Effect of beam loss on long-term beam survival in SIS100

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We present here results of beam loss during the injection of U^{+28} for an improved modeling of the nonlinear lattice of SIS100 as previous simulations reported in Ref. [1] where lacking of the effect of gradient errors. In Fig. 1a is shown for a possible model of the SIS100 the resonance web, which is formed by integer, half integer, third and fourth order normal and skew resonances. These resonances are found via tune scans of the short-term dynamic aperture (1000 turns). Beam survival (first bunch) for several intensities during one second storage are shown in Fig. 1b. The maximum intensity injected is of 0.625×10^{11} ions/bunch, which creates a large tune-shift represented schematically in the picture. The space charge tune-spread overlaps with 4 resonances hence several macro-particles will cross one or more lattice resonances, therefore periodic resonance crossing will affect the particle dynamics. The resulting first bunch survival is distinctively intensity dependent as shown by the black curve (0.125×10^{11} ion/bunch) in which beam survival is much better with almost no beam loss (Fig. 1b). Note that for the maximum intensity bunches, beam loss is more than 90% conflicting with the requirement of "low beam loss" needed for applying frozen model algorithms. Regardless the issue of self-consistency, the reduction of beam loss will certainly make the prediction with frozen algorithms more reliable. In Fig. 1c is shown again the working diagram with now the effect of an "ad hoc" activated compensation system, using also skew sextupoles located in the actual position of those foreseen in SIS100. The corresponding beam survival is comforting (Fig. 1d) as the beam loss appears significantly mitigated, validating also the computational algorithm for space charge. We also estimate the effect of the self-consistency on large beam loss scenario where the main complexity arises from the multiple resonance crossing. To assess the effect of large beam loss, as first approach we re-update in the algorithm only the intensity leaving the bunch sizes unchanged (hence noise is avoided). The results are shown in Fig. 2. The two black curves show the beam survival for 0.250×10^{11}, and 0.625×10^{11} ions/bunch, correspondent to the green and red curves in Fig. 1b. This improved procedure causes the black curves of beam survival to shift upward to the corresponding red curves as indicated by the blue arrows. The reason of this improved beam survival cannot be explained easier, but it appears that for SIS100 there is a beneficial effect. The green curves in Fig. 2 show results from an attempt of modeling the algorithm (Markovian mapping Ref. [2]) via a semi-analytic approach. These results are, however, conflicting with experimental findings in which beam loss (naturally self-consistent) are found larger than those predicted by simulations [3]. Further studies will be dedicated to this topic.

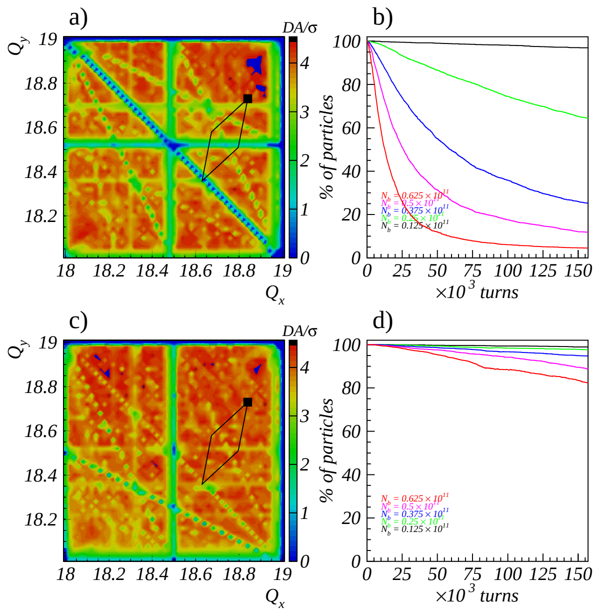

Figure 1: Resonance diagram and beam survival for uncorrected system (top). The same simulation when resonance overlapping the space charge tune-spread are compensated.

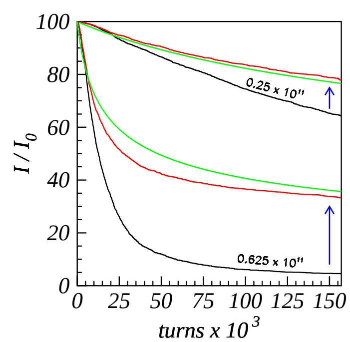

Figure 2: Comparison of the frozen space charge improved simulations (red curves) with a Markovian mapping approach (green curves). In black are shown the frozen space charge simulation results.

References

[1] G. Franchetti and S. Sorge, IPAC 2011, MOPS002. p. 589.
[2] G. Franchetti, Proc. HB2012, to be published on JACoW.
[3] G. Franchetti *et al.*, Phys. Rev. ST Accel. Beams **13**, 114203 (2010); G. Franchetti *et al.*, Phys. Rev. ST Accel. Beams **6**, 124201 (2003).