Minutes of 82th Collimation Upgrade Specification Meeting

Participants: F. Addesa (FA), G. Azzopardi (GA), R. Bruce (RB), F. Galluccio (FG), M. Garattini (MG), H. Garcia Morales (HG) (scientific secretary), A. Gorzawski (AG), D. Mirarchi (DM), S. Montesano (SM), M. Patecki (MP), S. Petrucci (SP), S. Redaelli (SR) (chairman), L. Rossi (LR), R. Rossi (RR), G. Smirnov (GS), C. Xu (CX), C. Zamantzas (CZ).

Remote: M. Fitterer (MFit), W. Scandale (WS), G. Stancari (GS), G. Valentino (GV).

Indico event [here](#).

1 Actions

Actions from this meeting:

- Understand quadrupole current stability issue during tune ripple MD.
- Finalize open issue with crystal data analysis.

2 Preliminary comments

- SR introduces Arek Gorzawski as a new fellow working on the BLM detectors and welcomes him to the team.

3 Analysis of the diamond detector data from 2016 (A. Gorzawski) [slides]

3.1 Summary of the presentation

Diamond beam loss monitors (dBLMs) allow a very fast acquisition (i.e. bunch by bunch) of the beam losses. Analysis of the data acquired in 2016 is important to understand the capabilities of such detectors.

- AG reports a summary of the analysis of the data acquired using diamond detectors during 2016. Three different units were installed in the LHC tunnel in IR7, one in TCPs for B1 and B2 and another one in B1 next to the crystal. AG shows the bunch structure as recorded by the dBLMs.

- AG shows how the data is stored in the EOS system. Two different data formats are available. The histogram data contains the counts when the loss threshold is overpassed without information about the loss magnitude. The waveform data is raw data containing the induced voltage which is scalable to the loss magnitude. In this presentation the analysis of the histogram data is shown while the waveform data analysis is still ongoing. The data sets include data from most of the fills and MDs between July and September 2016. AG shows a comparison of the RAW dBML data, the dBML 1.6 ns data adjusted to the first bunch and the FBCT data.
• Four data sets are analyzed including EoF MDs, regular MDs and stable beams with different crossing angles. AG shows a comparison of the data for two different fills, 5282 as a typical fill and 5338 as the first fill with reduced crossing angle. No big different between both scenarios is observed during squeeze. During adjust different patterns are observed in the loss distribution due to the difference in the crossing angle.

• AG presents a detailed analysis of the case with reduced crossing angle during adjust phase. It looks like a possible saturation effect is observed. **ACTION:** This has to be checked with experts for 2017

• During Stable beams, no significant difference between both fills is observed during the first hour.

• AG shows the analysis of the data for fill 5105 during halo scraping EoF MD and fill 5137 for long range beam beam MD.

• AG concludes that this is a very good data set from different fills which provides a new point of view on loss patterns. The frequency analysis on the waveform data is ongoing and may reveal more capabilities of the system. Need to understand some of the issues observed before 2017 operation. B2 data should be also available during 2017 run.

3.2 Discussion

• SR and RB point out the importance to record also the magnitude of the signal, not only the counts as a future improvement.

• SR encourages people to be aware of the capabilities of the new detectors to motivate future MDs.

• RB asks if some other fills post crossing angle reduction were recorded. AG replies that there is one more data set to be analyzed with reduced crossing angle.

• SR explains that currently there are two diamond detectors in B1 and the plan is to install one or two more in B2.

4 Status of tune ripple MD analysis (H. Garcia) [slides]

4.1 Summary of the presentation

• HG reports the status of the analysis of the data collected during the active halo control using tune ripple MD.

• HG explains the motivation of this technique among other techniques (narrow band excitation and electrons lens (see next section)) in view of the HL-LHC upgrade. This technique relies on the nonlinearities of the machine and the
tune spread generated by octupoles. The idea is to create side bands around existing resonance lines and put them on top of the tune footprint in such a way that only particles in the tail of the distribution are excited and, possibly, removed.

- HG explains that some tests were already performed in the SPS. He also gives the details of the procedure applied during the MD in the LHC. Two nominal bunches were injected per beam, one of them is kept untouched while the other one is blown up using white noise from the ADT. Octupole current is set to 10 A to generate enough detuning with amplitude. Wire scanners are used before, during and after the modulation with warm quadrupoles in IR7. Finally the beam is scraped down using single jaw of the primary collimator to reconstruct the beam profile.

- HG reports that the MD was carried out smoothly although some issue with the quadrupole current stability were observed. A reproducible current drop was observed during quadrupole modulation. Tests performed previously without beam did not show this behavior. **ACTION:** This issue remains to be understood for future tests.

- although the issue with quadrupole stability, HG explains that some clear intensity reduction is observed in the blown up bunch while the witness bunch intensity remains almost constant. Emittance did not show a clear core blown. Profile reconstruction from collimator scraping does not give a clear conclusion about the particle distribution of the tail before and after the modulation. The fact that two bunches per beam were scraped down limit the profile reconstruction due to the difficult disentanglement of the respective contributions. In future tests, one bunch per beam is going to be injected in order to avoid this limitation.

### 4.2 Discussion

- SR reflects that it is important to (**ACTION**) solve the issue of the quadrupole current stability. This is going to be checked with experts.

### 5 MD on core blowup from HEL-type excitations

#### (M. Fitterer) [slides]

#### 5.1 Summary of the presentation

- MFit reports the analysis of the data collected during the MD on core blow up from HEL-type excitations. She explains the principles of the electro lens. Proton beam travels inside a hollow electron beam. With this pattern, halo particles are kicked to higher amplitudes the the em field of the electron beam while the core is unaffected.
- Although for a perfect uniform, radially symmetric electron beam the field at the beam core is zero, residual fields and imperfections may affect the beam core. The estimated kick at the beam core is about 15 nrad.

- MFit explains that the pulsed mode of the HEL increases diffusion. Two different modes are considered: random mode and resonant mode pulsed every \(n\)-th turn inducing \(n\)-th order resonances. The goal is to understand whether tighter tolerances on the profile imperfections are required for operation.

- MFit explains the motivation of the experiment at the LHC. The goal is to understand the limits on tolerable kick from beam profile imperfections. To verify simulations with experiments. MFit explains the details of the experiment using ADT to create a dipole kick in the resonant mode. For detailed parameters see in the slides. In the filling scheme, 24 bunches were outside the ADT window and 24 more inside the excitation window.

- MFit shows some results concerning the simulations for a kick of 120 nrad every 7th and 10th turn. Simulations show large losses and bunch length decrease but also emittance growth. For other pulsed patterns small losses are observed.

- The MD results for pulses every 7th turn in the horizontal plane reveal higher losses than predicted by simulations. The distribution is already affected for 12 and 24 nrad amplitude. Quadratic scaling with excitation amplitude. For pulses every 10th turn the pattern is similar but smaller losses.

- The extrapolation to 15 nrad gives a loss rate of 13%/h and 17%/h with and without damper respectively on for pulses every 7th turn. For pulses every 10-th turn 3%/h and 2.9%/h respectively.

- MFit explains that the BSRT monitor was used to obtain the beam distribution and the emittance. The problems is that the emittance is calculated assuming a purely Gaussian distribution which is not always the case. So a q-Gaussian fit is used to characterize more precisely the beam distribution. Q values for overpopulated tails are between 1.3-1.4 and 0.9-1.0 for Gaussian and underpopulated tails. (See slides for more details of the fit).

- MFit shows the result of the fit for 7th and 10th turn excitations.

- MFit concludes that a 15 nrad excitation amplitude is not negligible. both affecting the tails and the core. For 7th turn pulsed pattern large losses are observed and a small emittance growth. For 10th turn pulsed pattern small losses are observed while a large emittance growth. Losses are in any case much higher than expected from simulations and emittance growth could not be reproduced. Next steps include data from diamond detectors and future MDs include the analysis of other pulsing patterns and to understand the differences between simulations and measurements.
5.2 Discussion

- SR asks about the normalization of the BSRT reconstructed profiles in terms of beam size units ($\sigma$). MFit replies that DSRT experts did not provide the exact beam size at the BSRT location.

- SR points out that there is a slight reduction of the core population. Maybe particles are going away from the core.

- SR explains that some more tests are going to be carried out at RHIC.

6 Crystal cleaning for ions - MD measurements (R. Rossi)  

6.1 Summary of the presentation

- RR presents the results of the last MD with crystal collimation during ion run. This is the last test with ions until the end of the run II in 2018, just before LS2.

- RR explains that crystals are already well integrated in the collimation system in IR7. In 2015 channeling was observed for the very first time with protons at flat top and ions at injection energy. The 2016 goals were to demonstrate the feasibility of the channeling and cleaning for ions at top energy.

- The MD was carried out on October the 29th. In the horizontal plane using strip crystal channeling was established for the first time at 6.5 Z TeV lead ion with the crystal at 5.5$\sigma$ and a deflection angle of 2046.4 $\mu$rad. The reduction factor observed was 10.33. In the vertical plane using quasi-mosaic crystal the noise generated with the ADT was very high and the reduction factor could not be calculated. Nevertheless channeling was observed with the crystal at 5.5$\sigma$ and a deflection angle of 2226.03 $\mu$rad.

- To compare the performance of the crystal collimation system with the standard collimation system the leakage of particles in the DS region is evaluated. It is needed to normalize to the beam flux. Different loss maps with different settings were measured to perform and extensive study:
  - Reference: Standard collimation system loss maps
  - Ideal case: one absorber system.
  - Best case: best performance system using several TCSGs
  - Different absorber settings with absorbers at different aperture.

- The details of the loss maps and the standard to crystal collimation loss ratio can be found in the slides for horizontal and vertical plane.
• RR explains that a difference in the Reference horizontal loss map between MD and commissioning was found. Maybe due to an orbit problem. **ACTION: this issue is under study.**

• RR concludes that channeling was established with both crystals with lead ions at flat top energy for the first time. He adds that cleaning performances has been measured not in perfect condition. In the near future he plans to finalize the open issue in data analysis and use SixTrack-Fluka coupling to study the debris coming from the absorber TCSGs.

### 6.2 Discussion

• SR explains that there is always an uncertainty in the orbit. Pascal Hermes simulations with single jaw may help. RB points out that Pascal presented some results before Christmas in ColWG meeting.

• RB asks about the origin of the fragments observed. SR says that maybe they are coming from the crystal itself and suggests to do more measurements to better understand the issue.

• SR explains that a second crystal is going to be installed in B2. In addition, some more tests are going to be carried out in the SPS and there are some plans to run Xenon ions in the LHC which could be another opportunity to test crystals.