Bremsstrahlung simulation with Geant4

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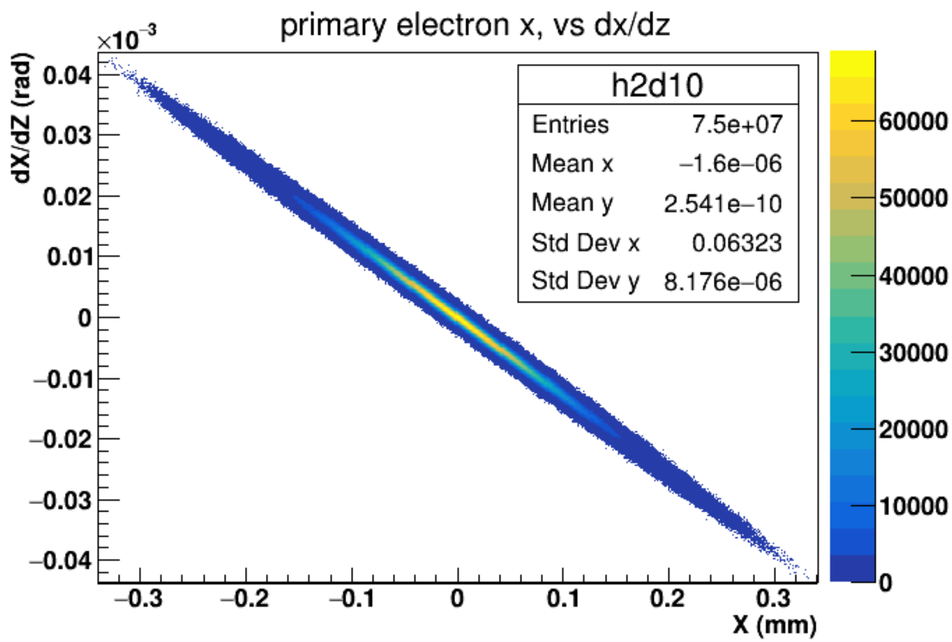
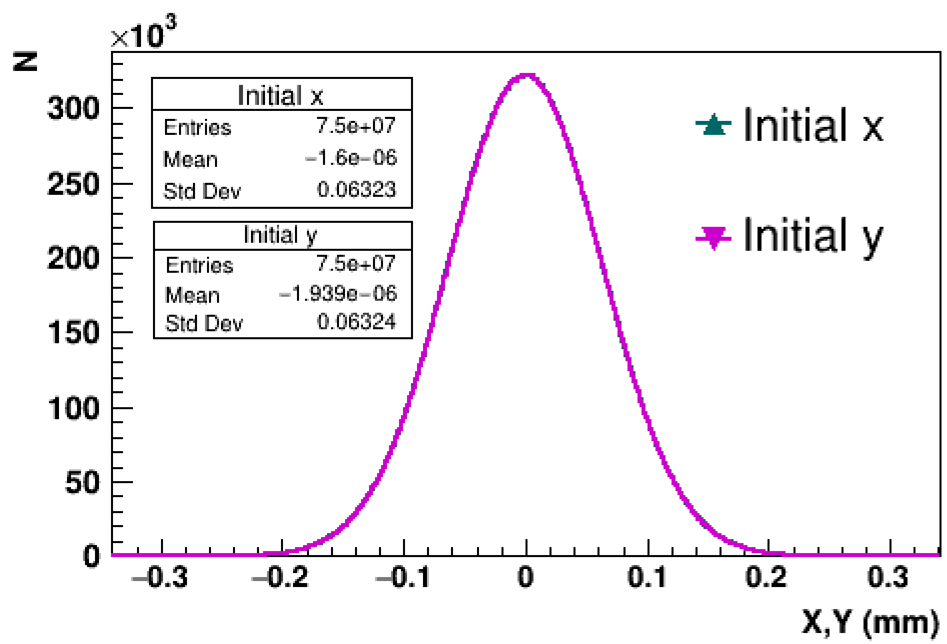
Electron beam parameters

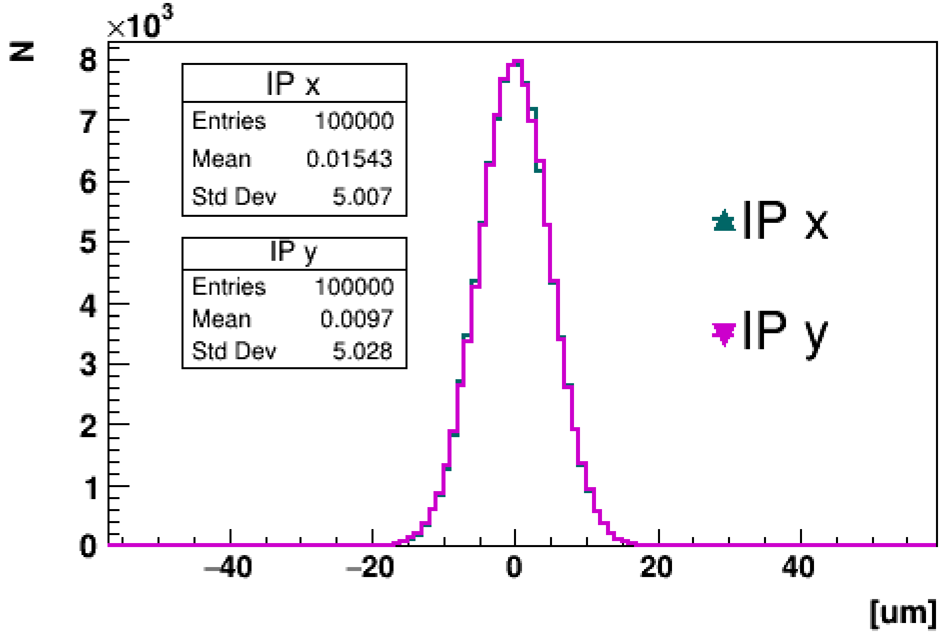
Crossing angle, rad	Laser σxy, µm	Laser σz, ps	N Electrons	Electron σx, µm	Electron σy, µm	Electron σz, ps	Emitt (mm mrad)	E, GeV
0.3	3, 8	0.035	1.5E+09	5	5	0.08 (24 µm)	1.4	16.5

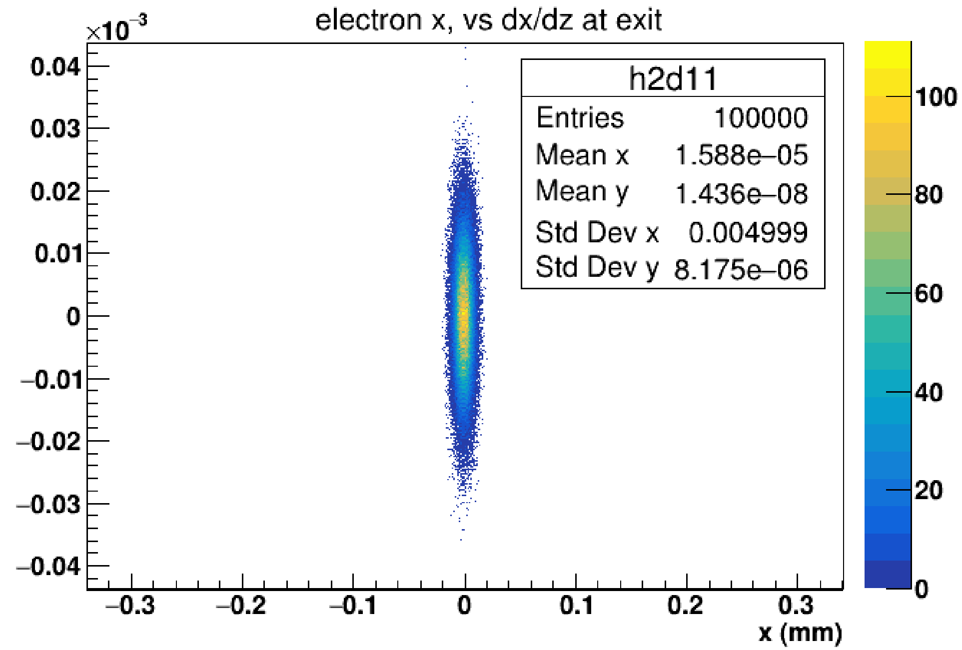
- Gaussian beam, focused on IP;
- Tungsten target 1%X0 (35um) thickness
- 7.51 m from IP;
- 15 M electrons (BX/100); (also 75M)
- Production cut: 1 µm.

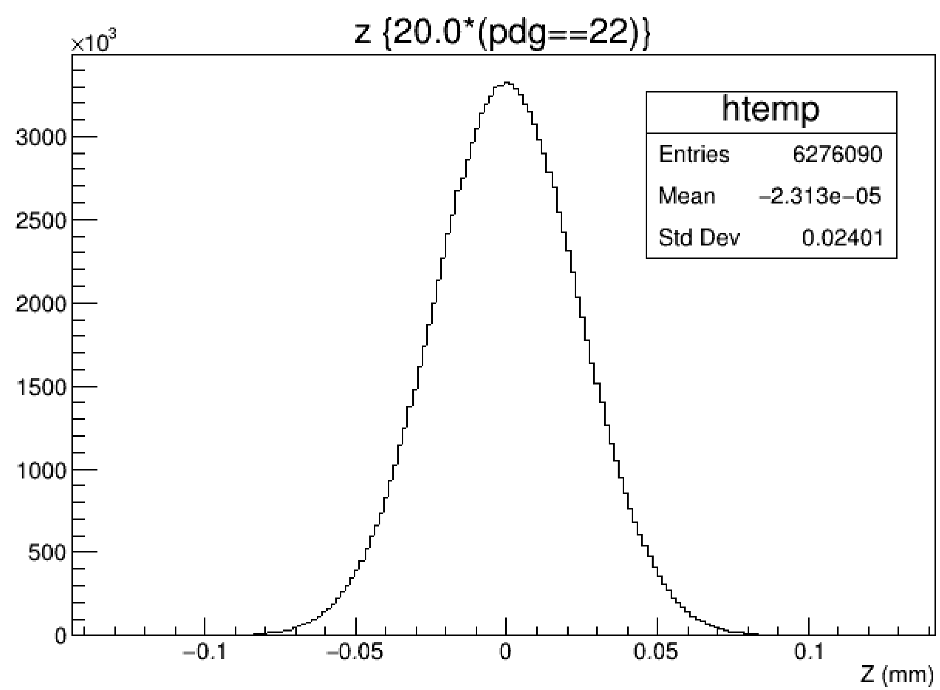




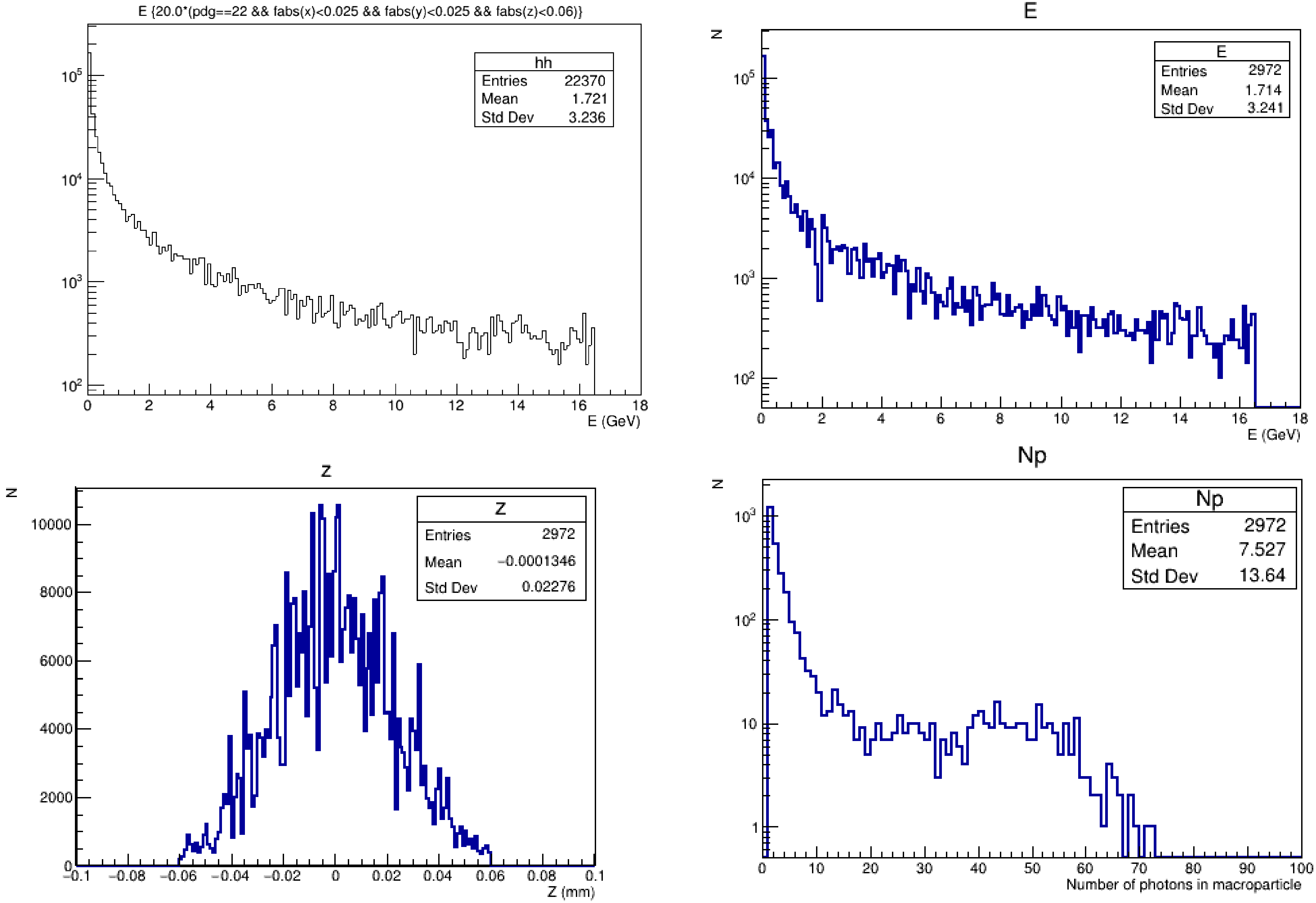
Electrons in IP without target and photons in IP



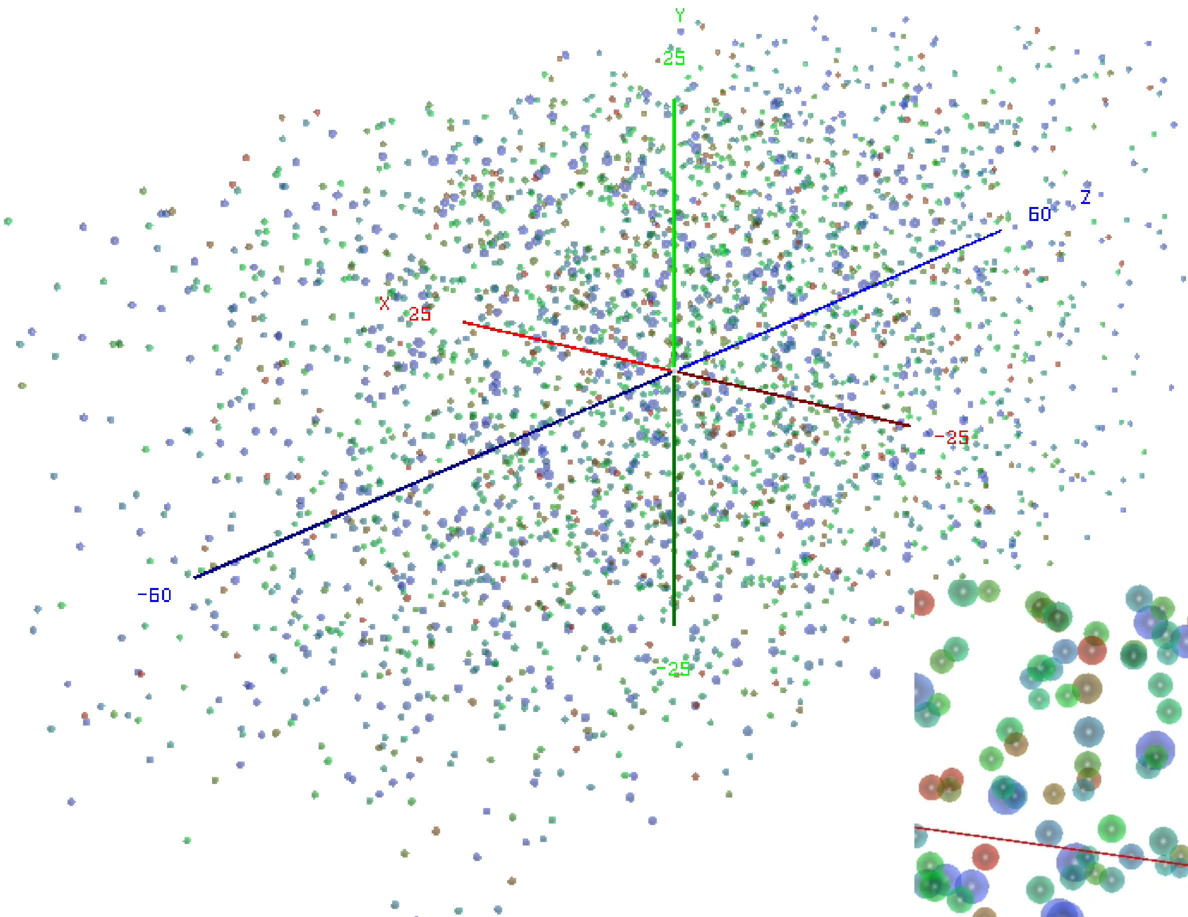


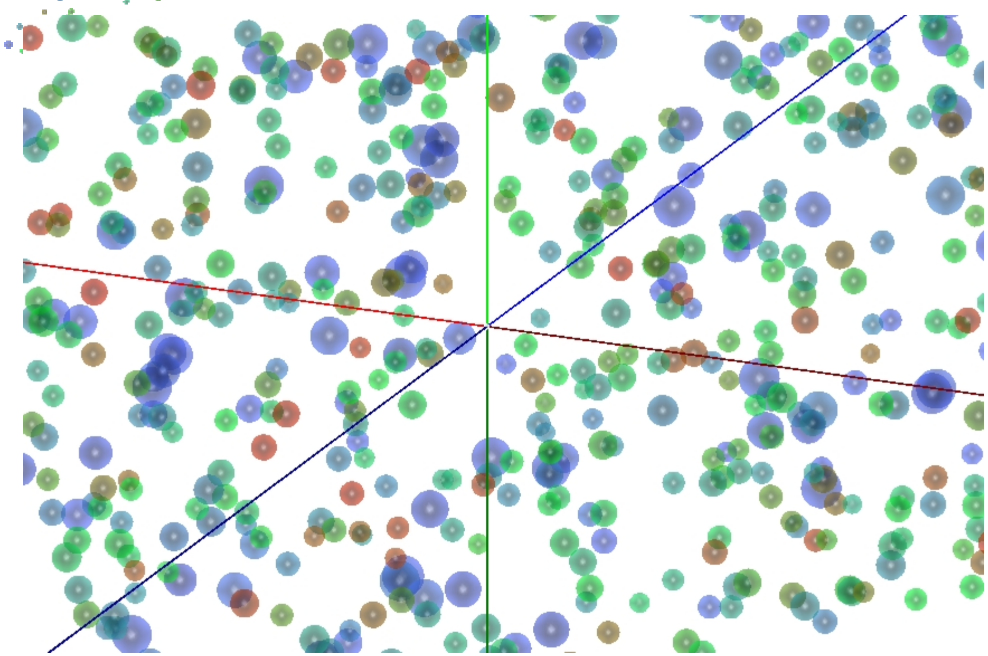


Photons and photon macro particles



Photon macro particles

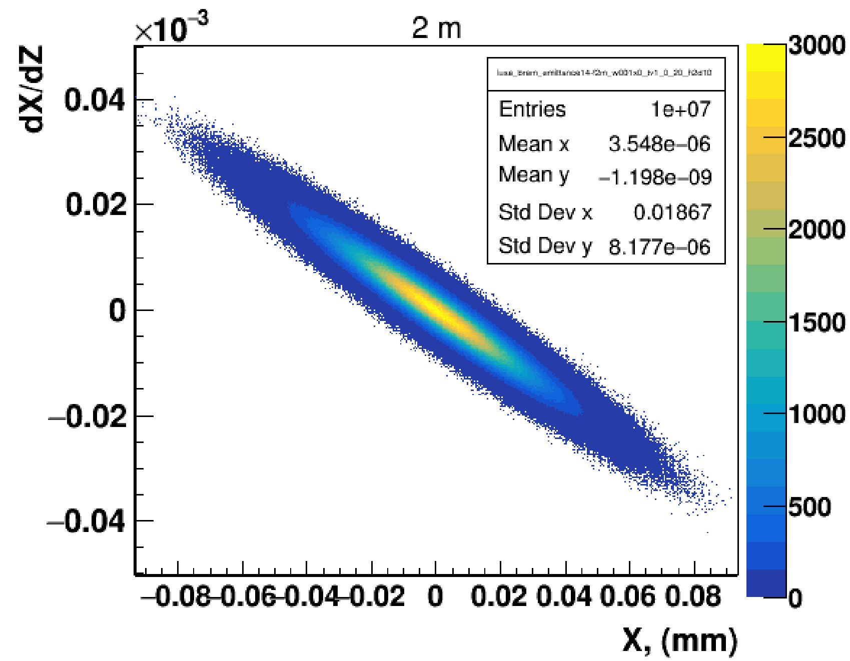


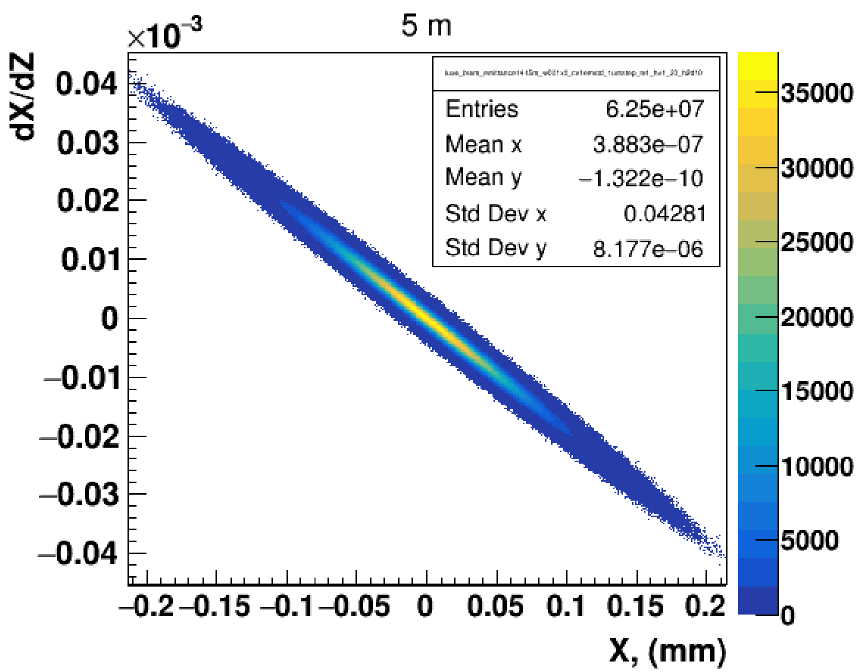


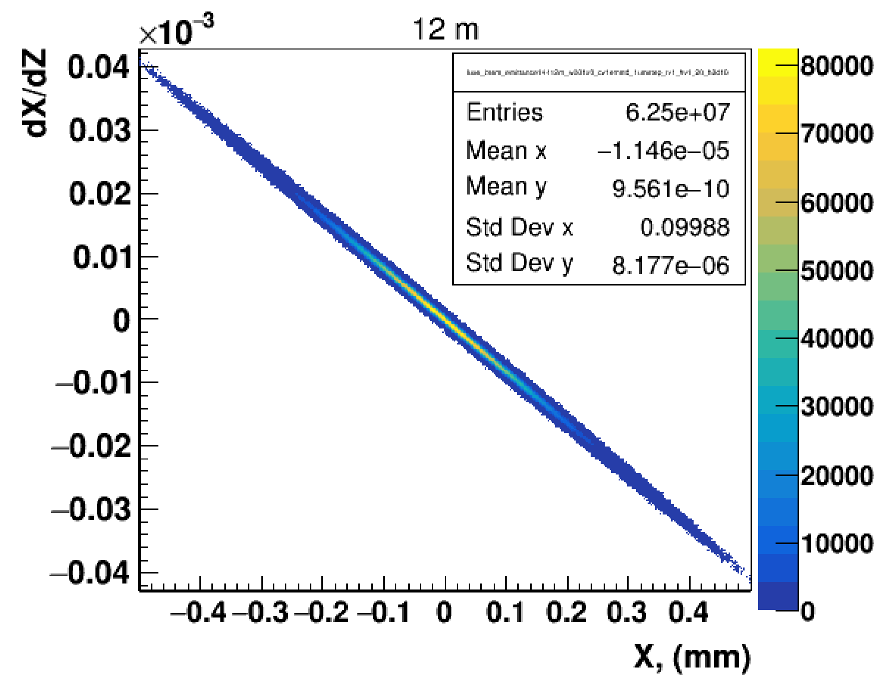
Backup

Target 2 m, 5 m and 12 m upstream of IP

- 2 m: σx = 19 μm;
- 5 m: σx = 43 μm;
- 12 m: σx = 100 μm;







Transverse beam dynamics

These are known as Hill's (homogeneous) Equations of Motion, more succinctly written as:

$$x'' + K_x(s)x = 0$$
$$y'' + K_y(s)y = 0$$

$$u = \sqrt{\varepsilon\beta(s)}\cos(\varphi(s) - \phi)$$

Phase advance is related to Beta function, β(s)

$$\varphi = \int_0^s \frac{1}{\beta(s)} ds$$

Beta function, β(s), is determined exclusively by magnetic lattice, K(s)

$$\frac{1}{2}\beta\beta'' - \frac{1}{4}\beta'^2 + \beta^2 K = 1$$

If K=0 (no field) $\beta(z) = \beta^* + \frac{z^2}{\beta^*}$

with z=0 at IP

$$\beta^* = \frac{\sigma^{*2}}{\varepsilon}$$

We can also define useful quantities related to the Beta function:

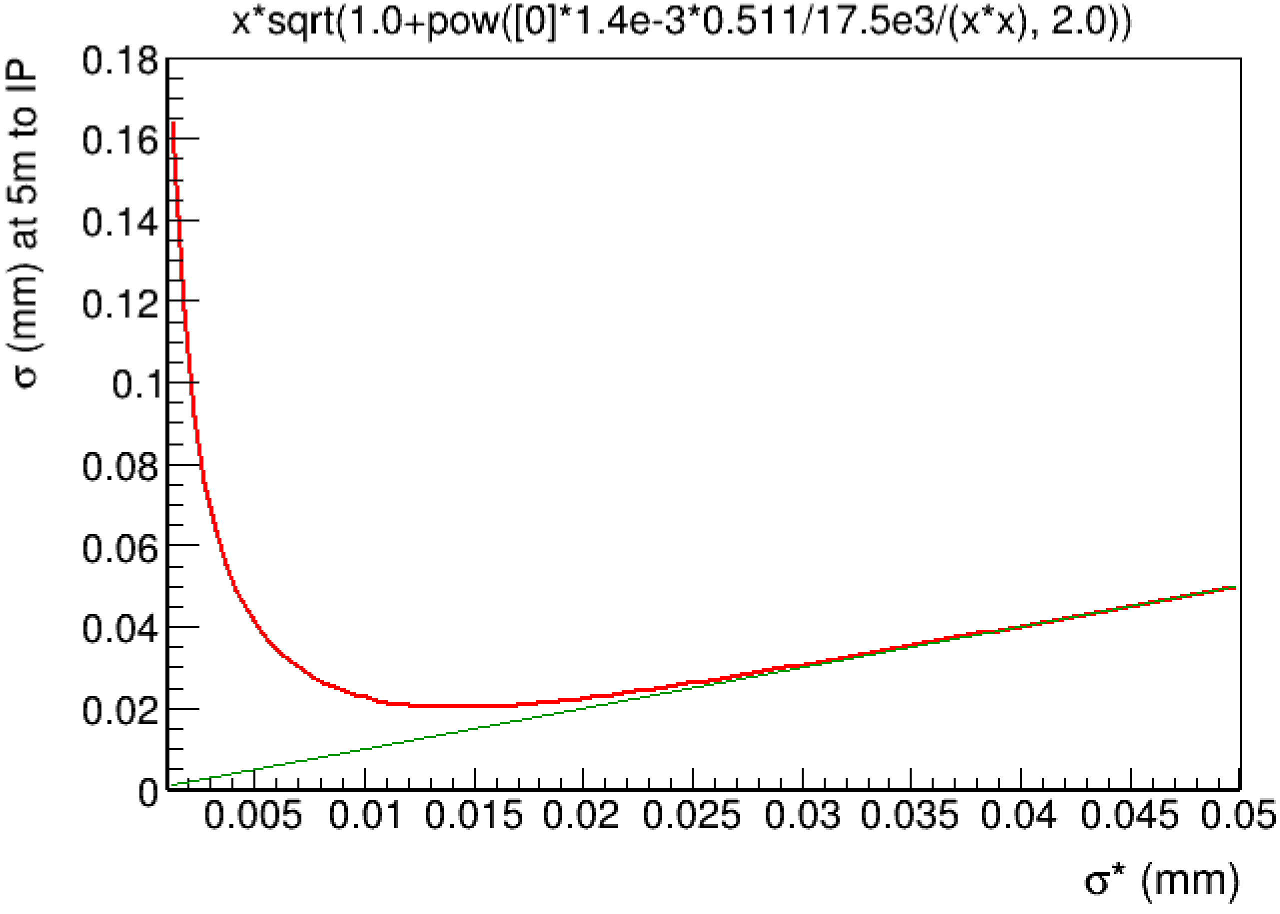
$$\alpha = -\frac{1}{2}\beta'$$

$$\gamma = \frac{1 + \alpha^2}{\beta}$$

Dependence between σ(z) and σ*

$$\sigma(z) = \sigma^* \sqrt{1 + \left(\frac{z\,\varepsilon}{\sigma^{*2}}\right)^2}$$

$$\frac{\sqrt{\langle p_{x,y}^2 \rangle}}{p_z} \frac{z}{\sigma_{x,y}^*}$$



RMS Quantities

We can relate our Twiss Parameters for the beam to RMS quantities, as well:

$$\beta = \frac{u_{\mathrm{RMS}}^2}{\varepsilon_{\mathrm{RMS}}}$$

$$\gamma = \frac{u'^2_{\mathrm{RMS}}}{\varepsilon_{\mathrm{RMS}}}$$

$$\alpha = \frac{-(uu')_{RMS}}{\varepsilon_{\mathrm{RMS}}}$$

Beam Ellipse in Phase Space: