Minutes of the 6th Meeting of the Quench-Test Analysis Working Group, 28.03.2014

Present: Bernhard Auchmann, Chiara Bracco, Vera Chetvertkova, Bernd Dehning, Wolfgang Hofle, Matti Kalliokoski, Anton Lechner, Juho Rysti, Belen Salvachua, Mariusz Sapinski, Rudiger Schmidt, Nikhil Shetty, Arjan Verweij

Chiara: MAD-X Analysis of the Large-Kick Event in 2008

Chiara presented MAD-X analysis of the quench that occurred in MB.B10R2.B1 during an aperture scan in IR7 on 2008/09/07. The beam was kicked with MCBV.9R2.B1 with different amplitude but due to a mistype 750 μrad was used instead of 75 μrad and thus the beam hit MB.B10R2.B1. The matching of the MAD-X results to BLM data depends strongly on initial conditions and on the information obtained from the BPMs. The analysis was done only in vertical plane.

Vera: MAD-X Analysis of the Dynamic Orbit-Bump Quench Test of 2010

A vertical bump was applied for circulating beam 2 of 3.5 TeV with intensity of 1.85×10^{10} protons. The bump was set to reach maximum deflection of 15 mm. During the quench test about 58% of the initial beam intensity was deposited in the MQ within 3.5-6 s.
Mariusz commented the duration depending on the initial point.
Rudiger asked if the sextupoles were on in the simulations. If they were not, this will have effects on the results.
Vera replied that no large impact can be seen. The main differences can be seen in variation of the step size. The single points with higher values in the plots are due to low statistics and binning. In the figures the Y-axis values are normalized and do not show the absolute measured values. Only one value of the orbital bump was used.
Mariusz commented that the shape of the distribution in the right plot in slide 5 is notably different from the others. *Vera* suggested that this is due to low statistics. *Anton* and *Rudiger* noted that this is not caused by lack of statistics; the distribution seems to be flat. *Rudiger* suggested checking if the kicks of the magnet are linear. *Anton* noted that the general issue is that the angular distribution of protons lost within the MQ looks rather flat, which appears (at a first glance) to be strange since particles are lost at different longitudinal positions within the MQ: in the tracking studies concerning the ADT quench test, Vera found a nice correlation between longitudinal impact position and angle, i.e. the impact angle was decreasing the further inside the magnet a particle was lost (which makes sense since particles are continuously experience the horizontally focusing quadrupole field). However, the question arising was if the different distribution of angles in the dynamic orbit bump test is due to a different particle dynamics (Vera increased the bump amplitude every 100 turns).

Nikhil: FLUKA Analysis of the Large-Kick Event in 2008

Nikhil presented the results of an analysis of an actual quench event, above discussed by Chiara; event number 2. The quench has been reported in LHC Project note 422. In the event a bunch of 2×10^9 protons quenched a MB in a vertical kick event (750 µm). There were no quadrupole magnets between the kicker and the dipole, thus simple beam trajectory was used. In the analysis, beam emittance of 2 µm was estimated.

When the results of FLUKA analysis were compared with BLM measurements that are presented in the note 422, it was seen that the simulations give a BLM profile that is shifted by one BLM for ideal orbit model. By correcting the tracking simulation model with corrections due to the orbit oscillations, the simulation results give good agreement with the measurement data. This shows that the results are very sensitive to the initial conditions. The simulations show that the maximum energy density is in the collar of the magnets, not in the coil. This is dependent on the horizontal deflection. The simulations gave maximum energy densities in the corrected case of ~25 mJ/cm^3, and ~18 mJ/cm^3 without the corrections, while calculated quench limit is 38 mJ/cm^3.

Bernhard: Overview of all Quench-Test Analyses in the Joint Paper

Bernhard gave an overview of the topics in the forthcoming paper of the quench-test analysis. 6 events/tests were selected to the analysis.

The first event that was analyzed was the 2008 strong-kick quench event. This was included to obtain information on quench level at injection energy and for fast losses at 1.9 K. It was also assumed that the event had straight-forward beam dynamics. At the moment upper boundary (UB) estimate of FLUKA model gives 18 (+7/-0) mJ/cm^3, and electro thermal Minimum Quench Energy Density (MQED) estimate 38 mJ/cm^3. *Anton* noted that in the note 422 the quench limit was 31 mJ/cm^3.

In the analysis of short-duration collimation quench test (QT) the MQED results are below the lower bound (LB) of the FLUKA results. This suggests that there might still be some geometrical features missing that could shield losses.

The wire-scanner QT analysis involved calculation of lost protons in the last quenching test. Good agreement between the simulations and the BLM measurements vindicate the calculations. In the analysis, losses in MQY (Q5) and MBRB (D4) were studied. For MBRB analysis, FLUKA suffers from incorrect coil geometry by putting an energy loss peak at the start point of the magnet, and the MQED estimate suffers from unknown field and cooling conditions in the magnet ends. Unknown timing of quenching requires parametric study since the differences between QPS time and the actual triggering time are not well known.

Unknown quench time is also a problem in intermediate-duration orbit-bump

QT studies. With MAD-X tuned to match BLM data, FLUKA model gives good BLM agreement. Large heat fluxes to nucleate-boiling helium for short duration could give one possible explanation for the factor of 4 discrepancies between FLUKA LB and MQED estimates.

In the collimation QT the FLUKA model gives good agreement overall, but a factor of 4 differences are seen in comparison with BLM data in the location of peak losses. There was no quench and thus there is no upper bound value. Therefore the estimate of the MQPD cannot be validated. Better BLM agreement and refined coil-energy model, and actual quench are needed. *Rudiger* asked if there has been observation in increase of temperature. *Arjan* mentioned that cryogroup can make the temperature measurements if requested. *Mariusz* mentioned that this was a steady state measurement and that some type of temperature measurements was made. This data should be requested.

For the steady-state orbit-bump QT the FLUKA analysis is strongly sensitive to the beam screen's surface roughness in the MAD-X model. When comparing the surface roughness of 10 μm and 30 μm, the results show the actual BLM signal to lie within the uncertainty. *Arjan* asked what the fluctuation due to the bin size is. *Anton* replied that longitudinally the error is within 2 – 10%.

Next meeting

Date and contents to be confirmed

Minutes by Matti.