

MUON TARGET PARTICLE PRODUCTION STUDY TAPER FIELD PROFILE

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Ding's Optimized Parameters

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

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

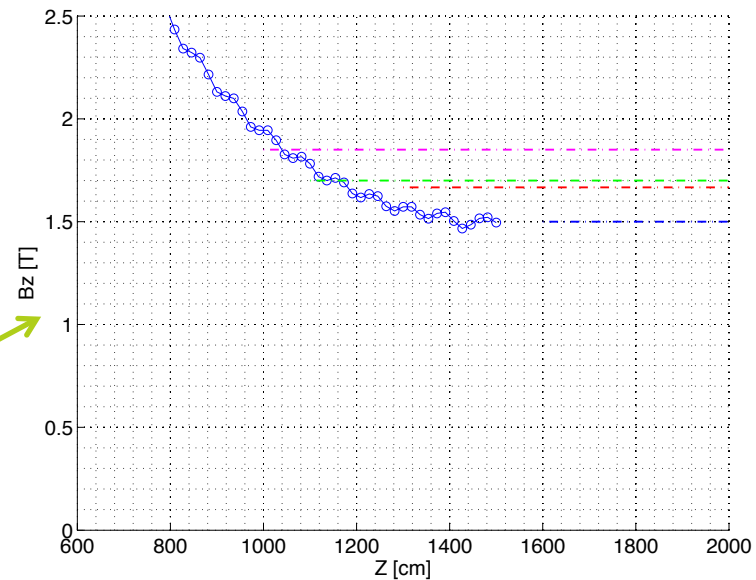
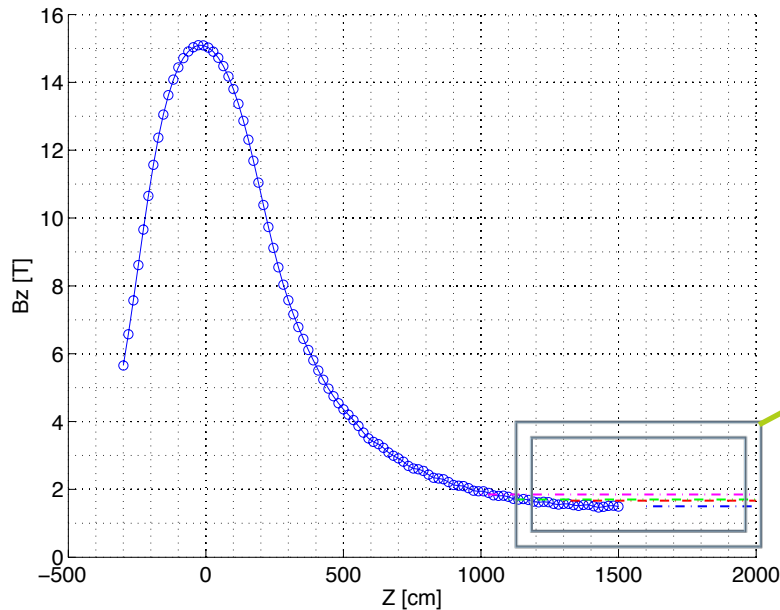
- Solenoid Field
 - IDS120h → 20 T peak field at target position ($Z=0$)
 - Aperture at Target $R=7.5$ cm - End aperture $R = 30$ cm
 - Fixed Field $Z = 1862.0$ → $B_z=1.5$ T

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

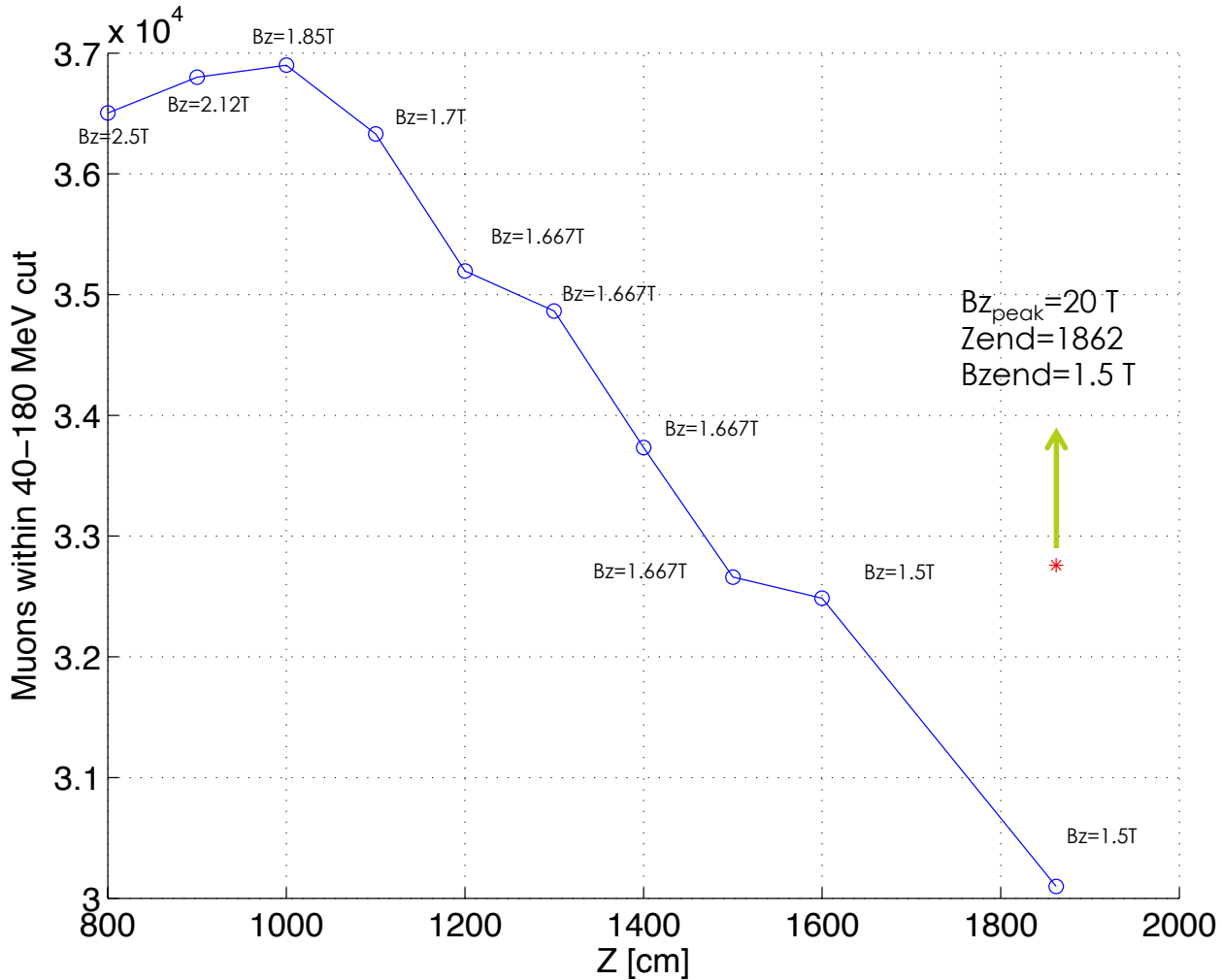
- 3.27×10^4 ($N_{\text{ini}}=10^5$)

Target Particle Production with 15 T Peak Solenoid Field

- Particle Capture requirement ($P_{\dagger} \sim 0.225 \text{ GeV}/c$)
- $Br = 20 \text{ T} \times \mathbf{7.5} \text{ cm} = 150 \text{ T cm}$ ----- $Br = 15 \text{ T} \times \mathbf{10} \text{ cm} = 150 \text{ T cm}$
- 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 ($R_{\text{taper}} = 10\text{-}30 \text{ cm}$)



Muon Production IDS120h 15 T



Analytic form for Tapered Solenoid (K. McDonald)

Inverse-Cubic Taper

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

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

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

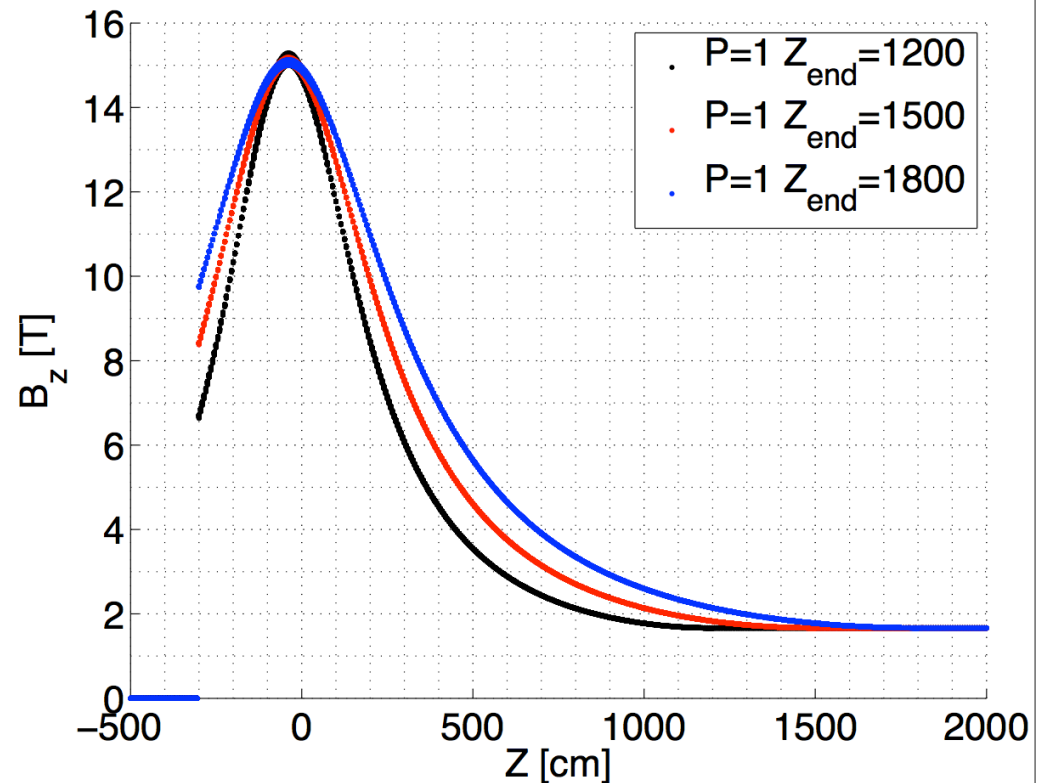
Off-axis field approximation

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

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

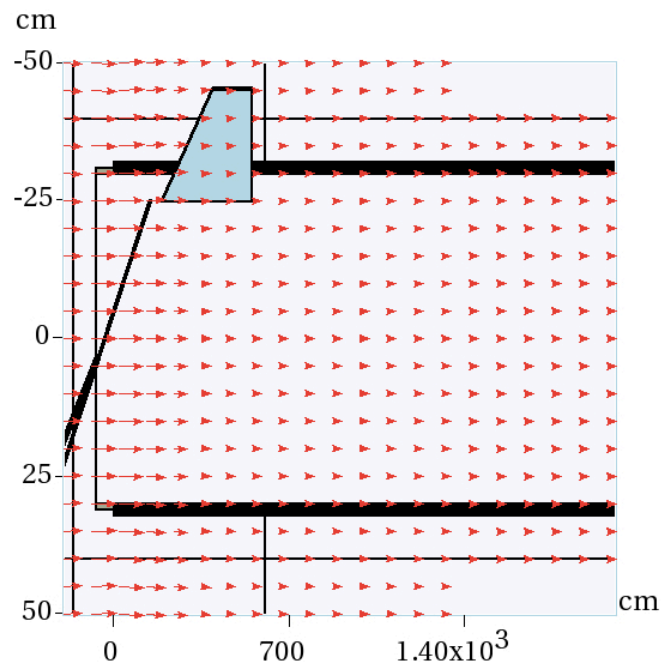
$$a_0^{(n)} = \frac{d^n a_0}{dz^n} = \frac{d^n B_z(0, z)}{dz^n}$$

Field at R=0



MARS RESULTS

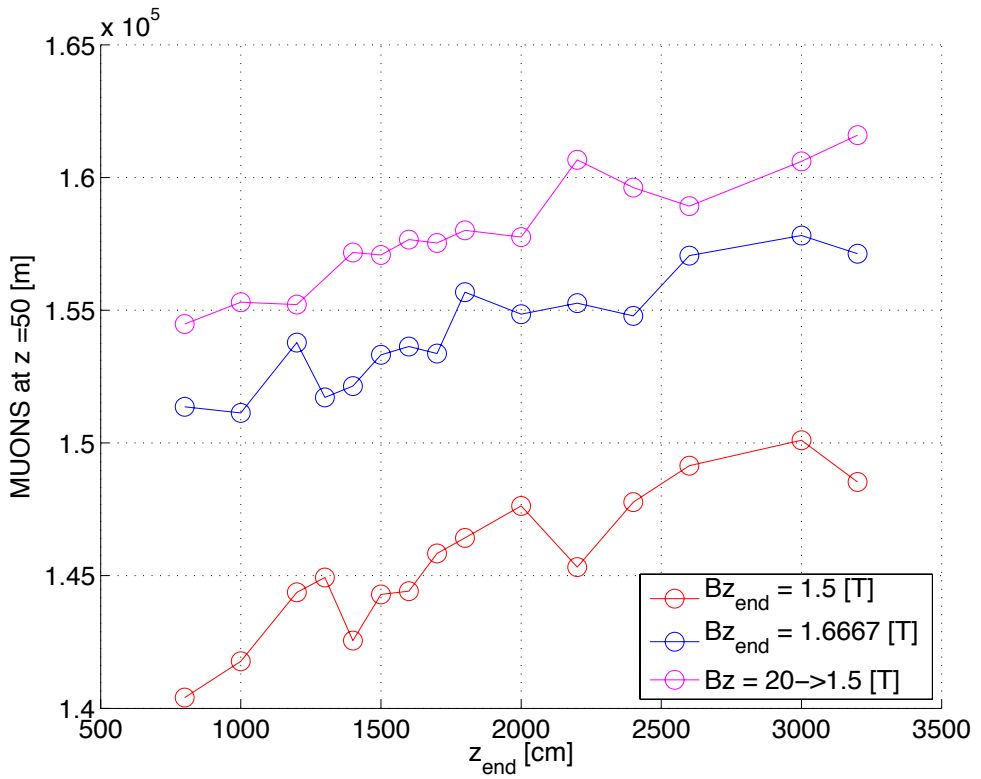
- Beam Pipe with constant $R=30$ cm
- Beam Pipe material changed to balckhole to speed calculations
- Added subroutine to m1510.f (FIELD) to calculate the field using inverse cubic equations



\vec{y} \vec{z}
y:z = 1:2.200e+01

Inverse Cubic Field (P=1)

Initial $N_p = 4 \times 10^5$



Tracking Through Phase Rotation & Cooling Sections

- MARS output at $z=0$
- ICOOL-IDS front end baseline lattice (2010-04-0)

Case	Good particles
Bz 20 \rightarrow 1.5 [T]	1910
Bz 15 \rightarrow 1.5 [T]	1595
Bz 15 \rightarrow 1.667 [T]	1637