Virtual slit for improved resolution in longitudinal emittance measurement

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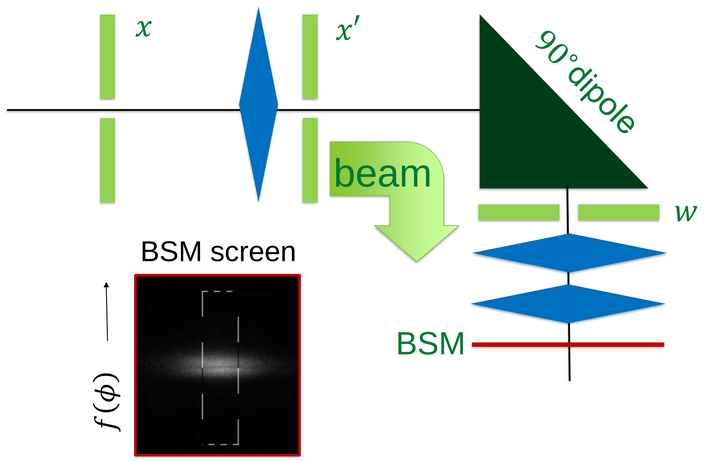
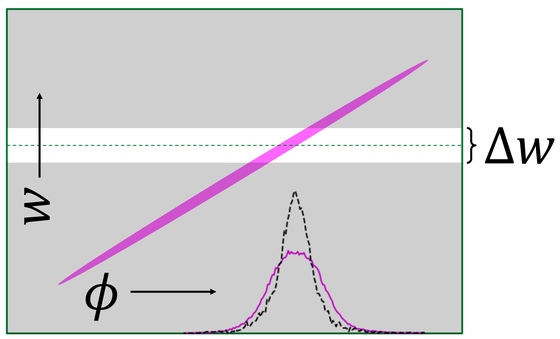
Motivation

The SNS Beam Test Facility is used for high dynamic range and high dimensional characterization of MEBT phase space distribution and benchmarking of simulations [1-4].



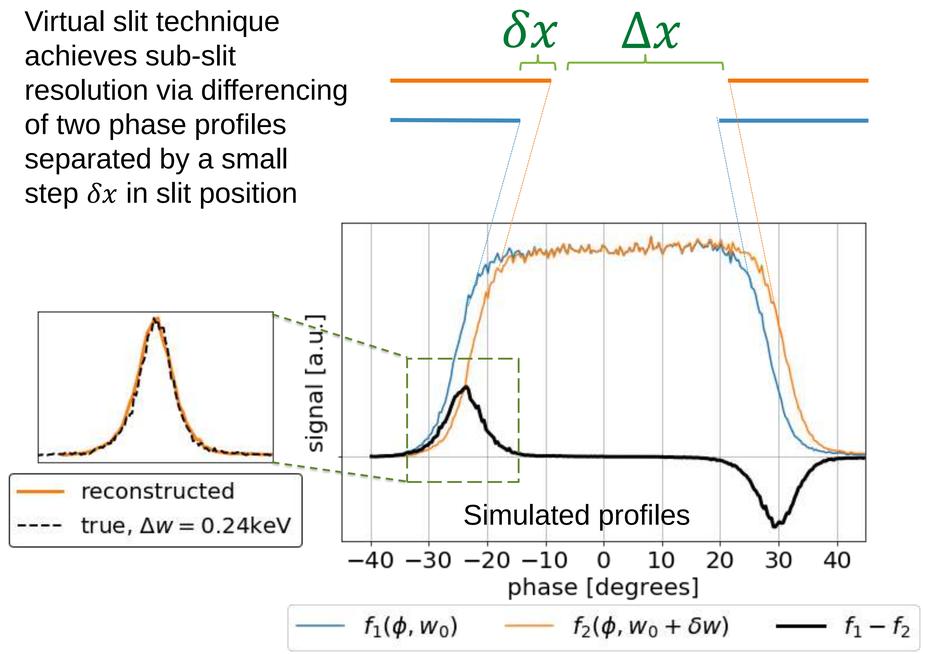
The apparatus for measurement of longitudinal phase space has large point spread error from width of energy-selecting slit [4].

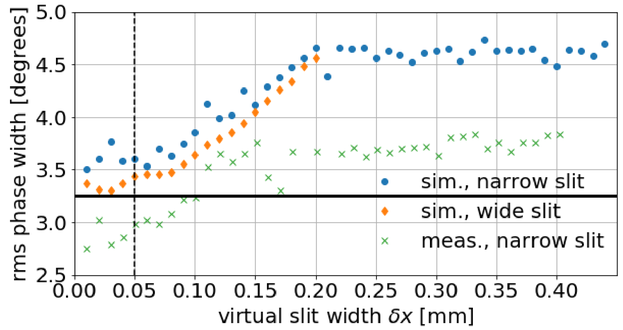


Magenta curve: projected phase profile for slit with width $\Delta x = 0.2$ mm ($\Delta w \sim 2$ keV)
Dashed black curve: phase profile for 10x narrower slit

Demonstration with 1 mm slit

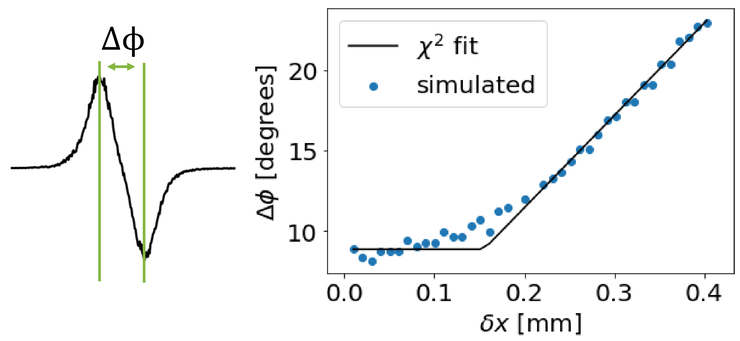
Virtual slit technique achieves sub-slit resolution via differencing of two phase profiles separated by a small step δx in slit position





Dependence of virtual slit profile on virtual slit width

Measurement of slit width

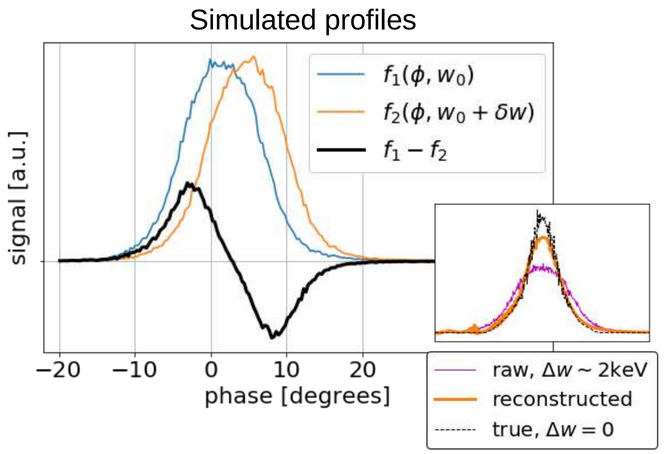


By least squares fit, slit width $\Delta x = 0.155 \pm 0.002$ mm is narrower than independent measurement of $\Delta x = 0.17 \pm 0.01$ mm.

Demonstration with 0.2 mm slit

For narrower slit, over-lapping profiles $g(\phi)$ must be separated, to get $G(\phi)$:

If $g(\phi) = G(\phi) - G(\phi + \Phi)$, then $G(\phi) = \sum_{i=0}^{\infty} g(\phi + i\Phi)$



Summary

The virtual slit technique can significantly reduce phase spread from energy slit width without the need to update hardware. The cost is doubling of measurement time and reduction of dynamic range (less than 1 order of magnitude). This technique can also be used to infer the physical slit width.

References and Acknowledgements

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