# LHC Beam Operation Committee

## Notes from the meeting held on 11th December 2012

Participants

### 1. Collimation after LS1: cleaning and β* reach (Roderik Bruce)

R. Bruce presented a summary of the possible scenarios and configurations of the collimation system after LS1. First he made a short introduction about the collimation system and a review of the 2012 run collimation settings. In 2012 non-critical margins have been reduced. Critical margins, calculated based on in-depth analysis of previous runs, depend on several components such as orbit, β –beat, luminosity scans, positioning errors and setup error. These margins have to be respected more than 99% of the time to avoid accidents. Next, collimator settings in 2012 were compared with 2011 settings, remarking that the goal of β*=0.6 m was successfully achieved. The triplet aperture at the IPs was measured by a TCT collimator scan after controlled blow-up induced by the transverse damper. The aperture was determined by observing the relative evolution of the losses at the triplet and TCT withlosses clearly moving from the triplet to the TCT when the TCT gap was reduced. The very good orbit stability in stable beams was remarked, although he pointed out that sometimes a slight negative offset was observed (although within tolerance.

Next R. Bruce introduced one of the main changes to be introduced in the system during LS1: **The BPM button collimators**. The 16 TCTs in all IRs and the two TCSGs in IR6 will be replaced by new collimators with integrated BPMs. The main advantage is that they can re-align dynamically during standard fills (so no need for special low-intensity fills), thus drastically reducing the TCT setup time (allowing more flexibility in IR configuration) and the orbit margins in cleaning hierarchy (allowing more room to squeeze β*). A 50 μm precision of orbit at TCTs and TCSG6 is assumed, although a better precision is expected.

R. Bruce presented next the preliminary machine scenarios after LS1, assuming both 25 and 50 ns bunch spacing. A 12σ beam-beam separation for 25 ns might be pessimistic, but results from MDs are needed for a better estimation. Regarding collimations settings, some margins will be reduced thanks to the BPM button collimators. These have been calculated following the same philosophy (to be respected more than 99% of the time) and an update on the margins will be carried out to know how much damage the TCTs can accept. Up to five different collimation settings are proposed, the case 1 corresponding to the most pessimistic calculations.

The β* was shown for different beam options. The crossing plane aperture has been scaled from most pessimistic 2011/2012 measurements (11σ at 4 TeV, 60cm, 145 μrad) to 6.5 TeV configurations. β* is given by the aperture which can be protected. Depending on the beam option, **the β* span in the crossing plane would be from 31 cm** (for a 50 ns beam with large emittance) **to 55 cm** (for a 25 ns beam with large emittance) in the crossing plane thanks to the BPM buttons. We might not want to go to the limit in β* for some reasons (pileup, intensity vs β* in case of instabilities, …). R. Bruce also showed that an earlier separation reduction would make us gain some cm but the difference would be rather small. He also mentioned the **possibility of using flat beams**, which could add some advantages. Once the parameters are chosen, the option to be taken would correspond to the one offering a higher luminosity.

All presented settings could be achieved under the consideration that octupoles current at 6.5 TeV will not limit collimation performance (impedances). In addition no optics constraints were considered and careful aperture measurements are required during re-commissioning.

***Discussion:***

Mike Lamont asked whether the reduction of the luminosity due to the geometric factor has been taken into account. R. Bruce answered that it was not taken into account, since it was not in the scope of this preliminary study. Jörg Wenninger said that the geometric factor might be around 50% for the small beta star considered

Stephane Fartoukh suggested that if one is not limited in β* by aperture but by the geometric factor intensity should pushed.

Jörg Wenninger mentioned that in spite of gaining in set up time in the TCT, we would not know how to do the loss maps. Stefano Redaelli replied that first we have to learn how to make them. R. Bruce added that it will take time to understand them also from an operational point of view.

Stefano Redaelli suggested that in IP6 it could be interesting to have more dynamic settings.

Stephane Fartoukh asked if one could think about changing the closed orbit in IR6 or 7.

Jörg Wenninger remarked that understanding the origin of the the offset with respect to reference orbit is important. R. Bruce answered that hopefully we will get rid of them thank to the bottom BPMs. We will then understand if the orbit fluctuations are real or not (they take into account the temperature).

Alexey Burov noted that collimator impedance is not the sole responsible for the stability limits at the end of the squeeze. Another source of impedance or loss of Landau damping related to the presence of the two beams is contributing to that. Alexey noted that electron cloud in the common regions could be responsible for that.

## 2. Preliminary summary of the LHC scrubbing run (Hannes Bartosik)

H. Bartosik started reminding the aims of the scrubbing, namely the reduction of the Secondary Electron Yield (SEY) to allowing MD studies at 25 ns, a better understanding of the SEY evolution as a function of the electron dose deposited on the beam screen and the learning of difference in operation between 25 and 50 ns. A fast intensity ramp up was achieved and **the overall efficiency was excellent**. The beam was under control despite the record intensities achieved.

In spite of the smooth run there were some factors limiting the efficiency, namely the pressure in the MKI regions and the cryogenics. Smaller perturbations were caused occasionally also by the vacuum pressure in ATLAS and the TDIs (which had to be opened after each injection in order to keep heating and outgassing under control).

Regarding beam quality evolution, initially some transverse instabilities were observed leading to beam dumps. Chromaticity was reduced in the middle of Fill 3389 without problems. Already in the course of the first fill trains of 288 bunches could be injected without instability. This had not been possible during the first injection tests on the same day and it is an indication of the reduction of the SEY already during the first fill.The initial beam lifetime was quite poor but a remarkable improvement took place within the first scrubbing fill. This lifetime continued increasing noticeably over the different fills, being always better for beam 2. The bunch length might have helped for this

improvement.

Elena Shaposnikova questioned the last point about the bunch length, since it was reducing. H. Bartosik replied that in the last fills no big length decrease was observed along the trains.

H. Bartosik next mentioned an important (not yet fully understood) emittance blow up in the middle of the first batch, in principle not related to e- cloud. This was suppressed by increasing the octupoles strength from -0.5 to -2.

Jörg Wenninger asked whether there was activity seen just after injection. H. Bartosik answered that at injection one does not see this activity, which comes after few minutes. Elena Shaposnikova asked for the gain in the damper and Wolfgang Hofle replied that it was already very high. Elena Shaposnikova noted that it had not the typical signatures related to electron cloud. H. Bartosik noted that different observations (BSRT, Wire Scanner, BBQ, damper pick-ups) were consistent.).

Alexey Burov asked the reason for considering that this instability is not related to e- cloud. H. Bartosik answered that this pattern was observed for the first train and not for the following ones furthermore on would expect the electron cloud instability to affect the trailing bunches of each train mainly.

Gianluigi Arduini reminded that a similar effect (sudden instability) was observed last year after 2011's scrubbing with 50 ns. It is not yet understood. Giovanni Iadarola pointed out that it cannot be 2 beams effect (as suggested by Alexey Burov during the discussion) because this is also observed only with one beam.

H. Bartosik finished mentioning that more information analysis is ongoing, but the e- cloud effects were clearly mitigated (although not suppressed yet) during the 3.5 days of scrubbing and that already valuable information on the SEY evolution vs. electron dose has been collected for validation and improvement of our models and for enabling us to extrapolate to post-LS1 operation.

### *Discussion:*

Alexey Burov asked about the equivalent original octupole current. The answered was that -2 corresponds approximately to 26 A.

Jörg Wenninger asked for the next steps. Gianluigi Arduini replied that beam-beam studies would follow collimation setting-up and loss maps, as a part of the plan for ramping up the intensity at 4 TeV. It is planned to use the BCMS beam for the beam-beam studies and to go bak to train of 72 bunches for the electron cloud studies at 4 TeV..

Frank Zimmermann asked at which point was the lifetime calculated. Hannes Bartosik answered that after one hour, which is a kind of figure of merit for figuring out whether ramping up in energy seems feasible or not.

Elena Shaposnikova suggested using a low voltage and longer bunches for the ramp. Gianluigi Arduini replied that bunch length does not affect significantly the heat load due to electron cloud when above threshold. Giovanni Iadarola added that the LHC bunches are very short, much shorter than in the SPS, so slight variations might not imply big advantages.

## Upcoming meeting:

**Tuesday, 22nd January 2013 15:30 in 871-1-011: LBOC**