The radiative decay width measurement of the η-meson at GlueX

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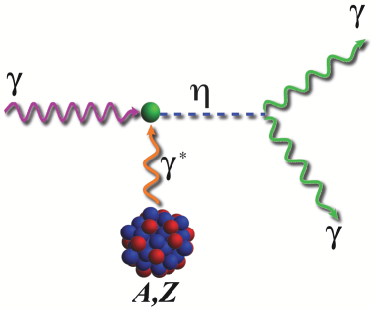
Introduction

Measuring the partial decay width of $\eta \to \gamma\gamma$:

- Decays mainly through the chiral anomaly
- Will improve other η partial decay width measurements
- Allows for determining fundamental aspects of QCD in a model-independent manner:
  - Light quark mass ratio $\mathcal{Q}^2 = \frac{m_s^2 - \hat{m}^2}{m_d^2 - m_u^2}$
  - $\eta - \eta'$ mixing angle

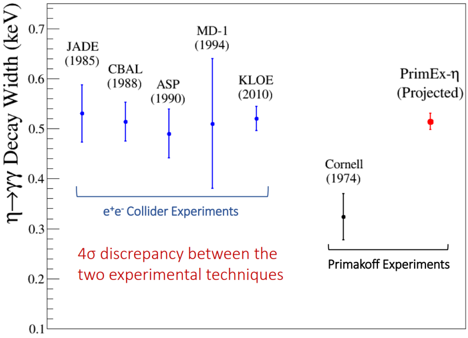


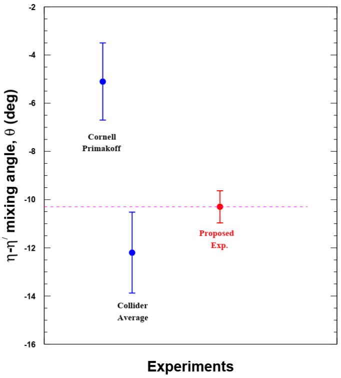
Primakoff photoproduction of an η-meson off a nucleus

Discrepancy between the existing measurements

Between Collider and fixed target experiments

- This discrepancy causes a difference in the calculated $\eta - \eta'$ mixing angle
- The mixing angle discrepancy is $> 6°$
- PrimEx-eta aims for a 3.2% uncertainty on $\Gamma_{\eta\to\gamma\gamma}$, which will yield a 0.45° uncertainty on the mixing angle



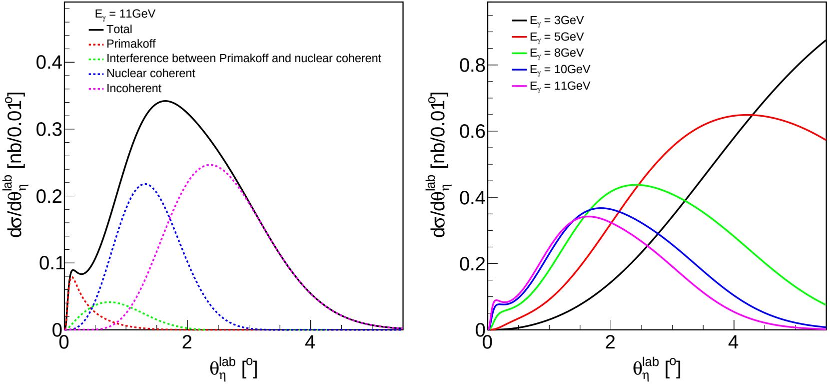


We will show today preliminary results of phase I PrimEx-eta measurements (2019 data set)

Theoretical differential cross-section

Known for spin-zero nucleus such as ^{4}He, $\gamma + {}^4\text{He} \to \eta + {}^4\text{He}$:

- Primakoff contribution is directly proportional to the $\Gamma_{\eta\to\gamma\gamma}$ decay width
  $\frac{d\sigma_P}{d\Omega} = \boxed{\Gamma_{\eta\to\gamma\gamma}} \frac{8\alpha Z^2}{m^3} \frac{\beta^3 E^4}{Q^4} |F_{e.m.}(Q)|^2 \sin^2\theta$
- Primakoff contribution increases with increasing incident photon-beam energies

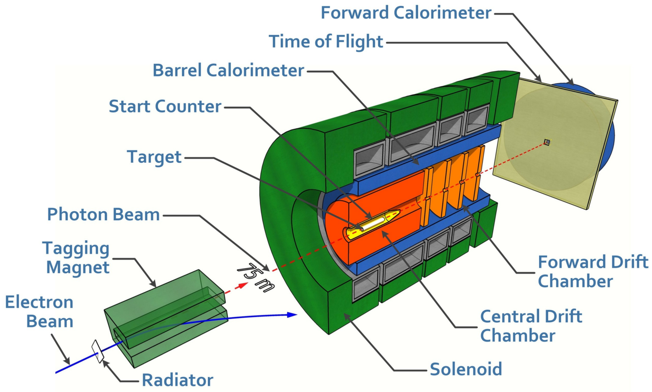


Simultaneously measuring Compton cross-section as an exactly calculable reference process

The GlueX setup

Photon-beam produced, 75 m upstream from the target center, by bremsstrahlung:

- Electron-beam energy varies between 11.1 and 11.6 GeV
- Solenoid not used (no magnetic field)

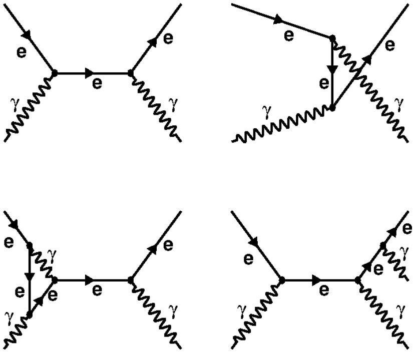


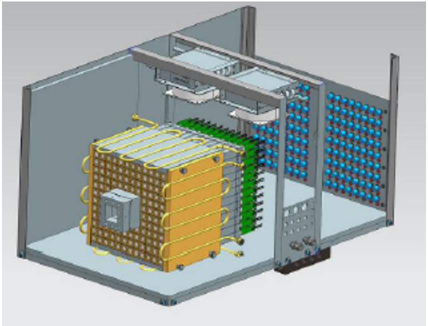
To increase acceptance to Compton events for incident photon-beam energies above 6 GeV, a calorimeter is added 4 m downstream from Forward Calorimeter

Compton photoproduction off an atomic electron

Hall D is not optimized for precision absolute cross-section measurements at forward angles

- Compton cross-section is a known QED process and is used as a reference process:
    - Verify systematics
    - Monitor luminosity
    - MC simulation validation





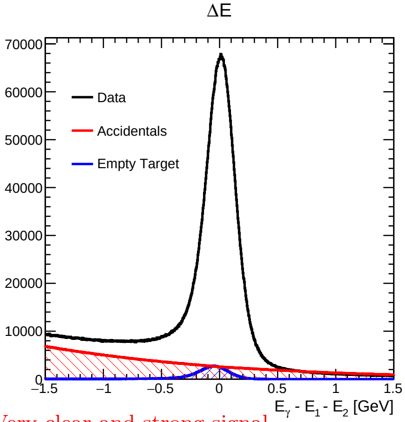
- Compton Calorimeter (right-figure) covers angle between 0.2 and 1^o

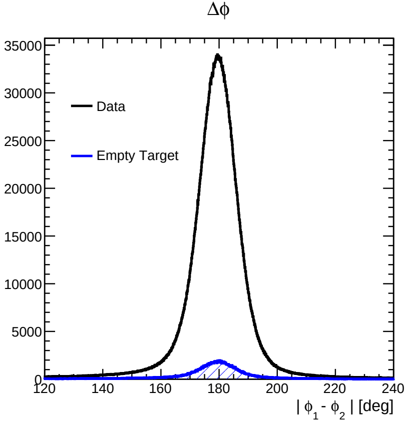
Compton detection efficiency varies between 12 and 5 % for E_γ between 6 and 11.3 GeV

Control channel: $\gamma e^- \rightarrow \gamma e^-$

Selection criteria:

- At least two clusters with one in the Forward and one in the Compton Calorimeters
- Elasticity required
  (energy difference between incident photon-beam and two clusters)
- Coplanarity required

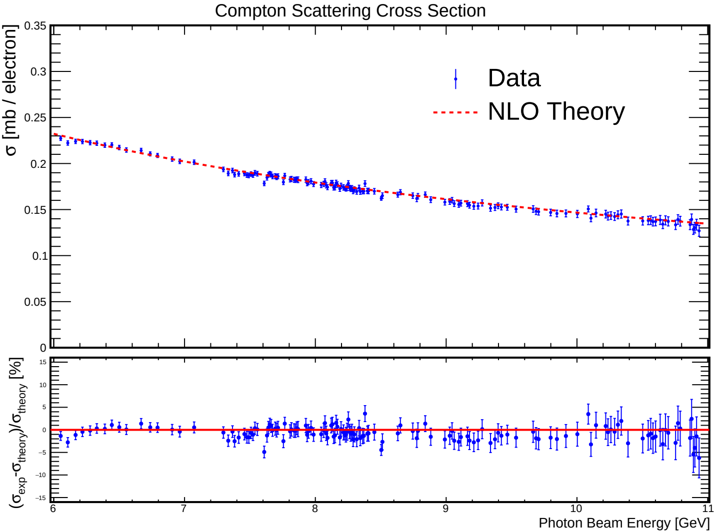




Very clear and strong signal

Preliminary Compton cross-section measurements

First cross-section measurements in this energy range:

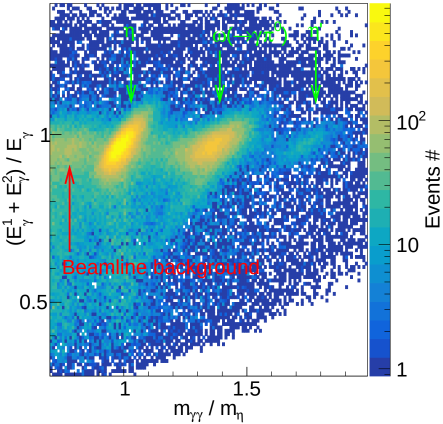


Within 5% from the theoretical cross-section

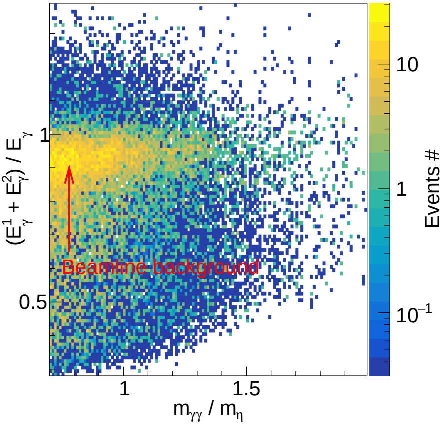
Two clusters in Forward Calorimeter:

- Barrel Calorimeter used to veto hadronic backgrounds
- Time-Of-Flight wall used to veto charged particles
- Elasticity required

- He target

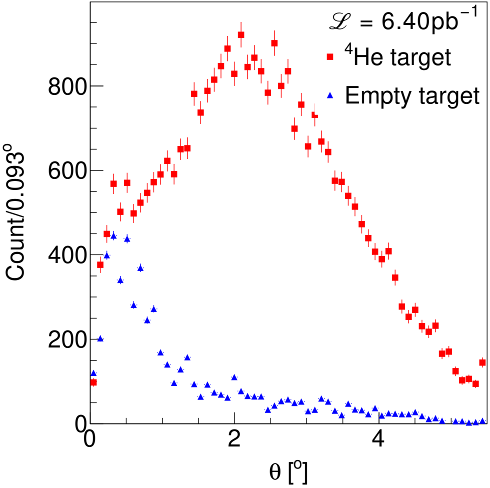


- Empty target



Clear signal but includes Primakoff and coherent events, and non-negligible background beneath η coming from beamline

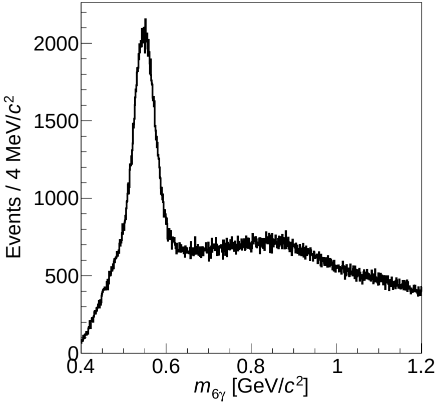
$\eta \to \gamma\gamma$, very preliminary polar angle distributions

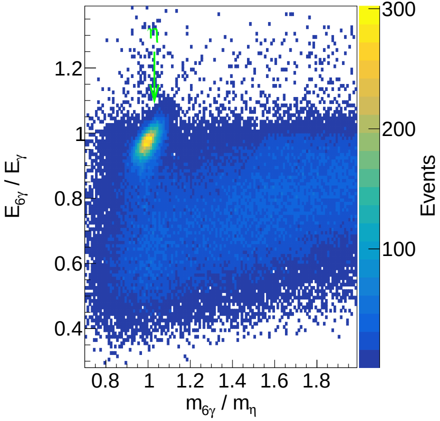


- Beamline background not yet understood
- Larger empty target sample is needed

$\eta \to \pi^0\pi^0\pi^0$, selection criteria

- 6 clusters (Barrel and Forward Calorimeters)
- Time-Of-Flight wall used to veto charge particles
- Elasticity required

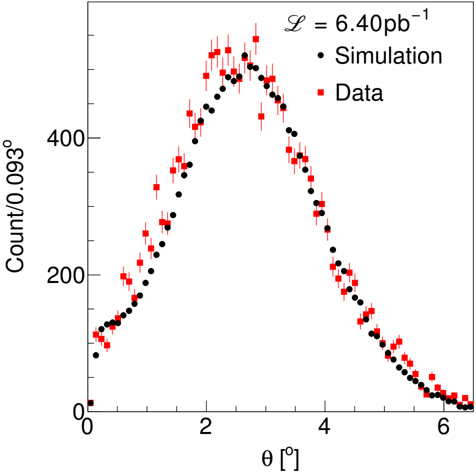




Lower statistic compared to $\eta \to \gamma\gamma$ but cleaner signal

$\eta \to \pi^0\pi^0\pi^0$, very preliminary polar angle distributions

Beamline background is not an issue and angular resolution similar to $\eta \to \gamma\gamma$



Fair agreement between data and simulation

Conclusions

Phase I data set of the PrimEx-eta measurements shows promising results for

- Preliminary Compton cross-section measurements in good agreement with theoretical cross-section
- $\eta \to \gamma\gamma$ but with non-negligible background coming from the beamline
- $\eta \to \pi^0\pi^0\pi^0$ but with lower statistics

Phase II will start in 3 weeks from now

- Electron-beam will be 10.3 GeV (not the optimal energy for this measurement)
- Will test beamline improvements: shielding added downstream from target and Helium beampipe added between Forward and Compton Calorimeters
- Will test magnetic effect (Solenoid will be turned on)

Phase III with optimal 12 GeV electron-beam scheduled for 2022

GlueX acknowledges the support of several funding agencies and computing facilities:
`http://www.gluex.org/thanks`

Thank you for your attention