Study of the MPD-TPC detector performance in pp collisions

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Detector Advisory Committee, January 2018.

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Outline

- Introduction
- Efficiency of event reconstruction in MPD-TPC
- Multiplicity distribution (model comparison)
- Primary vertex position
- p_T resolution
- Tracking efficiency
- Reconstructed p_T
- Lambda baryon reconstruction

Introduction

pp collisions

Event generation
(HSD model)

MC transport
(*G3 - MpdRoot*)

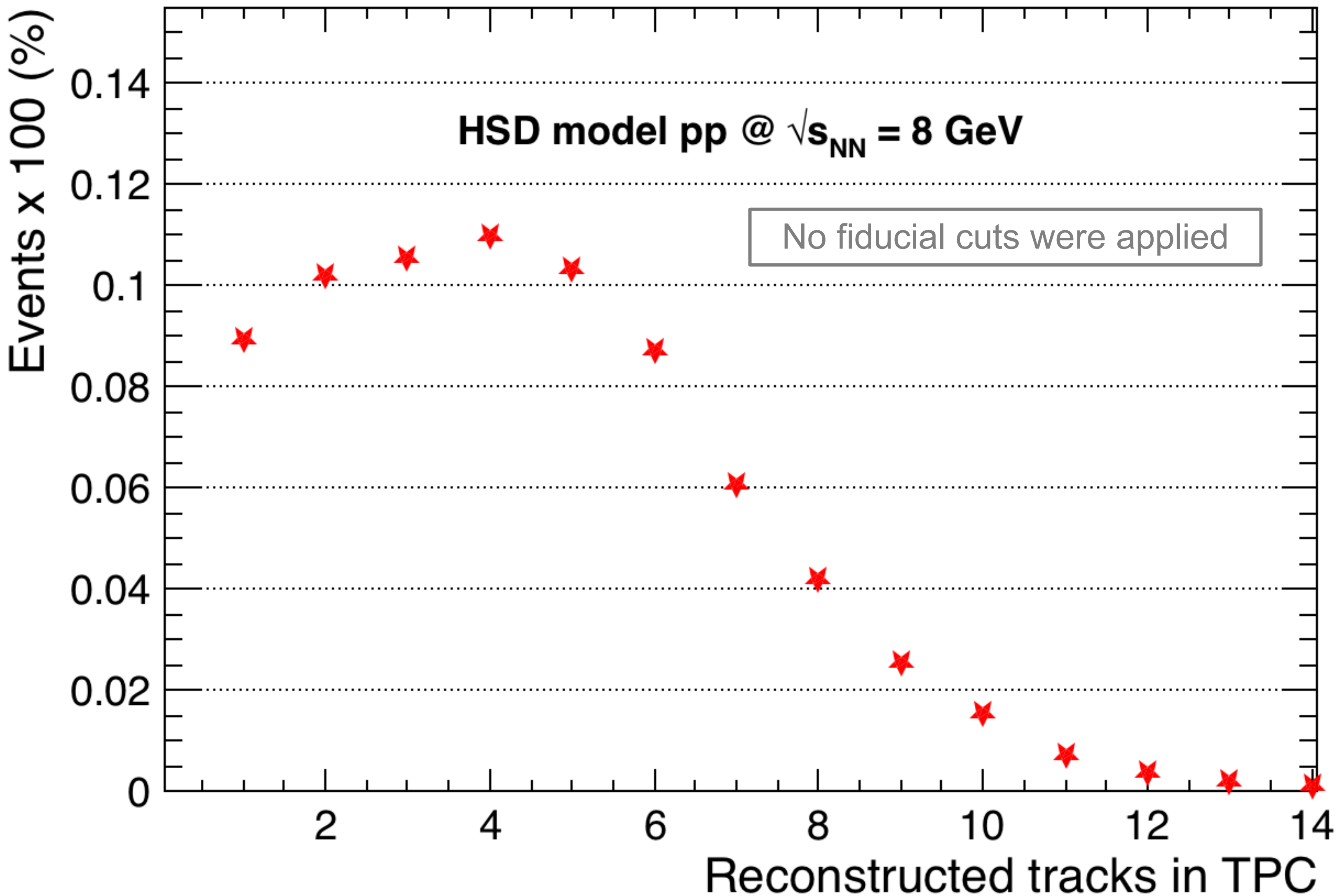
Reconstruction
(*MpdRoot: CF - KF*)

PHSD model (in **HSD** mode) was used to generate events
HSD mode => without partonic QGP phase.
High energy inelastic hadron – hadron collision in HSD is described by FRITIOF string model (including PYTHIA). The description of *p+p* reactions is almost equivalent to the Lund String model.

- 100000 events
- Point-like interaction
- Primary* and secondary tracks
- Analyzed TPC Kalman tracks and TOF matched tracks
- The reconstructed tracks are associated with the primary MC particle that 'caused' the reconstructed track
- Number of Hits > 20

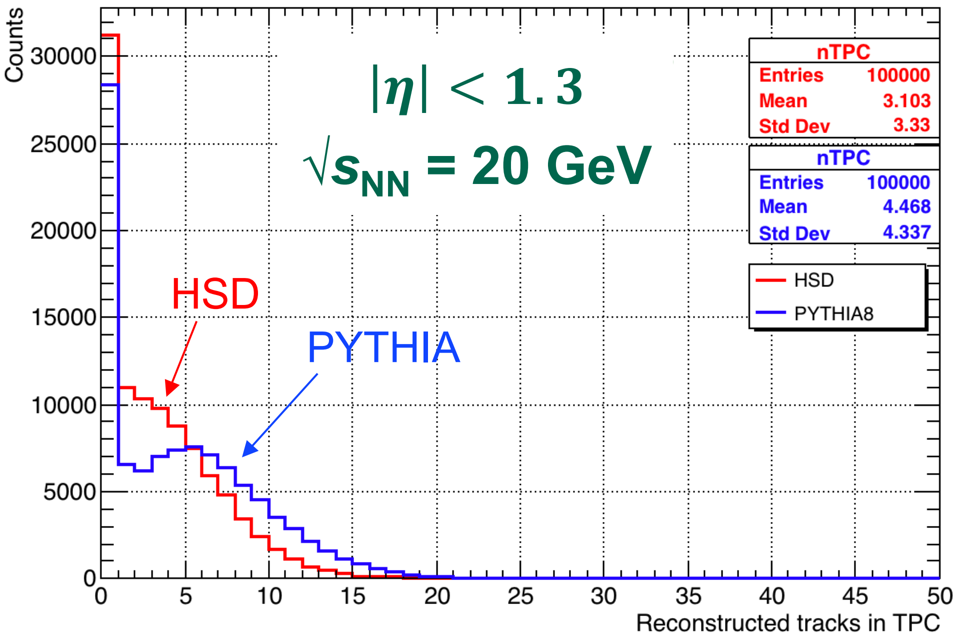
* **Primary particles** are defined as prompt particles produced in the collision including products of strong and electromagnetic decays, as well as weak decay of charmed and beauty particles except feed-down products from strange and other secondary particles.

The events with reconstructed tracks in TPC $\neq 0$ represent **75%** of the total amount of analysed events.

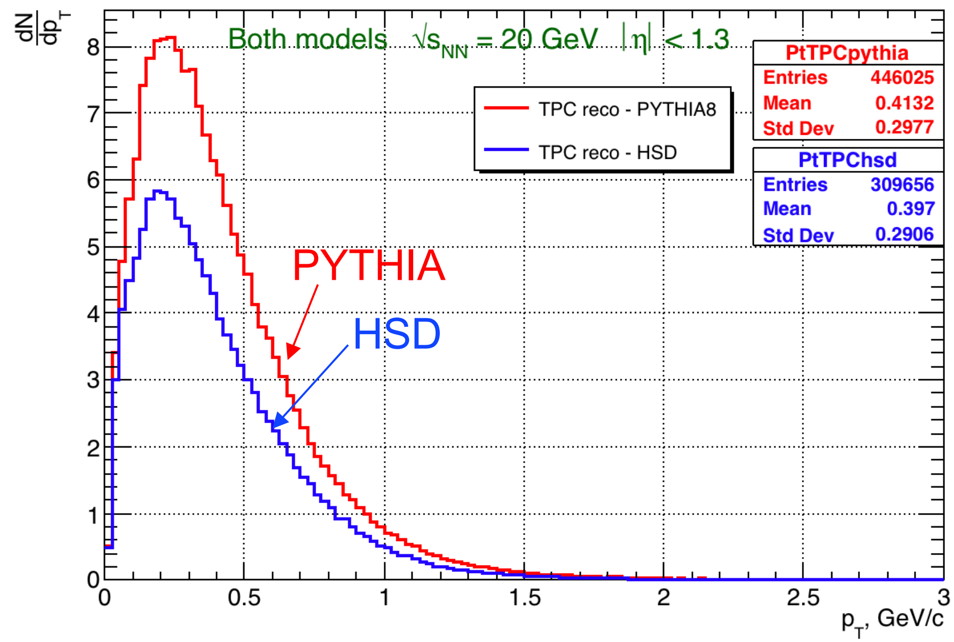


Multiplicity at $|\eta| < 1.3$

Reconstructed track distribution in TPC with HSD and PHYTHIA8 @ 20 GeV.



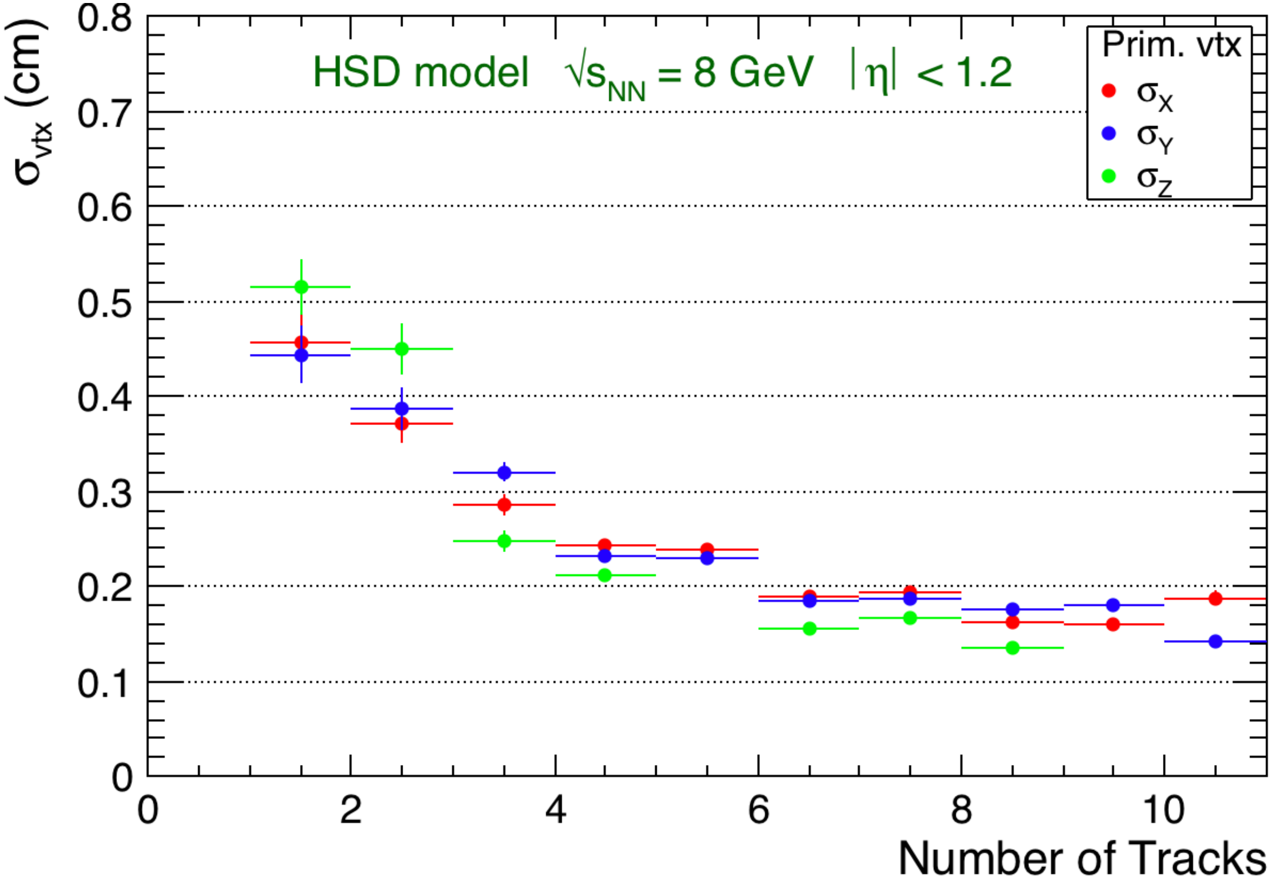
p_T **density distribution** @ 20 GeV with HSD and PHYTHIA8, normalized by number of events.



Pythia results obtained by A. Zinchenko

Multiplicity from p_T density distributions at $\|\eta\| < 1.3$	
TPC	
HSD	PYTHIA
3.09	4.46

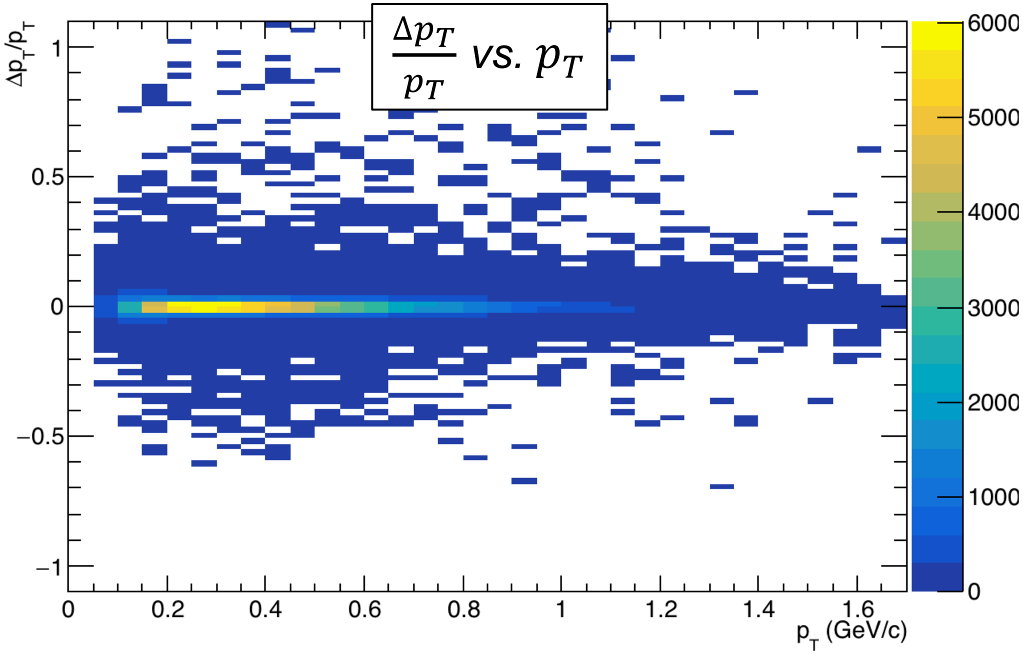
- Pythia predicts higher multiplicity than HSD in TPC for pp @ $\sqrt{s_{NN}}$ = 20 GeV

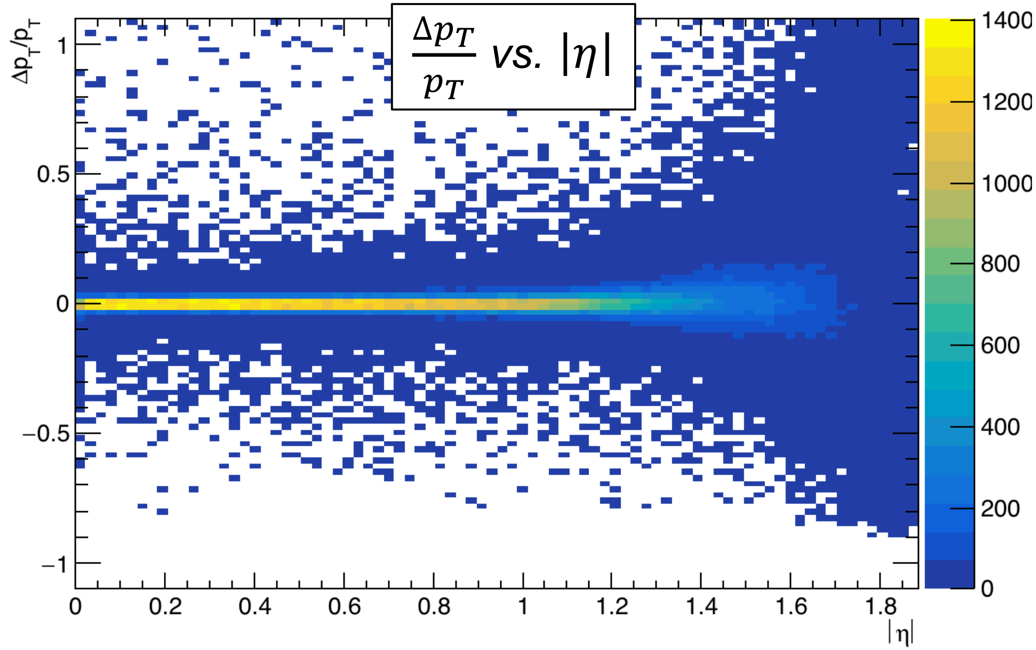


- The accurate position determination of the primary vertex is essential for p_T reconstruction. It depends on the number of tracks and the p_T of those tracks.

- The precision of primary vertex coordinates is better for large track multiplicities ($\sigma_{vtx} < 2mm$ for nTracks > 6).

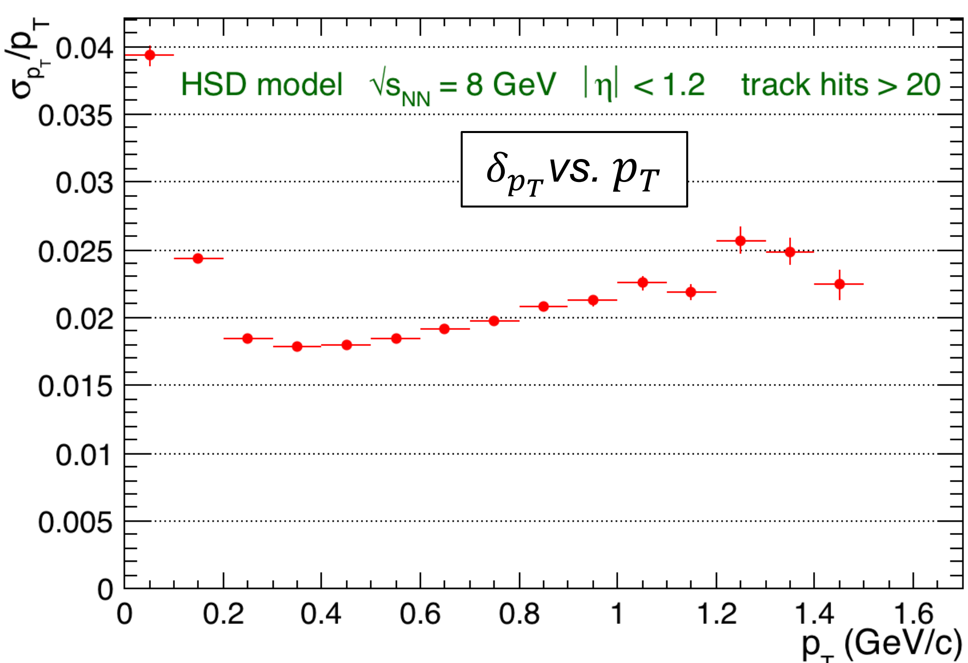
p_T resolution

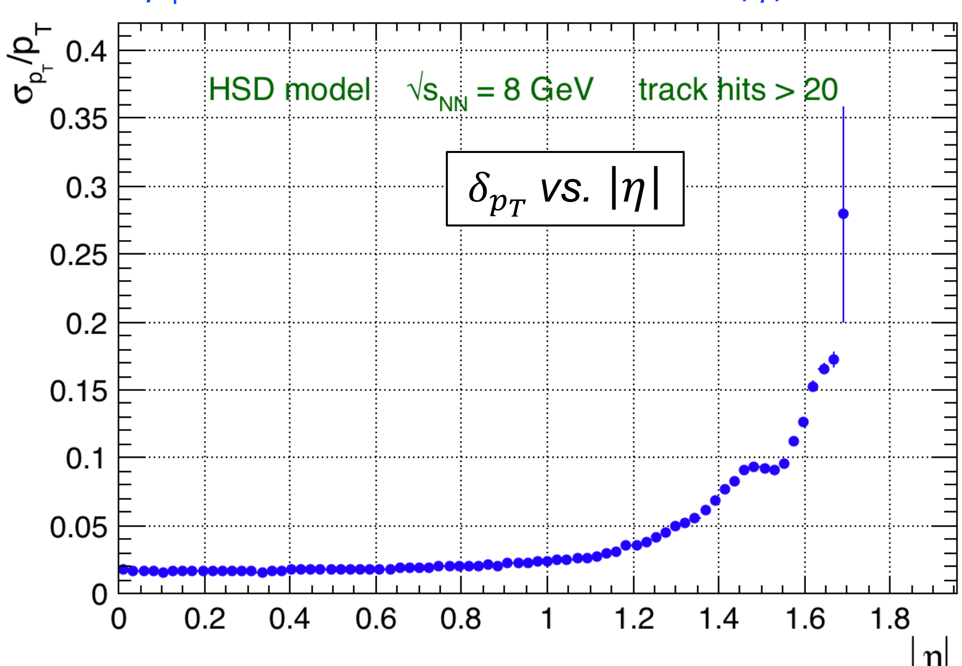




p_T resolution is better than **2.6%** for p_T in range 0.1 ÷ 1.5 GeV/c

p_T resolution is better than **2.6%** for $|\eta| < 1.1$

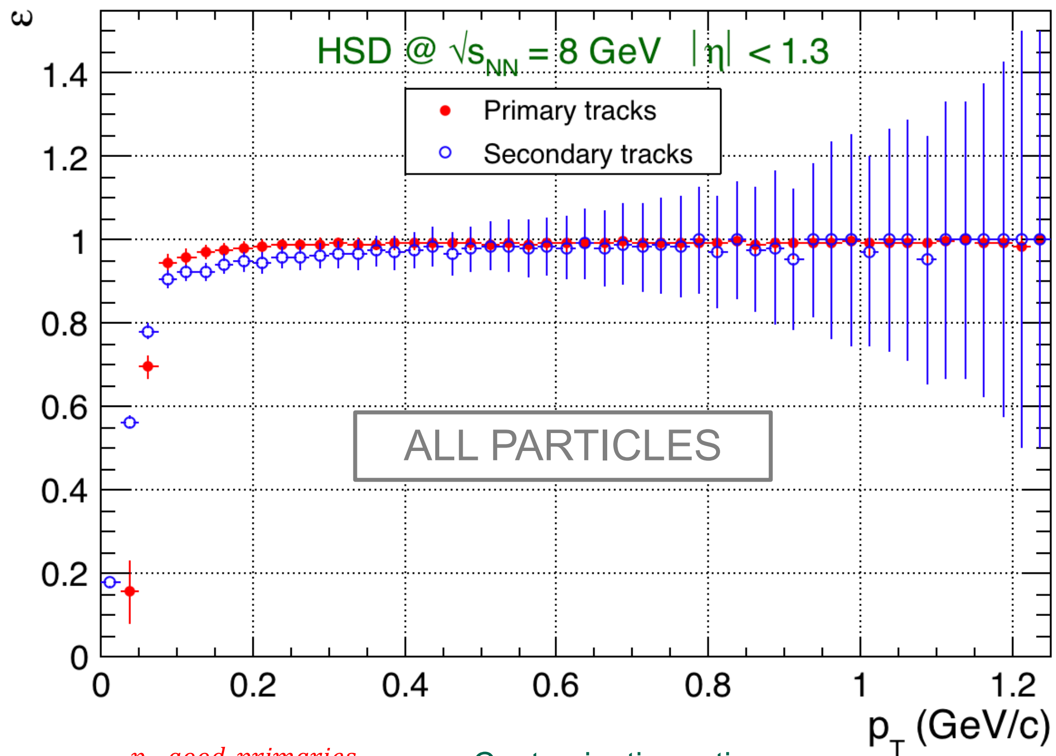


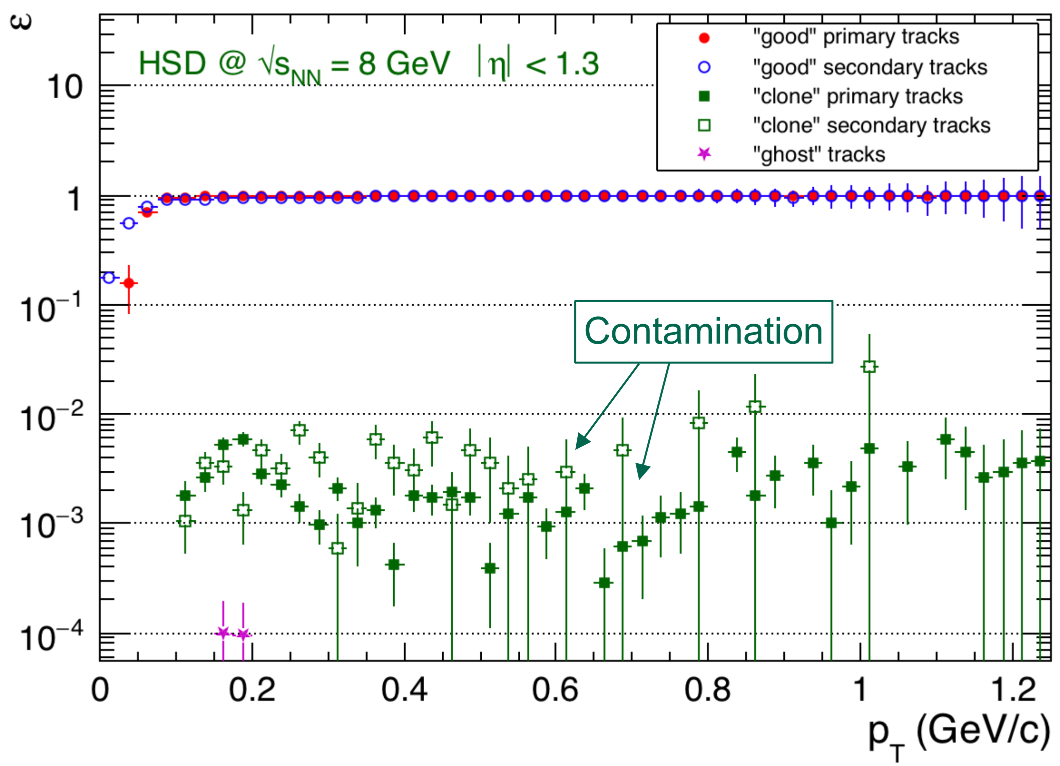


$$\boxed{\frac{\Delta p_T}{p_T} = \frac{p_{T,rec} - p_{T,MC}}{p_{T,MC}}}$$

Tracking efficiency vs. p_T

All particles





$$\varepsilon_{prim} = \frac{p_T\ good\_primaries}{p_T\ all\_primaries}$$

$$\varepsilon_{sec} = \frac{p_T\ good\_secondaries}{p_T\ all\_secondaries}$$

Contamination ratio:

$$\frac{p_T\ clone\_primaries}{p_T\ all\_primaries} \qquad \frac{p_T\ clone\_secondaries}{p_T\ all\_secondaries}$$

$$\frac{p_T\ ghost}{p_T\ all\_secondaries}$$

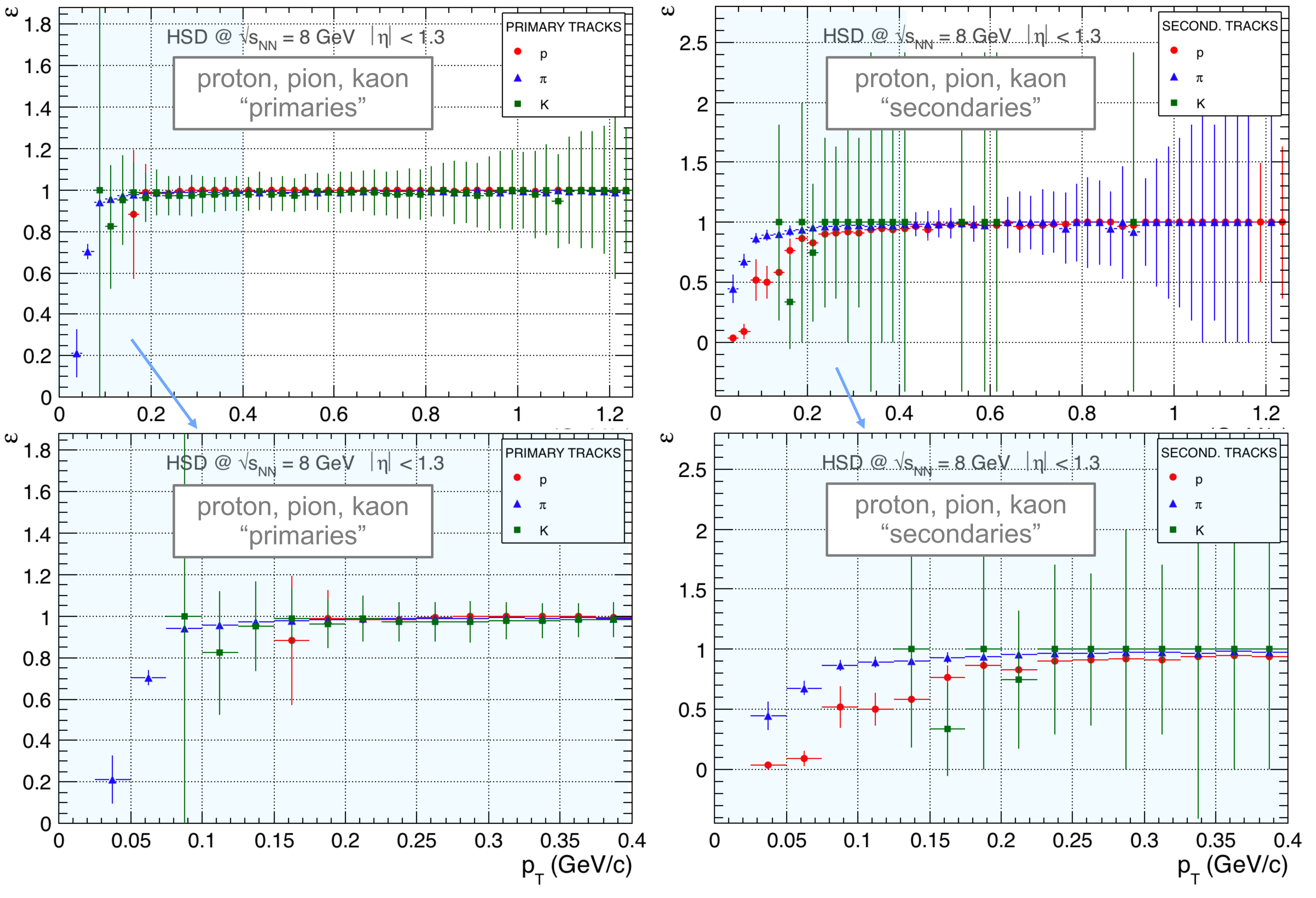
- "Ghost" tracks are negligible in pp collisions.
- There exist contamination of primary and secondary "clone" tracks at p_T > 0.1 GeV/c representing < 1%.

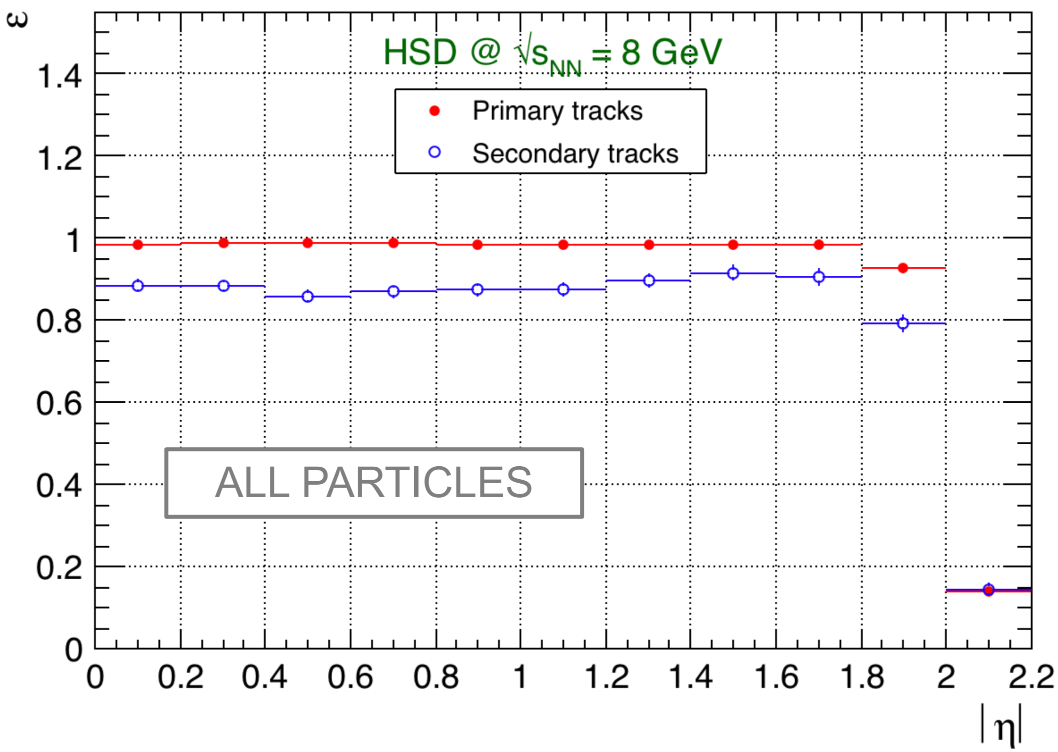
Definitions:

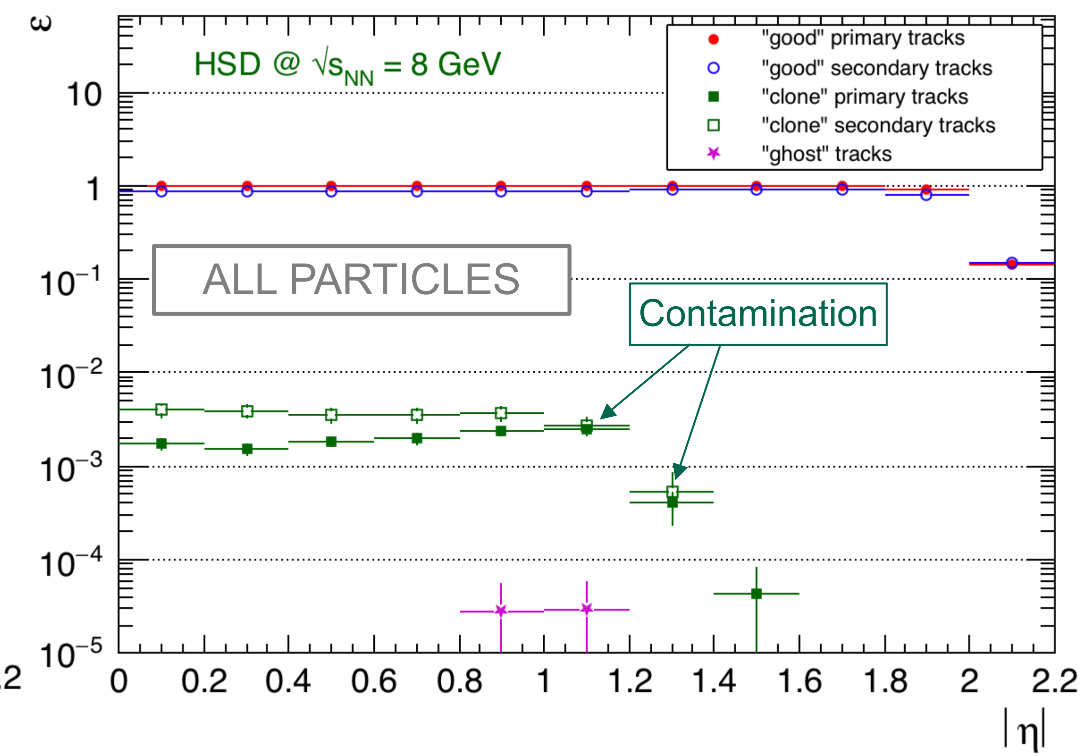
- **Good** tracks: Contain more than 50% hits from the same particle.
- **Clone** tracks: Are as "good" tracks, but consisting of several tracks from the same particle due to either:
  - One track splitting during reconstruction (true clones)
  - Several branches of low p_T tracks spiraling in TPC
- **Ghost** tracks: Contain less than 50% hits from the same particle.

Tracking efficiency vs. p_T

protons, pions, kaons







$$\varepsilon_{prim} = \frac{p_T\ good\_primaries}{p_T\ all\_primaries}$$

$$\varepsilon_{sec} = \frac{p_T\ good\_secondaries}{p_T\ all\_secondaries}$$

Contamination ratio:

$$\frac{p_T\ clone\_primaries}{p_T\ all\_primaries} \qquad \frac{p_T\ clone\_secondaries}{p_T\ all\_secondaries}$$

$$\frac{p_T\ ghost}{p_T\ all\_secondaries}$$

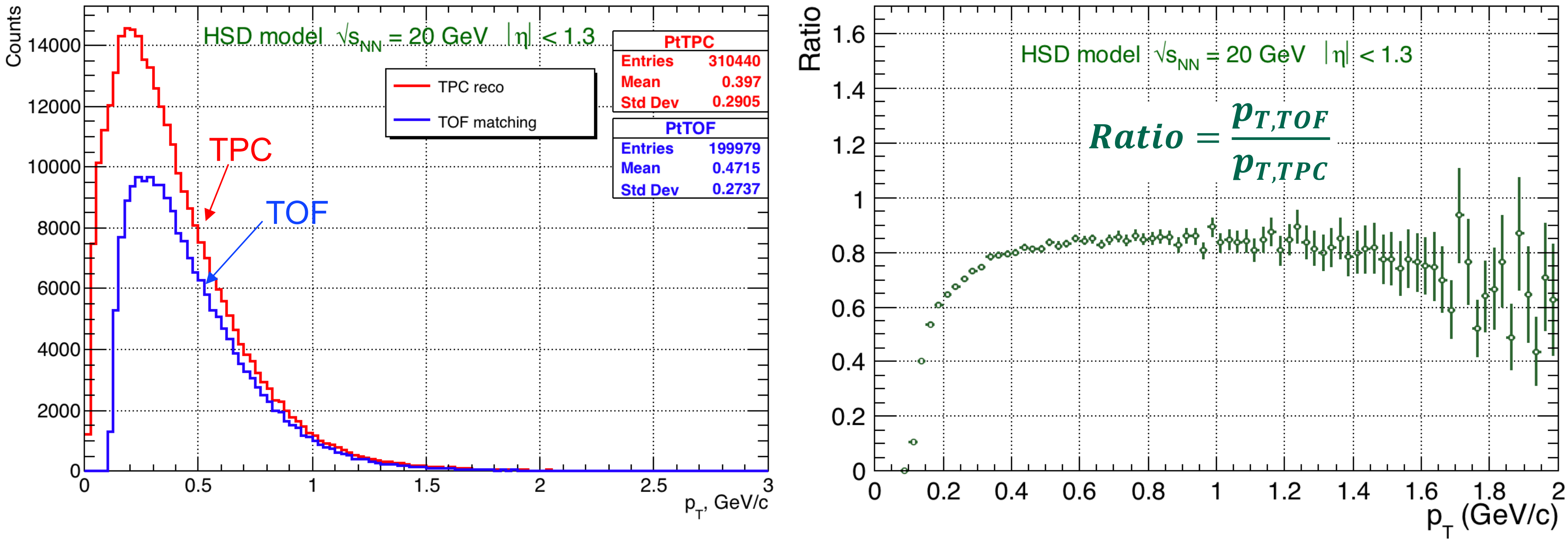
- The contamination due to primary and secondary “clone” tracks represents < 1% at $|\eta|$< 1.2

Definitions:

- **Good** tracks: Contain more than 50% hits from the same particle.
- **Clone** tracks: Are as “good” tracks, but consisting of several tracks from the same particle due to either:
  - One track splitting during reconstruction (true clones)
  - Several branches of low p_T tracks spiraling in TPC
- **Ghost** tracks: Contain less than 50% hits from the same particle.

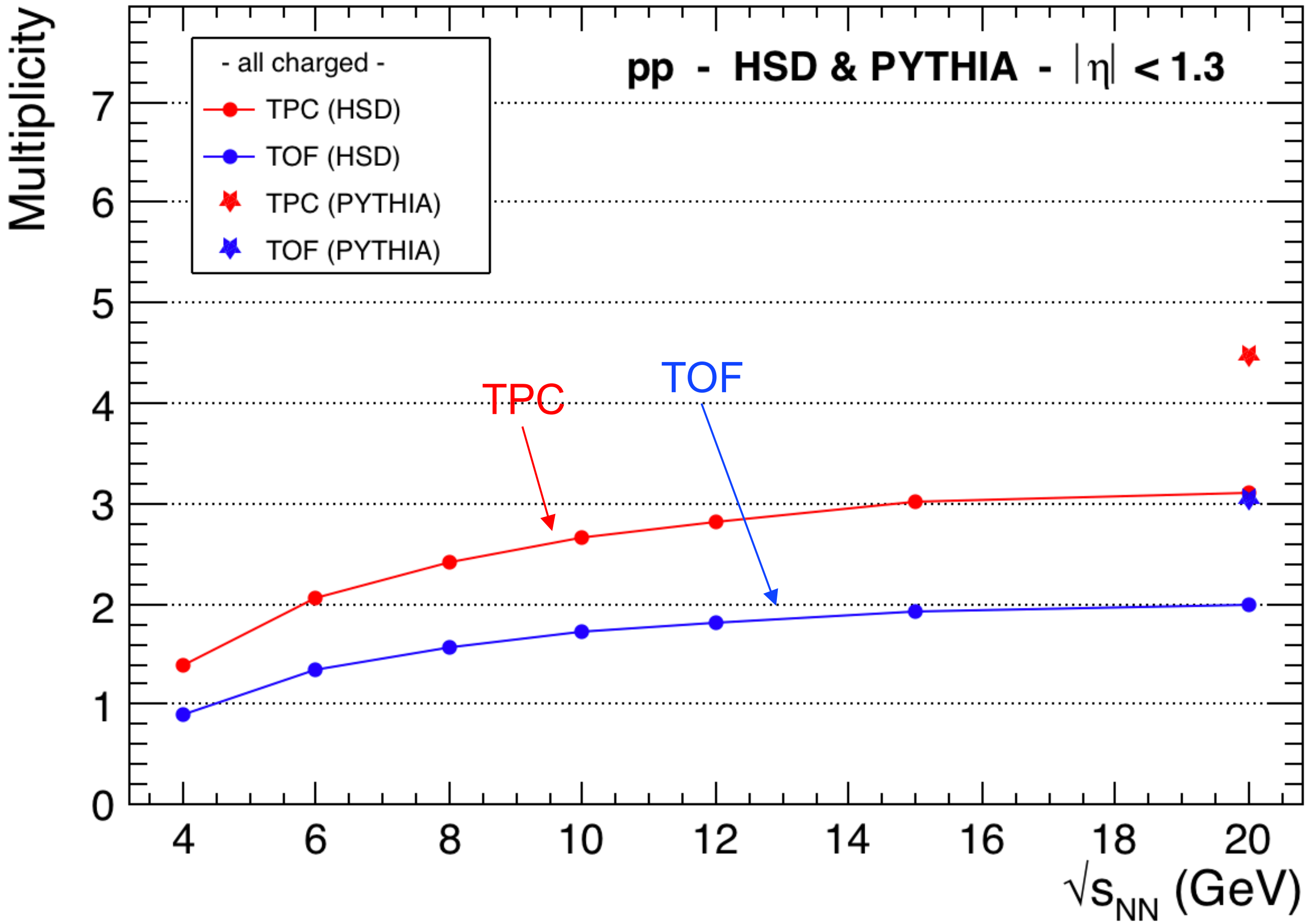
p_T distribution of reconstructed tracks in:

- TPC
- TPC + TOF



The reconstruction efficiency in TOF as defined above, is > 80% in the p_T range 0.3 ÷ 1.6 GeV/c. Different factors contribute to the inefficiency: TOF acceptance and dead spaces, decays of pions and kaons, TPC-TOF mismatch (especially at low p_T), etc. This should be investigated in detail further on.

Multiplicity for different p + p collision energies



S_{NN} (GeV)	Multiplicity at $|\eta| < 1.3$			
	TPC		TOF	
	HSD	PYTHIA	HSD	PYTHIA
4	1.38		0.89	
6	2.07		1.34	
8	2.42		1.58	
10	2.66		1.73	
12	2.81		1.82	
15	3.01		1.93	
20	3.10	4.46	2.00	3.03

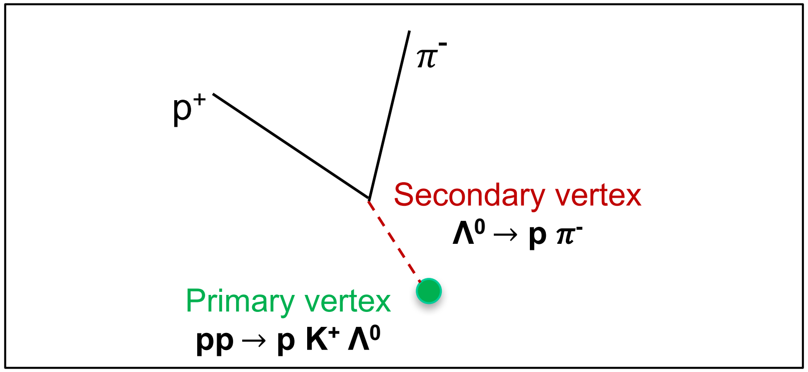
Pythia results obtained by A. Zinchenko

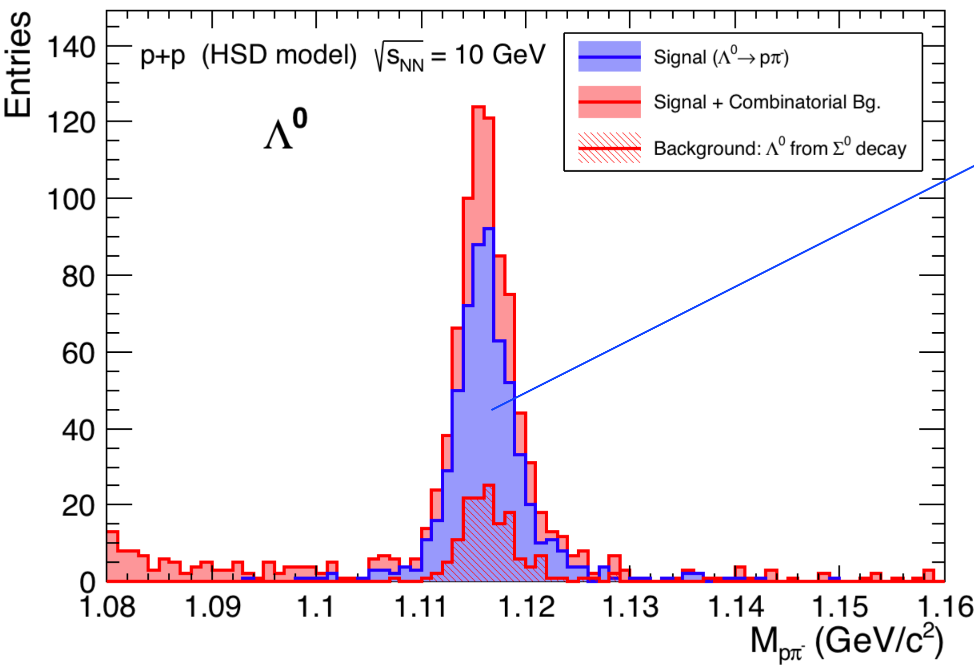
The multiplicity values were obtained from the p_T and pseudorapidity density distributions, $(\frac{dN}{dp_T})$ vs. $\sqrt{s_{NN}}$ and $(\frac{dN}{d\eta})$ vs. $\sqrt{s_{NN}}$, $(|\eta| < 1.3)$

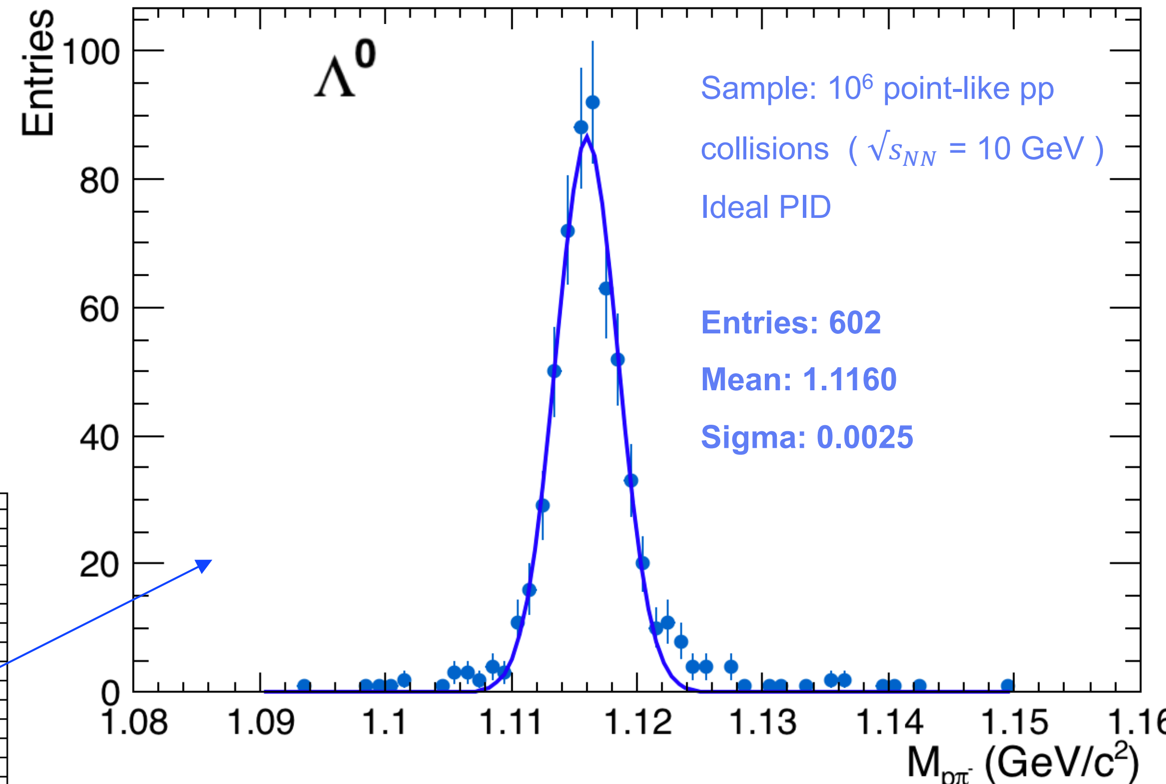
Neutral Lambda Baryon

Invariant mass spectrum of (p , π^-) pair

m_{Λ^0} = 1116 MeV



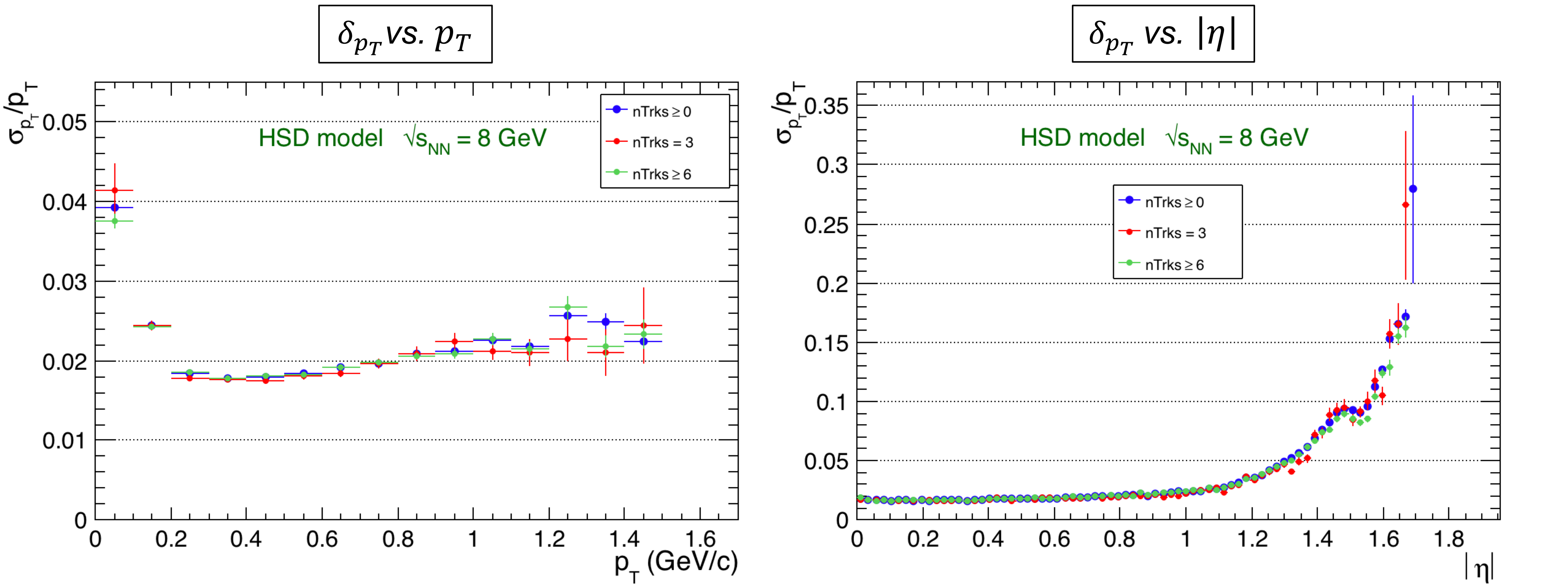




There is a weak combinatorial background due to the low multiplicity from p + p collisions.

- The performance studies of MPD, in its first stage, include the simulations of p+p collisions to estimate the feasibility of TPC as the main tracking detector for event reconstruction.
- Simulations indicates that the pseudorapidity and p_{T} density distributions as well as the multiplicity of charge hadrons from p+p collisions can be measured in MPD at collision energies $\sqrt{s_{NN}}$ = 4 ÷ 20 GeV.
- The primary vertex position may be estimated with a precision of 2 mm in events of more than 6 reconstructed tracks in TPC.
- The p_{T} resolution is better than 2.6% at p_{T} range: 0.1 ÷ 1.5 GeV/c.
- The reconstruction of Λ^0 baryon from p+p collisions has the advantage of a weak p,π^- combinatorial background.

BACKUP



The p_T resolution is not affected by the number of tracks.

Difference between $p_{T,rec}$ and $p_{T,MC}$
Only primary protons, pions, kaons