Minutes from the 28th BLM Threshold Working Group meeting – 01.12.15

Present: B. Auchmann, J. Ghini, L. Grob, E. B. Holzer, M. Kalliokoski, A. Mereghetti, S. Le Naour, M. Rijssenbeek, D. Wollmann, M. Zerlauth.

Thresholds for AFP BLMs (Michael Rijssenbeek)

One station will be installed at 217 meters, in front of TCL6, to the right of IP1. The rates from the RP here is assumed similar to the ones from the TOTEM RP, seeing as the TOTEM also uses horizontal pots. So the thresholds can be requested the same as for TOTEM; there is some differences between ATLAS and CMS, but this assumption should still be a good starting point.

During the technical stop, the locations of TOTEM BLMs were checked in the tunnel, Slide 2 shows a technical drawing of the area.

Barbara points out that it would be good to have the same layout as for TOTEM, *Matti* replies that they are, indeed, planning to do it that way. This way the thresholds themselves might also be similar. *Barbara* adds that, typically, monitors for collimators are located below the beam; they are often installed on the support of the vacuum pump, and if not, there is an extra support.

Markus asks about the difference in sensitivity for a BLM mounted vertically VS horizontally. *Alessio* answers that the BLMs will intercept different solid angles of the shower, meaning different energy components, and *Barbara* thinks this will translate into a factor between 2 and 10 difference (vert. VS horiz.); closer to 2 if the BLM is centred with the beam pipe.

In Slide 4, the dashed lines in both plots refer to the next downstream element and the solid lines are the TOTEM thresholds. In the left side plot the downstream element is the following cold magnet, and in the right hand plot, the downstream element is the TCL. The TOTEM thresholds were fixed by applying a flat top correction that will make sure that the monitor won't trigger on showers from the IP. AFP can use the same thresholds, even though it is only operating for certain ones (and so does not need protection all the time).

Michael asks if the numbers shown are purely simulated or if they are measurements. *Matti* answers that they are both, seeing as we have real data after operation. He is uncertain if they already reached the warning level. Note that the flat top level was set from extrapolation of measurements in order to reach the top luminosity we want to run.

Michael asks if these thresholds are for horizontal or vertical BLMs, to which *Matti* replies that those BLMs would have the same thresholds as they are in the same families, and so, it does not really matter. There certainly are families with both horizontal and vertical BLMs, although *Matti* thinks (not entirely sure) that the family of relevance here has only verticals.

Bernhard proposes to simply include the new BLMs in the existing family, as this leaves it with the possibility of increasing the threshold by a factor 3 very easily (all pots run with MF = 0.3).

The reason one wants to include the AFP monitors with the TOTEM ones and not with the nearby ALFA monitors is that since ALFA is not operational all the time, and also has a dedicated short RS correction to deal with all the UFOs there (see earlier meetings – see BLMTWG 20, 21, 22) the new BLMs will have more in common with the TOTEM BLMs (same pot design, equivalent locations, etc.).

BLM Thresholds for Ion Quench Tests (Alessio Mereghetti)

The aim of the test is to induce losses in the IR7 DS in such a way that the BLM signal is up to three times the local BLM thresholds for MF 0.333 Note that the reference scenario is the UFO or dynamic orbit bump scenarios.

The BLM thresholds are set according to this strategy:

- Get the BLM with the highest readout from IR7 DS (when excited in B2H). Here it is BLMQI.09L7.B2I10_MQ;
- Get the power loss necessary to induce a signal equal to the threshold at MF 0.333. Here 13.5 kW;
- The desired power loss during this test is this signal times three;
- To avoid the scaling problem seen for the proton quench test, we add another factor of 3 to this;
- To avoid being prematurely dumped during the test:
    - Get BLMs from LM which may trigger before reaching 135 kW,
    - Cold BLMs: modify MT such that the threshold is ten times the BLM signal at quench,
    - Non-cold BLMs: will need case-by-case consideration.

Alessio points out that the idea with the cold BLMs is to set the MT ten times higher than the quench level, and then initially use MF = 0.333, meaning that it would be the same as if we set MF = 1 with the current MT.

Bernhard wants to know if it is possible to justify the 135 kW losses in a different; for instance from what desired outcome we need for collimation or from a safety point of view. *Alessio* agrees, saying that a good answer could come from a simulation with a clean shower in the DS, we look then at the position with the highest energy deposition in the coil, and from that, we do the proper scaling. *Bernhard* points out that as of yet, we do not have the possibility to do such a simulation.

Daniel points out that there is an alternative: we can look at the damage limits in the collimators. MME allows 1 MW of protons, taking then a factor 8-10 higher ionization peak energy deposition for the ions, then we reach about 100 kW. This will be a damage limit approach with the collimators in mind, not the cold magnets. Also, it is clear that the thresholds cannot be set above the damage level.

Barbara asks if the ion collimation loss is considered more or less likel to quench the magnet than the thresholds for the UFO scenario/dynamic orbit bump scenario; is the shower in the magnet wider or narrower? As a first guess, it should be wider, i.e., thresholds should be higher than for the UFO scenario. However, for a UFO, the source of the loss is very small. *Bernhard* answers that this is exactly the question to which we do not have an answer at the moment. *Daniel* points out that in any case, we are very far away from the damage level in the magnets; he further assumes that taking ONLY the damage on the magnets into account, all the BLMs could probably be set to the electronic limit. Now, given a loss map, there is a 1:1 translation between losses in IR7 to losses in the cold magnet, so a limit of 135 kW, this also limits the energy deposition in IR7, which should not be limited, because it is reproducible (a given beam, excitation etc. will always cause the same loss in IR7). This means that we have to limit it to something we are comfortable with in IP7, which is the same approach as for the protons.

(Daniel takes out a printed plot from another meeting)
The y-axis gives the energy deposition and the x-axis gives the length of the collimator. The important point from the plot is that the ionization peak is higher than the hadronic peak for the ions. We need to keep the ionization peak below the hadronic peak of the ions. From the plot, it is seen that due to the ionization from having a large positively charged core, the same amount of charges will cause about a factor 10 more damage.

Alessio points out that the test is never intended to generate a loss larger than 3 * 13.5 kW, so setting the thresholds to 135 kW is simply to make sure that we are not trapped upwards. *Barbara* and *Daniel* both point out that the margin between the desired 3 * 13.5 kW and the thresholds of 135 kW is far larger than necessary.

Markus points out that we do not really know that the quench level is at 13.5 kW, which means that we can't conclude that 3 * 13.5 kW will cover all relevant operational scenarios. What, then, if we do not quench for 40 kW? *Alessio* answers that the BLM thresholds at the collimators are set for a loss of 200 kW.

Daniel points out that the reason for running this quench test with ions is that the needed loss in the cold magnets can be generated with a beam of much lower stored energy when using ions as compared to protons (this is due to the poorer cleaning efficiency for ions).

Markus proposes to set the MT so that a MF = 1 corresponds to the 100 kW loss rate, since this should allow room for the needed losses. *Alessio* agrees, but needs to take it to Stephano for approval.

Alessio says that they plan three or four ramps, with the first one going to 13.5 kW. Despite the idea of, now, setting thresholds at 100 kW, *Barbara* thinks it is a good idea to somewhat increase the number of BLMs we move to the family with increased thresholds, with the experience from the proton quench test in mind.

Daniel points out that the maximum allowed energy in IP7 has to be controlled by a mechanism IN IP7; there has to be a limit to how much energy can ever be deposited in IP7. At the moment the options are as such: 1) limit the level indirectly through the thresholds in the cold magnets, or 2) control it with the thresholds in IP7. For the second option, controlling with the TCPs should be sufficient.

Bernhard thinks that the hard limit at MF = 1 has to be set based on the damage level rather than a less tangible loss desired.

Bernhard suggests that for the cold magnets, we leave the MF as they are, and rather just multiply everything (the MT) by ten (even if this takes us a little higher (still far from damage)). The point of this is that in the process of changing MF, communication to electronics during the test might not be optimal, and something can go wrong.

Looking at the 2011 Ion Quench Test

Comparing the three closest RSs to RS09, plus RS01, Slides 6-8 give the increase factors between RSs of the measured signals. Keep in mind that these are factors from the signals, NOT the thresholds.

Bernhard points out that these signals look more like coming from short spikes than slow ramps, meaning that analysis will be more difficult.

The question Alessio tries to answer is whether or not one can trust the increase factor calculated based on measured signals when the threshold itself was altered in RS09.

Daniel points out that the 2011 quench test was very different from the one planned now using the ADT – in 2011 the test was done by increasing the tune from below to above the third-integer transition, which is a very fast and violent event, meaning that a comparison is difficult.

Other RSs

Slide 9:
The black curve is the applied threshold while the red curve is the threshold that would be required for 135 kW losses, calculated the same way as RS09 with the loss map, but now for all other RSs. The requirement is that the black (applied) curve is above the red one for all RSs. Note that the pink lines in the plots indicate the electronic limit and that the very high RS ratios in the slides are all noise (typically on the order of 25000 to 50000).

RS08 was the one to dump during last month's proton quench test. *Bernhard* notes that only unforeseen low-RS loss spikes are likely to cause trouble, so we should concentrate on the longer RS

Slide 10:
The lower plot indicates that the necessary increase factor is about 5. The proposed factor is 10, but even then, the resulting threshold will be below the electronic limit.

Slide 11:
For the MQYs in IR6 only a small correction is needed in RS09, but even if the short RS goes to the electronic limit it is not important.

Slide 12:
For the MQTL a factor of 16 is needed in RS10 (more than the proposed 10), however, as *Matti* points out that, since there will be a flat top correction, the RSs after RS09 will be at a higher level than what the applied threshold in the plots indicate, meaning that the necessary increase factor is smaller. *Alessio* points out that we have the option of applying the flat top correction already from RS06. The point is that we should start the flat top correction at a running sum with a necessary increase factor less than 10 in order to go above the required threshold.

Slide 13:
For the MQs there are no particular issues with the proposed increase factor (10).

Slide 14:
Regarding the TCSMs, *Alessio* believes that masks are not in the BIS, meaning that they will not trigger a dump; *Daniel* confirms. *Alessio* asks if the same goes for the TCDQA and TCDQM, *Daniel* and *Barbara* say that BLMs with the name BLM"**T**"I will be in the BIS.
Bernhard asks why the TCDQs have flat applied thresholds to which *Barbara* answers that it is probably because an actual threshold was never set (not needed), and so they were simply set to maximum with a small MF. *Alessio* points out that in any case, ignoring the short RSs, the TCDQs should be fine as they are.
For the TCSP, the MF is already 1, and we can see that for RS08 and RS09 the applied threshold needs changing.
Barbara points out that we should lift RS11 up to the same level as RS10 in the TCSP, and keep the ratio between RS11 and RS12 (lift 12).

Slide 15 and 16:
For the families shown, only small corrections are necessary, and MF change is sufficient.

Conclusions

- Implement a factor 10 on all cold magnets and leave MF as they are;

- A priori implement a flat top correction from RS08 (keeping the MF, and not worrying much about the short RS), also for the cold magnets;
- For the TCSP we just put a factor 2 on RS08 and RS09 in the MT to get the applied above the required threshold and RS11 and RS12 will be flattened to RS09;
- TCLAs will follow the same approach: change the MT a bit to move the few affected RS above the requirement;
- As was done for the proton quench test, an ECR will be prepared for the ion quench test, mostly for documentation purposes.

Daniel will go through cell 9 and 11 (left of 7) and look for magnet weaknesses.

Cell 11 BLMBI Monitors (Matti Kalliokoski)

The new families crated took into account only horizontal monitors for BFPP losses, so the monitors at the interconnects next to the empty cryostat were left out because they are in the family with other monitors on top of MB-MB interconnects.

Slide 3 shows the thresholds in the region, and the single monitor is about a factor 2 lower than the horizontal monitors.

During operation, the orbit bump did not perform everywhere as well as expected, and so the BLM on the interconnect registered a lot of losses. The solution to this was to set the MF to 1 on the fly.

Barbara asks why the TCTPH is also shown (Slide 4), *Markus* answers that it is debris from IR7 that turns out to be a different ion species than, so it follows a different orbit in the machine – the losses end up on the indicated BLM.

Matti suggests creating a brand new family for the four monitors in IR1 and IR5 that see an interconnect BLM between the last MB of the DS and the empty cryostat.

Apply a flat top correction just as the standard MBMB family and increase the running sum to the same level as the ion family. The losses seem to be of the same order, so this should be a good strategy. The idea is to be able to go back to 0.499 in the MF.

Bernhard suggests setting the interconnect BLM to maximum for the duration of the test.

Barbara suggests creating a separate family for the interconnect BLMs that have a flat top correction so that they will work for both ion and proton runs, and write a separate ECR for this change.

1. Triplet-Monitor Sig/Thres Scaling with Luminosity in IPs 1 and 5 (Bernhard Auchmann)

We need to make sure that even at increased luminosity, we will not permanently end up at the warning level in the triplet. So, at the beginning of Run 2 flattop corrections were implemented that ensured this condition for 1e34 $cm^{-2}s^{-1}$ luminosity with MF = 0.1667, and for 2e34 $cm^{-2}s^{-1}$ with MF = 0.333. This approach works, as seen by using Chen's signal to threshold ratio tool by filtering out the monitors around the interaction points, and the margin now is about 5% (we stay 5% below the warning level at the target luminosity).

Proposal for MP3 is to increase the current flat top correction by a factor 2 and stay with the current MF (even though the luminosity will go up to 1.6e34 $cm^{-2}s^{-1}$ (this number comes from Mike, but a better reference is needed to base numbers on)).

At IP8 we already agreed that we need a better FT correction. On top of that, the approach from IPs1 and 5 should be applied also for IP8 (see http://indico.cern.ch/e/blmtwg26).

2. Post-YETS UFO Strategy (Bernhard Auchmann)

To improve overall availability and keep the risk of protection-heater damage to a minimum, we propose to:

- Increase the RS 1-6 Master Thresholds (MT) by x5 (additional AdHoc correction);
- Reduce the MF to 0.2 (This means an effective further increase by x2 in short-RS thresholds.);
- (P3 MQ monitor MTs are unchanged, MF to 0.2.)
- Keep this setting (or even increase MF), provided we see no more than ~20 UFO-induced quenches per year.

Daniel points out that we should not accept 20 UFO quenches per year, as that essentially means 1 per week of proper operation. *Barbara* agrees. Aim for 10 or 15.

The new strategy for UFOs is to set thresholds so that the BLMs interfere less, as they have almost exclusively contributed to reducing the machine availability.

In the long term it will be interesting to see (with Christos) if the BLM threshold algorithm can be adapted to better account for UFOs (hi-lumi perspective).

For the time being, it seems UFOs do not cause **major** problems for machine protection and availability (barring the issue of too-tight BLM thresholds).

Matti will produce a “before and after” plot for the MB monitors (applied threshold now and applied threshold after) to show that at other energies and other RS we get tighter while here we get looser.

Minutes by Jonas