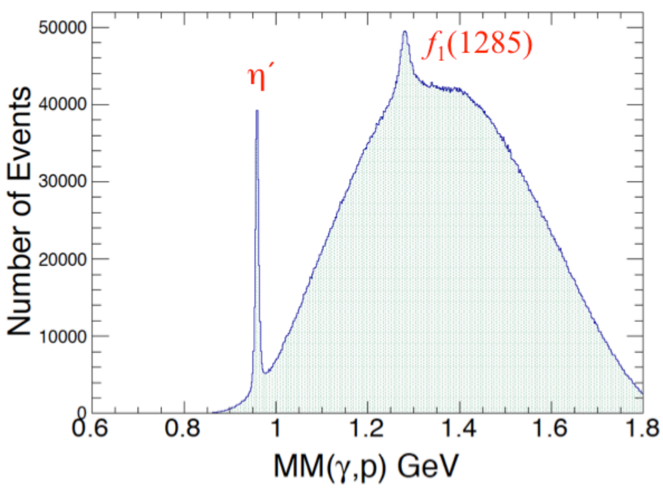
# First Photoproduction of the $f_1(1285)$ Meson

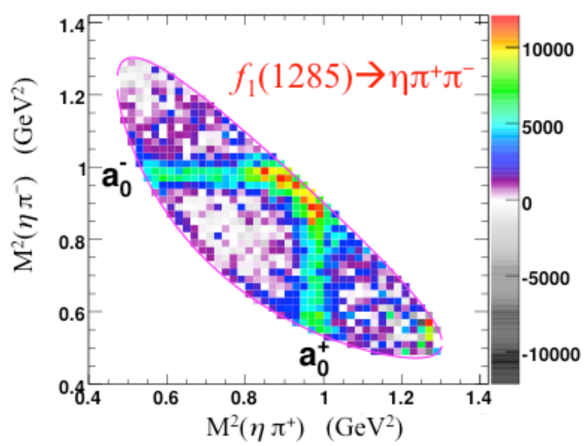
Pinning down the properties of subatomic particles is a key goal of particle physics. Beyond the stable particles that comprise our everyday world, dozens of unstable particles can be created and studied with facilities such as CLAS at Jefferson Lab. Physicists want to know their masses, lifetimes, decay products, intrinsic angular momentum ("spin"), parity, and their proclivity for being created when photon or electron beams strike a target made of protons. Collectively, this information allows us to find the big patterns in the subatomic world because all these particles are related within theories that we seek to improve upon.




For this experiment, CLAS was used to look at events where photon-proton collisions resulted in one $\pi^+$, one $\pi^-$, and one $\eta$ particle in addition to the target proton. The first Figure shows the mass distribution of created mesons using energy and momentum conservation. On a smooth background of unrelated events one sees two quite sharp spikes, one corresponding to the production of the well-known η' meson at a mass of 0.958 GeV and another spike at a mass close to 1.285 GeV. This second spike turned out, after careful study, to be the $f_1(1285)$ meson. No previous experiment has reported a sighting of this meson in this reaction [1].

In order for this identification to be made, it was necessary to examine the possibility that the second bump in the Figure was due to the η(1295) meson, which has nearly the same mass as the $f_1(1285)$. The quantum numbers for spin and intrinsic parity are not the same for these two states. In fact, both particles could be produced simultaneously, possibly even interacting with each other in ways stipulated by quantum mechanics. Telling them apart involved measuring the spin and parity of the events in the bump, after separating those events from the enormous number of background events at nearly the same mass.

The second Figure illustrates one step taken along this analysis trail. It shows the Dalitz plot of the squared mass combinations $\eta\,\pi^-$ vs. $\eta\,\pi^+$. After subtraction of the background, it turned out that the decay of the parent particle was dominated by prominent sub-decays into either of two charge combinations of the $a_0$ meson and the π meson, as seen in the two prominent bright bands in the plot. Furthermore, the brightest (red) portion of the plot, where the bands are close but don't touch, shows the signature of quantum mechanical constructive interference of the two dominant $a_0\,\pi$ decay amplitudes.




An amplitude analysis of the $a_0\,\pi$ decay bands showed that the quantum numbers of the decaying parent state were $J^P = 1^+$ and not $0^-$, with no sign of the η(1295) meson. Thus, it was shown that the photoproduced state is all the $f_1(1285)$ and not the η(1295). One reason this is significant is that an overpopulation of excited $0^-$ states in this mass range could be a sign of gluonic hybrids with these quantum numbers. The CLAS results reduce the likelihood of such supernumerary states being present. Production in the helicity system was dominant.

Also, the precise mass, decay width, differential production cross sections and several branching fractions for this meson were reported in the publication [1].


[1] R. Dickson, R. A. Schumacher *et al.* (CLAS Collaboration), *Photoproduction of the $f_1$(1285) Meson*, Physical Review C **93**, 065202 (2016).