STAR LiTe

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In November of 2011 work began on the installation of the silicon telescope array for reaction studies (STARS) and the Livermore-Berkeley array for collaborative experiments (LiBerACE) [1] at the Texas A&M Cyclotron Institute (TAMU-CI). The goal of this installation is to facilitate reaction studies making use of beams from the recently recommissioned K150 cyclotron. An official memorandum of understanding was signed in January of 2012. The new collaboration is referred to as STAR LiTe and consists of more than 55 researchers, post-docs, graduate and undergraduate students from five different countries and multiple national laboratories and universities.

Description of STARS

The silicon telescopes, reaction chamber and germanium clover array are as described in [1] and shown in Fig. 1. Briefly, a ΔE-E telescope of Micron S2 silicon detectors are placed in close proximity to the target, giving a large solid angle coverage. The Micron S2 detectors are annular silicon strip detectors which have 48 0.5 mm rings on the junction side and 16 wedge-shaped sectors on the ohmic side. Distance from the target to the detector determines the angular range covered, with approx. 30° to 62°

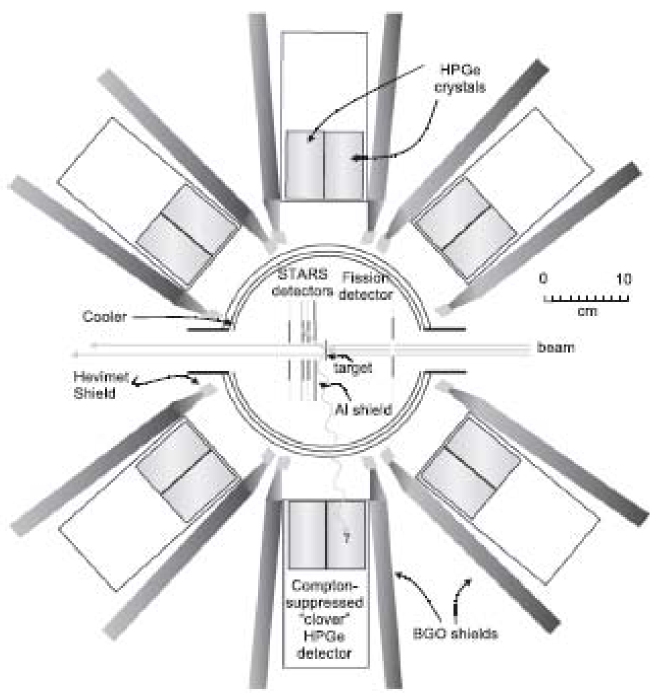

FIG. 1. STARS chamber and HPGe array [1].

being typical. An aluminum foil is placed in front of the ΔE detector in order to prevent δ electrons produced in the target from reaching the detectors. Additionally, an aluminum tunnel is used to block particles scattered at small angles (where the cross section is orders of magnitude larger than for the higher angles) from overwhelming the data acquisition system and damaging the inner rings of the detectors. An additional S2 detector is placed in the backward direction to detect fission fragments. γ-rays produced in the reactions are measured by a high efficiency array of segmented high purity germanium (HPGe) detectors. These detectors are Compton-suppressed by means of active bismuth germinate (BGO) shields. The signal of the each BGO shield is recorded for offline suppression.

A significant departure from the apparatus described in [1] is in the data acquisition system. CAMAC modules have been eliminated in favor of VME. CAEN N568B shaper-amplifiers are used for the silicon detectors as before, but now are also used for the BGO signals (one summed signal of the 16 individual BGO crystals is taken for each clover). For the silicon detector signals, discrimination of the N568B timing output is performed with CAEN V895 leading edge discriminators. The HPGe clover segment preamplifier outputs are fed into Mesytec MSCF-16s which act as both shaper amplifiers and discriminators. Digitization for all channels is by means of Mesytec MADC-32 VME ADCs. Timing information is through a CAEN V1190A TDC. An entirely new data acquisition software package has been developed which provides the user with comprehensive online data viewing and allows for a data rate in excess of 10 kHz. Currently the data rate is limited by the data network speed (10/100 Mbps), but near term plans to upgrade to a dedicated gigabit fiberoptic LAN should significantly raise this limit.

Installation at TAMU-CI

The new beamline was installed in Cave 4 in the place of the former Ion Interaction line. Special consideration was made to the quality of the beam spot that would be needed on target. Because of the close proximity of the silicon detectors to the target and the large solid angle covered, any beam halo that either hits the aluminum target frame or that scatters off the upstream collimators will have a significant impact on the data rate in the ΔE-E telescope and thus will severely limit the beam intensity that can be handled by the data acquisition system. This higher background rate has the effect of necessitating more beam time to achieve the same statistics for a given reaction being studied than would be the case with a better defined beam spot. Based on calculations performed by the accelerator physics group at TAMU-CI it was determined that two new quadrupoles would be necessary to achieve the desired beam spot quality. These consist of a y-focusing quadrupole immediately after the exit of the switching dipole (the Maryland magnet) at the beginning of line 7 and an x-focusing quadrupole just before the shield wall plug between the K150 vault and cave 4. These were in addition to the two existing quadrupoles that were part of the Ion Interaction line. An XY steering magnet was installed after the last quadrupole.

To aid in tuning the beam a large viewer was added just upstream of the chamber. Additionally, a series of targets are used to further improve the beam spot. First a solid phosphor target is used to focus the beam at the target position. This is then replaced by a phosphor with a ¼” hole in the center that is used to check for any halo on the beam. Further refinement is then achieved by minimizing the rate in the downstream silicon detector telescope while maximizing the current in the beam dump faraday cup with both the beam passing though the phosphor with the ¼” hole and also through an empty target frame.

A beam test was performed in February of 2012 with a 9 MeV/nucleon ^{18}O beam from the K150 cyclotron. A beam spot of 3mm at the target position was achieved and is shown in Fig. 2.

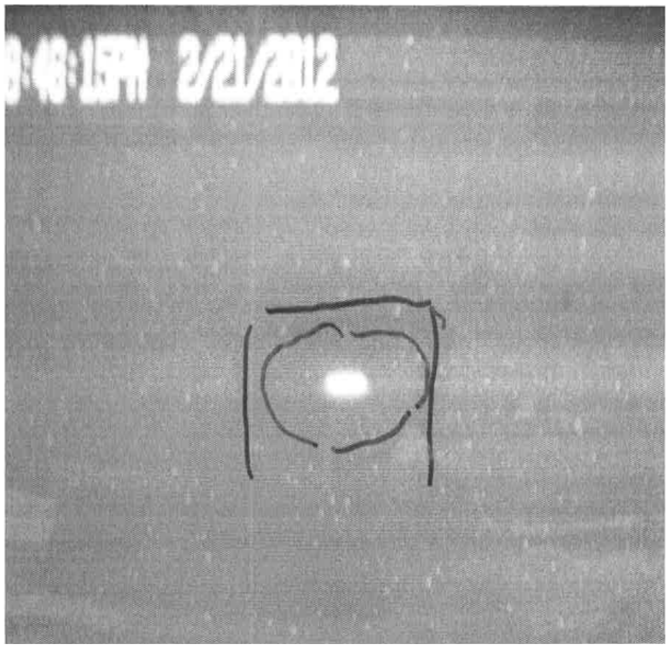

FIG. 2. First beam test on target. The target frame (with a ¾” hole) is drawn for reference.

Commissioning run: ^{240}Am(n,f)

For the first experiment a measurement of the ^{240}Am(n,f) cross section via the surrogate reaction ^{243}Am(p,t)^{241}Am* was performed. The beam of 34 MeV protons from the K150 cyclotron was used, with approximately 3.6 pnA on target and an empty frame background rate in the silicon detectors of approximately 1.2 kHz. Particle identification is shown in Figure 3. Analysis of this experiment is ongoing.

Summary

The STARS-LiBerACE experimental setup has been relocated to TAMU-CI in an effort to further the already established experimental program of measuring reactions of interest for nuclear astrophysics, stockpile stewardship and nuclear energy. Installation is complete and as of May 2012 two data-taking experiments have been performed.

Acknowledgements

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[1] S.R. Lesher *et al.*, Nucl. Instrum. Methods Phys. Res. **A621**, 286 (2010).