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

OSC Bypass with Moderate Focusing Strength

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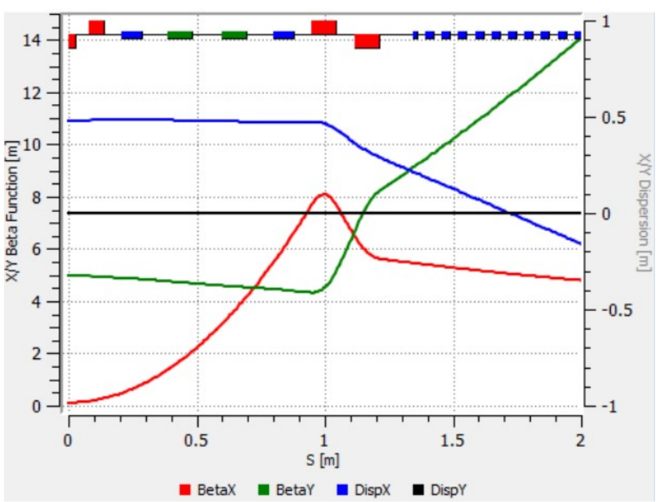
Classifying OSC Bypass Designs

- Classify OSC designs based on focusing strength & manipulation of bypass dispersions.

  1) Weak focusing.
     - IOTA Design
     - No focusing in bypass, aside from central quad.
     - Bypass treated like a drift.
     - Little control over M_{51}, M_{52}, M_{56}.
     - Does not benefit from extra real estate: properties dominated by delay length.
     - Per IPAC conversation: IOTA currently at 2 mm bypass delay w/ 2.2 μm light, considering 1 mm bypass delay w 0.8 μm light.



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

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

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

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

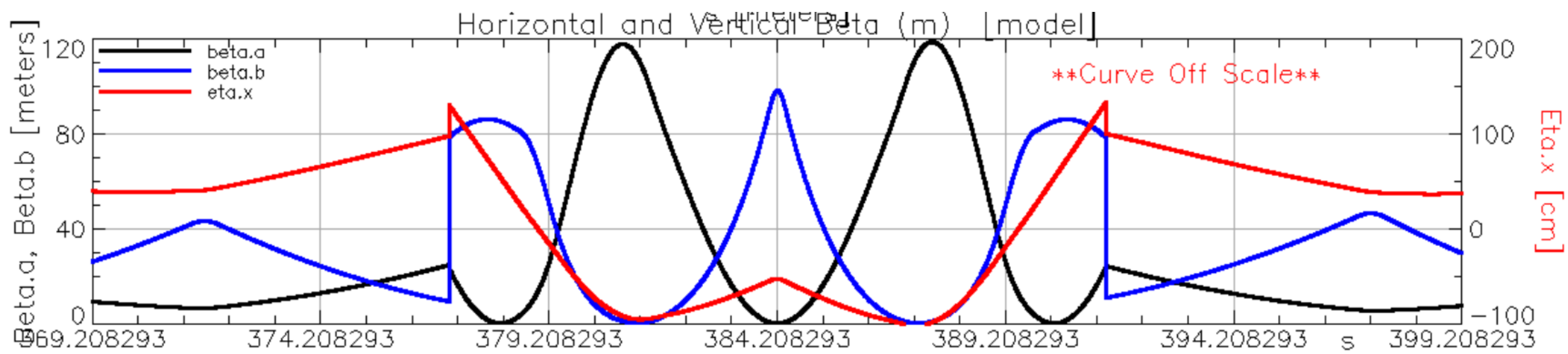
$$n_{\sigma x} \approx \mu_0 / \left(2kh\Phi\sqrt{\varepsilon\beta^{*}}\right),$$

Classifying OSC Bypass Designs

2) Isochronous: strong focusing in legs to make M_{51}, M_{52}, M_{56} zero.

- Needed for EOC.
- Not just zero, but manipulate near zero to control TTOSC parameters.
- Required focusing is large.
  - Large TOF nonlinearities require strong sextupoles
- Not easily incorporated into storage ring
  - Big optics derivatives, big chromaticity, big nonlinearities.
  - Additional constraints imposed on dispersion & phase advance through bypass.
- Big optics derivatives also mean optics only optimal for OSC for short segment of wigglers.

typical strong focusing result with large derivatives



Middle approach

3) Focusing in legs, control M_{51} & M_{52}, but not M_{56}.

- Focus M_{52} small.
- Take M_{56} as is.
- Manipulate M_{51} to obtain desired damping envelope.

$$\widetilde{J} = \beta_p M_{51}^2 - 2\alpha_p M_{51} M_{52} + \gamma_p M_{52}^2$$
$$\widetilde{M}_{56} = M_{51} D_p + M_{52} D_p' + M_{56}$$

small M_{52} →

$$\widetilde{J} \approx \beta_p M_{51}^2$$
$$\widetilde{M}_{56} \approx M_{51} D_p + M_{56}$$

OSC envelope no longer depends on optics derivatives

OSC Envelopes given by:

$$\epsilon_{max} = \frac{\mu_0^2 \lambda_L^2}{4\pi^2 \widetilde{J}} \qquad \sigma_{p,max} = \frac{\mu_0 \lambda_L}{2\pi \widetilde{M}_{56}}$$

Maximize $\sigma_{p,max}$: $M_{51} = \frac{-M_{56}}{D_p}$

Notice emittance envelope is determined: $\epsilon_{max} = \left(\frac{\mu_0 \lambda_L}{2\pi}\right)^2 \frac{1}{\beta_p M_{51}^2}$

For storage ring optics: want small β_x, big D_x , to minimize M51, and maximize ε_{acc}.

Middle approach (back of envelope)

- Incoming optics (not optics at pickup):
  - $\beta_x = 24.7$ m
  - $D_x = 0.98$ m
- Bypass $M_{56} = 7.3\ 10^{-3}$

$$M_{51} = \frac{-M_{56}}{D_p} = -7.4 \times 10^{-3}; \text{ This makes } \sigma_{p,max} \text{ big.}$$

$$\epsilon_{max} = \left(\frac{\mu_0 \lambda_L}{2\pi}\right)^2 \frac{1}{\beta_p M_{51}^2} = (9.38 \times 10^{-14}) \frac{1}{\beta_p M_{51}^2} = 71.3\text{pm}$$

0.8 μm light

Just back of envelope number.

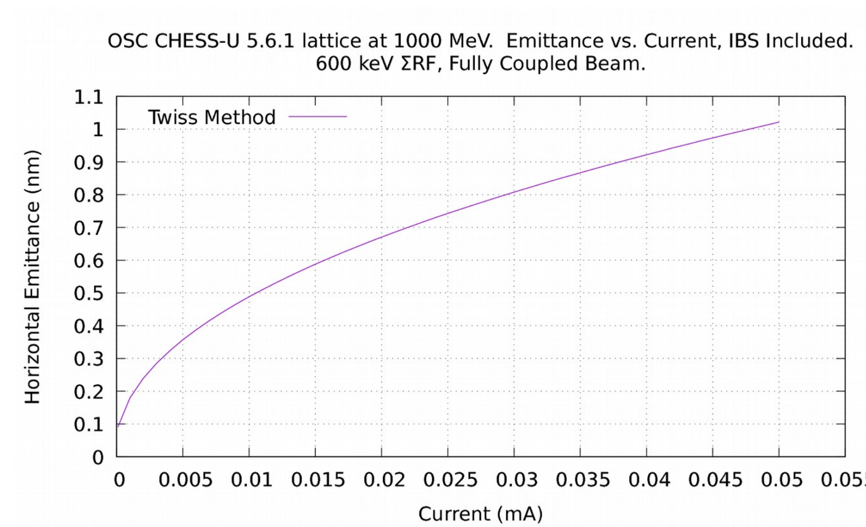
damping rates

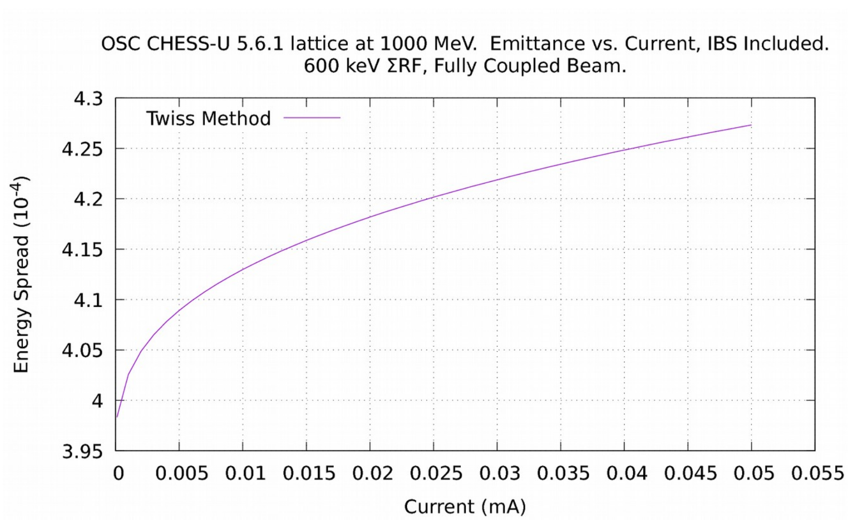
$$\lambda_x = \frac{k\xi_0}{2}\left(M_{56} - \tilde{M}_{56}\right)$$
$$\lambda_s = \frac{k\xi_0}{2}\tilde{M}_{56}$$

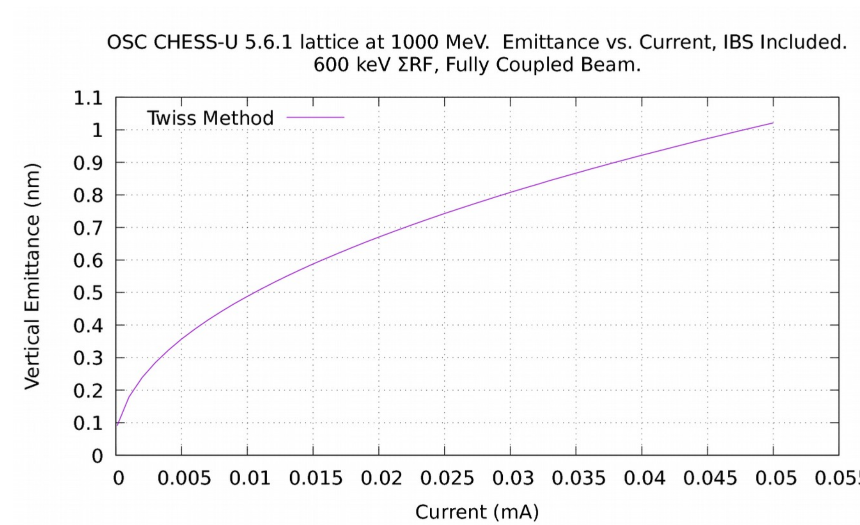
$\lambda_x = 28835\ \xi_0$ turns^{-1}, for $\xi_0 = 10^{-10}$, get ~350,000 turns damping time

Intrabeam Scattering

- 10 μA → $\varepsilon_x = \varepsilon_y = 500$ pm
- Fit in undulators?
  - If $\beta_y = 5$ m, then $\sigma_y = 50$ μm
- Coupling method: tune to coupling resonance, broaden resonance width with skew quads it needed … Add to MS program

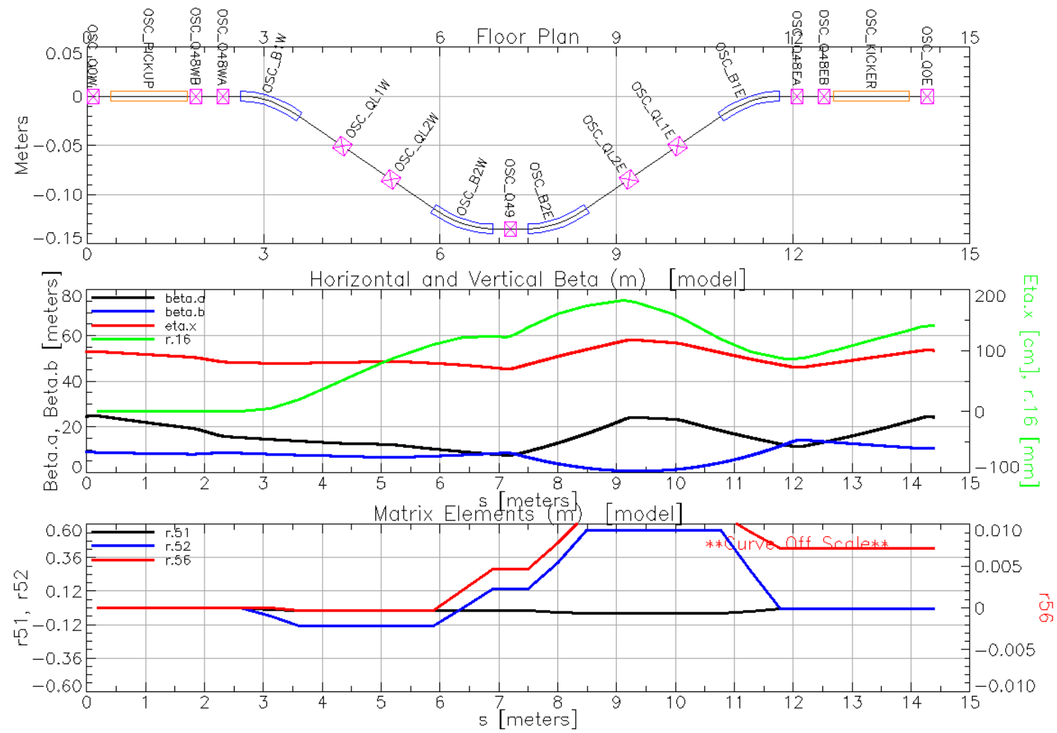






Bypass Design

- $M_{52} = 8\ 10^{-9}$
- $M_{56} = 7.1\ 10^{-3}$
- $M_{51} = -7.6\ 10^{-3}$
- Actual $\sigma_{p,max}$= 29.
  - Yes, twenty-nine.
- Actual $\varepsilon_{x,max}$= 74 pm



- This bypass is a drop-in match to CESR.
- 5 mm delay.

Note: With these β_x and D_x concerns in mind, Jim is working on a new 1 GeV CHESS-U OSC lattice.

Perhaps β_x = 10 m and D_x = 2 m is obtainable.

Back of envelope yields: $\varepsilon_{x,max}$ = 1 nm (7.6 nm with 2.2 μm light)

Conclusions

- Middle approach is distinct from IOTA design and overcomes shortcomings of IOTA design.
- Storage ring properties are critical.
  - Incoming β_x & η_x.
  - IBS at 10 μA (500 pm x & y)
  - Round beam necessary
    - Should add coupling resonance studies to machine studies.
- New 5.6.3 based CHESS-U 1 GeV lattice in works
  - 2 or 3 times ε_x acceptance @ 0.8 μm light.
  - colossal σ_p acceptance (although no σ_p damping)