Hadron Experimental Hall and High-Momentum Beamline at J-PARC

Shin’ya Sawada

澤田 真也

KEK

(High Energy Accelerator Research Organization, Japan)
Contents

- Overview of J-PARC and Hadron Experimental Facility (Hadron Hall)
- Hadron Hall
- High-momentum Beam Line and COMET
- Extension
- Summary
JFY2009 Beams

JFY2008 Beams

JFY2007 Beams

Hadron Exp. Facility

Materials and Life Experimental Facility

Bird's eye photo in January of 2008
n Overview of J-PARC and Hadron Experimental Facility (Hadron Hall)

n Hadron Hall

n High-momentum Beam Line and COMET Extension

n Summary
Hadron Experimental Facility (Current Layout)

- Hadron Hall
- 50GeV Synchrotron
- Beam Dump
- 50GeV Tunnel
- 's'P Target (30/50% Loss)
- Test BL
- Hi-P BL
- SM1 (2% Loss)
- T0 (0.1% Loss)
- Switchyard
- Extension
Current Hadron Hall

$\pi, K, \bar{p} < 2 \text{ GeV/c}$

$\pi, K, \bar{p} < 1.1 \text{ GeV/c}$

E05/07/10/13/19/27 Exp. (SKS & KURAMA spectrometers)

Neutral K

Kaon rare decay: KOTO

E15/17 Exp.
Experiments now and in the near future
Beam power of SX operation

MR cycle time: 6.0 s.

2012/06/09-2012/07/02

2012/12/14-2012/12/27

Beam power [kW]

Duty factor ~ 28%

Duty factor ~ 43%

Acc. Study (15 kW)

User operation (11 kW)

Duty factor was improved by new transverse RF system.
Extraction efficiency for 11kW beam

Real Time Dynamic Bump at 11kW beam very well worked

Average extraction efficiency is 99.5% at 11kW Operation
Spill structure of 11 kW beam

Optimized EQ,RQ spill feedback parameters
Transverse RF 3kW/each electrode, 1kHz width from 95.067MHz
coil short ON

#623470 (12/18)

5 shots average duty 43%
#623466-70

time-magnified spill
Problem at a septum magnet for slow extraction
**Season of Fruits at Hadron Hall Comes!**

### Beam Operation

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</thead>
<tbody>
<tr>
<td></td>
<td>&gt;5kW</td>
<td>&gt;10kW</td>
<td>&gt;50kW</td>
<td>&gt;100kW</td>
<td>&gt;100kW</td>
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### Beam Line & Experiment

<table>
<thead>
<tr>
<th>Beam line</th>
<th>Exp.</th>
<th>Subject</th>
<th>FY2012</th>
<th>FY2013</th>
<th>FY2014</th>
<th>FY2015</th>
<th>FY2016</th>
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<tbody>
<tr>
<td>K1.8</td>
<td></td>
<td>Spectrometer</td>
<td>SKS</td>
<td>SKS-KURAMA</td>
<td>KURAMA</td>
<td>KURAMA-S-2S</td>
<td>S-2S</td>
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<td>K1.8BR</td>
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<tr>
<td>KL</td>
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<td>High-P</td>
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<td>COMET</td>
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<td>K1.1</td>
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<tr>
<td>K1.1BR</td>
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<td>Const. btwn SY &amp; Hall</td>
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<td>Neutrino</td>
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</tbody>
</table>

### Beam Intensity

- >30kW
- >10kW
- >5kW
- 5kW
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High-p and COMET

- New primary Proton Beam Line
  = High-momentum BL + COMET BL
- Originally 3 years of construction.
- All the construction was approved by the supplementary budget of JFY2012.
  - Total amount = 35-oku Yen ~ USD35M
  - Money has to be spent until the end of JFY2013, with some extreme exceptions.
New Primary Proton Beam Line
High-p and COMET

- New primary Proton Beam Line
  = High-momentum BL + COMET BL

- High-momentum Beam Line
  - Primary protons ($\sim 10^{10} - 10^{12}$ pps)
    - E16 (phi meson) is considered to be the first experiment.
  - Unseparated secondary particles (pi, ...)
    - High-resolution secondary beam by adding several quadrupole and sextupole magnets.

- COMET
  - 8 GeV, 50 kW protons
  - Branch from the high-momentum BL
  - Annex will be built at the south side.
<table>
<thead>
<tr>
<th>Energy</th>
<th>Primary</th>
<th>Secondary</th>
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<tbody>
<tr>
<td>30 GeV</td>
<td>$10^{10}$/s</td>
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</tr>
<tr>
<td>8 GeV</td>
<td>$10^{12}$/s</td>
<td>$10^{14}$/s</td>
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<tr>
<td>&lt;30 GeV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **E16**
- **P04 etc.**
- **COMET**

**Available beam on high-p beam line**

**Hadron physics**
Unseparated Secondary Beam Intensity

beam loss limit @ SM1: 15kW (limited by the thickness of the tunnel wall)

extraction angle $\pm 15^\circ$ with 15kW beam loss
Secondary Beam Intensity

Graph showing the secondary beam intensity with different particle types: π+, π-, K+, K-, pbar.
High-p Line and E16 Spectrometer

Primary Beam Splitter ($10^{10}$ ppp)
15kW Target for $\pi$-beam
What is mu-e Conversion?

1s state in a muonic atom

Nuclear muon capture
\[ \mu^- + (A, Z) \rightarrow \nu_\mu + (A, Z - 1) \]

Neutrino-less muon nuclear capture
\[ \mu^- + (A, Z) \rightarrow e^- + (A, Z) \]

Lepton flavours changes by one unit

Muon decay in orbit
\[ \mu^- \rightarrow e^- \nu \bar{\nu} \]

\[ E_{\mu e} \sim m_\mu - B_\mu \]
- \( B_\mu \): binding energy of the 1s muonic atom

\[
B(\mu^- N \rightarrow e^- N) = \frac{\Gamma(\mu^- N \rightarrow e^- N)}{\Gamma(\mu^- N \rightarrow \nu N')} 
\]
COMET Phase-I Goal

- As an intermediate goal of the COMET experiment
  - gain experience to reach the final goal
- $7 \times 10^{-15}$ sensitivity (90% C.L.)
  - better than the current limit by SINDRUM-II ($7 \times 10^{-13}$) and compatible to MEG sensitivity
- Involve more collaborators
Extension of the hall

- COMET target and beam dump should be located outside the hall to keep enough space for COMET experiment.
- Hall will have an Annex at the south side.
Charmed Baryon Spectroscopy via the $(\pi, D^{*-})$ reactions

H. Noumi
Research Center for Nuclear Physics
Osaka University
for the P50 collaboration
Charmed Baryon

\[ \nu_{\text{CMI}} \sim [\alpha_s/(m_i m_j)]^* (\lambda_i, \lambda_j)(\sigma_i, \sigma_j) \]

Weak CMI with a heavy Quark

- [qq] is well isolated and developed

- Level structure of \( Y_c^* \) provides diquark properties
  - “diquark mass”
Large Acceptance, Multi-Particle
- $K$, $\pi$ from $D^0$ decays
- Soft $\pi$ from $D^{*-}$ decays
- (Decay products from $Y_c^*$)

High Resolution

High Rate
- SFT/SSD op. $>10$M/spill at K1.8
<table>
<thead>
<tr>
<th></th>
<th>FY2013</th>
<th>FY2014</th>
<th>FY2015</th>
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</thead>
<tbody>
<tr>
<td>Manufacturing Magnets,</td>
<td></td>
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<tr>
<td>Power Supply, etc.</td>
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<tr>
<td>Civil construction (utility building) and utilities (electricity and cooling water (PW1))</td>
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<tr>
<td>Installing Magnets, Power Supply, etc.</td>
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<tr>
<td>Commissioning</td>
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</table>
Hadron Hall in Coming Years: Present
Hadron Hall in Coming Years: 2014-
Hadron Hall in Coming Years: ?-
Contents

- Overview of J-PARC and Hadron Experimental Facility (Hadron Hall)
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A task force has worked to generate a preliminary design of the extended hadron hall.
Beam Lines at the Extended HH
Beam Lines and Major Physics Cases under discussion

- **K10**
  - High-momentum separated beams up to 6 (with electro-static separators) or to 10 (with RF separators) GeV/c.
  - Physics with kaons and antiprotons are under discussion.

- **HIHR**
  - High-intensity and high-resolution beams up to 2 GeV/c.
  - One stage separator presumably pions are used.
  - High resolution spectroscopy of S=-1 hyper nuclei.

- **K1.1**
  - Moved from the existing hall.
  - A lot of physics cases remaining.

- **KL**
  - Neutral kaon beam line with 5deg angle to the primary beam.
  - Essential to the step-2 KOTO experiment.
Physics experiments have started at the Hadron Hall of J-PARC, and the first physics paper was published from the E19 experiment. More to come soon.

The funding for the high-momentum beam line with COMET has been approved by the government!

The extension of the Hadron Hall is the next step. A working group discusses physics cases and beam lines.

Let’s discuss to generate good physics cases!