Dependence of momentum resolution on straw tracker spatial resolution

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Spatial resolution of straw tracker σ_R

- Currently, in SpdRoot σ_R is constant and its default value is 150 μm.

- In this report I consider other options for σ_R:

  - σ_R = const = 200, 250, 300, 350 μm;

  - σ_R = *f(R)* — based on Artem Chukanov's talk at the last CM.

How to change (constant) hit resolution in SpdRoot

To change hit resolution from the default value to another constant, there is no need to modify the source code, one has only to add two lines in the reco script:

```
...

SpdTsMCHitProducer* ts_hits_producer = new SpdTsMCHitProducer();

// here resolution is in mkm
ts_hits_producer->SetHitResolution(0, 'v', resolution*1e-4);   // barrel
ts_hits_producer->SetHitResolution(1, 'v', resolution*1e-4);   // endcaps

...
```
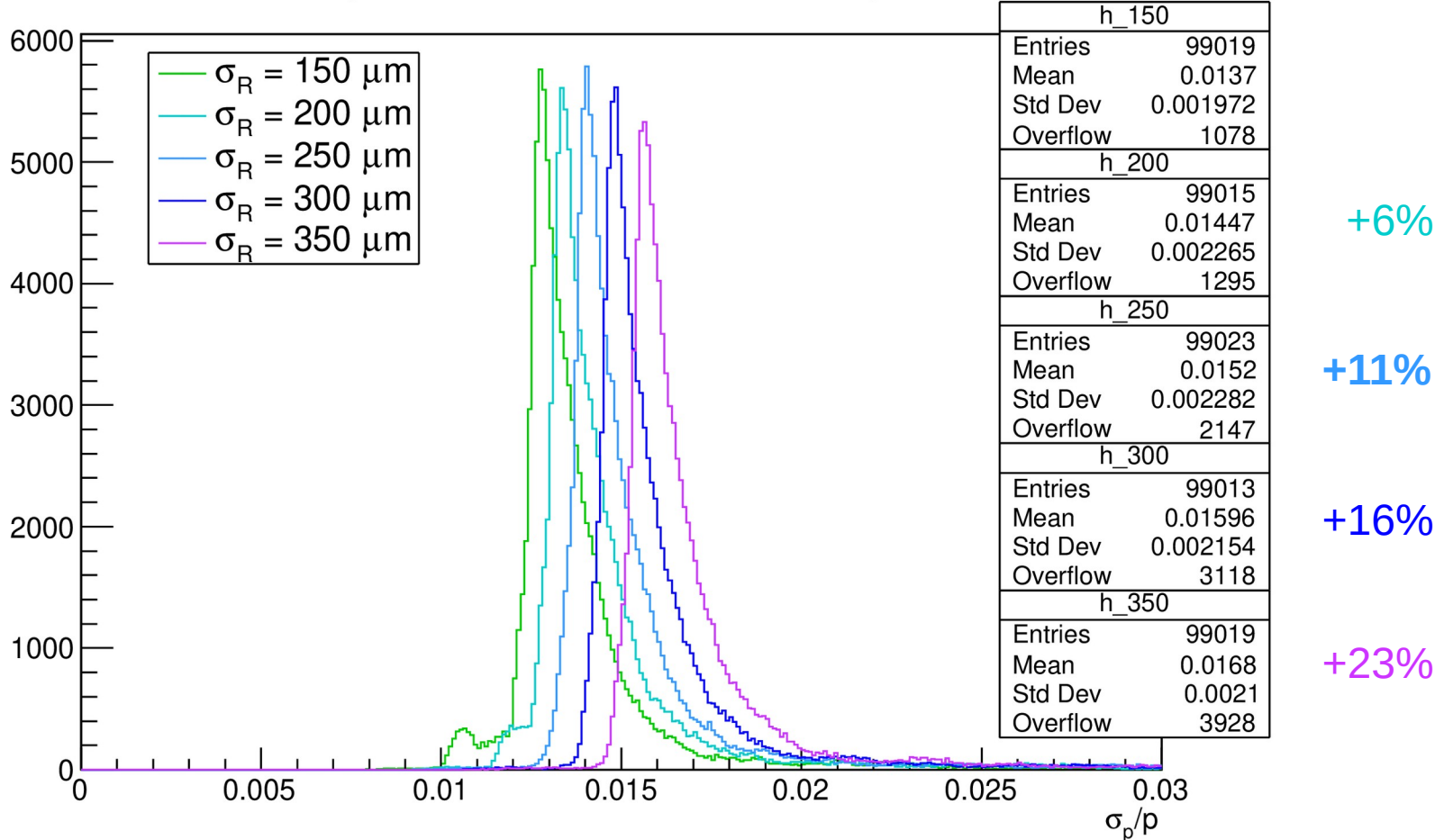
Note. The default value is defined in method:

```
Double_t SpdTsMCHitProducer::GetHitResolutionR(Int_t detPart, Char_t spec)
{
    TString key = DetResKey(detPart,spec);
    auto x = fResolution.find(key);
    return (x != fResolution.end()) ? (x->second)[0] : 150*mkm_; //ATTENTION
}
```
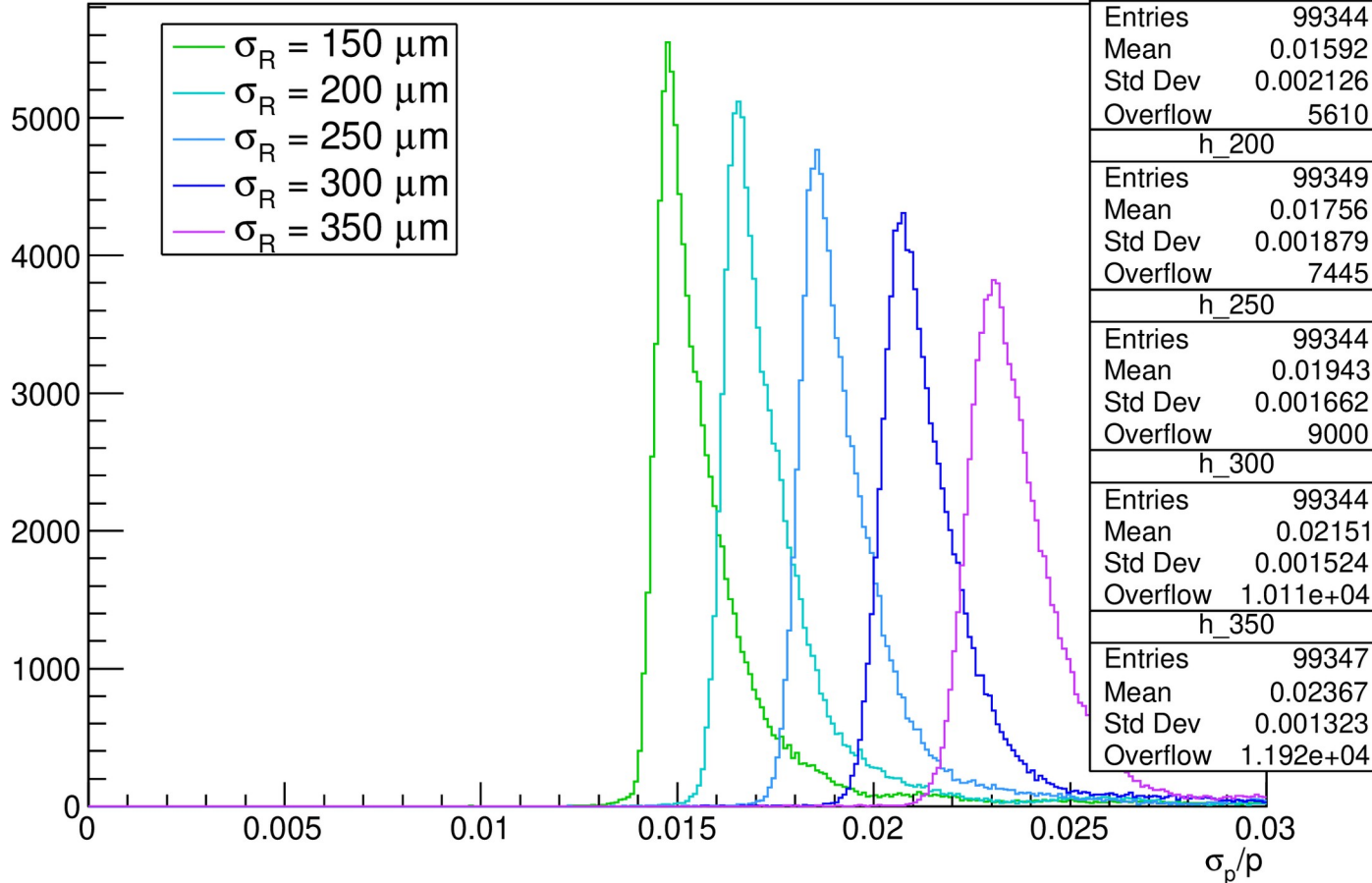
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Momentum resolution σ_p/p at 1 GeV/c

π^+, p = 1.0 GeV/c, θ = 90°, only ST

h_150	
Entries	99019
Mean	0.0137
Std Dev	0.001972
Overflow	1078
h_200	
Entries	99015
Mean	0.01447
Std Dev	0.002265
Overflow	1295
h_250	
Entries	99023
Mean	0.0152
Std Dev	0.002282
Overflow	2147
h_300	
Entries	99013
Mean	0.01596
Std Dev	0.002154
Overflow	3118
h_350	
Entries	99019
Mean	0.0168
Std Dev	0.0021
Overflow	3928

+6%

+11%

+16%

+23%

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Momentum resolution σ_p/p at 2 GeV/c

π^+, p = 2.0 GeV/c, θ = 90°, only ST

Legend:
- σ_R = 150 μm
- σ_R = 200 μm
- σ_R = 250 μm
- σ_R = 300 μm
- σ_R = 350 μm

h_150	
Entries	99344
Mean	0.01592
Std Dev	0.002126
Overflow	5610
h_200	
Entries	99349
Mean	0.01756
Std Dev	0.001879
Overflow	7445
h_250	
Entries	99344
Mean	0.01943
Std Dev	0.001662
Overflow	9000
h_300	
Entries	99344
Mean	0.02151
Std Dev	0.001524
Overflow	1.011e+04
h_350	
Entries	99347
Mean	0.02367
Std Dev	0.001323
Overflow	1.192e+04

+10%

+22%

+35%

+49%

x-axis: σ_p/p

Mean momentum resolution σ_p/p

θ=90°, only ST

Legend:
- σ_R = 150 μm
- σ_R = 200 μm
- σ_R = 250 μm
- σ_R = 300 μm
- σ_R = 350 μm

x-axis: p [GeV/c]
y-axis: mean σ_p/p

σ_R as a function of R

straw 1110, sigma

p0	-0.326 ± 0.0106
p1	0.6506 ± 0.01253

$$\sigma_R(R) = 0.6506 \exp(-0.326\,R)$$

(here all values in mm)

Plot and parameterization by Artem Chukanov.

Variable hit resolution in SpdRoot

Changes to class **SpdTsMCHitProducer**:

```
Double_t SpdTsMCHitProducer::GetHitResolutionR(Double_t Rdrift)
{
    Double_t p0 = 3.26;
    Double_t p1 = 0.06506;
    return p1*exp(-p0*Rdrift);
}




template <class T> SpdMCStrawHit1D* SpdTsMCHitProducer::CreateTsHit1D(T* p, Int_t detPart)
{
    ...

    // set hit resolution
    hit->SetResolutionR(GetHitResolutionR(detPart,fHitType));

    Double_t R = hit->GetPointRdrift();
    hit->SetResolutionR(GetHitResolutionR(R));

    ...
}
```
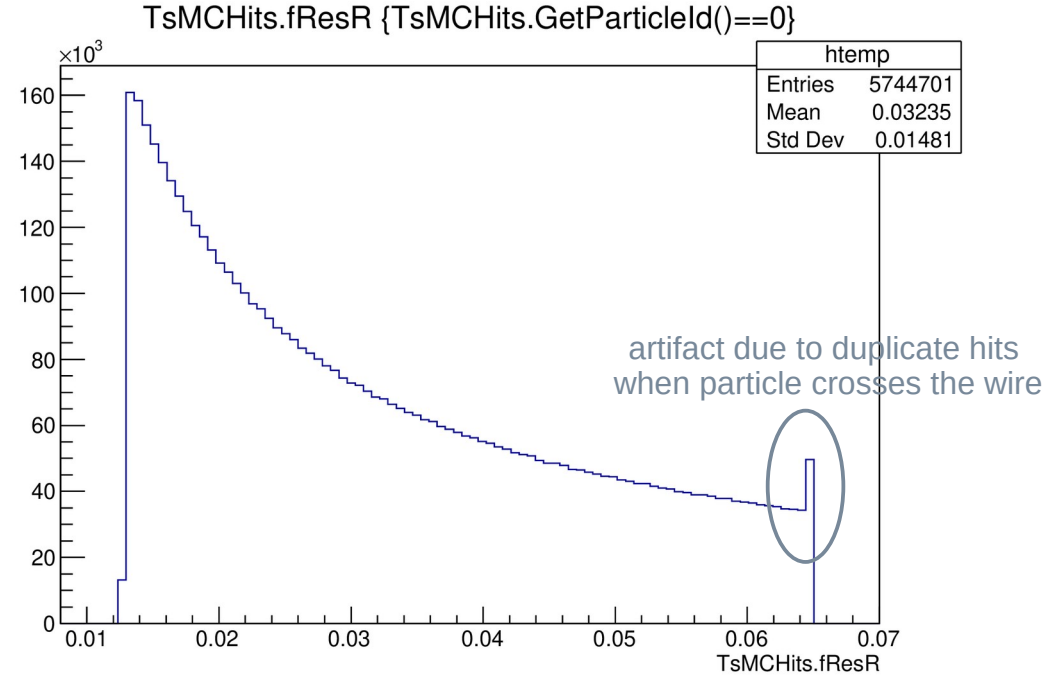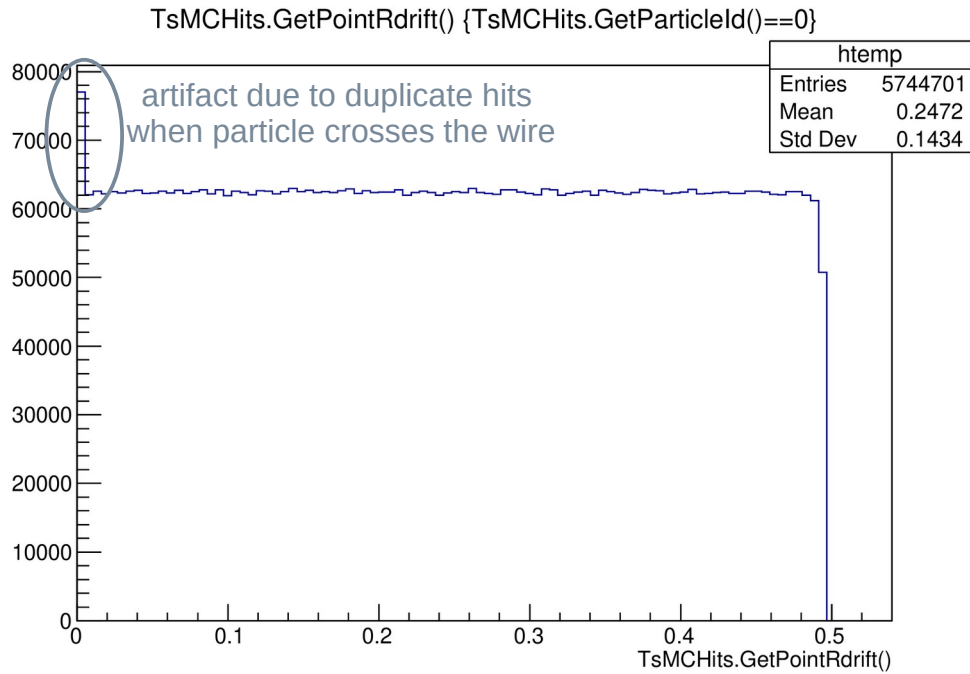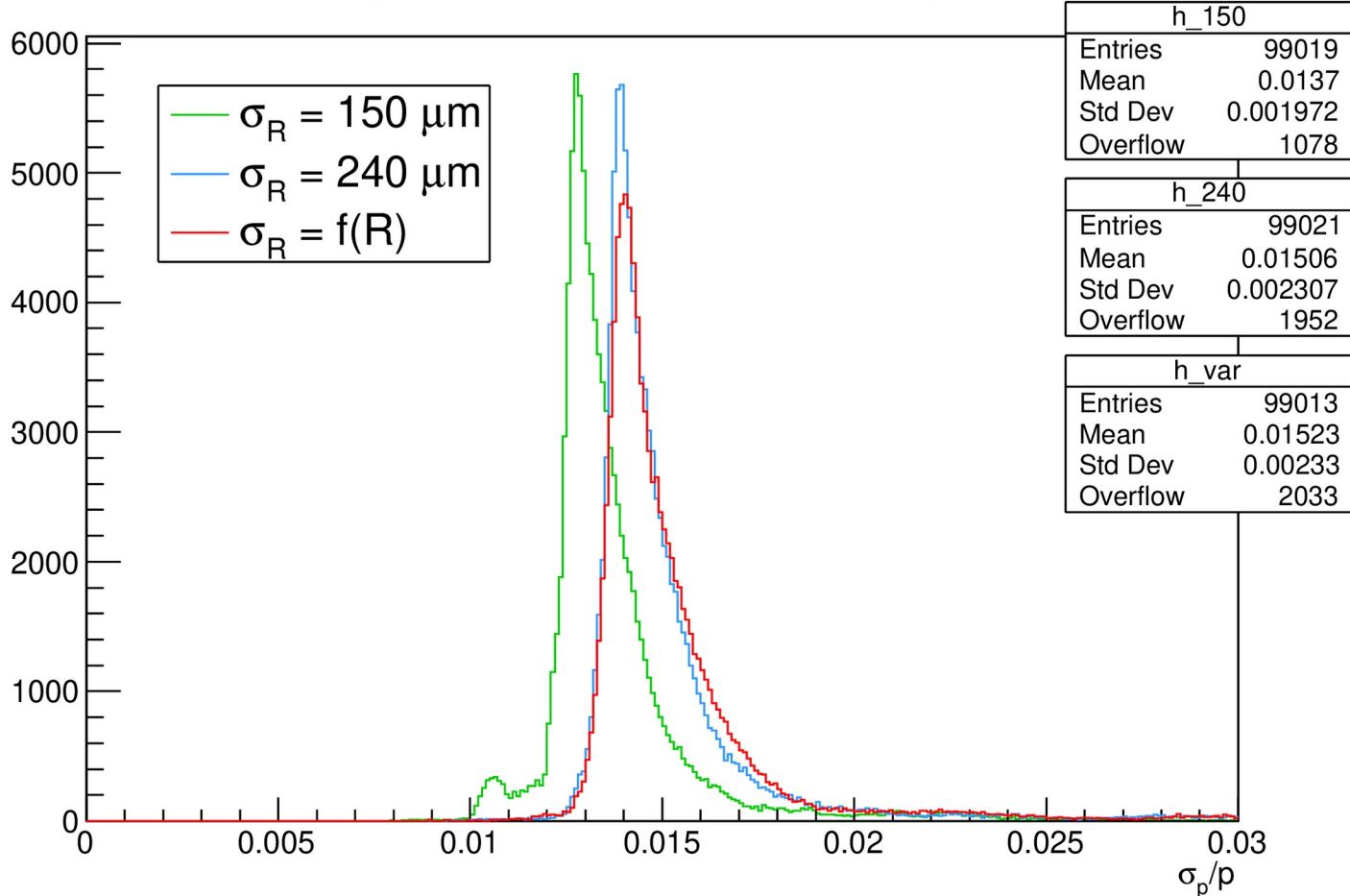
R and σ_*R* distributions

TsMCHits.GetPointRdrift() {TsMCHits.GetParticleId()==0}

artifact due to duplicate hits
when particle crosses the wire

htemp	
Entries	5744701
Mean	0.2472
Std Dev	0.1434

TsMCHits.GetPointRdrift()

TsMCHits.fResR {TsMCHits.GetParticleId()==0}

htemp	
Entries	5744701
Mean	0.03235
Std Dev	0.01481

artifact due to duplicate hits
when particle crosses the wire

TsMCHits.fResR

(plots for an artificial sample p = 1 GeV/c, θ = 90°)

$$\langle \sigma \rangle = 323 \, \mu m$$

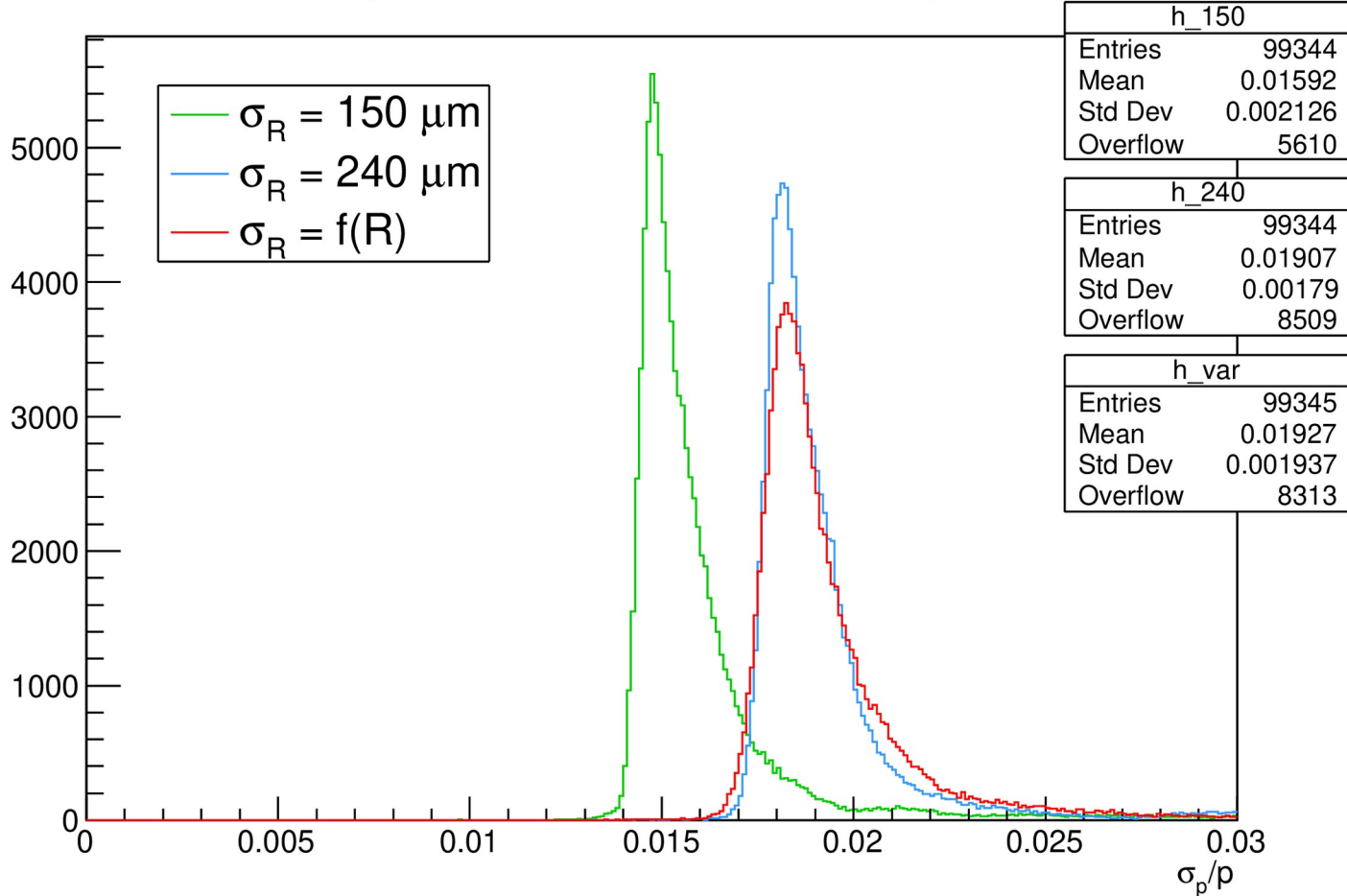$$\left(\langle \sigma^{-2} \rangle \right)^{-\frac{1}{2}} = 237 \, \mu m$$

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Momentum resolution σ_p/p at 1 GeV/c

π^+, p = 1.0 GeV/c, θ = 90°, only ST

h_150	
Entries	99019
Mean	0.0137
Std Dev	0.001972
Overflow	1078

h_240	
Entries	99021
Mean	0.01506
Std Dev	0.002307
Overflow	1952

h_var	
Entries	99013
Mean	0.01523
Std Dev	0.00233
Overflow	2033

σ_R = 150 µm
σ_R = 240 µm
σ_R = f(R)

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Momentum resolution σ_p/p at 2 GeV/c

π^+, p = 2.0 GeV/c, θ = 90°, only ST

h_150	
Entries	99344
Mean	0.01592
Std Dev	0.002126
Overflow	5610

h_240	
Entries	99344
Mean	0.01907
Std Dev	0.00179
Overflow	8509

h_var	
Entries	99345
Mean	0.01927
Std Dev	0.001937
Overflow	8313

σ_R = 150 μm
σ_R = 240 μm
σ_R = f(R)

σ_p/p

Mean momentum resolution σ_p/p

θ=90°, only ST

Legend:
- $\sigma_R = 150\ \mu m$
- $\sigma_R = 240\ \mu m$
- $\sigma_R = f(R)$
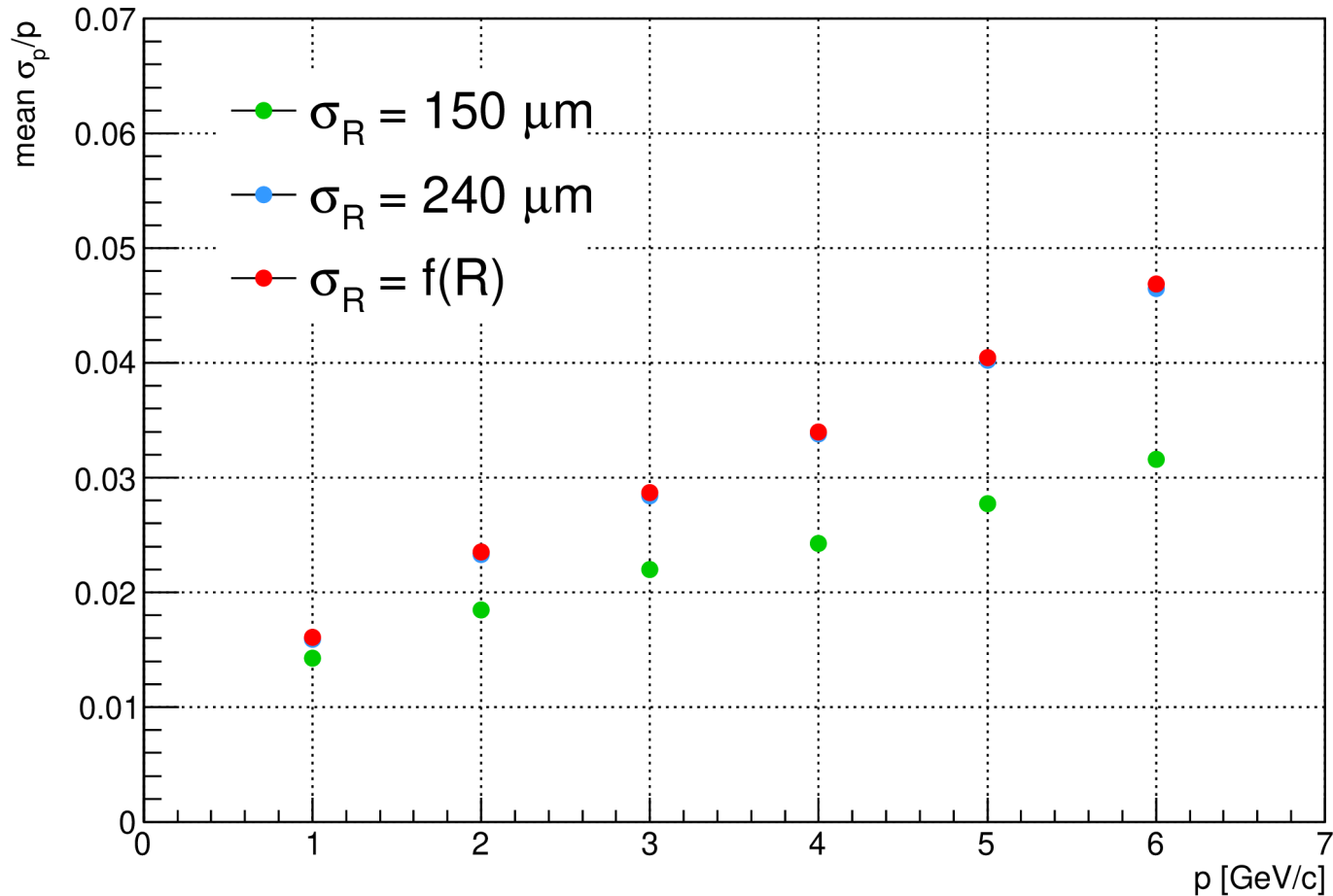
Conclusions

- Spatial resolution of straw tube σ_R as a function of drift distance R can be easily implemented in SpdRoot.

- Effective σ_R of our straw tubes is about 240 µm.