Session 8 – What we'll do for beam preparation in 2009

Powering Interlocks

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on behalf and with many contributions of colleagues from TE-MPE-MI

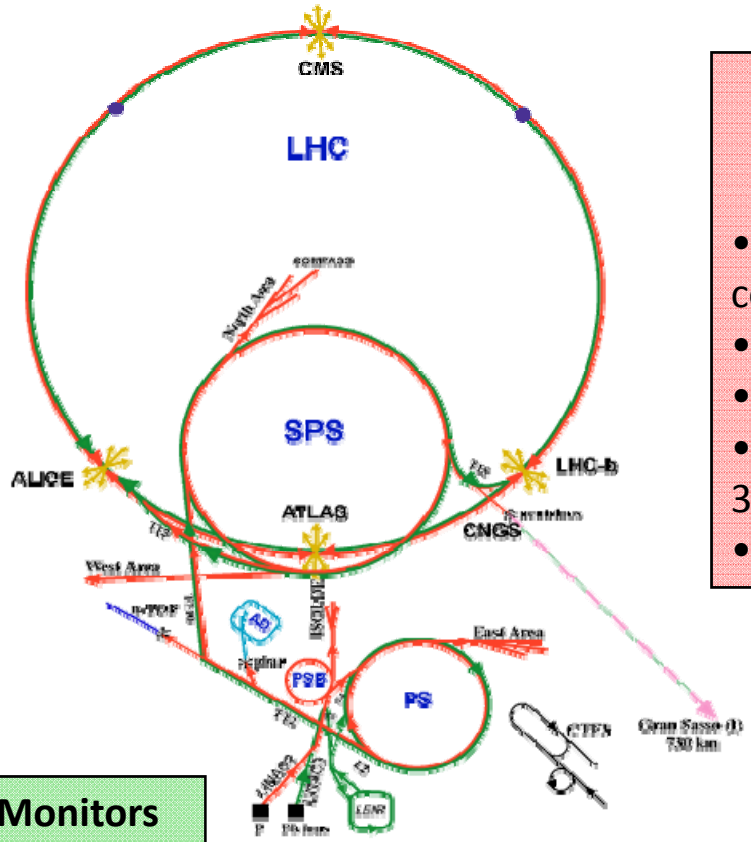
Outline

- Quick status after HWC and first operation of powering interlock systems in 2008
- Modifications during the Shut-down
- What needs to be re-commissioned/checked in 2009
- Tools available to speed-up the interlock system validation
- Pre-requisites
- Hoch much time does it take?
- Staged approach vs. energy, intensity

Powering Interlocks (+FMCM) in the LHC

Powering Interlock for sc circuits (PIC)

- Interfacing with QPS, converters, UPS, AUG and cryogenics
- 820 electrical circuits (+752 60A orbit correctors)
- >10.000 magnets
- 36 controllers SIEMENS 319
- Cycle time 1ms



Warm Magnet Interlocks for nc circuits (WIC)

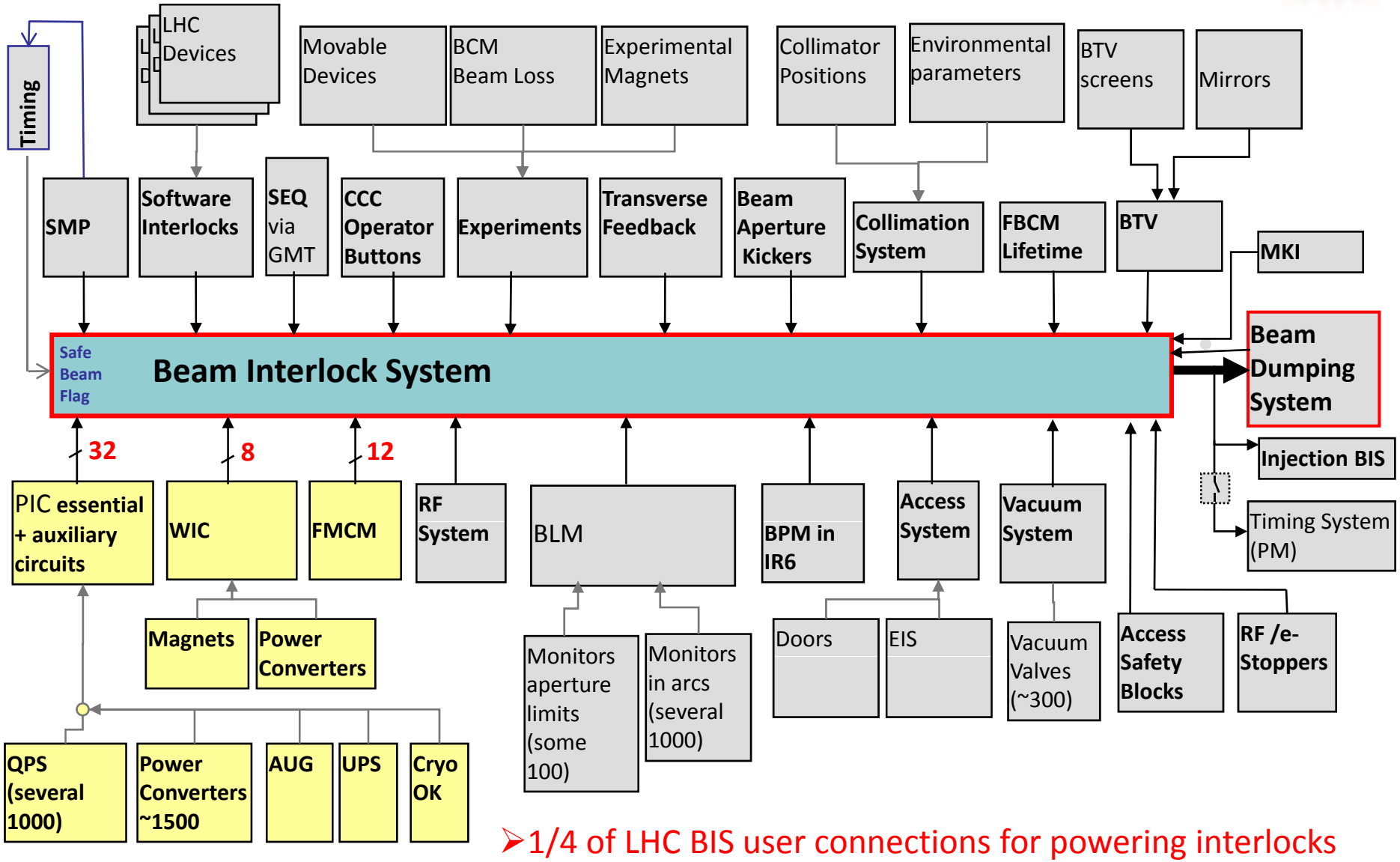
- Interfacing with converters and magnets
- 45 electrical circuits
- 149 nc magnets
- 8 controllers SIEMENS 300 Safety
- Cycle time ~ 100ms

Fast Magnet Current Change Monitors (FMCM)

- detection of fast current changes (10E-4 @ 1ms) for 12 critical nc circuits through V measurement
- D1, MSD, RD34 & Q4/5 in IR3 and IR7, Alice comp

Note: FMCM and WIC also exist in SPS-LHC Transfer Lines

Powering Interlocks vs Beam Interlock

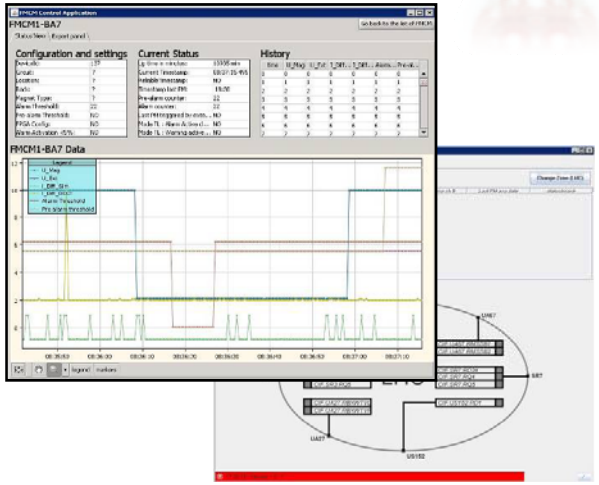


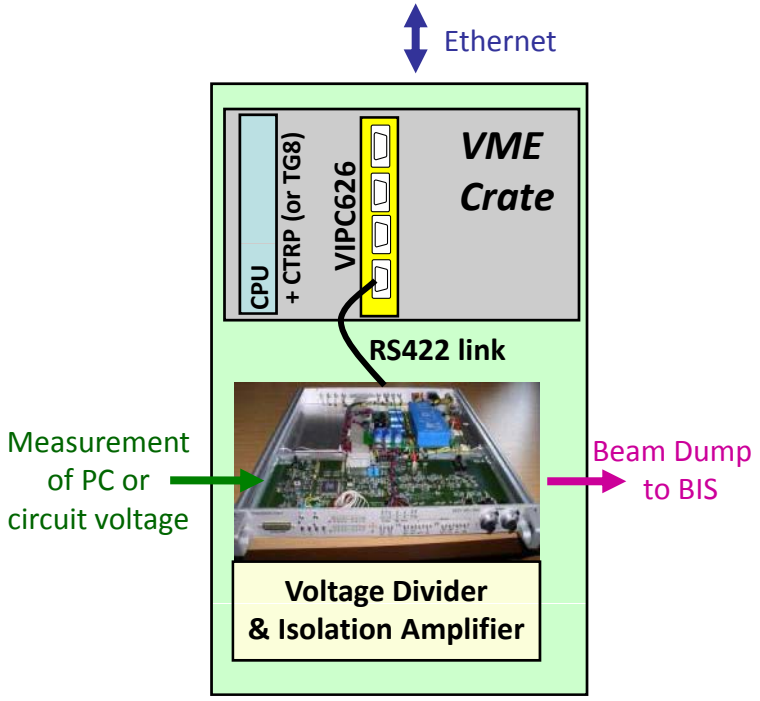
➢1/4 of LHC BIS user connections for powering interlocks , collecting a large inventory of interlock channels

Fast Magnet Current Change Monitors (FMCM) in 2008

- For startup 2008 11 oo 12 FMCM units installed
- Fully commissioned in TL (for previous CNGS runs and injection tests), partially commissioned in LHC (no priority during startup 08 as maskable inputs to BIC)
- With operational systems (once commissioned) very satisfactory functional performance

- 'Modifications' during shut-down:
  - Completion of installations (missing device on ALICE compensator)
  - Resolved and improved multiple pending issues on LHC devices (cross-talk on MSD, optimized settings for injection and nominal energy)
  - Completion of controls and PM interface (mainly transfer line issue with target dependent timing signals)





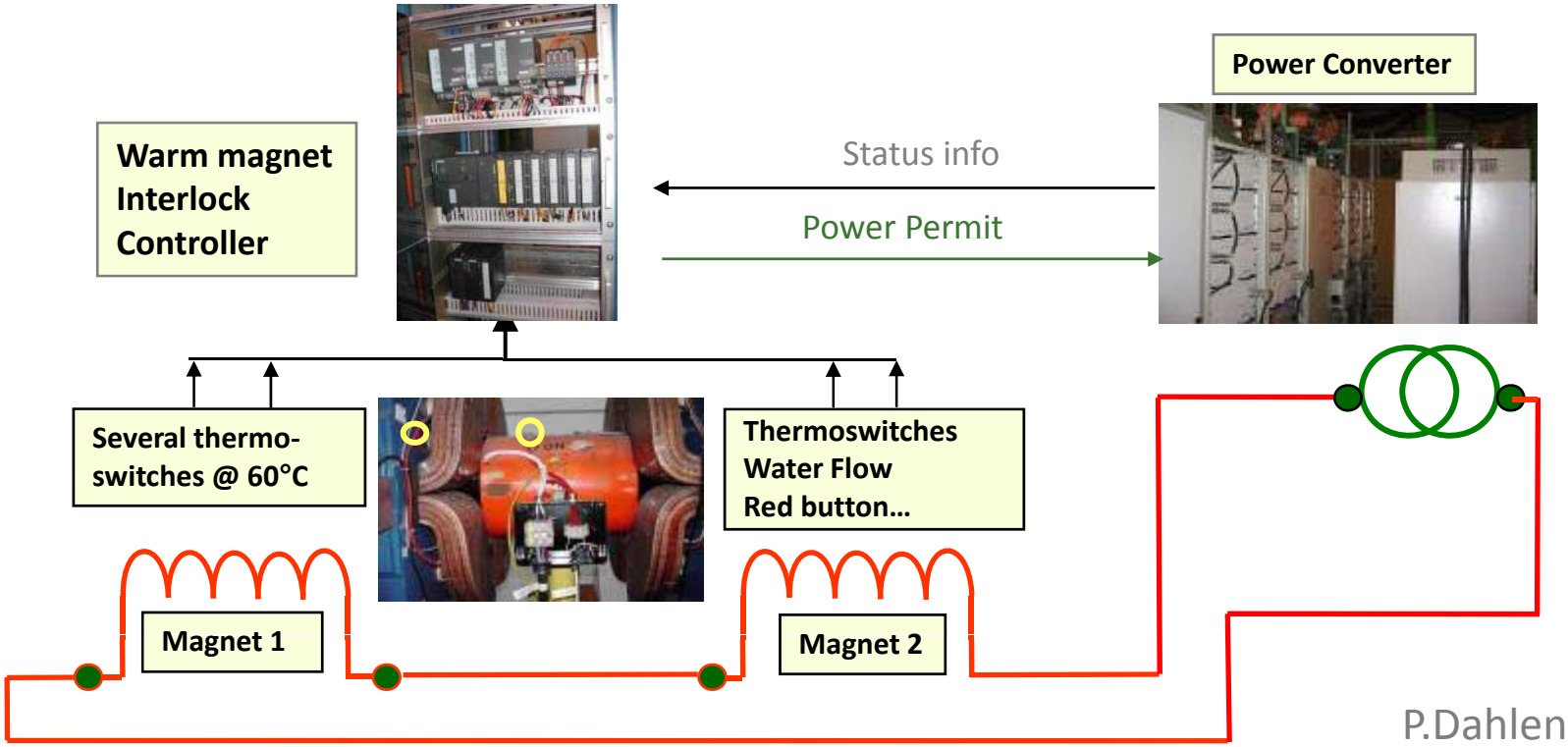
FMCM re-commissioning in 2009

- As never quite done and due to many changes in LHC devices, propose a systematic re-commissioning of all monitors and final validation of all thresholds
- For 2009 still manual commissioning, possibilities for automation will be addressed for next shut-down (lower priority due to few channels & fast commissioning)
- All 12 LHC devices can be commissioned remotely from the CCC in ~ half a day, through two current cycles + fault trigger @ injection and nominal
- Commissioning can take place immediately after circuit is HWC to nominal to be ready for first beam (FMCM functionality independent of energy & intensity)
- All FMCMs are maskable inputs to the BIC, thus absolutely required 'only' for unsafe beam
- Before unsafe beam, final validation of thresholds with dedicated beam tests, ie provoking powering failure on eg D1 and measuring beam excursion until beam dump
  - Can be combined with other tests but vital to validate the redundancy wrt BLM for such failure cases

MPS procedure: LHC-OP-MPS-0008

Warm Magnet Interlock System (WIC) in 2008

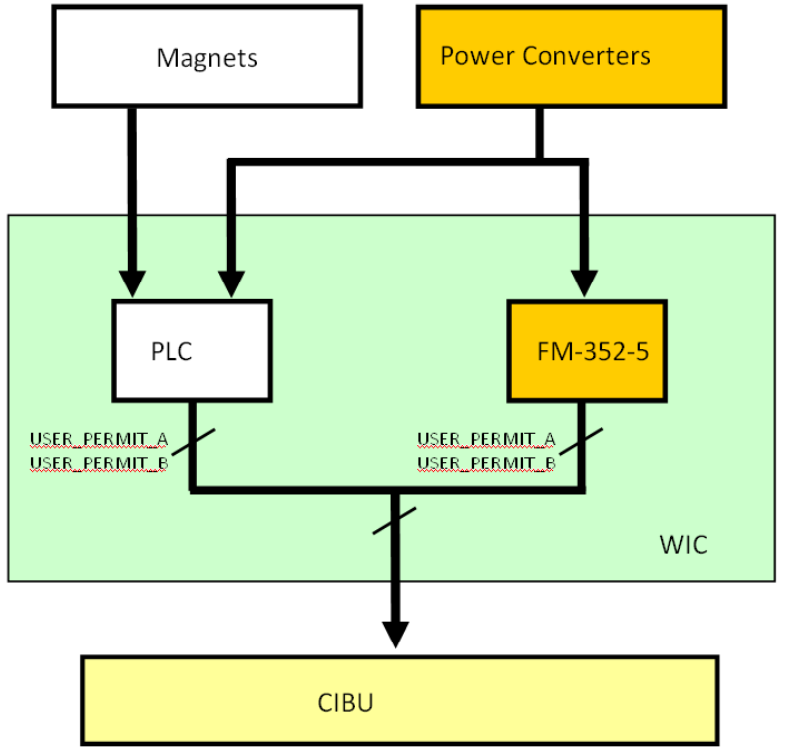
- All 8 systems installed and operational, driven almost exclusively by operations/HWC
- After HWC 08, WIC fully commissioned, except for the FM352 (=fast module for beam dump)
- WIC Commissoning in 08 done manually, ‚only' 45 circuits powering 149 magnets in LHC; commissioning takes couple of hours / point, IR3 and IR7 ~ half a day



P.Dahlen

WIC modifications during shut-down

- No modifications to WIC hardware nor connections, with exception of temporary removal of WIC in TZ76
- Inclusion and test of FM352 (redundant path to PLC for beam dump requests from power converters)
  - To assure fast transmission of beam dump request following internal PC faults (due to inherently longer cycle time of safety PLCs)
  - Modules were already installed in 2008
  - Will be connected into logic through new electronic card and tested during re-commissioning phase
  - SCADA representation & diagnostic for module will be added



WIC re-commissioning in 2009

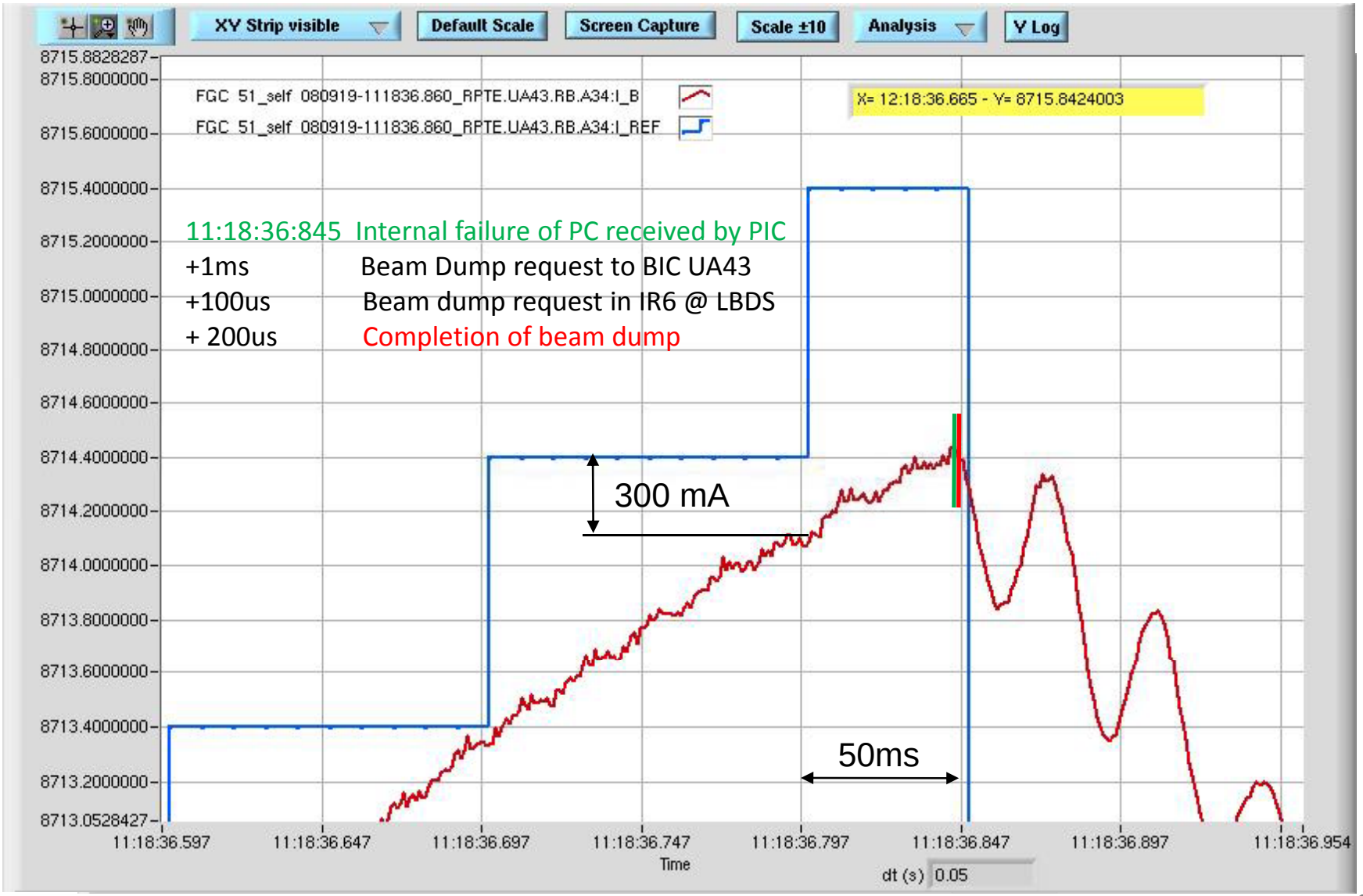
- Systematic re-commissioning of all systems (required for full validation of FM352)
- For 2009 still manual commissioning, possibilities for automation will be addressed for next shut-down (identical principle as PIC – see later)
- Pre-requisites: Commissioning can take place at zero current, before powering tests start
- All devices are to be commissioned locally with magnet and converter experts in ~ half a day per insertion region.
- Commissioning already during HWC period to be ready for first beam (WIC functionality independent of energy & intensity)
- All WICs are unmaskable inputs to the BIC, thus required for any beam operation
- No dedicated beam tests required, final validation of redundancy and reaction times can be done in parallel with other equipment tests

MPS procedure: LHC-OP-MPS-00010

Powering Interlock System (PIC) in 2008

- All 36 systems installed and operational, again to large extent driven by operations
- Hardwired Interlocks of 11 circuits (out of >900) not fully commissioned (due to NC in circuits/magnets…)
- Few ‚real' interlock issues found in Powering Interlock System during HWC, mostly configuration issues or cabling/connector issues
- Good news: So far exceeded reliability/availability predictions (overall MTBF expected to be ~ 9 months) as no critical component failure or ‚blind failure' observed in large installation during 2 years of ‚operation'
- Profited a lot from automated commissioning tools, clear need to continue in this direction to allow for systematic & regular re-testing of interlocks during operational periods
- Couple of first use-cases where powering system performed emergency dump (1st Emergency beam dump provoked on 11th Sept. after water fault in DC cable)
  - Worked well (redundancy towards BIC, <1ms until completion of beam dump

What would have happened with beam on 19th Sep 08 ?

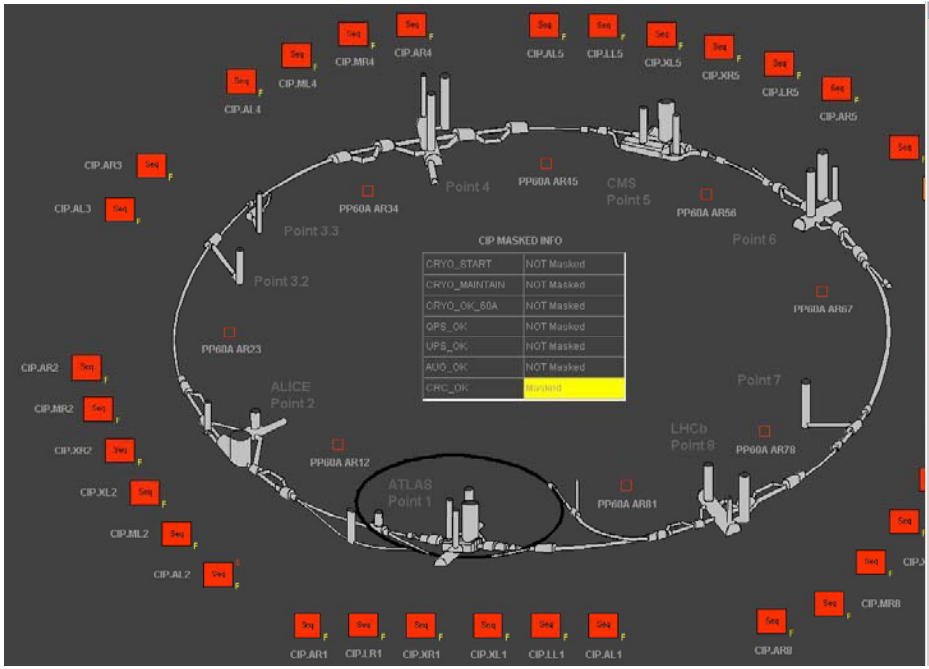


PIC modifications during the shut-down

- 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 modifications during the shut-down

- Several operational improvements & new functionalities in SCADA system (EN-ICE)
  - Uniform framework as for QPS/Cryo SCADA
  - ‘Super’-lock for circuits with NC
  - UPS start-up interlock (+additional diagnostics via TIM/DIP) operational in addition to hardwired interlock
  - ‘masking’ of SW channels during HWC and early beam operation
    - Proven vital for efficiency, but difficult to keep track despite procedures



1 - Masked settings...

CIPC	CRYO_START	CRYO_MAINTAIN	CRYO_START_PP60A	QPS_OK	UPS_OK	AUG_OK	CRC_OK	LASER MODE
CIP.UJ16.XR1							Masked	0
CIP.UJ16.LR1							Masked	0
CIP.UJ16.AR1							Masked	0
CIP.UA23.AL2							Masked	0
CIP.UA23.ML2							Masked	0
CIP.UA23.XL2							Masked	0
CIP.UA27.XR2							Masked	0
CIP.UA27.MR2							Masked	0
CIP.UA27.AR2							Masked	0
CIP.UJ33.AL3							Masked	0
CIP.UJ33.AR3							Masked	0
CIP.UA43.AL4							Masked	0
CIP.UA43.ML4							Masked	0
CIP.UA47.MR4							Masked	0
CIP.UA47.AR4							Masked	0
CIP.USC55.AL5							Masked	0
CIP.USC55.LL5							Masked	0
CIP.USC55.XL5							Masked	0
CIP.UJ56.XR5							Masked	0
CIP.UJ56.LR5							Masked	0
CIP.UJ56.AR5							Masked	0
CIP.UA63.AL6							Masked	0
CIP.UA63.ML6							Masked	0
CIP.UA67.MR6							Masked	0
CIP.UA67.AR6							Masked	0
CIP.TZ76.AL7							Masked	0
CIP.TZ76.AR7							Masked	0
CIP.UA83.AL8							Masked	0
CIP.UA83.ML8							Masked	0
CIP.UA83.XL8							Masked	0
CIP.UA87.XR8							Masked	0
CIP.UA87.MR8							Masked	0
CIP.UA87.AR8							Masked	0
CIP.UJ14.AL1							Masked	0
CIP.UJ14.LL1							Masked	0
CIP.UJ14.XL1							Masked	0

PIC re-commissioning in 2009 – Hardware Commissioning

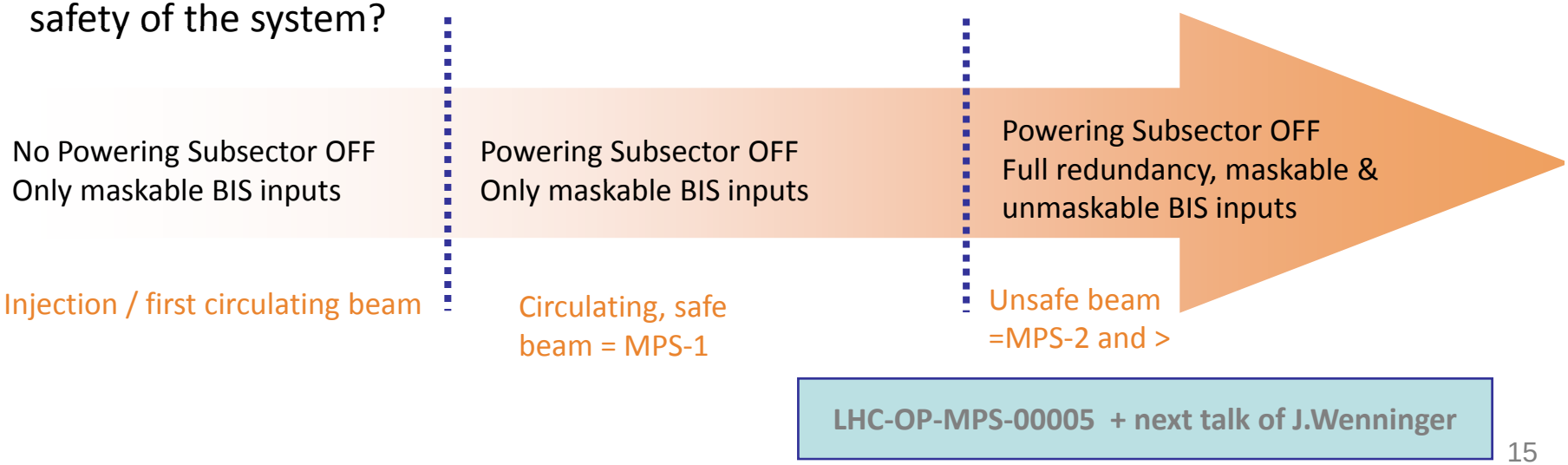
- From interlock point of view, no need to systematically re-test internal functionality (except for S34 and not yet commissioned circuits from HWC08)
- For all other sectors, need to test that no (unwanted) modifications of cabling have taken place, ie between PIC and QPS/PC
  - Systematically re-test 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	SUC	UNDER EXEC	HWC steps for Powering Interlocks								
RCD.A78B1	PNO.a3	14 / 14 (100%)	PNO.a3	Y	–	PCL	PCC.5	PIC2 CRYO-OK		PIC2 PC PERMIT		PIC2 CIRCUIT QUENCH VIA QPS		PIC2 TEST HW LINKS
RCD.A78B2	PNO.a3	14 / 14 (100%)	PNO.a3	Y	–	PCL	PCC.5	PIC2 CRYO-OK		PIC2 PC PERMIT		PIC2 CIRCUIT QUENCH VIA QPS		PIC2 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)

PIC re-commissioning in 2009 – Cold Checkout

- Powering Interlock System provides 32 inputs to the BIS, 16 maskable and 16 unmaskable
- Configuration defines which circuits are mandatory for beam operation (=unmaskable) or 'auxiliary' (=maskable)
- As 'guinea pig' for 2008, automated procedure to test and validate the interfaces and configuration before beam operation
- Takes around 1 hour/sector, due to topology of connections PIC-BIC needs 2 adjacent sectors reserved for test
  - Around 1500 logical tests per sector, test results stored in LSA and MTF
- Staged approach for PIC vs energy/intensity: When to activate the full redundancy and safety of the system?



LHC-OP-MPS-00005 + next talk of J.Wenninger

Conclusions

- Majority of powering interlock systems operational for most of 2008 (except FMCMs), resulting in valuable experience and feedback
- Based on extensive 2008 experience, don't expect major surprises in 09 and confident to comply with schedule
  - One doubt: CPLD XC95144 used in PIC vs SEE?
- Main priorities 2009 further automation of interlock tests (in view of regular automated tests with BIS) + traceability of masking
- No dedicated tests with beam with any of the systems, some few 'emergency dumps' demonstrated functionality of beam dumps from powering interlocks
- Need to agree on proposal for common staged approach (ie when to transit from flexible state to rigid & full system functionality)
  - Needs time for implementation and commissioning
- Encouraging experience with systems availability (MTBF) in view of the very complex MPS

THANKS FOR YOUR ATTENTION