Commissioning of neutron detector array TexNeut

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The capability to detect fast neutrons has a variety of applications including basic nuclear science, astrophysics, and national security. We have constructed a neutron detector array, TexNeut, for measuring fast neutron energies which are produced in nuclear physics experiments related to these topics. In 2021 TexNeut was assembled, and a two-week commissioning run followed.

After research and development during previous years [1-3], we constructed TexNeut in 2021, as seen in Fig. 1 (left). TexNeut is an array of pseudo-bar neutron detector modules. These bars are a novel take on conventional bar-type scintillation detectors commonly used for neutron TOF spectroscopy [4]. Each bar is comprised of 6 *p*-terphenyl organic crystal scintillators of dimensions 2x2x2 cm^3 which are optically coupled to make a segmented bar. The bar is wrapped in a specular film and light collection is readout by PMTs at both ends of the bar. The construction of these bars does not noticeably suppress the PSD capabilities of *p*-terphenyl but gives rise to position sensitivity in the bar with resolution that matches the size of the crystal. This position sensitivity can be seen in Fig. (right). A total of 48 bars were

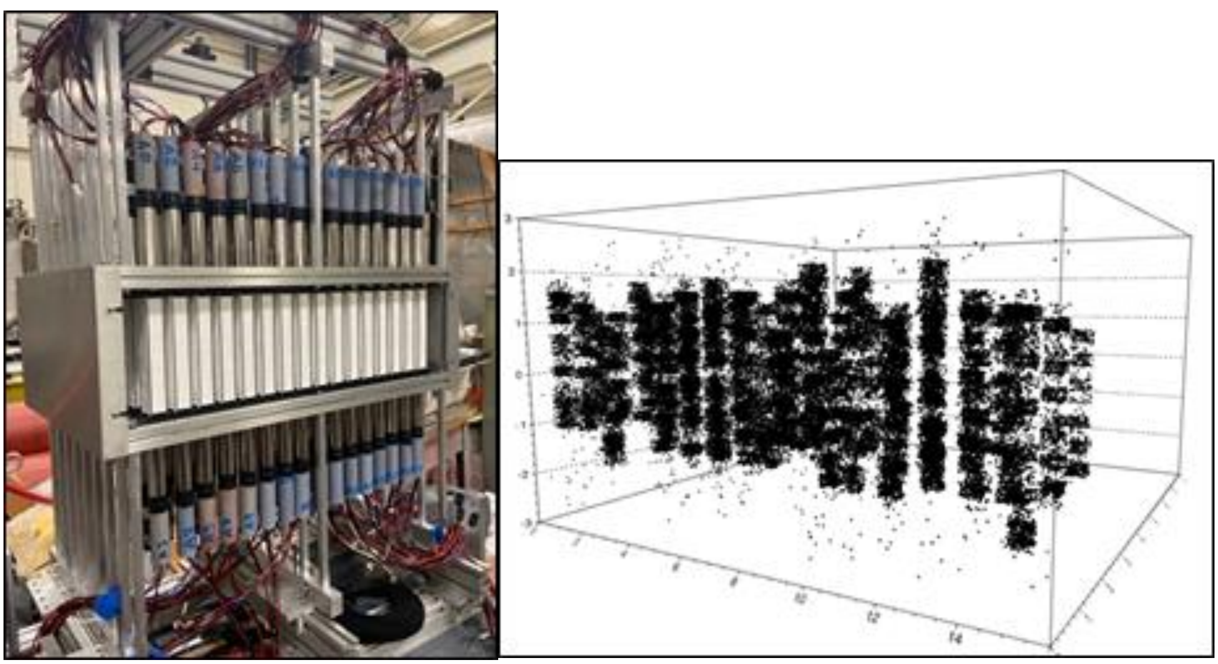

Fig. 1. (Left) A photo of the TexNeut array. (Right) A scatter plot showing the 3D hit pattern of neutrons in the array from ^{252}Cf. X- and Z- position are given in units of row number and column number. Y- is the calculated intra-bar position from pseudo-bar data. Note the discrete blobs which correspond to discernable crystals.

constructed for the commissioning run with upwards of 100 bars slated for the full assembly. Data are acquired by a Wash. U. St. Louis-developed DAQ that implements the PSD-8C ASIC chips [5].

A series of experiments were carried out during the beam time. These tests used TexAT as either a simple vacuum chamber or in its usual configuration as a gas tracking detector for thick target inverse kinematics (TTIK). First, we impinged a ^{7}Li beam on a thick tantalum foil to produce a localized γ-ray flash. A time-of-flight spectrum was generated by measuring the time between the TexNeut start trigger and the MARS scintillator, located just before the entrance to the TexAT chamber, as a stop. These γ rays were detected in TexNeut and will be used as a reference time for the event timing recorded by TDCs. We observed a γ-ray peak consistent with the TOF from the target to the detector.

After successful observation of the γ-ray peak, the tantalum foil was removed and was replaced by a solid thin polyethylene (CH_2) target with stable ^{7}Li beam. In this test, TexAT was operated as a vacuum chamber with no detectors or gas being used. We performed ^{7}Li(*p*,*n*) in this configuration and detected neutrons from the reaction and saw a peak in the timing spectrum corresponding to a ^{8}Be 3^{+} resonance that we expected to see. A preliminary spectrum for the solid target run is shown in Fig. 2 (left).

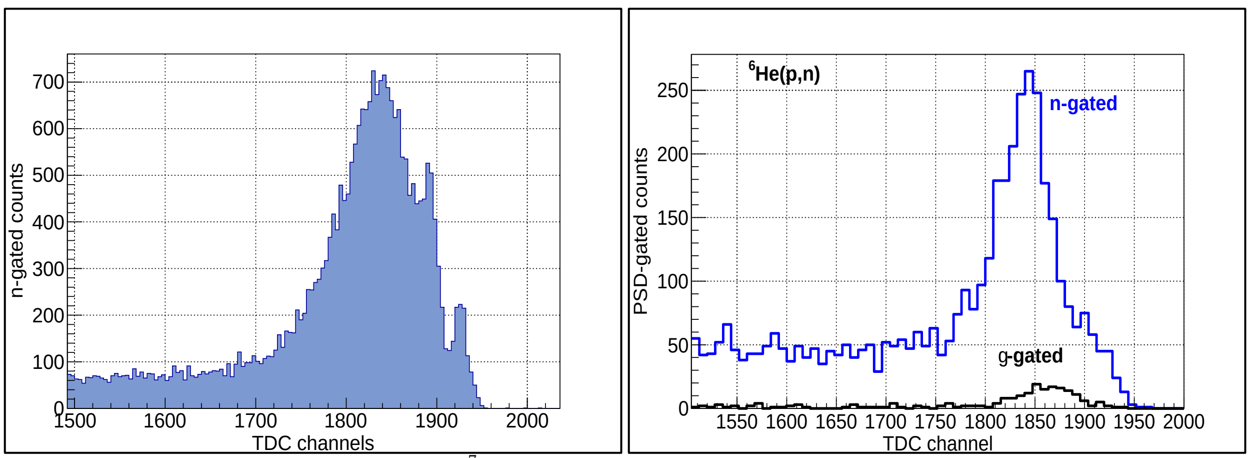

Fig. 2. (Left) Neutron TOF spectrum from ^{7}Li(*p*,*n*). Due to the nature of the triggers, low energy corresponds to the right side of the abscissa. Here, singular crystal position is not considered, causing the already broad resonance to appear slight more so. (Right) TOF spectrum for neutrons and γ-rays from the ^{6}He(*p*,*n*) reaction. Again, only the bar location is considered but not the crystal of interaction.

Following the thin target run, TexAT was filled with 200 Torr of isobutane. Using TexAT for TTIK, we performed the ^{6}He(*p*,*n*) reaction measurement. With gas in the chamber, the micromegas detectors were then employed. During online analysis, a preliminary spectrum was created which is shown in Fig. 2 (right). The spectrum seems to agree with the expected spectrum [6] which indicates the population of the T=3/2 isobaric analog state (IAS) of ^{7}He in the J^{π}=3/2^{-} state of ^{7}Li. The last week of the run was spent with a beam of ^{9}Li from MARS to perform the ^{9}Li(*p*,*n*)^{9}Be measurement. The purpose of this reaction is to populate T=2 IAS states in ^{10}Be which are analogues to states in ^{10}Li. This will help us continue our investigation of ^{10}Li with previous reaction data of the ^{9}Li(*p*,*p*) reaction performed in late 2020 [7].

At the end of our beam time, we have begun analysis of the data. Additional data were taken from multiple γ and n/γ sources to be used for energy calibration and optimization of n/γ PSD. Background runs were also taken for later assessment. We are currently working out the energy and PSD calibrations on a crystal-by-crystal bases. Following this will be the incorporation of TDC information for kinetic energy reconstruction.

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