Overview of neutral-meson production in pp, p-A and A-A collisions at the LHC measured by ALICE

D.Peresunko for the ALICE collaboration

NRC “Kurchatov Institute”

HARD PROBES 2018

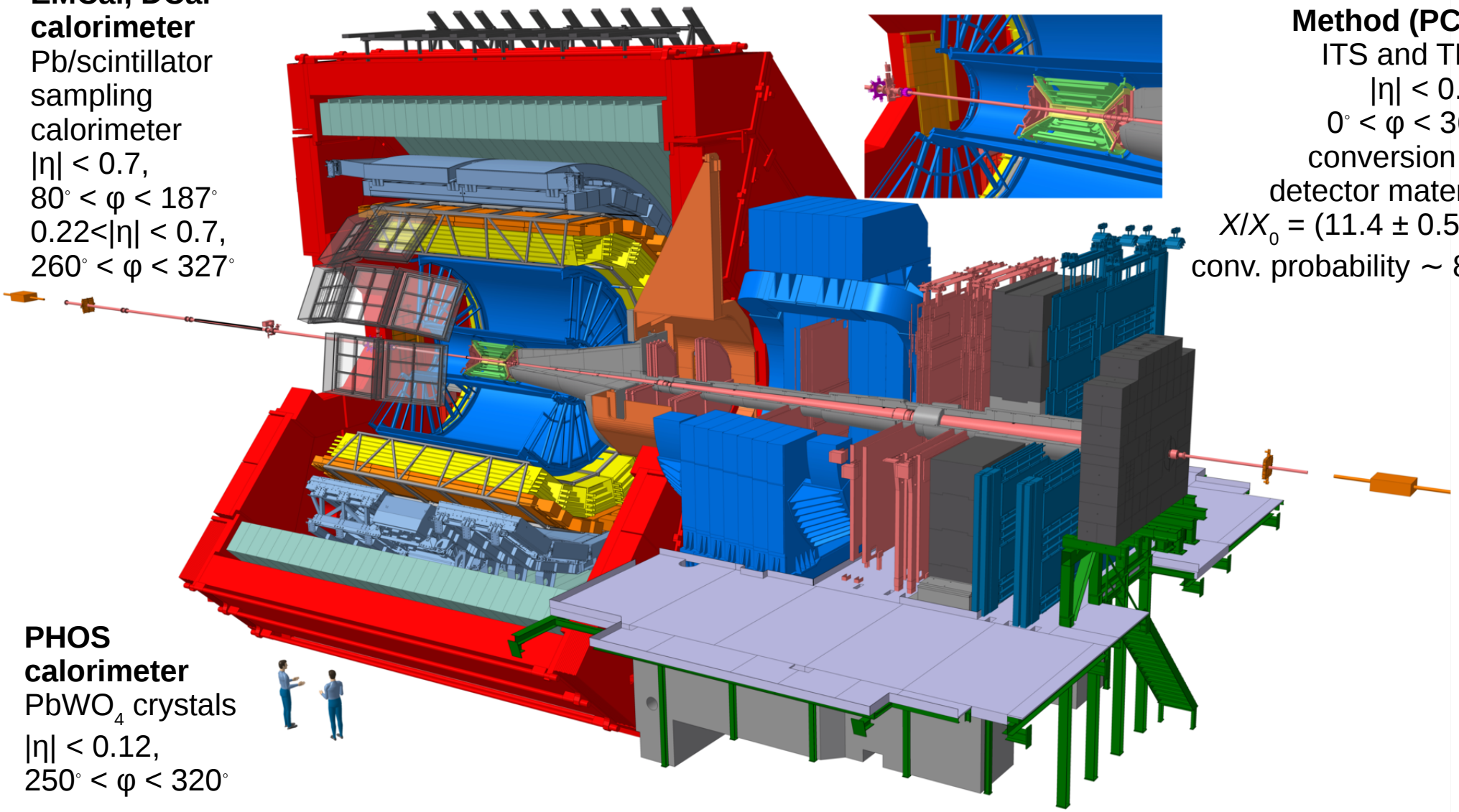
Why neutral mesons?

- Neutral mesons can be reconstructed and identified through photon decays in wide p_T range
- pp collisions QCD predictions, tuning of PDF and FF, baseline for p-A and A-A
- p-A: looking at collective effects, nuclear effects in PDF, cold nuclear effects, reference for A-A
- A-A: collective effects, parton-medium interaction etc.
- All collisions: main input for direct photon and dilepton cocktails

Photon reconstruction in ALICE

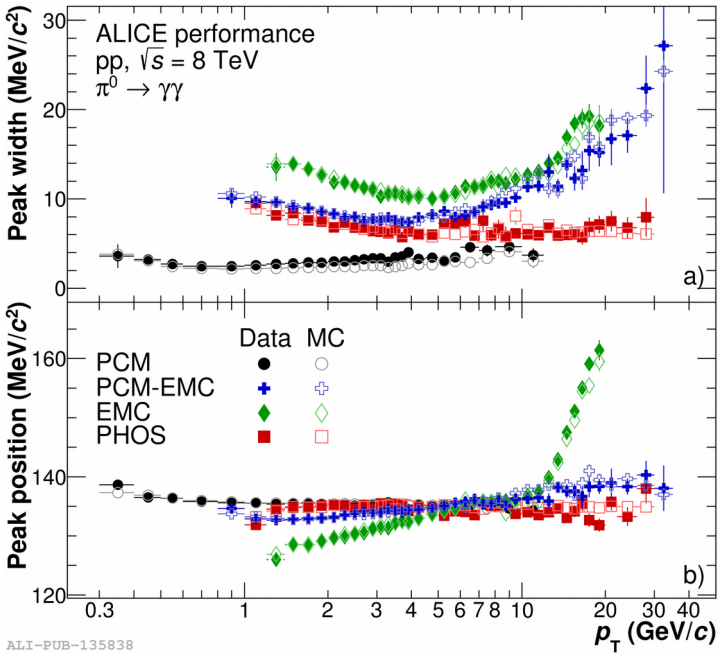
EMCal, DCal calorimeter
Pb/scintillator sampling calorimeter
$|\eta| < 0.7$,
$80^\circ < \varphi < 187^\circ$
$0.22 < |\eta| < 0.7$,
$260^\circ < \varphi < 327^\circ$

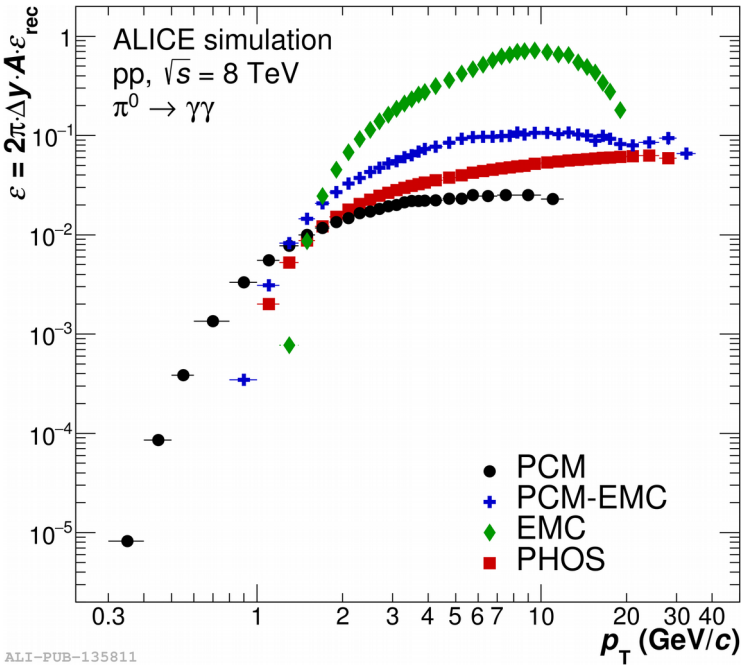
Photon Conversion Method (PCM)
ITS and TPC
$|\eta| < 0.9$,
$0^\circ < \varphi < 360^\circ$
conversion in detector material
$X/X_0 = (11.4 \pm 0.5)\%$
conv. probability ~ 8%

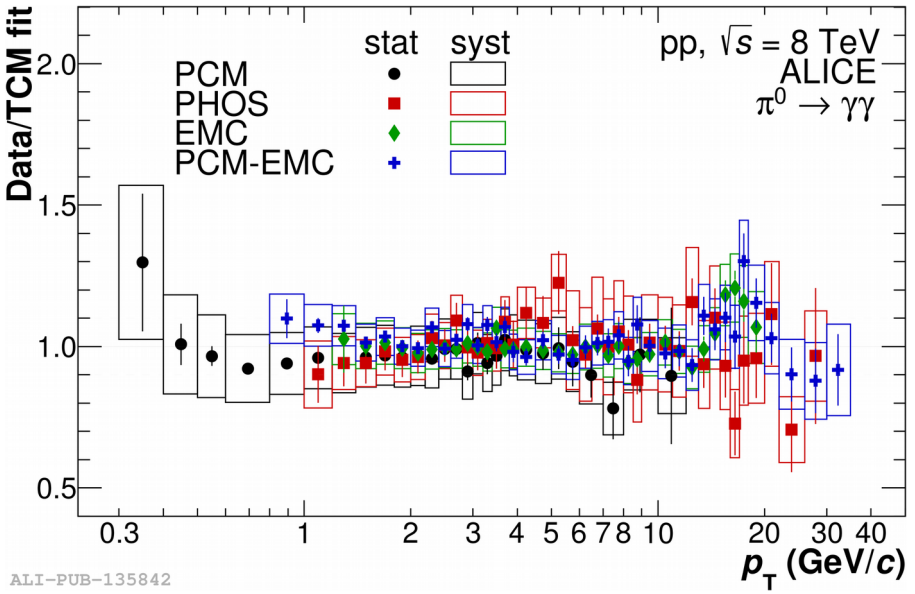


PHOS calorimeter
$PbWO_4$ crystals
$|\eta| < 0.12$,
$250^\circ < \varphi < 320^\circ$

PCM and calorimeter performance



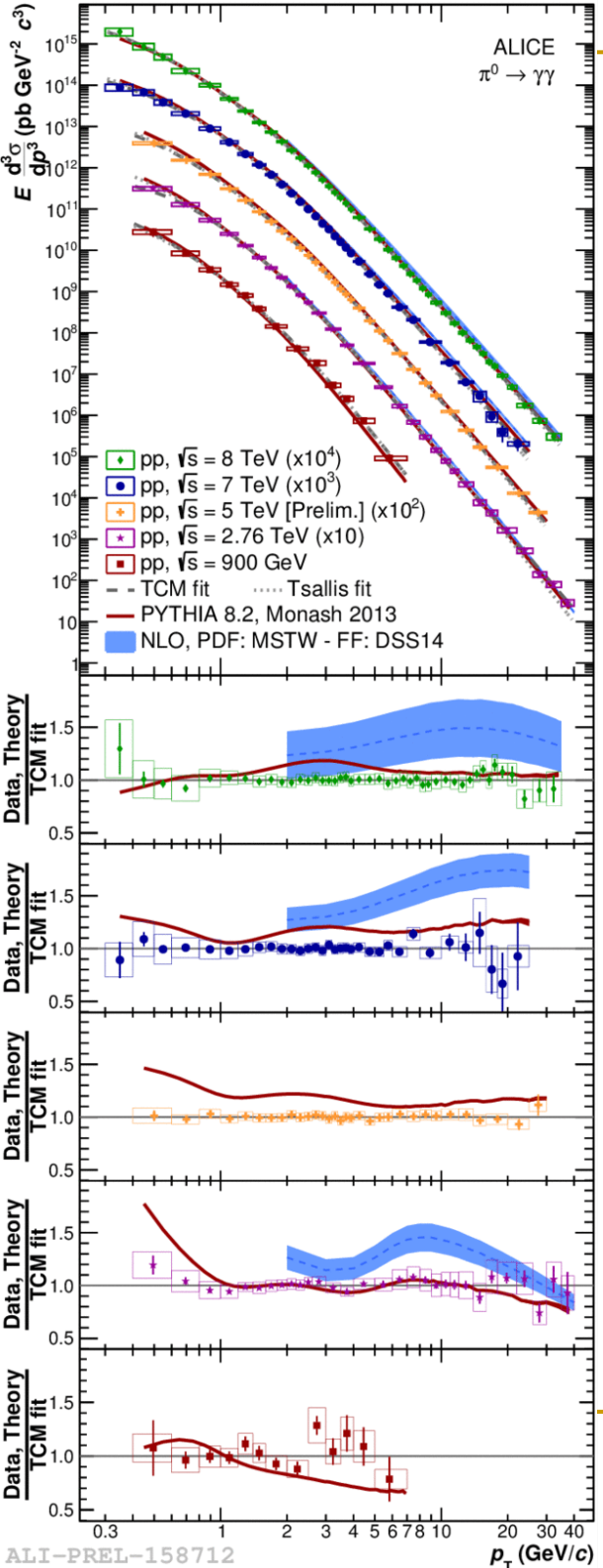




- Using different technologies allows wide extension of p_T range
- Combination of independent results provides cross-check and significantly reduces final uncertainties

ALICE collaboration: Eur. Phys. J. C (2018) 78:263

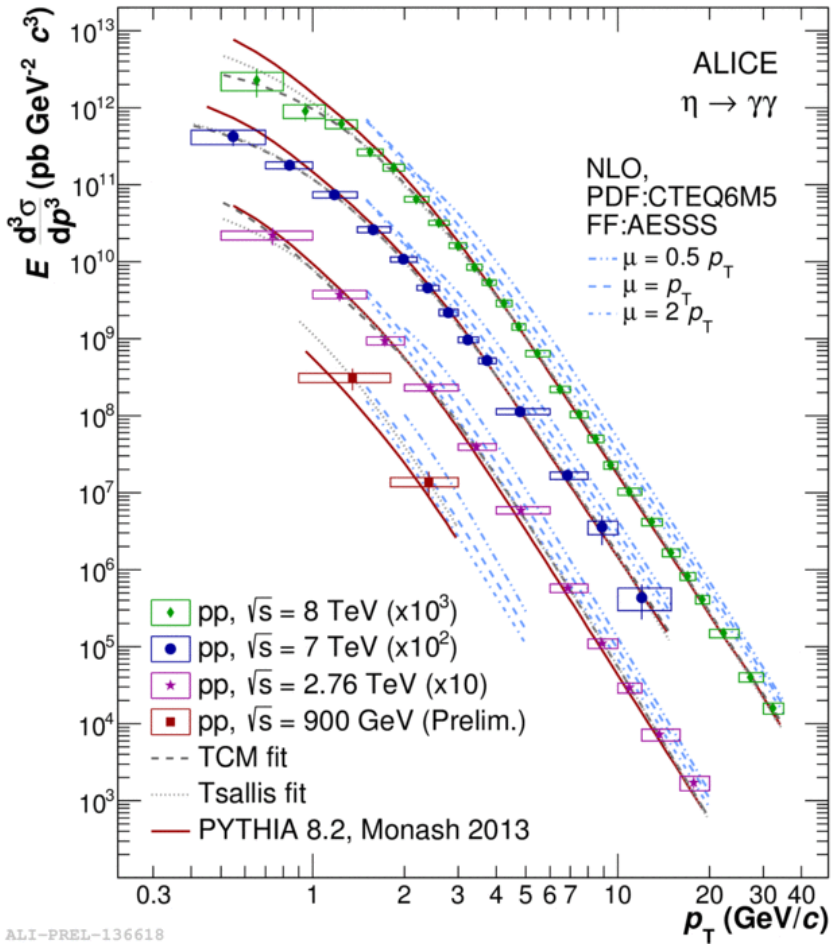
π^0 meson measurements in pp

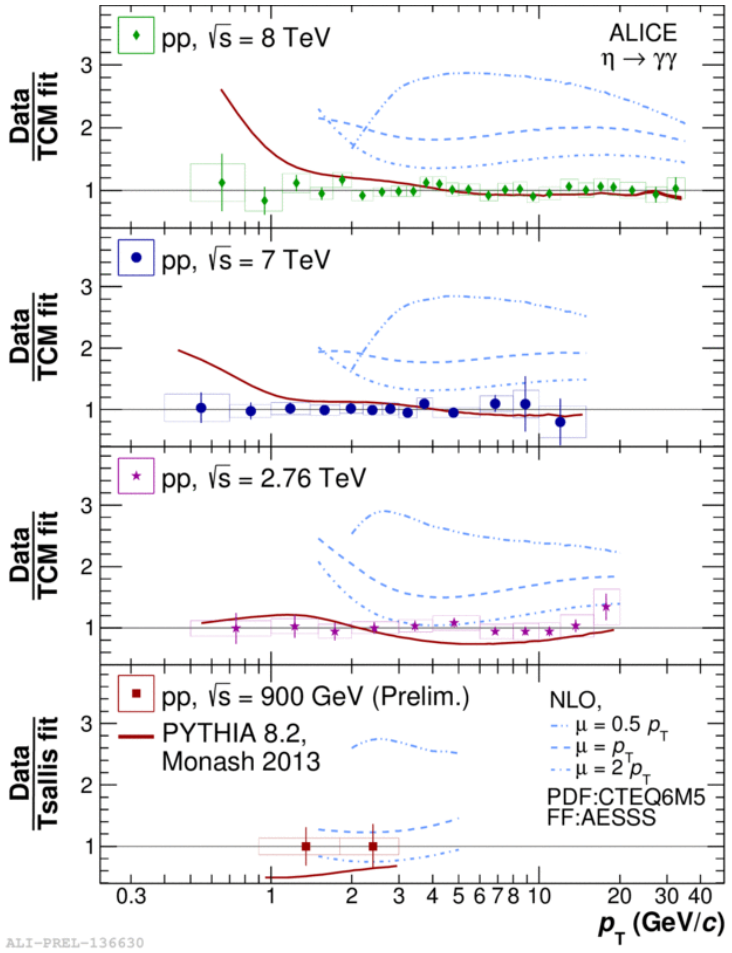


- Spectra measured in pp collisions at $\sqrt{s}$=0.9, 2.76, 5.02, 7 and 8 TeV
- Pythia 8.2 Monash 2013 reproduces approximately π^0 spectra at all energies
- NLO pQCD calculations predict ~20-30% higher yield
  - DSS14 already incorporates ALICE pp at $\sqrt{s}$=7 TeV results

8 TeV ALICE collaboration :
Eur. Phys. J. C (2018) 78:263
2.76 TeV ALICE collaboration :
Eur. Phys. J. C 77 (2017) 339
7 TeV ALICE collaboration :
Phys. Lett. B 717 (2012) 162-172

η meson measurements in pp

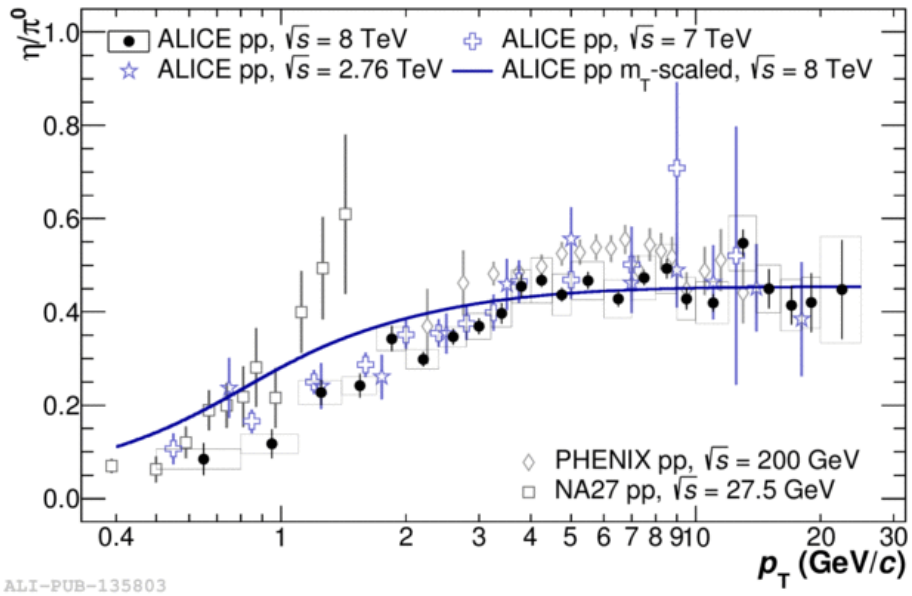


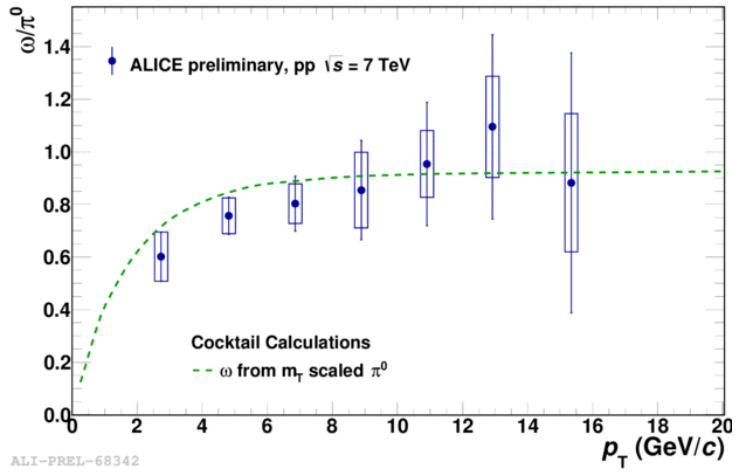


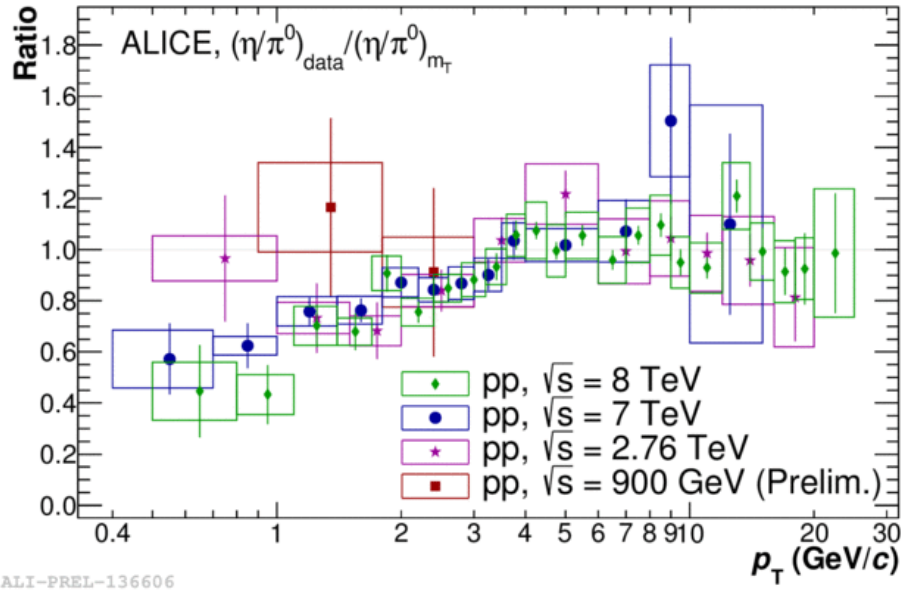
8 TeV ALICE collaboration : EPJC (2018) 78:263
2.76 TeV ALICE collaboration: EPJC 77 (2017) 339
7 TeV ALICE collaboration: PLB717 (2012) 162

- Pythia 8.2 Monash 2013 reproduces approximately η spectra at all energies
- NLO pQCD calculations predict ~2x higher yield
  - Revisiting η-meson FF is necessary

m_T scalings



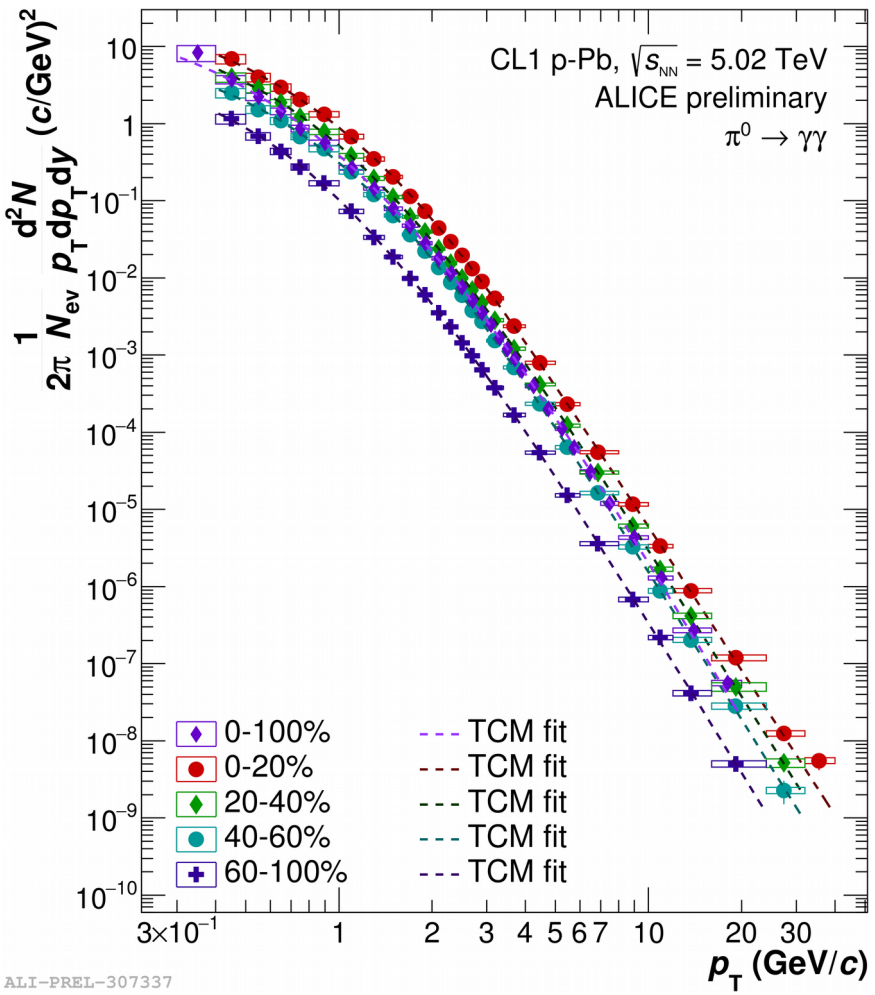


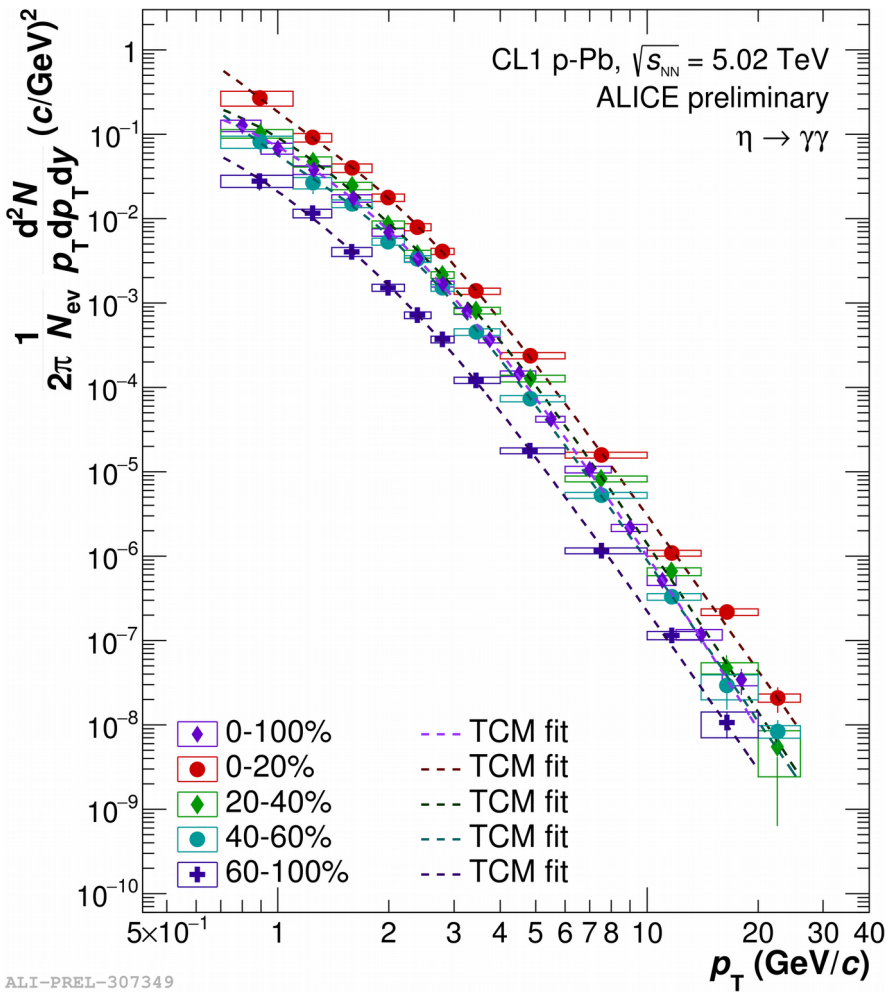


- Experimental parameterization
- Widely used e.g. in EM cocktails if hadron spectra are not know
- Holds at high p_T>3 GeV/c
- Deviations ~40% at low p_T

8 TeV ALICE collaboration: EPJC (2018) 78:263
2.76 TeV ALICE collaboration: EPJC 77 (2017) 339
7 TeV ALICE collaboration: PLB 717 (2012) 162

π^0 and η spectra in p-Pb 5.02 TeV

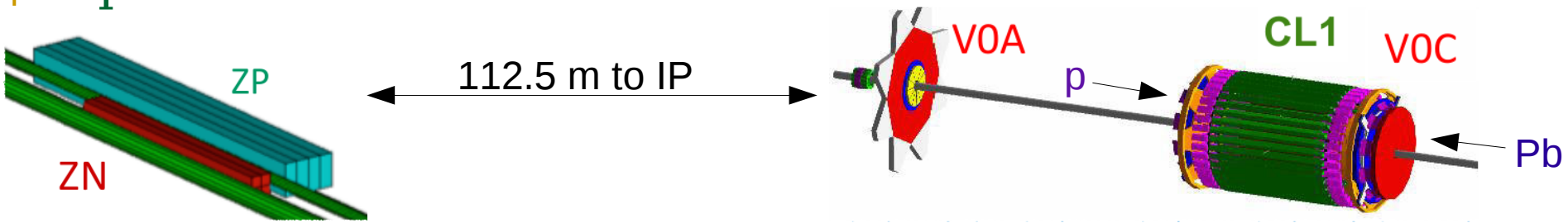




- π^0 and η spectra measured in p-Pb collisions in 4 centrality classes:
  - 0-20%, 20-40%, 40-60%, 60-100%
- p_T range extended up to 40 GeV/c by using PHOS trigger

p-Pb->π^0,η: 0-100% NSD:
Eur. Phys. J. C (2018) 78: 624

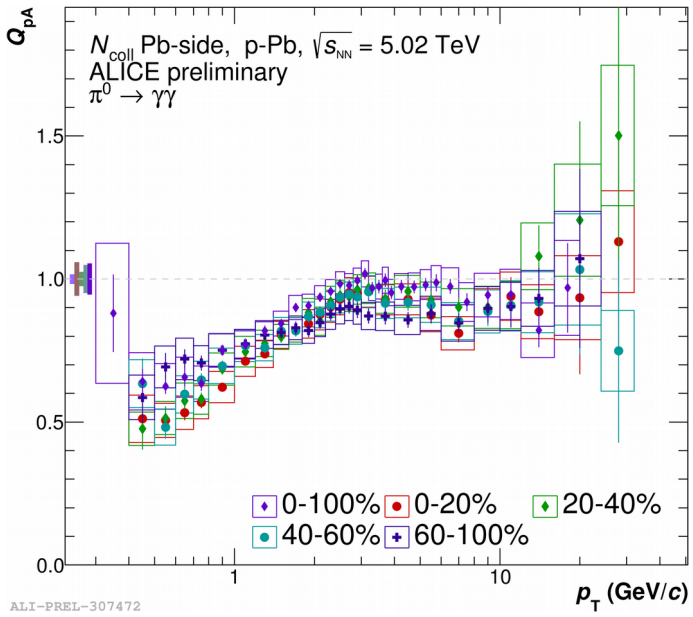
Q_{pA} multiplicity dependence

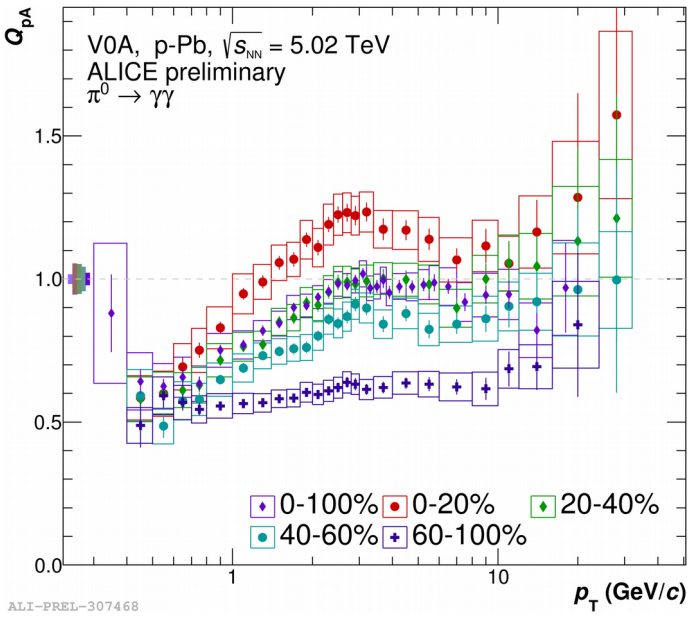


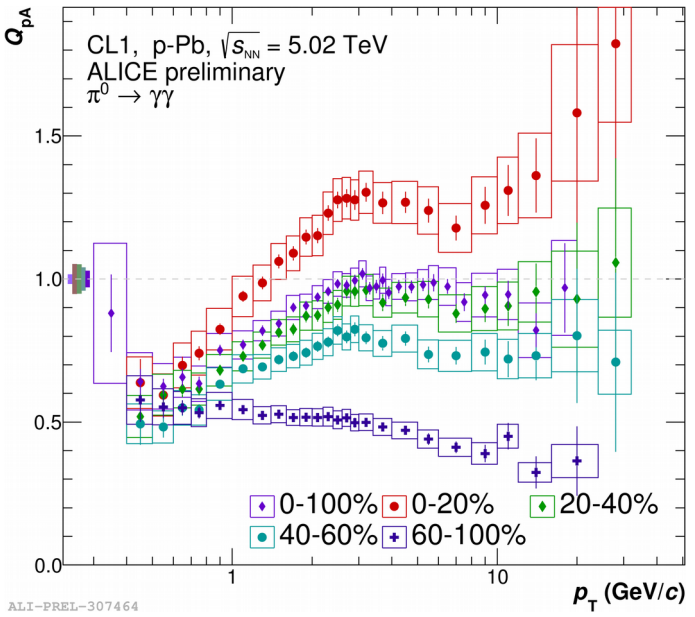
ZNA: $|\eta|>8.7$, Pb side

V0A: $2.0<|\eta|<5.1$, Pb side

CL1: $|\eta|<1.4$



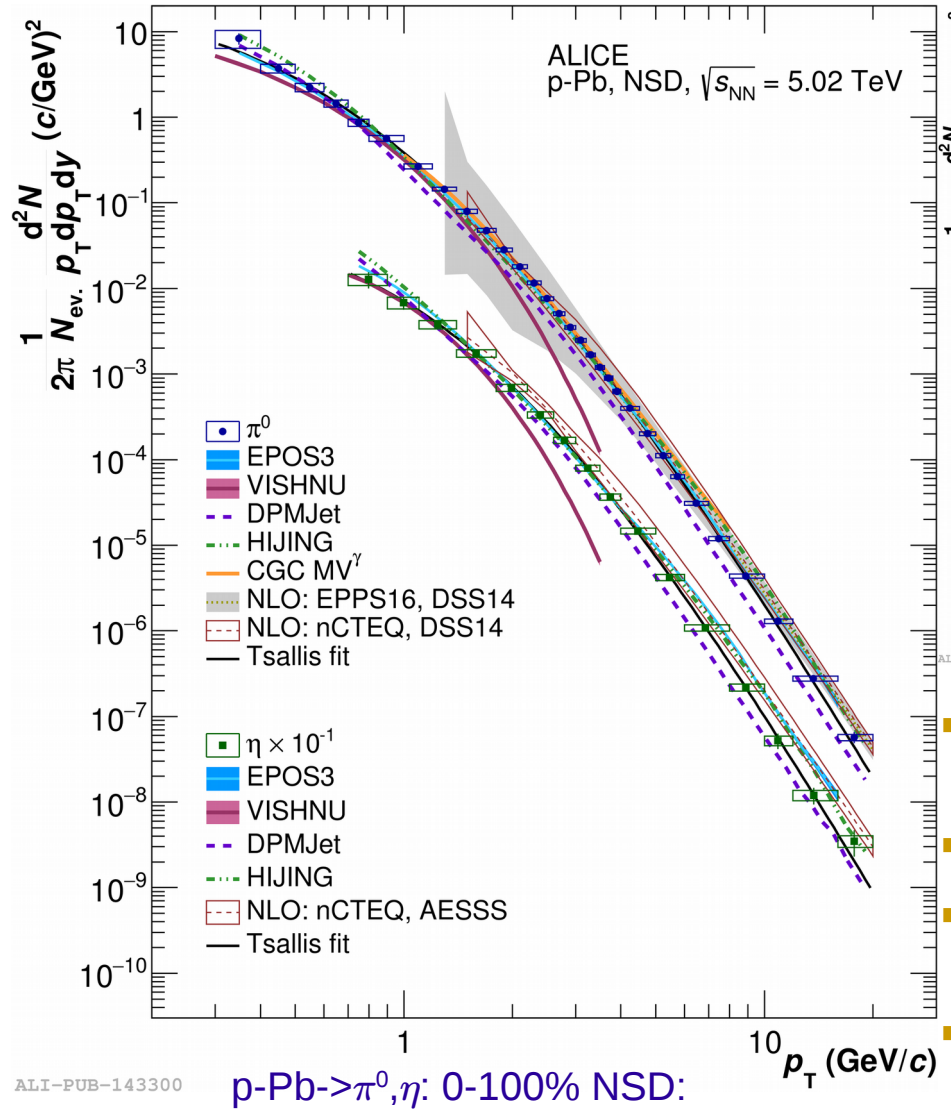


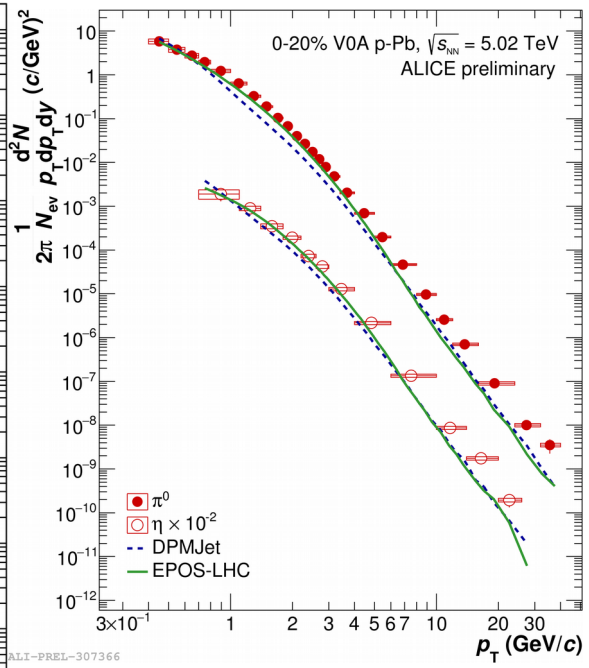


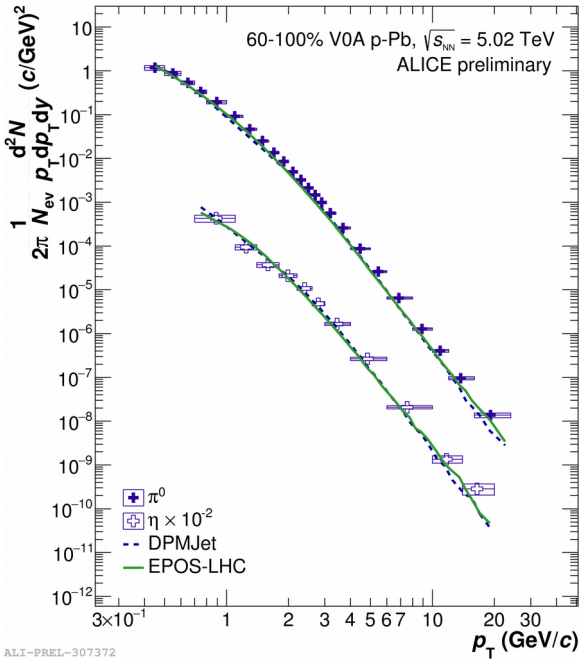
$$Q_{pA}(p_T) = \frac{\frac{1}{N_{evt}^{pA}} d^2N^{pA}(p_T)/d\eta dp_T}{\langle N_{coll}\rangle \frac{1}{N_{evt}^{pp}(p_T)} d^2N^{pp}/d\eta dp_T}$$

- No strong centrality dependence with ZNA estimator
- Visible centrality dependence for estimators with smaller centrality gap
- No trivial autocorrelations with cent. estimator

Comparison to models







- EPOS3 describes the data over the entire p_T range for π^0 and up to p_T= 4 GeV/c for η
- Hydrodynamic model (VISHNU) agrees with the data at low p_T
- NLO pQCD calculations describe the π^0 spectrum, but fail to describe the high p_T region for η
- DPMJet and EPOS-LHC predict smaller yield at high p_T at all centralities

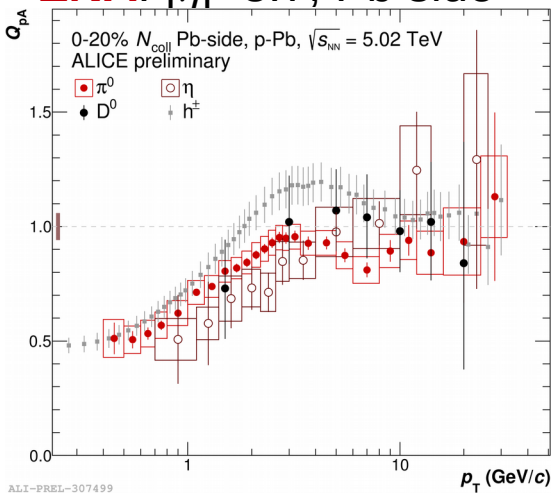
p-Pb->π^0,η: 0-100% NSD:
Eur. Phys. J. C (2018) 78: 624

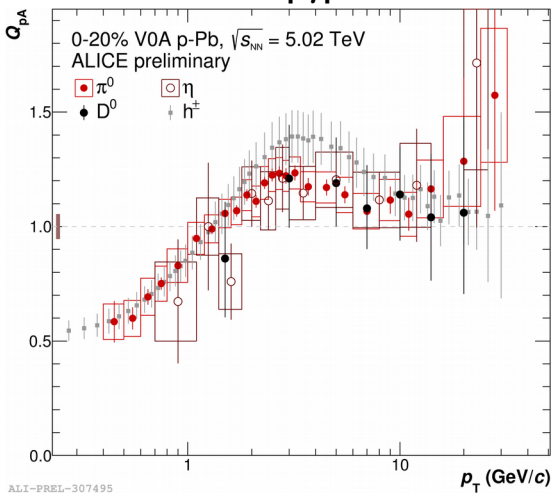
Particle-dependent Q_{pA}

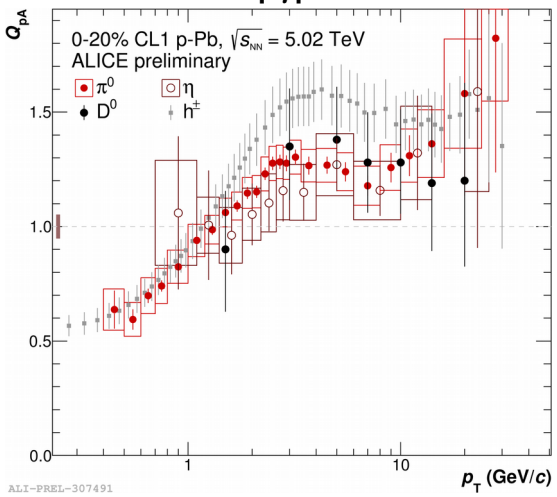
ZNA: $|\eta|>8.7$, Pb side

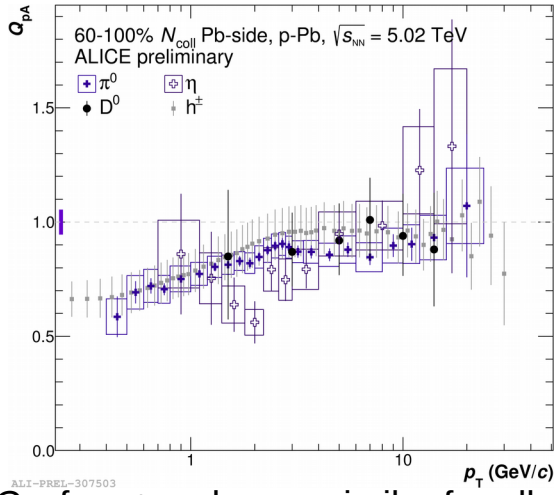
V0A: $2.0<|\eta|<5.1$, Pb side

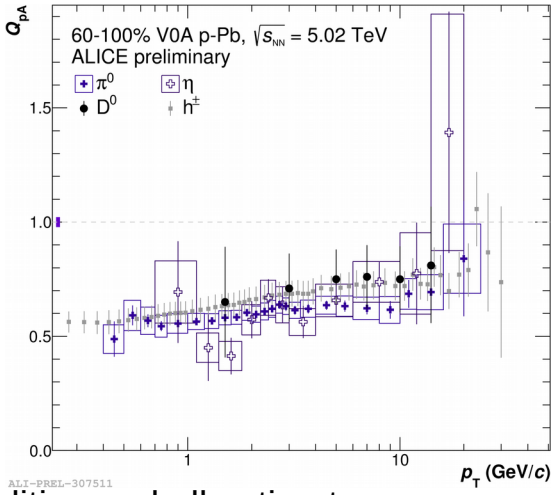
CL1: $|\eta|<1.4$

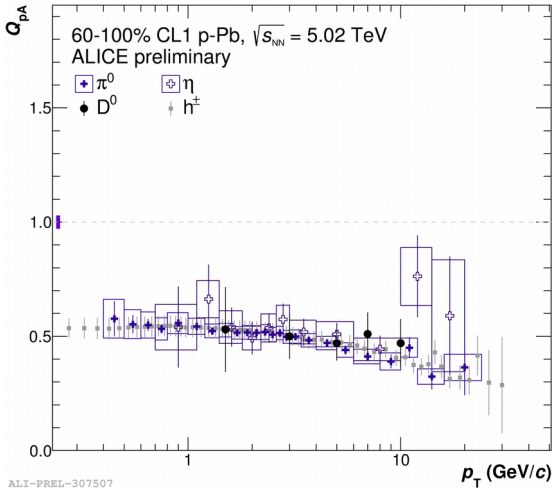








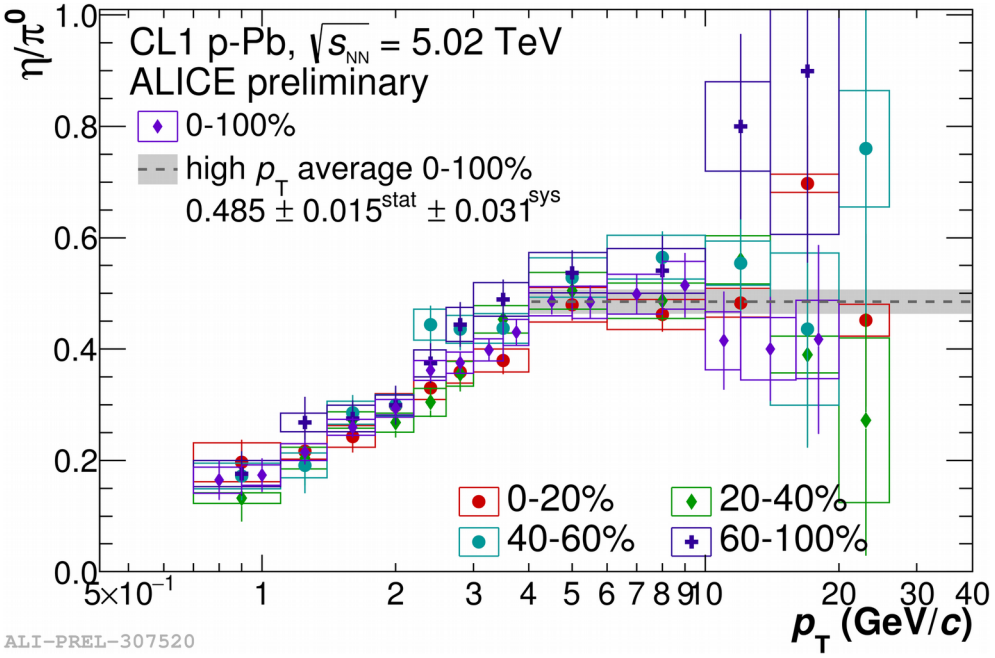


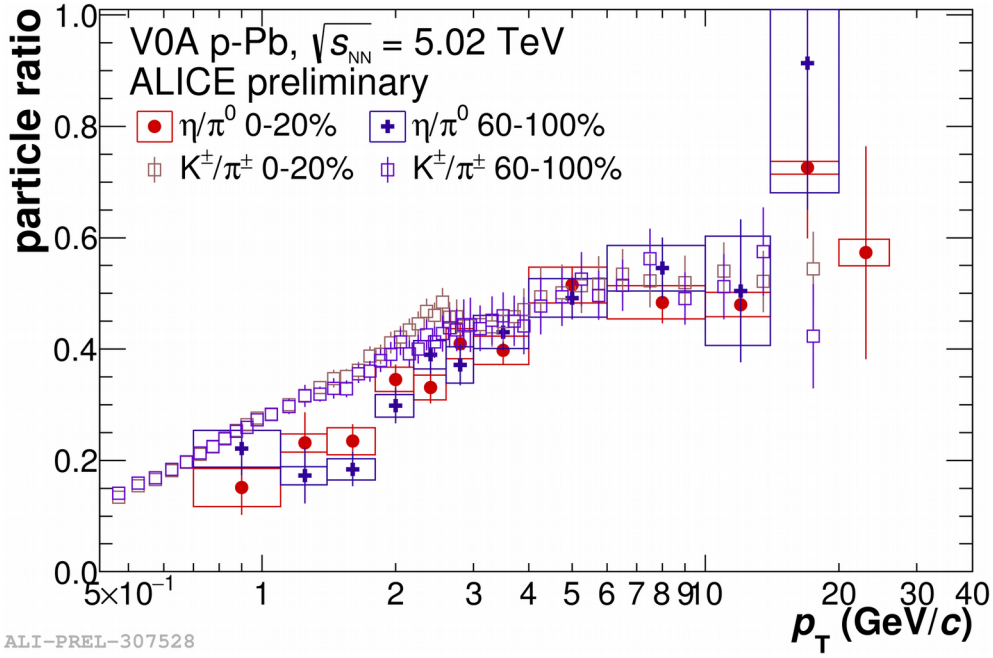


- Q_{pA} for π^0 and η are similar for all centralities and all estimators
- Q_{pA} for $h^{\pm}$ show a bump at p_T~2 GeV/c, (proton contribution ?)
- D^0-meson is consistent with π^0 and η trend

$h^{\pm}$: Phys.Rev. C91 (2015) 064905, 2015
D^0: JHEP 1608 (2016) 078, 2016

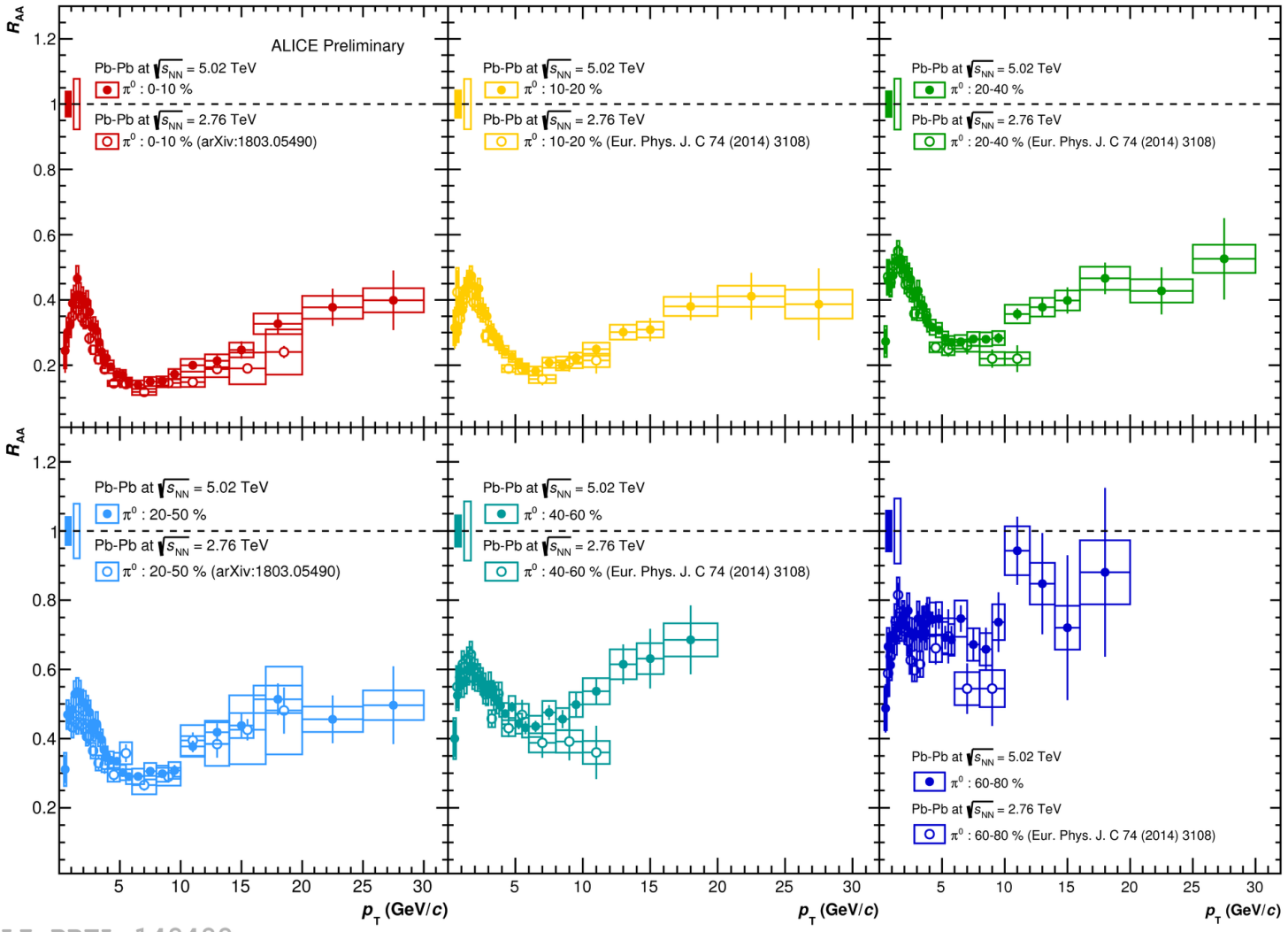
η/π^0 ratio in p-Pb collisions





- η/π^0 ratio shows no centrality dependence
- Same for $K^{\pm}/\pi^{\pm}$ ratio

R_{AA} in Pb-Pb at $\sqrt{s_{NN}}$=2.76 and 5.02 TeV



ALI-PREL-148488

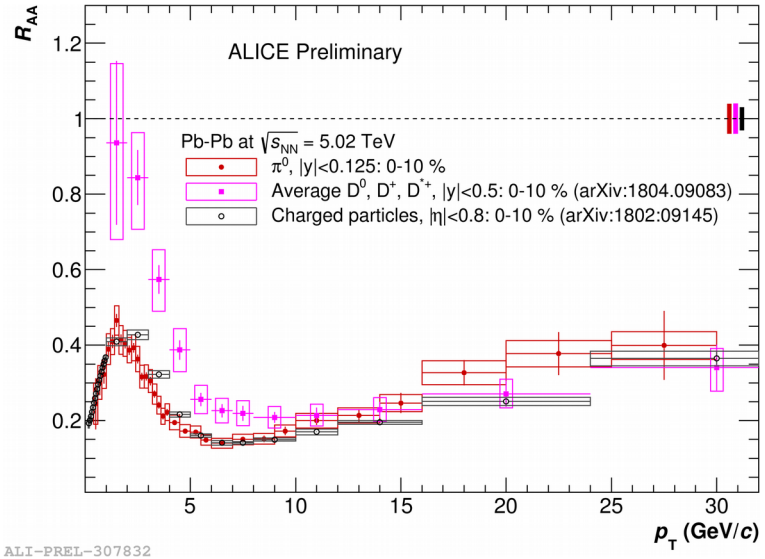
- Strong centrality dependence
- Similar R_{AA} for the two collision energies.

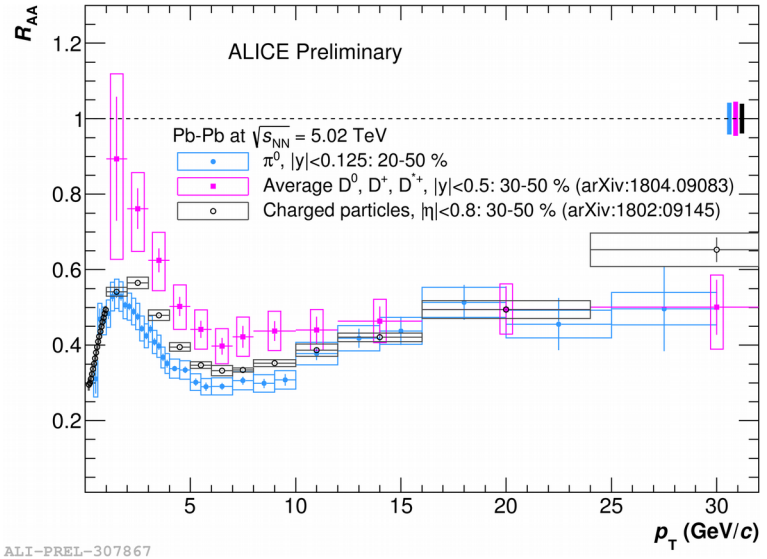
Pb-Pb $\sqrt{s_{NN}}$=2.76 TeV

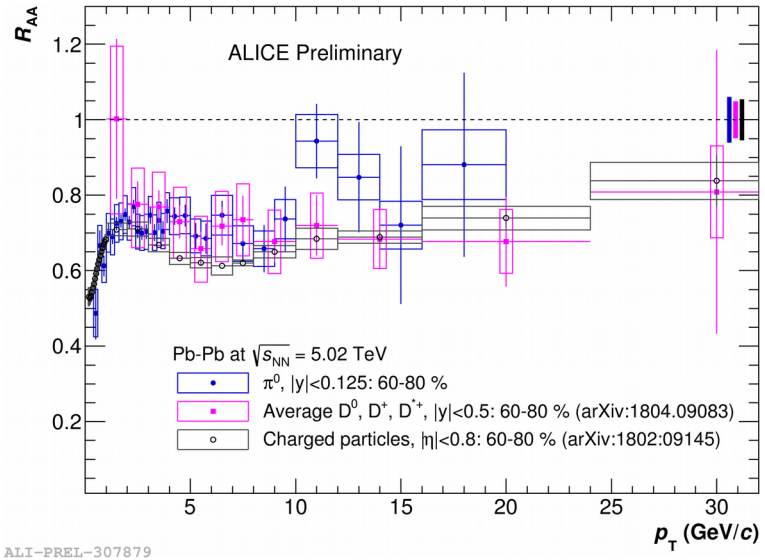
2010 data:
Eur. Phys. J. C (2014) 74:3108

2011 data:
arXiv:1803.05490

Comparison to D-mesons and hadrons

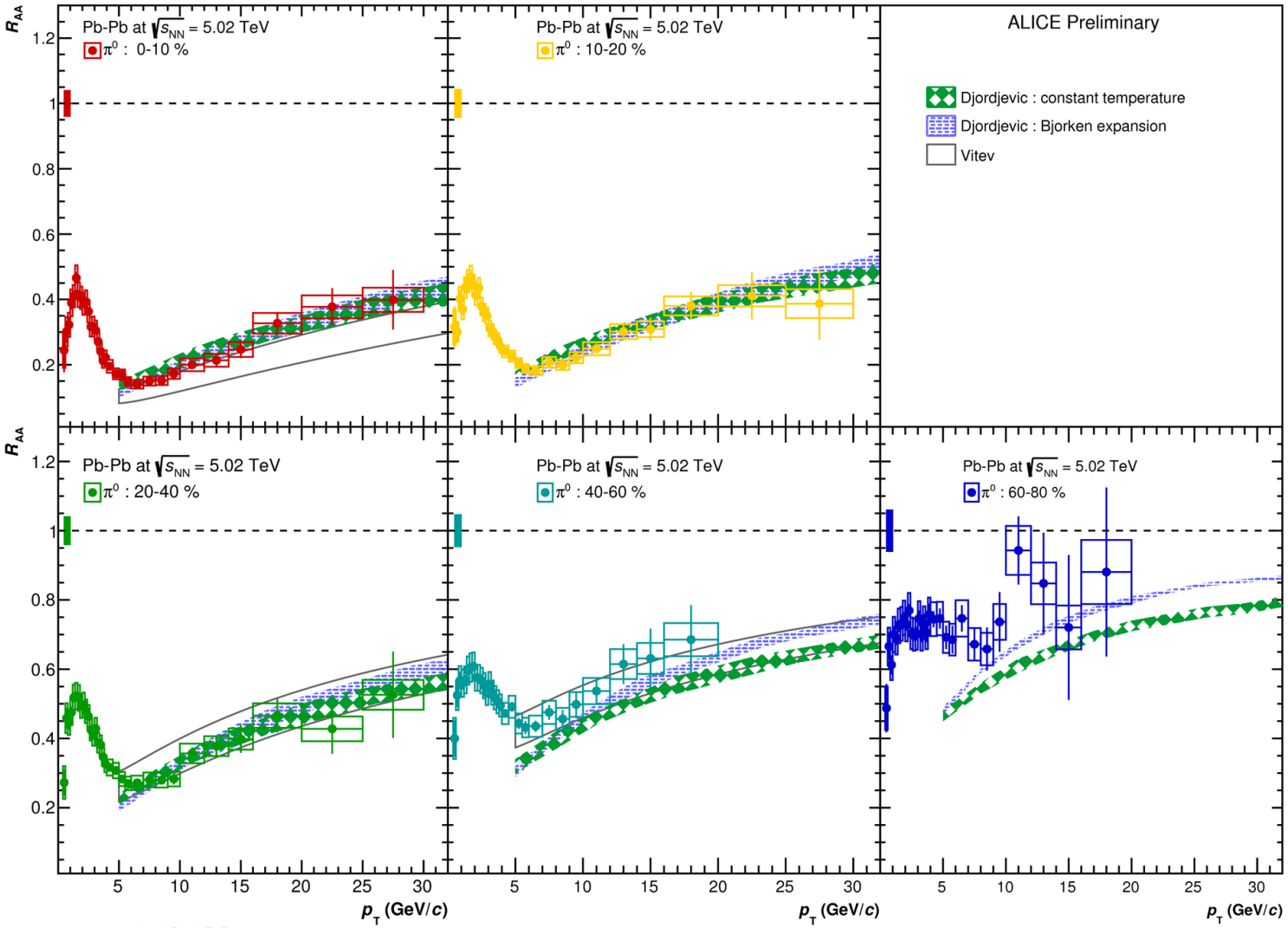






- Similar suppression at high p_T>10 GeV/c for all species
- Smaller suppression of D-mesons compared to pions and charged at low p_T
  - Quark mass difference?
  - Collective flow and recombination?
  - Soft pion production?
  - Another reason?

Comparison to theoretical calculations



ALI-PREL-148492

- Both models reproduce amount of suppression, p_T and centrality dependence

Djordjevic et al. :Phys. Rev. C 94, 044908 (2016) arXiv:1805.03494:Energy loss in evolving finite-size QGP

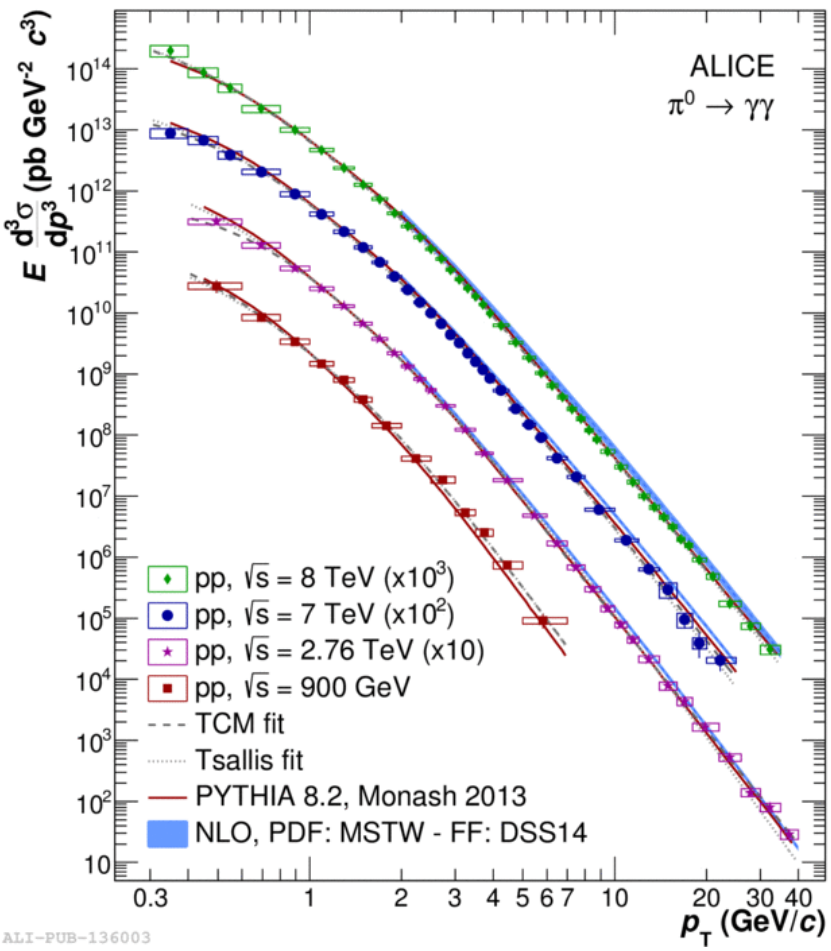
Vitev et al.: Phys. Rev. D 93, 074030 (2016): Soft-Collinear effective theory for jet propagation in matter.

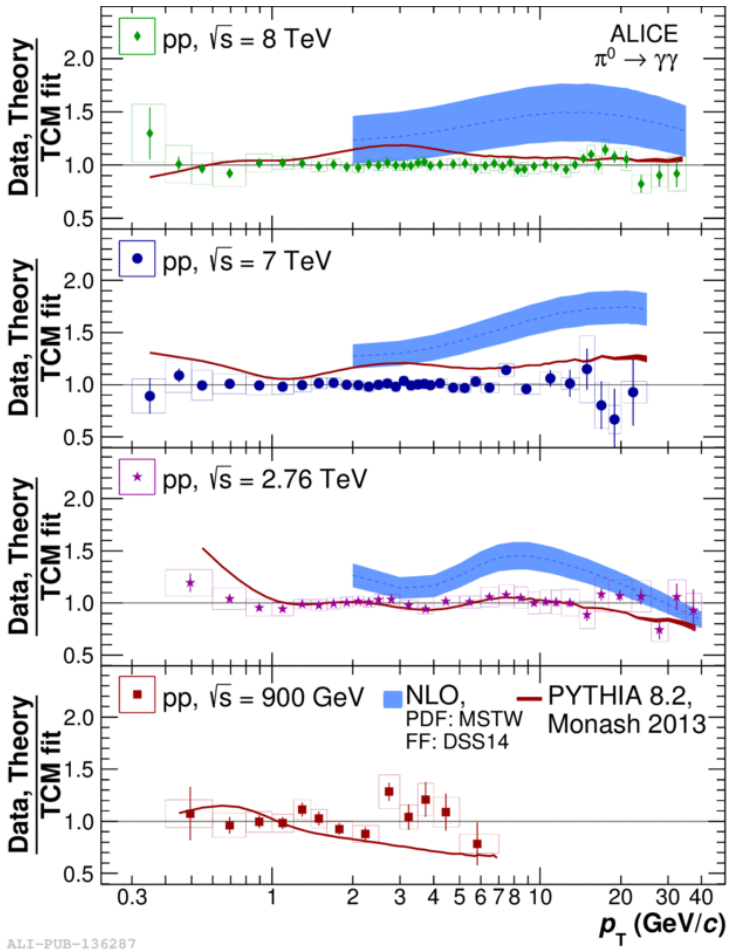
Conclusions

- π^0 and η spectra measured in pp collisions at $\sqrt{s}$=0.9, 2.76, 5.02, 7 and 8 TeV
  - NLO pQCD
    - π^0: PDF: MSTW+FF:DSS14 predicts 20-30% higher yield
    - η : PDF: CTEQ6M5+FF: AESSS predicts 2x higher yield
- π^0 and η spectra in p-Pb at $\sqrt{s_{NN}}$=5.02 TeV
  - centrality classes 0-20%, 20-40%, 40-60%, 60-100% with ZNA, V0A, CL1 centrality estimators
  - Strong dependence of Q_{pPb} on rapidity gap to centrality estimator
  - Consistent with D-mesons within uncertainties
- π^0 yield in Pb-Pb $\sqrt{s_{NN}}$=5.02 TeV
  - R_{AA} at $\sqrt{s_{NN}}$=2.76 and 5.02 TeV are very close
  - R_{AA} similar to one of D-mesons at p_T>10 GeV, but smaller at lower p_T
  - Models of Djordjevic et al. and Vitev et al., reproduce p_T and centrality dependence

Backup

Neutral meson measurements in pp





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Spectra vs centrality, V0A and ZNA