



EPS-HEP Conference 2019, Ghent



Light neutral meson production in the era of precision physics at the LHC

Mike Sas

ALICE Collaboration

Utrecht University & NIKHEF

July 11, 2019



Universiteit Utrecht



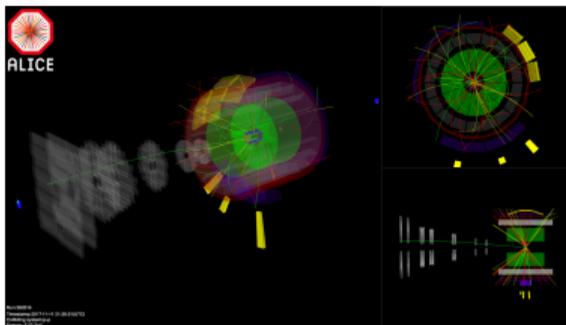
ALICE

A JOURNEY OF DISCOVERY

Nikhef

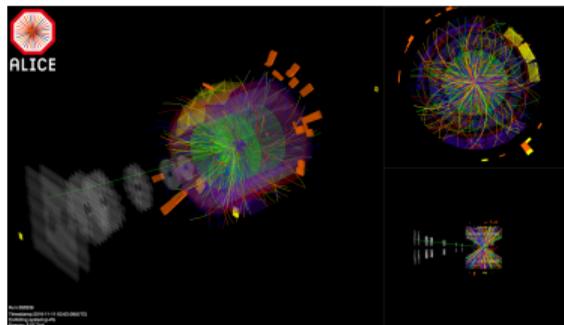
- What are the different particle production mechanisms across different system sizes?
- Can we find the onset of the QGP?
- Is a QGP droplet formed in small systems?

pp



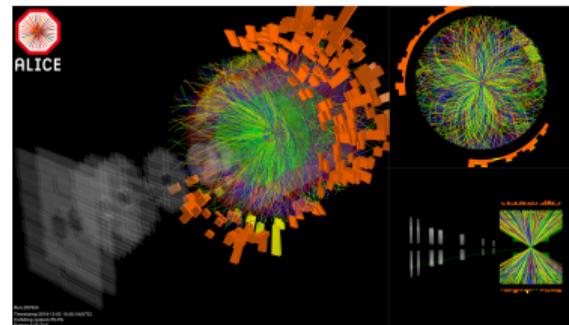
$N_{\text{particles}} \sim 10^1$

p-Pb



$N_{\text{particles}} \sim 10^2$

Pb-Pb



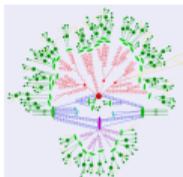
$N_{\text{particles}} \sim 10^4$

Why measure neutral mesons?

$$\pi^0 \rightarrow \gamma\gamma, \quad \eta \rightarrow \gamma\gamma, \quad \omega \rightarrow \pi^0\gamma, \quad \dots$$

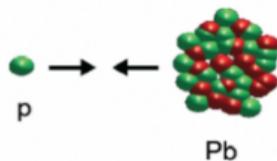
- Straightforward identification (M_{inv}) \rightarrow study the particle production mechanisms
- Main background for direct photons \rightarrow precise neutral mesons lead to precise direct photons

pp



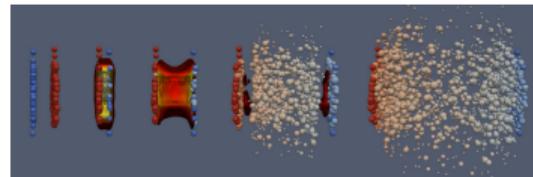
- Jet production
- Underlying event studies

p-Pb



- Cold nuclear matter effects
- Multiplicity dependence

Pb-Pb



- QGP effects
- Centrality dependence

Photon Conversion Method(PCM)

- ITS and TPC
- $|\eta| < 0.9$ and $0^\circ < \varphi < 360^\circ$
- $E_\gamma > 100$ MeV, $E_{\pi^0} > 300$ MeV
- conversion probability $\sim 8\%$

PHOS calorimeter

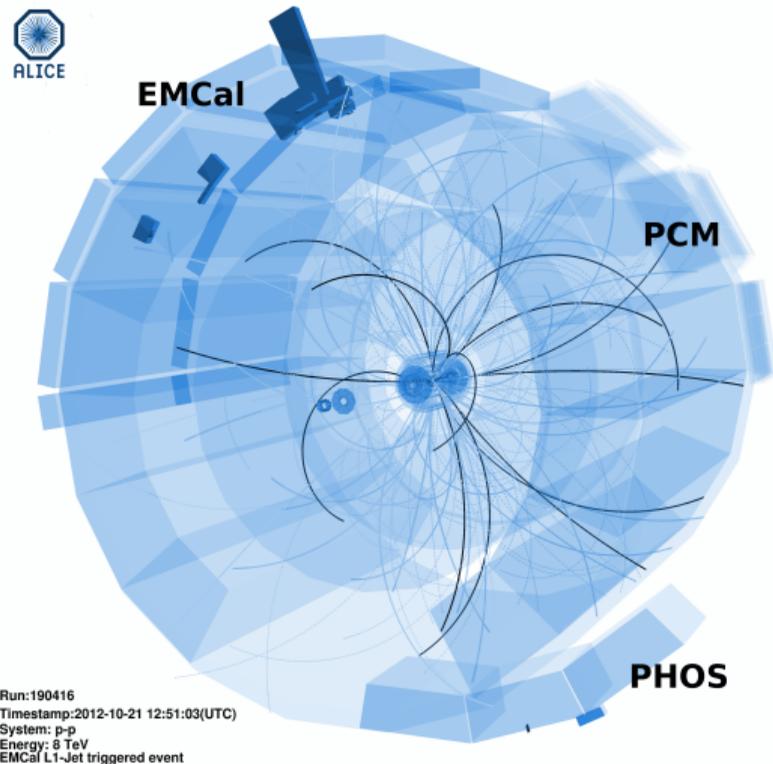
- PbWO_4 crystals (2.2 cm x 2.2 cm, at 4.6 m)
- $|\eta| < 0.12$ and $260^\circ < \varphi < 320^\circ$
- $E_\gamma > 200$ MeV, $E_{\pi^0} > 400$ MeV

EMCal calorimeter

- Pb-scintillator towers (6 cm x 6 cm, at 4.28 m)
- $|\eta| < 0.7$ and $80^\circ < \varphi < 180^\circ$
- $E_\gamma > 700$ MeV, $E_{\pi^0} > 1.4$ GeV

Centrality estimators

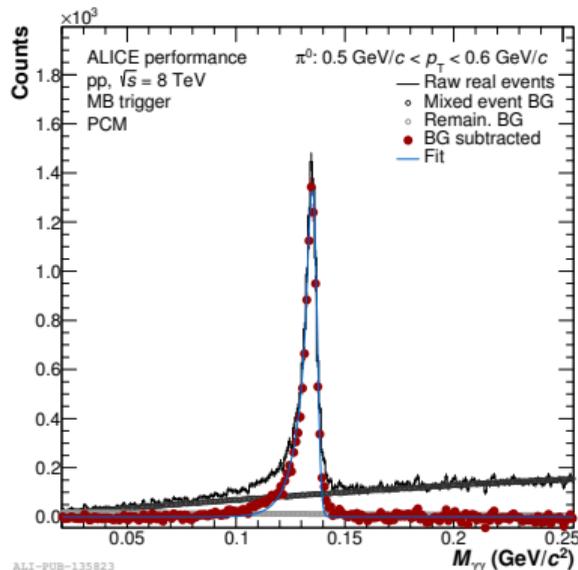
- V0M (V0A & V0C), measures forward multiplicity in central barrel
- ZDC (ZNA & ZNC), measures forward neutrons at large distance



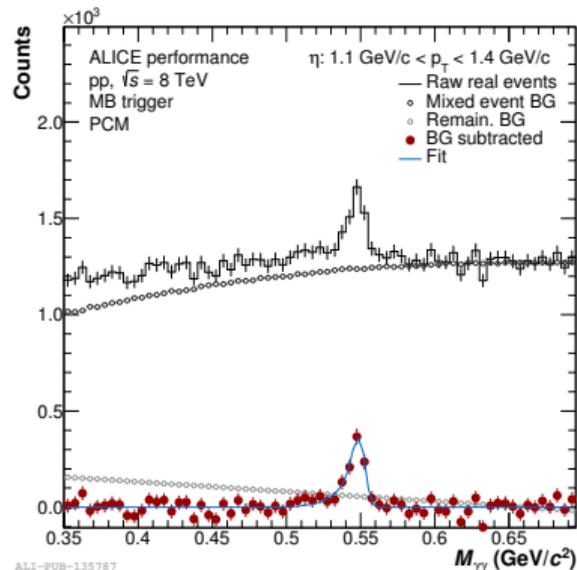
Analysis strategy:

- 1 Reconstruct the photons
- 2 Obtain the meson raw yield: integrate M_{inv} distributions
- 3 Correct raw yield for efficiency, acceptance, feed-down from secondaries
- 4 Combine the different reconstruction methods

π^0



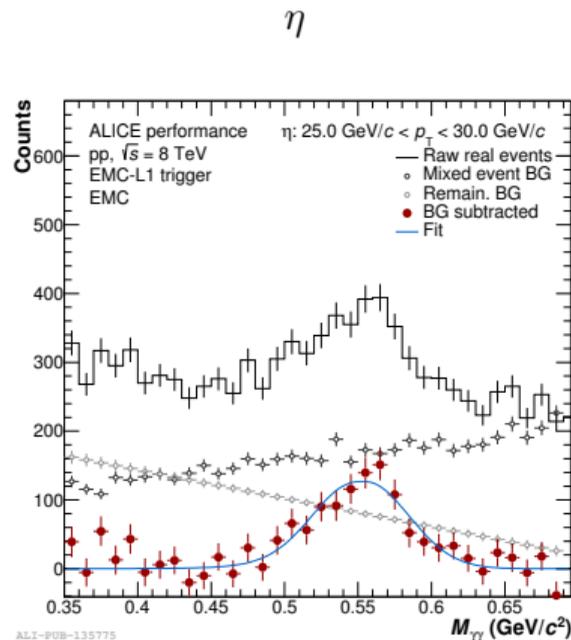
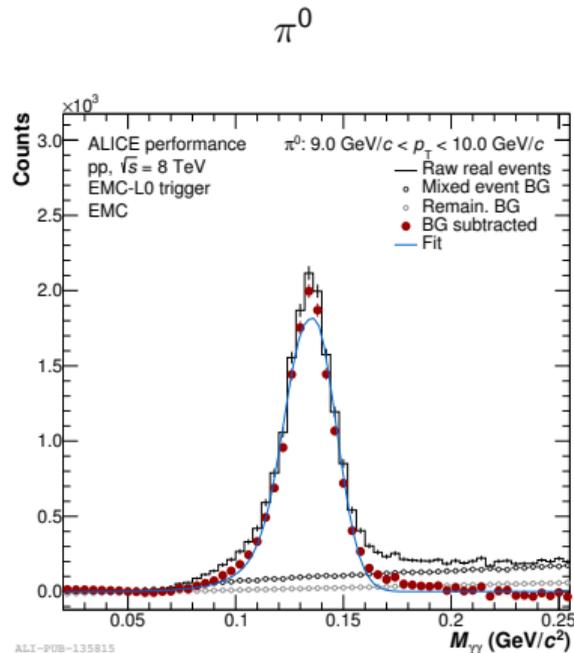
η



arXiv:1708.08745, Eur. Phys. J. C 78 (2018) 263

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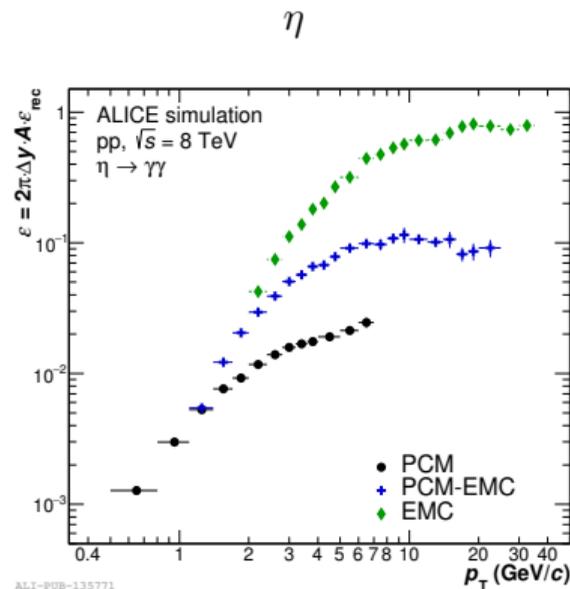
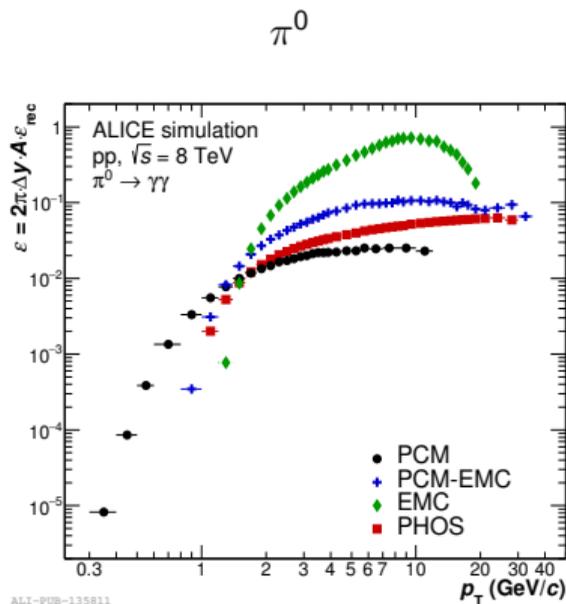
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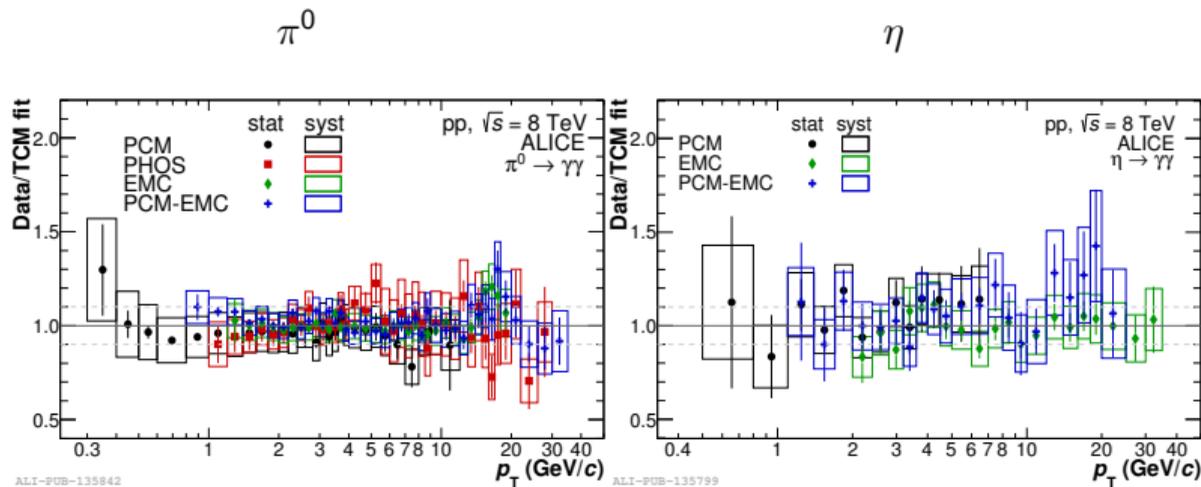
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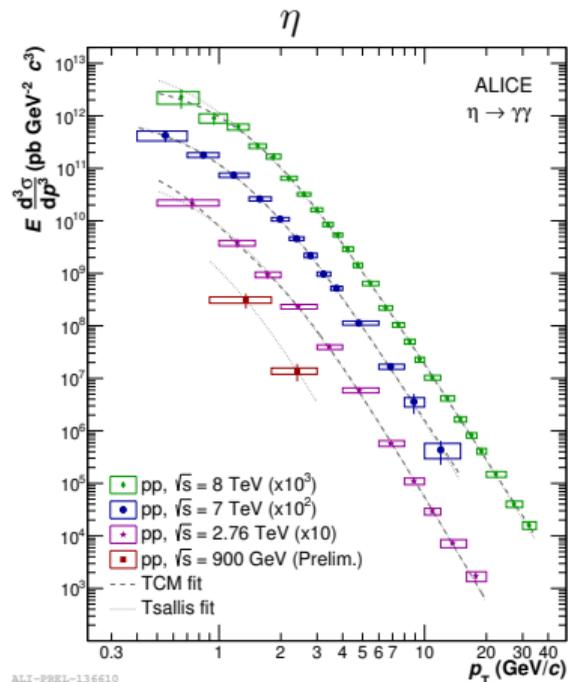
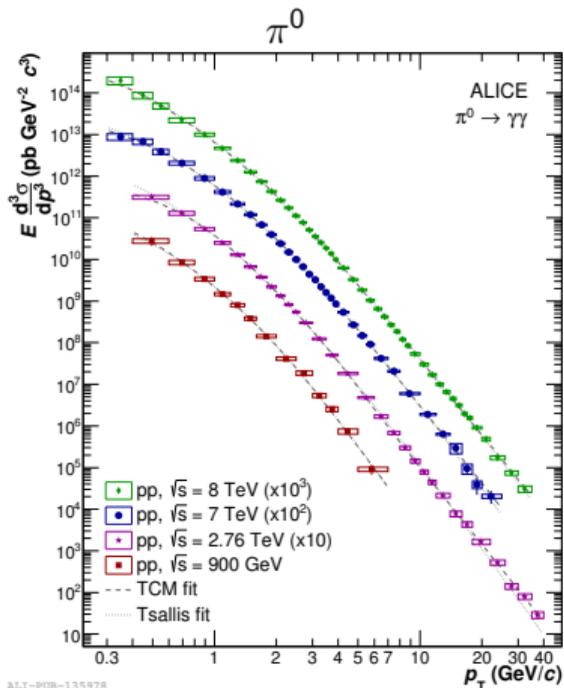
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Main reasons for study:

- Fragmentation & in-jet production
- Contribution underlying event
- Main background for γ_{direct}



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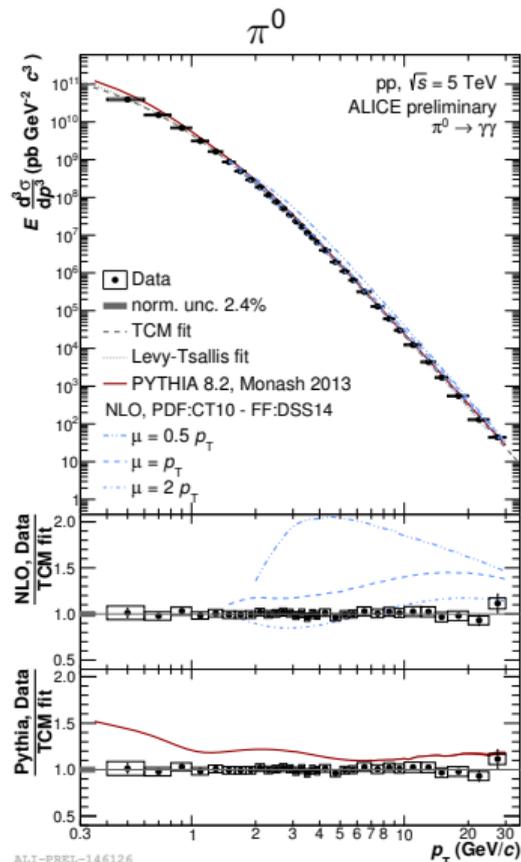
Neutral mesons in pp collisions

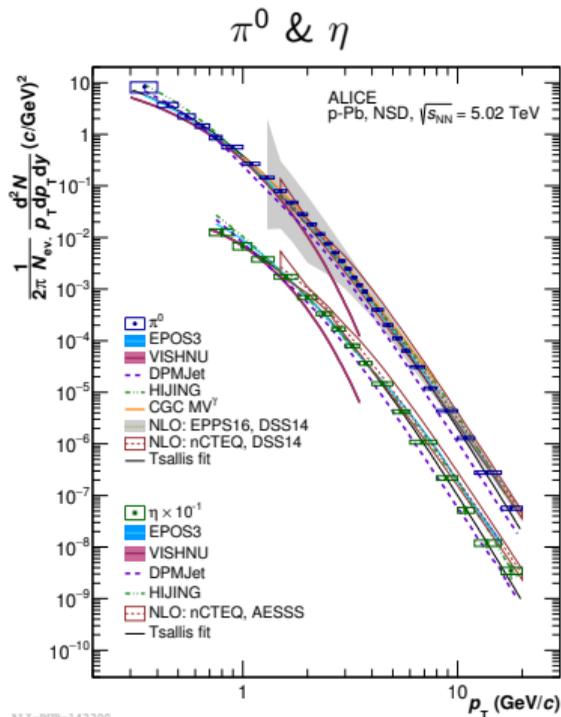
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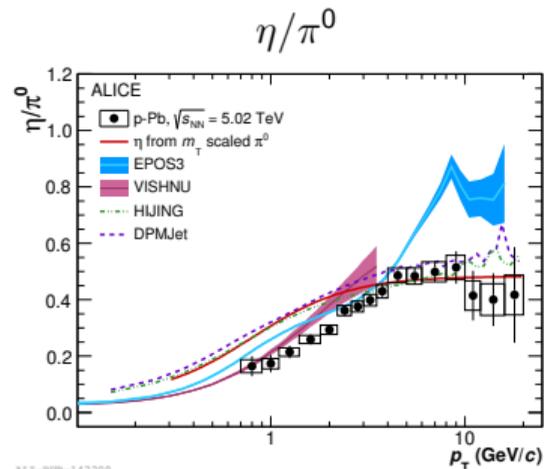
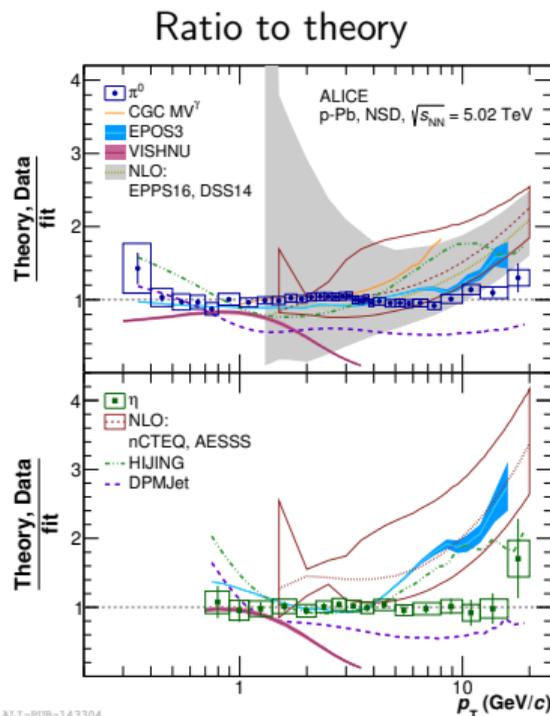
π^0 model comparisons:

- PYTHIA and NLO overpredict the production
- More differential studies can disentangle the jet and UE components



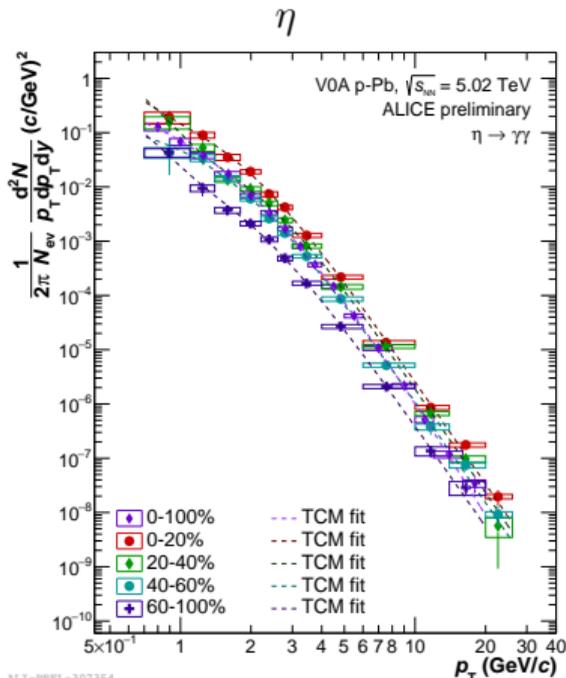
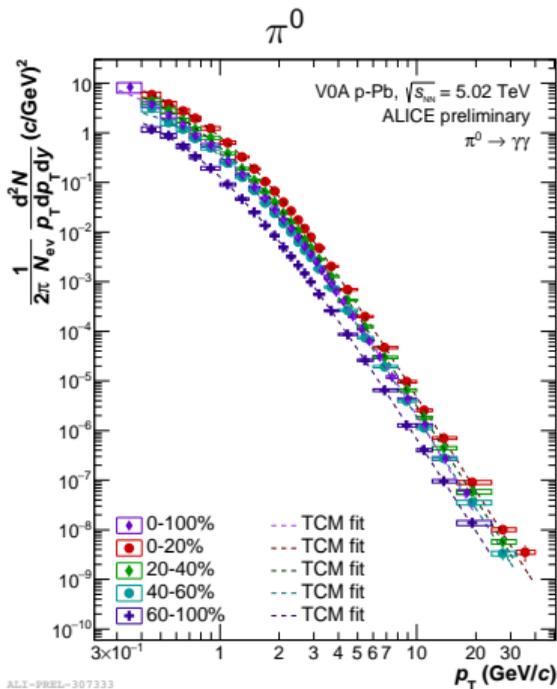


arXiv:1801.07051, Eur. Phys. J. C (2018) 78: 624



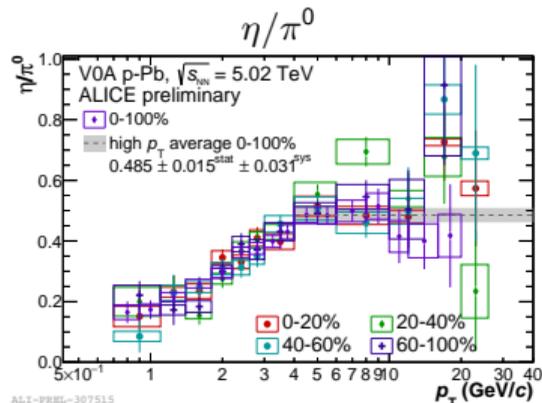
Minimum Bias production

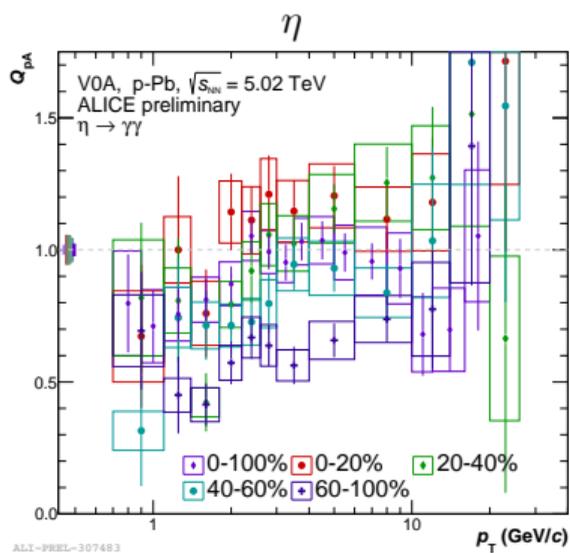
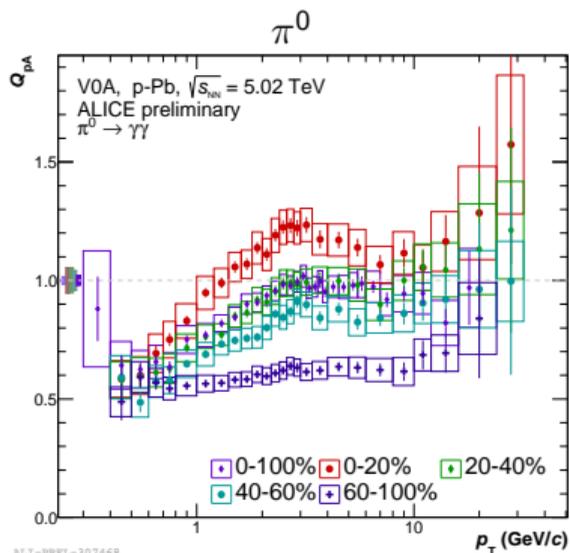
- Model comparisons show only consistency for limited p_T ranges
- Full Run 1 + Run 2 result promises to provide very detailed studies



V0A centrality estimation

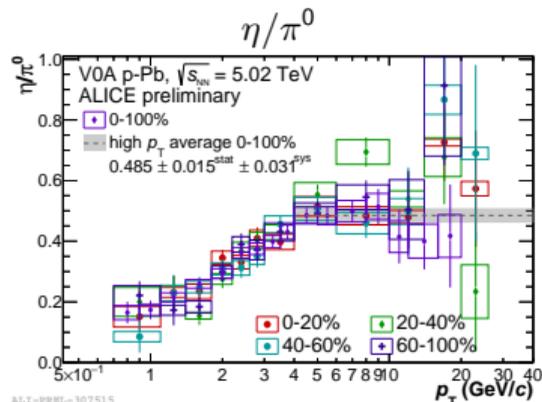
- Significant change of slope at low p_T
- No significant centrality dependence in the η/π^0 ratio





V0A centrality estimation

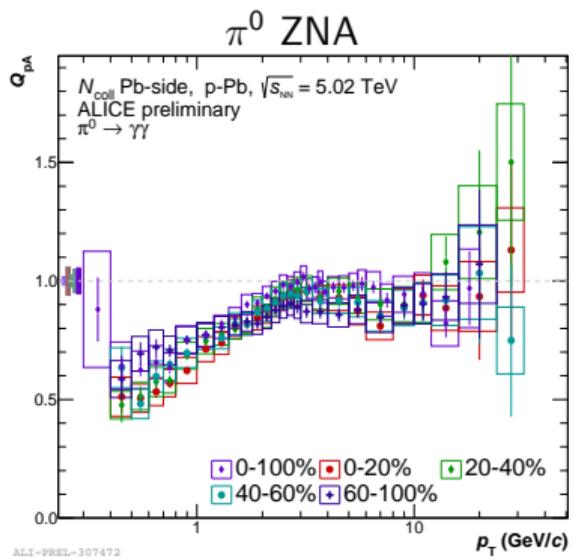
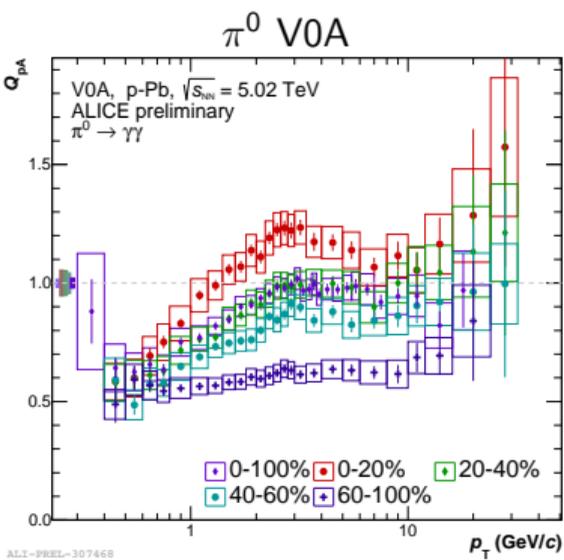
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Nuclear modification factor:

$$Q_{PA} = \frac{dN^{PA}/dp_T}{\langle T_{PA} \rangle d\sigma^{PP}/dp_T}$$

Neutral mesons in p-Pb collisions



Nuclear modification factor:

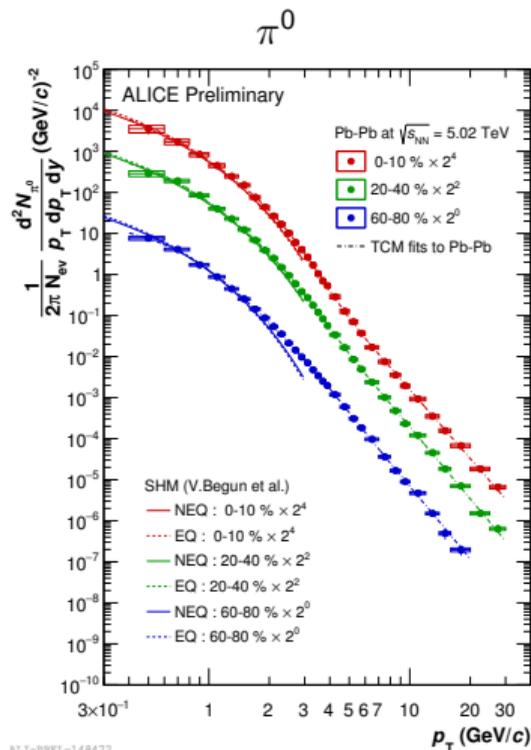
$$Q_{PA} = \frac{dN^{pA}/dp_T}{\langle T_{PA} \rangle d\sigma^{pp}/dp_T}$$

V0A centrality estimation

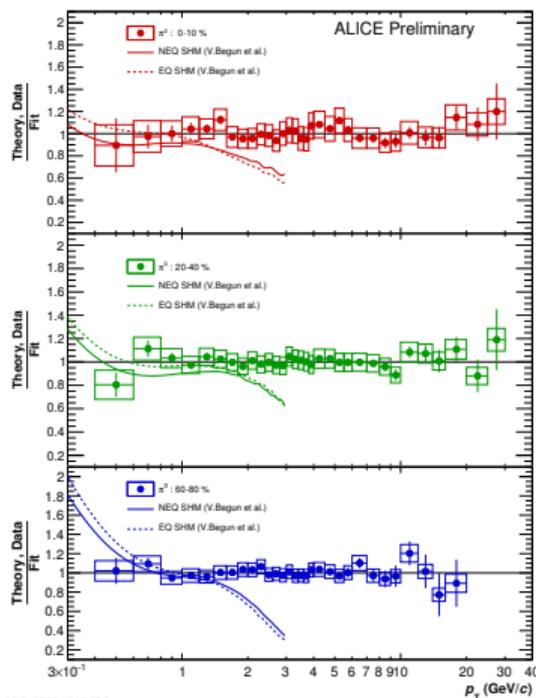
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ZNA centrality estimation

- Zero-degree calorimeter on A (Pb) side
- Measures energy of spectator nucleons, 114 m from interaction point
- Less centrality dependence observed wrt. V0A centrality estimation

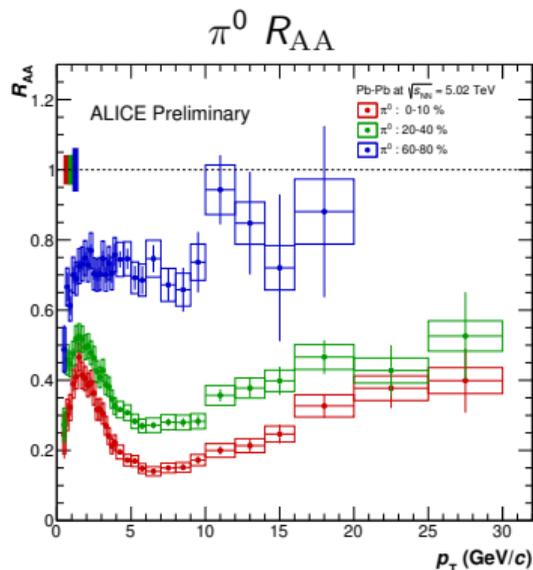
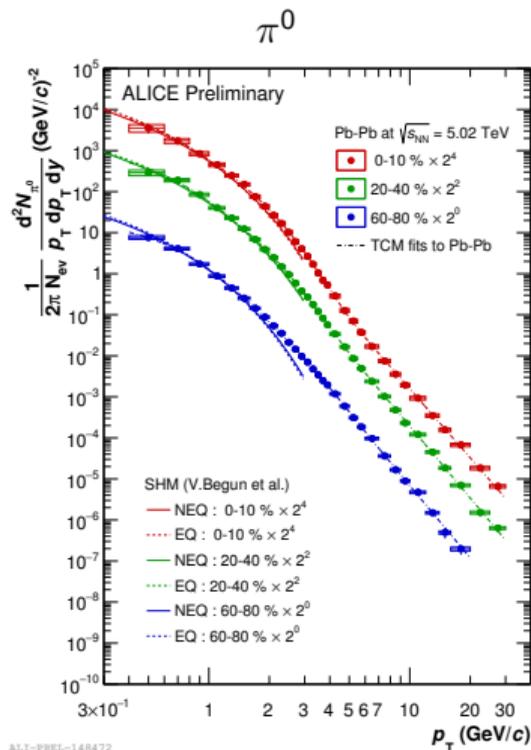


Ratio to theory



V0A centrality estimation

- Model comparisons show consistency for limited p_T ranges
- Basis for direct photon background subtraction



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Nuclear modification

$$R_{AA} = \frac{dN^{AA}/dp_T}{\langle T_{AA} \rangle d\sigma^{pp}/dp_T}$$

- Strong suppression for central collisions
- Full Run 2 result promises to provide detailed studies

Neutral mesons spectra measurements provide us with information on:

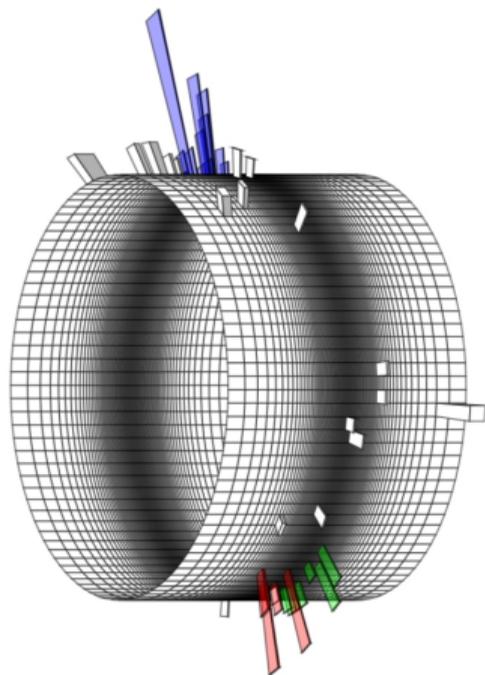
- Particle production mechanisms, by comparing to model calculations
- Decay photon background for direct photon measurements

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Where do the next opportunities lie?

- 1 Overall reducing the uncertainties in the measurements, by:
 - Using full Run 1+2 statistics \rightarrow factor $\sim 2 - 6$ increase
 - Combine all neutral meson reconstruction methods
- 2 additional differential studies:
 - Vs. multiplicity
 - Vs. event shapes (S_T, S_O)
 - In-jet production
- 3 Direct photons \rightarrow **under which conditions do we measure an excess of low p_T direct photons?**

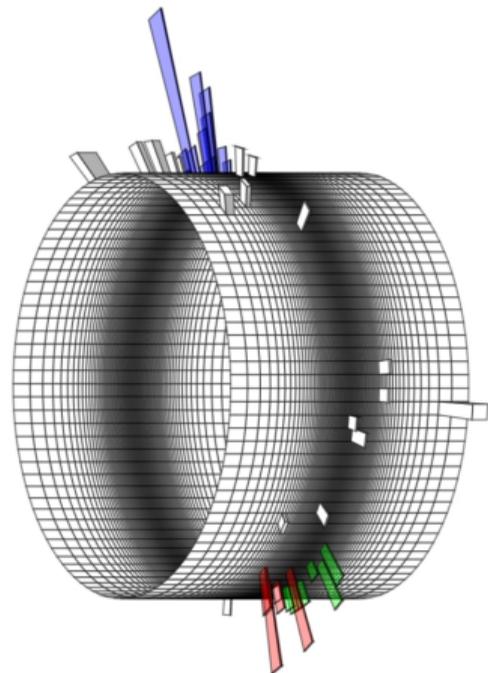


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Thanks for your attention.

The ALICE detector

- ITS
- TPC
- EMCal
- PHOS

