What else can go wrong : session summary

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Following the experience from the sector 34 incident, bus failures seem to be the most serious super-conducting magnet failures that one can think of at the present time. The worst consequences can be expected if such a failure affects

- A DBF,
- A triplet magnet,
- A matching/dispersion suppr. section.

The collateral damage can be severe for

- DBFs,
- super-conducting cavities,
- injection kickers,
- experiments beam tubes,
- the beam vacuum in general.

The issue with DFBs, RF cavitiea, kicker and experiments is the repair or replacement time that can be more than one year. The beam vacuum is affected in almost all scenarios. The installation of fast vacuum valves will be re-evaluated, where the issue is the speed of the shock wave and the reaction time of the valves (some tens of miiliseconds), not to speak about machine protection and interlocking issues. Among all the busbar issues, the risk of praying hands joints in MQM must be re-evaluated, since such connection have given trouble to the Tevatron during its early days.

Four redundant UPS systems protect one sector,

- 1 UPS in the UA for IT, IPQ and IPD circuits,
- 1 UPS in RE for the MB and MQ from cells C12L to C34L,
- 1 UPS in RE for the MB and MQ from cells C34R to C12R,
- 1 UPS in the UJ for IT, IPQ and IPD circuits.

In the event of a failure of the UPS a power abort is initiated. The consequences of a UPS failure are the loss of Post-mortem data, loss of control over the 60A orbit correctors and finally loss of protection of the RB and RQ (13 kA) circuits during the power abort. Shortly after the Chamonix workshop Decision it was decided to upgrade the UPS facility for the QPS by connecting it to the UPS systems from 2 different points. Another key point for the UPS systems is a proper testing (AUG) to ensure that all equipment are correctly connected.

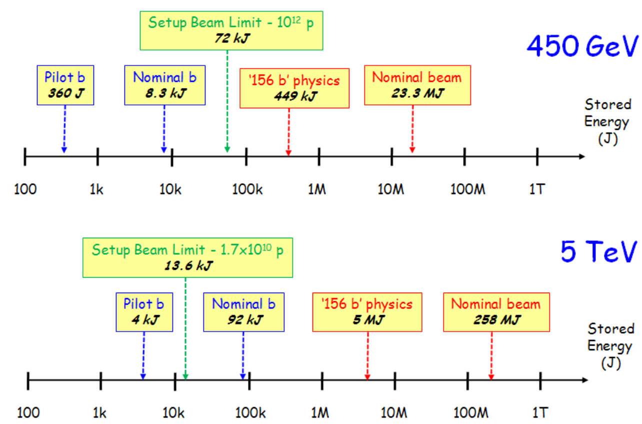

Figure 1: Stored beam energy at 450 GeV and 5 Tev for different beam types. 'b' stands for bunch, '156 b' physics corresponds for early physics with 4×10^{10} p/bunch.

Following the failure of CV equipment near the CNGS target area after only hours of high intensity running, the R2E group was created to re-asses the situation with respect to radiation and coordinate the work on radiation issues to electronics. A lot of work in ongoing within R2E to assess fluence/dose values, complete the inventory of electronics, identify problem areas and find solutions (relocation or better shielding). The outlook for 2009/2010 is good and no showstopper was identified for 156 bunch operation. There are no problems with MPS equipment, but the BIC and collimation crates in UJ56, UJ14/16 must be monitored carefully. Monitoring of radiation levels during LHC operation will be essential to evaluate simulation assumptions and asses the situation.

The estimates for damage limits for typical metallic objects seems to be consistent (better than order of magnitude), see Fig. 1 for the limits of the 'safe/setup' beam. Damage limits for complex equipment like superconducting magnets, RF cavities) are poorly known, or not known at all. An experimental verification of beam damage limits to super-conducting cables would be more than useful, for example at the HiRadMat facility in design at CERN. Recent simulation results show that tertiary collimators can be damaged by a pilot bunch at 7 TeV. A superconducting magnet can be sliced open over a length of a fraction of a meter with a beam of a few MJ. Such an incident could serve as possible trigger of a sector 34-like incident! The summary on recent damage simulations indicate that even what is considered to be safe beam (as defined by the Safe Beam Fag for masking) are not safe under all conditions.

The LHC MPS is designed to cope with the worst scenarios. To handle the variety of failures, critical components are designed with high reliability, a large amount of equipment and beam monitoring is part of the MPS and redundancy is used for the protection where possible. For beam incidents the beam loss monitors are always the last line of defense, in some cases they are the only line of defense. More severe cases are presently being analyzed in particular multiple failures and common cause failures where a single cause may take out more than one component or even compromise the redundancy.

All failures that occurred at Tevatron, HERA and SPS haven been analyzed and many of them cannot happen at the LHC because the MPS will prevent them. Some evident flaws of Tevatron, HERA and SPS MPS systems have been avoided at the LHC, for example beam loss monitor systems that use a fixed sampling and that cannot act below a certain minimum time interval (5 milliseconds at HERA, 20 ms at the SPS).

Operators and experts are able to trigger a large palette of actions and failures that stress the MPS or that open cracks in the MPS armor. But the LHC is not a turn-key system, and tuning of the performance is a trial-and-error process, even if it is guided by experience from other machines. Some errors are therefore inevitable when tuning the LHC. Expert mistakes may disable part of the MPS functions and lead to the worst possible failures, in particular a priori rare combined failures. Strick guidelines must be followed before changing parts of the MPS system. Tracking of changes is very critical. The human factor is the most difficult to anticipate!

A very classical question to the MPS team is: *What do we do if the dump doesnt react to a programmed request?* The is no simple answer to that question, but a procedure must be defined and maintained in the CCC for the operation crews in case this 'almost impossible' event would actually occur.