

MUON TARGET PARTICLE PRODUCTION STUDY: TAPERED FIELD PROFILE

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Ding's Optimized Parameters

- Hg Target
 - $\theta_{\text{Target}} = 0.137 \text{ rad}$
 - $R_{\text{target}} = 0.404 \text{ cm}$

- Proton Beam
 - $E = 8 \text{ GeV}$
 - $\theta_{\text{Beam}} = 0.117 \text{ rad}$
 - $\sigma_x = \sigma_y = 0.1212 \text{ cm}$ (Gaussian Distribution)

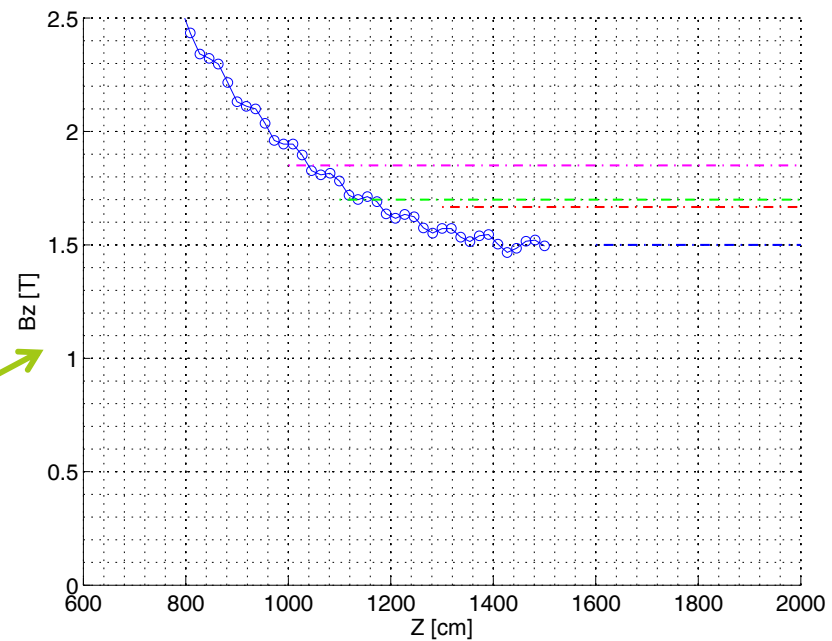
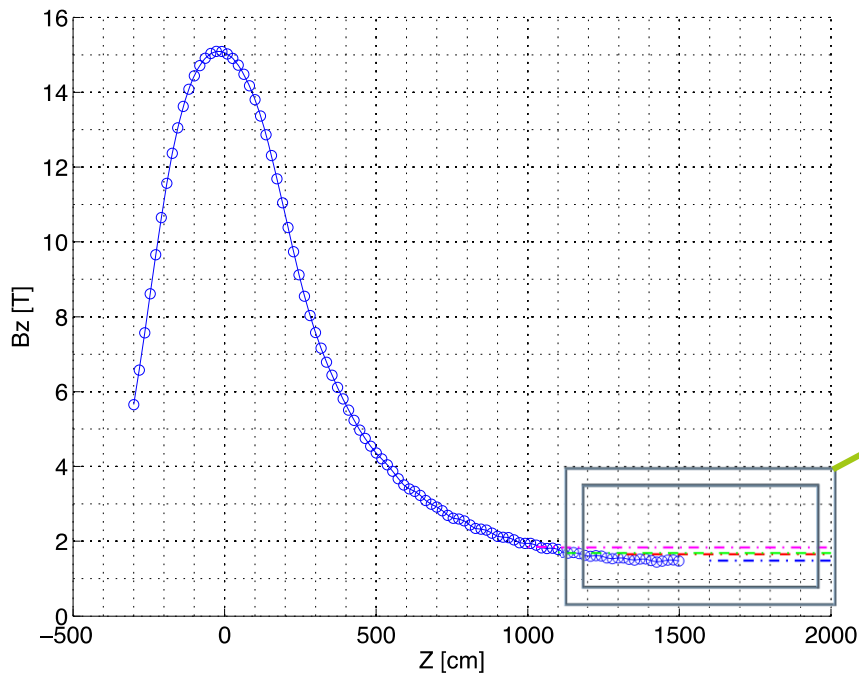
- Solenoid Field
 - IDS120h \rightarrow 20 T peak field at target position ($Z=0$)
 - Aperture at Target $R = 7.5 \text{ cm}$ - End aperture $R = 30 \text{ cm}$
 - Fixed Field $Z = 1862.0 \rightarrow B_z = 1.5 \text{ T}$

- Production: Muons within energy KE cut 40-180 MeV

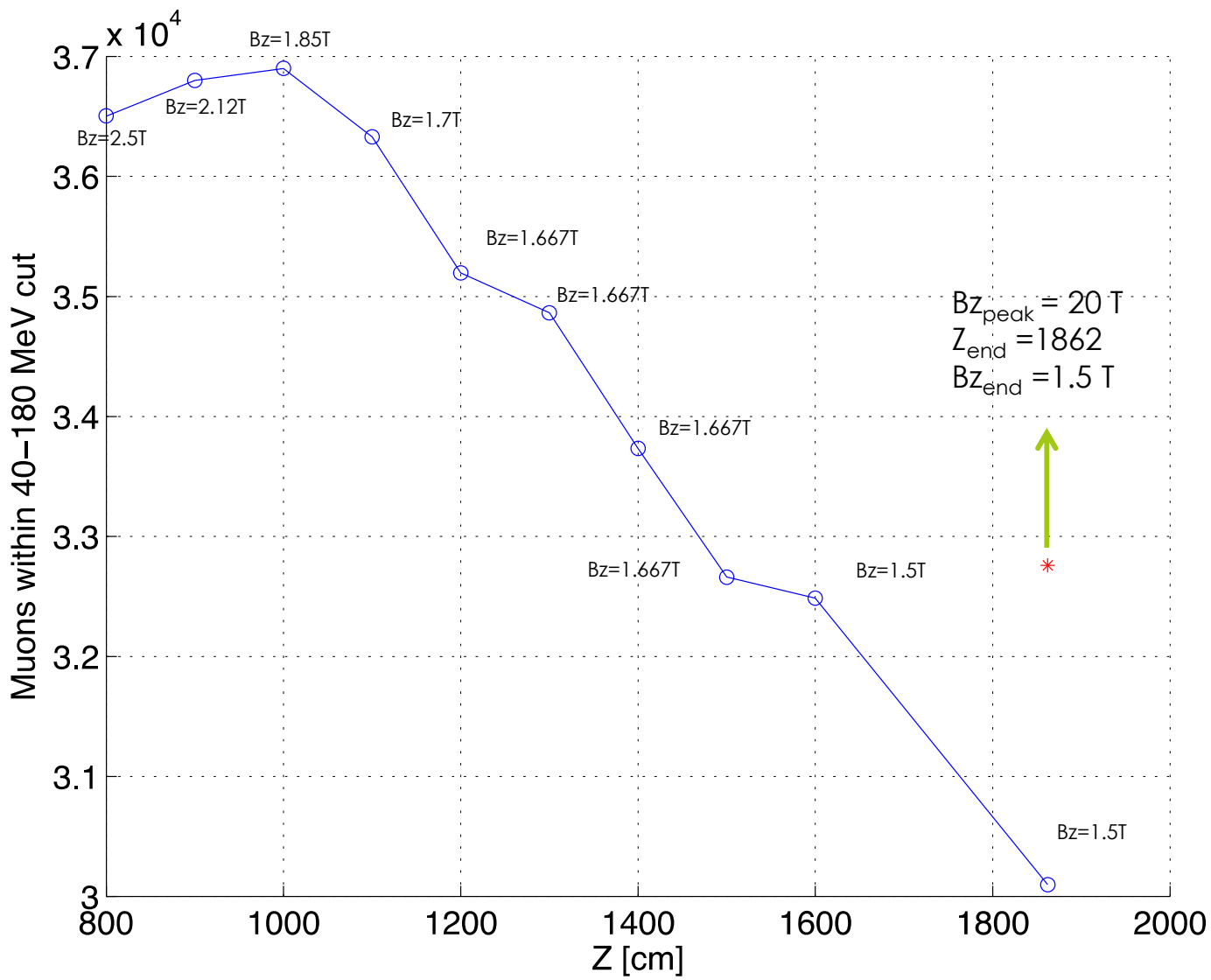
- 3.27×10^4 ($N_{\text{ini}} = 10^5$)

Target Particle Production with 15 T Peak Solenoid Field

- Particle Capture requirement ($P_{\dagger} \sim 0.225 \text{ GeV}/c$)
- $Br = 20 \text{ T} \times 7.5 \text{ cm} = 150 \text{ T cm}$ ----- $Br = 15 \text{ T} \times 10 \text{ cm} = 150 \text{ T cm}$
- Fixed flux requirement (Aperture Requirement)
- $Br^2 = 20 \times 7.5^2 = 1125 \text{ T cm}^2$ ----- $Br^2 = 15 \times 10^2 = 1500 \text{ T cm}^2$
- MARS simulations with 15 T peak field & new aperture settings (Taper R = 10-30 cm)



Muon Production IDS120h 15 T



Analytic form for Tapered Solenoid (K. McDonald)

Inverse-Cubic Taper

$$B_z(0, z_i < z < z_f) = \frac{B_1}{[1 + a_1(z - z_1) + a_2(z - z_1)^2 + a_3(z - z_1)^3]^p}$$

$$a_1 = -\frac{B_1'}{pB_1} \quad a_2 = 3\frac{(B_1/B_2)^{1/p} - 1}{(z_2 - z_1)^2} - \frac{2a_1}{z_2 - z_1}$$

$$a_3 = -2\frac{(B_1/B_2)^{1/p} - 1}{(z_2 - z_1)^3} + \frac{a_1}{(z_2 - z_1)^2}$$

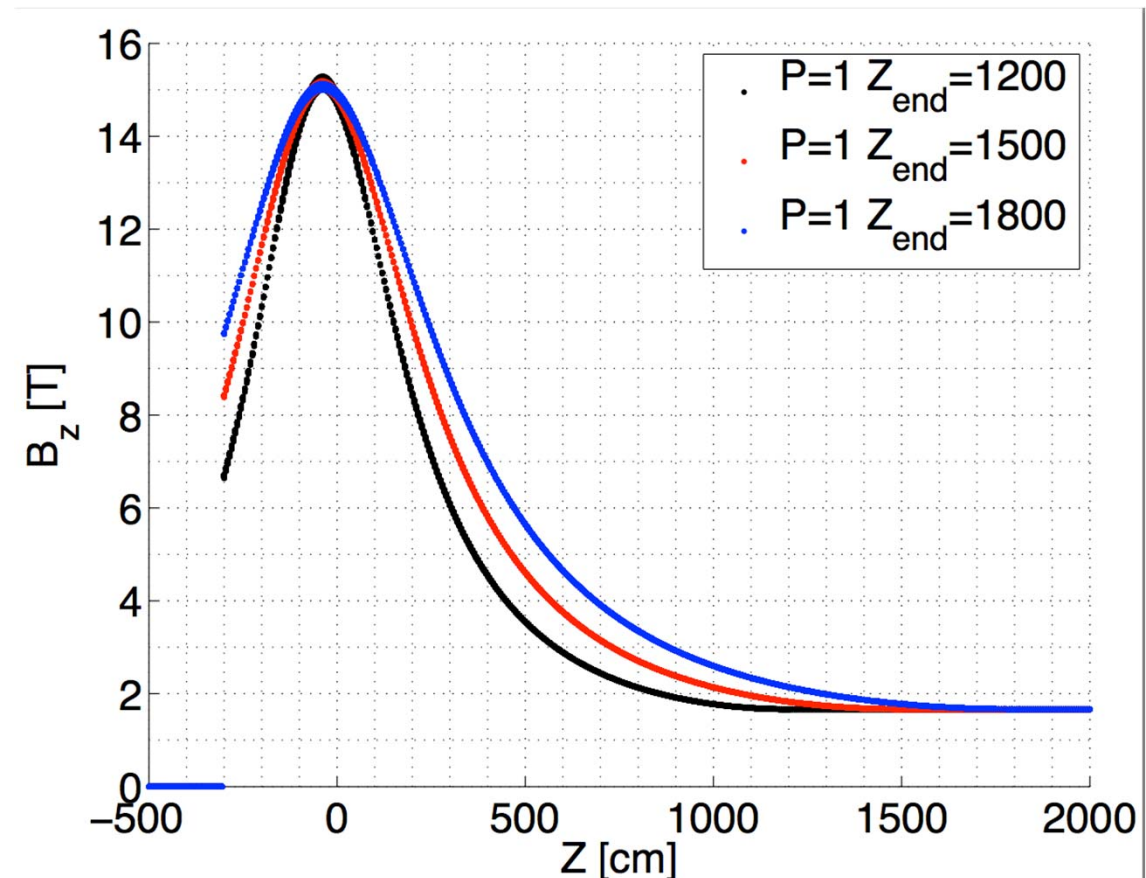
Off-axis field approximation

$$B_z(r, z) = \sum_n (-1)^n \frac{a_0^{(2n)}(z)}{(n!)^2} \left(\frac{r}{2}\right)^{2n}$$

$$B_r(r, z) = \sum_n (-1)^{n+1} \frac{a_0^{(2n+1)}(z)}{(n+1)(n!)^2} \left(\frac{r}{2}\right)^{2n+1}$$

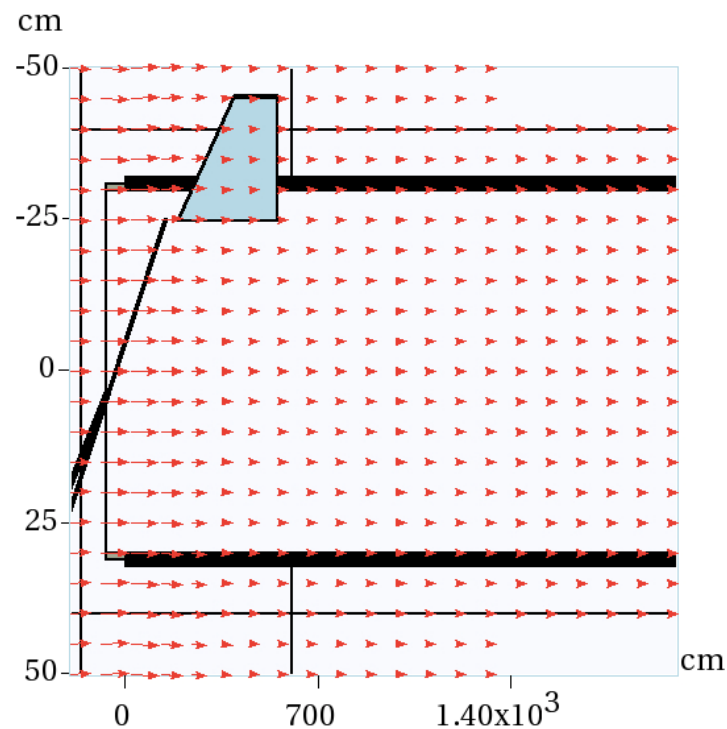
$$a_0^{(n)} = \frac{d^n a_0}{dz^n} = \frac{d^n B_z(0, z)}{dz^n}$$

Field at R=0



MARS RESULTS

- Beam Pipe with constant $R = 30$ cm
- Beam Pipe material changed to blackhole to speed calculations
- Added subroutine to m1510.f (FIELD) to calculate the field using inverse cubic equations



$$\begin{matrix} \vec{z} \\ \vec{y} \end{matrix} \quad y:z = 1:2.200e+01$$

Inverse Cubic Field ($P = 1$)

MARS simulation results:

Counting muons at 50 m with K.E. 80 -140 MeV

