Measurement of Neutral Mesons at High Transverse Momentum with the ALICE EMCal

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Motivation

EMCAL

ALICE 2012

π^0 **as a probe**

1. **pp collisions** Test of pQCD, extract fragmentation functions
2. **Pb-Pb collisions** Study jet quenching and hadronization

π^0 **measurement with ALICE**

1. **PHOS:** Measure decay photons with PHOS calorimeter
2. **Tracking:** Measure e^+e^- pairs from converted decay photons with ITS and TPC
3. **EMCAL:** Measure decay photons with EMCAL

Advantages of the EMCAL

1. **Detection efficiency** EMCAL: largest overall detection efficiency, larger acceptance than PHOS, no conversion needed (low probability)
2. **Trigger** EMCAL trigger enriches high p_T π^0 ⇒ high p_T spectrum

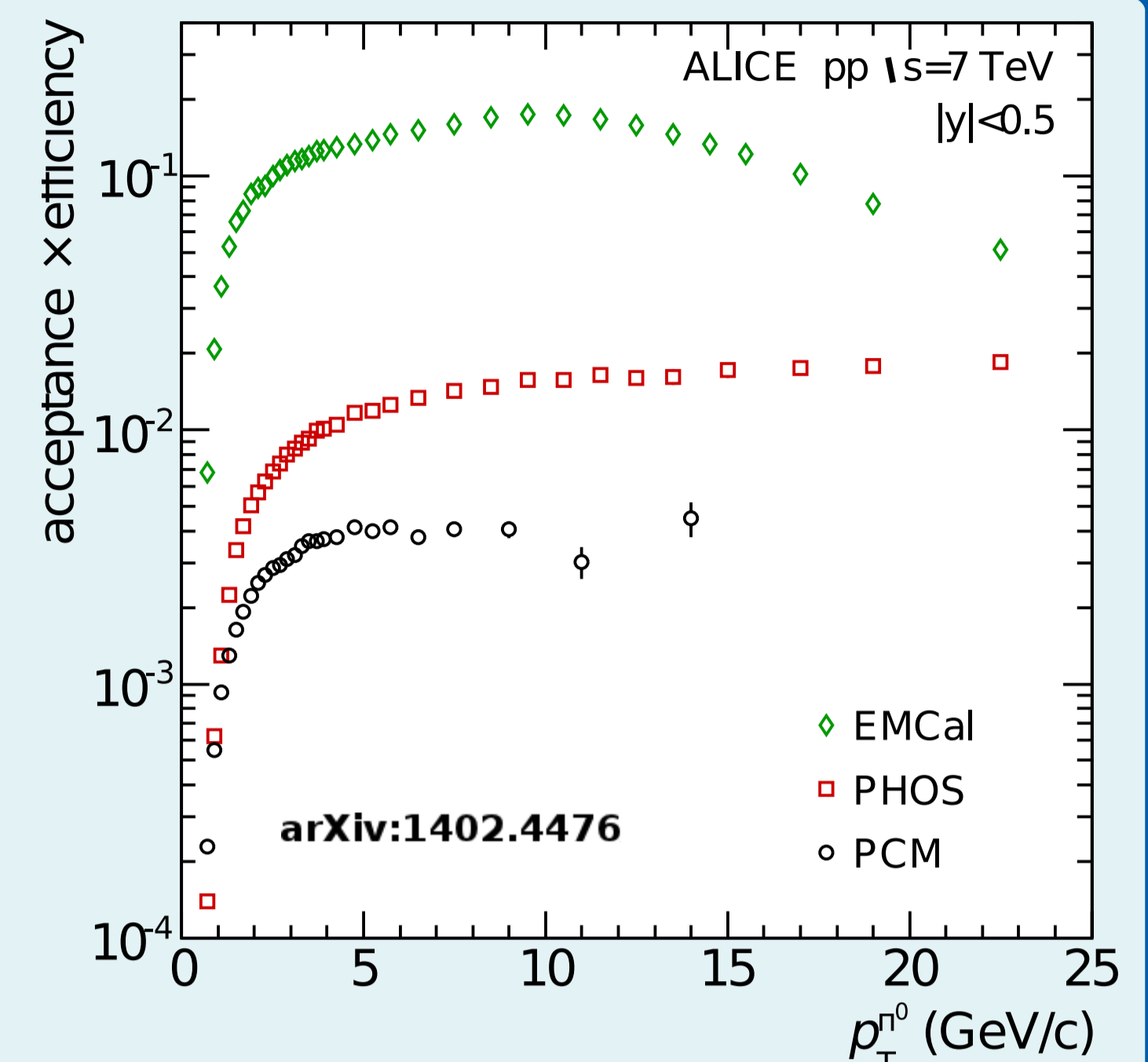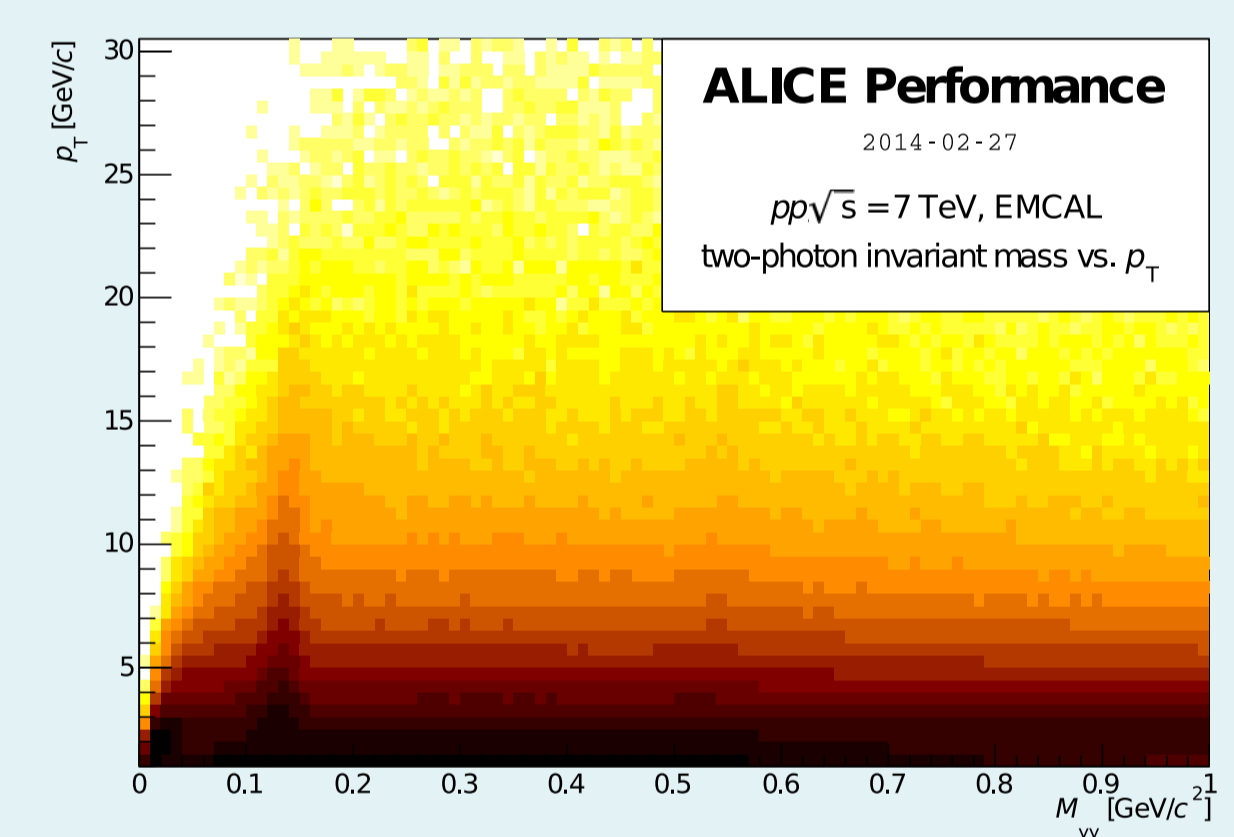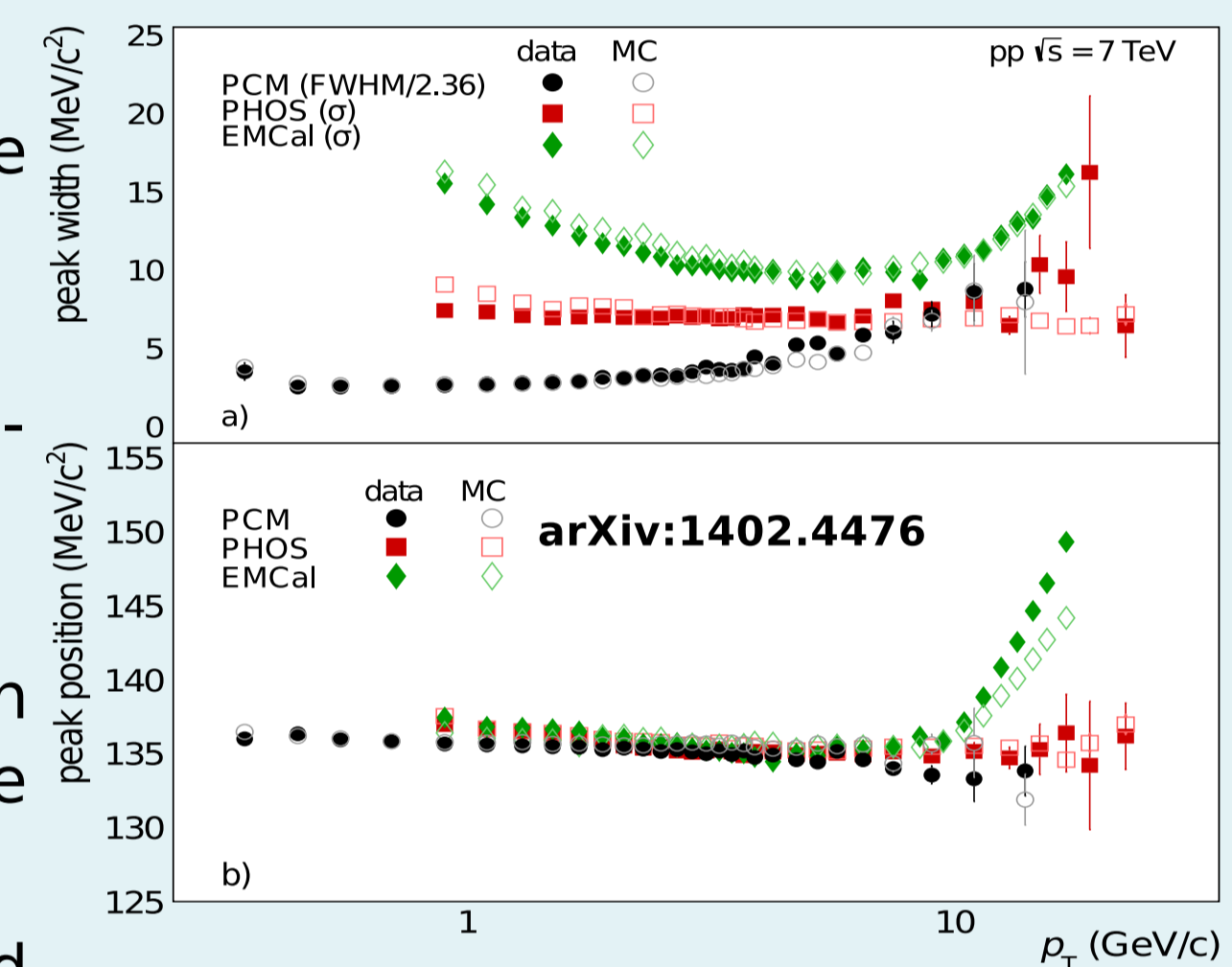ALICE pp $\sqrt{s}$=7 TeV
|y|<0.5
arXiv:1402.4476
- EMCal
- PHOS
- PCM

$p_T^{\pi^0}$ (GeV/c)

Clustering

Choice of clusterizer affects measurement, especially at high p_T. Various clustering algorithms developed for EMCAL.

Clustering concept: All clusterizers start with an EMCAL cell with an energy above E_{seed}.

- **Clusterizer 1:** all adjacent cells above E_{thres} grouped into one cluster
- **Clusterizer 1 with unfolding:** find local maxima in v1 cluster and fit maxima with expected cluster shape, add energy to clusters according to fit
- **Clusterizer 2:** group all adjacent cells above E_{thres} until new local maximum is reached, start new cluster from there

v1 | v1unfold | v2

η=0.027, φ=2.212, Energy =18.01 GeV

η=0.029, φ=2.202, Energy =4.67 GeV
η=0.024, φ=2.218, Energy =13.34 GeV

η=0.036, φ=2.203, Energy =3.74 GeV
η=0.023, φ=2.215, Energy =14.27 GeV

Challenges

Three main challenges (at high p_T)

1. **Limited energy resolution:** PHOS (at low p_T) and tracking have better energy resolution
2. **Material budget:** Photon conversions in front of EMCAL worsen S/B
3. **Decay photon merging:** Distance between π^0 decay photon decreases with p_T, clusters cannot be separated.
   - π^0 can only be reconstructed in asymmetric decays with larger opening angle ⇒ access only to small fraction of produced π^0. Trigger enhances available sample.
   - Background at low-mass tail cannot be reconstructed and estimated
   - Alternative method: reconstruct π^0 from single clusters, split clusters and calculate invariant mass from split clusters.

pp $\sqrt{s}$ = 7 TeV
PCM (FWHM/2.36)
PHOS (σ)
EMCAL (σ)
data MC

arXiv:1402.4476
p_T (GeV/c)

ALICE Performance
2014-02-27
$pp\sqrt{s}$ =7 TeV, EMCAL
two-photon invariant mass vs. p_T

$M_{\gamma\gamma}$ [GeV/c^2]

Detection of η Meson

ALICE Simulation
2014-04-29
pp, $\sqrt{s}$=2.76 TeV
PYTHIA +added π^0, η signals
$0 < p_T < 30$ GeV/c, |eta| < 1.2

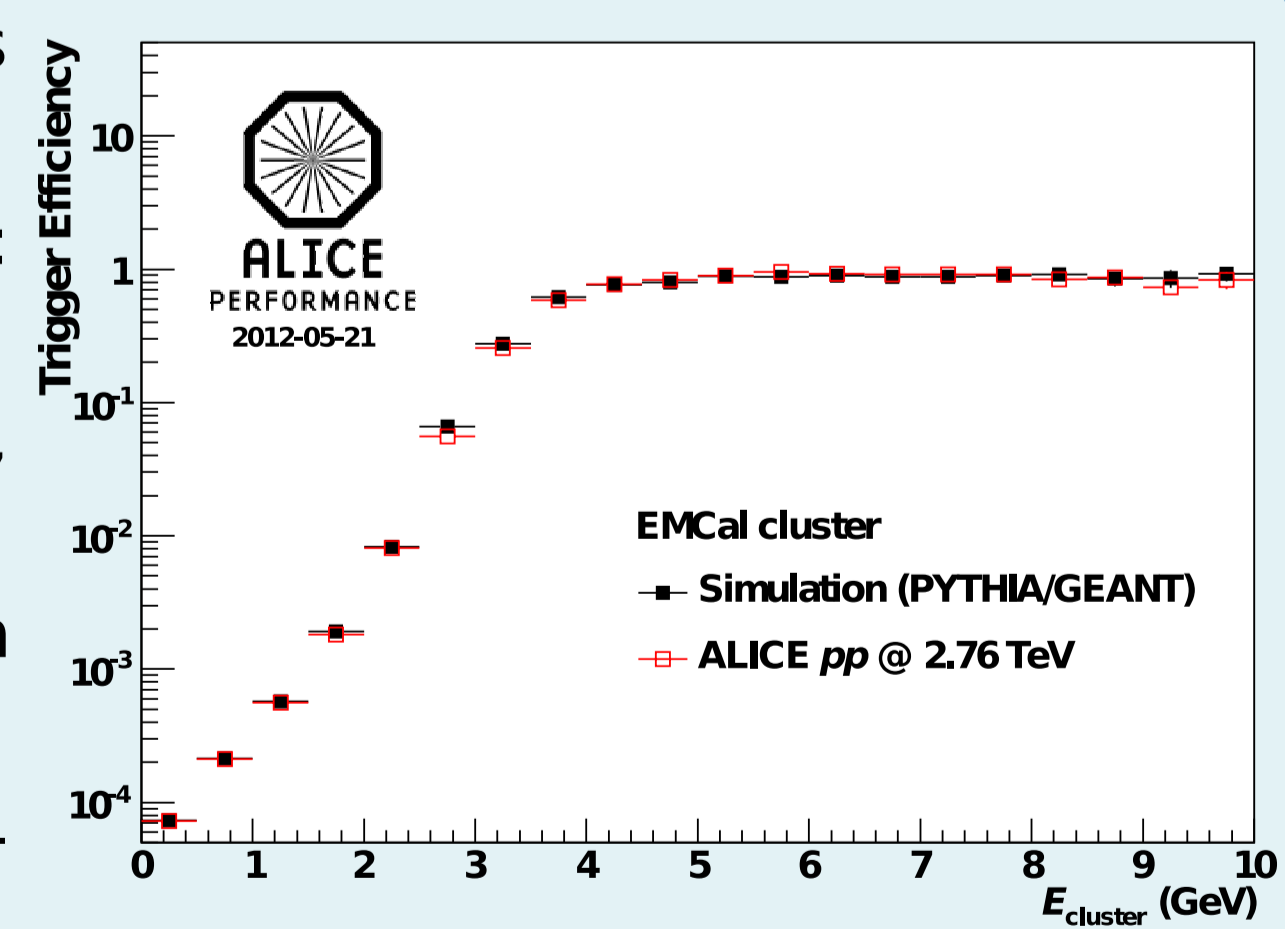$\frac{acc \times eff \times BR\,(\eta)}{acc \times eff \times BR\,(\pi^0)}$

p_T (GeV/c)

Alternative observable: η meson

- Very similar analysis, same decay mode as π^0, but smaller branching ratio (39.3 %)
- Advantage: larger mass ⇒ larger opening angle between decay photons, clusters can be separated (separation of one EMCAL tower at p_T ≈ 80 GeV/c, compared to p_T ≈ 20 GeV/c for π^0)

Observation: high p_T detection efficiency of η larger than of π^0

Trigger

- EMCAL trigger in ALICE increases event sample with high p_T clusters
- Example (pp, $\sqrt{s}$ = 2.76 TeV): $L_{int}^{MB} \approx 0.5$nb^{-1}, $L_{int}^{EMC} \approx 13.1$nb^{-1}
- Trigger threshold of $E_{4x4} = 3$ GeV, saturates for $E_{4x4} \approx 4.5$ GeV
- Trigger well understood in PYTHIA+GEANT simulations

Trigger enhances high p_T π^0 significantly

ALICE PERFORMANCE
2012-05-21
EMCal cluster
- Simulation (PYTHIA/GEANT)
- ALICE pp @ 2.76 TeV
$E_{cluster}$ (GeV)

Outlook

- EMCAL π^0 spectrum can be extended to higher p_T with trigger (In pp at $\sqrt{s}$ = 2.76 TeV: p_T ≈ 20 GeV/c vs. p_T ≈ 12 GeV/c using MB trigger)
- η has many similarities to π^0, but contains hidden strangeness. Access to s-quark fragmentation function.