

## ABSTRACT:

The GlueX experiment is a photoproduction medium energy experiment which is located at Thomas Jefferson National Laboratory in Newport News, Virginia. We report on measurements of the beam asymmetry( $\Sigma$ ) in the reaction  $\gamma p \rightarrow \eta' p$ , using a tagged, linearly polarized 9 GeV photon beam incident on a liquid hydrogen target. A previous measurement, which was limited to momentum transfer up to  $-t=0.9$  (GeV/c)<sup>2</sup>, indicated that the reaction mechanism is dominated by  $\rho$  and  $\omega$  meson exchanges[1]. Newly collected data with 3-4 times larger statistics will allow us to study whether this holds true at larger momentum transfer. We will present the preliminary results of azimuthal angular distributions and extracted beam asymmetries as a function of  $-t$  for different  $\eta'$  decay modes.

## 1. INTRODUCTION

The GlueX experiment is based at Thomas Jefferson National Laboratory, Newport News Virginia which aims to search hybrid mesons in particular exotics since such mesons expected to provide ideal laboratory for testing QCD in the confinement regime. This is because such mesons explicitly manifest gluonic degree of freedom. GlueX uses coherent bremsstrahlung technique to produce a linearly polarized photon beam. A solenoid based  $4\pi$  hermetic detector has been used to collect data with electron beam of energy approximately 12GeV.

## 2. MOTIVATION

The production of the lightest multiplet of exotic mesons with JPC  $(-1)^+$  involves the same Regge Exchange that appear in the production of ordinary pseudoscalar mesons like  $\pi^0$ ,  $\eta$  &  $\eta'$  and both natural  $(P(-1)^1=1)$  and unnatural parity exchanges  $(P(-1)^1=-1)$  contribute. One of key observable is Beam Asymmetry( $\Sigma$ ). It is related to cross-sections of natural and unnatural parity exchanges. Following reactions channels will be looked into to extract beam asymmetry( $\Sigma$ ) as a first measurement as well as at higher  $-t$  range .

$$\begin{aligned} \eta' &\rightarrow \pi^+ \pi^- \eta, \eta \rightarrow 2\gamma (42.6 \pm 0.7)\% \\ \eta' &\rightarrow \pi^0 \pi^0 \eta, \eta \rightarrow 2\gamma, \pi^0 \rightarrow 2\gamma (22.8 \pm 0.8)\% \\ \eta' &\rightarrow \pi^+ \pi^- \gamma (28.9 \pm 0.5)\% \\ \eta' &\rightarrow 2\gamma (2.22 \pm 0.08)\% \end{aligned}$$

## 3. GLUEX BEAMLINE AND POLARIZATION

The GlueX Beam line consist of different parts as shown in figure 1 and figure 2. We use linearly polarized photon beam for physics processes.

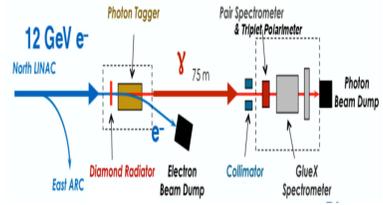
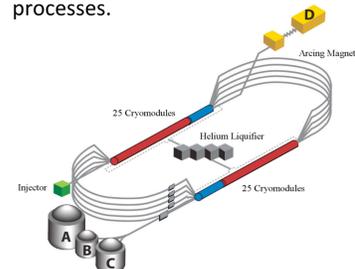


Fig.2 schematics of glueX beamline[3]

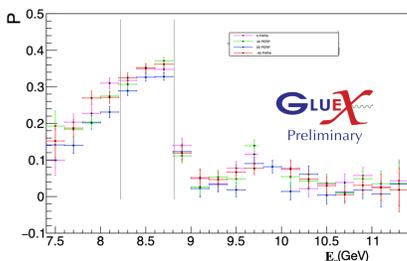


Fig.4. GlueX phase-I (Spring-2018) beam polarization for all orientations from TPOI measurements

Data has been collected for different orientations of photon polarization, 0 and 90 degrees, and 45 and -45 degrees. Sets with perpendicular polarization for example 0,90 degrees are used to extract the beam asymmetry.

The charged pions are tracked through the magnetic field of the solenoid by a set of drift chambers. Photons from eta decay are detected in calorimeter. Full reconstruction of the pi+, pi- photon final state allows identification of the etaprime meson in invariant mass distribution.

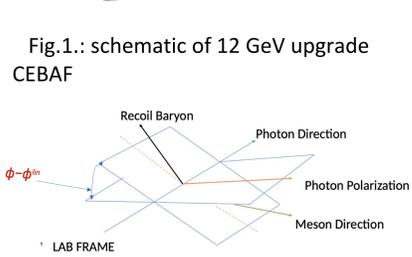


Fig. 3. A cartoon showing for photon polarization direction

## 4. EXPERIMENT SETUP

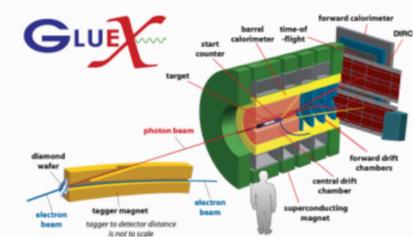


Fig.5. Schematic overview of GlueX detector[3]

## 5. EVENT SELECTION

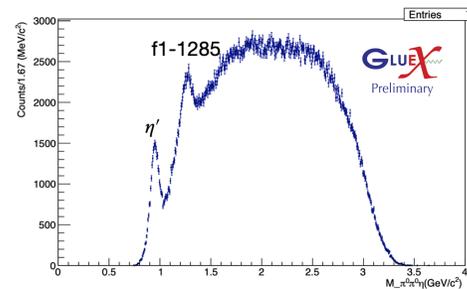


Fig.6.  $\pi^0 \pi^0 \eta$  invariant mass full spectrum

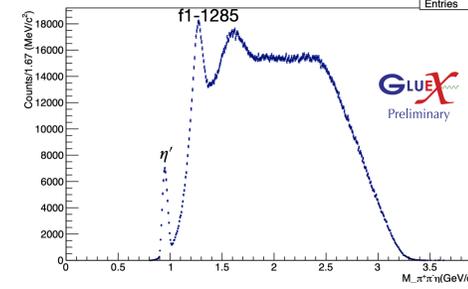


Fig.7.  $\pi^+ \pi^- \eta$  invariant mass full spectrum

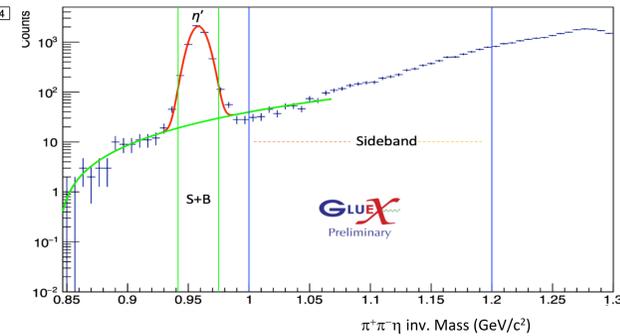


Fig.8.  $\pi^+ \pi^- \eta$  invariant mass spectrum showing also the sideband used to correct for background contributions.

## 6. RESULT AND DISCUSSION

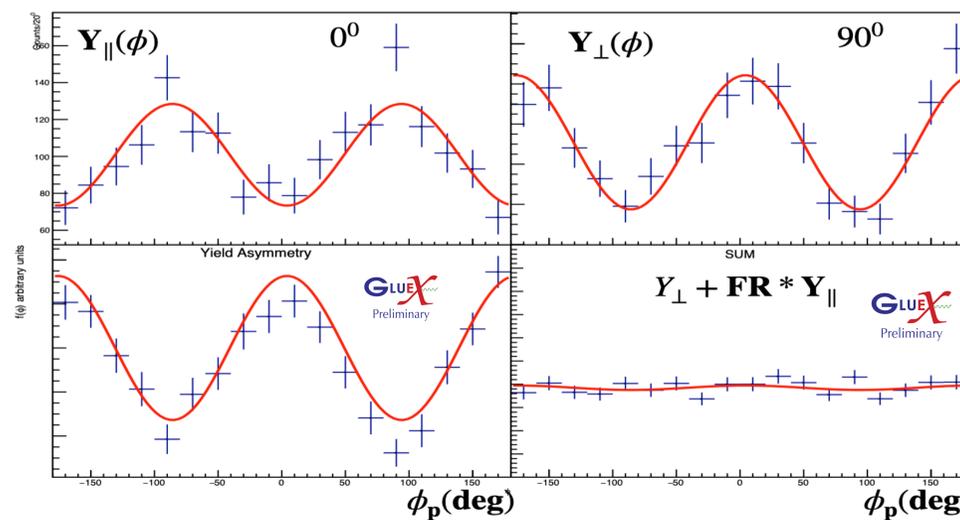


Fig.9. Quad panel plot to show angular distributions (0 degree para: Top left, 90 degree perp top right), Yield Asymmetry (bottom left) and Instrumental Asymmetry (bottom right)

We plotted the azimuthal angular distributions for different polarization orientations such as 0(deg), 45(deg), 90(deg) & -45(deg). Some of the distributions have been shown above together with the corresponding Yield Asymmetry as shown in above fig.(9). The Beam Asymmetries can then be extracted by using fit function using equation (2) on such Yield Asymmetry distributions making Sigma ( $\Sigma$ ) as a only free parameter which is to be extracted. Also the bottom right plot shows the instrumental asymmetry if any. It's mostly the flat distribution. We plotted 45/-45 as well in such quad panel fashion to see if there is any instrumental asymmetry and we saw mostly flat distribution. Instrumental Asymmetry will be extracted as systematics as our analysis progresses.

$$f(\phi) = \frac{Y_{\perp} - FR * Y_{\parallel}}{Y_{\perp} + FR * Y_{\parallel}} \quad \dots\dots\dots(1)$$

$$f(\phi) = \frac{(P_{\perp} + P_{\parallel}) \Sigma \cos 2(\phi - \phi_0)}{2 + (P_{\perp} - P_{\parallel}) \Sigma \cos 2(\phi - \phi_0)} \quad \dots\dots(2)$$

Data points in bottom left plot of fig. 9 can be calculated from  $\phi$  distributions (Fig. 9) by forming the ratio as shown in Eq. 1; here the flux ratio FR accounts for different integrated photon fluxes for the two orientations of the polarization. The solid red line is a fit to the data using Eq. 2. The P-s are the corresponding beam polarization for the two orientations.

### 6.1 BEAM ASYMMETRY $\Sigma$ (preliminary)

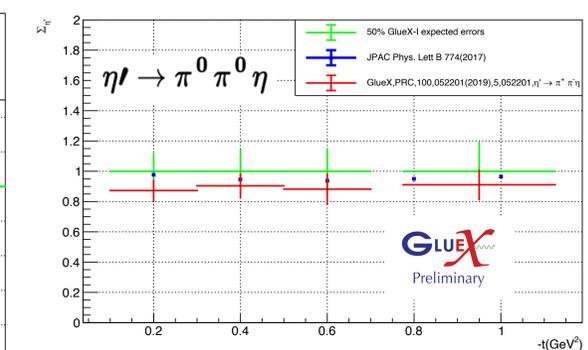
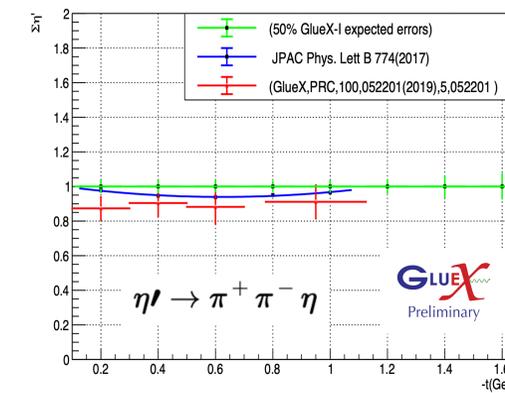


Fig.10. Expected reach of this measurement (green) compared to previous measurements (red) and theoretical predictions from JPAC (blue). Current data points are statistical errors only. Data points are set arbitrarily to  $\Sigma = 1$ .

## 7. SUMMARY AND OUTLOOK:

We here presented a first pass over ~50% of the GlueX Phase 1 data, for two decay channels. From this we already expect to be able to extend this measurement upto larger  $-t$ , and also with smaller statistical errors in the low  $-t$  region. In addition the measurement on the right is a first ever measurement at GlueX energy. As there are no prior published data for this neutral mode, we again compare with the published data from charged mode. The full data set, additional data to be taken, and analysis of additional decay channels should further improve this result.

## ACKNOWLEDGEMENTS

This work was partially supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics under contracts DE-SC0013620 and DE-AC05-06OR23177

## REFERENCES

- [1] S.~Adhikari { et al.} [GlueX Collaboration], Phys. Rev. C {100}, no. 5, 052201 (2019)
- [2] <https://www.jlab.org/physics/gev>
- [3] The GlueX-Collaboration. Hall D / GlueX Technical Design Report. 1997.
- [4] [https://halldweb.jlab.org/wiki/index.php/Main\\_Page](https://halldweb.jlab.org/wiki/index.php/Main_Page)