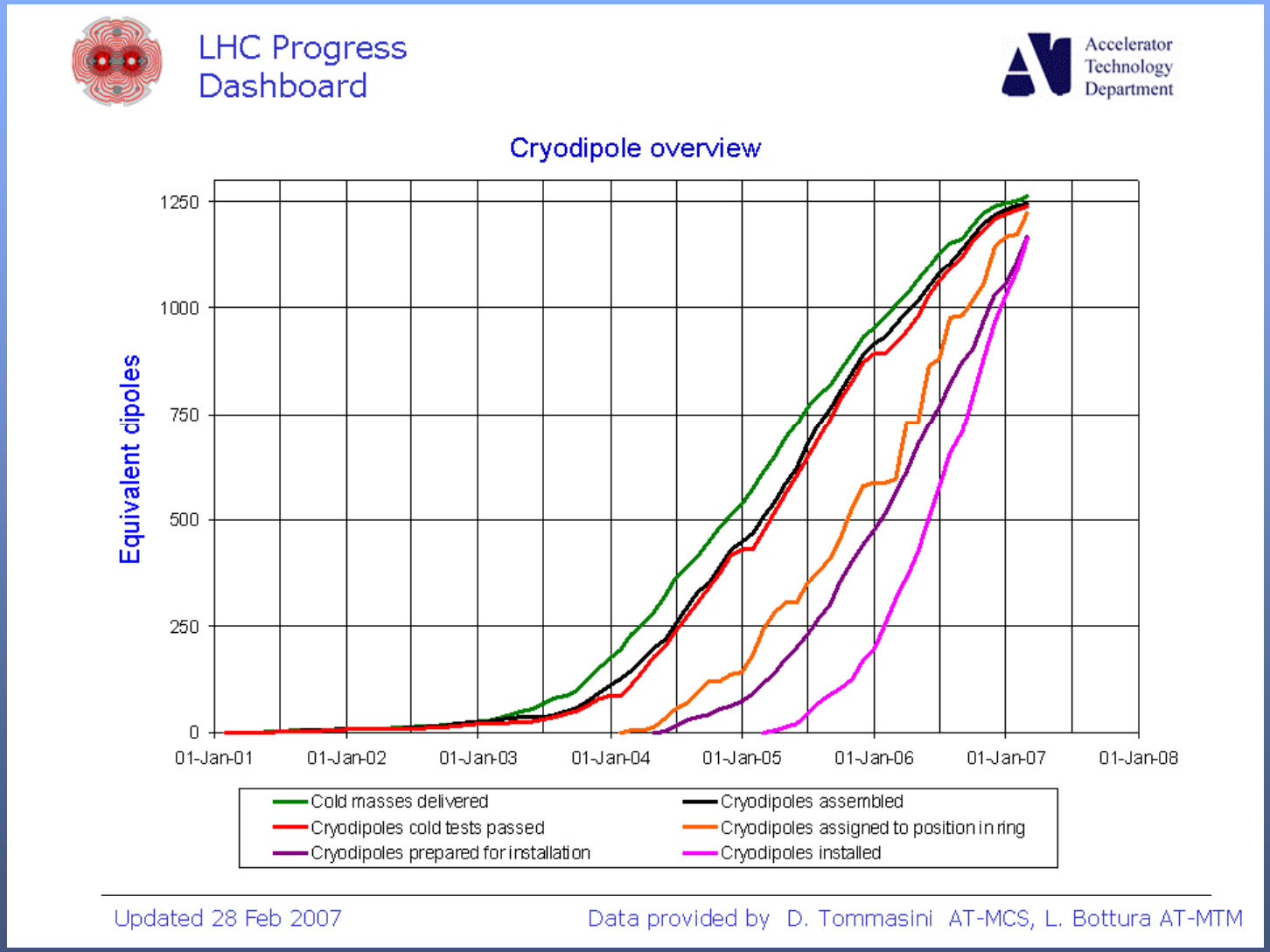
21 March 2007

Main Magnets

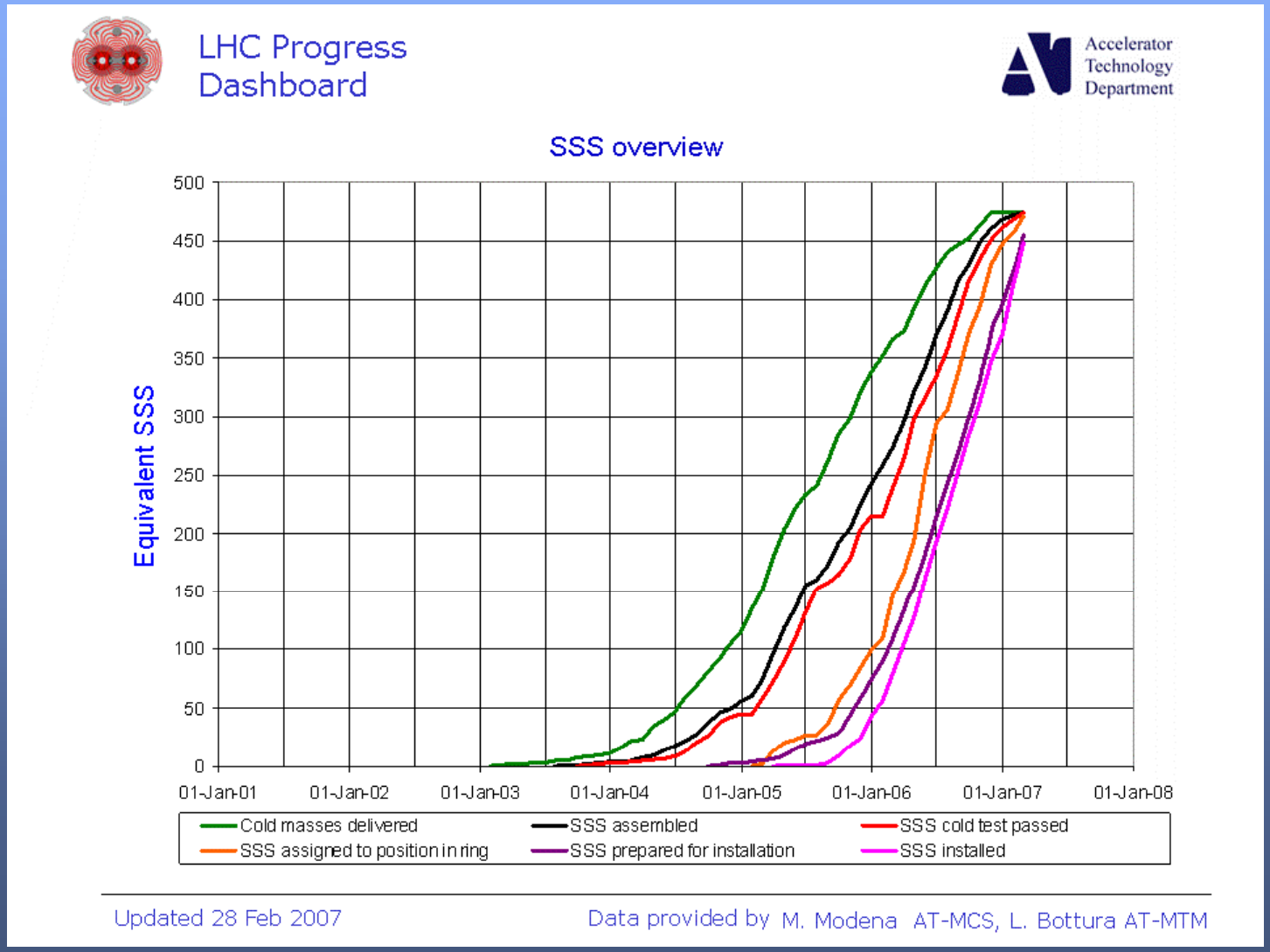
Dipole Cold Masses



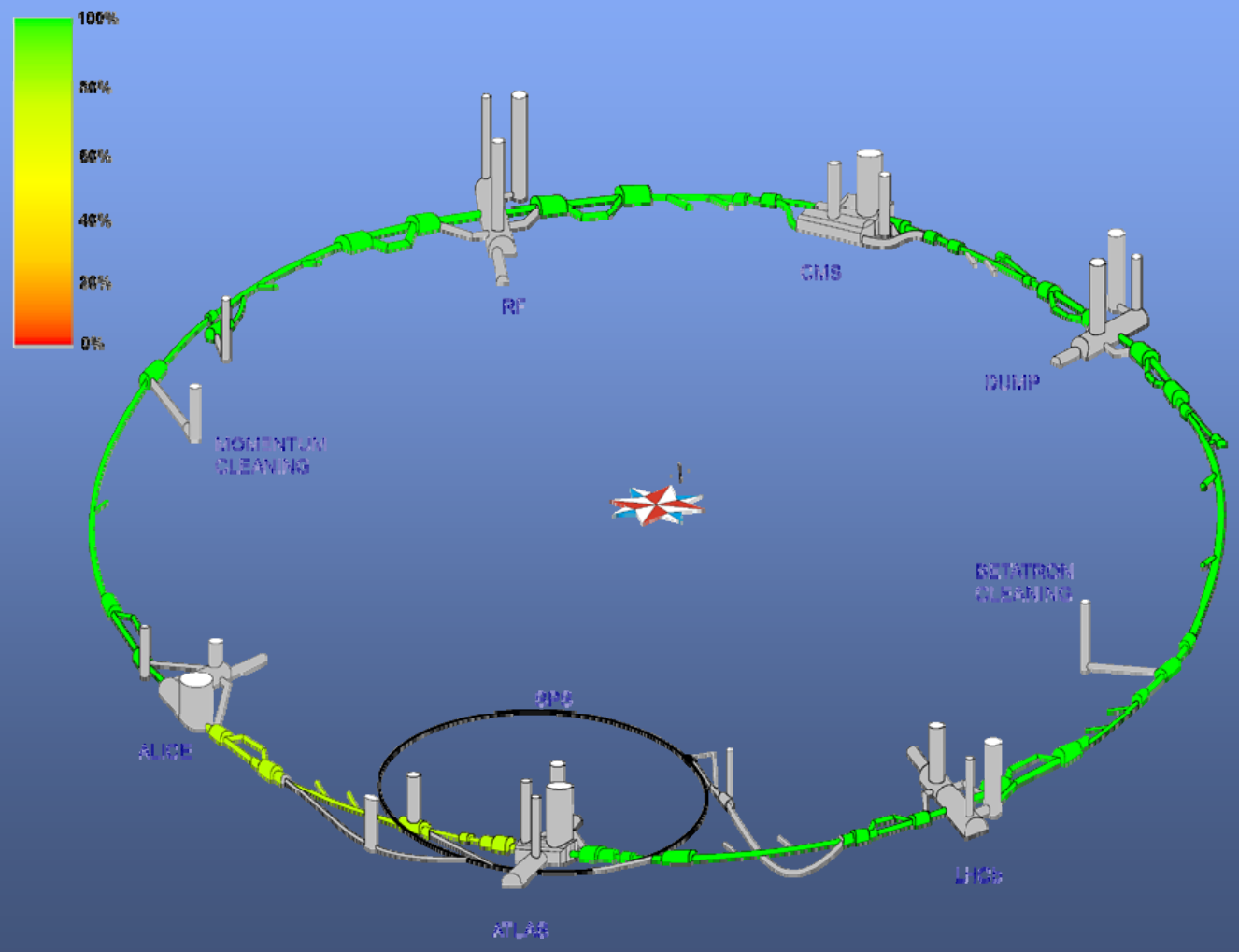
Cryodipole Overview



SSS Overview



Dipole Installation Progress



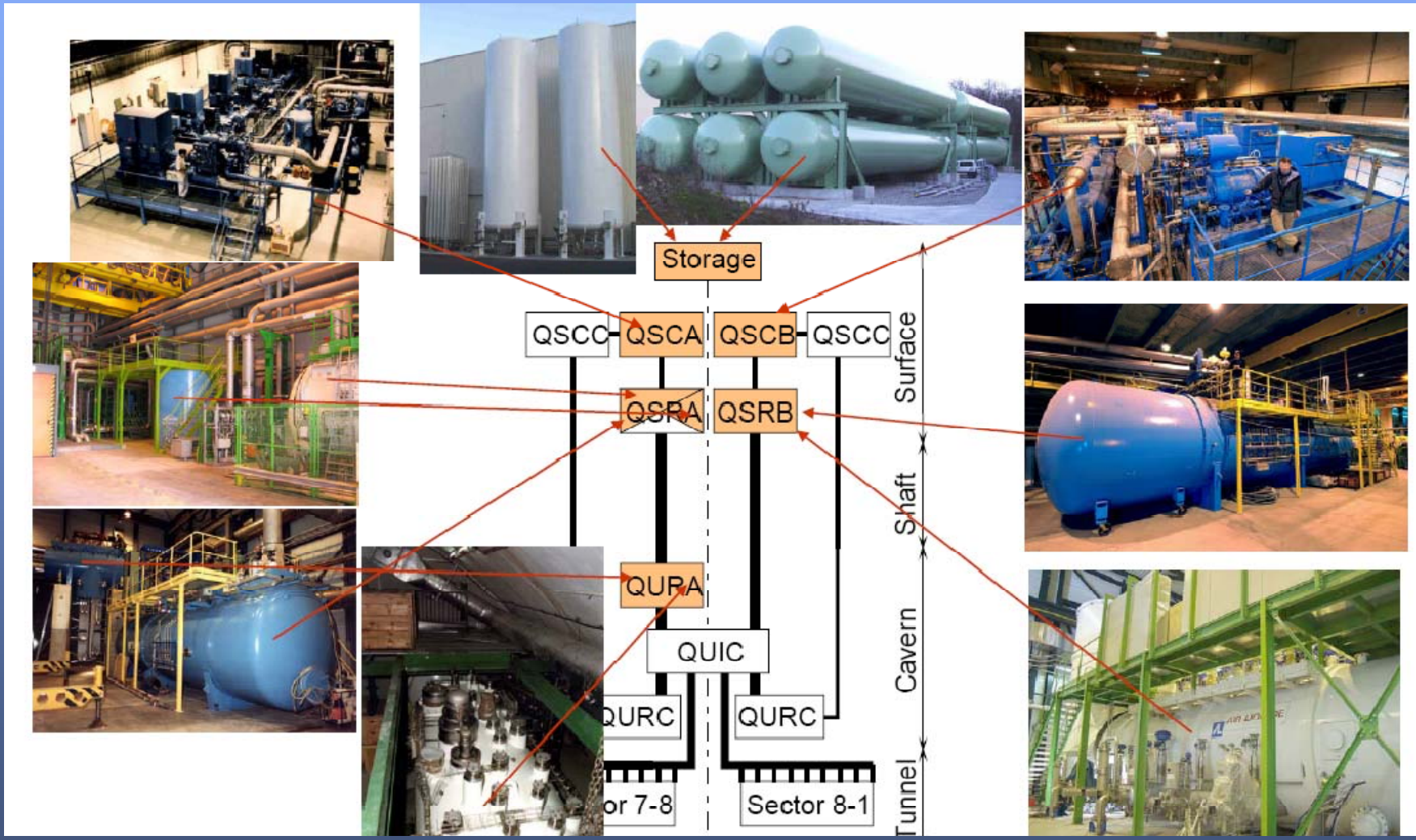
Installed Magnets

	Right					Left					Total				
	Cryo-magnets			DFB + others	Total	Cryo-magnets			DFB + others	Total	Cryo-magnets			DFB + others	Total
	In Arc		LSS			In Arc		LSS			In Arc		LSS		
	Dipoles	SSS (Arc + DS)				Dipoles	SSS (Arc + DS)				Dipoles	SSS (Arc + DS)			
Secteur 1-2	70	27	4	3	**104**	64	19		1	**84**	134	46	4	4	**188**
Secteur 2-3	77	28	8	4	**117**	77	27		6	**110**	154	55	8	10	**227**
Secteur 3-4	77	28	1	7	**113**	77	27	4	7	**115**	154	55	5	14	**228**
Secteur 4-5	77	28	4	7	**116**	77	27	7	6	**117**	154	55	11	13	**233**
Secteur 5-6	77	28	7	5	**117**	77	26	2	4	**109**	154	54	9	9	**226**
Secteur 6-7	77	27	2	4	**110**	77	27	1	9	**114**	154	54	3	13	**224**
Secteur 7-8	77	28	1	11	**117**	77	27	8	7	**119**	154	55	9	18	**236**
Secteur 8-1	77	28	8	7	**120**	77	27	7	6	**117**	154	55	15	13	**237**
LHC											1212	429	64	94	**1799**
Cryo-magnets													**1705**		

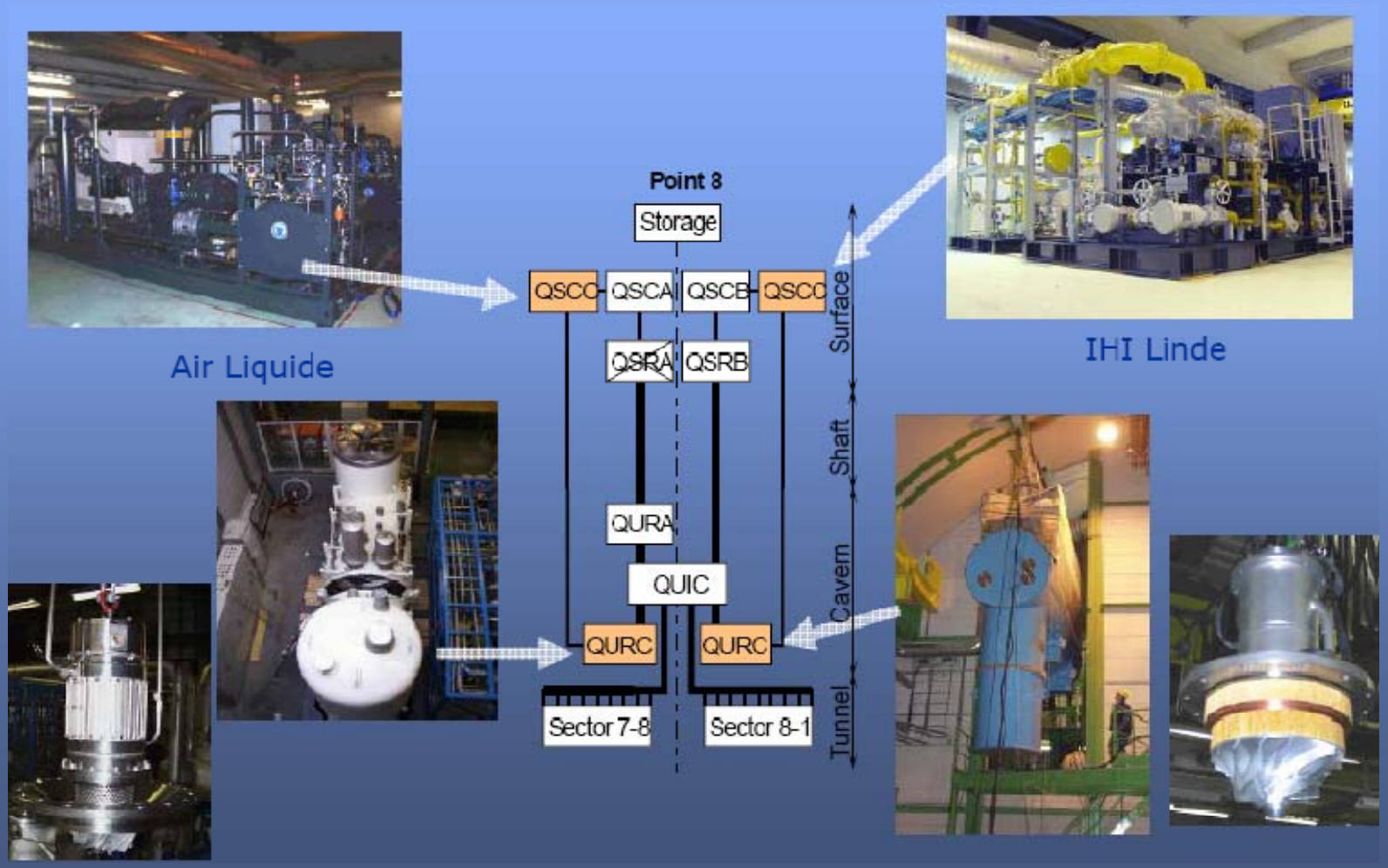
Prepared by Pascal Ponsot TS-IC 19/03/2007 15:04

Cryogenics

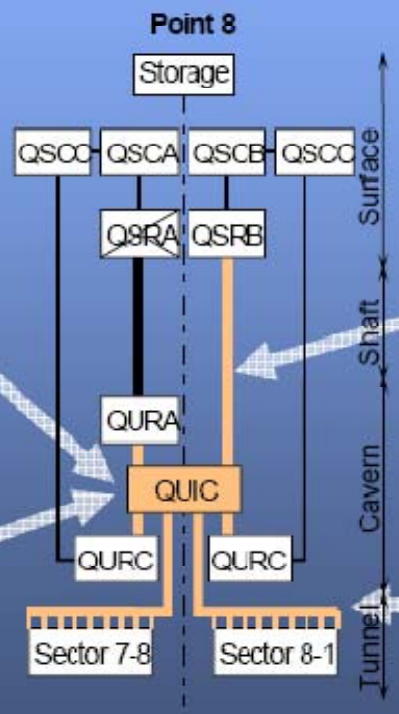
Infrastructure & 4.5 K Refrigerators



1.8 K Refrigerators



Cryogenic Distribution Infrastructure



QRL Installation

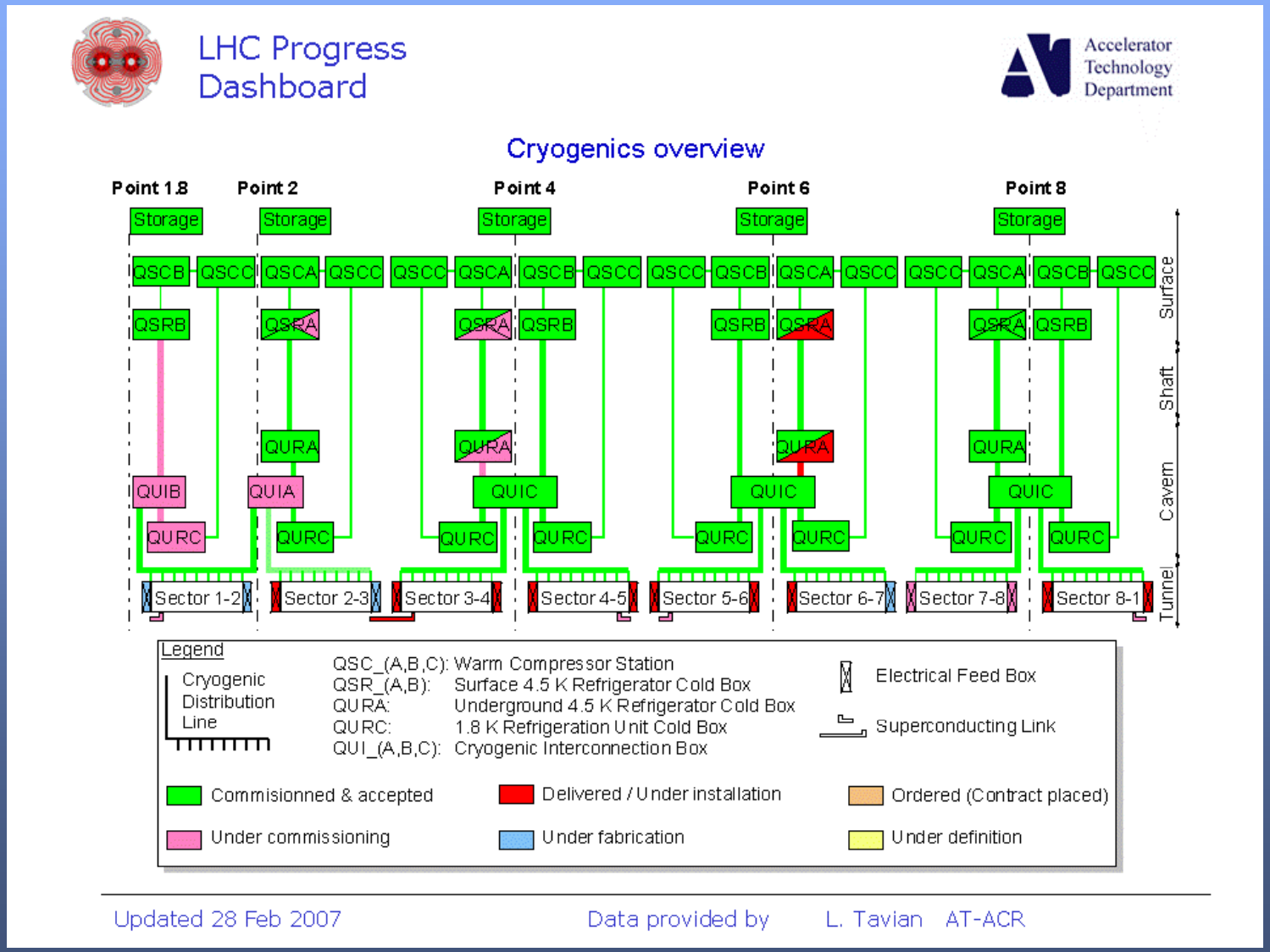
- 3.3 km of QRL / sector
  - 2100 internal welds made with automatic orbital welding machines
  - 700 external manual welds

Internal Compensators

Special Connections

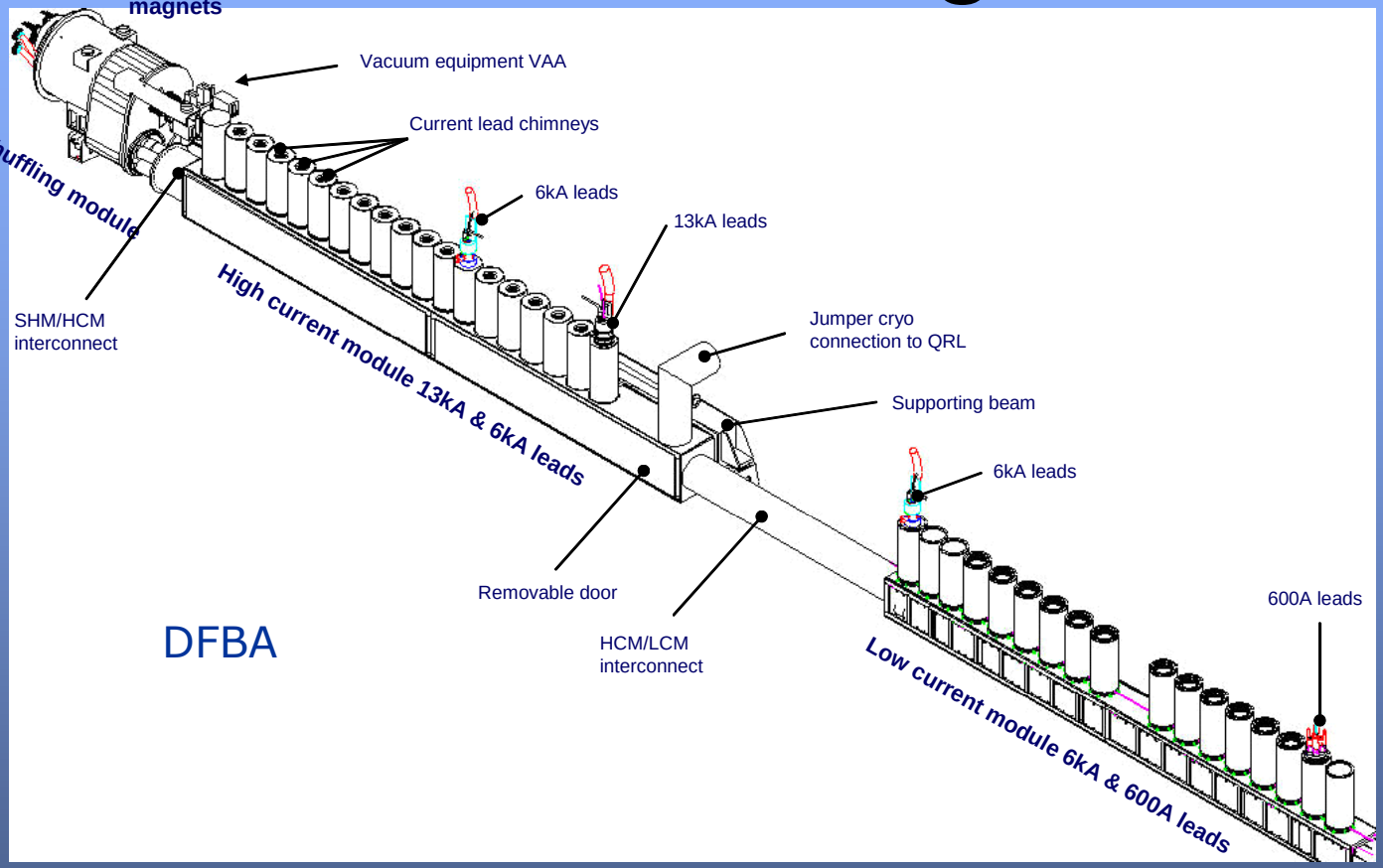
QRL Special Regions

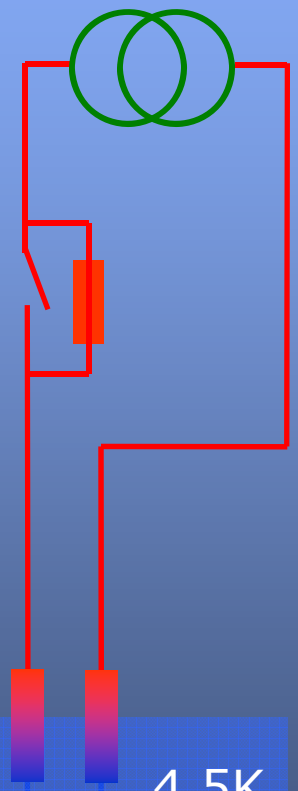
Progress Report – Cryogenic Plants



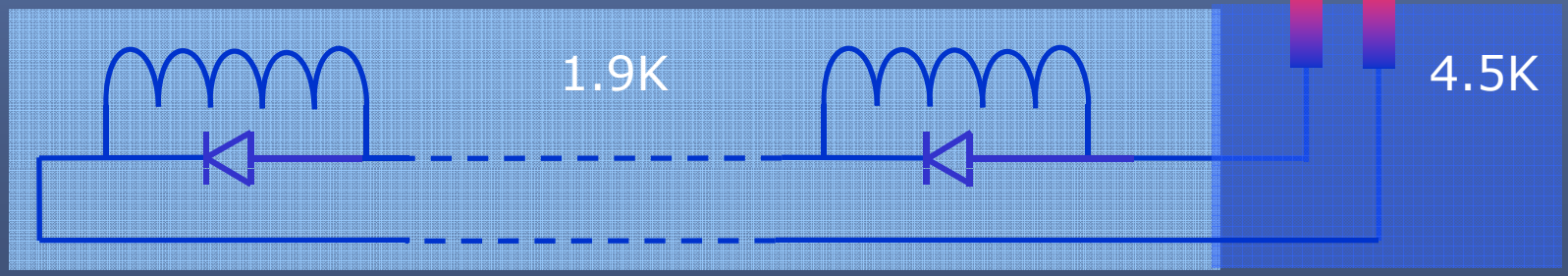
Electrical Feedboxes

Design





DFBA
DFBL
DFBM
DFBX



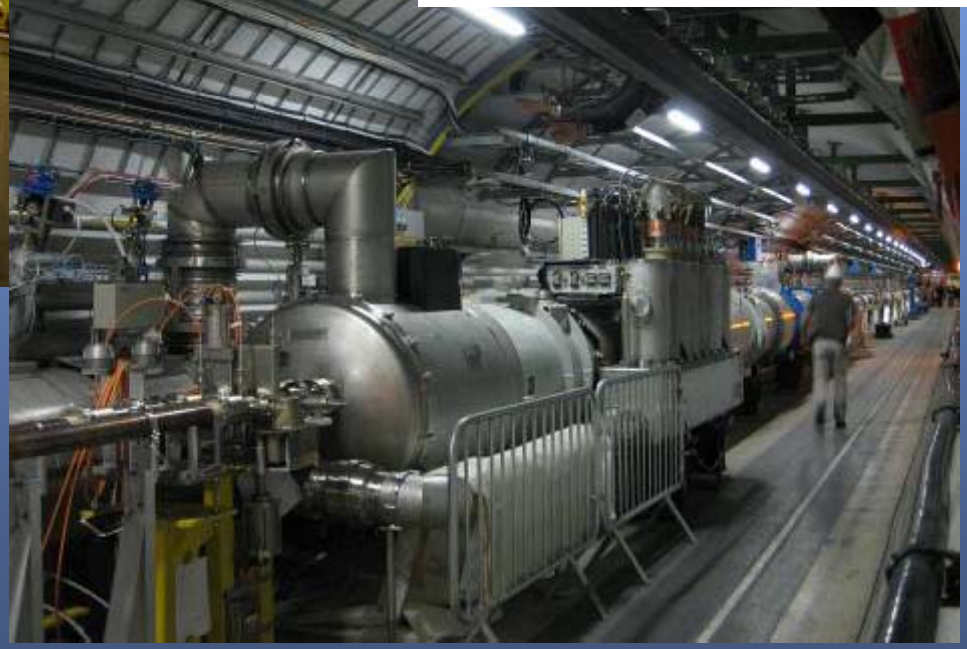
DFBA Installation

DFBAO-HCM Leaving Assembly Hall 183

DFBAO-HCM Lowered at Point 2

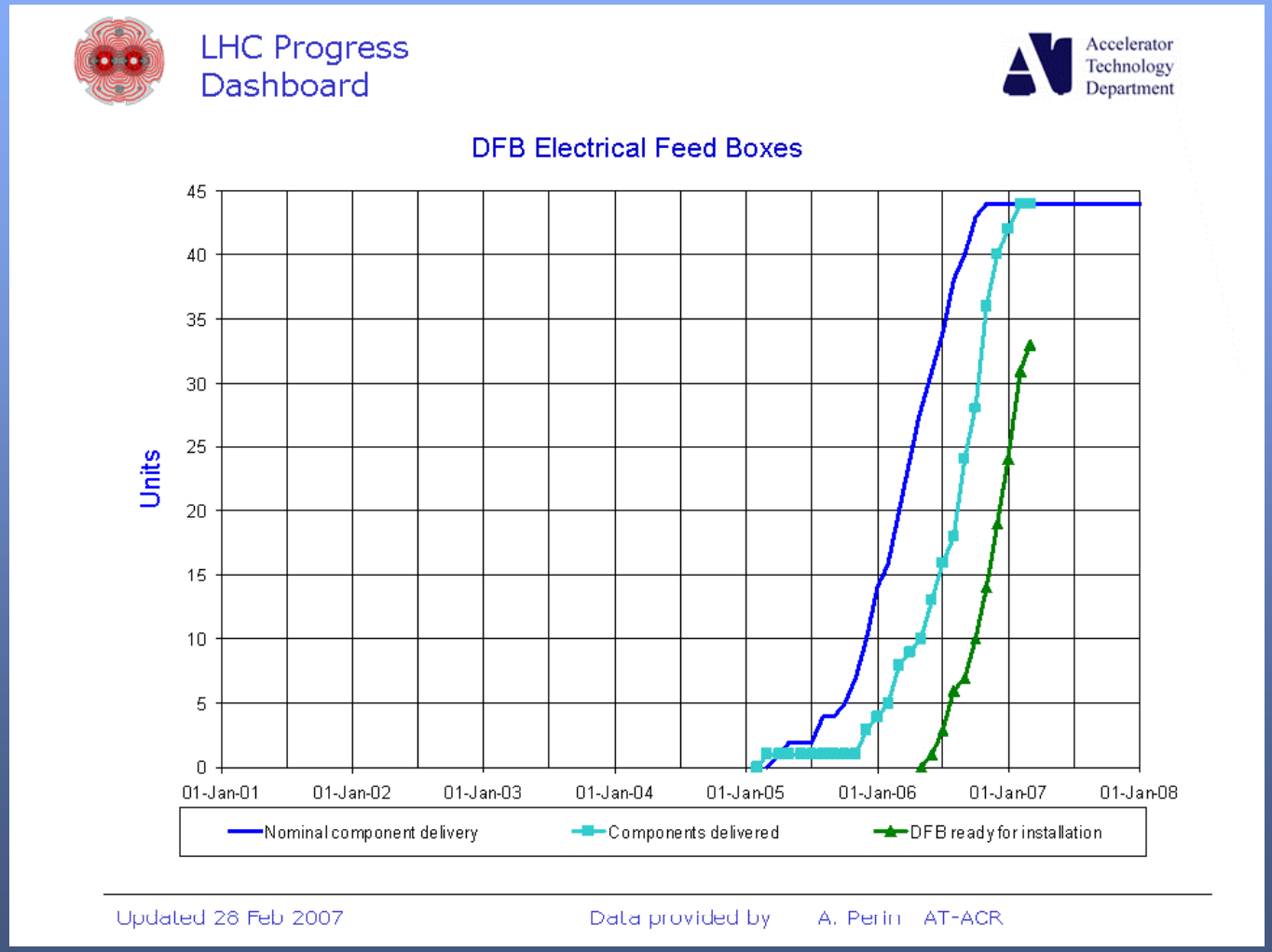
DFB Interconnection

DFBAO in Sector 7-8



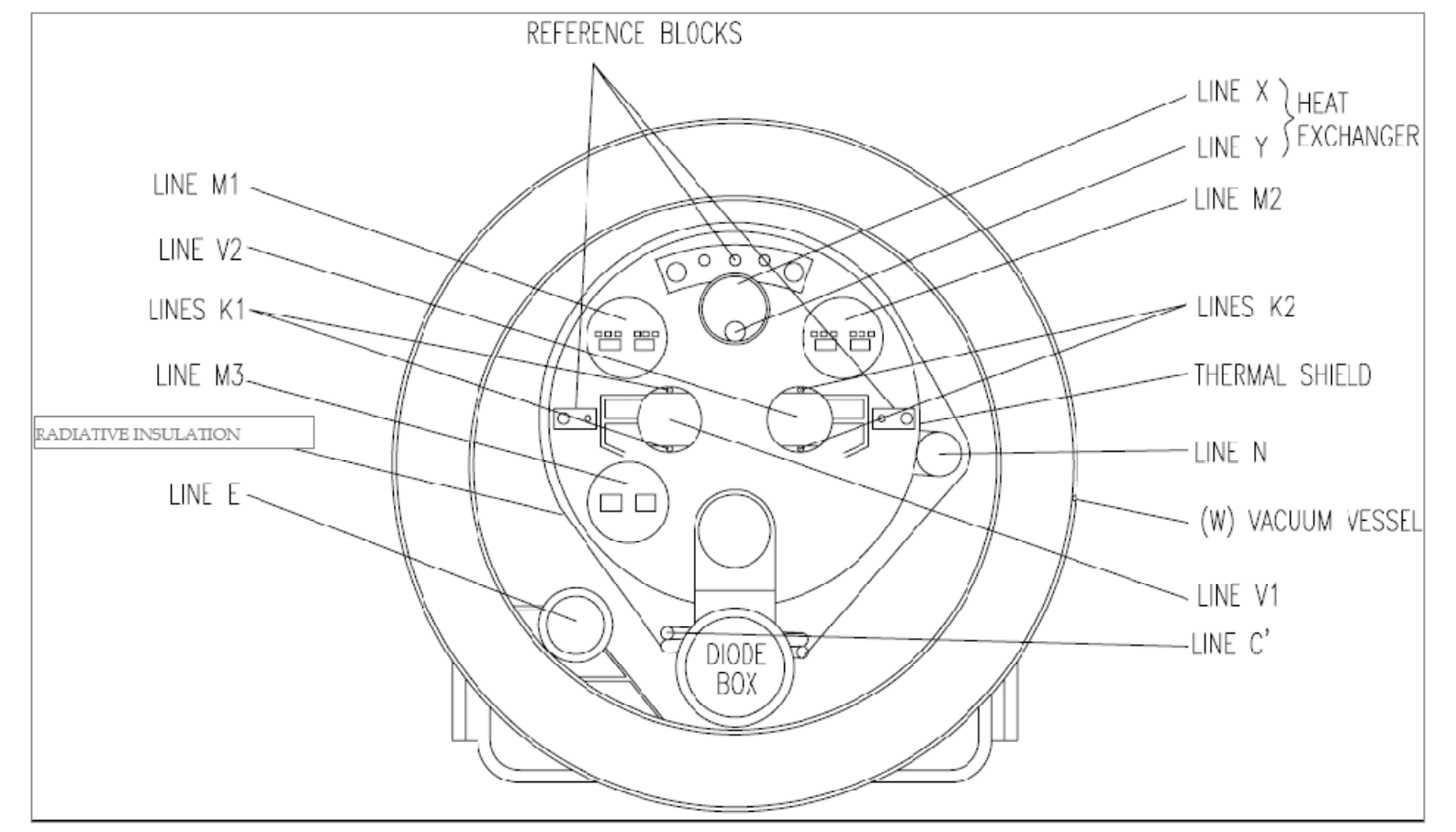
DFBMA in Sector 7-8

DFB Progress

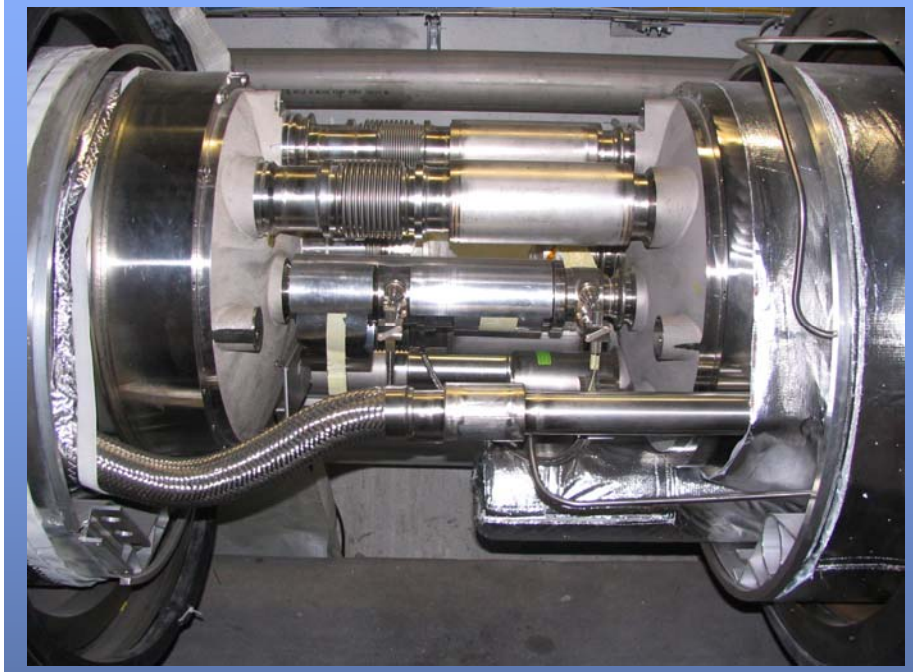


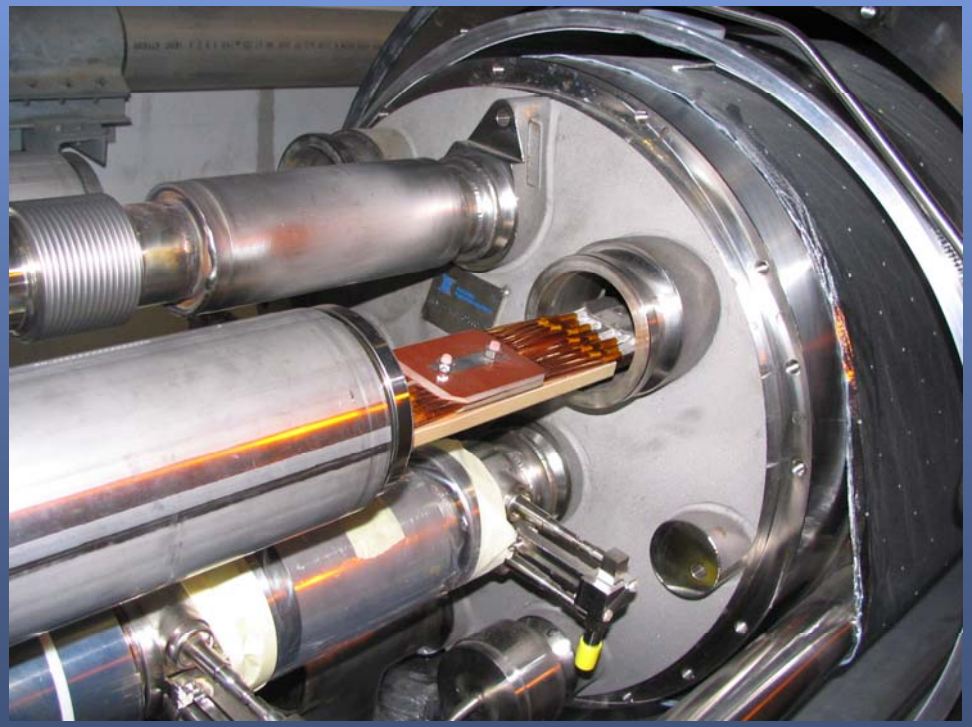
Interconnections

Identification of Lines

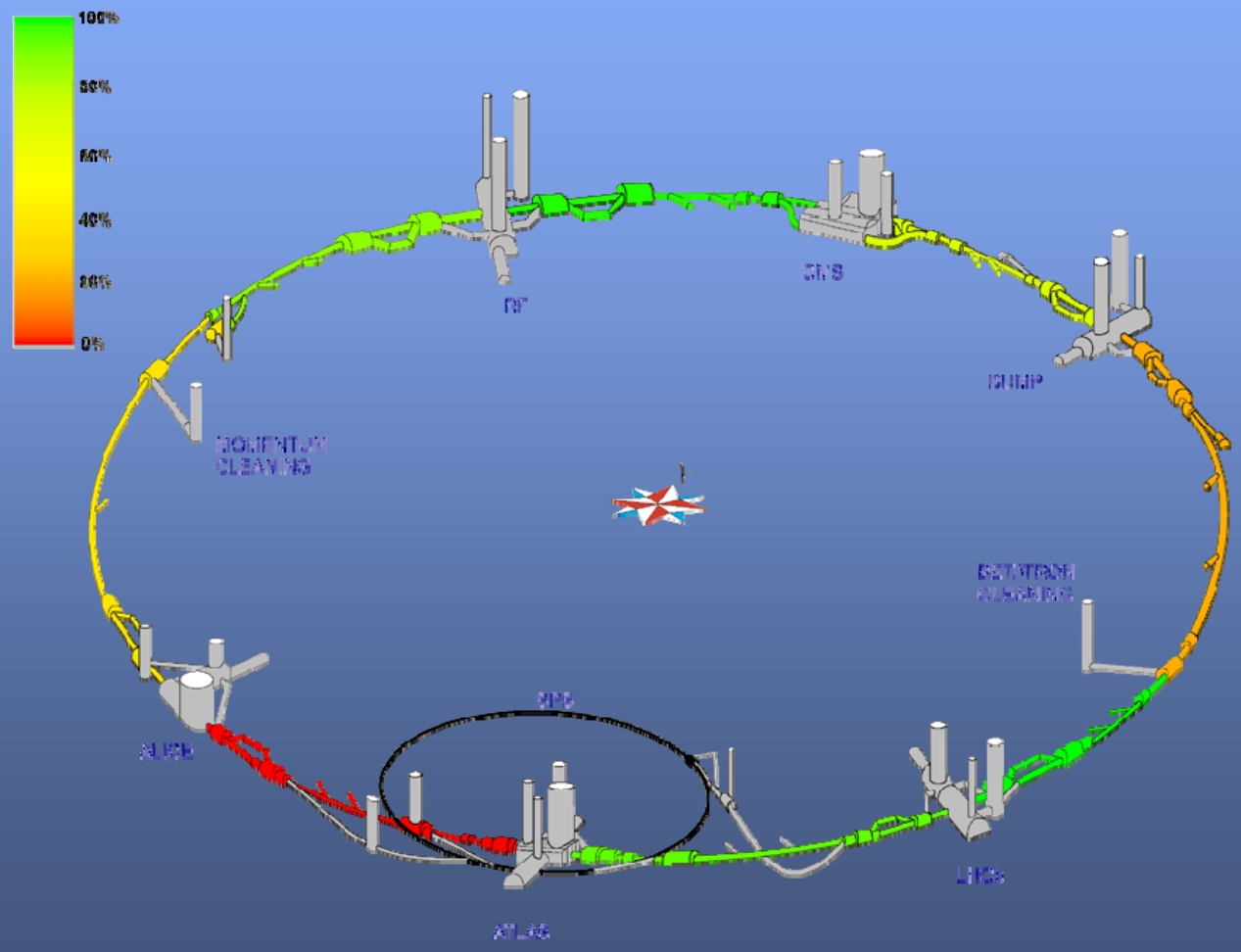


Dipole Interconnections

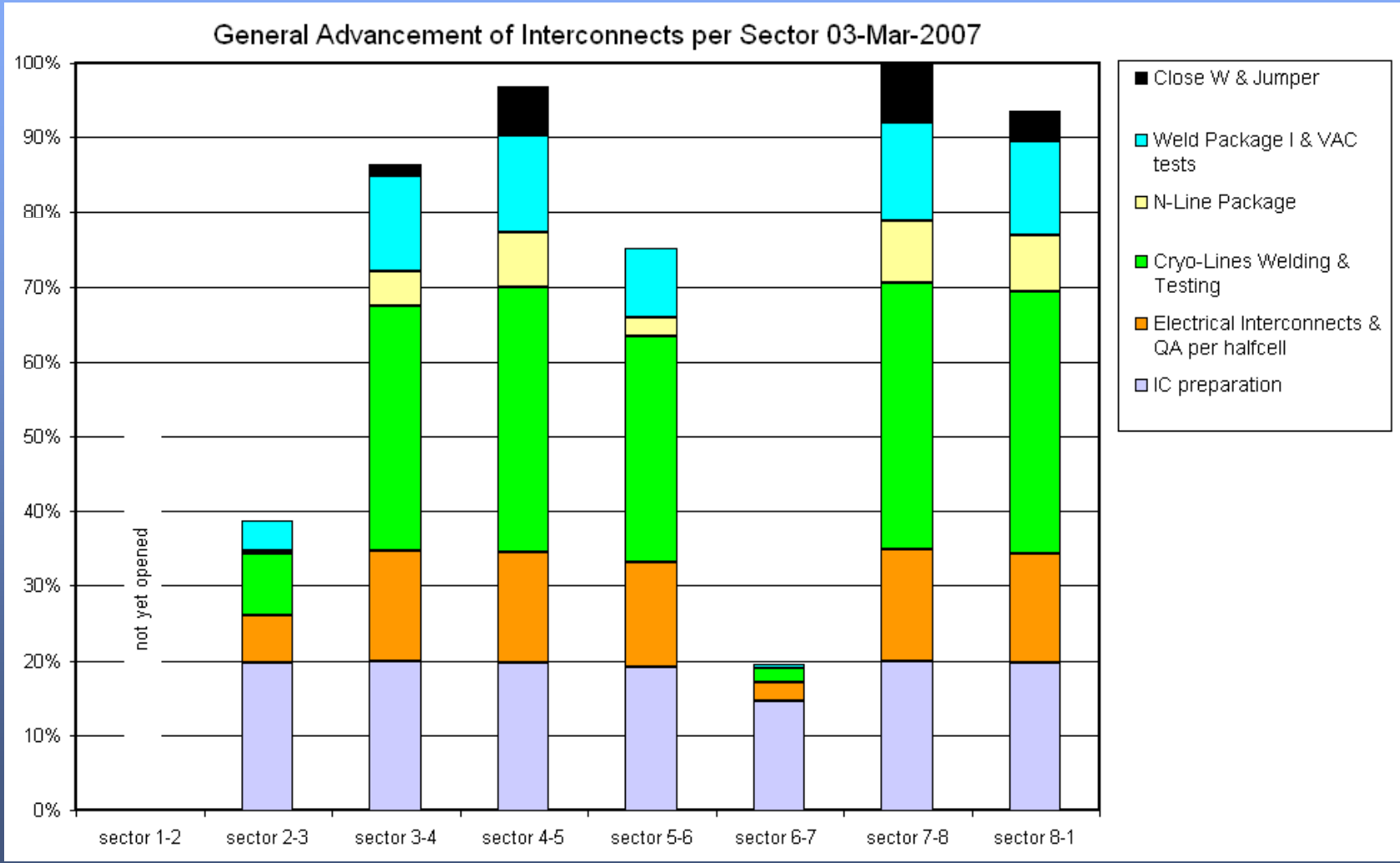




General Progress



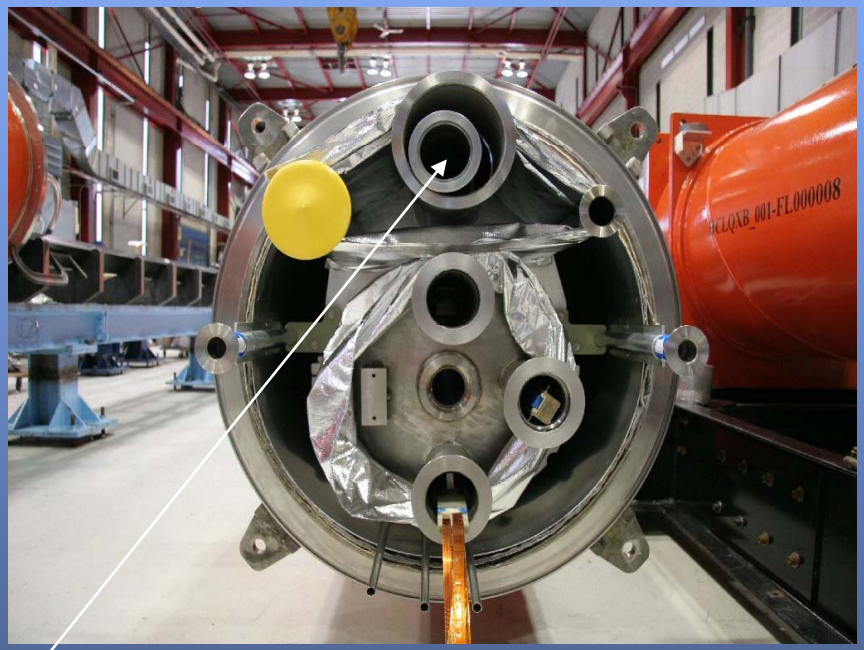
General Progress



Electrical Quality Assurance

Inner Triplets

Cryo-magnet Assembly

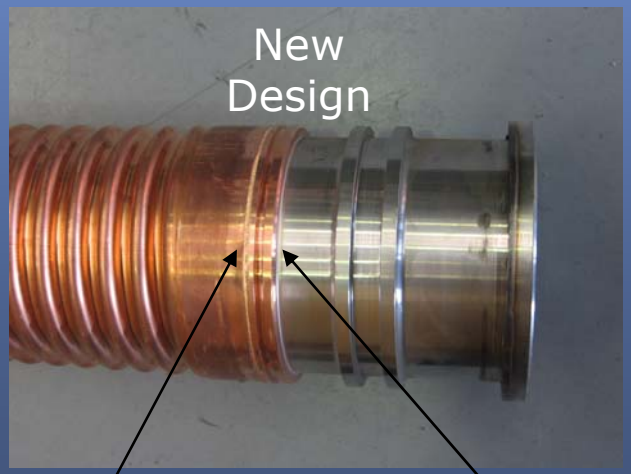


External Heat Exchanger

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

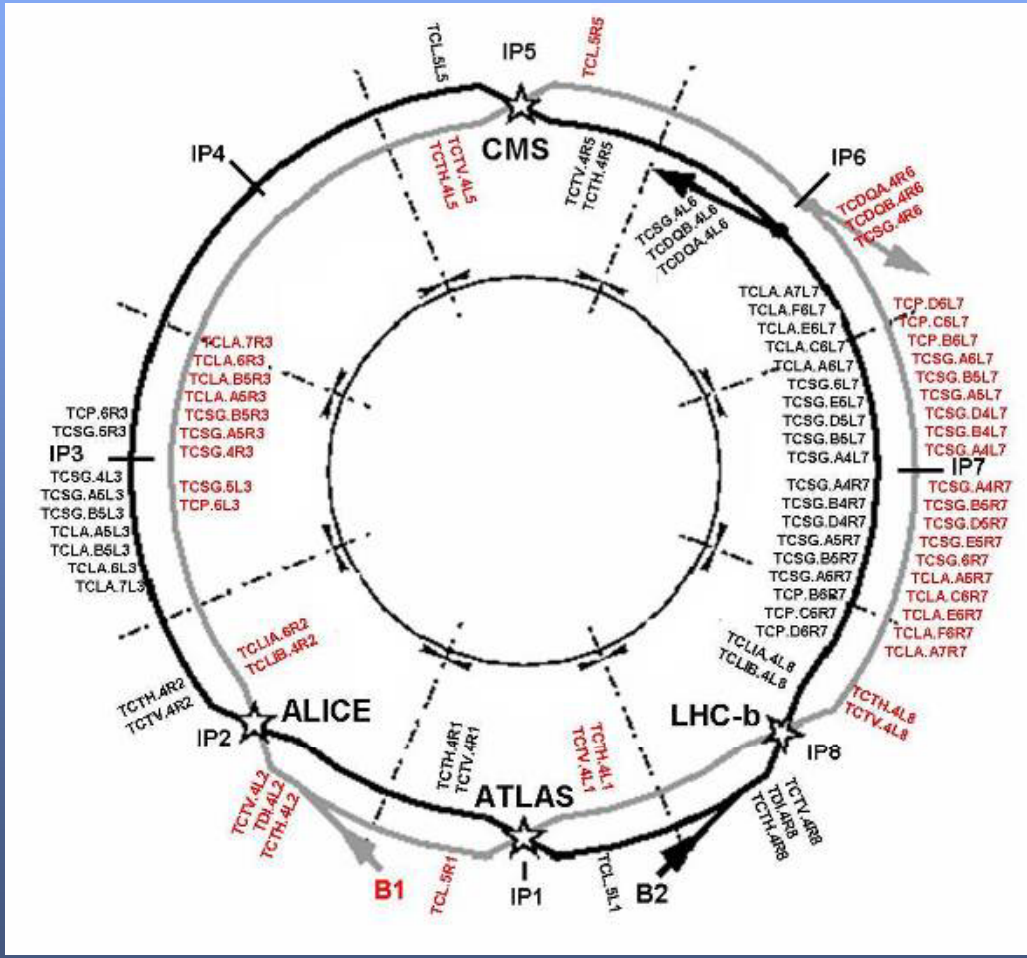


Inner Triplet Repair

- 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

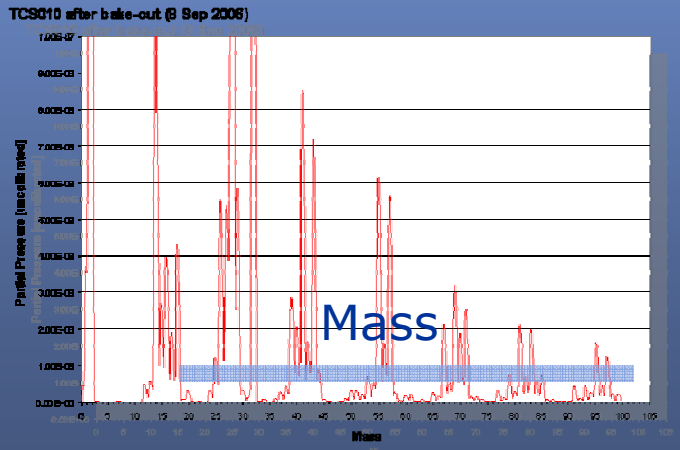
The Lay-out


IP5
CMS
IP4
IP6
IP3
IP7
ALICE
IP2
LHC-b
IP8
ATLAS
IP1
B1
B2
TCL.5L5
TCL.5R5
TCTV.4L5
TCTH.4L5
TCTV.4R5
TCTH.4R5
TCSG.4L6
TCDQB.4L6
TCDQA.4L6
TCDQA.4R6
TCDQB.4R6
TCSG.4R6
TCLA.A7L7
TCLA.F6L7
TCLA.E6L7
TCLA.C6L7
TCLA.A6L7
TCSG.6L7
TCSG.E5L7
TCSG.D5L7
TCSG.B5L7
TCSG.A4L7
TCP.D6L7
TCP.C6L7
TCP.B6L7
TCSG.A6L7
TCSG.B5L7
TCSG.A5L7
TCSG.D4L7
TCSG.B4L7
TCSG.A4L7
TCSG.A4R7
TCSG.B4R7
TCSG.D4R7
TCSG.A5R7
TCSG.B5R7
TCSG.A6R7
TCP.B6R7
TCP.C6R7
TCP.D6R7
TCSG.A4R7
TCSG.B5R7
TCSG.D6R7
TCSG.E5R7
TCSG.6R7
TCLA.A6R7
TCLA.C6R7
TCLA.E6R7
TCLA.F6R7
TCLA.A7R7
TCLA.7R3
TCLA.6R3
TCLA.B5R3
TCLA.A5R3
TCSG.B5R3
TCSG.A5R3
TCSG.4R3
TCSG.5L3
TCP.6L3
TCP.6R3
TCSG.5R3
TCSG.4L3
TCSG.A5L3
TCSG.B5L3
TCLA.A5L3
TCLA.B5L3
TCLA.6L3
TCLA.7L3
TCLIA.6R2
TCLIB.4R2
TCTH.4R2
TCTV.4R2
TCLIA.4L8
TCLIB.4L8
TCTH.4L8
TCTV.4L8
TCTV.4L2
TDI.4L2
TCTH.4L2
TCTH.4R1
TCTV.4R1
TCTH.4L1
TCTV.4L1
TCTV.4R8
TDI.4R8
TCTH.4R8
TCL.5R1
TCL.5L1

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

Plan

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!

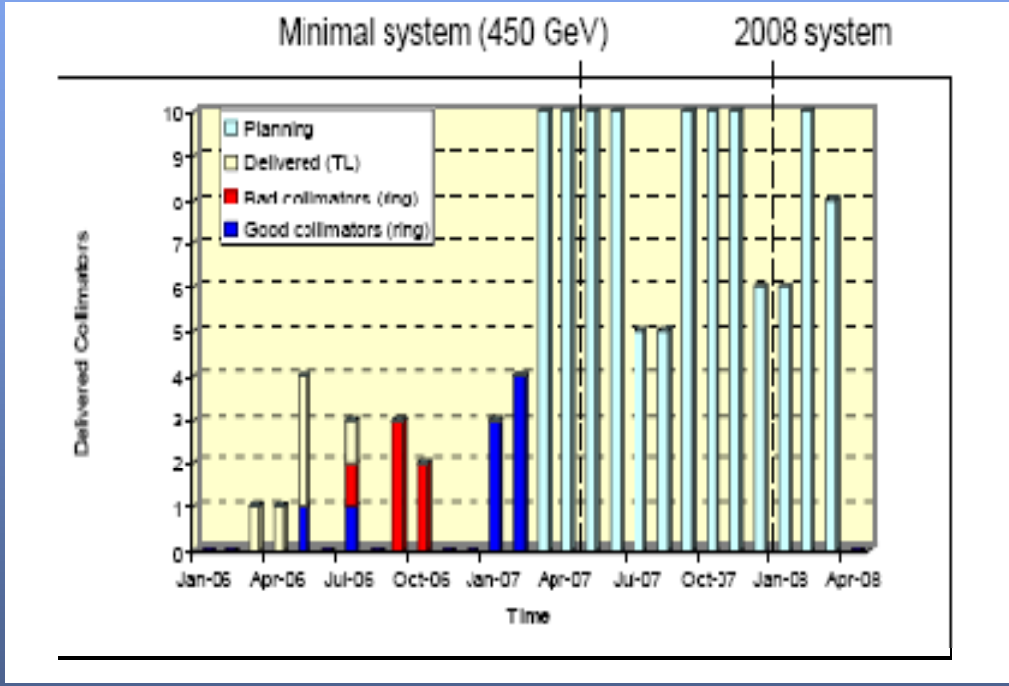
Intensity	Primary collimation (TCP) and scraper (TCHS)	Secondary collimation (TCS)	Absorbers for collimation debris (TCLA)	IR (exp) collimators (TCT, TCLP, TCLI)	Dump protection (TCDQ +TCS)	Total number (two beams)
$< 5 \times 10^{11}$	0	0	0	0	0	0
$< 1 \times 10^{13}$	8	0	0	0	2	10
$< 3 \times 10^{13}$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

2007 run goals

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

Production Progress

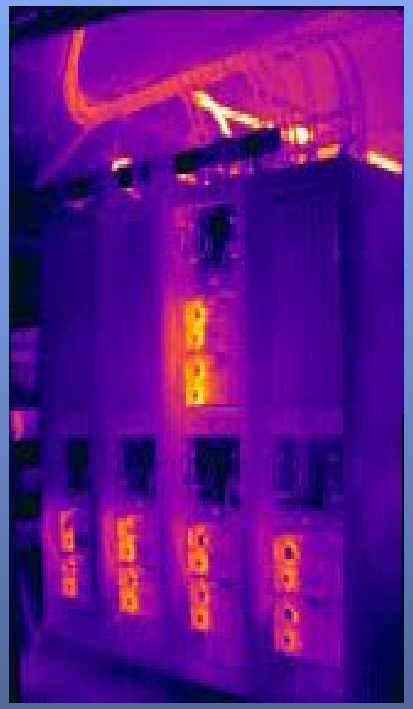
- Minimal system of 28 collimators to be delivered by beginning May 2007
  - Installation during LSS campaign up to July 2007
- The 58 additional collimators needed for 10^{33} cm^{-2} s^{-1} to be delivered by end 2007
  - Installation during 2007/2008 shutdown



Power Converters

Installation and Tests

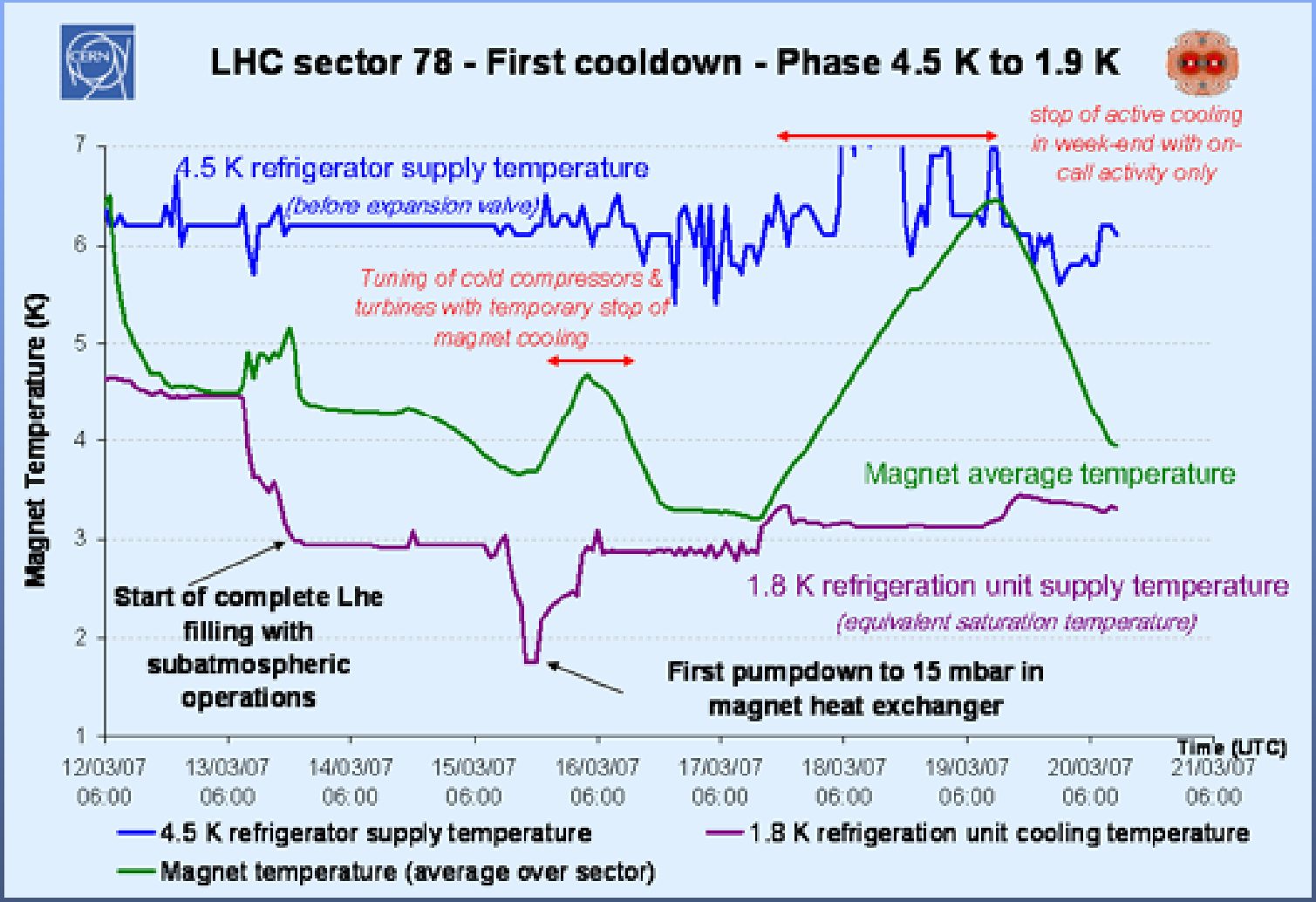
- All main magnet power converters installed (968 units).
  - Short-circuit tests approaching completion.
- Installation of orbit corrector power converters well underway.



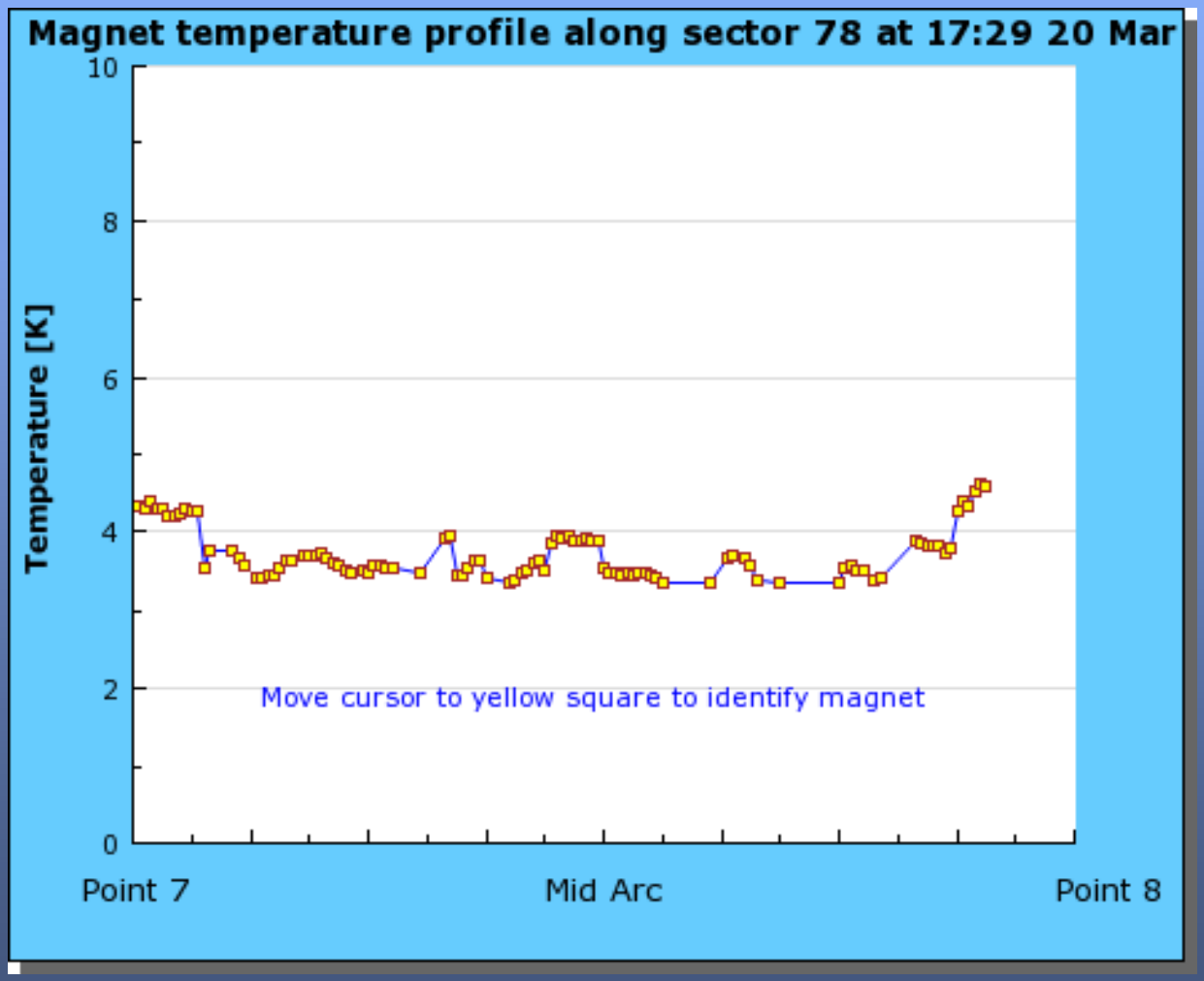
Infrared Tests

Cool-down of Sector 7-8

Progress


LHC sector 78 - First cooldown - Phase 4.5 K to 1.9 K
stop of active cooling in week-end with on-call activity only
4.5 K refrigerator supply temperature
(before expansion valve)
Tuning of cold compressors & turbines with temporary stop of magnet cooling
Magnet average temperature
1.8 K refrigeration unit supply temperature
(equivalent saturation temperature)
Start of complete Lhe filling with subatmospheric operations
First pumpdown to 15 mbar in magnet heat exchanger
Magnet Temperature (K)
7
6
5
4
3
2
1
12/03/07 06:00
13/03/07 06:00
14/03/07 06:00
15/03/07 06:00
16/03/07 06:00
17/03/07 06:00
18/03/07 06:00
19/03/07 06:00
20/03/07 06:00
21/03/07 06:00
Time (UTC)
4.5 K refrigerator supply temperature
1.8 K refrigeration unit cooling temperature
Magnet temperature (average over sector)

Magnet Temperature Profile



Activities in Progress

Ongoing Hardware Commissioning Activities in SECTOR 78

REGION	ACTIVITY TYPE	ACTIVITY
SECTOR 78		
	Cooldown to 4.5K, 1.9K	Cooldown continues, some magnets below 4K
	Preparation for Powering	Calibration of 60A converters
		600A PIC1 (interlock tests with magnets not connected to the power converters) - now P8 side
	Other	TS-EL installs and tests AC network control equipment in the alcoves.

Future Hardware Commissioning Activities in SECTOR 78

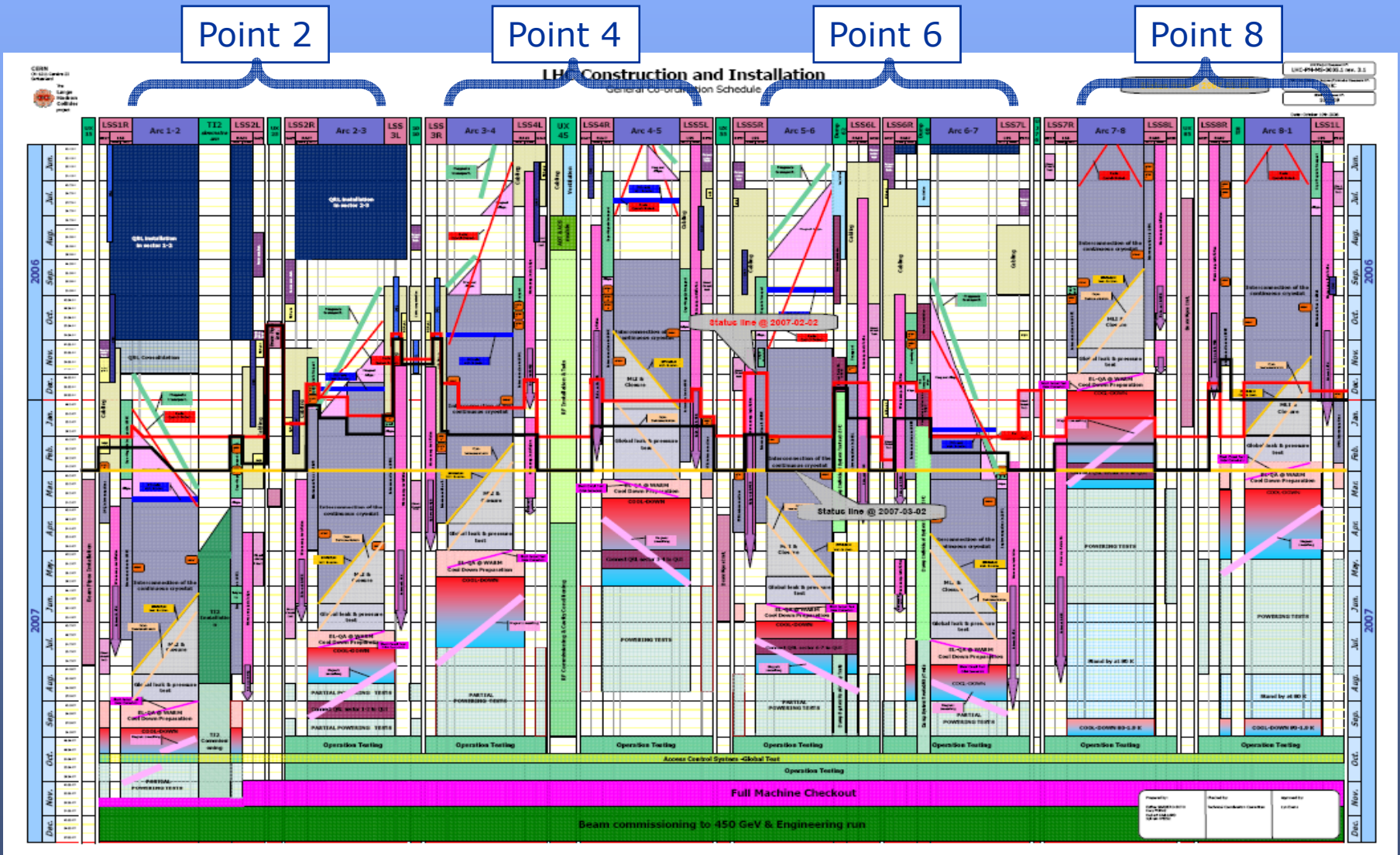
REGION	ACTIVITY TYPE	ACTIVITY
SECTOR 78		
	ElQA at Cold	to start after CRYO OK

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

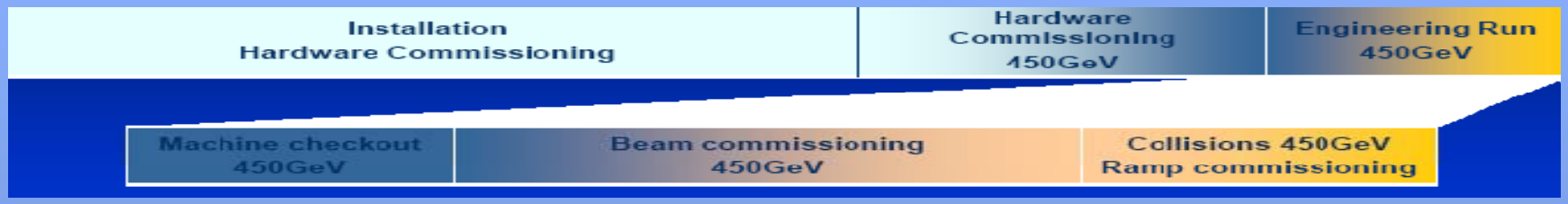
LHC Construction and Installation Schedule

LHC Master Schedule



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.

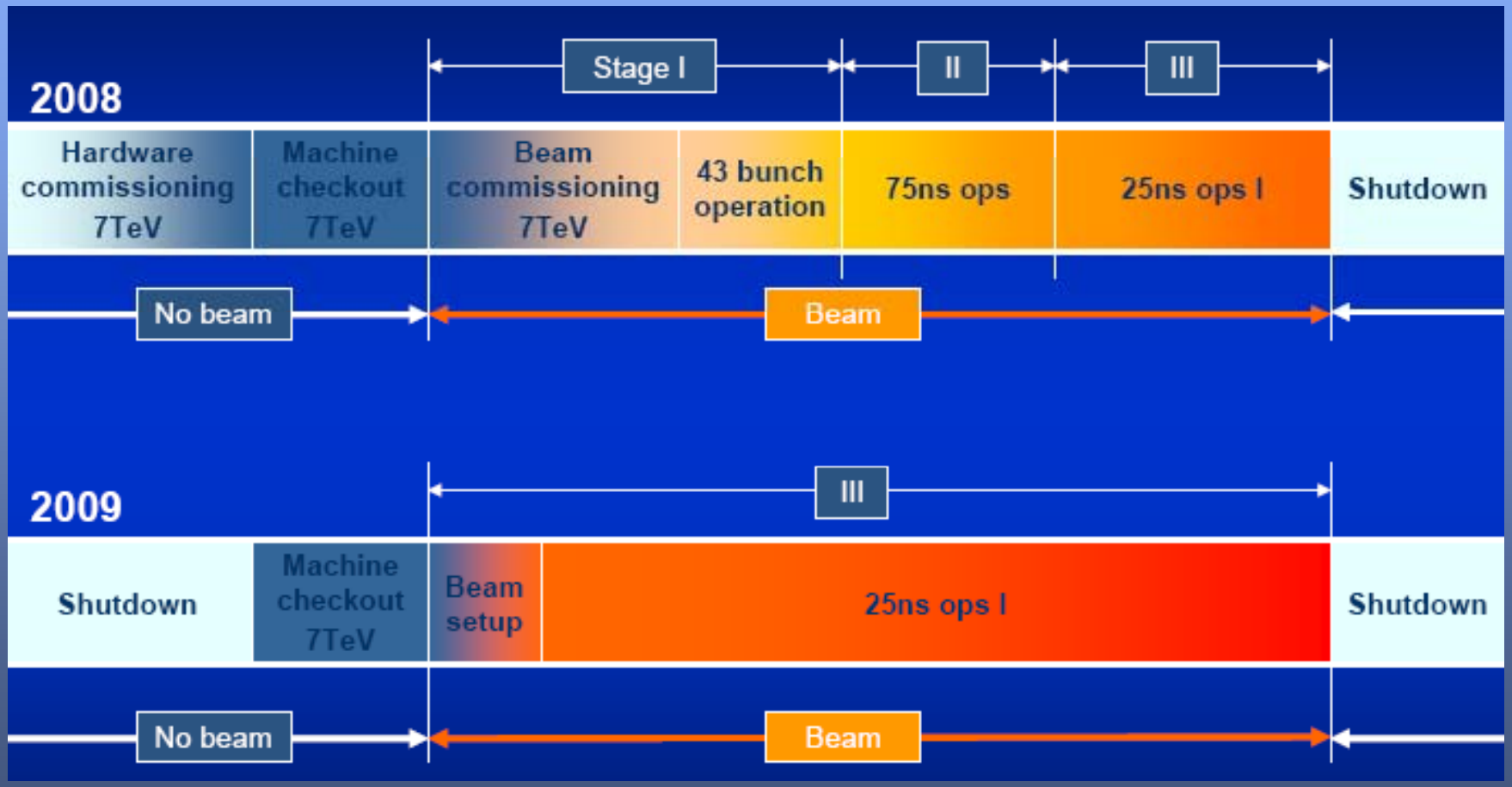
- Optics:
  - β*= 11 m in IR 1 & 5
  - β*= 10 m in IR 2 & 8
  - Limited by triplet aperture
- Crossing angles off
  - 1, 12, 43, 156 bunches per beam
- Separation bumps - two beam operation
- Shift bunches for LHCb
  - 4 out of 43 bunches, or 24 bunches out of 156
- Solenoids & Experimental Dipoles etc.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

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

Beyond 2007


2008
Stage I
II
III
Hardware commissioning 7TeV
Machine checkout 7TeV
Beam commissioning 7TeV
43 bunch operation
75ns ops
25ns ops I
Shutdown
No beam
Beam
2009
III
Shutdown
Machine checkout 7TeV
Beam setup
25ns ops I
Shutdown
No beam
Beam

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.

Last magnet delivered	**November 2006**
Last magnet tested	**January 2007**
Last magnet installed	**March 2007**
Machine ring closed	August 2007
First collisions at 450 GeV	November 2007
First collisions at 7 TeV	June 2008