Minutes of the SPS Studies Working Group (SSWG)

7^{th} meeting -6^{th} June 2000

Present: G. Arduini, T. Bohl, H. Burkhardt, R. Cappi, K. Cornelis (chairman), Y.C. Chao, W. Hofle, J. Klem, D. Manglunki, G. Rumolo, E. Shaposhnikova, L. Vos, F. Zimmermann, M.P. Zorzano (secretary)
Excused: T. Linnecar, J. Tuckmantel

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1 Discussions on the PS beam for high intensity at SPS (R. Cappi)

Presently the high intensity proton beam is extracted over five consecutive turns (known as Continuous Transfer CT) from the PS ring at 14 GeV/c and transferred through the TT2-TT19 line to fill the SPS in two pulses. The following scheme has been proposed for discussion as a hypothetical scenario to reach high intensity beams:

- 3 PS cycles (3 shots into SPS): produce a current of $3\times2.5\times10^{13} = 7.5\times10^{13}$ p/sypercycle. For cycles that are 1.2 s long the maximum momentum that can be reached is 20 GeV/c but the flat-top is too short to allow debunching and recapture of the beam at 200MHz. To operate in this scheme and in order to gain the 50 to 100 ms required for the bunching/rebunching manipulation we may need to reduce the momentum to about 16 GeV/c. If the SPS could accept 10MHz bunches (i.e.. 16 bunches) and transform (debunching-rebunching at 200MHz?) them to 200 MHz bunches, then the 20GeV/c option could be feasible. To be studied.

- Expected normalised transverse emittance $\epsilon^*_{x,y} = \sigma^2_{x,y}/\beta_{x,y} \times \beta\gamma$: typical emittances per 10^{13} p are $\epsilon^* = 6\mu$m, for $I = 2.5\times10^{13}$ p we expect $\epsilon^*_{x,y} = 15\mu$m The value of the vertical emittance is here is somehow conservative (it should be between 6 and 15 μm and the real value should be obtained by experimental results).

- If a new (with less losses) 3 turns Continuous Transfer extraction would be available the emittance could be: $\epsilon^*_x = 15/3 = 5\mu$m and $\epsilon^*_y = 15\mu$m (if needed the x and y values could be exchanged in TT10).

This improved 3 turns CT is presently under study (M.Giovannozzi et al.). A simulation code is being set up and the first results will not be available before roughly 3-4 months. Consequently for the time being these considerations are only speculations. The present 3turns CT is for high density beams is a very lossy operation and when it was tested some years ago it did not finally provide any practical improvement. Moreover it is limited to 14GeV/c.

- Another possible improvement would be to further reduce the PS cycle length from 1.2 to 0.6 s for proton bunches with energy $p \leq 14$ GeV/c. This could probably be possible for the PS but not for the PSB. This operation could be envisaged if a 2.2 GeV Superconducting Proton Linac (a yellow report is being prepared for next summer) would be actually built. In this case also the transverse emittances will be reduced by a large amount (a factor 2 or 3).

For the time being, the SSWG should study if a beam of 3 batches (3 turns CT) of 2.5×10^{13} protons/batch, 5μm and about $10-15\mu$m vertical and horizontal emittances respectivelly (after exchange in TT10) at about 14-16 GeV/c could be assimilated by the SPS.

(G. Arduini) For the 3 batch injection proposal two points are to be taken into account, if the PS boosters will be able to follow this repetition rate and the fact that a 3 batch injection does not fill completely the SPS ring and induces high local densities.

2 Results from recent MDs

2.1 Long MD cycle with LHC bunches (E. Shaposhnikova)

A number of studies have been performed for 1 to 3 batches of 84 LHC-like bunches and intensities between 1.7 and 5.5×10^{12} per batch. The current has been monitored as the capture voltage was varied. For high intensities strong losses were observed, typically continuous and slow during the long flat bottom and strong and sudden at the beginning of the ramp. The losses went up to a third of the total injected current. Lowering voltage decreased the first type of losses and increased the second. Opposite was true for increasing voltage. The longitudinal emittance reported from PS was about 0.35eVs for low intensities and 0.65eVs for high intensities. Measurements of the longitudinal profile also show bunch oscillations at flat top.

(R. Cappi) Notice that to measure the longitudinal emittance you need a matched beam but before being injected into SPS the LHC bunch suffers a non adiabatic bunch compression. Due to this only qualitative estimates with an accuracy of 30% can be given.

(G. Arduini) Vertical wire scanner measurements along the batches show blow-up in the tails of the 1st batch only.

2.2 Measurements on the 1st batch oscillations for the LHC beam (K. Cornelis)

Using a wide-band (from 1 MHz to 3 GHz) pick-up measuring the vertical position of a selected bunch (25 ns window) turn after turn, the spectrum shows a peak at a frequency of about

700MHz only for bunches located at the end of the batch.

(E. Shaposhnikova) An rf-mode with very low Q exists at 630 MHz.

This year SPS has a new device to measure the chromaticity by monitoring the phase difference between the head and tail of a single bunch. Using this device, we observe that whereas for bunches at the beginning of the batch the phase difference oscillates with Q_s, for those at the end of the batch it oscillates with a frequency of roughly $2Q_s$. The phase shift is presumably induced by an impedance, perhaps created by the electron cloud affecting the tails of the batch.

2.3 Single bunch impedance measurements (H. Burkhardt, F. Zimmermann, M.P. Zorzano).

As part of the effort to monitor the SPS impedance the first data of this year have been recorded for single proton bunches, at 26 GeV, and intensities varying typically between $0.7 - 7 \times 10^{10}$ p. Preliminary analysis of the coherent tune shifts as a function of currents show similar results to those of last year: a horizontal slope $\Delta Q_x / \Delta N_p[10^{10}]$ of the order of $+4 \times 10^{-4}$ and a vertical slope $\Delta Q_y / \Delta N_p[10^{10}]$ of the order of -3×10^{-3}. The bunch length increased typically over this range of currents from 0.47ns to 0.6ns. Some problems were reported: unavoidable horizontal oscillations at high currents that disappeared for lower currents, the Qmeter does not kick on the continuous mode and the horizontal wire scan shows two peaks by the sides of the central Gaussian shape yielding a wrong estimate of the horizontal emittance. The dampers were not available for these single bunch currents (W. Hofle may know how to fix this).

For more information about the MDs performed last year see *Measurements of coherent tune shift and head-tail growth rates at the SPS*, G. Arduini, H. Burhardt, K. Cornelis, Y. Papaphilippou, F. Zimmermann, M.P. Zorzano SL-Note-99-059 MD.

3 MDs planning

The single short bunch beam will be operational until Wednesday of next week (for disperssion measurements, resonance driving term measurements, etc), then we will switch to long single bunch MDs. A proposal has been made to prepare a cycle with a LHC-like ramp from 26GeV to 120 GeV, to be used for resonance driving term measurements (on a batch), impedance coherent tune shifts (single bunch), energy loss (beam in coast over 2-3 hours and extremely good vacuum needed) and for the 120 MHZ damper set-up.

4 Next meeting

The next meeting is scheduled for Tuesday 20th June, at 09:15, Room 865-1D17. A reminder will be sent by email in due time and the agenda will be announced on the web page of the working group

http://cern.ch/sl-mgt-sps-swg

M.P. Zorzano 6th May 2000