Gluons in the nucleon- The fundamental constituents of the atomic nucleus are protons and neutrons, collectively called nucleons. Both protons and neutrons are built from quarks bound together by the exchange of particles known as gluons. (They "glue" the quarks together in the proton or neutron.) The proton contains two "up" (*u*) and one "down" (*d*) valence quarks, while the neutron contains one *u* and two *d* valence quarks. By interchanging the *u* and *d* quarks in a nucleon, one changes from a proton to a neutron and *vice versa*. The relationship is known as isospin symmetry. It is believed that, since gluons interact in the same way with up and down quarks, the distribution of gluons in the proton and neutron should be identical. This statement requires experimental verification.

The gluon content of the proton and neutron can be probed by measuring processes that occur through the interactions of gluons from a beam and a target particle. The production of the Upsilon (ϒ) mesons is an example of such a process. (The ϒ consists of a "bottom" and an anti-"bottom" quark pair. The (anti-)bottom quark is too massive to exist within a nucleon.) A comparison of the rate of ϒ production with proton and neutron targets is then a comparison of the gluon content of those targets.

Using an energetic proton beam and hydrogen (proton) and deuterium (one proton and one neutron) targets, the E866/NuSea experiment at Fermilab was able to do just this. At the proton beam energy used by E866/NuSea, the production of ϒ's is completely dominated by the interaction of gluons. E866/NuSea isolated the ϒ by studying the invariant mass of its decay products (muons). From this, the number of produced ϒ's was extracted and the ratio of ϒ production on protons to ϒ production on neutrons determined. These data showed that the gluon content of the proton and the neutron are indeed very similar. Phys. Rev. Lett. **100**, 062301 (2008).

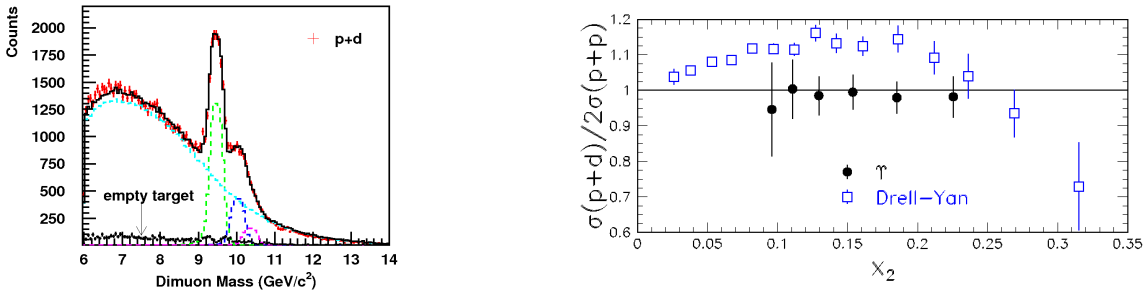

Figure: The invariant mass spectrum of muon pairs detected by E866/NuSea is shown on the left. The prominent peak is at 9.5 GeV is the ϒ. The ratio of ϒ production on deuterium to hydrogen is shown on the right (black circles) and is consistent with unity. Also shown is the same ratio for Drell-Yan production. The Drell-Yan mechanism is sensitive to the antiquark flavor in the nucleon, showing the isospin difference between the proton and neutron.

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