# Investigation of the tetraneutron by quasi-free $\alpha$-knockout from $^{8}$He

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The possible existence of a four-neutron system as well as its properties has been a long-lasting question in nuclear physics that can be traced back to the mid-1960s.[1)] A recent experiment carried out at the SHARAQ spectrometer uncovered 4 candidate events for a $^{4}n$ ground-state resonance at $E_{^4n} = 0.83 \pm 0.65(\mathrm{stat}) \pm 1.25(\mathrm{syst})$ MeV with a $4.9\sigma$ significance level generated in a $^{4}$He($^{8}$He,$^{8}$Be) reaction.[2)] This measurement triggered new enthusiasm for both theoretical and experimental investigations of the tetraneutron system. State-of-the-art *ab initio* theory indeed supports the existence of a low-lying $^{4}n$ resonance.[3–5)] However, the definite experimental evidence is still pending.

To this end, we have performed an experiment at SAMURAI[6)] to investigate the $^{4}n$ system *via* a new method, *i.e.*, the measurement of $^{8}\mathrm{He}(p,p\alpha)^{4}n$ at large momentum transfer using a secondary $^{8}$He beam at an energy of 156 MeV/nucleon impinging on a liquid-hydrogen target of 5 cm thickness from the MINOS system. The $^{8}$He nucleus is expected to be a suitable environment to form the $^{4}n$ system in a ground-state resonance and the reaction process described above will allow for its unambiguous identification. As a consequence of the reaction kinematics (see Fig. 1) all outgoing particles are largely separated in momentum space, *i.e.*, final-state interactions are minimized and the reaction products of interest have a clean signature.

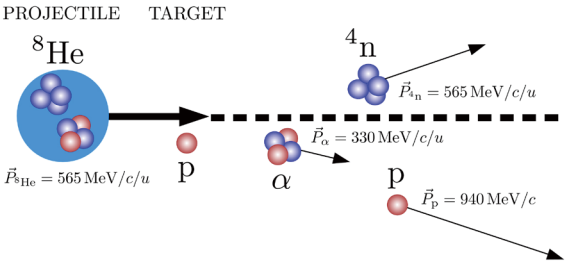


Fig. 1. Kinematics of the $^{8}\mathrm{He}(p,p\alpha)^{4}n$ reaction.

The $^{4}n$-energy spectrum will be deduced from the momenta of all charged particles *via* the missing-mass technique to identify the possible resonance and to determine its energy and width. Neutrons have been measured in addition with the combination of the neutron detectors R$^{3}$B-NeuLAND demonstrator and NEBULA, allowing for a kinematically complete investigation of the reaction and the study of the $^{4}n$ decay properties with lower but sufficient statistics. To reduce systematic uncertainties of the missing-mass reconstruction, an invariant-mass measurement for $^{6}$He, *i.e.*, $^{6}\mathrm{He}(p,p\alpha)^{2}n$ has been carried out for the purpose of calibration. The data analysis is in progress.

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