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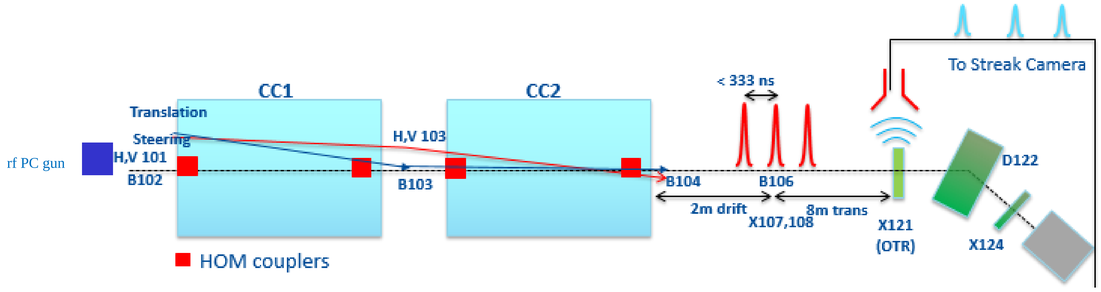
DIRECT OBSERVATIONS OF SUBMICROPULSE ELECTRON BEAM EFFECTS FROM SHORT-RANGE WAKEFIELDS IN TESLA-TYPE SUPERCONDUCTING RF CAVITIES

A.H. Lumpkin[1,2], R. Thurman-Keup[1] D. Edstrom[1], J. Ruan[1], B. Jacobson[2], A. Edelen[2], J. Diaz-Cruz[2], F. Zhou[2]

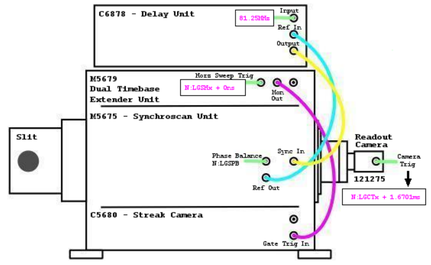
[1]Fermi National Accelerator Laboratory, Batavia, IL 60510 USA
[2] SLAC National Accelerator Laboratory, Menlo Park, CA 94025 USA

ABSTRACT

Experiments were performed at The Fermilab Accelerator Science and Technology (FAST) facility to elucidate the effects of short-range wakefields in TESLA-type rf cavities. FAST has a unique configuration of a photocathode rf gun beam injecting two TESLA-type single cavities (CC1 and CC2) in series prior to the cryomodule. To investigate short-range wakefield effects, we have steered the beam to minimize the signals in the higher-order mode (HOM) detectors of CC1 and CC2 for a baseline, and then used a vertical corrector between the two cavities to steer the beam off axis at an angle into CC2. A Hamamatsu synchroscan streak camera viewing a downstream OTR screen provided an image of y-t effects within the micropulses with ~10-micron spatial resolution and 2-ps temporal resolution. Head-tail kicks of 100s of microns with micropulse charge dependence were observed.

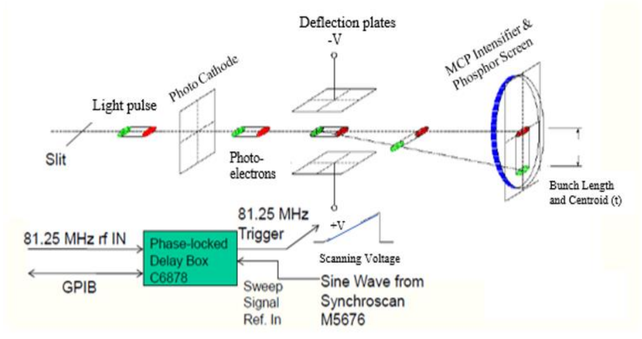


Schematic of the FAST linac showing the PC gun, capture cavities, HOM couplers, rf BPMs, imaging stations, and the path to the streak camera.

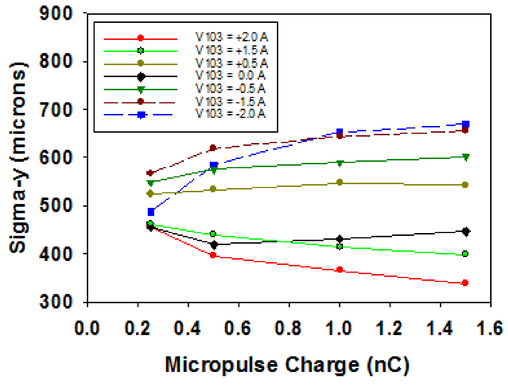


Dual sweep C5680 streak camera with MCP gating feature and phase locked at 81.25 MHz.

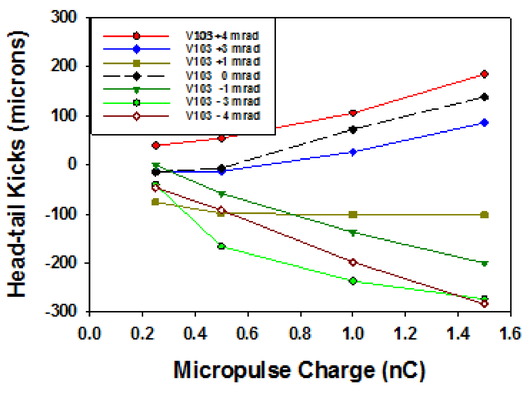
Schematic of the synchroscan streak camera. There is also a phase-lock-loop delay box, C6878, which stabilizes the image positions. Head-tail effects are displayed images.



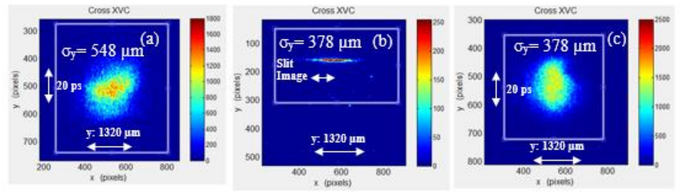
Transverse, projected y profiles for different V103 corrector steerings. 2-A current value gives a 4-mrad steering.



Gaussian fits to the y profiles for time slices at the head and tail of the micropulses show kicks of the centroids.

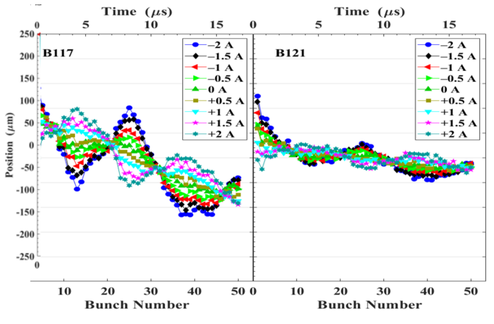


(a) As found HOMs, image shows head-tail kick with 40% larger projected size (b) focus image (c) Minimal HOMs, see ellipsoidal beam with minimal y-t tilt. Y-size 378 µm and bunch length 11.8 ps.

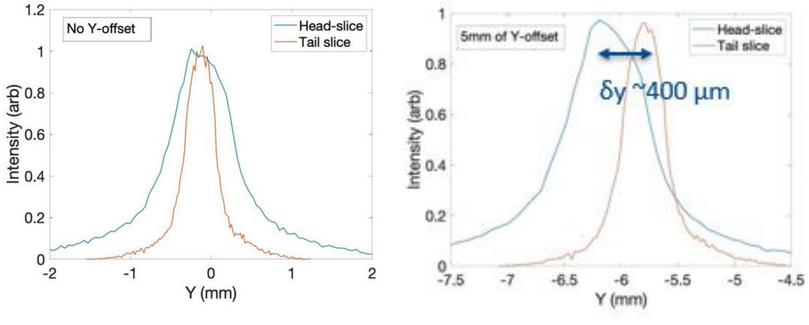


500 pC/b, 50b, laser spot size=0.2 mm

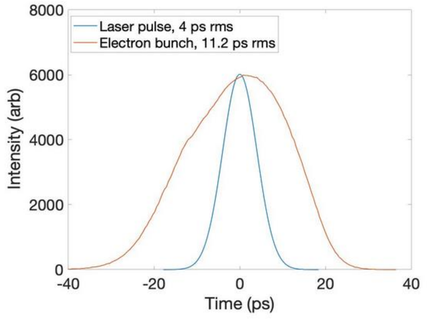
Two rf BPMs data downstream of CC2 show Mode 14 near-resonant effect at a difference frequency of 100 kHz. Steering with corrector V103 = -2.0 A to +2.0 A from reference, or about ± 4 mrad max.



ASTRA simulation of short range wakefields in TESLA-type Cavity show 400-µm head-tail kick with a 5-mm offset through the cavities.



Simulations result of the electron bunch elongation for 500 pC/b. the laser pulse was 4 ps rms.



SUMMARY

In summary, observations of short-range wakefield effects on beam dynamics were made using the streak camera to obtain y-t images at the submicropulse time scale. The HOM detectors and rf BPMs were used to evaluate off-axis steering related to these tests, and the HOM-induced sub-macropulse centroid motion was shown to be much smaller than the observed effects. Moreover, the head-tail centroid kicks were consistent with short-range wakefield results from ASTRA for the TESLA-type superconducting rf cavity and attributed to that effect.