# Nucleon-meson or quark-gluon?

Among the four fundamental forces in nature, the strongest interaction (strong interaction) and the weakest interaction (the gravity) are two least known forces. Quantum Chromodynamics (QCD), is the accepted theory of strong interaction with the underlying degrees of freedom being quarks and gluons. QCD has been extremely well tested by experiments at high energies where the interaction coupling constant becomes weaker and perturbative calculations can be carried out. However, in the non-perturbative regime, where ordinary matter lives, QCD is not solvable and is poorly understood. In low energies, nucleon and meson degrees of freedom have proven to be effective in describing strong interaction systems such as nucleon-nucleon interaction. The natural question to ask is where is the transition region between these two sets of degrees of freedom: meson-nucleon and quark-gluon.

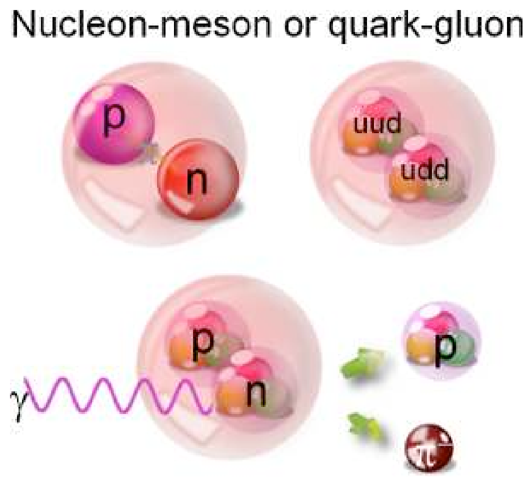


Figure 1: Illustration of the nucleon-meson and quark-gluon picture of the deuteron, and the pion photoproduction off neutron inside deuteron.

Pion is the lightest meson in nature and plays a very important role in the study of strong interaction. The processes of pion photo-production from nucleon have been the excellent candidates in the study of the transition from the meson-nucleon to the quark-gluon degrees of freedom. The constituent counting rule (CCR) behavior was proposed as a signature for the transition which predicts that the energy dependence of the differential cross sections at fixed angles is related to the total number of point particles and gauge fields involved in the process. Recently, we have completely mapped out such a "transitional" behavior in charged pion photoproduction from **CLAS g10 data** (Wei Chen *et al.* Phy. Rev. Lett. 103, 012301 (2009)).

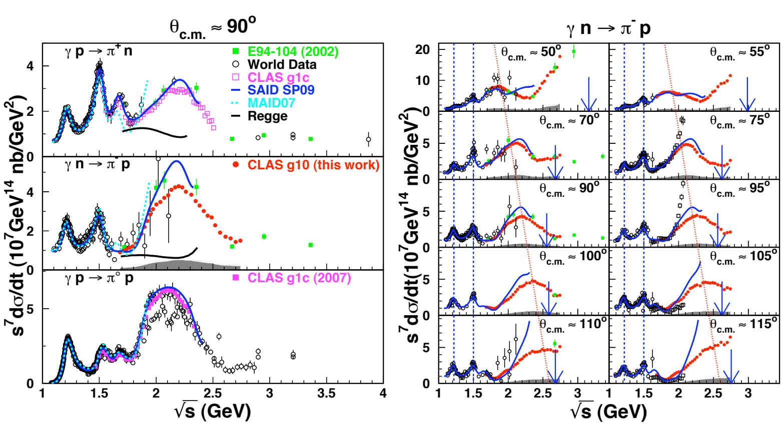


Figure 2: Scaled differential cross sections compared with world data and theories

With fine photon energy bins and high statistical precision, our data confirm a broad enhancement around $\sqrt{s}$ of 2.1 GeV in the scaled differential cross section as well as a marked fall-off of the differential cross section in a narrow energy window of about 400 MeV above this enhancement and the onset of the CCR scaling for $\sqrt{s}$ around 2.8 GeV (Fig. 2 (left)). An angular-dependent feature in the scaled differential cross section is clearly seen in our data (Fig. 2 (right)). It could be due to some unknown resonances which couple differently to the neutron channel than to the proton channel.