

Measurement of Neutral Mesons in pp Collisions at $\sqrt{s} = 13$ TeV with ALICE at the LHC

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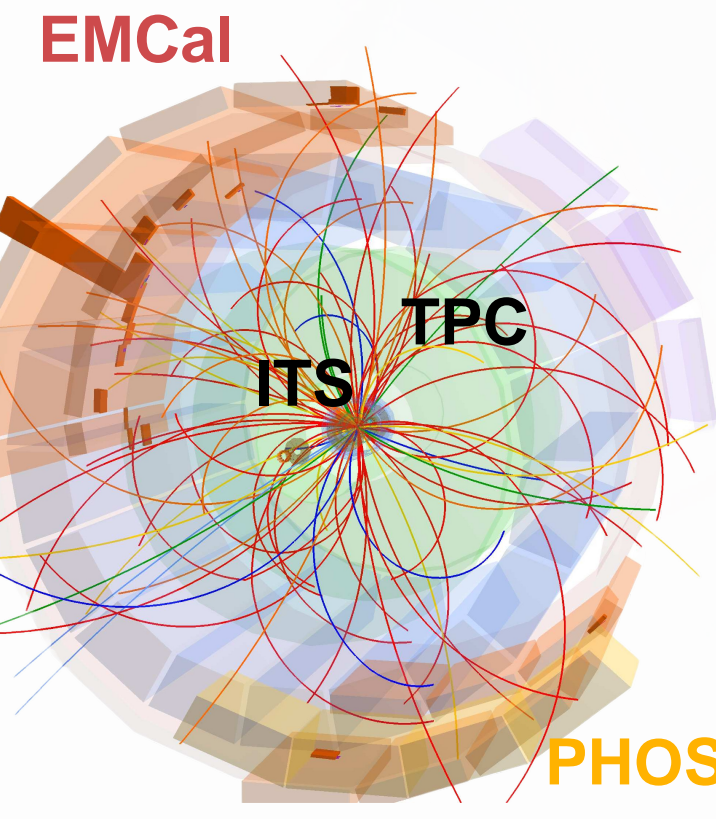
Motivation

The precise measurement of the neutral meson production in pp collisions can be used to constrain fragmentation functions and parton density functions used in pQCD calculations. Additionally, those measurements serve as input for direct photon analyses. Moreover, the dependence of the neutral meson cross section on the event charged-particle multiplicity can give further insight into possible final-state effects in high-multiplicity pp collisions, in which other measurements in pp collisions show surprising similarities with measurements in heavy-ion collisions. The analysis utilizes the $\pi^0, \eta \rightarrow \gamma\gamma$ and $\pi^0, \eta \rightarrow \gamma e^+ e^-$ decay channel and combines results from several partially independent invariant mass and purity based reconstruction techniques available in ALICE. The decay photons were either detected with the electromagnetic calorimeters or via the central tracking system using $e^+ e^-$ pairs from conversions in the detector material. The combination of these methods allows for a large p_T coverage, as well as small statistical and systematic uncertainties.

Detector setup

Electromagnetic calorimeter (EMCal)

- Large acceptance
- Used as γ trigger detector
- Single cluster measurement up to $E = 200$ GeV



Photon conversion method (PCM)

- Utilizing e^\pm tracks from converted γ in central tracking detectors
- Measurement of single γ down to $p = 75$ MeV/c in $B = 0.2$ T

Central tracking system

- Charged particle tracks measured in ITS and TPC

$\pi^0(\eta) \rightarrow \gamma\gamma$, BR $\approx 98.8\%$ (39.4%)
 $\pi^0(\eta) \rightarrow \gamma e^+ e^-$, BR $\approx 1.2\%$ (0.7%)

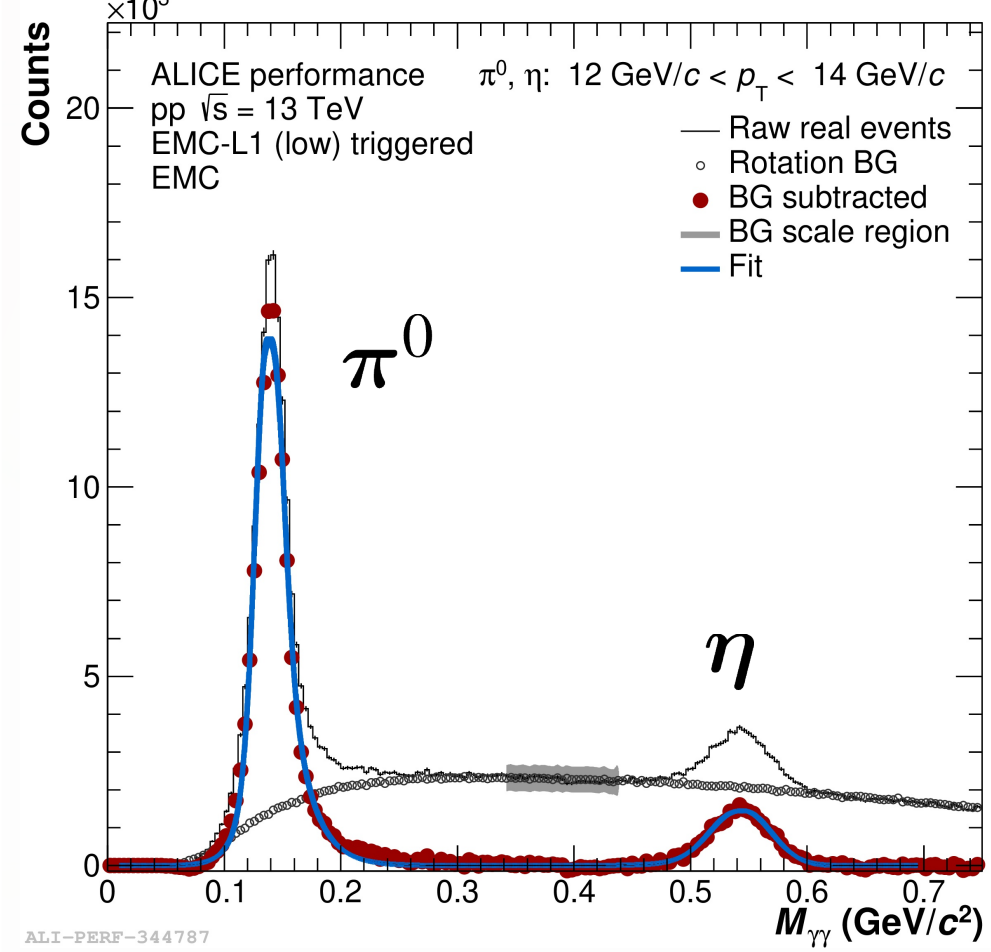
Photon spectrometer (PHOS)

- Good energy resolution
- Used as γ trigger detector

Neutral meson reconstruction

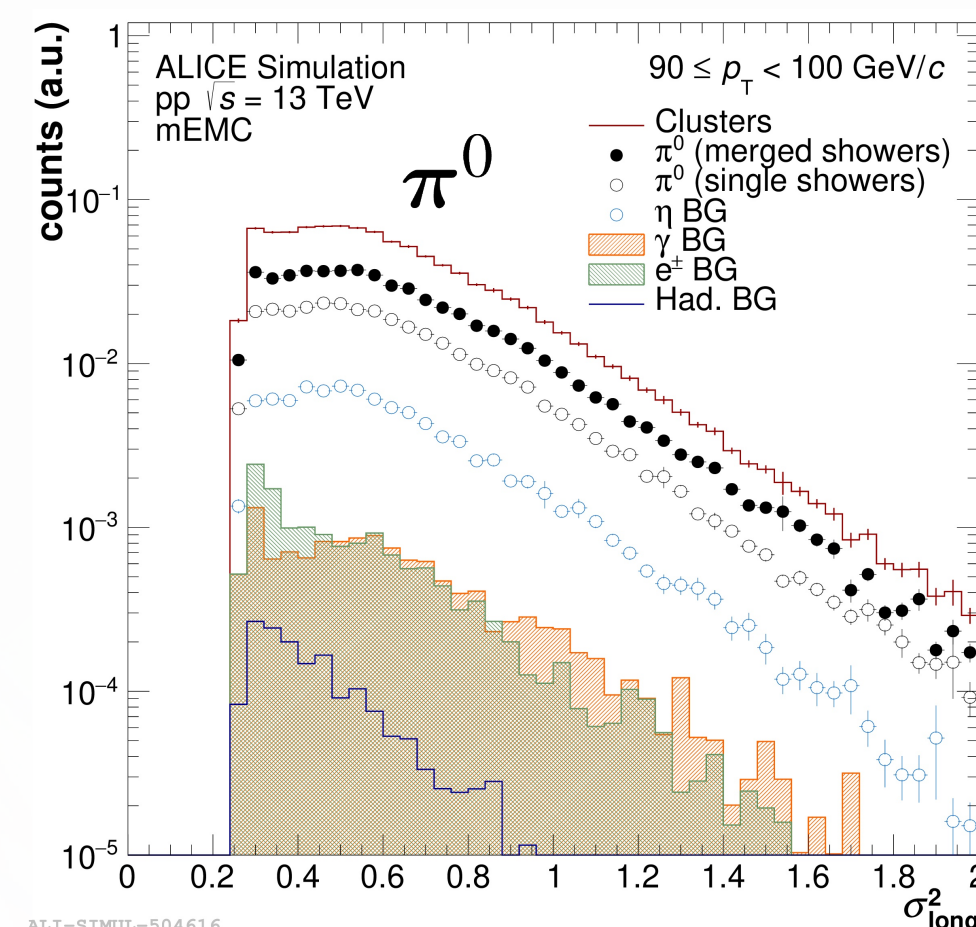
Invariant mass based

- Signal obtained by pair-wise combination of reconstructed photons
- Background description using mixed events or rotation method
- 6 independent meson reconstruction methods

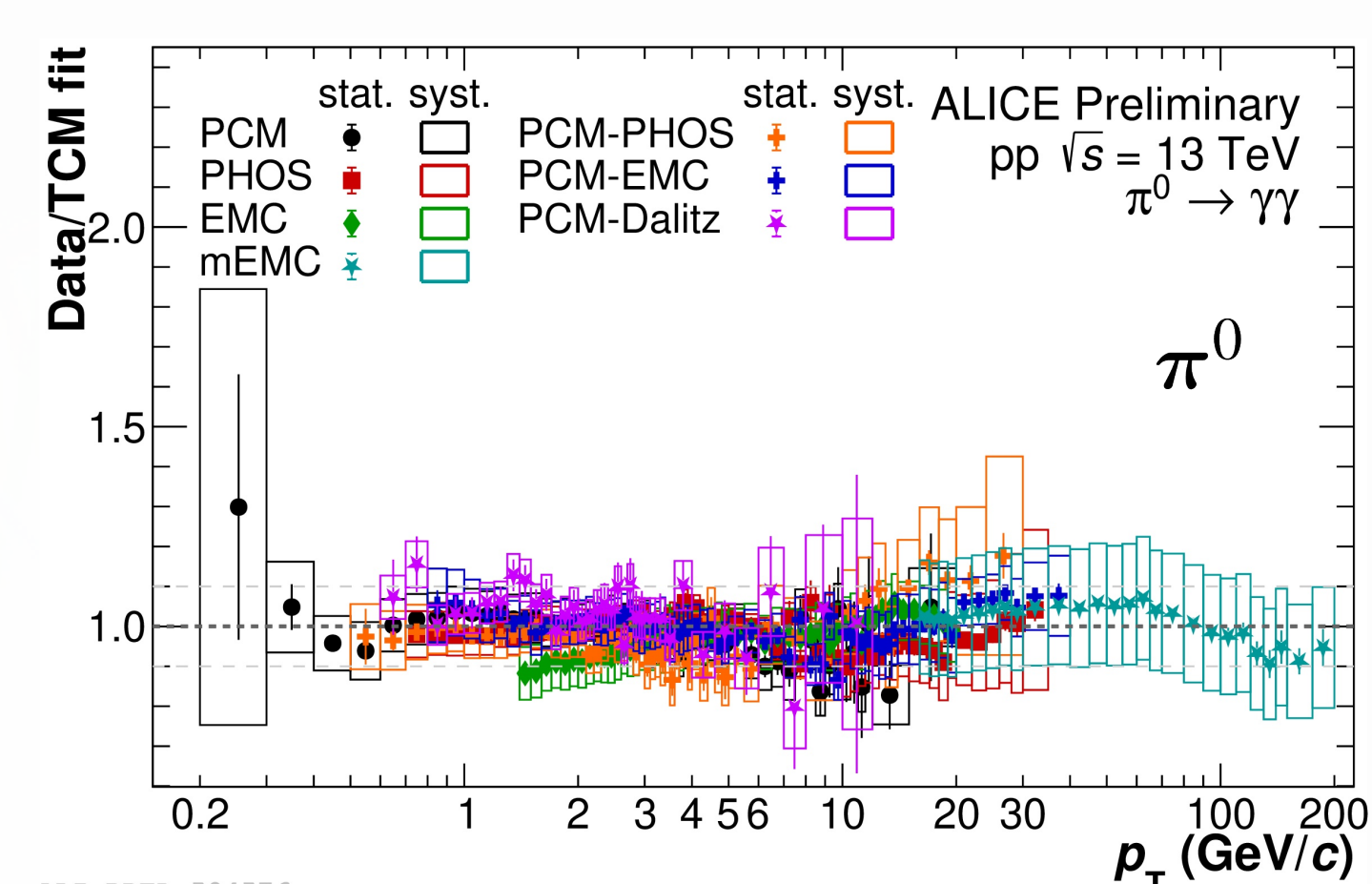


Purity based

- Using merged π^0 clusters from EMCal containing both decay photons
- Classification of clusters via shower shape σ_{long}^2
- Background mainly from η mesons, e^\pm and prompt photons \rightarrow abundancies in simulation corrected



Neutral meson cross section



- **Combination of all 7 (6) reconstruction methods** for the π^0 (η) meson
- **Large p_T coverage** of the light neutral meson production cross section:

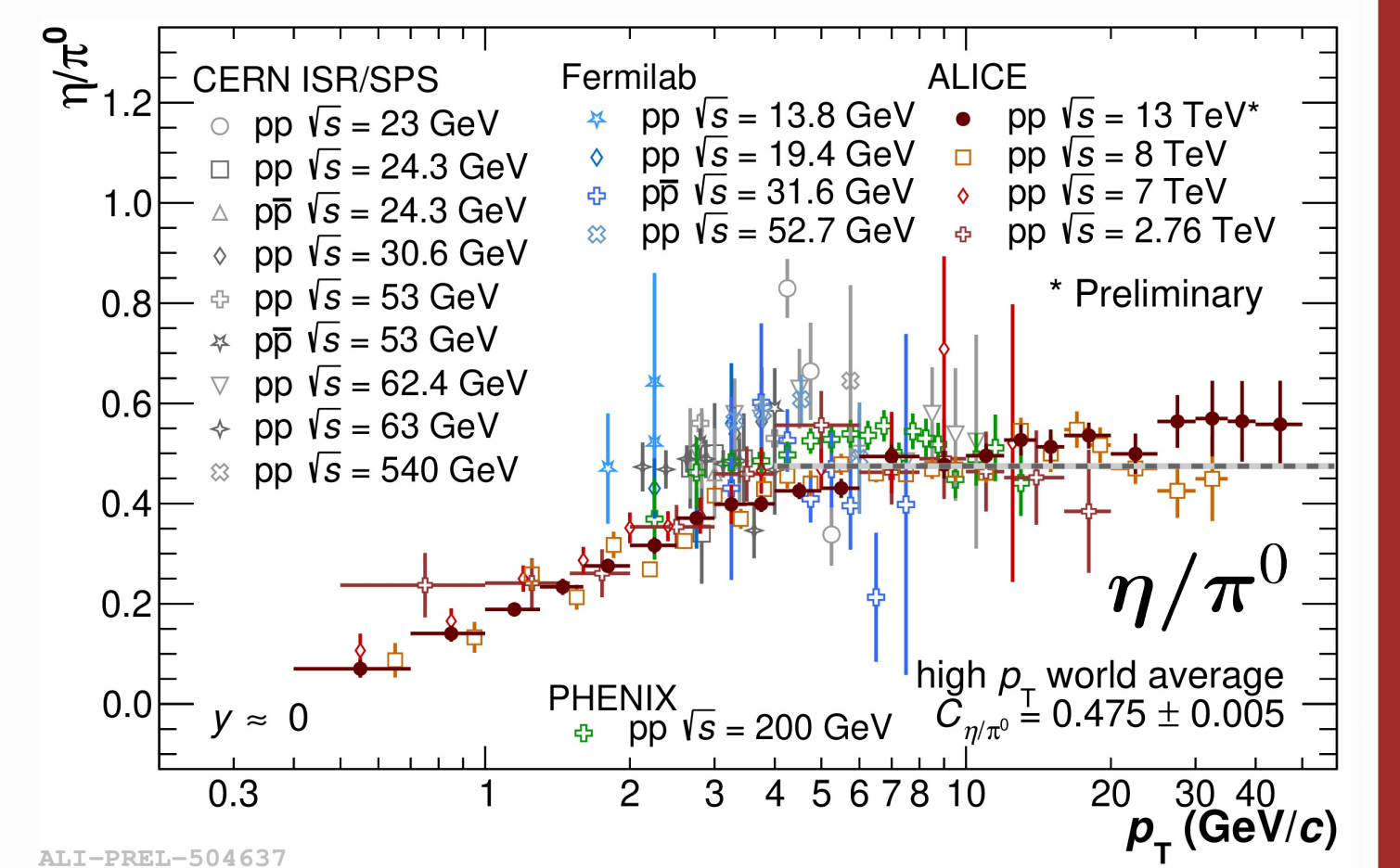
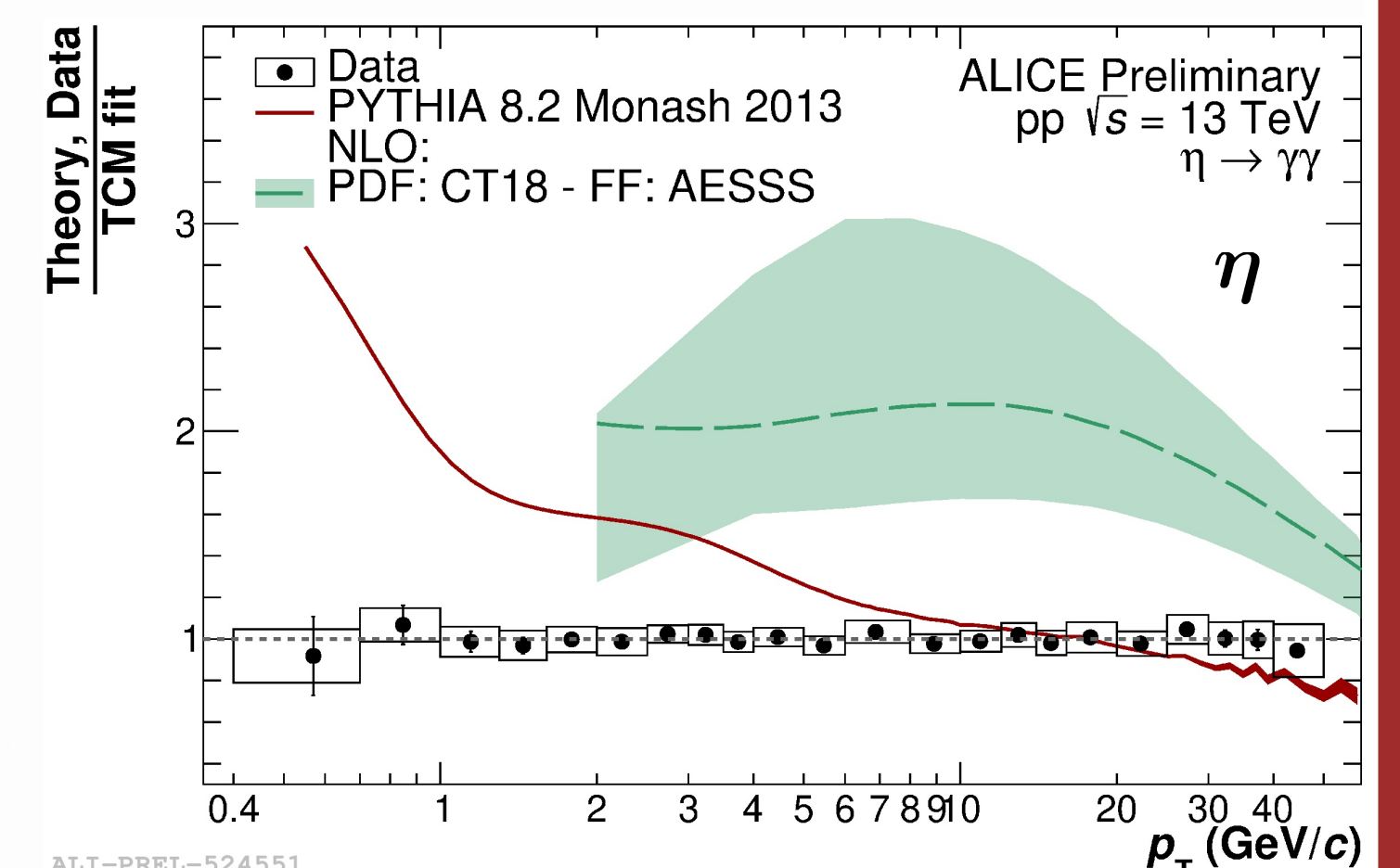
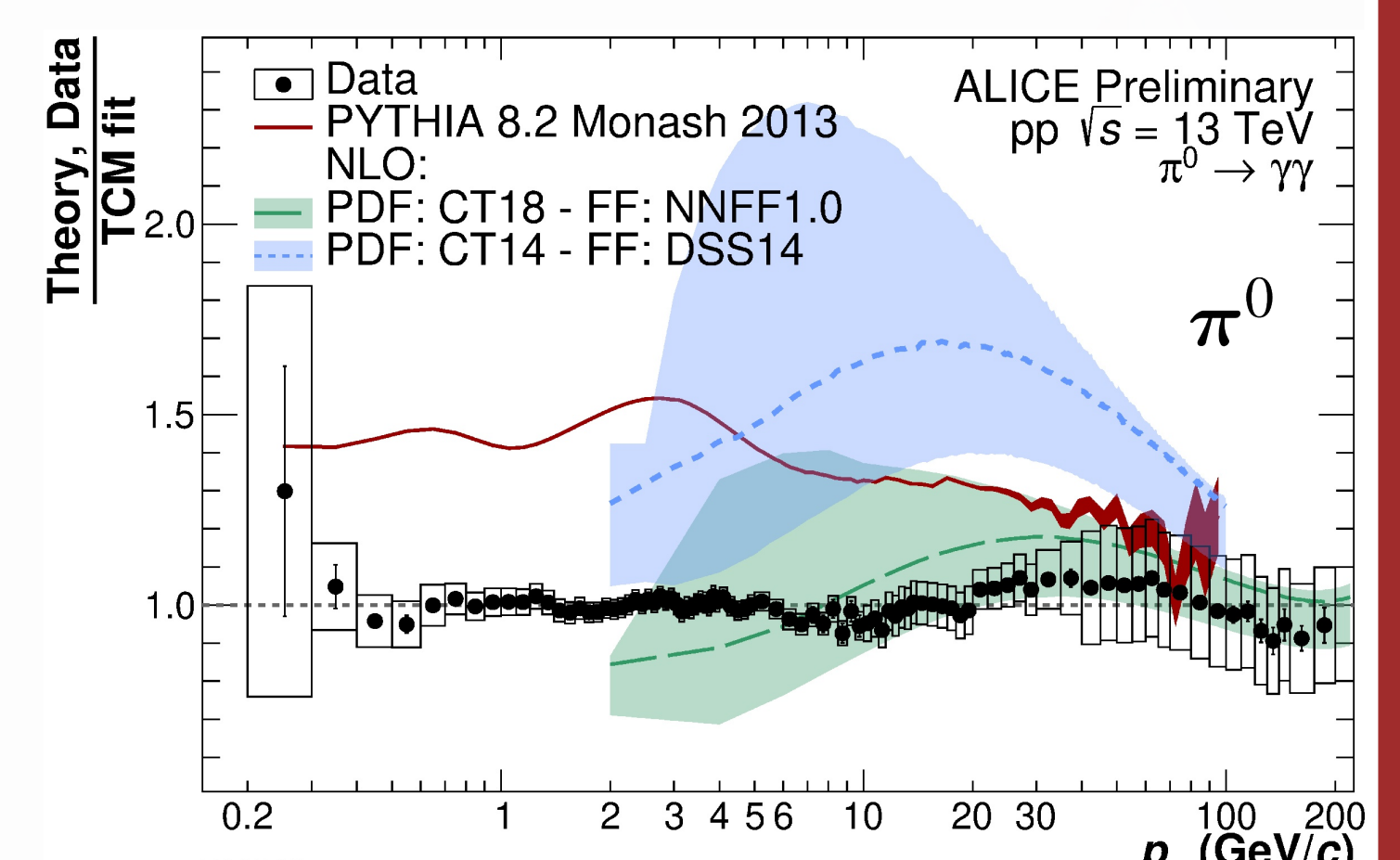
π^0 : $0.2 \leq p_T < 200$ GeV/c
 η : $0.4 \leq p_T < 50$ GeV/c

- Comparison to theory calculations:

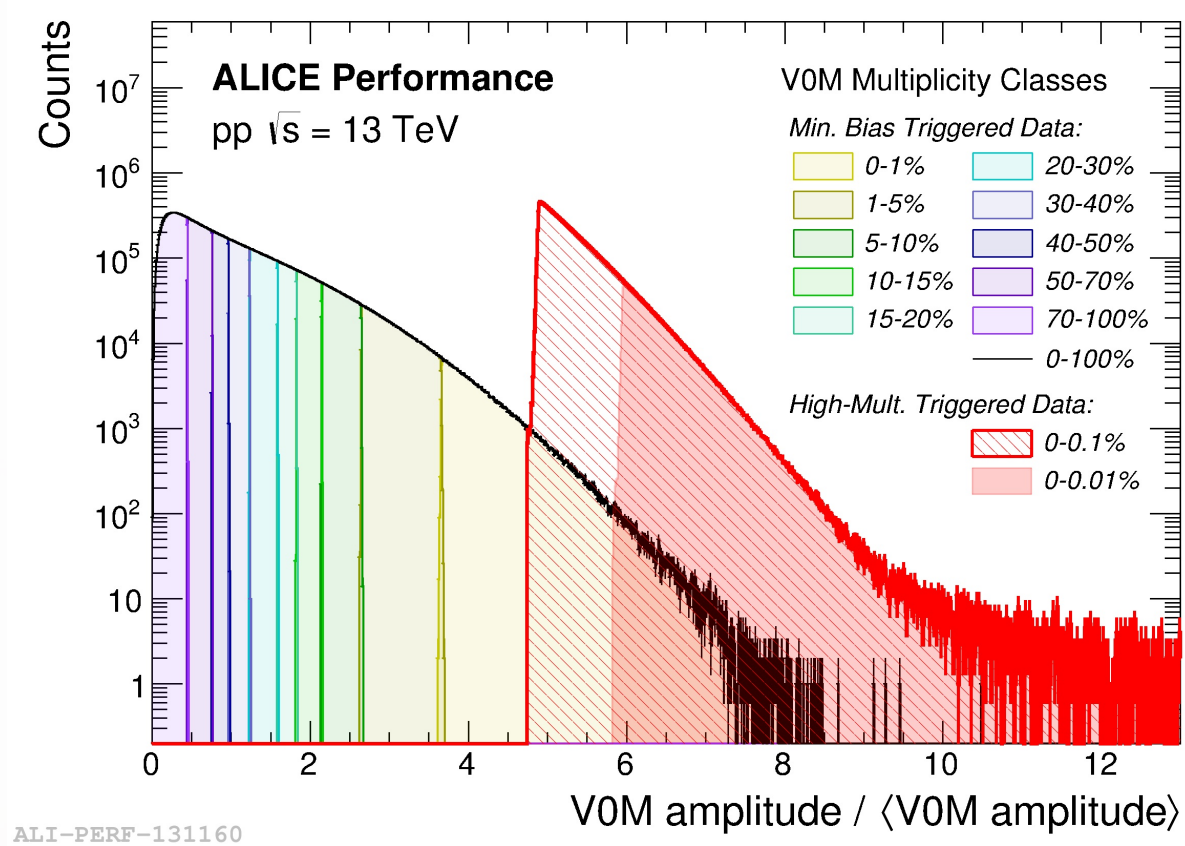
- PYTHIA 8.2 Monash 2013 overestimates production of π^0 , does not capture shape of η spectrum
- π^0 NLO_[1] calculation using:
 - FF: NNFF1.0 describes spectrum within uncertainties.
 - FF: DSS14 overestimates measurement by $\approx 50\%$
- η NLO calculation using:
 - FF: AESSS overestimates measurement by \approx a factor 2

- η/π^0 -ratio measured up to $p_T = 50$ GeV/c

- Comparison to other collision energies:
 - Agreement between different η/π^0 -ratios over three orders of magnitude in \sqrt{s}
 - Combined constant fit above $p_T = 4$ GeV/c: 0.475 ± 0.005

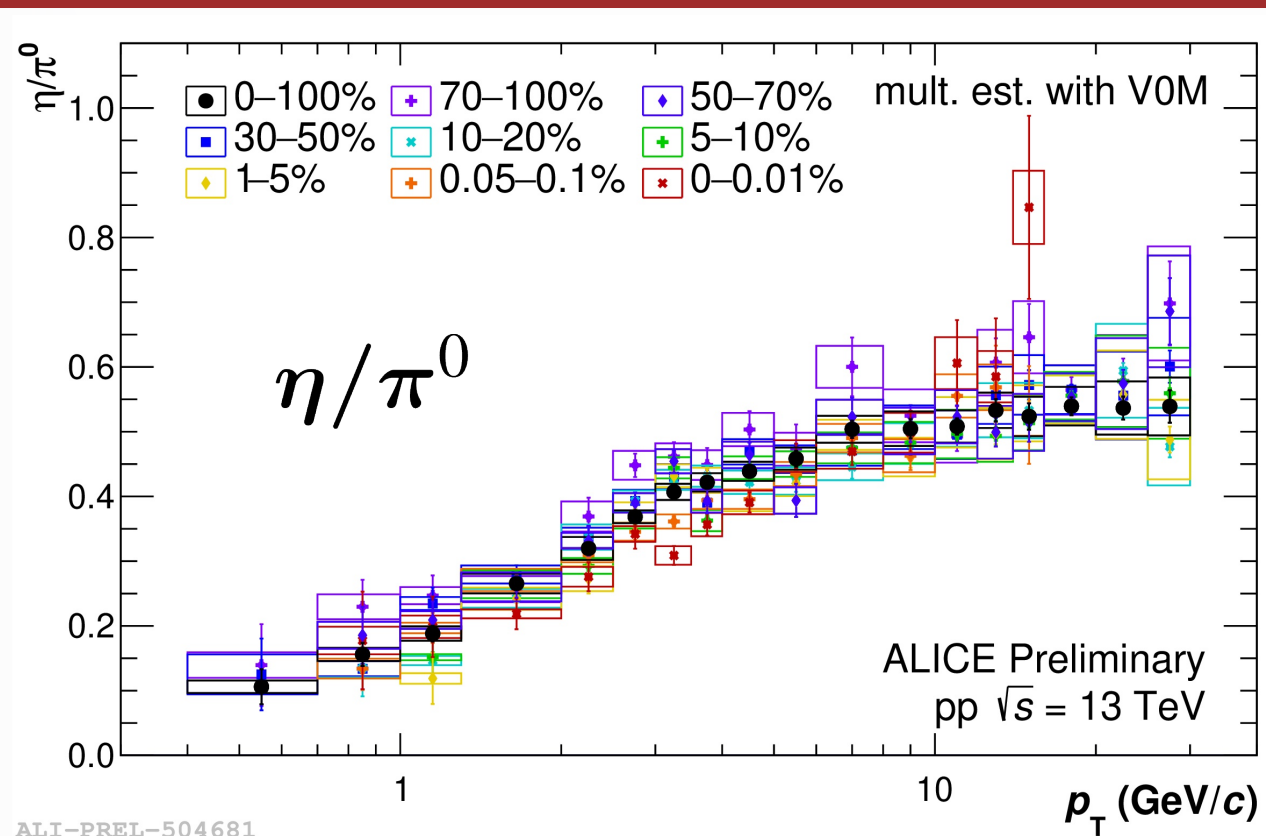


Multiplicity dependence

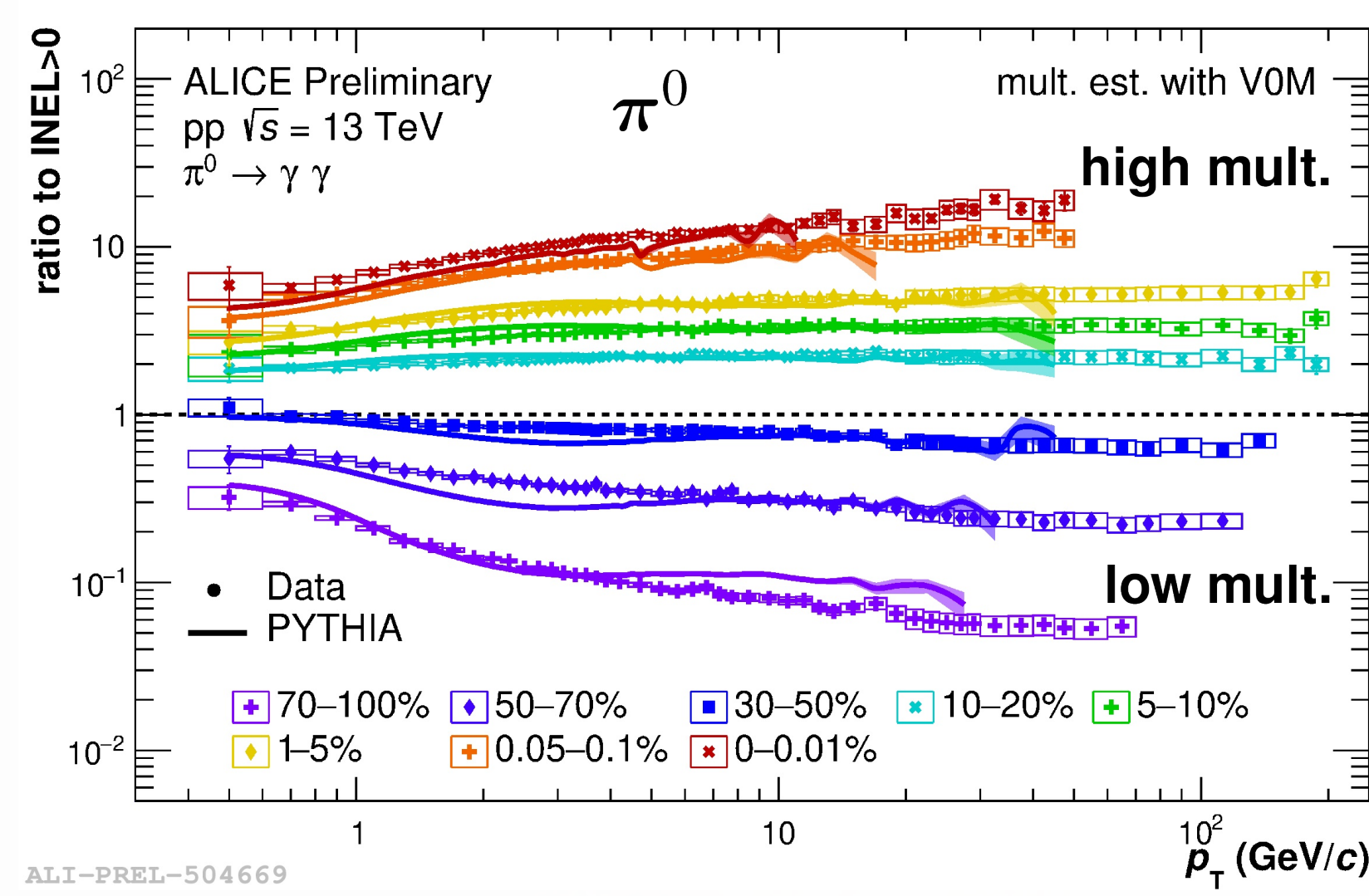


VOM multiplicity estimator:
 $2.7 < \eta < 5.1$
 $-3.7 < \eta < -1.7$

- Multiplicity dependent spectra extracted in 12 intervals
- Using VOM multiplicity triggered data for the 0.1% highest multiplicities
- π^0 (η) p_T spectra cover nearly 3 (2) orders of magnitude in p_T depending on multiplicity

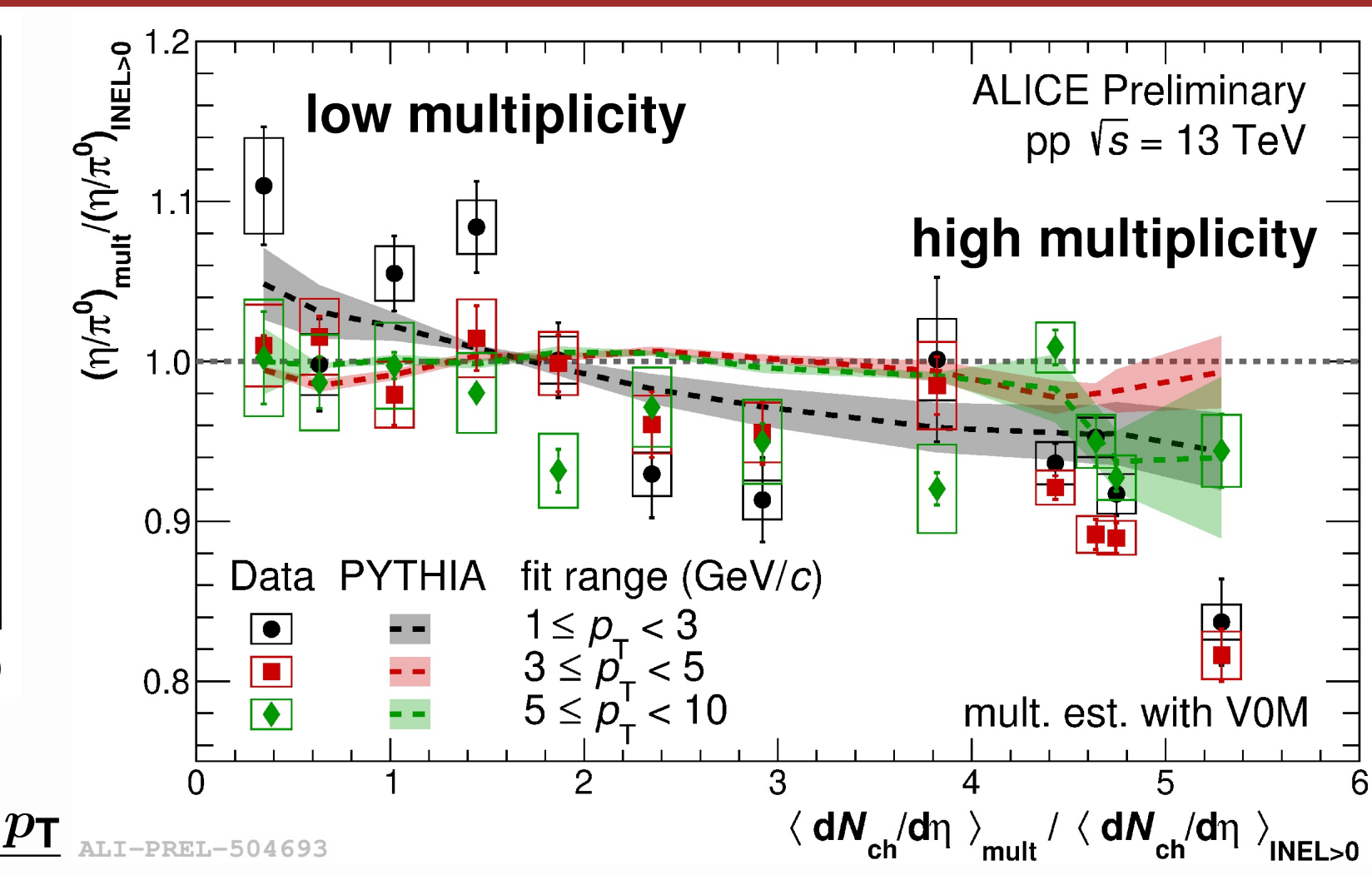


- low multiplicity
 - Slight enhancement at low p_T
 - For $p_T > 3$ GeV/c: Compatible with inclusive meas.
 - Prediction from PYTHIA compatible with measurement



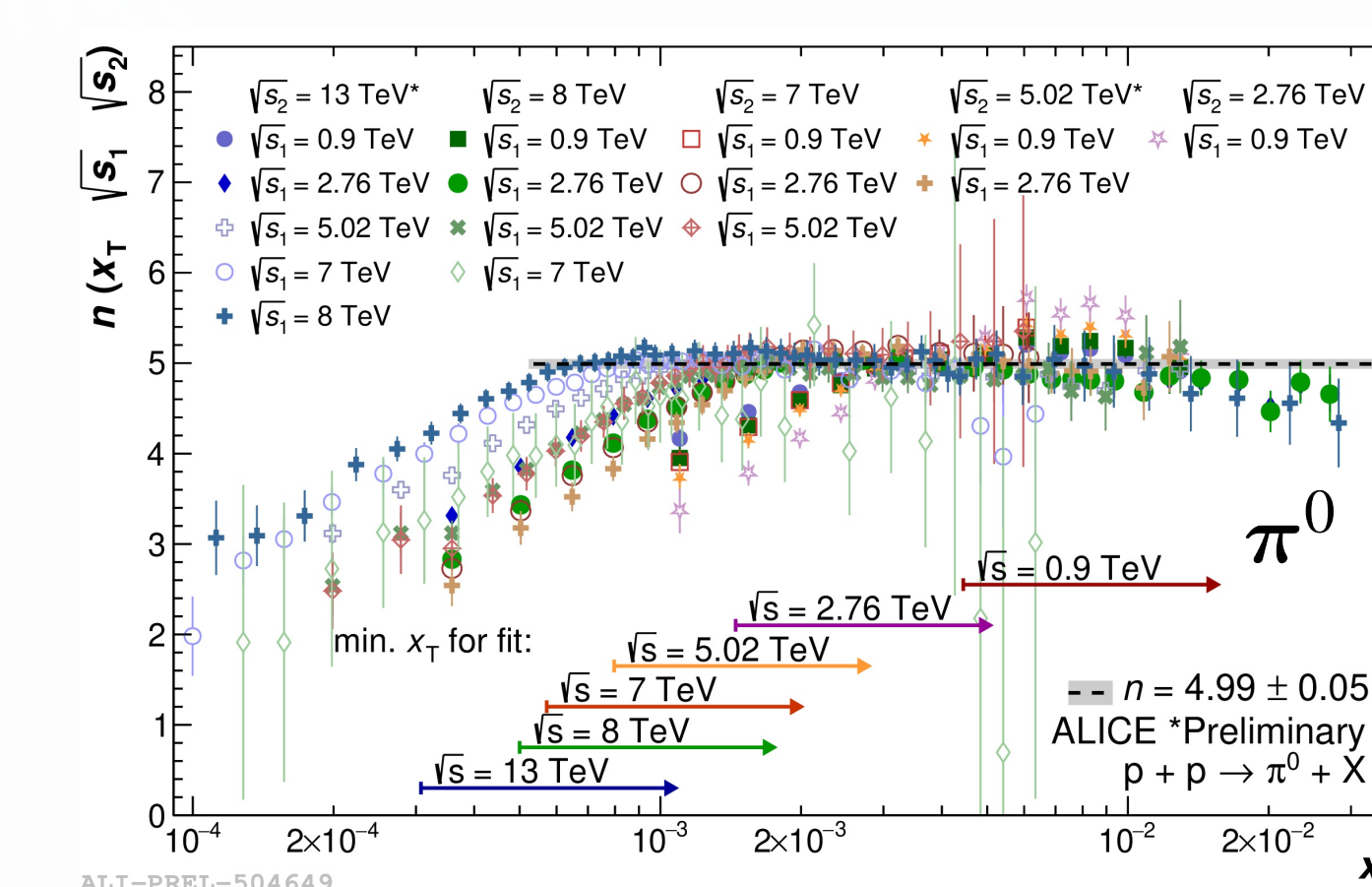
Ratio to INEL>0 spectrum

- **Hardening of p_T spectra** with rising multiplicity
- Comparison to PYTHIA:
 - General ordering and magnitude described by PYTHIA
 - Slightly different p_T dependence

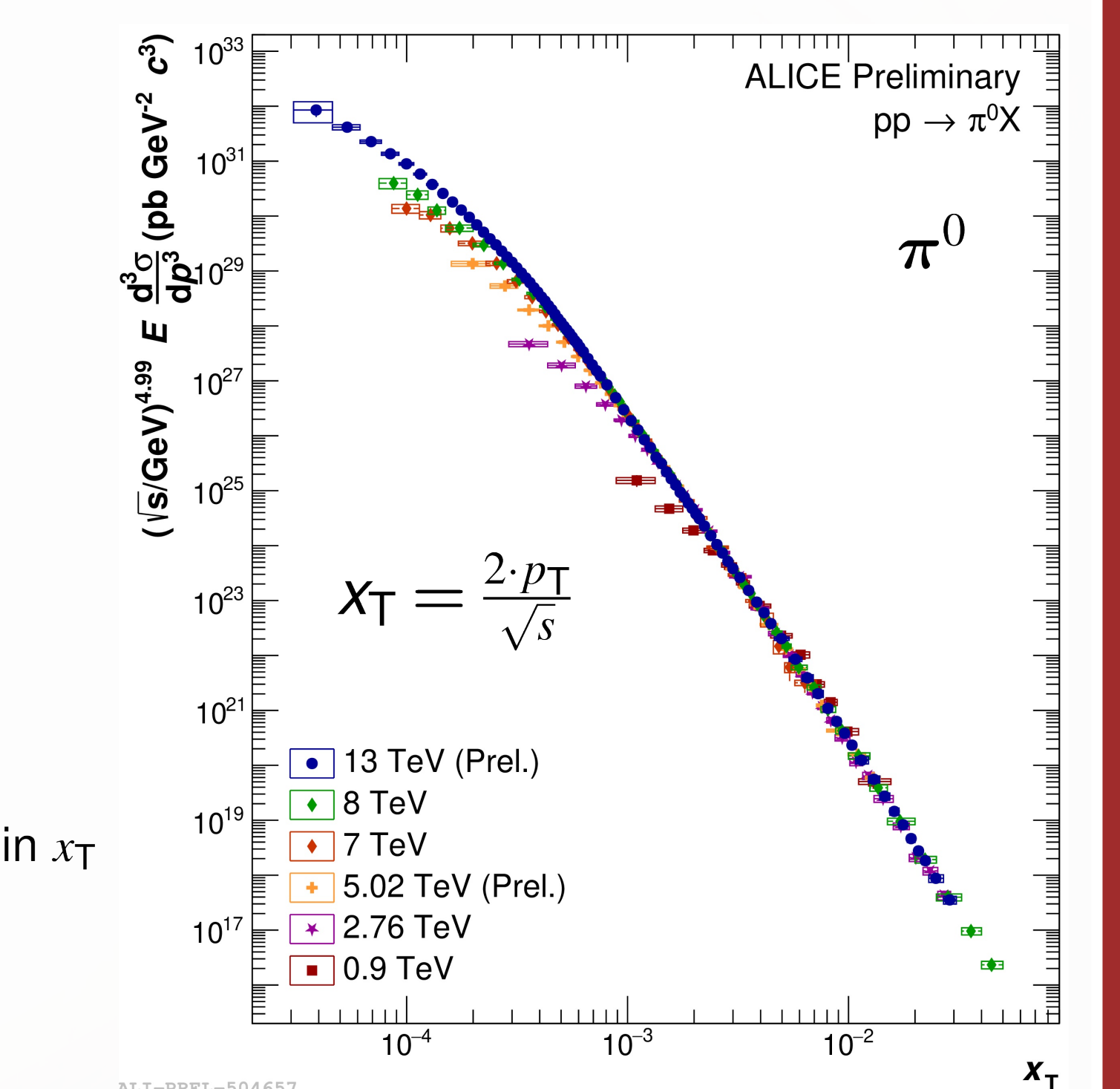


- high multiplicity
 - Slight suppression for $p_T < 5$ GeV/c
 - Above $p_T = 5$ GeV/c compatible with inclusive meas.
 - PYTHIA shows suppression for $p_T < 3$ GeV/c, no suppression for $p_T > 3$ GeV/c

x_T -scaling



- Expectation: Universal behavior for x_T -spectra scaled with \sqrt{s}^n
- Measurement at $\sqrt{s} = 13$ TeV has large overlap in x_T with previous ALICE results
 - $n_{\pi^0} = 4.99 \pm 0.05$
 - Universal behavior for $p_T > 3$ GeV/c
 - In agreement with results from charged pions $n_{\pi^\pm} = 5.04 \pm 0.02$ [2]



Outlook

- **Publication in preparation**
 - Additional purity based π^0 reconstruction technique using the PHOS detector
 - Comparisons to predictions from EPOS LHC
- Measurement of **light neutral meson production inside of jets**
 - Extraction of π^0 and η fragmentation function possible
 - Detailed studies of difference between fragmentation of π^0 and η as function of jet momentum
- Measurement of neutral mesons and photons in **LHC run 3**
 - Increased statistics compared to run 1 and run 2
 - New trigger possibilities thanks to offline trigger selection

11th International Conference on Hard and Electromagnetic Probes of High-Energy Nuclear Collisions

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