Reducing the Uncertainty in the Detection Efficiency for Π^0 Particles at *BABAR*

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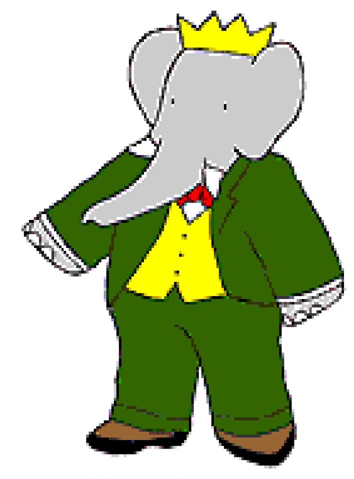

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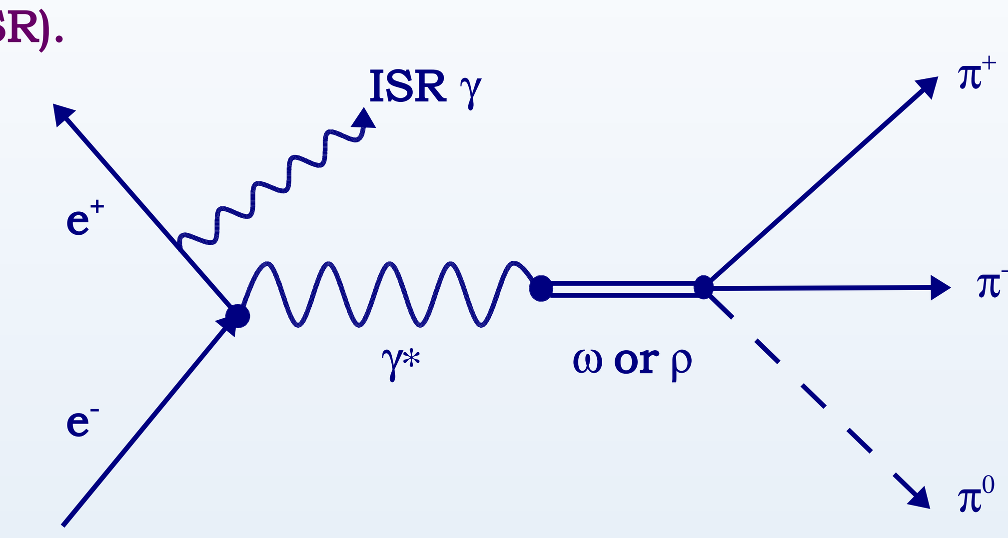
Initial State Radiation

At *BABAR*, electrons and positrons collide at a centre of mass energy of 10.6GeV to coincide with the Upsilon(4S) resonance. However, the electron-positron cross section is larger for the production of the omega (782MeV) and rho(770MeV) vector mesons. This means that sometimes the electron-positron pair will emit a photon before colliding, to bring the centre of mass down to these resonances. This is called initial state radiation, (ISR).

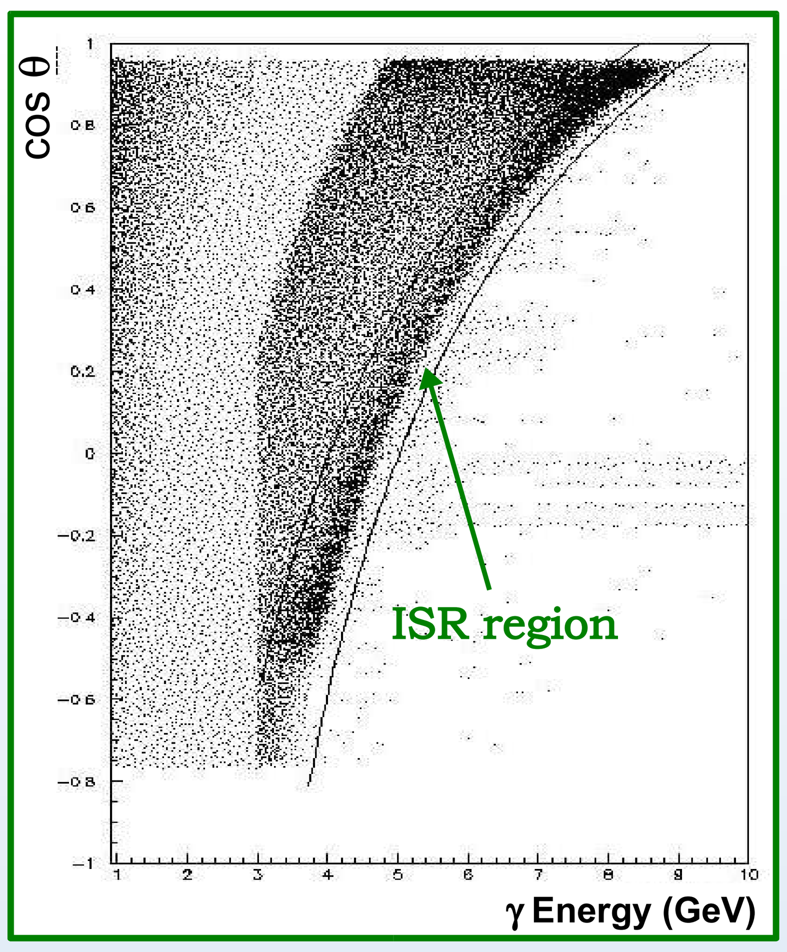


This Feyman diagram shows an initial state radiaition photon, (ISRγ), emitted in order to bring the centre of mass energy down to the omega or rho vector meson resonance.

The most common decay modes of these vector mesons are:

ω (782 MeV) $\rightarrow \pi^+\pi^-\pi^0$

ρ^0(770 MeV) $\rightarrow \pi^+\pi^-$



This plot shows the ISR photon energy versus the polar angle, θ, of the ISR photon. The Initial state radiation events are those which lie in the ISR region, between the curved lines.

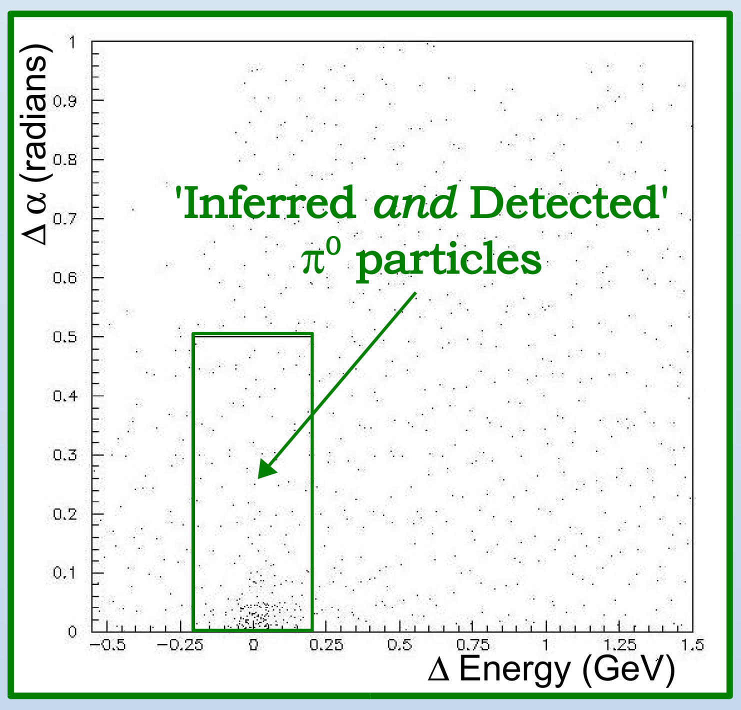
By working through the kinematics of the system and applying a Lorentz boost, a relationship between the ISR photon energy and the polar angle of the photon in the laboratory frame can be found. Therefore, if events are plotted on a graph of photon energy versus photon polar angle, the ISR events will be the ones found near to the curve of this relationship.

These events can be used to determine the π^0 detection efficiency, in order to reduce the systematic uncertainty.

'Inferred' and 'Detected' π^0s

There are two possible ways to 'find' a π^0 particle:

- First the ISRγ + $\pi^+\pi^-$ system is examined. The missing momentum of the system is fitted to a hypothesised π^0. Notice that this hypothesis will only be correct for events which decay via: $e^+e^- \rightarrow ISR\gamma\,\omega \rightarrow ISR\gamma\,\pi^+\pi^-\pi^0$. By plotting the fit probability, the events where the missing momentum is probably due to a π^0 can be found. For these events the existence of the π^0 has been 'inferred'.
- Secondly there are the π^0 particles which were detected by *BABAR* and reconstructed by the *BABAR* software. These are the π^0s which people use in their analyses. These π^0s have been 'detected'.

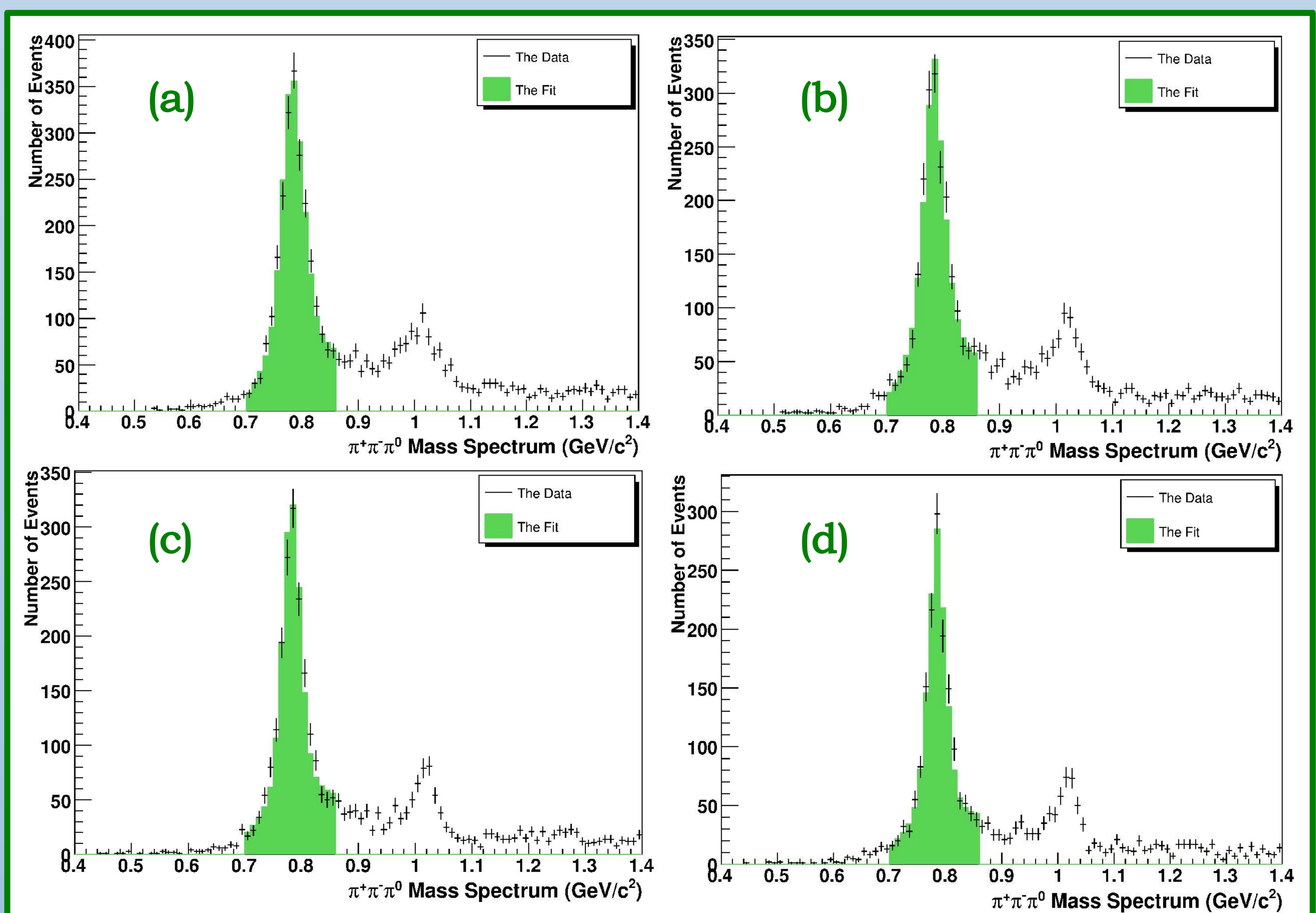


For each event, we can now look at our list of 'detected' π^0s to find whether each 'inferred' π^0 was detected or not.

But, how similar do the 'inferred' and 'detected' π^0 particles have to be before we can say that they are the same π^0?

The difference in energy between the 'inferred' and the 'detected' π^0 particles is plotted against the difference in angle between their tracks. The points which fall within the box indicate π^0 particles which we have defined as 'matching'. These π^0s are 'inferred *and* detected'.

Counting the π^0s



Now we need to know how many 'inferred' π^0 particles there are and how many of these are 'inferred *and* detected'.

The number of π^0 particles in a given set of events is found by counting the number of omega(782MeV) resonances, because the most common omega decay mode contains one π^0.

The $\pi^+\pi^-\pi^0$ system is reconstructed and the mass spectrum is plotted. The events which decay via the omega meson can clearly be seen as a peak centred on 782MeV.

The number of events in the peak is found by fitting the peak. The fitted function is a Breit-Wigner convoluted with the mass resolution of the detector.

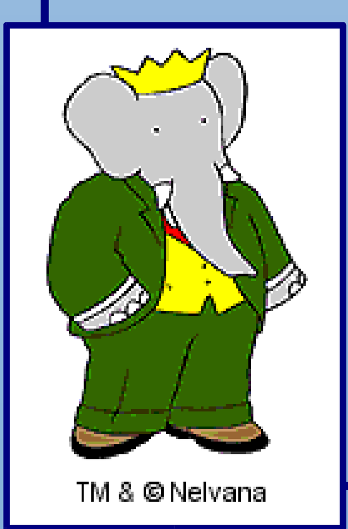
Fits like this are made for the 'inferred' π^0s and the 'inferred *and* detected' π^0s, for bins of π^0 energy from 0.0GeV to 6.0GeV.

These plots show examples of $\pi^+\pi^-\pi^0$ mass spectra (for data) for events with 'inferred *and* detected' π^0s. Each plot shows a different π^0 energy: (a) 0.4GeV to 0.6GeV; (b) 0.6GeV to 0.8GeV; (c) 0.8GeV to 1.0GeV; (d) 1.0GeV to 1.2GeV.

Finding the Efficiency

The efficiency with which *BABAR* detects π^0 particles is therefore given by:

$$Efficiency = \frac{\text{The number of 'inferred and detected' } pi^0 \text{ particles}}{\text{The number of 'inferred' } pi^0 \text{ particles}}$$



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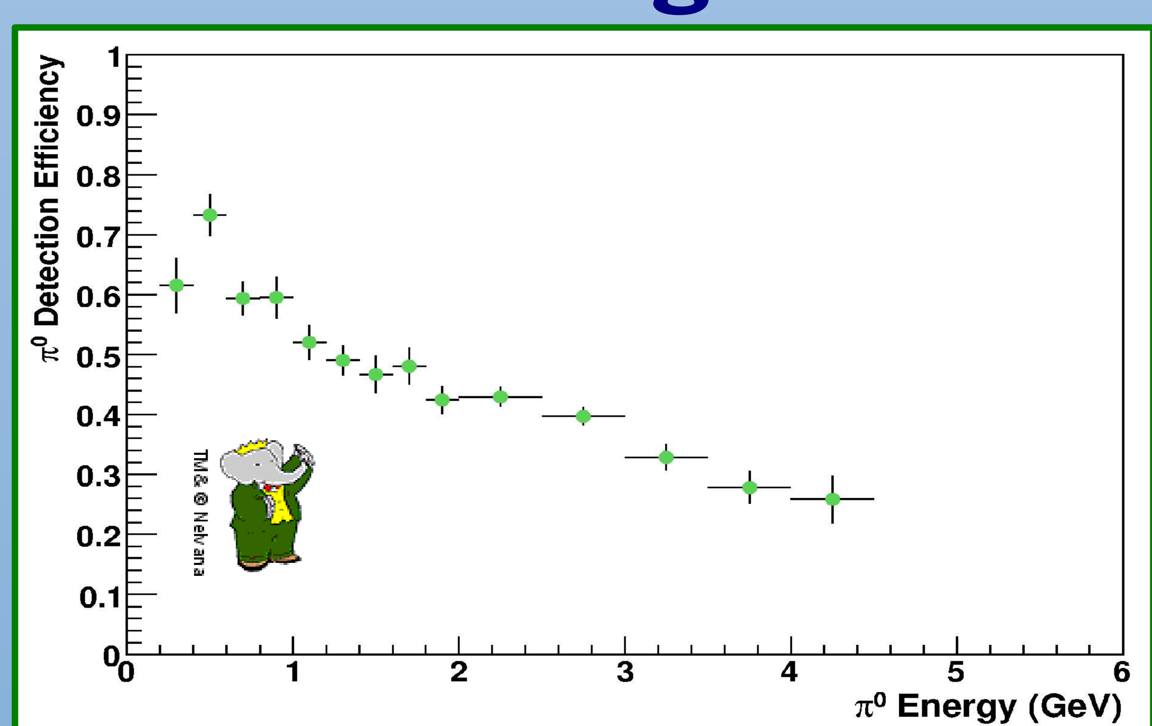
The efficiency is plotted as a function of π^0 energy. The entire method is repeated for Monte Carlo. The efficiency can then be expressed as a correction factor between data and Monte Carlo.

This method is being used to reduce the systematic uncertainty on the π^0 detection efficiency.



This plot shows the π^0 detection efficiency for data as a function of π^0 energy.

A similar plot is made for Monte Carlo. Then these are combined to give a correction factor.