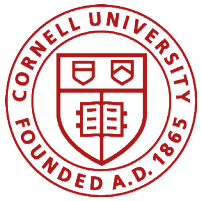


Cornell Laboratory for
Accelerator-Based Sciences
and Education (CLASSE)

Intrabeam Scattering in OSC Lattice

Michael Ehrlichman

Intrabeam Scattering Reminder

- Bunch-charge dependent emittances.
- Due to emittance, particles scatter off each other, transferring momentum between the bunch dimensions.
  - Scattering in dispersive regions particularly important: closed orbit jumps for scattered particles.
- Seen in CESR as a growth rate that competes with radiation damping & excitation to create new, generally larger, beam emittances.
- Growth rates scales roughly as $1/\gamma^4$.
- Dispersion makes it worse.
- Unlike SR growth & damping, IBS growth rates depend (nonlinearly) on emittance.
  - Iteration is required to find equilibrium.

IBS Theories & Beam Envelope

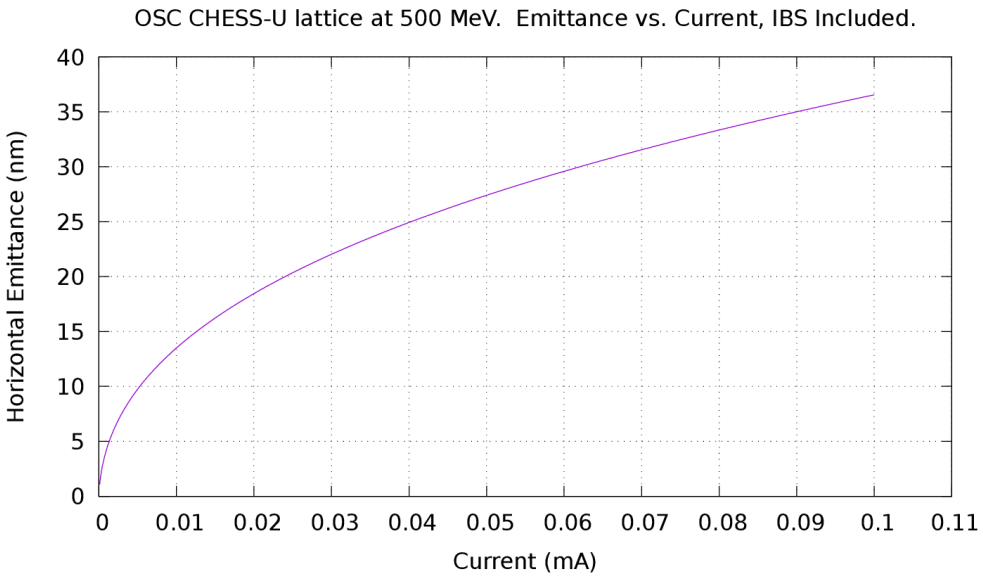
- Twiss Based: Piwinski or Bjorken/Mtingwa.
  - Many descendants exist of these two.
- Sigma-Matrix Based
  - General to arbitrary linear coupling conditions.
  - Solution can be found by:
    - Iterating analytic equations
    - Envelope tracking
  - **NOTE**: New to Bmad!
    - CesrTA IBS work had invoked a “Twiss wrapper”
    - Bmad now contains a native beam-envelope based, “Twiss Free” synchrotron radiation & intrabeam scattering modules.

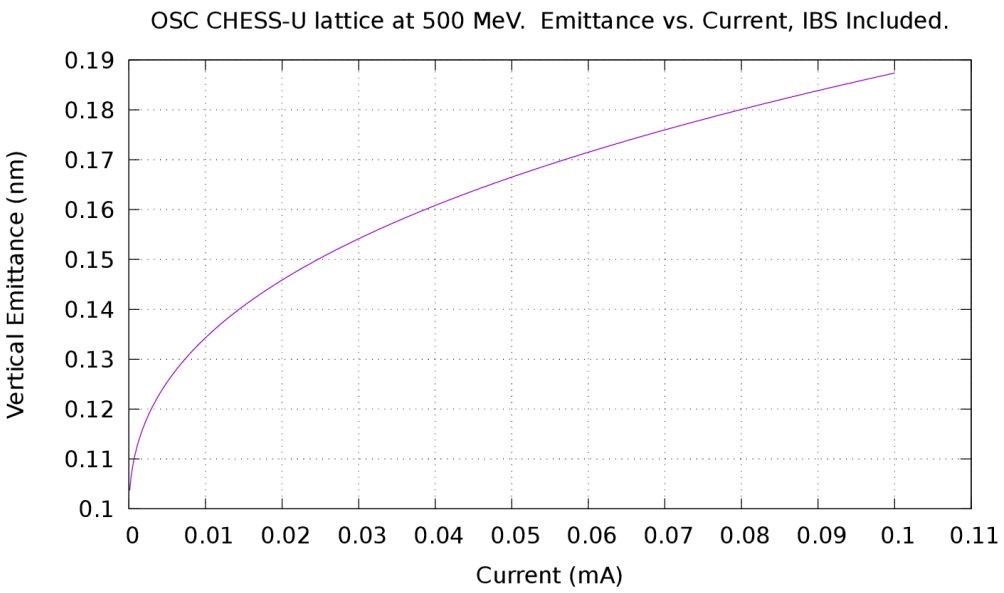
      1) **envelope_mod.f90**

Calculation Parameters

- chess-u_500mev_20170907_Rev5.6.1_10ccu
  - chess-u_6000mev_20170815_Rev5.6.1.lat
  - Simple periodic model for KYMA undulators
  - 500 MeV
  - 6 MV total RF (1.7 mm bunch length)
  - 1 cm RMS η_y (pluged in to IBS formulas)
- Following slide used Bjorken/Mtingwa's method, but to leading order, particular IBS theory is not significant.

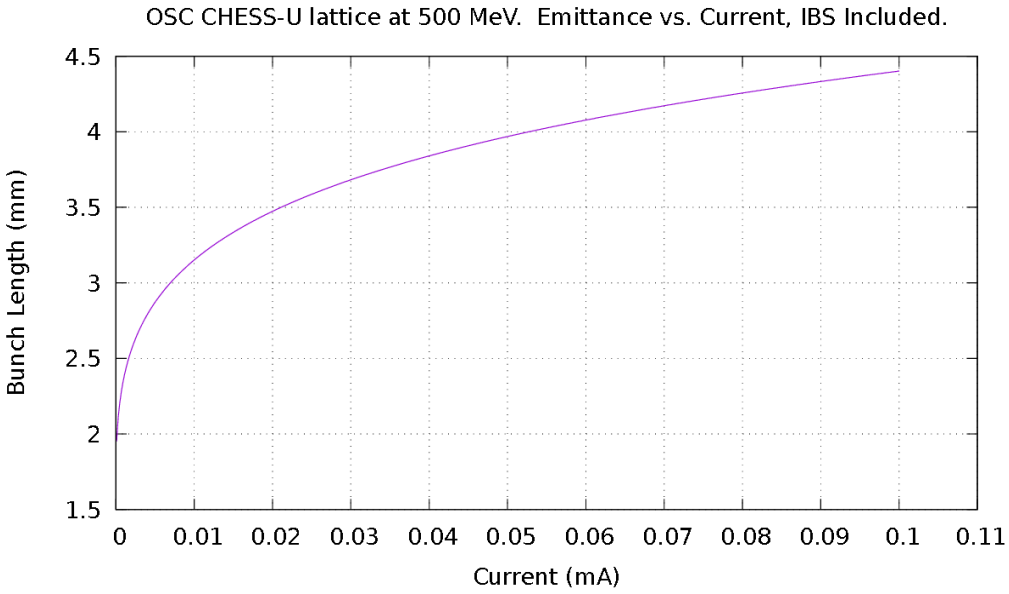
IBS Curves





- ε_x increases 2589 x SR emittance.

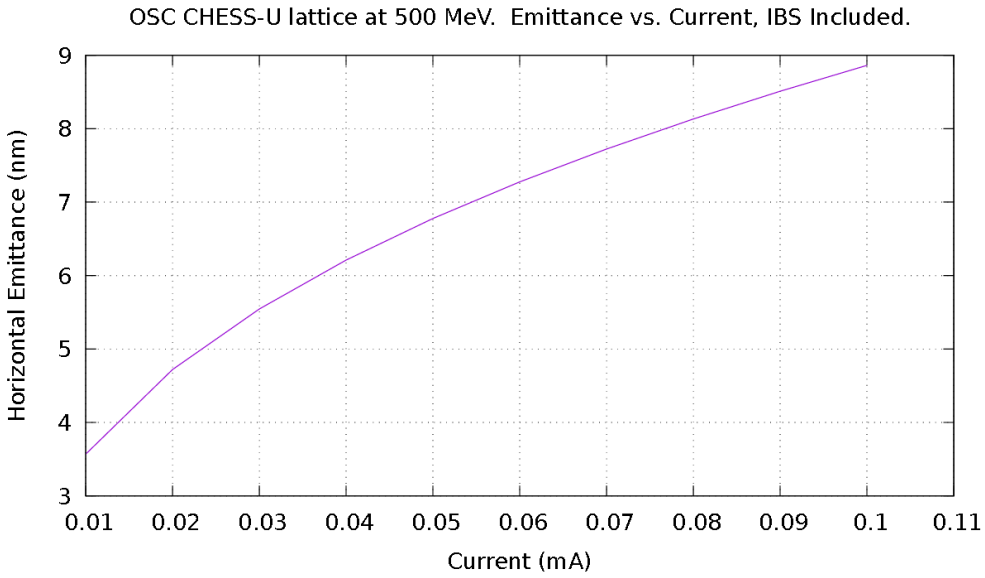
```
Beam parameters from radiation calculation:
   emit_a      :   1.41E-011
   emit_b      :   1.07E-013
   sigmaE_E    :   2.93E-004
   sigma_z     :   1.73E-003
User-adjusted beam parameters at zero current:
   emit_a      :   1.41E-011
   emit_b      :   1.00E-010
   sigmaE_E    :   2.93E-004
   sigma_z     :   1.73E-003
Beam parameters at full current with IBS:
   emit_a      :   3.65E-008
   emit_b      :   1.87E-010
   sigmaE_E    :   7.44E-004
   sigma_z     :   4.40E-003
```

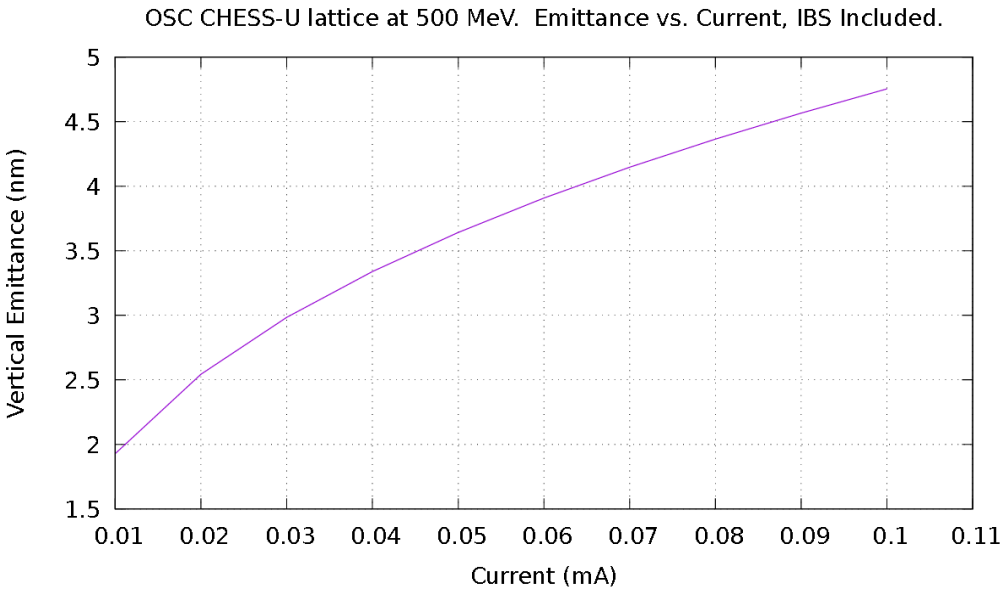


Strong Coupling & Lower RF

- Try to mitigate IBS with coupling and lower RF
  - Tilt quads to couple beam emittances.
    - “Roundish Beam”
    - Good: Larger beam volume reduces scattering rate.
    - Bad: generates vertical dispersion, which increases IBS & SR excitation.
      - Coupled lattice should be designed to couple beam with minimal impact to vertical dispersion.
  - Decrease RF voltage from 6 MeV to 4 MeV to lengthen bunch.

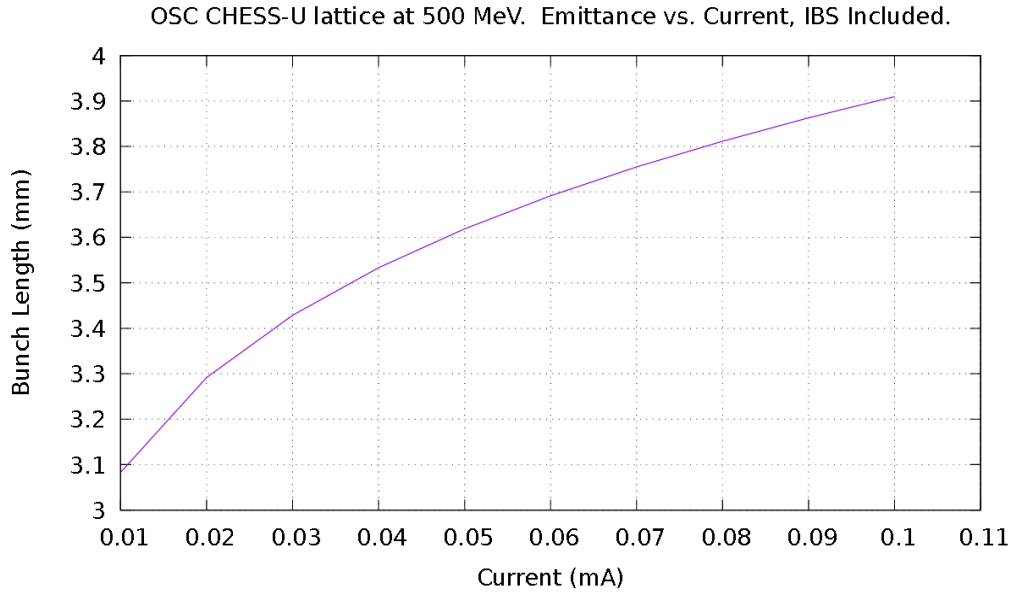
Trial Attempt at IBS Mitigation (coupling + reduced RF)





Equilibrium at 0.1 mA

	6 MV	4 MV
ε_x (nm)	9.6	8.9
ε_y (nm)	5.1	4.8
σ_z (mm)	3.3	3.9



To Note

- Large emittance vs current slope could be problem if lifetime is short.
  - Need Touschek & RGS calculations.
- Determining RF voltage flexibility requires momentum aperture & Touschek study.
- OSC bypasses have been evaluated assuming 50 pm emittances.
- Mitigation study should use more carefully designed coupling method.