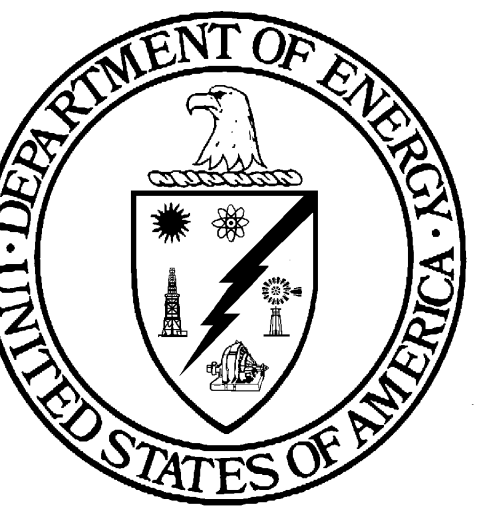




Transport efficiency of a cylindrical deflector for TAMUTRAP



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Motivation

Utilizing the radioactive beam capabilities of the T-REX upgrade at the Cyclotron Institute at Texas A&M University, the TAMUTRAP facility will make precision measurements of superallowed β -delayed proton decays for fundamental symmetry tests. At the heart of TAMUTRAP is an open-geometry, cylindrical Penning trap housed in a large-bore 7 Tesla superconducting solenoid magnet. In order to transport the radioactive ion beam from production to the Penning trap, three 90° bends in the beam line are required, which will be accomplished using electrostatic deflectors. Characterizing the bulk transport properties of these deflectors was the primary drive behind this REU project.

Electrostatic Deflectors

Given low beam energies of 10 to 15 keV, electrostatic optics can efficiently manipulate beam emittance and direction. Traditionally a deflector of spherical geometry would be optimally suited to this task due to its more consistent potential field (Fig. 1), however the immense amount of time required to machine a spherical deflector led to testing a deflector with cylindrical geometry.

Cylindrical Geometry	Spherical Geometry
Pros: <ul style="list-style-type: none">Easily machinedSimpler design and assembly Cons: <ul style="list-style-type: none">Less consistent potential field	Pros: <ul style="list-style-type: none">Consistent potential fieldProven design Cons: <ul style="list-style-type: none">Takes up to a year to machine

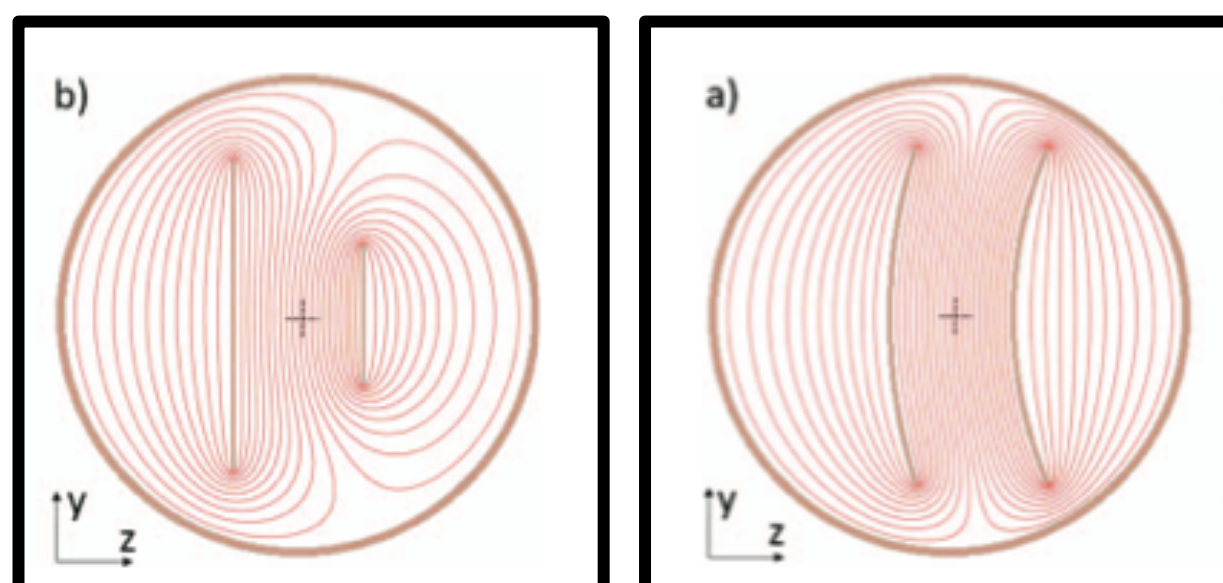
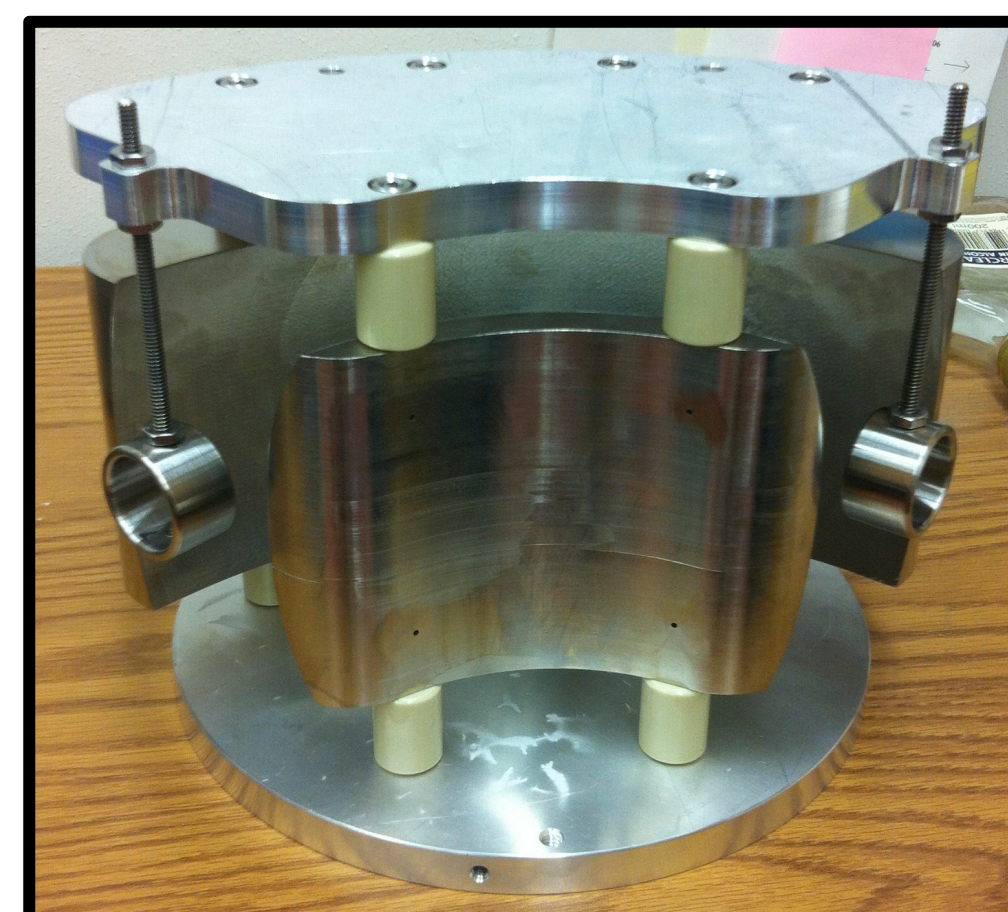


Figure 1, potential lines of the
a) spherical deflector and
b) cylindrical deflector seen on the y-z plane.¹

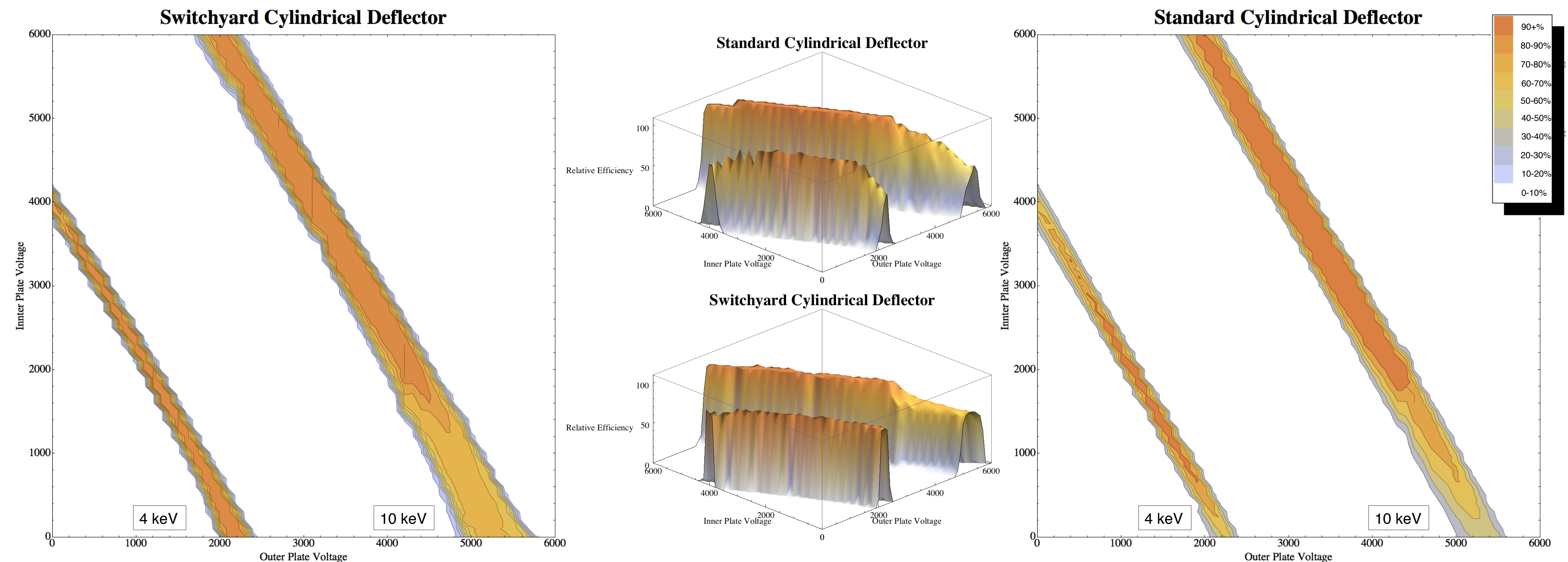


Figure 3, combined results for all tests. The leftmost pictured results are the 4 keV and 10 keV test for the switchyard variant of the deflector with the ridge profile figured to the lower right. To the right are the results for the 4 keV and 10 keV test for the standard variant of the detector with the ridge profile figured to the upper left. All plots are on the same scale and indicate the voltages required to achieve the indicated efficiencies.

Testing Transport Efficiency

In order to test the two variants of the cylindrical deflector, several beam lines were assembled (Fig. 2). We measured the amount of beam entering and exiting the deflector by reading the current at several points along the beam line. These readings were then used to calculate efficiencies by comparing the current entering the deflector with the current exiting the deflector.

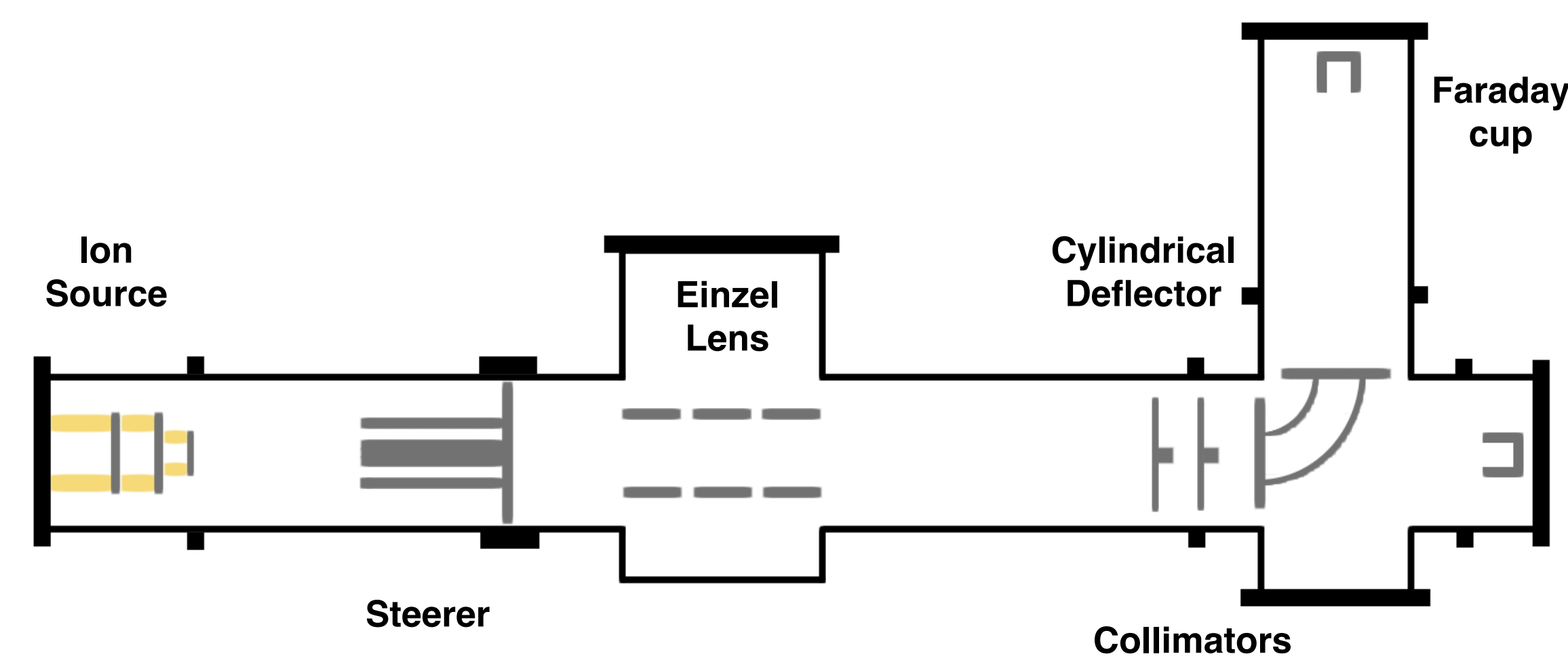


Figure 2, schematic of the beam line used to test the cylindrical deflector with the ion source and all electrostatic optics labeled.

Results

The results show a central ridge of efficiency in which the voltage ratios are such that they direct the beam primarily towards the Faraday cup (Fig. 3). Also notable are the 100% to 108% efficiencies towards the center of the ridge. We attribute this to experimental error and, while we understand the causes of this error, we cannot estimate it reliably, making all stated efficiencies relative.

Conclusions

While we cannot definitively state absolute efficiencies for a cylindrical electrostatic deflector, based on the results obtained in both simulations and testing, we may assume it is very high. Additionally, we can conclude there is no loss in efficiency between the switchyard deflector and the standard deflector. This data also gives a good baseline to compare to a spherical deflector under similar testing conditions. Based on these findings, we can conclude a cylindrical deflector is a feasible option for the TAMUTRAP beam line. Further research will include characterizing beam emittance and direct comparison to the spherical deflector.

References

- Kreckel, H., H. Bruhns, K. A. Miller, E. Wählin, A. Davis, S. Höckh, and D. W. Savin. "A Simple Double-focusing Electrostatic Ion Beam Deflector." *Review of Scientific Instruments* 81.6 (2010)