Ver. 15 June, 2007

Replies to FIFC questions on E10 experiment

Q1 : Do we need to confirm the E521 result with high statistics by E10, JPARC ?

A1 : No, we believe we don't need reconfirmation. The KEK-PS-E521 experiment was performed to confirm the feasibility of the production of the neutron-rich hypernuclei by using the double charge-exchange (DCX) reaction. The experiment was successful, and we wish to go to the next step at J-PARC. We are proposing to produce the ${}^{9}_{\Lambda}$He and ${}^{6}_{\Lambda}$H hypernuclei. The core nuclei of the ${}^{9}_{\Lambda}$He hypernucleus is a typical halo-nucleus ^{8}He. We are interested in the effect of the addition of a Λ hyperon on the halo structure. The ${}^{6}_{\Lambda}$H hypernucleus is a quite exotic hypernucleus with a large N/Z ratio.

The spectrometer system at J-PARC will be almost same as the old system at KEK-PS, so the reconfirmation just for a system check is not necessary, too. The measurement of the DCX reaction is time consuming, and the reaction is not a suitable reaction for the system check. We can make the system check by the ordinary (π^+, K^+) reaction.

Q2 : If so, why you do not plan the confirmation first ?

A2 : As we answer above, we don't need to confirm the E521 result.

Q3 : What is your relation to the E521 collaboration ?

A3 : Fukuda, Saha and Noumi are co-spokesperson of the KEK-PS-E521 experiment. Kishimoto, Sakaguchi, Ajimura, Takahashi and Bhang are the members of the collaboration.

Q4 : Can you show us the significance of signals as a function of energy resolution in order to verify the 2.5MeV (FWHM) requirement ?

A4 : Figure 1 is a result of the calculation of the S/N ratio in the case of the ${}^{6}_{\Lambda}$H production. In the calculation, the energy threshold of particle decay channels in ${}^{6}_{\Lambda}$H is assumed to be 3 MeV. The ratio of yields between the signal (hypernucleus production) and the background (quasi-free Λ production from 0<-BE<20MeV) is assumed to be 1:10. These parameters are same as that used in the discussion described in the document for FIFC (see Fig.2 in the document). The energy window for signal selection are set to $\pm 2\sigma$ (σ is the energy resolution in rms).

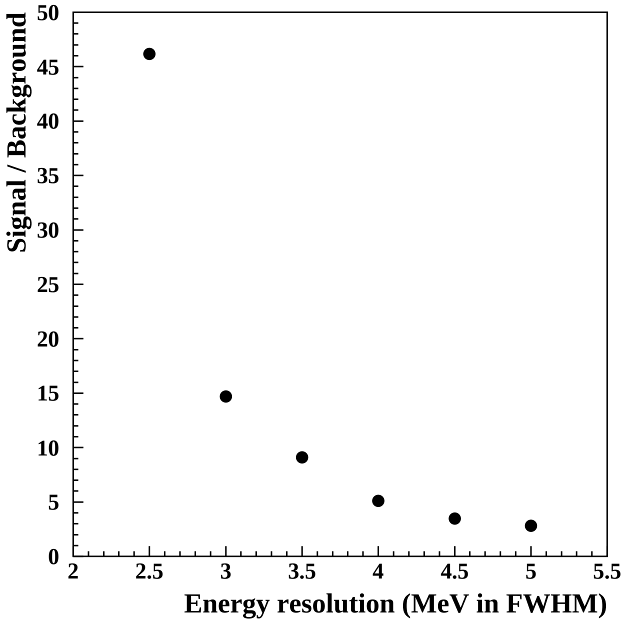

Figure 1: S/N ratio as a function of energy resolution in the case of the ${}^{6}_{\Lambda}H$ production. For more details see the text.

The result shows the signal is quite significant in the case of the 2.5 MeV resolution. The S/N ratio drops quite rapidly with the increase of the energy resolution.

Q5 : What is the status of DC1 and DC2 (1mm MWPC) ?

A5 : Currently, we have no practical drawing for the DC1 and DC2 tracking detectors based on the 1 mm wire-spacing MWPC because the 1mm MWPC is still under development at KEK. We are waiting for the completion of the R&D works.

A difference between BC1/BC2 and DC1/DC2 is the size of the detectors. BC1 and BC2 (1 mm MWPC) have the same size of the sensitive area, 256mm(W)×100mm(H). DC1 has a sensitive area, 288mm(W)×150mm(H), and DC2 has a sensitive area, 384mm(W)×250mm(H). The size of DC1 is similar with that of BC1/BC2, so we believe we can fabricate the 1mm MWPC version of DC1 without any difficulties if R&D of BC1 and BC2 will be completed. The fabrication of DC2 may need some development due to the larger size than BC1/BC2, but we believe knowhow to be obtained during the BC1/BC2 R&D works will help us.

Some amount of budget is allocated for the fabrication of DC1 and DC2 and readout electronics as written in the E10 document for FIFC.

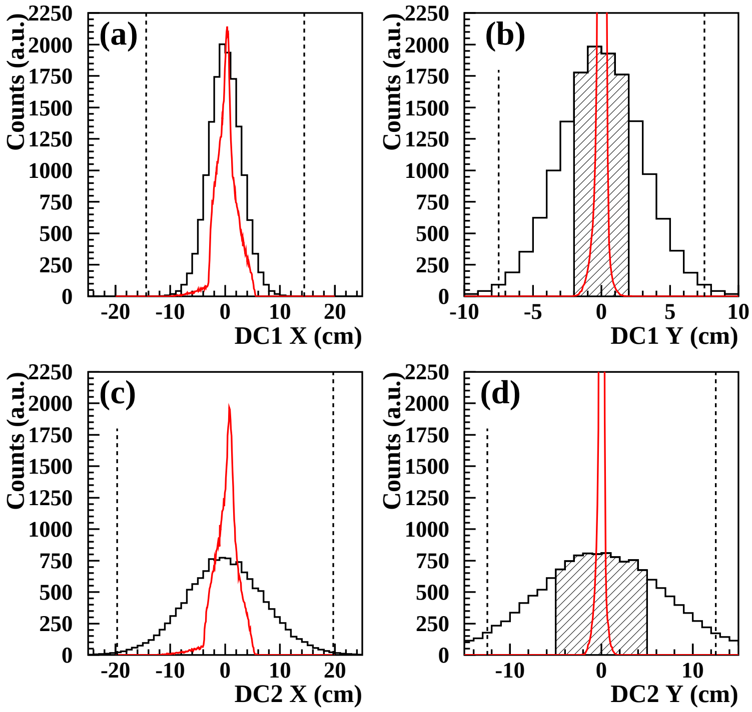

Figure 2: Simulated hit distributions at DC1 and DC2. Black and red colored histograms corresponds to hypernuclear events and beam hits, respectively. See text for more details.

Q6 : What is the DC update in "Time Schedule, p.25 in your presentation" ?

A6 : The 1st version of DC1 and DC2 for SKS will be prepared by the E05 collaboration (practically by KEK and Kyoto University groups). But, the 1st version is the 3 mm wire-spacing drift chamber. So, we wish to update DC1 and DC2 by the 1 mm MWPC version for the E10 experiment (and also for E22). We call it "DC update".

As we mention in A5, we believe the fabrication of the 1 mm MWPC version of DC1/DC2 is rather straightforward if the R&D works will be finished by the E05 collaboration. So, the time allocated for the DC update is essentially the time needed for the chamber fabrication.

Q7 : Can you show us K^+ distribution in DC1, DC2 together with the beam ?

A7 : Figure 2 shows simulated hit distributions at DC1 and DC2. The distribution projected to the x (a) and y (b) axes at DC1, and the x (c) and y (d) distributions at DC2. The black colored histograms correspond to events with the production of hypernuclei, and red colored histograms correspond to beam hit distributions.

For the simulation, the angular dependence of the differential cross section of the production cross section of hypernuclei is included in the black histograms, but he SKS acceptance is not included. The SKS acceptance changes the x distributions, (a) and (c), a little. For the y distributions, (b) and (d), the hatched areas roughly show the SKS acceptance.

The vertical dashed lines indicate the edge of DC1 and DC2.

Q8 : What is the momentum resolution as a function of spatial resolution of DC1 and DC2 in SKS ?

A8 : We don't have result of the simulation study on the effect of the DC1 and DC2 resolution to the momentum resolution for the original SKS setup. We have an example of the simulation for the SksPlus case (see E05 documents to FIFC). The result tells that the momentum resolutions are roughly 10% worse with 500 μm chamber resolutions in comparizon with the 300 μm resolution case. This weak dependence of the momentum resolution on the tracker position resolutions mainly comes from the multiple scattering effects. Further, in the practical offline momentum analyses of the SKS spectrometer, the final resolution does not depend so much on the chamber position resolution but depends largely on how to remove or cancel the systematic correlation in the wide SKS acceptance.

We also wish to mention that the nominal position resolution of the existing SKS tracking chambers (5 mm wire-spacing DCs) is roughly 300 μm and the position resolution of 1 mm MWPC is expected to be $1000/\sqrt{12} \sim 290\mu$m. So, we believe the replacement of the 3 mm DC by the 1 mm MWPC affects not so much to the momentum resolution of the SKS system.

Q9 : What is the status of cryocooler system in SKS ?

A9 : As the SKS user group announced, we will replace the cooling system of the SKS magnet by a system with three modules of GM-JT 4K cryocooler (3.5 W cooling power for each). In FY2006, we made a bench test of a cryocooler which was fabricated in FY2005, and obtained a net cooling power of 3.32 W. Since the heat leak of the SKS cold box is in 5 W level, the performance of the cryocooler is enough good for our purpose.

In FY2007–2008, the fabrication of two other cryocoolers and the modification of the cooling system will be proceeded.

Q10 : What is the status of chambers (BC1-4) and counters(BH1-2) in K1.8 beam line, which will be fabricated in FY2007 ?

A10 : BC1 and BC2 are 1 mm wire-spacing MWPC. The R&D works for the 1 mm MWPC is in progress at KEK (by the E05 collaboration). They designed a prototype MWPC (version 1) with 1 mm wire-spacing, 3 mm anode-cathode gap and 15μmϕ anode wires. During the bench test of the prototype MWPC, we had a problem of a discharge at the chamber edge. The discharge damaged the cathode plane, aluminum coated poly-alamide film. The anode wires had no damage.

E05 is preparing another prototype MWPC (version 2). For the version 2 MWPC, E05 is planning following modifications:

- Modify the wire configuration at the edge of the chamber. Several dummy wires are added to hide the edge wires from the cathode plane.
- Use thiner wire, 12.5 μmϕ, to reduce the operation voltage.
- Look for other martial for the cathode film coating because the thin aluminum layer is fragile for the discharge.

We hope the updated prototype MWPC will have a good performance after the modifications, then we can proceed to the BC1/BC2 productions.

BC3 and BC4 are 3 mm wire-spacing drift chambers. The design of the 3 mm chambers is similar with that of the 5 mm wire-spacing drift chambers used for the beam tracking chambers at KEK-PS K6 beam line. Practical design works will start at Kyoto University, soon.

The beam line hodoscope BH1 was designed and fabricated already by the E05 collaboration at KEK. It will be placed at the upstream end of the beam line momentum analyzer system. This beam line hodoscope BH1 is common for all K1.8 experiments. We need another beam line hodoscope BH2 for E10 to be placed at the downstream end of the beam analyzer. We are planning to design BH2 in FY2007 and fabricate it in FY2008. We have no technical problem for BH2.

Q11 : What is the R&D status of 1mm MWPC for BC4 although it is the second option ?

A11 : If we will fabricate 1 mm MWPC version of BC4, the structure of BC4 may be exactly same as that of BC1/BC2. So, no additional R&D work is necessary. We will just make a copy of BC1/BC2. The concern is only the cost for fabrication.

Q12 : Can you explain the beam distribution in BC4, p.11, especially the sharp edge in left ?

A12 : First of all, let us describe the design principles of the K1.8 beam line optics very briefly (you can find details in the report of the Hadron Beam Line Group to FIFC). The most important design principles are:

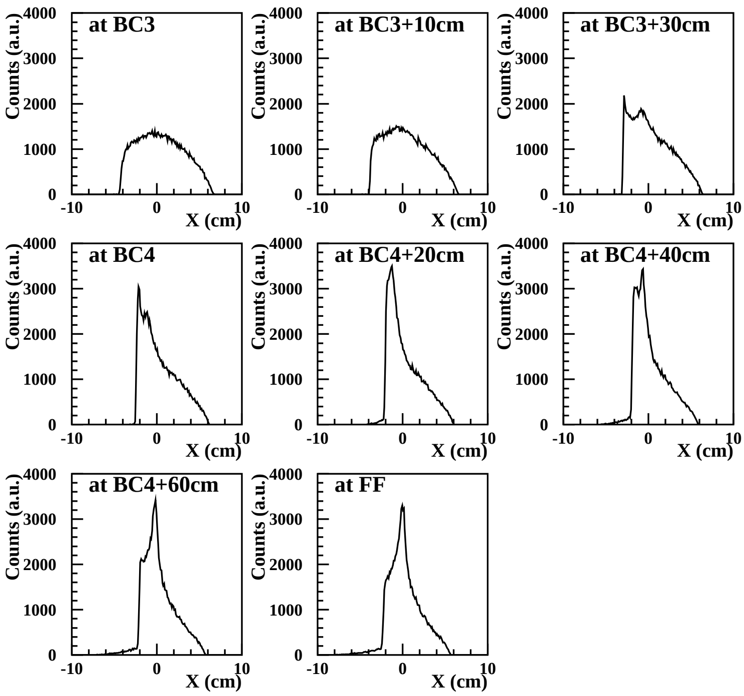

Figure 3: Hit profile change from BC3 to the final focus point (FF) in the x (horizontal) direction.

- Higher order corrections to obtain very small beam size at the mass slits (MS1 and MS2). This is inevitable to realize the good K/π ratio.
- Point to point optics from the BC2 position to the BC3 position. This is inevitable to obtain the excellent momentum resolution by the beam line spectrometer.

The optimization of the beam optics according to the design principles may affect to the beam profiles around BCs and also the final focus point (FF). Especially, the optimization may introduce higher order aberrations in the beam profiles. Other minor issues of the beam line optics are:

- Chromaticity at FF, $(x|\delta)$=0, δ=dp/p.
- Small x and y beam sizes at FF (or no beam divergence toward FF).

We believe these design of the beam optics creates the somewhat "singular" beam profile at BC4.

Figure 3 shows the hit profile change from BC3 to the final focus point (FF) in the x (horizontal) direction. The beam focusing becomes significant around BC4 position. The peak structure at the left end at the BC4 position seems to move toward center (x=0) from BC4 to FF.

To see the profile change more clearly, 2 dimensional profiles are created (see Fig. 4). The left and right sides show the correlations of position-angle (x-x') and position-momentum (x-dp/p), respectively. The monitoring points are 20 cm downstream of BC3, BC4, 30cm downstream of BC4 and final focus point (FF) from top to bottom. The dashed lines are shown to guide the symmetry axis (not perfect symmetry) of the profile distributions. The dashed lines rotate clockwise and anti-clockwise from top to bottom for the left and right plots, respectively, and lines becomes almost parallel to the vertical axises at FF. This means the focusing is realized at FF.

The 2 dimensional profiles have non-uniform distributions and there are 2 clear loci maybe due to the higher order aberrations. At the BC4 position one of the loci accidentally becomes almost parallel to the vertical axis. This is the reason that the BC4 profile has very asymmetric distribution.

We wish to mention that the BC4 x profile is quite asymmetric in shape, but the asymmetric profile causes no technical problems in the E10 experiment.

Q13 : What is background in the chambers from the π^- beam in SKS ? The high intensity beam would hit the SKS magnet.

A13 : In the KEK-PS E521 experiment, the trigger rate of the (π^-, K^+) reaction was typically about 130 per 5×10^6 pions, which was factor five to six smaller than that of the (π^+, K^+) reaction. We learned that scattered particles associated with the pion beam absorption at the SKS return yoke did not contribute to the count rate very much.

Trigger, time-of-flight (TOF), aerogel Čerenkov (AČ) and lucite Čerenkov (LČ) detectors, and tracking chambers were located backward from the beam absorption. Energetic and fast charged particles could not be emitted backward. Low energy and slow charged particles were smeared out by a strong magnetic field of SKS.

A γ-ray could reach the trigger counters to sneak into the kaon time window. The γ-ray could interact with TOF and kick out a fast electron, which could fire both of TOF and lucite. In fact, we experienced an increase of the trigger rate by this effect in the KEK-PS E438 experiment. E438 is an experiment to measure the (π^-, K^+) spectra at a Σ^- production region. The beam momentum was used at 1.2 GeV/c, but SKS excitation was greater than that for E521. The background from the γ-rays was enhanced in E438 since LČ was moved to be located just behind TOF, while LČ was usually located 1 m behind TOF and AČ was placed between them. These γ-ray oriented events could be removed by increasing a threshold of TOF discriminators, since an energy deposit was small.

Q14 : Can you show us a breakup in the 1kHz trigger rate which you mentioned ?

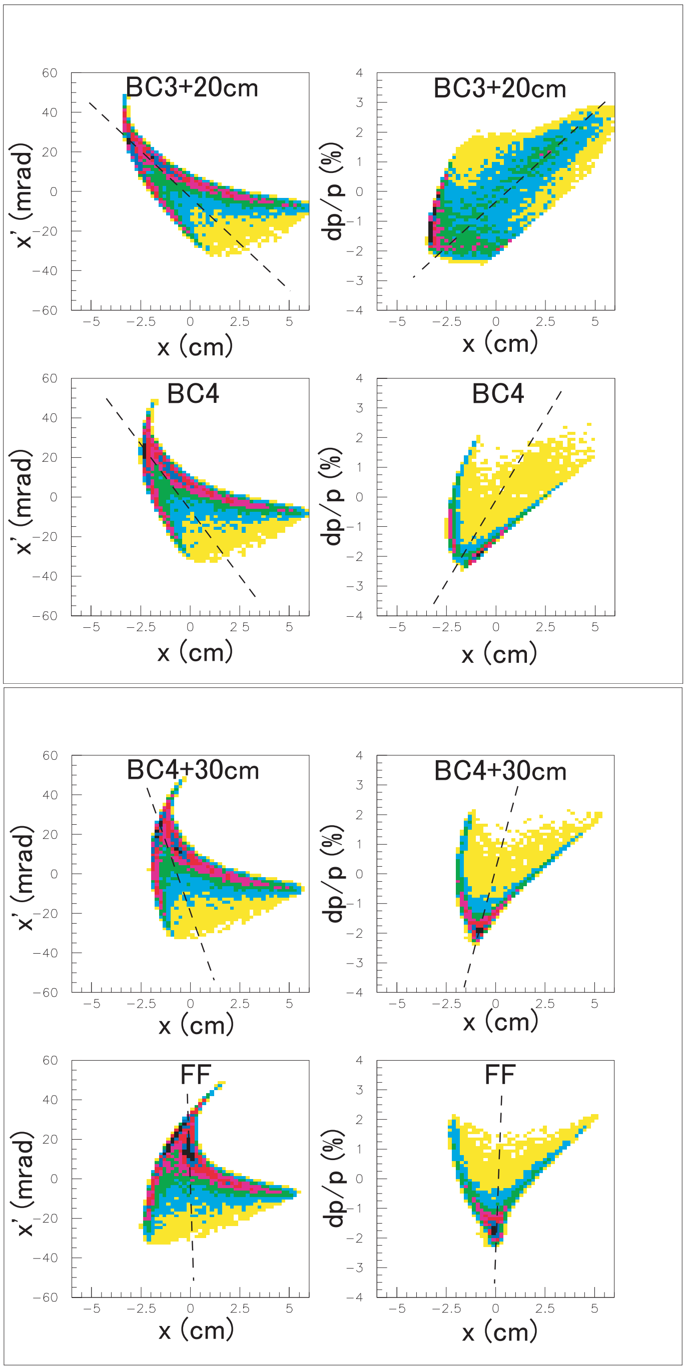

Figure 4: Correlation (left) between position, x, and angle, x', and (right) between position, x, and momentum difference, $\delta=\Delta p/p$. (From top to bottom) positions are at 20cm downstream from BC3, at BC4, at 30cm downstream from BC4 and at final focus point, FF.

A14 : According to the E521 data analysis, almost all the (π^-, K^+) triggers are the (π^-, p) reactions in the target. A fast proton kicked out at a forward angle has a velocity close to that of the kaon, and thus can sneak into the kaon trigger logic and time window. This is due to a large acceptance of SKS.

As we mention in A13, the trigger rate for the (π^-, K^+) reaction was 130 per 5×10^6 pions in the E521 experiment. This means the trigger rate in the E10 experiment is estimated to be about 400 triggers/spill if we will use the 5×10^6 pions/s beams and employ the 3 s beam spill. So, our estimation of the trigger rate is less than a half of that we mentioned in the FIFC meeting.