Status of TeBAT (Texas-Birmingham Active Target) detector development

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A new state-of-the-art active target TPC (Time Projection Chamber) detector system, TeBAT, has been under development at the Cyclotron Institute since 2019. The TeBAT detector utilizes a new technology based on Micromegas with a DLC (Diamond-like **c**arbon) resistive readout layer, which allows for position resolution as good as 200 μm. We expect this will result in unprecedented angular resolution on the order of 0.1 degrees, which is critical for many nuclear reaction studies.

The design of TeBAT is similar to the existing TexAT detector [1] in terms of geometry. TeBAT consists of a micromegas-based gas detector, surrounded by an array of Si/CsI(Tl) detector telescopes to measure the total energy of light fragments escaping the active TPC volume. Both TexAT and TeBAT setups will share solid-state detector parts. The details of the conceptual design of TeBAT are presented in [2].

Here we report on the status of the TeBAT project.

Detectors:

- The first (out of five total) resistive (DLC) layer micromegas detector has been manufactured by CERN, delivered, and is under testing in the lab (shown in Fig.1). Two more DLC- layer micromegas detectors are in production now and are expected to be delivered by the end of 2023. Another standard micromegas (no DLC) is expected by the Fall of 2023.
- Five GEM (**G**as **E**lectron **M**ultipliers) produced by CERN are delivered and ready to be tested. They consist of a thin (50 mm) double-copper-clad kapton foil, chemically perforated by a high density (50 holes/mm^2) holes of □=50 mm. The geometry of the active area is custom designed to fully match the TeBAT Micromegas detector. The GEM foil is segmented into 6 zones allowing us to create avalanche areas with different gas gain by varying the applied bias by region.
- A set of 10 custom-designed silicon detectors to match the current TexAT/TeBAT detectors from Micron Semiconductor Co. (UK) have been purchased and were delivered in 2022. The thickness of the Si- detectors is 500 μm (8 total) and 1000 μm (2 total). They will be shared between both the TexAT and TeBAT setups. With the 10 existing 50 mm x 50 mm Si-detectors for TexAT, the total Si-detector coverage is about 30%. We are planning to order ten more Si detectors in 2023 to make all but the bottom sides of TexAT/TeBAT covered.
- CsI(Tl) scintillation detectors are available to totally cover TexAT/TeBAT.

- Beam monitoring detectors - 3 different detectors are designed for TexAT and will be shared for operation with TeBAT. They are a) a gas ionization counter; b) an auxiliary small Micromegas-based gas detector ([3]); c) a thin scintillation detector with SiPM readout following the design used for TexAT_v2 ([4]).

a b

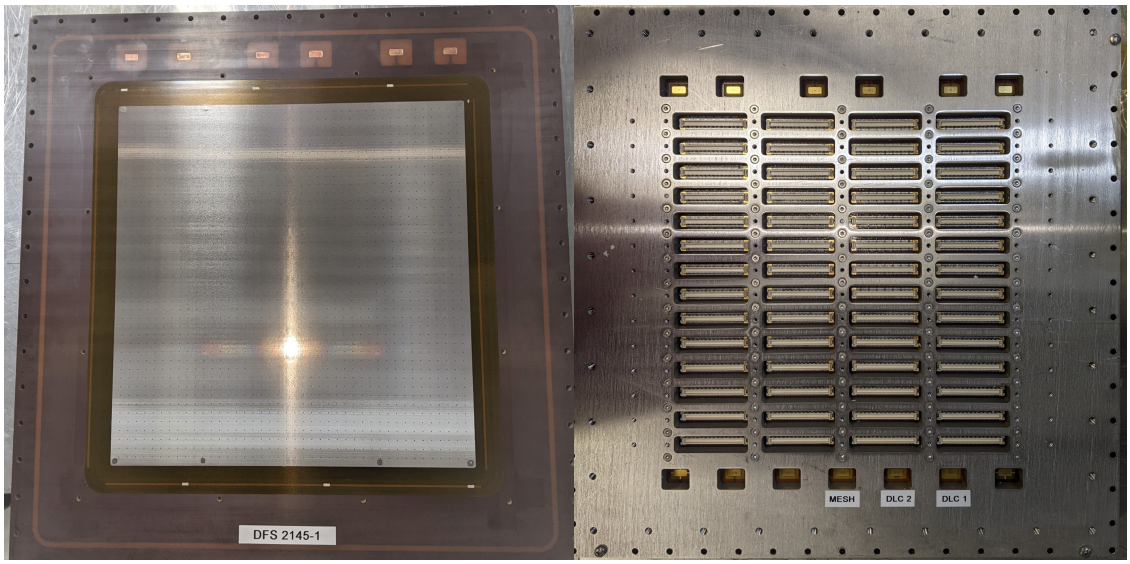

Fig. 1. TeBAT DLC Micromegas detector. a) Front side view; b) Rear (readout) side view.

Hardware:

- The flexible printed circuits (FPC) "flex" cables to carry signals from 7,000 channels without any cross-talk among channels were designed and tested. Four out of 28 cables have been produced by CERN, the rest are expected by the end of 2023. Each cable carries 256 signals.
- The Scattering chamber has been designed and now is in production at local workshops (split between the Cyclotron Institute and the Department of Physics TAMU). We expect it to be ready for tests by early Fall 2023.
- The support structure for the front-end electronics (ASAD- boards) and ZAP (protection) boards have been designed and developed in-house.
- The vacuum/gas handling system, similar to TexAT's has been designed. The parts of the system have been purchased. The system is expected to be completed by the Fall of 2023.
- Additional LV and HV supplies have been ordered. The LV modules to power all the ASAD boards have been delivered and tested.

Parts to be made:

- Transparent field cage for TeBAT – designed and expected at the end of 2023.
- Gating grid to solve the "space charge" problem of the incoming beam area.

Electronics:

As described previously [2], the readout of signals from TeBAT is performed by the General Electronics for TPC (GET) [5]. The GET electronics for TeBAT consist of 1 μTCA crate, 1 Mutant trigger module, 9 CoBo (Concentrator Board) modules, and 28 AsAd motherboards. Two of these AsAd boards will have the new STAGE chips to replace the older AGET chips. These new chips have been tested recently and allow for better low-multiplicity triggering and a long peaking time (8 μs) to facilitate the readout of the CsI(Tl) detectors directly without the need for external shaping. A detailed description of the GET electronics is explained in Ref. [5]. Most of the electronic modules are present and are to be shared with TexAT. The new AsAd (24 total) and CoBo modules (6 total) are tested and operational.

Software:

A new streamlined conversion tool to allow for quicker analysis of the data (Catalytic [6]) has been developed and tested. Additionally, a base analysis framework (Himalaya [7]) to analyze the new TeBAT data has also been written and tested with previous TexAT data. Both of these software tools will undergo further development as the first test data become available from TeBAT to optimize the track reconstruction techniques.

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[5] E.C. Pollacco *et al.*, Nucl. Instrum. Methods Phys. Res. **A887**, 81 (2017).
[6] https://github.com/tamu-edu/gr-Catalytic
[7] https://github.com/tamu-edu/gr-Himalaya