SESSION II SUMMARY

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LHC CONDITIONS : WHAT CAN BE EXPECTED AND OPTIMIZED

Vacuum

A. Rossi presented the expected vacuum conditions. All warm LHC sections will be backed out. Vacuum conditions are generally expected to be good and the resulting beam gas backgrounds of no major concern to the experiments under nominal conditions.

The vacuum model predicts the static pressure distributions and the dynamic pressure rise in the presence of beams resulting in desorption by synchrotron radiation or induced by ion or electron cloud effects. Uncertainties were considered and the estimates given generally represent the upper limits. The effects of local heating by beam loss on aperture restrictions (collimators) is currently not included in the vacuum model.

It will be important to verify, check and benchmark the vacuum predictions by observations with beam. It will also be important to help to diagnose and regularly follow up on observations in operation which could indicate potential vacuum problems, like locally increased beam loss rates or detector backgrounds.

Background simulations

Even if much has been done on simulations for the LHC [1], it already became clear during the preparation of this workshop, that the LHC experiments require further work and clarification on this subject. A good fraction of the second session of this workshop was therefore scheduled for presentations and discussions on simulations of backgrounds and their effects on experiments.

In principle, signatures and effects of machine induced backgrounds are well predictable. Operation of the TEVATRON with measurements of backgrounds in the CDF and D0 detectors constitute over 15 years of experience and allowed for benchmarking and calibration of background simulations.

Quantitative background predictions crucially depend on the knowledge of the input parameters to the models. Ideally a complete set of input parameters would include

- a realistic description of the physical aperture
- an accurate machine-lattice description with magnet imperfections, misalignment, noise and ripple and beam-beam effects
- the actual values of adjustable optics parameters like tune and chromaticity
- rf voltage and phase stability
- knowledge of the vacuum conditions for beam-gas background predictions.

A complete simulation would also require a full description of the beams with bunch intensities and profiles with halo in all dimensions. Beam profiles and in particular the halo are generally not a priory known and the evolution with time will be very sensitive to tuning of the machine and maybe rather different from fill to fill.

Practical simulations rely on simplifying assumptions. LHC simulations for collimation and background generally assume the nominal machine with no or few imperfections and do not actually model the beam but rather use loss rates as input parameter. Cross talk between experiments due to pp-scattering close to the machine acceptance were not included until very recently : a first estimate of losses around the ring originating in pp collisions in IR5 was presented by R. Assmann at this workshop.

The high luminosity experiments ATLAS and CMS have been designed to be able to cope with very high collision rates. Machine induced backgrounds are normally expected to add little in energy and extra tracks to the signals from collisions.

Machine induced backgrounds mostly scale linearly with beam intensity, while the luminosity scales with the sum of the square of the bunch intensities. Signal to background ratios are expected to be worse in earlier LHC operation. In addition, the triggers for the experiments will be less selective and the LHC machine less well known and corrected. Machine induced backgrounds may be rather important for all experiments in the earlier operation of the LHC and in high luminosity operation for the lower luminosity experiments ALICE and LHCb.

Collimation

The LHC has a three stage collimation system. Collimation systems in most machines are designed to minimize backgrounds to the experiments. The LHC system was designed for high collimation efficiency, or essentially to minimize beam losses in the cold parts of the machine. The LHC has no collimators dedicated to background control and reduction to the experiments.

Tertiary collimators are installed around all experiments, to shadow the triplet magnets and reduce tertiary halo losses on the triplet magnets. They reduce the loss of halo particles in the detector region and are at the same time source of secondary particles and in particular secondary muons reaching the detectors. The LHC collimation system is rather tightly constraint. To minimize beam induced quenches and exclude damage, a hierarchy between primary, secondary and tertiary collimators will have to be respected with safety margins on tolerances, orbit and optics errors. This will leave little freedom for safe tuning of tertiary collimators under nominal conditions. More margin will be available for less squeezed beams, i.e. $\beta^* \gtrsim 2\,\mathrm{m}$ rather than the nominal 0.55 m.

Secondary collimators should remain in the shadow of the primaries, and tertiary collimators in the shadow of the secondary collimators.

Scraping into the halo using primary collimators is expected to be useful for diagnostics purposes in machine studies to allow to distinguish between halo and other sources of background. Optional scraping before the ramp or squeeze could be useful to anticipate later uncontrolled losses. It is at present not clear if halo scraping will also be needed or helpful in regular physics operation in the LHC. The functionality to be able to perform automatic scraping with primary collimators will be implemented such that scraping can be tested and applied if required.

The collimators for the betatron cleaning are located in a single straight section (IR 7). Depending on the distance and phase advances from the collimators to the experiments, the induced backgrounds for the experiments from beam 1 and beam 2 can be rather different.

The same collimation system will also be used for heavy ion operation in the LHC. Beam intensities will be much reduced compared to proton operation. Cross sections instead will be much larger and loss distributions quite different from proton operation. The optimisation of the running conditions for heavy ion operation in the LHC will require extra time and efforts.

Experiments protection

Session 2 ended with a review about protection of experiments in case of failures and exchange of signals. These subjects are followed up in working groups [2, 3]. Protection in case of beam failures were also the subject of a previous dedicated workshop [4]. The experiments all have fast beam condition monitors and can quickly dump the beam. The infrastructure for the signal exchange between the machine and experiments is set up and will soon be tested. Some details of the contents and meaning of the data will still have to be worked out and will require follow up during the commissioning. This includes the definition of a small number of normalized figure of merit background numbers from each experiment.

REFERENCES

[1] LHC Machine Induced Background Group Working MIBWG and Session V of the LHC Chamonix XV Workshop 2006

[2] SPS and LHC Machine Protection Working Group LHC-MPWG

[3] LHC Experiment Accelerator Data Exchange Working Group LEADE

[4] Joint LHC Machine-Experiments Meeting on experiment protection from beam failures