Activities at J-PARC

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I. Charmed Baryon Spectroscopy at the J-PARC High-Momentum Beam Line

We are constructing a new platform of hadron physics under the MoU between RCNP, IPNS, and J-PARC at the J-PARC High-momentum Beam Line. We are preparing for an experiment on charmed baryon spectroscopy via the $p(\pi^-, D^{*-})$ reaction (E50) [1]. We report progress on some detector developments for E50 below.

We carried out a test experiment [2] for timing counters, trackers, and streaming data acquisition (DAQ) system with high-intensity electron/positron beams at the Research Center for Electron Photon Science (ELPH) in Tokoku University. Cherenkov counters were developed as a new type of the start (time zero) counter, T0 [3]. Acrylic (Polymethyl Methacrylate, PMMA) bars of 1 mm and 3 mm in widths, 3 mm in thickness, and 150 mm in length were prepared as cherenkov radiators. The acrylic bar is tilted 48 degrees to the beam axis so that cherenkov photons reach the photosensor placed at an edge of the bar by the shortest path. A cross type of acrylic bar of 3 mm width was also prepared, as illustrated in Fig. 1, which is expected to reduce position dependences of time resolution and time offset. The timing signals of each counters were measured by using a Flexible Programable Gate Array (FPGA) based high-resolution TDC which was developed in a DRS4 module [4] The 1-mm and 3-mm width acrylic bars show a time resolution of 55 ps at beam rates of 1.8 MHz and 4 MHz, respectively. The cross type shows a better time resolution of 50 ps at a beam rate of 4 MHz. As a reference, a time resolution of a plastic scintillator with the same size was measured to be about 60 ps at the same beam rate of 4 MHz. All the counters satisfied the required time resolution of better than 100 ps. The cherenkov counters show better performance. In particular, the cross type show the best resolution among them. We find beam rate dependence; the time resolution becomes better as the beam rate decreases. A base-line shift by pile-up signals causes this dependence in part. Response of the amplifier in the DRS4 module may have a rate dependence and affects the time resolution. Further improvement of the time resolution can be expected as the time resolution of better than 40 ps was achieved by the cross type at a beam rate of 1 MHz.

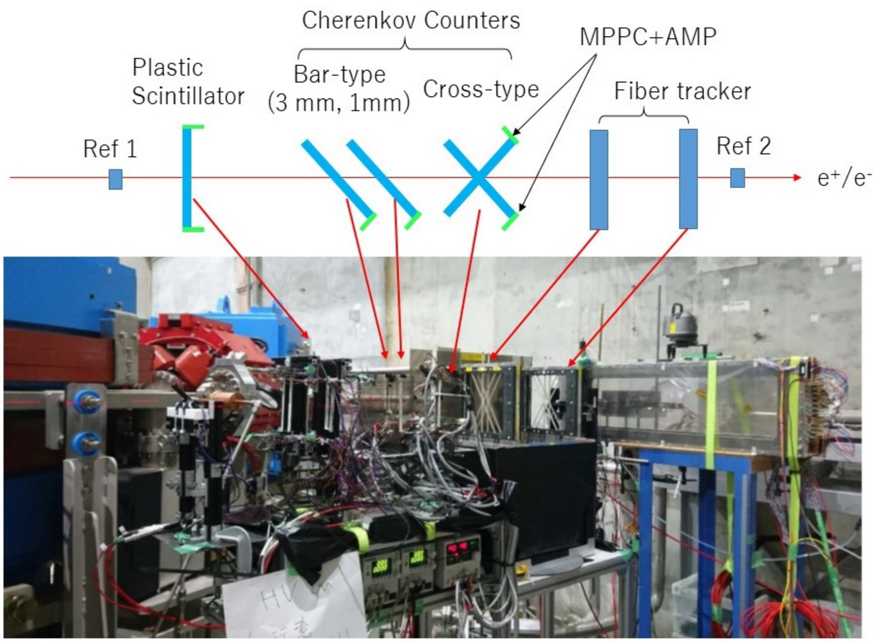

Figure 1: Setups of a beam test experiment for timing counters and scintillation fibers at ELPH.

A streaming DAQ system [11] is a key technology for E50 to handle a number of event data due to a high interaction rate of greater than 3 MHz caused by an intense pion beam of 30 MHz. Fast and inteligent event filtering is required to pick up wanted event candidates efficiently. A hardware trigger system will be hardly constructed in this high rate environment.. A concept of the streaming DAQ system was demonstrated at the test experiment mentioned above [5]. We set up a minimal DAQ system for the fiber tracker of 12 layers, 128 ch.

Signals from the fiber tracker were read out through a TDC built in a Hadron Universal Logic (HUL) module [6] operated by streaming mode. We successfully read out TDC signals without any losses up to a signal rate as high as 1 MHz. This rate capability was actually limited by network speed of 1 Gbps. This saturation will be improved by increasing parallel readout modules.

We are considering radiation safety issues when a 15-kW loss production target is placed in the primary beam line at the begining of the high-momentum beam line [7]. We developed a simulation code based on MARS [8] to study

(1) radiation level to satisfy a limit at the radiation controlled area boundary (0.5 μSv/h),

(2) residual dose around the target to establish reasonable maintenance scenario, and

(3) concentration of airborn activities.

We need to place additional shielding irons along the beam line so as to reduce radiation level at the controlled area boundary. We need to place sufficient amount of irons surrounded by 1.5 m thick concrete layers around the target to be less than 0.1 mSv/h in a day after 30-day beam irradiation, which is a guideline required for maintenance. Further studies for optimization of the radiation shield, maintenance scenario for the target replacement when necessary, local confinement of airborn activities to reduce the concentration of airborn activities in the whole beam line tunnel (switch yard), and so on so forth are under progress.

II. Study of Hyperon Resonances below $\bar{K}N$ threshold via the $d(K^-, n)$ reaction (E31)

The E31 experiment [9] aims at investigating the so-called double pole structure of $\Lambda(1405)$ [10] via the (K^-, n) reaction on a deuteron target.

Since we carried out the first physics run in May and June, 2016, the second physics run was scheduled once in June, 2017. However, it was postponed in January and February, 2018 due to a trouble of a beam extraction device of the accelerator. Allocated beam time for E31 has been completed by collecting 40 Giga kaons on the deuteron target as we expected. Analysis of the second run data is in progress.

As already reported in [12], we successfully identify the $d(K^-, n)X_{\pi^0\Sigma^0}$ reaction. The missing mass spectrum of $\pi^0\Sigma^0$ observed in the 1st run is shown in Fig. 2 [13]. Although statistics is still poor, one can see a peak structure around the K^-p mass threshold in this figure. In the second run, we enlarged an acceptance of the backward proton chamber (Fig. 3) by a factor of about 2. In the end, we expect to increase a several times more statisics of the $\pi^0\Sigma^0$ mode.

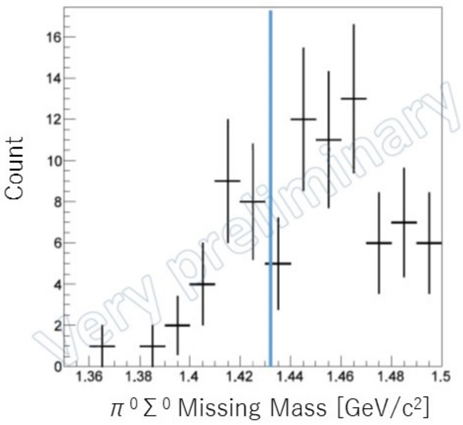

Figure 2: Missing mass spectrum of $d(K^-, n)\pi^0\Sigma^0$. A blue vertical line indicates the K^-p mass threshold.

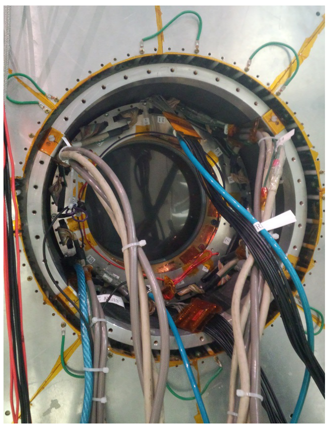

Figure 3: Acceptance of the backward proton chamber was doubled in the 2nd run

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[5] Y. Ma, R. Honda, and T. N. Takahashi are in charge of the present work. Front end read out of the fiber tracker was set up by H. Asano in this test experiment.

[6] R. Honda *et al.*, http://openit.kek.jp/project/HUL (in Japanese).

[7] Y. Komatsu is in charge of this work under supervision of the Hadron Beam Line group of J-PARC.

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[13] Analyzed by S.Kawasaki.