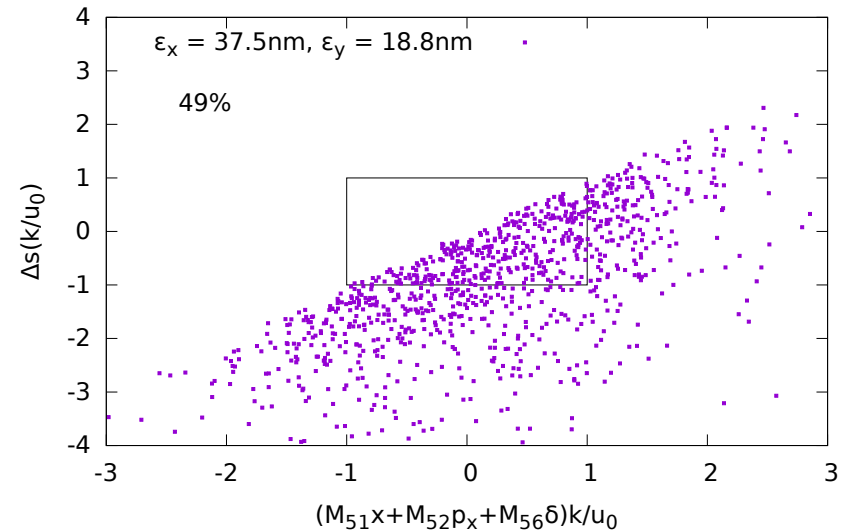
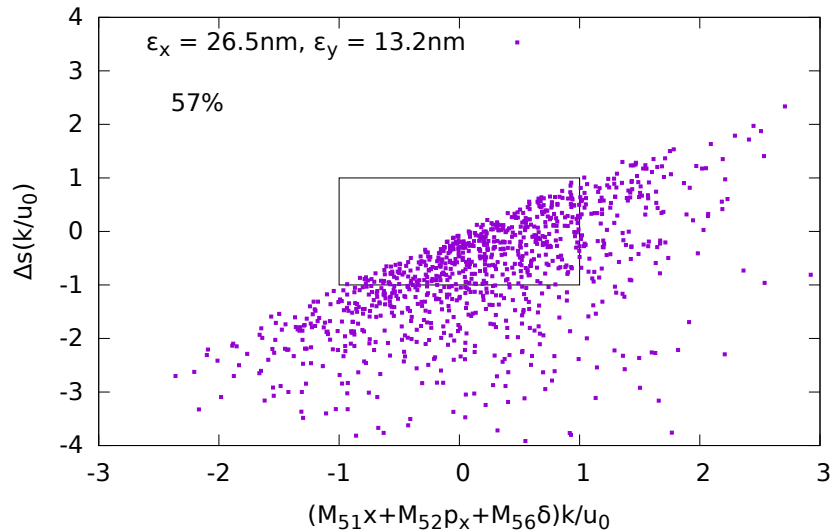
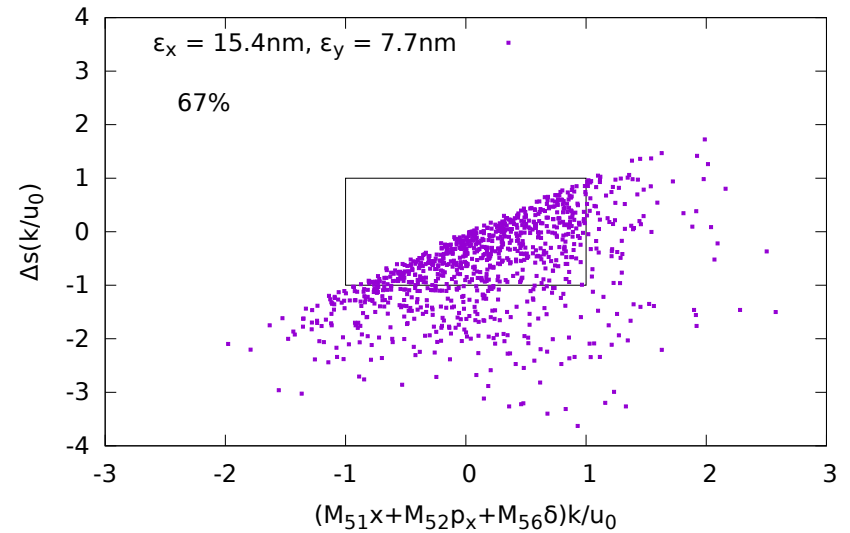
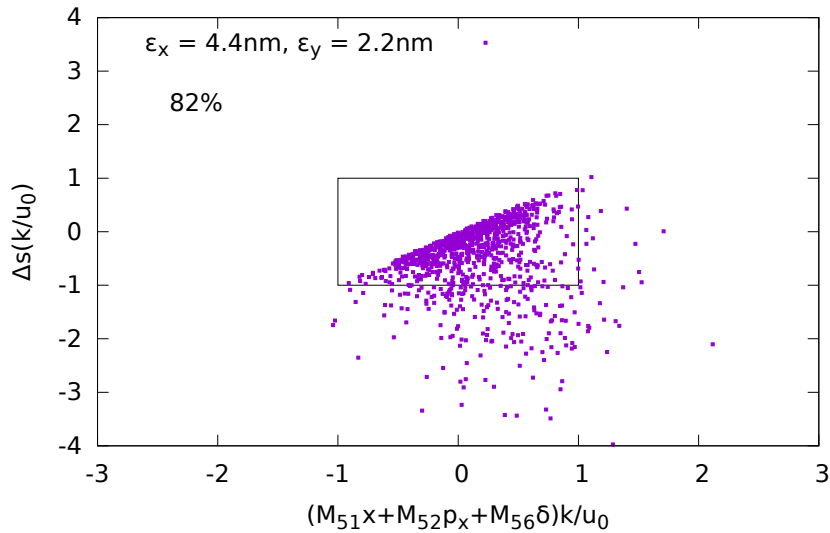


# Bypass nonlinearity

D. Rubin

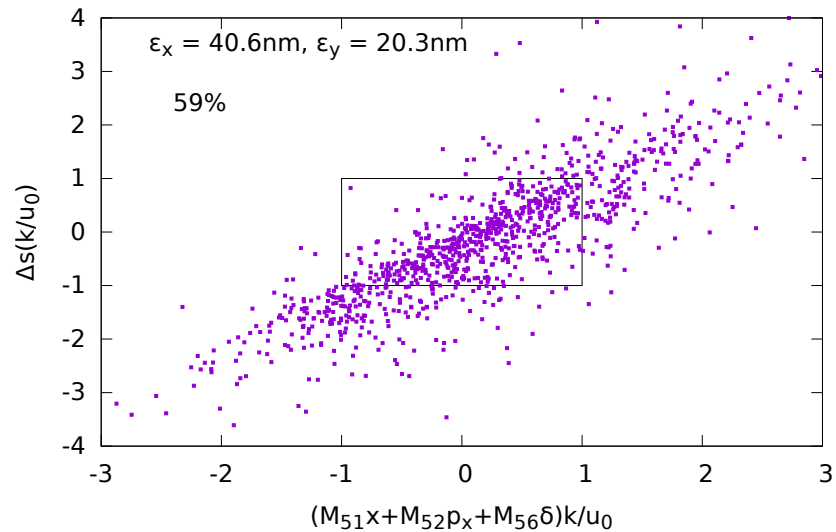
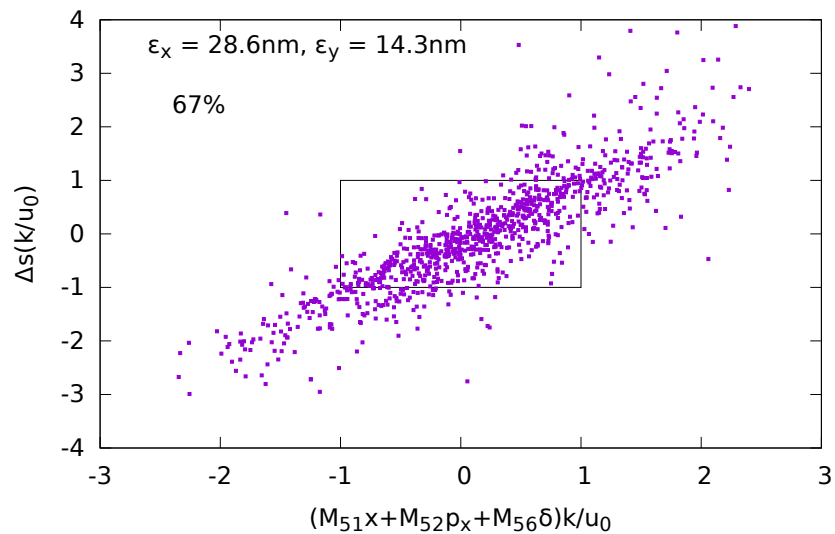
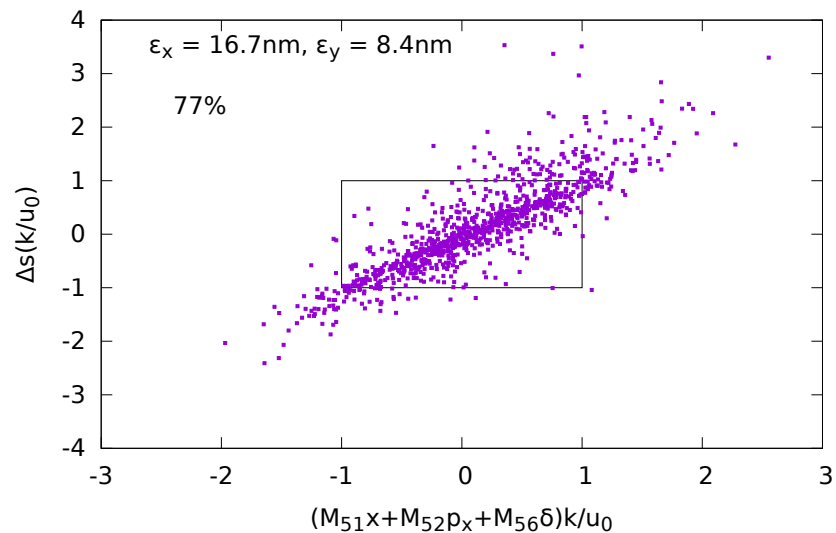
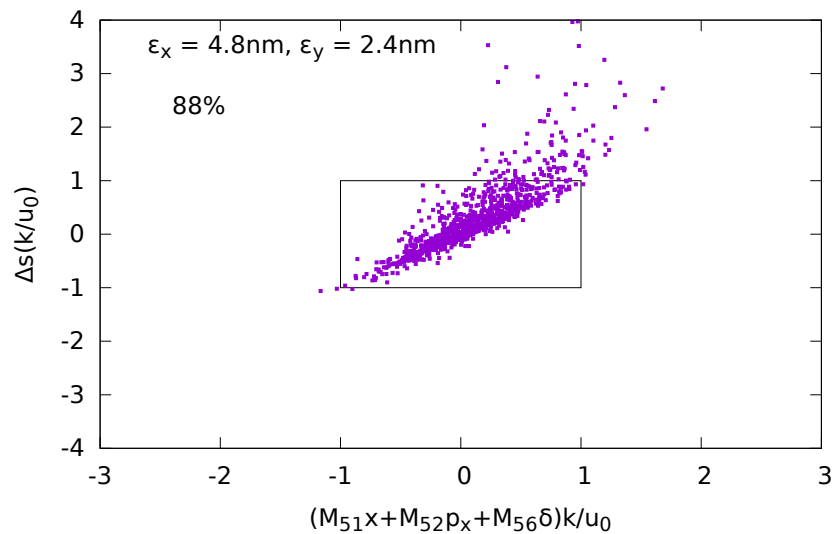
August 22, 2018

Minimize  $\int (x')^2 ds$  for a particular betatron phase



Minimize  $\langle \int (x')^2 + (y')^2 ds \rangle$  (Averaged over all  $\phi$ )

And second order bypass matrix elements  $T_{511}$   $T_{512}$   $T_{522}$   $T_{516}$   $T_{526}$



## Second order lengthening

$$\Delta s = T_{511}x^2 + T_{512}xx' + T_{522}(x')^2$$

$$x = \sqrt{\epsilon\beta} \cos \phi$$

$$x' = -\sqrt{\frac{\epsilon}{\beta}} (\alpha \cos \phi + \sin \phi)$$

$$\langle(\Delta s)\rangle = \int (\Delta s) d\phi$$

$$\sigma_l^2 = \langle(\Delta s)^2\rangle - \langle\Delta s\rangle^2$$

$$\rightarrow \sigma_l^2 = \epsilon^2 [2(T_{511}\beta - T_{521}\alpha + T_{522}\gamma)^2 + (T_{521}^2 - 4T_{511}T_{522})]$$

Parameters - bmad\_3.7nm-45.6nm\_dp100.lat

Delta s = 1.9201E-03, emit\_max = 4.5634E-08, dp/p\_max = 1.0085E-02

$T_{51} = -3.3674E-04$   $T_{52} = -3.3624E-03$   $T_{56} = 3.1608E-03$

$T_{511} = -4.4622E-02$   $T_{512} = 6.5993E-01$   $T_{516} = -1.9159E-03$

$T_{522} = -1.8039E+00$   $T_{526} = -1.9131E-02$   $T_{566} = -4.1577E-03$

$T_{533} = -1.4974E-01$   $T_{534} = -1.9555E+00$   $T_{536} = 0.0$

$T_{544} = -1.2384E+01$   $T_{546} = 0.0$

sum theta\_x2 = 2.6022E+00 sum theta\_y2 = 2.9913E+00

second\_order\_x = 9.6858E-01 second\_order\_y = 3.6449E+00

Beam Energy = 1.0000E+09 gamma\_e = 1.9570E+03

Wiggler:B\_max = 1.4 kG wiggler\_period = 32.5cm K = 4.2479

Optical wavelength = 8.0810E-07

Pickup: beta/alpha/gamma = 8.1892E+00 -1.0000E-01 1.2333E-01

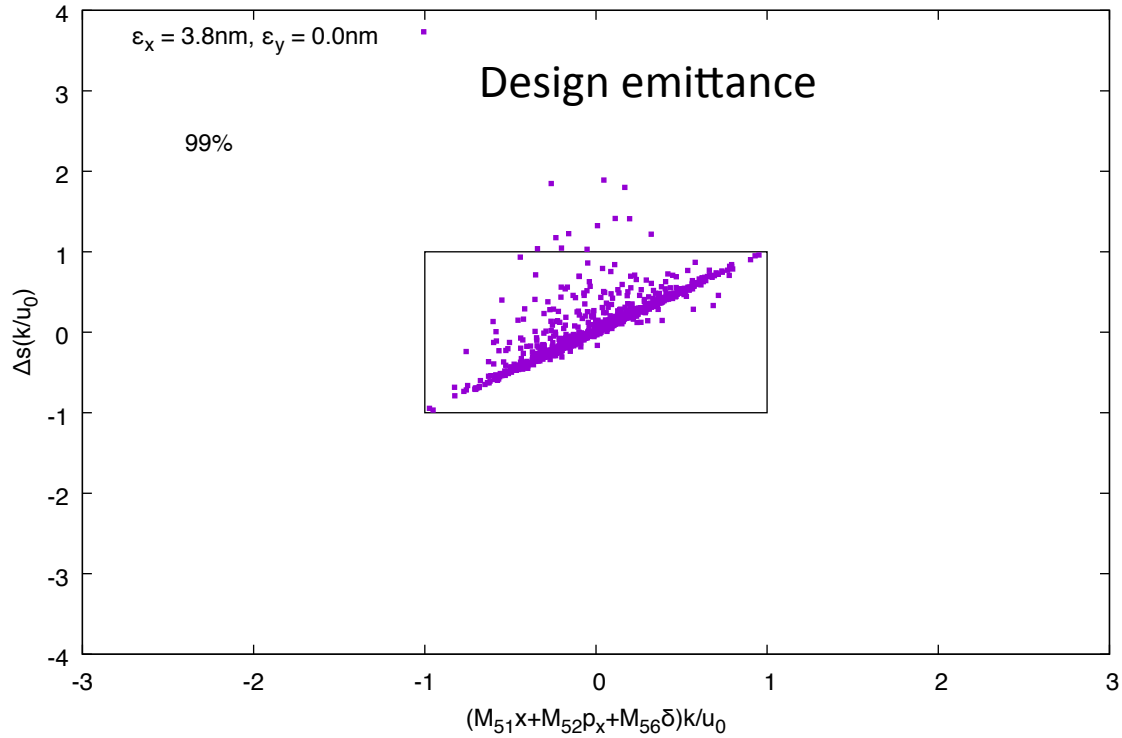
kicker: eta/etap = 3.5276E+00 -5.5766E-01

kicker: Curly H = 2.1154E+00

Horizontal emittance = 3.7804E-09 emit\_max = 4.5634E-08

Fractional energy spread = 4.0656E-04 dp/p\_max = 1.0085E-02

Ratio transverse/longitudinal rate = 4.1524E+01



$\epsilon_y = 1\% \epsilon_x$   
 95% is  $\epsilon_y$  from xy coupling

$N=1E7, I \sim 0.625 \mu\text{A}, \epsilon_x \sim 4.69 \text{ nm}$

$N=1E8, I \sim 6.25 \mu\text{A}, \epsilon_x \sim 5.46 \text{ nm}$

$N=1E9, I \sim 62.5 \mu\text{A}, \epsilon_x \sim 9.30 \text{ nm}$

