Optimized Target Parameters and Meson Production by IDS120h with Focused Gaussian Beam and Fixed Emittance (Update)

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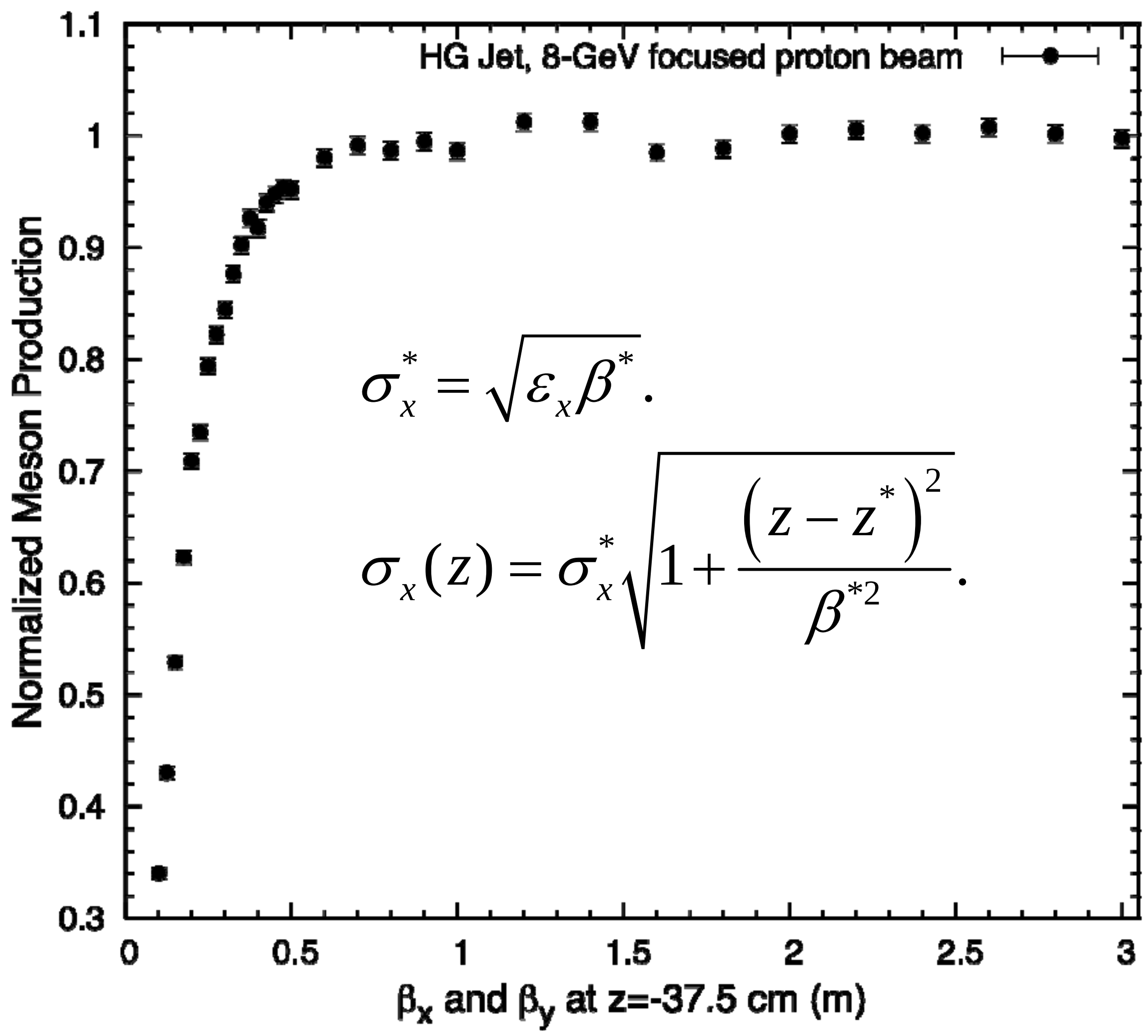
Optimized Target Parameters and Meson Productions at 8 GeV (Non-Focused Gaussian beam, Zero emittance)

Target Jet	HG	GA
Emittance/ μ m	0	0
Beam radius/cm	0.404	0.44
Target radius/cm (Fixed at 30% of beam radius)	0.1212	0.132
Crossing angle between beam and Jet at z=-37.5 cm/mrad	20.6	13
Beam angle at z=-37.5 cm/mrad	117	88
Jet angle at z=-37.5 cm/mrad	137.6	101
Meson Production (400000 protons)	130254	113297

Focused Incident Proton Beam at 8 GeV

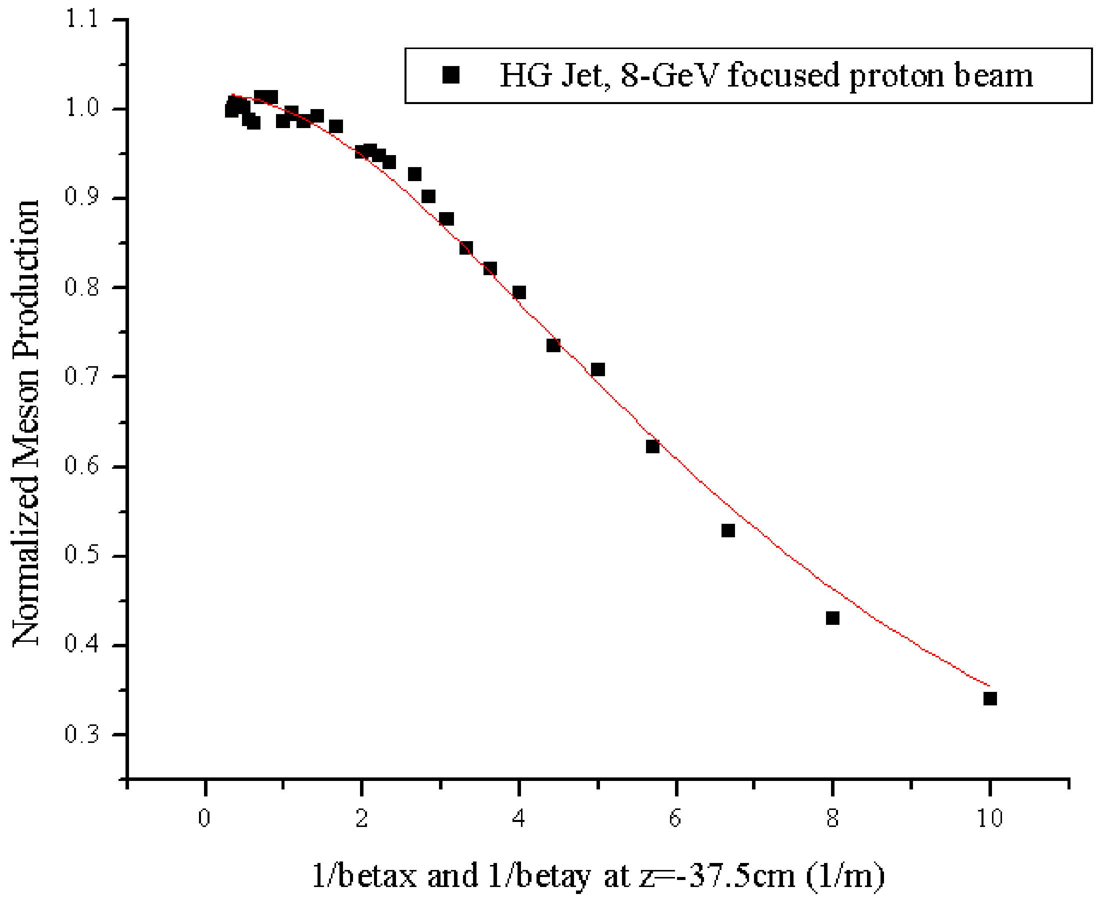
(Beam radius is fixed at 0.12 cm at z=-37.5 cm)



Relative normalized meson production is 0.84 of max at β^* of 0.3 m for $\varepsilon_x = \varepsilon_y = 5\ \mu$m.

For low β^* (tight focus) the beam is large at the beginning and end of the interaction region, and becomes larger than the target there.

Focused Incident Proton Beam at 8 GeV (Cont'd) (Beam radius is fixed at 0.12 cm at z=-37.5 cm)



Non-Linear Fit
(Growth/sigmoidal, Hill)

$Y=N/(1+K2/beta^{-2})$
N=1.018
Sqrt(K2)=0.1368

Linear emittance is 5 μ m with beam radius of 0.1212 cm and β * of 0.3 m.

Gaussian distribution
(Probability density)

- In two dimensional phase space (u,v):

$$w(u,v) = \frac{1}{2\pi\sigma^2}\exp\left(-\frac{u^2+v^2}{2\sigma^2}\right)$$

where u-transverse coordinate (either x or y),
v = α u+ β u′

α , β are the Courant-Snyder parameters at the given point along the reference trajectory.

In polar coordinates (r, θ):
u = r cos θ v = r sin θ
u′= (v- α u)/ β =(r sin θ - α u)/ β

Distribution function method

$$\theta = 2\pi\xi_1, \qquad \theta \in [0, 2\pi]$$

$$r = \sqrt{-2\sigma^2 \ln \xi_2}, \quad r \in [0, \infty]$$

Random number generator:

Θ = 2 π *rndm(-1)
R = sqrt(-2*log(rndm(-1))* σ

Setting with focused beam trajectories

- Modeled by the user subroutine BEG1 in m1512.f of MARS code

x_v or x_h (transverse coordinate: u);

x'_v or x'_h (deflection angle: u′)

$XINI = x_0 + x_h$ $DXIN = dcx_0 + x'_h$

$YINI = y_0 + x_v$ $DYIN = dcy_0 + x'_v$

$ZINI = z_0$ $DZIN = sqrt(1-DXIN^2-DYIN^2)$

Twiss parameters based on Formulae (old method)

- Intersection point (z=-37.5 cm):

  $\alpha^* = 0,\ \beta^*,\ \sigma^*$

- Launching point (z=-200 cm):

  L = 200-37.5 = 162.5 cm

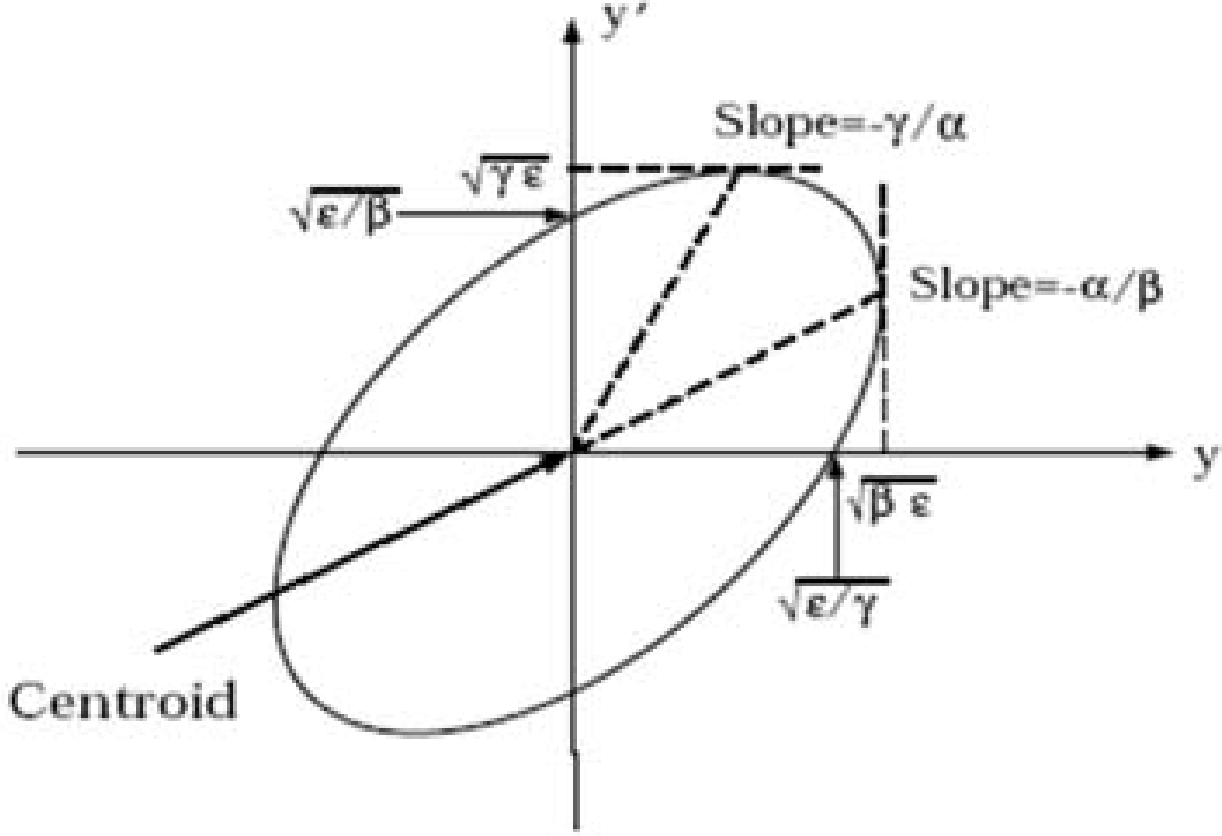
  $\alpha = L/\beta^*$

  $\beta = \beta^* + L^2/\beta^*$

  $\sigma = \sigma^*\mathrm{sqrt}(1+L^2/\beta^{*2})$

These relations strictly true only for zero magnetic field.

Courant-Snyder Invariant



Emittance (rms) and Twiss Parameters

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

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

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

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

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

Twiss parameters based on backtrack (new method)

- Effect of Solenoid Field

  1. Backtrack particles from z = -37.5 cm to z = - 200 cm.

  2. Using the particle coordinates and momentums at Z=-200 cm to calculate the α, β, σ at z = -200 cm.

Optimization Procedures
(Focused Beam and Fixed Beam Emittance)

Optimization method in each cycle

(1) Vary beam radius σ^*, while vary the β^* at the same time to fix the beam emittance;

(2) Very target radius;

(3) Vary beam/jet crossing angle;

(4) Rotate beam and jet at the same time to keep the crossing angle same.

Optimized Target Parameters and Meson Productions at 8 GeV and Different Emittance (HG Jet Case)

Emittance/ μ m	2.5 (old method)	2.5 (new method) (1st Run)
Beam radius/cm	0.135	0.148
Target radius/cm	0.47	0.494
Crossing Angle/mrad	23	25.2
Beam angle/mrad	118	118
Jet angle/mrad	141	143.2
Meson production (400000 protons)	125991	124255

Optimized Target Parameters and Meson Productions at 8 GeV and Different Emittance (HG Jet Case)

Emittance/ μ m	5 (old method)	5 (new method) (1st Run)
Beam radius/cm	0.15	0.195
Target radius/cm	0.548	0.605
Crossing Angle/mrad	26.5	30.6
Beam angle/mrad	127	127
Jet angle/mrad	153.5	157.6
Meson production (400000 protons)	121696	116523

Optimized Target Parameters and Meson Productions at 8 GeV and Different Emittance (HG Jet Case)

Emittance/ μ m:q	7.5 (old method)	7.5 (new method) (1st Run)
Beam radius/cm	0.2025	0.2424
Target radius/cm	0.60	0.66
Crossing Angle/mrad	29.3	34.1
Beam angle/mrad	131	126
Jet angle/mrad	160.3	160.1
Meson production (400000 protons)	115760	109916

Optimized Target Parameters and Meson Productions at 8 GeV and Different Emittance (HG Jet Case)

Emittance/ μ m	10 (old method)	10 (new method) (1st Run)
Beam radius/cm	0.2325	0.274
Target radius/cm	0.65	0.70
Crossing Angle/mrad	32	37.3
Beam angle/mrad	135	127
Jet angle/mrad	167	164.3
Meson production (400000 protons)	113020	105730