Lambda Proton Elastic Scattering in CLAS

Noraim Nunez[1], John W. Price[1], Kenneth Hicks[2]

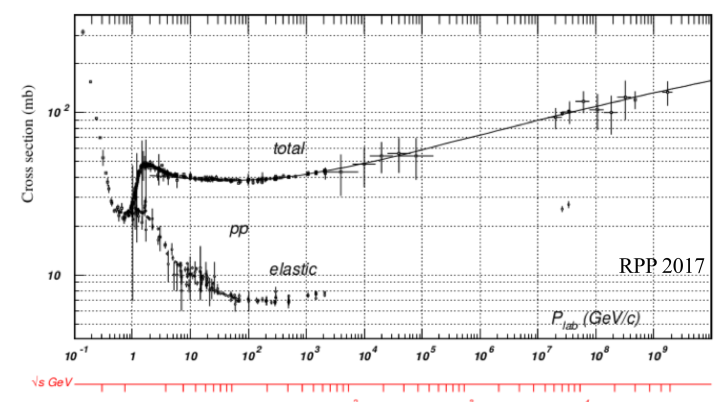
California State University, Dominguez Hills[1]

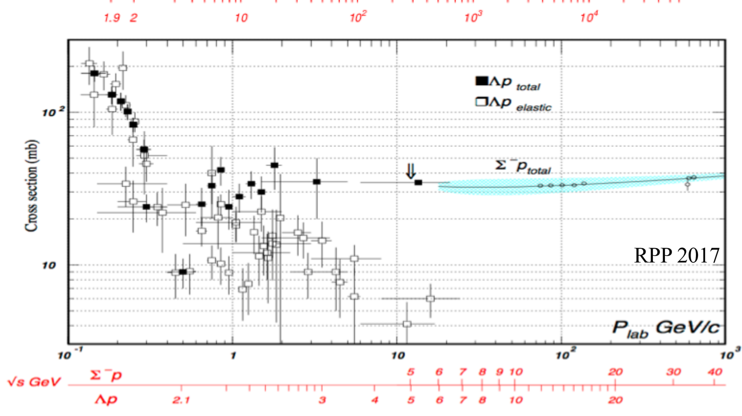
Ohio University[2]

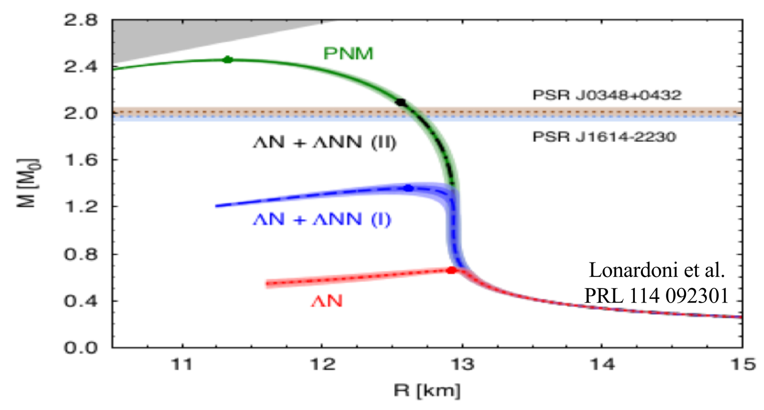
Motivation

SU(3) flavor symmetry implies a similarity between the pp and Λp elastic scattering processes. It is based on the QCD Lagrangian, which can be written as the sum of a mass-independent and a mass-dependent term:

$$\mathcal{L} = \underbrace{\left(\sum_q \bar{\psi}_{q,a}(i\gamma^\mu \partial_\mu \delta_{ab} - g_s \gamma^\mu t^C_{ab} A^C_\mu)\psi_{q,b} - \frac{1}{4}F^A_{\mu\nu}F^{A\mu\nu}\right)}_{\mathcal{L}_0} - \underbrace{\sum_q \bar{\psi}_{q,a} m_q \delta_{ab} \psi_{q,b}}_{\mathcal{L}_m}$$





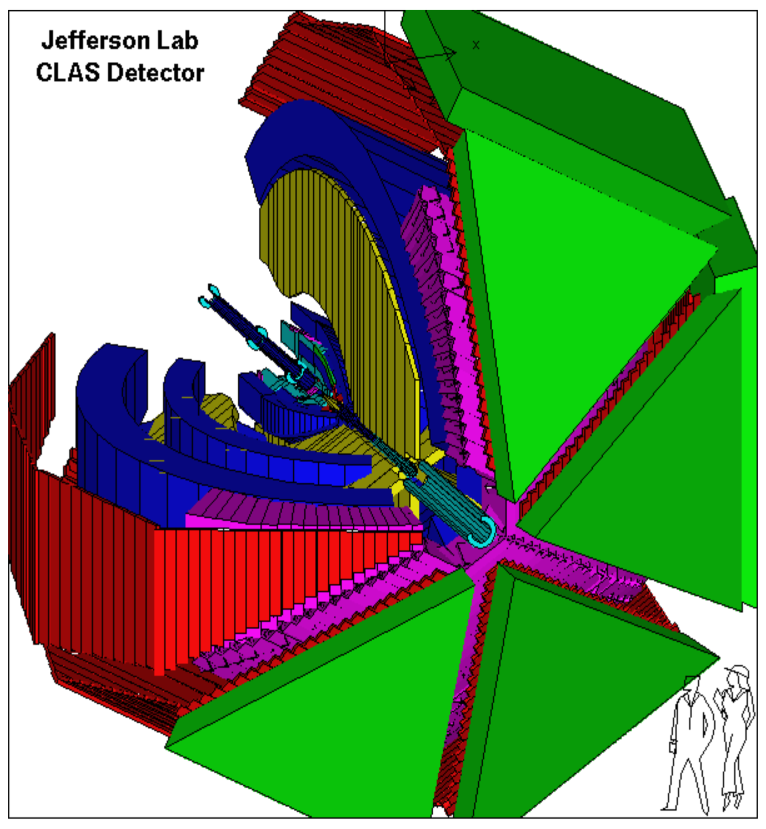


The existing data for Λp scattering are much more sparse than that for pp scattering. The world data sample has 13 measurements for Λp and 1500 observed events, all using bubble chambers.

Better data for this process can help solve the hyperon puzzle, the conflict between our expectation of the existence of hyperons in neutron stars and the effect that existence has on the maximum mass of neutron stars.

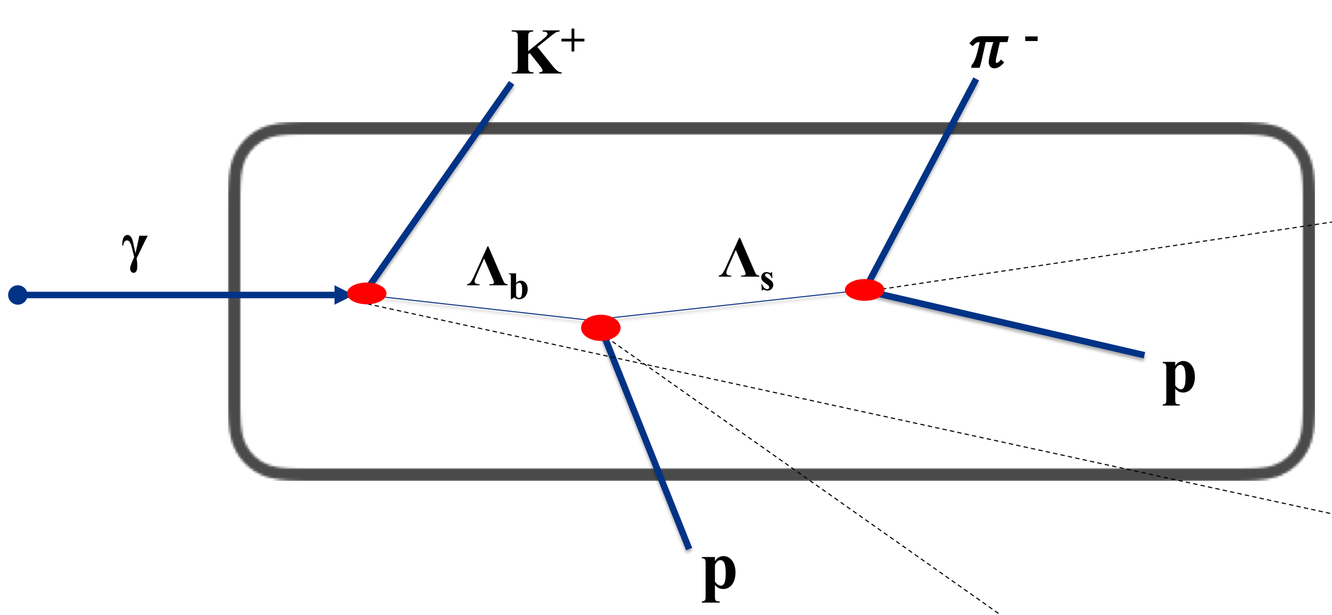
Experiment

We selected the CLAS g12 data set for this purpose: This data set contains 52 pb^{-1} of γp data at $3.6 < E_\gamma < 5.4$ GeV on a 40 cm liquid hydrogen target. The Λ is produced via a process such as $\gamma p \rightarrow K^+\Lambda$. The Λ then interacts with a second proton inside the target before decaying to π^-p. Although CLAS was not designed for this process, its good angular acceptance and its good angular and momentum resolution make it well-suited for measurements such as this.

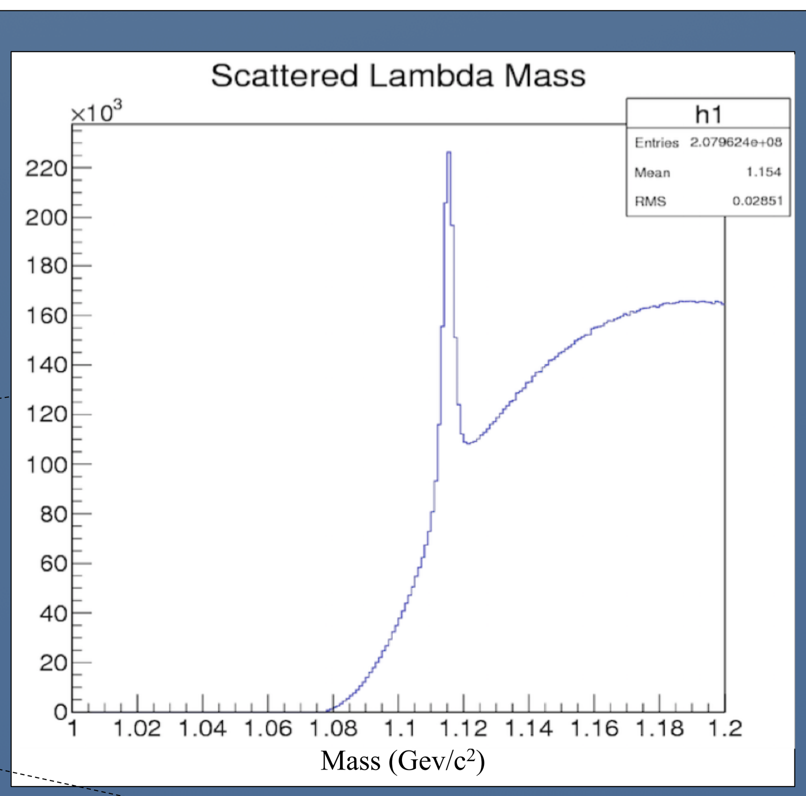


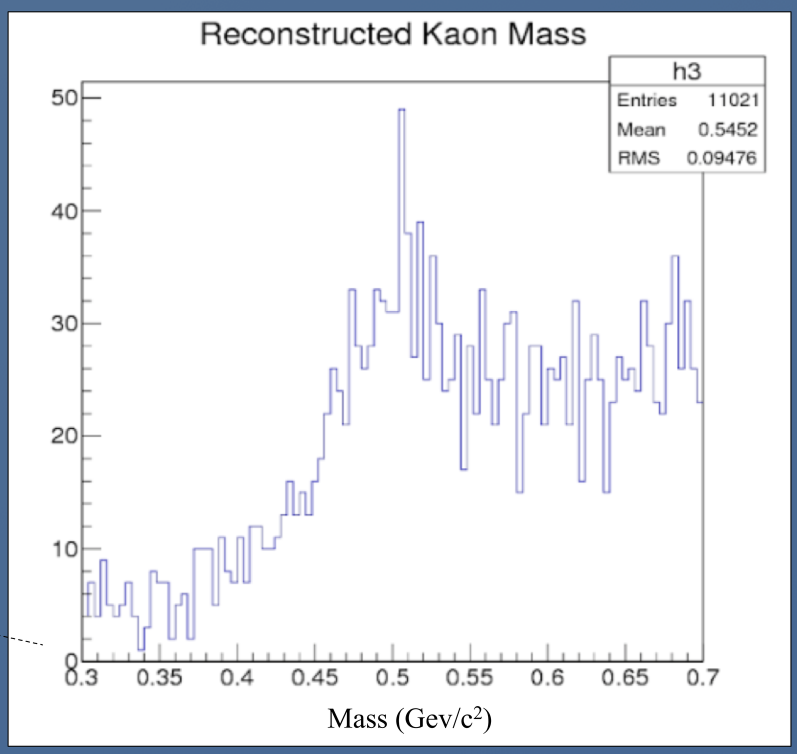
Analysis

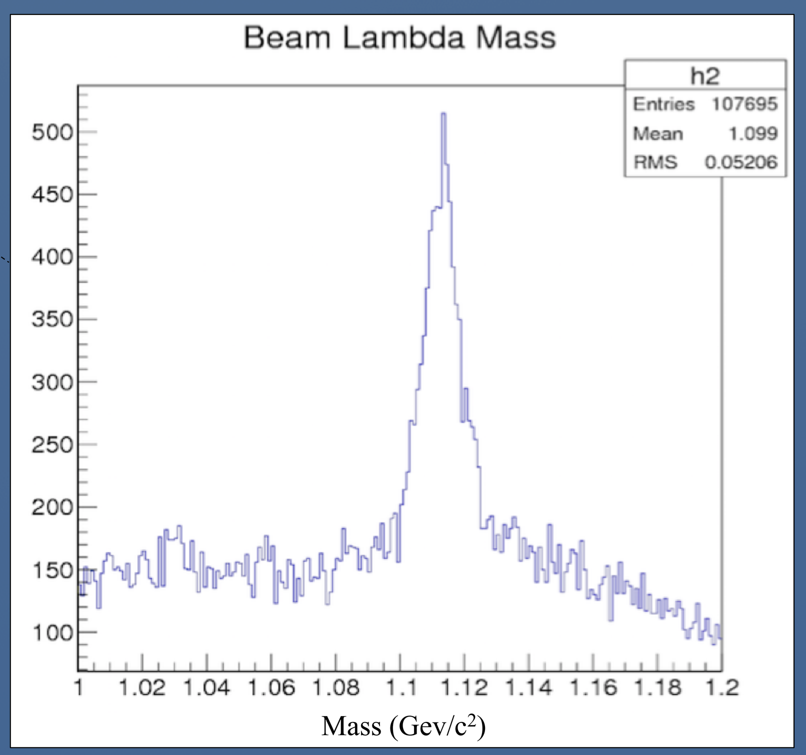
The process $\gamma p \rightarrow K^+\Lambda_b$; $\Lambda_b p \rightarrow \Lambda_s p$ has a final state of $K^+\pi^-$pp. We first calculate the invariant mass of the two π^-p pairs, and plot the one closest to the Lambda mass. There are more than 100,000 events in this peak, within 5 MeV of the known Lambda mass. For these events, we attempt to reconstruct the mass of the "beam" Lambda in the process $Xp \rightarrow \Lambda_s p$.



This peak has more than 2,500 events, more than the published world data sample. To fully reconstruct this process, we then use the resulting beam Lambda four-vector to look for a peak at the K$^+$ mass in the missing mass of the process $\gamma p \rightarrow \Lambda_b X$







Results

We have clearly observed Λp elastic scattering in the CLAS g12 run. A significant fraction of these events are initiated by the process $\gamma p \rightarrow K^+\Lambda$. By determining the number of events as a function of beam Lambda momentum and scattering angle, we hope to be able to greatly improve our present understanding of the cross section for this process.

Future Work

To calculate the cross section, we need to determine the integrated Λp luminosity. This will be accomplished by studying the momentum and angle dependence of the beam Lambda, and comparing it with published cross section measurements of the process $\gamma p \rightarrow K^+\Lambda$. In the future, this technique can be extended to other types of tertiary particles produced in the CLAS detector for measurements with beams other than photons and electrons.

Acknowledgements

This work is supported by the US Department of Energy under award number DE-SC0016547 and T34 GM008683 by the MARC U Star program at CSUDH.

U.S. DEPARTMENT OF ENERGY | Office of Science

MARC U*STAR Maximizing Access to Research Careers Undergraduate Students Training in Academic Research

clas

CSUDH CALIFORNIA STATE UNIVERSITY, DOMINGUEZ HILLS