

Title

Blake
Leverington

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$\eta\pi^0$ Physics Analysis

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GlueX Physics Meeting

Outline

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$\eta\pi^0$ Reconstruction

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

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- $\gamma p \rightarrow \eta\pi^0 p \rightarrow 4\gamma p$ 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 $\gamma p \rightarrow \eta\pi^0 p \rightarrow 4\gamma p$ 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

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- 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)
- HDParseSim: 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 HDParseSim is advantageous at this time.

Background simulation

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- Hadronic: BGGEN (PYTHIA 6.4 + custom < 3 GeV) - crosssection of $124 \mu\text{b}$ @ 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

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- 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

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- It is required that there are 4 good photons showers (none are due to charged particles - comparing swum tracks to shower positions), and 1 proton. This gives 6 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 $124 \mu b$ 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

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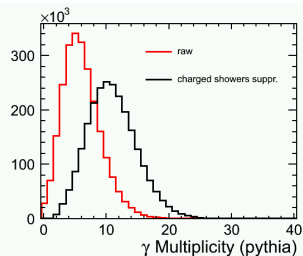
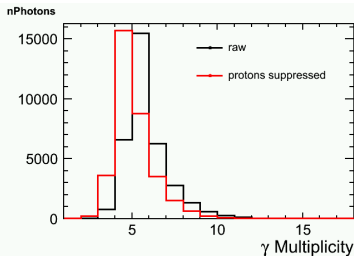


Figure: Photon multiplicity, raw and after proton shower suppression. Signal events (left) and Pythia events (right)

Candidate Multiplicity

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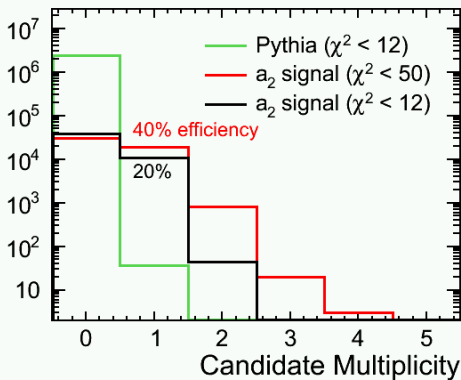


Figure: PYTHIA and signal a_2 candidate multiplicity (number of events that pass a given χ^2 cut)

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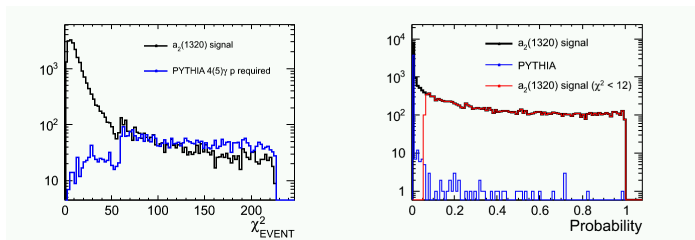


Figure: χ^2 (left) and probability(right) distributions from kinematic fit of event for Pythia and signal events.

π^0 and η

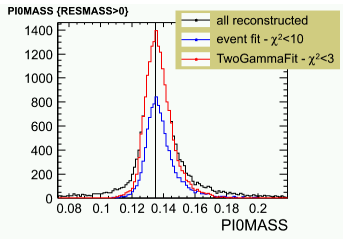
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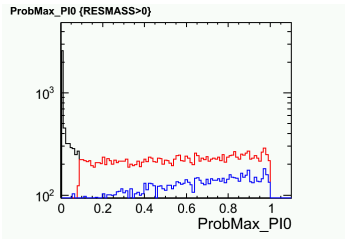
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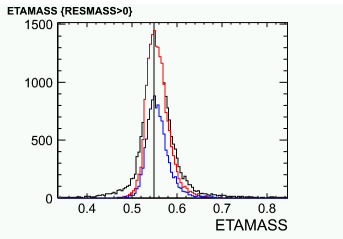
Results



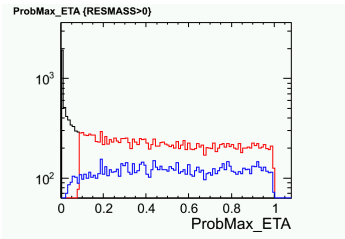
(a) M_{π^0}



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



(c) M_{η}



(d) $Prob_{\eta}$

$a_2(1320)$

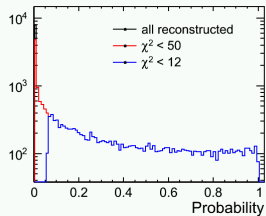
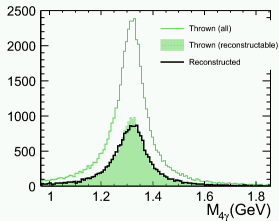
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Mass constraints have been set on the π^0 and η mass in the kinematic fit of the event.

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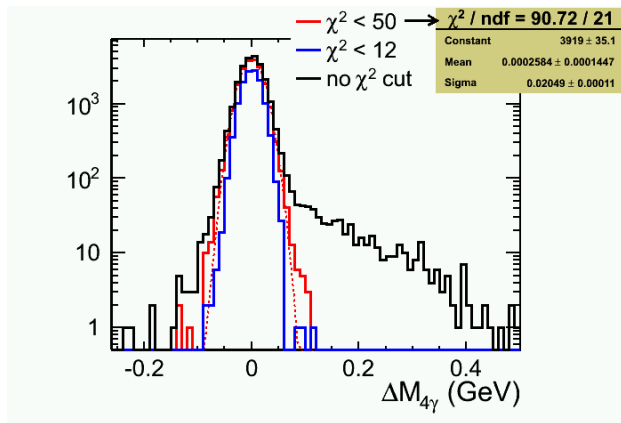


Figure: The difference between thrown and reconstructed 4γ resonance masses.

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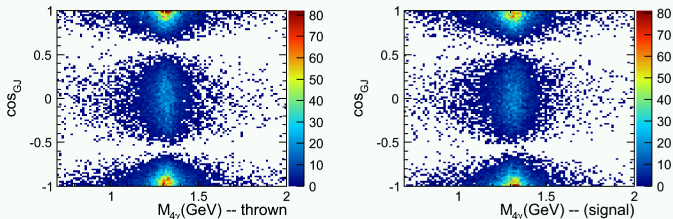


Figure: Cosine of the Gottfreid-Jackson angle versus the reconstructed a_2 mass for thrown(left) and reconstructed(right) events.

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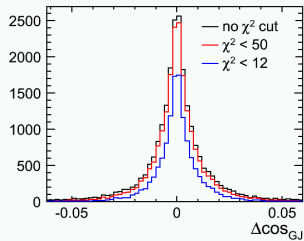
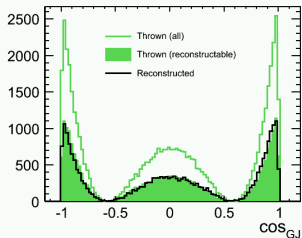


Figure: The Cosine of the Gottfreid-Jackson angle (left) and the difference between the thrown and reconstructed, $\Delta \cos \theta_{GJ}$ (right).

lowest energy photons

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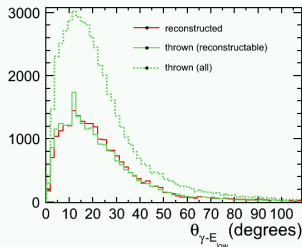
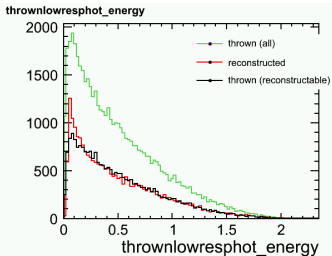


Figure: Energy spectrum and angular distribution of the lowest energy photon in each $\eta\pi^0$ pair.

lowest energy photons

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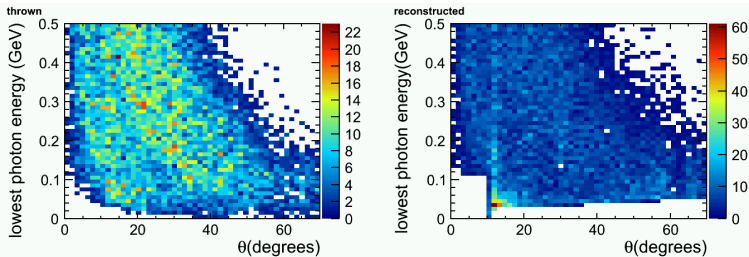


Figure: Photon spectra for the lowest energy photon in each $\eta\pi^0$ pair. Thrown (left), reconstructed(right)

lowest energy photons

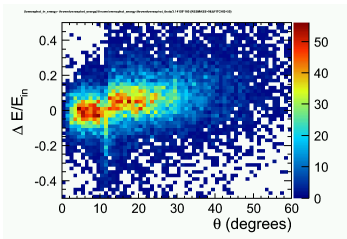
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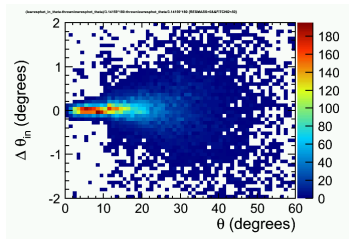
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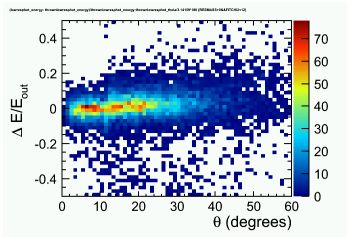
Results



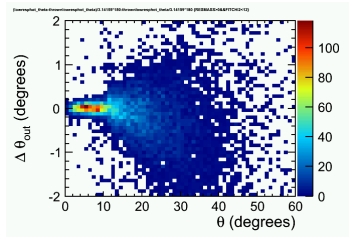
(a) ΔE before kin. fit



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



(c) ΔE after kin. fit



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

ΔE

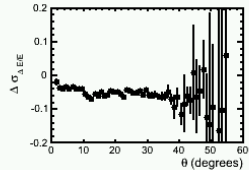
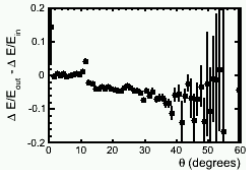
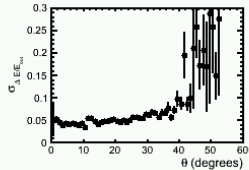
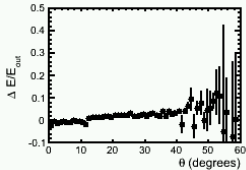
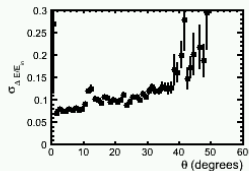
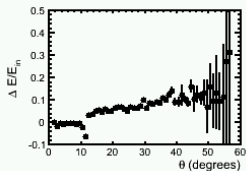
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$\Delta\theta$

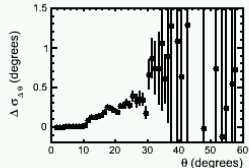
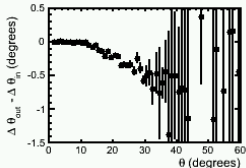
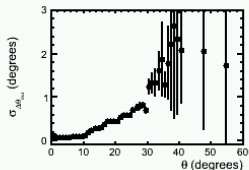
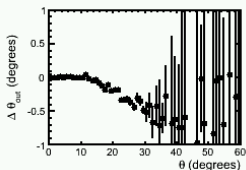
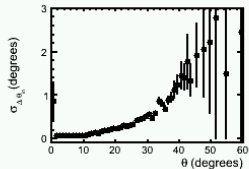
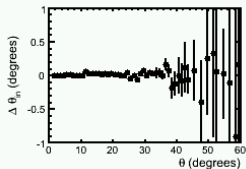
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Summary

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- All the tools exist to do a full reconstruction of specific channels including hadronic and electromagnetic background.
- This is possibly the furthest and most in detail GlueX analysis to date. Much more to come, from others as well.
- The GlueX “detector” seems to work quite well!

Title



A. Abele et al.

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Evidence for a $\eta\pi$ P-wave in $\bar{p}p$ annihilations at rest into $\pi^0\pi^0\eta$.

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Phys. Lett., B446:349–355, 1999.

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