Shifting the Position of Focal Point of Proton Beam Relative to Intersection Point with Fixed Emittance for IDS120h Configuration

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Target Studies

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Optimized Target Parameters and Meson Production at 8 GeV and Emittance of 5 μm (HG Jet and Focal point at z = -37.5 cm)

Transverse Emittance (μm)	5
Target radius (cm)	0.548
Beam radius (cm)	0.15
Crossing Angle (mrad)	26.5
Beam angle (mrad)	127
Jet angle (mrad)	153.5
Meson production (400000 protons)	121697

Procedures

(1) Initial focal point at z = -37.5 cm:

$\alpha^* = 0$, β^*, σ^*, $(\sigma^*)^2/\beta^* = 5\ \mu m$

(2) Assuming a new position of focal point having the same $\alpha^* = 0$, β^*, σ^* in step (1) and a distance of L relative to z = -37.5 cm, then we can estimate the Twiss parameters at z = -37.5 from $\alpha = L/\beta^*$, $\beta = \beta^* + L^2/\beta^*$, $\sigma = \sigma^* \mathrm{sqrt}(1+L^2/\beta^{*2})$.
In other words, we can get our desired alpha at z = -37.5 cm by shifting the position of focal point relative to the intersection point.

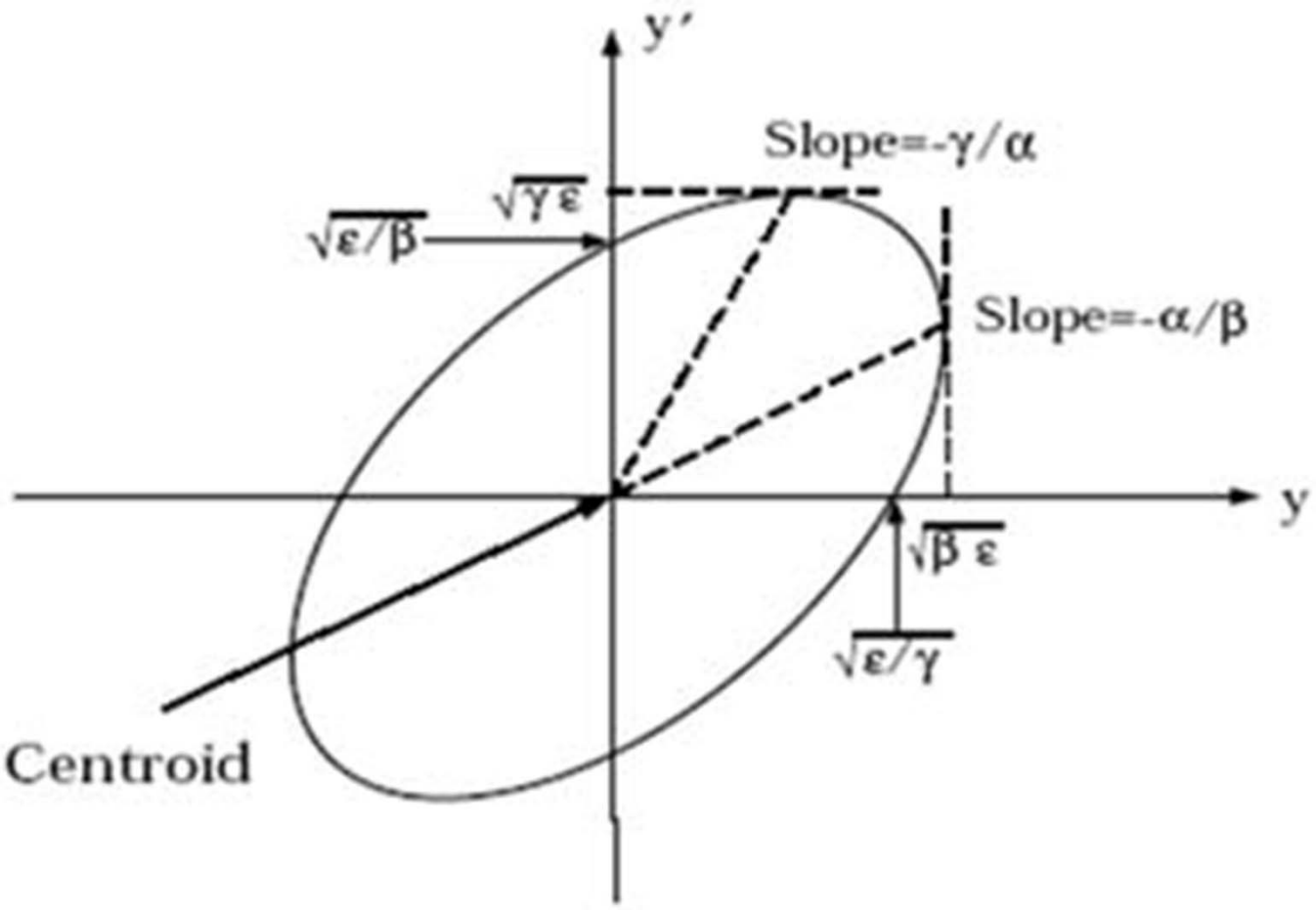
Procedures (Cont'd)

(3) Track the beam, with the estimated Twiss parameters at z = -37.5 cm without the HG target in the IDS120h configuration, back to find the launched-beam distribution at z = -200 cm.

(4) Launch the beam at z = -200 cm (without HG target) to find the beam distribution at different planes in z, and calculate the corresponding Twiss parameters in each plane.

We can also study the meson production by adding back the HG target.

Courant-Snyder Invariant



Emittance (rms) and Twiss Parameters

$$\varepsilon_{rms,x} = \sqrt{\langle x^2 \rangle \langle x'^2 \rangle - \langle xx' \rangle^2}$$

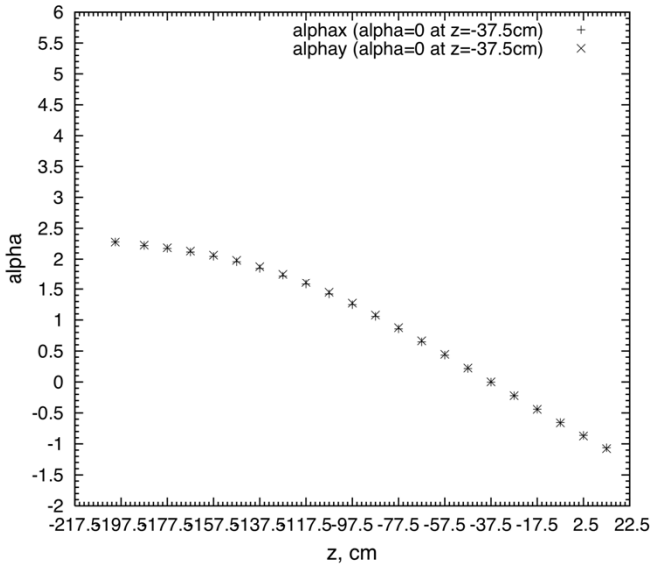
$$\alpha_x = -\frac{\langle xx' \rangle}{\varepsilon_{rms,x}}$$

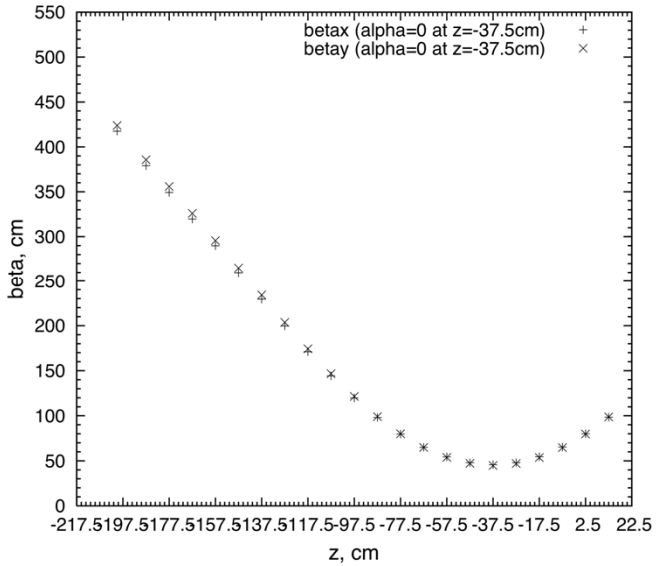
$$\beta_x = \frac{\langle x^2 \rangle}{\varepsilon_{rms,x}}$$

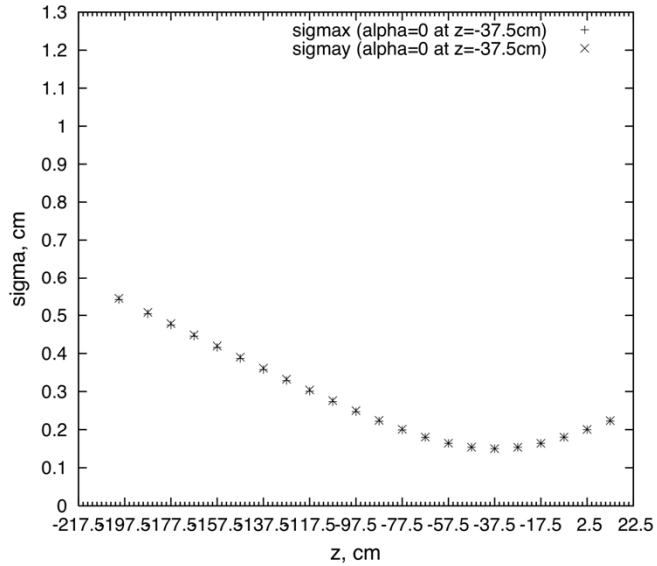
$$\gamma_x = \frac{\langle x'^2 \rangle}{\varepsilon_{rms,x}}$$

$$\beta_x \gamma_x - \alpha_x^2 = 1$$

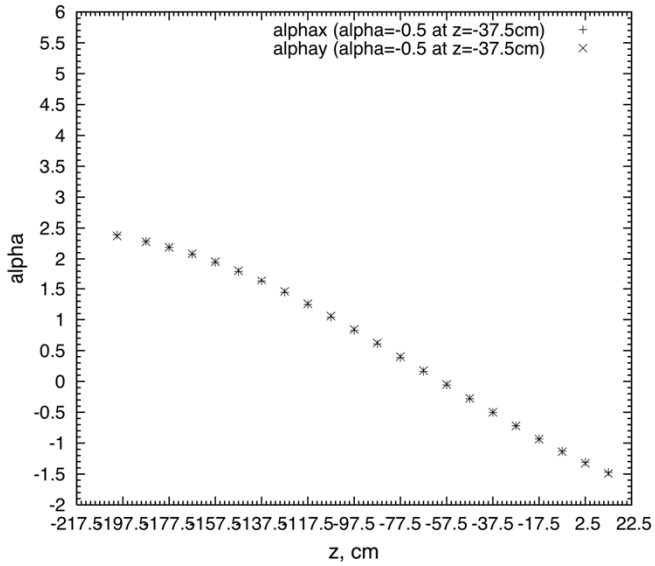
Shifting the Focal Point
(α = 0 at z = -37.5 cm)

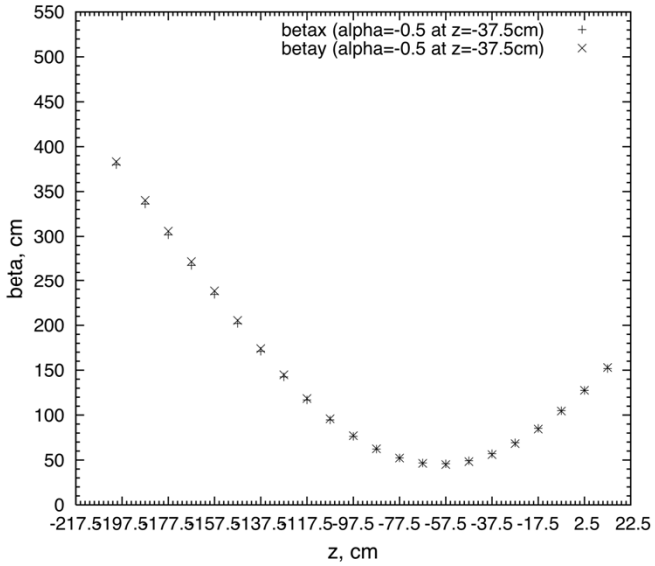


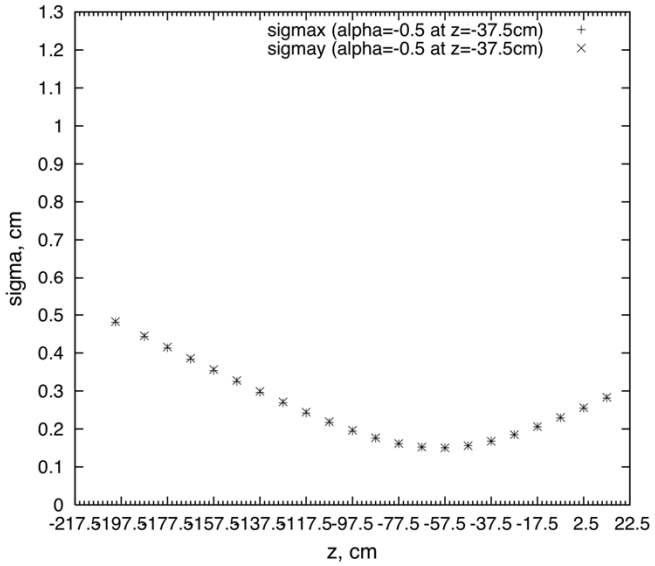




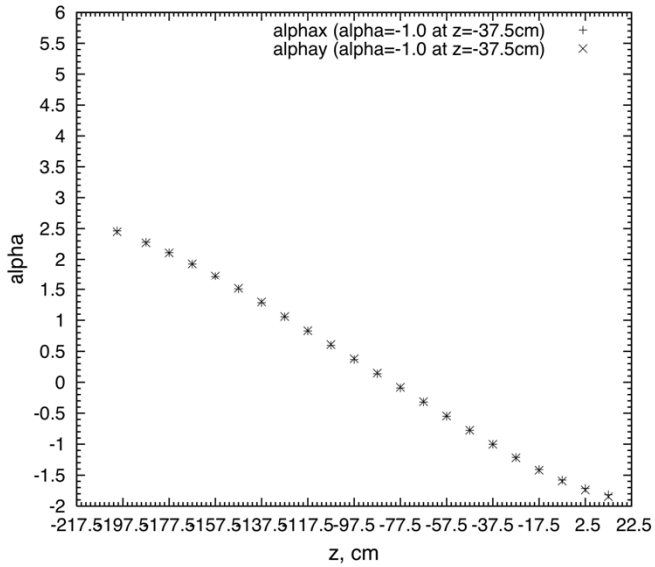
Shifting the Focal Point
(α = -0.5 at z = -37.5 cm)

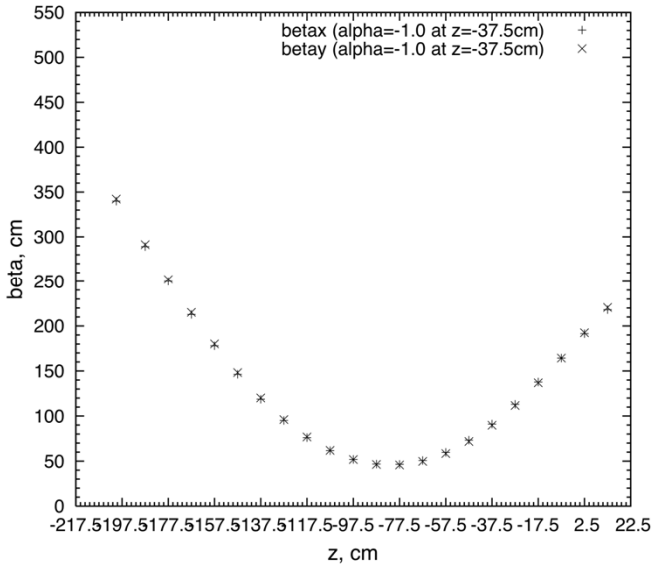


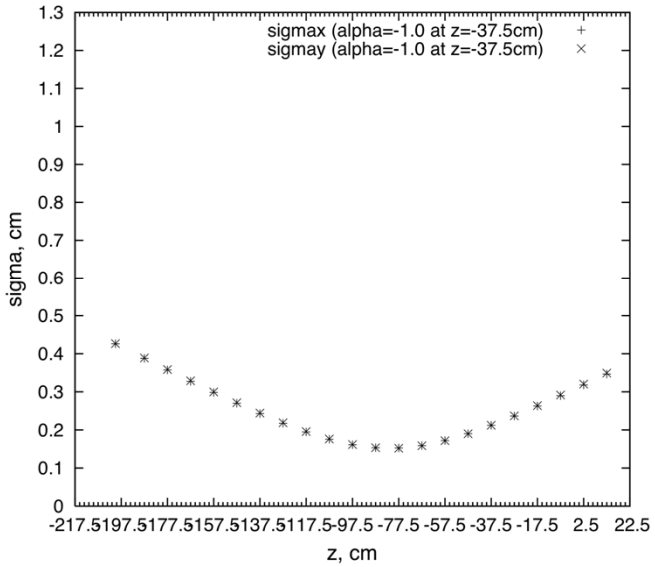




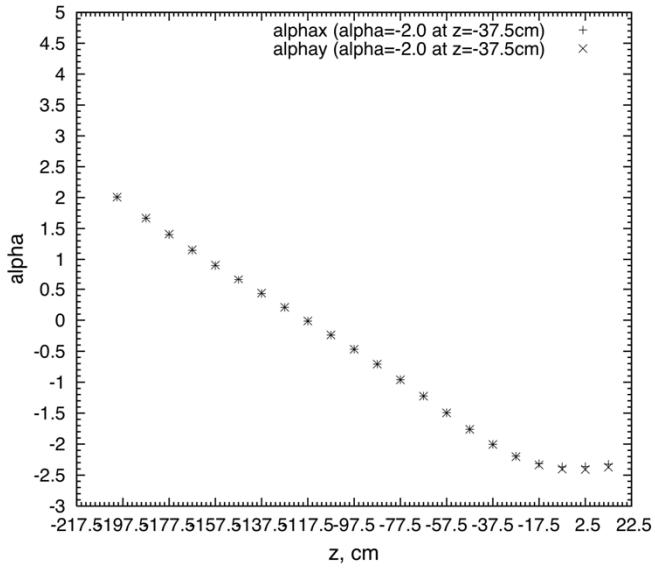
Shifting the Focal Point
(α = -1.0 at z = -37.5 cm)

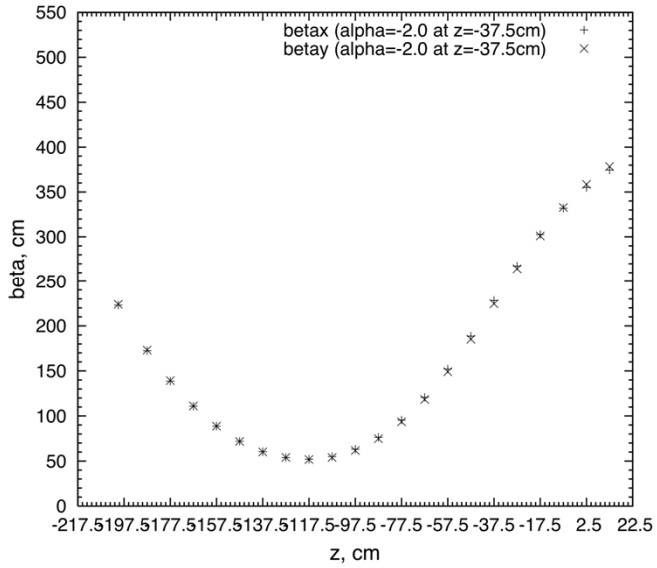


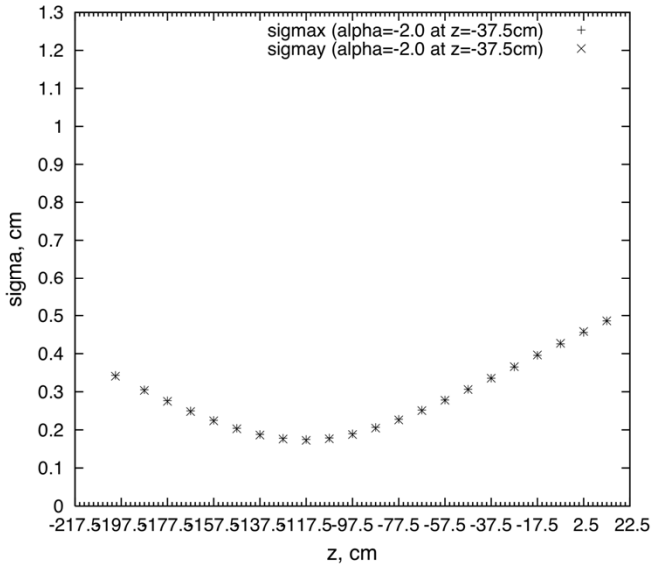




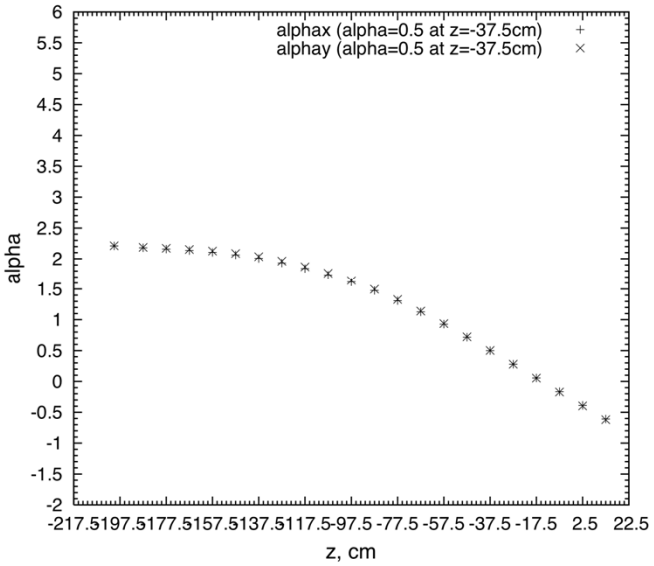
Shifting the Focal Point
(α = -2.0 at z = -37.5 cm)

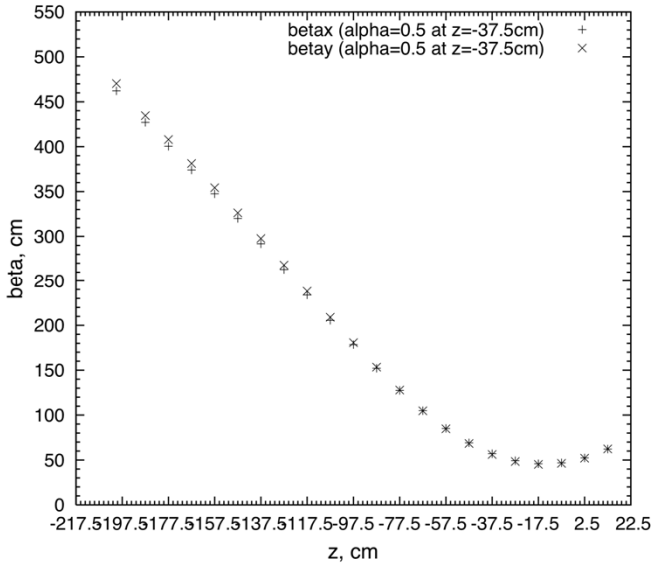


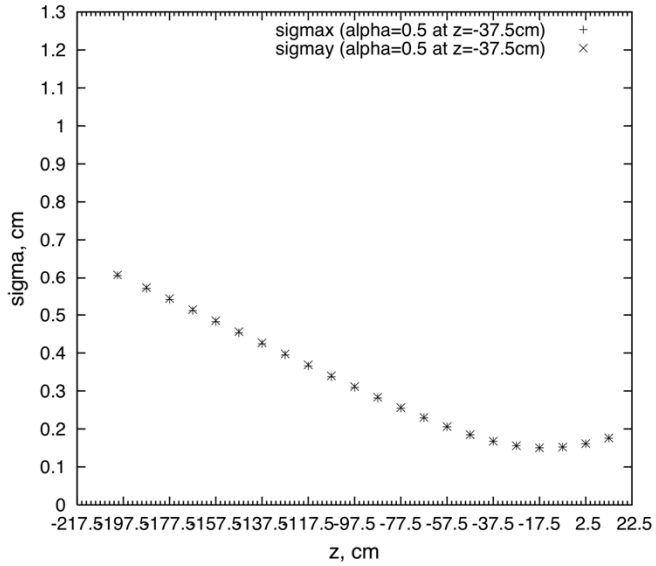




Shifting the Focal Point
(α = 0.5 at z = -37.5 cm)







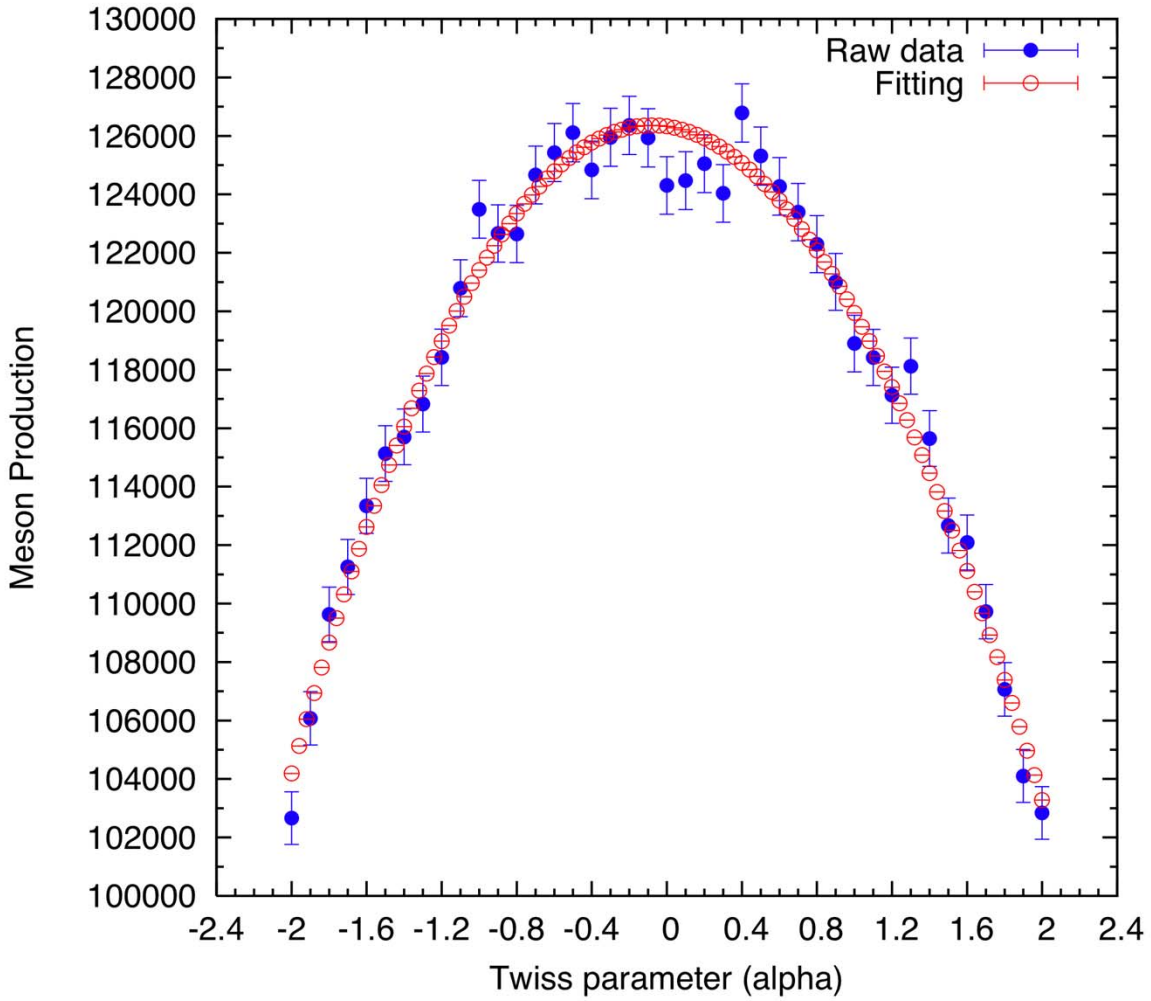
No focal point below z = -37.5 cm

Estimating the Focal Point

Setting α at z =- 37.5 cm	Expected (actual) position of the focal point in units of cm (α = 0)
0	-37.5 (-37.5)
-0.5	-37.5-0.5*46 = -60.5 (-60.5)
-1.0	-37.5-1.0*46 = -83.5 (-81.5)
-1.5	-37.5-1.5*46 = -106.5 (-101)
-2.0	-37.5-2.0*46 = -129.5 (-117.5)
0.5	-37.5+0.5*46 = -14.5
1.0	-37.5+1.0*46 = 8.5

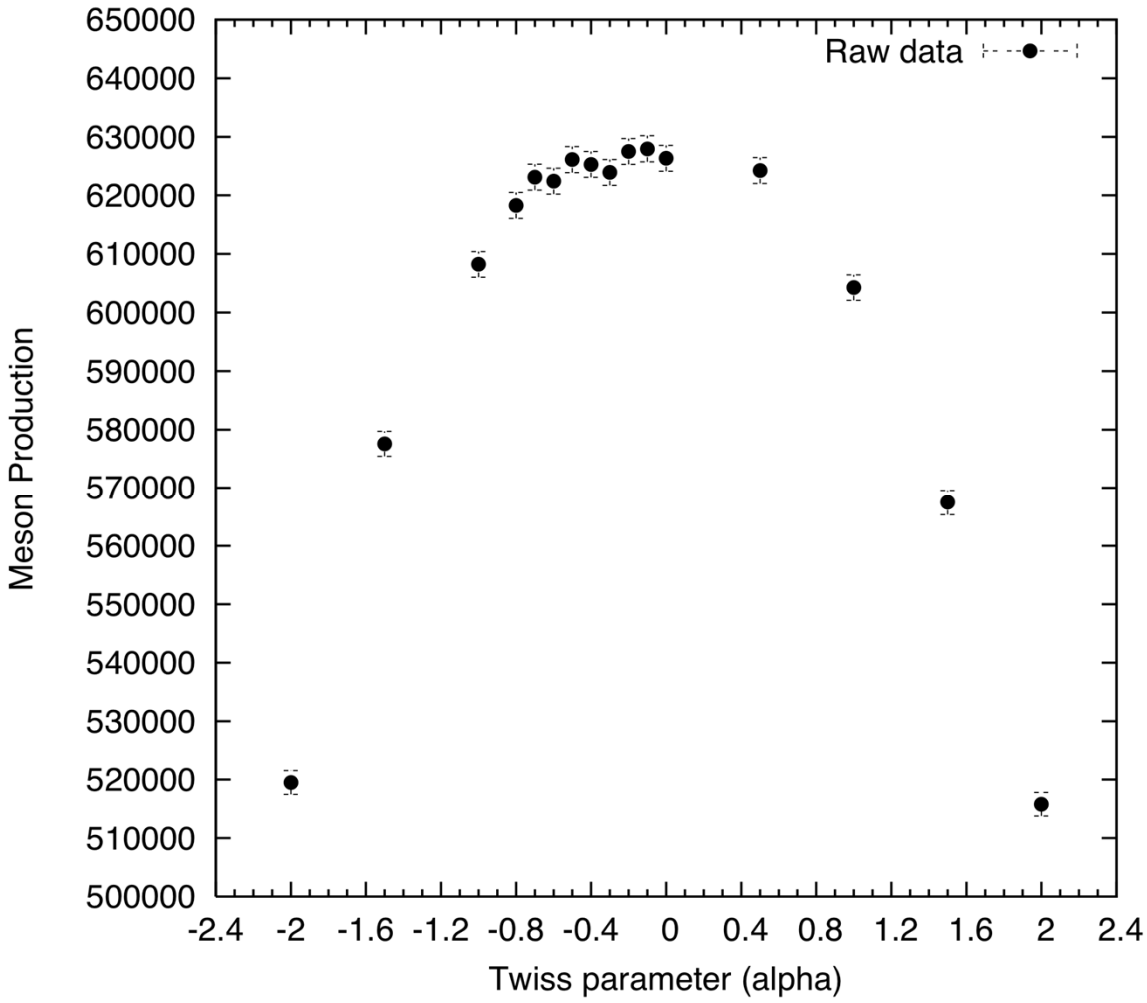
Meson Production as a function of α at z = -37.5 cm

(400000 events)



Meson Production as a function of α at z =-37.5 cm

(2000000 events)



Do we need to shift the focal point away from z =-37.5 cm ?

It seems Not.