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Proposed Longitudinal Profile Diagnostics for Optical Stochastic Cooling of Stored Electrons in the IOTA Ring

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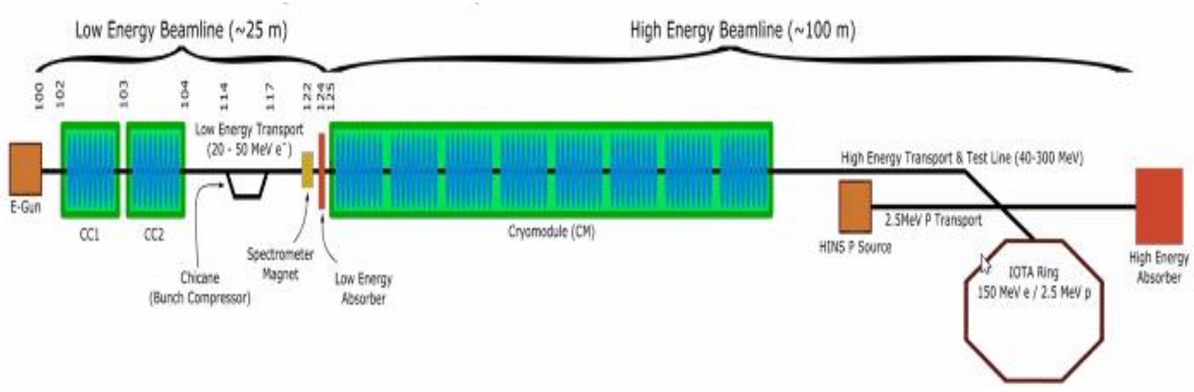
ABSTRACT

The Fermilab Integrable Optics Test Accelerator (IOTA) ring optical stochastic cooling (OSC) experiment is designed for a low nominal beam current (~0.1 microAmps of 100-MeV electrons) to reduce intrabeam scattering (IBS), and during cooling, OSC is expected to reduce the bunch length from ~200 ps to ~130 ps. These equilibrium bunch lengths can be measured using a streak camera and the optical synchrotron radiation (OSR) generated in a ring dipole by the circulating beam as demonstrated on a small ring at APS/ANL recently. The same model streak camera has been installed on IOTA, and one expects the integrated system will have sufficient sensitivity and resolution for measuring the evolution and equilibrium values of the bunch length during OSC experiments.

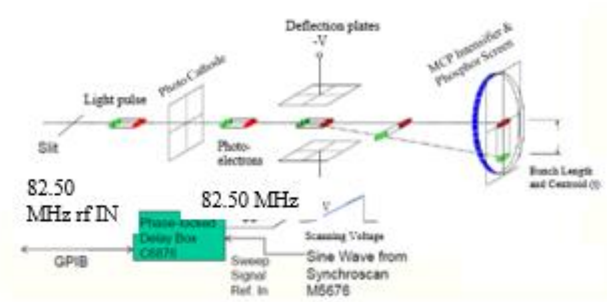


Schematic of the FAST linac showing the path to the IOTA ring.

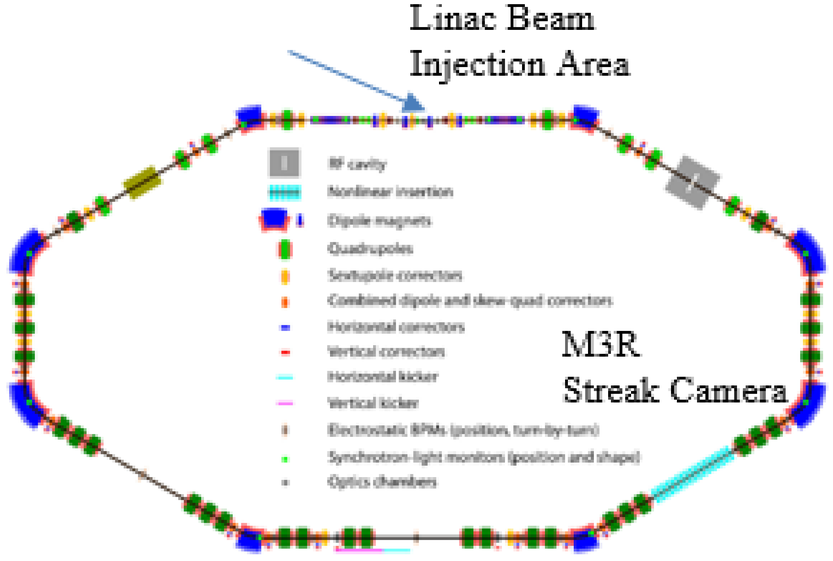
Table 1: Linac Parameters for PC Gun Beam injected into IOTA.

Parameter	Units	Value
Energy	MeV	100
Charge	pC	100-300
Emittance	mm mrad	2-5
Bunch length	ps	4-6

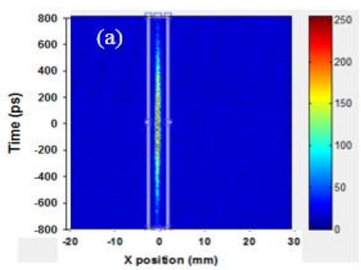
Schematic of the C5680 synchroscan streak camera with phase-locking at 82.50 MHz, the 11th harmonic of the IOTA revolution frequency.

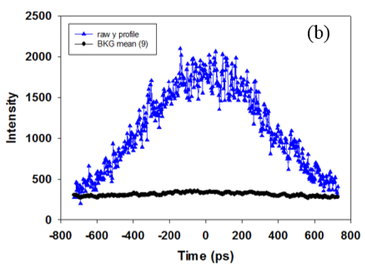


Schematic of the proposed seed laser, modulator, chicane, and diagnostics chamber in the LEA tunnel.

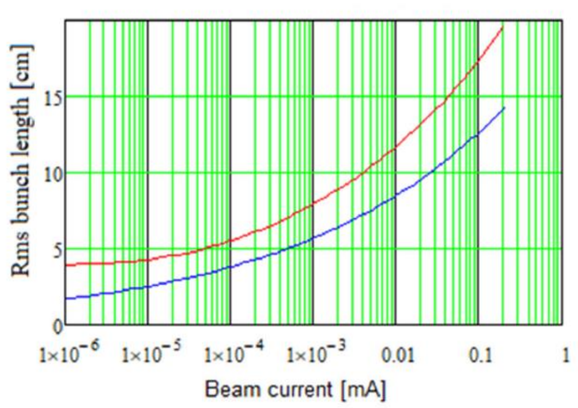


Example streak camera (a) sum image and (b) temporal axis projection from the APS Particle Accumulator Ring for 389 electrons stored. A bunch length of 354 ± 12 ps was determined. (also, Lumpkin and Wootton, PRAB 24, 072806 (2021).





Dependence of the rms bunch length on beam current with (blue) and without (red) OSC. (Lebedev et al., Arxiv.org/abs/2012.09967)



SUMMARY

In summary, we have described a technique using a synchroscan streak camera and OSR to measure the electron-beam equilibrium longitudinal distributions in the IOTA ring as a function of stored beam current and under the OSC process. A proof-of-principle result for 389 electrons stored was shown from another small ring. An extensive set of experiments has been done with this technique to support OSC studies at IOTA in the past months which will be reported elsewhere.