MSWG Meeting 23-April-2013

Present:

M Schaumann, R Versteegen, H Bartosik, K Cornelis, S Gilardoni, H Damerau, A Guerrero, L Soby, W Bartmann, J Jowett, Y Papaphilippou, E Gschwendtner, S Hancock, D Manglunki, T Bohl, E Chapochnikova, W Höfle, F Antoniou

Agenda:

- Approval of minutes
- Main presentations:
  - Ion-LHC Beam in the SPS 2012-2013, Present status of the analysis of observations concerning the longitudinal plane – Thomas Bohl
  - Ions transverse measurements in the SPS – Karel Cornelis
  - Ions emittance measurements in the LHC - Michaela Schaumann
- AOB

The minutes of the last meeting were approved.

Ion-LHC Beam in the SPS 2012-2013, Present status of the analysis of observations concerning the longitudinal plane – Thomas Bohl

Thomas presented the problem of dispersion of bunch parameters for ions at flat bottom in the LHC. This dispersion is mainly introduced during the time the LHC ion beam stays at the flat bottom of the SPS. A difference of the dispersion of the bunch parameters had been observed in 2011 comparing results using FFA (FM, AM) and using a generator, a fixed external source without loop control (no FM, no AM) . In 2012, with an improved set-up using a modified analogue LO with phase and synchro loops one could see a clear improvement of the stability of peak amplitude and bunch length with respect to the FFA case. Comparing the phase noise using FFA or FHA, with low intensity beams, a standard deviation of the bunch position at flat bottom of 16.5 ps for FFA, and of 9 ps for FHA was observed in September 2012. In case of FFA the peak amplitude lifetime was between 100 s and 200 s depending on the bunch intensity. In the case of FHA the peak amplitude lifetime was larger than 1000 s, too good to be determined precisely because the length of the flat bottom was too short with respect to the lifetime. In December 2012, after the introduction of new hardware in the RF low level and using a beam of 2.2e10 ppb, a standard deviation of the bunch position of initially 23 ps was measured. This value was then reduced to 9 ps by the elimination of noise sources. E Chapochnikova asked about the phase noise measurement – the bunch position is measured, centre of mass wrt the rf. J Jowett asked about the reasons of the bunch length reduction - it is probably a combined effect of rf noise, IBS, tune, chromaticity and longitudinal and transverse emittance.

After the low level improvement, the peak amplitude of the bunches of the first batch showed a lower peak amplitude while the peak amplitude of the bunches of the following injections stayed at a higher level, D Manglunki was wondering about the bunches of the first injection having a lower peak amplitude – injection oscillations are immediately damped by the phase loop which works only on the first batch. This results in a smaller longitudinal emittance for the bunches of the first batch and could lead to increased IBS losses?

Thomas investigated the reasons for the degradation of the performance along the flat bottom 2013 vs. 2012. Looking at the BCT data over the cycle for different intensities injected, a trend not comparable to protons can be seen. The peak amplitude lifetime is improving for lower intensities which is supposed to be not due to rf noise; S Gilardoni was asking whether a bigger longitudinal emittance from the PS could help – first it is aimed at understanding the effects on SPS flat bottom; an emittance blow-up could also be done in the SPS. W Höfle was asking about the measurement of the peak amplitude – signal as seen on the scope from the WCM.

Measuring the transmission on flat bottom with rf off for the iLHC cycle Q20 and Q26 shows only for the Q20 optics case an intensity loss of 1/3. K Cornelis was asking whether the tune was adapted during the unbunched measurement since there should be an optimum working point where an unbunched beam stays stable. The single particle loss effect seems to be due to a resonance and therefore it is difficult to compare the Q20 and Q26 optics. H Bartosik suggested a scan of the working point for this measurement. The lifetime increase for lower intensities is probably due to SC and resonances.

Measuring the peak amplitude lifetime for Q20 and Q26, it is improving in both cases for lower injected intensities and it is slightly better for Q20.

Comparing Q20/Q26 there are higher capture losses for Q26 and higher losses during transition and high energy in the case of Q20. DM commented that it seems less intensity is injected for Q26 although while the same is delivered from the injectors; what counts is the intensity injected into LHC.

Concerning the high energy losses, in case of Q20 the bucket area is too small, one would need a huge voltage increase if it should be increased to the same bucket area as for Q26 which is not available.

Thomas showed the improvement of bunch length uniformity for 24 bunches on flat top for Q20 in 2013. EC asks whether a smaller bunch length might not be worse - if the dispersion of the bunch length over the batch is smaller, a more uniform blow-up can be performed.

S Hancock asked if the error bars included systematic errors – not it is pure statistics; due to the dependency on the bunch shape it is difficult to include them.

SG asked in which conditions the restart is planned – same conditions as in the end. KC comments that the situation in the end of the 2013 run was the best we ever had, the rf noise was significantly reduced but one has to be aware that by increasing the intensity effects of SC and IBS will become more critical.

DM comments that the ratio bunch intensity ratio within a batch was reduced from about 2 to 1.5 between the run in 2011 and 2013 which is believed to be due to a combination of rf noise improvement, Q20 and the delivered intensity.

Ions transverse measurements in the SPS – Karel Cornelis

Karel was discussing the fact that protons and lead ions with the same beam parameters apart from the energy behave so differently.

Measurements of the transverse emittance on flat bottom with 3.5e10 don't show an emittance growth when the beam is unbunched, but a significant increase with rf on. The same measurement with protons does not show this transverse emittance increase.

The suspects are SC and IBS. Karel pointed out the dependency of the space charge tune shift on γ^{-3} and classical radius. γ for lead is much smaller at injection than for protons and the radius is bigger, however this effect is partly compensated by the reduced number of ions. The resulting tune shifts are 0.13 and 0.2 for the above mentioned measurement. There is no flexibility to move the vertical tune. H Bartosik was asking when the emittance measurement was taken – about 100 ms after injection. HB commented that the beam could be already blown up.

For IBS there is again a dependence on the momentum but here the radius goes in quadratically. L Soby asked about the link between rf and the emittance increase – the particle distribution in a bunched beam is much denser which makes SC and IBS important.

EC reminded that about 10 years ago it was considered to inject ion bunchlets with reduced intensity into the LHC to avoid to strong emittance growth from SC tune shift. The bunchlets would have been merged again in LHC; DM commented that the 100 MHz cavities necessary for this manipulation were considered to be too expensive and H. Burkhard had shown in measurements that a tune shift of 0.13

Below transition, relevant for SPS flat bottom, IBS makes the longitudinal motion behave like a damped oscillator with noise resulting in a Gaussian bunch shape. The speed of reaching the equilibrium shape depends on the density.

Random momentum kicks give horizontal emittance blow up due to kicks in regions of dispersion. Measurements show a much larger increase of emittance in the horizontal than in the vertical plane. The emittances shown in the plots are normalised as for protons.

Looking at the horizontal profiles a nice Gaussian shape appears which is not often the case for pure resonances.

YP commented that we have to understand the interplay between SC and IBS, presently the two phenomena are calculated separately.

KC commented that the 10 s lifetime behaviour is also coming back in longitudinal measurements.

F Antoniou commented that theoretical calculations show much lower IBS effects than measured in the longitudinal plane and possibly the Touschek effect has to be taken into account.

Ions emittance measurements in the LHC - Michaela Schaumann

Michaela introduced the emittance measurement devices in the LHC and their limited availability during the 2013 run.
The average intensity performance improved by 30% from 2011 to 2013. The injected lead emittances were about the same value in 2011 and 2013, but with a great improvement in intensity.

The differences in the bunch emittances along a train arise from IBS (and SC) at the flat bottom of the SPS (slide 7). The differences between the two runs (slide 6) are due to blow up during the ramp since the data was taken at injection (2013) and in collisions (2011).

Simulations include IBS, luminosity burn-off and radiation damping and quantum excitation. There is good agreement with the measured intensity and horizontal emittance, the vertical emittance shows an unexpected growth in the measurements. The losses seen apart from luminosity burn-off are mainly due to IBS.

HB asked whether coupling is included in the simulation - only complete coupling can be included, no fractions.

KC commented on the fact that we don't see the expected horizontal emittance growth in physics during the p-Pb run that for lead on protons, the proton beam will scrape off ions if outside the proton beam diameter (http://sl-div.web.cern.ch/sl-div/publications/LHC99BB/PAPERS/kornelis.pdf). The resulting beam size should stay the same, but the intensity is reduced. R Versteegen comments that this should be seen in additional losses.

KC asked about the effect of the unequal distribution of emittances in the LHC. JJ answers that there are differences when looking at the luminosity per bunch crossing, but there are always matching bunches colliding with high luminosity for ALICE (the difference in luminosity between bunch crossings were up to a factor 6 in the 2011 run).

Concerning the future of proton-lead collisions - the Alice upgrade is approved.

SH asked if there were conclusions on which batch spacing to be used, 225 vs. 200 ns – HB and YP answer that this cannot be answered yet.

KC added that in view of normal operation, it would be useful to have a damper in the SPS working for low intensities.

AOB:

-

Next meeting: 7-May 2013