Development of Radiation Tolerant Systems, Including VHDL codes – Status and Plans

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Development of radiation tolerant systems – outline

- 2010 experience and conclusions
- Field-bus couplers
- Quench detection systems
- Long term perspectives
- Resources

QPS events during 2010 which have been caused by radiation induced faults (not necessarily due to Single Event Upsets)

Event type	Cases	Electronics failure	Remark
Loss of communication DQQBS type circuit board (nQPS splice protection)	1	Stalled interface or microcontroller	Remote recovery by power cycle, during ion run
Permanent trigger on DAQ systems type DQAMC	12+3	Latched digital I/O of digital isolator (ISO150)	8 during proton run (basically during specific tests), 7 during ion run, 3 events observed with updated firmware → no stalling of DAQ system
Lost fieldbus communication DAQ systems type DQAMC	2	MicroFip™ chip (old version)	During ion run

Conclusions from 2010 run

- So far only non-destructive faults recoverable by power cycles
  - With one exception only DAQ systems affected
  - Faults were not stopping a fill but required access prior to refill
  - Firmware upgrade of DQAMC type DAQ systems cures most of the problems → on the way for all hot zones (3, 7, L2, R8)
    - Additional benefit: secondary DAQ trigger on DQHDS discharge
  - No real showstoppers so far and no events outside hot zones
- Fault occurrence in contradiction to some of the radiation test results
  - Consistent with CNGS data but in contradiction to TCC2 and some PSI tests
- Radiation to electronics is real – not the result of simulations
- Electronics exposed to radiation in the long term to be minimized not to be extended
  - E.g. relocation of systems located in UJ14, UJ16 and UJ56
  - ALARA principle for exposure of people to radiation

New developments – fieldbus couplers

- Present fieldbus coupler based on the MicroFIP™ chip shows more problems in radiation environments then expected from some test results
  - Firmware upgrade will cure most of the problems
- Chip will become obsolete soon → replacement needed
  - Proposed solution by BE-CO: nanoFIP
    - Based on ACTEL PROASIC3™ FPGA (in use by QPS and others ...)
    - Neither hardware nor software compatible with existing device
    - For the time being nanoFIP and MicroFIP™ cannot coexist on one QPS fieldbus segment (at least upgrade of gateways required …)
- Development of new QPS fieldbus coupler in 2011 (DQAMCN)
  - Additional requirements to be defined soon (see Joaquim's talk)
- Re-configuration and extension of QPS fieldbus networks in order to allow relatively smooth upgrade
  - Number of tunnel segments (not clients!) to be doubled
  - Initial phase will only concern segments around hot zones

New developments – quench detection systems

- Concerns in the midterm devices currently installed in areas formerly known as radiation free, e.g. RR17 …
- Replacement of quench detection systems type DQQDI (IPQ, IPD, IT) and DQQDG (600 A circuits)
  - Prototype of DQQDIN currently under lab test including firmware
  - Based on PROASIC3^{TM} FPGA – optional hardening of VHDL code provided by tool chain (implementation of triple module redundancy TMR)
  - Hardware compatible with DQQDI – only minor changes for local DAQ system
  - Next step will be the DQQDGN, which is a non trivial task
    - Significant effort in the past to get the 600 A detectors working without the radiation constraint
  - No immediate action required for detection systems type DQQDC and DQQBS (splice and HTS lead protection) due to satisfying results in CNGS tests 2009 and 2010 (not to forget LHC operation in 2010)

New developments – long term considerations

New developments – resources

- All new developments will be performed in parallel to LHC exploitation
  - Limited expert availability as LHC has priority
  - All developments require a close collaboration of several experts
    - QPS hardware experts, controls experts etc.
  - Additional resources would be highly appreciated e.g. Marie Curie fellows
- Some upgrades will implicate significant costs
  - e.g. DQAMCN for complete machine (1624 devices) estimated to 0.5 MCHF plus installation
- Experience with existing devices to be integrated into all new developments
  - Additional requirements to be defined at an early stage
- Radiation tests to be minimized and closely coordinated with R2E community
  - Time consuming in preparation and execution
  - Lack of suitable test facilities (mixed radiation fields)