**Beam Physics Note**
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# OSAKA Magnetic Field Deflection

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**Abstract:** In this report, vertical beam deflection as caused by a new permanent magnet at the ISAC-I Osaka experiment is computed in TRANSOPTR. An adjusted tuning strategy is prescribed, if count rates need to be increased at the experiment during beam delivery.

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# OSAKA S1840

The OSAKA experiment has installed a permanent magnet at their apparatus, shown in Figure 1. The final quadrupoles before the experiment are ILE2A:Q8,Q9,Q10 and Q11, which are paired as ILE2A:(Q8,Q11) and (Q9,Q10). For a 30 keV $^{31}Mg^{+}$ run scheduled to start on on 2023-11-29, the Beam Physics Dept. was asked to compute the effects of the new deflection magnet on the beam, and identify any requisite tuning strategies necessary to accomodate this new addition, should vertical adjustment of the beamspot position be required. The polarizer to OSAKA beamline is shown in Figure 4 for reference. **All envelopes shown in this report use 17$\pi\mu$m emittances.**

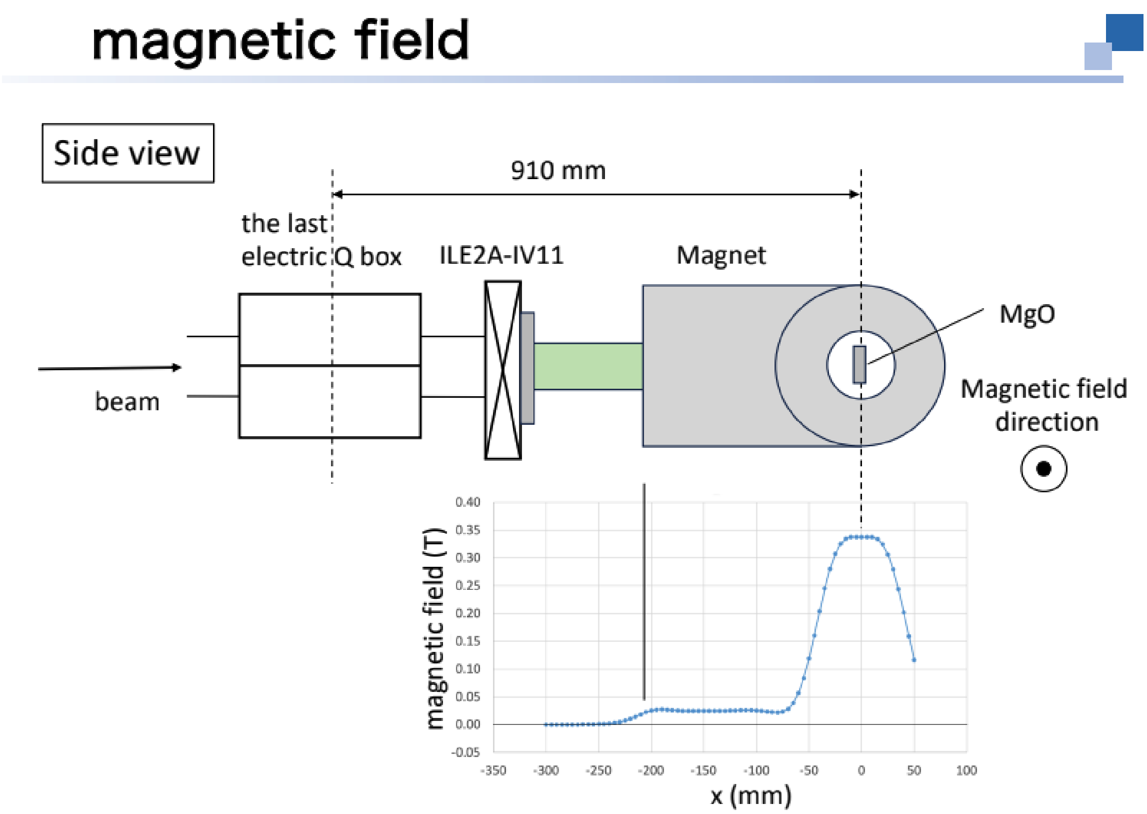


Figure 1: Schematic representation of the ILE2A beamline termination at OSAKA, including a field profile for the new permanent magnet. Magnetic field is oriented along the east-west (horizontal) axis. Image and data courtesy of Prof. H. Nishibata, Kyushu University.

Rick's computed envelopes to OSAKA is shown in Figure 2, while the electrostatic quadrupole settings can be found at this link.

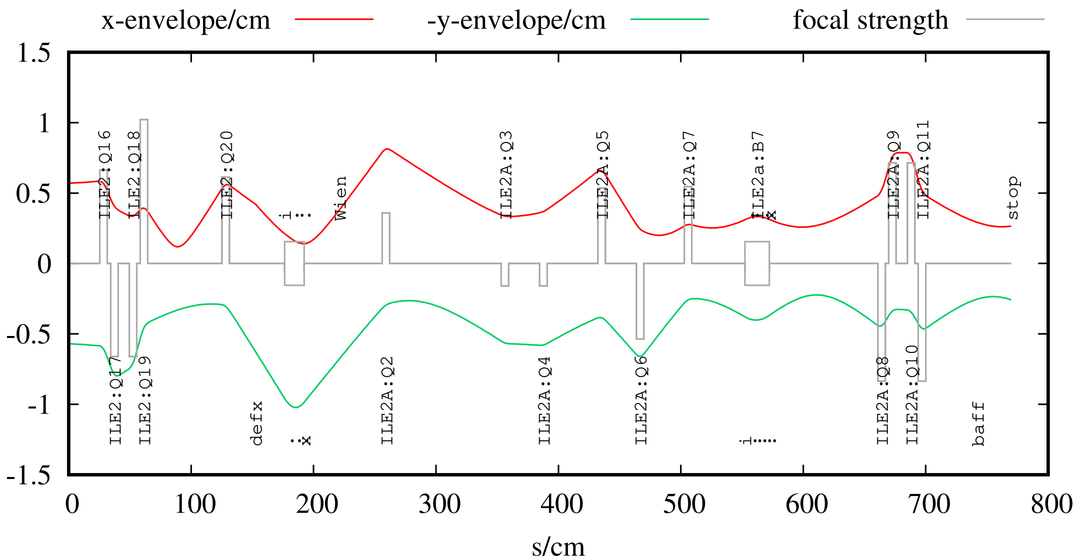


Figure 2: TRANSOPTR envelopes showcasing Baartman's theoretical OSAKA tune for the ILE2/ILE2A line, for which the He cell is unpowered.

| Name | He on | He off |
|---|---|---|
| ILE2:Q16 | 2.027 | 1.135 |
| ILE2:Q17 | 1.494 | 1.226 |
| ILE2:Q18 | 1.494 | 1.226 |
| ILE2:Q19 | 1.445 | 1.905 |
| ILE2:Q20 | .640 | 1.472 |
| ILE2a:Q2 | .696 | |
| ILE2a:Q3 | .309 | |
| ILE2a:Q5 | 1.036 | |
| ILE2a:Q7 | 1.057 | |
| ILE2a:Q8 | 1.616 | |
| ILE2a:Q9 | 1.385 | |

Figure 3: Baartman's commputed quadrupole setpoints used for a 30 keV, charge state 1 beam to OSAKA.

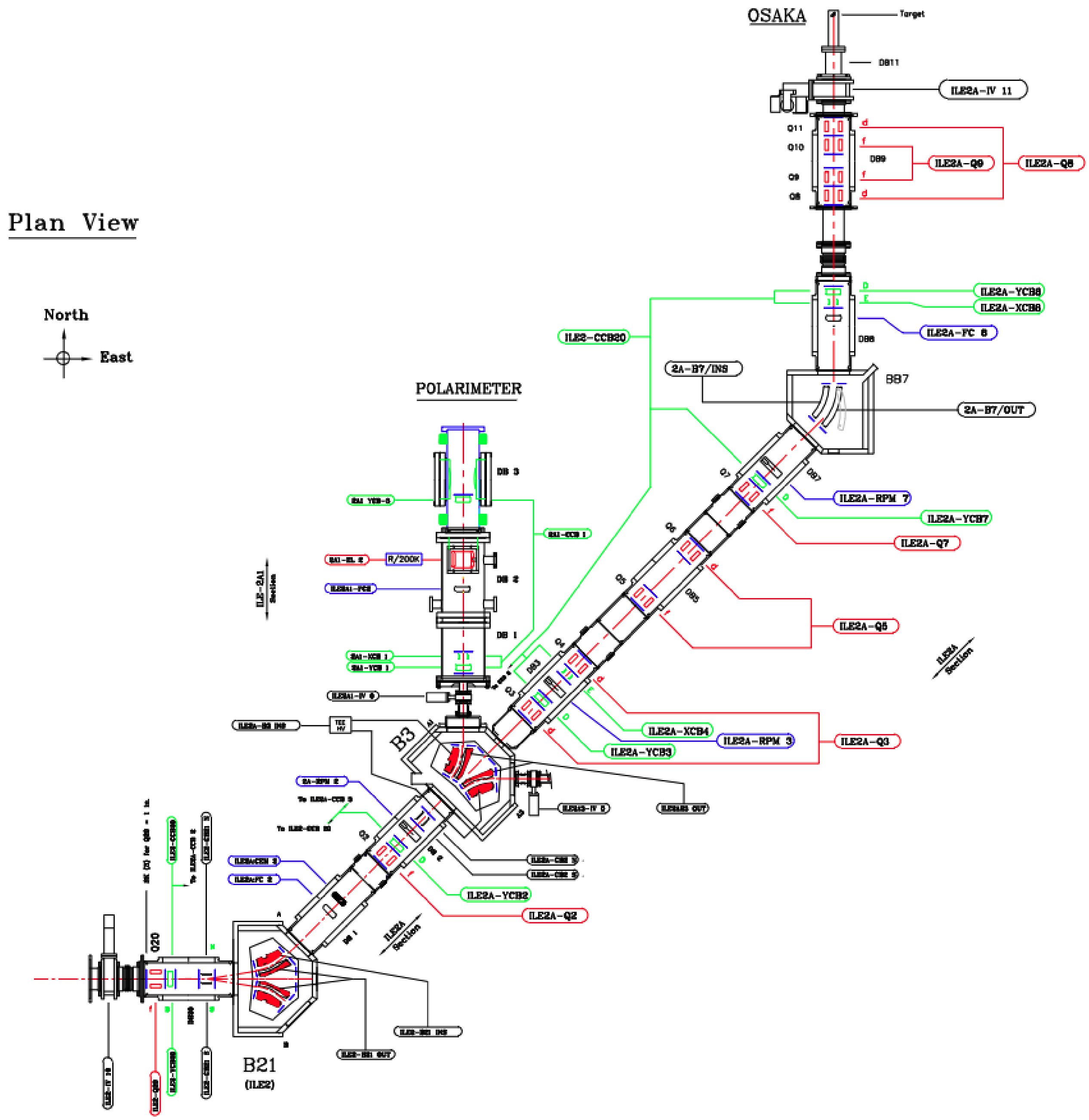


Figure 4: Schematic representation of the polarizer to OSAKA beamline. Beam propagates from bottom left (polarizer exit) to top (OSAKA experiment). Drawing `ISK4253D-rev6`.

# Magnetic Field Deflection

The field shown in Figure 1 was used together with the new TRANSOPTR subroutine strayB[1] for the purposes of centroid offset tracking. **For a 30 keV beam at charge state 1, we expect a vertical deflection of roughly 0.6 cm from the beam axis.**

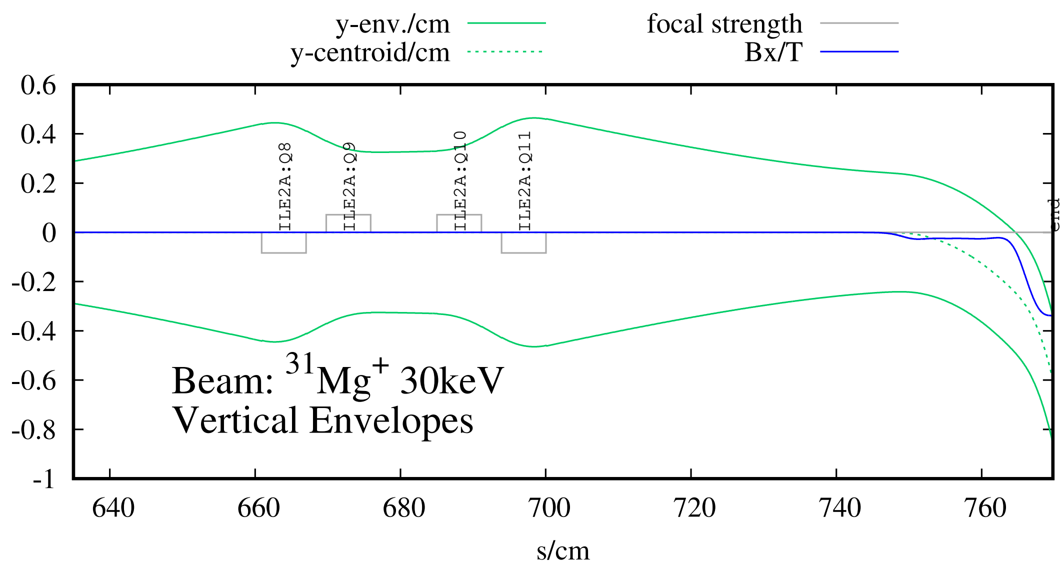


Figure 5: TRANSOPTR envelope simulations showing magnetic deflection of the 2rms vertical beam envelopes due to the field shown at the bottom of Figure 1.

# Tuning Strategy

TRANSOPTR **simulations suggest that using vertical steerers ILE2A:YCB7 and YCB8 should enable correction of the vertical spot location, effectively bringing back the y-distribution on-axis. Thus, these two steerers should be used together to adjust rates on the experiment's end, if necessary.** Simulations suggest that the 1.27 cm skimmer plate apertures in the beamline should not interfere with the vertically displaced beam.

The centroid correction is shown in Figure 6, where ILE2A:YCB7 produces a -6 mrad vertical correction and YCB8 produces a 9 mrad kick. For 30 keV energy and charge state 1, this could correspond to roughly -180 V and 270 V difference between the steerer and common plate voltages.

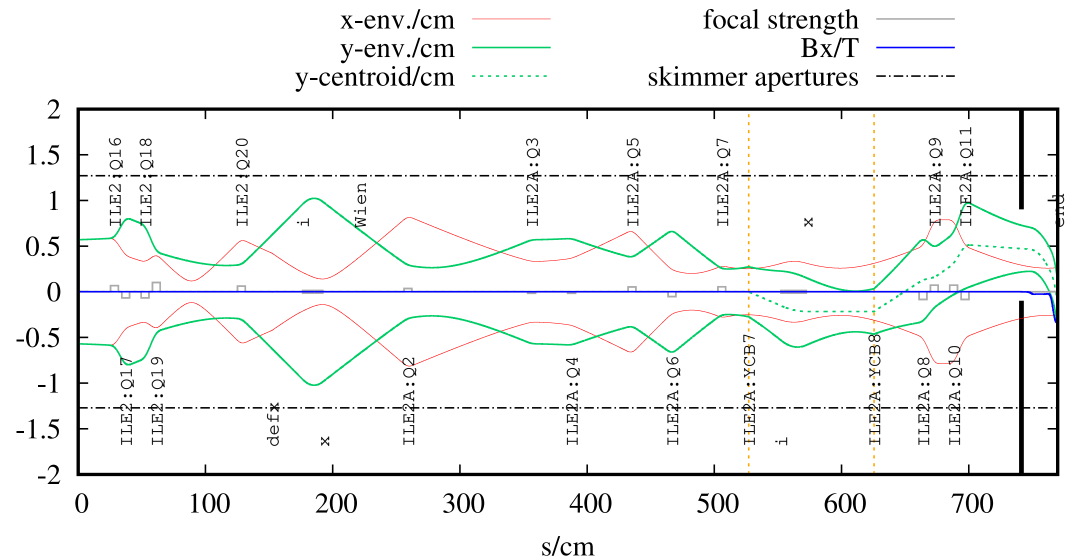


Figure 6: Vertical steerers ILE2A:YCB7 and YCB8 (dotted orange lines on the plot show locations) are used to bring back vertical centroid at experiment on-axis.

## Conclusion

Addition of a permanent deflection magnet at the ISAC-I OSAKA experiment has been simulated in TRANSOPTR and predicts a roughly 0.6 cm vertical beam centroid deflection (downward), for a $^{31}Mg^{+}$ beam at 30 keV energy. Vertical corrective steering using ILE2A:YCB7 and YCB8 should enable vertical correction of the beamspot location at OSAKA, without causing skimmer losses in the transport line.

# References

[1] Thomas Planche, Suresh Saminathan, and Rick Baartman. Stray Magnetic Field in TRANSOPTR. Technical Report TRI-BN-23-19, TRIUMF, 2023. https://beamphys.triumf.ca/~tplanche/text/note/transoptr-externalfield/beam-note.pdf.

# Appendix A: Magnetic Field Distribution used in `strayB`

The data below consists of (s,Bz,Bx,By), with the s-coordinate being in inches, and the magnetic field has been normalized to its peak value, 0.3378 T.

```
0.00000 0.000000 0.0000000 0.00000
0.19685 0.000000 0.0000000 0.00000
0.39370 0.000000 0.0000000 0.00000
0.59055 0.000000 0.0000000 0.00000
0.78740 0.000000 0.0001360 0.00000
0.98425 0.000000 0.0002690 0.00000
1.18110 0.000000 0.0004650 0.00000
1.37795 0.000000 0.0007580 0.00000
1.57480 0.000000 0.0011930 0.00000
1.77165 0.000000 0.0018440 0.00000
1.96850 0.000000 0.0028210 0.00000
2.16535 0.000000 0.0042890 0.00000
2.36220 0.000000 0.0064980 0.00000
2.55906 0.000000 0.0097950 0.00000
2.75591 0.000000 0.0146320 0.00000
2.95276 0.000000 0.0214930 0.00000
3.14961 0.000000 0.0306760 0.00000
3.34646 0.000000 0.0419330 0.00000
3.54331 0.000000 0.0541700 0.00000
3.74016 0.000000 0.0656080 0.00000
3.93701 0.000000 0.0744880 0.00000
4.13386 0.000000 0.0797870 0.00000
4.33071 0.000000 0.0814420 0.00000
4.52756 0.000000 0.0802160 0.00000
```

| | | | |
|---|---|---|---|
| 4.72441 | 0.000000 | 0.0774750 | 0.00000 |
| 4.92126 | 0.000000 | 0.0747251 | 0.00000 |
| 5.11811 | 0.000000 | 0.0729905 | 0.00000 |
| 5.31496 | 0.000000 | 0.0724576 | 0.00000 |
| 5.51181 | 0.000000 | 0.0726944 | 0.00000 |
| 5.70866 | 0.000000 | 0.0731207 | 0.00000 |
| 5.90551 | 0.000000 | 0.0733427 | 0.00000 |
| 6.10236 | 0.000000 | 0.0732598 | 0.00000 |
| 6.29921 | 0.000000 | 0.0730319 | 0.00000 |
| 6.49606 | 0.000000 | 0.0729609 | 0.00000 |
| 6.69291 | 0.000000 | 0.0733131 | 0.00000 |
| 6.88976 | 0.000000 | 0.0741834 | 0.00000 |
| 7.08661 | 0.000000 | 0.0754118 | 0.00000 |
| 7.28346 | 0.000000 | 0.0766255 | 0.00000 |
| 7.48031 | 0.000000 | 0.0773537 | 0.00000 |
| 7.67717 | 0.000000 | 0.0771701 | 0.00000 |
| 7.87402 | 0.000000 | 0.0757878 | 0.00000 |
| 8.07087 | 0.000000 | 0.0731858 | 0.00000 |
| 8.26772 | 0.000000 | 0.0697284 | 0.00000 |
| 8.46457 | 0.000000 | 0.0663776 | 0.00000 |
| 8.66142 | 0.000000 | 0.0650455 | 0.00000 |
| 8.85827 | 0.000000 | 0.0690446 | 0.00000 |
| 9.05512 | 0.000000 | 0.0834012 | 0.00000 |
| 9.25197 | 0.000000 | 0.1144320 | 0.00000 |
| 9.44882 | 0.000000 | 0.1681400 | 0.00000 |
| 9.64567 | 0.000000 | 0.2479570 | 0.00000 |
| 9.84252 | 0.000000 | 0.3525910 | 0.00000 |
| 10.0394 | 0.000000 | 0.4749150 | 0.00000 |
| 10.2362 | 0.000000 | 0.6033150 | 0.00000 |
| 10.4331 | 0.000000 | 0.7251510 | 0.00000 |
| 10.6299 | 0.000000 | 0.8297670 | 0.00000 |
| 10.8268 | 0.000000 | 0.9099440 | 0.00000 |
| 11.0236 | 0.000000 | 0.9626760 | 0.00000 |
| 11.2205 | 0.000000 | 0.9901250 | 0.00000 |
| 11.4173 | 0.000000 | 0.9994580 | 0.00000 |
| 11.6142 | 0.000000 | 1.0000000 | 0.00000 |
| 11.8110 | 0.000000 | 0.9991390 | 0.00000 |
| 12.0079 | 0.000000 | 0.9996000 | 0.00000 |
| 12.2047 | 0.000000 | 0.9986500 | 0.00000 |
| 12.4016 | 0.000000 | 0.9888910 | 0.00000 |
| 12.5984 | 0.000000 | 0.9609890 | 0.00000 |

```
12.7953 0.000000 0.9077510 0.00000
12.9921 0.000000 0.8269810 0.00000
13.1890 0.000000 0.7216400 0.00000
13.3858 0.000000 0.5988570 0.00000
13.5827 0.000000 0.4691220 0.00000
13.7795 0.000000 0.3447970 0.00000
```