Session 8: What we will do for beam preparation in 2009

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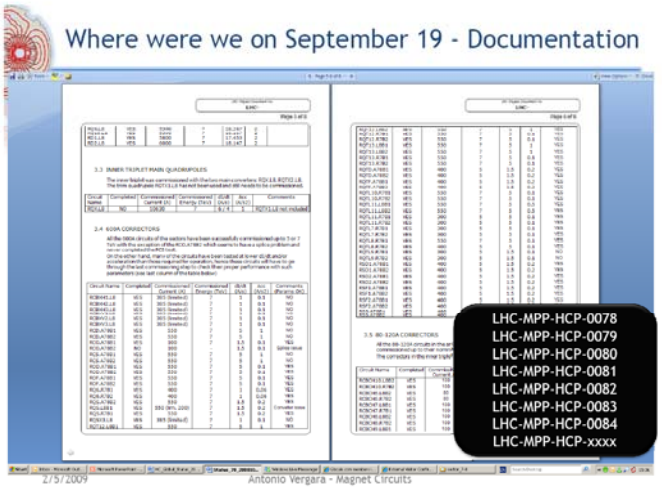
What we will do for beam preparation in 2009

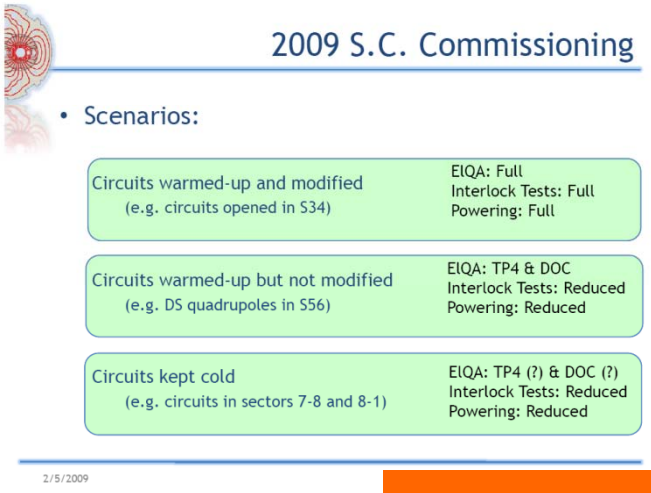
- Magnet circuits (A.Vergara)
- Powering interlocks (M. Zerlauth)
- Beam interlocks (J. Wenninger)
- Injection and Beam Dump (J. Uythoven)
- RF (E. Ciapala)
- SC magnet (re)training (E. Todesco)

What we will do for beam preparation in 2009

- Main questions for the speakers:
  - What could not be completed in 2008 and needs to be done in 2009?
  - Planned modifications and impact on the re-commissioning of the systems.
  - New procedures for the commissioning as a function of Sector 34 incident.
  - Tools to speed-up the re-commissioning.
  - Impact of new access rules on “sectorized” cold check-out in parallel to HW Commissioning.
  - Needs and possible strategy for training of the SC circuits for 5 TeV operation or higher.

Magnet circuits

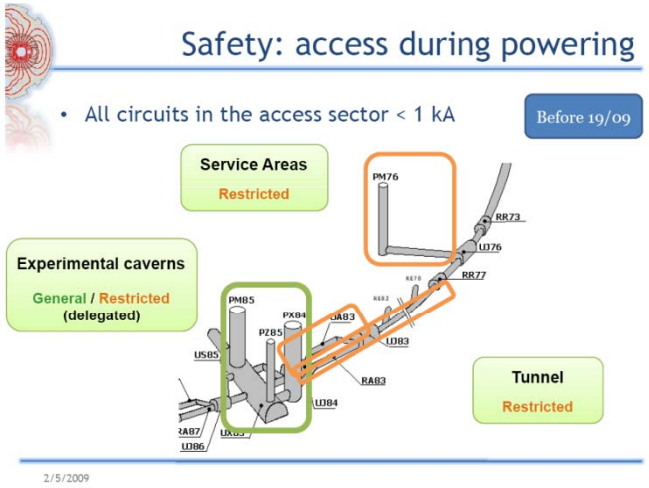


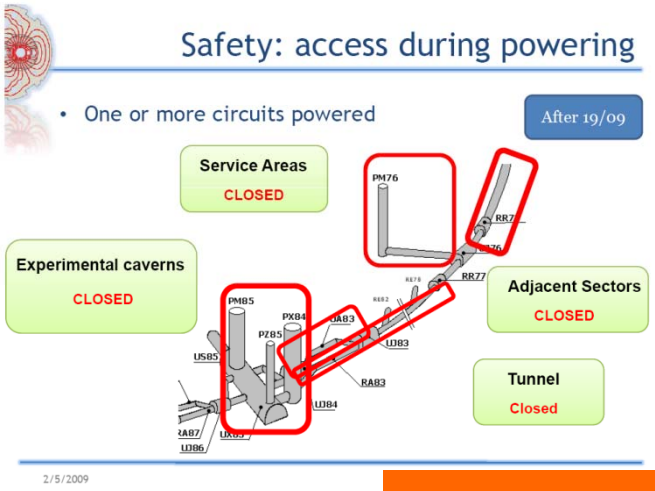


A. Vergara

- Status of the commissioning of the circuits and existing non-conformities known and (being) summarized in EDMS documents
- The main lines of the strategy for the re-commissioning are sketched:
  - 3 different scenarios have been identified
  - Possible subsets of tests have been identified
- Commissioning up to ≤ 5 TeV does not save powering time but will reduce risks (for main circuits)
- Need a review of the parameters required for operation (e.g. current ramp rate and acceleration) before starting the tests
- Need re-definition of the detailed procedures for each of the commissioning scenarios above identified ➔ started

Magnet circuits

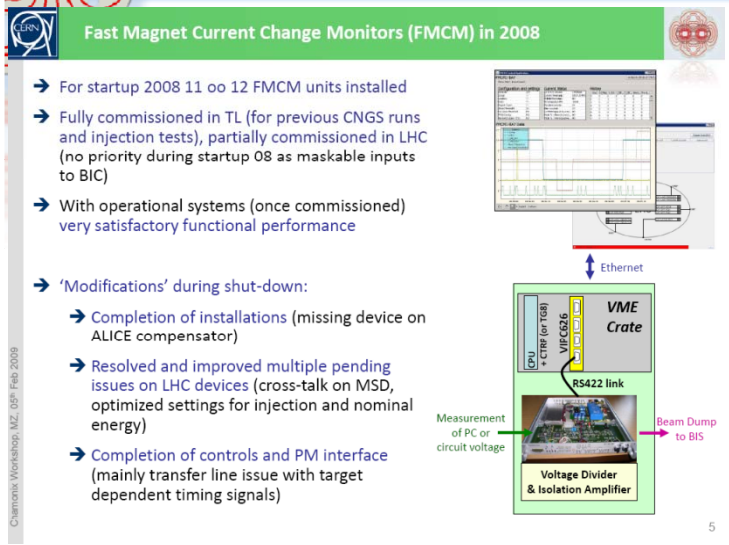


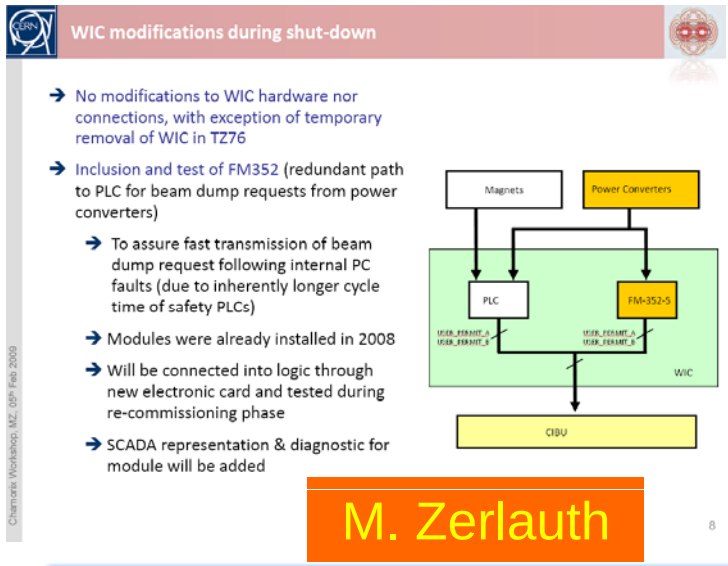


A. Vergara

- Parallelism is possible but will be strongly conditioned by access procedures during powering.
- Most of the powering tests at low current
- 2 access modes/powering phases:
  - Sector in Low Current Mode ➔ Restricted access with current limitation (HW)
  - Sector in High Current Mode ➔ Machine closed and no current limitation
- Need to define the access conditions during powering ➔ ongoing
- Tools for showing on-line powering conditions and compatibility with access are needed
- Possibility of running nights/WE: feasible? Enough expert coverage? Many people involved in HW Commissioning have left!

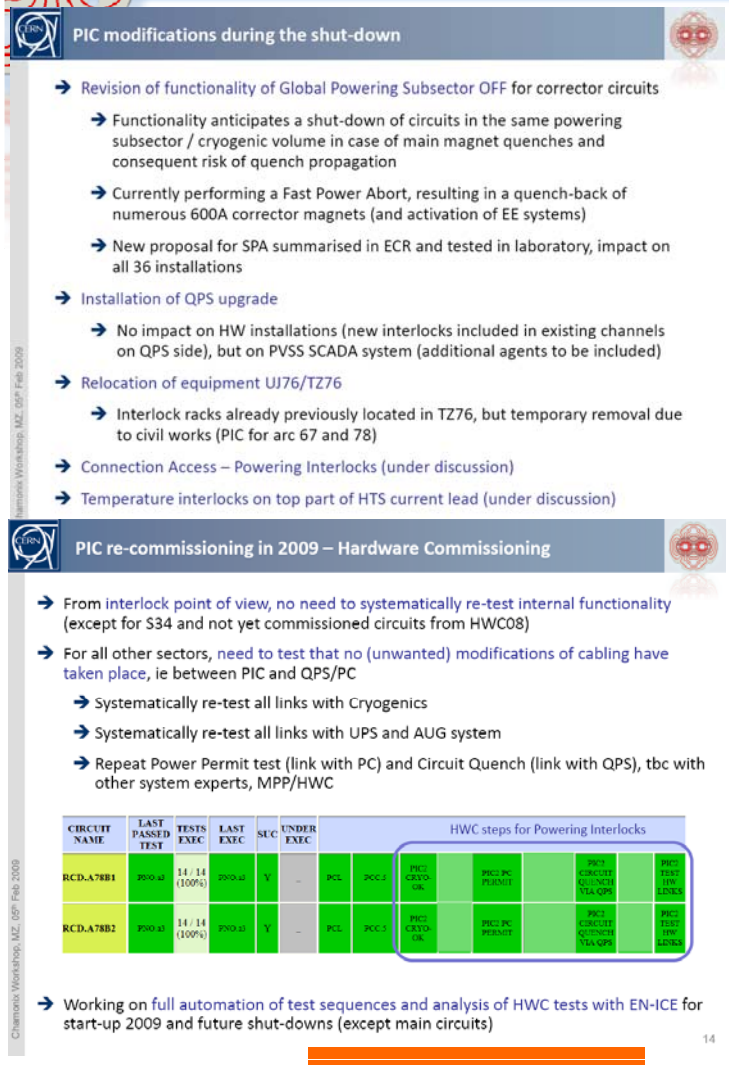
Powering interlocks





- Modifications ongoing in the protection of the warm magnet circuits:
  - FMCM (12 circuits):
    - To complete the installation (1 –unused- circuit missing on 10/9)
    - To improve settings for full operational range (injection to nominal) and complete controls interface
  - Warm Magnet Interlock Controller (45 circuits):
    - To add redundancy and even faster reaction time (required for operation with “unsafe beams”)
- Need full re-commissioning
- Given the limited number of circuits and the limited time required for the commissioning of a circuit no automatic procedure will be available for 2009 (but later)

Powering interlocks



PIC modifications during the shut-down

- Revision of functionality of Global Powering Subsector OFF for corrector circuits
  - Functionality anticipates a shut-down of circuits in the same powering subsector / cryogenic volume in case of main magnet quenches and consequent risk of quench propagation
  - Currently performing a Fast Power Abort, resulting in a quench-back of numerous 600A corrector magnets (and activation of EE systems)
  - New proposal for SPA summarised in ECR and tested in laboratory, impact on all 36 installations
- Installation of QPS upgrade
  - No impact on HW installations (new interlocks included in existing channels on QPS side), but on PVSS SCADA system (additional agents to be included)
- Relocation of equipment UJ76/TZ76
  - Interlock racks already previously located in TZ76, but temporary removal due to civil works (PIC for arc 67 and 78)
- Connection Access – Powering Interlocks (under discussion)
- Temperature interlocks on top part of HTS current lead (under discussion)

PIC re-commissioning in 2009 – Hardware Commissioning

- From interlock point of view, no need to systematically re-test internal functionality (except for S34 and not yet commissioned circuits from HWC08)
- For all other sectors, need to test that no (unwanted) modifications of cabling have taken place, ie between PIC and QPS/PC
  - Systematically re-test all links with Cryogenics
  - Systematically re-test all links with UPS and AUG system
  - Repeat Power Permit test (link with PC) and Circuit Quench (link with QPS), tbc with other system experts, MPP/HWC

CIRCUIT NAME	LAST PASSED TEST	TESTS EXEC	LAST EXEC	ST/C	UNDER EXEC	HWC steps for Powering Interlocks							
RCD.A78B1	PNO.a2	14 / 14 (100%)	PNO.a2	Y	-	PCL	PCC.3	PIC1 CRYO OK		PIC2 PC PERMIT		PIC1 CIRCUIT QUENCH VIA QPS		PIC1 TEST HW LINKS
RCD.A78B2	PNO.a2	14 / 14 (100%)	PNO.a2	Y	-	PCL	PCC.5	PIC1 CRYO OK		PIC2 PC PERMIT		PIC1 CIRCUIT QUENCH VIA QPS		PIC1 TEST HW LINKS

- Working on full automation of test sequences and analysis of HWC tests with EN-ICE for start-up 2009 and future shut-downs (except main circuits)

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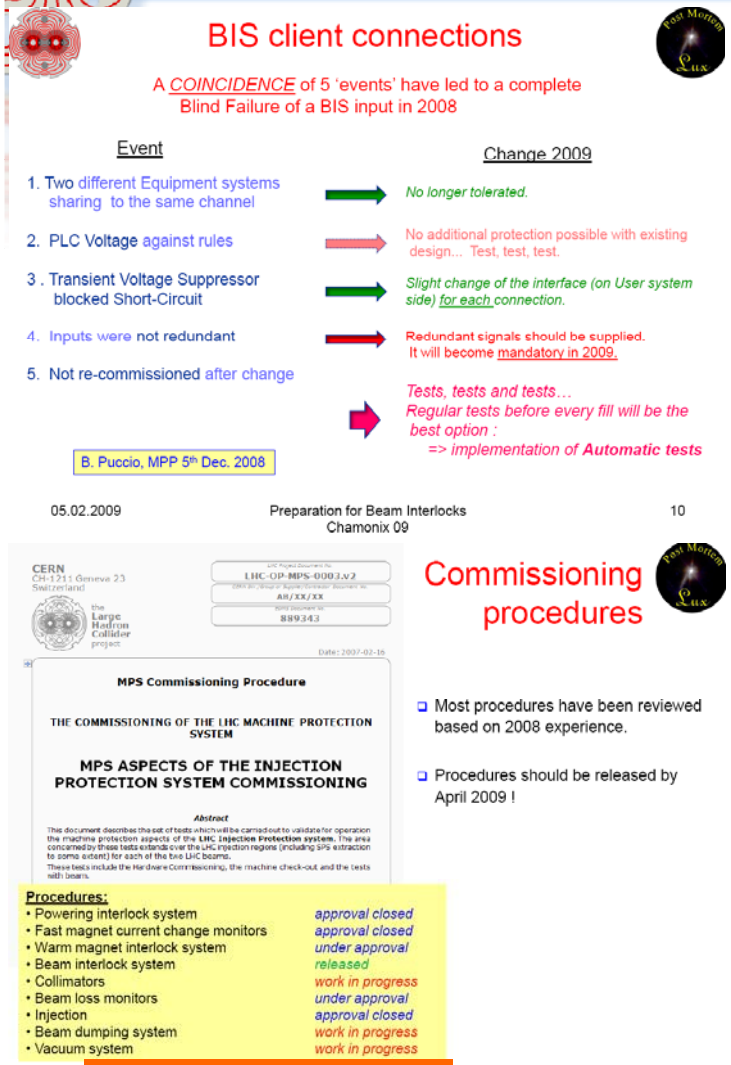
M. Zerlauth

- Powering Interlock Controller (820 circuits + 752 - 60 A orbit correctors). No modification of the HW but:
  - Different logic for the "Global Powering Sub-Sector"
  - Relocation of equipment due to civil engineering in TZ76
  - A New QPS System connected to PIC.....
- Except for Sector 34 (to be considered a new sector) HWC steps for powering interlocks need to be repeated ➔ automatic procedure being put in place (except for main circuits)
- Automatic tests procedures for the PIC to BIC connection verification are available as well (1 hour/sector)
- Potential issue: Robustness of CPLD XC95144 used in PIC against Single Event Upsets after recent radiation tests (not conclusive yet).

Beam Interlocks



- Very large Beam Interlock System (BIS):
  - ~10000 devices/interlocks connected to Beam Interlock Controllers (BIC)
  - ~3800 Software Interlocks
- 2008 experience & status:
  - Blind failure detected during LHC cold check-out ➔ solution in place for 10/9
  - Definitive changes and measures being implemented during the SD ➔ 2 new channels (+ additional one)
  - Safe beam flag not commissioned (we ran only with probe beam)
- Full test needed of all the system
- Automation is a must ➔ started in 2008 (e.g. PIC-BIC connection) ➔ being extended
- Documentation/issue tracking effort ongoing (procedures, MTF)

Beam Interlocks

MPS Commissioning Phases

Phase	Energy	Int.	Comments
MPS-1: Probing 450 GeV	0.45	≤ 10^{10}	• Early commissioning phase. • Can run with 'minimal' interlocks – '2008-style' • 'Light' powering interlocking (maskable). • Experiments protection must be ready !
MPS-2: Ramp	0.45 – 7	≤ 10^{10}	• All interlocks commissioned. • Post-mortem recording operational. • Beam related MPS tests passed at 450 GeV. • Commission in steps of 0.5-1 TeV.
MPS-3: Increased intensity at 450 GeV (injection ≤ 10^{11})	0.45 – 7	≥ 10^{11}	• All interlocks commissioned. • Post-mortem recording operational. • Beam related MPS tests passed at 450 GeV.
MPS-4: Squeeze			• All interlocks commissioned. • Subset of beam tests must be repeated for every significant squeeze step.
MPS-5: Unsafe injection	0.45	≥ 10^{11}	• All beam related injection MPS tests passed.

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MPS test with 'entire' LHC

- Some MPS components can only be tested when the Beam Energy Tracking System (BETS) of the LDBS is working.
- Requires dedicated periods where *eventually* at least ½ of the LHC must be available (also ramps !) – sectors 45,56,67 and 78.
- Systems:
  - BETS – internal interlock tests.
  - LBDS dry dumps.
  - SMP : Safe Energy.
  - BLM thresholds with energy.
  - Full chain interlock tests (source → dump) on a selection of inputs.

>> we must avoid to push that to the 'last minute' – 2008 effect!

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J. Wenninger

- Reliability run is needed for the BLM system (~4000 channels) on top of radioactive source verification.
- Post-mortem (including BIS, powering and BI) is needed.
- Phases for the commissioning identified to provide some flexibility for safe beam and MPS parallel commissioning:
  - few days with machine closed and operational are needed to commission the Beam Dump System + BIS for low intensity and energy operation
  - Rule of the Probe: go back to probe beam any time new territory is explored (energy, optics, ...)
- Need MPS Experts to trigger and follow-up MPS staged/safe commissioning and to support Machine Coordinators/EiCs in the definition of the possible envelope of operation in case of abnormal operation of any BIS element.

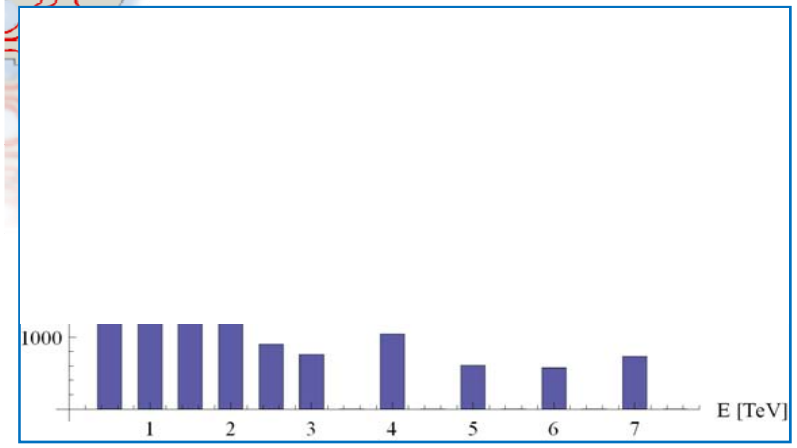
Injection and Beam Dump

J. Uythoven

2008 experience thanks to dry runs:

- MKI magnet D in LSS2L showed a breakdown (over-voltage during lab conditioning?) ➔ replaced by spare
- MKI flashovers due to beam loss (aperture studies)?: ➔ BLM installation (interlocks?) and improved conditioning sequence (SoftStart)
- Injection absorbers (TDI) and TI8 transfer line collimators (TCDI) being "consolidated" ➔ need re-commissioning
- Effect of the injection magnetic septum (MSI) stray field on the circulating beam orbit ➔ need to test possibility to run magnetic septum in DC
- Dependence of the strength of beam dump extraction kickers MKD on tunnel temperature (~ -0.2%/^{0}C) ➔ Regulation of the MKD generator temperature & interlock on it at ±1 ^{0}C ➔ need operational experience ➔ availability !!

Injection and Beam Dump



- Beam dump dilution kicker (MKB) flashovers:
  - Weak elements identified and replaced
  - "Common mode" failure due to vacuum deterioration ➔ reduction of conductance and additional pumping speed
  - MKBH installation will become nominal
  - MKBV: 4 out of 6 magnets

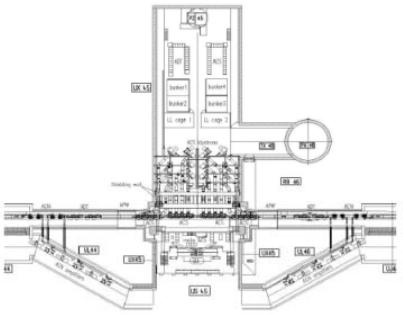
➔ Beam Dump Reliability run is needed: > 4 weeks effective running for failure statistics

- Energy tracking to be tested before beam (main bends in 45/56/67/78) ➔ coordination required
- Additional redundancy will be added for the verification of the position of TCDQ collimator (protecting Q4 and the arc in case of asynchronous dump): 'independent' check vs. beam energy (now only triggered via timing)

RF

RF System – Status up to Sept 19th

- Klystrons, controls & LLRF electronics in UX45 cavern
  All fully commissioned
- 16 ADT Transverse Damper kickers- 4 modules left / 4 right of IP4
  Kickers & amplifiers fully power tested
- 16 SC cavities, in 4 Cryomodules (each 4 single cell cavities).
  All 16 conditioned to nominal gradient in 2008
  (Checked with beam)
  BUT Problem with tuning mechanism found..
- APW Wideband Monitors 3 left / 3 right of IP4
  Set up and used for beam measurements
- Beam controls for RF synchro, capture, and transverse damping tested with beam
  Beam 2 successfully captured
- Collision, acceleration, radial loop
  Nearly tested (Was planned Sept 19/20th) 2008



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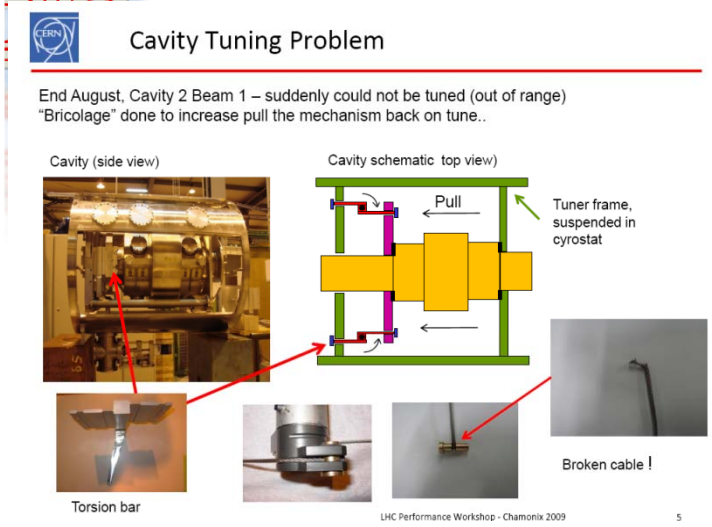
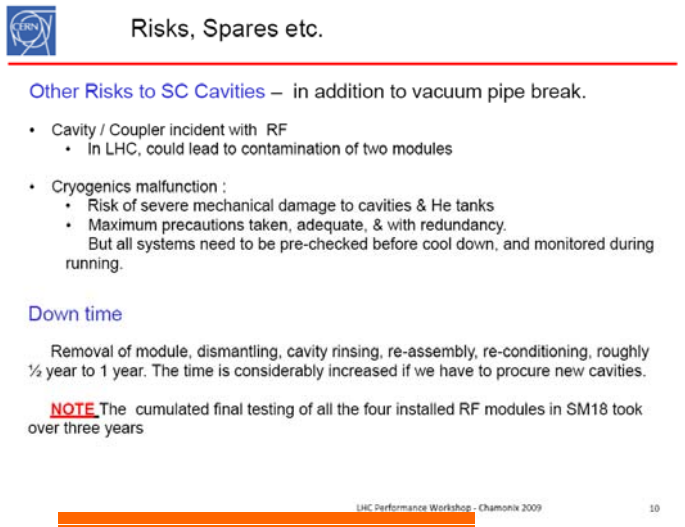
E. Ciapala

- Some of the Beam Controls systems could not be tested with beam due to the abrupt stop on 19/9 ➔ still a lot of work to be done!
- No damage to the RF systems on 19/9
- Similar event close to IP4, with sector valves open would result in dust contamination or even mechanical damage ➔ Need to keep valves closed during powering tests without beam
- Use of fast sector valves evoked but perhaps only limited protection for cavities from vacuum incidents occurring in the LSS and additional risk that the beam might not be dumped before the valves close with more severe risk of damage for the cavities.

RF



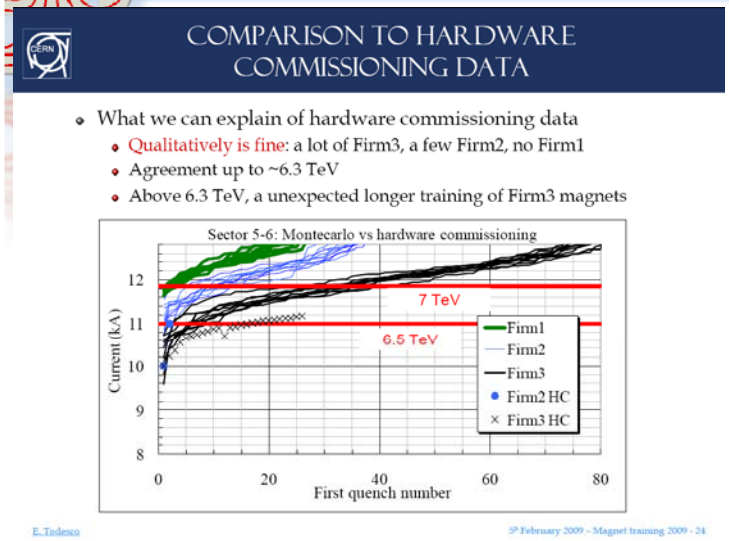


E. Ciapala

- Weakness in the tuning system detected and being repaired
- Powering tests of the acceleration and transverse damping system are required. In particular Cavity Conditioning.
- Access restrictions in UX45 can slow down this process ➔ definition of access procedures

- Situation of the spares is worrying
  - Proposal to purchase 3 more spare cavities + He tanks (~300 kCHF) whilst companies have still the know-how.
  - Possible to run cavities to ~half gradient should be possible (limited voltage at capture)

Magnet (re)training



E. Todesco

- Analysis of the data collected in SM18 and during HW Commissioning for all the magnet types
- For the dipoles Monte-Carlo simulation of the training based on SM18 and HW Commissioning data
- Comparison of the model with the experience in Sector 56 is good up to 6.3 TeV equivalent current

- Retraining estimates (mainly dominated by dipoles):
  - 5.5 TeV: a few (<5) quenches over all the machine
  - 6.0 TeV: ~15 quenches from MB, 5 from MQM and 5 from MBR
  - 6.5 TeV: ~80 quenches from MB, 5 from MQ, 15 from MQM-Y, 10 from MBR
- Difficult to give an estimate of how to get to 7 TeV before having the experience of at least one octant

Conclusions

- Quite some modifications are taking place on top of those resulting from the Sector 34 incident or as a result of the experience collected during HWC/Dry Runs/Machine Check-Out/Beam Commissioning in 2008
- We know what needs to be re-commissioned
- For the superconducting circuits the following issues need to be addressed and are being addressed:
  - New procedures for powering safely taking into account the modifications of the magnet protection systems
  - Definition of access conditions during powering
- As a result of the 2008 experience the steps for a staged commissioning of the Machine Protection System have been sketched ➔ This requires in particular a period of a few days with machine closed and operational before establishing circulating beam.
- In general we know how to do the Commissioning (2008 experience) but some of the people have left ➔ procedures, automation are essential
- Number of spare RF cavities to be increased before the know-how in industry is lost