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Development of a multi-segmented proportional gas counter for β-decay spectroscopy at KISS

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We have developed a new multi-segmented proportional gas counter (MSPGC) [1] for β-decay spectroscopy of nuclei with neutron number $N \sim 126$ relevant to the 3rd peak in the r-process. These nuclei are produced by multi-nucleon transfer (MNT) reactions of ^{136}Xe beam and ^{198}Pt target [2], and can be extracted from KEK Isotope Separation System (KISS) [3]. KISS is an argon-gas-cell based laser ion source combined with an on-line isotope separator, and therefore it can select mass and atomic numbers. The extracted nuclei are implanted into a tape in the KISS detector system. In order to perform the β-decay spectroscopy precisely and efficiently, the background event rate of a β-ray detector should be less than 0.1 cps considering the typical extraction yield of neutron-rich nuclei of a few pps, and detection efficiency should be as high as possible.
The MSPGC comprises a pair of 16-segmented proportional gas counters in 2-cylindrical layers (total 32 ch) in order to identify β-ray events with high-efficiency and eliminate background events such as cosmic-rays by two-dimensional tracking effectively. The small energy losses in detector gas of argon (90%) + CH_4 (10%) and the cathode made of aluminized Mylar foils have allowed us to realize an absolute detection efficiency of 45% at $Q_\beta = 1$ MeV along with detection of low-energy conversion electrons. We successfully achieved our desired background event rate of 0.1 cps.
We performed the hyperfine structure measurements of neutron-rich nuclei by in-gas-cell laser ionization spectroscopy and β-γ spectroscopy including identification of isomeric states through the detection of conversion electrons. In the presentation, we will discuss the properties of the MSPGC and the experimental results. We will also present the current status of three-dimensional tracking in the MSPGC to realize the background event rate of 0.01 cps by applying resistive carbon wire anodes.

[1] M. Mukai et al., Nucl. Instrum. and Meth. A 884 (2018) 1.
[2] Y.X. Watanabe et al., Phys. Rev. Lett. 115 (2015) 172503.
[3] Y. Hirayama et al., Nucl. Instrum. and Meth. B 353 (2015) 4.; B 376 (2016) 52.; B 412 (2017) 11.

Primary author: MUKAI, Momo (University of Tsukuba)

Co-authors: Dr WATANABE, Yutaka (KEK, WNSC); Dr HIRAYAMA, Yoshikazu (KEK, WNSC); Dr SCHURY, Peter (KEK, WNSC); Mr AHMED, Murad (University of Tsukuba); HABA, Hiromitsu (RIKEN); Dr ISHIYAMA, Hironobu (IBS); Dr JEONG, SunChan (IBS); Mr KAKIGUCHI, Yutaka (KEK, WNSC); Dr KIMURA, Sota (RIKEN); Dr MOON, JunYoung (IBS); Mr OYAIZU, Michihiro (KEK, WNSC); Prof. OZAWA, Akira (University of Tsukuba); Dr PARK, JinHyung (IBS); Dr UENO, Hideki (RIKEN); Prof. WADA, Michiharu (KEK, WNSC); Prof. MIYATAKE, Hiroari (KEK, WNSC)

Presenter: MUKAI, Momo (University of Tsukuba)

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