OPTIMIZING THE MUON COLLIDER CAPTURE TARGET & FRONT END

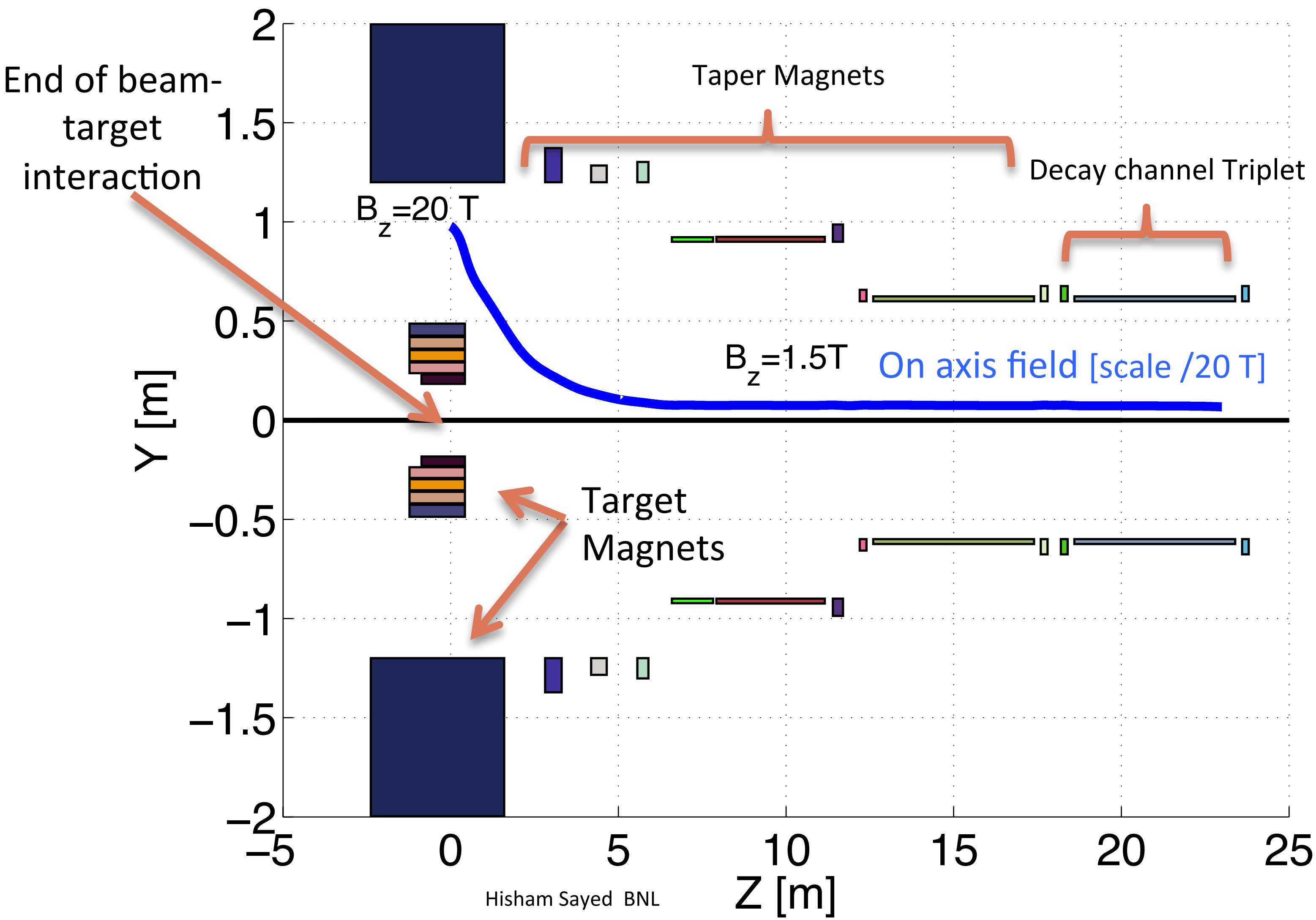
HISHAM KAMAL SAYED
COLLIDER ACCELERATOR DEPARTMENT
BROOKHAVEN NATIONAL LABORATORY

April 11 2013

BROOKHAVEN
NATIONAL LABORATORY

NEW SHORT TARGET CAPTURE MAGNET (WEGGEL)

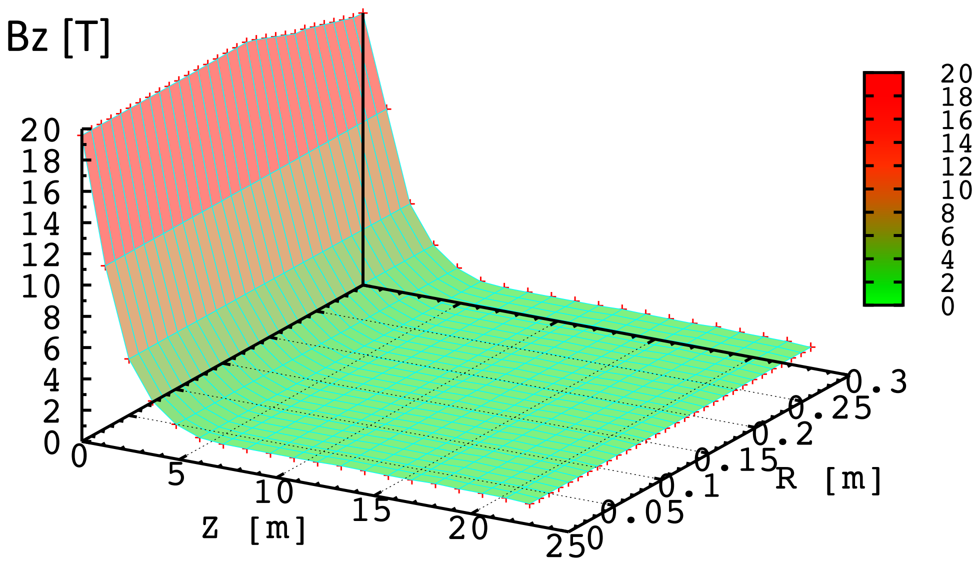
Muon Target Short Taper Magnet taper length =7 m- B=20-1.5 T

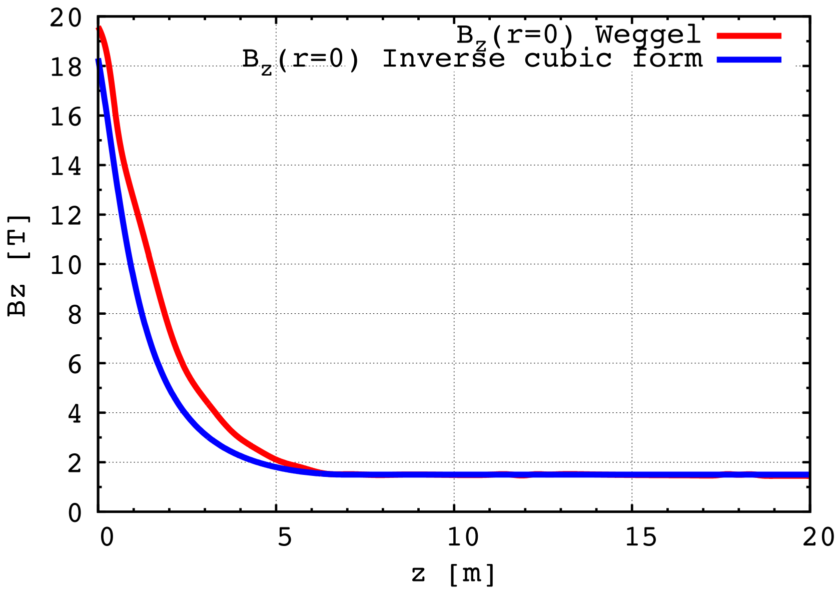


BROOKHAVEN NATIONAL LABORATORY

NEW SHORT TARGET CAPTURE MAGNET (WEGGEL)

Muon Target Short Taper Magnet taper length =7 m- B=20-1.5 T





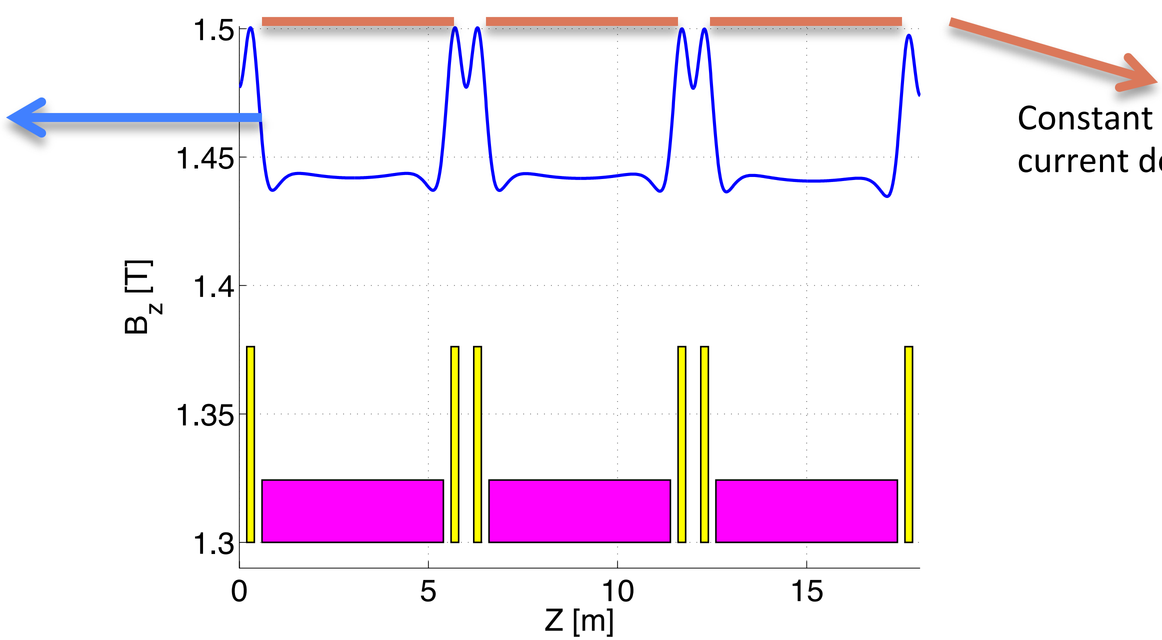
Target SC Magnets Field Map

Field map calculated from coil current densities using Icool grid routine

New Decay channel magnet (Weggel)

Muon Target Decay channel Solenoid Magnet (Weggel)

Field map from magnet coils

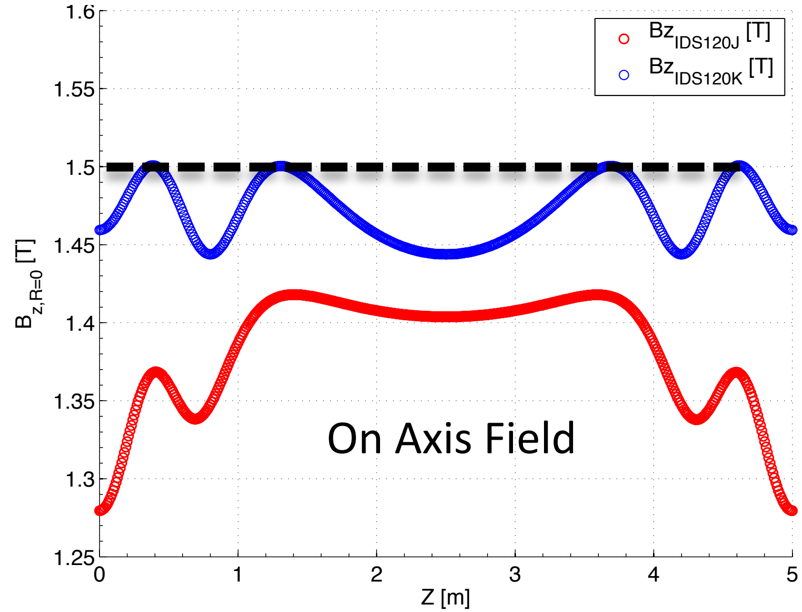


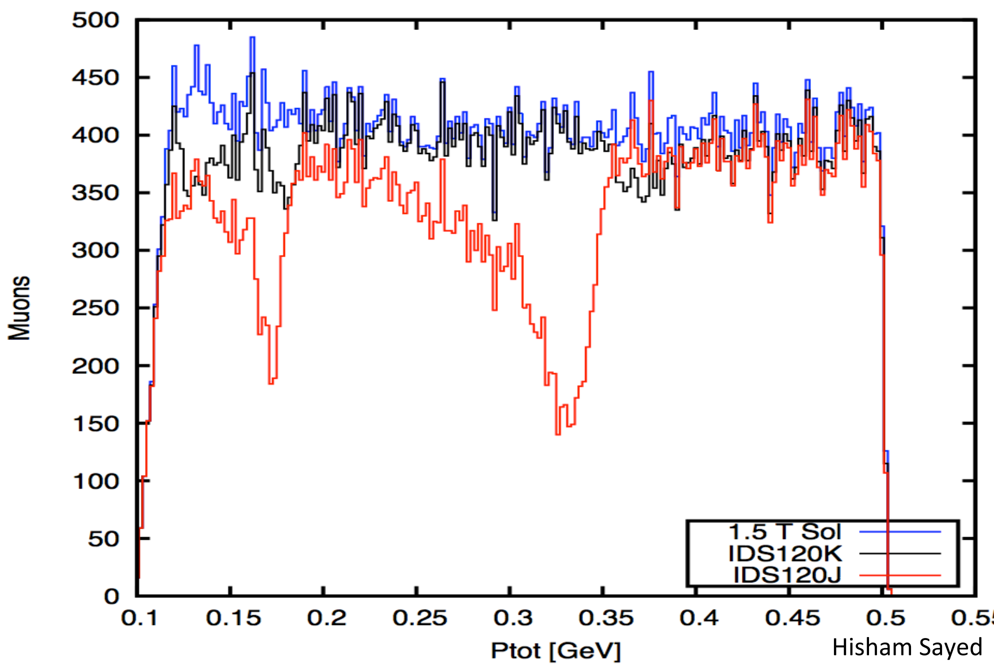
Constant 1.5 Field in current decay channel

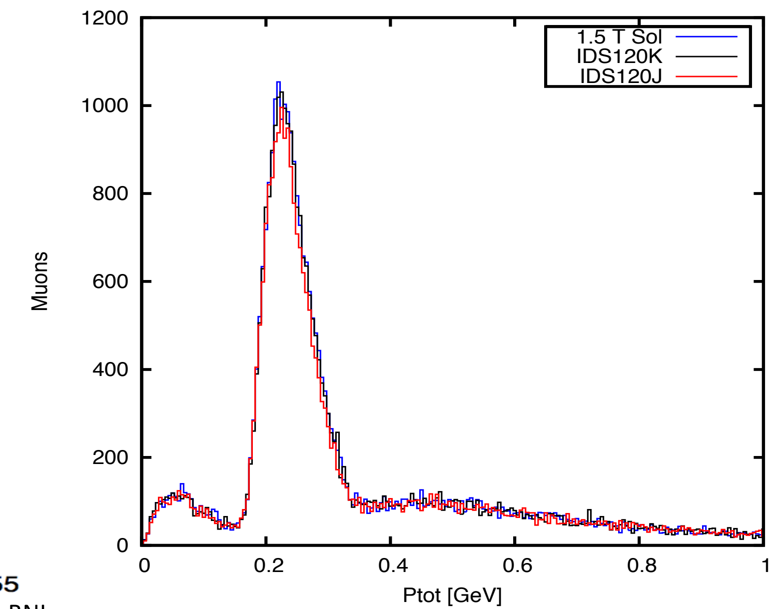
Magnet	Length [m]	Inner R [m]	Outer R [m]	J [A/mm^2]
1	0.2	0.6	0.6762	47.15
2	4.7949	0.6	0.6243	47.15
3	0.2	0.6	0.6762	47.15

OLD SOLENOID COILS (IDS120K(J)) 2012

Length [m]	Inner R [m]	Outer R	Current [A/mm^2]
0.05	0.5	0.868	45.815
3.483	0.5	0.523	47.67
0.05	0.5	0.868	45.815





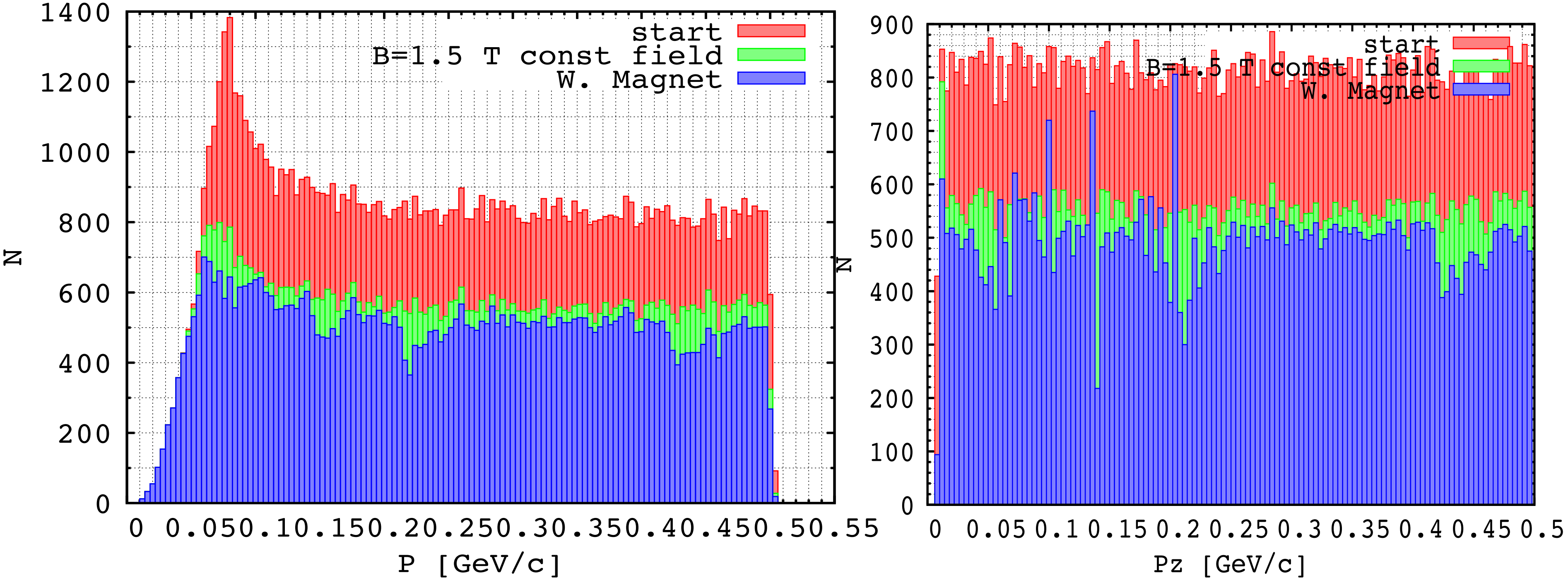


Hisham Sayed BNL

NEW DECAY CHANNEL SOLENOID STOP BAND STUDY

Tracking 100k muons through decay channel -10 cells (60 m)

Initial momentum of survived muons



Transmission:

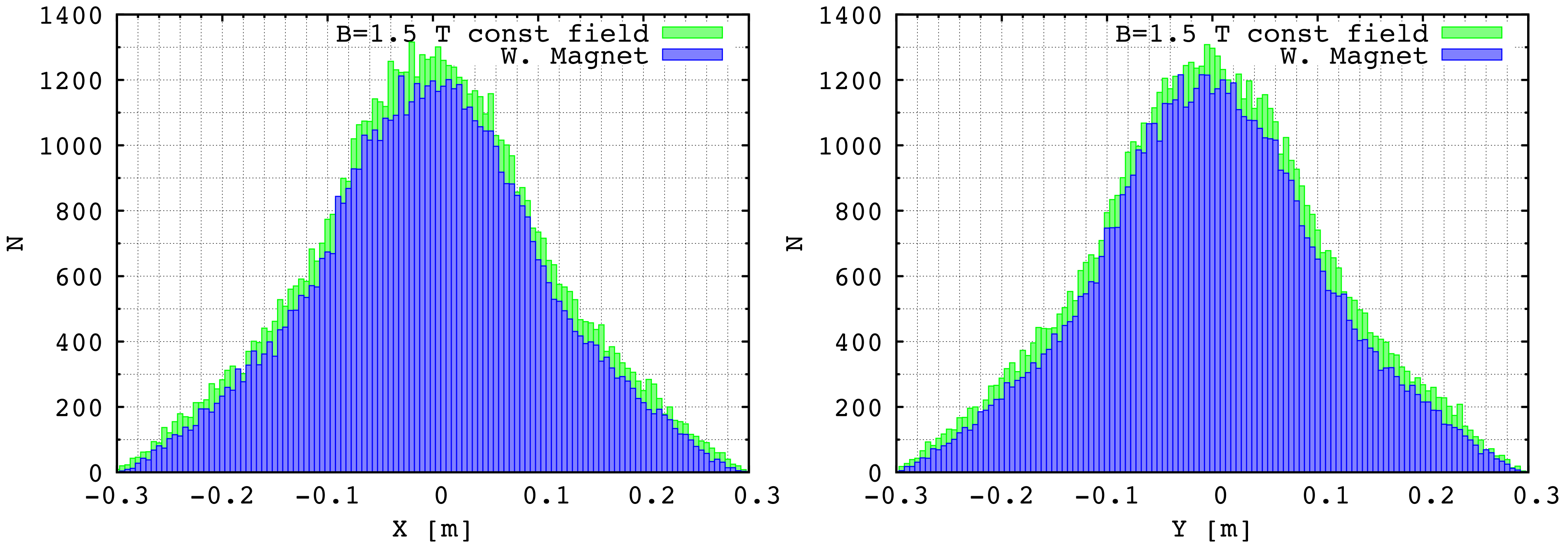
Constant 1.5 Solenoid Field %67

Field map from realistic coils %60

NEW DECAY CHANNEL SOLENOID DYNAMIC APERTURE

Tracking 100k muons through decay channel -10 cells (60 m)

Initial coordinates of survived muons

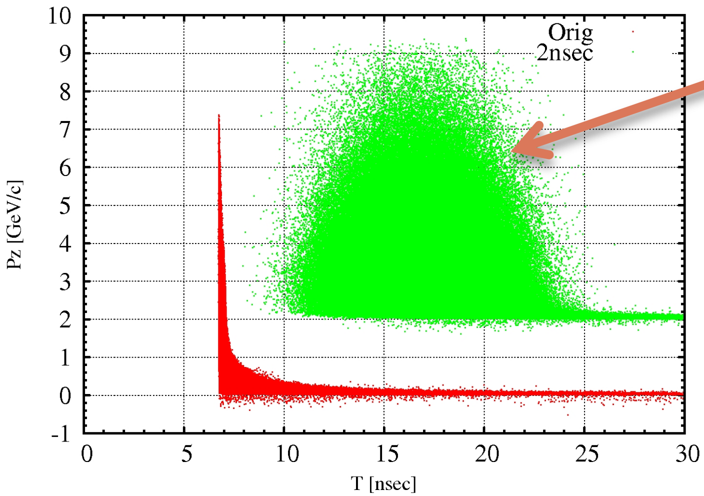


Transmission:
Constant 1.5 Solenoid Field %67
Field map from realistic coils %60

High statistics Target production for FE studies

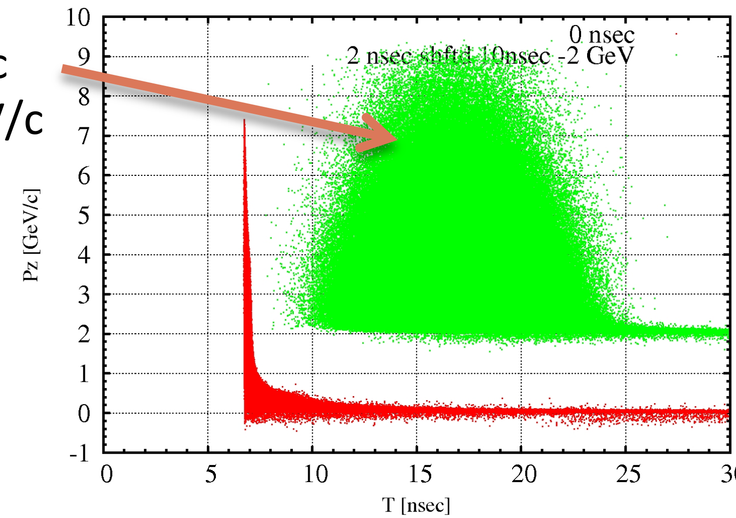
- High statistics particle distributions for the muon collider/Nu fact target using MARS1510 for particle production.
- Nprotons=5E6 → Nmoun~> 2E6 at z=0.
- ID cuts at z=0 to select only pions, kaons, and muons.
- Two data sets (positive & negative charge) posted at the link for 20T & 15 Ttarget solenoid peak filed.
- For each case I have supplied a proton pancake time distribution and a distribution with σ_t=2 nsec

B=20-1.5 Ltaper=15 m



Δt=10 nsec
Δpz=2 GeV/c

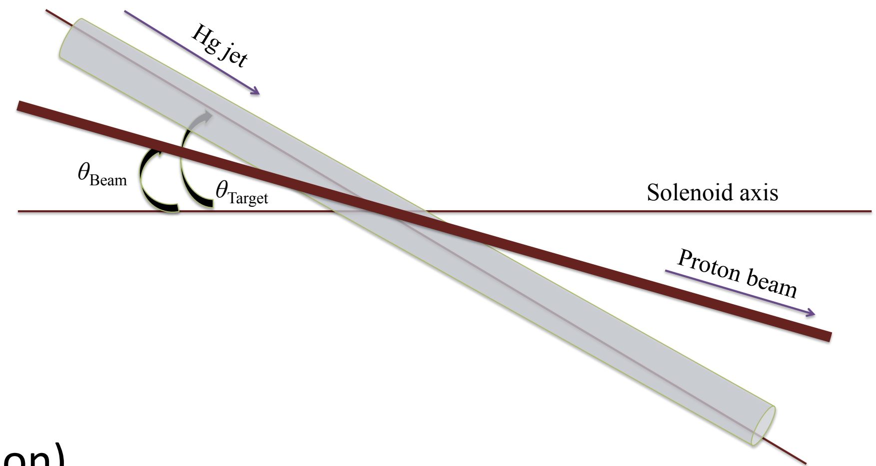
B=15-1.5 Ltaper=15 m



https://pubweb.bnl.gov/~hsayed/Muon_collider/High_stat_pdist_muon_target/

Baseline Optimized Parameters used for particle production

- 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)
  - $\sigma_t=\sigma_z$=0 (Pancake Distribution)
- Solenoid Field
  - 20 T peak field at the target position
  - Taper Field B(Z = 0)=20 T → Bz (Z = 15 m)=1.5 T
  - Aperture at Target R=30 cm - End aperture R = 30 cm



Conclusion:

1- New short taper target magnet is delivering the required on axis field.
2- Performance to be evaluated by particle tracking.
2- Decay channel (1.5 T) magnets has minor stop bands
3- High statistics production posted online

Optimize the match to the cooler

1- FE cooler match was designed to match 1.5(1.75)T FE solenoid channel to alternating 2.8/-2.8T cooler channel
2- Target & FE optimization studies showed better performance with 2.0 -2.5 T solenoid channel (might consider 2.8 T still need to match going from constant to alternating solenoid channel)
3- Muon beam phase space ellipse coming out of periodic solenoid channel into different channel will experience a filamentation and emittance growth due to mismatched ellipses

Emittance magnification factor EM_F *

$$\mathrm{EM}=\frac{1}{2}[\frac{\beta_b}{\beta_s}+\frac{\beta_s}{\beta_b}+(\sqrt{\frac{\beta_b}{\beta_s}}\alpha_s-\sqrt{\frac{\beta_s}{\beta_b}}\alpha_b)^2]$$ At s=0

Beam ellipse → $\beta_b,\alpha_b,\gamma_b$

Periodic solenoid channel ellipse → $\beta_s,\alpha_s,\gamma_s$

* C. Wang – K-J Kim NFMCC-doc-205-v1

Optimize the match to the cooler

Algorithm

1- Match Beam phase space ellipse at end of phase rotator to the cooler solenoid channel periodic solution
3- Muon beam comes with considerable momentum distribution. We need a broad spectrum match
4- We are interested in fitting good particles that make it through the cooler & acceleration acceptance
5- Construct partition function $F = \chi_1 \, EM1 + \chi_2 \, EM2 + \ldots..$
χ_1 → Number of particles with momentum Ps1
χ_2 → Number of particles with momentum Ps2

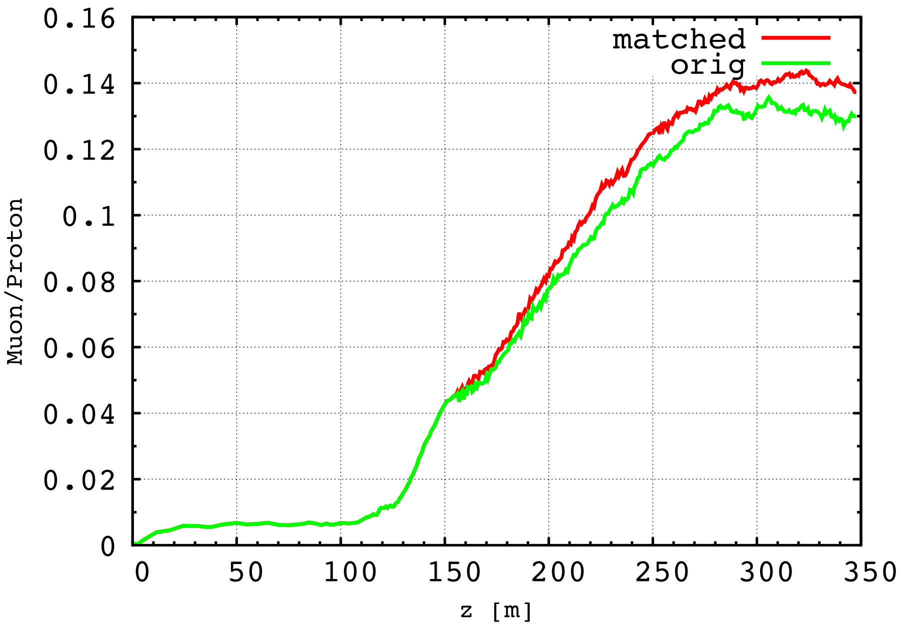
Where N(Ps1) > N(Ps2) => $\chi_1 > \chi_2$
6- Use GE optimizer to adjust coil settings to minimize the objective function "fit (match) the two ellipses"

7- Smooth optimization by adding the number of good muons at end of cooler.

Utilizing GE optimization to optimize the match to the cooler

Differential Evolution Algorithm (DE): Developed at LBL
PDE: MPI- Code developed by Ji Qiang (LBL).
- Multivariable test problem: 9 parameters for 9 sheets currents. Optimized matching coils upstream of the frontend cooler.

B=20-2.5 T



B=20-2.0 T