Ring Coolers with Lithium Lenses

Yasuo Fukui UCLA

- Tracking in Straight Channels

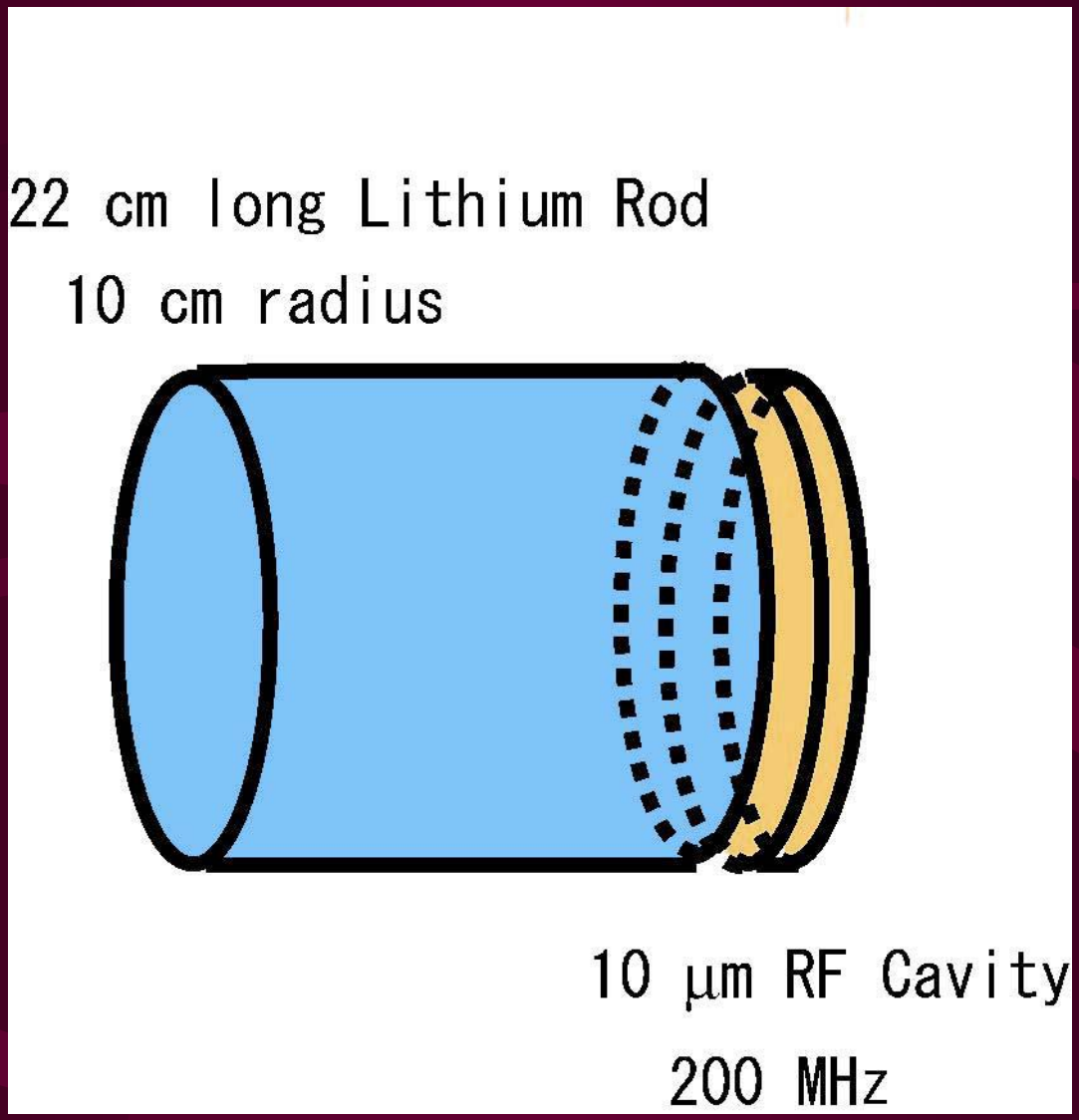
  Li β=1 cm

  Li β=(4,1,4) cm

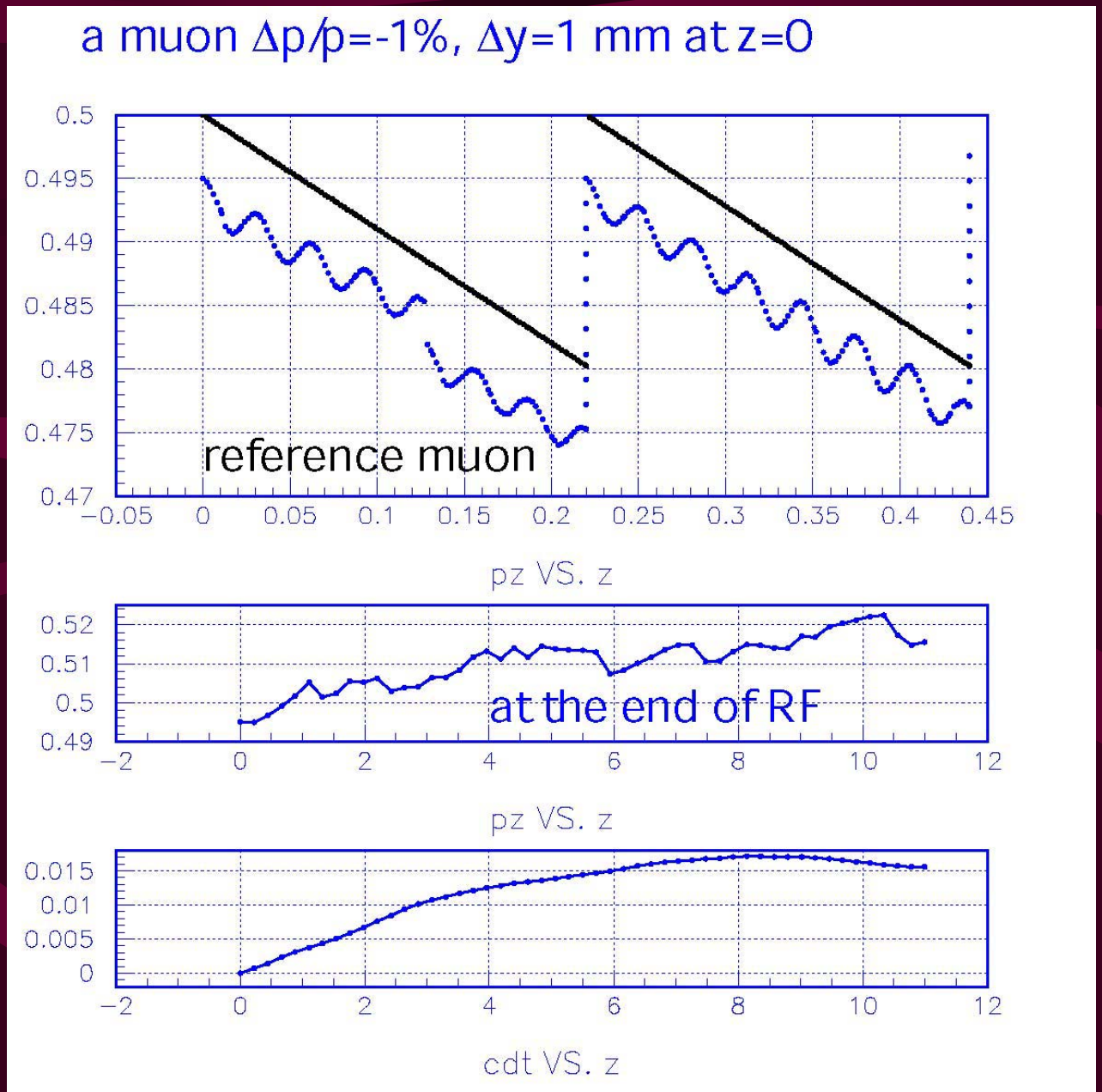
  Li β=(4,1,4) cm + Quad. Matching Cell

  Li β=(4,1,4) cm + Solen. Matching Cell
- Tracking in a Ring

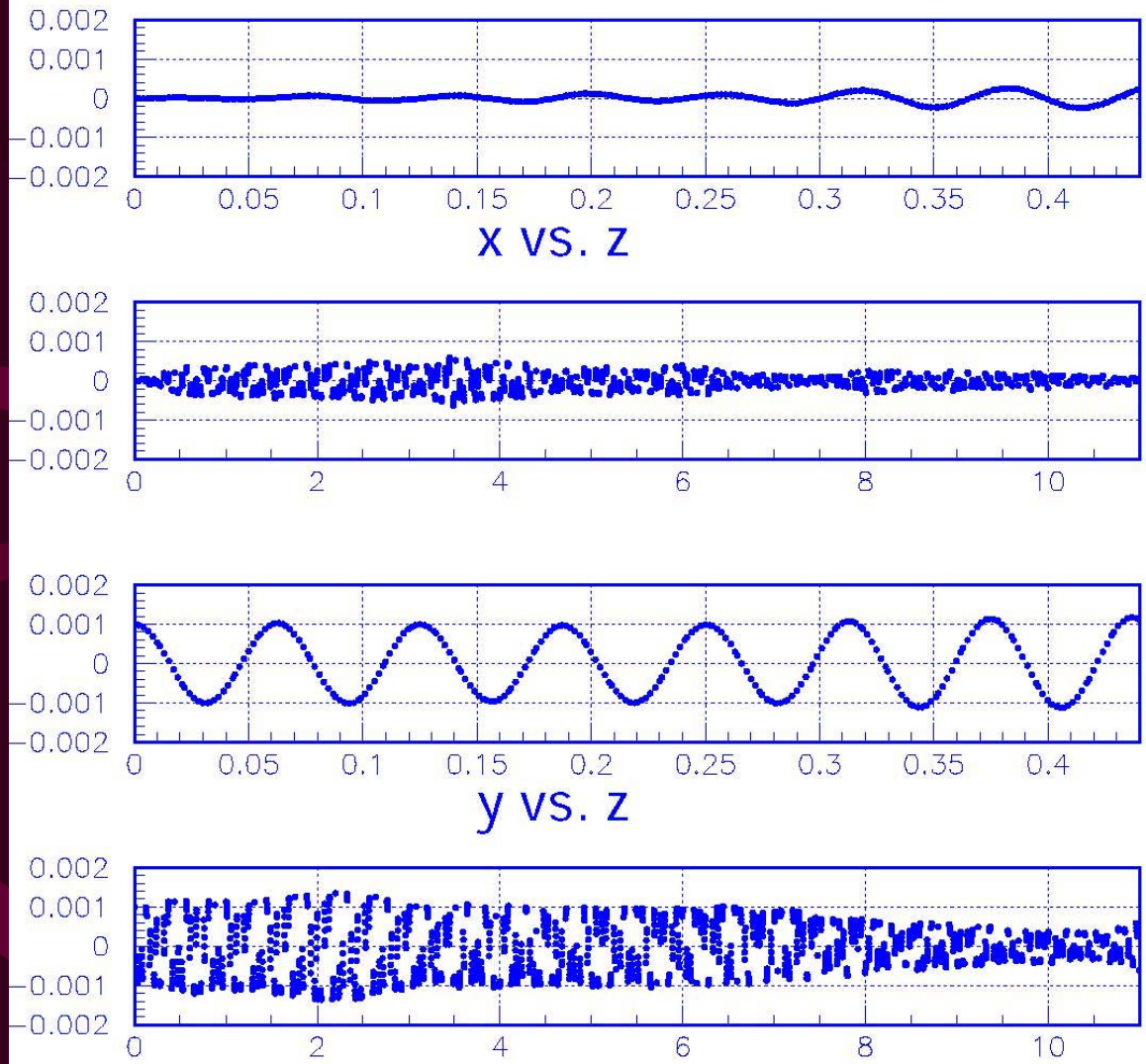
Li β=1 cm



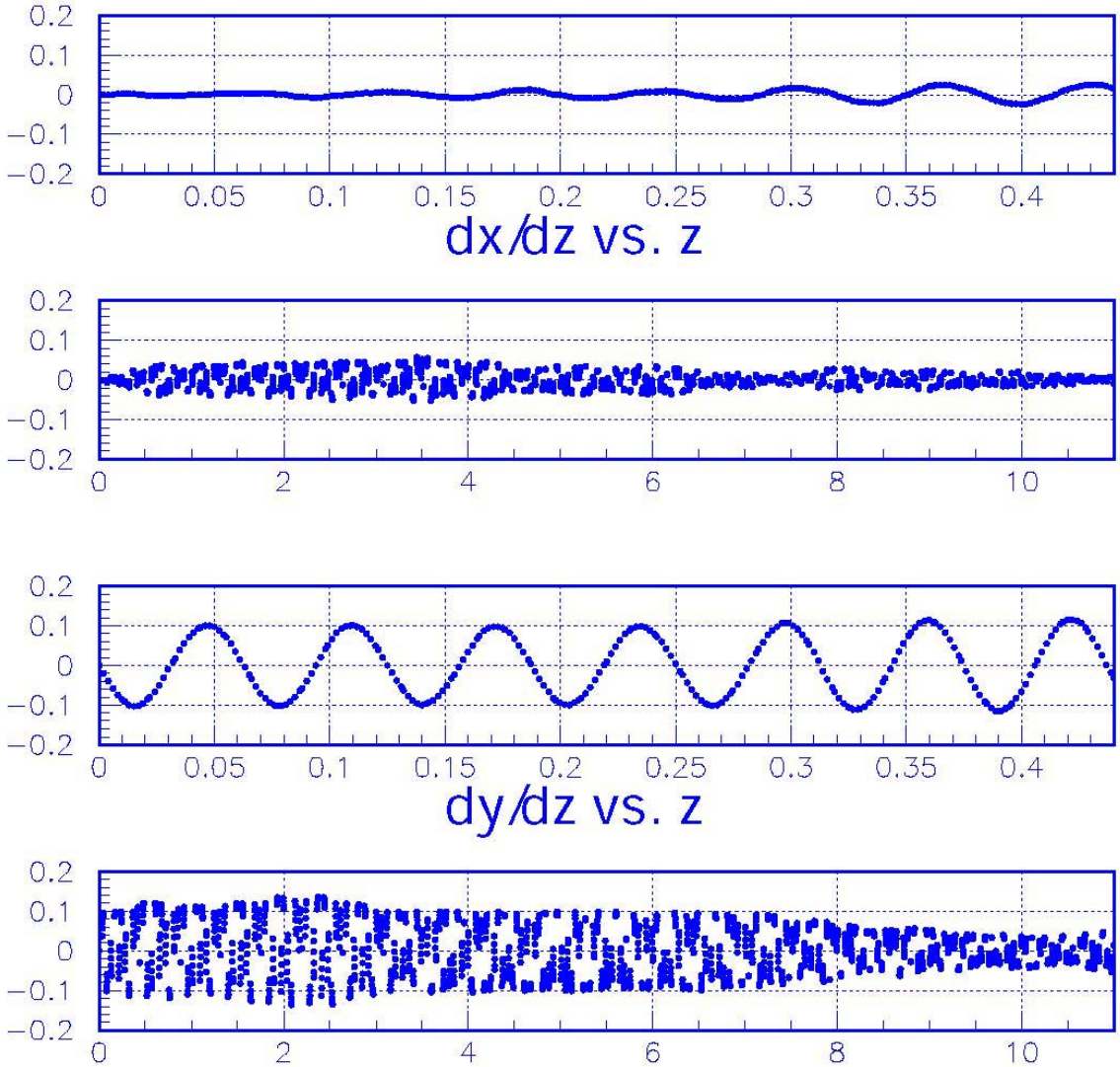
Li β=1 cm


a muon Δp/p=-1%, Δy=1 mm at z=0
reference muon
pz VS. z
at the end of RF
pz VS. z
cdt VS. z

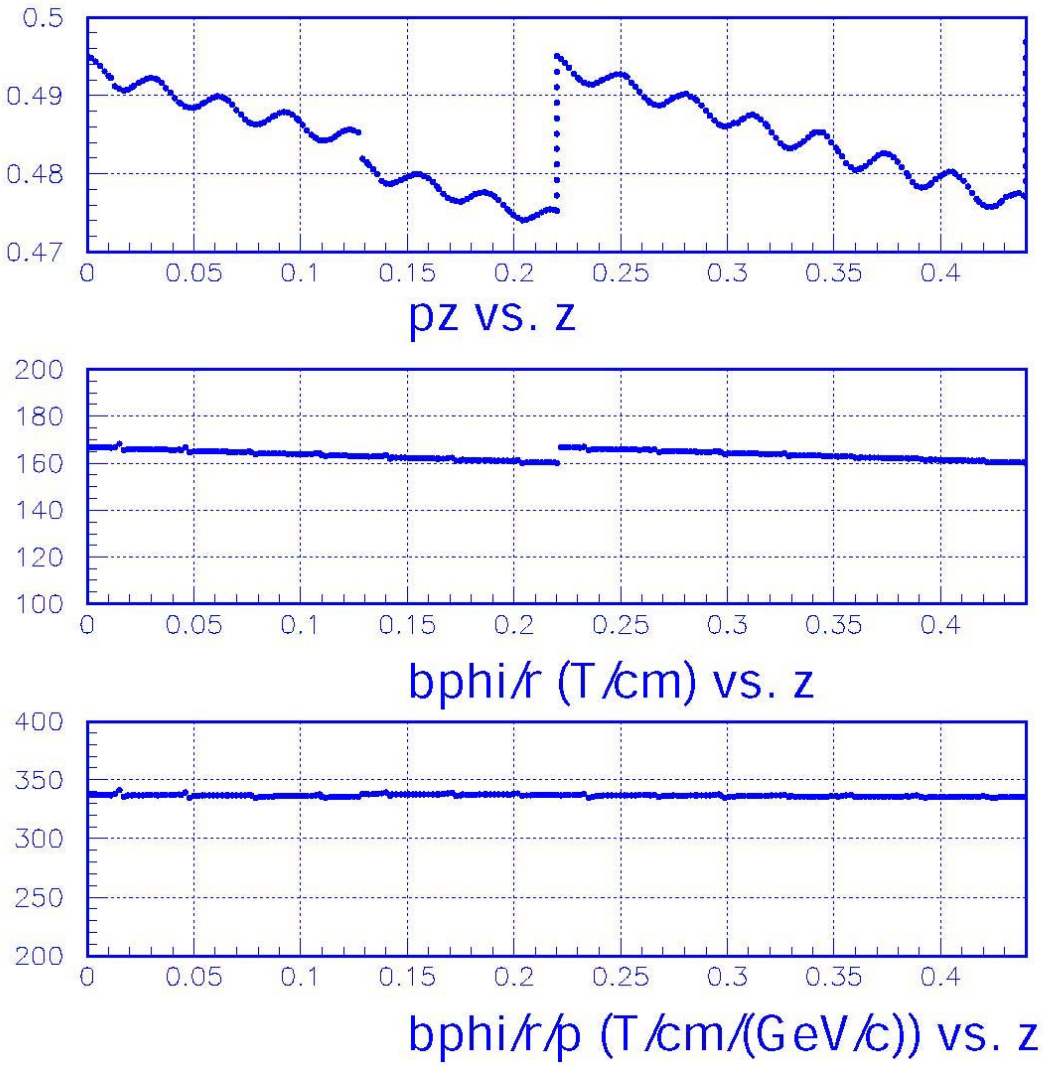
Li β=1 cm


0.002
0.001
0
−0.001
−0.002
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
x vs. z
0.002
0.001
0
−0.001
−0.002
0
2
4
6
8
10
0.002
0.001
0
−0.001
−0.002
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
y vs. z
0.002
0.001
0
−0.001
−0.002
0
2
4
6
8
10

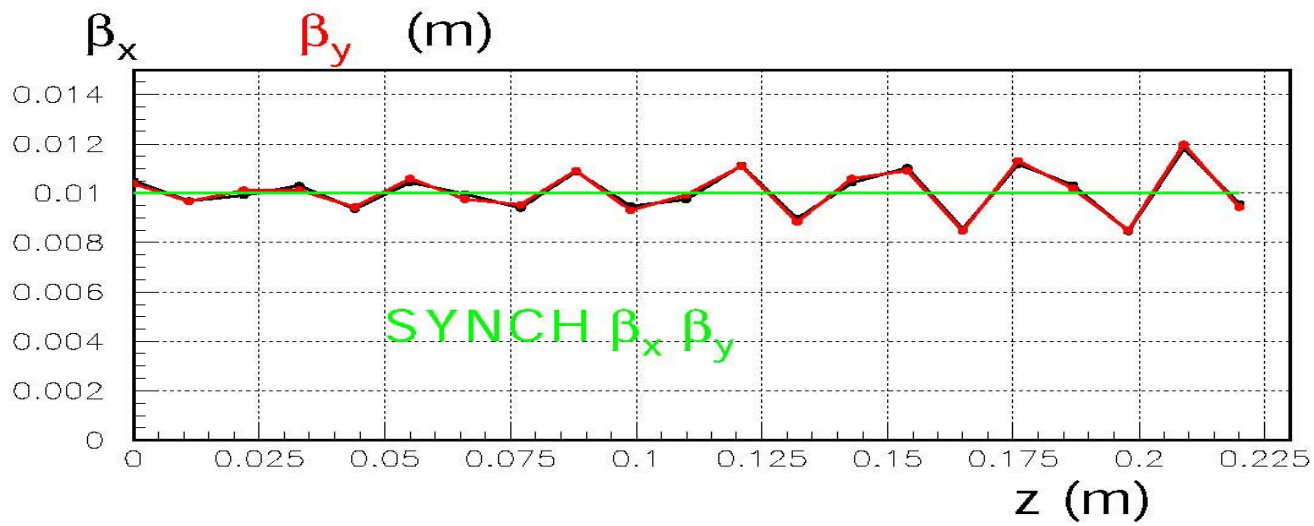
Li β=1 cm


0.2
0.1
0
−0.1
−0.2
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
dx/dz vs. z
0.2
0.1
0
−0.1
−0.2
0
2
4
6
8
10
0.2
0.1
0
−0.1
−0.2
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
dy/dz vs. z
0.2
0.1
0
−0.1
−0.2
0
2
4
6
8
10

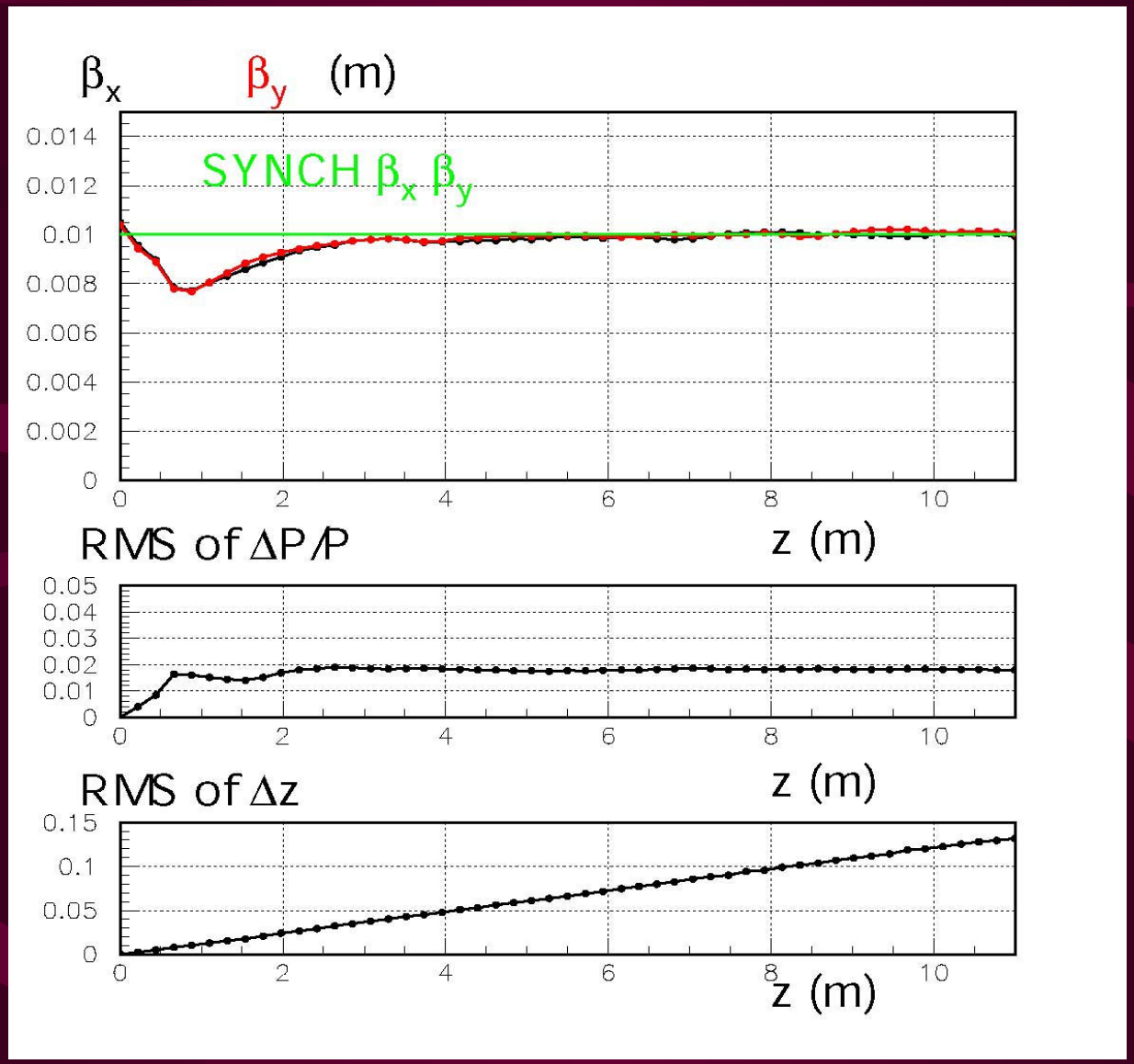
Li β=1 cm


0.5
0.49
0.48
0.47
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
pz vs. z
200
180
160
140
120
100
bphi/r (T/cm) vs. z
400
350
300
250
200
bphi/r/p (T/cm/(GeV/c)) vs. z

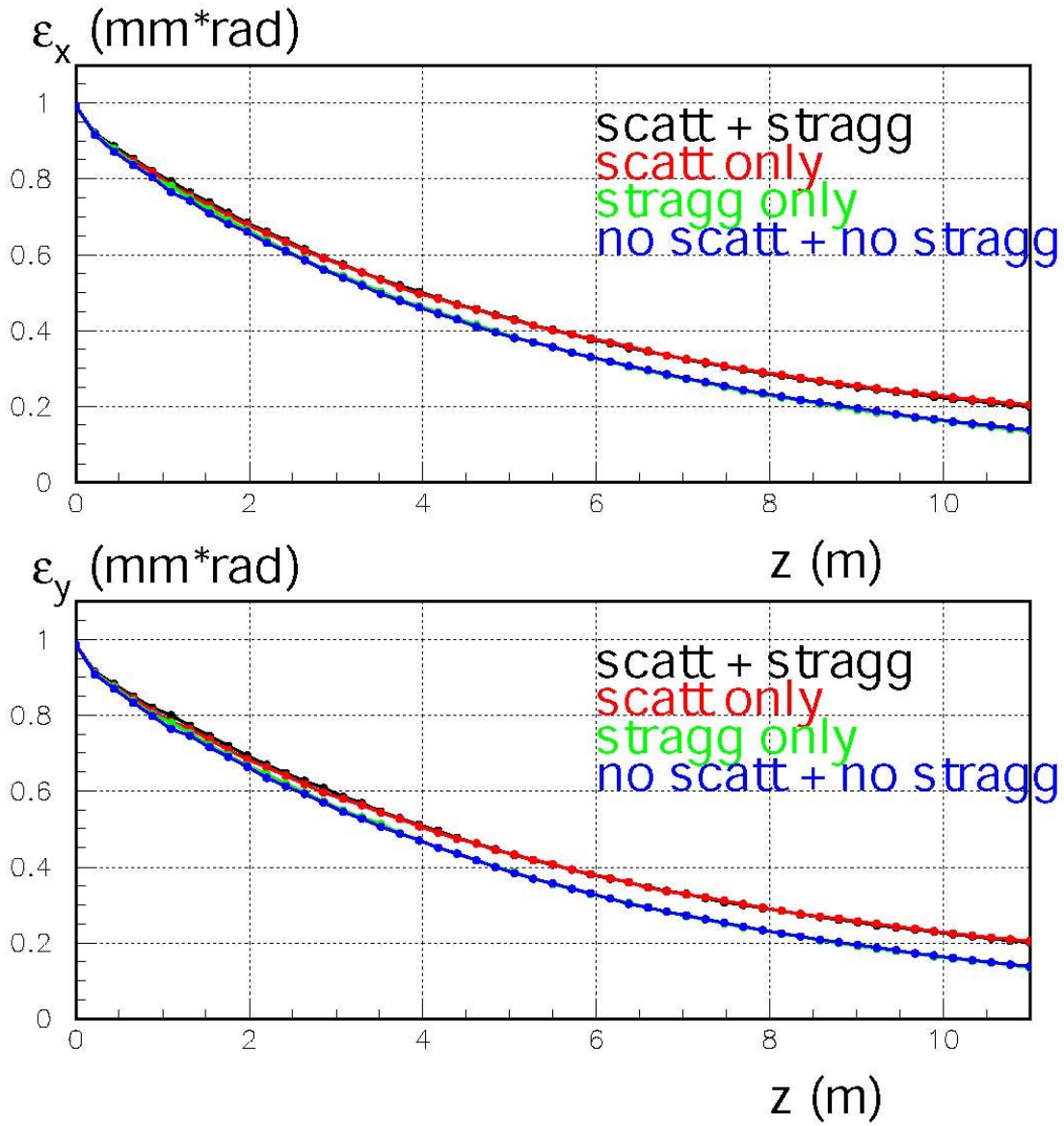
Li β=1 cm


β_x
β_y (m)
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
SYNCH β_x β_y
0
0.025
0.05
0.075
0.1
0.125
0.15
0.175
0.2
0.225
z (m)

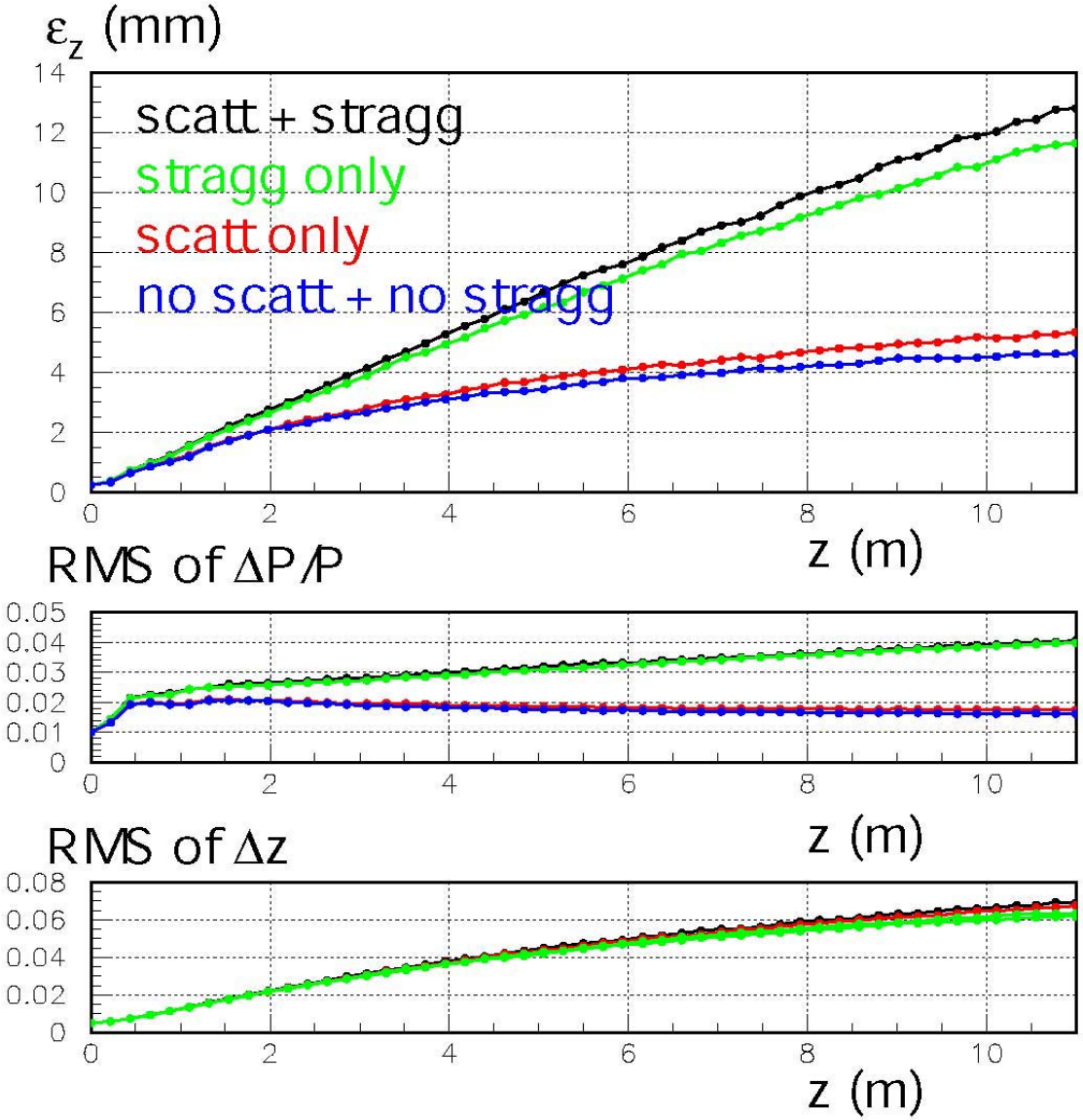
Li β=1 cm


βx βy (m)
SYNCH βx βy
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0 2 4 6 8 10
z (m)
RMS of ΔP/P
0.05
0.04
0.03
0.02
0.01
0
0 2 4 6 8 10
z (m)
RMS of Δz
0.15
0.1
0.05
0
0 2 4 6 8 10
z (m)

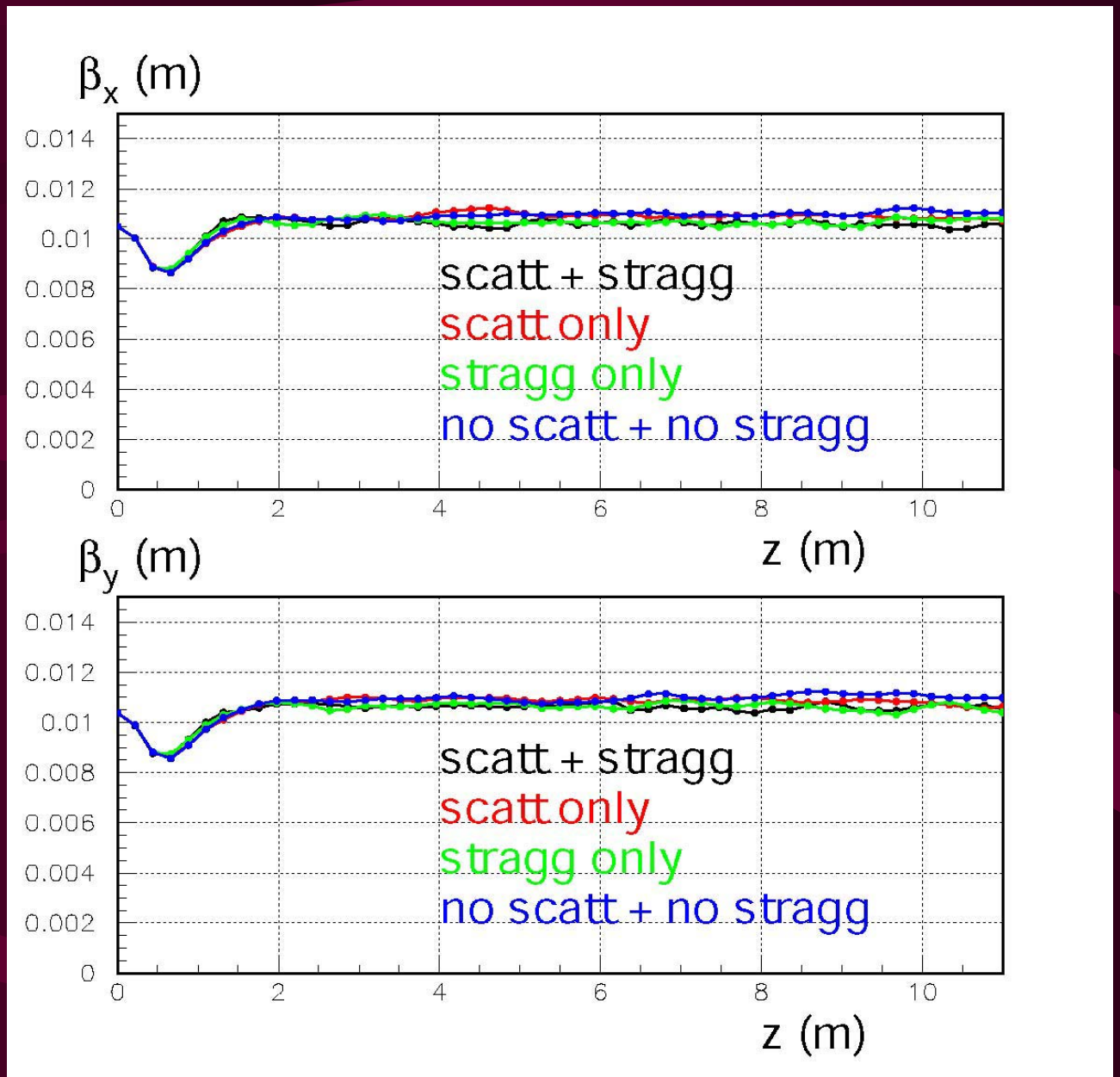
Li β=1 cm


ε_x (mm*rad)
scatt + stragg
scatt only
stragg only
no scatt + no stragg
z (m)
ε_y (mm*rad)
scatt + stragg
scatt only
stragg only
no scatt + no stragg
z (m)

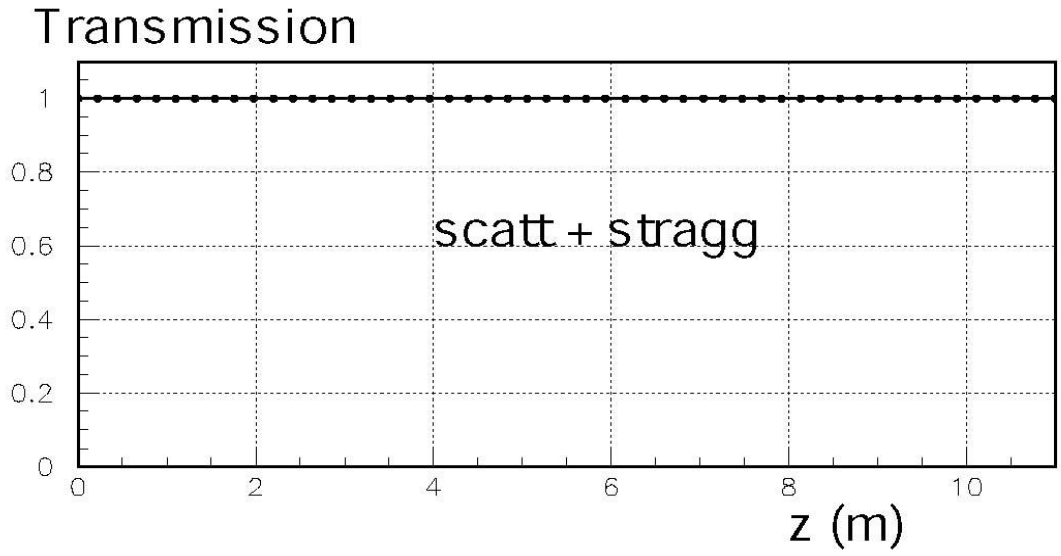
Li β=1 cm


ε_z (mm)
scatt + stragg
stragg only
scatt only
no scatt + no stragg
z (m)
RMS of ΔP/P
z (m)
RMS of Δz
z (m)

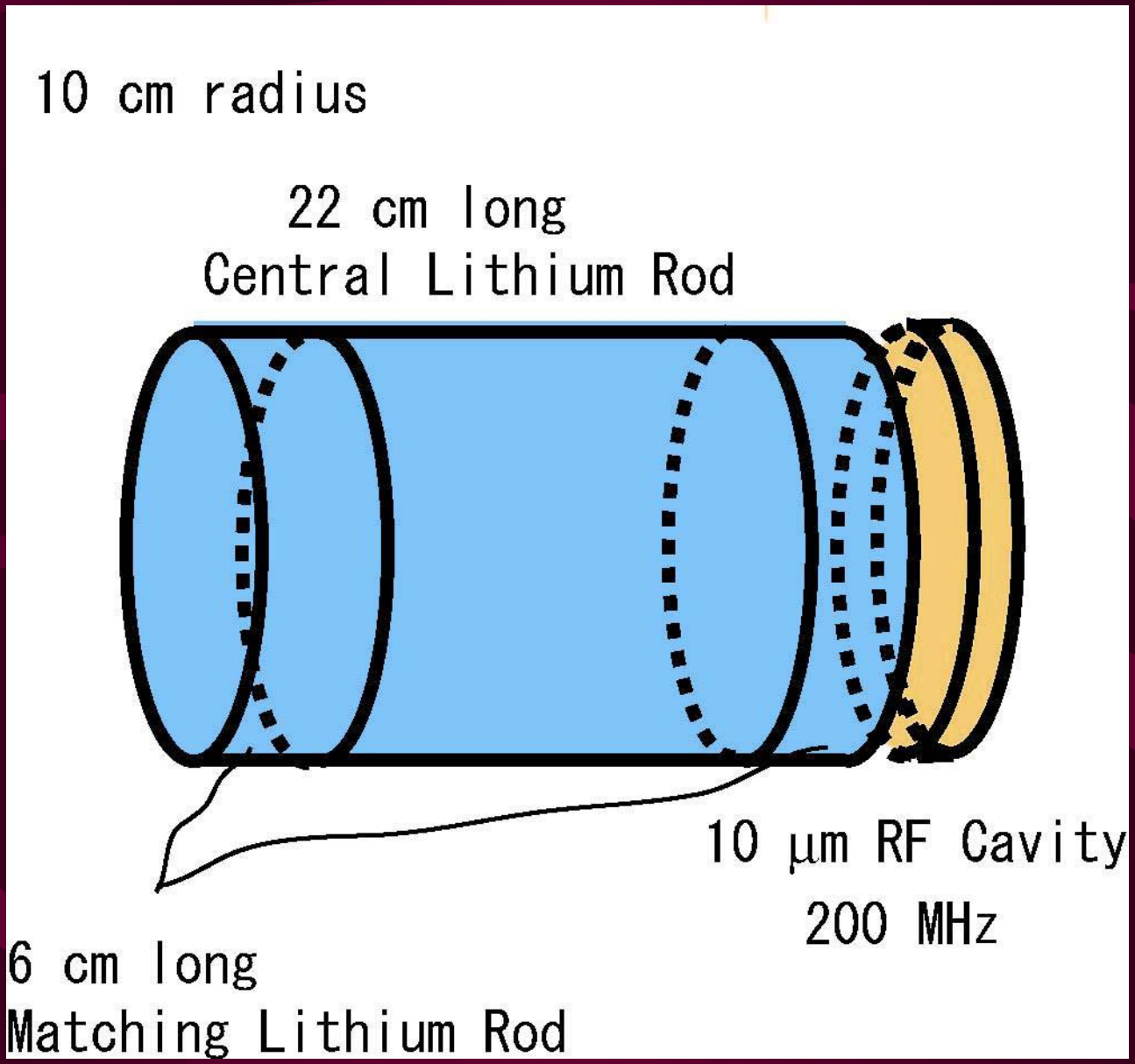
Li β=1 cm


β_x (m)
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
2
4
6
8
10
z (m)
scatt + stragg
scatt only
stragg only
no scatt + no stragg
β_y (m)
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
2
4
6
8
10
z (m)
scatt + stragg
scatt only
stragg only
no scatt + no stragg

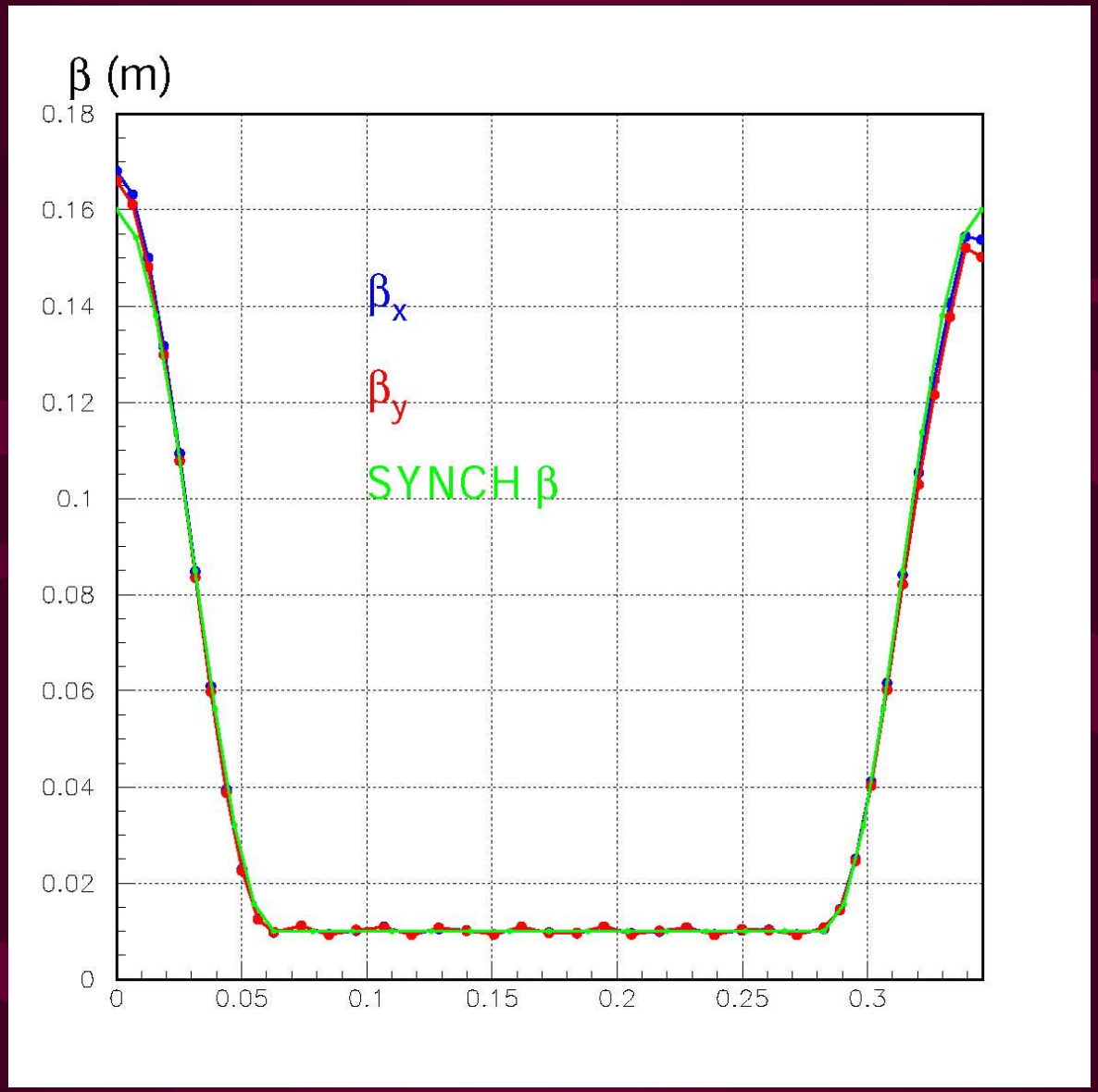
Li β=1 cm



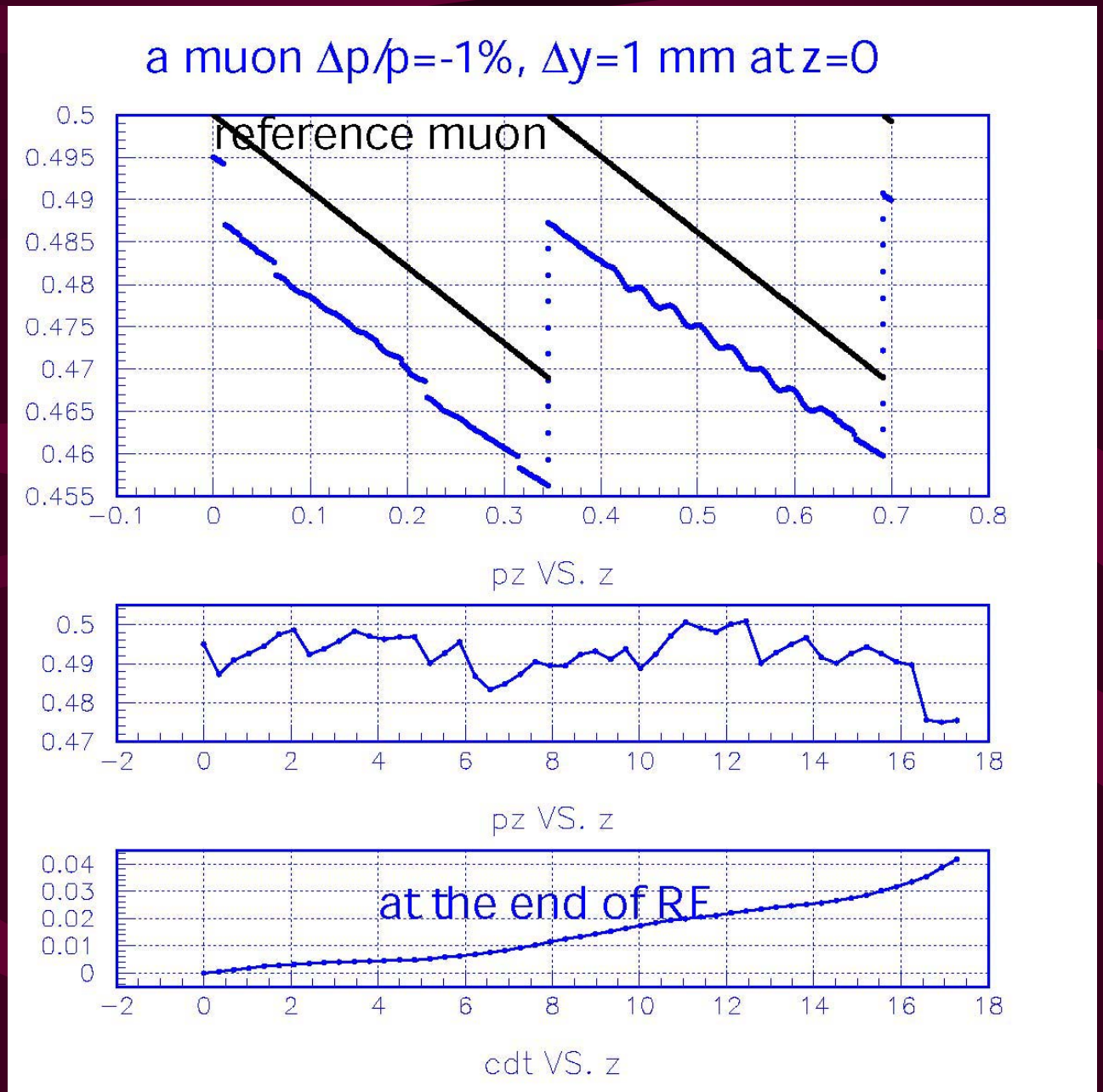
Li β=(4,1,4) cm


10 cm radius
22 cm long
Central Lithium Rod
10 μm RF Cavity
200 MHz
6 cm long
Matching Lithium Rod

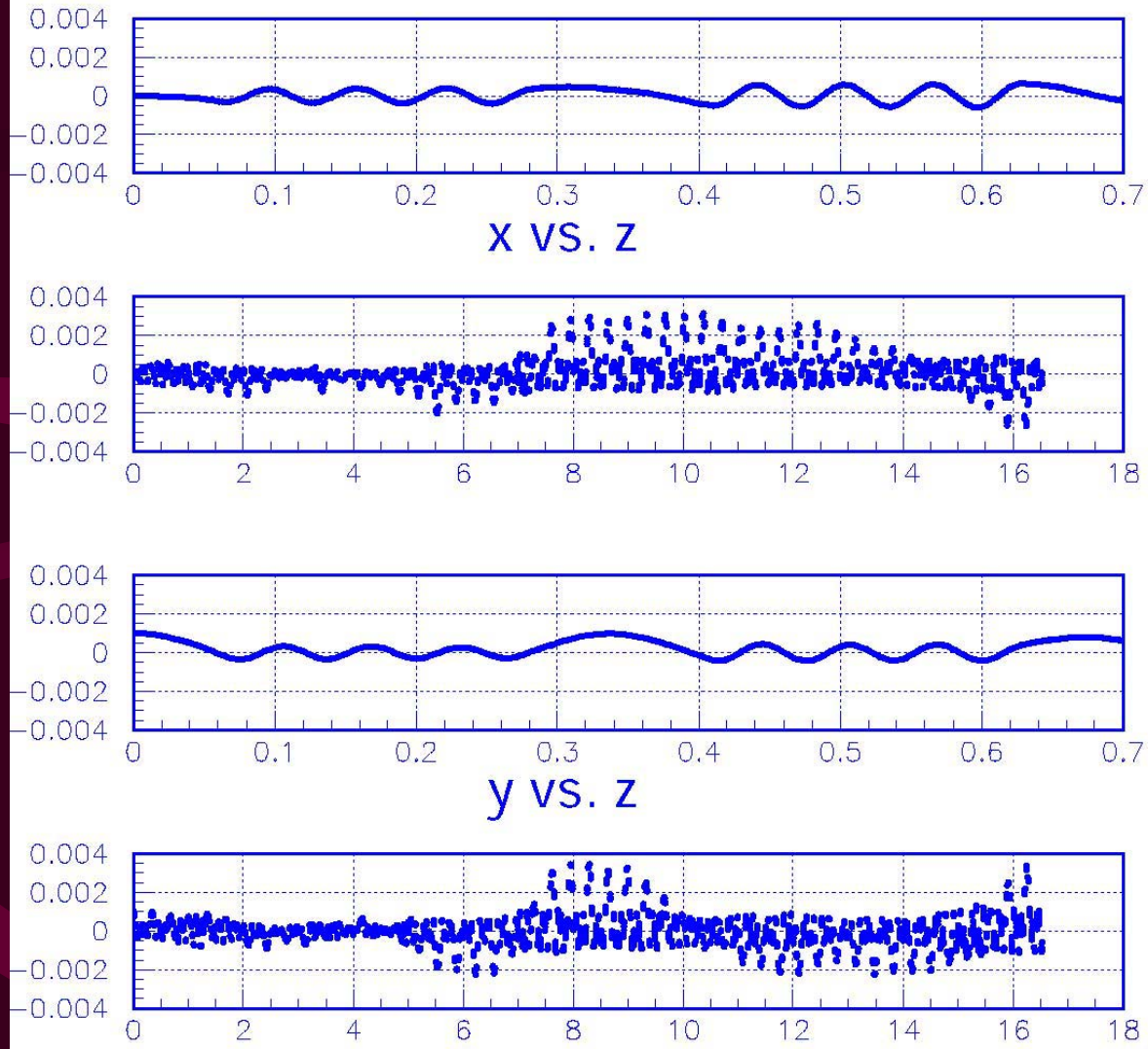
Li β=(4,1,4) cm


β (m)
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
0.05
0.1
0.15
0.2
0.25
0.3
β_x
β_y
SYNCH β

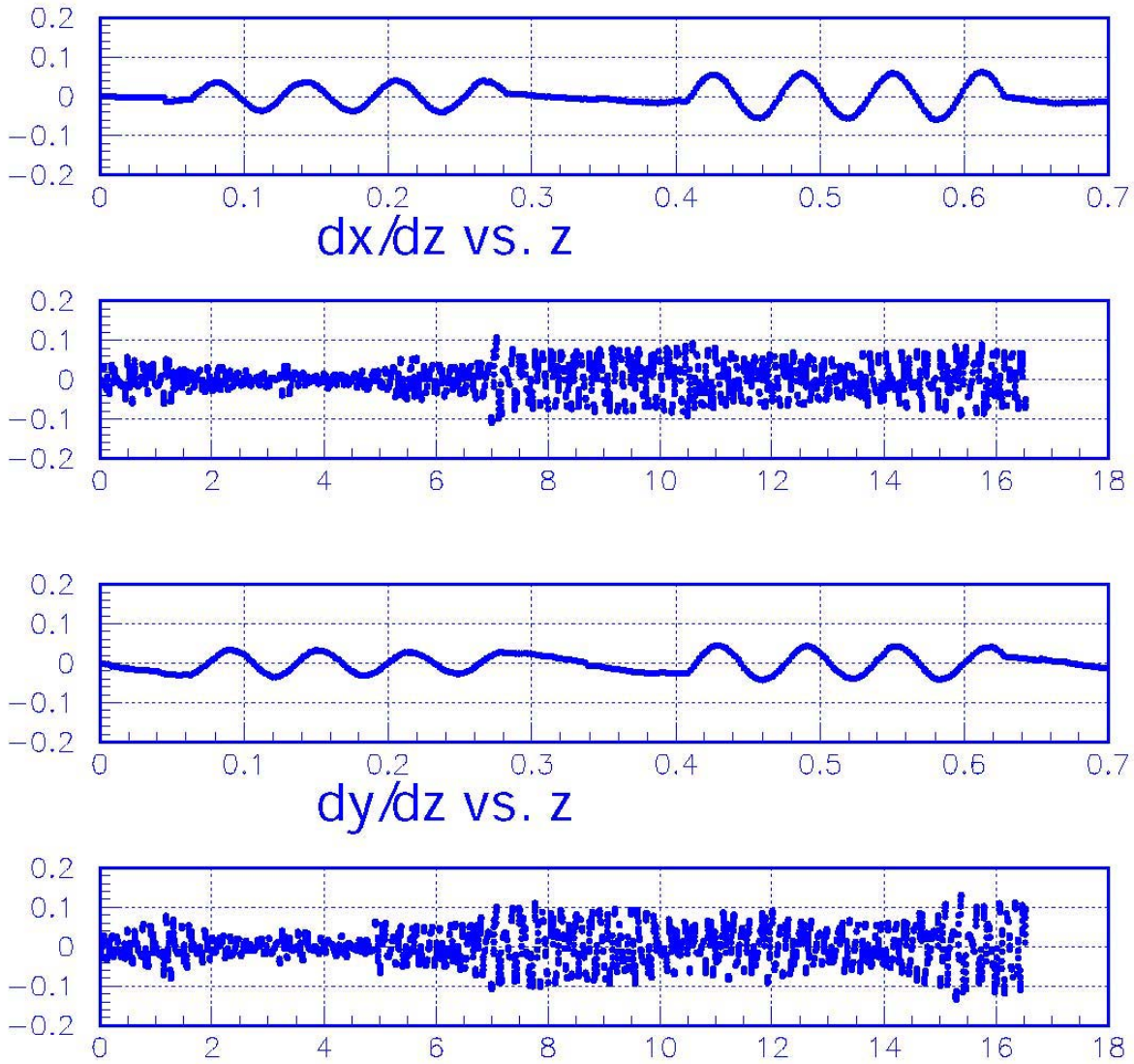
Li β=(4,1,4) cm


a muon Δp/p=-1%, Δy=1 mm at z=0
reference muon
0.5
0.495
0.49
0.485
0.48
0.475
0.47
0.465
0.46
0.455
−0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
pz VS. z
0.5
0.49
0.48
0.47
−2
0
2
4
6
8
10
12
14
16
18
pz VS. z
0.04
0.03
0.02
0.01
0
at the end of RF
−2
0
2
4
6
8
10
12
14
16
18
cdt VS. z

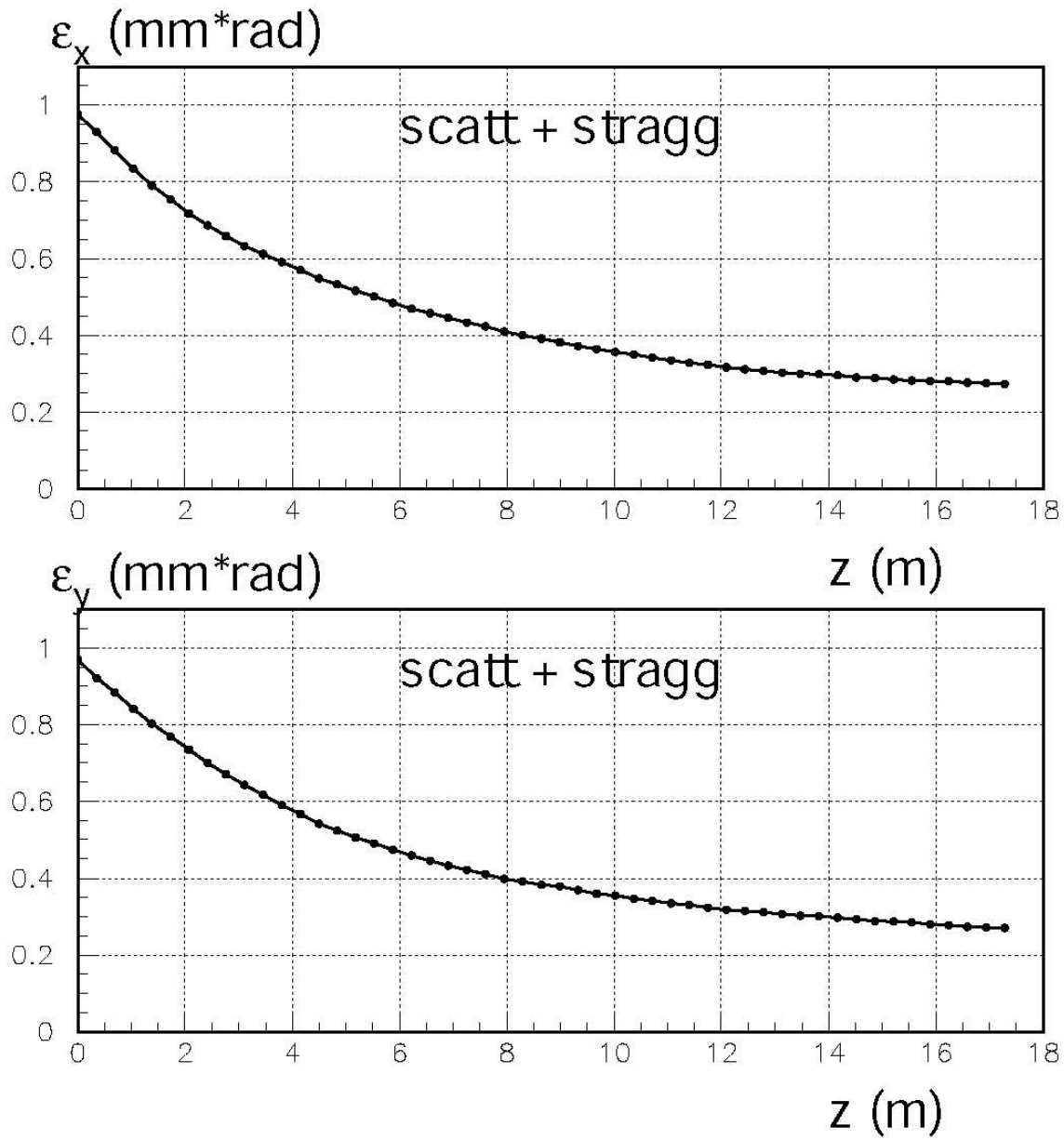
Li β=(4,1,4) cm


0.004
0.002
0
−0.002
−0.004
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
x vs. z
0.004
0.002
0
−0.002
−0.004
0
2
4
6
8
10
12
14
16
18
0.004
0.002
0
−0.002
−0.004
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
y vs. z
0.004
0.002
0
−0.002
−0.004
0
2
4
6
8
10
12
14
16
18

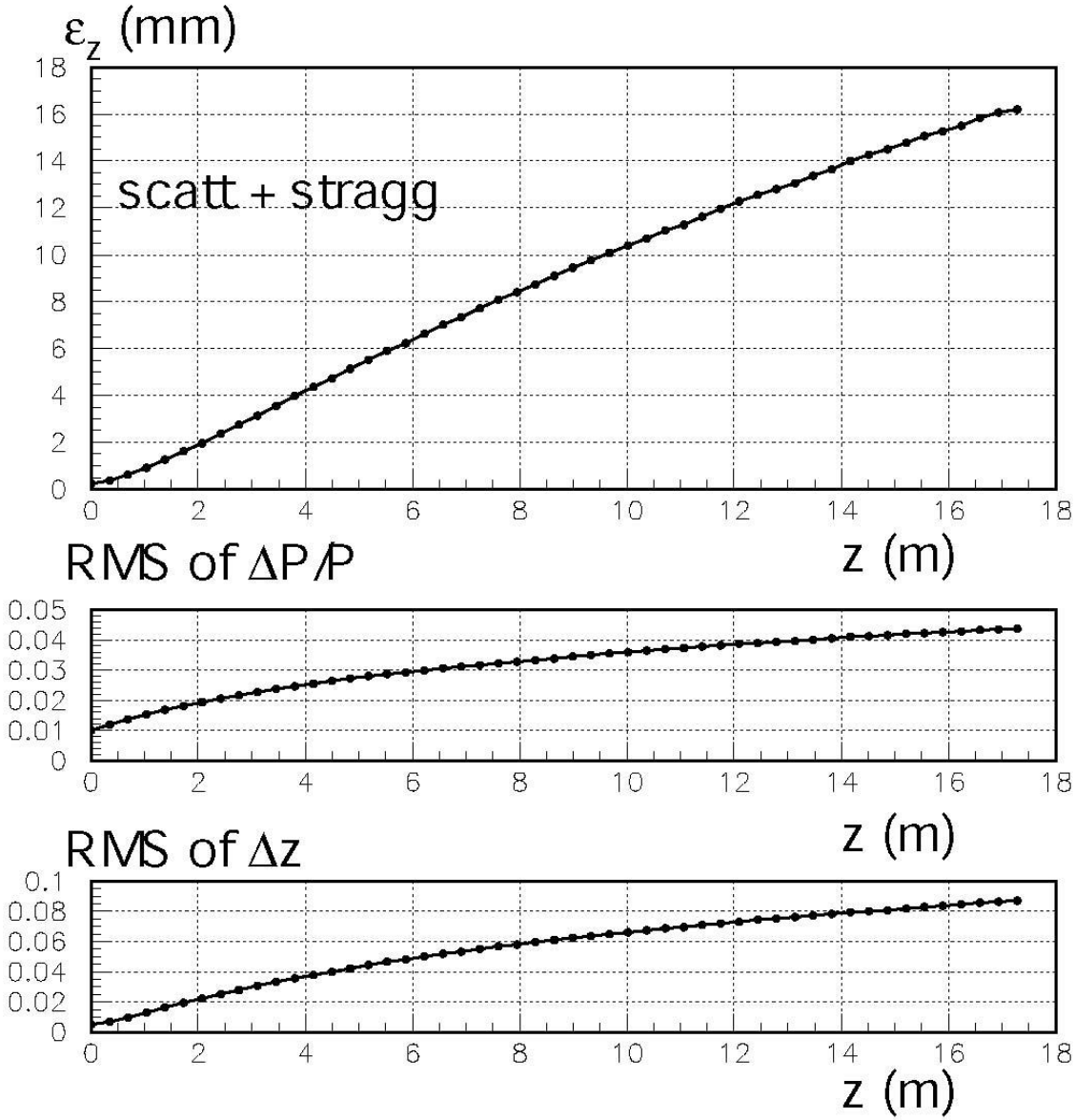
Li β=(4,1,4) cm


0.2
0.1
0
−0.1
−0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
dx/dz vs. z
0.2
0.1
0
−0.1
−0.2
0
2
4
6
8
10
12
14
16
18
0.2
0.1
0
−0.1
−0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
dy/dz vs. z
0.2
0.1
0
−0.1
−0.2
0
2
4
6
8
10
12
14
16
18

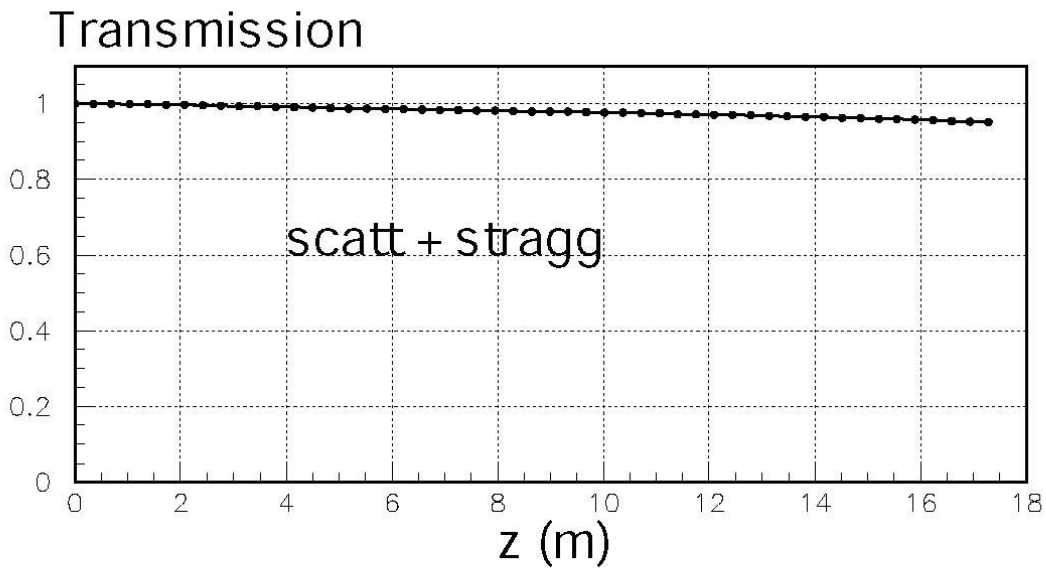
Li β=(4,1,4) cm


εx (mm*rad)
scatt + stragg
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
16
18
z (m)
εy (mm*rad)
scatt + stragg
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
16
18
z (m)

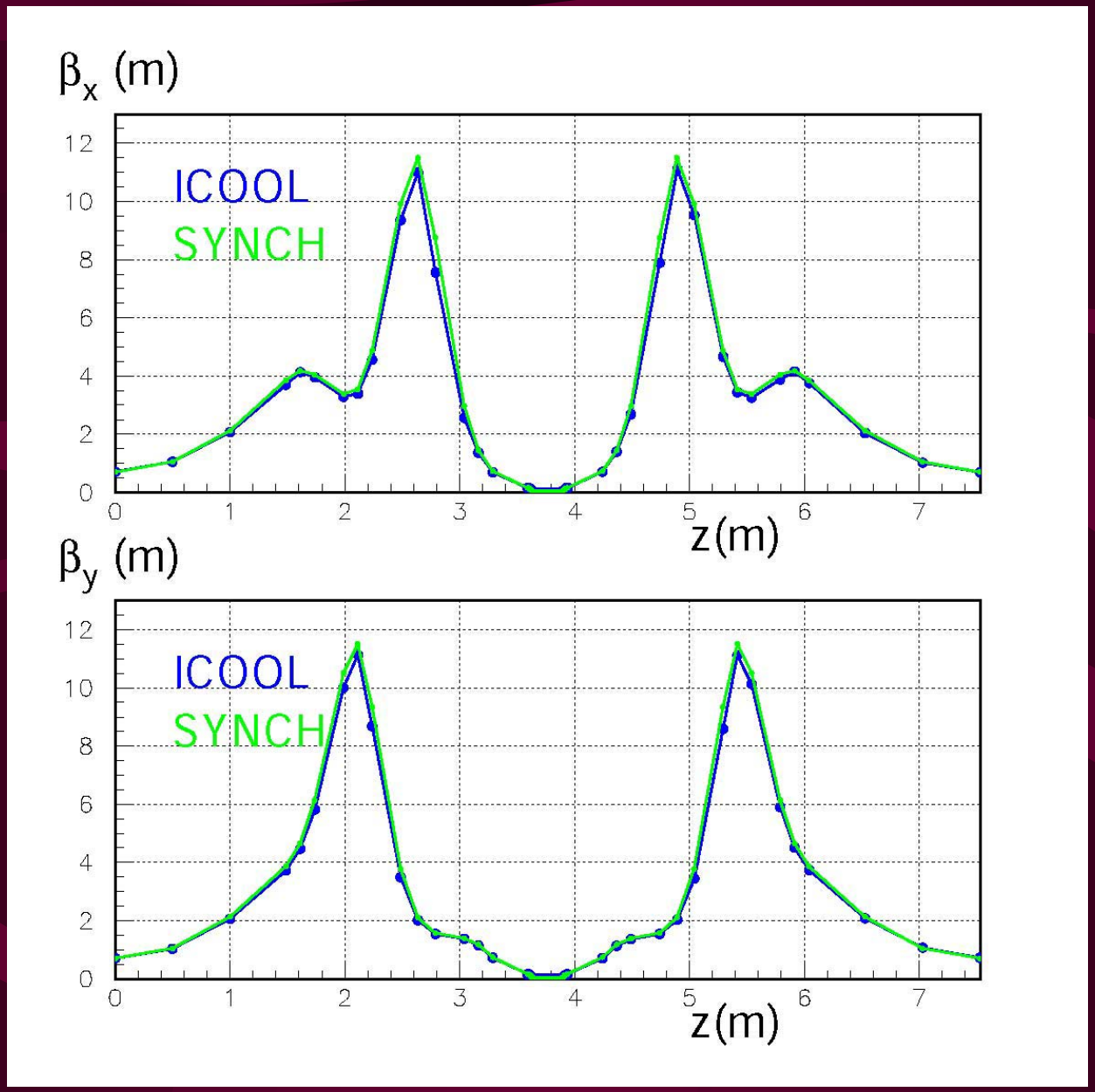
Li β=(4,1,4) cm



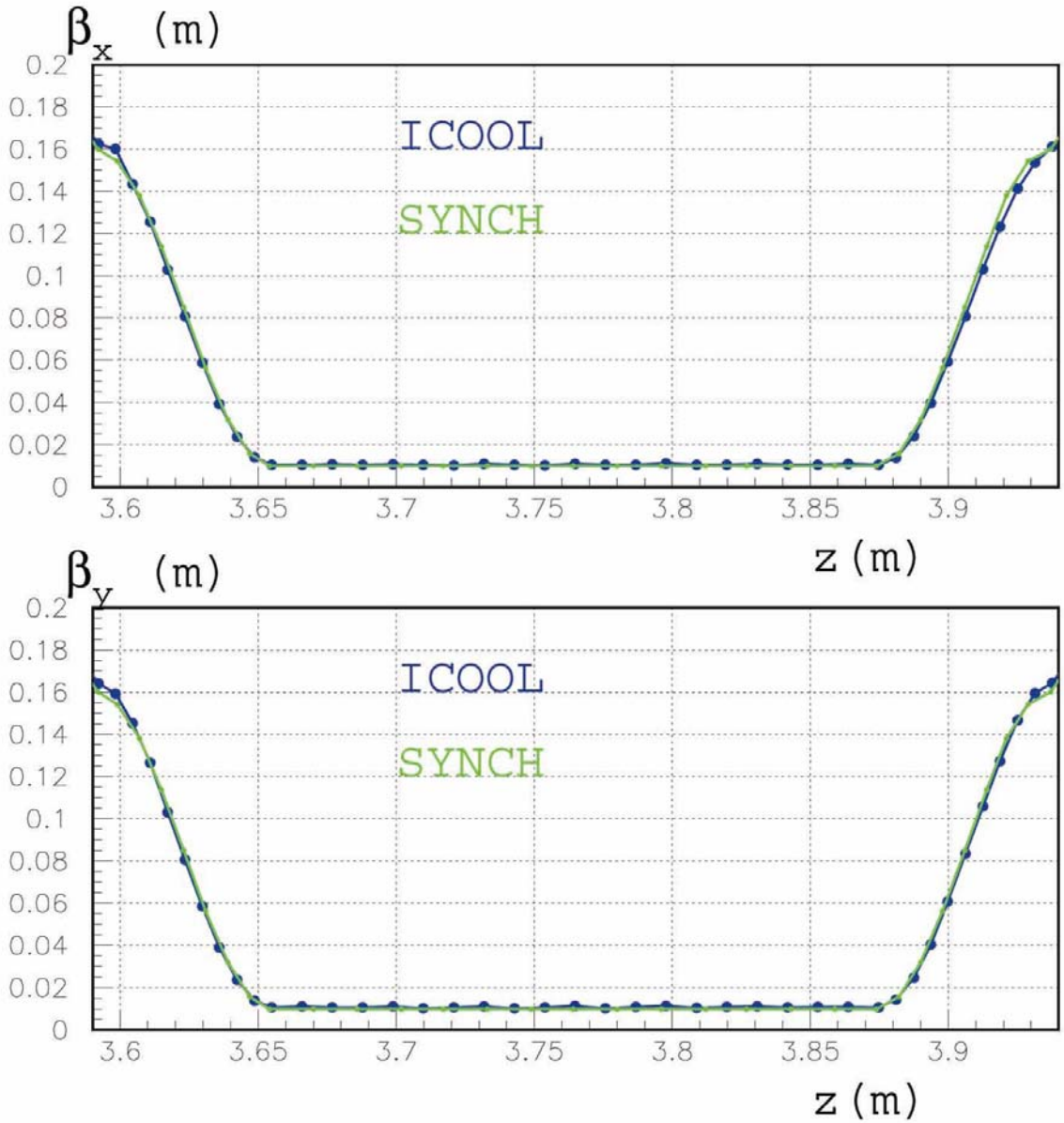
Li β=(4,1,4) cm


Transmission
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
16
18
z (m)
scatt + stragg

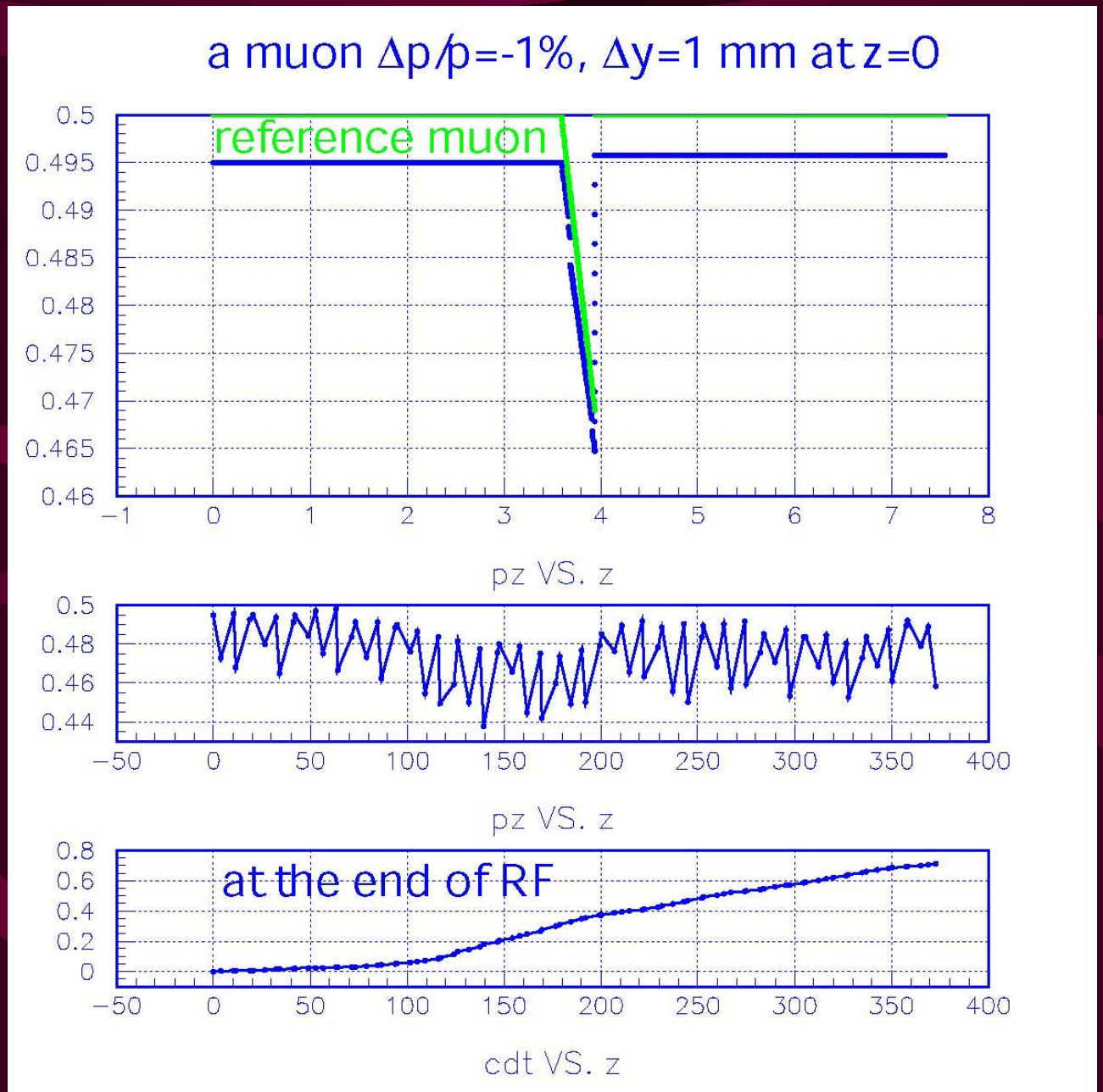
Li β=(4,1,4) cm + Quad. Matching Cell



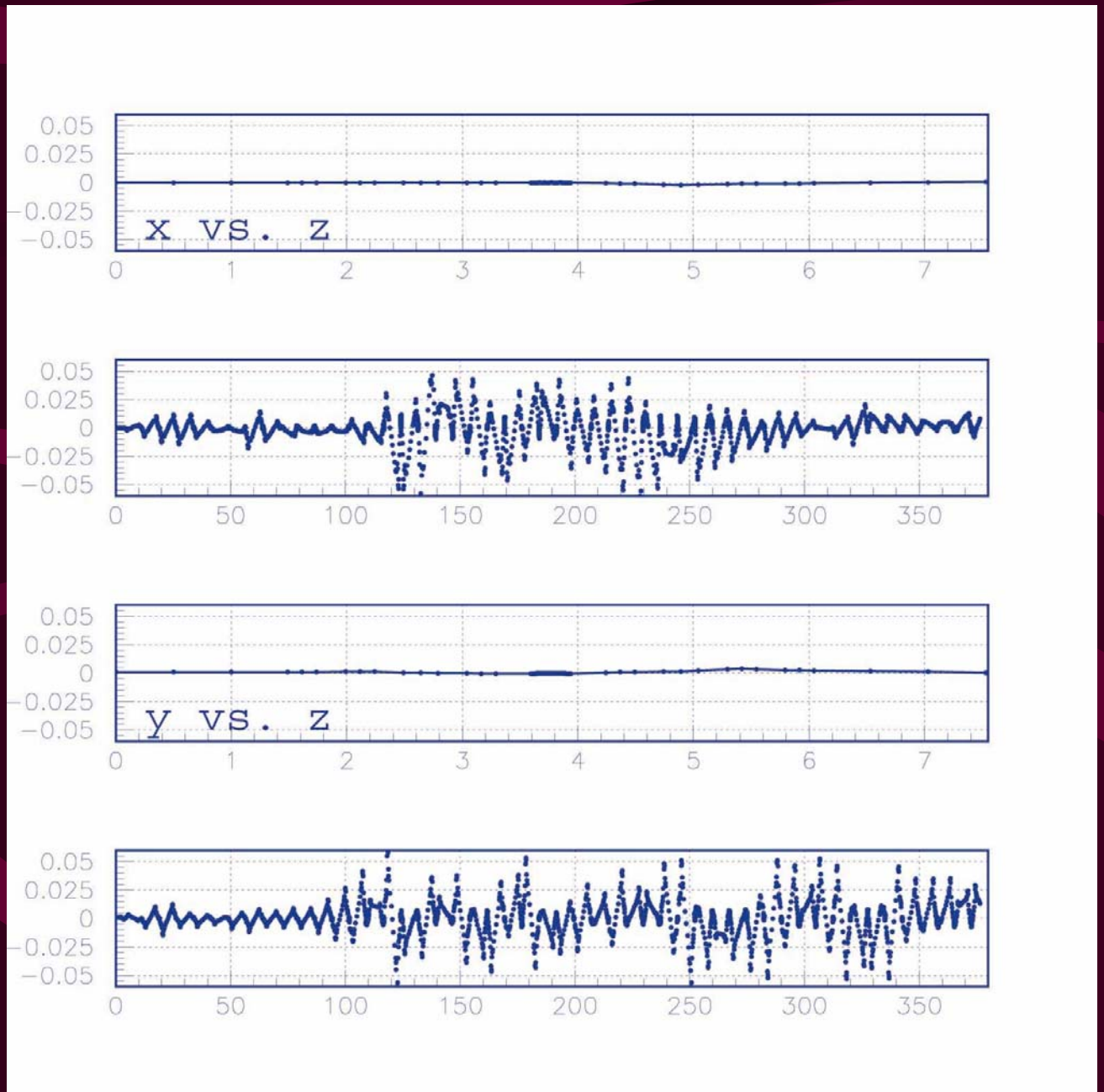
Li β=(4,1,4) cm + Quad. Matching Cell



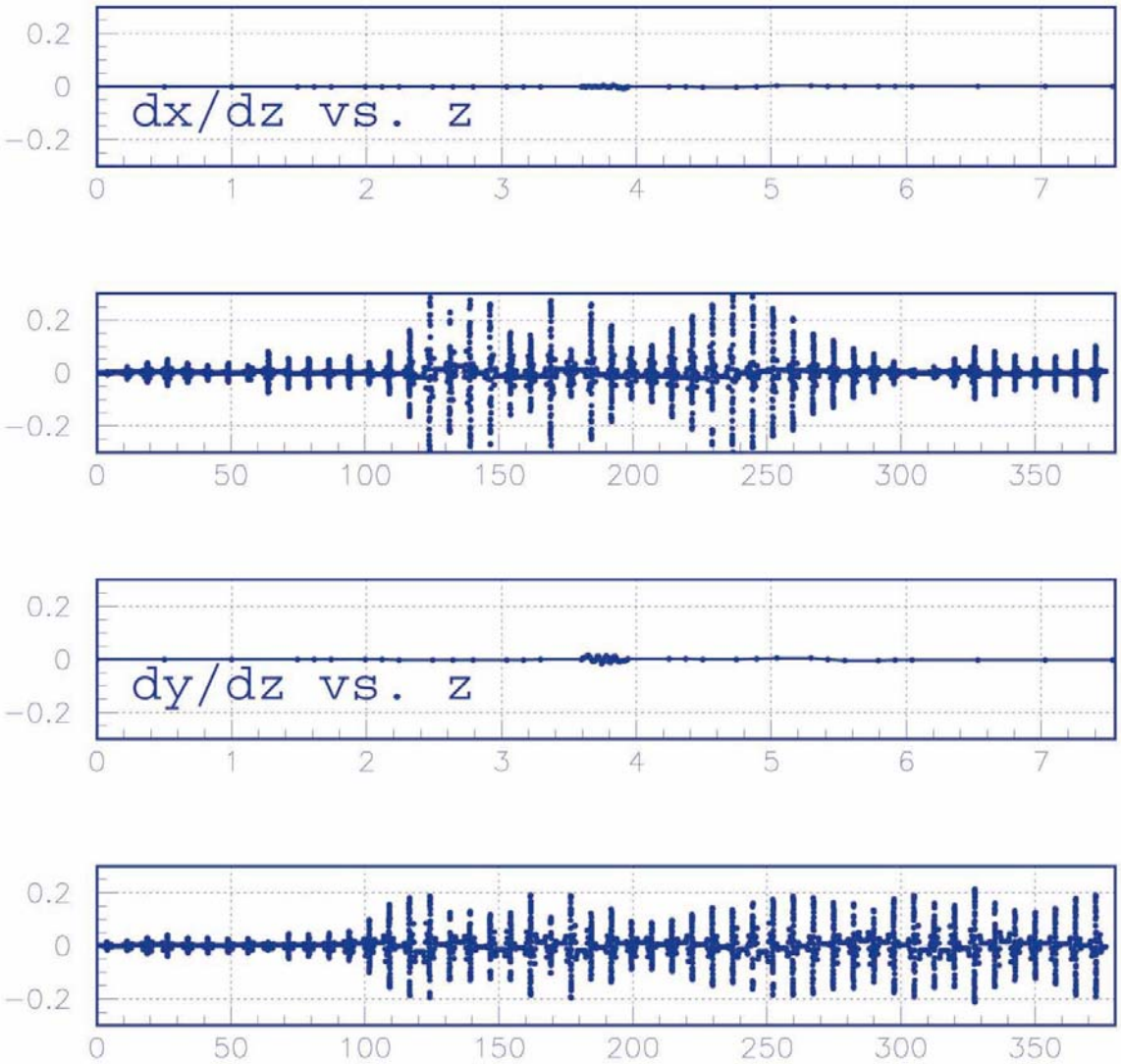
Li β=(4,1,4) cm + Quad. Matching Cell



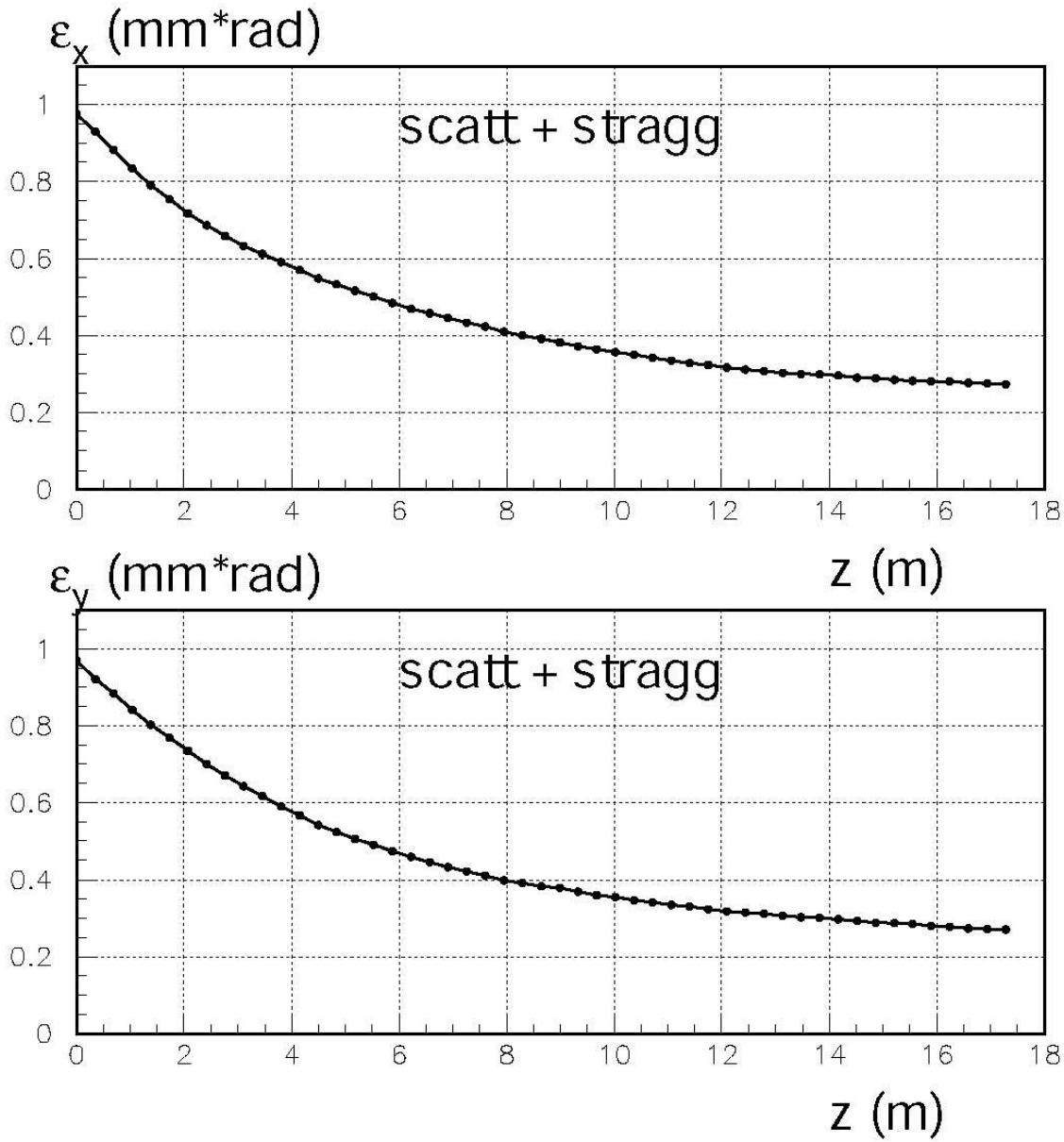
Li β=(4,1,4) cm + Quad. Matching Cell



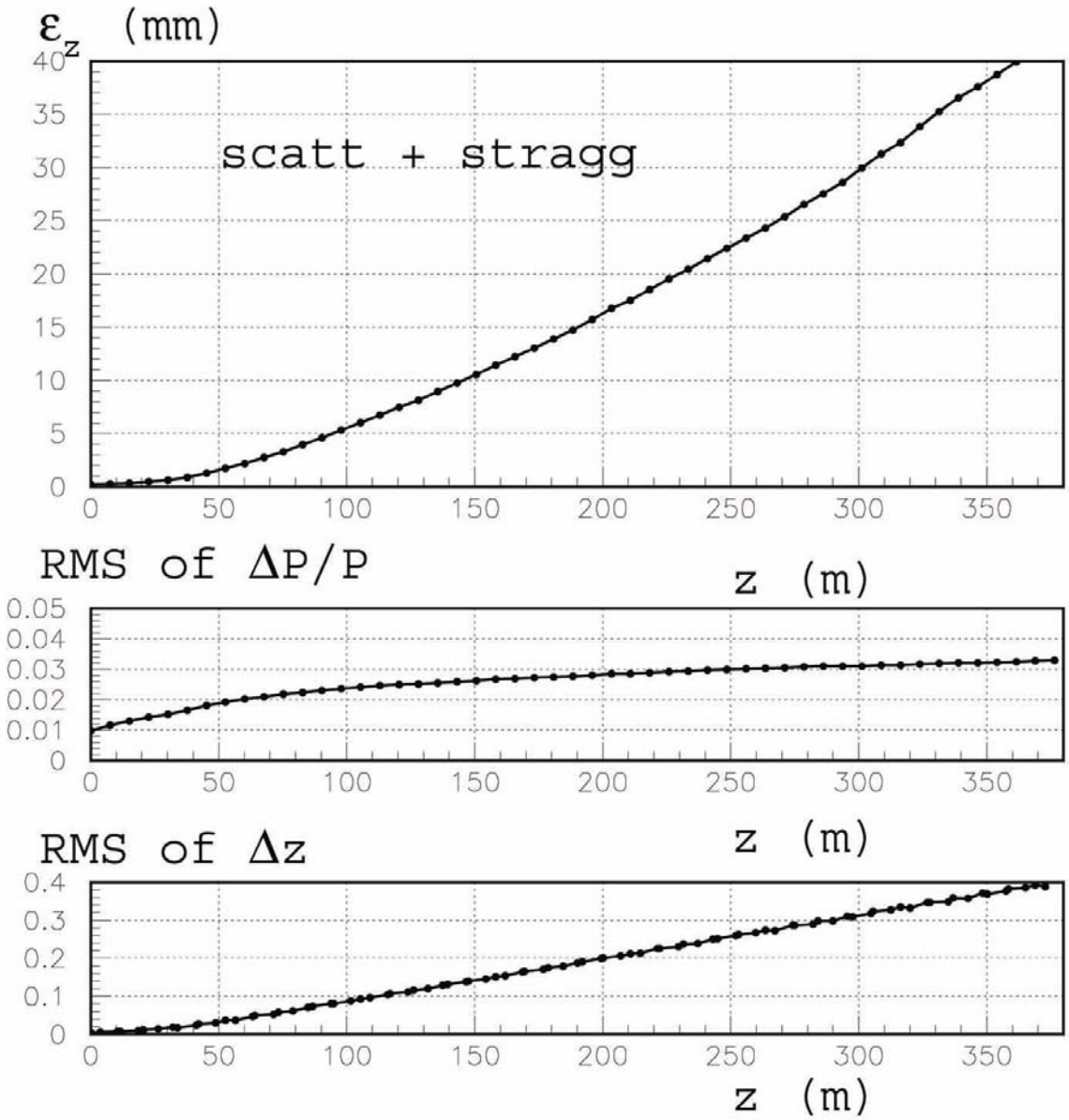
Li β=(4,1,4) cm + Quad. Matching Cell



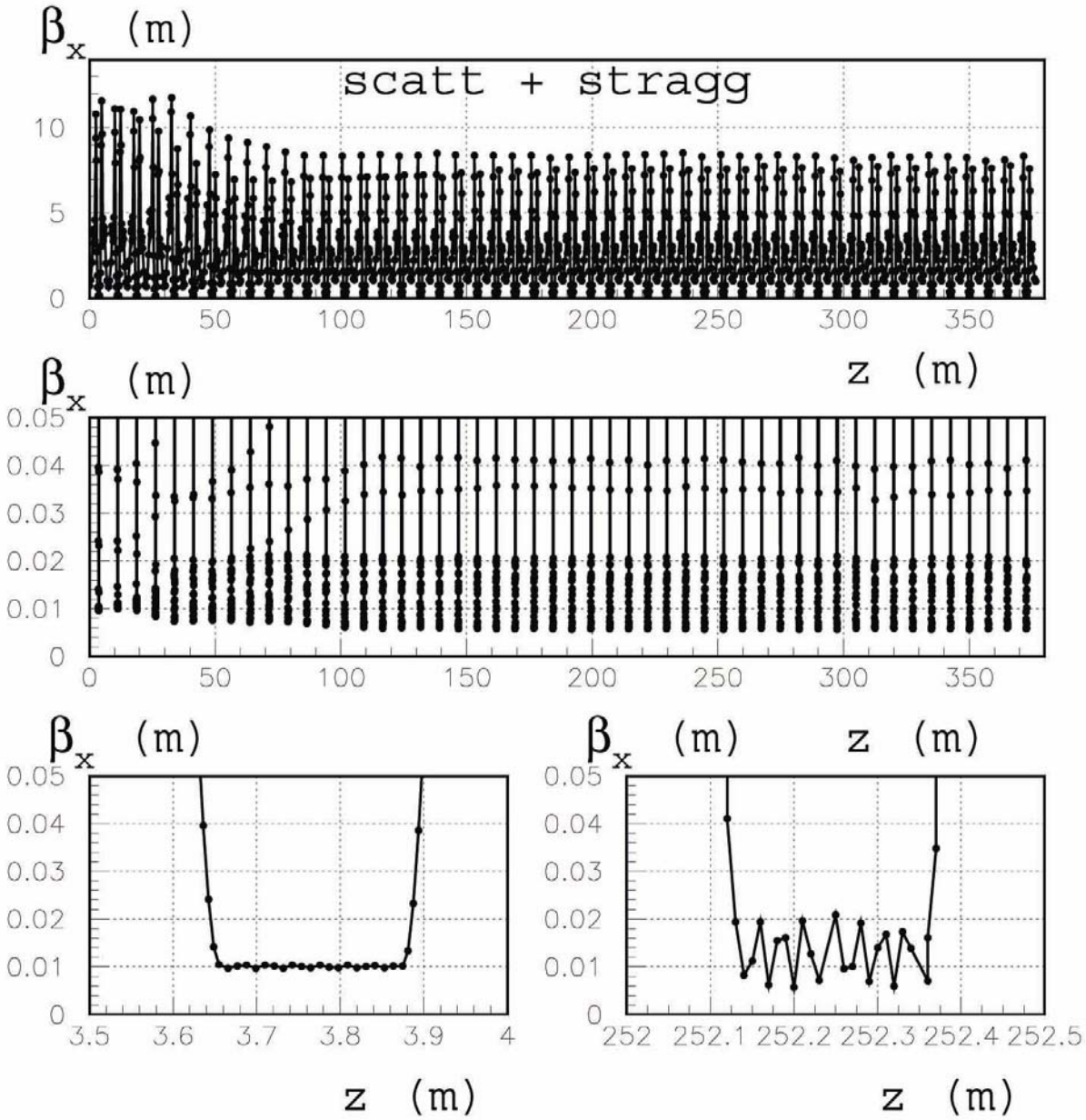
Li β=(4,1,4) cm + Quad. Matching Cell



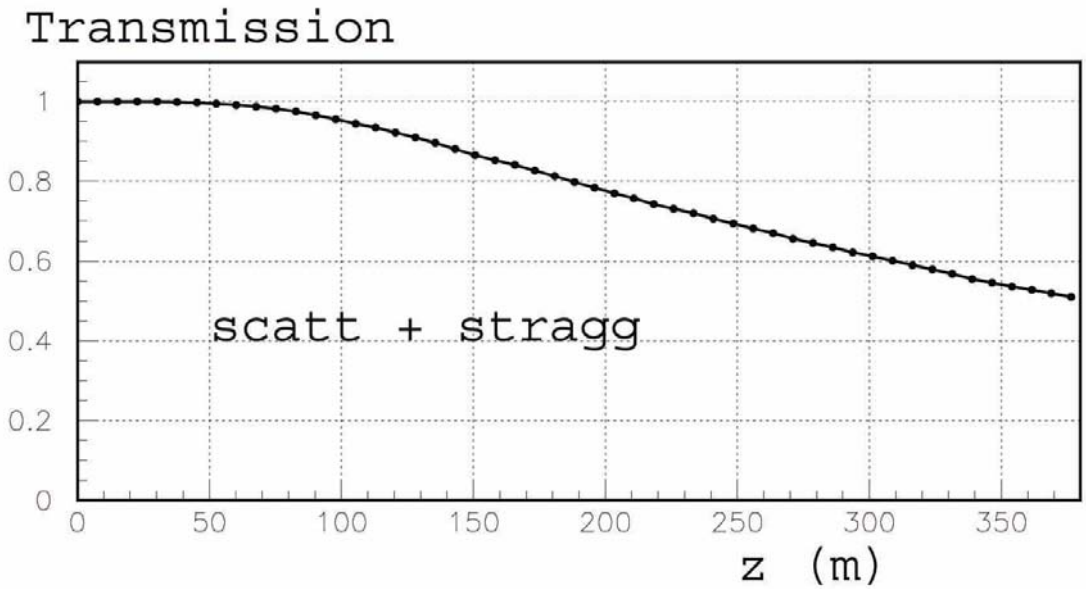
Li β=(4,1,4) cm + Quad. Matching Cell



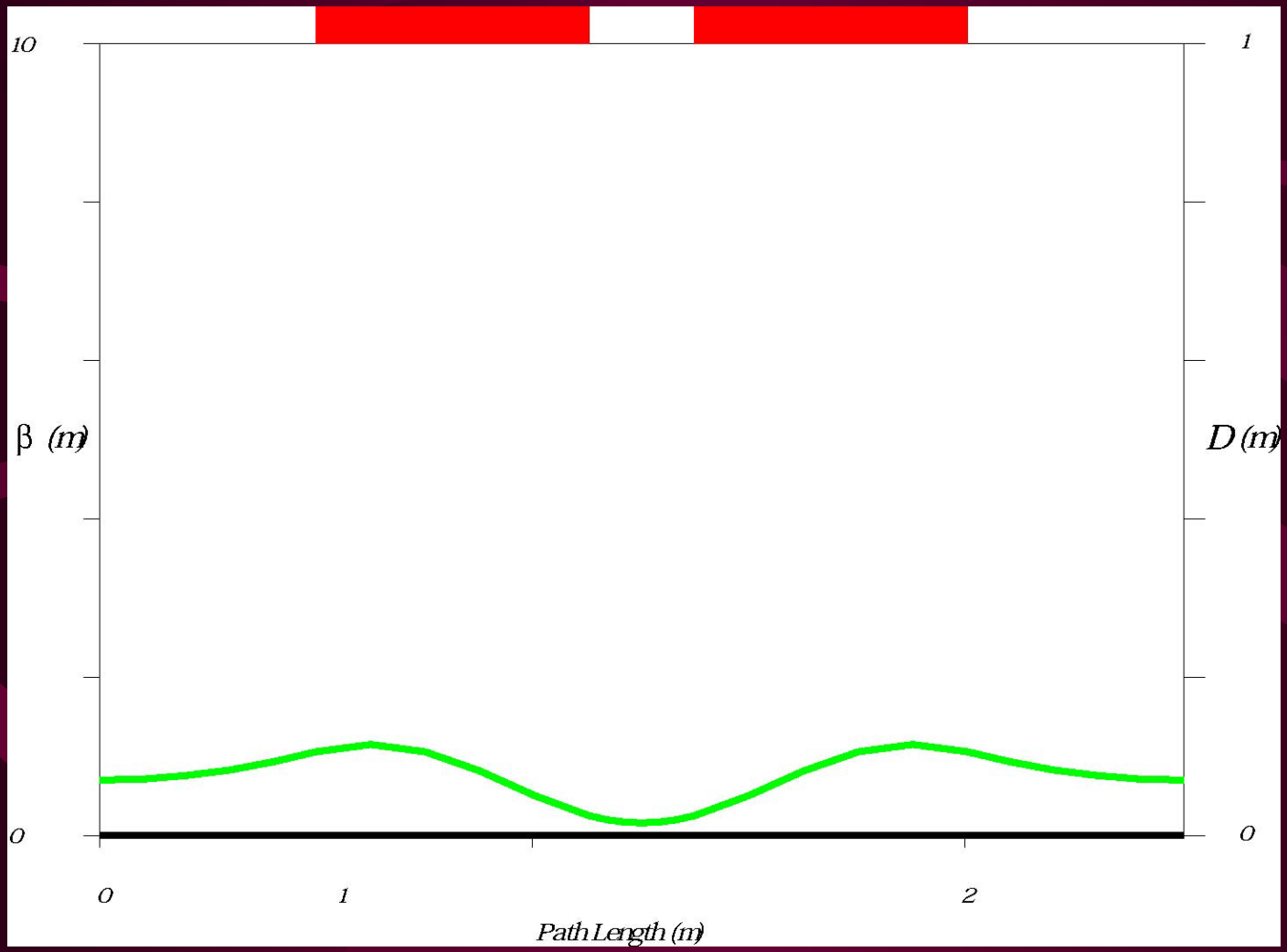
Li β=(4,1,4) cm + Quad. Matching Cell



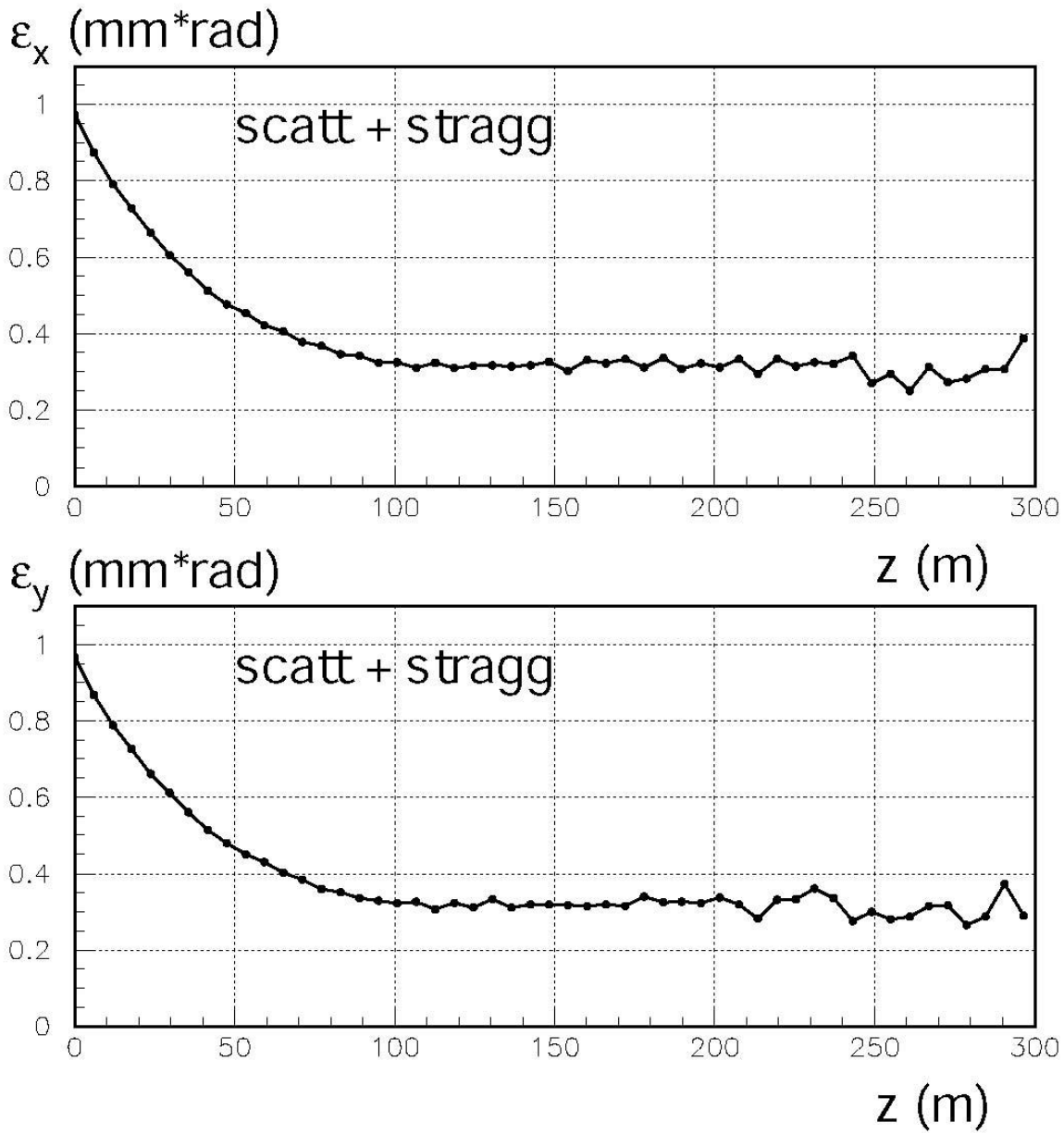
Li β=(4,1,4) cm + Quad. Matching Cell



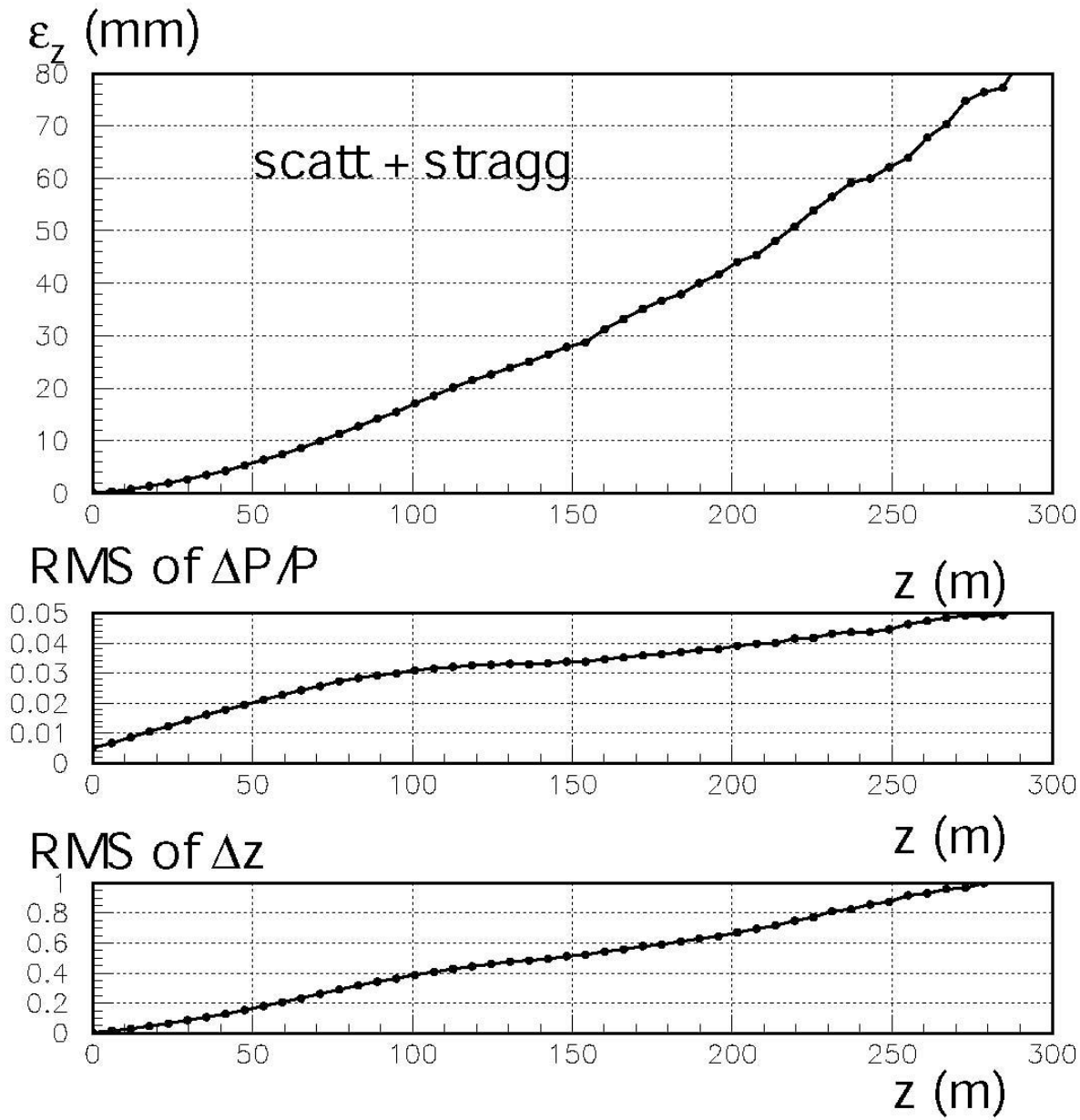
Li β=(4,1,4) cm + Solenoid Matching Cell
only matching cells are shown



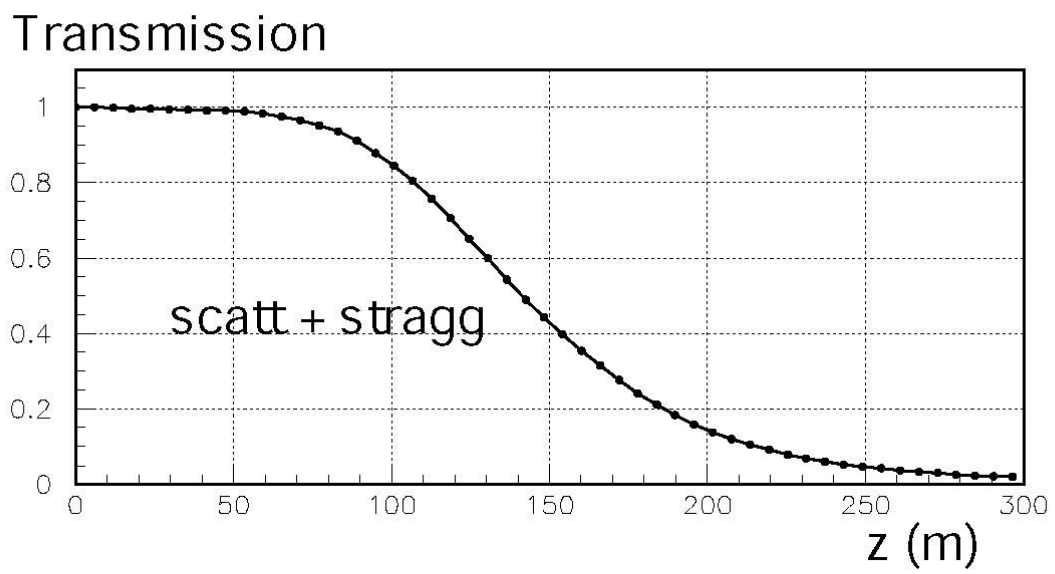
Li β=(4,1,4) cm + Solenoid Matching Cell



Li β=(4,1,4) cm + Solenoid Matching Cell



Li β=(4,1,4) cm + Solenoid Matching Cell



Li β=(4,1,4) cm + Solen. Matching Cell

- Solenoid Matrix of SYNCH is used in ICOOL. Need edge Bz field in ICOOL.

  β function in ICOOLwas checked and OK.
- Tapered the Lithium lens current, and

  getting emittance development at 250 MeV/c .

Summary

- Beam dynamics study in straight channels show promising transverse cooling through Lithium lenses
- Momentum acceptance of the channel is a key issue in the muon cooling with Lithium lenses
- Study in a Ring Cooler is the next step.