From matching performances to charm/beauty separation

Run 3 preparation with ALICE and MFT

Nicolas Bizé, based also on Rita Sadek's results - 04/05/22

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Subatech

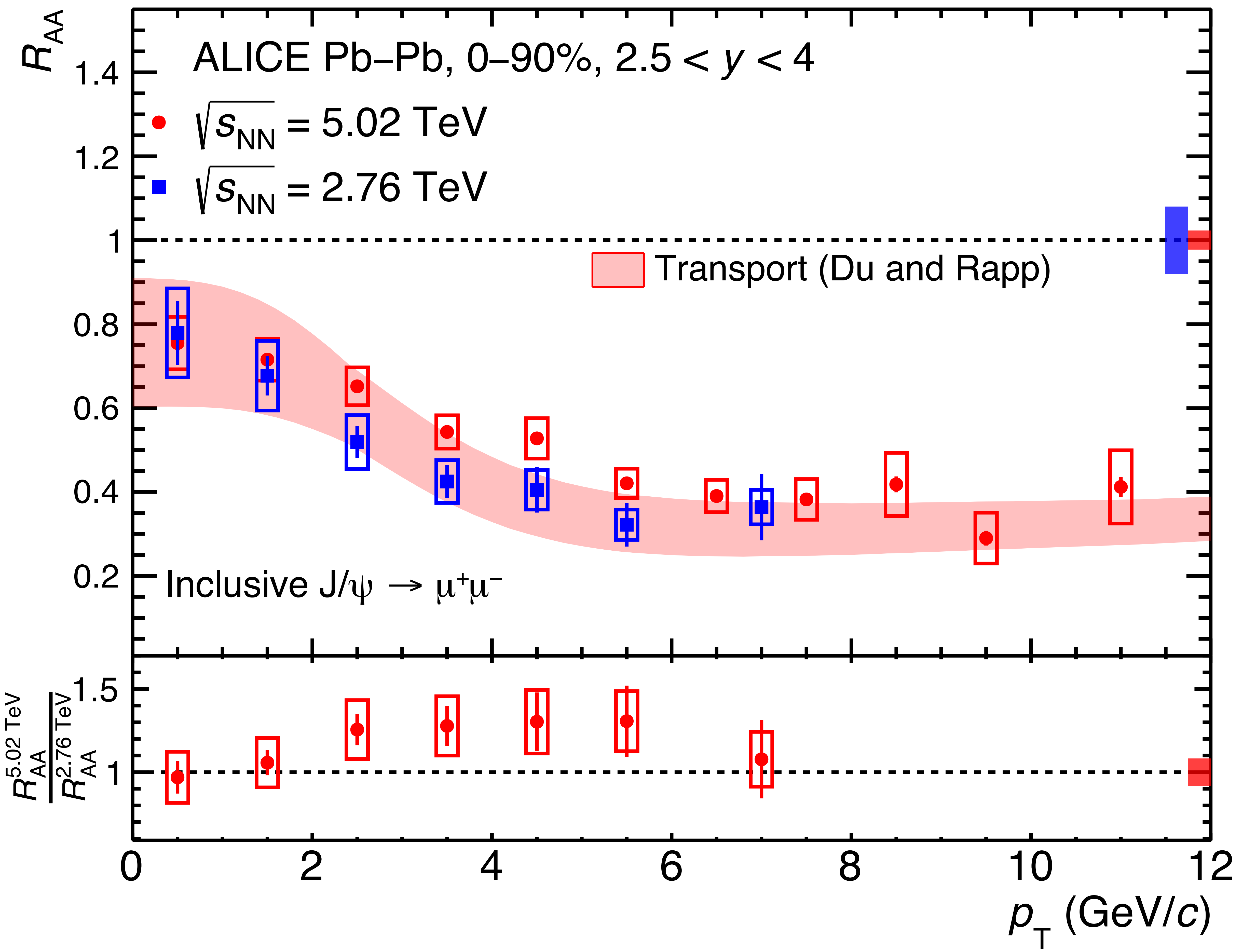
Charmonia studies in heavy ion collisions

- $c\bar{c}$ pairs created within hard partonic interactions
- Depending on medium temperature :
  - ➡ $c\bar{c}$ pairs may be dissolved (suppression)
- Possible recombinaison due to energy in c.m.
- Processes quantified through nuclear modification factor :

$$R_{AA} = \frac{N_{AA}^{Q\bar{Q}}}{\langle T_{AA} \rangle \cdot \sigma_{pp}^{Q\bar{Q}}}$$

J/ψ suppression in ALICE

- Inclusive J/ψ suppression studied at forward rapidity down to zero p_T
- No differentiation between prompt and non-prompt J/ψ in Run 1 and Run 2 at forward rapidity
- To do so, tracking and vertexing performances need to be improved



JHEP 02 (2020) 041

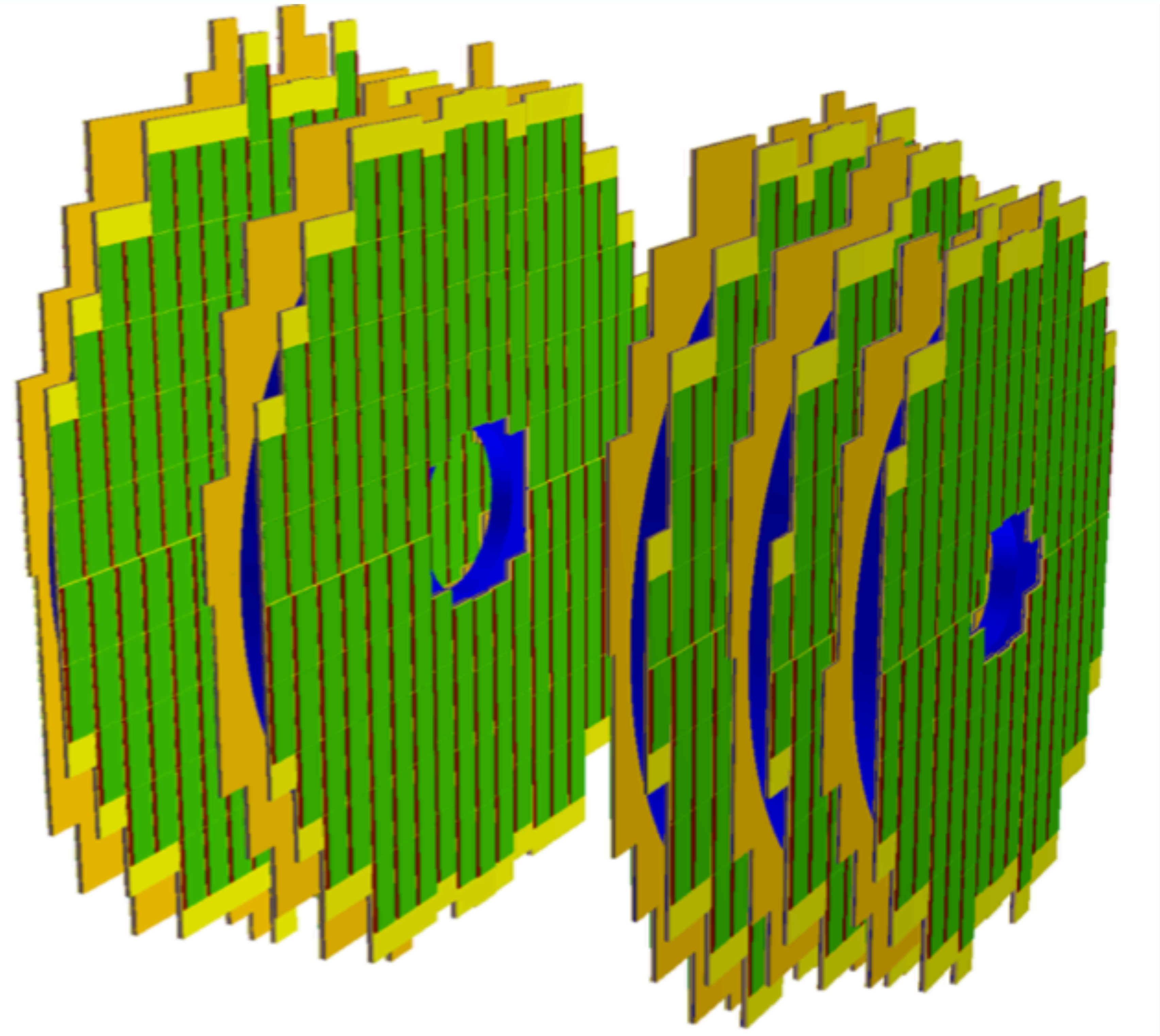
MUON spectrometer Run 2

Muon tracking and vertexing limitations due to the front absorber :

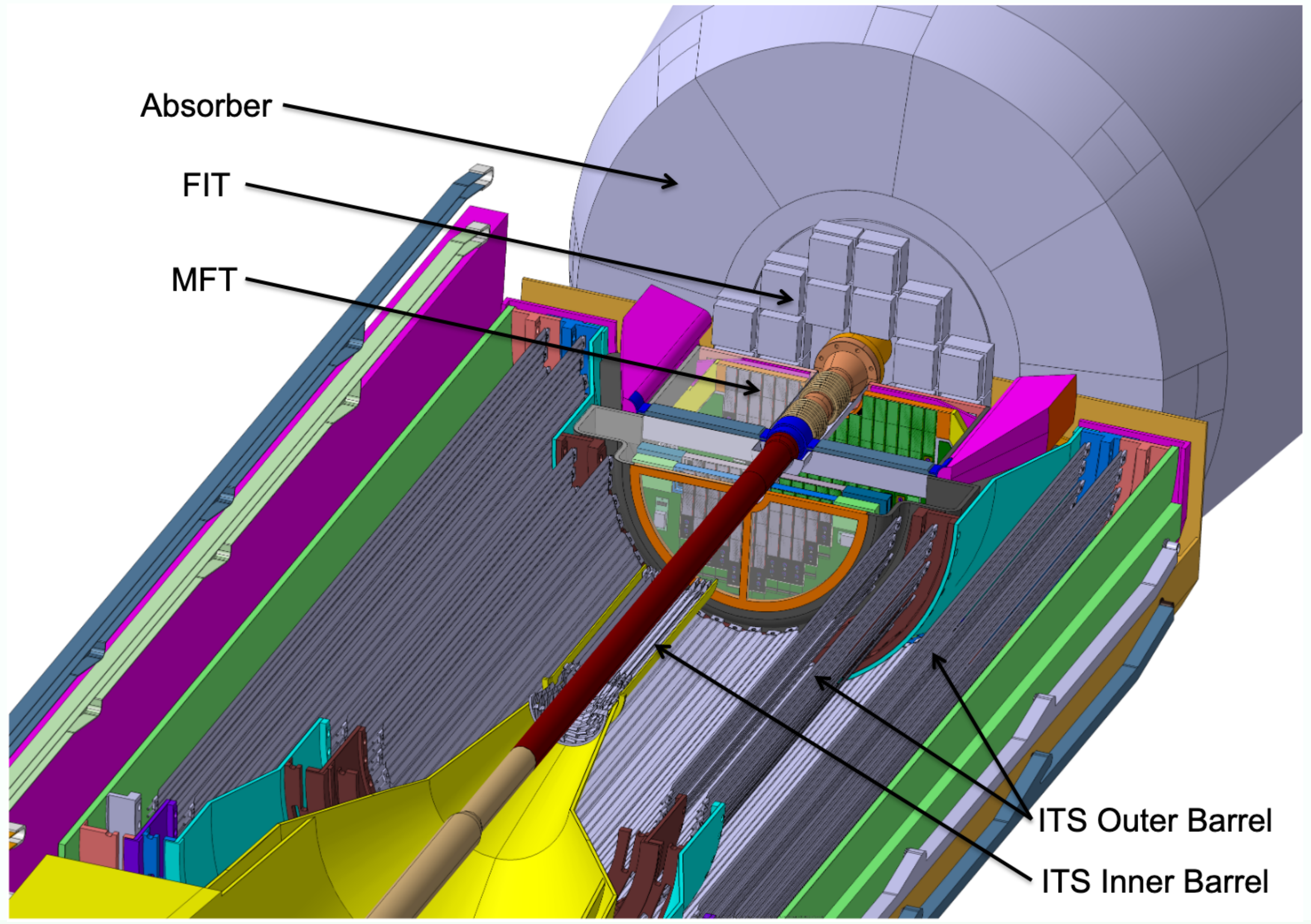
- ✦ Energy loss : modification of track transverse momentum
- ✦ Multiple Scattering
- ✦ No tracking station before the absorber

Muon Forward Tracker

- Installed between ITS and the absorber
- Designed to obtain high spatial resolution
- Five double sided disks composed of 936 silicon pixel sensors



ALICE-TDR-018



$$-3.6 < \eta < -2.5$$

MUON spectrometer + MFT Run 3

Improve tracking precision and vertexing capabilities :

- ✦ Distinction between primary vertex and secondary vertex
- ✦ Known muon entry angle
  - ➡ Better mass resolution

Matching studies between MFT and MUON spectrometer

Matching in Global MUON

- Global MUON : MFT-(MCH-MID)
  - ✦Matching MCH and MID
  - ✦Tracking in MFT standalone
  - ✦MCH-MID track extrapolated to first MFT disk before absorber

Matching achieved over 5 parameters :
X, Y, ϕ, tan(λ), Q/p_T

Global MUON matching assessment tools

- Assessing the matching performances :

✦ Pairing purity

$$P_{pairing} = \frac{N_{True}}{N_{Rec}}$$

✦ Pairing efficiency

$$\varepsilon_{pairing} = \frac{N_{Rec}}{N_{Pairable}}$$

✦ True pairing efficiency

$$\varepsilon_{pairing}^{true} = \frac{N_{True}}{N_{Pairable}}$$

✦ Fake pairing efficiency

$$\varepsilon_{pairing}^{fake} = \frac{N_{Fake}}{N_{Pairable}}$$

True : Track that have correct MFT-MCH pair association

Rec : Reconstructed Global MUON track

Pairable : track that have been correctly reconstructed by both MFT and MCH and comes from the same generated track

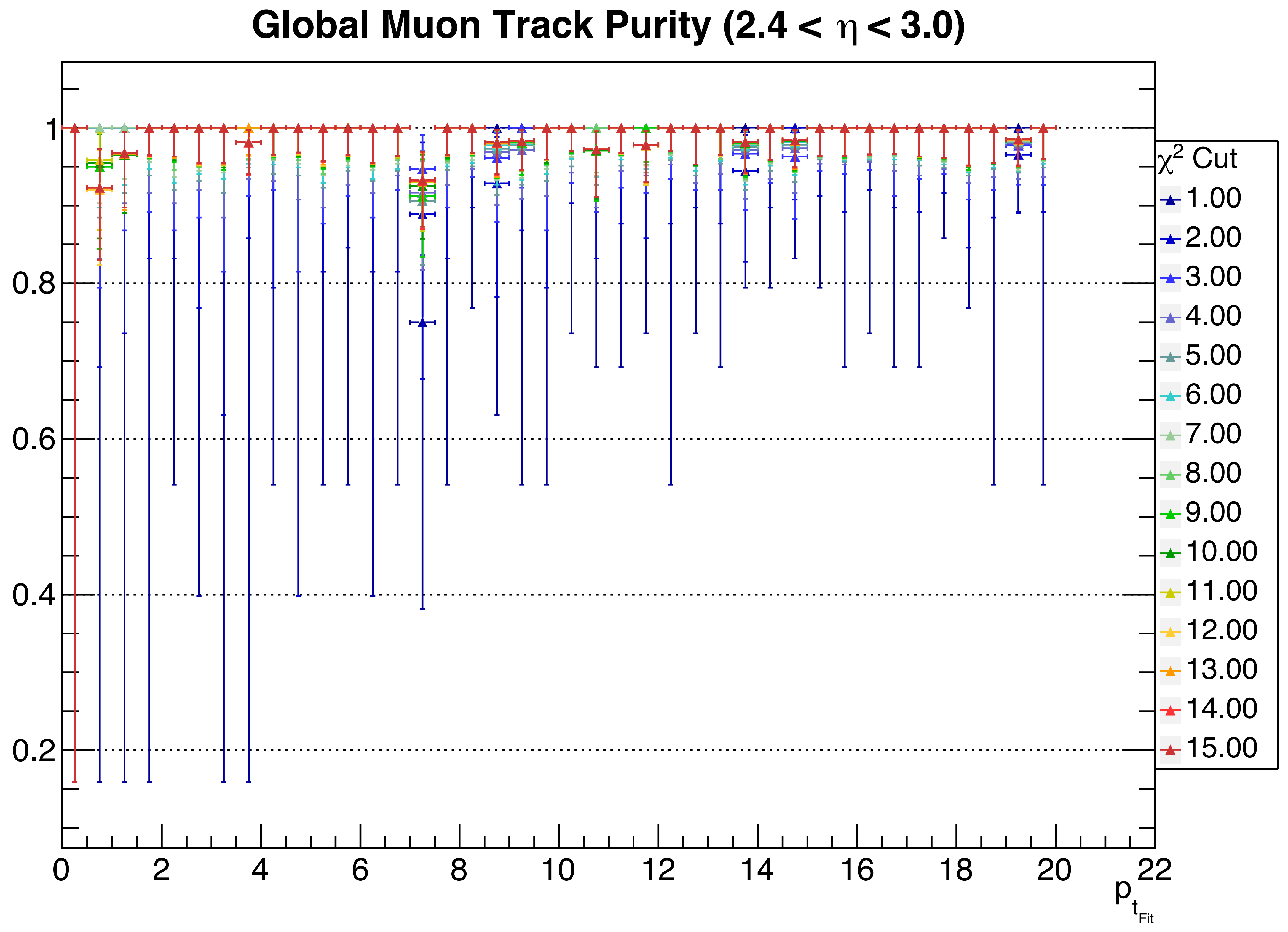
Developing assessment tools

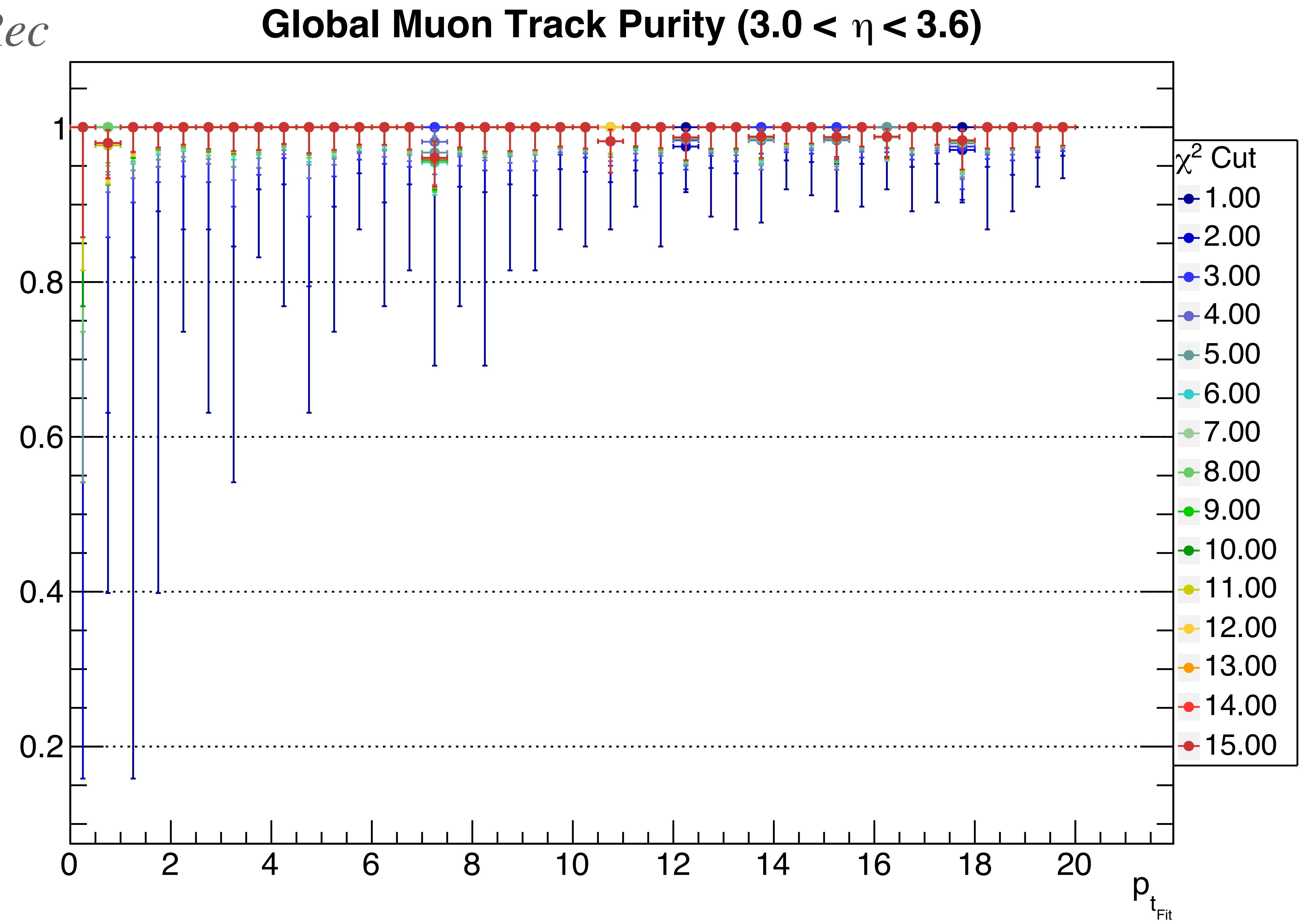
- Test with simple simulation
  - ➡ 10 μ per events ~1000 events

$$P = \frac{N_{True}}{N_{Rec}}$$

χ^2 calculated between MFT and MCH parameters

x, y, ϕ, $\tan(\lambda)$, q/p_T





True : Track that have correct MFT-MCH pair association

Rec : Reconstructed Global MUON track

Developing assessment tools

- Test with simple simulation
  - ➡ 10 μ per events ~1000 events

$$\varepsilon_{pairing} = \frac{N_{Rec}}{N_{Pairable}}$$

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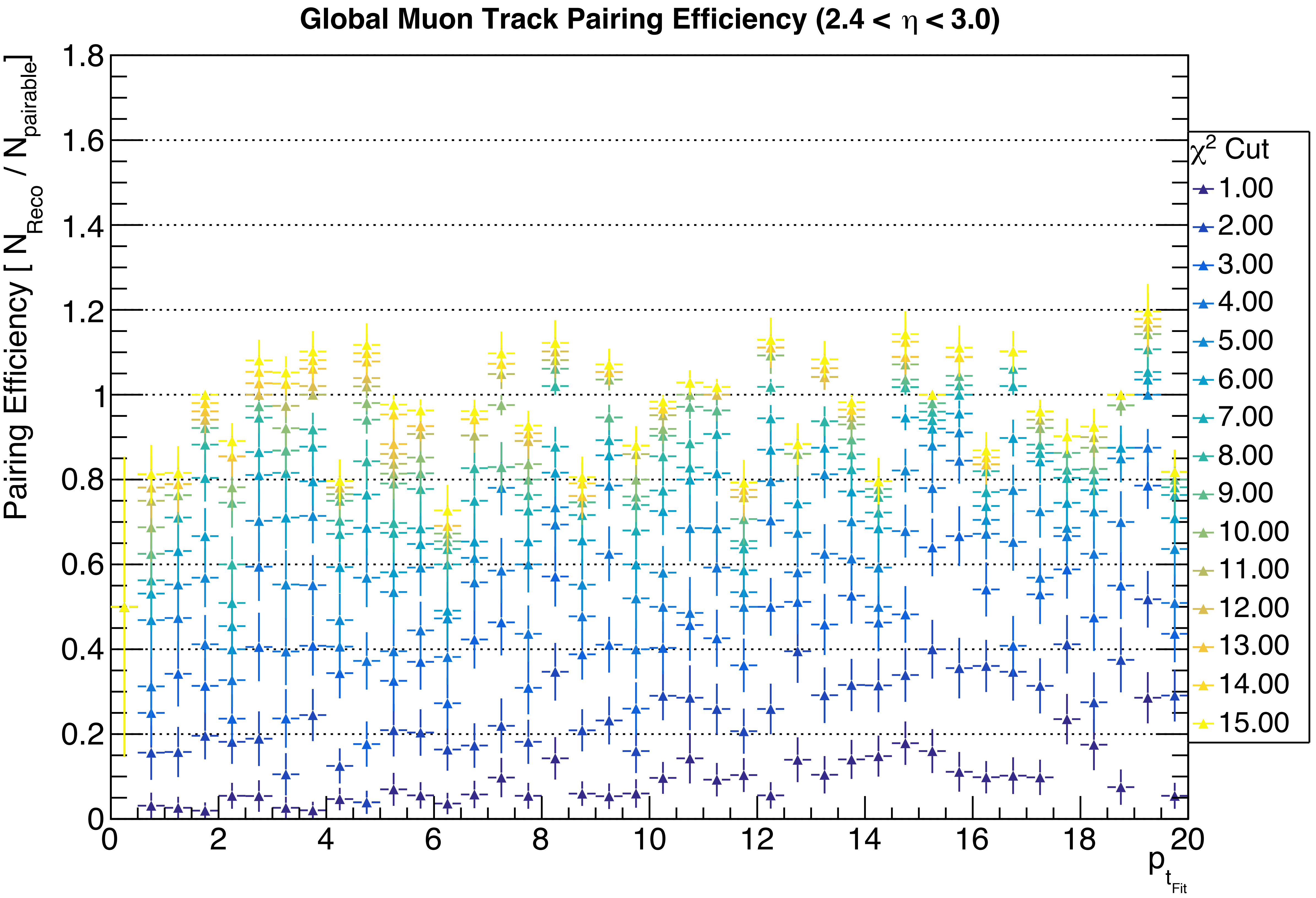
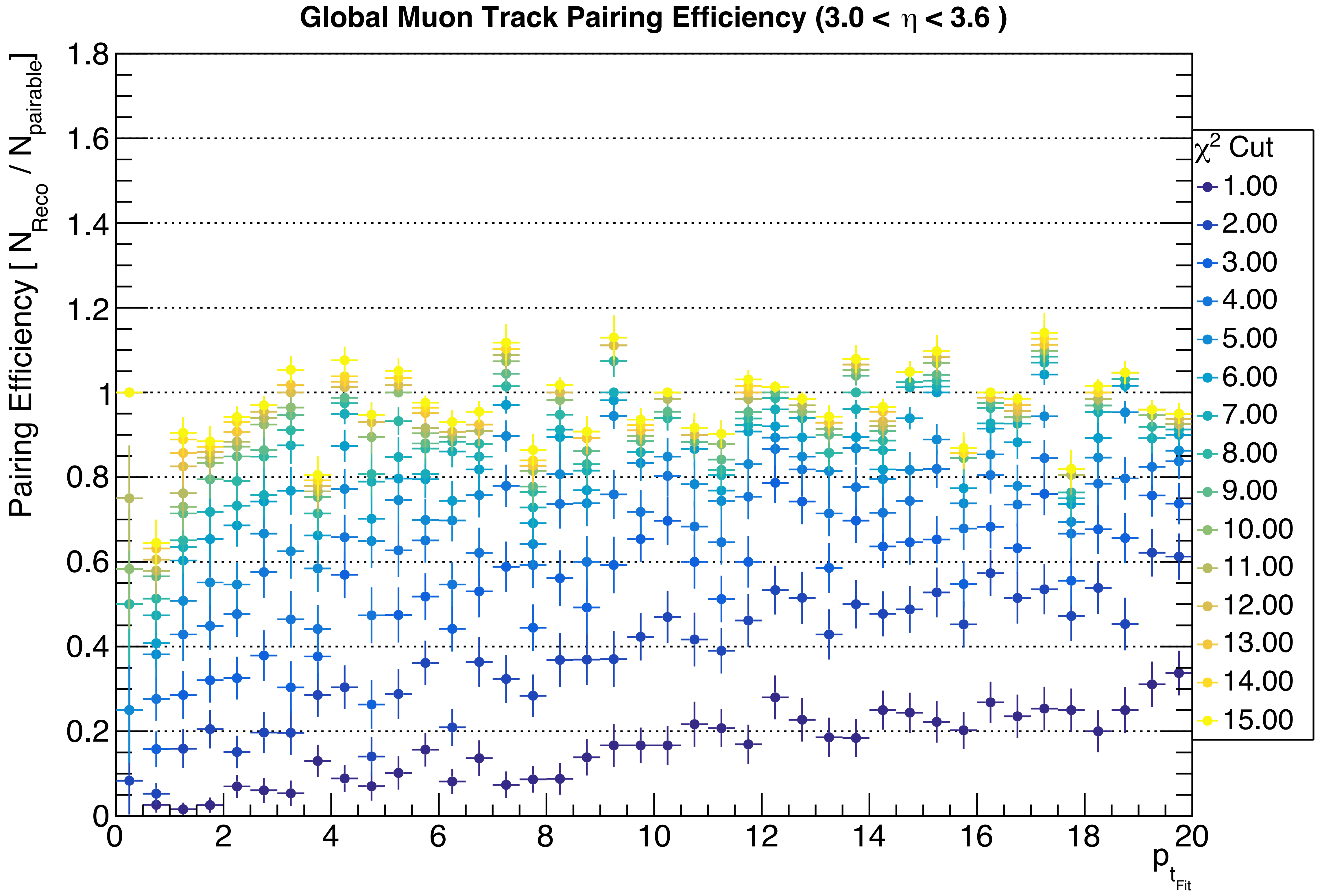
$x, y, \phi, \tan(\lambda), q/p_T$





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Developing assessment tools

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χ^2 calculated between MFT and MCH parameters

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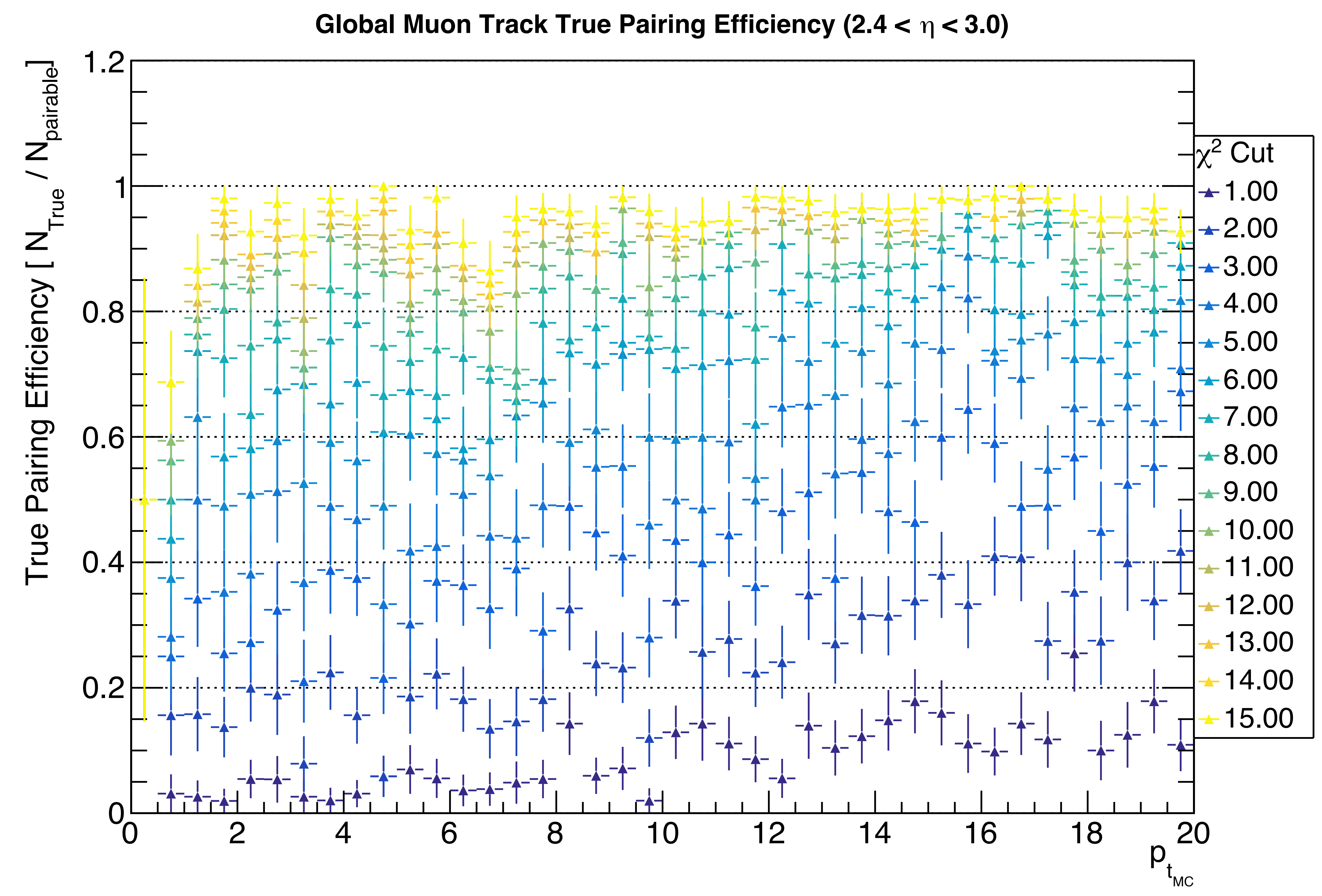
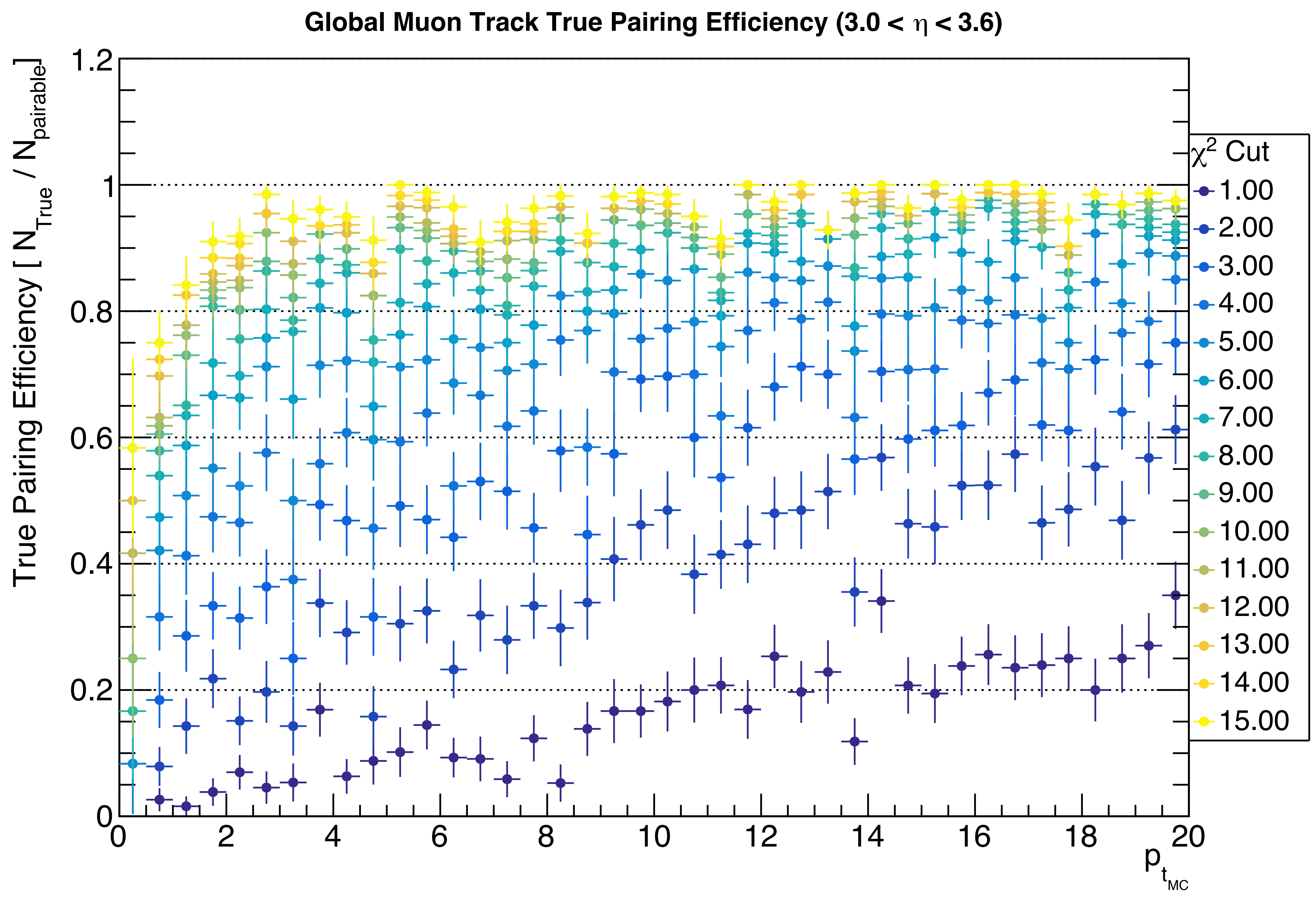




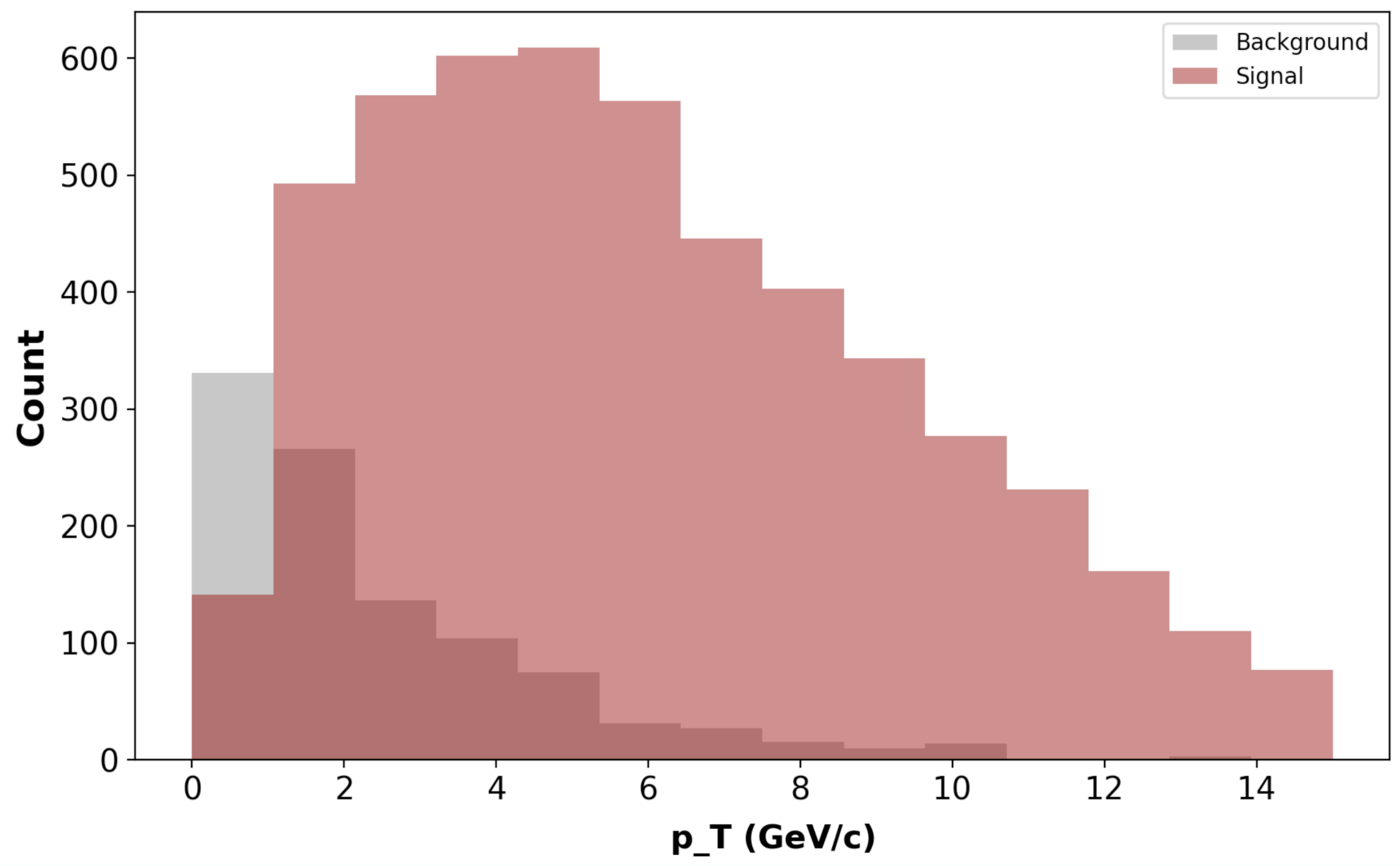
Matching performances with Machine Learning

ALICE

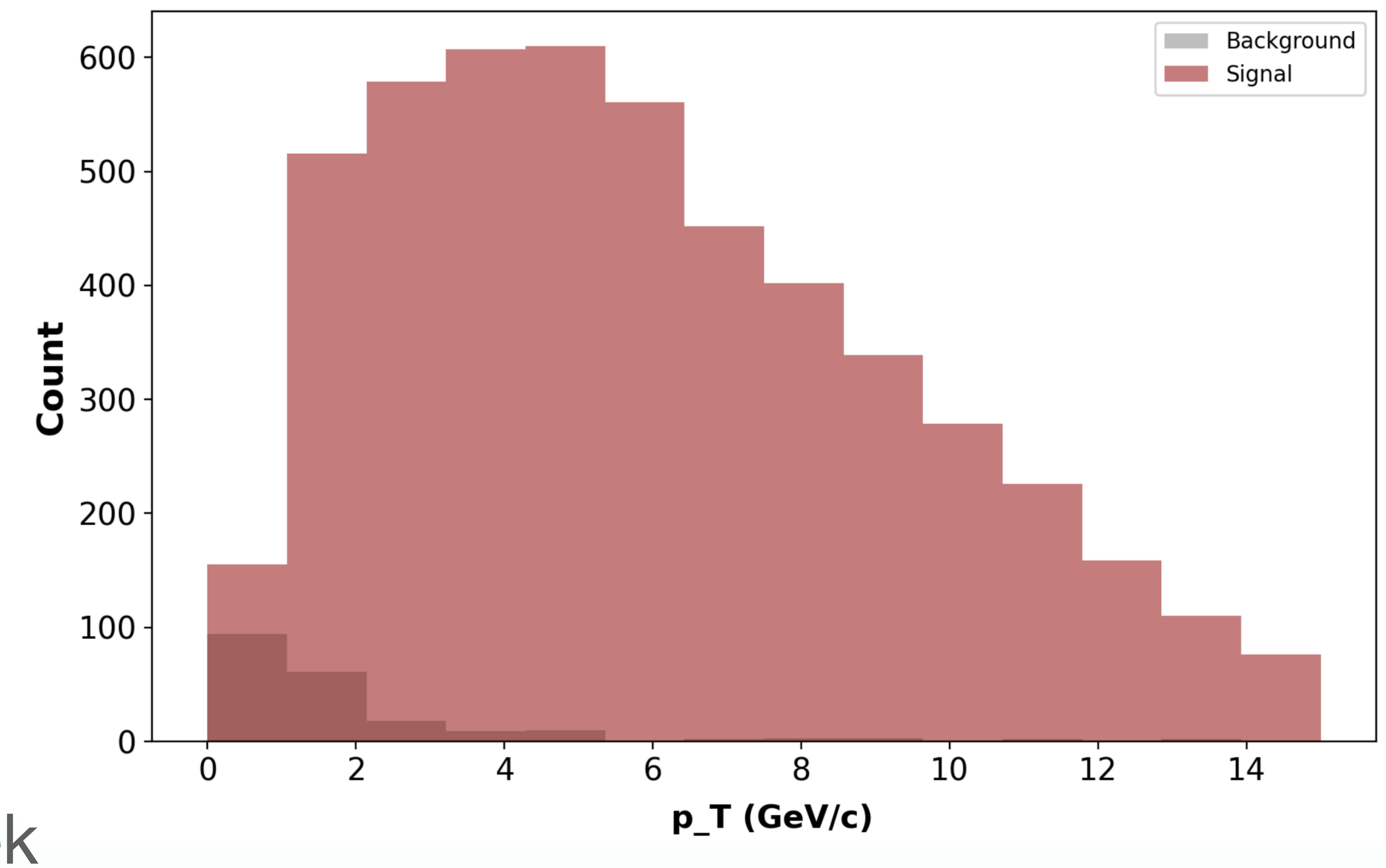
- In development : matching based on Machine Learning (ML) to minimise effects on muon path inside the absorber
- Neural network with Tensorflow :
  - ✦ Input layer : coordinates for MFT-MCH tracks and χ^2 score associated
  - ✦ Output layer : score of a correct match

Correct matches
Bad matches

Matching based on χ^2



Matching based on ML



Rita Sadek

Vertexing and charm/beauty separation studies

How do we separate prompt and non-prompt ?

- Pseudo proper decay time τ_z used at forward rapidity :

$$\tau_z = \frac{(z_{J/\psi} - z_{vtx}) \cdot M_{J/\psi}}{p_z}$$

- Calculation of distance between primary vertex and secondary vertex (presented at QGP France 2021)

ALICE-TDR-018

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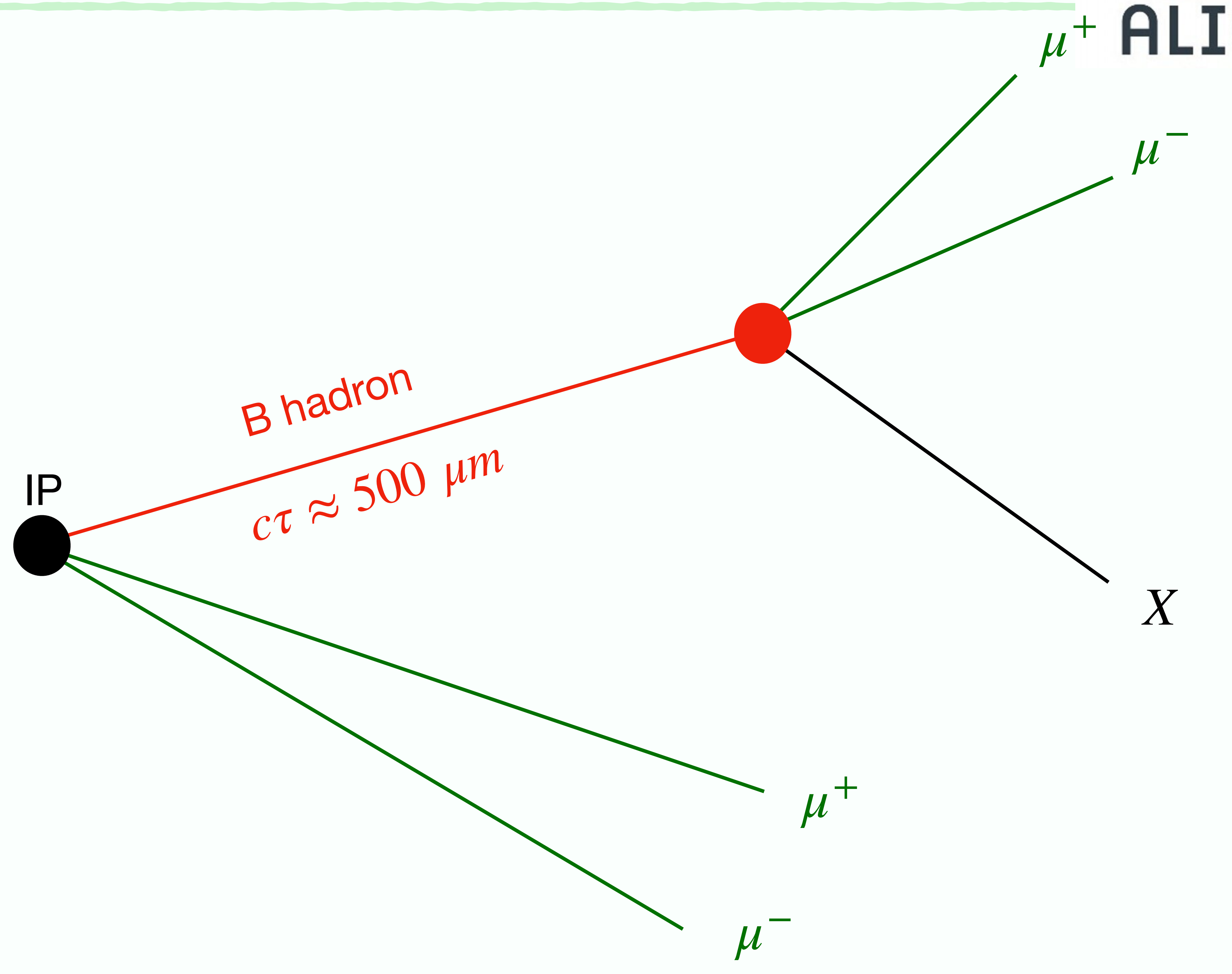

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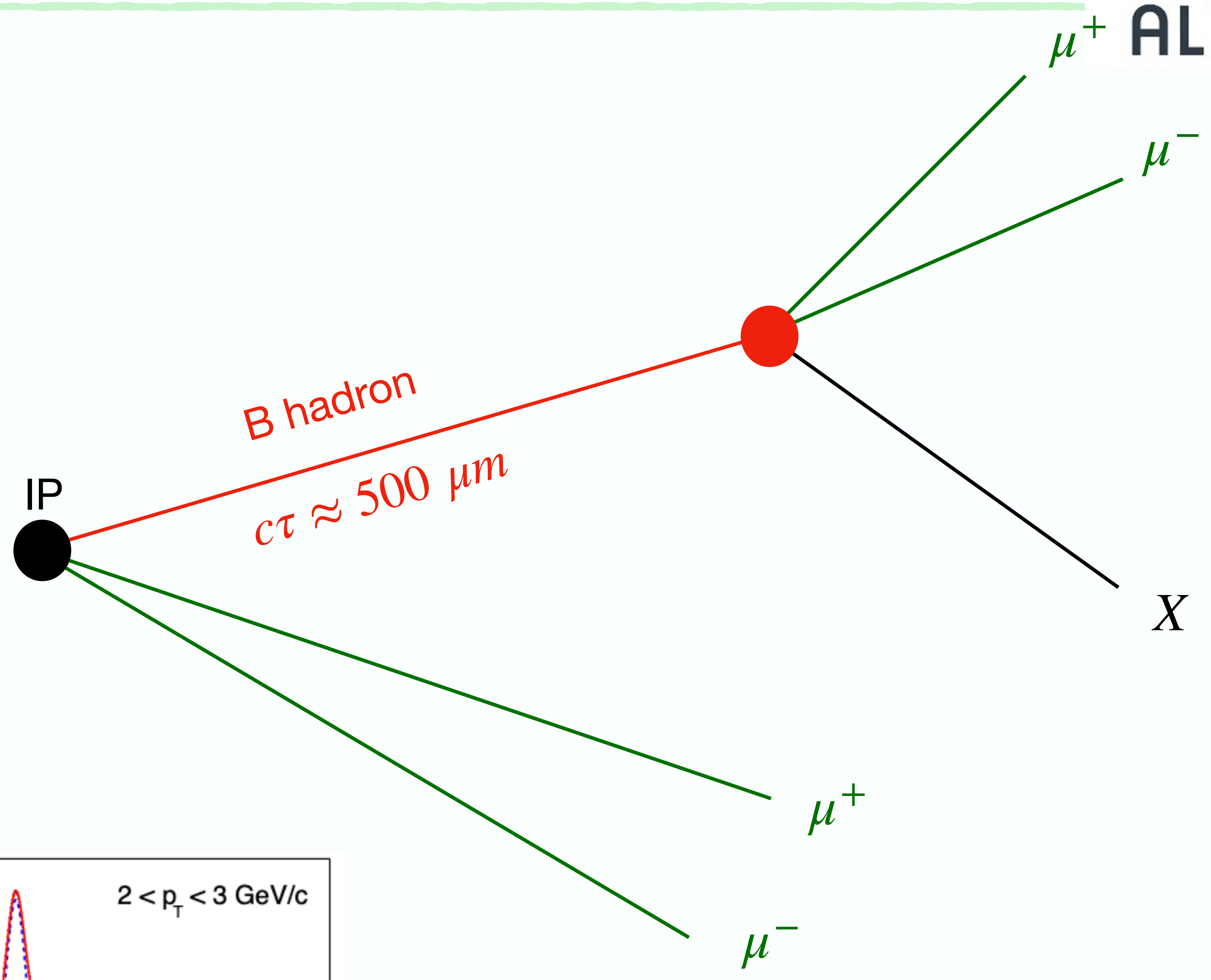

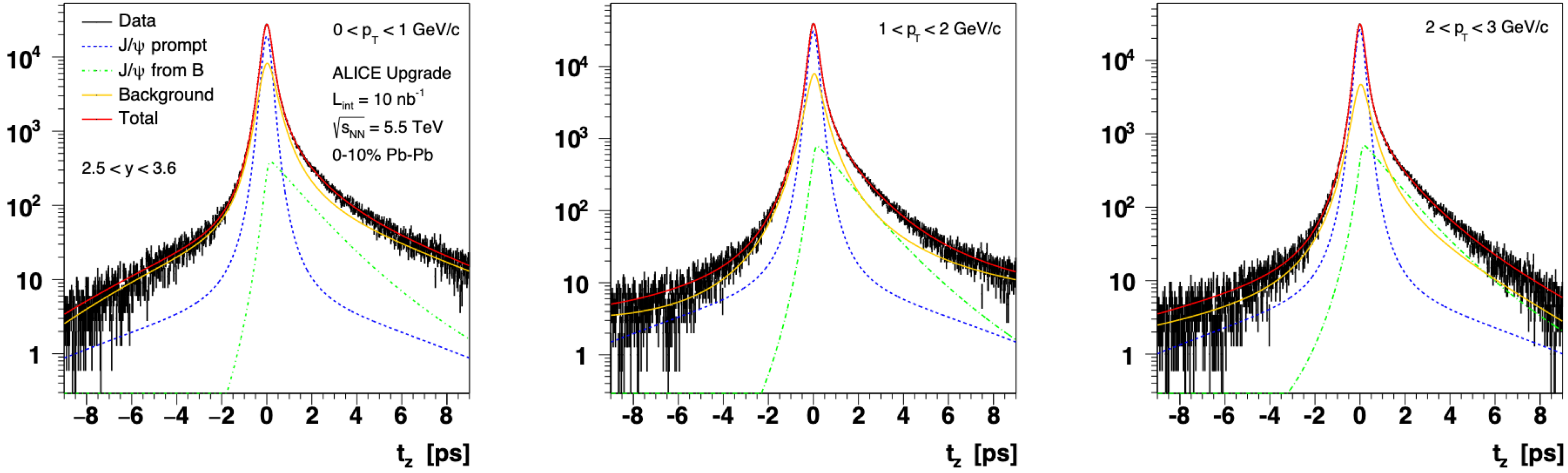

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Toward charm/beauty separation

- Exemple on an analysis :

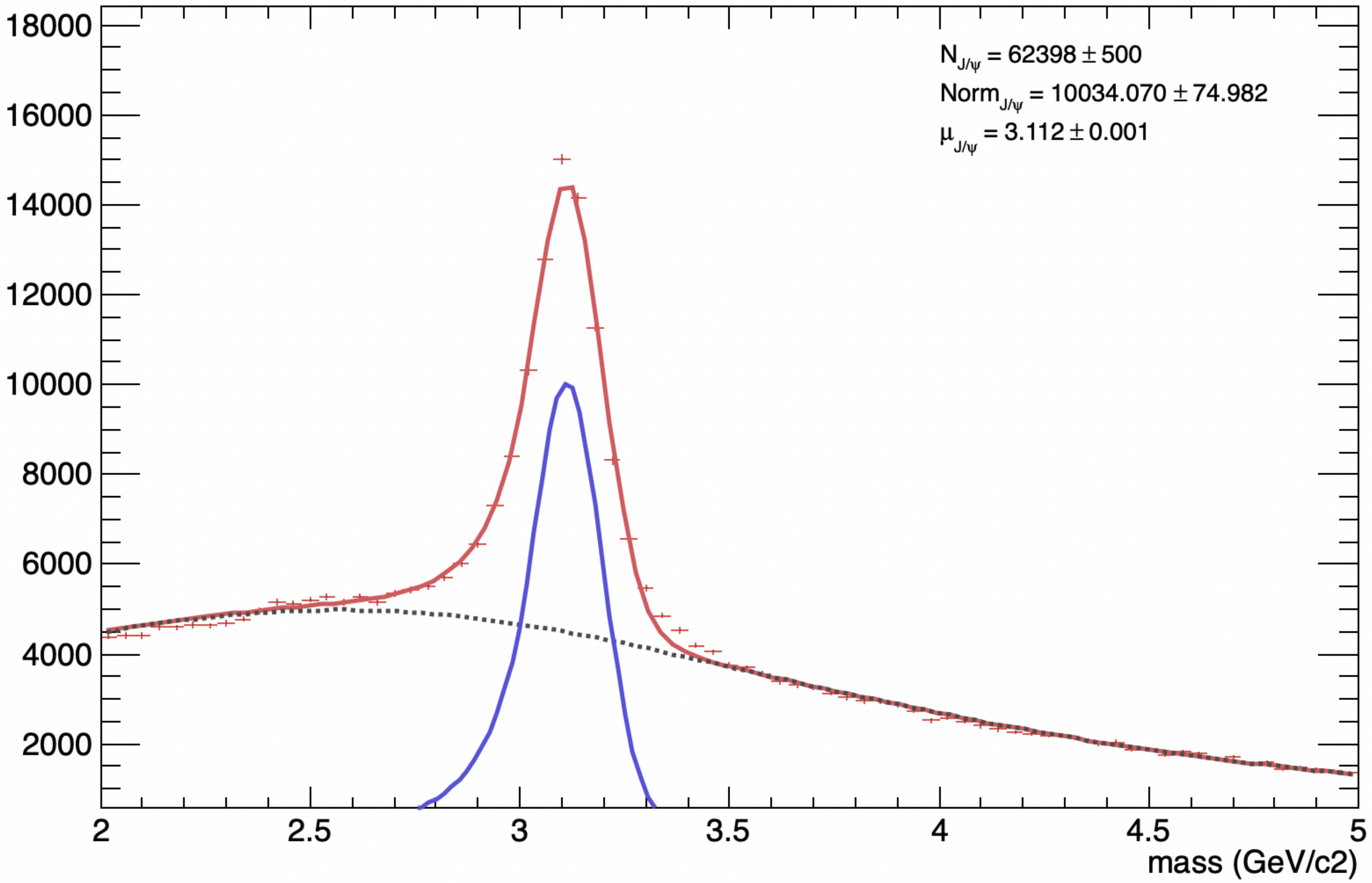
  ✦ Prompt charmonia embedded production :

  ➡ pp at 900 GeV

  ➡ 4 J/ψ and 2 $\psi(2S)$ per event

  ✦ Study of τ_z distribution in dimuon channel :

$$\tau_z = \frac{(z_{J/\psi} - z_{vtx}) \cdot M_{J/\psi}}{p_z}$$



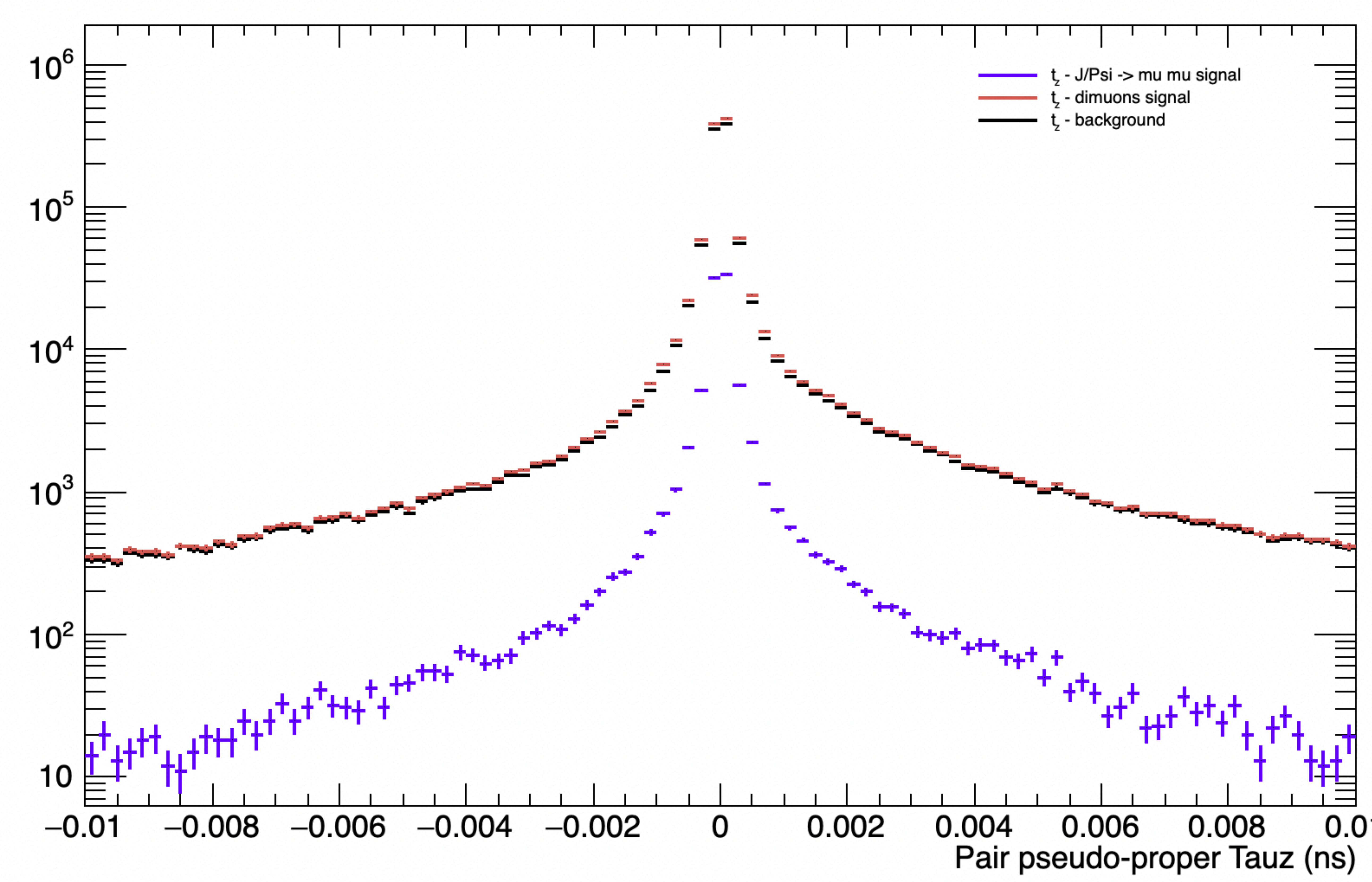
Study of prompt charmonia Monte Carlo

ALICE

- Observation of **background** much higher than the **signal**

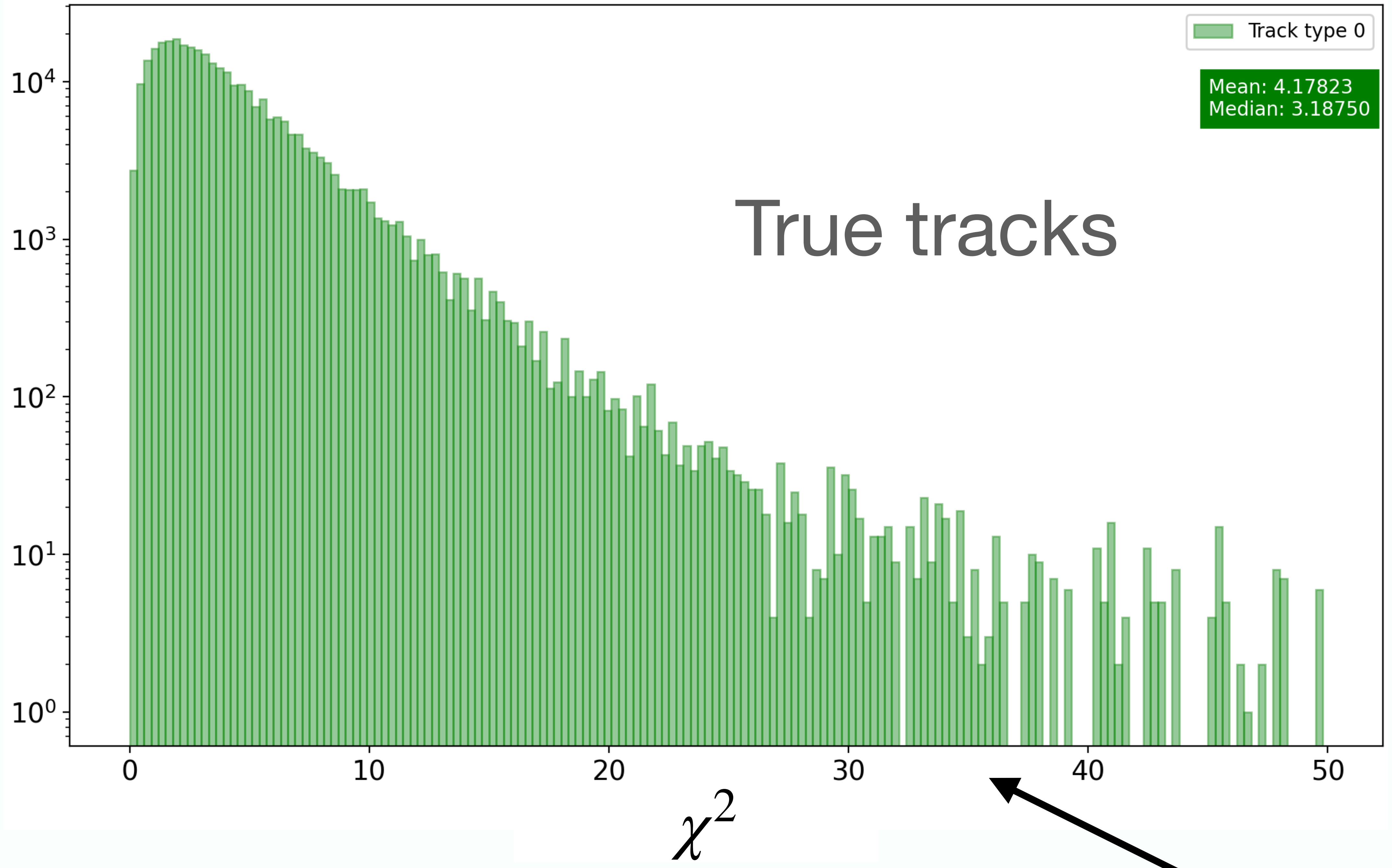
  ➡ Explained by number of 4 J/ψ and 2 $\psi(2S)$ per event

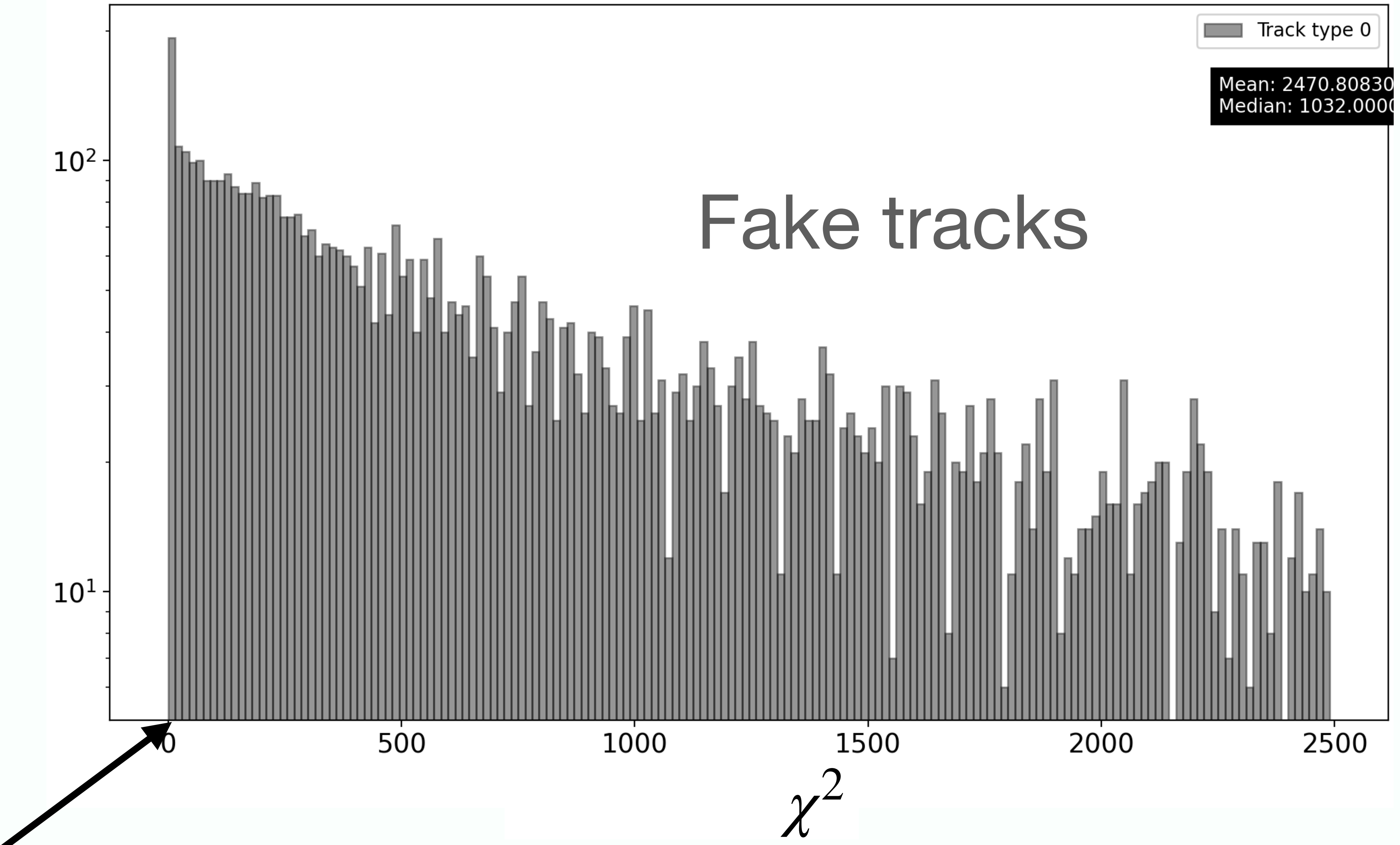
- Asymmetry for τ_z distribution on prompt charmonia Monte Carlo production



Study of prompt charmonia Monte Carlo

- Asymmetry study by comparing true and fake tracks
- χ^2 matching distributions for tracks matched in MFT-(MCH-MID)





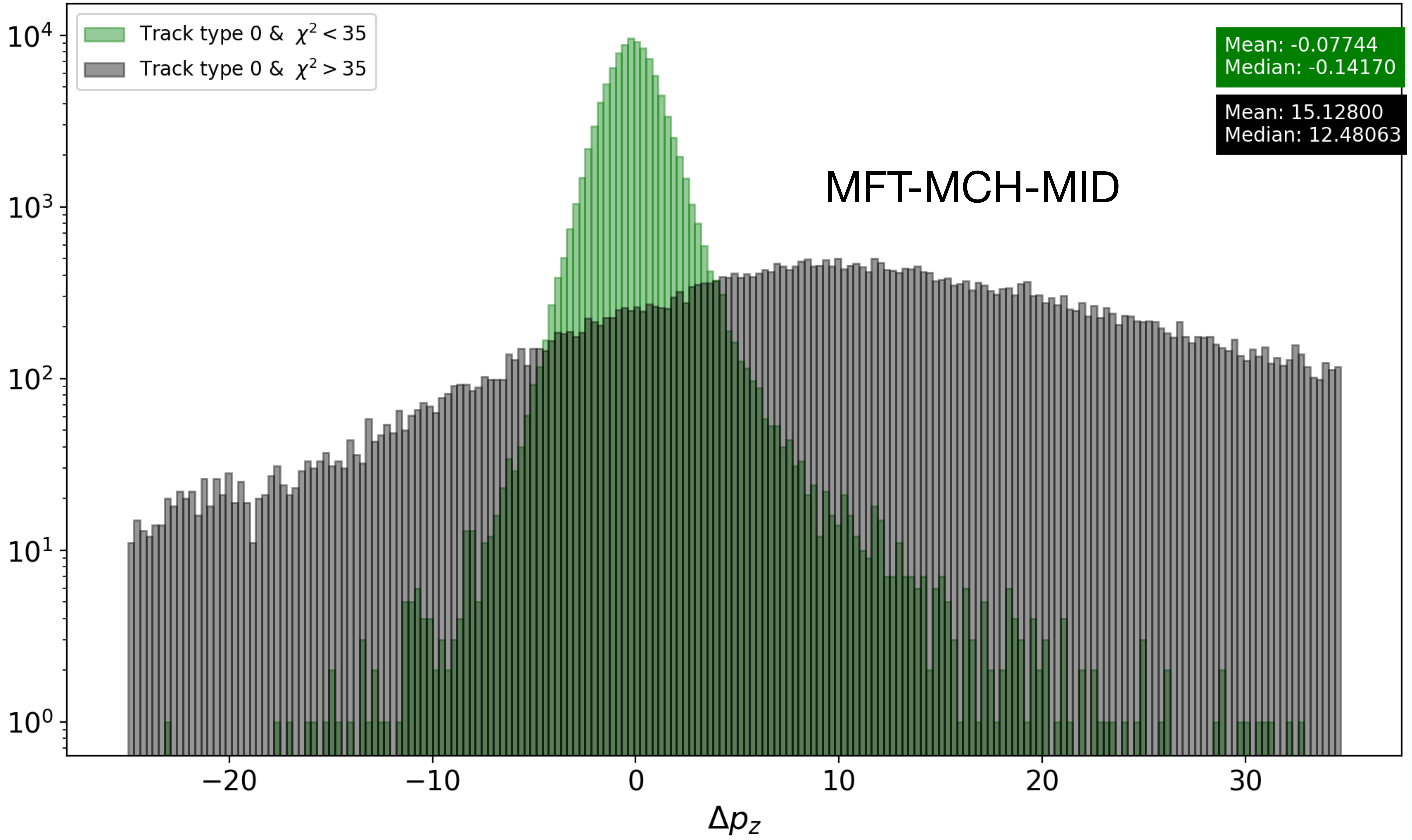
Arbitrary χ^2 cut > 35 to remove most of fake tracks but conserving most of true tracks

Study of prompt charmonia Monte Carlo

- True tracks $\chi^2 < 35$ and true tracks $\chi^2 > 35$

- χ^2 cut > 35 removes fake matches to Δp_z distribution

$$\Delta p_z = p_z^{Rec} - p_z^{MC}$$

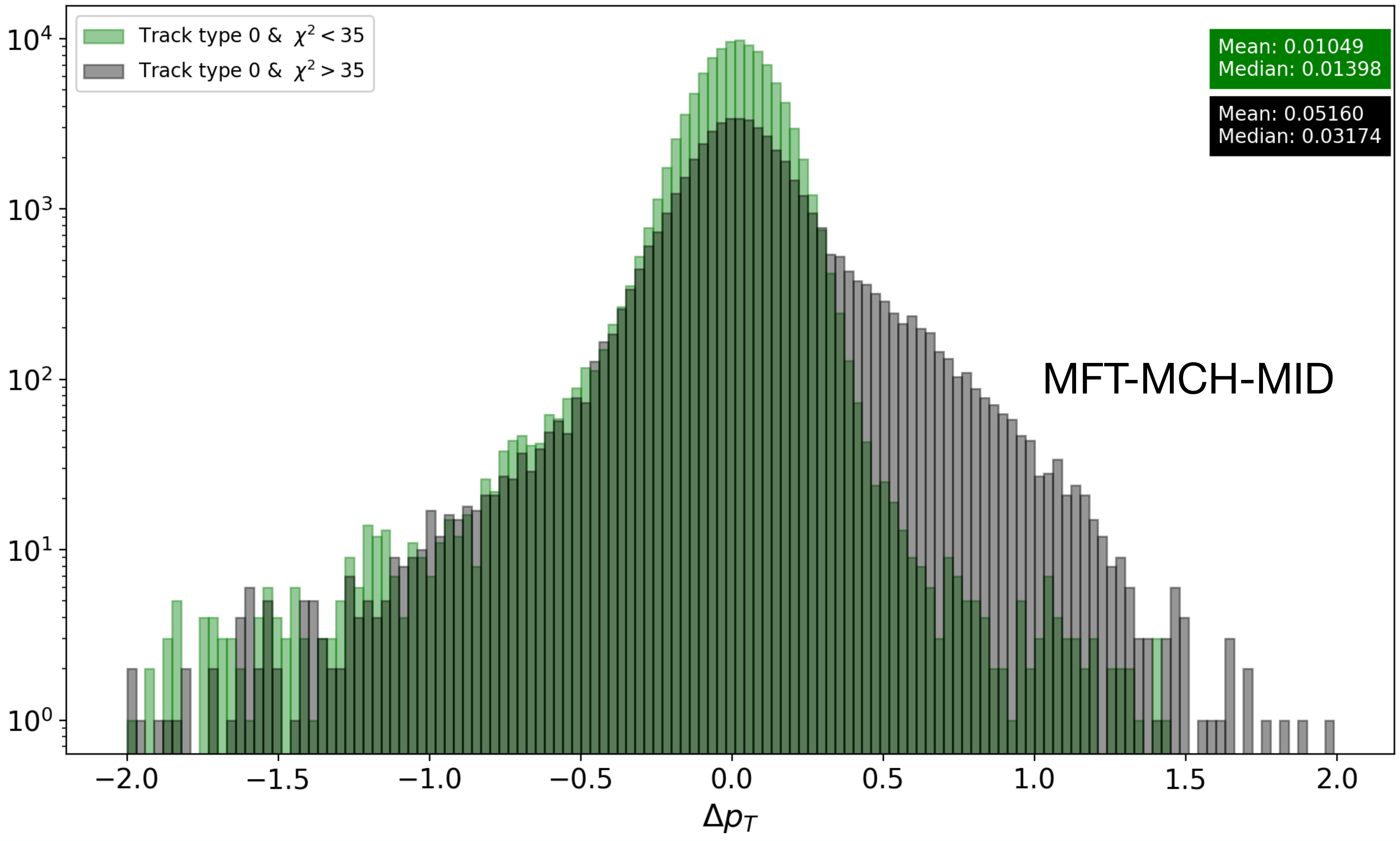


Study of prompt charmonia Monte Carlo

- True tracks $\chi^2 < 35$ and true tracks $\chi^2 > 35$

- χ^2 cut > 35 removes fake matches to Δp_{T} distribution

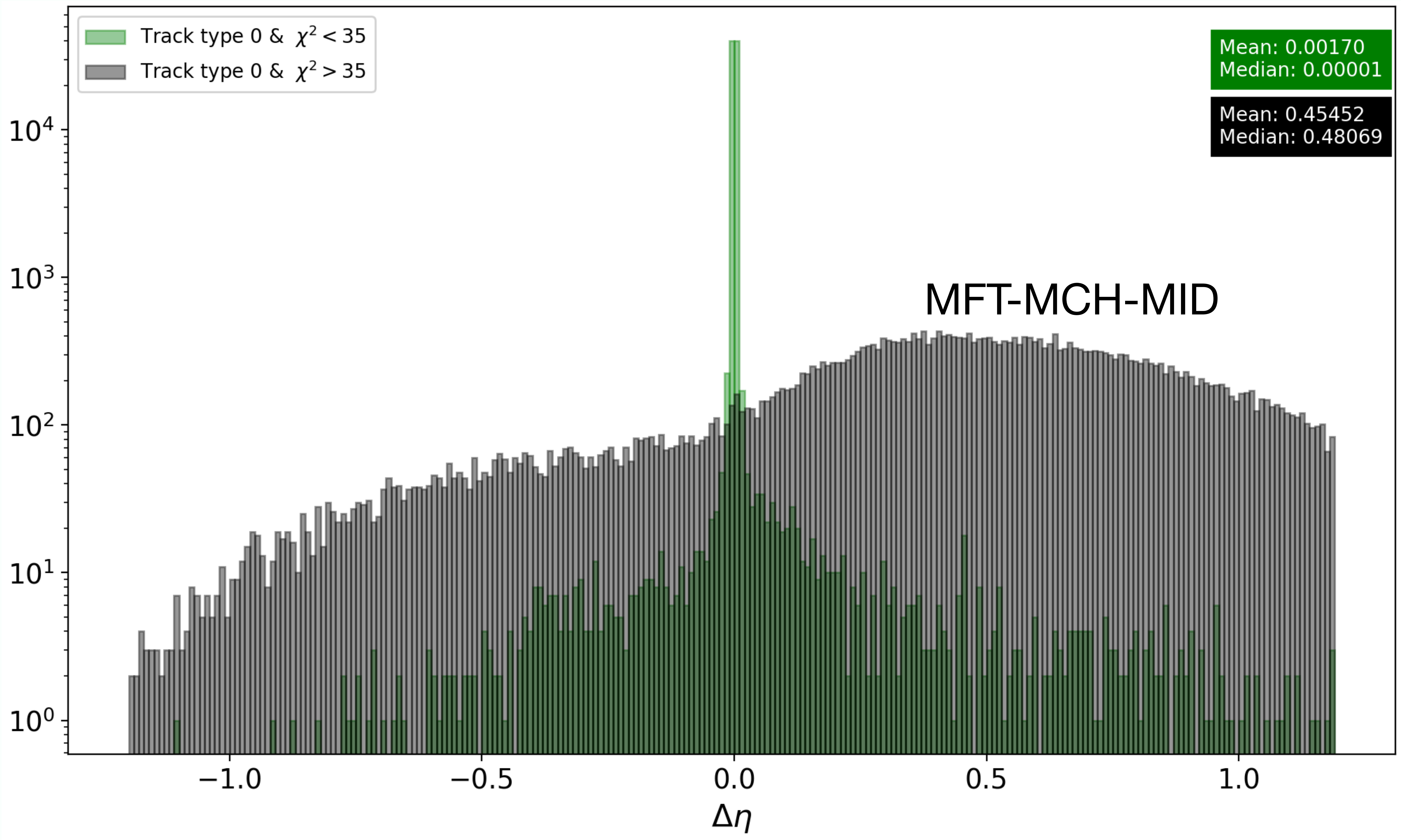
$$\Delta p_T = p_T^{Rec} - p_T^{MC}$$



Study of prompt charmonia Monte Carlo

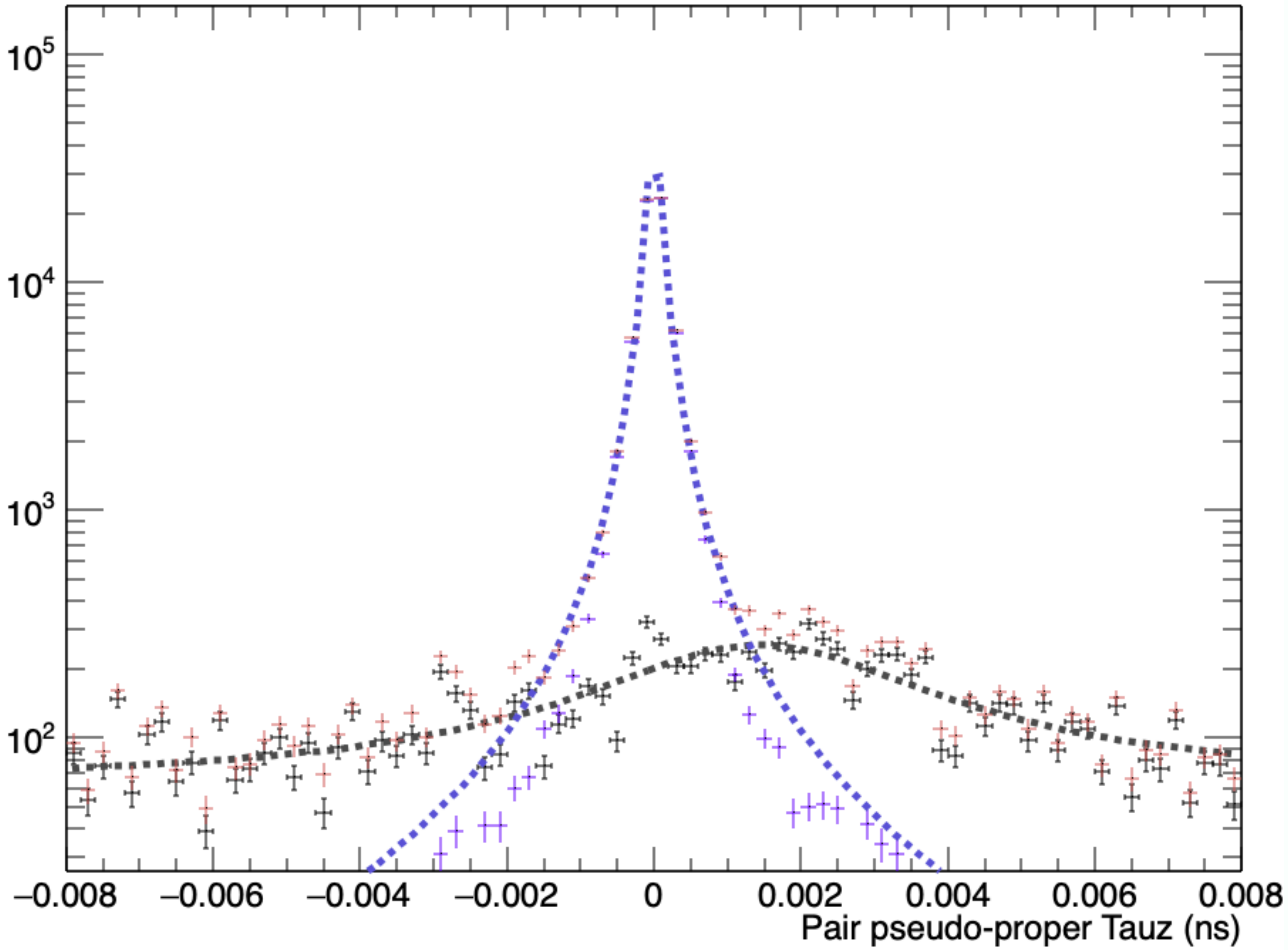
- True tracks $\chi^2 < 35$ and true tracks $\chi^2 > 35$
- χ^2 cut > 35 removes fake matches to $\Delta\eta$ distribution

$$\Delta\eta = \eta^{Rec} - \eta^{MC}$$



Study of prompt charmonia Monte Carlo

- Combinatorial background removed
- χ^2 cut > 35 suppress fake tracks
  ➡ Symmetry observed in prompt charmonia MC as expected



Conclusion and perspectives

- Matching performances
  - ✦ Global MUON matching assessment is on going
  - ✦ Encouraging results for matching based on Machine Learning compared to χ^2 based method
- Vertexing performances
  - ✦ First studies with tracks matched with MFT-(MCH-MID) on Monte Carlo
  - ✦ Assessment for τ_z distribution in prompt/non-prompt charmonia pp and Pb-Pb simulations