Spill time-structure and main dipole power converter ripple in SIS-18

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Tracking studies were carried out with an in-house code in order to estimate the severity of the power converter induced ripple in the dipoles as concerns its influence on the roughness of the spill when undergoing transverse RF "Knock-Out" (KO) excitation. The excitation comes from a strip-line exciter. In addition, a lattice resonance at Q_x=13/3 is created by sextupole magnets which were powered to provide an amplitude of K_2L=0.03 m^{-2}. The working point's tunes were Q_x=4.3296 and Q_y=3.27. With the longitudinal RF off, the reference $^{12}C^{6+}$ DC beam had a Half-Width in its relative momentum spread of $\delta_{p,2\sigma}$=0.04%. A Hardt condition was imposed on the optics to minimize ions lost to the first extraction septum by adding the offset K_2L=0.206 m^{-2} to each of the 1C-sextupoles and setting K_2L=-0.369 m^{-2} to each 3C-sextupole, producing losses at the septum's wires ≈3.5% of the initially stored ions, with ripple in the dipoles taken from Fig. 1. This loss is close to the simulated loss of 3.3% in the absence of the dipole magnet B-field ripple. It is therefore assumed that the ripple in the spill in Fig. 2, is not caused by septum collisions to a large extent.

A single power converter is connected in series to the dipoles. Fig. 1 taken from [1] shows the dipole circuit ripple at the nominal direct current of I_n=1190 A which was (partially) reconstructed from the discrete Fourier transform of an 8-bit oscilloscope trace of the difference between the set-point and actual current. With identifiable components in the range 100 to 1100 Hz (including the anticipated 300 and 600 Hz) added together to give Fig. 1 and implemented in the simulation, Fig. 2 was produced.

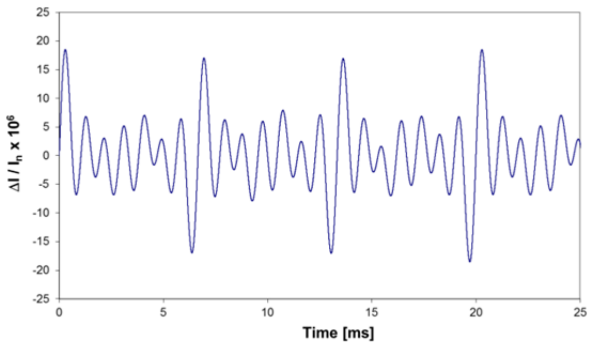

Figure 1: Partially reconstructed dipole current ripple. Maximum relative deviation in current is ca. 1.8×10^{-5}.

Each of the stored ions received, per transit through the exciter, a perturbation in its horizontal trajectory angle made with the design orbit, the magnitude of which was sampled randomly (per ion) from a Gaussian distribution cut at ±3σ, thereby allowing the contribution to the spill from just the dipole current to be determined. In Fig. 2 which shows the induced spill-ripple, the regularly spaced strong peaks occurring at 150 Hz are suspected to be directly correlated to the power converter ripple's signal envelope.

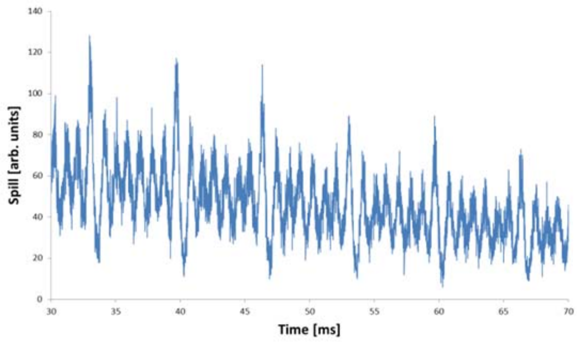

Figure 2: Simulated spill with dipole ripple.

In Fig. 3, which shows the distribution of the spill's Maximum-to-Average current from a 100-bin window (10 µs bins) moving over the spill of Fig. 2, one sees a clear degradation in spill smoothness. However, with nominal operation (K_2 offsets zero) for which the amplitude was raised to K_2L=0.064 m^{-2}, to permit a potential closed orbit bump of ~20 mm, no spill-ripple was observed.

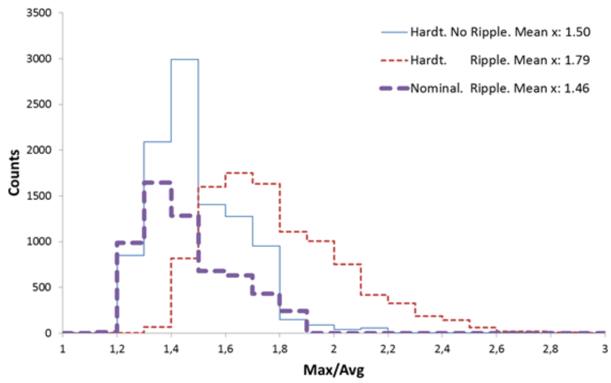

Figure 3: Simulated spill "roughness" distribution.

Measured spill-ripple, due to magnets, is considered excessive. Ions crossing the separatrix faster should reduce it. To this end, a recent prototype modification to the KO system, capable of delivering a new KO voltage form and higher maximum voltage, may achieve this.

References

[1] M. Kirk et al., "SIS-18 RF Knock-Out Optimisation Studies", IPAC'13, Shanghai, May 2013, MOPFI007, http://www.jacow.org .

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