Development and characterization of new position-sensitive silicon strip detectors at CENS

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Introduction

Direct reaction experiments are one of the best suited tools to probe a broad range of nuclear properties, providing great insight into the nuclear structure of exotic nuclei and allowing the measurement of reactions relevant to many astrophysical scenarios. In order to fully exploit RIB facilities, CENS has devoted a large amount of effort to design and develop nuclear detection instruments specially designed for direct reaction experiments, such as STARK silicon telescope array and ATOM-X Active Target TPC. An integral part of the design of both STARK and AToM-X are the X6 position-sensitive double sided silicon strip detectors.

STARK & STARK Jr silicon telescope arrays

Silicon Telescope Array for Reaction studies in inverse Kinematics, STARK, is a large solid angle silicon detector array intended for direct reactions experiments.

- Array consisting of 40 double-sided resistive silicon strip detectors.
- Barrel shaped aarrangement:
  - 3 ring configuration: 12, 16 and 12 sided rings
    - ➪ 92.5, 118.8 and 92.5 mm radii.
  - 28.4 mm gap for target
- Wide angular coverage: 43º - 78º and 105º - 150º.
  - Expected angle resolution less than 1º.
- GET (General Electronics for Time projection chamber project) electronics system is used to handle nearly 1000 channels from the detectors.

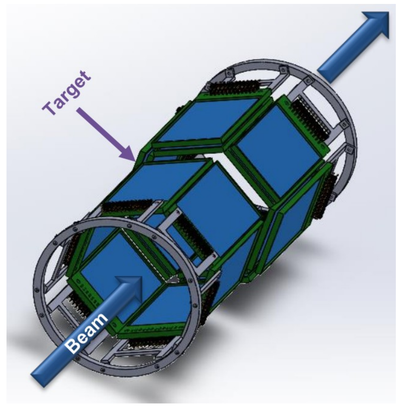
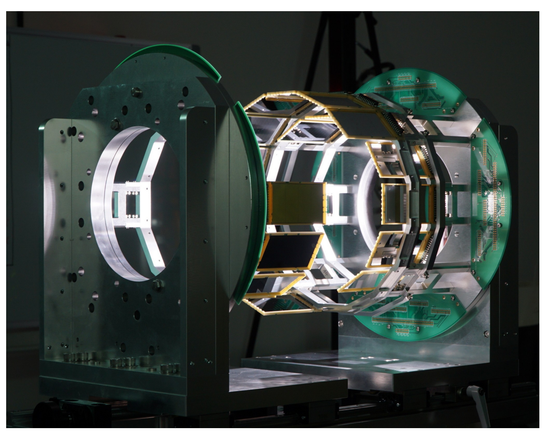


Figure 1: *STARK Jr, compact design intended for γ-spectroscopy studies.*



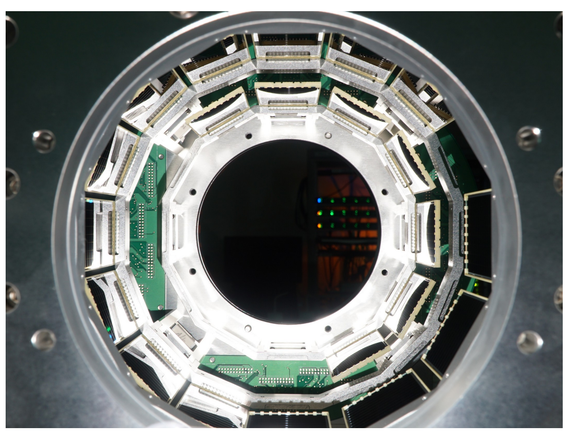
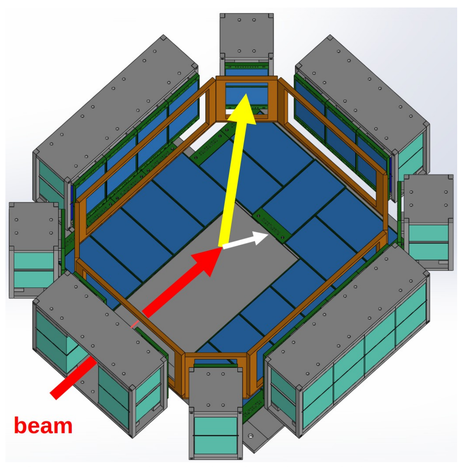


Figure 2: *X6 position-sensitive silicon strip detectors mounted in STARK supporting frame.*

ATOM-X Active Target TPC

Active target Tpc fOr Multiple nuclear eXperiments, ATOM-X, is a time projection chamber intended for the study of nuclear reactions of astrophysical interest such as (α,p), (p,γ) and (d,p). Its design is an upgrade of the Texas A&M Active Target detector.

- Active volume of 244 x 185 x 289 mm^3.
  - Octogonal chamber.
- Target gas: CH_4, C_4H_{10}, CD_4, CO_2 and He/CO_2 (90/10).
- Silicon and CsI walls for total energy measurements of charged particles.
- Over 5000 channels (4000 from Micromegas, 1000 from aux detectors).
  - ASIC electronics system and cluster DAQ.



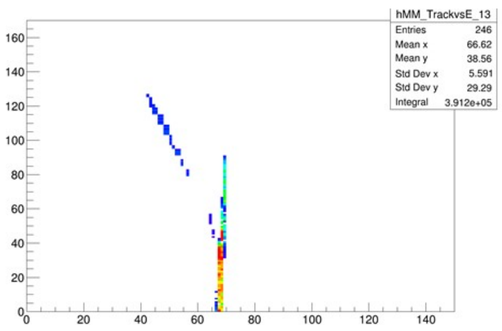


Figure 3: *Schematic drawing of the ATOM-X design (left) and 14N(α,α) track from the commissioning experiment for some of the components (right).*

X6 Specifications

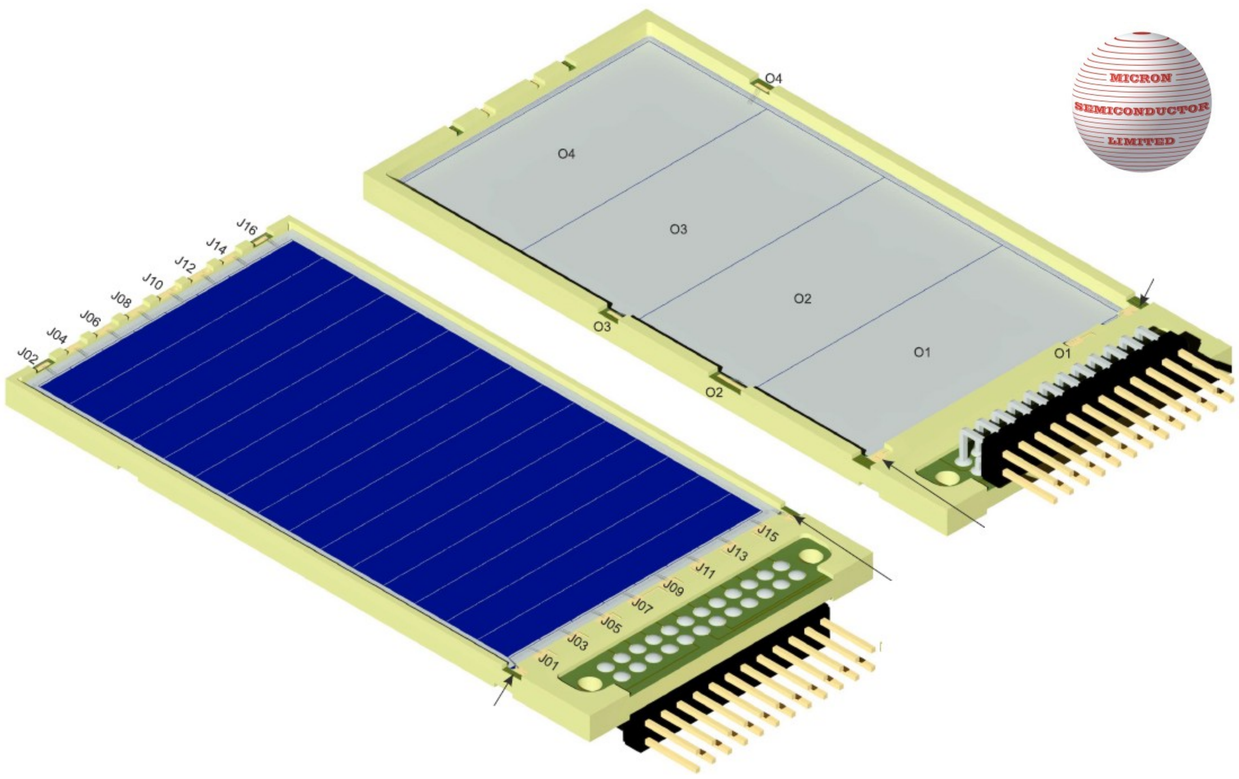


Figure 4: *Schematic diagram of X6 position-sensitive silicon strip detectors (provided by MICRON Semiconductors Ltd) displaying the junction side (left) and ohmic side (right).*

X6 position sensitive double sided silicon strip detectors have a custom-made design by MICRON Semiconductors Ltd.

- **PCB dimensions:** 93.1 x 45.2 mm
- **Active area:** 75.0 x 40.3 mm
- **Thickness:** 1 mm
- **Dead layer:** 0.5 µm, Al
- **Segmentation:**
  - Ohmic side: 4 transversal strips
    - ➪ Pitch: 18.7 mm
  - Junction side: 8 longitudinal resistive strips
    - ➪ Pitch: 5 mm

The design incorporates a multi-guard ring to support bias beyond full depletion and avoid premature breakdown. This particularly convenient for thick detectors such as these that require high voltage for optimum operation.

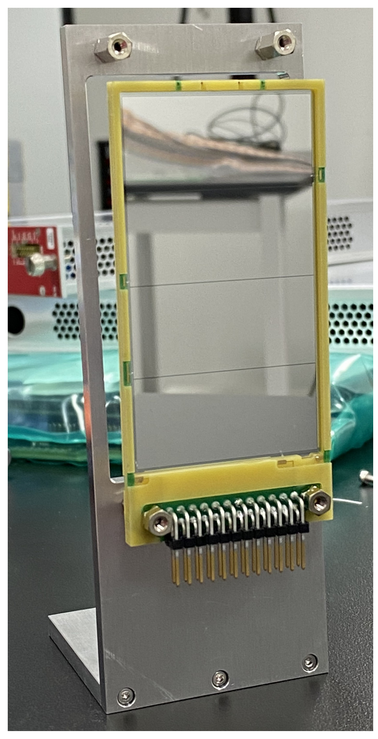


Figure 5: *Picture of an X6 detector (ohmic side).*

Performance & operation

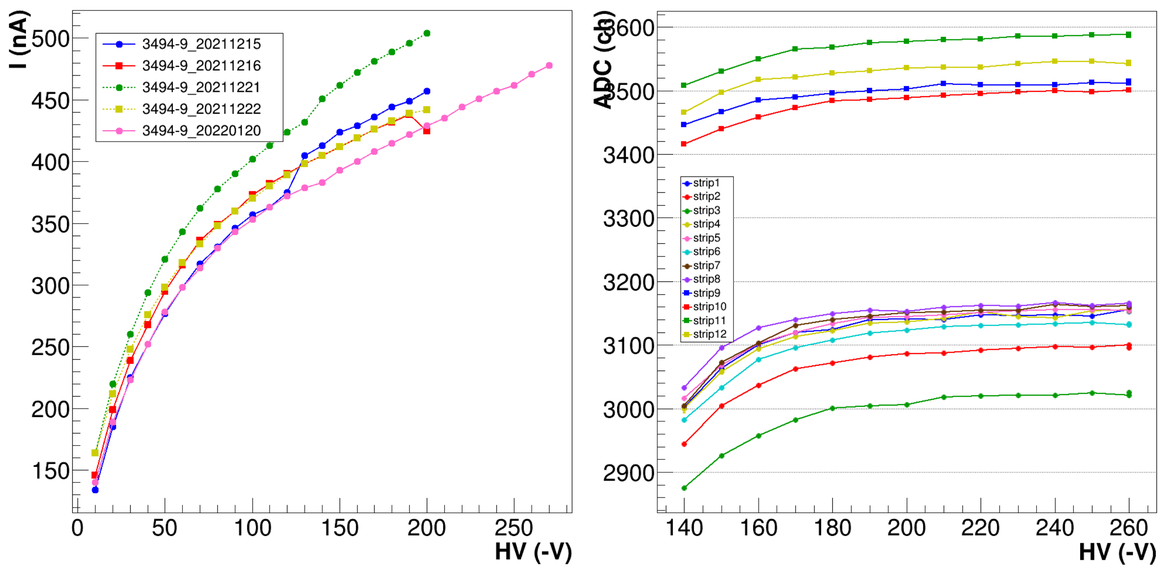


Figure 6: *Tests were conducted to determine the full depletion voltage. Leakage currrent was sampled at different bias (left). Plotting mean position of 5.5 MeV α's vs high voltage (right), we observe it remains constant after reaching full depletion.*

Energy

As X6 detector has resistive charge-splitting strips on its junction side, the total energy is obtained by adding the signals from the read outs on each strip end:

$$E_T = E_{up} + E_{down}$$

- Energy resolution of <60 keV (~1%).
  - ➪ Despite being more sensible to noise than traditional DSSDs.
- Small ballistic deficit was observed.

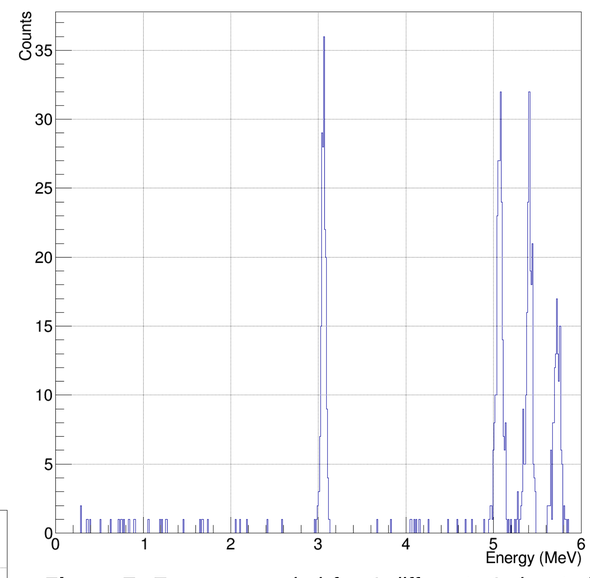


Figure 7: *Energy recorded for 4 different α's located between 3 and 6 MeV. Energy resolution <60 keV was measured.*

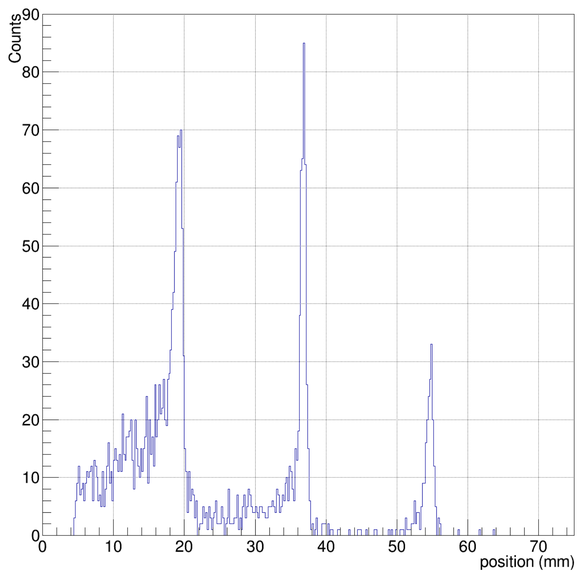


Figure 8: *The position resolution was observed to be better than 1mm by looking at energies in coincidence with interstrip events on the back strips.*

Position

Because of the resistive strips with read outs at both strip ends, the position is on the front side is given by:

$$pos = \frac{E_{up} - E_{down}}{E_{up} + E_{down}}$$

- Position resolution better than 1mm.
  - ➪ Excellent position resolution with a much smaller number of signals than traditional DSSDs with similar resolution.
- Threshold influence.

Acknowledgements

The authors wish to acknowledge the support from the Institute for Basic Science (IBS) of the Republic of Korea under Grant No. IBS-R031-D1. Byul MOON and the STARK Jr project are fully supported by IBS-R031-Y1.