Minutes of the meeting of the SPS Upgrade Study Group on 16 June 2011

Present: T. Argyropoulos, H. Bartosik, C. Bhat, T. Bohl, A. Burov, H. Damerau, B. Goddard, R. Garoby, V. Lebedev, J. E. Muller, Y. Papaphilippou, E. Shaposhnikova, M. Taborelli, J. Tuckmantel,

Excused: G. Arduini, F. Caspers, B. Salvant, G. Rumolo

• **Possible increase of bunch intensity in the SPS for HL-LHC - E. Shaposhnikova**

(1) In case maximum bunch intensity delivered by the PS at the 50 ns bunch spacing is significantly below that required by HL-LHC some possible methods of doubling bunch intensity in the SPS can be investigated. Taking into account that present LHC beams fill only a half of the SPS ring and that controlled longitudinal emittance blow-up is required for beam stability at the end of the ramp, one can consider bunch merging by a slip stacking on the intermediate flat portion during the ramp (around 200 GeV). It is in principle possible with existing wide-band 200 MHz RF system after corresponding upgrade of the beam control. Main issues of this scheme are related to emittance blow-up (beam transfer to LHC), use of the 800 MHz RF system for beam stability, beam loading in both RF systems and particle losses at high energies. Progress and difficulties with ESME simulations performed by T. Argyropoulos were also reported. The purpose of simulations was to determine the minimum emittance blow-up which can be achieved with this method.

Additional points raised during discussion were:

- e-cloud issue for very high intensity beam with reduced bunch spacing in the process of merging,

- the effect of beam loading in two separate RF systems used to control different parts of the beam,

- operation of the transverse damper during slip stacking,

- higher voltage required with Q20 optics could have in this case a positive effect for beam loading.

• **Recent MD results for nominal SPS and low γ_t optics: tune scans and transverse emittances for single bunches - H. Bartosik**

The tunes scans around WPs of the Q20 and Q26 optics were performed to study the strength of different resonances from the particle loss rates. The actual tunes were monitored by BBQ. The identified important resonances are different for the two optics under study.

Transverse emittance measurements performed in 2011 confirm in general results obtained in 2010 for the Q20 optics and they are very different for the nominal optics with much smaller emittances obtained for high intensities in 2011. In 2010 for the same bunch intensity transverse emittances measured with low transition energy were significantly smaller than those with nominal optics, which is not the case anymore (al least for emittance at the end of the 3.5 s long flat bottom). Note that many wire scanners in the LHC injector chain were re-calibrated during last weeks and smaller transverse emittances were also measured in 2011 for LHC beams with 50 and 25 ns bunch spacings. The results obtained for the Q20 and Q26 optics have been compared. For the Q20 optics emittances in the SPS seem to follow injected emittances (PS) with some blow-up starting above intensity of 2.2×10^{11}. Emittances measured at the end of the flat bottom for the Q26 optics (with V=2 MV) were slightly higher than for the Q20 case (V=3.9 MV). Continuous losses on the flat bottom are larger for the Q26 optics. Vertical tune scan with high intensity bunches for nominal optics shows significant emittance blow-up when approaching Q_v=26.05 (with $Q_h = 26.18$).

The most important question for the next MD is the stability of multi-bunch LHC beams in the Q20 optics and the required RF voltage.

- **CPS/SPS MD with 50 ns beam of 2011-05-11 - T. Bohl**

The aim of this MD was to measure beam transmission and stability in the SPS for high intensity ($1.4-1.7\times10^{11}$/bunch) 50 ns beam with different injected longitudinal emittance and bunch length. Bunch length was varied by using 2 or 3 the 80 MHz cavities in the PS. Controlled emittance blow-up in the SPS (not optimised for this intensity) was on or off. Other parameters varied in the SPS were horizontal chromaticity (during ramp and on the flat bottom) and phase loop gain. Beam stability in the SPS could be improved by injecting bunches with larger longitudinal emittance or for the same emittance with larger bunch length (2x 80 MHz cavities). In the latter case the transmission was slightly worse. For higher bunch intensity beam became more unstable on the flat top and transmission was also worse. Lowering phase loop gain (from 10 to 4) also helped to improve beam stability but slightly increased beam losses. Better stability was also achieved without emittance blow-up in the SPS (with old settings). For larger emittance transmission is better with 3 PS cavities. Dipole instability on the flat top is correlated with quadrupole instability. Dipole instability has been also observed on the flat bottom.

Due to a large parameter space and many changes performed during this part of MD parameters which could lead to optimum transmission and beam stability simultaneously were not explored.

→ Next MD:

- optimise longitudinal blow-up for high intensities
- perform emittance scan with 3 PS cavities (as was done already with 2 cavities).

- The next meeting will be on **14 July 2011** at 15:30.

Preliminary agenda:

- Results of the SPS MD week 27:

  transverse emittance measurements - G. Rumolo/B. Salvant

  longitudinal parameters - T. Argyropoulos/T. Bohl

  Q20 optics - H. Bartosik/Y. Papaphilippou

- ESME simulations of single bunch stability in the SPS - C. Bhat

Elena Shaposhnikova, 27.06.2011