Minutes of the LIU-PS BD WG #31 on the 6th of June 2019

Agenda (https://indico.cern.ch/event/825325/***)***

1. *Introduction*
2. *Update on turn-by-turn measurements with SEM grids*
3. *AOB*

Present:

Foteini Asveta, Hannes Bartosik, Denis Cotte, Heiko Damerau, Marc Delrieux, Gian Piero Di Giovanni, Matthew Fraser, Klaus Hanke, Alexander Huschauer, Alexandre Lasheen, Bettina Mikulec, Salim Ogur, B. Kosta Popovic, Frank Tecker, Ben Woolley, Piotr Skowronski

1. Introduction

Heiko gave a brief summary of the last meeting. Heiko stated that another iteration on the definition of the intermediate plateau for rf manipulations will be scheduled before the end of the year.

Concerning the presentation on wire scanners, the WG should follow-up on the tests for the low intensity LHCINDIV beam. Gian Piero underlined that the readiness of the FESA class will be followed up in the commissioning working groups (partial software ready during summer, but full implementation to be followed up).

2. Update on turn-by-turn measurements with SEM grids – M. Fraser (pptx)

Matthew continued to present his analysis on Turn by Turn (t-b-t) data acquired (LIU-PS Beam Dynamics WG meeting #23). There were three different transfer line optics applied during the data acquisition. Re-matched (ReM) beam-transfer line optics of Vincenzo Forte, operational optics (OP), and intentionally mis-matched (MisM) optics to boost the betatronic mismatch relative to the dispersive component. The beam profile data was recorded with SEM grid (BSG52). The Gaussian fit has been made to the profiles to compare the beam size for the ReM and OP optics. The dispersion measurement is done by changing the RF frequency in PSB to adjust the injected momentum offset in PS. He concluded that the dispersion has not only linear terms, but there is a growth of non-linear dispersion on slide #8. Alexander suggested to cross-check with the dispersion calculated by the BPMs without the SEM grid inserted where the sample size (number of turns) will be far larger. Matthew responded affirmatively to perform it. Matthew reported that the ReM optics demonstrates smaller amplitudes of oscillation in beam size due to the better matched dispersion (both linear and non-linear). In slide #11, Matthew showed the calculated chromaticity from T-b-T data and concluded that the calculated chromaticity is twice that measured later in the cycle in both planes. The reason is not yet understood. Alexander would need to check if the turn-by-turn tune measurements at injection were made for the new BCMS cycle with low chromaticity. The analytical results of Benedikt-Carli were

applied to the t-b-t normalized beam size and dispersion. Except the fractional tune and amplitude of the oscillation, the other fit parameters may not be conclusive regarding the 7 free parameters to fit 30 data points especially in terms of the values of the emittance and momentum spread. In this analysis, Matthew avoids the complications of deconvolution and focused mainly on the amplitude of the oscillation as an indication of the level of matching.

Matthew also presented a Discrete Fourier Transform (DFT) of the data to calculate the frequency of the envelope's oscillation, which agrees well with the one from analytical fit. This was repeated for different injected momentum offsets. Heiko ask what window function to DFT was applied? Matthew explained that although he considered windowing, the limited number of data points (30 turns) makes it challenging. In fact, the limited sample size is essentially a rectangular window. Matthew concluded that the frequency of the envelope oscillations depends strongly on momentum of OP optics rather than ReM. Currently, Salim is asked to simulate whether the non-linear dispersion is behind this effect by using MADX/PTC.

Matthew also presented the analysis in the vertical plane. Here, the scattering due to the wires of the SEM was dominant since the vertical beam size is smaller compared to horizontal, the beta function larger and the effect of the tails develops sooner affecting the Gaussian fit.

Lastly, the MisM optics, which stands between ReM and OP in terms of dispersion mismatch but with a larger betatronic mismatch, is analysed. The analytic fit of the beam profile is not good for the first turns where large betatronic mismatch is observed to change the distribution of the beam strongly.

The talk was concluded by comparing the geometrically calculated emittance values of ReM and OP. The expected emittance blow in OP should be about 20% more than ReM. Yet, only a difference of 2.5% of emittance blow-up was reported at the last meeting in which the emittance was measured for the ReM and OP optics. Therefore, there is something else causing the emittance blow, such as dispersion mismatch and space charge, or even systematic errors arising from, e.g. the changing beam profile distribution. Matthew also added that after LS2, all BSG system (48, 52 and 54) will have fast readout systems. As a back-up slide, Matthew showed that the BGI is capable of measuring turn-by-turn data with the advantage that the beam is not perturbed by the interaction with wires.

Matthew made it clear that the non-linear component of the dispersion function develops linearly with the number of turn made in the PS due to different TL optics. Fanouria commented that the Gaussian fitting to the distributions overestimates the beam size and the fit functions applied should be reviewed.

The next steps will be to compare the measured non-linear behaviour to prediction from simulation, to understand the effect of filamentation and changing distributions on emittance blow-up in simulation and finally to compare with space-charge effects implemented in simulation.

3. AOB

Alexander notified that the PS optics is being updated.

Simulations with space charge in the vertical plane.

Alexandre informed that simulations are ongoing to evaluate the benefits of improved RF feedbacks on bunch-by-bunch variability.

Minutes by *S. Ogur* and *A. Lasheen*