Momentum resolution dependence on straw tube orientation, polar angle, and momentum

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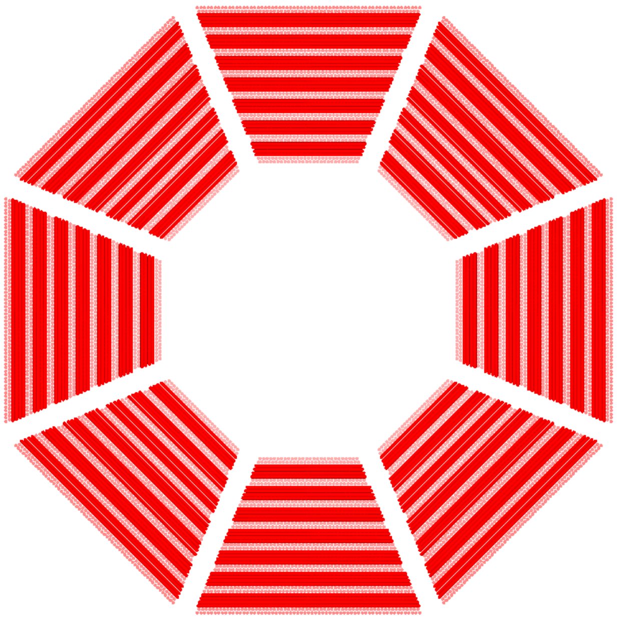
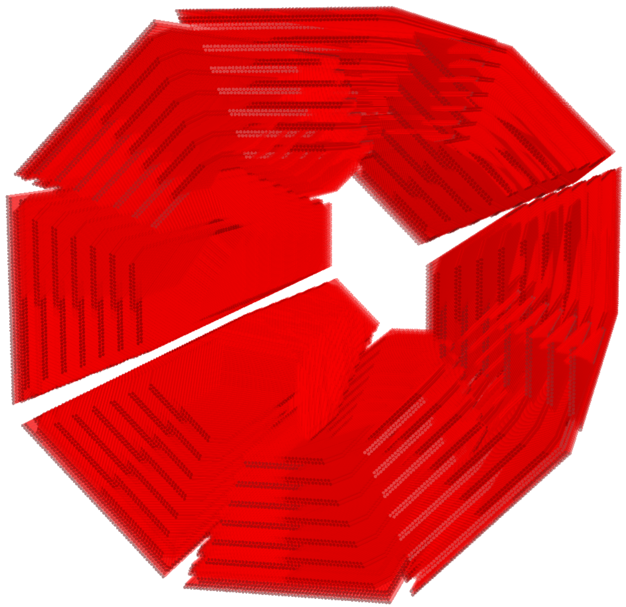
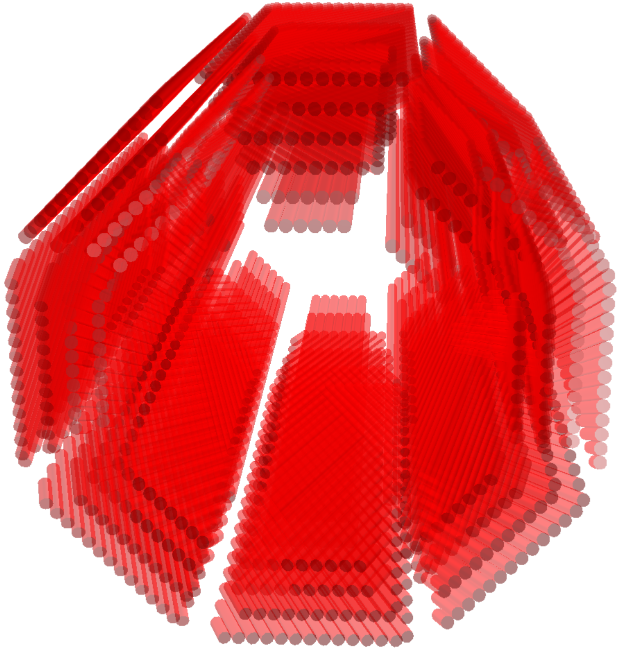
Straw tracker geometry







```
SpdTsTBGeoMapper* mapper = SpdTsTBGeoMapper::Instance();

mapper->SetStrawModulePars(1,   0., 'e', 1.0, 0);

mapper->SetStrawLayerPars(1,    0., 'e', 1.0, 0.);
mapper->SetStrawLayerPars(1,    0., 'o', 1.0, 0.);
mapper->SetStrawLayerPars(1,   deg, 'e', 1.0, 0.);
mapper->SetStrawLayerPars(1,   deg, 'o', 1.0, 0.);
mapper->SetStrawLayerPars(1,  -deg, 'e', 1.0, 0.);
mapper->SetStrawLayerPars(1,  -deg, 'o', 1.0, 0.);
```

(picture with enlarged tubes and gaps between layers for better visibility)

Angle (α) is varied from 0.1 to 20 degrees.

No vertex detector.

Generation of events

- `SpdIsotropicGenerator`
- Muons with fixed momentum p and polar angle θ.
- Azimuthal angle φ is varied from 0° to 360°.
- 100 events with 100 tracks in each event.
- Scan over values:
  - α: 0.1°, 0.2°, 0.3°, 0.5°, 1°, 2°, 5°, 10°, 20°;
  - θ: from 40° to 90° with step 5°;
  - p: from 0.5 to 4 GeV/c with step 0.5 GeV/c.

Cuts on tracks used in the analysis

- Only tracks from primary vertex.
- Fit parameters exist.
- `GetIsAcceptable()`
  (no fit error flags, ndf ≥ 3, χ^2/ndf ≥ 2)
- [No hits in endcaps.]

About 80% of tracks pass these cuts.

Calculation of momentum resolution

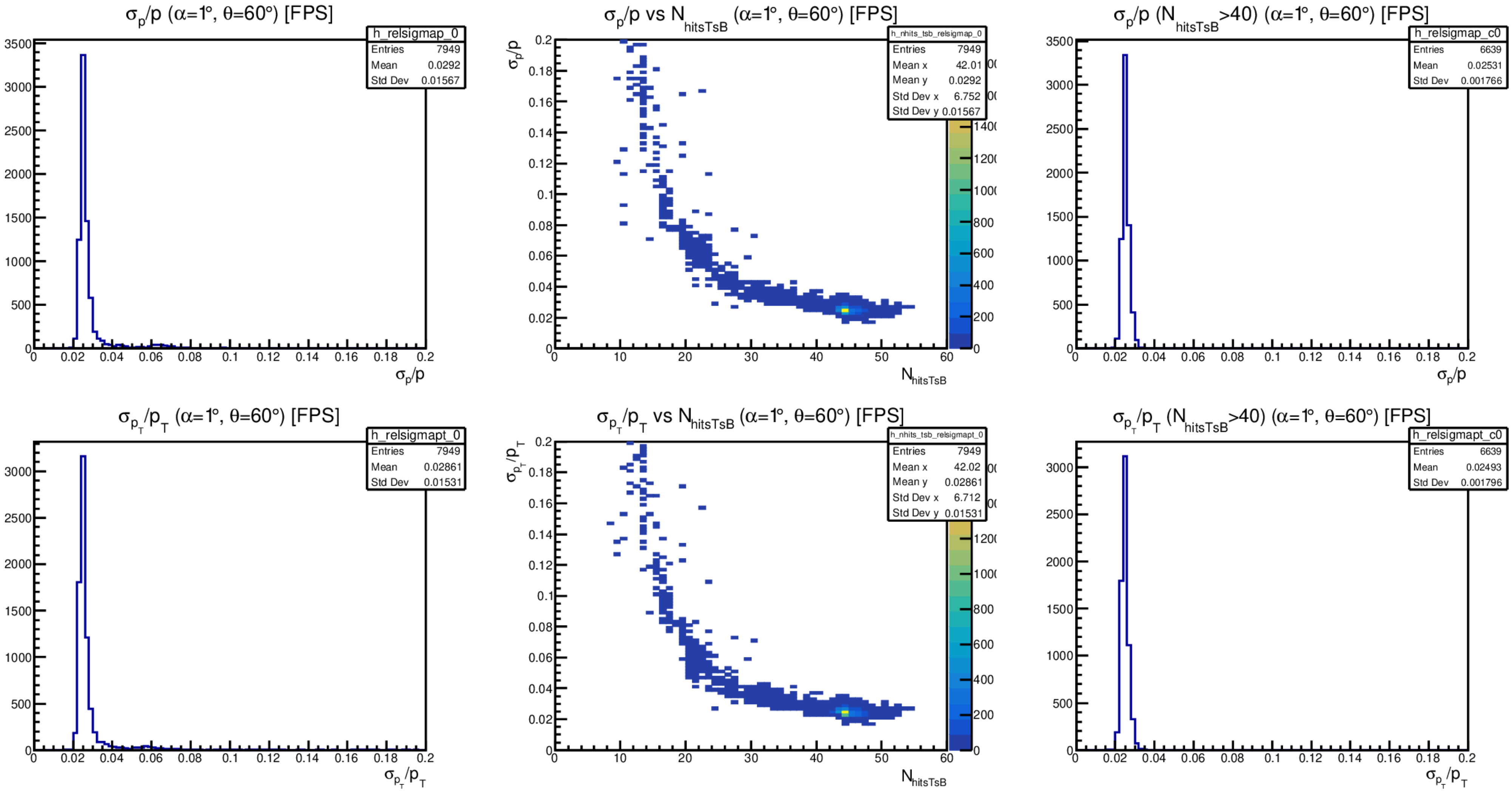
$$\sigma_p^2=\left(\frac{\partial p}{\partial p_x}\right)^2\sigma_{p_x}^2+\left(\frac{\partial p}{\partial p_y}\right)^2\sigma_{p_y}^2+\left(\frac{\partial p}{\partial p_z}\right)^2\sigma_{p_z}^2+2\frac{\partial p}{\partial p_x}\frac{\partial p}{\partial p_y}\mathrm{cov}(p_x,p_y)+2\frac{\partial p}{\partial p_x}\frac{\partial p}{\partial p_z}\mathrm{cov}(p_x,p_z)+2\frac{\partial p}{\partial p_y}\frac{\partial p}{\partial p_z}\mathrm{cov}(p_y,p_z)$$

$$=\left(\frac{p_x}{p}\right)^2\sigma_{p_x}^2+\left(\frac{p_y}{p}\right)^2\sigma_{p_y}^2+\left(\frac{p_z}{p}\right)^2\sigma_{p_z}^2+2\frac{p_x p_y}{p^2}\mathrm{cov}(p_x,p_y)+2\frac{p_x p_z}{p^2}\mathrm{cov}(p_x,p_z)+2\frac{p_y p_z}{p^2}\mathrm{cov}(p_y,p_z)$$

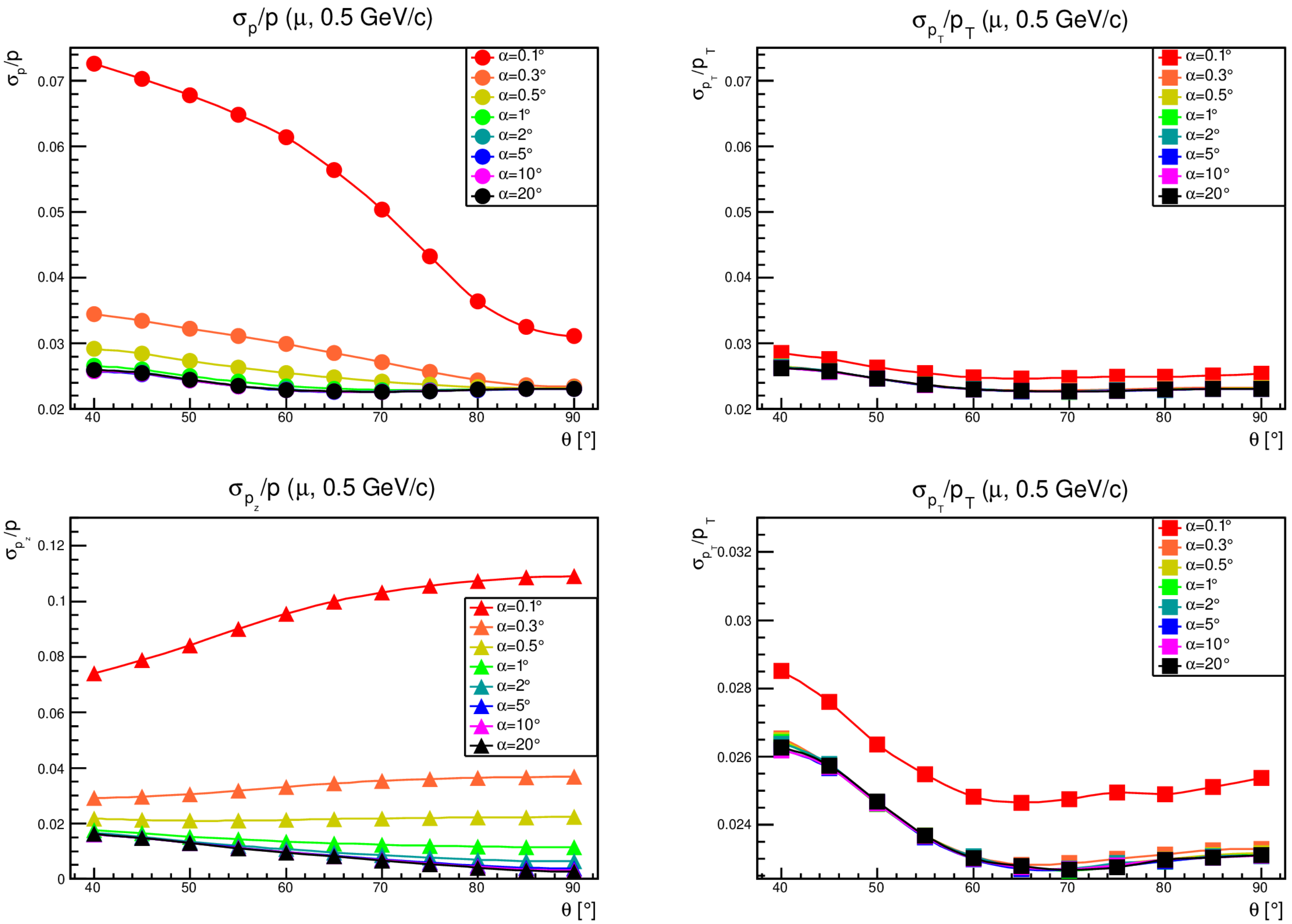
$$\sigma_{p_T}^2=\left(\frac{\partial p_T}{\partial p_x}\right)^2\sigma_{p_x}^2+\left(\frac{\partial p_T}{\partial p_y}\right)^2\sigma_{p_y}^2+2\frac{\partial p_T}{\partial p_x}\frac{\partial p_T}{\partial p_y}\mathrm{cov}(p_x,p_y)=\left(\frac{p_x}{p_T}\right)^2\sigma_{p_x}^2+\left(\frac{p_y}{p_T}\right)^2\sigma_{p_y}^2+2\frac{p_x p_y}{p_T^2}\mathrm{cov}(p_x,p_y)$$

$$p=\sqrt{p_x^2+p_y^2+p_z^2},\quad p_T=\sqrt{p_x^2+p_y^2}$$

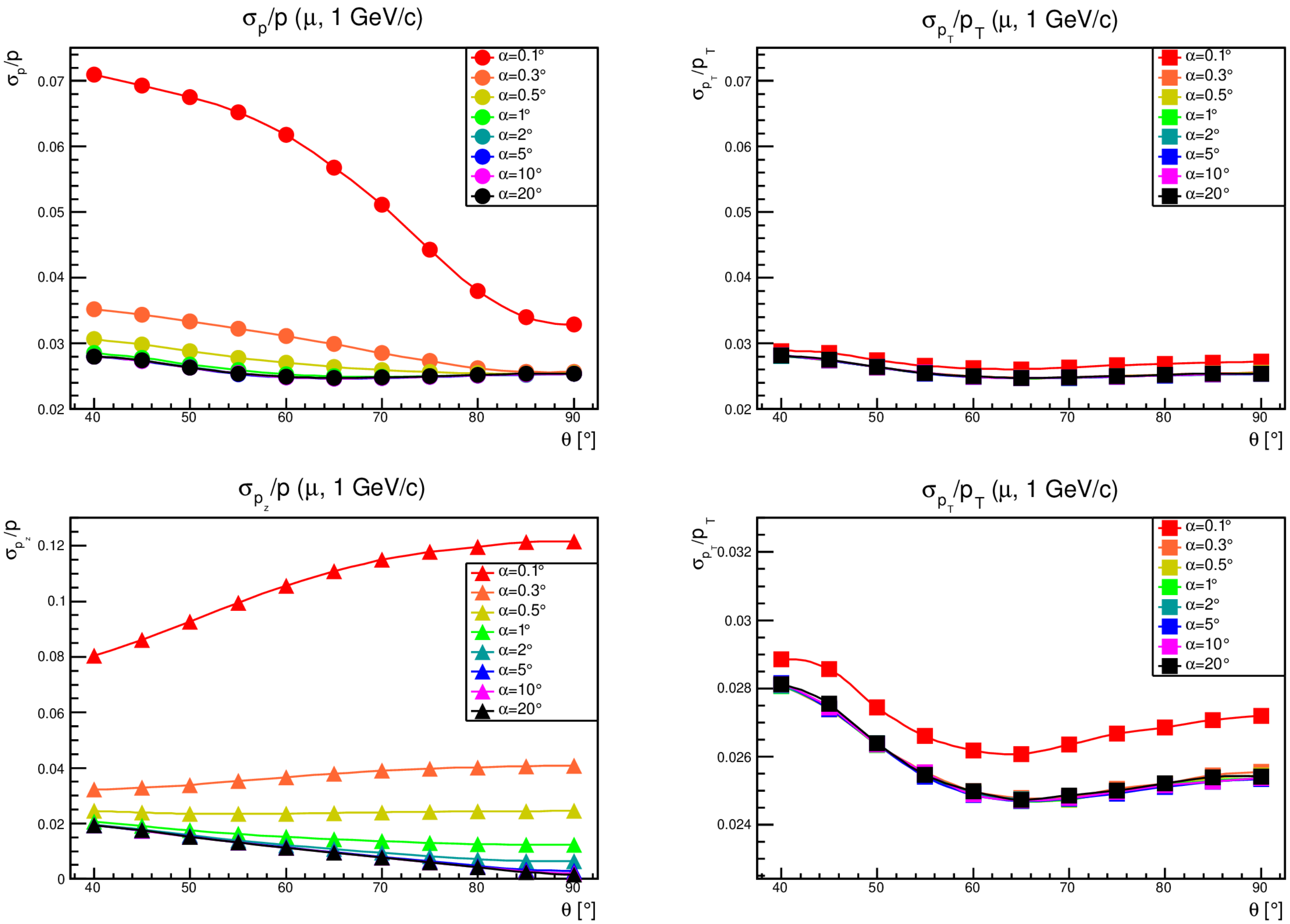
Relative momentum resolutions



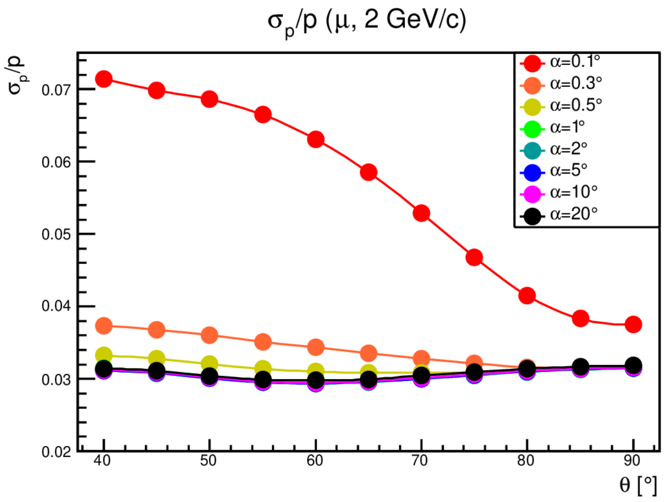
Momentum resolution dependence on polar angle

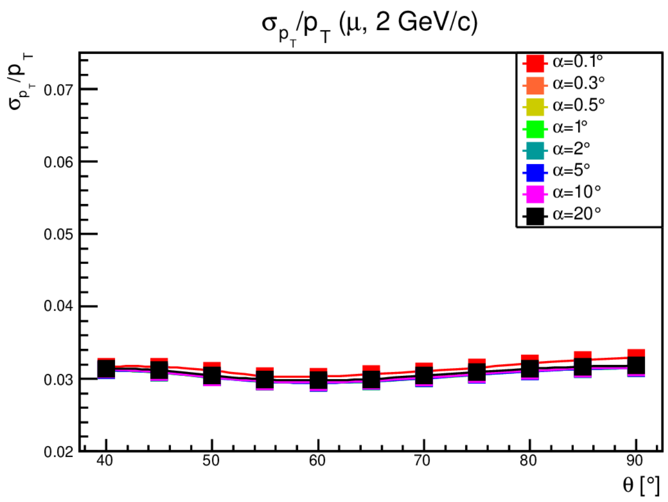


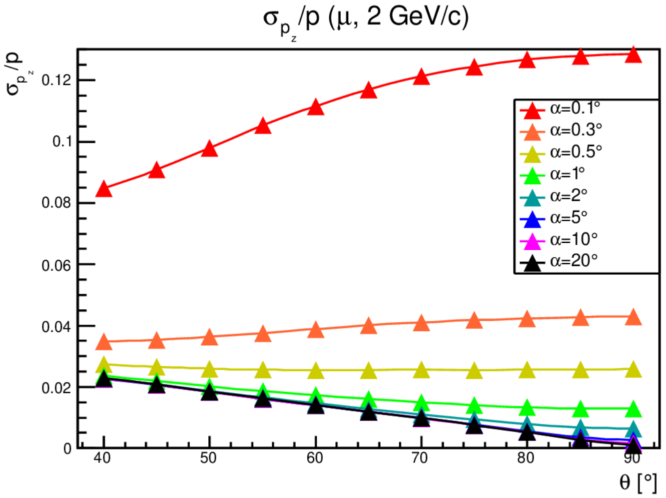
Momentum resolution dependence on polar angle

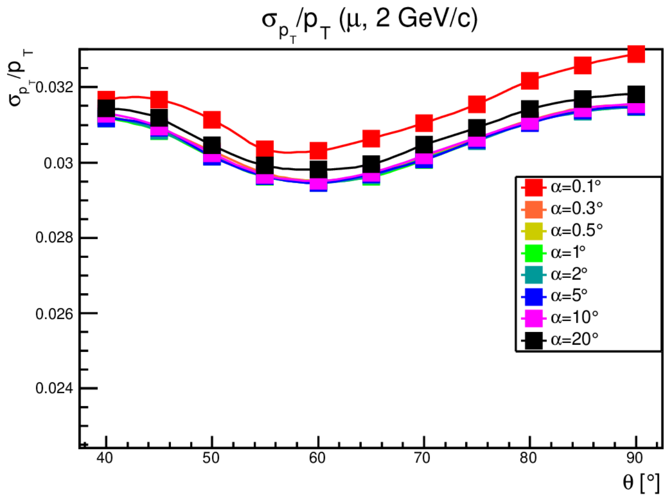


Momentum resolution dependence on polar angle

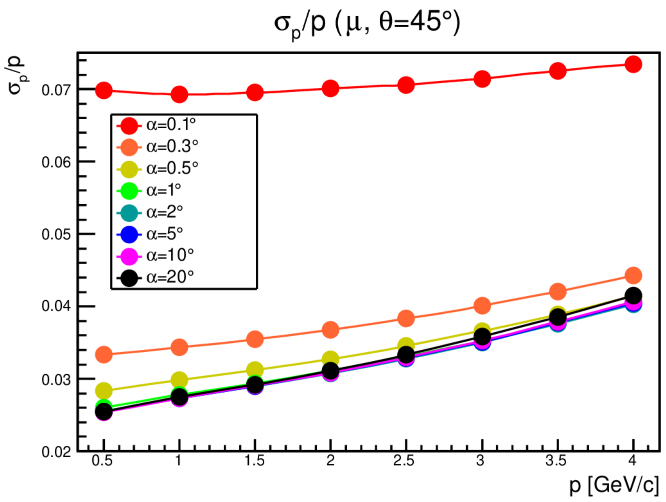


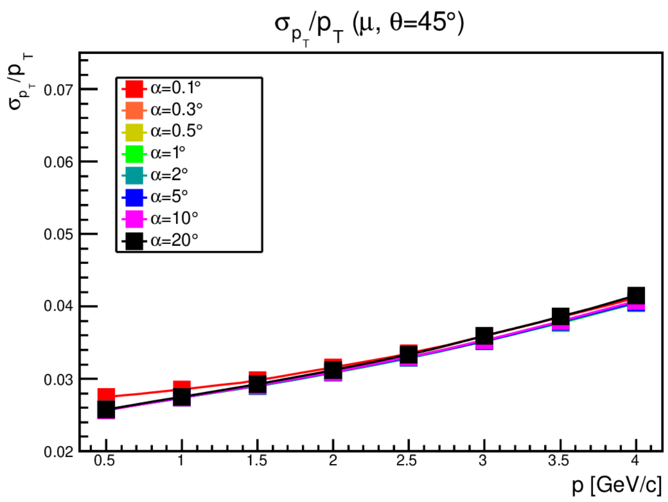


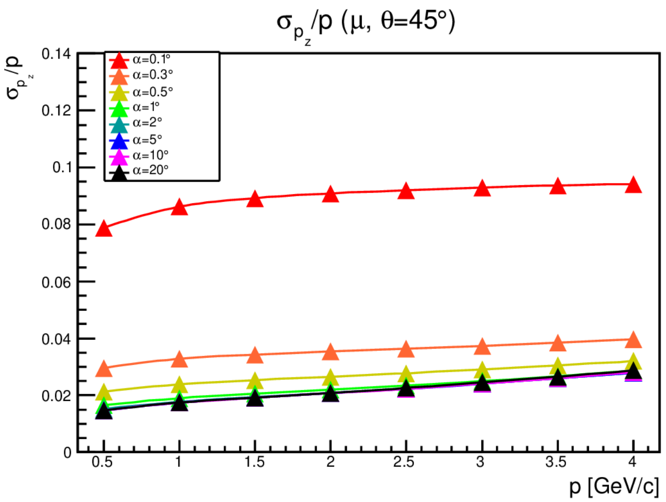


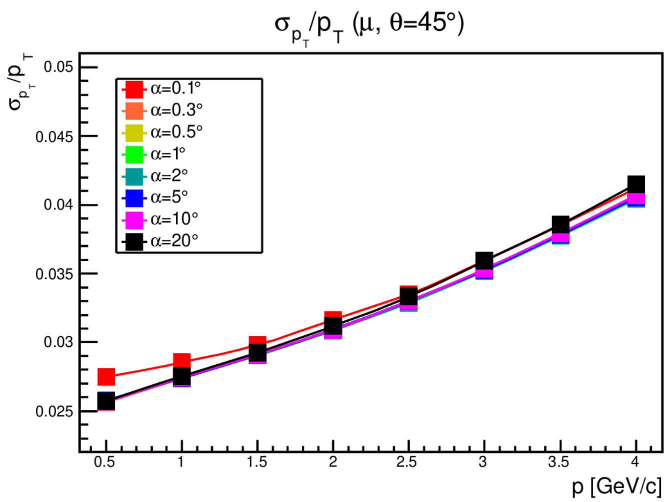


Momentum resolution dependence on momentum

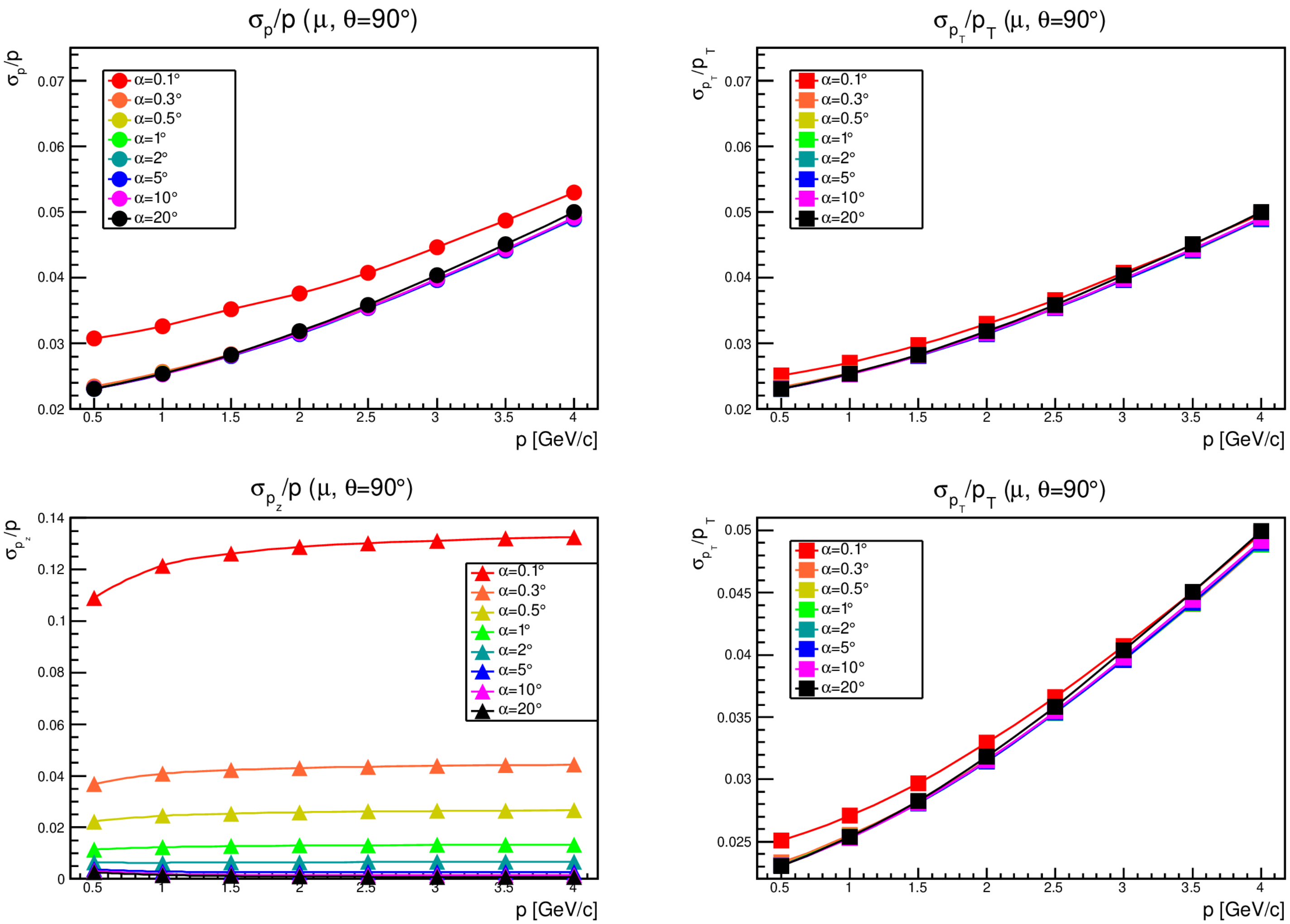








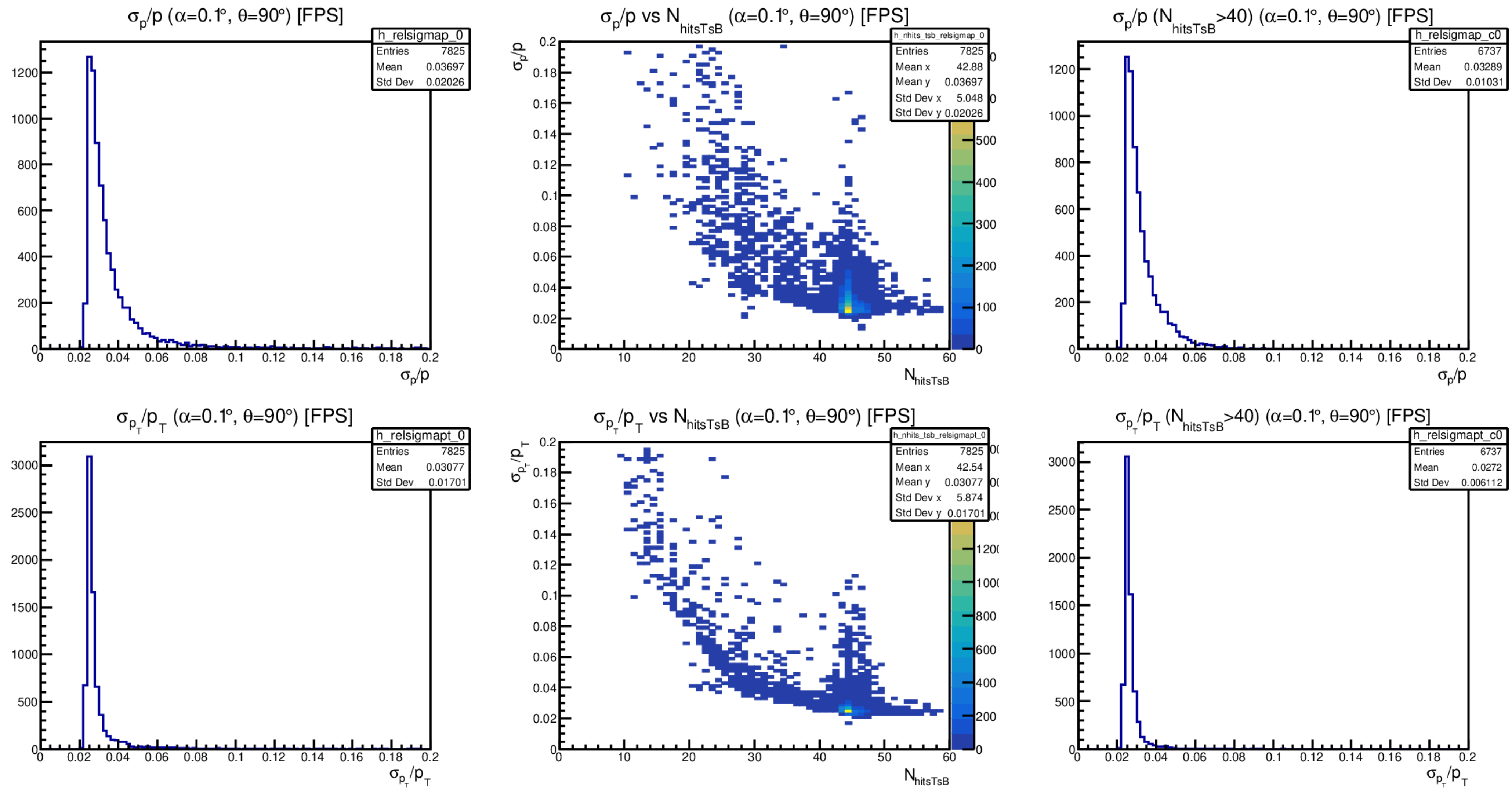
Momentum resolution dependence on momentum



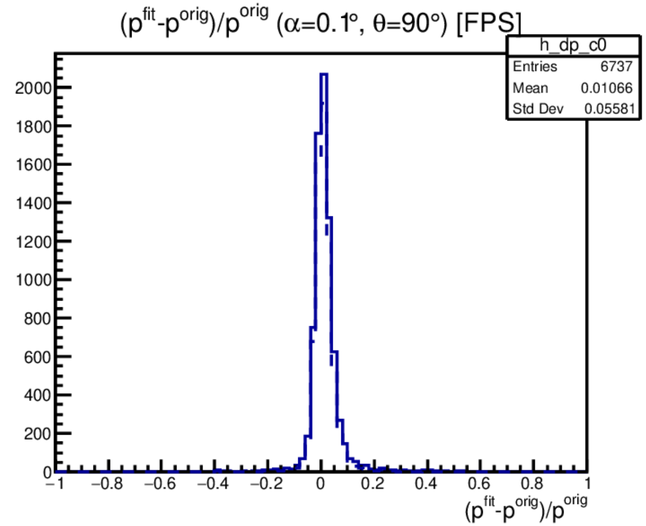
Conclusions

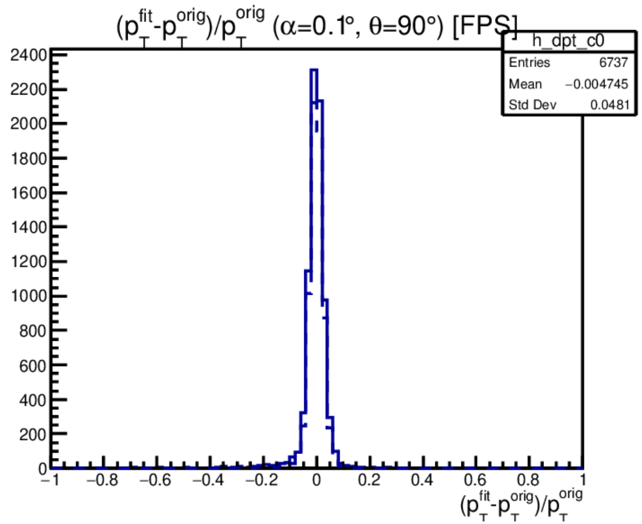
- The momentum resolution does not change significantly starting from a straw tilt angle of 1°.
- Transverse momentum resolution depends very weakly on α, but uncertainty in longitudinal momentum is large for small α.
- Relative momentum resolution grows approximately linearly in momentum.

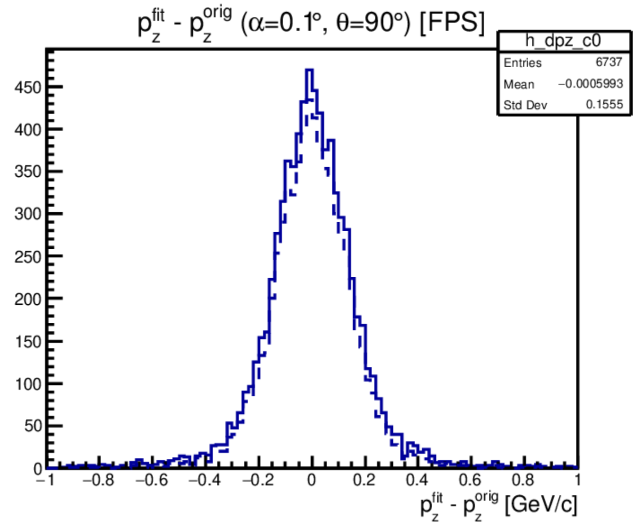
backup

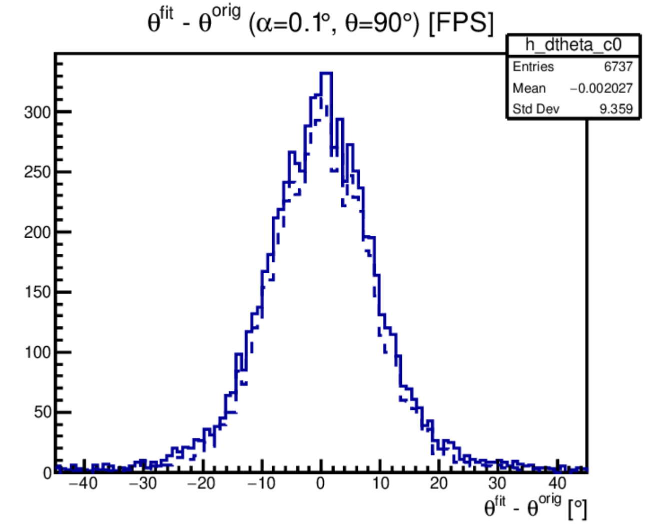


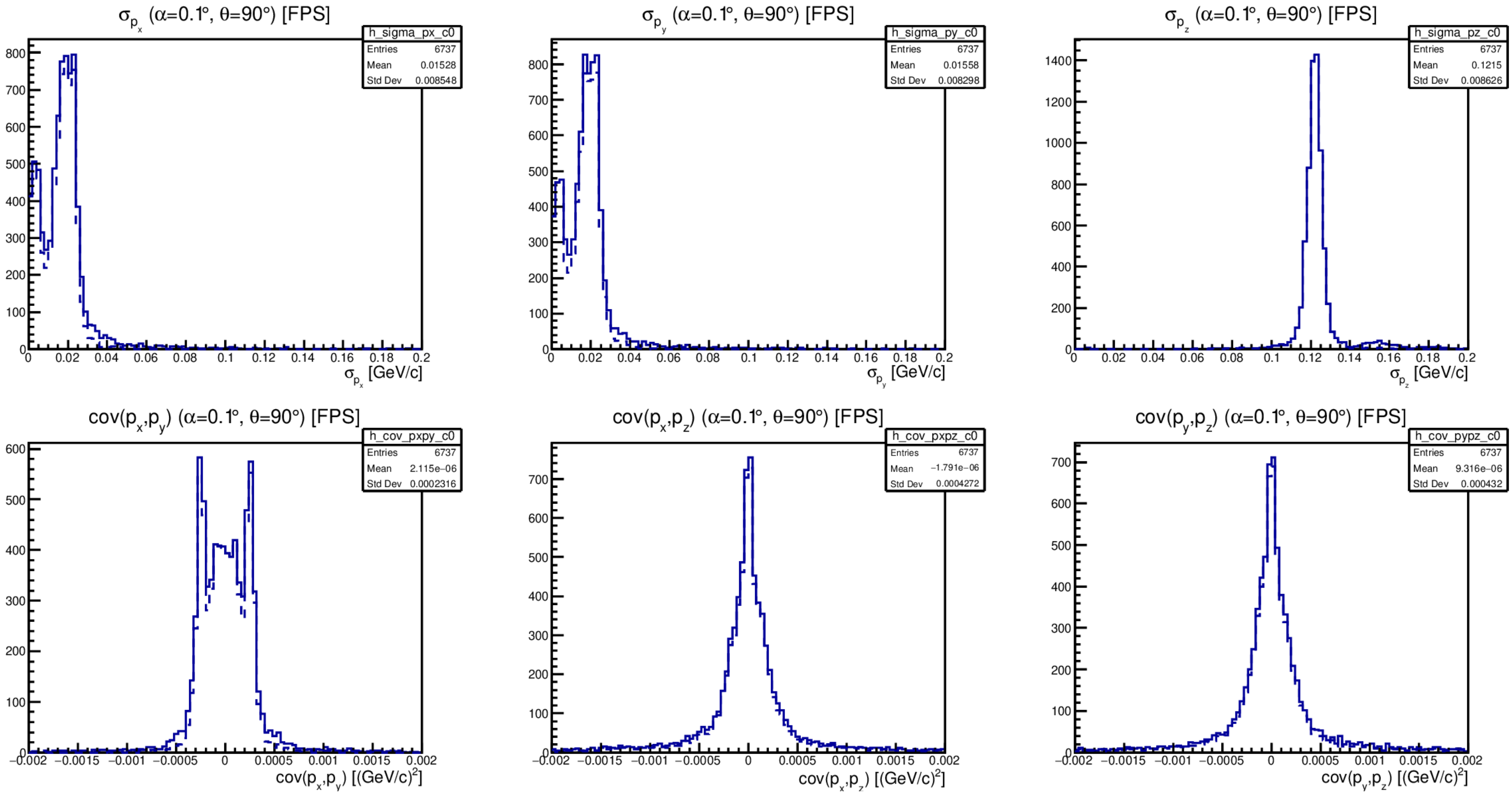
σp/p (α=0.1°, θ=90°) [FPS]
h_relsigmap_0
Entries 7825
Mean 0.03697
Std Dev 0.02026
σp/p
σp/p vs NhitsTsB (α=0.1°, θ=90°) [FPS]
h_nhits_tsb_relsigmap_0
Entries 7825
Mean x 42.88
Mean y 0.03697
Std Dev x 5.048
Std Dev y 0.02026
σp/p
NhitsTsB
σp/p (NhitsTsB>40) (α=0.1°, θ=90°) [FPS]
h_relsigmap_c0
Entries 6737
Mean 0.03289
Std Dev 0.01031
σp/p
σpT/pT (α=0.1°, θ=90°) [FPS]
h_relsigmapt_0
Entries 7825
Mean 0.03077
Std Dev 0.01701
σpT/pT
σpT/pT vs NhitsTsB (α=0.1°, θ=90°) [FPS]
h_nhits_tsb_relsigmapt_0
Entries 7825
Mean x 42.54
Mean y 0.03077
Std Dev x 5.874
Std Dev y 0.01701
σpT/pT
NhitsTsB
σpT/pT (NhitsTsB>40) (α=0.1°, θ=90°) [FPS]
h_relsigmapt_c0
Entries 6737
Mean 0.0272
Std Dev 0.006112
σpT/pT


(p^fit-p^orig)/p^orig (α=0.1°, θ=90°) [FPS]
h_dp_c0
Entries 6737
Mean 0.01066
Std Dev 0.05581
(p^fit-p^orig)/p^orig


(p_T^fit-p_T^orig)/p_T^orig (α=0.1°, θ=90°) [FPS]
h_dpt_c0
Entries 6737
Mean −0.004745
Std Dev 0.0481
(p_T^fit-p_T^orig)/p_T^orig

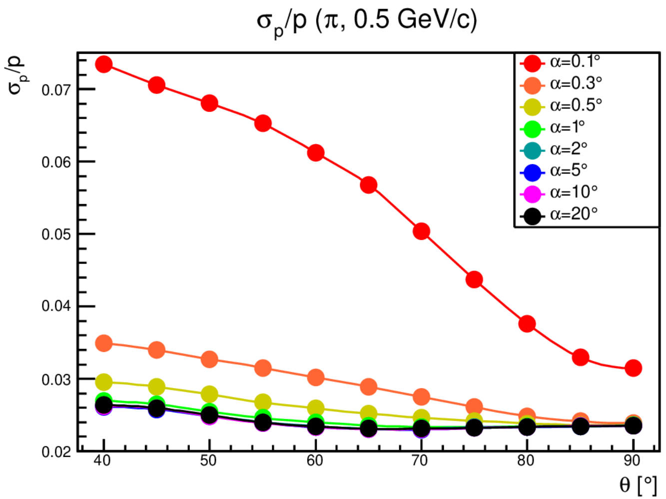

p_z^fit - p_z^orig (α=0.1°, θ=90°) [FPS]
h_dpz_c0
Entries 6737
Mean −0.0005993
Std Dev 0.1555
p_z^fit - p_z^orig [GeV/c]

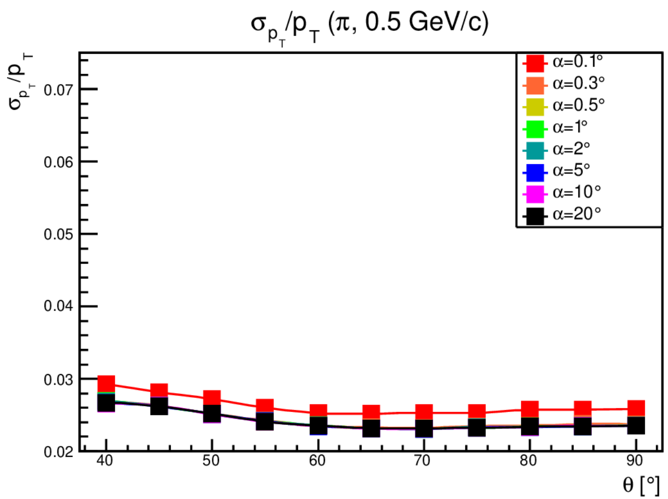

θ^fit - θ^orig (α=0.1°, θ=90°) [FPS]
h_dtheta_c0
Entries 6737
Mean −0.002027
Std Dev 9.359
θ^fit - θ^orig [°]

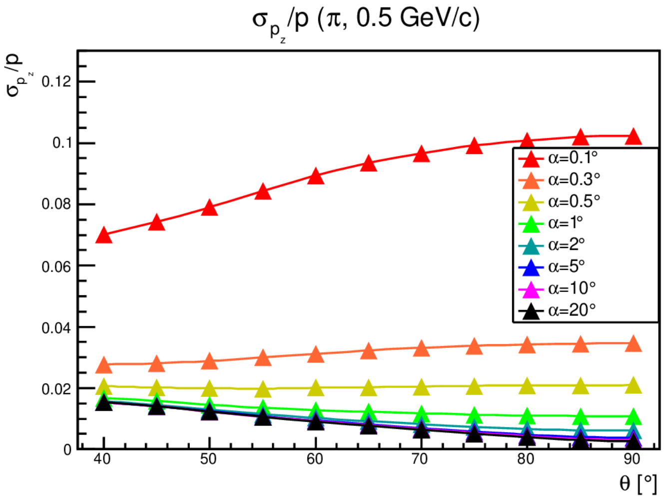


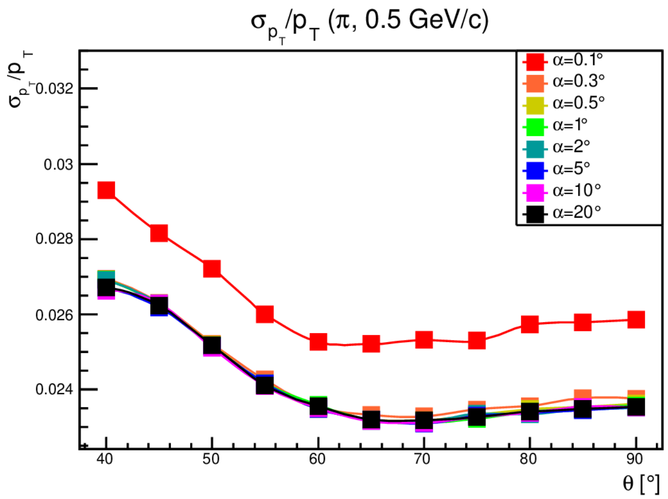
σ_{p_x} (α=0.1°, θ=90°) [FPS]
h_sigma_px_c0
Entries 6737
Mean 0.01528
Std Dev 0.008548
σ_{p_x} [GeV/c]
σ_{p_y} (α=0.1°, θ=90°) [FPS]
h_sigma_py_c0
Entries 6737
Mean 0.01558
Std Dev 0.008298
σ_{p_y} [GeV/c]
σ_{p_z} (α=0.1°, θ=90°) [FPS]
h_sigma_pz_c0
Entries 6737
Mean 0.1215
Std Dev 0.008626
σ_{p_z} [GeV/c]
cov(p_x,p_y) (α=0.1°, θ=90°) [FPS]
h_cov_pxpy_c0
Entries 6737
Mean 2.115e−06
Std Dev 0.0002316
cov(p_x,p_y) [(GeV/c)^2]
cov(p_x,p_z) (α=0.1°, θ=90°) [FPS]
h_cov_pxpz_c0
Entries 6737
Mean −1.791e−06
Std Dev 0.0004272
cov(p_x,p_z) [(GeV/c)^2]
cov(p_y,p_z) (α=0.1°, θ=90°) [FPS]
h_cov_pypz_c0
Entries 6737
Mean 9.316e−06
Std Dev 0.000432
cov(p_y,p_z) [(GeV/c)^2]

Momentum resolution dependence on polar angle (π)

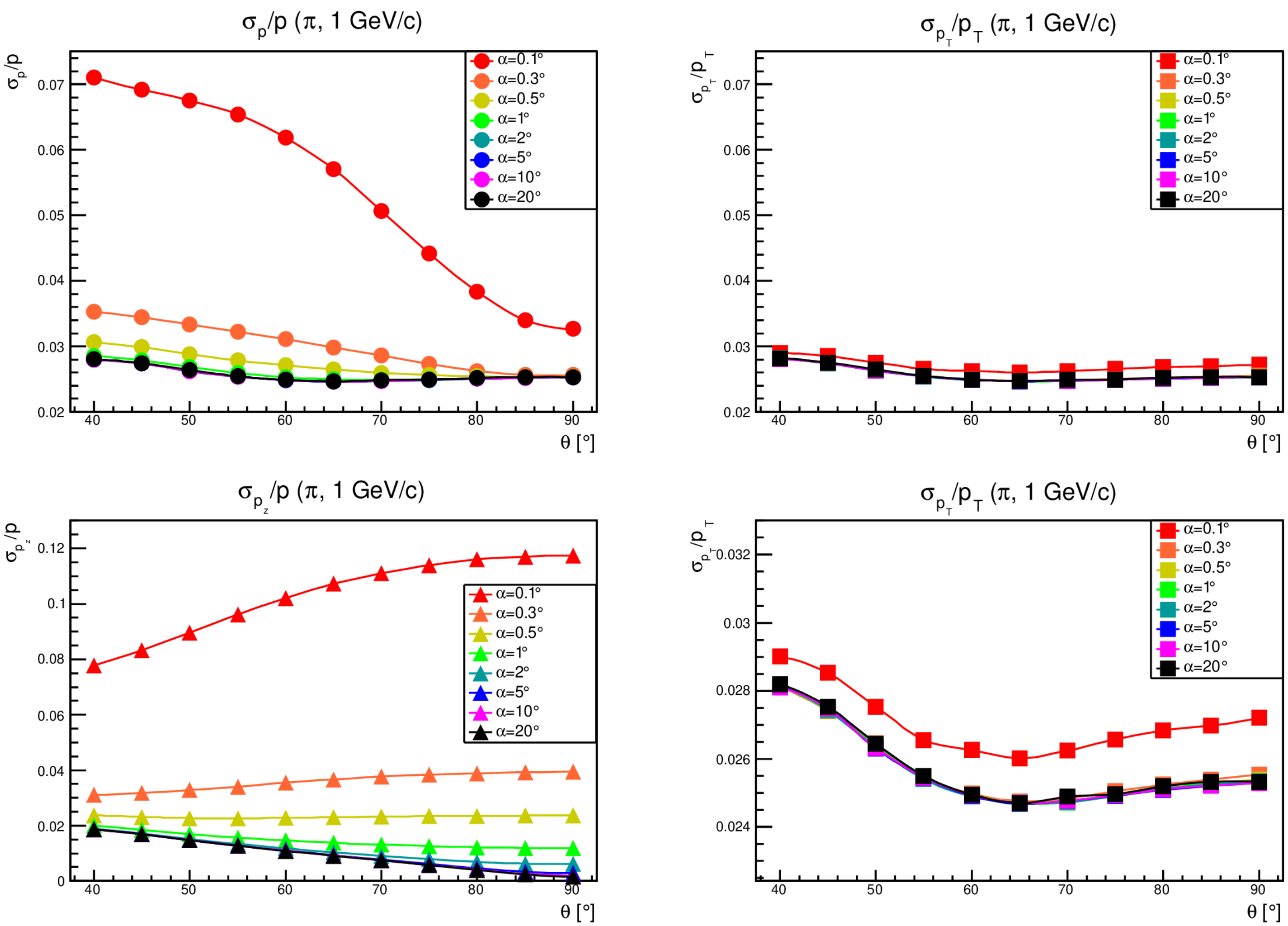








Momentum resolution dependence on polar angle (π)



Momentum resolution dependence on polar angle (π)