PROGRESS REPORT ON THE π^0 LIFETIME EXPERIMENT (PRIMEX) AT JLAB

D. E. McNulty

(for the PrimEx Collaboration*)

Laboratory for Nuclear Science,
Massachusetts Institute of Technology,
Cambridge, Mass 02139, USA
**E-mail: mcnulty@jlab.org*
www.jlab.org/primex

A precision measurement of the π^0 photo-production cross section from ^{12}C and ^{208}Pb nuclear targets has been made by the PrimEx Collaboration at Jefferson Lab using 4.9 to 5.5GeV photons tagged by the Hall B tagger facility. The experimental goal is to measure the $\pi^0 \to \gamma\gamma$ decay rate to an accuracy of 1.5% using the Primakoff component of the measured cross section. This represents an order of magnitude improvement over current world-data precision and will allow for powerful tests of the Axial Anamoly plus Chiral corrections—primarily from isospin-breaking and π^0, η, $\eta\prime$ mixing. In this presentation, the status of the π^0 lifetime analysis is given, including detector performance, γ-flux control, systematic checks, and experimental π^0 yields.

1. Motivation

The $\pi^0 \to \gamma\gamma$ decay rate is a fundamental prediction of QCD which gives insight into one of its most profound symmetry issues—namely, the Axial or Chiral Anomaly. It is this anomalous symmetry-breaking mechanism by which the $\pi^0 \to \gamma\gamma$ decay channel proceeds, and thus a measure of its rate or partial width, $\Gamma_{\gamma\gamma}$, represents a direct probe of the anomaly.

In the chiral limit, an *exact* expression for the π^0 decay amplitude can be formed resulting in the Leading Order (LO) prediction, $\Gamma_{\pi^0\to\gamma\gamma} = 7.725 \pm 0.044$eV, using the current value for the pion decay constant. However, for non-zero quark masses, corrections to the decay amplitude give rise to the Next to Leading Order (NLO) $\Gamma_{\gamma\gamma}$ prediction. The current state of world-data on this subject is presented in Figure 1.

*Supported in part by NSF MRI grant PHY-0079840

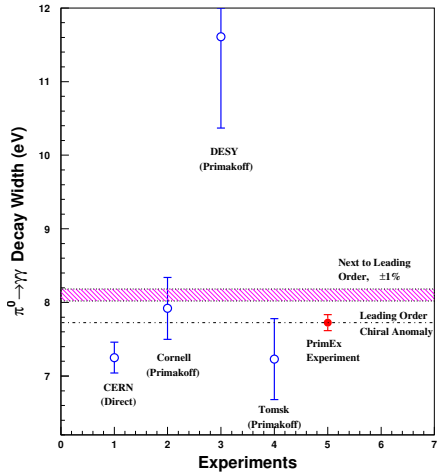

Fig. 1. Previous data on $\Gamma_{\pi^0 \to \gamma\gamma}$. PrimEx data-point is arbitrarily plotted at the LO value with the projected $\pm 1.5\%$ errorbar. The current PDG book value is $\Gamma_{\gamma\gamma} = 7.84 \pm 0.56$eV. The NLO prediction[1] is $8.1\text{eV} \pm 1\%$. The precision of the PrimEx measurement will distinguish between LO and NLO predictions.

2. Experiment Design and Analysis Status

Use of the Hall B γ-tagging facility provides unprecedented γ-flux control $(1-2\%)$ which substantially reduces systematic errors associated with the flux normalization. This is combined with a new, high resolution calorimeter[2] designed to detect the two π^0 decay γ's. The precise energy and time resolution of the combination allow for a clean separation of signal and background events. Both e^+e^- pair-production and Compton scattering cross sections were measured for cross-checking the setup's ability to measure well known processes; both results are in excellent agreement with theory.

The Primakoff process is defined as π^0 photo-production from the Coulomb field of a nucleus. This implies an equivalent π^0 production and decay mechanism–which means the cross section $\propto$ lifetime. $\Gamma_{\gamma\gamma}$ is extracted from the data using a multi-parameter fit to the overall cross section measurement; preliminary π^0 cross section and lifetime results available soon.

References

1. J. L. Goity *et al.*, *Phys. Rev.* **D66**, p. 076014 (2002).
2. M. Kubantsev *et al.*, in *CALOR 2006 Proceedings*, (Chicago, June 2006).