Status - SIS-18 Slow Extraction

M. Kirk, D. Ondreka, and P. J. Spiller

GSI, Darmstadt, Germany

We report here recent investigations with the aim to reduce the ripple in the spill coming out of SIS-18.

Tracking studies were undertaken in which the RF Knock-Out modulation was switched from the existing BPSK based method to the dual FM method. Instead of the conventional BPSK carrying a pseudo-random bit train from a 16-bit Linear Feedback Shift Register, the dual FM consists of two anti-phased saw-tooth FM signals [1]. In both cases the excitation spectrum is at the lowest frequency betatron sideband. Similar techniques have been evaluated by simulation for single FM as well as for band-limited white noise [2] however without the aim to assess the spill's microstructure.

Dual FM requires a larger peak voltage; however improvement to the microstructure has been demonstrated. Figure 1 shows a few ms of spill at 10 µs resolution with the Hardt condition set. The Hardt condition [3] is particularly important for high current operation. It remains to be seen if it would be simpler to increase the bandwidth and peak voltage of the BPSK modulation while observing that the voltage is limited by the size of the deflection angle of the ions from the RF exciter which should be small enough to maintain the beam's diffusion. The increased smoothness is also evident from figure 2 for the same spill at ms resolution for which the smoother curve results from dual FM. The BPSK's peak voltage was adjusted to closely match the curves for valid comparison.

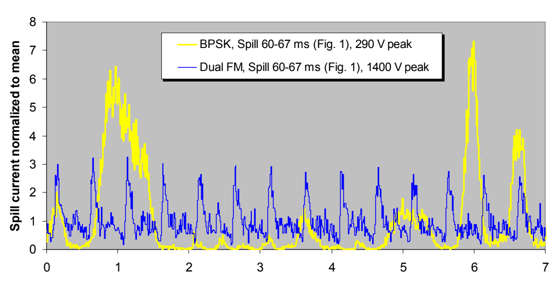

Figure 1: Simulated spills from a DC circulating beam.

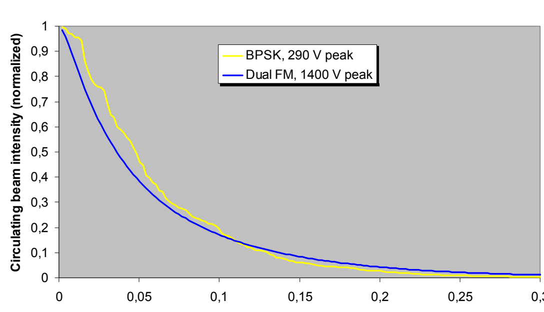

Figure 2: Simulated circulating beam intensity.

Experimental confirmation of the above prediction requires the Hardt condition to be fulfilled through a lowering of the horizontal chromaticity from its natural value. Accurate determination of chromaticity is necessary as the chromaticities are known to differ a lot from their set values according to analysis of head tail oscillations [4]. The histogram in figure 3 demonstrates the marginal improvement in spill quality by increasing the bandwidth of the BPSK excitation defined as the full width of the center lobe (i.e. twice the bit-train's frequency) in the spectral power density, normalized here to the revolution frequency. The spill quality factor (abscissa) is the spill current normalized to its local moving average in a window 100 bins wide. Each bin is as usual, 10 µs in size. As before, the circulating DC beam intensity curves were made to coincide by adjusting the peak voltage.

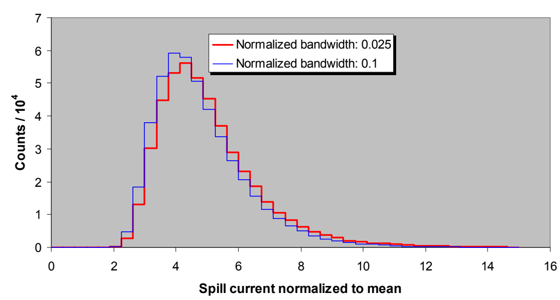

Figure 3: Spill quality measured for BPSK knock-out.

Dual FM is foreseen as a temporary solution; Demonstrated in [1], a third mono-frequency may serve to extract the ions close to the separatrix while the dual FM diffuses ions towards this region. Diode white noise is yet another alternative. It should be noted that power supply ripple to magnets, neglected in these simulations, may considerably add to the spill ripple making experimental confirmation more difficult but not impossible.

References

[1] K. Noda et al., "Advanced RF-KO slow-extraction method for the reduction of spill ripple", NIM A 492, (2002) p. 253.

[2] V. Nagaslaev et al., IPAC'11, "Third Integer Resonance Slow Extraction Using RFKO at High Space Charge", San Sebastián, September 2011, p. 3559.

[3] W. Hardt, "Ultraslow Extraction out of Lear", CERN/PS/DL/LEAR, Note 81-6.

[4] R. Singh, "Chromaticity Measurements using the Head-Tail modes at SIS-18", GSI 2012-Report.