Identifying and Correcting Preshowering Photons in BaBar

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Outline

• Motivation
• Separation of preshowers and non-preshowers
• Energy correction of preshowers
• Performance
• Implementation
Motivation

- Ideally, photons travel through BaBar, interacting in the EMC
- Photons can interact before reaching the EMC (preshowering photons) pair producing and possibly creating an electromagnetic shower
  - Some of the energy of the preshowering photon is lost, i.e. is not measured by the calorimeter

Photons only (from truth matching) using GoodPhotonsLoose

- Photons 81%
  - 72% EMC (post-DIRC)
  - 8% DIRC
  - 1% pre-DIRC
- Neutrals 13%
- Charged particles 6%

\[ E_{\text{meas}} : (\text{calibrated}) \]
\[ E_{\text{true}} : \text{true energy from MC} \]
Motivation

• Would like to be able to separate photons (actually EmcCands) into preshowers and non-preshowers
• For preshowering photons would like to correct for energy lost due to preshowering
• Divide problem into 2 tasks
  1. Separate photons into preshowers and non-preshowers
  2. Determine energy lost due to preshowering and add this back on to the energy measured by the EMC
Preshower/Non-Preshower Separation

• What information is available to separate preshowers from non-preshowers?
  – EMC info (shower shape variables, nCrystals, etc.)
  – DIRC info (success/failure of ring fit, nPhot, thetaC, etc.)

• How is DIRC information associated with an EMC cluster?
Preshower/Non-Preshower Separation

How is DIRC information associated with a cluster?

Neutral tracks faked by drawing straight line between cluster and IP (unique association)

All DIRC hits not associated with charged tracks are written to a list. The neutral tracks and the DIRC in this list are used as input to the DrcReco software.
Preshower/Non-Preshower Separation

DIROC software performs ring fit to the faked tracks and the DIROC hits.

Results of the fit are assigned to the cluster and persisted.

Results put into EmcPreshowerInfo object (accessed through EmcCand)

- $\theta_C$ (Cherenkov angle)
- $\epsilon \theta_C$ (error on Cherenkov angle)
- $n_{\text{Phot}}$ (number of Cherenkov photons assigned to cluster) - We call it $n_{\text{Hits}}$
- $\text{fitFailed}$ (true if ring fit failed, false if ring fit successful)
- Other quantities (see PidData/EmcPreshowerInfo.hh for full list)
Preshower/Non-Preshower Separation

Babar Generic SP 1237

nHits≥5
Successful ring fit

- Purity
- Efficiency

Overall
Eff. = 41%
Pur. = 50%

nHits≥10
Successful ring fit

- Purity
- Efficiency

Overall
Eff. = 23%
Pur. = 73%

Attempted to use cuts on DIRC variables to separate preshowers from non-preshowers
Preshower/Non-Preshower Separation

Bbbar Generic SP 1237

Tested many classifiers, MLP (neural network) seems to give the best separation

Tested using other combinations of variables. This combination gave the best efficiency and purity.
Preshower/Non-Preshower Separation

Bbbar Generic SP 1237

Overall
Eff. = 42%
Pur. = 55%

MuMuGamma SP 3981

Overall
Eff. = 58%
Pur. = 80%
Energy Correction: Theta Correction

\[ s = \frac{w}{\sin \theta} \]

\[ E_{\text{loss}} \propto \text{path length} \]

\[ E_{\text{loss}} = \frac{dE}{dx} \quad s = \frac{dE}{dx} \frac{w}{\sin \theta} \]
Energy Correction: Theta Correction

- Use MC to determine $E_{\text{loss}} = E_{\text{meas}} - E_{\text{true}}$

- Fit histograms with Novosibirsk function

- Difference between MPVs is taken as energy correction, $E_{\text{corr}}$

48 theta bins

Theta Index 11

Non-Preshower: MPV = -0.008 GeV

Preshower: MPV = -0.052 GeV

$E_{\text{corr}} = 0.044$ GeV

typical theta bin
Energy Correction: Theta Correction

Endpoints excluded from fit

Determined using generic BBbar

\[
E_{\text{corr}} = \frac{a}{\sin \theta}
\]

- All preshowers at the same theta receive the same energy correction, \(E_{\text{corr}}\)
- Would like an event-by-event correction
Energy Correction: nHits Correction

Use profiles of $E_{loss}$ in nHits bins to determine value of $E_{loss}$ for a given bin

$n_{Hits} = 10$
Non-Preshower: peak = -0.007 GeV  
mean = -0.018 GeV

Preshower:      peak = -0.037 GeV  
mean = -0.056 GeV

$E_{corr} = 0.030$ GeV (peak)  
$E_{corr} = 0.038$ GeV (mean)
Try to combine theta correction and nHits correction
Energy Correction: nHits & Theta Correction

- Use 3D plot of nHits, theta and $E_{\text{loss}}$ to produce a histogram of $E_{\text{loss}}$
- 6 evenly spaced theta bins spanning the EMC barrel
- 20 nHits bins (0-19)

• Difference between histogram means for preshowers and non-preshowers of $E_{\text{loss}}$ used to determine $E_{\text{corr}}$

$E_{\text{corr}}$ (GeV)
Energy Correction: nHits & Theta Correction

Energy Correction: Theta Bin 0

Energy Correction: Theta Bin 1

Energy Correction: Theta Bin 2

Energy Correction: Theta Bin 3

Energy Correction: Theta Bin 4
Energy Correction: nHits & Theta Correction

BBbar Generic (SP 1237)

Truth matching used for separation
Energy Correction: nHits & Theta Correction

\[ E_{\text{corrected}} = E_{\text{meas}} + E_{\text{corr}} \]

Bbbar Generic (SP 1237)

Truth matching used for separation
Energy Correction: nHits & Theta Correction

\[ E_{\text{corrected}} = E_{\text{meas}} + E_{\text{corr}} \]

MuMuGamma (SP 3981)

![Graphs showing energy correction for all photons and preshowers with truth matching used for separation.](image)

Truth matching used for separation
Performance

BBbar Generic (SP 1237)

MLP used for separation
Performance

Data: AllEvents-Run6-R24

MLP used for separation
Performance

$$E_{\text{corrected}} = E_{\text{meas}} + E_{\text{corr}}$$

BBbar Generic (SP 1237)

MLP used for separation
Performance

$$E_{\text{corrected}} = E_{\text{meas}} + E_{\text{corr}}$$

MuMuGamma (SP 3981)

All Photons

Preshowers

MLP used for separation
Performance

\[ E_{\text{corrected}} = E_{\text{meas}} + E_{\text{corr}} \]

MuMuGamma (AllEventsSkim, Run6, R24a)

MLP used for separation

tuples generated using NeutralMiniUser

\[ E_{\text{true}} \] for data found from the ratio
\[ R(E_{\text{fit}}) = \frac{E_{\text{fit}}}{E_{\text{true}}} \]. \( R(E_{\text{fit}}) \) is determined from MC. Here \( E_{\text{fit}} \) is the energy from the mmg kinematic fit.
Implementation

• Store MLP cut(s) and energy correction as tables in conditions database
  – Will be used in EMC software as EmcTables (similar to edge correction)
• New class in EmcPreshower called EmcPreshowerCorr
  – Determines whether or not EmcCand is a preshower
  – Calculates energy correction
• Each EmcCand can determine corrected energy/energy correction and whether or not it is a preshower (through calls to EmcPreshowerCorr object)
  – Add new method to EmcCand called isPreshower which returns true for preshower and false otherwise
Implementation (cont’d)

• Users give ability to turn on/off the correction through a tcl parameter
  – Only turns off energy correction
  – Users may still call isPreshower()

• Users may choose from one of three MLP cuts
  – loose: E=42%, P=55%
  – tight: low efficiency, high purity
  – veto: high efficiency, low purity

Based upon generic Bbbar
Implemented as tcl parameter
• Data points from means of profiles from scatter plot of 
  $R(E_{\text{fit}}) = E_{\text{fit}} / E_{\text{true}}$ vs $E_{\text{fit}}$

• Take $E_{\text{true}} = E_{\text{fit}} / R(E_{\text{fit}})$ for data (fit using pol3 over two regions 
  $0.25\text{GeV} < E_{\text{fit}} < 1.0\text{GeV}$ & $1.0\text{GeV} < E_{\text{fit}}$)
No correction applied and no real discrepancy between Runs 2 and 6.
No correction applied and some small discrepancy between Runs 2 and 6. Do we know why?