Minutes of the SPS Studies Working Group (SSWG)

4$^{\text{th}}$ meeting 25$^{\text{th}}$ June 2002

Present: G. Arduini, R. Bailey, T. Bohl, H. Burkhardt, K. Cornelis (chairman), B. Dehning, M. Giovannozzi, N. Iida, D. Manglunki, E. Metral, F. Roncarolo, F. Schmidt, E. Shaposhnikova, J. Tückmantel, L. Vos, F. Zimmermann (secretary)

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1 Beta-Functions at Splitters in TT20 (G. Arduini)

There are two splitting stations. Each consists of a collimator and three splitter magnets. The beam is cut into two halves. The lower half is deflected horizontally by the splitter.

Beam losses in the splitter region are a concern. They arise either from particles hitting the collimator and septum or from aperture limitations. The first effect can be reduced by increasing the (vertical) beta function at the splitter, the second by reducing this beta function. Thus there should be an optimum beta function for which the losses are minimized. At present the computed aperture is as low as 4σ for asymmetric splitting. For operation with lower-energy ions, the aperture will be even tighter, and, therefore, a back-up optics with smaller β_V is desirable for the ion run.

The nominal beta functions at the splitter are $\beta_H = 14$ m and $\beta_V = 23$ km. For machine study purposes, G. Arduini created 4 different test optics with a reduced vertical beta function of either $\beta_V = 20$ km or $\beta_V = 15$ km, and a horizontal beta function of either $\beta_H = 9$ (for optimum aperture) or 14 m (present value). The 9 m for the horizontal beta function should give the minimum size at the entrance and exit of the splitter. All four optics maintain constant conditions at the target.

The result of the study was that decreasing β_V enhanced the beam loss. There was an indication of a tiny improvement when the horizontal beta function was optimized so as to center the horizontal waist. A subsequent attempt of increasing β_V instead of reducing it failed, because of an unexpected growth in the horizontal beam size, possibly related to poor convergence in the optics matching.

In cocnlusion, there is no evident aperture limitation in the case of 50%/50% beam splitting. An optics with larger aperture is available that could be used for the low-energy ion run, if the latter takes place. In the future, G. Arduini plans to explore again the optics with larger β_V, and also to reduce β at the ‘bottleneck’ in the TT20 beam line. Only small re-steering was required after changing the optics, which could indicate that the magnets are fairly well aligned, or that the changes in the quadrupole strengths were small (about 10% for the upstream magnets).

2 Transverse Impedance Measurements (H. Burkhardt)

Impedance data were taken on three days in the week after EPAC, by H. Burkhardt, G. Rumolo, F. Zimmermann, with help from P. Baudrenghien, T. Bohl, J. Wenninger, N. Iida, and others.

The differences to the measurements in 2001 are: The tunes in 2002 are 26.19 and 26.23. In the long MD, the beam was accelerated to 80 GeV, which avoided possible contributions from space charge. This year, higher-order head-tail modes were systematically observed, and coherent tune shifts were recorded for different settings of the chromaticity. At 26 GeV for the first time the beam intensity was varied by using the vertical scrapers in the SPS. Previously this scraping had been done with closed orbit bumps.

In detail the following measurements were conducted on the various days: On Monday 10/6 the rf voltage was 2 MV (previous years: 3 MV), and coherent tune shifts were measured at 26 GeV for $\xi = 0.0$, 0.1, and 0.2. On Tuesday 11/6, head-tail growth and decay rates were measured at 26 GeV for rf voltages of 2, 0.2 and 0.4 MV. The lower voltage results in longer bunches, which enhances the sensitivity to the resonant impedance frequency. On Thursday 13/6 both coherent tune shifts and growth/decay rates were measured at 80 GeV. Note that this increases the distance from the transition energy, and, thus, affects the conversion of chromaticity into chromatic frequency shift.

The results are that the coherent tune shifts appear to be slightly (10–20%) smaller than in 2001. L. Vos commented that this is consistent with his prediction published in a recent beam physics note. Scaling the tune shift measured at 80 GeV to 26 GeV indicates a somewhat smaller value still ($>$25% reduction). However, all these results are preliminary and require further analysis and interpretation.

For all measurements, bunch lengths were recorded as a function of intensity. The bunch length typically increases from about 0.5 ns at 10^{10} protons per bunch to about 0.65 ns at 10^{11} at 2 MV rf voltage. For the lowest rf voltage, the rms bunch length was about 0.8 ns.

Growth and decay rates were analysed for the $m = 0$ head-tail mode. The fitted growth rates for negative chromaticity saturate around 1 GHz, which indicates the presence of impedance resonances in this frequency range. The coherent tune shifts at 26 GeV did not much depend on the chromaticity over the range $\xi \approx 0$ to $\xi \approx 0.2$, which corresponds to a chromatic frequency shift of up to about 500 MHz. This is consistent with expectations for impedance frequencies at or above 1 GHz. The horizontal tune shift is close to zero in all cases, in agreement with previous results. The growth rates in the vertical and horizontal plane differ by a factor of about two, again confirming earlier findings. The data taken for longer bunch lengths will provide a lower limit on the impedance frequency.

3 Coupling and Resonant-Driving Terms (F. Schmidt)

F. Schmidt reported on the result of the resonant-driving term experiment performed by M. Hayes, R. Tomas, and F. Schmidt. He thanked R. Jones for invaluable help in adjusting the BPM timing for this experiment, which significantly improved the data quality.

The coupling is inferred from the relative magnitude of the two tune lines. It is measured all around the machine. Local correction proved efficient in reducing the coupling at all BPMs, but at 26 GeV a non-flat structure remained, with two pronounced peaks near BPMs no. 20 and 50. This may indicate the presence of real coupling sources at these two locations. At 80 GeV after correction the coupling ratio is completely flat all around the SPS ring. The optimum skew quadrupole current at 26 GeV was about 0.1 A, at 80 GeV about 2 A.

Driving terms for the third-order resonance were measured at 80 GeV in the nominal configuration and when exciting the extraction sextupoles. The preliminary results look promising.

It is planned to next study the dependence of this measurement on the beam intensity.

4 Nonlinear Chromaticity (F. Zimmermann)

Nonlinear chromaticity was measured on Friday, 21/6, by G. Arduini, B. Desforges, N. Iida, and F. Zimmermann. For positive momentum deviations larger than 3×10^{-3} a rapid change in both tunes was observed, sugggesting a strong nonlinear field. Despite of tune changes of the order of 0.02 there was no beam loss. On the other hand, for negative momentum deviation the beam loss became severe near $\Delta p/p \sim -3 \times 10^{-3}$, but in this case the tunes remained almost constant.

On Monday 24/6 the Q-meter pick ups were calibrated and the detuning with amplitude was measured. The present setting of the octupoles appears to give zero detuning.

This new set of data is being analysed by A. Faus Golfe, who will update the optics model and check consistency with previous years.

5 Electron Cloud instability for Fixed-Target Beam (K. Cornelis)

An electron-cloud instability is observed at 26 GeV on the FT beam when the LHC beam is injected on the MD cycle. A possible explanation is that a significant number of electrons survive between the different cycles.

The vertical instability of the FT beam has a different character than that of the LHC beam. K. Cornelis showed snap shots of a few hundred bunches, taken by the wide band pick up. The FFT of the difference signal reveals a frequency of 30–50 MHz, corresponding to an oscillation wavelength of a few bunches. Thus, in the case of the fixed-target beam the vertical instability is a coupled-bunch instability, whereas the LHC beam exhibits the characteristics a single-bunch vertical instability.

For the fixed-target beam, the instability which occurs somewhere along the bunch train typically decays again already after a few wavelengths, well before the end of the bunch train. The dependence on the bunch intensity is also different from that seen for the LHC beam. For the FT beam, the instability does not show a trivial correlation.

6 Next Meeting

The next meeting of the SPS SWG is tentatively scheduled for Tuesday, 9th 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, 25th June 2002