ALTERNATIVE CAPTURE SOLENOID STUDY FOR THE MUON COLLIDER TARGET

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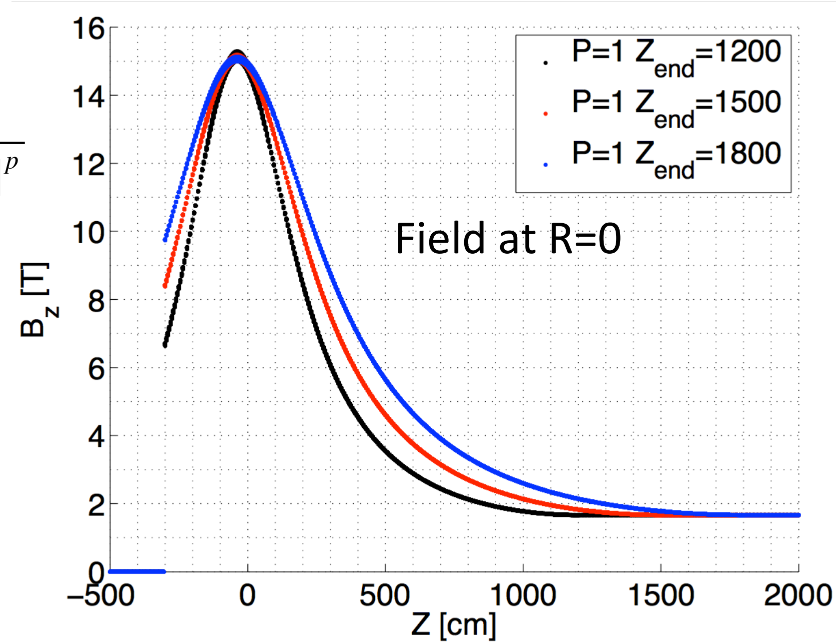
ANALYTIC FORM FOR TAPERED SOLENOID

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

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

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

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

```
! First Order
BZ = B1 / CUBIC**POW
BR = -R / 2. * DBZ1
! Second Order
BZ = BZ - R**2 / 4. * DBZ2
BR = BR + R**3 / 16. * DBZ3
! Third Order
BZ = BZ + R**4 / 64.0 * DBZ4
BR = BR - R**5 / 384.0 * DBZ5
! Fourth Order
BZ = BZ - R**6 / 2304.0 * DBZ6
BR = BR + R**7 / 18432.0 * DBZ7
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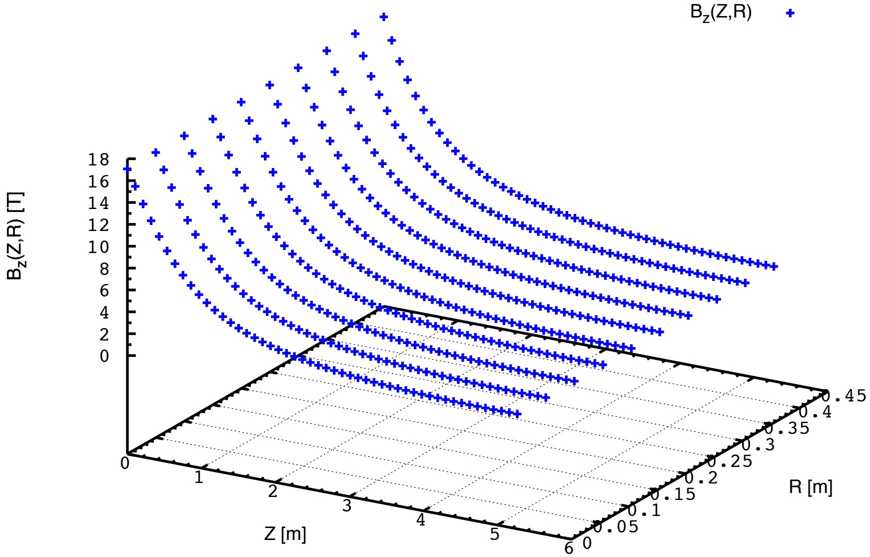
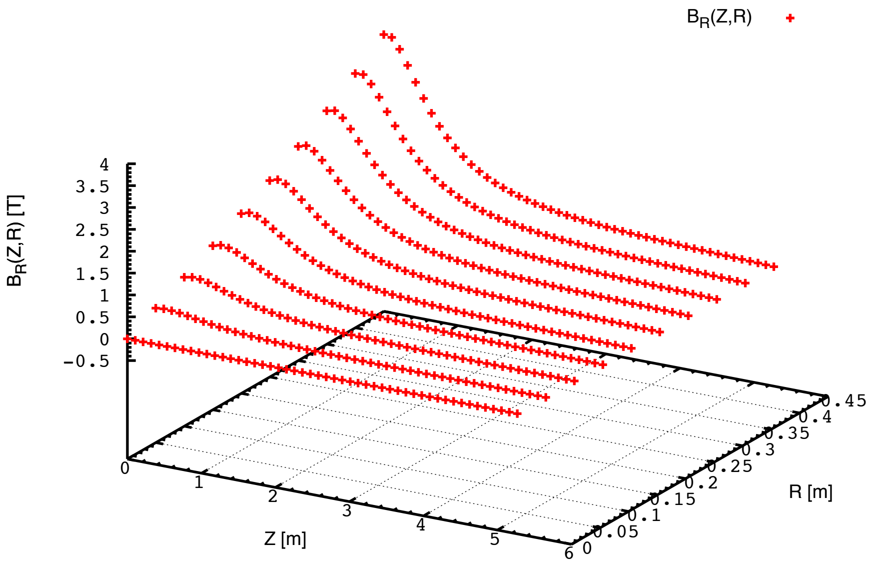
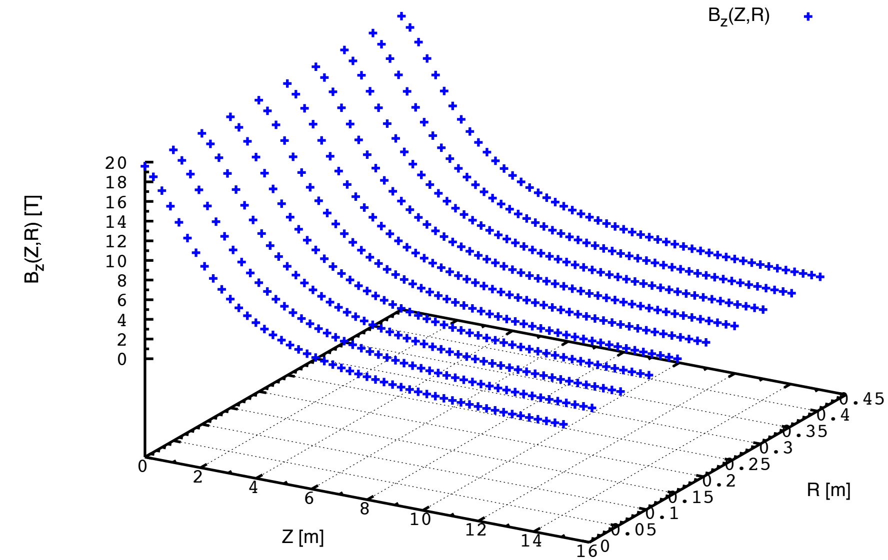
Solenoid Tapered Field

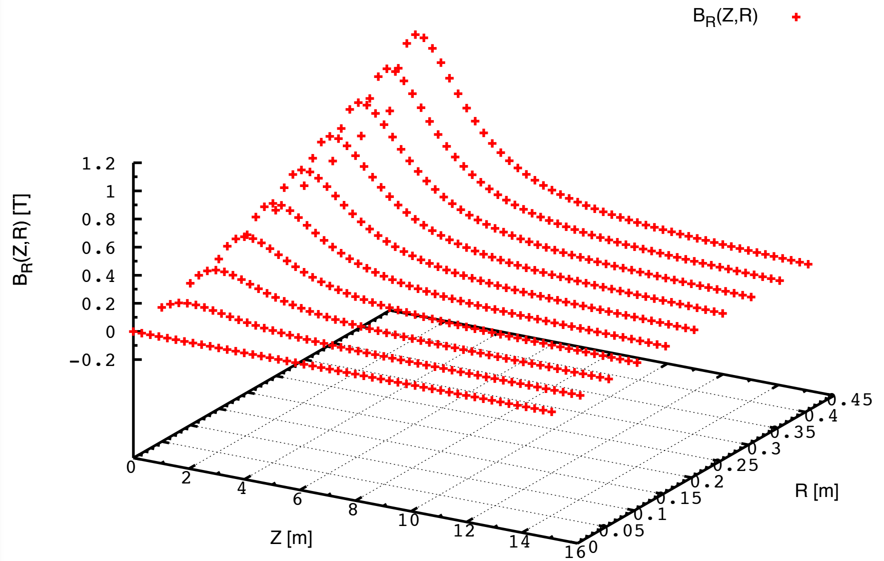
Bz=20-1.5T Ltaper=4 m





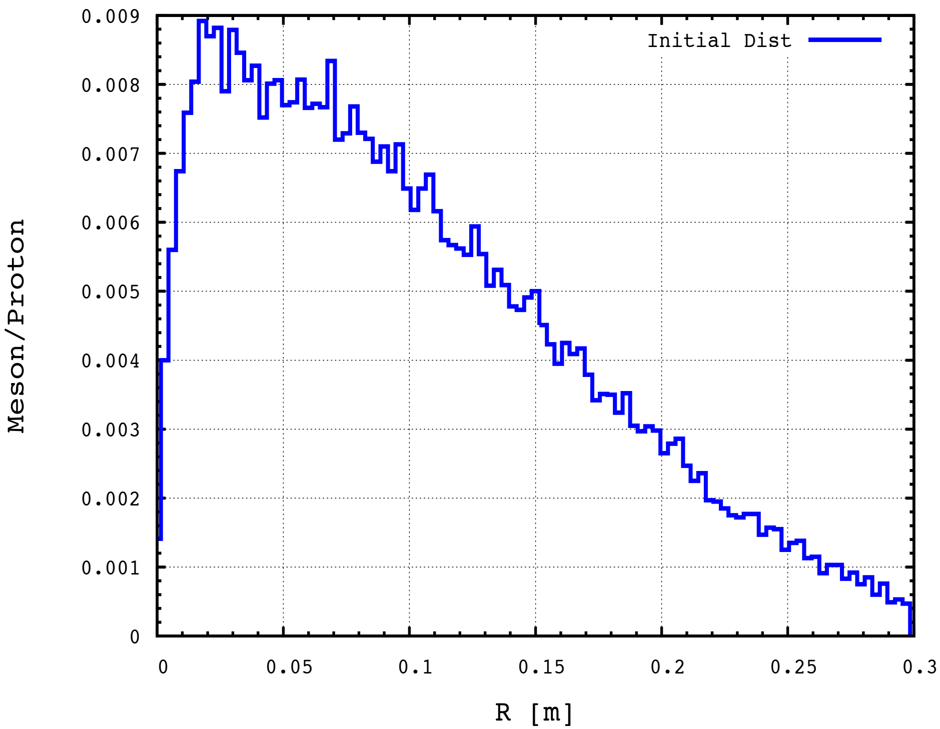
Bz=20-1.5T Ltaper=14 m



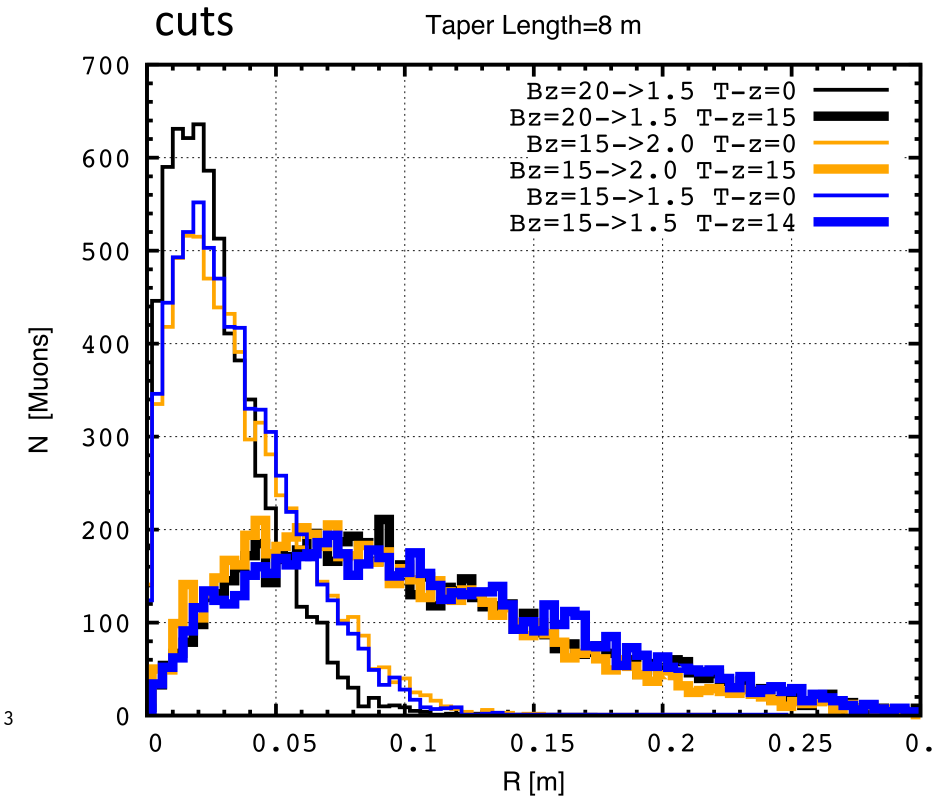


INITIAL PARTICLE DISTRIBUTIONS

Distribution of all Mesons at z=0

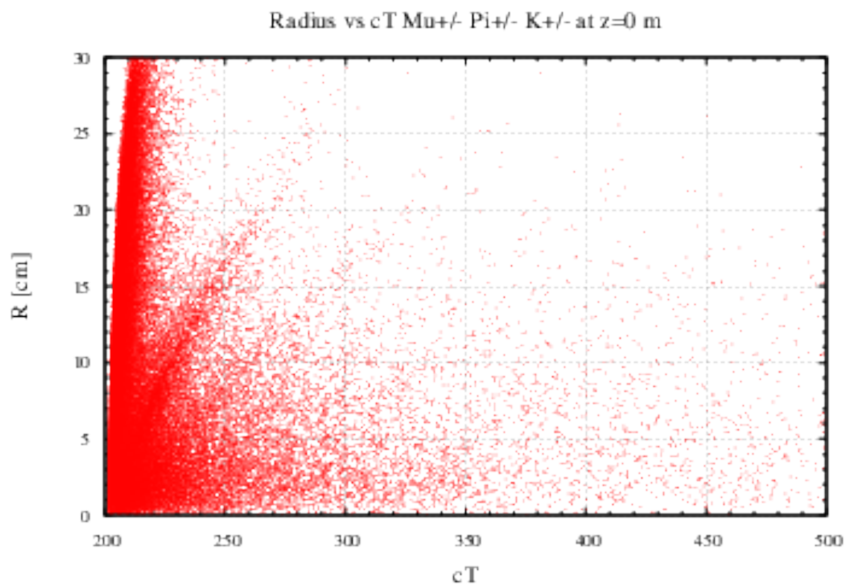


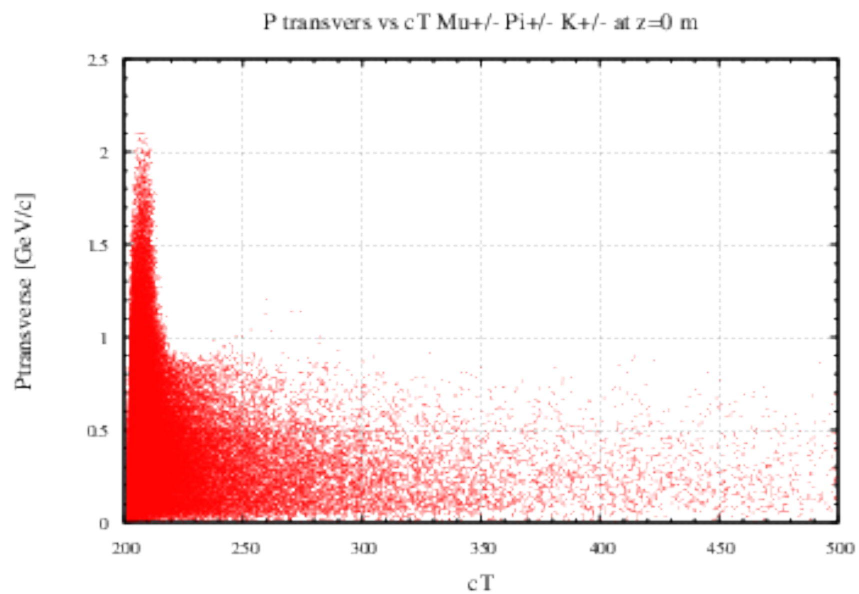
Distribution of Muons which made it to the end of cooling section and satisfied acceleration acceptance cuts



Initial Particle Distributions

Distribution of all Mesons at z=0





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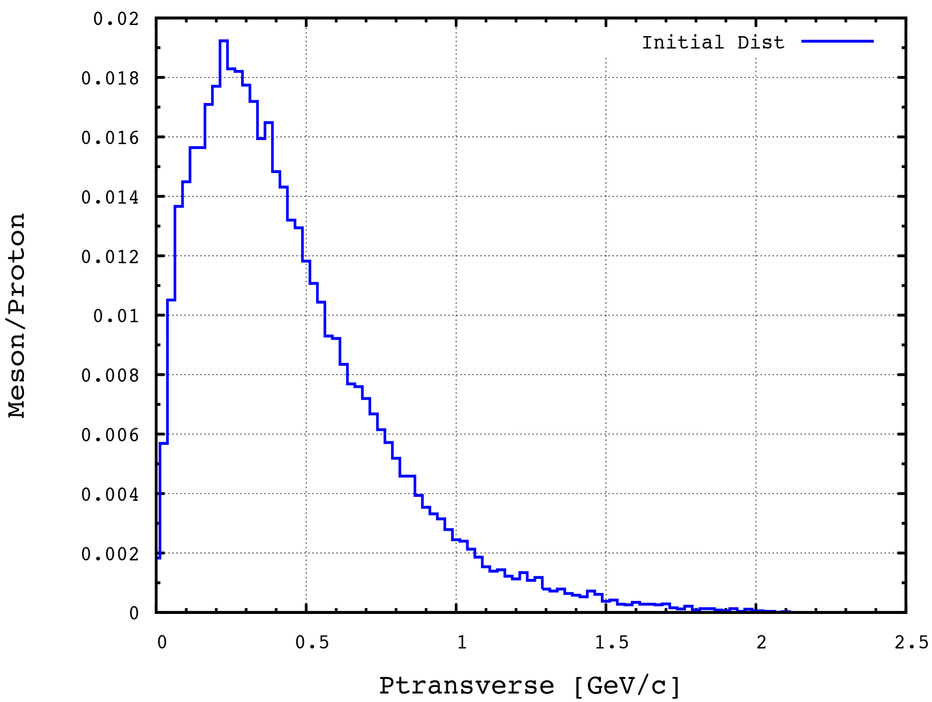
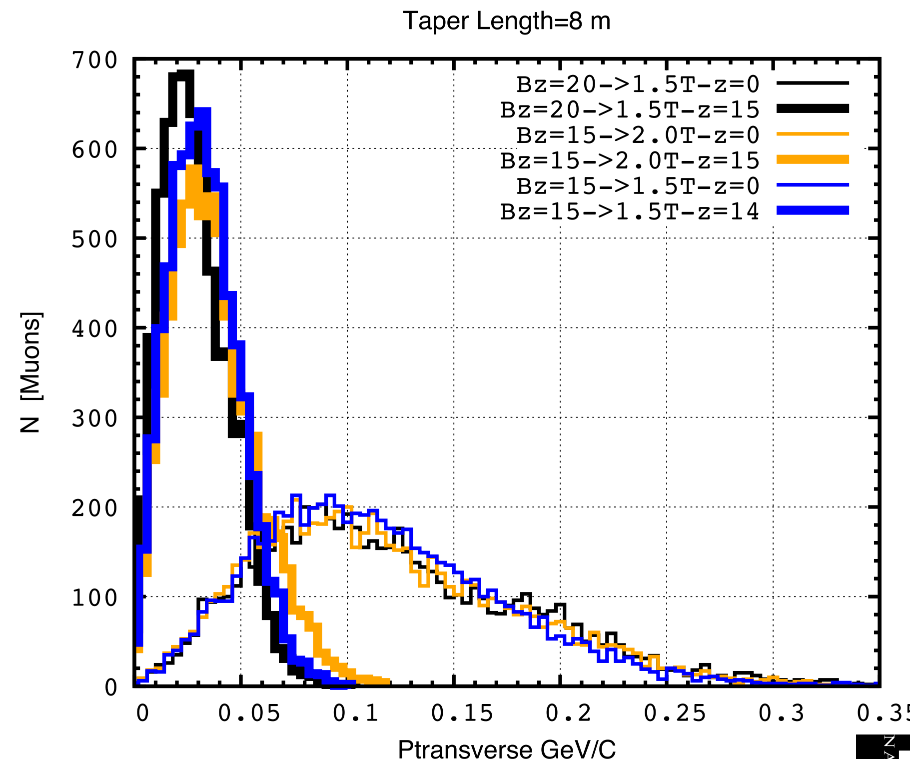
Good Muons Particle Distributions

Distribution of all Mesons at z=0



Distribution of Muons which made it to the end of cooling section and satisfied acceleration acceptance cuts



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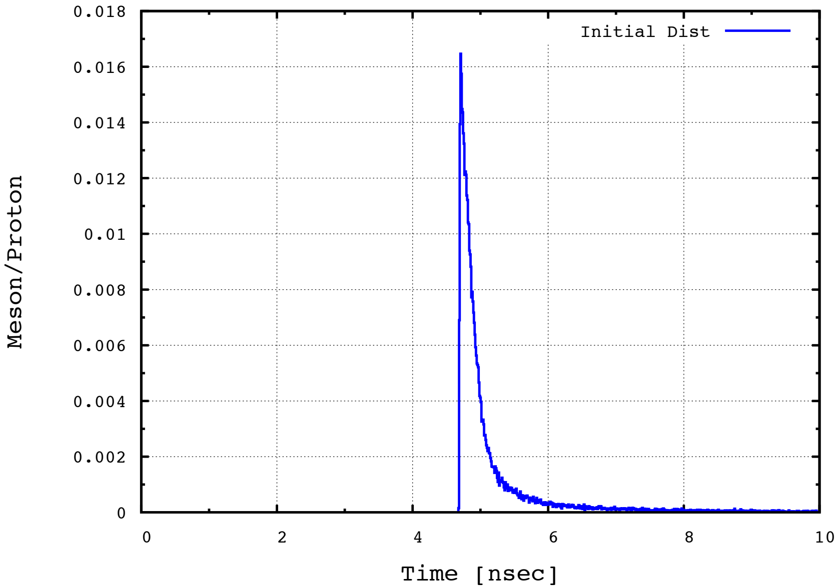
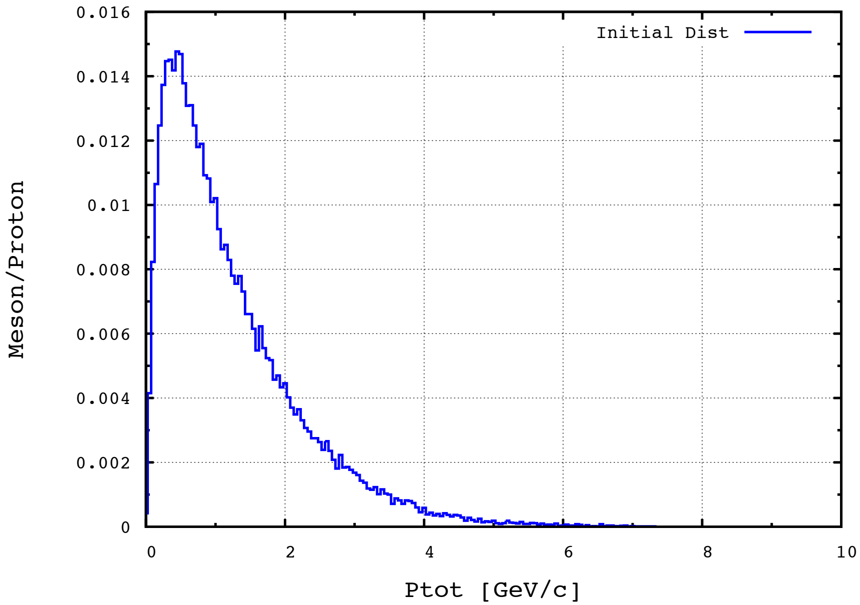
Mesons Initial Distribiution

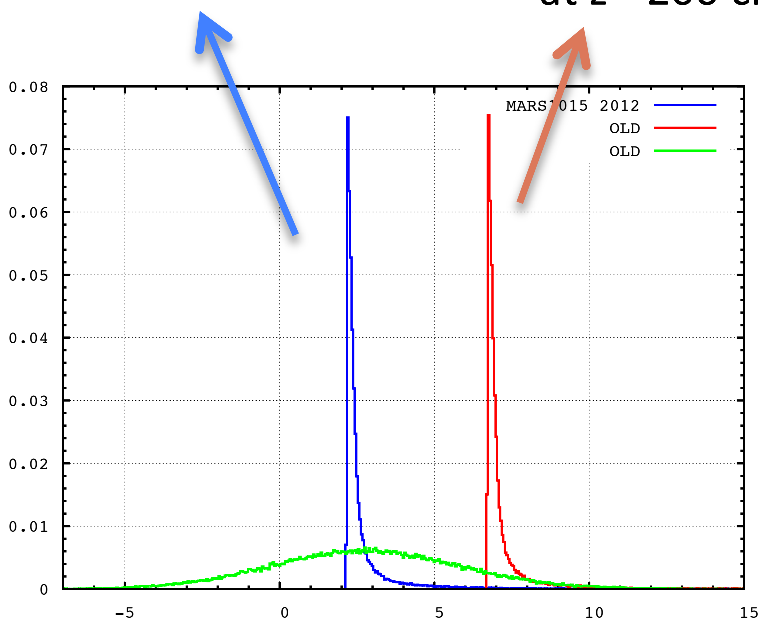


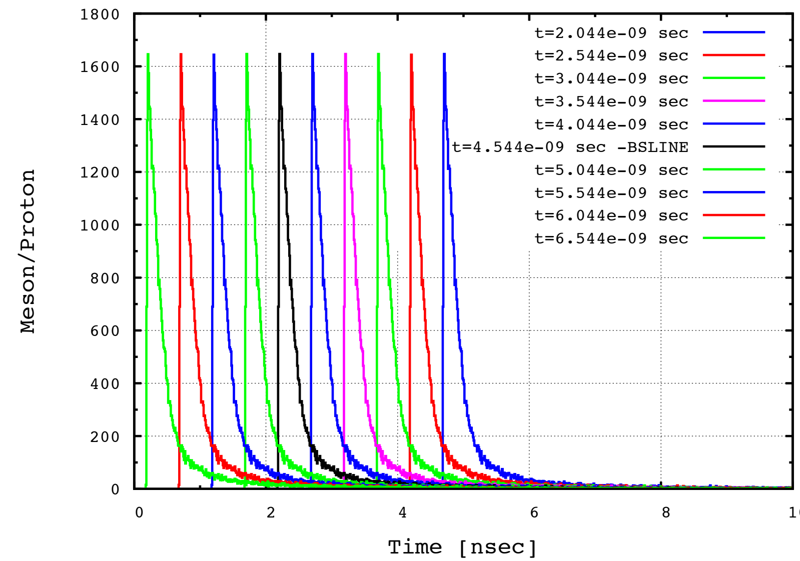


Fixing time of arrival

TOA Protons at z=-75 cm

TOA Protons at z=-200 cm

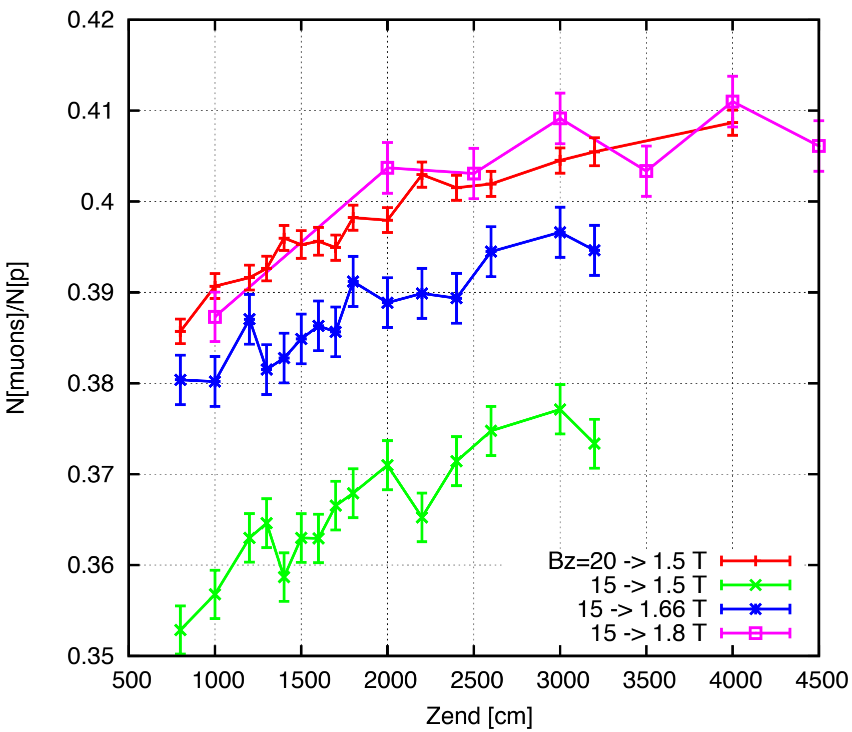




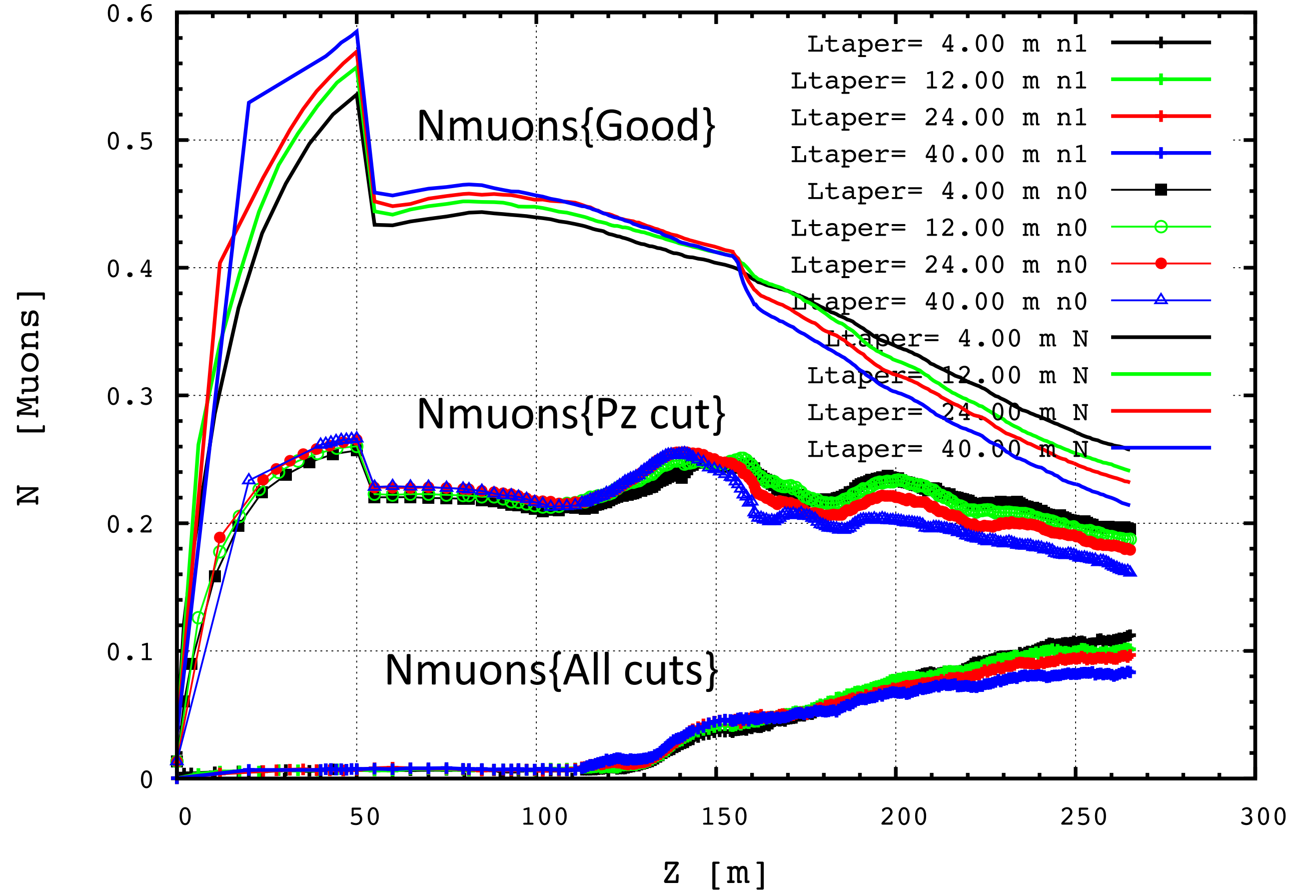
MARS simulations performed with a "pancake" beam, launched at t = 0 from a specified z < 0. Gaussian beam time distribution with sigma_t = 3 ns later simulated by convolution of many "pancake" distributions with different time offsets.

Transmission

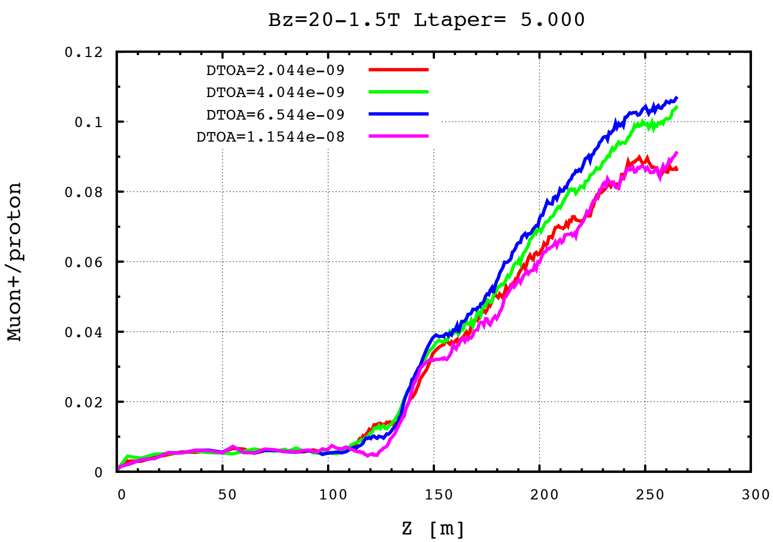
MARS simulation results:
Counting muons at 50 m with K.E. 80-140 MeV

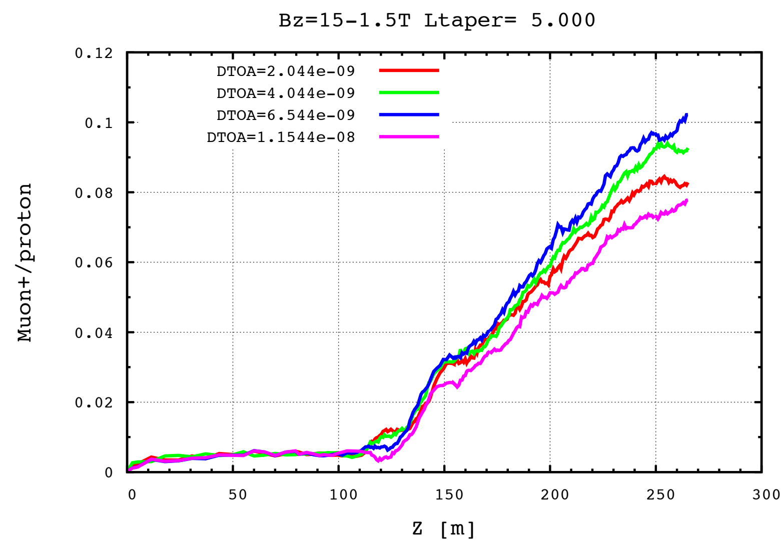


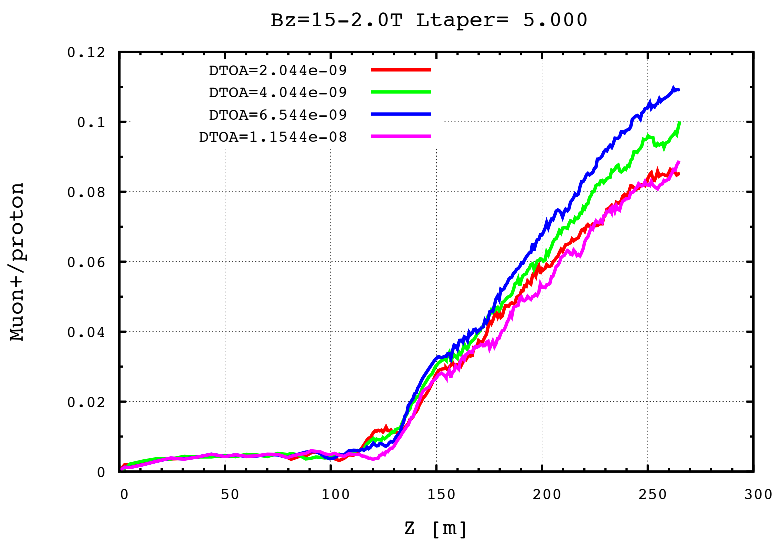
TRANSMISSION



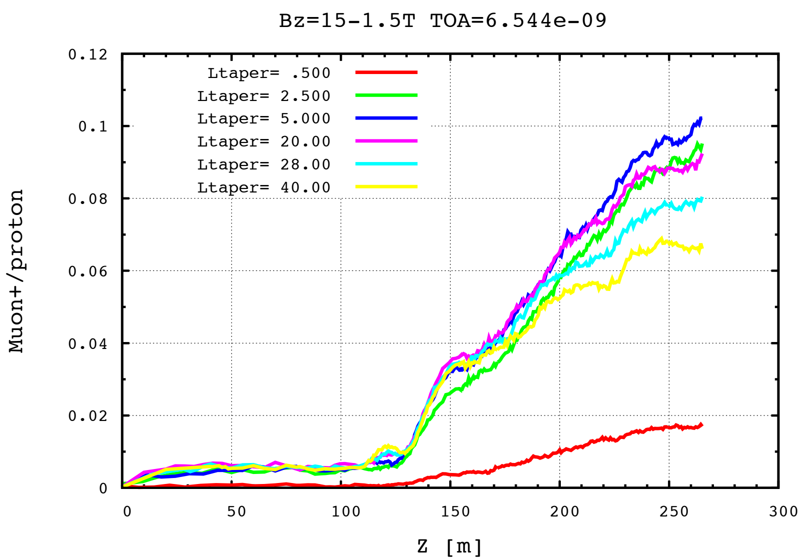
TIME OF ARRIVAL SCAN

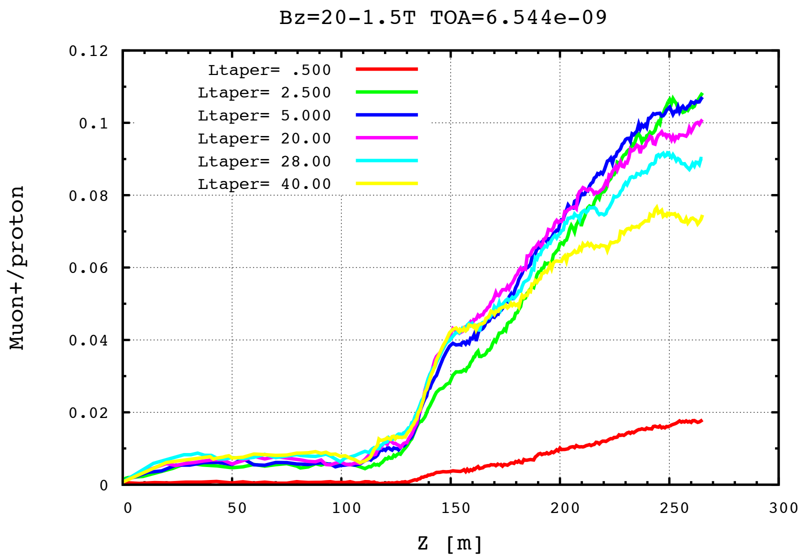






TAPER SCAN


Bz=15-1.5T TOA=6.544e-09
Ltaper= .500
Ltaper= 2.500
Ltaper= 5.000
Ltaper= 20.00
Ltaper= 28.00
Ltaper= 40.00
Muon+/proton
Z [m]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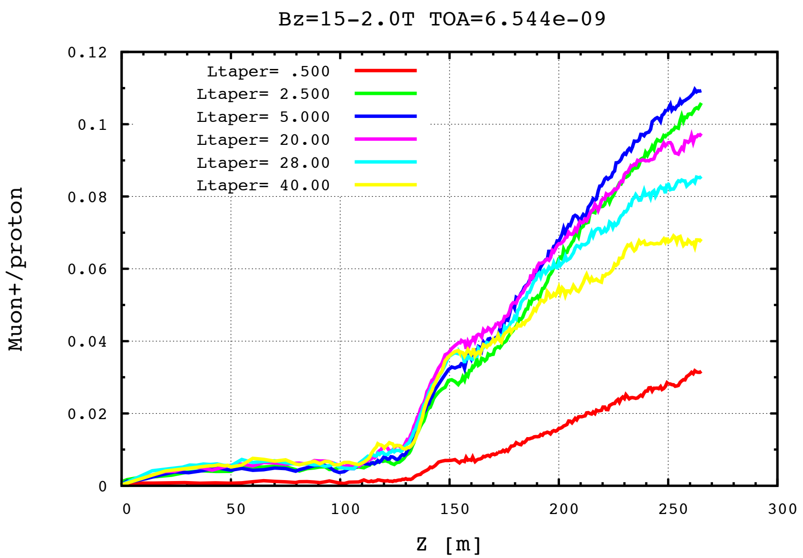
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Ltaper= 5.000
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Ltaper= 28.00
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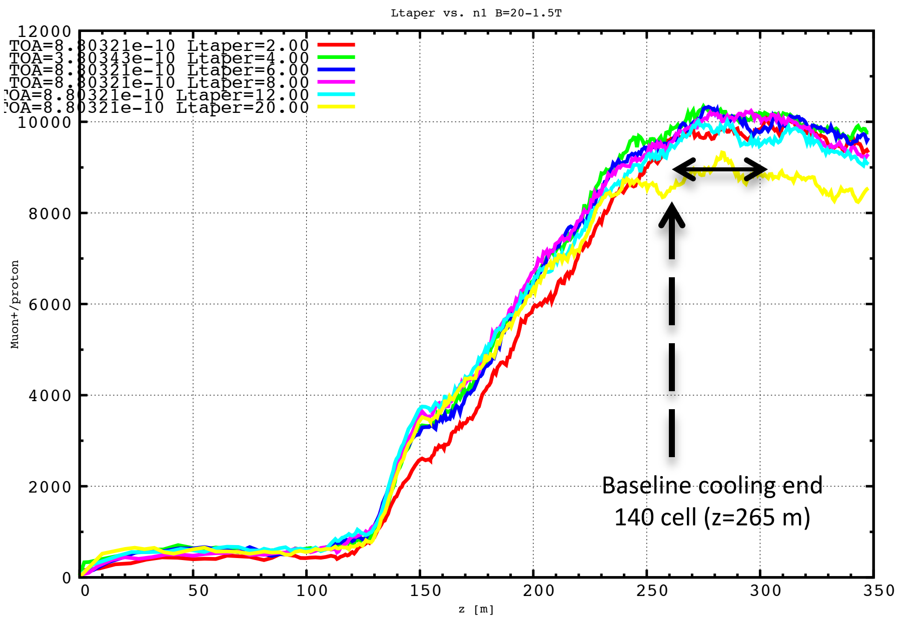
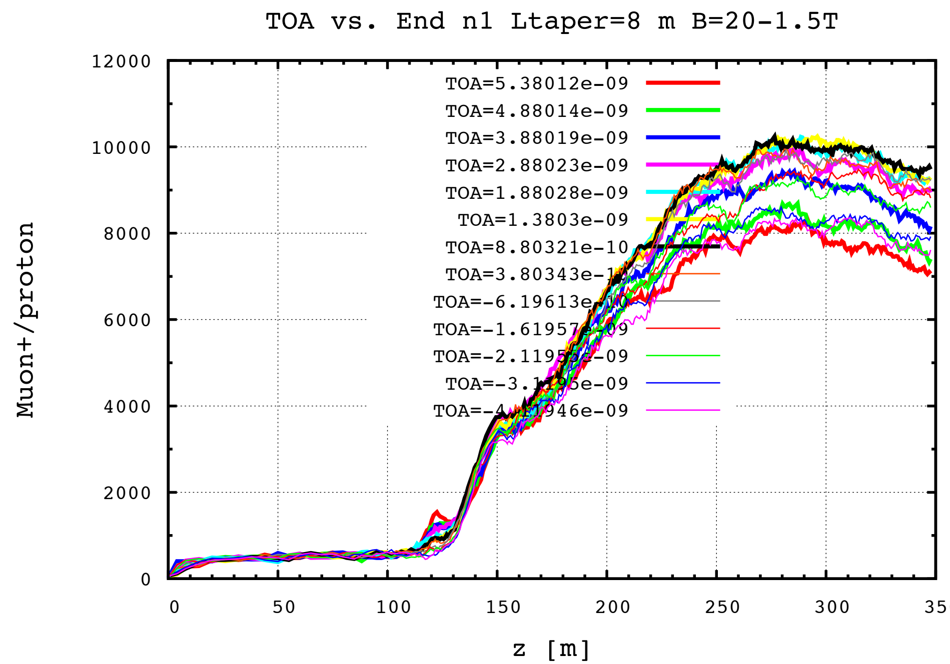
Muon+/proton
Z [m]

More Cooling

For every taper length optimized TOA



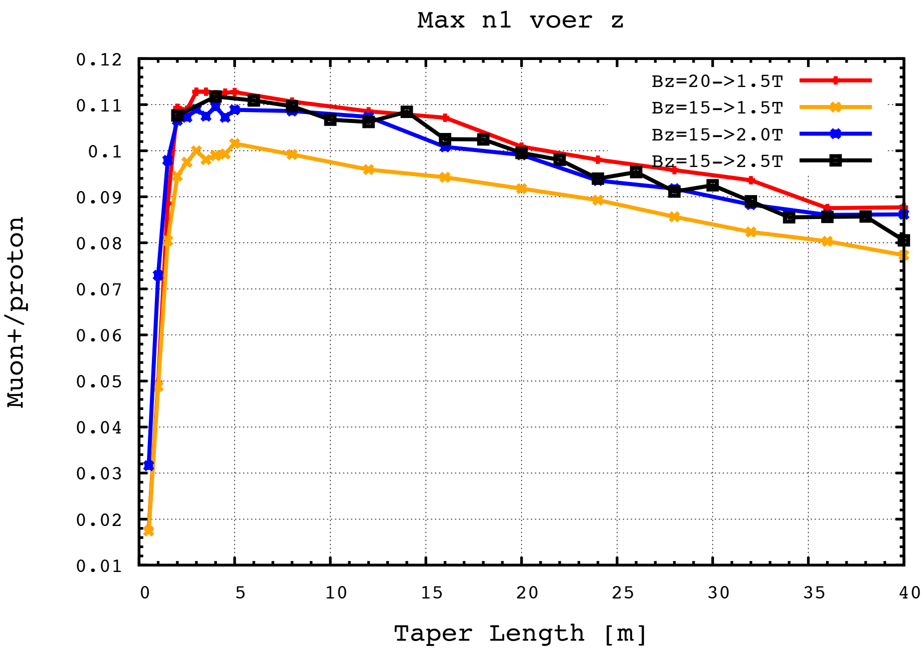
For 8 m taper length TOA scan



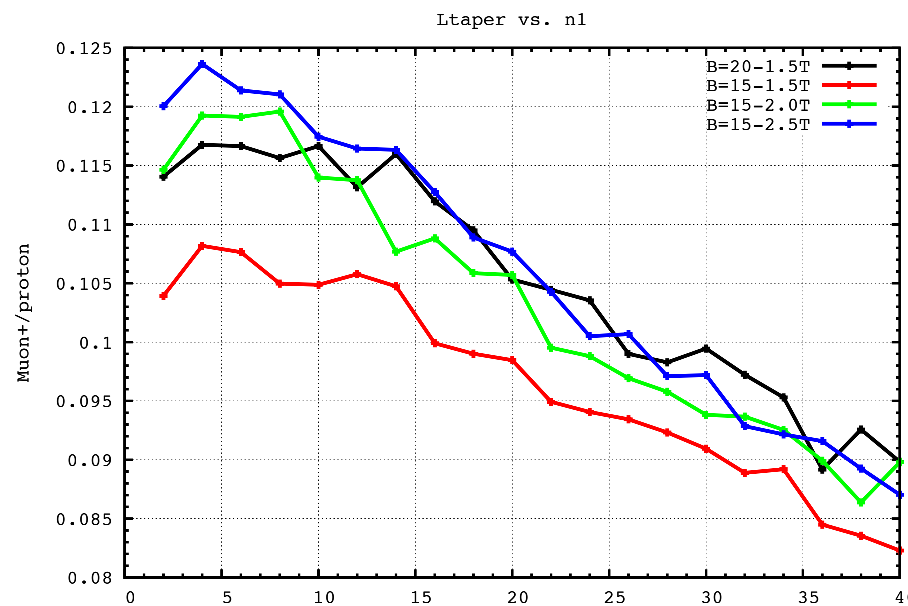
TIME & TAPER LENGTH SCAN

Scan performed in 0.5-ns steps

Using baseline cooling section (140 cooling cell)



Using longer cooling section (200 Cooling cell)



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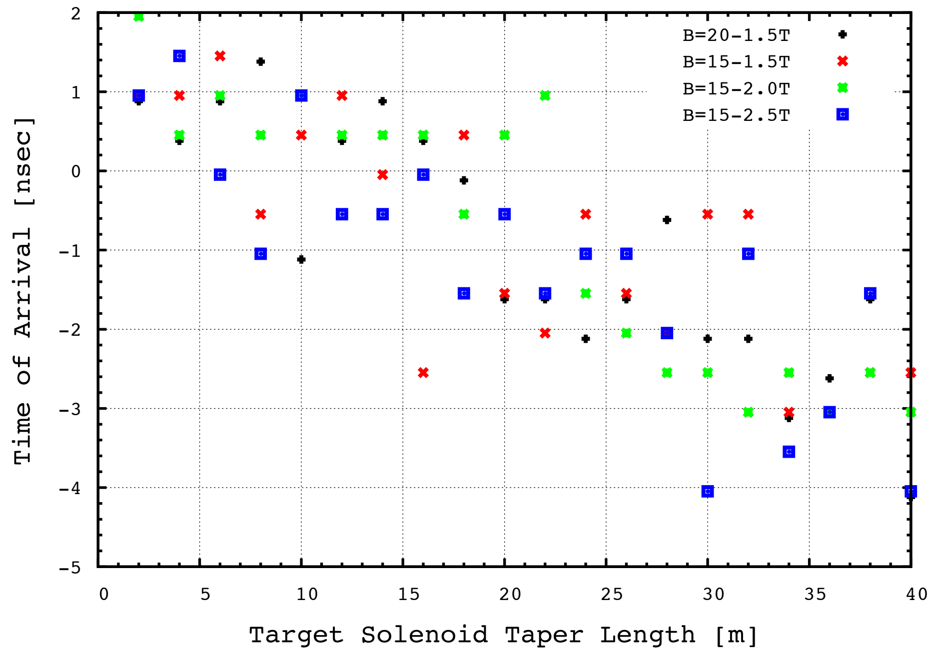
TIME & TAPER LENGTH SCAN

TOA for optimum throughput at end of cooling for each capture solenoid case



Conclusion & Summary

- Varying the capture solenoid settings requires optimizing the time of arrival.
- Longer tapers have more meson yield at decay channel (z=50).
- Shorter tapers produce more good muons which could be bunched & cooled.
- The maximum yield requires tapers with z=4-6 m.
- Particle loss at z=150 m needs more detailed study.
- Adding longer cooling channel is required to reach maximum cooling.