**Electron lens activities at Fermilab: scraping of high-power beams, beam-beam compensation, and nonlinear optics**

**Abstract:**

We discuss recent applications of electron lenses: hollow electron beams for proton scraping and electron-lens "wires" for long-range beam beam compensation in the LHC; electron beams as nonlinear elements for testing integrable optics at Fermilab's Integrable Optics Test Accelerator.

**Summary:**

Electron lenses are pulsed, magnetically confined electron beams whose current-density profile is shaped to obtain the desired effect on the circulating beam. Electron lenses were used in the Fermilab Tevatron collider for bunch-by-bunch compensation of long-range beam-beam tune shifts, for removal of uncaptured particles in the abort gap, for preliminary experiments on head-on beam-beam compensation, and for the demonstration of halo scraping with hollow electron beams. Electron lenses for beam-beam compensation are being commissioned in RHIC at BNL. Within the US LHC Accelerator Research Program and the European HiLumi LHC Design Study, hollow electron beam collimation was studied as an option to complement the collimation system for the LHC upgrades. A conceptual design was recently completed, and the project is moving towards a technical design in 2014 for construction in 2015-2017, if needed, after resuming LHC operations and re-assessing collimation needs and requirements at 6.5 TeV. Because of their electric charge and the absence of materials close to the proton beam, electron lenses may also provide an alternative to wires for long-range beam-beam compensation in LHC luminosity upgrade scenarios with small crossing angles. At Fermilab, we are planning to install an electron lens in the Integrable Optics Test Accelerator (a 40-m ring for 150-MeV electrons) as one of the implementations of nonlinear integrable optics.