QPS R2E activities

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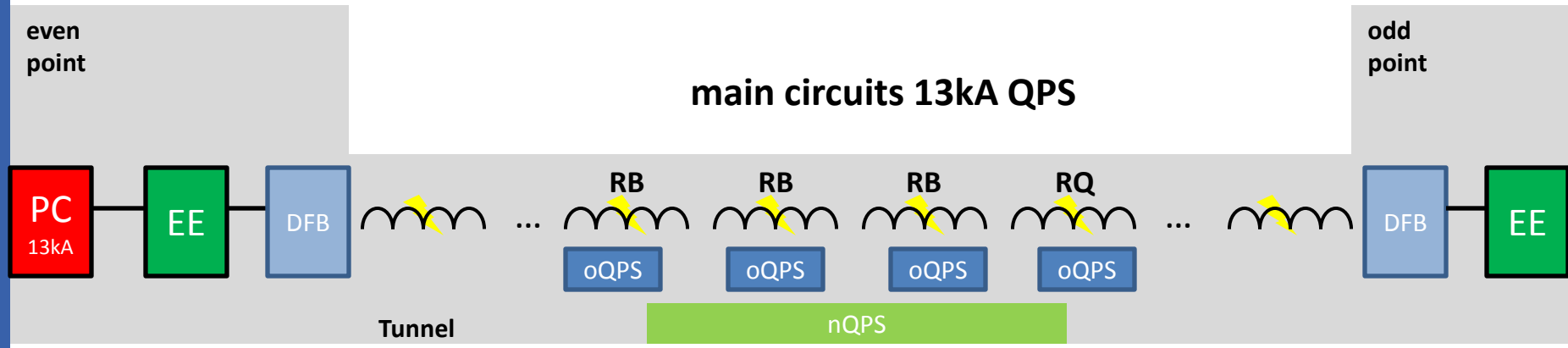
Topics

- QPS overview
- R2E issues
- R2E activities for LS1
- R2E mini review outcome

Introduction

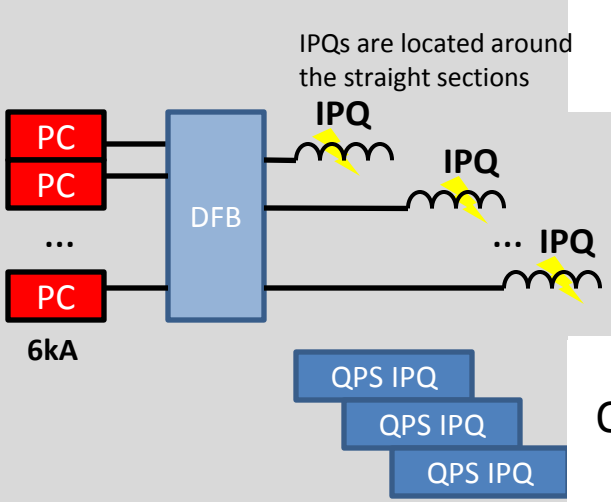
- The QPS system is distributed all over the LHC machine (75% tunnel, 25% UA, RR, UJ)
- Installations include areas with radiation level of different intensity/dose
- Radiation issues cannot be fully solved by shielding/relocation
- Development of radiation tolerant digital quench detectors is ongoing
- The program for LS1 is established

QPS overview

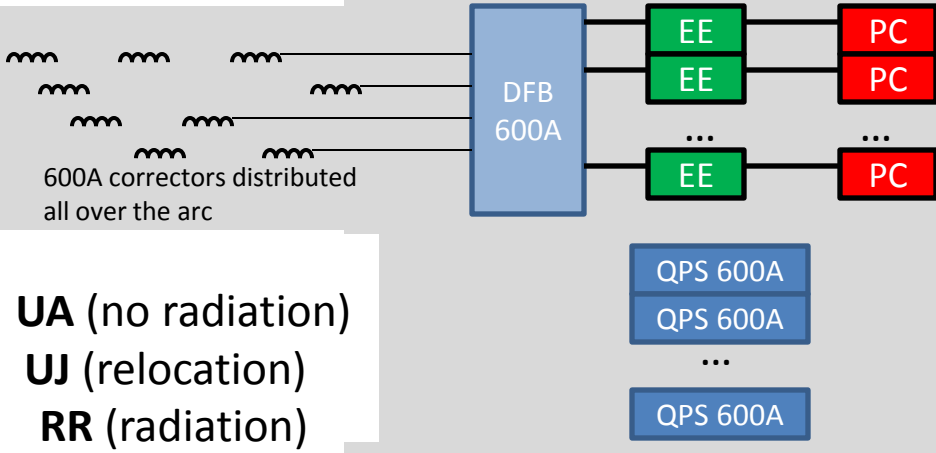


QPS located in: **Arc** (less radiation)
DP (more radiation)

6kA QPS

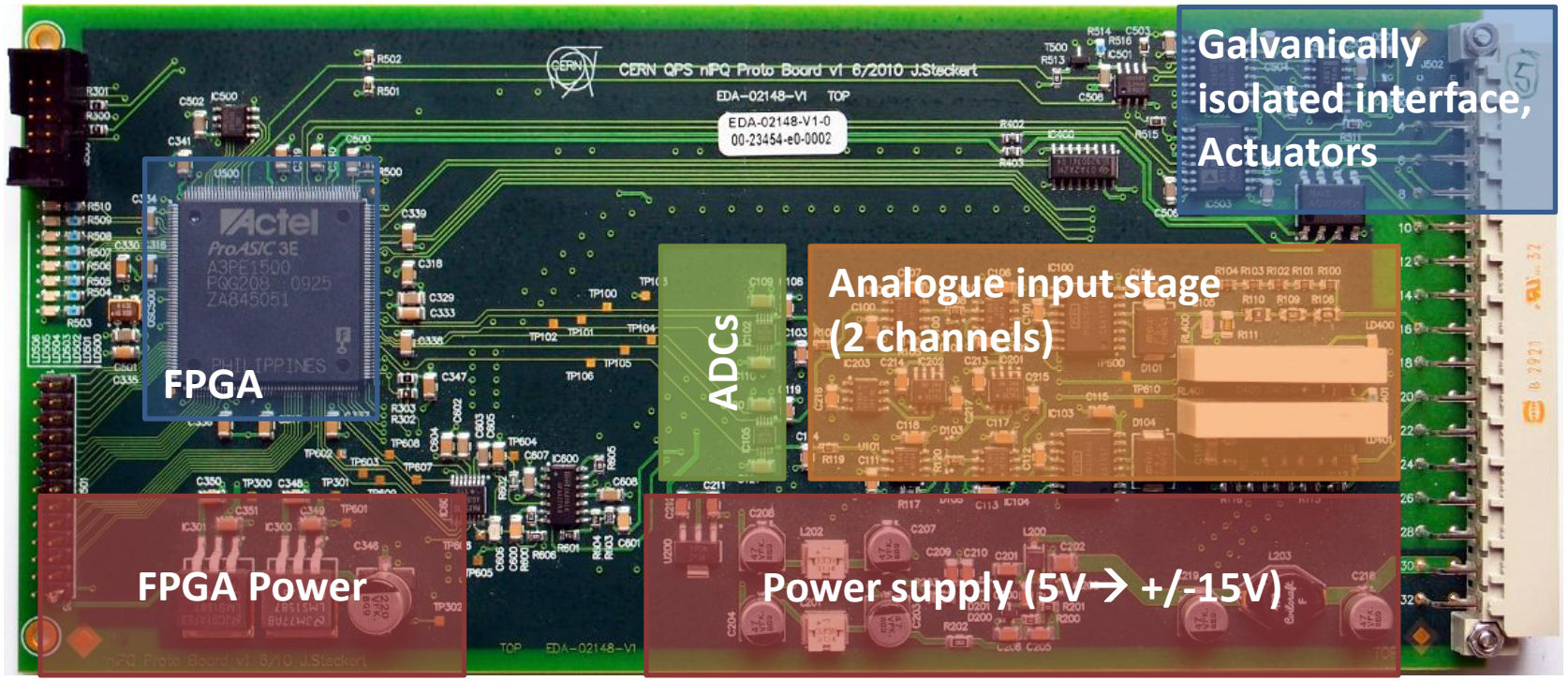


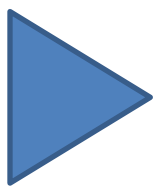
600A QPS

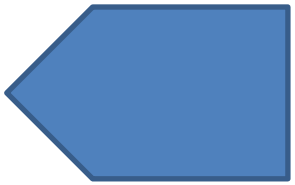


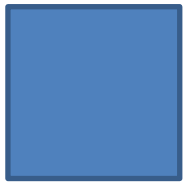
QPS located in: **UA** (no radiation)
UJ (relocation)
RR (radiation)

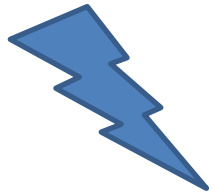
Typical QPS system




Analog input

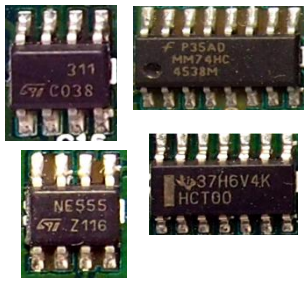

ADC

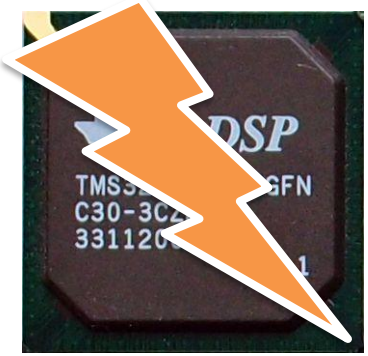

Logic device


Actuator(s)

Auxiliary circuits

Logic device technology overview





➔ QPS system uses different technologies to perform the protection logic

- Analog, comparators, TTL: DQQDL → >4000 boards
- Digital, uC ADuC834: DQQDC, DQQBS
- Digital, DSP TMS320C62: DQQDI/DT/DG
- Digital, FPGA Actel ProAsic3: DQQDS, DQHSU
  nDQQDI (soon)
  nDQQDG (this year)

R2E issues

R2E issues (areas)

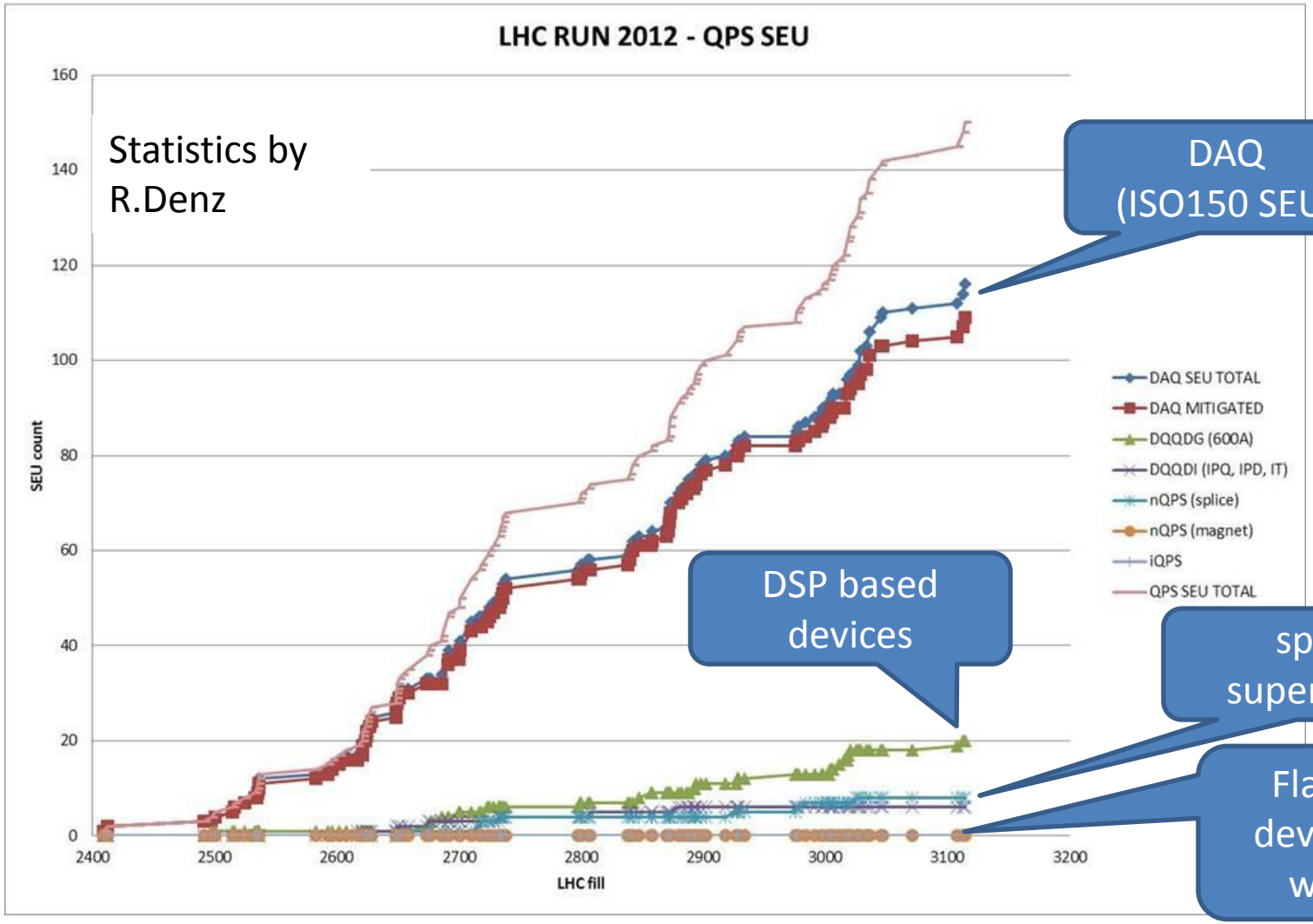
- Areas with installed QPS equipment and radiation
  - Dispersion suppressor (straight tunnel sections around IP)
  - RR
  - UJ (no equipment after R2E relocation)
  - Arc (varies depending on position)

- Areas with QPS equipment, no radiation
  - UA

R2E issues (devices)

- DSP based devices are very sensitive, virtually impossible to mitigate by software
  ➔ **Relocation** or **replacement** by rad-tol device
- uC based devices show some sensitivity, can be partially mitigated by firmware (memory triplication)
  ➔ Firmware upgrades (replacement long term)
- Flash FPGA based devices show no radiation issues so far
  ➔ The preferred solution up to LS2

R2E issues (statistics)



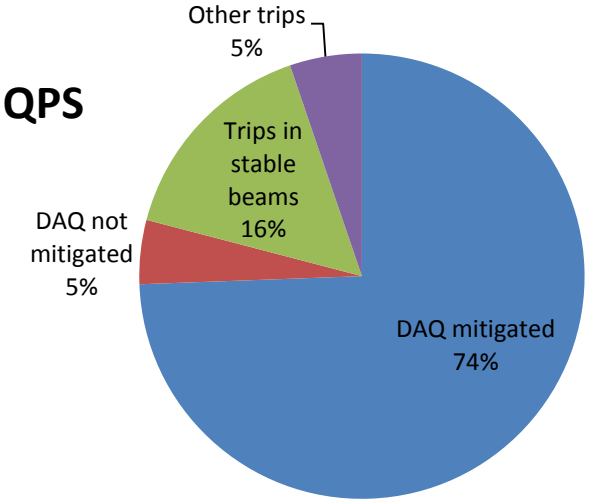
➔ Most SEUs are caused by DAC systems which are mitigated

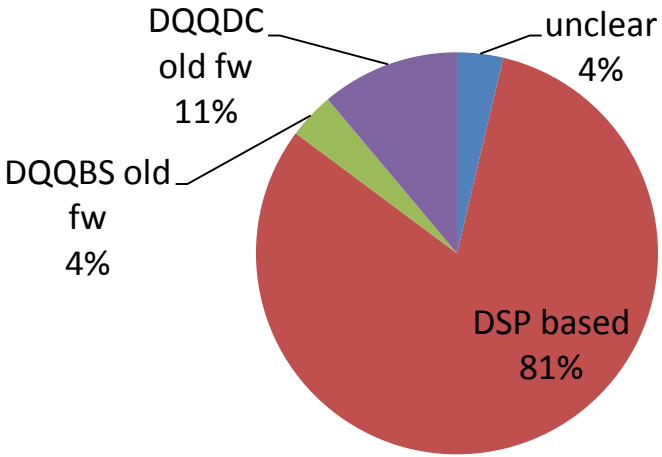
➔ SEUs in DSP based systems (DQQDI/DQQDG) are critical (lead to beam dump)

➔ nQPS(magnet) was designed to be rad tolerant: no SEU induced errors so far

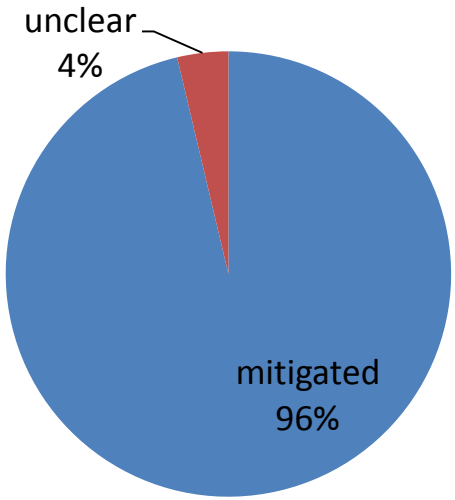
Statistics analysis

2012: 172 R2E events in QPS





R2E consolidation



2012: 27 R2E trips during stable beam

with all foreseen measures in place: 1

R2E activities for LS1

R2E tolerant devices

- DSP based detectors had never been designed to withstand radiation
  (zones had been declared radiation free in the past…)
- Detectors designed to be rad-tol performed extremely well:
  - DQQDS: 1750 boards installed in tunnel (based on ProAsic3)
    → 0 radiation induced faults so far
  - DQQDL: > 4000 boards except the on board DAQ system
    → 0 radiation induced faults

- Replacing the DSP based devices by rad-tol versions and upgrading the firmware of the uC based boards should greatly reduce the number of r2e trips

QPS R2E activities: oQPS, nQPS

Mandatory

- Firmware upgrade for all DAQ systems
- Firmware upgrade for all dipole splice supervision boards
- Firmware upgrade for all current lead protection systems installed in RR (the ones in the UJs will be relocated)
- Installation of quench detectors with rad-tol DAQ in cells 8-12 (nDQQDL)

Optional

- Development of special, rad tolerant splice supervision boards for cells 8 – 12
- BricoFIP™ add-on for the DQAMC crate controllers in the dispersion suppressor

QPS R2E activities: IPQ/IPD/IT

- Relocation of equipment installed in UJ areas
- Installation of a rad-tolerant DQQDI detector in the RR-areas

Status

- 200 nDQQDI boards produced
- 1 test installation currently running in LHC (RQ6.R5)

QPS R2E activities: 600A

- Relocation of equipment installed in UJ areas
- Development of rad-tol 600A quench detection board

Status

- Prototype developed, works fine in lab
- Test foreseen after current LHC run
- Final choice of ADC subject to radiation test result

R2E mini review outcomes

- Rad-testing of high-res ADC
  (blocks further development)
- Overall rad-hard design not feasible for QPS
  (resources, cost)
- Design with rad-tested COTS, focus on weak points
- ProAsic3 will replace DSPs in rad-tol designs
- Option to introduce 1 out of 2 AND 1 out of 2 redundancy scheme in critical areas
- Outlook beyond LS2 ?
- Additional manpower should be put on rad tolerant development

Summary

- R2E issues in QPS systems known and monitored (R2E statistics)
- Program for LS1 mostly clear
- Rad-tol IPQ/IPD/IT boards developed and produced (ready for installation during LS1)
- Still some development/component testing ahead for rad-tol 600A board
- Firmware upgrades for the uC based precision boards (DQQBS, DQQDC) planned
- Replacement of the field bus couplers for a later date after LS1 prepared

➔Measures should ensure operation between LS1 and LS2 and for most systems beyond