ALTERNATIVE CAPTURE SOLENOID STUDY
FOR THE MUON COLLIDER TARGET

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Nov 29, 2012
Inverse-Cubic Taper

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

\[ a_1 = -\frac{B_1}{pB_1} \quad a_2 = 3 \left( \frac{B_1}{B_2} \right)^{\frac{1}{p} - 1} \frac{1}{(z_2 - z_1)^2} - \frac{2a_1}{z_2 - z_1} \]

\[ a_3 = -2 \left( \frac{B_1}{B_2} \right)^{\frac{1}{p} - 1} + \frac{a_1}{(z_2 - z_1)^3} \frac{1}{(z_2 - z_1)^2} \]

Off-axis field approximation

\[ B_z(r, z) = \sum_n (-1)^n \frac{a_0(2n)(z)}{(n!)^2} \frac{r^{2n}}{2} \]

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

\[ a_0^{(n)} = \frac{d^n a_0}{dz^n} = \frac{d^n B_z(0, z)}{dz^n} \]
**Solenoid Tapered Field**

**Bz=20-1.5T Ltaper=4 m**

![Graphs showing Bz and BR fields for a solenoid with taper length of 4 meters.]

**Bz=20-1.5T Ltaper=14 m**

![Graphs showing Bz and BR fields for a solenoid with taper length of 14 meters.]

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

Taper Length=8 m

Bz=20→1.5 T-z=0
Bz=20→1.5 T-z=15
Bz=15→2.0 T-z=0
Bz=15→2.0 T-z=15
Bz=15→1.5 T-z=0
Bz=15→1.5 T-z=14
INITIAL PARTICLE DISTRIBUTIONS

Distribution of all Mesons at z=0
**Good Muons Particle Distributions**

Distribution of all Mesons at $z=0$

![Graph showing distribution of all Mesons at $z=0$.](image)

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

![Graph showing distribution of Muons.](image)

- **Taper Length = 8 m**
- **Initial Dist**
- **Bz=20 → 1.5T - z=0**
- **Bz=20 → 1.5T - z=15**
- **Bz=15 → 2.0T - z=0**
- **Bz=15 → 2.0T - z=15**
- **Bz=15 → 1.5T - z=14**
MESONS INITIAL DISTRIBUTION

![Graph showing the distribution of mesons over time and momentum.](image)
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.
MARS simulation results:
Counting muons at 50 m with K.E. 80-140 MeV
For every taper length optimized TOA

Baseline cooling end
140 cell (z=265 m)

For 8 m taper length TOA scan

TOA vs. End nl Ltaper=8 m B=20-1.5T
Scan performed in 0.5-ns steps

Using baseline cooling section
(140 cooling cell)

Using longer cooling section
(200 Cooling cell)
TOA for optimum throughput at end of cooling for each capture solenoid case
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.