Open heavy-flavour hadron decay muon production in pp collisions with ALICE

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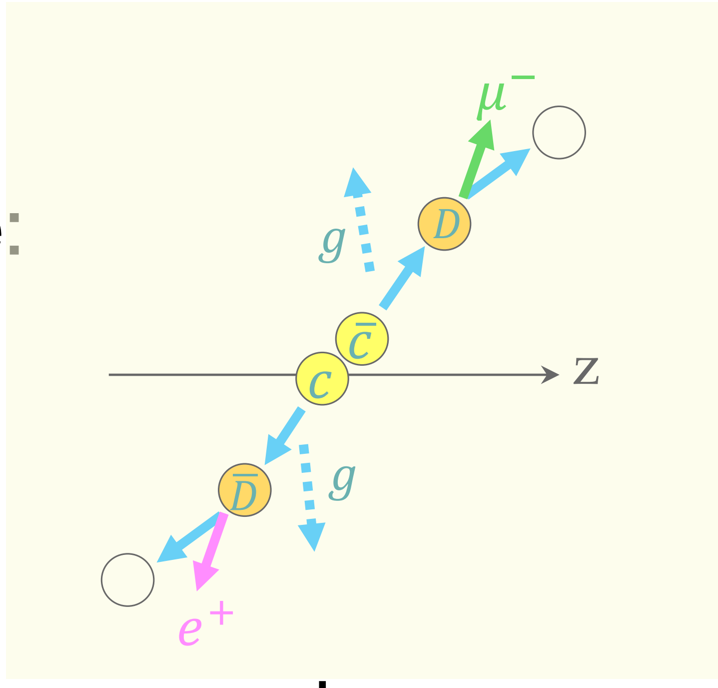
Motivation

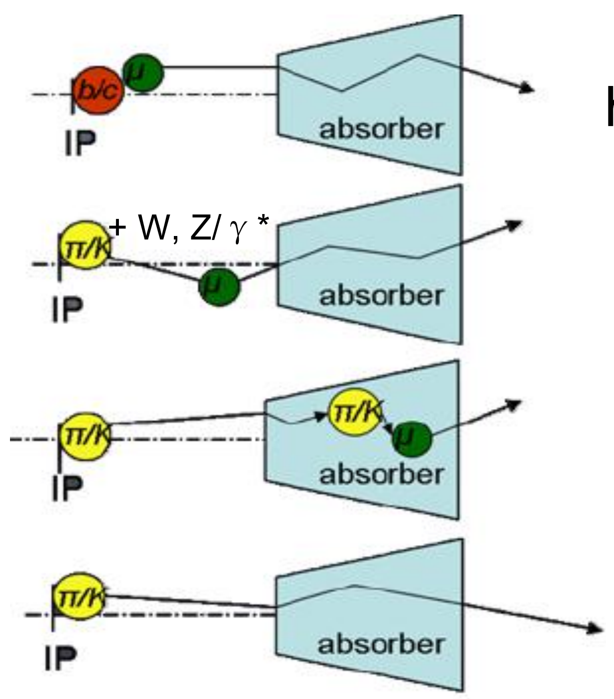
♦ In relativistic heavy-ion collisions:
a) heavy quarks are produced much before the formation of deconfined medium consisting of quarks and gluons called quark-gluon plasma (QGP)
b) experience full evolution while propagating through the produced medium and lose energy by successive elastic and inelastic collisions in the fireball

♦ The study of Heavy Flavour (charm and beauty) production in proton-proton (pp) collisions at LHC energy regime:
a) provides an investigation of pQCD calculations.
b) as a baseline for the same measurement in heavy-ion collisions.



The experimental study in ALICE Run 3 will allow subsequent increment in statistical significance and precision measurements.

The study of HFM production as a function of charged particle multiplicity (N_{ch}) in pp collisions =>
i) could provide more insight of the interplay between the soft and hard physics with better precision.
ii) helps to improve understanding the phenomenological model to explain the underlying physics.



Extraction of
Open Heavy Flavour hadron decay Muons

$$\frac{dN_{pp}^{\mu\leftarrow HF}}{dp_T} = \frac{dN_{pp}^{incl\ \mu}}{dp_T} - \frac{dN_{pp}^{\mu\leftarrow\pi,K}}{dp_T} - \frac{dN_{pp}^{sec\ \mu}}{dp_T} - \frac{dN_{pp}^{\mu\leftarrow J/\psi}}{dp_T} - \frac{dN_{pp}^{\mu\leftarrow W/Z/\gamma^*}}{dp_T}$$

Particle production at high multiplicity in small systems

Observations of features similar to Heavy-ion collisions for high multiplicity pp events at LHC=>

a) near side ridge [Phys. Lett. B 765 (2017) 193 https://doi.org/10.1016/j.physletb.2016.12.009]

b) strangeness enhancement [Nature Phys. 13 (2017) 535 https://doi.org/10.1038/nphys4111]

=> Understanding the phenomenology of hadronization mechanisms, huge kinetic energy is involved irrespective of collision system sizes.

=> More insight of the interplay between soft and hard physics.

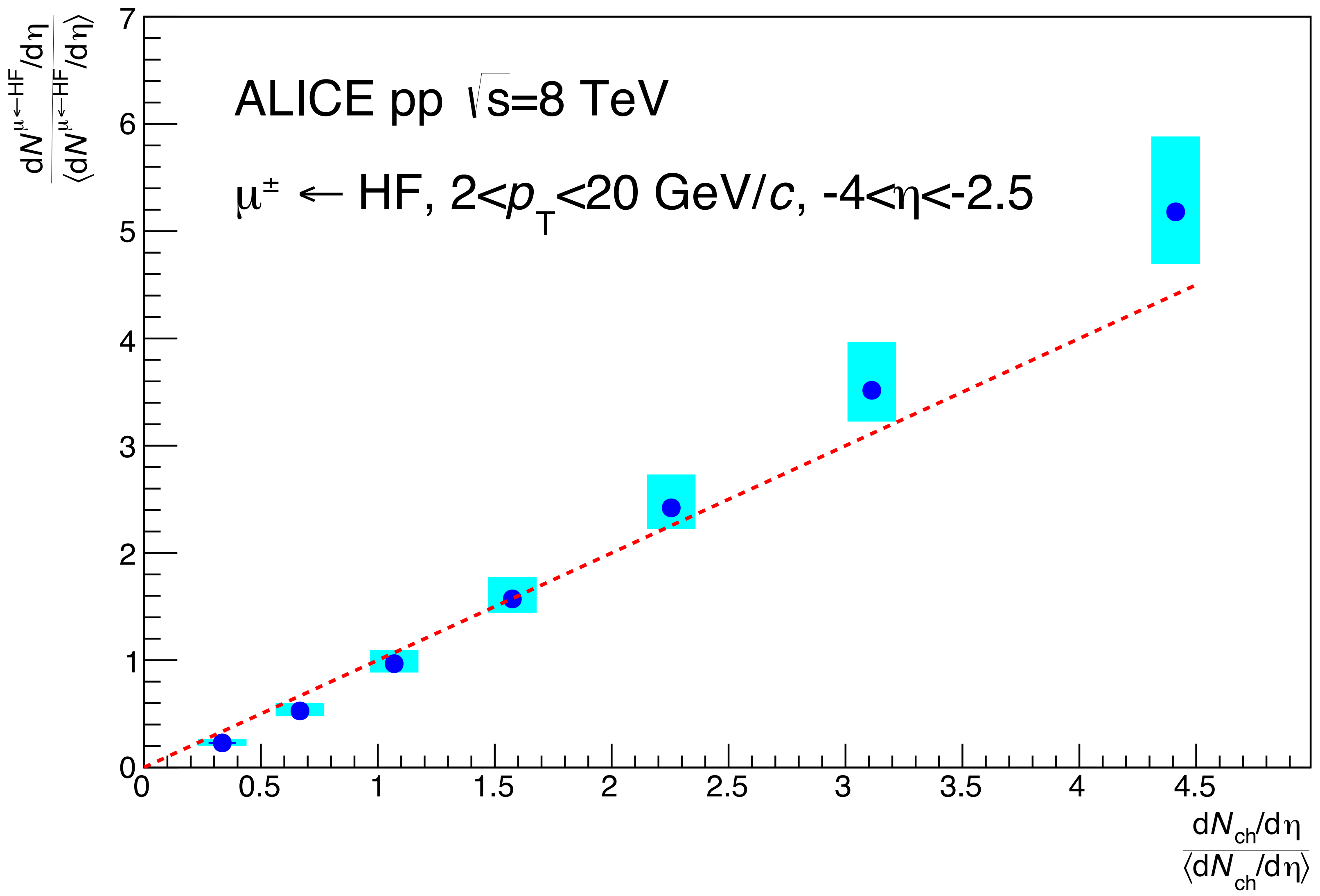
=> To understand the description of the final hadronic state of the underlying events :

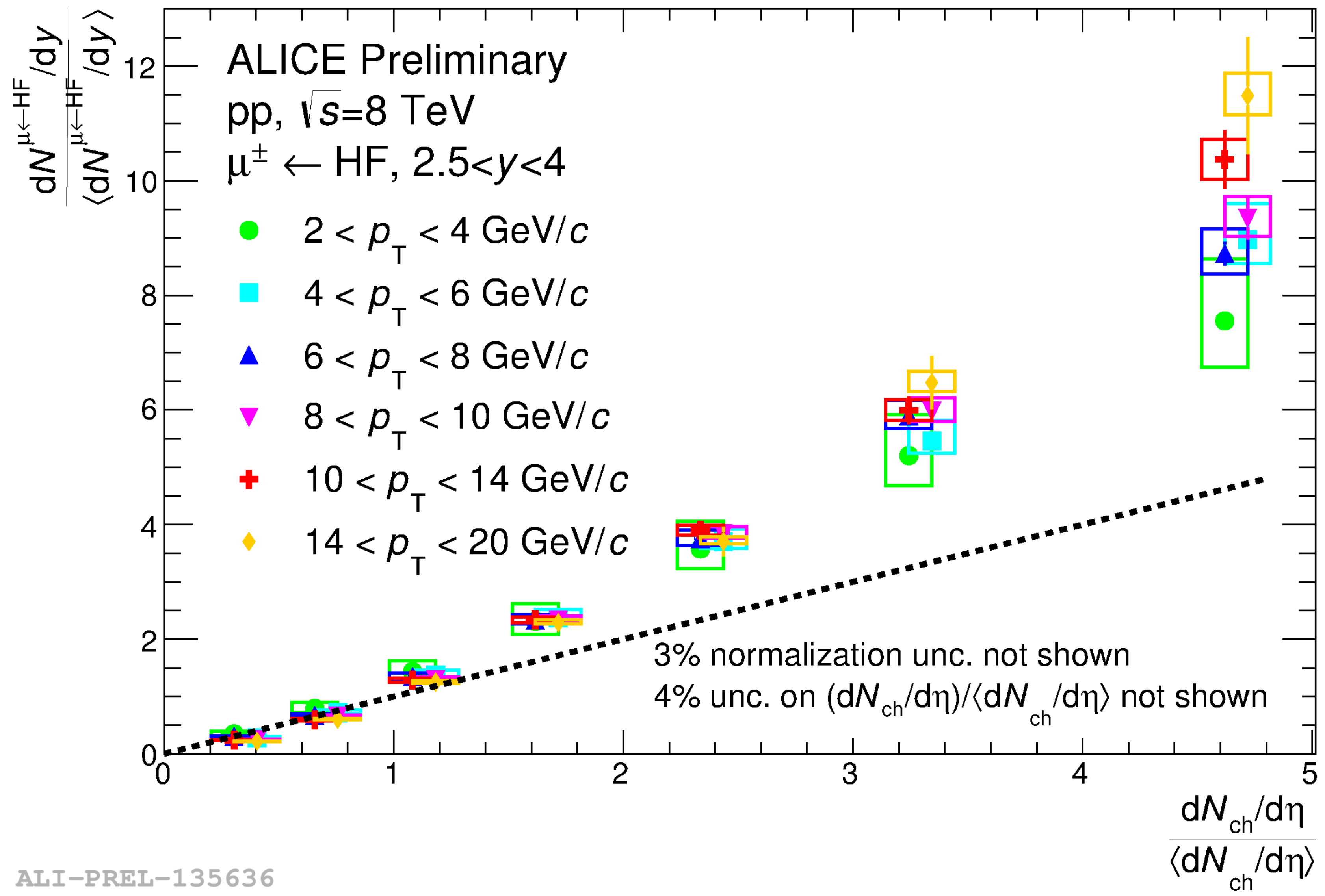
i) **Multiple parton-parton interactions (MPI):** average multiplicity is proportional to average number of MPI.

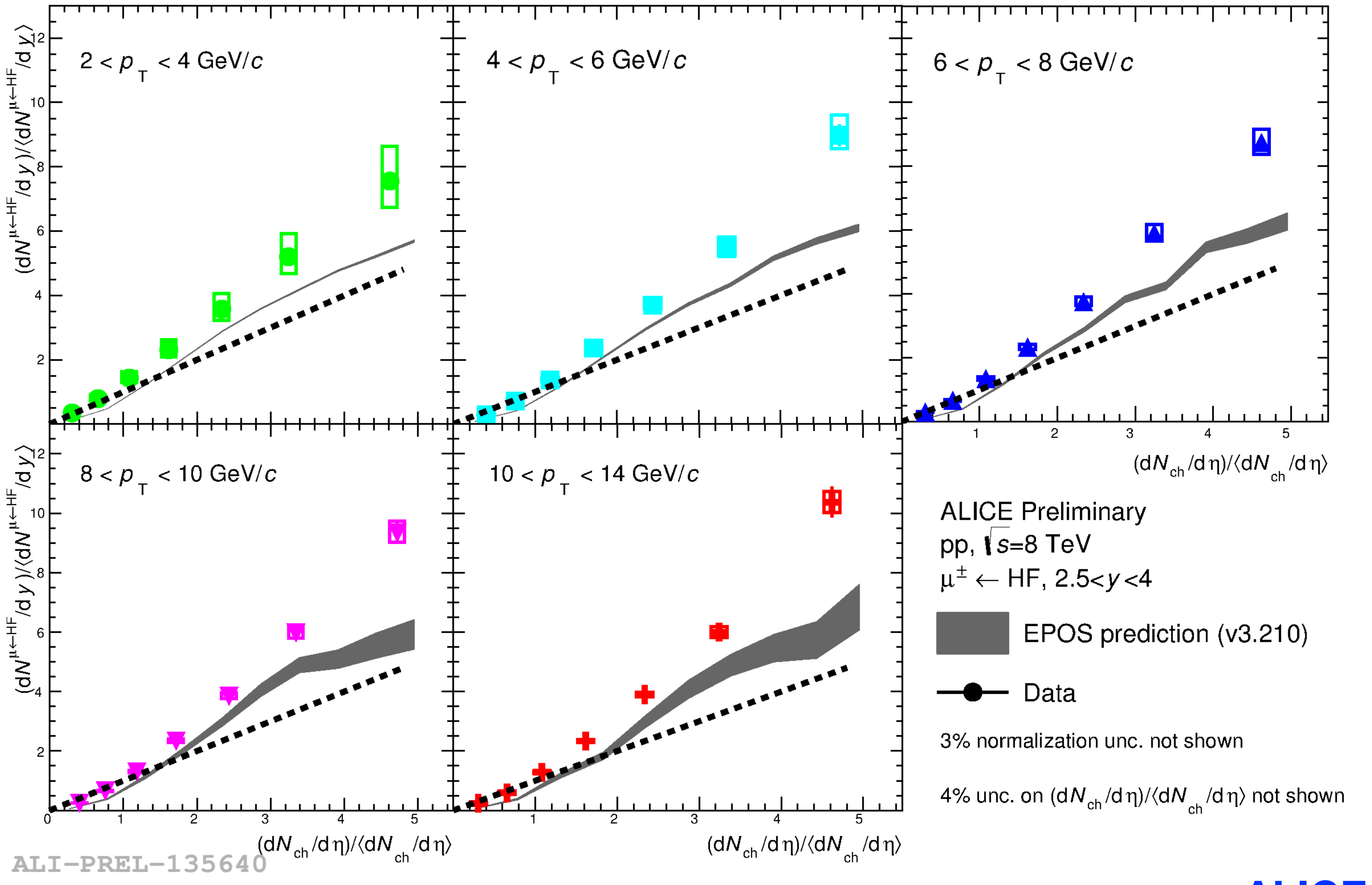
ii**) Colour reconnection (CR):** rearrangement of partons at the perturbative level just before hadronization => hadronization gets modified => could explain the flow like effect in pp collisions.

Multiplicity dependence of HFM production in pp at $\sqrt{s}$ = 8 TeV

https://alice-notes.web.cern.ch/node/642







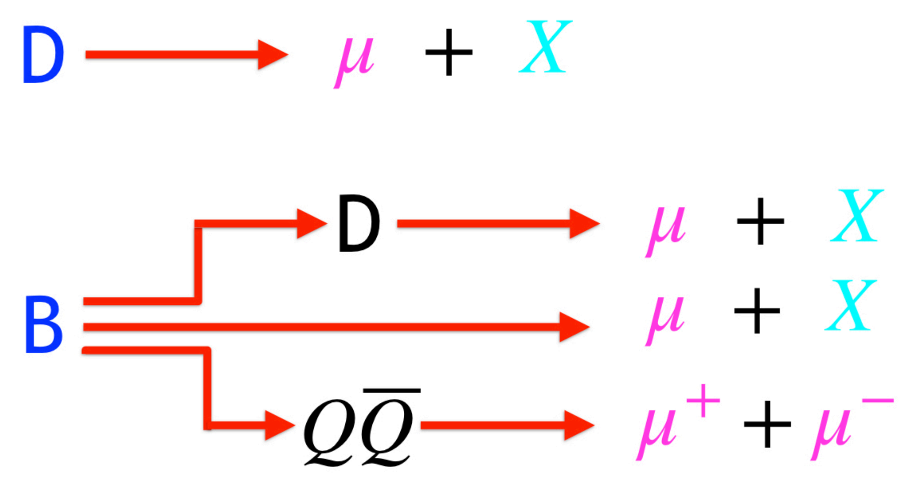
=> Production of HFM is faster than the linearly increasing trend
=> production of HFM is steeper at higher multiplicities.

=> EPOS prediction without hydrodynamics underestimated compared to data for all p_T ranges => hints to understand hadronization mechanism at high multiplicity events.

=> Study of multiplicity dependence for the production of HFM in pp collisions at $\sqrt{s}$ = 13.6 TeV with much higher precision measurements.

=> Investigation for the separation of charm and beauty component.

Scope with MFT+ MuonSpectrometer of ALICE



Muons produced via semi-muonic decays of open charm (D) and open beauty (B) hadrons at forward rapidity.

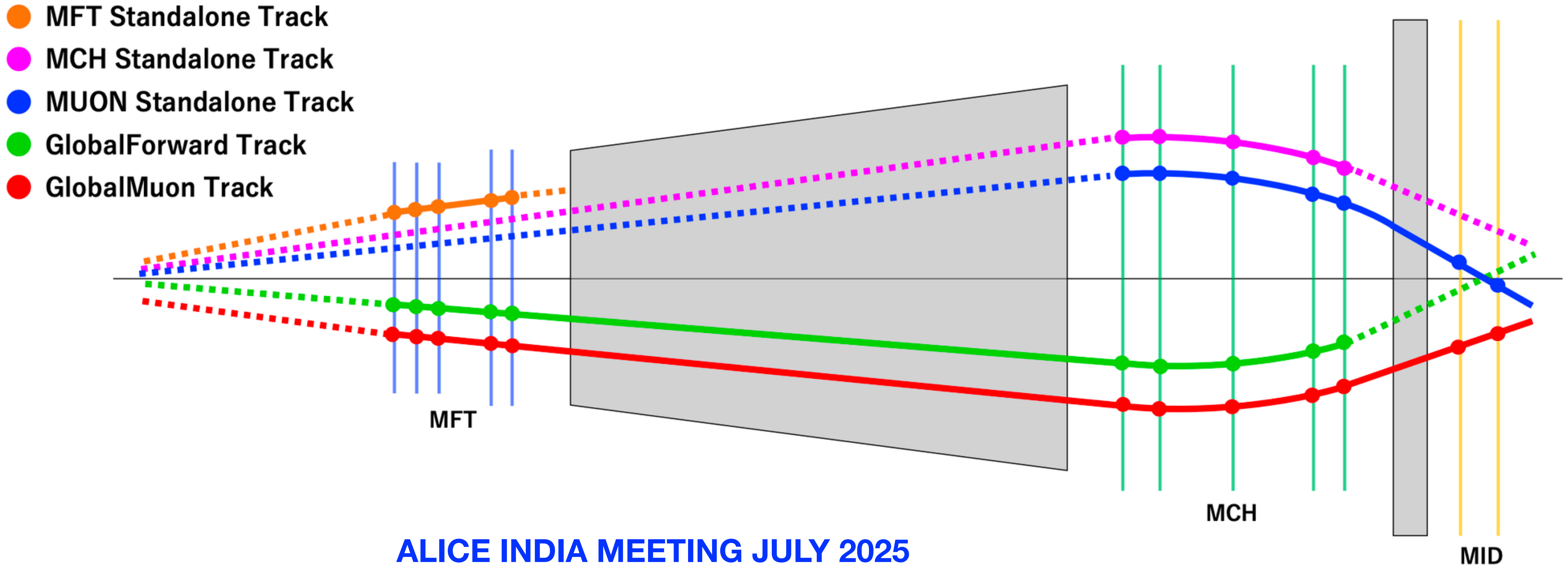
Muon physics program suffered several limitations during Run 1 and Run 2, specially due to the multiple scattering experienced by the muon tracks inside hadron absorber => vertex region smears.

Matching of tracks reconstructed in the tracking system of Muon Spectrometer and that with MFT cluster =>

i) Separation of prompt J/ψ from b-decay J/ψ.

ii) Open charm and open beauty via semi-muonic decay can be distinguished.

iii) Study of heavy-flavor (HF) using single muons down to p_T ~1 GeV/c.

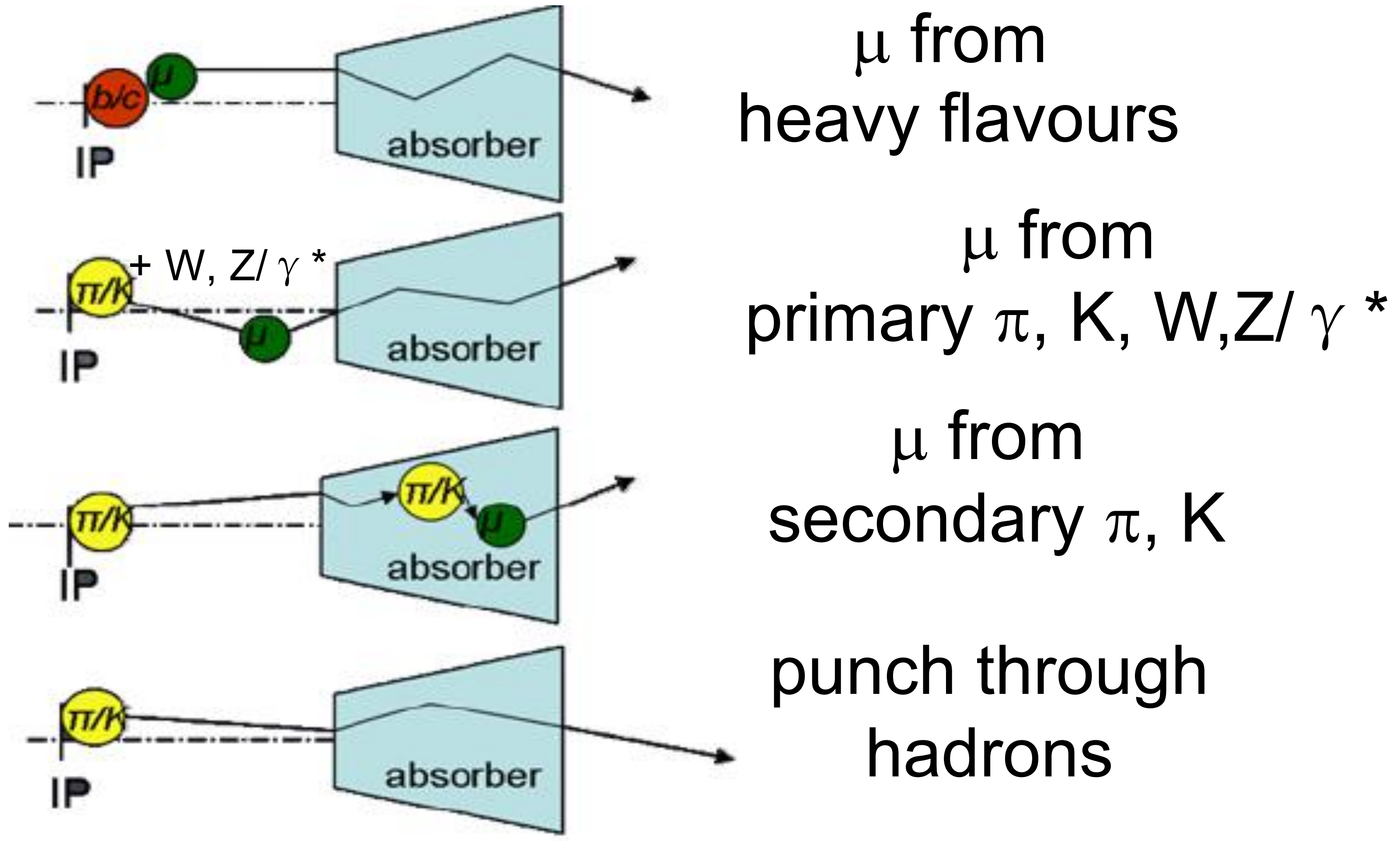


Muon Selection

- pp collisions at $\sqrt{s}$ = 13.6 TeV

  DataSet: LHC22o_apass7

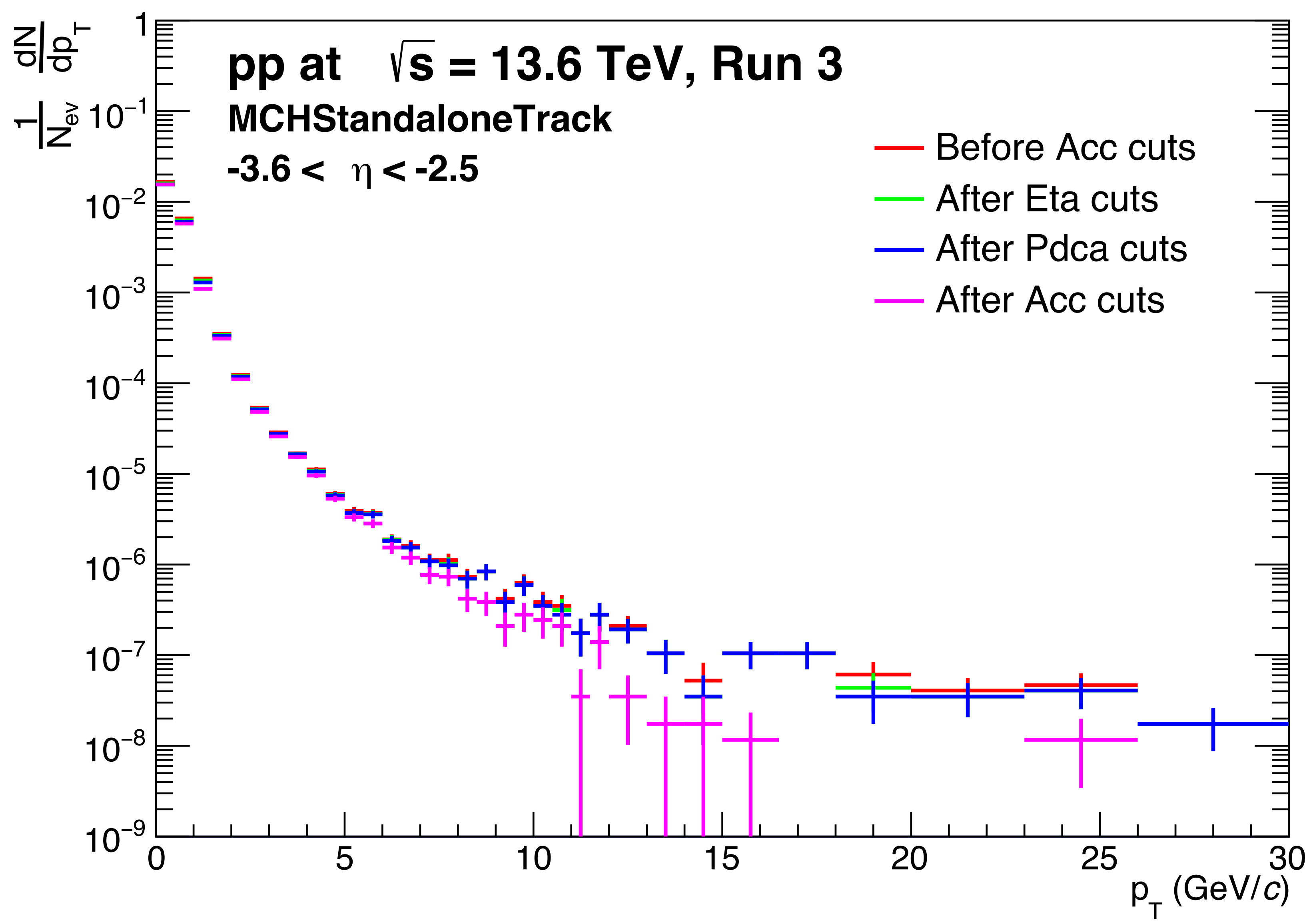
  Number of events after selections : ~57M

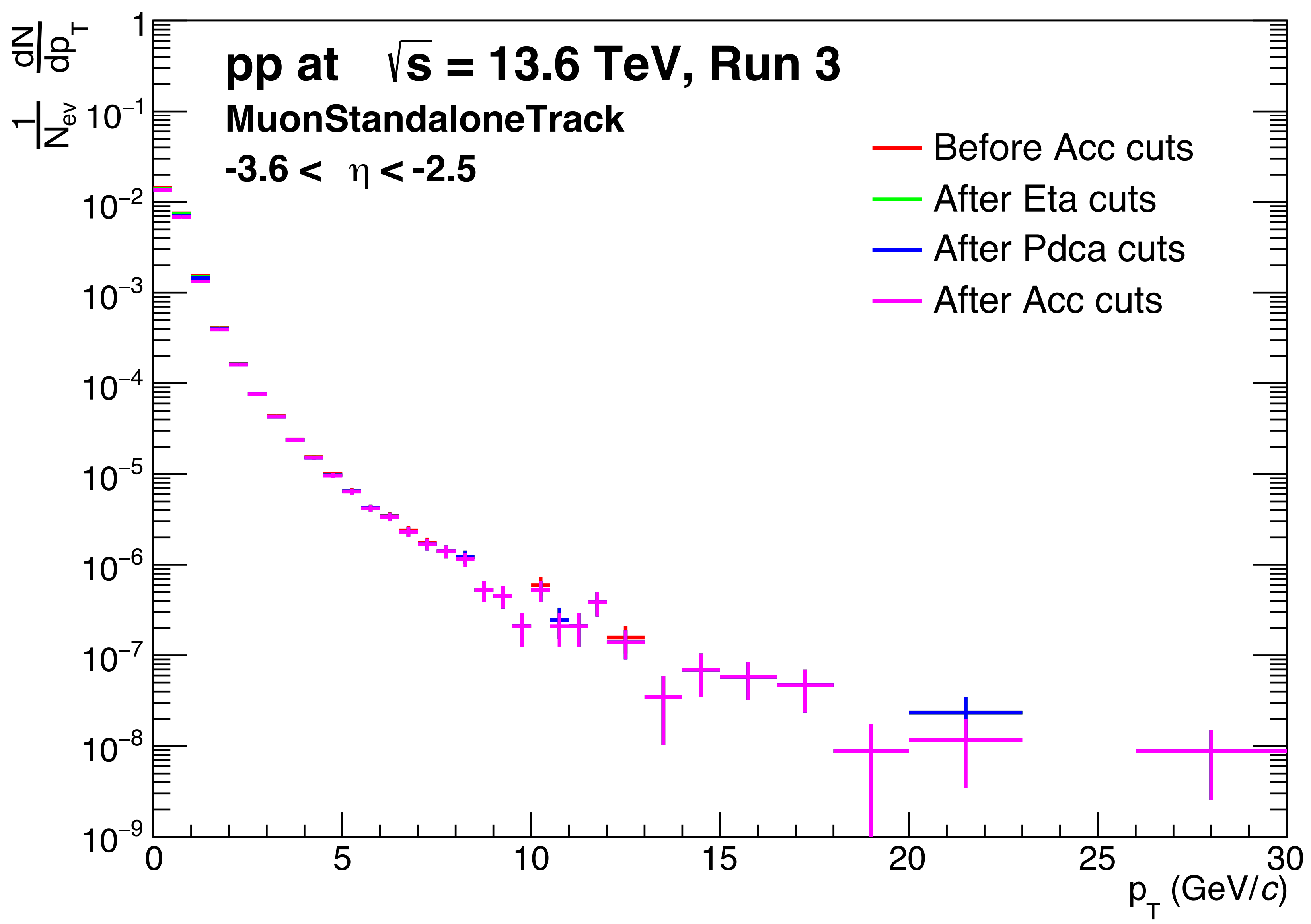


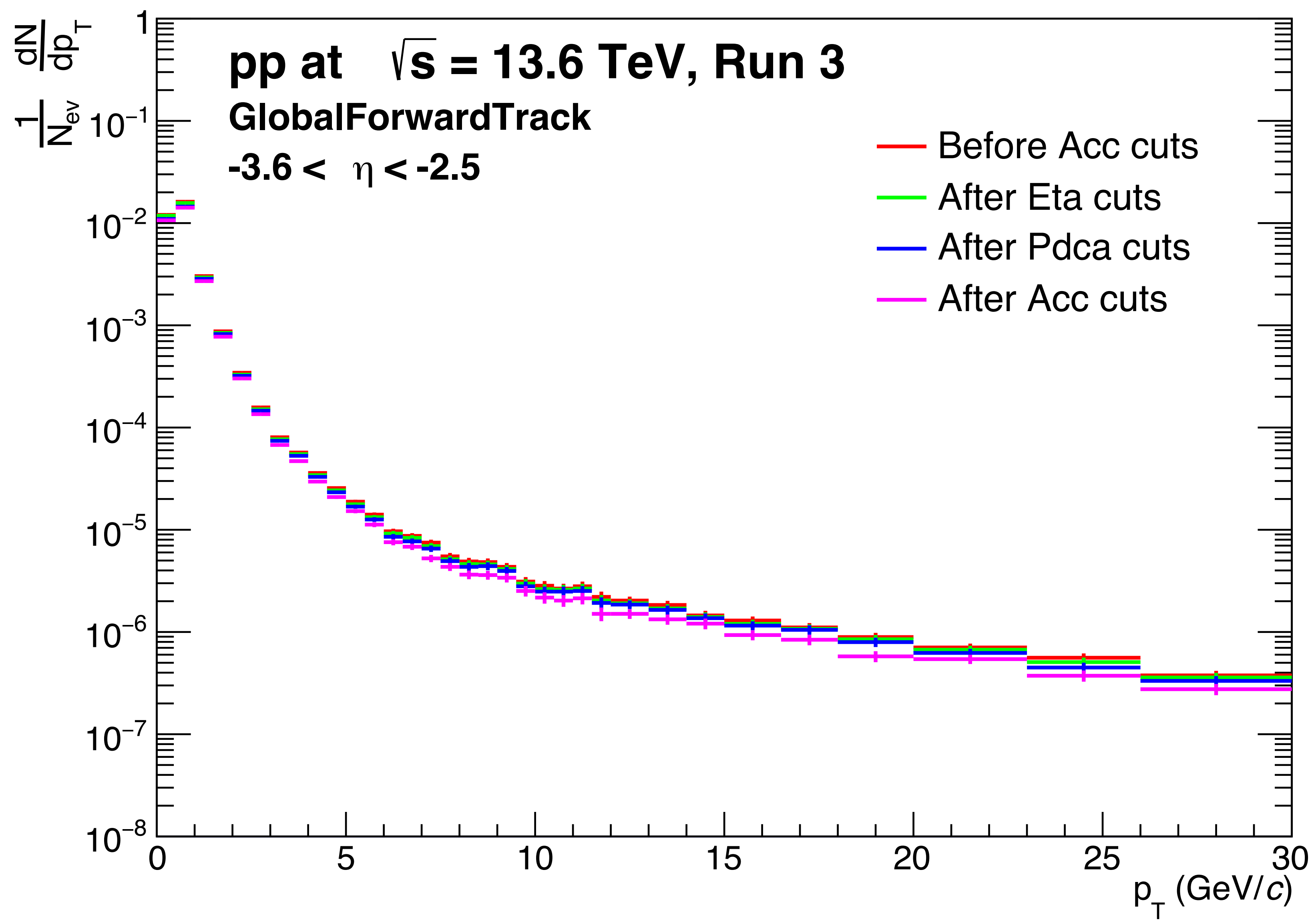
- **Event Selection Cuts :**
  - Sel8
  - Vertex: z-component of vertex selection within $|V_z| < 10\ cm$

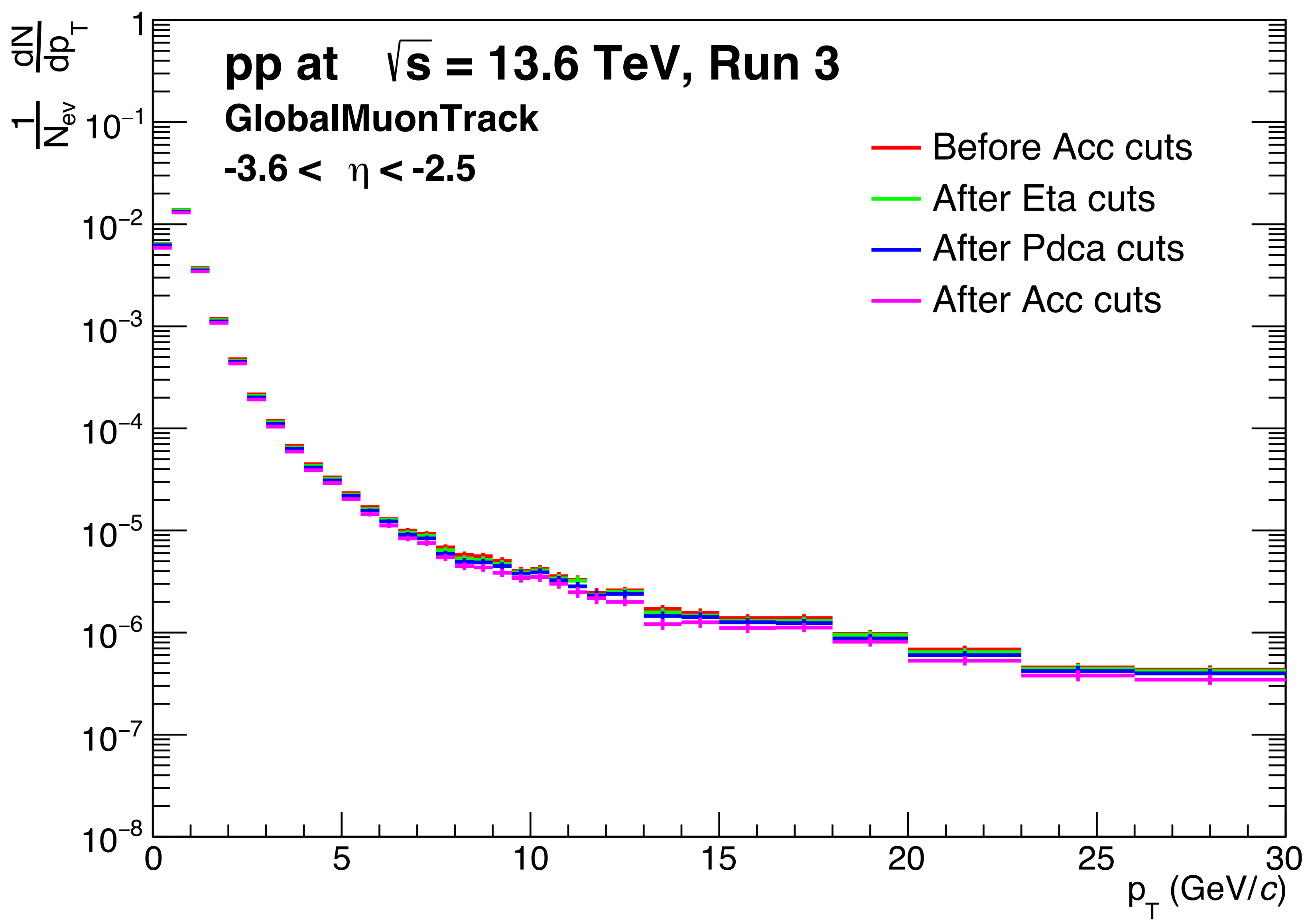
Track Selection Cuts	
Charged Tracks	**Muon Tracks**
i) $-0.8 < \eta < 0.8$ ii) $p_T > 0.15$ GeV/c	i) $-3.6 < \eta < -2.5$ ii) 17.6 cm $< R_{abs} <$ 89.5 cm iii) pDCA: 6σ .... iv) chi2 v) Δp_T

p_T spectra after applying different selection cuts



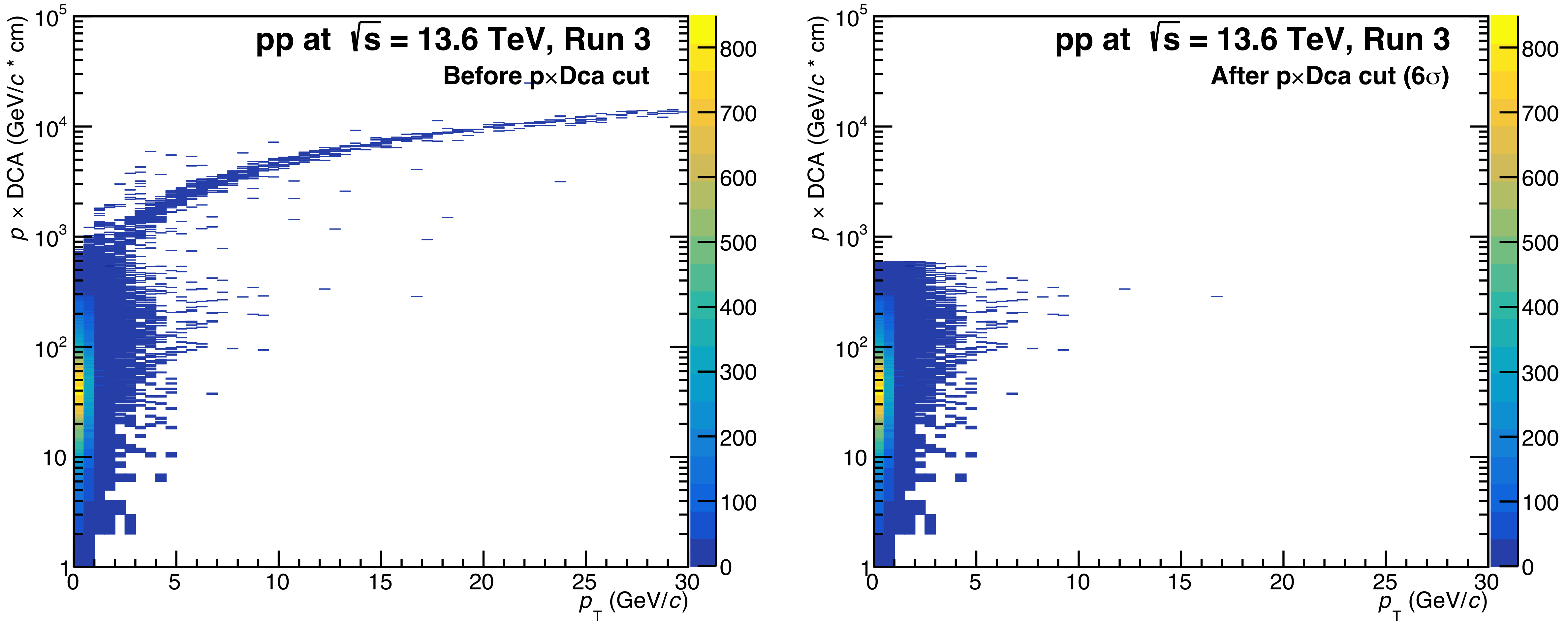




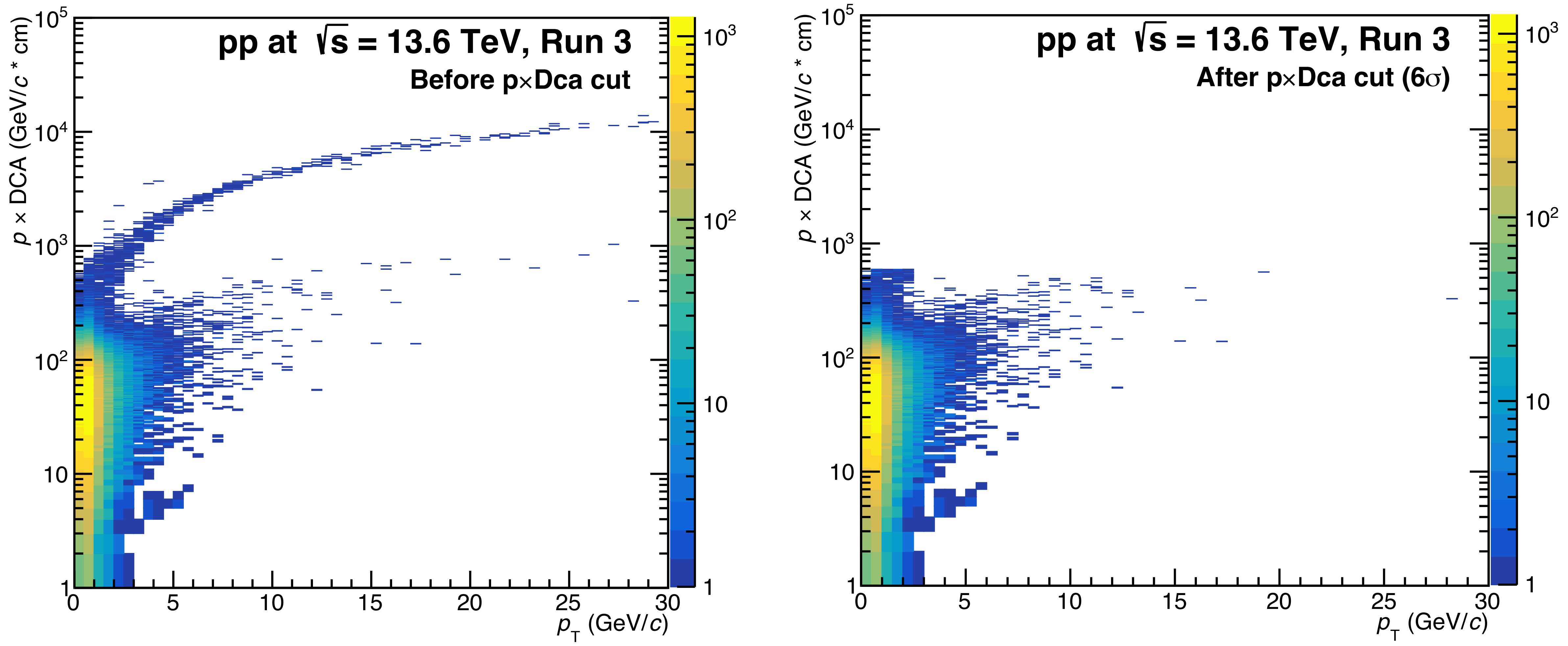


p_T vs $pDCA$ distribution for different type of reconstructed muon tracks

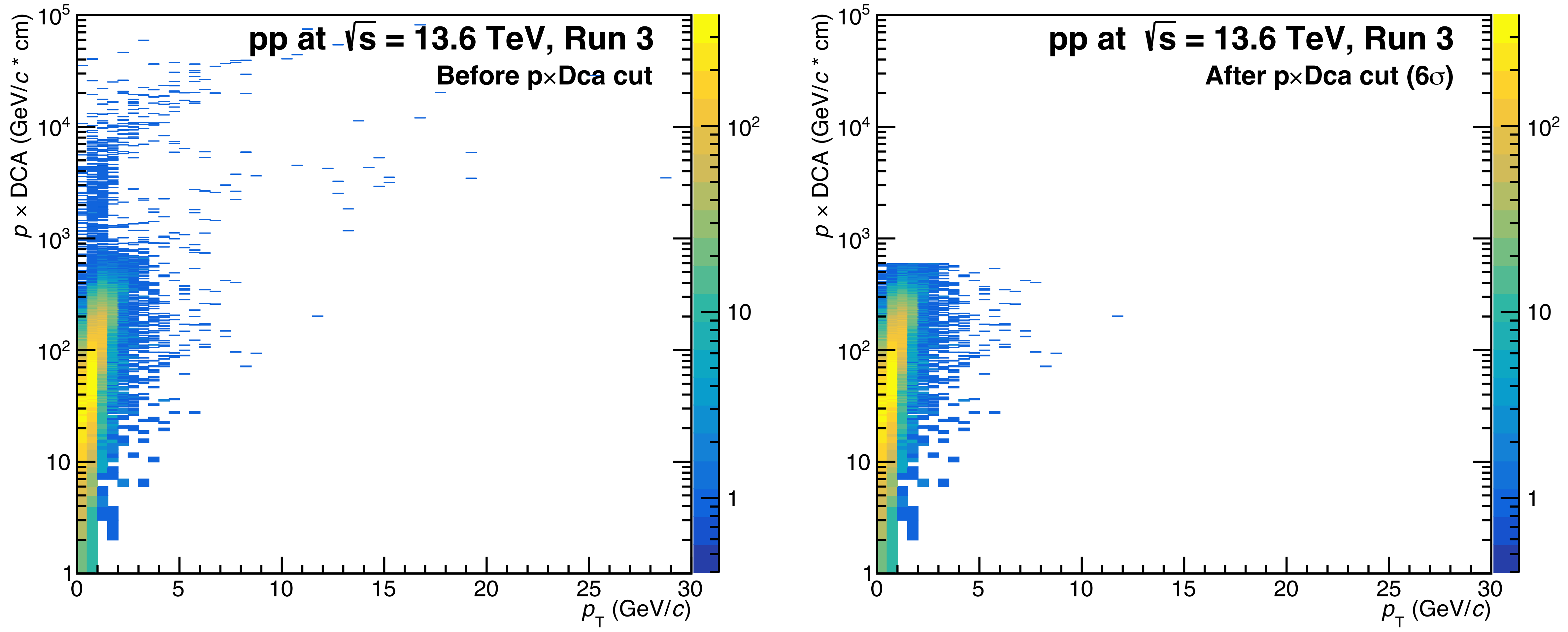
MCH Standalone Tracks (TrackType=4)



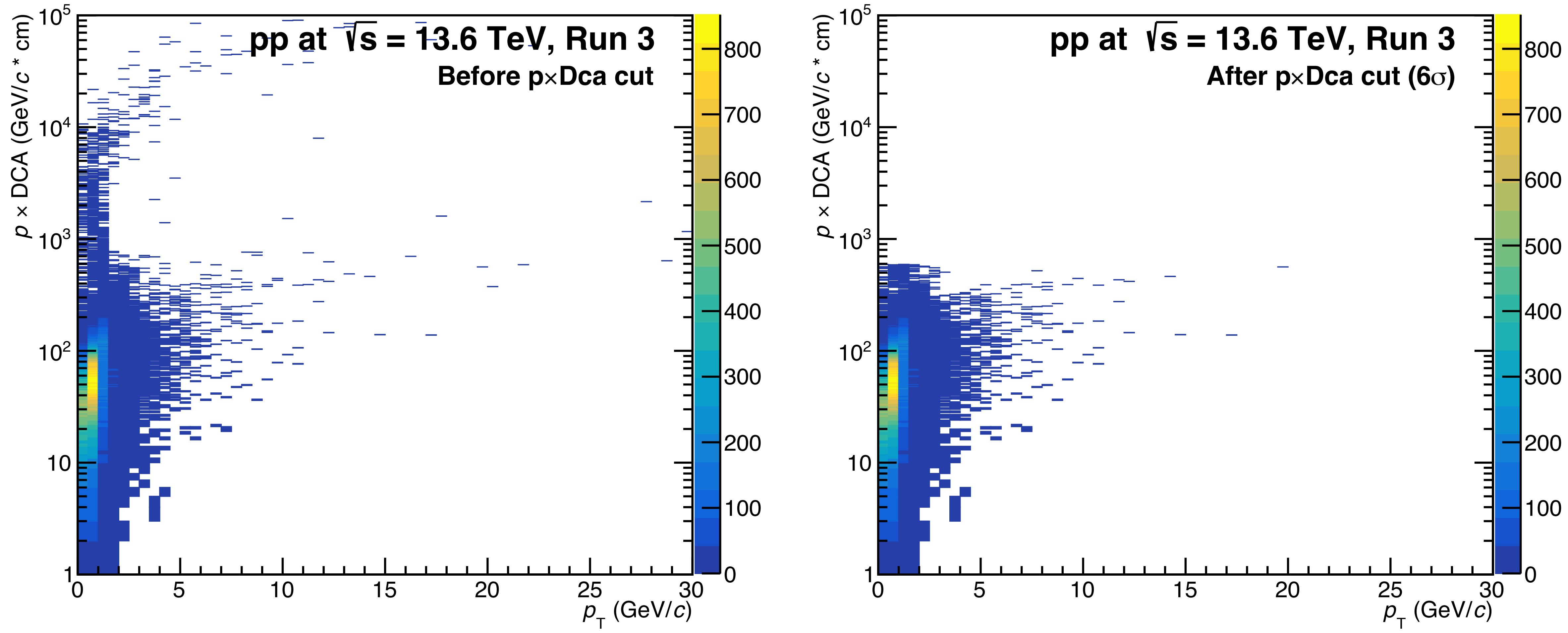
Muon Standalone Tracks (TrackType=3)



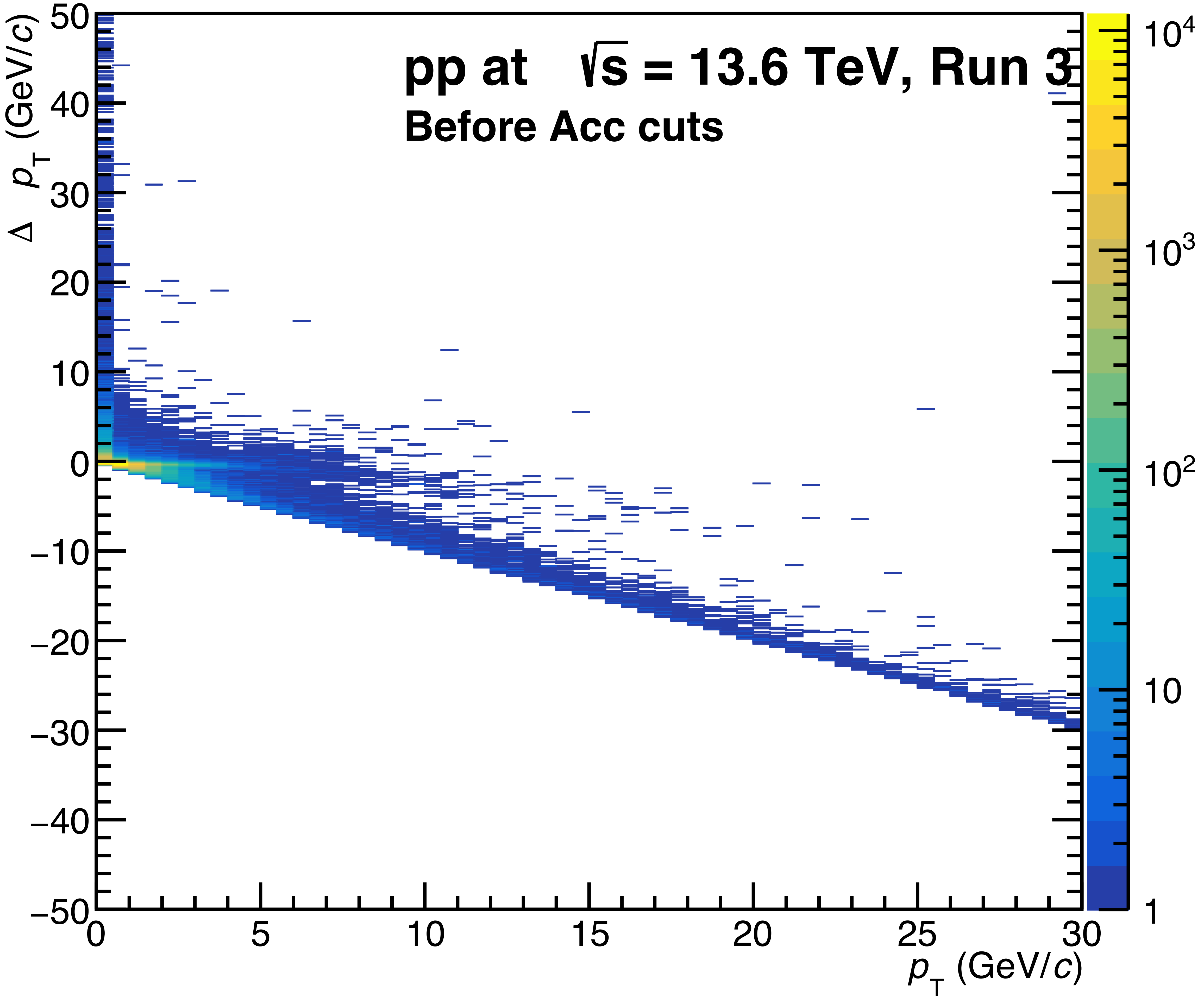
Global Forward Tracks (TrackType=2)

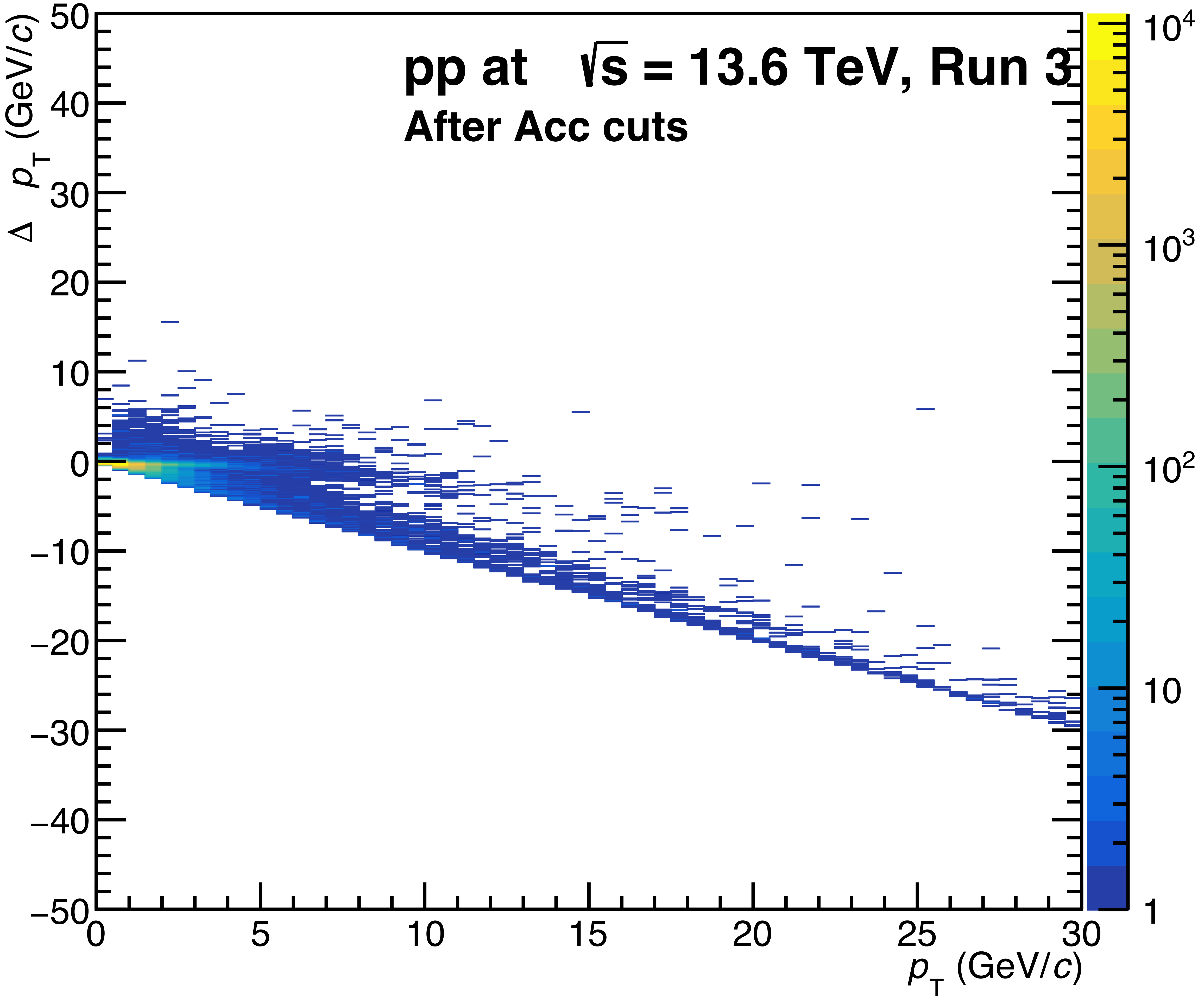


Global Muon Tracks (TrackType=0)

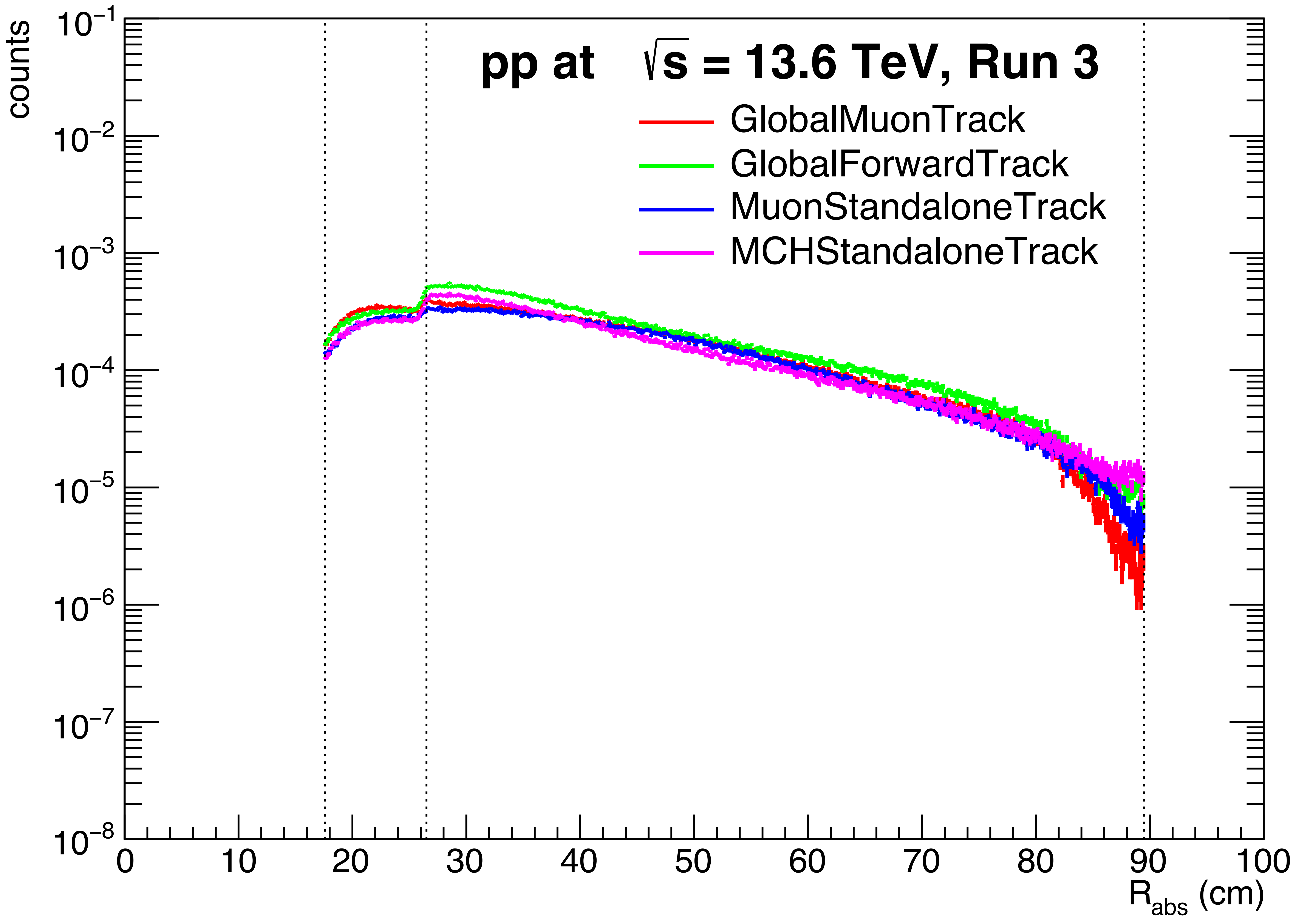


Δp_T (p_T standalone tracks - p_T global tracks) distribution

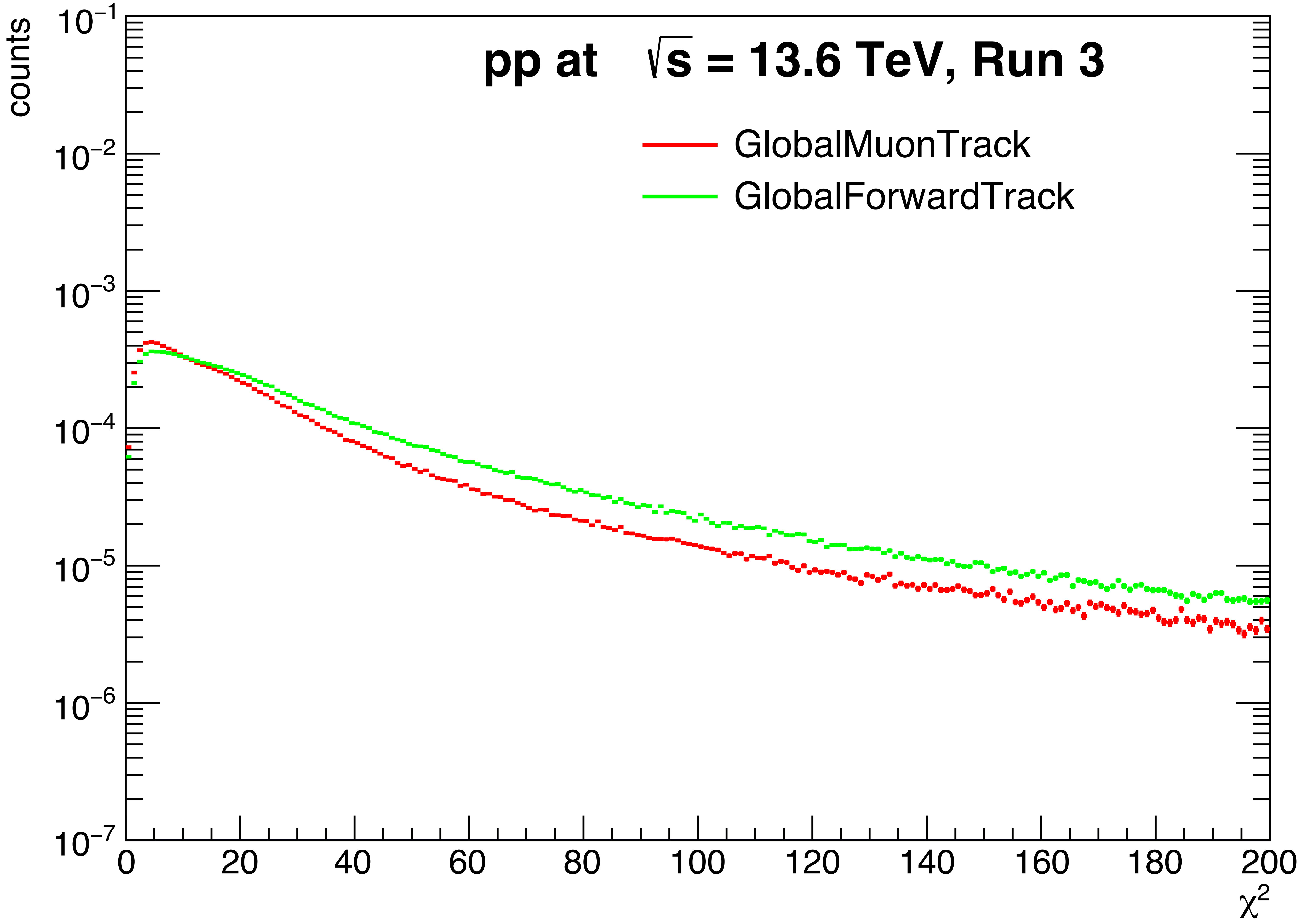




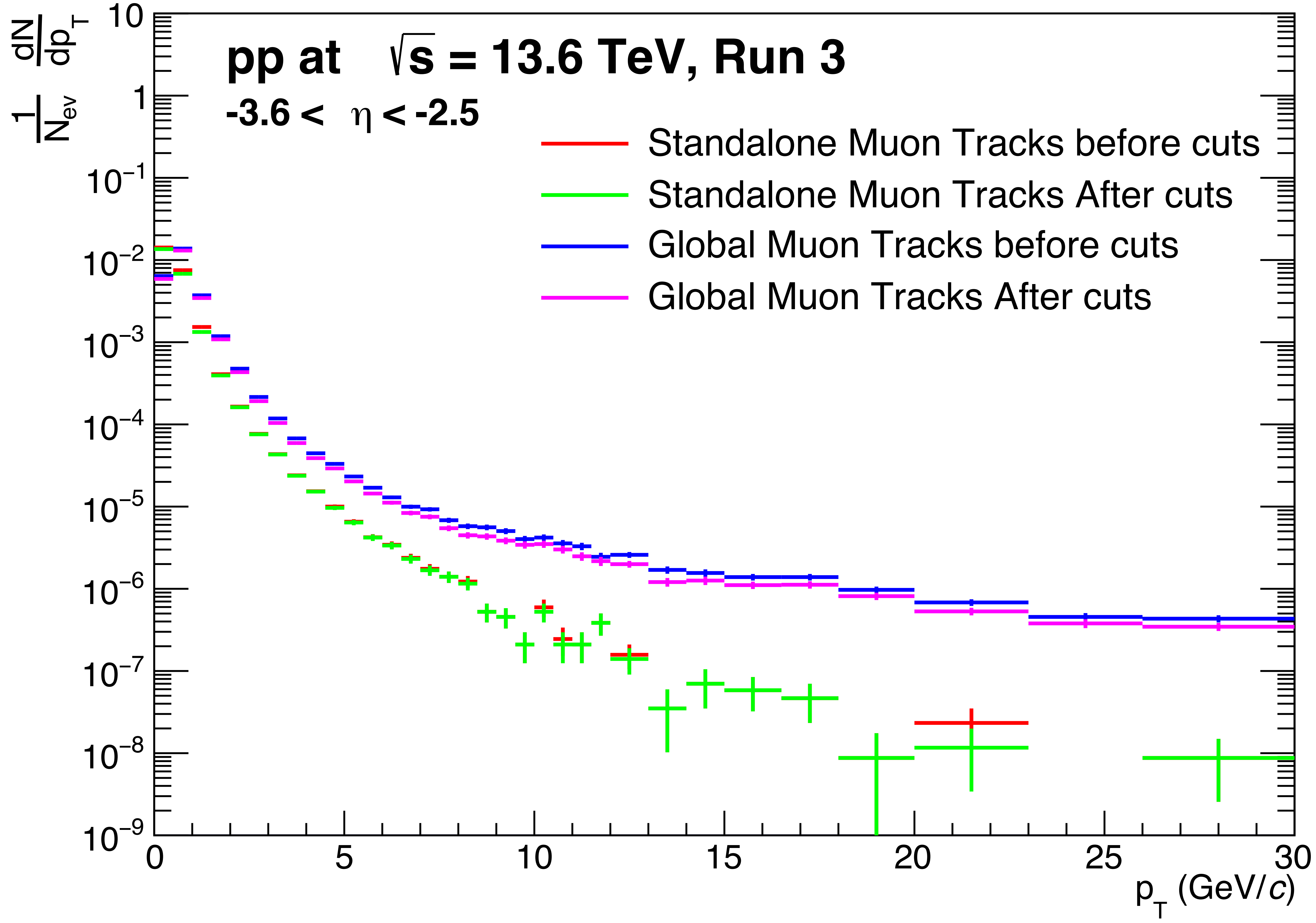
Comparison of R_{abs} distribution

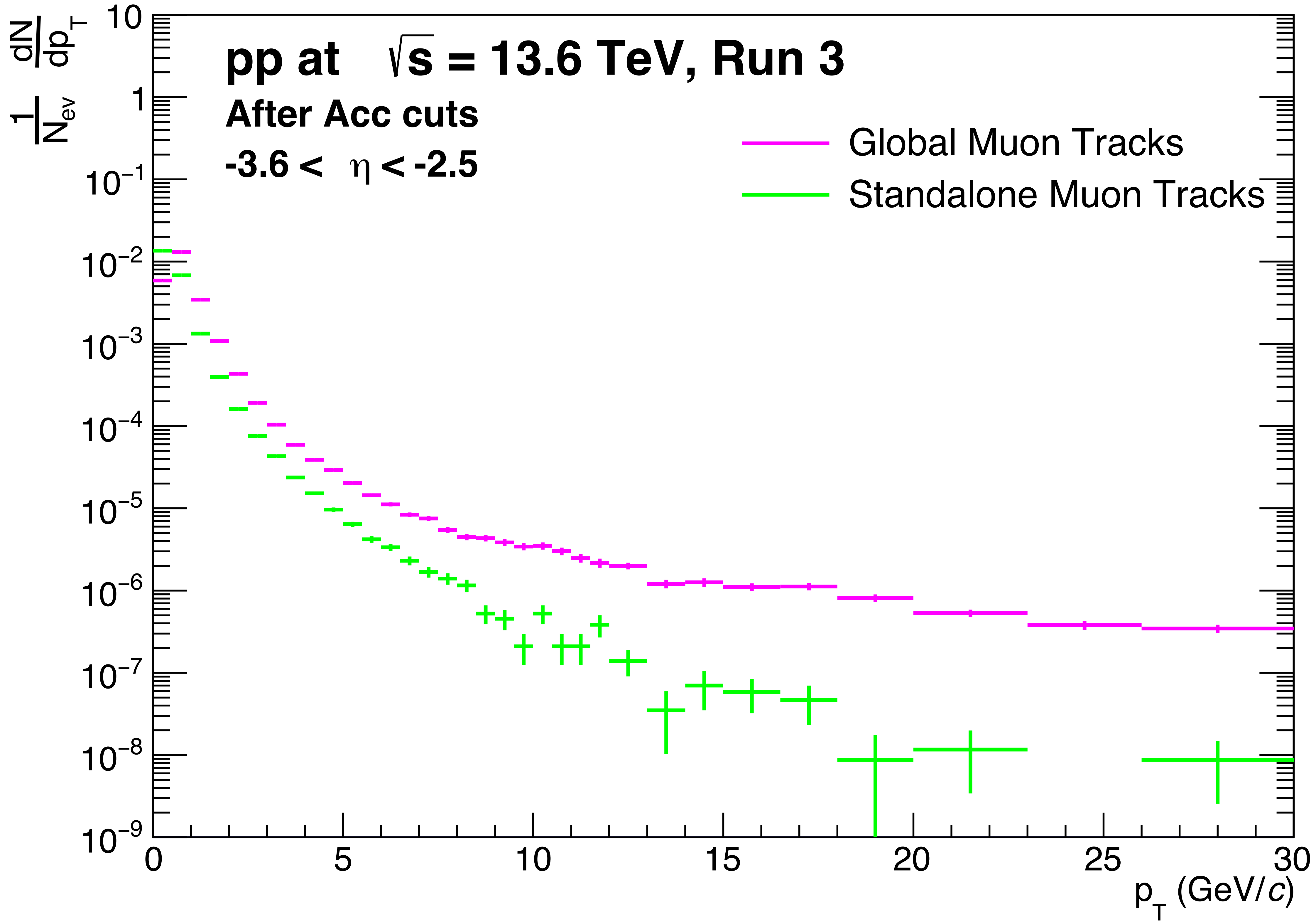


Comparison of χ^2 distribution

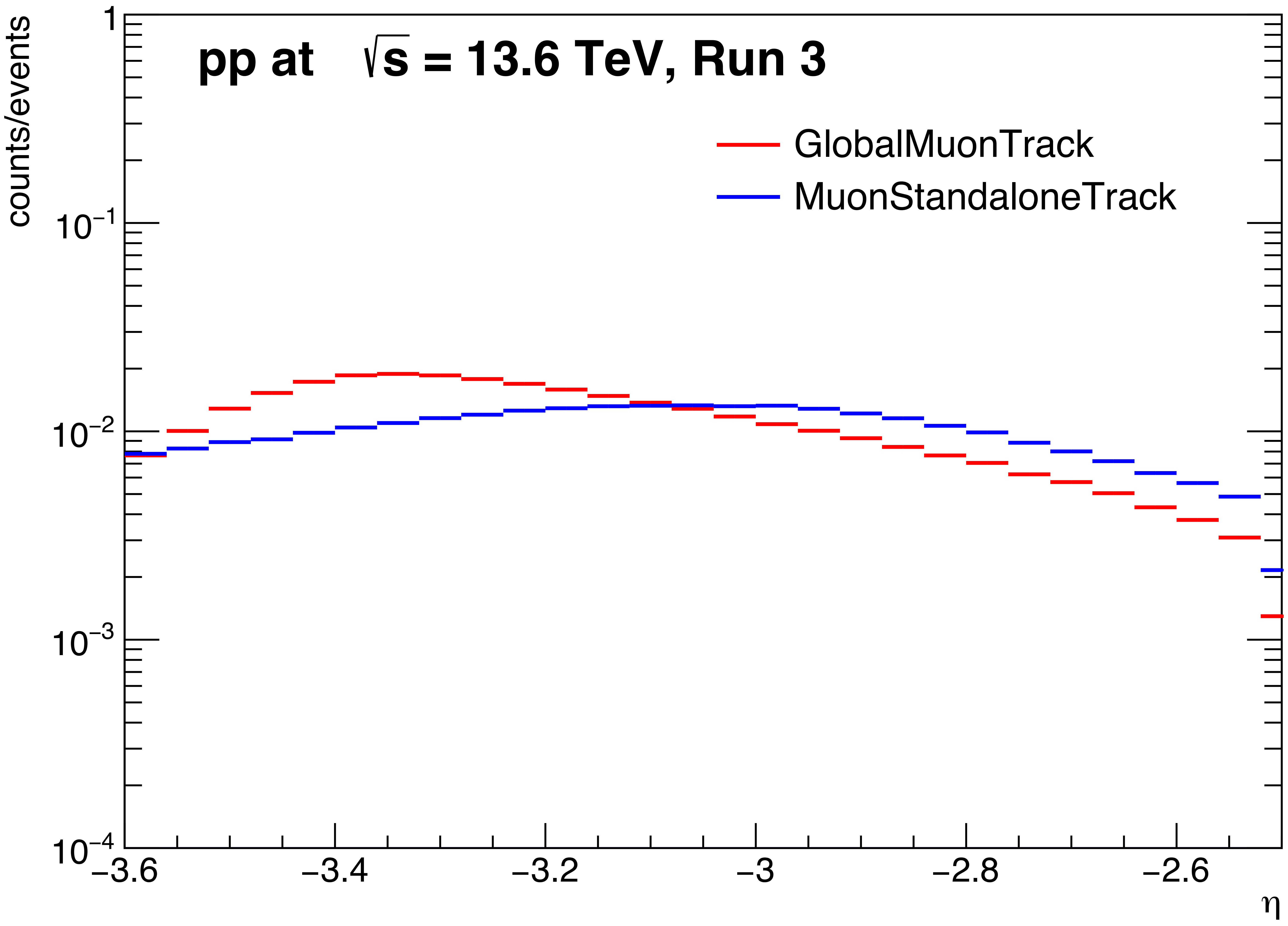


p_T spectra of Muon Standalone Tracks and Global Muon Tracks

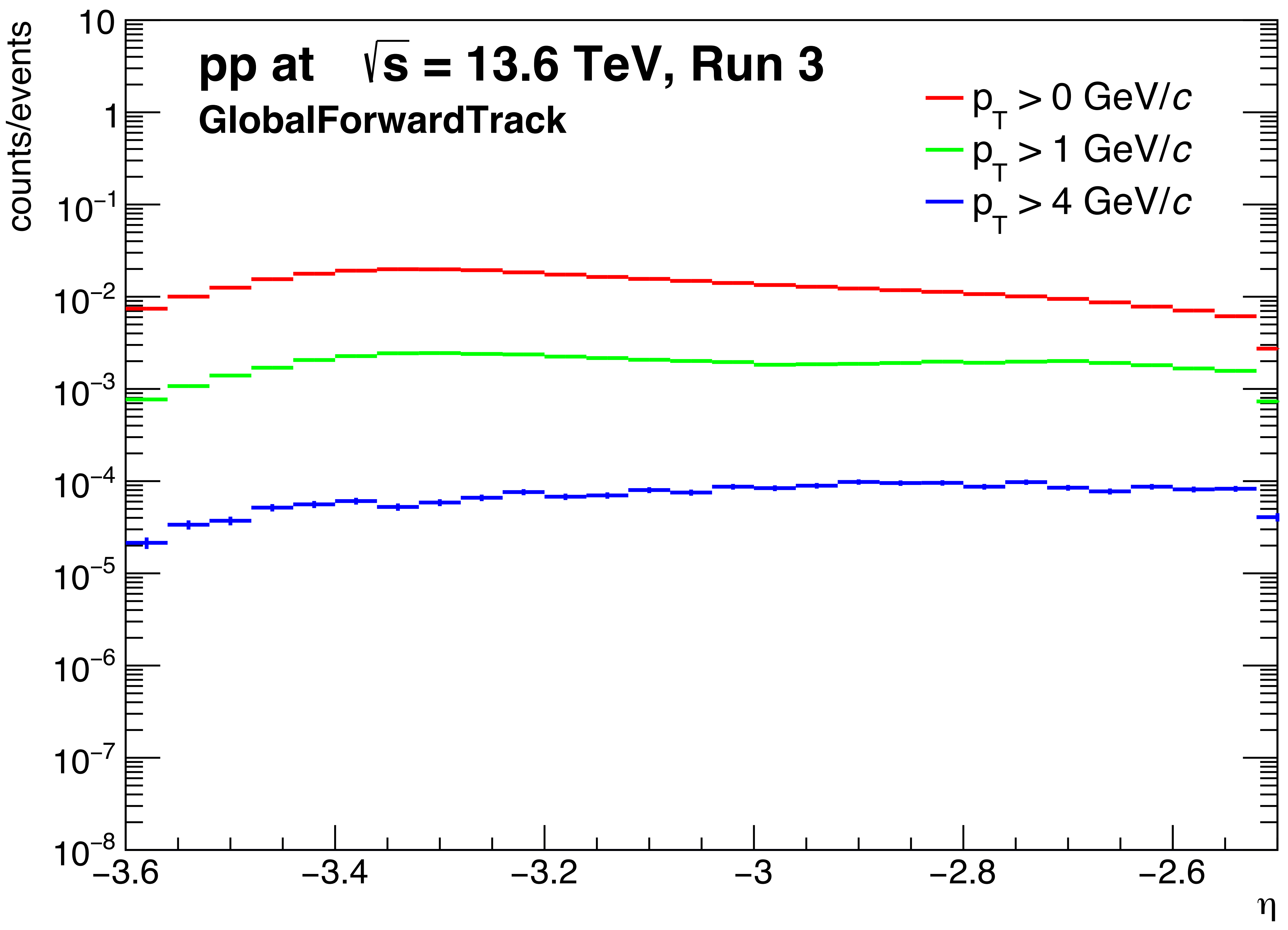


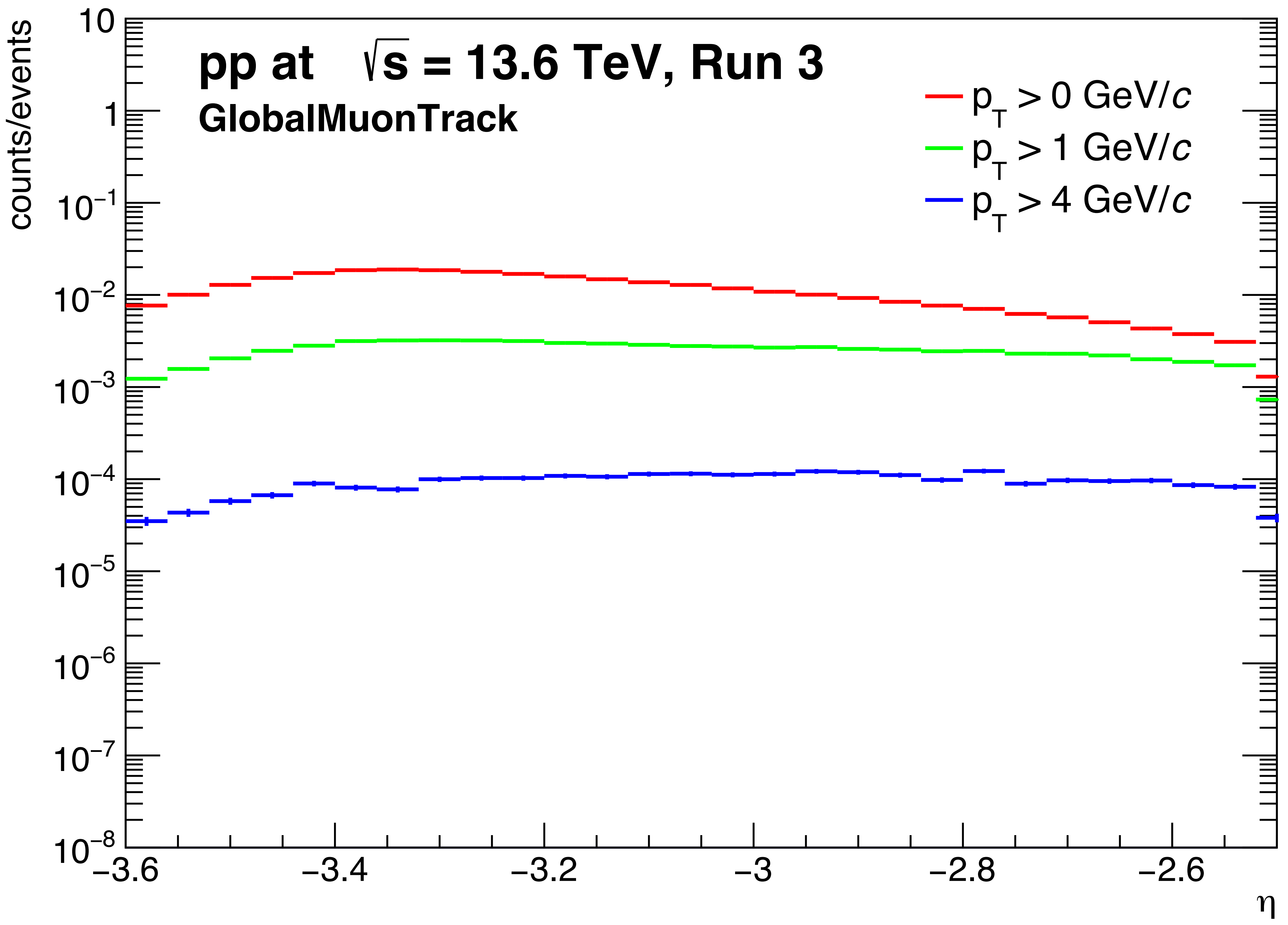


Comparison of η distribution between Muon Standalone tracks and Global Muon tracks

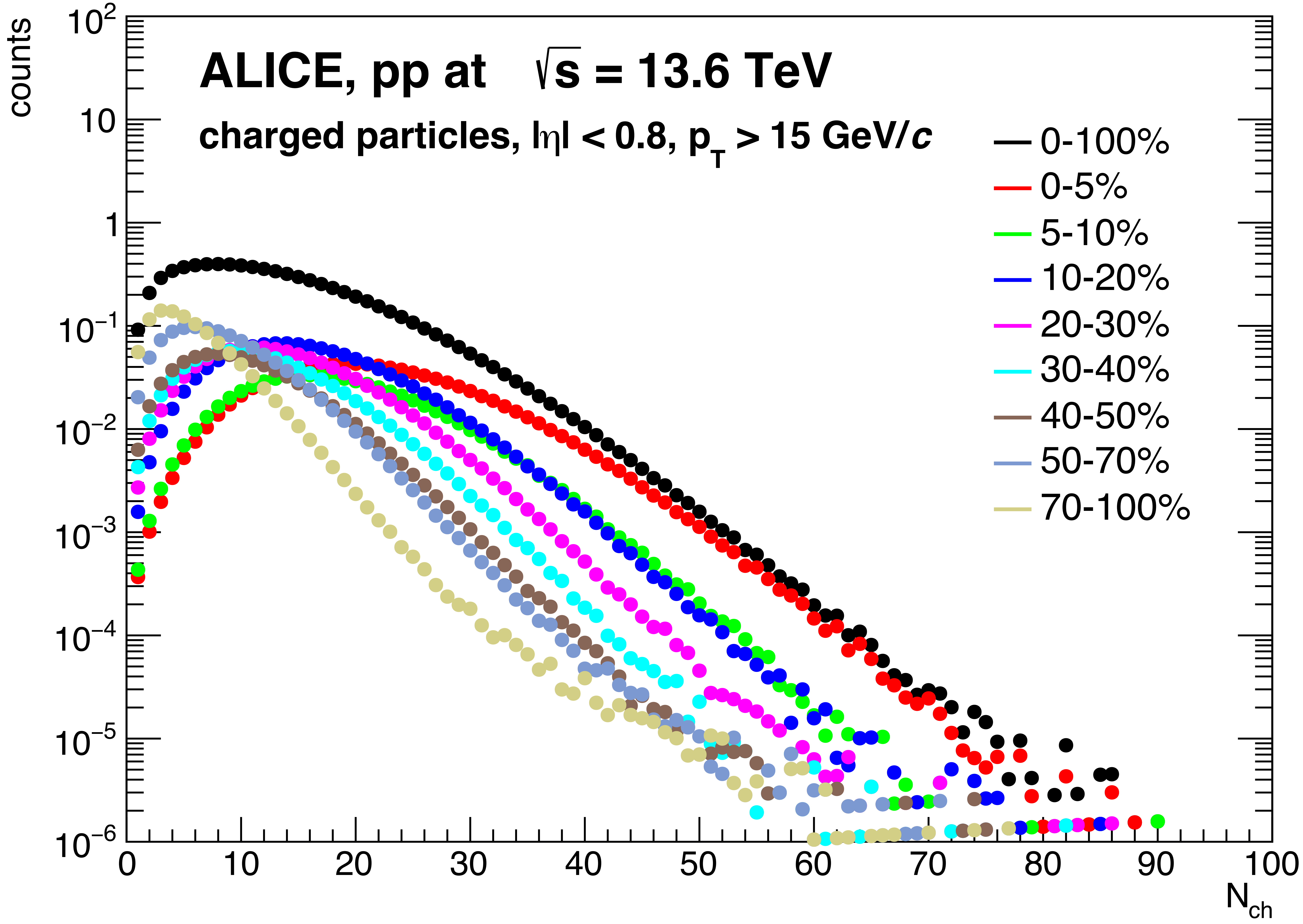


Comparison of η distribution at different p_T cuts

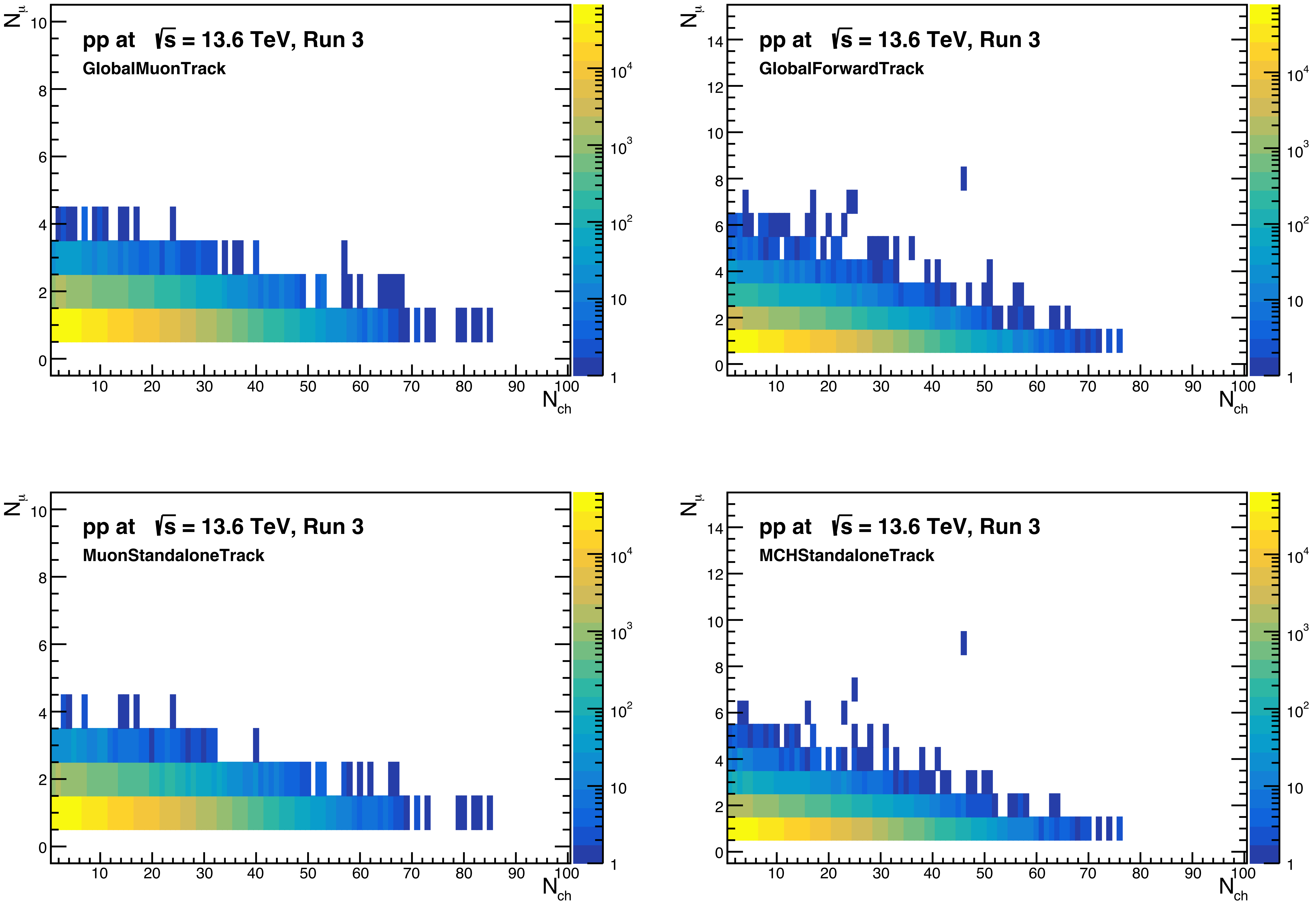




Charged Particle Multiplicity at various T0M Multiplicity percentile



Charged Particle Multiplicity Vs Inclusive Single Muon



Summary & Outlook

- p_T -spectra of muons at various selection cuts are observed.
- Matching the MCH tracks that with MFT clusters seen to have effect in reducing the beam induced background specially at high p_T region.
- Application of 6σ cut on $p \times DCA$ is efficient to removed the beam induced background.

- To explore study with MC including Acceptance times efficiency ($A \times \epsilon$)correction.
- Need to explore tuning for $\Delta p_T, \chi^2$, pDCA values in matching the MCH-MFT tracks in order to match the spectra of Muon Standalone Tracks and Global Muon Tracks.
- The analysis task is committed in O2Physics repository: https://github.com/AliceO2Group/O2Physics/pull/10435
- Analysis with full dataset in pp collisions at $\sqrt{s}$ = 13.6 TeV.

thank you

backup

Selection cuts for globalTrack

Cuts	globalTrack
min number of crossed rows TPC	70
min ratio of crossed rows over findable clusters TPC	0.8
max chi2 per cluster TPC	4.0
max chi2 per cluster ITS	36.0
require TPC refit	true
require ITS refit	true
max DCA to vertex z	2.0
max DCA to vertex xy	$0.0105 * 0.035 / p_T^{1.1}$
cluster requirement ITS	Run 2 (Run 3): at least one hit in SPD (in 3 innermost ITS layers) [*]
p_T range	0.1 - 1e10
η range	-0.8 - 0.8

https://aliceo2group.github.io/analysis-framework/docs/basics-usage/HelperTasks.html#track-selection