Development of Silicon-strip detector for cluster knockout reactions

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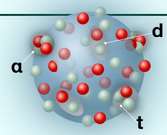
I. Introduction



Recent study using knockout reactions reported the formation of α clusters on the surface of nuclei.

A new project, **ONOKORO**, have been launched to elucidate the formation mechanism of clusters in atomic nuclei.

→ Probe cluster formations of deuterons, tritons, alpha particles, etc. in radioactive isotopes !

Cluster knockout reactions of unstable nuclei can be performed in inverse kinematics.

→ A new detector array, **TOGAXSI** [PS-8-5], is under development for this purpose.

TOGAXSI consists mainly of silicon-strip detectors and GAGG scintillators

Prototype Silicon-Strip Detector

- ✓ Thickness 100 μm.
- ✓ Strip pitch 100 μm.
- ✓ Sensitive area 8 cm × 5 cm.
- ✓ Number of strips 768 channel.

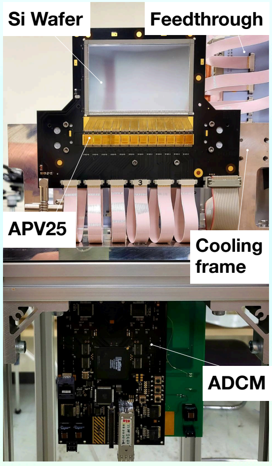


Fig. 1: Mounted prototype SSD.

II. Readout System

- Large numbers of signals from strip electrodes are read out by the **APV25-s1 chip** (Fig. 2).
  - The ASIC chip was developed for the CMS tracker at CERN-LHC.
  - The chip processes has 128 channels of signals in parallel (Fig. 3).
  - Dynamic ranges are adjusteble (Fig. 4).

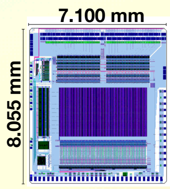


Fig. 2: APV25 Layout [1].

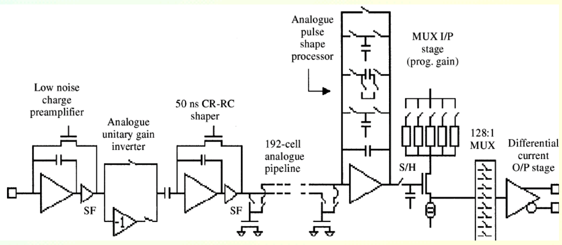


Fig. 3: The block diagram of 1 channel[2].

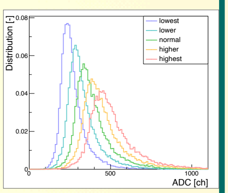


Fig. 4: The signals obtained by the diffrent gains, which is programmable in the chip.

- Output signals from APV25 are converted to digital signals by ADCM made by TU Munchen.
- The data acquisition is controled in the TRB3 system developed by GSI.

III. Experiment

Evaluation items

- ✓ To separate the energy loss signals of charged particles from noise.
- ✓ To identify protons and alpha particles from background particles.
- ✓ To evaluate the detection and tracking efficiencies.

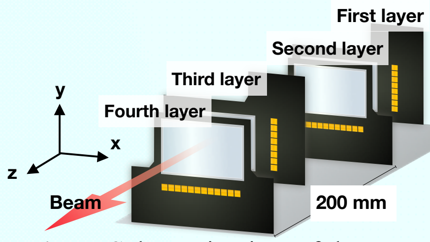


Fig. 5: Schematic view of the experiment. Two types of SSD with different strip direction were installed.

The experiment was performed at HIMAC. A light-ion beam was injected into a silicon detectors installed in the beamline (Fig. 5).

IV. Analysis Results

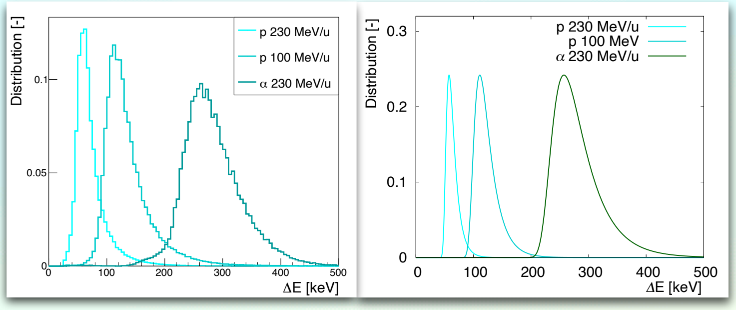


Fig. 6: Left: Experimental data. Right: Caliculations with landau distributions.Energy loss spectra of various beams in a 100 μm-thick silicon detectors.

- ✓ The energy-loss signal of the 230 MeV proton beam was well separated from the noise (4 keV), and the obtained spectra were in good agreement with the landau distributions.
- ✓ The energy-loss resolutions were good enough to identify the emitted particles.
- ✓ Detection efficiencies were evaluated (Table 1).

Detection efficiency	Tracking efficiency
100%	97.5%

Table 1: Detection efficiencies.

V. Conclusion

We established the readout method for a silicon-strip detector with the required particle-identification performance and angular resolution of less than 3mrad for measuring cluster knockout reactions.

The new silicon-strip detectors for TOGAXSI array are under construction.

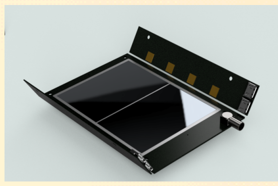


Fig. 7: New SSD design for TOGAXSI. In addition to the same specifications as the prototype, it also has a large acceptance.

Collaborators

J. Tanaka, T. Uesaka, R. Tsuji, J. Zenihiro, S. Kawase, S. Kurosawa, S. Takeshige, H. Baba, Y. Hijikata, K. Yahiro, R. Matsumura, H. Takahashi, for ONOKORO collaboration.

Reference [1] L. Jones, APV25-S1 User Guide Version 2.2 (2001) 4, [2] M.J. French et al, Nuclear Instruments and Methods in Physics Research A 466 (2001) 360

Development of Silicon strip detector for cluster knockout reactions

K. Higuchi, J. Tanaka, T. Uesaka, R. Tsuji, J. Zenihiro, S. Kawase, S. Kurosawa, S. Takeshige, H. Baba, Y. Hijikata, K. Yahiro, R. Matsumura, H. Takahashi, for ONOKORO and TOGAXSI-construction project

The ONOKORO project has been launched to understand what kind of clusters exist in the atomic nucleus, and how the formation of the clusters changes depending on the neutron richness. The cluster knockout reactions in inverse kinematics are to be performed using heavy nuclear beams. A detector array TOGAXSI is going to be constructed to measure 100-230 MeV/u light ions emitted from the reactions. In the presentation, the silicon strip detector composing TOGAXSI will be introduced. A performance evaluation experiment of the silicon detectors with a thickness of 100 µm and strip width of 100 µm was performed. The energy losses of light ions are key observables to identify the type of knocked-out clusters. The energy loss spectra with proton beams and alpha particle beams were obtained. In particular, the 230 MeV/u proton beam gives 58 keV at the peak value of the Landau distribution, and its spectrum starts from about 40 keV. The low noise condition has been achieved using APV25s1 chips, and succeeded in measuring them with good detection efficiency.

✓

✓口頭で説明すること

✓ブロックダイアグラム

✓ The noise levels were low enough to Separate the energy loss signals of the 230 MeV proton beam.We succeted to separate smol signals from noise, and obtain energy loss spectra showed a goog agreeement with the landau distribution.

✓230MeVの陽子ビームの測定がなぜ難しいか。→230M protonは大きいエネルギーを持ち，質量が小さいためエネルギー損失が非常に小さい。また，100µmの非常に薄いシリコンで測定することもエネルギー損失の小さい要因である。

原稿

挨拶　Thank you for coming this session today. I'm Koshi Higuchi from RIKEN Nishina Center and master course student. Title is "Development of silicon strip detector for cluster knockout reactions.
In this session, I would like to talk about silicon-strip detector …

発表

近年、ノックアウト反応を用いた研究により、原子核の表面にαクラスターが形成されることが報告されています。この研究を契機に，クラスターの形成機構の解明を目的とした新しいプロジェクト「ONOKORO」が発足した。この研究では，放射性同位元素を含む核種に存在する， 重陽子、三重子、α粒子などのクラスターを調査することで，新たな原子核の描像を提唱します。

実験ではクラスターノックアウト反応を用います。しかし，不安定原子核を調査する場合，クラスターノックアウト反応は逆運動学で行う必要があります。このために、新しい検出器アレイTOGAXSIを開発する予定です。TOGAXSIは主にシリコンストリップ検出器とGAGGシンチレータで構成され，粒子の角度とエネルギーの情報を得ることができます。ここではシリコンストリップ検出器について，読み出し方法や，プロトタイプの単エネルギービームに対する応答を報告します。

First, let me give an intro.Recently, studies using knockout reactions have reported the formation of α-clusters on the surface of nuclei.
This research led to the launch of a new project, ONOKORO, which aims to "elucidate the formation mechanism of clusters.
In this study, we propose a new picture of nuclei by studying clusters of deuterons, triplets, and α-particles that exist in nuclei containing radioisotopes.
Cluster knockout reactions are used in the experiments.However, when studying radionuclides, cluster knockout reactions must be performed in inverse kinematics. For this purpose, we plan to develop a new detector array TOGAXSI.
TOGAXSI consists mainly of a silicon strip detector and a GAGG scintillator, which provides information on the angle and energy of the particles. Here we report on the silicon strip detector, including the readout method and the response of the prototype to a single energy beam.