

# MUON TARGET PARTICLE PRODUCTION STUDY TAPER FIELD PROFILE

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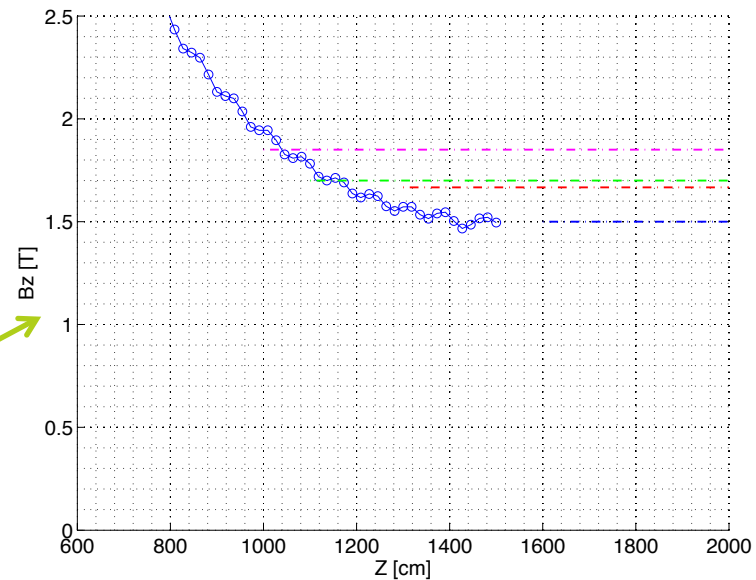
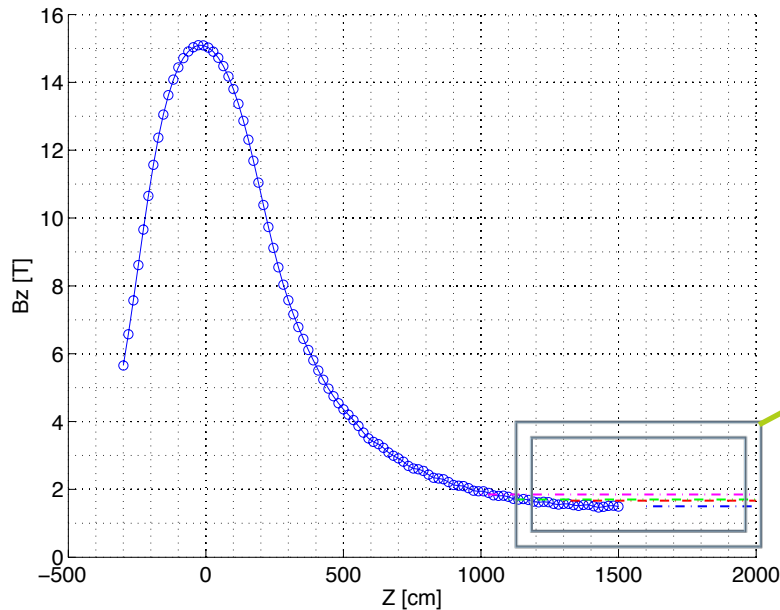
**Brookhaven National Lab**

# Ding's Optimized Parameters

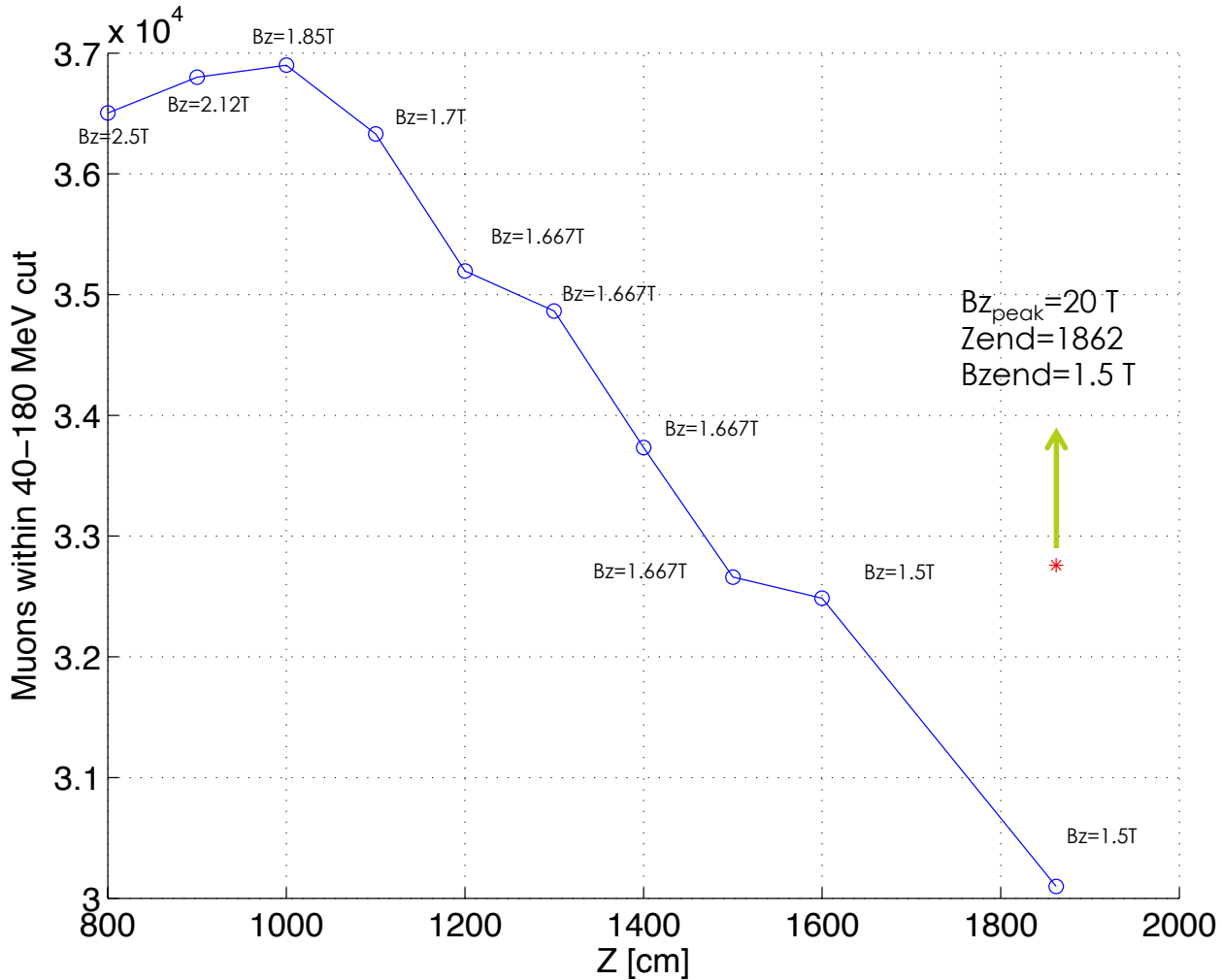
- Hg Target
  - $\theta_{\text{Target}}=0.137$  rad
  - $R_{\text{Target}}=0.404$  cm
  
- Proton Beam
  - $E=8$  GeV
  - $\theta_{\text{Beam}}=0.117$  rad
  - $\sigma_x=\sigma_y=0.1212$  cm (Gaussian Distribution)
  
- Solenoid Field
  - IDS120h → 20 T peak field at target position ( $Z=0$ )
  - Aperture 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
  
- $3.27 \times 10^4$  ( $N_{\text{ini}}=10^5$ )

# 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

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

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

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

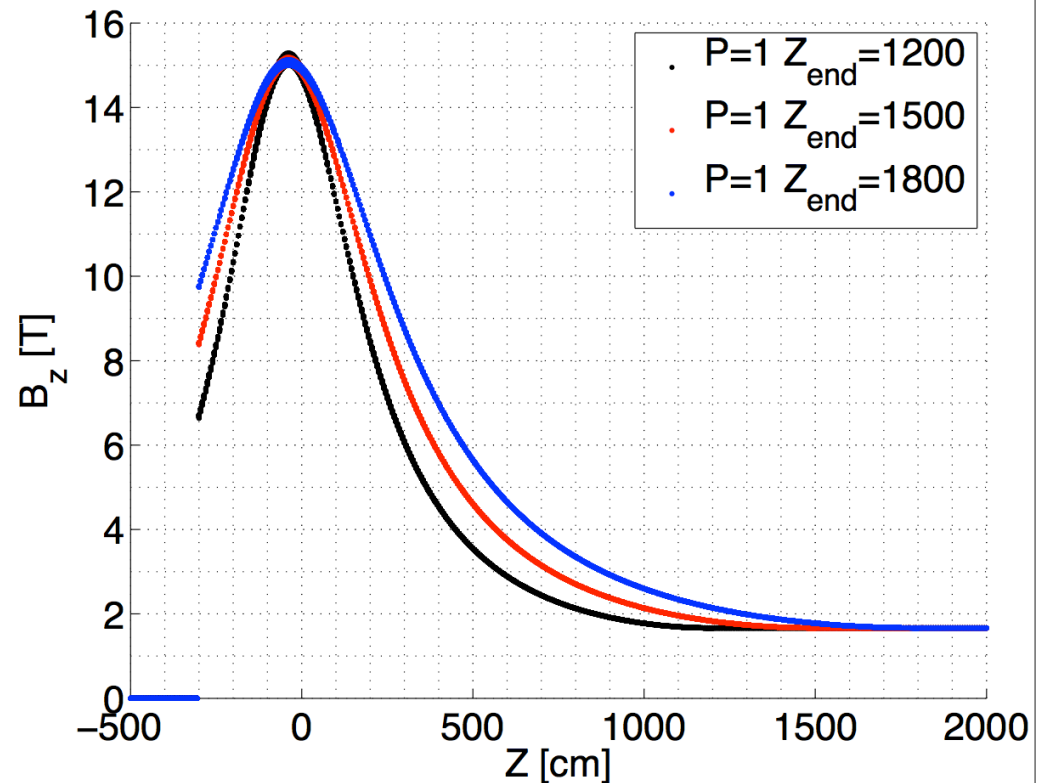
Off-axis field approximation

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

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

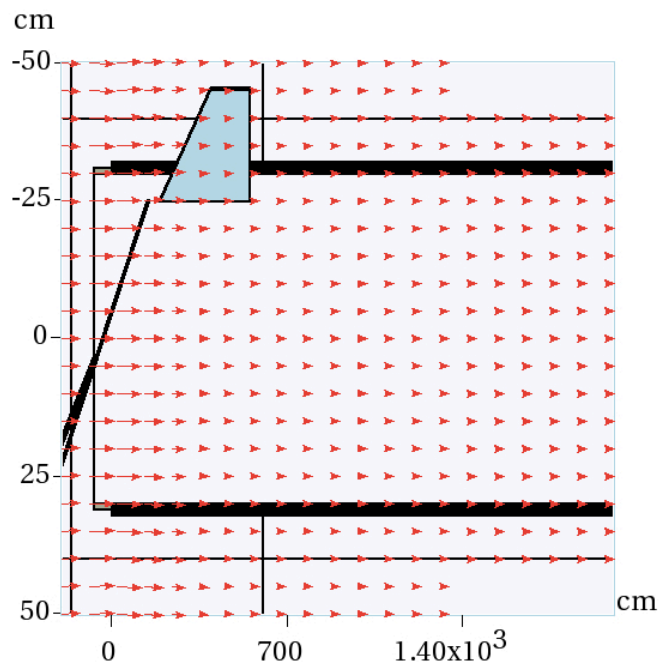
$$a_0^{(n)} = \frac{d^n a_0}{dz^n} = \frac{d^n B_z(0, z)}{dz^n}$$

Field at R=0



# MARS RESULTS

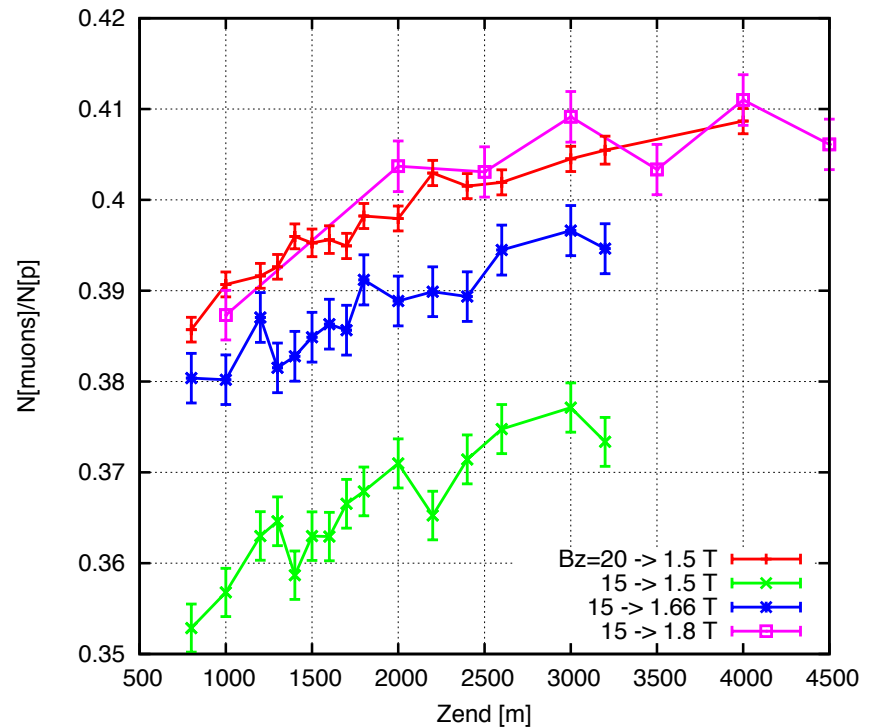
- Beam Pipe with constant  $R=30$  cm
- Beam Pipe material changed to balckhole to speed calculations
- Added subroutine to m1510.f (FIELD) to calculate the field using inverse cubic equations



$\vec{y} \quad \vec{z}$   
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



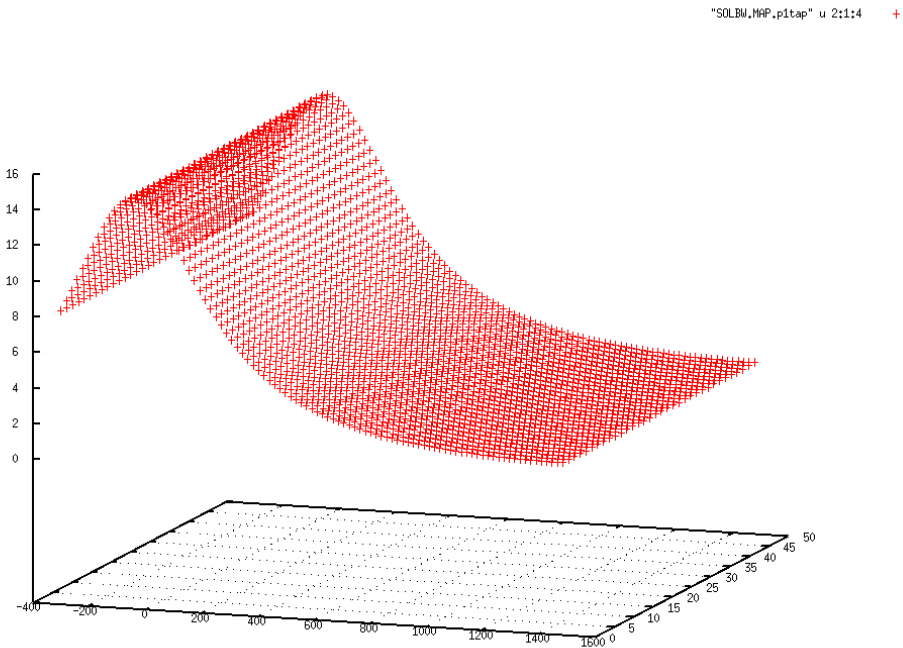
## Tracking Through Phase Rotation & Cooling Sections

- MARS output at  $z=0$
  - ICOOL-IDS front end baseline lattice (2010-04-0) converted to ICOOLV329
  - ICOOL 329 bench marked with ICOOL320 using the IDS front end baseline lattice (Decay region read from field map) → %22 loss
  - Replaced decay region field map with taper field solenoid model “11” run on fido cluster Red Hat Linux – GCC4.1 compilation
- Huge loss of particles (%97)
- Re-run on mac GCC4.6 compilation & Windows intel fortran (R. Fernow) → %40 loss

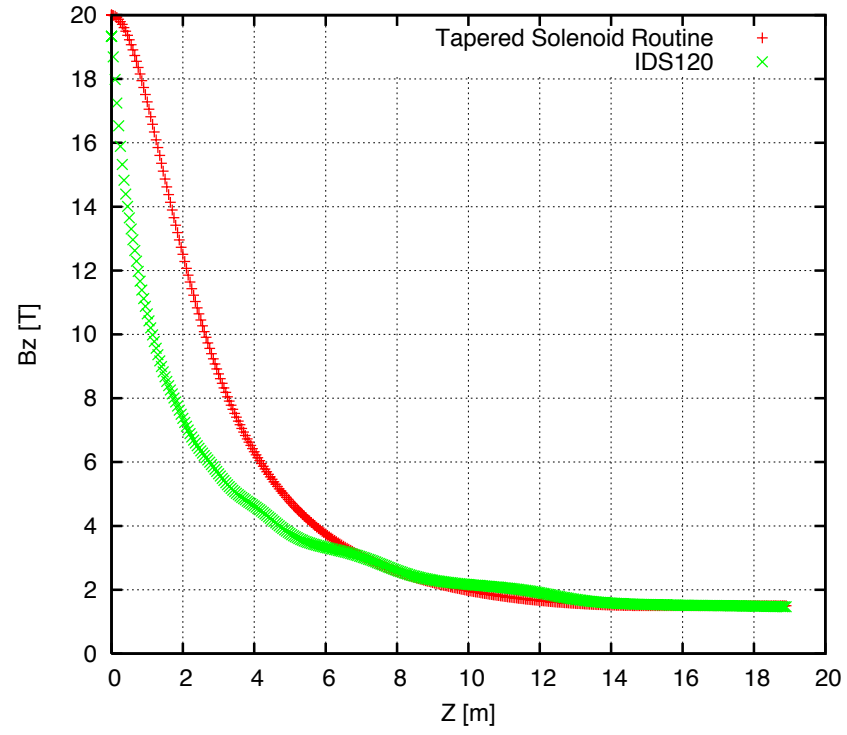


# INVERSE CUBIC Fit (ICP1) FIELD MAP

ICP1 Input Field Map from Standalone code



$B_z(Z=0)$  from ICOOL329



# Taper Solenoid Model in ICOOL329

- Subroutine had minor bugs which were fixed but results did not change on GCC4.1 compilation.
  - Undefined/unused variables
  - Unsaved variable
- Used intel-fortran compiler on fido → compatible results with mac & Windows runs.
- Checked tapered Solenoid subroutine in standalone and produced field map (works -----)
- Used ICOOL329 Solenoid Model 10 (which reads solenoid field map from a file) run ICOOL329 produced the same results.