23rd LIU PSB Beam Dynamics Working Group

Participants: S. Albright, F. Asvesta, H. Bartosik, C. Bracco, G. P. Di Giovanni, A. Huschauer, E. Koukovini Platia, B. Mikulec, E. Renner

Quadrupoles for Beta-Beating Correction (Hannes Bartosik)

Hannes presented an updated proposal for the correction of the beta-beating in the PSB, using a different pair of quadrupoles than the baseline. The difference between the new pair, namely quads QDE2 & QDE15, and the baseline (quads QDE3 & QDE14) is that the new one provides a better correction for the working points below the half integer. This tune regime will be preferable for the recommissioning. In addition, in the new scheme each quadrupole does not induce beta-beating at the location of the other one simplifying the measurements for the correction in the machine such as the K-modulation. It should be noted that this pair is closer to the injection chicane and the beta beating after the correction is more localized. **Both configurations need to be furthered studied in space charge simulations in order to finalize the proposal and decide which one should be used**, as discussions with colleagues from EN-EPC and EN-EL have concluded that quick switching between the two schemes is not possible. Swapping the two systems will require long interventions that could be done only before startup or during YETS.

Discussion:

- **Gian-Piero** further stressed that a decision between the schemes need to be made as the cost for a system that would allow swapping between them cannot be justified.
- **Simon** wanted a description of the K-modulation measurement and **an extra slide explaining the procedure**. **Hannes** explained that in this type of measurement each quadrupole is modulated individually inducing a tune change directly proportional to the beta beating wave. During the measurement choosing a suitable modulation, such as a sinusoidal one, the beta function at the location of the quadrupole can be determined.

Brightness Curve Simulations (Foteini Asvesta)

Foteini presented the simulations for the brightness curve at 160 MeV. The operational working point is confined to the tune space below the half integer, as previous studies have shown that in the presence of even small quadrupolar errors there is large beam degradation for tunes above Q_y=4.5. In order to enhance performance, a small percentage of losses from uncaptured beam can be tolerated. The brightness curve for 0% losses, depending on the quadrupolar error, could lay almost on top or above the LIU target for PSB injection. However, allowing 1-2% losses the brightness curve lays below the LIU

target for all errors tested thus far. More studies are needed to **benchmark** the simulations, include more **realistic modeling of the longitudinal space charge** and **machine errors**.

Discussion:

- **Bettina** wanted some extra explanation on the mechanism for losses of uncaptured beam in the presence of a large quadrupolar error and in particular why the losses were mostly vertical and not horizontal as it would be expected from the dispersion. **Foteini** said that due to the large quadrupolar error the particles are affected by the half integer resonance and get directly lost before the different orbit can take effect and push the particles on the horizontal aperture.
- **Elizabeth** noted that depending on the line density some of the blow-up could be compensated by injecting off or on axis.
- **Hannes** said that an important consideration is what the real energy spread at injection will look like as some extra losses could be connected to that.
- **Simon** asked if the real energy spread can be measured for the different debuncher settings in Linac4 and **Hannes** replied that it is not possible.

AOB: Preliminary Studies on Injection Optimization (Simon Albright)

Simon gave an overview of the injection optimization of the longitudinal parameters. The main point of the presentation was to showcase that the parameter space is very large and the definition of optimal may defer for the various beams. Starting from the LHC25ns beam, simulations were conducted and some values have been defined as optimal for the various figures of merit chosen. It should be noted that those values were optimized for the flat bottom while the transition to the ramp still needs to be studied.

Discussion:

- **Hannes** noted that besides the INDIV type beam the optimal configuration would be to fill the bucket as much as possible. **Chiara** argued that only in the LHC-type beams the optimization should be done in terms of brightness while for the rest it should be done in terms of losses. **Simon** noted that even for the MTE type the main consideration is the vertical emittance. **Hannes** suggested that above a certain intensity limit, ~1e13 ppb, the fullest bucket would be the priority. However, the off-bucket losses could be avoided in beams other than the LHC-type to which **Chiara** agreed. **Elisabeth** said that the main concern should be the LHC and ISOLDE type while **Simon** said that in his opinion all beams should be optimized.
- **Hannes** asked what was the bunching factor in the examples presented and **Simon** answered that the one with the higher emittance was the one with the larger bunching factor.

- **Elizabeth** explained the list of the various optima. The first one was the best observed with 0% losses, the second allowing 1-2%, the third had the lowest spread from Linac4 and the last 2 were the extreme cases.
- **Hannes** noted that the voltages are quite large. **Foteini** confirmed that in the flat1 configuration the voltages at the flat bottom were in the order of 3 and 4 V for the two systems. **Hannes** noted that under those conditions the BCMS beam would not work.
- **Elizabeth is running the same simulations as Simon to check how well they match**.
- **Hannes** pointed out that we still don't know how the distribution will be so the optimization may not work for a different type. **Simon** said this work will give a feeling of what we need and how to proceed.

AOB: Wrap-up of the LHCINDIV Longitudinal Setup (Simon Albright)

Simon gave an overview of the schemes he had prepared for the LHCINDIV in previous meetings and provided the final proposal based on the requirements discussed in the 20th LIU-PSB Beam Dynamics WG. In the final scheme, the pulse length and the energy are fixed while there is the option to work only with a single cavity. Operationally the beam parameters can be varied playing with the turns, the shaving and the choke. The injection for the operational beam will be 3 turns.

Discussion:

- **Gian Piero** asked which would be the voltages and **Simon** said that the voltages are not changed.
- **Hannes** stressed the superiority of the new scheme versus the older ones by pointing out that changing the dE_{RMS} through the debuncher would give very different optics in the transfer line and complicate further the injection.
- **Gian Piero** noted that the operation would be the same as pre-LS2.
- **Chiara** said there is a profit from the 3 turns injection for the operational beam to achieve the target emittance.
- The dE_{RMS} is set at 100 keV.

AOB

- **Hannes** asked if there are any news concerning the possibility to keep the beam on the foil after the injection process in order to blow it up.
    - **Gian Piero** said that there are problems in the controls and we shouldn't rely on this

- **Chiara** noted that it should be possible during commissioning and even though it is not an ideal procedure it might be a useful option.
- **Gian Piero** wondered if there are any simulation results for the transverse emittance, but the beam has not yet been checked transversely. **Elizabeth** said that she had tested a case with a single turn injection with an offset only in horizontal. **Hannes** noted that offset in both planes would result in a not Gaussian beam so it should be avoided.
- **Hannes** said that blowing-up on the integer may not work as good as expected since the beam has a very small spread and a large tune variation is needed.
- **Bettina** suggested to use the dumper for the blow-up. **Hannes** and **Gian Piero** noted that it needs to be commissioned first so it cannot be the only option.
- **Gian Piero** said it would be nice to have simulations checking the effects, like painting, foil etc, independently and combined. **Elisabeth** noted that the reliability of the results is not a given. **Hannes** agreed and stressed the need for testing.
- **Simon** asked if the blow-up could be done later in the accelerator chain and in particular in the SPS transfer line and **Hannes** replied it was considered but it is not possible.

- **Gian Piero** referred to the documentation and said that the options for the longitudinal plane need to be set so that other beams can be included. In his opinion, the request for the BCMS will come quite early on. The BCMS doesn't need to be in the LIU target but it has to be improved from the past run.
    - **Hannes** noted that in his perspective the previous bucket was limiting the emittance at 1.4 eVs so a similar procedure limiting the emittance at 1.5 eVs would be usable for the BCMS.

Foteini Asvesta

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