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# PS Injection Bump Tune Swing Simulations

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# Injection Bump: Motivation

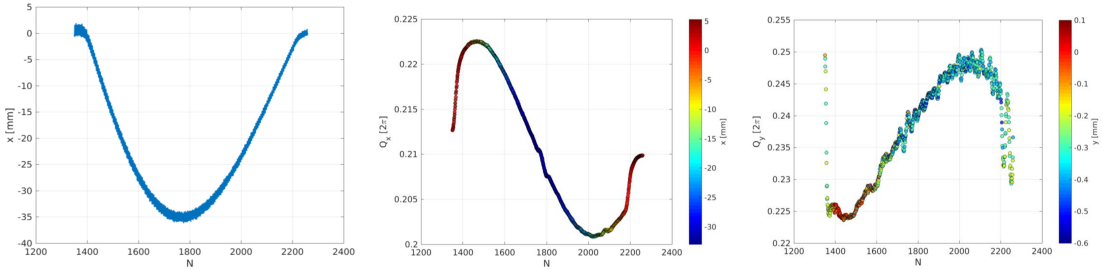



**Figure:** Measured closed orbit horizontal bump (left), horizontal tune (middle), and vertical tune (right), in 2018. **Measurements show tune swing caused by sextupolar components in BSW magnets**. Implement in MAD-X/PTC and thus create tables for PTC in PyORBIT.

PS: Measurements for the Linear Optics Model, P. Zisopoulos et. al., 2nd Space Charge Collaboration Meeting, 12.03.18.

# Injection Bump Closure: Implementation

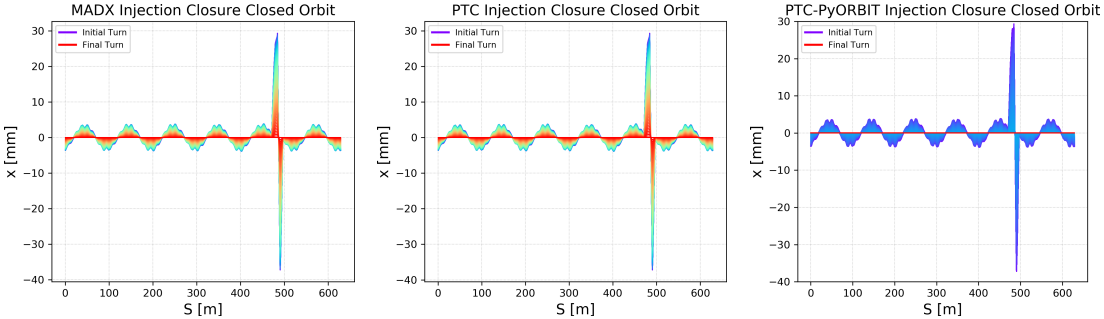
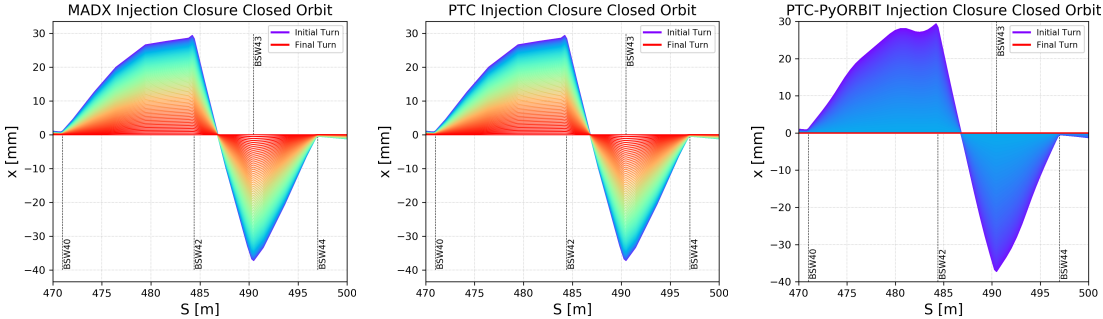



**Figure:** Closed orbit for injection bump closure comparing MAD-X (left), PTC (middle), and PTC-PyORBIT (right).

# Injection Bump Closure: Implementation

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# Injection Bump Tune Swing: Implementation

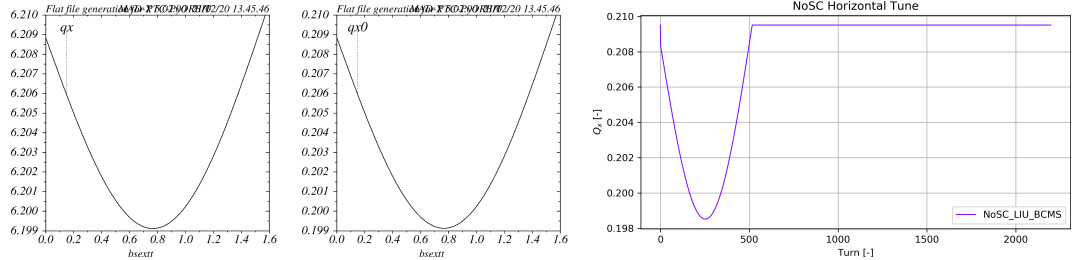



**Figure:** Horizontal tune $Q_x$ for injection bump closure comparing MAD-X (left), PTC (middle), and PTC-PyORBIT (right).

# Injection Bump Tune Swing: Implementation

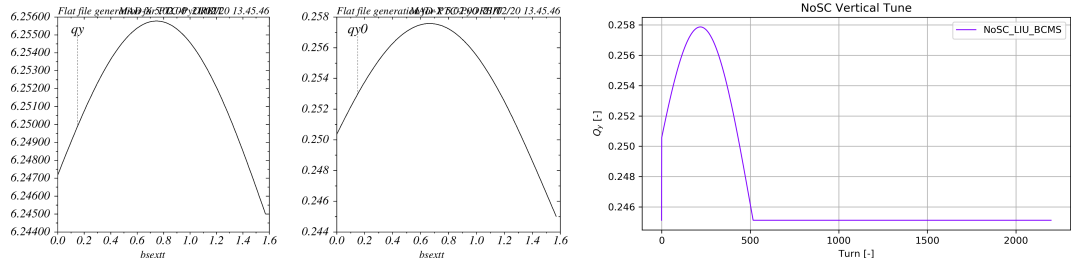



**Figure:** Vertical tune $Q_y$ for injection bump closure comparing MAD-X (left), PTC (middle), and PTC-PyORBIT (right).

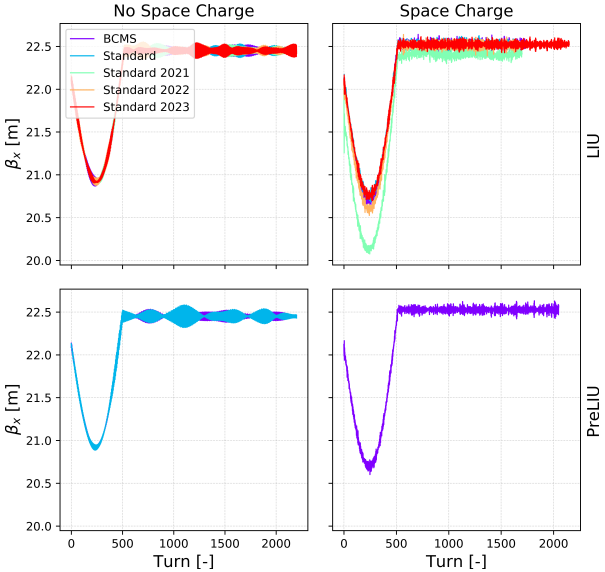
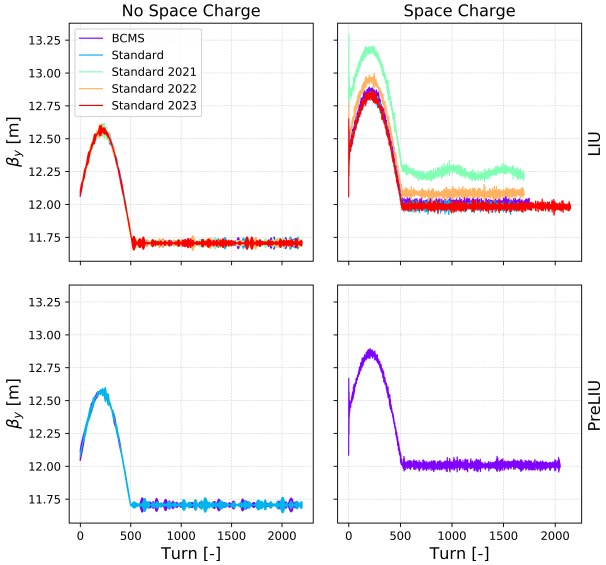



**Figure:** Horizontal beta function $\beta_x$ as calculated from the bunch in PyORBIT.

Left column using no space charge, right column using slice-by-slice PIC space charge. Top row for LIU beams, bottom row for PreLIU beams.

The effect of the injection bump is evident from turn 0 - 500.

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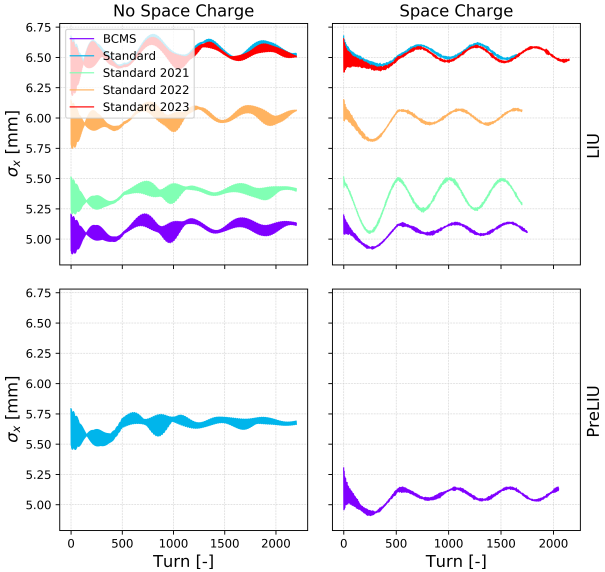


**Figure:** Horizontal Beam size $\sigma_x$ as calculated from the bunch in PyORBIT.

Left column using no space charge, right column using slice-by-slice PIC space charge. Top row for LIU beams, bottom row for PreLIU beams.

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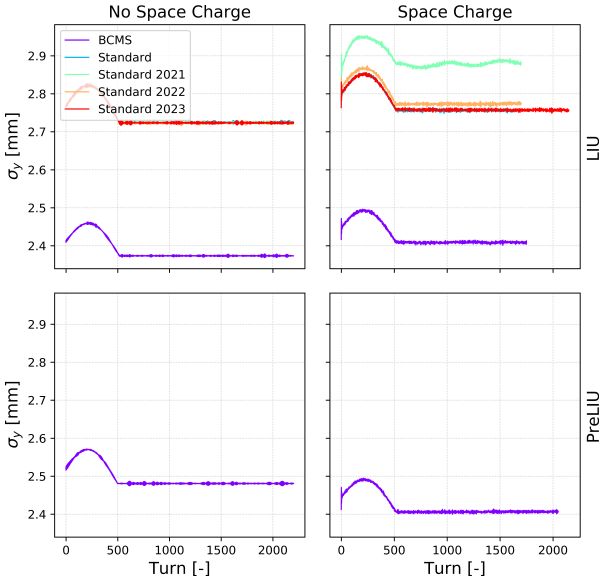


**Figure:** Vertical Beam size $\sigma_y$ as calculated from the bunch in PyORBIT.

Left column using no space charge, right column using slice-by-slice PIC space charge. Top row for LIU beams, bottom row for PreLIU beams.

The effect of the injection bump is evident from turn 0 - 500. Only LIU Standard 2021 shows beam size growth.

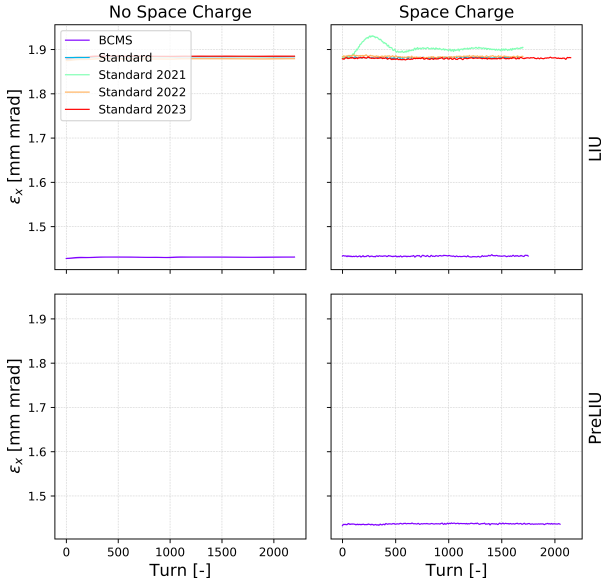


**Figure:** Horizontal normalised RMS emittance $\epsilon_x$ as calculated from the bunch in PyORBIT.

Left column using no space charge, right column using slice-by-slice PIC space charge. Top row for LIU beams, bottom row for PreLIU beams.

The injection bump tune swing causes horizontal emittance growth in LIU Standard 2021 only.

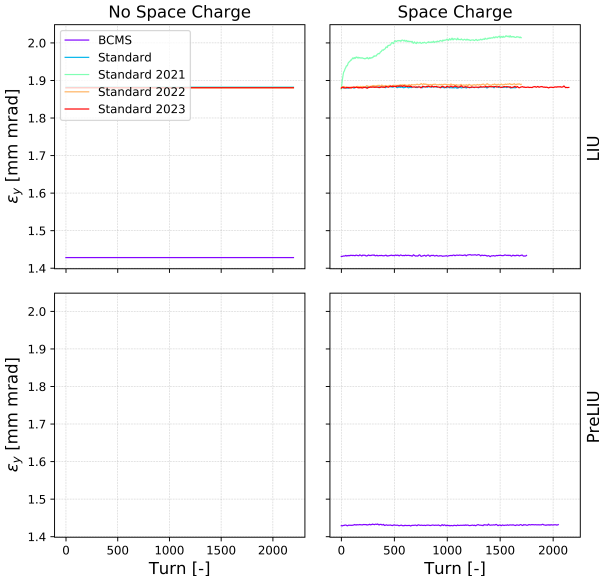


**Figure:** Vertical normalised RMS emittance $\epsilon_y$ as calculated from the bunch in PyORBIT.

Left column using no space charge, right column using slice-by-slice PIC space charge. Top row for LIU beams, bottom row for PreLIU beams.

The injection bump tune swing causes vertical emittance growth in LIU Standard 2021 only.

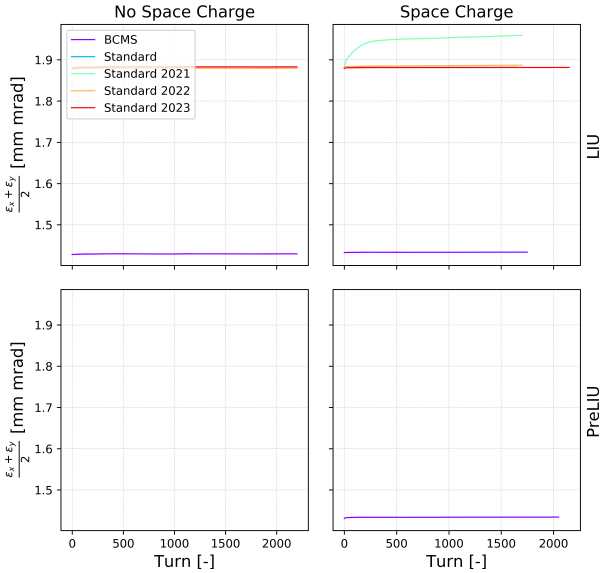


**Figure:** Average normalised RMS emittance $\frac{\epsilon_y+\epsilon_x}{2}$ as calculated from the bunch in PyORBIT.

Left column using no space charge, right column using slice-by-slice PIC space charge. Top row for LIU beams, bottom row for PreLIU beams.

The injection bump tune swing causes average emittance growth in LIU Standard 2021 only.

## Conclusion

## Acknowledgements

# Conclusion

**What have we learnt?**

- Injection bump tune swing modelled in MAD-X, PTC, PTC-PyORBIT by applying Sextupole field as an error on the BSW bumpers.
- The effect of the bump on the beam is evident, yet in all previously stable cases, the beam remains stable.
- Only the 2021 LIU Standard beam parameters show emittance growth - this is present without the bump also.
- We conclude that the injection bump and resulting tune swing has negligible effect on the beam for the simulated cases.
- Working examples can be found on GitHub: https://github.com/HaroonRafique/PS_LIU_Tunespread/tree/master/11_Injection_Bump.

Conclusion

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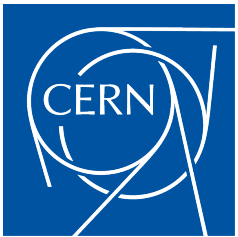
**“If I have seen further it is by standing on the shoulders of Giants” - Newton**


- E. Senes: Original MAD-X tune swing work.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