
CERN

Quench Protection Systems

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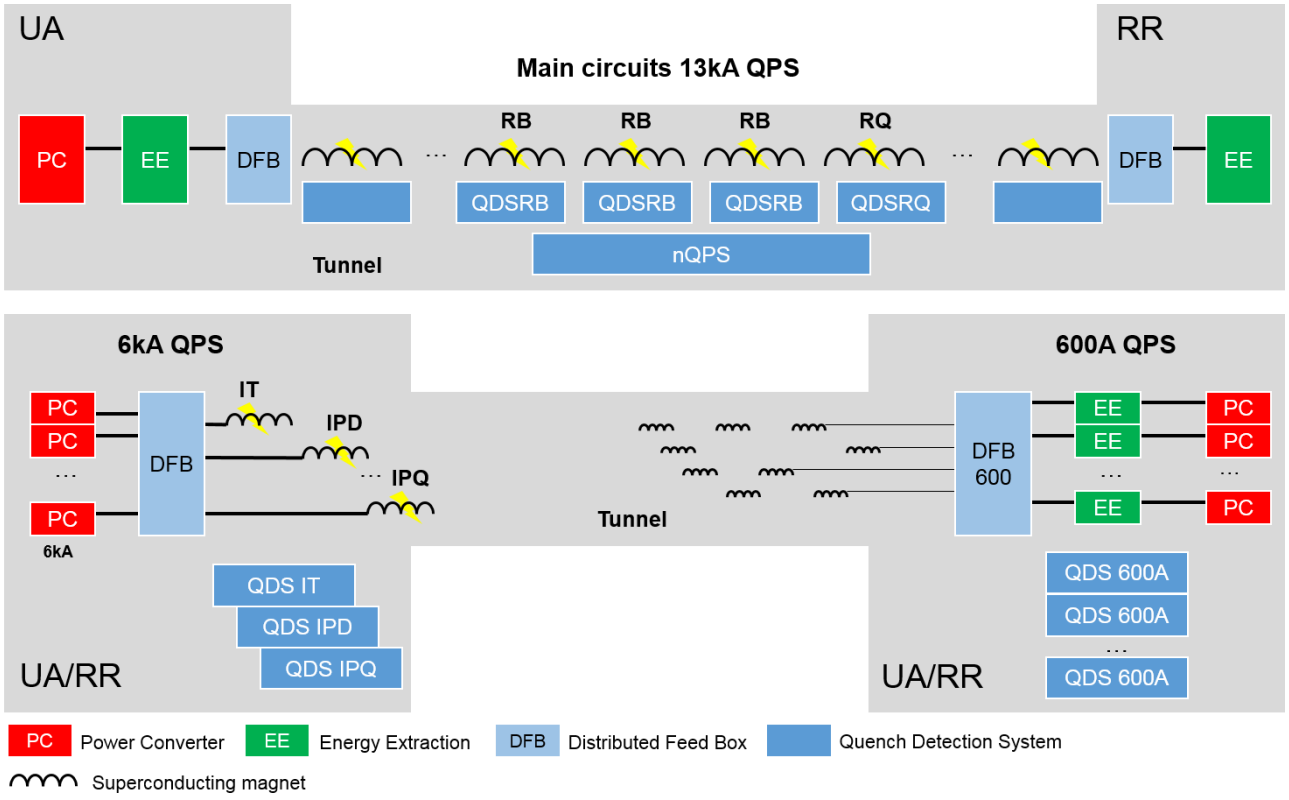
Outline

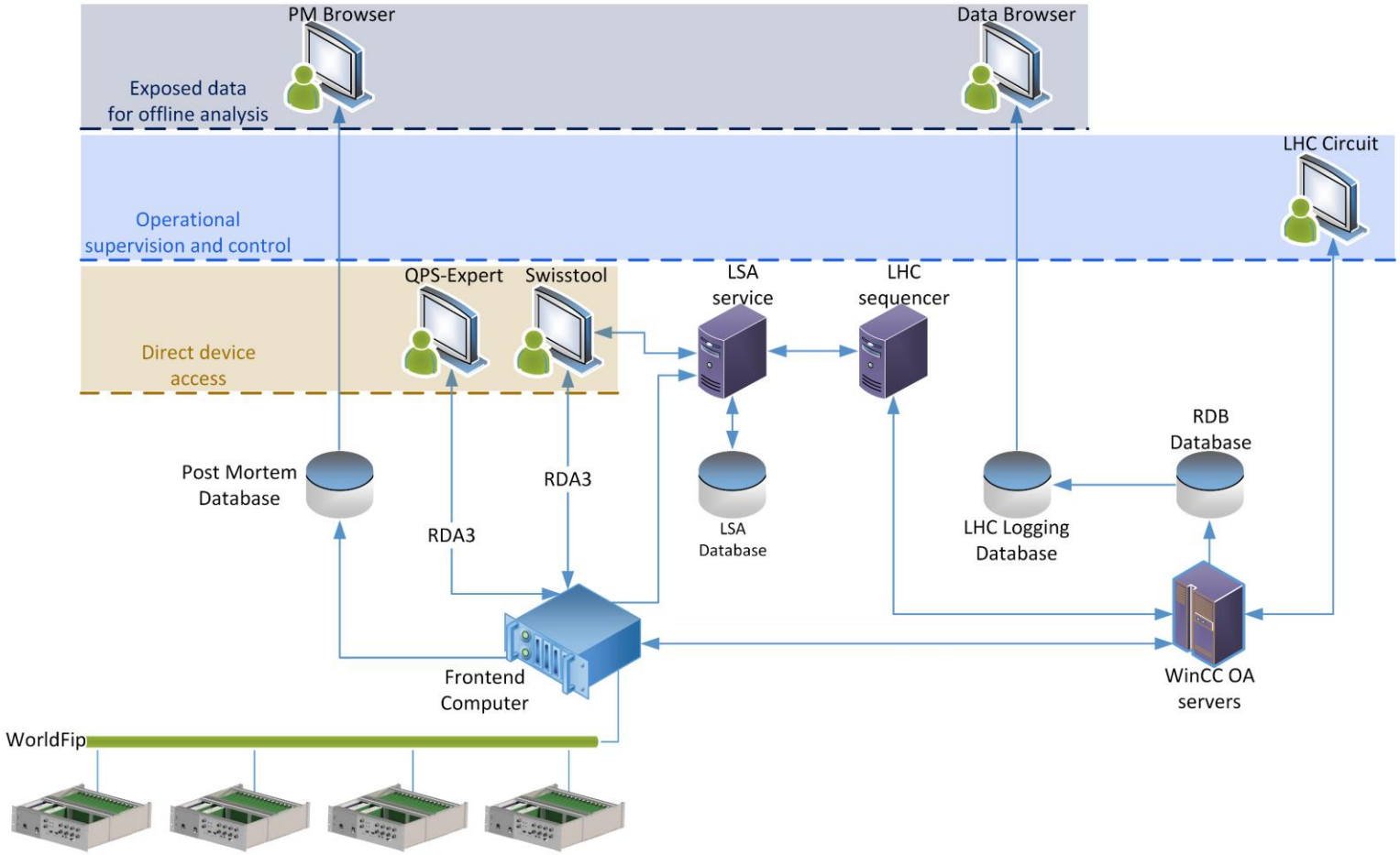
- Introduction to **Q**uench **P**rotection **S**ystems
- Planned changes in QPS for LS2
- Upgraded QPS – closer look
  - QPS for main quadrupoles (MQ)
  - QPS for 11T dipole
  - QPS for individually powered magnets (IPx)
- Conclusions

Introduction to **Q**uench **P**rotection **S**ystems 1/2



Item	Count
EE13kA	**32**
EE600	**202**
HDS	**6084**
QDSRB	**1232**
Magnet detector	2464
QDSRQ	**392**
Magnet detector	1568
nQPS	**436**
Magnet detector	1632
Bus-bar detector	4096
QDSIPX	**76**
IP magnet detector	360
IT magnet detector	48
Current lead detector	1124
QDS600	**114**
Magnet detector	624
Rad-tol magnet det.	212
Current lead detector	1672
Total	**8568**
Interlocking	**13800**

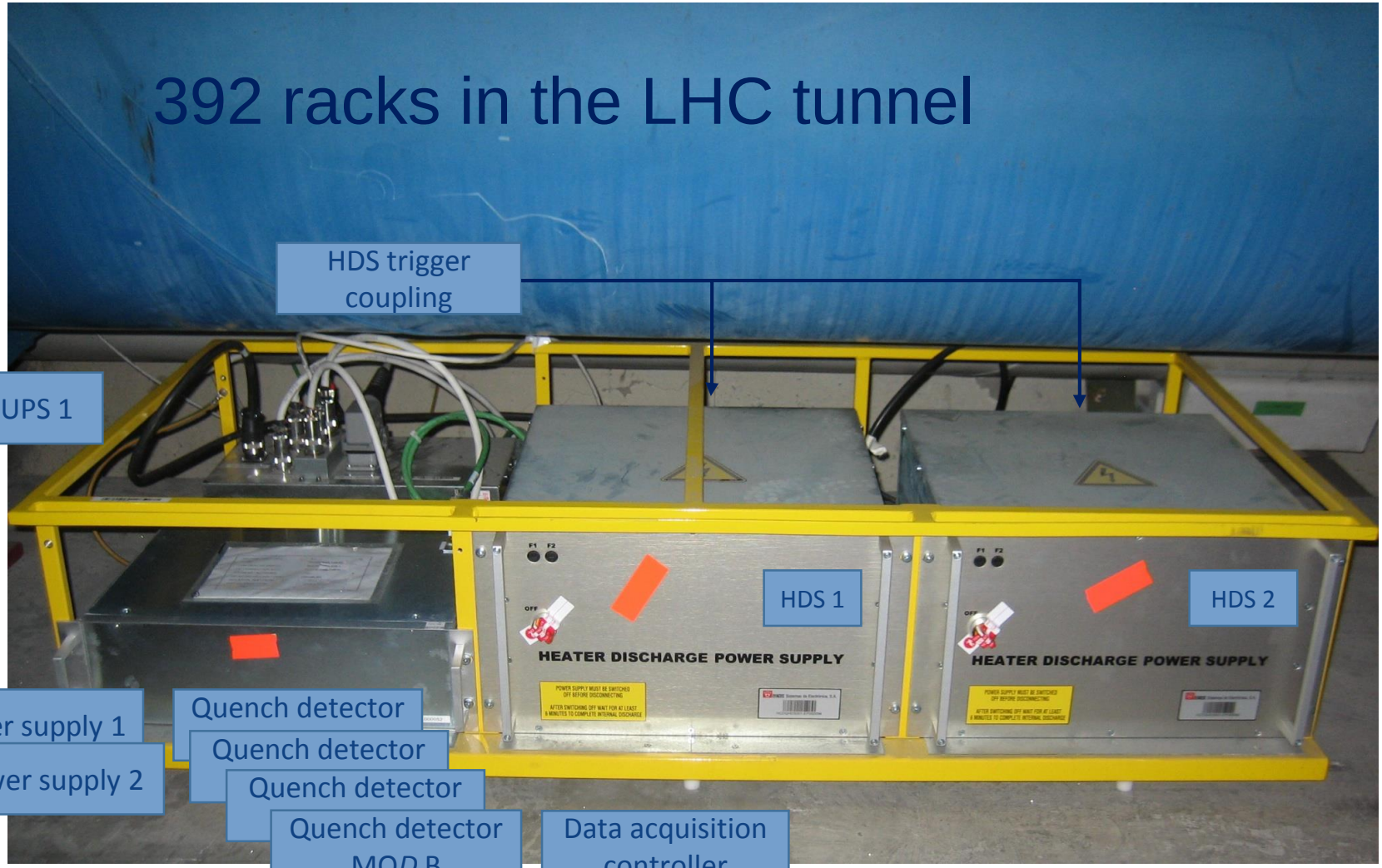
Introduction to **Q**uench **P**rotection **S**ystems 2/2



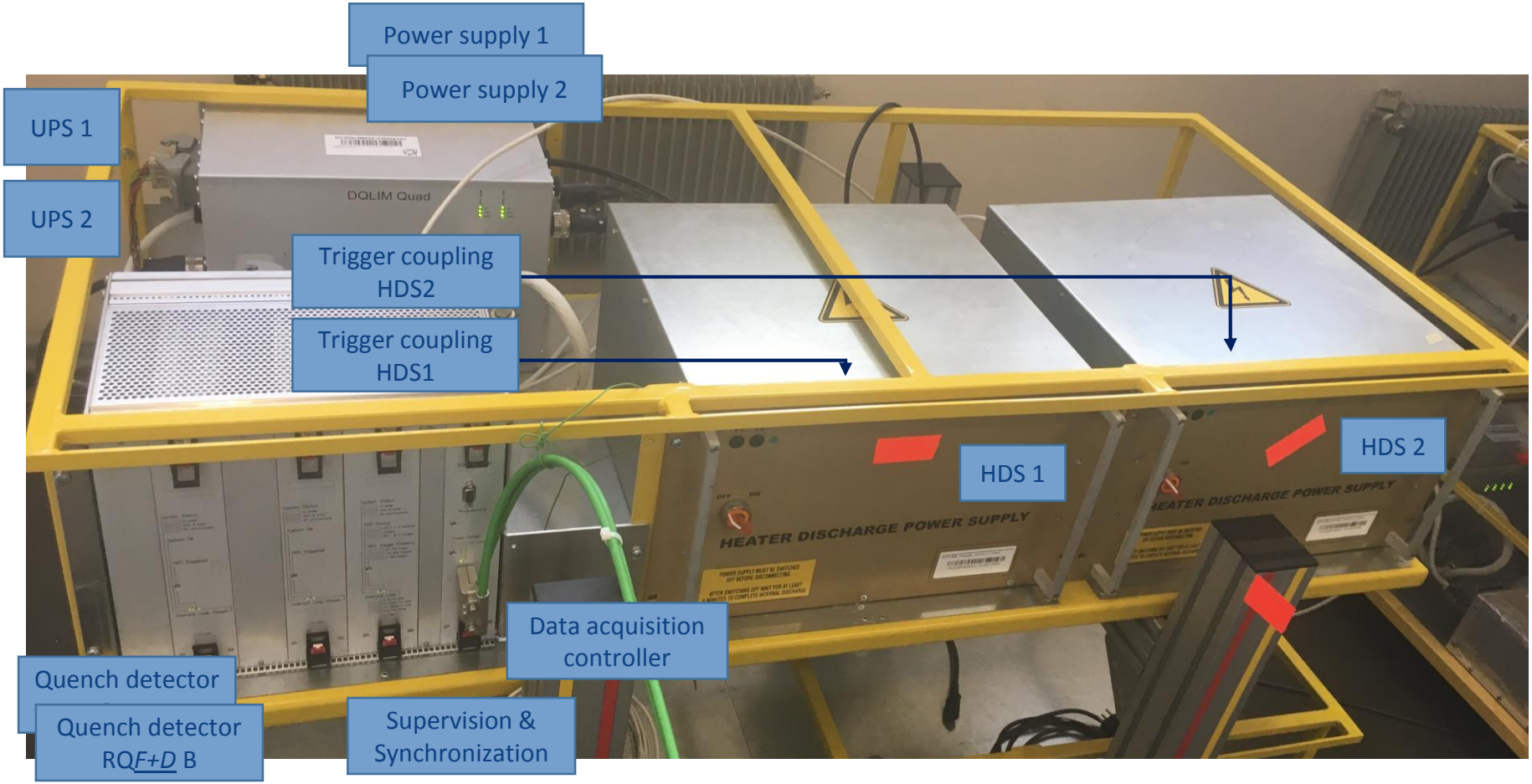
Planned Changes in QPS for LS2

- QPS for MQ (DYPQ)
  - Lifecycle management driven
  - Enhance diagnostics and remote maintenance
  - Improve reliability and radiation tolerance
- QPS for 11T
  - New quench protection system needed
- QPS for IPx (IPQ, 600A)
  - Reduce susceptibility to thunderstorms – IPQ
  - Improve detection of symmetric quenches – IPQ
  - Improve EMC of current sensors – 600A
  - Maintenance, test and reduction of units – EE 600A

Old DYPQ


392 racks in the LHC tunnel
HDS trigger coupling
UPS 1
HDS 1
HDS 2
HEATER DISCHARGE POWER SUPPLY
HEATER DISCHARGE POWER SUPPLY
Power supply 1
Power supply 2
Quench detector
Quench detector
Quench detector
Quench detector MQD B
Data acquisition controller

New DYPQ


Power supply 1
Power supply 2
UPS 1
UPS 2
Trigger coupling HDS2
Trigger coupling HDS1
HDS 1
HDS 2
Data acquisition controller
Quench detector
Quench detector RQF+D B
Supervision & Synchronization
DQLIM Quad
HEATER DISCHARGE POWER SUPPLY

DYPQ Upgrade

Core Functions

- Redundant powering on the UPS level
- Quench detection logic and signal filtering in digital domain
- Enhanced quench heater supervision
- Qualified in radiation
  - Components in PSI, device in CHARM – radiation tolerant up to 300 Gy (with an exchange of data acquisition controller)

Enhanced Diagnostics

- Quench heater trigger monitoring
- Interlock loop monitoring
- Power supply monitoring
- Enhanced PM timing precision
- Continuous configuration transmission

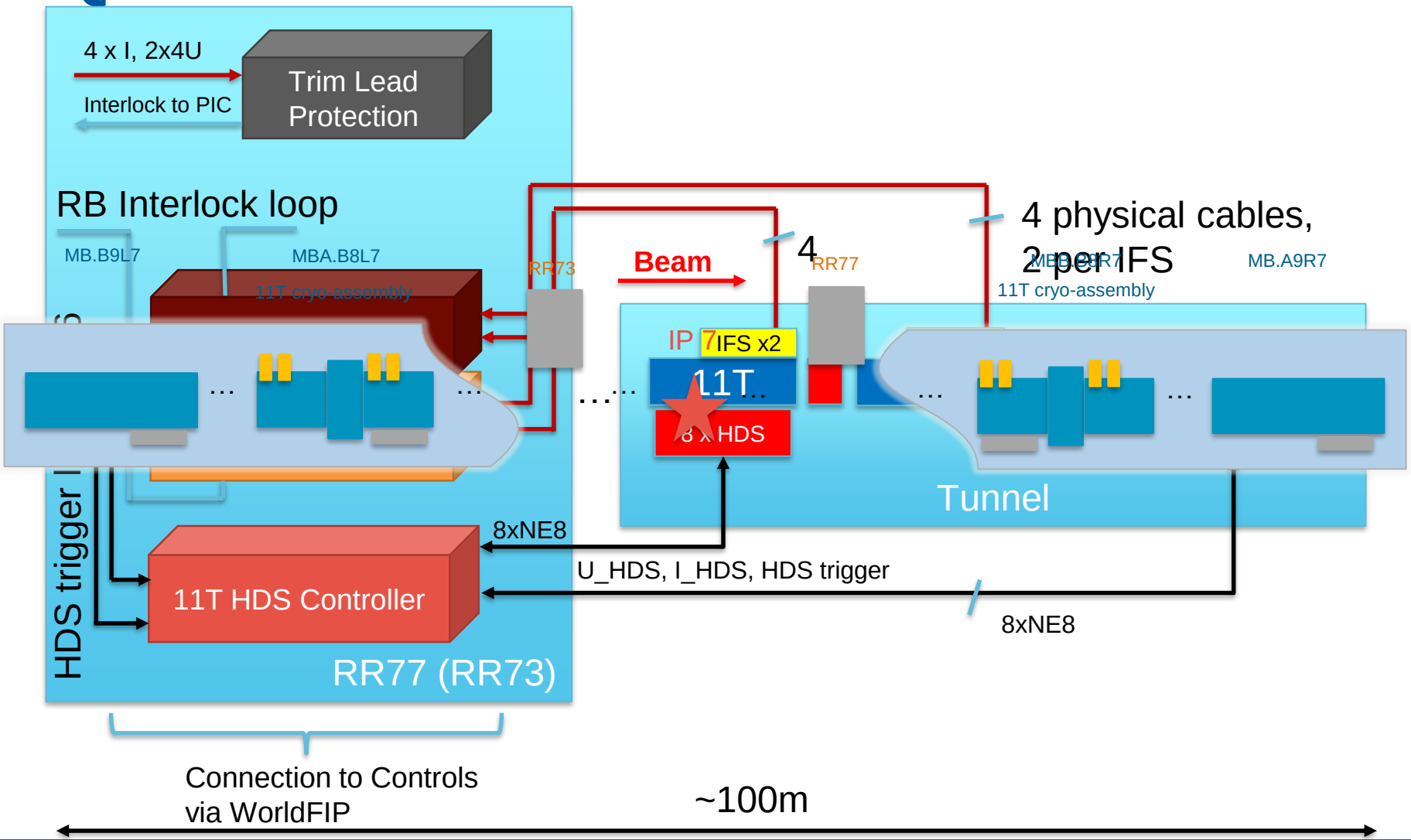
Enhanced Maintenance

- Remote power cycle
- Boards in metallic enclosures (cassettes)
- Tool-less exchange of the cassettes
- Dedicated LED indicators on the front panel allowing quick status assessment by Piquet

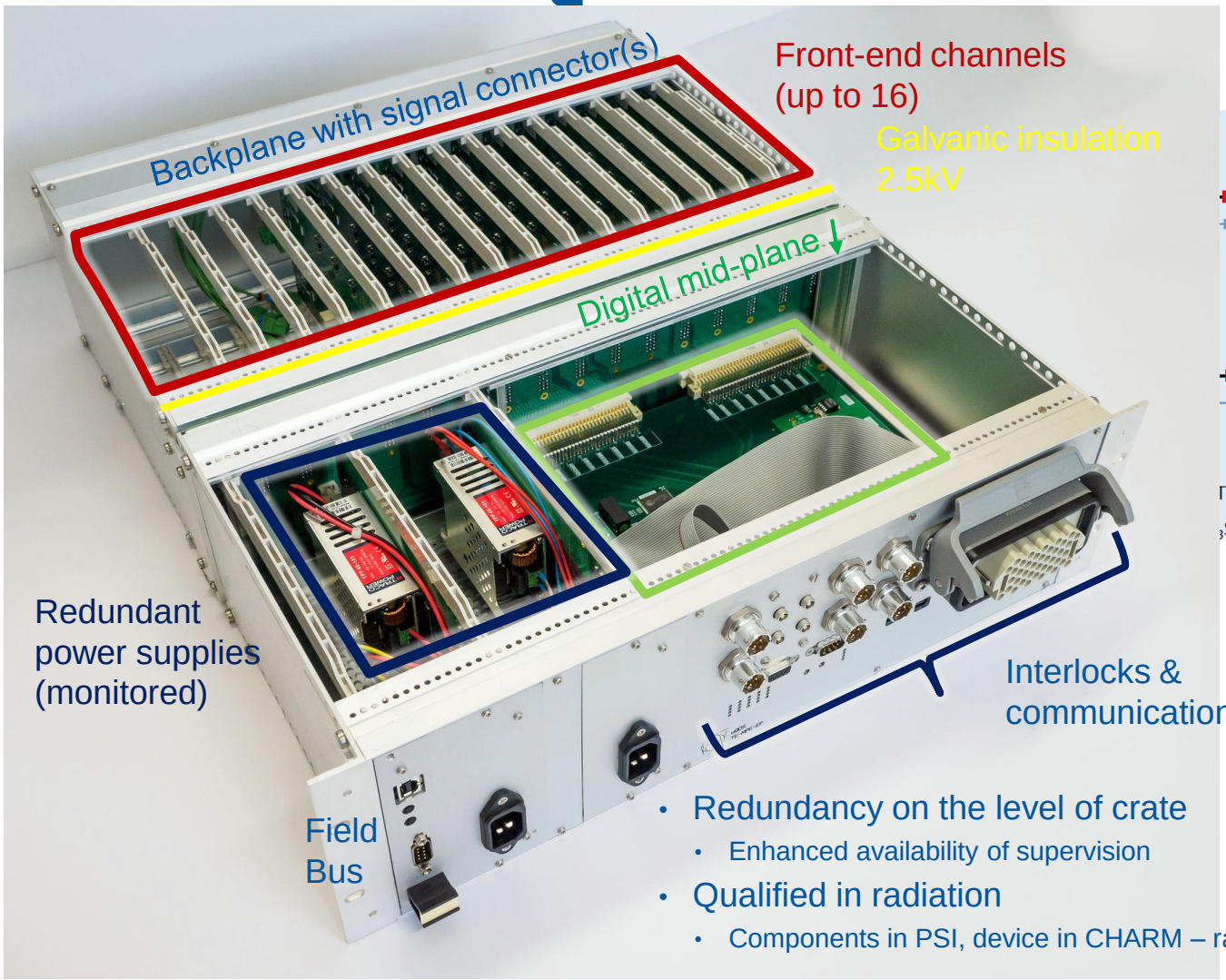
DYPQ Upgrade – Operational View

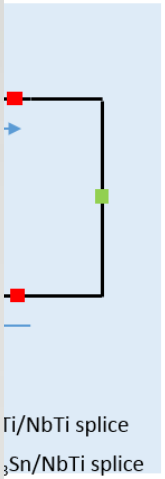
- Signals from redundant quench detectors sent at the same time
- System configuration continuously transmitted
- Larger number of signals transferred to the LHC controls
  - All power supplies provided by DQLIM are monitored
  - HDS trigger links are monitored for the first time in the LHC
  - HDS voltage and current are monitored
  - Interlock loop state is monitored
- Improved PM data timing
- Selectable PM analysis resolution
- Remote power cycle

QPS for 11T


4 x I, 2x4U
Interlock to PIC
Trim Lead Protection
RB Interlock loop
MB.B9L7
MBA.B8L7
11T cryo-assembly
RR73
Beam
4
RR77
4 physical cables, 2 per IFS
MB.A9R7
11T cryo-assembly
IP 7
IFS x2
11T
8 x HDS
Tunnel
HDS trigger
8xNE8
11T HDS Controller
U_HDS, I_HDS, HDS trigger
8xNE8
RR77 (RR73)
Connection to Controls via WorldFIP
~100m

Universal Quench Detection

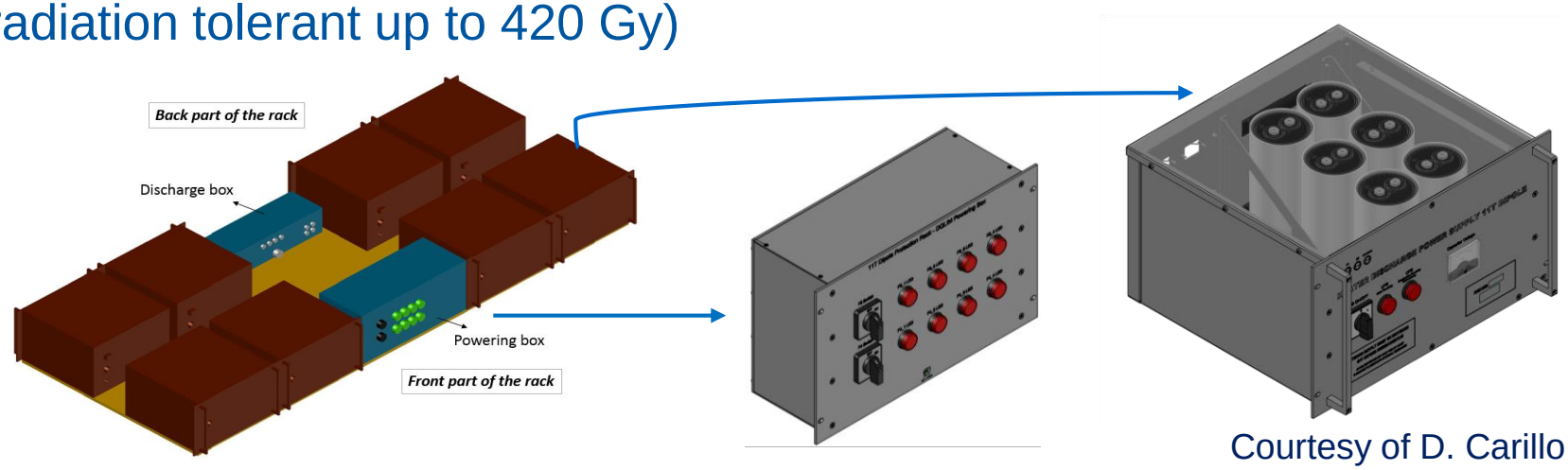




- Redundancy on the level of crate
  - Enhanced availability of supervision
- Qualified in radiation
  - Components in PSI, device in CHARM – radiation tolerant up to 100 Gy

HDS Rack

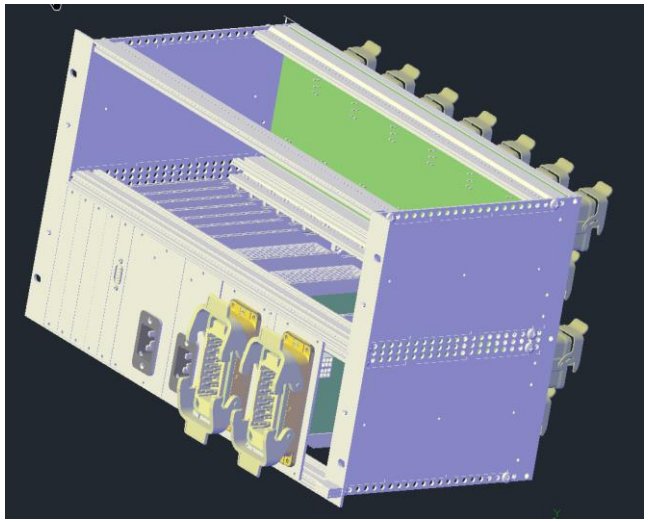
- DQHDS supplied by both F3 (UPS1) and F4 (UPS2)
- Switches on the front side to turn on/off the eight DQHDS
- For maintenance purposes, the current transformers installed inside the DQHDS
- New DQHDS has relays in the internal discharge circuit for safety
- New DQHDS has a voltage indicator
- Qualified in radiation (components in PSI, device in CHARM – radiation tolerant up to 420 Gy)



Courtesy of D. Carillo

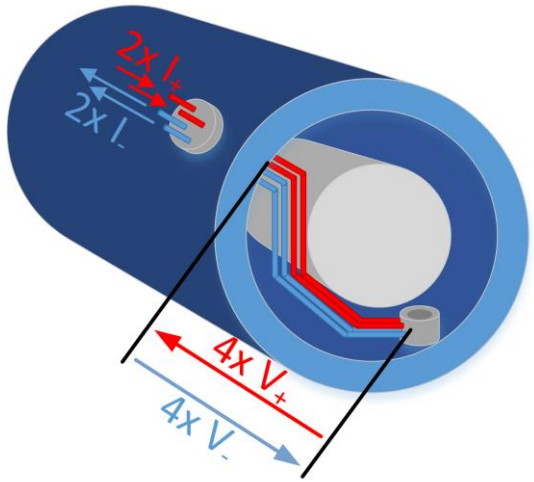
11T HDS Controller

- Monitoring 16 quench heater voltages and 16 currents
- Trigger coupling of 2x16 HDS trigger lines from UQDS (fully passive, no fan-out required)
- HDS trigger monitoring
- Supervision of Heater-to-IFS box cable connection



Trim Lead Protection Unit

- The resistive leads of the 11T trim circuit require active protection
- Lead voltage will be measured redundantly (2x4 voltages)
- Short bas-bars connecting circuit to the magnet will be included in measurements
- Current sharing will be monitored and optionally interlocked (1x4 currents)
- Unit will be composed of existing quench detection boards (DQQDC & DQAMG) or UQDS will be used



Consolidation of QPS for IPQ

- Reduce susceptibility to thunderstorms
  - Separation of magnet and bus-bar protection
- Enhance detection of symmetric quenches
  - Use of current derivative sensors
  - New quench detection unit to interface current derivative sensors
- Improve quench heater supervision
  - Use existing DQHSU units (used for main dipoles)
- Improve remote maintenance
- Partial upgrade planned for LS2
  - According to priority list that is in preparation by MP3

Consolidation of QDS for 600A

- Improve EMC of current sensors
  - Exchange of current sensors in sensitive areas (RR)
  - Installation of redundant sensors to switch in case of faults
  - New sensor candidate showed very good noise performance and was qualified in irradiation testing campaign in PSI up to 420 Gy
- Improve ramp rate limits
  - Use of current derivative sensors for high-inductance circuits – planned but not confirmed for beginning of Run 3
- General maintenance
  - Improve PM timing
  - Improve remote maintenance
  - Improve current sensor cabling (RR)

Consolidation of EE 600A

- General maintenance of 600A EE systems
  - Systems targeted according to closing failure rate
- Reduction of 600 A EE units in operation
  - Circuits with operational currents below 300 A to be by-passed
  - Changes in firmware required
  - Interlock configuration affected
- Four vacuum breaker-based systems will replace four electromechanical ones
  - Exact circuits to be decided
- Transparent for operation

Upgrade of QPS: Miscellaneous

- Partial replacement of obsolete detection boards by new generation QDS for ITs
- Fast quench loop controllers for S67 and S78
  - Fast (<1 ms) transmission of circuit abort signal to PIC – required to dump the beam prior to heater firing in 11 T dipoles
- Reconfiguration of the nQPS layer in S67 and S78 after 11 T dipole installation
  - 11 T dipoles cannot serve as reference magnets for aperture symmetric quenches
- 13 kA EE systems
  - Consolidation and maintenance of 256 circuit breakers
  - Inspection and maintenance of dump resistors
  - Consolidation of controls

Upgrade of QPS Supervision & Control

- MasterFIP replaces WorldFip (test successful so far)
- Major software stack update
- NXCALS logging – in cooperation with BE-ICS
- Refactoring of real time application
  - Data processing optimization
  - State machine controller
  - Automatic fault recovery
- Automatic analysis of state of health of the system
- Swisstool extension
- Supervision must be fully operational before QPS IST and LHC HWC!

Conclusions

- QPS for MQ will be upgraded due to approaching the end of the system lifetime, and as well to enhance diagnostics and remote maintenance
- QPS for 11T will be deployed to protect 11T magnet
- Partial consolidation of QPS for IPx circuits will be performed
- We do not expect any surprises in QPS due to operation at 7 TeV

Thank you for your attention!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