# Meeting of LIU SPS-BD WG on 06.06.2018

Present

Elena Shaposhnikova, Wolfgang Hofle, Alessio Mereghetti, Patrick Kramer, Joël Repond, Hannes Bartosik, Markus Schwarz, Giulia Papotti, Alexandre Lasheen, Danilo Quartullo, Heiko Damerau, Aaron Farricker, Marcin Patecki, Ezgi Sunar, Kevin Shing Bruce Li

Agenda

1. Status of the SPS collimator system studies – M. Patecki
2. Slip-stacking simulations with intensity effects – D. Quartullo
3. Update on the SPS 80 MHz RF system evaluation – J. Repond
4. HOM damping in the 3-section 200 MHz TWC – P. Kramer
5. Preliminary results of the 2018 MDs – M. Schwarz

Actions

* pending
* **M. Beck**: News on the MKE impedance model.
* **N. Nasresfahani**: Study the possibility to use the new coupler design to replace all existing 630 MHz HOM couplers.
* **Markus**: Include the momentum acceptance limitation in simulations.
* **Markus**: Is it possible to understand if the instability observed with the radial-loop is real or only related to numerical problems?
* New
* **Measurements**
* For the slip-stacking cycle, determined the aperture needed for the collimation system.
* A list of the key moments in the various cycles (slip-stacking!) is necessary to adjust the design of the collimation system.
* Measurements of the beta beating to include optics errors in simulation of the collimation system.
* Check the impedance of the new collimation system.
* Measurements of variations along the batch (intensity, emittance) for ions (slip-stacking simulations). Look into the 2016/2017 data available.

**1 – Status of the SPS collimator system studies – M. Patecki**

Losses in the SPS are significant and with the increased intensity beams the use of a new collimation system similar to the LHC one is considered. Such a system would allow to localize the SPS beam losses and control them to lower the activation and longer the machine components lifetime. The beam quality could be constrained during the cycle by this system and it would be used for clean scraping and would provide protection for beam failures and avoid damages to the machine. The main challenges are to make the system work for the three different optics avoiding movements of the collimators between the cycles. Moreover, the system must fit into very limited empty spots with sufficient beam clearance. This talk presents the present status of the SPS collimator system design.

* Beam losses observations
  + Injection, extraction.
  + Most severe: off-momentum losses (capture, full bucket on flat bottom, acceleration) 🡪 in high dispersion region.
  + Losses budget for LIU-SPS project: 10% at 2.5E11.
    - **E. Shaposhnikova**: The 10% includes the scraping at flat top 🡪 3% are lost from scraping, the budget is 7%
    - **M. Patecki**: The budget is important when we do scaling. We are already more pessimistic in our calculations.
* Challenges
  + Fit the collimation system into very limited empty spots.
  + Protect the machine without consuming the useful beam.
  + Avoid movement of the collimators between cycles.
* The design is done using simulations with sixtrack + fluka.
* **E. Shaposhnikova**: Is the system movable? Can it be an obstacle for the slip-stacking (300 GeV)?
  + **M. Patecki**: Not within the cycle. How much space is needed?
    - **E. Shaposhnikova**: It depends when intensity effects are included 🡪 see talk of D. Quartullo.
* **E. Shaposhnikova**: You suppose a 5 mm improvement in aperture when fixing the QD issue, this is in which direction?
  + **M. Patecki**: Inner part of the ring, the low momentum particles move in this direction.
  + **H. Bartosik**: On the inside of the machine, we have 5 mm less than expected.
* **H. Bartosik**: We have a systematic problem of 5 mm reduction (this will be changed) + the variations along the machine due to misalignment (will not change) 🡪 we will not have the ideal aperture.
* **E. Shaposhnikova**: In normal operation, LHC is not running with protons and ions simultaneously. The collimators can be moved when the type of particles changes.
  + All key moments in the cycle should work with the collimation system without modification 🡪 need a list with parameters to adjust the system
* **M. Patecki**: We only need the inner jaw to make the system efficient so if needed, we can use an orbit jump. We can find a mechanical solution to cycle the collimator system if necessary.
* **H. Bartosik**: The primary collimator is after the absorber (5 mm of graphite)?
  + **A. Mereghetti**: Yes, the collimation is done in multi-turn. This is the best design to optimize the tiny length available.
* **E. Shaposhnikova**: The design is still optimum in Q22/Q26?
  + **M. Patecki**: The dispersion peaks in Q22 are the same (Q20), it’s optimized. No limitations for Q26.
* Even after improvement, losses in QD locations are a limitation.
* **E. Shaposhnikova**: What is assumed for dp/p of the initial distribution?
  + **A. Mereghetti, M. Patecki**: For cpu reasons, we simulate only protons hitting directly the primary collimator. The initial distribution is uniform and dp/p is chosen as the one where particles hit the collimator (3.8e-3, unperturbed bucket 4 MV in Q20).
    - **E. Shaposhnikova**: Presently, limited by momentum aperture. At larger intensity, I expect already 50% larger dp/p from the bucket.
    - **E. Shaposhnikova**: Losses are not symmetric, all particles move toward the inside of the ring.
      * **M. Patecki**: The primary collimator is on the inside.
* Optics errors affect the cleaning efficiency 🡪 dispersion beating needs to be controlled.
* **H. Bartosik**: The beta beating can be measured 🡪 could be included in simulation.
* **A. Farricker**: Instead of offsetting the QDs, we could replace the flange by a MBB type to buy an extra couple of meters and reduce the losses.
  + **H. Bartosik**: I think the problem is the QD pipe. Probably it won’t help, losses will just be displaced by a few meters.
* **E. Shaposhnikova**: Impedance of the collimator?
  + **M. Patecki**: Most of the elements are already in place, it should not add much impedance but needs to be checked.
* **A. Mereghetti**: The primary collimator will suffer more with ions than protons.
* **E. Shaposhnikova**: It is very nice to have other means of managing the losses. They will not disappear and can be a problem for radioprotection during commissioning etc…. Is there any money allocated for this system?
  + **M. Patecki**: It is a question for V. Kain.

**2 – Slip-stacking simulations with intensity effects – D. Quartullo**

The baseline scheme for the production of an HL-LHC ion beam in the SPS requires momentum slip-stacking to reduce bunch spacing and double the number of bunches in the LHC. This scheme cannot be tested before RF upgrade (LS2) and backup scenario are developed in parallel. However, particle simulations suggest the feasibility of the slip-stacking in the SPS with bunch rotation before extraction to the LHC to meet the HL-LHC beam parameters. New results are presented in this talk for the slip-stacking in the SPS with intensity effects. This talk will be presented at the HB conference this year.

* Goal: test the slip-stacking feasibility with
  + Full SPS impedance model.
  + Measured beam parameters.
  + Optimized slip-stacking parameters.
* Due to RF perturbation the focusing effect can be lost, chaotic regions, not necessary unstable due to intensity effects.
* **E. Shaposhnikova**: Due you take into account the time needed to reach the peak voltage? When the two batches approach what is the transition?
  + **D. Quartullo**: The time needed to switch the RF on/off is 1.3 microsec. When the two batches meet, the voltage is considered on, no smooth transition for the moment.
  + **E. Shaposhnikova**: You cannot assumed constant voltage during this transition, the voltage cannot reach its peak instantaneously.
  + **W. Hofle**: During the transition time, if the parameter is larger than 4, the voltage overlap of the two distinct RF systems is only a small perturbation and cannot drive chaotic motion.
  + **E. Shaposhnikova**: The motion can be chaotic, it should be taken into account in simulation. Moreover, the filling time of the new cavity scheme (4x3-section + 2x4-section) should be determined.
  + **W. Hofle**: The process when goes from 4 to 0 is not adiabatic and there is no time to drive chaotic motion.
  + **E. Shaposhnikova**: We need to do it adiabatically otherwise the beam can be lost. It’s probably the worst case scenario with RF on (peak voltage) during the transition.
* Significant variations of intensity and emittance along the batch are measured.
* **E. Shaposhnikova**: A train of 24 bunches corresponds to six injections🡪 the two batches are different. The two batches in simulations should take this into account (two batches similar in simulation for the moment).
  + Is it possible to change the injection scheme?
  + **H. Bartosik**: Due to kickers rise time we cannot inject easily where we want in the machine like in the LHC.
  + **E. Shaposhnikova**: We need to measure intensity along the batch for ions. Look into 2016, 2017 data available.
* For the three different optics, the bunch rotation seems needed.
* For one batch, 5.76 mm 🡪 we have margins for the collimation system.
* Next step: try to counteract the loss of landau damping but we have hollow bunches, difficult to stabilize with Landau system.

**3 – Update on the SPS 80 MHz RF system evaluation – J. Repond**

Losses increasing with intensity are a bottleneck in the production of HL-LHC proton beams and need to be mitigated. Moreover the PS suffers coupled-bunch instability at flat top and larger longitudinal emittance bunches would be beneficial. The introduction of a lower-harmonic RF system in the SPS would increase the longitudinal acceptance and can reduce capture losses if they are mainly related to the bunch shape at injection (bunch rotation in PS). However, the beam stability in the lower-harmonic RF would be more difficult to ensure and the re-bucketing in the main 200 MHz RF system would require very large voltages if the PS bunches have large tails. Indeed the 200 MHz RF system in the SPS is necessary to accelerate both ion and proton beams to the LHC and the beams need to be transferred from the lower-harmonic RF to the main 200 MHz RF bucket. Moreover, the beam-loading and the power limitation after RF upgrade will limit the maximum emittance that can be accelerated. This talk presents the latest update.

* B. Goddard asked in which locations this system could be installed.
* The phase space should be generated from the binominal distribution and not the bunch line density.
* What about the impedance of the new system? The stability at flat top is the most crucial.
* Bunch rotation in the SPS for transfer to the main 200 MHz RF bucket?
* Add the 800 MHz RF system in simulations because it is locked on the flat bottom and cannot be removed.

**4 – HOM damping in the 3-section 200 MHz TWC – P. Kramer**

The efficiency of the new 630 MHz HOM (longitudinal) damping scheme for the 3-section cavity has been proven in electromagnetic simulations. Addition of new RF couplers on the top ports of the cavity pushes the electrical field to the bottom. Perturbations are added inside the pumping ports to change the field pattern and suppress the modes degrading beam stability. The effect on the fundamental passband is analyzed in this talk. An equivalent circuit is derived to study further the damping from new RF probes.

* Matching of FPC for travelling condition very important otherwise we have non symmetric impedance
  + Very broad band reflexion from coupler if not well matched and can drive instability already from the fundamental.
* New circuit model can be used now for study and replace the CST simulations.
  + **E. Shaposhnikova**: It shows that all previous approaches was not so successful because we were moving from the optimum situation.
* **W. Hofle**: Inductance added in parallel, it acts only at one frequency? How do you realize it in operation?
  + **P. Kramer**: e.g. by a stub.
  + **W. Hofle**: It could have a negative influence on other HOMs?
  + **P. Kramer**: Probably not within the narrow 630 MHz band.

**5 – Preliminary results of the 2018 MDs – M. Schwarz**

The talk will be presented at the next meeting.

Minutes written by J. Repond