LLNL direct reactions experiments at TAMU-CI

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Lawrence Livermore National Laboratory has two ongoing experimental setups at the Texas A&M Cyclotron Institute NeutronSTARS and Hyperion. Experiments in low energy nuclear physics reactions are conducted using the NeutronBall and a highly segmented charged particle detector array called STARS. Together the system is called NeutronSTARS and allows the direct detection of charged particles and neutrons from charged particle induced nuclear reactions. Similarly, Hyperion is a charged particle array surrounded by up to 14 HPGe Clover detectors which can detector gamma rays.

NeutronSTARS

NeutronSTARS consists of a highly segmented (192 element) silicon telescope array, in vacuum target changer, a segmented (6 volumes) 3.5 ton pseudocumene scintillator doped with 0.4% Gd neutron detector and high speed digital and conventional VME based electronics readout system.

The NeutronSTARS detector system was installed on the NIMROD beam line at the Texas A&M University Cyclotron Institute (see Fig. 1), and a benchmark experiment was fielded in December 2015,

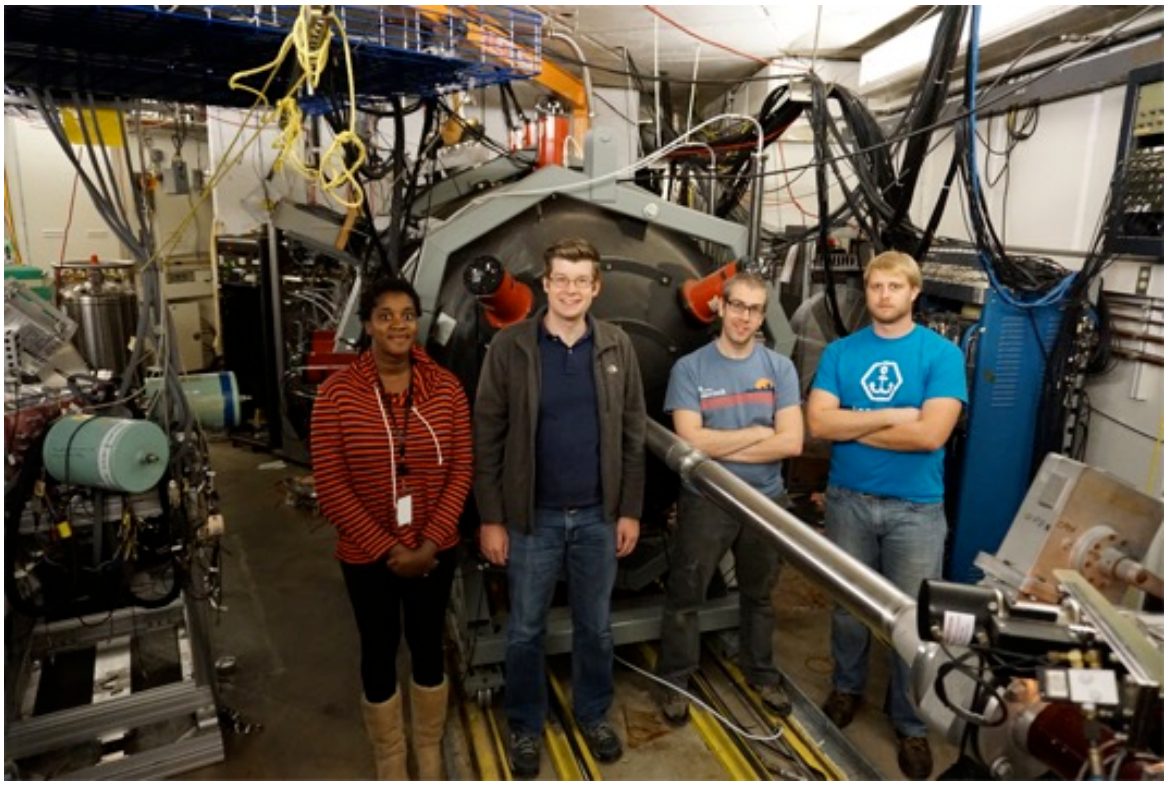

FIG. 1. NeutronSTARS detector system on a K150 Cyclotron beam line at Texas A&M Cyclotron Institute. The NeutronSTARS chamber is in the core of a 3.5 ton pseudocumene doped with ~0.4% of natural Gadolinium segmented detector tank. From left: Tomi Akindele (UC Berkeley PhD graduate student), Robert Casperson (LLNL staff member), Richard Hughes (LLNL post-doctoral researcher) and John Koglin (Lawrence Graduate Scholar/Penn State graduate student).

which involved an alpha particle beam incident on a ^{236}U target. The purpose of the experiment was to reproduce the ^{235}U(n,2n) cross section using the surrogate reactions ^{236}U(α,α'2n) and ^{236}U(α,α'f), along with the ^{235}U(n,f) reference reaction in an internal ratio. This experiment is intended to validate the technique, and analysis of the experiment is underway. As a number of repairs were made to the array before the experiment, the array has been recalibrated using the ^{12}C(α,α'γ) reaction, and spontaneous fission from a ^{252}Cf source. The reaction on ^{12}C is particularly useful, as it provides a 4.44 MeV gamma ray in coincidence with an alpha particle, and time gating can be used to isolate the signal. The ^{252}Cf source provides a known number of neutrons with a fission fragment tag.

NeutronSTARS is currently being used to measure cross sections of previously unobtainable (n,2n) reactions using the surrogate ratio method. Oluwatomi Akindele, from the University of California Berkeley, will be using the array to obtain the data needed for her PhD thesis. A summer student from Oregon State University was also participated in the test runs of NeutronSTARS, namely Aaron Tamashiro. A graduate student from the Pennyslvania State University has also participated in the experiments at NeutronSTARS; Johnathan Koglin.

Hyperion detector array

The Hyperion detector array was installed and commissioned at the Texas A&M Cyclotron Institute in the summer of 2015 (see Fig. 2). Hyperion is the largest gamma ray array owned and operated by the National Nuclear Security Agency. When fully instrumented it will hold up to 14 HPGe Clover detectors surrounding a central vacuum chamber where the targets are located. Hyperion has approximately a 12% photopeak efficiency at 150 keV and 3.5% at 1.0 MeV. Fully instrumented Hyperion will be a $4M detector array available to TAMU-CI and its collabroators for basic and applied science research.

Hyperion will be used to perform nuclear structure measurements, study the lifetimes of nuclear states, determine level densities and gamma ray strength functions and measure fundamental data to then use for surrogate reaction cross sections. All measurements use charged particle beams from the K150 Cyclotron at the Texas A&M Cyclotron Institute to induce low energy nuclear reactions.

Hyperion has been comissioned and performed two nuclear structure measurements since July 2015 before the Clover Share detectors had to be returned to the user community.

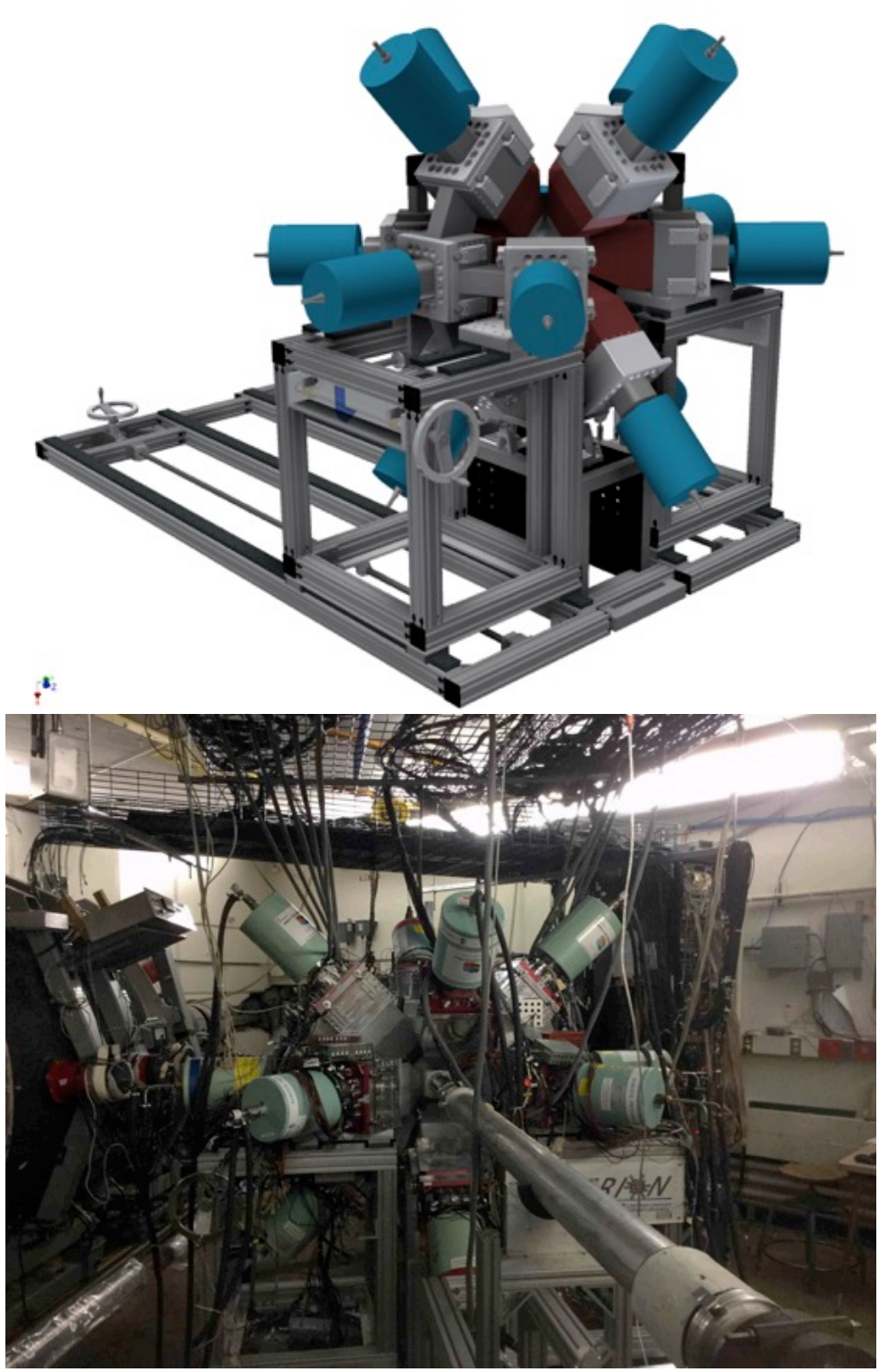

FIG. 2. Hyperion conceptual drawing in 2013 (above) and fully assembled with 13 HPGe Clovers from LLNL, the CloverShare program, the University of Richmond, and Texas A&M University (below).