J-PARC hadron physics and future possibilities on color transparency

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Workshop on The Future of Color Transparency and Hadronization Studies at Jefferson Lab and Beyond
Online, USA-eastern time, MSU/Orsay/FIU/Penn State, June 7-8, 2021
https://indico.jlab.org/event/437/timetable/#all.detailed

June 7, 2021

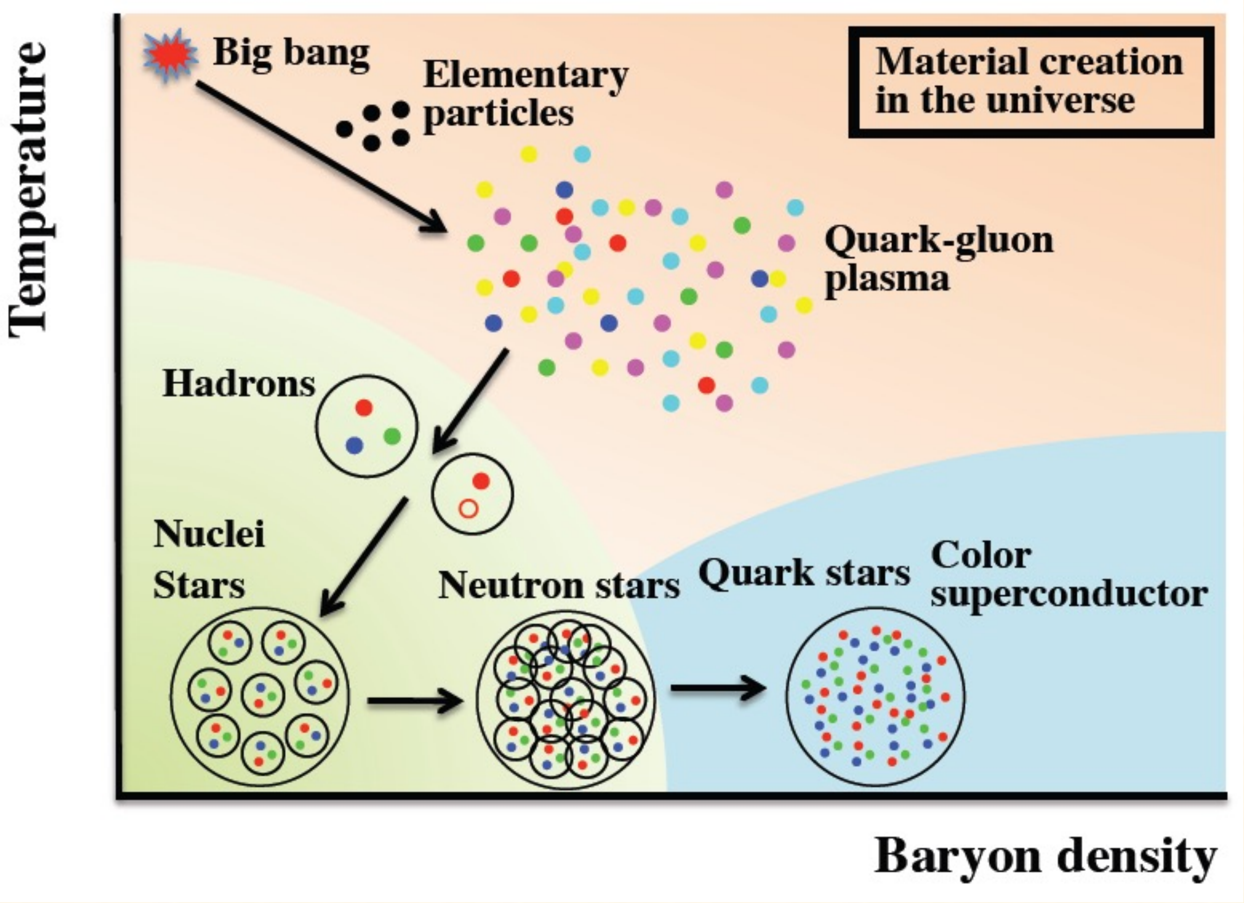
Contents

- Introduction: color transparency and GPDs
  (GPD: Generalized Parton Distribution)
- GPDs by hadronic 2→3 processes
  at hadron accelerator facilities
- Color transparency by hadronic 2→3 processes
- J-PARC hadron-physics projects
  (J-PARC: Japan Proton Accelerator Research Complex)
- Future possibility at J-PARC on color transparency
- Summary

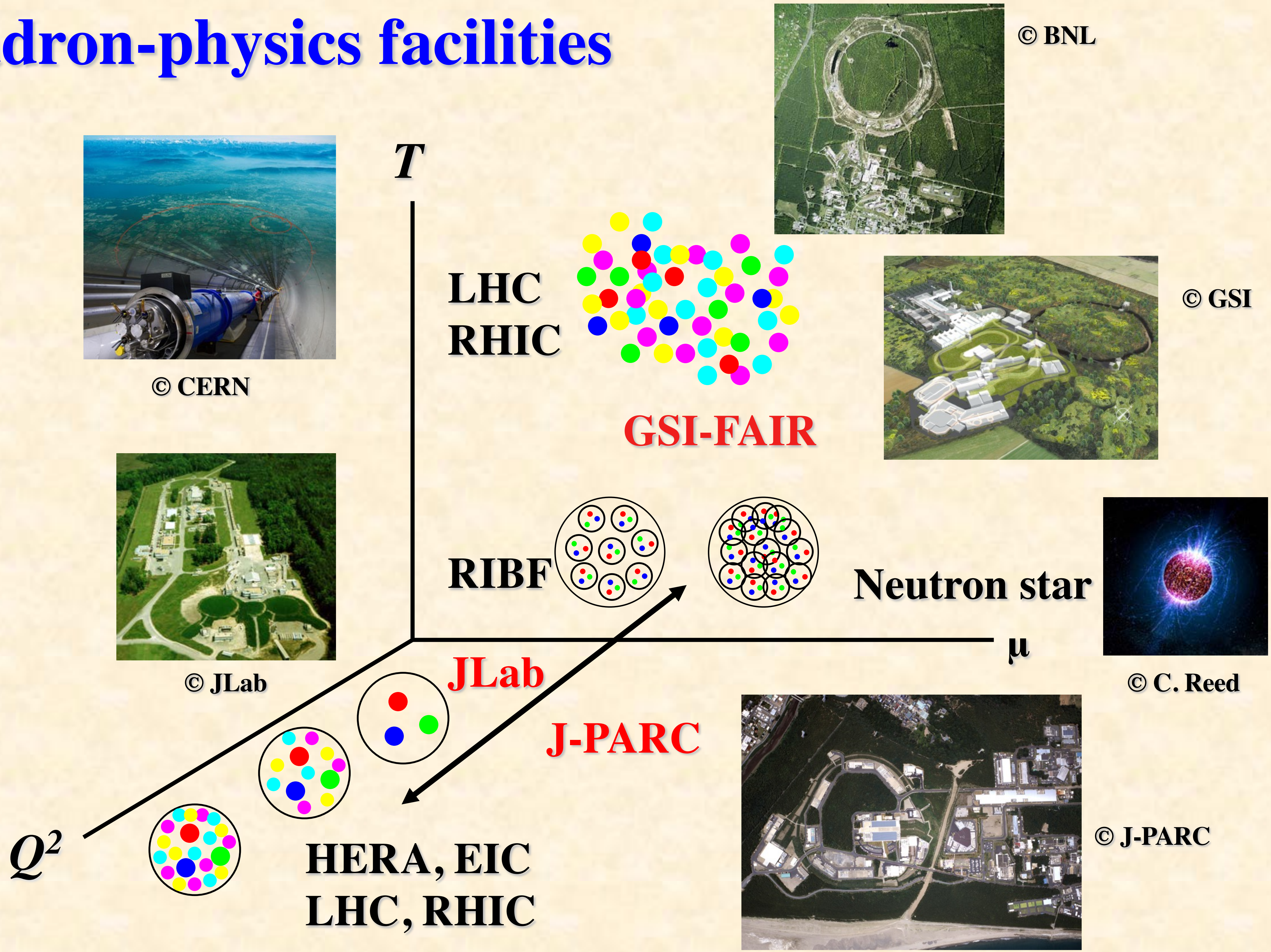
Nuclear Physics: Ultimate high-density quantum many-body system bound by strong interactions

Nuclear physics is a field of investigating

- matter generation of universe
- properties of quark-hadron many-body systems as ultimate materials.



Hadron-physics facilities



Constituent-counting rule in perturbative QCD: Form factor

H. Kawamura and SK, PRD 89 (2014) 054007 on exotic hadrons

Consider the magnetic form factor of the proton

$$\langle p'|J^\mu|p\rangle \simeq \bar{u}(p')\gamma^\mu G_M(Q^2)u(p) \ \text{ at } \ Q^2 = -q^2 \gg m_N^2$$

$$G_M(Q^2) = \int d[x]d[y]\phi_p([y])H_M([x],[y],Q^2)\phi_p([x])$$

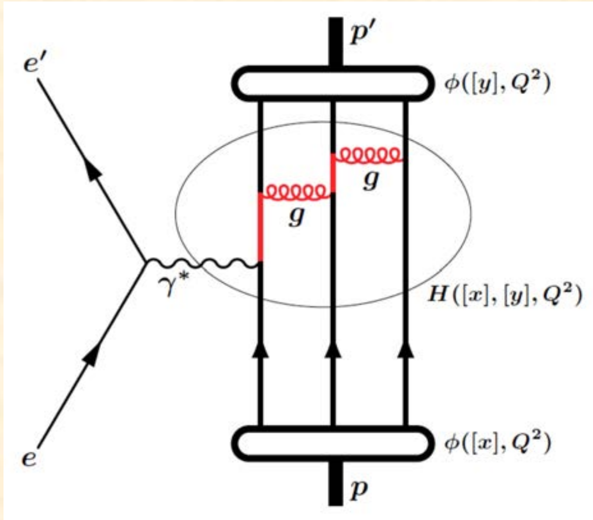
ϕ_p = proton distribution amplitude, H_M = hard amplitude (calculated in pQCD)

In the Breit frame with $q = (0,\vec{q})$, $|\vec{p}| = |\vec{p}'| \equiv P \sim O(Q)$.

$u^\dagger u = 2E \ \Rightarrow$ External quark line: $u \sim \sqrt{P} \sim \sqrt{Q}$

$$\langle p'|J^\mu|p\rangle \simeq \bar{u}(p')\gamma^\mu G_M(Q^2)u(p) \sim (\sqrt{Q})^2 G_M(Q^2)$$

- Two quark propagators: $\dfrac{1}{Q^2}$
- Two gluon propagators: $\dfrac{1}{(Q^2)^2}$
- Six external quark lines: $(\sqrt{Q})^6$

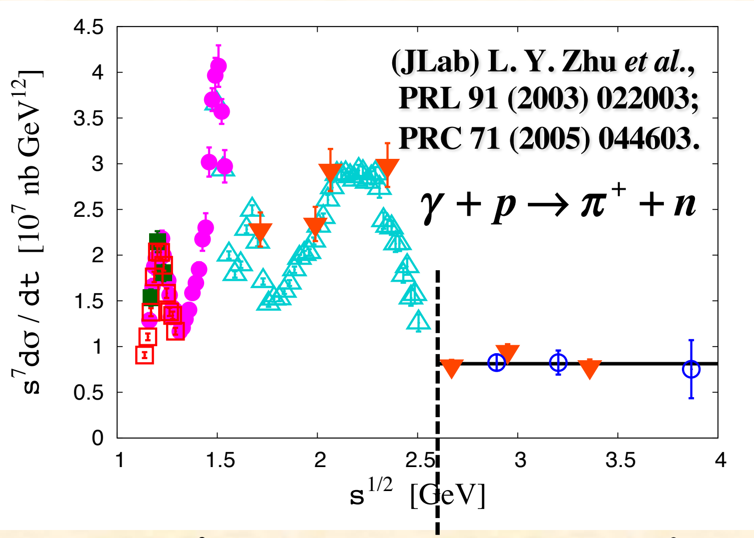


$$\langle p'|J^\mu|p\rangle \sim \frac{1}{Q^2}\frac{\alpha_s(Q^2)}{(Q^2)^2}(\sqrt{Q})^6 = \frac{\alpha_s(Q^2)}{(Q^2)^{3/2}}$$

$$\Rightarrow G_M(Q^2) \sim \frac{1}{(\sqrt{Q})^2}\langle p'|J^\mu|p\rangle \sim \frac{1}{(Q^2)^{1/2}}\frac{\alpha_s(Q^2)}{(Q^2)^{3/2}} = \frac{\alpha_s(Q^2)}{(Q^2)^2} \sim \frac{1}{t^{n_N-1}}, \ n_N = 3, \ \ -t = Q^2$$

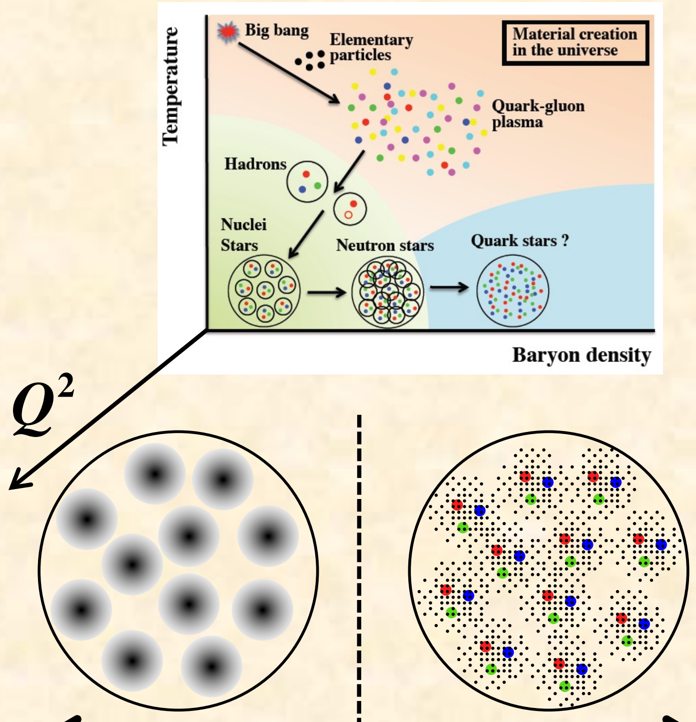
Counting rule for the form factor: $G_M(Q^2) \sim \dfrac{1}{t^{n_N-1}}$, $n_N = 3$ $\quad\Rightarrow$ Dipole form: $F(q) = \dfrac{1}{\left(1+|\vec{q}|^2/\Lambda^2\right)^2}$

Hadron degrees of freedom (d.o.f.) ⇔ Quark d.o.f.



Low energies:
Hadron degrees of freedom (Resonances)

High energies:
Quark-gluon degrees of freedom (Perturbative QCD: Constituent-counting rule)



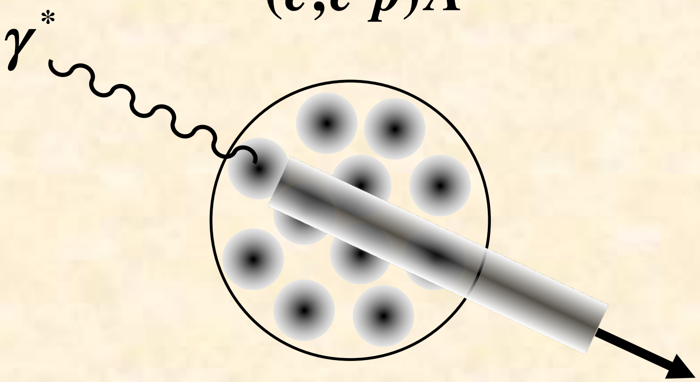
Low energies:
Hadron degrees of freedom

High energies:
Quark-gluon degrees of freedom

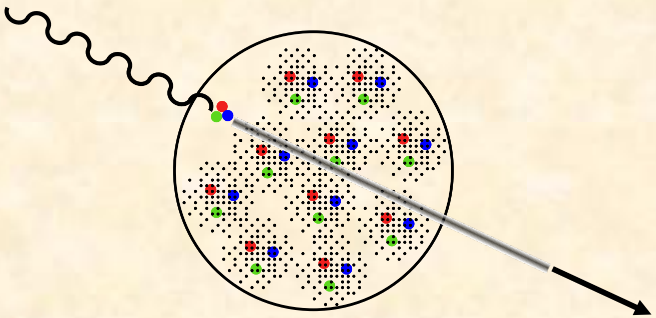
Nuclei should be described by quark and gluon degrees of freedom in principle; however, descriptions in terms of hadron degrees of freedom are often effective.

Color transparency and hadronization

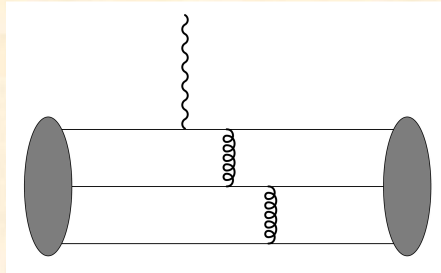
$(e,e'p)A$



Interact strongly
in the nuclear medium



No interaction
in the nuclear medium

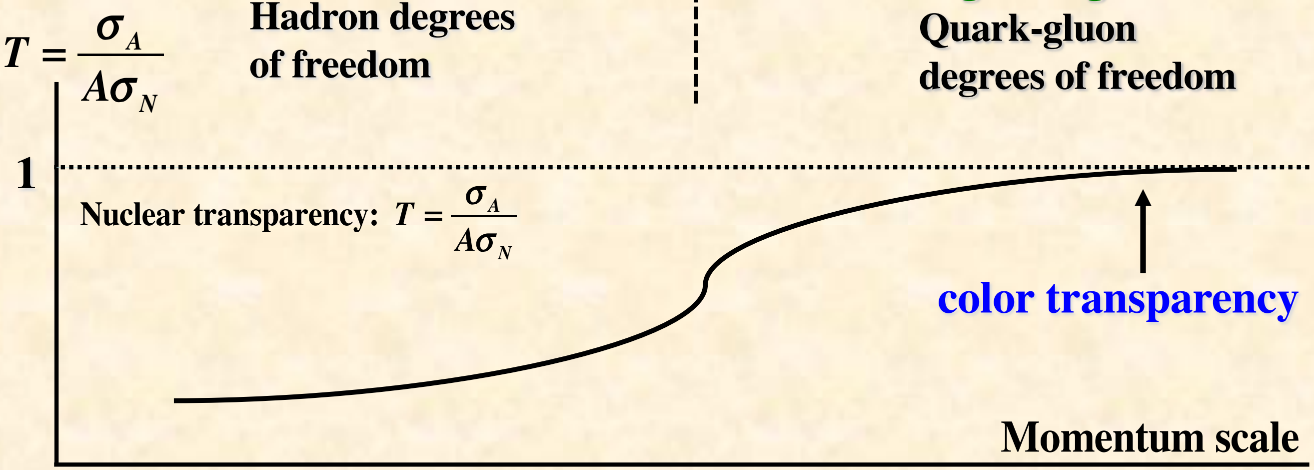


Hard gluon exchanges at high energies
→ quarks are close with each other
→ struck nucleon should be compact
→ nucleon could pass though the medium
without interaction (color transparency)

Low energies:
Hadron degrees
of freedom

High energies:
Quark-gluon
degrees of freedom

At large momentum transfer,
a small-size hadron could freely pass
through nuclear medium. (Transparent)



The color transparency is an important phenomena
to understand the quark-hadron many-body systems
from low to high energies and from low to high densities.

Mystery on color-transparency experiments

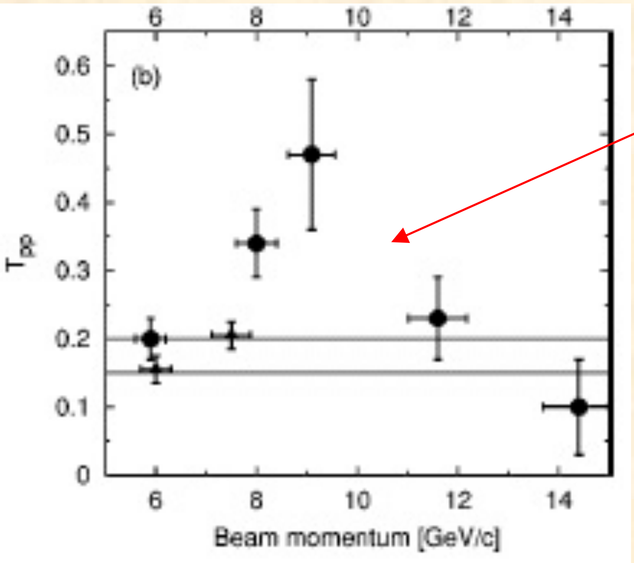
At large momentum transfer, a small-size hadron could freely pass through nuclear medium.

Experimenets: $pA \to pp(A-1), \quad eA \to ep(A-1)$

Nuclear transparency: $T = \dfrac{\sigma_A}{A\sigma_N}$

Color transparency: $T \rightarrow$ larger $(=1)$ as the hard scale $\rightarrow$ larger

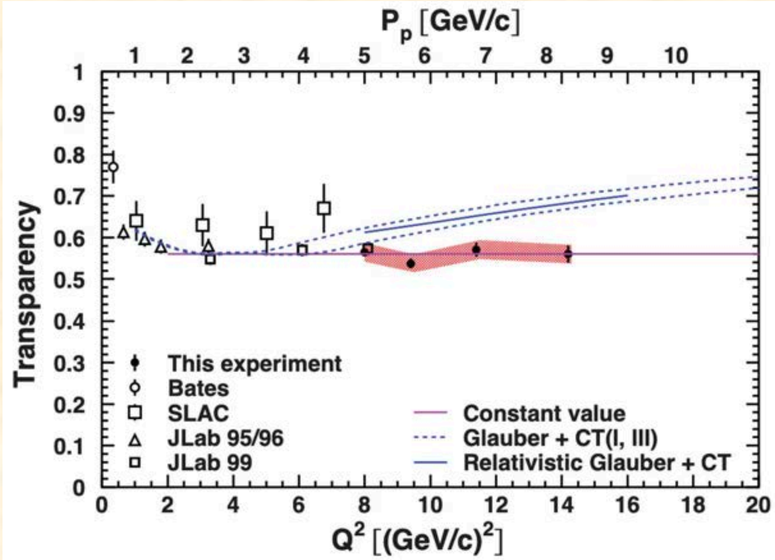
(BNL-EVA) J. Aclander *et al.*, PRC 70 (2004) 015208



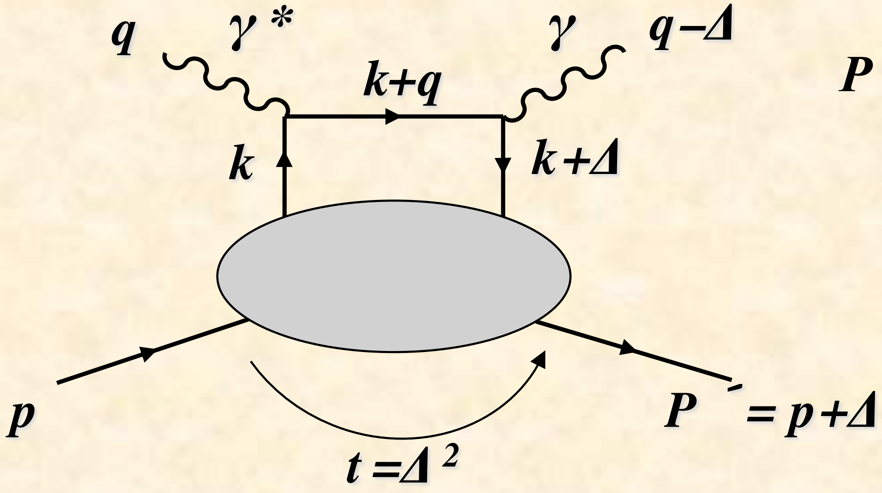
reason for this drop?

It should be checked at hadron accelerator facilities such as J-PARC.

Recent finding at JLab (Hall-C): D. Bhetuwal et al., PRL 126 (2021) 082301.



Generalized Parton Distributions (GPDs)



$$P = \frac{p+p'}{2}, \quad \Delta = p' - p$$

Bjorken variable $\quad x = \dfrac{Q^2}{2p\cdot q}$

Momentum transfer squared $\quad t = \Delta^2$

Skewdness parameter $\quad \xi = \dfrac{p^+ - p'^+}{p^+ + p'^+} = -\dfrac{\Delta^+}{2P^+}$

GPDs are defined as correlation of off-forward matrix:

$$\int \frac{dz^-}{4\pi} e^{ixP^+z^-} \langle p' | \bar{\psi}(-z/2)\gamma^+\psi(z/2) | p\rangle \Big|_{z^+=0,\vec{z}_\perp=0} = \frac{1}{2P^+}\left[H(x,\xi,t)\bar{u}(p')\gamma^+u(p) + E(x,\xi,t)\bar{u}(p')\frac{i\sigma^{+\alpha}\Delta_\alpha}{2M}u(p)\right]$$

$$\int \frac{dz^-}{4\pi} e^{ixP^+z^-} \langle p' | \bar{\psi}(-z/2)\gamma^+\gamma_5\psi(z/2) | p\rangle \Big|_{z^+=0,\vec{z}_\perp=0} = \frac{1}{2P^+}\left[\tilde{H}(x,\xi,t)\bar{u}(p')\gamma^+\gamma_5u(p) + \tilde{E}(x,\xi,t)\bar{u}(p')\frac{\gamma_5\Delta^+}{2M}u(p)\right]$$

Forward limit: PDFs $\quad H(x,\xi,t)\big|_{\xi=t=0} = f(x), \quad \tilde{H}(x,\xi,t)\big|_{\xi=t=0} = \Delta f(x),$

First moments: Form factors

Dirac and Pauli form factors F_1, F_2 $\quad \int_{-1}^{1} dx\, H(x,\xi,t) = F_1(t), \quad \int_{-1}^{1} dx\, E(x,\xi,t) = F_2(t)$

Axial and Pseudoscalar form factors G_A, G_P $\quad \int_{-1}^{1} dx\, \tilde{H}(x,\xi,t) = g_A(t), \quad \int_{-1}^{1} dx\, \tilde{E}(x,\xi,t) = g_P(t)$

Second moments: Angular momenta

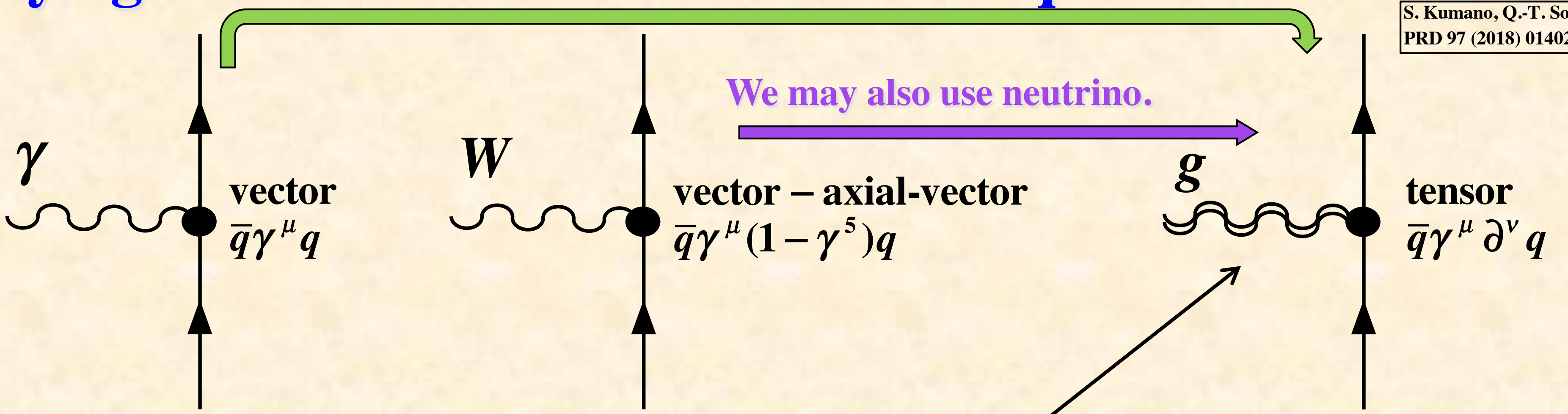
Sum rule: $J_q = \dfrac{1}{2}\displaystyle\int_{-1}^{1} dx\, x\left[H_q(x,\xi,t=0) + E_q(x,\xi,t=0)\right], \quad J_q = \dfrac{1}{2}\Delta q + L_q$

$\Rightarrow$ probe L_q, key quantity to solve the spin puzzle!

Why "gravitational" interactions with quarks

We studied in 2017-2018.

S. Kumano, Q.-T. Song, O. Teryaev, PRD 97 (2018) 014020.



GPDs (Generalized Parton Distributions), GDAs (Generalized Distribution Amplitudes) = timelike GPDs

$$\int \frac{dz^-}{4\pi} e^{ixP^+z^-} \langle p' | \bar{q}(-z/2)\gamma^+ q(z/2) | p \rangle \Big|_{z^+=0,\vec{z}_\perp=0} = \frac{1}{2P^+}\left[H(x,\xi,t)\bar{u}(p')\gamma^+ u(p) + E(x,\xi,t)\bar{u}(p')\frac{i\sigma^{+\alpha}\Delta_\alpha}{2M}u(p) \right]$$

Non-local operator of GPDs/GDAs:

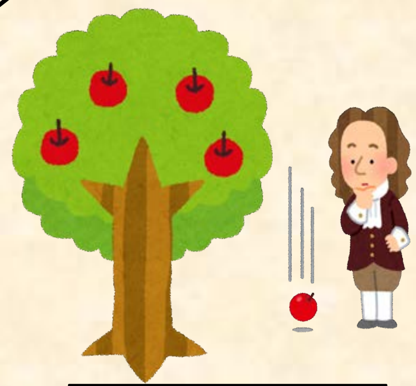
$$\left(P^+\right)^n \int dx\, x^{n-1} \int \frac{dz^-}{2\pi} e^{ixP^+z^-} \left[\bar{q}(-z/2)\gamma^+ q(z/2) \right]_{z^+=0,\vec{z}_\perp=0}$$

$$= \left(i\frac{\partial}{\partial z^-} \right)^{n-1} \left[\bar{q}(-z/2)\gamma^+ q(z/2) \right]_{z=0}$$

$$= \bar{q}(0)\gamma^+ \left(i\overleftrightarrow{\partial}^+ \right)^{n-1} q(0)$$

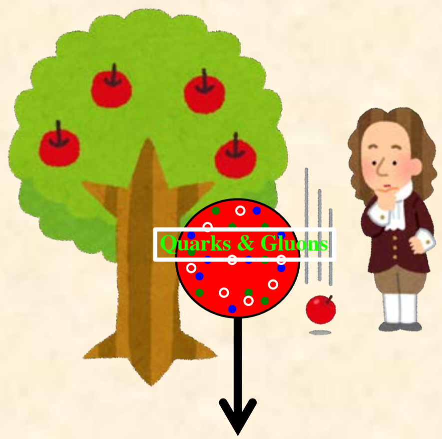
= energy-momentum tensor of a quark for $n = 2$
(electromagnetic for $n = 1$)

= source of gravitiy



17th century

@home due to plague pandemic



21st century

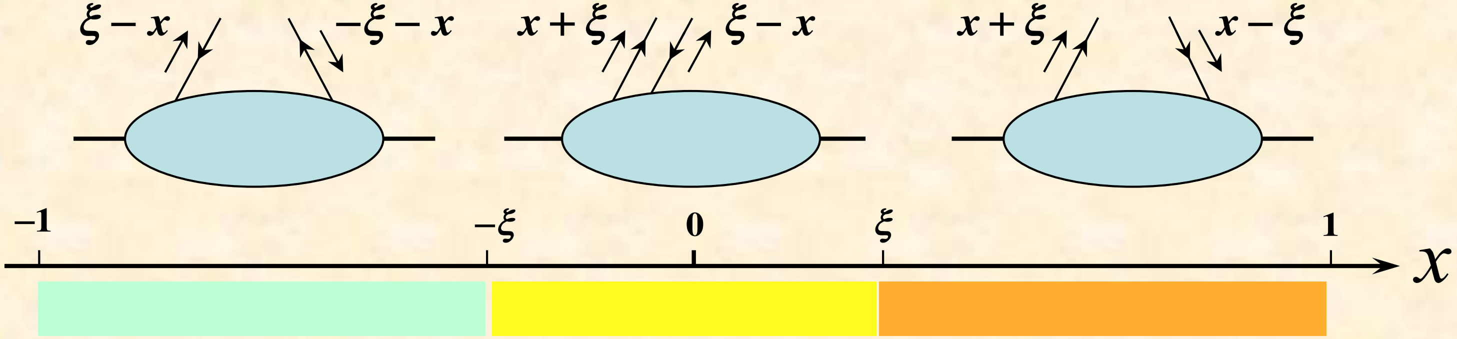
@home due to coronavirus pandemic

It is possible to probe gravitational sources in the microscopic level without gravitons.

Generalized parton distributions (GPDs)
by hadronic 2→3 processes
(at hadron accelerator facilities)

Novel two-to-three hard hadronic processes and possible studies of generalized parton distributions at hadron facilities, S. Kumano, M. Strikman, K. Sudoh, Phys. Rev. D 80 (2009) 074003.

GPDs in different x regions and GPDs at hadron facilities



$-1 < x < \xi \quad (x + \xi < 0,\ x - \xi < 0)$

$\xi < x < 1 \quad (x + \xi > 0,\ x - \xi > 0)$

$-\xi < x < \xi \quad (x + \xi > 0,\ x - \xi < 0)$

Quark distribution

Emission of quark with momentum fraction x+ξ
Absorption of quark with momentum fraction x-ξ

q$\bar{\text{q}}$(meson)-like distribution amplitude

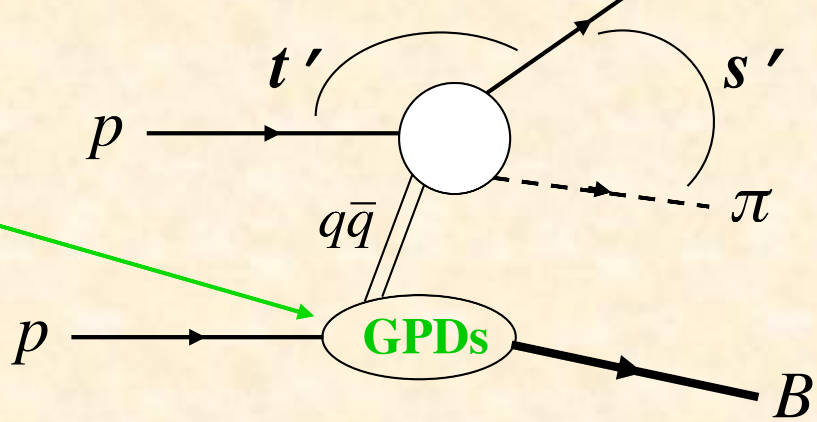
Emission of quark with momentum fraction x+ξ
Emission of antiquark with momentum fraction ξ-x

Antiquark distribution

Emission of antiquark with momentum fraction ξ-x
Absorption of antiquark with momentum fraction -ξ-x

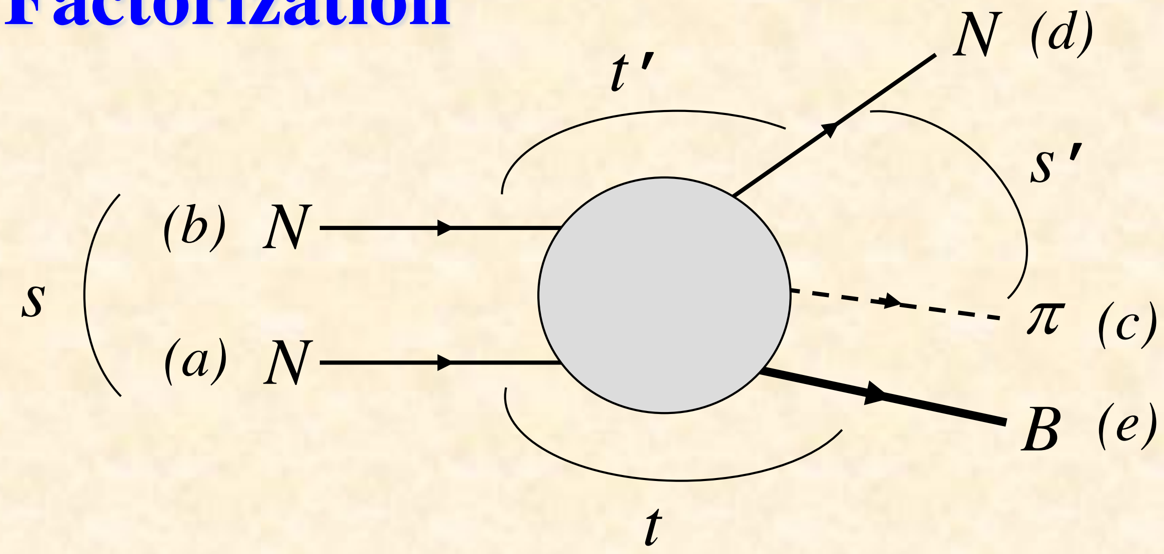
Consider a hard reaction with

$|s'|,\ |t'|,\ |u'| \gg M_N^2,\quad |t| \ll M_N^2$



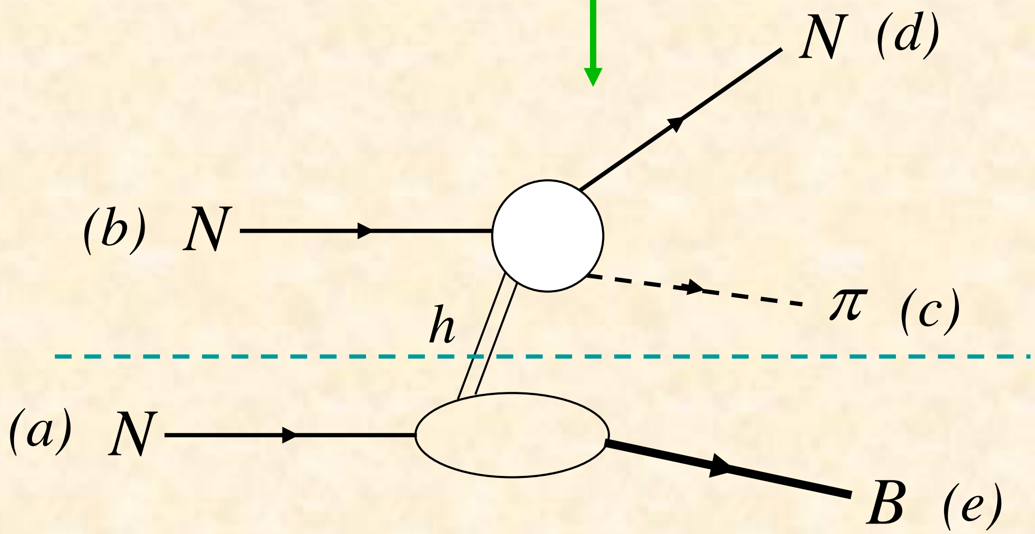
Efremov-Radyushkin -Brodsky-Lepage (ERBL) region

Factorization

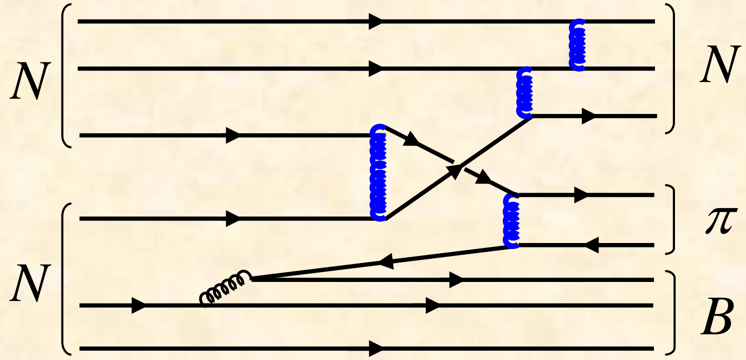


Consider a hard reaction with

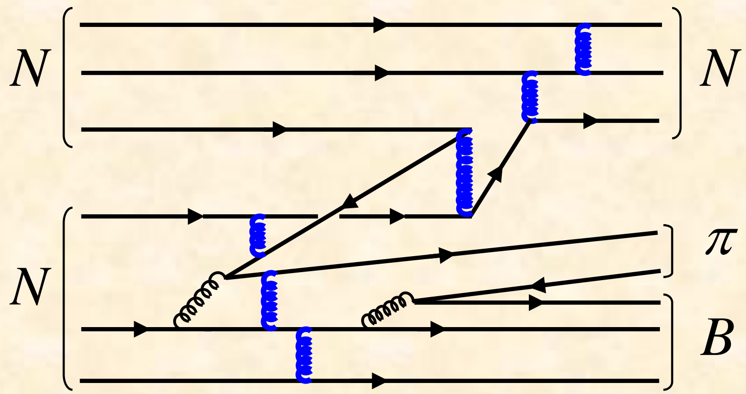
$$|s'|,\ |t'|,\ |u'| \gg M_N^2,\quad |t| \ll M_N^2$$

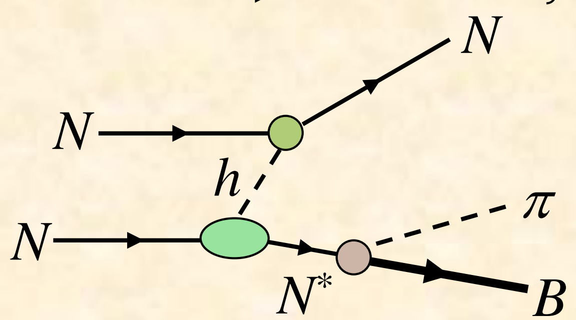


Typical leading process

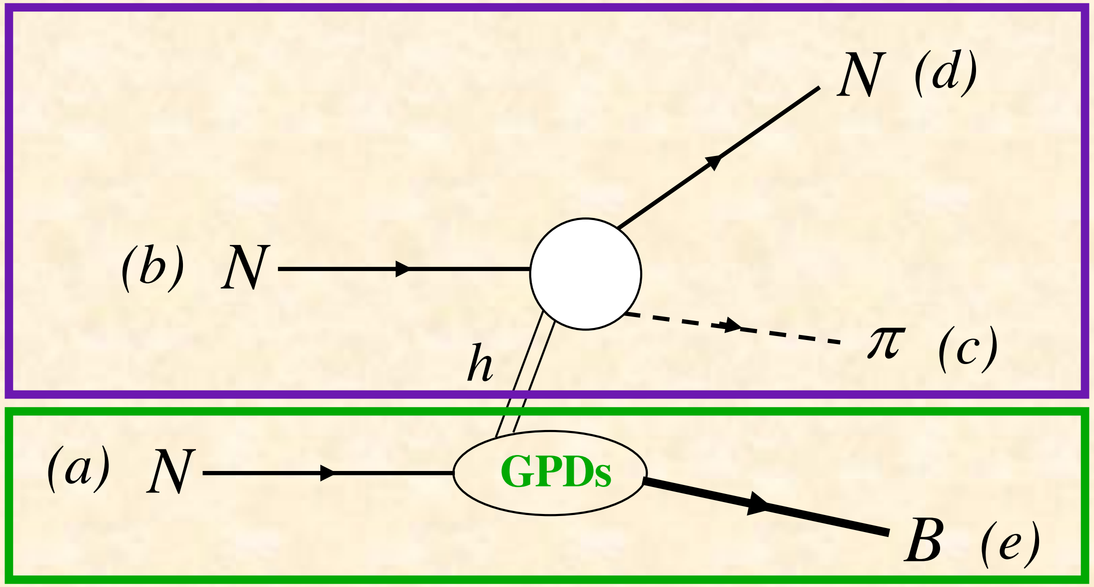


Typical sub-leading process
(cannot be factorized)
More hard gluon exchanges
→ suppressed





Cross section estimates



$\dfrac{d\sigma(s',t')}{dt'}$ so as to explain

BNL-AGS experimental data on

$\pi + p \to \pi + p, \ \ \pi + p \to \rho + p$

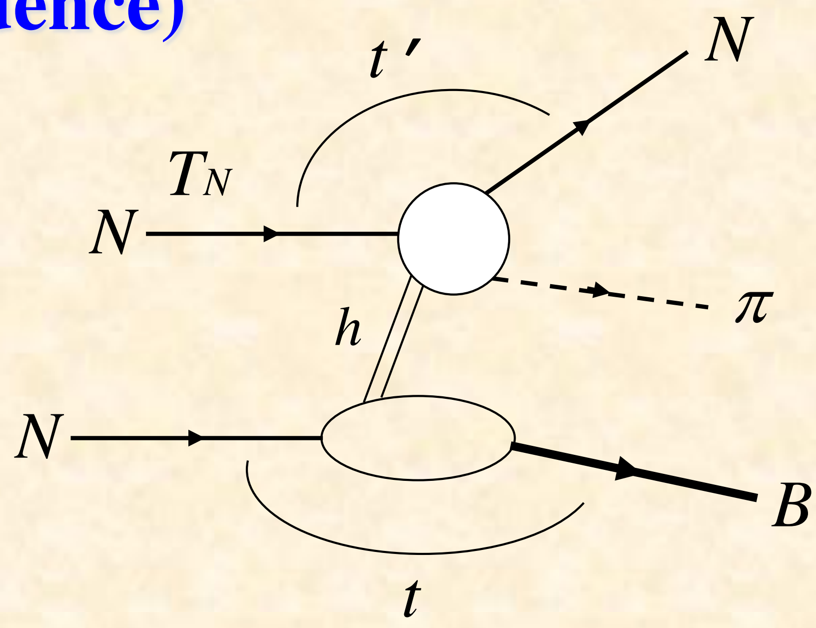
This part is expressed by GPDs.

Purposes of our studies:

(1) The ultimate purpose is to extract the GPDs in the ERBL region by measurements at hadron facilities in addition to lepton ones.

(2) Since our work is the first one to point out the GPD studies at hadron reactions, we estimate the order of magnitude of cross sections simply by using meson-pole expressions of the GPDs.
→ For experimental feasibility studies.

Cross section estimate (ξ dependence)

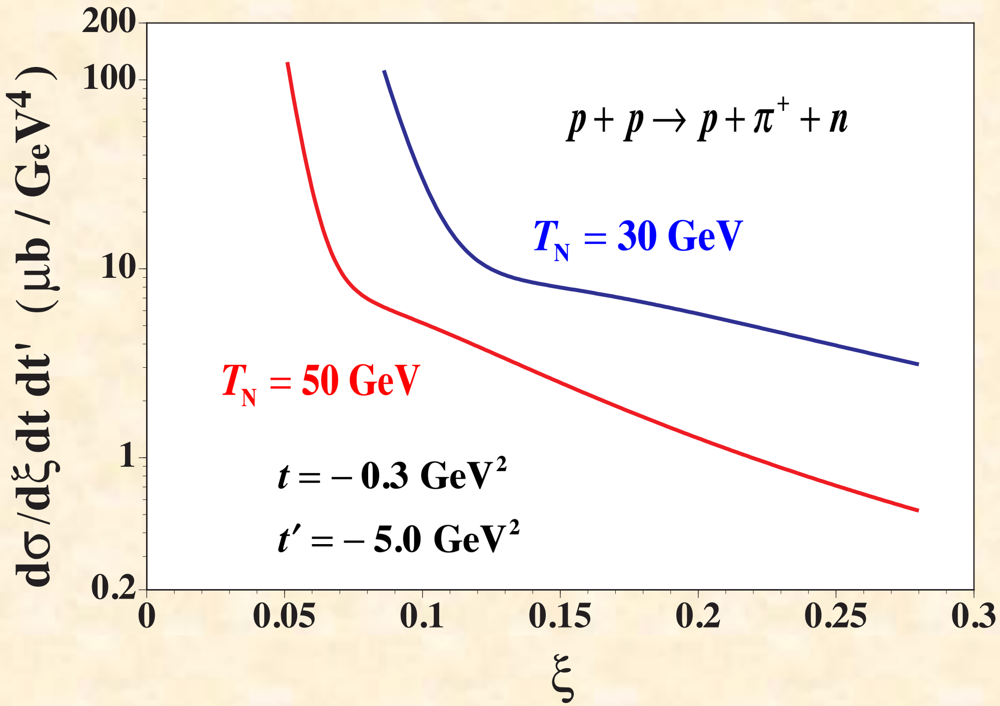


Skewdness parameter: $\xi = \dfrac{p_N^+ - p_B^+}{p_N^+ + p_B^+}$

$\dfrac{d\sigma}{d\xi dt dt'} \left(\dfrac{\mu\text{b}}{\text{GeV}^2} \right)$ as a function of ξ

at fixed $T_N = 30$ (50) GeV,

$t = -0.3$ GeV^2, $t' = -5$ GeV^2.



At this stage, our numerical results are for rough order of magnitude estimates on cross sections by assuming π- and ρ-like intermediate states.

For the details, please look at our PRD paper in 2009.

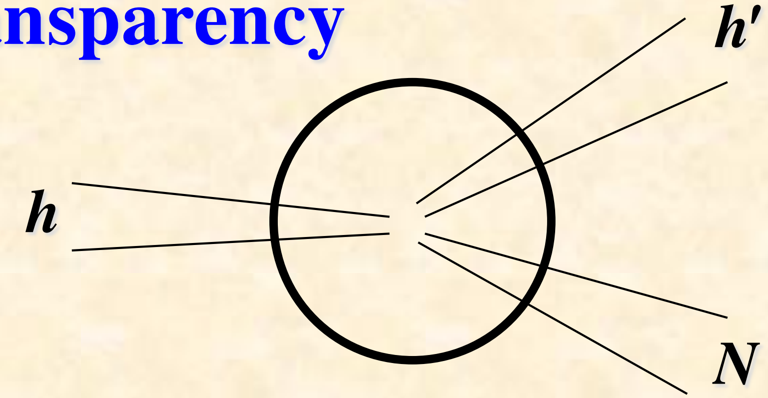
Color transparencty

by hadronic $2 \rightarrow 3$ processes

(at hadron accelerator facilities)

Using branching processes in nuclei to reveal dynamics of large-angle two-body scattering,
S. Kumano, M. Strikman, Phys. Lett. B 683 (2010) 259.

A new strategy for studying color transparency



Difficulty in A(h,$h'N$):

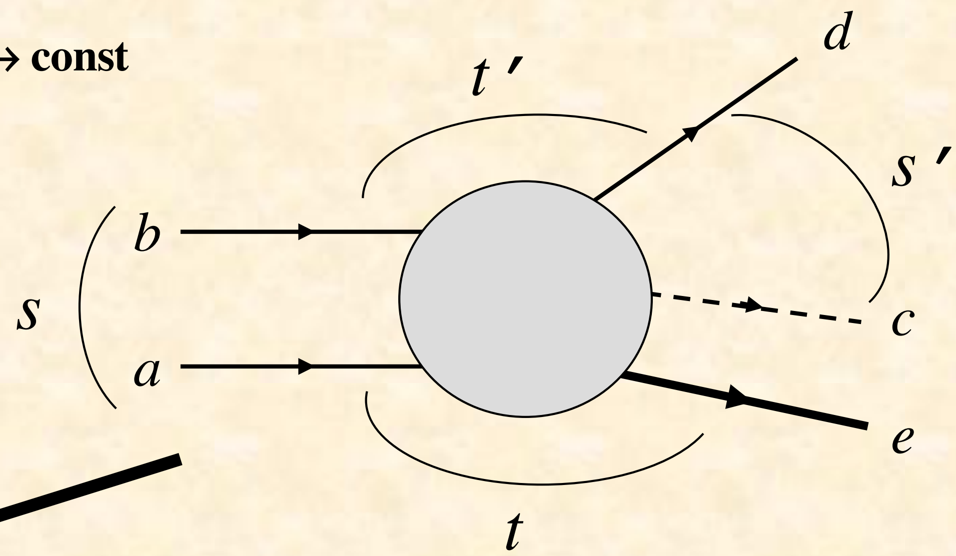
Two phenomena at the same time:

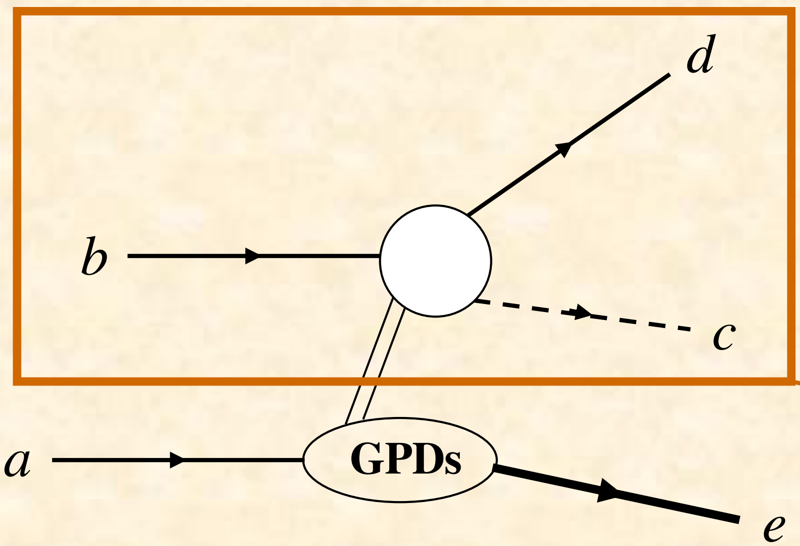
1. squeezing at the initial point
2. pattern of expansion

Use hard branching $2 \to 3$ processes: $a + b \to c + d + e$
with the kinematical condition:

$$-t' = -(p_b - p_d)^2 \to \infty, \quad s' = (p_c + p_d)^2 \to \infty, \quad -\frac{t'}{s'} \to \text{const}$$

$$-t = -(p_a - p_c)^2 = \text{const} < m_N^2$$

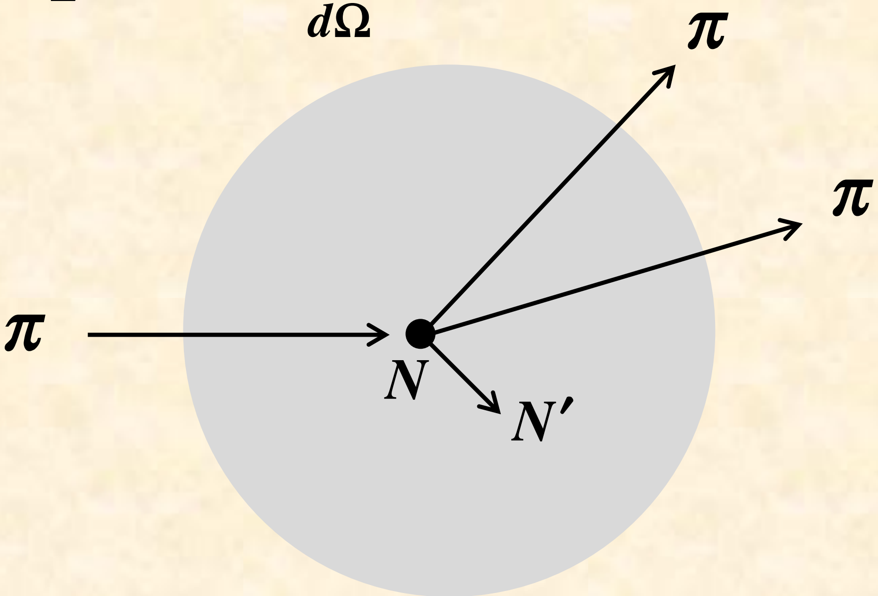




Hard process $\to$ suppression of space-time evolution effects
$\to$ studies of onset of point-like configuration

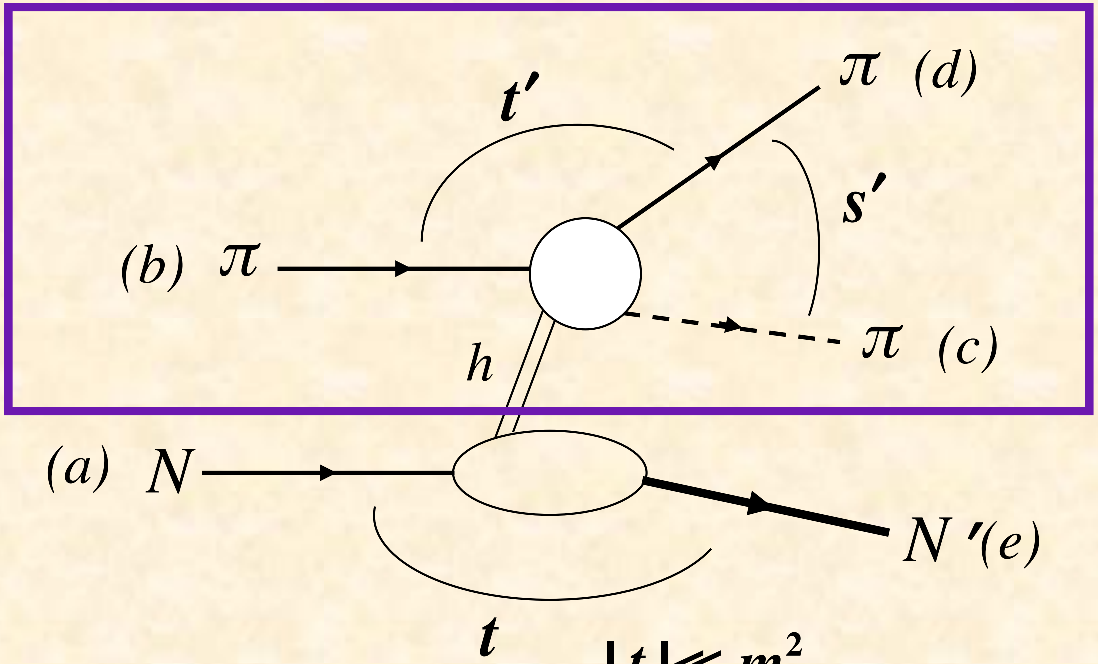
Color transparency in 2→3 processes with high-energy pion beam

$$T = \frac{\dfrac{\sigma(\pi^- + A \to \pi^+ + \pi^- + A^*)}{d\Omega}}{Z\dfrac{\sigma(\pi^- + p \to \pi^+ + \pi^- + n)}{d\Omega}}$$



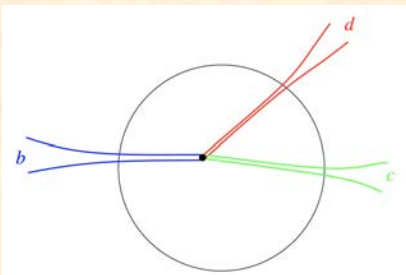
$$\pi^- + A \to \pi^+ + \pi^- + A^*$$

$$|s'|, |t'|, |u'| \gg m_N^2$$



$$|t| \ll m_N^2$$

Experimental possibilities:
COMPASS, J-PARC, · · ·



Advantage of 2→3 over 2→2:

There is no correlation between p of initial π and p_T of the final pions in 2→3, whereas p_T is uniquely determined by initial p_π in 2→2.
→ Possible to regulate the degrees of freezing during propagation in 2→3.

Nuclear transparency in $\pi^-+A\to\pi^-+\pi^++A^*$

$$T_A = \frac{\dfrac{d\sigma(\pi^- A\to\pi^-\pi^+A^*)}{d\Omega}}{Z\dfrac{d\sigma(\pi^- p\to\pi^-\pi^+ n)}{d\Omega}},\quad \Omega = \text{solid angle of } \pi^-\pi^+ \text{ system}$$

Theoretical estimate of T_A

$$T_A(\vec p_b,\vec p_c,\vec p_d) = \frac{1}{A}\int d^3r\ \rho_A(\vec r)P_b(\vec p_b,\vec r)P_c(\vec p_c,\vec r)P_d(\vec p_d,\vec r)$$

$\rho_A(\vec r)$ = nuclear density

$$P_j(\vec p_j,\vec r) = \exp\left[-\int dz\,\sigma_{eff}(\vec p_j,z)\rho_A(z)\right]$$

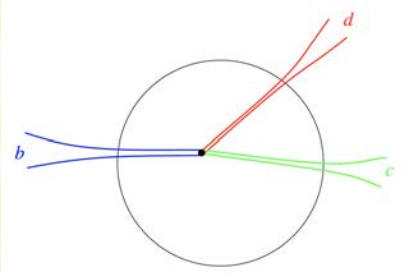
= probability of hadron j with momentum $\vec p_j$ to propagate along a path from the hard interaction point $\vec r$, z is the distance from the interaction point.

diffusion model: $\sigma_{eff} = \left[\sigma_{hard} + \frac{z}{l_{coh}}(\sigma_{soft}-\sigma_{hard})\right]\theta(l_{coh}-z) + \sigma_{soft}\theta(z-l_{coh})$

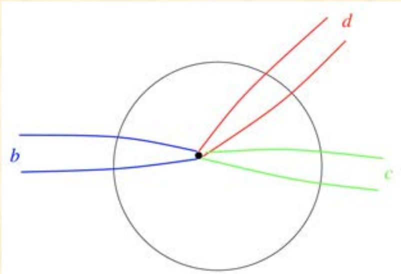
coherence length: $l_{coh} = l_0 p_\pi / \text{GeV}$, $\sigma_{soft}\sim\sigma_{tot}(\pi N)$

l_0 = 0.57 fm, A. Larson, G. A. Miller, M. Strikman, PRC 74 (2006) 018201

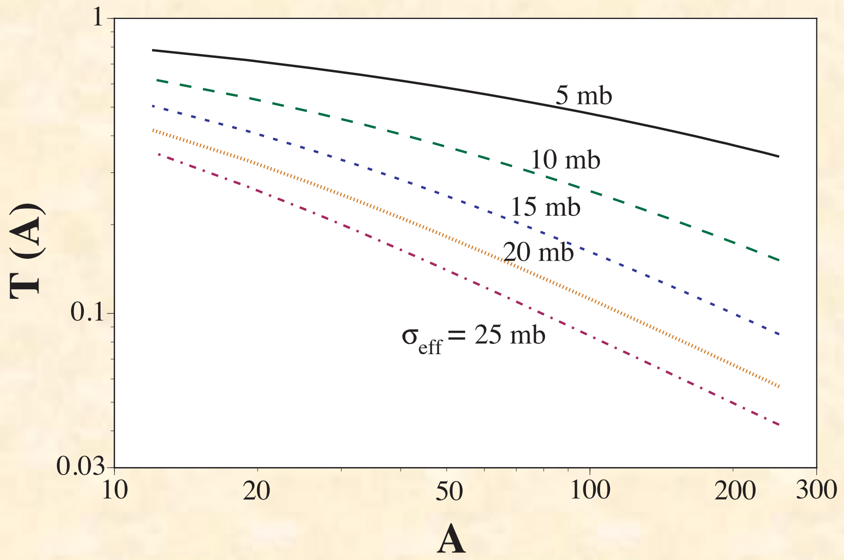
Space-time evolution of wave packets

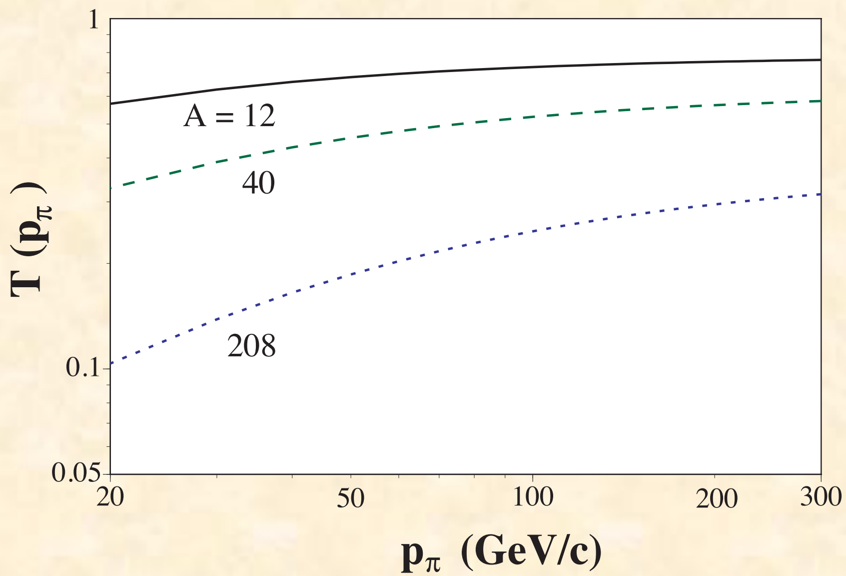


low energy π



high energy π





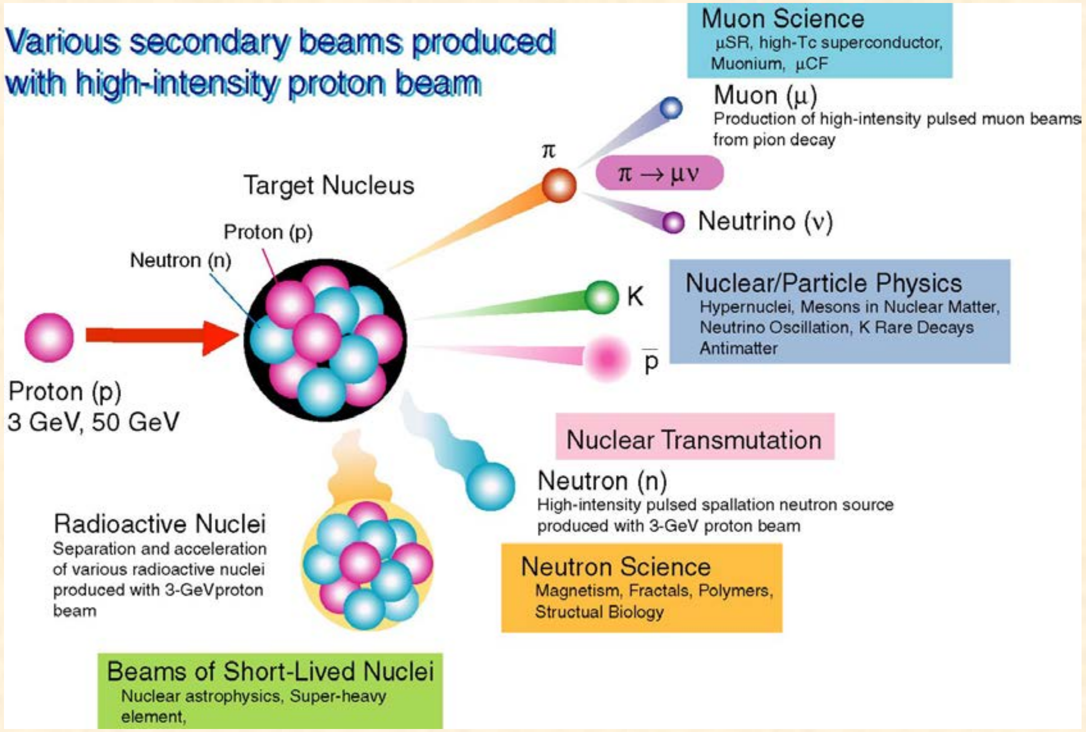
J-PARC hadron-physics projects

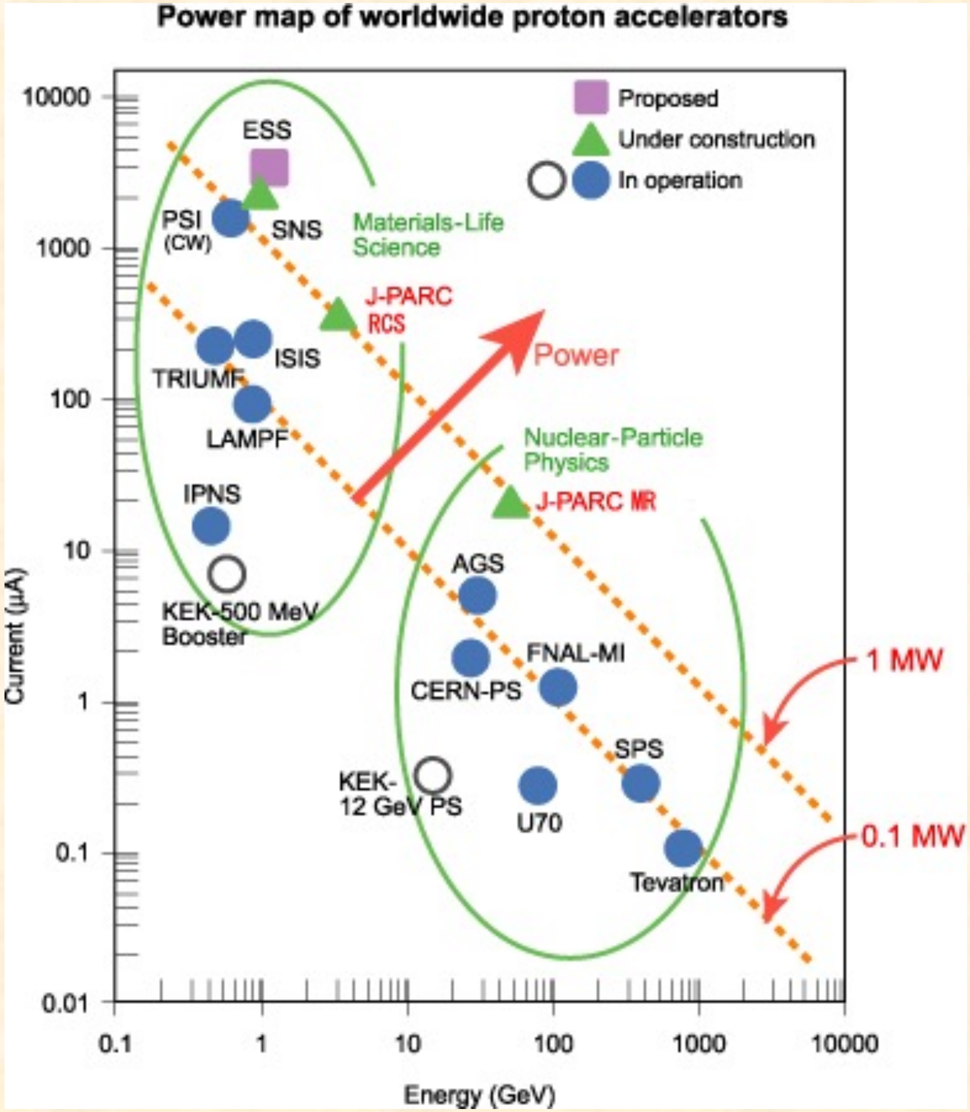
https://j-parc.jp/c/en/facilities/nuclear-and-particle-physics/hadron.html

(PAC) https://j-parc.jp/researcher/Hadron/en/PAC_for_NuclPart_e.html

High-Intensity Frontier of Proton Accelerator

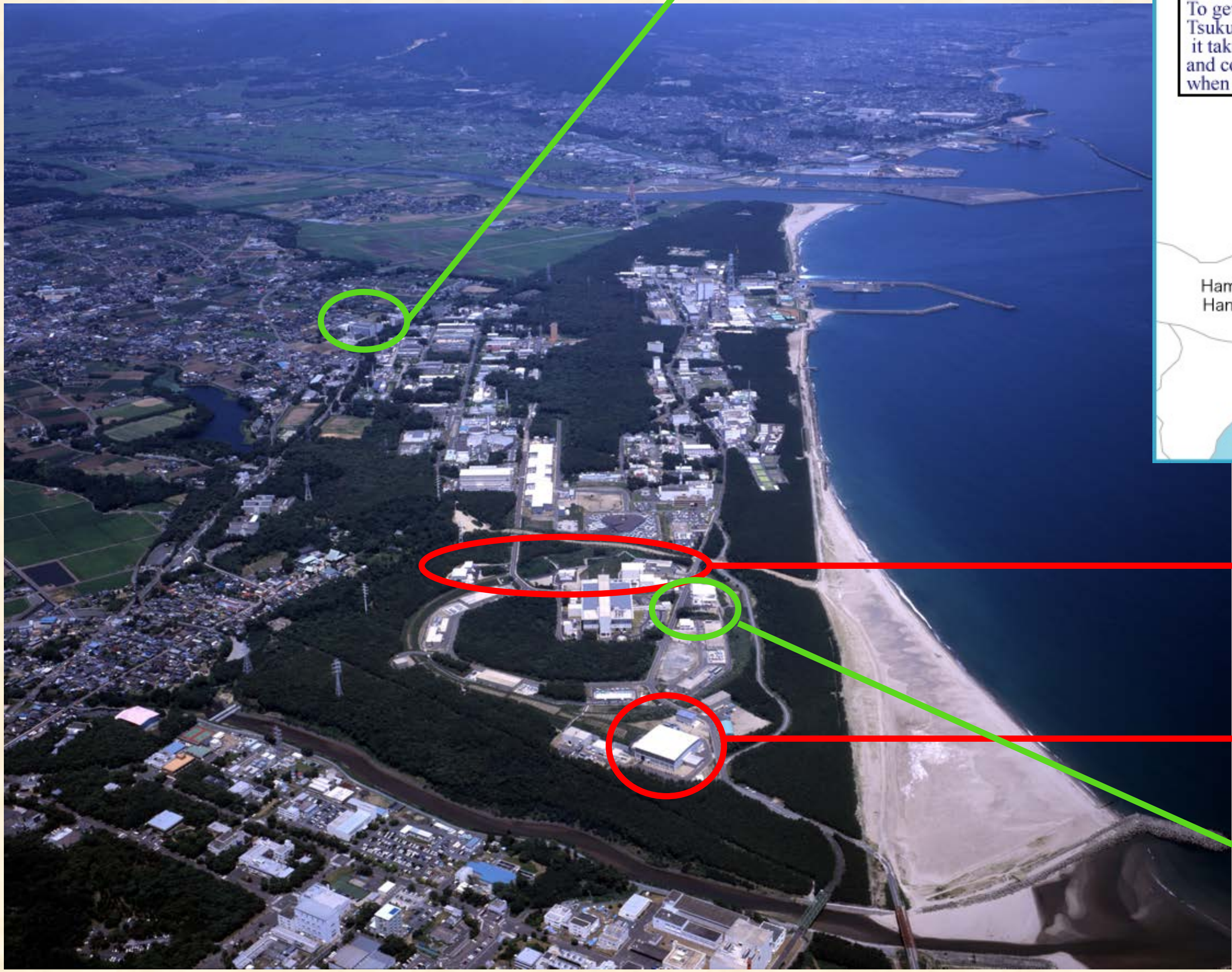
High-intensity proton beam
→ High-intensity secondary beams
(Neutrino, Kaon, Pion, Neutron …)

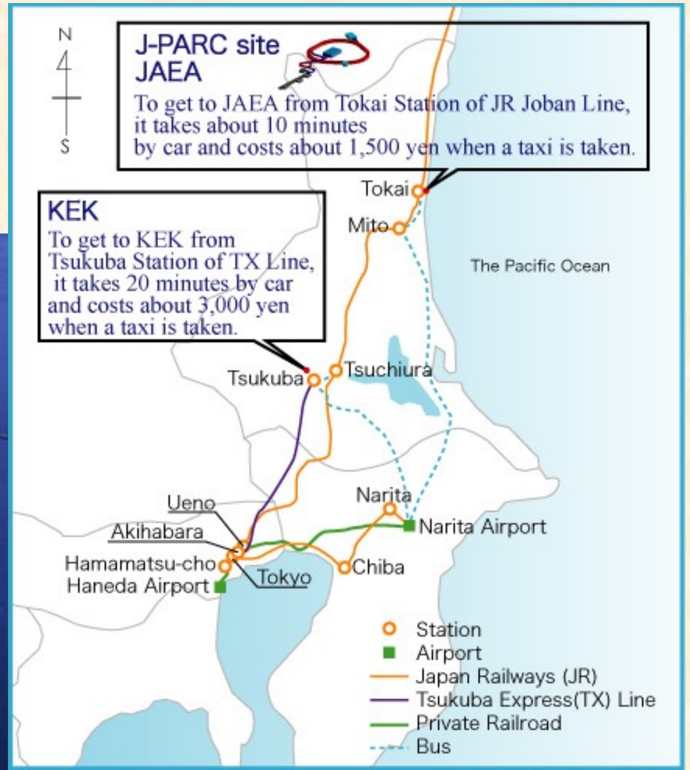




Aerial photograph

KEK Tokai building





Neutrino facility

Hadron facility

Research building

J-PARC hadron physics

Possibilities

Approved proposals

Approved projects

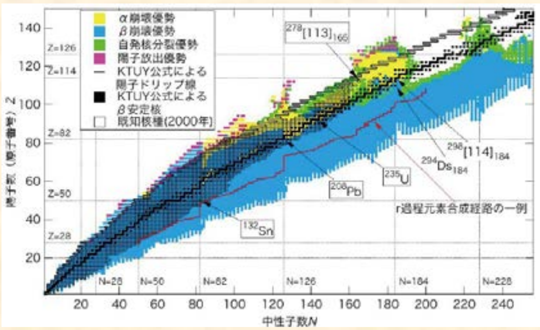
Next projects

Need major upgrades

- Strangeness nuclear physics
- Hadrons in nuclear medium
- Charmed baryons
- Nucleon structure
- Quark-hadron matter (heavy ion)

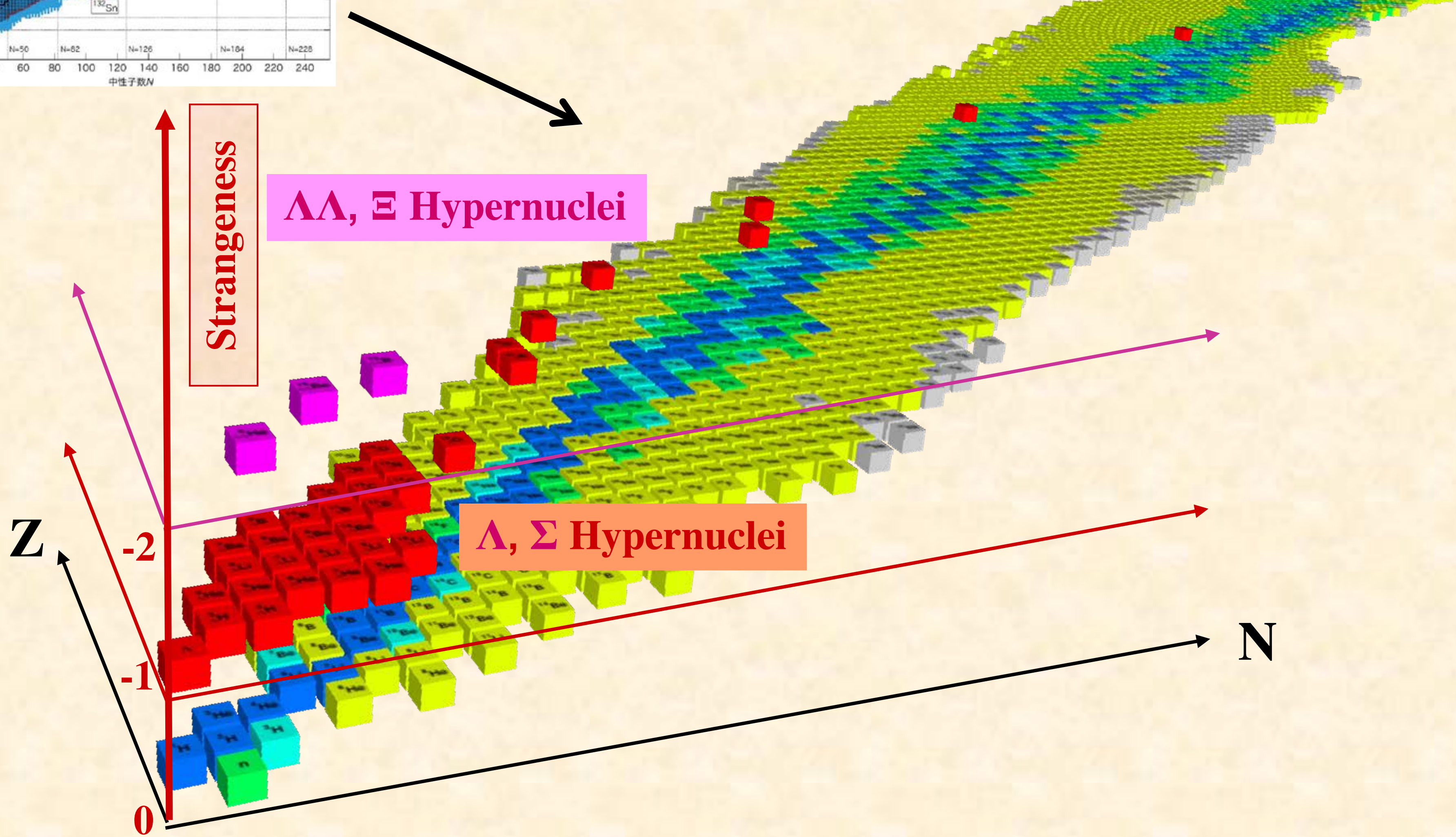
"Possible" high-momentum beamline projects

Strangeness nuclear physics

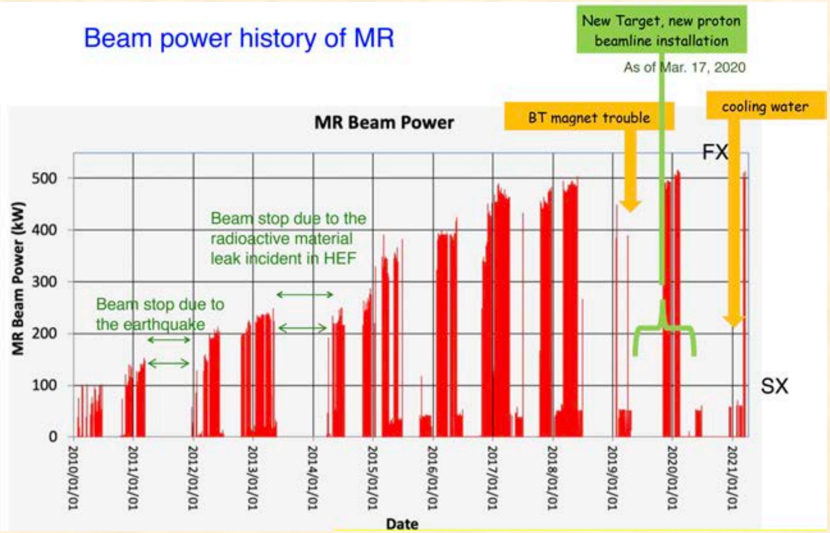


US-FRIB (Facility for Rare Isotope Beams)
Riken-RIBF (Radioactive Isotope Beam Factory)

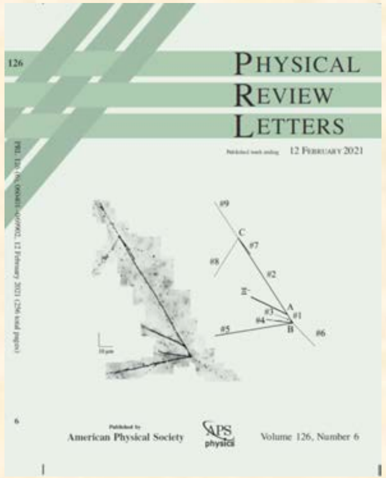
3-dimensional nuclear chart



Recent research highlights in hadron physics



Ξ^--^{14}N system, PRL 126 (2021) 062501
(see also arXiv:2103.08793)



Doubly strange nucleus

$$\Xi^- + {}^{14}\mathrm{N} \rightarrow {}^{15}_{\Xi}\mathrm{C} \rightarrow {}^{10}_{\Lambda}\mathrm{Be} + {}^{5}_{\Lambda}\mathrm{He}$$

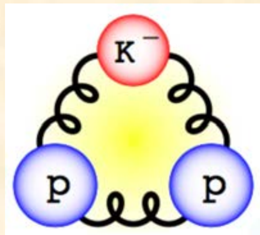
$$B_{\Xi} = 1.27 \pm 0.21\ \mathrm{MeV}$$

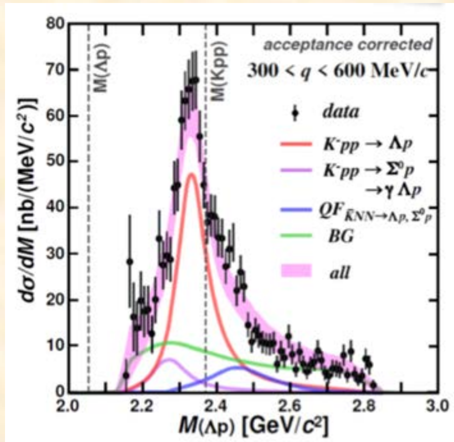
Kaonic and hyper-nuclei, PTEP (2020) 123D01

Missing mass spectrum of ^{12}C(K$^-$,p)

https://jpsht.jps.jp/article/248.html

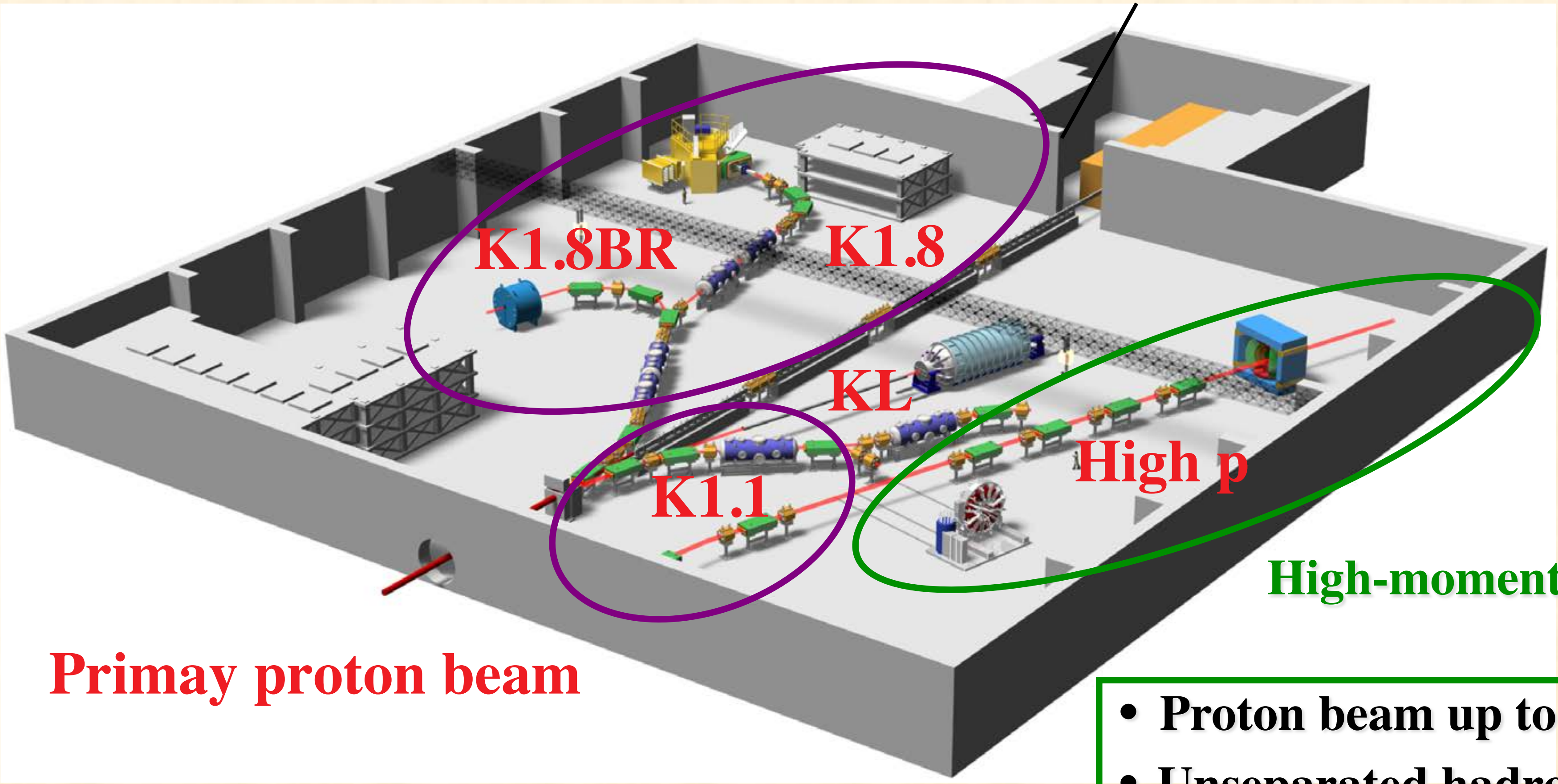
$\bar{K}NN$ bound state in $^3\mathrm{He}(K^-, \Lambda p)n$, PRC 102 (2020) 04402





Hadron facility

(Low energy) Kaon and pion experiments are done at these beamlines.



Primay proton beam

High-momentum beamline

- Proton beam up to 30 GeV
- Unseparated hadron (pion, …) beam up to 15~20 GeV

You may propose a color-transparency experiments at this beamline.

Physics of J-PAC high-momentum beamline

2019 — 2021 — 2023

Hadron masses in nuclear medium . . . **Charmed baryons**

E16

Proposal

Electron pair spectrometer at the J-PARC 50-GeV PS to explore the chiral symmetry in QCD

April 28, 2006
June 07, 2006 rev.1

S. Yokkaichi[1], H. En'yo, M. Naruki, R. Muto, T. Tabaru
RIKEN

K. Ozawa, H. Hamagaki
Center for Nuclear Study, Graduate School of Science, University of Tokyo

K. Shigaki
Graduate School of Science, Hiroshima University

S. Sawada, M. Sekimoto
High Energy Accelerator Research Organization (KEK)

F. Sakuma, K. Aoki
Department of Physics, Kyoto University

E50

KEK/J-PARC-PAC 2012-19

Charmed Baryon Spectroscopy via the (π, D^{*-}) reaction

Y. Morino, T. Nakano,* H. Noumi†,* K. Shirotori, Y. Sugaya, and T. Yamaga
Research Center for Nuclear Physics (RCNP), Osaka University, 10-1, Mihogaoka, Ibaraki, Osaka, 567-0047, Japan

K. Ozawa‡
Institute of Particle and Nuclear Studies(IPNS), High Energy Accelerator Research Organization (KEK), 1-1 Oho, Tsukuba, Ibaraki 305-0801, Japan

T. Ishikawa
Reserach Center for Electron Photon Science, Tohoku University, 1-2-1, Mikamine, Taihaku-ku, Sendai, Miyagi 982-0826, Japan

Y. Miyachi
Physics Department, Yamagata University, 1-4-12, Kojirakawa-machi, Yamagata 990-8560, Japan

K. Tanida
Department of Physics and Astronomy, Seoul National University, Seoul 151-747, Korea

High-energy hadron (LoI)

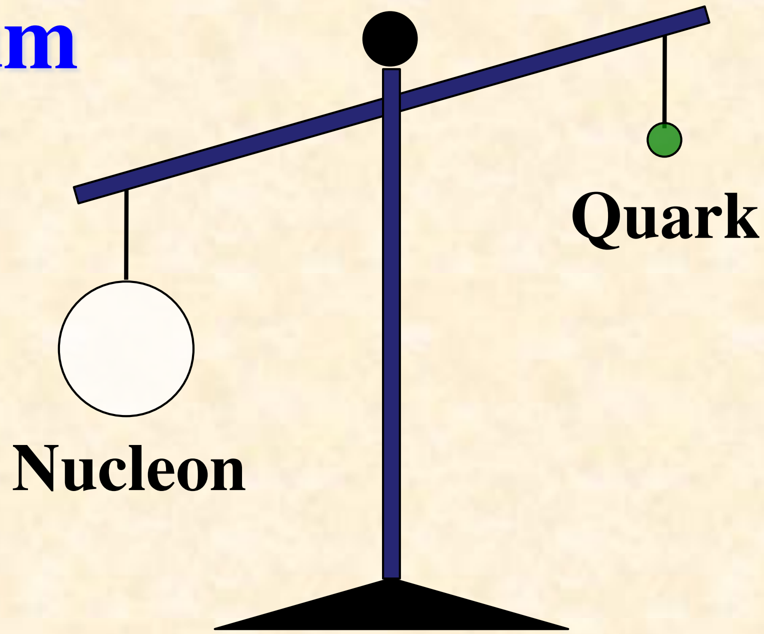
There is a possibility for high-energy hadron physics, including nucleon structure, ...

LETTER OF INTENT

Studying Generalized Parton Distributions with Exclusive Drell-Yan process at J- PARC

JungKeun Ahn,[1] Sakiko Ashikag,[2] Wen-Chen Chang,[3,*] Seonho Choi,[4] Stefan Diehl,[5] Yuji Goto,[6] Kenneth Hicks,[7] Youichi Igarashi,[8] Kyungseon Joo,[5] Shunzo Kumano,[9,10] Yue Ma,[6] Kei Nagai,[3] Kenichi Nakano,[11] Masayuki Niiyama,[12] Hiroyuki Noumi,[13,8,†] Hiroaki Ohnishi,[14] Jen-Chieh Peng,[15] Hiroyuki Sako,[16] Shin'ya Sawada,[8,‡] Takahiro Sawada,[17] Kotaro Shirotori,[13] Kazuhiro Tanaka,[18,10] and Natsuki Tomida[13]

Hadron masses in nuclear medium



Origin of the nucleon mass:

Why $m_{quark} << m_{nucleon}$?

Chiral-symmetry breaking

Order parameter:
"quark condensate $<q\bar{q}>$"

$<q\bar{q}>$ depends temperature and density

$<q\bar{q}>$ is not a direct observable, so look at nuclear-medium modification of hadron masses.

Vector-meson masses vs. density

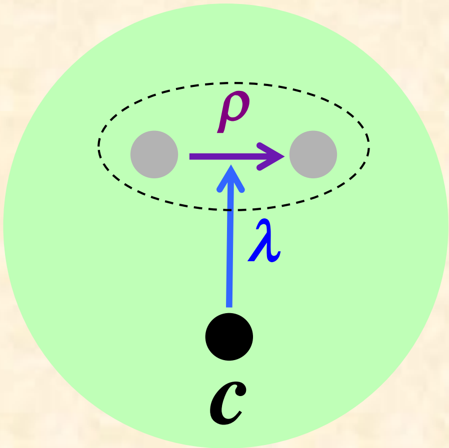
Modifications even at "normal nuclear density"

Reduction in ρ, ω masses at normal nuclear density

Charmed-baryon physics

J-PARC is a facility to create new states of hadrons by extending flavor degrees of freedom.

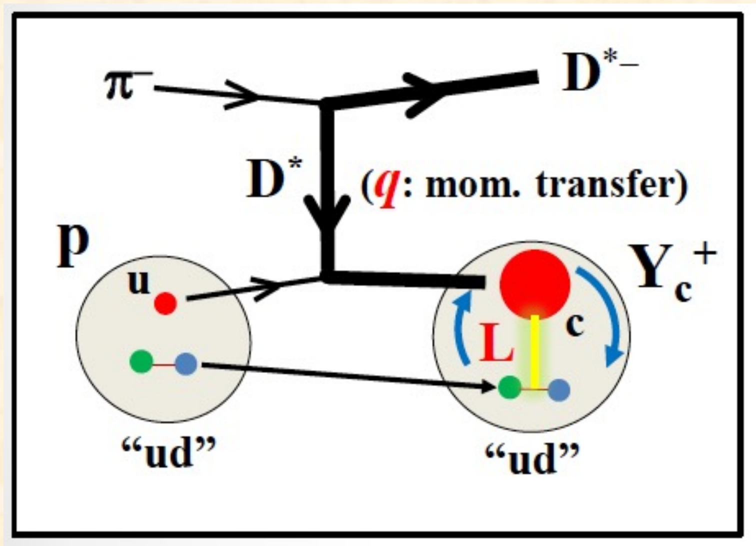
From "strangeness hadron physics" to "charm hadron physics"



- one heavy quark: ρ and λ modes
- roles of diquark

E50 experiment: $\pi^- + p \to D^{*-} + Y_c^+$

J-PARC: 30 GeV
$\to \sqrt{s} = 8$ GeV



Future possibility at J-PARC on color transparency

(E50 project) At this stage, only on charmed baryons,

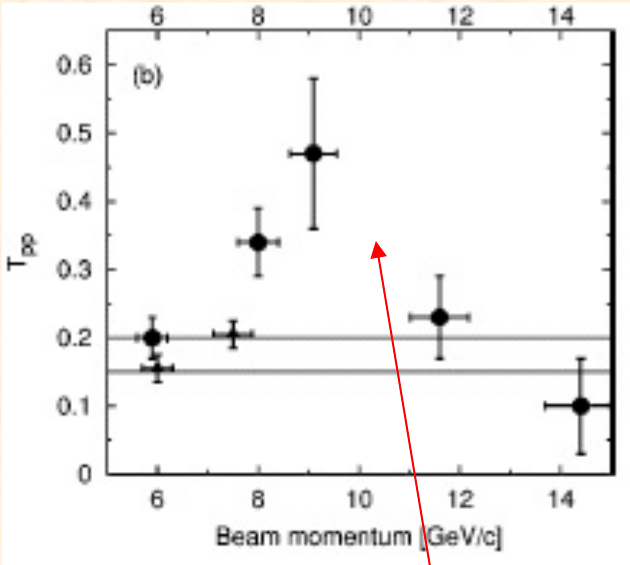
https://www.rcnp.osaka-u.ac.jp/~noumi/puki/E50/

(GPD by Drell-Yan) GPD project could join this E50 collaboration,

Wen-Chen Chang's talk on June 8, 2021 at this workshop.

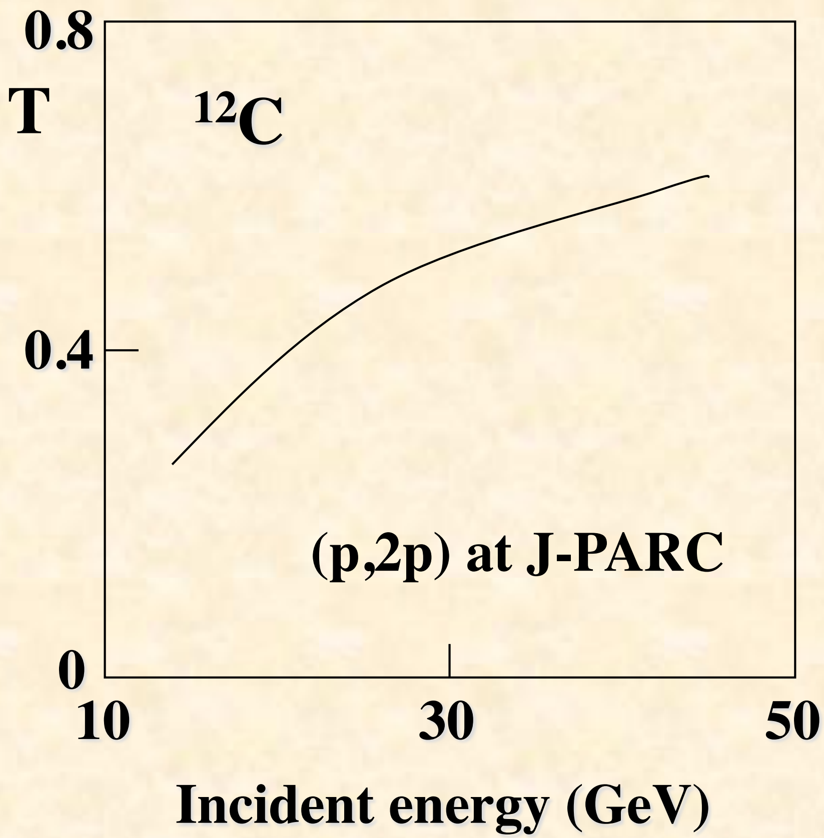
Color transparency at J-PARC

(BNL-EVA) J. Aclander *et al.*, PRC 70 (2004) 015208



reason for this drop?

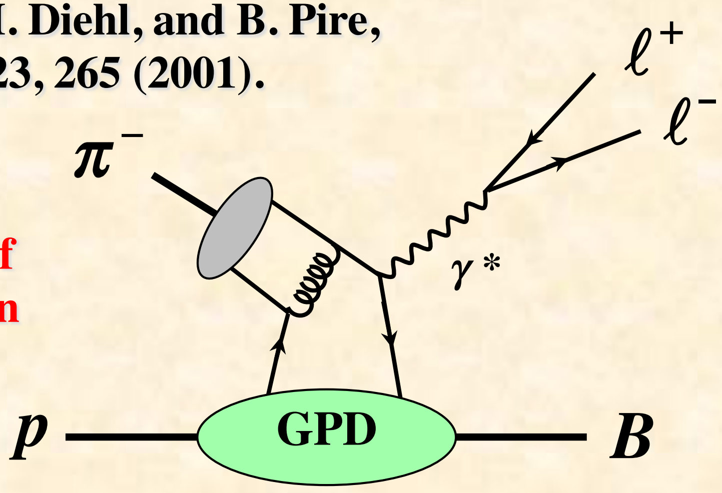
The mysterious BNL result could be clarified by a possible J-PARC experiment.



Toward J-PARC experiments on GPDs

E. R. Berger, M. Diehl, and B. Pire,
Phys. Lett. B 523, 265 (2001).

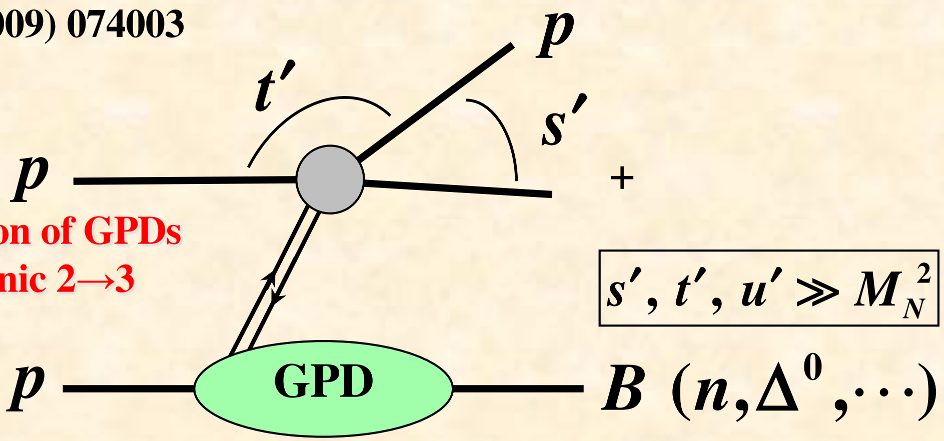
Investigation of GPDs with pion distribution amplitude



$$\pi^-(\bar{u}d) + p(uud) \rightarrow B(udd) + \gamma^*(\rightarrow \ell^+\ell^-)$$

S. Kumano, M. Strikman, K. Sudoh,
PRD 80 (2009) 074003

Investigation of GPDs with hadronic 2→3 processes



$\boxed{s', t', u' \gg M_N^2}$

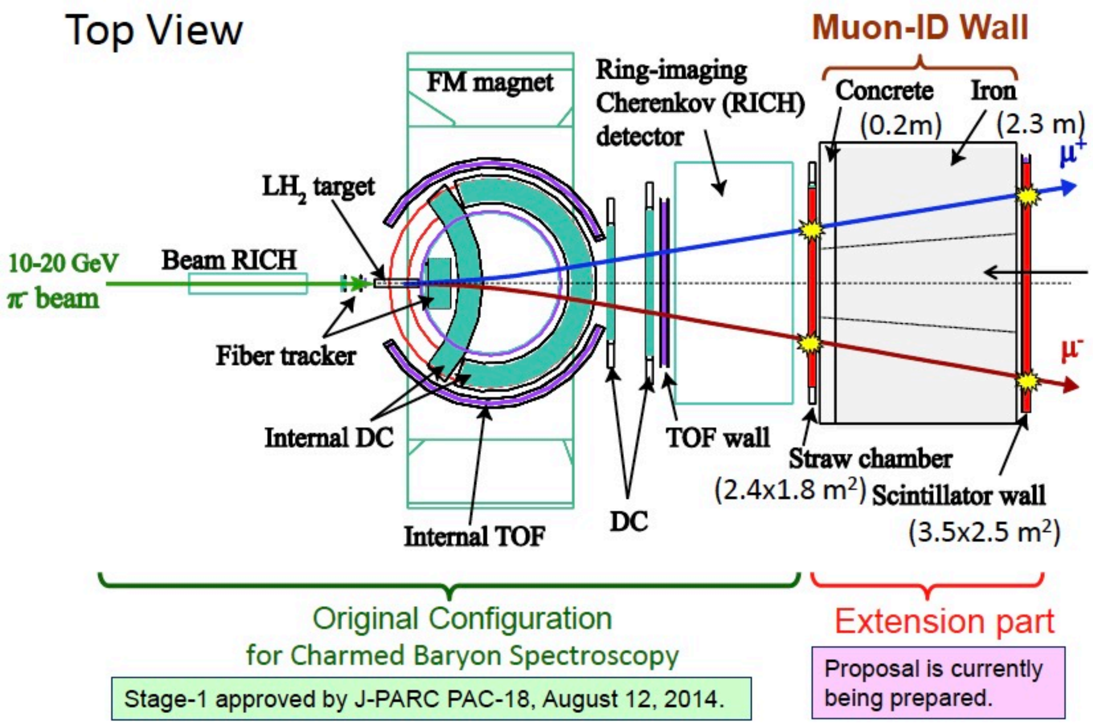
Letter of Intent to join J-PARC-E50 collaboration (Jan. 2019)

LETTER OF INTENT

Studying Generalized Parton Distributions with Exclusive Drell-Yan process at J- PARC

JungKeun Ahn,[1] Sakiko Ashikag,[2] Wen-Chen Chang,[3,*] Seonho Choi,[4] Stefan Diehl,[5] Yuji Goto,[6] Kenneth Hicks,[7] Youichi Igarashi,[8] Kyungseon Joo,[5] Shunzo Kumano,[9,10] Yue Ma,[6] Kei Nagai,[3] Kenichi Nakano,[11] Masayuki Niiyama,[12] Hiroyuki Noumi,[13,8,†] Hiroaki Ohnishi,[14] Jen-Chieh Peng,[15] Hiroyuki Sako,[16] Shin'ya Sawada,[8,‡] Takahiro Sawada,[17] Kotaro Shirotori,[13] Kazuhiro Tanaka,[18,10] and Natsuki Tomida[13]

Extension of J-PARC E50 Experiment for Drell-Yan measurement



→**Wen-Chen Chang's talk**

If you are interested in proposing a color-transparency experiment

- At this stage, there is no proposal to measure the color transparency.
- You may get in touch with Wen-Chen Chang and
  and then join the high-momentum-beamline/E50 collaboration.
- It would be nice if you communicate also with
  Hiroyuki Noumi (E50, Osaka U/KEK) and
  Sinya Sawada (KEK/J-PARC).
- Understanding of color transparency is not excellent
  in the Japanese hadron-physics community,
  so you need to first explain from the basic part.
- I am thinking about organizing a small workshop
  on the J-PARC GPD project in this year (2021),
  so some of you may explain your interest on color transparency.

U.S.-Japan Hadronic Physics Exchange Program for Studies of Hadron Structure and QCD

Travel support to Japan on joint projects, https://www.jlab.org/usjhpe


Jefferson Lab

A-Z INDEX | SIGN IN

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U.S. DEPARTMENT OF ENERGY

US-Japan Hadronic Physics Exchange Program for Studies of Hadron Structure and QCD

USJHPE
About
Application
Travel
Governance
Archive

ABOUT USJHPE

USJHPE is a US-Japan exchange program supporting collaborative scientific research in hadronic physics. It focuses on subject areas related to the programs at current and future experimental facilities in the US and Japan and supports both experimental and theoretical studies.

USJHPE particularly aims to realize synergies between the hadronic physics programs at Jefferson Lab 12 GeV and J-PARC resulting from the complementarity of electromagnetic and hadronic probes in the multi-GeV energy range. Subject areas of common interest include the quark-gluon structure of hadrons and nuclei, meson and baryon spectroscopy, strangeness and hypernuclear physics, and other related topics.

USJHPE also supports research in hadronic physics and nuclear-physics-enabled tests of fundamental symmetries related to the programs at Brookhaven National Lab, Fermilab, KEK, Spring-8, and university-based facilities in the US and Japan. USJHPE especially promotes collaboration between the US and Japanese nuclear physics communities in the development of the physics program for the future Electron-Ion Collider.

USJHPE is intended to provide travel grants to US-based scientists (primary institutional affiliation with a US university, national laboratory, or other research center) to visit Japanese institutions and conduct collaborative research there. The program can support senior researchers, postdoctoral fellows, and students.

Researchers interested in participating in the program should submit an application following the guidelines given in Application. Applications will be reviewed by a Coordinating Committee, and awards will be made competitively, subject to the availability of funds.

For questions about the program, please contact usjhpe@jlab.org

USJHPE is supported by the US Department of Energy under grant DE-SC0021359 "U.S.-Japan Hadronic Physics Exchange Program for Studies of Hadron Structure and QCD." The program governance is described in Governance.

Summary

- The color transparency is an important phenomena
  to understand the quark-hadron many-body systems
  from low to high energies and from low to high densities.
- There was a mysterious result on the color transparency
  in the BNL experiment [$pA \to pp(A\text{-}1)$], which needs to be clarified
  by hadron accelerator facilities such as J-PARC.
- We proposed to use hadronic $2 \to 3$ processes to study
  the color transparency in comparison with the usual $2 \to 2$ ones.
- The new JLab measurement of this year (2021) provides
  a clue in understanding the nuclear transparency
  and the role of color transparency.
- It is in principle possible to investigate the color transparency
  at J-PARC. You may talk with J-PARC experimentalists.
  Current efforts on nucleon-structure physics will be
  explained by Wen-Chen Chang, so you may listen to
  his talk, especially on facility conditions.

The End

The End