Analyzing $\pi^0\eta$ and $\pi^0\eta'$ systems in the search for exotic hybrid mesons at GlueX

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Abstract

With a need to understand the physics attributed to the light-quark meson spectrum, searching for non quark-antiquark (exotic) quantum numbers is of great interest. Emphasis has been placed on both the $\pi^0\eta$ and $\pi^0\eta'$ systems due to their strong possibility of containing the desired exotic quantum numbers. By comparing both of these channels, meson production mechanisms will be accentuated and better understood. Preliminary results in preparation for a partial wave analysis are shown for $\gamma p \to \pi^0\eta^{(\prime)}p \to 4\gamma\pi^+\pi^-p$, utilizing all of the GlueX Phase-1 data.

Motivation

- **Mesons can be characterized by quantum numbers denoted by J^{PC}**

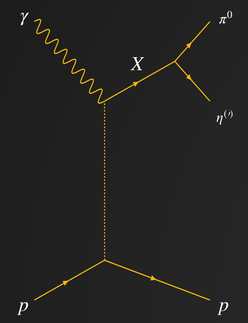
Total angular momentum $J = 0,1,2,...$

Parity $P = (-1)^{L+1}$

Charge Conjugation $C = (-1)^{L+S}$

L is the relative orbital angular momentum of the q and $\bar{q}$

S is the total intrinsic spin of the $q\bar{q}$ pairs



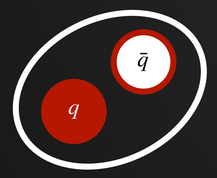
ALLOWED quantum numbers

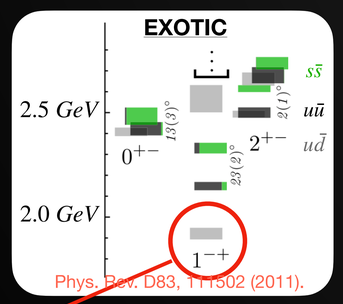
$J^{PC} = 0^{-+},0^{++},1^{--},1^{+-},1^{++},2^{--},2^{-+},\ldots$

FORBIDDEN quantum numbers

$J^{PC} = 0^{--},0^{+-},1^{-+},2^{+-},\ldots$

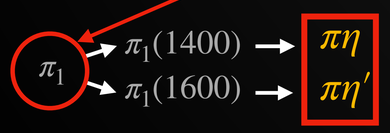
Meson





Phys. Rev. D83, 111502 (2011).

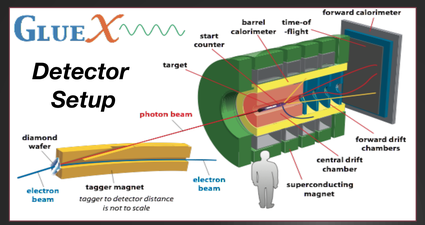
- **Lattice QCD predicts "gluonic excitations", confirming mesons that are not in the constituent quark model (known as exotic mesons)**



Possible J^{PC} for $\pi^0\eta^{(\prime)}$

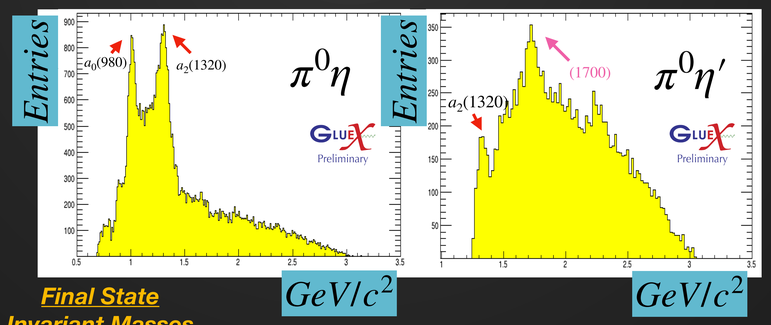
L	S	P	D	F	...
J^{PC}	0^{++}	1^{-+}	2^{++}	3^{-+}	...

Experiment

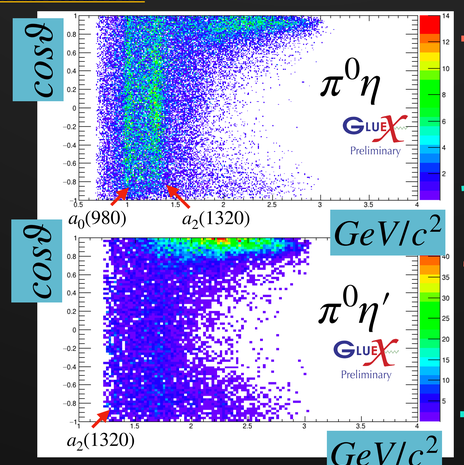


- **12 GeV linearly polarized photon beam incident on a proton target**

Results



Final State Invariant Masses



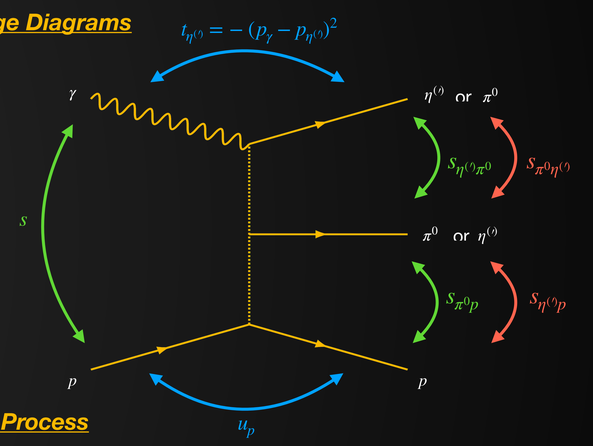
$cos(\vartheta_{GJ}) \approx 1$
Forward $\eta^{(\prime)}$

$cos(\vartheta_{GJ}) \approx -1$
Backward $\eta^{(\prime)}$

Gottfried-Jackson Frame

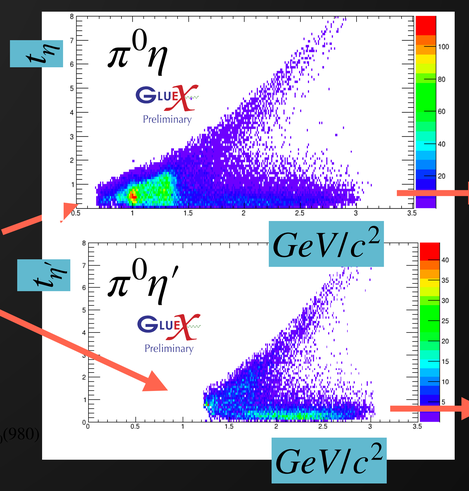
Background

Vertex Exchange Diagrams



- **Exotic signature enhanced by double Regge process**

Double Regge Process



- **Can study the upper vertex exchange of the faster $\eta^{(\prime)}$ particles through a beam asymmetry**

$t_\eta \approx < 1$
Faster η Particles

- **Beam asymmetries for different decay modes will behave the same**

$t_{\eta'} \approx < 1$
Faster η' Particles

Future Work

- **Partial wave analysis will be performed to understand the odd and even angular momentum characteristics in each system**