# Development of a surface alpha ray detector applying μ-TPC in low radioactivity background

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**Introduction** In a direct search for the dark matter, leading experiments make use of massive and low background detectors. Particularly, the detector is required to be designed with low radio-purity materials, whose contamination level of U-238 and Th-232 are in the order of ppb. We have been developing a new detector for alpha-rays emitted from the material surface based on a time projection chamber (TPC) technology. A μ-TPC, NEWAGE-0.3a, originally used for a direction-sensitive dark matter direct search in Kamioka mine underground, was modified and used [1].

**Methods** The detector has an advantage of a position sensitivity in comparison with a conventional alpha-ray detector [2], thus the distribution of the contamination on the sample surface can be obtained. The drift plate (Cu) has a sample-window (10 cm × 10 cm) in the center and the sample is set on the copper mesh covering the window, so that the alpha rays from the sample can enter the fiducial volume, (10 cm × 10 cm) × 30 cm, as shown in Fig. 1. The read-out device, a μ-PIC, was replaced with a low alpha-emitting μ-PIC, whose impurities were reduced down to less than $10^{-4}$ αs/cm$^2$/hr [3].

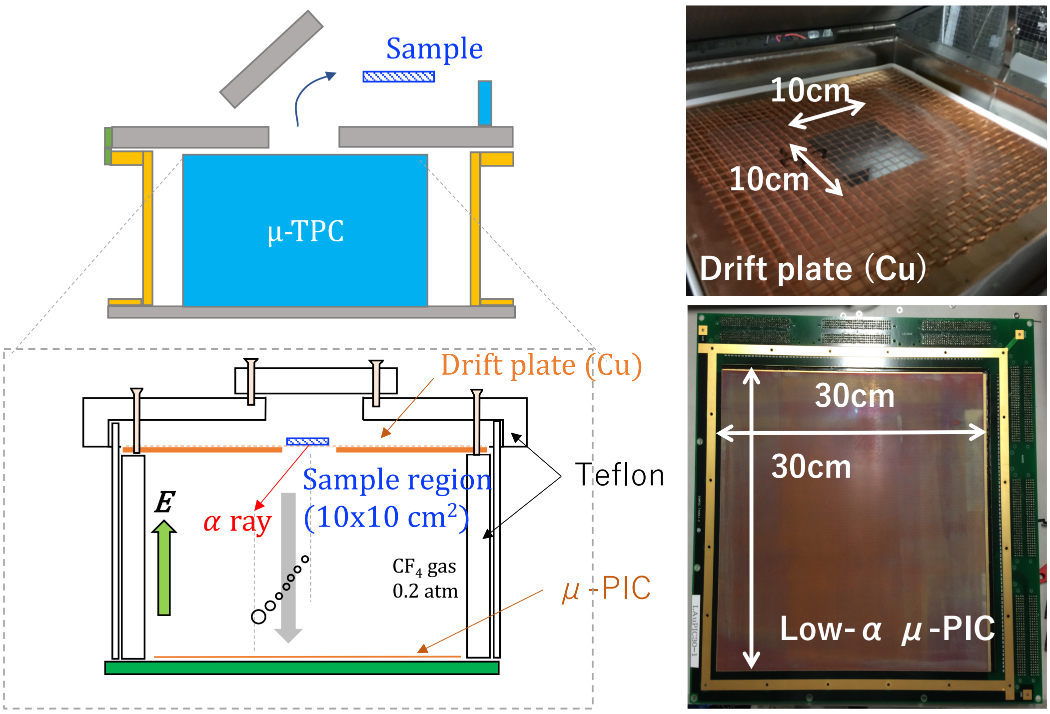


Fig. 1. Cross section schematic drawings of the alpha detector and pictures of the drift plate and the low-alpha μ-PIC.

The energy and position calibrations were performed using Am-241 alpha-ray (5.4-5.5 MeV). Then, the energy resolution and detection efficiency were estimated. Furthermore, a new algorithm to determine the sense of the alpha-ray track, whether from the sample or from the μ-PIC, was developed based on the waveform analysis. Since the deposit energy of alpha rays is larger (Bragg peak) right before it stops, the waveforms of the upward and downward tracks of the flash ADC differs as shown in Fig. 2.

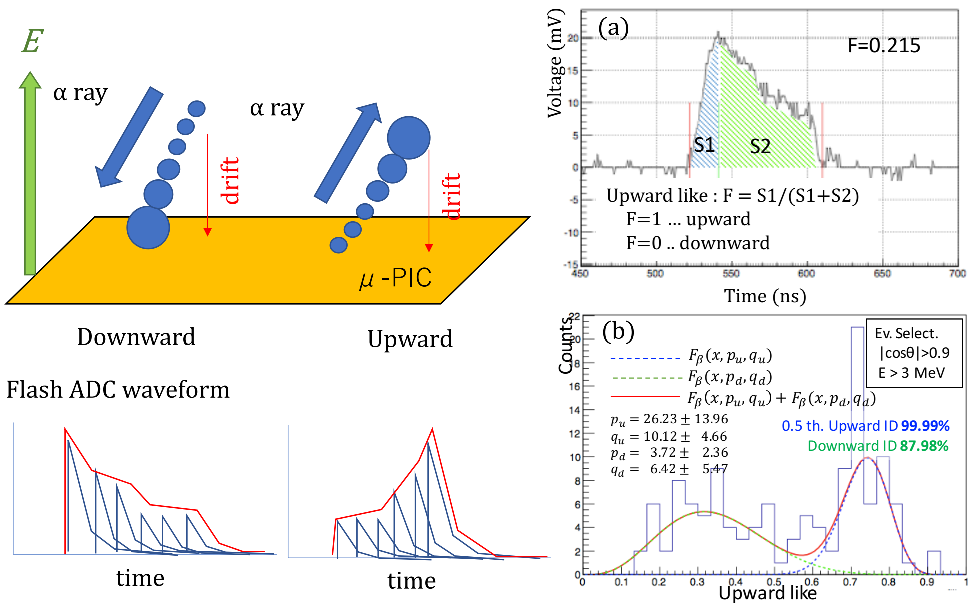


Fig. 2. Process schematic of the track-sense recognition. (a) Typical waveform of a 5 MeV alpha ray record with a flash ADC. (b) Distribution of an upward-like parameter on isotropic alpha rays from radon.

**Results** The energy resolution was estimated to be $\sim 11\% \ (\sigma)$. For a determination of upward or downward track, it is defined as upward like F = S1/(S1+S2), where S1 and S2 are integrated area before and after the peak as shown in Fig 2 (a). In the isotropic alpha rays emitted from radon in the detector, Fig. 2 (b) shows the distribution of an upward-like parameter. There are two components with a criteria of zenith angle cut, $|\cos\theta| > 0.9$, thus it was estimated that the upward and downward tracks can be identified by a probability of 99% or more and ~87% with threshold of F=0.5, respectively. By rejecting the upward-like tracks (no emit from sample), the sensitivity as background level was improved by factor 2. In addition, by replacing with low alpha-emitting μ-PIC, the background level was achieved to $10^{-2}$ $\alpha s/cm^2/hr$.

**Conclusion** We have been developing a new detector of alpha-rays emitted from the material surface based on a time projection chamber technology. Upgradable plans to achieve the goal of less than $10^{-4}$ $\alpha s/cm^2/hr$ will also be presented.

**Reference**


[1] K. Miuchi, et al., Phys. Lett. B, 686, 11 (2010). [2] B. D. McNally, et al., Nucl. Instr. Meth. A 750 (2014) 96-102.

[3] T. Hashimoto, et al., AIP Conf. Proc. 1921, 070001 (2018).