Measurement of neutral mesons in pp collisions at $\sqrt{s}$ = 5 TeV with the ALICE EMCal

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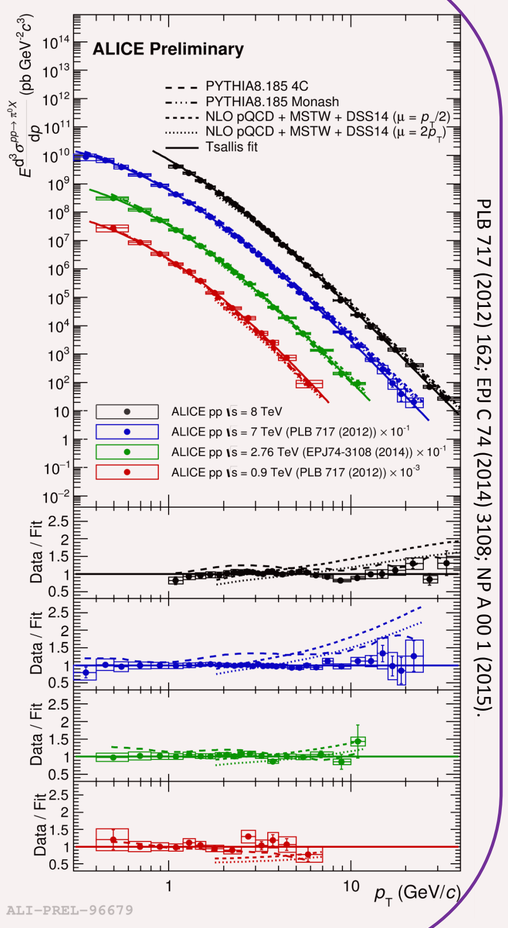
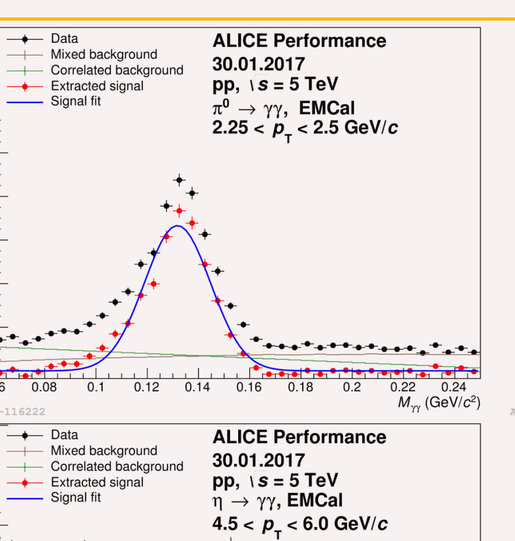
Motivation

- ALICE performs studies on neutral meson production in pp collisions at all LHC energies.
- Neutral meson production is relatively well described by pQCD in pp collisions in a limited kinematic range.
- Both π^0 and η meson spectra constrain parameters of theoretical models in both perturbative (NLO, NNLO) and non-perturbative regimes (structure function, fragmentation function).
- Result at $\sqrt{s}$ = 5 TeV will add a new measurement to already available spectra at $\sqrt{s}$ = 0.9, 2.76 and 7 TeV to study energy evolution of meson production and validate pQCD in the broad range of LHC energies (see Satoshi Yano poster, no. 255).
- Result in pp collisions is important reference for Pb-Pb and p-Pb collisions at the same per nucleon collision energy.
- Neutral mesons are sources of decay photons which are a major background for direct photon measurements.



PLB 717 (2012) 162; EPJ C 74 (2014) 3108; NP A 00 1 (2015).

ALICE detector in LHC Run II



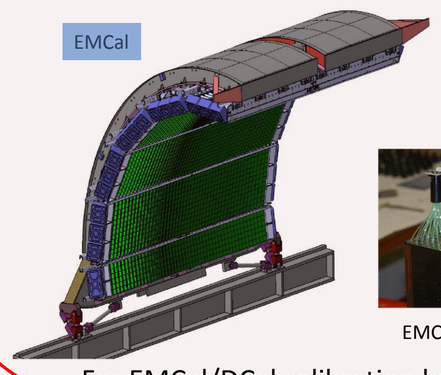
EMCal - electromagnetic calorimeter.

- Lead (76 layers) scintillator (77 layers) shashlik.
- Tower size: 6 cm × 6 cm × 24.6 cm.
- 12 super-modules (10 + 2 × 1/3).
- Acceptance: 80° < φ < 187°, | η| < 0.7.
- 428 cm from the beam line.
- ~ 20 radiation length.
- Energy resolution:
  $\sigma/E = (4.8 \pm 0.8)/E \oplus (11.3 \pm 0.5)/\sqrt{E} \oplus (1.7 \pm 0.3)\%$.

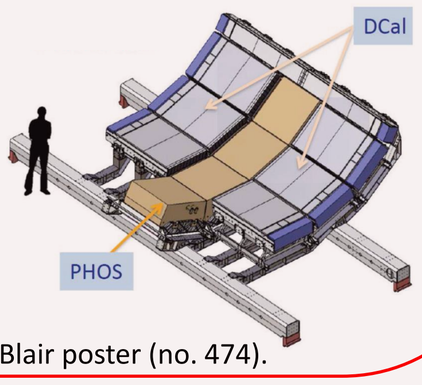
ALICE EMCal PPR, arXiv:*1008.0413 [*physics.ins-det*]*(2010).

DCal

- EMCal extension, same technology.
- 8 super-modules (6 × 2/3 + 2 × 1/3).
- Acceptance: 260° < φ < 327°, 0.22<| η|<0.7.



EMCal Module



For EMCal/DCal calibration look at Justin Blair poster (no. 474).

Neutral meson reconstruction

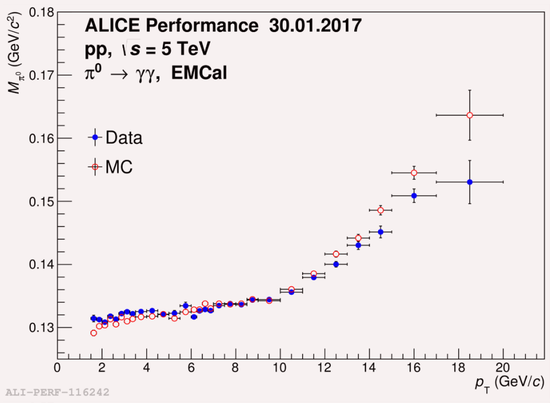
- Two triggers used:
  - Minimum Bias trigger (114 M events),
  - EMCal trigger with the energy threshold E_{min}^{th} = 5 GeV (1.6 M events).
- Two-photon decays with a branching ratio:
  - BR($\pi^0 \to \gamma\gamma$) = 98.8 %,
  - BR($\eta \to \gamma\gamma$) = 39.3 %.
- Invariant mass technique:

$$M_{\gamma_1\gamma_2} = \sqrt{2E_{\gamma_1}E_{\gamma_2}(1-\cos\theta_{\gamma_1\gamma_2})}.$$

$E_{\gamma1}$,$E_{\gamma2}$ – photon energies.
$\theta_{\gamma1\gamma2}$ – opening angle.

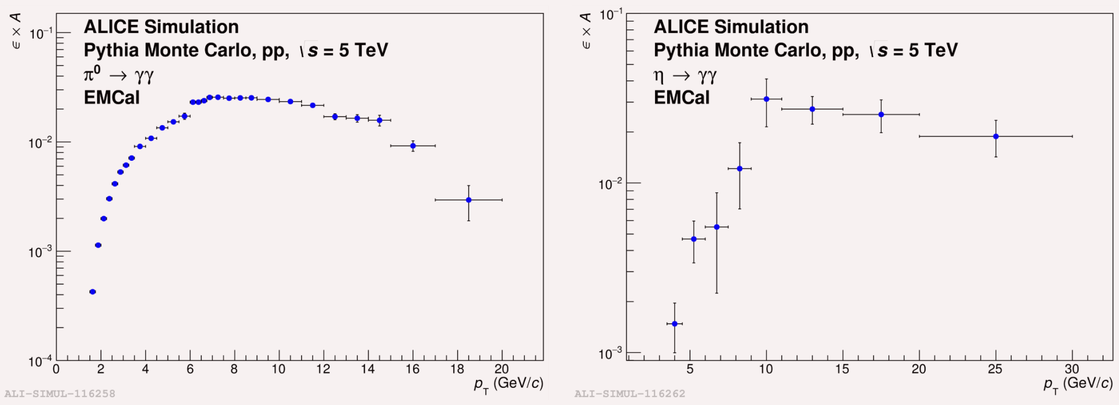
- Uncorrelated background estimated by the mixed event technique, normalized in a sideband region.
- Correlated background parametrized by a polynomial of the 1st order.
- Signal parametrized by a Gaussian function.

Data and Monte Carlo comparison



MC simulations with realistic detector response and event environment were tuned to reproduce data by adjusting calibration and non-linearity parameters. Good agreement was achieved.

Efficiency $\varepsilon \times$ Acceptance A correction



$$\varepsilon \times A = \frac{N_{meson}^{rec}}{N_{meson}^{gen,|\eta|<1}}$$

η = - ln tan (θ/2), where θ is the inclination angle.

N_{meson}^{rec} - Number or π^0 or η mesons reconstructed in EMCal.

$N_{meson}^{gen,|\eta|<1}$ - Number of π^0 or η mesons generated in pseudo-rapidity | η| < 1.

$\varepsilon \times A$ is normalized to the rapidity |y| < 1 and full azimuth angle $\Delta\varphi = 2\pi$.

Outlook

- Invariant cross-section:

$$E\frac{d^3\sigma}{dp^3} = \frac{1}{2\pi}\frac{1}{p_T}\frac{\sigma_{MB}}{N_{evt}}\frac{1}{\varepsilon \times A}\frac{1}{BR(M \to \gamma\gamma)}\frac{dN^M}{dp_T dy}.$$

- Extend analysis to DCal.

p_T – transverse momentum.
σ_{MB} – visible cross-section.
N_{evt} – number of events.
$\varepsilon \times A$ – efficiency and acceptance correction.
BR(M→$\gamma\gamma$) – branching ratio.
dN^M/dp_Tdy – corrected meson M yield.
y – rapidity.

Summary

- Good agreement between data and Monte Carlo for M and σ dependence on p_T for π^0 or η meson ⇒ good calibration of the detector.
- Measured transverse momentum range of π^0 meson is 1.5 < p_T < 20 GeV/c.
- Measured transverse momentum range of η meson is 3.5 < p_T < 30 GeV/c.
- Drop in efficiency × acceptance correction at high-p_T due to merged photon clusters.
- Neutral mesons can be measured in other ALICE detectors (PHOS, PCM), systems (Pb-Pb, p-Pb) and energies. See posters of Meike Danisch (no. 89), Daiki Sekihata (no. 122), Hikari Murakami (no. 139), Daniel Michael Muhlheim (no. 102) and Annika Passfeld (138).