Isolated Photon – Hadron Correlations

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for the ALICE collaboration

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ALICE
A JOURNEY OF DISCOVERY

cnrs dépasser les frontières IN2P3 Les deux infinis

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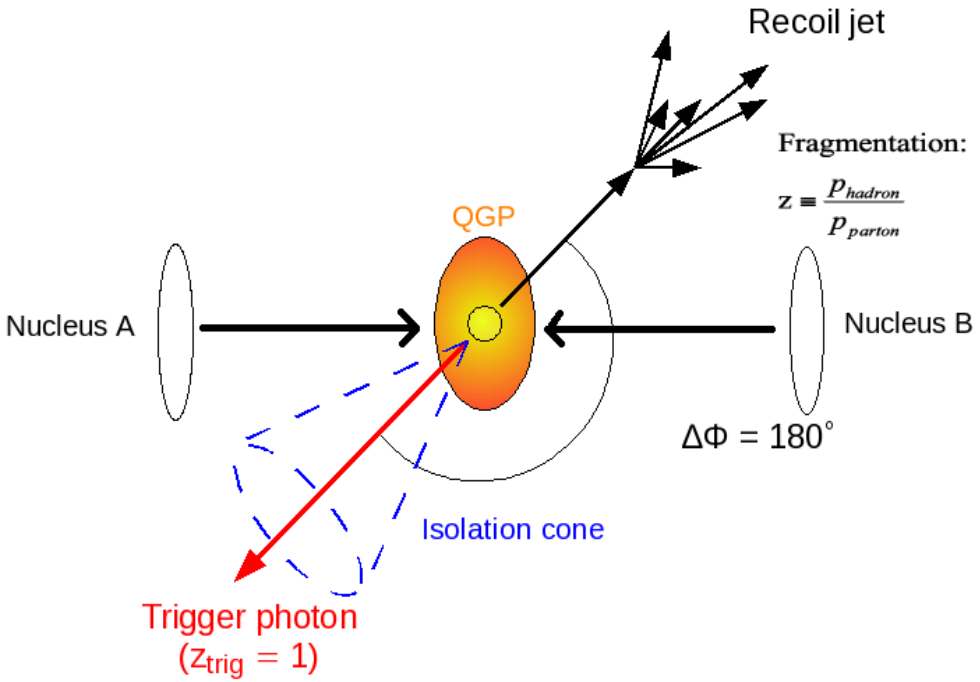
Motivations

Probe transport properties of QCD medium via parton fragmentation :

- photon-tagged jets (without jet reconstruction)
- **analysis method on pp data** to be used as a baseline for Pb-Pb



Observables

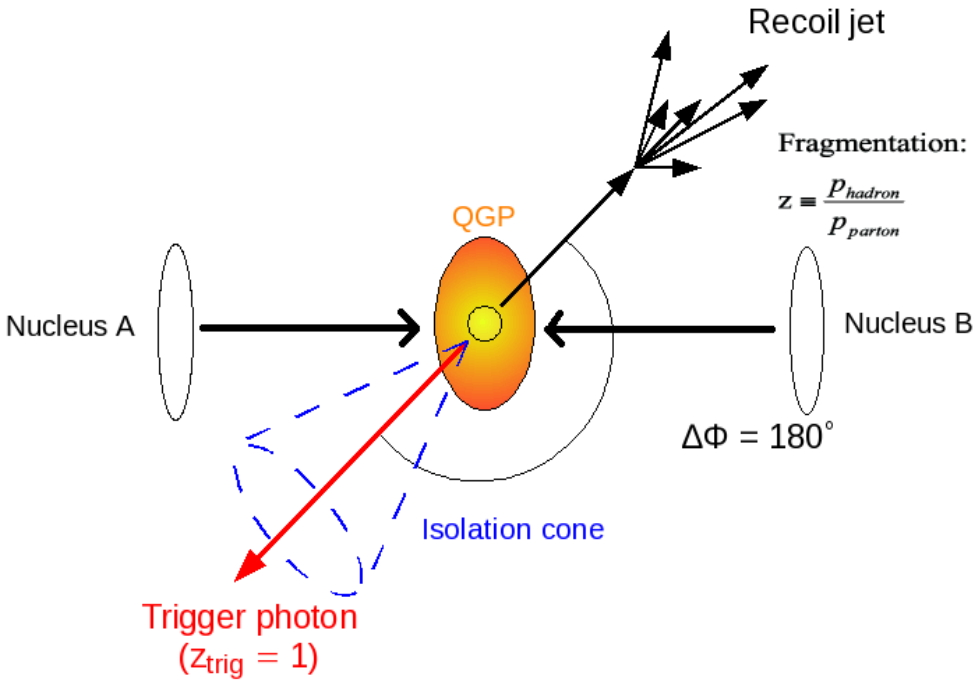
Imbalance parameter :

$$x_E = -\frac{p_{\mathrm{T}}^{h}}{p_{\mathrm{T}}^{\gamma}}\cos\Delta\Phi$$

Isolated photon

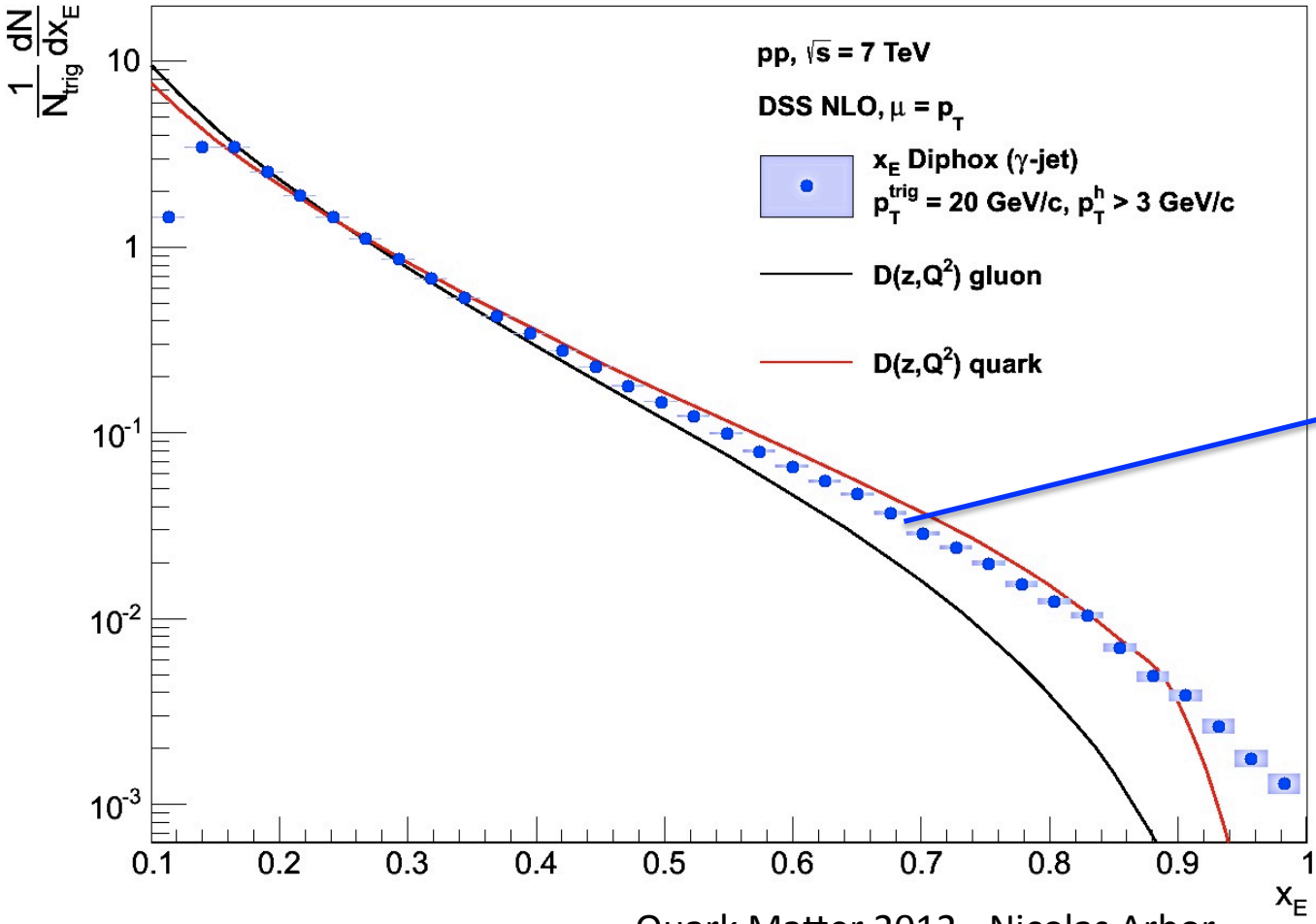
$p_T^{\gamma} \approx p_T^{parton}$

$$x_E \approx z = \frac{p^{h}}{p^{parton}}$$

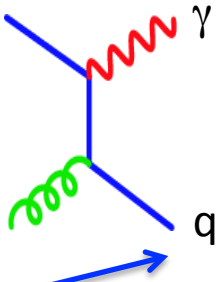


Fragmentation function

- x_E distribution describes fragmentation function for $0.2 < x_E < 0.8$
- γ-hadron correlations mainly reflect quark fragmentation



Compton scattering

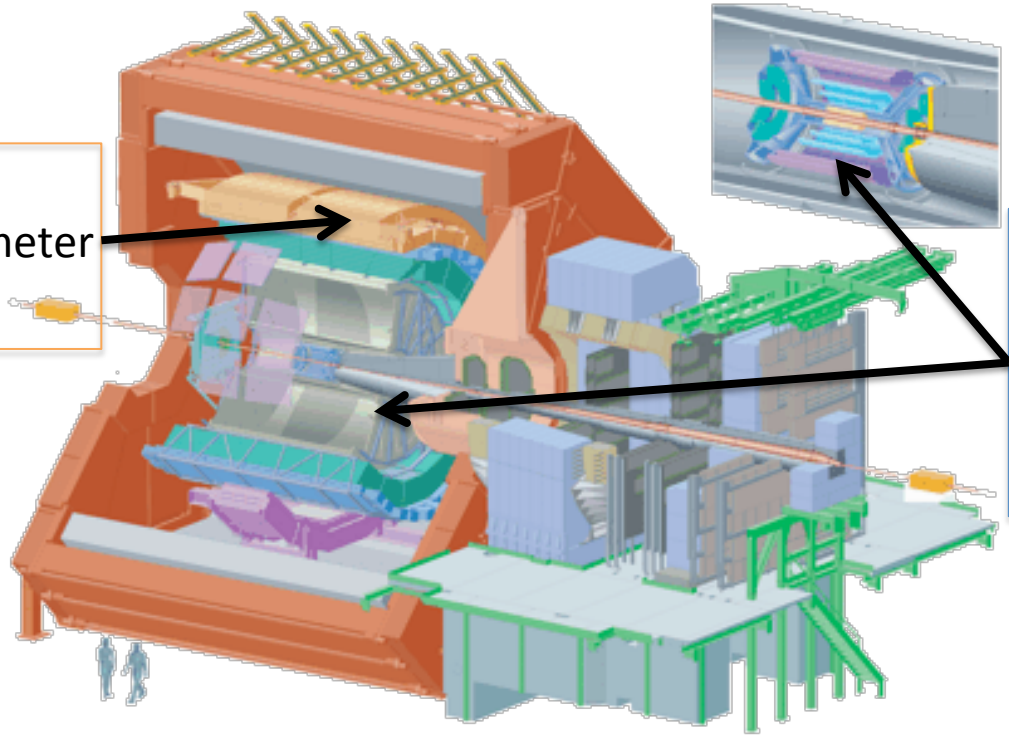


7 TeV pp data (2011)

Detectors involved

- Photons are reconstructed and identified using **EMCal**
- Charged hadron tracks are reconstructed using **TPC+ITS**

EMCAL
Pb-Scintillator calorimeter
$|\eta| < 0.7$, $\Delta\varphi = 100°$



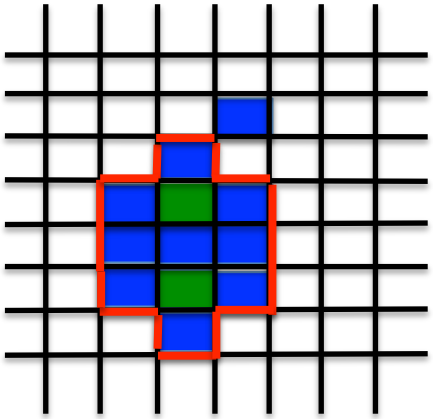
Tracking
ITS : silicon tracker
TPC : time projection chamber
$|\eta| < 0.9$, $\Delta\varphi = 360°$

EMCal trigger

- Use **EMCal trigger** capabilities to enrich high-p_T photons statistics
- Threshold ≈ 5 GeV/c ⇔ gain factor ≈ 3000 for $p_T > 8$ GeV/c
- Analysis used about 10M triggered events ($L_{int} \approx 500$ nb^{-1})

Electromagnetic Calorimeter

Clusterizer



Clusterization = connect adjacent fired cells

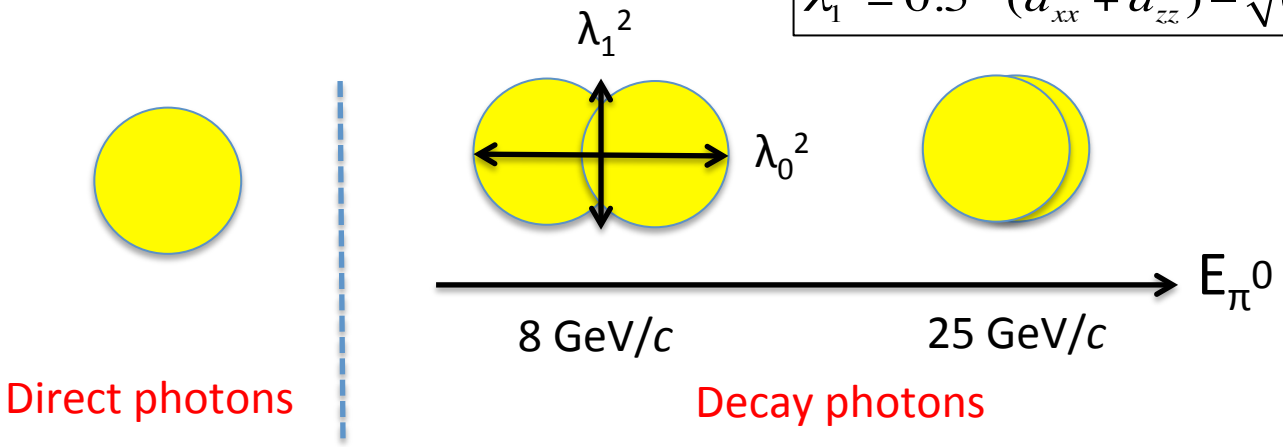
= fired cell

= local maxima

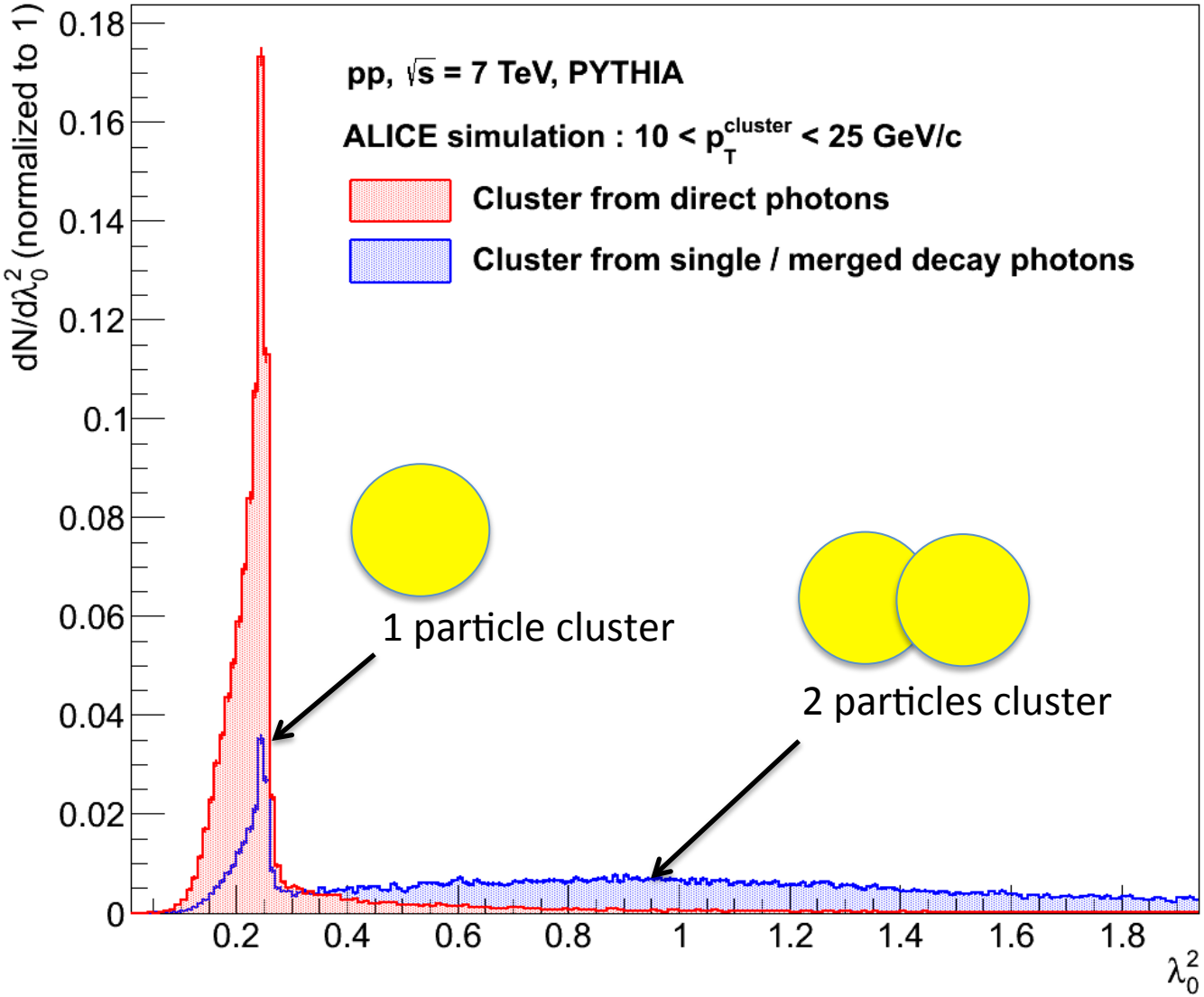
Shower shape

$$\lambda_0^2 = 0.5*(d_{xx}+d_{zz}) + \sqrt{(0.25*(d_{xx}-d_{zz})^2 + d_{xz}^2}$$

$$\lambda_1^2 = 0.5*(d_{xx}+d_{zz}) - \sqrt{(0.25*(d_{xx}-d_{zz})^2 + d_{xz}^2}$$



Shower shape



See M. Cosentino poster 456 – 16/08/2012

Photon :

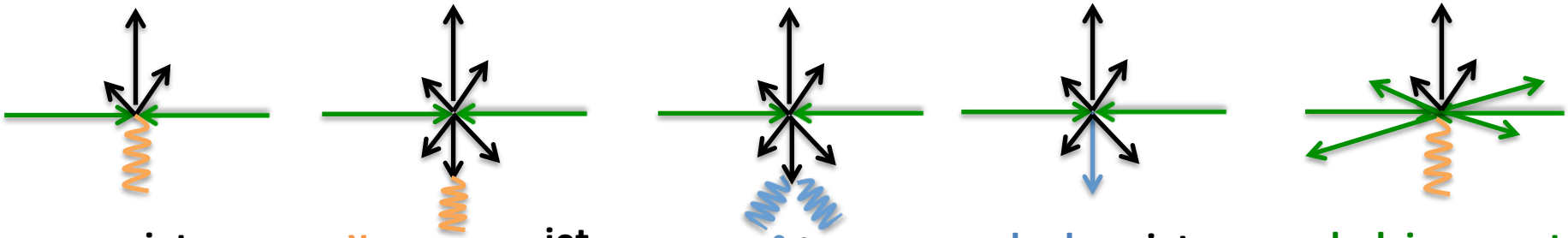
$0.1 < \lambda_0^2 < 0.27$

π^0 :

$\lambda_0^2 > 0.5$

Analysis strategy

EMCal clusters : Isolation + Photon identification



Inclusive isolated clusters | **UE**

Purity : p = S/(S+B)

(Background (B) dominated by π^0)

Signal | **Background** | **UE**

$$x_E^{\gamma\ iso} = \frac{1}{p} x_E^{clusters\ iso} - \frac{(1-p)}{p} x_E^{\pi^0\ iso} - x_E^{UE}$$

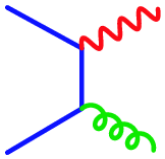
($x_E^{\pi^0} \approx x_E^{hadron}$)

Isolation

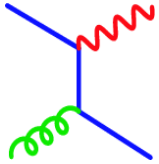
Select **direct photons :**

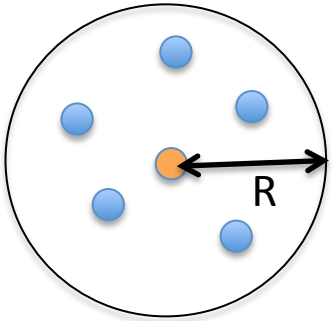
- most of direct photons are isolated, most of decay photons are not (jet)
- isolation parameters : cone radius $R = \sqrt{\Delta\eta^2 + \Delta\varphi^2}$, $p_T^{threshold}$

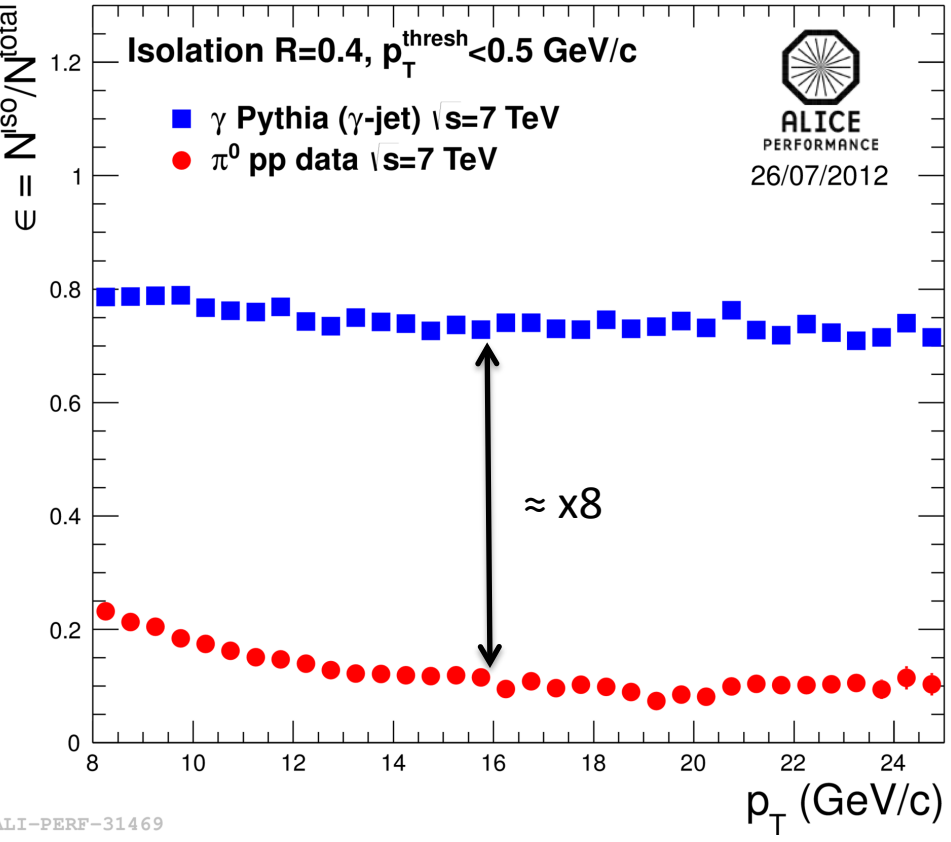
Annihilation



Compton







Isolated cluster

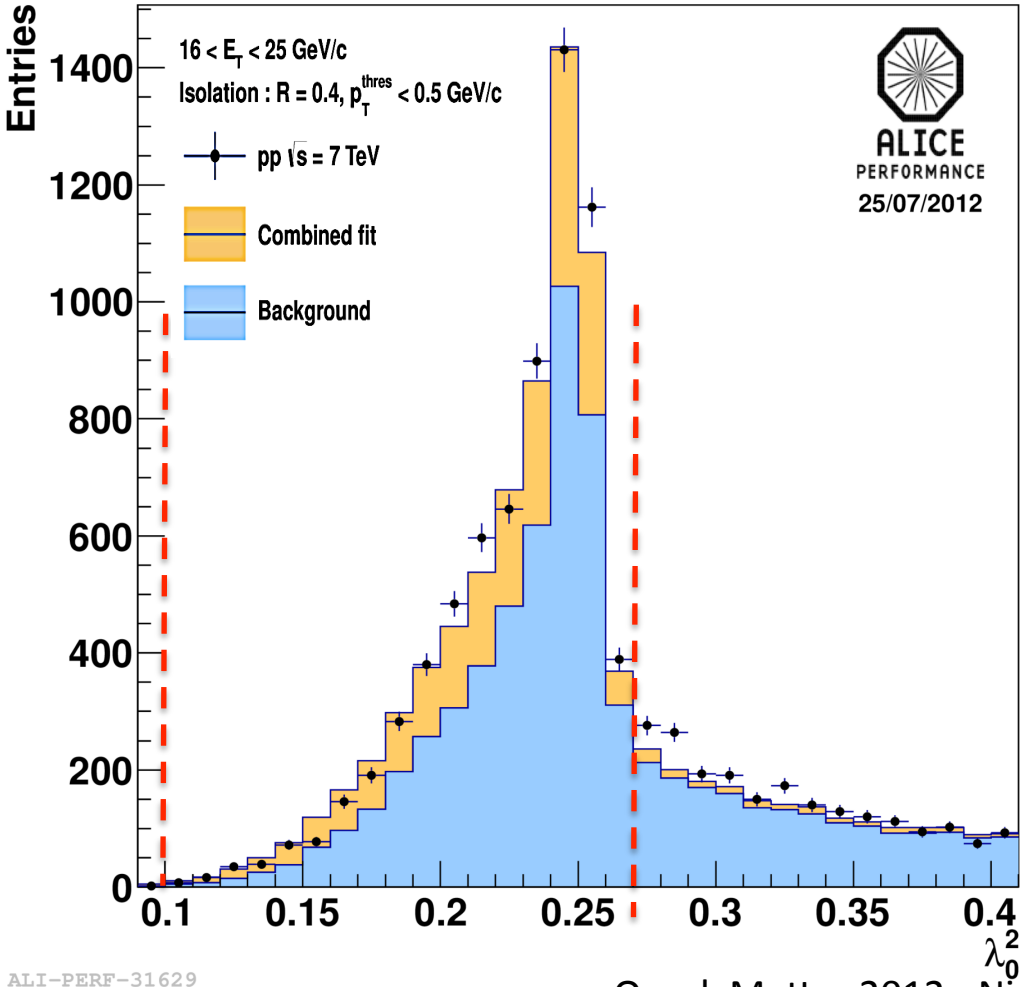
⇔

no particle with p_T above 0.5 GeV/c in cone R = 0.4

Shower shape : purity estimate

- Isolated clusters sample = isolated photons + background
- Binned likelihood **fit of the shower shape distribution** :

  ⟹ combined signal (MC) and background (data) shower shape to fit data



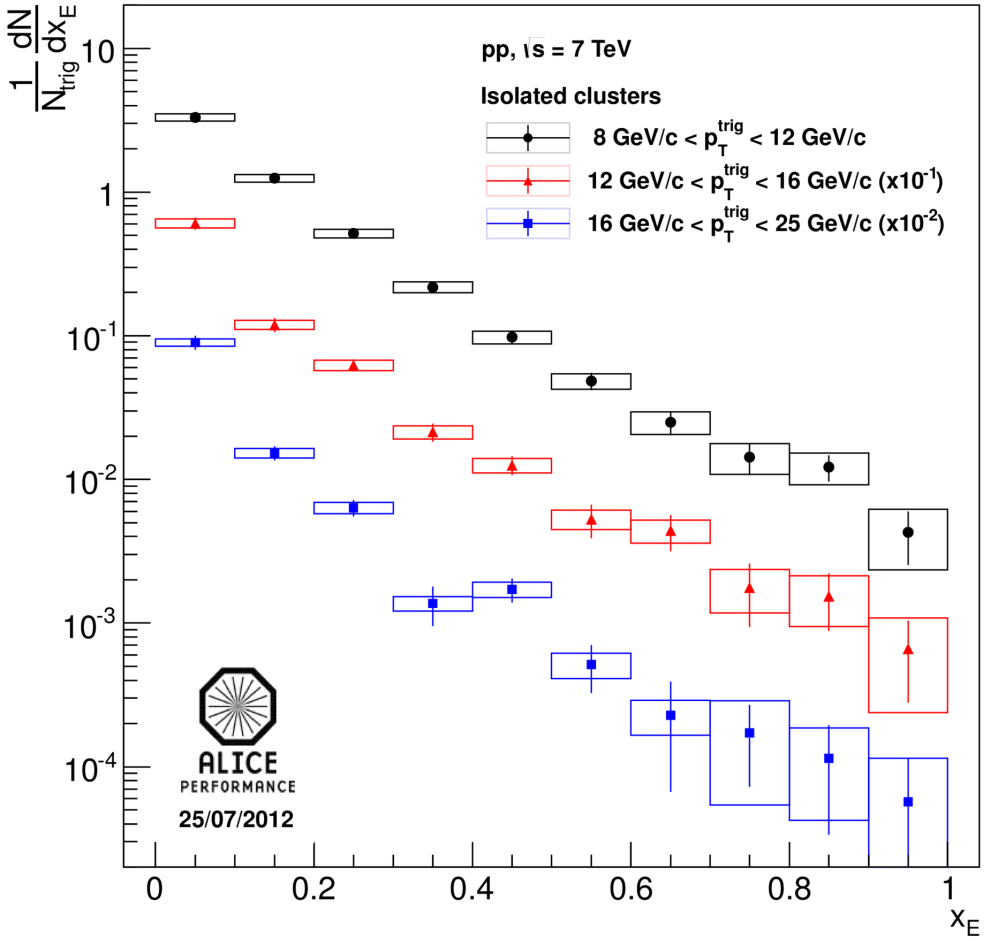
$$\text{Purity} = \frac{\int_{\lambda_0^2=0.1}^{\lambda_0^2=0.27}}{\int_{\lambda_0^2=0.1}^{\lambda_0^2=0.27} + \int_{\lambda_0^2=0.1}^{\lambda_0^2=0.27}}$$

p_T bins (GeV/c)	Purity
8-12	0.08 ± 0.01
12-16	0.31 ± 0.05
16-25	0.59 ± 0.04

x_E isolated clusters

- Underlying event subtracted

$$x_E^{\gamma\ iso} = \frac{1}{p} x_E^{clusters\ iso} - \frac{(1-p)}{p} x_E^{\pi 0\ iso}$$



$8 < p_T^{trig} < 12$ GeV/c

$12 < p_T^{trig} < 16$ GeV/c

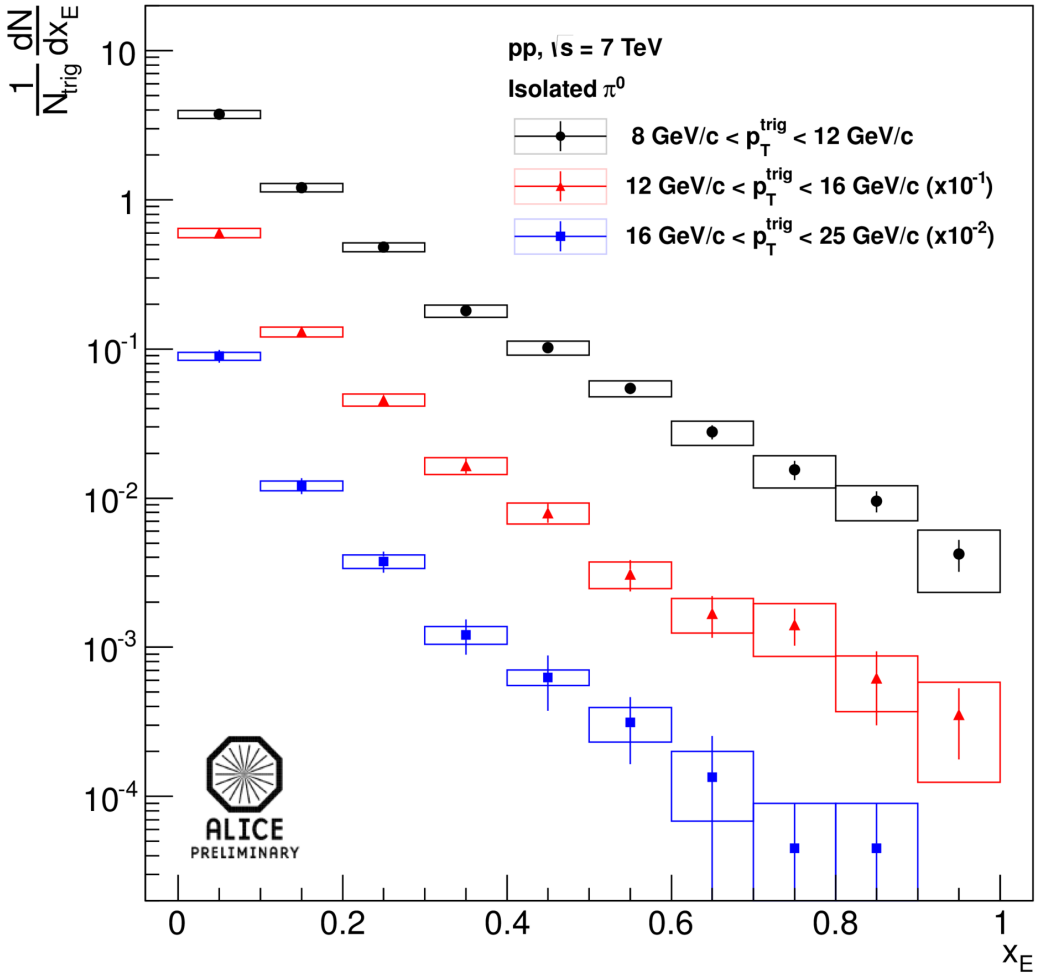
$16 < p_T^{trig} < 25$ GeV/c

Result is a mix of isolated photons and background

x_E isolated π^0

- Background = 95% π^0 decay photons
- Use π^0 to evaluate background

$$x_E^{\gamma\ iso} = \frac{1}{p} x_E^{clusters\ iso} - \frac{(1-p)}{p} x_E^{\pi 0\ iso}$$



$8 < p_T^{trig} < 12$ GeV/c

$12 < p_T^{trig} < 16$ GeV/c

$16 < p_T^{trig} < 25$ GeV/c

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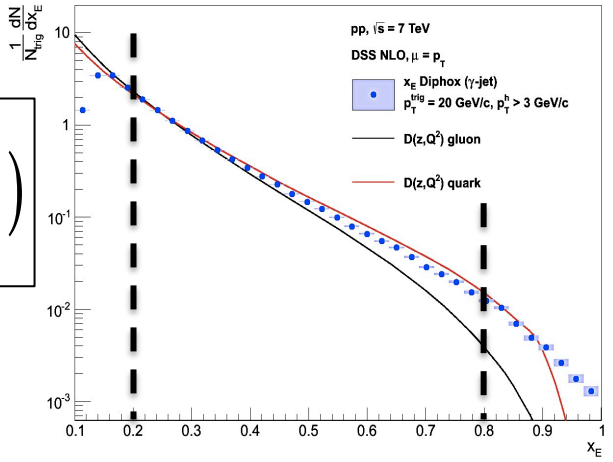
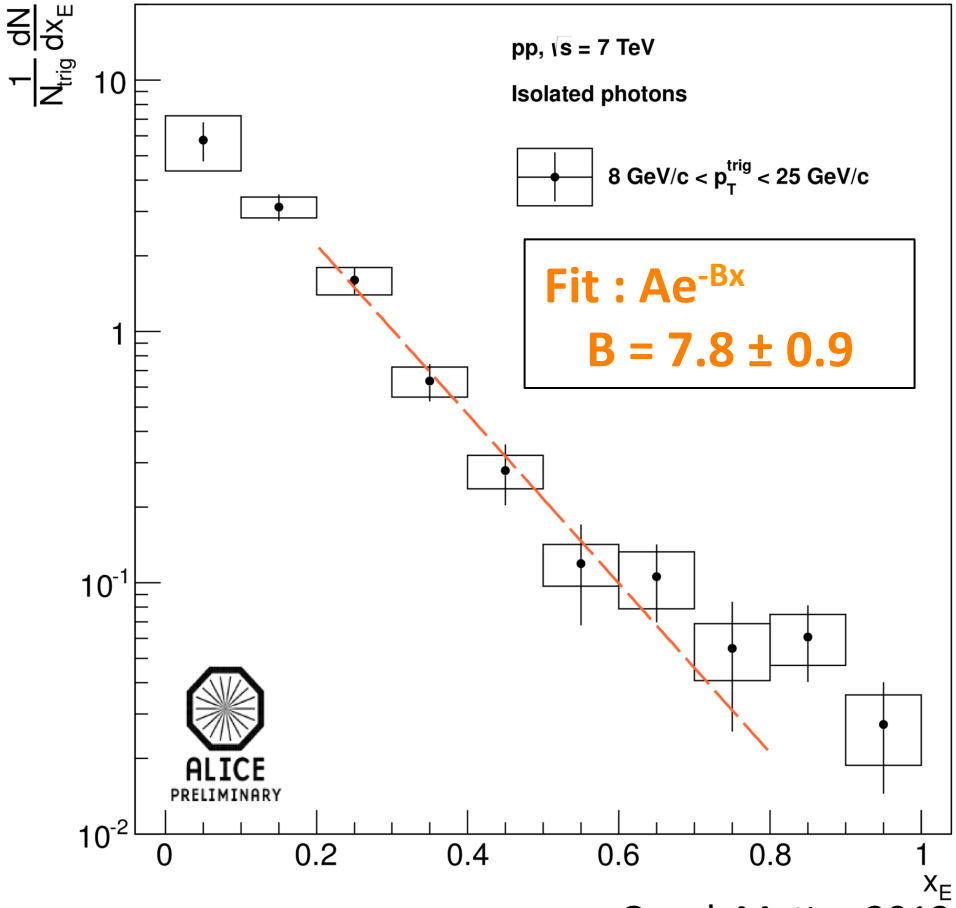
x_E isolated photons

- **Subtract contamination** in p_T bins (Δp_T = 1 GeV/c)

$$x_E^{\gamma\ iso} = \sum_{i=8}^{25\ GeV/c} \left(\frac{1}{p_i} x_E^{clusters\ iso(i)} - \frac{(1-p_i)}{p_i} x_E^{\pi 0\ iso(i)} \right) - \sum_{i=8}^{25\ GeV/c} \left(x_E^{UE(i)} \right)$$



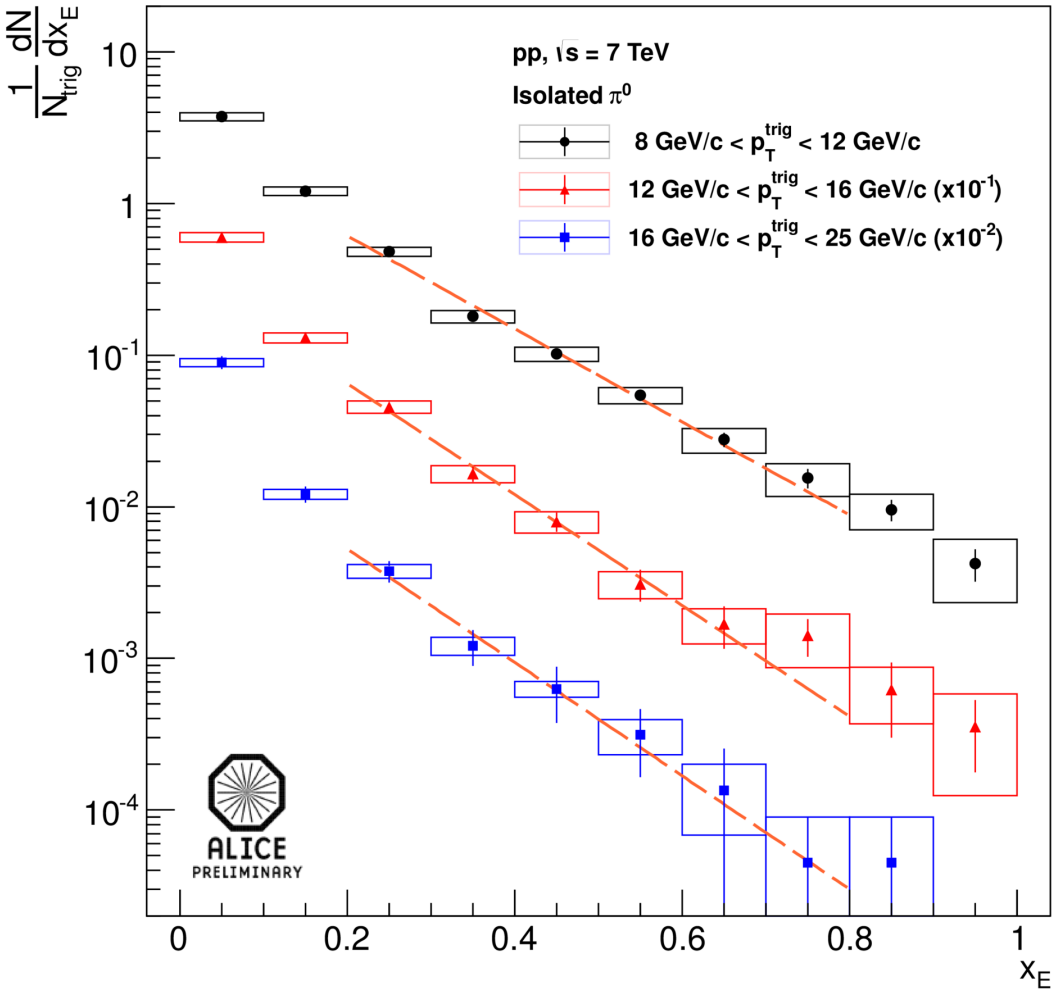
Exponential shape [0.2-0.8]



Baseline for the study of medium modified parton fragmentation in Pb-Pb

x_E π^0 : slope parameter (1)

- Inclusive hadron-hadron correlation : jet energy unknown
- Isolated π^0 : E_{π^0} samples a large fraction of E_{parton} ⇔ $\langle z_{\pi^0} \rangle = 0.8$ (Pythia+cuts)

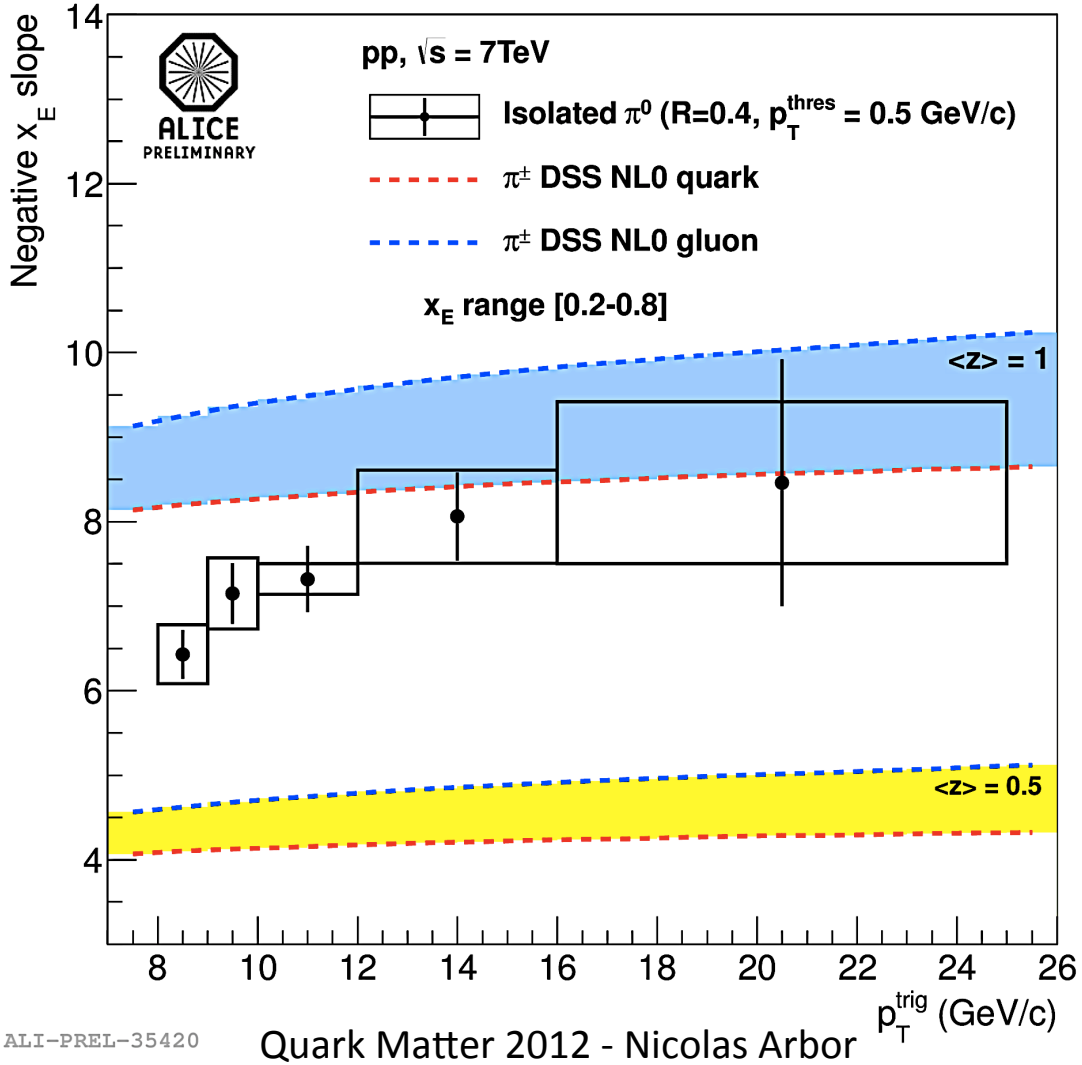


Exponential fit (slope) :

[8-12] GeV/*c* : **6.9 ± 0.4**
[12-16] GeV/*c* : **8.1 ± 0.6**
[16-25] GeV/*c* : **8.5 ± 0.7**

x_E π^0 : slope parameter (2)

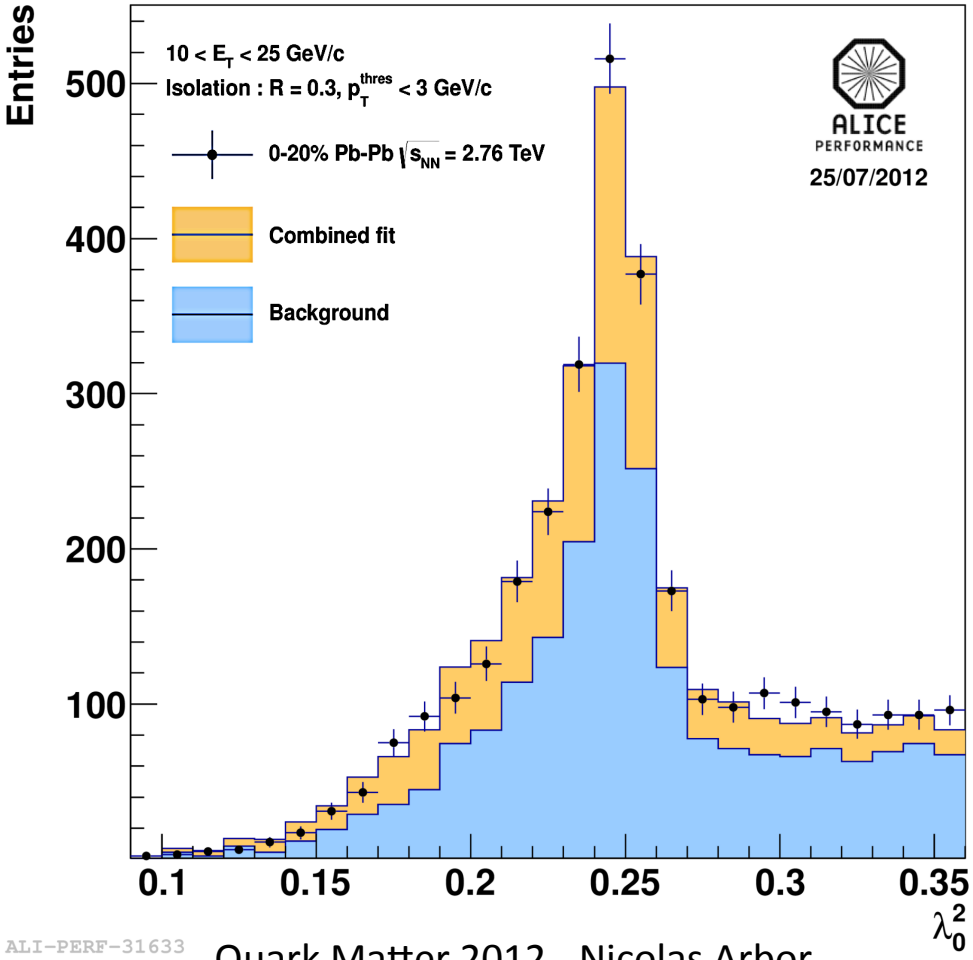
- Compare slopes from isolated π^0 with fragmentation function
- Isolated π^0 slopes sample <z> ≈ 0.8



Isolated photons : Pb-Pb 2.76 TeV

Photon identification on **Pb-Pb data :**

- Started to separate isolated photons from background
- Still work needed to understand the more complex background (flow)



Summary and Outlook

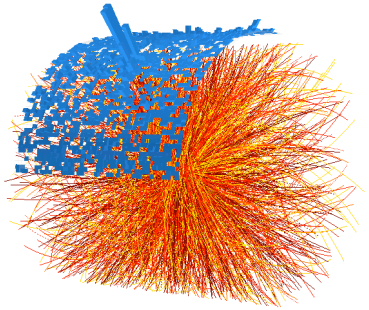
- Establish global shape of fragmentation function through the measurement of isolated photon-hadron correlations in $\sqrt{s}$ = 7 TeV pp collisions in the p_T range [8-25] GeV/c

- Extract isolated π^0 slope parameter to study fragmentation bias in using isolated π^0 – hadron correlations

- Next : measure medium modified x_E distribution in Pb-Pb in the same p_T range

Isolated photons in pp collisions

See M. Cosentino poster
456 – 16/08/2012



π^0 – hadron correlations in pp and Pb-Pb collisions

See X. Zhu poster
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Back up

Experimental aspects

- **Background from decay**

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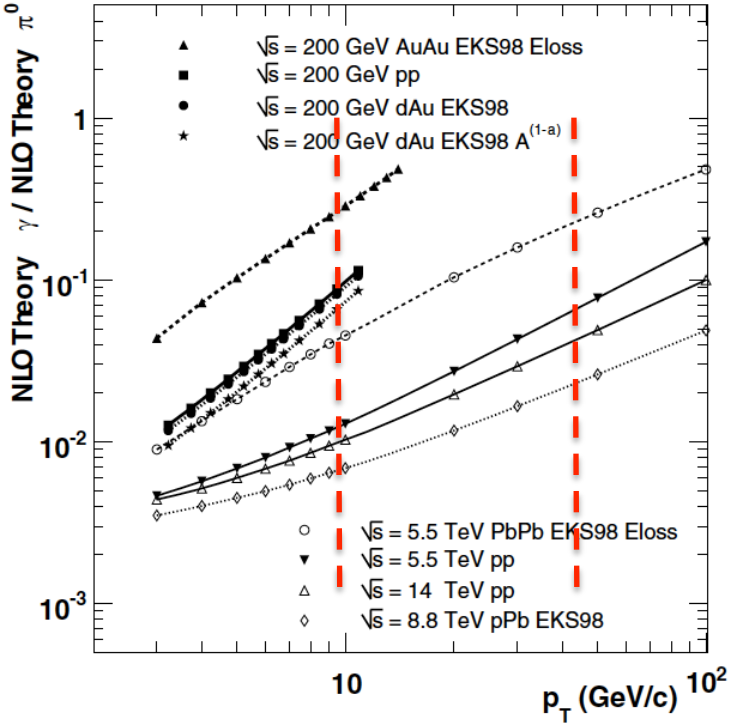
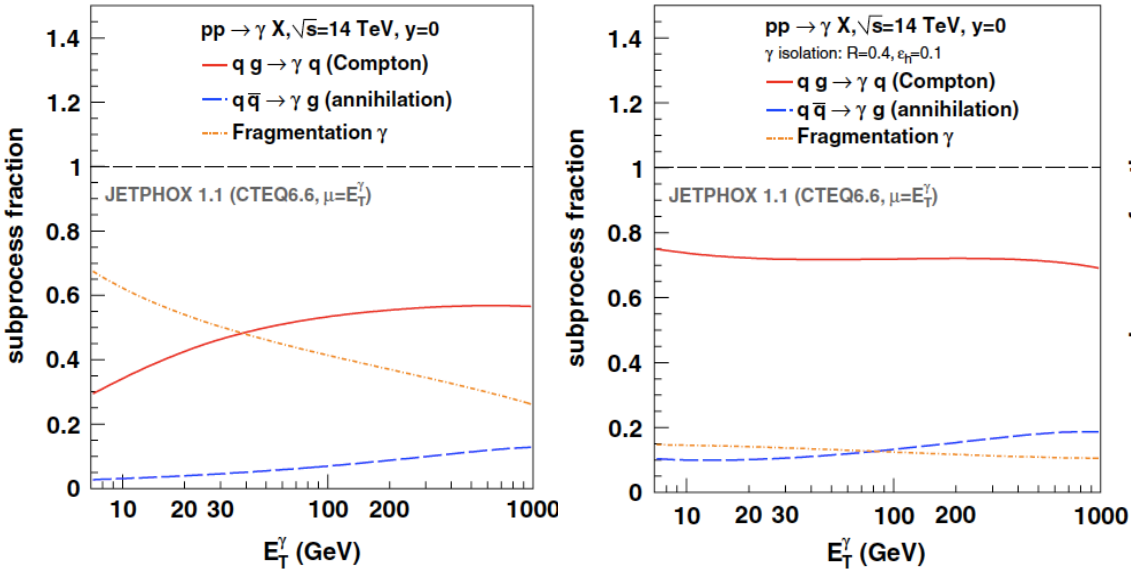


- **Isolation**

R. Ichou et al. arXiv:1005.4529[hep-ph]



EMCal shower shape

- Semi-converted photons from π^0

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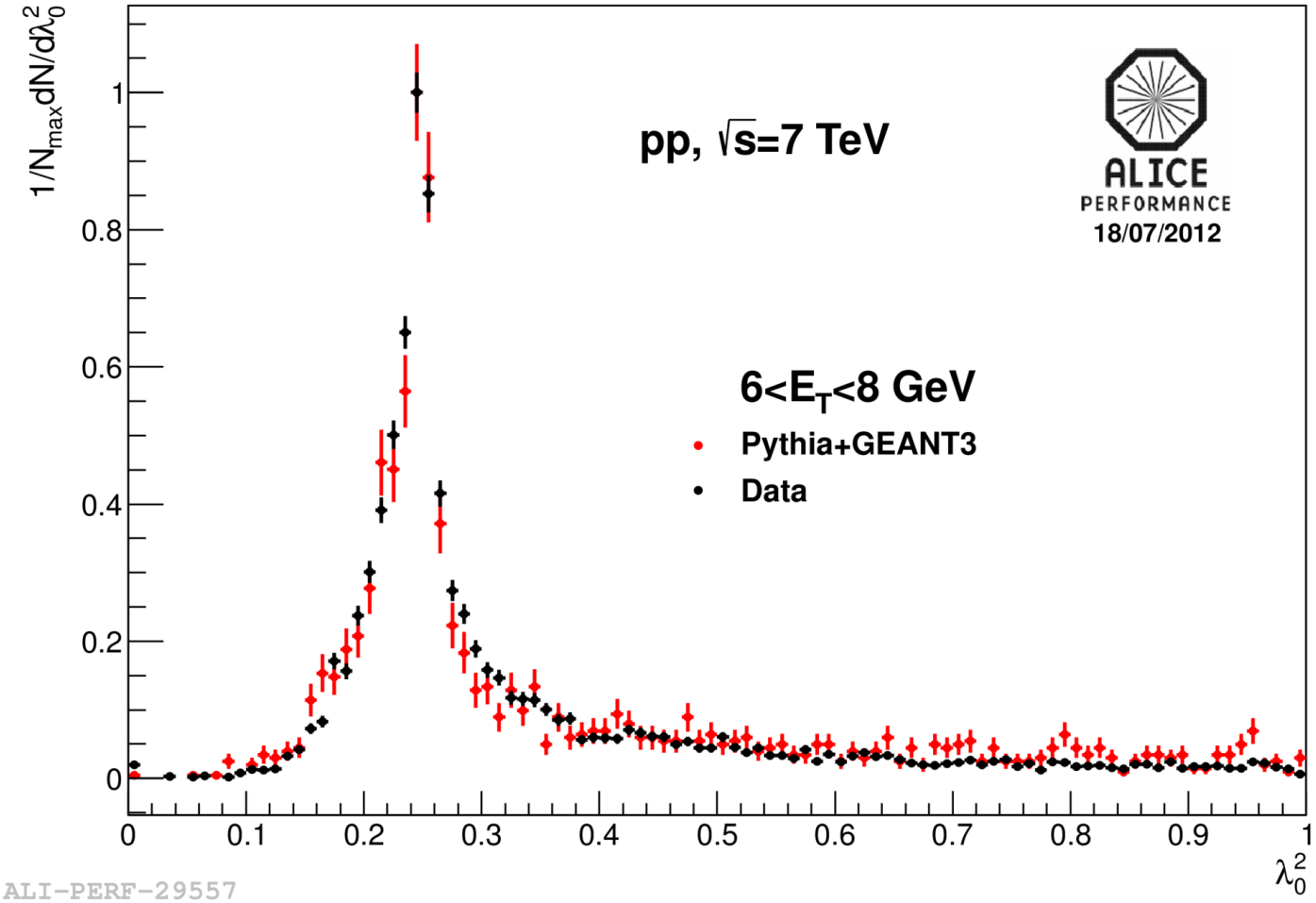
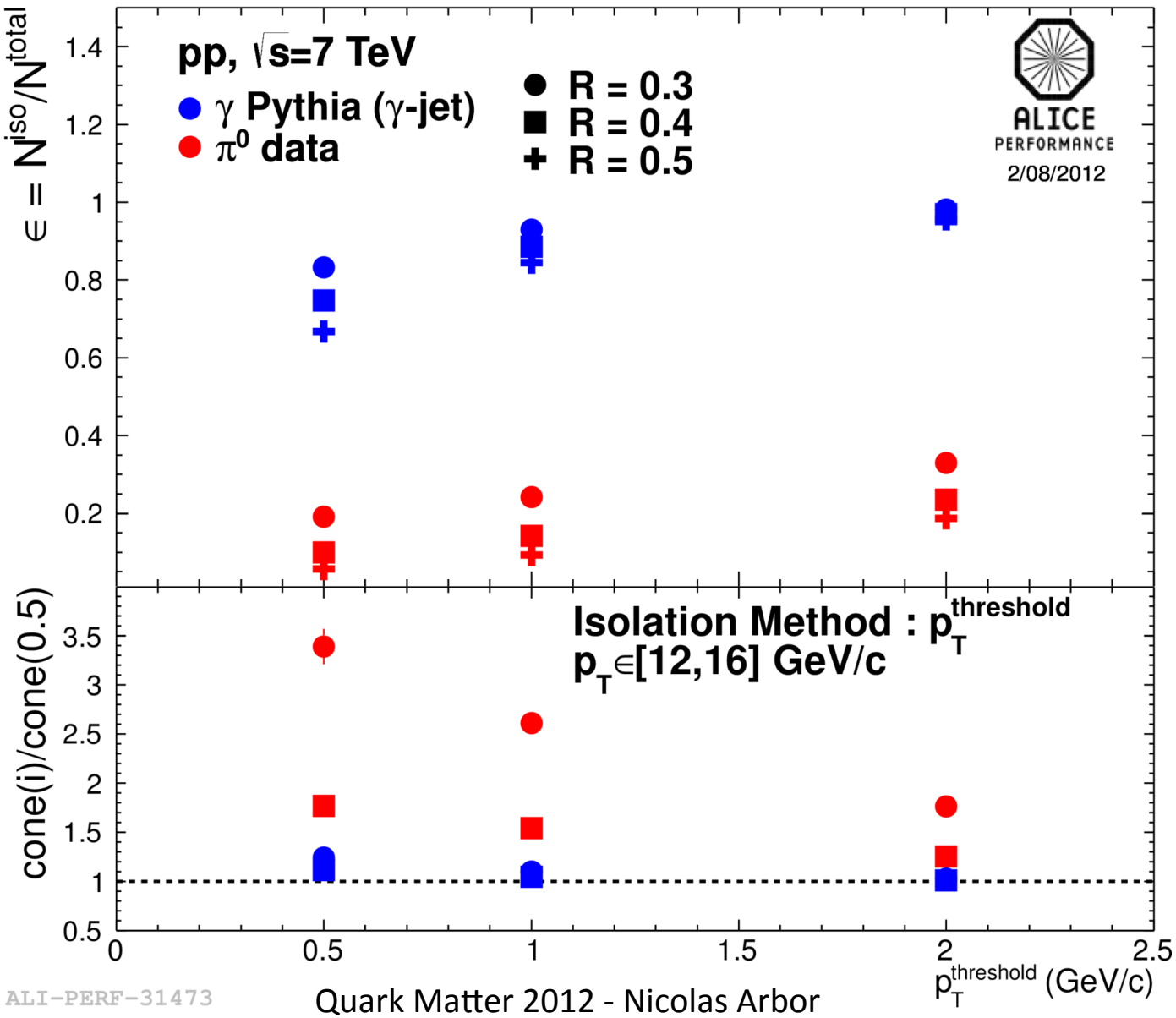
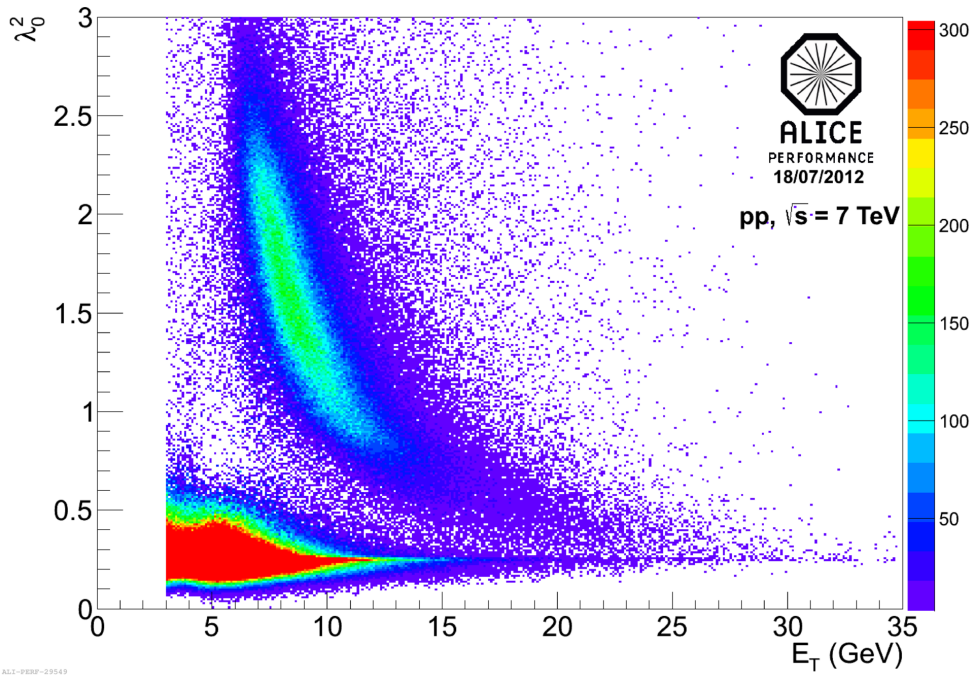


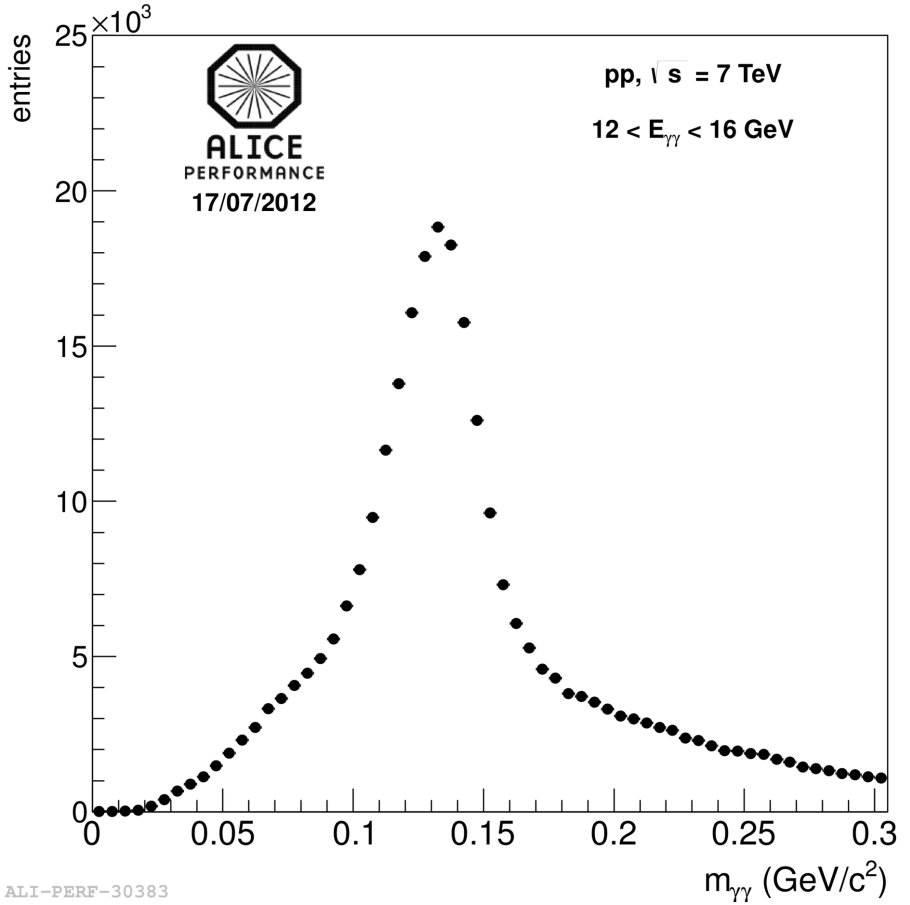
Isolation criteria



π^0 identification



Shower shape from neutral clusters



Invariant mass of splitted clusters

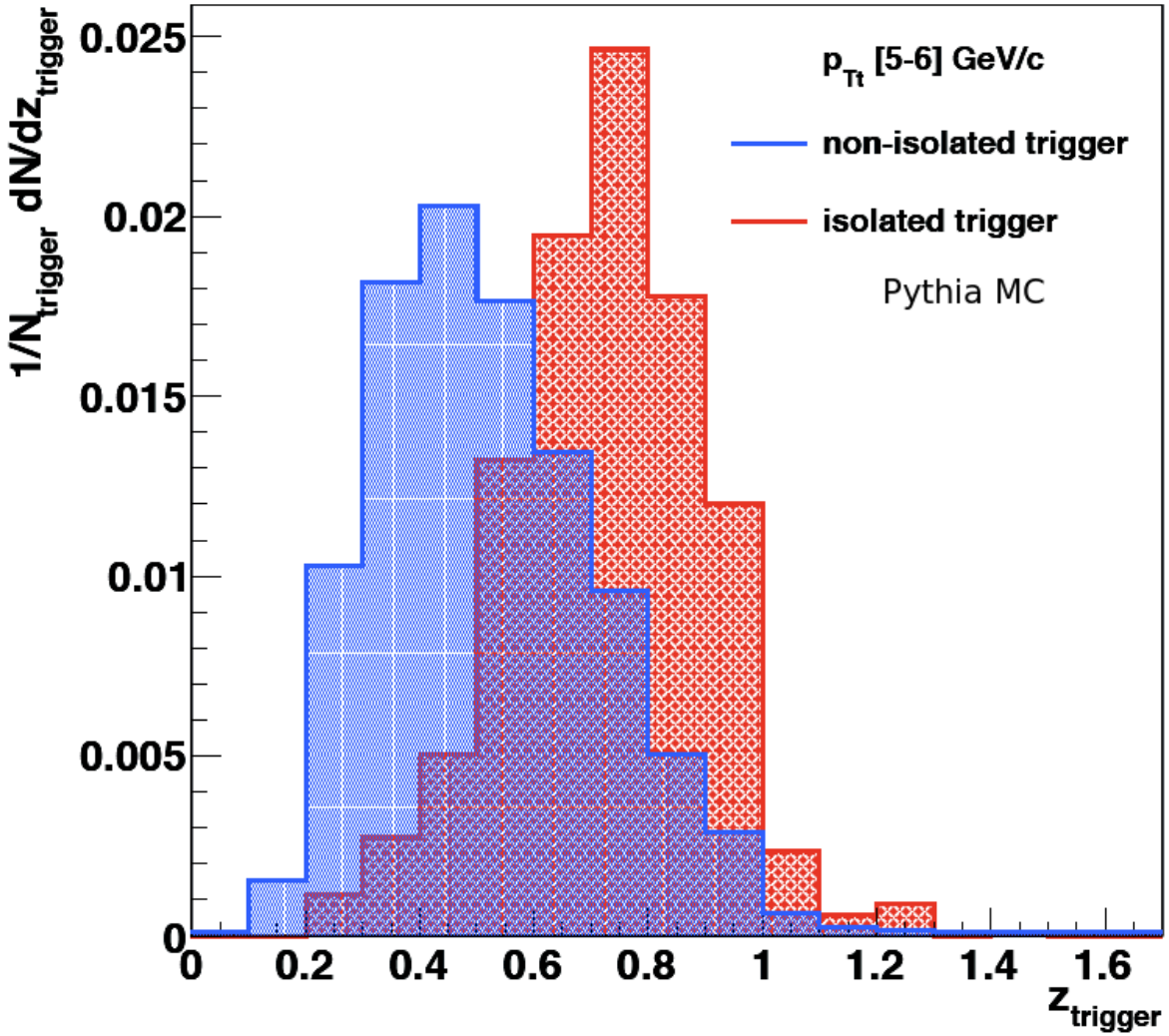
Systematics uncertainties

Main systematic uncertainties are :

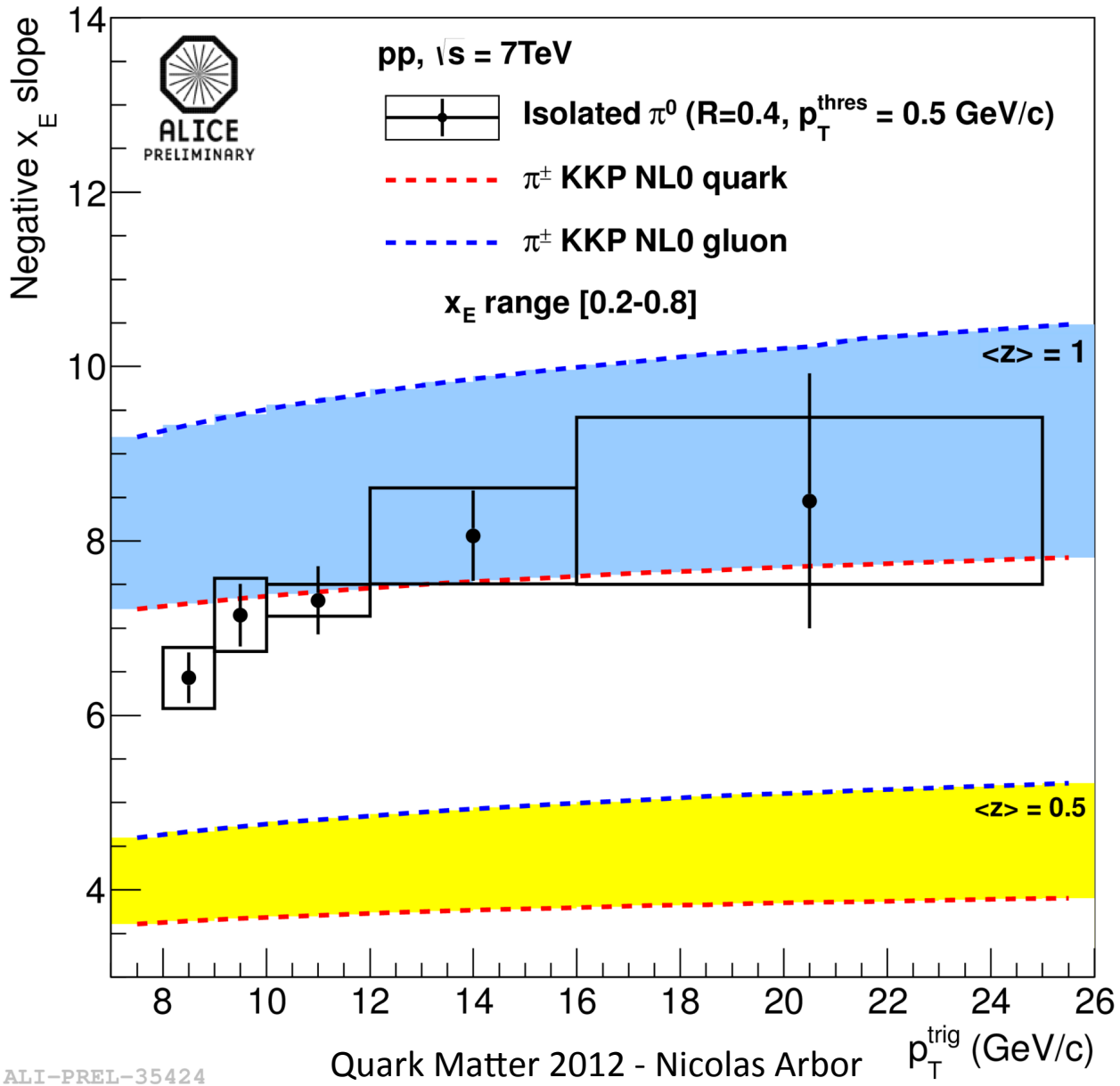
- Shower shape MC / Data
- Likelihood fit parameters (binning, range)
- Background template composition (signal contamination, shower shape)
- Underlying event subtraction
- Detectors effects correction

x_E	systematics
[0-0.1]	24%
[0.1-0.2]	10%
[0.2-0.3]	13%
[0.3-0.4]	14%
[0.4-0.5]	15%
[0.5-0.6]	18%
[0.6-0.7]	25%
[0.7-0.8]	26%
[0.8-0.9]	23%
[0.9-1.0]	32%

Isolated π^0 <z>



Isolated π^0 slopes : KKP



Medium modified FF

X.N Wang et al.,PhysRevLett 77 231 (1996)