Preparation status of the $(p, 2p)$ fission experiment with the SAMURAI spectrometer

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The experiment NP-1306-Samurai14 is the first attempt at determining fission barrier heights for unstable nuclei like ^{212}Bi or ^{213}Po[1)]. For this the missing mass spectroscopy of the two protons from the $(p, 2p)$ reaction in inverse kinematics provides a suitable method of determining the threshold for the fission barrier height unambiguously and directly. We report on the development status of the experimental setup for measuring the $(p, 2p)$ reaction using the heaviest projectiles.

The goal for the resolution power of the setup is to achieve an energy resolution of σ=1 MeV for the reconstructed excitation energy. The systematic uncertainty in the reconstructed missing energy should be less than 0.1 MeV. To realize this goal we need to measure the opening angle and energies of two emitted protons with resolutions of $\sigma_{\theta_{op}} < 3$ mrad and $\sigma_{E_p}/E_p < 2\%$.

The design of the $(p, 2p)$ setup is schematically shown in Fig. 1. The setup consists of a vacuum chamber containing a liquid hydrogen target and three layers of single-sided detectors on two arms with respect to the beam line. The reaction point and the emission angles of emitted protons are determined by the silicon detectors in connection with the beam trackers of the standard SAMURAI setup, BDC1 and BDC2. The setup has additional plastic scintillation detectors at a distance of 1.6 m from the target and outside the vacuum chamber to measure the time of flight (TOF) of protons in order to determine their kinetic energies.

We prepare two types of silicon detectors with the same dimensions of 51 × 78 mm; the first type (type A) is segmented to 768 strips parallel to the short side with a 100 μm pitch, whereas the other type (type B) has 498 strips parallel to the long side with the same pitch size as type A.

The three layers in one arm are structured in this way: The closest one to the target is type A, from which two sets of type A and B detectors are placed at a center distance of 10 cm to fit the solid angle coverage. They are mounted in parallel with the beam line as shown by the red lines in Fig. 1, aligning the shorter side of the detector vertically.

The type A and B detectors are used to determine horizontal and vertical positions of proton tracks, respectively. To meet the requirements on the opening angle and proton energy measurements, the thicknesses of the detectors must be thin as long as the signal-to-noise ratio in the charge readout of each strip allows a clear detection of protons. We aim at using 50 μm silicon detectors for the innermost layer and 100 μm ones for the others, to satisfy the requirements. At the end of 2014, 100 μm ones were ordered. A readout system based on the highly integrated APV25 chips[2)] is currently set up for full system tests.

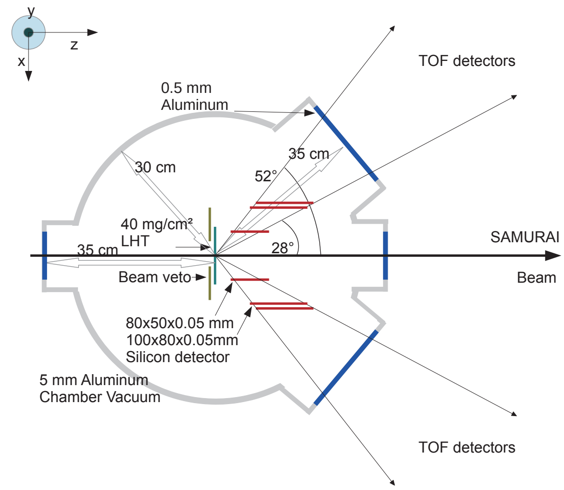

Fig. 1. Target chamber (top view) including three layers of one-dimensional silicon strip detectors on each side.

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