Systematic study of the spectral shape dependence on neutral meson reconstruction in the ALICE EMCal

Alena Lösle

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Dr. Constantin Loizides

Student Session
- $\pi^0$ reconstruction in ALICE EMCal
- our ToyMC analysis
- spectral shape dependence of reconstructed $\pi^0$
- summary
π^0 reconstruction in ALICE EMcal

- combine all γγ pairs in EMCal
- estimate and subtract background
- fit mass peak

\[ p_T \text{ range: } 1.8 - 2.0 \text{ GeV} \]

Counts

<table>
<thead>
<tr>
<th></th>
<th>Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>raw real events</td>
<td></td>
</tr>
<tr>
<td>estimated total bkg</td>
<td></td>
</tr>
<tr>
<td>correlated bkg</td>
<td></td>
</tr>
<tr>
<td>mixed events</td>
<td></td>
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</tbody>
</table>

= 2.76 TeVs

pp,
π^0 reconstruction in ALICE EMcal

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p_T range: 1.8 - 2.0 GeV

Counts

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= 2.76 TeV

pp,

Crystal Ball Fit

ALICE Performance

2014-05-10

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Student Session

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π⁰ reconstruction in ALICE EMcal

π⁰ reconstruction:
- combine all γγ pairs in EMCal
- estimate and subtract background
- fit mass peak

p_T range: 1.8 - 2.0 GeV
Our ToyMC analysis

$$\pi^0 \rightarrow \gamma \gamma$$ using TGenPhaseSpace

- energy smearing:  
  $$\frac{\sigma_E}{E} = A \oplus \frac{B}{\sqrt{E}} \oplus \frac{C}{E}$$
- position smearing:  
  $$\sigma_P = a + \frac{b}{\sqrt{E}}$$

A constant term: detector geometry  
B sampling term: counting statistics $\propto$ signal  
C noise term: pedestal due to electronics

http://arxiv.org/abs/1008.0413
Our ToyMC analysis

$\pi^0 \rightarrow \gamma\gamma$ using TGenPhaseSpace

- energy smearing:
  
  \[
  \frac{\sigma_E}{E} = A \oplus \frac{B}{\sqrt{E}} \oplus \frac{C}{E}
  \]

- position smearing:
  
  \[
  \sigma_P = a + \frac{b}{\sqrt{E}}
  \]

- kinematic cut $p_T^\gamma > 0.2$ GeV

- apply single photon efficiency

\[\chi^2/\text{ndf} = 365.7/52\]

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Our ToyMC analysis

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- kinematic cut $p_T^\gamma > 0.2 \text{ GeV}$

- apply single photon efficiency

- reconstruct $\pi^0$ by adding $\gamma\gamma$ pairs

http://arxiv.org/abs/1008.0413
Mass distribution of reconstructed $\pi^0$

- mass distribution as function of pion $p_T$
  → project different $p_T$ slices

- fitting of mass peaks for different $p_T$ slices with gaussian
  → get $\mu$ and $\sigma$ as function of pion $p_T$
Effect of energy smearing on reconstructed $\pi^0$ using EMCal parametrization for mass distribution: 

\[
\sigma \frac{E}{E} = A \oplus \frac{B}{\sqrt{E}} \oplus \frac{C}{E}
\]
Effect of energy smearing on reconstructed $\pi^0$

using EMCal parametrization for mass distribution:

$$\frac{\sigma E}{E} = A \oplus \frac{B}{\sqrt{E}} \oplus \frac{C}{E}$$

constant term

$A=1.68 \quad B=11.27 \quad C=4.838$

$A^2 \quad B=0 \quad C=0$
Effect of energy smearing on reconstructed $\pi^0$ using EMCal parametrization for mass distribution:

$$\sigma_E/E = A \oplus B \sqrt{E} \oplus C/E$$

constant term  sampling term

\[ m_{[GeV]} \]
\[ p_{[GeV]} \]

\[ \sigma_{[GeV]} \]
\[ p_{[GeV]} \]

$A=1.68$  $B=11.27$  $C=4.838$

$A^2$  $B=0$  $C=0$

$A=0$  $B^2$  $C=0$
Effect of energy smearing on reconstructed $\pi^0$ using EMCal parametrization for mass distribution: 

$$\frac{\sigma E}{E} = A \oplus \frac{B}{\sqrt{E}} \oplus \frac{C}{E}$$

- constant term
- sampling term
- noise term

\[ \text{mass $[\text{GeV}]$} \]

\[ \text{E$_{p_T}$ [GeV]} \]

\[ \text{A=1.68  B=11.27  C=4.838} \]

\[ \text{A*2  B=0  C=0} \]

\[ \text{A=0  B*2  C=0} \]

\[ \text{A=0  B=0  C*2} \]
Compare fitted $\pi^0$ mass distribution

closest to GEANT simulation:

→ ToyMC and MC GEANT fit reasonably well
Compare fitted $\pi^0$ mass distribution

compare to GEANT simulation and data:

$\rightarrow$ ToyMC and MC GEANT fit reasonably well

$\rightarrow$ different shapes for ToyMC and data
Compare fitted $\pi^0$ mass distribution

compare to GEANT simulation and data:

→ ToyMC and MC GEANT fit reasonably well

→ different shapes for ToyMC and data

→ merged conversion photons!

![Graph showing the comparison of fitted $\pi^0$ mass distribution with ToyMC, MC GEANT, and data.](graph.png)
Compare fitted $\pi^0$ mass distribution

compare to GEANT simulation and data:

$\rightarrow$ ToyMC and MC GEANT fit reasonably well

$\rightarrow$ different shapes for ToyMC and data

$\rightarrow$ merged conversion photons!
Compare fitted $\pi^0$ mass distribution

c ompare to GEANT simulation and data:

→ ToyMC and MC GEANT fit reasonably well

→ different shapes for ToyMC and data

→ merged conversion photons!
How to deal with non merging $e^+ e^-$

with B field

$\pi^0$

$\gamma_1$

$\gamma_2$

$e_1$

$e_2$

- conversion decreases reconstructed $\pi^0$

- without magnetic field: conversion $e^+ e^-$ merge in one EMCal cluster

$\rightarrow$ estimate material budget

Systematic Uncertainty

<table>
<thead>
<tr>
<th>$[\text{GeV}/c]$</th>
<th>$T_p$</th>
<th>$10$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^0$</td>
<td>mat</td>
<td>material budget (conv)</td>
</tr>
<tr>
<td>$\text{feed-down correction}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{acceptance}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{total}$</td>
<td></td>
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How to deal with non merging $e^+e^-$

- conversion decreases reconstructed $\pi^0$ yield
- without magnetic field: conversion $e^+e^-$ merge in one EMCal cluster
- compare yield with and without magnetic field → estimate material budget
How to deal with non merging $e^+e^-$

- conversion decreases reconstructed $\pi^0$ yield
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Summary

- ToyMC looking at $\pi^0 \rightarrow \gamma\gamma$ (no photon conversion)
- comparison of $\pi^0$ mass position from ToyMC to data and GEANT
  → take conversion photons into account
- to deal with conversion $e^+e^-$ that don’t overlap in EMCal:
  → compare $\pi^0$ yield with and without magnetic field
  → material budget estimation in front of EMCal
Back-up
Example: Impact of TRD on $\pi^0$ reconstruction

![Graph 1](image1)

![Graph 2](image2)

![Graph 3](image3)
Crystal Ball function:

```c++
Double_t CrystalBall(Double_t *x, Double_t *par) {
  // The Crystal Ball shape is a Gaussian that is 'connected' to an exponential tail at 'alpha' sigma of the Gaussian. The sign determines if it happens on the left or right side. The 'n' parameter controls the slope of the exponential part. // typical par limits: 1.0 < alpha < 5.0 and 0.5 < n < 100.0
  Double_t alpha = par[0];
  Double_t n = par[1];
  Double_t meanx = par[2];
  Double_t sigma = par[3];
  Double_t nn = par[4];
  Double_t a = TMath::Power((n/TMath::Abs(alpha)), n) * TMath::Exp(-0.5*alpha*alpha);
  Double_t b = n/TMath::Abs(alpha) - TMath::Abs(alpha);
  Double_t arg = (x[0] - meanx)/sigma;
  Double_t fitval = 0;
  if (arg > -1.0*alpha) {
    fitval = nn * TMath::Exp(-0.5*arg*arg);
  } else {
    fitval = nn * a * TMath::Power((b-arg), (-1*n));
  }
  return fitval;
}
```

// here's just the lefthand part:

```c++
TF1 *f_cr = new TF1("f_cr",
  "[4]*TMath::Power(([1]/TMath::Abs([0])), [1])*TMath::Exp(-0.5*[0]*[0])*TMath::Power((([1]/TMath::Abs([0])) - TMath::Abs([0])) - (x - [2])/[3]),(-1*[1])))", 0.01,0.13)
```

Crystal Ball
remaining issue: understanding the width distribution