Study of elastic proton-proton scattering at $\sqrt{s} = 5$ and 10 GeV at NICA SPD

SPD Physics and MC meeting, 01.06.2022

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Used generators and geometry

Used generators:

Pythia8, minimum bias, $\sqrt{s} = 10\ GeV$

```
*-------  PYTHIA Process Initialization  ------------------------*
|                                                                |
| We collide p+ with p+ at a CM energy of 1.000e+01 GeV          |
|                                                                |
|----------------------------------------------------------------|
|                                                  |             |
| Subprocess                                 Code  |   Estimated |
|                                                  |    max (mb) |
|                                                  |             |
|----------------------------------------------------------------|
|                                                  |             |
| non-diffractive                             101  |   2.531e+01 |
| A B -> A B elastic                          102  |   7.114e+00 |
| A B -> X B single diffractive               103  |   2.583e+00 |
| A B -> A X single diffractive               104  |   2.583e+00 |
| A B -> X X double diffractive               105  |   8.662e-01 |
| A B -> A X B central diffractive            106  |   0.000e+00 |
|                                                  |             |
*-------  End PYTHIA Process Initialization ----------------------*
```

Reconstruction efficiency ($pp \rightarrow pp$): $\approx 4.13\,\%$

Estimated $N_{events} = 8.8e10$, $(\tau_{data\ taking} = 0.3 \cdot 10^7 s)$.

FTFGen, $\sqrt{s} = 5\ GeV$

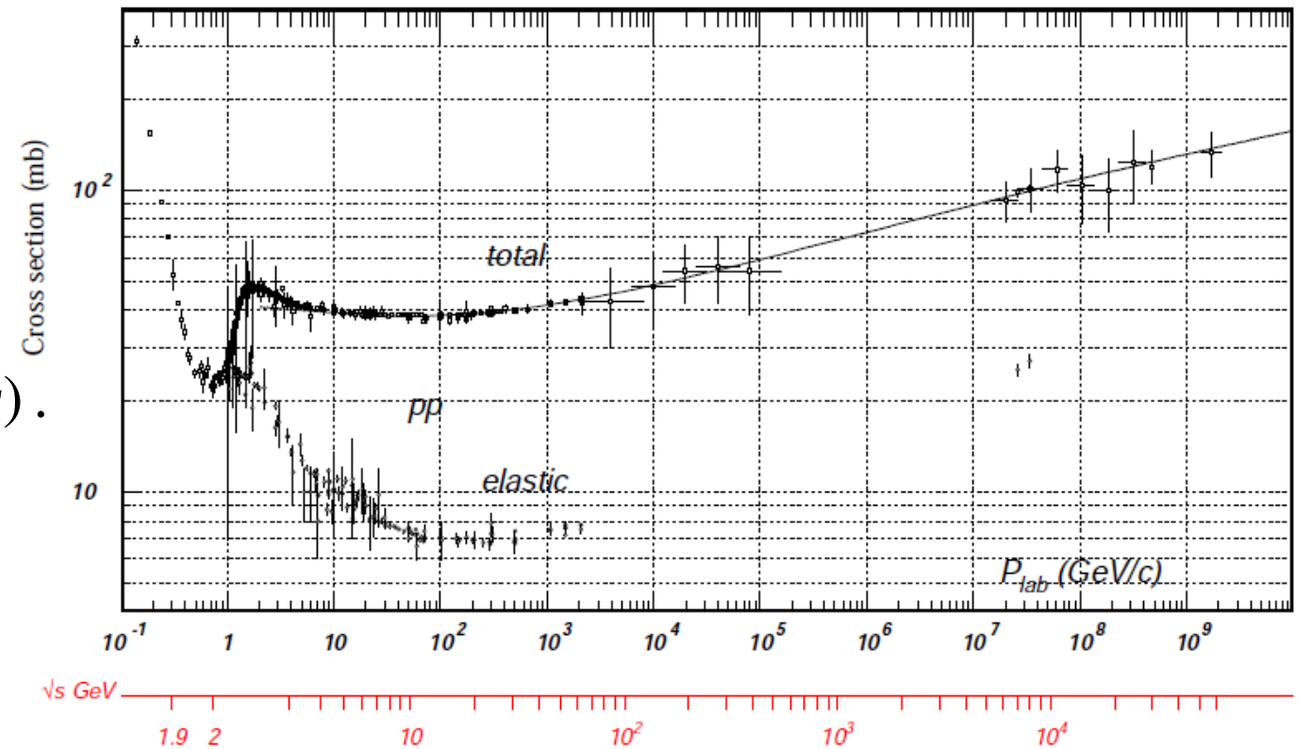
```
Using G4HadronInelasticDataSet()
Try 1 cross_secel 0.000000e+00
cross(mb)in= 8.953248e+00
cross(mb)el= 0.000000e+00

Element A Z N: 1 1 0
Proposed Xs (mb): Tot El In: 8.953248e+00 0.000000e+00 8.953248e+00
CHIPS cross sections are used:----------------------
Plab          Total         Elastic       Inelastic
 1.233759e+01 3.899851e+01 9.576042e+00 2.942247e+01
```

Reconstruction efficiency ($pp \rightarrow pp$): $\approx 20.9\,\%$

Estimated $N_{events} = 6e11$ $(\tau_{data\ taking} = 0.3 \cdot 10^7 s)$.

Used geometry:

+ recent geometry
(3x less straw tubes in endcaps)
+ new field map
+ latest generation script
+ VertexDetector: MVD



Results with previous geometry:
BiWeekly Physics Meeting, 5.04.22

Selection criteria

- One primary vertex;
- MCtrack is associated with MCparticle;
- Final state exists (track is fitted);
- Two particles in the final state;
- Charge of final state particles == 2;

Signal event at $\sqrt{s} = 10\ GeV$:

```
p1 gen = 4.91118, theta = 0.117419
p2 gen = 4.91118, theta = 3.02417
p1 rec = 2.14337, theta = 0.118148
p2 rec = 2.06263, theta = 3.02502
```

$$pp \to pp, \Delta p/p_{gen} \approx -0.5$$

Large difference between generated and reconstructed momentum could be explained by the fact that there are no hits in the VD for the most part of generated events.

Background event:

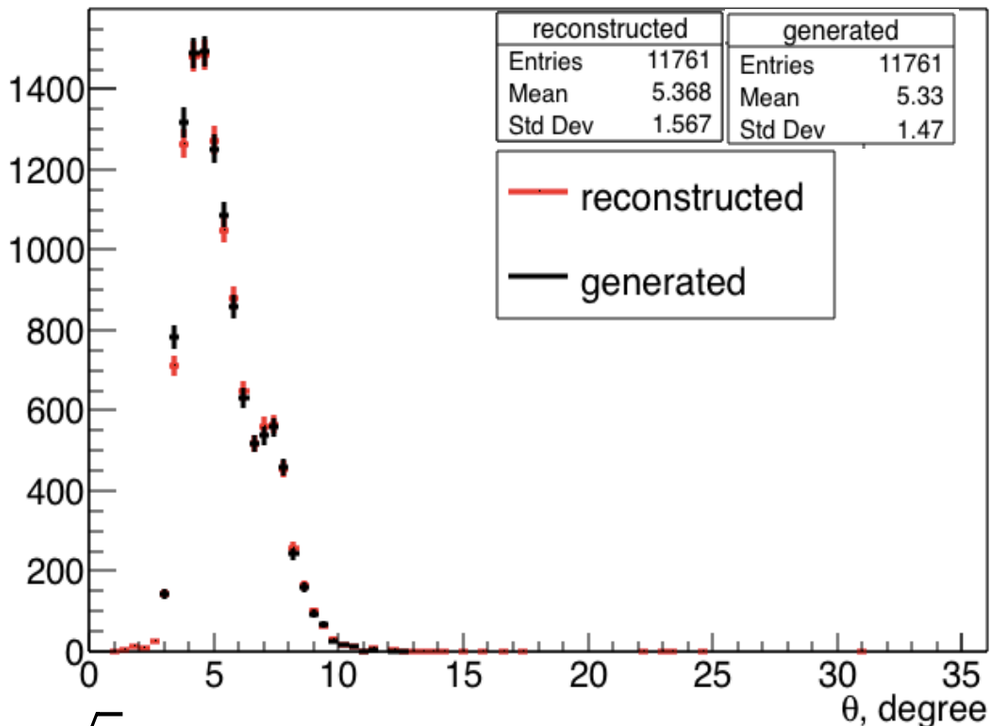
```
part pdg = 2112
part pdg = 2212
part pdg = 211
is background
charge = 2
```

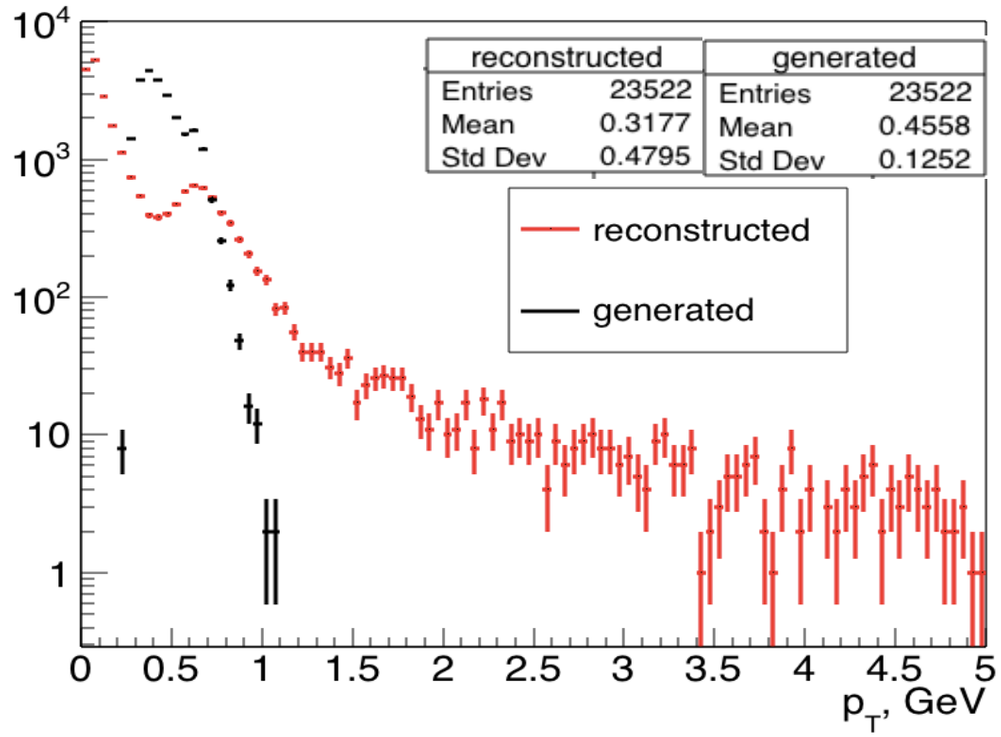
$$pp \to pn\pi^+$$

Actually, any event with two positively charged particles in the final state.

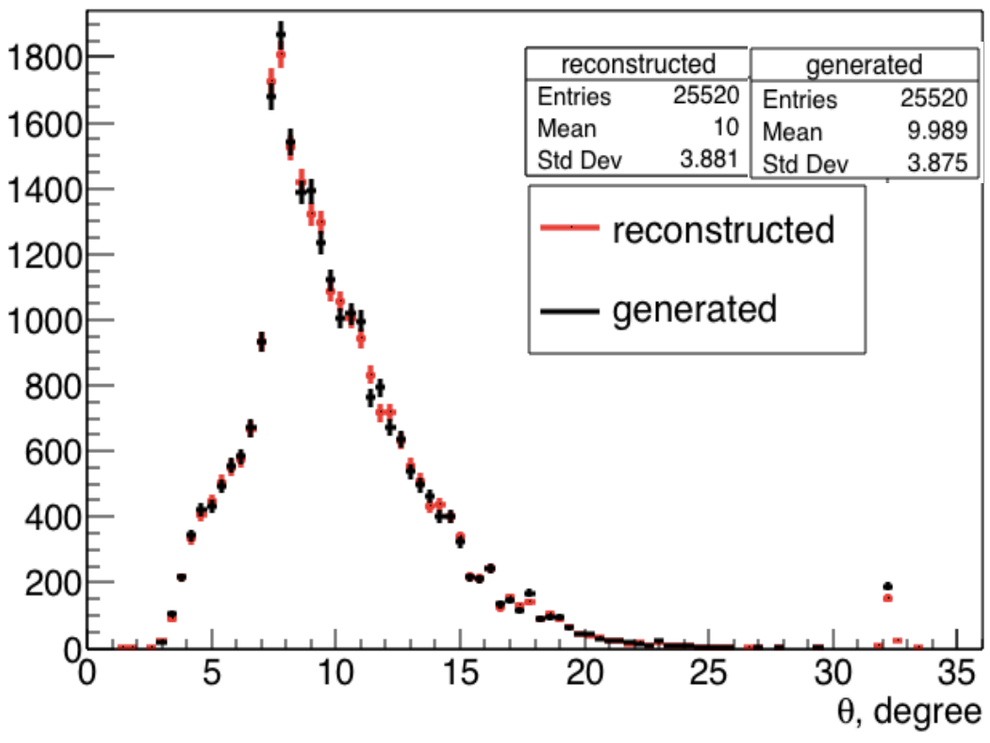
Generated (selected) and reconstructed events

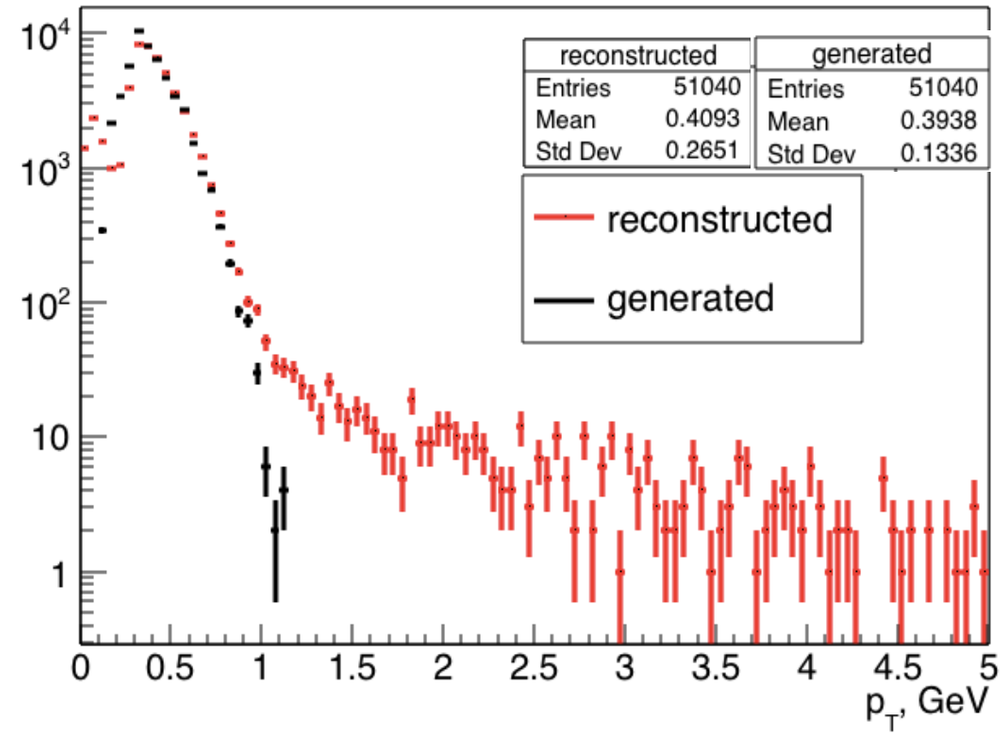
$\sqrt{s} = 10\ GeV$





$\sqrt{s} = 5\ GeV$

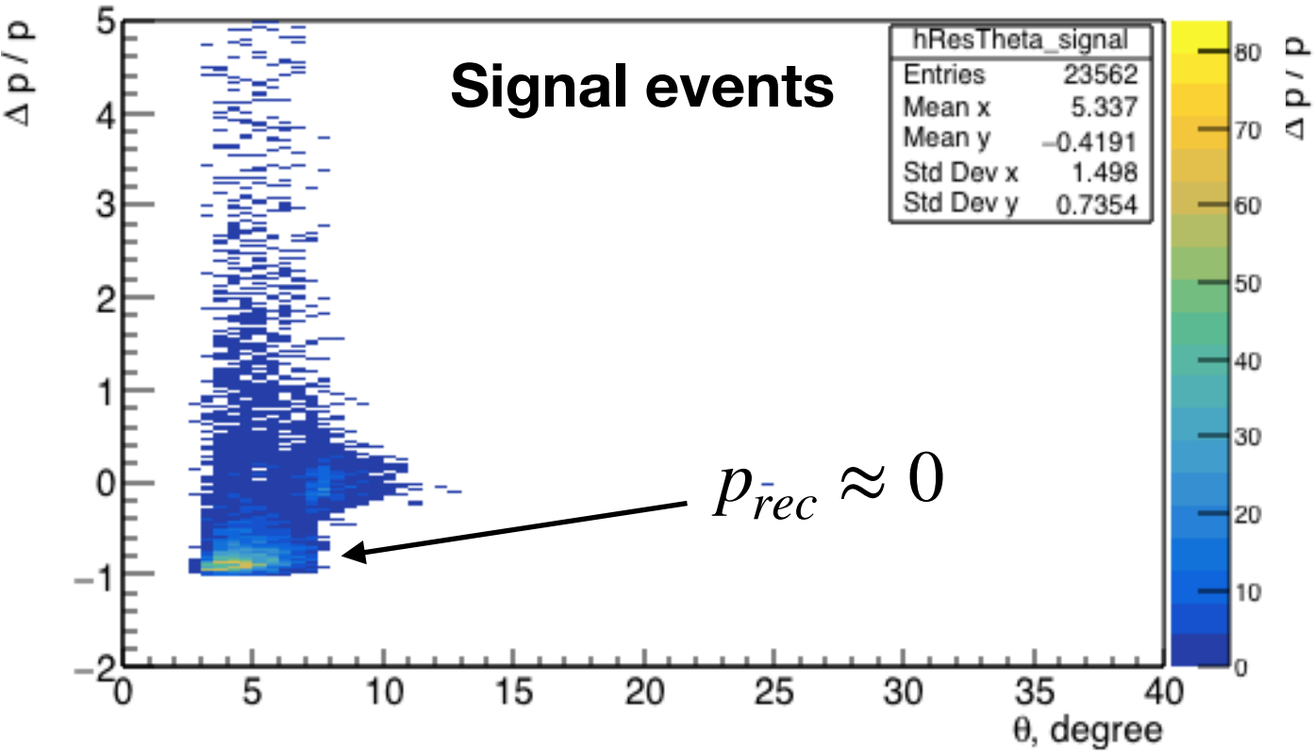




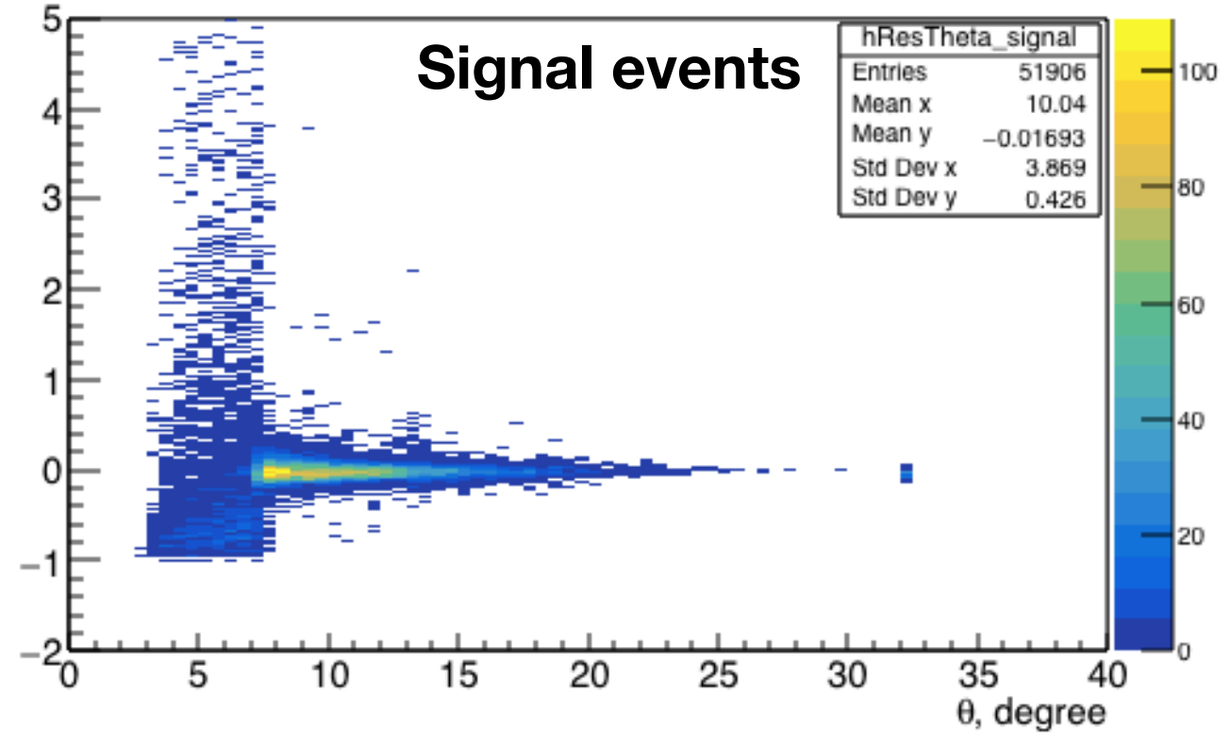
Momentum resolutions

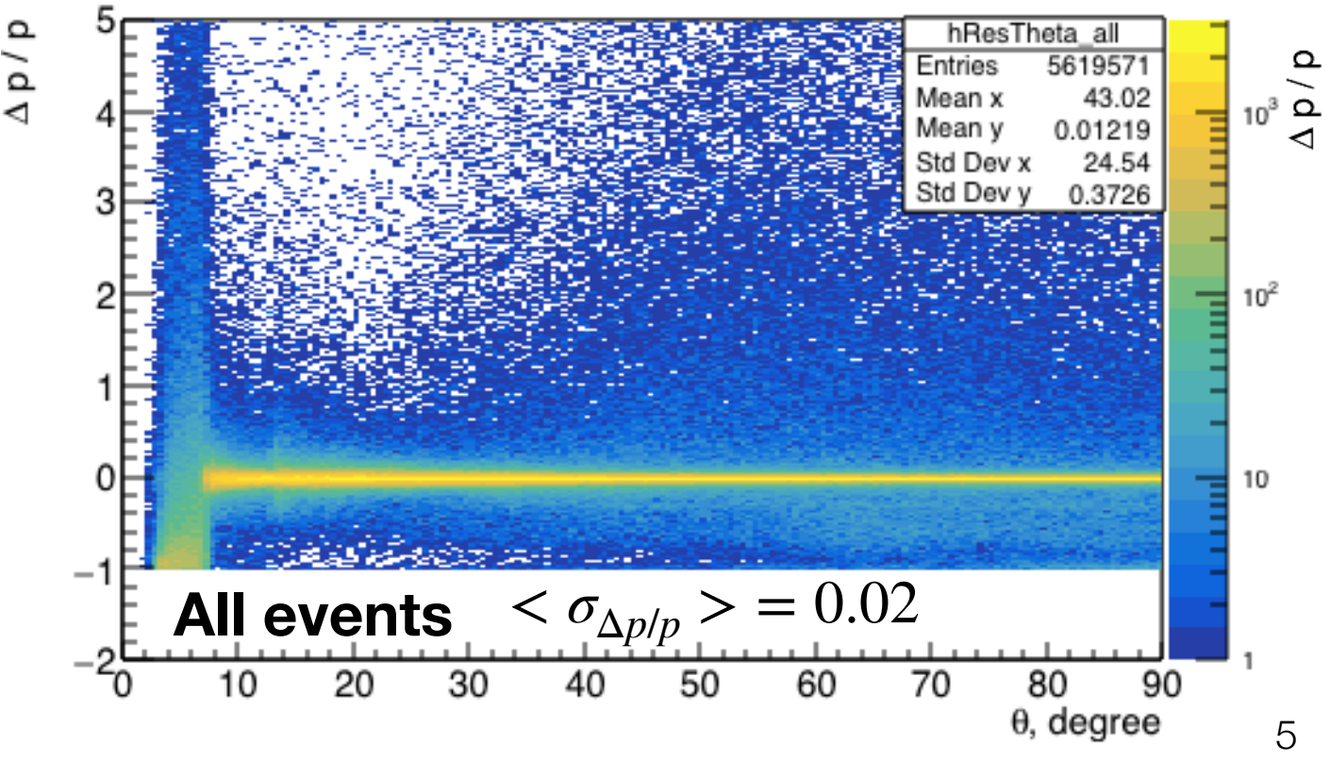
Plots are shown only for signal events, $\Delta p/p = \dfrac{p_{rec} - p_{gen}}{p_{gen}}$

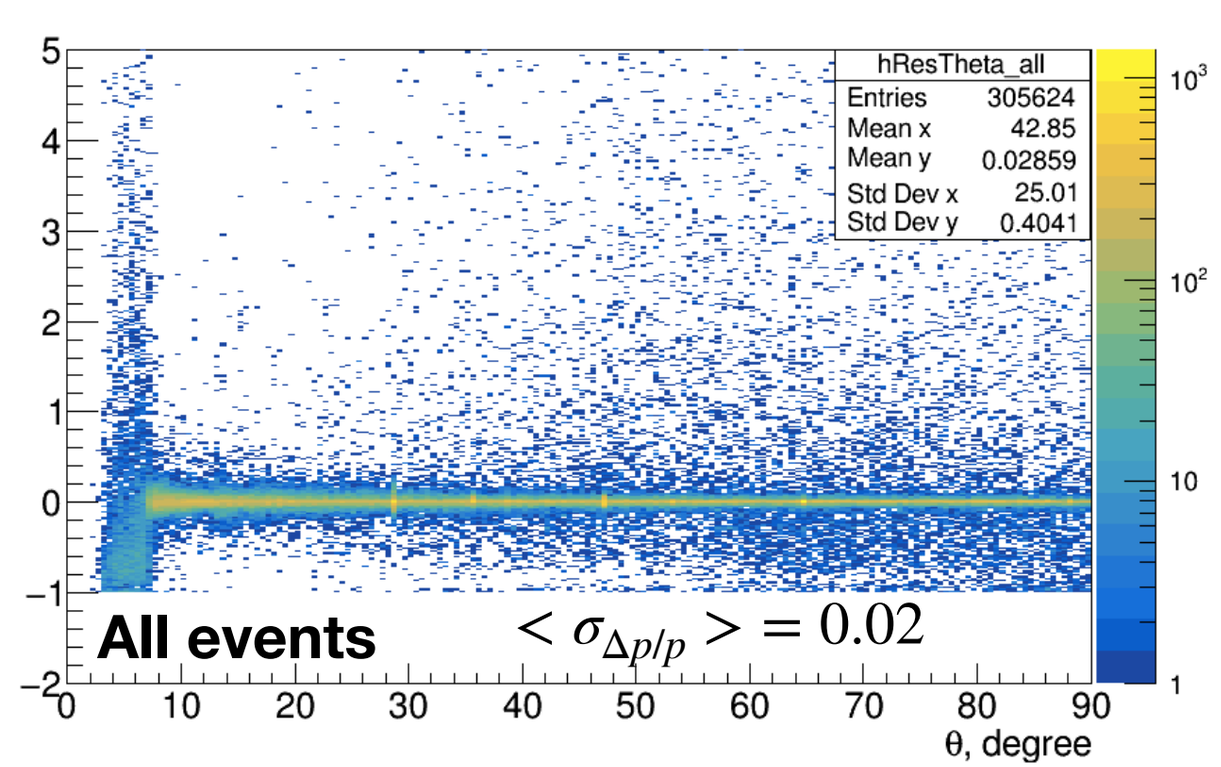
$\sqrt{s} = 10\ GeV$



$\sqrt{s} = 5\ GeV$

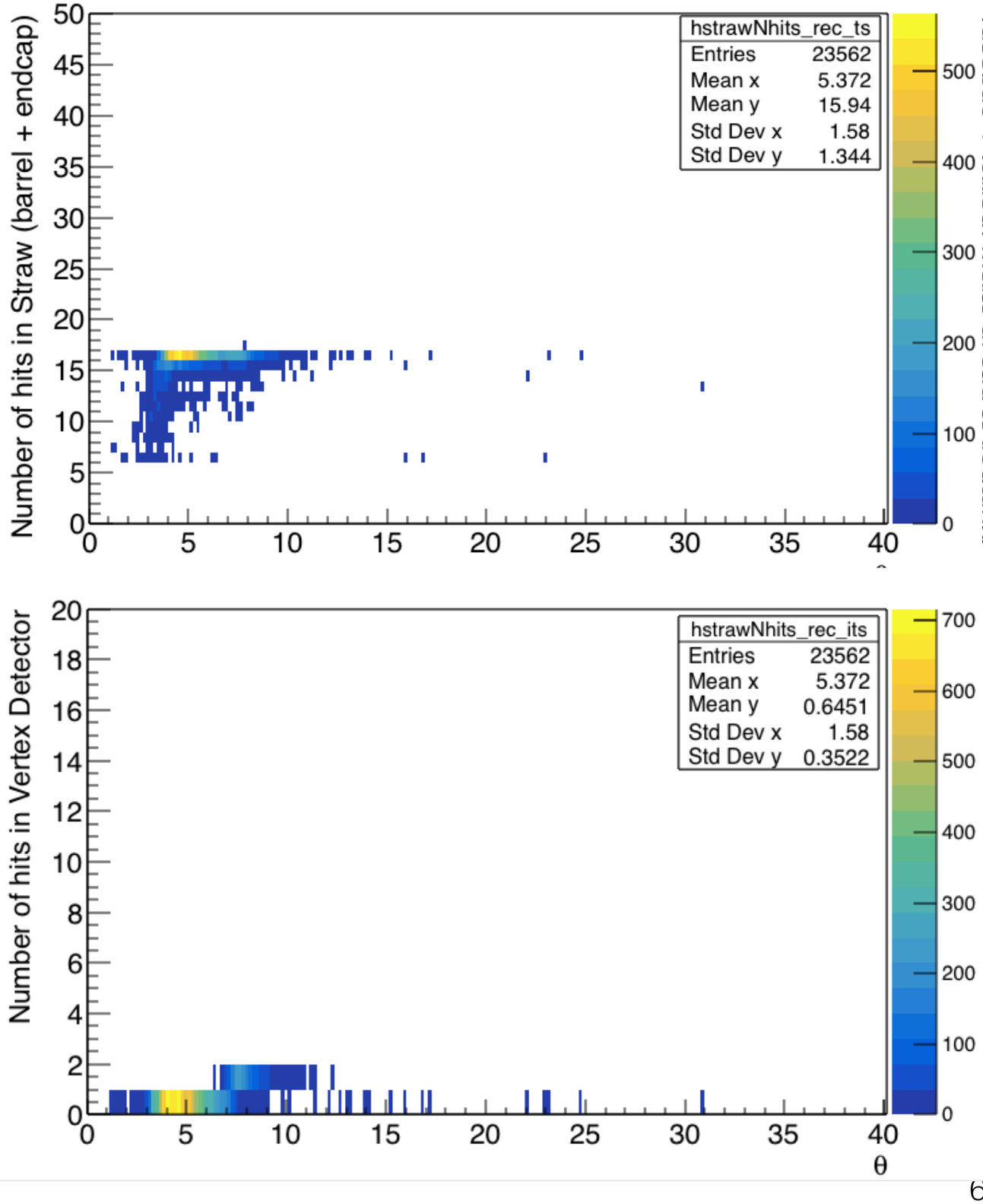




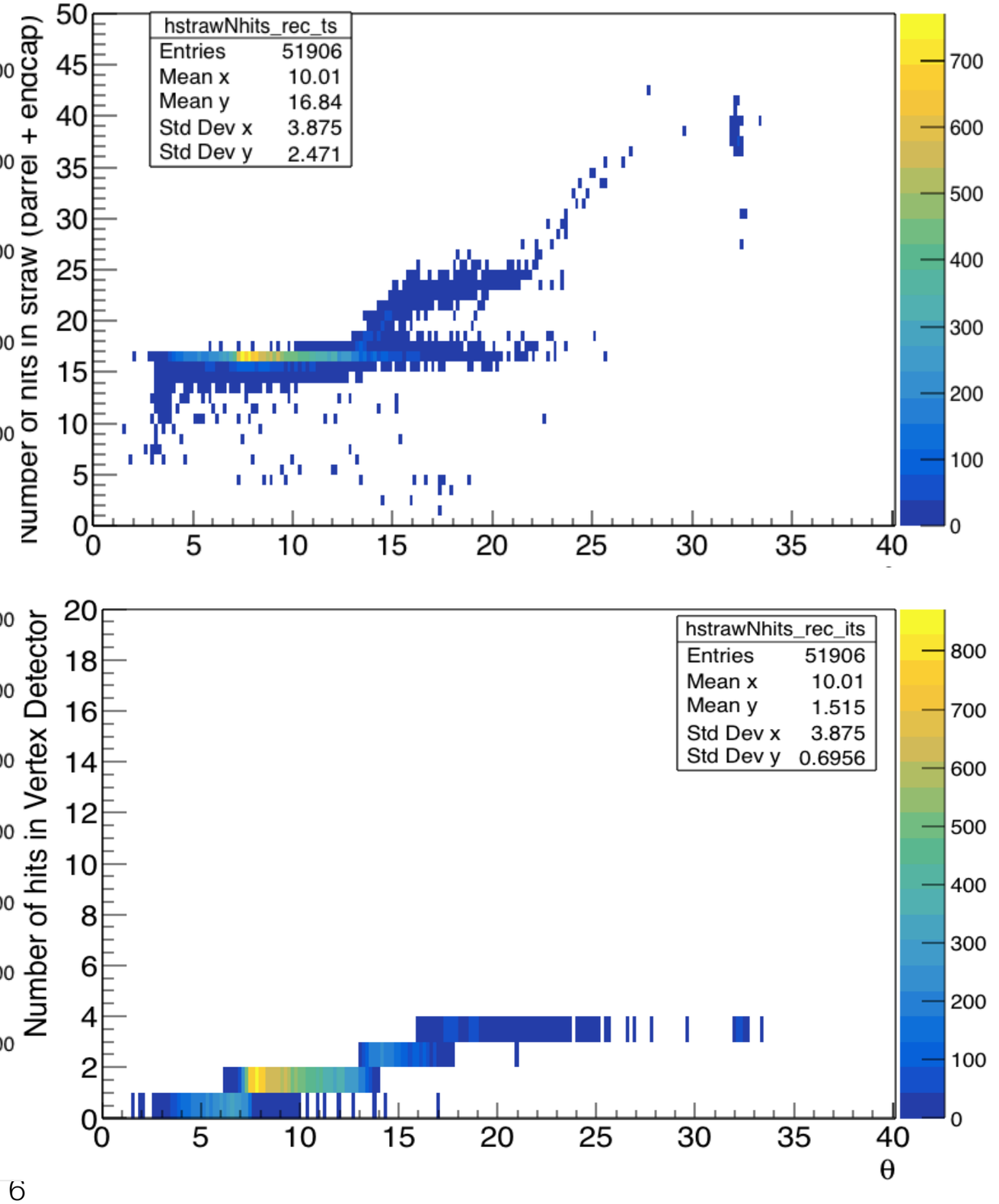


Number of hits in Straw and TS

Signal events, Pythia8, $\sqrt{s} = 10\ GeV$

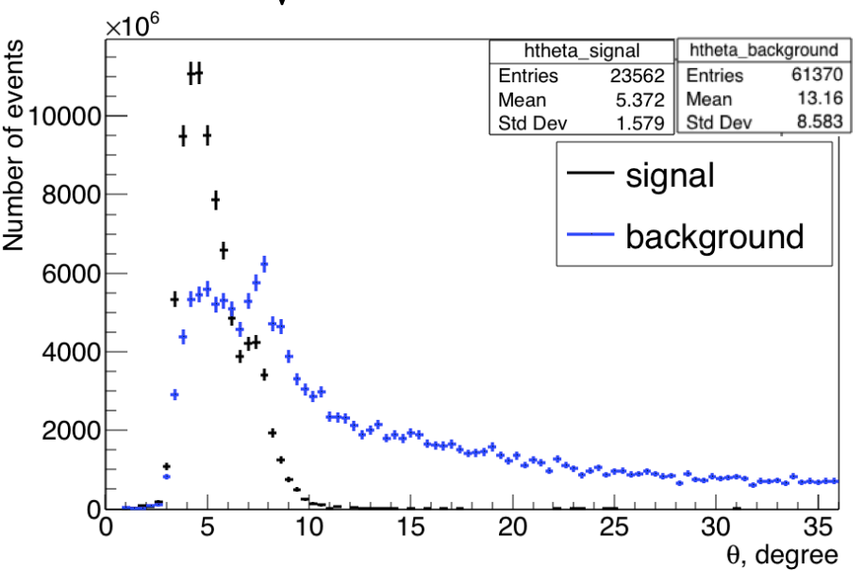


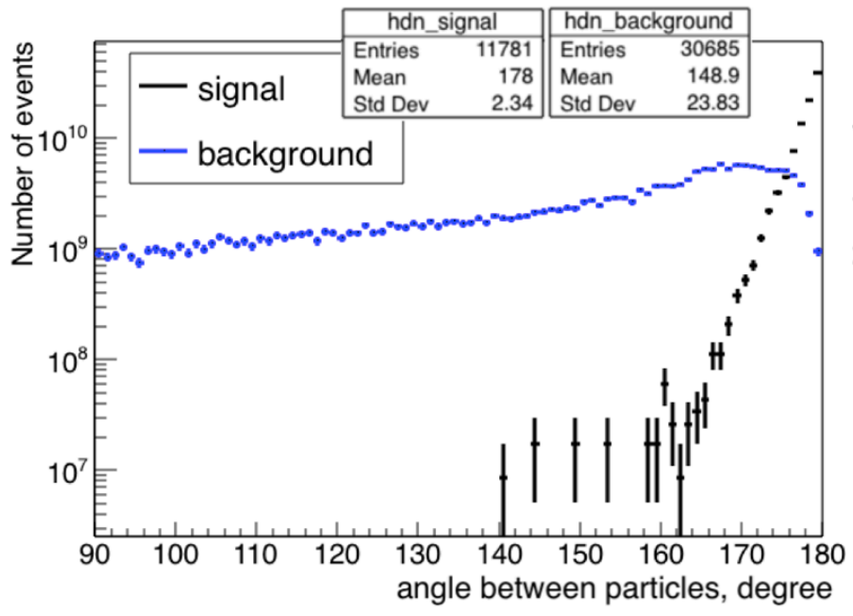
Signal events, FTF, $\sqrt{s} = 5\ GeV$

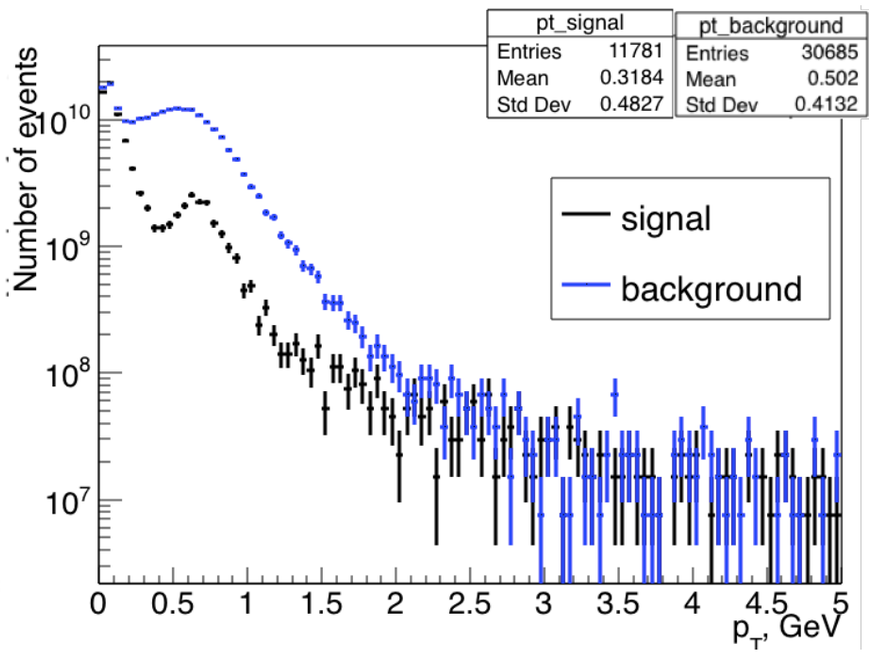


Reconstructed kinematic distributions

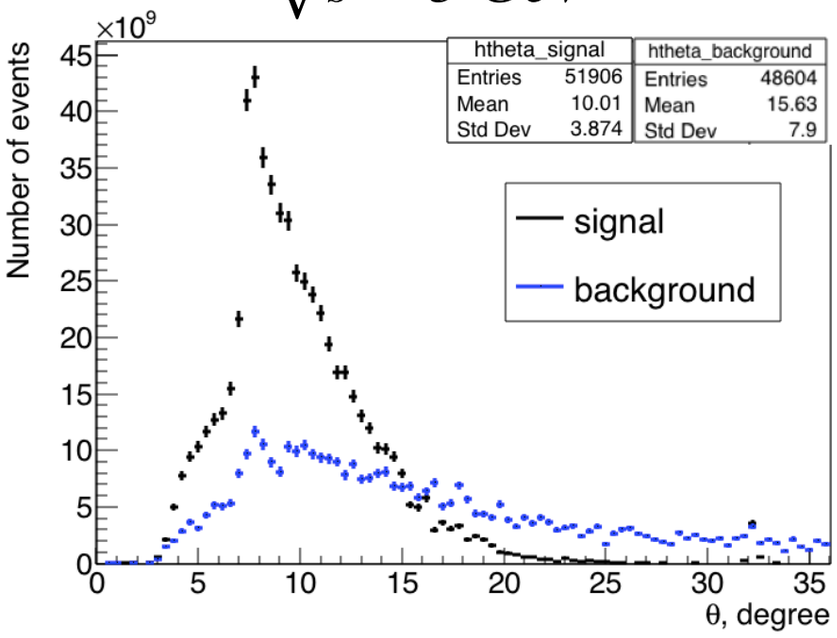
$\sqrt{s} = 10\ GeV$

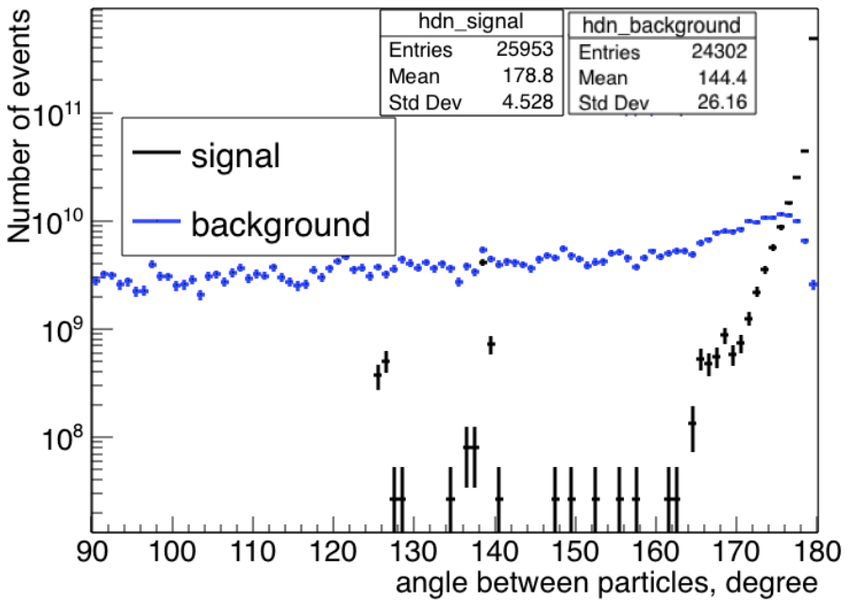


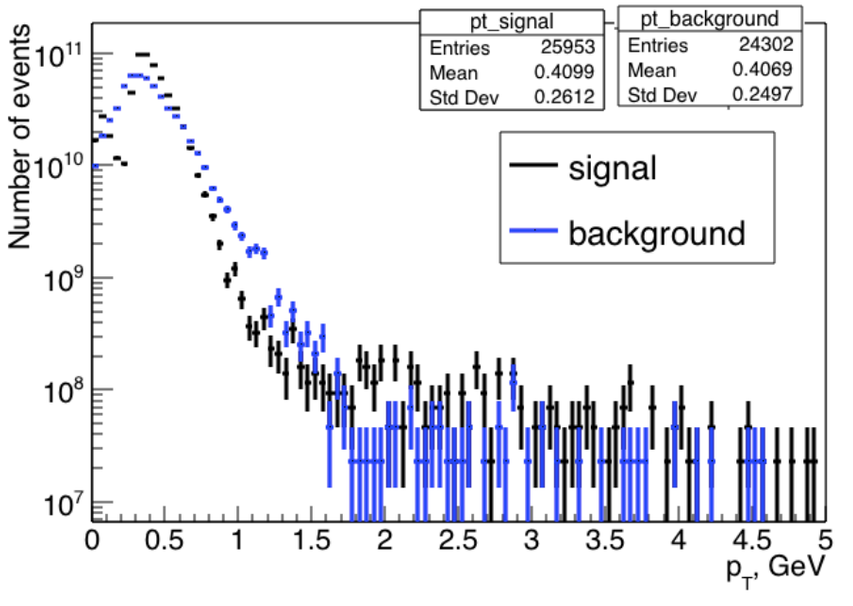




$\sqrt{s} = 5\ GeV$





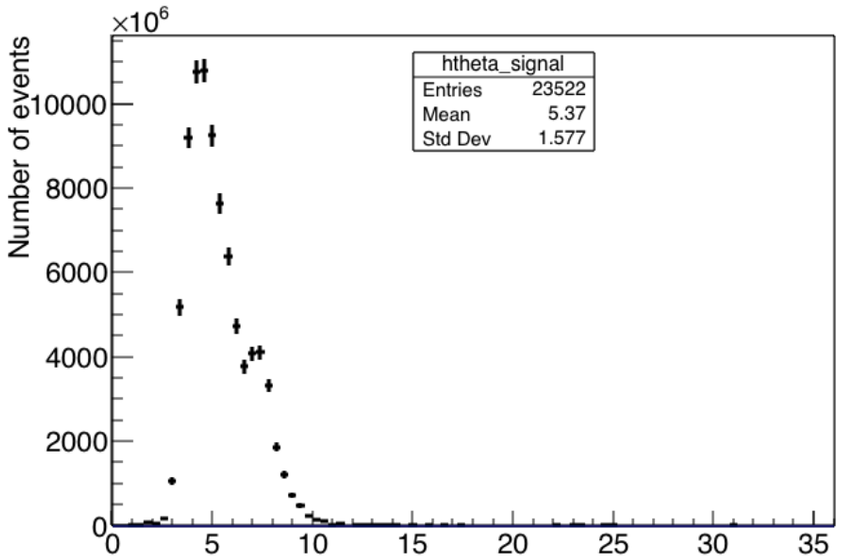


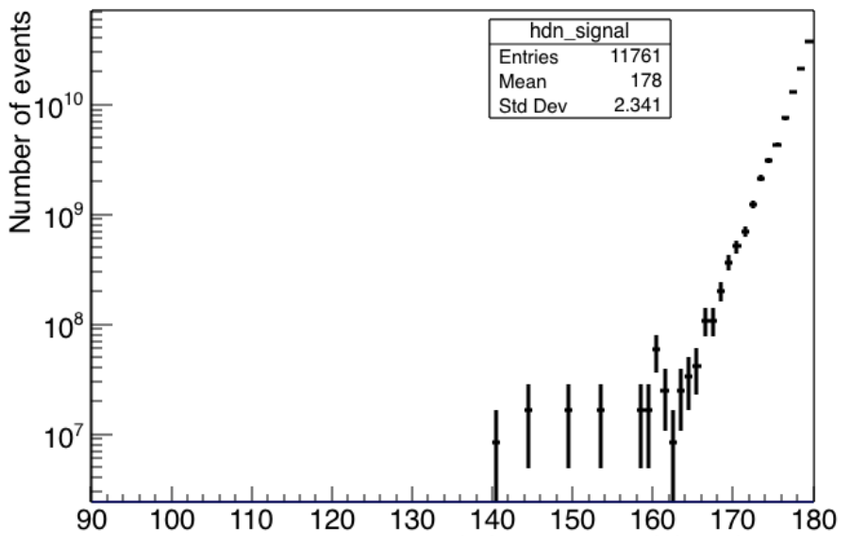
Plots are scaled to the number of registered $pp \to pp$ events during the $0.3 \cdot 10^7\ s$ of data taking.

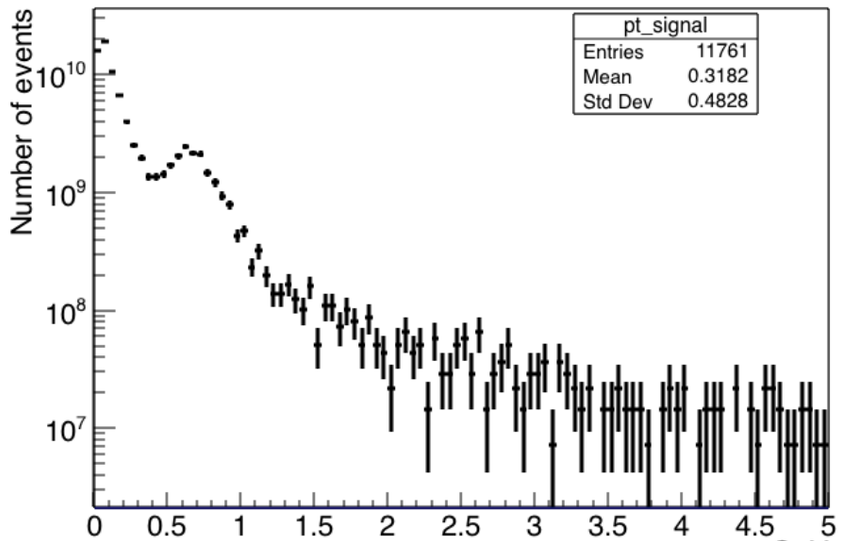
Kinematic distributions

Coplanarity cut: $\vec{a} \cdot (\vec{b} \times \vec{c}) = 0$ **- rejects** $\approx 1\,\%$ **of signal events**

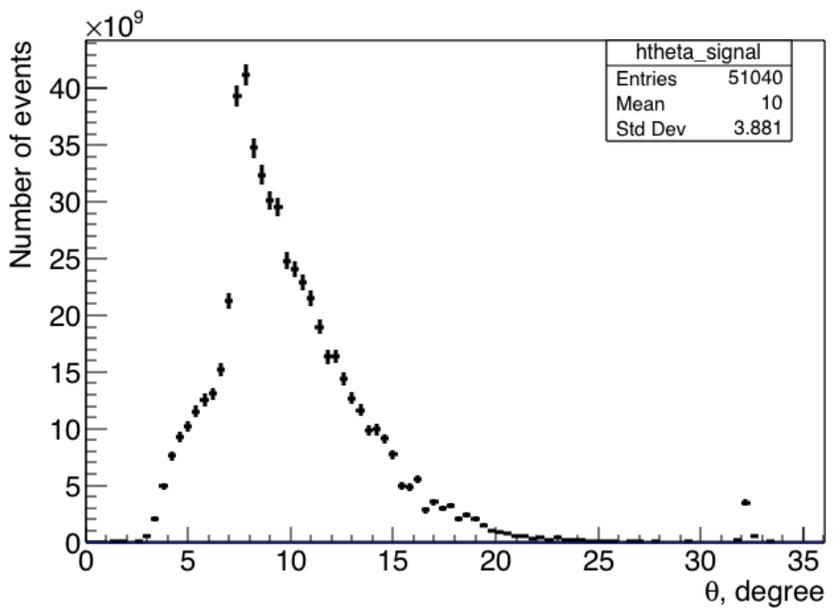
$\sqrt{s} = 10\ GeV$

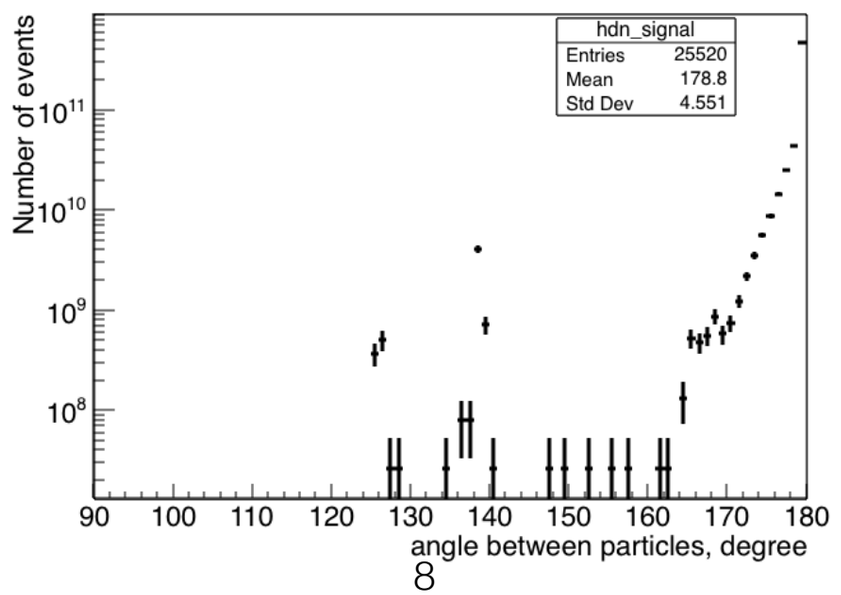


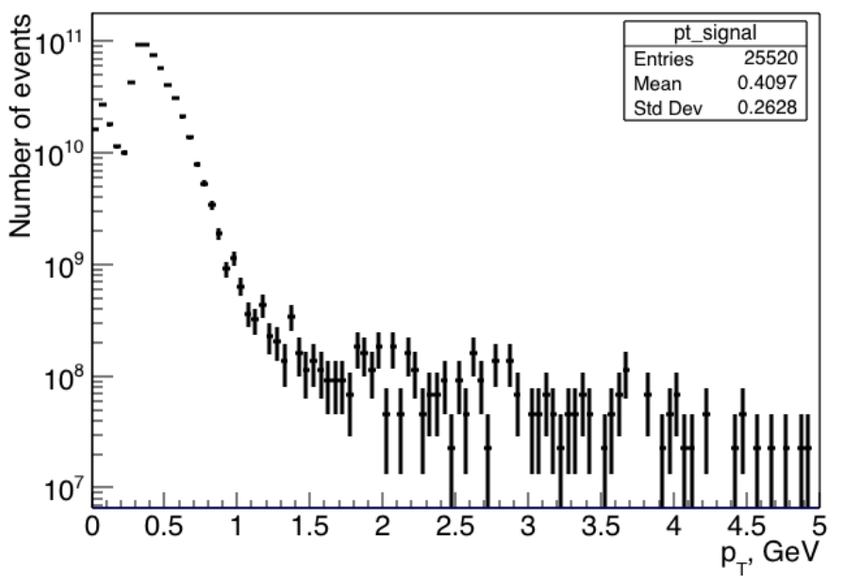




$\sqrt{s} = 5\ GeV$

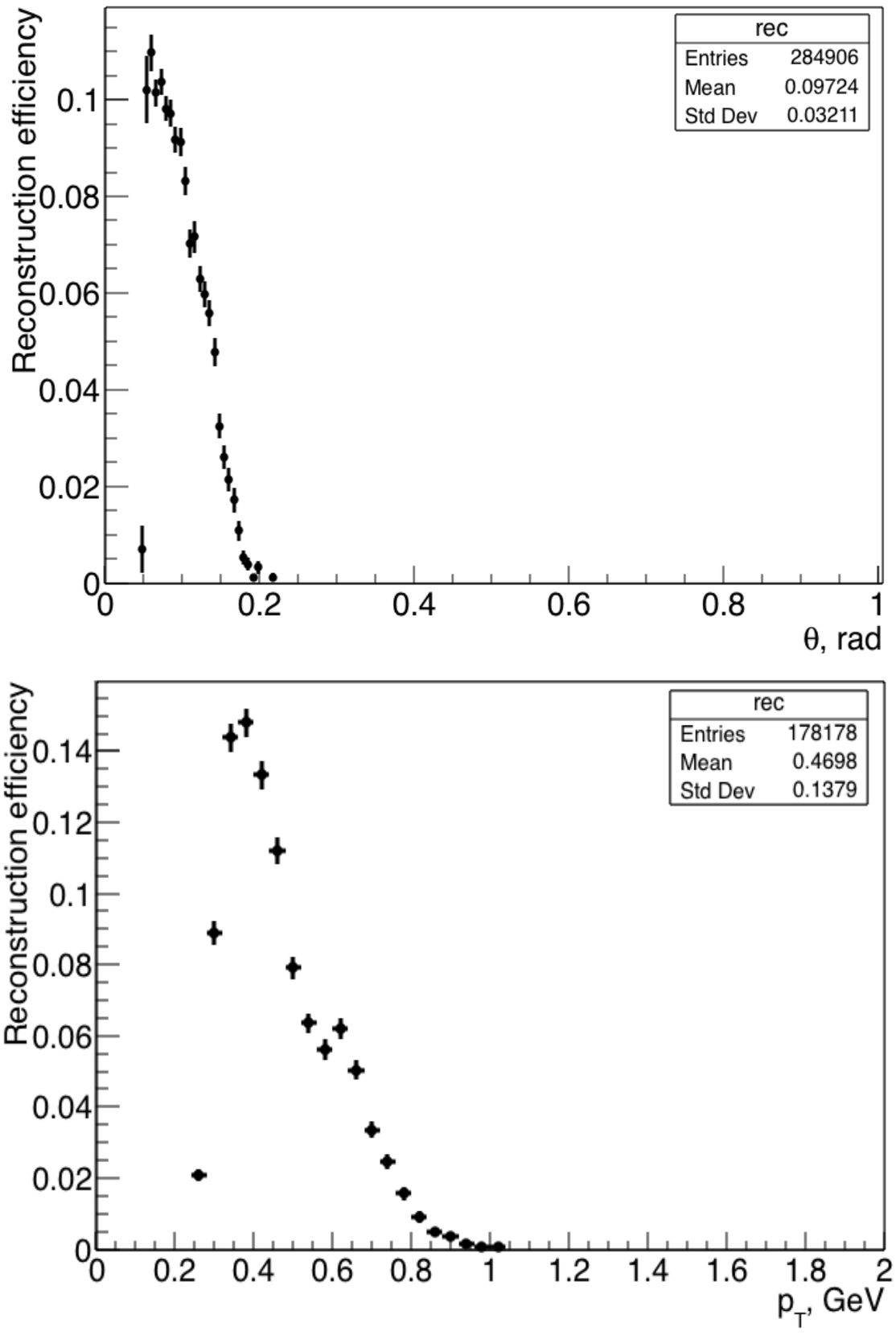




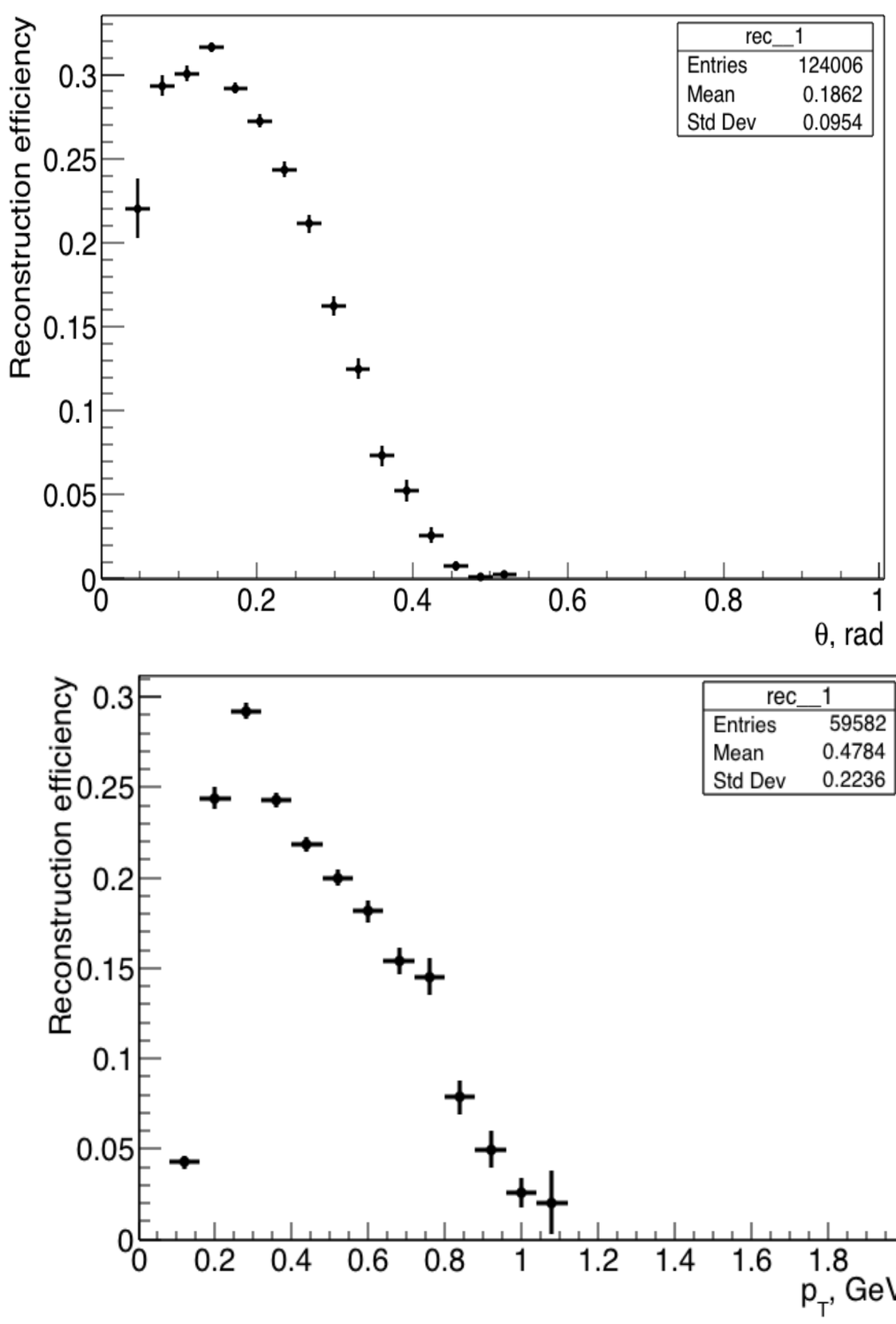


Reconstruction efficiencies

$\sqrt{s} = 10\ GeV$

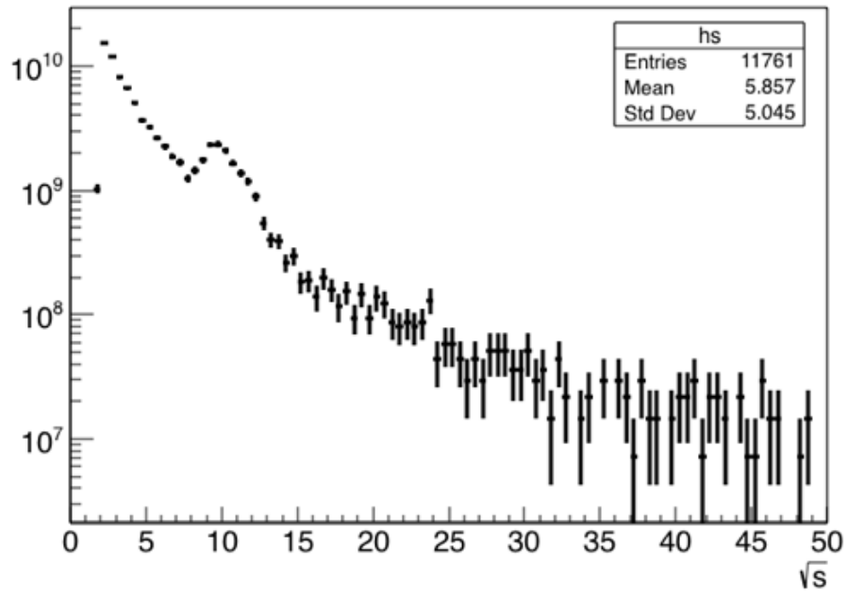


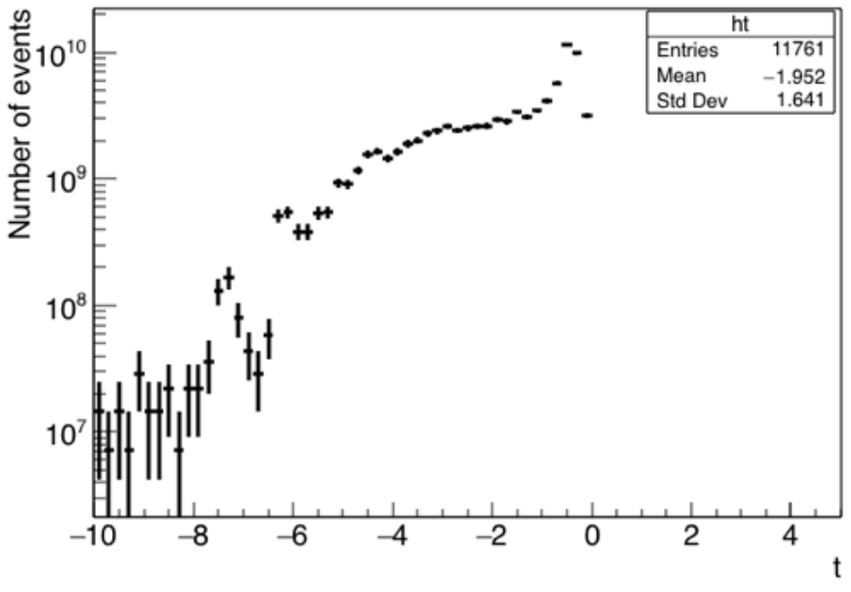
$\sqrt{s} = 5\ GeV$

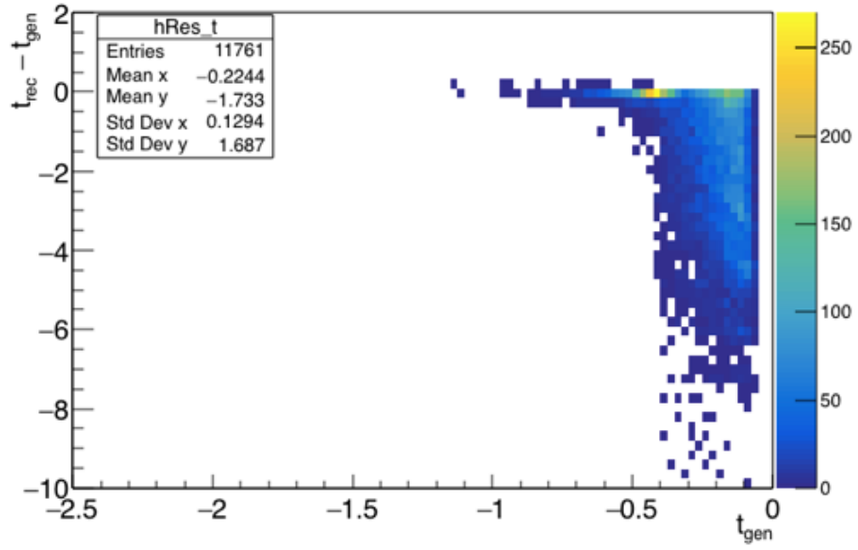


Mandelstam variables

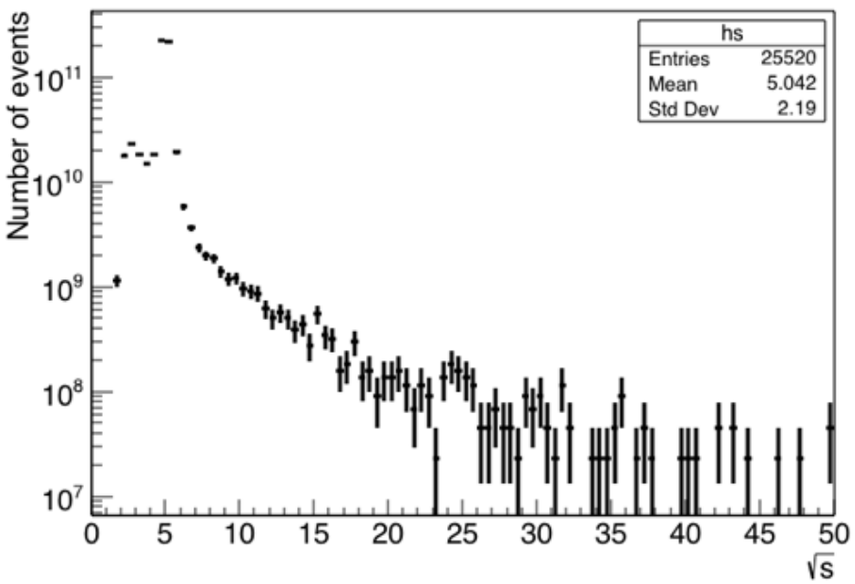
$\sqrt{s} = 10\ GeV$

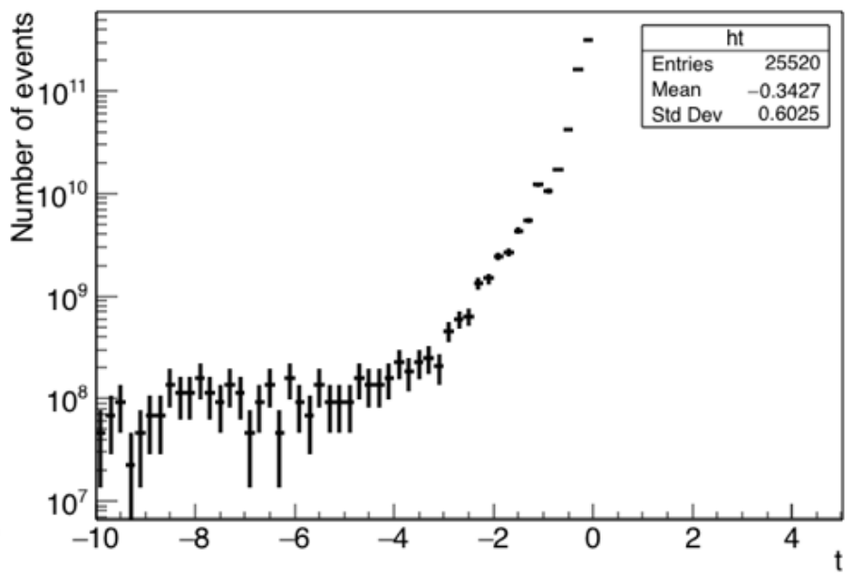


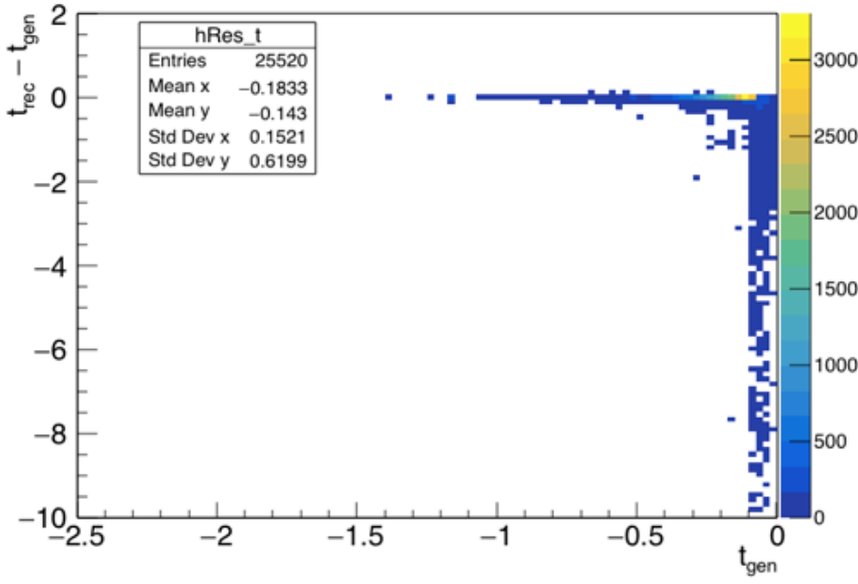




$\sqrt{s} = 5\ GeV$







Summary

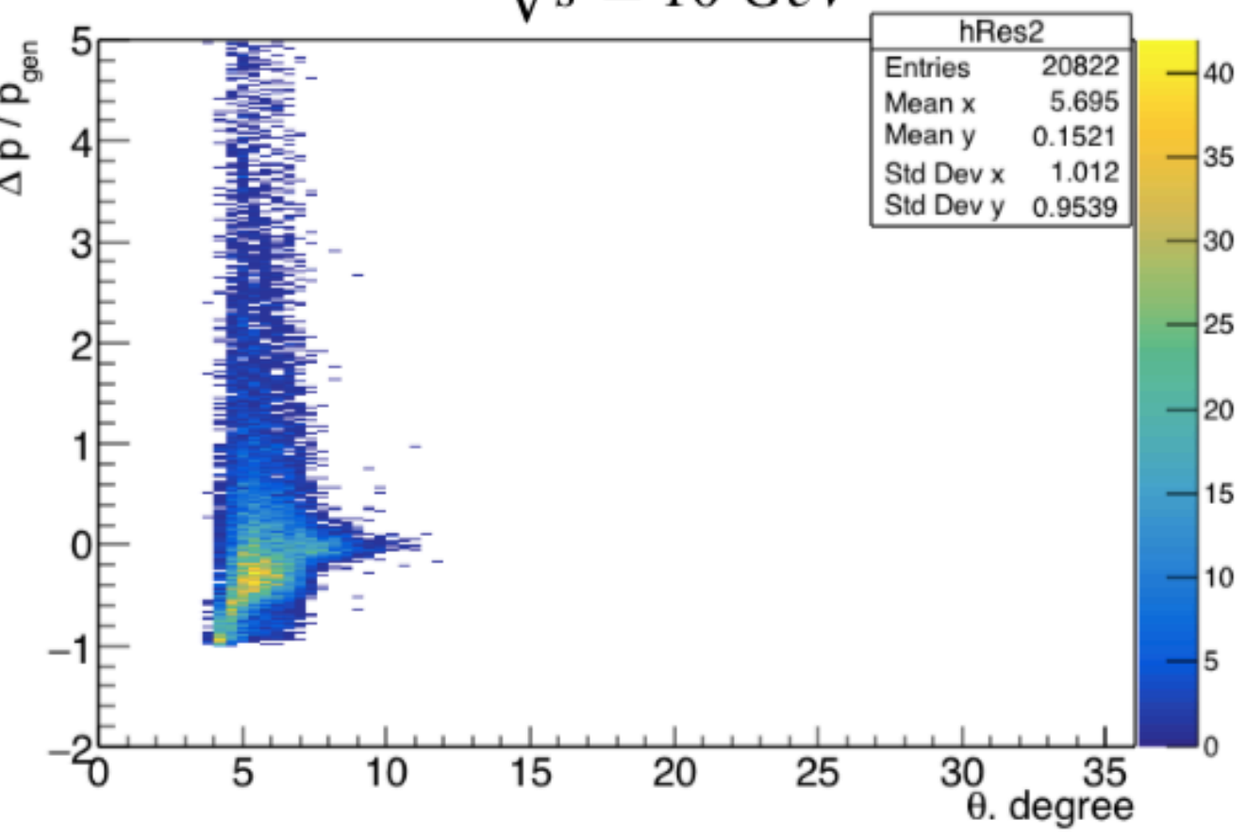
- There is poor momentum resolution for elastic events at $\sqrt{s} = 10\ GeV$. Most of events do not produce a hit in the Vertex Detector.

- Coplanarity (mixed product) cut effectively rejects background events;

backup:Momentum resolutions with previous geometry (more straw tubes)

Plots are shown only for signal events, $\Delta p/p = \dfrac{p_{rec} - p_{gen}}{p_{gen}}$

$\sqrt{s} = 10\ GeV$



$\sqrt{s} = 5\ GeV$