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Probing Neutron Stars with Neutron/Proton Ratios

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The symmetry energy contribution in the nuclear equation of state (EOS) can be used to learn about properties in the interior of neutron stars, like the composition of the star as well as its radius. So far constraints have been made on the EOS in symmetric nuclear matter in a range from 1 to 4.5 times saturation density while constraints on asymmetric nuclear matter above saturation density are not well determined [1][2]. Heavy ion collisions (HIC) have been used to probe the density dependence of the equation of state so as to gain better constraints for asymmetric matter [2]. At the NSCL we will be using the HiRA10 (High Resolution Array), an array of 12 charged particle telescopes, and LANA (Large Area Neutron Array) two neutron walls to measure neutron/proton ratios in HIC to help provide constraints on the EOS. Each of the HiRA10 telescopes consists of a 32 strip double-sided E detector, behind which is a 2 by 2 array of 10cm long CsI crystals. The two neutron walls each of which is made up of 24 bars filled with liquid scintillator, will be placed in front of one another so as to obtain the best possible efficiency. In front of the two neutron walls, we are adding a veto wall made of 24 overlapping thin plastic scintillator bars. The veto wall will be used to remove charged particles from our neutron spectra, which is a problem that we have had in previous experiments. In this presentation, I will discuss the progress of preparation of the two approved NSCL experiments using this set up and how we plan to extract the neutron/proton ratios and place better constraints on the nuclear equation of state.
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[2] D.D.S Coupland, W.G. Lynch, M.B. Tsang, P. Danielewicz, Y. Zhang, Phy. Rev. C 84, 054603 (2011).

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