Status of the SKS spectrometer and experiments at K1.8

2012 Jan.14
13th J-PARC PAC
T.Takahashi (KEK)
**Beam Time Request before Summer Shutdown**

- **Confirmation of Beamline & Detector Recovery** 4 days
- **Trigger & Detector tuning, high-rate study** 5 days
- **Spectrometer & Range Counter calibration** 3 days
  - $p(\pi^+,K^+)\Sigma^+$ at 1.37 and 1.5 GeV/c with SKS=350 A
  - Beam Through RUN at various momenta
  - RC Calibration
- **E19 RUN for $p(\pi^-,K^-)$ at 2.0 GeV/c (2nd step RUN)** 8 days
- **E27 RUN for $p(\pi^+,K^+)$ at 1.7 GeV/c** 1 day
- **E27 Empty target RUN** 1 day
- **E27 RUN for $d(\pi^+,K^+)$ at 1.7 GeV/c (1st step RUN)** 10 days
- **Kaon beam tuning & study** 2 days
- **Resolution check by $^{12}\text{C}(\pi^+,K^+)^{12}_\Lambda\text{C}$ at 1.2 GeV/c** 1 day

**Total** 36 days
Contents

• Recovery Status of K1.8 and SKS
  – Sks configuration
  – Cooling and Excitation Tests

• Status & RUN Plan
  – E19
  – E27
  – E10
  – Fiber Tracker under R&D

• Plan for February RUN
Changes from 2010 Autumn (1)

SKS Magnet position is changed !!
SksZero → SksMinus’

Aerogel Cerenkov Counter
AC1/AC2 (1.2m) → LAC (1.8m)
Changes from 2010 Autumn (2)
PreCooling & Excitation Test of SKS

- Cooling of the magnet  Oct.3—Nov. 10
- Power supply shutdown test on Nov. 14
- 8-hours excitation test on Nov. 16
**E19: Θ⁺ Search via the p(π⁻,K⁻)X**

- **at 11th PAC**

- **7.8x10^{10} π⁻ @1.92GeV/c in 2010 Autumn**
  - 16% statistics of the proposal

- **Next step (April 2011)**
  - Similar statistics at 2.0 GeV/c (max. at K1.8)
    - 6 days with 1.1M/spill (16% duty factor)

- **Further (Autumn 2011 – )**
  - To reach 75nb/sr sensitivity
  - p dependence with 3 different momenta
E19: Achievement & Next Goal

2010 Autumn RUN@1.92GeV/c

U.L. $\sim 0.3 \mu b/sr$ (2—15° Ave.)

$\Leftrightarrow 0.3 \mu b$

$\Gamma \leq 1 \text{MeV/c}^2$

Paper is under preparation.

Next RUN @2.0GeV/c

The same sensitivity of $\sim 0.3 \mu b$

(7+1 days with 1M/spill beam)

If $\Theta^+$ exists @ 0.5$\mu$b,

$\Rightarrow$ Some structure can be seen.

If not,

$\Rightarrow$ Limit to the decay width of 0.6 MeV.

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Table 1

<table>
<thead>
<tr>
<th>$\frac{1}{2}^+$ $\Gamma=1$MeV</th>
<th>$P_{\text{lab}}$</th>
<th>$P_{\text{lab}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.92 GeV/c</td>
<td>2 GeV/c</td>
</tr>
<tr>
<td>PS  Fs 500MeV</td>
<td>9.2 $\mu$b</td>
<td>9.8 $\mu$b</td>
</tr>
<tr>
<td>Fc 1800MeV</td>
<td>5.3 $\mu$b</td>
<td>4.9 $\mu$b</td>
</tr>
<tr>
<td>PV  Fs 500MeV</td>
<td>0.51 $\mu$b</td>
<td>0.75 $\mu$b</td>
</tr>
<tr>
<td>Fc 1800MeV</td>
<td>0.29 $\mu$b</td>
<td>0.50 $\mu$b</td>
</tr>
</tbody>
</table>

T.Hyodo: private com.

DIANA: $\Gamma=0.36 \pm 0.11$ MeV

Belle ($K^+n\to K^0_spX$) : $\Gamma<0.64$ MeV
E19: Acceptance of SksMinus’

350A:
Better (Flat) acceptance for missing mass region $1.50 \sim 1.57$ GeV/c$^2$.
Same current setup as E27.
$\Rightarrow$ Common calibration $p(\pi^+, K^+)\Sigma^+$ at 1.37GeV/c
Necessary time (E19)

• Beam line & Detector commissioning: 4 days
  – Trigger & detector tuning: 2 days
    – Including E27 Trigger studies
  – Beam tuning & high rate study: 3 days
    – 0.5 days for determination of parameters at -2.0/+1.5/+1.7GeV/c
    – 0.5 days for D1 study (interfere between K1.1BR)
    – 0.5 days for MWPC/MWDC optimum condition
    – Fiber Tracker Study & High rate beam Σ+ data and analysis
      (1.5 days) (after April)

• Calibration run: 2 days
  – 1 day for p(π+, K+)Σ+ : 1.37 and 1.5 GeV/c (SKS 350A)
  – 1 day for Beam Through RUN at various momenta w/ and w/o target

• E19 production run: 8 days (including 1 day down time)
  – p(π−, K−)Θ+: 2.0 GeV/c (SKS 350A)
E27: Search for “K^-pp” bound state in the d(π^+,K^+)X reaction

• “K^-pp” is produced through Λ* doorway in the d(π^+,K^+) reaction

• Semi-exclusive measurement by Range Counter Array (RCA) in order to suppress quasi-free B.G.
  - K^-pp → Λ p_1, Λ → p_2 π^-
  - K^-pp → Σ^0 p_1, Σ^0 → (Λγ) → p_2 π^- γ
  - π^+d → Λ* K^+ p_{1s}, Λ* → Σ π, Σ^+ → p_2 π^0

• Original Proposal: 5M/spill beam
  - 6x10^4 Λ*/day
  Assuming 1% trapping probability
  - 600 bound states/day (inclusive)
  - ~300 events/40 days (exclusive)
  with ε_{RCA} ~14% for two protons
E27: The first step Goal

- Inclusive d(π⁺,K⁺)X spectrum @2.2 < Mₓ < 2.5 GeV/c².
  - The first measurement of this reaction and this missing mass region. \(1.7 \times 10^5 \Lambda(1405)’s @10 \text{ days}\)
  - To evaluate the maximum value of the cross section, and to understand the background shapes.
  - p(π⁺,K⁺)X for one day
  - contribution of “p” in “d”

- Check the feasibility of coincidence measurement
  - One proton tag/Two proton tag
E27: Expected inclusive spectrum

\[ P_\pi = 1.7 \text{GeV/c}, \ SKS=350A \]

10 days with 1M/spill beam

\[ K+p+p \sim 2.37[\text{GeV/c}^2] \]

\[ \text{K+pp} \]

50—85 times as many statistics from the past experiment for \( Y^* \) reaction.

with the same angular distribution as process Yield/the elem.

+ Fermi gas model (MC)

\begin{align*}
\pi^+ \ "n" & \rightarrow \Sigma^0 K^+ & 120.6 \mu b \\
\pi^+ \ "n" & \rightarrow \Lambda K^+ & 174.7 \mu b \\
\pi^+ \ "n" & \rightarrow \Lambda(1405) K^+ & 20.6 \mu b \\
\pi^+ \ "n" & \rightarrow \Sigma\pi K^+ & 40 \mu b \\
\pi^+ \ "n" & \rightarrow \Sigma^0(1385) K^+ & 76.7 \mu b \\
\pi^+ \ "n" & \rightarrow \Lambda\pi K^+ & 13.7 \mu b \\
\pi^+ \ "p" & \rightarrow \Sigma^+ K^+ & 470 \mu b \\
\pi^+ \ "p" & \rightarrow \Sigma^0(1385) K^+ & 124 \mu b \\
\pi^+ \ "p" & \rightarrow \Lambda\pi K^+ & 40 \mu b \\
\pi^+ \ "p" & \rightarrow \Sigma\pi K^+ & 28.9 \mu b \\
\end{align*}
E27: Expected spectrum with one proton tag

- $\pi^+ \ "n" \rightarrow \Sigma^0 K^+$
- $\pi^+ \ "n" \rightarrow \Lambda K^+$
- $\pi^+ \ "n" \rightarrow \Lambda(1405) K^+$
- $\pi^+ \ "n" \rightarrow \Sigma \pi K^+$
- $\pi^+ \ "p" \rightarrow \Sigma^+ K^+$
- $\pi^+ \ "p" \rightarrow \Sigma^+(1385) K^+$
- $\pi^+ \ "p" \rightarrow \Lambda \pi K^+$
- $\pi^+ \ "p" \rightarrow \Sigma \pi K^+$

$P_{\pi} = 1.7\text{GeV/c, SKS}=350\text{A}$

10 days with 1M/spill beam

$\text{Mom}_{\text{proton}}>350\text{MeV/c}$

$K^+p+p \sim 2.37\text{[GeV/c}^2\text{]}$

$K^-pp = 50\text{events/10 days with }1\text{ proton coincidence (1% sticking)}$

FINUDA, DISTO
Necessary time (E27)

- **Beam line & Detector commissioning**: 4 days
  - Including E27 Trigger studies
- **Trigger & detector tuning**: 2 days
  - Including E27 Trigger studies
- **Beam tuning & high rate study**: 3 days
  - 0.5 days for determination of parameters at -2.0/+1.5/+1.7GeV/c
  - 0.5 days for D1 study (interfere between K1.1BR)
  - 0.5 days for MWPC/MWDC optimum condition
  - Fiber Tracker Study & High rate beam $\Sigma^+$ data and analysis (1.5 days) (after April)
- **Calibration run**: 3 days
  - 1 day for $p(\pi^+, K^+)\Sigma^+$: 1.37 and 1.5 GeV/c (SKS 350A)
  - 1 day Beam Through RUN at various momenta w/ and w/o target
  - 0.5 days for $p(\pi^+, K^+)\Sigma^+$: +1.37 or 1.5 GeV/c (SKS 350A) with E27 target position
  - a few hours for $p(\pi^+, p\pi^+)$ @0.5GeV/c for RC Calibration
- **E27 Empty Target RUN**: 1 day
- **E27 production run**: 1+10 days
  - $p(\pi^+, K^+)X$ @1.7GeV/c (SKS 350A) 1 day
  - $d(\pi^+, K^+)X$ @1.7GeV/c (SKS 350A) 10 days
E10: n-rich $\Lambda$ hypernuclei ($^6\Lambda$H and $^9\Lambda$He)

FINUDA: 3 candidates for $^6\Lambda$H

E.Botta Hadron2011 Proceeding

$K^- + ^6\text{Li} \rightarrow ^6\Lambda\text{H} + \pi^+$

$^6\Lambda\text{H} \rightarrow ^6\text{He} + \pi^-$

Important to confirm the existence of $^6\Lambda\text{H}$!

- Bound state or not?
- Binding energy?

Yield Estimate
11nb/sr ($^{10}\Lambda\text{Li}$, KEK-PS E521)
3.5g/cm$^2$ target
3M/spill beam

2012 Autumn after improvement of duty factor
introduction of high-rate detectors

100 events / 3 weeks

Check of the resolution for SksMinus’ by $^{12}\text{C}(\pi^+,K^+)^{12}\Lambda\text{C}$ reaction (1 day)
Development of Beamline Fiber Tracker

- Handling of high intensity beam (> $10^7$Hz) at J-PARC
  - Stable operation for high intensity beam
  - Good time resolution to identify triggered event

![Beamline Fiber Tracker system diagram]

Fiber tracker with good timing resolution
MPPC readout of fiber
Multichannel MPPC readout

2 layers of 1mm diameter fiber
160mm $\times$ 50mm active area

MWPC (12 layes in X, U, V)
$\rightarrow$ BFT(2 layers in X)
@Beam Spectrometer
Development of Beamline Fiber Tracker

- Handling of high intensity beam (> $10^7$Hz) at J-PARC
  - Stable operation for high intensity beam
  - Good time resolution to identify triggered event

Fiber tracker with good timing resolution
MPPC readout of fiber
Multichannel MPPC readout

- Good timing resolution ($\sigma = 0.7$ns)
- MWPC
- Fiber tracker
- Time Gate 80 ns
- Time Gate < 5 ns

Photon number

- Enough photon number for MIP
- Efficiency 99% (@ 300kHz/fiber)
- > 95% (@ 1MHz/fiber)

Prototype detector
Readiness

- Beamline & SKS standard detectors will be ready by February.
- Liq. H$_2$ target will be ready by February.
  - Liq. D$_2$ target will be ready soon after H$_2$ target
- Range Counter for E27 will be installed after February RUN
  - will be ready by March
- Fiber tracker will be ready by April.
Beam Time Plan in February RUN

- Confirmation of Beamline & Detector Recovery 4 days
- Trigger & Detector tuning, high-rate study 3 days
- Spectrometer & Range Counter calibration 2 days
  - $p(\pi^+, K^+)\Sigma^+$ at 1.37 or 1.5 GeV/c with SKS=350 A
  - Beam Through RUN at various momenta
- E19 RUN for $p(\pi^-, K^-)$ at 2.0 GeV/c 8 days
- E27 RUN for $p(\pi^+, K^+)$ at 1.7 GeV/c 1 day
- E27 Empty target RUN 1 day
- E27 RUN for $d(\pi^+, K^+)$ at 1.7 GeV/c 10 days
- Kaon beam tuning & study (0.5x2) 1 day
- Resolution check by $^{12}\text{C}(\pi^+, K^+)_{^{12}\Lambda}\text{C}$ at 1.2 GeV/c 1 day

Total 18 days

1-2 days interval is necessary to fill $H_2$
Beam Time Plan in February RUN (short)

- Confirmation of Beamline & Detector Recovery 4 days
- Trigger & Detector tuning, high-rate study 3 days
- Spectrometer & Range Counter calibration 1 day
  - $p(\pi^+, K^+)\Sigma^+$ at 1.37 or 1.5 GeV/c with SKS=350 A
  - Beam Through RUN at various momenta
- E19 RUN for $p(\pi^-, K^-)$ at 2.0 GeV/c (Test) 1 day
- E27 RUN for $p(\pi^+, K^+)$ at 1.7 GeV/c 1 day
- E27 Empty target RUN 1 day
- E27 RUN for $d(\pi^+, K^+)$ at 1.7 GeV/c 10 days
- Kaon beam tuning & study (0.5x2) 1 days
- Resolution check by $^{12}\text{C}(\pi^+, K^+)^{12}\Lambda\text{C}$ at 1.2 GeV/c 1 day

Total 10 days

1-2 days interval is necessary to fill $\text{H}_2$
Summary

• We request 36 days beam time by Summer Shutdown.
  – E19 2nd step RUN / E27 1st step RUN.
  – Studies

• In February, we can start E19 RUN within 10 days beam time.
  – If 18 days is allocated, 2nd RUN will be completed.

• If the beam time is allocated separately, a few days overhead beam time may be necessary.
backups