Minutes of the 6th BLM Threshold Working Group Meeting
February 10, 2015

Present: B. Auchmann, F. Carra, F. Cerutti, E. B. Holzer, M. Kalliokoski, O. Picha, R. Schmidt, E. Skordis, G. Valentino

BLM Thresholds for the Inner Triplets (O. Picha)

Ondrej recalls the naming convention of beam-loss monitors in the inner triplets. There are 9 per triplet and beam. Q1 has monitors in position 1, 2, and 3, Q2, being composed of two magnets, has positions 21, 22, 23, and 3, and Q3 has positions 2 and 3. The positions are antisymmetric on the interior and exterior side.

Luminosity debris is the major source of beam losses in the triplets. From Run 1 there is measured BLM data for all IPs. IPs 1 and 5 show similar loss patterns, as do IPs 2 and 8. The difference between 1/5 and 2/8 is the absence of a TAS absorber in points 2/8. The FLUKA model gives BLM signals per proton-proton collision in the IP and agrees very well with measurement. Some BLMs are slightly overestimated (up to a factor 2.5) by the model.

The model also provides the energy deposition in the SC coils per proton-proton collision. This result can be scaled to an assumed luminosity, and the resulting value be compared to the estimated quench level in terms of the minimum power-density to quench (MQPD). Values for MQPD are given in early publications of the KEK and FNAL magnet programs. These values are reproduced by the QP3 software, using a bulk-insulation model, i.e., a model without micro-channels filled with superfluid helium. Experiments at FNAL had indicated, that such micro-channels, which play a major role in the main dipole quench levels, are not present in the MQXB magnets. Comparison of FLUKA-calculated power depositions and the QP3 model show that it is not expected the triplets could be quenched by luminosity debris in Run 2. Note that these models only take into account the heat transfer through the insulation, and not the entire heat transport via the heat exchanger.

Since physics debris is not expected to quench magnets, the BLMs may be set to protect magnets from different accidental beam-loss scenarios. For Q2 there is the so-called Q2B scenario, described in detail in CERN-ATS-Note-2012-014, which constitutes an orbit-bump scenario with the loss-peak in the Q2(b) magnet. For Q1 and Q3, informal discussions with numerous experts at CERN did not produce a viable scenario. *Rüdiger* interjected that particle showers from the TCTs could probably cause a quench in the Q3 magnet. *Francesco* agreed. The topic should be studied, but results will not be available until the beam startup.

Ondrej recalls that BLM thresholds decrease with the running sum, i.e., RS12 (83 s) has a ~2x lower threshold, expressed in Gy/s, than RS9 (1.3 s). At 6.5 TeV, BLM thresholds must be set such that physics debris does not trigger thresholds.

In fact, we would like to operate during stable beams without any BLMs even reaching the warning level. *Barbara* says that warning levels are implemented in software and, for the time being, were set homogeneously at 30% of the BLM thresholds in all locations, RSs, and energy levels. This could be changed. The discussion brought consent, that for the IT region (only), where the dominant loss scenario is very stable and well-known, 70% would be an appropriate warning level.

In Q2, the applied thresholds are proposed to be set a factor 2 below the BLMSignal@Quench for the Q2B scenario. These thresholds should be used for operation up to 10^{34} $cm^{-2}s^{-1}$. A 2-fold increase in the monitor factor could scale the thresholds for an ultimate luminosity of up-to 1.75x (source: M. Giovannozzi private communication).

To ensure, that for the above-described applied thresholds physics debris cannot trigger warnings, the thresholds in those monitors that are most sensitive to physics debris must be kept constant starting at a specific RS.

Since the Q1 and Q3 monitors are not necessary for protection against the Q2B scenario, the dynamic orbit-bump scenario is proposed for the setting of their thresholds. This scenario is not realistic, yet allows to set thresholds in all energy levels and running sums with reasonable values. (The above-mentioned TCT study may be used in the future to replace the dynamic orbit bump scenario in Q3 magnets.)

Eventually, Ondrej gives a proposal how to group triplet monitors into families. In a first step, monitors are grouped wrt. their position, as it is done in all other locations where no physics debris is present. In a second step, corrections in the long RSs are introduced, allowing the physics debris to be measured in all monitors of the family without reaching the warning level. In the third and last step, those monitors are identified, which were the most sensitive for their respective loss scenario, and where the correction of Step 2 causes the largest loss in terms of sensitivity. These two monitors – one for each scenario – are removed from their families and given two special families. For IPs 2 and 8 the Step 3 turns out not to be necessary.

The new thresholds are shown for two cases. They differ significantly from the old thresholds, which should not come as a surprise, given the patchwork of BLMResponse, EnergyDeposit, and QuenchLevels, that all came from different scenarios. Nonetheless, in cases where thresholds are reduced, *Barbara* urges to check thresholds against fill data from 2012.

Rüdiger proposes to abandon the naming by B1 and B2 in the triplets, since the triplet magnets are single-aperture. *Barbara* mentions that the naming referred to the respective sides of the magnets where B1 and B2 would end up beyond the separation dipole.

Barbara asks if there are foreseen lower-energy runs with colliding beams. *Rüdiger* assures her that no high-luminosity collisions would take place at energies below 6.5 TeV.

Bernhard asks if the new threshold software allows to apply corrections (to avoid warnings from physics debris) at specific energy-levels only. *Matti* says this will be possible.

Following up on a request by MPP, Barbara introduces the topic of disabling rules for triplet BLMs. In the past it was stated that operation could not be allowed with a defective monitor in the triplets (i.e., triplet BLMs could not be disabled under any circumstances). With new safety rules for Run 2, an intervention on BLMs requires that the triplets are emptied from helium, i.e., any intervention takes several days. Bernhard and Ondrej say that based on Ondrej's studies it is clear that there is significant redundancy in the BLM configuration of the triplets. Barbara proposes the following rule which the present working-group member agree upon: Position-3 monitors, which are most affected by physics-debris background, can be regarded as redundant. In fact, the two monitors at the triplet's extremities are set to maximum. Two out of the remaining four monitors can be disabled. For the remaining position 1 and 2 monitors, one monitor per magnet can be disabled, but no more than two monitors per side should be disabled. The proposal was to be presented at MPP. (Update: MPP heard the proposal and approved it.)

Status of FLUKA Simulations for Collimation BLM Thresholds (E. Skordis)

Lefteris started the presentation giving an outline of what could be an ideal strategy for finding thresholds for BLMs on collimators. For each monitor, a loss scenario should be identified, and the distribution of protons lost be calculated with SiXTrack. FLUKA simulations would give the resulting energy-deposition in the collimators and the BLM signal. The energy-deposition would be used in a thermo-mechanical simulation to identify the limiting energy deposition for which thresholds should be set.

In contrast to this procedure, the actual request to the FLUKA team was to provide values that translate the number of protons lost on a given collimator into BLM signals. For the geometrical pattern of the losses, it is assumed that the given element acts as a primary collimator. This proton-to-BLMSignal mapping, together with the intensity-rate limits to be provided by EN-MME and BE-ABP will define the first version of thresholds. This initial setting is to be corrected to account for cross-talk and other operational scenarios.

Lefteris states that, depending on the required accuracy of their simulations, many factors may or may not need to be taken into account (BLM positions, collimator settings, jaw lengths, etc.).

A summary of simulations done up to now, also shown in the BLMTWG/CWG joint meeting in August 14, is presented. Lefteris explains that, based on these simulations, BLM response maps are given, distinguishing between Inermet 180 and carbon jaw materials, horizontal and vertical collimators, and 3.5 and 7 TeV beam energy. In every case, the minimum (worst-case) BLM response is given, together with an estimate of the potential overprotection due to this worst-case assumption. Values are provided with a disclaimer that worst-case conditions are assumed, cross-talk is neglected, and for more accuracy, a strategy as discussed on the first slides should be considered.

Bernhard compares the resulting BLM response maps, ranging from 0.5 to 6 times 4.6 10^{-12} Gy/p, to the value used for Run 1 of 6.2 10^{-13} Gy/p. The latter value is considerably more conservative. To be discussed with colleagues from collimation in the next meeting.

Rüdiger asks whether there are other elements than collimators which may be more liable to damage due to showers from collimators within the BLM integration times? *Francesco* thinks that damage on other elements is more a concern for accumulated, year-long irradiation (e.g.: MQWs).

Next Meeting

The next BLMTWG meeting will be on Tuesday, February 24, 10h30 in Bldg 864 1-C02. Topics will include

- Threshold values for BLMs on collimators (t.b.c.).
- E. Skordis: FLUKA simulations for MQW BLM thresholds.

Minutes by B. Auchmann (TE-MPE)