ANTIBARYON PHOTOPRODUCTION USING CLAS AT JEFFERSON LAB

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Overview

- Introduction
 - Resonance production
 - Production mechanism
- Experiment Overview
- Experimental Results:
 - Proton-Antiproton reaction cross sections
 - Antineutron reaction results
- Summary / Outlook

Introduction: Motivation

- Baryon-Antibaryon production has been studied since the early days of nuclear physics, in particular looking for resonances which decay to proton antiproton
- There is limited photoproduction data and the photoproduction mechanism is not well understood
- The main focus of this work is
 - Provide more details on the production mechanism through
 - Cross section measurements
 - A search for wide meson resonances using Partial Wave Analysis
 - Antibaryon photoproduction can be probed using:

 $\gamma p \to p p \bar{p} \qquad \gamma p \to p p \bar{n} \pi^2$

*Never seen before

Introduction: History

- Narrow "resonances" first reported in pion production data
 - Seen with Δ's and N*'s present in the reaction
- Later seen in photoproduction
- These mass enhancements have been much disputed throughout their history



P. Benkheiri et al., Phys. Lett. B 68, 483 (1977)

Introduction: Meson decay

- BES III reported on near threshold mass enhancements as well as possible meson resonances above 2 GeV
- In addition, a large number of mesons are observed in proton antiproton annihilation

experiments

- Similar widths to the proton antiproton mass distribution width
- Multiple large width mesons could be contributing
- PWA would be the only way to get a better understanding



M. Ablikim et al., Phys. Rev. Lett. 108, 112003 (2012)

Abridged Resonance Candidates (MeV)	Г (МеV)	Jbc
rho ₃ (1990)	196±31	3
f ₀ (2020)	442±60	0++
f ₂ (2150)	152±30	2++
rho(2150)	~250-320(?)	1
rho ₃ (2250)	~220	3
rho ₅ (2350)	400±100	5
f ₆ (2510)	283±40	6++

Introduction: Production Mechanism

- Analysis of CLAS g6c data showed that the data was difficult to model
- Mixing of two production models shown in red
- Differential cross sections to form the basis of Monte Carlo model
- Total cross section is sensitive to simulation model, an accurate model is needed





Experiment: The Facility

- 6 GeV continuous electron beam (now upgraded and operating at 12 GeV)
- Superconducting linear accelerator with bending arcs for recirculating the beam
- Capable of simultaneously and continuously providing beam to 3 halls



Experiment: Aerial View of JLab



Aerial Photo, October 2013

Experiment: Overview

- gl2 experiment
 - LH₂ target, ran in 2008
 - Target was -90 cm from center of CLAS
 - Photoproduction: I.I-5.45 GeV
 - Circularly polarized
 - Total integrated luminosity: 68 pb⁻¹
 - 7 ·10⁷ tagged photons/s
 - Highest statistics photoproduction experiment to date in this energy range
 - CLAS is ideally suited for these reactions due to the multi-track acceptance



Experimental Results: Features of the Data



- Unprecedented statistics in proton antiproton photoproduction
- E_{γ} from reaction threshold (3.9 GeV) to 5.45 GeV
- 2.5*10⁵ events combined

Experimental Results: Narrow Resonances?



Bodenkamp et al, Nucl. Phys. B255 717. (1985)

- Narrow resonances have been observed in the past
- No clear evidence for narrow resonances in current analysis



Experimental Results: Simulation

- Current simulation is based on a tuned diffractive model
- First step in an iterative process to create a more accurate simulation model
- Differential cross sections calculated using this model are being used as a MC model with PLUTO



2.0

1.8

1.9

2.1

2.2

2.3

MM(p_{slow}) [GeV]

2.4



- Data

Experimental Results: $d\sigma/dcos(\theta)$

- First (preliminary) angular differential cross section measurement shown, E_{γ} from 3.95-5.45 GeV
- Fits to Chebyshev polynomials are used to calculate the preliminary total cross section
- Monte Carlo model dependence is being investigated



*Statistical errors only

Experimental Results: do/dm

- Preliminary differential cross section shown, E $_{\gamma}\,$ from 3.95-5.45 GeV
- Double counting in the proton antiproton mass cross section due to the ambiguity between the protons



*Statistical errors only

Experimental Results: Total Cross Section



*CLAS results unpublished, statistical errors only for 2015 results

Experimental Results: Antineutron Reaction



- After many iterations simulation that matches the data was found
- Momentum, angles, and t distributions match

$$\gamma p \to p p \pi^-(\bar{n})$$





Summary

- Preliminary (First time) differential and total cross sections shown for proton antiproton reaction
- No clear evidence of narrow resonance production
- Model for generating Monte Carlo is in progress
 - Using PLUTO++ for differential cross section defined reaction model
- Partial Wave Analysis searching for broad resonances is underway
 - As a cross-check for the PLUTO++ simulation, use the production amplitudes from the fit to construct a model to generate Monte Carlo
- First time observation and cross section for an antineutron in photoproduction