Machine Protection Working Group

Minutes of the 61st meeting, held 1st December 2006

Present: Y. Papaphilippou, J. Wenninger, L. Ponce, R. Assmann, D. Kramer, M. Sapinski, A. Gomez-Alonso, B. Todd, R. Steinhagen, B. Dehning, M. Ferro-Luzzi, D. Macina, M. Artuso, S. Stone.

Meeting Agenda:

- Collision Bump Amplitudes for the 450GeV Run [YP]

Collision Bump Amplitudes for the 450GeV Run [YP]

Y. Papaphilippou made a brief presentation. Machine protection issues have been raised following studies into 450GeV collision runs which are foreseen in 2007 and 2008. Two key questions have been addressed:

1. Can the spectrometer magnets in IR2 and IR8 be operated at maximum field strength? This would allow a better calibration and alignment check of the experiments.

2. Can the VELO detector in IR8 be closed to its minimum aperture? This would allow LHC-b to test and commission trigger electronics and attempt an absolute luminosity measurement using the novel beam-gas method.

IR2 - ALICE

Y. Papaphilippou described the nominal injection optics around the ALICE experiment in IR2. The ALICE spectrometer magnet is a 3m long dipole (**MBAW** shown in slides), giving a nominal integrated field of 3Tm, which deflects the beam 130μrad at 7TeV. This is compensated by three dipole magnets: two to the left and one to the right of the Interaction Point (**MBXWT** and **MBWMD**). Two beam position monitors (**BPMWS**) are used to monitor the closure of the internal bump created by the combination of the four dipole magnets.

Y. Papaphilippou carried on to explain that in IR2 the beam is focussed in the centre of the interaction point, with a minimum β of 10m, the aperture limitations in this area of the machine are the corrector dipoles that have an aperture of only 26-30mm, the nominal internal crossing bump at IP2 generates a crossing angle of ±70μrad.

Using the nominal crossing bump and considering the beam parameters for a nominal injection and nominal tolerances scenarios leads to a loss of around 50% of the available aperture in the compensator dipoles and 40% in the spectrometer magnet. Several different scenarios have been considered, and the aperture of the beam varies for less than 3σ in all the cases and for both beams. **R. Assmann** noted that 20% β-beating might be too optimistic, **various members** agreed, since there is sufficient margin in these areas, the aperture should be fully sufficient.

Y. Papaphilippou then described the change in bump when the spectrometer dipole is set to collision strength. In this case the crossing angle increases to ±1.1mrad, with a maximum deflection in the vertical plane of ±11mm. This change only has an impact on aperture around the MBWMD corrector, where only about 30% of the aperture will remain.

IR8 – LHC-b

Y. Papaphilippou explained that the optics of LHC-b in IR8 have a similar structure to IR2. The LHC-b spectrometer is a 1.9m long dipole (**MBLW** shown in slides) giving a nominal integrated field of 4.2Tm, which deflects the beam 180µrad at 7TeV. This is compensated by three dipole magnets: two to the left and one to the right of the Interaction Point (**MBXWS** and **MBXWH**). As in IR2, two beam position monitors (**BPMWS**) are used to monitor the closure of the internal bump created by the combination of the four dipole magnets.

Y. Papaphilippou carried on to explain that in IR8 the beam is focussed in the centre of the interaction point, with parameters very similar to those given for IR2, having a slightly larger nominal crossing angle of ±135µrad. Using the nominal crossing bump and considering the beam parameters for a nominal injection and nominal tolerances scenarios leads to a loss of around 50-60% of the available aperture in the compensator dipoles and 40% in the spectrometer magnet.

Y. Papaphilippou then explained that when the spectrometer magnet is increased to collision strength the crossing angle increases to ±2.1mrad in the horizontal plane. This is equivalent to a deflection of 10mm at the MBXWH. The machine aperture at this element is reduced to 6mm, corresponding to about 24% of available.

IR8 – VELO

Y. Papaphilippou carried on by describing the Vertex Locator (VELO). This experiment is part of LHC-b, surrounding IP8, and is used to detect tracks close to the interaction region. It consists of a series of retractable silicon sensors which close down to around 5mm from the centre of the beam. The sensor boxes can move 30mm laterally and 5mm vertically to track to the centre of the beam. Beam-gas events allow the beam centre to be precisely located.

Y. Papaphilippou then explained that the mechanical tolerances around VELO could be considered as either tight (0.2mm) having a higher accuracy or loose (2.2mm) having a lower accuracy. This can be combined with the tolerance of the closed orbit to give the maximum closure of VELO that should be permitted to ensure that the device is not damaged.

For a loose mechanical tolerance, VELO cannot be closed less than 9.6mm, after centering it around the closed orbit, it can then be closed down to 5.6mm for no internal crossing angle or 7.1mm for the extreme crossing angle. For a tight mechanical tolerance, VELO can be safely closed to its minimum dimension. **Y. Papaphilippou** noted that this means the precision of the VELO sensor movement is very important.

Machine Protection Issues

Y. Papaphilippou then continued to describe that several machine protection issues result from these studies, in particular due to the reduced aperture around the IR2 and IR8 compensators.

1. It is not advisable to inject with extreme bump in place to ensure the protection of the experimental areas.

Y. Papaphilippou noted that in early stages the machine optics may be far from the nominal values used for these aperture estimations, the LTC has also recommended that the beam optics be measured during the commissioning run, but there may be no time for this. **J. Wenninger** agreed, suggesting that the bump of the orbit could be limited by very low-level settings in the Power Converter.
R. Assmann questioned whether the bump should not fall under the auspices of the Management of Critical Settings, **various members** suggested that this may be difficult, as other magnets such as orbit correctors can have the same effect and they would all have to be then controlled by the MCS.

Action: Determine the most appropriate method for interlocking the collision bump

2. VELO can be closed to its minimum dimensions only if the beam position can be located very precisely from the tracking, else the mechanical tolerances would prevent a full closure.

Y. Papaphilippou noted that the estimation of the beam position is difficult when VELO is not closed, and that the 5mm aperture can be considered to be one of the smallest around the machine.
R. Assmann pointed out that the roman pots and collimator controls are linked to ensure that the various elements work correctly together, and questioned why the VELO control system is separate.
D. Macina said that when VELO is in the OUT position it is over 30mm from the beam, the ‘stable beams’ flag is used to interlock its movement.

3. Protecting VELO from damage due to equipment failures of beam distortions has to be discussed.

R. Assmann questioned what radiation tolerance VELO has, **M. Ferro-Luzzi** said that the VELO was designed to survive approximately 6 fb^{-1} of integrated pp(14TeV) luminosity at IP8 with an expected irradiation of up to 10^{14} 1-MeV neutron equivalent dose/cm2 in the hottest place (nearest to beam axis). This life should not be substantially reduced due to sporadic “splashes” originating from beam failures.

Action: Carry out fast failure studies to determine the exposure of VELO, include secondary particles.

4. Fast Magnet Current Change Monitors are needed for the protection of all spectrometer compensation magnets.

J. Wenninger questioned the availability of the FMCMs for 2007 and early 2008, **B. Puccio** said that FMCM would have to be moved from other machine elements if they were required, as spares may not be available.

J. Wenninger mentioned that the inhibit of beam injection at 450GeV has to be looked into, as the energy interlock will not work at 450GeV.

Action: Develop ideas related to the injection inhibit during the 450GeV commissioning run.

The following detailed action list was agreed upon:

- **J. Wenninger** agreed to put together a list of failure scenarios involving LHCb, emphasizing the differences or specialties of the 450 GeV collisions vs 7 TeV collision runs. At least two failure scenarios were mentioned by **J. Wenninger** which are specific to the 450 GeV pilot run:
  - Non-working energy interlock for injection (already mentioned above).
  - Local bumps: beams move 16 times faster and potentially much farther out.
- **A. Gomez-Alonzo** agreed to make simulations for such scenarios to determine where protons would be lost. Four possible configurations:
  B_lhcb ON/OFF and VELO IN/OUT.
- **R. Assmann** would communicate with Andres to ensure the most realistic collimation scenario is used in the simulation.
- **D. Macina** agreed to ask **V. Talanov** to take **A. Gomez-Alonzo** ' results and propagate showers to Point 8. LHCb will take **V. Talanov's** results and evaluate the impact on its detector, in particular the VELO.
- The issue of repeated wrong injection (into e.g. a detector) was raised. It did not seem to be quite clear if it is actually possible to loose a pilot bunch inside a detector without triggering any BLMs in the corresponding IR. This issue will also be looked at.

A first meeting with the people involved will be held on Dec. 19 Tue, morning. The outcome of the studies will be presented at a LEMIC early in 2007.

AOB

The presentation regarding the interlocking of injection and extraction beam screens has been postponed until further notice.

Next Meeting
Meeting 62, (TBC)

BT