5 The Slow Positron Facility

5-1 Overview

The slow positron facility, equipped with a dedicated 55 MeV linac, provides a high intensity, pulsed slow positron beam. Two operation modes, the long pulse (1 µs) mode and the short pulse (12 ns) mode, are available. The beam intensity in the long pulse mode is ~10^7 e^+/s, which is one or two orders of magnitude higher than that obtained using a commercially available ^{22}Na positron source. The high intensity enables us to make various applications such as the transmission positron microscope (TPM). The short pulse mode has been used for measuring the positronium (Ps) time-of-flight. The mode is also suitable for experiments combined with a high power nano-second laser synchronized with the positron pulses.

5-2 Development of an Apparatus for the Study of Photodetachment of Positronium Negative Ions

In 2009, we developed an apparatus for studying the photodetachment of the positronium negative ion (Ps^-), a bound state of one positron and two electrons [1]. Since the prediction of Ps^- by Wheeler in 1946 [2], there have been many theoretical investigations of the decay rate and the binding energy of Ps^-. The photodetachment process has also been studied theoretically and cross sections have been calculated [3]. In contrast, experimental investigations are very scarce: only a few measurements of the decay rate have been performed since the first observation of the ions in 1981 [4]. This is due to the low production efficiency of the ions.

Recently, efficient production and emission of Ps^- from alkali metal coated tungsten surfaces has been observed [5]. The new apparatus employs the Ps^- produced via this process.

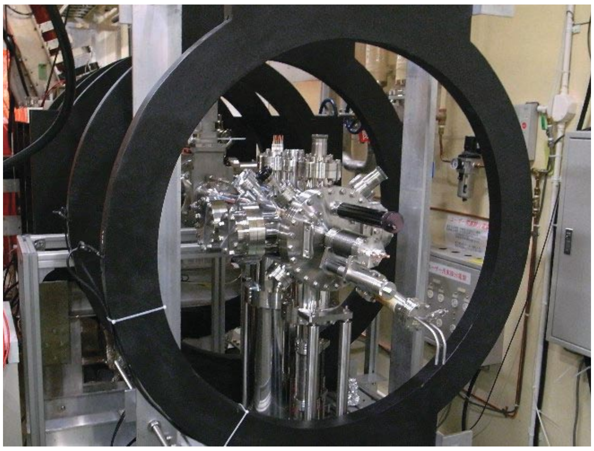

Figure 1
Apparatus for the photodetachment of Ps^- before the laser was installed.

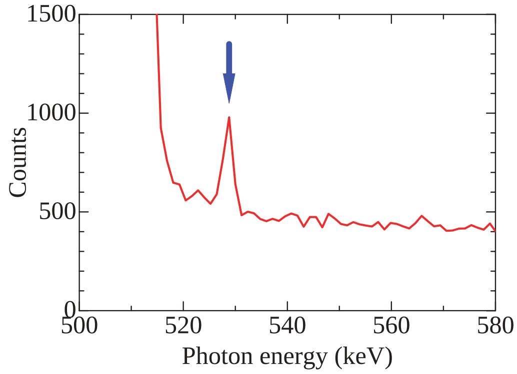

Figure 2
The blue shifted energy spectrum of the γ-rays from the self-annihilation of the Ps^- accelerated after the emission from the Na

The positrons generated in the short pulse mode were transported in UHV and injected into an Na coated polycrystalline tungsten target. The Ps^- ions emitted from the target were accelerated and the blue-shifted γ-rays from the 2γ annihilations were detected using Ge detectors. In order to lower the background due to the γ-rays from the positrons annihilating in the tungsten target, the detectors were surrounded by lead shielding with a slit to allow only the γ-rays from the Ps^- ions in the region of interest. Two detectors were used to increase statistics. In order to avoid the background due to the Bremsstrahlung radiation from the simultaneously operating injector linac for KEKB and PF, the 55 MeV linac was operated with the delay of a few µs, and the detectors were gated with the trigger signals from the latter.

Figure 2 shows the γ-ray energy spectrum obtained. The blue shifted γ-rays attributable to the annihilation of the Ps^- ions accelerated after emission from the target are observed clearly.

The apparatus, together with an intense pulsed laser synchronized with the positron pulses, will allow observation of the Ps^- photodetachment. We expect to perform the first observation in 2010. We will also attempt to produce an energy-tunable Ps beam in the near future by collecting the Ps produced in the photodetachment of the accelerated Ps^- ions.

REFERENCES

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