Momentum resolution for different configurations of straw tracker end-caps

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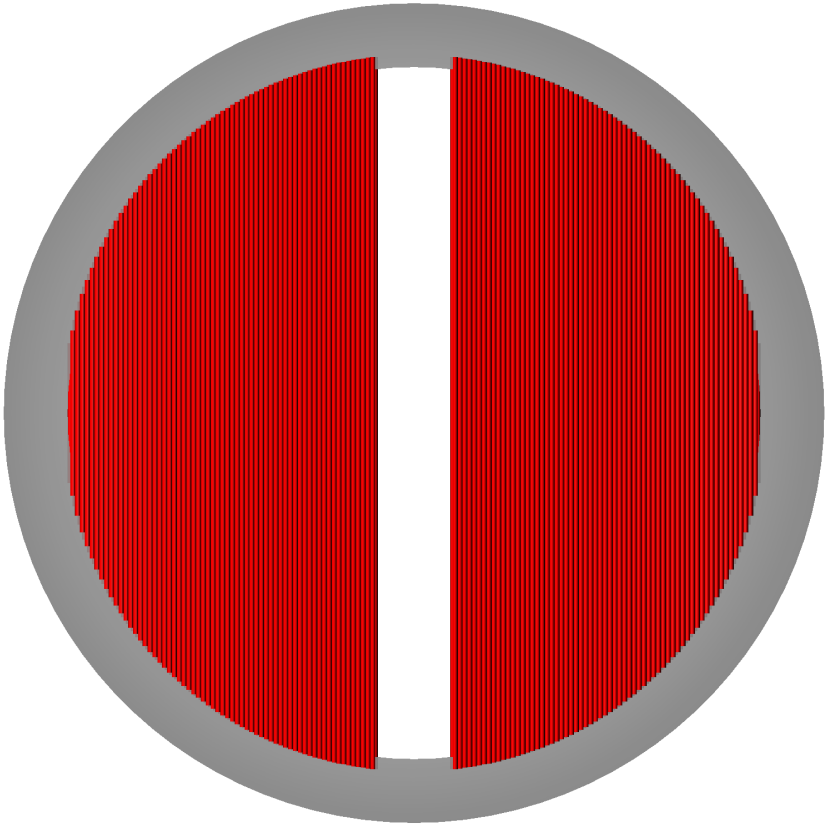
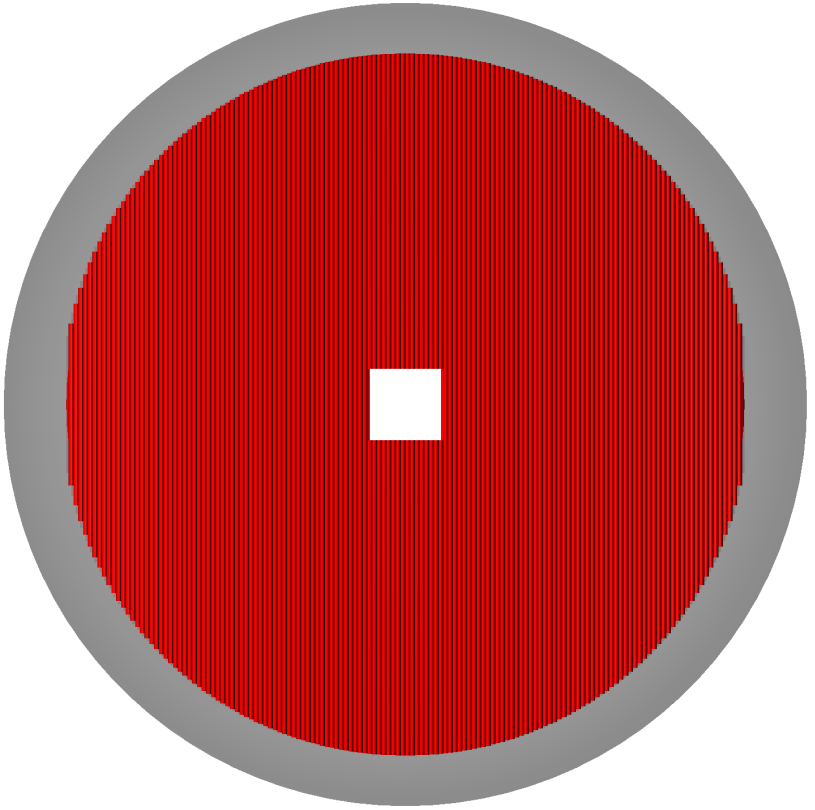
Introduction

- SPD Physics&MC Meeting 26/11/2025:
  V.Kuzmin "Modelling of the SPD end-cap detector" —
  stand-alone simulation of straw tracker end-cap detector for a lot of variants of geometry
- SPD Physics Weekly Meeting 09/12/2025:
  R. Akhunzyanov "Updates to straw tracker end-caps geometry in SpdRoot" —
  new options for straw tracker endcap geometry introduced in SpdRoot

Hole shape



`tsec_mapper->SetHoleShape("strip")`

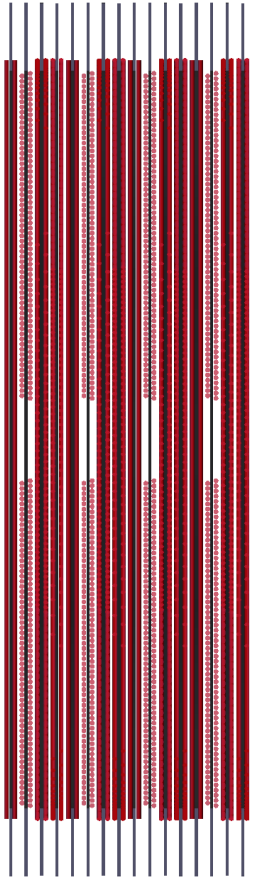


`tsec_mapper->SetHoleShape("square")`

Now default.

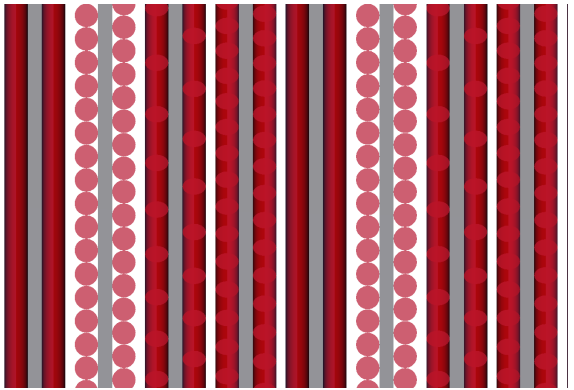
How to change number of planes in end-cap ?

```
void CustomTsEC()
{
      SpdTsTECGeoMapper* tsec_mapper = SpdTsTECGeoMapper::Instance();

     // Change total length
      SpdParameter* par;
      par = tsec_mapper->AddParameter("TsTECLength");
      if (par) *par = 48.;  // cm

      // Set default parameters (straw radius, etc.) of modules
      tsec_mapper->SetParameters(1);
      tsec_mapper->SetParameters(2);

      // Set number and orientation of planes
      Int_t  n = 16;
      std::vector<Double_t> angle_pattern = {0, 90, 45, 135};
      Int_t n_angles = angle_pattern.size();

      Double_t gap = 0.4; // gap between planes
      Double_t d;
      for(Int_t i = 0; i < n; i++) {
          d = (i==0) ? 0 : gap;
          tsec_mapper->AddForwardModule(1, d, angle_pattern[i%n_angles]);
      }
      for(Int_t i = 0; i < n; i++) {
          d = (i==0) ? 0 : gap;
          tsec_mapper->AddBackwardModule(2, d, angle_pattern[i%n_angles]);
      }
}
```

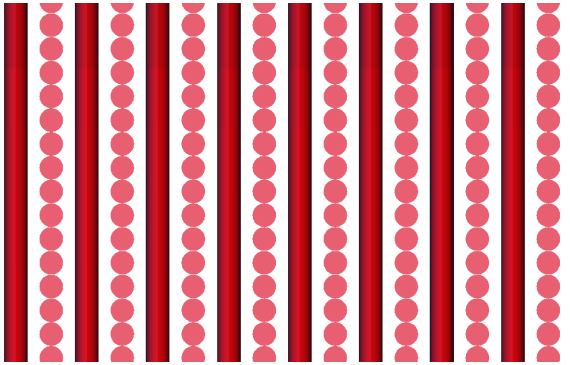


Single layers

- Also an option was introduced where each plane is a **single** layer of straws.
- No passive elements are implemented yet for this option.
- Default configuration:
  16 layers, angle pattern: 0°/90°
- Customizable (see next slide)
- Choice between default configurations with double layers and single layers is done via `"TsTECGeoType"` parameter:
  1 — single layers,
  2 — double layers



double layers



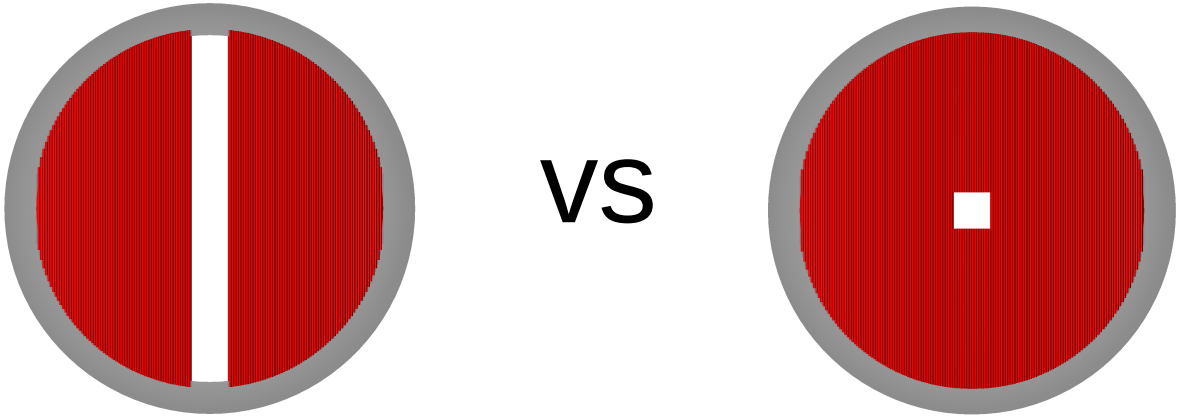
single layers

Single layers: customization

```
void CustomTsEC_SingleLayers()
{
    SpdTsTECGeoMapper* tsec_mapper = SpdTsTECGeoMapper::Instance();

    // Change total length
    SpdParameter* par;
    par = tsec_mapper->AddParameter("TsTECLength");
    if (par) *par = 48.;

    // Set default parameters (straw radius, etc.) for module with single layers
    Int_t module_type = 3;
    tsec_mapper->SetParameters(module_type);

    // Set orientation of layers
    Int_t n = 32; // number of layers
    std::vector<Double_t> angle_pattern = {0, 45, 90, 135};
    Int_t n_angles = angle_pattern.size();

    Double_t gap = 0.5; // gap between layers
    Double_t d;
    for(Int_t i = 0; i < n; i++) {
       d = (i==0) ? 0 : gap;
       tsec_mapper->AddForwardModule(module_type, d, angle_pattern[i%n_angles]);
    }
    for(Int_t i = 0; i < n; i++) {
       d = (i==0) ? 0 : gap;
       tsec_mapper->AddBackwardModule(module_type, d, angle_pattern[i%n_angles]);
    }
}
```

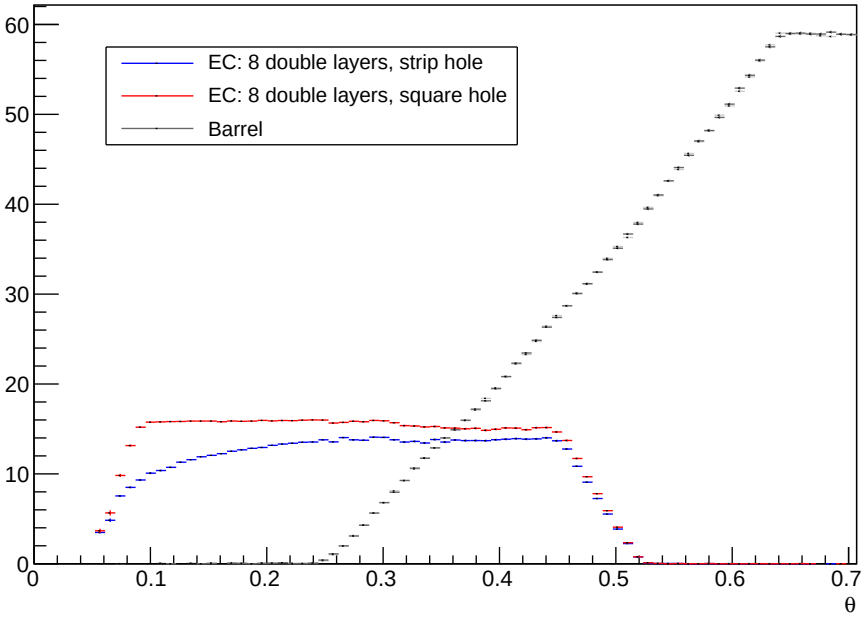
Samples used for comparison of momentum resolution

- Isotropic
- p = 1 GeV/c
- $Z_{prim.vtx}$ = 0
- Tracking detectors:
  Micromegas + Straw Tracker Barrel + Straw Tracker Endcaps
- Other detectors: as in the 1st phase
- Covariance matrix provided by GenFit2 was used to calculate momentum resolution for each track, after that mean momentum resolution for each θ bin was found.

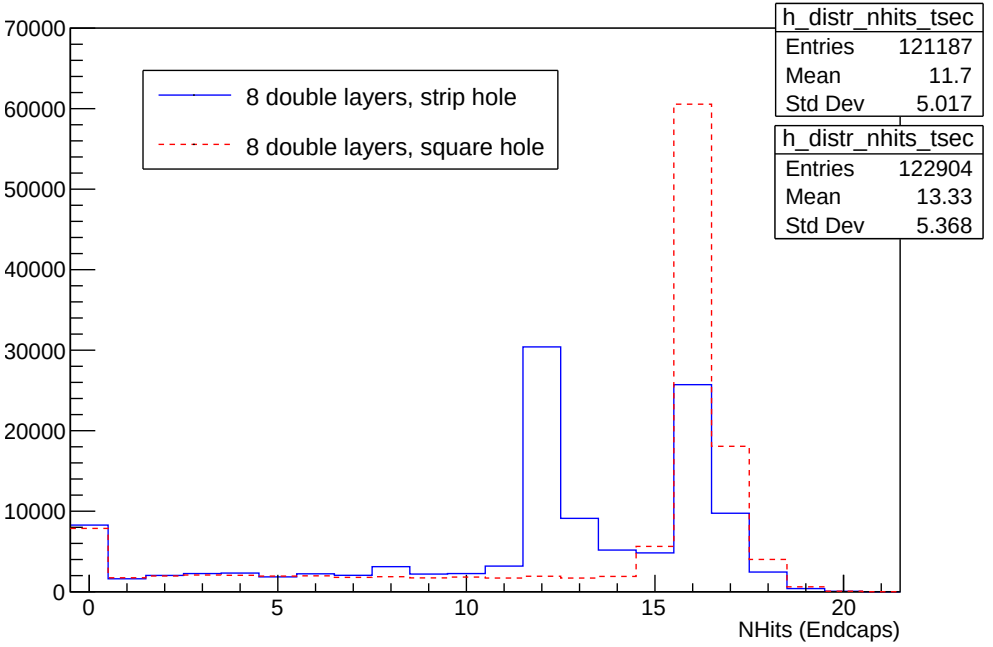

VS

Number of hits

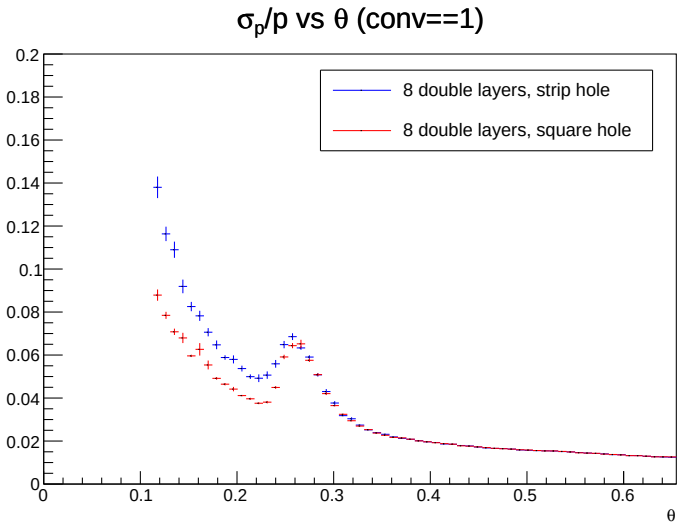
Mean number of hits in barrel and endcap

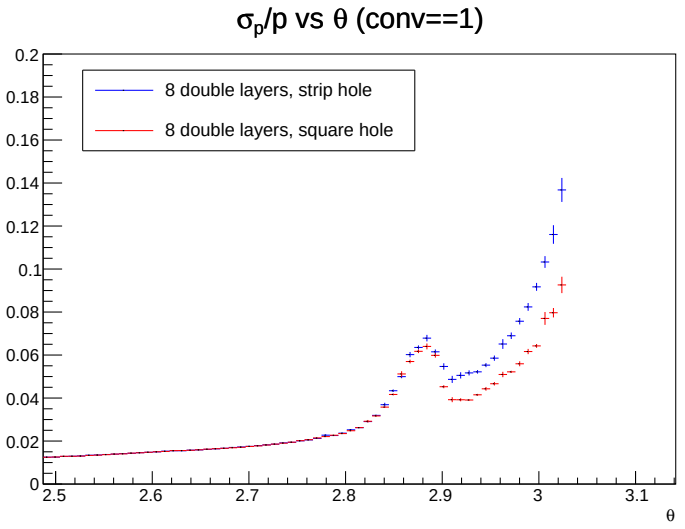


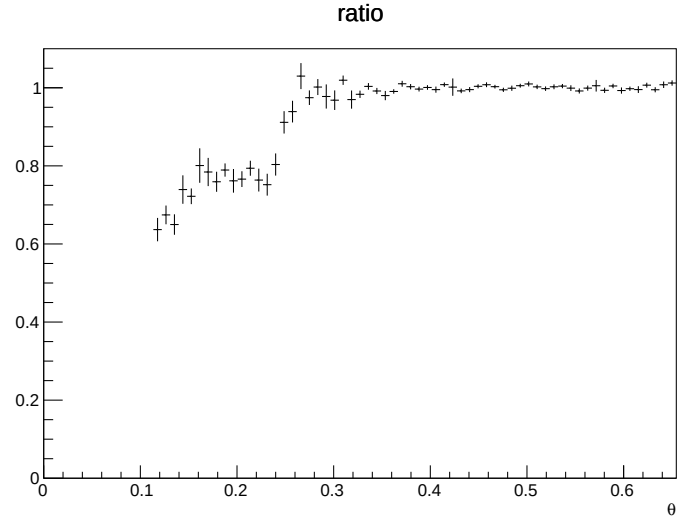
Number of hits in endcap, θ < 0.52 or θ > 2.62

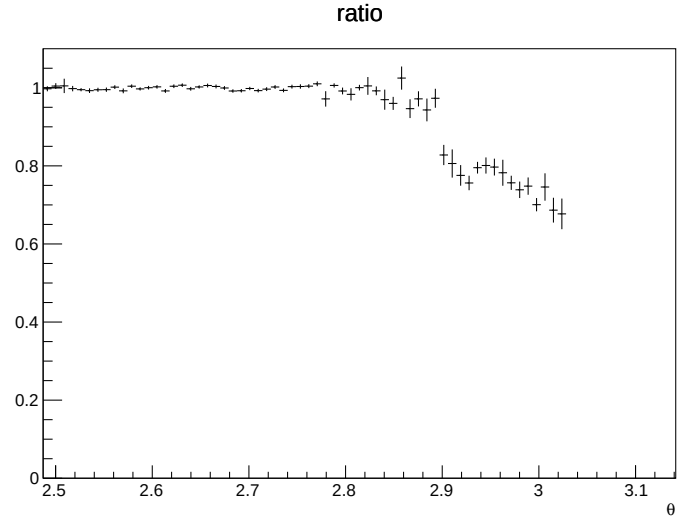


Momentum resolution σ_p/p (p = 1 GeV/c)





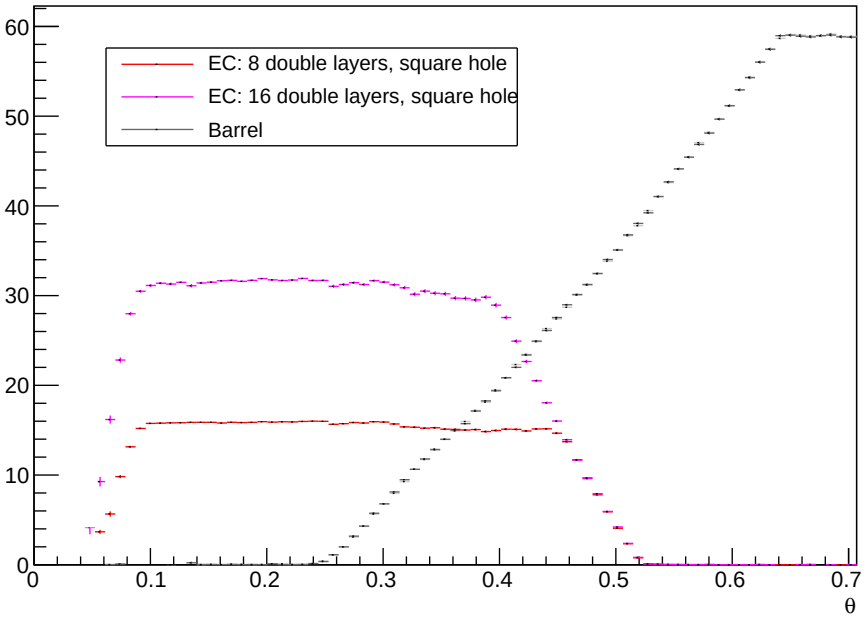




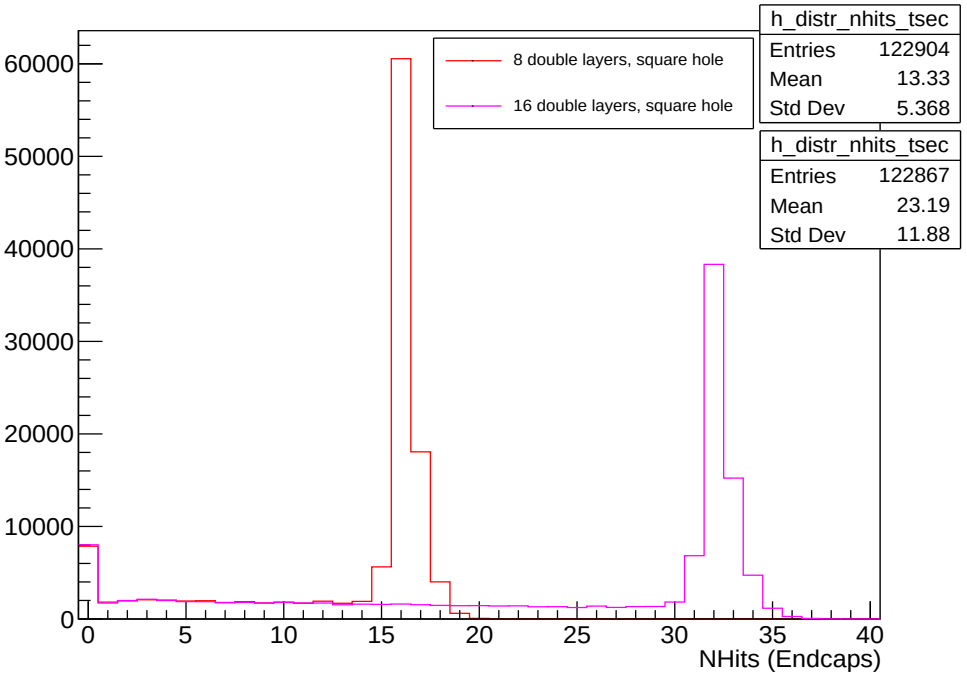
8 double layers
vs
16 double layers

Number of hits

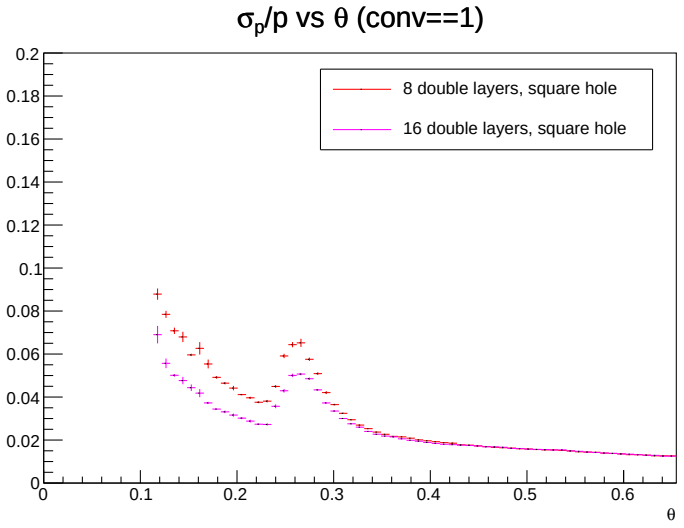
Mean number of hits in barrel and endcap

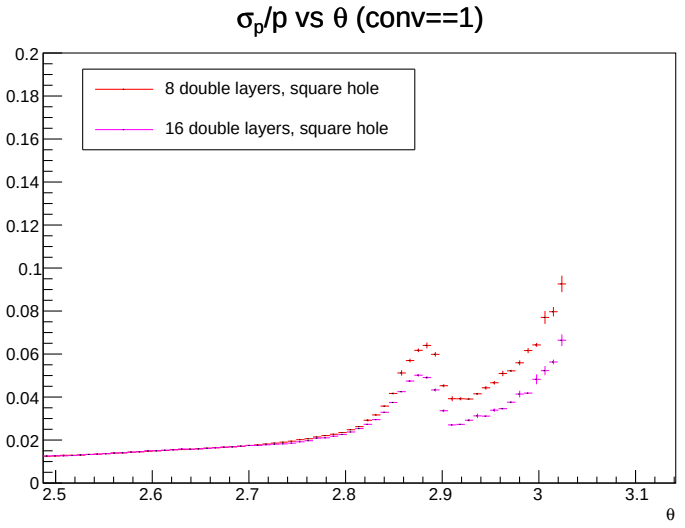


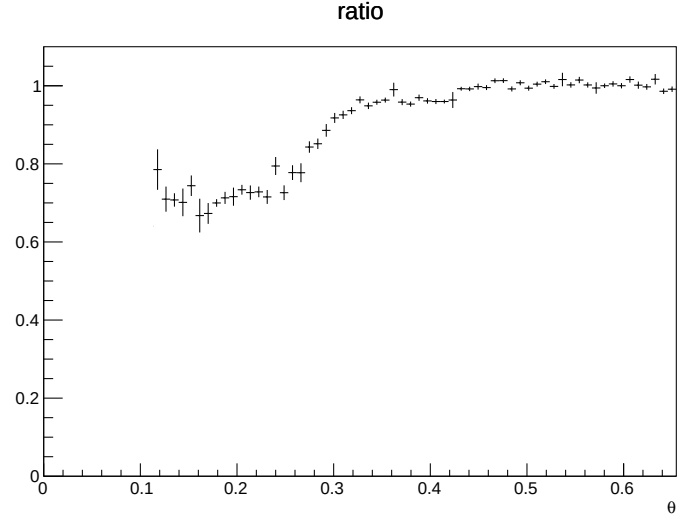
Number of hits in endcap, θ < 0.52 or θ > 2.62

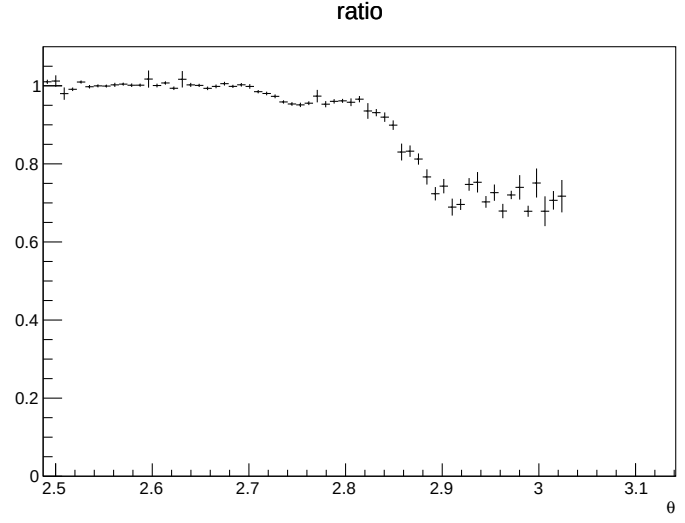


Momentum resolution σ_p/p (p = 1 GeV/c)





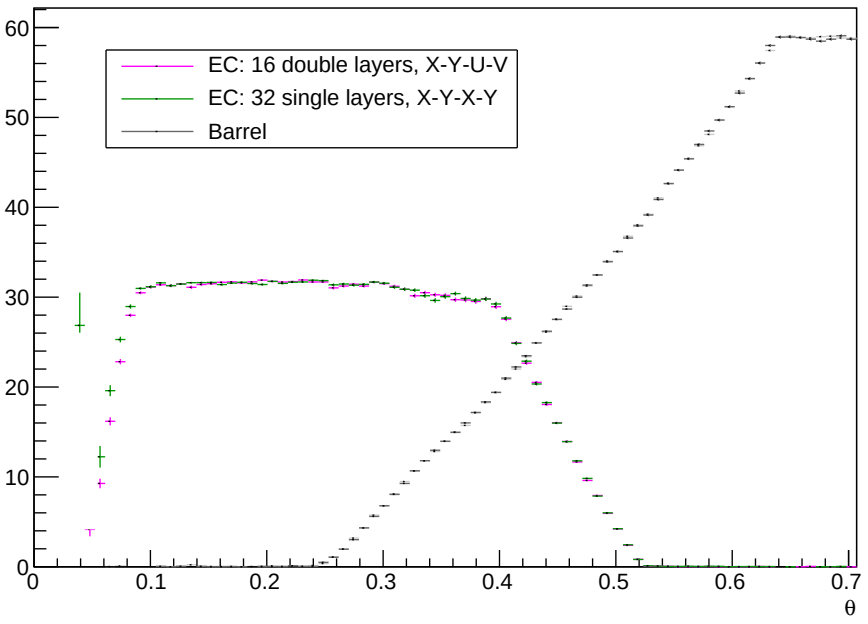




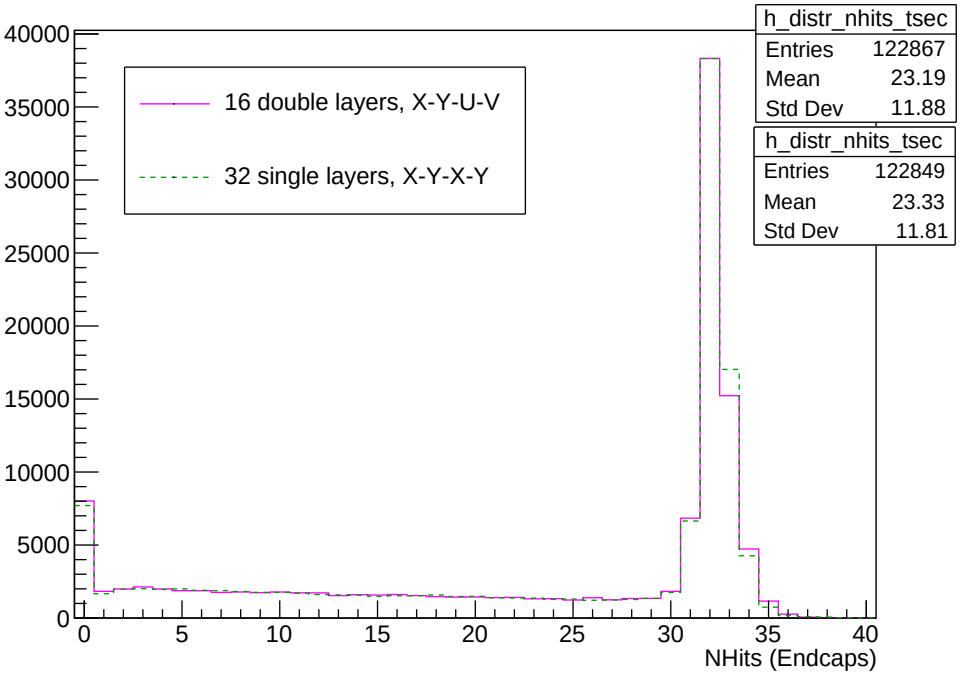
double layers
vs
single layers

Number of hits

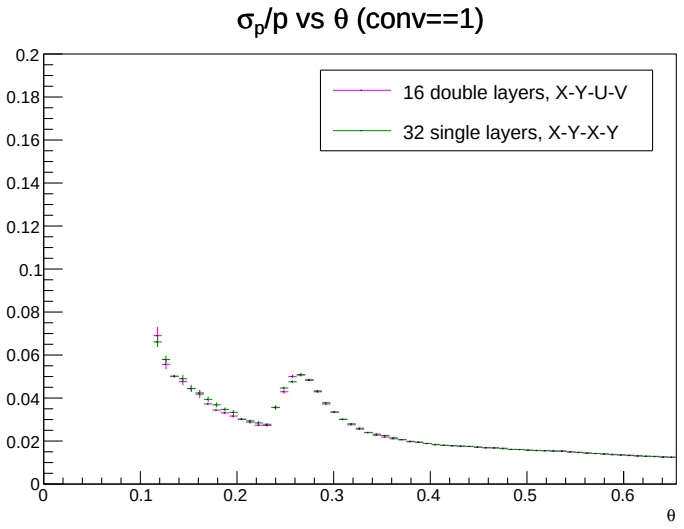
Mean number of hits in barrel and endcap

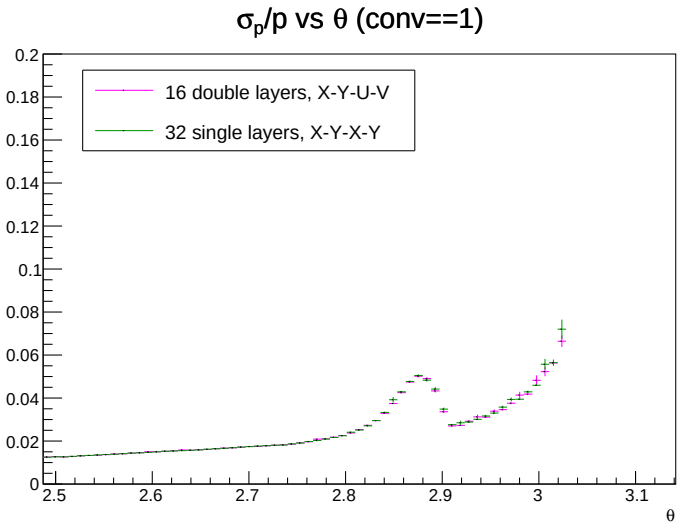


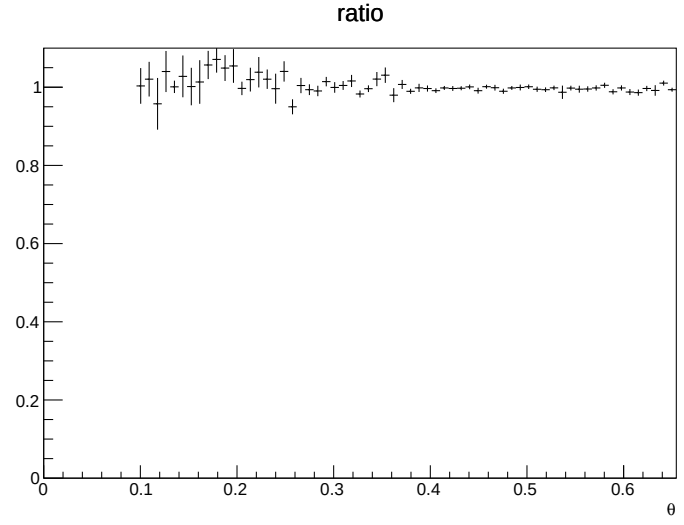
Number of hits in endcap, θ < 0.52 or θ > 2.62

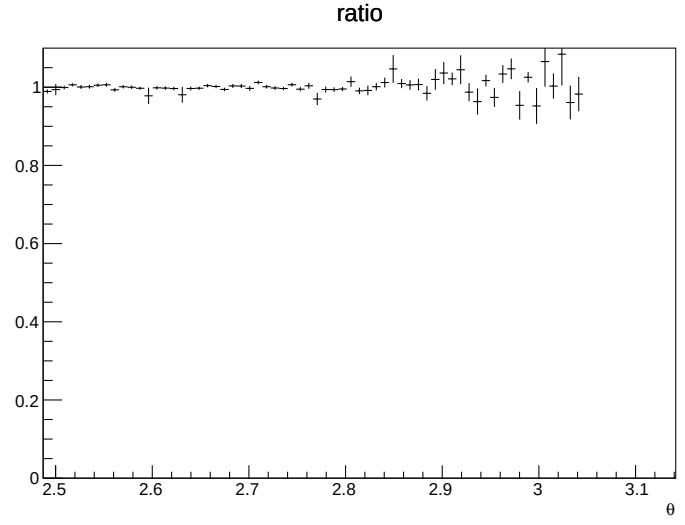


Momentum resolution σ_p/p (p = 1 GeV/c)





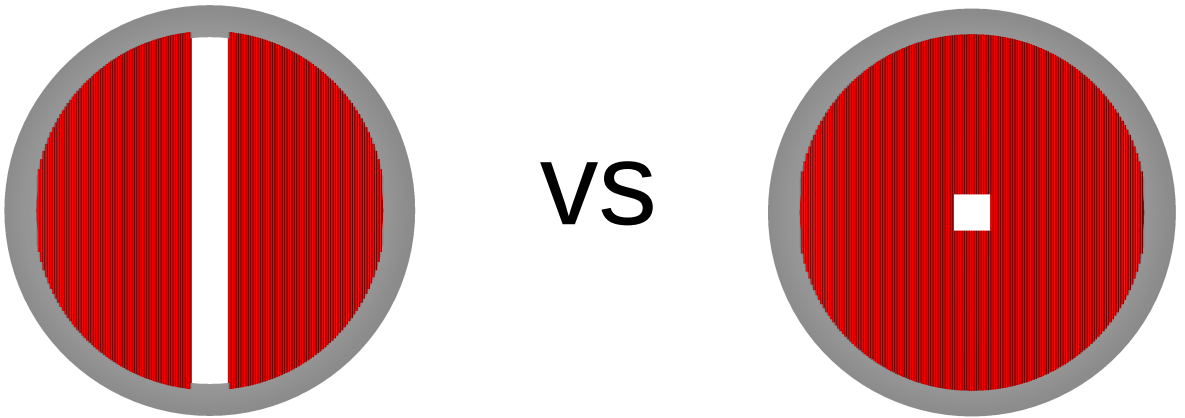




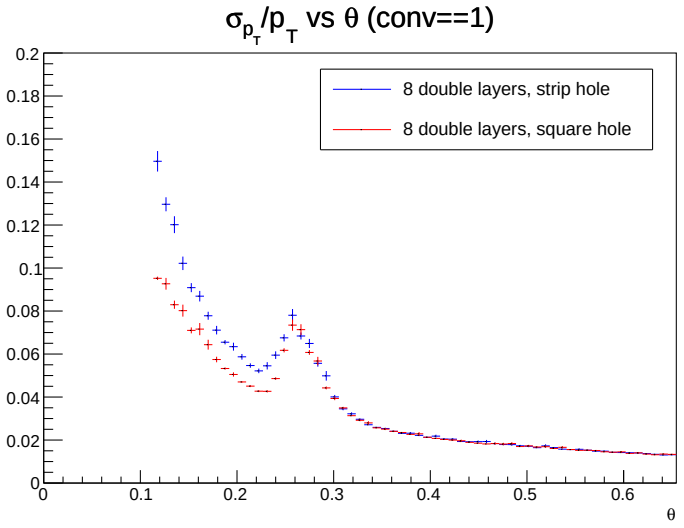
Conclusions

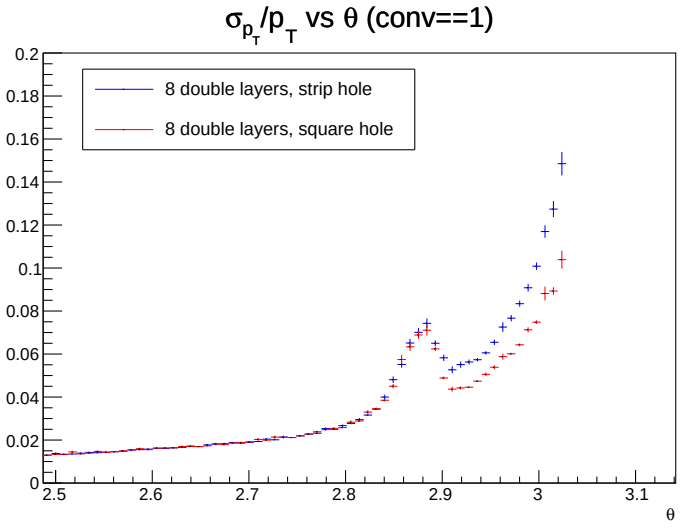
- In case of square hole, the momentum resolution is up to 1.5 times better (depending on θ) than for a strip-shaped hole.
- Doubling the total number of layers from current 16 to 32 improves the momentum resolution by up to 1.4 times.
- Preliminarily, the momentum resolution alone does not allow to select between single layers/double layers options or to find an optimal angle pattern.

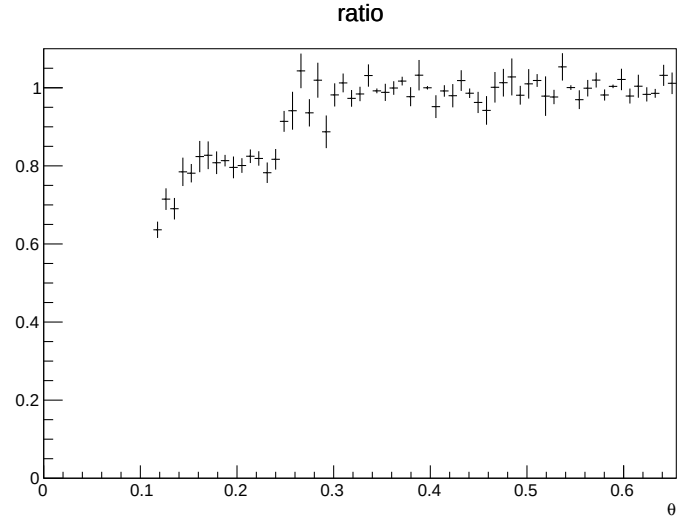
backup

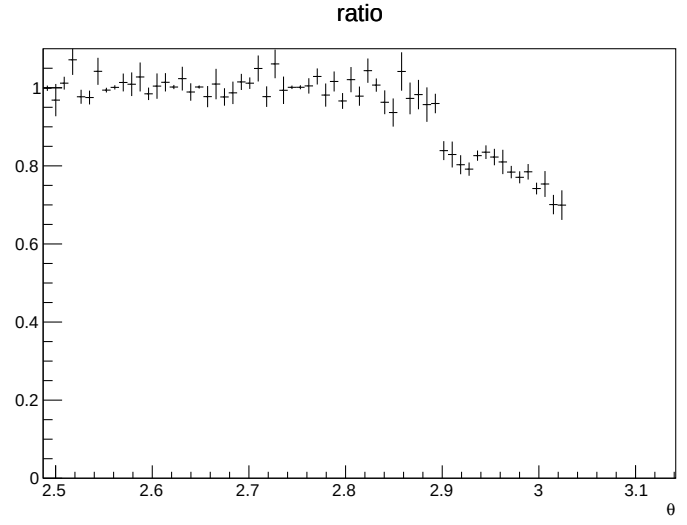

VS

Transverse momentum resolution σ_{pT}/p_T (p = 1 GeV/c)

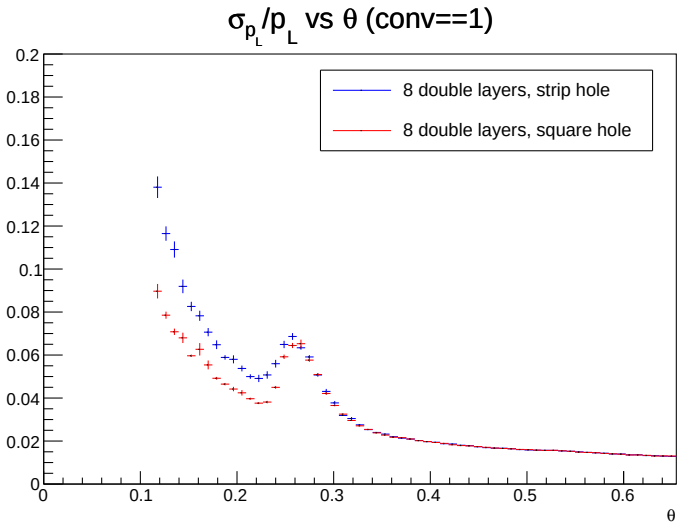


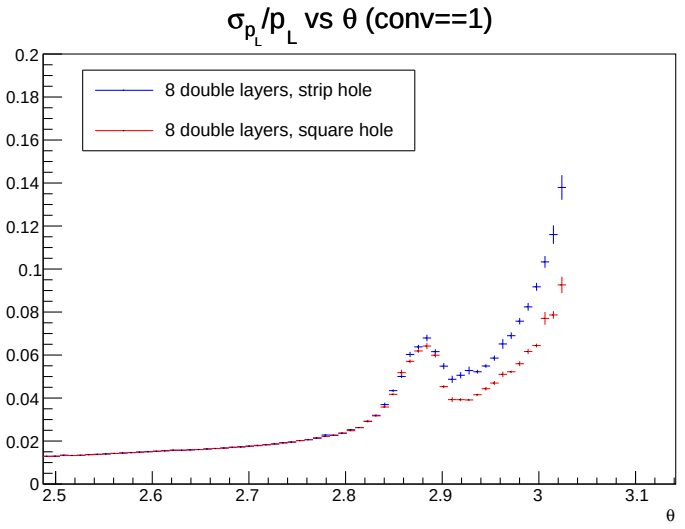


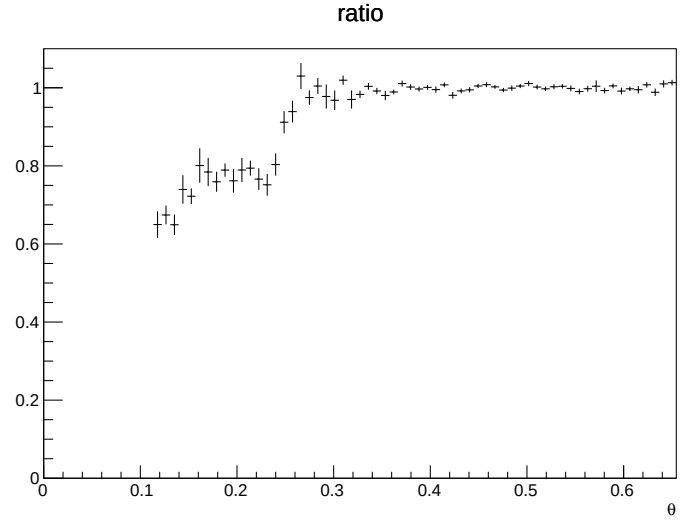


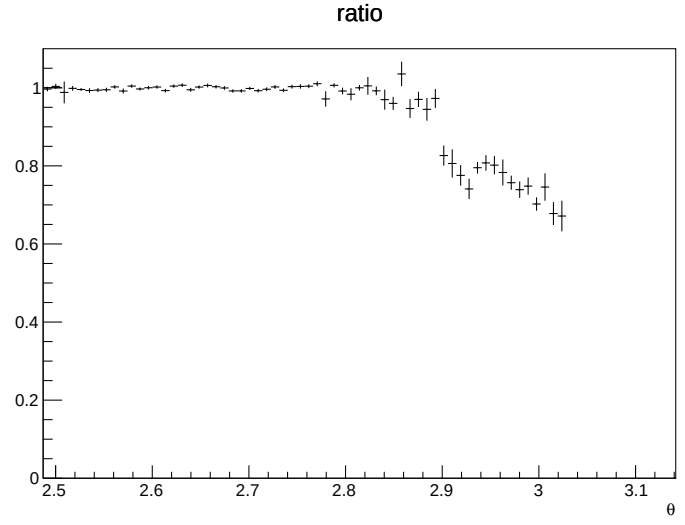


Longitudinal momentum resolution σ_{pL}/p_L (p = 1 GeV/c)



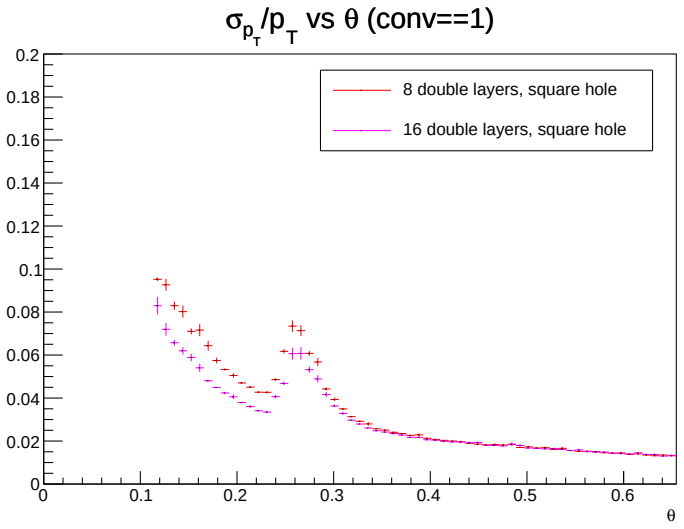


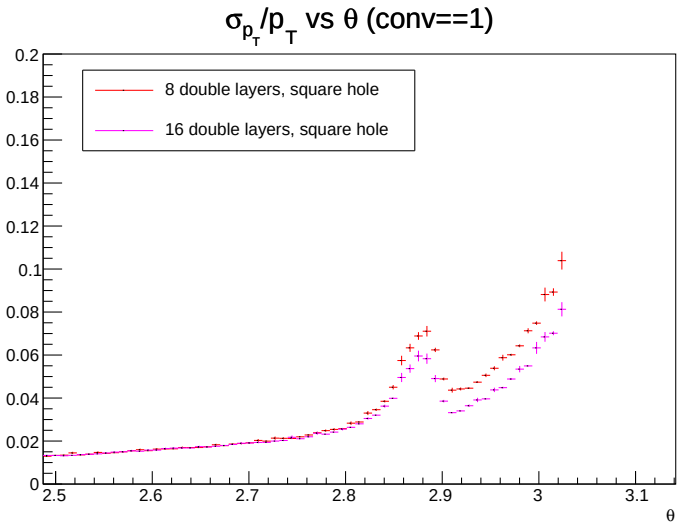


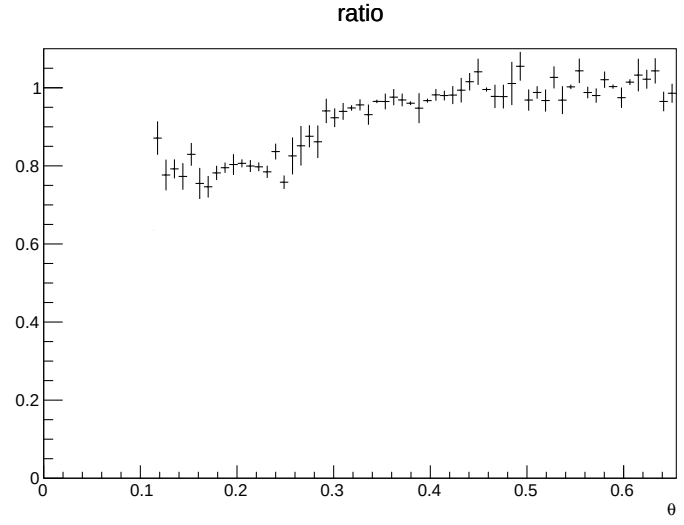


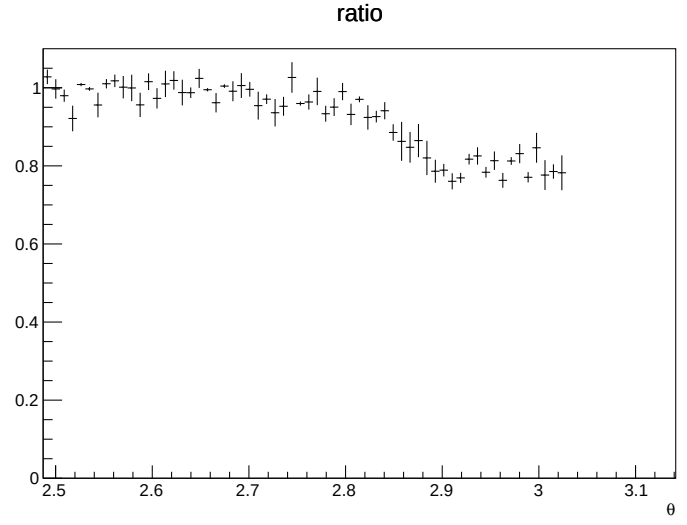
16 vs 32

Transverse momentum resolution σ_{pT}/p_T (p = 1 GeV/c)

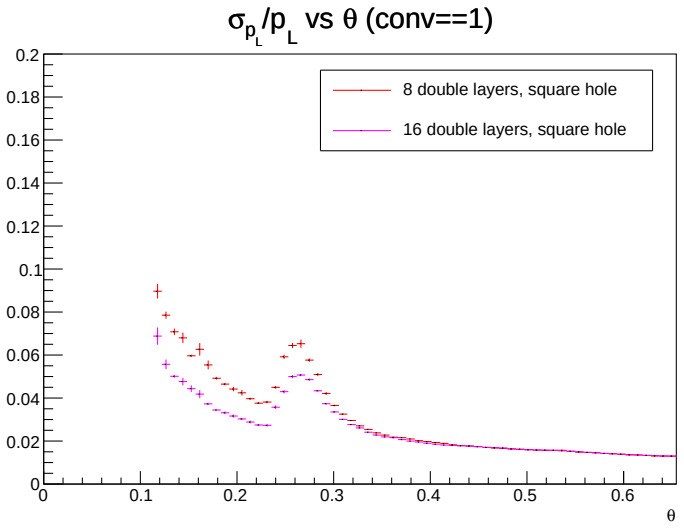


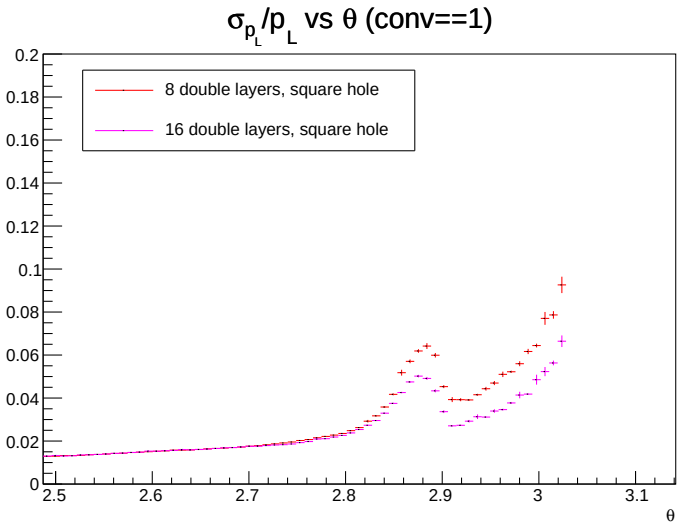


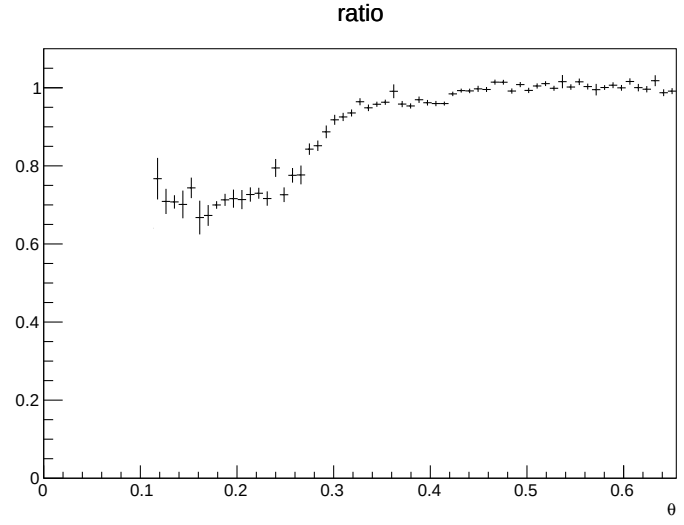


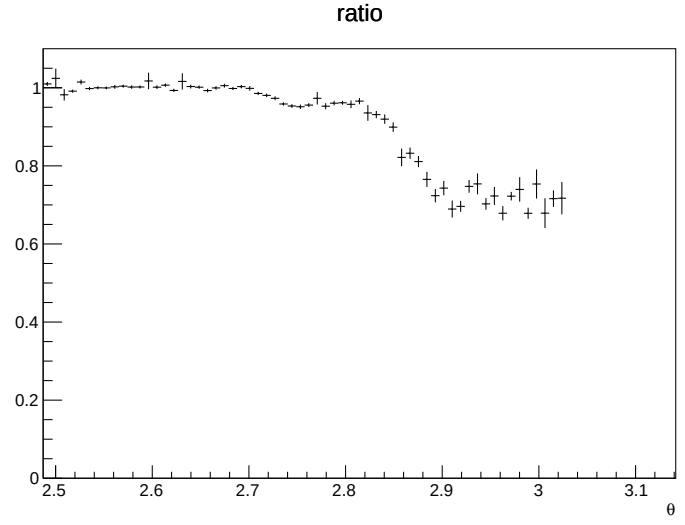


Longitudinal momentum resolution σ_{pL}/p_L (p = 1 GeV/c)



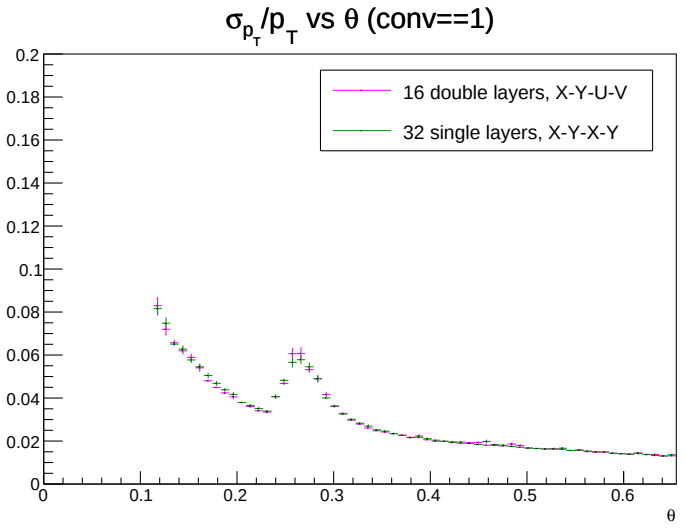


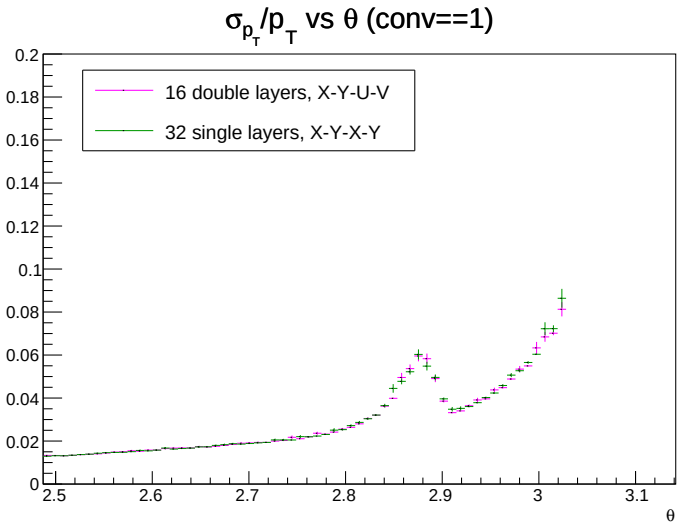


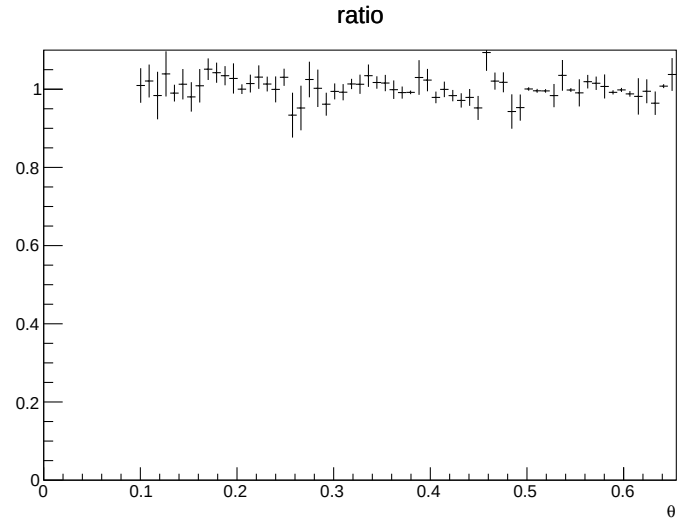


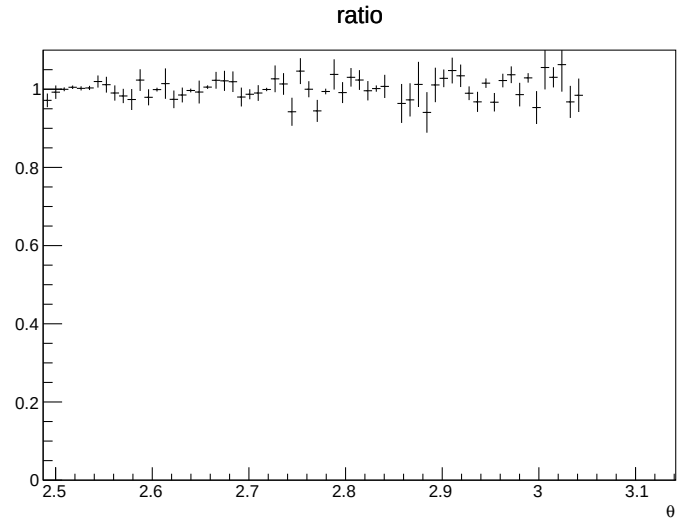
double layers
vs
single layers

Transverse momentum resolution σ_{pT}/p_T (p = 1 GeV/c)









Longitudinal momentum resolution σ_{pL}/p_L (p = 1 GeV/c)