
CERN

PS Space Charge Simulations

Updates

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Table of Contents

MD4224 Injection Bump

PS Transfer

Methods Explored

At each of the four sections (40, 42, 43, 44) in the PS we use:

- Two 10 cm HKICKER with MULTIPOLE inbetween for the sextupole component.
- A single zero-length MULTIPOLE with dipolar and sextupolar components.
- A single 20 cm (zero gradient) QUADRUPOLE with dipolar and sextupolar components added as errors.
- A single 20 cm (zero angle) SBEND with dipolar and sextupolar components added as errors.

Issues

- Make sure to update PTC and PyORBIT every turn.
- Include calls to correct PTC files (energize lattice, update twiss, read final settings etc).
- Unknown environment bug on LXPlus and HPC-Batch: causes simulation to run without updating PTC every turn - for unknown reason. Now seems to work - not satisfied with not knowing more - will keep an eye out for future wierdness.
- Dipole component needed to be normalised when used in QUADRUPOLE and SBEND methods.

Horizontal Closed Orbit Maximum and Minimum

Extrema of the closed orbit as a function of turn.

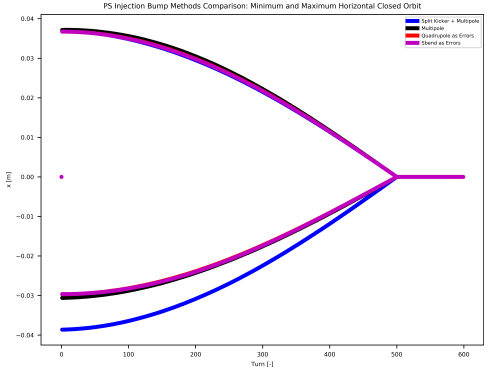


Figure: PyORBIT Horizontal Orbit Extrema: Only the negative extrema for the split HKICKER method is different.

Injection Bump

- All single element methods agree, only the split HKICKER method is different.
- Tunes however are not in agreement.

Note: all simulations run at the most extreme vertical working point of (Q_x, Q_y) = (6.21, 6.10).

Split HKICKER + MULTIPOLE

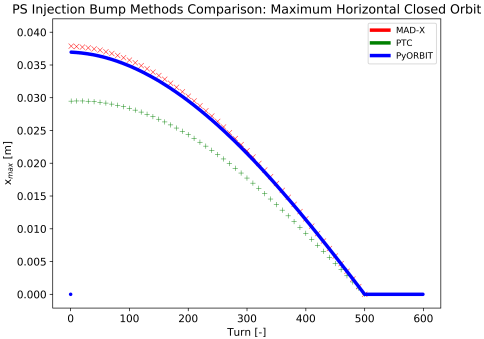


Figure: Horizontal Orbit Extrema for split HKICKER + MULTIPOLE: PyORBIT and MADX agree.

Split HKICKER + MULTIPOLE

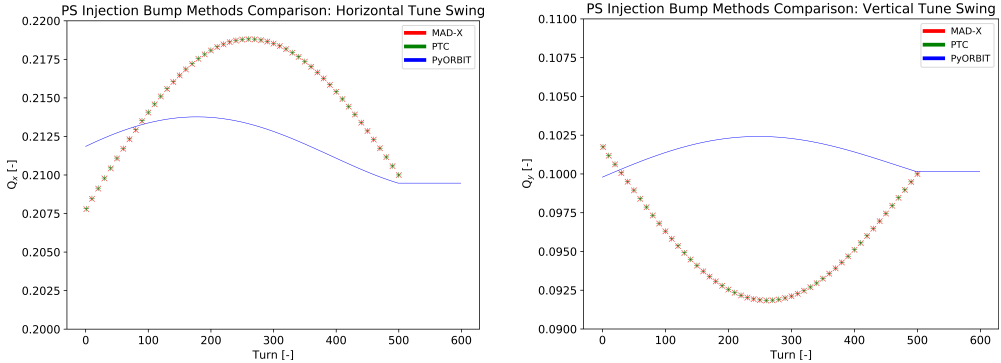


Figure: Tunes for split HKICKER + MULTIPOLE: magnitude and Q_y sign incorrect.

MULTIPOLE

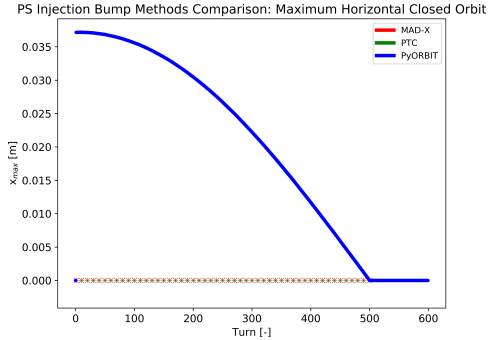


Figure: Horizontal Orbit Extrema for MULTIPOLE: MADX and PTC show no change, however effect is visible in PyORBIT.

MULTIPOLE

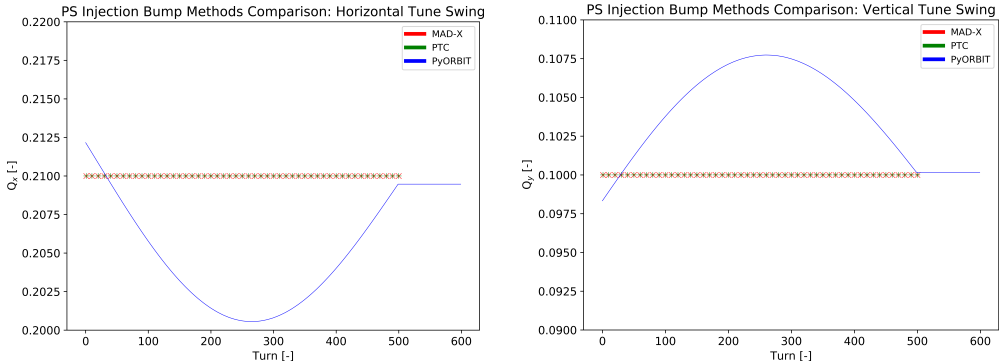


Figure: Tunes for MULTIPOLE: magnitude correct, sign opposite from expected, no change in MADX or PTC.

QUADRUPOLE

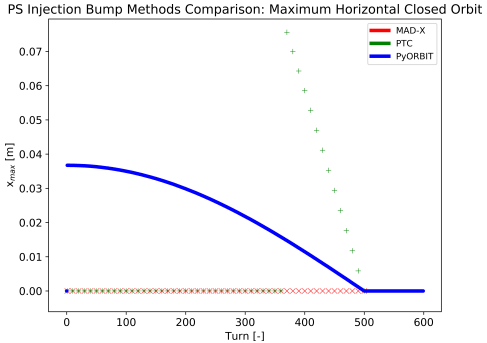


Figure: Horizontal Orbit Extrema for QUADRUPOLE: No bump in MADX, PTC acting strangely, PyORBIT as expected

QUADRUPOLE

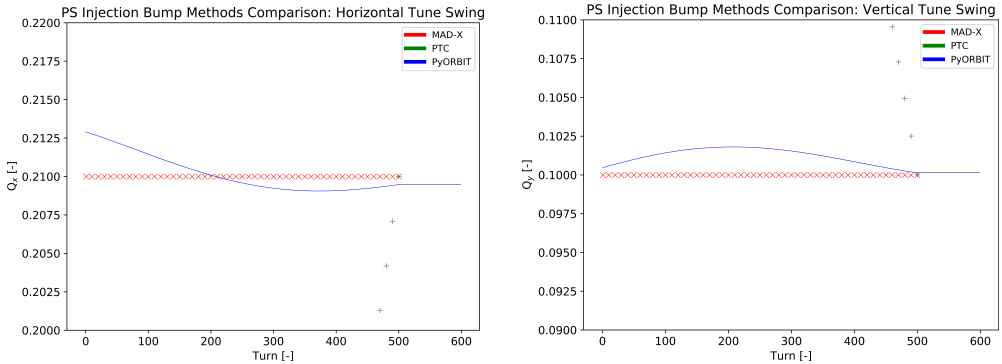


Figure: Tunes for QUADRUPOLE: MADX and PTC disagree, PyORBIT magnitude and sign incorrect.

SBEND

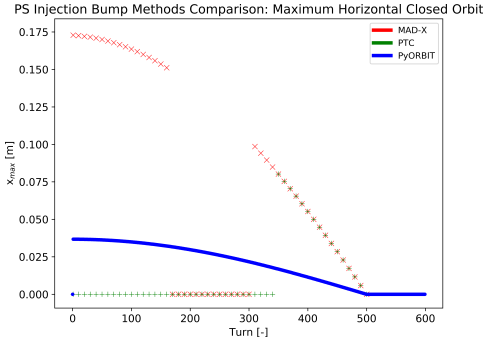


Figure: Horizontal Orbit Extrema for SBEND: unexplained behaviour in MADX and PTC, PyORBIT as expected.

SBEND

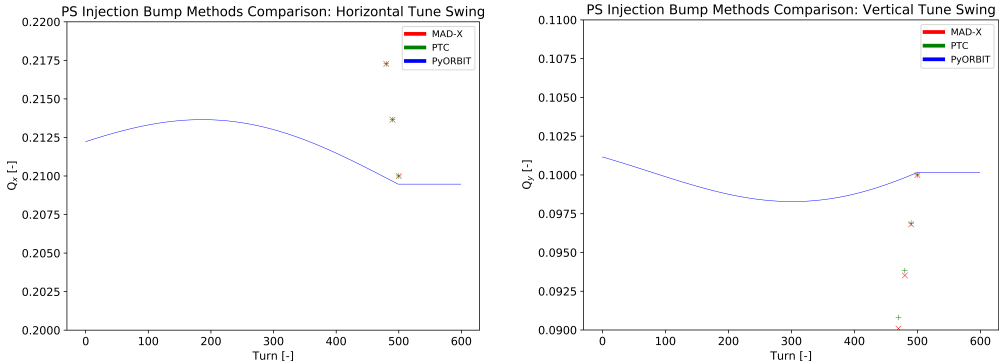


Figure: Tunes for SBEND: MADX and PTC agree but magnitude is large, PyORBIT magnitude incorrect but sign ok.

Test Conversion from MADX Table to PyORBIT Table

- As MULTIPOLE method seems almost correct (tunes are incorrect sign but good magnitude) check for sign error in tables.
- As Split HKICKER + MULTIPOLE tunes both increase (expect Q_x to increase but Q_y to decrease) check for sign error in tables.
- As Split HKICKER + MULTIPOLE tunes are $\approx$ half magnitude expected, check if factorial should not be included.
- Abandon SBEND and QUADRUPOLE methods for now due to unexpected behaviours and disagreements between PTC and MADX.

MULTIPOLE Sign Check

Multiply all sextupole components by -1. Bump unchanged.

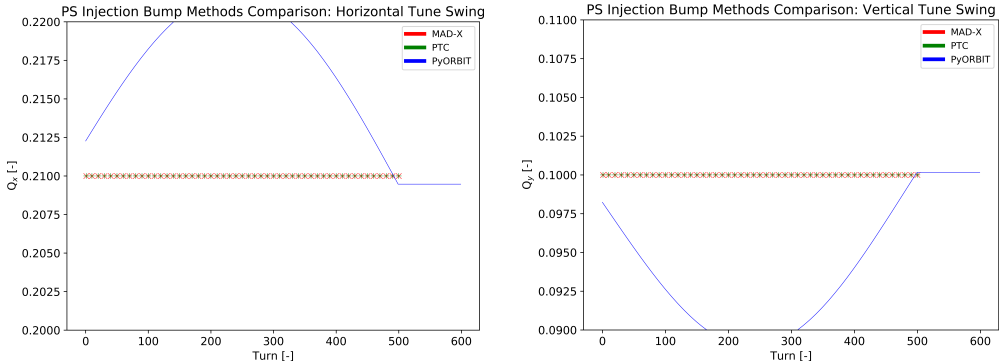
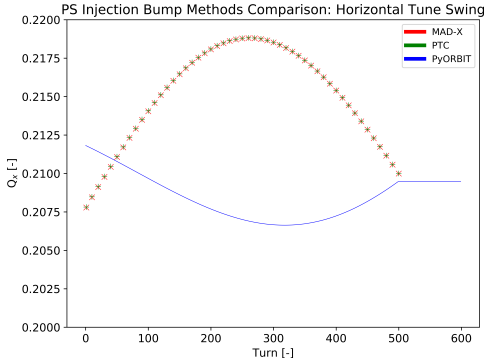


Figure: Tunes for MULTIPOLE Sign Check: Magnitudes changed unexpectedly - too large.

Split HKICKER + MULTIPOLE Sign Check

Multiply all sextupolar components (i.e. only the MULTIPOLE) by -1. Change in bump negligible.



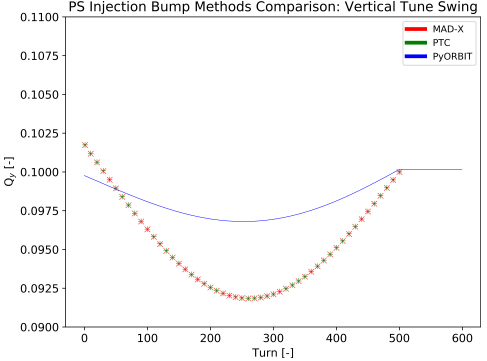


Figure: Tunes for Split HKICKER + MULTIPOLE Sign Check: both tunes flipped.

Split HKICKER + MULTIPOLE Factorial Check

Do not include the factorial in sextupolar components (i.e. only the MULTIPOLE). Bump unchanged.

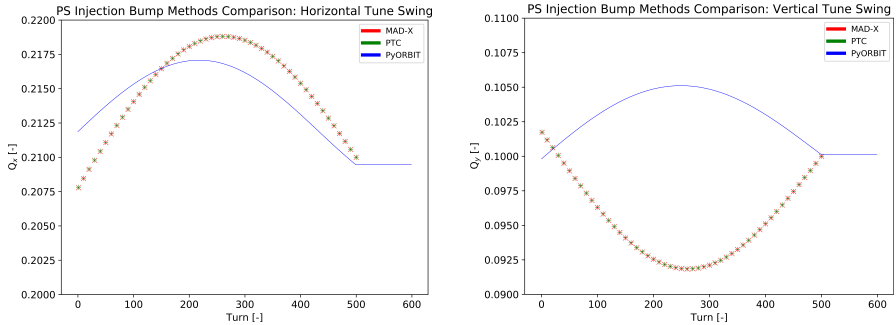


Figure: Tunes for Split HKICKER + MULTIPOLE Factorial Check: Some improvement in magnitude.

Injection Bump Conclusions

- Split HKICKER + MULTIPOLE: Bump OK, tune swing small, Q_y incorrect sign.
- MULTIPOLE: Bump OK, tune swing correct magnitude, tunes incorrect sign.
- QUADRUPOLE: Bump OK, tune swing small, tunes incorrect sign.
- SBEND: Bump OK, tune swing small, tunes correct sign.
- Tests show that multipole method is perhaps the closest to the desired tune swing - only when flipping sign on sextupolar components.

MD4224 Injection Bump

PS Transfer

Goals

- To investigate the space charge contribution to beam envelope oscillations observed in the PS immediately after injection.
- Reproduce measurements performed using BGI and SEM Grids in PTC-PyORBIT in order to understand the contribution of space charge.

Current Plan

- Start with matched distribution and track without space charge.
- Add dispersion mismatch as constant factor (will obtain parameterised values from Selim/Matthew soon).
- Start with PTC TWISS to match distribution, later use end of transfer line values transported to BGI/SEM position (to be provided by Selim/Matthew).

Note: all simulations run at the nominal working point of $(Q_x, Q_y) = (6.21, 6.24)$.

Matched Distribution

No Space Charge

Mismatch of factor 0% and +10%.

- Had to correct units of dE (factor 1E3).
- Matching not correct.
- Abandon and use tomo distribution.

Matched Distribution Longitudinal Motion

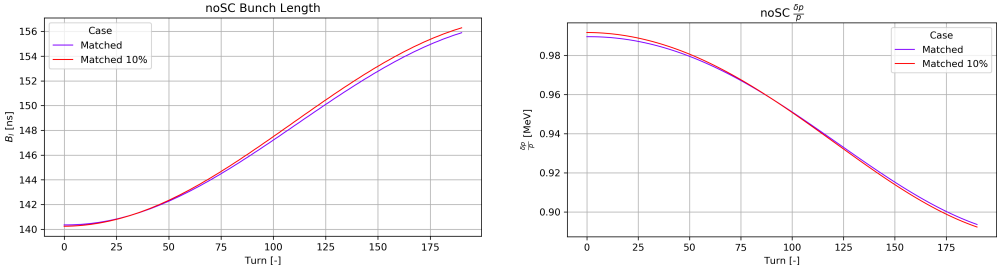


Figure: Longitudinal motion for `matched` distribution: oscillations larger than expected - indicates mismatch.

Matched Distribution Horizontal Dispersion

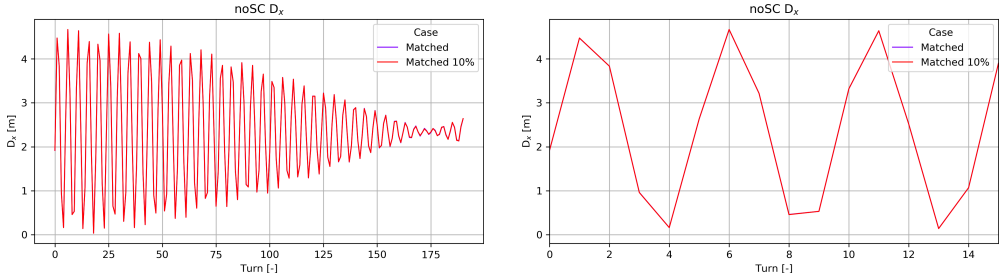


Figure: Horizontal dispersion for `matched` distribution: 10% mismatch identical to 0% mismatch - indicates existing mismatch already larger than 10%.

Matched Distribution Emittances

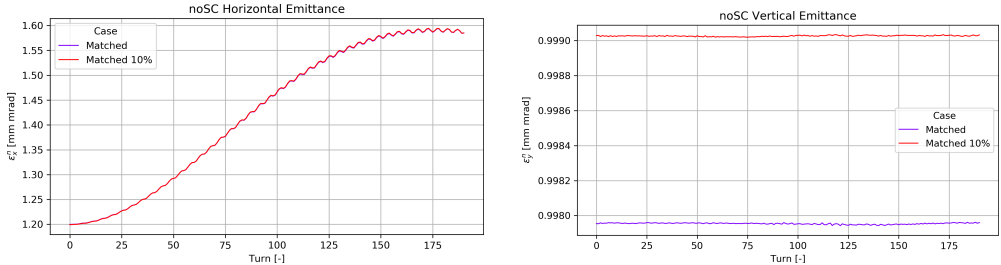


Figure: Emittances for `matched` distribution: 10% mismatch identical to 0% mismatch - indicates existing mismatch already larger than 10%.

Tomo Distribution

No Space Charge

Mismatch of factor 0%, +10%, +20%, and +30%.

Tomo Distribution Longitudinal Motion (No Space Charge)

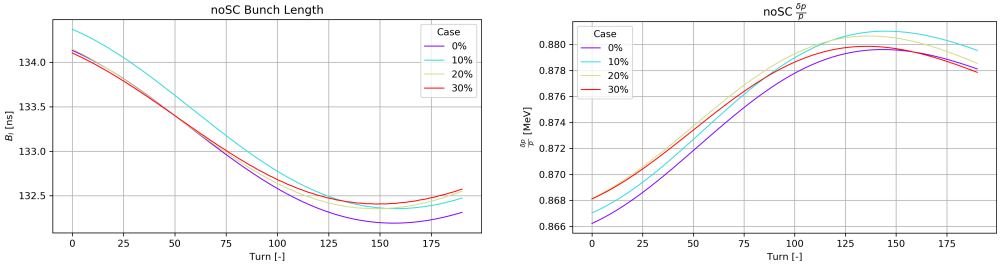


Figure: Longitudinal motion for `tomo` distribution: oscillation magnitude as expected.

Tomo Distribution Horizontal Dispersion (No Space Charge)

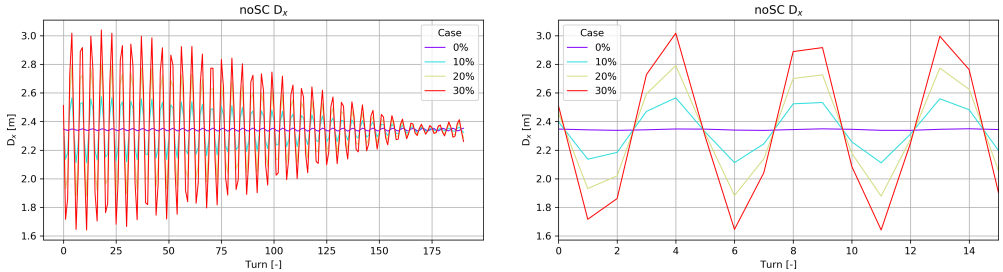


Figure: Horizontal dispersion for `tomo` distribution: oscillation magnitude is a function of mismatch as expected.

Tomo Distribution Emittances (No Space Charge)

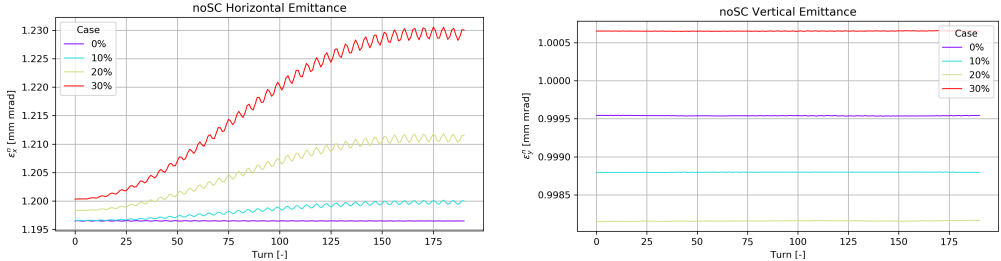


Figure: Emittances for `tomo` distribution: horizontal emittance growth is a function of dispersion mismatch.

Tomo Distribution

With Space Charge

Mismatch of factor +10%, +20%, and +30%.

Tomo Distribution Longitudinal Motion (With Space Charge)

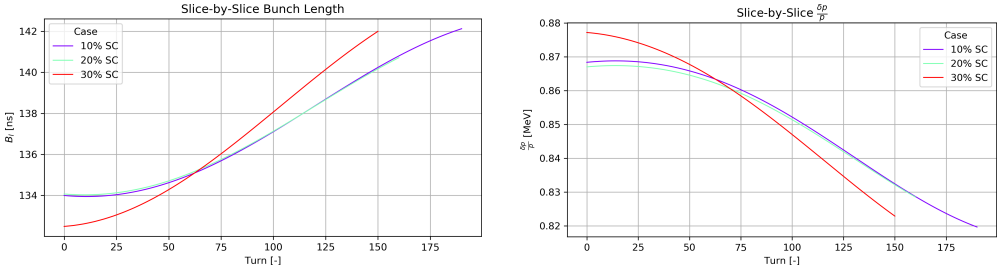


Figure: Longitudinal motion for `tomo` distribution with space charge: oscillation has opposite sign to no space charge case - SC drives bunch lengthening at the start?

Tomo Distribution Horizontal Dispersion (With Space Charge)

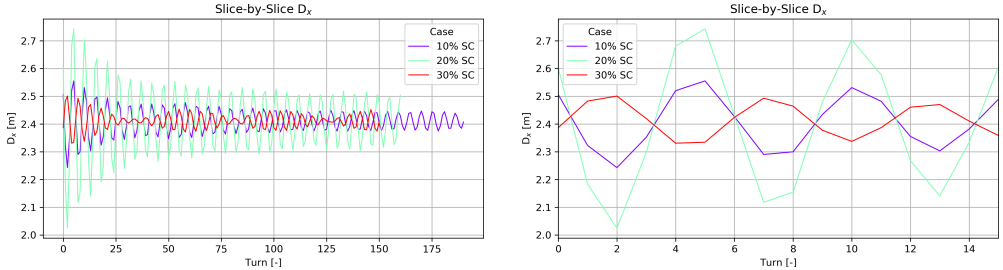


Figure: Horizontal dispersion for `tomo` distribution with space charge: dispersion oscillations have longer period, highest mismatch in anti-phase rather than larger magnitude.

Tomo Distribution Emittances (With Space Charge)

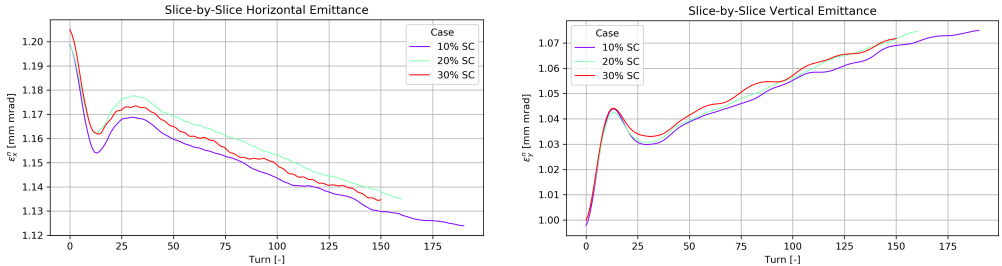
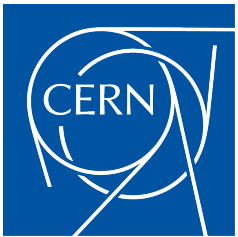


Figure: Emittances for `tomo` distribution with space charge: clear emittance exchange.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