Auxiliary detectors for TexAT detector

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The active target detector system TexAT (Texas Active Target) is being constructed at the Cyclotron Institute to study nuclear reactions with radioactive beams (see the 2015 Cyclotron Annual Report for general outline of the detector). One of the important applications of the TexAT detector is to study the transfer reactions, such as (*d,p*) and (d,^{3}He), in inverse kinematics using radioactive ion beams (RIBs). That requires auxiliary detector systems to be implemented for TexAT. The sketch of the complete system is shown in Fig. 1.

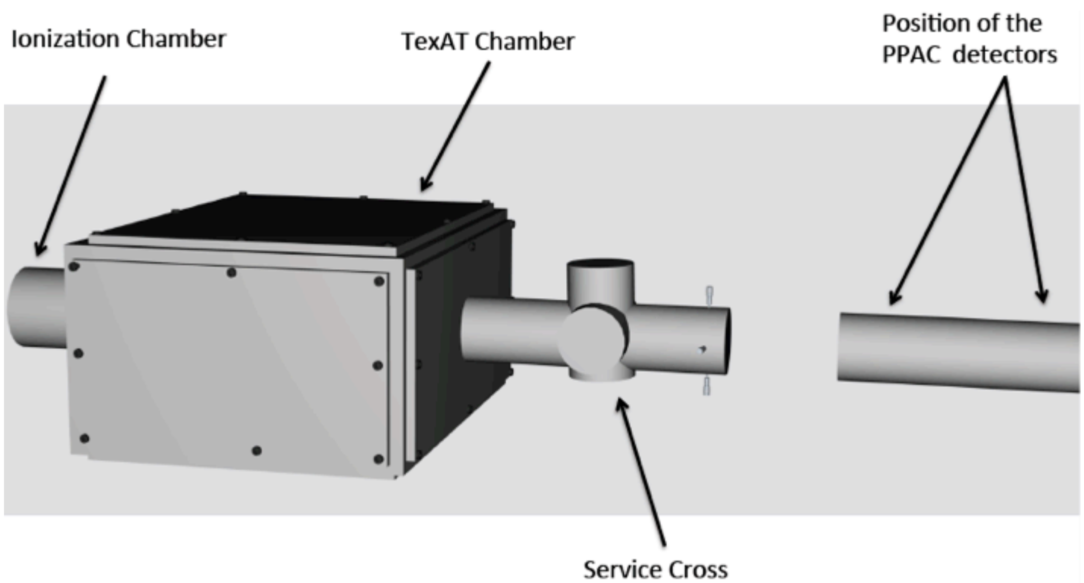

FIG. 1. General sketch of the custom vacuum and target gas chamber of the Texas Active Target (TexAT) Detector.

First, a beam monitor detector system should be added to the TexAT detector to facilitate rare isotope beams development and diagnostics and to provide additional beam tracking capabilities during the experiment. Two PPAC detectors [1-2] will be installed to measure the profile of the radioactive ion beam and track the incoming beam ions. Both PPAC detectors are 2D position-sensitive. The PPAC detectors will consist of two orthogonal planes of wires (X and Y directions), which serve as anodes. The active area of the PPAC detector is 1024 mm^2 (32x32 mm). PPAC detector board circuits are shown in Fig. 2. The wire planes (X and Y) are separated by 10 mm. They consist of 32 wires of ~0.02 mm gold-plated tungsten, equally separated by 1 mm and soldered on a printed circuit. The signal of each wire will be read separately and will be sent to the GET readout electronics system through a protection board. The whole detector is operated inside a container closed by two 1.5 μm self-supporting Mylar windows. These windows will be strongly stretched and glued on a metallic frame. The windows have to be as thin as possible to minimize the energy loss of the beam, which makes the PPAC detector quite suitable for use as a transparent detector. The PPAC is operated under a pressure between 10 and 30 Torr. Using two

PPAC detectors separated by approximately sufficient distance will provide a measurement of the particle's position.

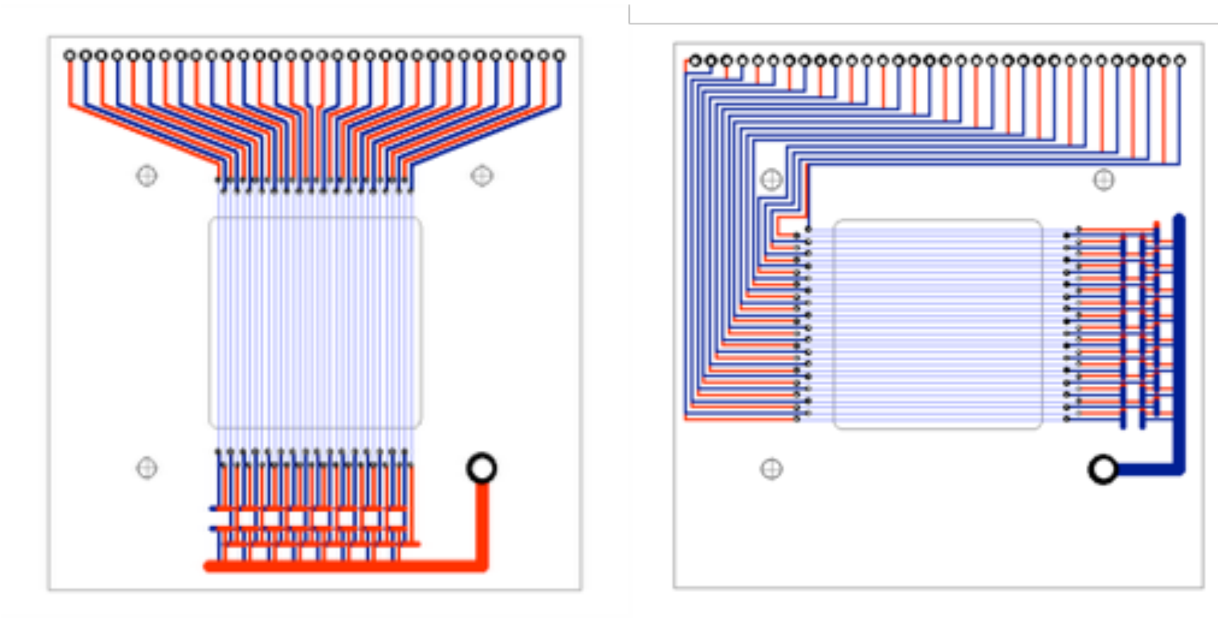

FIG. 2. PPAC detector board circuits. X-Grid (Left) and Y-Grid(right). A total of 32 gold plated tungsten wires are equally soldered over each frame.

A monitor detector will be needed to measure the spot size of the beam. For this purpose we will use a position-sensitive double striped silicon detector from Micron Semiconductor Ltd. It will be used offline to measure the beam spot size. The mechanical system will be designed and developed to install the monitor detector and to be pulled in and out of the beam-line without breaking vacuum.

To extend the capabilities of the TexAT detector, it is necessary to efficiently and accurately detect beam and beam-like ions downstream at forward angles in coincidence with the light particles detected in the TexAT detector. A new ionization chamber (4,5) that can detect particles at rates above 100 kcps with efficiency close to 100% and with a Z resolution of Z/Z better than 2% is under development at the Cyclotron Institute. One of the main targets to design this Ionization Chamber detector is to have the power to differentiate between the different contaminations usually excited in the radioactive ion beams from different elements having the same energy and masses. The anode and cathode electrodes will be made of copper frames. Gold-coated tungsten wires will be soldered to the frames with 2 mm spacing. The electrode grids will be supported by four steel rods that are shielded by thin electric insulation. The design of the wired grid will allow for most low energy particles to travel through without any energy loss. However, there is a small probability that incoming particles will be totally screened by the wires and be completely stopped, resulting in a loss of efficiency. For grids with 2 mm spaced wires, this loss of efficiency is less than 1% per grid. The chamber is filled with an inert gas such as Tetrafluoromethane (CF_4) that is ionized as the heavy recoils move through it. The entrance window will be made of a thin Mylar film (~5 um thick). The alternating arrangement of anode and cathode planes close together (~ 0.5 Inch) will achieve a short drift time for released negative and positive ions, allows fast counting rates. The signals from the first several anodes are combined together to give an energy loss (ΔE) signal for the incident particle, and the remaining anodes are used for the residual energy (E) signal. Using the Ionization Chamber detector will allow us to track the path of ions as they move through the chamber at fast counting rates.

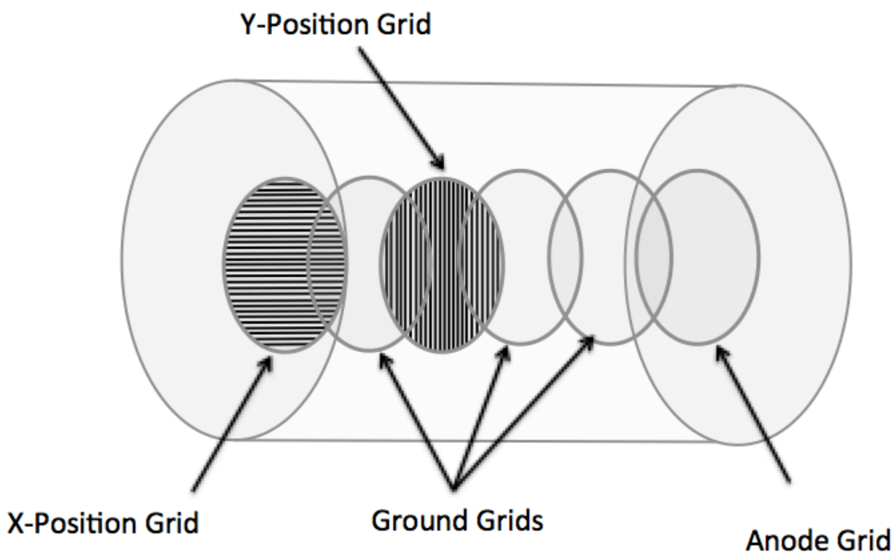

FIG. 3. Configuration of the position-sensitive ionization detector.

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[2] H. Kumagai *et al.*, Nucl. Instrum. Methods Phys. Res. **B317**, 717 (2013).
[3] K.Y. Chae *et al*., Nucl. Instrum. Methods Phys. Res. **A751**, 6 (2014).
[4] J.C. Blackmon, private communication.