Activities at J-PARC

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

This year, we formed a High-p Collaboration among experimental groups, activities for a future project, other potential users, and the hadron experimnetal facility group in order to make cooperative efforts for constructing the beam line and spectrometer equipments at the J-PARC High-Momentum Beam Line. A high-speed data acquisition (DAQ) system is one of key items to be developed. The experiment on charmed baryon spectroscopy (E50) [1] needs to handle a data rate of as high as about 50 giga bytes (GB) per spill (spill interval $\sim$ 6 seconds). Then, a dead-time-less DAQ system is proposed for the E50 experiment. This is based on frontend electronics associated with individual detectors and a PC farm. Conceptual configuration of the DAQ system and data flow are shown in Fig. 1. Signals from each detector will be digitized at a frontend electronics module and the digitized data will be send to and accumurated in a buffer PC. Data buffers from all the detectors will be collected by a Filter PC. Here, event reconstruction will be made to identify if the event is a candidate of the reaction to be measured and recorded. The signal digitization will be pipelined and the data buffereing and filtering processes will be made in parallel with mutli-CPUs linked through high-speed data communication network to eliminate dead time. This DAQ system requires no hardware trigger but will be able to accommodate various types of software-based event selections (event filtering) rather flexibly.

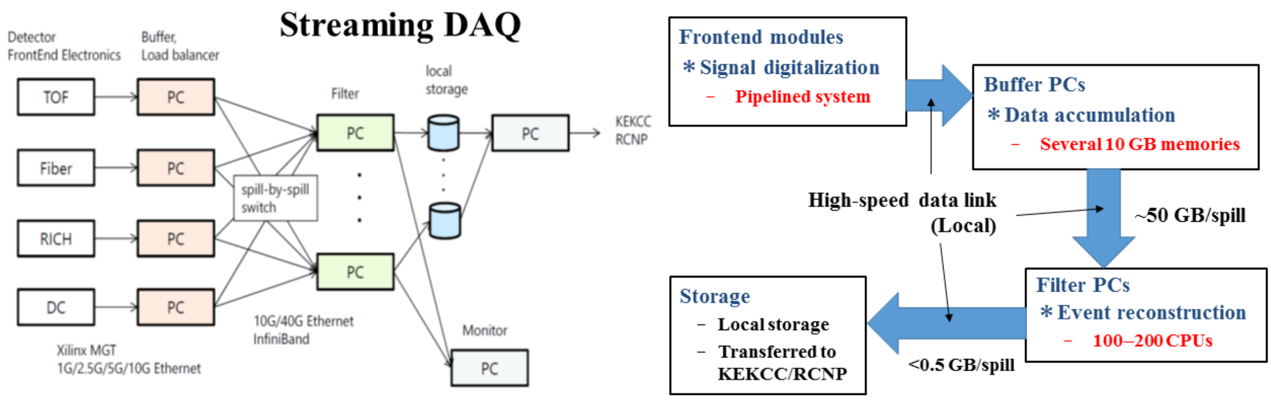

Figure 1: Conceptual configuration of the deadtime-less data acquisition system for E50

Cooperative works on detector development are also in progress. Resistive plate chambers (RPCs) are considered for several experiments at J-PARC as timing counters with a high time resolution of much less than 100ps. Large size RPCs are being developed for LEPS2 [2], which will be introduced to the J-PARC experriments. LEPS2 and J-PARC are closely collaborating in research and development on RPC and high-resolution TDC for high-precision timing measurement with RPCs.

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

Beam has come back in the J-PARC Hadron Experimental Facility in April, 2015 since the accident on a leakage of radioactive materials assoiated with the production target melted by unexpectedly short-pulsed extraction primary proton beam occurred May 23, 2013. This year, the E31 experiment [3] successfully demonstrated experimetal feasibility based on a data set taken as calibration data for E15 [4].

The experimental set up of E31 is illustrated in Fig. 2. Typically 1.3×10^5 kaons at 1 GeV/c were delivered from the K1.8BR beam line every 6 seconds, and irradiated on a liquid deutrium target for about 2.2 days. Scattered neutrons were detected by Neutron Counters (NC), an array of plastic scintillators, located about 15m downstream of the deuterium target..A typical time resolution was 150ps for gamma-rays. Charged particles emitted from the target were identified by the Cylindrical Detector System (CDS), surrounding the target in a solenoid magnet, as shown in Fig. 3. Event samples of the $d(K^-, n\pi^+\pi^-)$"n" reaction were collected, where n and $\pi^\pm$ were measured by NC and CDS, respectively, and "n" was identified in a missing mass spectrum of $d(K^-, n\pi^+\pi^-)$. These samples are candidates of signal events, $d(K^-, n)\pi^\pm\Sigma^\mp$. However, they contains three types of background events: (1) quasi-free $K^-p \to \bar{K}^0 n$ reaction took place in a deuteron, (2) Σ^- production associated with a π^+ detected by CDS, and decay particles from Σ^-, n and π^-, are dtected by NC and CDS, respectively, and (3) Σ^+ production associated with a π^- detected by CDS, and decay particles from Σ^+, n and π^+, are detected by NC and CDS, respectively. These background events identified respectively in invariant mass spectra of $\pi^+\pi^-$, $n\pi^-$, and $n\pi^+$ were discarded from the collected event samples. Then, we obtained a missing mass spectrum of the $d(K^-, n)\pi^\pm\Sigma^\mp$ reaction, which must carry information on the $\bar{K}N \to \pi\Sigma$ scattering amplitudes of both isospins $I = 0$ and 1. We observed a structure just below the K^-p mass threshold together with a quasi-free like bump structure above the threshold.

We can decompose the spectrum into two final $\pi^\pm\Sigma^\mp$ states by identifying a Σ^-/Σ^+ peak in a missing mass spectrum of $d(K^-, n\pi^+)/d(K^-, n\pi^-)$, respectively [5]. We need more statistics in order to decompose the spectrum significantly. We will increase statistics more in the physics run, which will start in next fiscal year 2016.

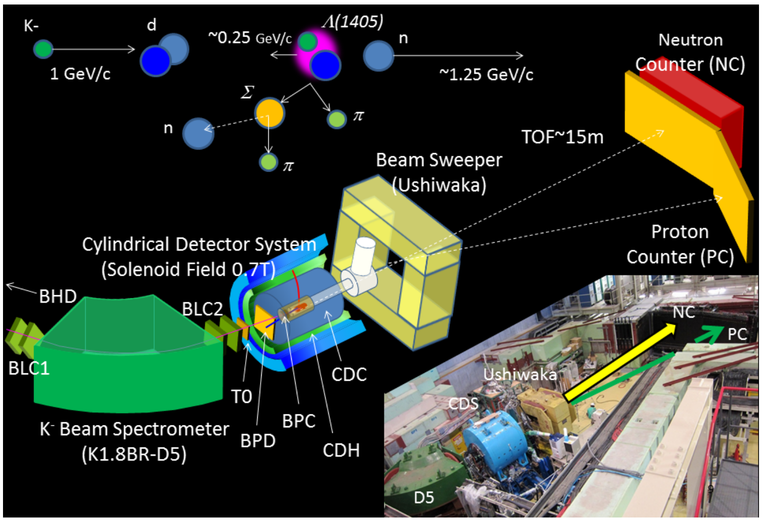

Figure 2: Illustration of the E31 experimental setup at the K1.8BR beam line.

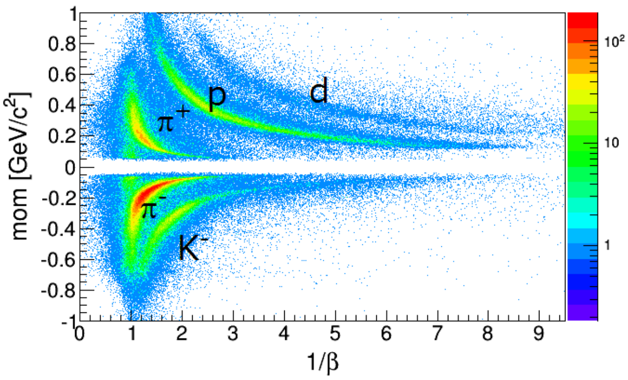

Figure 3: Particle identification of CDS.

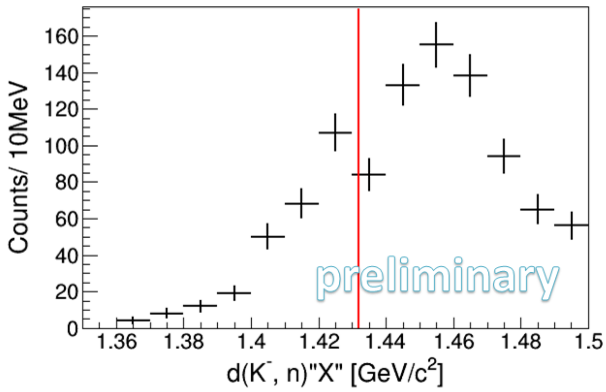

Figure 4: Preliminary result of a missing mass spectrum of $d(K^-, n)\pi^\pm\Sigma^\mp$.

References

[1] J-PARC E50 proposal. http://www.j-parc.jp/researcher/Hadron/en/Proposal_e.html#1301

[2] N. Tomida *et al.*, Nucl. Instrum. Meth. A766, 283(2014).

[3] J-PARC E31 proposal. http://www.j-parc.jp/researcher/Hadron/en/Proposal_e.html#0907

[4] J-PARC E15 proposal. http://www.j-parc.jp/researcher/Hadron/en/Proposal_e.html#0606

[5] K. Inoue *et al.*, Proc. of 12th Int. Conf. on Hypernucl. and Strange Part. Phys. (HYP2015), Sendai, Sep., 2015, to be published.