J-PARC MUSE H-Line Optimization for the g-2/EDM and MuHFS experiments

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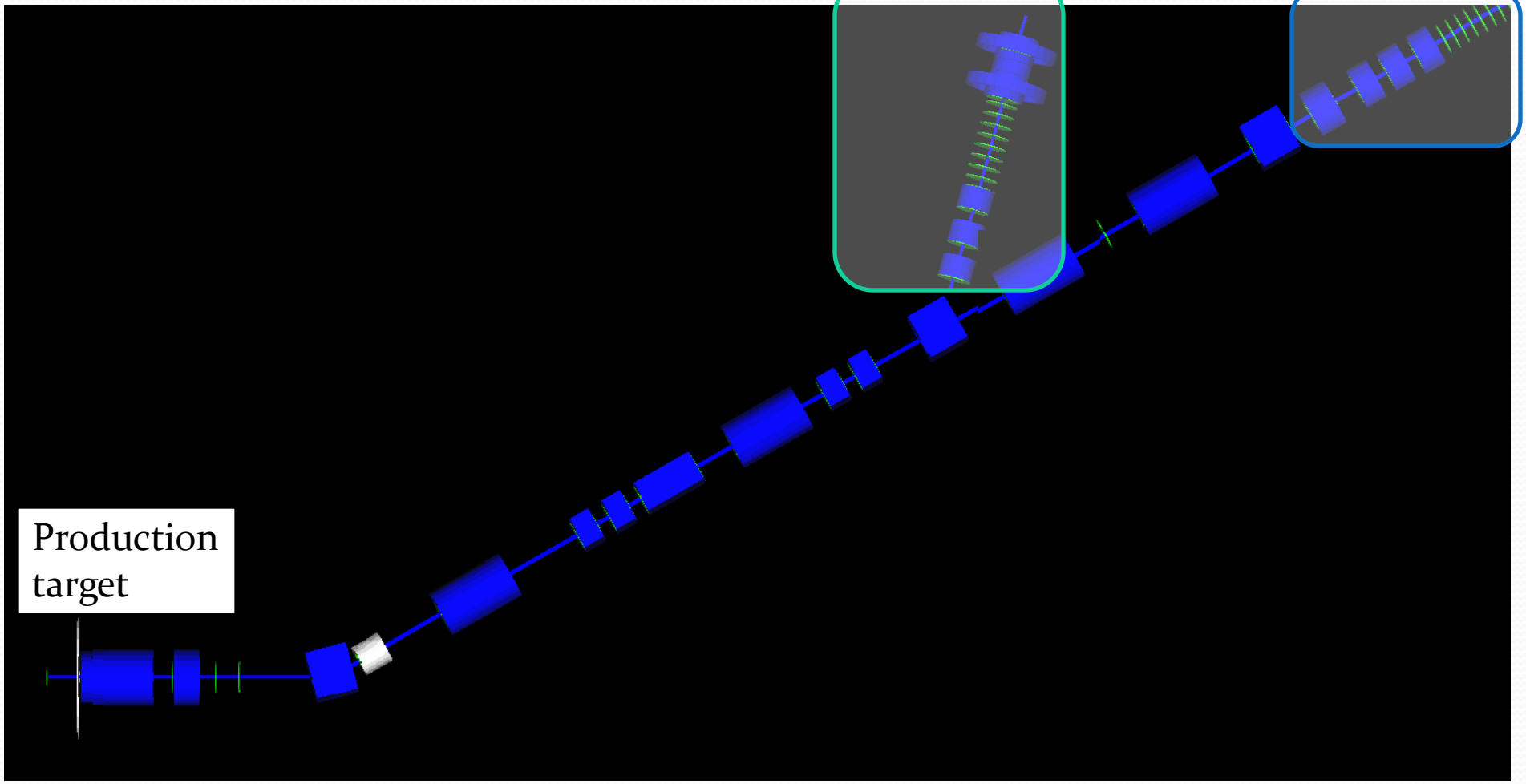
Outline

- g-2/EDM beamline Final Focus(FF) optimization
  - Requirements
  - Option 1: 1-Solenoid case
  - Option 2: 3-Quads case
  - Option 3: 1-Solenoid + 3-Quads case
  - Summary
- MuHFS beamline FF optimization
  - Requirements
  - 3-Quads + HFS magnet case
  - Summary

H-Line Layout



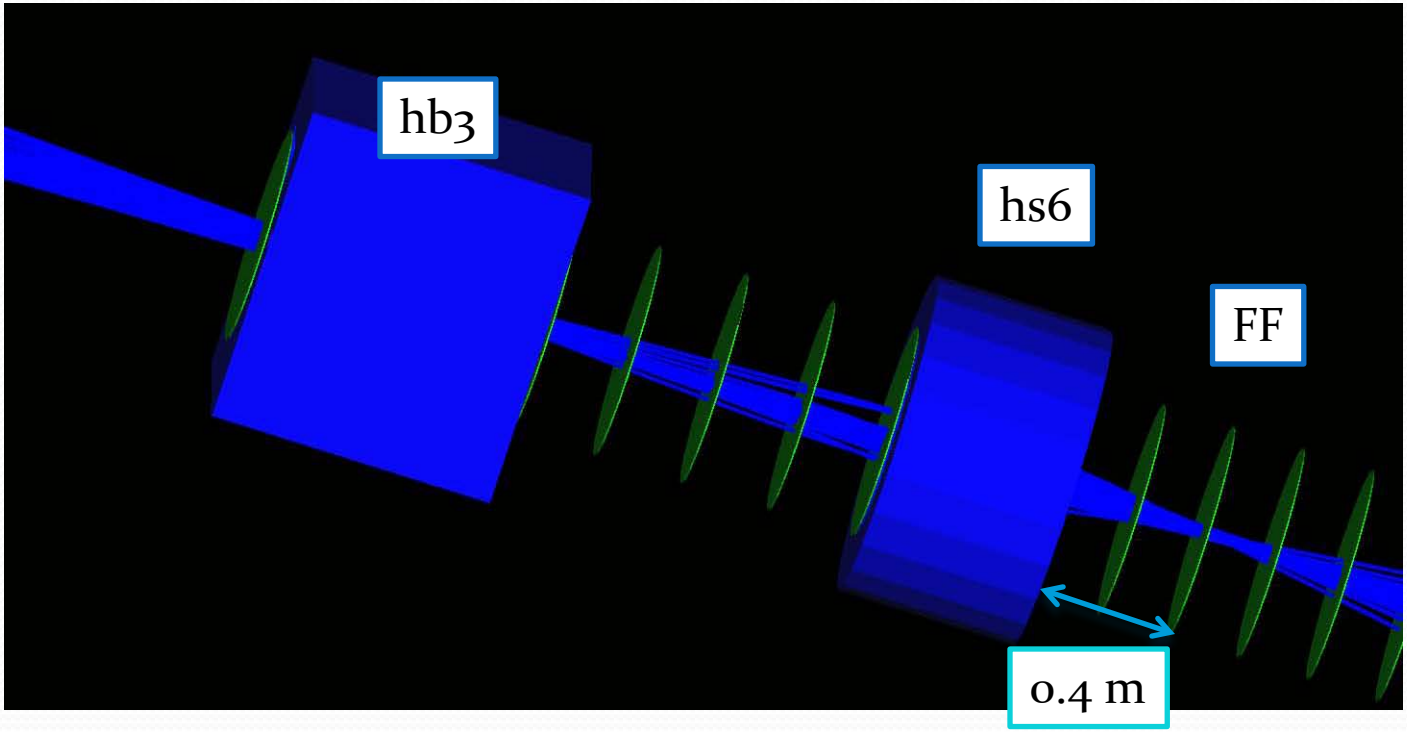
g-2/EDM beamline: Final focus

Requirements

- Transmission: as high as possible
- Focus point size < 4 cm ϕ
  - Small focus point helps to increase laser density.
- Leakage field of final focus magnets: as small as possible
  - This may affect slow muon beam transport

g-2/EDM BL: 1 Solenoid case

G4BL



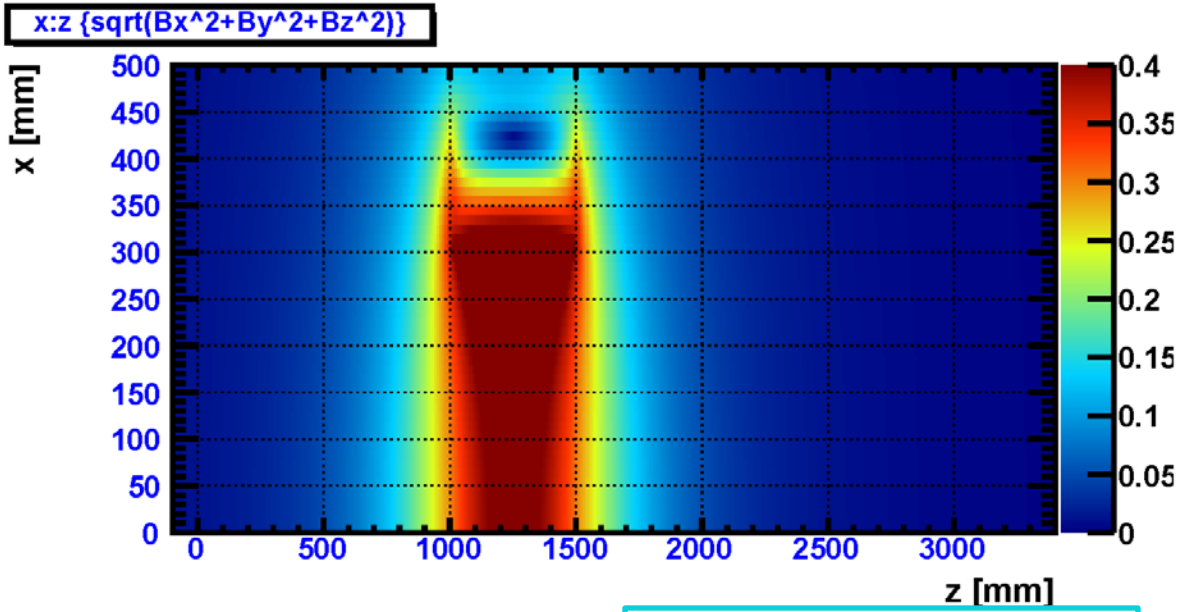
Profile @ FF

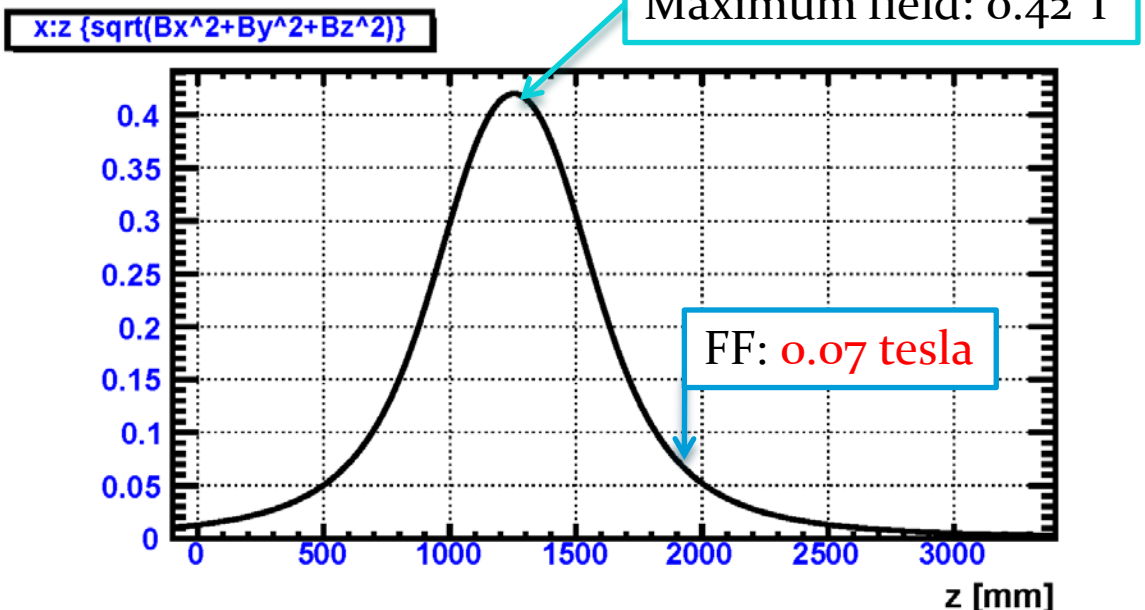
x 1.7 cm, xp 38.5 mrad , 87.5 % inside 40 ϕ

y 1.8 cm, yp 48.2 mrad

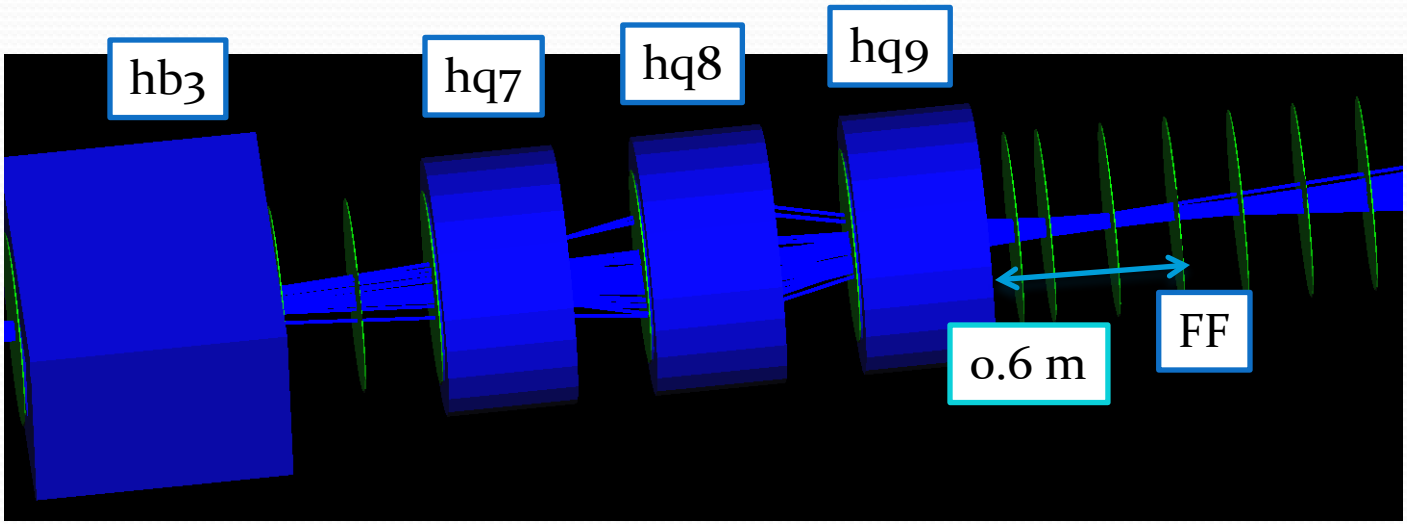
g-2/EDM BL: hs6 field by G4BL

hs6





g-2/EDM BL: 3 Quads case (w/ hs5 tuning)

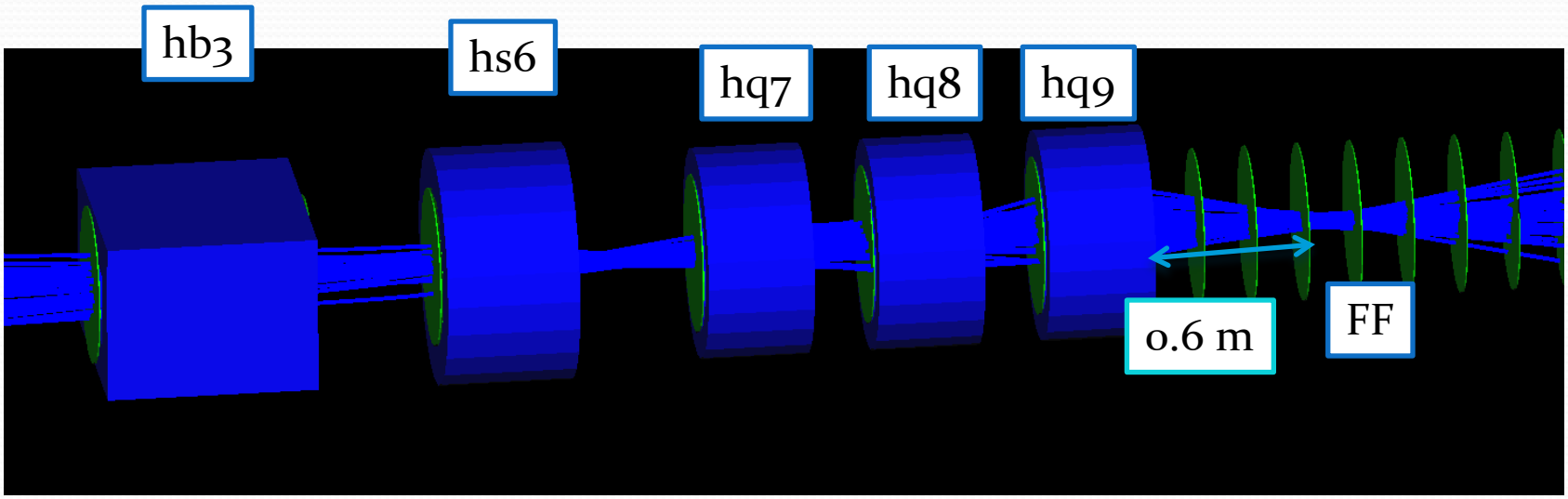


Profile @ FF

x 3.5 cm, xp 46.9 mrad, 63.7 % inside 40 ϕ

y 0.8 cm, yp 97.8 mrad

g-2/EDM BL: 1 Sol +3 Quads case



Profile @ FF
x 2.1 cm, xp 50.6 mrad, 83.4 % inside 40 ϕ
y 1.1 cm, yp 95.7 mrad

Summary and future plans: g-2/EDM

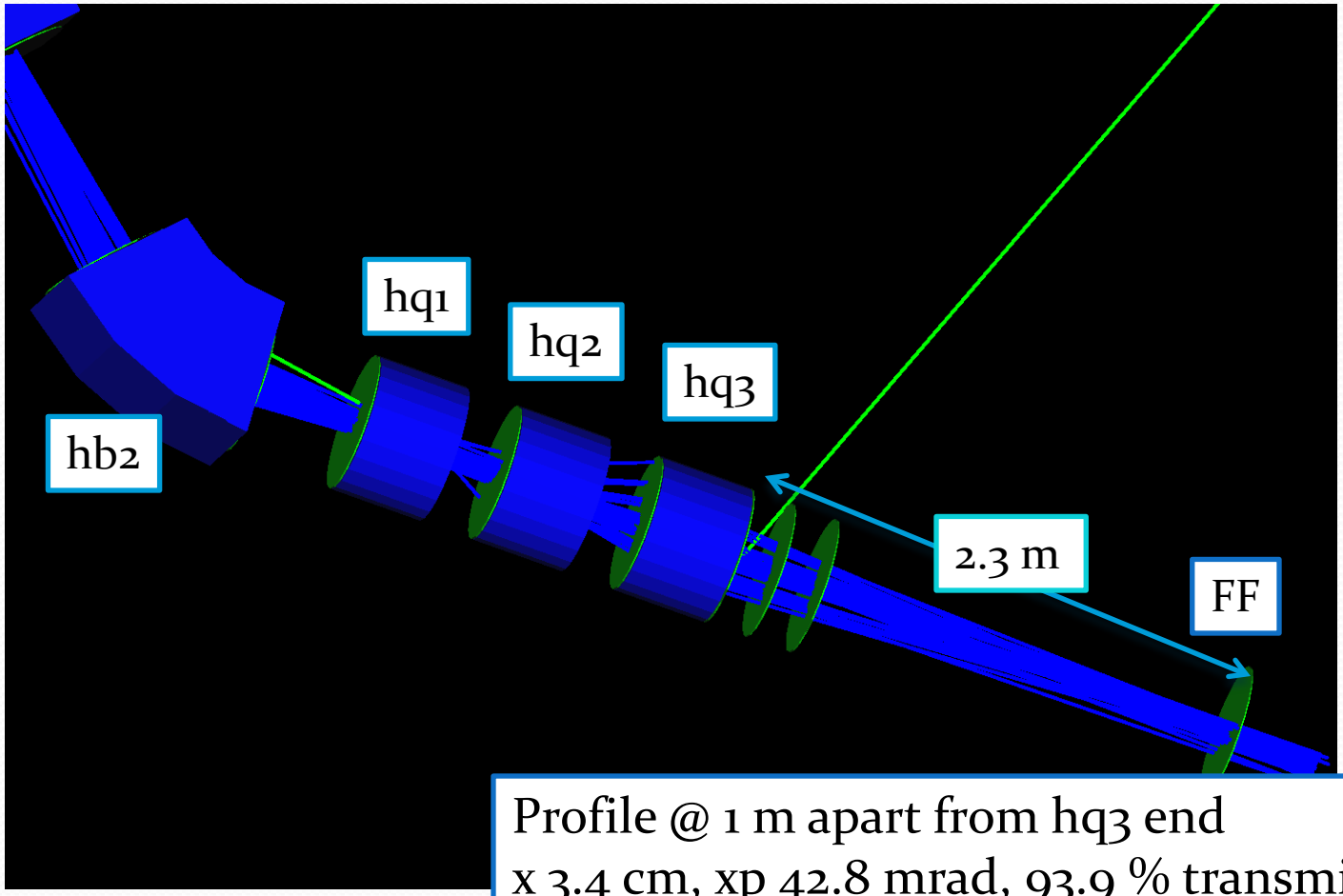
- Option 1: 1 solenoid for FF
  - Beam size is small: σx 1.7 cm, σy 1.8 cm, 87.5 % inside 40 ϕ.
  - Distance between solenoid end and FF is 0.4 m
  - Leakage field to FF is as high as 0.07 T, thus some magnetic shield is necessary.
- Option 2: 3 Quads (+ hs5 tuning)
  - Beam size is: σx 3.5 cm, σy 0.8 cm, 63.7 % inside 40 ϕ.
  - Distance between last Q end and FF is 0.6 m
- Option 3: 1 solenoid + 3 Quads
  - Beam size is small: σx 2.1 cm, σy 1.1 cm, 83.4 % inside 40 ϕ.
  - Distance between last Q end and FF is 0.6 m
- Future plans
  - 3 Quads + hs1-4 tuning to maximize intensity inside 40 ϕ.
  - Estimation of Q leakage field to FF
  - Short version

MuHFS beamline: Final focus

Requirements

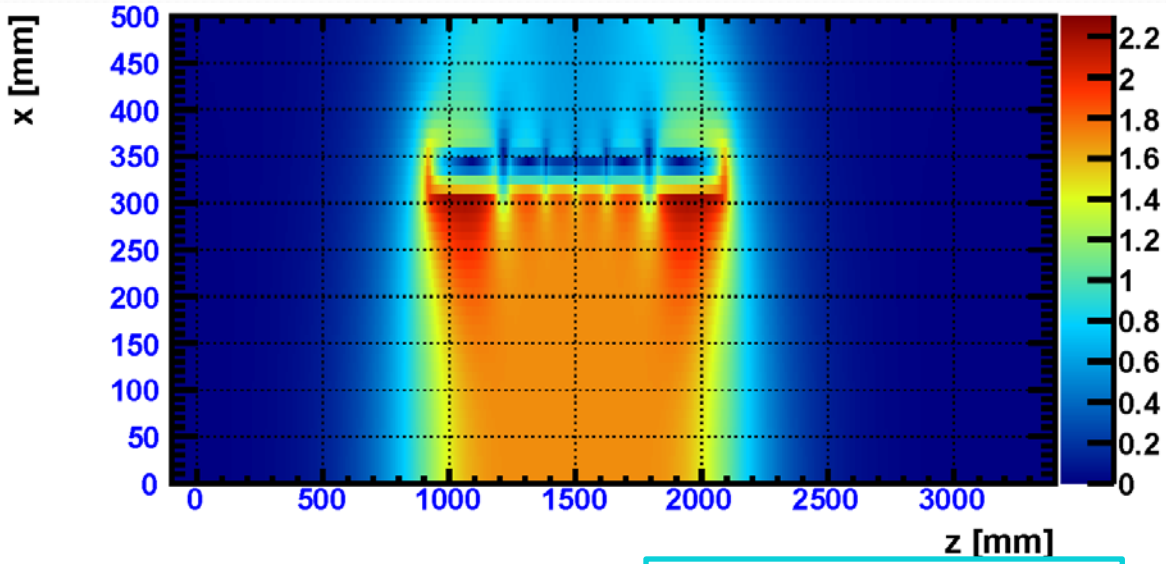
- Transmission: as high as possible
- Focus point size < 6 cm ϕ
  - all muons inside good field region of HFS magnet (20 cmϕ)
  - Not so difficult due to high HFS solenoid field
- Momentum spread: muon stopping distribution
  - all muons inside good field region of HFS magnet (30 cm long)
- Leakage field of final focus magnets: less than 1.7 gauss(100 ppm)
  - limit of magnetic field correction by HFS magnet Shim coil

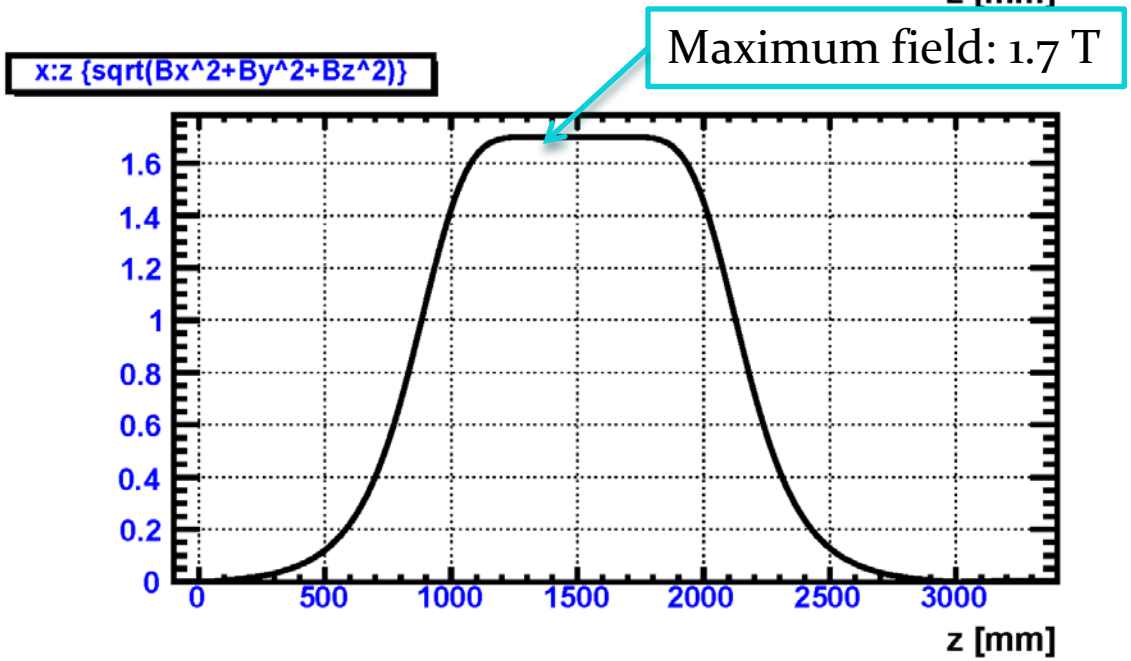
MuHFS BL: 3 Quads No HFS case



Profile @ 1 m apart from hq3 end
x 3.4 cm, xp 42.8 mrad, 93.9 % transmission
y 3.0 cm, yp 34.8 mrad

MuHFS: HFS magnetic field

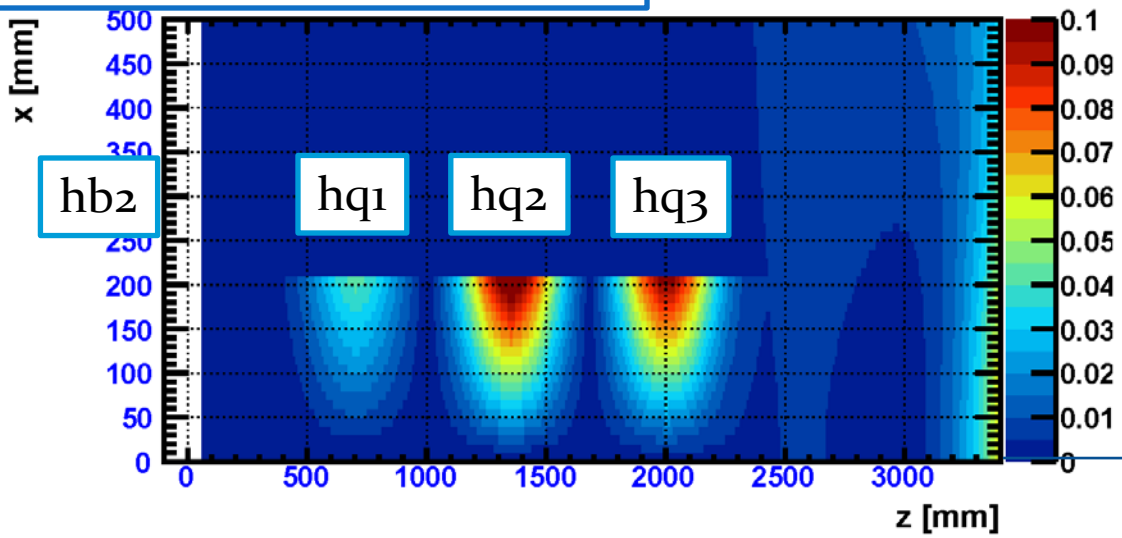




Consistent
with Opera calculation
by Sasaki-san

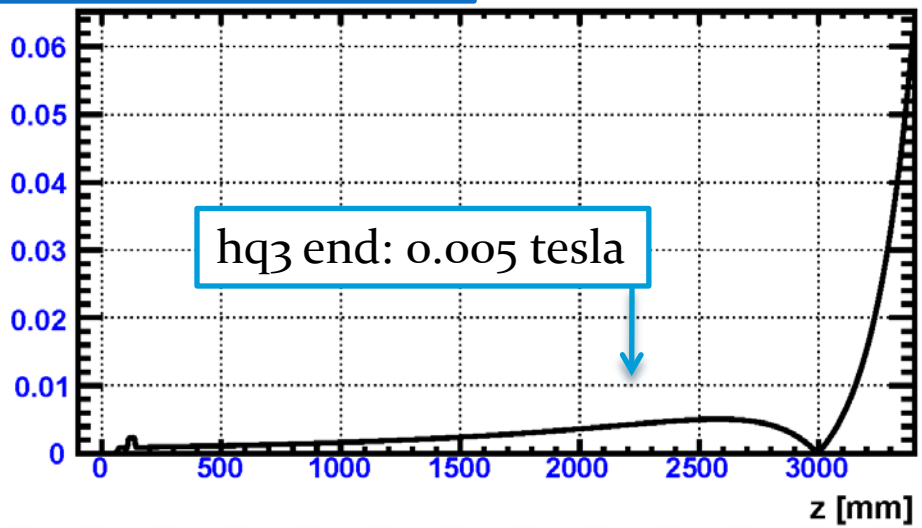
MuHFS: HFS magnetic field

Magnetic field map on x-z plane



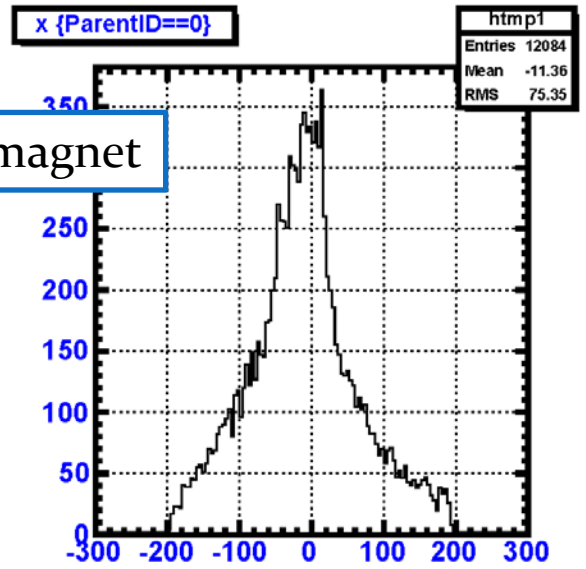
HFS center: 4500 mm

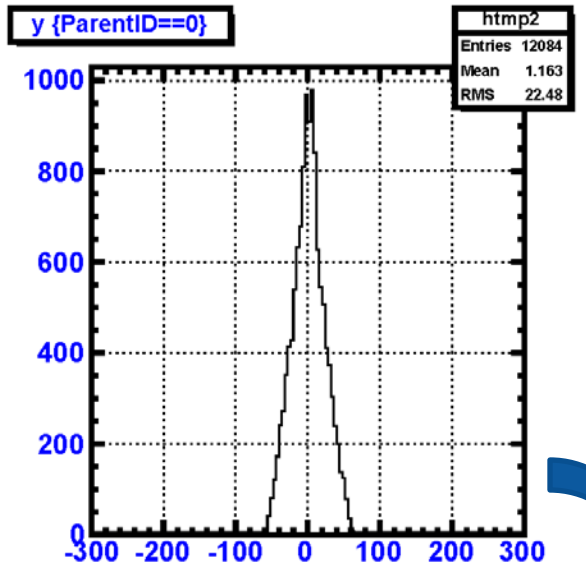
Magnetic field on beam axis



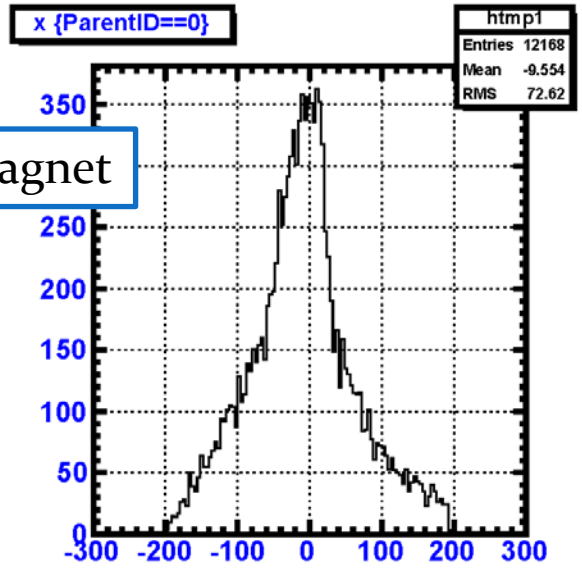
MuHFS: HFS leakage field effect @ hq3 end

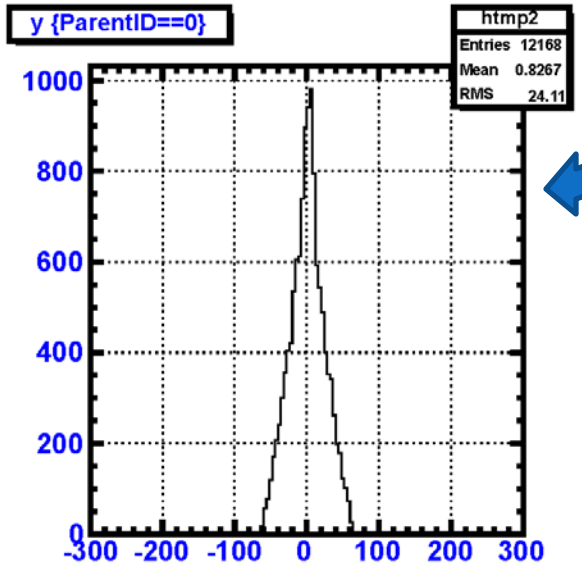
w/o HFS magnet





w/ HFS magnet

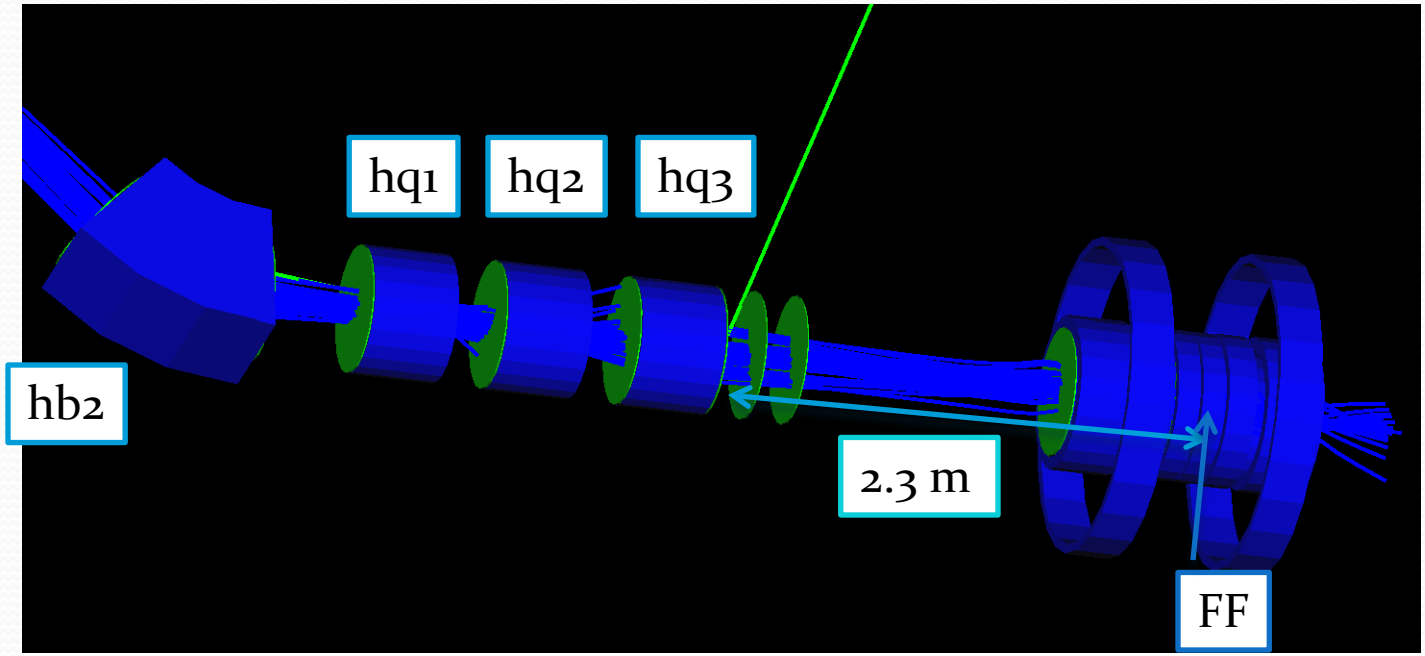




Almost the same

HFS leakage field does not seriously affect beam profile.

MuHFS BL: 3 Quads+HFS



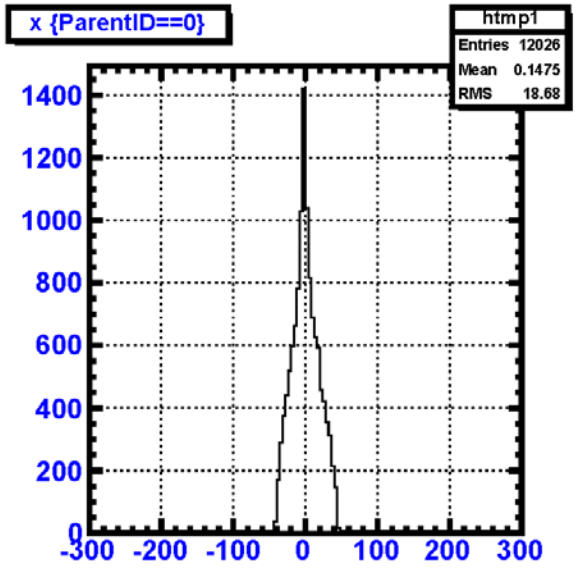
Profile @ FF
x 1.3 cm, xp 161.5 mrad, 93.6 % transmission
y 1.3 cm, yp 137.4 mrad

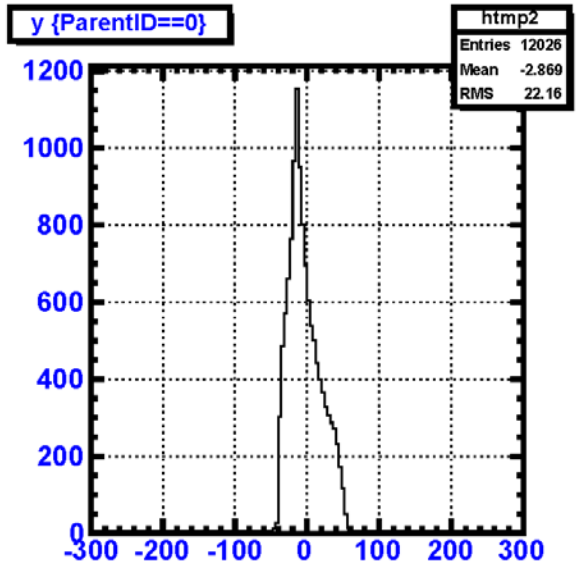
Summary and future plans: MuHFS

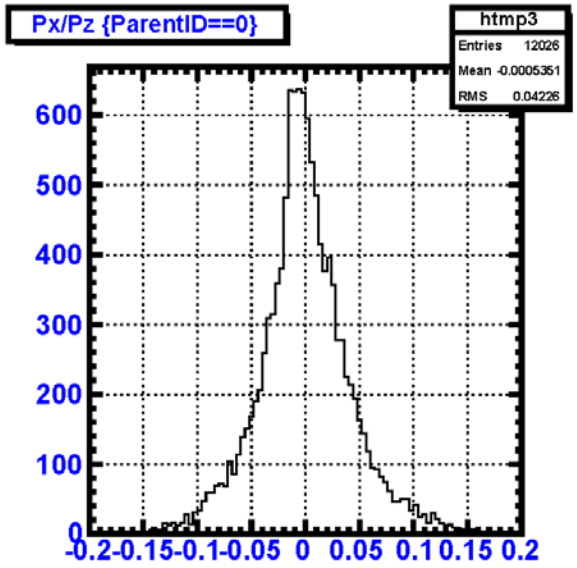
- 3 Quads + HFS magnet for FF
  - Beam size is small: σx 1.3 cm, σy 1.3 cm, 93.6 % transmission
  - Distance between last Q end and FF is 2.3 m
  - Leakage field at last Q is as small as 0.005 T
- Future plans
  - Leakage field of beamline magnets in HFS magnet region
  - Muon stopping distribution estimation

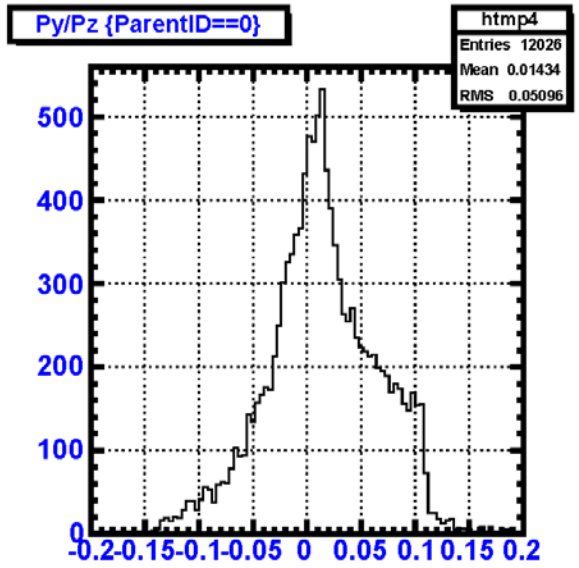
Spare slides

g-2: 1 Sol profile

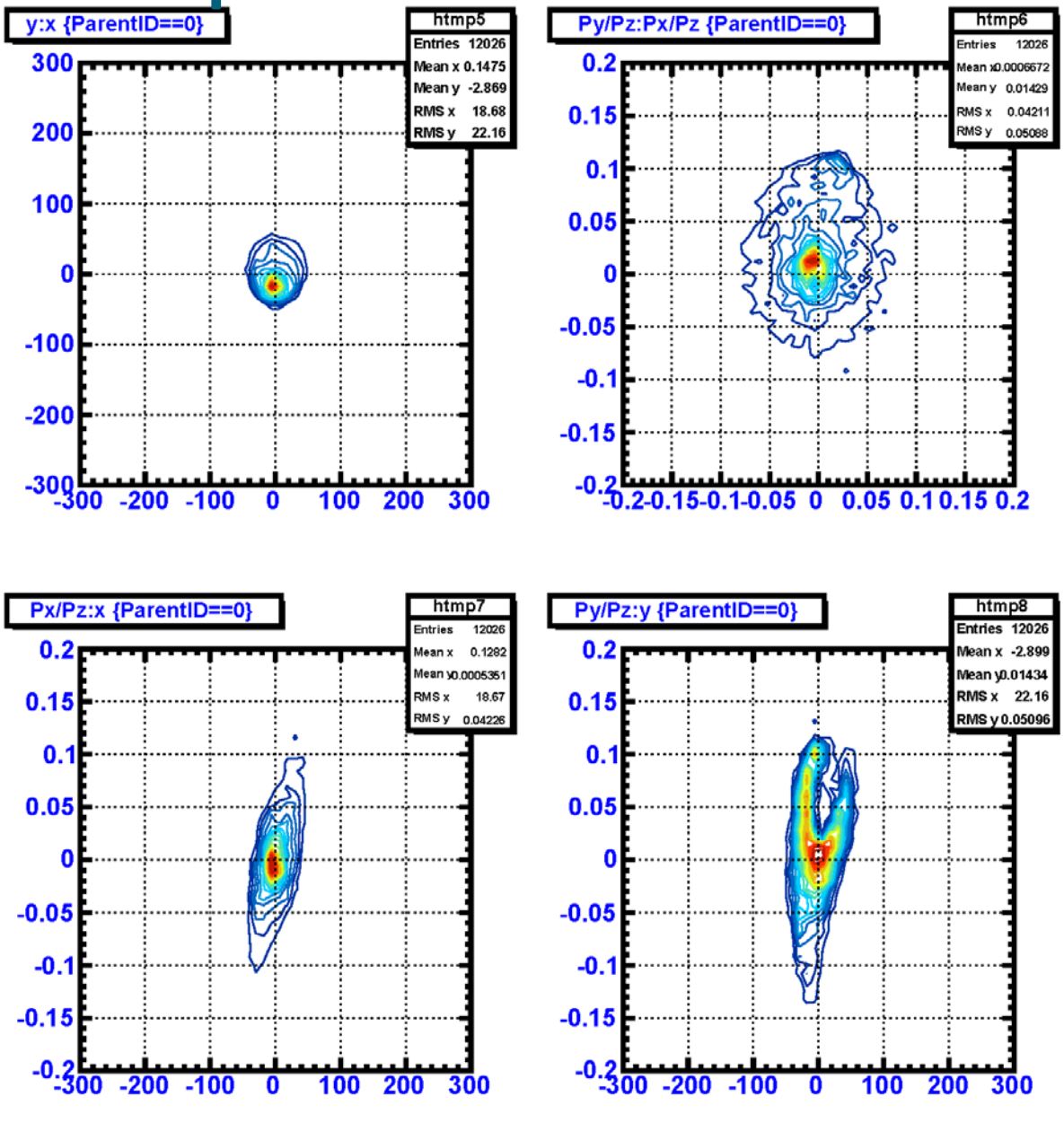




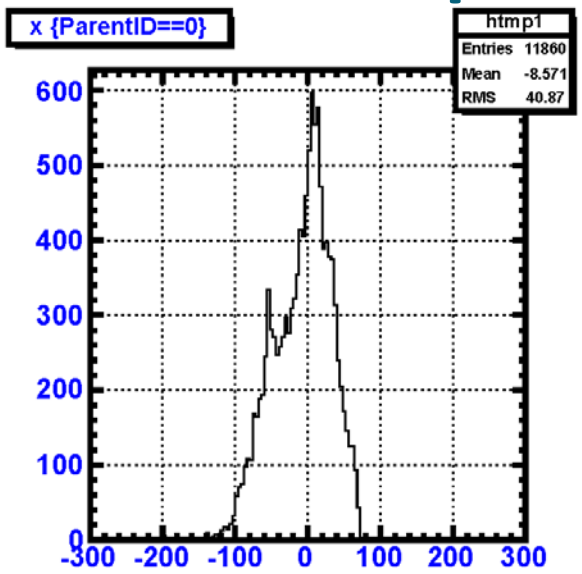


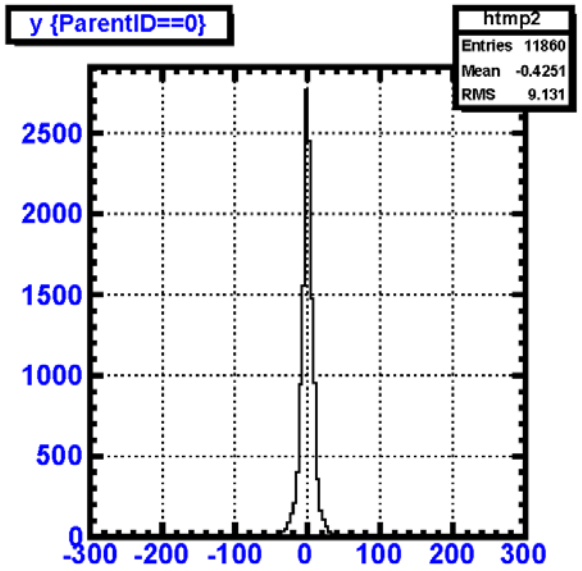


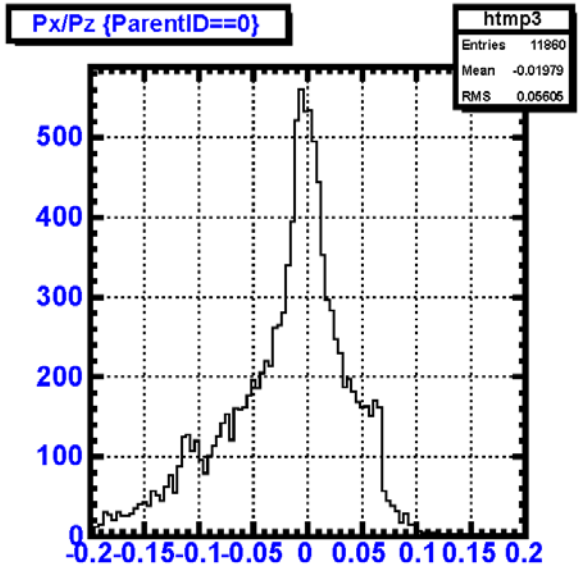
g-2: 1 Sol profile

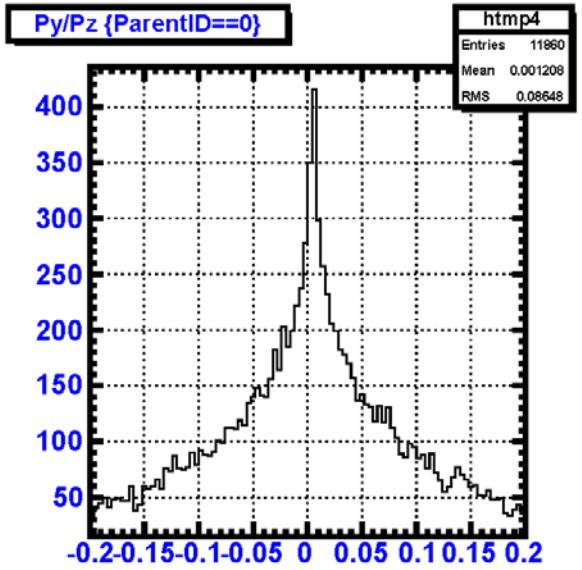


g-2: 3 Quads profile

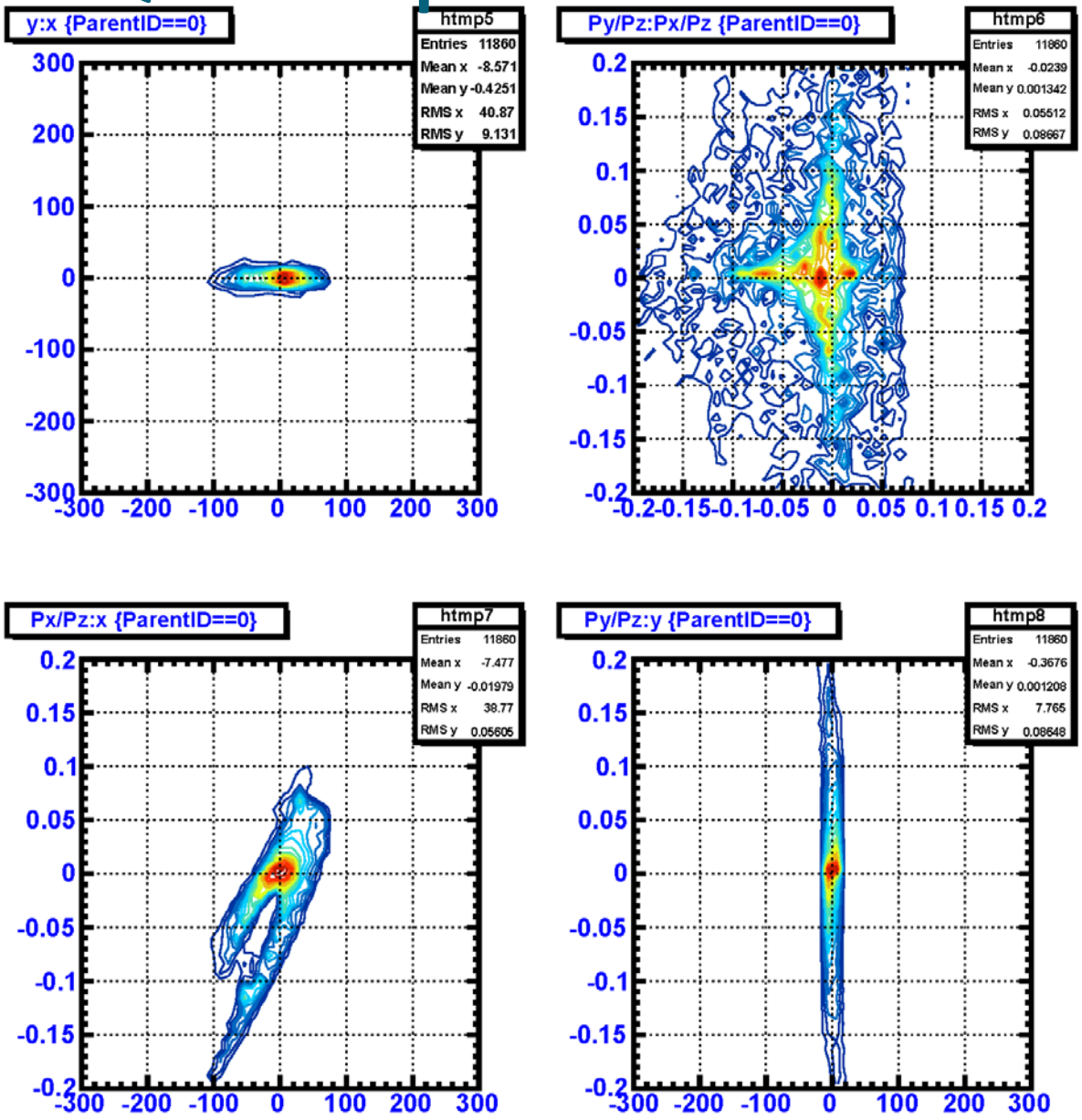




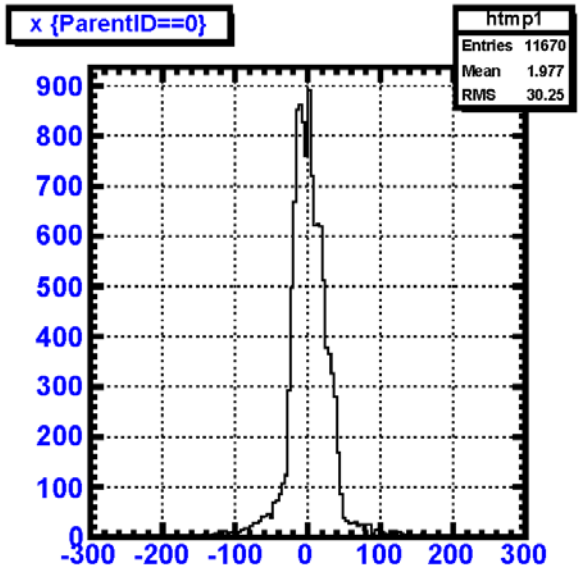


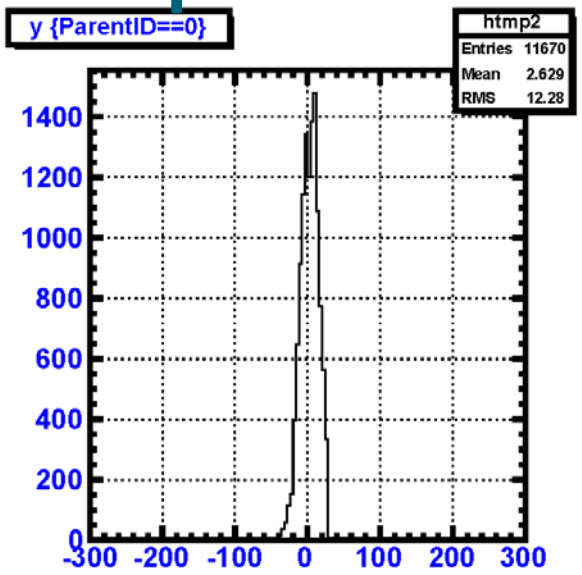


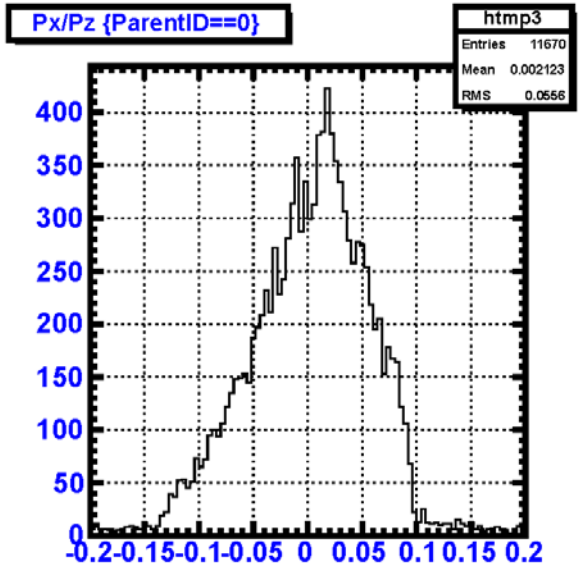
g-2: 3 Quads profile

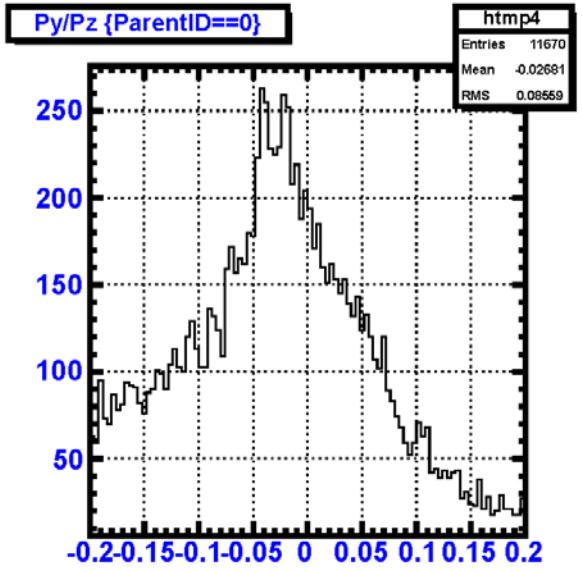


g-2: 1 Sol+3 Quads profile

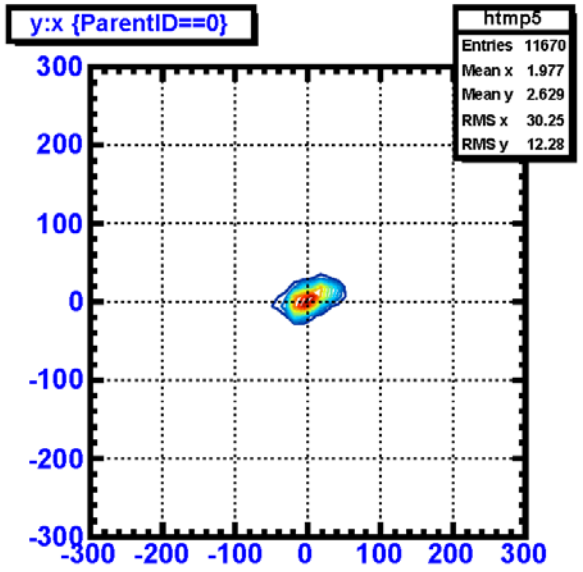


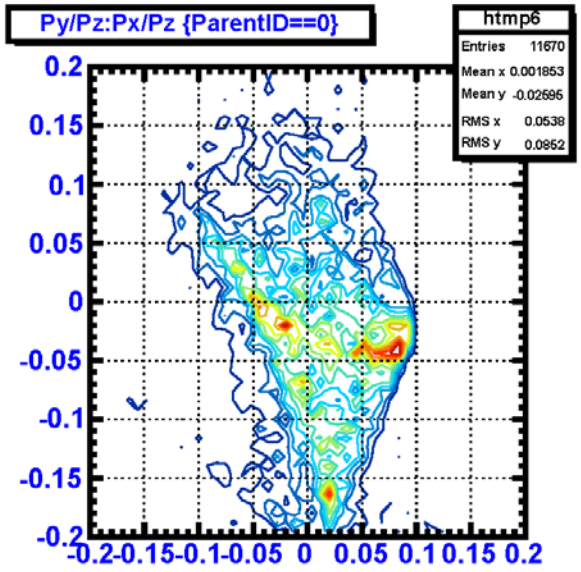


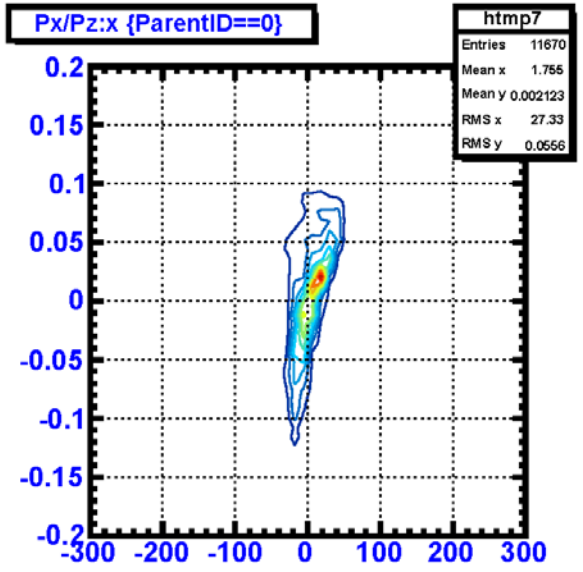


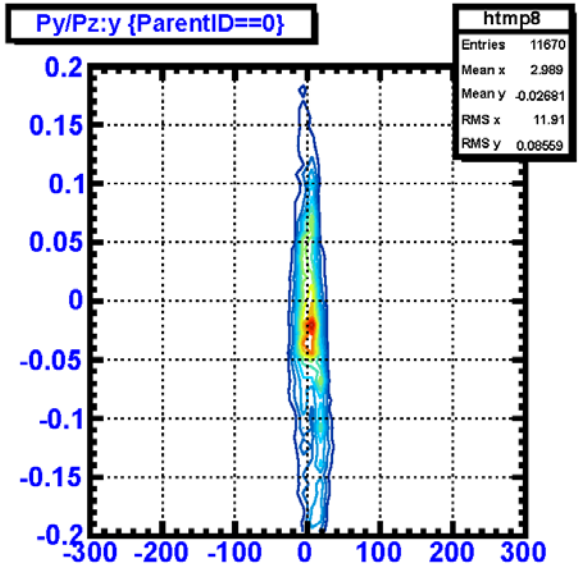


g-2: 1 Sol+3 Quads profile

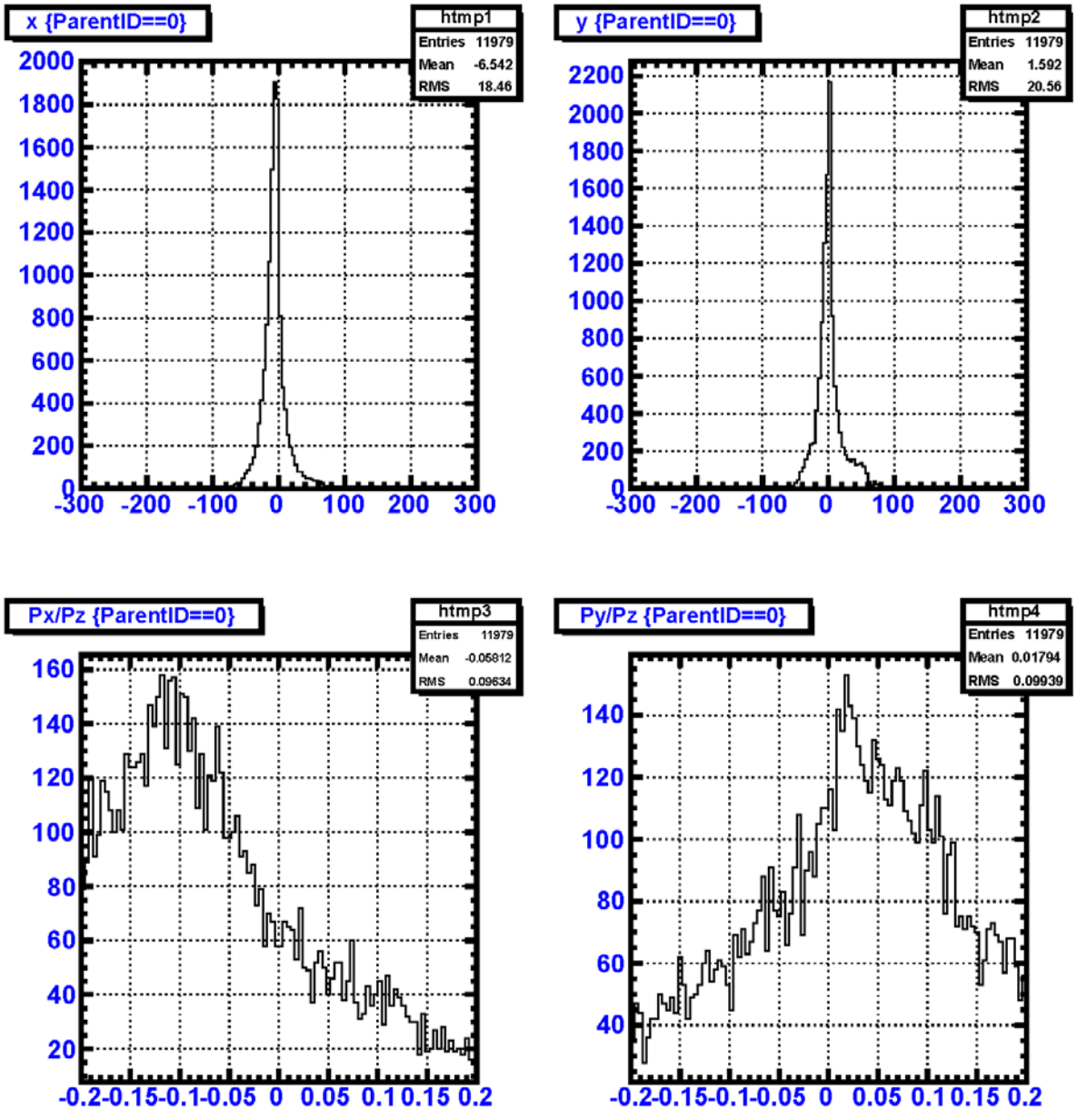




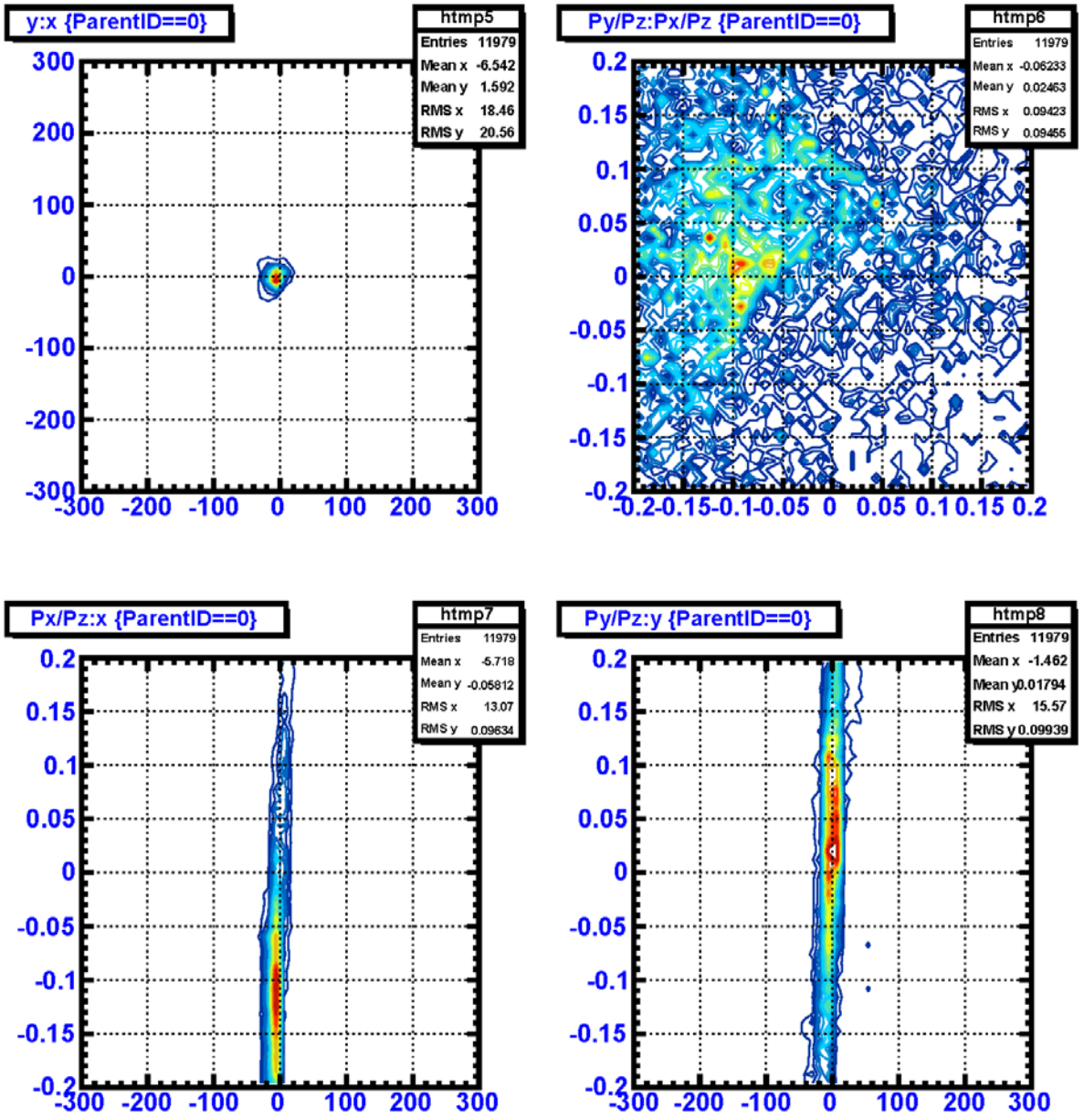




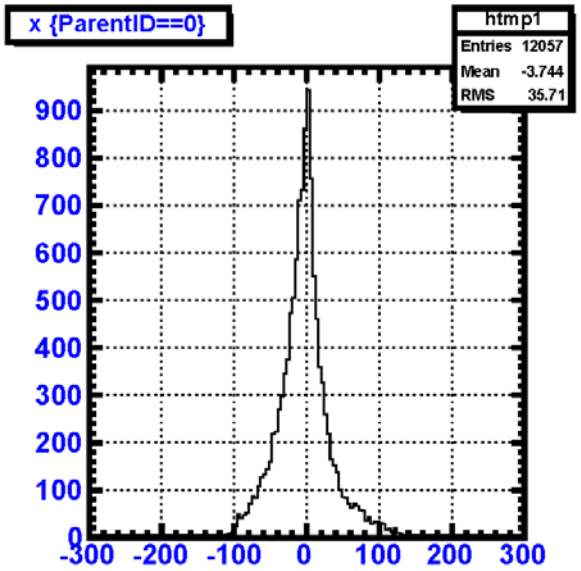
MuHFS: 3 Quads profile

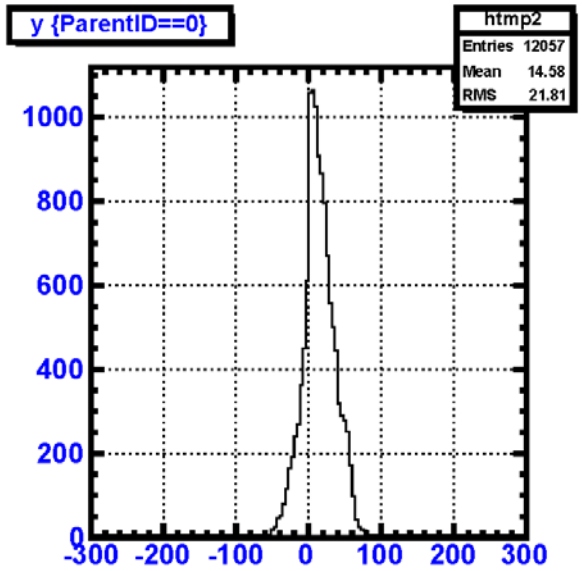


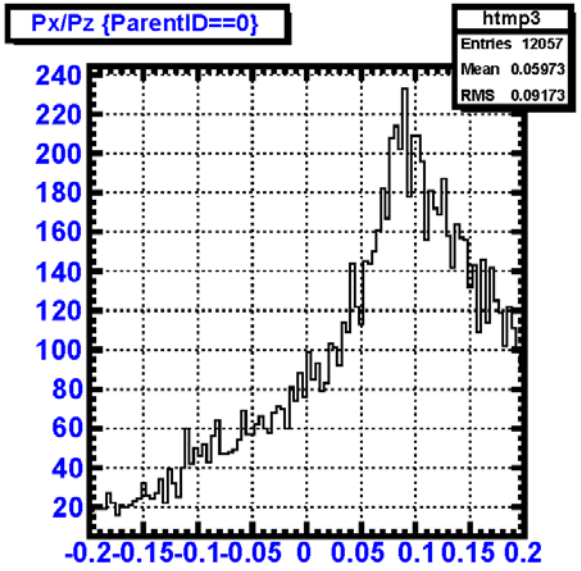
MuHFS: 3 Quads profile

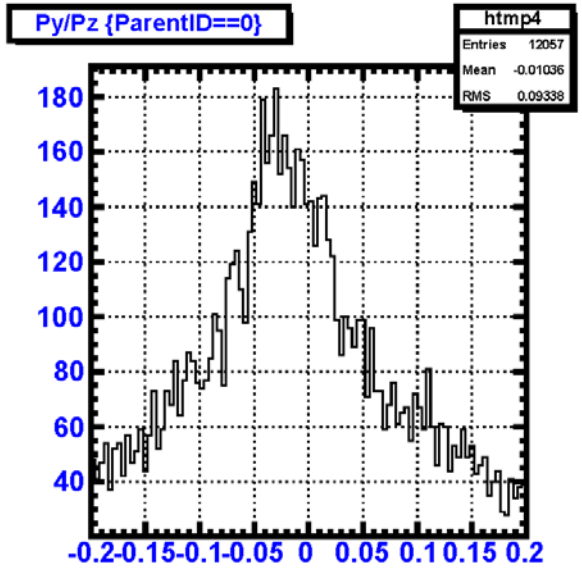


MuHFS: 3 Quads profile@hfs entrance

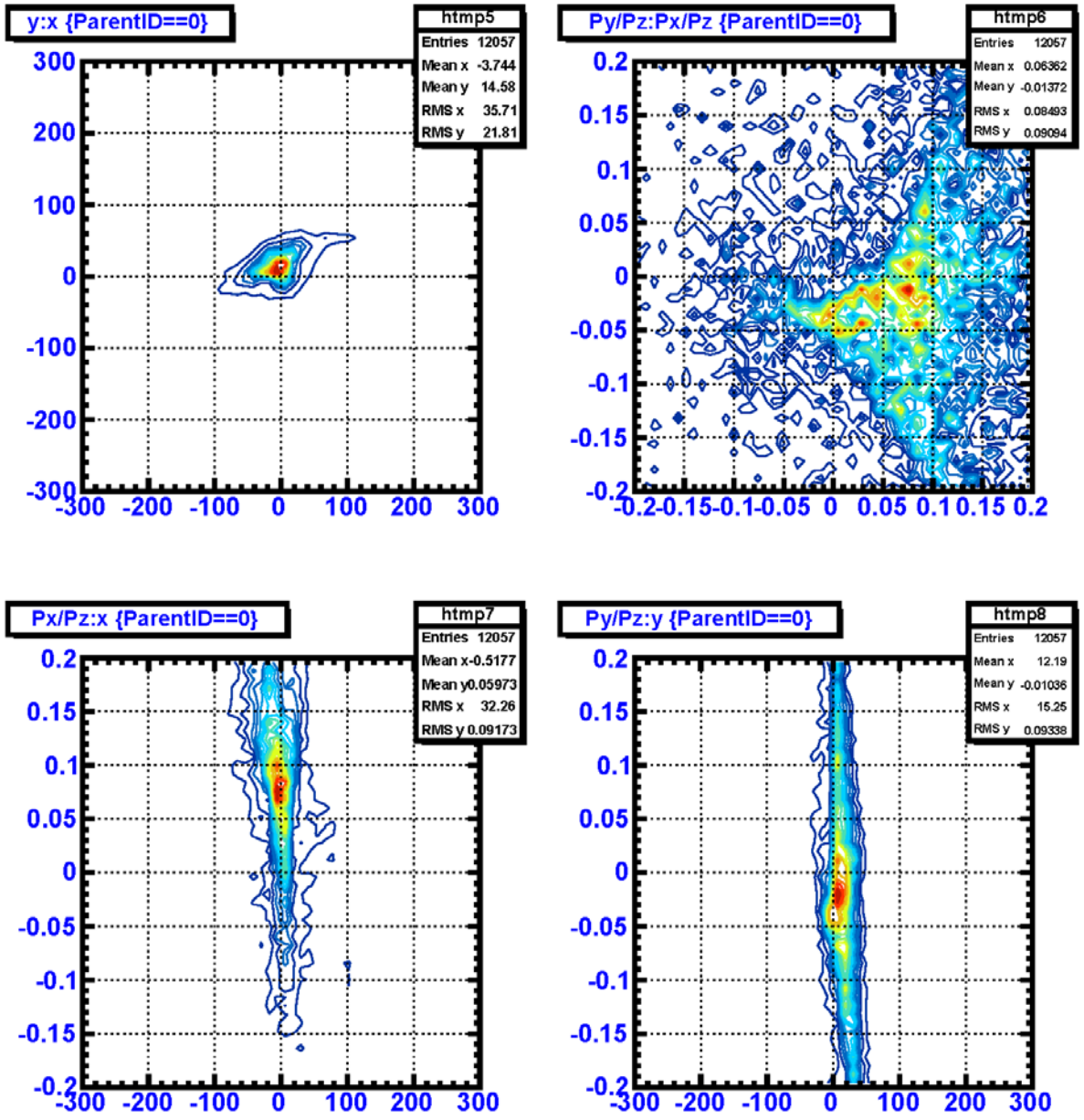






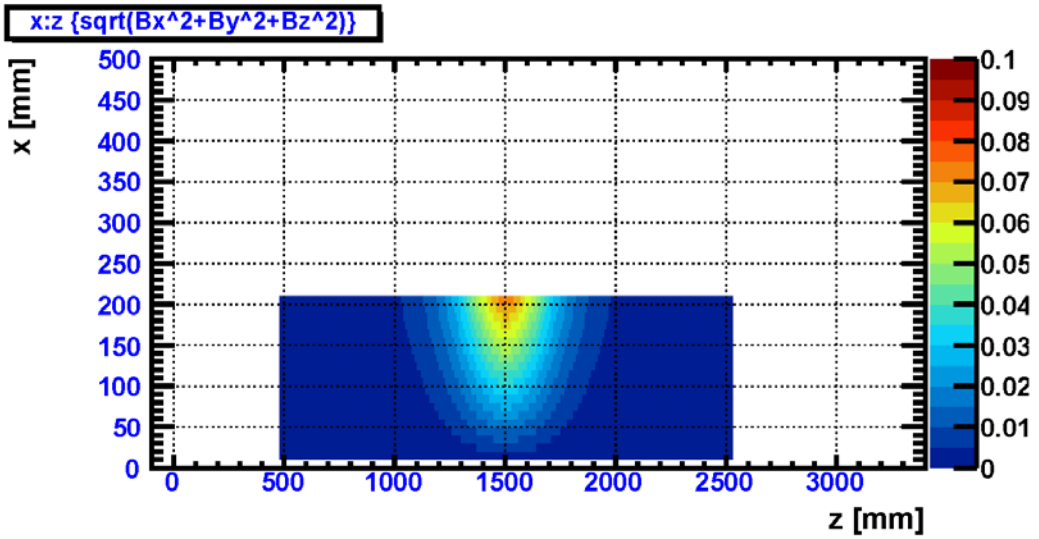


MuHFS: 3 Quads profile profile@hfs entrance



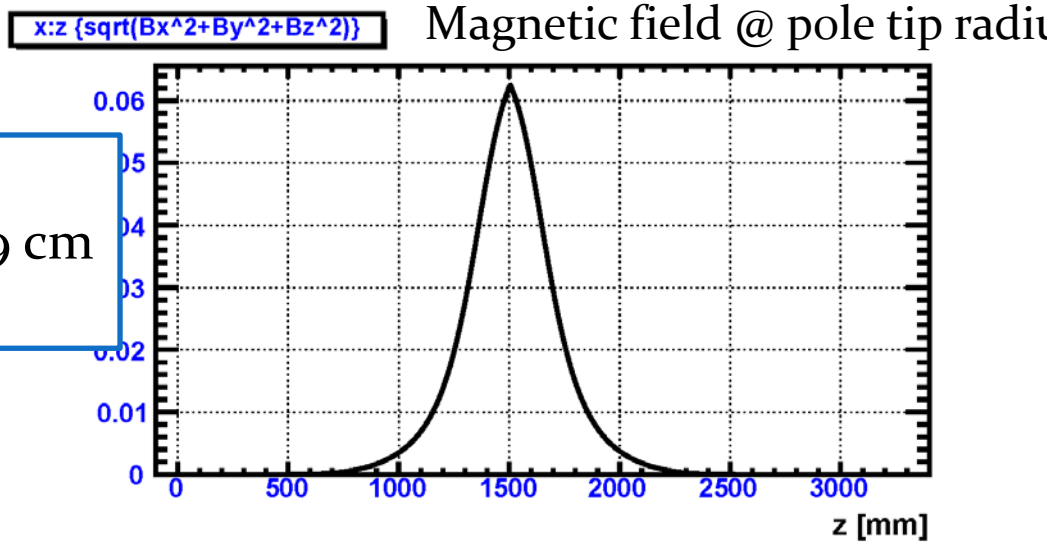
Q fringing field

hq1 without fringe parameters



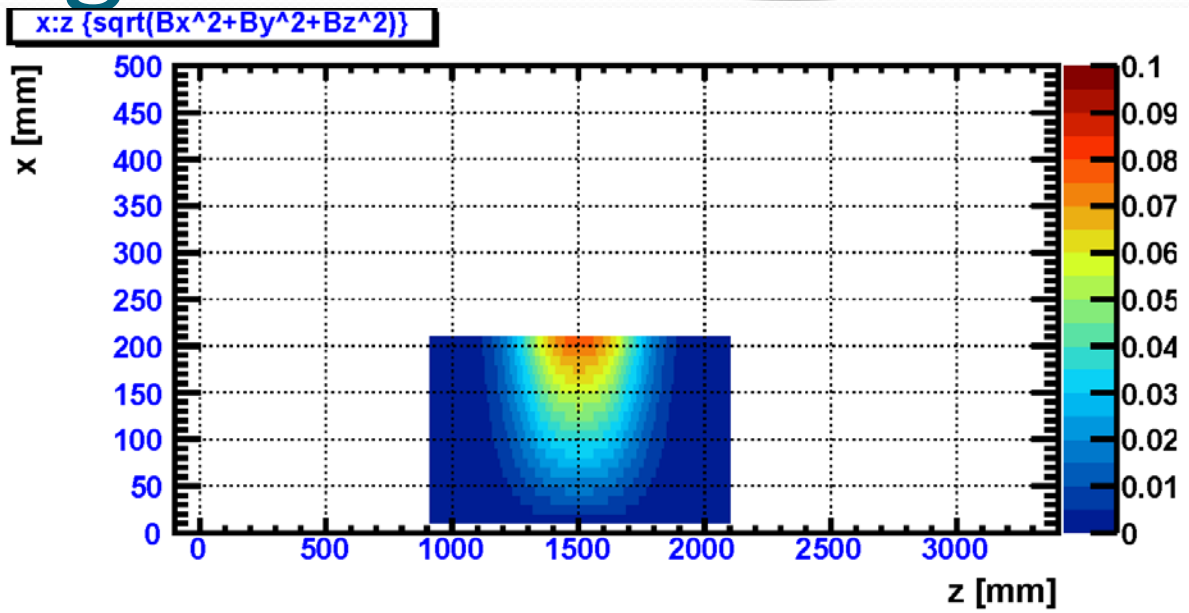
Magnetic field @ pole tip radius = 175 mm

Profile @ FF , w/o HFS
RMSx 2.7 cm, RMSy 2.9 cm
94.6 % transmission



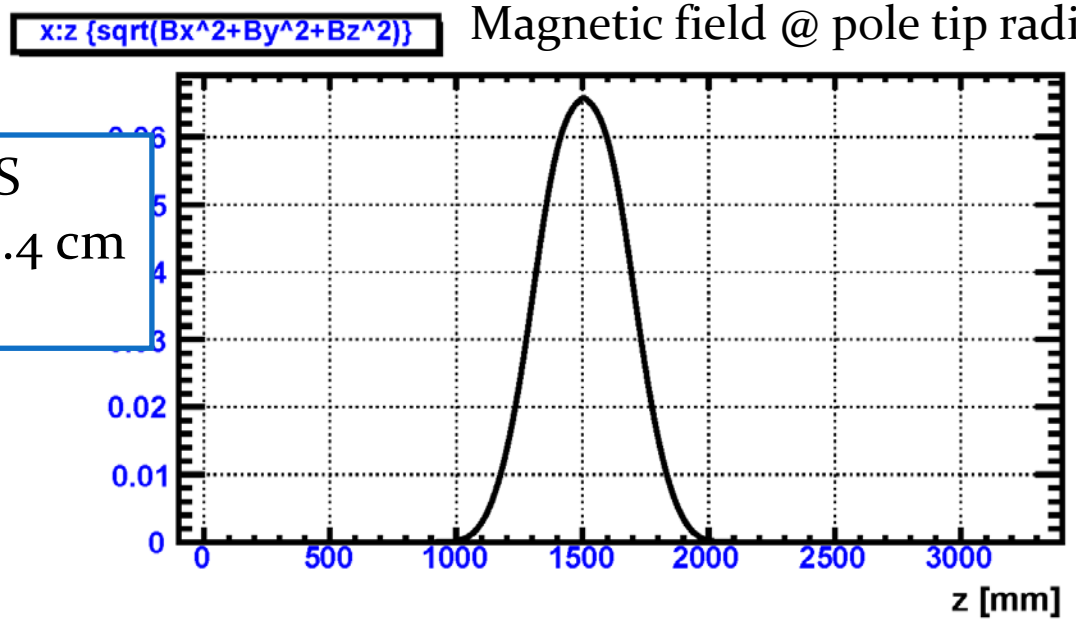
Q fringing field

hq1 with dq2 fringe parameters,
FieldLength=506.037
param=0.5873,5.894,
-0.5713,5.784,
2.947,-1.054



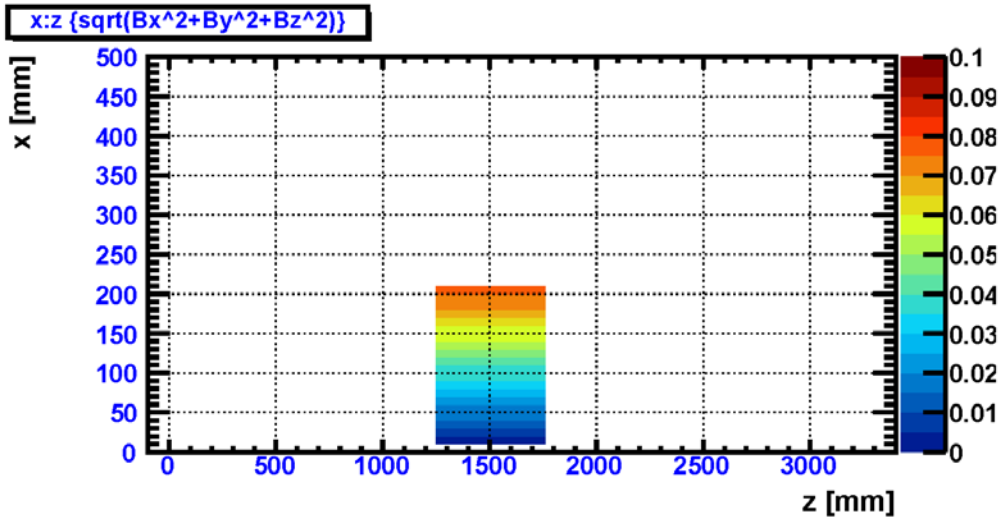
Magnetic field @ pole tip radius = 175 mm

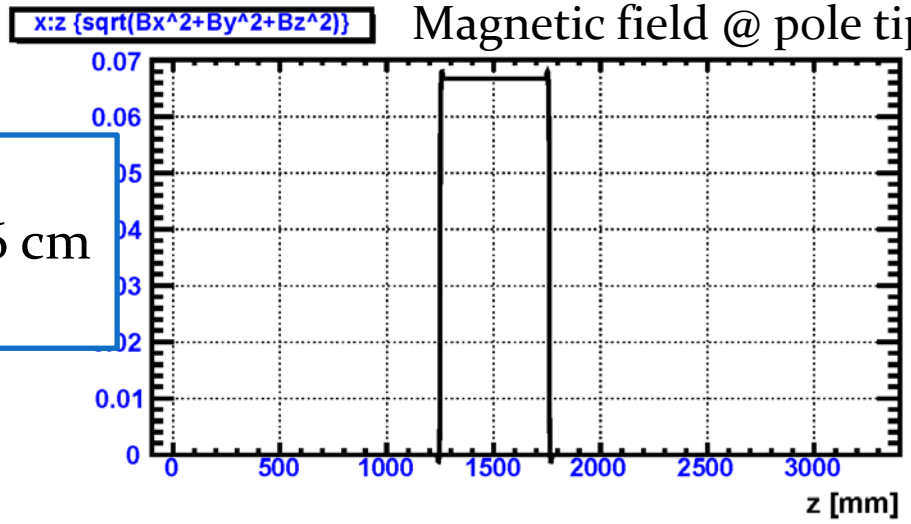
Profile @ FF, w/o HFS
RMSx 3.1 cm, RMSy 3.4 cm
96.3 % transmission



Q fringing field

hq1 with fringe parameters,
FieldLength=506.037
param=0.0 ,0.0,
0.0,0.0,
0.0,0.0

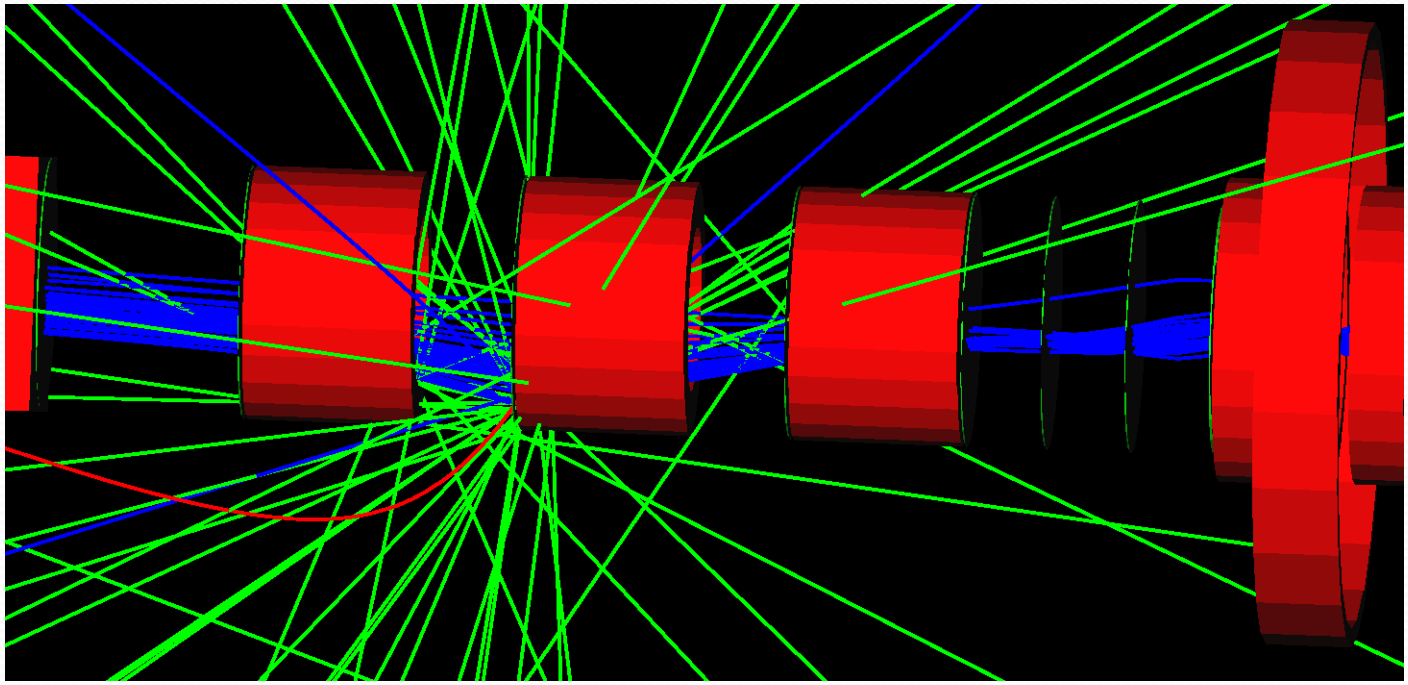




Magnetic field @ pole tip radius = 175 mm

Profile @ FF , w/o HFS
RMSx 10.7 cm, RMSy 1.6 cm
93.0 % transmission

Q fringing field w/ HFS mag.

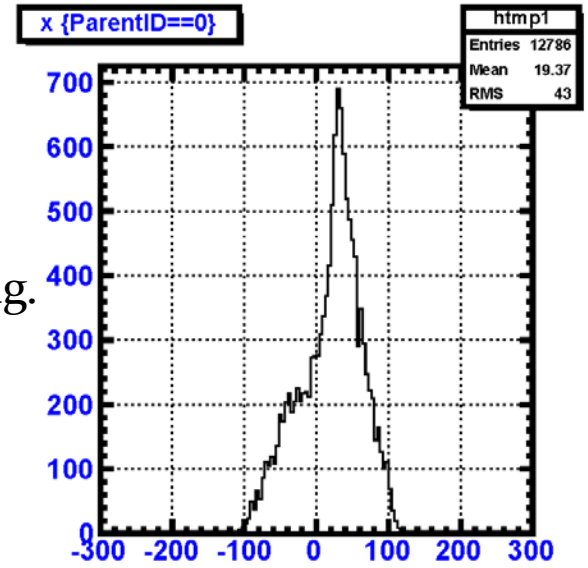


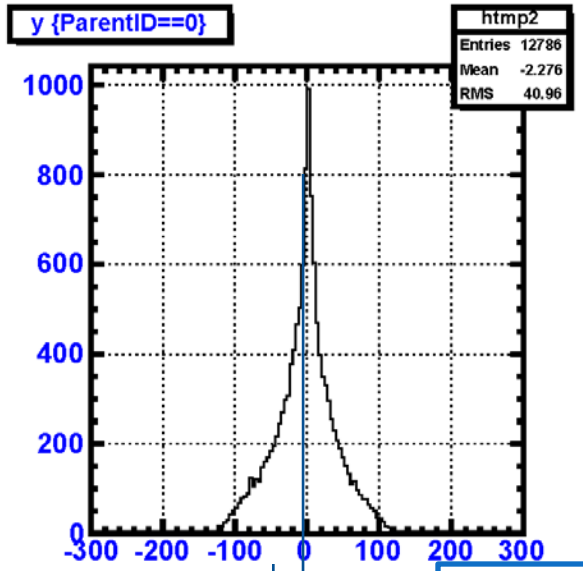
Profile @ FF , w/o Q fringe w/ HFS
RMSx 1.5 cm, RMSy 2.6 cm
66.5 % transmission

Profile @ FF , w/ Q fringe w/ HFS
RMSx 1.5 cm, RMSy 2.6 cm
71.4 % transmission

hb2 end profile w/o, w/ HFS mag

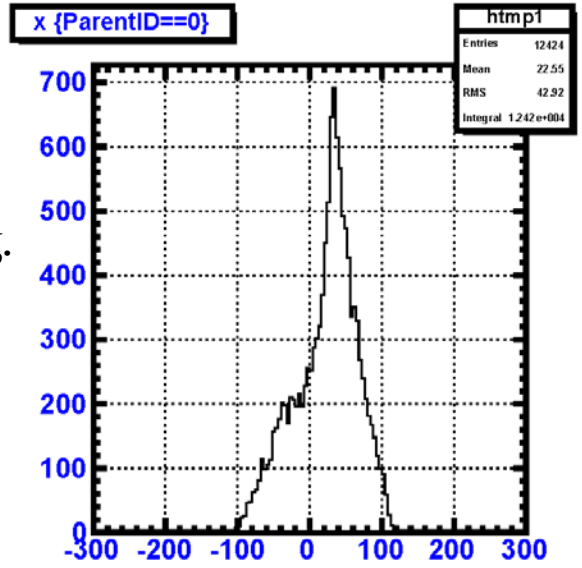
w/o HFS mag.

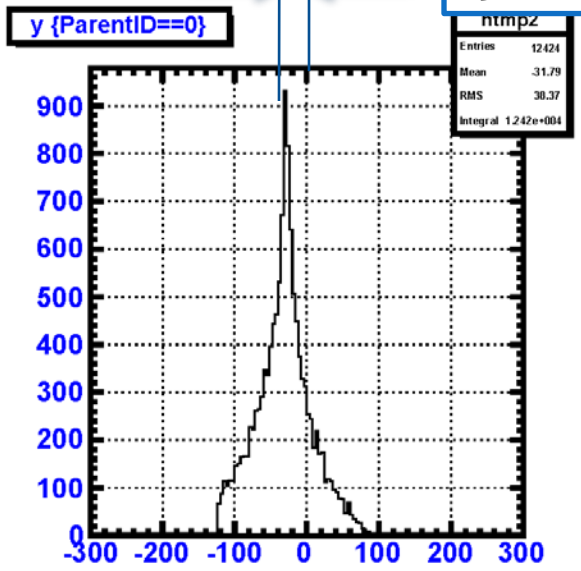




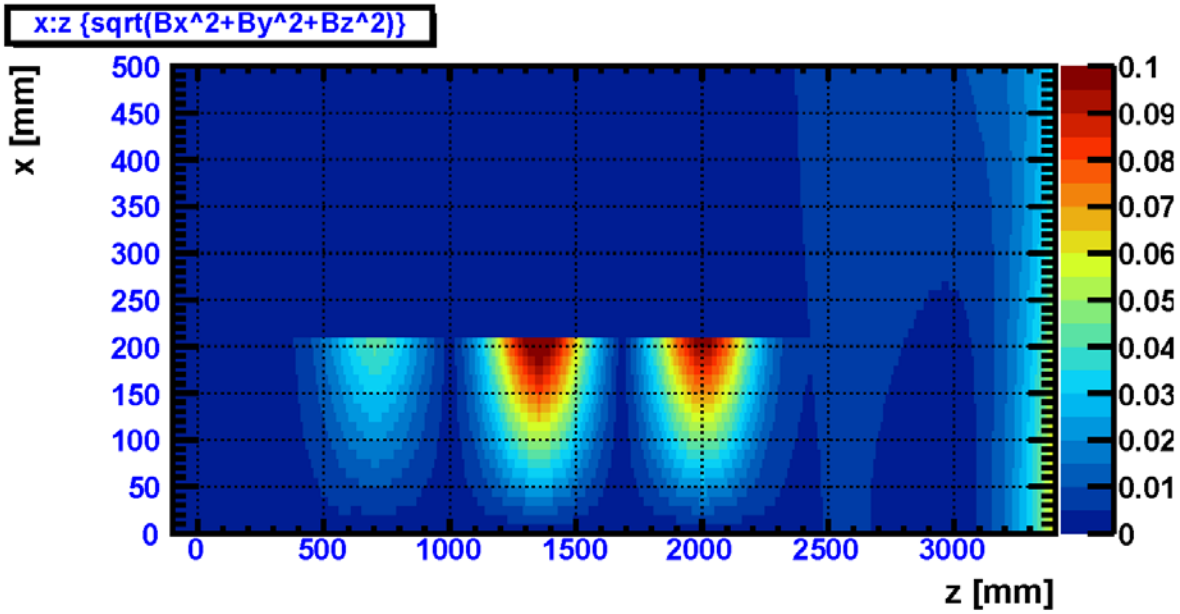
-30 mm shift!

w/ HFS mag.

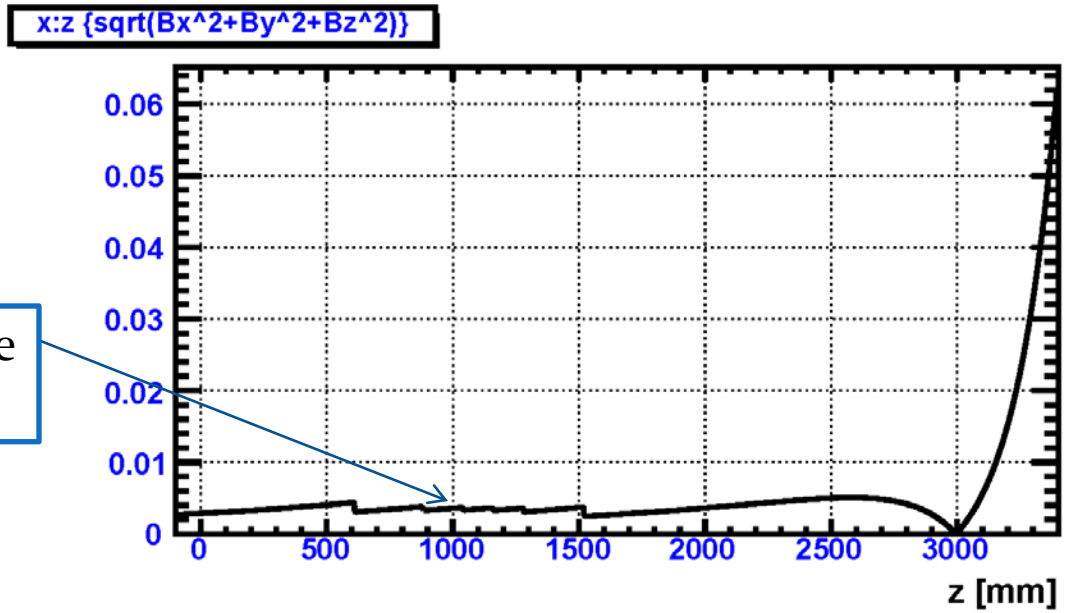




HFS field map at around Quads



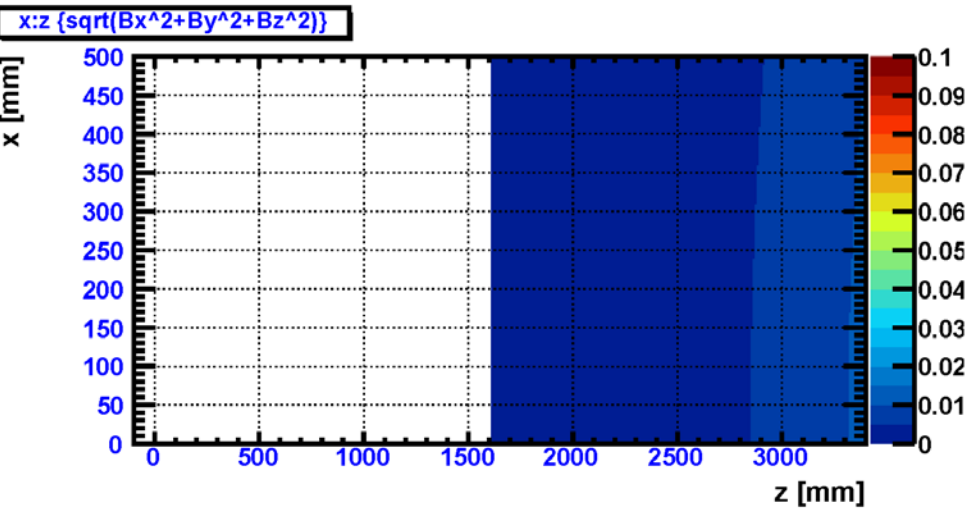
HFS center: 4500 mm

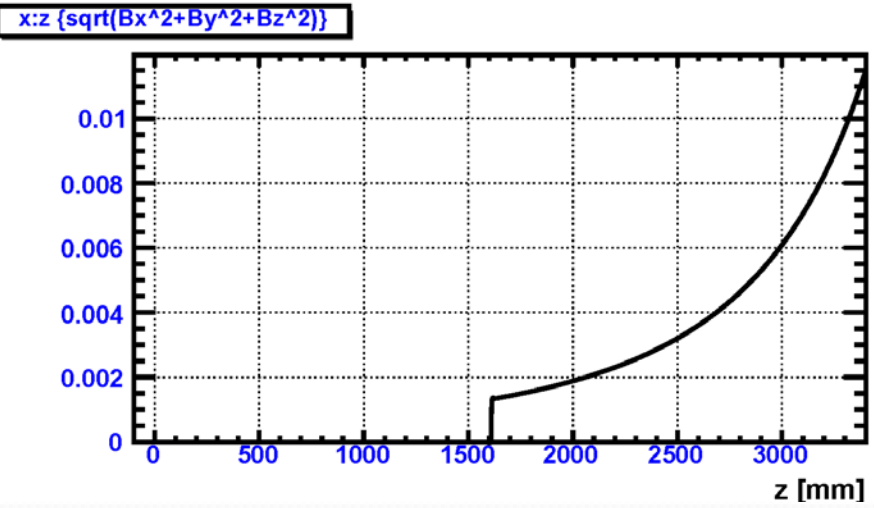


Very strange structure!

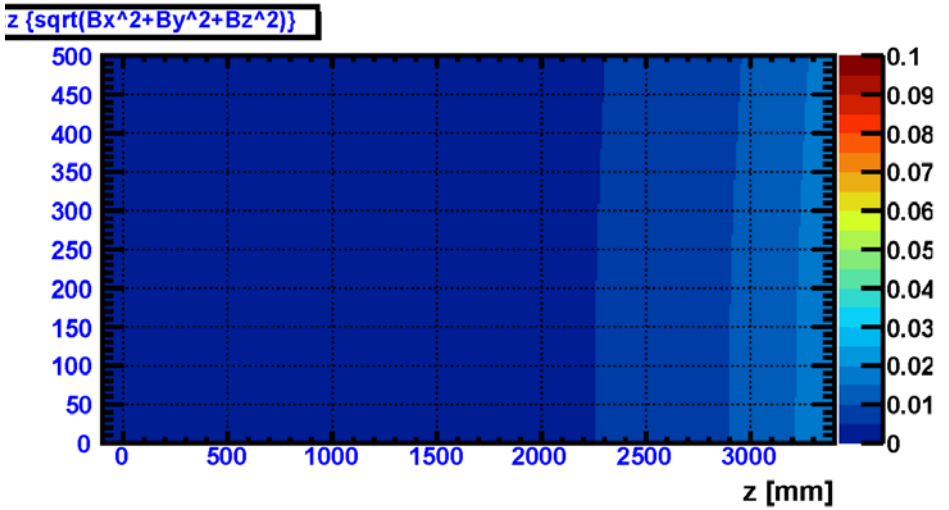
Mag. field for each coil

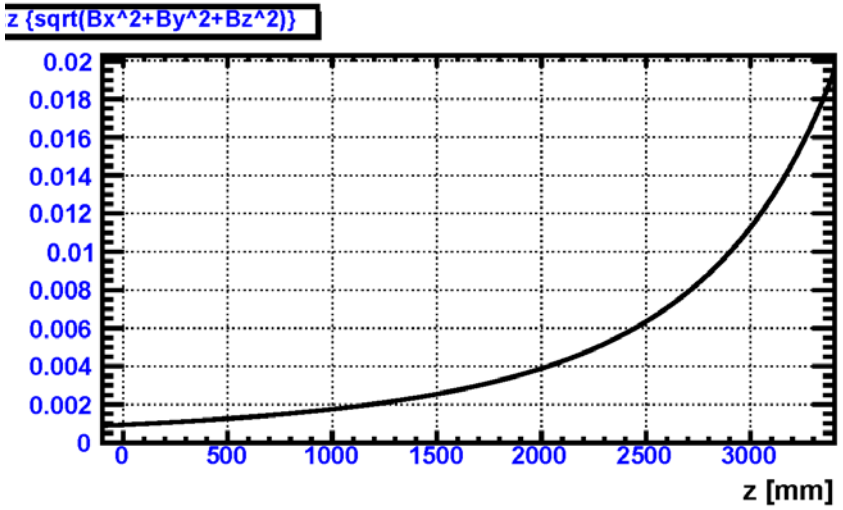
MC12



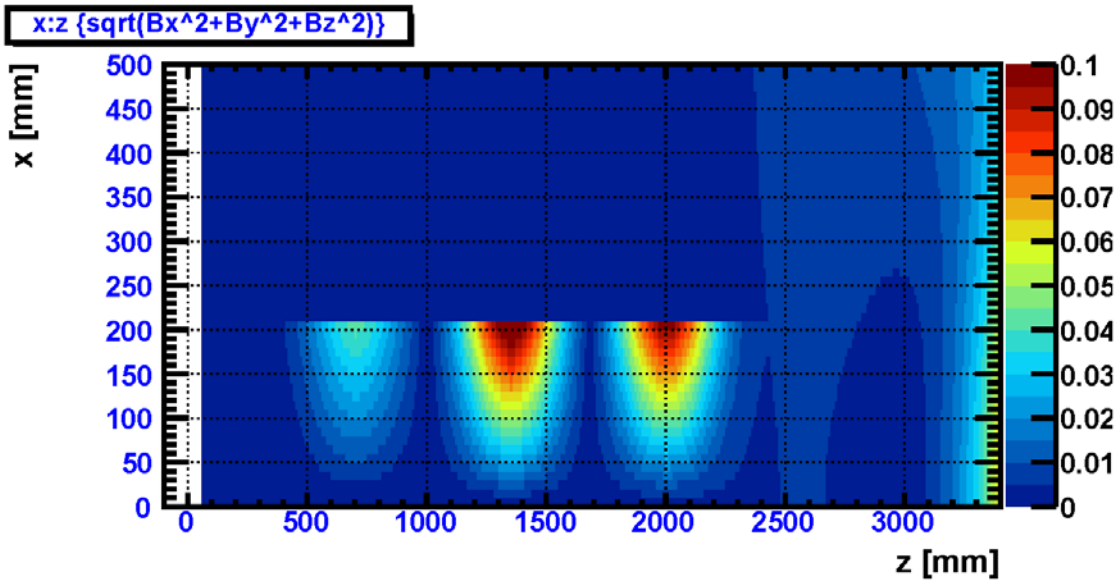


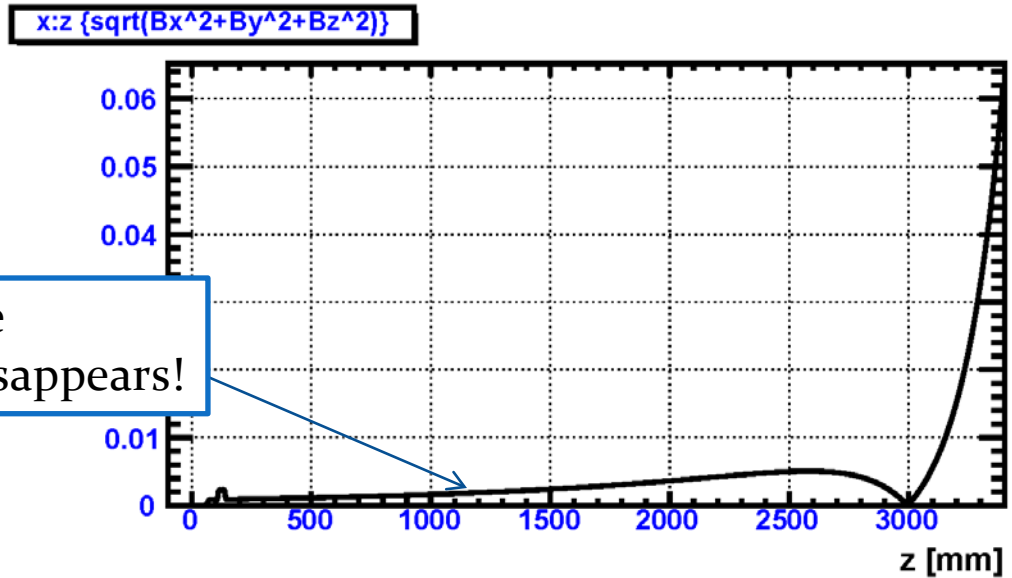
SC12





Mag. field w/ maxZ correction

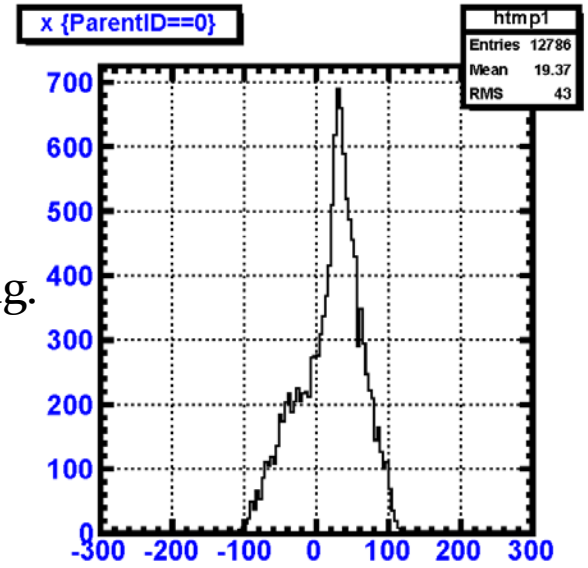


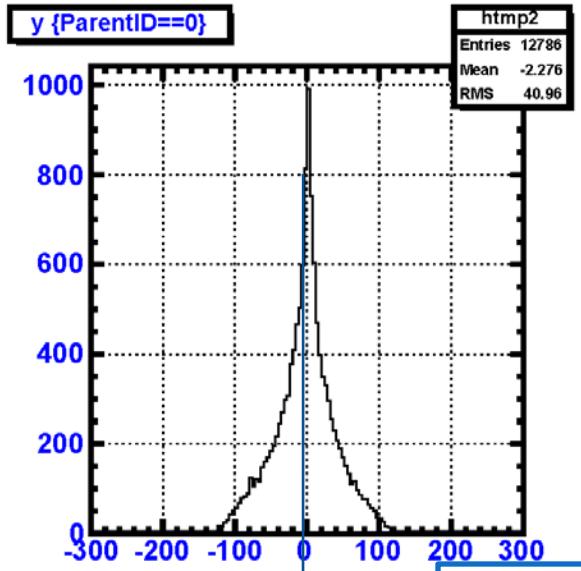


Very strange structure disappears!

hb2 end profile w/o, w/ HFS mag

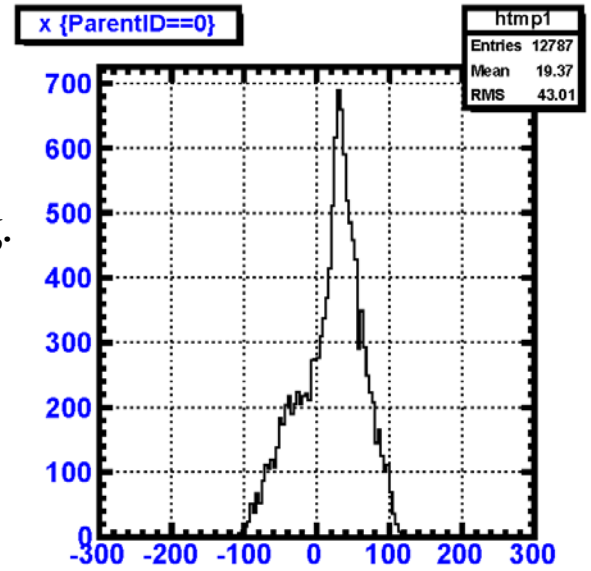
w/o HFS mag.

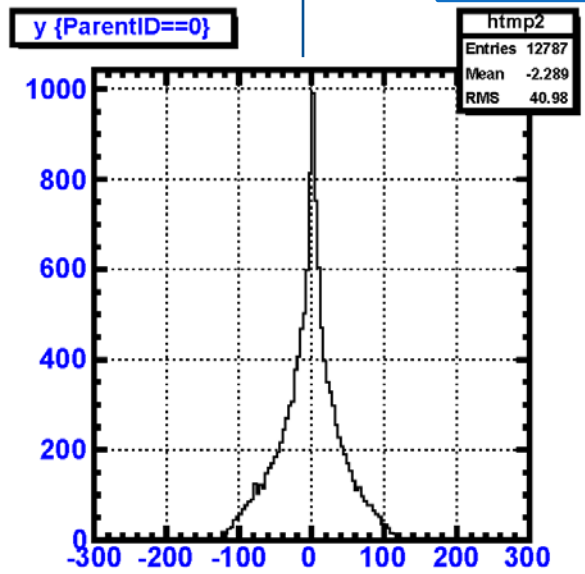




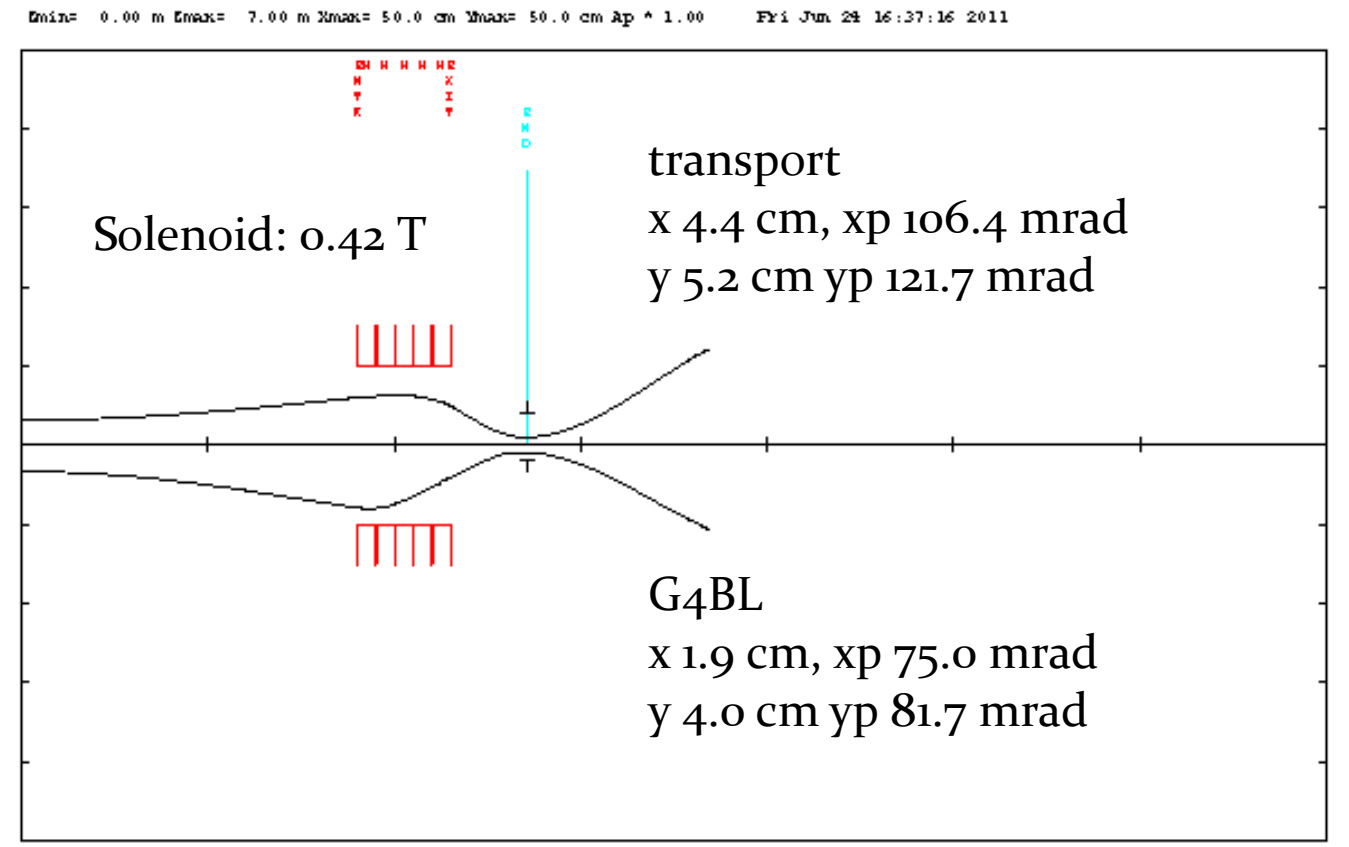
No shift!

w/ HFS mag.

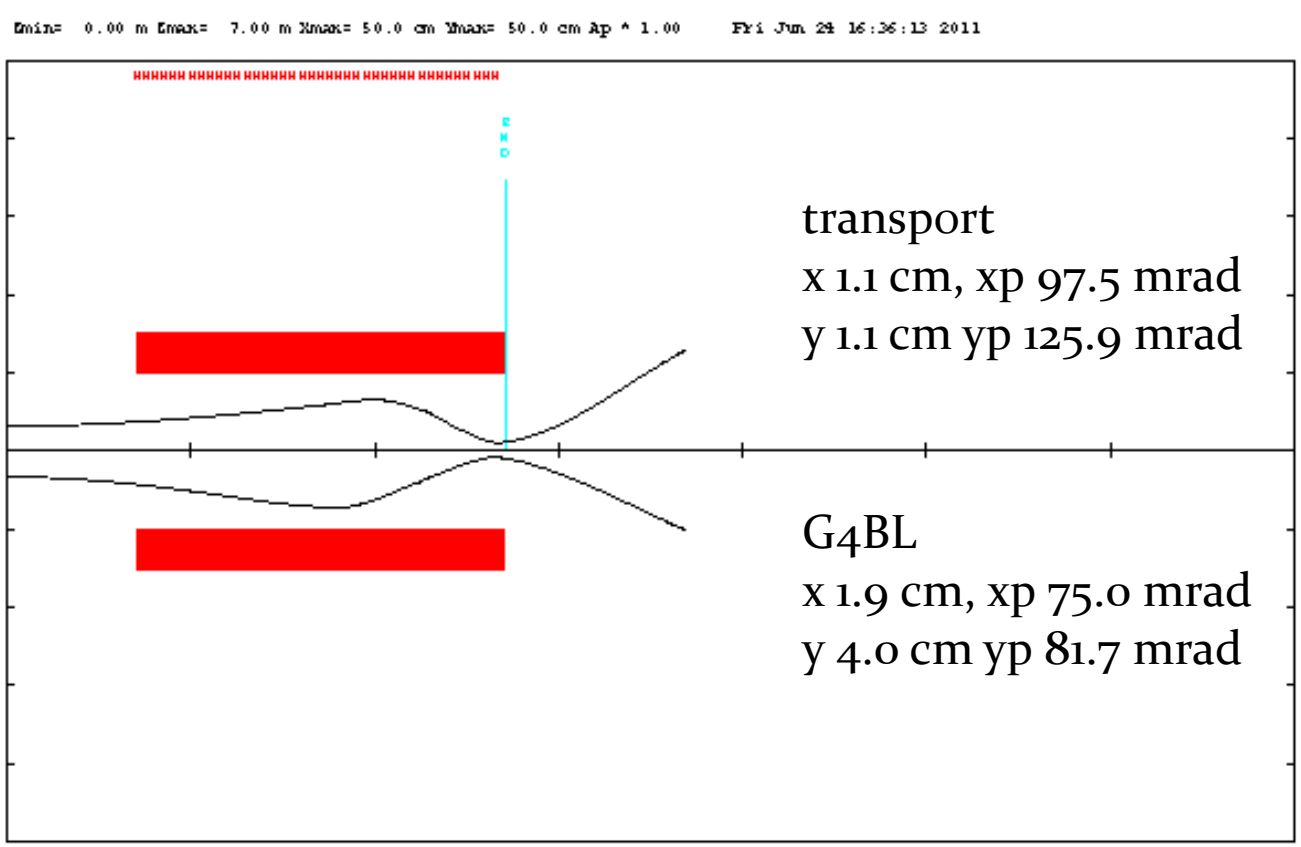




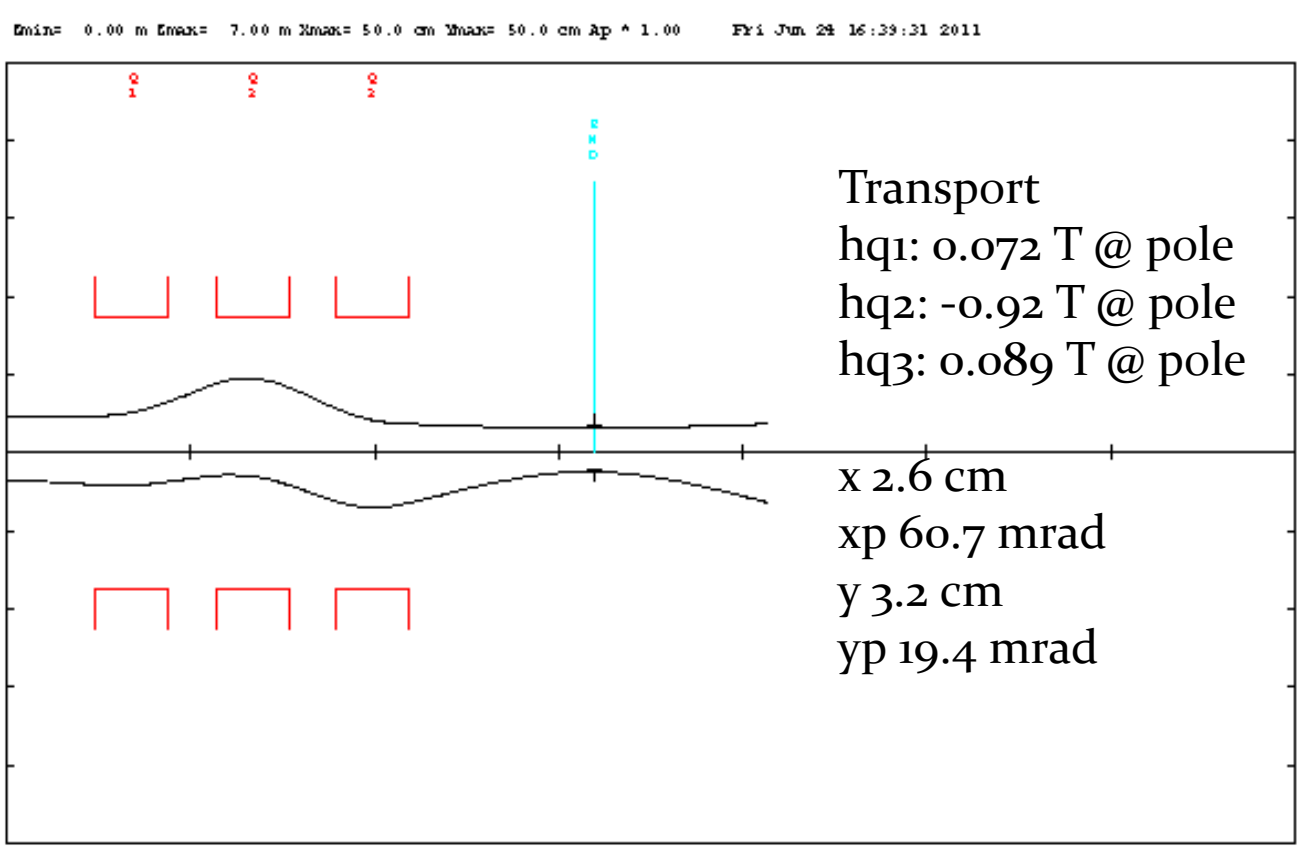
g-2 BL: optimization by transport



g-2 BL: transport result with G4BL magnetic field



MuHFS BL: optimization by transport



Transport
hq1: 0.072 T @ pole
hq2: -0.92 T @ pole
hq3: 0.089 T @ pole

x 2.6 cm
xp 60.7 mrad
y 3.2 cm
yp 19.4 mrad

G4BL
hq1: 0.069 T @ pole
hq2: -0.117 T @ pole
hq3: 0.109 T @ pole

x 2.1 cm
xp 70.0 mrad
y 3.6 cm
yp 45.6 mrad