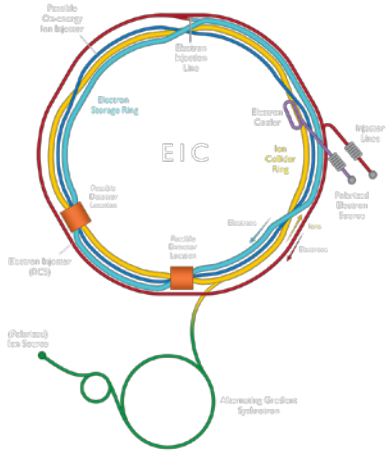
Hadronic Physics at J-PARC with the memory of Prof. Oh

July 12, 2023

Shinya SAWADA

KEK/J-PARC

Prof. Oh has been a center of the collaboration on hadronic physics in Asia and worldwide…



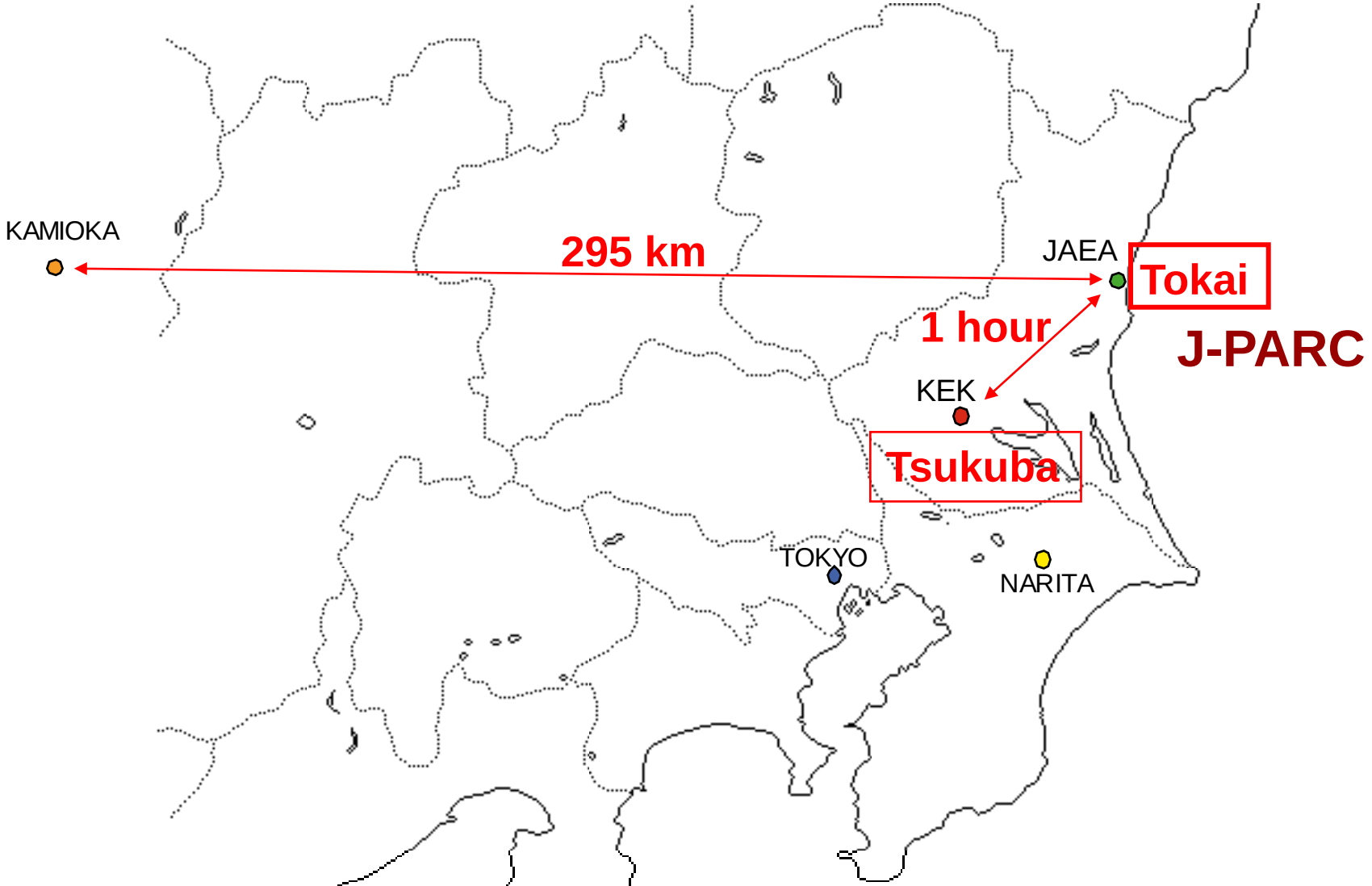
EIC

J-PARC

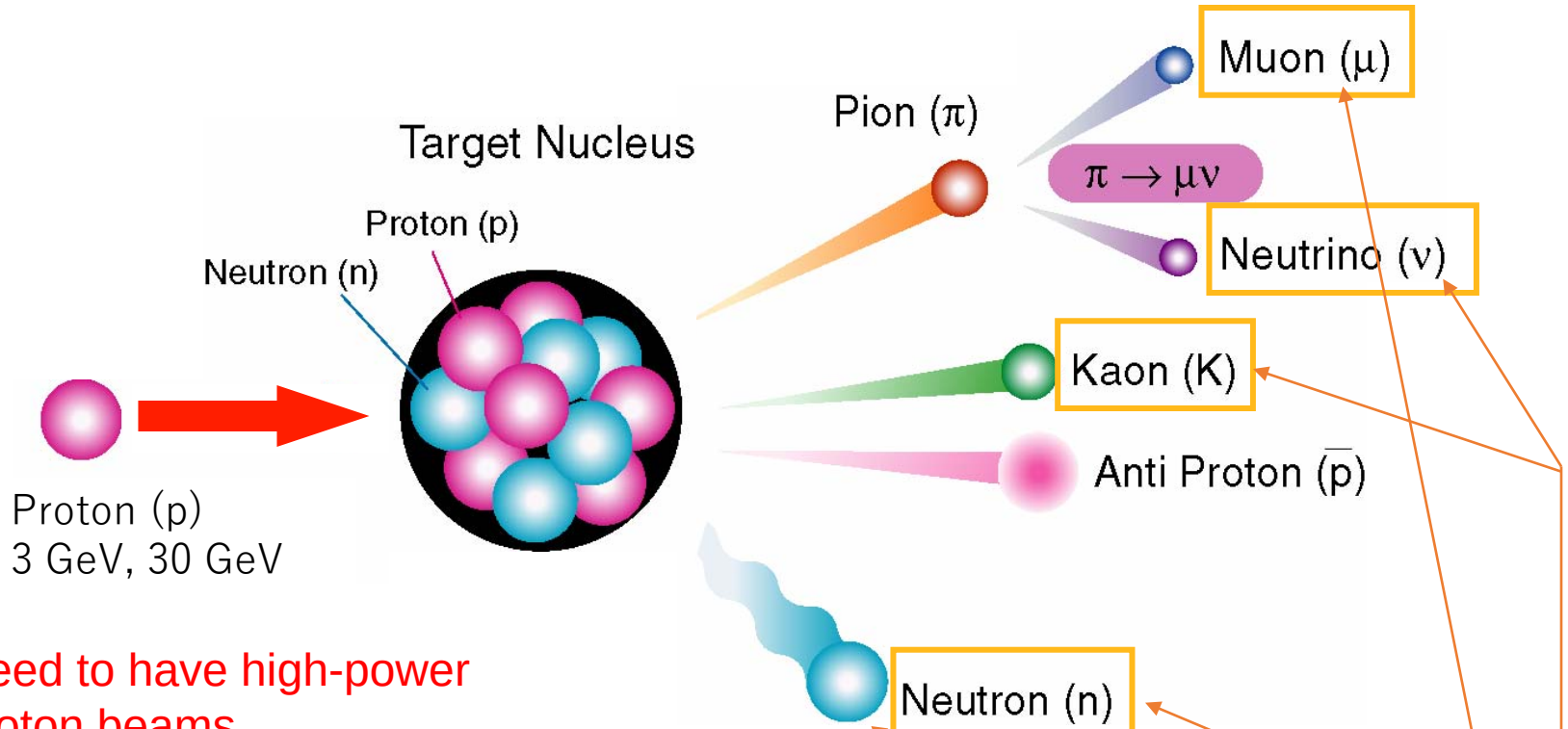
JLab

Bird's eye photo in January of 2016

Location of J-PARC



Goals of J-PARC

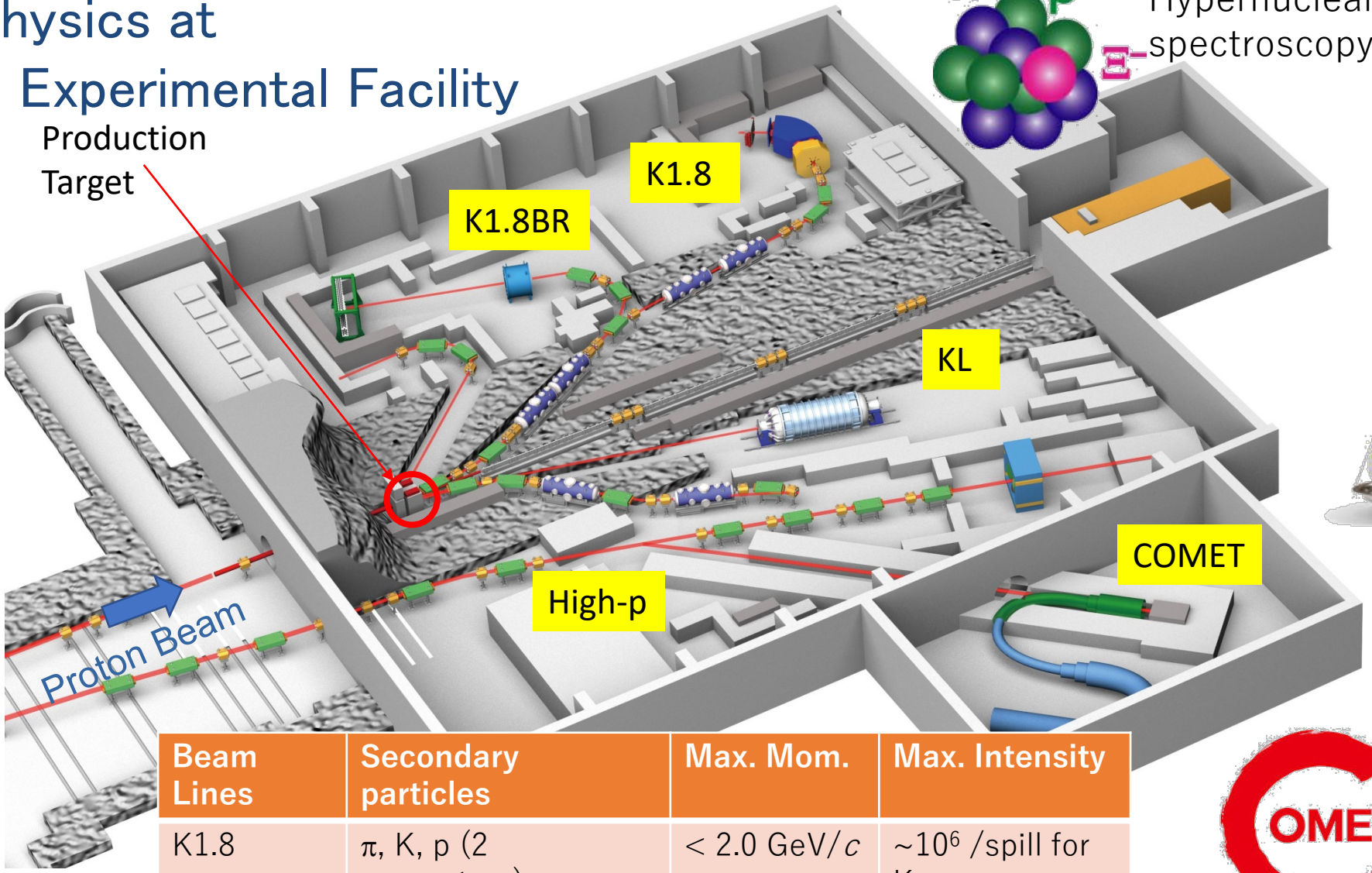


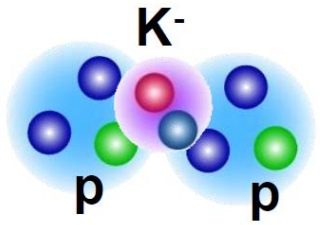
Need to have high-power proton beams

→ MW-class proton accelerator (current frontier is about 0.1 MW)

Materials & Life Sciences at RCS
Nuclear & Particle Physics at MR
R&D toward Transmutation at Linac

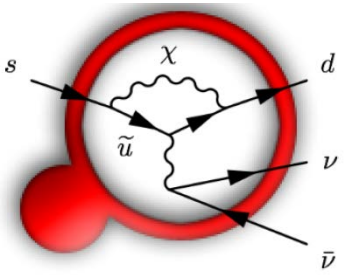
Hadronic Physics at the Hadron Experimental Facility



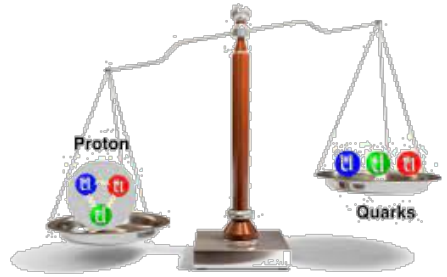


Kaon in nuclei

Hypernuclear spectroscopy



Neutral kaon rare decay



QCD mass and chiral symmetry

Beam Lines	Secondary particles	Max. Mom.	Max. Intensity
K1.8	π, K, p (2 separators)	< 2.0 GeV/c	~10^6 /spill for K^-
K1.8BR	π, K, p (1 separator)	< 1.1 GeV/c	~10^5 /spill for K^-
KL	Neutral Kaon	~ 2.1 GeV/c	~10^7 /spill

COMET μ e

Electron-muon conversion

Recent

Achievements in research at the Hadron Experimental Facility

Flavor Physics

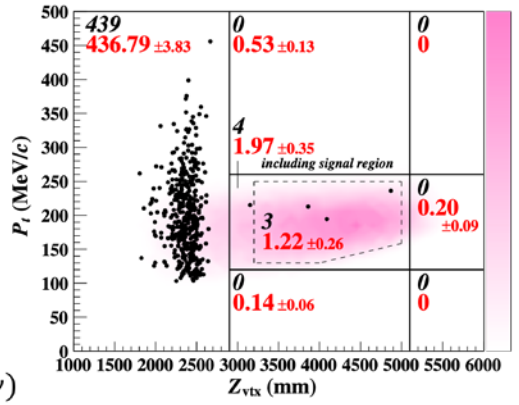
$K_L^0 \to \pi^0\nu\bar{\nu}$ search @ KOTO

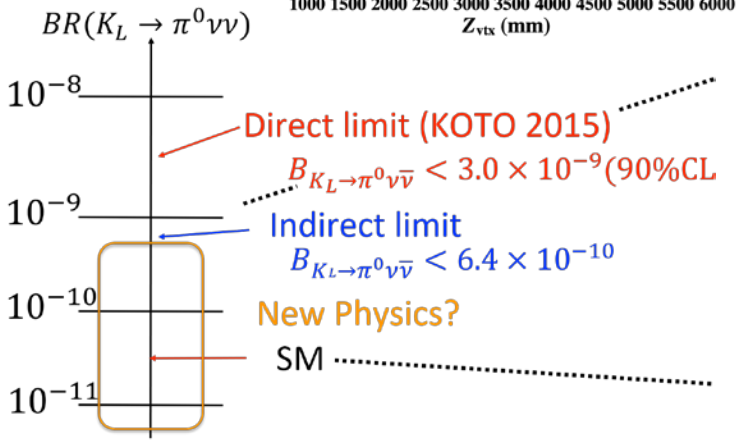
→ Approaching the SM sensitivity for CP violation

KOTO 2015

Single Event Sensitivity = 3×10^{-9}

KOTO 2016-18



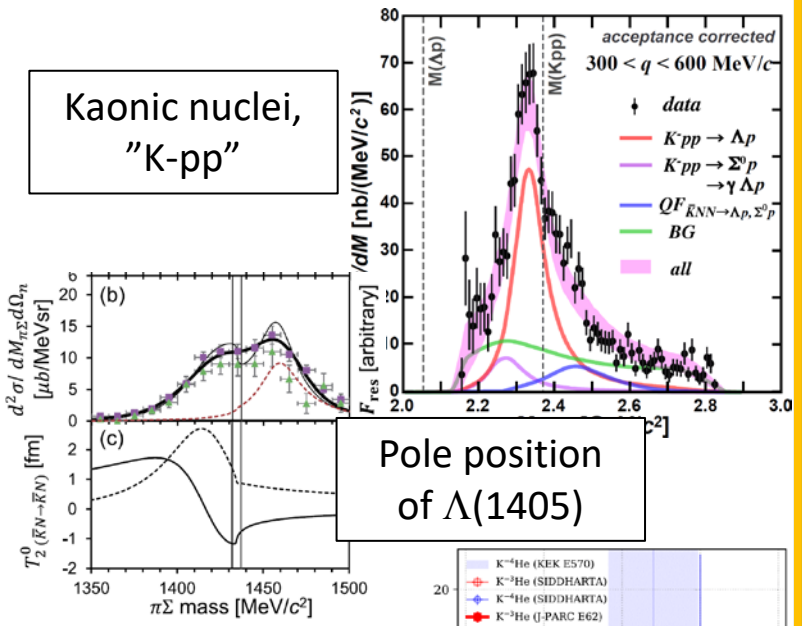


Hadron Physics

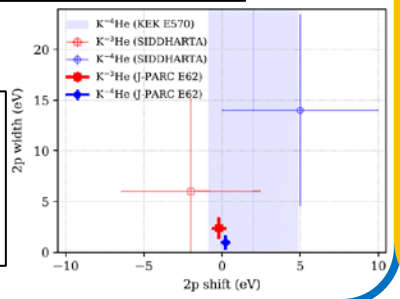
Observation of an exotic hadron bound system including K^- meson

→ Established a new direction to understand meson-baryon int.

Kaonic nuclei, "K-pp"



Pole position of Λ(1405)



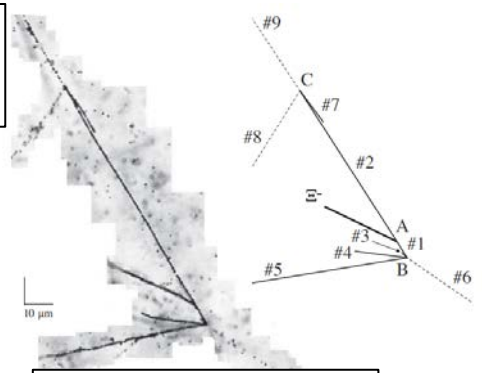
Ultra-precise measurement of kaonic atoms

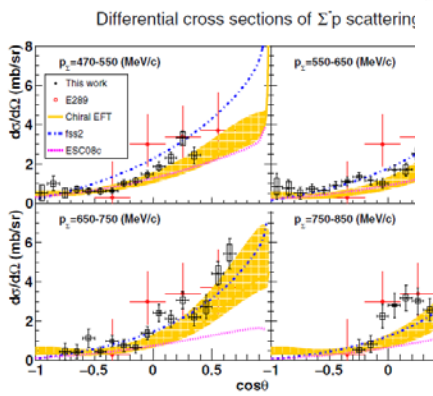
Strangeness Nuclear Physics

A lot of progress in hypernuclear research

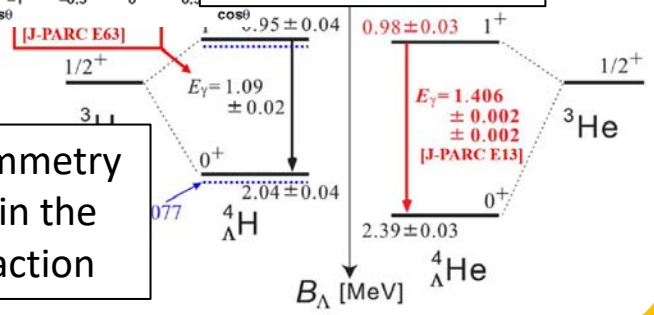
→ Clarified attractive S=–2 ΞN interaction and deepened S=–1 ΛN, ΣN interactions

Observation of Ξ hypernuclei





First precise hyperon-nucleon scattering



Charge-symmetry breaking in the ΛN interaction

Effective interactions of hyperons and mass-radius relation of neutron stars

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[2]*Department of Physics, Pusan National University, Busan 46241, Korea*
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(Received 9 August 2017; published 18 January 2018)

We examine the role of hyperons in a neutron star based on the relativistic mean field approach. For nuclear matter below 1.5 times the normal nuclear density we constrain the model parameters by using the symmetric nuclear matter properties and theoretical investigations for neutron matter in the literature. We then extend the model to higher densities by including hyperons and isoscalar vector mesons that contain strangeness degree of freedom. We confirm that the ϕ meson induces a Λ repulsive force and hardens the equation of state. The hardening arising from the ϕ meson compensates the softening from the existence of hyperons. The flavor SU(3) and spin-flavor SU(6) relations are examined as well. We found that the coupling constants fitted by neutron matter properties could yield high enough maximum mass of a neutron star and the obtained results satisfy both the mass and radius constraints. The onset of the hyperon direct Urca process in neutron stars is also investigated using our parametrization

DOI: 10.1103/PhysRevD.97.023010

Discussed one of the major physics cases investigated at J-PARC: Hyperon Pazzle

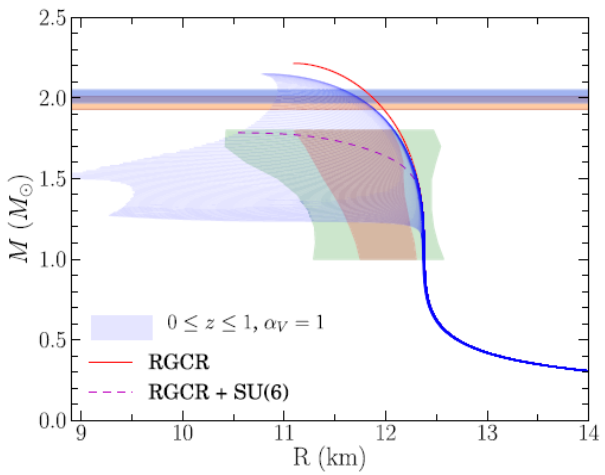

FIG. 10. Mass and radii curves with the variation of z with $\alpha_V = 1$ in the RGCR model, i.e., case II. The red solid line is the result of the model in the SU(2) case and the dashed line is that of case I.

$\bar{K} + N \to K + \Xi$ reaction and $S = -1$ hyperon resonances

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(Received 4 March 2015; revised manuscript received 17 May 2015; published 25 June 2015)

The $\bar{K} + N \to K + \Xi$ reaction is studied for center-of-momentum energies ranging from threshold to 3 GeV in an effective Lagrangian approach that includes the hyperon s- and u-channel contributions as well as a phenomenological contact amplitude. The latter accounts for the rescattering term in the scattering equation and possible short-range dynamics not included explicitly in the model. Existing data are well reproduced and three above-the-threshold resonances were found to be required to describe the data, namely, the $\Lambda(1890)$, $\Sigma(2030)$, and $\Sigma(2250)$. For the latter resonance we have assumed the spin-parity of $J^P = 5/2^-$ and a mass of 2265 MeV. The $\Sigma(2030)$ resonance is crucial in achieving a good reproduction of not only the measured total and differential cross sections but also the recoil polarization asymmetry. More precise data are required before a more definitive statement can be made about the other two resonances, in particular, about the $\Sigma(2250)$ resonance that is introduced to describe a small bump structure observed in the total cross section of $K^- + p \to K^+ + \Xi^-$. The present analysis also reveals a peculiar behavior of the total cross-section data in the threshold energy region in $K^- + p \to K^+ + \Xi^-$, where the P and D waves dominate instead of the usual S wave. Predictions for the target-recoil asymmetries of the $\bar{K} + N \to K + \Xi$ reaction are also presented.

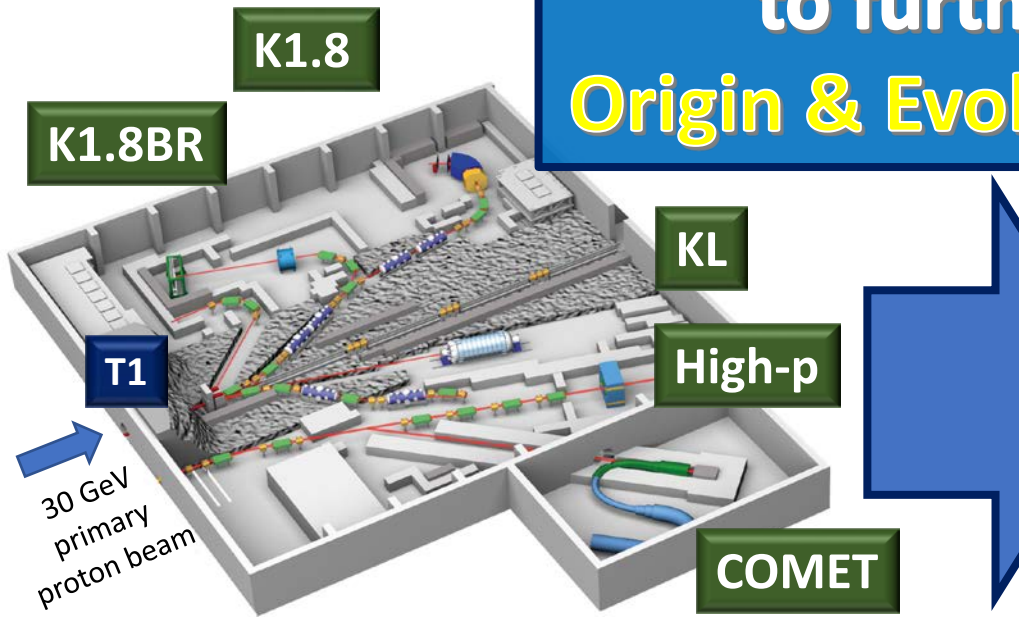
DOI: 10.1103/PhysRevC.91.065208 PACS number(s): 13.75.Jz, 13.60.Rj, 13.88.+e, 14.20.Jn

Pointed out the importance of the experimental data from J-PARC and other experimental facilities.

Hadron Experimental Facility eXtension (HEF-ex) Project

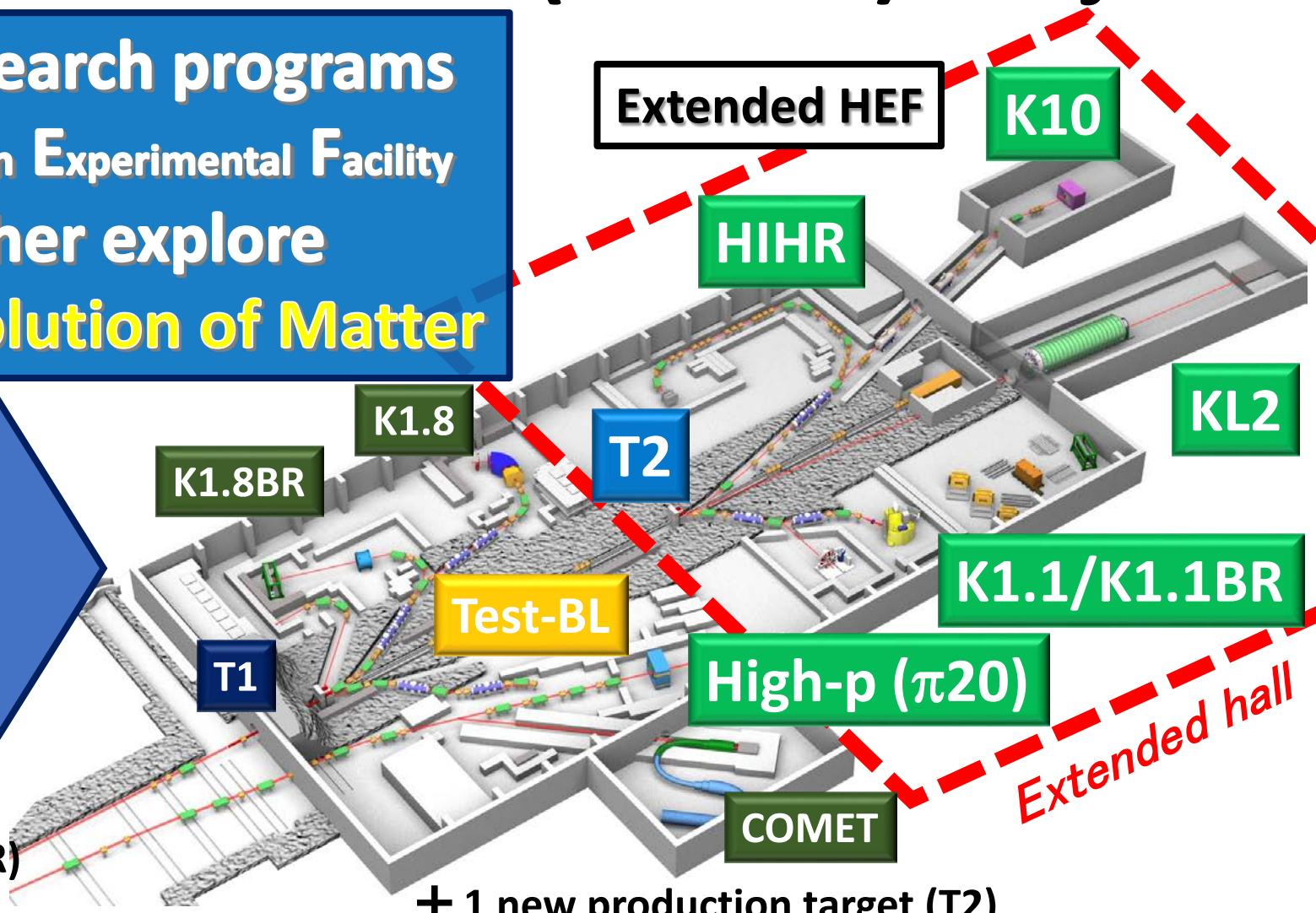
Present HEF (2009～)

expand research programs at the Hadron Experimental Facility to further explore Origin & Evolution of Matter



1 production target (T1)
1 secondary-charged beamline (K1.8/K1.8BR)
1 neutral beamline (KL)
1 primary beamline (High-p)
1 muon beamline (COMET)

Extended HEF



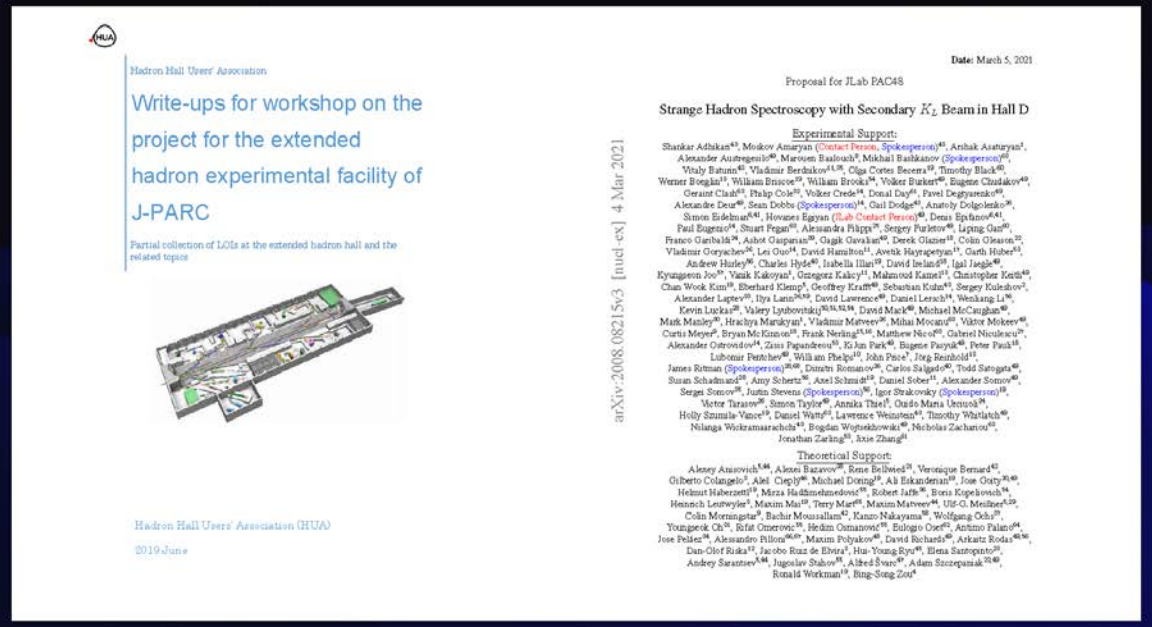
＋1 new production target (T2)
＋4 new beamlines (HIHR, K1.1/K1.1BR, KL2, K10)
＋ 2 updated beamlines (High-p (π20), Test-BL)

3rd International WS on the Extension Project for the J-PARC Hadron Experimental Facility (3rd J-PARC HEF-ex WS), Mar.14-16 2023, J-PARC

Kbar-N scattering for Ξ production

Yongseok Oh (Kyungpook National University, Korea)

3rd International Workshop on the Extension Project for the J-PARC Hadron Experimental Facility
2023. 3. 14 - 3.16, J-PARC, Tokai, Japan



Hadron Hall Users' Association

Write-ups for workshop on the project for the extended hadron experimental facility of J-PARC

Partial collection of LOIs at the extended hadron hall and the related topics

Hadron Hall Users' Association (HUA)

2019 June

Date: March 5, 2021

Proposal for JLab PAC48

Strange Hadron Spectroscopy with Secondary K_L Beam in Hall D

Experimental Support:

Theoretical Support:

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- Ξ production as a probe to study hyperon resonances of S=-1
- Ξ spectrum to understand hyperon structure
- Theoretical investigation of the reactions for Ξ production

$$\gamma N \to KK\Xi \text{ (JLab)} \quad \bar{K}N \to K\Xi \text{ (J-PARC)}$$
$$p\bar{p} \to \Xi\bar{\Xi} \text{ (FAIR)} \quad \pi N \to KK\Xi \text{ (J-PARC)}$$

- Extension of Ξ production to Ξ* production

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Prof. Oh's activities extended even for EIC

Korean EIC & J/ψ Photoproduction

Yongseok Oh
(Kyungpook National University)

NCU Workshop on EIC Physics and Detectors, National Central University, Dec. 9 - 10, 2022

Asia Pacific Center for Theoretical Physics (APCTP)

- A hub for our activities

Potential Korean involvement for EIC

From Yongsun Kim's slides

J/ψ Photoproduction off Nucleons

T.-S. H. Lee, S. Sakinah, Y. Oh, arXiv:2210.02154, to be published in Eur. Phys. J. A

I would like to offer my deepest condolences. We, the hadronic physics community, miss Professor Yongseok Oh forever.