

Neutral mesons and direct photon measurements with the ALICE experiment

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on behalf of the ALICE collaboration

SUBATECH - Nantes

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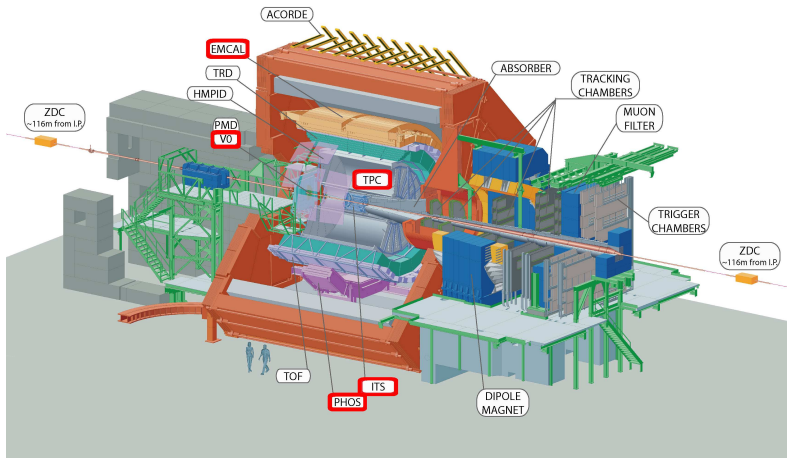
- 1 Neutral mesons and direct photons as probes of hadronic matter
- 2 The ALICE experiment
- 3 Neutral mesons in pp collisions
- 4 Neutral mesons in Pb-Pb collisions
- 5 Direct photons in Pb-Pb collisions
- 6 Conclusions

pp collisions

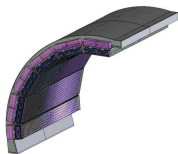
- Test pQCD
- Constrain Parton Distribution Functions and Fragmentation Functions
- Reference for Pb-Pb analysis

Pb-Pb collisions

- π^0 and η production
 - ▶ Probe the matter via parton energy loss
- Direct photon (prompt and thermal) production
 - ▶ Low p_T access to thermal photon measurement
 - probes the medium properties
 - ▶ Higher p_T access to prompt photon measurement
 - is a reference for jet quenching
 - tests the N_{coll} scaling assumption
 - tests possible initial state modifications

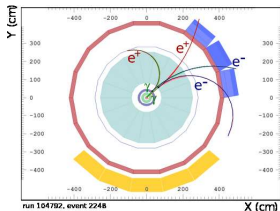


- Charged particles: **ITS** and **TPC**
- Electromagnetic particles: **EMCal** and **PHOS**
- Centrality via multiplicity: **V0**



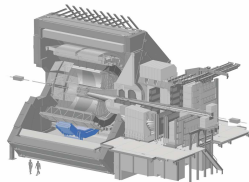
PHOTon Spectrometer (PHOS)

- $PbWO_4$ crystal calorimeter
- $|\eta| < 0.13$ and $260^\circ < \phi < 320^\circ$
- $\frac{\sigma}{E} = 0.011 \oplus \frac{0.033}{\sqrt{E}} \oplus \frac{0.018}{E}$
(IJMPA 29 (2014) 1430044)
- Intermediate to high p_T



ElectroMagnetic CALorimeter (EMCal)

- Pb/scintillator sampling calorimeter
- $|\eta| < 0.7$ and $80^\circ < \phi < 180^\circ$
- $\frac{\sigma}{E} = 0.017 \oplus \frac{0.11}{\sqrt{E}} \oplus \frac{0.05}{E}$ (NIM 615 (2010) 6-13)
- Intermediate to high p_T



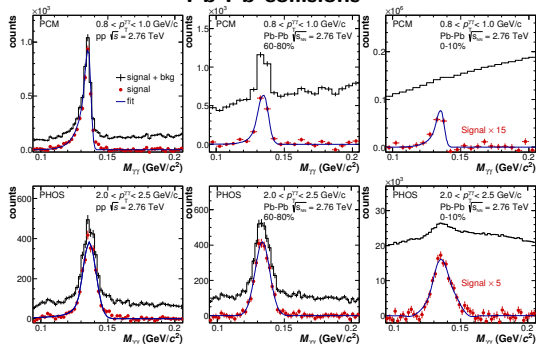
Photon Conversion Method (PCM)

- Conversion probability $\sim 8.5\%$
(IJMPA 29 (2014) 1430044)
- $|\eta| < 0.9$ and $0^\circ < \phi < 360^\circ$
- Low to intermediate p_T

Invariant mass reconstruction

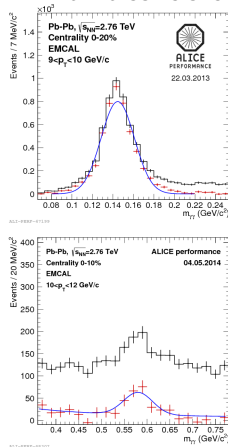
Invariant mass reconstruction from decay photons

PCM and PHOS, π^0 invariant mass in pp and Pb-Pb collisions



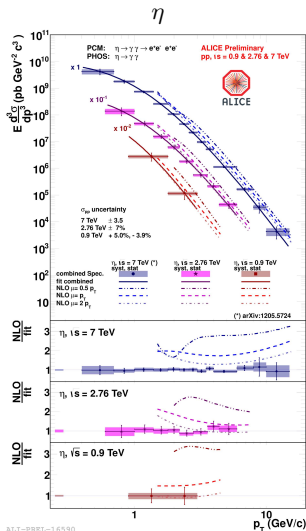
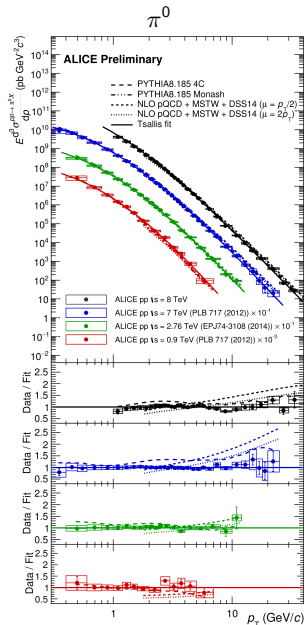
EPJC 74 (2014) 3108

EMCAL π^0 and η invariant mass in Pb-Pb collisions



⇒ Combination of independent measurement using different detectors/methods

π^0 and η in pp collisions with PCM+PHOS: cross section

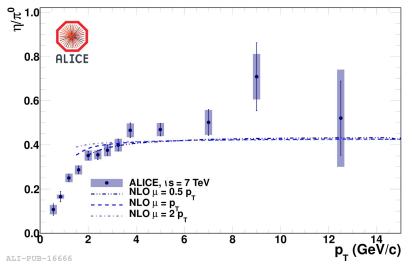


- π^0 and η cross section measurement $\sqrt{s} = 0.9, 2.76, 7$ TeV
- π^0 at $\sqrt{s} = 8$ TeV

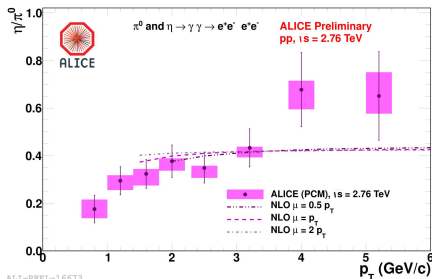
\Rightarrow pQCD calculations (PRD 91 (2015) 014035) do not reproduce the data for larger \sqrt{s} at high p_T

arxiv:1205.5724

π^0 and η in pp collisions with PCM+PHOS: η/π^0 ratio



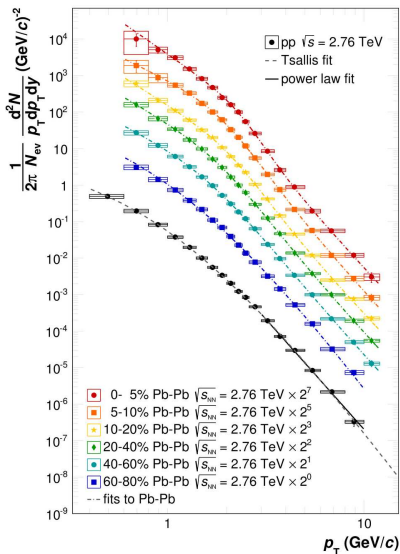
PLB 717 (2012) 162-172



arxiv:1205.5724

- η/π^0 ratio reduces influence of the PDF choice in the pQCD calculation
- PDF:CTEQ6M5,FF:AES for η
- PDF:CTEQ6M5,FF:DSS for π^0

⇒ Measurements and pQCD NLO calculation show similar trend at both \sqrt{s}

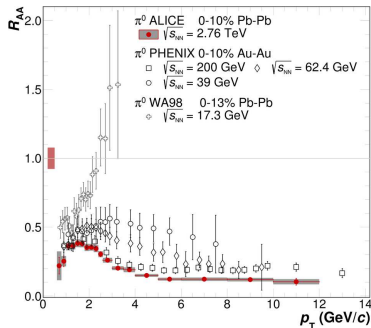
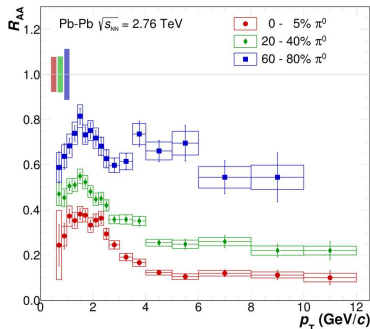


- 2010 data
- Pb-Pb spectra measurement at $\sqrt{s_{NN}} = 2.76$ TeV
- pp spectrum $\sqrt{s_{NN}} = 2.76$ TeV as reference in the nuclear modification factor

\Rightarrow Nuclear modification factor to quantify nuclear effects

$$R_{AA} = \frac{d^2 N_{AA}/dp_T dy}{\langle T_{AA} \rangle d\sigma_{pp}^2/dp_T dy}$$

π^0 in Pb-Pb collisions with PCM+PHOS: R_{AA}



EPJC 74 (2014) 3108

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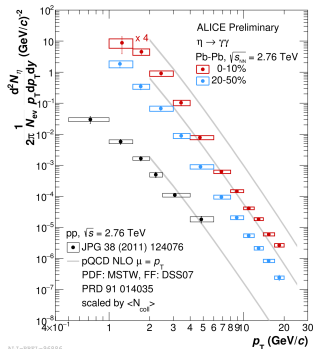
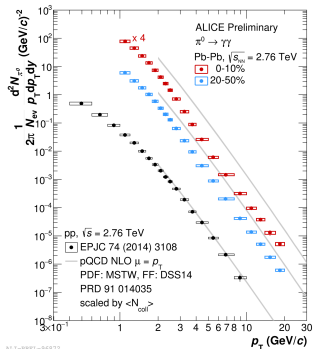
- Suppression at high p_T and increasing with the centrality

⇒ increasing medium energy loss with centrality

- Stronger suppression than at PHENIX (*PRL* 109 (2012) 152301 and *PRL* 101 (2008) 232301) and SPS (*PRL* 100 (2008) 242301)

⇒ increasing medium energy loss with $\sqrt{s_{NN}}$

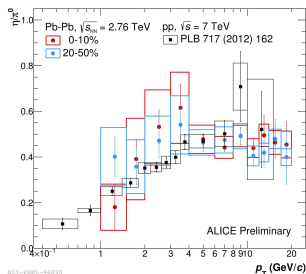
π^0 and η in Pb-Pb collisions with PCM+EMCAL: invariant yield



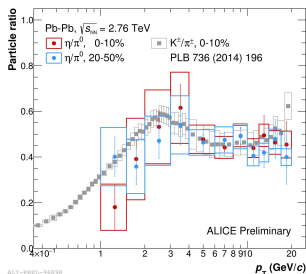
- 2011 data with $\times 10$ statistics
- Higher p_T π^0 measurement compatible with PCM+PHOS results
- First η measurement

\Rightarrow Comparison with pQCD calculation (PRD 91 014035) shows suppression both for π^0 and η

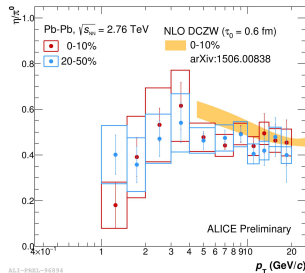
π^0 and η in Pb-Pb collisions with PCM+EMCAL: η/π^0 ratio



ALICE-PPREL-96890



ALICE-PPREL-96890



ALICE-PPREL-96890

- Comparison with other ALICE results on K^\pm/π^\pm (PLB 736 (2014) 196) shows similar behaviour
- Comparison with pp η/π^0 ratio measurement shows comparable values

- pQCD NLO calculations at high p_T with energy loss reproduce the data

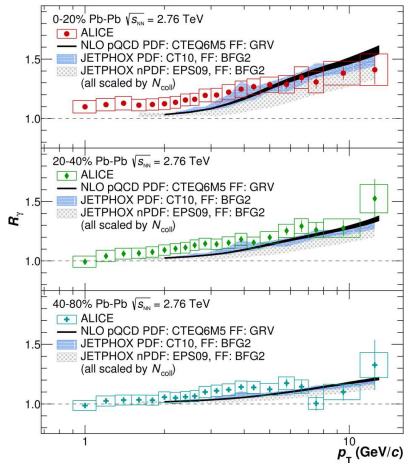
Direct photons measurement in Pb-Pb collisions with PCM+PHOS: R_γ comparison with pQCD



$$\gamma_{direct} = \gamma_{incl} - \gamma_{decay} = \left(1 - \frac{1}{R_\gamma}\right) \gamma_{incl}$$

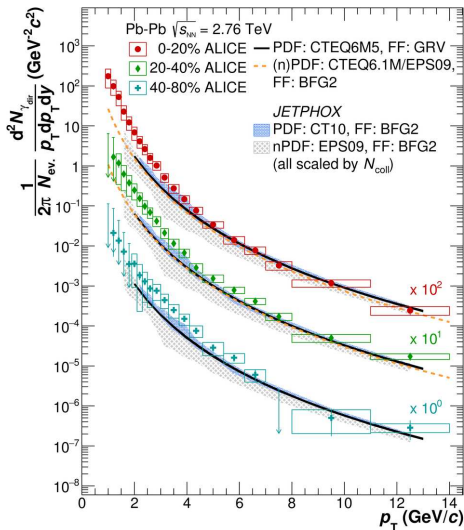
$$\text{with } R_\gamma = \frac{\gamma_{incl}}{\gamma_{decay}} = \frac{\gamma_{incl}}{\pi_{param}^0} / \frac{\gamma_{decay}}{\pi_{param}^0}$$

- Combination of PCM and PHOS independent measurements
- R_γ comparison to pQCD NLO theoretical predictions shows good agreement at high p_T



PLB 754 (2016) 235-248

Direct photons in Pb-Pb collisions with PCM+PHOS: comparison with pQCD



- At high p_T good agreement with pQCD calculations

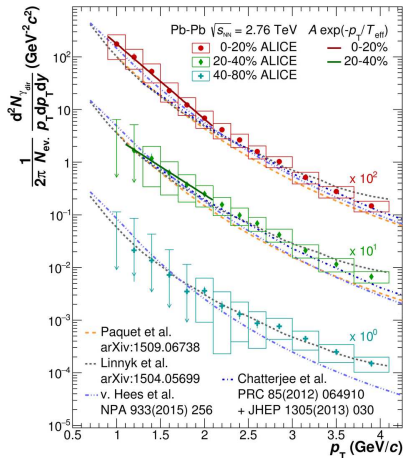
⇒ Excess of yield at low p_T attributed to thermal photons

Direct photons in Pb-Pb collisions with PCM+PHOS: comparison with models



- Comparison with different models including thermal photon radiation

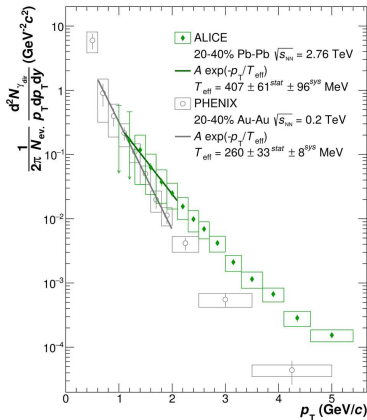
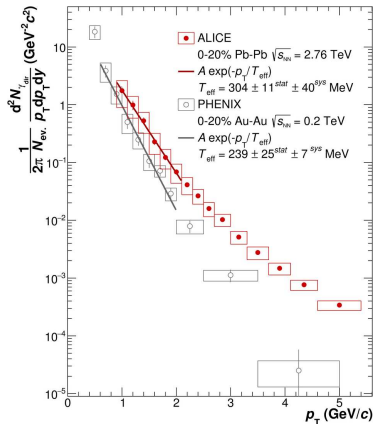
- ▶ Van Hees et al.: space-time evolution $\tau_0 = 0.2 fm/c$, temperatures $T_0 = 682, 641, 461$ MeV for the 0-20%, 20-40% and 40-80%
- ▶ Chatterjee et al.: (2+1D) hydrodynamics model with fluctuating initial conditions, $\tau_0 = 0.14 fm/c$, $T_0 \approx 740, 680$ MeV for the 0-20% and 20-40%
- ▶ Paquet et al.: (2+1D) hydrodynamics model with IP-Glasma initial conditions, $\tau_0 = 0.4 fm/c$, $T_0 \approx 385, 350$ MeV for the 0-20% and 20-40%
- ▶ Linnyk et al.: evolution of the collisions described microscopically



Phys. Lett. B 754 (2016) 235-248

⇒ Spectrum in agreement with models including QGP formation with an initial temperature > 350 MeV

Direct photons in Pb-Pb collisions with PCM+PHOS: \sqrt{s} dependence



PLB 754 (2016) 235-248

- At low p_T , exponential fit of the excess in the direct photon yield
- Comparison with PHENIX results (*PRL104 (2010)132301 and PRC91/6 (2015) 064904*)

⇒ Increasing inverse slope parameter with $\sqrt{s_{NN}}$ for 0-20% and 20-40% centrality classes

Neutral mesons in pp collisions

- Compatible with pQCD models for the lower p_T values
- Good agreement of η/π^0 ratio measurement with the pQCD calculations

Neutral mesons in Pb-Pb collisions

- π^0 measurement with PCM+PHOS and PCM+EMCAL
- Suppression observed with $\pi^0 R_{AA}$ increasing in the most central collisions and with higher $\sqrt{s_{NN}}$
- η measurement with PCM+EMCAL

Direct photons in Pb-Pb collisions

- Direct photon excess below 3 GeV/c in the most central collisions attributed to thermal photons
- Spectrum in agreement with models including QGP formation

Thank you for your attention!

Back up

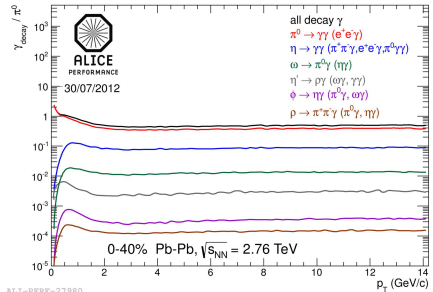
Direct photon measurement in Pb-Pb collisions with PCM+PHOS: R_γ cocktail



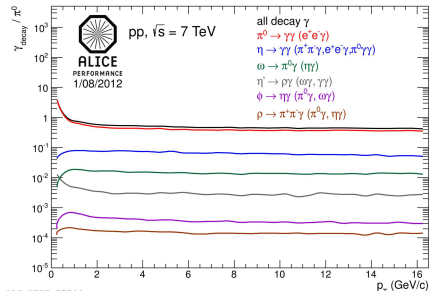
$$\gamma_{\text{direct}} = \gamma_{\text{incl}} - \gamma_{\text{decay}} = \left(1 - \frac{1}{R_\gamma}\right) \gamma_{\text{incl}}$$

$$\text{with } R_\gamma = \frac{\gamma_{\text{incl}}}{\gamma_{\text{decay}}} = \frac{\gamma_{\text{incl}}}{\pi^0_{\text{param}}} / \frac{\gamma_{\text{decay}}}{\pi^0_{\text{param}}}$$

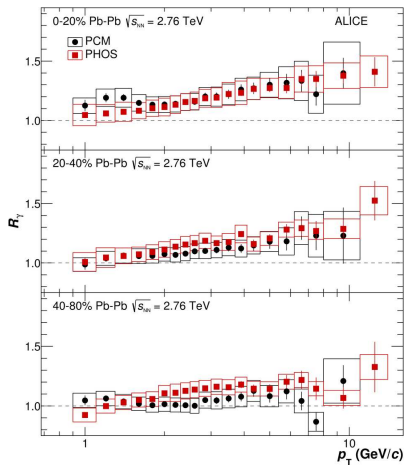
- $\frac{\gamma_{\text{decay}}}{\pi^0_{\text{param}}}$ obtained via calculations based on MC simulations anchored to data
- η meson contribution assuming transverse mass scaling or that η p_T have the same shape as K_S^0 spectrum



ALI-PROD-27980



Direct photon in Pb-Pb collisions with PCM+PHOS: R_γ



- PHOS and PCM individual results

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