DA studies with Xsuite

K. André

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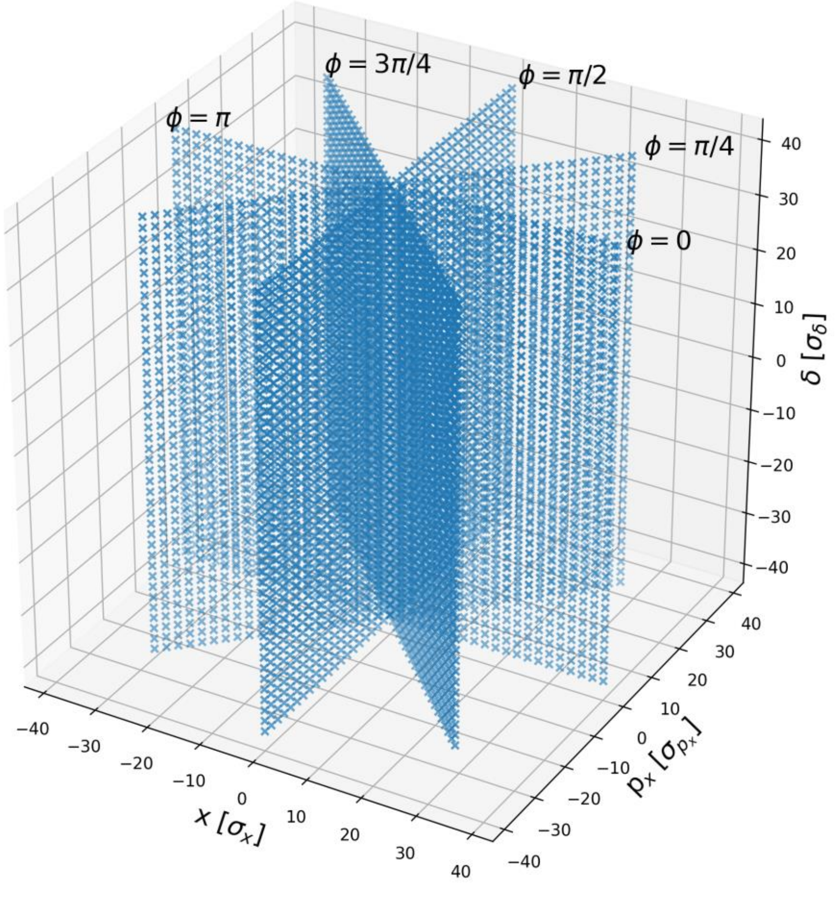
Model and notation corrections

- X, Y = $J_{x,y}\cos(\Phi)$, PX, PY = $J_{x,y}\sin(\Phi)$
- $J_x = (2\ \varepsilon_x)^{1/2}$ hence $J_x/J_y = (\varepsilon_x/\varepsilon_y)^{1/2} = (\varepsilon_x/0.002\varepsilon_x)^{1/2} \approx 22.36$
- $A_x = (2\ J_x)^{1/2} = (x^2 + p_x^2)^{1/2}$ called amplitude
- x and p_x are normalised hence the normalised amplitude is plotted

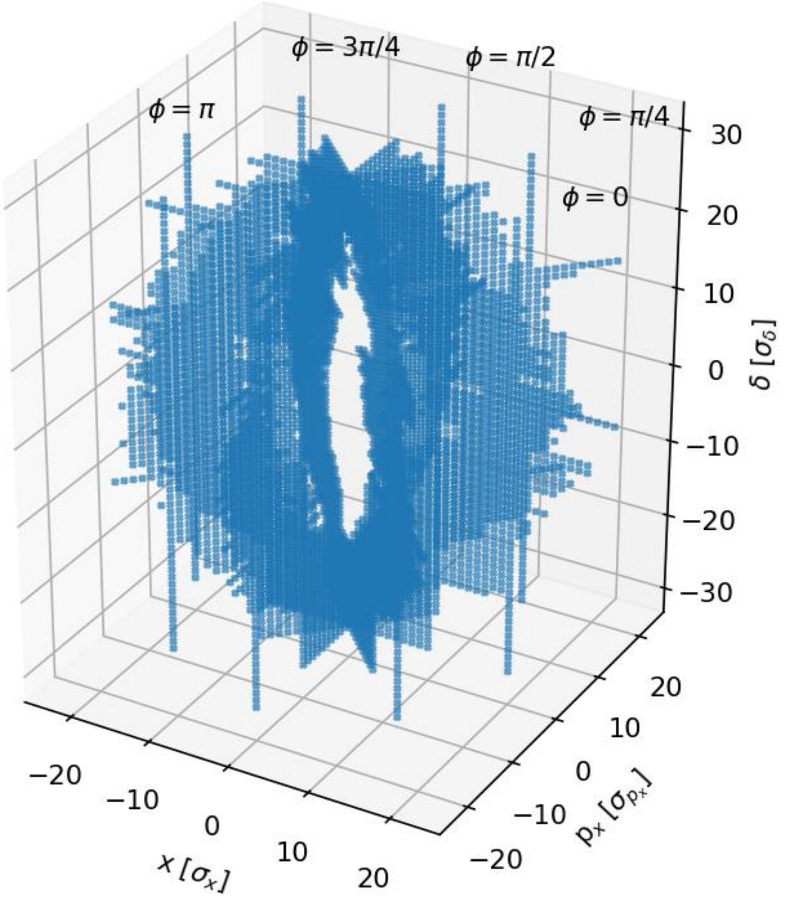
Fig. 2.11. Dynamic apertures in z–x plane after sextupole optimisation with particle tracking for each energy. The initial vertical amplitude for the tracking is always set to $J_y/J_x = \varepsilon_y/\varepsilon_x$. The number of turns corresponds to about 2 longitudinal damping times.

Additionally, the SR model only features **damping** as the 'mean' model in Xsuite.

Oide’s DA - Macroparticle grid



‘Brute force’ grid

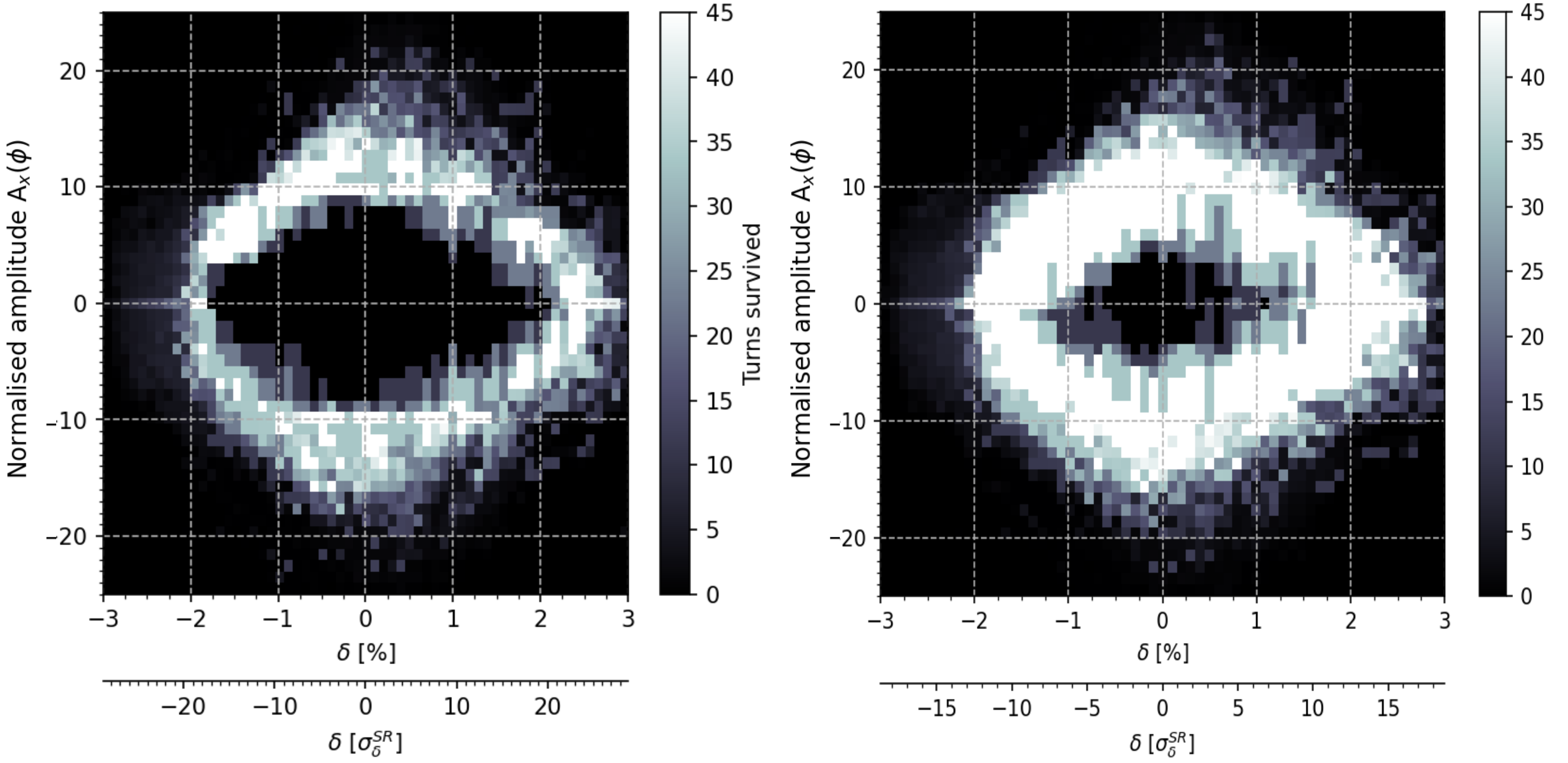


Grid resulting from bisection

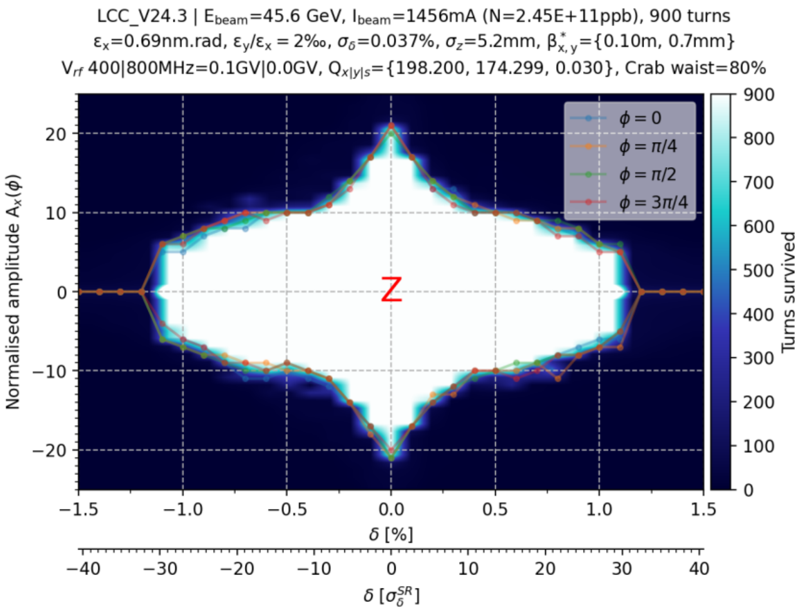
Resulting DA

As you increase the ‘depth’ of tracked macroparticle in action J, the central area becomes increasingly whiter, proving the particles survived.

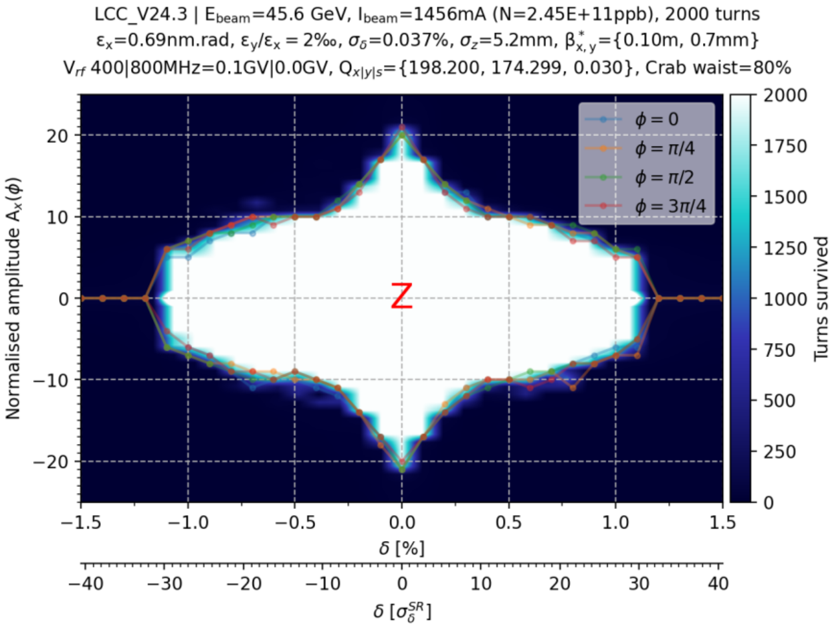
Some parts of the central region appear less white because of the average between phase planes because some planes have no data at this (δ,J) position.



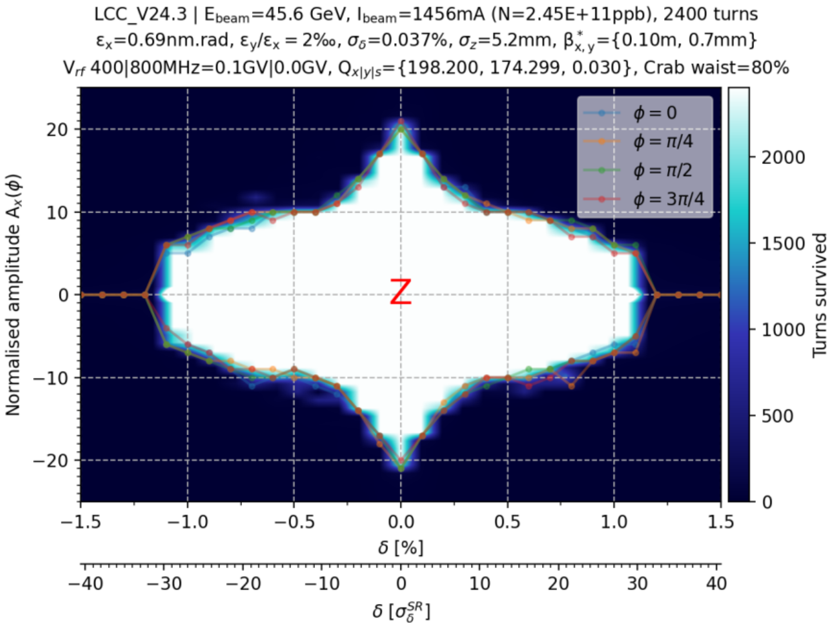
Results with increasing number of turns



900 turns ~ 2h40
Including slicing and Xsuite line conversion from MADX sequence



2000 turns ~ 3h32
including slicing and Xsuite line conversion from MADX sequence



2400 turns ~ 5h50
including slicing and Xsuite line conversion from MADX sequence

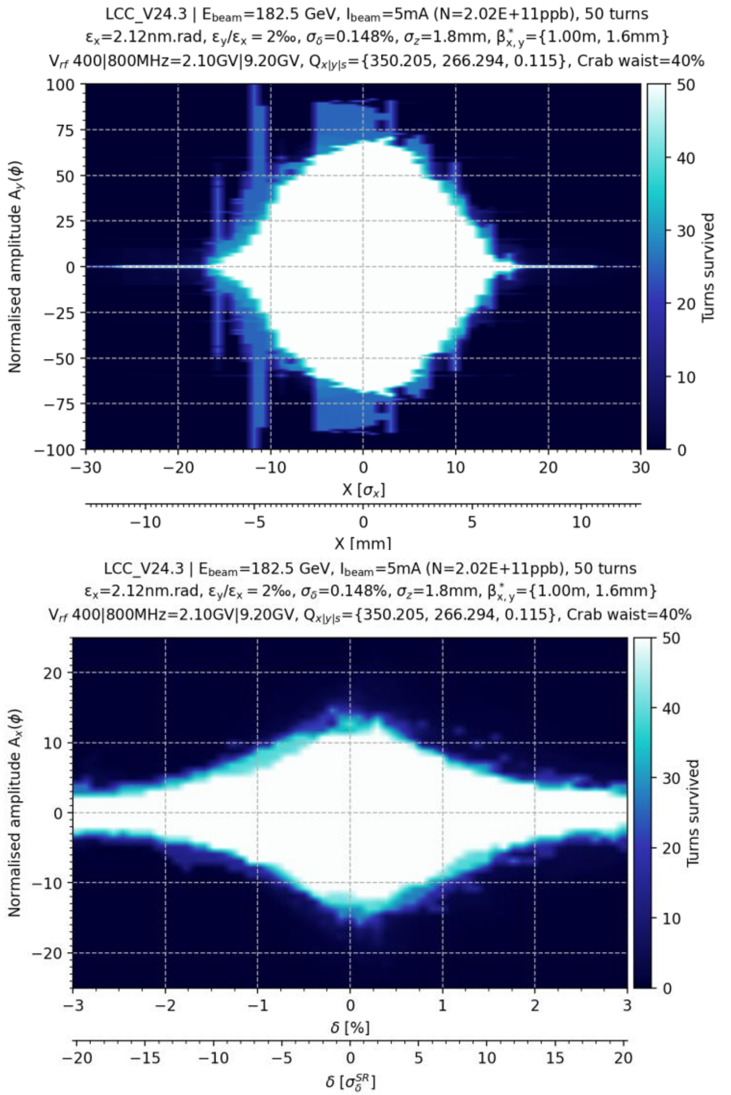
Probably an expected behaviour without quantum fluctuation.

Reduction to one RF section

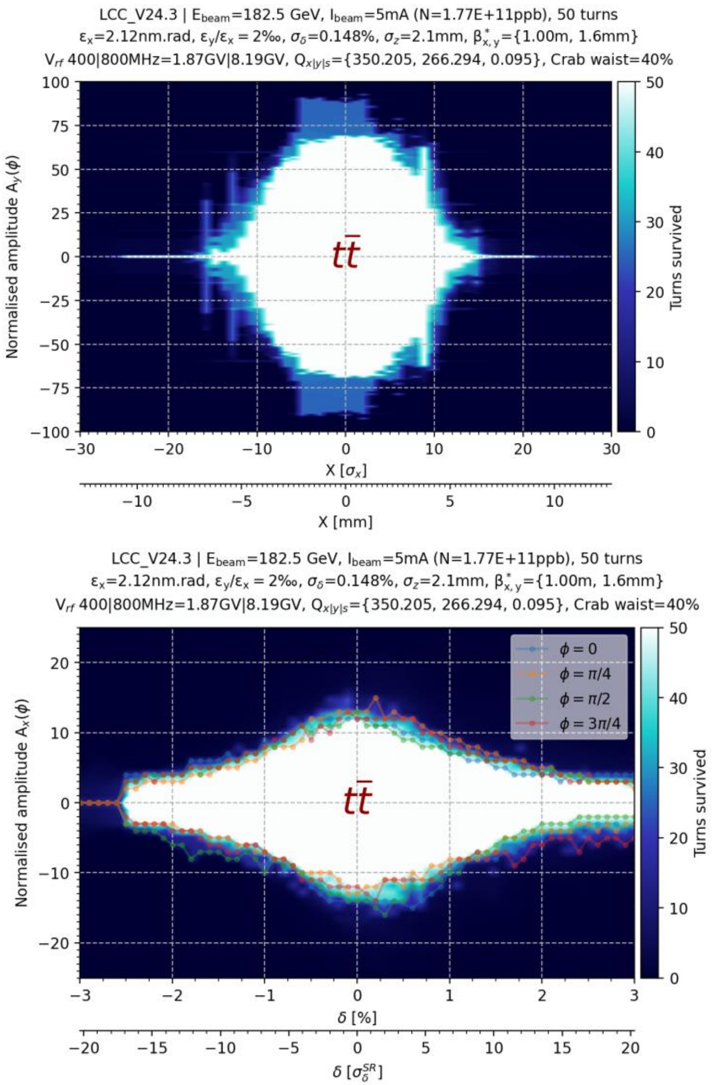
From 4 RF cavities at 400MHz evenly distributed in the ring (one in each straight section) to **1 RF section** including 400 MHz RF cavities and 800 MHz RF cavities.

Single RF section for the LCC lattice (nominal)

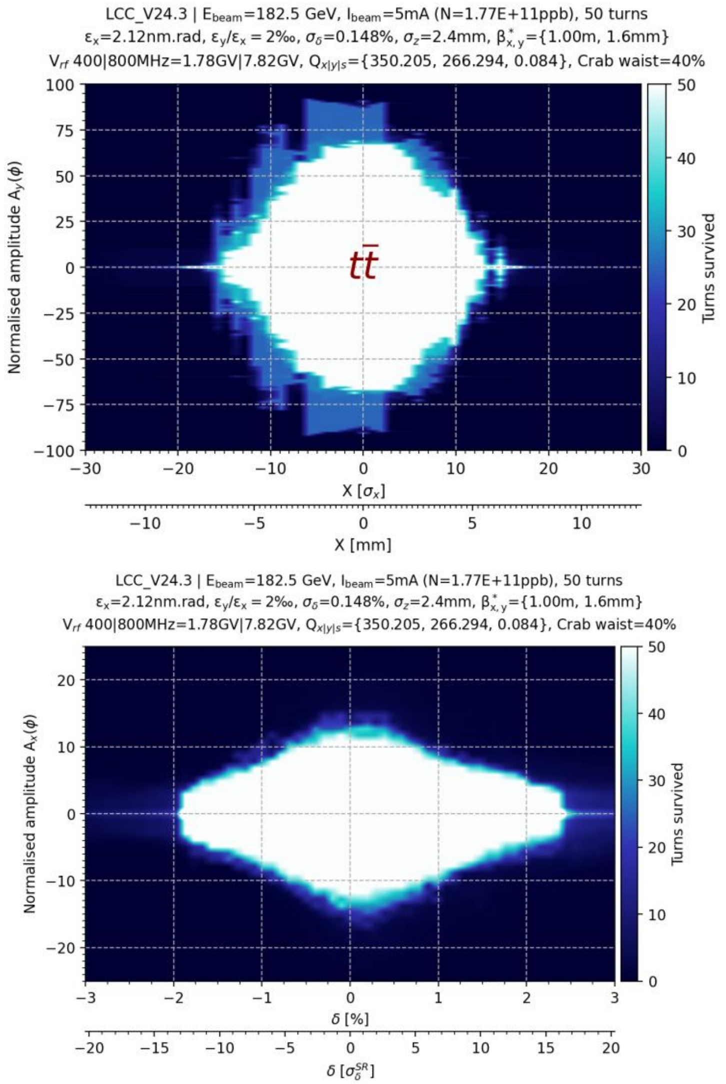
Single RF section **same** total RF voltage



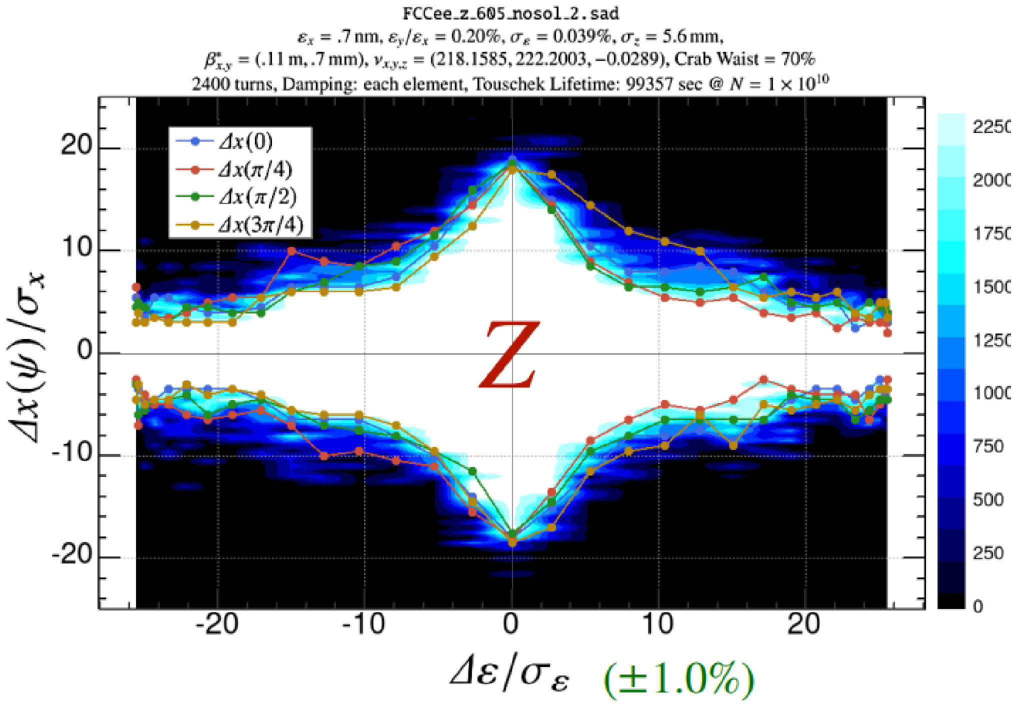
Single RF section **10%** lower total RF voltage

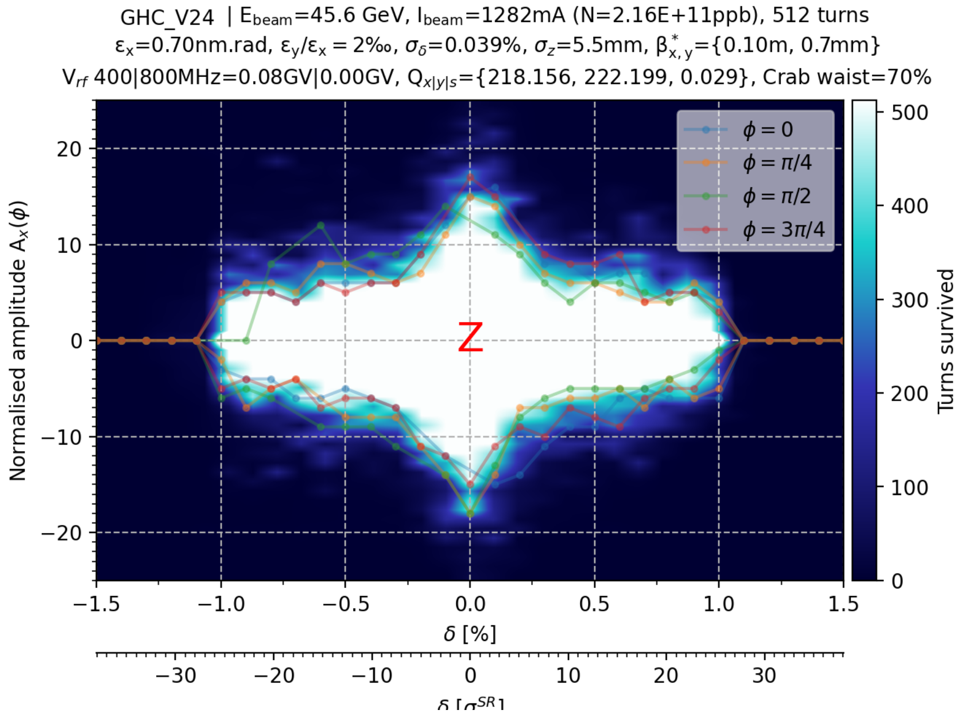


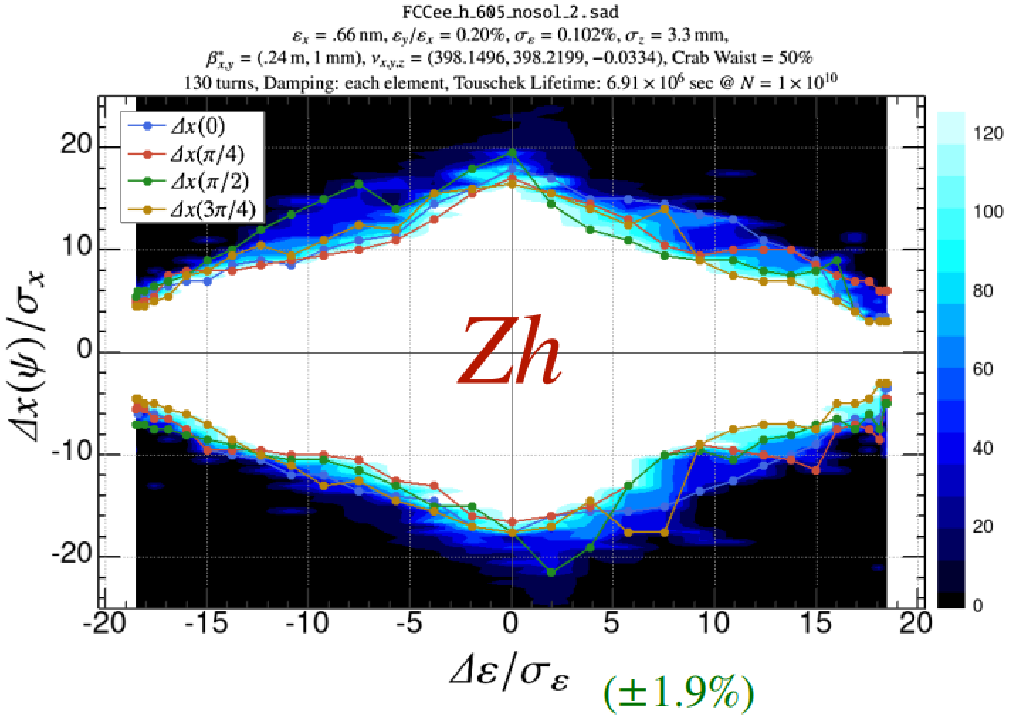
Single RF section **15%** lower total RF voltage

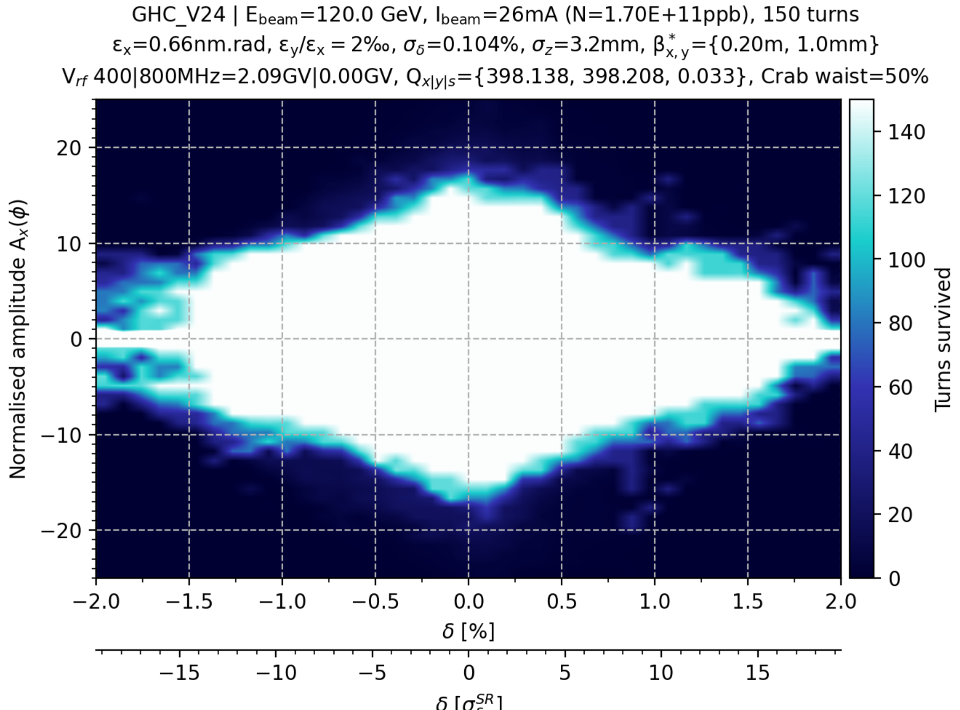


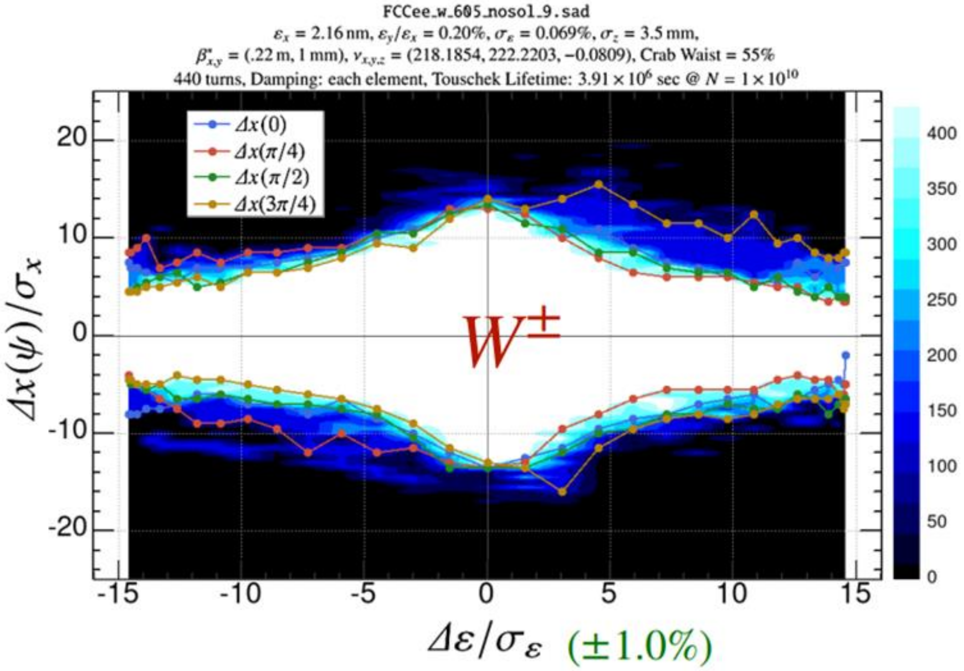
MA comparison between SAD and Xsuite for the V24 version of the GHC lattice V24

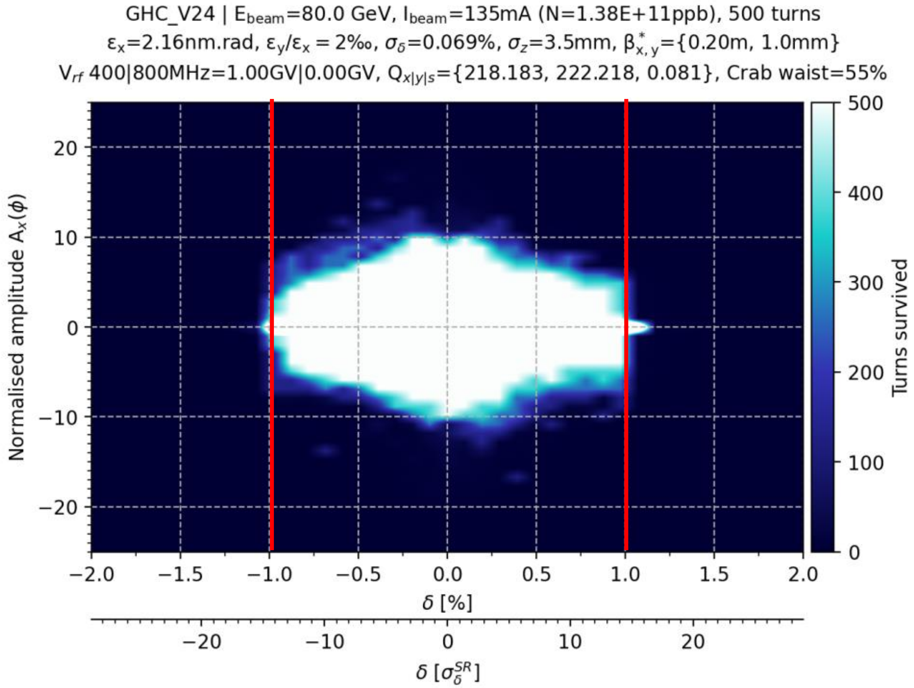

FCCee_z_605_nosol_2.sad
εx = .7 nm, εy/εx = 0.20%, σε = 0.039%, σz = 5.6 mm,
β*x,y = (.11 m, .7 mm), νx,y,z = (218.1585, 222.2003, −0.0289), Crab Waist = 70%
2400 turns, Damping: each element, Touschek Lifetime: 99357 sec @ N = 1 × 10^10
Δx(0)
Δx(π/4)
Δx(π/2)
Δx(3π/4)
Δx(ψ)/σx
Z
Δε/σε
(±1.0%)

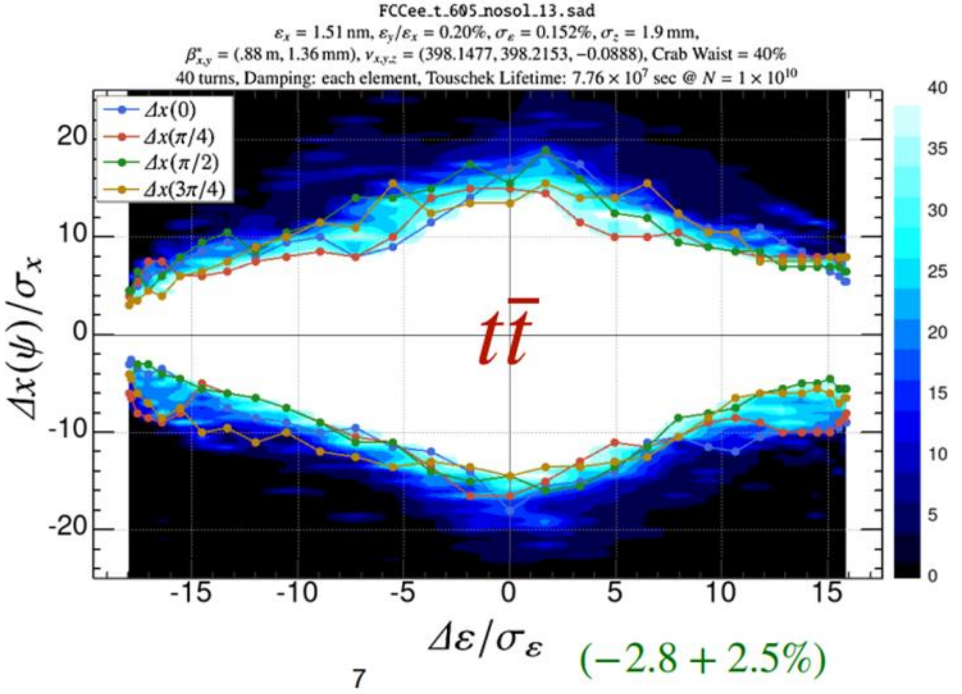

GHC_V24 | Ebeam=45.6 GeV, Ibeam=1282mA (N=2.16E+11ppb), 512 turns
εx=0.70nm.rad, εy/εx = 2‰, σδ=0.039%, σz=5.5mm, β*x,y={0.10m, 0.7mm}
Vrf 400|800MHz=0.08GV|0.00GV, Qx|y|s={218.156, 222.199, 0.029}, Crab waist=70%
ϕ = 0
ϕ = π/4
ϕ = π/2
ϕ = 3π/4
Normalised amplitude Ax(ϕ)
Z
Turns survived
δ [%]

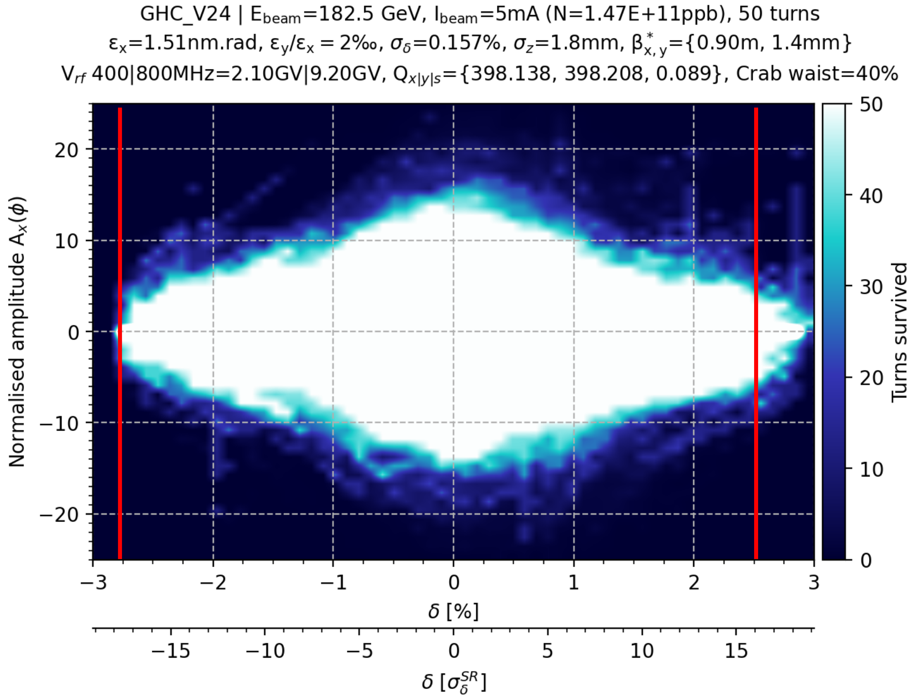

FCCee_h_605_nosol_2.sad
εx = .66 nm, εy/εx = 0.20%, σε = 0.102%, σz = 3.3 mm,
β*x,y = (.24 m, 1 mm), νx,y,z = (398.1496, 398.2199, −0.0334), Crab Waist = 50%
130 turns, Damping: each element, Touschek Lifetime: 6.91 × 10^6 sec @ N = 1 × 10^10
Δx(0)
Δx(π/4)
Δx(π/2)
Δx(3π/4)
Δx(ψ)/σx
Zh
Δε/σε
(±1.9%)


GHC_V24 | Ebeam=120.0 GeV, Ibeam=26mA (N=1.70E+11ppb), 150 turns
εx=0.66nm.rad, εy/εx = 2‰, σδ=0.104%, σz=3.2mm, β*x,y={0.20m, 1.0mm}
Vrf 400|800MHz=2.09GV|0.00GV, Qx|y|s={398.138, 398.208, 0.033}, Crab waist=50%
Normalised amplitude Ax(ϕ)
Turns survived
δ [%]


FCCee_w_605_nosol_9.sad
ε_x = 2.16 nm, $\varepsilon_y/\varepsilon_x$ = 0.20%, σ_ε = 0.069%, σ_z = 3.5 mm,
$\beta^*_{x,y}$ = (.22 m, 1 mm), $\nu_{x,y,z}$ = (218.1854, 222.2203, −0.0809), Crab Waist = 55%
440 turns, Damping: each element, Touschek Lifetime: 3.91×10^6 sec @ $N = 1\times10^{10}$
$\Delta x(0)$
$\Delta x(\pi/4)$
$\Delta x(\pi/2)$
$\Delta x(3\pi/4)$
$W^{\pm}$
$\Delta x(\psi)/\sigma_x$
$\Delta\varepsilon/\sigma_\varepsilon$ (±1.0%)

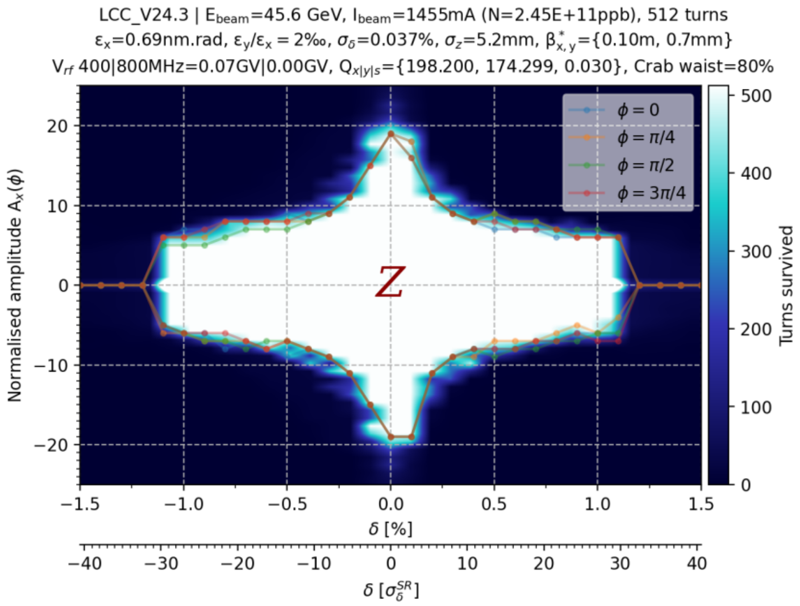

GHC_V24 | E_{beam}=80.0 GeV, I_{beam}=135mA (N=1.38E+11ppb), 500 turns
ε_x=2.16nm.rad, $\varepsilon_y/\varepsilon_x$ = 2‰, σ_δ=0.069%, σ_z=3.5mm, $\beta^*_{x,y}$={0.20m, 1.0mm}
V_{rf} 400|800MHz=1.00GV|0.00GV, $Q_{x|y|s}$={218.183, 222.218, 0.081}, Crab waist=55%
Normalised amplitude $A_x(\phi)$
Turns survived
δ [%]
δ [σ_δ^{SR}]

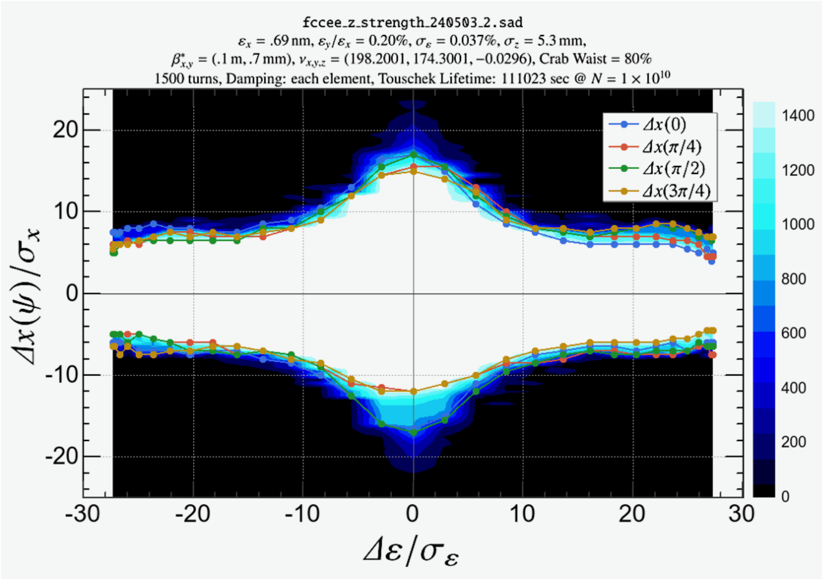

FCCee_t_605_nosol_13.sad
ε_x = 1.51 nm, $\varepsilon_y/\varepsilon_x$ = 0.20%, σ_ε = 0.152%, σ_z = 1.9 mm,
$\beta^*_{x,y}$ = (.88 m, 1.36 mm), $\nu_{x,y,z}$ = (398.1477, 398.2153, −0.0888), Crab Waist = 40%
40 turns, Damping: each element, Touschek Lifetime: 7.76×10^7 sec @ $N = 1\times10^{10}$
$\Delta x(0)$
$\Delta x(\pi/4)$
$\Delta x(\pi/2)$
$\Delta x(3\pi/4)$
$t\bar{t}$
$\Delta x(\psi)/\sigma_x$
$\Delta\varepsilon/\sigma_\varepsilon$ (−2.8 + 2.5%)
7


GHC_V24 | E_{beam}=182.5 GeV, I_{beam}=5mA (N=1.47E+11ppb), 50 turns
ε_x=1.51nm.rad, $\varepsilon_y/\varepsilon_x$ = 2‰, σ_δ=0.157%, σ_z=1.8mm, $\beta^*_{x,y}$={0.90m, 1.4mm}
V_{rf} 400|800MHz=2.10GV|9.20GV, $Q_{x|y|s}$={398.138, 398.208, 0.089}, Crab waist=40%
Normalised amplitude $A_x(\phi)$
Turns survived
δ [%]
δ [σ_δ^{SR}]

Differences between Xsuite and SAD (LCC)

- I spotted differences with the variable cs_comp that is not used (at least in the converted MADX file, Oide-san sent me.)
- DA recomputed without decapoles and cs_comp = 0 that would explain the differences observed with and without crab sextupoles as the decapoles are turned on also without crab waist.





Relaxed optics DA/MA