77th Meeting of the Machine Protection Panel

Participants: W. Bartmann, C. Bracco, V. Chareyre, V. Chetvertkova, B. Dehning, E. B. Holzer, V. Kain, E. Nebot, I. Romera, O. Stein, J. Uythoven, S. Wenig, D. Wollmann, M. Zerlauth.

1 Presentations

The slides of all presentations can be found on the website of the LHC and SPS Machine Protection Panel:
http://lhc-mpwg.web.cern.ch/lhc-mpwg/

1.1 LICs: Summary of experimental results (E. Nebot Del Busto).

Several measurement campaigns have been performed to qualify the short ionization chambers (LICs) and to compare them to standard LHC-ICs:

- Mixed field irradiation - CNRad (450 GeV protons).
  - ✓ In total 8 detectors tested: Three standard LHC-ICs for calibration, LIC prototypes with 0.1 and 1.1 bar filling pressure, and three final production LICs with a pressure of 0.4 bar.
  - ✓ Few months of data taken resulted in more than 1 month of data with very stable beam conditions.
    - Daniel asks what was the particle fluence in the experiment as compared to the one expected in the injection regions of the LHC.
    - Eduardo answers that the fluence was 10^{10} particles/cm^2 (nominal bunch), however he is not sure what was expected in the injection region.
- PSB dump line: Proton irradiations with beams directly onto the chamber (1.4 GeV protons, ~10^{10} p/bunch, ~60ns bunch length, ~1mm beam size.).

- ✓ Multiple detectors tested in the same setup: SEM, LIC 0.1 bar, LIC 0.4 bar, LIC 1.1 bar , FIC and LHC-IC.
- ✓ The 0.4 bar LICs showed a strong increase of output signal and a broadening of the signal peak for high beam intensities, due to charge multiplication effects (avalanche). This behavior is known for low pressure ionization chambers, but undesirable as the response is not anymore linear. In addition the 0.4 bar LICs show a significant longer signal decay time than all other detectors used in the experiment.

- Mixed field irradiation – HiRadMat (450 GeV protons, 10^{11} p/bunch, 1-144 bunches, 50ns bunch spacing):
  - ✓ Detectors tested: LHC-IC, LIC 1.1 bar, LIC 0.4 bar, FIC.
  - ✓ Due a wrong filter the data from the 1.1bar LIC and the FIC could not be used.
  - ✓ The LHC-IC and the 0.4 bar LIC showed a linear dependence wrt beam intensity. The normalized response of both was found to be constant within 3% (IC) respectively 1% (LIC 0.4 bar).
  - ✓ The ratio of the signal between LHC-IC and 0.4 bar LIC was ~58.
- Mixed field irradiation – LHC (new LIC-FIC detectors).
  - ✓ To further investigate their behavior a LIC 1.1 bar, a FIC 1.1 bar and a LIC 0.4 bar were installed close to the TDI.4L2 in B1. The signals from these detectors were then compared to standard ICs close by.
  - ✓ The signals were analyzed for all injections during the 08.11.2012 and 15.02.2013.
  - ✓ Compared to the standard IC (BLMEI.04L2.B1E10_TCDD.4L2) all three new BLMs show a good agreement and linearity. The comparison to two other standard IC close by shows non linear behavior for higher loss rates and a bigger spread of the signals.
    - Bernd points out that the very good correlation with one of the surrounding standard IC BLMs confirms the correct functioning of the three new BLMs. The differences to the

other BLMs maybe due to different loss patterns seen by these ICs.

- ✓ The ratio between standard LHC-IC and the 0.4 bar LIC varies between 30 and 60. For the 1.1 bar LIC and the FIC the ratio varies between 20 and 30.
- ✓ Summarizing all experimental data:
  - Ratio standard IC to LIC (0.4 bar): 57.7 ± 2.0
  - Ratio standard IC to LIC (1.1 bar): 12.4 ± 4.0
    - Markus comments that the goal for the installation of LICs in the injection region is to overcome the limitations due to the saturation of the standard ICs during injection losses. Will the factor 12.4 be sufficient to overcome this problem?
    - **Action**: Review measured signals in the ICs during injection, extrapolate the signals expected in the LICs (1.1bar) and compare to the factors quoted above (E. Nebot, W. Bartmann, C. Bracco).

Questions and comments:

- Bernd asks: What is the final signal ratio to LHC-IC?
  - Eduardo answers: The reference value is 16.
- Jan: is the conclusion that LICs with 0.4 bar and 1.1 bar pressure can be used?
  - Eduardo: No, **we should not use 0.4 bar, due to the non-linear multiplication effects seen for high particle fluencies. We should stick to 1.1 bar.**

1.2 Injection region BLMs – left IP2. Suggestion of changes – version 1. (E.B.Holzer)

- Barbara reminds the MPP on the planned redistribution of arc BLMs during LS1:
  - ✓ The second of the three BLMs per arc quadrupole (per beam) will be placed on top of the interconnection between two MBs.

- ✓ In the new position theses BLMs will measure equal loss signals from the two beams.
- ✓ The signal from the ICs per lost proton is expected to be smaller than in the current locations. Therefore new simulations are necessary to determine the thresholds for these BLMs.

- Redistribution of BLMs in the dispersion suppressors of IP2 and IP8 to overcome the problem of BLM saturation during injection losses. For the restart in 2015 it is not foreseen to implement a blind-out of some BLMs during injection. Nevertheless these BLMs will be connected to a dedicated crate, which will significantly ease a later implementation of the blind-out if necessary.
- Assumptions and criteria:
  - ✓ Allow for losses / BLM signals 5 times higher than described in W. Bartmann's 2011 analysis. Furthermore another factor 2 was implemented as safety margin.
  - ✓ Thresholds are presented for 450GeV and the 40us running sum (RS01).
  - ✓ Maximum threshold is 23 Gy/s (electronic limit).
  - ✓ Thresholds for all monitors will have to be adjusted at 450GeV.
  - ✓ Factors which were applied on the expected signals to reflect filters and LICs are:
    - Small filter (2200pF, 150kOhm): 1/20.
    - Big filter (47000pF, 150kOhm): 1/180.
    - LIC: 1/14.
  - ✓ From these factors it can be concluded that a LIC is equivalent to a standard IC with a small filter and LIC with a small filter equivalent to a standard IC with a big filter. Therefore Barbara proposes to always choose the smallest filter possible.
  - ✓ Barbara mentions the problem, that LICs and ICs with filter could have a too low sensitivity at 7 TeV for short running sums in case of magnets with low quench thresholds (e.g. BLMs at Q6, Q7 and Q8). The quench and damage limits for these cases need to be studied.

- ✓ Therefore the concerned channels should be equipped with ICs with filter. In case of the implementation of the blind-out the filters could simply be removed and the thresholds adjusted.
    - Jan comments: ICs with RC filter have a delay in time response; however they have a good resolution for very low losses.
    - Jan asks for a table with the dynamic range and the time response of the different monitor-filter combinations.
    - Bernd answers that the time response of an IC with filter is identical to one without filter for short running sums. The delay only plays a role for long running sums.
    - Jan summarizes: The advantage of ICs+filter against LICs is that at low losses the LICs have noisier signals.
    - Bernd adds that the dynamic range of the BLMs is determined by the electronics to 250000.

- Barbara shows tables for each element in the DS with the current BLM monitor name, the expected BLM thresholds, the proposed monitor-filter combination, the connection to the dedicated crate and expected sensitivity problems.
- **Action:** MPP asks Barbara to correct inconsistencies in the table and add another column, which describes the proposed change. This table will be circulated for comments.
    - Jan asks if LICs+filter have any advantages for longer RS during normal operation at 7 TeV?
    - Barbara answers that the LICs react faster.
    - Verena asks: What is the real limitation, when using a filter?
    - Markus answers: They have additional time delays.
    - Jan proposes that for choosing between LIC and IC + filter, the thresholds and time response should be taken into account.
    - Jan proposes to use a combination of LICs and IC, as both have advantages and disadvantages.

  - Bernd comments that sometimes it is important to resolve the change of the loss shape in time. For this ICs or LICs without filters are preferred.
  - Jan comments that the choice of IC or LIC with or without filter does not only depend on the expected threshold, but must be due to a combination of threshold and location.
  - Barbara mentions that the behavior of standard LHC ICs is well studied compared to the LICs, which have not been used in the LHC for a very long time.
- Barbara asks if all SEMs installed at Collimators should be replaced by LICs (as foreseen for the magnets).
  - Jan comments that SEMs work for big losses (as regularly observed in the dump region). In case of major beam losses the SEMs could help to understand better what happened.

1.3 Validation of Redundant Powering for Machine Protection Systems after LS1 (V. Chareyre)

- Introduction to the redundant powering for MP systems:
  - ✓ MP systems (especially QPS systems) are powered by Uninterruptible Power Supplies (UPS) via two independent and redundant power paths (F3 and F4 distribution line).
  - ✓ Redundancy can be achieved by equipment with dual input power supplies or independent and redundant equipment - one connected to each of the lines (e.g. initial QPS and new QPS).
  - ✓ Mistakes, which were observed are:
    - Dual input power supplies connected to the same line.
    - Redundant equipment powered from the same distribution line.
- Why should the redundant powering be tested?
  - ✓ Verify the redundant powering for individual systems.
  - ✓ Verify the correct powering path.
  - ✓ Verify that MP is fully operational even if one complete distribution line is lost.

- ✓ Find out interdependencies between systems.
- ✓ Discover/verify the impact on other users.
- ✓ Verify that magnet powering is also stopped under these conditions.
  - ✓ Jan asks: What happens when the PIC is not triggered by UPS?
    - Vincent responds that there are 2 cases when PIC may not be triggered, i.e. the UPS-PIC signals remains OK: 1) UPS failure without bypass. 2) Short circuit on the switchboard.
    - Markus recalls that the implementation is done via Hardware link between each UPS and the powering interlock system of the respective zone. If redundancy is lost the PIC will initiate a fast abort of all circuits in the 2 adjacent sectors.

- Recently a test has been performed on the LBDS (April 2013) to verify if the beam dump is triggered in case of a total power cut:
  - ✓ Simple and fast procedure for EN-EL.
  - ✓ Problems discovered:
    - IT star-point rack had to be changed to another power supply.
    - One server did not restart after transferring the star point rack to a temporary power supply. Repair of the internal power supply was required.
  - ✓ The test was successfully repeated at 500 and 5000 GeV. Each time the expected synchronous beam dump was achieved.
- Vincent presents a detailed procedures how to test the redundant powering after the UPS replacement project during LS1 (see slides):
  - ✓ The even points stay with the existing UPS configuration.
  - ✓ The odd points and alcoves will have a new configuration with 3 UPS systems and two redundant power paths
    - Markus comments that for the future test it might make sense in some regions to also switch off both UPSs at the same time (i.e. to repeat the above tests for the LBDS).

  - Jan adds that this can be simply done by first cutting one UPS and then cut the second one.
  - Vincent comments that the change in the alcoves and odd points will be made to improve the current situation, which was discovered in 2009: If one line is lost all users at this line will be lost. There is currently no redundancy of the UPS there as each line only has one UPS.
  - In the even points there are always two independent lines one from the UA UPS and one from the US UPS.
- The tests at the end of LS1 should be performed during hardware commissioning, as all systems will then be present and connected.
- One day is required for the test per RE alcove and LHC odd point. Two days are required for the even points of the LHC.
- The tests have a strong impact on all users (especially cryogenics, vacuum and the star-point racks) and therefore need to be organized with the LHC coordination team, which has already been informed.

Questions and comments:

- Jan comments: Test to switch off one at a time. Equipment shouldn't be on complete power cut.
- Markus points out that cryogenics and vacuum are not redundantly powered.
- Jan proposes that 1 or 2 zones should be selected for a full power cut, to test how the beam dump reacts in the worst case.
- Markus comments that this type of tests needs to be discussed in detail with the main systems in advance to perform it efficiently and in a useful manner for all concerned equipment.
- Bernd points out that for the BLMs the UPS powering is just a matter of availability of the system.
- Markus states that if the powering tests can be done transparently during hardware commissioning there is a strong recommendation from MPP to perform it ahead of the restart in 2015.

- **Action: digest test procedure, discuss with hardware commissioning coordinators.**