Minutes of the LIU-PS BD WG #30 on the 16th of May 2019

Agenda (https://indico.cern.ch/event/819656/)

1. ***Update on Wire Scanner studies***
2. ***Considerations for intermediate energy plateau for RF manipulations***
3. *AOB*

Present:

Foteini Asveta, Denis Cotte, Heiko Damerau, Gian Piero Di Giovanni, Jonathan Emery, Matthew A. Fraser, Ana Guerrero Ollacarizqueta, Klaus Hanke, Myrsini Kaitatzi, Salim Ogur, Federico Roncarolo, Haroon Rafique, Markus Schwarz, James Storey, Ben Woolley.

1. Update on Wire Scanner studies

Jose Luis Sirvent Blasco presented a comparison of the old and new wire scanners mounted in the Booster and PS. The new WS has been adopted since it scans faster, which is due for the energy upgrade in LIU-PS. The mechanical calibration of the wire position is checked with a laser system mounted in mobile stages. Recorded data is fitted with a 5^{th}-order polynomial, even though the initial analytical angular-to-projected motion equation has 3 parameters, see slide #4. Heiko asked the reason behind this choice of fitting to which Jose explained that it is due to the non-linearities of the residuals, the real motion is better explained with a polynomial expression. All in all, the uncertainty in the wire position determination is calculated to be below 10 um. After, an introduction of the WS baseline fitting and analysis of the beam size, the results of some 3k scans carried out in 2018 were presented. It was stated that previous LIU-PS presented results shown over-estimated beam profile sizes (by ~ 10%) due to an incorrect processing of the PMT signal. This issue was fixed with a new processing algorithm and a comparison of the resulting beam size measurement was shown for understanding by using NEW (b.size 3.45mm) and OLD (b.size 3.86) algorithms for the same LIU-PS scan. The dispersion and movement of the beam centroid was measured by radial steering in which BPMs were used as well as the old and new WS's for comparison. He certified an agreement within 1%, the beam centroid measurements were un-affected by the over-estimation of the beam size. Heiko asked how it was first realised that the analysis needed checking and what was the motivation to rethink of the reconstruction of the signal? Jose and Federico have replied in harmony: when comparing the emittances calculated with LIU-PS BWS54H VS Operational BWS65H there was a big disagreement, this issue could not be identified before the emittance of LIU-PS was cross-checked with operational scanners. Heiko: is it linked to the way the PMT signal was processed? they replied affirmatively.

Jose also reported a comparison between operational and re-matched optics, he noted a 2.5% smaller emittance for the re-matched optics. Apart from this, he also presented that a systematic discrepancy was observed between IN and OUT scans . The beam was measured to have a non-Gaussian profile on some scans, with further work needed to understand the discrepancy. He is suspicious of the vibrations on the wire. In slide #17, he also showed some measurements taken for SFRPRO-FT beam. He has got reasonable results at CTIME 185, but not for 710 ms. Jose pointed out that his emittance calculation is missing the exact dispersion value, and Matt said that reference measurements were taken, including the dispersion, before the end of the run. Also, 5 islands of the beam is measured and presented.

Matt reminded that on the TOF beam, the QKE (quadrupoles) fire just before the extraction, changing the optics dynamically during the wire-scan measurement. We should check the trigger times of the wire-scanner and QKE to try and conclude on this.

Heiko asked if we could confirm the results with an oscilloscope?
Federico: We are currently using PicoScopes for acquisition. In any case for final systems one channel per scanner will be provided on OASIS. Jose pointed that: If needed in operation, the system can always be de-coupled from operational acquisition electronics and use oscilloscopes for verification in specific MDs.
Matt: What about analysing BGI data and compare brightness curves with the WS to rule out the systematic errors? Jose and Federico: this can be done later.

2. Considerations for intermediate energy plateau for RF manipulations

The intermediate flat-top at a kinetic energy of 2.5 GeV was originally introduced to provide sufficient bucket area for the BCMS manipulation, in particular during merging. After the increase of the injection energy to 2 GeV, the intermediate flat-top energy is very close to the injection energy. With the twice brighter beams in the post-LS2 era, space charge at 2.5 GeV can be an issue again during the RF manipulations. Therefore, the intermediate plateau energy needs to be increased in a way to mitigate the space charge issues while keeping longitudinally favourable conditions for the RF manipulations in terms of voltage and duration. In addition, the energy, and hence the revolution frequency, needs to be an integer sub-harmonic of the resonance frequency of the 200 MHz cavities to allow controlled blow-up.

He starts with a thorough explanation of the RF manipulation, which takes in total 385 ms for BCMS with pre-LS2 cycle. Indeed, with an increase in the intermediate energy, some of the RF manipulation steps needs to be performed slower to keep the same adiabaticity. Slide #7 discusses the energy scaling and outlines advantages and disadvantages of the energy increase. A higher plateau energy will shorten the bunch length, therefore voltage needs to be reduced to keep the bunch length same during merging and triple splitting. Indeed, the space charge will cause problems at 2.5 GeV, and the increase in energy will reduce the impact of space charge by $1/\beta\gamma^2$. To sum up, the bucket area for merging and triple-splitting needs to be conserved to keep a comparable sensitivity of the relative phases as before LS2. In addition, the space charge tune shift ratio compared with the pre-LS2 beams at 1.4 GeV needs to be around 1. Heiko then simply compares all possible energies, and the most optimum is found to be 3.08 GeV. However, he pointed out that there was little choice. At lower plateau energies space remains and issue. Going higher in energy would cause the adiabaticity to become even worse for the RF manipulations. For example, at 3.24 GeV the synchrotron frequency (at constant bucket area) is already 2.5 lower than at 2.5 GeV. Denis has generated magnetic cycles using the POPS editor and finds a maximum plateau length of about 472 ms at 3.08 GeV.

However, the main issue for the RF manipulations at higher energy will be adiabaticity, since the synchrotron frequency at 3.08 GeV will only be about half the frequency at 2.5 GeV (for the same bucket area). How to fit even shorter allocated time for RF manipulations even with higher energy? Firstly, the batch compression seems to be not seriously affected if performed twice faster in simulations. It is moreover not particularly sensitive to relative phases and bunch length. It can hence be executed with 60 kV RF voltage per cavity group. Triple splitting however, will only require 20 kV (single cavity) per harmonic. The early simulations for the batch compression indicate that the manipulation duration of 130 ms should be feasible, leaving more time for merging and triple splitting. This will be checked in more detail with respect to 2012 data for benchmarking. All in all, he concluded that the pre-LS2 beam (injected at 1.4 GeV) having an intermediate plateau at 2.46 GeV had 385 ms for RF manipulations, while the 2 GeV post-LS2 beam may have the plateau at 3.08 GeV with 400 ms.

Matthew asked if any intermediate step would be interesting before switching 3.08 GeV? Heiko proposed to immediately start with that energy. In case of problems, the intermediate plateau energy could be lowered within about one day.

Heiko suggested to re-discuss the energy of the intermediate plateau again during late 2019/early 2020.

Minutes by S. Ogur and A. Lasheen