Beam Physics Note
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Report On OLIS Quadrupoles 5 and 7

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Abstract: Updated OLIS drawings show a shift in quadrupole IOS:Q5 position, which has been corrected in the `acc/` database. The source data and a `TRANSOPTR` simulation of the consequences of this quadrupole shift upon the design OLIS envelopes is presented, offering a possible explanation for an observation by RIB Operators that quadrupole IOS:Q7 must now be run significantly lower than in the past.

Summary

Using drawing ILE2918 of the OLIS line between the OLIS dipole and IOS:Q7, the latest state of quadrupoles IOS:Q4,5,6 and 7 were measured. This was compared with previously recorded values listed in cite [1] and a significant positional error for IOS:Q5 was found and is shown in Figure 1. A position error of 2.537 cm (0.999") has been found and corrected in acc/, with Q5 now shifted closer to Q4. Further scrutiny is warranted as Q5 may lack its own skimmers, instead using those of its neighbors (Q4,Q6) by design. If Q5 is closer to Q4, this will alter the grounded skimmer to quadrupole electrode distances, which may change the effective length of the quadrupole.

OLIS Element	s-ILE2918 [cm]	optr s [cm]	TRI-BN-20-13R s [cm]
IOS:Q4	25.720	25.720	25.716
IOS:Q5	34.633	37.170	37.166
IOS:Q6	48.621	48.621	48.617
IOS:Q7	94.818	94.819	94.814
	Q5 error [cm]	2.537	
	Q5 error [in]	0.999	

Figure 1: Optical element setpoints for OLIS quadrupoles Q4 to Q7, measured on (**left**) drawing ILE2918, (**center**) previous acc/ database implementation generated TRANSOPTR output file fort1abel and (**right**) Reference [1]. Note that the rightmost value has been rounded to two decimal places in the model/center column.

Possible Explanation for IOS:Q7 Tuneshift?

Operators at ISAC have reported that the operational setpoints for IOS:Q7 suddenly had to change from one run to the next. Operators found that running the normal Q7 settings for delivery would result in drastic transmission losses downstream of IOS:FC6, and that to correct for this, device Q7 had to be significantly lowered in voltage. To understand the effects upon the envelopes, a generic round starting beam spot measuring (x, x') = (0.07 cm,20 mrad) and with $r_{12} = r_{34} = 0$ was used. Figure 2 shows transverse envelopes from SuperNanogan (MCIS) up to position monitor IOS:RPM8, using the original OLIS design tune. The dotted lines show envelopes with the original (unshifted) Q5 position, while solid lines show the new (Δs = -1) Q5 position. Observe the emergence of a prominent horizontal bulge in the envelopes at the approximate location of IOS:Q8, with beam more than doubling in size. In other words, the horizontal beam distribution can exceed the Q8 skimmer aperture of 1" (2.54 cm). In these cases, since quadrupole Q7 is defocusing, reducing its voltage would cause the x-envelope to shrink at Q8, allowing for transmission through the device, shown in Figure 2. Manual correction of this tuneshift is shown in Figure 3, where reduction of IOS:Q7 to about one third of its original value approximately restores the original OLIS tune, at IOS:RPM8, while minimizing the horizontal bulge. Skimmer losses at IOS:Q8 in both figures is shown using TRANSOPTR subroutine SLIT [2], used to represent the 2.54 cm (1") quadrupole skimmer aperture for IOS:Q8. Note that since the envelopes are rms, even though they remain smaller than the skimmer apertures, a beam loss is nevertheless experienced.

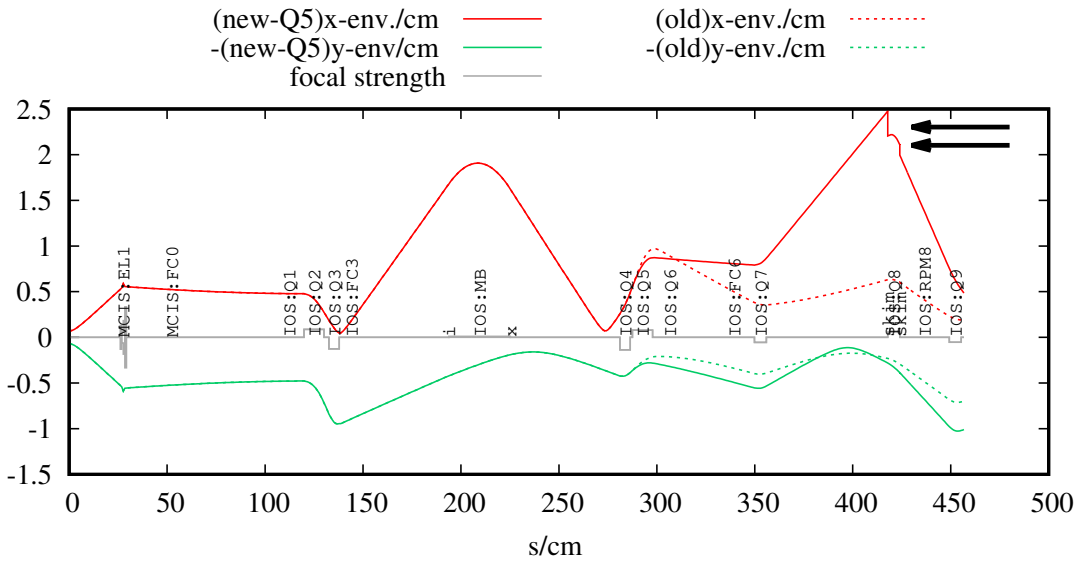

Figure 2: TRANSOPTR simulation of the design OLIS tune for an A/q = 3/2 beam at 30.0 keV, showing transverse beam envelopes for the original Q5 position (dotted lines) and the new, shifted position (solid). Upstream and downstream Q8 skimmer losses are shown with arrows.

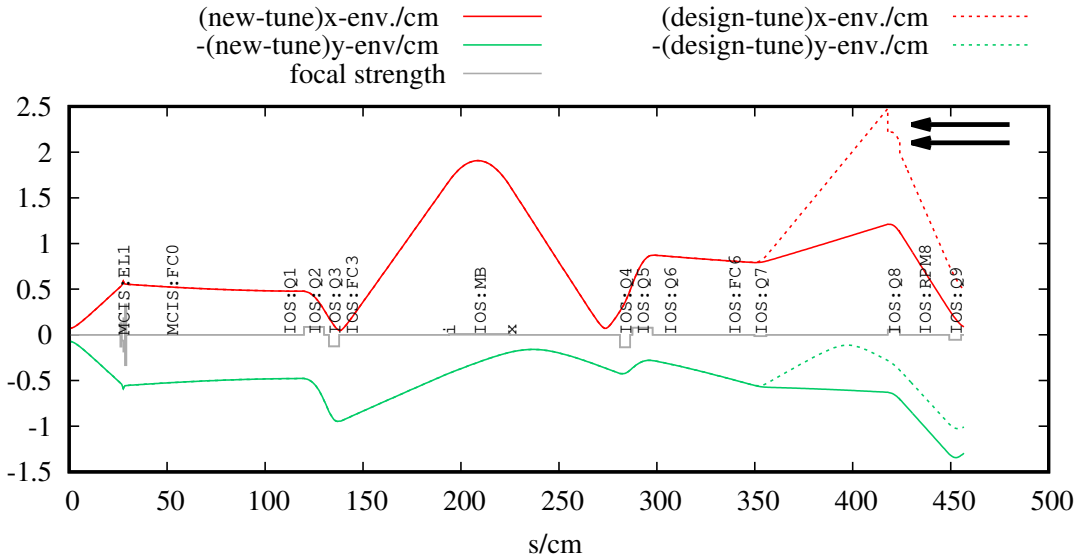

Figure 3: TRANSOPTR simulation of the present OLIS optics for an A/q = 3/2 beam at 30.0 keV, showing the quadrupole Q7 operating at 30% of its original value. Dotted lines show transverse beam envelopes for the original design tune, while a manually established corrective tune, which roughly reproduces the design match at IOS:Q8 is shown as solid lines. Upstream and downstream Q8 skimmer losses are shown with arrows.

References

[1] Olivier Shelbaya. OLIS to RFQ Beam Transport and Acceleration in TRANSOPTR. Technical Report TRI-BN-20-13, TRIUMF, 2020.

[2] Richard Baartman. SLIT routine for TRANSOPTR. Technical Report TRI-BN-19-21, TRIUMF, 2019.