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Measured Dynamic Aperture and Detuning of Nonlinear Integrable Optics

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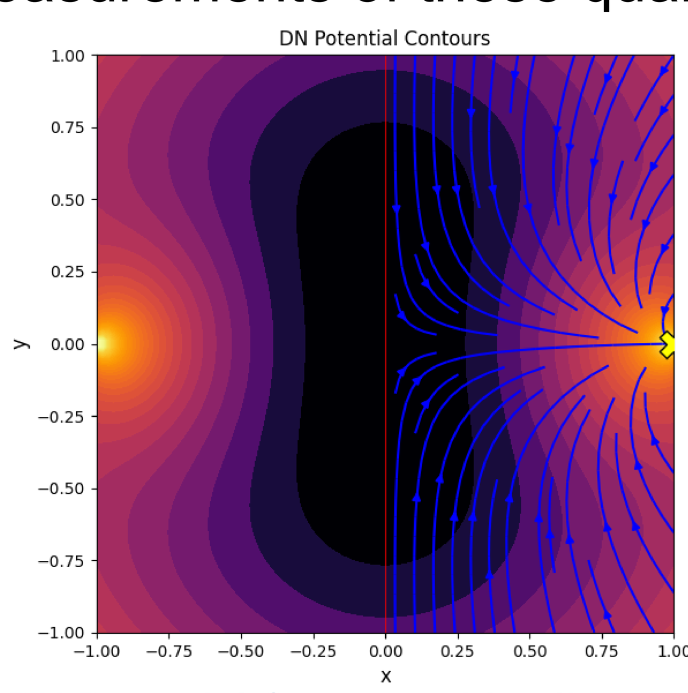
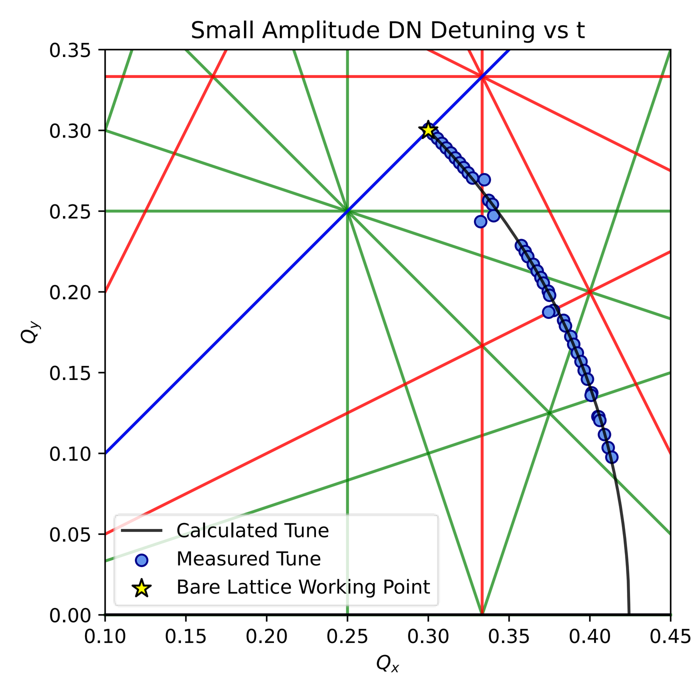
J. Wieland, A. Romanov, G. Stancari, A. Valishev, Fermilab; N. Kuklev Argonne

Nonlinear integrable optics (NIO) combine strong amplitude dependent tune shift with bounded single particle trajectories.

Tune spread improves intense beam stability by providing conditions for landau damping. Generating tune spread typically reduces single particle dynamic aperture. Experimental measurements of these quantities were conducted in IOTA.

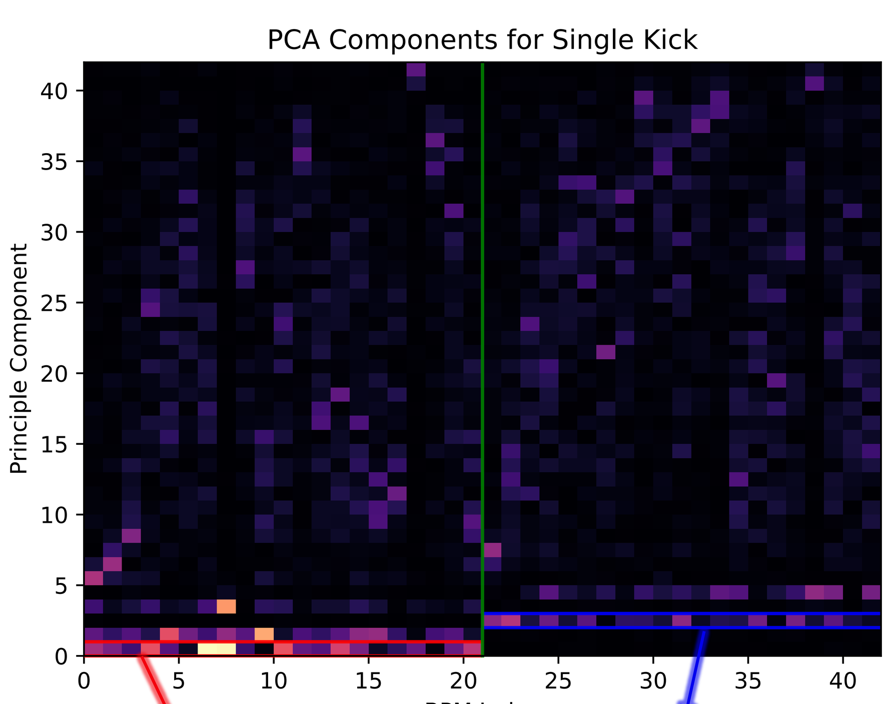


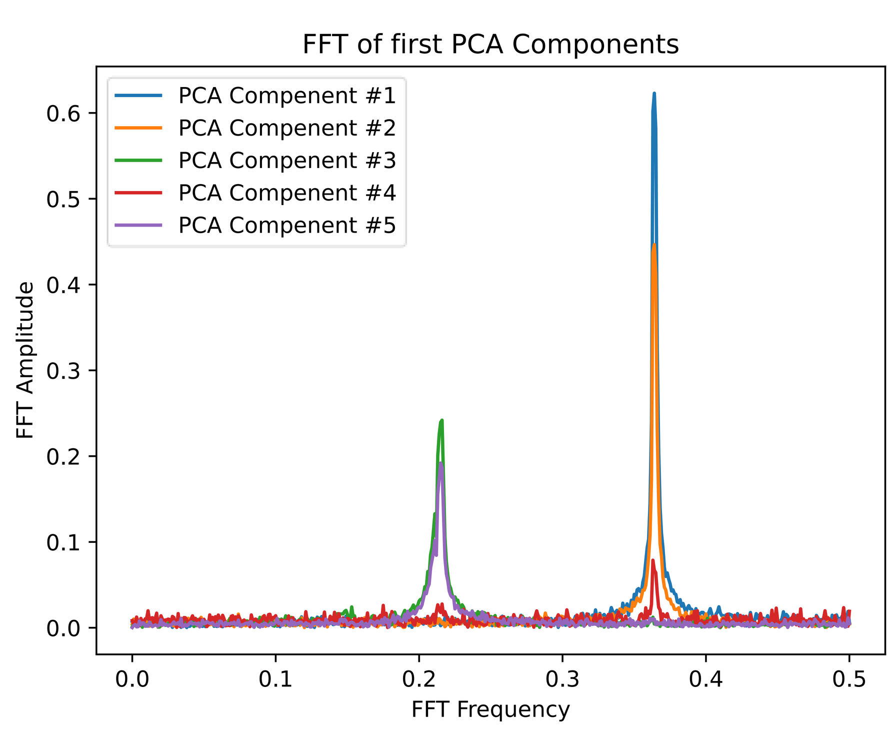
DN Potential Contours, blue lines are gradient of nonlinear component, proportional to "t" parameter. Yellow marker is location of singularity



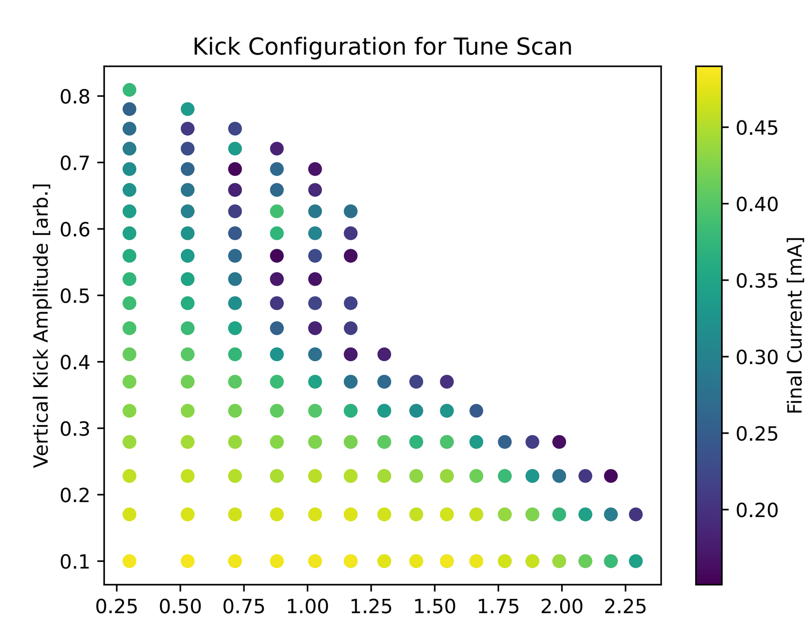
Small amplitude detuning due to DN insert, proceeds from bare lattice working point toward vertical integer resonance for increasing t along calculated line

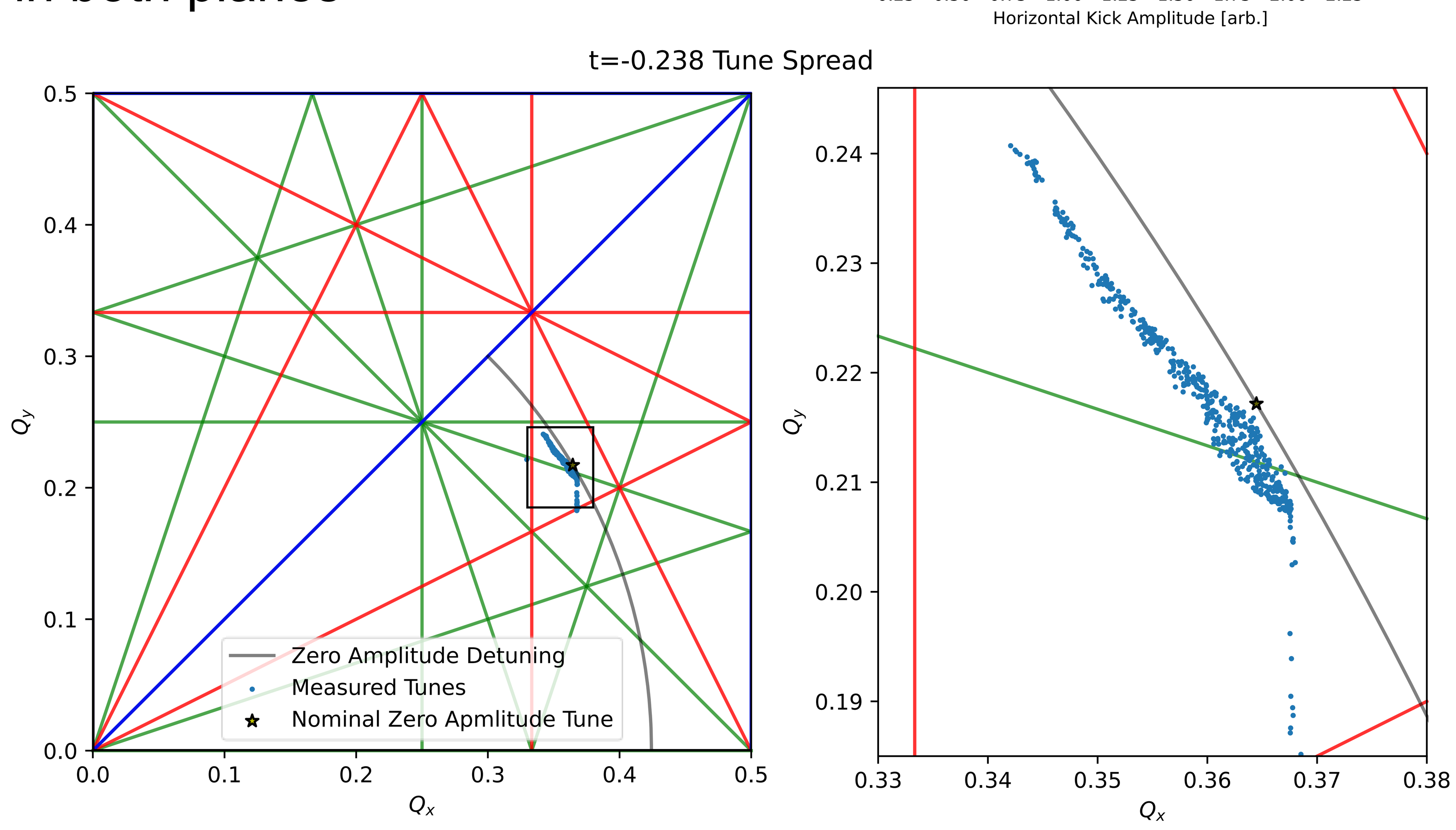
Tune Measurement





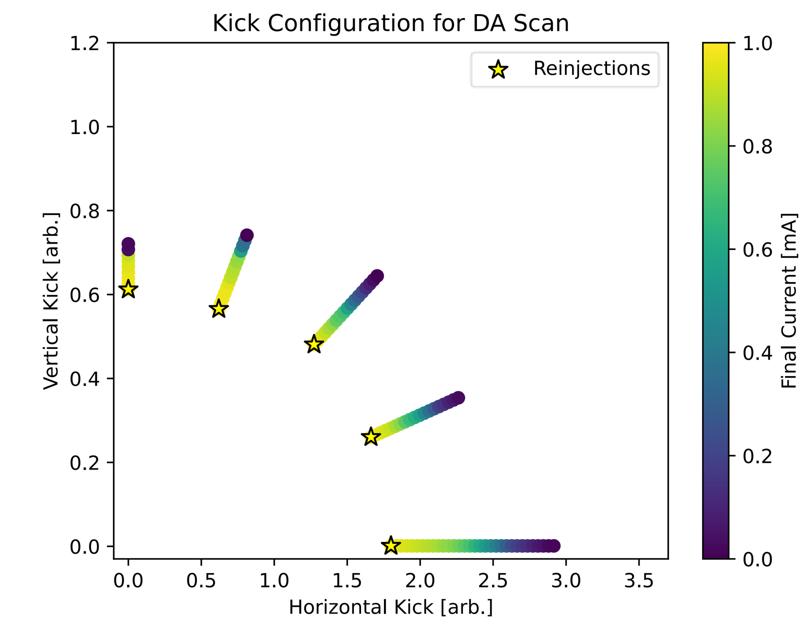
Tune Measurements are made using principle component analysis of all 21 BPMs in IOTA. The dominant mode for each BPM plane is selected and the tune calculated using NAFF. Tune kicks were always in both planes



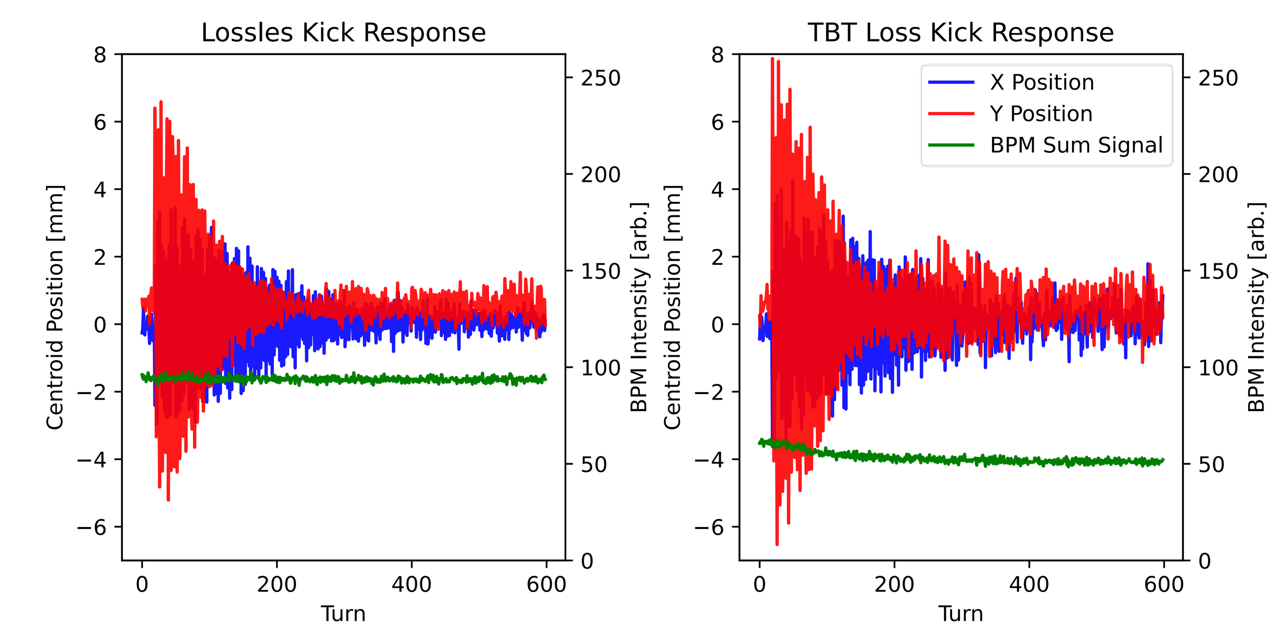


Dynamic Aperture Scan Method

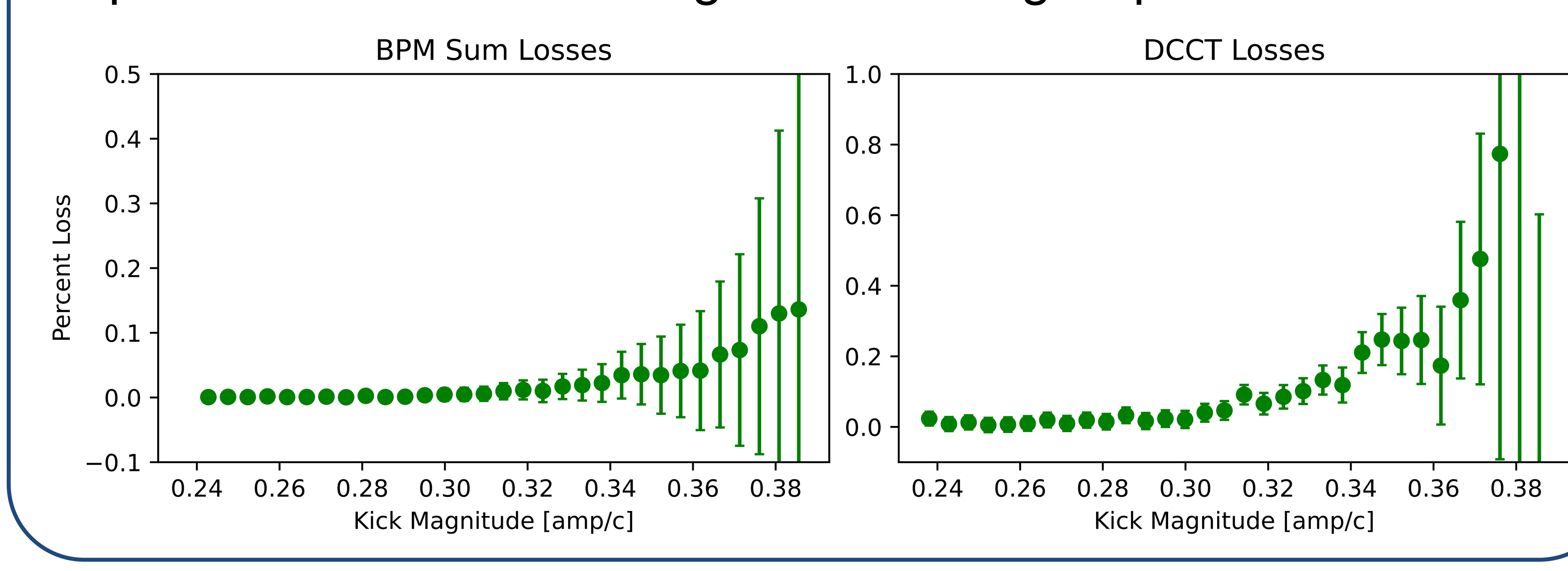
1. Inject single bunch and scrape to BPM sensitive current
2. Iteratively kick with increasing amplitude along fixed aspect ratio "spokes"
3. Terminate at DCCT low current threshold



Turn by turn BPM response to a kick. Right plot demonstrates losses on first tens of turns visible as reduction in sum signal.

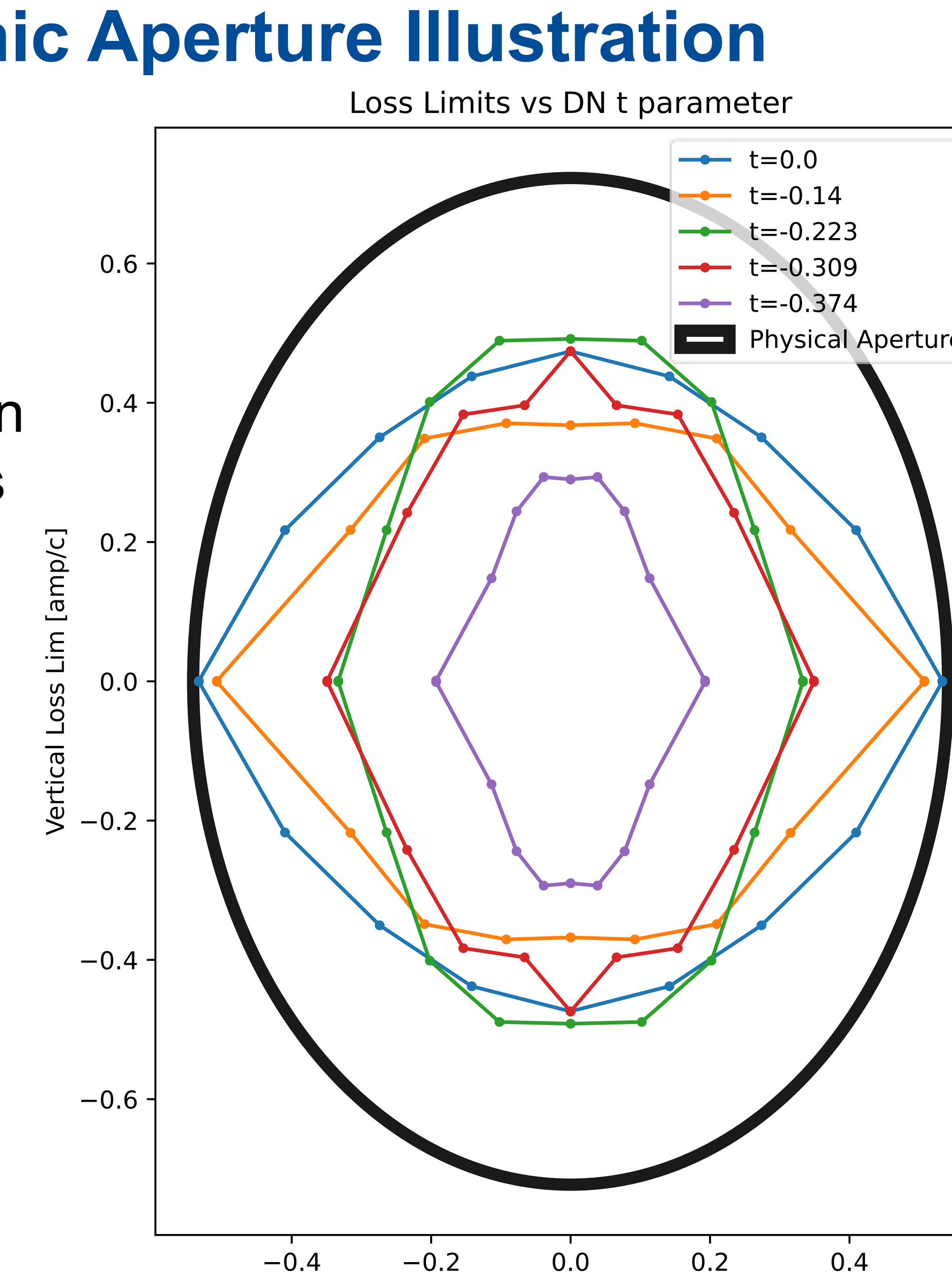


Evaluation of losses used BPM sum signal and DCCT current measurement. DCCT was sampled before and after kick, verified that losses occur in this span by comparing with next turn initial sample. BPM sum signal consisted of ~7000 turns, losses slower than this. Plotted below are percent losses on both signals for a single spoke.



Approximate Dynamic Aperture Illustration

A strict definition the Dynamic Aperture not pursued due to the level of experimental uncertainty. On the right is an illustration of the same qualitative loss threshold for different configurations of the nonlinear t parameter. Points along spokes were selected when percent losses exceeded 25% or subsequent 10% losses. Amplitude was calculated using measured kicker calibration and first order effect on the envelope.



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