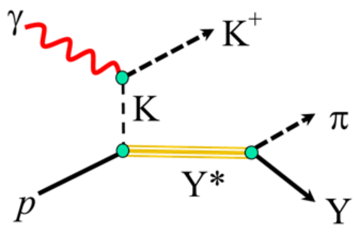
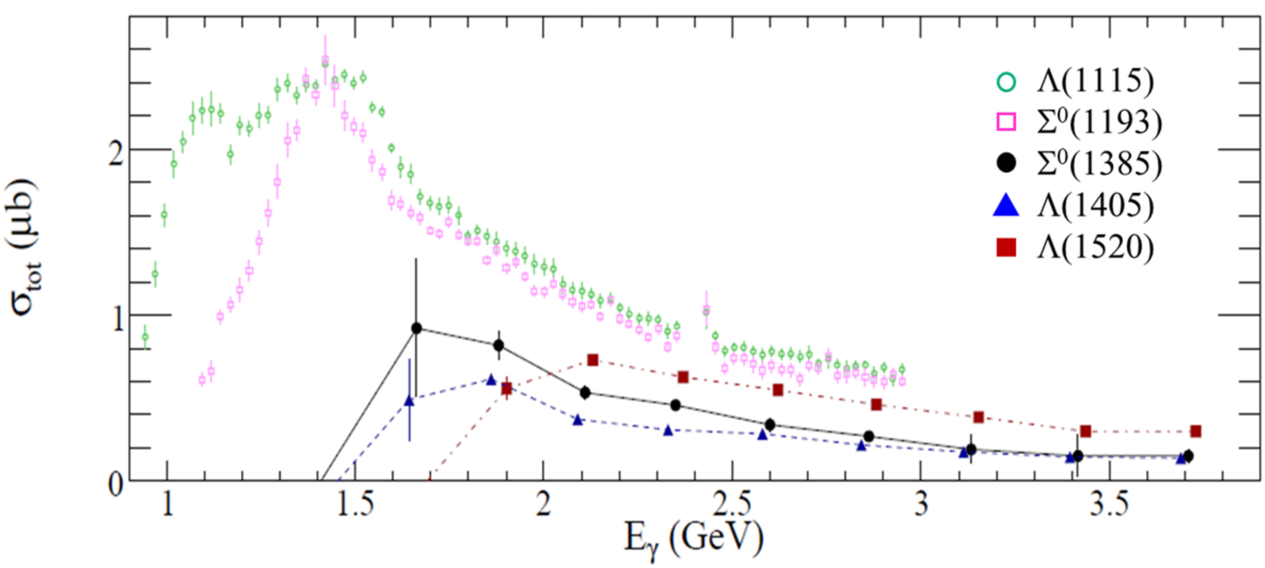
Photoproduction Cross Sections of the Excited Hyperons



Hyperons are 3-quark particles (baryons) related to protons and neutrons which contain one or more "strange" quarks in place of the usual "up" and "down" quarks. They are unstable, though the ground state hyperon lives long enough to travel several centimeters in the laboratory before decaying to lighter particles. With suitable particle physics detectors such as CLAS, however, all hyperons can be studied in detail. Properties of these "strange" particles are useful for understanding physics in areas as diverse as CP violation, the collective behavior of baryons in nuclei, and the structure of neutron stars. In the paper summarized here [1], the production cross sections for the first three "excited" hyperons, the Σ(1385), the Λ(1405), and the Λ(1520), were measured fully for the first time in reactions where a photon impinges upon a proton target. (Note that the numbers in parentheses are the mass-energy of the respective particles in MeV, to be compared to the 938 MeV mass-energy of a proton.) This production process "blows the proton apart" to create a new pair consisting of a strange quark and an anti-strange quark out of the vacuum, using the energy of the photon. In the laboratory, the end result is appearance of a *K* meson and one of the hyperons named above. Theoretical models for how this can happen are brought to bear on the data, and these models in turn probe questions of how Quantum Chromodynamics, the theory of the strong interaction, works in this energy regime.

The theoretical models tested in this study were based on the effective-Lagrangian approach, and the accuracy of the predictions was seen to vary widely (not shown on this page). The cross sections for the Λ(1405) region were seen to be strikingly different in the three available decay modes, $\Sigma^+\pi^-$, $\Sigma^0\pi^0$, $\Sigma^-\pi^+$, in contrast to any other state seen so far. This indicates the presence of isospin interference in the production mechanism of the Λ(1405), an effect not been seen in the cases of the other two hyperons. This suggests that there may be "new" isospin-one baryonic structure lurking underneath the Λ(1405), which is something that has been tentatively suggested by so-called chiral unitary models and models based on a diquark ansatz of baryonic structure. This line of research has sparked community interest and is being followed up at accelerator laboratories in Germany (Bonn/ELSA) and Japan (Osaka/Spring-8).

The figure below shows the integrated (total) cross section for the reactions measured in this experiment and also for production of the previously-measured ground state hyperons. All three excited hyperons are seen to have about the same size total cross sections, and they have comparable magnitudes to the ground state hyperons at high energies. This is the first time such a direct comparison of five different hyperon photoproduction cross sections has been achieved. This paper was selected as an "Editors Suggestion" at Physical Review for being particularly interesting or well written.



[1] K. Moriya, R. A. Schumacher *et al.* (CLAS Collaboration), *Differential photoproduction cross sections of the Σ^0(1385), the Λ(1405), and the Λ(1520)*, Physical Review C **88**, 045201 (2013).