Dilepton Measurement and Future Possibilities at J-PARC

M. Naruki (Kyoto Univ.)
at ISMD2023, Gyöngyös, Hungary
on 23th Aug. 2023
Hadron Physics at J-PARC

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J-PARC

Materials & Life Science Facility

3GeV PS (RCS)

Hadron Experimental Facility

400MeV LINAC

Main Ring (MR)

Fast extraction 510kW

Slow extraction 64.5kW

Tokai, Ibaraki
Physics at J-PARC Hadron Facility
intense kaon beam

Hypernuclei
multi-strangeness hypernuclei

Few-body systems
K-pp

Hadron-Hadron Interaction

Exotic Hadrons
Pentaquark $\Theta^+$
H dibaryon

CP violation

COMET

Hadron Mass

Baryon spectroscopy

Physics at J-PARC Hadron Facility intense kaon beam
Hadron Physics at J-PARC

Quark degrees of freedom - Nuclear Force

NN potential from LQCD

Hadron-Hadron Interaction
YN scattering

Hypernuclei
multi-strangeness hypernuclei
ΞN, ΛΛ

Few-body systems

K-pp
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N. Ishii, S. Aoki and T. Hatsuda,
PRL 99, 022001 (2007)
Highlights from J-PARC

Quark degrees of freedom - Nuclear Force

ΣN scattering

Charge Symmetry Breaking in hypernuclei

Observation of K-pp

Consistent with LQCD

* E40 collaboration, PTEP 2022 093D01
* E15 coll., PLB. 789, 620 (2019)
High-momentum beamline

- at SM1 protons branches off from the primary line
- 30 GeV primary proton ($10^{10}$/s)
- 8 GeV primary proton for COMET
- 2 - 20 GeV/c secondary particles

### Table: Particles and Intensities

<table>
<thead>
<tr>
<th>Name</th>
<th>Particles</th>
<th>$P_{\text{max}}$ (GeV/c)</th>
<th>Intensity (/spill)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1.8</td>
<td>$\pi, K$</td>
<td>2.0</td>
<td>$10^6$ K^-</td>
</tr>
<tr>
<td>K1.8BR</td>
<td>$\pi, K$</td>
<td>1.1</td>
<td>$10^6$ K^-</td>
</tr>
<tr>
<td>KL</td>
<td>$K^0$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-p</td>
<td>proton</td>
<td>31</td>
<td>$10^{10}$ p</td>
</tr>
<tr>
<td>High-p2</td>
<td>$\pi/K$</td>
<td>20</td>
<td>$10^6$ K^-</td>
</tr>
</tbody>
</table>

SM1: branched by 5°
Dilepton Measurement - Schedule

- **2020-2021 RUN0** -- 320 hours, C/Cu targets
  - Beamline / Detector commissioning

- **2023 Run0d** -- 201 hours
  - Beamline commissioning, pilot run

- **2024 RUN1** -- 1280 hours, C/Cu targets
  - Physics run 15k of $\phi$ mesons

- **2025 RUN2** -- 2560 hours, C/Cu/Pb targets
  - Nuclear size & velocity dependences
  - Dispersion relation
Future Possibilities
Dilepton $\rightarrow$ Dihadron Spectrometer

- $\eta \rightarrow e^+e^−γ$
- $\rho \rightarrow e^+e^−$
- $\omega \rightarrow e^+e^−$
- $\phi \rightarrow e^+e^−$
- $K_S^0 \rightarrow π^+π^−$
- $ρ \rightarrow π^+π^−$
- $φ \rightarrow K^+K^−$

E16 $\rightarrow$ E88

PRL 96, 092301

Sakuma et al., PRL 98 (2007) 152302
Strange & Charm Baryon Spectroscopy at high-p secondary beamline

- $N/\Delta$
- $\Omega$
- $\Lambda_c$
- $\Xi$

Partially quark-antiquark states: $<qq>$, $<qs>$
Expected spectra

- Missing mass & decay measurements
  - $\Delta M$ of 7 MeV

$\sigma_{G.S.} = 1$ nb in 100 days
$\Delta M = 8$ MeV
Hadron Experimental Facility extension (HEF-ex) Project

- High-resolution hypernuclei spectroscopy
- New production target
- HIHR
- Test-BL
- High-p ($\pi20$)
- $\Lambda^c$ spectroscopy
- $\Xi/\Omega$ spectroscopy
- $\Lambda$ spectroscopy
- $\Lambda_c$ spectroscopy
- Systematic $\Lambda N$ scattering
- CP violation in rare $K_L^0$ decay

Primary proton
Schedule

• Listed as 1st priority in KEK Project Implementation Plan 2022
Summary

• J-PARC Hadron Facility has been operated since 2009, many study findings have been published to date.
• Recently new beamline was constructed, and the dilepton measurement has been successfully launched.
• The high-momentum beamline will be utilized as the secondary beamline, and it will open to new opportunities for systematic baryon spectroscopy from strange to charm.
• The hadron extension project was selected as the first priority in the KEK long-range plan.