Removing Lensing Effects from Electrostatic Steerers on OLIS beams using BOIS

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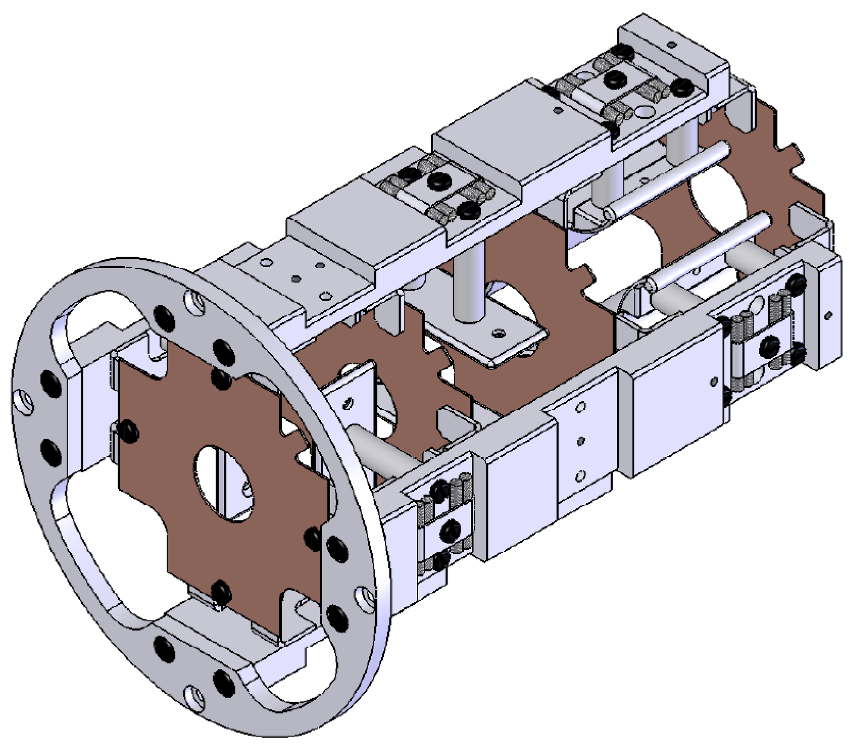
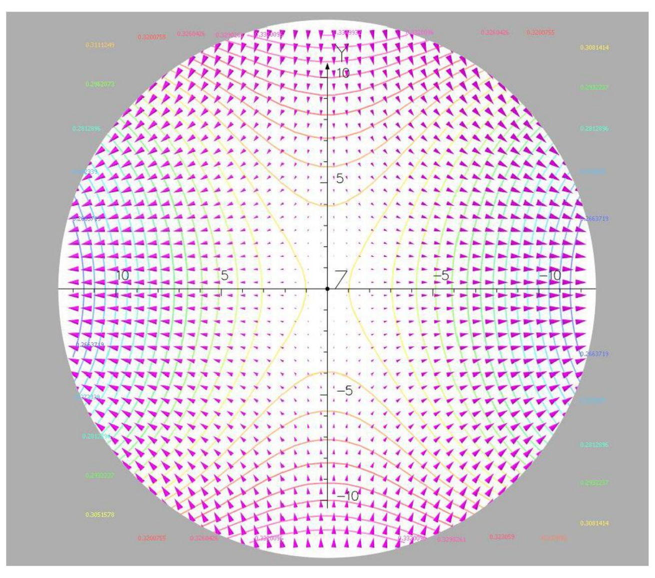
1. Abstract

The BOIS tool [1] was adapted to address the issue of steerer lensing present in the OLIS beamline [2]. The solutions aimed to find a steering tune that lowered the common plate voltage as low as possible, while still delivering the maximum transmission. Success of removing lensing was determined by comparing beam profile scans at two locations, on either end of the tuned section, with the goal of producing the correct optics.





2. Electrostatic Steerer Lensing

ISAC electrostatic steerers are built using two sets of parallel plate electrodes, for x and y, separated by a circular grounded aperture. This choice of **circular slot** along with operating steering plates at a **net bias** (same polarity, but with potential difference), causes the assembly to gain **quadrupole behaviour** [3,4], described as:

$$quadrupole\ effect\ \propto sum\ of\ steering\ plate\ voltages.$$

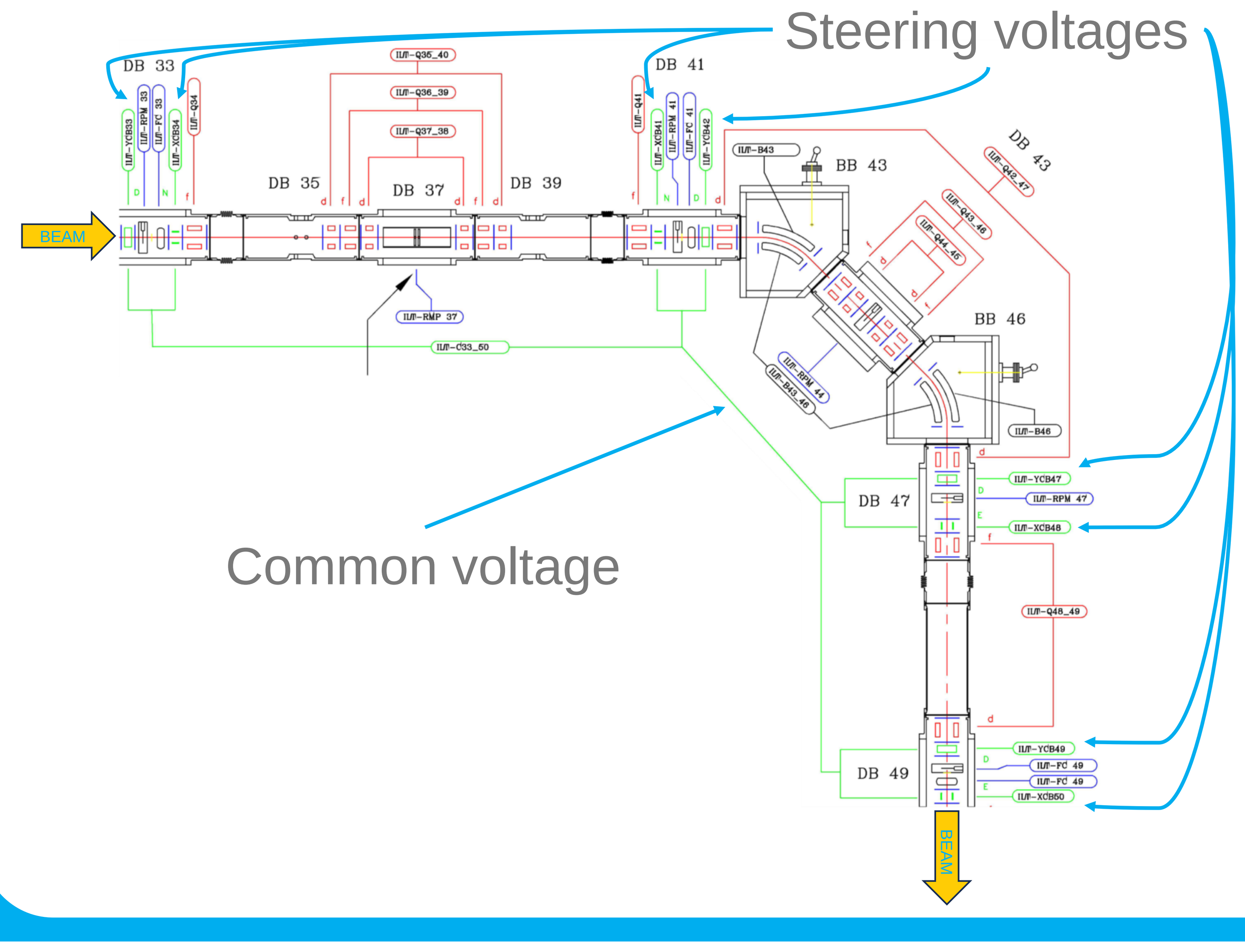
The quadrupole effect is enhanced by

- Increasing parallel plate voltages
- Lowering beam energy

The quadrupole effect can be removed by:

- Changing skimmer apertures to match electrode shape
- Using opposing polarities to steer

The power supplies for the steerers are all unipolar, so to create forces in either direction one plate is held at a constant "common" voltage, and one plate is set variably above or below to steer the beam. Common plates are "common" because they are shared between several sets of steers. Lowering this common voltage is difficult because it effects every steerer connected.



3. BOIS

Bayesian optimization for ion steering (BOIS) is a tool developed at TRIUMF to find optimal steering parameters to maximize beam transmission.

This tuning tool can incorporate additional objectives into solutions, such as finding tunes in reduced parameter spaces and favouring tunes which use less steering.

4. Methods

Steerer lensing removal methods focused on finding a tune with the lowest value possible for common plates. These methods involve "reducing field", which is where across all steerers connected to one common the system is moved to the lowest possible voltage configuration for each plate which preserves the same difference between plates. These included:

1. **BOIS with reduction**

   Tune with BOIS normally → Reduce field after

2. **BOIS with continuous reduction**

   Do one BOIS tuning iteration → Reduce field → loop

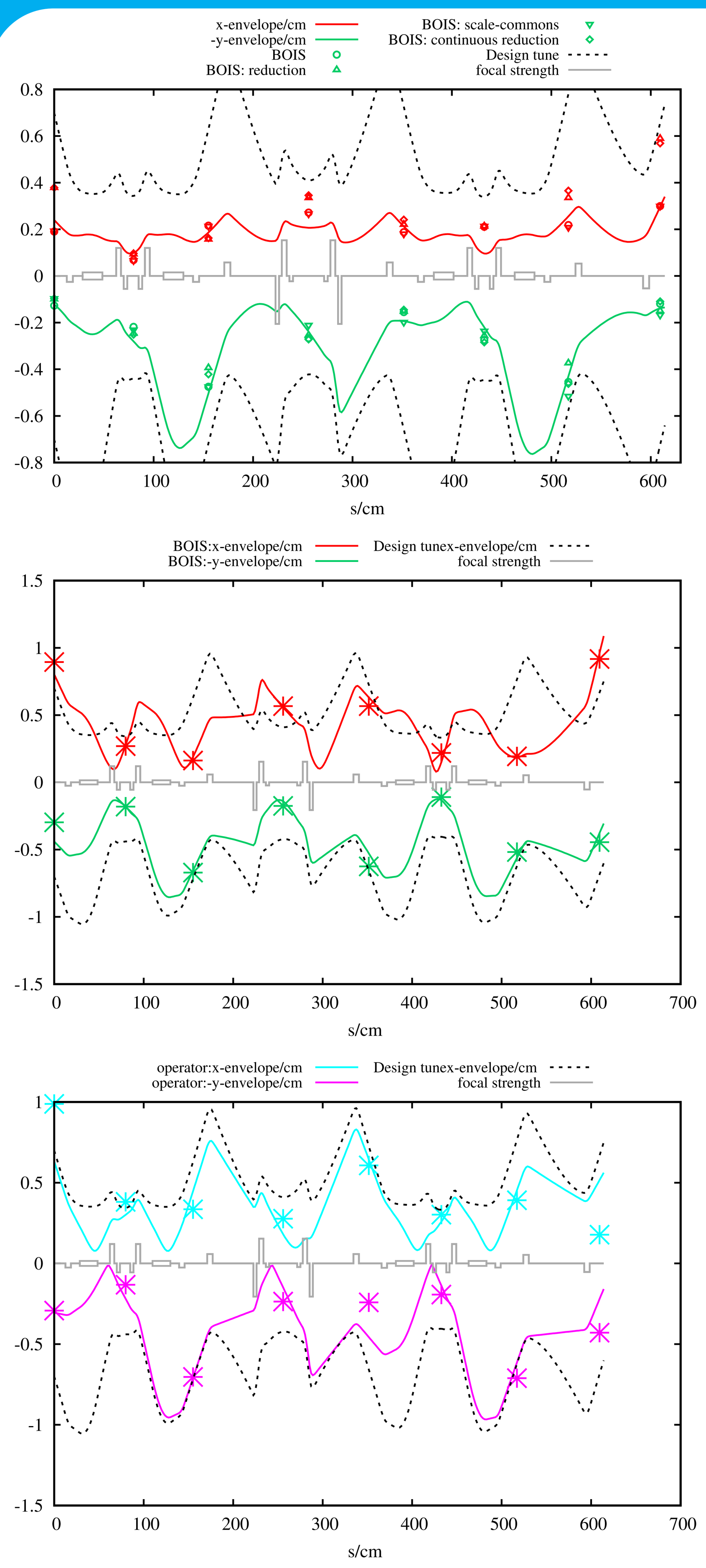
3. **BOIS with scaled commons**

   Include commons in BOIS tune, artificially decrease transmission performance when commons are high

4. **BOIS with smart bounds**

   Reduce field before tuning → Tune with BOIS normally

5. Results



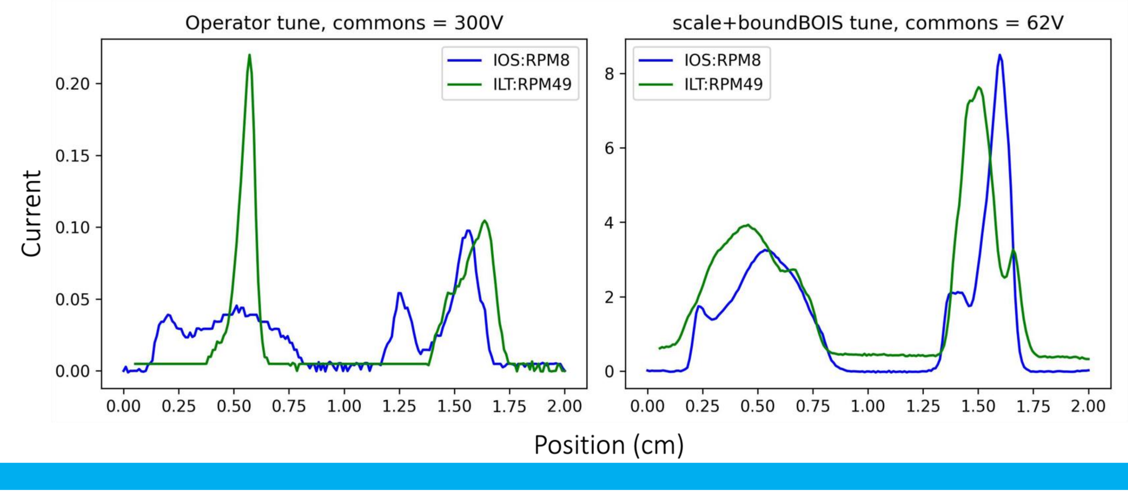
[Top] $^{14}N^{+}$ beam at 28.56 keV/u tuned using three different methods to reduce common plate voltage.
[Middle] $^{7}Li^{+}$ beam at 14.28 keV/u tuned with common plates restricted to 62V.
[Bottom] Operator tune on same conditions, but with commons at 300V.

Beam profiles were fit using a beam envelope code that modeled the beam without any extra lensing from the steerers.

Initial tests on methods 1,2, and 3 could not be fit well by the optics model.

The method with greatest success was reducing common plates before tuning. Lower commons reduces steering range. Accounting for this, steerers were lowered to allow for steering on the order of the beam divergence ($\pm 2 mrad$).

Noticeably, none of the fits match the design tunes. This is because OLIS initial beam conditions are currently not well known. OLIS initial conditions are difficult to extract, and the steerer lensing plays a large role in the disagreement from model.



6. Conclusion

Using BOIS, OLIS beam was tuned at low common voltage and the lensing from the quadrupole effect was greatly reduced. This effect makes modeling beams difficult when high steering is needed, and when beams have low energy. While only tested with OLIS beam to the RFQ, this method can be applied to all electrostatic beamlines.

References

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