FOOT magnetic field study
(Momentum resolution)

Ch. Finck

Introduction

Guariguanchi

Magnetic Field

Detectors positions

Alpha particles

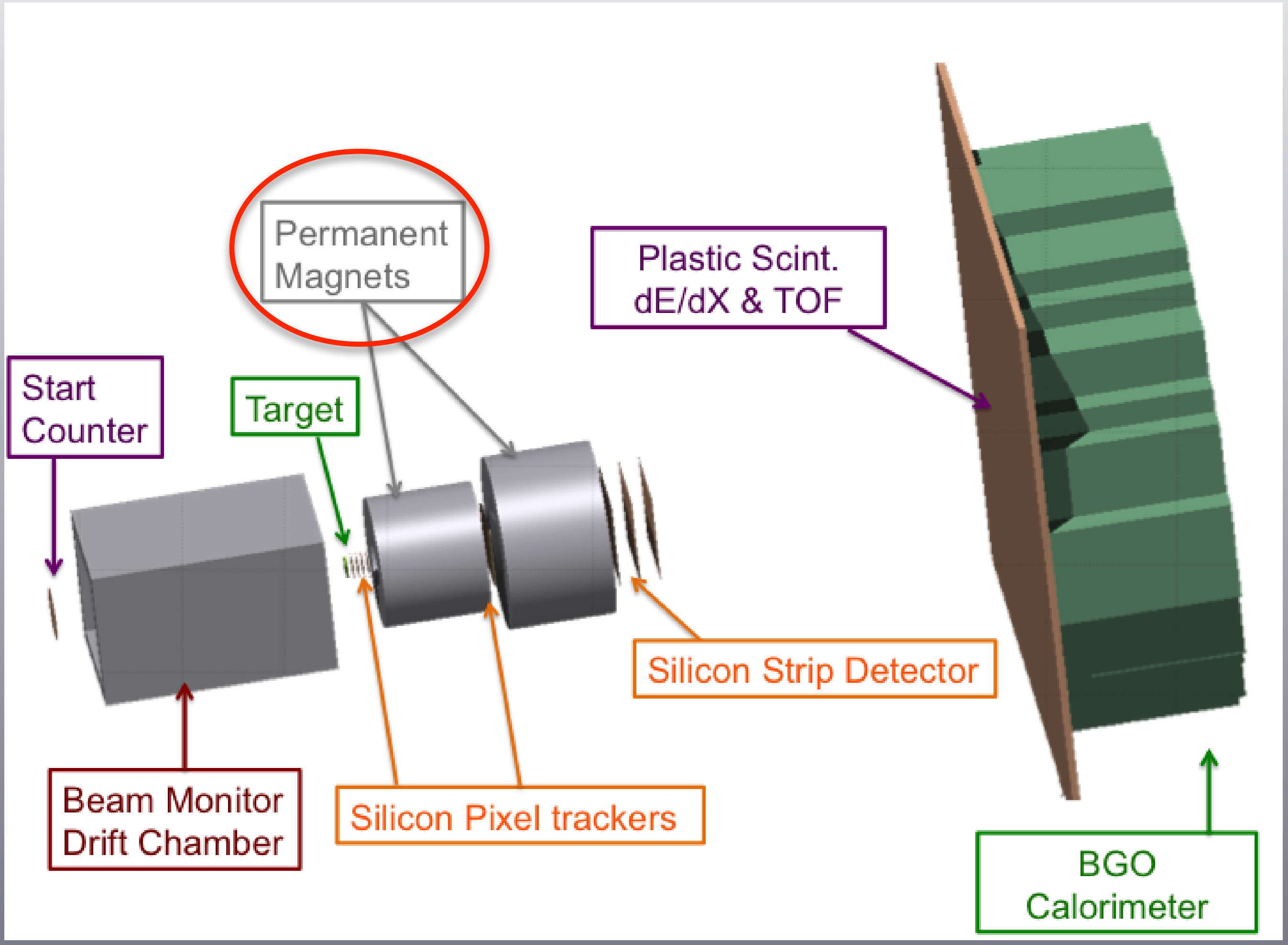
Protons

Particles with Z ≥ 3

Conclusions

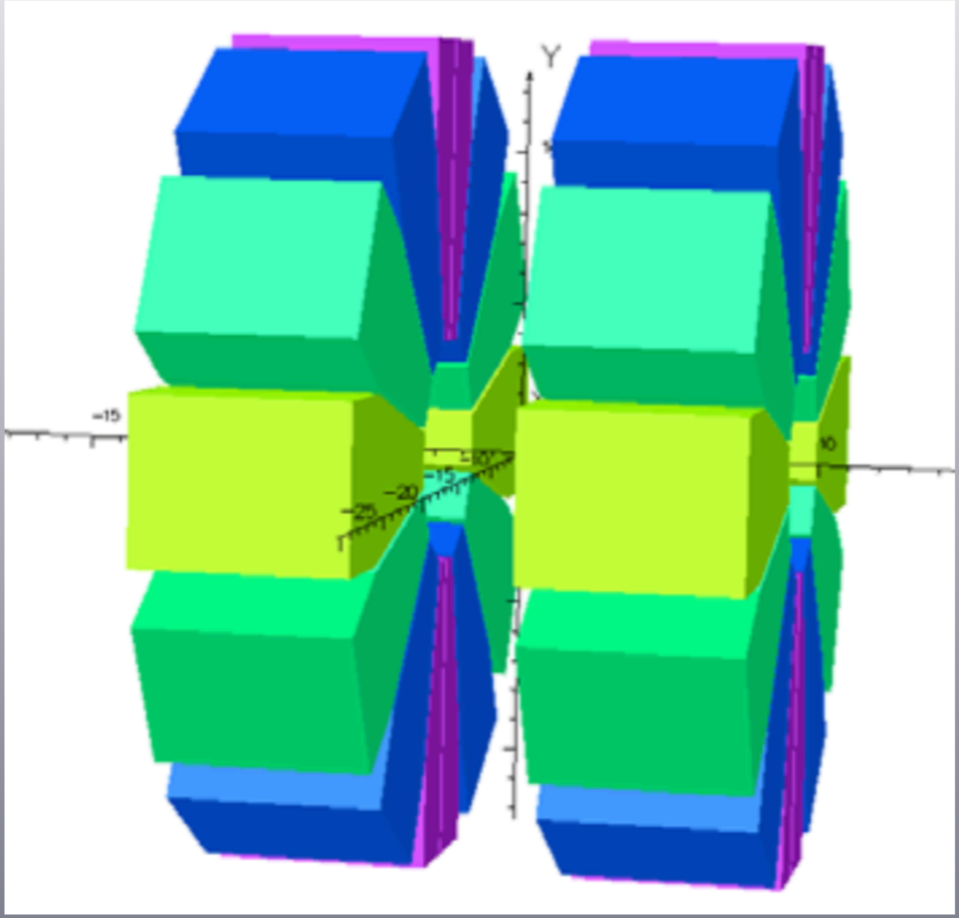
Introduction (i)

- FOOT experimental setup

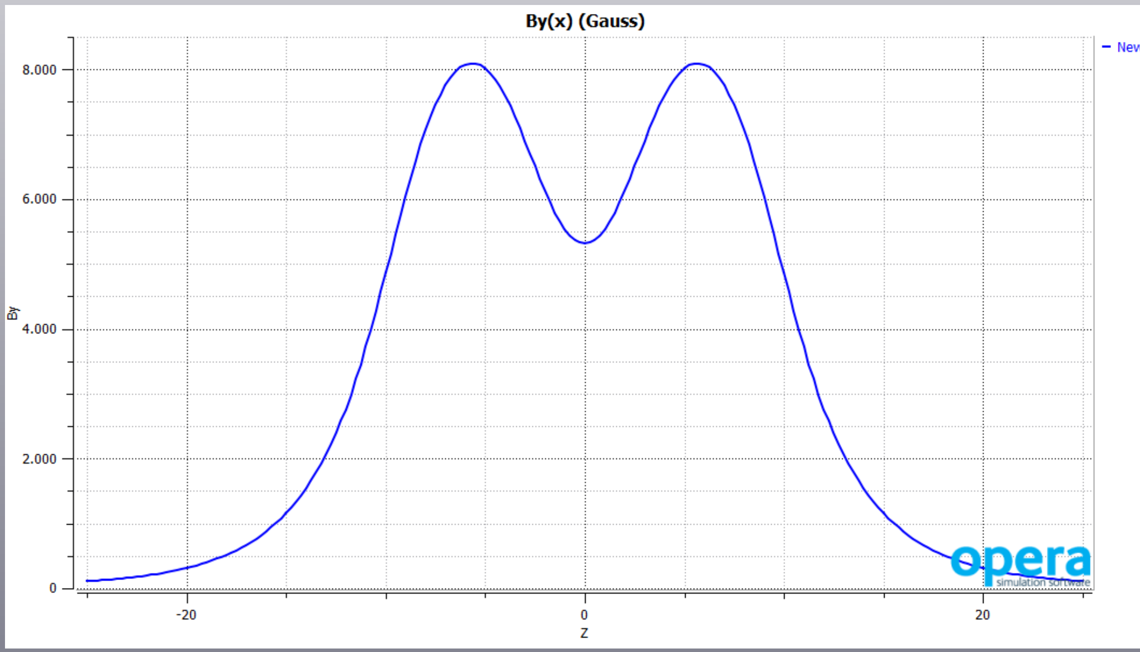


Introduction (ii)

- Permanent magnet

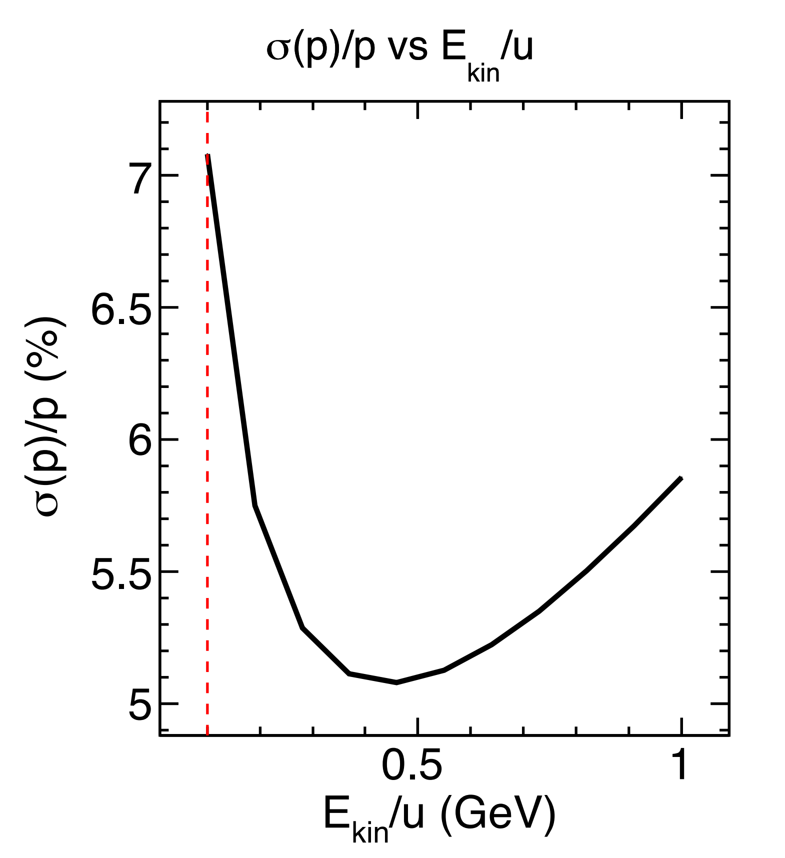


(C. Sanelli & E. Spiriti)



Guariguanchi (i)

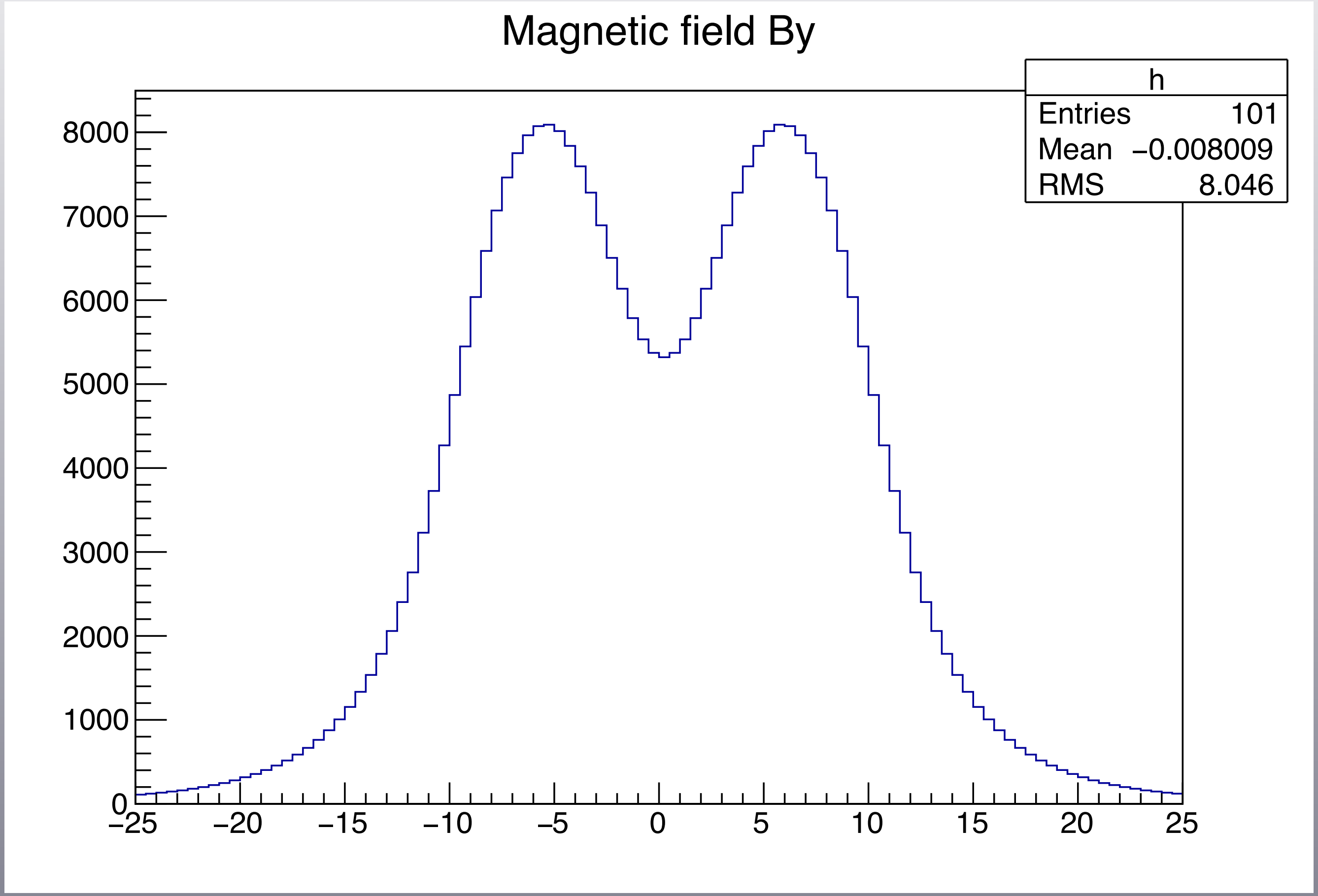
- An analytical code (A. Perez - PICSEL-IPHC) for momentum resolution computing
  - The package has a set of tools which allows to calculate for a given momentum (p,θ,φ) the track parameters covariance matrix.



Example of output for alpha particles with an impinging energies 0.1 to 1 GeV (θ = φ = 0)

Guariguanchi (ii)

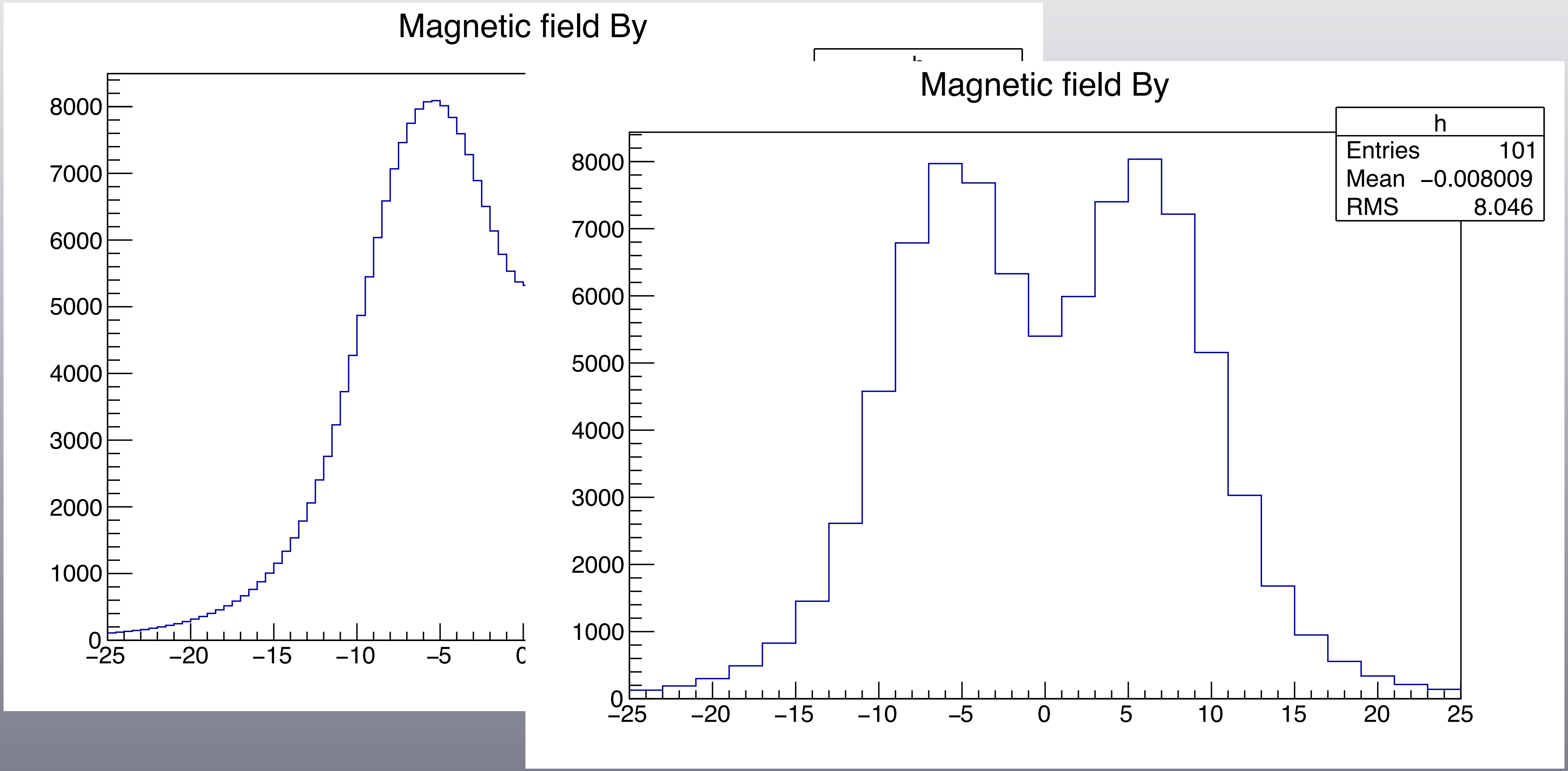
- Magnetic field:



Description of magnetic field in step of 0.5 cm

Guariguanchi (ii)

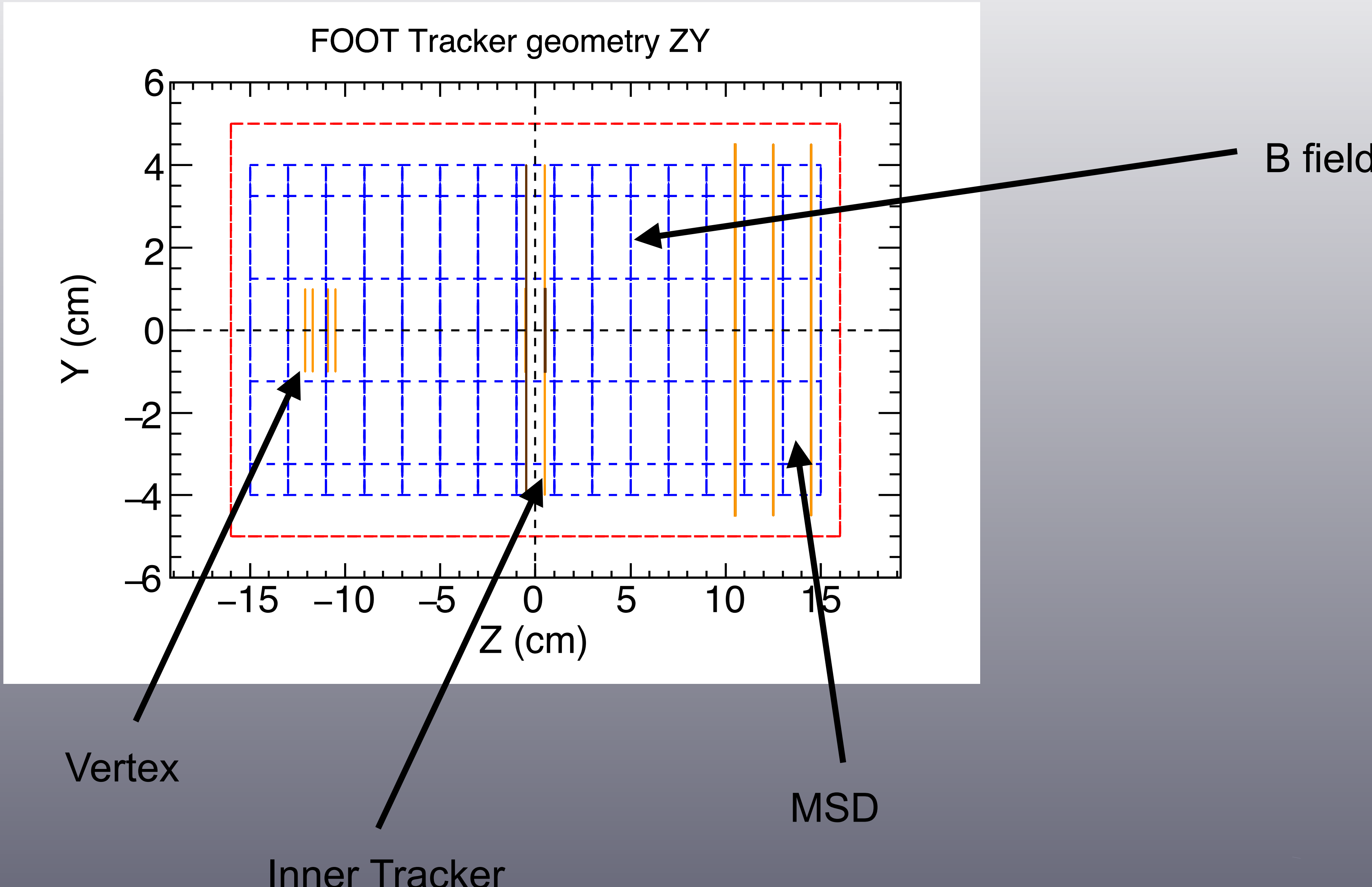
- Magnetic field:



Description of magnetic field in step of 2 cm

Guariguanchi (iiia)

- Geometry:



Guariguanchi (iiib)

- Geometry (VTX):

```
BeginGeoPlane
  Name            1-4 Mi28 VPT
  Position        0.0  0.0 -12.1/-11.7/-10.9/-10.5  cm
  RotAngles       0.0  0.0   0.0  deg
  Material        silicon
  Thickness         50.0   um
  widthU           2.0   cm
  widthV           2.0   cm
  LayerName         VPT-1
  IsSensitive      true
  ResolutionU       3.5   um
  ResolutionV       3.5   um
  Efficiency       0.98
  …
EndGeoPlane
```

Guariguanchi (iiic)

- Geometry (IT):

```
BeginLadderPlane
  LadderName       1-2 IPT station
  LadderPosition      0.0  0.0  -0.5/+0.5 cm
  LadderRotAngles  0.0  0.0    0.0  deg

  BeginPlane
    Name          Sensor
    Position       0.0  0.0  0.0  um
    Thickness      50.0 um
    Material       silicon
    widthU         2.0 cm
    widthV         2.0 cm
    LayerName      IPT-1
    IsSensitive    true
    ResolutionU       3.5   um
    ResolutionV       3.5   um
    Efficiency        0.98
    ROtime          200.0   us
    ……
 EndPlane
```

Guariguanchi (iiid)

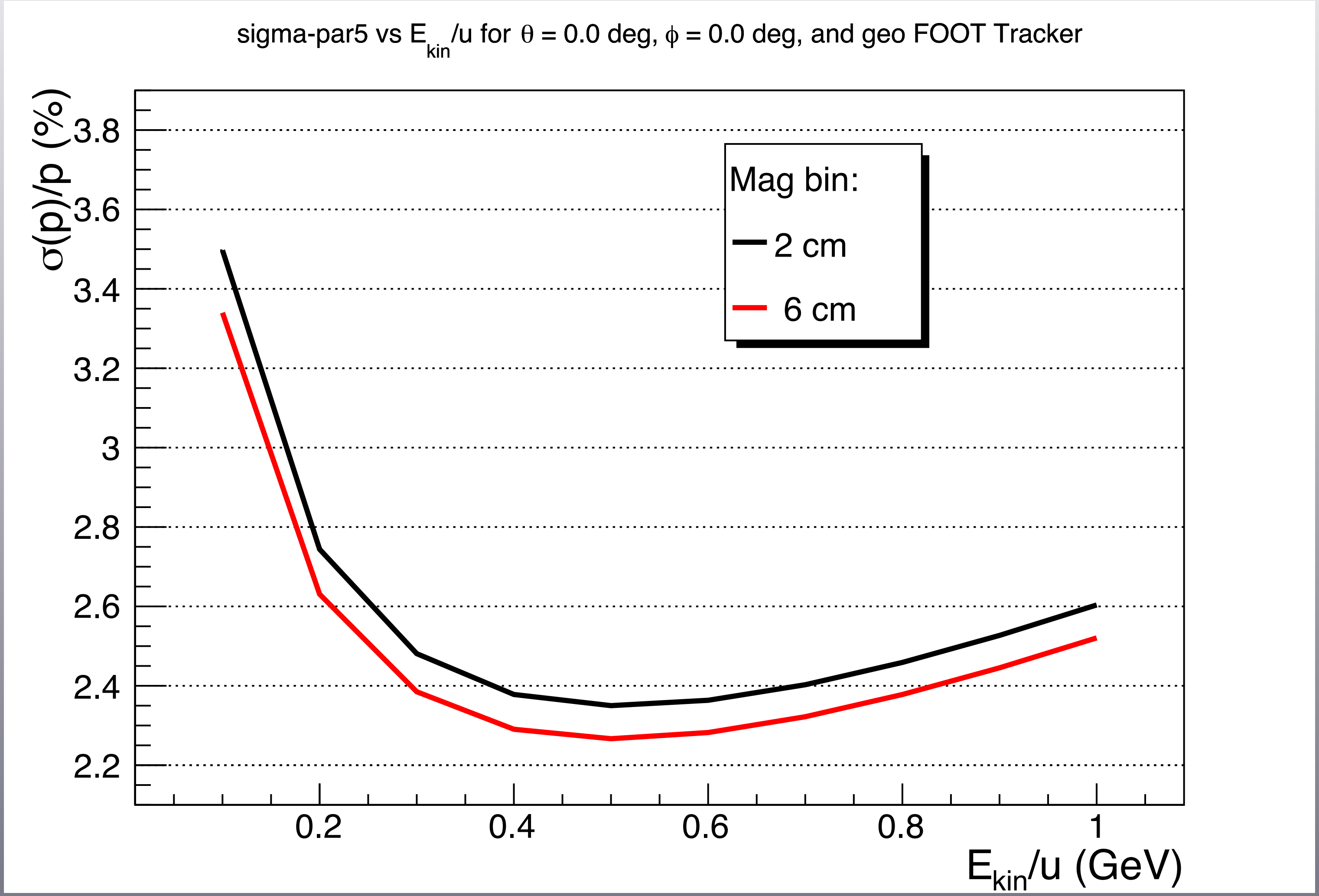
- Geometry (MSD):

```
BeginLadderPlane
  LadderName        1-3 ST station
  LadderPosition     0.0  0.0  10.5/12.5/14.5/ cm
  LadderRotAngles  0.0  0.0   0.0  deg

  BeginPlane
    Name              sensitive silicon
    Position         0.0  0.0  0.0  um
    Thickness        150.0 um
    Material         silicon
    widthU           9.0 cm
    widthV           9.0 cm
    LayerName          SP-1
    IsSensitive       true
    ResolutionU       36.0   um
    ResolutionV       36.0   um
    Efficiency       0.98
    …..
 EndPlane
```

Magnetic Field (i)

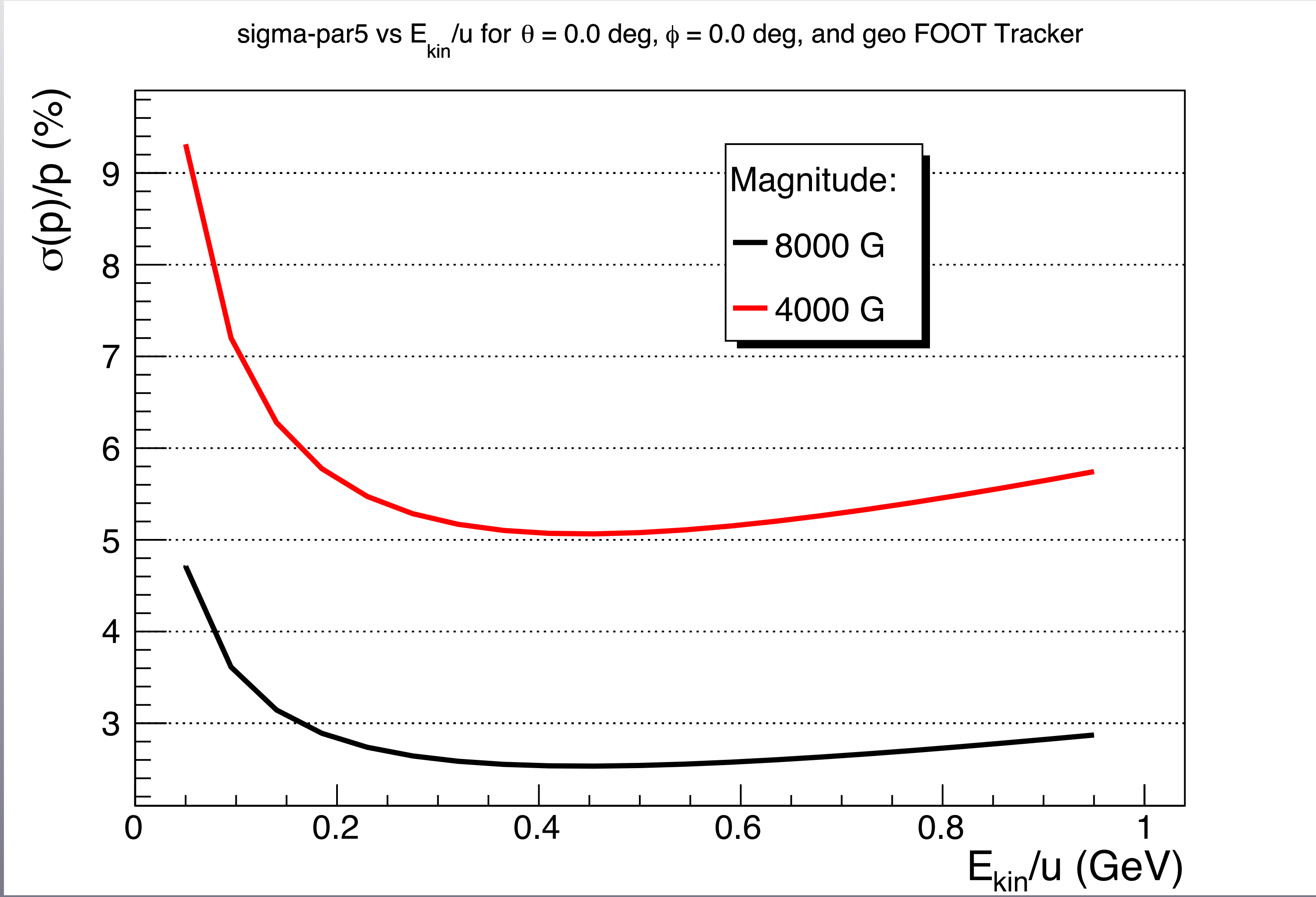
- Field binning with alpha particles:



- No big difference in momentum resolution: 0.2 % variation at 0.7 GeV/c
- CPU time ~15 times lower !

Magnetic Field (ii)

- Field strength for alpha particles (6 cm bin):

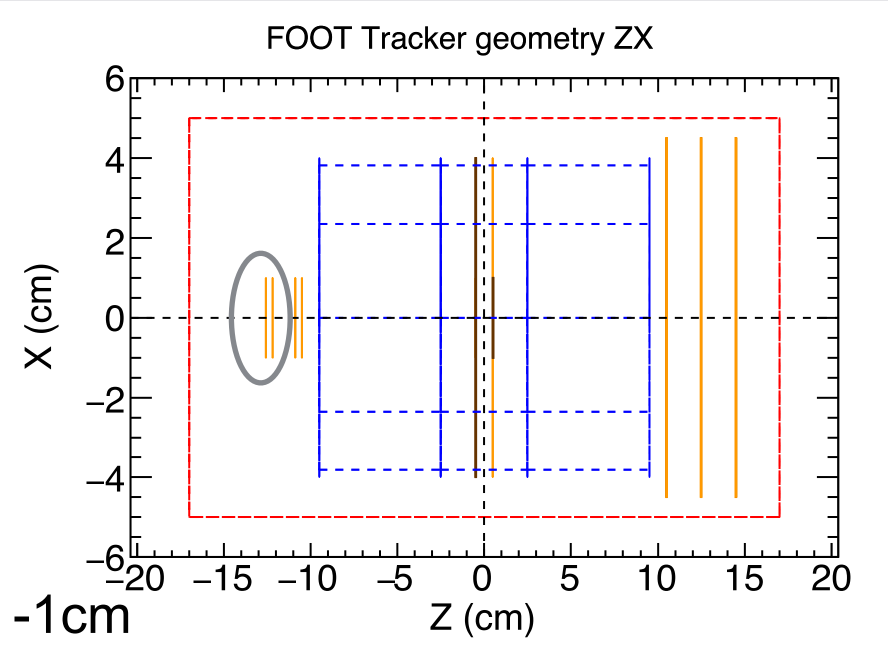


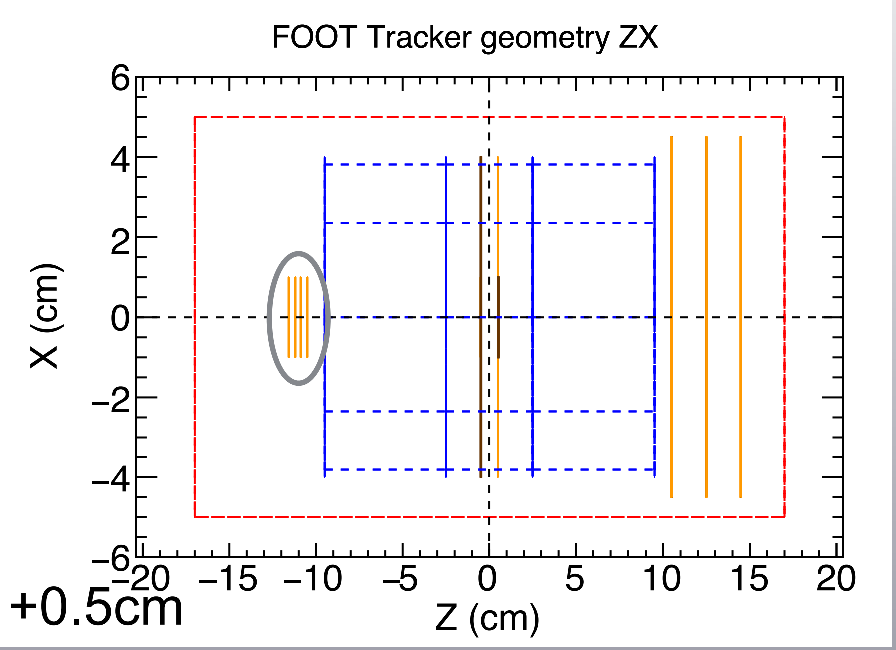
- Factor 2 in field strength leads to factor 2 in resolution: $\frac{\sigma_p}{p} = \frac{p}{BL}$

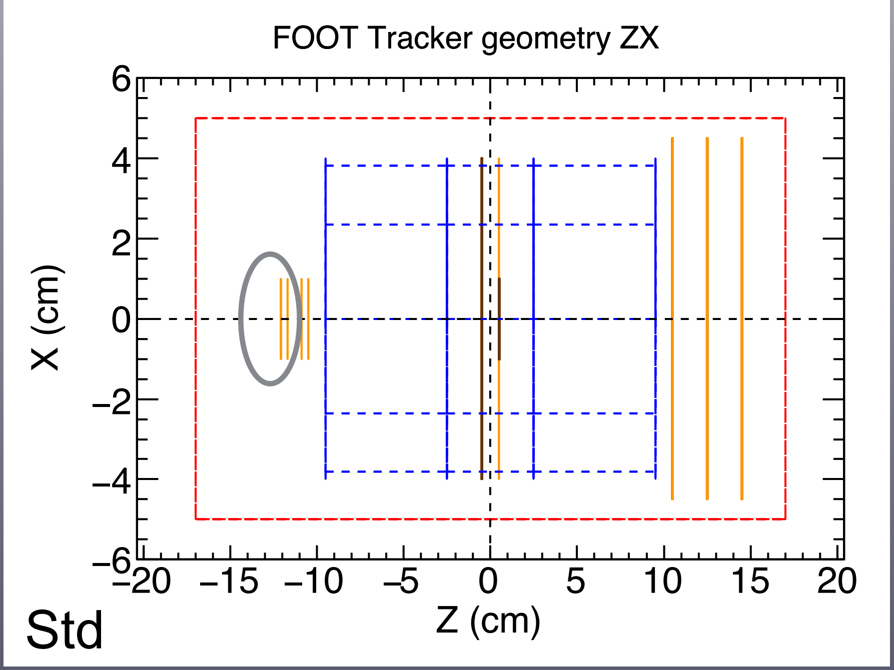
⇨ Field in 6 cm bin and 8000 G strength

Detectors positions (i)

- Shift VTX 2 first planes of -1 cm and +0.5 cm

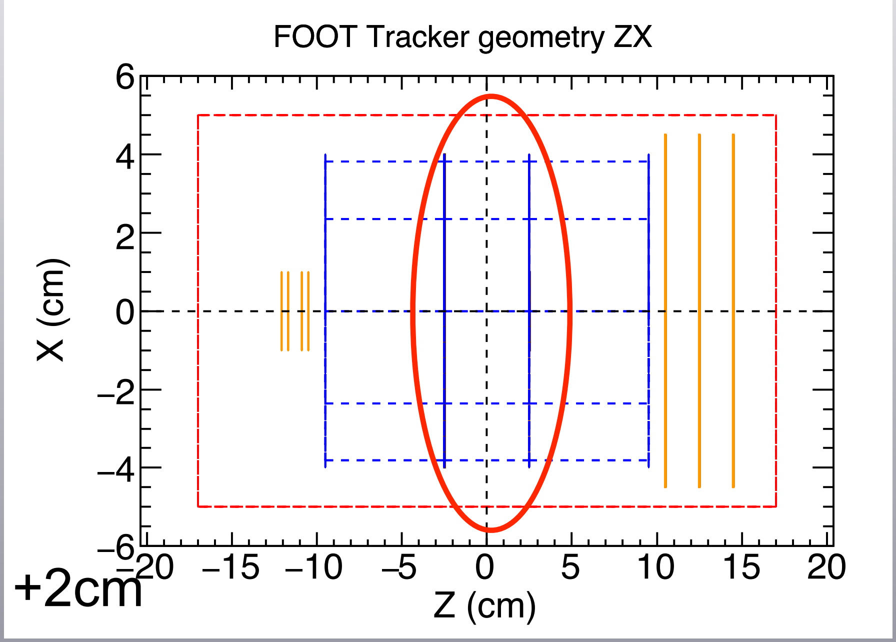


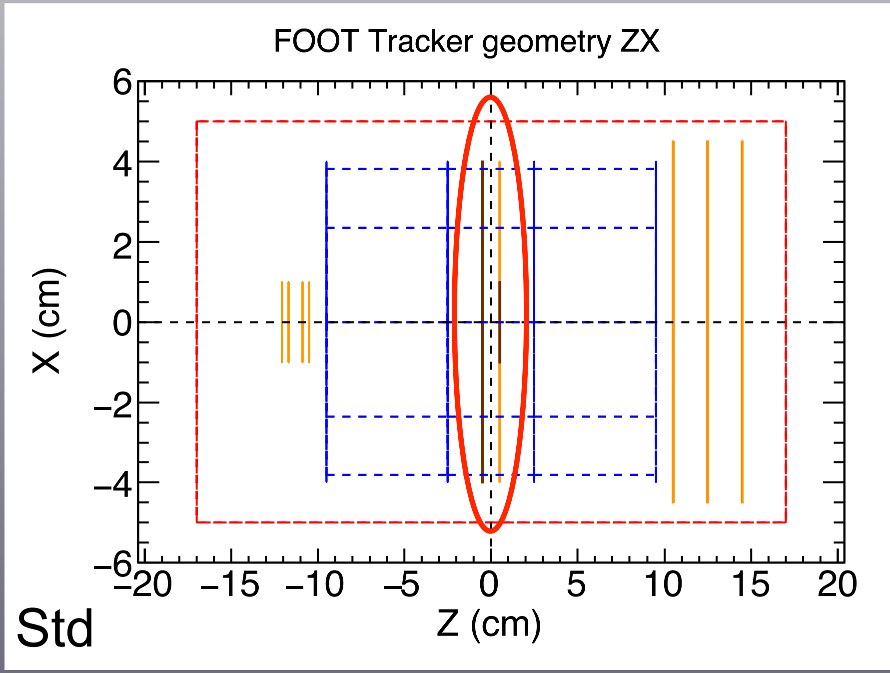




Detectors positions (ii)

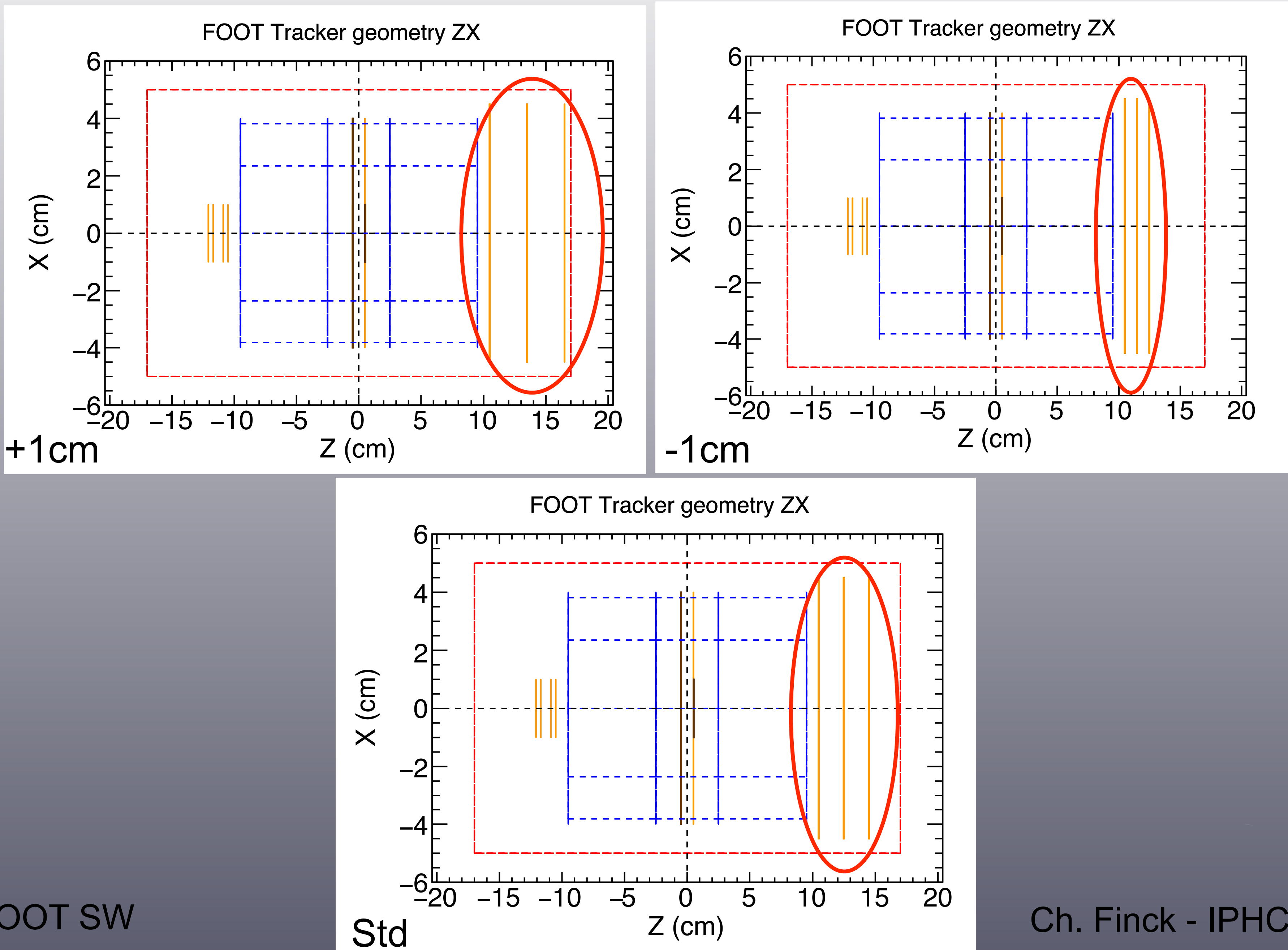
- Increase distance of IT +2.0 cm





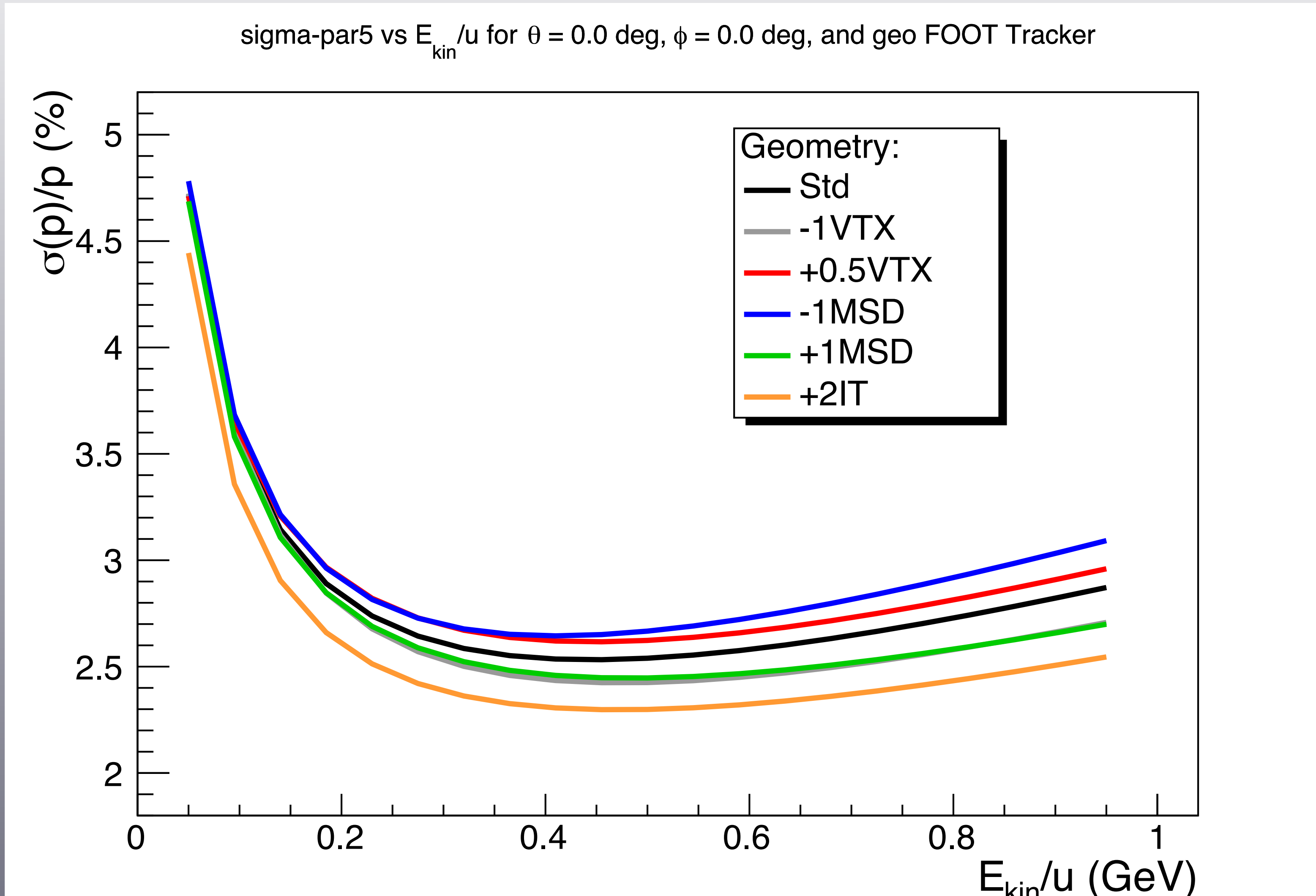
Detectors positions (iii)

- Increase/decrease distance of MSD planes of 1cm



Alpha particles (i)

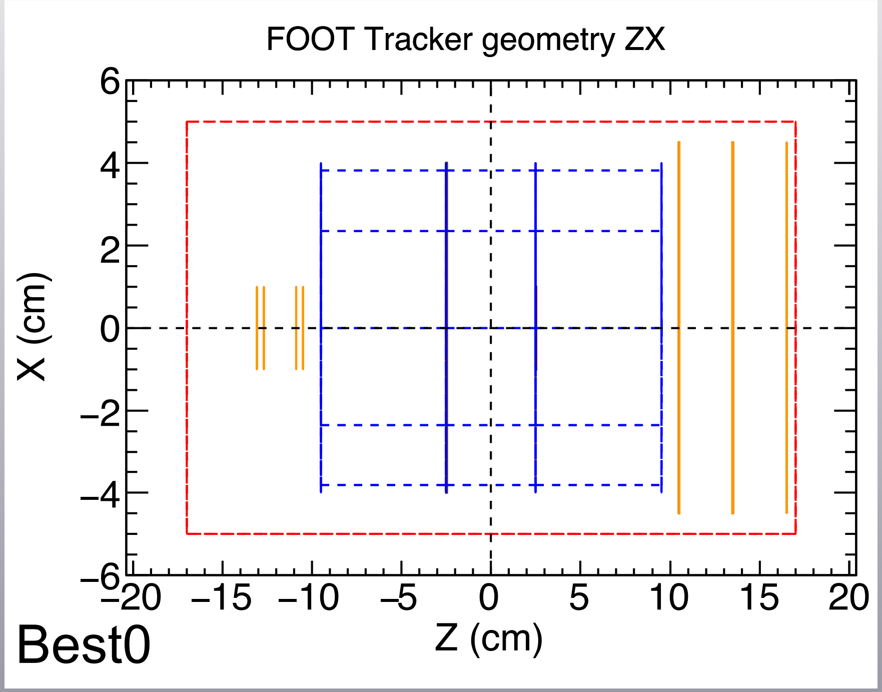
- Momentum resolution θ = 0º

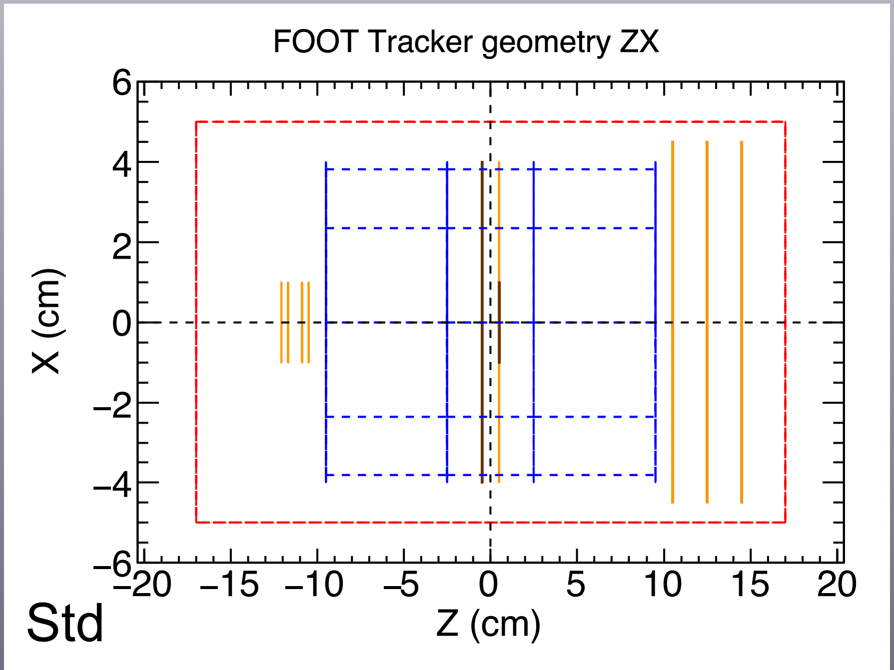


better resolution for position -1VTX, +1MSD and +2IT

Alpha particles (ii)

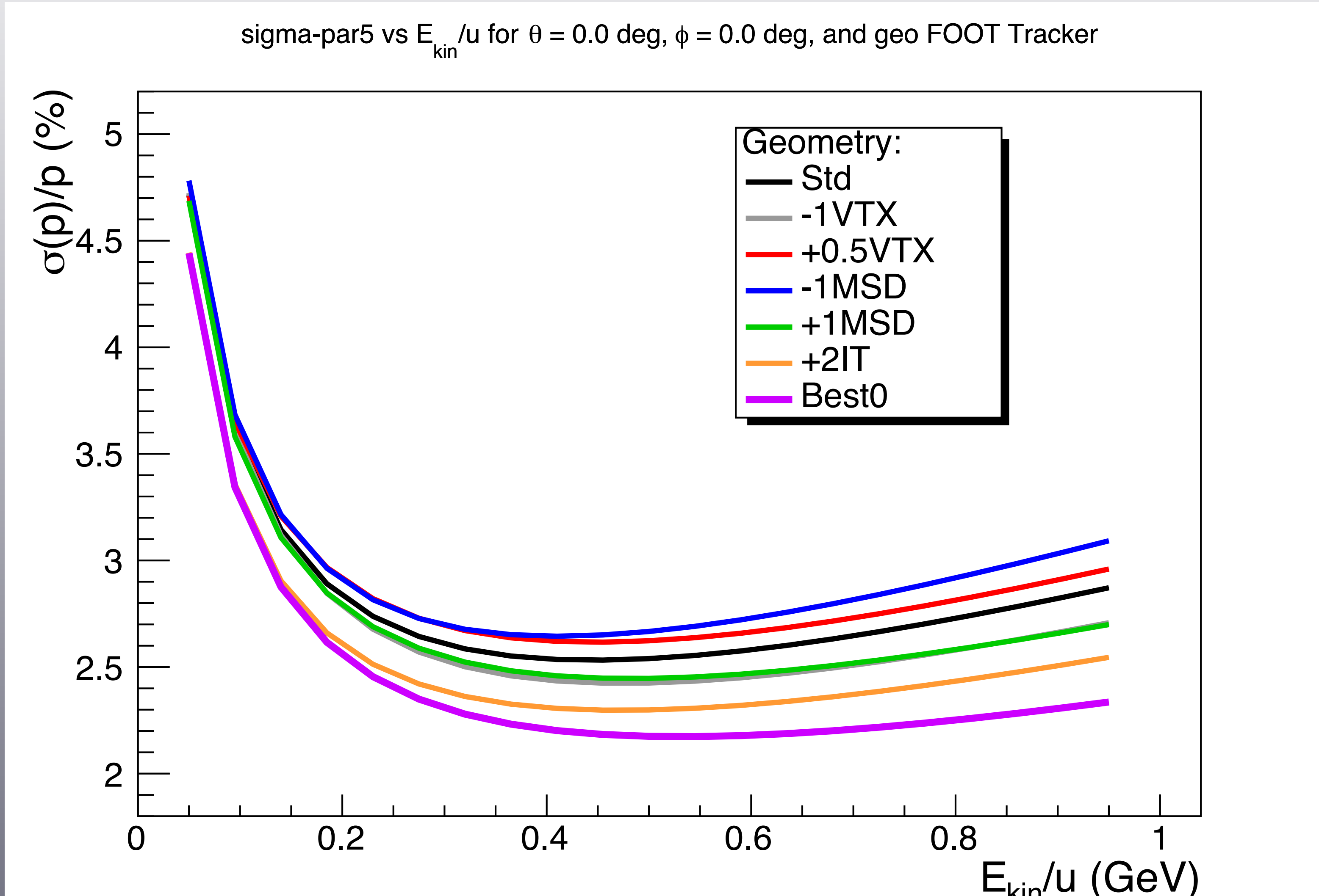
- Merge best geometries, θ = 0º





Alpha particles(iiia)

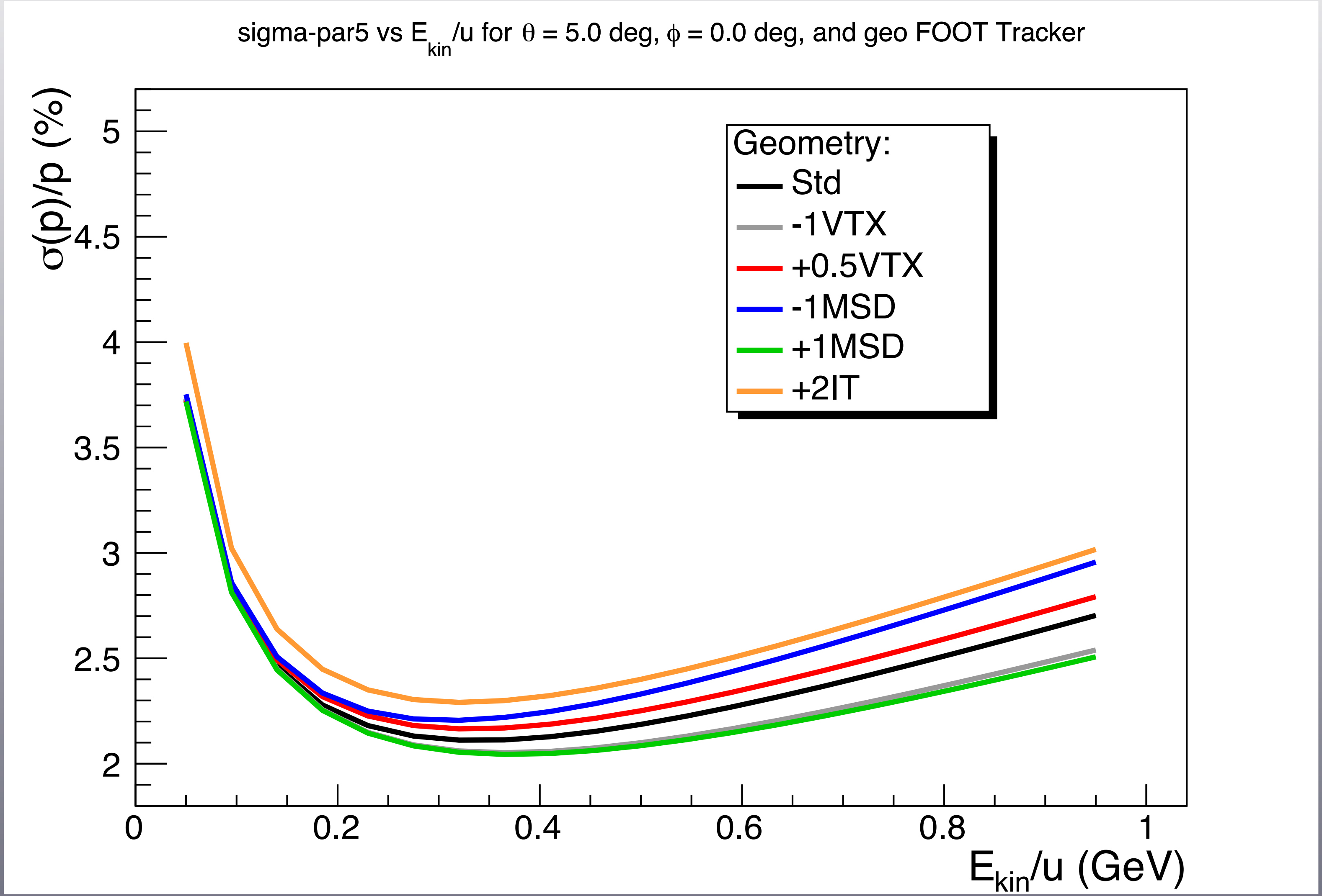
- Momentum resolution (including best geometry), θ = 0º



Gain of ~20 % compared to standard geometry (black line) for E_{kin} > 0.6GeV

Alpha particles(iiib)

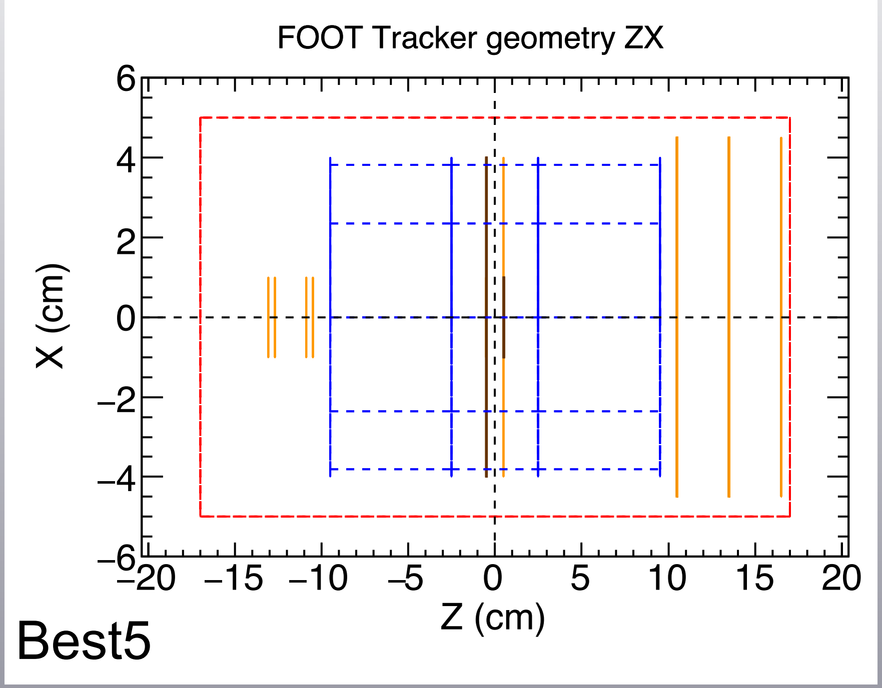
- Momentum resolution, $\theta = 5^o$

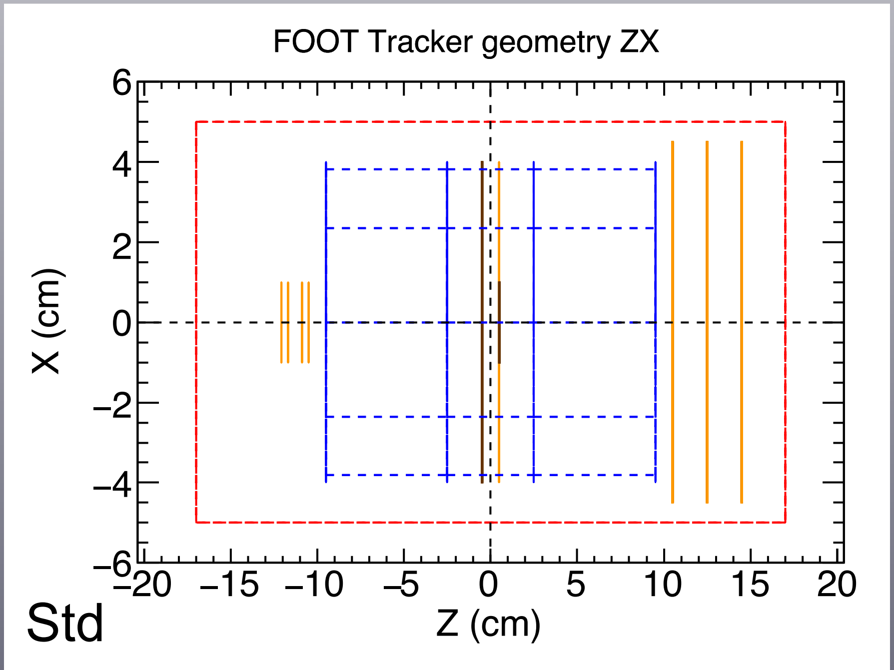


better resolution for position -1VTX, +1MSD ~~and +2IT~~

Alpha particles (ii)

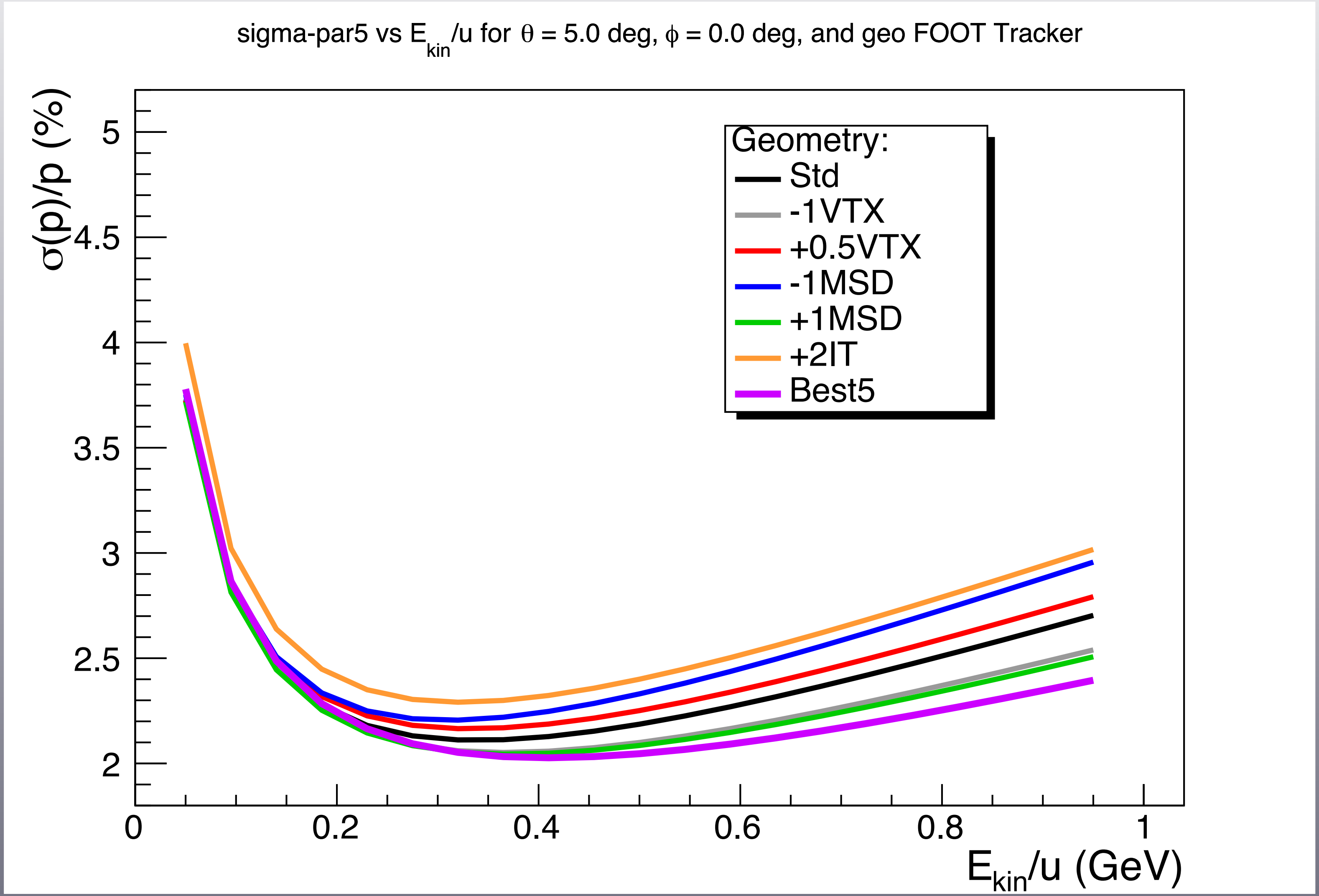
- Merge best geometries, θ = 5º





Alpha particles(iiic)

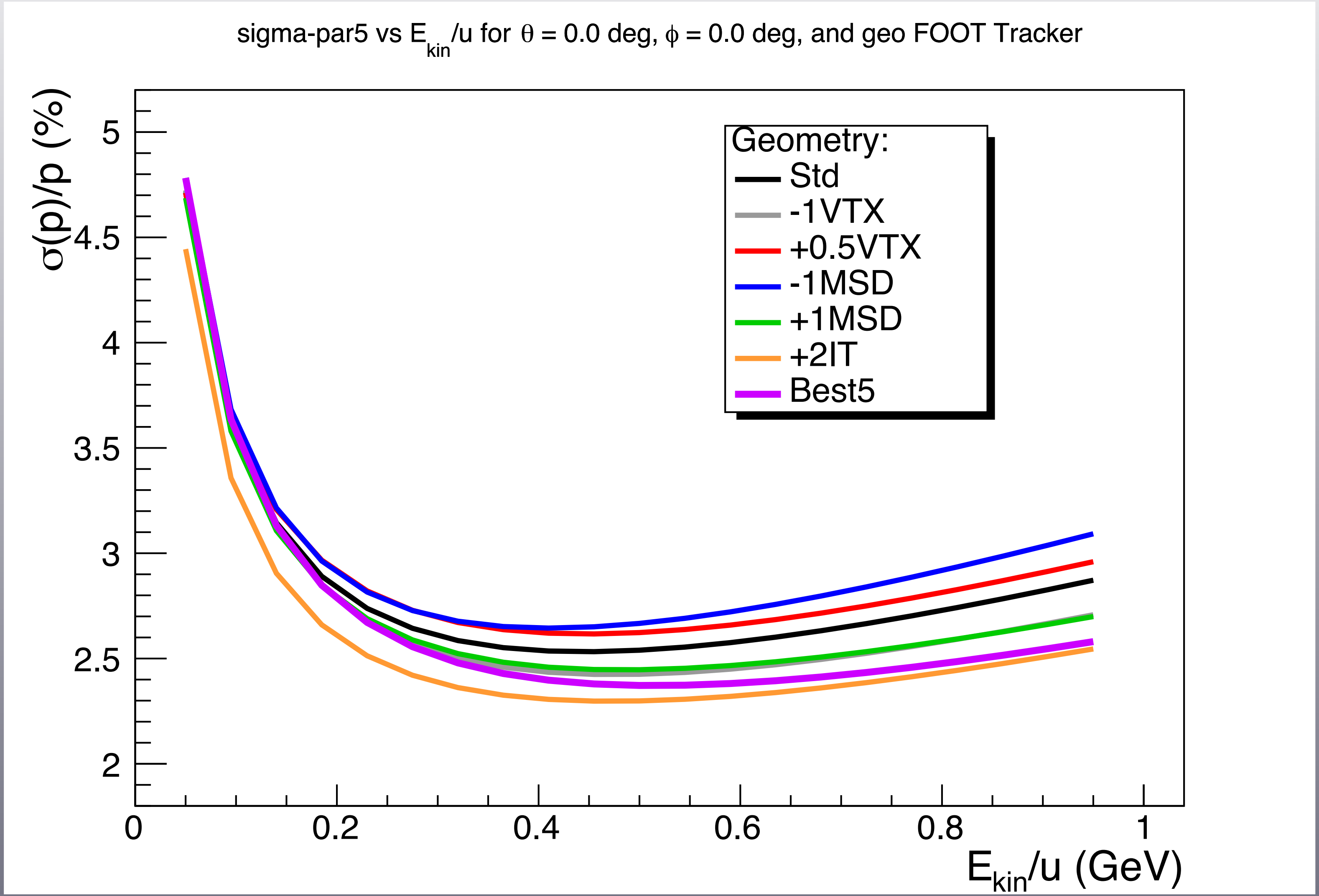
- Momentum resolution (including best geometry), θ = 5º



Gain of ~15 % compared to standard geometry (black line) for E_{kin} > 0.8GeV

Alpha particles (iiid)

- Taking best geometry for θ = 5º and apply to θ = 0º

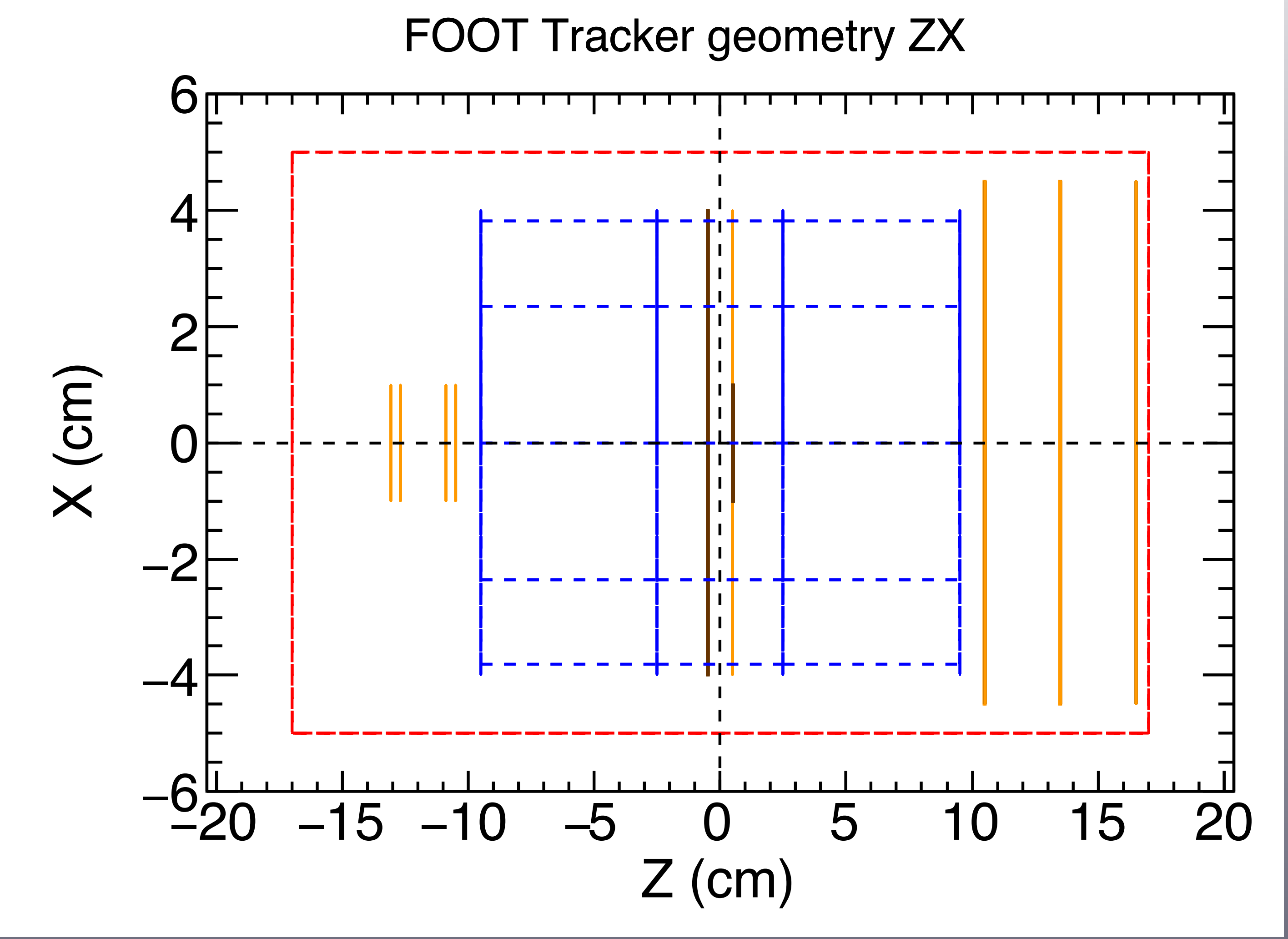


Still gain of ~10 % compared to standard geometry (black line) for E_{kin} > 0.8 GeV

Variation of ~ 10 % between 0.2 GeV/c and 0.7 GeV/c

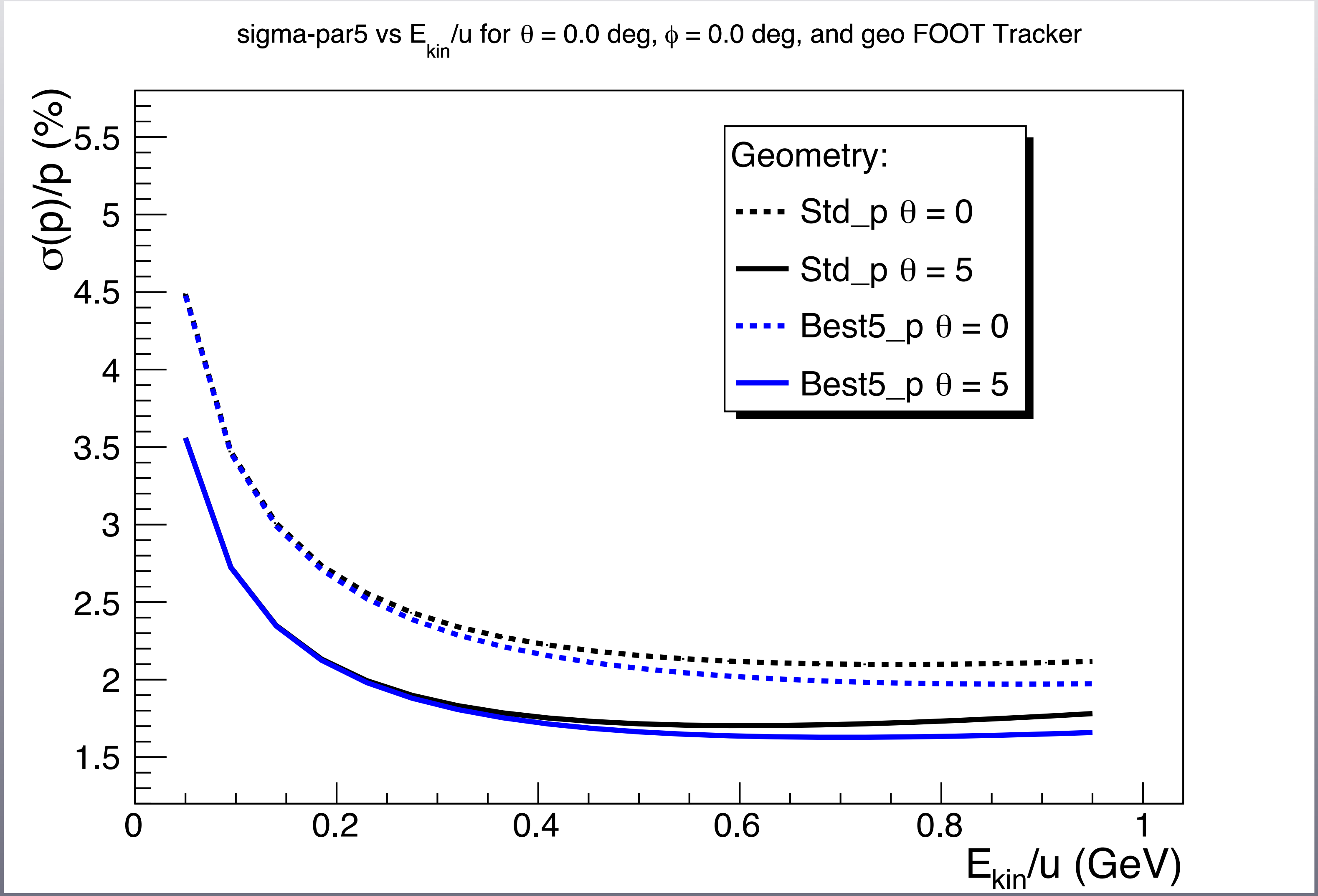
Alpha particles (vii)

- Best geometry for θ = 5º and θ = 0º



Proton particles (i)

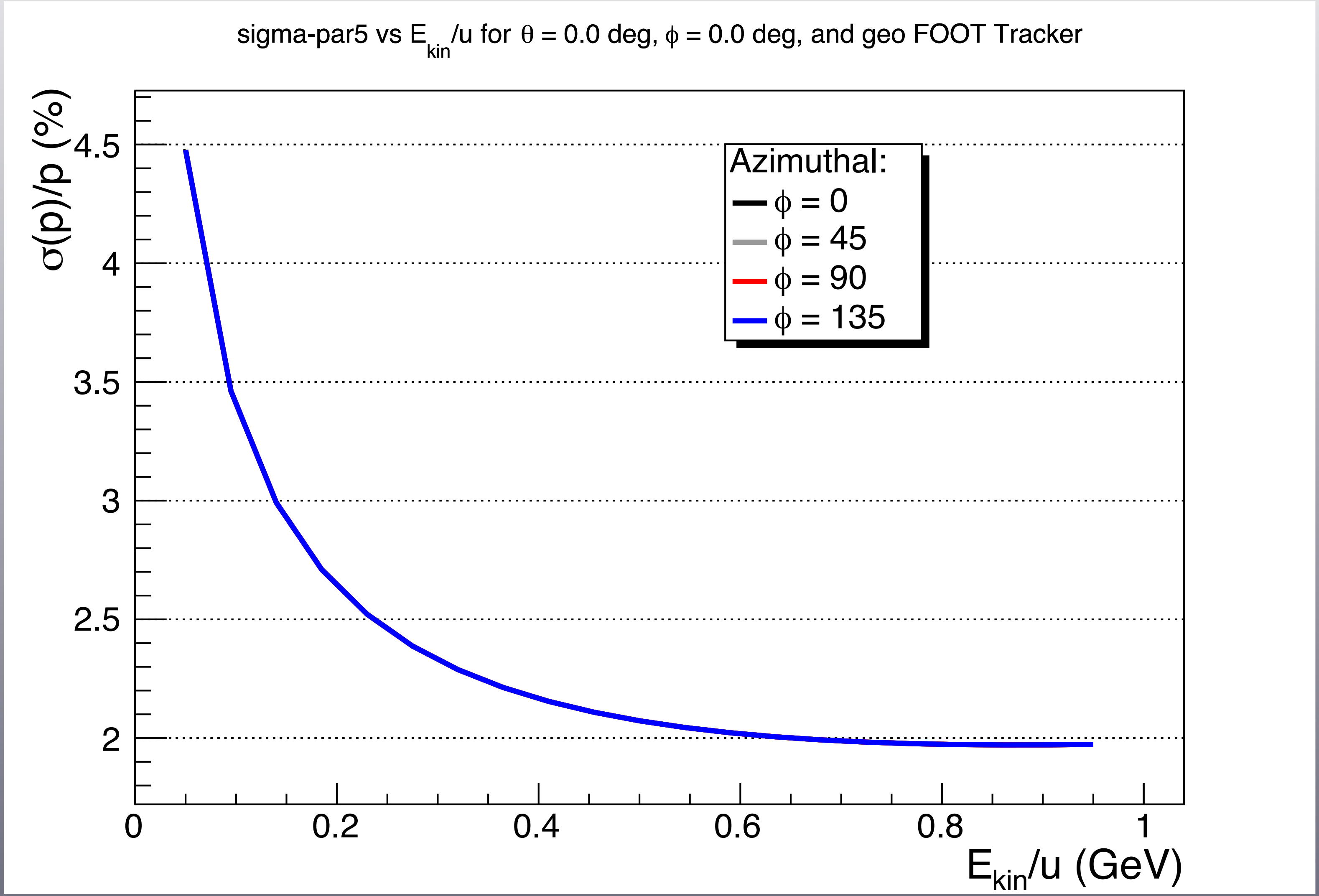
- Taking Best5 geometry



Gain of ~25 % compared to standard geometry (dotted line) for E_{kin} > 0.8GeV

Proton particles (ii)

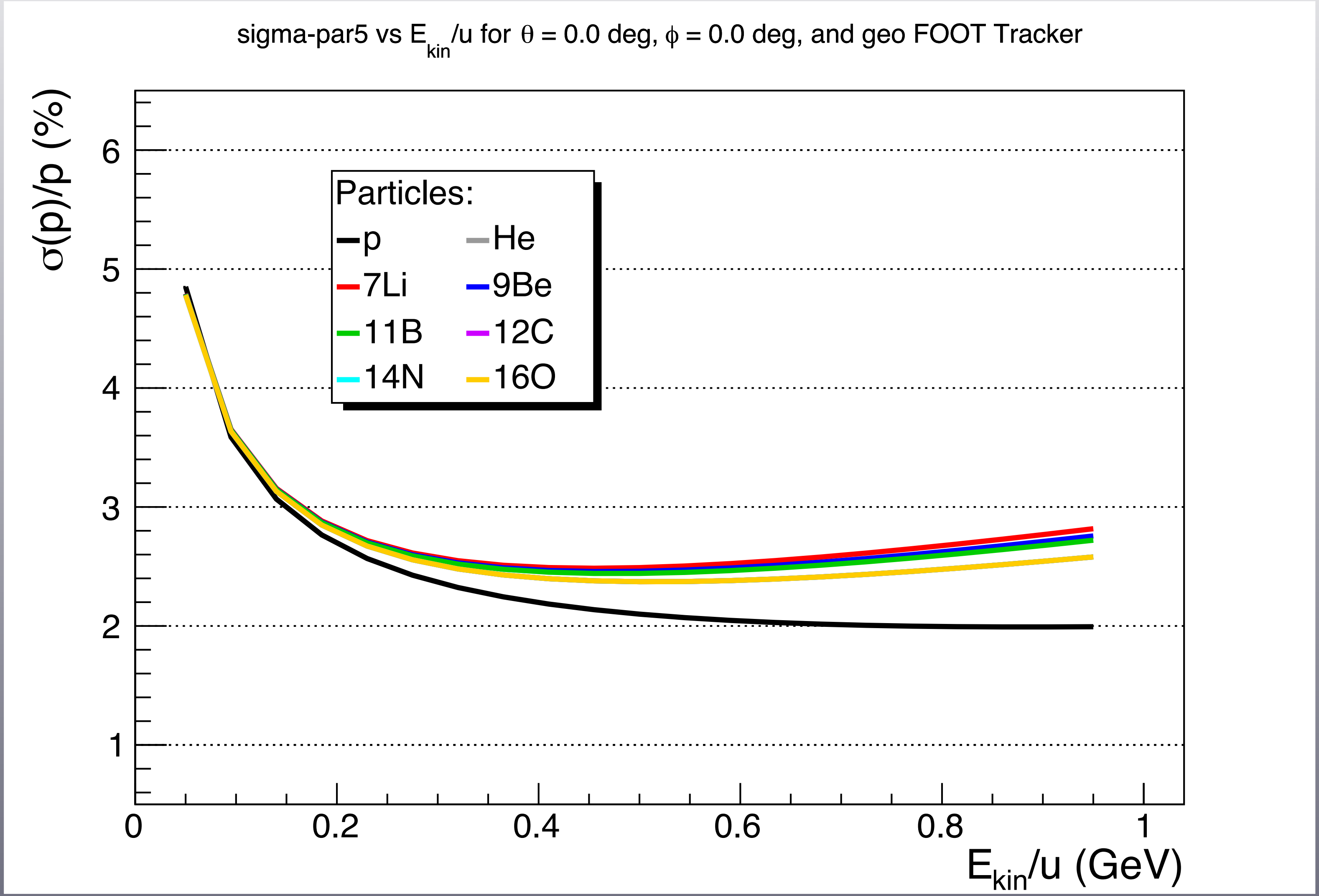
- Taking Best5 geometry, θ = 0º



No change, symmetrical around Z axis

Particles with Z ≥ 3 (i)

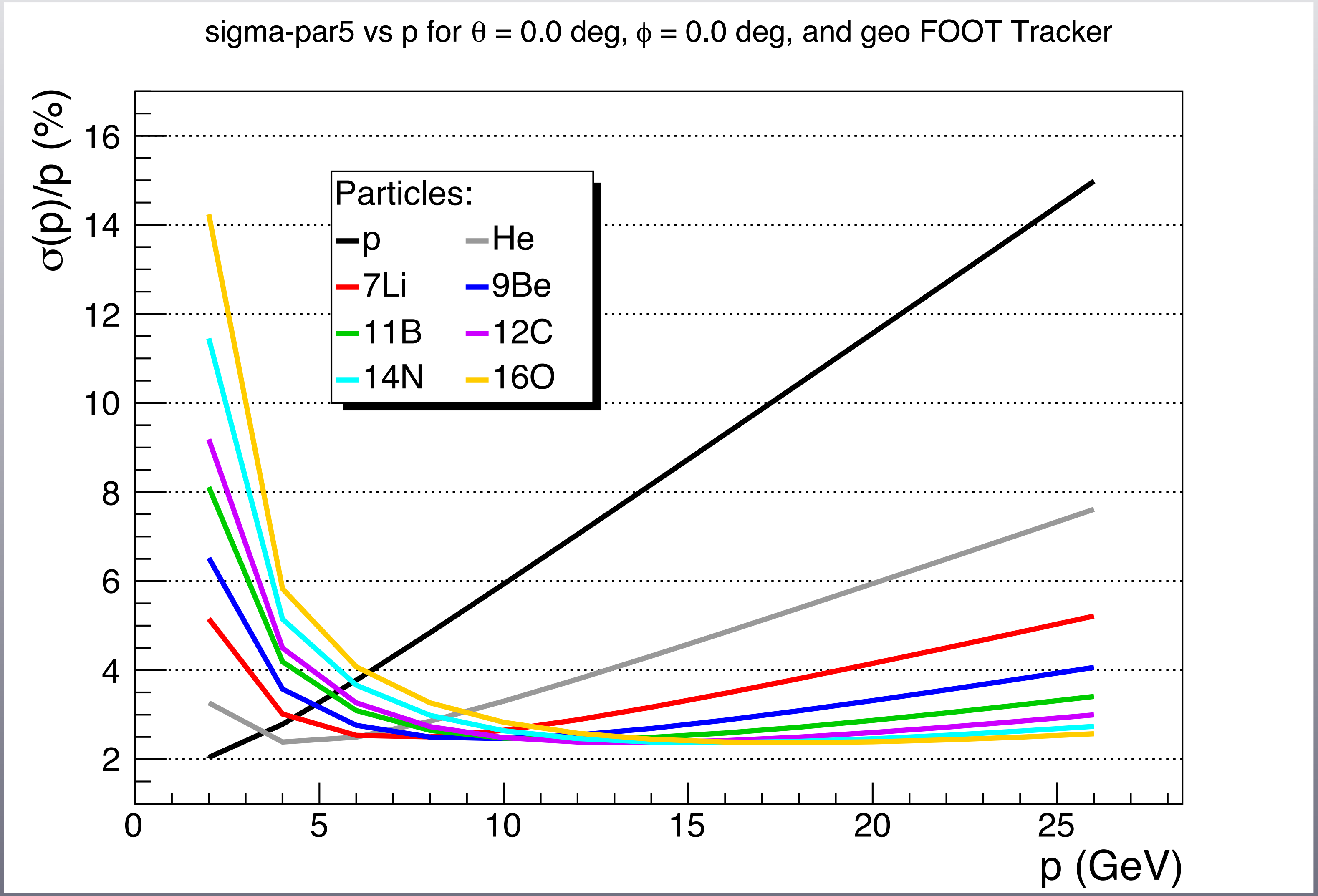
- Taking Best5 geometry, θ = 0º



Resolution lower than 3 % for E_{kin} > 0.2 GeV/c

Particles with Z ≥ 3 (ia)

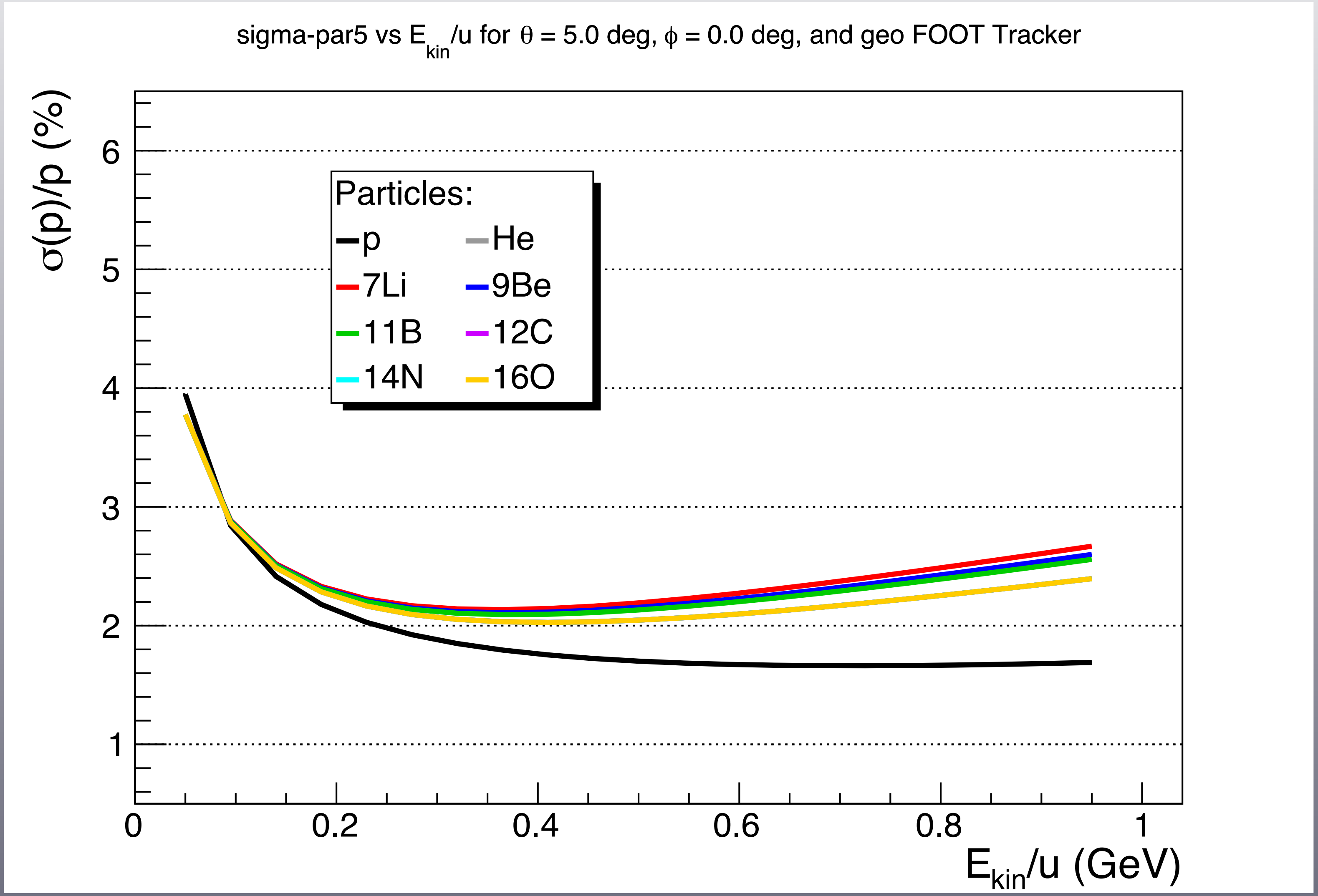
- Taking Best5 geometry, θ = 0º



At low p, MS is predominant. At high p, $\sigma_p/p = p/BL$

Particles with Z ≥ 3 (ii)

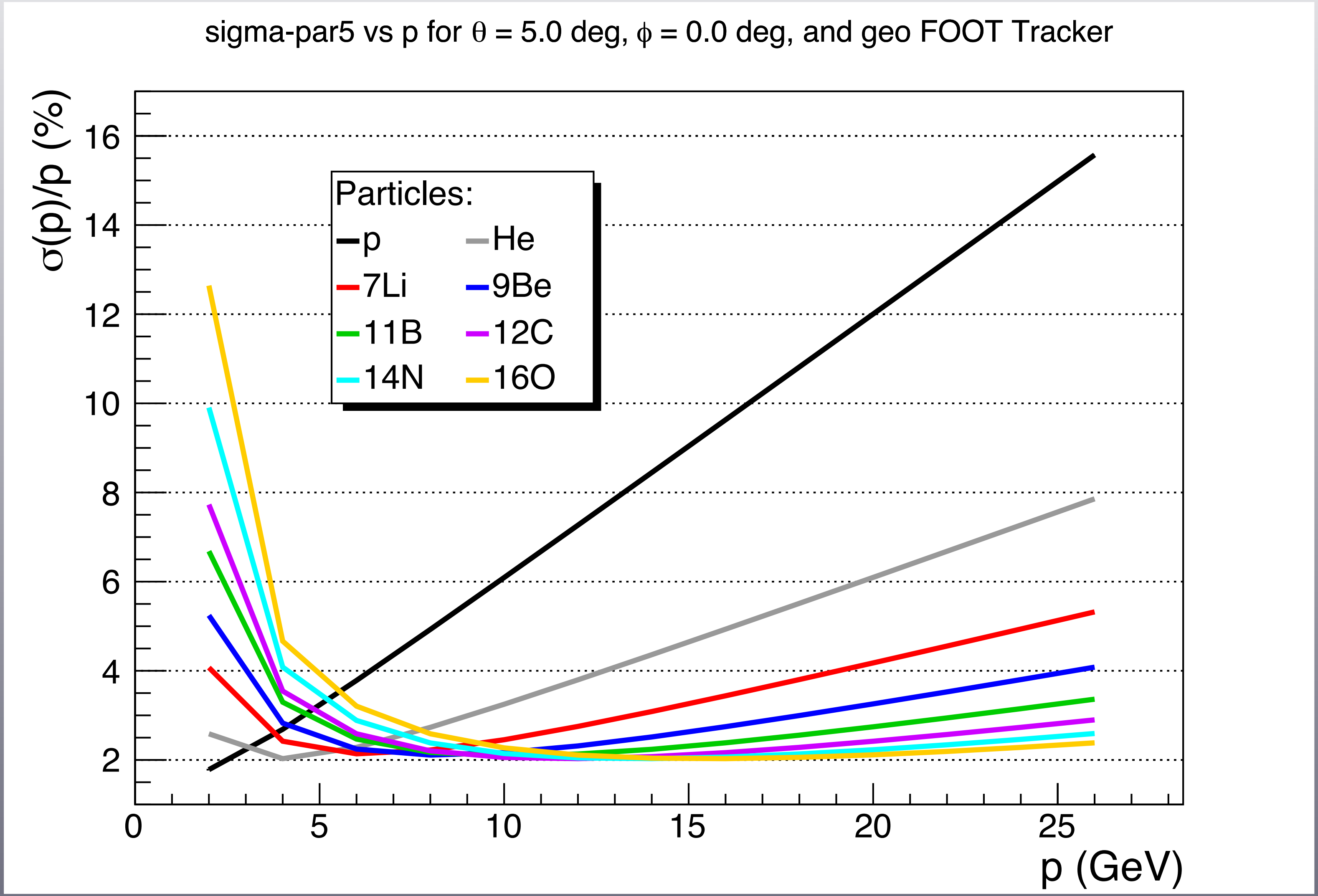
- Taking Best5 geometry, θ = 5º



Same as for θ = 0º

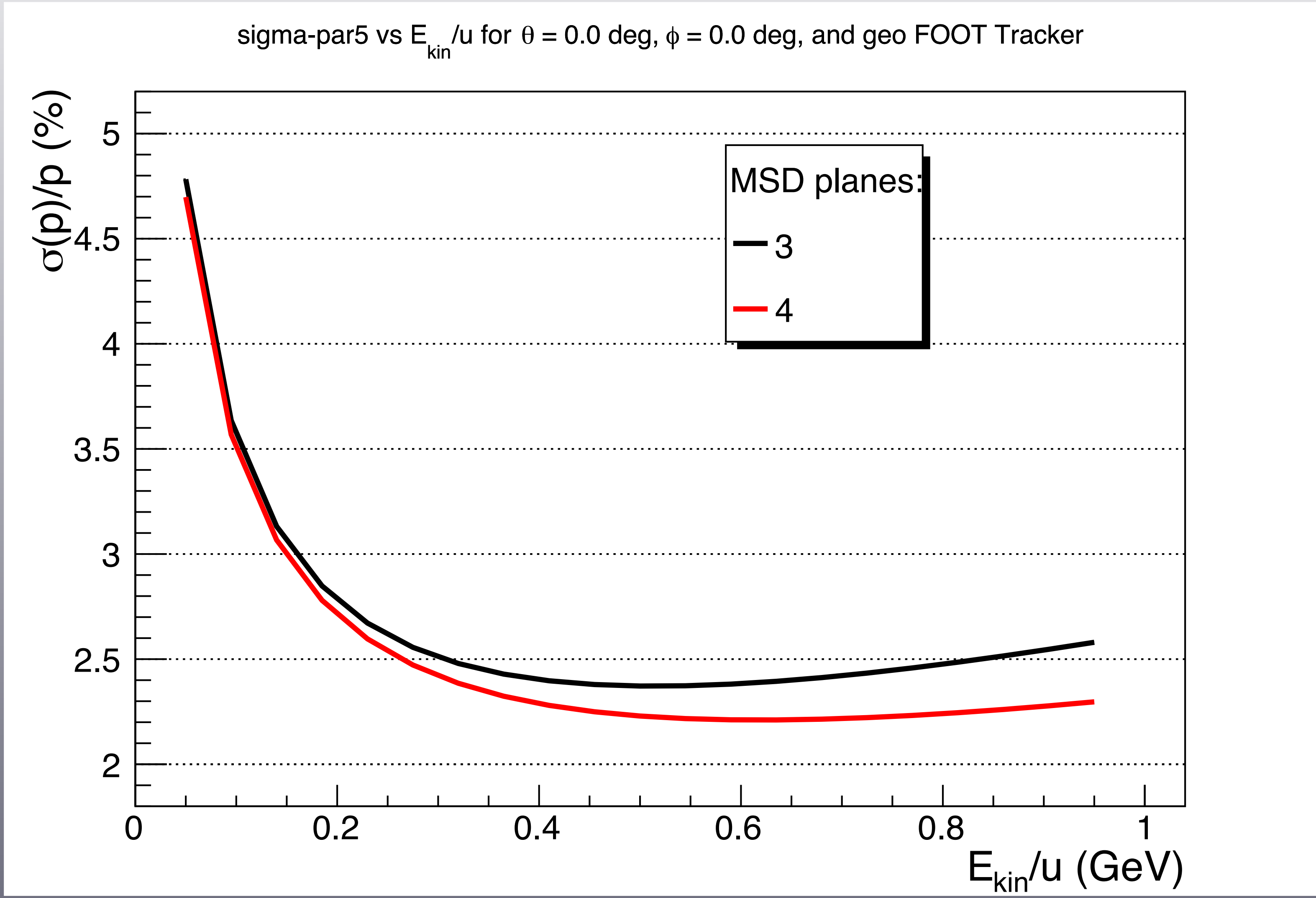
Particles with Z ≥ 3 (iia)

- Taking Best5 geometry, θ = 5º



MSD planes (i)

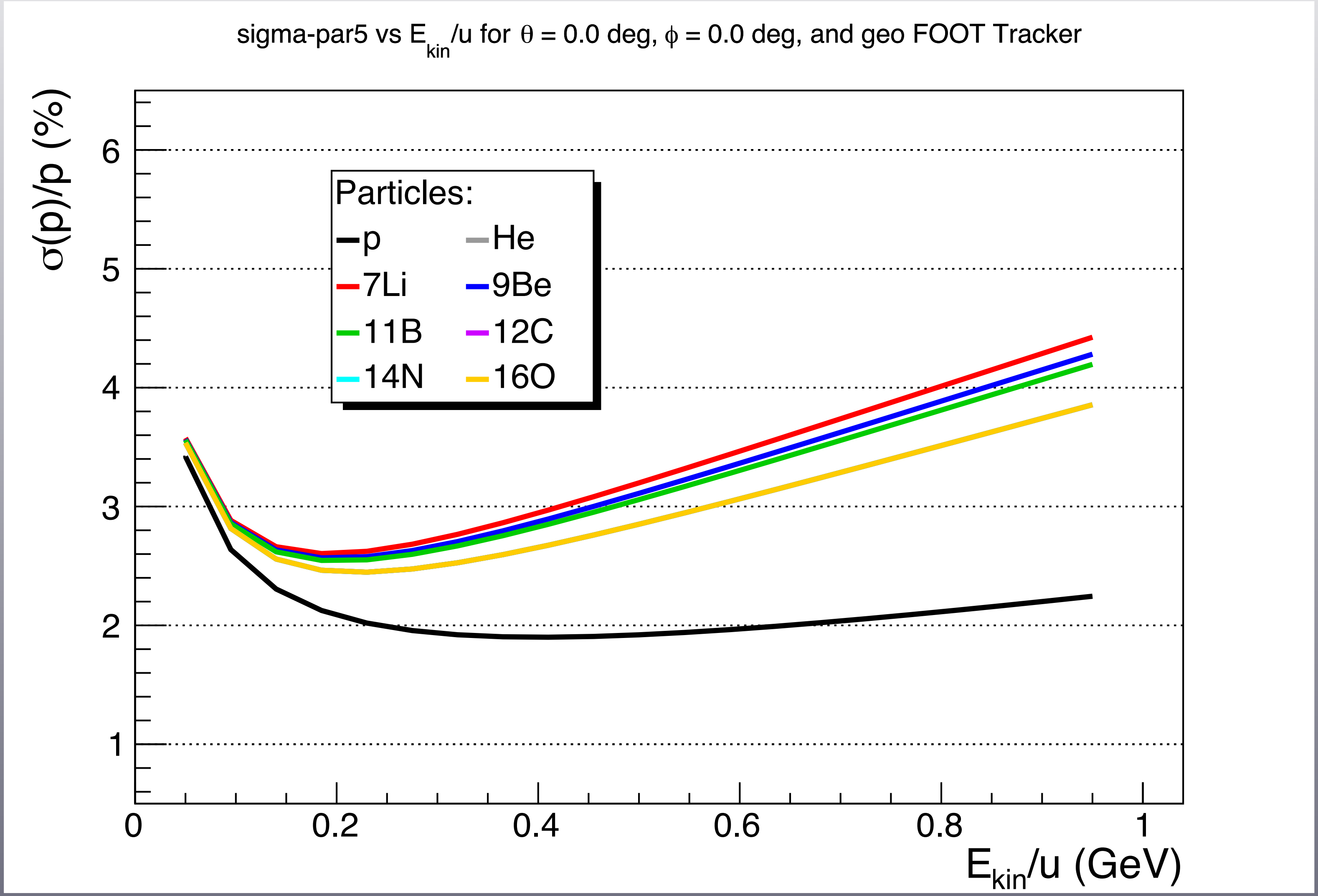
- Add a 4th plane to MSD



A gain of 10 % for higher kinetic energies

MSD planes (ii)

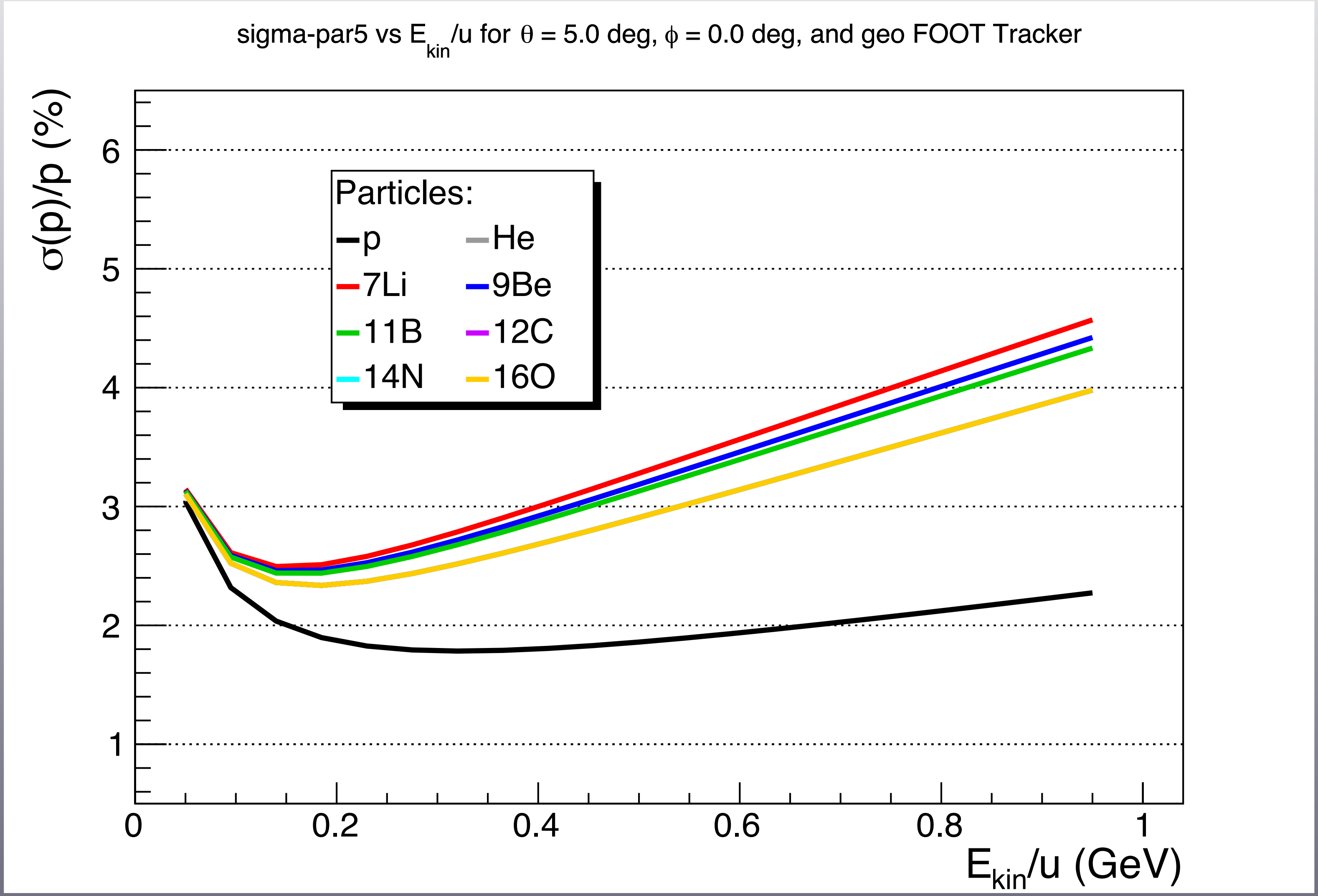
- Set 300 μm thickness for Best5 geometry, θ = 0º



Resolution lower than 5 % for E_{kin} > 0.2 GeV/c

MSD planes (iii)

- Set 300 μm thickness for Best5 geometry, $\theta = 5^o$



Resolution lower than 5 % for $E_{kin} > 0.2$ GeV/c

Conclusions

- No change with magnetic field binning
- Direct dependence of field magnitude

- Optimized geometry, gain of 10 to 25 % depending particle species and polar angle

- Momentum resolution in any case better than 3 % for E_{kin} 0.4 GeV/c - 1 GeV/c
  with ~15 % variation over 0.2 GeV/c - 0.7 GeV/c for $Z \geq 2$
  ➡ expected σ_p/p ~ 5 %

In progress