Two particle azimuthal correlations : isolated cluster - charged hadrons

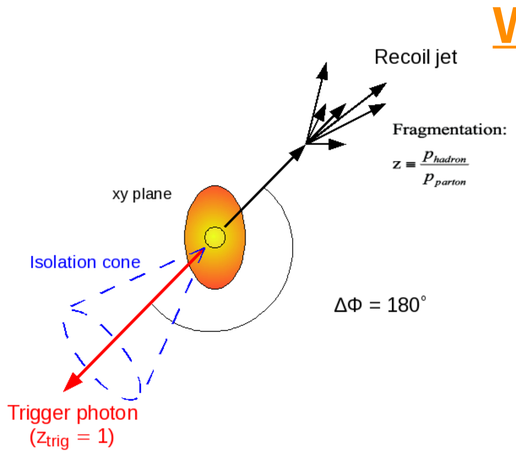
Nicolas Arbor for the ALICE Collaboration
Laboratoire de Physique Subatomique et de Cosmologie, UJF, CNRS/IN2P3, INPG, Grenoble France

What ?

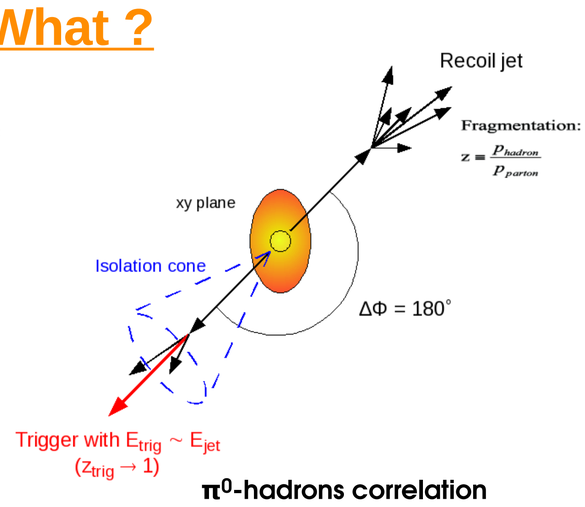
WHY ?

. Study jet fragmentation without jet reconstruction

. Tomography of the Quark Gluon Plasma (pp vs AA)



γ-hadrons correlation



π^0-hadrons correlation

HOW ?

. Correlate a trigger particle with all charged tracks

. Use isolation to select high z trigger events

Detectors :

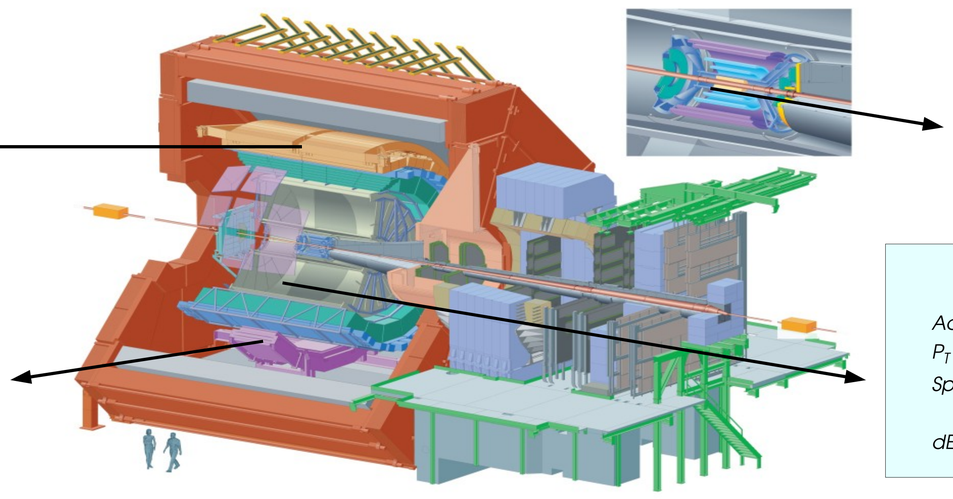
Calorimeters

ElectroMagneticCALorimeter

Pb/Polystyrene sampling calorimeter : X_0 = 12.3 mm, R_M = 3.20 cm
Base unit (tower) : 6 x 6 cm² (0.0143 x 0.0143)
Energy resolution : $\frac{\sigma_E}{E} = \frac{11\%}{\sqrt{E}} + 1.7\%$
Acceptance : -0.7 ≤ Δη ≤ 0.7
80° ≤ ΔΦ ≤ 100° (2010) and 80° ≤ ΔΦ ≤ 180° (2011)

PHOtonSpectrometer

$PbWO_4$ crystals calorimeter : X_0 = 89 mm, R_M = 2.0 cm
Base unit (cell) : 2.2 x 2.2 cm² (0.004 x 0.004)
Energy resolution : $\frac{\sigma_E}{E} = \frac{3.3\%}{\sqrt{E}} + 1.1\%$
Acceptance : -0.12 ≤ Δη ≤ 0.12 , 220° ≤ ΔΦ ≤ 320°



ALICE experiment

Tracking detectors

InnerTrackingSystem

6 layers of silicon mixing 3 technologies : pixel, drift and strip
Spatial resolution in rφ : 12 µm, 35 µm, 20 µm
in z : 100 µm, 25µm, 830 µm

TimeProjectionChamber

Acceptance : -0.9 ≤ Δη ≤ 0.9 , 0° ≤ ΔΦ ≤ 360°
P_T range : 0.1 GeV/c to 100 GeV/c
Spatial resolution in rφ : 1100 to 800 µm (inner/outer radii)
in z : 1250 to 1100 µm
dE/dx resolution : 5%

Analysis :

1. Minimum bias 2010 pp collisions at √s = 7 TeV

- Online trigger : V0 detector identifies Beam-Beam collisions from timing information
  SPD detector checks number of tracks in central barrel
- Offline reconstruction :

Clusterization (EMCal)

Cluster = group of linked towers (E_{tower} > 45 MeV)
accept cluster if $E_{cluster}$ > 100 MeV
QA : make trending plots
remove runs if criteria > ± 2σ of mean value
Criteria : clusters multiplicity
cells multiplicity
π^0 invariant mass and width

Track reconstruction (TPC)

Reconstruction : Kalman filtering
(actual data analysis only use TPC tracks fit)
QA : remove fake tracks
Cuts : η acceptance
vertex range |z| < 10 cm
DCA to vertex < 3.2cm (xy), < 2.4cm (z)
number of TPC clusters > 70

2. Clusters selection

What kind of trigger do we want ?

Theoretically, study jet fragmentation from correlations requires a trigger candidate with $z = \frac{p_T^{trigger}}{p_T^{parton}} \approx 1$
2 neutral candidates : → π^0 jet
→ direct photons

How to select them from the inclusive clusters ?

✘ 1) ***Track matching*** : reject charged clusters matching a track
✘ 2) ***Shower shape analysis*** : identify decay photons component from the elliptic shape of merged cluster
✔ 3) ***Isolation method*** : apply isolation cut on calorimeter clusters

⇒ in this analysis we apply **isolation method only** !

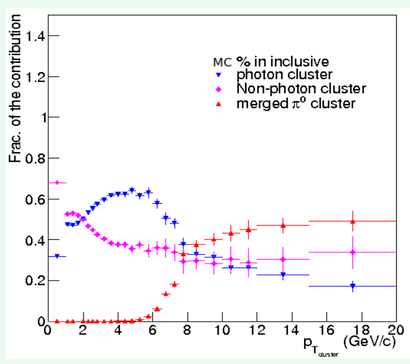


Fig 1. EMCal clusters inclusive composition

3. Isolation method

Objectives :

- select jet event with z_{trig} close to 1 (fig. 2)
- enrich data sample with direct photons (fig. 3 & 4)
  ⇒ reduce the contamination from decay photons and charged hadrons

➪ **approximate γ/π^0-hadrons correlations** (fig. 5)
(*"Rome wasn't built in a day"*, French proverb)

Method :

1. select leading cluster with p_T > 5 GeV/c
2. make a cone with radius R = 0.4 ($R = \sqrt{\Delta\eta^2 + \Delta\phi^2}$)
3. sum all charged activity in the cone
4. if $\Sigma p_T < 0.1 \times p_T^{trigger}$ → **trigger is isolated !**

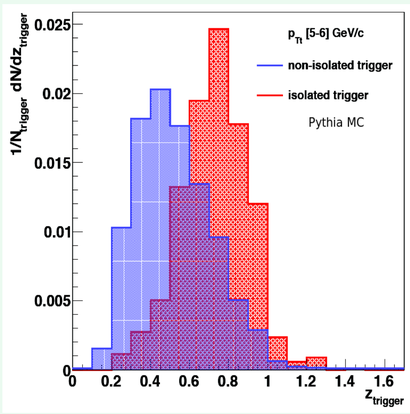


Fig 2. $z_{trigger}$ with/without isolation

⇒ **isolation select high z triggers**
(<z> = 0.5 → <z> = 0.8)

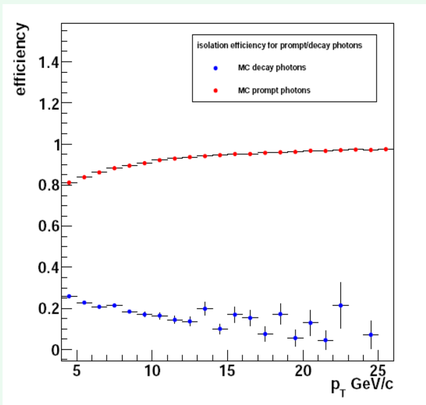


Fig 3. Isolation efficiency for prompt photons (red) and decay photons (blue)

⇒ **isolation removes more than 80% of decays by keeping 80-95% of prompt photons**

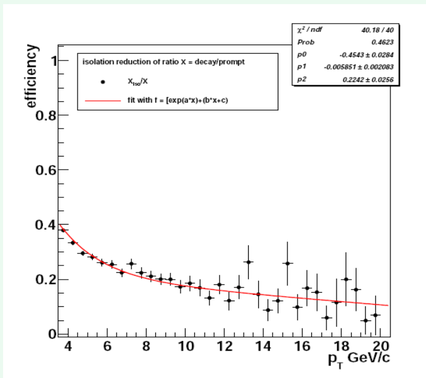


Fig 4. X = decay/prompt is the initial (unknown) Background/Signal ratio
X^{iso}/X ≡ isolation gain for S/B

⇒ **isolation enhances prompt photons component by a factor 4 (5 GeV/c) to 10 (20 GeV/c)**

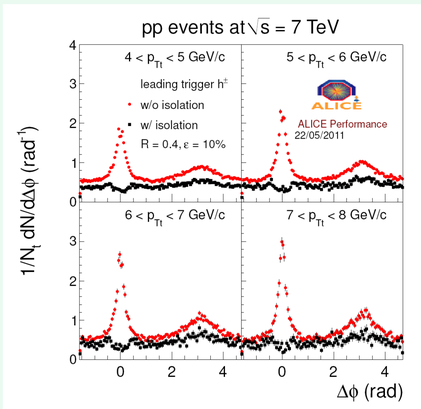


Fig 5. Azimuthal correlation with / without isolation

⇒ **isolation suppresses near side peak (π^0 jets and direct photons ?)**

Results & Outlook :

What are we looking for ?

We want to extract the parameter : $x_E = \frac{-\vec{p}_T^{\,h} \cdot \vec{p}_T^{\,trig}}{|\vec{p}_T^{\,trig}|^2}$

With $z_{trigger}$ ~ 1, we expect $x_E \sim z$ (jet fragmentation)

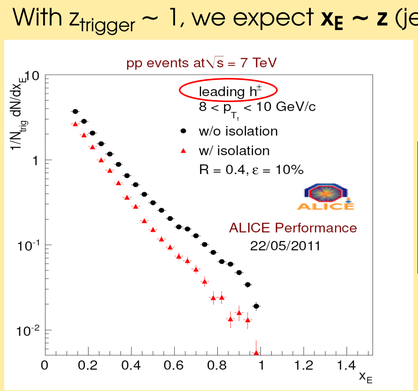


Fig 6. x_E for charged trigger particle

⇒ **we already get promising results for neutral particles**
⇒ **we need to increase statistic to finalize analysis**

Conclusion :

1. Isolation removes a large fraction of the contamination
2. Isolation enhances event selection with high $z_{trigger}$ (~ 0.8)
3. Isolation makes the x_E distribution steeper (→ approaching jet fragmentation ?)

To be continued :

- Identify photons by using track matching and shower shape analysis
- Use photons and neutral mesons spectra to estimate $R_\gamma = \gamma^{inclusif}/\gamma^{decay}$
- Extract the direct photon per-trigger yield :

$$Y_{direct} = \frac{1}{R_\gamma - 1}(R_\gamma Y_{inclusif} - Y_{decay}) \quad \text{with :} \quad Y_x = \frac{\#x-hadrons}{\#x\,trigger}$$

- Improve isolation method by including neutral information in the cone
- Study the medium effect with 2010 Pb-Pb collisions at $\sqrt{S_{NN}}$ = 2.76 TeV
  (quenching ↔ medium modified fragmentation function)

More informations ?

Bibliography (selected) :

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Contact :

alice-PartCorr@cern.ch (photon/π0 correlations group)
arbor@lpsc.in2p3.fr (me)