$\eta\pi^0$ Physics Analysis

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Gluex Physics Meeting

Outline

$\eta\pi^0$ Reconstruction

$\gamma p \to a_2(1318)p \to \eta\pi^0 p \to 4\gamma p$

- $\gamma p \to \eta\pi^0 p \to 4\gamma p$ is simple all-neutral final state which can be used to study the overall calorimeter performance as well as the ability to reconstruct all-neutral states.
- The observation of exotic states in $\gamma p \to \eta\pi^0 p \to 4\gamma p$ have been claimed [1].
- To add some structure to the $\eta\pi^0$ system the $a_2(1318)$ resonance was generated with realistic angular distributions

Current reconstruction tools at our disposal

- DPhoton: photon reconstruction in the FCAL and BCAL
- PID $\rightarrow$ DMagneticFieldStepper $\rightarrow$ SwimToRadius and SwimToPlane are used to identify showers due to charged particles in the BCAL and FCAL
- DKinFit: kinematic fitter (can reconstruct η and π^0 - returns pulls, χ^2 and probability
- HDParSim: a parametric simulation for handling acceptance and resolution of charged DParticle objects: i.e. protons and pions

We can now identify the protons and photons of our all neutral channel. Previously, this couldn't be done. Full charged particle tracking capabilities are still in development but are quite slow and cpu intensive therefore the HDParSim is advantageous at this time.

Background simulation

- Hadronic: BGGEN (PYTHIA 6.4 + custom < 3 GeV) - crossection of 124 μb @ 9 GeV
- EM: HDGeant will produce the em background by overlaying the tracks/hits coming from the bg interactions on top of the tracks/hits coming from the physics interaction vertex

Amplitude Analysis

- Monte Carlo tools exist to generate proper angular distributions and interferences between waves.
- PWA analysis to come. Tools exist from IU and CMU. [See Physics Analysis on the GlueX Wiki]

Reconstruction

- It is required that there are 4(5) photons showers (none are due to charged particles - comparing swum tracks to shower positions), and 1 proton. This gives 6(30) possible combinations.
- The event candidate is chosen as the photon combination with the highest probability from the kinematic fit with constraints on the π^0 and η masses.
- Before χ^2 cuts $\sim$ 50% of the generated signal events can be reconstructed. A cut on $\chi^2 < 12(50)$ leaves approximately 20(40)% of generated events.
- 10^7 Pythia events, 50,000 signal $a_2(1318)$ events (200:1) where the Pythia cross section at 9 GeV is 124 μb giving a cross section for the a_2 to be $\sim 0.6 \mu b$. The 4 photon, 1 proton requirement leaves 12,690 background events and 24,870 signal events (5% more including 5 photon events).

Photon Multiplicity

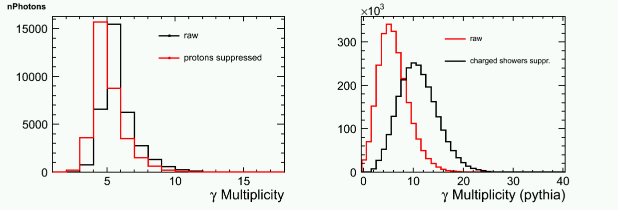


Figure: Photon multiplicity, raw and after proton shower suppresion. Signal events (left) and Pythia events (right)

Candidate Multiplicity

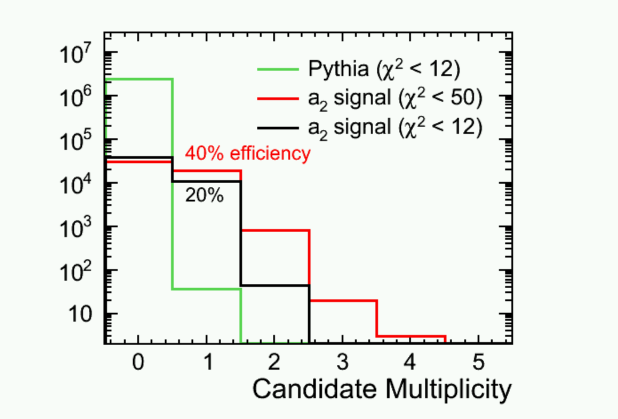


Figure: PYTHIA and signal a_2 candidate multiplicity (number of events that pass a given χ^2 cut)

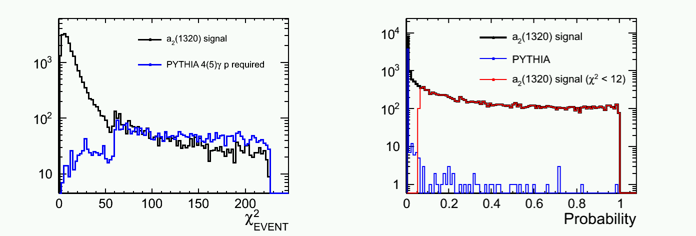
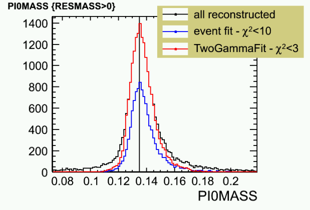
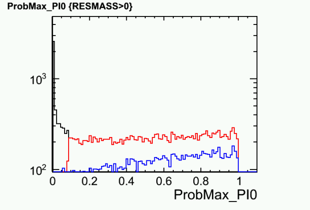


Figure: χ^2(left) and probability(right) distributions from kinematic fit of event for Pythia and signal events.

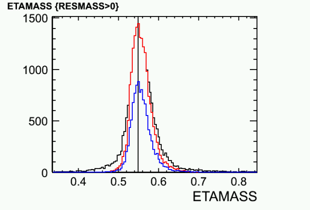
π^0 and η



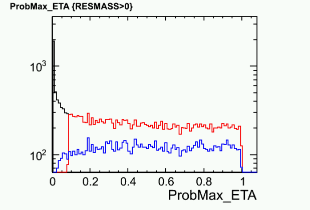
(a) M_{π^0}



(b) $Prob_{\pi^0}$

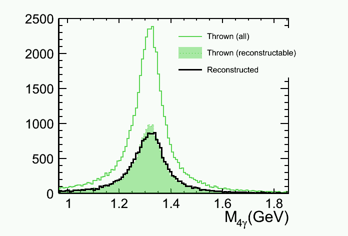


(c) M_{η}

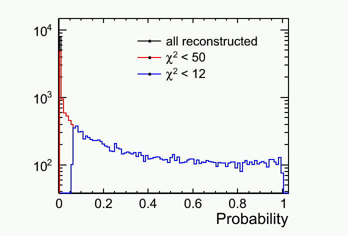


(d) $Prob_{\eta}$

$a_2(1320)$



(e) $M_{4\gamma}$



(f) $Prob_{4\gamma}$

Mass constraints have been set on the π^0 and η mass in the kinematic fit of the event. The generated event mass has been corrected. (Mistake in the generator code.)

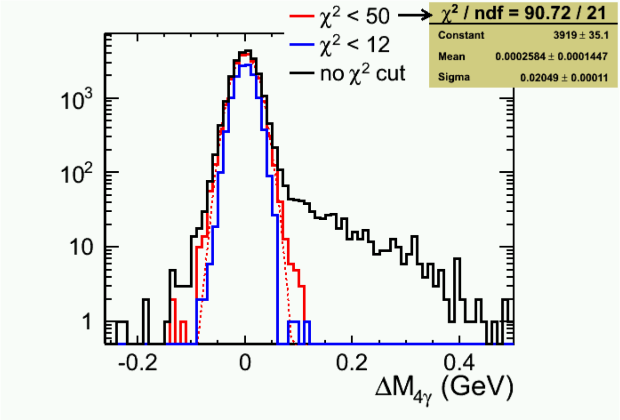


Figure: The difference between thrown and reconstructed a2 resonance masses.

$cos_{GJ} vs. a_2$

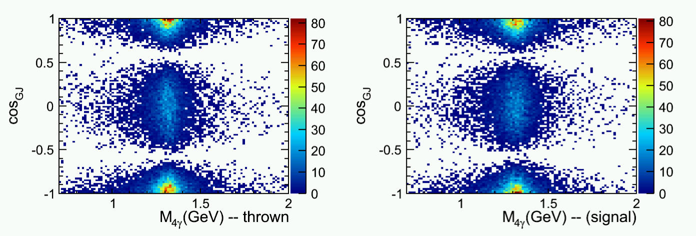


Figure: Cosine of the Gottfreid-Jackson angle versus the reconstructed a_2 mass for thrown(left) and reconstructed(right) events.

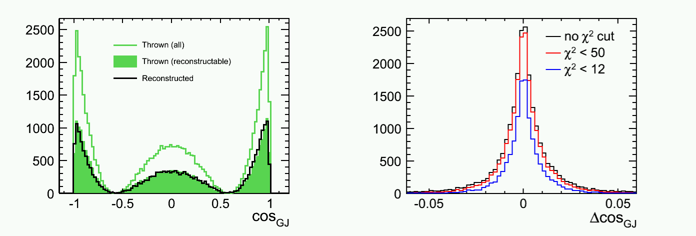
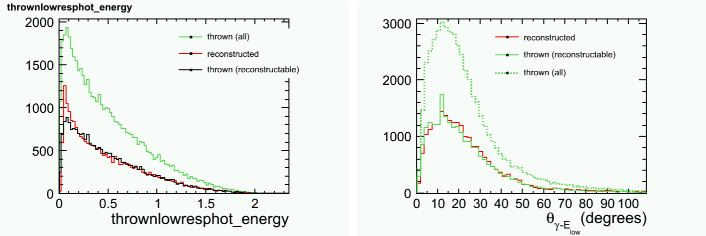


Figure: I am bothered by Δcos_{GJ}.

lowest energy photons



(a) energy spectrum (b) photon angle

Figure: Energy spectrum and angular distribution of the lowest energy photon in each $\eta\pi^0$ pair.

lowest energy photons

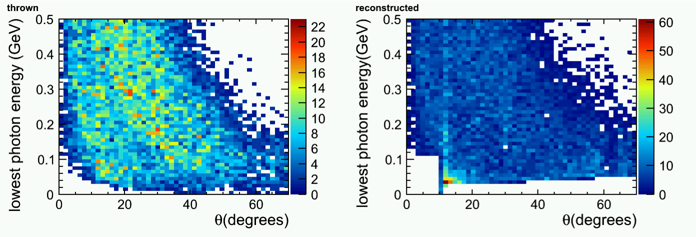
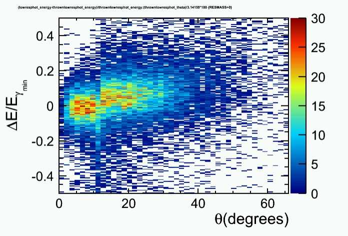
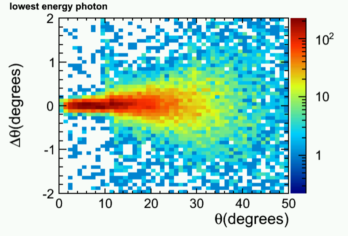


Figure: Photon spectra for the lowest energy photon in each $\eta\pi^0$ pair. Reconstructed (left), thrown(right)

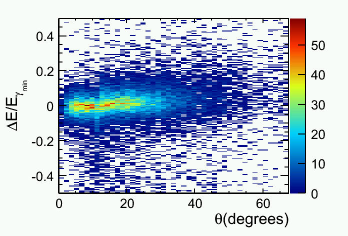
lowest energy photons



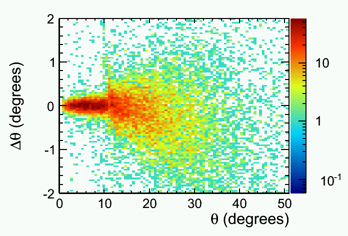
(a) ΔE before kin. fit



(b) $\Delta\theta$ before kin. fit



(c) ΔE after kin. fit



(d) $\Delta\theta$ after kin. fit

A. Abele et al.
Evidence for a $\eta\pi$ P-wave in $\bar{p}p$ annihilations at rest into $\pi^0\pi^0\eta$.
Phys. Lett., B446:349–355, 1999.