# Analysis of $\pi^0\eta$ and $\pi^0\eta'$ systems in $\gamma p \to \pi^0\eta^{(\prime)}p$ at GlueX

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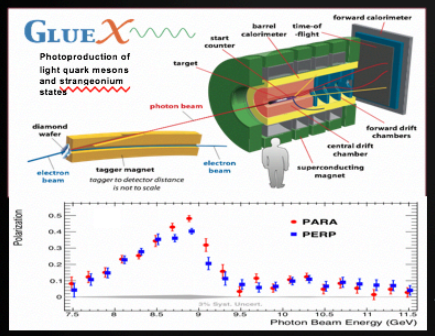
## Abstract

In order to search for the existence of exotic hybrid mesons, the GlueX experiment, at Jefferson Lab, utilizes a linearly polarized photon beam at $E_\gamma = 8 - 9\ GeV$ to map the spectrum of light mesons. A particular interest has been placed on the $\pi^0\eta$ and $\pi^0\eta'$ systems, as an observation of odd angular momentum L waves in this final state may indicate the presence of exotic quantum numbers. By comparing both systems, the role of flavor symmetry should be highlighted as to allow for a better understanding of meson production mechanisms. We will present preliminary results from initial studies of these channels from more than four petabytes of data recorded by the GlueX experiment, and compare the results to previous experimental observations of the same channels.

## GlueX




The GlueX experiment utilizes a linearly polarized photon beam constructed through coherent Bremsstrahlung radiation. The photons are tagged by the scattered electrons coming off of a diamond wafer. Once tagged, the photons will then proceed to collide with a liquid hydron target located inside of the detector. The barrel calorimeter is largely accountable for the detection and identification with a large acceptance to neutral and charged particles.

## Motivation

In meson spectroscopy, quantum numbers are determined through the values associated with $\vec{J} = \vec{L} \oplus \vec{S}$ $\quad P = (-1)^{\vec{L}+1}$ $\quad C = (-1)^{\vec{L}+\vec{S}}$

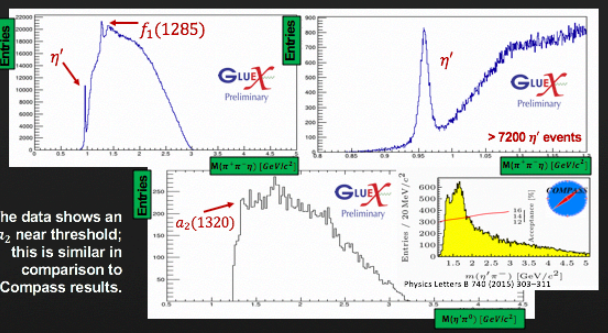
Certain $J^{PC}$ values are forbidden in the constituent quark model which would give rise to the implications of non $qq$ structures. Possible quantum numbers for a $\pi^0\eta^{(\prime)}$system include:

| | $S$ | $P$ | $D$ | $F$ | $G$ | ... |
|---|---|---|---|---|---|---|
| $J^{PC}$ | $0^{++}$ | $1^{-+}$ | $2^{++}$ | $3^{-+}$ | $4^{++}$ | ... |

Here the possible exotic configurations are located in the P and F-waves in which past experiments have made the claim that in the P-wave, the exotic hybrid candidate is either the $\pi_1(1400)$ or $\pi_1(1600)$.

## $\pi^0\eta'$

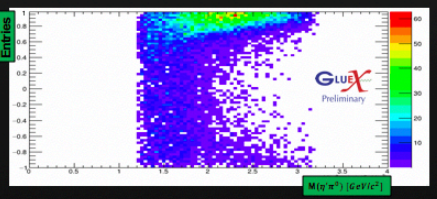
### Event Selection > 60% of GlueX Phase 1 data



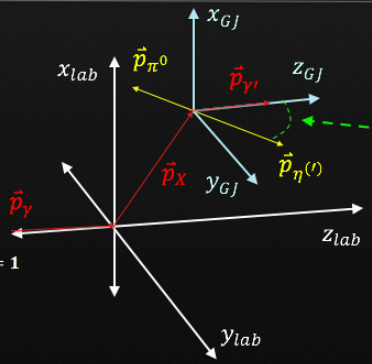

The data shows an $a_2$ near threshold; this is similar in comparison to Compass results.

*No plots are acceptance corrected

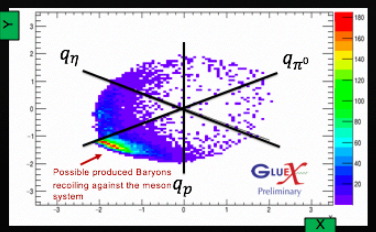
### Angular Distributions




- Large contribution of forward going $\eta'$ at $cos\vartheta_{GJ} = 1$
- Greater asymmetry in resonance region than compared to $\eta\pi^0$
- This forward/backward asymmetry is due to the interference between even and odd waves



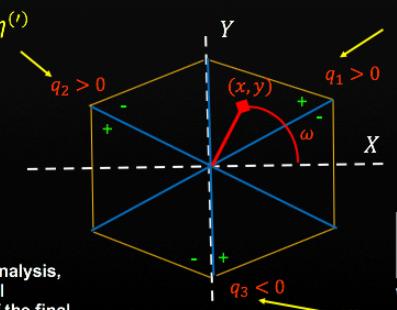

### VanHove Distributions




$$X = \sqrt{\frac{3}{2}}q_3 = -\sqrt{\frac{3}{2}}(q_1+q_2)$$

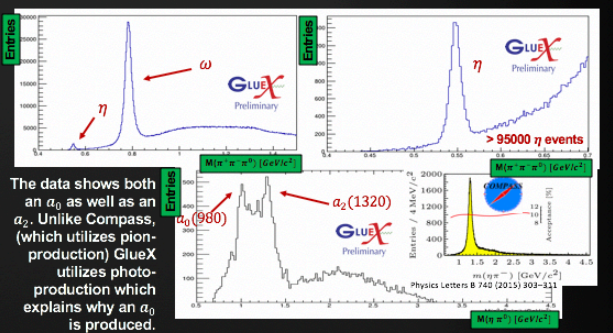
$$Y = \sqrt{\frac{1}{2}}(q_1-q_2)$$

$$\omega = tan^{-1}\frac{(q_1-q_2)}{-\sqrt{3}(q_1+q_2)}$$




In a VanHove analysis, the longitudinal components of the final state particles are in the center of mass reference frame such that $\sum q_i = 0$.

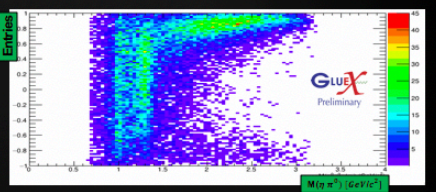
## $\pi^0\eta$




The data shows both an $a_0$ as well as an $a_2$. Unlike Compass, (which utilizes pion-production) GlueX utilizes photo-production which explains why an $a_0$ is produced.

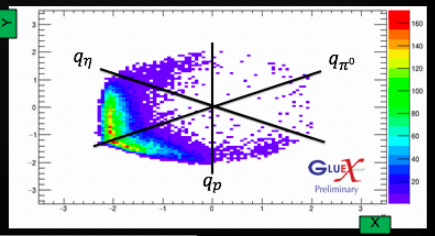
### Angular Distributions

The Gottfried Jackson frame (GJ) is a reference frame where z is the direction of the photon in the reference frame of $X \to \eta^{(\prime)}\pi^0$




- Large contribution of forward going $\eta$ at $cos\vartheta_{GJ} = 1$
- At 1 GeV due to $a_0(980)$ we see a flat intensity
- Need acceptance correction to understand $cos\vartheta_{GJ} = -1$

### VanHove Distributions




## Outlook

With the data analyzed thus far, important structures can already seen and with 40% more data to be analyzed, statistics will only improve. Improving the purity of both channels and beginning the process of a partial wave analysis will be the following steps to observe the possible exotic hybrid candidate.