ECT* workshop
“Dilepton Productions with Meson and Antiproton Beams”
Nov. 06-10, 2017

Feasibility of Exclusive Drell-Yan Experiment at J-PARC

Takahiro Sawada
University of Michigan

Based on the paper of
T. Sawada, W. C. Chang, Kumano, J. C. Peng, S. Sawad, K. Tanaka,
Phys. Rev. D93 (2016) 114034, arXiv:1605.00364

Timetable

Mon 06/11 | Tue 07/11 | **Wed 08/11** | Thu 09/11 | Fri 10/11 | All days

Print | PDF | Full screen | Detailed view | Filter

09:00 **The Exclusive Drell-Yan Process** *Peter Kroll*

Exclusive Drell-Yan (Theory)

*ECT** 09:00 - 09:45

Hadron Physics at J-PARC *Shin'ya Sawada*

10:00

J-PARC, High Momentum Beamline

*ECT** 09:45 - 10:30

Coffee break

*ECT** 10:30 - 11:00

11:00 **Charm Physics with Meson Beam at J-PARC** *Hiroyuki Noumi*

E50 Experiment

at J-PARC High Momentum Beamline

*ECT** 11:00 - 11:45

Feasibility of Exclusive Drell-Yan Experiment at J-PARC *Takahiro Sawada*

12:00

Measurement of the Exclusive Drell-Yan

as an extension of J-PARC E50

*ECT** 11:45 - 12:30

Outline

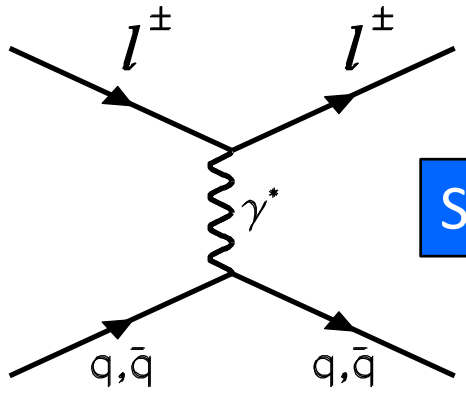
- Extraction of PDFs and GPDs via Space-like and Time-like processes
- Exclusive pion-induced Drell-Yan process ($\pi^- p \to \mu^+ \mu^- n$)
- Related Issues:

  Nucleon GPD, Pion DA, Transition DA, Transition GPD,
  Pion-pole, Soft nonfactorizable mechanism
- High momentum beamline at J-PARC and E50 experiment
- Feasibility study of exclusive pion-induced Drell-Yan experiment at J-PARC E50
- Summary

Extraction of **PDFs**

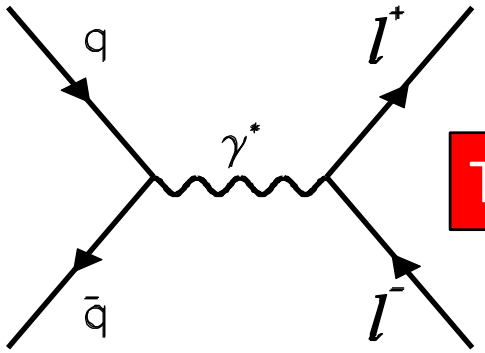
Complementarity between **Space-like** and **Time-like** processes

Deep Inelastic Scattering (DIS)



Space-like

Drell-Yan (DY) process



Time-like

Main Processes in Global PDF Analysis

Eur. Phys. J. C (2009) 63: 189–285

Process	Subprocess	Partons	x range	
$\ell^{\pm}\{p,n\} \to \ell^{\pm}X$	$\gamma^* q \to q$	$q, \bar{q}, g$	$x \gtrsim 0.01$	DIS
$\ell^{\pm} n/p \to \ell^{\pm}X$	$\gamma^* d/u \to d/u$	d/u	$x \gtrsim 0.01$	DIS
$pp \to \mu^+\mu^- X$	$u\bar{u}, dd \to \gamma^*$	$\bar{q}$	$0.015 \lesssim x \lesssim 0.35$	DY
$pn/pp \to \mu^+\mu^- X$	$(u\bar{d})/(u\bar{u}) \to \gamma^*$	$\bar{d}/\bar{u}$	$0.015 \lesssim x \lesssim 0.35$	DY
$\nu(\bar{\nu})N \to \mu^-(\mu^+)X$	$W^* q \to q'$	$q, \bar{q}$	$0.01 \lesssim x \lesssim 0.5$	DIS
$\nu N \to \mu^-\mu^+ X$	$W^* s \to c$	s	$0.01 \lesssim x \lesssim 0.2$	DIS
$\bar{\nu} N \to \mu^+\mu^- X$	$W^* \bar{s} \to \bar{c}$	$\bar{s}$	$0.01 \lesssim x \lesssim 0.2$	DIS
$e^{\pm} p \to e^{\pm} X$	$\gamma^* q \to q$	$g, q, \bar{q}$	$0.0001 \lesssim x \lesssim 0.1$	DIS
$e^+ p \to \bar{\nu} X$	$W^+\{d,s\} \to \{u,c\}$	d, s	$x \gtrsim 0.01$	DIS
$e^{\pm} p \to e^{\pm} c\bar{c} X$	$\gamma^* c \to c, \gamma^* g \to c\bar{c}$	c, g	$0.0001 \lesssim x \lesssim 0.01$	DIS
$e^{\pm} p \to \text{jet} + X$	$\gamma^* g \to q\bar{q}$	g	$0.01 \lesssim x \lesssim 0.1$	
$p\bar{p} \to \text{jet} + X$	$gg, qg, qq \to 2j$	g, q	$0.01 \lesssim x \lesssim 0.5$	
$p\bar{p} \to (W^{\pm} \to \ell^{\pm}\nu)X$	$ud \to W, \bar{u}\bar{d} \to W$	$u, d, \bar{u}, \bar{d}$	$x \gtrsim 0.05$	
$p\bar{p} \to (Z \to \ell^+\ell^-)X$	$uu, dd \to Z$	d	$x \gtrsim 0.05$	

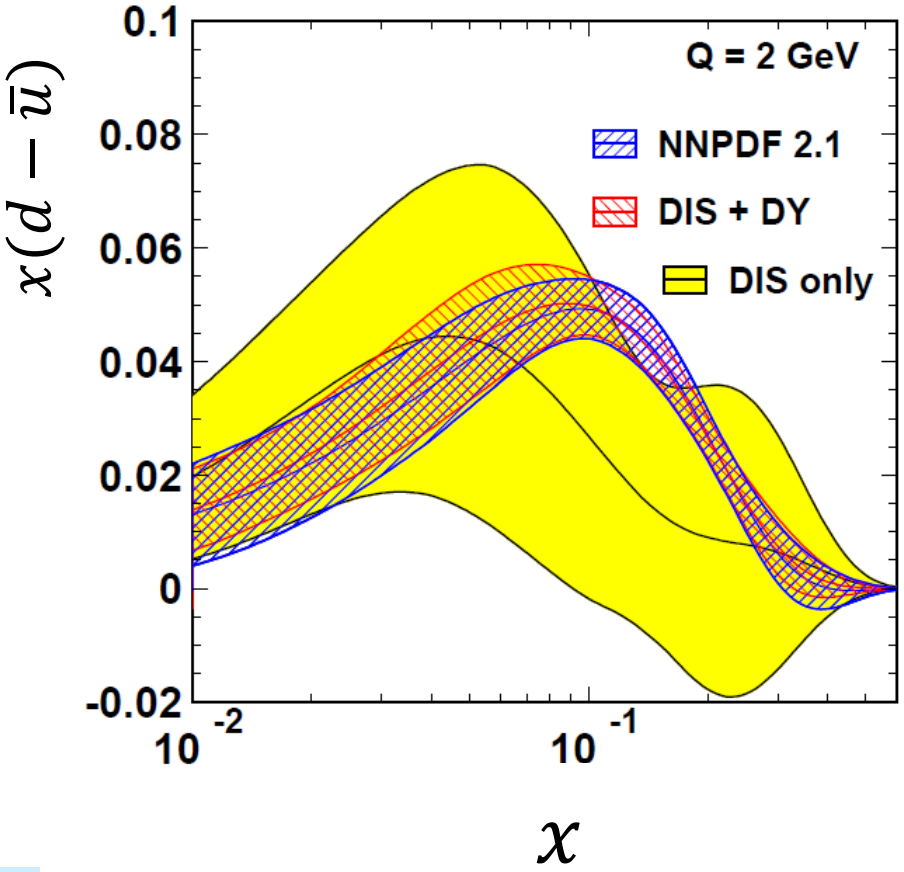
Both DIS and Drell-Yan process are powerful tools to probe the quark and anti-quark structure in hadrons (Universality, Factorization)

Extraction of **PDFs**

Complementarity between **Space-like** and **Time-like** processes

The asymmetry of the light sea "$\bar{d}(\mathrm{x}) - \bar{u}(\mathrm{x})$ "
and its one standard deviation uncertainty

E. Pereza and E. Rizvib, arXiv:1208.1178



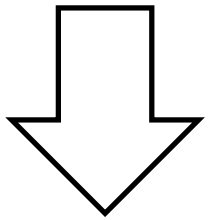
Example:

Constraint of $x(\bar{d} - \bar{u})$ in Global Analysis

- When only DIS data are included in the fit
  → Yellow contour
- When DY data are included in addition
  → Red hashed contour
- Reference NNPDF2.1 fit
  → Blue hashed contour

Use of both DIS and DY provides the strong constrain of $x(\bar{d} - \bar{u})$

The measurements of both Space-like process (DIS) and Time-like process (DY) are helpful to probe the PDFs.



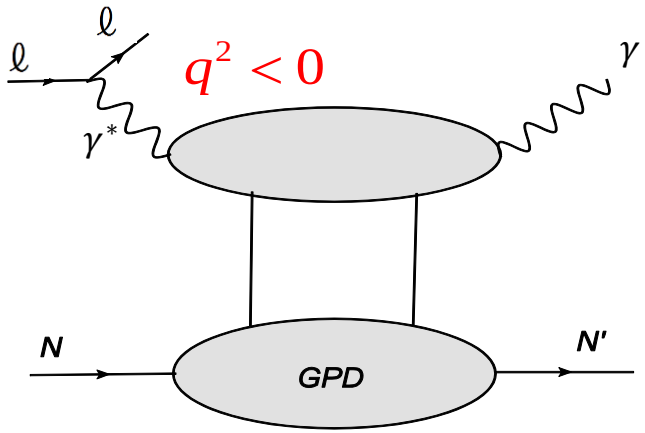
Analogy

The measurements of both Space-like process and Time-like process are helpful to probe the GPDs ?

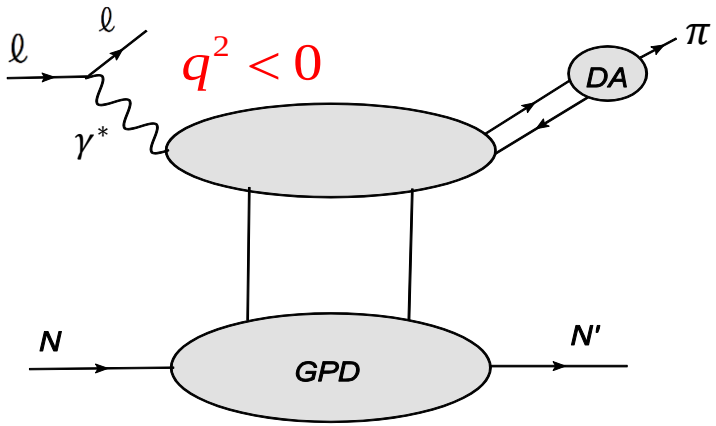
Extraction of **GPDs**
by Lepton Beam (Space-like Processes)

Muller et al., PRD 86 031502(R) (2012)

Deeply Virtual Compton Scattering (DVCS)



Deeply Virtual Meson Production (DVMP)



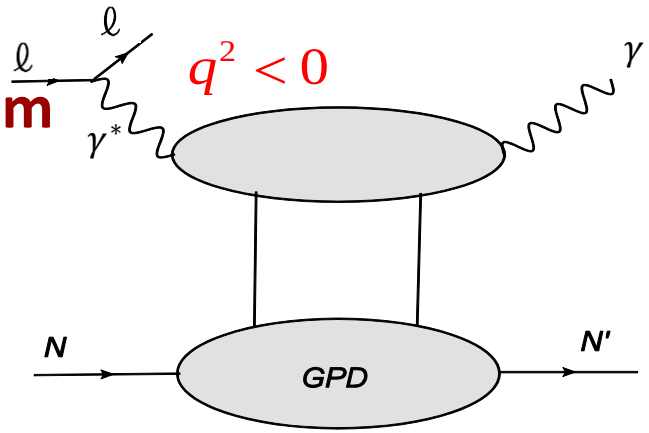
Extraction of **GPDs**

Space-like vs. **Time-like** Processes

Muller et al., PRD 86 031502(R) (2012)

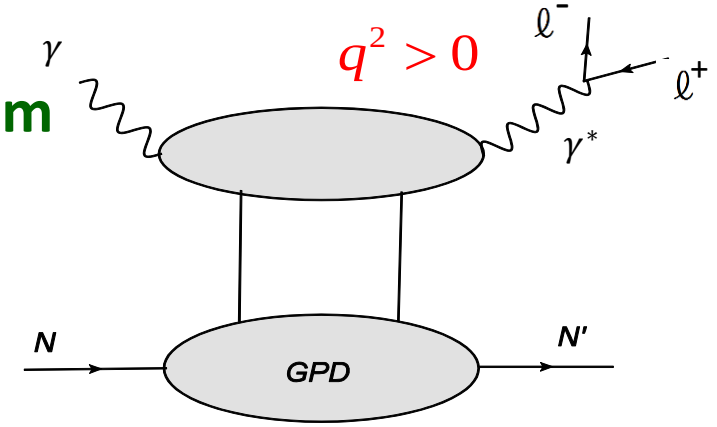
Deeply Virtual Compton Scattering (DVCS)

Lepton Beam



Time-like Compton Scattering (TCS)

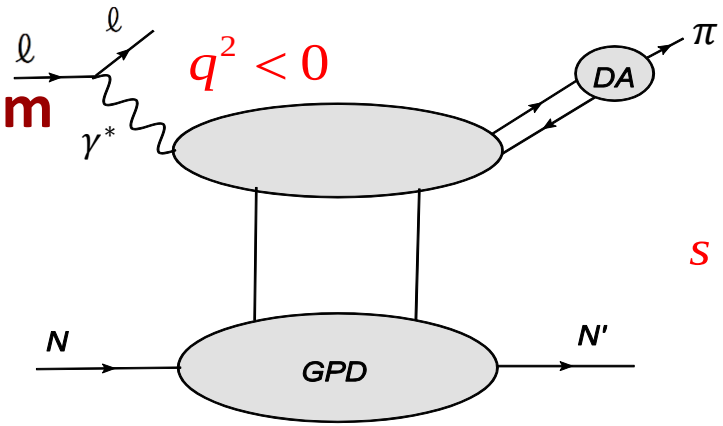
Photon Beam



$s \leftrightarrow u$ channel crossing

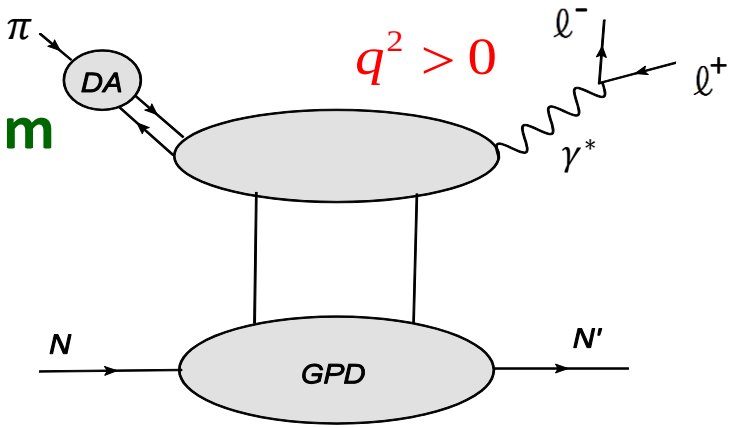
Deeply Virtual Meson Production (DVMP)

Lepton Beam



Exclusive meson-induced DY

Meson Beam



$s \leftrightarrow u$ channel crossing

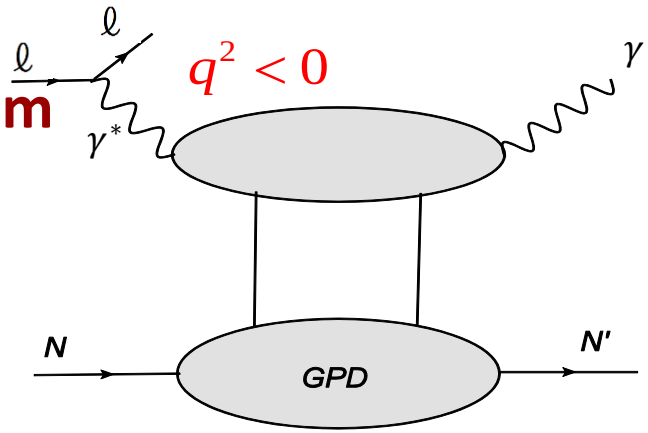
Extraction of **GPDs**

Space-like vs. **Time-like** Processes

Muller et al., PRD 86 031502(R) (2012)

Deeply Virtual Compton Scattering (DVCS)

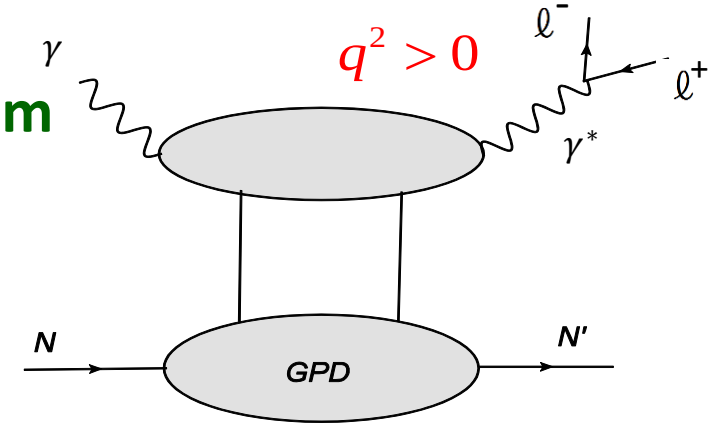
Lepton Beam



$s \leftrightarrow u$ channel crossing

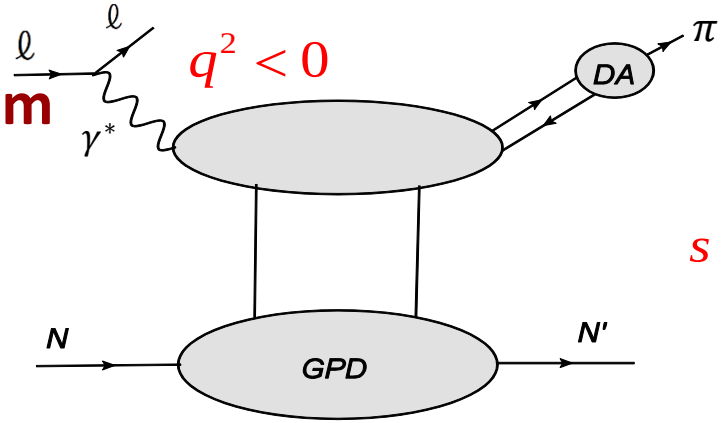
Time-like Compton Scattering (TCS)

Photon Beam



Deeply Virtual Meson Production (DVMP)

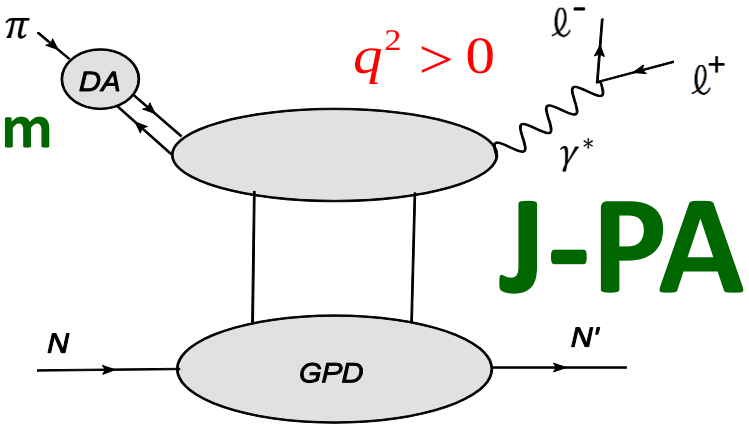
Lepton Beam



$s \leftrightarrow u$ channel crossing

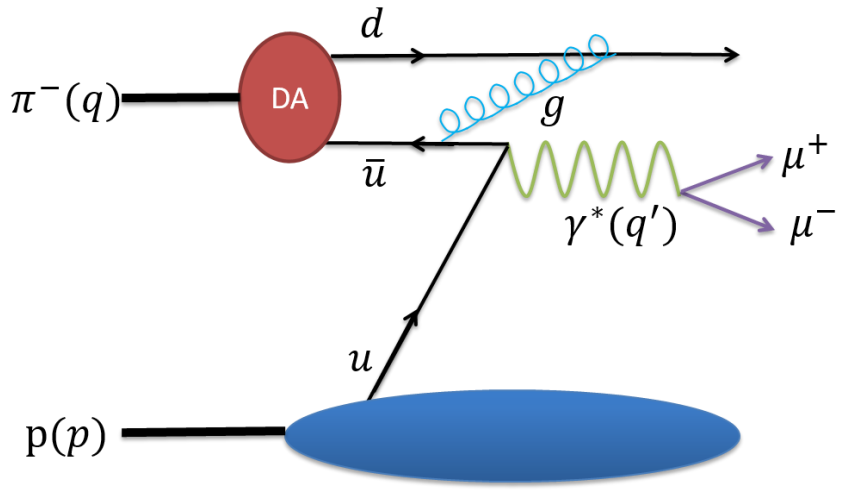
Exclusive meson-induced DY

Meson Beam



J-PARC

Semi-exclusive pion-induced DY at large x_π



When Longitudinal momentum fraction $x_\pi \longrightarrow 1$

- Virtual photon polarization:

  Transverse $\longrightarrow$ Longitudinal

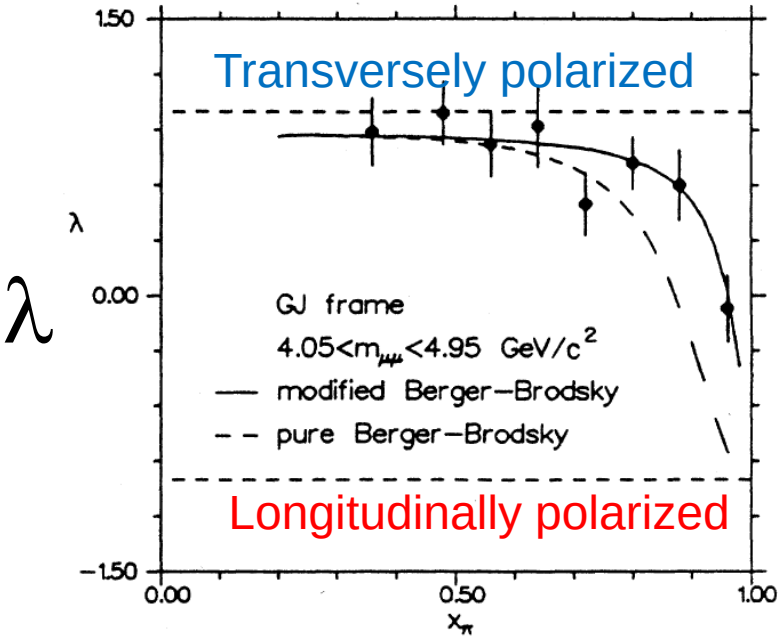
- Dimuon angular distribution:

  $(1 + \cos^2\theta) \longrightarrow \sin^2\theta$

Dominance of higher-twist contributions in the forward production

Drell-Yan decay angular distributions

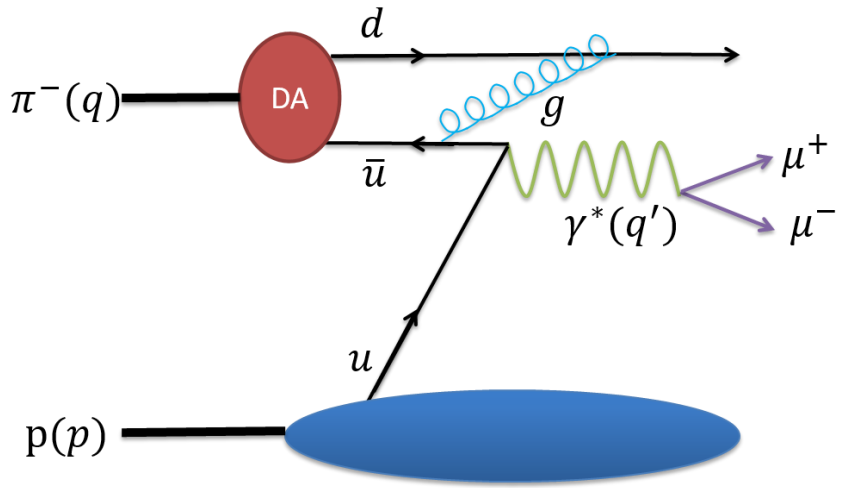
E615, PRD 39, 92 (1989)



λ

X_π

Semi-exclusive pion-induced DY at large x_π



When Longitudinal momentum fraction $x_\pi \longrightarrow 1$

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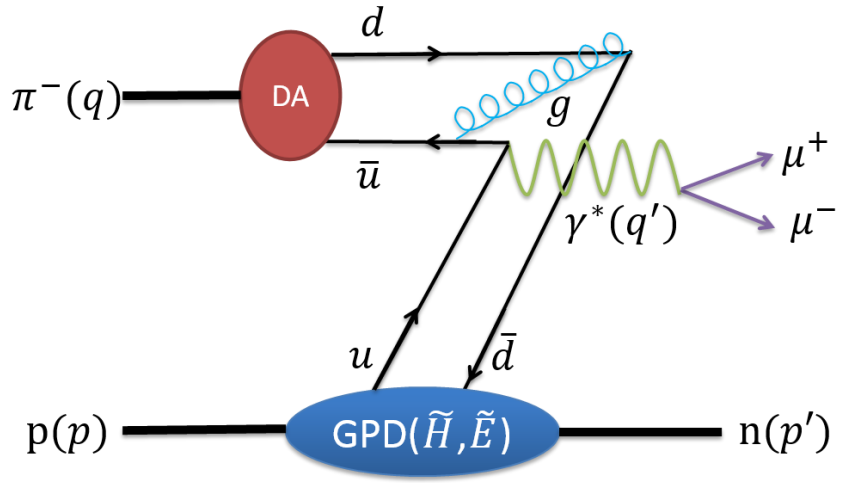
  $(1+\cos^2\theta) \longrightarrow \sin^2\theta$

Dominance of higher-twist contributions in the forward production

Exclusive pion-induced DY $\pi\ N \rightarrow \gamma^* N'$

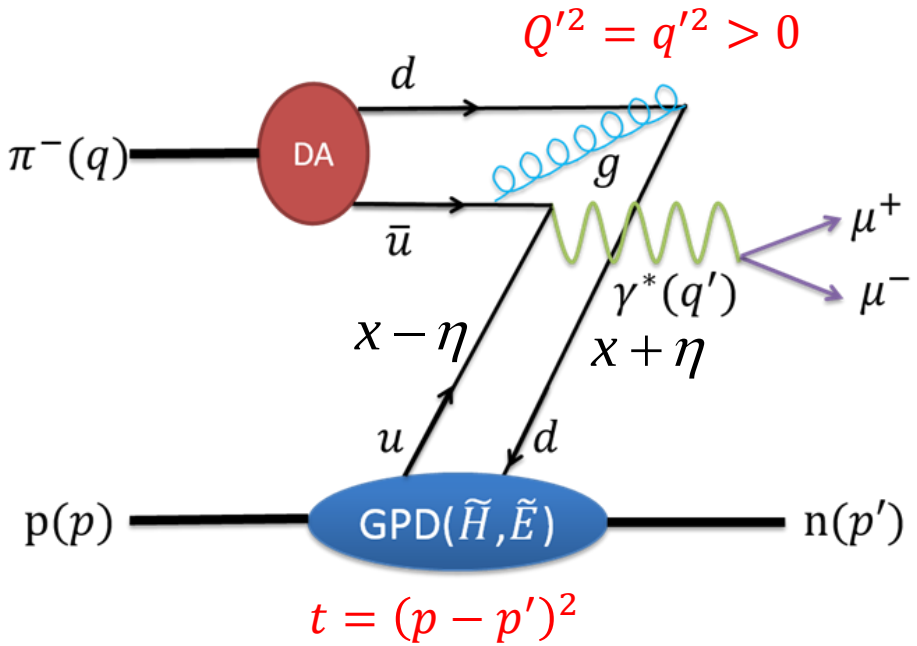


- Spectator quark originating from the pion may be absorbed by the remnant of the target

- The target matrix element is given by a GPD with skewness

Exclusive Drell-Yan process: $\pi^- p \to \mu^+ \mu^- n$

E.R. Berger, M. Diehl, B. Pire, PLB 523 (2001) 265



$$\tau = \frac{Q'^2}{2pq} \approx \frac{Q'^2}{s - M_N^2} \qquad \xi = \frac{(p-p')^+}{(p+p')^+} = \frac{\tau}{2-\tau}$$ (skewness)

$$\tilde{x} = -\frac{(q+q')^2}{2(p+p')\cdot(q+q')} \approx -\frac{Q'^2}{2s - Q'^2} = -\xi$$ (scaling variable)

$$\tilde{\mathcal{H}}^{du}(\tilde{x},\xi,t) = \frac{8}{3}\alpha_s \int_{-1}^{1} dz \frac{\phi_\pi(z)}{1-z^2}$$ ← Twist-two Pion DA

$$\times \int_{-1}^{1} dx \left(\frac{e_d}{\tilde{x} - x - i\epsilon} - \frac{e_u}{\tilde{x} + x - i\epsilon} \right)$$ ← Electric charges

$$\times (\tilde{H}^d(x,\xi,t) - \tilde{H}^u(x,\xi,t)),$$ ← GPD $\tilde{H}$ for $p \to n$ transition

Leading-twist cross section:

$$\left.\frac{d\sigma_L}{dt dQ'^2}\right|_\tau = \frac{4\pi\alpha_{\rm em}^2}{27}\frac{\tau^2}{Q'^8} f_\pi^2 \left[(1-\xi^2)|\tilde{\mathcal{H}}^{du}(\tilde{x},\xi,t)|^2 \right.$$

$$\left. - 2\xi^2 \mathrm{Re}\left(\tilde{\mathcal{H}}^{du}(\tilde{x},\xi,t)^* \tilde{\mathcal{E}}^{du}(\tilde{x},\xi,t)\right) - \xi^2 \frac{t}{4m_N^2} |\tilde{\mathcal{E}}^{du}(\tilde{x},\xi,t)|^2 \right],$$

Two GPDs inputs

BMP2001

E. R. Berger, M. Diehl and B. Pire, Eur. Phys. J. C 23 (2002) 675
E. R. Berger, M. Diehl and B. Pire, Phys. Lett. B 523 (2001) 265

$$\tilde{H}^{d,u}(x,\xi,t) = \tilde{H}^{d,u}(x,\xi,0)\,[g_A(t)/g_A(0)]$$

Here, $\tilde{H}^q(x,\xi,0)$ constructed from an ansatz based on double distributions as an integral of $\tilde{H}^q(x,0,0) = \Delta q(x)$ combined with a certain profile function generating the skewness ξ dependence

$\phi_\pi(z) \to (3/4)(1-z^2)$ asymptotic form

GK2013

P. Kroll, H. Moutarde and F. Sabatie, Eur. Phys. J. C 73 (2013) 1, 2278

The parameters are determined from the HERMES data on the cross sections and target asymmetries for pi+ electroproduction

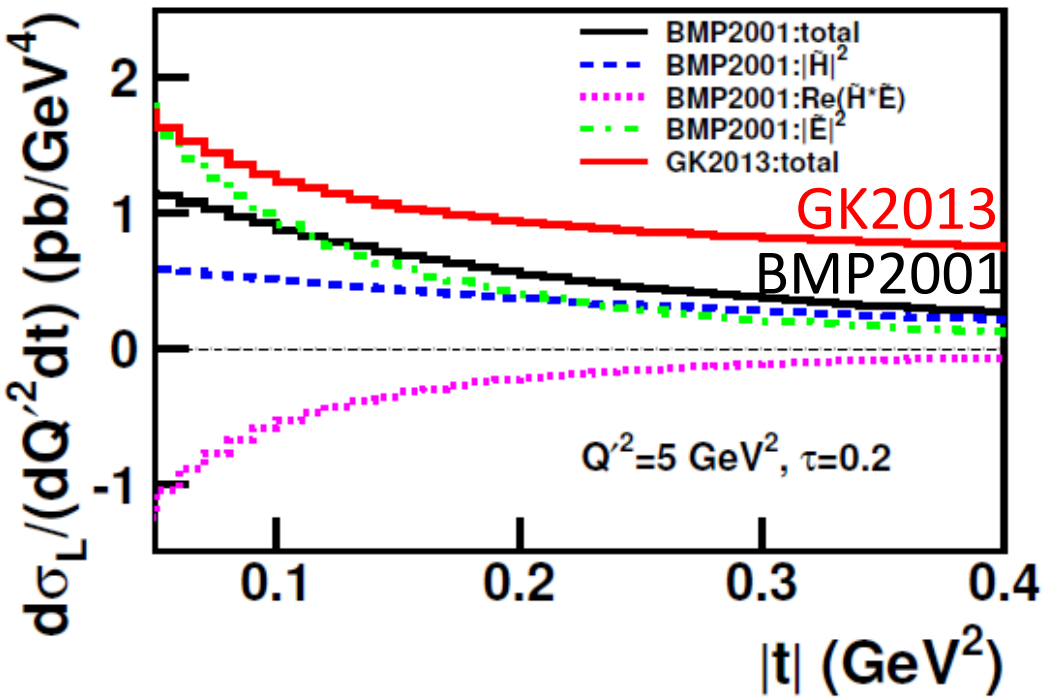
$$\phi_\pi(z) = (3/4)(1-z^2)[1 + a_2 C_2^{(3/2)}(z)]$$

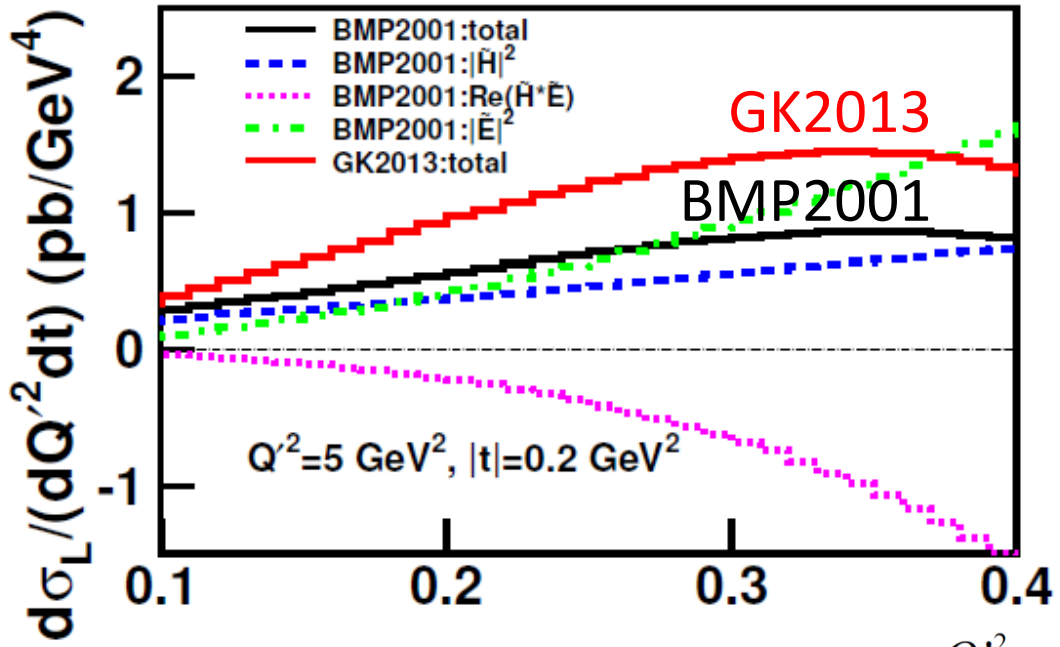
$$\text{with } a_2\ (\mu = 2\ \text{GeV}) = 0.22$$

Differential cross sections of exclusive Drell-Yan

at $\tau = \frac{Q'^2}{2pq} \approx \frac{Q'^2}{s - M_N^2} = 0.2$ $Q'^2 = q'^2 = 5\ GeV^2$

at $t = (p - p')^2 = -0.2\ GeV^2$





Production is dominant at forward angles

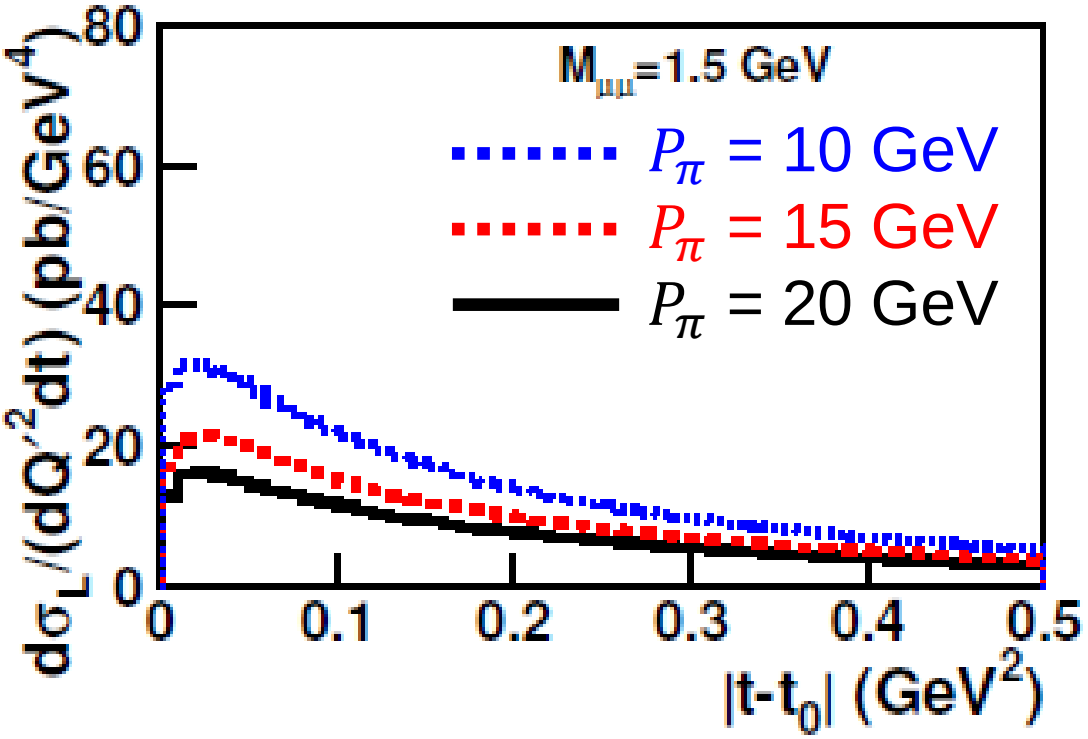
Cross sections increase toward small *s* (→ Low beam energy)

$\tau = \frac{Q'^2}{2pq} \approx \frac{Q'^2}{s - M_N^2}$

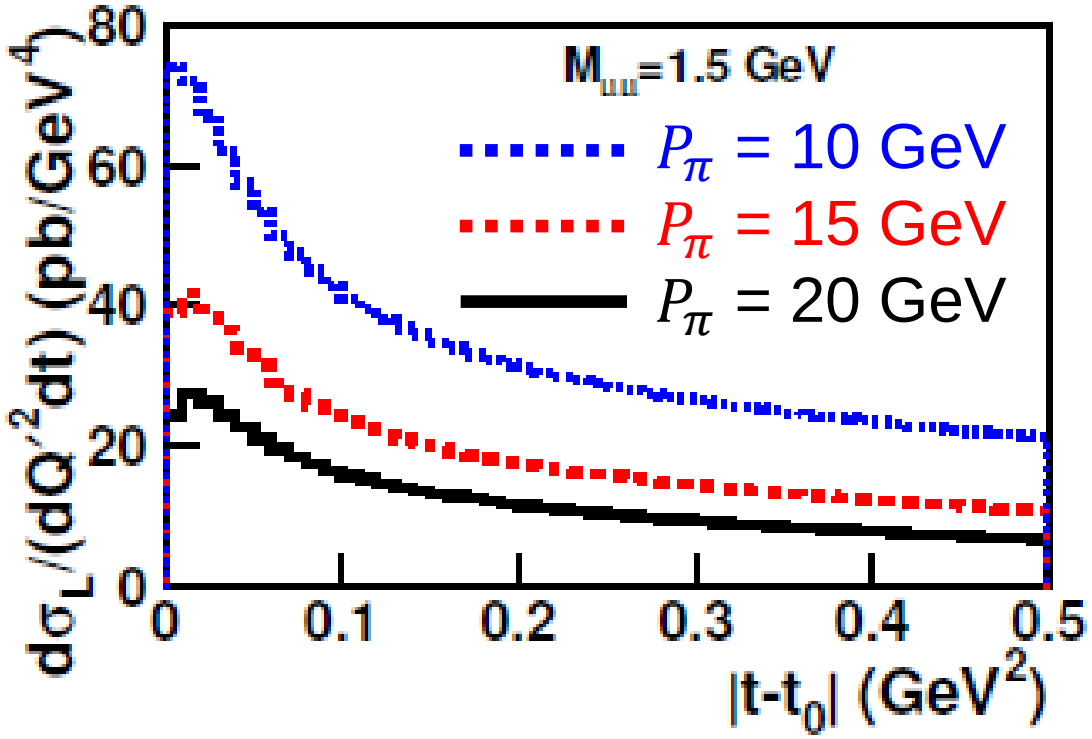
Different GPD inputs → Factor of ~2 difference at cross section

Differential cross sections of exclusive Drell-Yan

BMP2001



GK2013

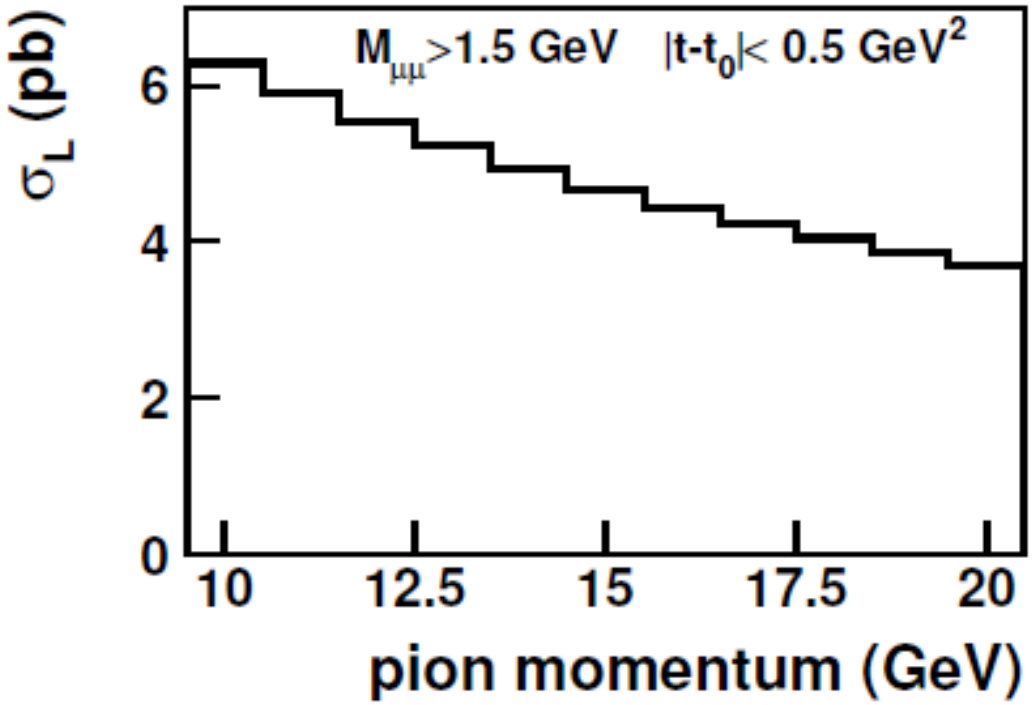


*Where t_0 is the limiting value of t at $\theta^{CM} = 0$

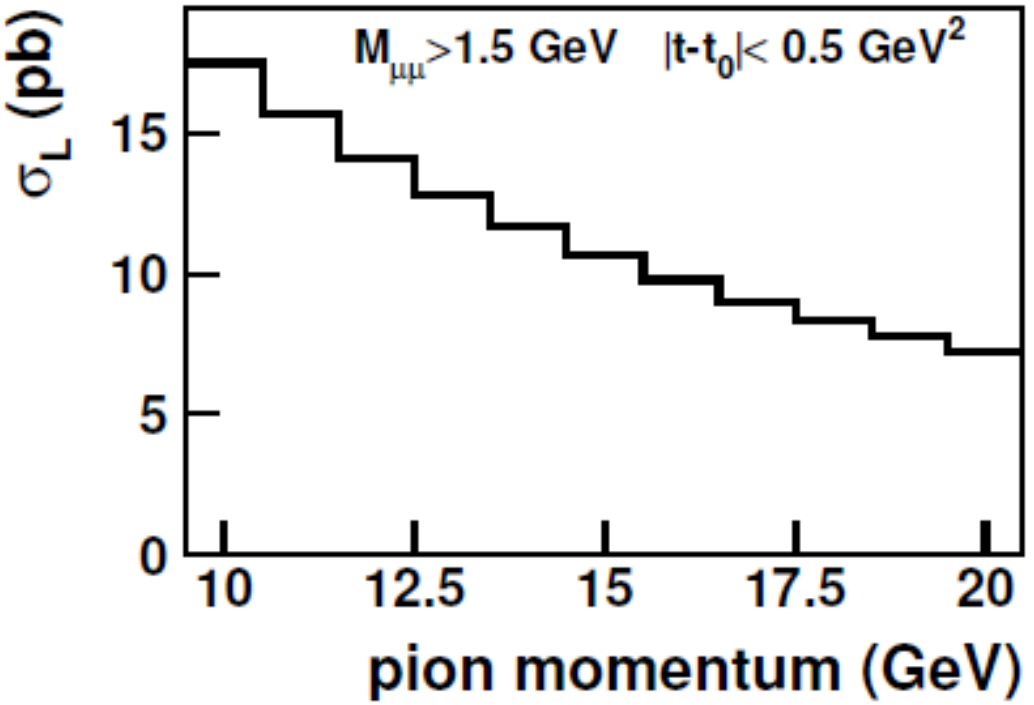
- Pion beam with lower momentum → Larger cross section

Total LO cross sections of exclusive Drell-Yan

BMP2001



GK2013

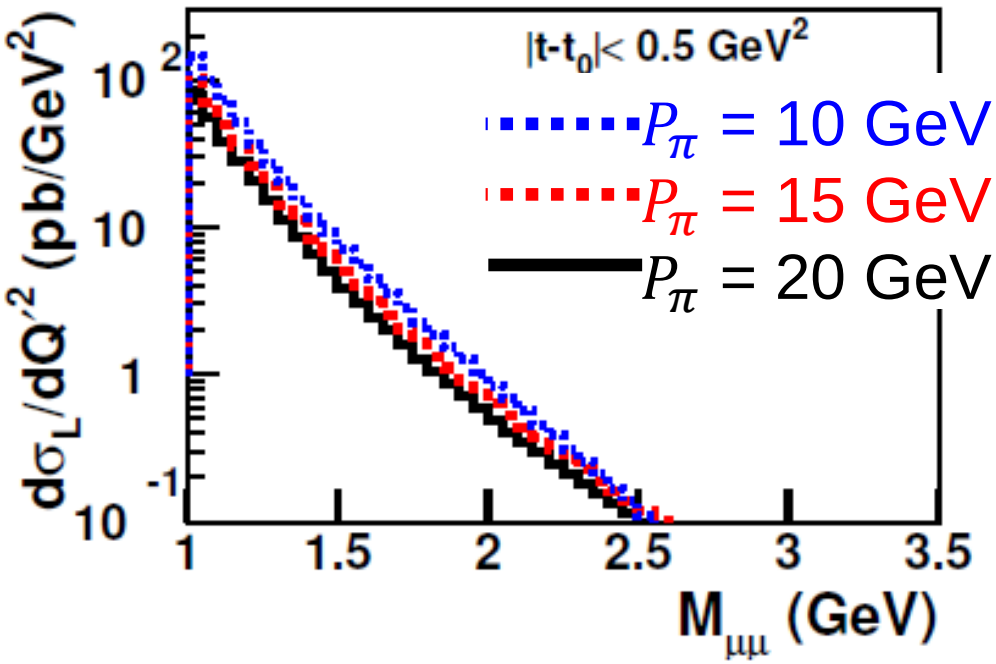


J-PARC **(Pπ = 10-20 GeV) σ = 5 ~ 15 pb**

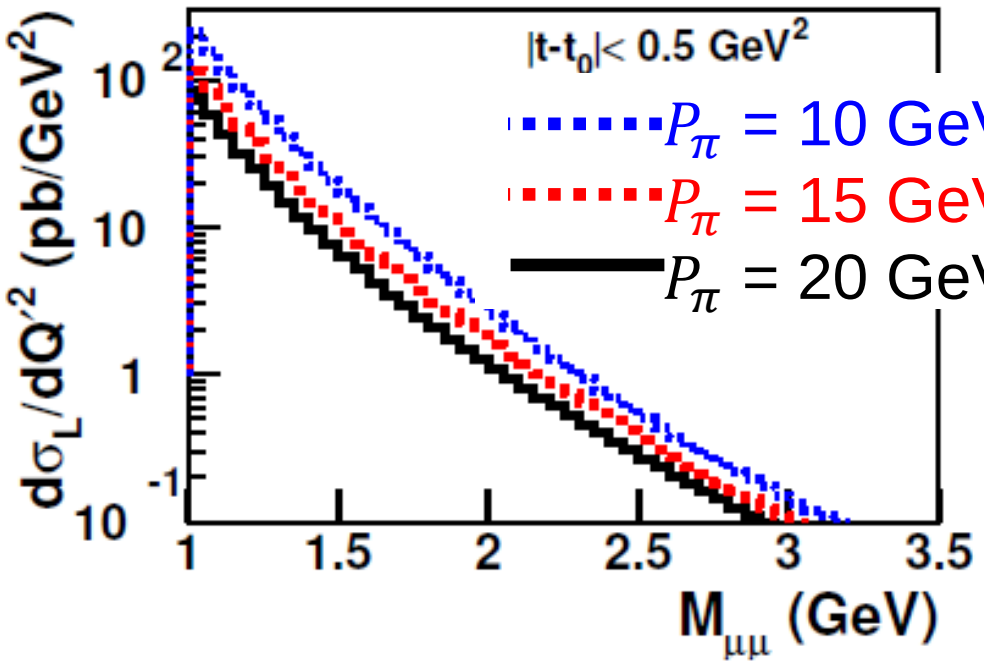
CERN COMPASS (Pπ = 190 GeV) σ = 0.65 pb

Differential cross sections of exclusive Drell-Yan

BMP2001

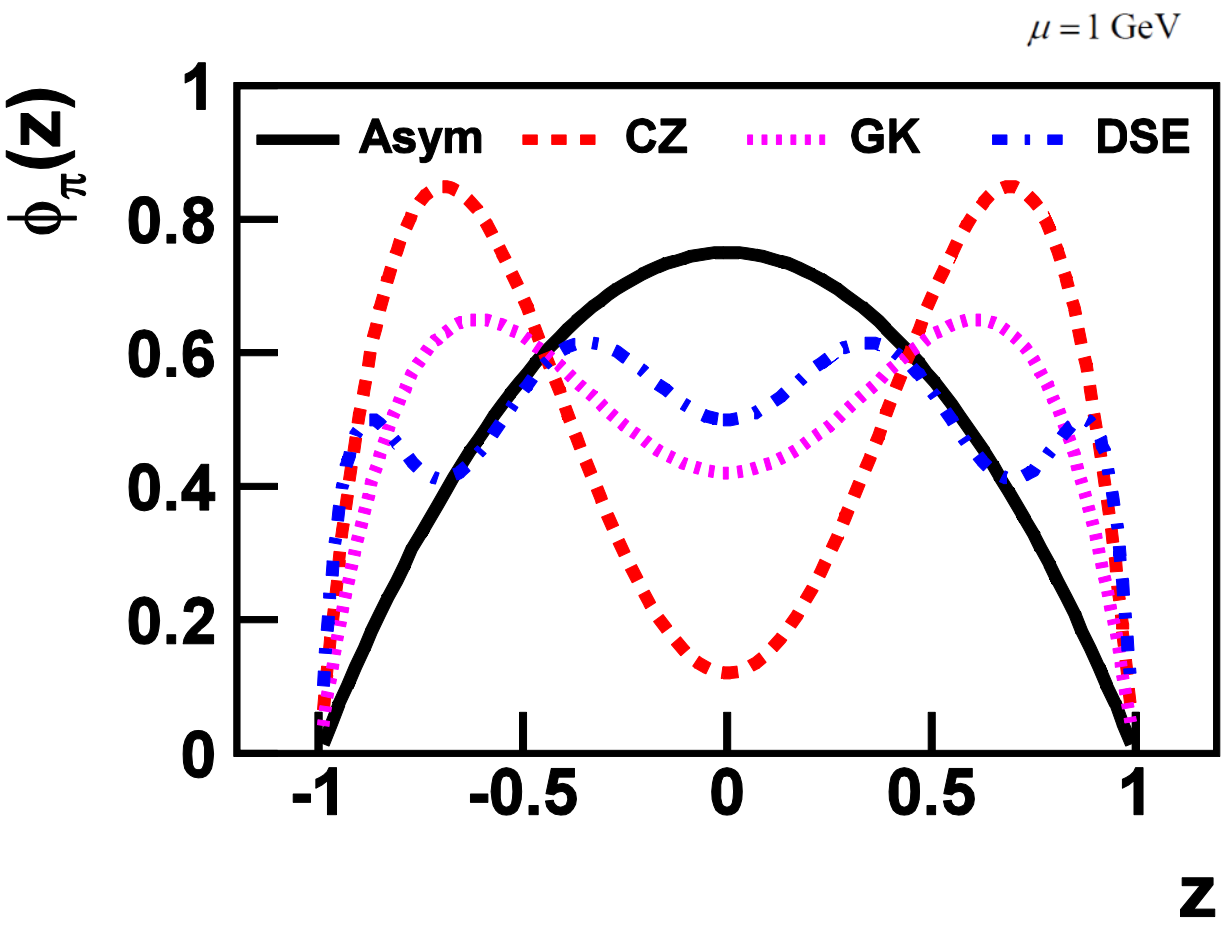


GK2013



Dimuons with $1.5 < M_{\mu^+\mu^-} < 2.9$ GeV (below J/ψ mass) will be used for the exclusive DY analysis. The contribution from exclusive DY could be well separated from others (Accidental BG, Inclusive DY, etc) by using the missing mass technic.

Sensitivity to Pion DAs



G. P. Lepage et al., Phys. Lett. B 87, 359 (1979)
A. V. Efremov et al., Phys. Lett. B 94, 245 (1980)
V. L. Chernyak et al., Phys. Rept. 112 (1984) 173
P. Kroll et al., Eur. Phys. J. C 73 (2013) 1, 2278
I. C. Cloet et al., Phys. Rev. Lett. 111 (2013) 092001

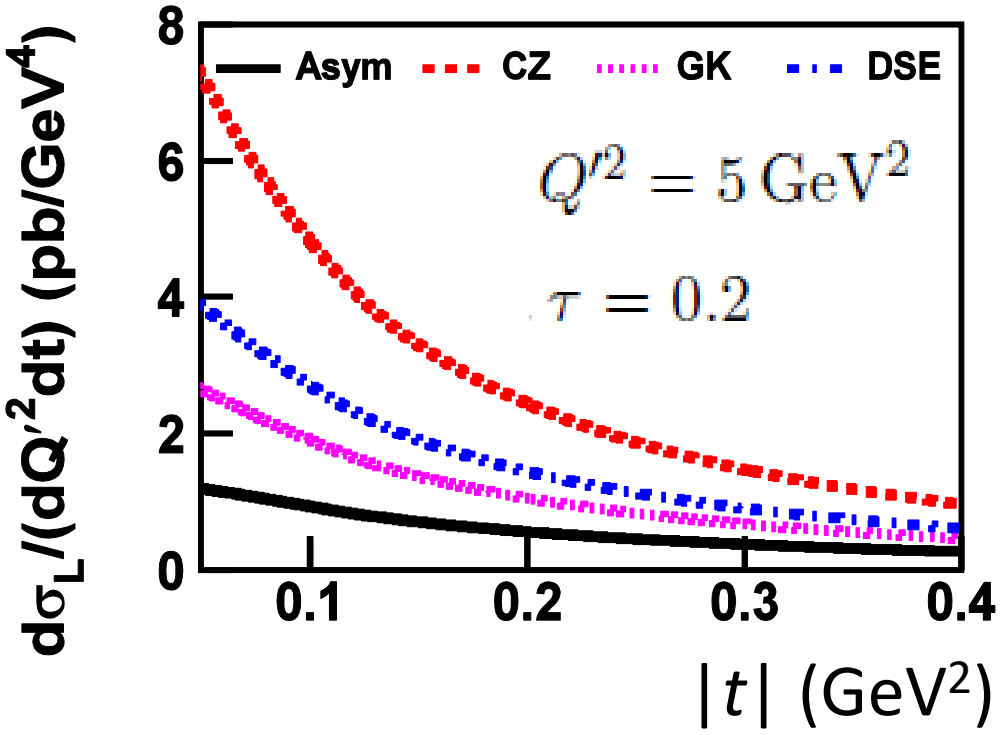
TABLE I: Modeling of pion DAs

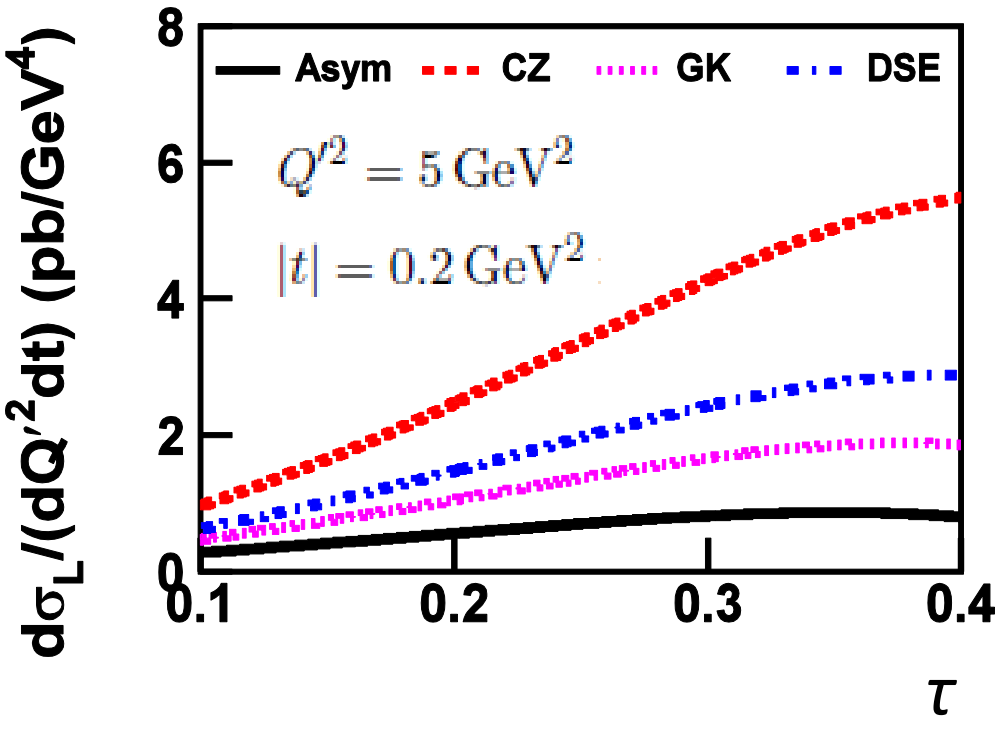
$\phi_\pi(z,\mu)$	Asymptotic [41]	CZ [42]	GK [51]	DSE [52]
a_2	0	2/3	0.22	0.20
a_4	0	0	0	0.093
a_6	0	0	0	0.055
μ^2 (GeV^2)	1	0.25	4	4

Asym: Asymptotic form
CZ : by Chernyak and Zhitnitsky
GK : by Goloskokov-Kroll
DSE : using the Dyson-Schwinger equation framework

Sensitivity to Pion DAs

Fixed the GPDs to “BMP2001”, and replaced the pion DAs

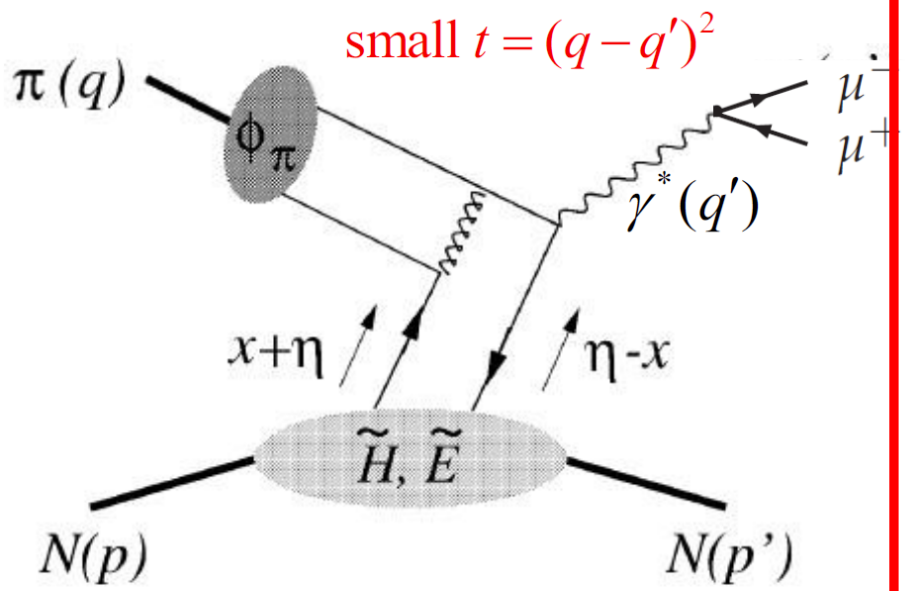


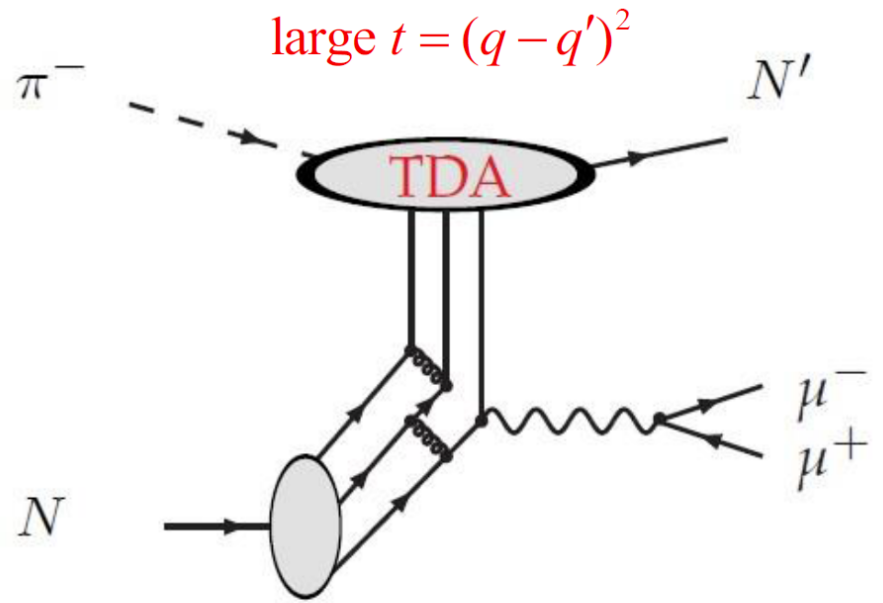


Differential cross section of exclusive DY is strongly sensitive to the input of pion DAs

Exclusive DY at large momentum transfer $|t|$

Bernard Pire , IWHS2011





ϕ_π : pion distritribution amplitude (DA)

- DA characterizes the minimal valence Fock state of hadrons.
- DA of pion are also explored by pion-photon transition form factor in Belle and Barbar Exps.

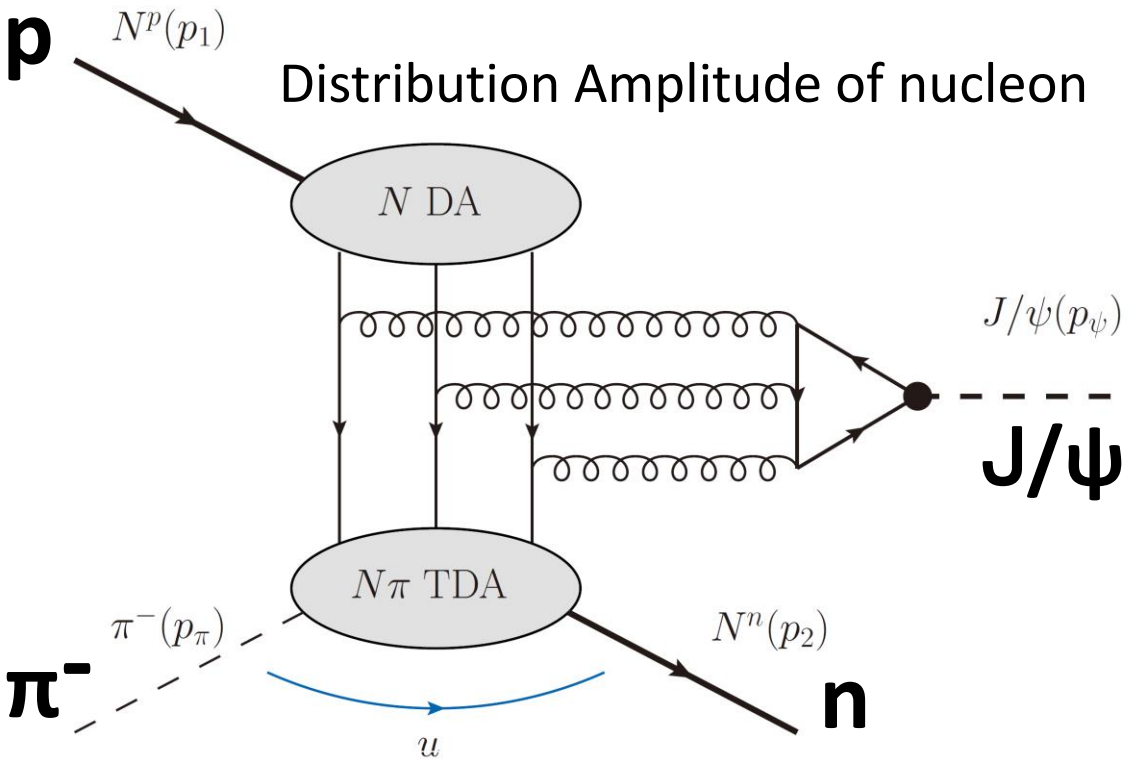
TDA : π-N transistion distritribution amplitude

- TDA characterizes the next-to-minimal valence Fock state of hadrons.
- TDA of pion-nucleon is related to the pion cloud of nucleons.

52

Pion-induced exclusive backward J/ψ production

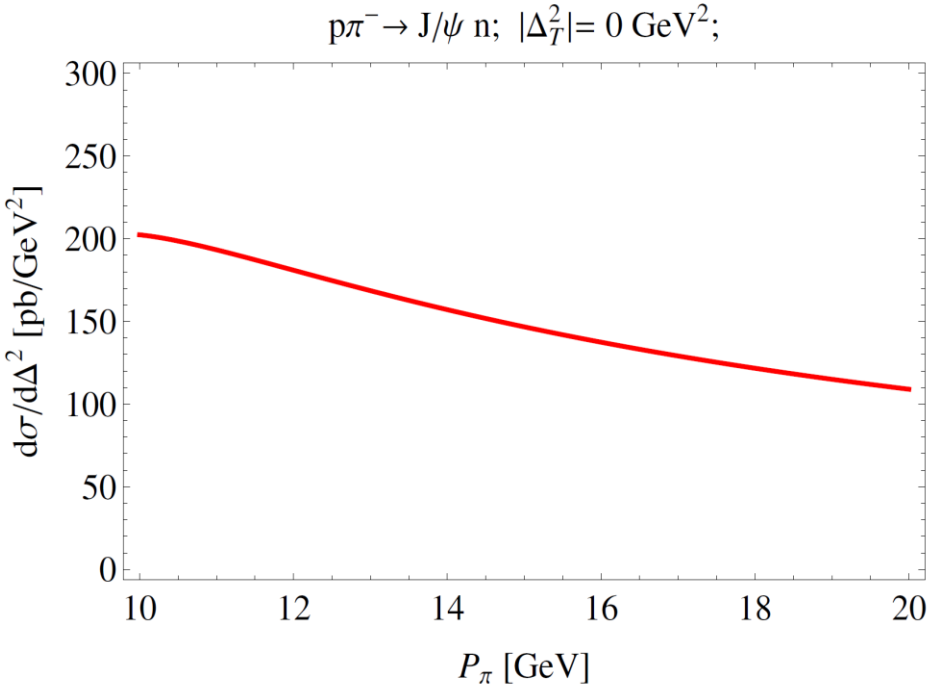
B. Pire et.al
Phys. Rev. D 95, 034021 (2017)



Distribution Amplitude of nucleon

Transition Distribution Amplitude for pion → nucleon

Differential cross section at J-PARC energy

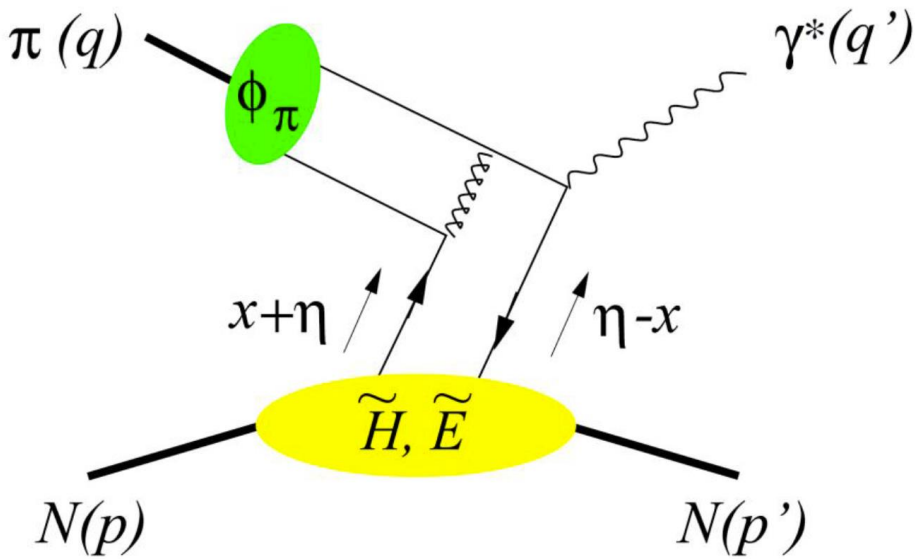


Momentum of Pion Beam (GeV)

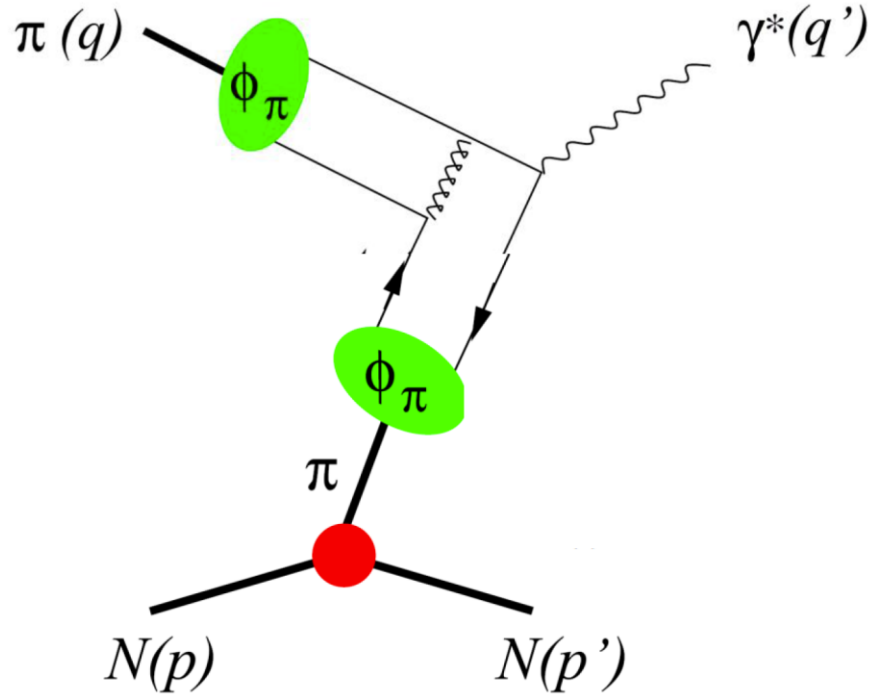
might be observed in J-PARC ?

Exclusive DY at small momentum transfer $|t|$

Leading-Twist Diagram

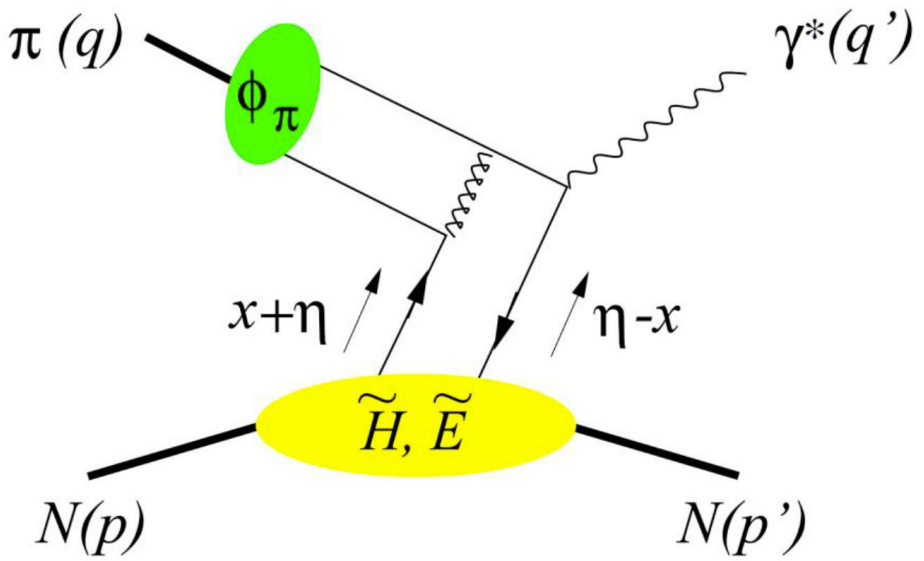


Pion-pole Dominance for $\tilde{E}$

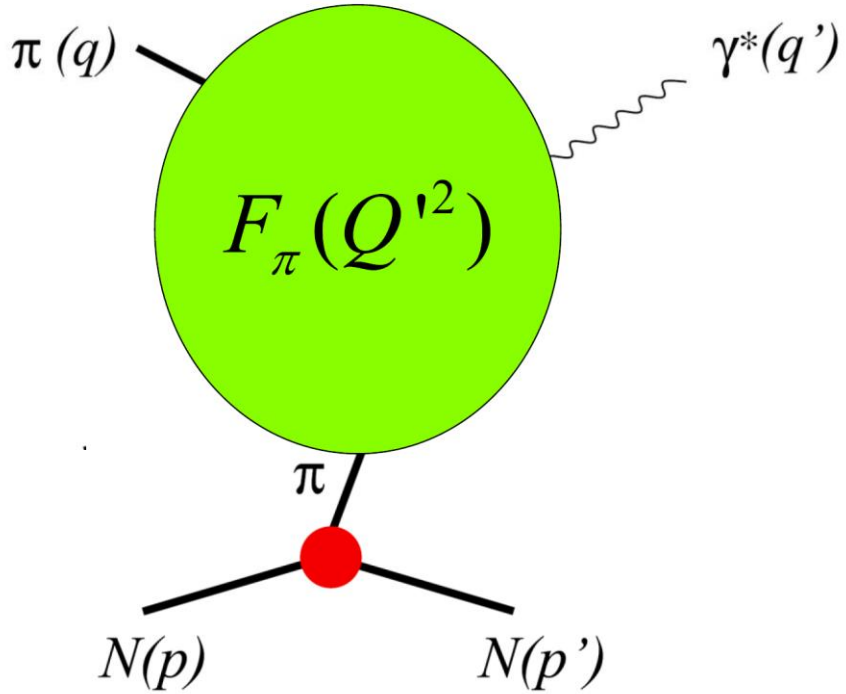


Exclusive DY at small momentum transfer $|t|$

Leading-Twist Diagram



Time-like Pion FF

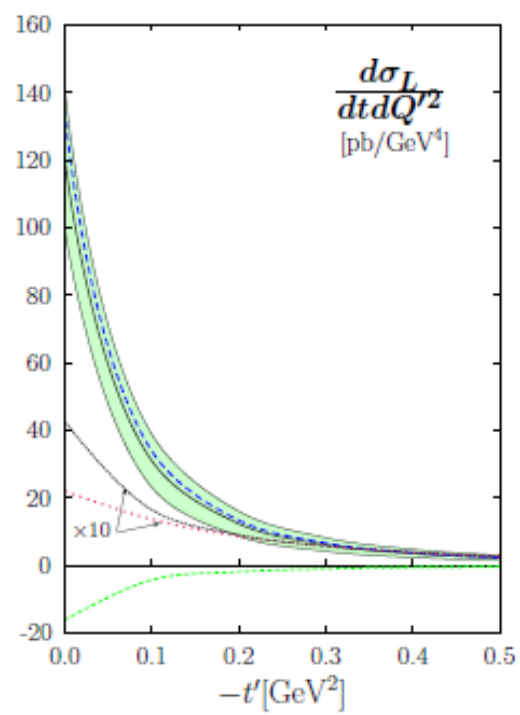


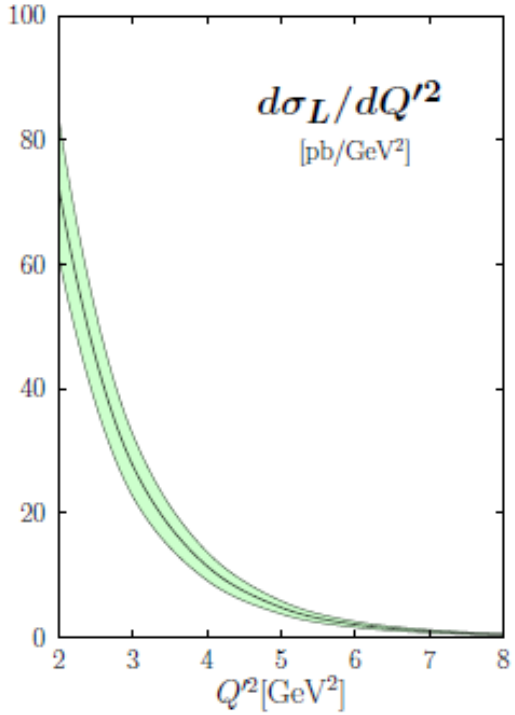
Unique opportunity to access the pion timelike FF, compared with the other measurements in e^+e^-

Differential cross sections with an updated time-like pion FF

P. Kroll @MENU2016

S.V. Goloskokov, P. Kroll, PLB 748 (2015) 323





$Q'^2 = 4\,\mathrm{GeV}^2$ and $s = 20\,\mathrm{GeV}^2$ solid lines with error bands: full result

pion pole, $|\langle \widetilde{H}^{(3)} \rangle|^2$, interference, short dashed: leading-twist contribution

time-like pion FF: $Q'^2|F_\pi(Q'^2)| = 0.88 \pm 0.04\,\mathrm{GeV}^2$ (CLEO, BaBar, $J/\Psi \to \pi^+\pi^-$)

phase $(\exp[i\delta(Q'^2)])$ from disp. rel. Belicka et al(11) for $Q'^2 < 8.9\,\mathrm{GeV}^2$

$\delta = 1.014\pi + 0.195(Q'^2/\mathrm{GeV}^2 - 2) - 0.029(Q'^2/\mathrm{GeV}^2 - 2)^2$

for $Q'^2 \geq 8.9\,\mathrm{GeV}^2$: $\delta = \pi$, the LO pQCD result

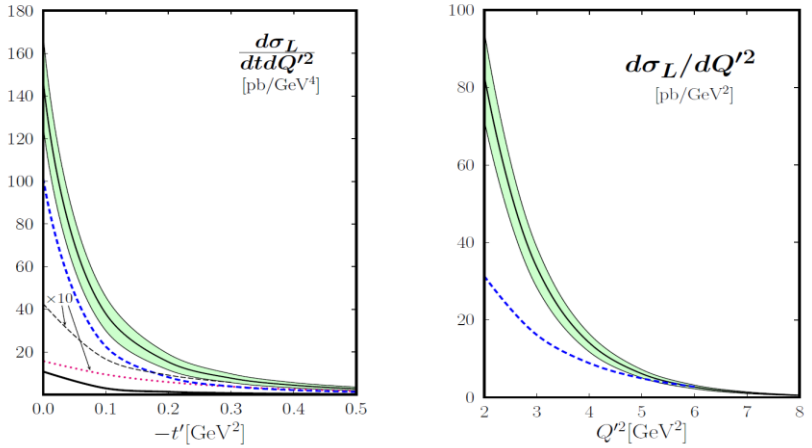
Beyond the Leading Twist

S.V. Goloskokov, P. Kroll, PLB 748 (2015) 323

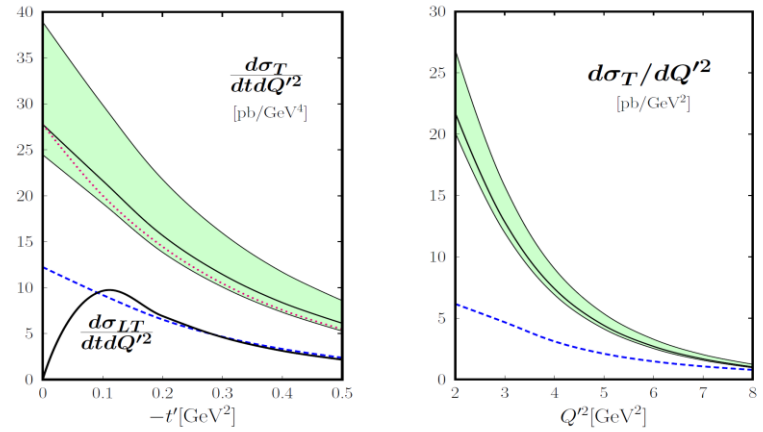
$$\frac{d\sigma}{dtdQ'^2 d\cos\theta d\phi} = \frac{3}{8\pi}\left\{\sin^2\theta\,\frac{d\sigma_L}{dtdQ'^2} + \frac{1+\cos^2\theta}{2}\,\frac{d\sigma_T}{dtdQ'^2} + \frac{\sin(2\theta)\cos\phi}{\sqrt{2}}\,\frac{d\sigma_{LT}}{dtdQ'^2} + \sin^2\theta\cos(2\phi)\,\frac{d\sigma_{TT}}{dtdQ'^2}\right\}$$

The measurement of angular distributions provides the each terms

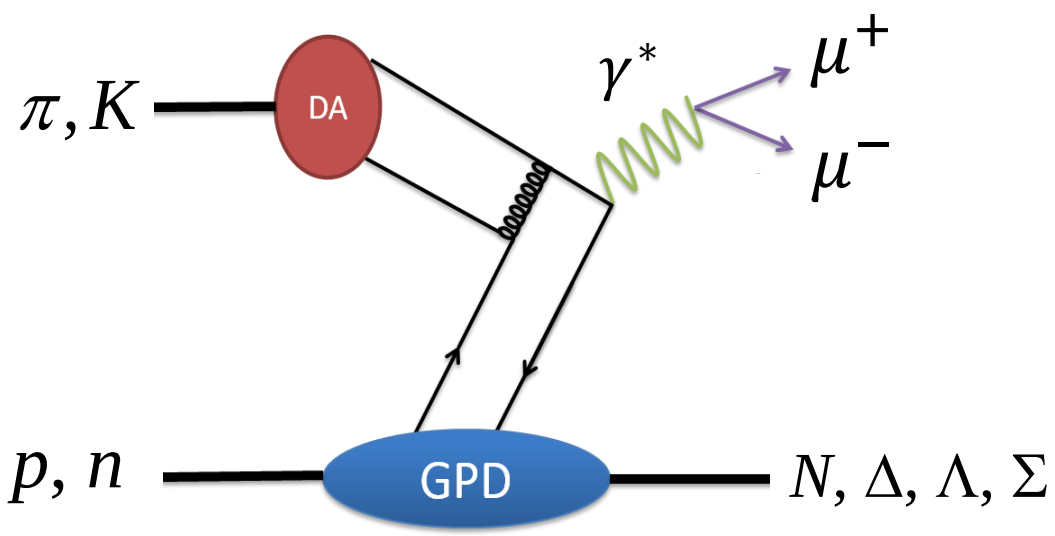
Longitudinal cross sections



Transverse cross sections



Accessing transition GPD via the exclusive dimuon measurement



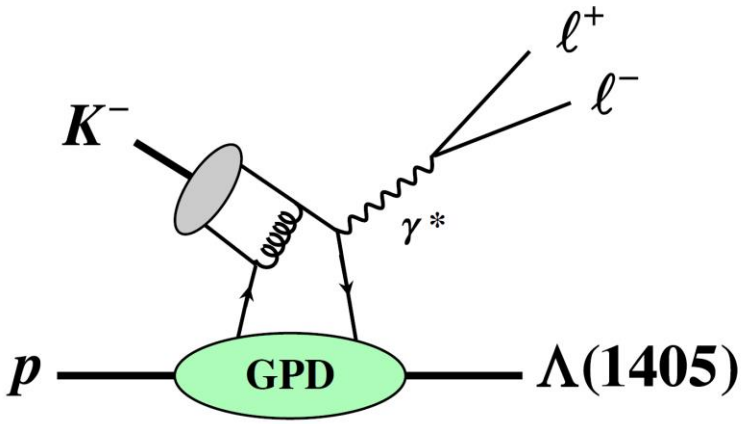
- $\pi^- \mathrm{p} \to \gamma^* n$
- $\pi^- \mathrm{p} \to \gamma^* \Delta^0$
- $\pi^- \mathrm{n} \to \gamma^* \Delta^-$
- $\pi^+ \mathrm{n} \to \gamma^* \mathrm{p}$
- $\pi^+ \mathrm{p} \to \gamma^* \Delta^{++}$
- $\pi^+ \mathrm{n} \to \gamma^* \Delta^+$

Talked by S. Kumano

- $K^- \mathrm{p} \to \gamma^* \Lambda$
- $K^- \mathrm{p} \to \gamma^* \Lambda(1405)$
- $K^- \mathrm{p} \to \gamma^* \Lambda(1520)$
- $K^- \mathrm{n} \to \gamma^* \Sigma^-$
- $K^+ \mathrm{n} \to \gamma^* \Theta^+$

The exotic hadrons cannot exist as stable fixed targets.
→ The GPDs of the exotic hadrons could not be observed directly.

However, the transition GPDs such as for proton → an exotic hadron can be investigated. For example, the transition GPDs of $p \to \Lambda(1405)$ should reflect the exotic nature of $\Lambda(1405)$.



Soft Nonfactorizable Mechanism

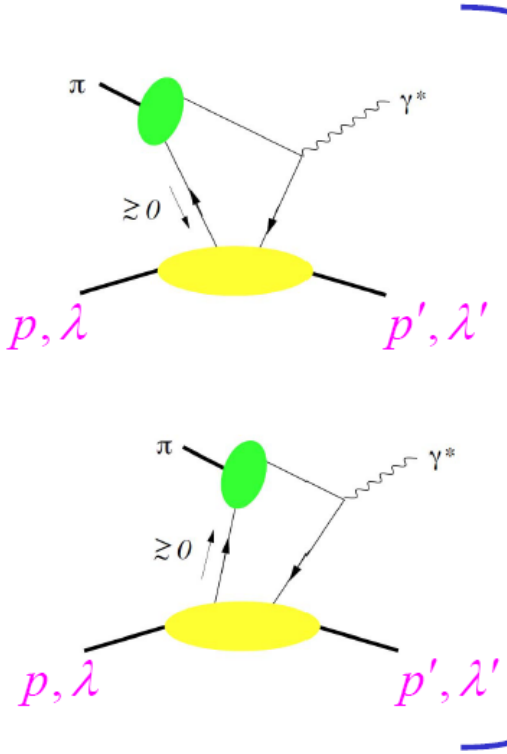
LCSR for nonfactorizable amplitude

SNM > factorization

interplay of soft/hard QCD mechanism

K. Tanaka, arXiv:1703.02190

"nonfactorizable" mechanism



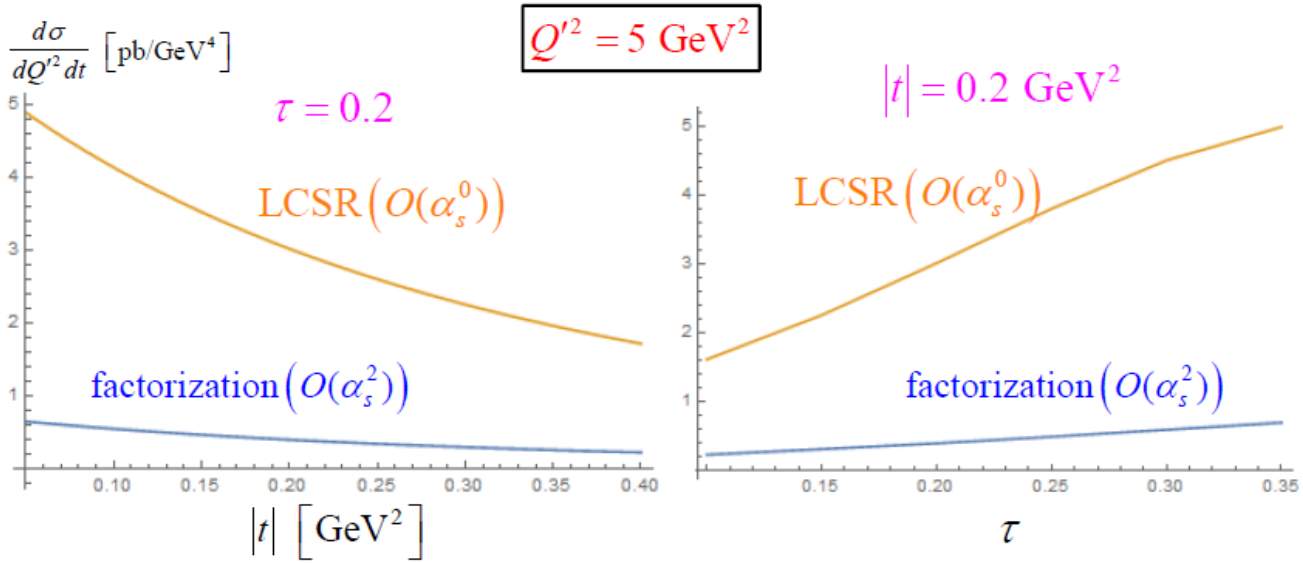
"Light-cone QCD SR (LCSR)"

$$= g_\nu^- \int_\eta^{x_0} dx\, e^{-\frac{x-\eta}{x+\eta}\frac{Q'^2}{M_B^2}} \tilde{C}_H(x,\eta,Q'^2)$$

$$\times\left[e_u \tilde{H}^{du}(x,\eta,t) - e_d \tilde{H}^{du}(-x,\eta,t)\right]$$

$$\times \bar{u}(p'\lambda')\gamma^+\gamma_5 u(p\lambda) + \cdots$$

$$\tilde{H}^{du}(x,\eta,t) = \tilde{H}^u(x,\eta,t) - \tilde{H}^d(x,\eta,t)$$



$$\frac{d\sigma}{dQ'^2 dt}(\pi^- p \to \gamma^* n) = \frac{4\pi\alpha_{em}^2}{27}\frac{\tau^2}{Q'^8} f_\pi^2 \left[(1-\eta^2)\left|\widetilde{\mathcal{H}}^{du}\right|^2 - 2\eta^2 \mathrm{Re}\left(\widetilde{\mathcal{H}}^{du*}\widetilde{\mathcal{E}}^{du}\right) - \eta^2 \frac{t}{4M^2}\left|\widetilde{\mathcal{E}}^{du}\right|^2 \right]$$

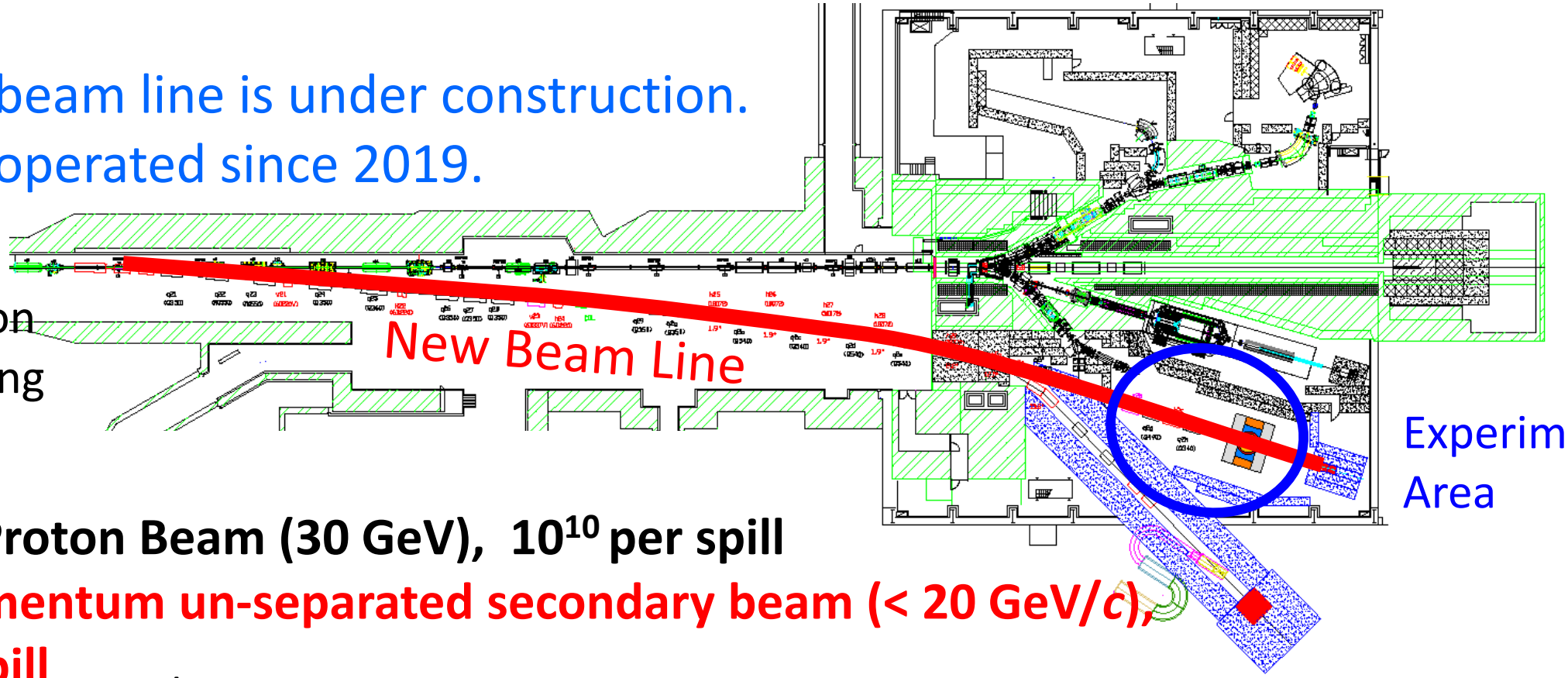
Experiment at J-PARC

Bird's eye photo in January of 2016

High Momentum Beam Line at J-PARC

Talked by
Shin'ya Sawada

The new beam line is under construction.
It will be operated since 2019.



- **Primary Proton Beam (30 GeV), 10^{10} per spill**
- **High Momentum un-separated secondary beam (< 20 GeV/*c*), 10^{8} per spill**

Physics:

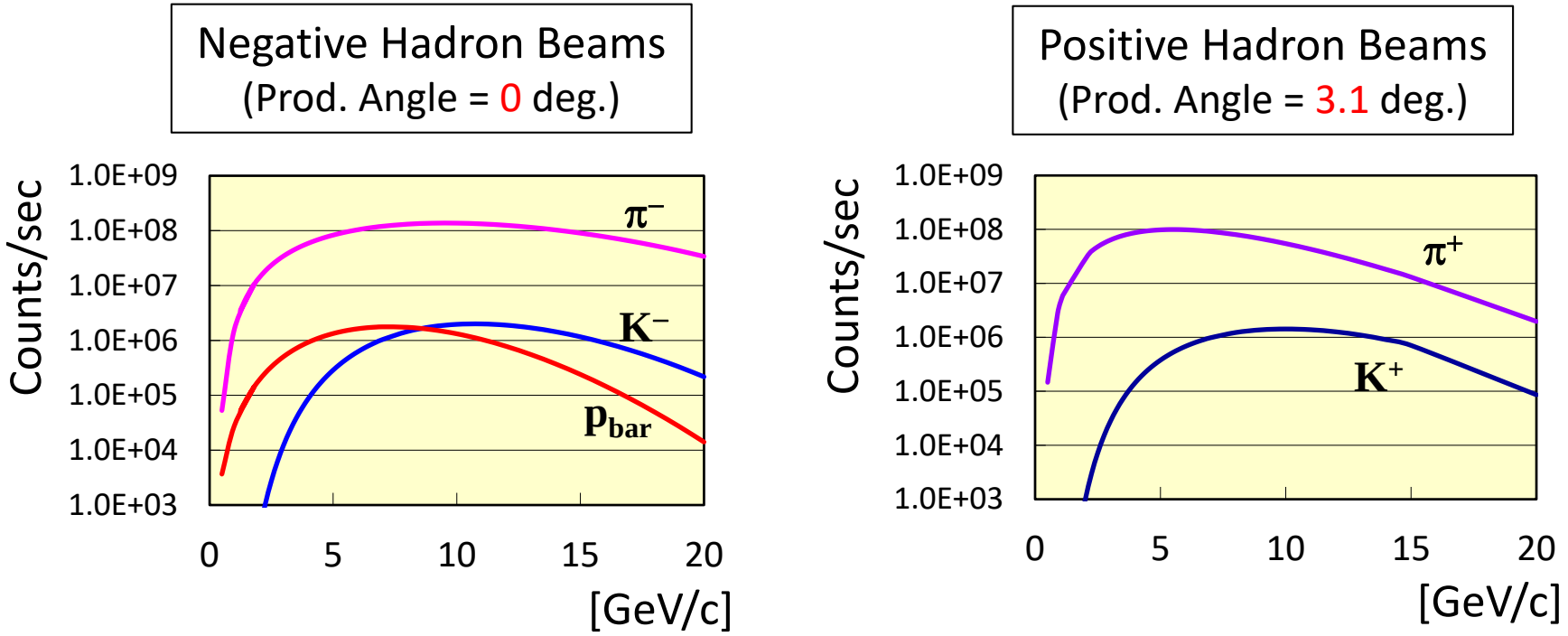
Vector meson modification in the nuclear matter
Charmed Baryon spectroscopy
Nucleon Structure

High Momentum Beam Line in J-PARC

Talked by
Shin'ya Sawada

Unseparated secondary beams

- High-intensity secondary Pion beam
- High-resolution beam: $\Delta p/p \sim 0.1\%$



* Sanford-Wang: 15 kW Loss on Pt, Acceptance :1.5 msr%, 133.2 m

Uniqueness of pion-induced Drell-Yan physics studied at High Momentum Beam Line in J-PARC

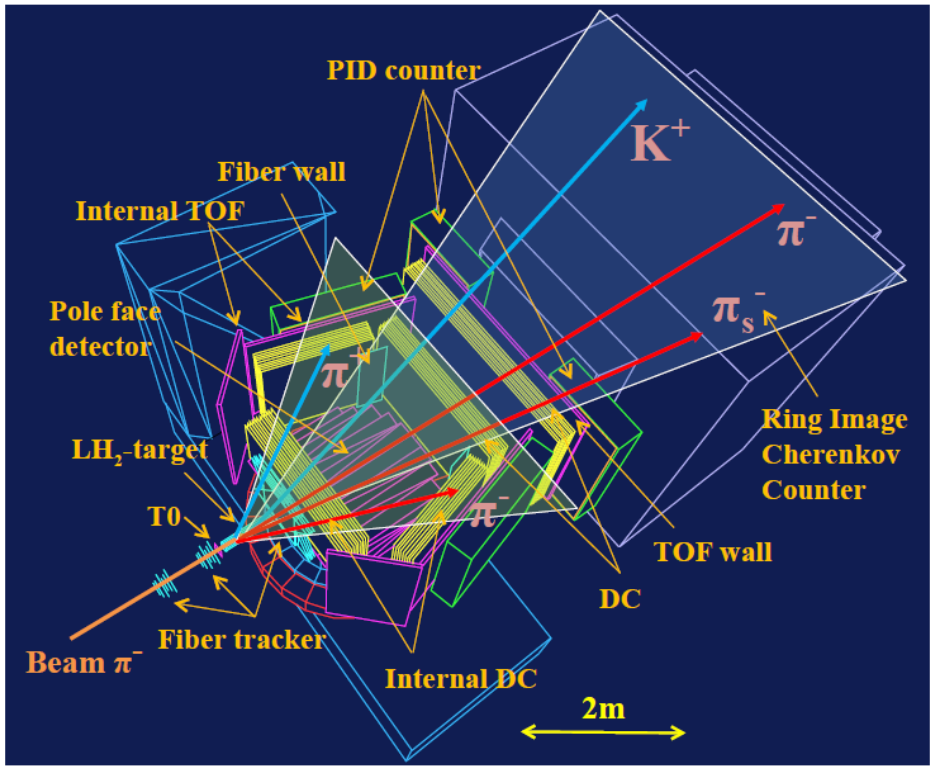
1970s -1980s	Beam Particle	Beam Momentum(GeV)	Target	
CERN-NA3	$\pi^{\pm}$	150/200/280	H, Pt	Inclusive Drell-Yan $\pi^{\pm}N \rightarrow \mu^{+}\mu^{-}X$
CERN-NA10	π^{-}	140/194/286	D, W	
CERN-WA11	π^{-}	150/175	Be	
CERN-WA39	$\pi^{\pm}$	39.5	W	
Fermilab-E326	π^{-}	225	W	
Fermilab-E537	π^{-}	125	W	
Fermilab-E615	π^{-}	252	W	
2010s				
CERN-COMPASS	π^{-}	190	polarised NH_3, Al, W	
202X				
J-PARC	π^{-}	**10 ~ 20**	**H**	**Exclusive Drell-Yan** $\pi^{-}p \rightarrow \mu^{+}\mu^{-}n$ **+ Inclusive Drell-Yan** $\pi^{-}p \rightarrow \mu^{+}\mu^{-}X$

J-PARC E50 Experiment

for Charmed Baryon Spectroscopy

Talked by
Hiroyuki Noumi

Spectrometer (Charmed baryon prod. and decay)



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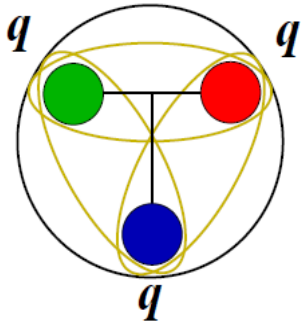
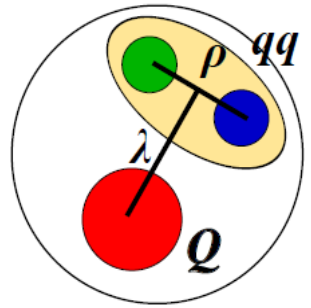
Stage-1 approved by J-PARC PAC-18, August 12, 2014.

Quark correlation





- color-spin interaction between quarks $\propto 1/m_i m_j$
- 3 light diquark pairs ⇒ difficult to distinguish
- Heavy Q ⇒ separate to Q and $q-q$

We will investigate the diquark correlation by measurement of charmed baryon's properties

- Level structure
- Production rate
- Decay branching ratio

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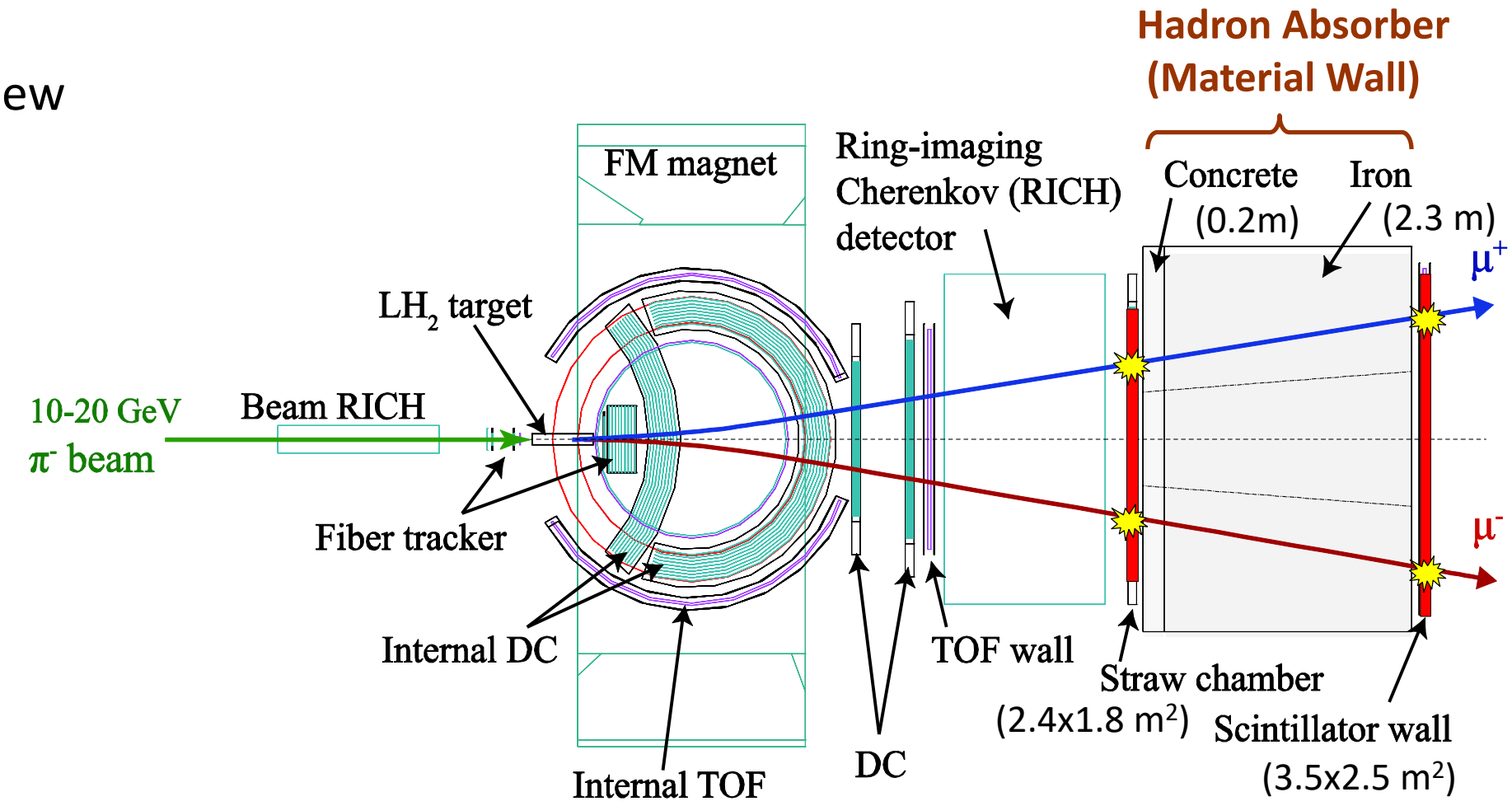
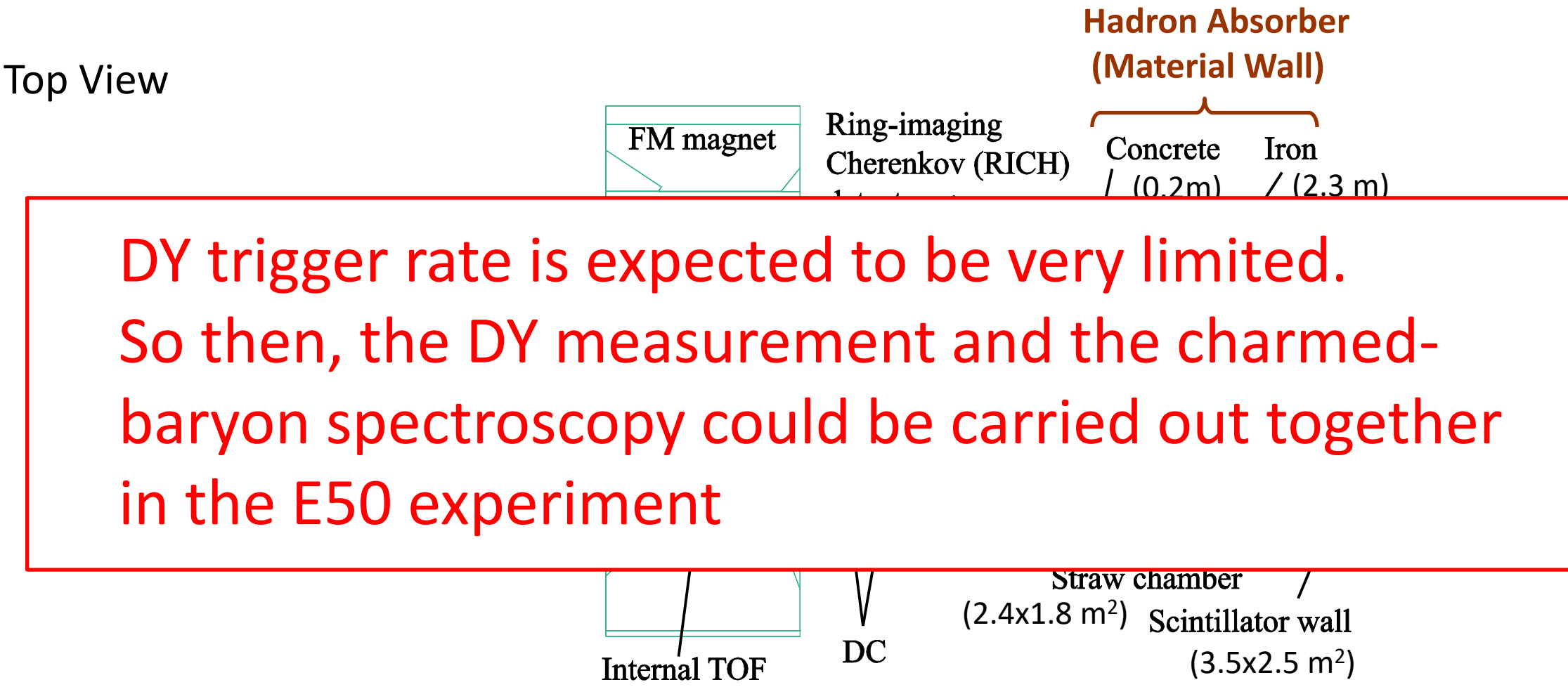
Extension of J-PARC E50 experiment for Drell-Yan measurement

Top View



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

Top View



DY trigger rate is expected to be very limited.
So then, the DY measurement and the charmed-baryon spectroscopy could be carried out together in the E50 experiment

Identifying the Exclusive Drell-Yan Process with Missing Mass Technique

$$\pi^- p \rightarrow \mu^+ \mu^- X$$

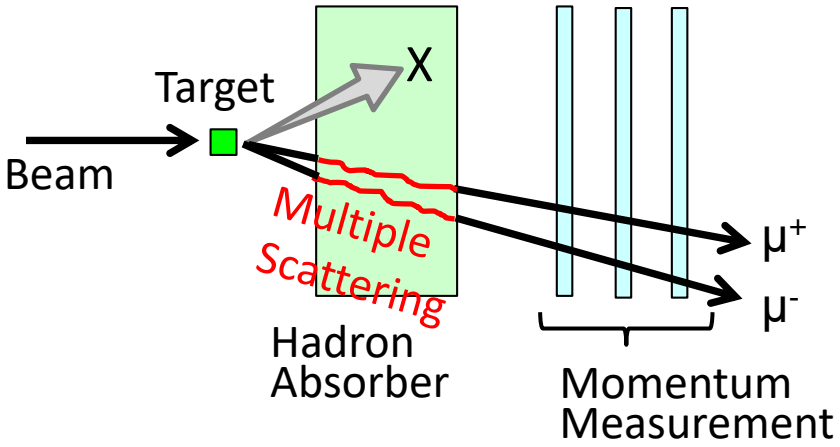
Beam — At rest — Detect — Missing

$$M_X^2 = \left(\sum E_{in} - \sum E_{out}\right)^2 - \left(\sum \boldsymbol{p}_{in} - \sum \boldsymbol{p}_{out}\right)^2$$

- Exclusive Drell-Yan process
  $M_X = M_n$ (Neutron Mass)
- Inclusive Drell-Yan process, other Backgrounds
  $M_X > M_n$

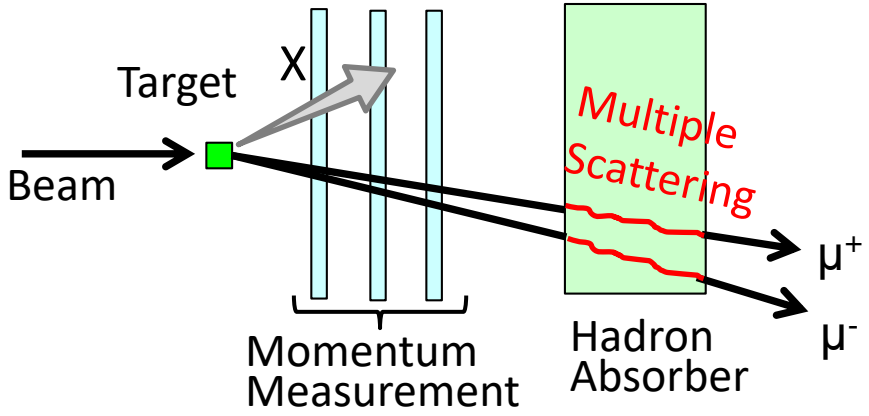
Typical Drell-Yan experiments

with high energy beam



Proposed Drell-Yan experiment at J-PARC

with (Relatively) lower energy beam



Open-aperture spectrometers
→ Good resolution for M_x

Yield Estimation

Beam Energy	10 GeV/c	15 GeV/c	20 GeV/c
Beam Intensity	High	←	Low
Total Cross Section of Exclusive DY	High	←	Low
Total Cross Section of Inclusive DY	Low	→	High
Acceptance for exclusive DY	Low	→	High

	π^- beam (prod. angle 0 deg)		π^+ beam (prod. angle 3.1 deg)
Beam Intensity	High	←	Low
Total Cross Section of DY	High	←	Low

Simulation

Assumptions:

- Target : 57cm LH_2 (n_{TGT} = 4 g/cm^2)
- Beam momentum resolution($\Delta p/p$) = 0.1 %
- 1.83/1.58/1.00 *10^7 π^- /spill for 10/15/20 GeV beam
- Data Taking: 50 days (→ 100 days or more)
- E50 spectrometers + μ ID system

Expected cross sections for the exclusive/inclusive Drell-Yan processes

	Exclusive Drell-Yan ($M_{\mu^+\mu^-} > 1.5$ GeV, $\lvert t - t_0 \rvert < 0.5$ GeV^2)		Inclusive Drell-Yan ($M_{\mu^+\mu^-} > 1.5$ GeV)
	"BMP2001"	"GK2013"	
P_π= 10 GeV	6.29 pb	17.53 pb	2.11 nb
P_π= 15 GeV	4.67 pb	10.65 pb	2.71 nb
P_π= 20 GeV	3.70 pb	7.25 pb	3.08 nb

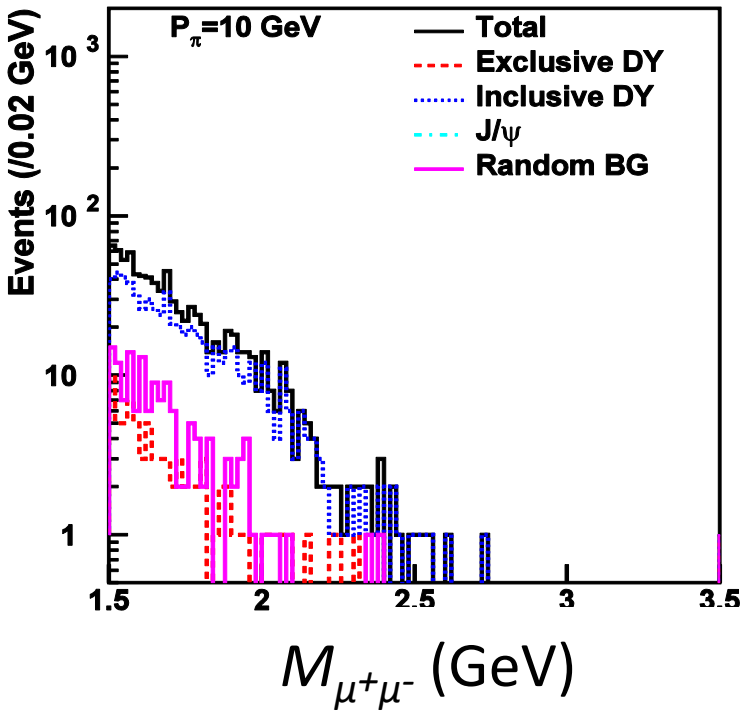
・Total hadronic interaction cross sections of $\pi^- p$ is about 20-30 mb while the production of J/ψ is about 1-3 nb

Simulated invariant mass $M_{\mu^+\mu^-}$ spectra of the $\mu^+ \mu^-$ events

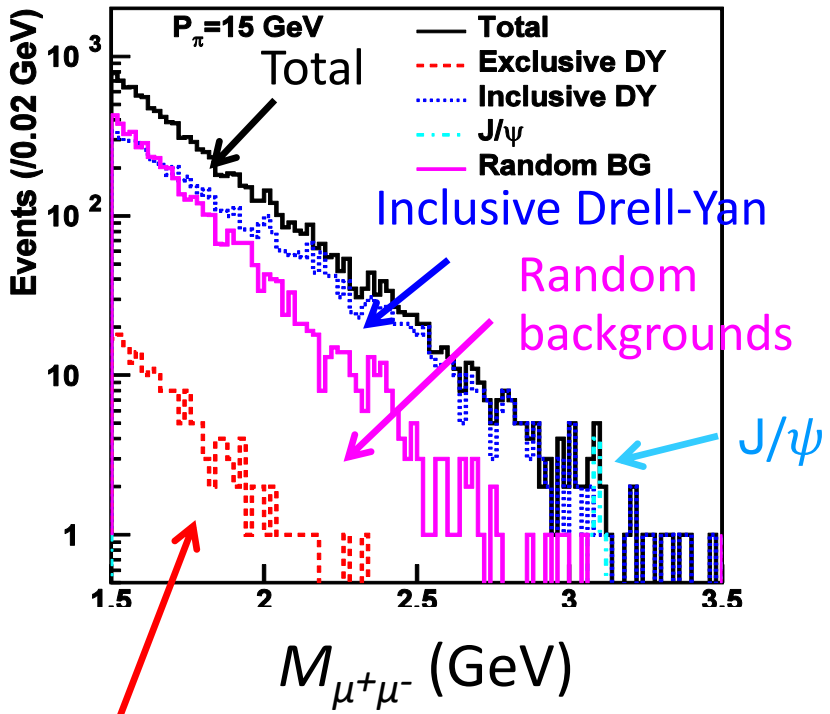
- Data Taking: 50 days
- $|t - t_0| < 0.5$ GeV^2
- "GK2013" GPDs

π^- Beam Momentum

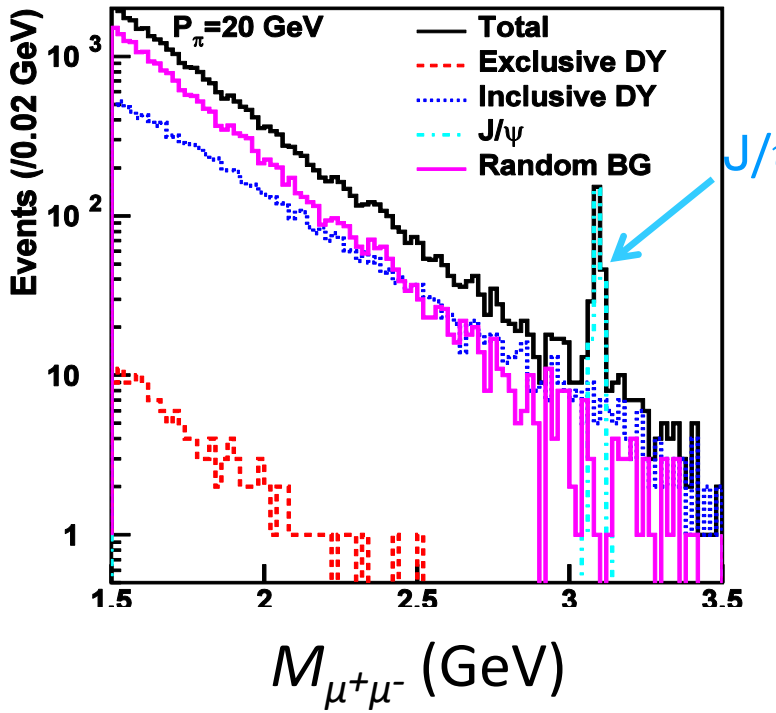
P_π = 10 GeV



15 GeV



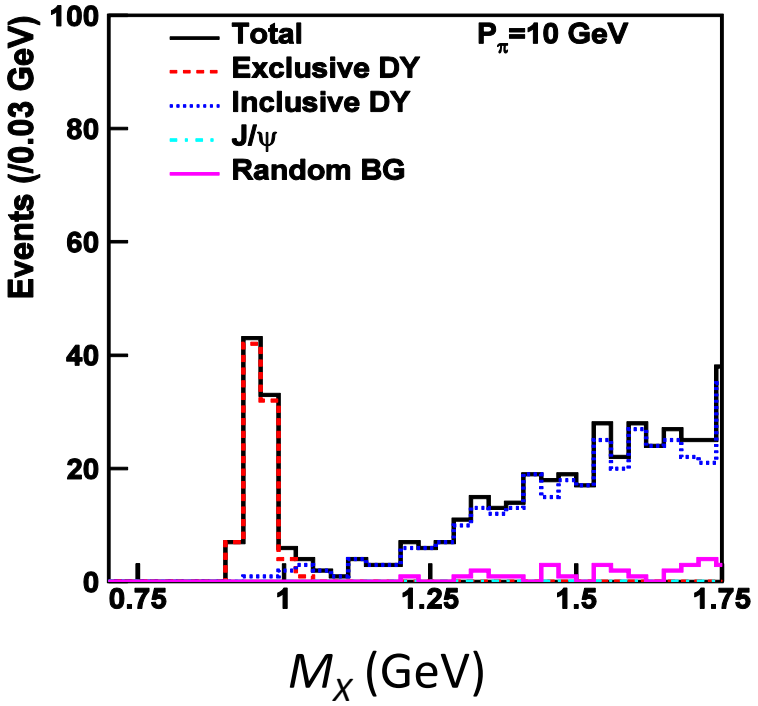
20 GeV



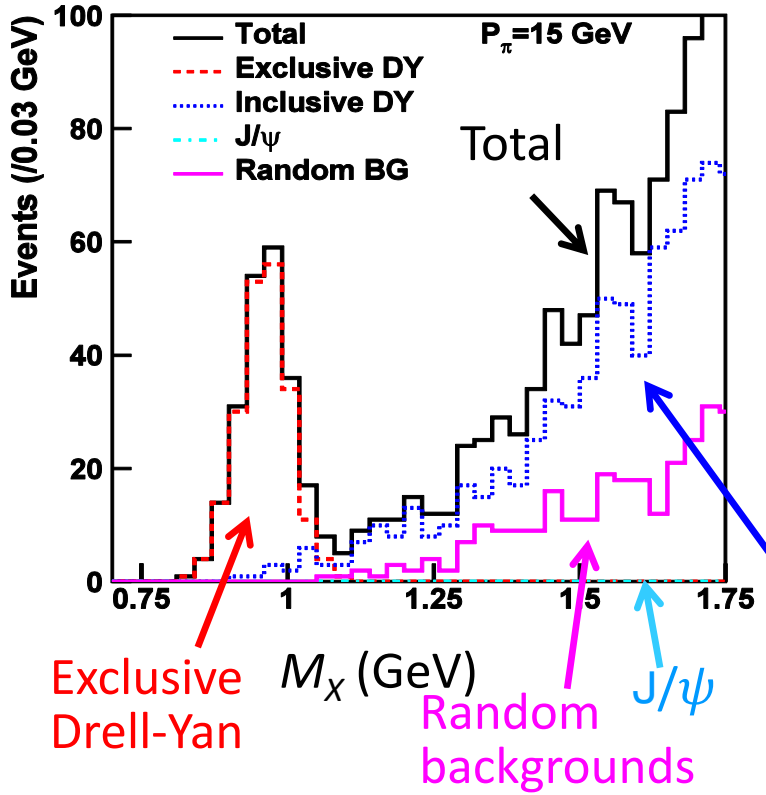
Simulated missing-mass M_X spectra of the $\mu^+ \mu^-$ events

π^- Beam Momentum

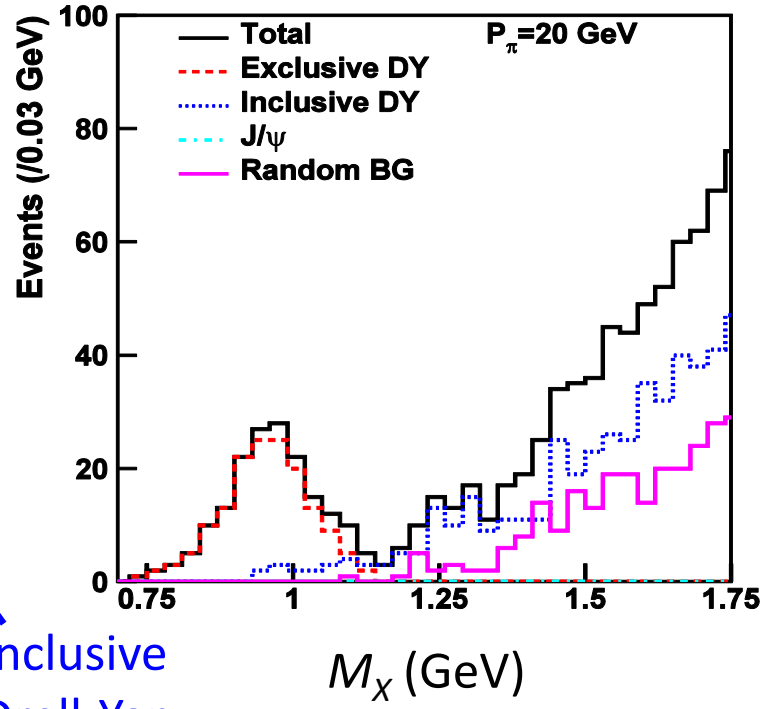
P_π = 10 GeV



15 GeV



20 GeV



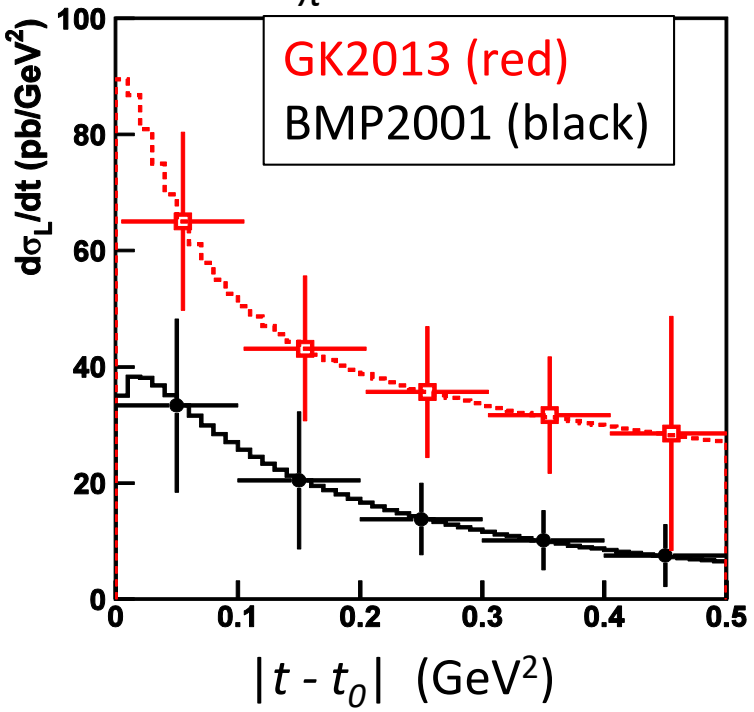
- Data Taking: 50 days
- $1.5 < M_{\mu^+\mu^-} < 2.9$ GeV
- $|t - t_0| < 0.5$ GeV^2
- "GK2013" GPDs

The exclusive Drell-Yan events could be identified by the signature peak at the nucleon mass in the missing-mass spectrum for all three pion beam momenta.

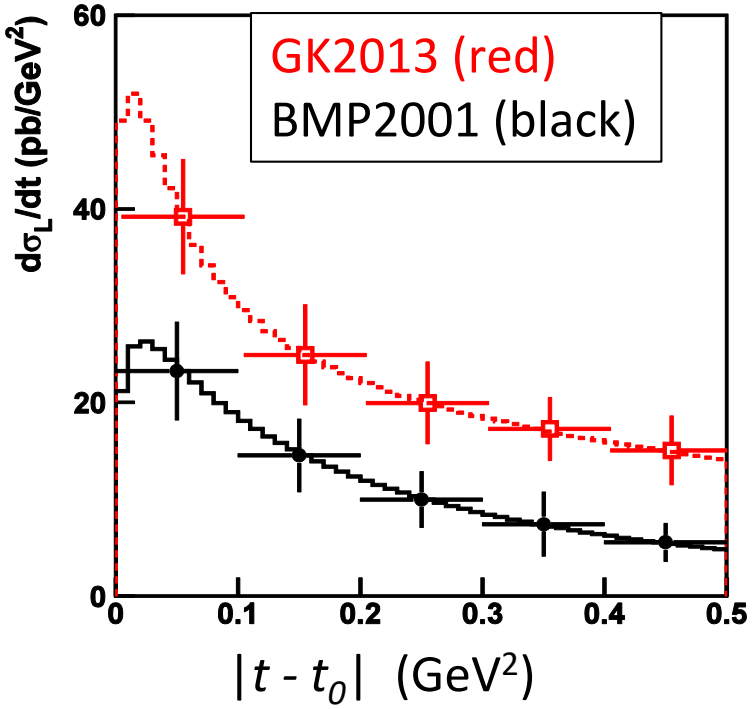
The expected statistical errors of the exclusive Drell-Yan measurement for two GPDs inputs

π^- Beam Momentum

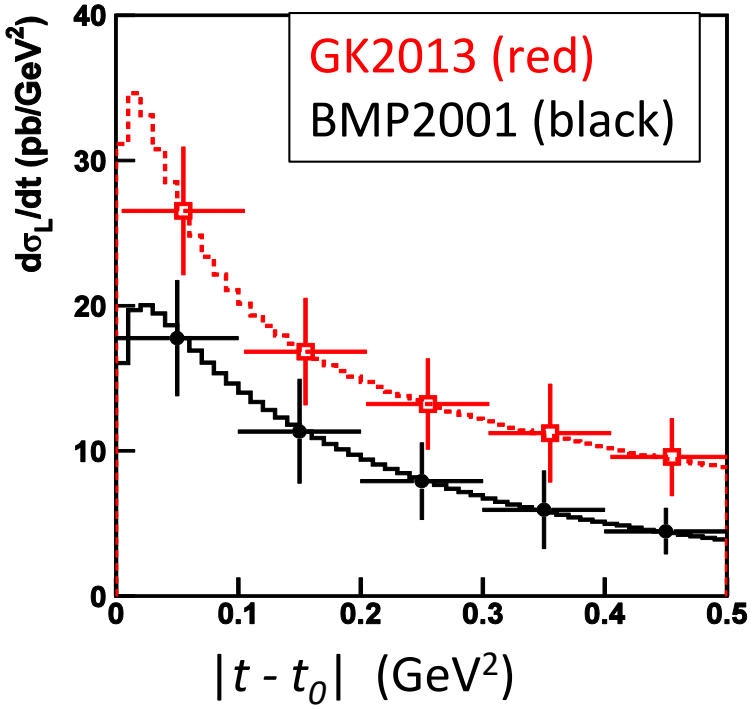
P_π = 10 GeV



15 GeV



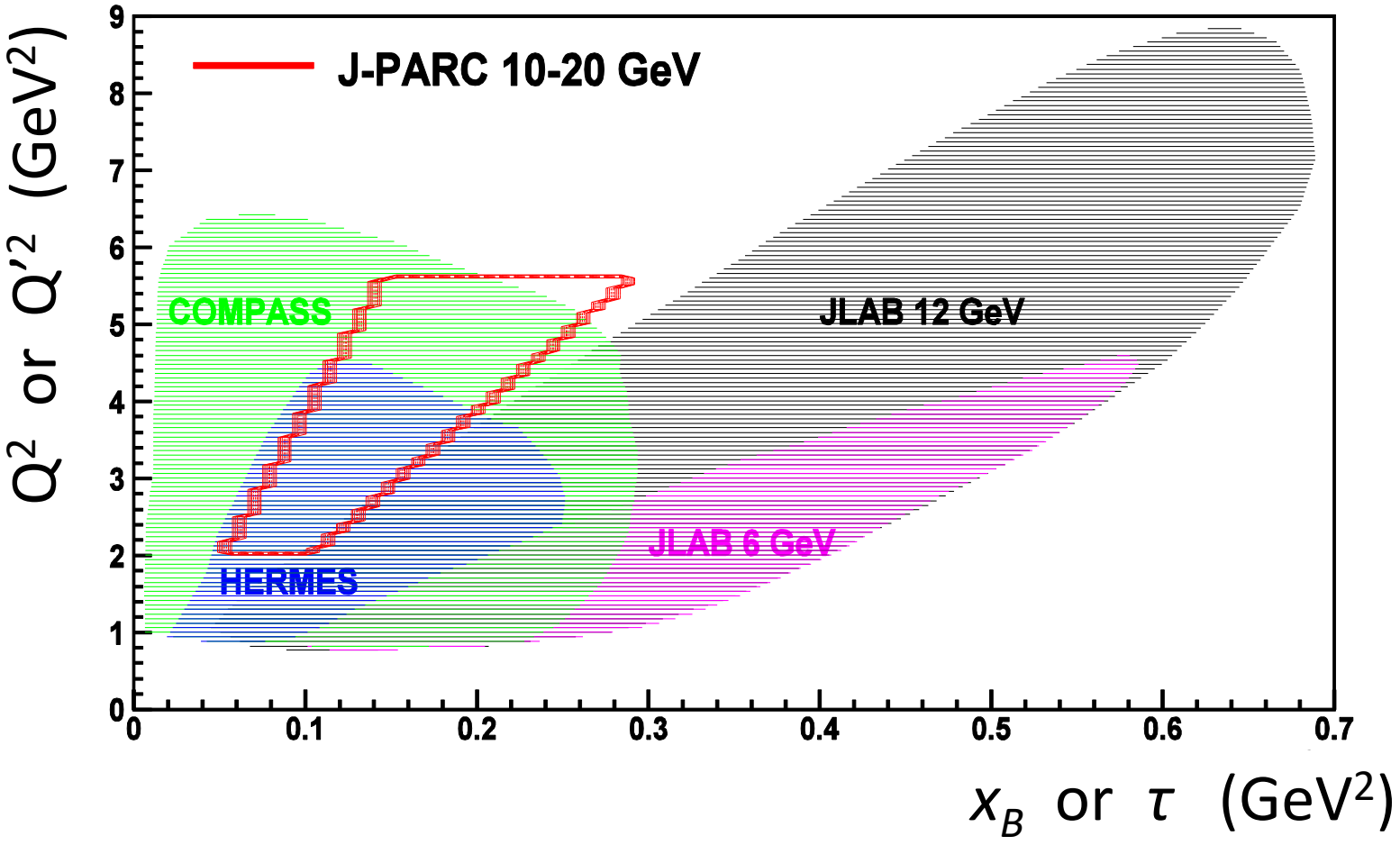
20 GeV



- Data Taking: 50 days
- $1.5 < M_{\mu^+\mu^-} < 2.9$ GeV
- $|t - t_0| < 0.5$ GeV^2

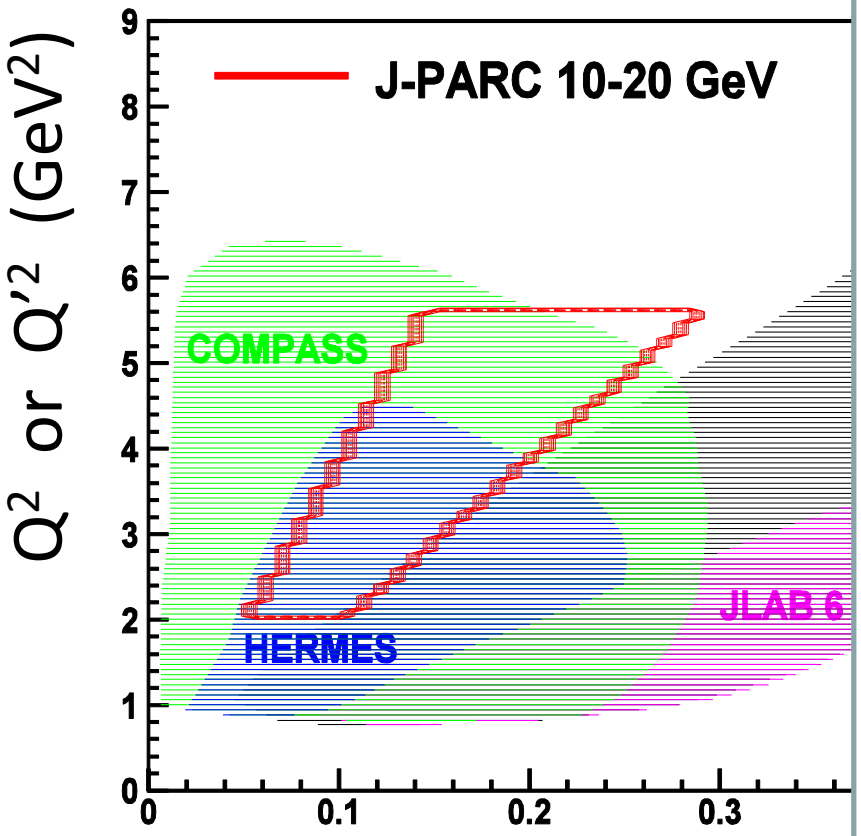
The statistics accuracy is adequate for discriminating between the predictions from two current GPD modelings.

Kinematic regions of GPDs explored by space-like and time-like processes



- JLAB, HERMES, COMPASS : Spece-like approach
- J-PARC : Time-like approach

Kinematic regions of GPDs explored by space-like and time-like processes

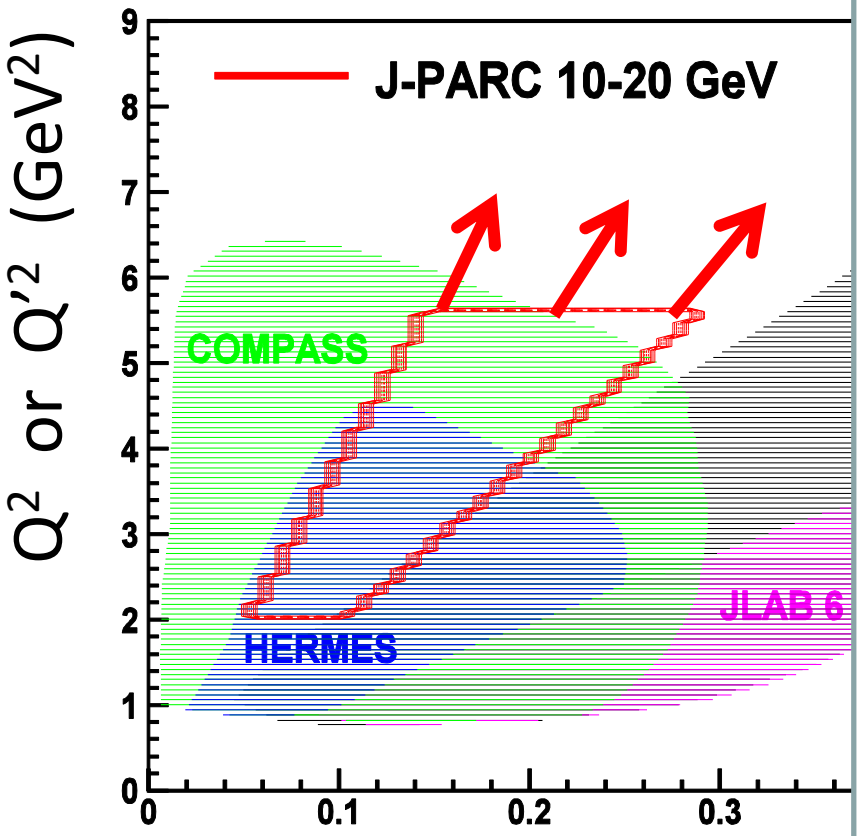


- JLAB, HERMES, COMPASS : S
- J-PARC : Time-like approach

Impacts of GPD measurement at J-PARC :

- Test of **universality of GPD** in space-like and time-like processes
- Test of **factorization of exclusive Drell-Yan process**

Kinematic regions of GPDs explored by space-like and time-like processes



- JLAB, HERMES, COMPASS : S
- J-PARC : Time-like approach

Impacts of GPD measurement at J-PARC :

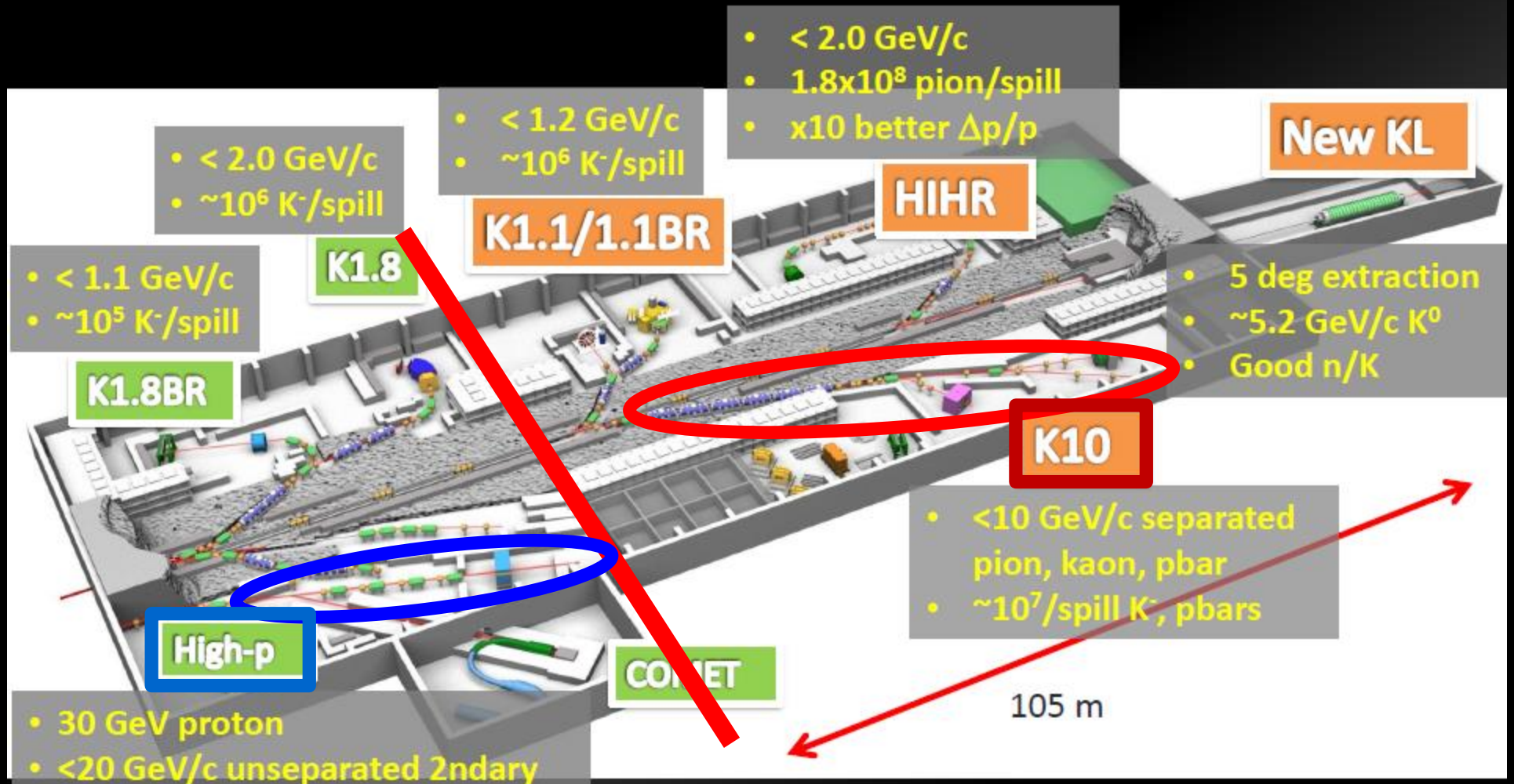
- Test of **universality of GPD** in space-like and time-like processes
- Test of **factorization of exclusive Drell-Yan process**

Further possibilities :

- Information of GPD at large-Q'^2 region
- Test of QCD-evolution properties of GPD

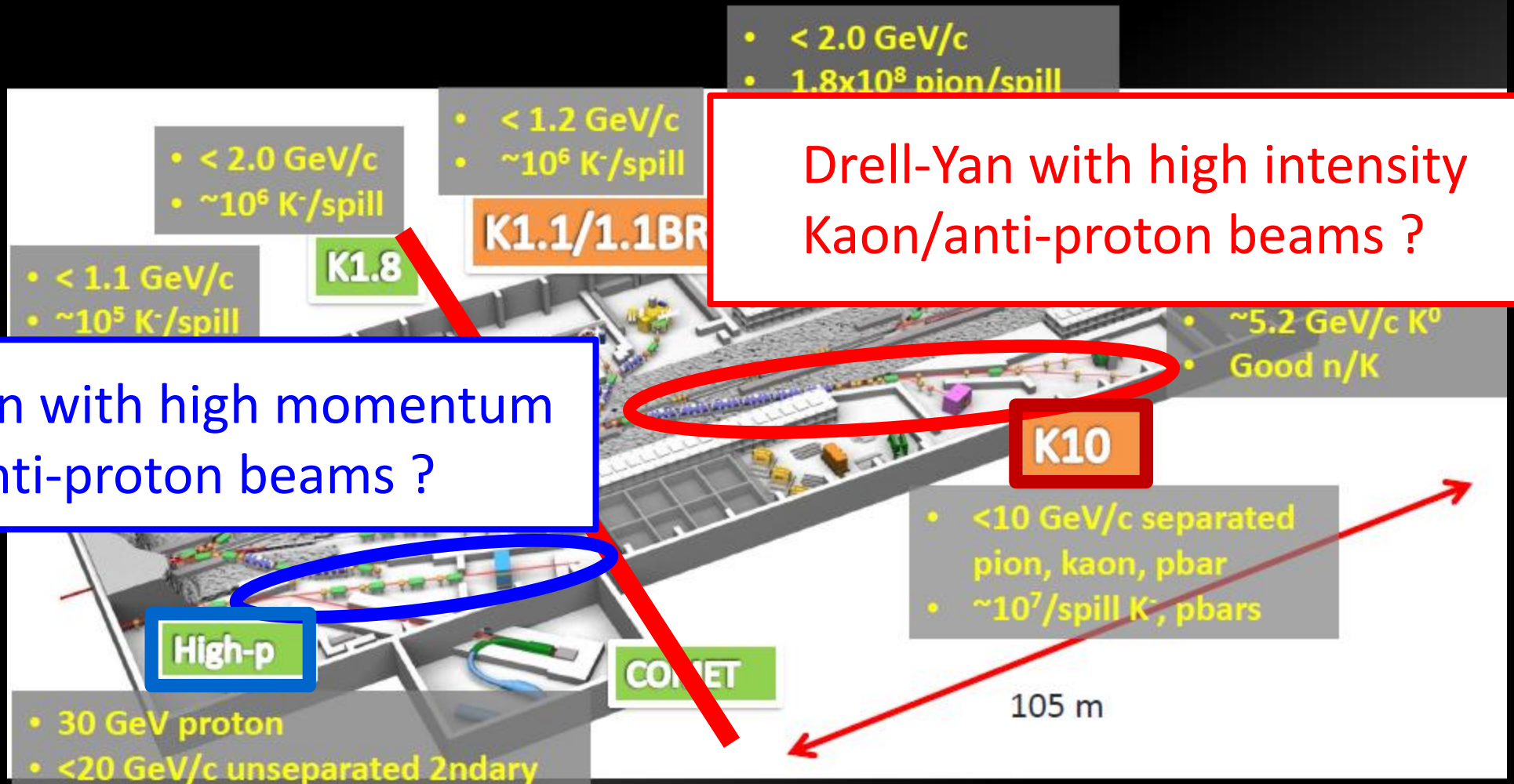
Talked by
Shin'ya Sawada

Overview: Extension of the Hadron Experimental Facility



Talked by
Shin'ya Sawada

Overview: Extension of the Hadron Experimental Facility



Drell-Yan with high intensity Kaon/anti-proton beams ?

Drell-Yan with high momentum Kaon/anti-proton beams ?

Summary

- Drell-Yan process is a powerful tool to explore the partonic structures of nucleons. We are moving ahead from 1D to 3D imaging of nucleons
- Measurement of GPDs through the exclusive π-induced Drell-Yan process will offer

  - Test of universality of GPD in space-like and time-like processes.

  - Test of factorization of exclusive Drell-Yan process.

  - Pion DA, Pion timelike FF (at small |t|), Transition DA (at large |t|), Transition GPD

  - Transition of Inclusive DY → Semi-inclusive DY → Exclusive DY

  with an increase of beam time (50 days in simulation → 100 days or more) or beam luminosity, optimization of setup:

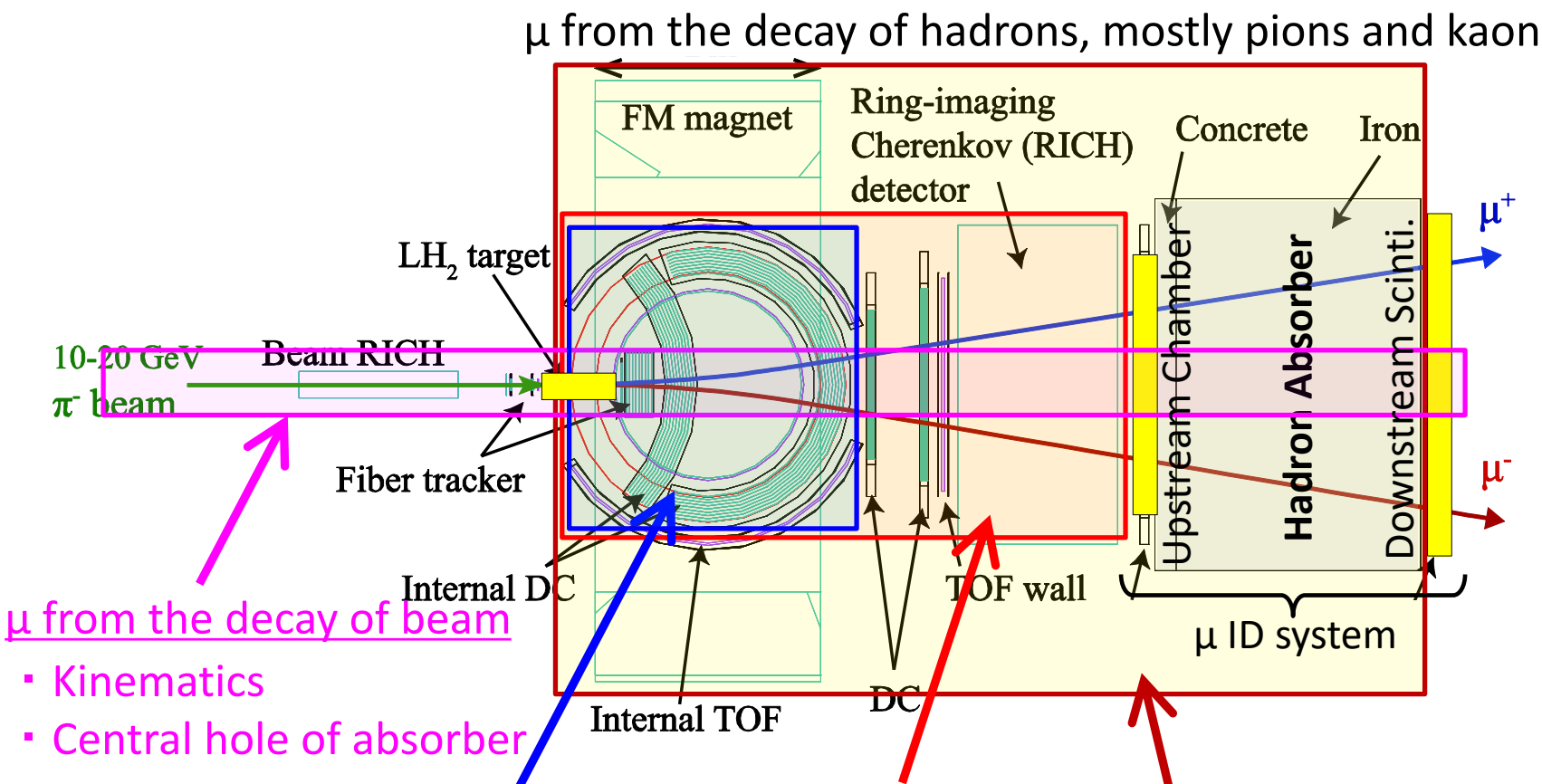
  - GPD at large-Q'^2 region

  - QCD-evolution properties of GPD

- The preliminary study shows that such measurement is feasible with E-50 spectrometers in the coming high momentum beamline at J-PARC.

Spares

Background μ rejection (Offline)



μ from the decay of beam

- Kinematics
- Central hole of absorber

- Bad χ^2 probability in the reconstructions
- Vertex position
- Kink of the decay vertex

- Inconsistency of the trajectory between the spectrometer and the upstream chamber in μID system

- Inconsistency of the hit location between the upstream chamber and downstream Scinti. in μID system