**Abstract**

To explore physics beyond the Standard Model, the experiment called Rare Eta Decays with a TPC for Optical Photons (REDTOP) is in its proposal stage at Fermi National Accelerator Laboratory to study $\eta$ decays. The existing delivery ring will destabilize the beam as it is decelerated for REDTOP’s use, so modifications to the magnet arrangement have been proposed and must be simulated. This work focused on using MAD-X to model the introduction of new quadrupoles and sextupoles to raise the transition energy and shape the beam for extraction.

**Quadrupole Modeling**

Using the Twiss module of MAD-X, the Twiss parameters such as $\beta_x$, $\beta_y$, $\alpha_x$, $\alpha_y$, $\gamma$, and $\mu_y$ were calculated and plotted for each element in the lattice. In Figures 2 and 3, the beta functions and horizontal dispersion is plotted. Transition energy is inversely proportional to the square root of $\beta$, so it was confirmed the new quadrupoles decrease the transition energy of the delivery ring. While the beta functions look high, the actual beam width is proportional to the square root of $\beta$, so the 9 times increase in the beta function is only a 3 times increase in beam size, which does not cause beam loss in this case.

**Sextupole Modeling**

In order to redirect a continuous beam of particles to the target hall, REDTOP proposes using a third integer resonance extraction method. This means the beam shape will essentially be a triangle, with each particle returning to near its original position every third turn. Then, sextupole magnets will be powered to limit the phase space of the beam, forcing any particles outside that space to cross a septum and be redirected to the target hall. A Gaussian distribution of 5000 particles was run through 100 turns of the delivery ring, and plots were made of the phase space and individual particle positions at the septum for each turn, where $Z = \alpha X + \beta X'$, a rescaling for ease of viewing.

**Future Work**

While this work proved the addition of quadrupoles to raise the transition energy and the sextupoles to change the beam shape are theoretically feasible, REDTOP’s proposed setup cannot be confirmed possible until the full deceleration and extraction process is modeled.

**References**