Texas active target (TexAT) detector – part 1: Design and construction progress

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Construction of a general purpose active target detector - Texas Active Target (TexAT) for experiments with rare isotope beams at the Cyclotron Institute is in progress. TexAT will be used for wide variety of experiments to detect the charged products of nuclear reactions with rare isotope beams. Resonance elastic and inelastic scattering of protons and α-particles, (α,p) and (p,α) reactions, nucleon-transfer reactions, such as (d,p), (d,^{3}He), (p,d), (p,t), (^{4}He,t) and decay spectroscopy studies are the examples of the experiments that can be performed with TexAT. The Monte Carlo simulation package has been developed to guide the design of the layout of TexAT and to evaluate the reliability of tracks reconstruction, energy and position resolution. More details on the Monte Carlo simulation package are given in a separate report.

The general layout of the TexAT detector is shown in Fig. 1. Setup contains a Time Projection Chamber (TPC) with a high level of segmentation in the readout plane, surrounded by array of 58 Si detectors backed with an array of up to 58 CsI detector. The length of an active area is 224 mm and it covers solid angle of about 3π, providing high efficiency for experiments with low intensity exotic beams.

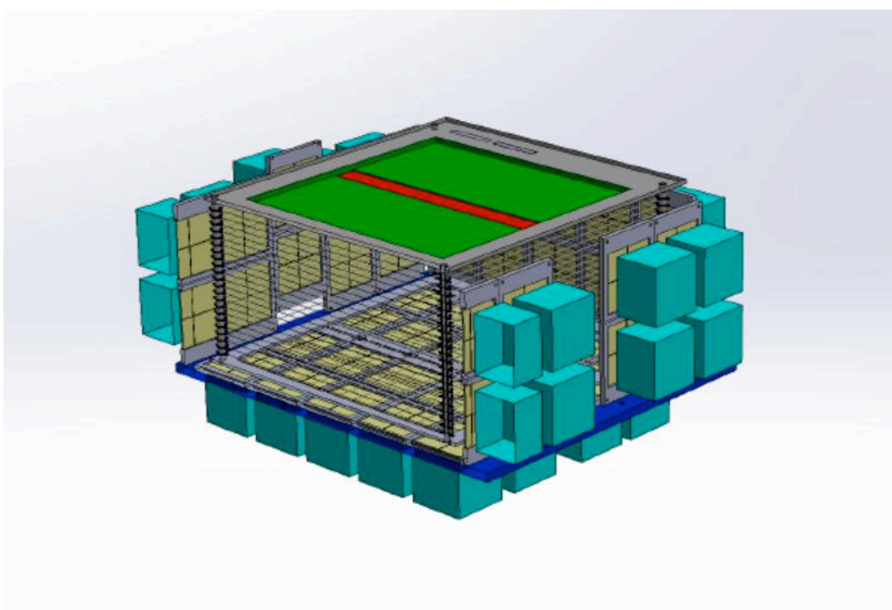

FIG. 1. TexAT assembly (one side of array is removed to show details).

I. Time projection detector.

The key component of TexAT is a time projection chamber with a readout based on Micromegas (Micro-MEsh Gaseous Structure) technology [1]. The mesh and the readout pads are mounted on PC board plate that covers active area of 224mm x224 mm. A Field Cage provides a uniform electric field that generates a drift of electrons produced by the ionization of incoming ions and recoils. The total number of readout channels is 1024. The board is divided into three areas as shown in Fig.2: the zone to the left of a beam axis (L), the beam axis zone (C) and the zone to the right of the beam axis (R). Central part along the beam axis (21 mm wide) has high segmentation: 128x6=768 individual pads (the pad size is 1.75mm x 3.5 mm). The pads are arranged so that there are 128 pads in the direction of the beam (long 224 mm side) and 6 pads in the direction perpendicular to the beam (21 mm long side). The left (L) and right (R) areas are identical and have dimensions 224 mm x 101.5 mm. Each one consists of of 64 strips, perpendicular to the beam axis. The strip is 1.75mm x101.5mm. There is 1.75mm space between strips to allow for an individual pad to be placed between the strips. Distance between the centers of the strips is 3.5 mm. There are 64 individual 1.75mm x 1.75 mm pads between each two strips. These pads are not connected between each other. However, each pad is connected to the corresponding pads placed between other strips, so that there are 64 "chains" of pads arranged in the direction parallel to the beams axis.

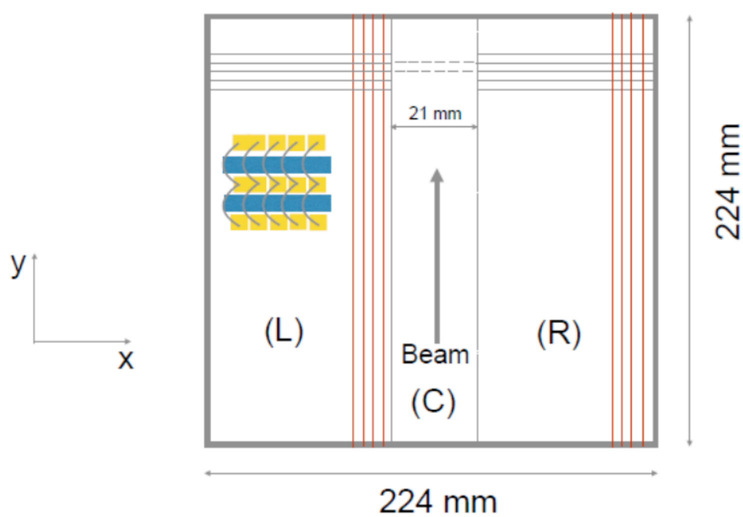

FIG. 2. Micromegas PC board design.

Optimized channel map has been designed to provide for a more uniform expected readout rate for different AGET chips. After fabrication at CERN Micromegas PC-board and bulk detector (PC board and installed mesh) has to be fully tested at IRFU (Saclay, France) and sent to Cyclotron Institute. Expected lead time: Fall of 2015.

II. Field cage design.

Field cage must generate the uniform electric field for time projection volume with sufficient field strength to provide constant electron drift velocity. Besides, the cage has to be as transparent as possible for the reaction products escape the field cage and be detected in Si array with minimal losses. The geometry of field cage is specified by Micromegas detector and Si detectors design: 260 mm x 260 mm x 150mm; a 50 micron thick gold plated tungsten wire has been chosen as an element to create transparent cage.

To optimize geometry of field cage the simulations with computer codes GARFIELD [2], GMSH [3], ElmerFEM [4] have been performed to estimate electric field uniformity for different wires spacing, and create the best condition for electron drift inside the active target. It was shown (see Fig.3) that the field fluctuations appear to be around 10% which leads to less than 1% change in velocity if we run with correct field strength. The sufficient spacing between field cage wires is about 5 mm, that allow us to load wires with extension springs to avoid wire sagging.

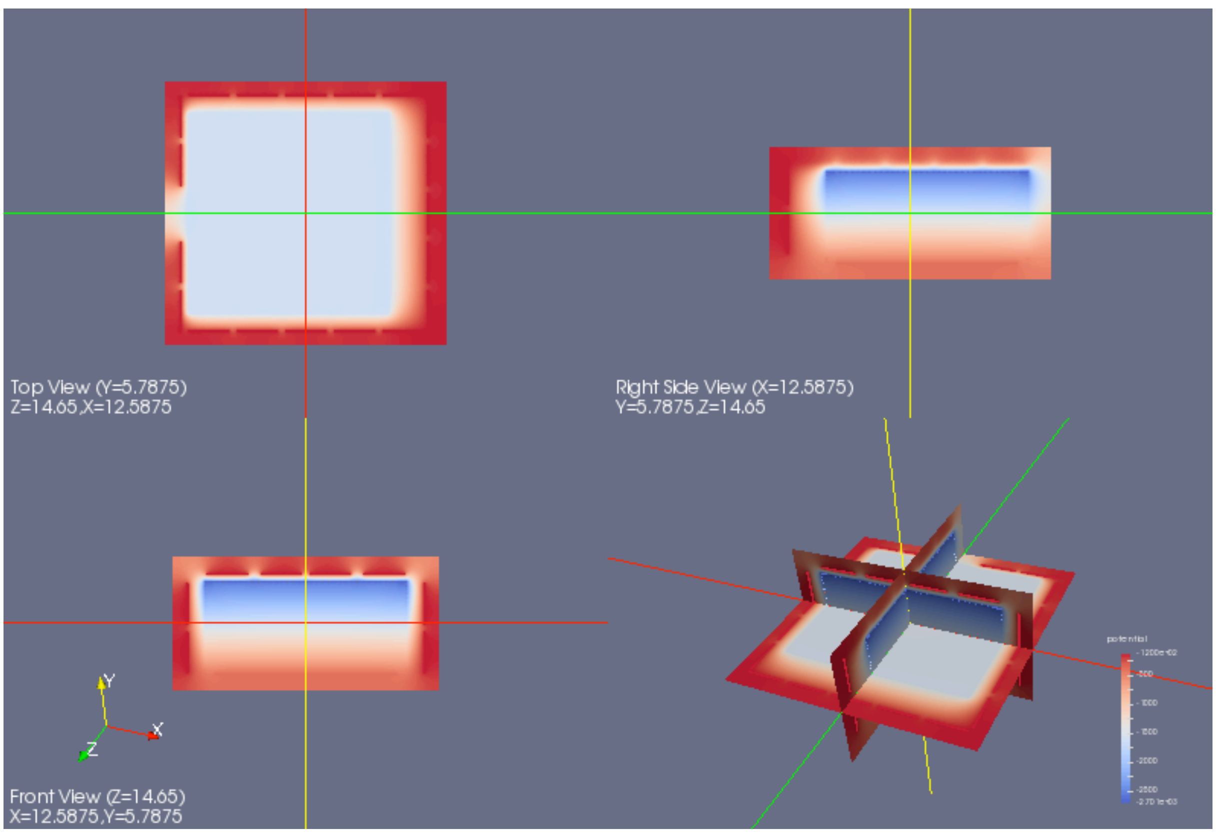

FIG. 3. TexAT electric field simulations.

III. Solid state detectors array.

Quad-segmented Si detectors (58 total) will surround bottom and four sides of TPC independently, providing an easy access to any component of detector array. Geometry of side, upstream and downstream arrays are slightly different, allowing entrance for incoming beam in upstream wall. We received a first set of five Si- detectors, designed at BIT Ltd (Kiev, Ukraine). These detectors have been tested with alpha- source, and the performance has been found to be meet expectations (an average energy resolution of all detectors is less than 50 keV). The remaining detectors will be ordered at the same company. A set of first five custom scintillation CsI(Tl) detectors with scintillator dimensions 50x50x40 mm^3 was produced by SCIONIX (Netherlands). They will be tested after shipping (expected by the end of May, 2015).

IV. Scattering Chamber.

A custom vacuum and target gas chamber has been designed to hold the detector array and to maintain the workable conditions for both gaseous and solid state (silicon and scintillation) detectors. It provides an easy access to any component of the detector array and versatile installation at any beam line (either the beam line at the end of the MARS separator or a future designated beam line). Chamber meets the stringent requirements for steady operation of impurities-sensitive Micromegas detector, namely: clean vacuum/gas (avoid as much as possible

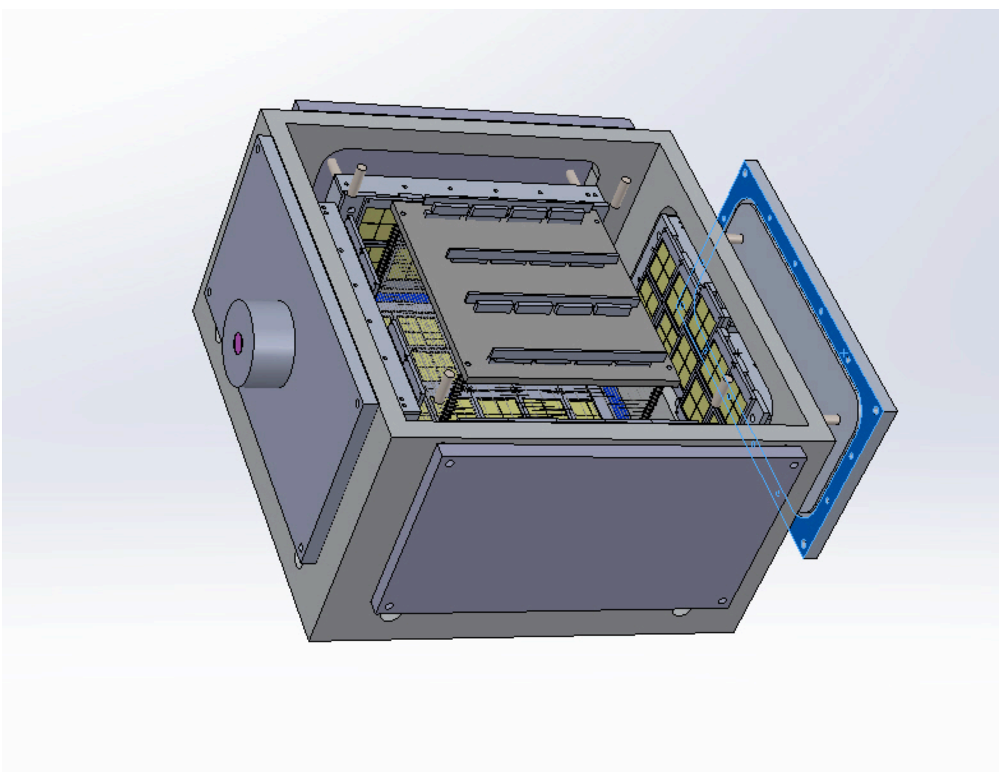

FIG. 4. TexAT design (general view).

outgassing from the chamber walls and a vacuum leak rate at the range of 10E-8 atm-cc/sec). It has aluminum body cuboid shape: 20" x 20" x 13.5" with lids and all necessary ports for vacuum/gas handling installation and signal feedthroughs. A fabrication order has been submitted to A&N Corporation and it has to be complete at the end of May, 2015. The general view of TexAT setup is shown in Fig.4. Most of the major components of TexAT have been designed and ordered and now they are nearing completion on schedule. We expect that the first commissioning run with TexAT will take place at the end of 2015.

[1] Y. Giomataris *et al.*, Nucl. Instrum. Methods Phys. Res. **A376**, **29** (1996).
[2] http://garfield.web.cern.ch/garfield/
[3] http://www.geuz.org/gmsh
[4] http://elmerfem.org/