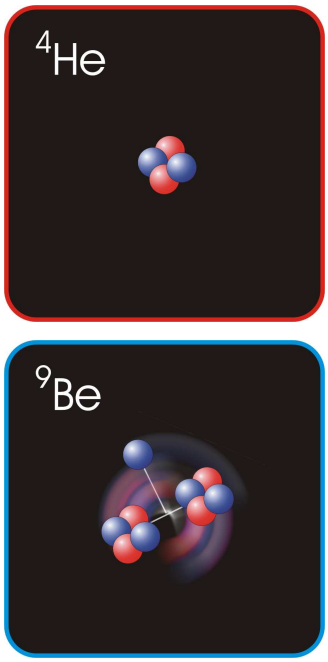
Density dependence of the quark structure of light nuclei

Electron scattering measurements from nuclei have shown a clear difference between the quark distributions in heavy nuclei and in deuterium, a phenomenon called the EMC effect. Our understanding of the origins of this difference is limited by the difficulty involved in modeling complex heavy nuclei. Answers to even very general questions have also been elusive: does the change in the quark distributions scale with the mass or average density of the nucleus, and is the effect simply the result of the binding of nucleons together into nuclei, or does it require a modification of the intrinsic quark sub-structure of the nucleons themselves?



Visualization of the dominant ^{4}He and ^{9}Be configurations

The Argonne Medium Energy Physics group proposed and performed JLab experiment E03-103, a clean and precise measurement of the structure functions of very light nuclei. These data can be compared directly to reliable few-body calculations, thus bridging the gap between measurements on complex nuclei and new, model-dependent, attempts to isolate modification to nucleon structure. We find that the EMC effect is similar for ^{4}He and ^{12}C, but much smaller for ^{3}He. The large difference between ^{3}He and ^{4}He rules out the mass-dependent fits that have been used to describe older data. In addition, the unusual structure of ^{9}Be, essentially two orbiting alpha-like clusters with an additional neutron, provides a unique test for the scaling of the EMC effect. The orbiting clusters yield a large radius and an anomalously *low average density*, even though most nucleons are contained within the *high local densities* of the alpha clusters. The large EMC effect for ^{9}Be rules out the models based on average density and provides the first evidence that it is the *local density* that determines the impact of the nuclear environment.

Size of the EMC effect vs. average nuclear density. A clear breakdown of the simple density dependence model for the EMC effect for ^{9}Be is observed.