MUON TARGET PARTICLE PRODUCTION STUDY:
15-1.5T TAPERED FIELD PROFILE

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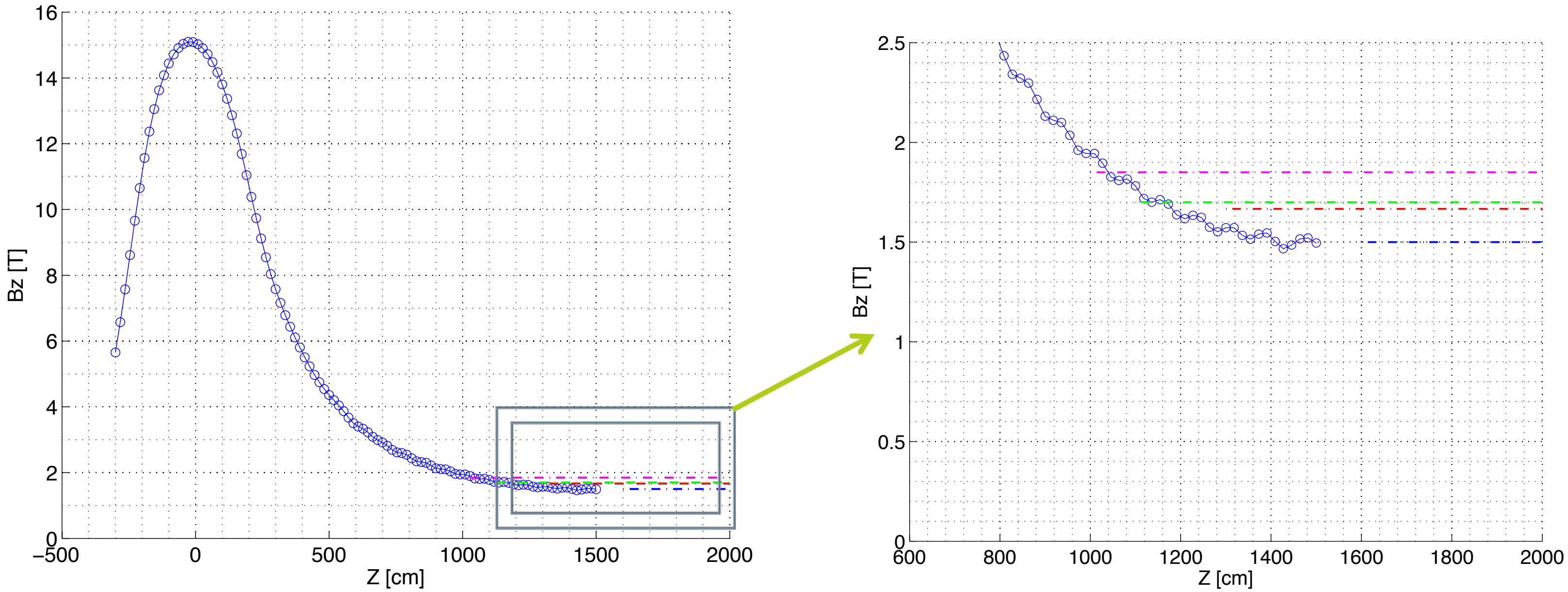
Ding's Optimized Parameters

- Hg Target
  - θ_{Target}=0.137 rad
  - R_{Target}=0.404 cm
- Proton Beam
  - E=8 GeV
  - θ_{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 → Bz=1.5 T

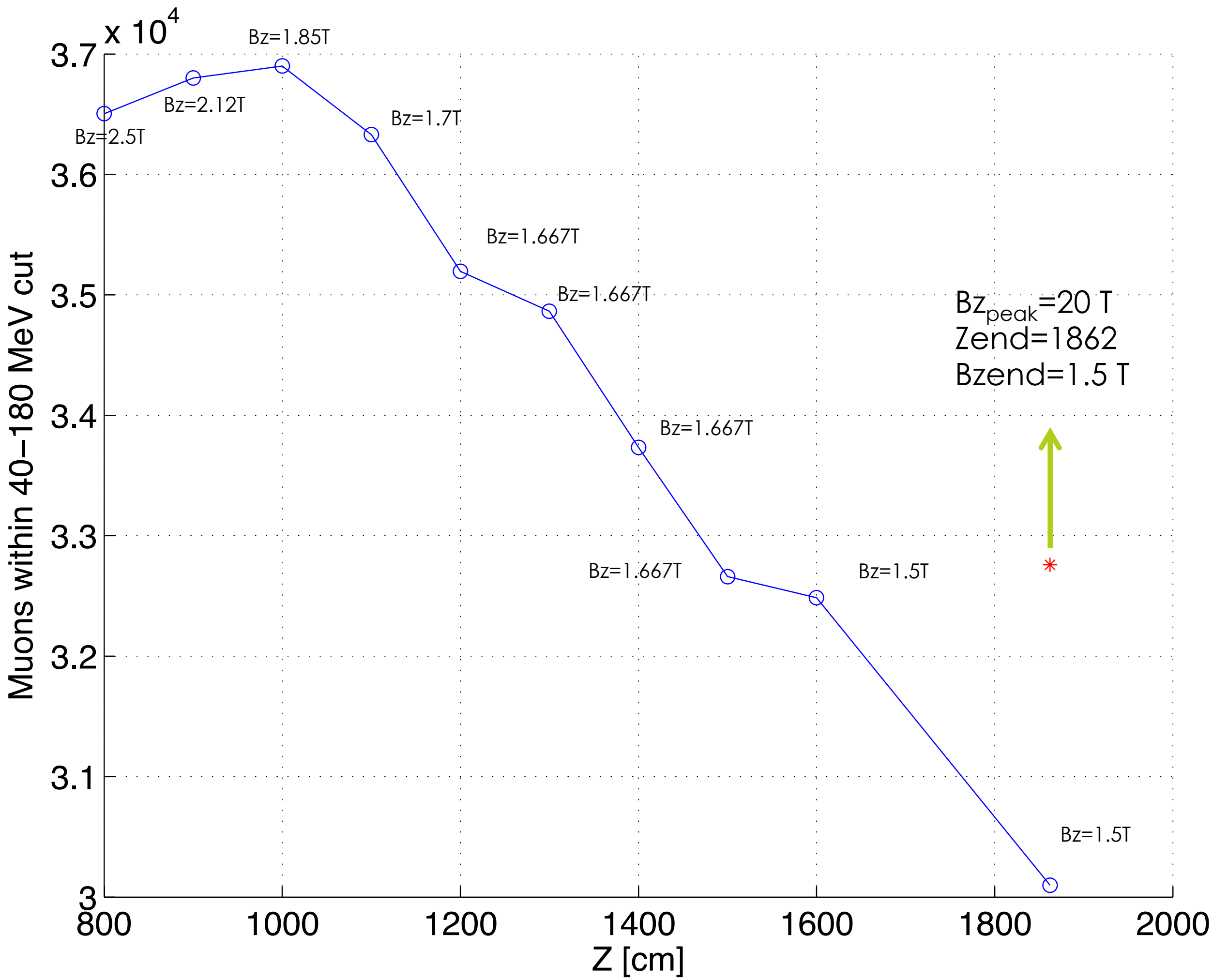
- Production: Muons within energy KE cut 40-180 MeV
- 3.27×10^4 ($N_{ini}=10^5$)

Target Particle Production with 15 T Peak Solenoid Field

- Particle Capture requirement (P_t ~ 0.225 GeV/c)
- Br = 20 T X **7.5** cm = 150 T cm ----- Br = 15 T X **10** cm = 150 T cm
- Fixed flux requirement (Aperture Requirement)
- $Br^2 = 20 \times 7.5^2 = 1125$ T cm^2 ------ $Br^2 = 15 \times 10^2 = 1500$ 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

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

$$a1 = -\frac{B_1^{'}}{pB_1} \qquad a_2 = 3\frac{(B_1/B_2)^{1/p} - 1}{(z_2 - z_1)^2} - \frac{2a_1}{z_2 - z_1}$$

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

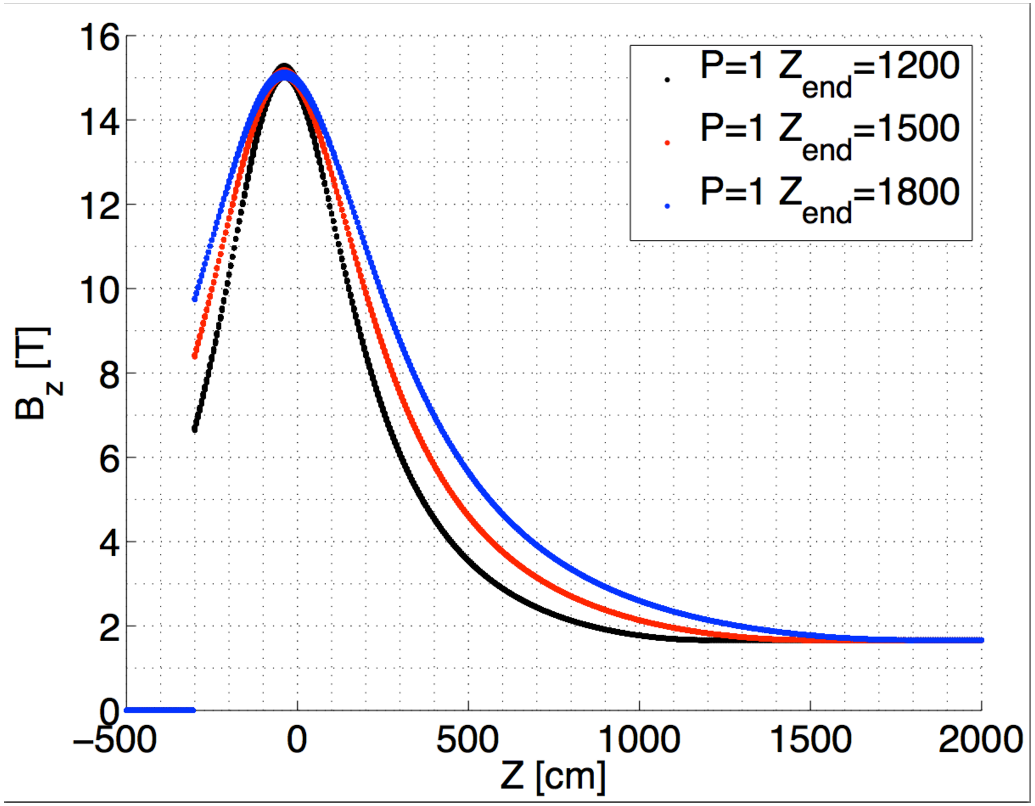
Off-axis field approximation

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

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

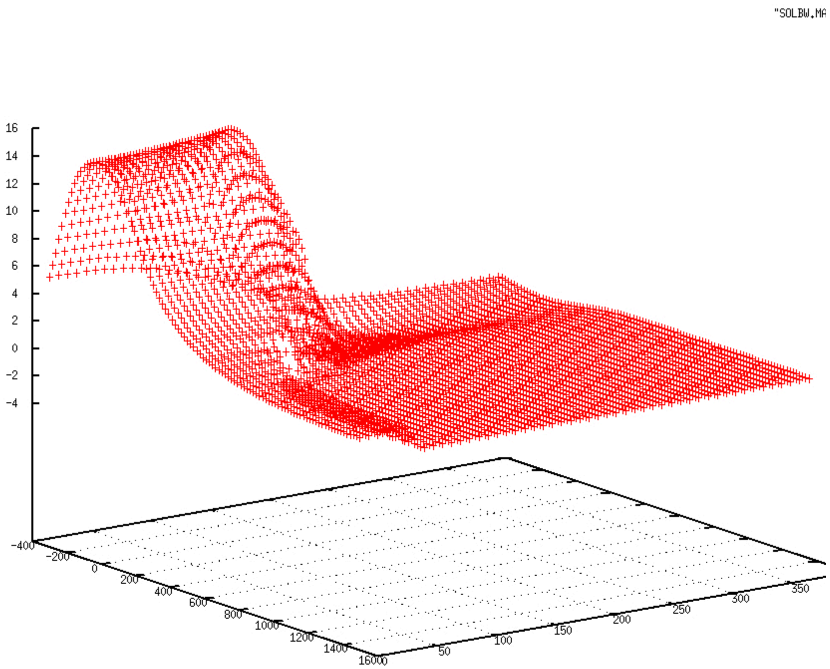
$$a_0^{(n)} = \frac{d^n a_0}{dz^n} = \frac{d^n B_z(0,z)}{dz^n}$$

Field at R=0

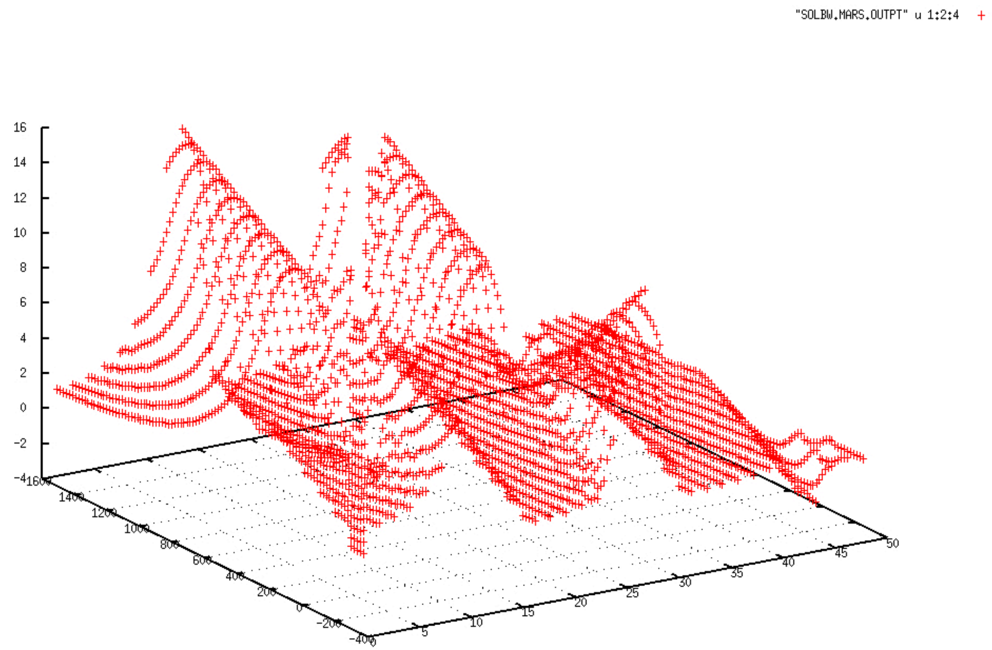


IDS120H Field Map

IDS120H Input Field Map



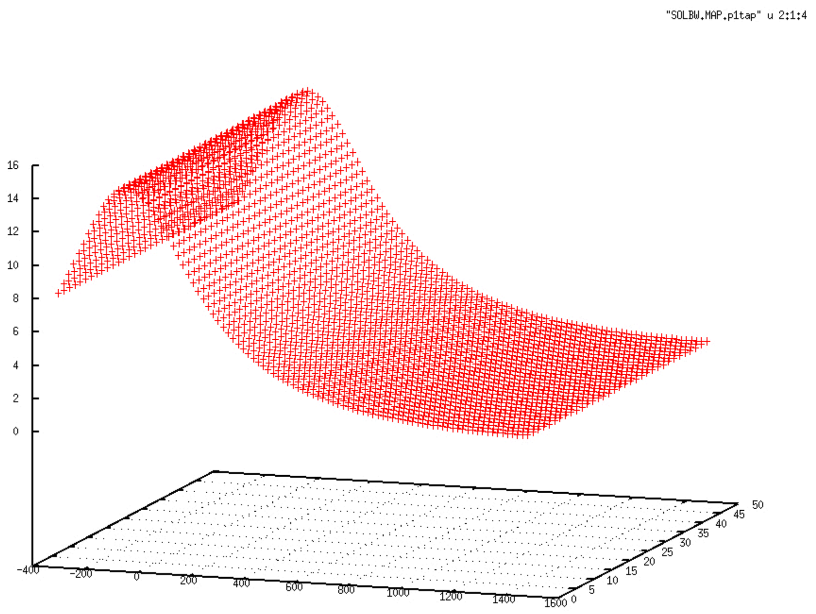
IDS120H MARS FIT2D Output Field Map



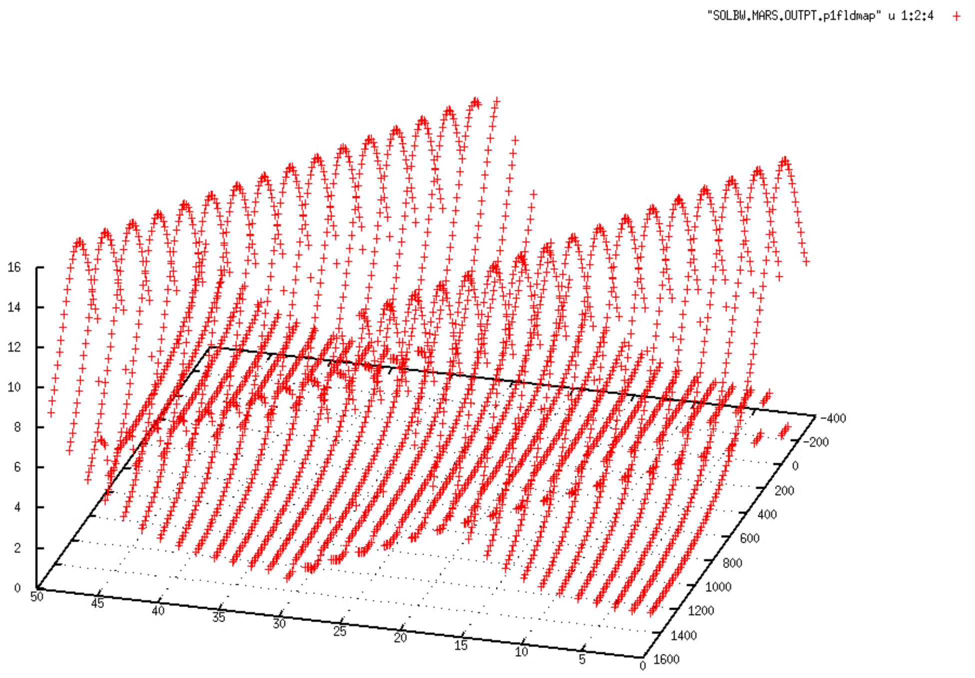
In case MARS reads field map up to R=50 [cm]

INVERSE CUBIC Fit (ICP1) FIELD MAP

ICP1 Input Field Map

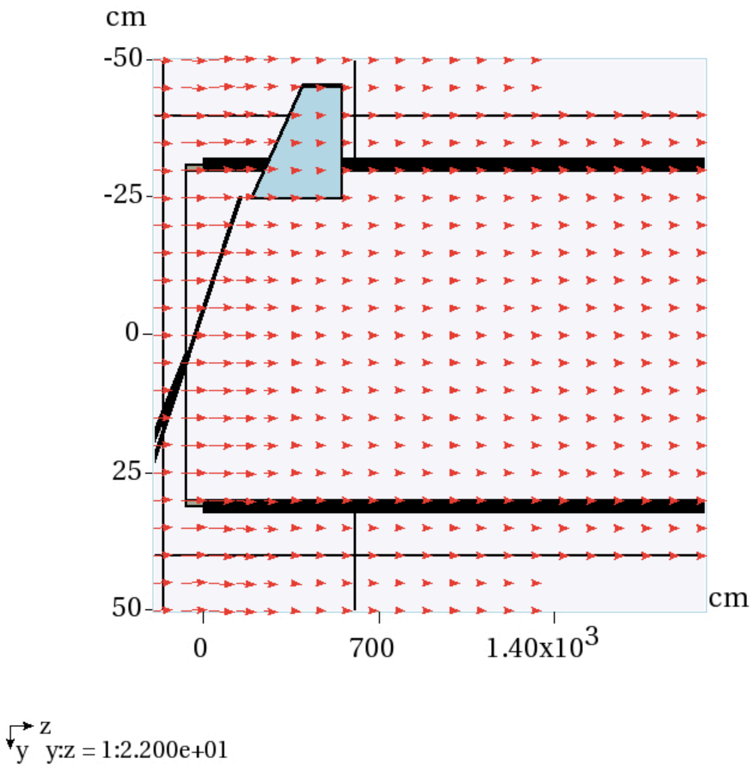


ICP1 MARS FIT2D Output Field Map



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



Inverse Cubic Field(P=1)

Initial $N_P = 4 \times 10^5$

Compare: 1.3e5 "good" muons for 20 T and zend = 1500 cm.

Note: Present study uses 30 cm bore tube, rather than a tapered tube.