# Quench Detection Systems & Quench Heater Powering

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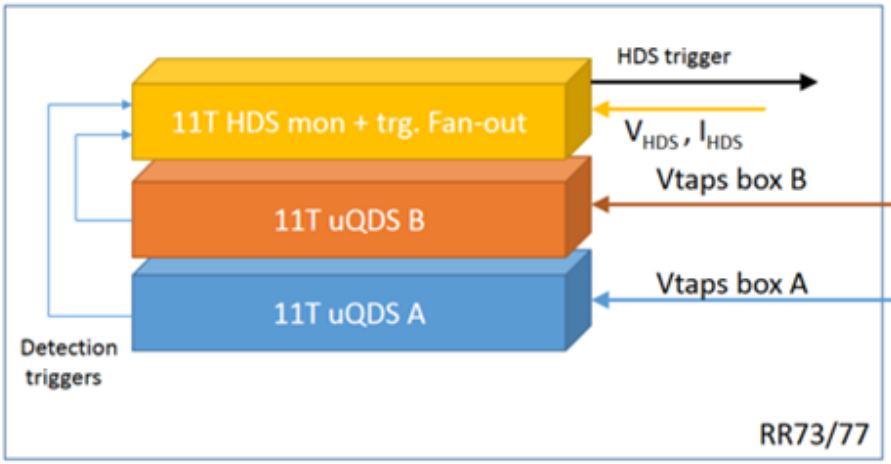
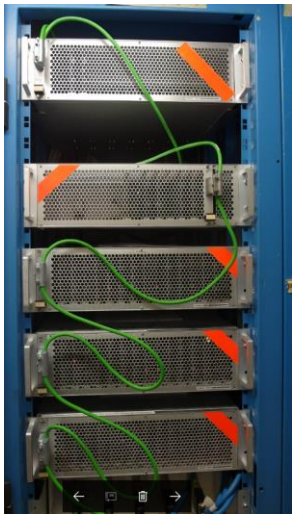
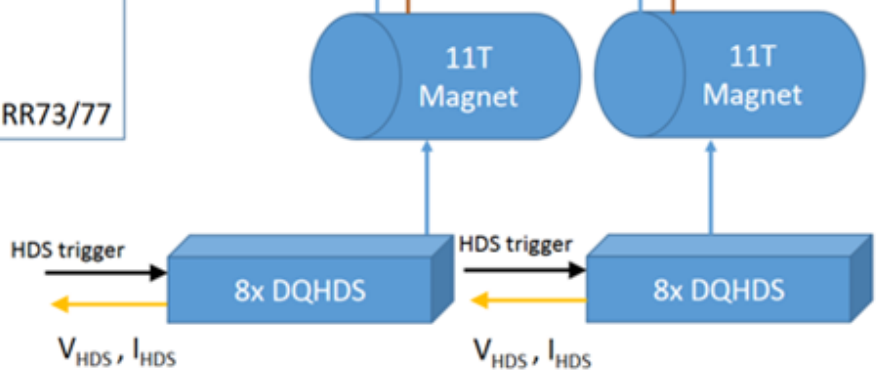
# 11 T protection & quench detection



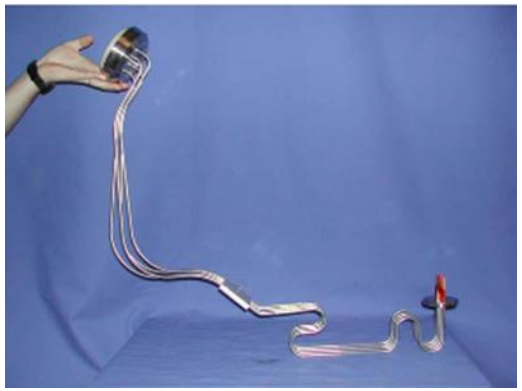
1 Gy/year




up to 40 Gy/year

# 11 T trim lead protection

- The 2 x 2 resistive leads used for the powering of the 11 T trim circuit require a dedicated detection system supervising the lead voltages and currents
  - System will be installed in RR73/77 in a rack shared with the PIC
  - Current sensors will clamped on the cables powering the trim circuit
  - Detection system interlocks the trim circuit power converter



# Quench heater powering & supervision

- 2 x 8 quench heater discharge power supplies (DQHDS) per MBH
  - Enhanced version of the default LHC DQHDS
    - 2 x UPS feed for each power supply NEW
    - Current transformers type DQCLT integrated into DQHDS NEW
    - **14 out of 16** DQHDS required for proper magnet protection (MB 1 out of 4)
    - → software interlock settings as for MQ, IPQ, IPD and IT:
      - 1 x DQHDS on fault → after a certain evaluation period (typically 1 hour) and pre-warning to LHC-OP and experts, beams will be dumped and RB circuit ramped down
  - Cable connection between DQHDS and magnet is interlocked via the quench heater supervision unit
  - DQHDS are radiation tolerant → currently under test in CHARM

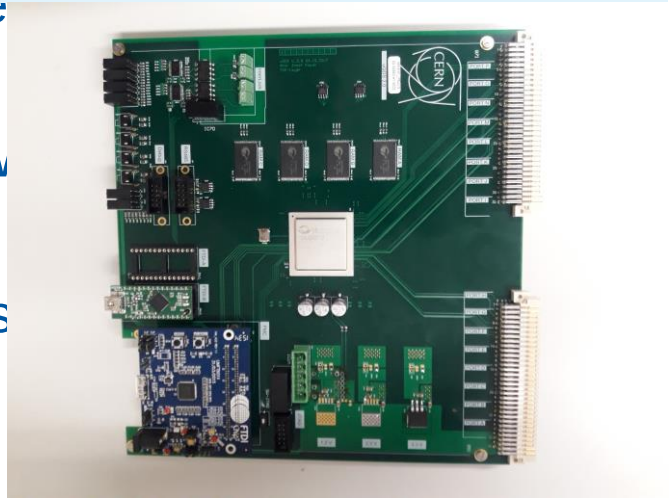
# Quench heater powering & supervision II

- Enhanced quench heater supervision for all quench heater circuits
  - As for MB and MQ (after LS2) these dedicated units monitor the charging voltage of the DQHDS record simultaneously voltage and current during a discharge
    - Current measurement with the help of DQCLT
    - 16 Bit resolution with sampling rates up to 192 kS/s
  - Proven concept capable of detecting pre-cursors of possible quench heater firing
  - Hardwired DQHDS trigger lines supervised NEW

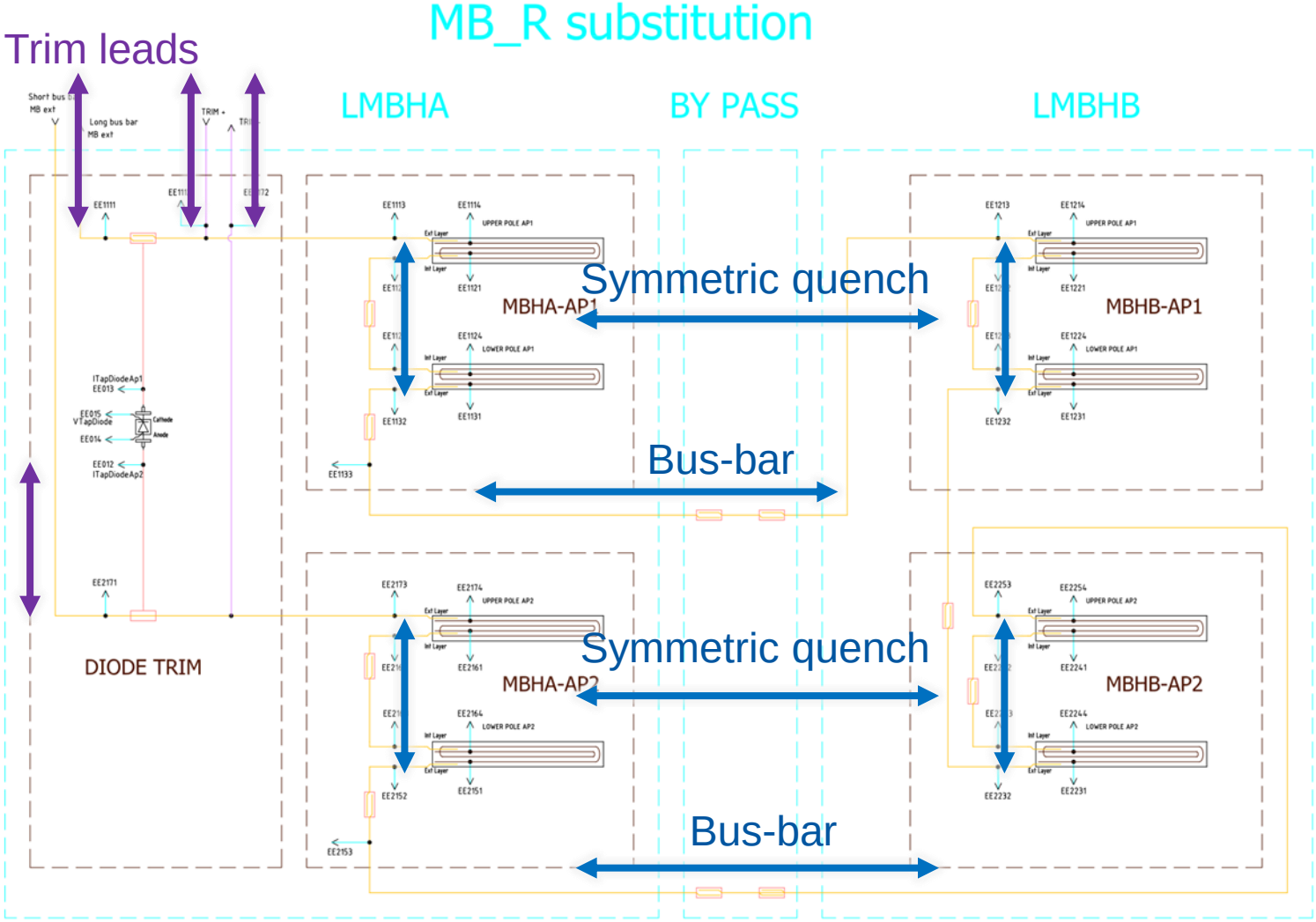
# Quench detection systems – MBH protection

- A prototype uQDS unit is currently installed in SM18 / cluster C and running in parallel with the existing SM18 protection systems
  - uQDS deployment has started for B180/FAIR (2018) and will continue in 2019 with B163 / FRESCA 2 and SM18 / cluster F
- The configuration of the detection algorithm can be optimized for maximum flux jump rejection depending on the results with prototype/series magnets
- A prototype uQDS unit has been recently successfully tested in CHARM for radiation tolerance

  - 2 x 1 magnet current (for current depe
    settings)
- Calculated signals (linked to hardw
  - 4 x output of numerical bridges
  - 2 x output of MBHA – MBHA comparis
    symmetric quenches)



# Quench detection systems – MBH protection




Technically any magnet signal can be compared with any other!

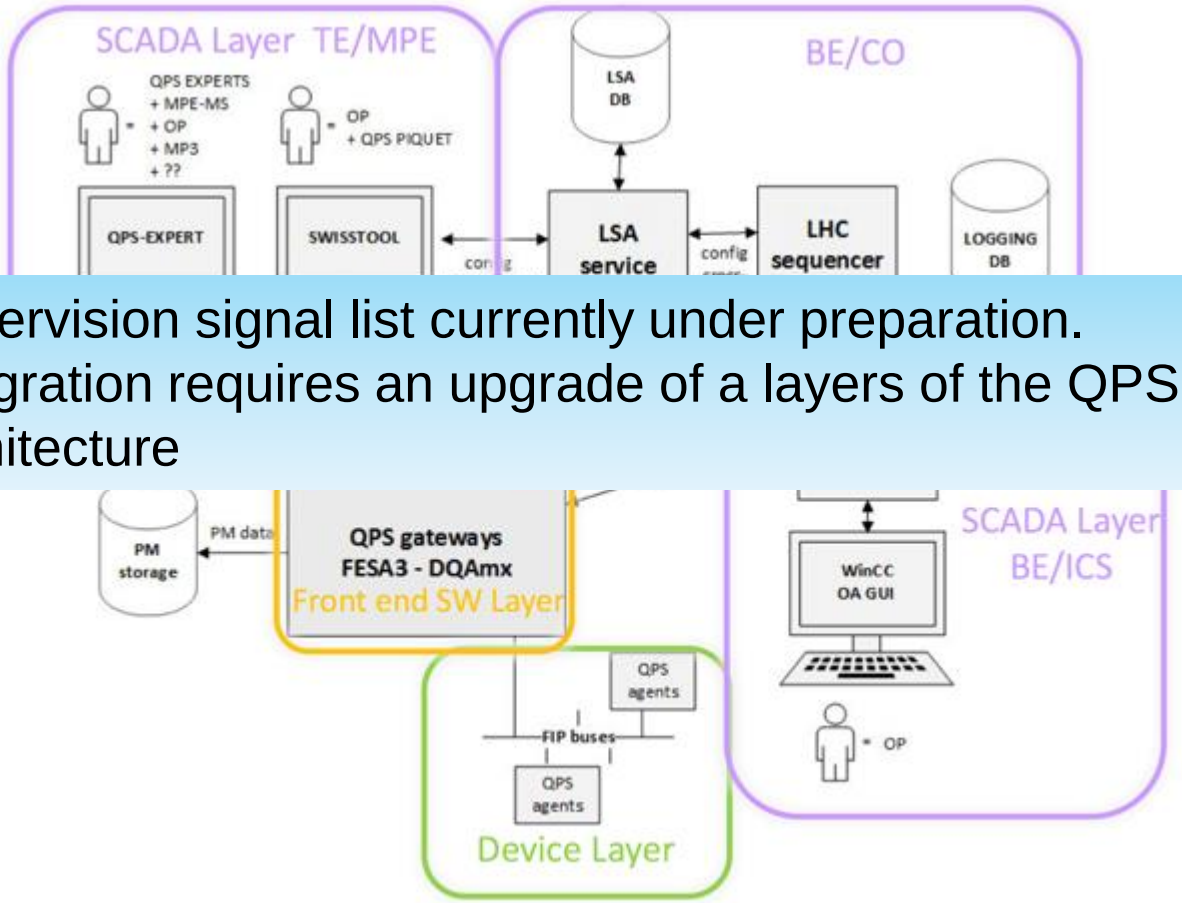
# Quench detection systems – trim circuit

- Input signals
  - 2 x 4 lead voltages
  - 4 x 1 lead current
- Calculated signals (linked to hardware triggers)
  - Threshold on current balance
  - Threshold for each individual lead voltage
- Default interlock configuration
  - Interlocking trim circuit power converter via PIC (600 A configuration)

# Supervision and data acquisition systems

- The QPS supervision will assume multiple tasks
  - Logging of signals from magnet & circuit
  - Logging of signals and status of protection & detection systems
  - Record post mortem data in case of events e.g. a magnet quench
  - Transmit signals associated with software interlocks
    - QPS_OK, DQHDS availability (14 out of 16)
  - Remote diagnostics, test, maintenance and configuration of protection & detection systems
    - Interlock tests, quench detection settings …
- Data transmission from the underground areas to the surface via a field-bus link
  - Currently of the WorldFip™ standard, which may be upgraded at a later stage

# Supervision and data acquisition systems




- Supervision signal list currently under preparation.
- Integration requires an upgrade of a layers of the QPS supervision architecture

# Summary

- Design, test, production  and delivery of all protection and detection systems for the 11 T dipoles and the trim circuits on track
- Integration into the LHC/QPS supervision has started
- The installation of the MBH magnets in sectors 6-7 and 7-8 requires as well a modification of the nQPS system
- Installation in LHC from July 2020 onwards
- Looking forward to see the first quench detection system for $Nb_3Sn$ magnets operating in LHC