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Rapid Tuning of Synchrotron Surrogate Models at the Recycler Ring

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4th ICFA Beam Dynamics Mini-Workshop Machine Learning Applications for Particle Accelerators

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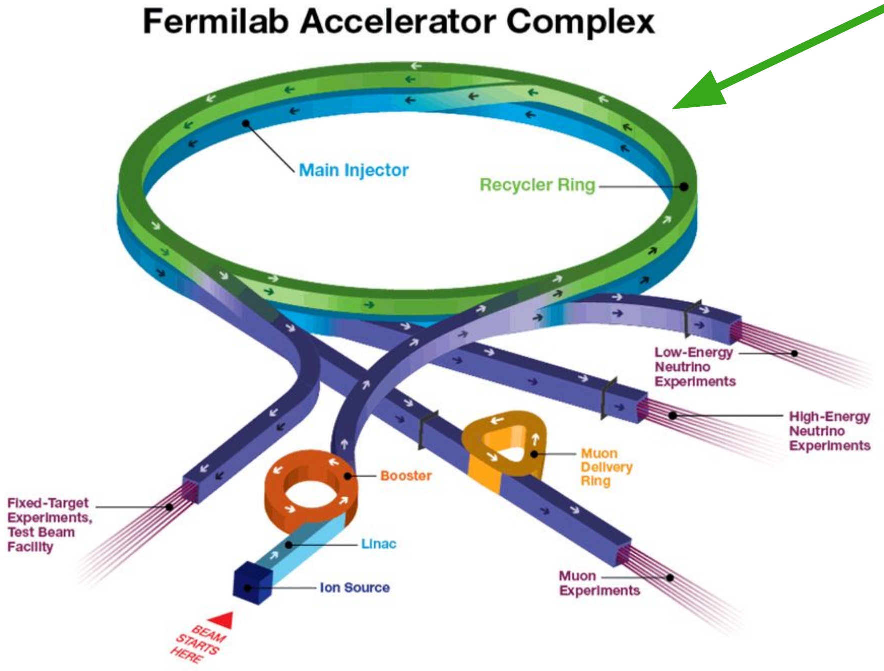
The Recycler Ring and High-Power Neutrino Beams



Recycler Ring is essential to Fermilab:

megawatt proton beams → high-intensity neutrino beams

SciDAC Scientific Discovery through Advanced Computing

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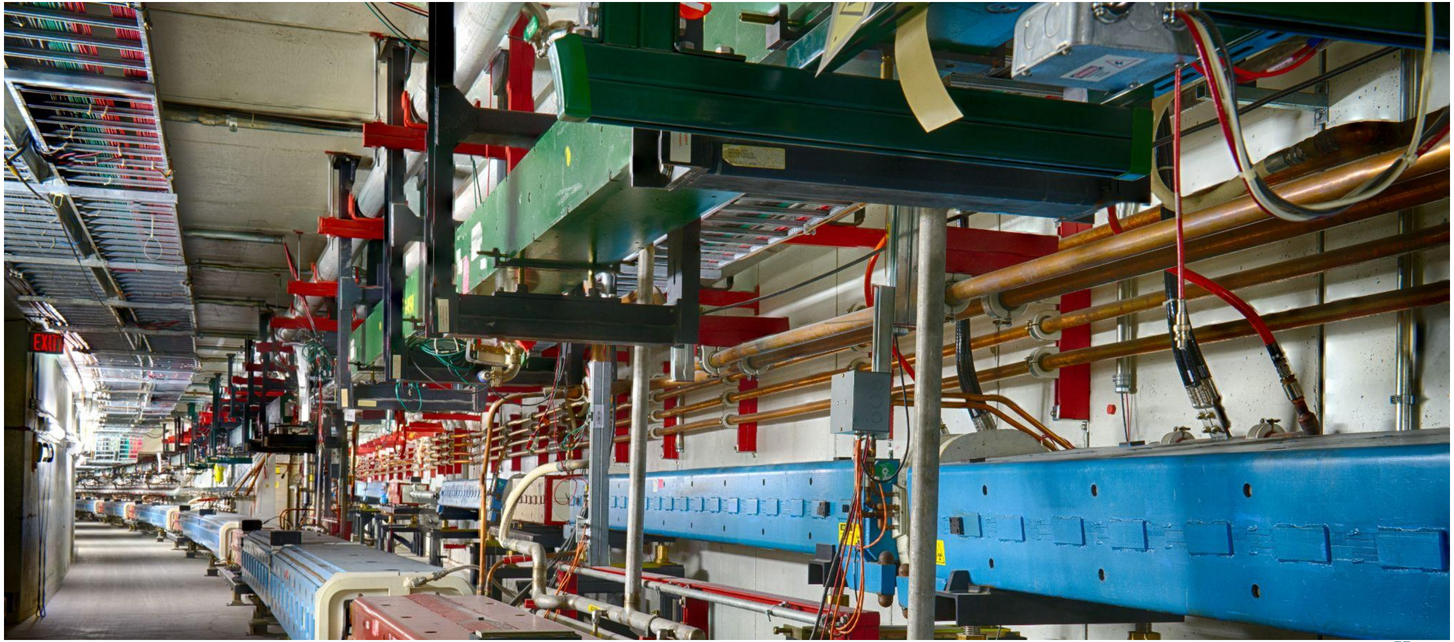
The Recycler Ring

Recycler Ring is a permanent-magnet storage ring

Matched to Main Injector 8 GeV proton KE



The Recycler Ring Multipole Shims

"Computer Generated End Shims for Recycler Ring Magnets" C.N. Brown, G.W. Foster, G. P. Jackson, J. T. Volk, Proceedings of the 1999 Particle Accelerator Conference, New York, 1999

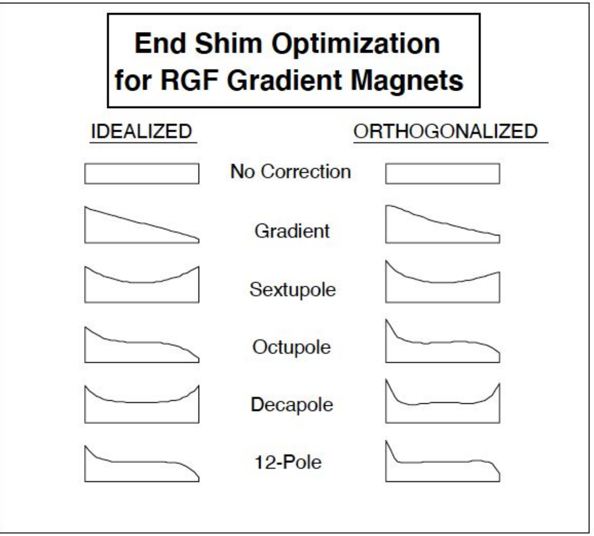
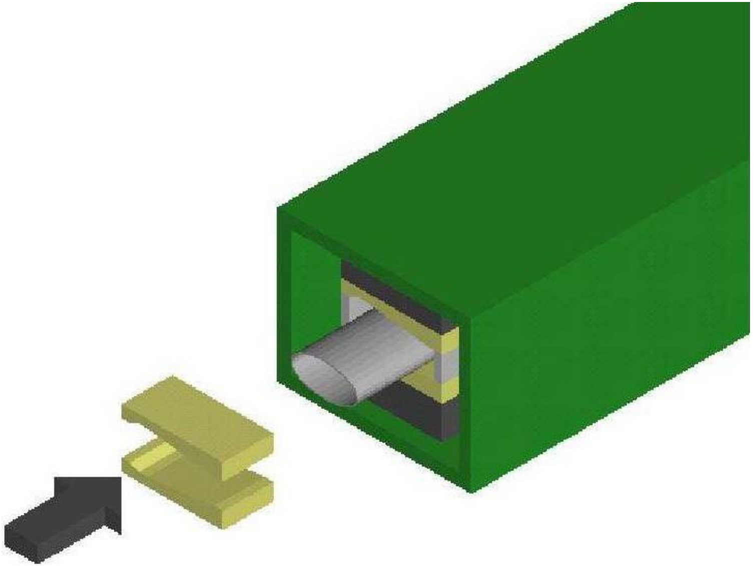
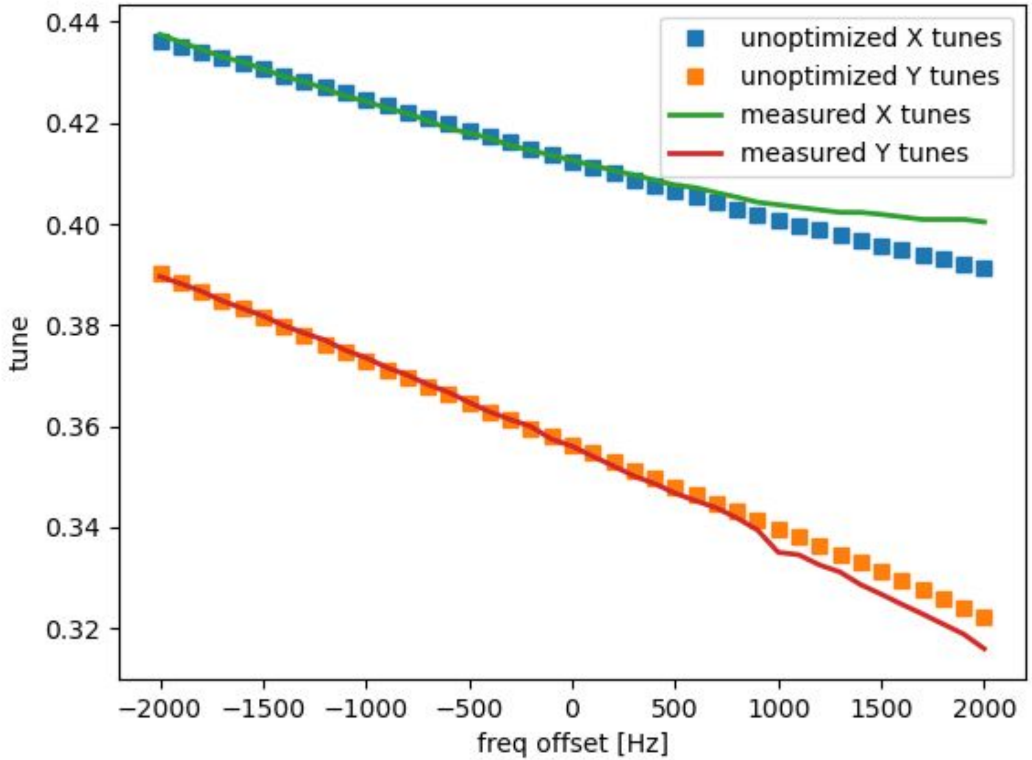


Fig. 2 – Elementary monomial Z-shim designs used as a starting point, and shim designs which were found to produce pure multipole shifts after re-orthogonalizing the multipole contributions from the elementary shims.



Magnetic shim plates were installed to correct for undesirable multiple moments observed in the Recycler.

The Recycler Ring Chromaticity



Challenge:

Tune simulated chromaticity to better match observed, using only additive corrections of multipole moments at shims.

Can small errors in shim plate shape account for the observed difference?

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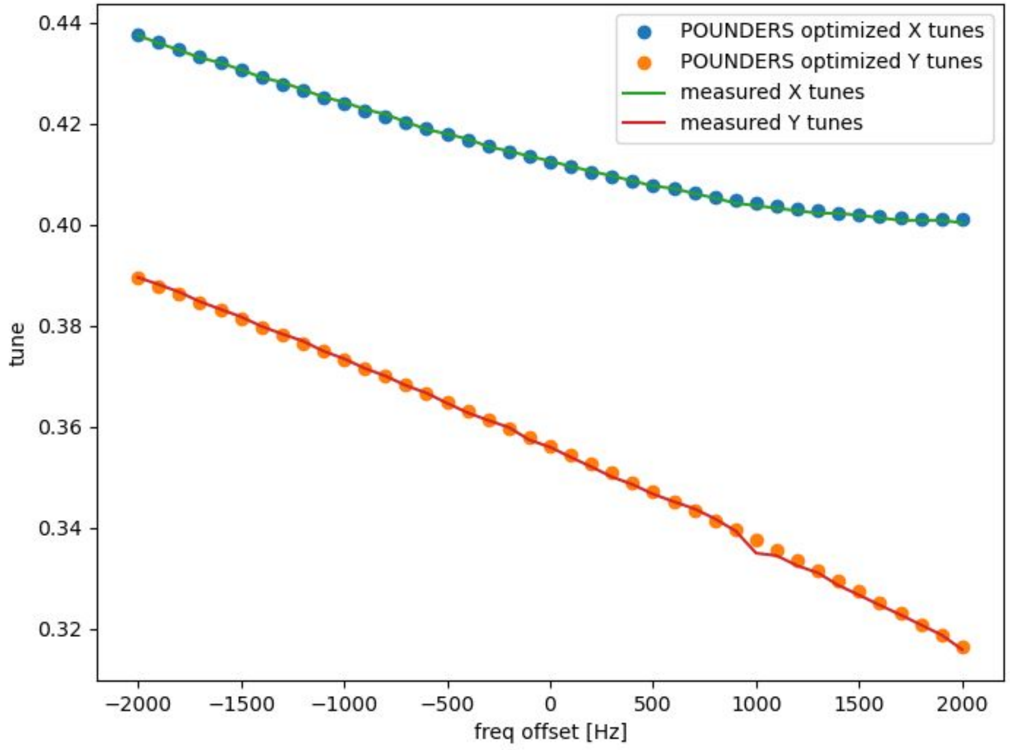
The Recycler Ring Chromaticity



Challenge:

Tune simulated chromaticity to better match observed, using only additive corrections of multipole moments at shims.

Can small errors in shim plate shape account for the observed difference?

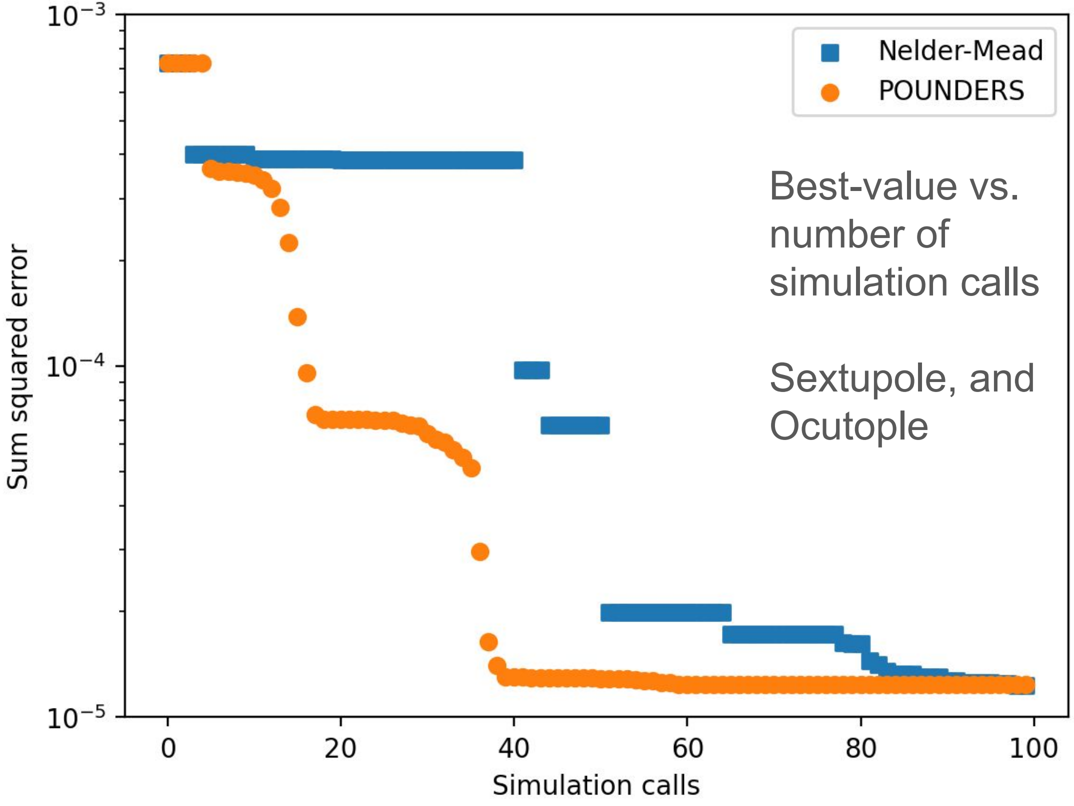
Yep! very fast with POUNDERS

Parameter Optimization with POUNDERS

Comparison to Nelder-Mead downhill simplex method (NM). Both are set to minimize the sum of squared errors.

Different inputs:
N-M: sum sq. err's
POUNDERS: vector of sq. err's

POUNDERS converges faster (~60 vs ~100 steps)



Best-value vs. number of simulation calls

Sextupole, and Ocutople

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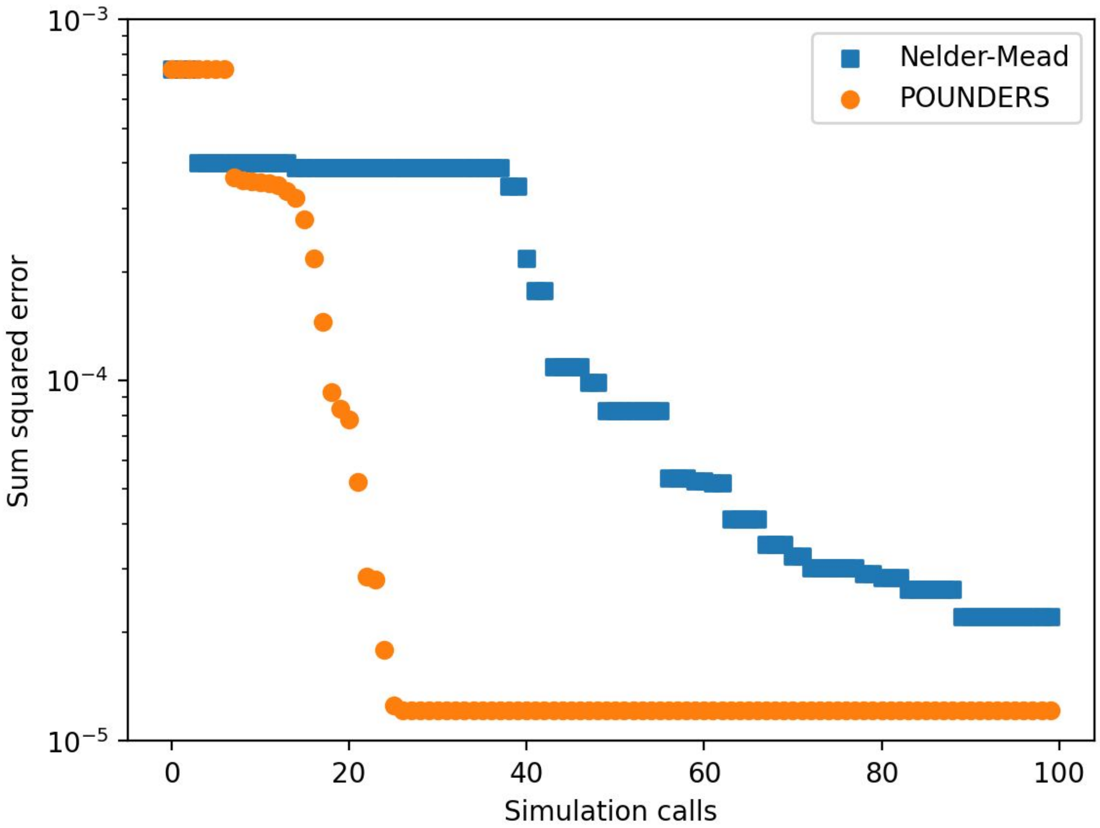
Final parameter values very close to NM result

	H sext.	V sext.	H octu.	V octu.
POUNDERS	-0.00107	-0.00099	0.37075	0.40921
NM	-0.00108	-0.00097	0.34959	0.45167

A tool for self-updating accelerator models?



Best-value vs. number of simulation calls

Sextupole, and Ocutople, and **Decapole**