CW 3GeV Linac Error Simulations at 10 mA

60 parameters scanned / TRACKv39_15JUNE2010

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ALIGN/ALGN2 Parameter TRACKv39

n ALIGN name δ_{xy} δ_z ϕ_z $\delta\phi_{dyn.}$ $\delta F_{dyn.}$ $\delta\phi_{static}$ δF_{static}
n ALGN2 name δ_x δ_y δ_z ϕ_x ϕ_y ϕ_z $\delta\phi_{dyn.}$ $\delta F_{dyn.}$ $\delta\phi_{static}$ δF_{static}

- $\delta_{xy}[cm]$ From the max allowed displacement of element ends, the maximum allowed rotation is calculated. Then the random errors are generated for both displacement and rotation. The generated errors are accepted only if the final displacements of the element ends is within the tolerence (max allowed displacement) specified as input. Uniform distribution.
- $\delta_x[cm]$ Displacement parallel to the x-axis. Uniform distribution.
- $\phi_x[mrad]$ Rotation of the element with respect to the center of the element. Uniform distribution
- $\delta\phi_{dyn.}[deg]$: Amplitude of the dynamic phase error of the device. Gaussian distribution truncated at 3 sigma.
- $\delta F_{dyn.}[\%]$: Amplitude of the dynamic field error of the device. Gaussian distribution truncated at 3 sigma.
- $\delta\phi_{static}[deg]$: Amplitude of the static phase error of the device. Uniform distribution.
- $\delta F_{static}[\%]$: Amplitude of the static field error of the device.

Error Simulation (24000 runs)

- From RFQ exit to end of the CW 3 GeV linac ($\sim$420 meters)
- 60 errors simulated with TRACKv39
- Each error simulated with 400 seeds with 3D SC (10 mA) and 50k per seed
- $60 \times 400 = 24000$ runs with TRACKv39 on FermiGrid

Analysis *à la M. Baylac* , Error Study of CERN Linac

$$\Delta\epsilon = \frac{\delta\epsilon_{err} - \delta\epsilon_{nom}}{\delta\epsilon_{nom}} \tag{1}$$

- $\delta\epsilon_{err}$ is the emittance growth of the beam through the CW linac **with** errors
- $\delta\epsilon_{err}$ is the emittance growth of the beam through the CW linac **without** errors
- Each error simulation consist of 400 runs (1000 runs in case of CERN), 10 mA, 50k.

Parameters 01-20

- 01/ Solenoids $\delta_x = 150\ \mu$m
- 02/ Solenoids $\delta_x = 300\ \mu$m
- 03/ Solenoids $\delta_x = 500\ \mu$m
- 04/ Solenoids $\delta_x = 750\ \mu$m
- 05/ Solenoids $\delta_x = 1000\ \mu$m

- 06/ Solenoids $\phi_x = 1$ mrad
- 07/ Solenoids $\phi_x = 2$ mrad
- 08/ Solenoids $\phi_x = 3$ mrad
- 09/ Solenoids $\phi_x = 4$ mrad
- 10/ Solenoids $\phi_x = 5$ mrad

- 11/ Solenoids $\delta_{xy} = 150\ \mu$m
- 12/ Solenoids $\delta_{xy} = 300\ \mu$m
- 13/ Solenoids $\delta_{xy} = 500\ \mu$m
- 14/ Solenoids $\delta_{xy} = 750\ \mu$m
- 15/ Solenoids $\delta_{xy} = 1000\ \mu$m

- 16/ Quads $\delta_x = 150\ \mu$m
- 17/ Quads $\delta_x = 300\ \mu$m
- 18/ Quads $\delta_x = 500\ \mu$m
- 19/ Quads $\delta_x = 750\ \mu$m
- 20/ Quads $\delta_x = 1000\ \mu$m

Parameters 21-40

- 21/ Quads $\phi_x = 2$ mrad
- 22/ Quads $\phi_x = 4$ mrad
- 23/ Quads $\phi_x = 6$ mrad
- 24/ Quads $\phi_x = 8$ mrad
- 25/ Quads $\phi_x = 10$ mrad

- 26/ Quads $\delta_{xy} = 150\ \mu$m
- 27/ Quads $\delta_{xy} = 300\ \mu$m
- 28/ Quads $\delta_{xy} = 500\ \mu$m
- 29/ Quads $\delta_{xy} = 750\ \mu$m
- 30/ Quads $\delta_{xy} = 1000\ \mu$m

- 31/ Cav. $\delta_x = 150\ \mu$m
- 32/ Cav. $\delta_x = 300\ \mu$m
- 33/ Cav. $\delta_x = 500\ \mu$m
- 34/ Cav. $\delta_x = 750\ \mu$m
- 35/ Cav. $\delta_x = 1000\ \mu$m

- 36/ Cav. $\phi_x = 2$ mrad
- 37/ Cav. $\phi_x = 4$ mrad
- 38/ Cav. $\phi_x = 6$ mrad
- 39/ Cav. $\phi_x = 8$ mrad
- 40/ Cav. $\phi_x = 10$ mrad

Parameters 41-60

- 31/ Cav. $\delta_{xy} = 150\ \mu m$
- 32/ Cav. $\delta_{xy} = 300\ \mu m$
- 33/ Cav. $\delta_{xy} = 500\ \mu m$
- 34/ Cav. $\delta_{xy} = 750\ \mu m$
- 35/ Cav. $\delta_{xy} = 1000\ \mu m$

- 46/ Cav. Field $\delta\phi_{dyn.} = 0.5°$
- 47/ Cav. Field $\delta\phi_{dyn.} = 1.0°$
- 48/ Cav. Field $\delta\phi_{dyn.} = 1.5°$
- 49/ Cav. Field $\delta\phi_{dyn.} = 2.0°$
- 50/ Cav. Field $\delta\phi_{dyn.} = 2.5°$

- 51/ Cav. Phase $\delta F_{dyn} = 0.5\ \%$
- 52/ Cav. Phase $\delta F_{dyn} = 1.0\ \%$
- 53/ Cav. Phase $\delta F_{dyn} = 1.5\ \%$
- 54/ Cav. Phase $\delta F_{dyn} = 2.0\ \%$
- 55/ Cav. Phase $\delta F_{dyn} = 2.5\ \%$

- 56/ $\delta\phi_{dyn.} = 0.5°$ & $\delta F_{dyn} = 0.5\ \%$
- 57/ $\delta\phi_{dyn.} = 1.0°$ & $\delta F_{dyn} = 1.0\ \%$
- 58/ $\delta\phi_{dyn.} = 1.5°$ & $\delta F_{dyn} = 1.5\ \%$
- 59/ $\delta\phi_{dyn.} = 2.0°$ & $\delta F_{dyn} = 2.0\ \%$
- 60/ $\delta\phi_{dyn.} = 2.5°$ & $\delta F_{dyn} = 2.5\ \%$

(001) Solenoids $\delta_x = 150\ \mu$m

Figure: RMS Emittance X

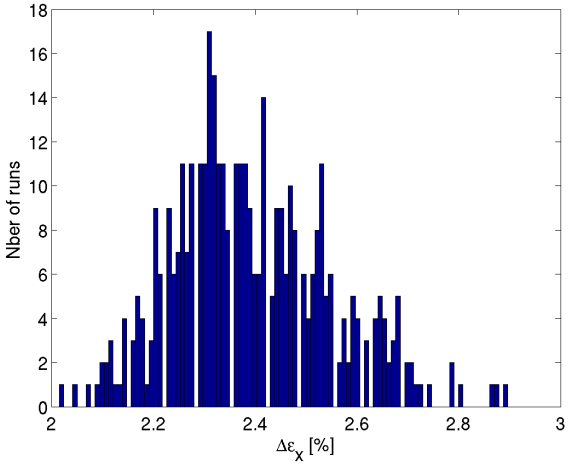


Figure: Centroid X

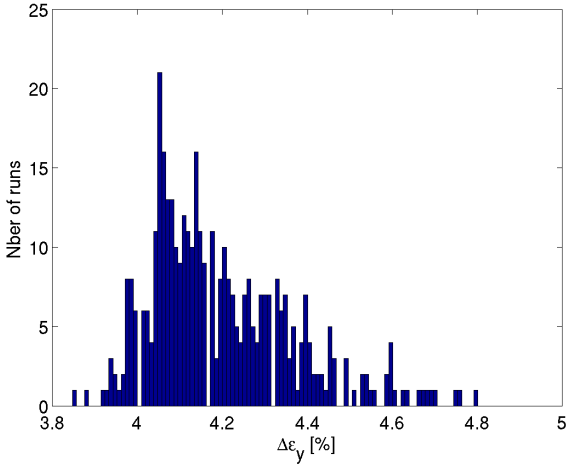


Figure: RMS Emittance Z

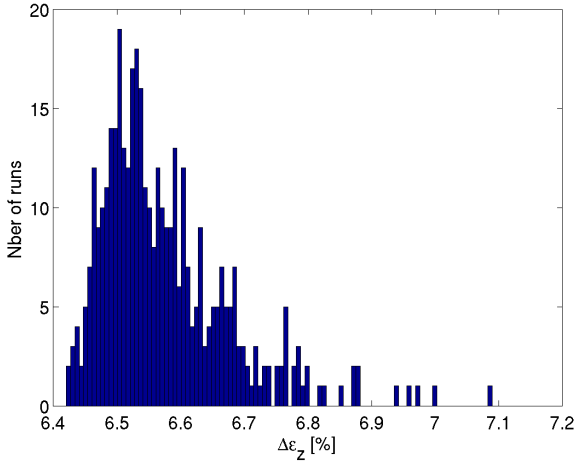
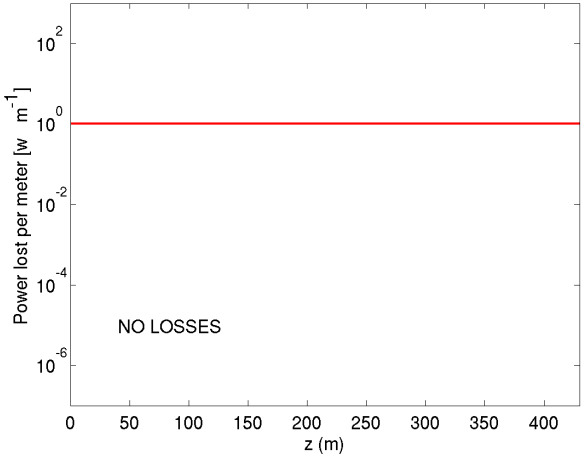


Figure: Losses [W·m^{-1}]



(002) Solenoids $\delta_x = 300\ \mu$m

Figure: RMS Emittance X

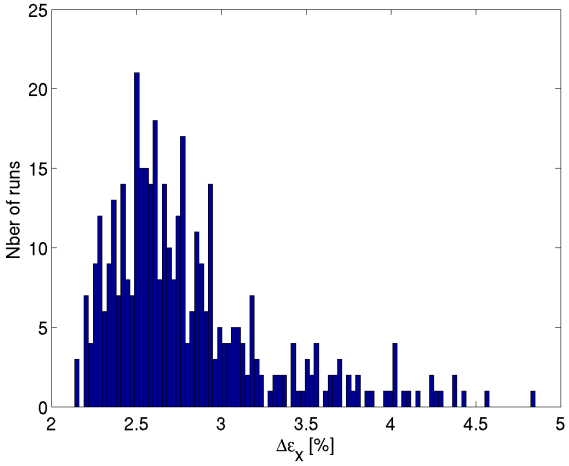


Figure: Centroid X

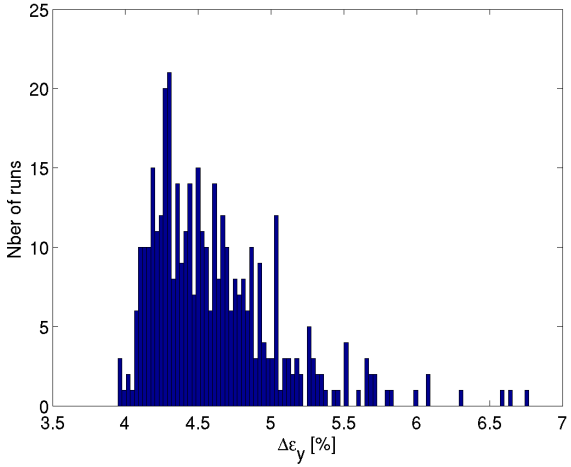


Figure: RMS Emittance Z

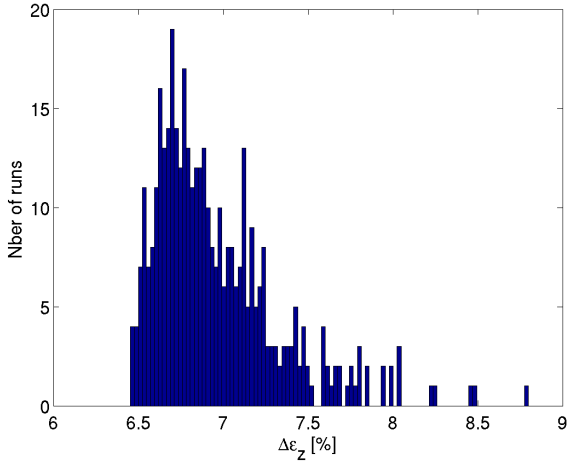
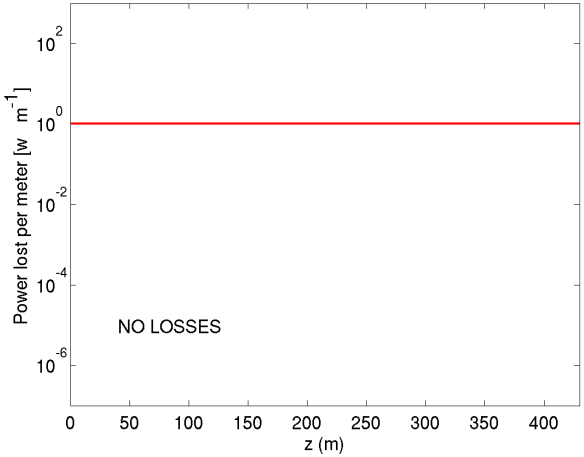


Figure: Losses [W·m^{-1}]



(003) Solenoids $\delta_x = 500\ \mu$m

Figure: RMS Emittance X

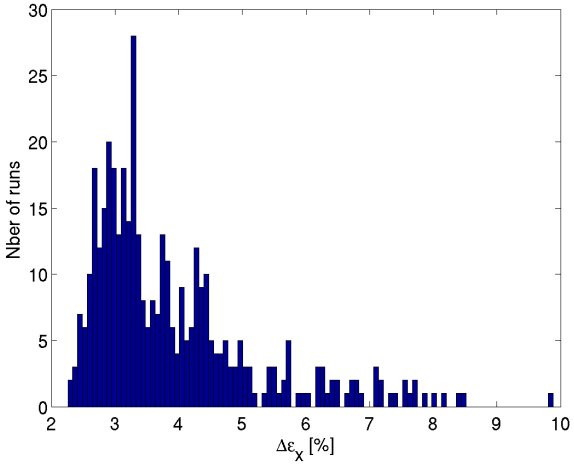


Figure: Centroid X

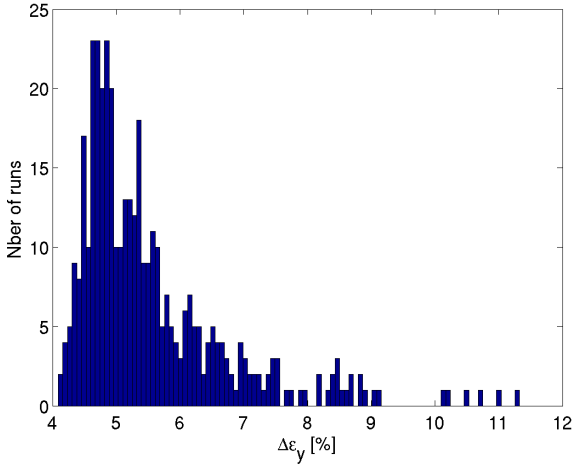


Figure: RMS Emittance Z

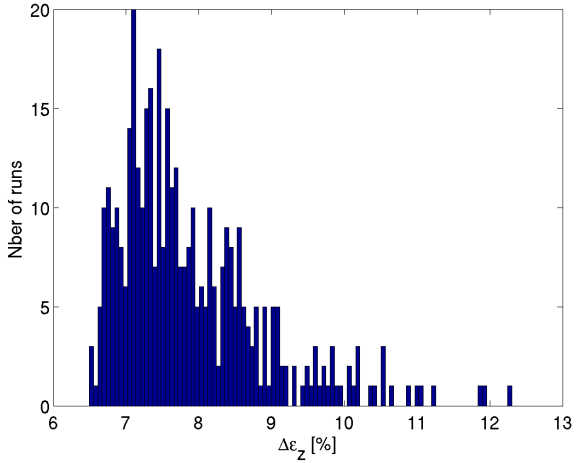
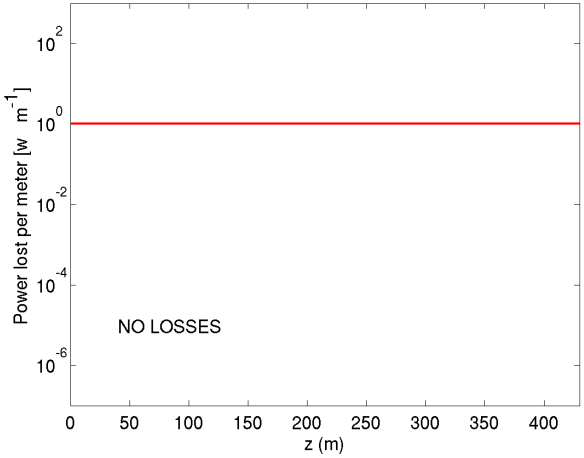


Figure: Losses [W·m^{-1}]



(004) Solenoids $\delta_x = 750\ \mu$m

Figure: RMS Emittance X

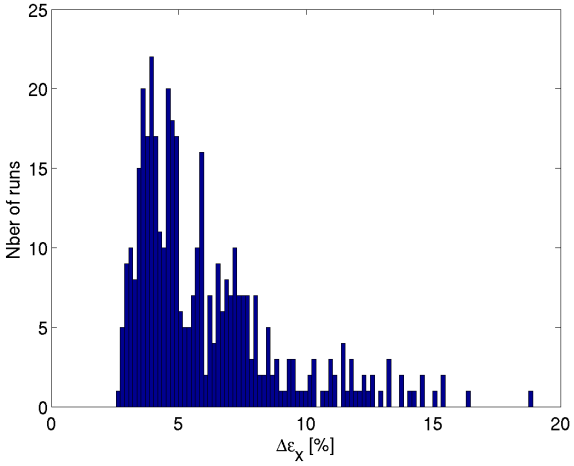


Figure: Centroid X

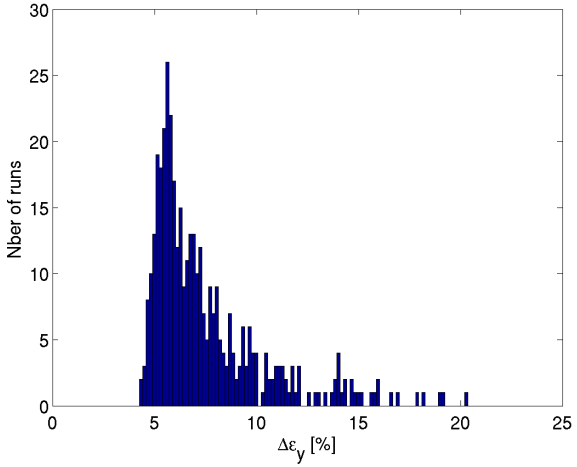


Figure: RMS Emittance Z

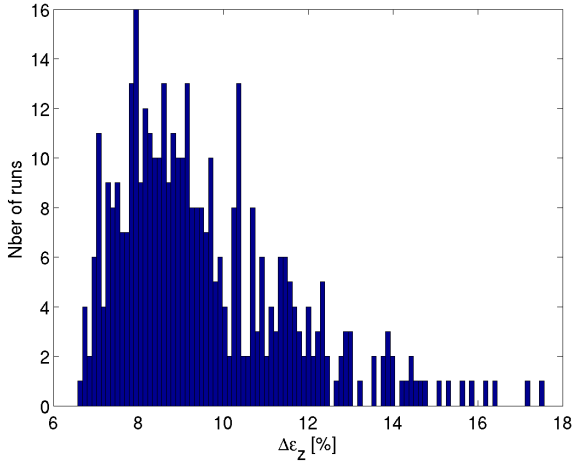
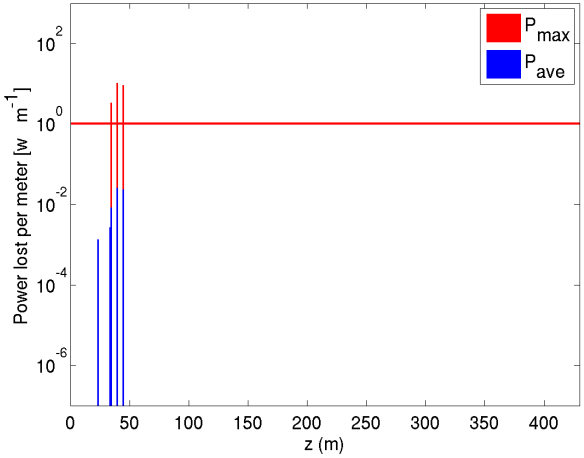


Figure: Losses [W·m^{-1}]



(005) Solenoids $\delta_x = 1000\ \mu$m

Figure: RMS Emittance X

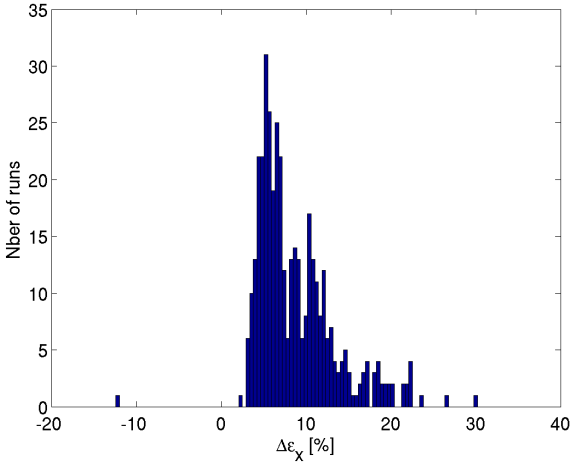


Figure: Centroid X

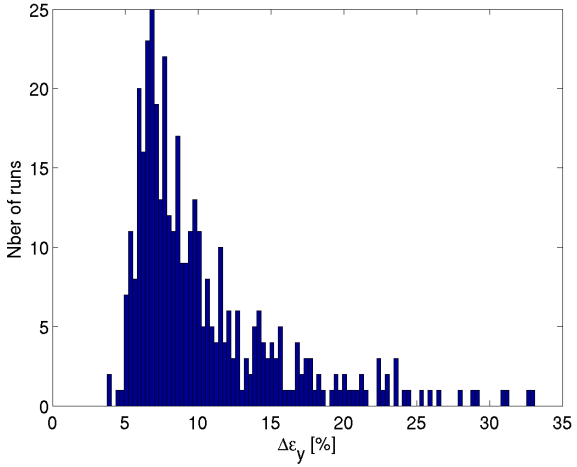


Figure: RMS Emittance Z

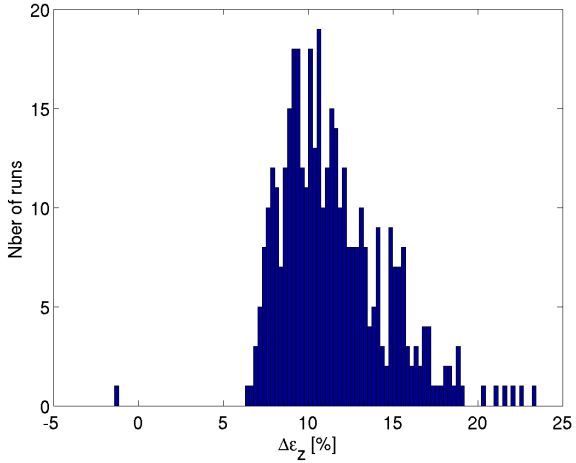
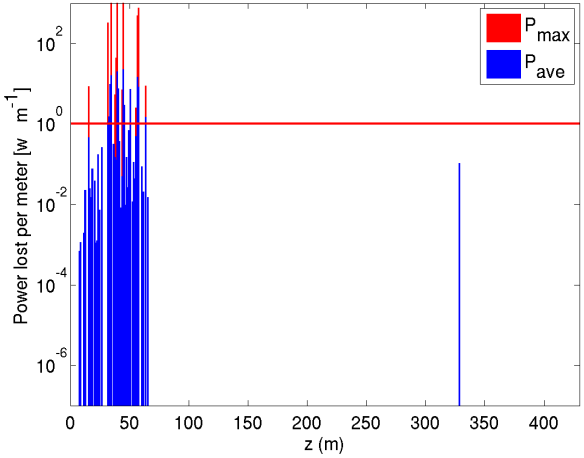


Figure: Losses [W·m^{-1}]



(006) Solenoids $\phi_x = 1$ mrad

Figure: RMS Emittance X

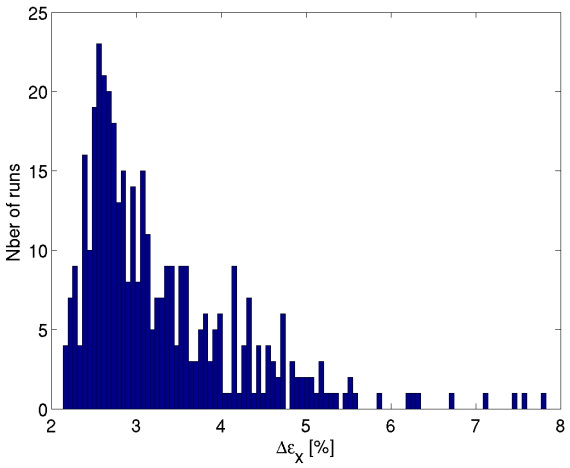


Figure: Centroid X

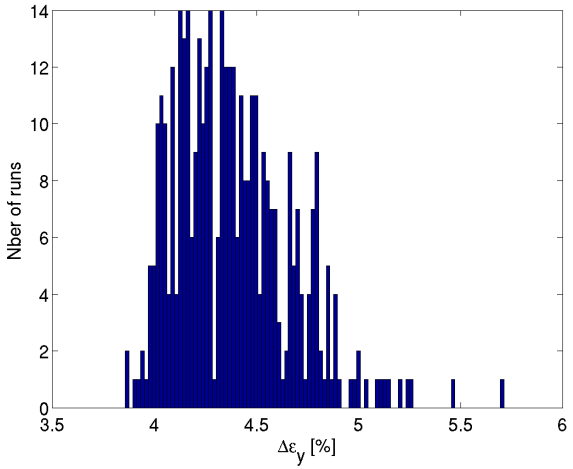


Figure: RMS Emittance Z

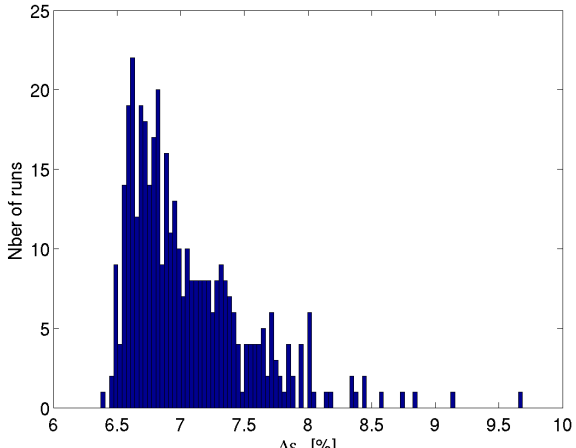
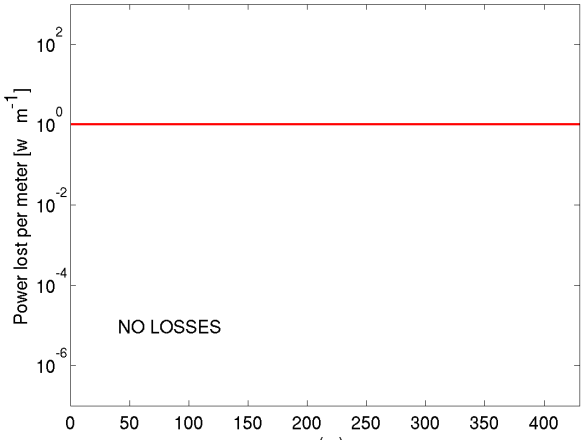


Figure: Losses [W·m^{-1}]



(007) Solenoids $\phi_x = 2$ mrad

Figure: RMS Emittance X

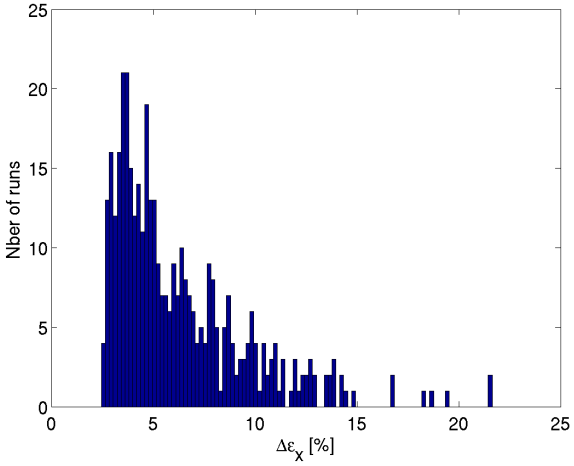


Figure: Centroid X

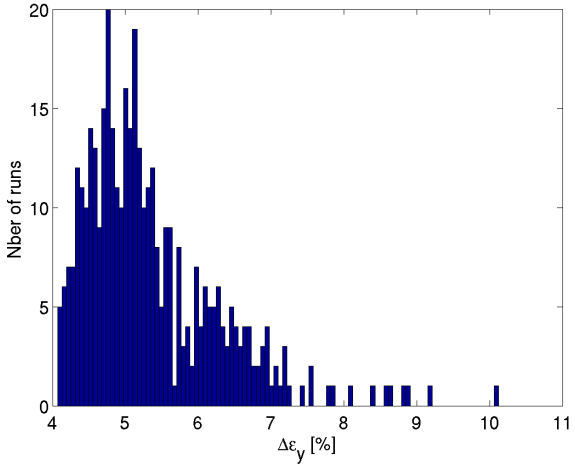


Figure: RMS Emittance z

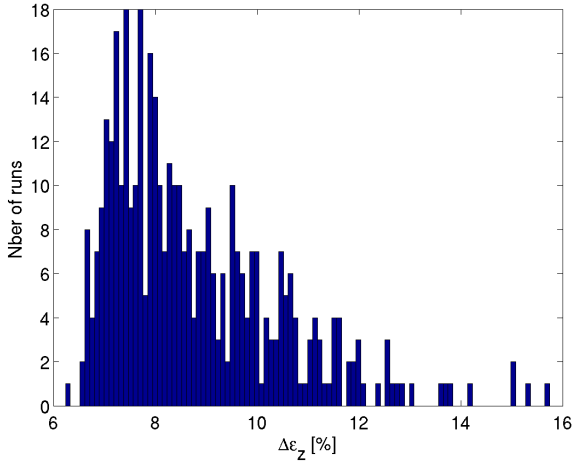
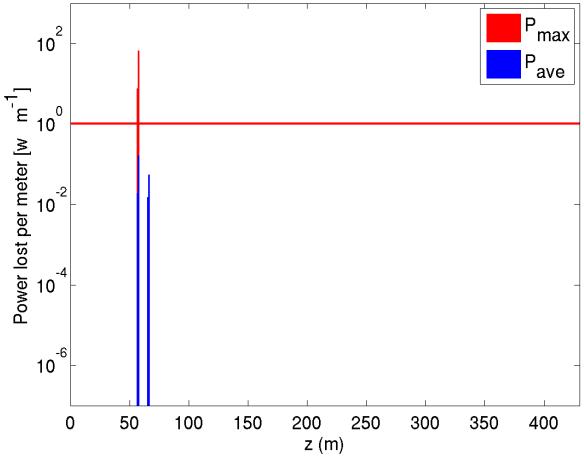


Figure: Losses [W·m^{-1}]



(008) Solenoids $\phi_x = 3$ mrad

Figure: RMS Emittance X

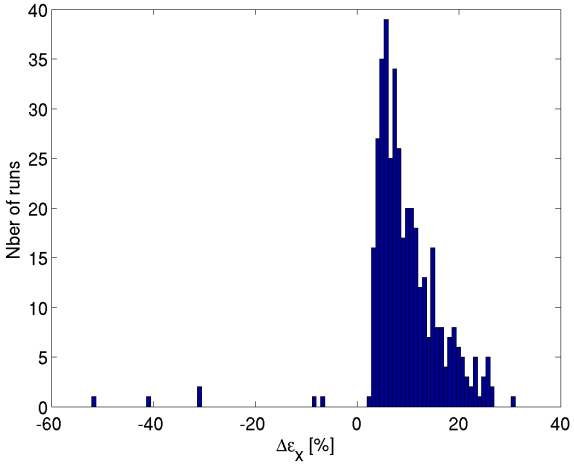


Figure: Centroid X

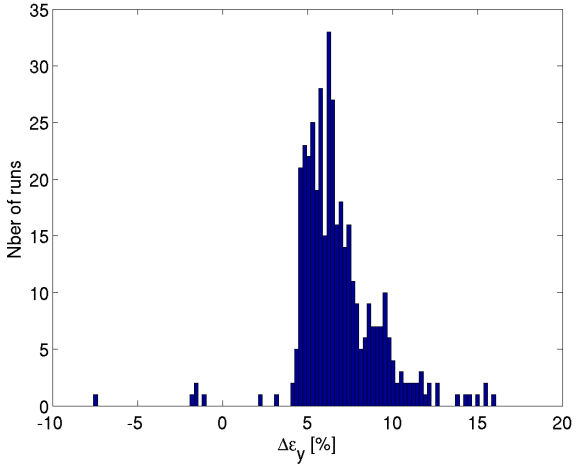


Figure: RMS Emittance Z

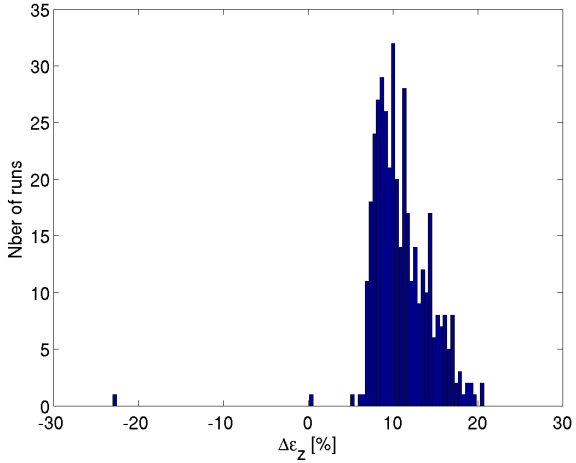
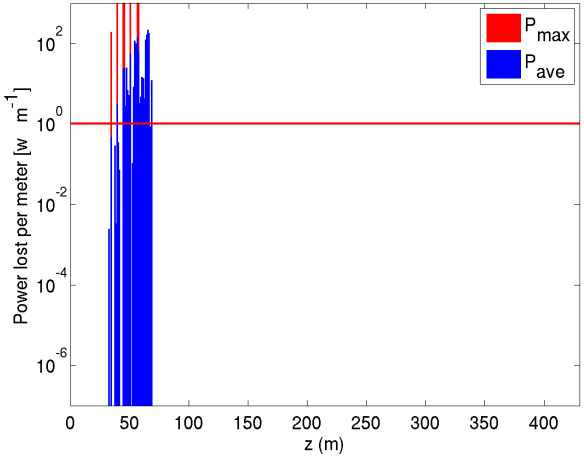


Figure: Losses [W·m^{-1}]



(009) Solenoids $\phi_x = 4$ mrad

Figure: RMS Emittance X

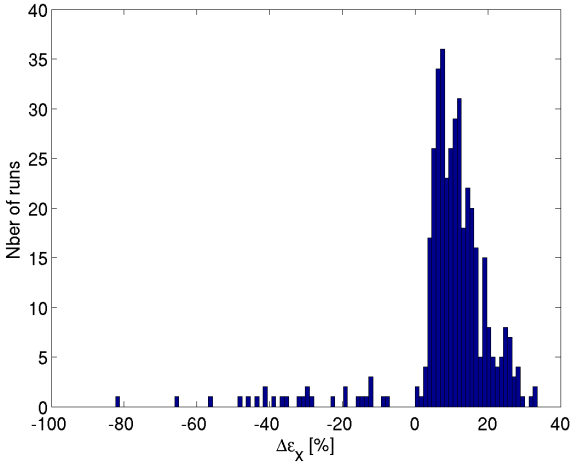


Figure: Centroid X

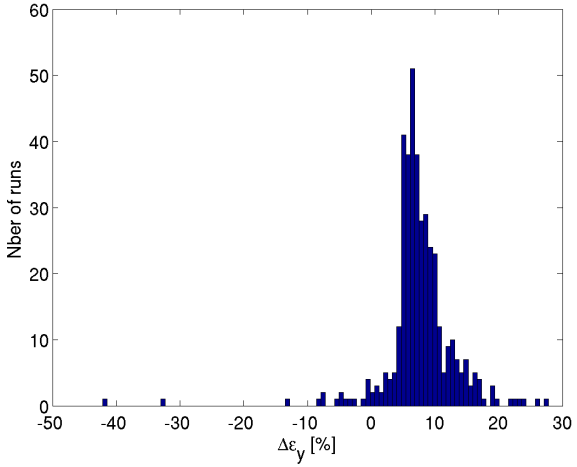


Figure: RMS Emittance Z

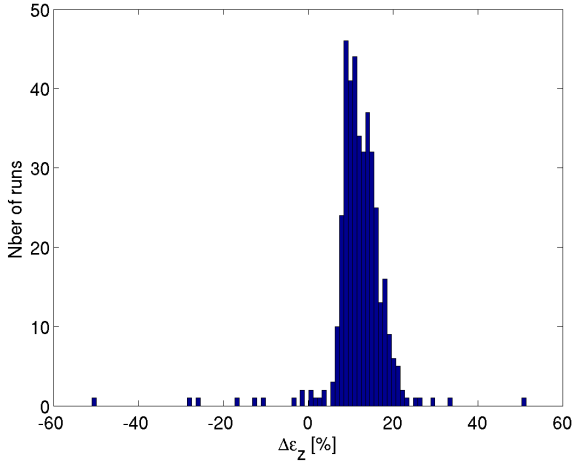
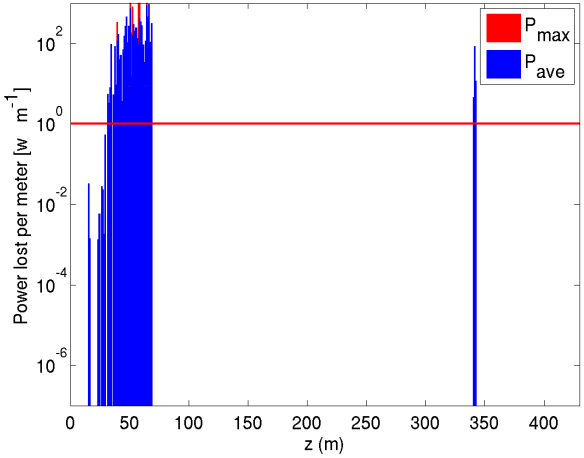


Figure: Losses [W·m^{-1}]



(010) Solenoids $\phi_x = 5$ mrad

Figure: RMS Emittance X

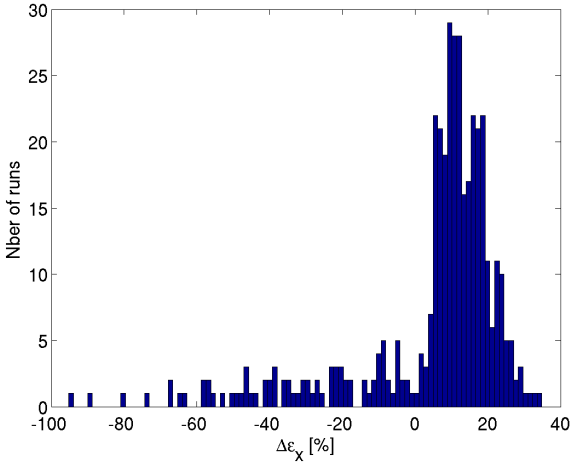


Figure: Centroid X

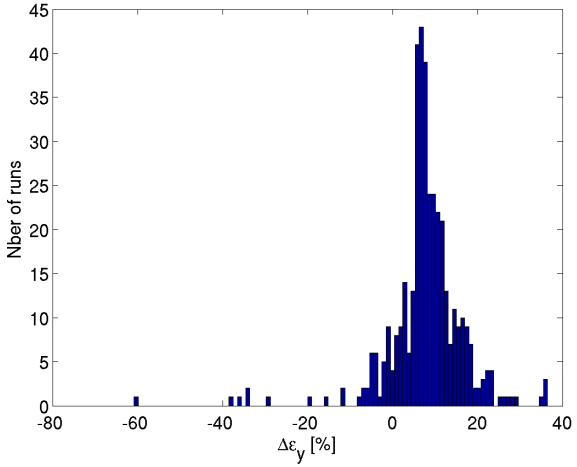


Figure: RMS Emittance Z

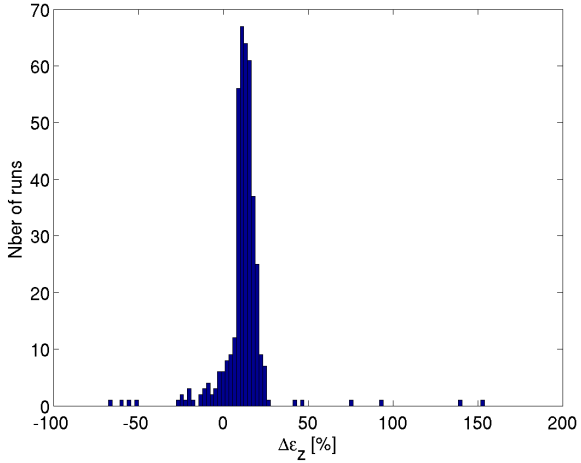
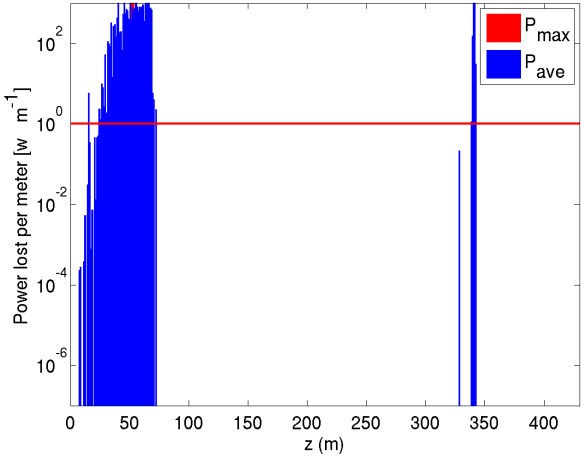


Figure: Losses [W·m^{-1}]



(011) Solenoids $\delta_{xy} = 150\ \mu$m

Figure: RMS Emittance X

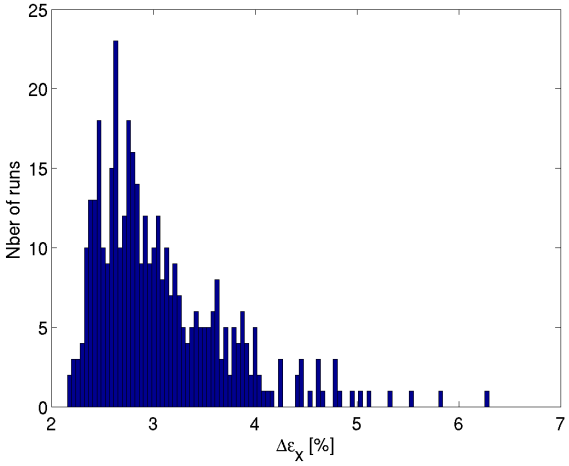


Figure: Centroid X

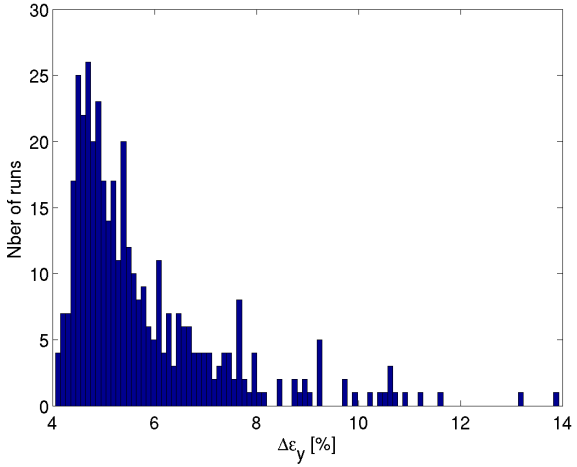


Figure: RMS Emittance Z

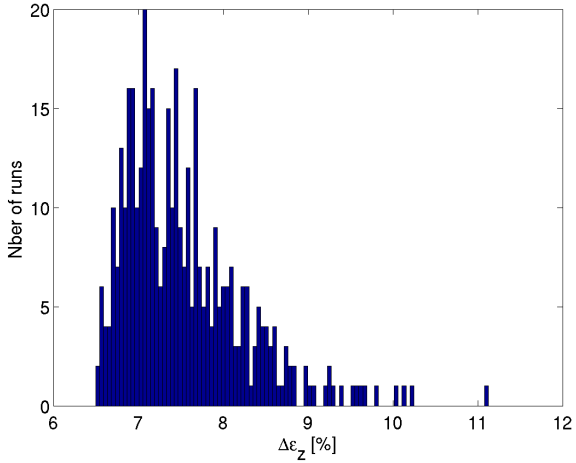
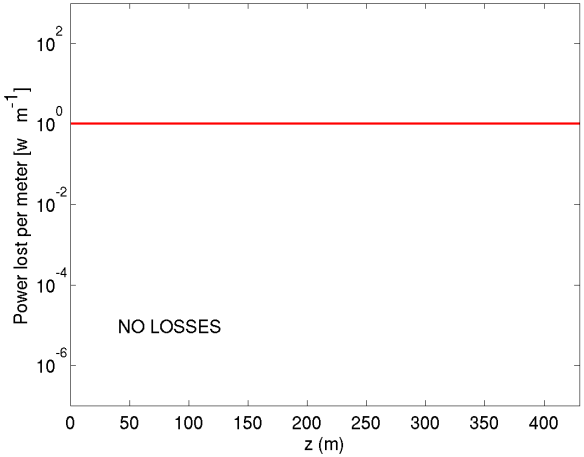


Figure: Losses [W·m^{-1}]



(012) Solenoids $\delta_{xy} = 300\ \mu$m

Figure: RMS Emittance X

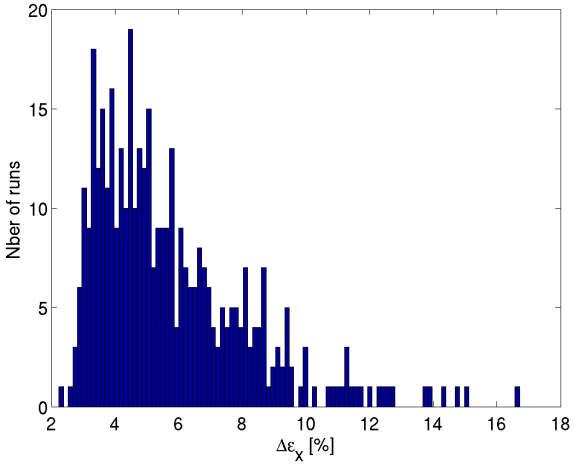


Figure: Centroid X

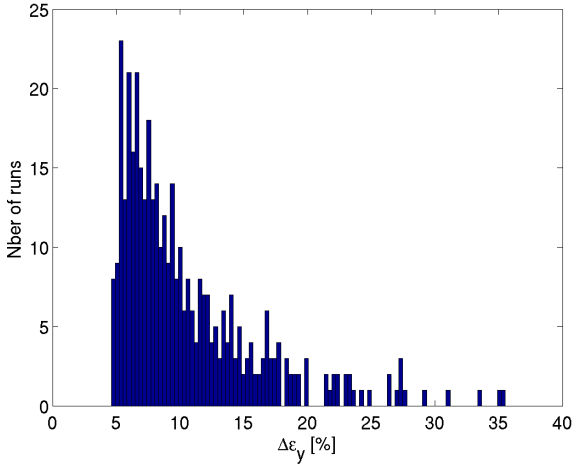


Figure: RMS Emittance Z

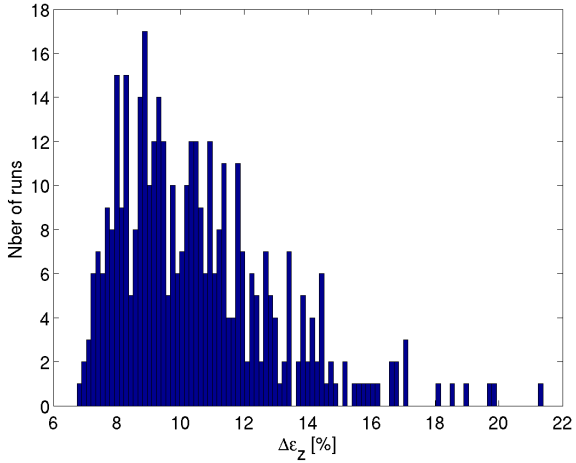
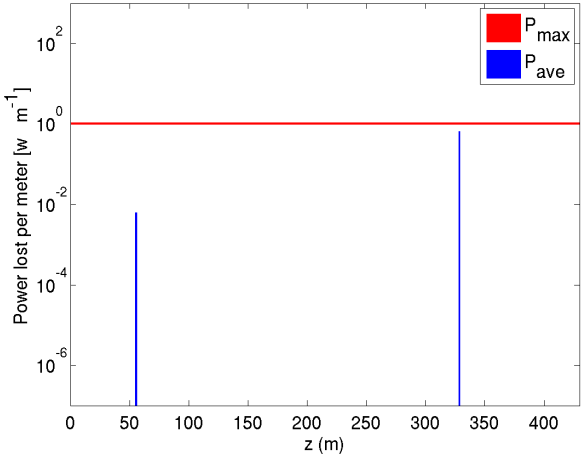


Figure: Losses [W·m^{-1}]



(013) Solenoids $\delta_{xy} = 500\ \mu$m

Figure: RMS Emittance X

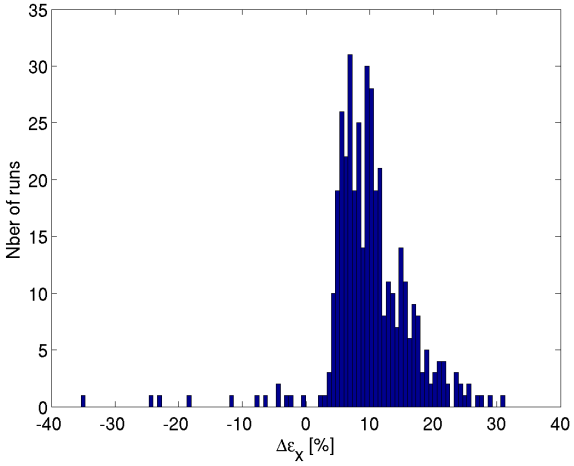


Figure: Centroid X

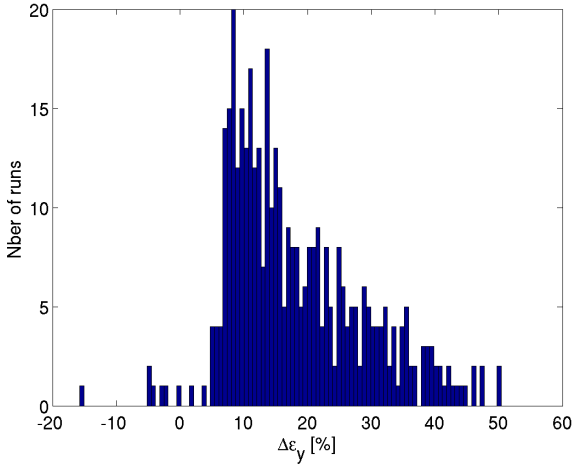


Figure: RMS Emittance Z

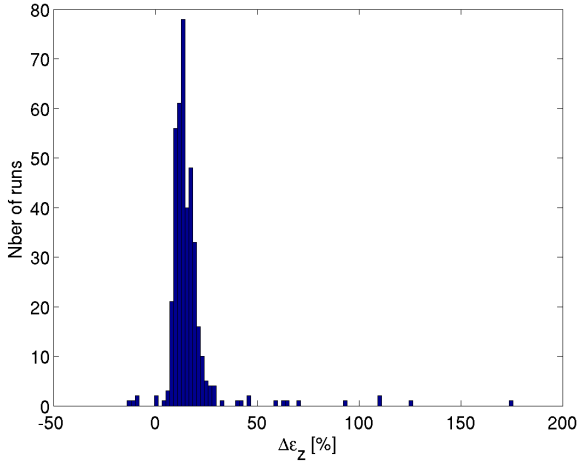
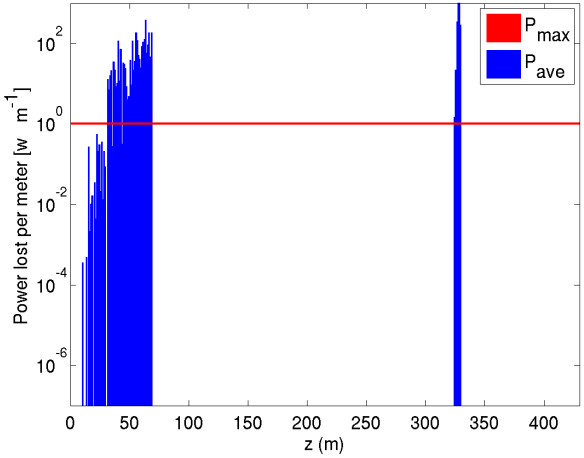


Figure: Losses [W·m^{-1}]



(014) Solenoids $\delta_{xy} = 750\ \mu$m

Figure: RMS Emittance X

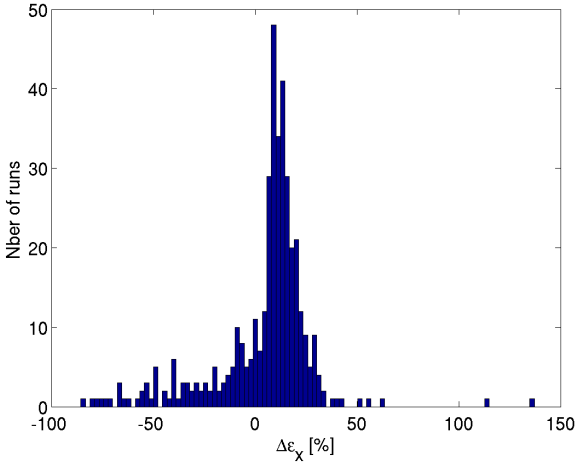


Figure: Centroid X

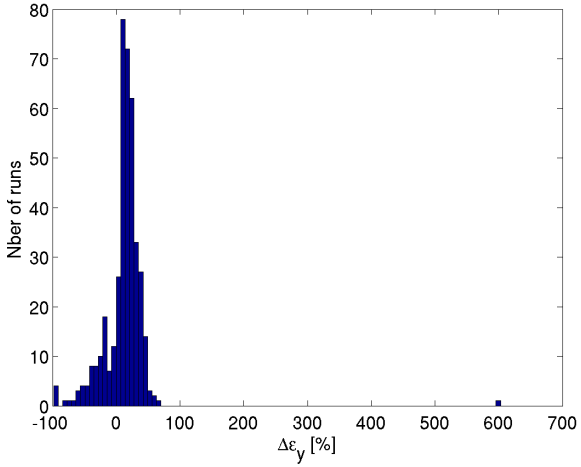


Figure: RMS Emittance Z

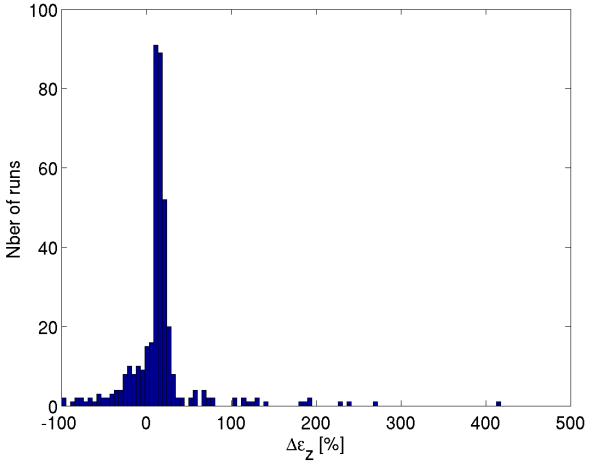
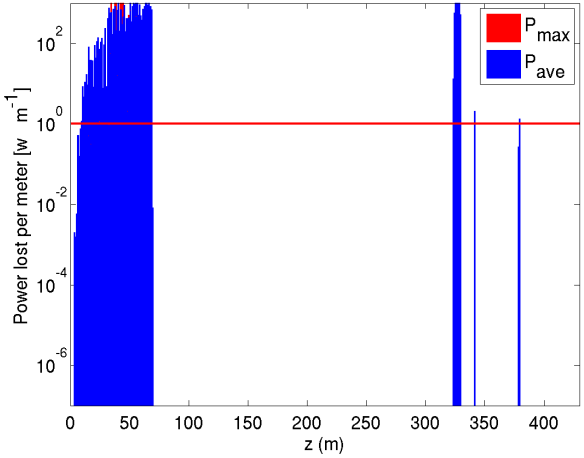


Figure: Losses [W·m^{-1}]



(015) Solenoids $\delta_{xy} = 1000\ \mu$m

Figure: RMS Emittance X

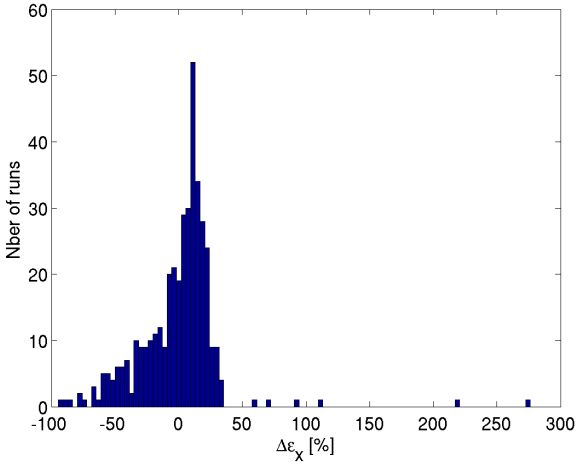


Figure: Centroid X

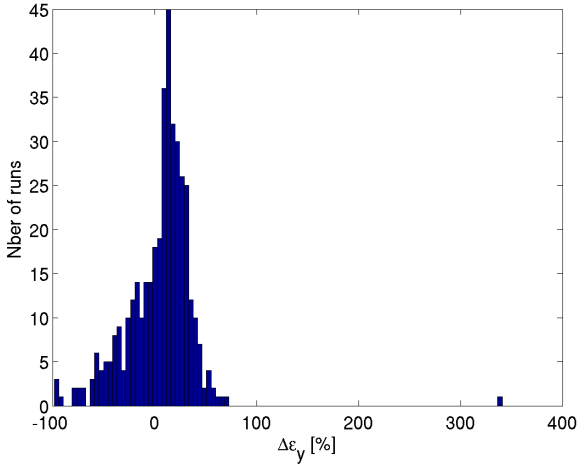


Figure: RMS Emittance Z

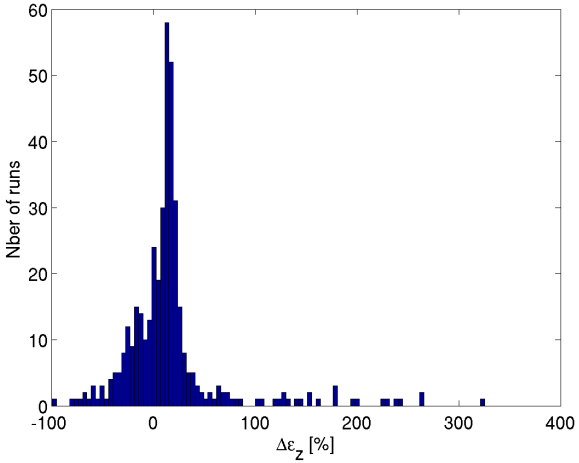
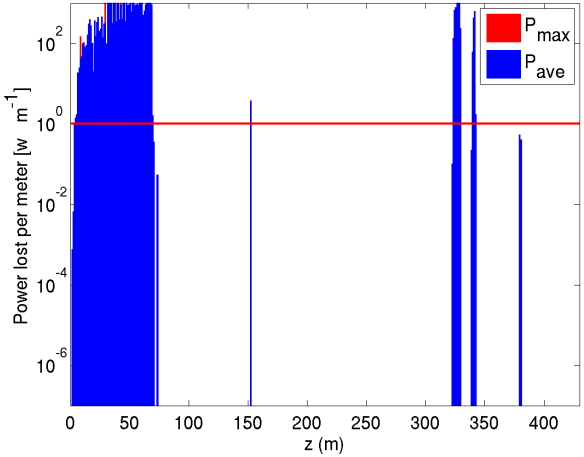


Figure: Losses [W·m^{-1}]



(016) Quads $\delta_x = 150\ \mu$m

Figure: RMS Emittance X

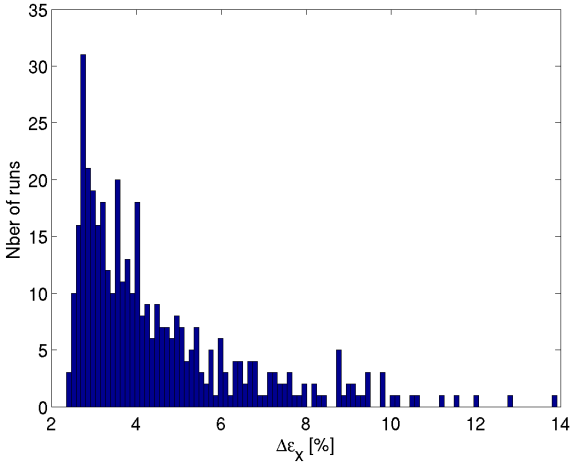


Figure: Centroid X

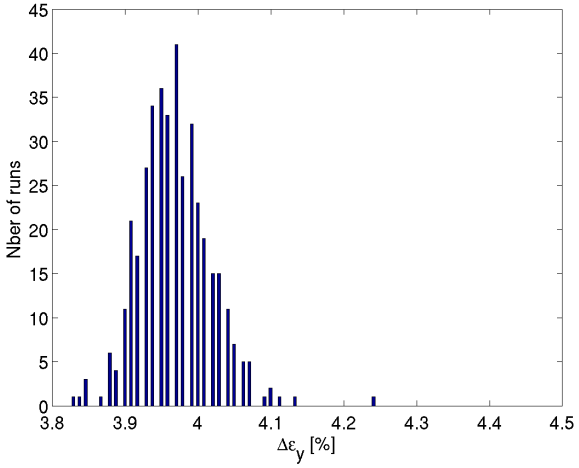


Figure: RMS Emittance Z

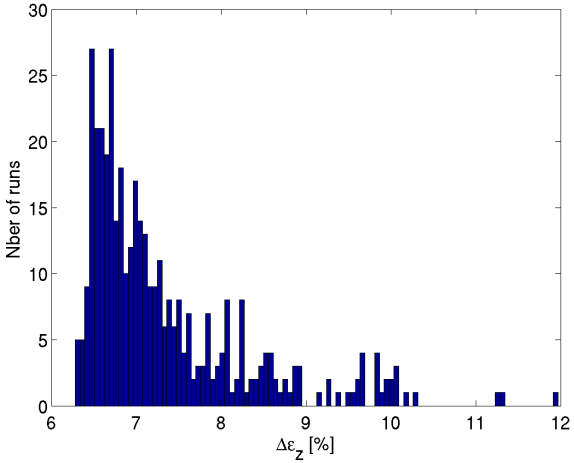
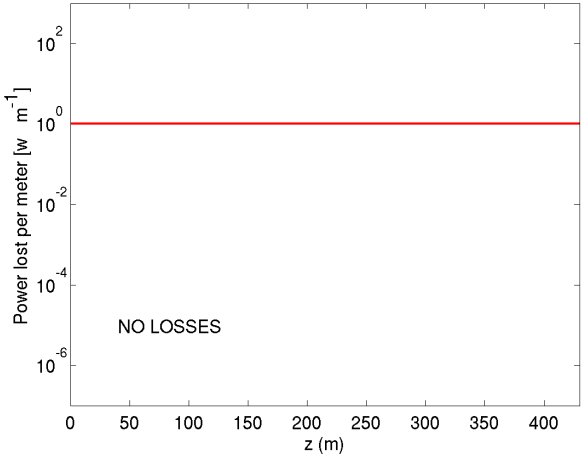


Figure: Losses [W·m^{-1}]



(017) Quads $\delta_x = 300\ \mu$m

Figure: RMS Emittance X

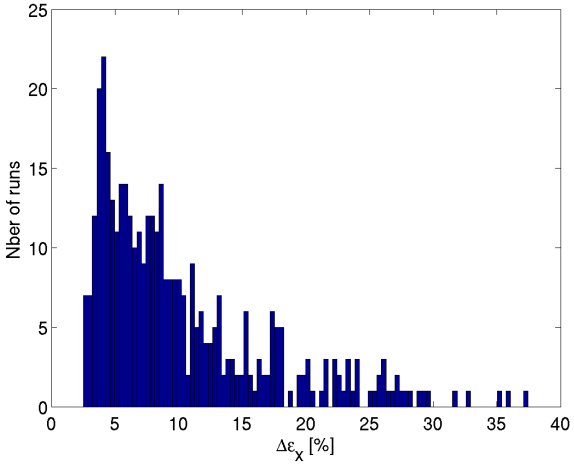


Figure: Centroid X

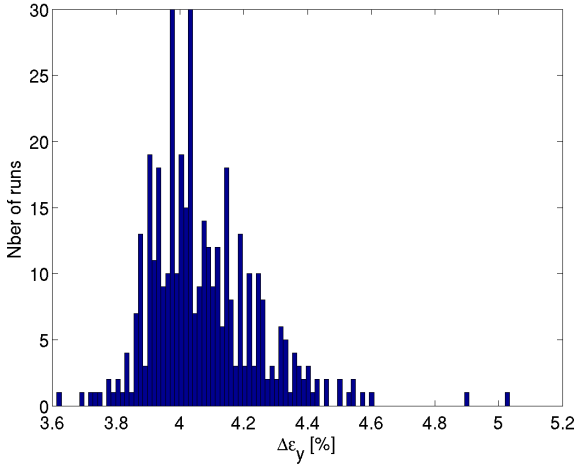


Figure: RMS Emittance z

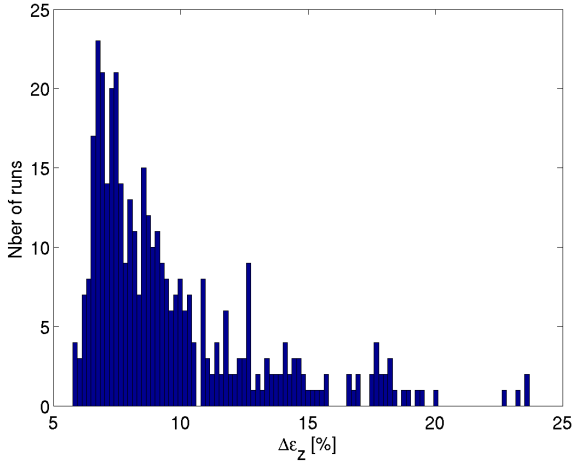
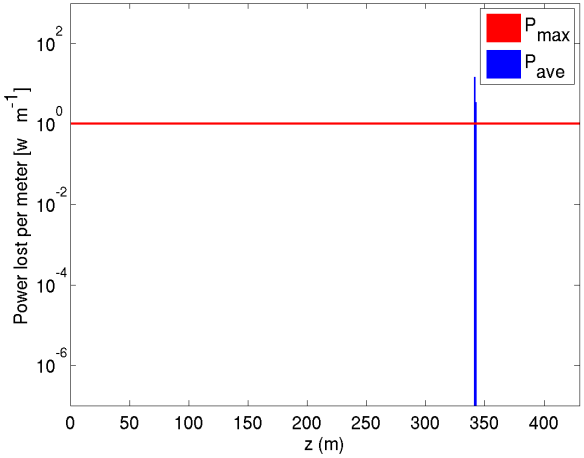


Figure: Losses [W·m^{-1}]



(018) Quads $\delta_x = 500\ \mu$m

Figure: RMS Emittance X

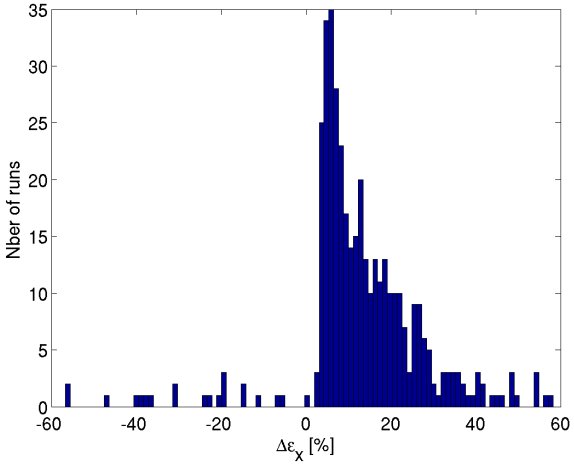


Figure: Centroid X

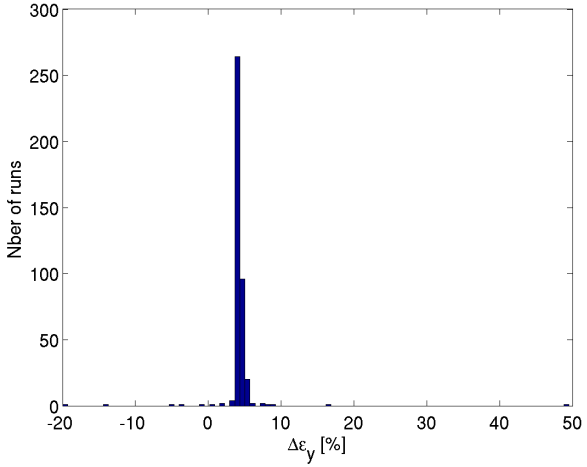


Figure: RMS Emittance Z

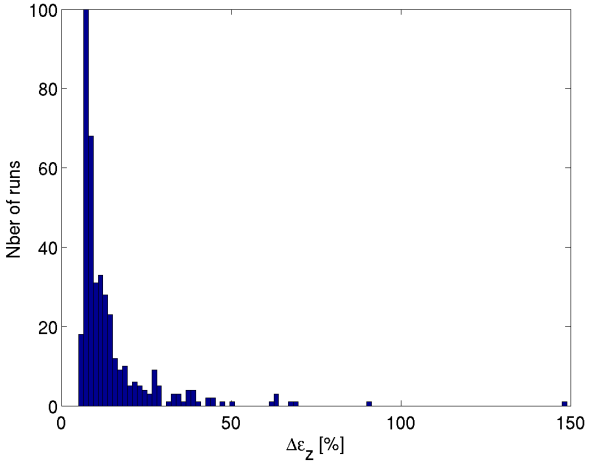
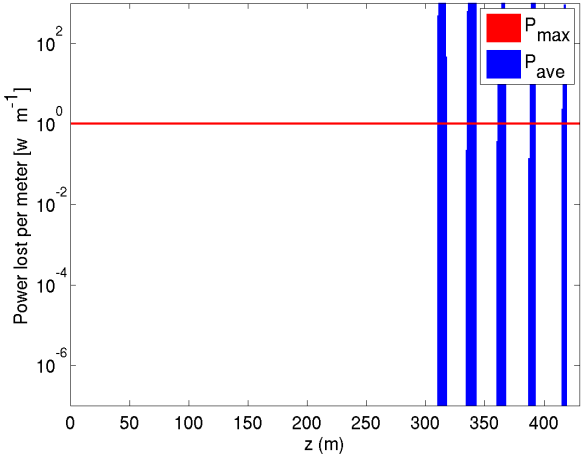


Figure: Losses [W·m^{-1}]



(019) Quads $\delta_x = 750\ \mu$m

Figure: RMS Emittance X

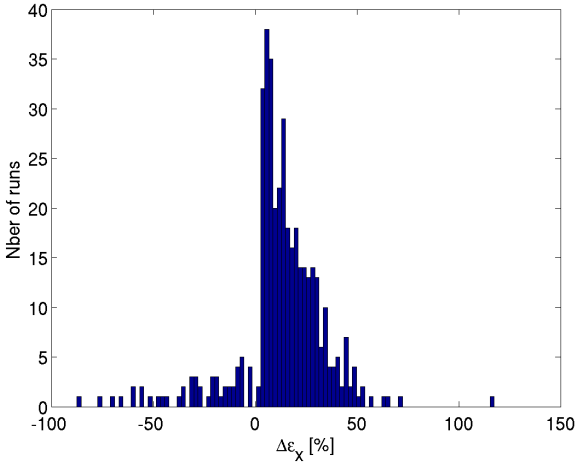


Figure: Centroid X

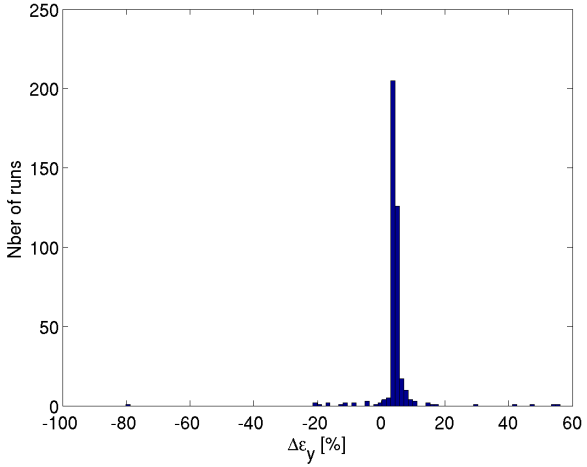


Figure: RMS Emittance Z

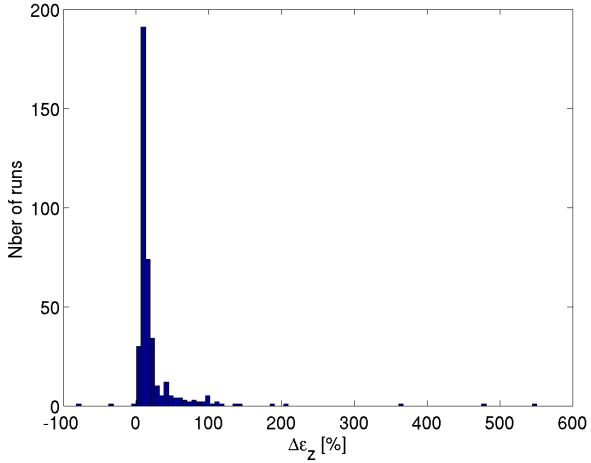
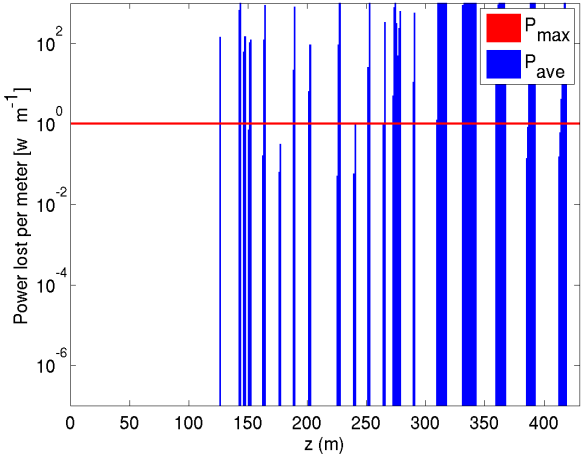


Figure: Losses [W·m^{-1}]



(020) Quads $\delta_x = 1000\ \mu$m

Figure: RMS Emittance X

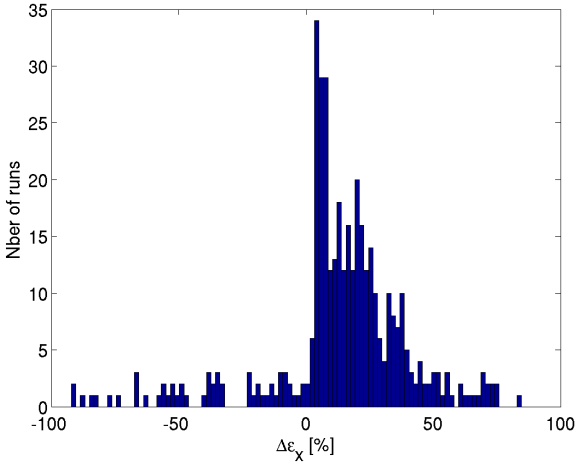


Figure: Centroid X

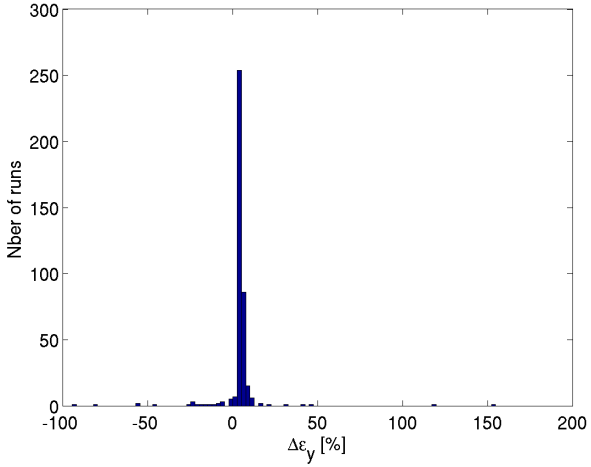


Figure: RMS Emittance Z

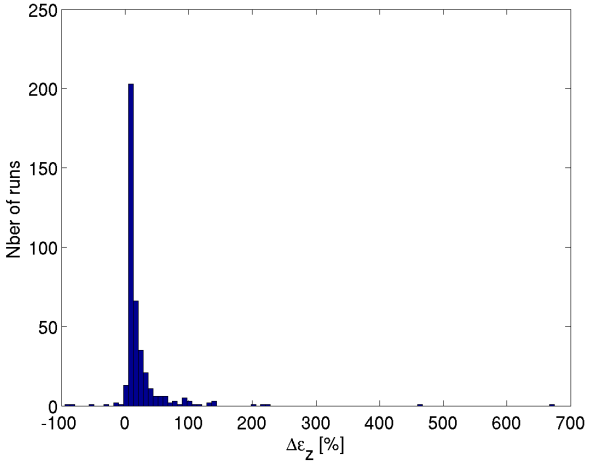
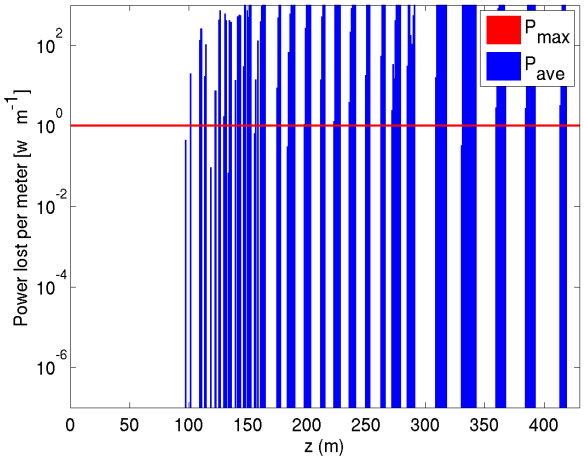


Figure: Losses [W·m^{-1}]



(021) Quads $\phi_x = 2$ mrad

Figure: RMS Emittance X

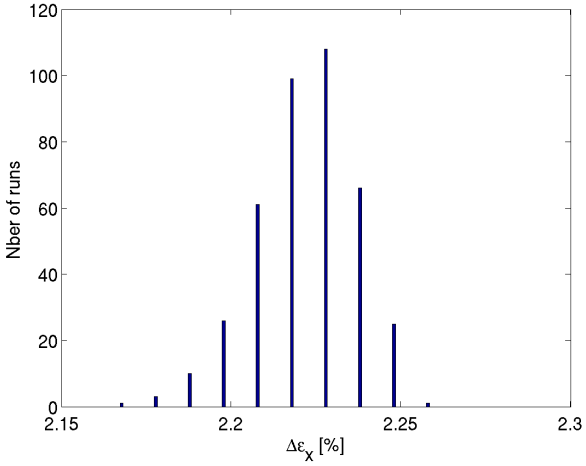


Figure: Centroid X

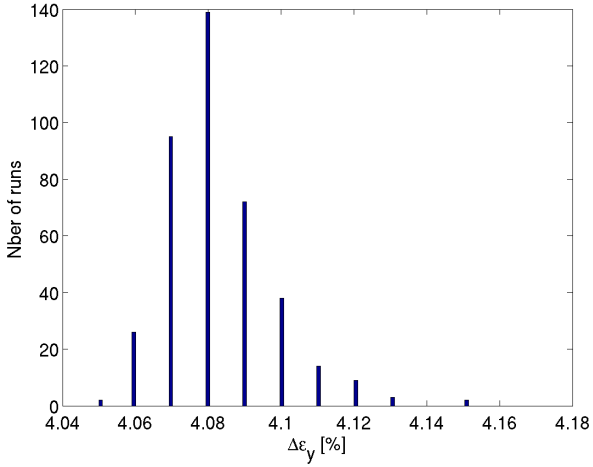


Figure: RMS Emittance Z

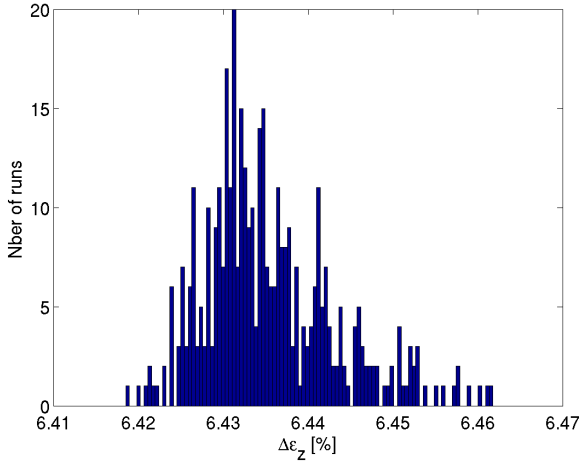
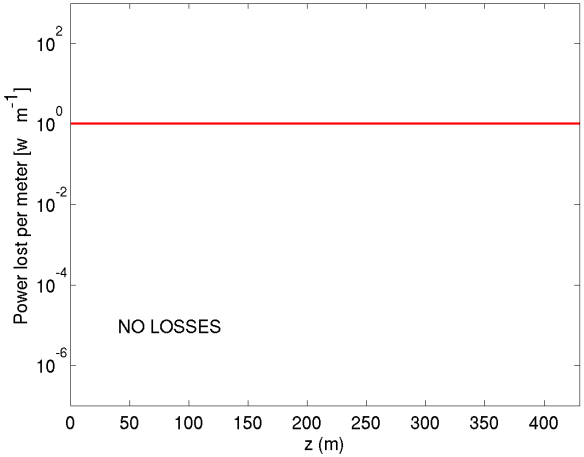


Figure: Losses [W·m^{-1}]



(022) Quads $\phi_x = 4$ mrad

Figure: RMS Emittance X

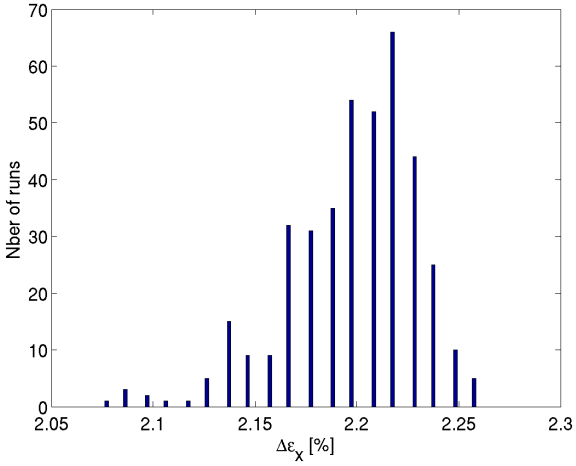


Figure: Centroid X

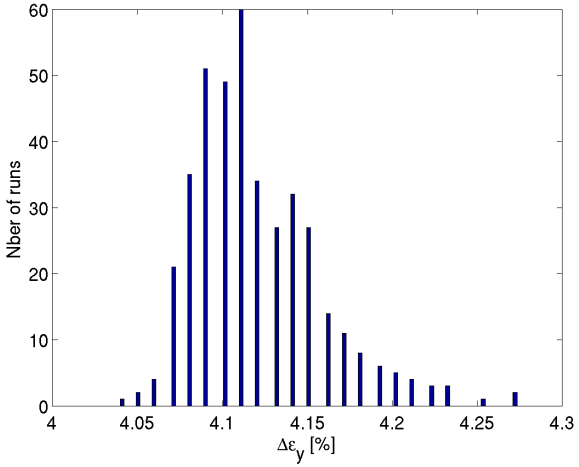


Figure: RMS Emittance Z

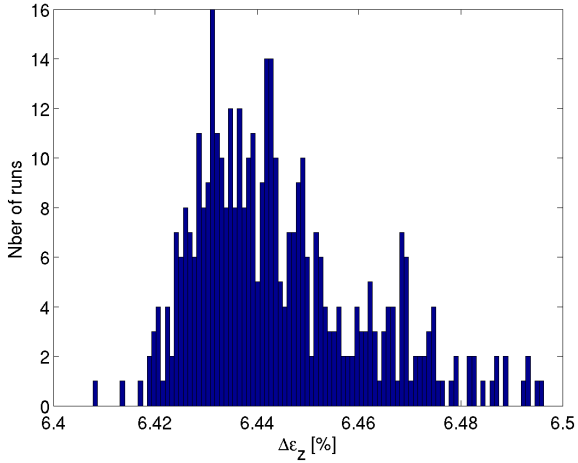
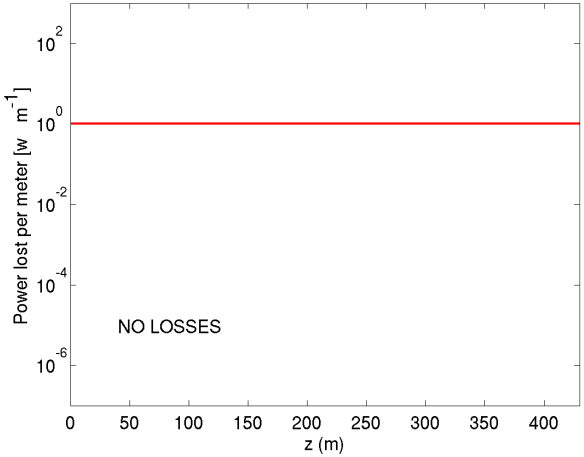


Figure: Losses [W·m^{-1}]



(023) Quads $\phi_x = 6$ mrad

Figure: RMS Emittance X

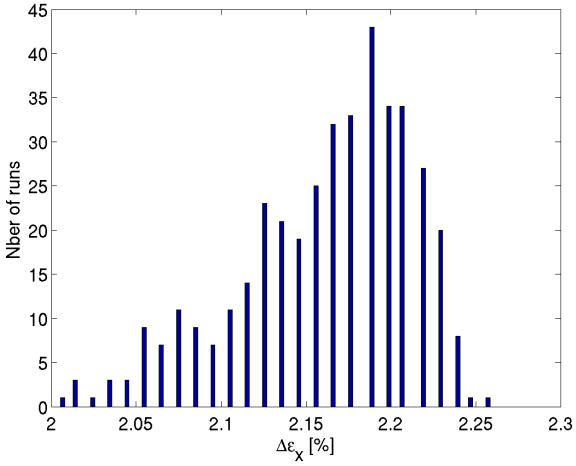


Figure: Centroid X

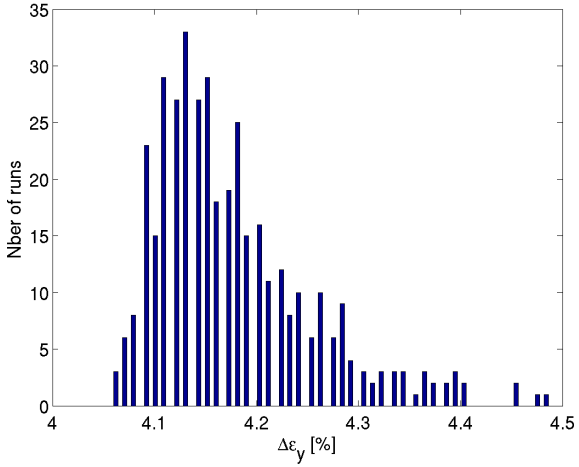


Figure: RMS Emittance Z

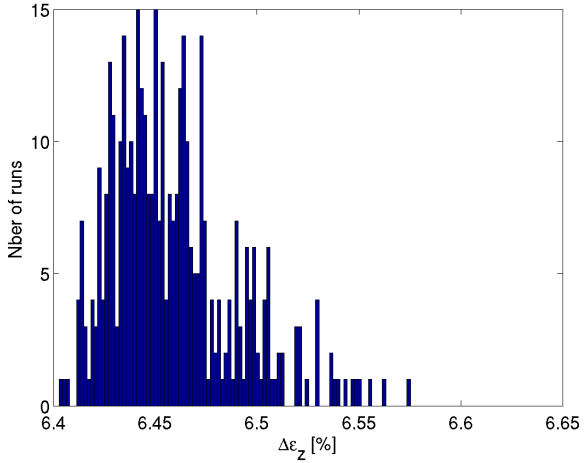
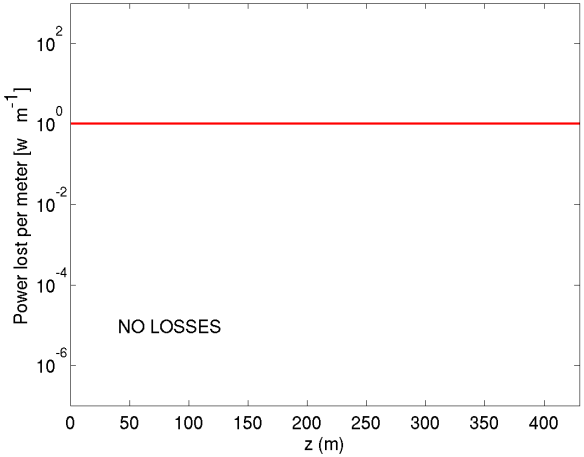


Figure: Losses [W·m^{-1}]



(024) Quads $\phi_x = 8$ mrad

Figure: RMS Emittance X

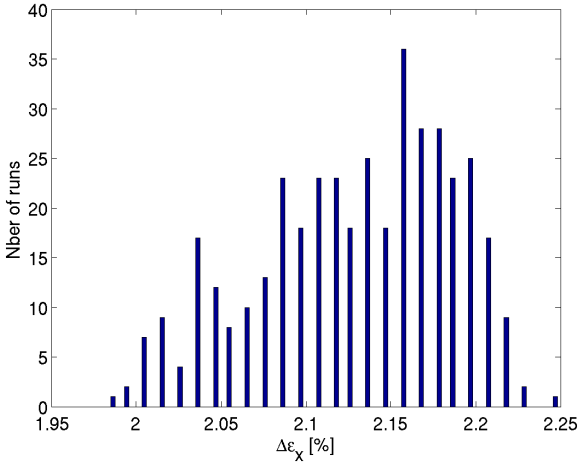


Figure: Centroid X

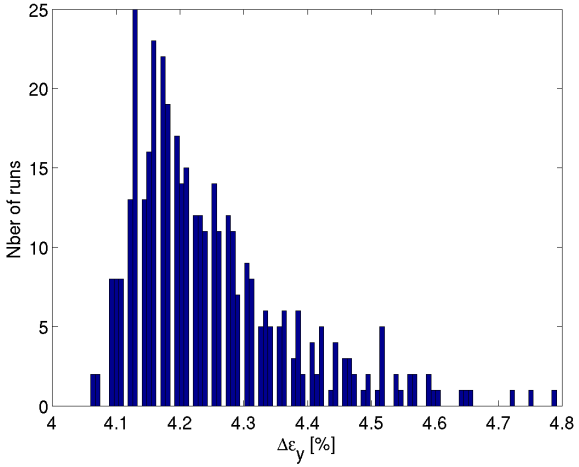


Figure: RMS Emittance Z

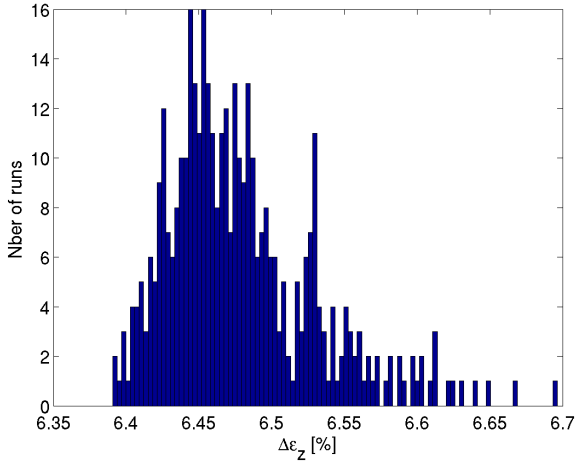
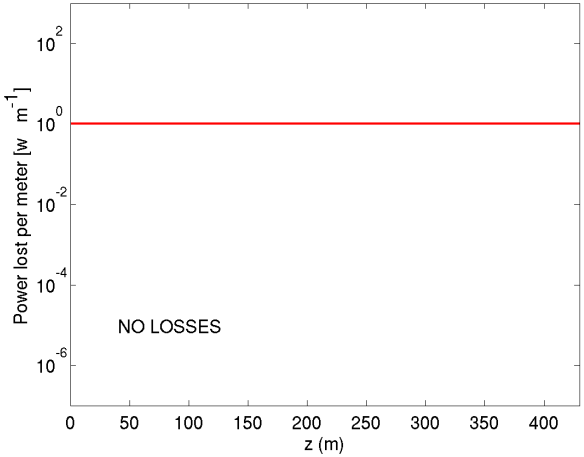


Figure: Losses [W·m^{-1}]



(025) Quads $\phi_x = 10$ mrad

Figure: RMS Emittance X

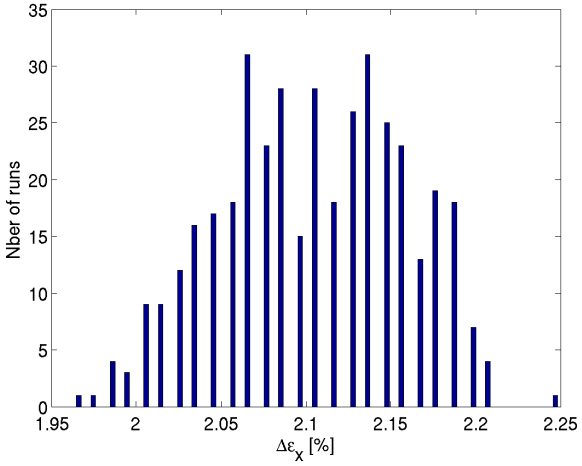


Figure: Centroid X

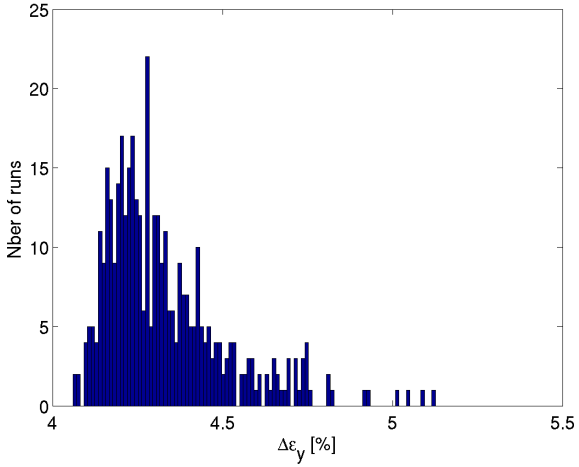


Figure: RMS Emittance Z

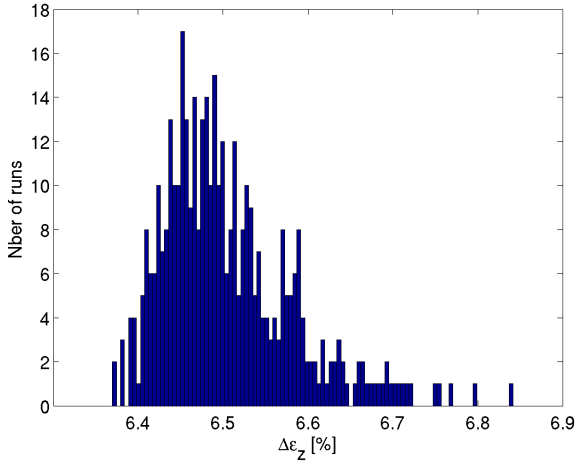
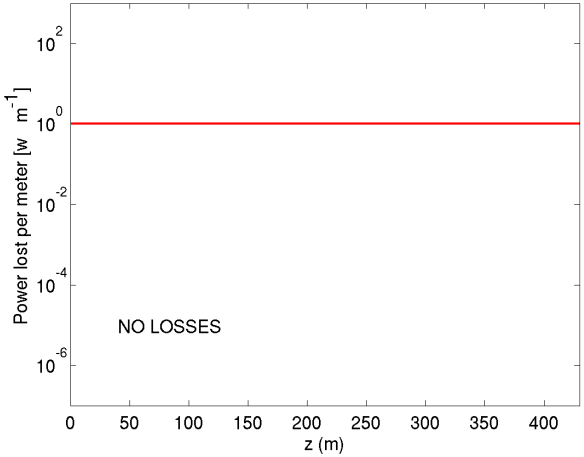


Figure: Losses [W·m^{-1}]



(026) Quad. $\delta_{xy} = 150\ \mu$m

Figure: RMS Emittance X

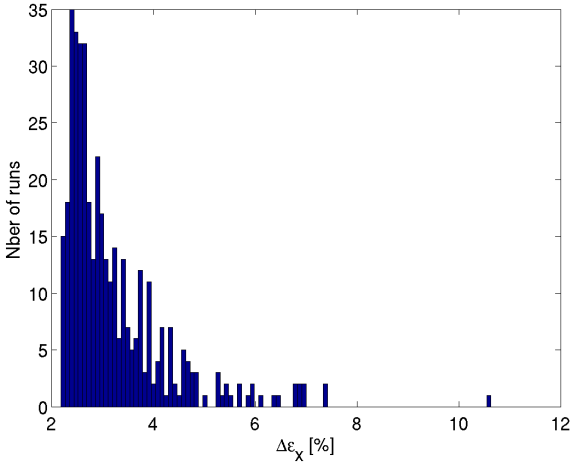


Figure: Centroid X

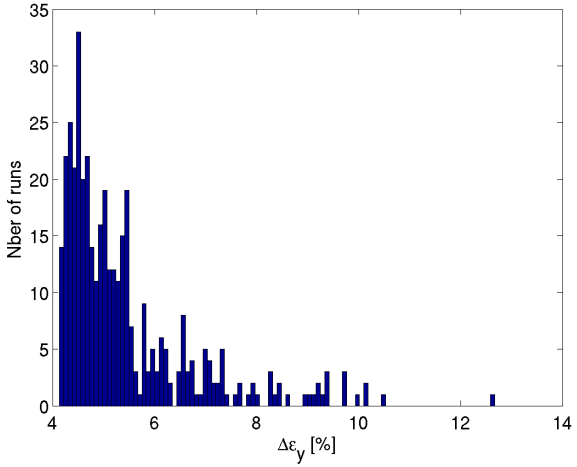


Figure: RMS Emittance Z

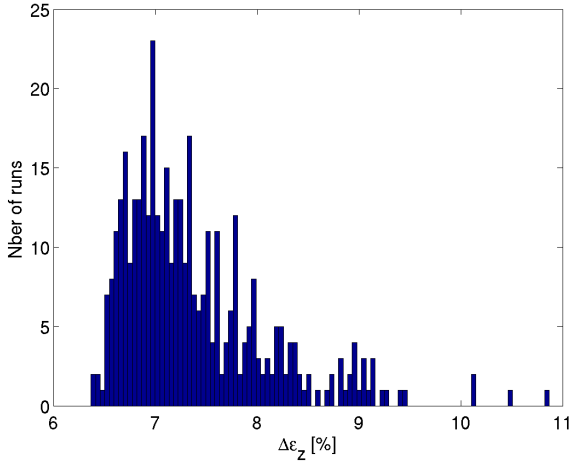
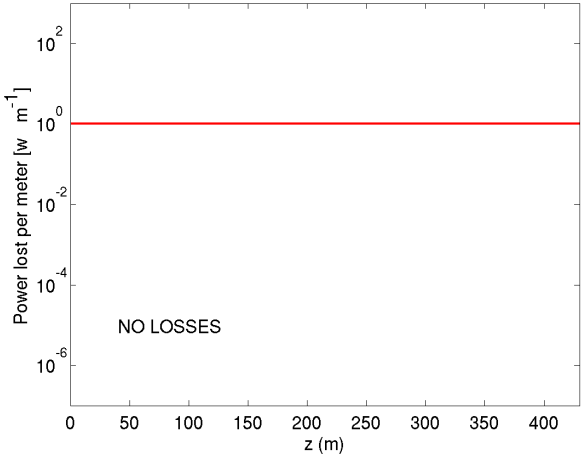


Figure: Losses [W·m^{-1}]



(027) Quad. $\delta_{xy} = 300\ \mu$m

Figure: RMS Emittance X

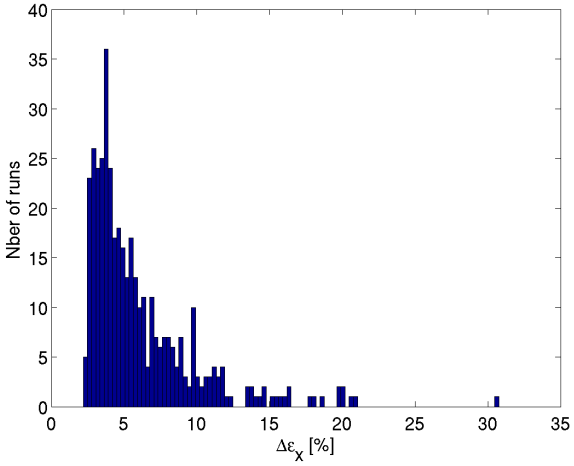


Figure: Centroid X

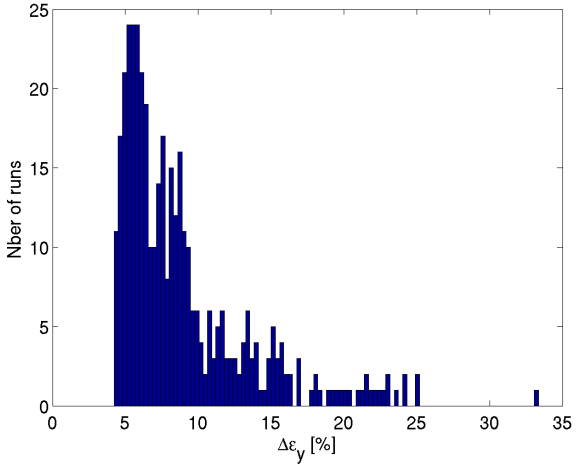


Figure: RMS Emittance z

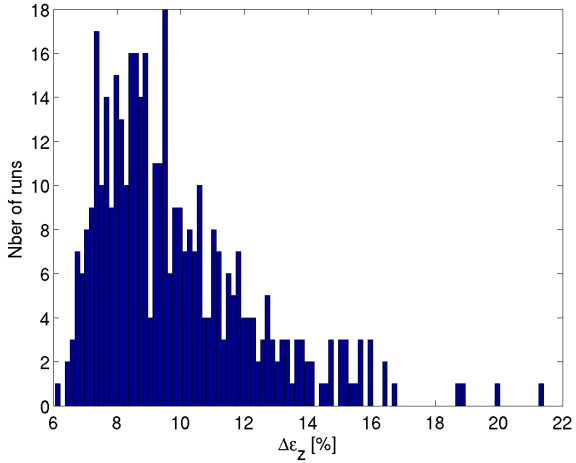
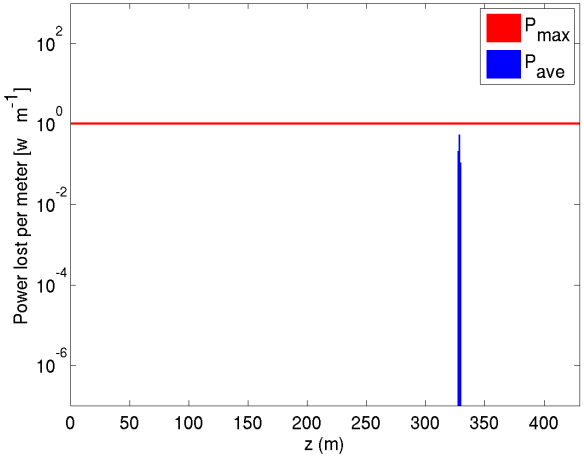


Figure: Losses [W·m^{-1}]



(028) Quad. $\delta_{xy} = 500\ \mu$m

Figure: RMS Emittance X

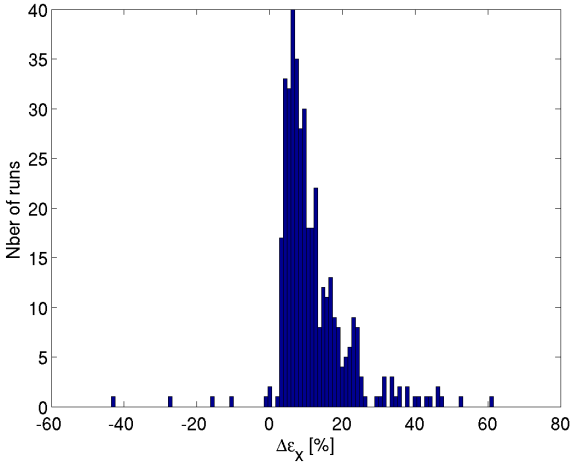


Figure: Centroid X

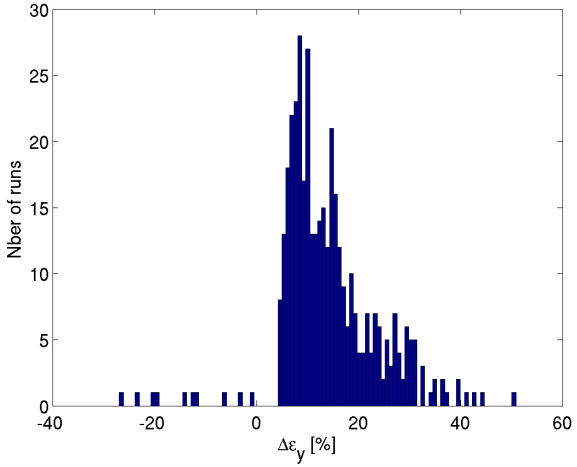


Figure: RMS Emittance Z

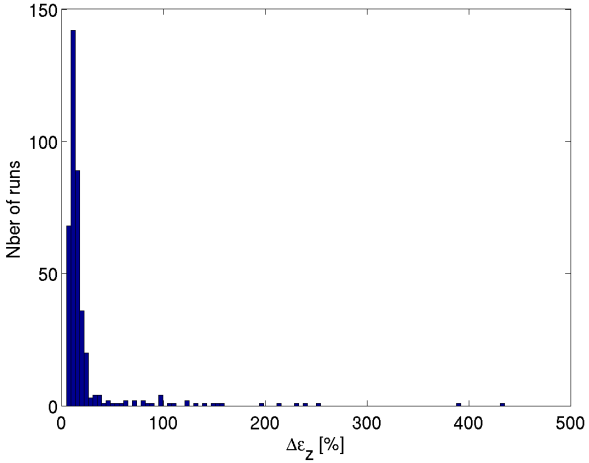
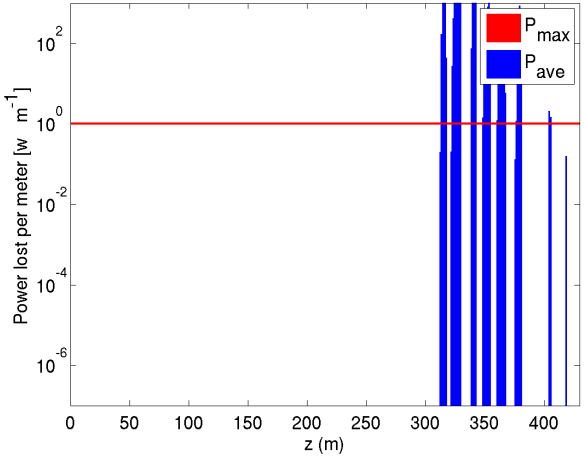


Figure: Losses [W·m^{-1}]



(029) Quad. $\delta_{xy} = 750\ \mu$m

Figure: RMS Emittance X

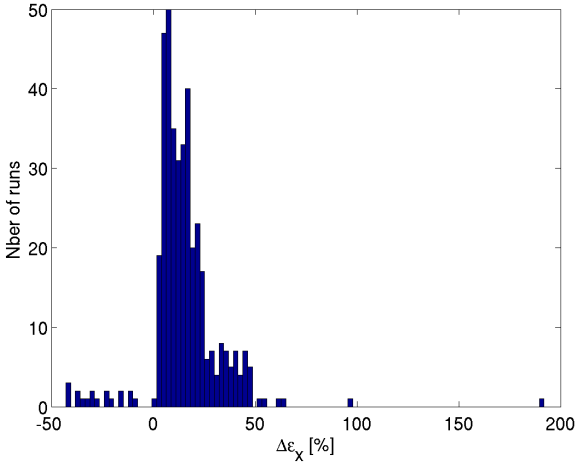


Figure: Centroid X

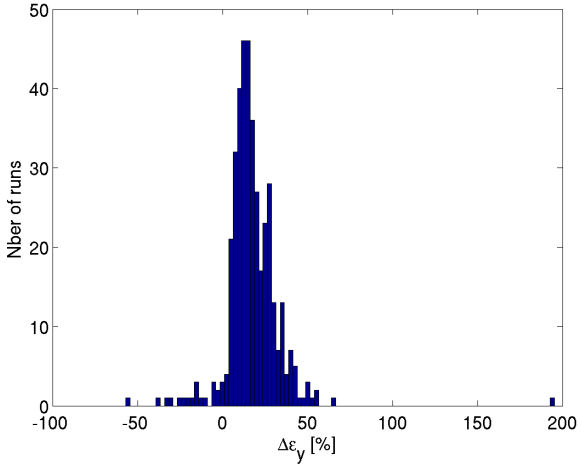


Figure: RMS Emittance Z

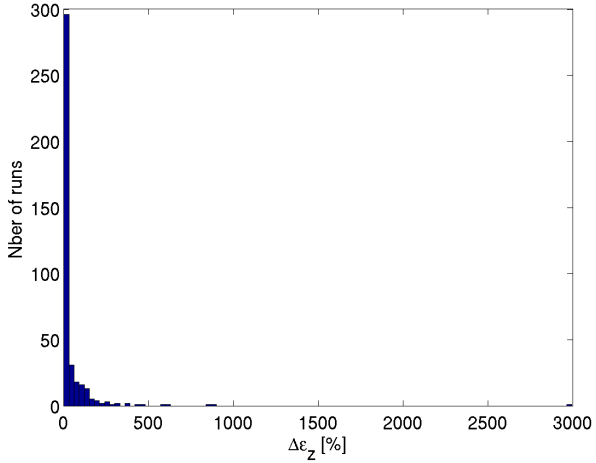
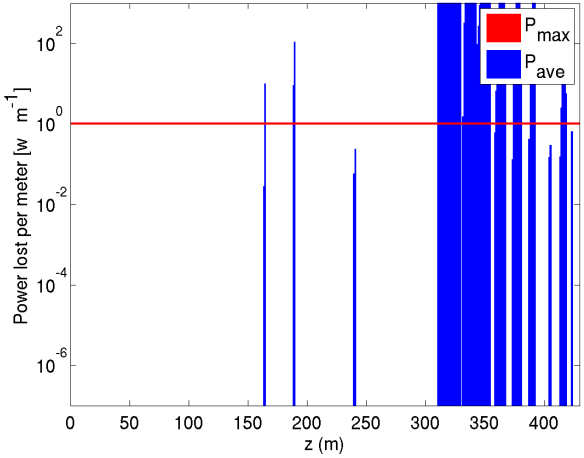


Figure: Losses [W·m^{-1}]



(030) Quad. $\delta_{xy} = 1000\ \mu$m

Figure: RMS Emittance X

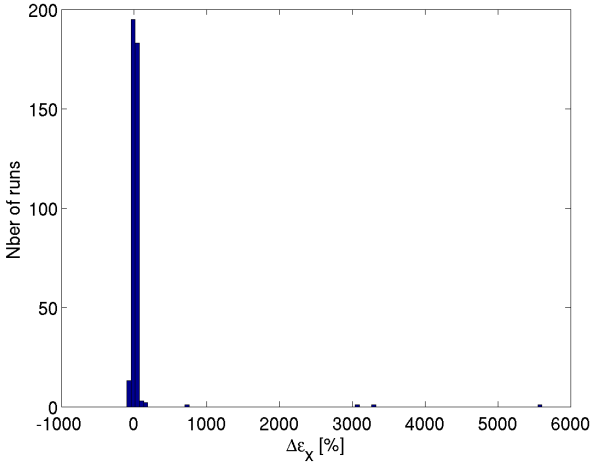


Figure: Centroid X

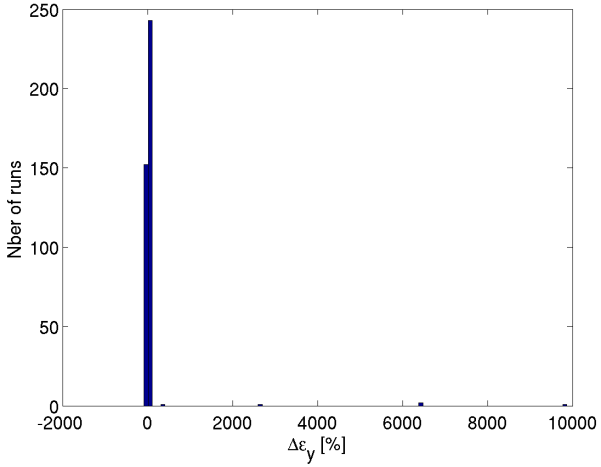


Figure: RMS Emittance Z

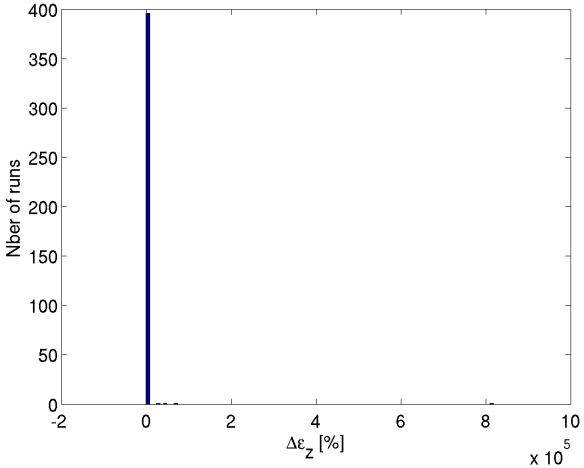
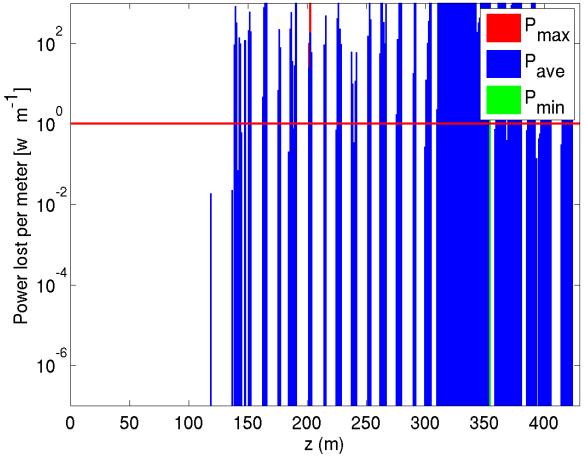


Figure: Losses [W·m^{-1}]



(031) Cav. $\delta_x = 150\ \mu m$

Figure: RMS Emittance X

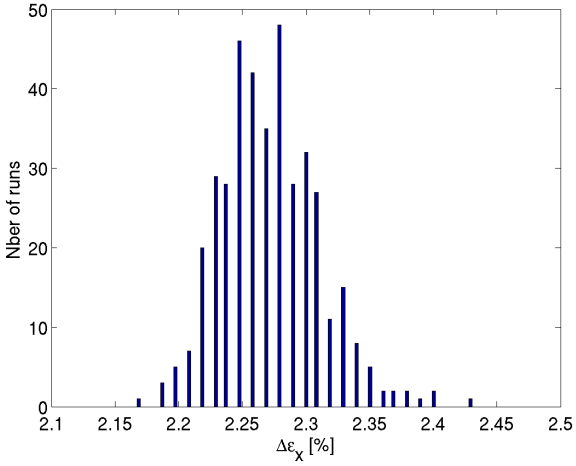


Figure: Centroid X

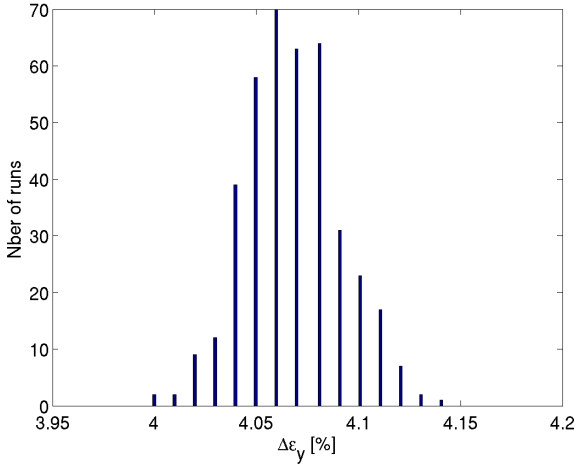


Figure: RMS Emittance Z

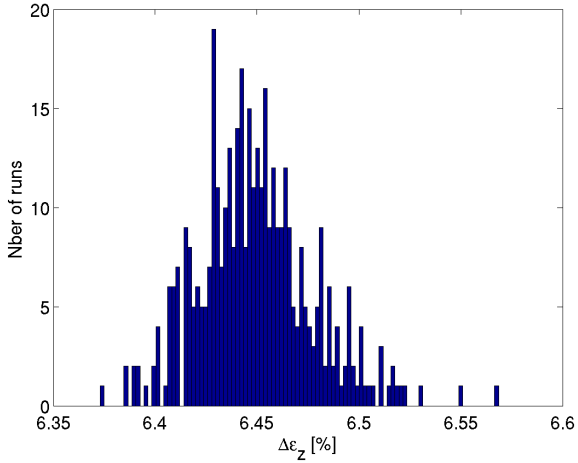
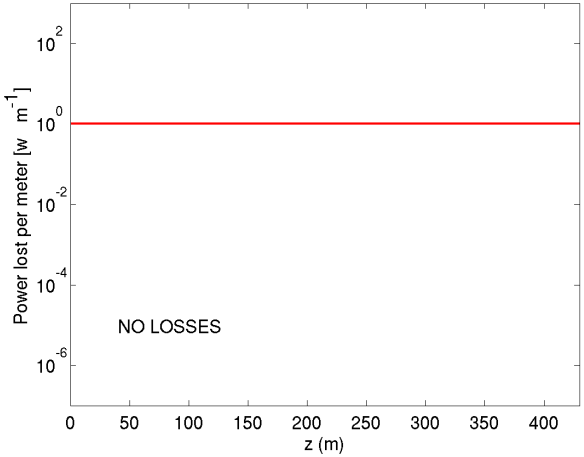


Figure: Losses [W·m^{-1}]



(032) Cav. $\delta_x = 300\ \mu m$

Figure: RMS Emittance X

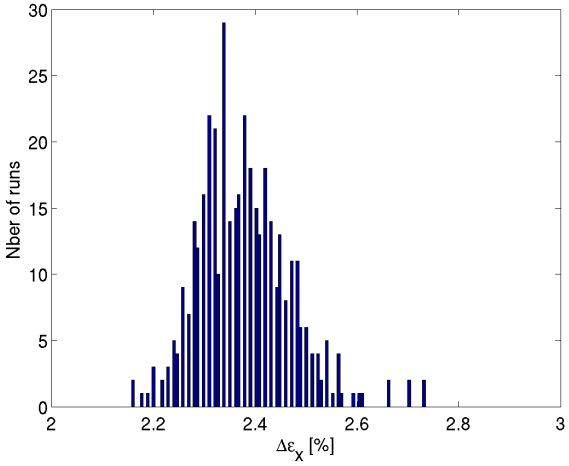


Figure: Centroid X

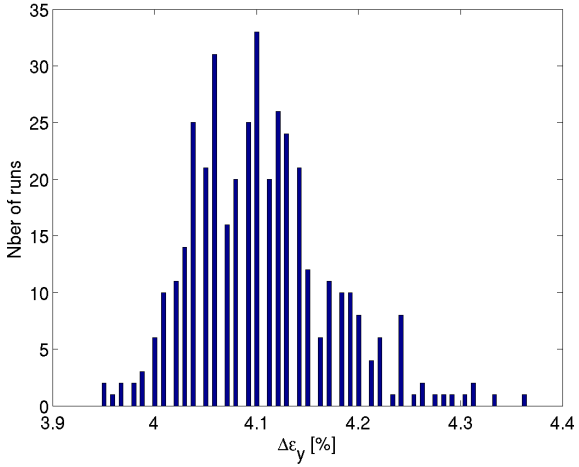


Figure: RMS Emittance Z

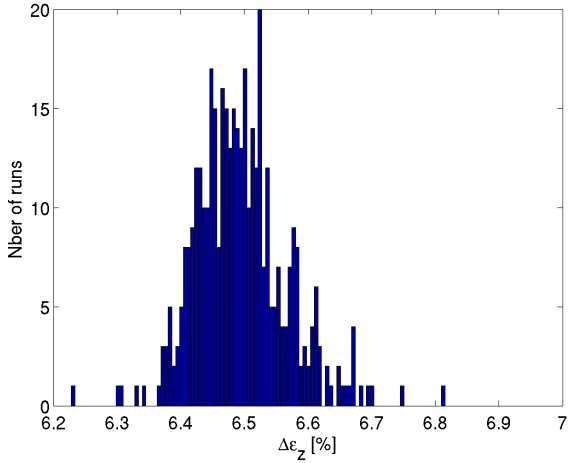
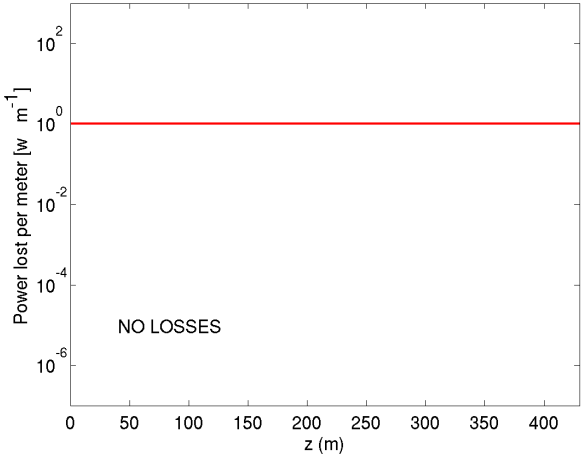


Figure: Losses [W·m^{-1}]



(033) Cav. $\delta_x = 500\ \mu m$

Figure: RMS Emittance X

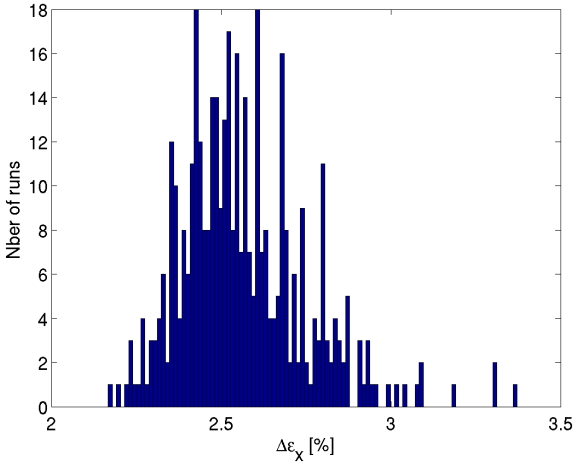


Figure: Centroid X

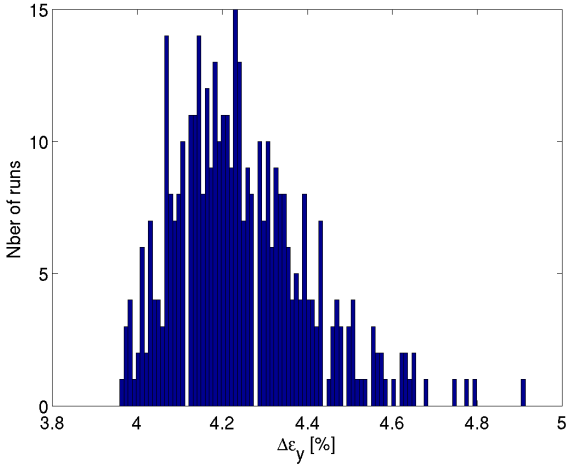


Figure: RMS Emittance Z

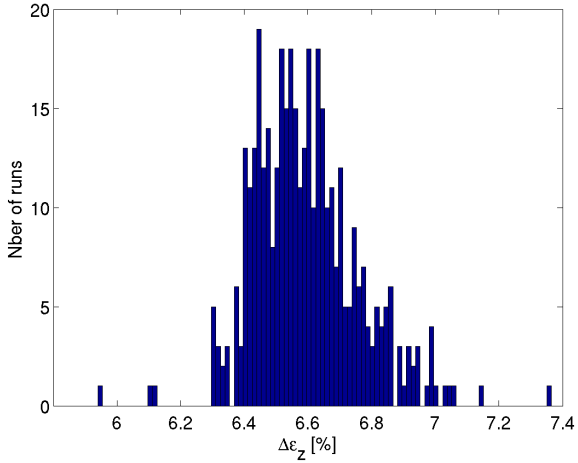
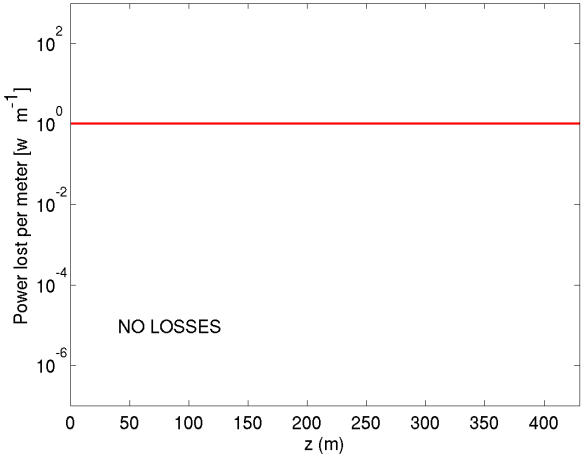


Figure: Losses [W·m^{-1}]



(034) Cav. $\delta_x = 750\ \mu$m

Figure: RMS Emittance X

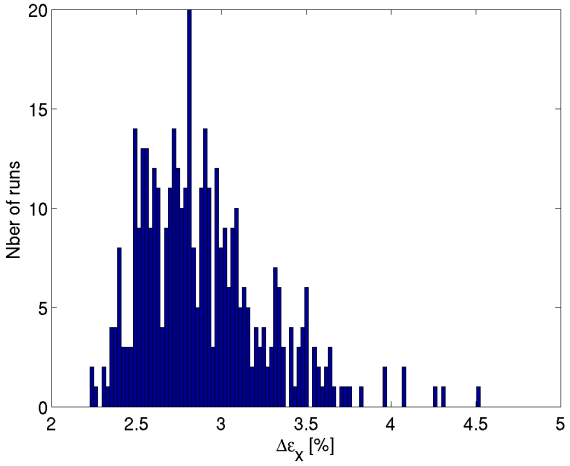


Figure: Centroid X

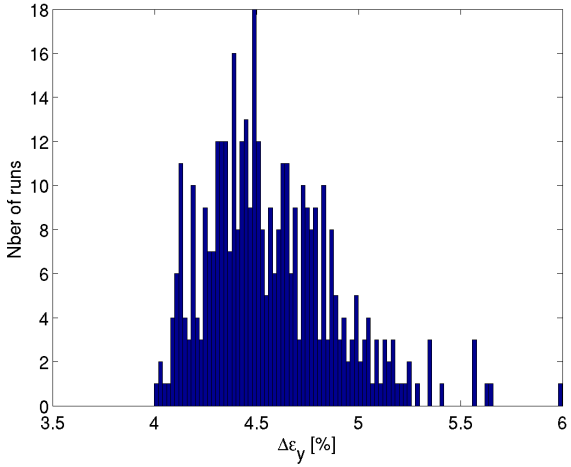


Figure: RMS Emittance Z

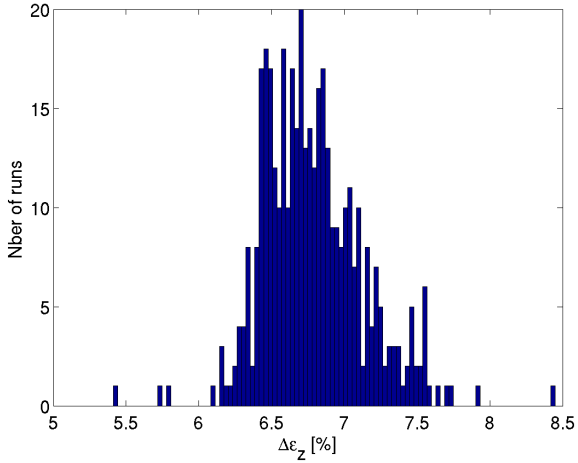
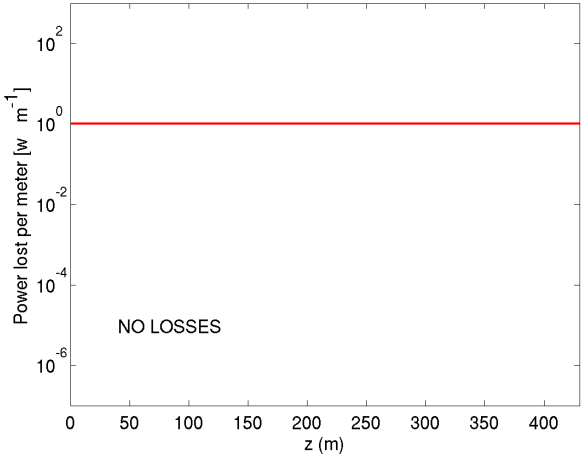


Figure: Losses [W·m^{-1}]



(035) Cav. $\delta_x = 1000\ \mu$m

Figure: RMS Emittance X

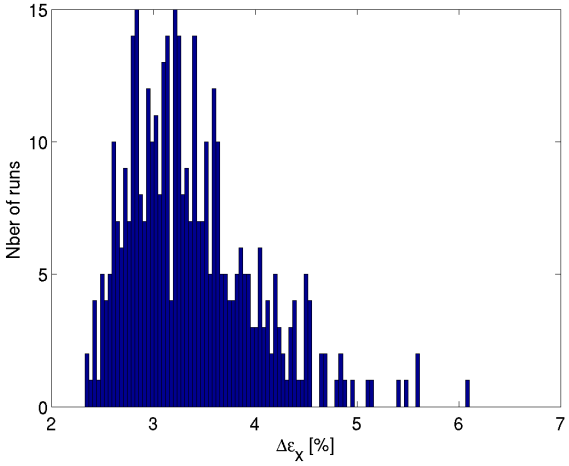


Figure: Centroid X

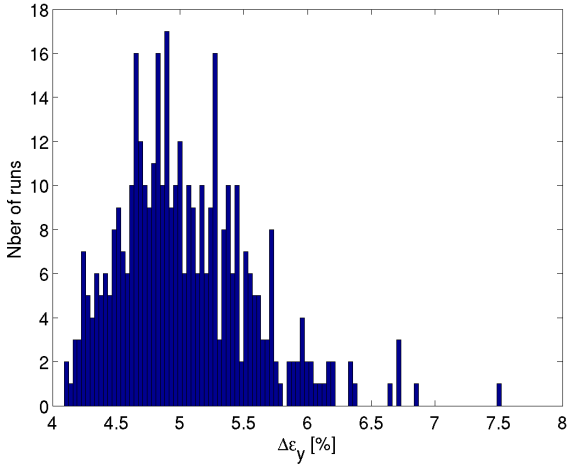


Figure: RMS Emittance Z

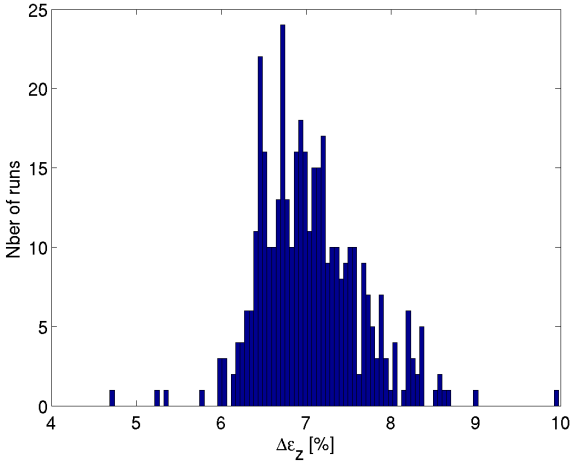
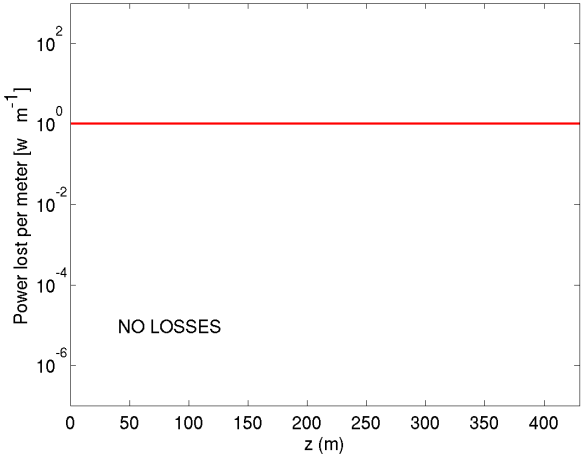


Figure: Losses [W·m^{-1}]



(036) Cavities $\phi_x = 2$ mrad

Figure: RMS Emittance X

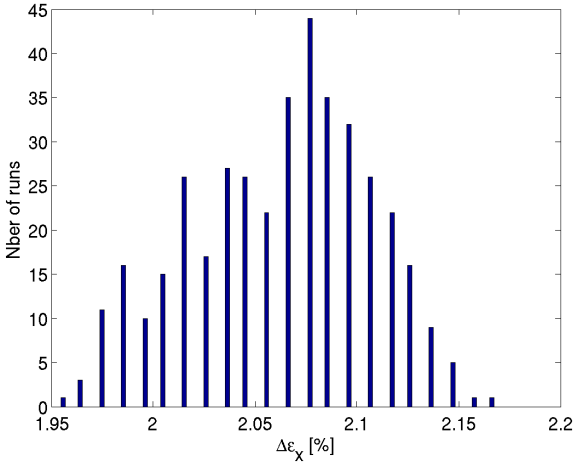


Figure: Centroid X

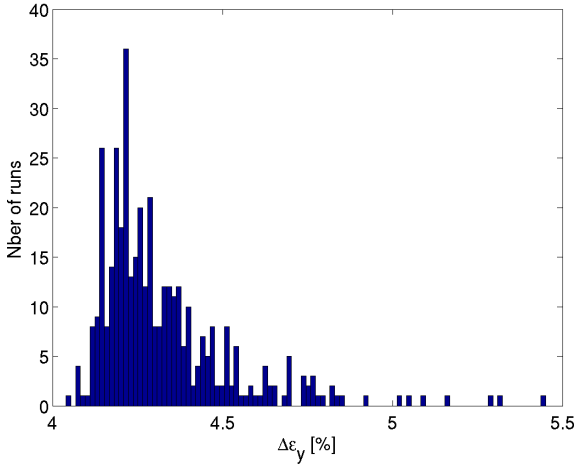


Figure: RMS Emittance Z

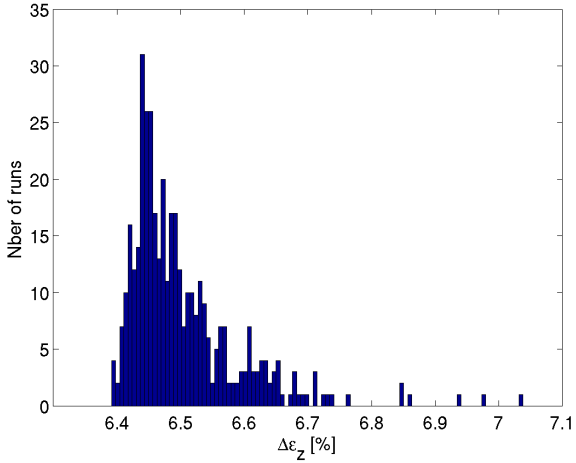
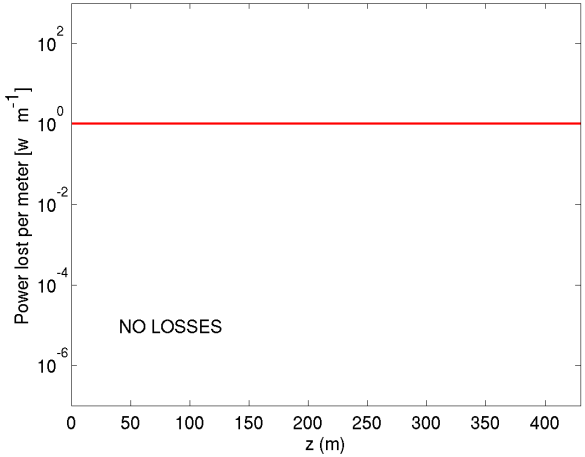


Figure: Losses [W·m^{-1}]



(037) Cavities $\phi_x = 4$ mrad

Figure: RMS Emittance X

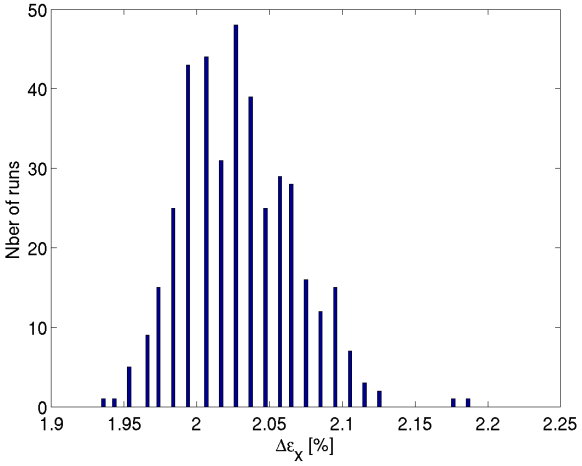


Figure: Centroid X

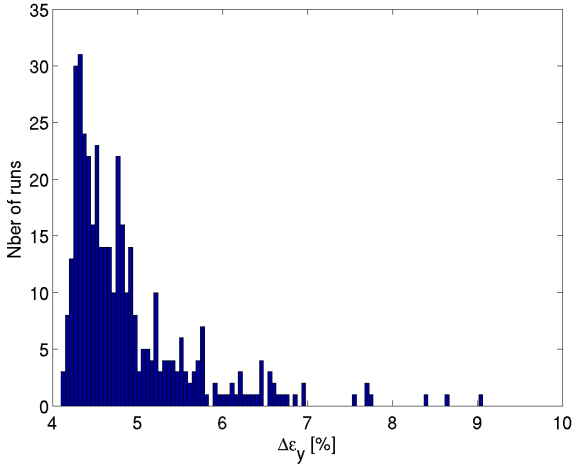


Figure: RMS Emittance Z

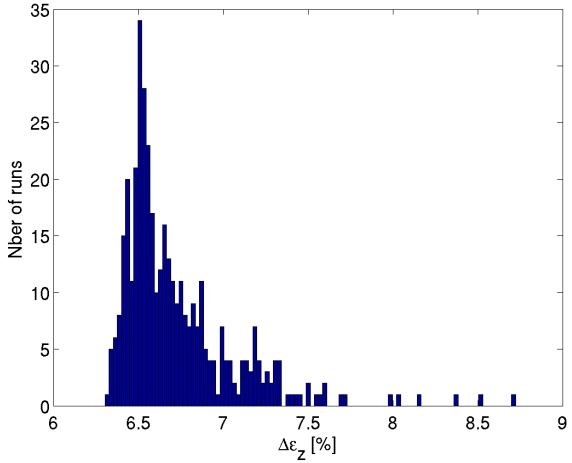
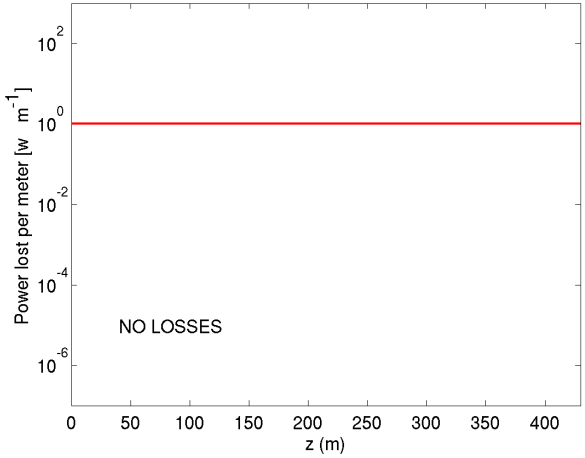


Figure: Losses [W·m^{-1}]



(038) Cavities $\phi_x = 6$ mrad

Figure: RMS Emittance X

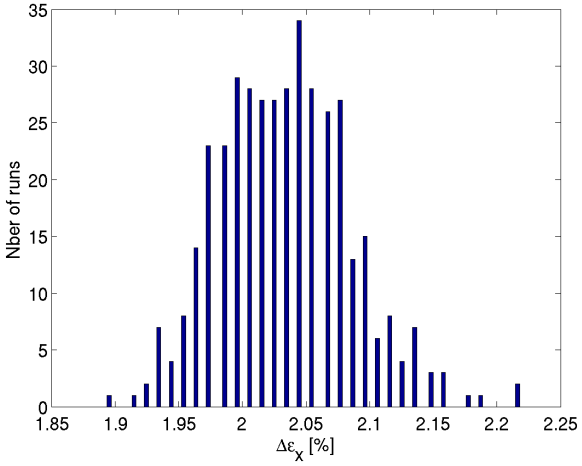


Figure: Centroid X

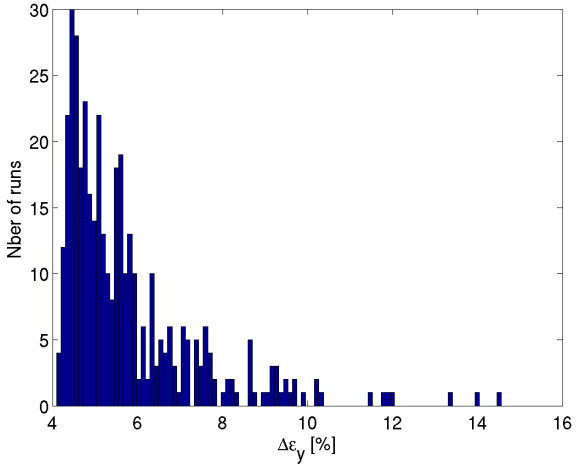


Figure: RMS Emittance Z

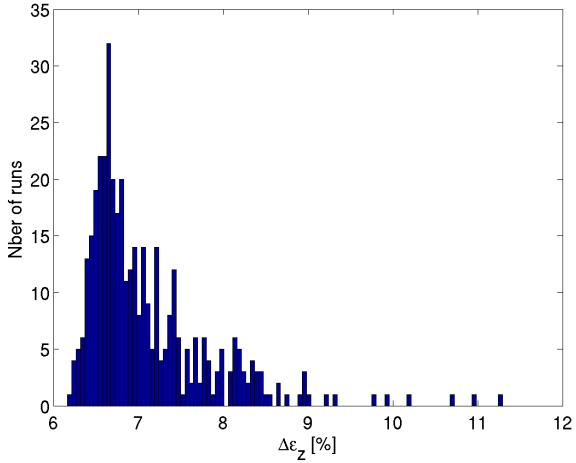
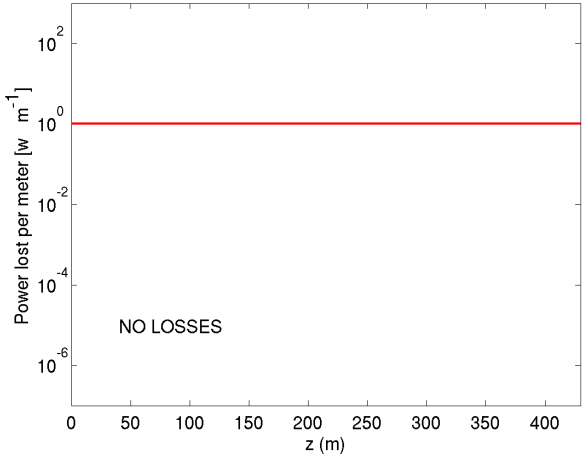


Figure: Losses [W·m^{-1}]



(039) Cavities $\phi_x = 8$ mrad

Figure: RMS Emittance X

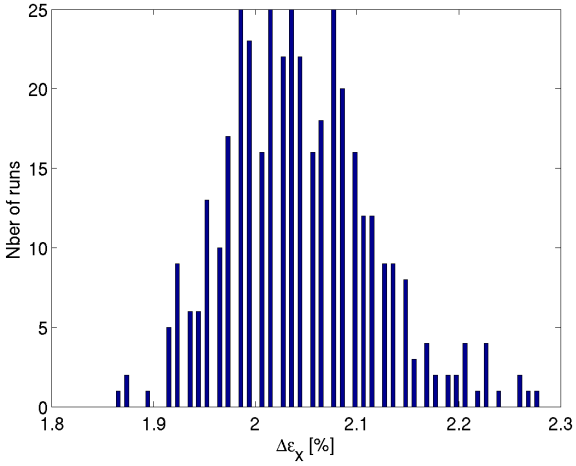


Figure: Centroid X

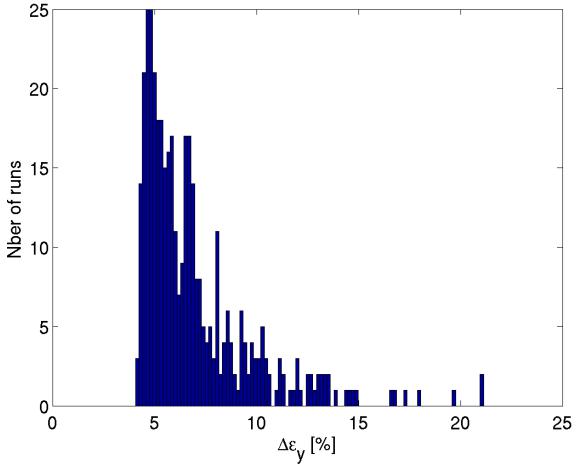


Figure: RMS Emittance Z

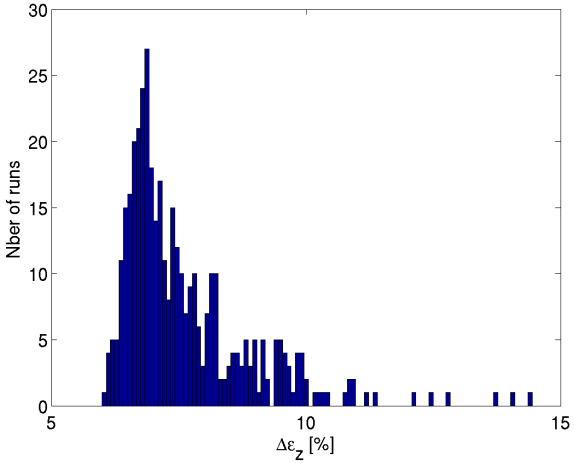
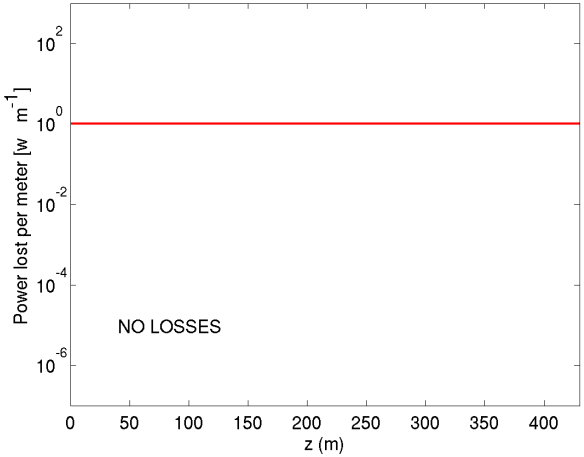


Figure: Losses [W·m^{-1}]



(040) Cavities $\phi_x = 10$ mrad

Figure: RMS Emittance X

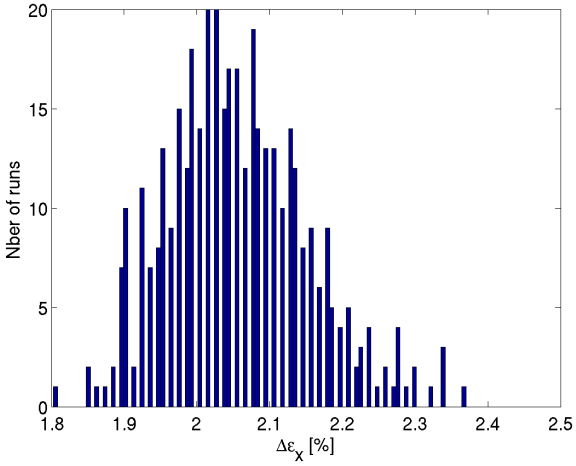


Figure: Centroid X

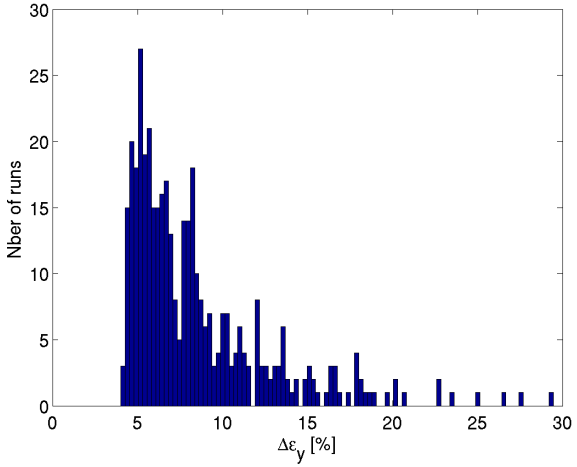


Figure: RMS Emittance Z

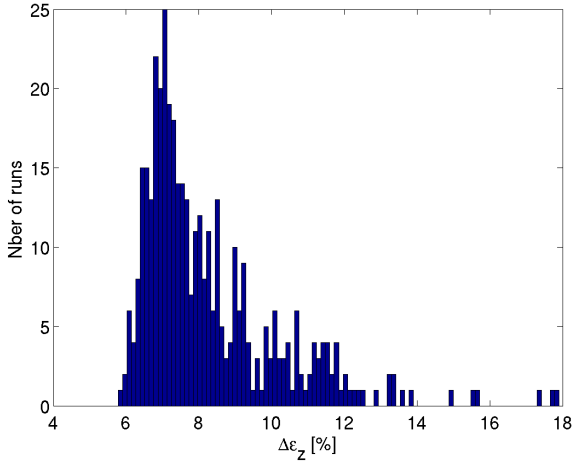
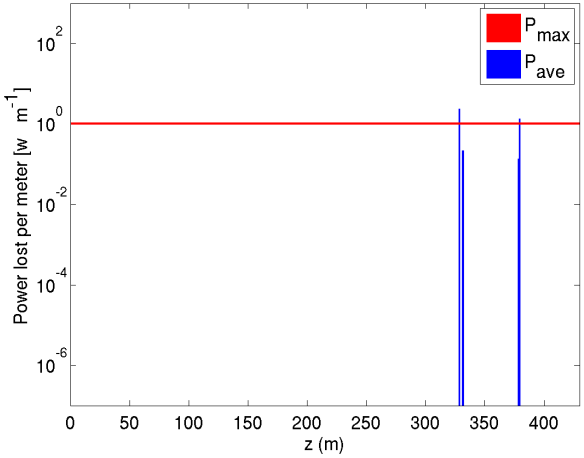


Figure: Losses [W·m^{-1}]



(041) Cavities $\delta_{xy} = 150\ \mu$m

Figure: RMS Emittance X

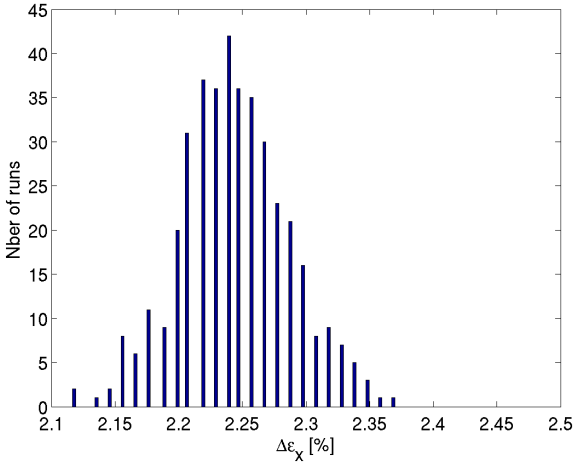


Figure: Centroid X

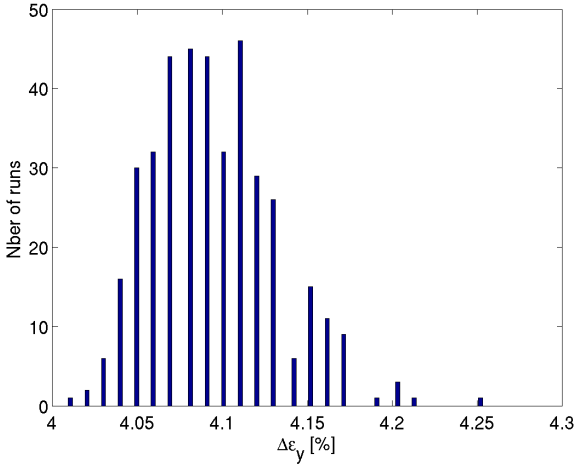


Figure: RMS Emittance Z

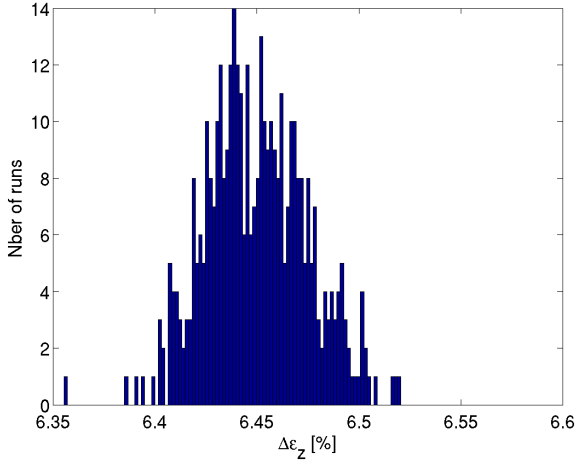
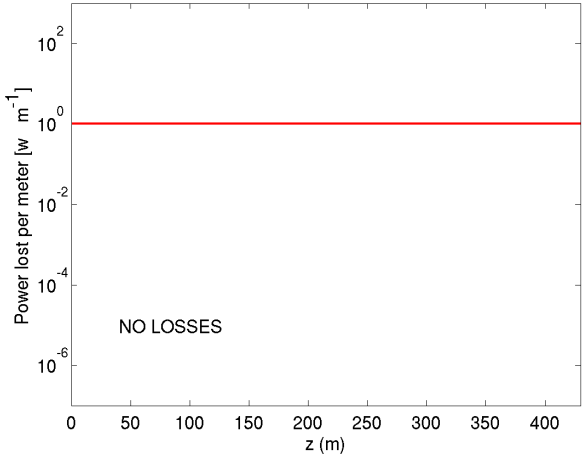


Figure: Losses [W·m^{-1}]



(042) Cavities $\delta_{xy} = 300\ \mu$m

Figure: RMS Emittance X

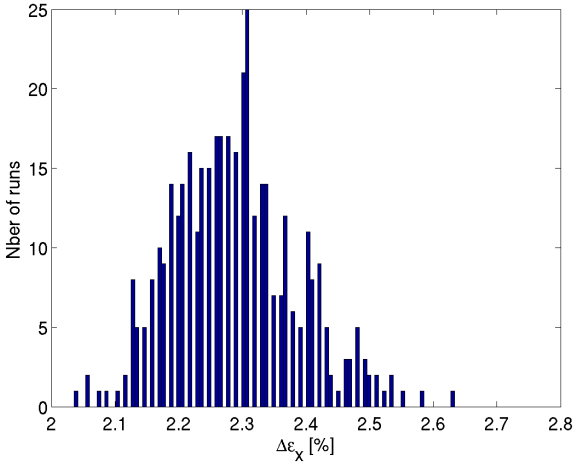


Figure: Centroid X

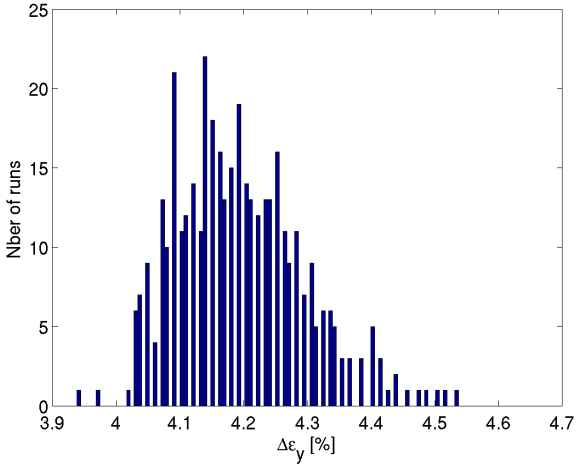


Figure: RMS Emittance Z

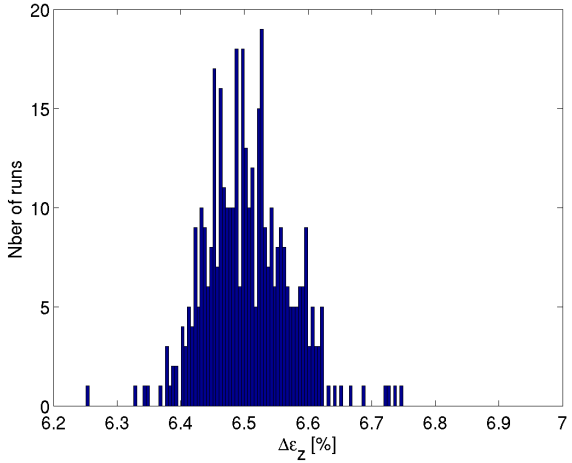
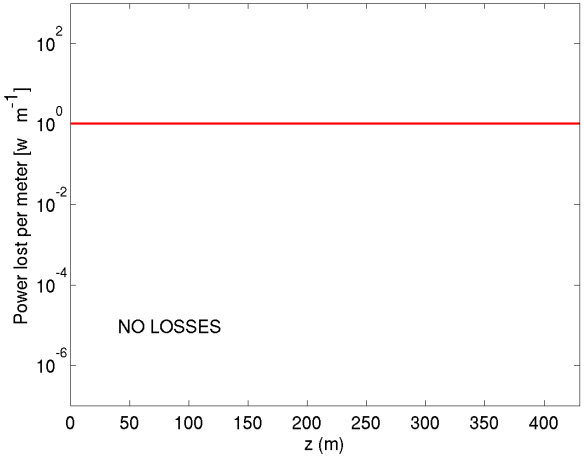


Figure: Losses [W·m^{-1}]



(043) Cavities $\delta_{xy} = 500\ \mu$m

Figure: RMS Emittance X

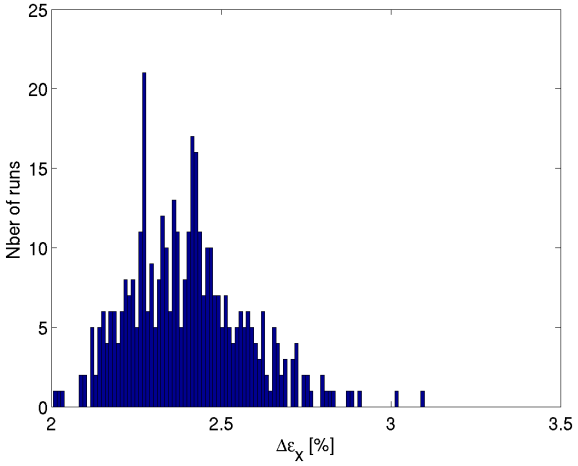


Figure: Centroid X

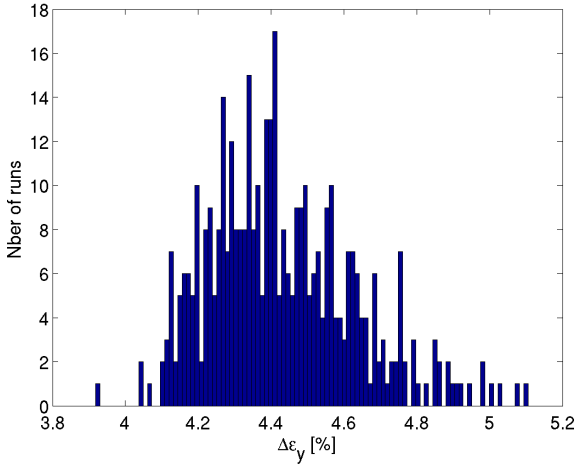


Figure: RMS Emittance Z

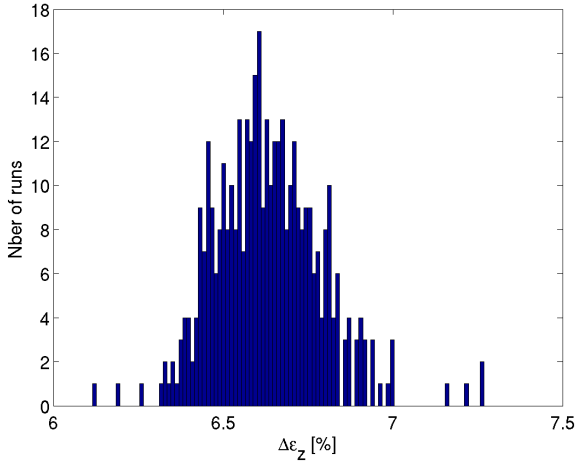
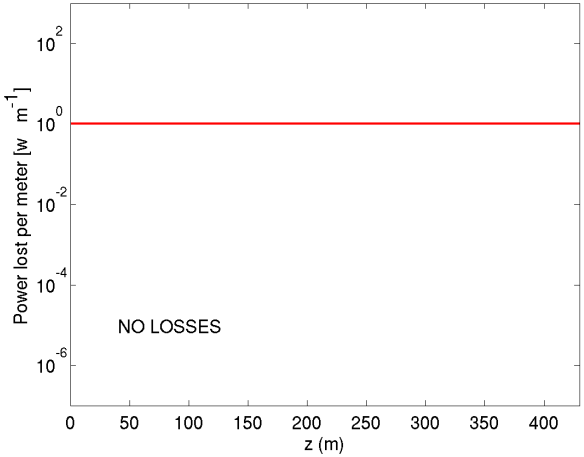


Figure: Losses [W·m^{-1}]



(044) Cavities $\delta_{xy} = 750\ \mu$m

Figure: RMS Emittance X

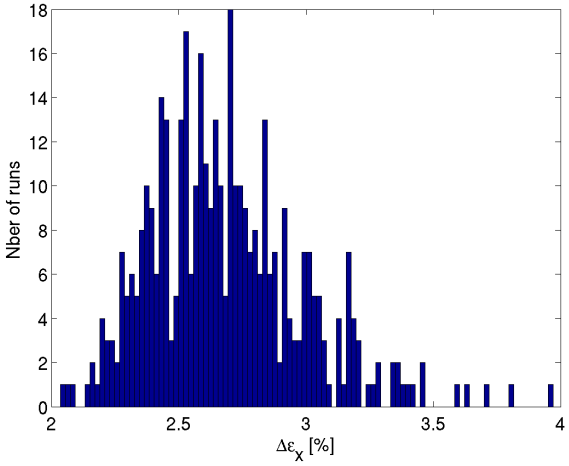


Figure: Centroid X

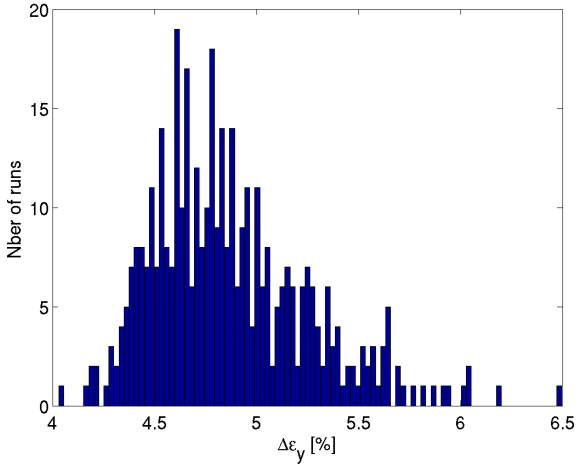


Figure: RMS Emittance Z

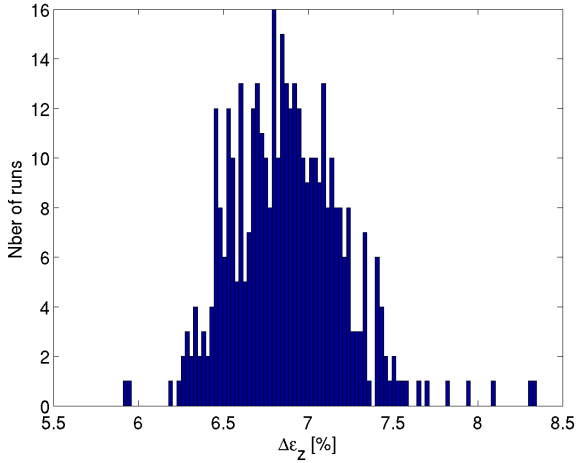
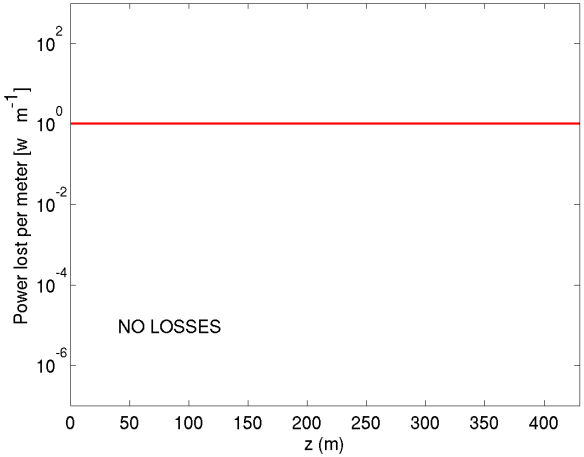


Figure: Losses [W·m^{-1}]



(045)Cavities $\delta_{xy} = 1000\ \mu$m

Figure: RMS Emittance X

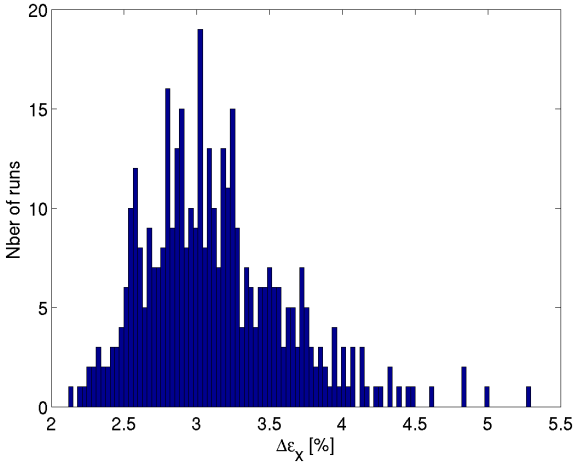


Figure: Centroid X

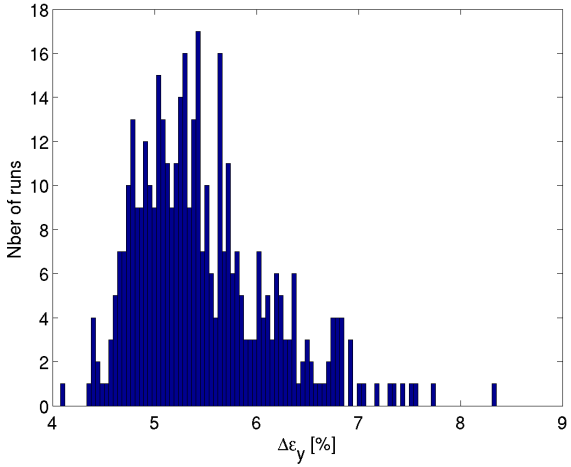


Figure: RMS Emittance Z

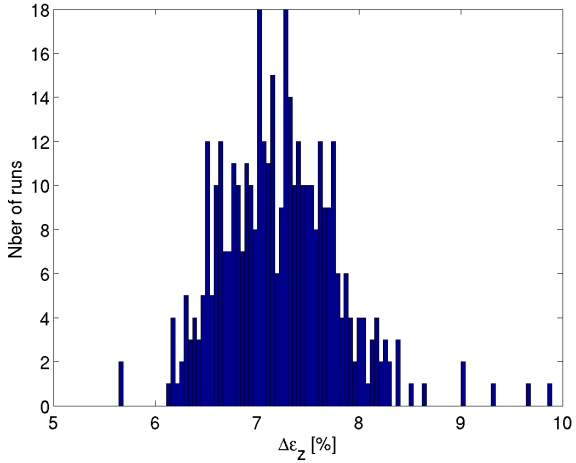
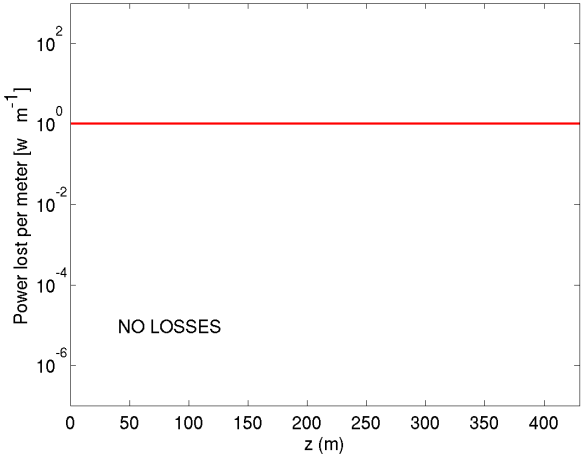


Figure: Losses [W·m^{-1}]



(046) Cav. Field $\delta\phi_{dynamic} = 0.5°$

Figure: RMS Emittance X

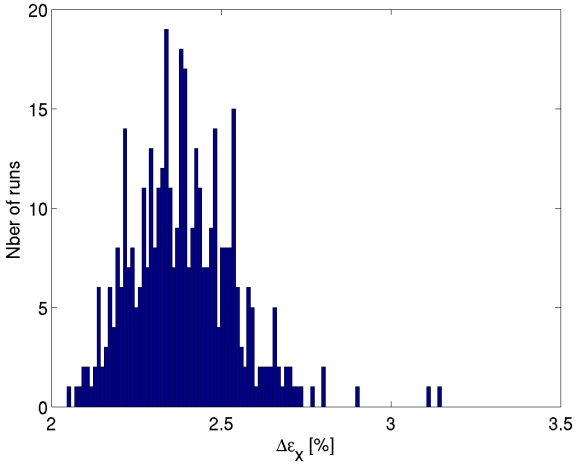


Figure: Centroid Z

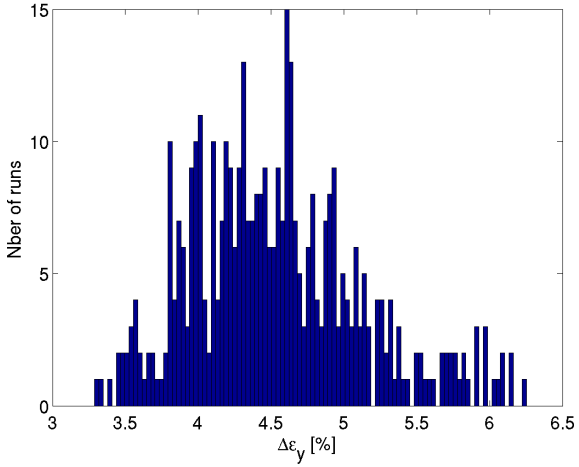


Figure: RMS Emittance Z

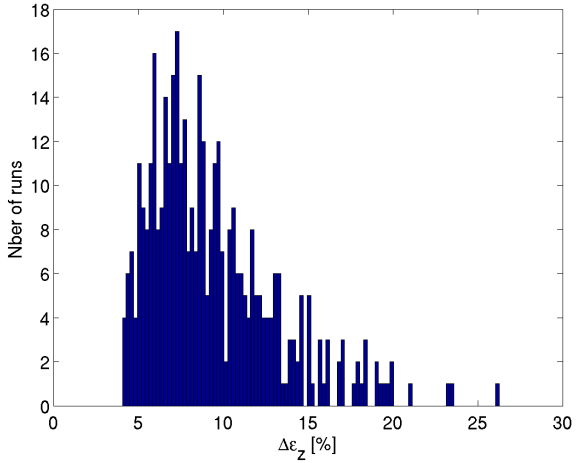
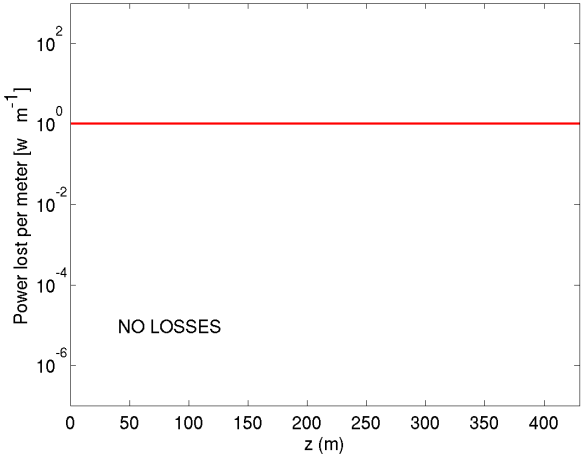


Figure: Losses [W·m^{-1}]



(046) Cav. Field $\delta\phi_{dynamic} = 1.0°$

Figure: RMS Emittance X

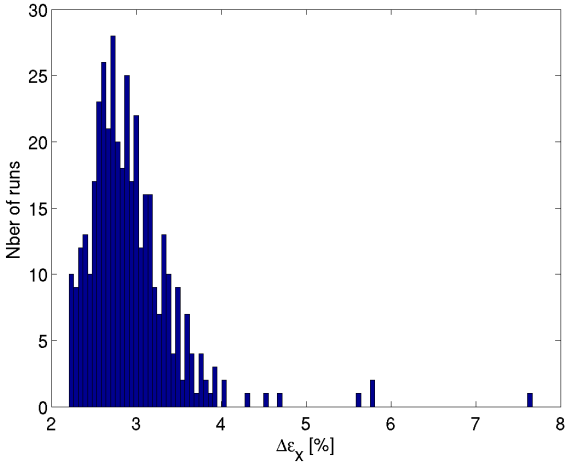


Figure: Centroid Z

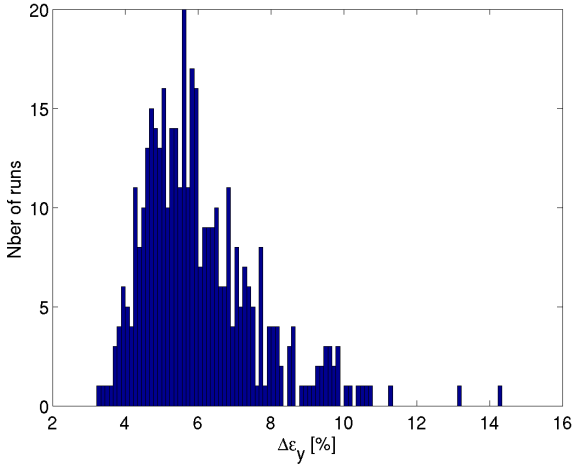


Figure: RMS Emittance z

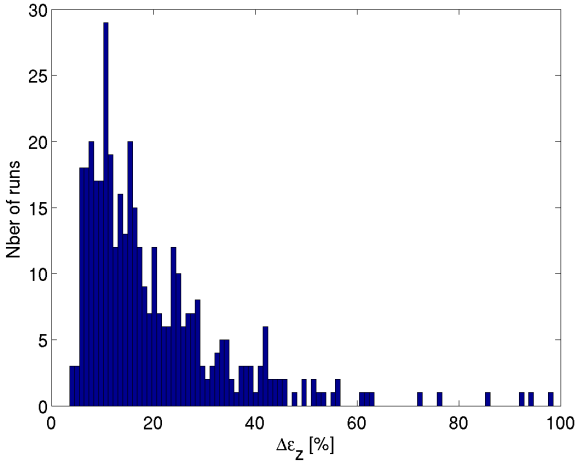
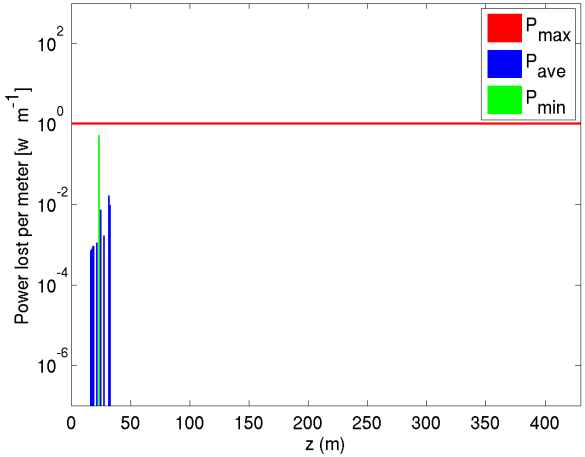


Figure: Losses [W·m^{-1}]



(046) Cav. Field $\delta\phi_{dynamic} = 1.5°$

Figure: RMS Emittance X

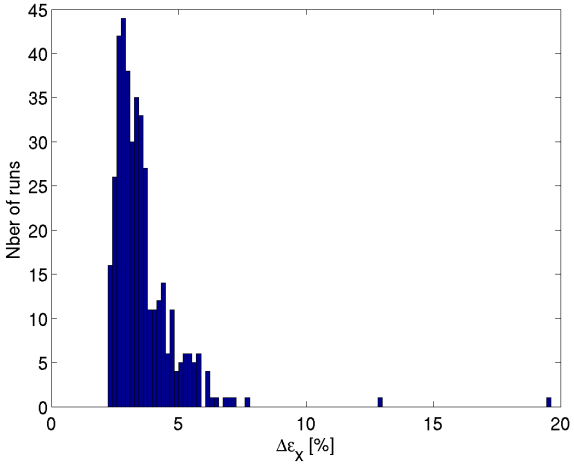


Figure: Centroid Z

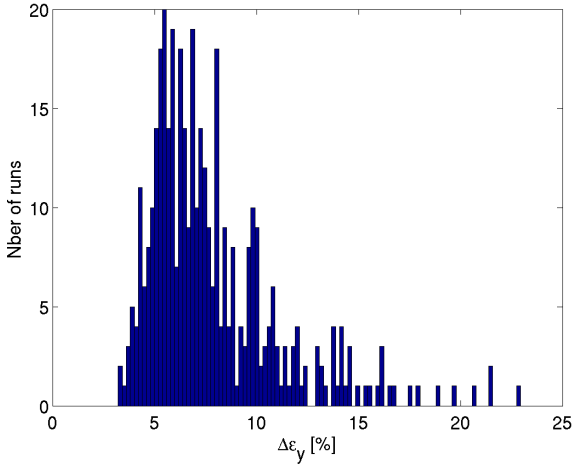


Figure: RMS Emittance Z

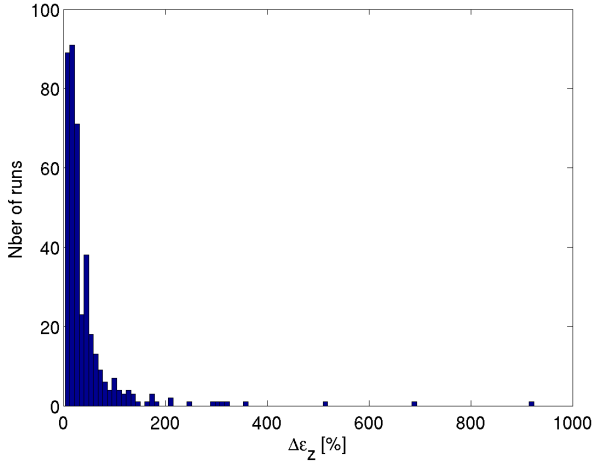
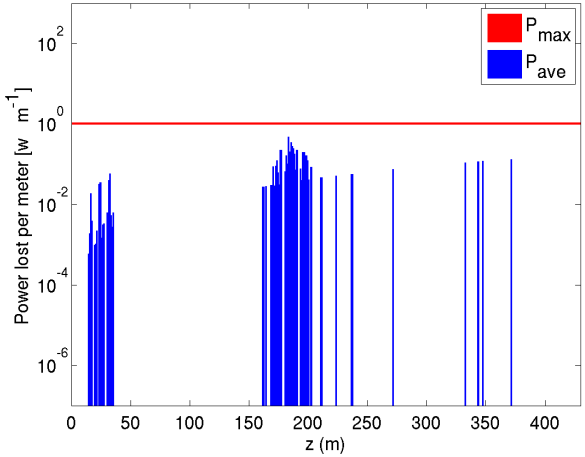


Figure: Losses [W·m^{-1}]



(046) Cav. Field $\delta\phi_{dynamic} = 2.0°$

Figure: RMS Emittance X

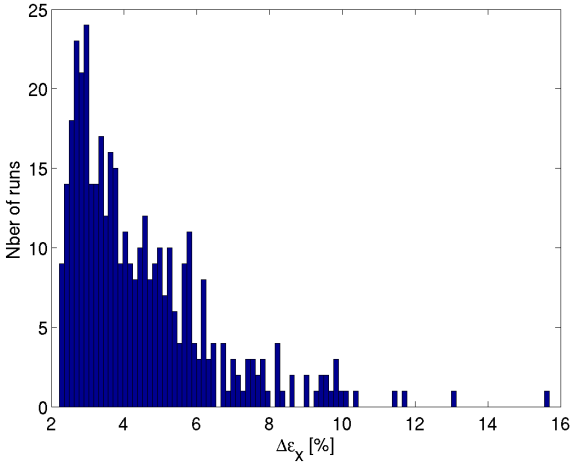


Figure: Centroid Z

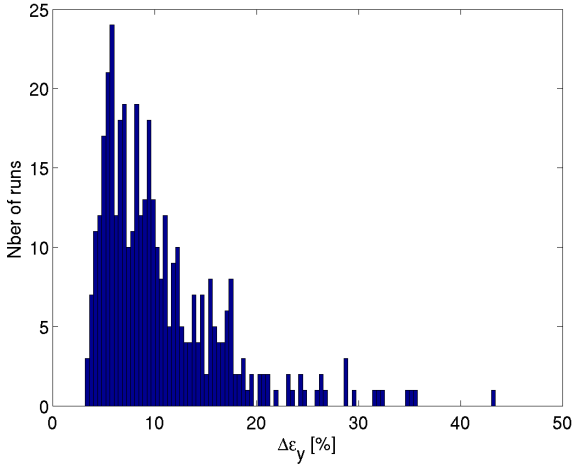


Figure: RMS Emittance Z

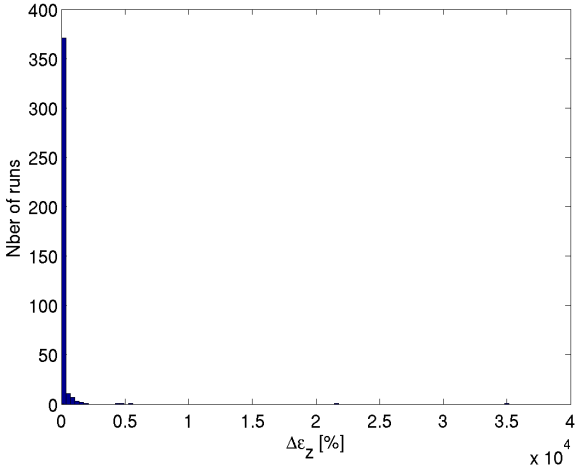
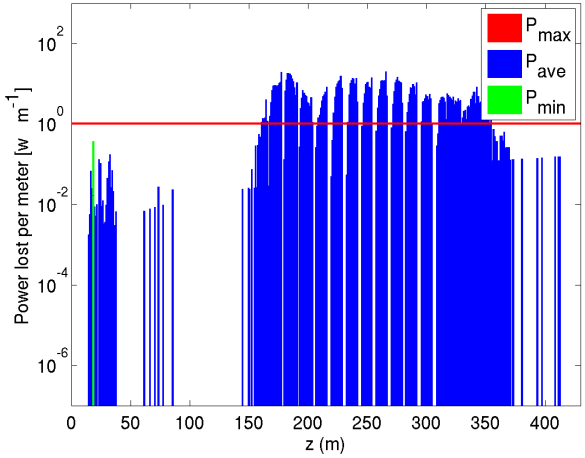


Figure: Losses [W·m^{-1}]



(046) Cav. Field $\delta\phi_{dynamic} = 2.5°$

Figure: RMS Emittance X

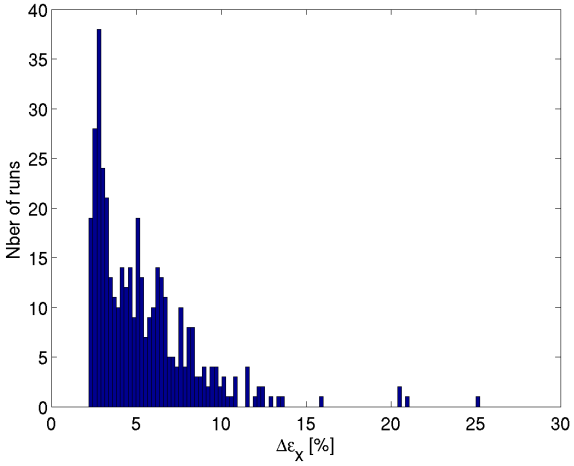


Figure: Centroid Z

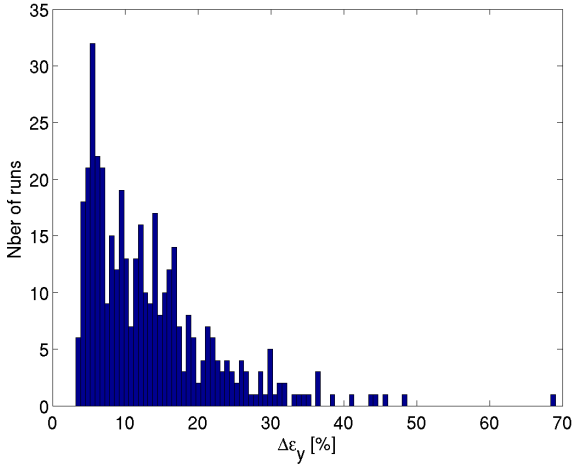


Figure: RMS Emittance Z

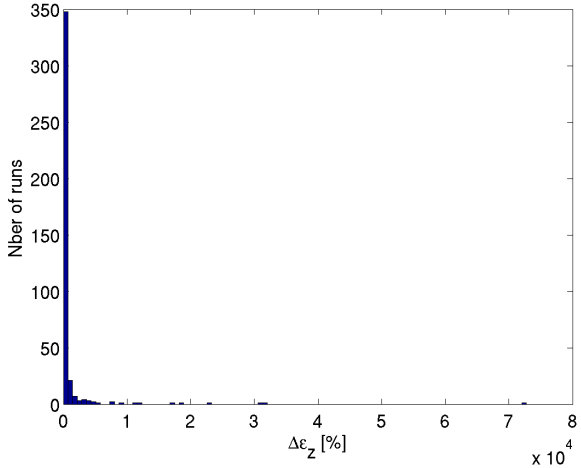
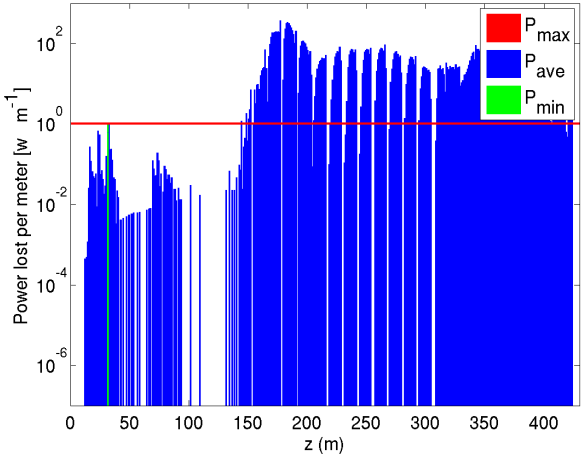


Figure: Losses [W·m^{-1}]



(051) Cav. Field $\delta F_{dyn} = 0.5$ %

Figure: RMS Emittance X

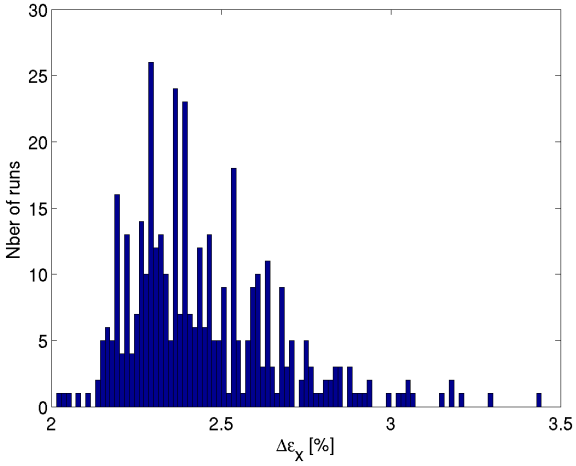


Figure: Centroid Z

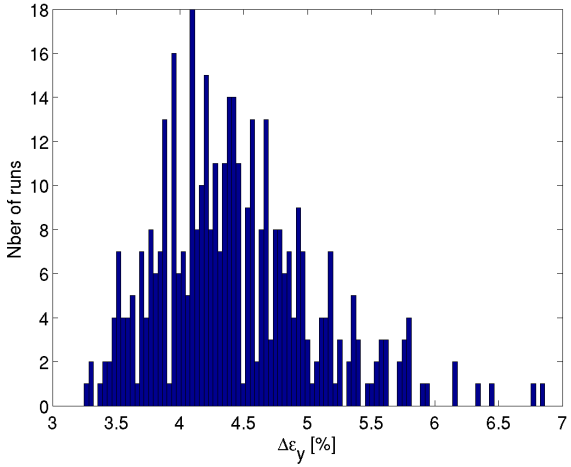


Figure: RMS Emittance Z

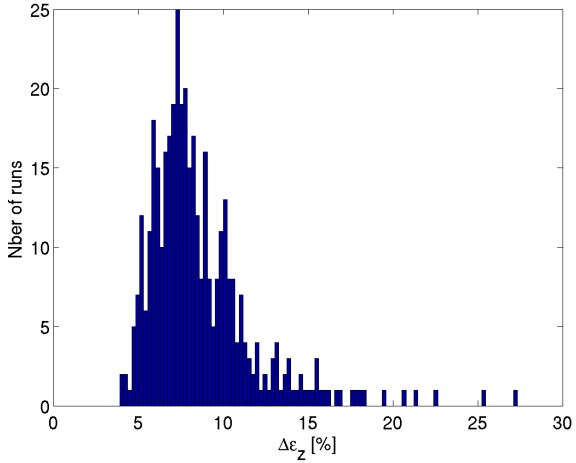
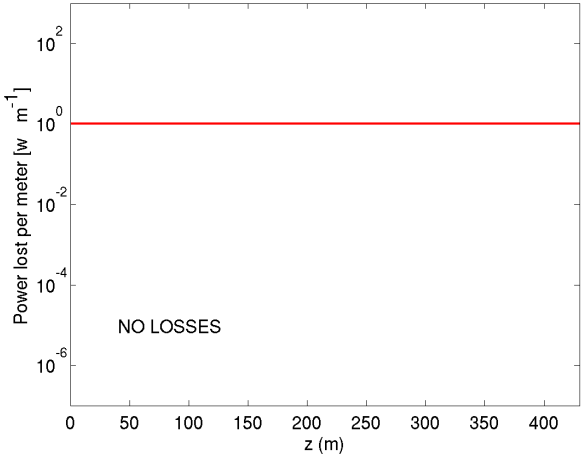


Figure: Losses [W·m^{-1}]



(052) Cav. Field $\delta F_{dyn} = 1.0$ %

Figure: RMS Emittance X

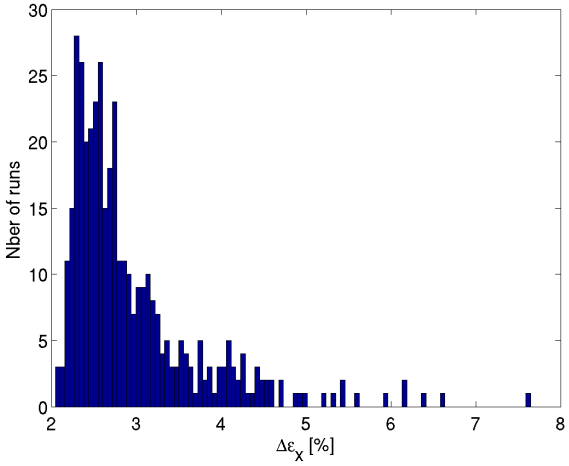


Figure: Centroid Z

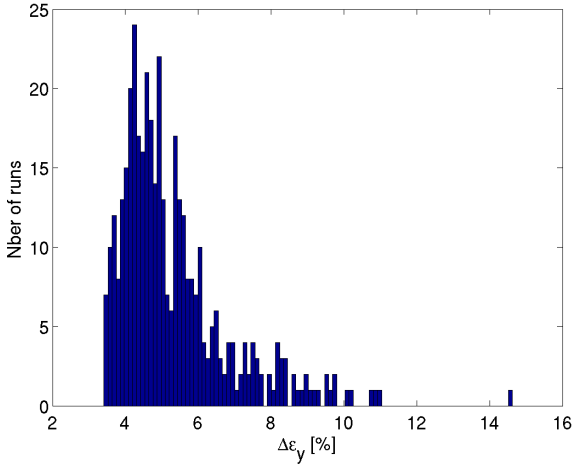


Figure: RMS Emittance Z

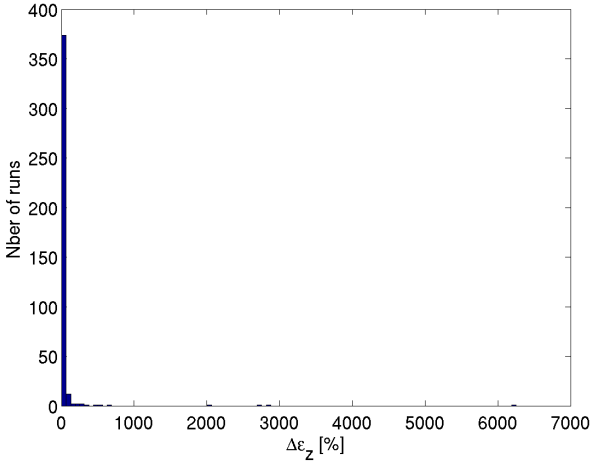
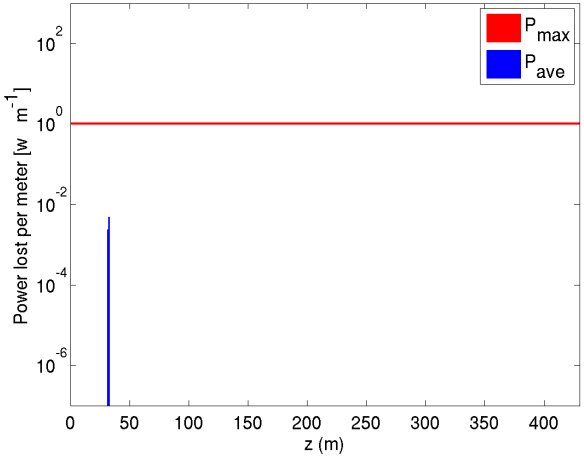


Figure: Losses [W·m^{-1}]



(053) Cav. Field $\delta F_{dyn} = 1.5$ %

Figure: RMS Emittance X

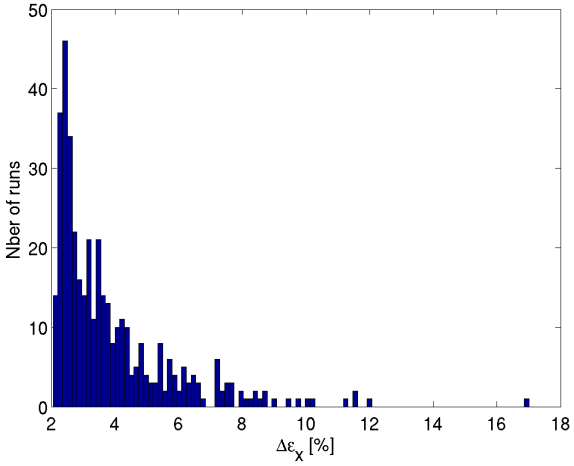


Figure: Centroid Z

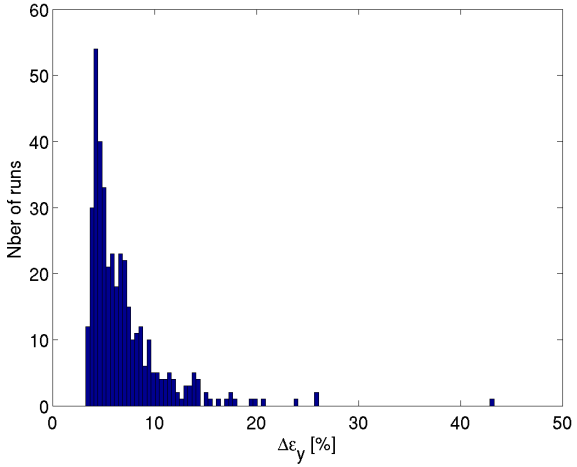


Figure: RMS Emittance Z

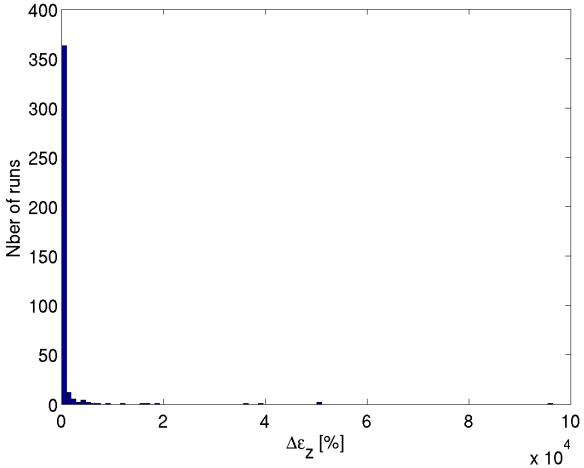
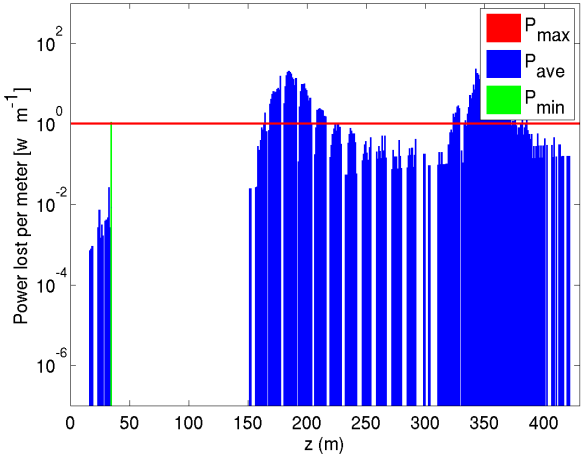


Figure: Losses [W·m^{-1}]



(054) Cav. Field $\delta F_{dyn} = 2.0$ %

Figure: RMS Emittance X

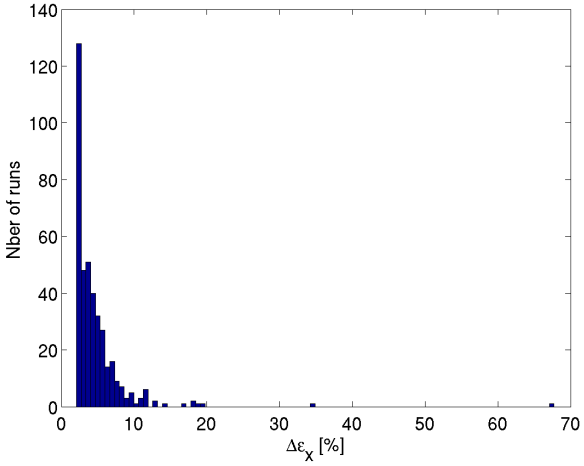


Figure: Centroid Z

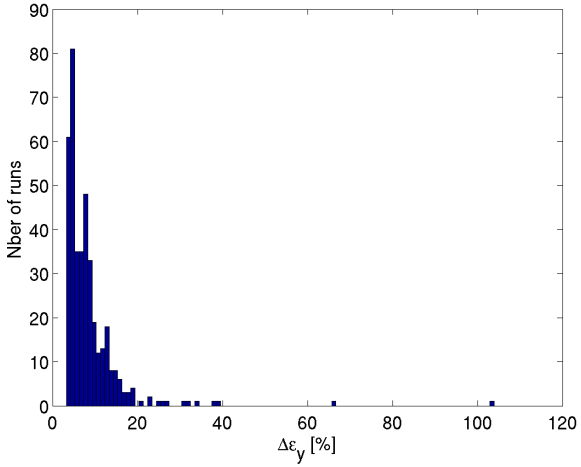


Figure: RMS Emittance Z

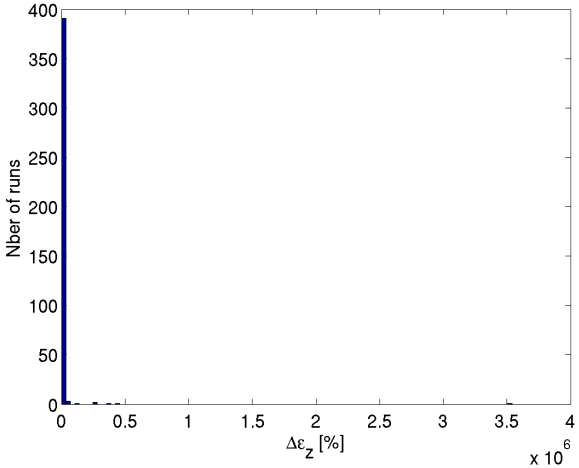
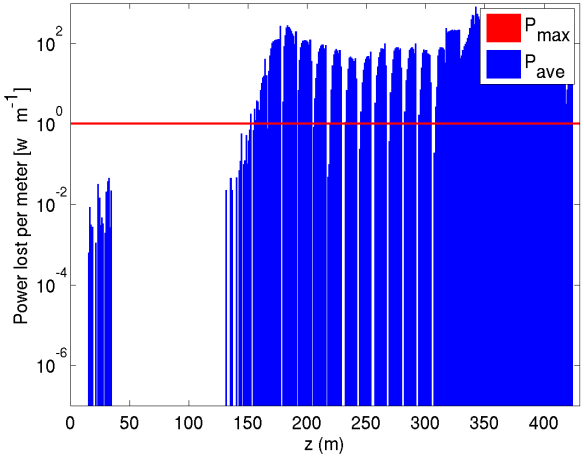


Figure: Losses [W·m^{-1}]



(055) Cav. Field $\delta F_{dyn} = 2.5$ %

Figure: RMS Emittance X

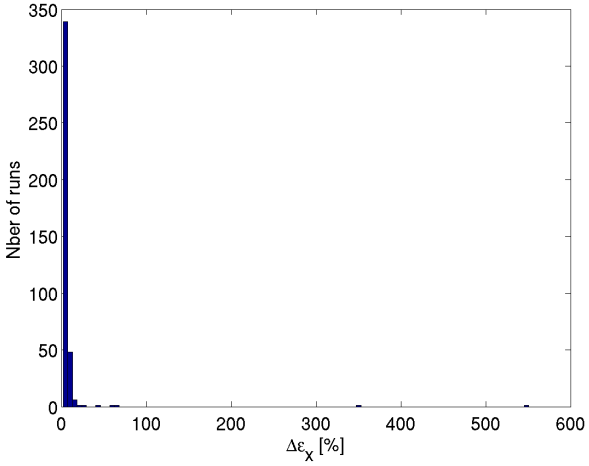


Figure: Centroid Z

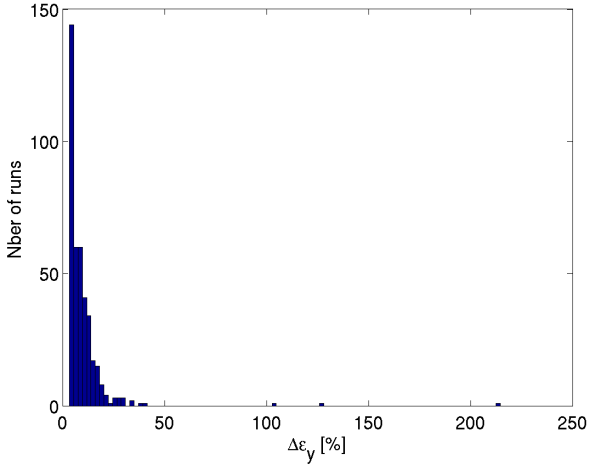


Figure: RMS Emittance Z

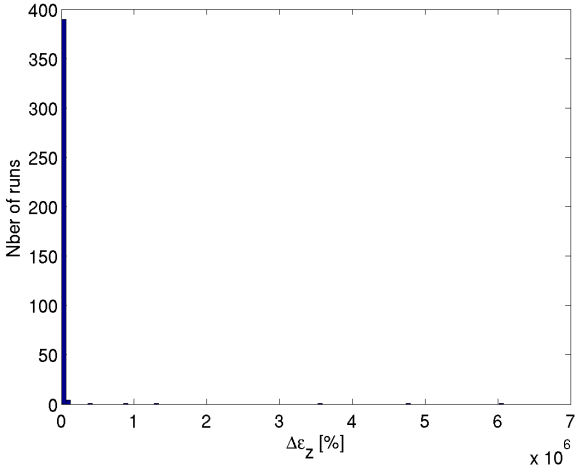
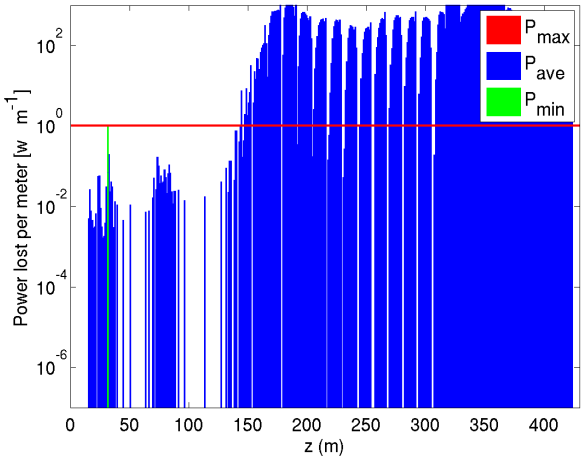


Figure: Losses [W·m^{-1}]



(056) Cav. Phase and Field $\delta\phi_{dyn.} = 0.5^\circ$ & $\delta F_{dyn.} = 0.5$ %

Figure: RMS Emittance X

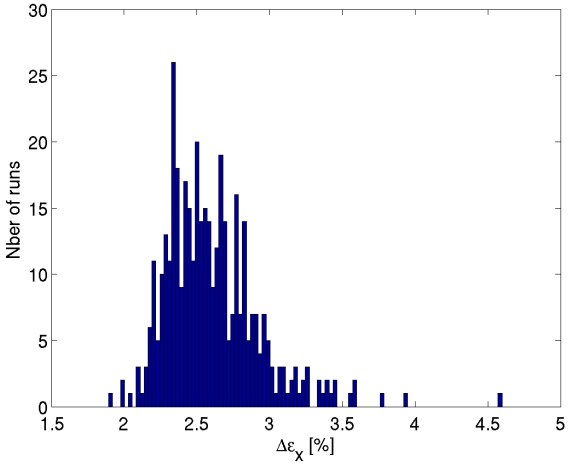


Figure: Centroid Z

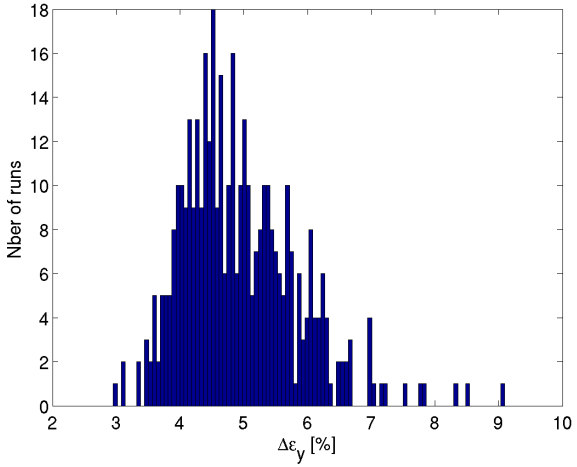


Figure: RMS Emittance Z

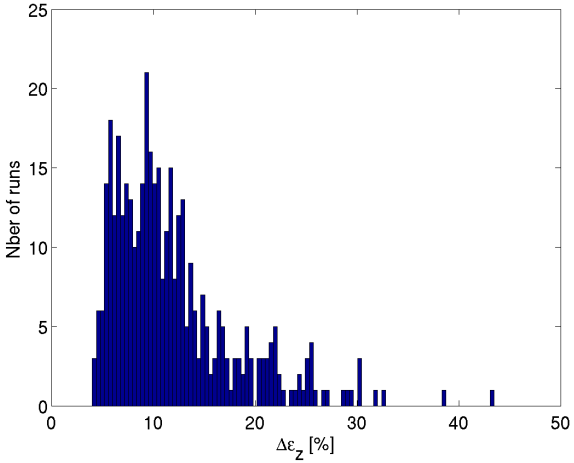
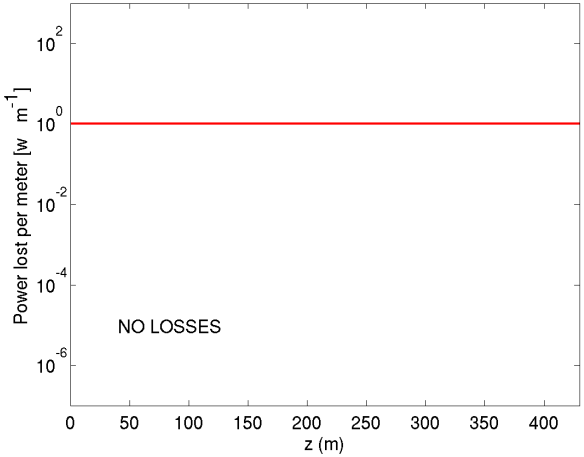


Figure: Losses [W·m^{-1}]



(057) Cav. Phase and Field $\delta\phi_{dyn.} = 1.0^\circ$ & $\delta F_{dyn.} = 1.0$ %

Figure: RMS Emittance X

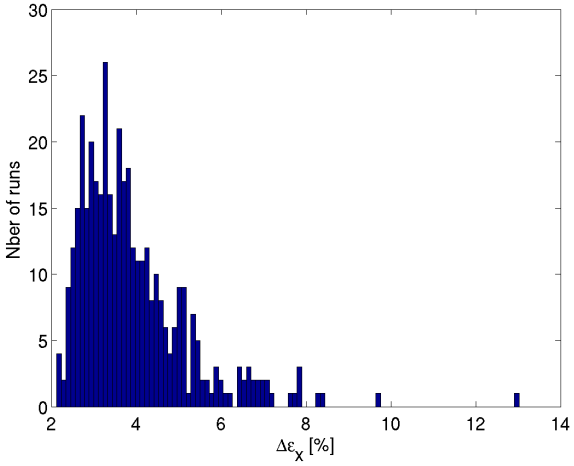


Figure: Centroid Z

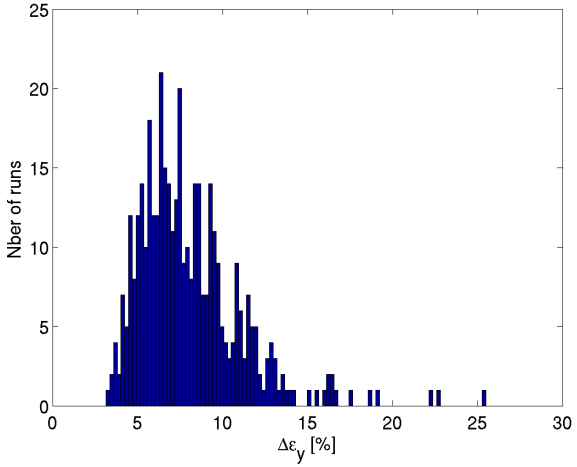


Figure: RMS Emittance Z

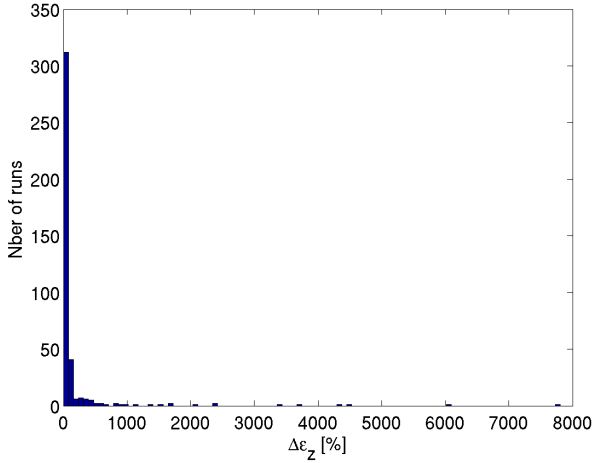
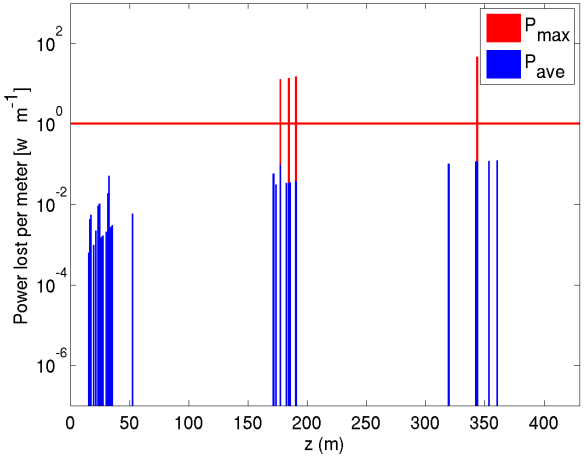


Figure: Losses [W·m^{-1}]



(058) Cav. Phase and Field $\delta\phi_{dyn.} = 1.5^\circ$ & $\delta F_{dyn.} = 1.5$ %

Figure: RMS Emittance X

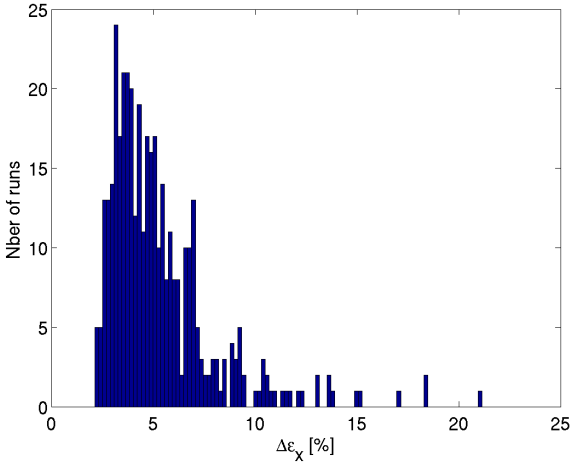


Figure: Centroid Z

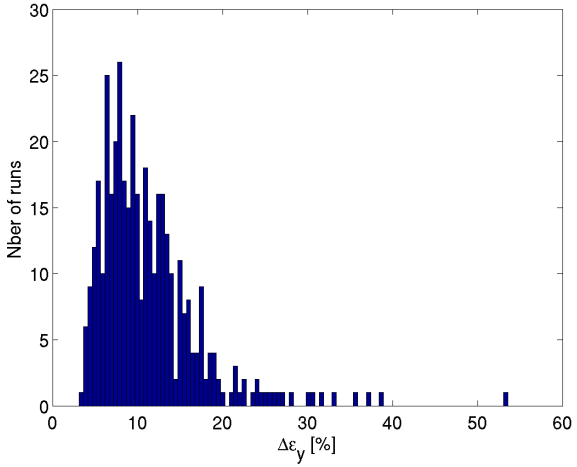


Figure: RMS Emittance Z

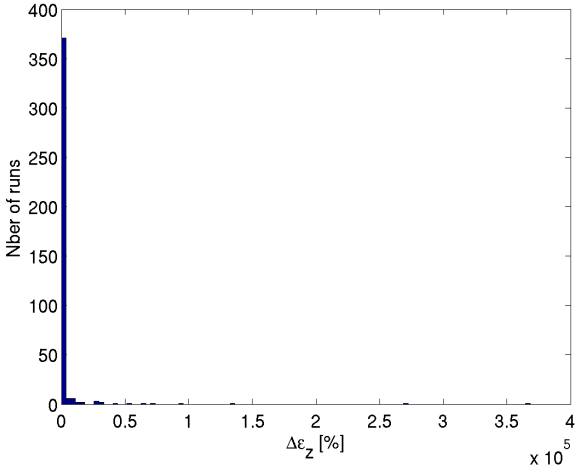
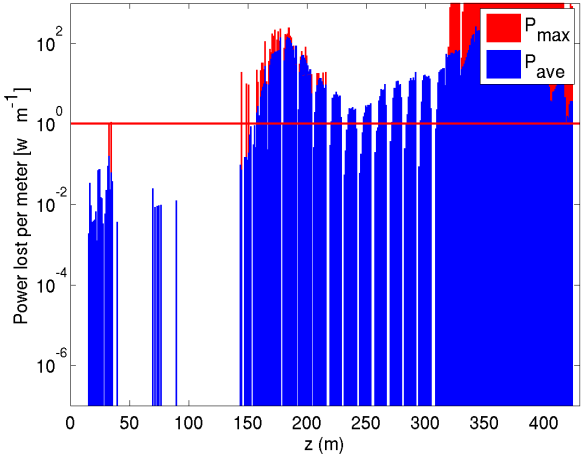


Figure: Losses [W·m^{-1}]



(059) Cav. Phase and Field $\delta\phi_{dyn.} = 2.0^\circ$ & $\delta F_{dyn.} = 2.0$ %

Figure: RMS Emittance X

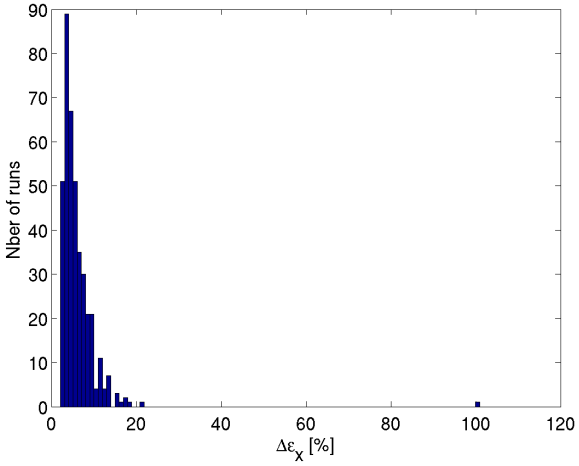


Figure: Centroid Z

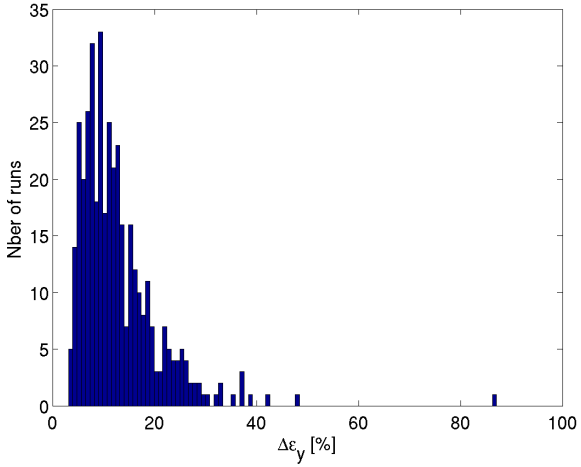


Figure: RMS Emittance Z

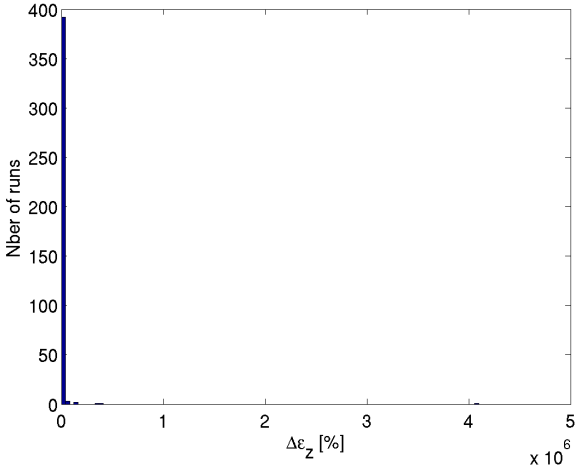
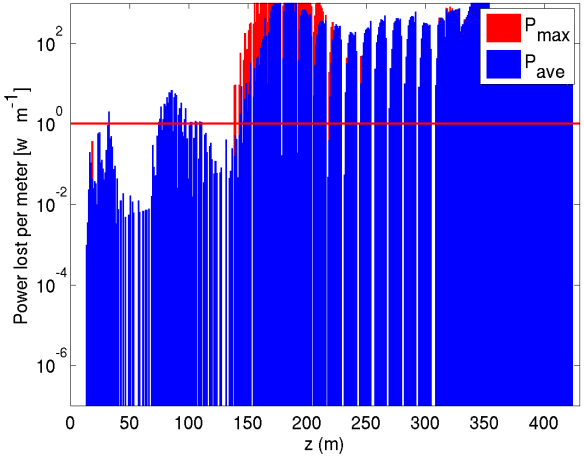


Figure: Losses [W·m^{-1}]



(060) Cav. Phase and Field $\delta\phi_{dyn.} = 2.5^\circ$ & $\delta F_{dyn.} = 2.5$ %

Figure: RMS Emittance X

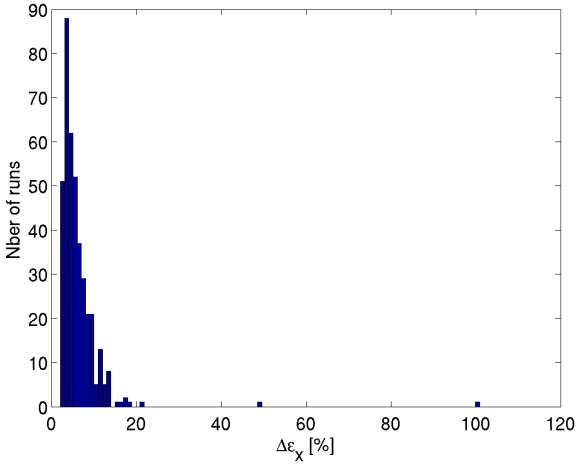


Figure: Centroid Z

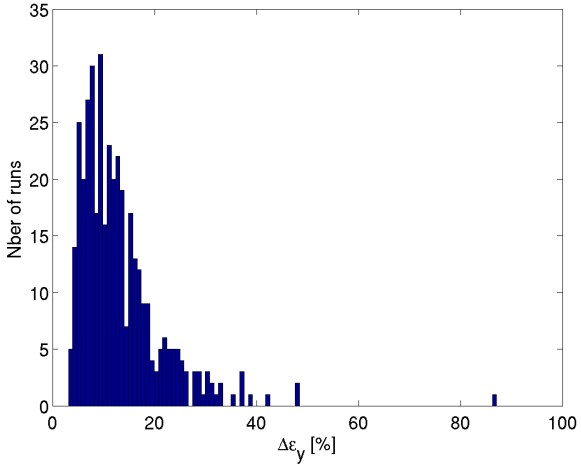


Figure: RMS Emittance Z

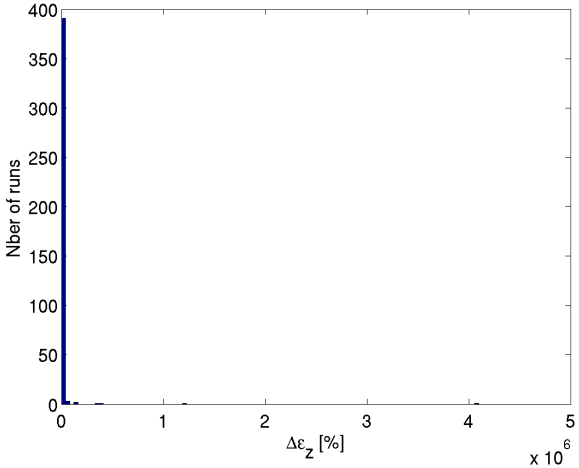
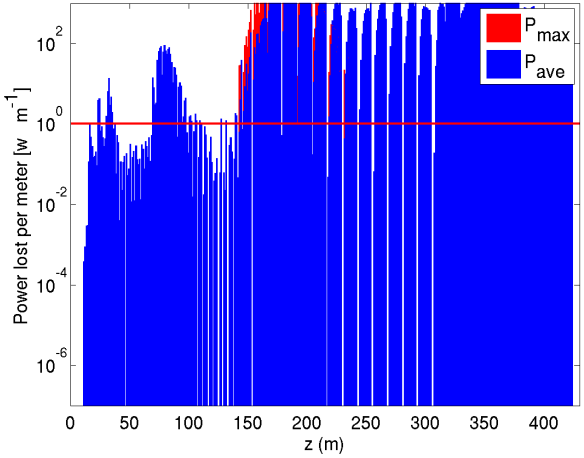



Figure: Losses [W·m^{-1}]