Minutes of the SPS Studies Working Group (SSWG)

5^{th} meeting 9^{th} July 2002

Present: G. Arduini, T. Bohl, P. Collier, K. Cornelis (chairman), J. Gareyte, N. Iida, L. Jensen, D. Manglunki, J. Tückmantel, J. Wenninger, F. Zimmermann (secretary)
Excused: W. Höfle

---

1 First results with a "pilot" bunch (G. Arduini)

During the last long MD on 26/06, a problem with the 20-MHz rf cavity in the PS prevented the operation with the LHC beam. This provided an opportunity to study the behavior of a single low-intensity LHC 'pilot' bunch in the SPS.

The beam was of the type 'MESPS Short' and its parameters were: bunch length $\tau_{\rm bunch} \approx 4.5$ ns, longitudinal emittance $\epsilon_L \approx 0.23$ eVs, maximum intensity $N_b \approx 7 \times 10^{10}$, rms momentum spread $(\Delta p/p)_{\rm rms} \approx 0.61 \times 10^{-3}$.

In order to switch from the LHC beam to the pilot the following changes were necessary:

- injection-bucket selector; the beam arrives at a different time, 745 ns earlier, than the LHC beam;
- attentuation level of the phase pick up was adjusted to cope with the lower intensity; for the LHC beam the phase is sampled over 10 bunches;
- the BPM acquisition was changed; G. Arduini asked whether it is possible to use the single-bunch BPM mode for the LHC beam; L. Jensen will look into this question;
- the dampers were turned off.

The voltage function and working point in the tune diagram (0.19, 0.23) were the same as for the LHC beam. The normalized transverse emittance of the injected beam was about 1.05 ± 0.1 μm. Hence, the transverse emittance of a single bunch at $N_b = 7 \times 10^{10}$ is a factor 2.5 smaller than for the LHC beam.

The beam was scraped horizontally in the SPS to further reduce the intensity. A bunch population of $(5.20 \pm 0.35) \times 10^9$ was obtained. The maximum observed intensity deviation was 13%. The

transverse normalized emittances were also reduced by the scraping, from initially $1.04, 1.03$ μm to final values of $0.24, 0.93$ μm, with 10% reproducibility.

The transverse profiles measured with the rotational wire scanners appeared to be almost Gaussian, which is surprising. The profile should be verified using the more accurate linear wire scanners. The chromaticities during the experiment were about $\xi_{x,y} \approx 0.1 \pm 0.03$. K. Cornelis suggested to look at the signal from scintillators installed next to the collimators, in order to verify whether the beam tails are immediately repopulated after the scraping.

G. Arduini mentioned that thanks to its smaller emittance this beam could also be used to more precisely measure the blow up in the transfer line. He then summarized the *instrumentation status* as follows:

- the SPS scrapers were working;
- the linear wire scanners were not working during the MD (now 5 out of 6 should be operational);
- there is a problem with the dynamic range of the rotational wire scanners; at injection less than 10% of the full scale is used; a dynamic change during the cycle would be desirable;
- the IPM only worked at 450 GeV/c;
- no signal from the luminiscence monitor;
- there is no continuous emittance measurement during the cycle (confirmed by experts: a minimum intensity of 2×10^{11} protons is required to monitor the emittance).

Future plans for the pilot-bunch studies include the optimization of the settings for higher intensities, the behavior of the RF loops after scraping, working with dampers on, applying vertical scraping, verifying the beam profile with the linear wire scanners, *measuring the emittance as a function of intensity*, and monitoring the long-term stability of emittance and intensity. K. Cornelis suggested that the beam intensity could also be varied by applying an rf voltage dip.

P. Collier asked whether there is a plan for improving the scraper control, so that one could more easily switch between the two modes of scraper operation, namely (1) tail removal, and (2) intensity reduction. L. Jensen responded that this was not the case, since the scraper had been rarely used in the past. He will contact J.-J. Gras, when the latter is back from vacation. G. Arduini mentioned that the switching between timing events should be improved. K. Cornelis reported that a young operator (Anthony) is now working on the scrapers. The beam-loss monitors near the collimator can be acquired using the 'colmon' software.

It was reported that the present location of the collimators is poorly chosen, as scraping sprays all the instruments in that region. The OTR-screen matching camera has already suffered. Therefore, the collimators should soon be moved to a different 'hotter' location.

K. Cornelis asked whether the re-synchronization for the LHC uses a beam signal, or whether it is possible to inject into the wrong LHC bucket. No immediate answer was available.

2 Energy calibration at LHC extraction energy (J. Wenninger)

Similar to the old LEP method, comparing the central energy of two particle species with different charge-to-mass ratios allows for an absolute calibration of the beam energy. J. Wenninger studied which accuracy can be obatined in the SPS by comparing the central revolution frequencies for lead ions and protons. The ratio of revolution frequencies equals the ratio of velocities. Combining this with the kinematic relation of velocity and momentum, he derived the following expression for the accuracy of the measurement:

$$\frac{\Delta p}{p} \approx \left(\frac{Zp}{m^i c}\right)^2 \Delta\kappa \tag{1}$$

where $\Delta\kappa$ is the relative change in central frequency, Z the ion charge, m^i the ion mass, and p the momentum. If the central frequency can be measured with an accuracy of 1 Hz, the error in momentum is 4×10^{-4}. For 10 Hz, it would be 10 times larger. K. Cornelis pointed out that a resolution at the 10^{-3} level is interesting, as in the past experiments have claimed the SPS energy to be wrong by as much as 1%.

Since this year's lead ion run offers the last opportunity for a long time to make such a measurement, P. Collier proposed to install an NMR system which could thereby be calibrated, and which will serve as a reference for the future.

A discussion ensued on the use of Pb^{53+} instead of Pb^{82+}. The lower-charge ions will improve the resolution of the energy calibration. If the beam is not stripped in the transfer line, the velocity and thus rf frequency remain the same, but the strength of the SPS magnets needs to be adjusted.

The LHC ion beam should be injected at the proton-equivalent energy of 26 GeV. In this case, transition crossing in the PS may be necessary. The possibility of a first test in the PS this year was discussed and will be further examined. Transition crossing for the LHC ion beams will probably be unavoidable in the SPS. In principle, the procedure should be similar to that for the fixed-target beam, except for a few points, *e.g.*, the speed of the ramp may be different.

3 Modified SPS Schedule (K. Cornelis)

K. Cornelis reported recent changes to the 2002 SPS schedule. Since NA60 is not ready to take data, the ion run was shortened and only the low-energy part of the run was retained, for NA49. As a compensation for missing MD time on the parasitic cycle, about 8–9 days of dedicated MD time are now scheduled immediately prior to the ion run, during the weeks 38 and 39 (mid-September). The MDs will continue 24 hours per day. This period might resemble the scrubbing run earlier this year.

4 Next Meeting

The next meeting of the SPS SWG is tentatively scheduled for Tuesday, 23rd July, 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, 9th July 2002