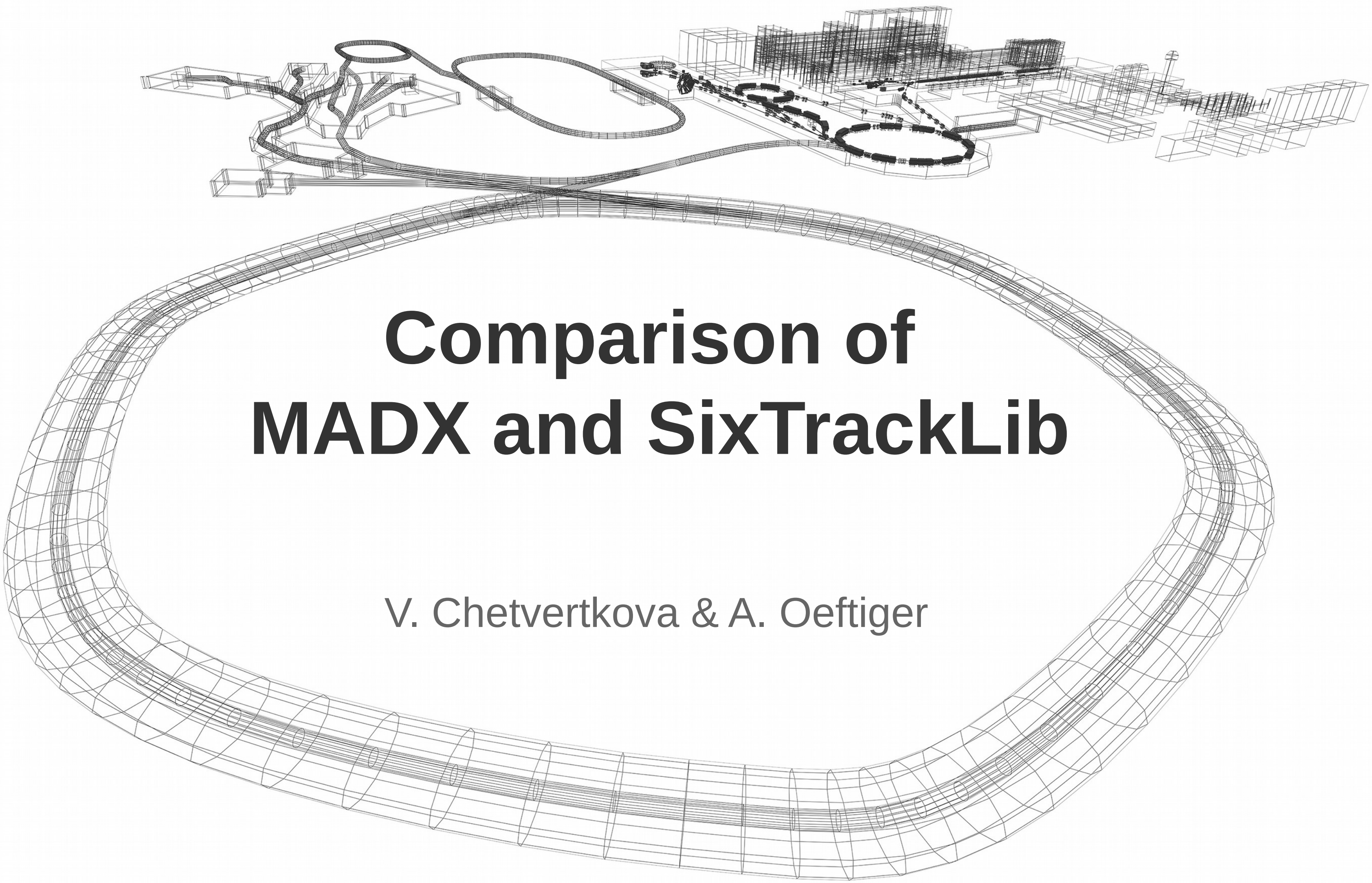


Comparison of MADX and SixTrackLib

V. Chetvertkova & A. Oeftiger

Model description

- MAD-X: frozen space charge
  (non-adaptive, scfix=True [see last presentation])
- STL+PyHT: 2.5D particle-in-cell space charge

→ no magnet errors taken into account

→ goal: compare SC footprints across codes!

→ to simplify space charge model compatibility:

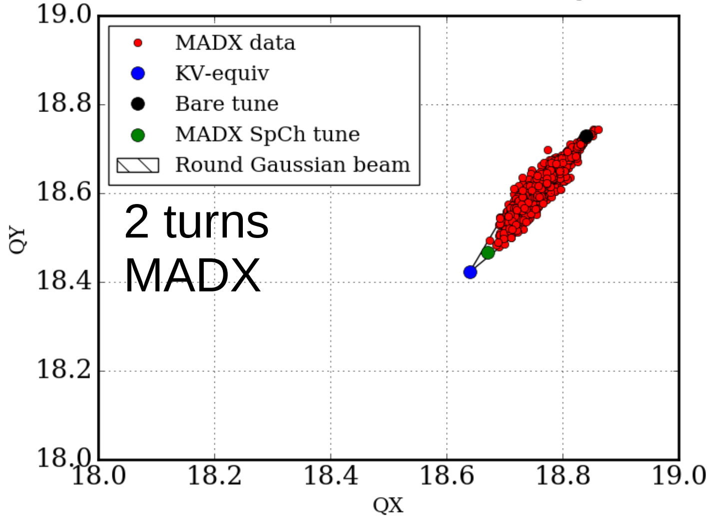
consider uncut Gaussian transverse distributions

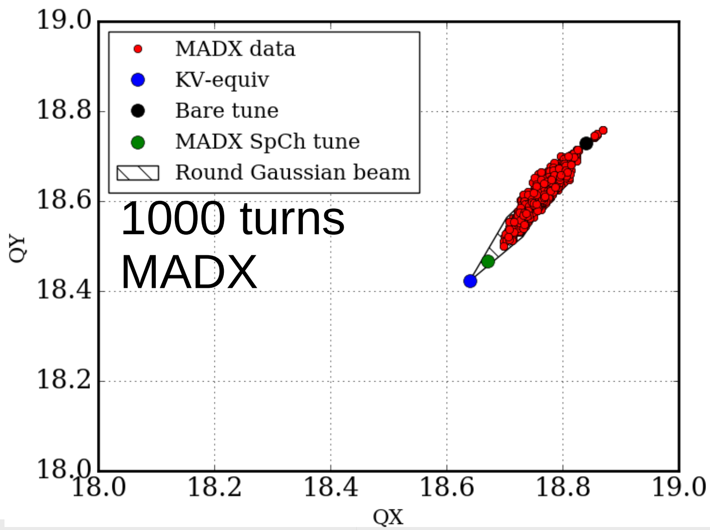
Initial beam parameters

- U28+ 200 MeV/u
- 3D Gaussian distribution:
  - Emittance_x_rms=8.75e-6; Emittance_y_rms=3.75e-6 (geometrical)
  - RMS Bunch length: 14.5m
  - RMS Momentum spread: 0.5e-3
- RF voltage 58.2 kV
- Harmonic number h=10
- Particle number per bunch Np=0.625e11
- Bunching factor 0.03(35)
- Distribution matched to unperturbed twiss functions

Space charge, no errors
Qx, Qy = 18.84, 18.73

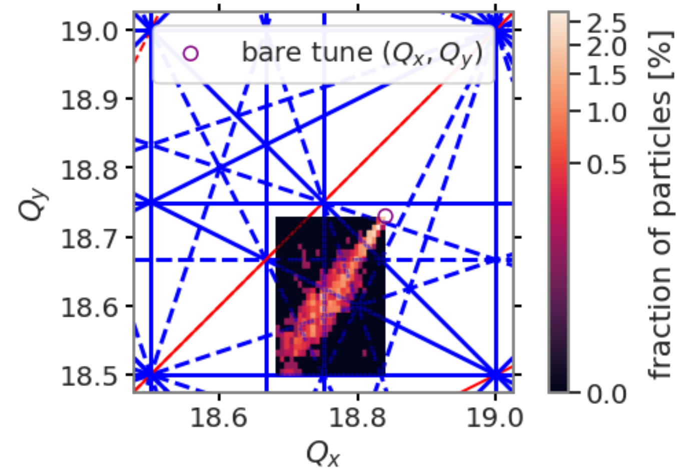
Phase advance analysis



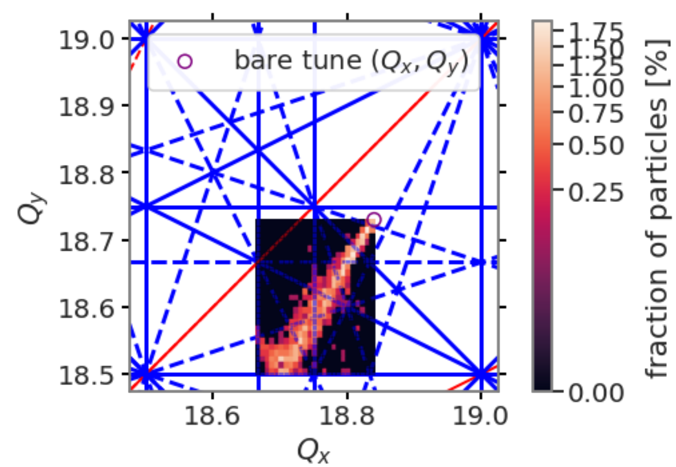


Frequency analysis 128 turns

MAD-X

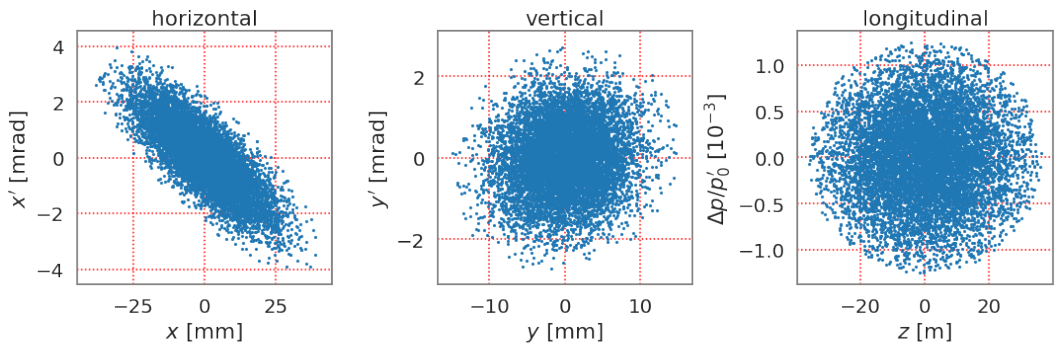


SixTrackLib + PyHT:

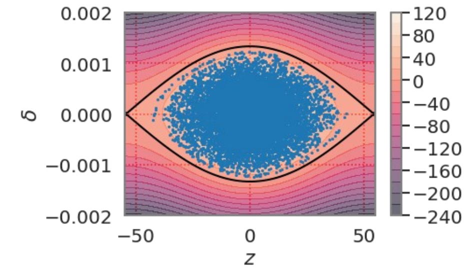


STL+PyHT: Qx, Qy = 18.84, 18.73

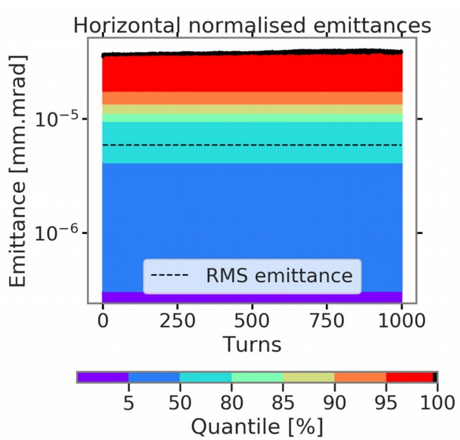
Initial phase space (3.4 and 2.5 sigma cut):

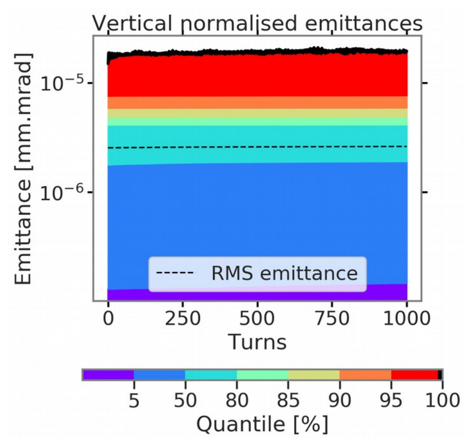


Long. after 1000 turns:

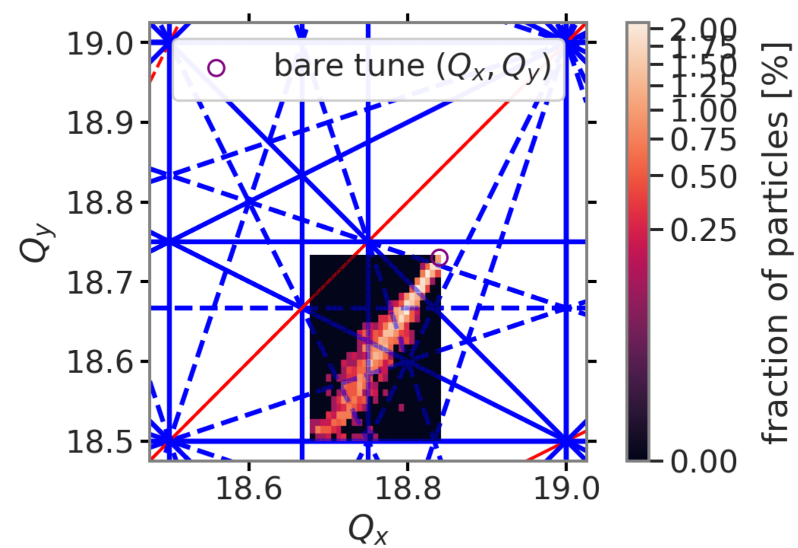


Vert. core emittance (5%, purple) slightly grows:

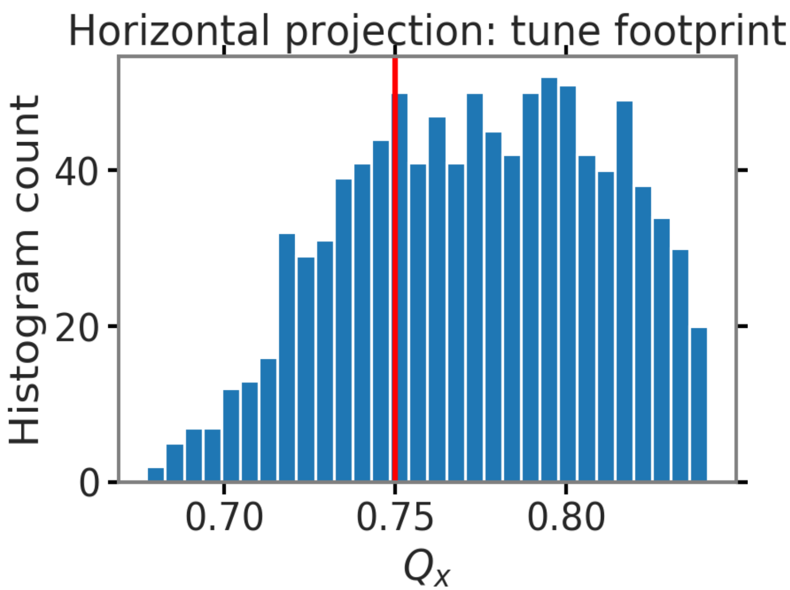


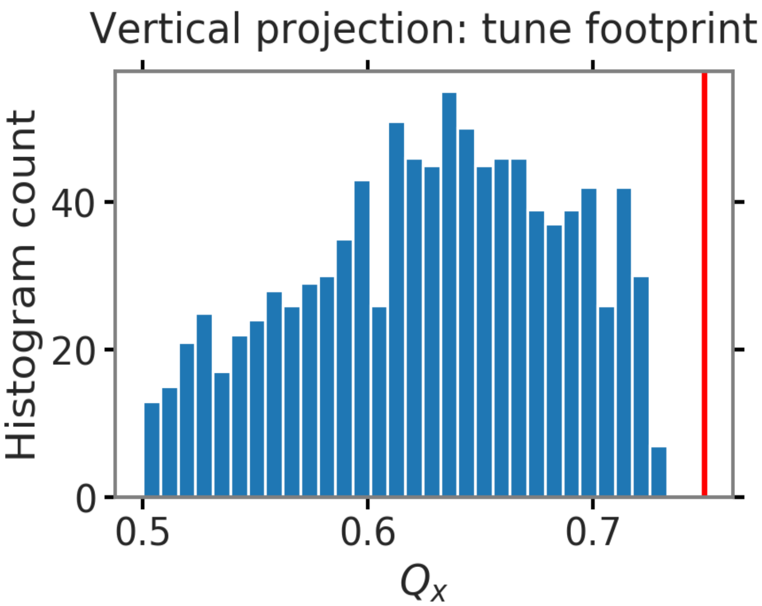


Tune footprint over 1000 turns:



STL+PyHT: Qx, Qy = 18.84, 18.73



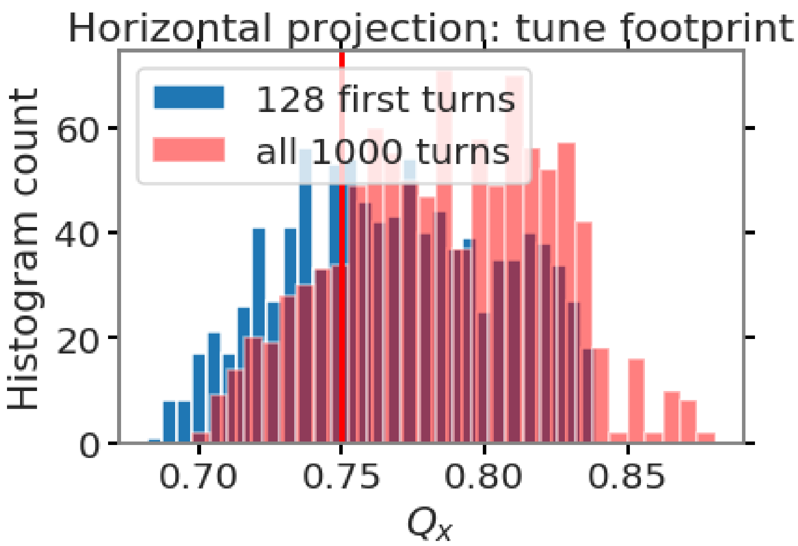


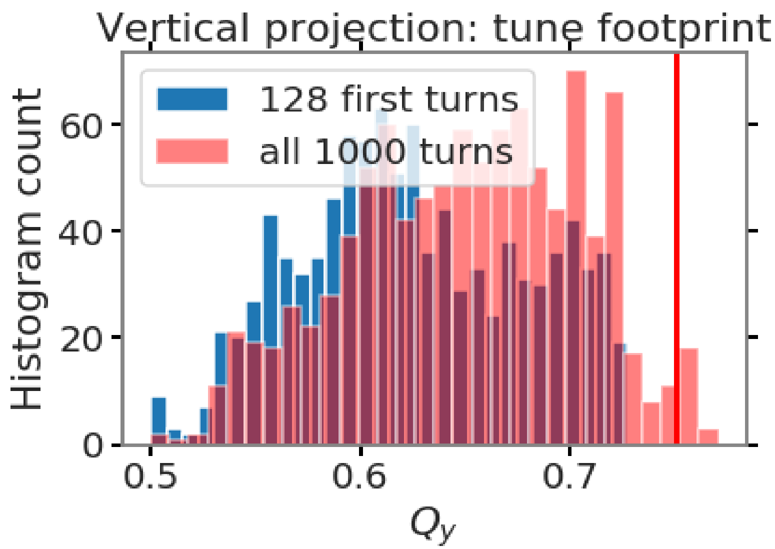
From 1000 turns frequency analysis:
dQ_x = 0.164 and dQ_y = 0.233

Attention: the tune footprint indicates overlap (reflection at 0.5) in vertical!
→ the actual vertical tune spread extends a bit further
→ push working point higher just to compare (also avoids half-integer resonance!)

Frozen MAD-X: vertical half-integer

Also in MAD-X + frozen space charge:
→ half-integer

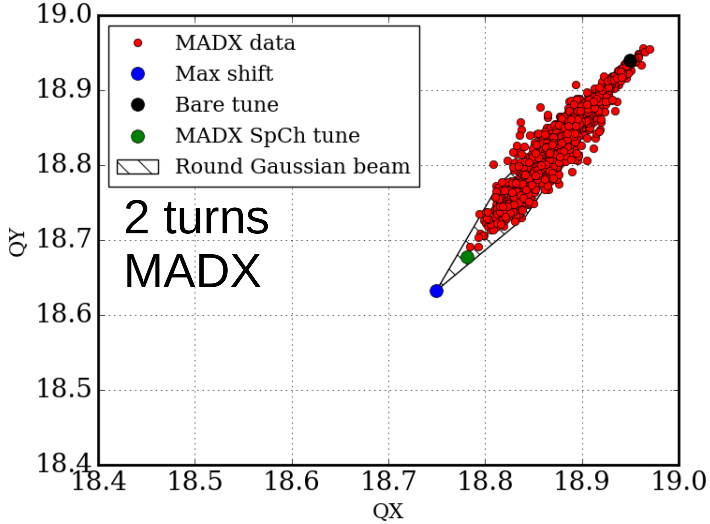


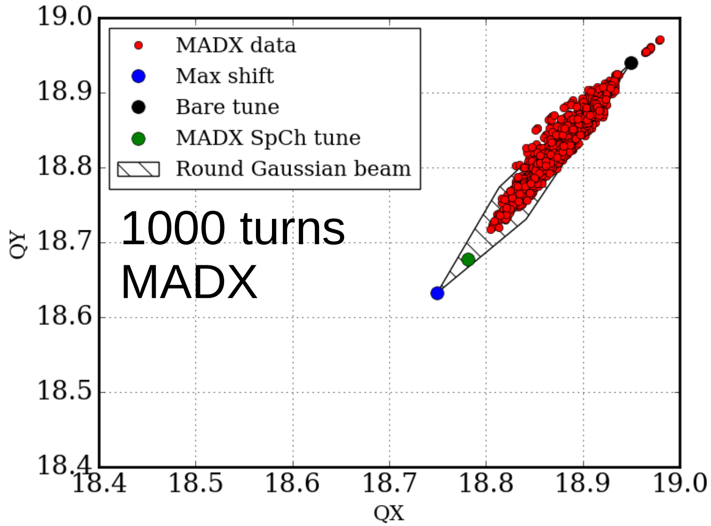


From 1000 turns frequency analysis:
dQ_x = 0.157 and dQ_y = 0.228

Space charge, no errors
Qx, Qy = 18.95, 18.94

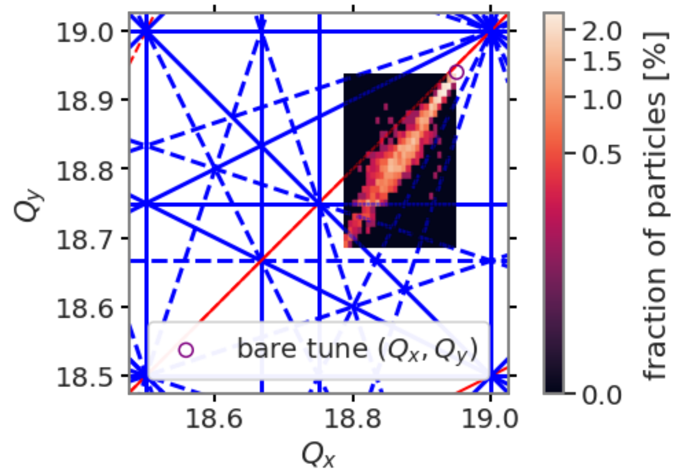
Phase advance analysis



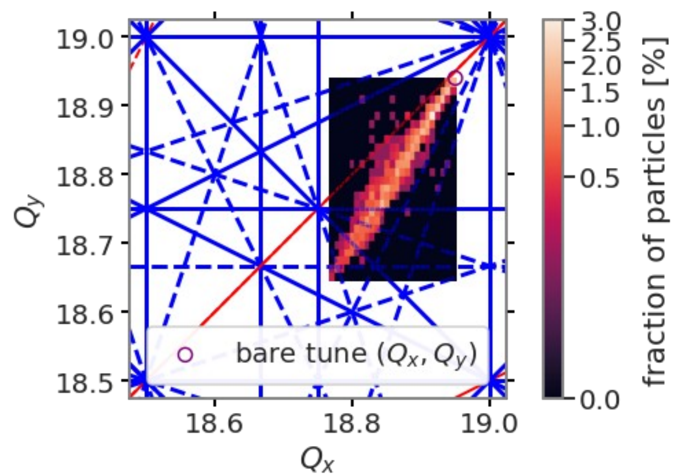


Frequency analysis 128 turns

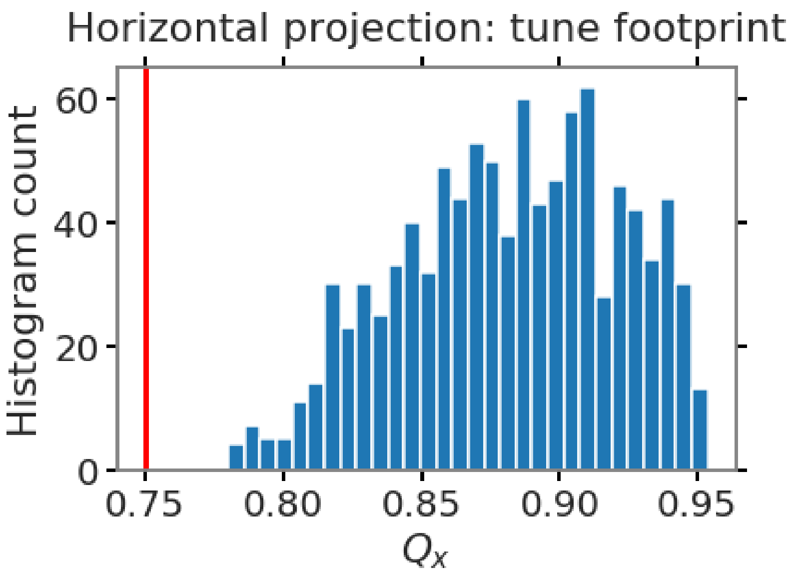
MAD-X

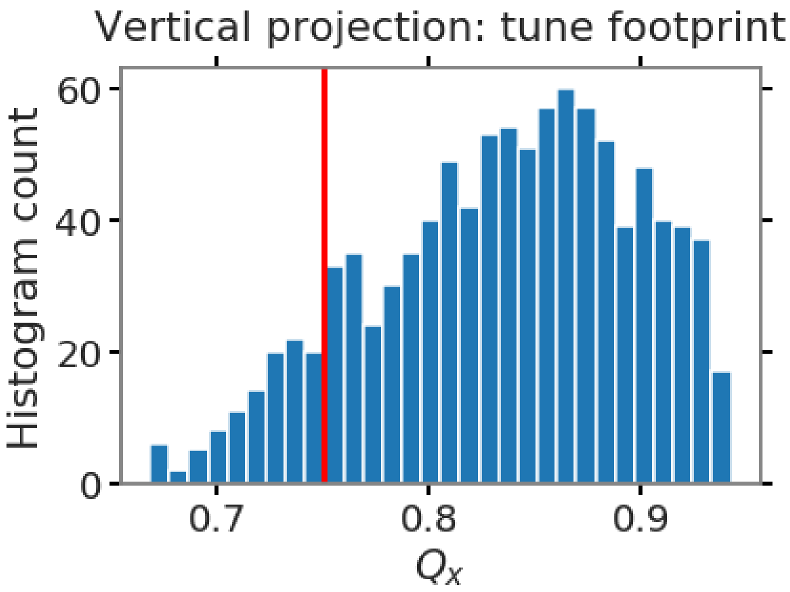


SixTrackLib + PyHT:



STL+PyHT: Qx, Qy = 18.84, 18.73

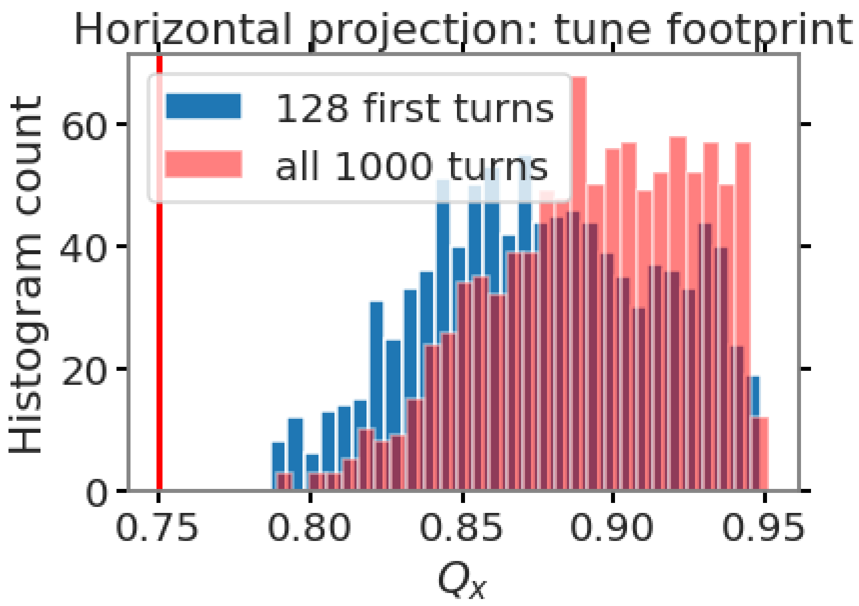




From 1000 turns frequency analysis:
dQ_x = 0.174 and dQ_y = 0.273

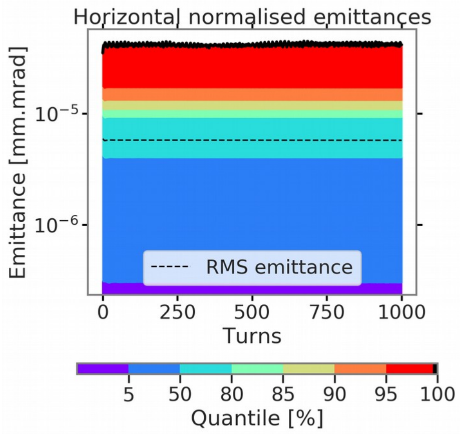
Compare to theoretical 2D formula at long. bunch core:
dQ_x = 0.18 and dQ_y = 0.276

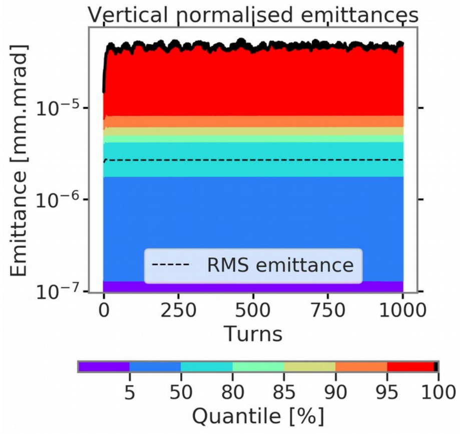
MAD-X: tunes drift



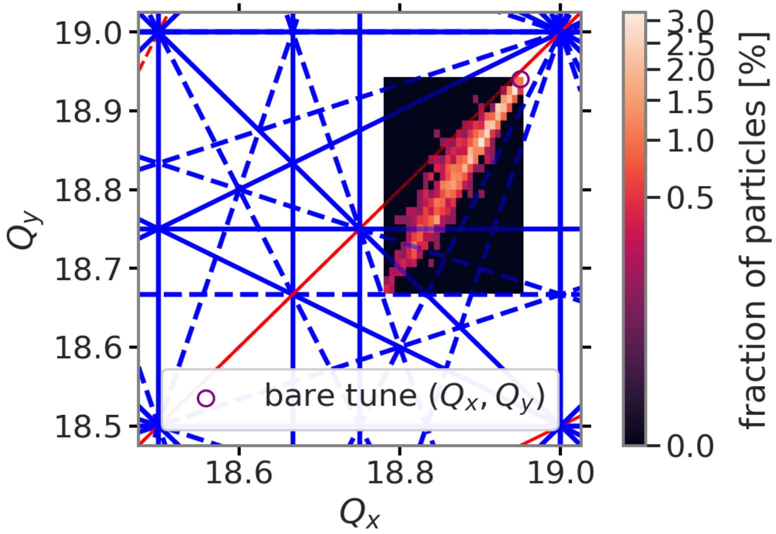
STL+PyHT: Qx, Qy = 18.95, 18.94

Vert. core emittance quantiles (<50%) const.:





Tune footprint over 1000 turns:



Summary

→ codes do coincide on the tune footprint side,

indication for different dynamics though

(frozen vs. PIC!!)

→ Gaussian tune spreads fit theoretical expectation!

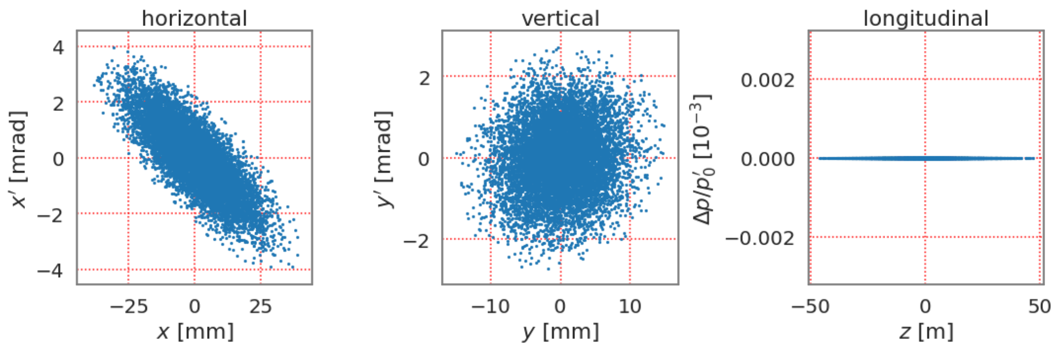
Next Steps

- Tracking (dipoles without dipedges):
  - „No space charge“ case with errors
  - „Space charge“ case with errors

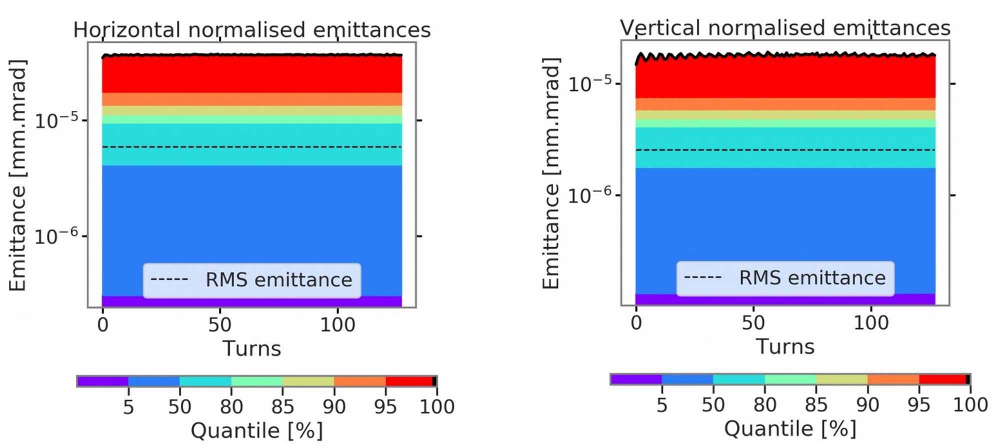
- Tracking (dipoles with dipedges):
  - „No space charge“ case with errors
  - „Space charge“ case with errors

STL+PyHT: dp/p = 0

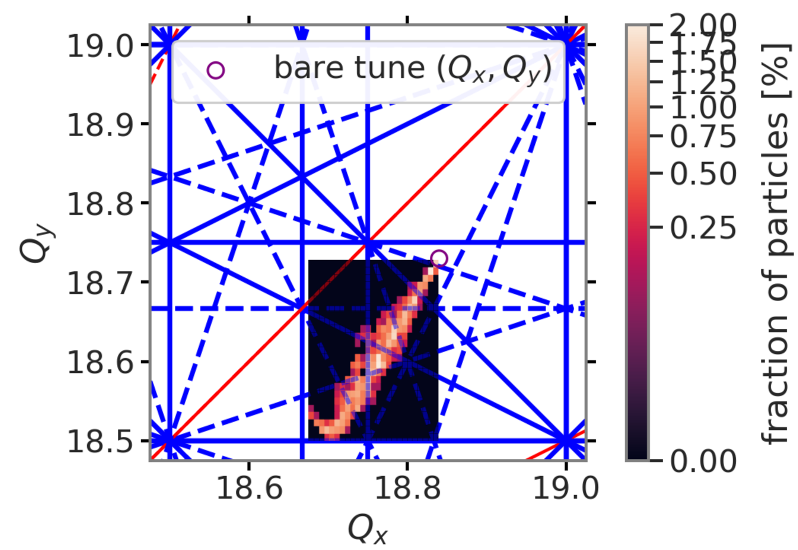
Initial phase space (3.4 and 2.5 sigma cut):



Vert. core emittance (<50%) slightly grows:



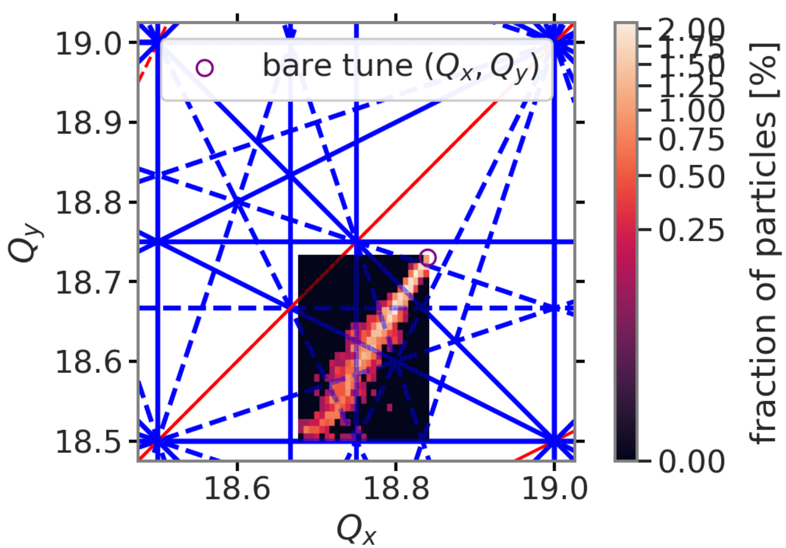
Tune footprint over 1000 turns:



dp/p = 0 vs. finite dp/p (chroma!)

STL + PyHT for 1000 turns, frequency analysis, comparing finite momentum spread (with corresponding chromatic tune spreads and dispersion → weaker space charge) to vanishing momentum spread (no chromatic tune spread, stronger space charge):

RMS dp/p = 0.5e-3



RMS dp/p = 0