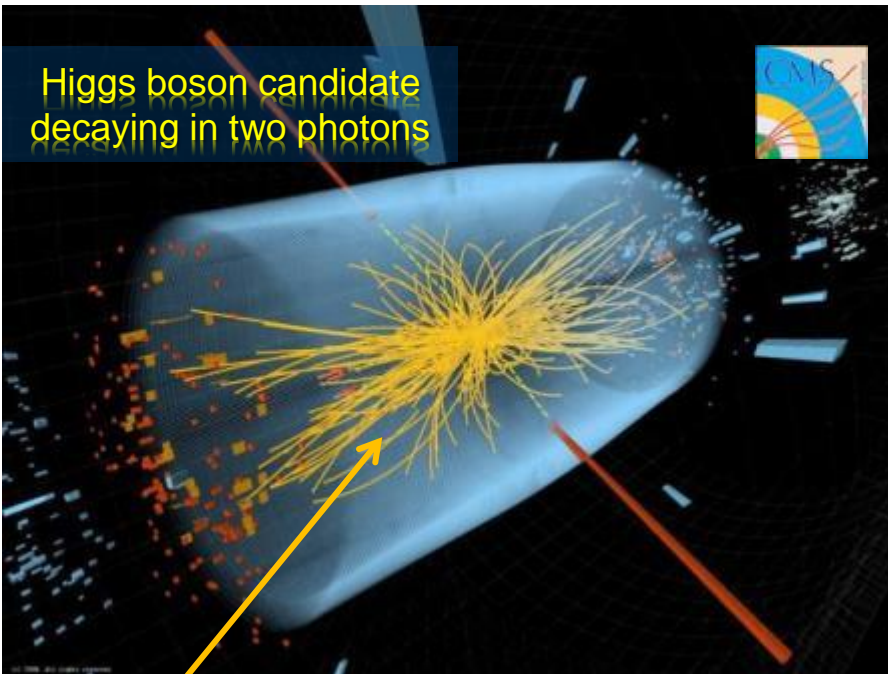




# The cryogenic systems of the ATLAS and CMS detectors

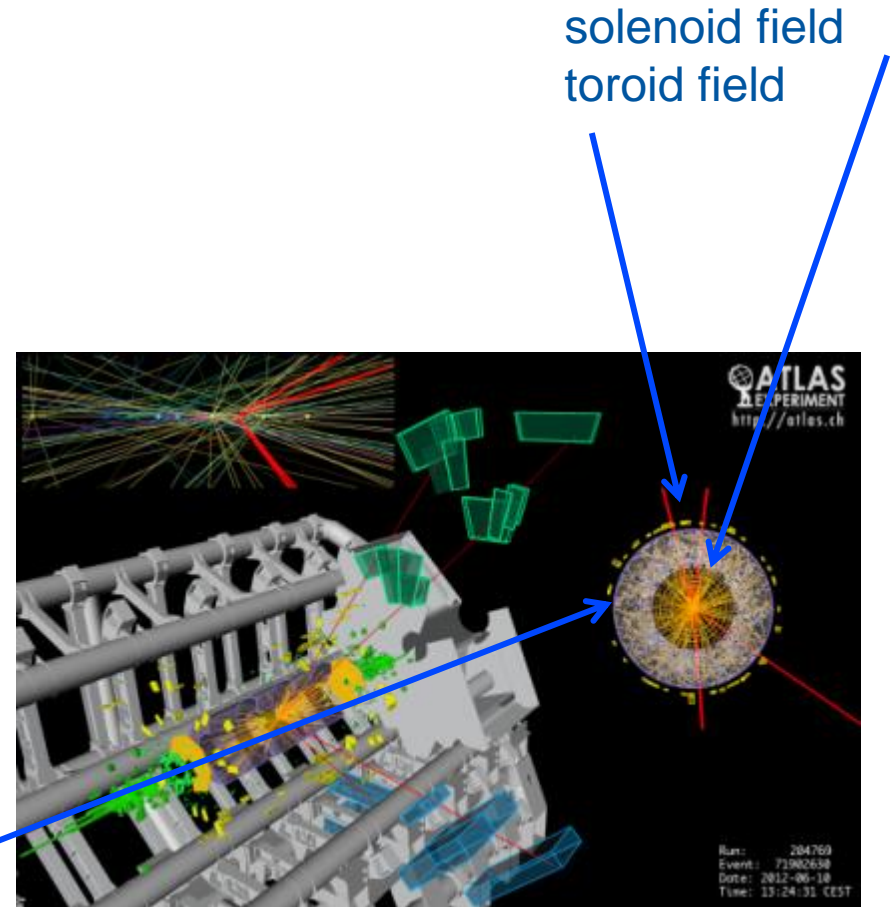
Johan Bremer on behalf of TE/CRG

# Presence of cryogenics at ATLAS and CMS



solenoid field

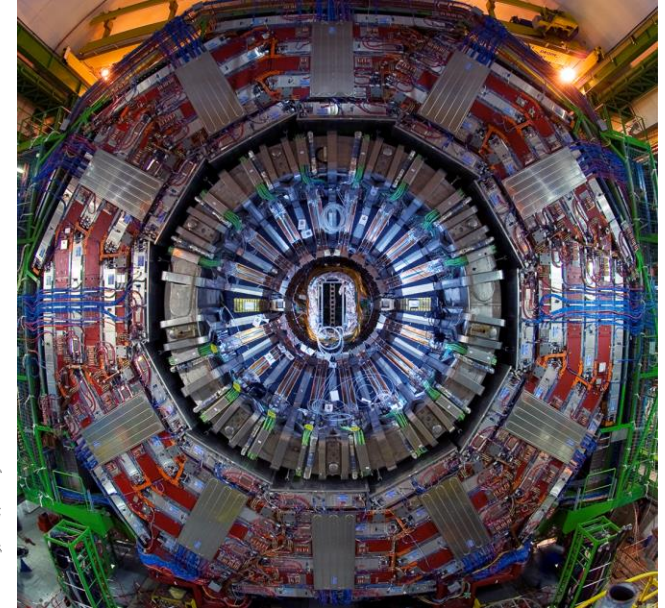
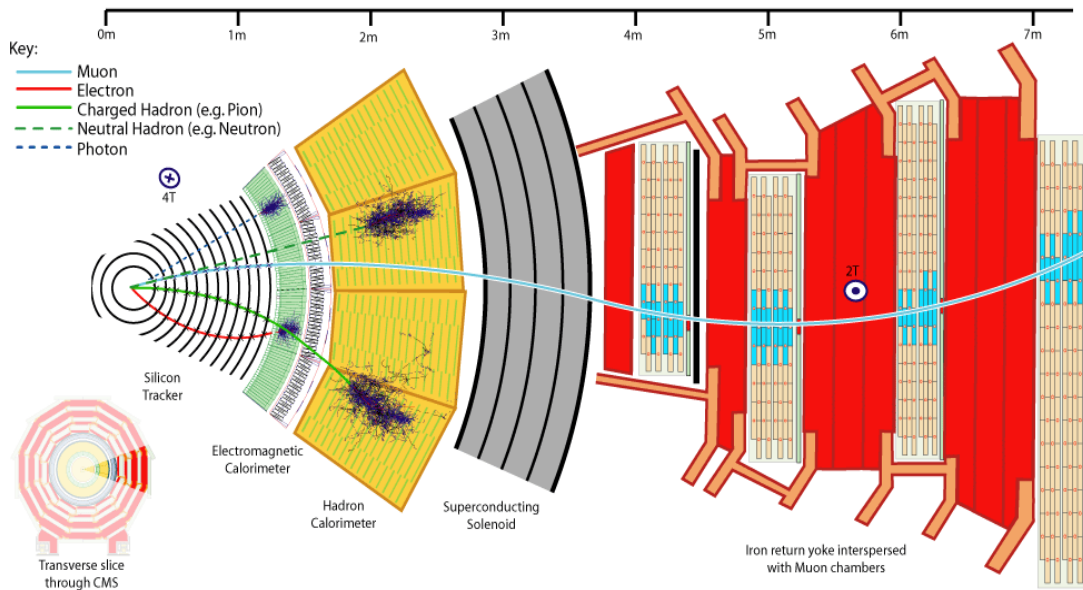
liquid argon  
calorimeter



# Overview

- Cryogenic system of
  - the CMS magnet
  - the ATLAS magnets
  - the ATLAS calorimeter
- Organization of the operation of these installations
- Performance over 2011 and 2012
- Helium inventory
- Consolidations being applied
- Conclusions

# CMS magnet system



Magnet data:

Operation temperature:

Dimensions

Cold mass

Magnetic field

Stored energy

4.5K

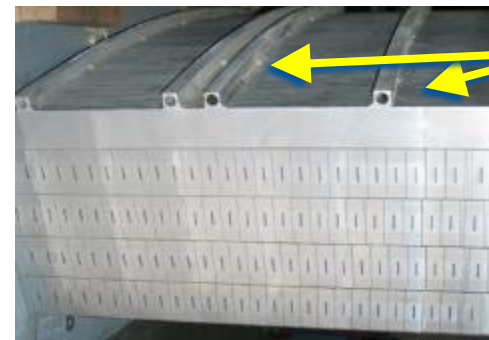
12.5 m long

6 m diameter

225 tons

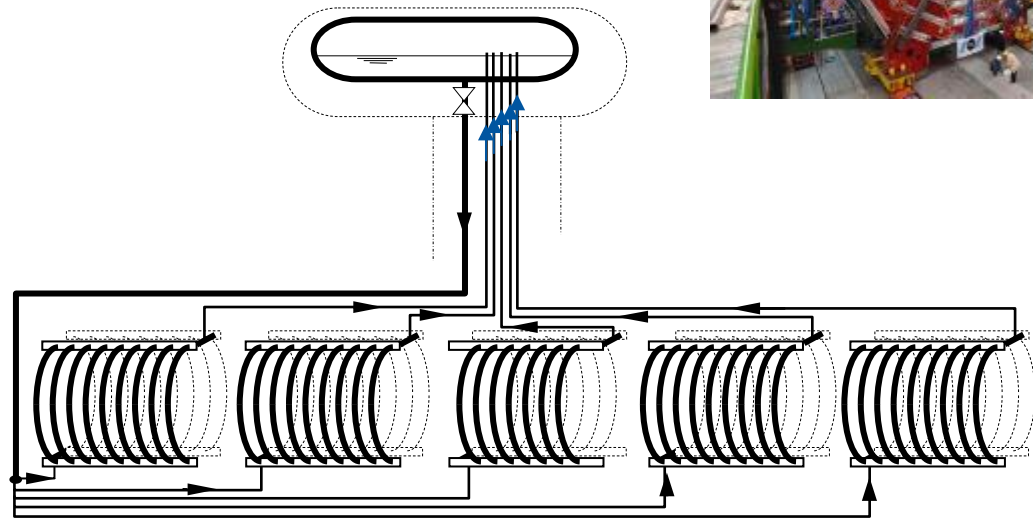
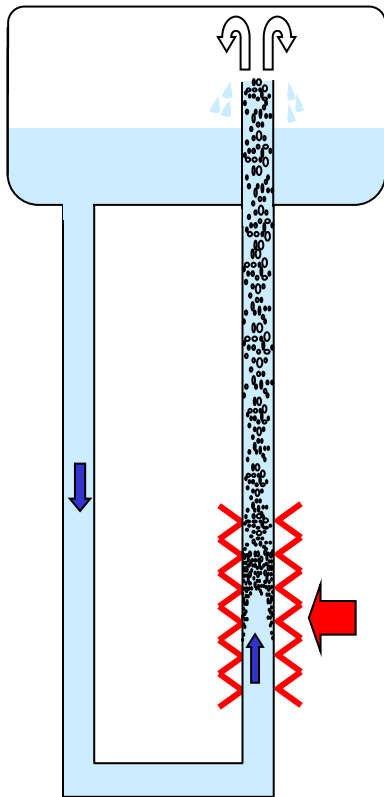
4T @ IP

2.6 GJ



LHe cooling circuit

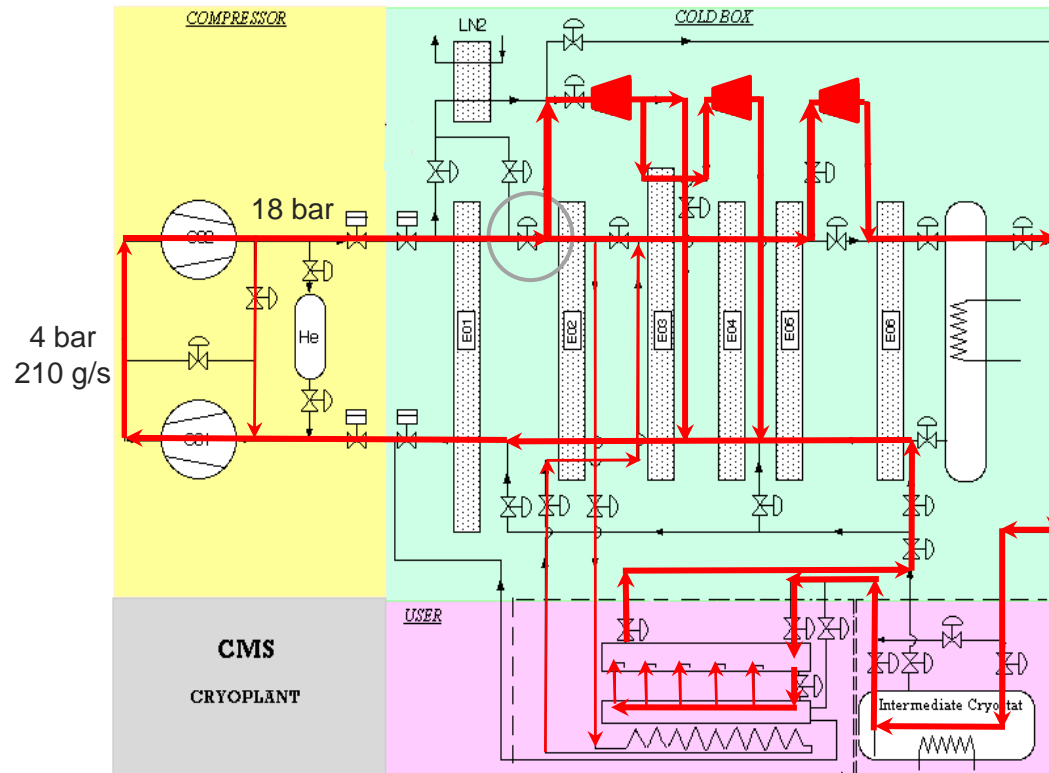
# The CMS thermosyphon refrigeration mode



Driving force created by the difference in density between the liquid supply and the two phase return column  
Natural circulation, no cold mechanical pump needed  
When sufficient liquid available: magnet system can go into slow-dump in case of power failure

# The CMS refrigerator system

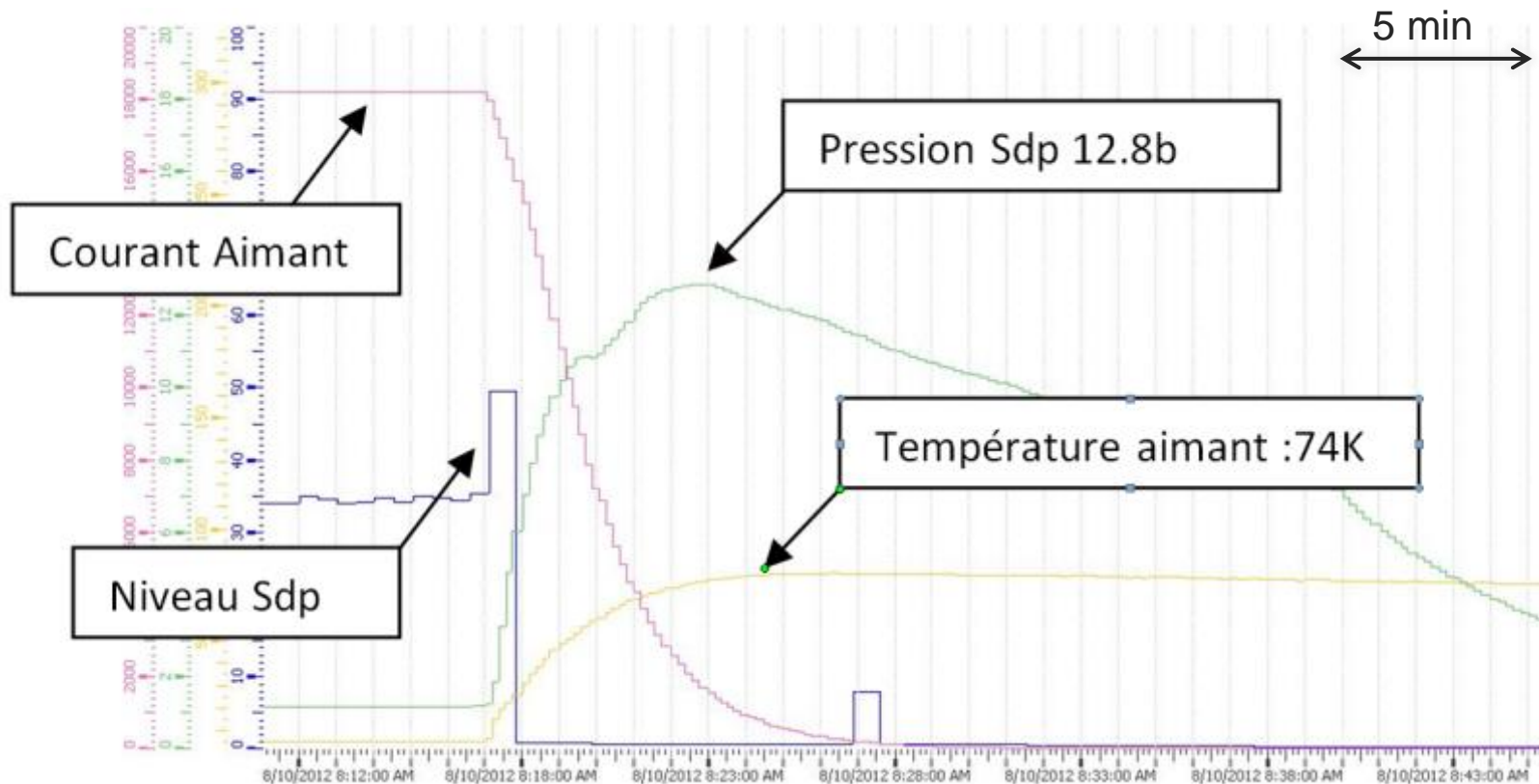
At 4.5K



Refrigerator data:  
800 W @ 4.5K  
4.5 kW @ 70K  
4 g/s for current leads



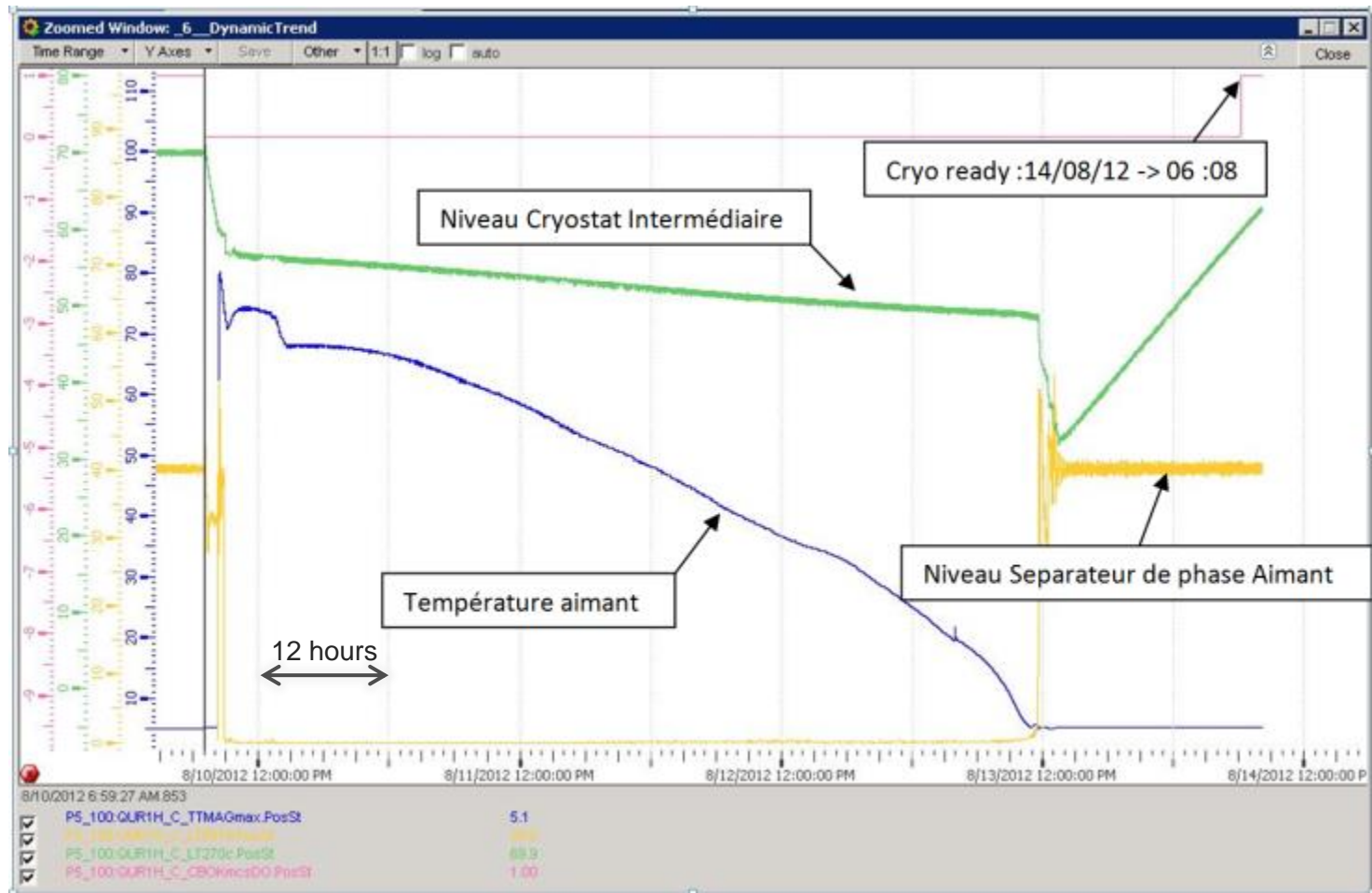
# Fast dump CMS magnet



Helium loss: 180 kg



# CMS: Recovery after fast dump

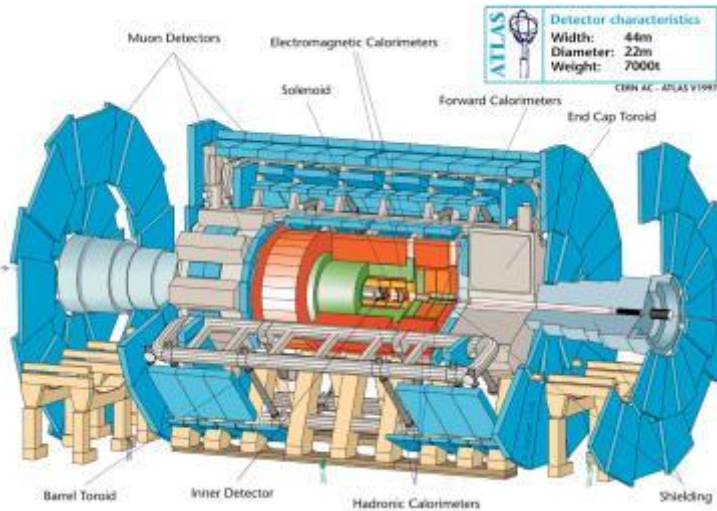


Time from fast dump to cryo-ready: 95 hours

# ATLAS magnet system



Dimensions: 8 x 25 m length  
5 m width  
Magnetic field 1T  
Stored energy 1.1 GJ (total)



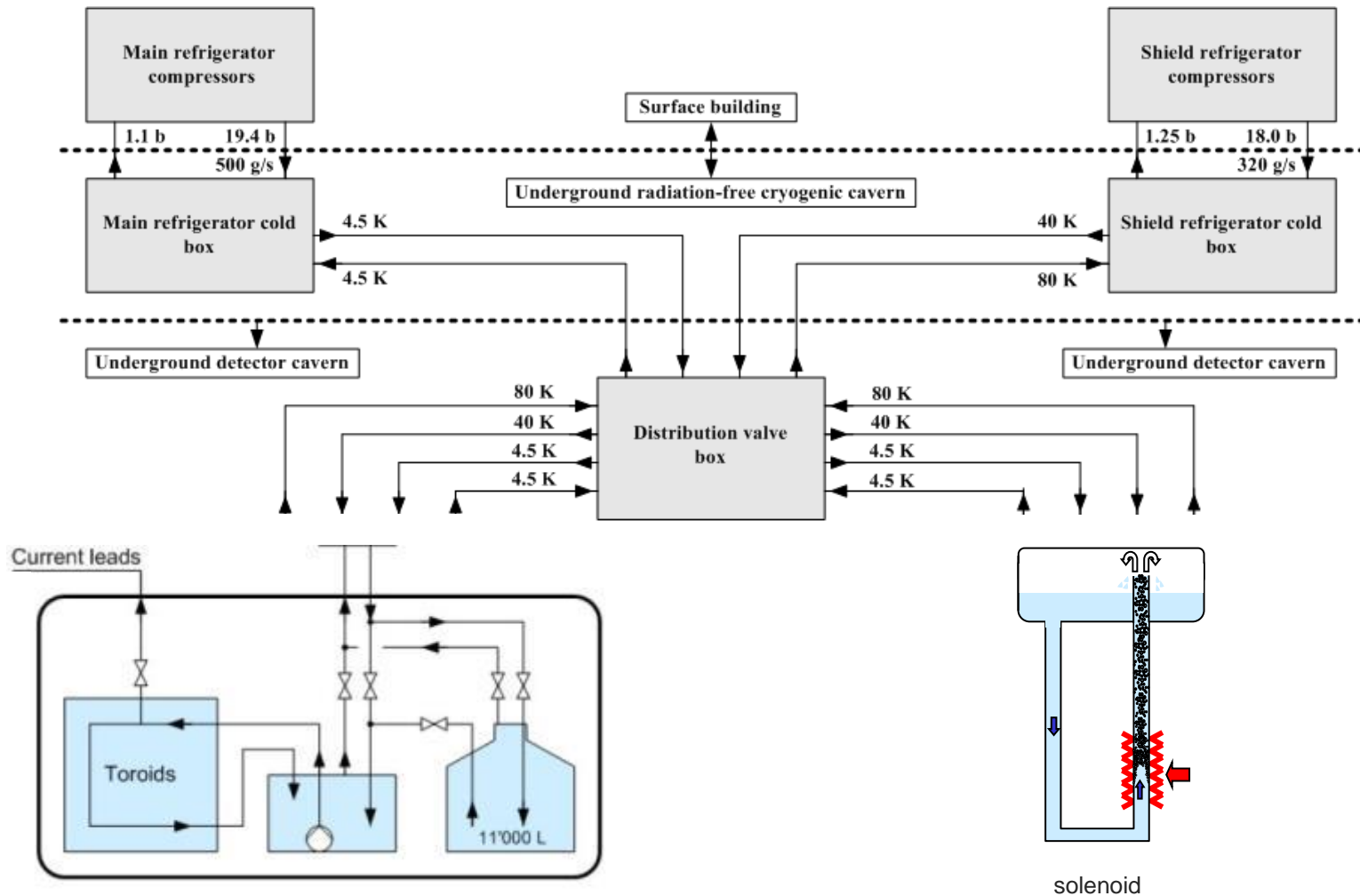
Dimensions 5 m length  
2.5 m diam.  
Magnetic field 2T  
Stored energy 39 MJ



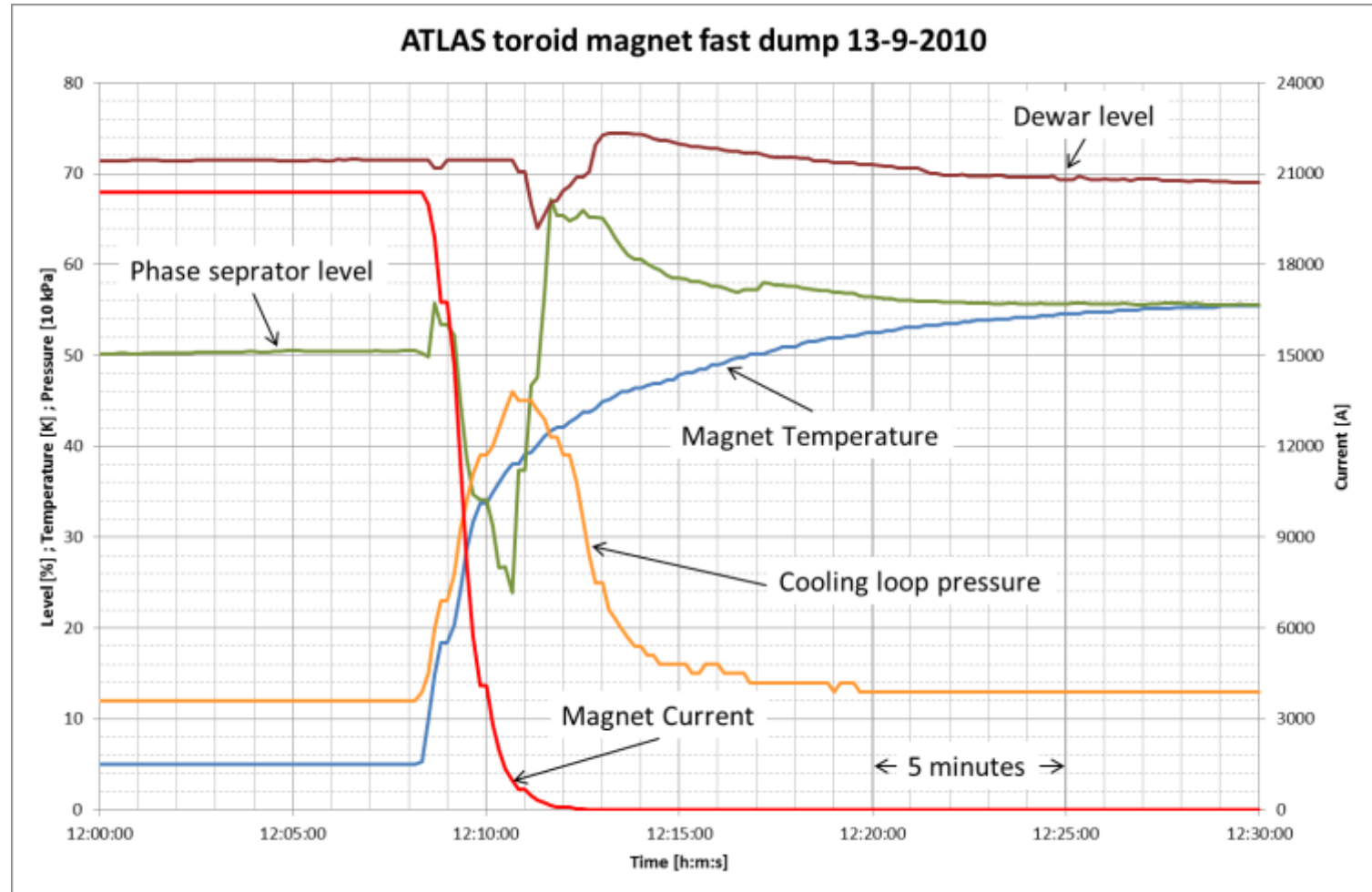
Dimensions: 2x 11 m diam.  
5 m width  
Magnetic field 1T  
Stored energy 0.5 GJ

Total cold mass: 680 tons

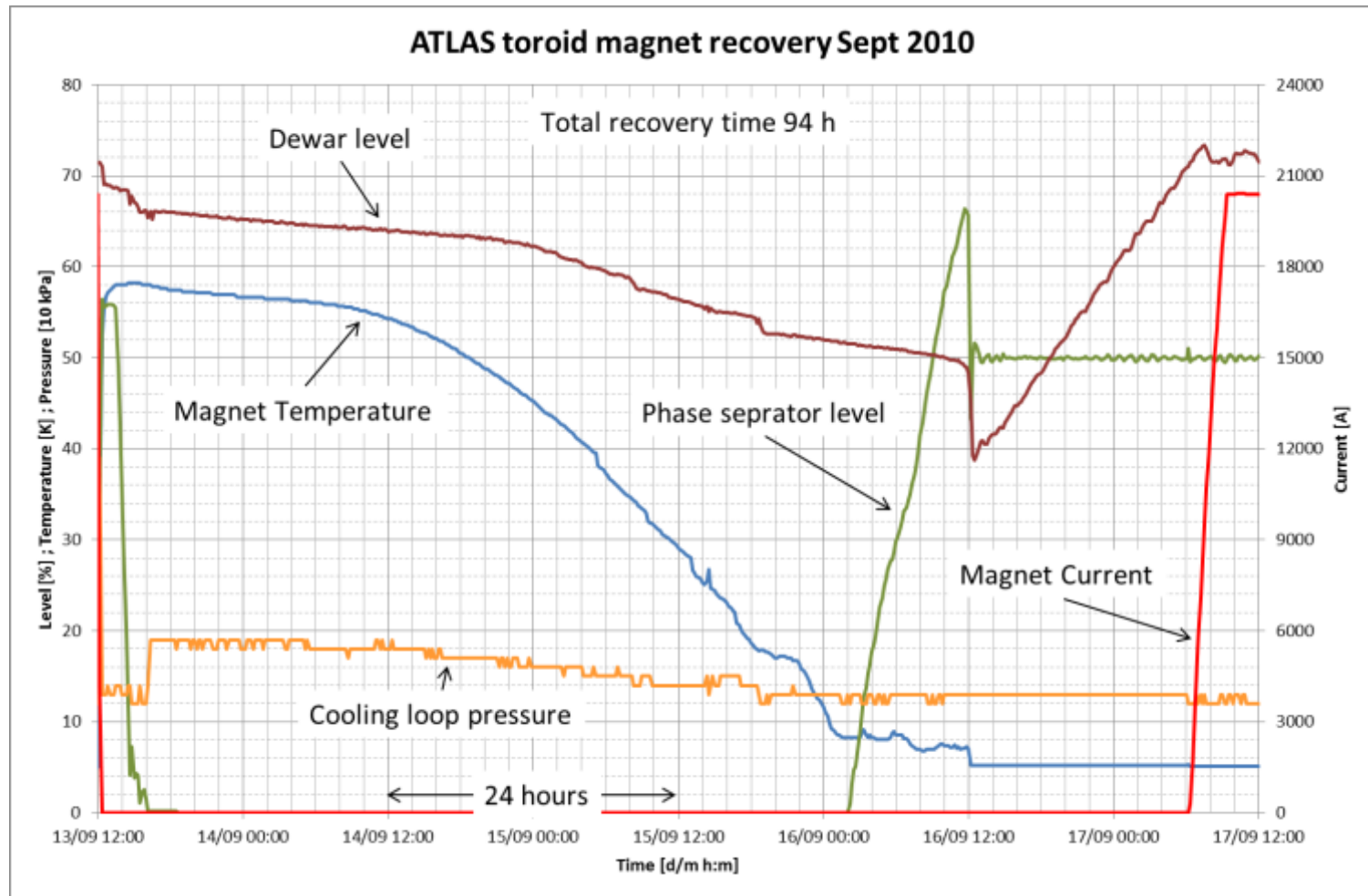
# ATLAS refrigerator system



# Fast dump ATLAS toroid magnets

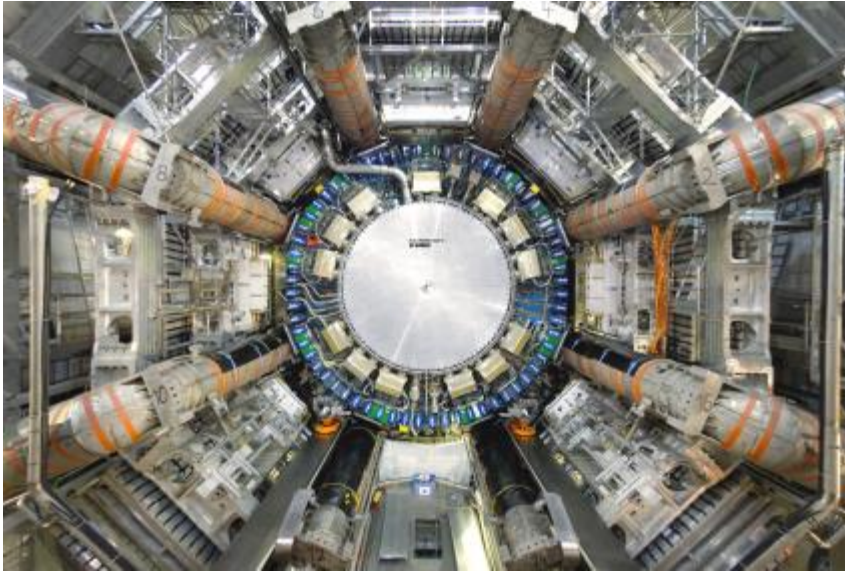


# Fast dump ATLAS toroid magnets





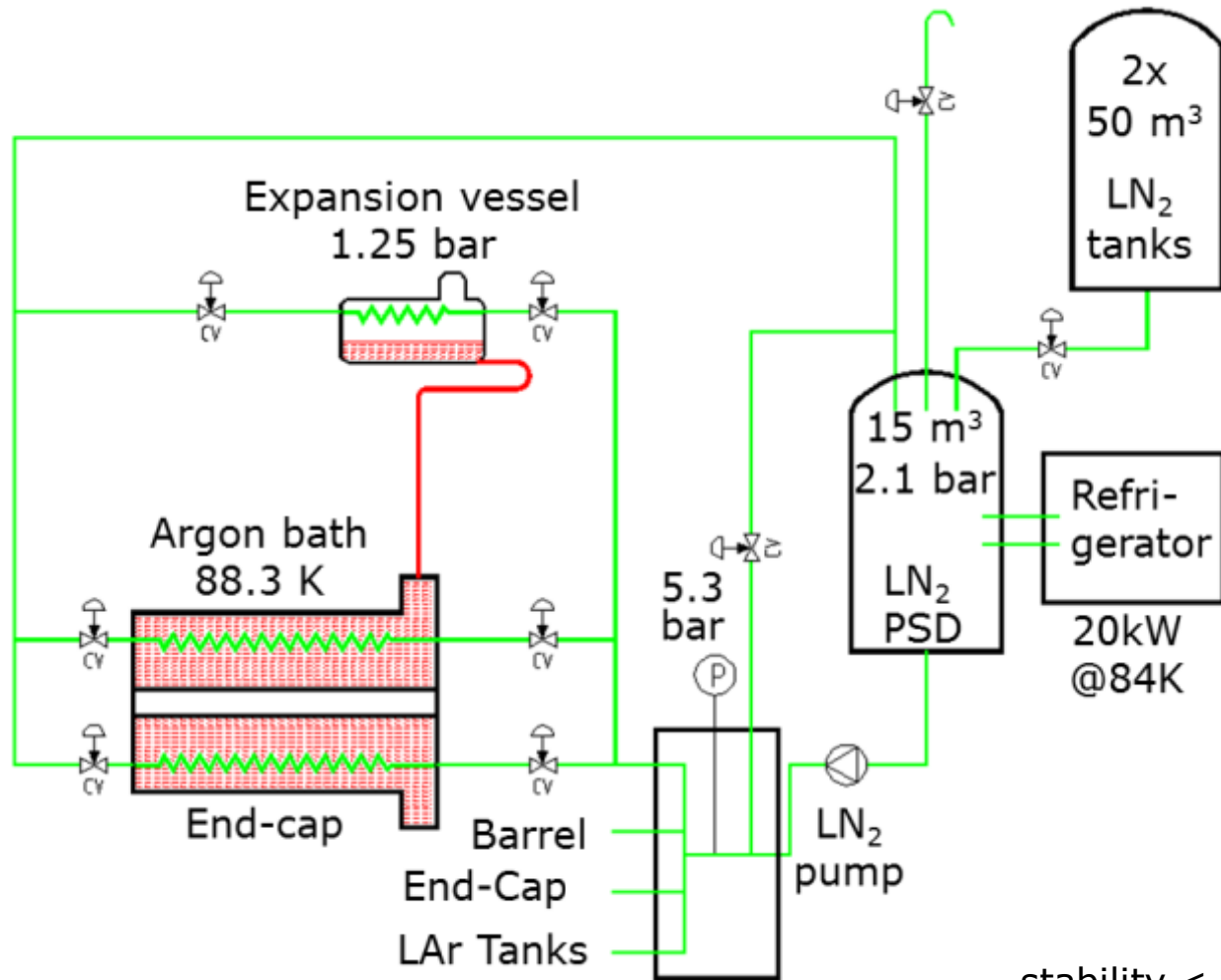
# ATLAS calorimeter system



three cryostats, total mass 740 tons

- temperature around 88.3 K
- total liquid argon volume 100 m<sup>3</sup> in underground
- 228000 signal wire feed-through
- operational 365/365 since 2005

# ATLAS calorimeter cryo system



stability < 10 mK over stable operation periods



# Operation of LHC detector cryogenic installations

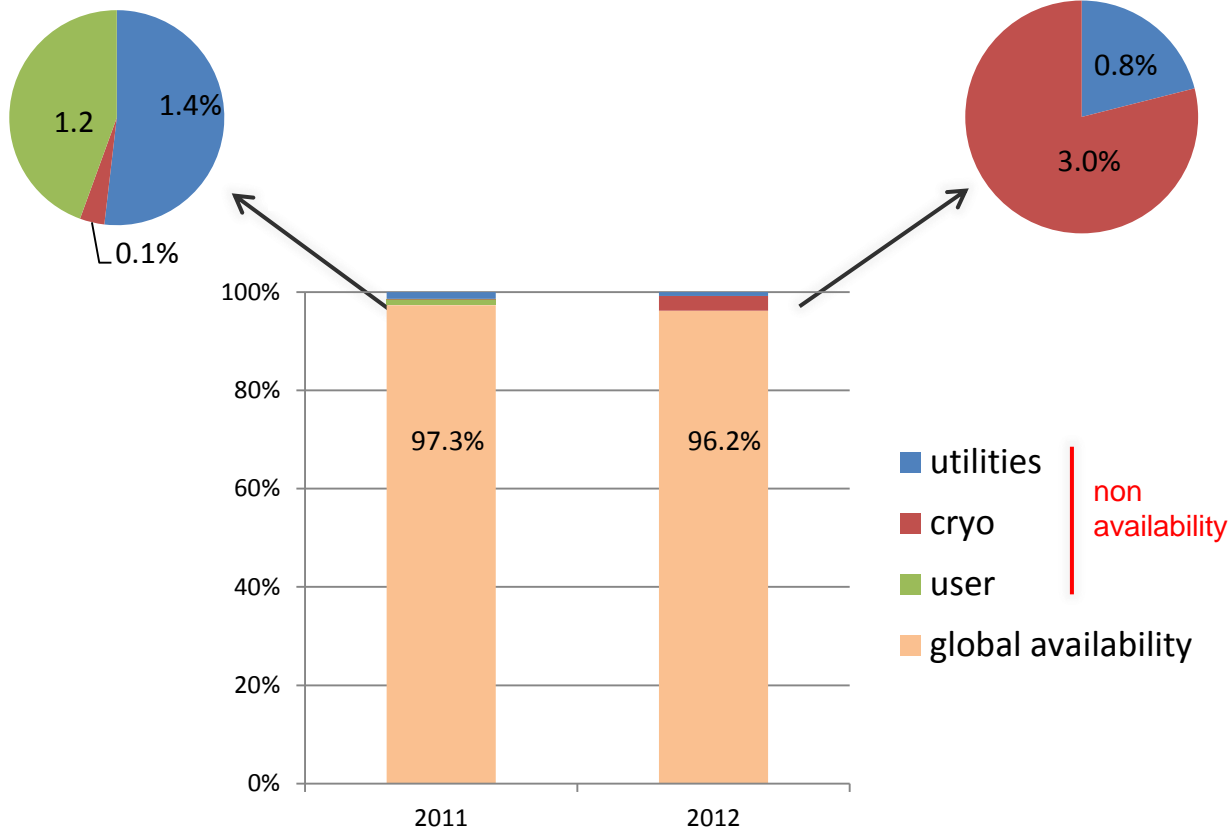
## LHC detectors operation:

- 365 day operation
- by CERN staff
- daily operation by 4 operators and one team leader

## On-call service for outside of working hours interventions :

- 4 “entitled” operators and one team leader
- start of on-site intervention within 1 hour from triggering of alarm
- back- up by 2<sup>nd</sup> line “Best Effort” support :
  - for operational or expert support in exceptional situation
  - for assistance of other support services (controls, electricity, maintenance...)

# Performance CMS of cryogenic system



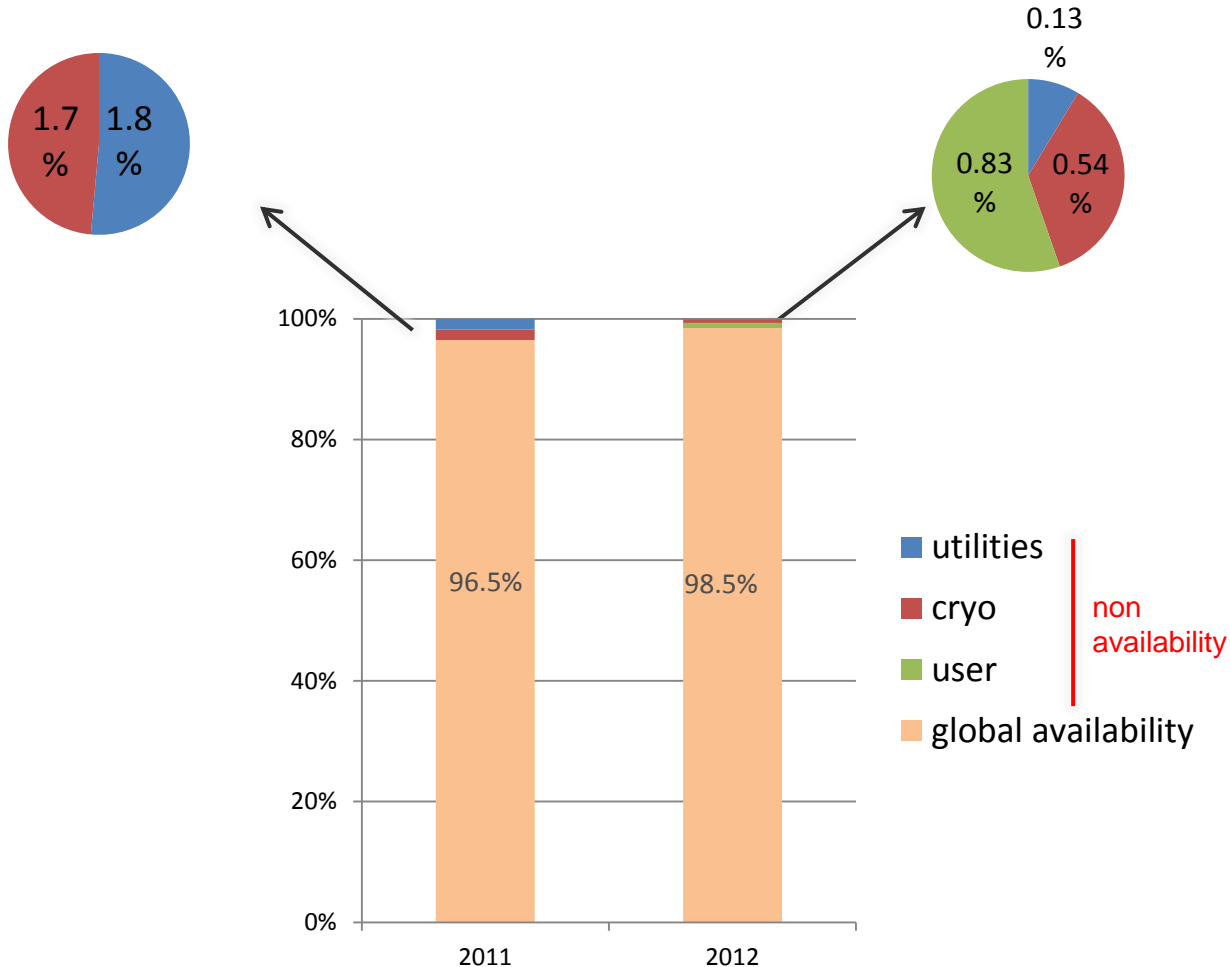
2011:

- 3 long power cuts by thunder storms
- problem current-lead regulation: fd → 83h
- problems cryo mostly solved during TS

2012:

- 4 problems with compressor safety chain
- 1 fd: wrong operation on cryo system
- cryo stop by problem UPS system

# Performance ATLAS of cryogenic system



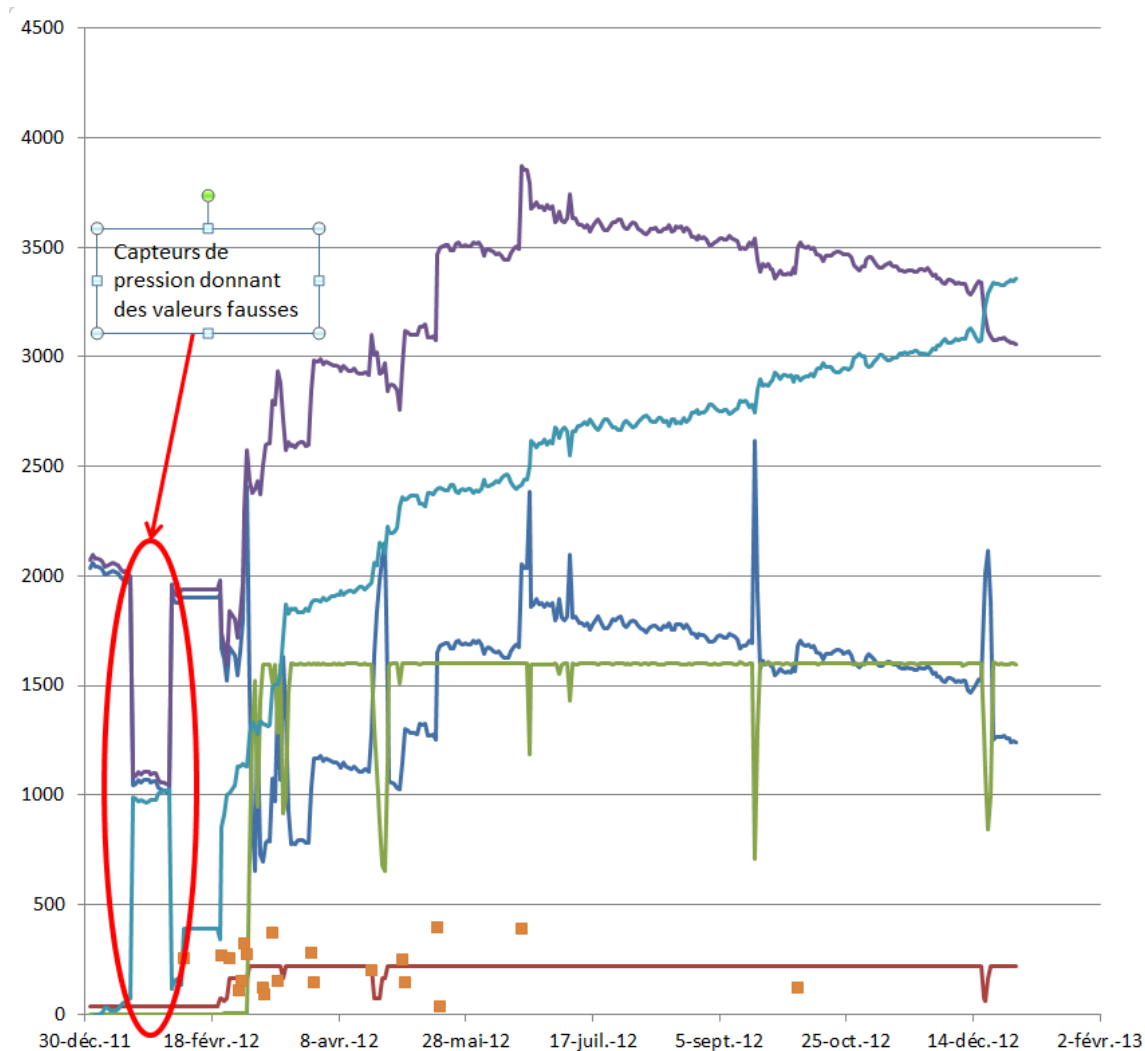
2011:

- 3 long power cuts by thunder storms
- stop of helium circulator: fd → 100h
- problems cryo mostly solved during TS

2012:

- Loss of magnet data: fd → 94 h
- Problem security chain T3, SD

# ATLAS helium inventory 2012



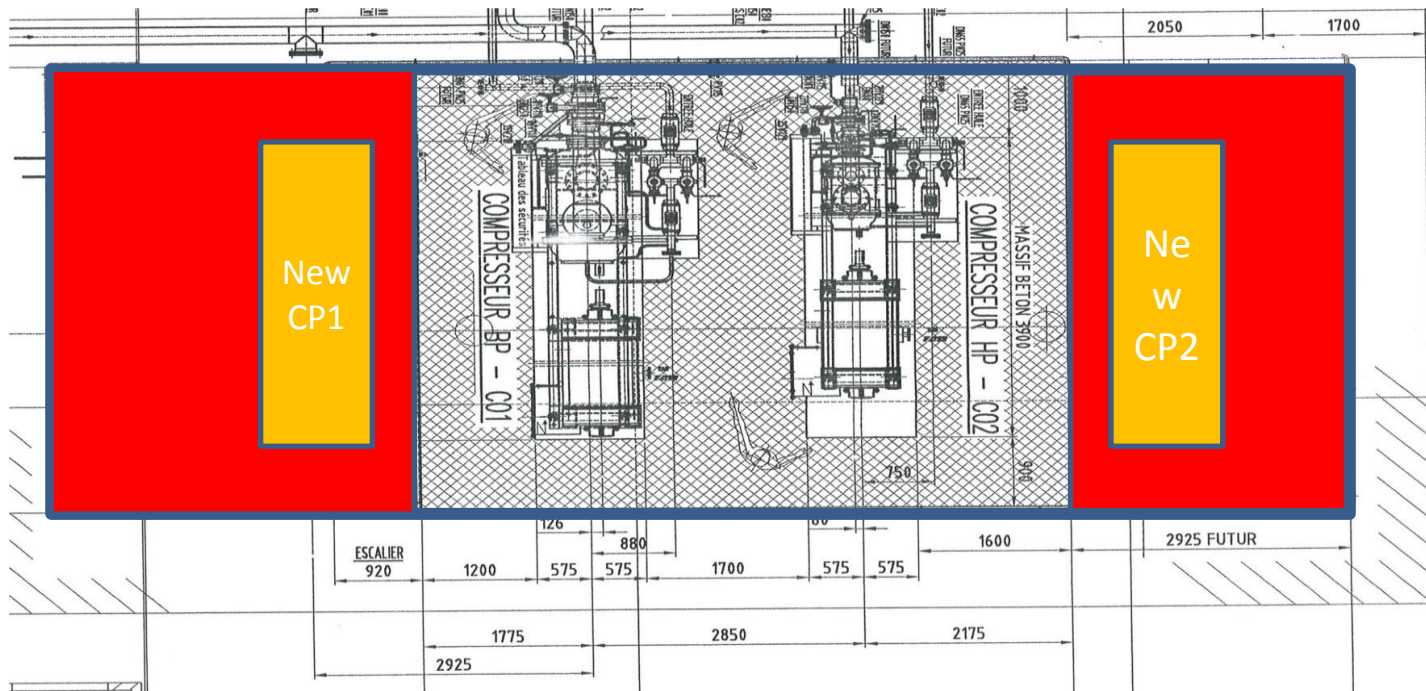
# Performance of ATLAS cryogenic system

	Nominal inventory (kg)	Strategic inventory (kg)	Total losses 2012 (kg)	Permanent losses (kg)	Losses due to stops (kg)	Others
CMS	900	1200	-1600	330 (~27% of SI) (0.9 kg / day)	660 (~ 80 kg / stop)	610 (purges)
ATLAS	2600	3500	-3350	1095 (~30% of SI) (3 kg / day)	740 (~185 kg / stop)	1515 (purges + CP6 installation)

# CMS Consolidation

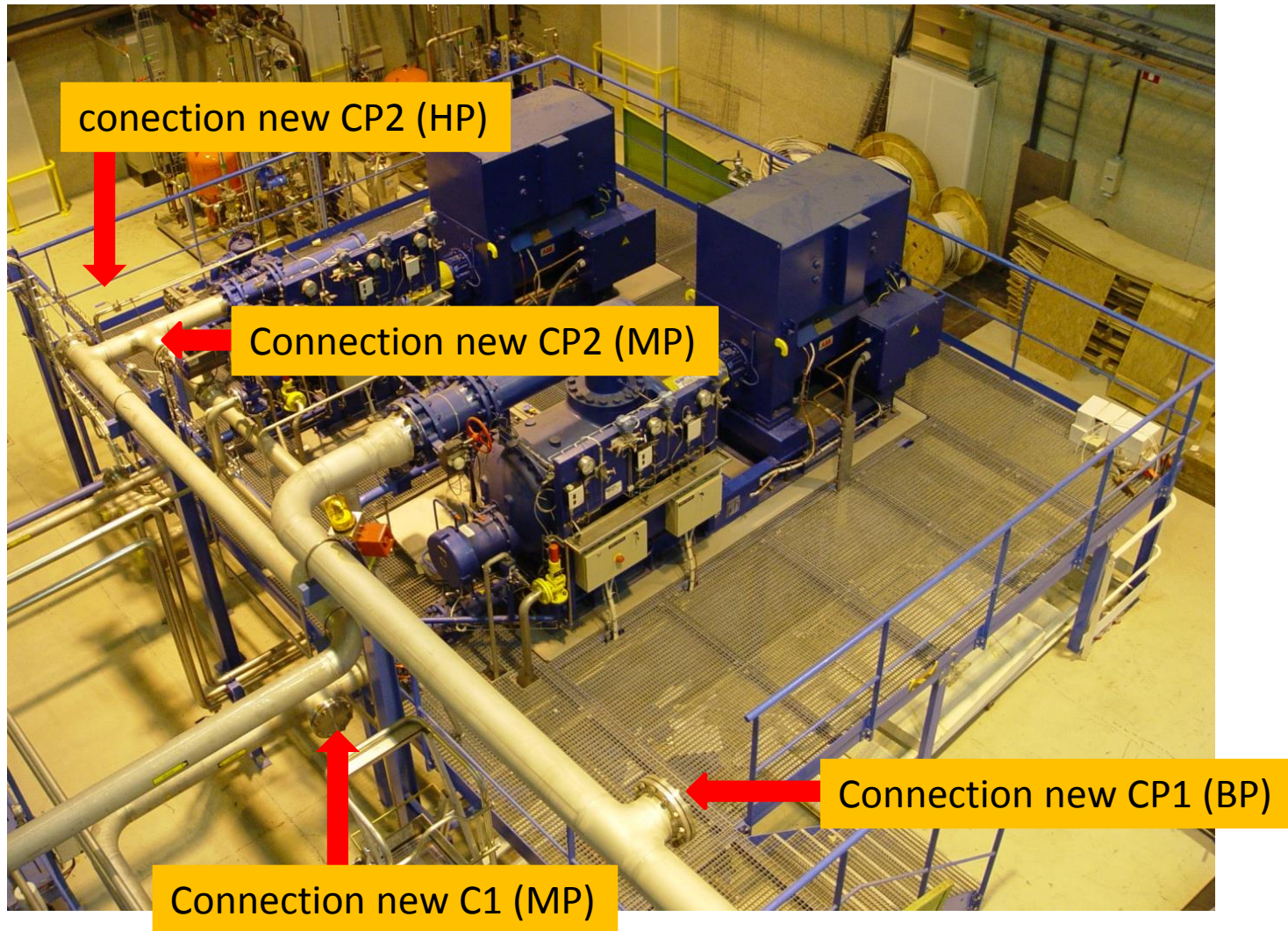
Installation two “parallel” compressor stations:

- To diminish down-time in case of large equipment failure





# CMS Consolidation



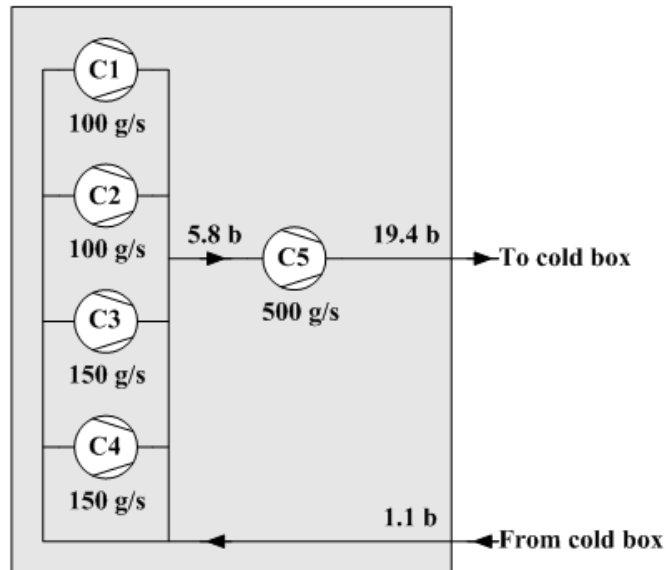


# ATLAS Consolidation

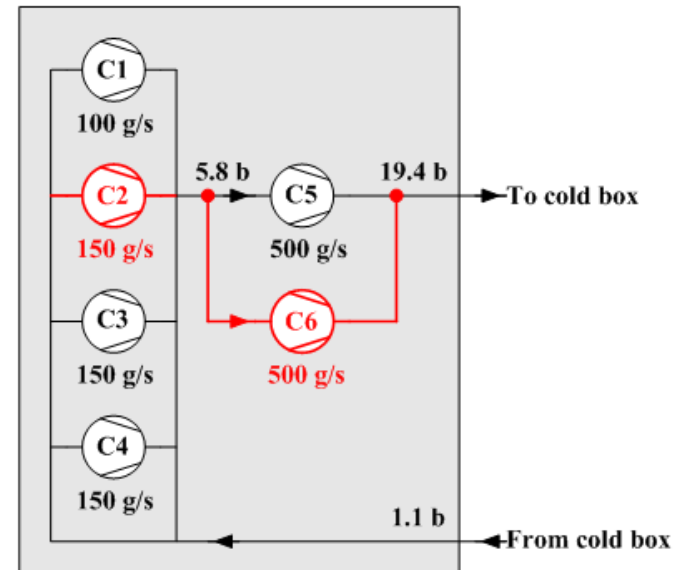
Installation two compressor stations:

- to diminish down-time in case of large equipment failure, keeping same operation conditions

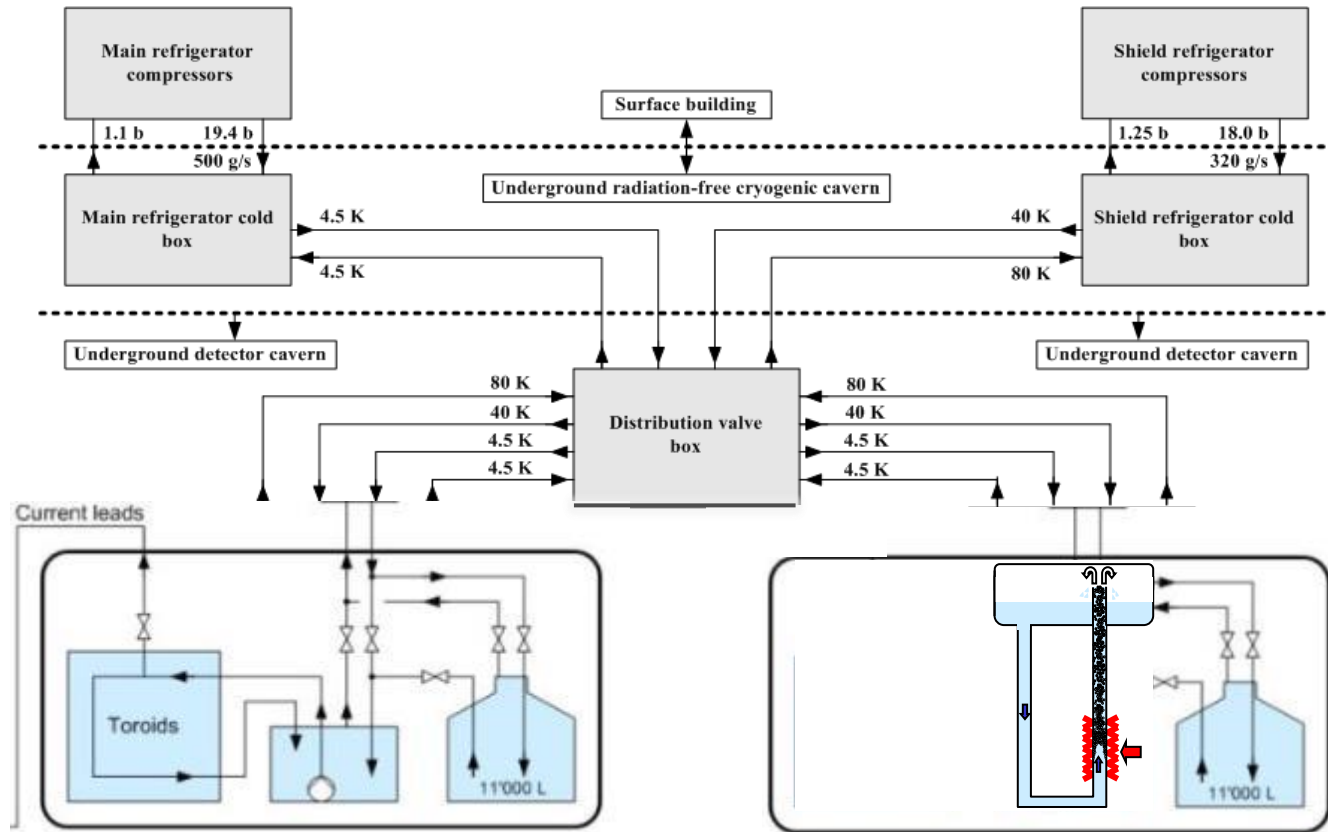
Configuration **BEFORE** consolidation:



Configuration **AFTER** consolidation:



# ATLAS Consolidation



De-coupling of the toroid and solenoid system by adding 11000 liter dewar to solenoid system

# Conclusions

- The ATLAS and CMS cryogenic installations are fulfilling the requirements of the detector systems;
- The control systems (hardware and software) have been improved to diminish the down time (sensitivity for micro-power cuts)
- Consolidations diminishing the long-term effect of mal-functioning compressor stations are implemented;
- Concerning ATLAS: de-coupling of toroid and solenoid system will diminish the effect of an eventual toroid fast-dump on the physics measurements

The consolidation of the ATLAS and CMS cryogenic systems should be finished in the 2<sup>nd</sup> half of 2014.



[www.cern.ch](http://www.cern.ch)