Minutes of the SPS Studies Working Group
(SSWG)

4^{th} meeting 17^{th} July 2001

Present: G. Arduini, V. Baglin, T. Bohl, P. Collier, K. Cornelis (chairman), O. Gröbner, M. Hayes, W. Höfle, M. Jimenez, J. Klem, T. Linnecar, D. Manglunki, E. Metral, F. Schmidt, E. Shaposhnikova, R. Tomas, J. Tückmantel, J. Uythoven, L. Vos, K. Weiss, J. Wenninger, F. Zimmermann (secretary)
Excused: G. Roy

---

1 MD Next Week (G. Arduini et al.)

Presently, strong vacuum activity is observed already at $2 - 2.5 \times 10^{10}$ per bunch with a 48-bunch LHC batch. The high vacuum pressure of about 10^{-7} mbar is attributed to the opening of the machine during the shut down, the shielding of the pumping ports, and the higher duty cycle of almost 30%.

Therefore, during the MD next week, it may not be possible to operate at much higher bunch intensity. G. Arduini proposed instead, after setting up the cycle, to inject several LHC batches with a nominal inter-batch spacing and with a bunch population of 2×10^{10}, and to attempt accelerating this beam. The transverse emittance evolution can be measured using the wire scanner and, possibly, the luminescence monitor. About 6–8 hours will be required for the rf set up. T. Linnecar mentioned that the rf group would like to study the controlled longitudinal emittance blow up, which can be tested at the lower bunch intensity. O. Gröbner recommended to measure the present threshold of multipacting, so as to obtain a first reference point. It was also noted that according to magnetic-field measurements in the CPS at the moment the SPS injection momentum appears to be 26.3 GeV/c rather than 26.0 GeV/c (D. Manglunki).

2 Status of SPS Electron-Cloud Monitors (M. Jimenez, V. Baglin, G. Arduini)

A large number of different electron-cloud monitors have been installed prior to the 2001 SPS run. M. Jimenez gave a brief overview and reported the present status of these monitors.

Four pick ups measuring the electron cloud build up are installed in vacuum chambers that have undergone different types of treatment (argon glow discharge, bakeout, etc.). These monitors already deliver a signal. Two further pick ups of the 'Rosenberg type' allow measuring the energy distribution of the electrons. These are installed, but not yet connected to a power supply. There is a further pick up to be used as a trigger for the LHC batch. This monitor is operational.

In addition there are three monitors designed to measure the position of the multipacting stripes in a dipole magnetic field. One is a 'strip' detector. The signal from this monitor shows a single stripe when the magnetic field is turned on. The width of the stripe is not larger than about 5 mm. It moves with the beam. The signal intensity is higher than anticipated. Observations so far are consistend with expectation, since a single stripe was predicted by simulations for the present bunch intensity. In addition, two 'triangular' stripe detectors are installed but not yet tested. These monitors compare the signal from a triangular pick up with that from a rectangular one, which should also yield the position of the stripes. One of the triangular monitors is equipped with a filtering grid, in order to determine the spatially resolved electron energy distribution.

As a further monitor an apparatus for in situ measurements of the secondary emission yield has been installed. First measurements at the beginning of the run indicate a value of $\delta_{\rm max} \approx 1.8$ at the monitor. Additional ion detectors will allow distinguishing the electron cloud from ion induced desorption.

V. Baglin discussed a 1.3-m long copper calorimeter, whose purpose is to directly measure the heat load deposited by the electron cloud, and to observe the expected 'cleaning effects'. The signal of this calorimeter can in particular be used to benchmark the simulations. Associated supplementary monitors detect contributions from gas desorption and the 'cleaning' related to the ion desorption process. A heater attached to the calorimeter is used for calibration. It was found that a heat deposition of 5 Watt induces a temperature rise of 0.25 K per minute. Hence, in order to observe a 1 K change in temperature for a 1-W power deposition, the LHC beam must be stored for at least 2.5 hours.

The contributions to the heating from resistive wall was computed prior to installation. It was shown to be smaller than the expected heating from the cloud. More, specifically, considering a copper pipe with 2 cm radius, the computed resistive heating is about 10^{-10} J/m per turn and bunch, which amounts to 4 mW/m for nominal LHC bunch charge and 25 ns spacing (F. Zimmermann). However, the power loss by geometric wake fields could be substantial, for imperfect shielding.

G. Arduini presented the first data taken with the strip detector, which look extremely promising. The strip is recorded over the full cycle of 4 s with a spacing of 20 ms between samples. It is correlated with the position of the beam as expected.

3 Reports from PAC 2001 (F. Zimmermann, G. Arduini)

Some results of interest to the SPS transverse impedance meaurements were reported by the ESRF group. Nagaoka and Revol measured current-dependent tune shifts and instability thresholds. The tune shifts in the horizontal plane are of opposite sign from those in the vertical. The tune shift measured for a single bunch and that measured between the head and tail of a bunch train agree well with Yokoya's theory of resistive wall in a flat chamber. However the ratio of horizontal to vertical 'multi-turn' tune shifts is quite different in the case of a long bunch train. A tentative explanation of this difference is that the diffusion time of the fields through the chamber are more than an order of magnitude different for the two planes. This issue is not completely understood.

Multi- and single-bunch instability thresholds were also measured, as a function of current, chromaticity and fill pattern. The horizontal single-bunch instability is of the conventional head-tail type, the vertical belongs to the post head-tail regime, where modes are no longer separated. Operating at high chromaticity increases the instability threshold by a factor of 10. In order to explain the dependence of the mode frequencies on current both broadband impedance and the resistive wall wake (excited by other bunches) must be taken into account.

Other presentations interesting to the SPS are of course those on electron cloud effects. Apparently electron cloud phenomena of the Los Alamos type have first been observed at Novosibirsk in 1965. They were explained by Budker. A feedback was built to suppress the instability. Another, surprising, cure appears to have been increasing the number of electrons.

PEP-II electron cloud instability simulations have started. They follow the approach adopted by CERN and KEK. The PEP-II simulation results are still preliminary.

At PAC2001, G. Rumolo presented results of his upgraded instability simulation program, which now contains a PIC (particle-in-cell) code, and optionally includes both broadband impedance and space charge in addition to the electron cloud. While the space charge stabilizes the effect of the broadband impedance alone, it appears to further destabilize the beam, when the electron cloud is also present. Computed growth rates and chromaticity dependence for the SPS resemble the observations much more closely than in the past.

There were various interesting talks on plasma wake field acceleration experiments at PAC2001. Some of the effects occuring when a beam passes through a plasma may be quite similar to the interaction of a beam with an electron cloud. For this reason, since last fall we have already initiated a collaboration with T. Katsouleas' group at USC. Their first 6D PIC simulation result indicates the possibility not only of transverse wake fields, but also of significant longitudinal fields, due to the electrons.

4 Measurements of Resonance Driving Terms at the SPS (F. Schmidt)

F. Schmidt showed intriguing results on the measurement of resonance driving terms by analyzing lines in the Fourier spectrum of multi-turn BPM signals. The effects of the finite beam distribution and filamentation were studied by R. Tomas, who derived a reduction factor, which depends on the resonance order. From the shape of the Fourier spectrum near a resonance, additional informations can then be extracted, such that a single measurement yields the bare tune, the amplitude of the kick, the detuning with amplitude, and the resonance driving terms.

For the SPS MD at 120 GeV, taking into account the correction factor for filamentation, a good agreement for both detuning and the strengths of the (3,0) and (1,2) resonances is obtained between the measurements and the model prediction. Also the large variation of the resonance terms, computed at each pair of BPMs, around the ring is now consistent with the model prediction. It was thereby demonstrated that this type of analysis can localize nonlinear field errors. Previous discrepancies were traced back to an inversion in the sign of the extraction sextupoles as compared to the normal sextupoles. It was suggested to apply this technique to infer the sextupole component in the SPS bending magnets at 26 GeV.

The method presented also allows for a measurement and minimization of linear coupling.

5 Next Meeting

The next meeting of the SPS SWG is tentatively scheduled for Tuesday 31st July, at 09:15, Room 865-1D17.

An announcement will be sent by email in due time and the agenda will be posted on the web page of the working group http://cern.ch/sl-mgt-sps-swg

F. Zimmermann, 17th July 2001