

Observation of Current-Driven Features of 2.5 MeV Ion Bunch With Complete and Efficient 5D Measurements at the SNS Beam Test Facility

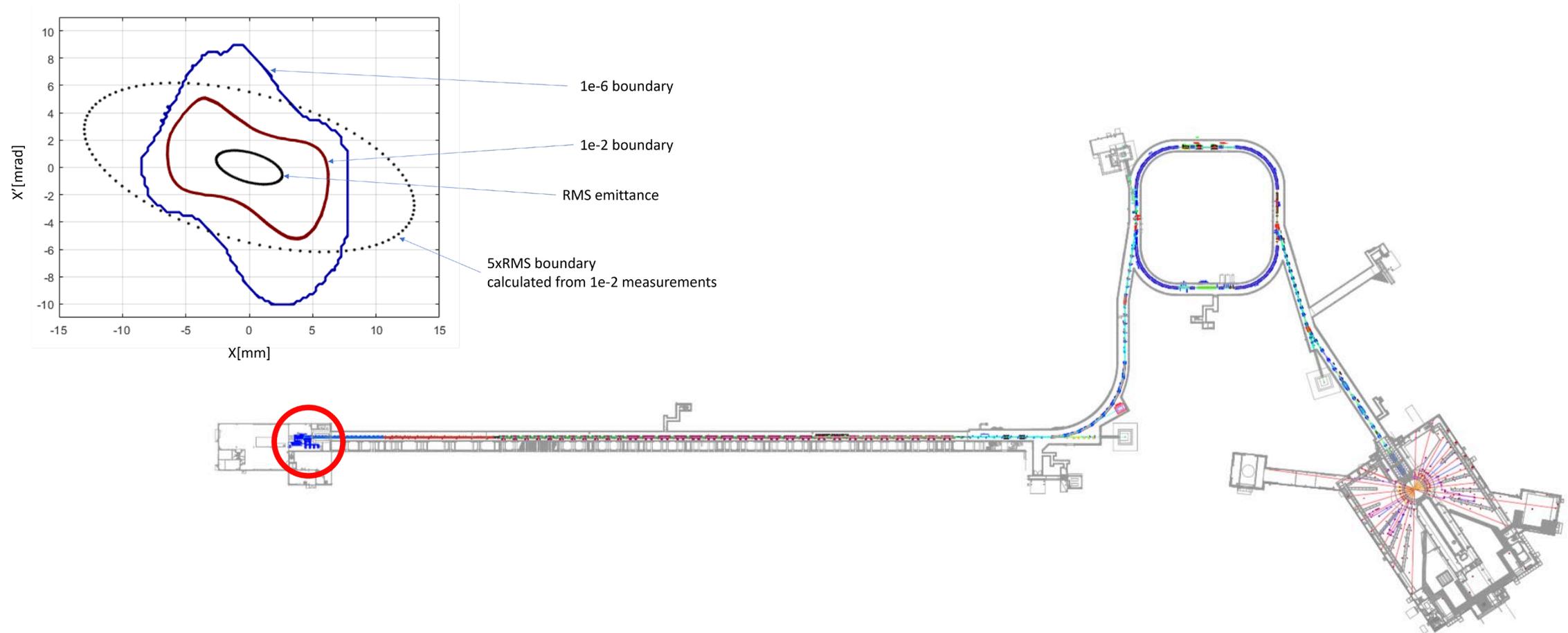
Kiersten Ruisard

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On behalf of team working on SNS Beam Test Facility

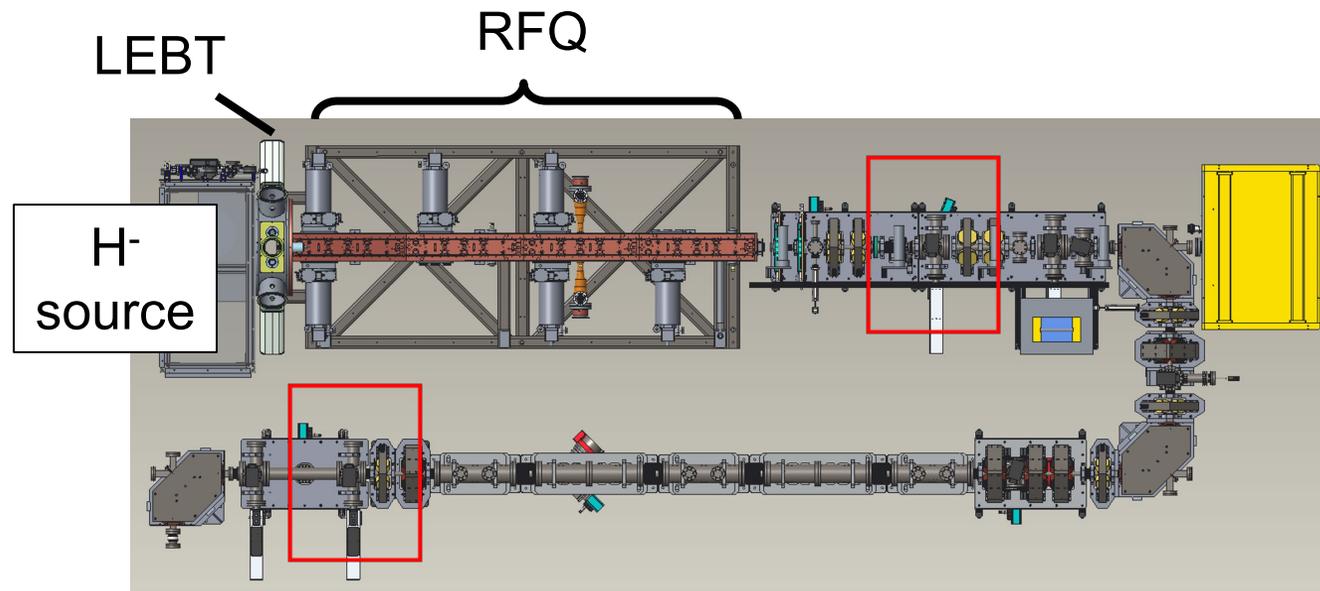
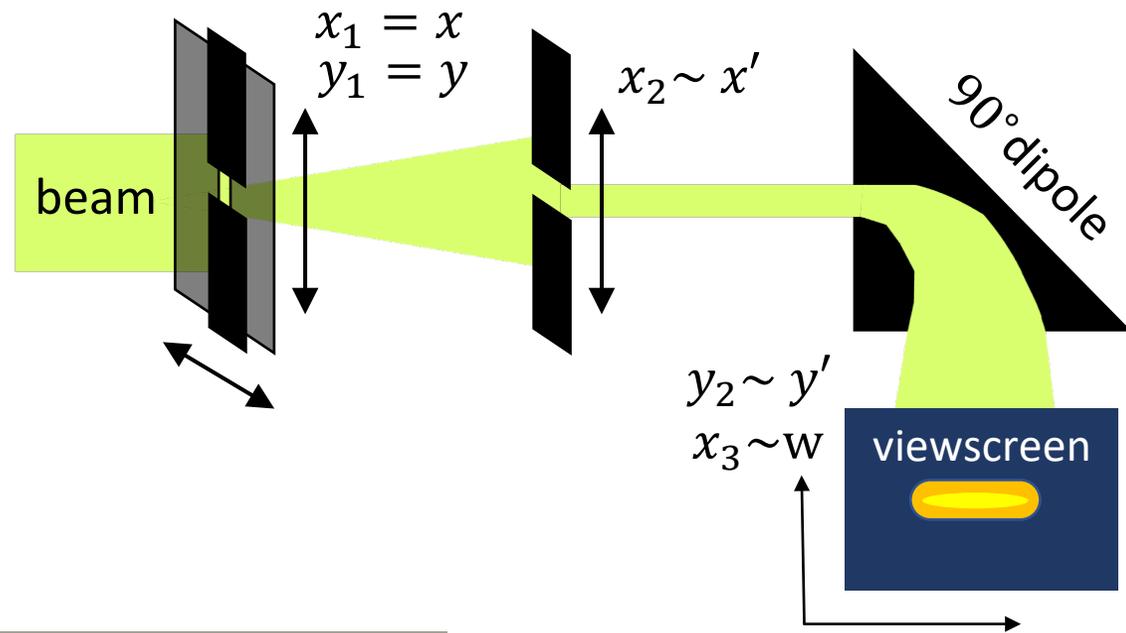
Motivation:

- predictive modeling for beam distribution with halo
- better understanding of beam losses

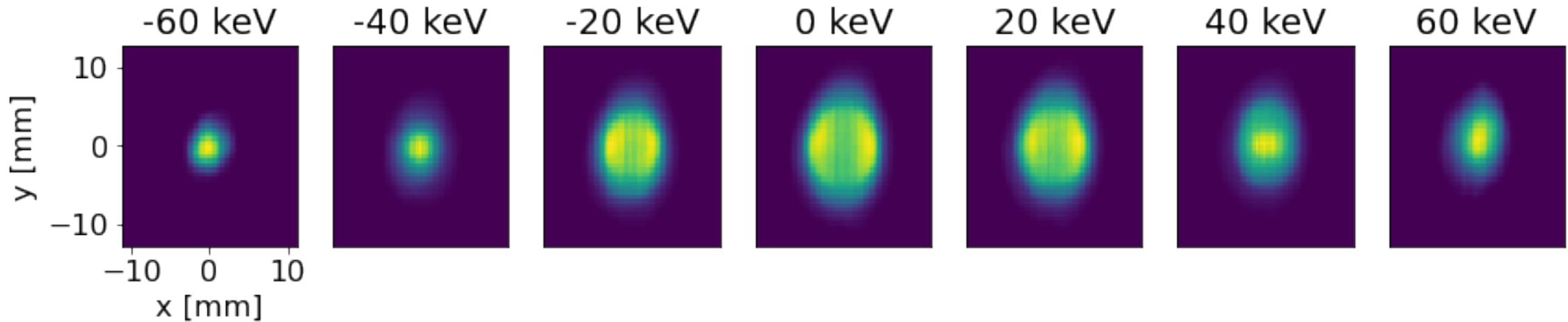
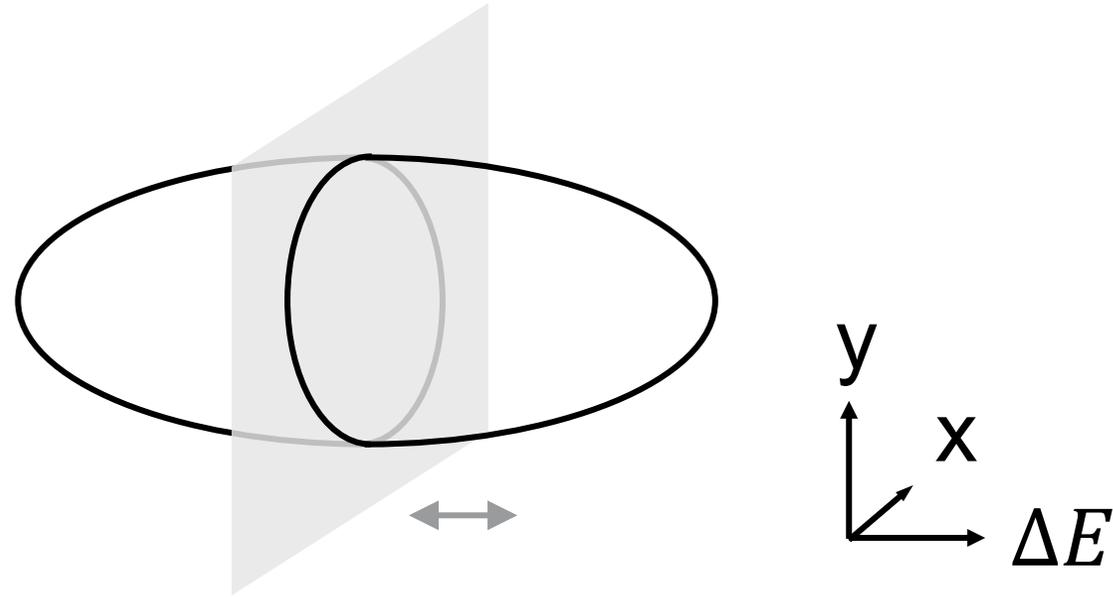
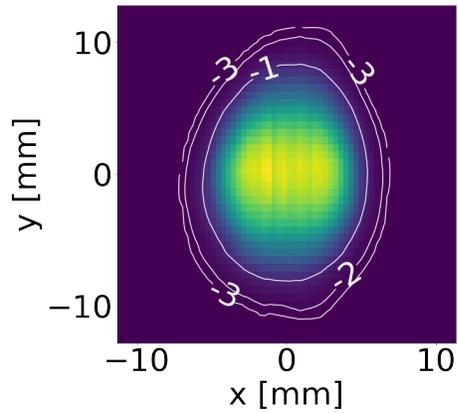


SNS Beam Test Facility is measuring full 6D distribution of H- bunch

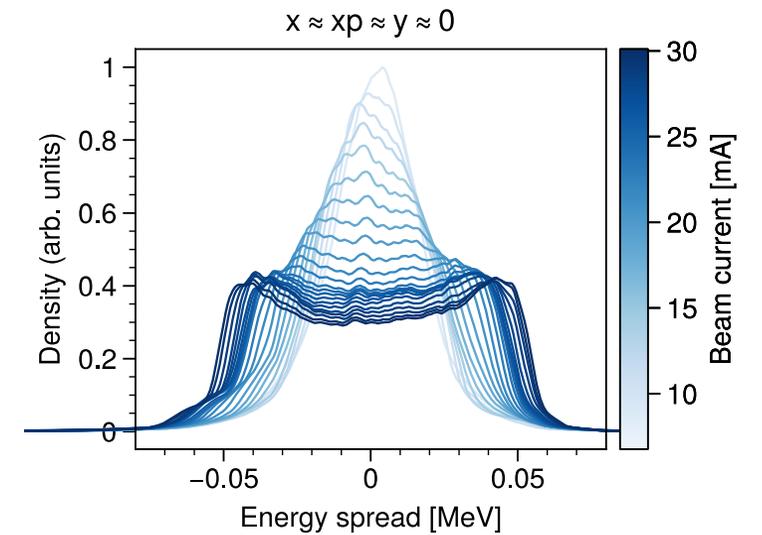
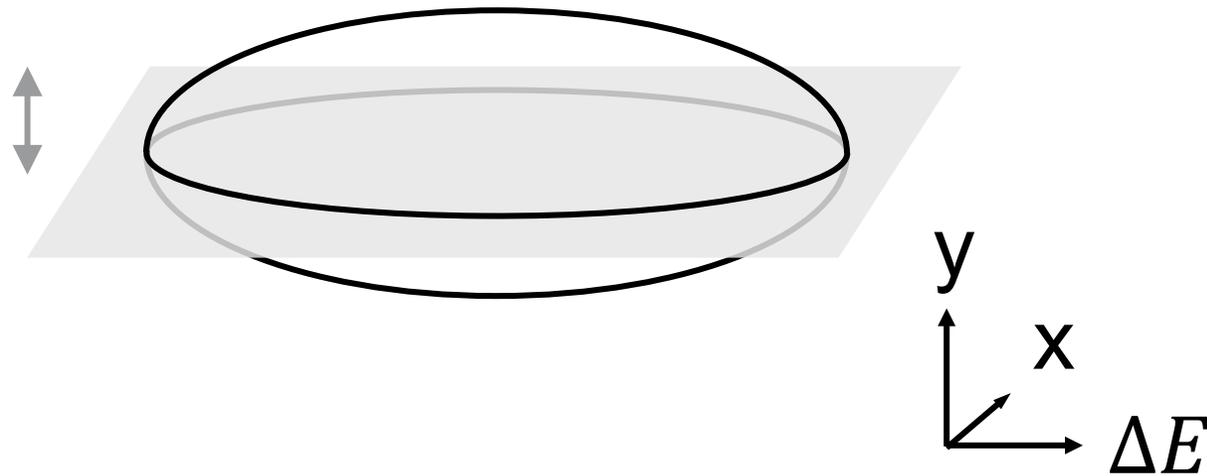
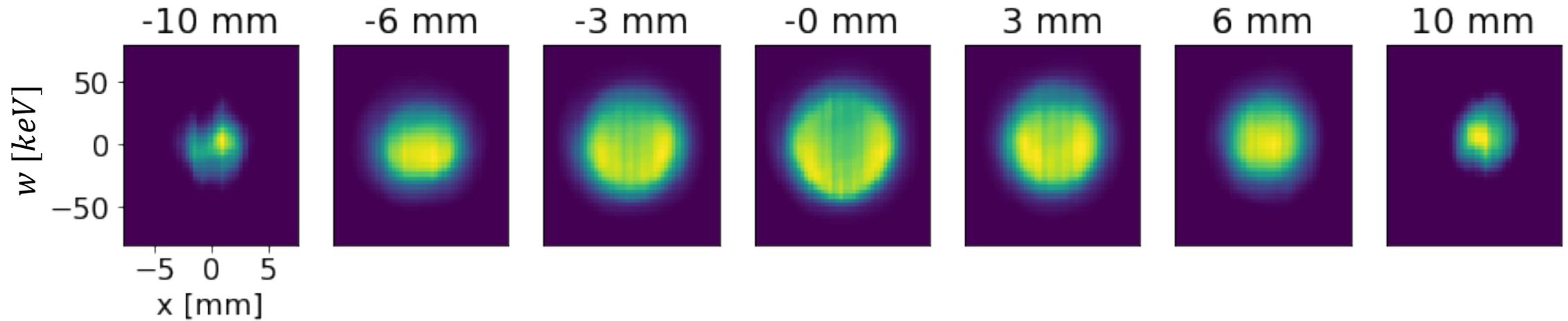
H- beam,
Up to 50 mA,
2.5 MeV MEBT



Longitudinal core is transversely hollowed



Transverse core is longitudinally hollowed



Thanks for your attention!

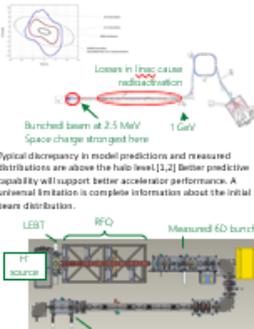
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Observation of Current-Driven Features of 2.5 MeV Ion Bunch With Complete and Efficient 5D Measurements at the SNS Beam Test Facility

 U.S. DEPARTMENT OF ENERGY

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Motivation and Approach

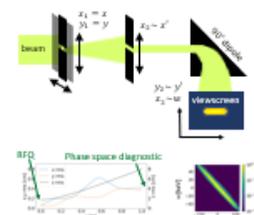


Losses in [100] cause radiation. Bunched beam at 2.5 MeV. Space charge strongest here. Typical discrepancy in model predictions and measured distributions are above the halo level [1,2]. Better predictive capability will support better accelerator performance. A universal limitation is complete information about the initial beam distributions.

Model/measurement comparison including halo distribution.

The SNS Beam Test Facility enables advanced diagnosis of beam distributions, including full and direct 5D measurements [1] as well as 2D phase space imaging with resolution of beam halo down to 10⁻⁶ fractional levels [4].

Method



Beam test facility uses a slit scan method to map high-dimensional distributions of 2.5 MeV H⁺ bunch.

The schematic shows configuration for 5D measurement, $f_{5D} = \int d\phi f(x, x', y, y', \phi, w)$ where $w = Z - Z_0$.

- 3 slits + 2 camera arms = 3D raster scan
- 65x56x56x51x2x12 grid takes 16 hours at 5 Hz

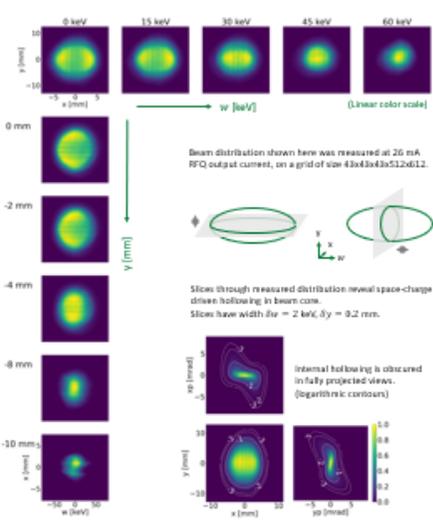
This is a significant performance increase from full 6D:

- 4 slits + 1 wire + 2 camera arms = 5D raster scan
- 10x10x32x10x51x2x12 grid takes 24 hours at 5 Hz

References

[1] S. Bang, M. Dobson, S. M. S. ... [2] ... [3] ... [4] ...

Measurements of SNS 2.5 MeV H⁺ bunch reveals core hollowing



Beam distribution shown here was measured at 26 mA RFO output current, on a grid of size 48x48x51x2x12.

Slices through measured distribution reveal space-charge driven hollowing in beam core. Slices have width $\Delta w = 2$ keV, $\Delta y = 0.2$ mm.

Internal hollowing is also used in fully projected views (logarithmic contours).



Hollowing is observed to be dependent on beam current [see Ref [3]]. This can be understood as a signature of space charge nonlinear forces (above reproduced from Ref [5]).

Outlook + Future Work



Commissioning of new RFQ will enable access to higher bunch charge via better transmission, 60 → 80% (35 → 50 mA).

De-correlating the planes in the initial bunch produces very different predictions at end of SNS drift tube [16a].

Acknowledgements

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