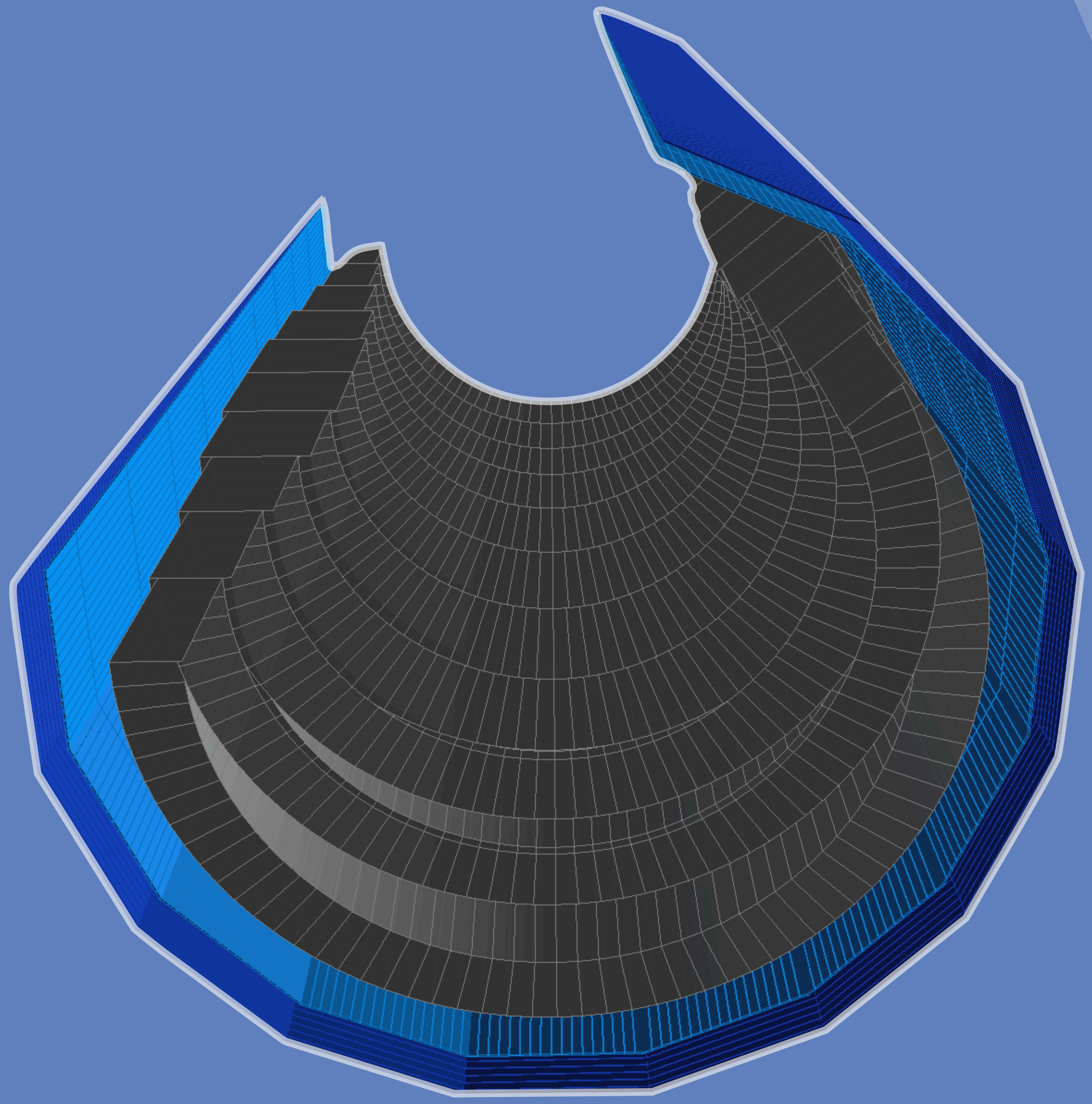


MuonID Simulations: Scintillators

Performance in heavy-ions collisions

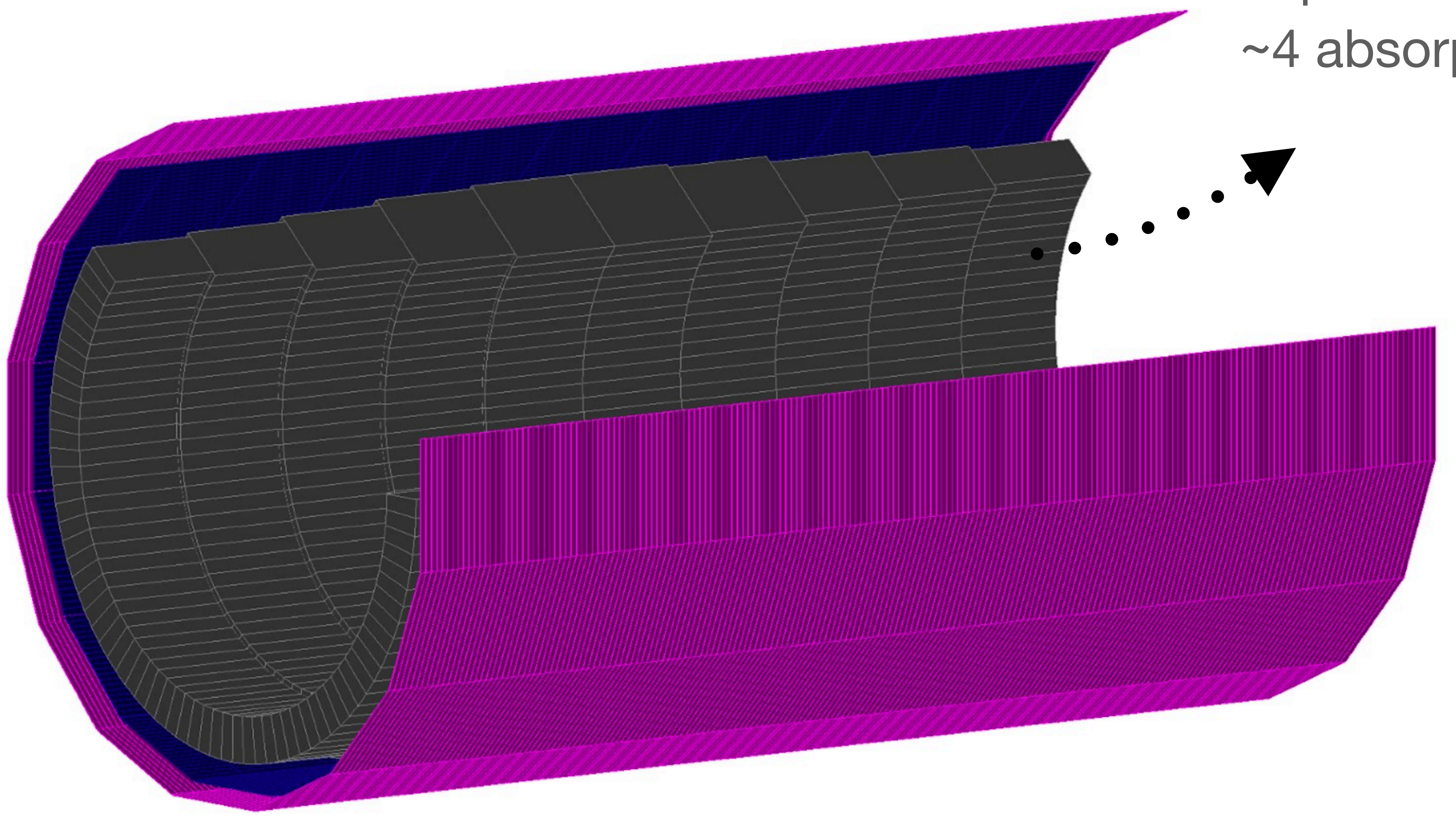
Jesús Eduardo Muñoz Méndez
for MID working group

Oct 7, 2024

Instituto de Ciencias Nucleares UNAM

MID specifications

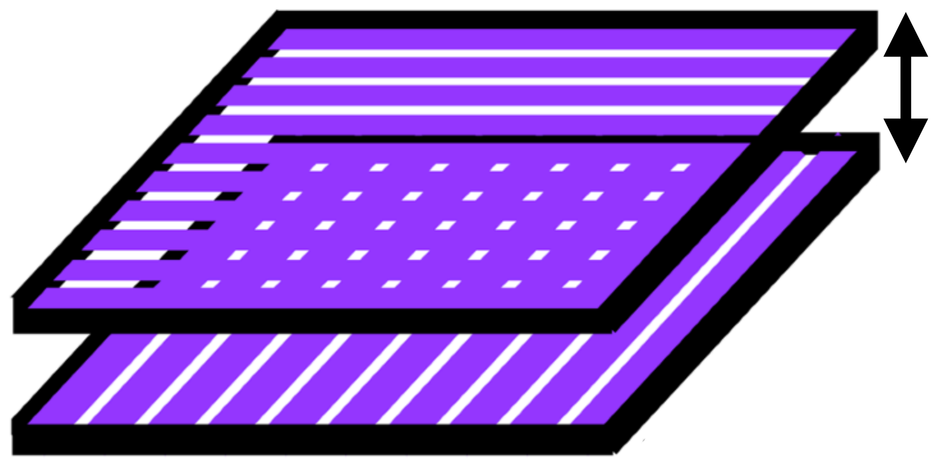
$|\eta| < 1.25$



Iron absorber, pseudorapidity-dependent thickness: ~4 absorption lengths

	Absorber	MID layer 1	MID layer 2
Inner radius (m)	220	301	311
Outer radius (m)	290	302	312
z range (m)	10	10	10.5
No. sectors in z	9	10	10
No. sectors in φ	1	16	16
Scint. bar length (cm)		99.8	123.5
Scint. bar width (cm)		5.0	5.0
Scint. bar thickness (cm)		1.0	1.0

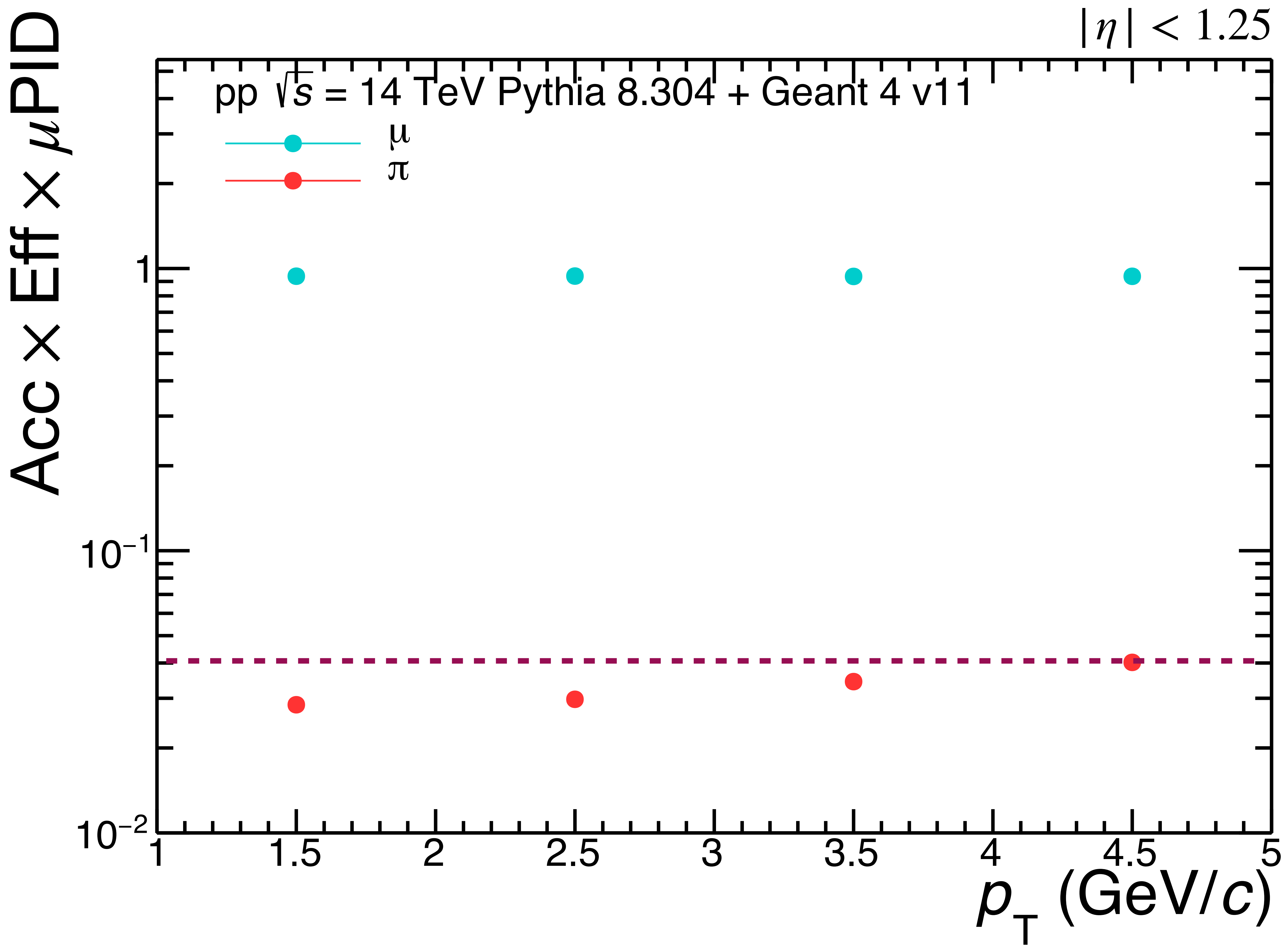
No. of bars
4048 in layer 1
3200 in layer 2



One of the proposals for the MID are **plastic scintillators equipped with wavelength-shifting fiber and SiPM for readout**

Proton-proton results

- Granularity 5×5 cm^2, machine learning, E_{dep} and time information were implemented
- Muon efficiency around 94% for $p_T > 1.5$ GeV/c
- Pion rejection at the level of 3-4%



Heavy-Ion collisions

Central (0-10%) Pb-Pb collisions *embedded* with signals from particle guns were used to train the BDT, considering the following variables

- Momentum before the absorber
- **Matching window ($\Delta\eta, \Delta\phi$)**
- Number of bars activated around the extrapolation
- Highest **energy deposition** in the activated bars around to the extrapolation
- **Arrival time**

$$\text{MW} = \sqrt{\Delta\eta^2 + \Delta\varphi^2} = \sqrt{(\eta^{\text{extr.}} - \eta^{\text{bar}})^2 + (\varphi^{\text{extr.}} - \varphi^{\text{bar}})^2}$$

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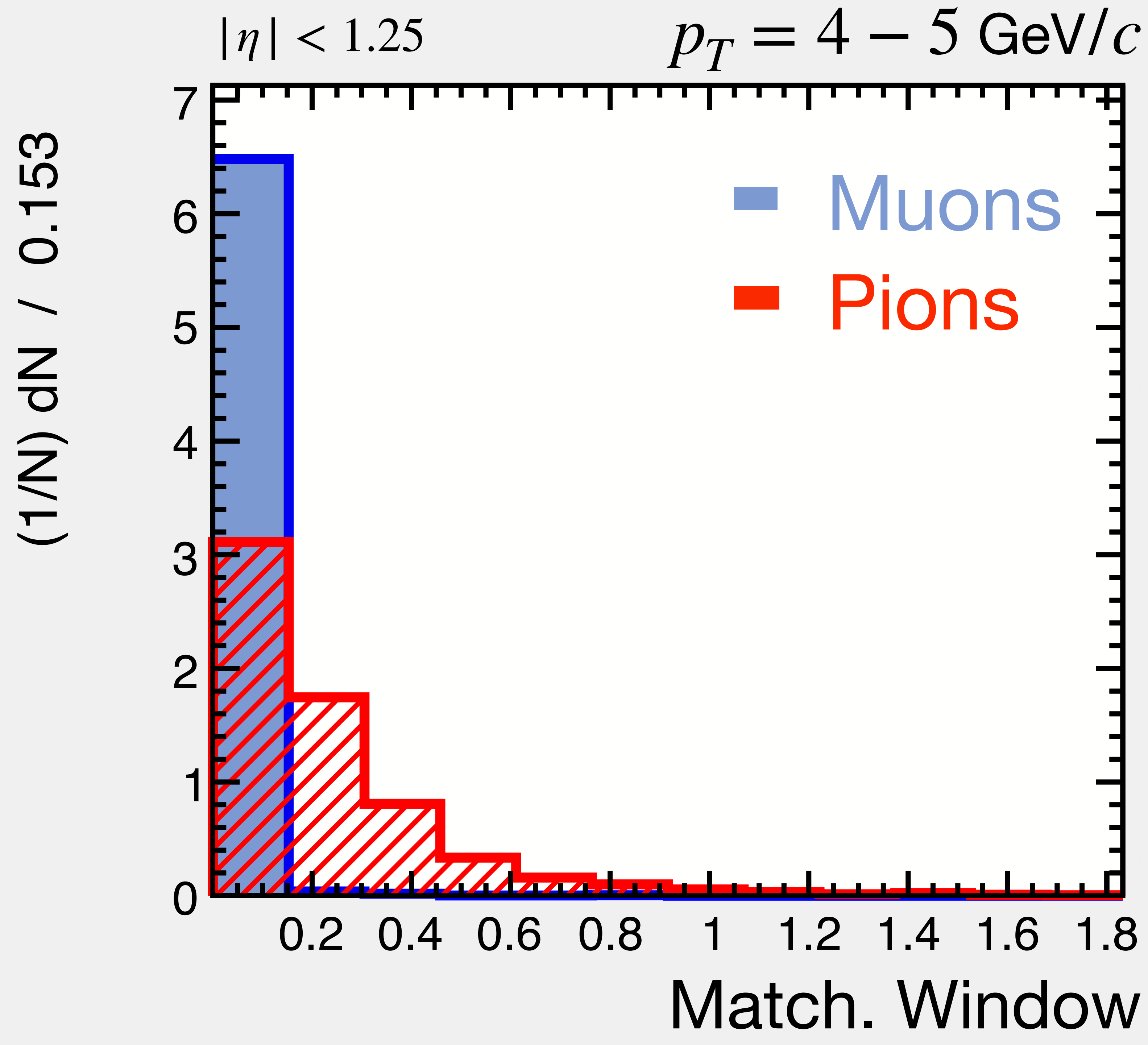

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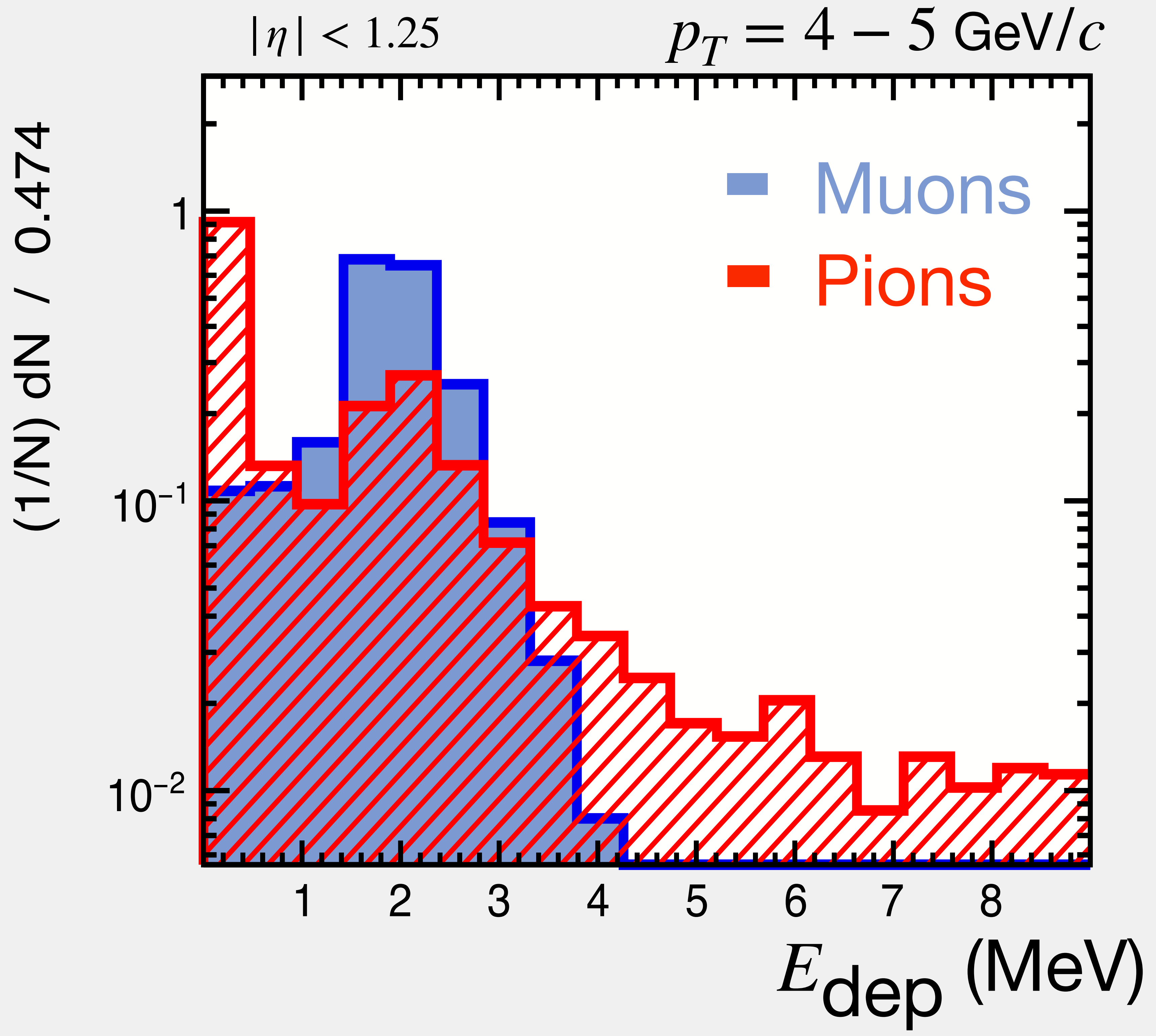

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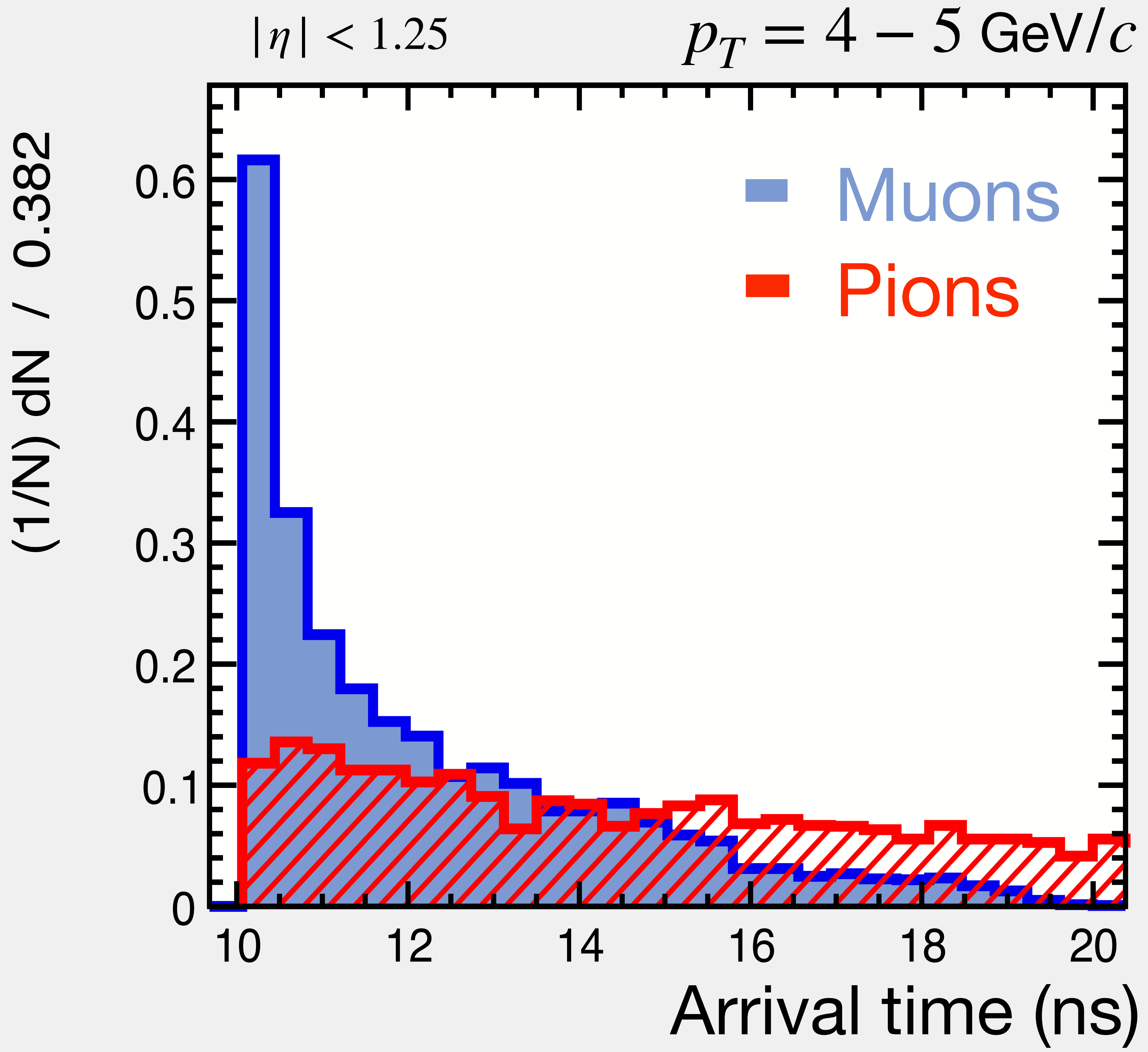
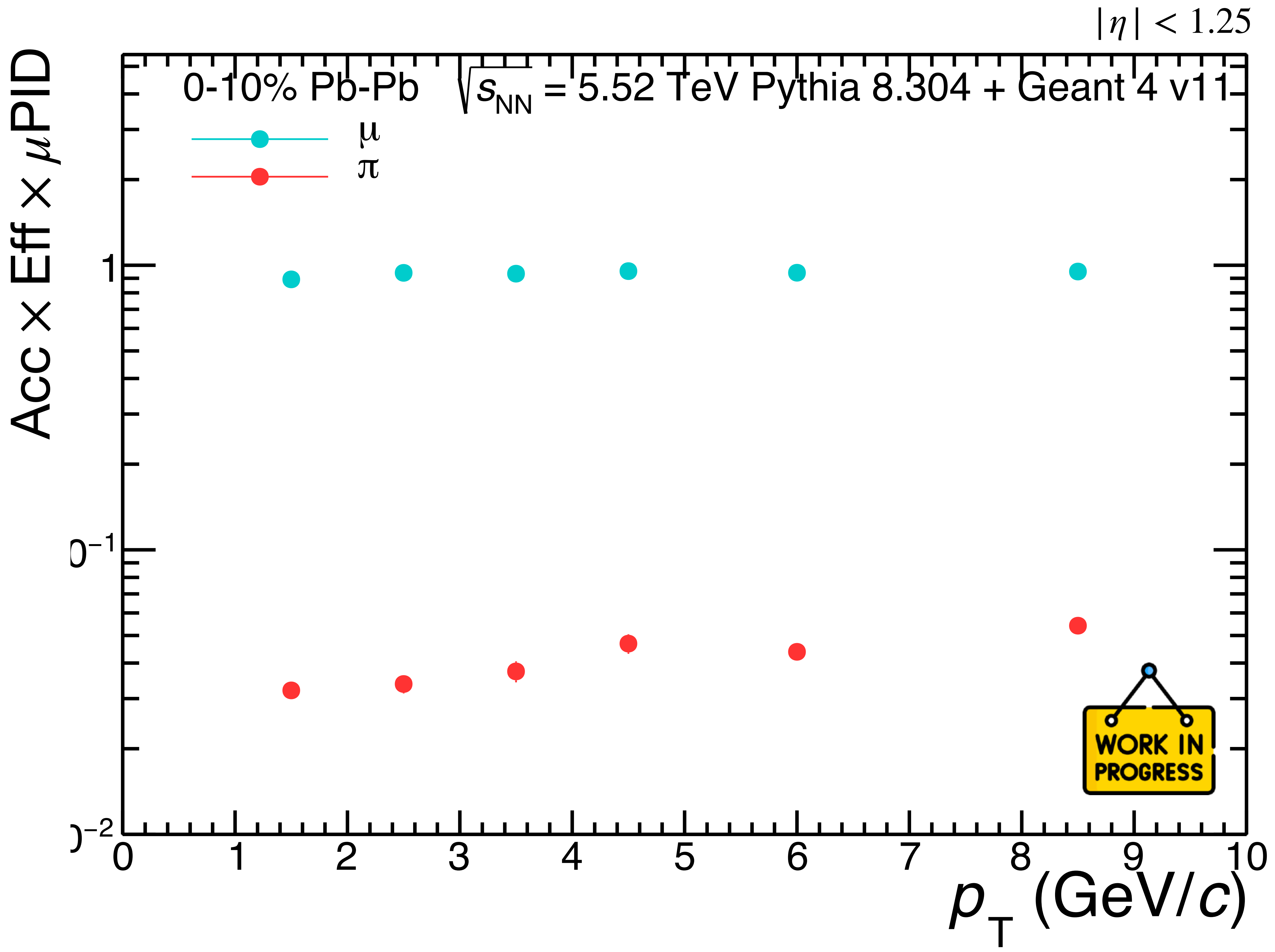


Heavy-Ion results



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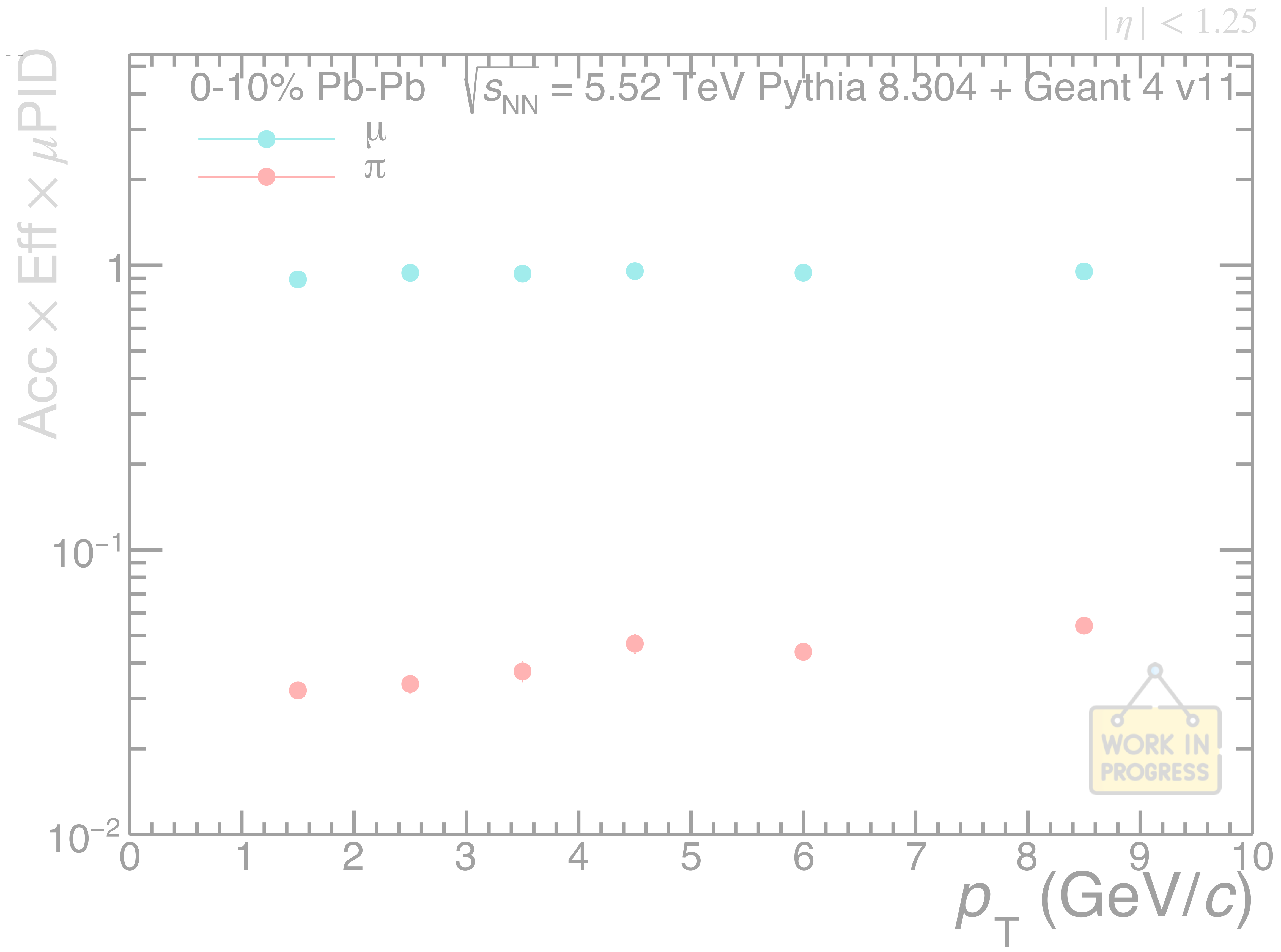
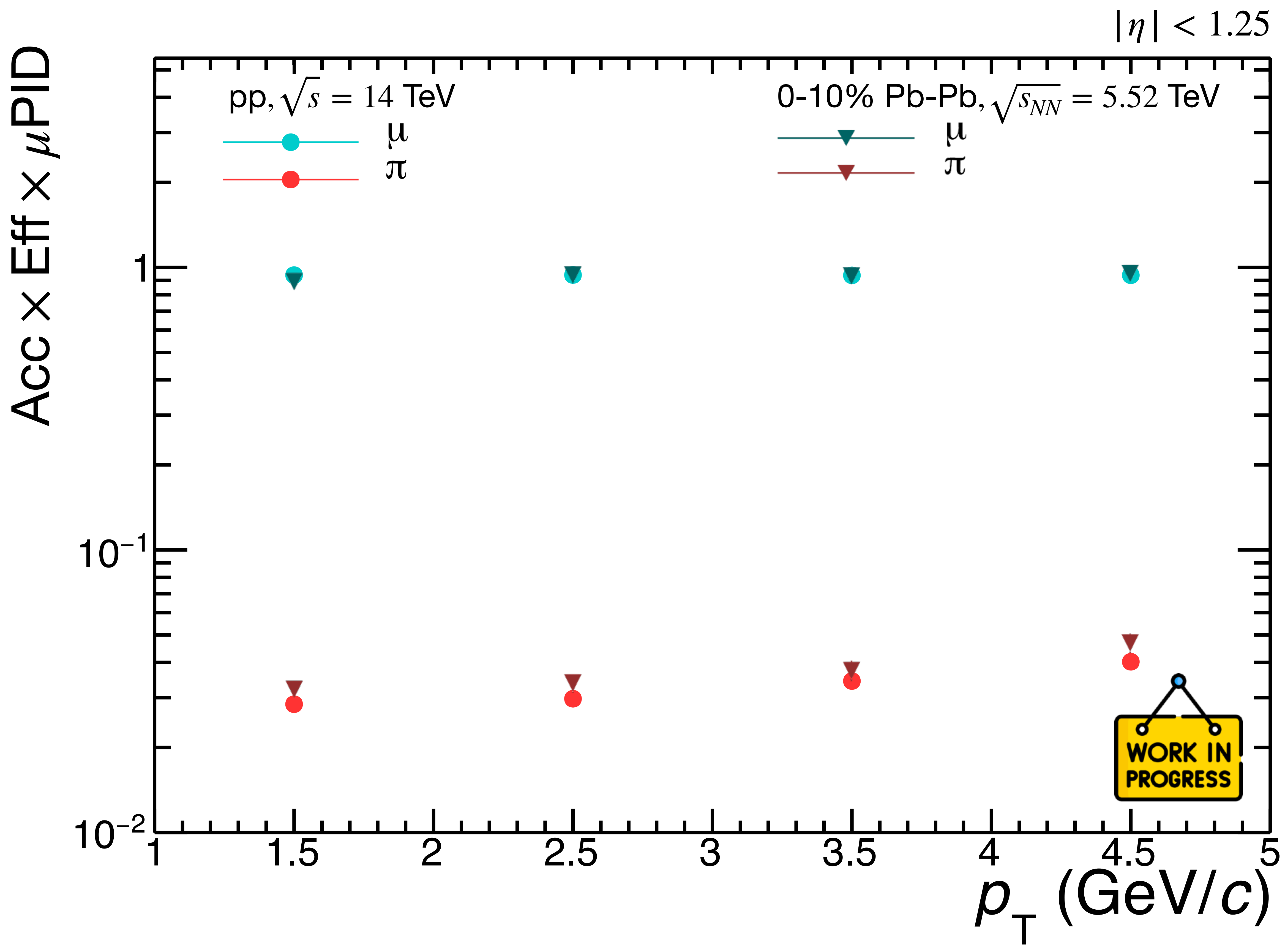


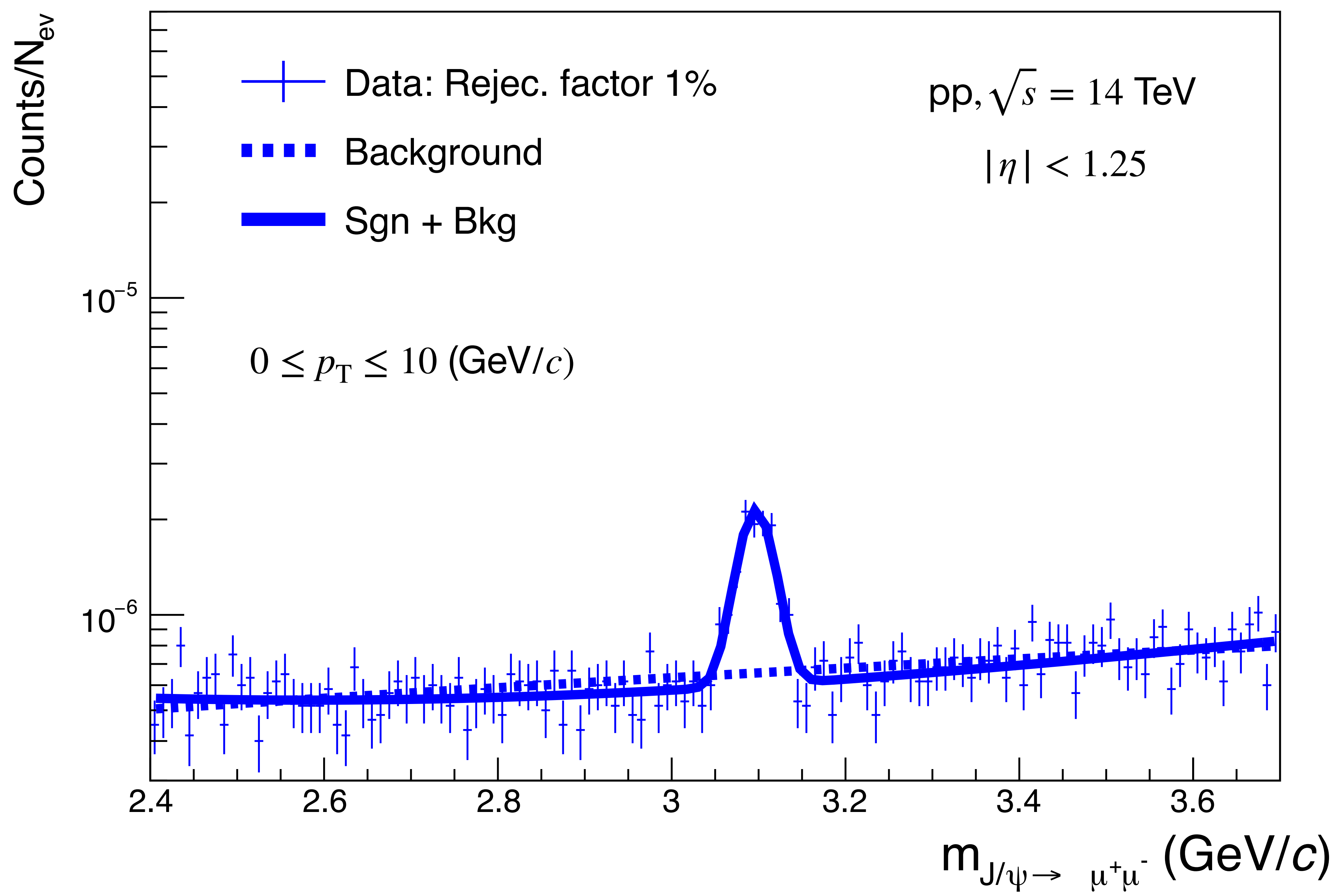


- Muon efficiency around 94% for $p_T > 1.5$ GeV/c
- Pion rejection at the level of 3-5%

- Slightly above to the the pion rejection factor obtained in **pp simulations**

J/ψ reconstruction

The MID will allow the reconstruction of J/ψ down to $p_{\mathrm{T}} = 0$ via its dimuon decay channel



J/ψ reconstruction efficiency similar to LOI

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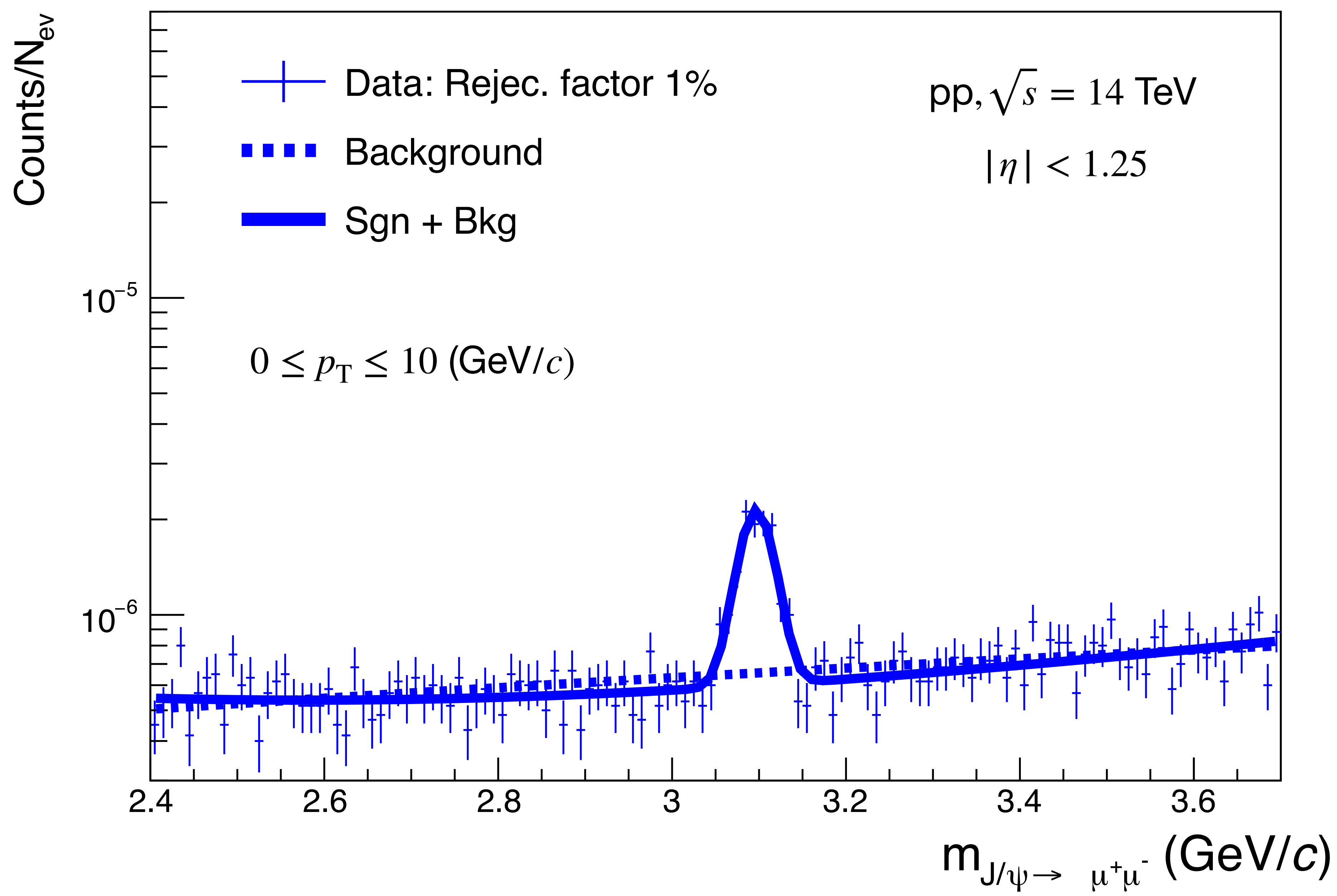
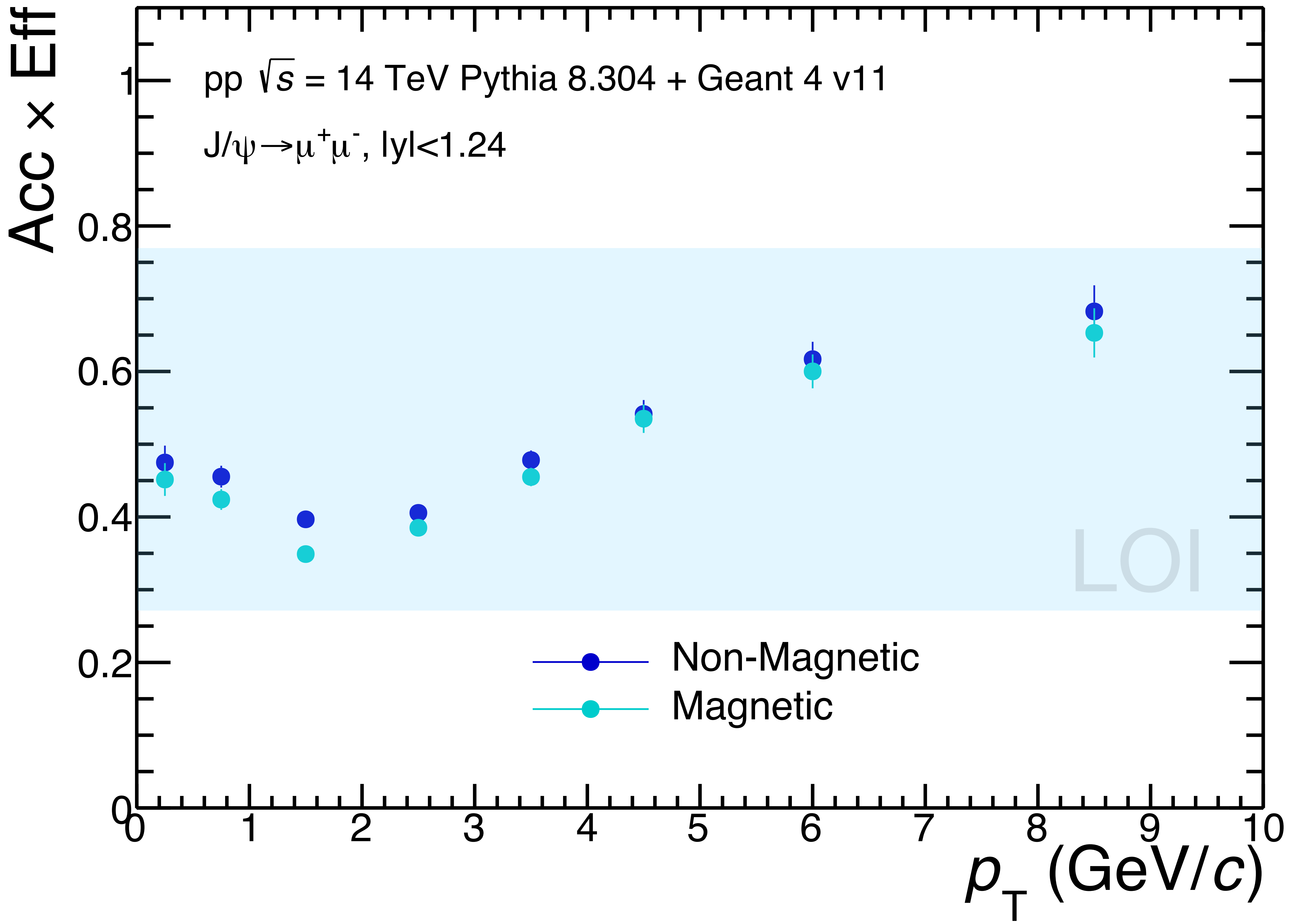


J/ψ reconstruction efficiency similar to LOI



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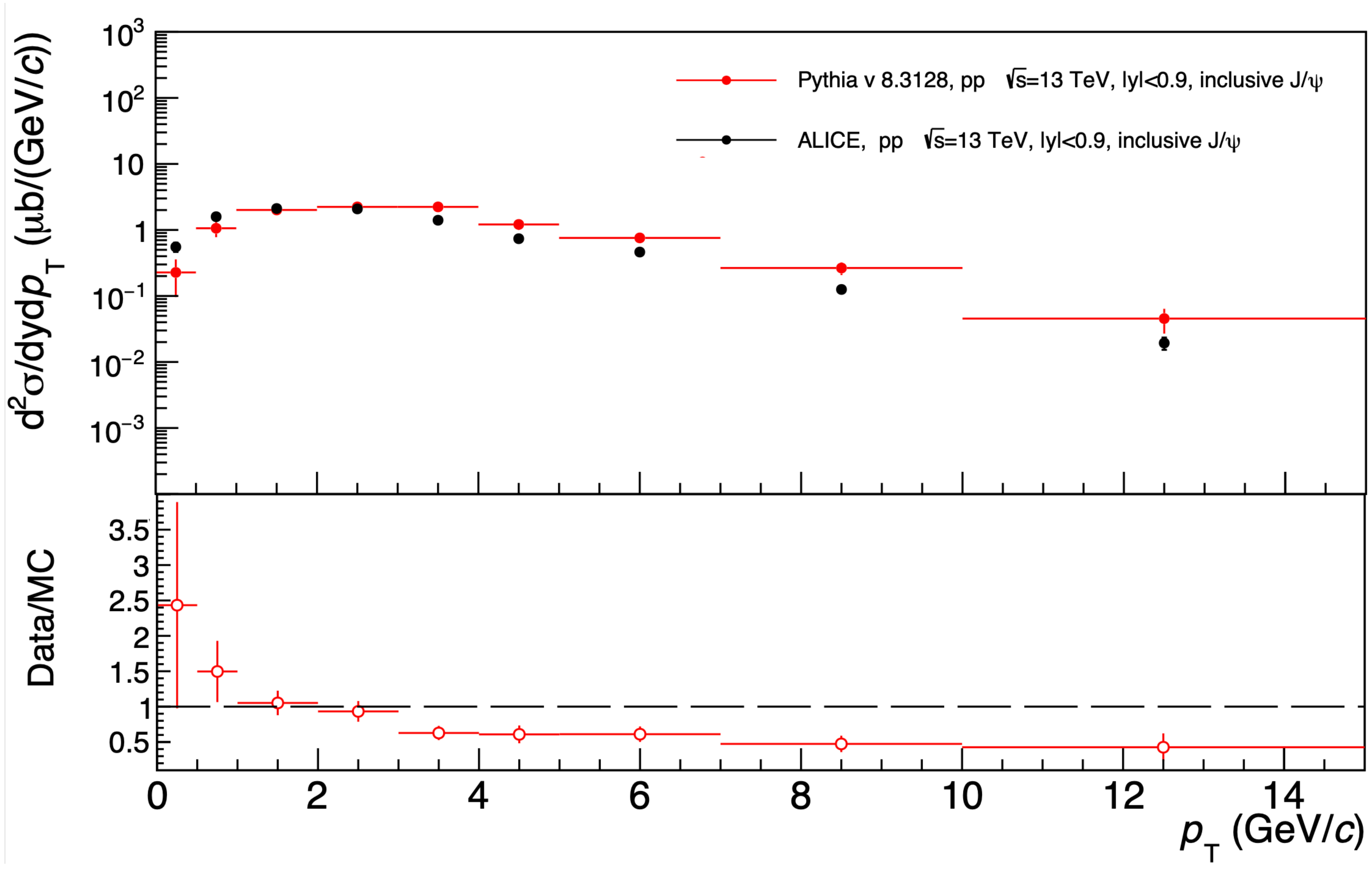
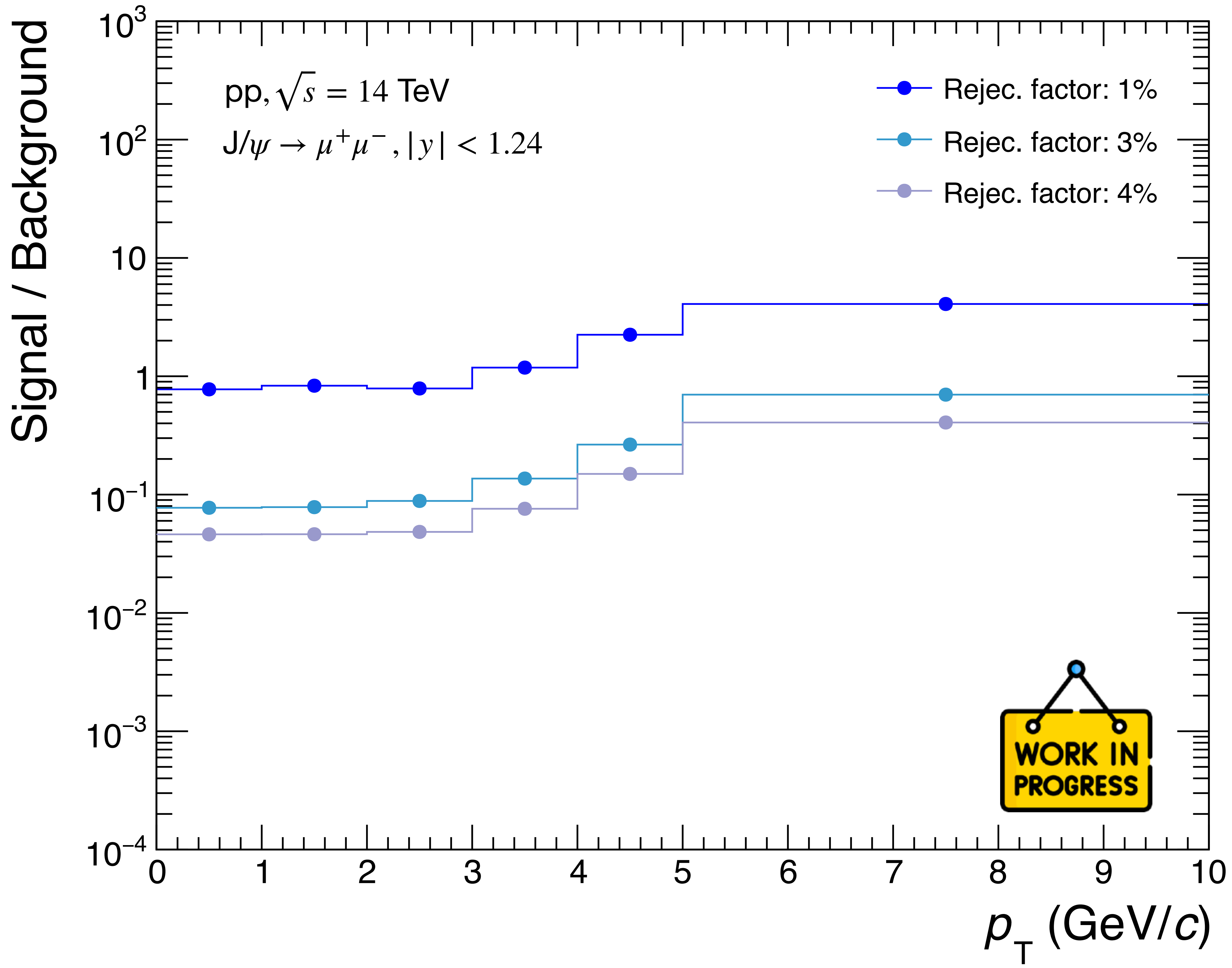


Fig. Inclusive J/ψ production cross section at midrapidity in pp collisions

Disclaimer:
underestimation and overestimation in PYTHIA's predictions for J/ψ that needs to be compensated in further studies

J/ψ reconstruction (pp collisions)



Even though the signal-to-background ratio varies with the **pion rejection factors**…

…the **significance is less affected**, ensuring reliable detection of the signal across different conditions

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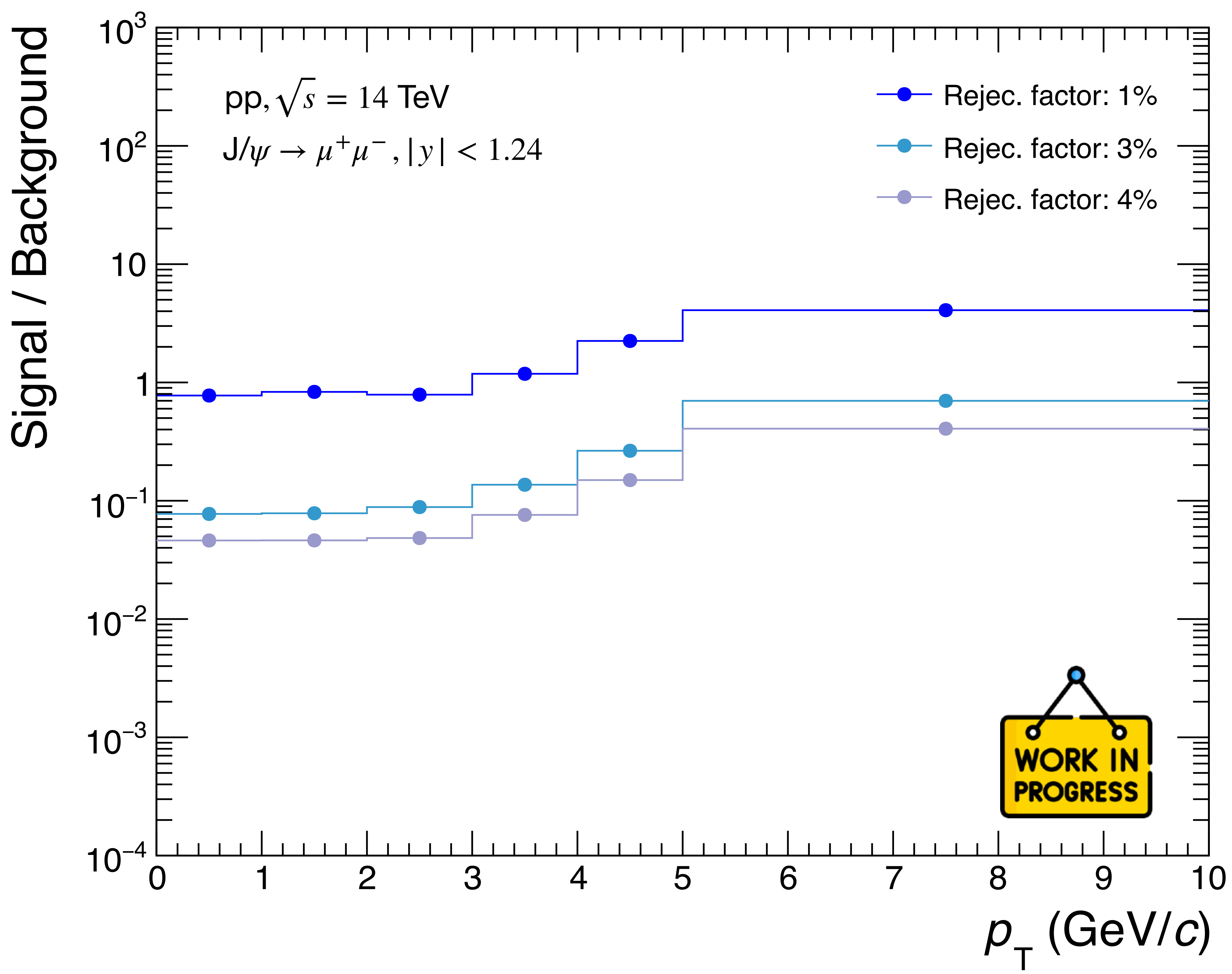

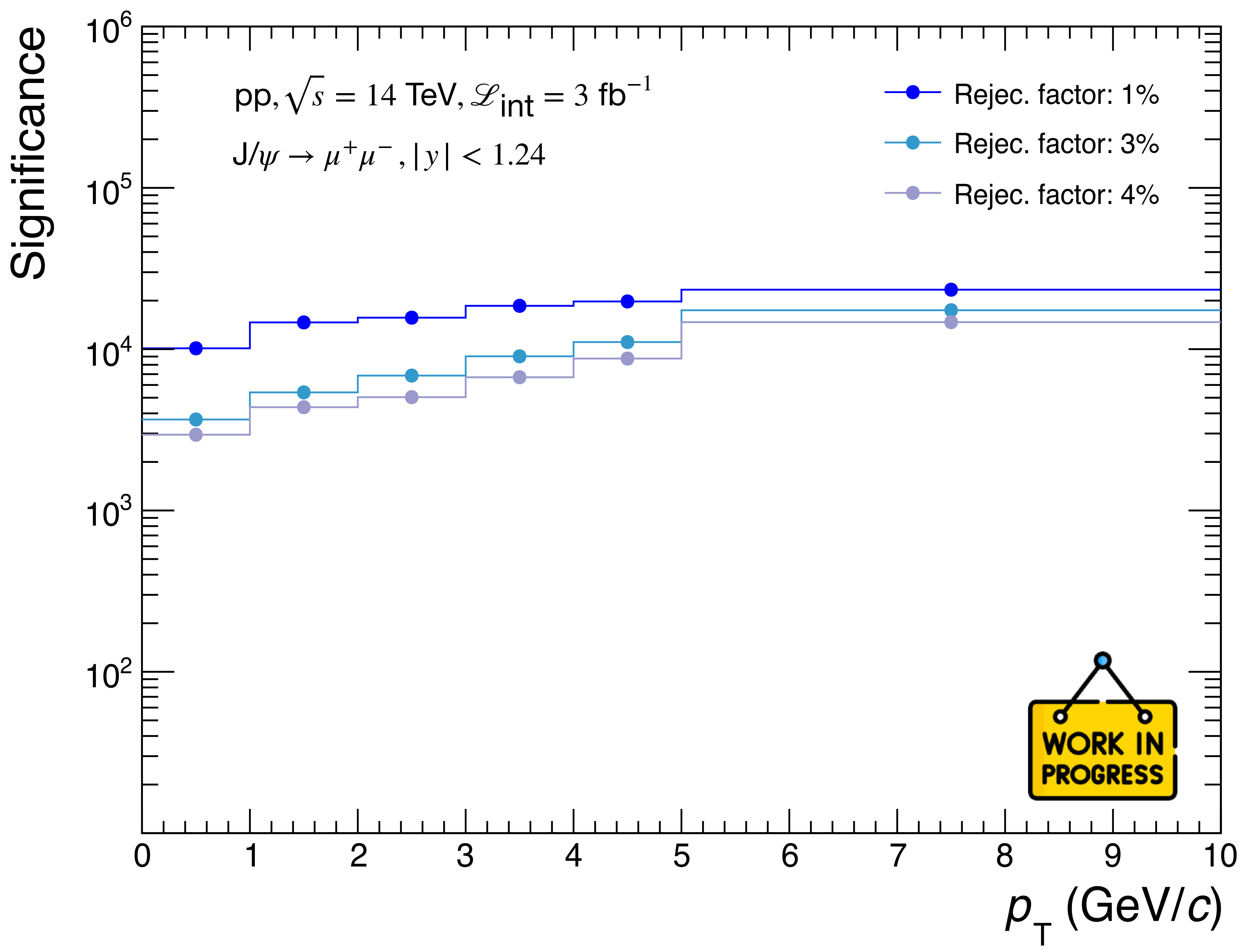

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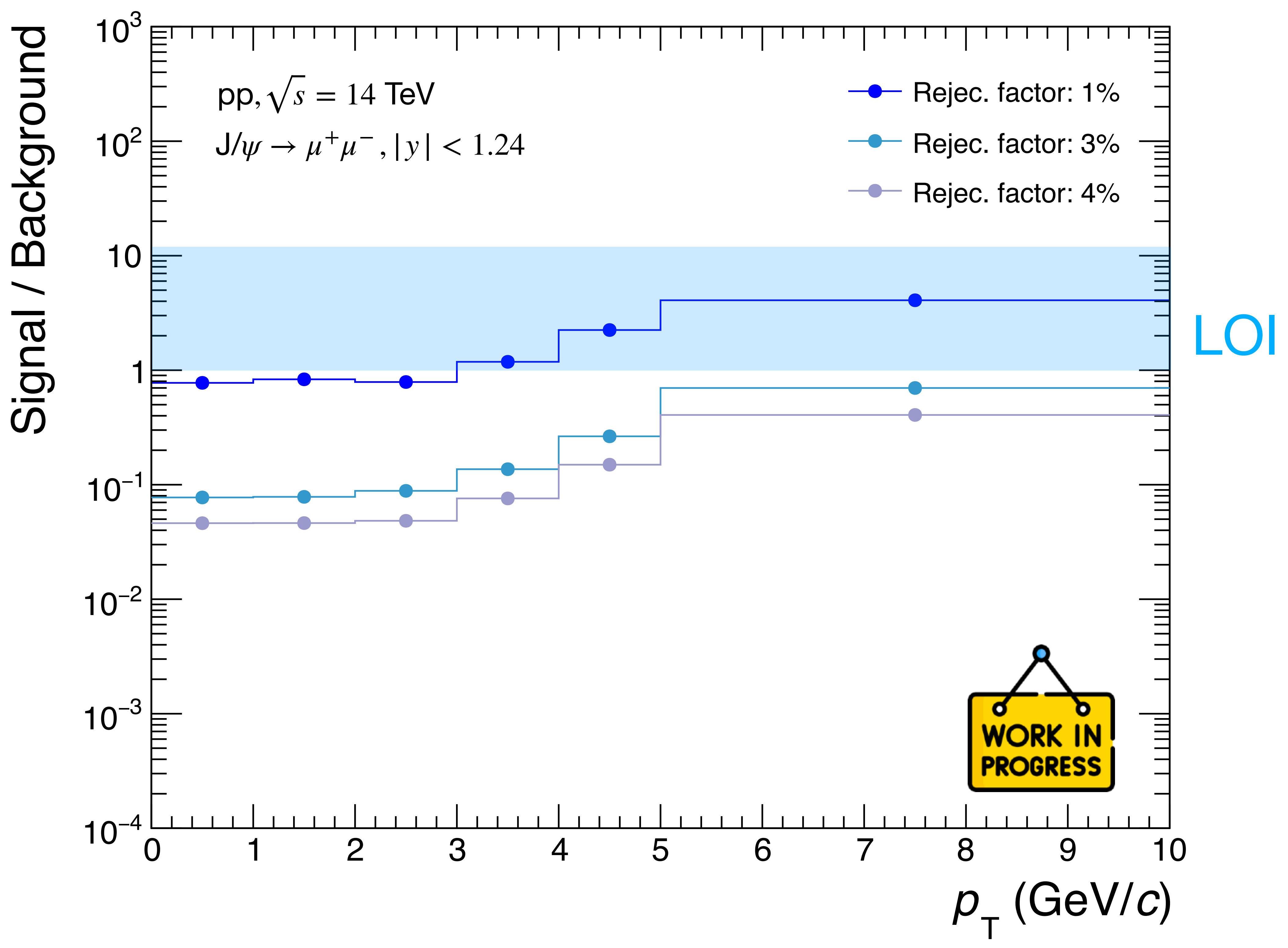
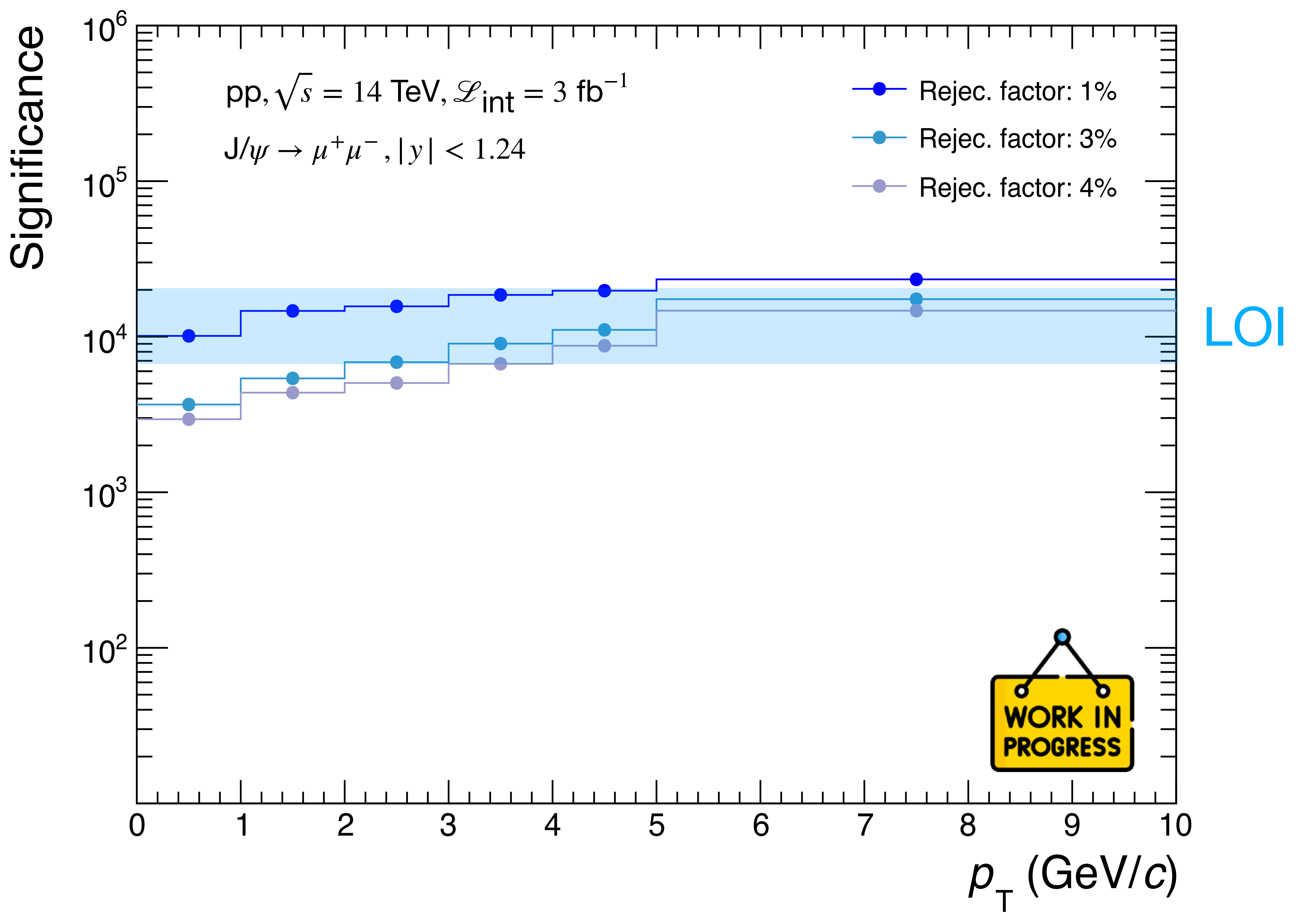




Agreement with the LOI results for a 1% rejection factor

**LOI simulations: no segmentation and ideal granularity*

Conclusions

- **Muon efficiency** around 94% for $p_{\mathrm{T}} > 1.5$ GeV/*c* in both pp and central Pb-Pb collisions

- **Pion rejection** at the level of 3-4% in pp
  of 3-5% in central Pb-Pb

- **Significance** doesn’t have a big impact due to different pion rejection factors

Radiation Load Studies Update

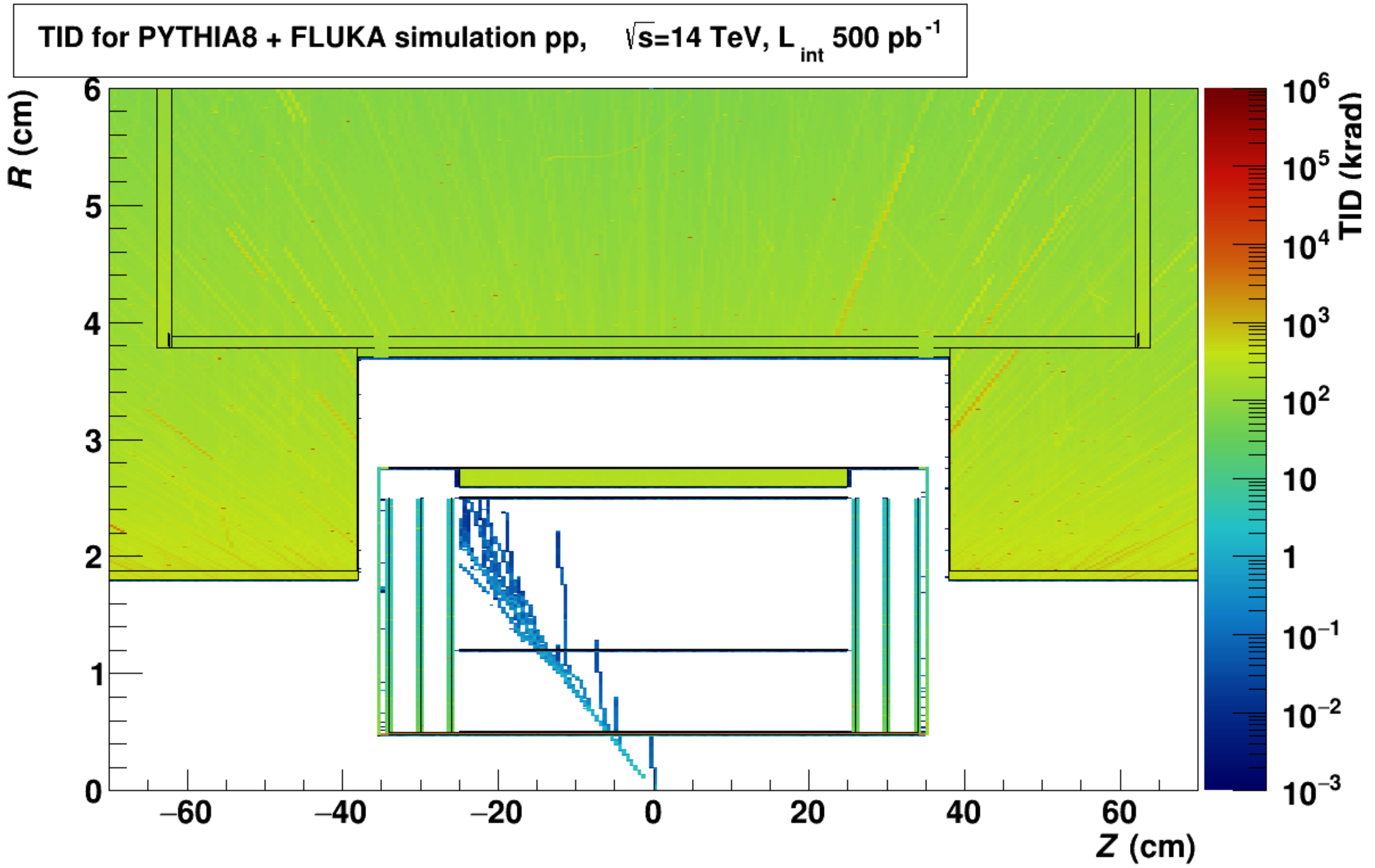
Radiation load studies update

Updated values are on their way

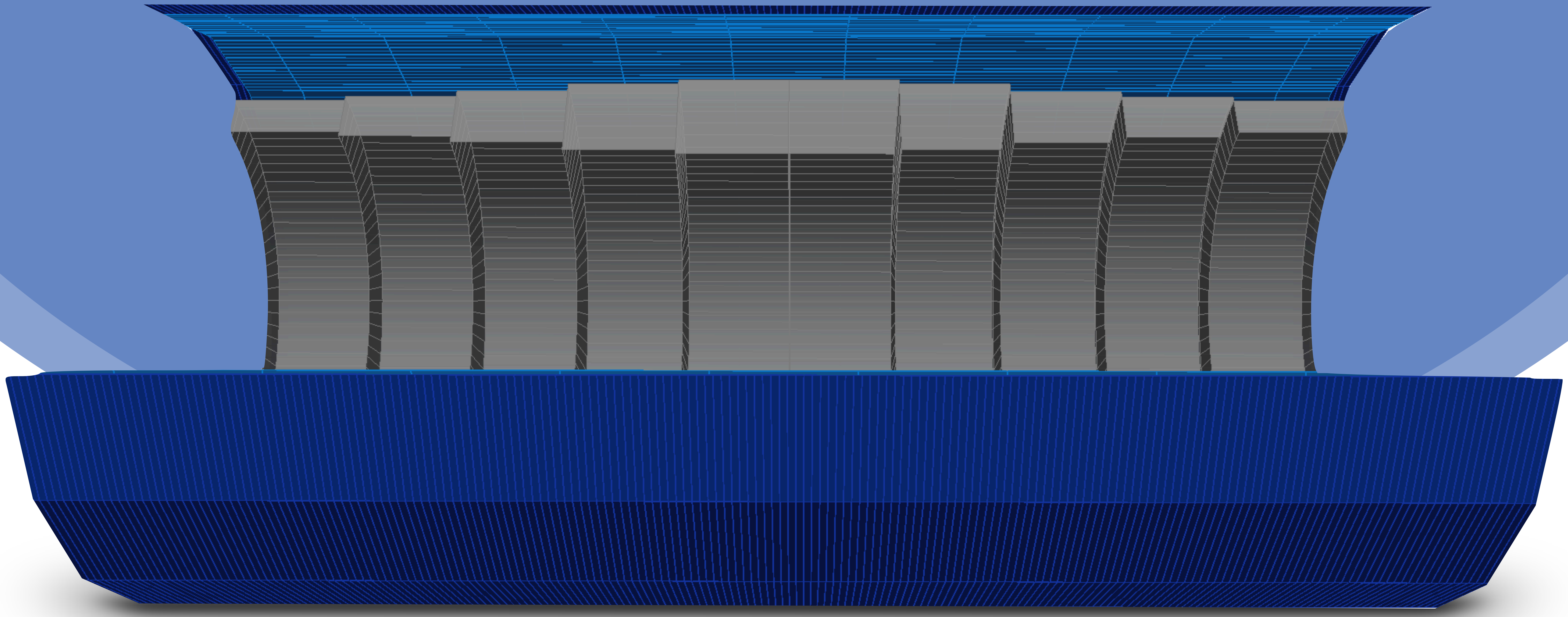
LOI / FLUKA at r = 0.5 cm

	previous ratio	current ratio
TID	15.26	***1.09***
NIEL	3.6	**1.83**
Ch. particle fluence rate	1.36	**0.98**

Table 1. Ratio between the pp values reported in the LOI and the simulations in FLUKA (*<u>per operational month and assuming a running efficiency of 65%</u>*).



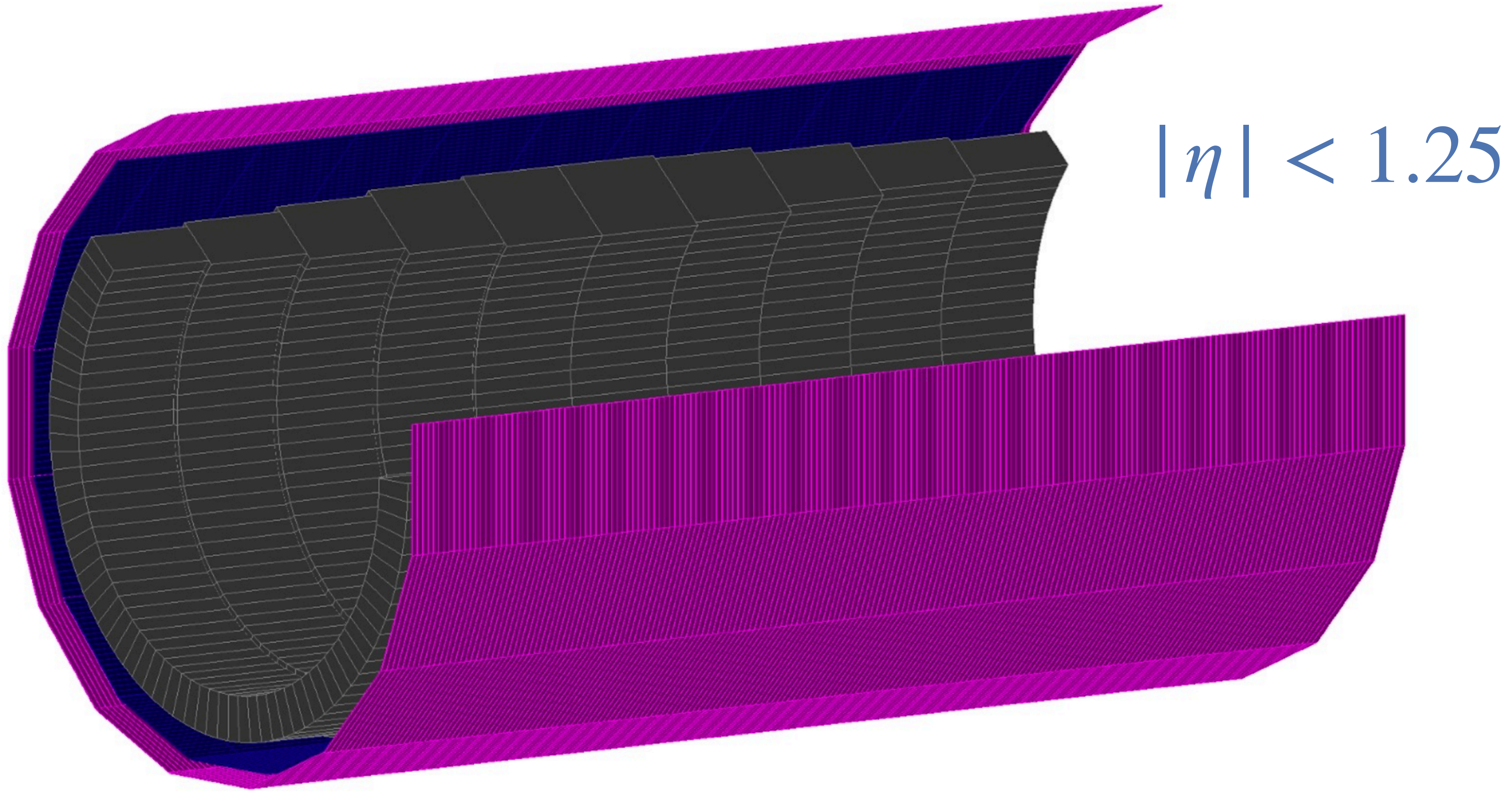
Thank you for your attention!



MID (plastic scintillator option)

Baseline option:
Low cost plastic scintillator bars (FNAL-NICADD) equipped with wave-length shifting fibers and SiPM

- **simplicity** (no need of gas mixture)
- **excellent timing resolution** (ns)
- **good performance** under the expected radiation load



	pp	Pb-Pb
TID (rad)	54	0.94
NIEL (1 MeV neq/cm^2)	3.4×10^{10}	4.7×10^{8}

Table. Radiation load in the MID simulated with FLUKA for the Run 5+6 period

- FNAL-NICADD scintillators have a **decrease in light yield of ~5%** after a **dose of 1 Mrad** [FERMILAB-PUB-05-344]
- **Our typical signals ~40 photoelectrons,** therefore single photoelectron detection with the SiPM is not required (impossible at 10^{11} MeV neq/ cm^2 at room temp.)

[Nucl. Instrum. Meth. Phys. Res A, A 922 (2019)]