# Machine Protection Working Group

*Minutes of the 25th meeting held on August 29th 2003*

**Present:** R. Assmann, E. Carlier, C. Dehavay, P. Dahlen, B. Goddard, G. Guaglio, M. Gyr, V. Kain, V. Montabonnet, D. Macina, B. Puccio, C. Rathjen, R. Schmidt, J. Uythoven, R. Veness, J. Wenninger, C. Zamantzas, M. Zerlauth

**Excused** : R. Denz, B Dehning, B. Holzer

**Topics of this meeting:**

- Asynchronous beam dumps : bunches that "come back" (M. Gyr)
- New simulations on D1 failures and apertures in IR1 (V. Kain)
- Beam position interlocks (J. Wenninger)
- AOB

**Asynchronous beam dumps: bunches that "come back" (M. Gyr )**

**M. Gyr** presented results on the trajectory of bunches that are affected by the rising edge of the asynchronous kicker pulse and that travel once around the machine before being extracted on the second turn, this time with the full kick strength. For those calculations he ignored the presence of the collimators, since their effect depends strongly on phase advance and jaw positioning. The TCDQ is the only obstacle that was considered, with an opening of $\pm 10\sigma$.

In his presentation **M. Gyr** considered extraction kicks of up to 110% of the nominal, but **B. Goddard** noted during the meeting that on the second turn one should consider a nominal kick strength, which gives additional margin at lower fractional tune values. Since this suggestion affects the results, **M. Gyr** provided new calculations after the meeting. With the new results the acceptable range for the fractional tune at 450 GeV covers a range of 0.18 to 0.39, for a nominal tune of 0.28. Within this tune range, the $4\sigma$ envelope of the beam can be extracted with an orbit offset of up to 2 mm within touching vacuum chambers within the septa… At 7 TeV there is no constraint on the tune.

In the discussion **B. Goddard** confirmed that the TCDS would be a two-sided object, but a compromise must still be found between the best protection of all vacuum chamber elements and the available aperture for the beam. Reacting to a comment by **R. Assmann** who said that for some collimation scenarios the TCDQ must be opened much more than $10\sigma$ at 7 TeV, he also insisted that the strategy for positioning the TCDQ needs to be defined more clearly and that one cannot assume that the TCDQ position can be adapted arbitrarily to any scenario. **R. Schmidt** also insisted that the baseline collimation scenario that assumes that the collimators are only re-adjusted before the squeeze should be re-visited. He does not think that this baseline scenario is acceptable for machine protection.

**ACTION :** A clear strategy on how to set collimators must be defined (**R. Assmann, V. Kain, R. Schmidt**).

**Linear and non-linear tracking of D1 failures and apertures in IR1 (V. Kain)**

**V. Kain** recalled the principle of the fast simulation model that she used so far to study the D1 magnet failures. She then explained how the same simulations are performed with MADX, where collimators are represented by observation points and where the beam/particle positions are recorded turn after turn. The D1 failure was simulated with MADX including the effect of the lattice sextupoles: $10^4$ particles are tracked over 40 turns in 30 minutes on a PC, with a significant fraction of the time used by pre- and post-processing of the MADX data. The simulation results agree within the statistical fluctuations due to the small particle sample with the fast simulations (MPWG meeting of 22nd November 2002). **V. Kain** concludes that the fast tracking tools that she has developed can be used for further studies. Concerning the D1 failures, the first beam loss is observed in IR7 after 5-15 turns for the D1 in IR5 and after 10-20 turns for the D1 in IR1. The results are valid for Gaussian beam distributions and for the 55 cm $\beta^*$ optics.

**B. Goddard** remarked that in any case the beam dump is safe in this failure scenario (provided the BLMs trigger) since the total orbit movement is less than 1 mm at the dump kickers and septa. **R. Assmann** suggested that effects from higher order fields are probably at the level of few nanometers per turn, similar to what is expected for particle diffusion. He suggested however to repeat the simulations with machine errors (alignment, field errors, coupling…) that may have more influence. **R. Schmidt** proposed to verify the effect of the D1 on the injection optics, where the $\beta$-function at the D1 is much smaller and where the orbit drift should be significantly slower. **D. Macina** proposed to run the simulation with the high-beta optics for TOTEM. In the context of this discussion, **R. Schmidt** and **M. Zerlauth** said that ACCEL has made an offer for 2 SC solenoid systems for 600 k€. The solenoids increase the time constant of the D1 electrical circuit by a factor 3**. R. Schmidt** said that he will bring up this possibility at a future LTC. He also mentioned that further studies are also in progress concerning precise detection of current changes, but it will take some time before the feasibility of such a monitoring can be confirmed.

In the second part of her presentation **V. Kain** presented the aperture information that she was able to collect in collaboration with many colleagues of the vacuum group. The aim is to gather all the relevant information and make is available for aperture studies with tracking programs (MADX). The data between the 2 TANs in IR1 is now complete. In the triplet the full aperture is ~ 18$\sigma$, leaving about 12$\sigma$ when the crossing angle bump is subtracted. For most accelerator components of MADX the aperture is now an attribute of each element, but for vacuum chamber pieces between components, bellows, interconnects… one has to introduce markers into MADX. The data is now practically complete for IR1 and ready for MADX simulations, and the files can be used as a basis for IR5.

**R. Assmann** suggested to cross-check all the data with **B. Jeanneret**. He was asked to mention this work at the ABP optics meeting to see how it can be integrated into the optics team studies. **R. Veness** commented that the tricky parts in terms of aperture are the small pieces, while the apertures of the beam screens are well known. Mechanical and alignment tolerance should also be verified and included in the data. Concerning the tertiary collimators near the triplets, **R. Assmann** pointed out that they are very useful for cleaning but that there is a conceptual for the vertical plane with horizontal separation (and vice-versa) : a single jaw would affect both beams, which makes the positioning delicate in the presence of orbit tolerances. Ideally one would therefore like to have separate jaws for the two beams.

**Beam position interlocks (J. Wenninger)**

**J. Wenninger** gave an update on the state of beam position interlocks. Four beam position monitors dedicated to position interlocks will be installed for each beam in IR6, the phase advance between the two pairs being 90°. The three issues related to beam position interlocks are:

- *Protection of the dump* (limited aperture) : the position of the beam should never wander off by more than about ±3.5 mm with respect to the reference position in IR6. This interlock will be applied on a turn-by-turn and bunch-by-bunch basis and does not pose particular problems, but requires a modified acquisition board.
- *Protection of the triplets in case of asynchronous dump kicks and collimation efficiency* : ensure that the beam position at the TCDQ remains within a tolerance of about $\pm 0.5\sigma$ compared to the reference. Here the tolerances are tighter but the surveillance can be performed on time scales of 0.1 to 1 second. A software interlock may there be sufficient. Details must be worked out.
- *Detection of fast orbit changes* (e.g. D1 failures : 500-1000 μm over 20 turns) : this is the most tricky interlock since deliberate kicks given due to beam or injection errors should not trigger an interlock.

A number of points must still be clarified – for example if different interlock algorithms can be run at the same time on the BPM data… **J. Wenninger** will follow up this point.

**AOB**

**R. Schmidt** and **B. Puccio** said that they were surprised to hear at a meeting of the CEIWG that apparently nobody requested precise timing in the LHC underground areas. **E. Carlier** confirmed that he had asked for it a long time ago within the TIMWG. The interlock system is another client for this precise timing.