Photo-production of $\pi^+\pi^-$ pairs on the proton

Mesons are unstable particles and can be studied measuring their decays to lighter particles. Many mesons decay to pions, which live long enough to be detected; the simplest channel to study is the ($\pi^+\pi^-$) system.

This channel offers the possibility of investigating various aspects of the meson resonance spectrum. It couples to the scalar-isoscalar channel that contains the σ and the f_0(980); it is the main decay mode of the lowest isoscalar-tensor f_2(1270) resonance and it is the only decay mode of the isovector-vector resonance, the ρ(770). Unfortunately the probabilities to produce these mesons are very different and therefore it is difficult to distinguish the small, and usually more interesting, states from the dominant ones. To select and isolate each meson we can exploit the different quantum numbers they have. In fact, the total angular momentum, J, carried by a particle is conserved in its decay and therefore, being the pion spin-less, J shows up in the relative wave of the ($\pi^+\pi^-$) system: the S-wave only contains contributions from scalar mesons (e.g. the f_0(980)), the P-wave from the vector mesons (e.g. the ρ(770)) and the F-wave from tensor-2 mesons (e.g. the f_2(1270). The other trick we used in the analysis was to look for observables that are sensitive to the interference of different waves. In particular, we looked for the interference of the dominant P-wave and the small and poorly-known S-wave. In this way a reliable extraction of tiny resonances was possible.

The results obtained with the technique described above (the so called *Partial Wave Analysis*) allowed us to isolate the contributions to the different partial waves and derive, for the first time in a photo-production experiment, the cross sections of the f_0(980) and the f_2(1270) mesons.

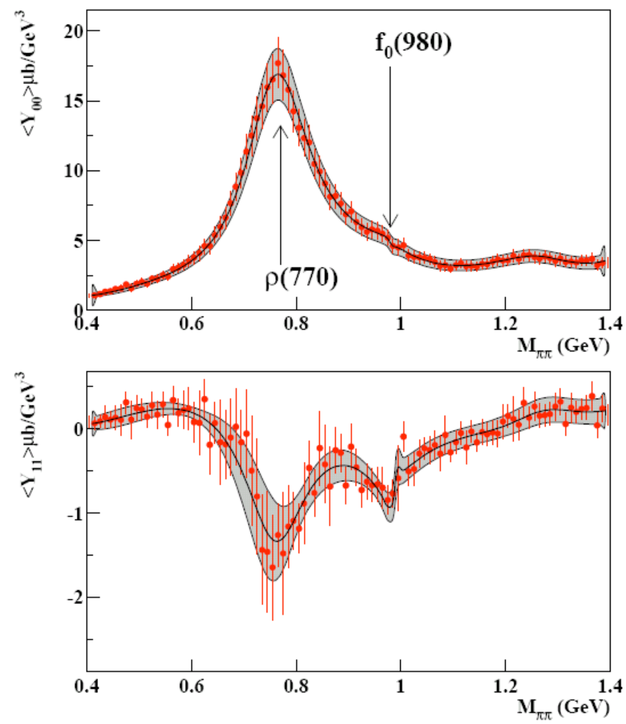

Figure 1: Invariant mass distributions of the measured ($\pi^+\pi^-$) system for all partial waves (top) and for a combination that enhances the contribution of the S- and P-wave interference (bottom). A meson resonance decaying into this final state is expected to appear in these spectra as a mass-dependent structure. No obvious signal for the f_0(980) is observed in the top plot because of the dominance of the ρ(770), while the signal becomes visible in the bottom spectrum, thanks to interference with the dominant P-wave.

We are planning to use the same technique on the data that will be collected with the CLAS12 detector to isolate and extract the weak signals associated to 'exotic' mesons, i.e. states that are not made by the standard quark-antiquark configurations but can consist of tetraquarks, hybrids (qqg) or glueballs.