

SIS100: Tune scans with and without space charge

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- U28+ 200 MeV/u
- 3D Gaussian distribution truncated at 2 sigma, sigmas were chosen to ensure the RMS values after truncation:
 - Emittance_x_rms=8.75e-6; Emittance_y_rms=3.75e-6
 - RMS Bunch length: 14.5m
 - RMS Momentum spread: 0.5e-3
- Cavity voltage 58.2kV
- Harmonic number h=10
- Particle number per bunch $N_p=0.625e11$
- Bunching factor 0.03

- Quadrupole families and ratios of warm to cold quads:
 - K1NL_S00QD1D := kqd (defocusing)
 - K1NL_S00QD1F := kqf (focusing)
 - K1NL_S00QD2F := kqf (focusing)
 - K1NL_S52QD11 := 1.0139780 * kqd ;
 - K1NL_S52QD12 := 1.0384325 * kqf ;

- No sextupoles
- No orbit correction
- No collimators
- No cryo-catchers

- Makethin: Quadrupoles divided into 9 lenses
- Statistics: 1000 particles
- Turns: 20,000
- Tune matched after error assignment
- Space charge implemented after matching the tune
- Reassigning the initial errors in MADX after implementing the space charge
- If tracking with space charge: 500 space charge kicks

Error definitions



!!Displacement errors of main dipoles

eDX = 0 ;
eDY = 0 ;
eDPSI = 1.9e-4 ;

!!Relative systematic errors of the dipoles

RSys2n = 2.29063e-4 ;
RSys4n = 1.68153e-4 ;
RSys6n = 0.09823e-4 ;

!!Relative random errors of the dipoles

rErr0n = 2.0e-4 ;
rErr1n = 0.36393e-4 ;
rErr1s = 0.68885e-4 ;
rErr2n = 0.30741e-4 ;
rErr2s = 0.35778e-4 ;
rErr3n = 0.11589e-4 ;
rErr3s = 0.24067e-4 ;
rErr4n = 0.10267e-4 ;
rErr4s = 0.26934e-4 ;
rErr5n = 0.02879e-4 ;
rErr5s = 0.03291e-4 ;
rErr6n = 0.03051e-4 ;
rErr6s = 0.05756e-4 ;

!!Displacement errors of main quadrupoles

eDX = 27e-6 ;
eDY = 27e-6 ;
eDPSI = 0 ;

!!Relative systematic errors of the quadrupoles

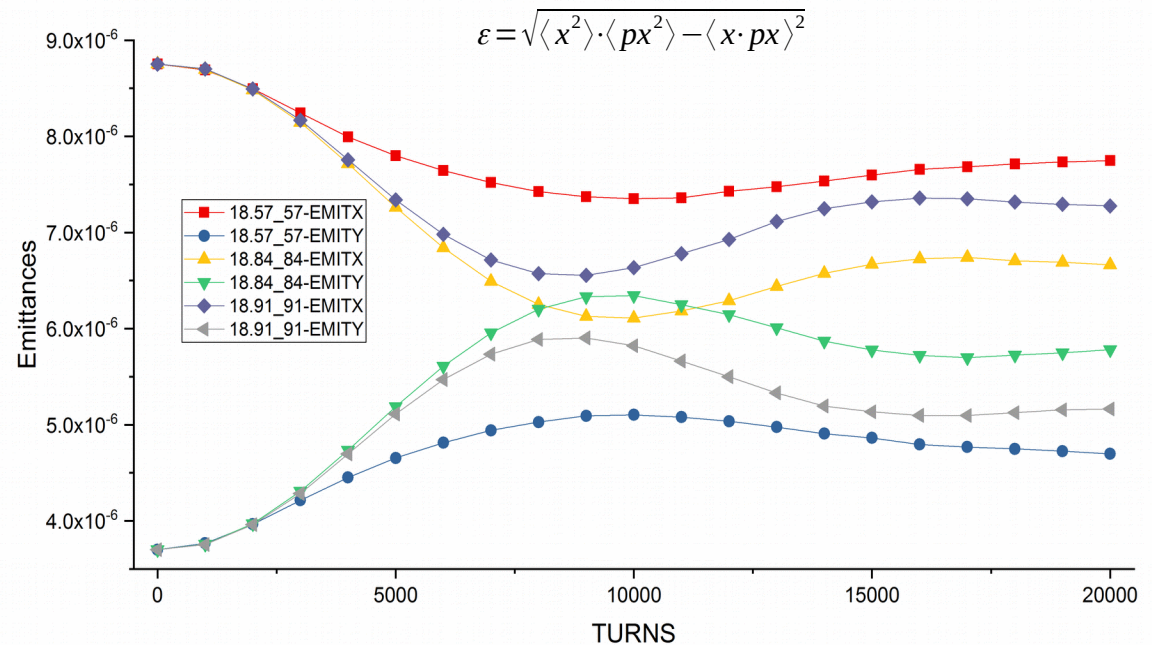
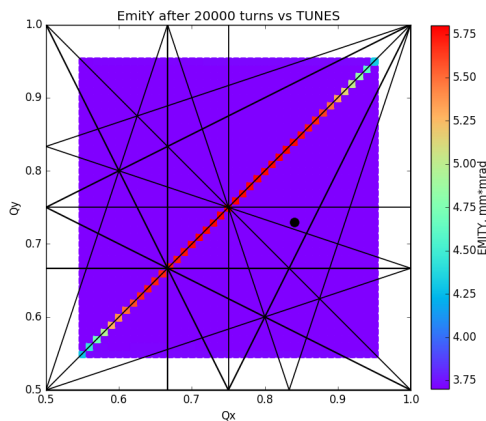
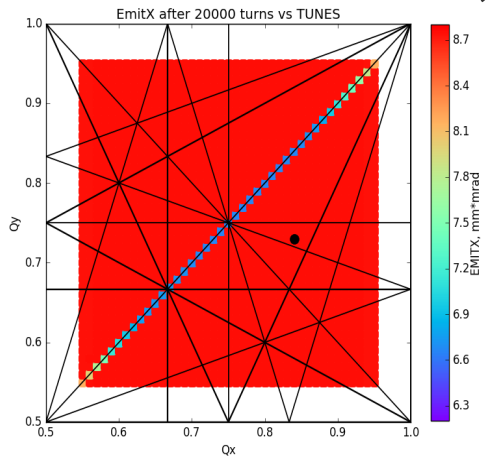
RSysQD5n = 6.9e-4 * 1.3/9 ;

!!Relative random errors of the quadrupoles

rErrQD_1n = 12e-4 * 1.3/9 ;
rErrQD_1s = 20e-4 * 1.3/9 ;
rErrQD_2n = 0.7e-4 * 1.3/9 ;
rErrQD_2s = 1.2e-4 * 1.3/9 ;
rErrQD_3n = 2.7e-4 * 1.3/9 ;
rErrQD_3s = 2.6e-4 * 1.3/9 ;
rErrQD_4n = 1.0e-4 * 1.3/9 ;
rErrQD_4s = 0.7e-4 * 1.3/9 ;
rErrQD_5n = 3.45e-4 * 1.3/9 ;
rErrQD_5s = 1.0e-4 * 1.3/9 ;
rErrQD_6n = 0.3e-4 * 1.3/9 ;
rErrQD_6s = 0.3e-4 * 1.3/9 ;

Tracking: No Space Charge + No Errors

- RMS emittances after 20,000 turns (tune scan)
- With DIPEDGE, no apertures

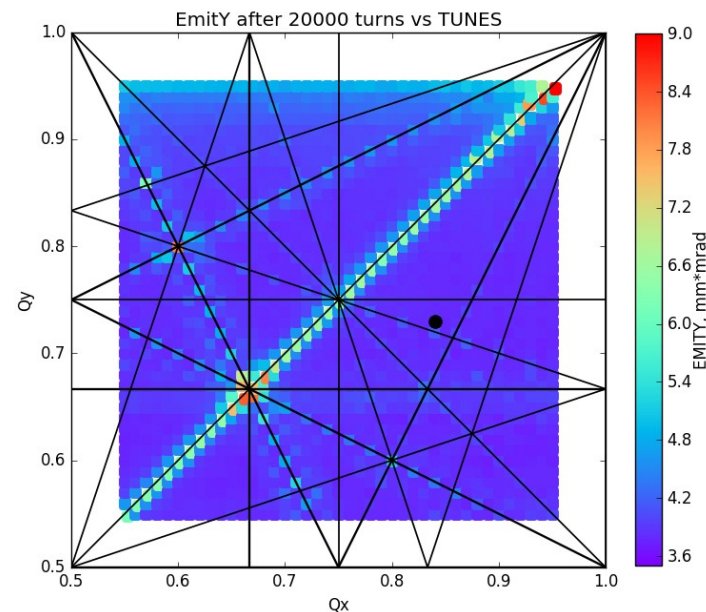
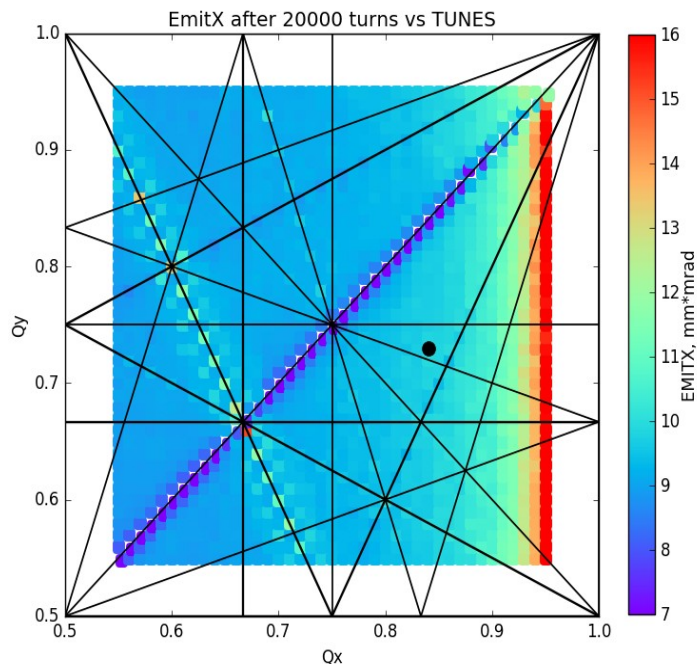


- Coupling observed when QX=QY
- Emittance exchange between planes

Results: Emittances-noErr-noaper-dipedge.dat

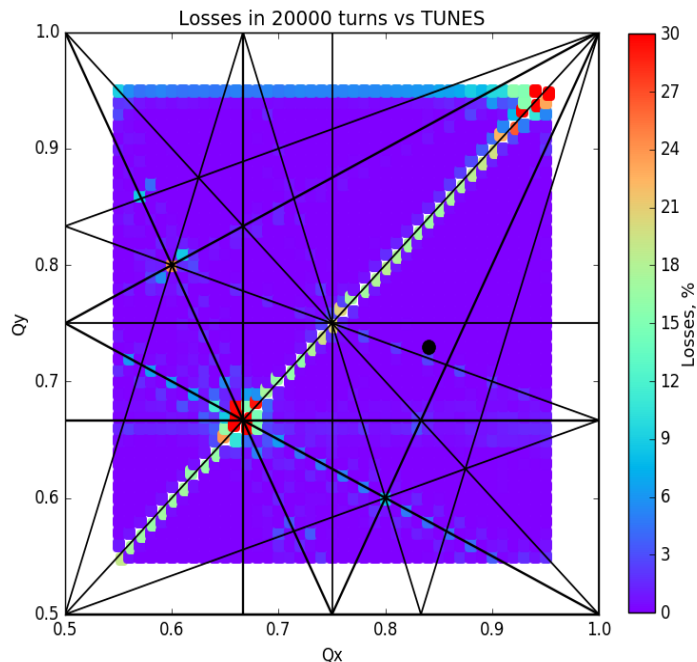
Tracking: No Space Charge + Errors

- RMS emittances after 20,000 turns
- No DIPEDGE, no apertures
- Error ensemble # 1 (misalignments and fields)



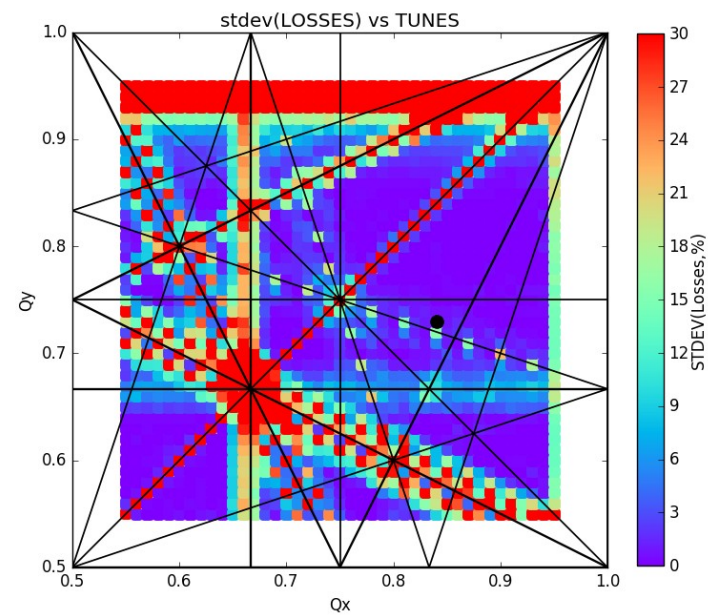
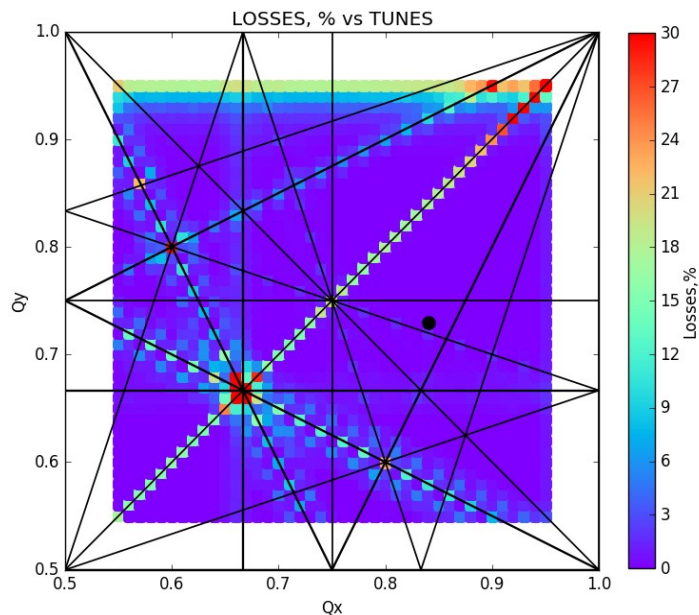
Results: Emittances-AllErr-noaper-nodipedge.dat

- Losses after 20,000 turns
- With DIPEDGE, with apertures
- Error ensemble # 1 (misalignments and fields)



Results: Emittances-AllErr-aper-dipedge_set1.dat

- Losses after 20,000 turns
- With DIPEDGE, with apertures
- 9 different error-ensembles (misalignments and fields)
- Average and standard deviation data:

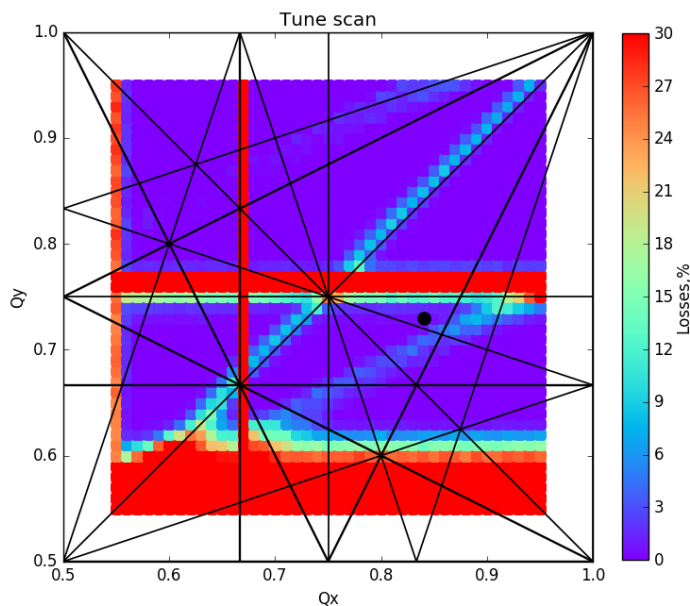


Results: Emittances-AllErr-aper-dipedge_sets2-10.dat

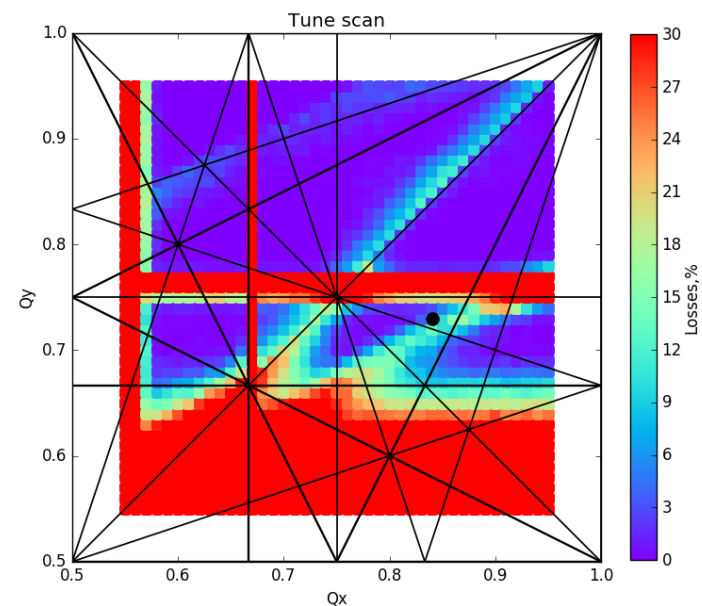
- Comment in MADX source:
! Exact formulation might be too computational time costly:
! $DPI = (\sqrt{(one + z(6,i) * betas)^2 - gammas^{(-2)}}) / betas - one$
- Possible options:
- Option, SC_CHROM_FIX = FALSE (default, original!)
 - $DPI = (z(6,i) - orbit(6)) / betas$
 - $z_part_array(i) = (z(5,i) - orbit(5)) * betas$
- Option, SC_CHROM_FIX = TRUE (FRS add-ons)
 - $DPI = (z(6,i) - orbit(6))$
 - $z_part_array(i) = (z(5,i) - orbit(5))$

- DPIs are used in the following:
 - $XI = z(1,i) - \text{orbit}(1) - dx_start * DPI$
 - $PXI = z(2,i) - \text{orbit}(2) - dpx_start * DPI$
 - $YI = z(3,i) - \text{orbit}(3) - dy_start * DPI$
 - $PYI = z(4,i) - \text{orbit}(4) - dpy_start * DPI$
 - $lx_array(i) = (\text{gamax_start} * XI * XI + \text{two} * \text{alfax_start} * XI * PXI + \text{betax_start} * PXI * PXI) / \text{two}$
 - $ly_array(i) = (\text{gamay_start} * YI * YI + \text{two} * \text{alfay_start} * YI * PYI + \text{betay_start} * PYI * PYI) / \text{two}$
 - $dpi_array(i) = DPI$
- To be checked: definitions of dx_start and dpx_start

Tracking: Space Charge + No Errors



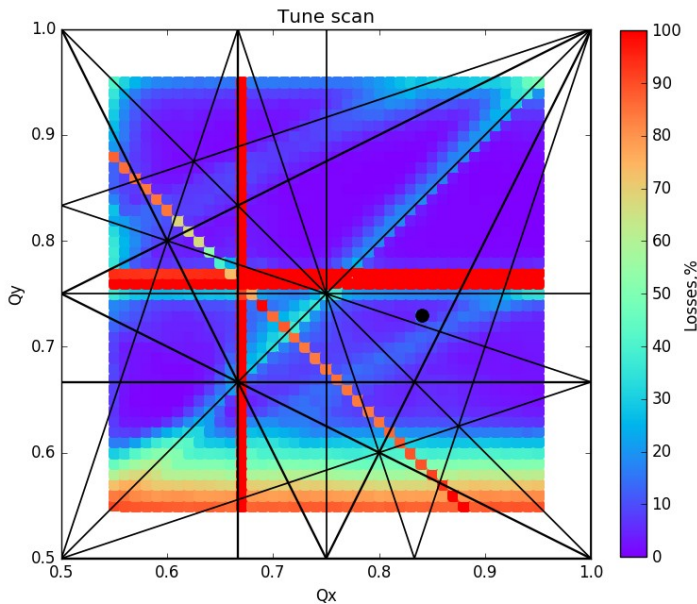
$sc_chrom_fix = true$



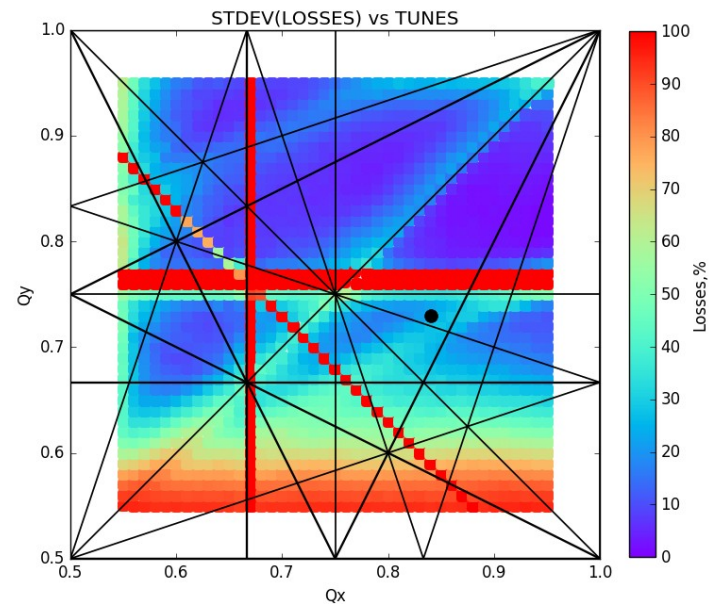
$sc_chrom_fix = false$

Results: SC_Emittances-noErr-aper-dipedge-scfixTRUE.dat
SC_Emittances-noErr-aper-dipedge-scfixFALSE.dat

- >4 different error-ensembles (misalignments and fields)
- Average and standard deviation data:
- NB! Different scale!



sc_chrom_fix = true



sc_chrom_fix = false

Results: SC_Emittances-AllErr-aper-dipedge-scfixTRUE.dat
SC_Emittances-AllErr-aper-dipedge-scfixFALSE.dat