Minutes of the SPS Studies Working Group (SSWG)

8^{th} meeting 17^{th} September 2002

Present: G. Arduini, T. Bohl, H. Burkhardt, R. Cappi, P. Collier, K. Cornelis (chairman), J. Gareyte, W. Höfle, N. Iida, L. Jensen, G. Rumolo, J. Tückmantel, F. Zimmermann (secretary)

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1 Intense PS Bunch at 14 GeV/c (R. Cappi, K. Cornelis)

In order to measure space-charge effects and single-bunch stability below transition, it had originally been considered to inject a bunch at 26 GeV/c and ramp down through transition. Since the decelerating through transition has not been successful in the past, in the last meeting it was proposed instead to inject the intense bunch at 14 GeV/c directly from the PS.

After consulting with R. Garoby, today R. Cappi confirmed that this scheme is indeed feasible, and that it only requires a minor change to the electronics. However, two days of set-up time are needed. September 23 and 24 are foreseen for this purpose. The bunch would be rotated prior to extraction, and an injected bunch length of 4–5 ns should be attainable. Stability of the beam in the PS might turn out to be a problem, if the small longitudinal emittance of 0.2 eVs shall be maintained. The procedure of generating the beam in the PS includes dumping 7 of 8 bunches at the moment of extraction. Therefore, this beam should not be used for long periods of time.

During the meeting, the space-charge tune shift was estimated to be of the order of 0.1–0.2. H. Burkhardt pointed out that the bunch length could be shortened in the SPS by increasing the rf voltage, thereby enlarging the tune shift.

R. Cappi remarked that in the PS, no blow up is seen for space-charge tune shifts less than 0.2; at 0.3 there is a 30% blow up, and for tune shifts larger than 0.4–0.5, beam losses occur. These effects are sensitive to the tune.

2 MD Program during the Scrubbing Week (G. Arduini)

The cycle for the scrubbing run will be set up on Wednesday. The cycle length is 21.6 s to avoid overheating. The energy is kept constant, at 26 GeV/c. After the set up of the cycle, a long access is scheduled for the installation of a new NEG chamber. COLDEX will be moved into the beamline during this time as well.

Bunch populations will stay between 1.1×10^{11} and 1.3×10^{11}. For most of the time, the SPS will run with 1 or 2 LHC batches; only on Thursday 8:00–16:00 and Friday 16:00–24:00, up to 4 batches will be injected.

On Friday, a ramp to 55 GeV is added to the cycle. The ramp will start after a 10.8-s period on the flat bottom. COLDEX will be moved out on Saturday. From Sunday through Wednesday various different studies are planned, concerning, *e.g.*, the damper, long-range beam-beam compensator, matching monitors in LSS4 & LSS5, longitudinal impedance under matched conditions at 26 GeV, LHC pilot bunch, transverse impedance, with 2 bunches, transverse & longitudinal impedance with long bunches, 14 GeV with single high-intensity bunch, space-charge studies at 14 GeV/c, transition crossing with the intense bunch, longitudinal impedance measurements under matched conditions at 14 GeV/c, and BI tests.

It was concluded that no plateau at 20 GeV/c is needed during the acceleration of an intense bunch through transition. G. Arduini posed the question whether we want to use Pb^{53+} ions at 26 GeV/c proton equivalent energy for a beam energy calibration (see earlier presentation by J. Wenninger), in about 1 month time. The PS will look into this option. The lifetime due to electron stripping could be estimated beforehand.

P. Collier asked if it might be of interest to operate with 3 LHC batches and 1 pilot bunch, to pursue two studies in parallel. This was not felt to be the case, as the two beams could not be manipulated independently.

3 Transverse Impedance Measured with Long Bunches (H. Burkhardt)

H. Burkhardt reported on an MD with long bunches (rf off) performed by the RF group (T. Bohl, T. Linnecar, E. Shaposhnikova) and members of SL/AP (H. Burkhardt, A. Koschik, G. Rumolo, F. Zimmermann) on July 25 and 26. Longer bunches promise an improved frequency resolution of the impedance. The idea of the MD was to detect resonance frequencies of the transverse impedance in the spectrum of the debunching beam.

Observations with the tune meter gave tunes and an indication of growth rates as a function of orbit and chromaticity. K. Cornelis suspected that the timing of the tune meter and its stroboscopic nature were not appropriate for a long bunch without rf, and he recommended to look at the signal from the pick up on a scope. A significant tune shift with chromaticity was detected, which indicates that the horizontal orbit was not centered in the sextupoles, presumably due to an energy error. Beam losses were inferred from the BCT signal. They were maximum for medium negative chromaticities around $\xi_y \approx -0.3$.

The wideband pick up of teh rf group was used to acquire both the longitudunal and transverse frequency contents of the beam. A peak in the transverse spectrum, which varied linearly with the chromaticity setting, corresponds to the chromatic frequency $f_\xi = Q f_{\rm rev} \xi / \eta \approx (2\ {\rm GHz}\ \xi)$.

K. Cornelis suggested to plot either the amplitude or the growth rate of this peak as a function of chromaticity in order to uncover the impedance frequencies. Simulations by G. Rumolo, including both the transverse broadband and longitudinal (200 MHz rf) impedance, show that the beam is self-bunched after a few hundred turns.

F. Zimmerman mentioned that for an orbit offset the longitudinal spectrum should also contain the frequencies of the transverse impedance (Panofsky-Wenzel theorem). Orbit bumps were created in the rf section and in the kicker region. No effect was observed at the cavities, but it seemed as if bumps at the kickers gave rise to additional peaks in the spectrum.

J. Gareyte explained the role of the chromaticity for a coasting beam. The latter is Landau damped both by the transverse tune spread due to nonlinear detuning (e.g., octupoles) and by the chromaticity. The strong Landau damping arising from the chromaticity vanishes exactly at the chromatic frequency. Thus at this frequency the beam is most unstable. J. Gareyte recalled that a long time ago a similar measurement was performed, when an impedance peak at about 700 MHz was observed. The fact that the beam self-bunches during the measurement may complicate the analysis. A reasonable measure of the impedance strength at a certain (chromatic) frequency could be the initial growth rate.

K. Cornelis mentioned that in the times of the collider. the 460-MHz dipole signal from the cavities had been used for measuring the tune of the antiprotons. T. Bohl and R. Cappi hypothesized that the effect of the cavity self-bunching should be weaker below transition.

4 Nonlinear Optics at 26 GeV/c (F. Zimmermann)

Nonlinear chromaticity and detuning with amplitude was measured on two occasions, 20.06.02 and 23.08.02, with an LHC beam of 72 bunches. In the second MD, also multi-turn BPM data were acquired for different radial steerings. The linear chromaticity and detuning with amplitude were corrected prior to the measurement.

Both measurements show a strongly nonlinear and asymmetric component in the tune shift with rf frequency starting at a positive momentum deviation of 0.003–0.005. The vertical tunes were different in the two MDs. In the second case, the transverse tunes crossed in the nonlinear region.

A SUSSIX analysis was started by R. Tomas, who computes the coupling and resonances around the machine for different radial steerings, and will report in a later meeting. The chromaticity data are fitted to the MAD model by A. Faus-Golfe. A computation using SAD by N. Iida is in progress.

5 Next Meeting

The next meeting of the SPS SWG is tentatively scheduled for Tuesday, 1st October, at 09:15, in Room 865-1D17. The agenda will be posted on the web page of the working group http://cern.ch/sl-mgt-sps-swg, and an invitation will be sent by email.

F. Zimmermann, 17th September 2002