



# Status of the LHC

Lyn Evans

**SUSY'07**

Karlsruhe, 27 July 2007

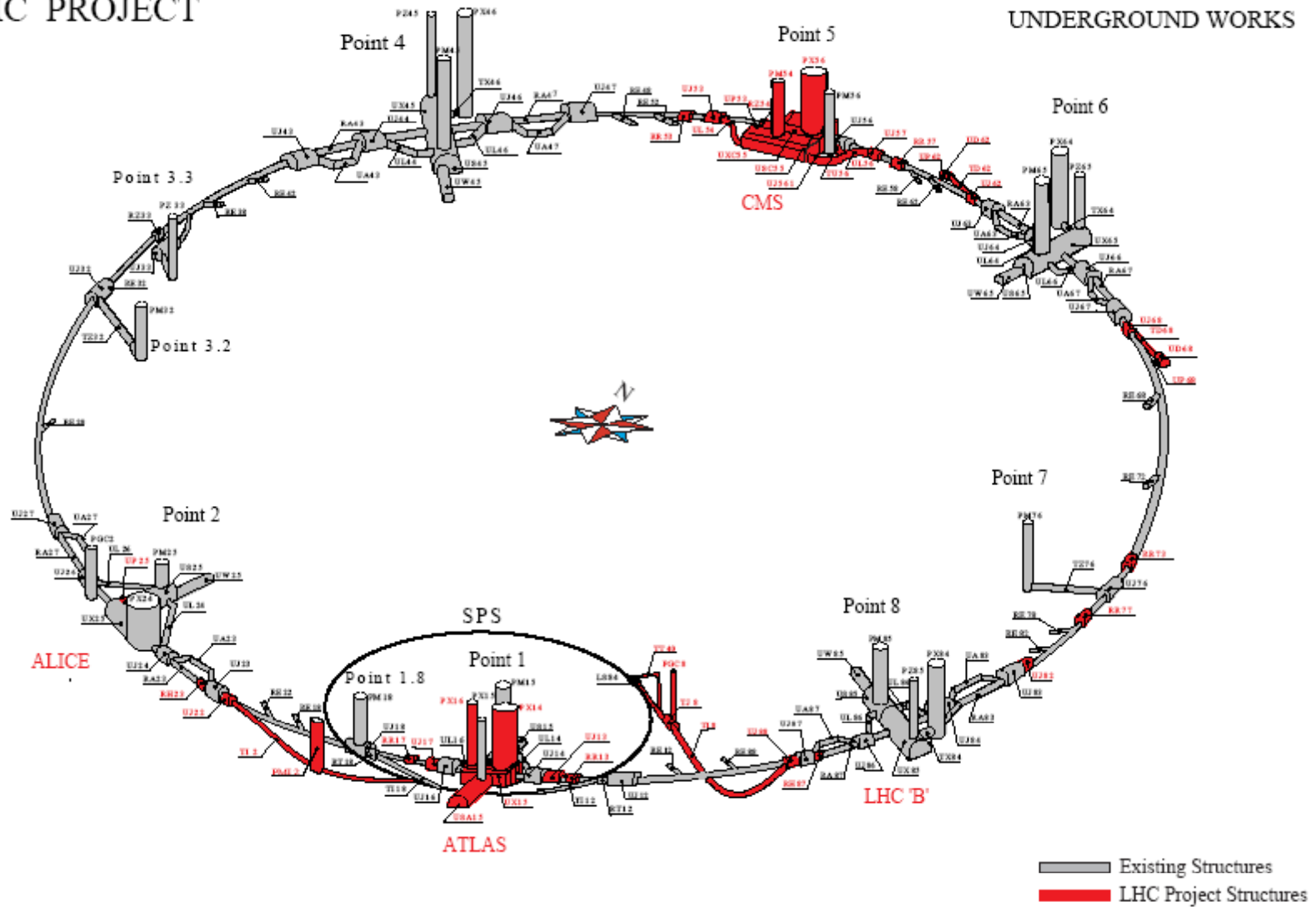


# Machine layout



LHC PROJECT

UNDERGROUND WORKS



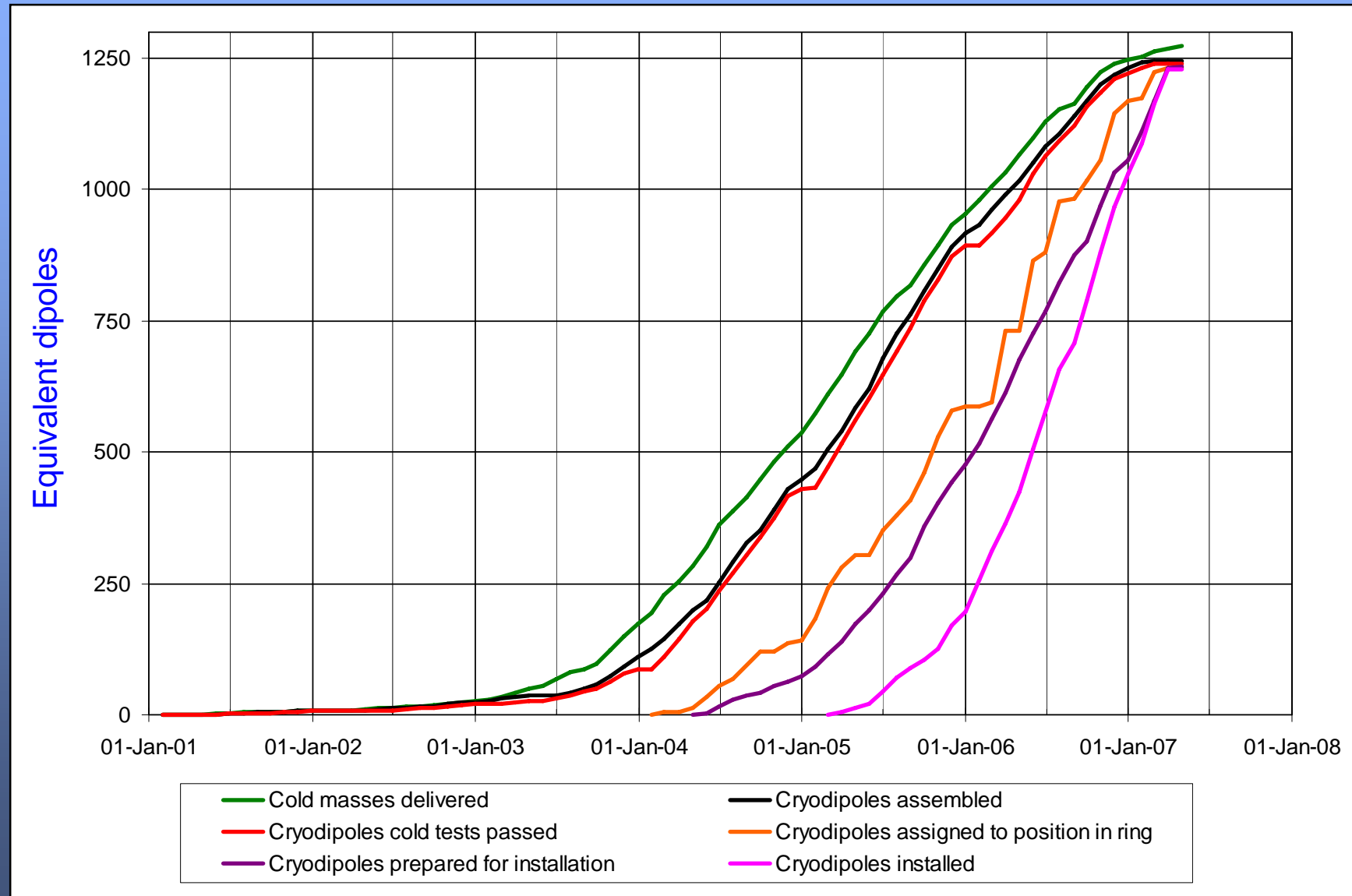
ST-CE/JLB-hlm  
18/04/2003

# List of superconducting magnets and their function

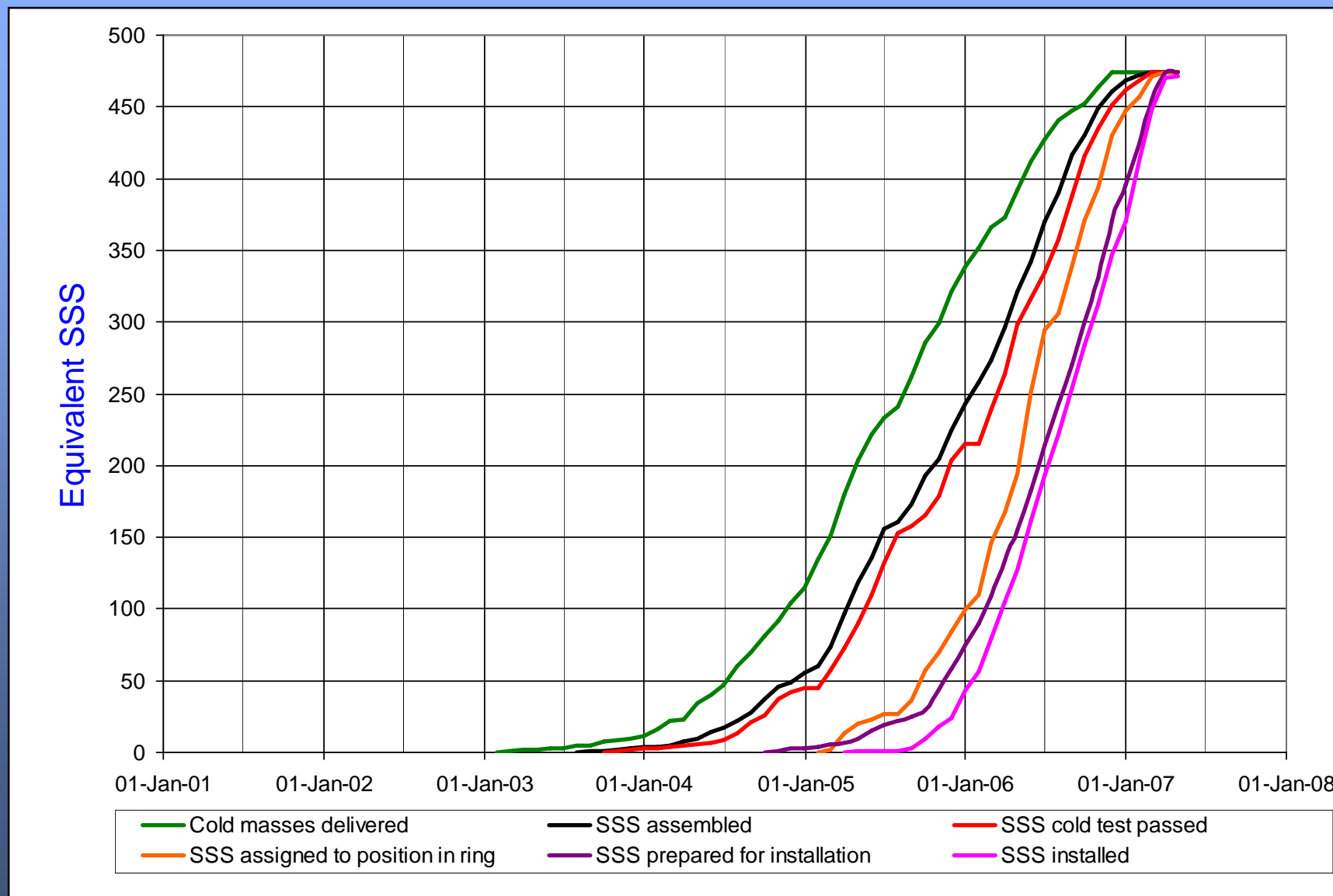


Type	Number	Function
MB	1232	Main dipoles
MQ	392	Arc quadrupoles
MBX/MBR	16	Separation and recombination dipoles
MSCB	376	Combined chromaticity and closed orbit correctors
MCS	2464	Sextupole correctors for persistent currents at injection
MCDO	1232	Octupole/decapole correctors for persistent currents at injection
MO	336	Landau damping octupoles
MQT/MQTL	248	Tuning quadrupoles
MCB	190	Orbit correction dipoles
MQM	86	Dispersion suppressor and matching section quadrupoles
MQY	24	Enlarged-aperture quadrupoles in insertions
MQX	32	Low-beta insertion quadrupoles

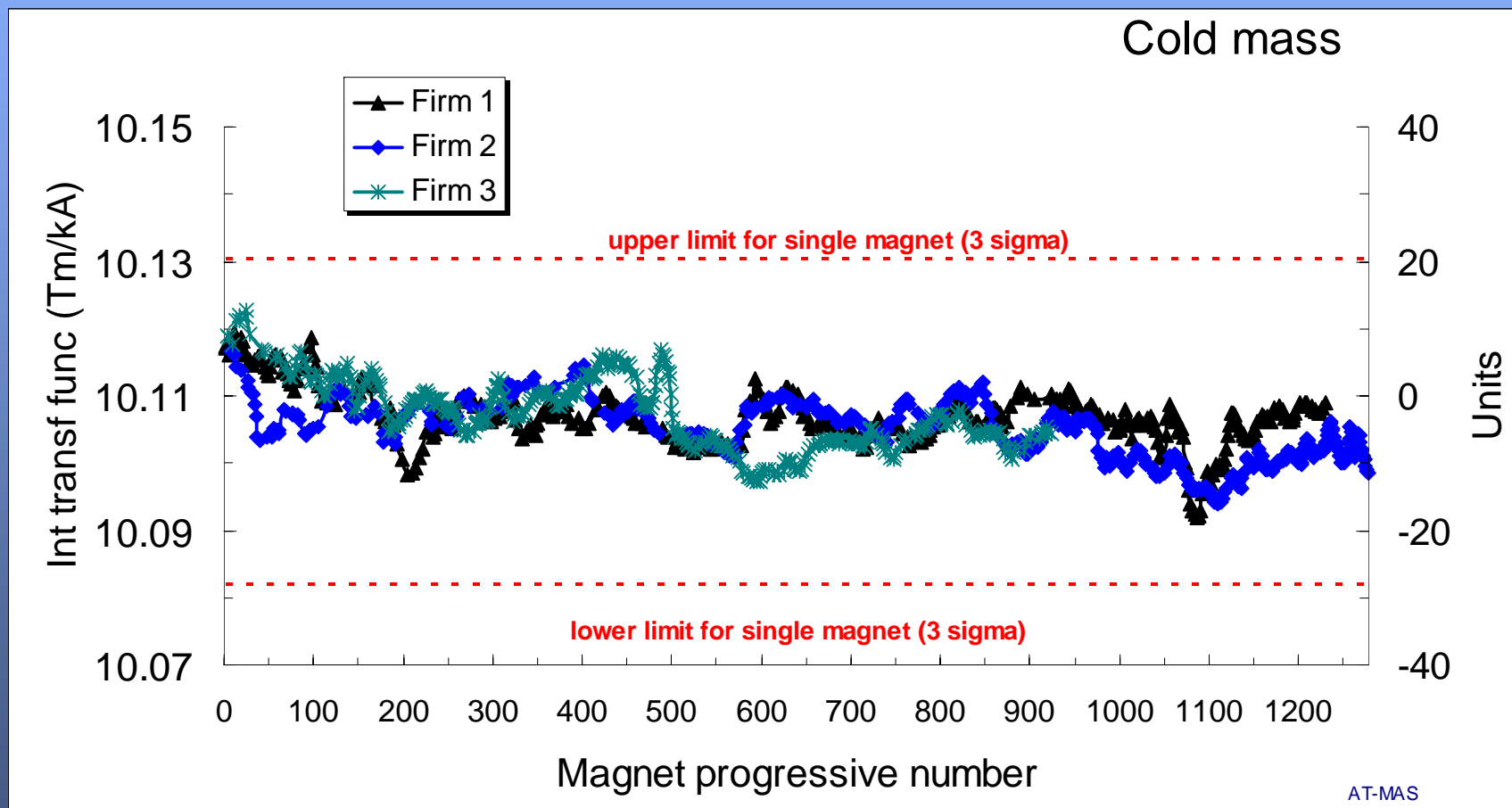
# Cryodipole overview



# Short Straight Section overview

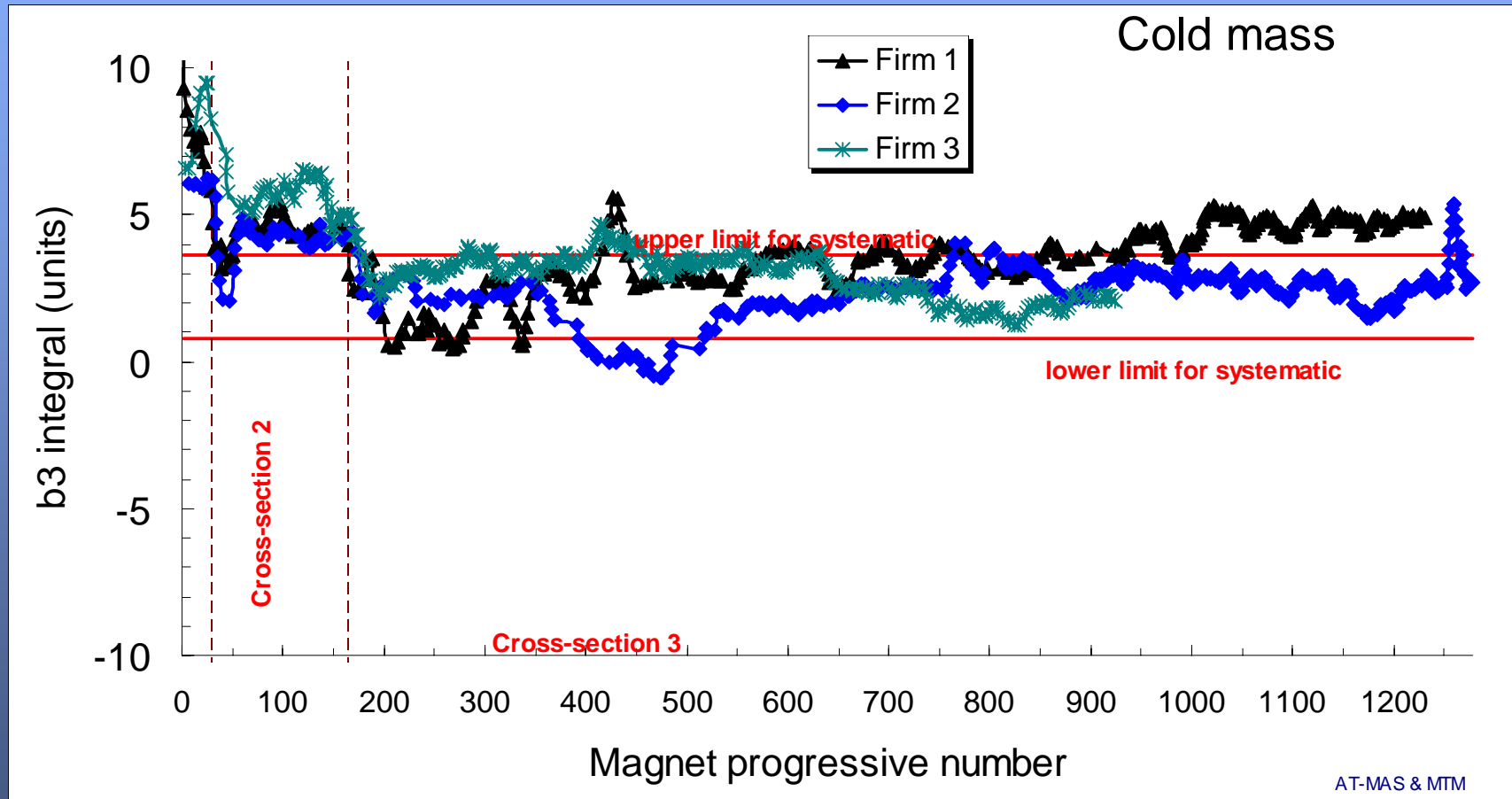


# Bending strength of dipoles

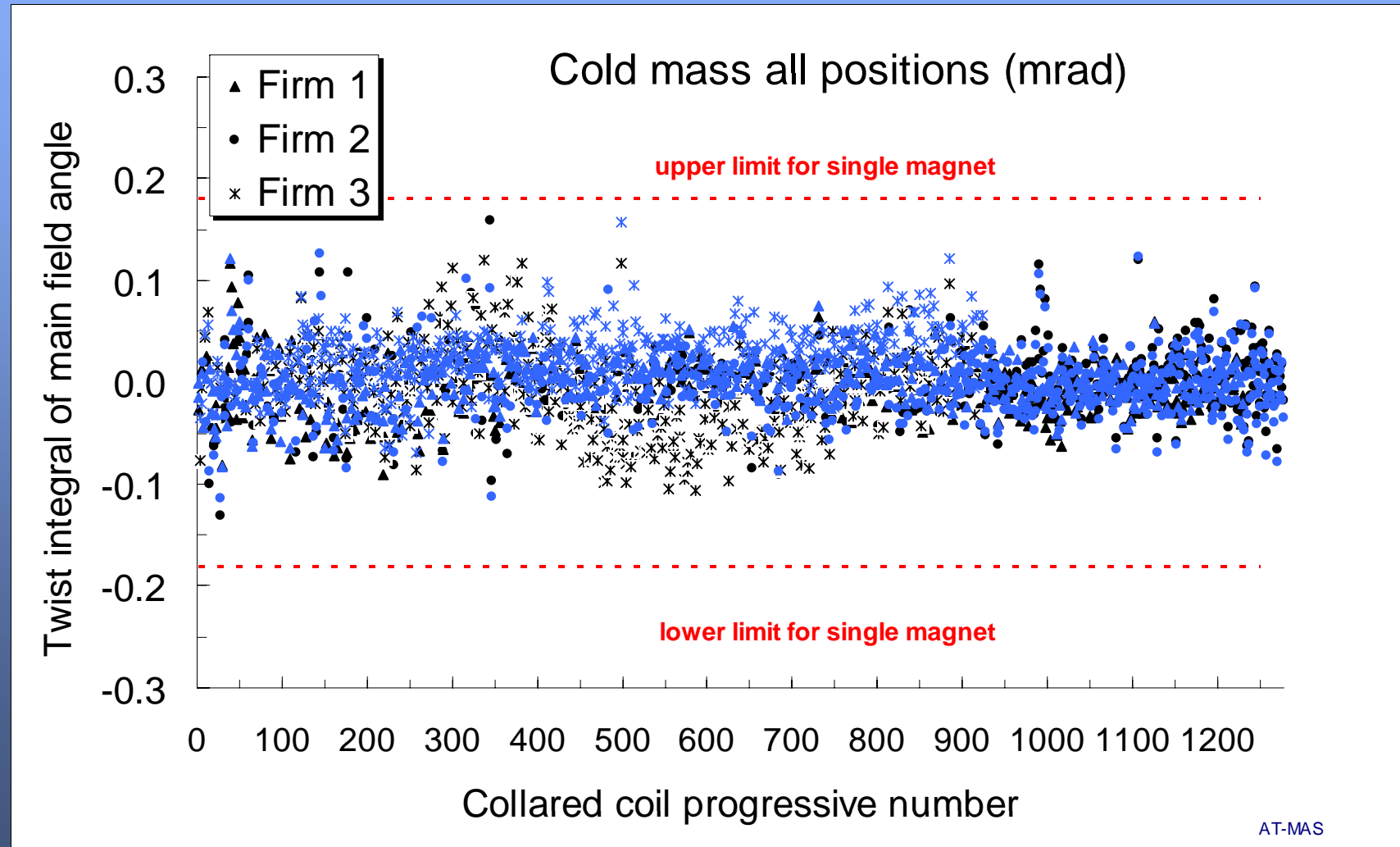




# Field errors in dipole production: b3

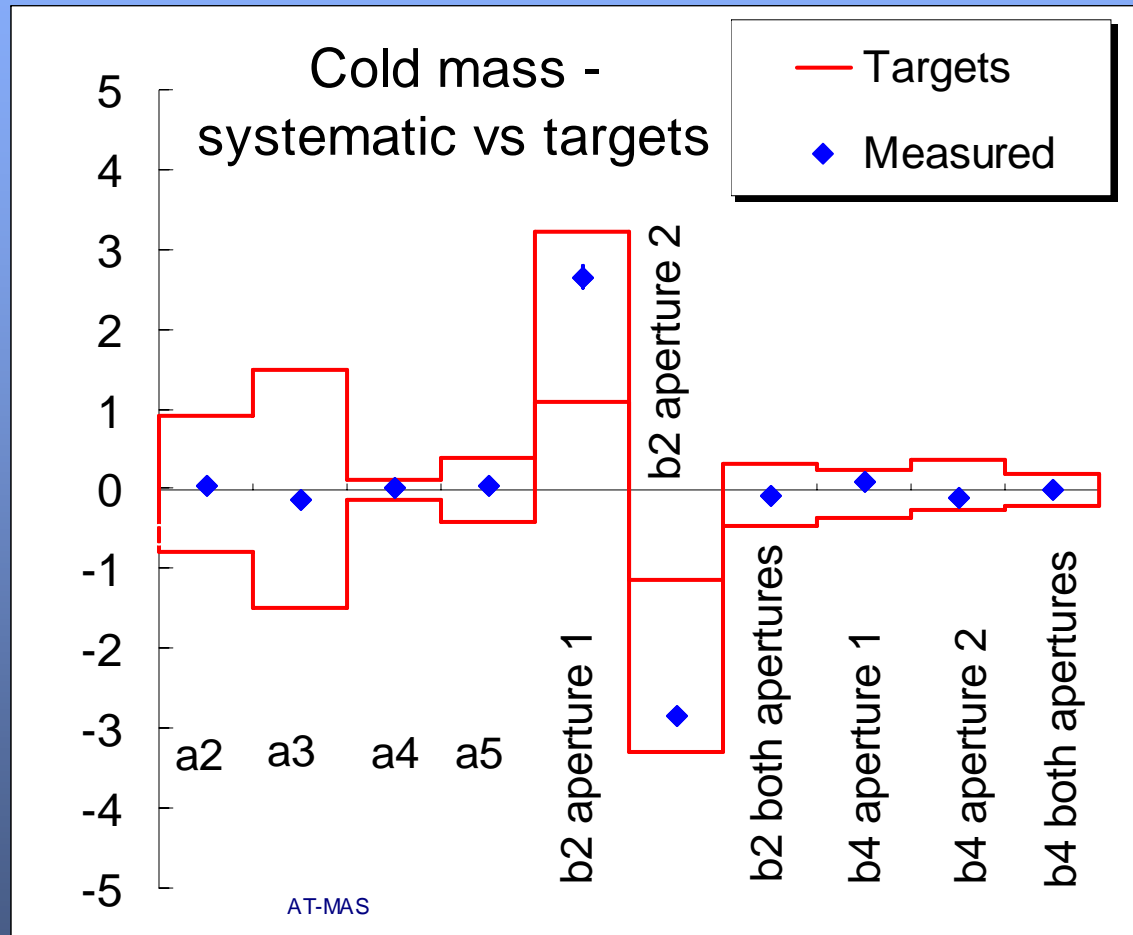
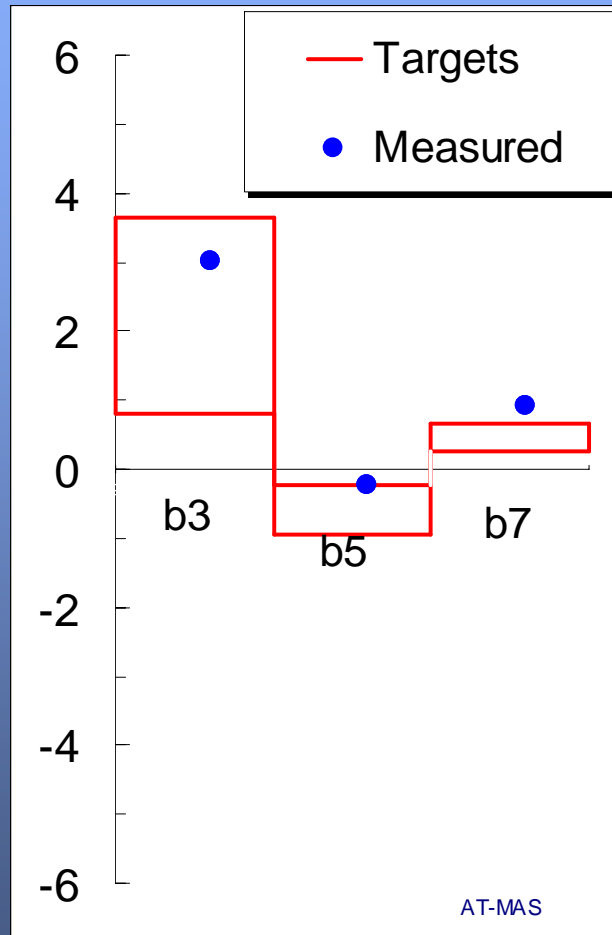


# Field orientation in dipoles

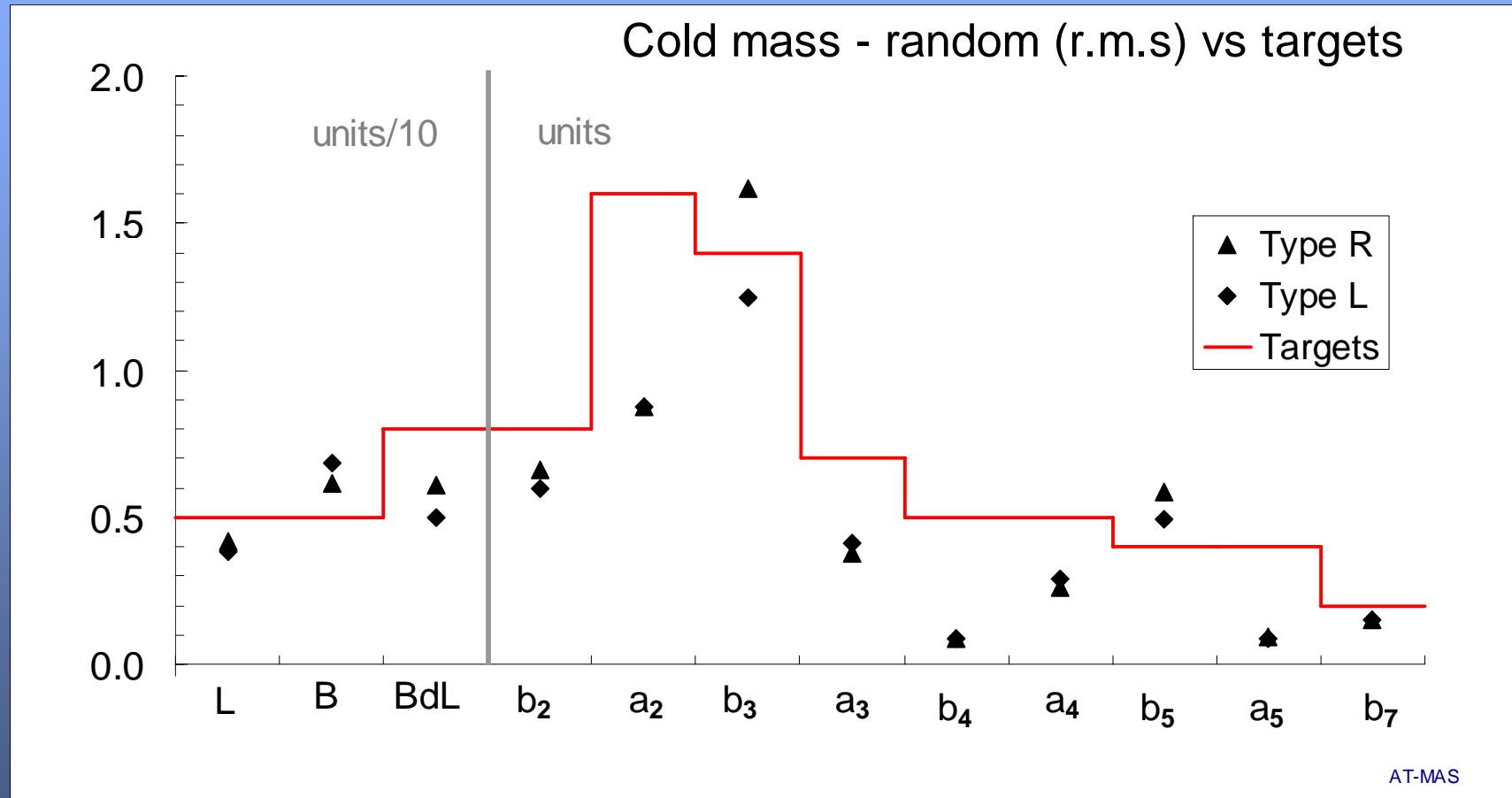




# Systematic field errors in dipoles



# Random field errors in dipoles



# Completion of magnet cryostating & tests, 1 March 2007



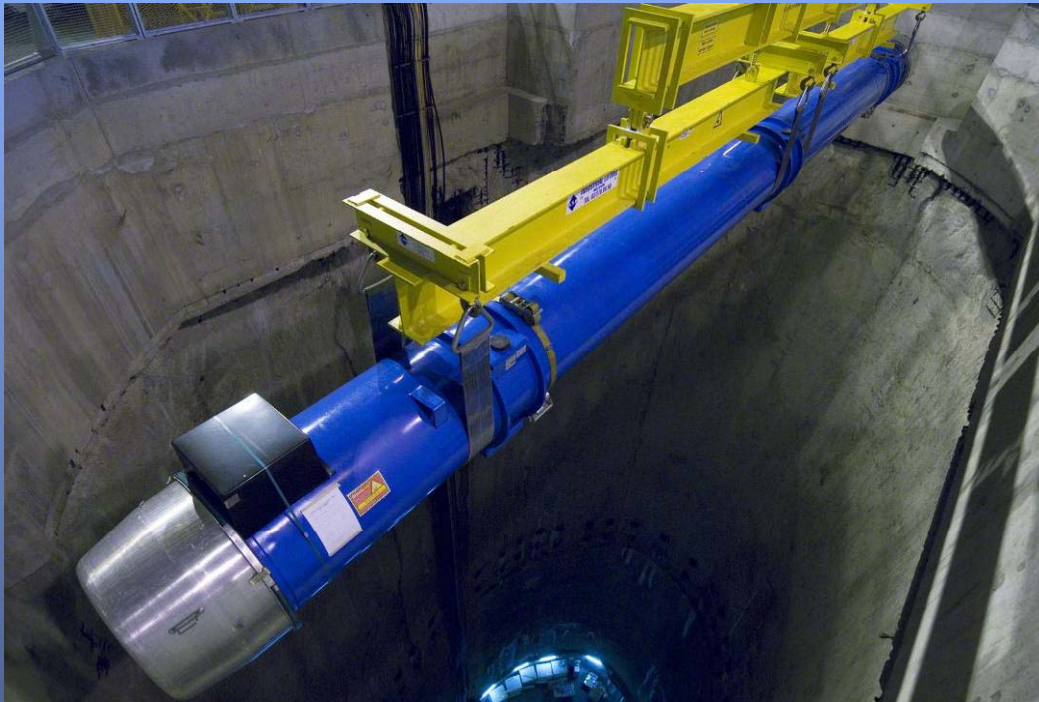
Cryostating 425 FTE.years

Cold tests 640 FTE.years





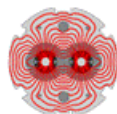
# Descent of the last magnet, 26 April 2007



30'000 km underground at 2 km/h!



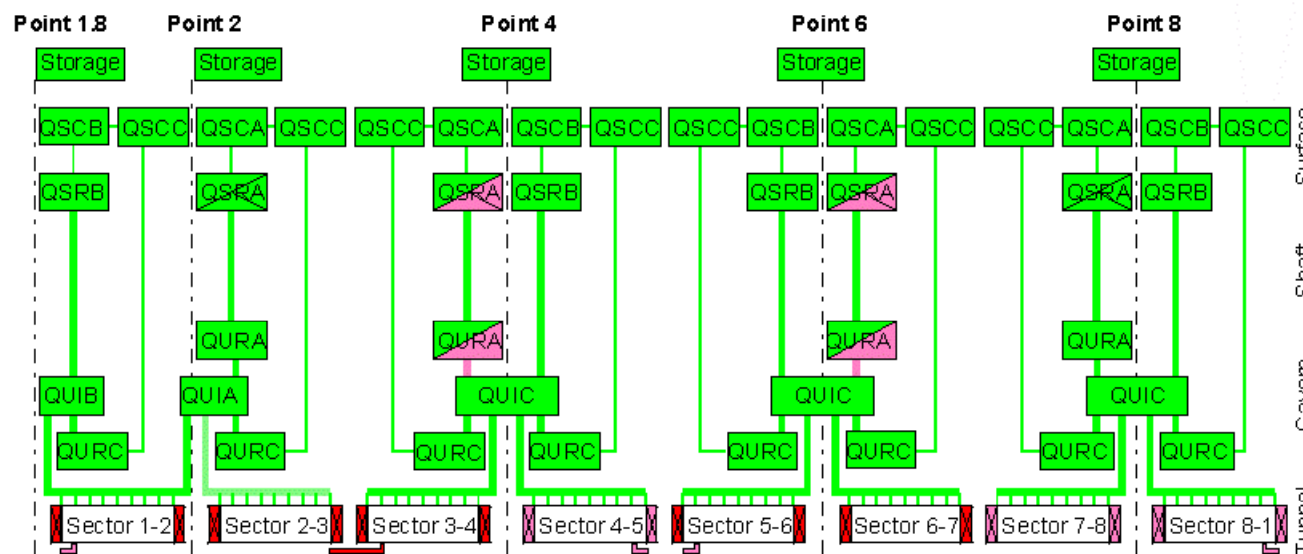
# Cryogenic system overview



LHC Progress Dashboard

Accelerator Technology Department

## Cryogenics overview

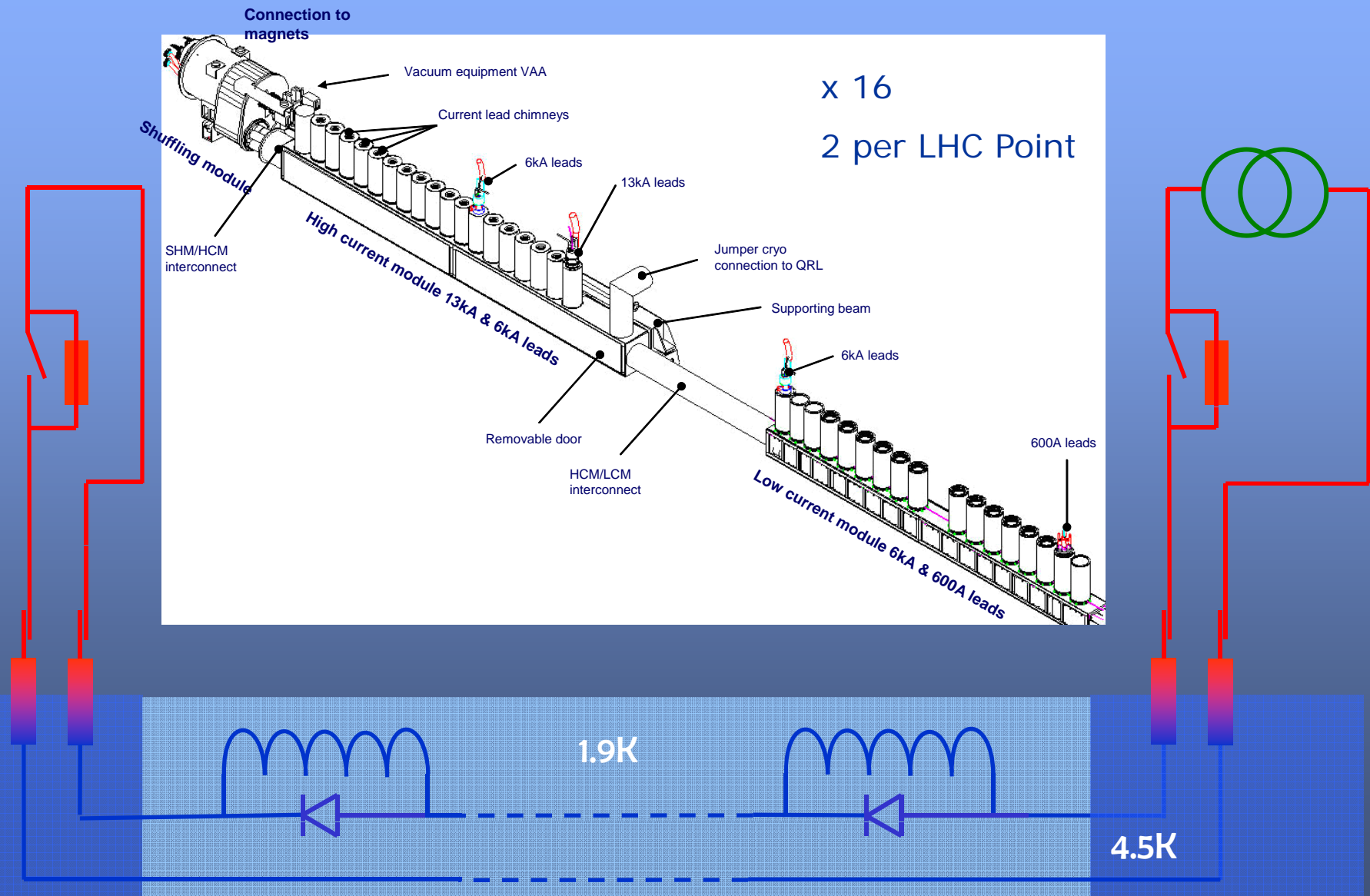


Legend		
Cryogenic Distribution Line	QSC_(A,B,C): Warm Compressor Station	Electrical Feed Box
Under commissioning	QSR_(A,B): Surface 4.5 K Refrigerator Cold Box	Delivered / Under installation
Under fabrication	QURA: Underground 4.5 K Refrigerator Cold Box	Ordered (Contract placed)
Under definition	QURC: 1.8 K Refrigeration Unit Cold Box	Under definition
Delivered / Under installation	QUI_(A,B,C): Cryogenic Interconnection Box	
Commissioned & accepted		

Updated 30 June 2007

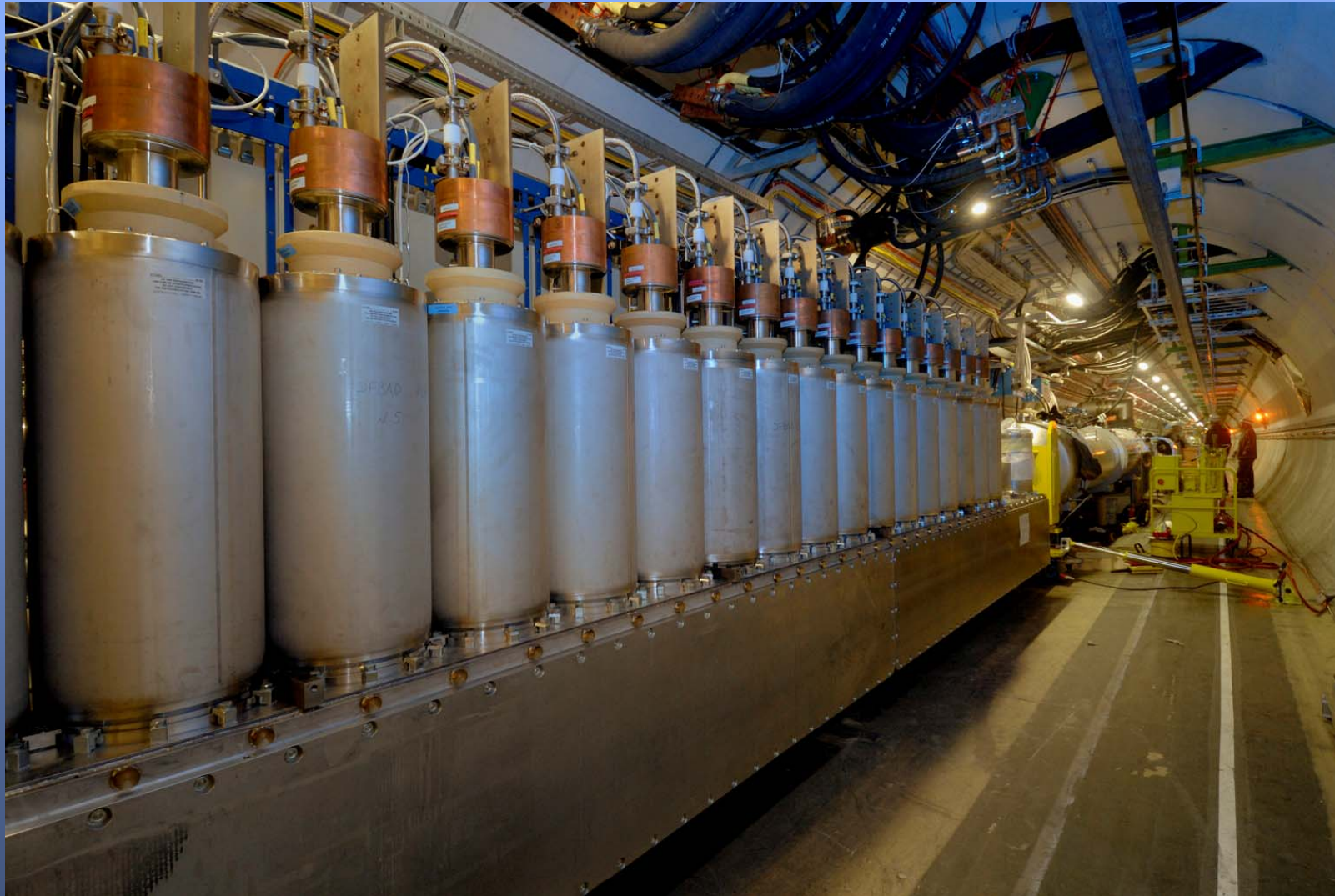
Data provided by L. Taviani AT-ACR

# DFBA Electrical Feed Box



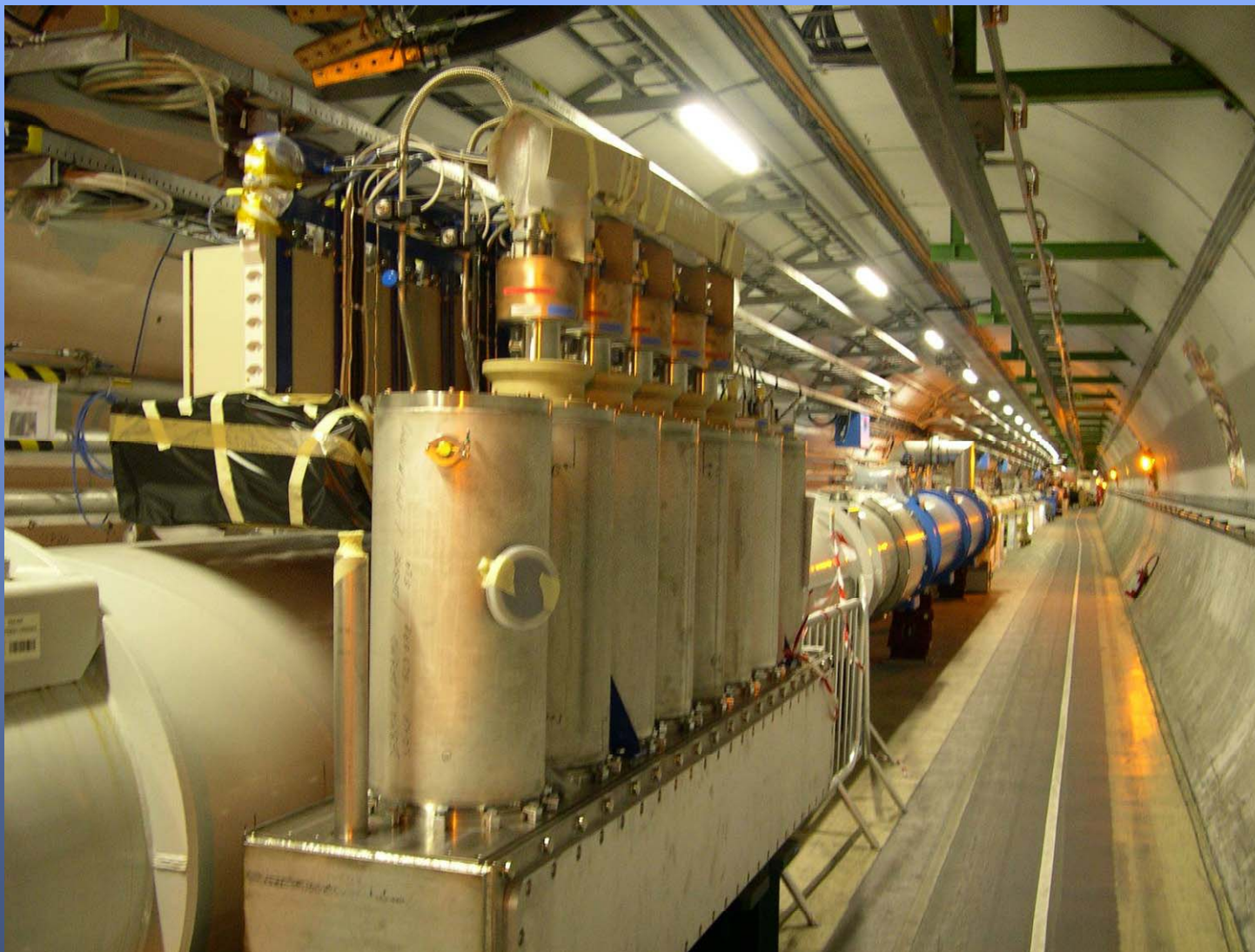


## DFBAO in Sector 7-8

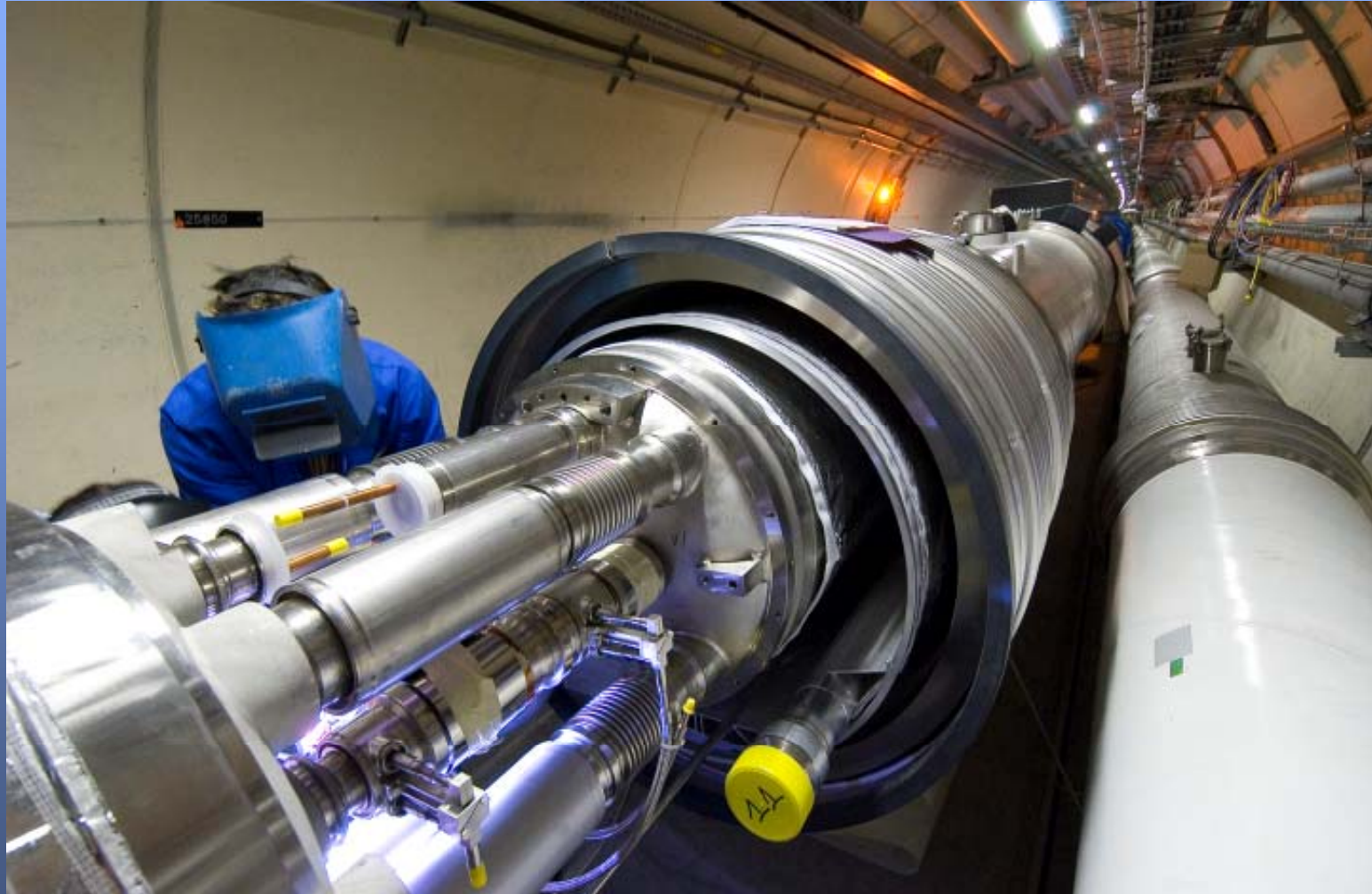




## DFBMA in Sector 7-8



# Dipole-dipole interconnect



## Dipole-dipole interconnect: electrical splices

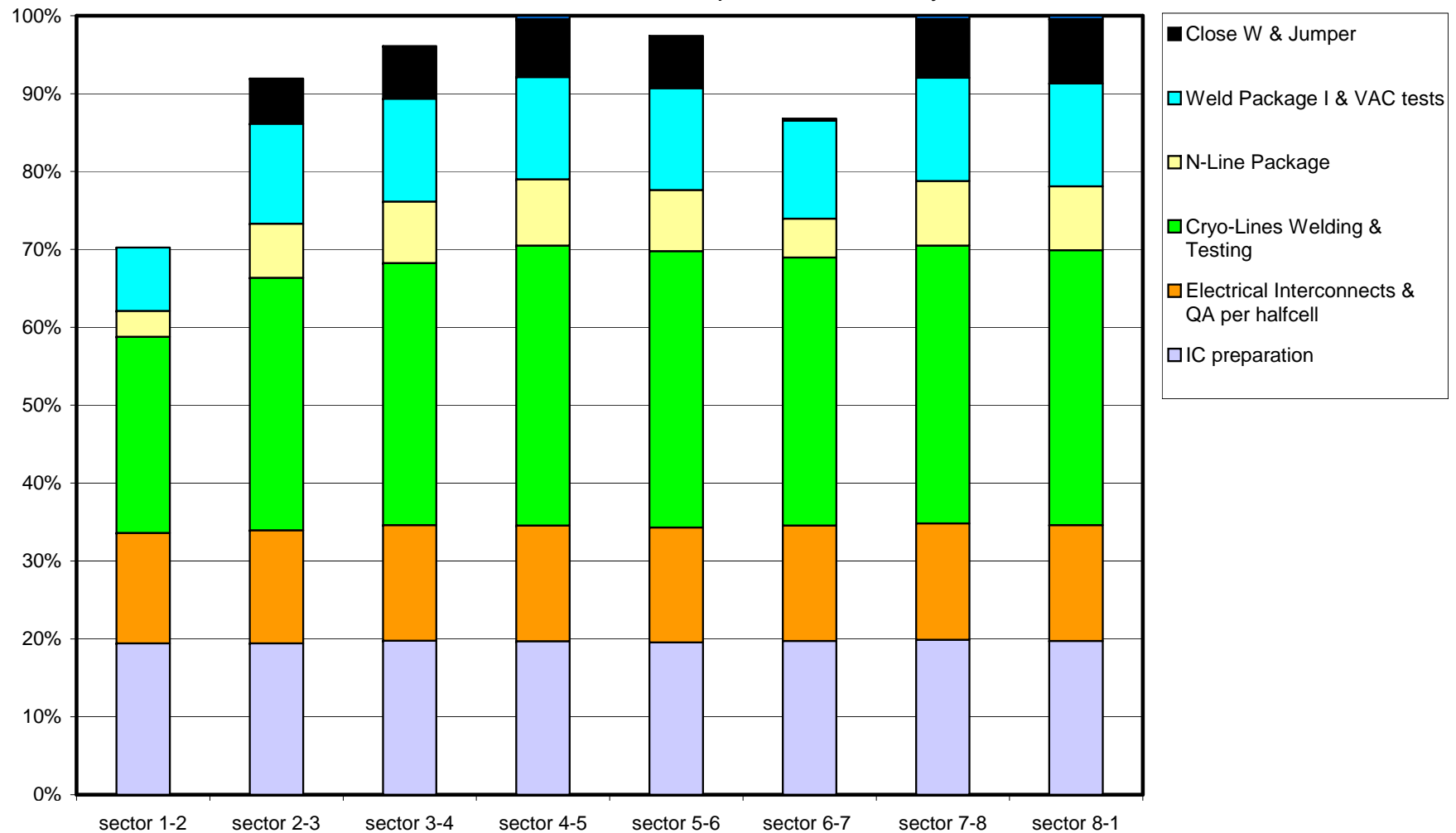




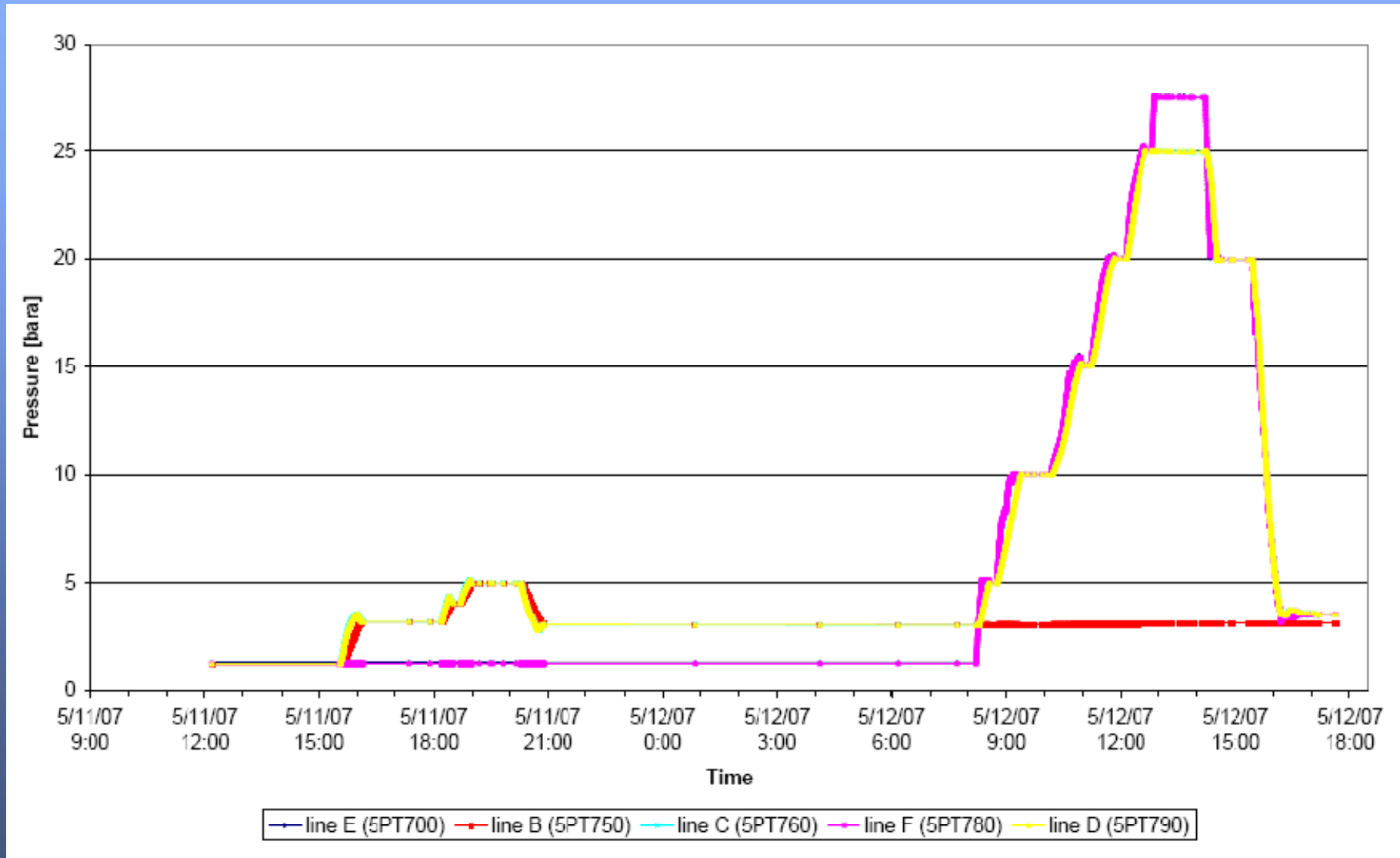
# Magnet interconnections



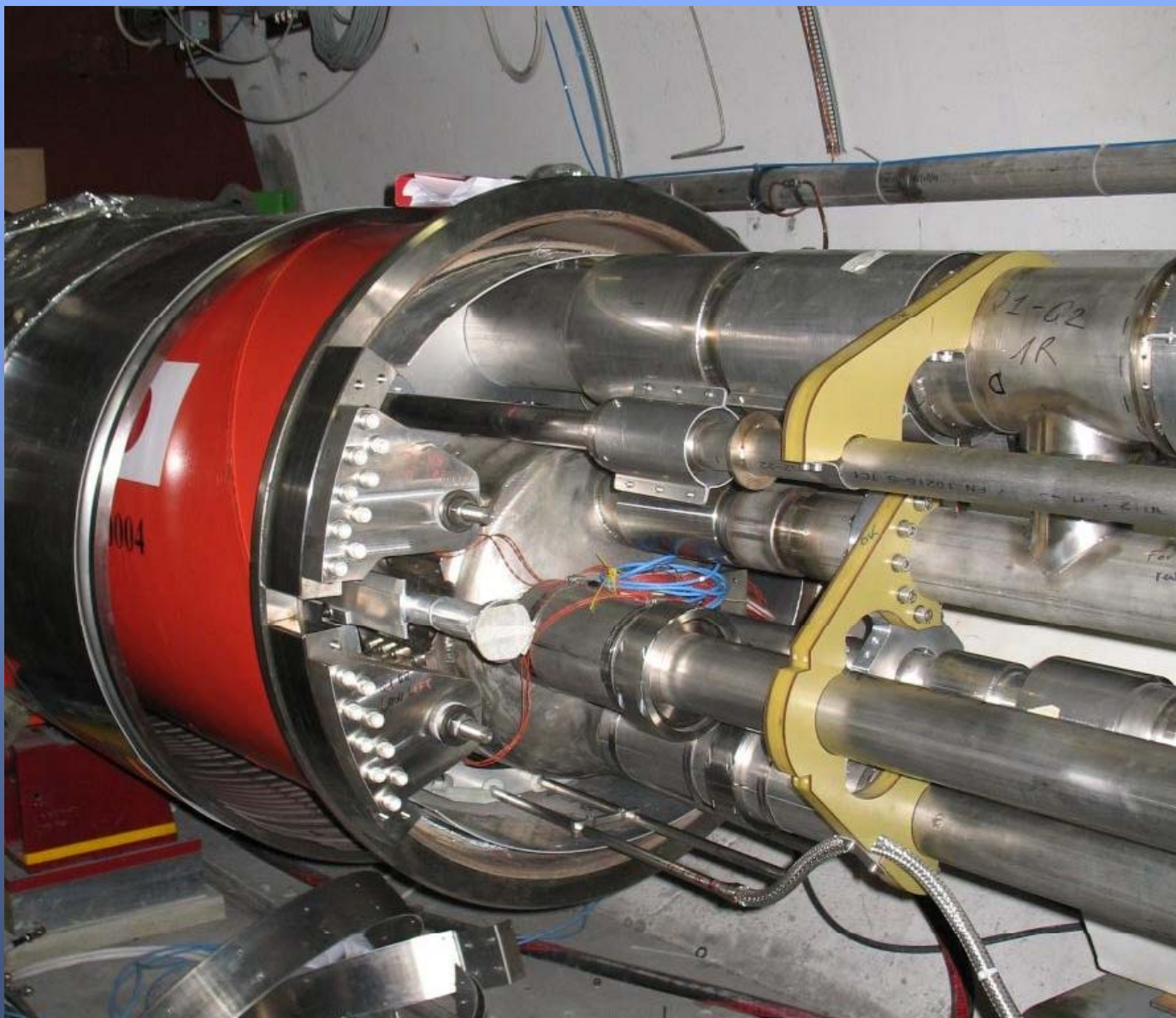
General Advancement of Interconnects per Sector 16-July-2007



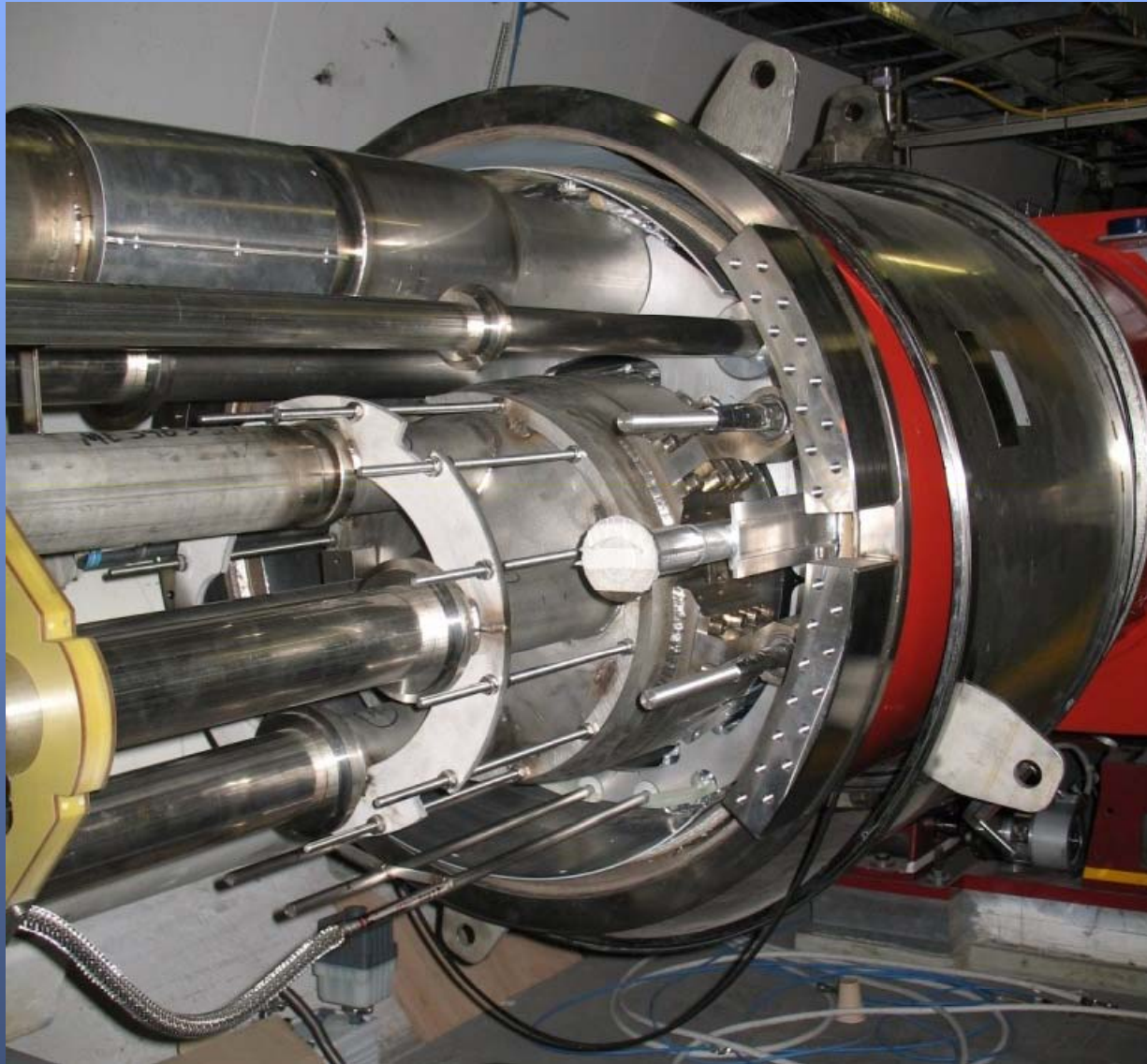
# Global pressure test of Sector 4-5, 12 May 2007



# Q1.R8



## Q3.R8





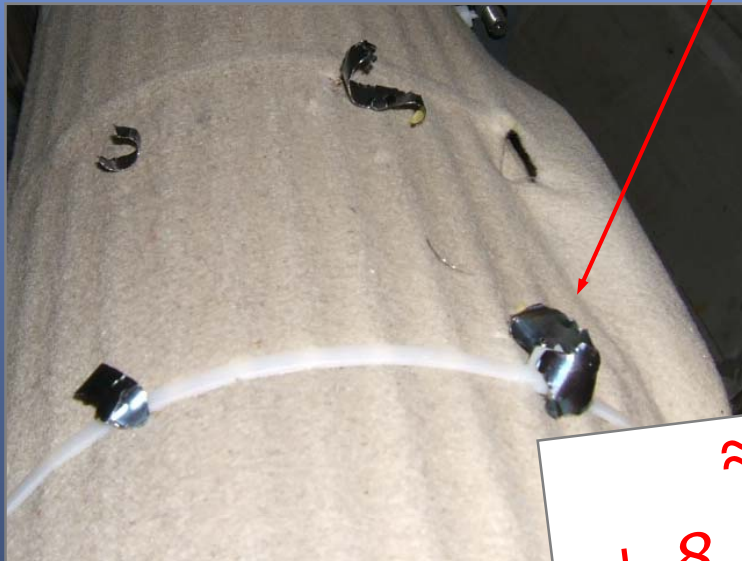
# Flushing machine - Wk 2 January 07



Before

After

Kapton bits  
Metal strips



*≈ 50 h  
+ 8 L of Water*

## Cooldown of Sector 7-8



- From RT to 80K precooling with LN2. 1200 tons of LN2 (64 trucks of 20 tons). Three weeks for the first sector.
- From 80K to 4.5K. Cooldown with refrigerator. Three weeks for the first sector. 4700 tons of material to be cooled.
- From 4.5K to 1.9K. Cold compressors at 15 mbar. Four days for the first sector.

# Large helium refrigerator for cooling down to 4.5 K



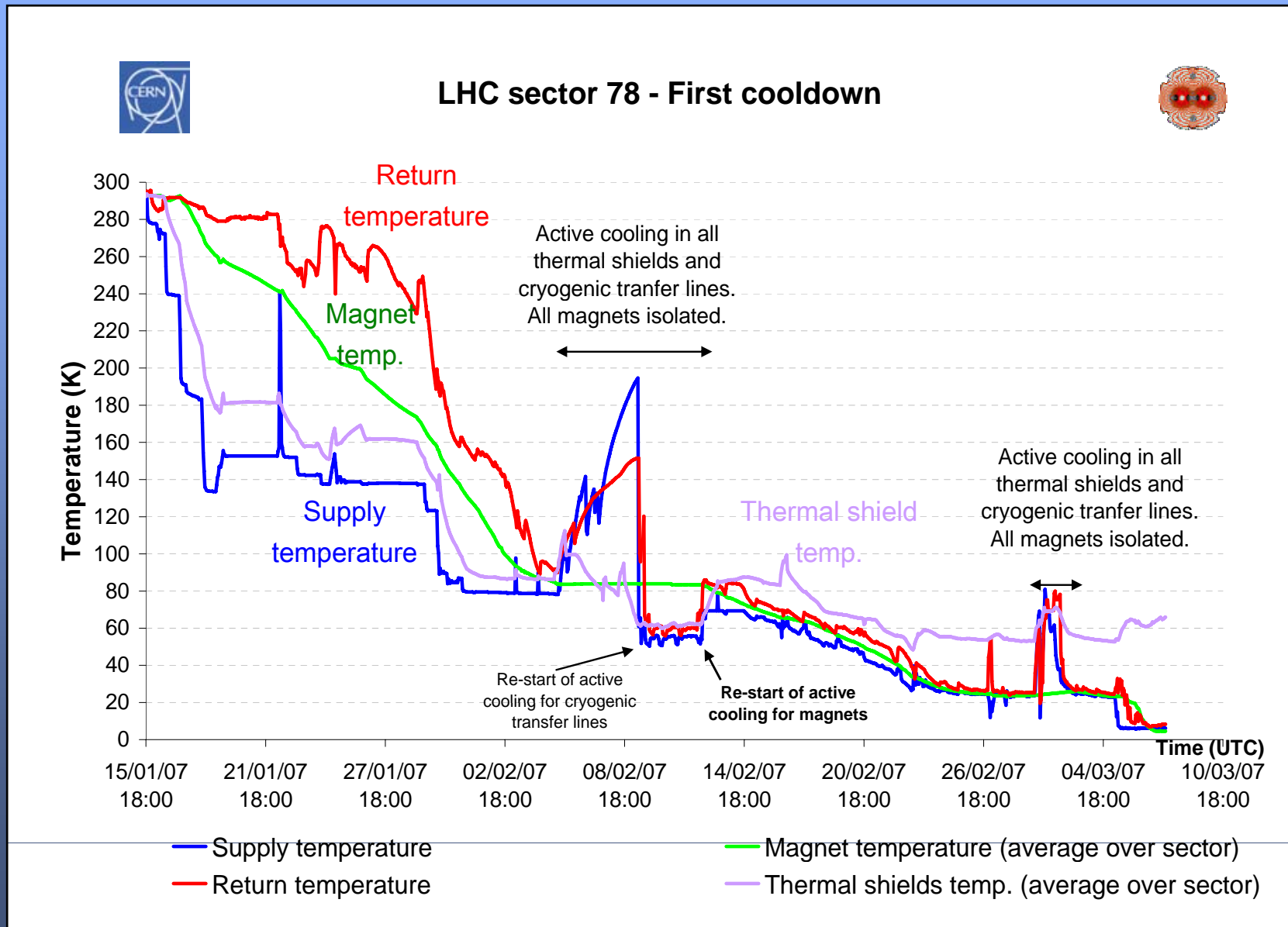
33 kW @ 50 K to 75 K  
23 kW @ 4.6 K to 20 K  
41 g/s liquefaction

600 kW precooling to 80 K  
with LN<sub>2</sub> (up to ~5 tons/h)

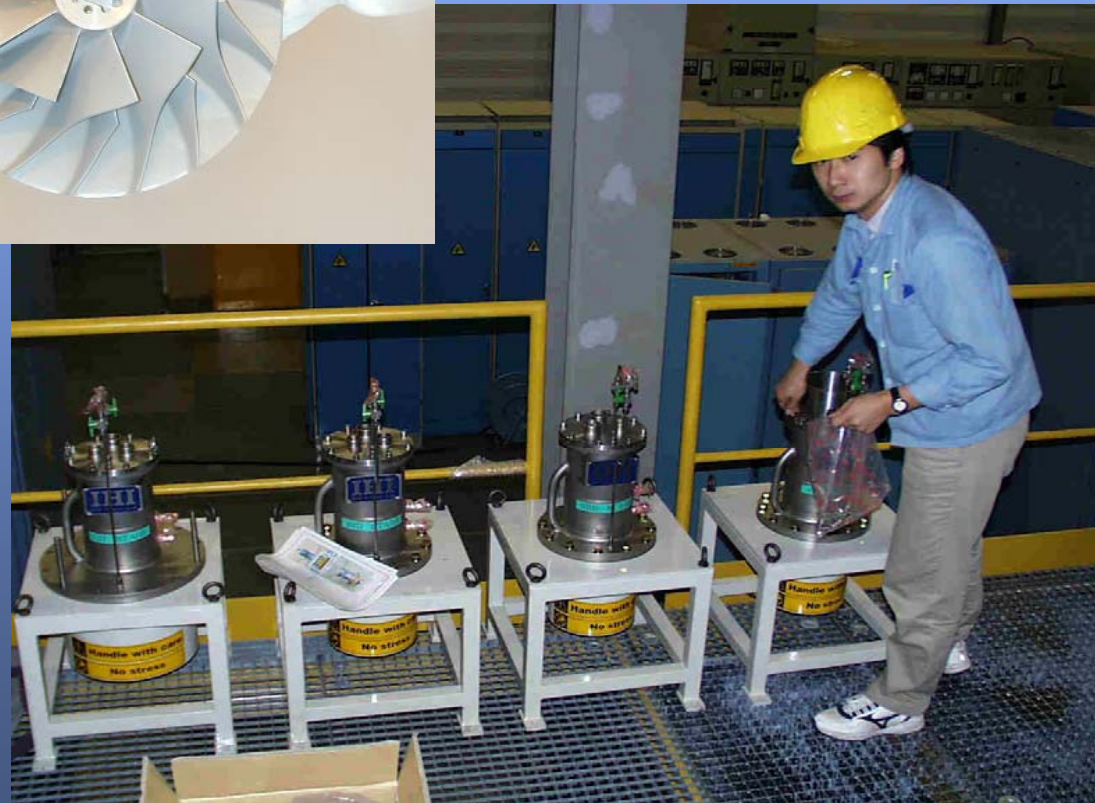




# First cool-down of Sector 7-8

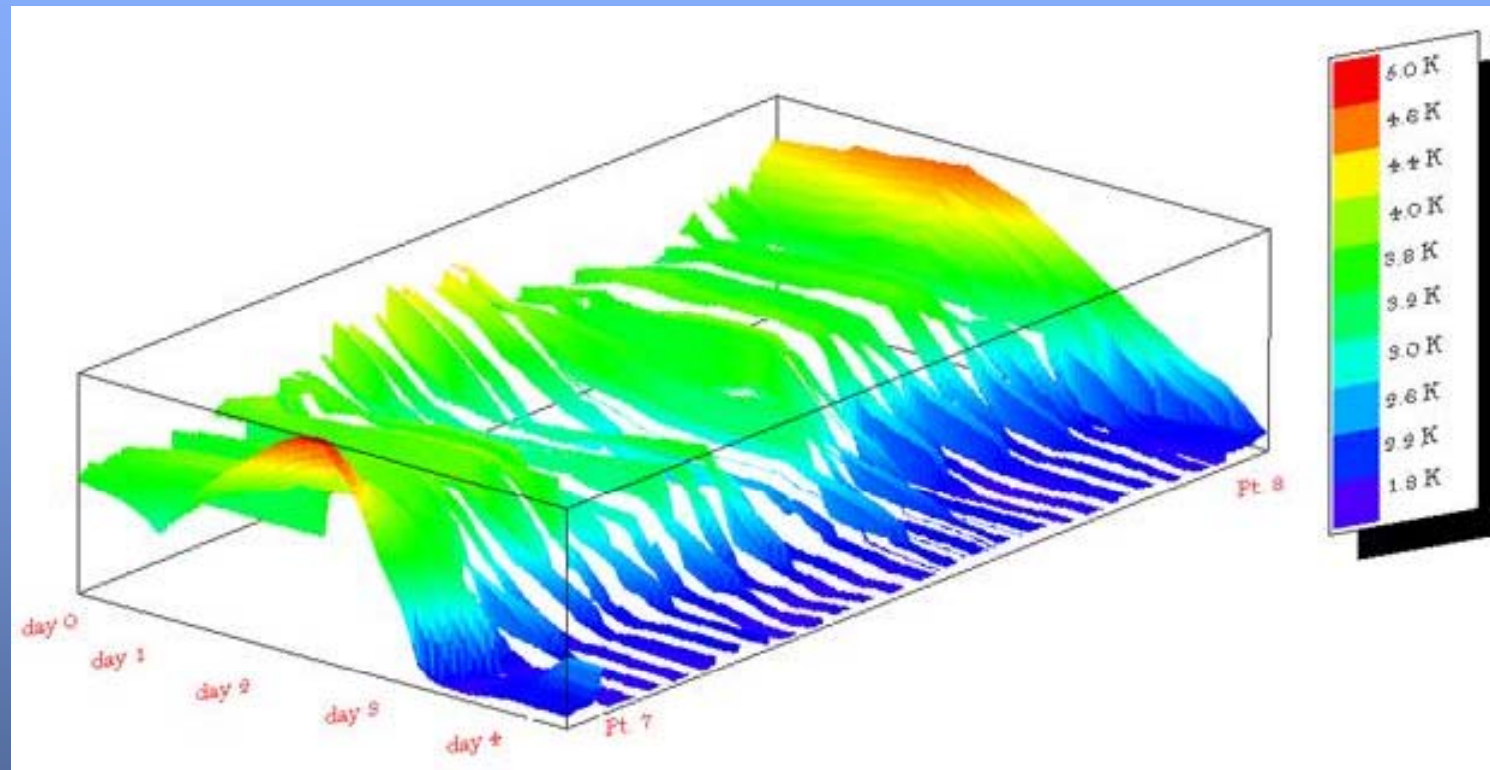


# Hydrodynamic cold compressors for 1.8 K refrigeration



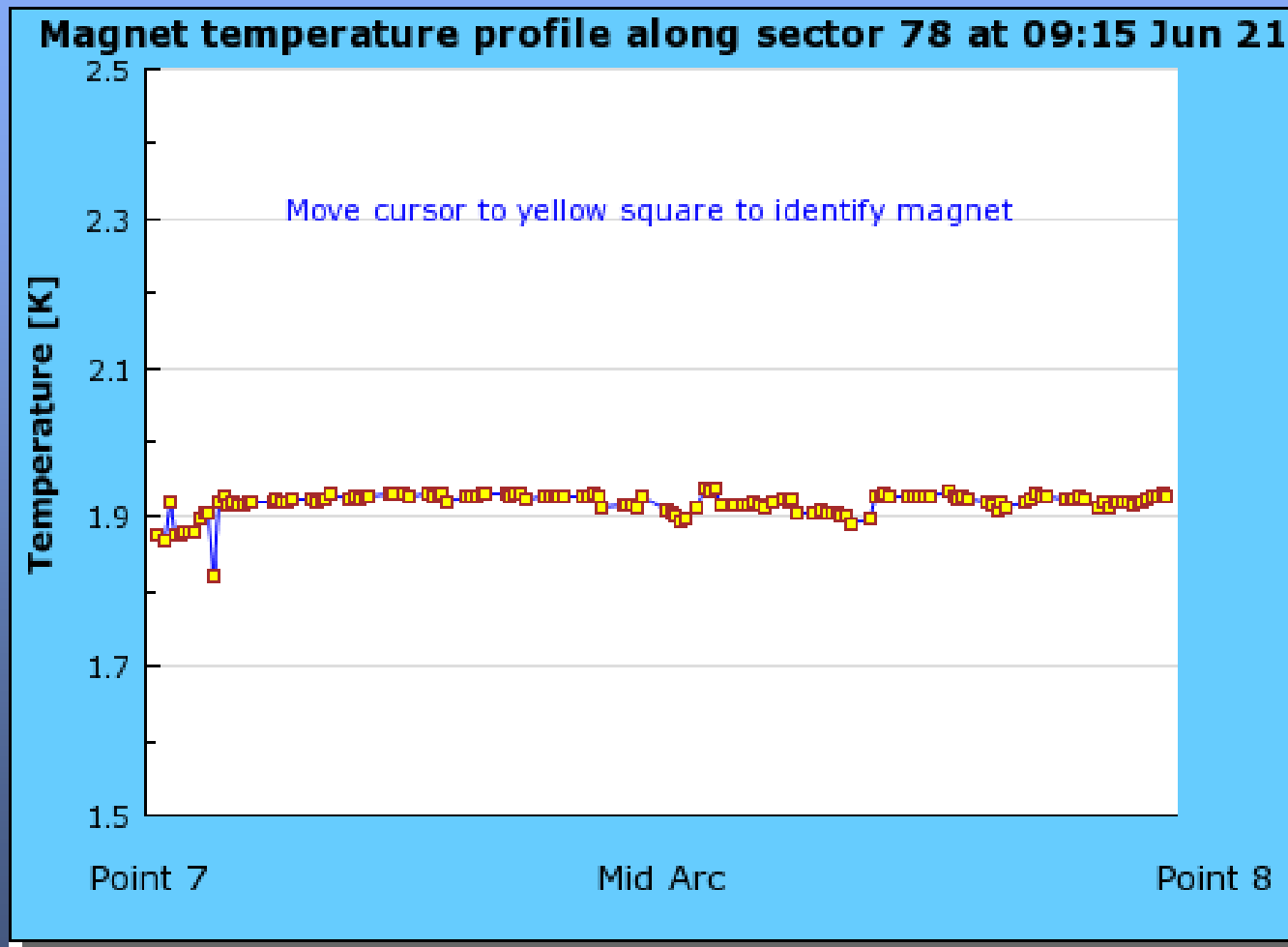
120 g/s GHe from 15 mbar with 4 stages

# First cool-down of Sector 7-8



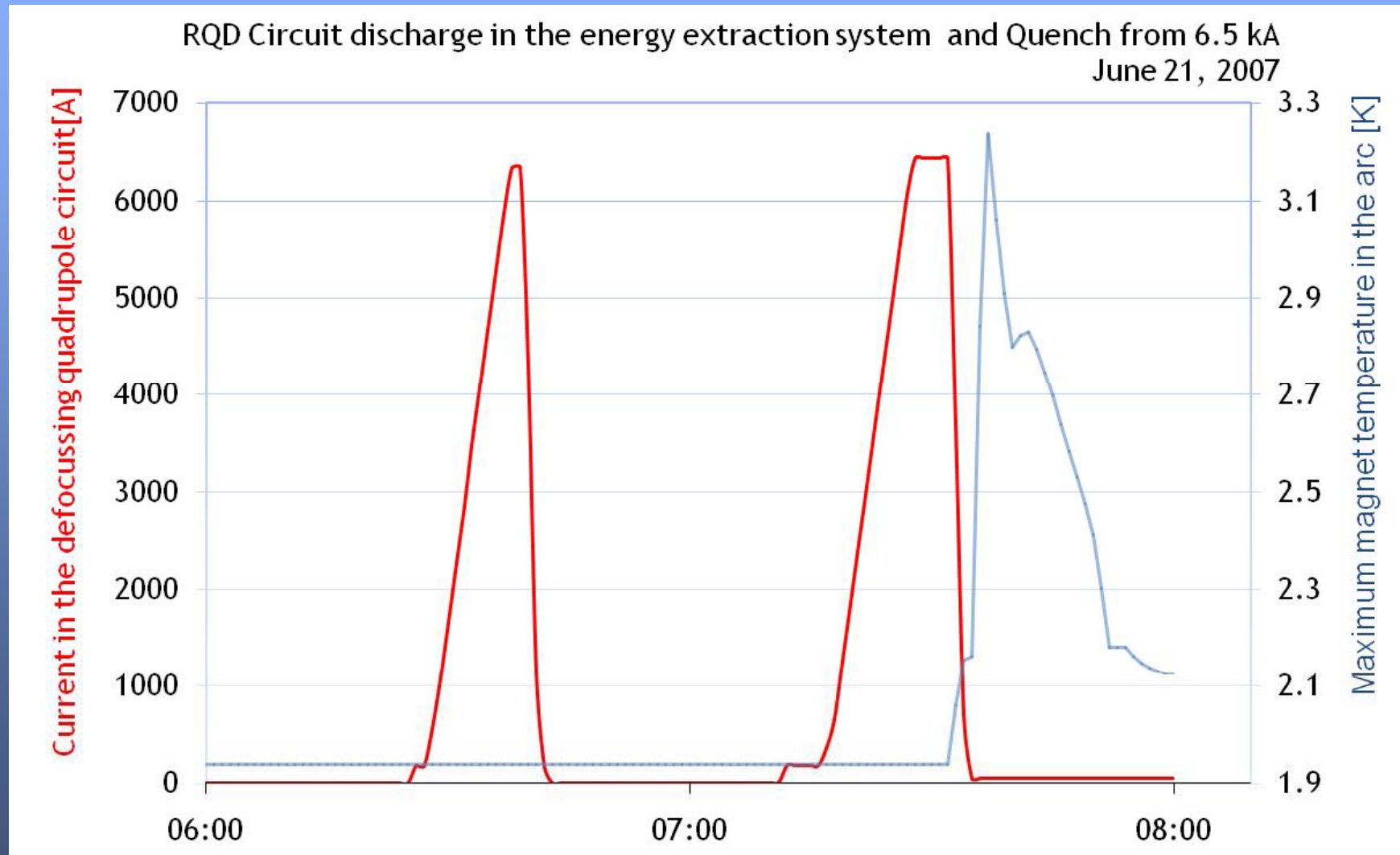
Magnet temperature profile along Sector 7-8 during final cool down to He II

# Sector 7-8 Cooldown





# First powering of main quadrupoles

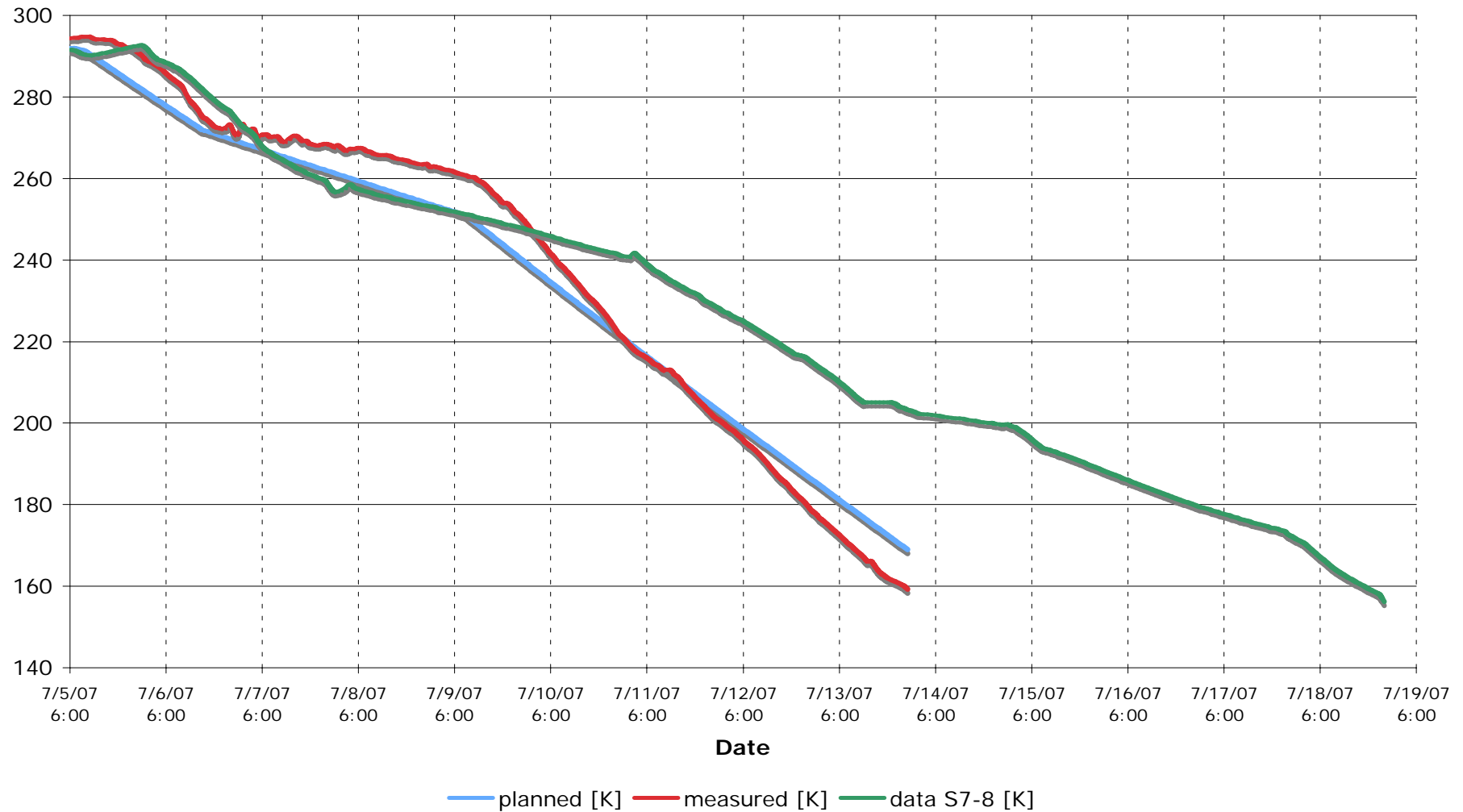


# Cool-Down until Saturday 14-7-7

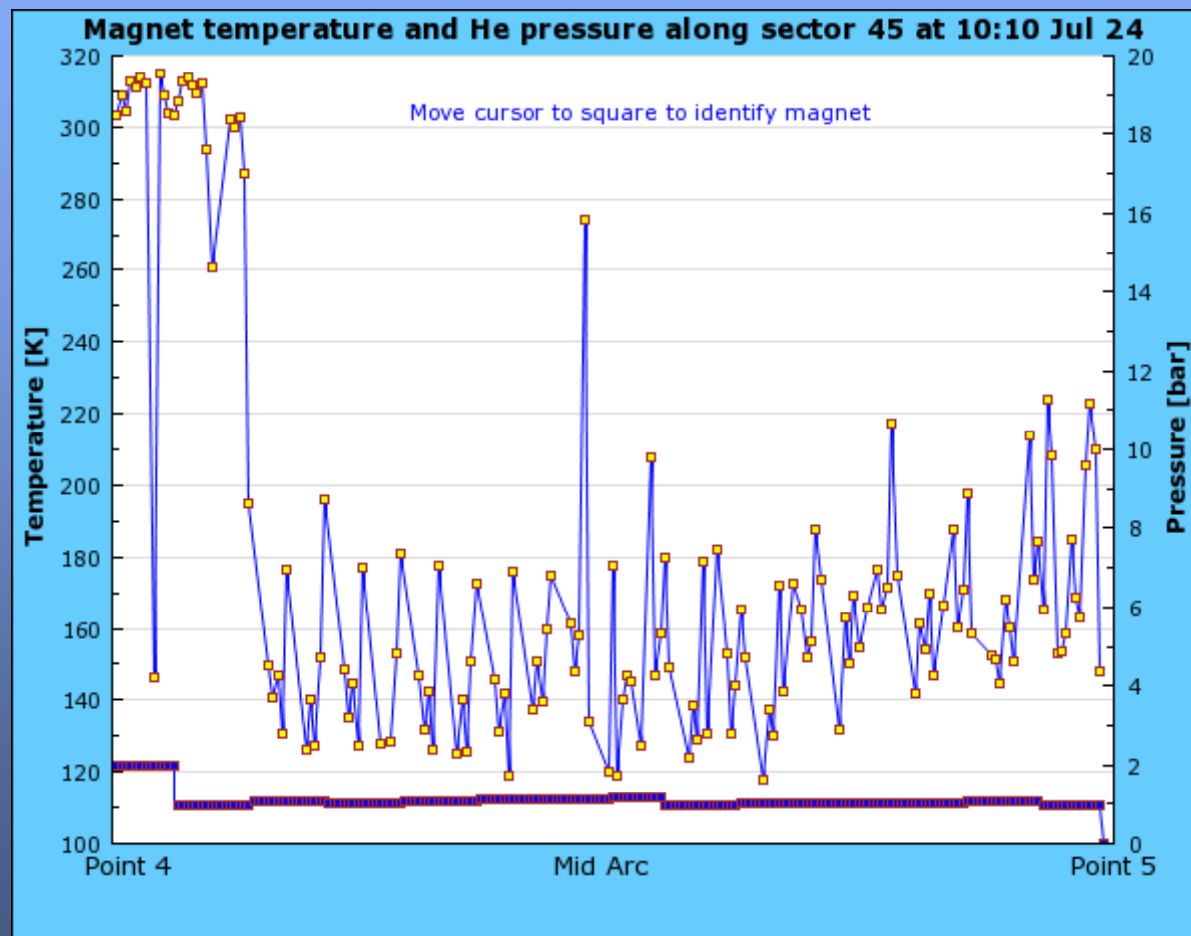
## Cool-Down Speed



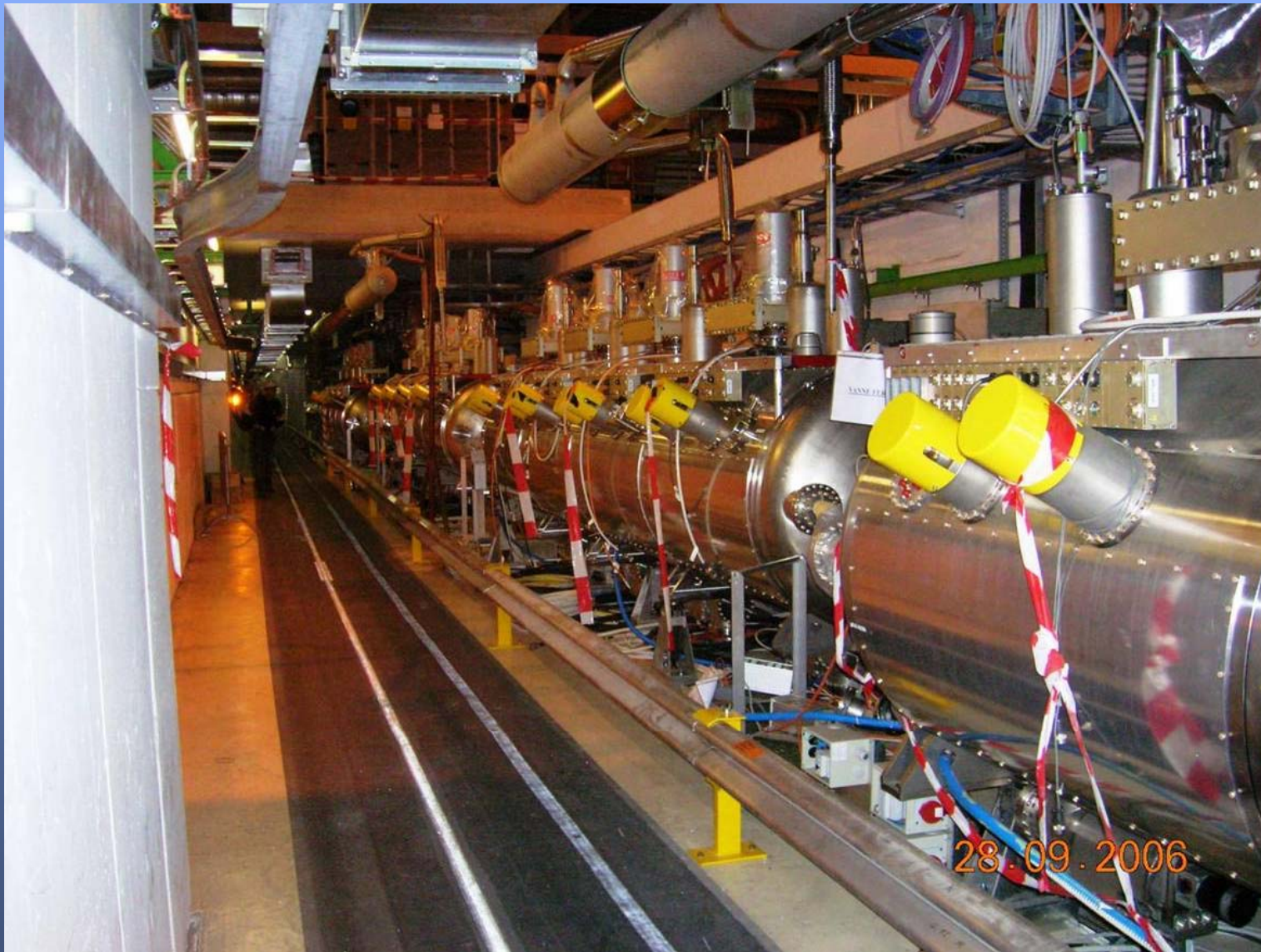
Avg. Cold Mass Temperature



# Sector 4-5 Cooldown



# RF cavities





## Two 300 kW klystrons with circulators and loads





- Procurement problems of remaining components (DFBs, collimators) now settled
- Good progress of installation and interconnection work, proceeding at high pace in tunnel
- Numerous non-conformities intercepted by QA program, but resulting in added work and time
- Technical solutions found for inner triplet problems and repair well underway.
- Commissioning of first sectors can proceed by isolating faulty triplets, but will have to be re-done with repaired triplets (needing additional warm-up/cooldown cycles)
- First sector cooled down to nominal temperature and operated with superfluid helium; teething problems with cold compressor operation have now been fixed. Second sector being cooled down.
- Power tests have started.

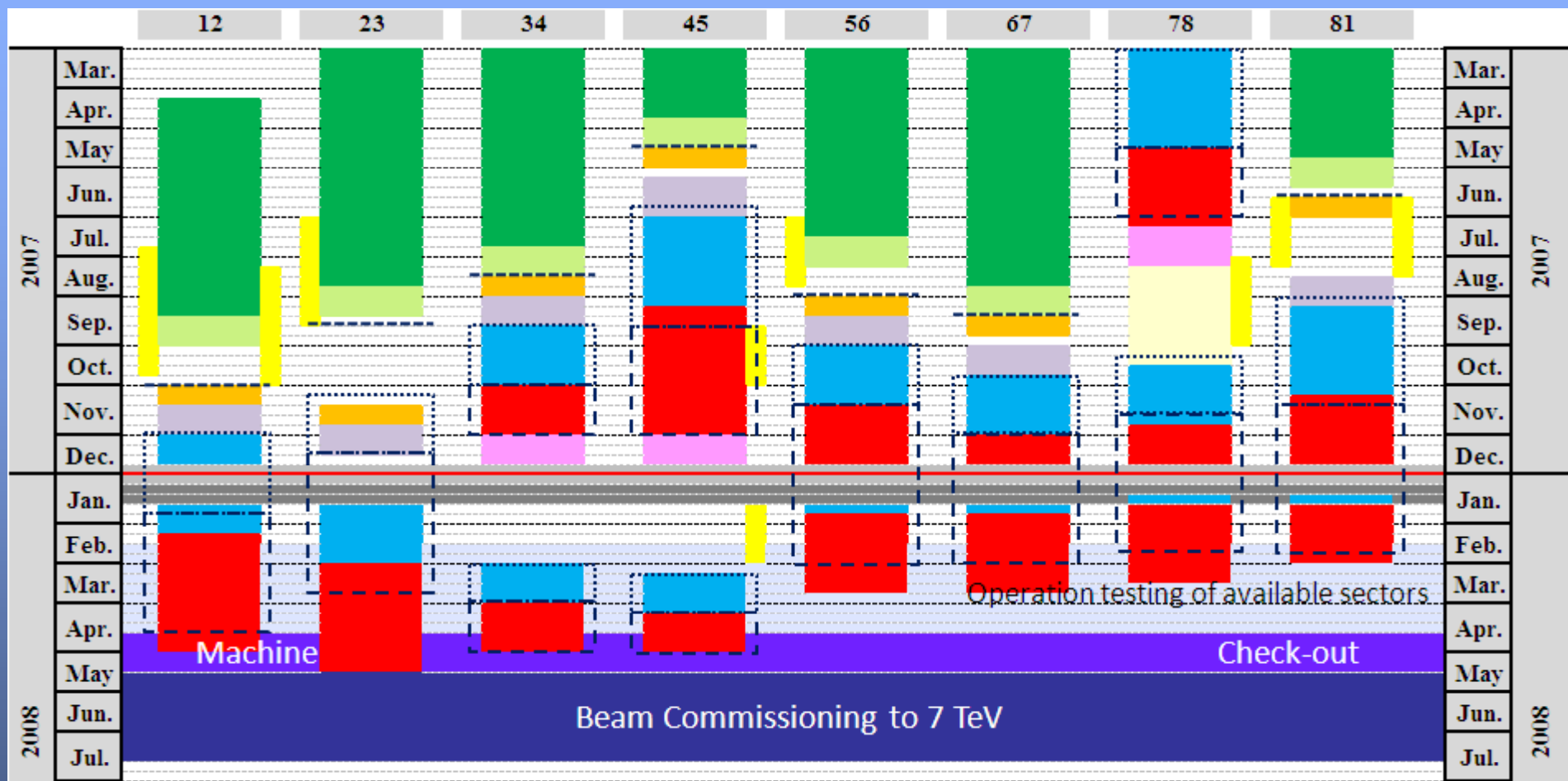
# General schedule



- Engineering run originally foreseen at end 2007 now precluded by delays in installation and equipment commissioning.
- 450 GeV operation now part of normal setting up procedure for beam commissioning to high-energy
- General schedule being reassessed, accounting for inner triplet repairs and their impact on sector commissioning
  - All technical systems commissioned to 7 TeV operation, and machine closed April 2008
  - Beam commissioning starts May 2008
  - First collisions at 14 TeV c.m. July 2008
  - Luminosity evolution will be dominated by our confidence in the machine protection system and by the ability of the detectors to absorb the rates.
- No provision in success-oriented schedule for major mishaps, e.g. additional warm-up/cooldown of sector



# LHC General Schedule, 5 July 2007



**General schedule Baseline rev. 4.0**

- ..... Global pressure test & Consolidation
- Cool-down
- Powering Tests
- Interconnection of the continuous cryostat
- Leak tests of the last sub-sectors
- Inner Triplets repairs & interconnections
- Global pressure test & Consolidation
- Flushing
- Cool-down
- Warm up
- Powering Tests