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Present and Future Lead-based Supernova Detectors

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Lead is an interesting target material for a supernova detector. The neutron excess in lead nuclei leads to Pauli-blocking of the charged-current $\overline{\nu_e}$ interaction, and the high atomic number of lead Coulomb enhances ν_e over $\overline{\nu_e}$ giving a large ν_e CC neutrino interaction cross-section. This leaves a lead-based SN detector dominantly sensitive to ν_e through CC channels and to a lesser extent to ν_x through NC channels. Therefore, such a detector complements the dominantly $\overline{\nu_e}$ sensitivity of current water Cherenkov and liquid scintillator detectors worldwide. Supernova neutrinos, which undergo CC or NC interactions with the lead nuclei, eject one or two neutrons; so instrumenting lead with neutron detectors can be a cost efficient approach to robust supernova detector. The HALO detector at SNOLAB, running since May 2012, was designed to be a high live-time, low-maintenance, and low-cost dedicated supernova detector. HALO consists of a core of 79 tonnes of lead instrumented with 376 m of ^{3}He neutron detectors and surrounded by a layer of water shielding. The measurement of the ratio of two detected neutrons to one neutron has been shown to provide a measure of the temperature of the neutrinos, due to the distinct thresholds for one and two neutron emission in neutrino-lead interactions. Since October 2015 HALO has been a part of the network of SN neutrino sensitive detectors participating in the Supernova Early Warning System (SNEWS). The decommissioning of the OPERA detector at LNGS has potentially made available 1.3 kilo-tonnes of lead for future experiments. Efforts are currently underway to explore neutron detection technologies that could be used to instrument this sixteen-fold increase in mass for a more sensitive version of HALO at LNGS. The status of HALO at SNOLAB and plans for HALO at LNGS are reported.

Primary author: VIRTUE, Clarence (Laurentian University)

Presenter: VIRTUE, Clarence (Laurentian University)

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