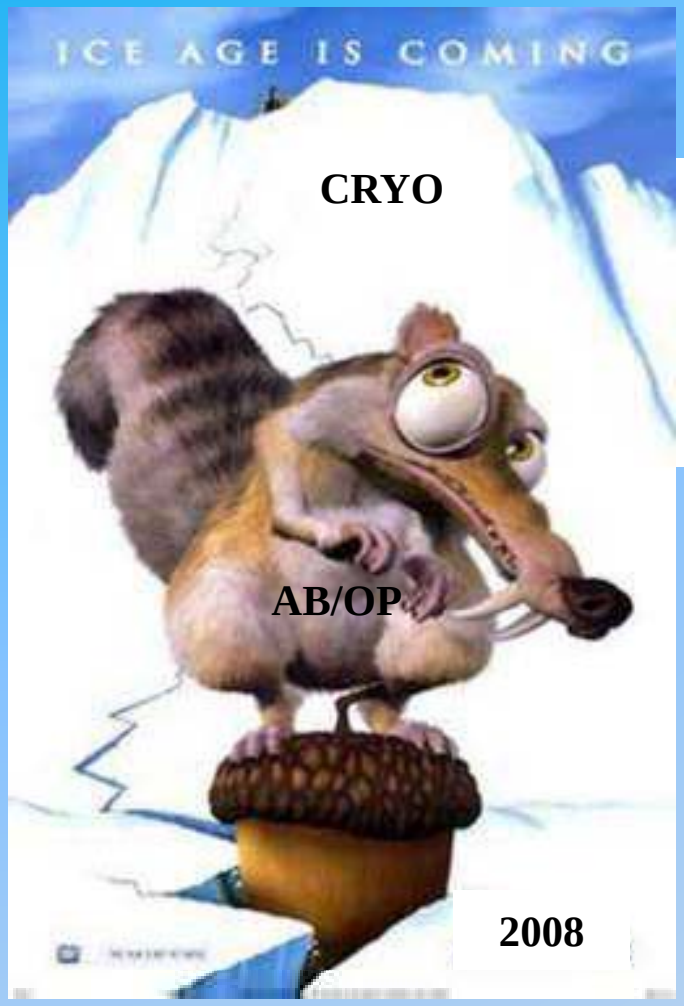
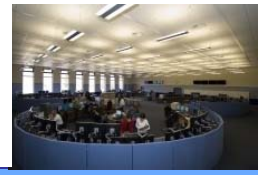


CRYOGENICS

8th November 2007
Workshop Machine Checkout

E. VEYRUNES
AB/OP

Presentation Layout



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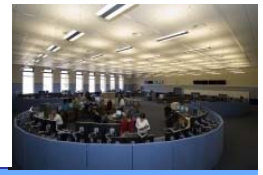
    - Cryo application
  - PM (Offline), LASER
- SUMMARY

Presentation Layout



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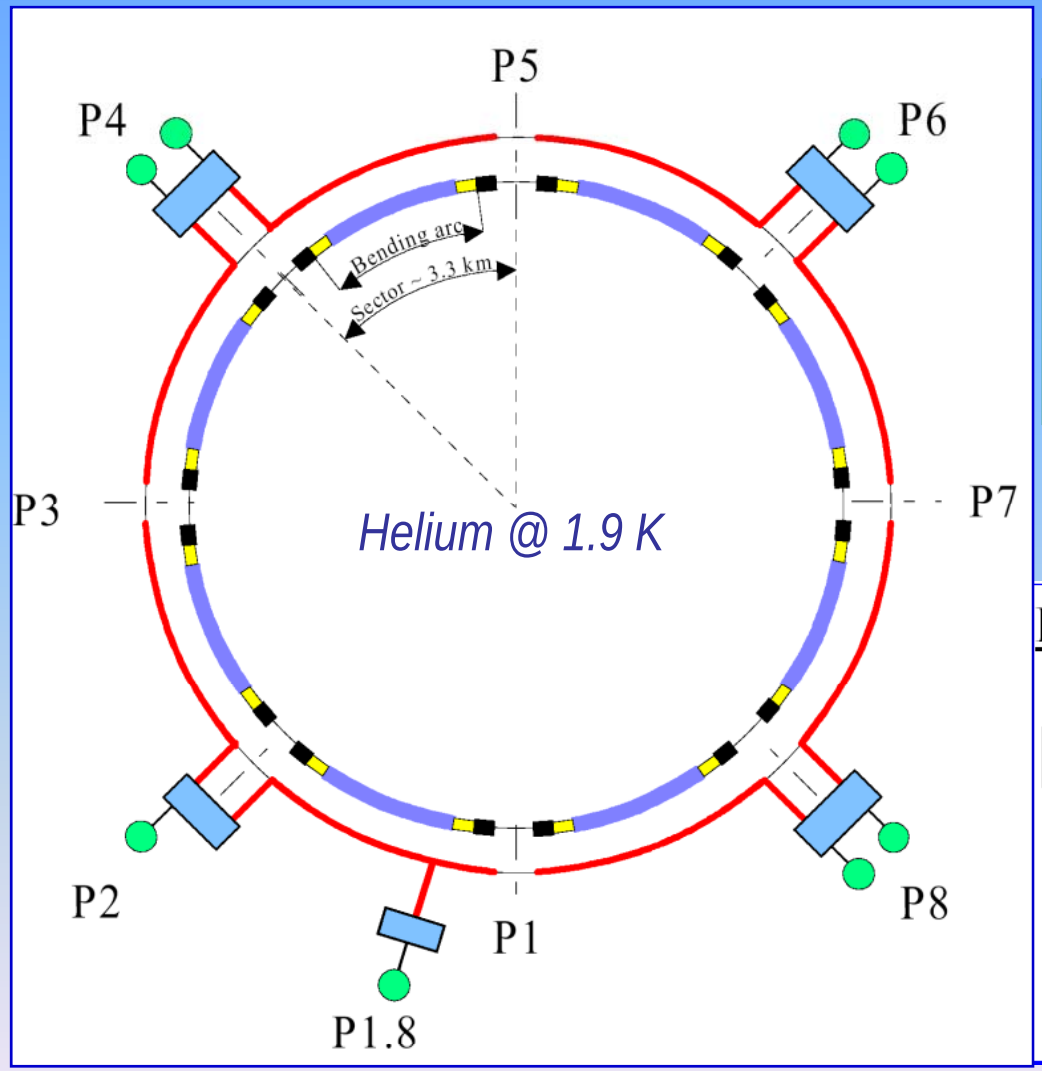
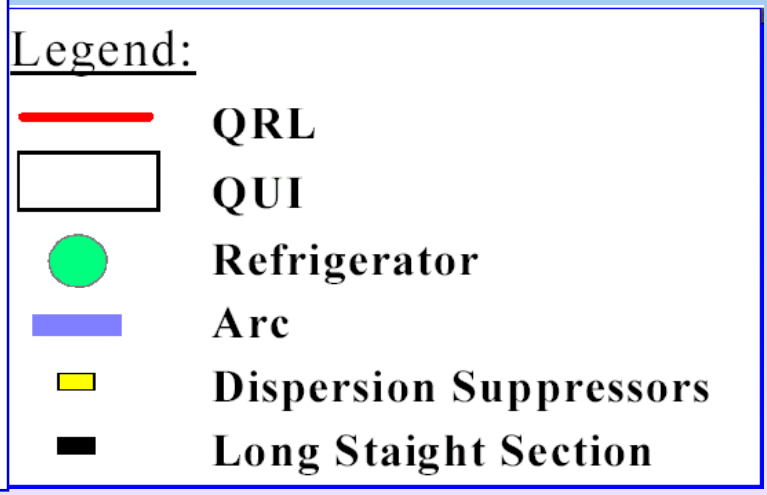
Cryogenics architecture

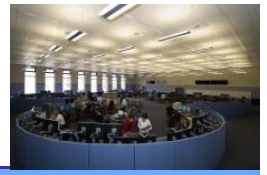


- Helium
- 5 Cryogenics plant
- Single cryo line along the machine



From S. Claudet, 18/10/07, LHC HWC safety

Cryogenics system introduction

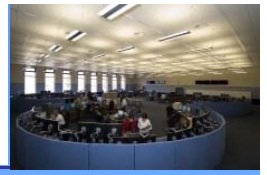


CRYO_START (authorization for powering)

- The CRYO_START is a start interlock. Therefore once the conditions are met the powering is authorised without any further acknowledgement. It requires a manual intervention (operator request) by the cryogenic operator. It will also modify the control temperature of the HTS (High Temperature Superconducting) leads.
- The CRYO_START ensures that the required conditions to power the magnets are met.
- It gives sufficient margins to “safely” operate cryogenic equipment (temperatures, pressures, levels).
- It does not protect equipment (it does not replace the quench protection system, the voltage taps, the beam monitors, etc.).
- If the CRYO_START disappears the machine can still safely run for several minutes.

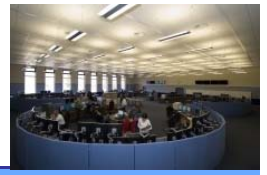
From L. SERIO, 29/03/07, CRYOGENICS AND POWERING

Cryogenics system introduction



CRYO_START

1. Superconducting magnets OK
   - Magnets below threshold (1.95 K) and pressure above threshold (1 bar)
   - Stand alone above threshold (level above threshold)
   - Beam screen temperature below 25 K
2. Line D (T lowest point above 5 K) and Quench Tanks empty (pressure)
3. DFB's OK
   - Liquid helium level between thresholds in DFB (to cover LTS-HTS joint and below maximum level)
   - Current leads temperature between threshold (48 K – 52 K)
4. DSL OK: temperature below threshold (5.2 K)
5. Sector refrigerators OK (Cryoplant Ok for powering)
   - Compressors
   - Cold compressors
   - Turbines
   - Phase separator above 50 %
6. Ethernet communication OK
7. Vacuum OK (Magnets and QRL): pressure below threshold (10^{-3} mbar)

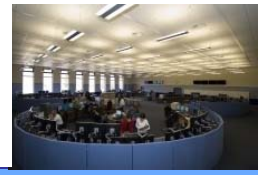


CRYO_MAINTAIN (request for slow discharge)

- The CRYO_MAINTAIN is a full stop interlock which cause a slow discharge. An operator acknowledgement is therefore needed to be able to power again the magnets.
- Only the conditions that will directly and rapidly provoke a quench (magnets, current leads, bus-bars) will be considered.
- A filtering logic on the sensor used for CRYO_MAINTAIN will be necessary in order to avoid unnecessary downtime due to failing sensors or electrical noise. In principle it will be based on the verification of 2 out of 3 sensors in the cell requesting the discharge or in the case of only 2 sensors both must be out; the conditions must be valid for at least 30 sec. Instrumentation clearly not functioning (open or short circuit) will be flagged out.

From L. SERIO, 29/03/07, CRYOGENICS AND POWERING

Cryogenics system introduction



CRYO_MAINTAIN

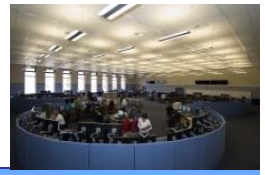
1. Magnets below temperature threshold or above liquid helium level (2 K or minimum level for stand alone)

2. Liquid helium level inside thresholds in DFB (above LTS (Low Temperature Superconductor)-HTS joint or below maximum level)

3. Current leads temperature below threshold (60 K)

4. DSL temperature below threshold (5.6 K)

Cryogenic conditions for RF



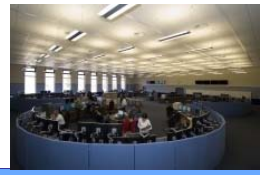
THE CRYO NOMINAL FOR START POWERING (Cryo Start):

- RF OK
- Liquid helium level in RF cavities between threshold: (40% = 100mm - 80% = 200mm)
- Pressure between 1335 mbar and 1365 mbar
- Vacuum RF Ok
- Cryo enable
- Cryoplant Ok for Powering
- Ethernet communication Ok

THE CRYO ACCEPTABLE FOR MAINTAIN POWERING (Cryo Maintain) :

- To have a Cryo for RF request to Stop the condition must stay active more than 30 seconds
- Liquid helium level in RF cavities below threshold (20%=50mm)
- Pressure above 1.5 bar

Cryogenic conditions for powering



Cryogenics conditions for powering:

- Conditions to authorize magnet powering

  (CRYO_START=TRUE and CRYO_MAINTAIN=TRUE)

- Conditions that do not authorize magnet powering but if there is already current in the magnets there is no request for discharge (the conditions of magnet powering were met at the time of the start of powering but have disappeared meanwhile)

  (CRYO_START=FALSE and CRYO_MAINTAIN=TRUE)

- Conditions that do not authorise magnet powering and request a slow current discharge

  (CRYO_START=FALSE and CRYO_MAINTAIN=FALSE)

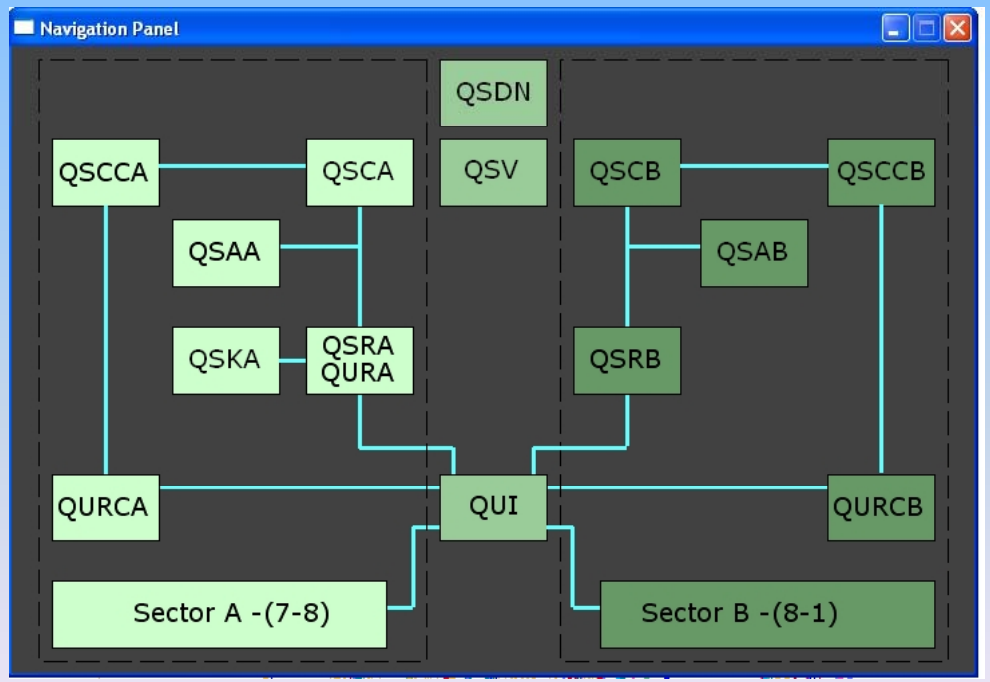
- RF has a separate cryo start and cryo maintain as an independent cryo sector.

Each circuits of sector have a CRYO_START and a CRYO_MAINTAIN

Status on 25/05/07

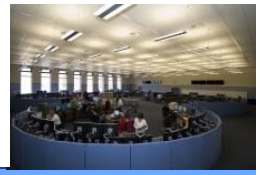
High level of detail in the application available in CCC.
Possible to navigate through the Cryogenic system.
Four access levels (the first three with password):

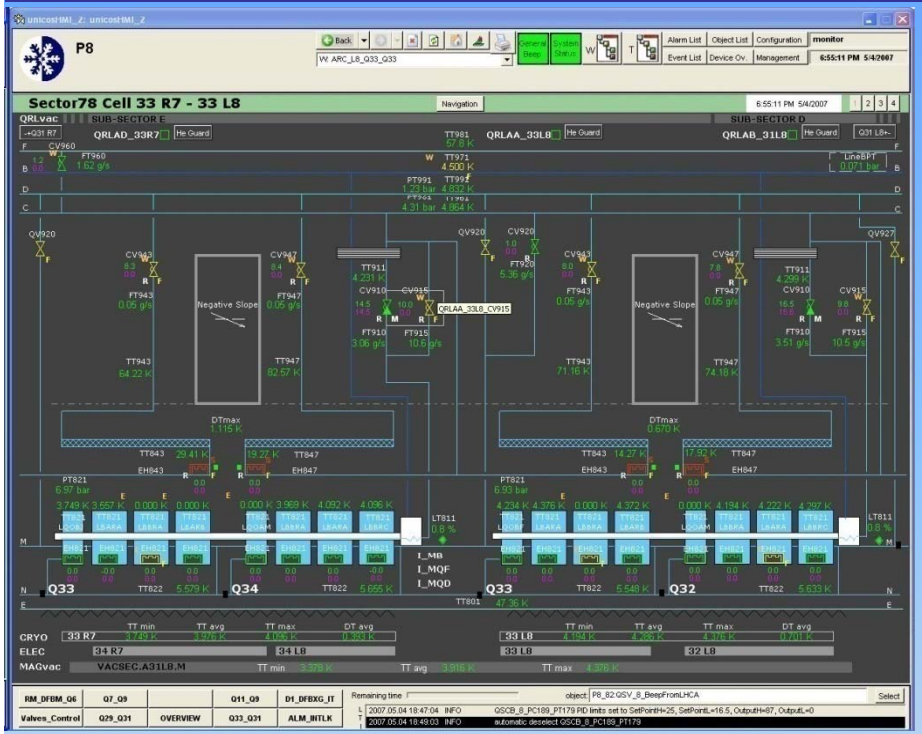
- Administrator: omnipotent
- Expert login: for experts only, direct control on each piece of equipment of the cryo system. Possibility to change interlock level.
- Operator: can operate the system, accessing the equipment but cannot change interlock levels.
- Monitor: Read access only ➔ this is the mode in which we should use the application. Under deployment: nominative access with role-based rights



From G. ARDUINI/S. REDAELLI, 25/05/07, LHC Systems Cryo

Status on 25/05/07





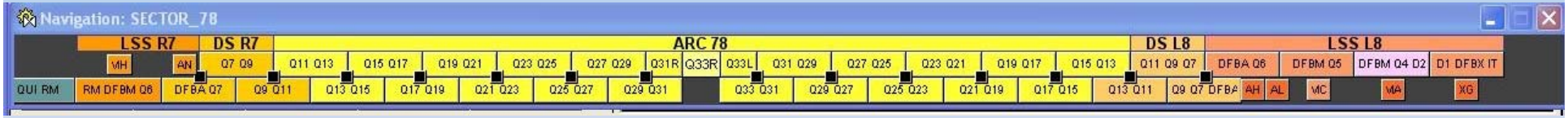
Green=OK

Yellow=Warning

Red=Not Ok

Blue=Invalid Data

Purple=Not Avail.



From G. ARDUINI/S. REDAELLI, 25/05/07, LHC Systems Cryo

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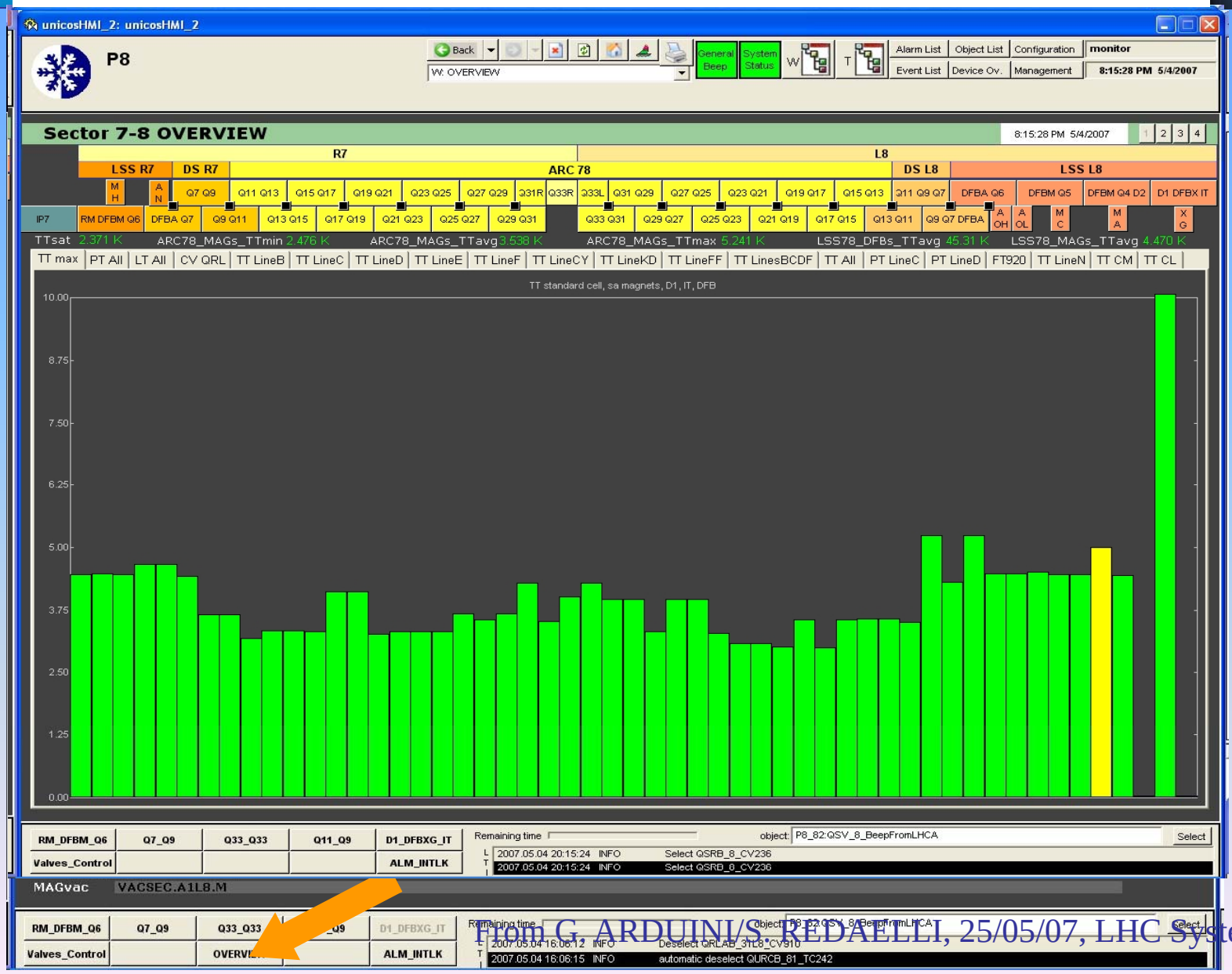

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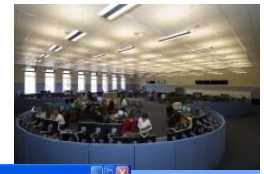
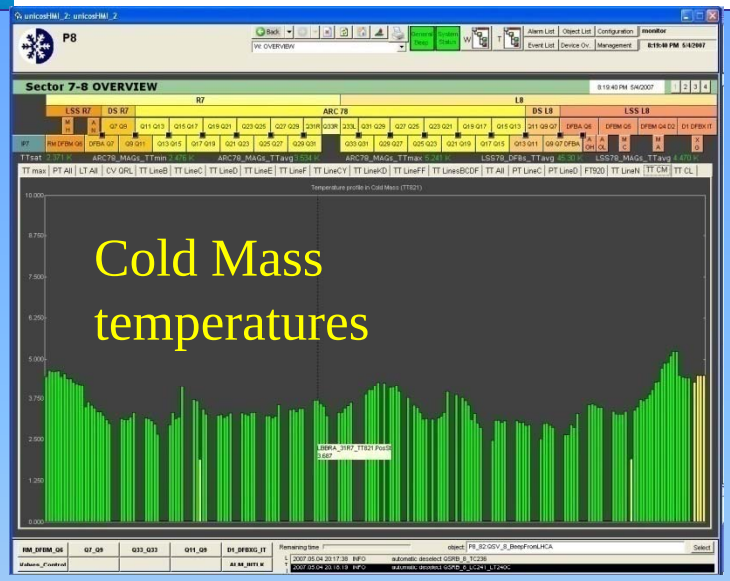
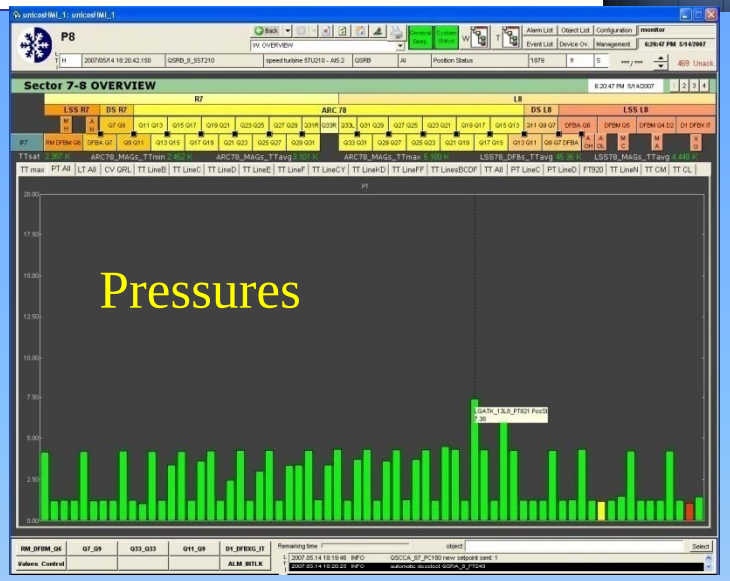
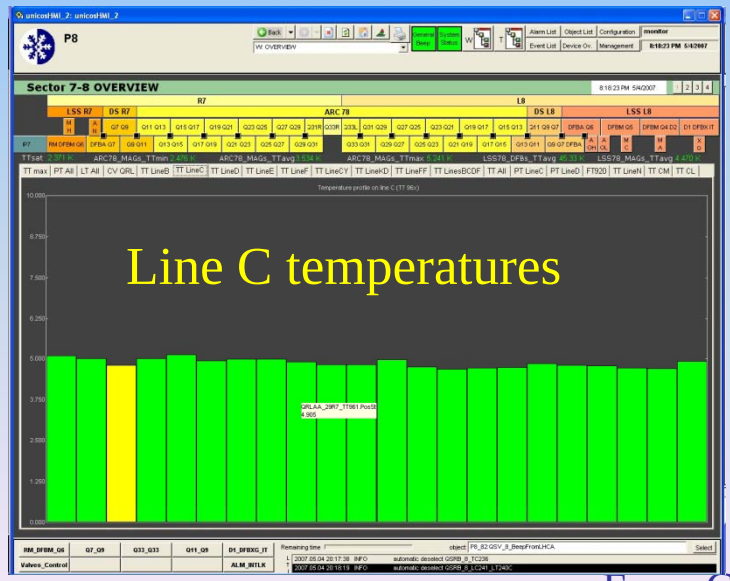


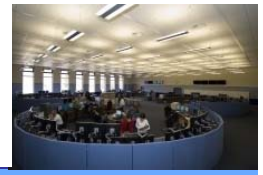






From G. ARDUINI/S. REDAELLI, 25/05/07, LHC Systems Cryo

Question and Request by OP

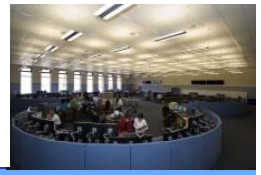


- ACR Support during Checkout first beam ?
- Global display of LHC situation (via Cryo_Start/Cryo_Maintain) ?
- Cryogenics Application improvement, for non-expert :
  - Cryo_Maintain and Cryo_Start easier to localize a problem :
    - By Sector
    - By Magnet
  - Trend instead of numeric value (not really readable)
  - Temperature charge during ramp of magnets
  - Who is responsible for Insulation Vacuum
  - Linked to alarm system
  - PVSS not accessible from LINUX

Post Mortem :

  - Delay of PM reading
  - Why Measurement DB not accessible ?

Presentation Layout



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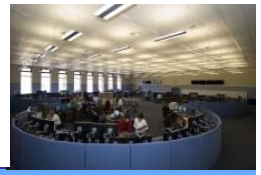
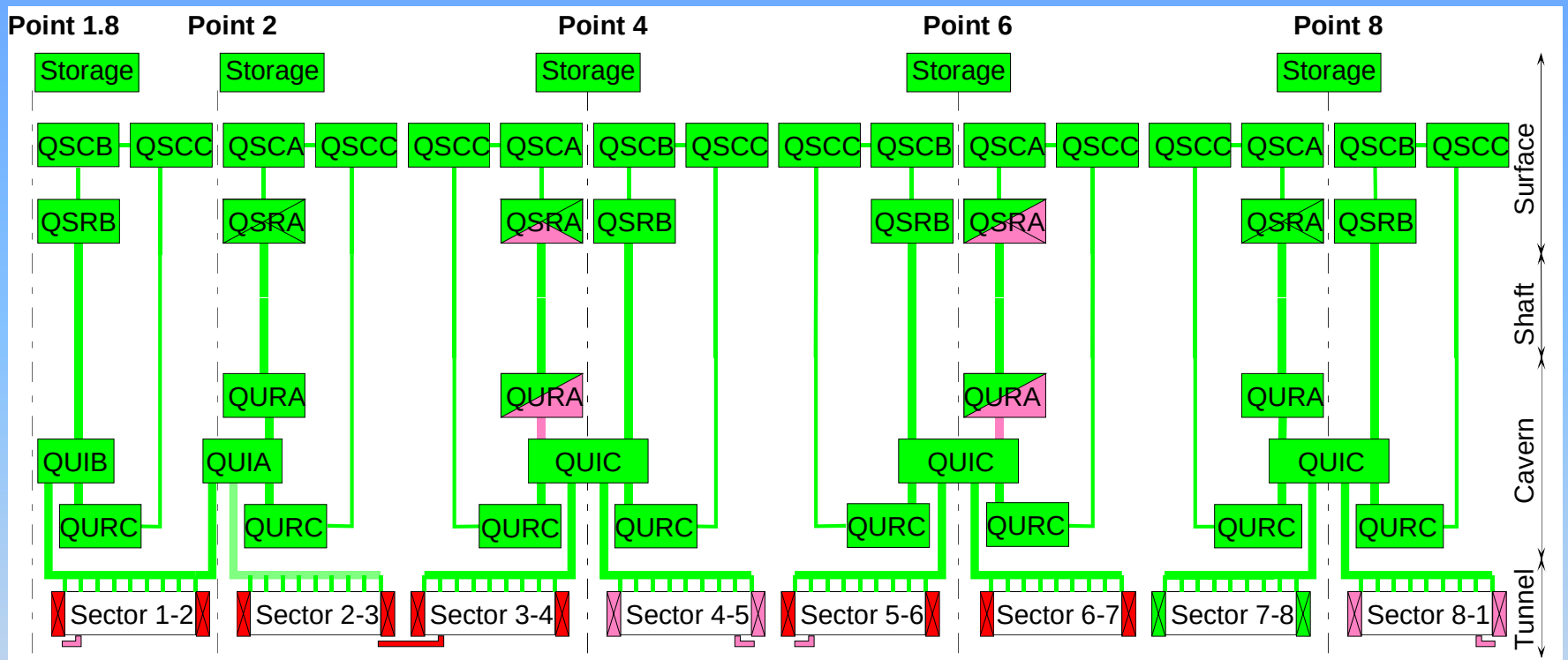
ACR Support during Checkout first beam



- **On-line:**
  - **Cryogenics :**
    - **As soon as 2 sectors cold at the same time, ACR operators will be in CCC.**
    - **2 × 8 h shift + on-call experts.**
  - **Insulation Vacuum :**
    - **Managed by AT/VAC.**

- **Off-line:**
  - **Cryogenic Performance Panel (CPP – Chair: L. Serio):**
    - **Analyze off-line, manage all aspects of cryogenic performance,**
    - **Study, propose improvements of functional procedure and consolidations,**
    - **Record and track cryogenic sub-system performance in relation to their manufacturing and test data.**
    - **Design and set-up of the tools for the additional on-line monitoring of the cryogenics during beam commissioning.**

Hardware situation

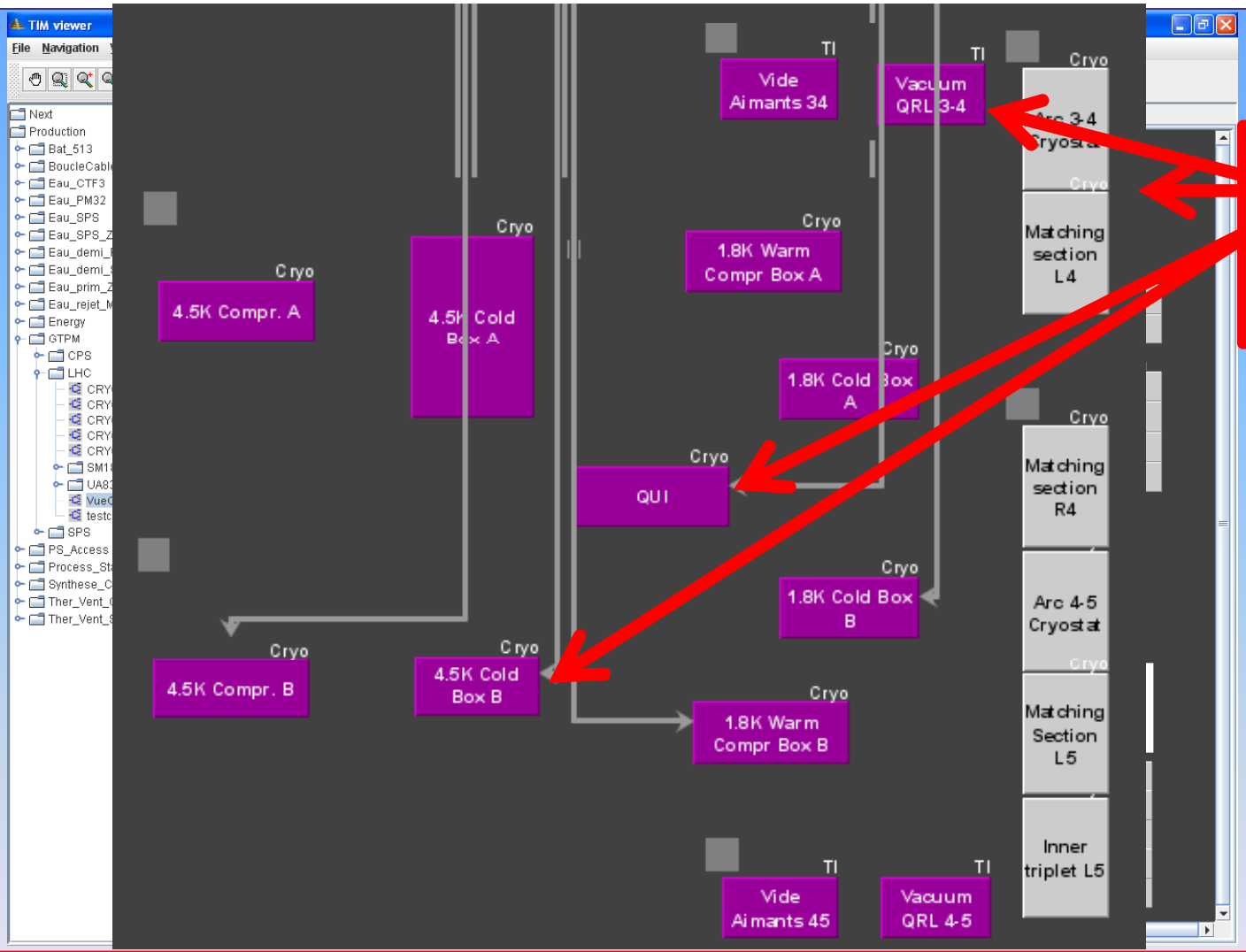


Display Cryogenics Status (Online)

- **Summary of the Cryo Maintain/Start conditions for the different Sub-Sectors**

Project has been put in low priority by ACR,
no resources by CO to developed it.

Display Cryogenics Status (Online)

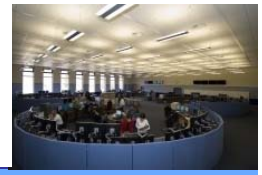


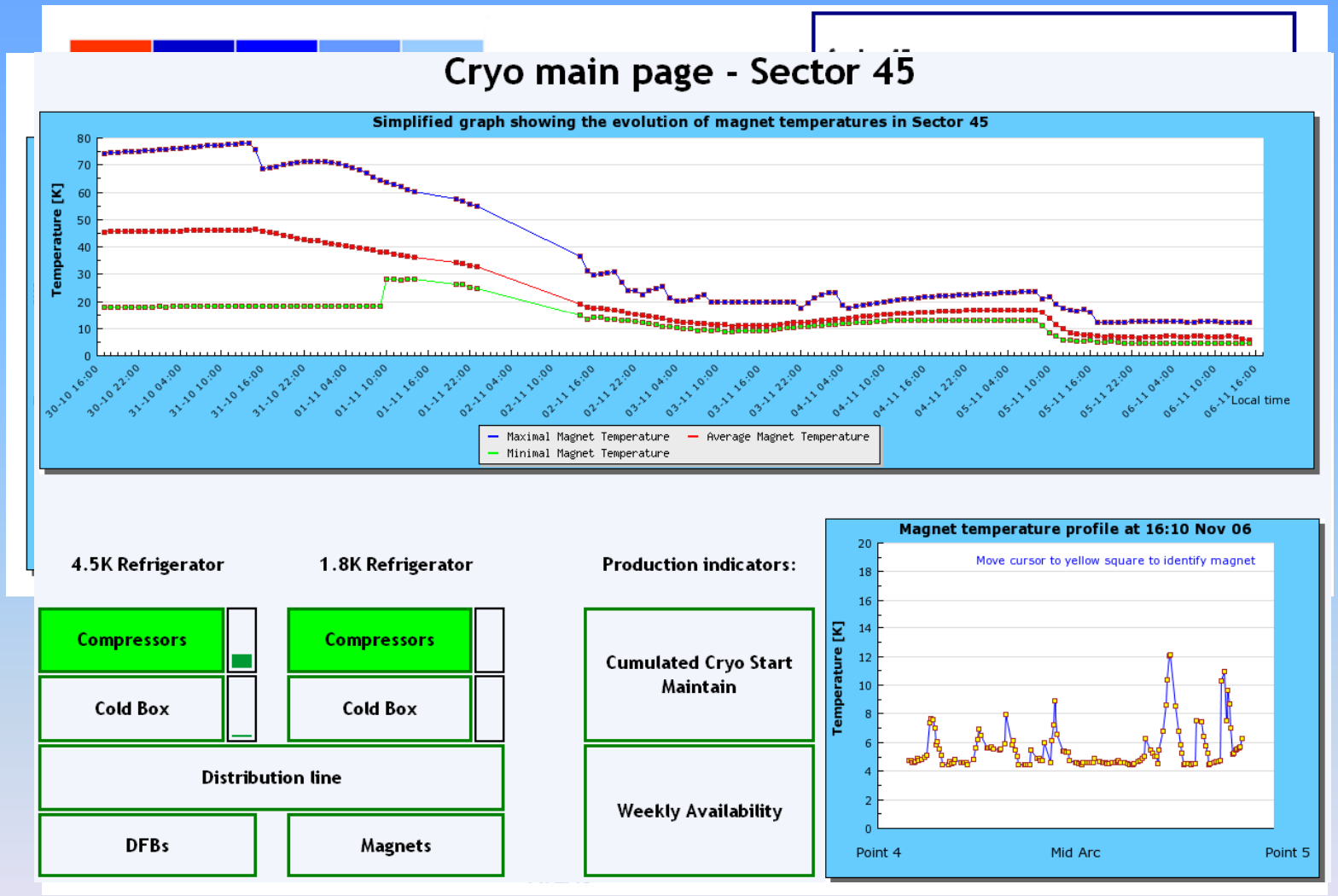
INPUT Already Connected

TI works on a TIM solution

A beam oriented fixe display can be developed in few week.

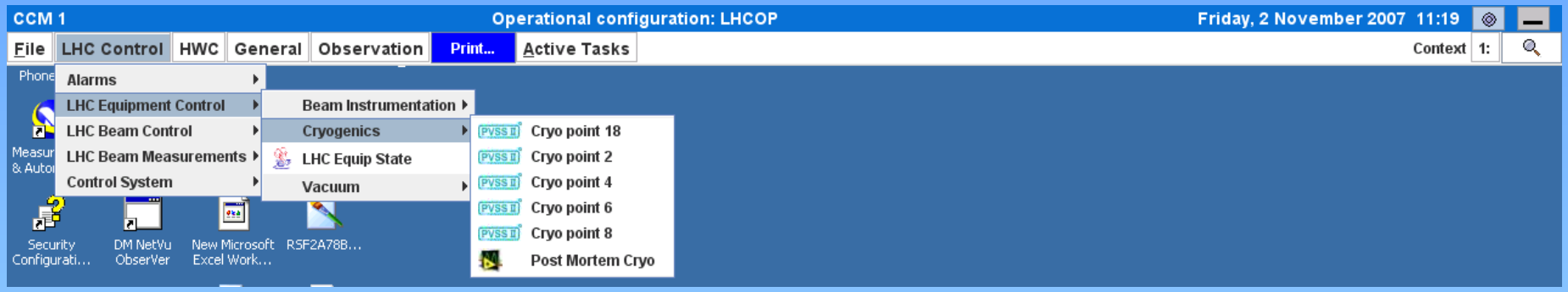
Display Cryogenics Status (Online)





HWC web pages via php to TIMBER DB,
but update every 1-5 min, can be made for AB/OP in few days.

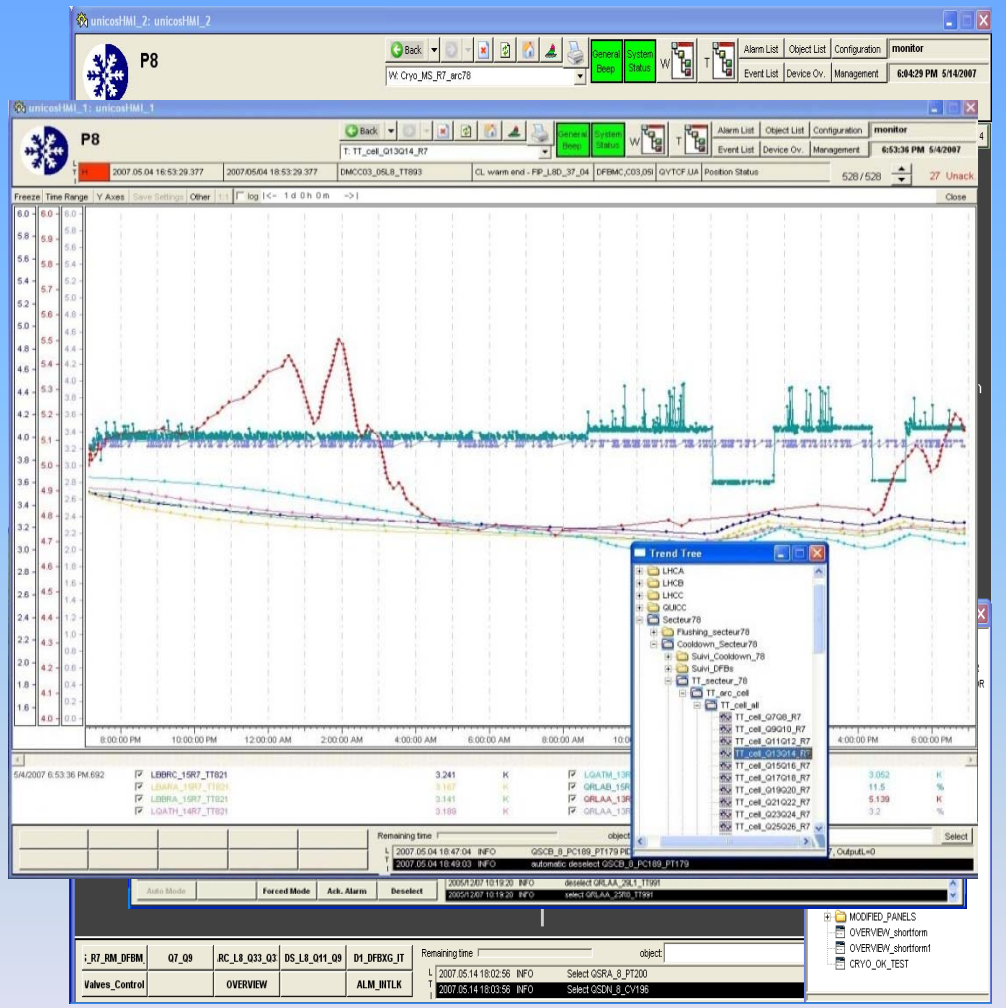
Access to Cryogenics application



- Monitor by default, in read access only.
- Actually only working on Windows, but February/March UI will work on Linux.
- There is actually no PVSS application grouping cryo data, each sectors are independent.

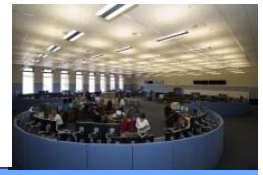
Application Investigation

- Cryo-Start/Cryo-Maintain
- Temperature
- Pressure
- Insulation Vacuum
- LHe level
- Current
- All I/O can be plot



No general view available for all cryo plant to localize a problem.
Because, actually each cryo plant independent

Other tools link with Cryo



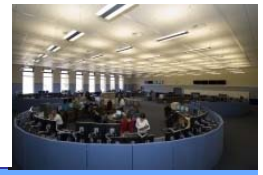
•PM:

-Login DB, or Measurement DB data up to last 7 days with high frequency record is manage by the application.
-Access to DB has been increased.
-Accessible from CCM via cryogenics menu.
Next step possible to be requested :
-Defined all signals needed by operation to define number of input to transfer from DB.
-GUI modification (if needed, during HWC).
\\cern.ch\dfs\Users\l\labsyste\Public\PM_PC_Browser_Next.exe

•LASER:

PVSS CRYO will be linked to LASER, end of November.

Presentation Layout



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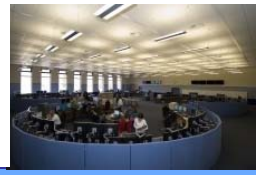
SUMMARY



- Cryogenics plant are closed to be ready.
- OP/ACR will be in CCC, as soon as 2 sectors cold at the same time.
- A display solution need to be found, before beam ready.
- PVSS Application need to be tune for a global view of the ring.
- Cryo will be ready for beam other application like Alarm, PM, TIM.

Documentation / Information

Thanks for your help:

- S. Redaelli (AB/OP), G. Arduini (AB/BI), L. Serio (AT/ACR), E. Blanco (AB/CO), H. Reymond (AB/CO), A. Rijllart(AB/CO), N. Stapley(AB/CO), P. Sollander (AB/OP), J. Szkutnik (TS/HDO).

Presentation :

- Special cases of cryogenic intervention(S. Claudet, 18/10/07)
- LHC-Sytem-Cryo (S. Redaelli, G. Arduini, 25/05/07)
- Cryogenics and Powering (L. Serio, 29/03/07)
- Controls for LHC cryogenics (L. Serio, 20/09/05)

Meetings:

- Soft requirements(P. Gayet, L. Serio, M. Sanmarti, M. Lamont, A. Butterworth, 31/06/01)

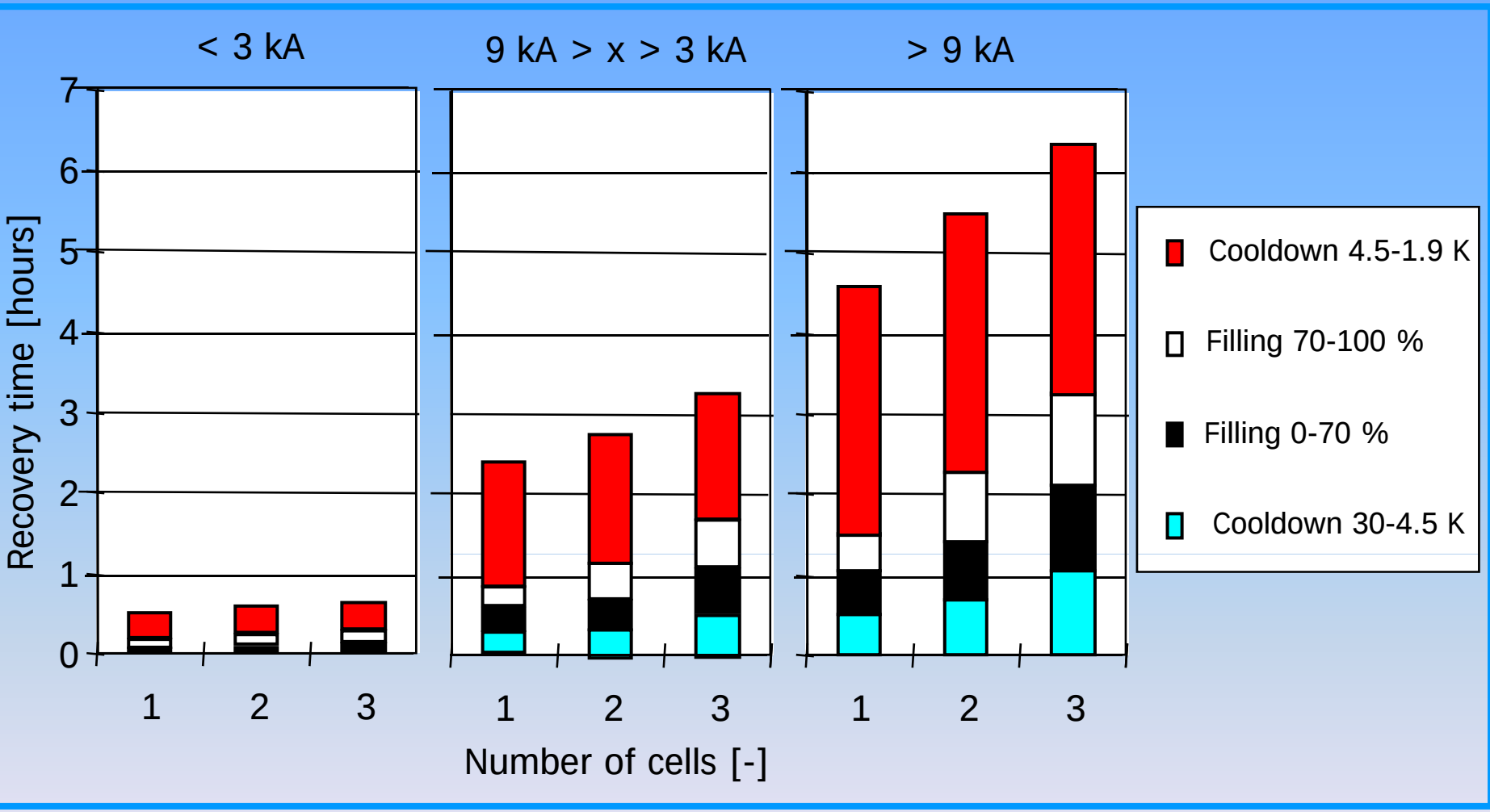
EDMS Doc:

- The Process of the Cryogenic System for LHC
- (G. Gubello, L. Serio, M. Soubiran, 18/10/06)

END

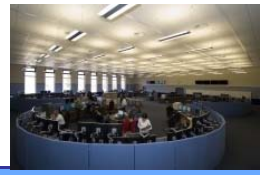
THANKS

Expected performances and limitations: cell quench recovery



- ✓Quench propagation within two adjacent cell
- ✓More than 14 cells or full sector recovery up to 48 hours

Expected interfaces and interactions



1. Machine setting-up and performance improvement
   - Strong reciprocal relationship between the magnets powering and cryogenics
     - Magnet powering requires accurate preparation of the cryogenic system and constant monitoring during ramping to avoid operational quenches
2. Machine reliability and availability
   - Monitoring, control, recovery actions coordinated with magnet powering for reciprocal optimization and increased availability
   - Monitoring, control, recovery actions coordinated with technical infrastructures for start-up and recovery optimization