Magnet protection and Interlock systems

Ongoing improvements for increasing the availability for the LHC

Workshop on Machine availability and dependability for post LS1 LHC

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28th November 2013

Outline

Magnet protection and Interlock Layout

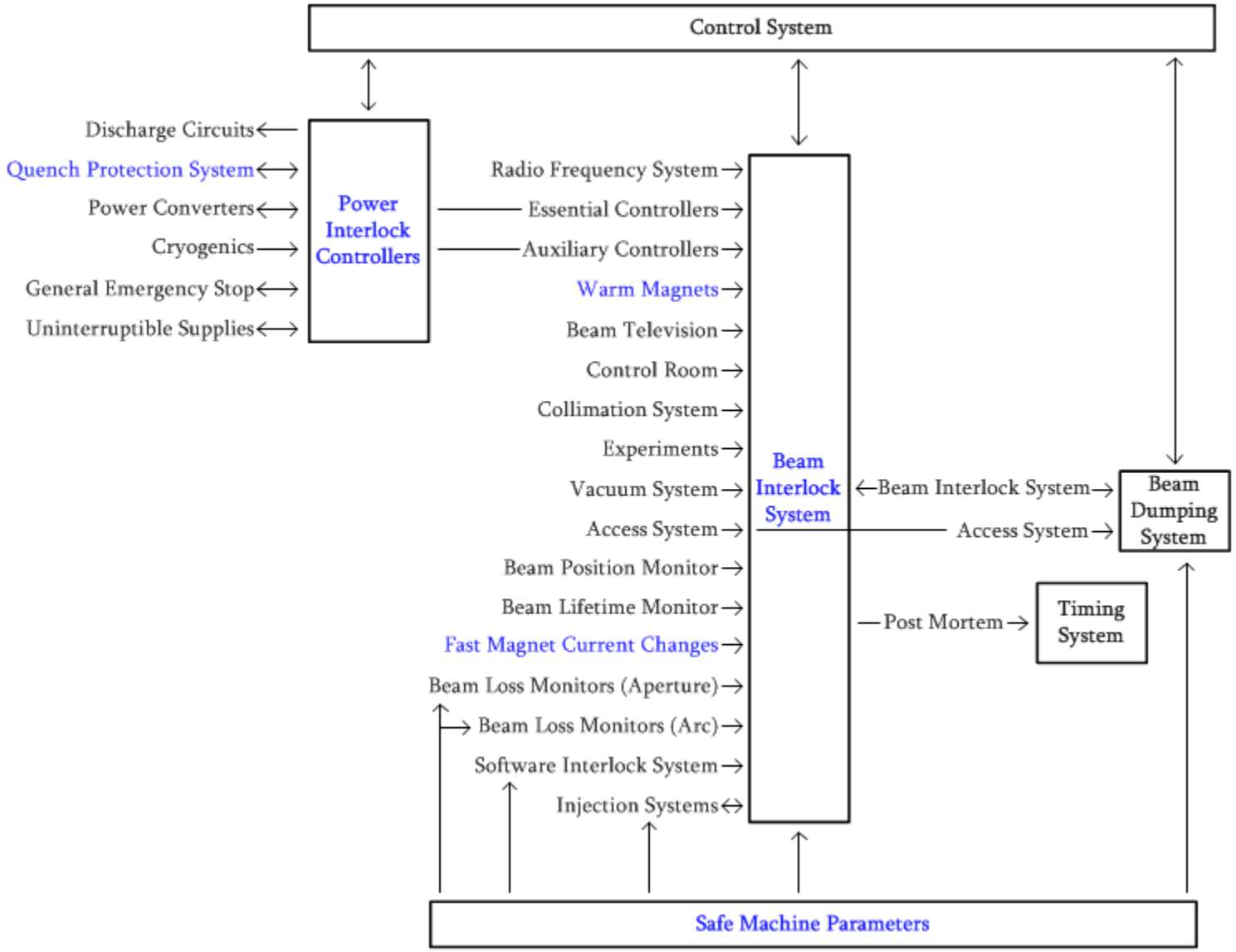
Issue tracking tools

System by system availability and dependability study

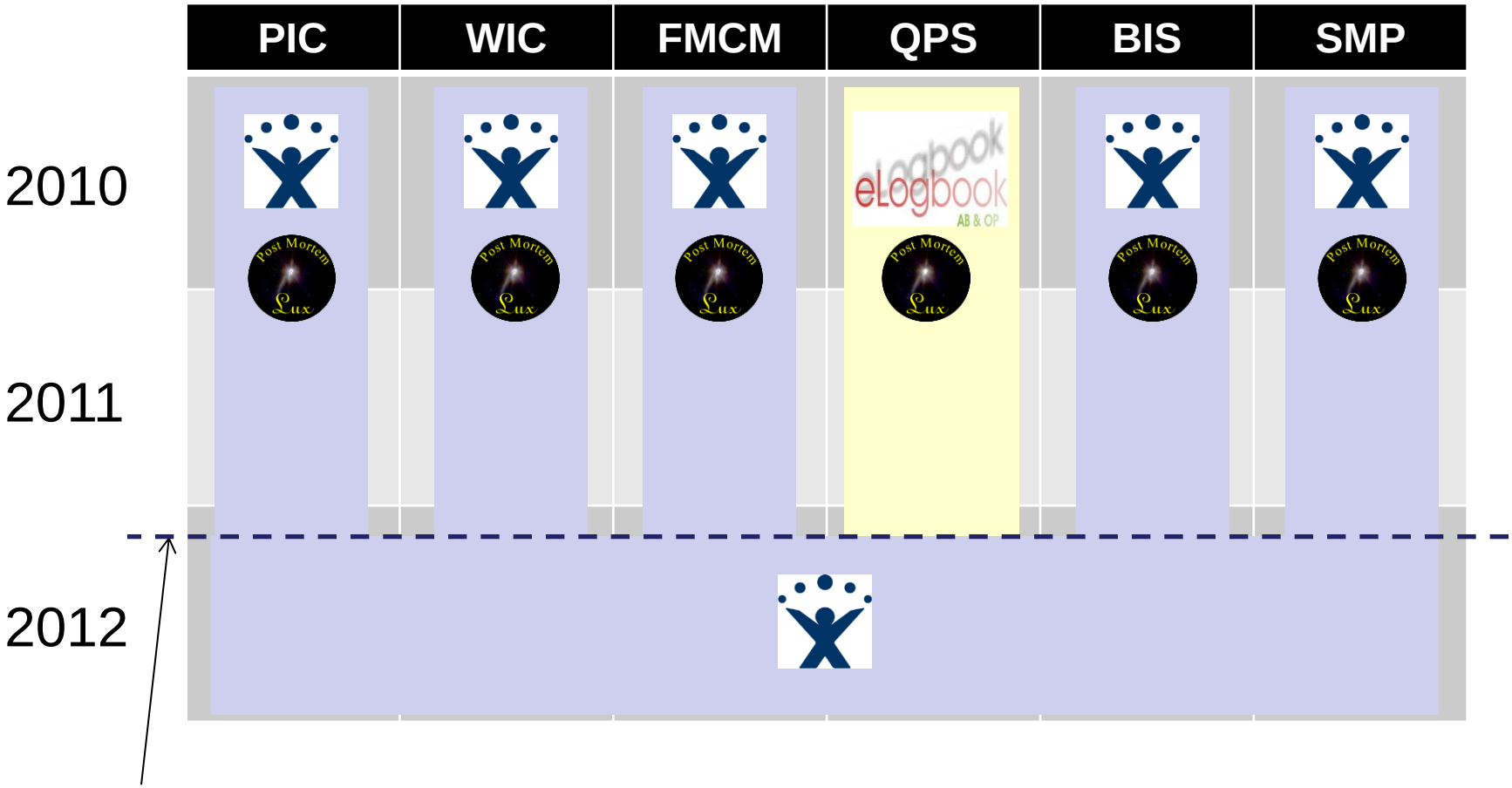
- Availability matrix
- System modifications to improve availability and dependability
- Further improvement during LS1

Discussion

Magnet protection and Interlock Layout



Issue Tracking tools



System by system availability and dependability study

For each of the 6 systems:

- Powering Interlock Controller (PIC)
- Warm magnets Interlock Controller (WIC)
- Fast Magnet Current Monitor (FMCM)
- Beam Interlock System (BIS)
- Safe Machine Parameters (SMP)
- Quench Protection System (QPS)

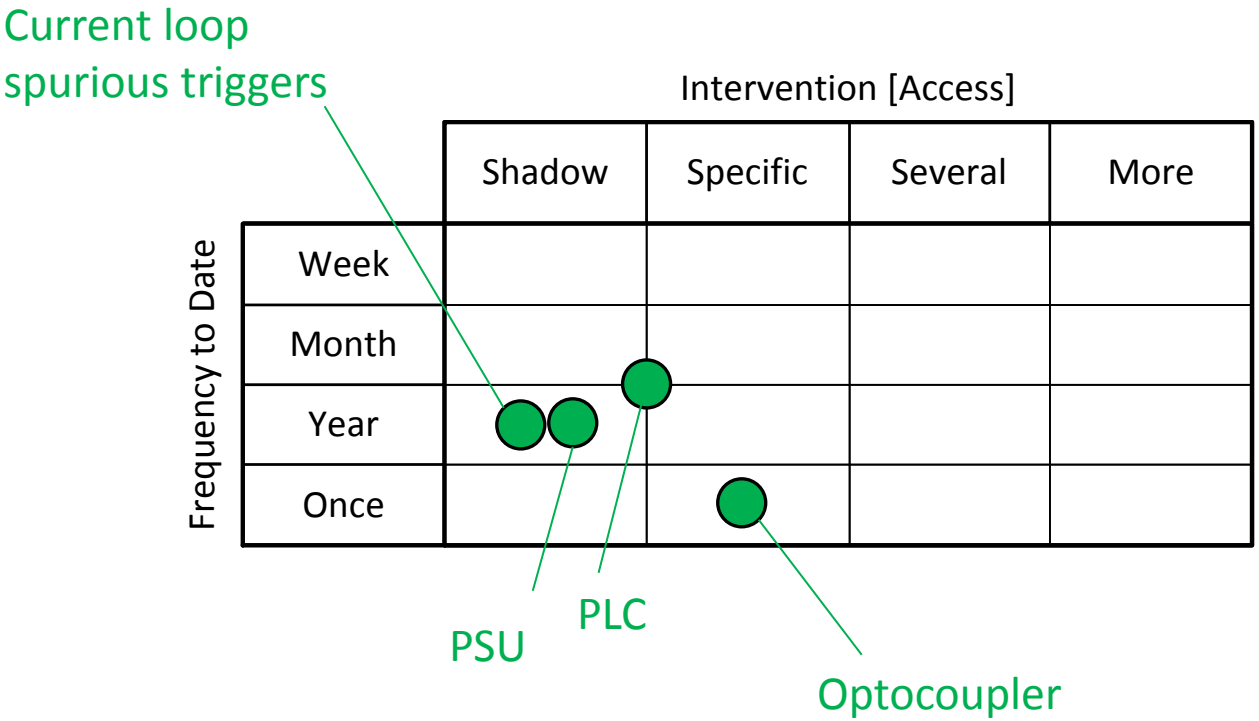
Availability matrix with failures:

- Responsible or not responsible of beam dump
- Induced by the system itself or by external perturbation

Details about improvements:

- When the failure comes from the system itself
- Other modifications to be mentioned

Powering Interlock System (PIC)



PLC : SEU problems (UJ14, UJ16, UJ56) solved by relocation (2011)

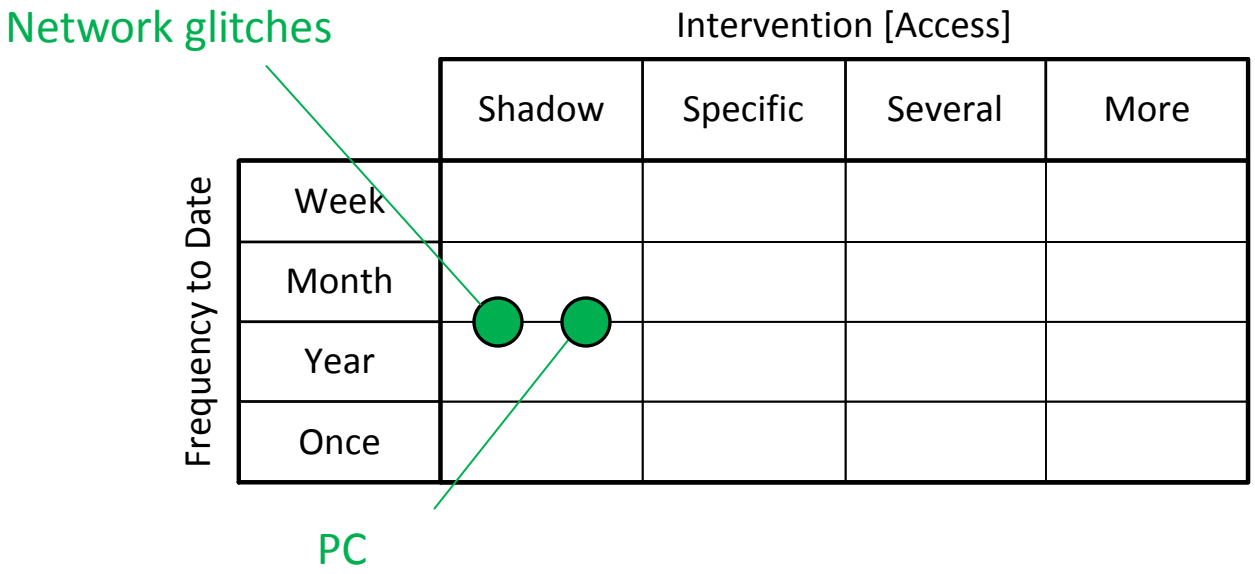
Current Loop Spurious trigger : Not fully understood (connectivity issues?)

Optocoupler : due to intervention? Studies* shows a low failure probability

PSU : (redundant → no beam dump induced) is solved by replacement

* Reliability Analysis for the LHC Powering Interlock Controller - M.Zerlauth - 2004

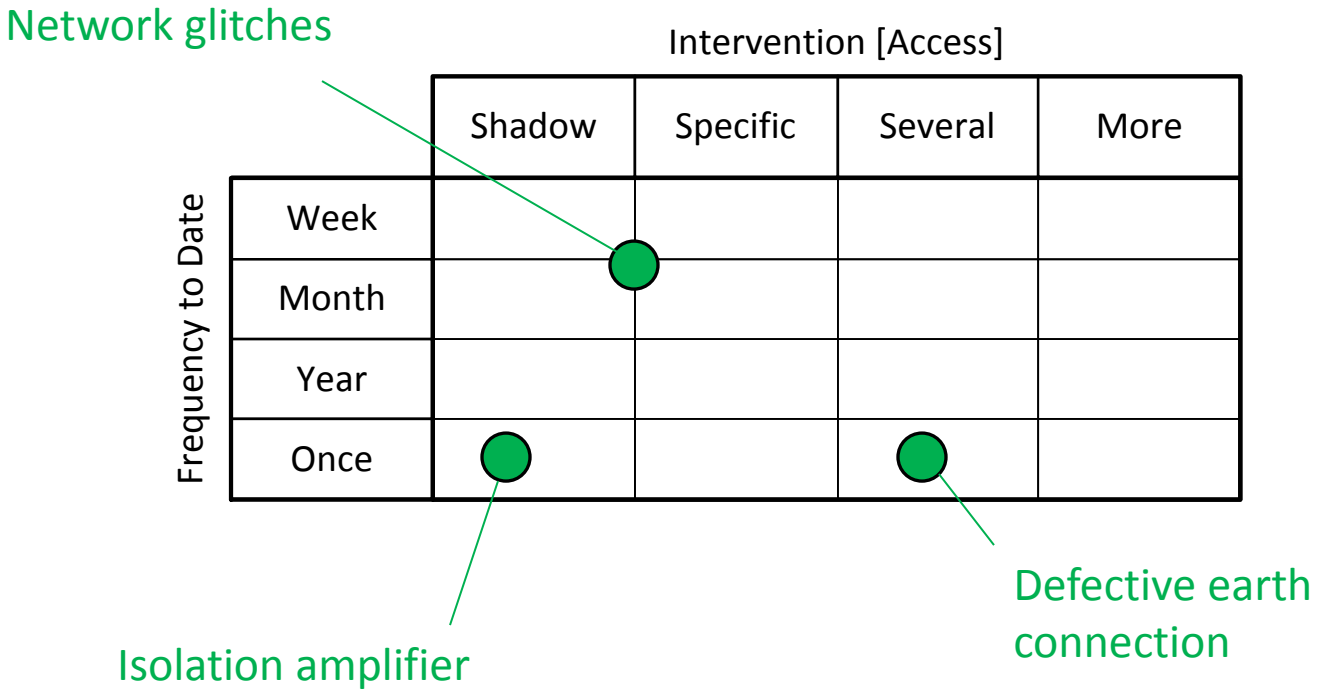
Warm magnets Interlock (WIC)



Network glitches : Spurious electrical network glitches

PC : Power converter failure induces beam dump through the WIC

Fast Magnet Current Monitor (FMCM)



Network glitches : Due to high sensitivity of RD1 and RD34 power converters

=> PC regulation improvement during LS1

Defective earth connection : Faulty PC earth connection provoked FMCM triggers

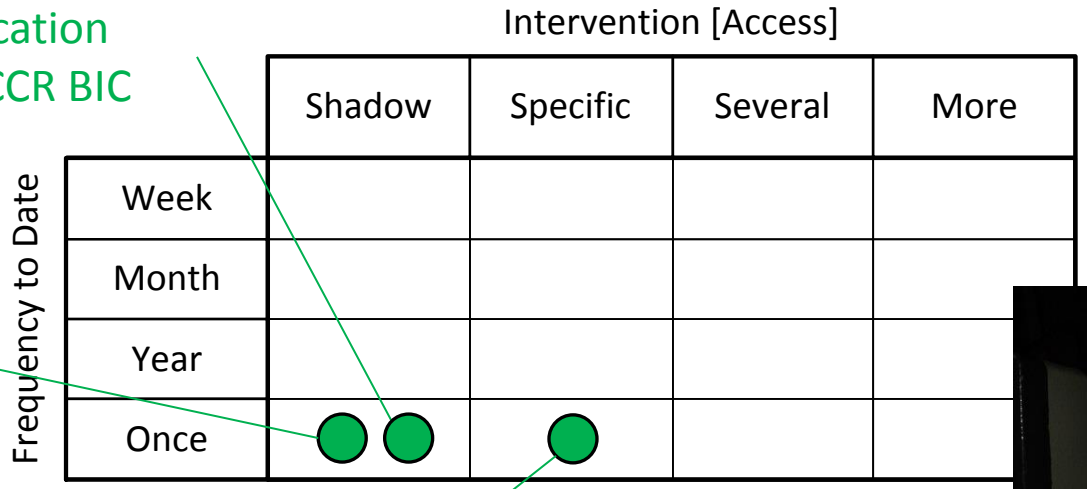
Isolation Amplifier : Problem solved by replacement

Beam Interlock System (BIS)

Communication lost with CCR BIC

Spurious dump from OP button

Glitches on Optical Fibers



Communication lost with CCR BIC : FESA class upgrade has cured the problem

Spurious dump from OP button : Button contact inversion solved the problem

Glitches on Optical Fibers : Optic Fibres attenuation -> CIBO changed

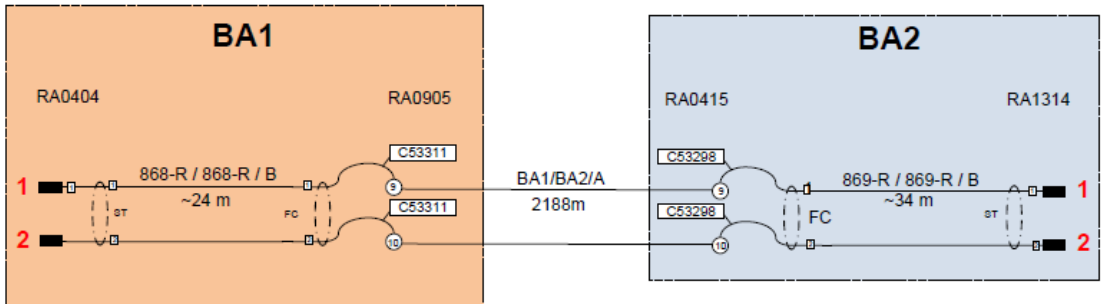
=> New system to monitor fibres

Beam Interlock System (BIS)

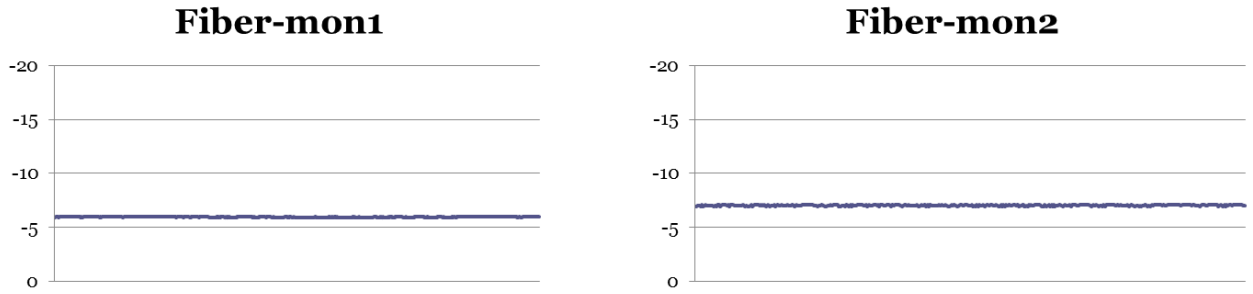
Fibres monitoring (Jonathan Burdalo):

- Monitor fibres to measure their attenuation
- Use of Raspberry Pi + Xilinx Spartan6 Dev Board

- Installed in June 2013 for test on SPS spare fibres between BA1 and BA2



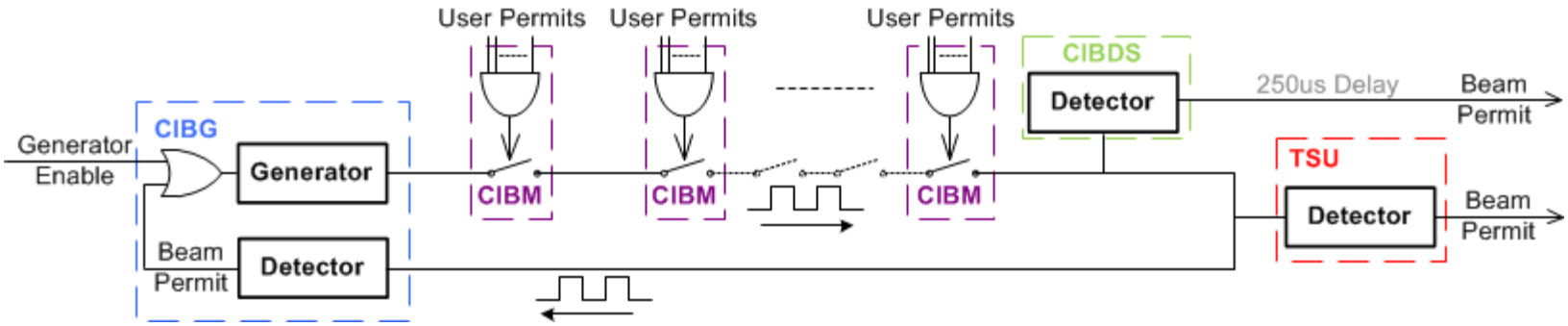
- No attenuation so far



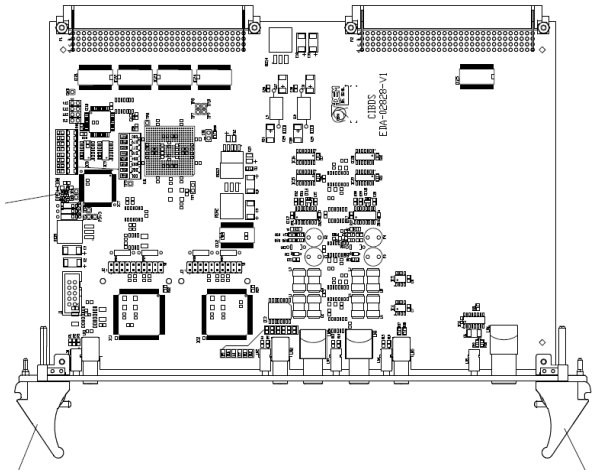
Beam Interlock System (BIS)

BIS retriggering channel LBDS reliability:

- A new channel from BIS electronic to LBDS retriggering lines will be installed in 2014



- New VME board : CIBDS (Dumping System)

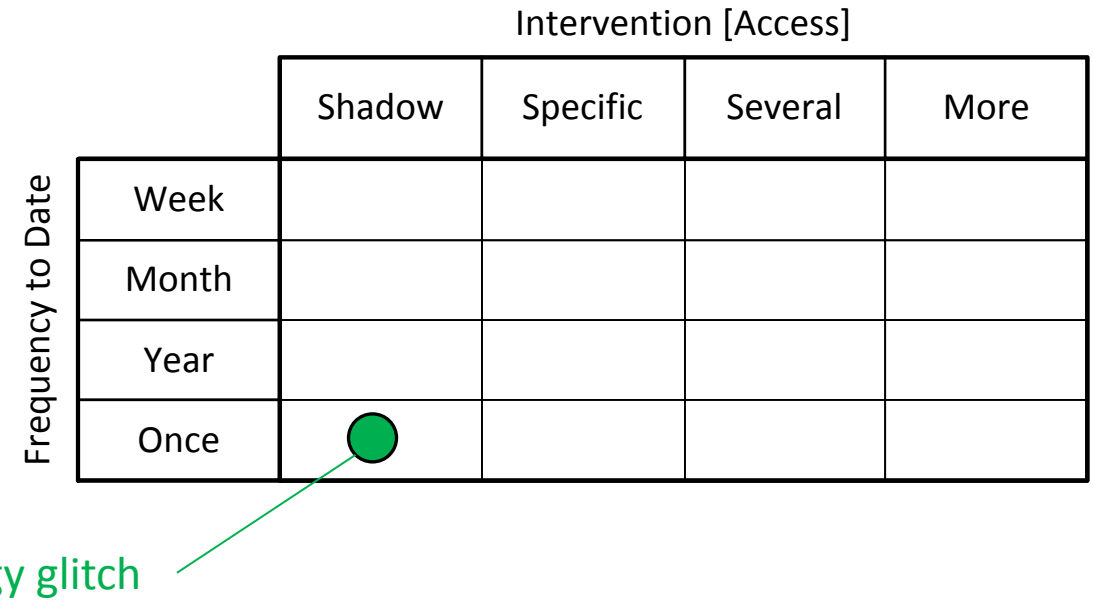


- Has to increase the reliability and keep a high availability

Specific study on the reliability and availability (by Volkan Vatansever – Stuttgart University)

⇒ Very high availability

Safe Machine Parameters (SMP)



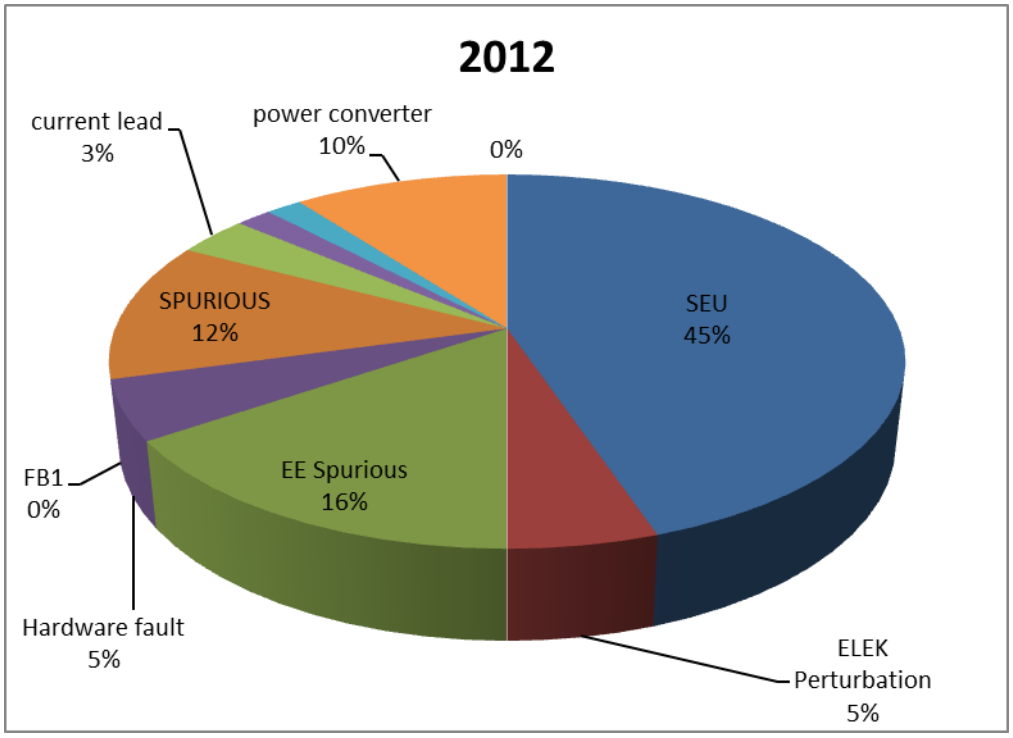
Energy glitch : No glitch detection in the SMP (SMP output / cross checker)

Cable connection?

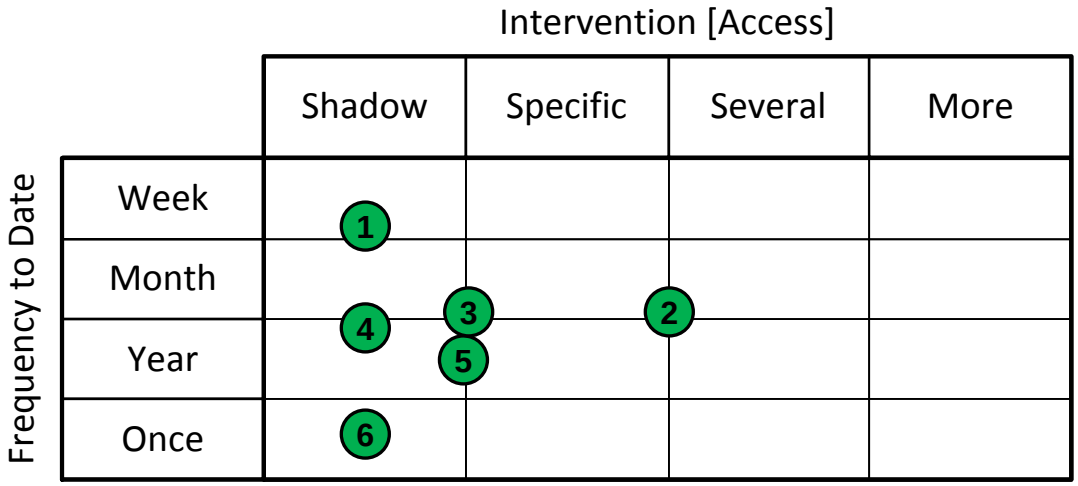
Quench Protection System (QPS) in 2012

We consider:

- Failures (not only from QPS!) provoking beam dump
- Only during 2012 as some 2010-2011 failures are “obsolete”



Quench Protection System (QPS) in 2012

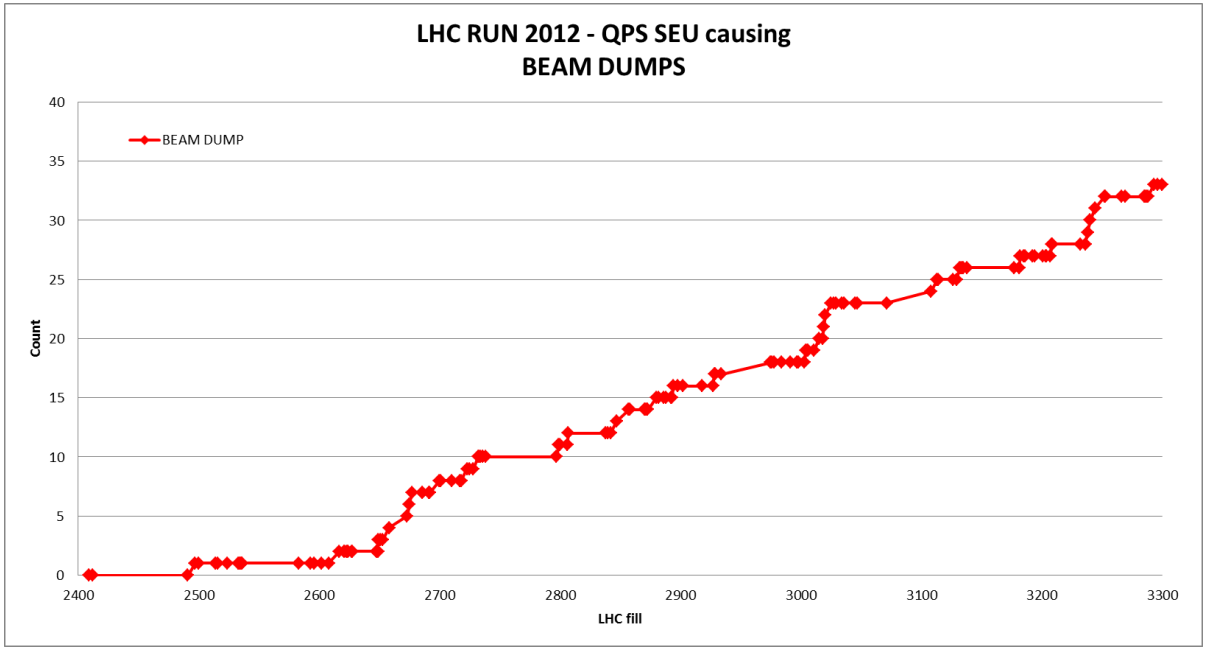


1. SEU (33): Radiation level
2. EE spurious (9): Mainly bad connections
3. Spurious (8): Bad connections and more
4. Power converter (5)
5. Electrical perturbation (3)
6. Human Error (1) : Operator manipulation

Quench Protection System (QPS) in 2012

1. Single Event Upsets :

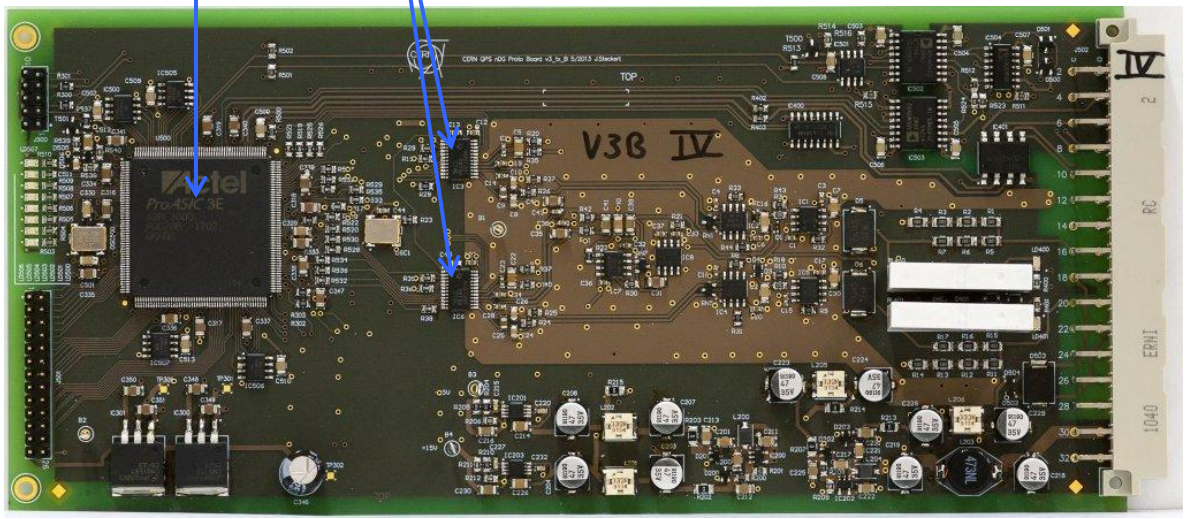
- In total, 128 SEU occurred in 2012 (33 inducing beam dumps)
- 30% will be solved by moving the systems into protected zones:
  - UJ56 -> UL557
  - UJ16 -> UL16
  - UJ14 -> UL14



Quench Protection System (QPS) in 2012

1. Single Event Upsets :

- Will be reduced by electronic upgrade (in the RR) :
  - DSP replaced by FPGA(ProASIC 3) for IPQs and 600A protection circuits
  - Rad-tol FPGA + ADC with SEU correction
  - Firmware upgrades for several units to enhance rad tolerance



- Availability will increase, even with post-LS1 beam energy and intensity

Quench Protection System (QPS) in 2012

2 EE Spurious :

- Mainly due to bad connections
  ⇒ Campaign during LS1 to check all cables
- Better monitoring for Switch overheating (new temperature sensor)
- Mouse traps…

3 Spurious :

- Some bad connections
- Few unexplained triggers

5 Electrical perturbation :

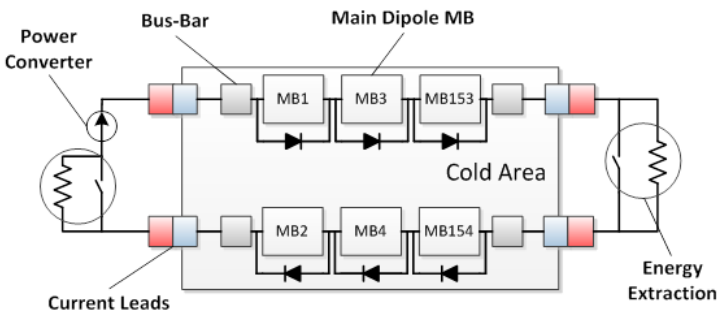
- Change some cables routings / twist pairs to better resist EMC

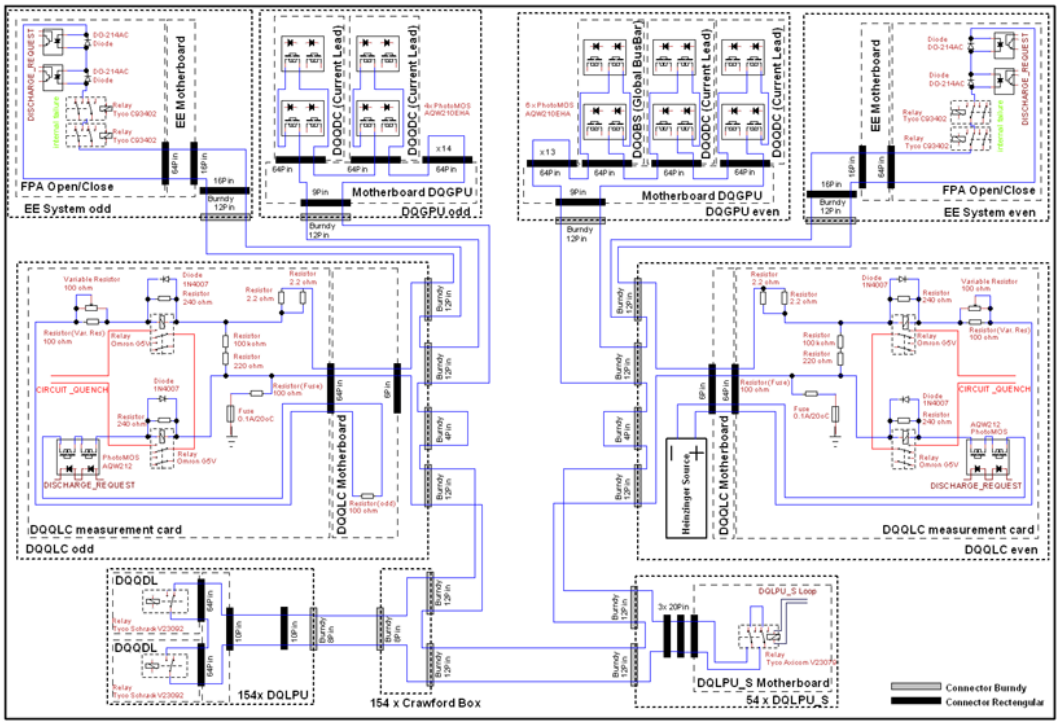
Other improvements for availability:

- Firmware update for auto-reset in case of lost communication
- Remote reset functionality extended to the Local Quench Detectors

Quench Protection System (QPS) in 2012

Study about the Dependability of QPS interlock loop
(by Steffen Guenther - Stuttgart University)





- 2000 components
- Analysis of failure modes and rates, MTTF calculation
- The main weakness for availability is the number of connectors

- As an example: nDQLPU-A internal connections made by soldering connectors

Summary

- We have a common tool (JIRA) to track issues for all Interlock systems and magnet protection

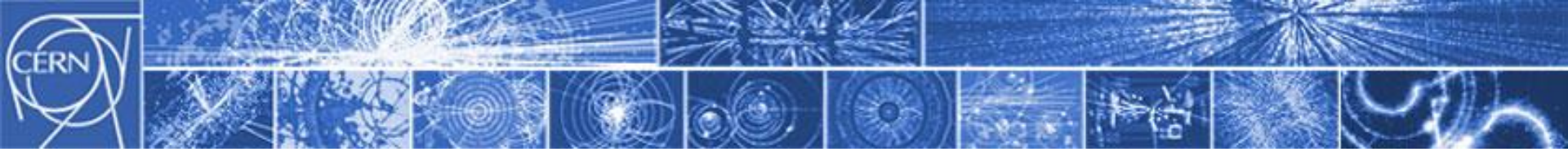
- Ongoing work ensure a better availability of all systems for post-LS1

- MPE Internal studies allow us to improve existing systems and

    - Have a follow up of issues we cannot solve (optical fibres monitoring)
    - prevent future failures which were not observed yet (QPS connectors)
    - Build new system with high reliability and availability (BIS CIBDS)

- Interest to have a common tool to track beam dump issues (in parallel with actual JIRA)

Thanks → Discussion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