Cornell Laboratory for
Accelerator-Based Sciences
and Education (CLASSE)

IOTA OSC Bypass Design

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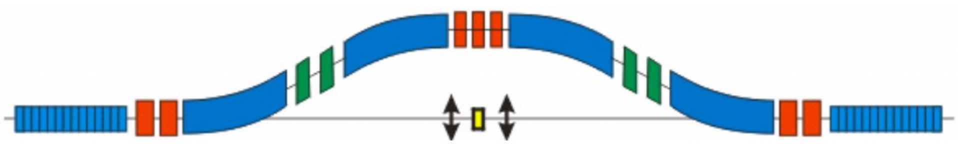
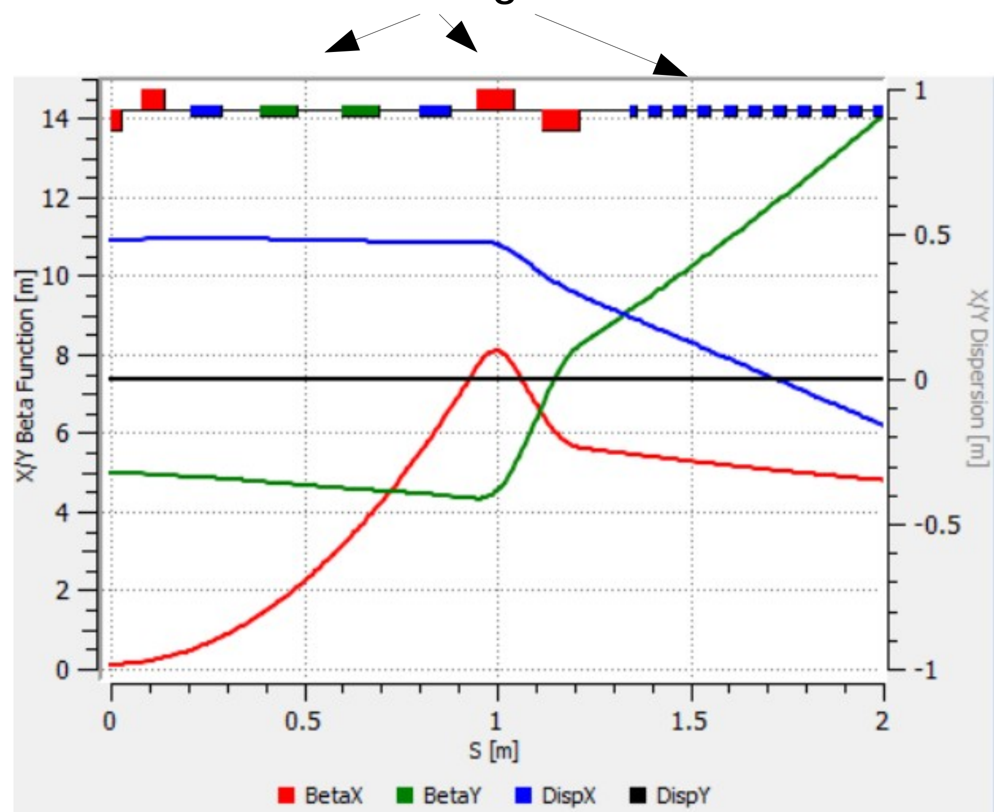
IOTA Optics & Layout



-Note: Element lengths in this diagram are misleading.

These element lengths are correct.



- Effectively: IOTA design treats bypass as an insertion device.

- Simple design, straightforward solutions.
- Easy to parameterize.

- Weak control of M5x terms.
  - EOC not possible.
- Weak control over phase advance between sextupoles.
- Scalability is an open question.
  - Bigger bypass generates more M_{56} -> needs more $\tilde{M}_{56}$ -> requires more central focusing -> reduces acceptances.
- Less flexibility. See above, and limited options for reducing θ^2 lengthening, controlling phase advance, etc.

$$M_{56} \approx 2\Delta s\,,$$

$$\tilde{M}_{56} \approx 2\Delta s - \Phi D^* h\,,$$

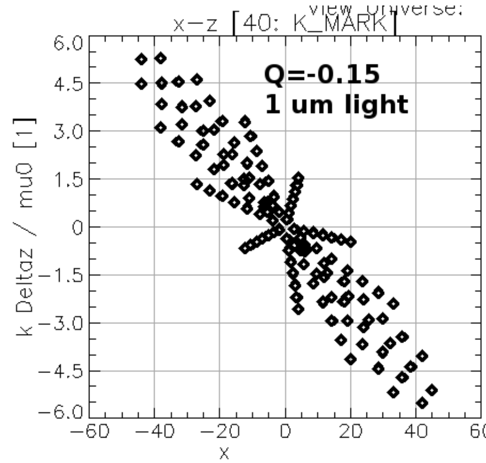
$$\lambda_x / \lambda_s \approx \Phi D^* h / \left(2\Delta s - \Phi D^* h\right),$$

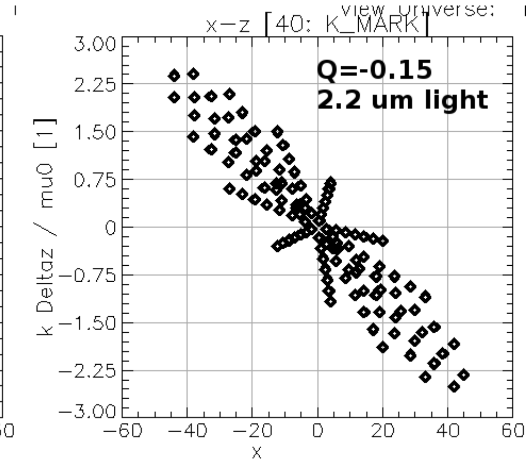
$$n_{\sigma p} \approx \mu_0 / \left(\left(2\Delta s - \Phi D^* h\right) k \sigma_p\right),$$

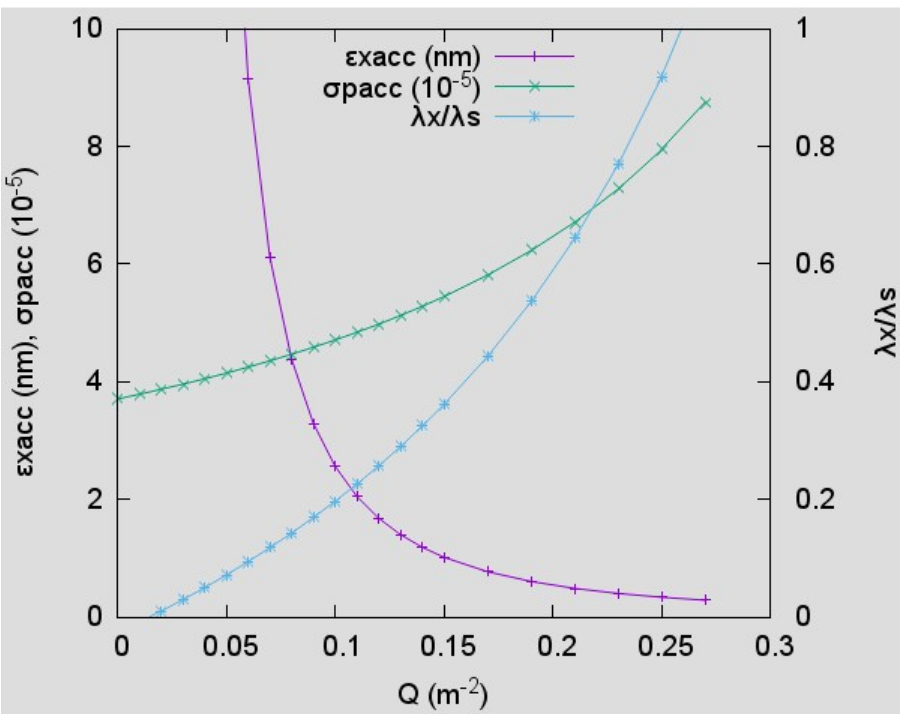
$$n_{\sigma x} \approx \mu_0 / \left(2kh\Phi\sqrt{\varepsilon\beta^*}\right),$$

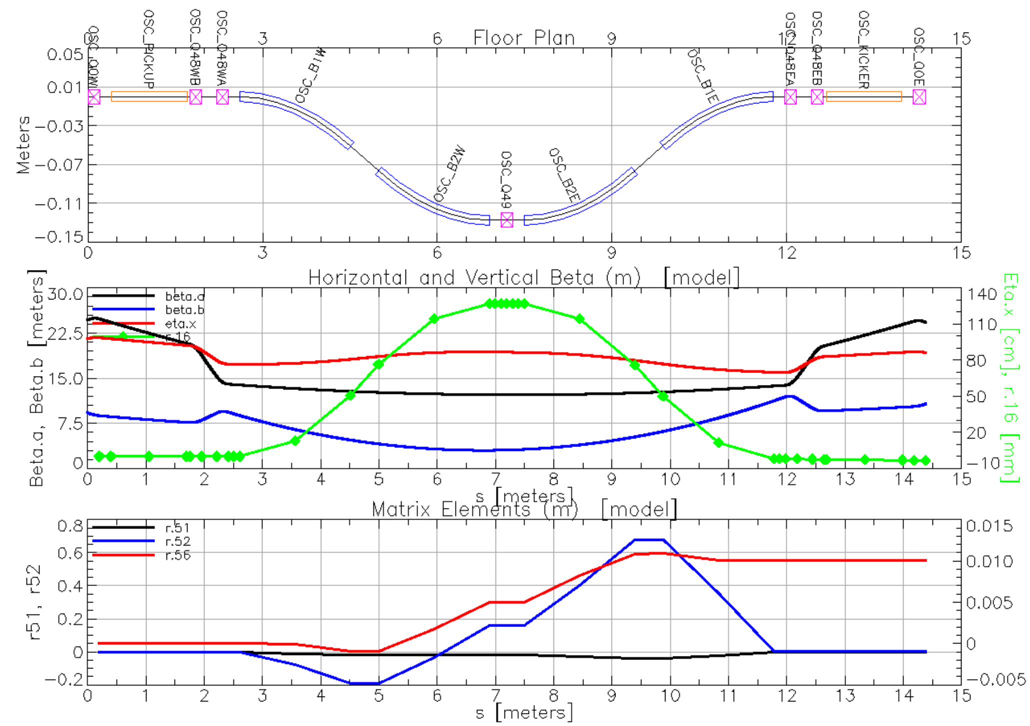
IOTA Design Applied to CESR

- Easy to match: essentially just focusing through a straight.
- M_{56} gets large, requires strong Q49 to shift cooling fraction to transverse.
- Free parameters: Dispersion & Beta at Q49.









Light Wavenumber

- TTOSC emittance acceptance can be increased by using larger λ light.

$$\epsilon_{acc} = \frac{\mu_0^2 \lambda_L^2}{(2\pi)^2 \widetilde{J}} \qquad \sigma_{p,acc} = \frac{\mu_0 \lambda_L}{2\pi \widetilde{M}_{56}}$$

$$\underbrace{\left(\beta_p M_{51}^2 - 2\alpha_p M_{51} M_{52} + \gamma_p M_{52}^2\right)}_{\tilde{J}}$$

$$\underbrace{\left(M_{51} D_p + M_{52} D_p' + M_{56}\right)^2}_{\tilde{M}_{56}}$$

- Note: IOTA (2014) started at 750 μm, switched (2016) to 2.2 μm.

Conclusion

- IOTA design is a light-focusing bypass that effectively treats OSC as an insertion device.
  - i.e. Focus into device, minimal perturbation to lattice optics.
  - Not clear if this can scale to a larger bypass (acceptances seem to vanish), or make good use of additional real estate CESR offers.
- CESR's design has thus far utilized tight-focusing design to control M_{5x} terms (esp M_{56}).
  - In principle, more flexible.
    - Larger delay, scalability, EOC, sextupole compensation.
  - Difficult to match … tight focusing creates large optics derivatives.
  - Need (not just ability) to adjust these: nonlinearities, phase advances, χ-contribution, derivatives through undulators, M_{5x} terms, θ^2 lengthening.