

# Investigation of the Beam Propagation Through the FNAL LEBT

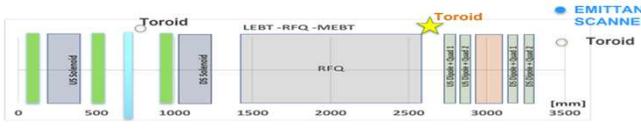
Daniel C. Jones, Daniel Bollinger, Valery Kapin, Kiyomi Seiya  
Fermi National Accelerator Laboratory, Batavia, IL, USA

## Introduction

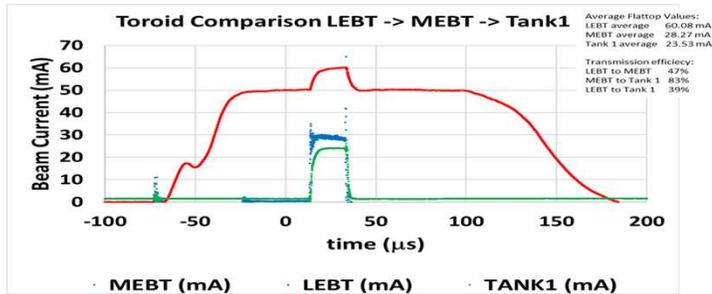
The Fermi National Accelerator Laboratory (FNAL) Pre-accelerator sends 25 mA H<sup>+</sup> beam with a 30 μs pulse length at 15Hz. The machine's uptime was increased in 2012 by the replacement of the Cockcroft Walton Accelerator with a Radio Frequency Quadrupole (RFQ) system to take the 35 keV beam from the ion source to 750 keV. The transmission efficiency has fallen over the last decade from 47% to 40% with no clear explanation.

## New Diagnostic Elements

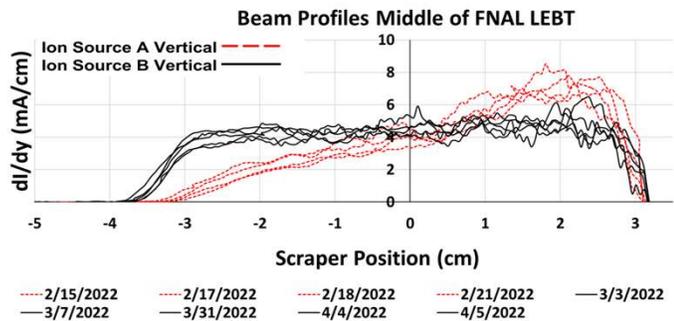
The limited space of the injector line has restricted the diagnostic elements for many years. The addition of a beam scraper in the LEBT and a temporary toroid at the RFQ exit has shed new light on the beam profiles in the LEBT and the transmission efficiencies for different sections of the injector.



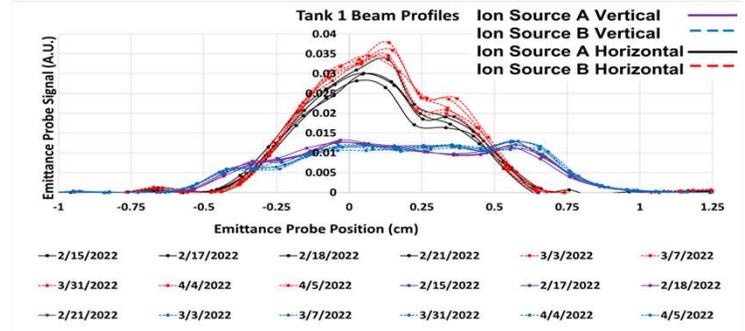
Schematic of the FNAL 750 keV injector. Beam travels left to right. The new diagnostic elements are the beam scraper, bright blue, and the MEBT toroid yellow star.



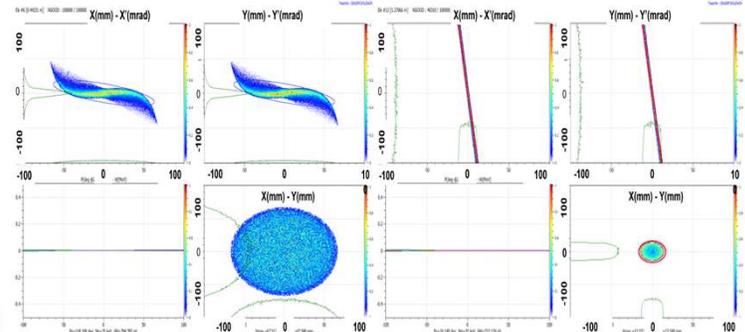
Comparing beam currents in the LEBT, at the RFQ exit, and then entrance to Tank 1.



Comparing the beam profiles between the two operational sources in the LEBT.

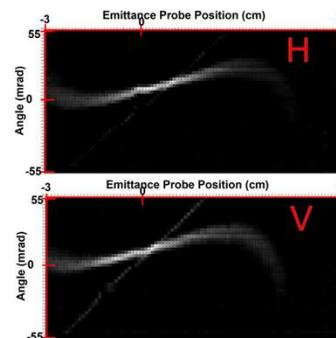


Comparing the beam profiles at injection into LINAC shows that the beam is consistent between the two ion sources



TraceWin simulation of the beam at the middle of the operational LEBT.

TraceWin simulation of the beam at the entrance of the RFQ.



Heat maps from the test bench emittance probes.

## Summary

Based on the new data it appears that the primary contribution to the low beam transmission efficiency is the beam properties in the LEBT not matching the RFQ acceptance parameters. The overall beam transmission efficiency of the injector was determined to be 39%. Simulations updated with the new data indicate that only 40% of the beam in the LEBT is entering the RFQ. We hope to verify this by turning the beam scraper into a collimator. We have begun investigating the possibility of an Einzel Lens right after the ion source to improve beam transmission efficiency

