Light Meson Decays from Photon-Induced Reactions with CLAS

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Abstract. Photo-production experiments with the CEBAF Large Acceptance Spectrometer (CLAS) at the Thomas Jefferson National Laboratory produce data sets with unprecedented statistics of light mesons. With these data sets, measurements of transition form factors for η, ω, and η' via conversion decays can be performed using a line shape analysis on the invariant mass of the final state dileptons. Tests of fundamental symmetries and information on the light quark mass difference can be performed using a Dalitz plot analysis of the meson decay. An overview of the first results and future prospects within the newly upgraded CLAS apparatus will be given.

INTRODUCTION

Decays of light mesons provide insight into the structure of the meson. The Light Meson Decay (LMD) group, established at the Thomas Jefferson National Facility with worldwide collaboration, investigates physics pertaining to, but not limited to, transition form factors, anomalous decays and the search for CP violation through Dalitz plot analysis. The presentation given was an overview of the LMD program, recent updates on measurements and an outlook on measurements that can be taken with the CLAS12 detector.

Light Meson Decay Program

The light meson group was established in 2013. The goal of the group is to investigate properties of light meson decays using data obtained from the CLAS detector. Figure 1 shows the CLAS detector and its sub components. Since decays

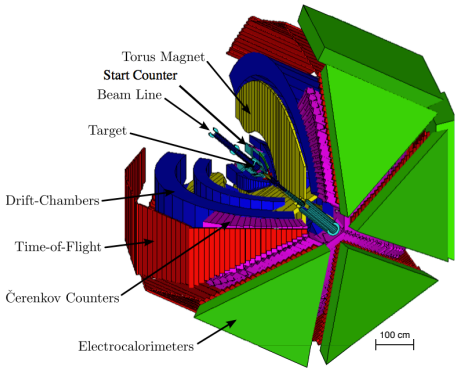


FIGURE 1: The CEBAF Large Acceptance Spectrometer (CLAS)

of hadrons are independent of production, all CLAS data can be used, however there are two experiments that were

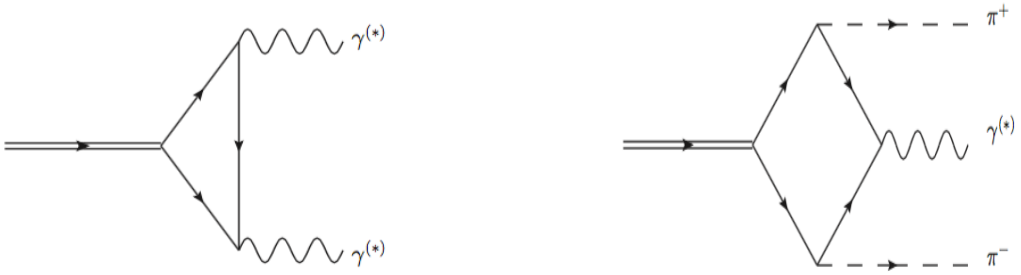
chosen as flagships for the program, the g11 and g12 experiment. Both experiments use a photon beam incident on a liquid hydrogen target which created photo-induced reactions, 800 MeV - 3.8 GeV for g11 and 1.1 GeV - 5.5 GeV for g12. See Table 1 for a list of meson decays the LMD group plans to investigate.

TABLE 1: LMD planned measurements

Meson Decay	Physics Interest	Meson Decay	Physics Interest
$\pi^0 \to e^+e^-\gamma$	Heavy photon upper limit	$\eta' \to \pi^+\pi^-\gamma$	Box anomaly
$\eta' \to e^+e^-\gamma$	Transition form factor	$\omega \to \pi^+\pi^-\gamma$	Upper limit branching ratio
$\omega \to e^+e^-\pi^0$	Transition form factor	$\eta, \omega, \phi \to \pi^+\pi^-\pi^0$	Dalitz plot analysis
$\eta' \to e^+e^-\pi^0$	C violation	$\eta' \to \pi^+\pi^-\eta 0$	Dalitz plot analysis
$\eta' \to e^+e^-\pi^+\pi^-$	CP violation	$\phi \to \pi^+\pi^-\eta 0$	G-parity violation

Update on the Radiative decay of the η and η' meson

The 2 photon decay of pseudoscalar mesons $\pi^0, \eta, \eta' \to \gamma\gamma$ proceed from the understood triangle or axial anomaly. While radiative decays of $\eta, \eta' \to \pi^+\pi^-\gamma$ are related to a less understood box anomaly. Figure 2 shows the Feynmann diagrams for the two processes previously described. The radiative decay widths of η' and η' are determined by the



A. Triangle diagram

B. Box diagram

FIGURE 2: Feynmann diagram of the two photon decay (A). Feynmann diagram of the axial anomoly, box diamgram (B)

box anomaly in the chiral limit by use of equation 1.

$$\frac{d\Gamma(\eta^{(\prime)} \to \pi^+\pi^-\gamma)}{ds_{\pi\pi}} = A|P(s_{\pi\pi})F_V(s_{\pi\pi})\Gamma_0(s_{\pi\pi})| \tag{1}$$

Where $\Gamma_0(s_{\pi\pi})$ is the P-wave phase-space constant, denoted in equation 2. $F_V(s_{\pi\pi})$ is the pion form factor that can be approximated by the equation 3 and $P(s_{\pi\pi})$ is expanded in the chiral limit, $s_{\pi\pi} = 0$, and is written in equation 4.

$$\Gamma_0(s_{\pi\pi}) = \frac{\kappa\left(M^2_{\eta^{(\prime)}} - s_{\pi\pi}\right)^3 s_{\pi\pi}\left(1 - \frac{4M^2_\pi}{s_{\pi\pi}}\right)^{\frac{3}{2}}}{M^3_{\eta^{(\prime)}}} \tag{2}$$

$$|F_V(s_{\pi\pi})| \approx 1 + (2.12 \pm 0.01)s_{\pi\pi} + (2.13 \pm 0.01)s^2_{\pi\pi} + (13.89 \pm 0.14)s^3_{\pi\pi} \tag{3}$$

$$P(s_{\pi\pi}) = 1 + \alpha s_{\pi\pi} + O(s^2_{\pi\pi}) \tag{4}$$

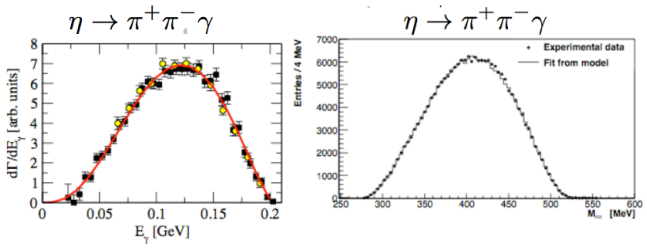


FIGURE 3: Current

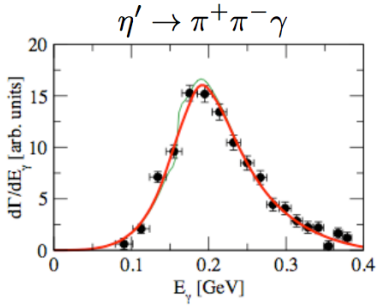


FIGURE 4: Current

Update on the transistion form factor measurement of the ω meson

Update on the branching ratio measurement of the η' meson $\to e^+e^-\gamma$

Future measurement of the η' meson transsition form factor with CLAS12

ACKNOWLEDGMENTS

The reference section will follow the “Acknowledgment” section. References should be numbered using Arabic numerals followed by a period (.) as shown below, and should follow the format in the below examples.

REFERENCES

[1] A. Abele and et al., Physics Letters B **402**, 195 – 206 (1997).
[2] D. Babusci and et al., Physics Letters B **718**, 910 – 914 (2013).

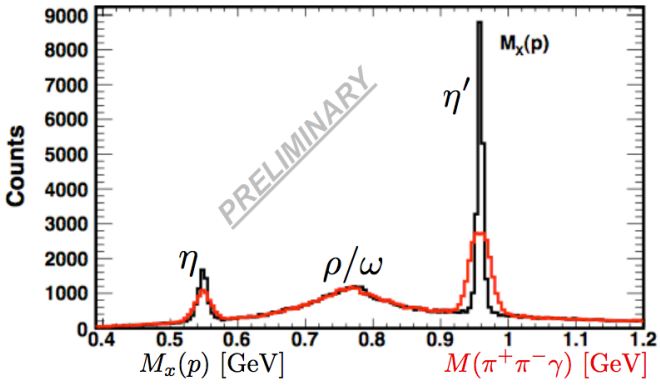


FIGURE 5: CLAS data yield for $\gamma p \to p\eta^{(\prime)} \to \pi^+\pi^-\gamma$ from g11 data set

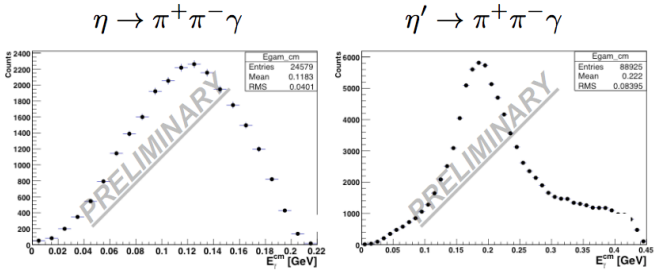


FIGURE 6: The CEBAF Large Acceptance Spectrometer (CLAS)