Minutes of the SPS Studies Working Group (SSWG)

16$^{\text{th}}$ meeting -21$^{\text{th}}$ November 2000

Present: G. Arduini, T. Bohl, H. Burkhardt, R. Cappi, Yu-Chiu Chao, K. Cornelis (chairman), A. Faus-Golfe, J. Gareyte, M. Giovannozzi, W. Hofle, L. Jensen, R. Jones, J. Klem, E. Metral, G. Rumolo, F. Schmidt, E. Shaposhnikova, R. Tomas, J. Tuckmantel, L. Vos, F. Zimmermann (secretary)

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1 Electron Cloud in the PS (E. Metral)

Electron-cloud effects have been seen recently with the nominal PS beam for LHC. In the PS, the LHC beam is produced with triple splitting at injection energy and two times double splitting at top energy. Prior to ejection from the PS, the bunches are compressed via bunch rotation within a quarter synchrotron period.

All emittances throughout the PS cycle are below the design values, except for the transverse emittances measured on SEMs (secondary emission monitors) in the TT2 transfer line for short bunches after bunch rotation. In the latter case, the SEMs do not show a well-defined beam profile, but the diluted signal indicates the presence of a large number of electrons deposited on the SEM filaments. A deposition of electrons on the monitor is confirmed by a signal polarity opposite to the normal. Under the same beam conditions, electrostatic pick ups in TT2 show a baseline drift during the batch passage, similar to that seen previously on the SPS damper pick ups. The magnitude of the baseline shift corresponds to about 10^9 electrons. It is seen on the horizontal, vertical and sum signals. A solenoid with about 100 G field wound on both sides of a pick up removes the baseline drift from the sum and horizontal signals, but it doubles the vertical shift. The latter can be cancelled as well by steering the beam far off center through the pick up.

Similar BPM signal distortions are seen in the PS ring on the last turns before ejection. Here the baseline shifts occur mainly in the vertical plane and not in the horizontal one, which is attributed to the fact that the pick ups are located in regions with vertical magnetic field. Comparing observations for 72 and 84 bunches (ring completely filled) does not show big differences. This suggests that the BPM signal distortions are not due to a coupled-bunch instability. Eperiments with missing booster bunches have shown that a gap in the bunch train removes the BPM baseline distortions.

Next studies will clarify the beam stability at the end of TT2 and aim for clean emittance measurements. New coupler pick ups in TT2 (help from SL/BI) may answer the first question.

2 LHC Beam Transverse Stability (G. Arduini)

Several electron-cloud studies were performed over the course of this year, *e.g.*, using the TSTLHC beam on MD cycle in May, MDRF beam with 48 bunches on MD cycle in August, during a long MD session in September, and on MD cycle in October, and the first LHC beam with 72 bunches on MD cycle in early November.

Transverse emittances were measured by wire scanners at different sections along the batch directly after injection and several tens or hundreds of milliseconds later. A recurrent feature is that, if no counteremasures are taken, horizontal and vertical emittances blow up significantly in the second half of the batch. Also the last bunches are lost a few ms after injection. Head-tail monitor data with a time resolution of 0.5 ns reveal that the beam is oscillating. In the horizontal plane, the oscillations are coupled over a few bunches, whereas in the vertical plane the oscillation appears to be random from bunch to bunch.

Attempts were made to suppress the instability by increasing the octupole strength. A large value of the horizontal octupoles prevented the vertical blow up, but it did not stop the emittance growth in the horizontal plane. In addition, the beam lifetime was poor for large octupole settings. More promising is the introduction of a large chromaticity in both planes. Chromaticities of $\xi_{H,V} \approx 0.5$ resulted in no beam losses with 48 bunches, and no measurable emittance growth. Two transverse dampers were active during these studies. With 72 bunches, even higher chromaticities (0.6 and 0.9) and a change in working point are required in order to maintain a small emittance. Even when a 300-ns gap was generated at the center of the batch, large emittance blow up was still observed for low chromaticity.

Open questions are up to which point the high chromaticity can help, which part of the horizontal blow up comes from the longitudinal motion (the wire is at a dispersive location), the efficiency of 50-ns bunch spacing, and electron cloud phenomena during the ramp.

Data from the pick ups operated by LHC/VAC and from the transverse damper (W. Höfle) confirm a beneficial effect of the 300-ns bunch gap within the batch, but they also show that the electron cloud is rapidly reestablished even after long gaps. Thus, there appears to be a long-time memory of the cloud.

3 AC Dipole (R. Jones)

A first test of an ac dipole was conducted at the SPS, reproducing earlier studies at BNL. The motivation is to excite a large oscillation without diluting the beam emittance. Possible applications include measurements of dynamic aperture, resonance driving terms, beta functions and betatron phases. At the SPS, an ac dipole was implemented by feeding a ramped sinewave input signal to the transverse damper. Typical rise and decay times chosen were 50 ms, with

100 ms flat top. The amplitude of the coherent motion is 21 micron / δ, with δ denoting the difference between excitation signal and betatron tune. When $\delta > 0.02$ no emittance blow up was observed. A test of the adiabaticity condition was made at $\delta = 0.014$, by measuring final emittances for various ramp rates. The observed emittance growth of 20–60% was not due to violation of adiabaticity, but it rather can be explained by closeness to the betatron tune. If δ is small, resonances are excited within the beam. The measured blow up also depends strongly on the chromaticity. Experiments should be repeated at higher beam energy and at $\delta > 0.02$, in order to be sure that the excitation frequency is well outside the beam tune spread.

4 Damper Bandwidth (W. Hofle)

Amplitude and phase transfer functions were measured in BA2. The observed phase errors translate into an effective bandwidth of 20 MHz in the vertical plane, and 10 MHz in the horizontal plane.

5 Next meeting

The next meeting is tentatively scheduled for Tuesday 12th December, 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

F. Zimmermann, 21th November 2000