

Overview of experimental efforts on GPDs

AdT

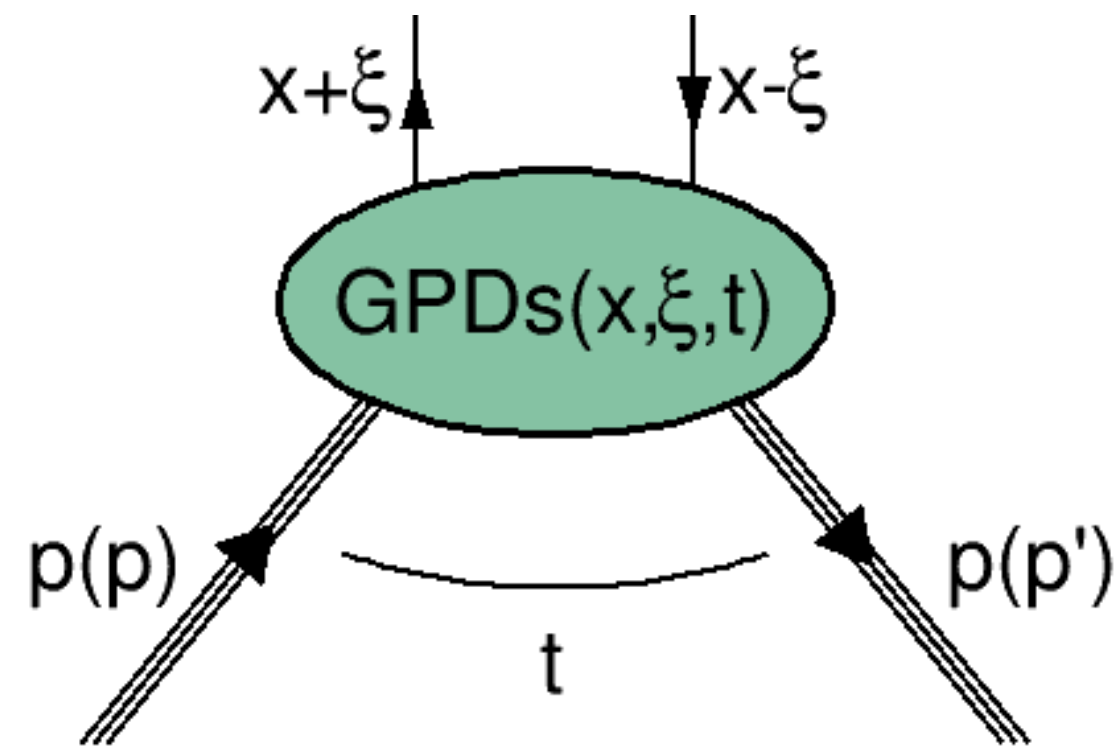


**Comunidad
de Madrid**

Charlotte Van Hulse
University of Alcalá

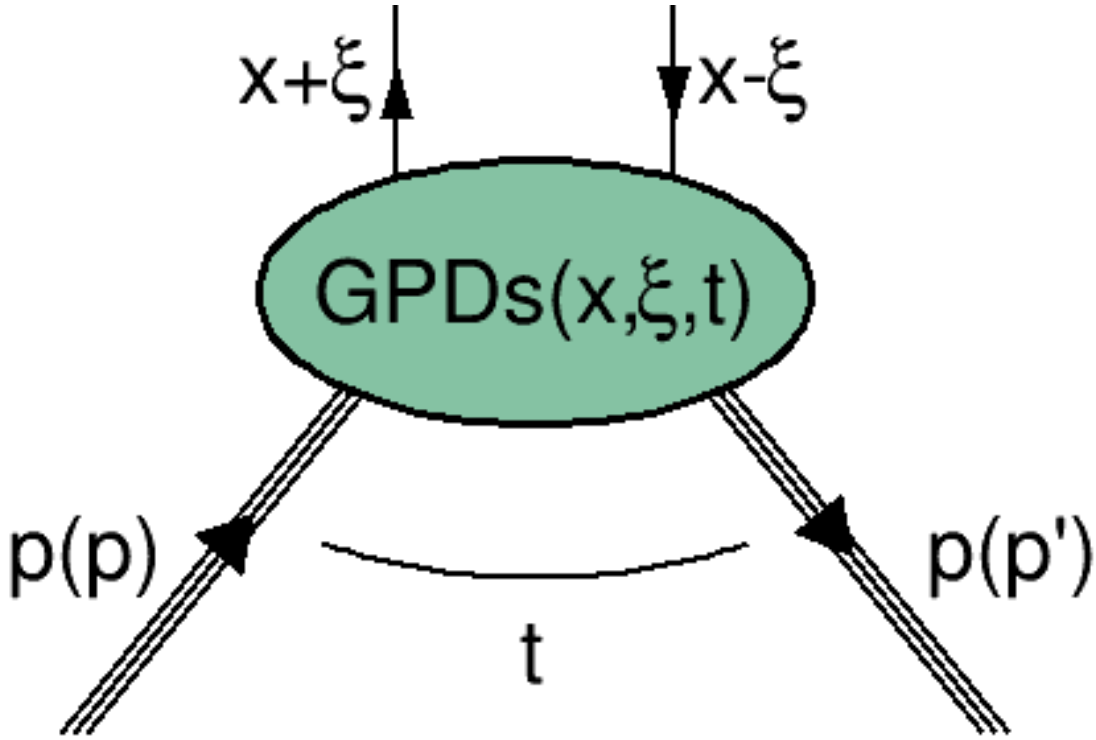
EINN2025
Paphos, Cyprus
October 27 – November 1, 2025

Generalised parton distributions (GPDs)



- x =average longitudinal momentum fraction
- 2ξ =longitudinal momentum transfer
- t =squared momentum transfer to hadron
- experimental access to t and ξ
- in general: no experimental access to x

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for spin-1/2 hadron:

Four parton helicity-conserving twist-2 GPDs

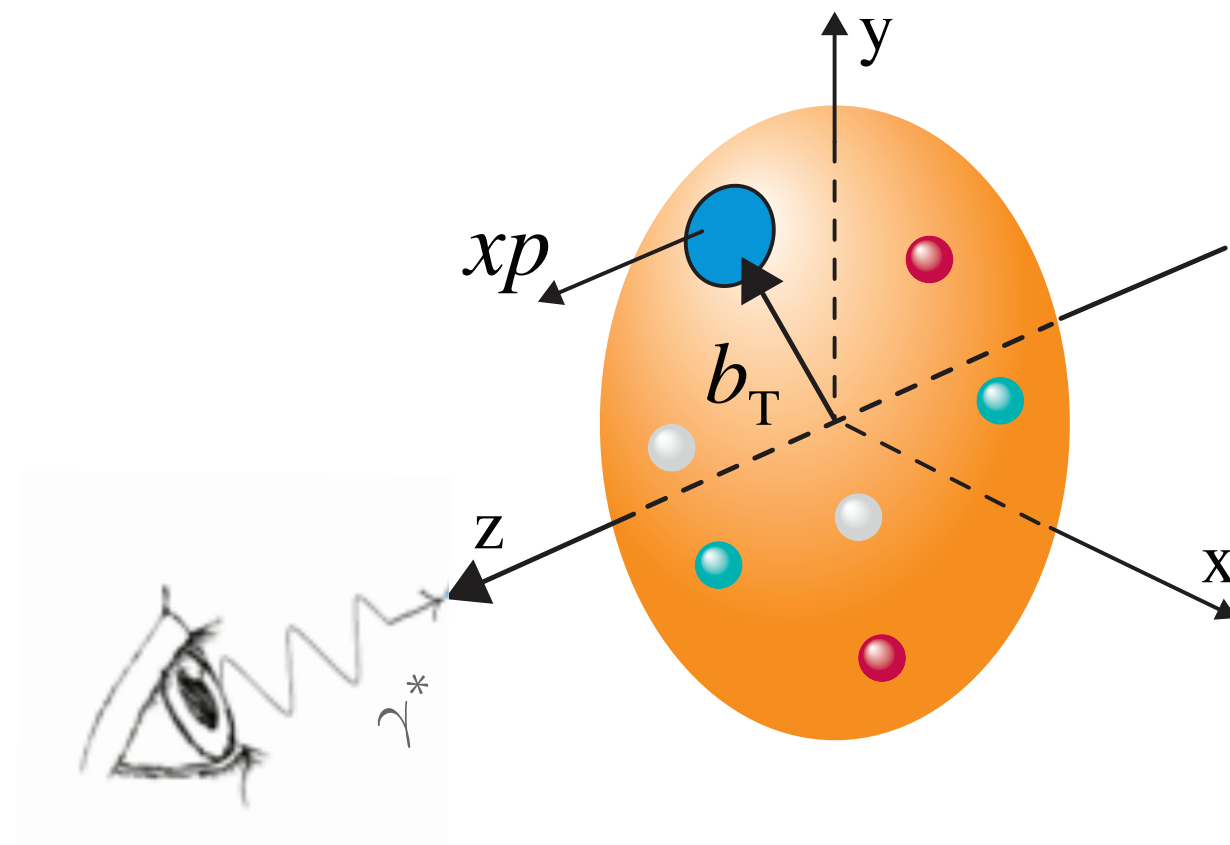
$H(x, \xi, t)$	$E(x, \xi, t)$	parton-spin independent
$\tilde{H}(x, \xi, t)$	$\tilde{E}(x, \xi, t)$	
proton helicity non flip	proton helicity flip	

Four parton helicity-flip twist-2 GPDs

$H_T(x, \xi, t)$	$E_T(x, \xi, t)$
$\tilde{H}_T(x, \xi, t)$	$\tilde{E}_T(x, \xi, t)$

GPDs and the nucleon structure

3D parton distributions

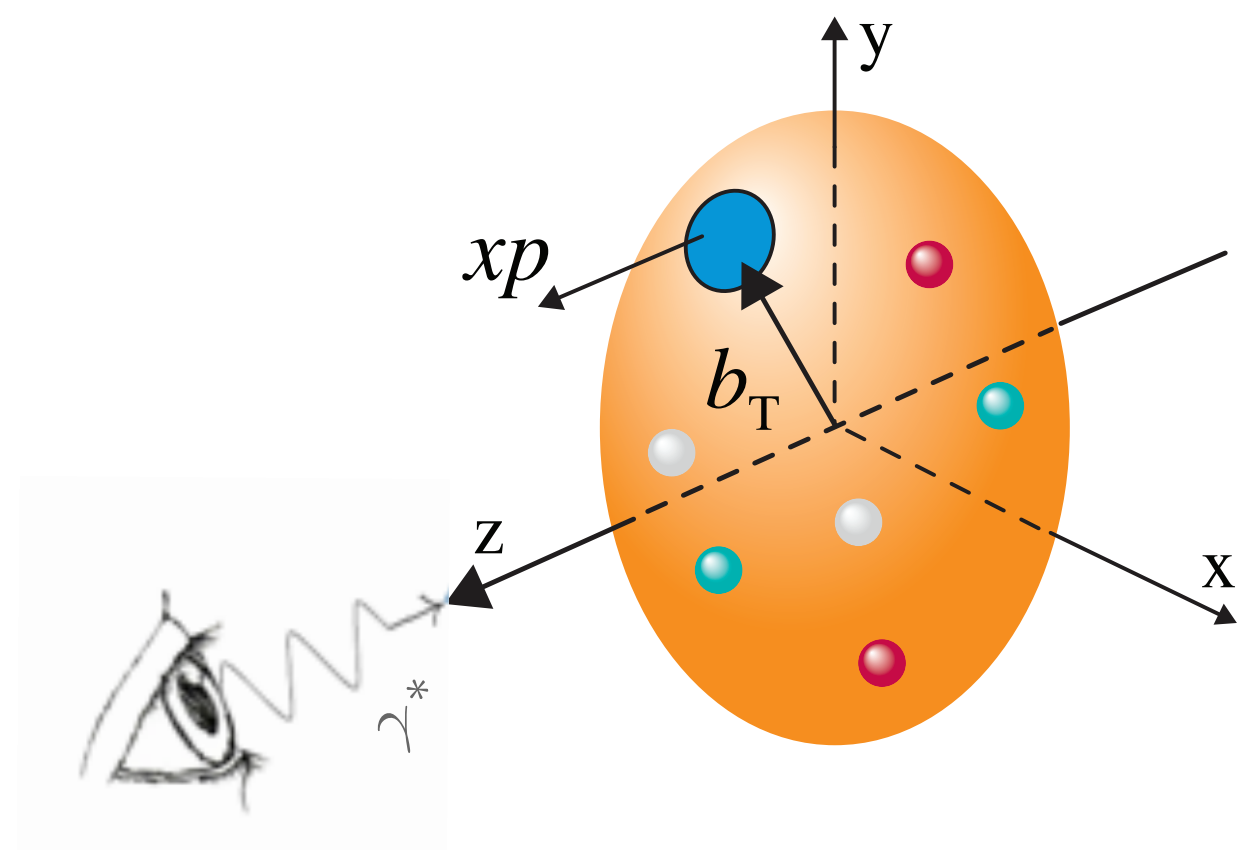


impact-parameter dependent distributions:
probability to find parton (x, b_T)

↑ Fourier transform ($\xi=0$)
M. Burkardt,
PRD **92** ('00) 071503
JMP A **18** ('03) 173
GPDs

GPDs and the nucleon structure

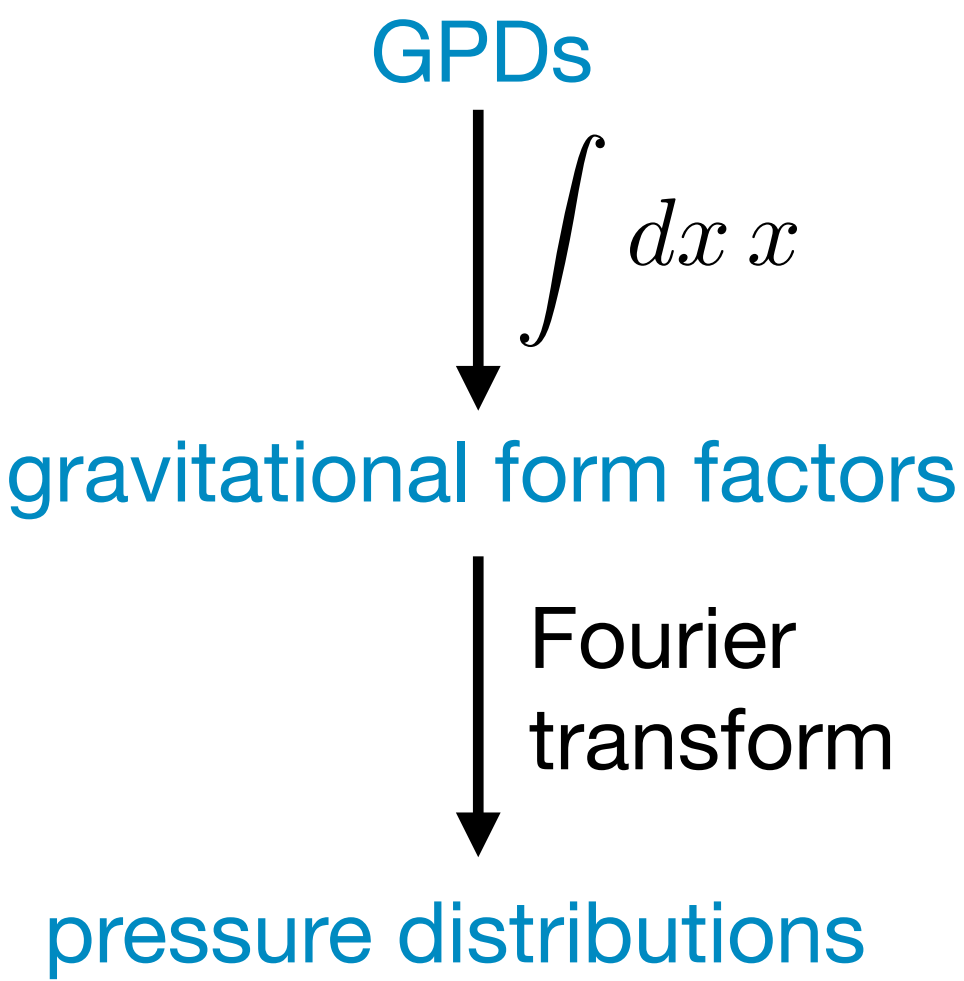
3D parton distributions



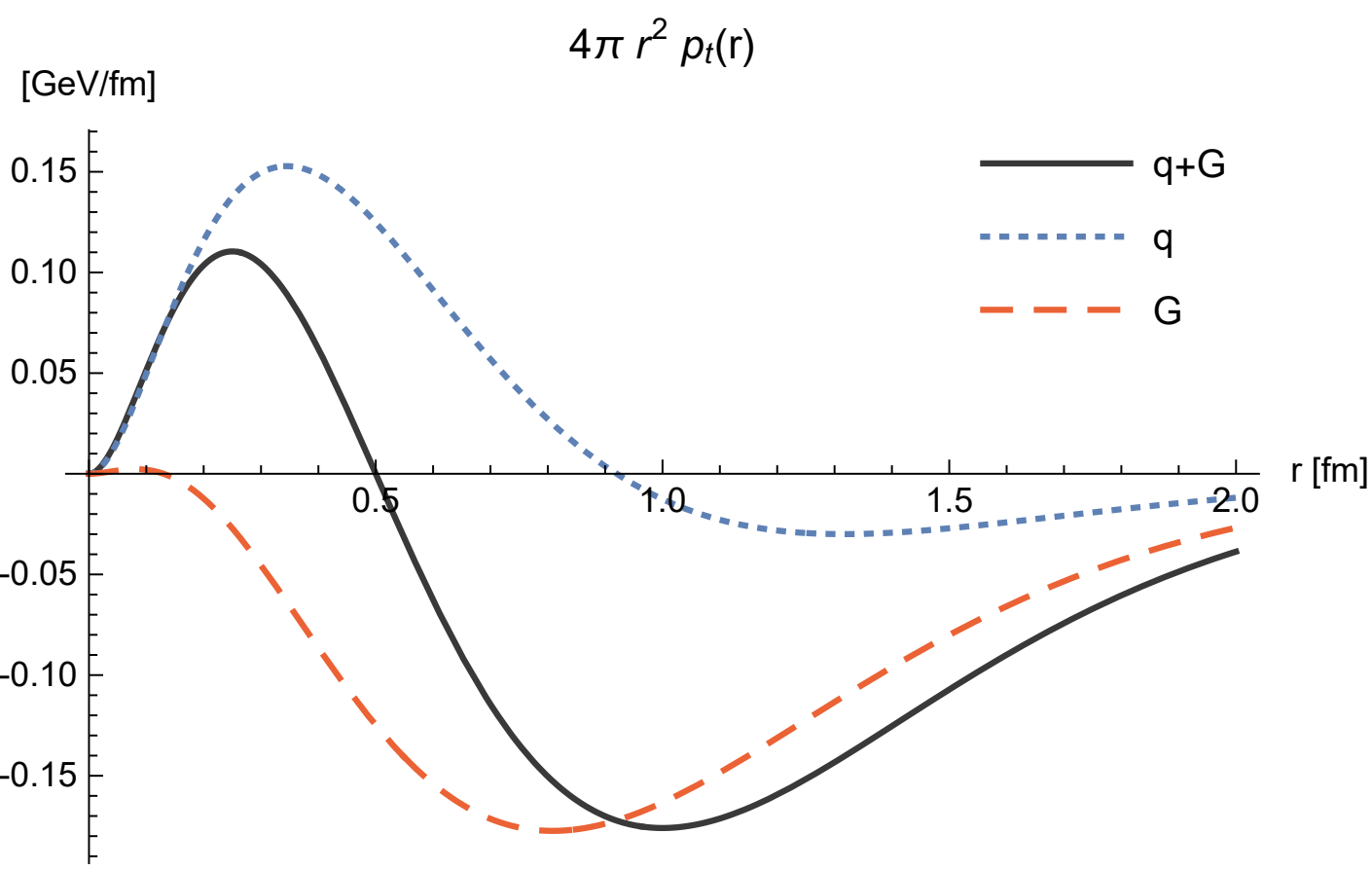
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GPDs

pressure distributions

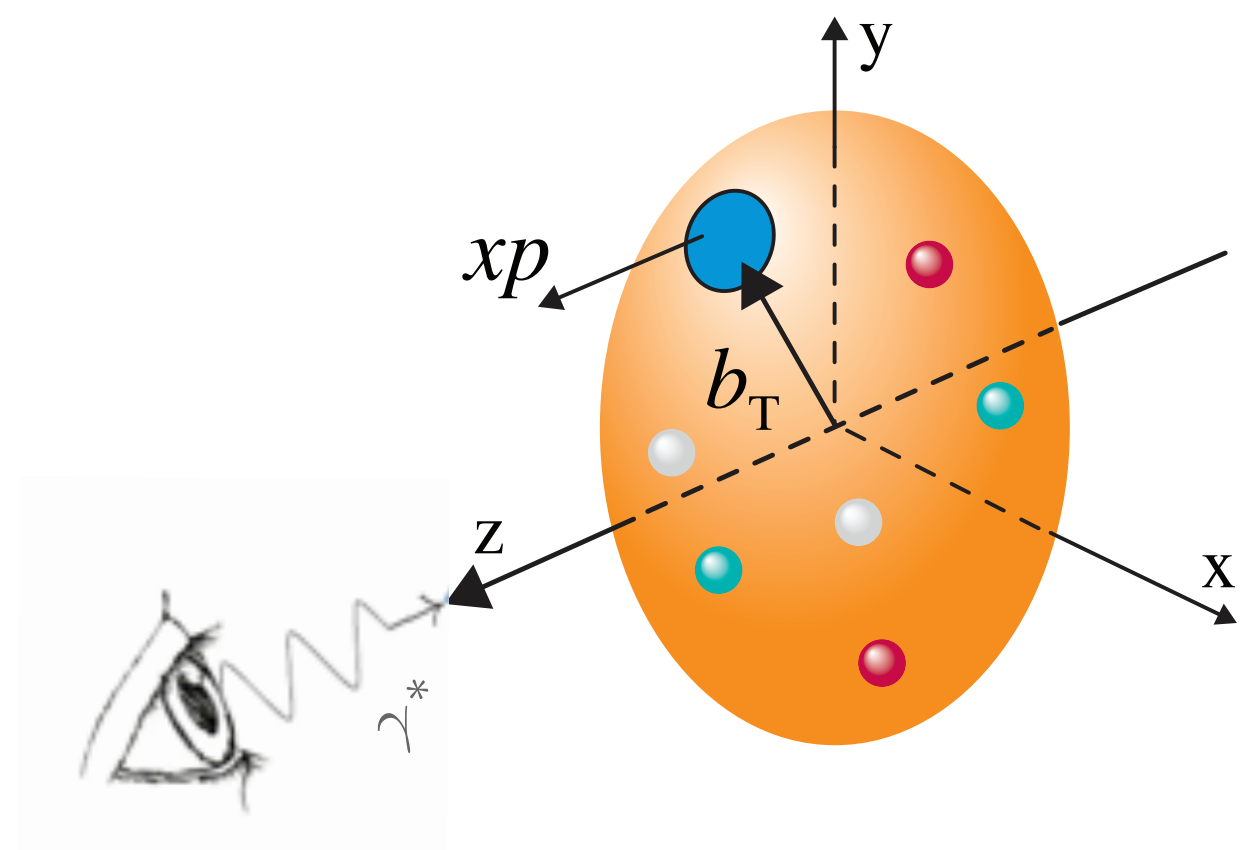


tangential pressure



GPDs and the nucleon structure

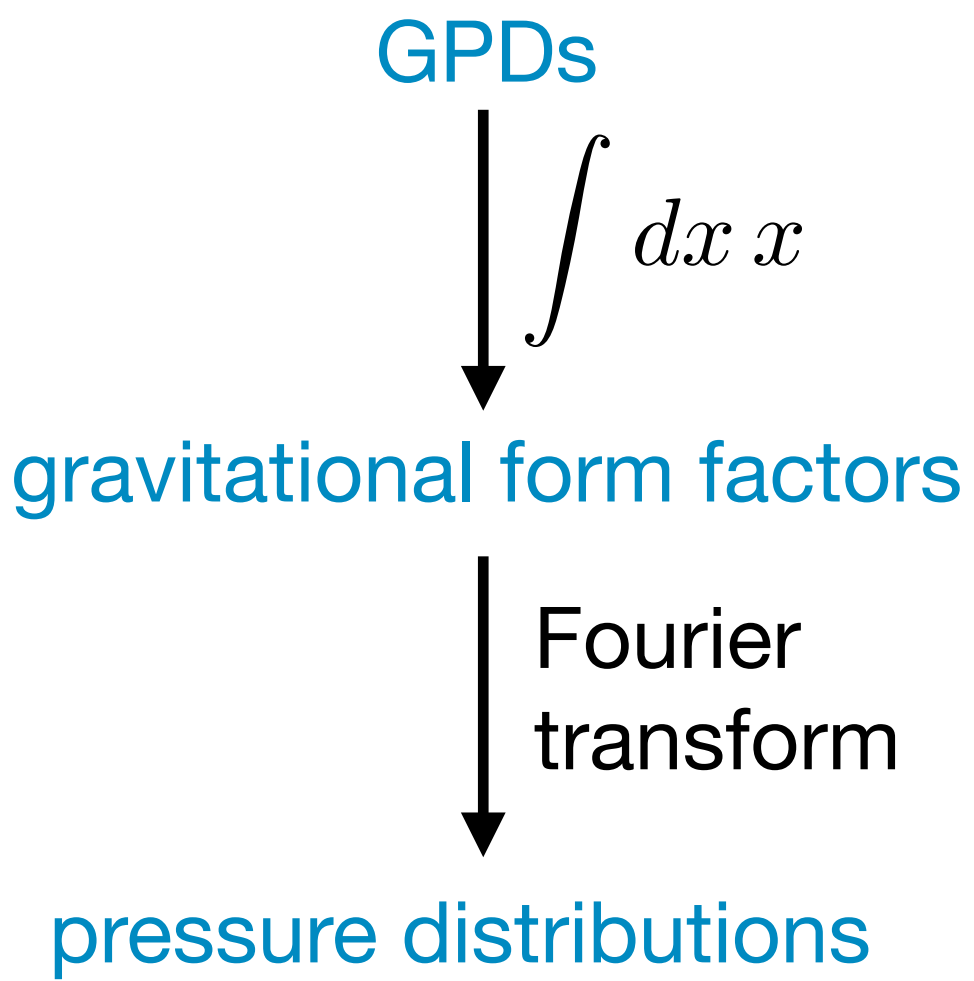
3D parton distributions



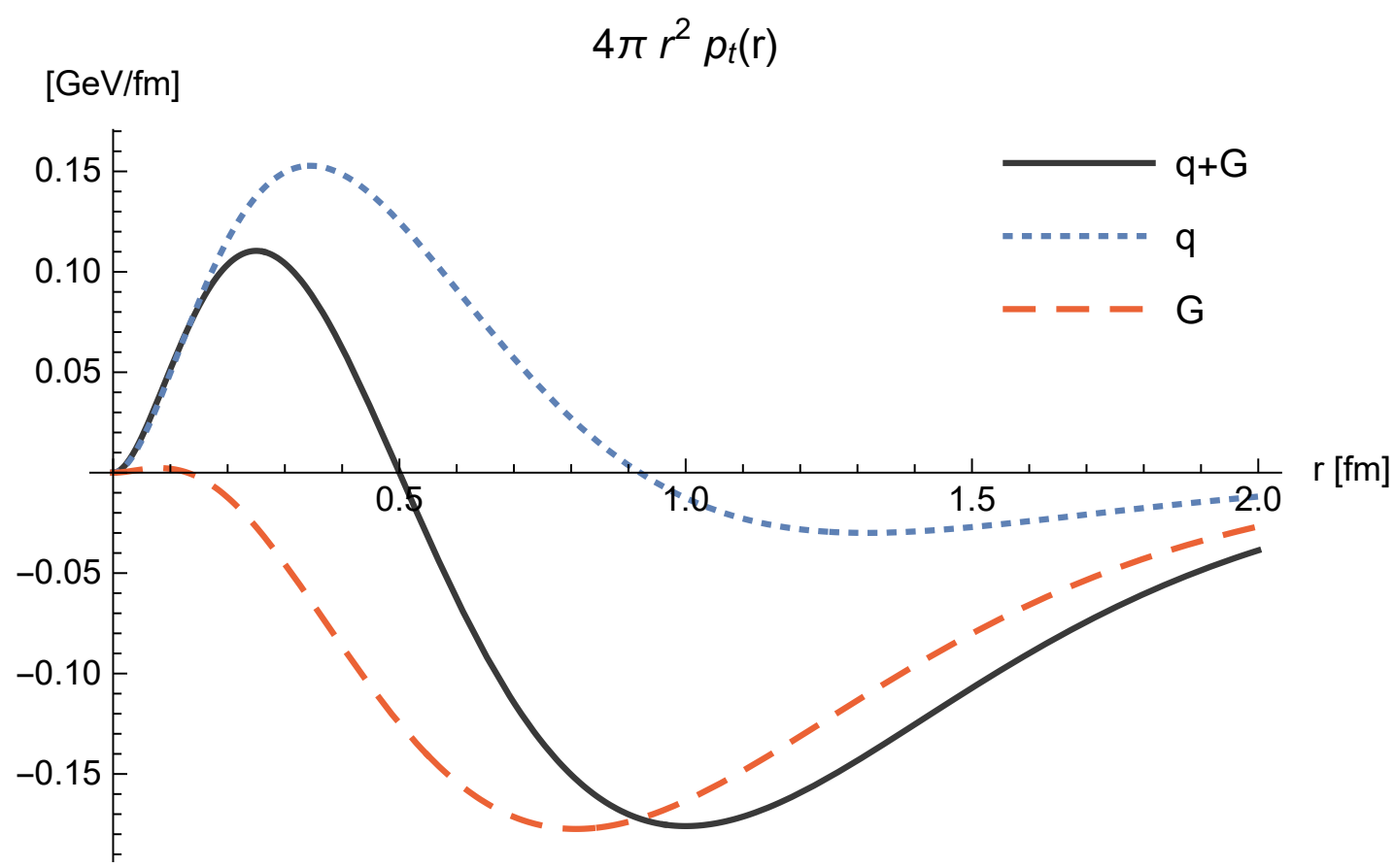
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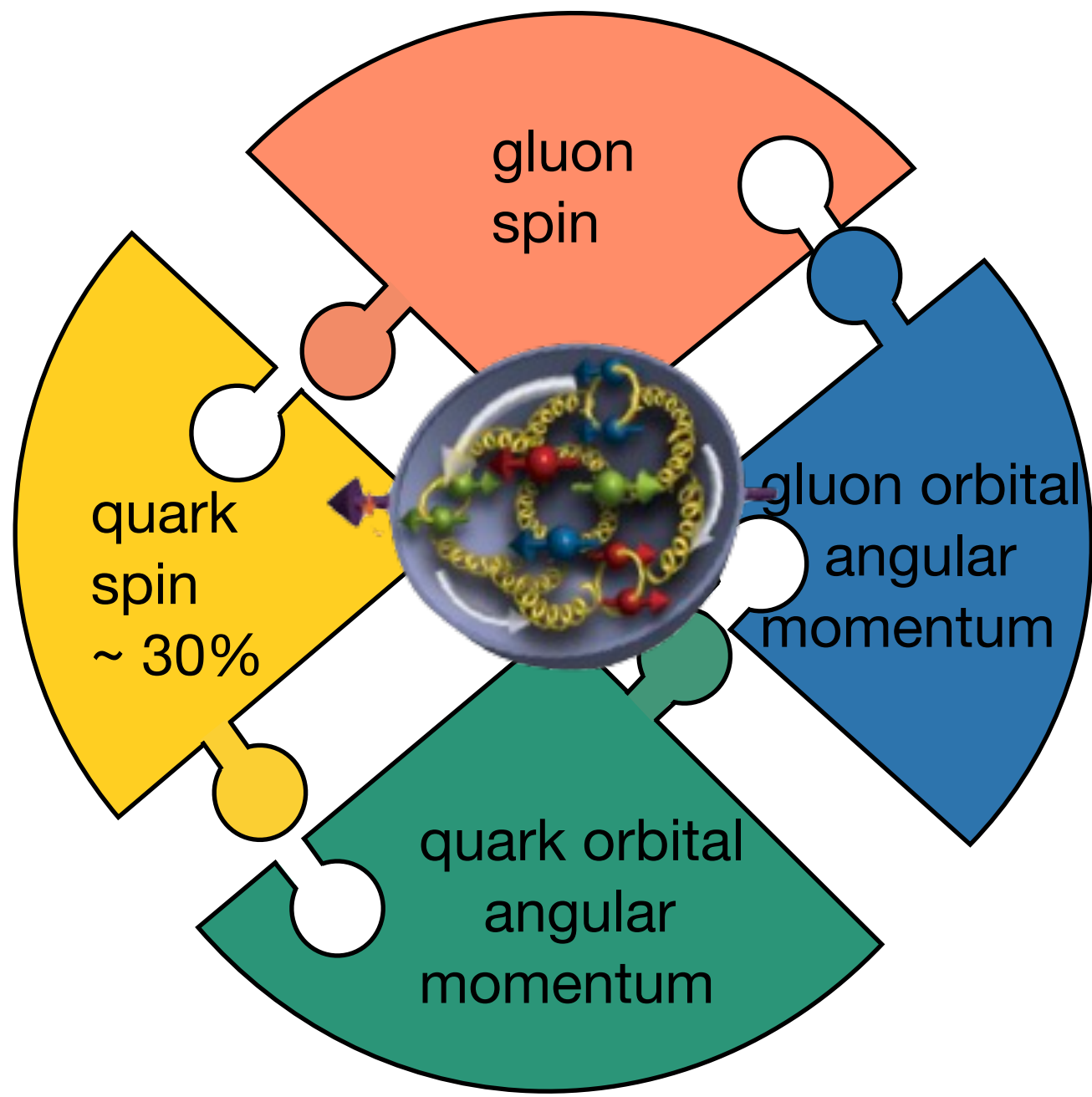
pressure distributions



tangential pressure



angular momentum

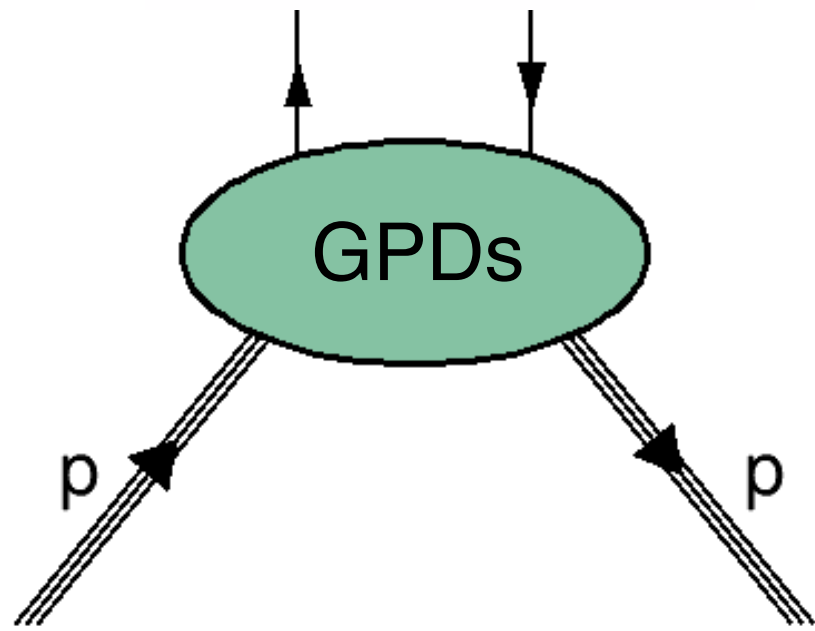


Ji relation:

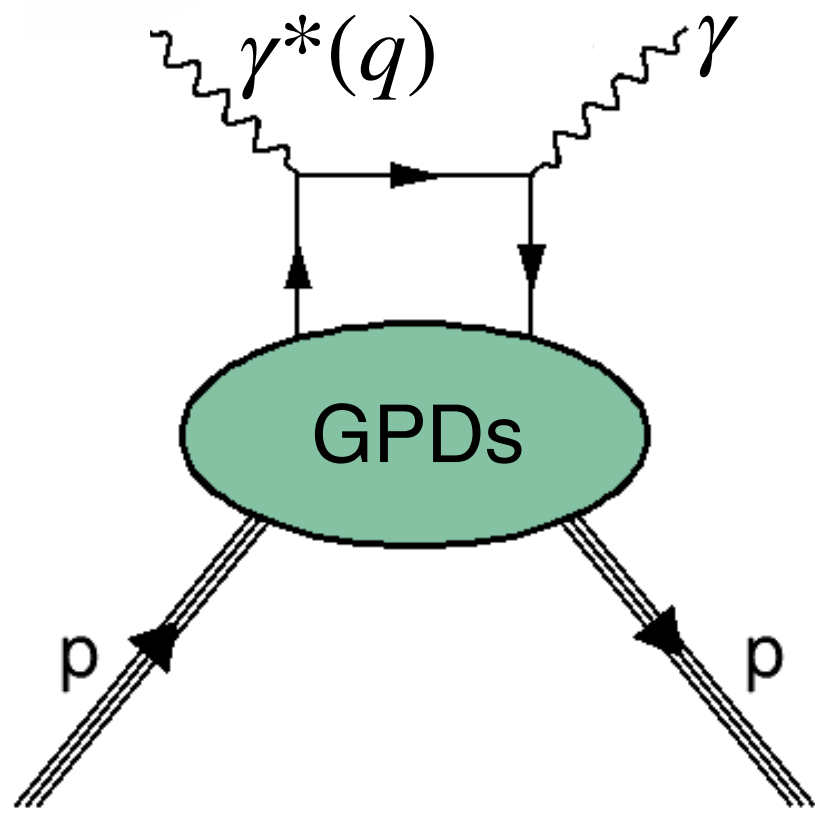
$$J^{q,g} = \lim_{t \rightarrow 0} \frac{1}{2} \int_{-1}^1 dx (x) [H^{q,g}(x, \xi, t) + E^{q,g}(x, \xi, t)]$$

X. Ji, PRL **78** (1997) 610

Experimental access to GPDs



Experimental access to GPDs

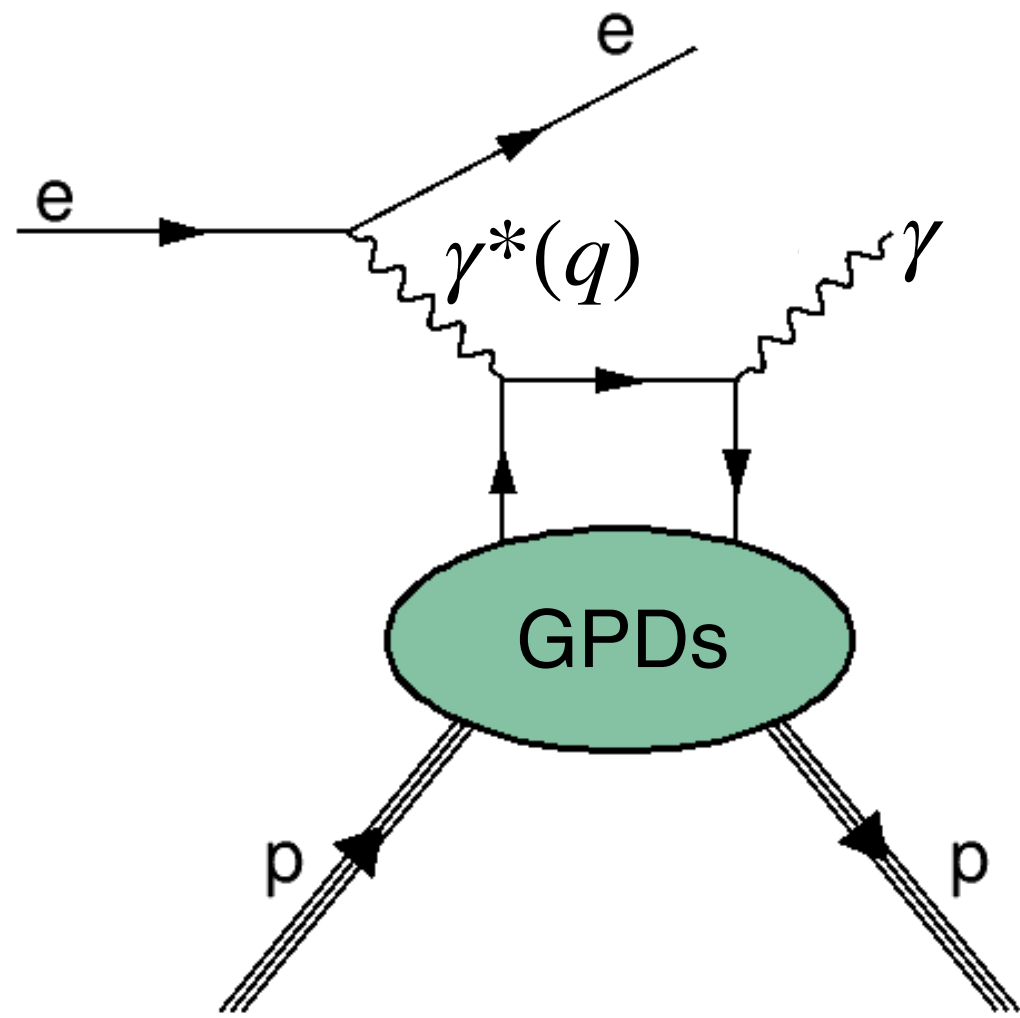


Deeply virtual Compton scattering
(DVCS)

Hard scale=large $Q^2=-q^2$

Theoretically cleanest process

Experimental access to GPDs

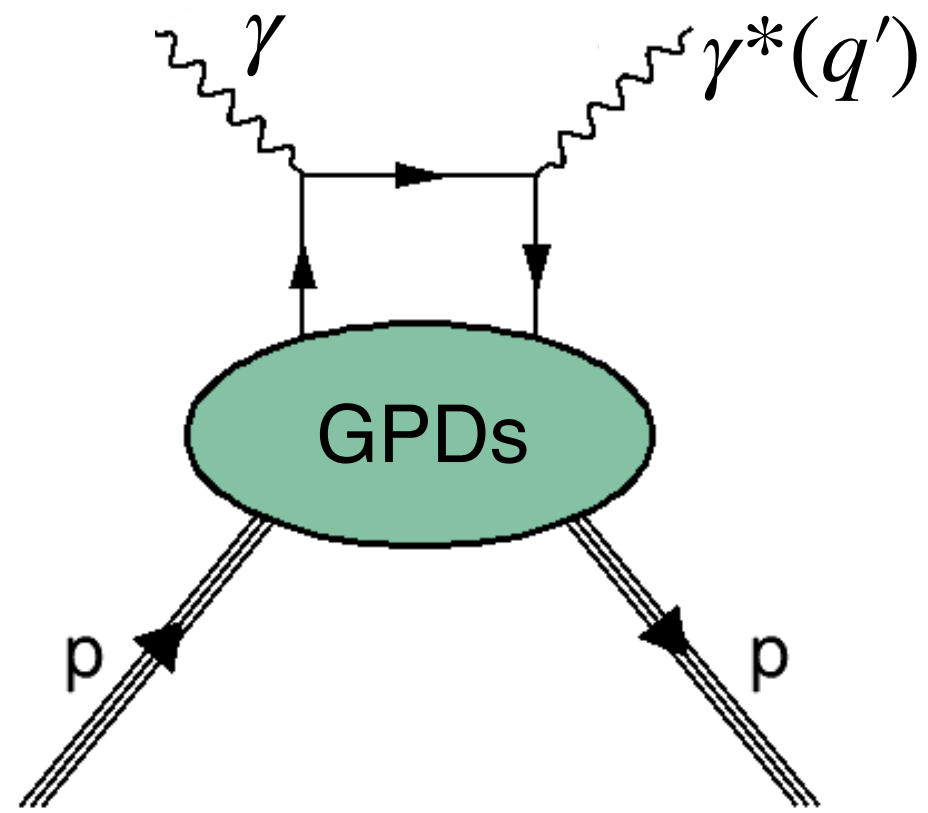


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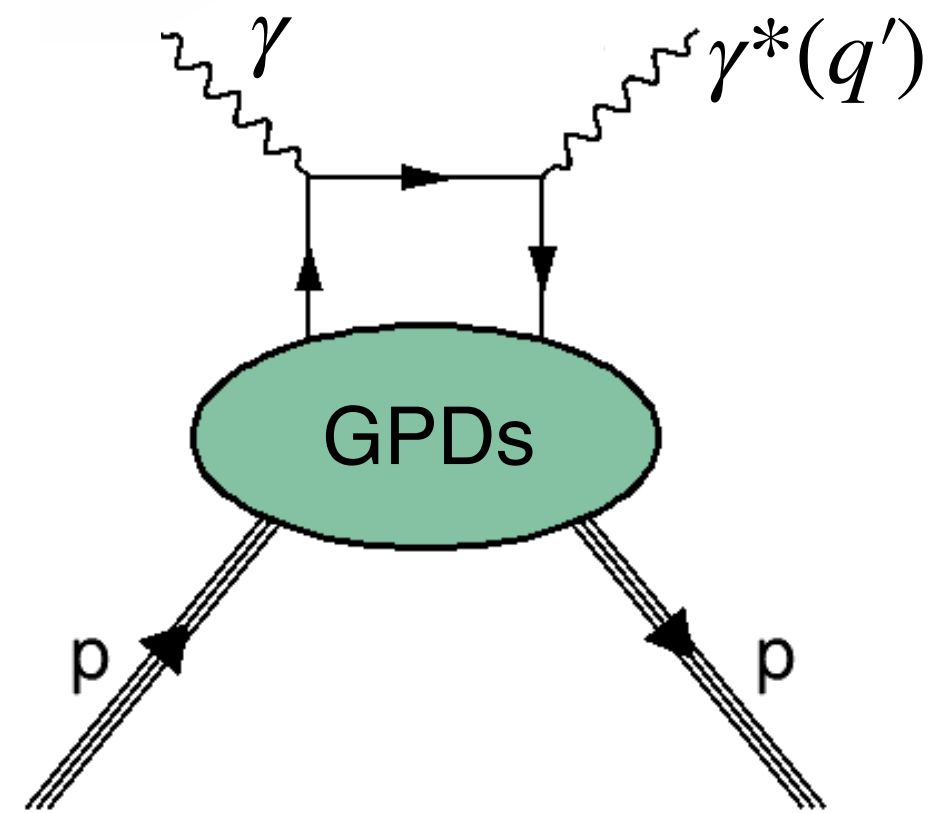


Timelike Compton scattering
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Crucial test for universality of GPDs

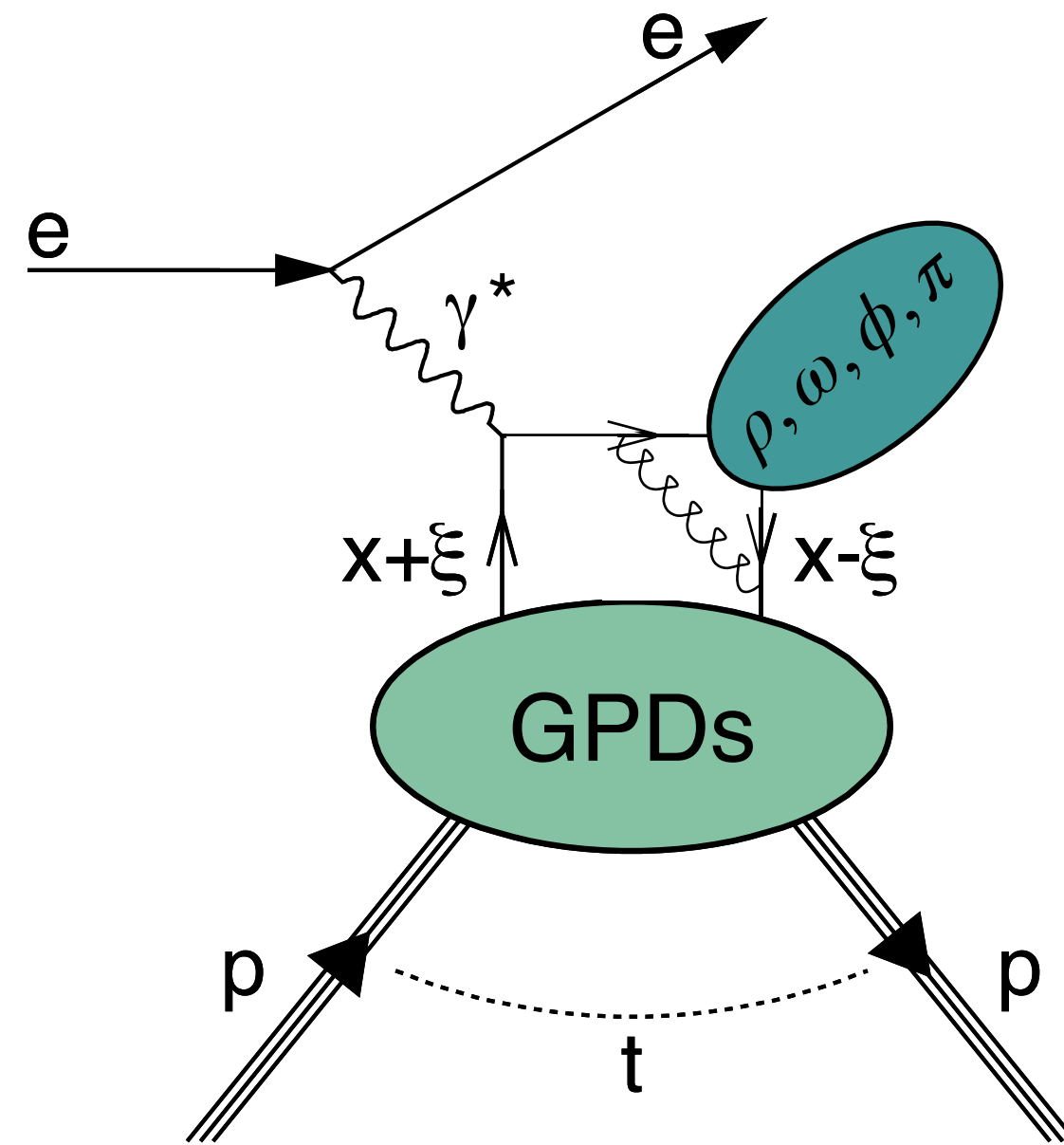
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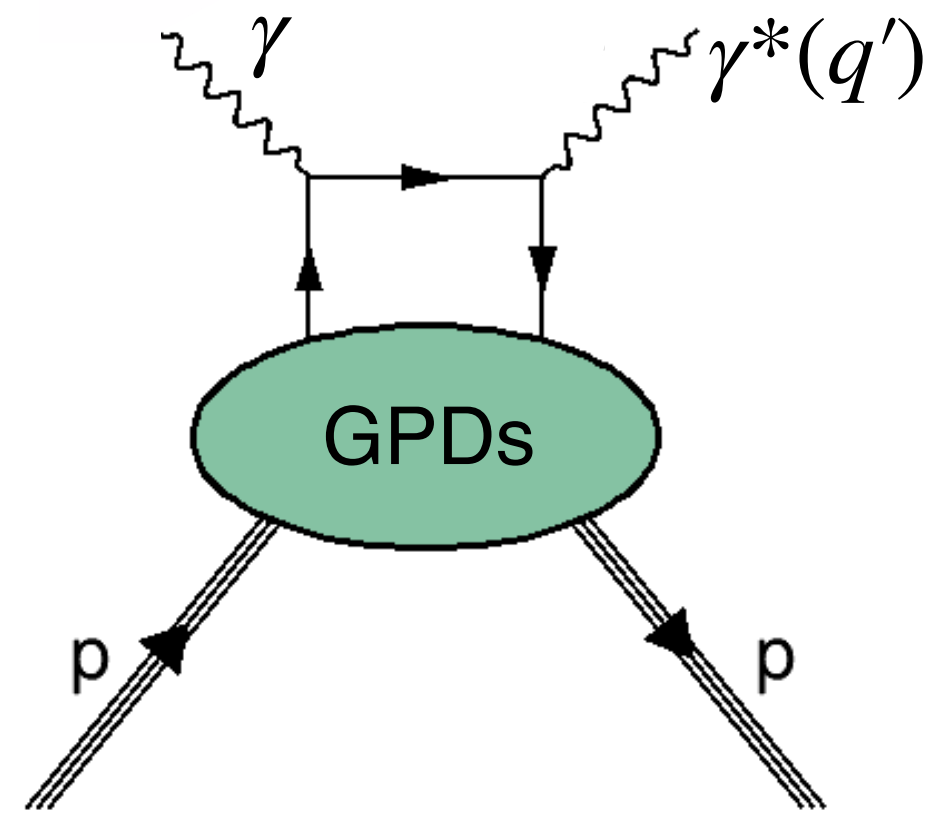


Hard exclusive meson production

Hard scale=large Q^2

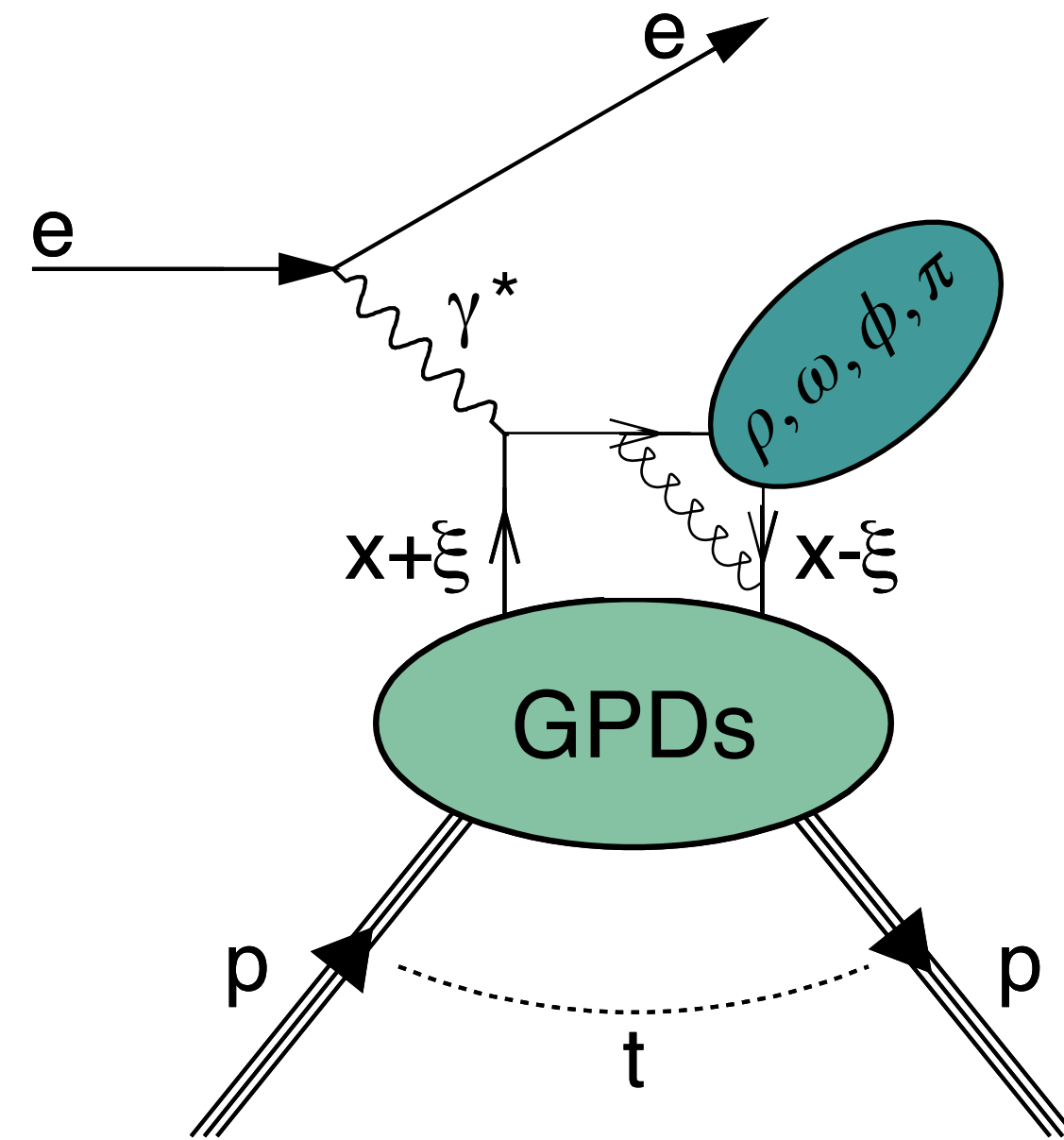
Sensitivity to different GPDs

Experimental access to GPDs



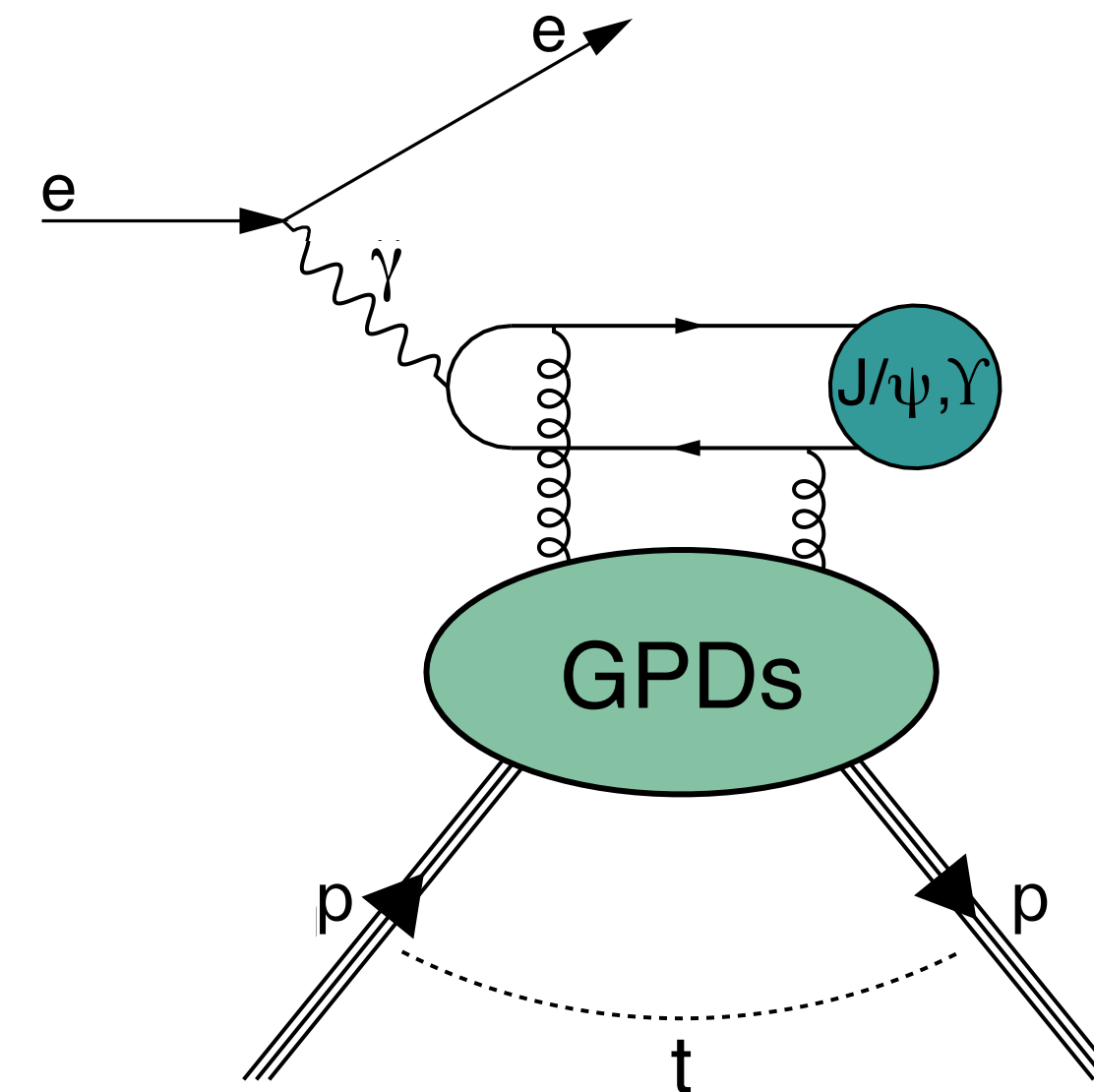
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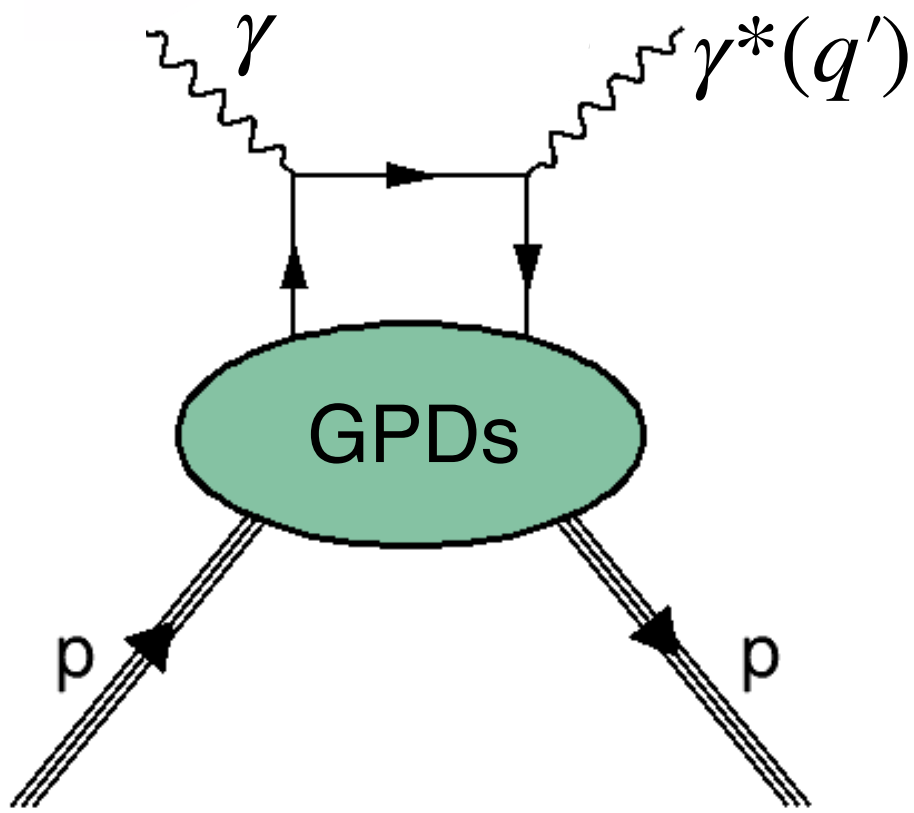
Sensitivity to different GPDs



Exclusive meson photoproduction
Hard scale = large c/b-quark mass

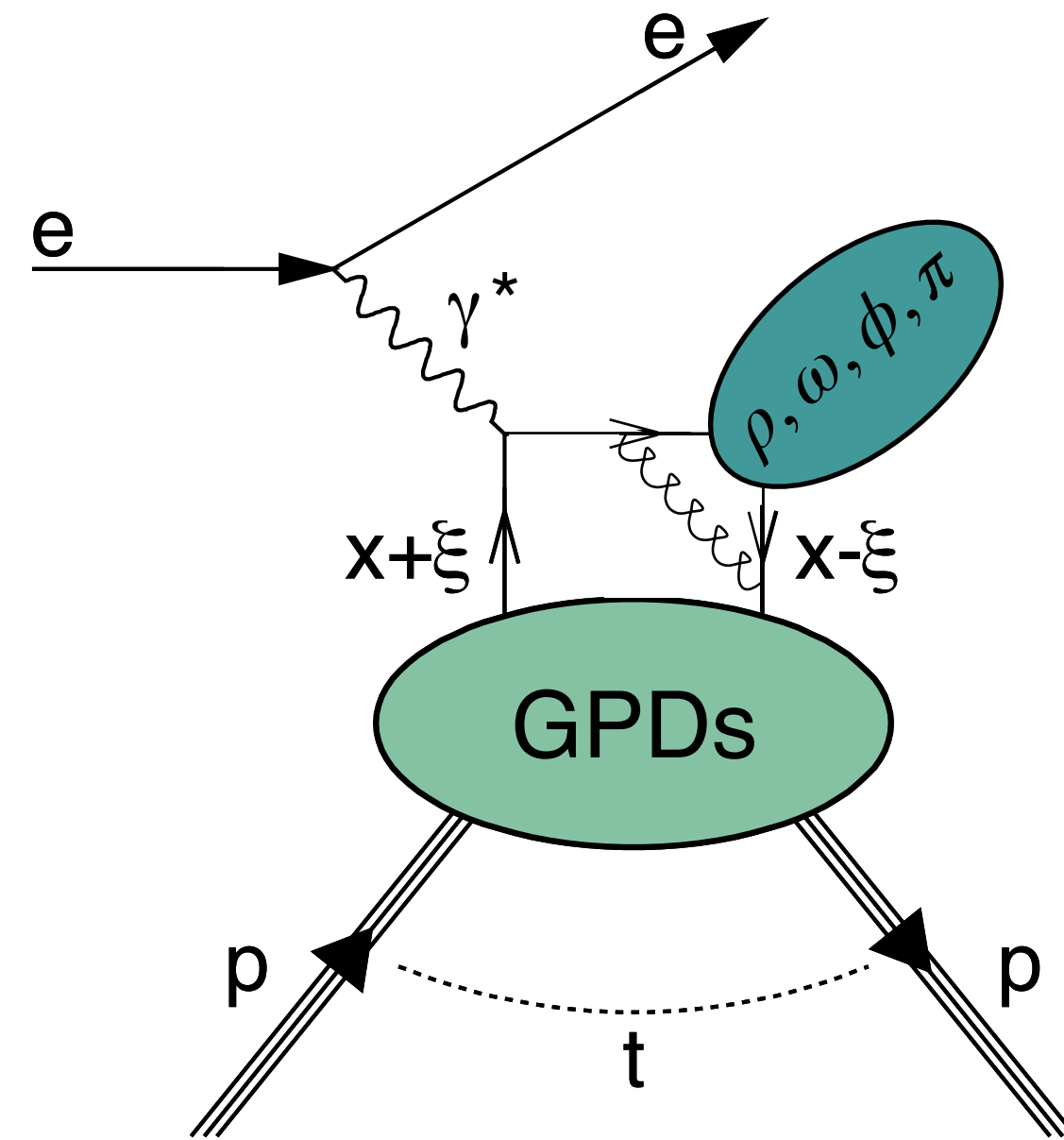
Clean access to gluons

Experimental access to GPDs



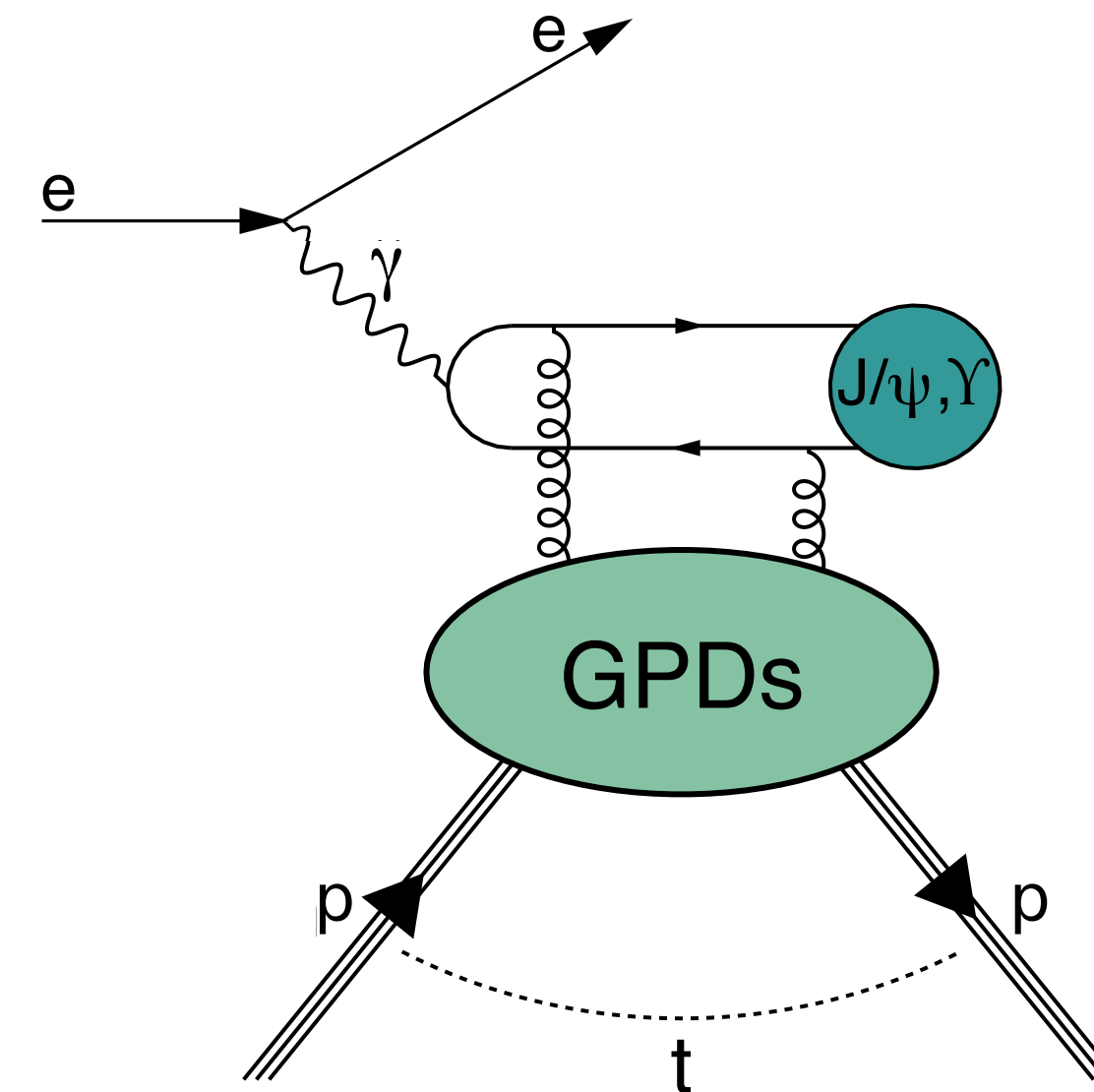
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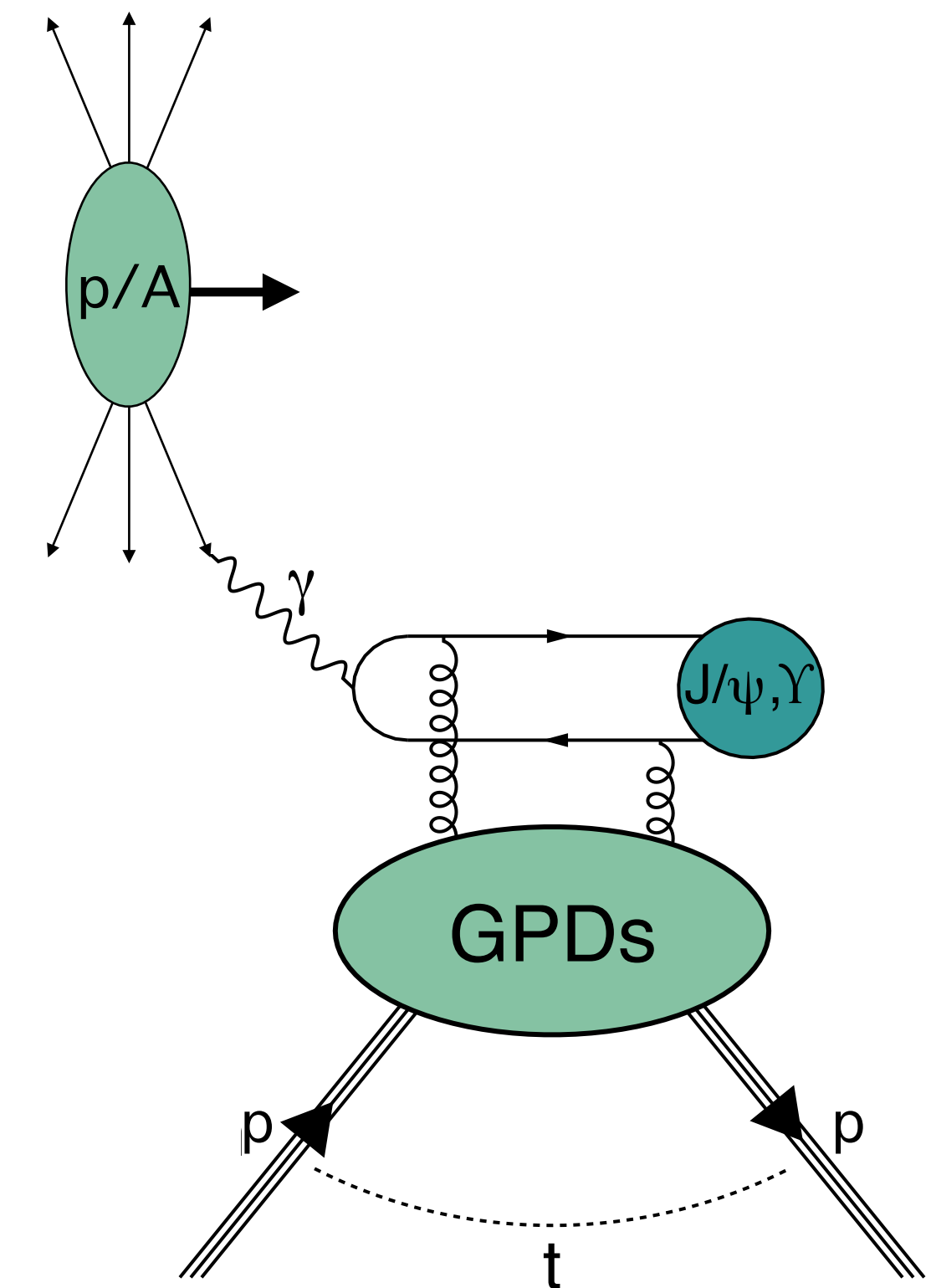
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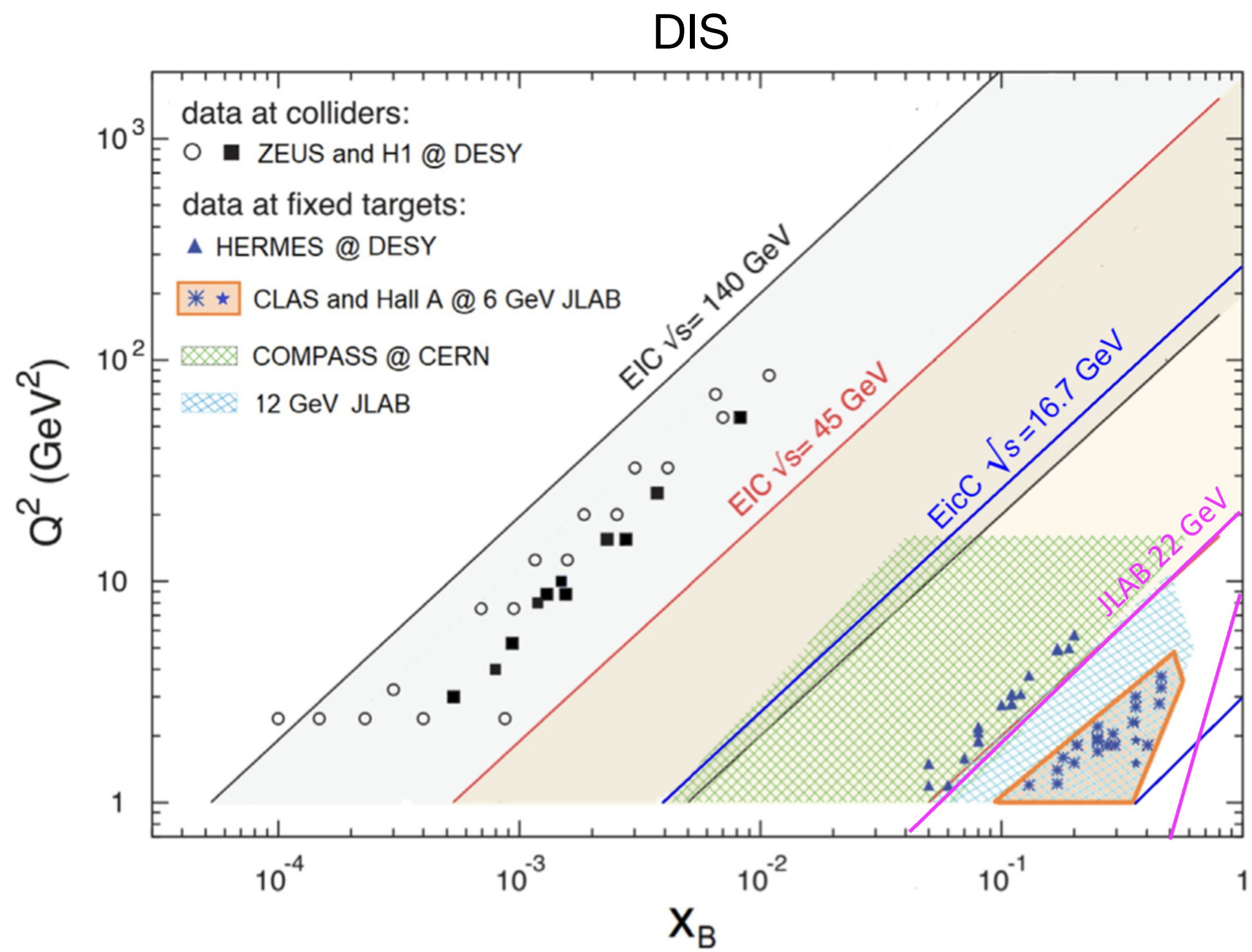
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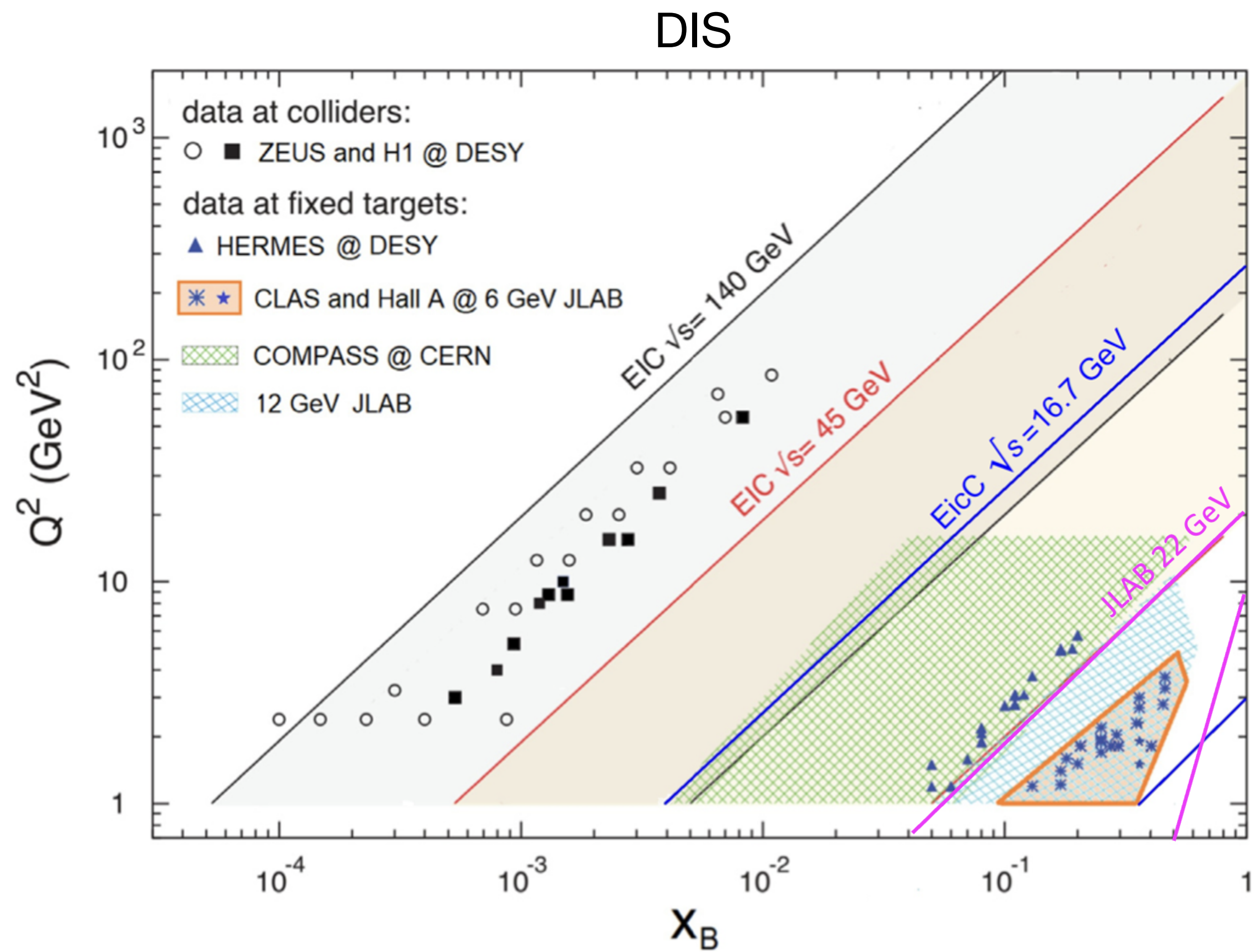
Sensitive to very low x_B

Kinematic coverage

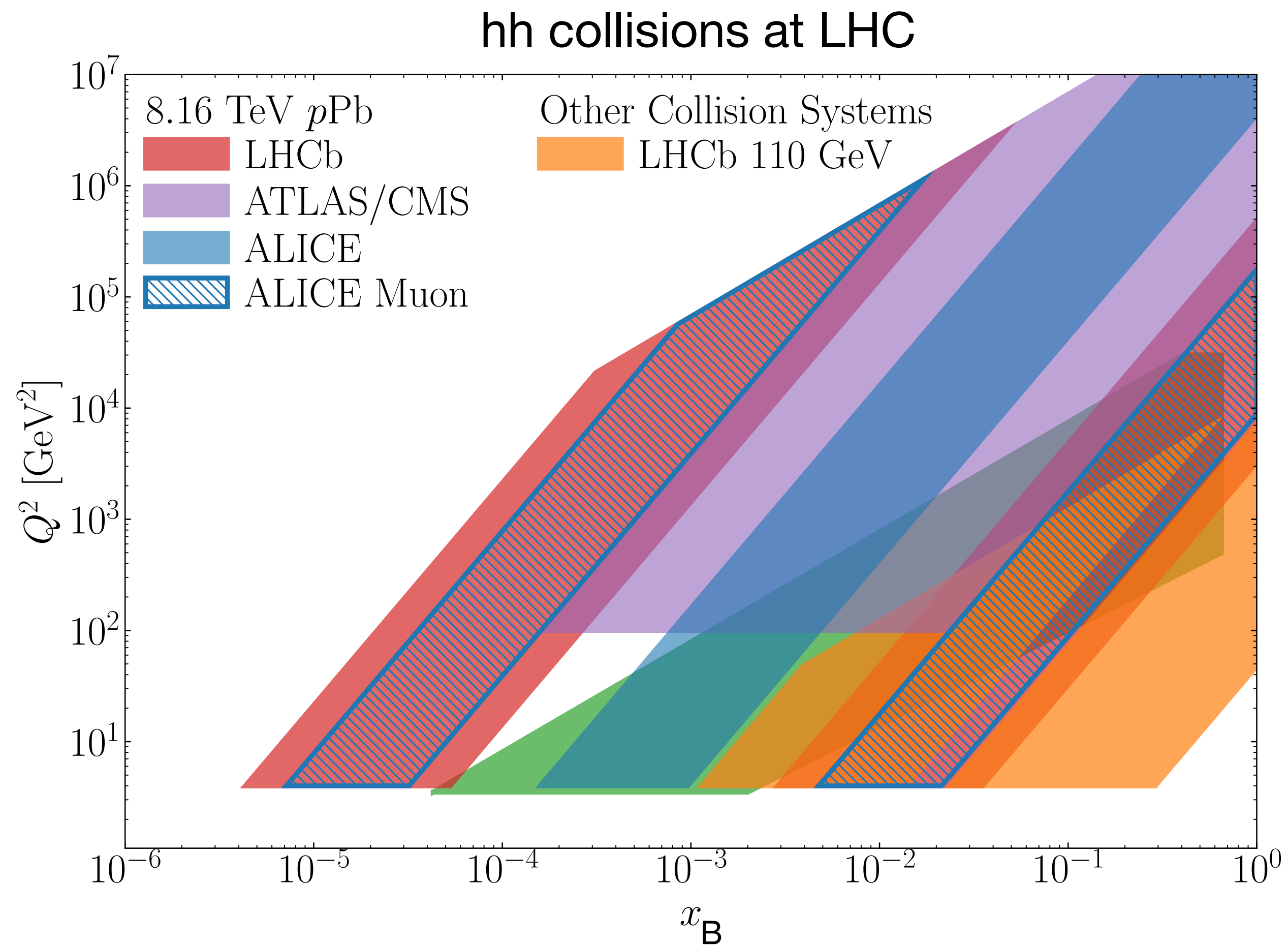


down to $x_B=10^{-4}$ at HERA/EIC in ep
 $x_B=10^{-3}$ at EIC in eA

Kinematic coverage

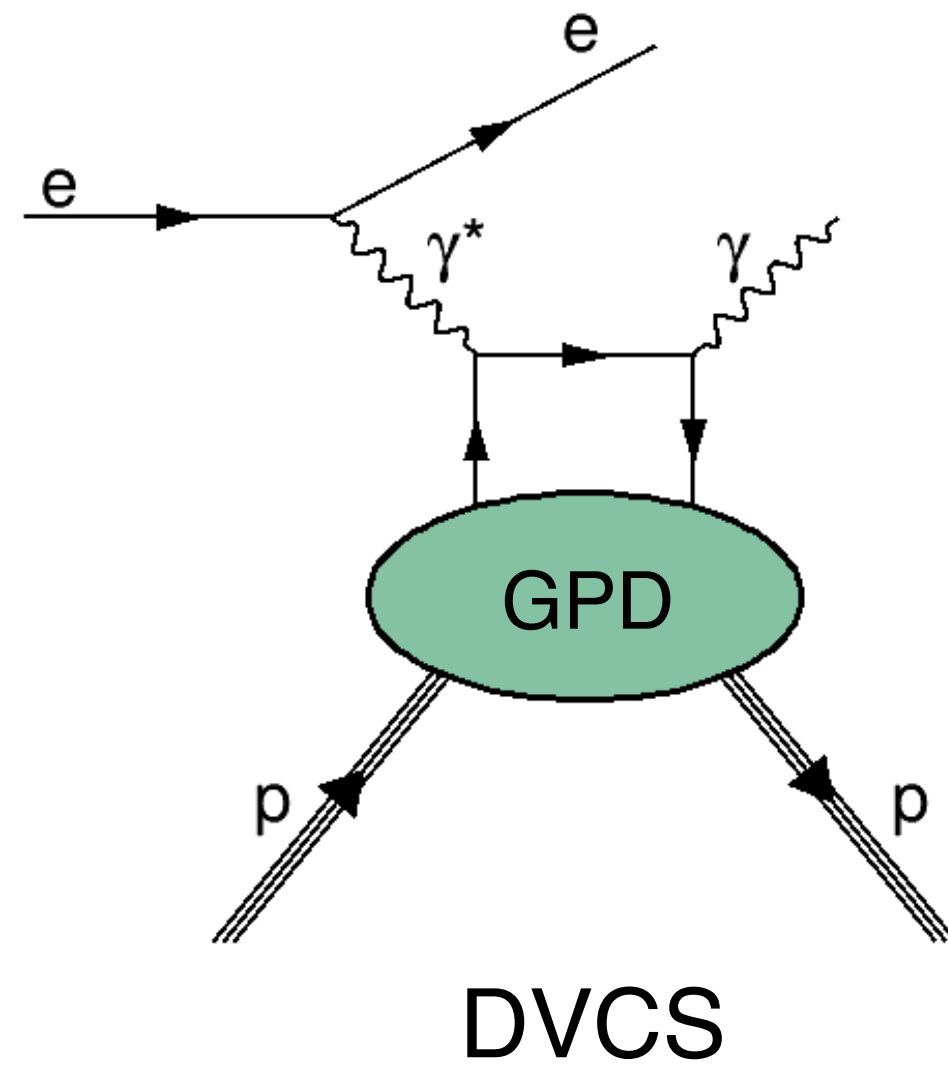


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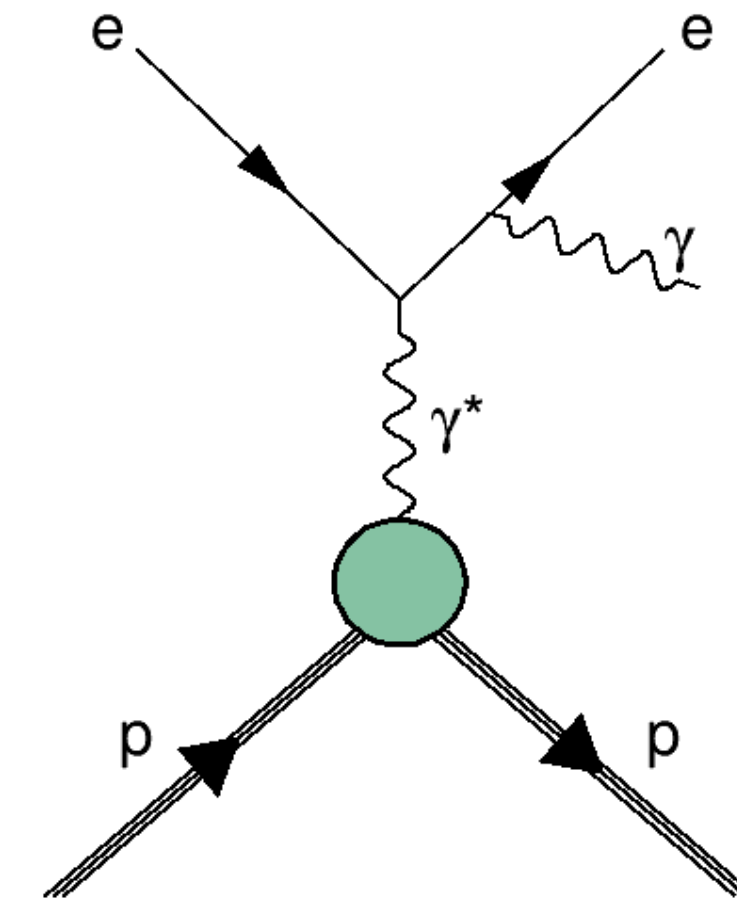
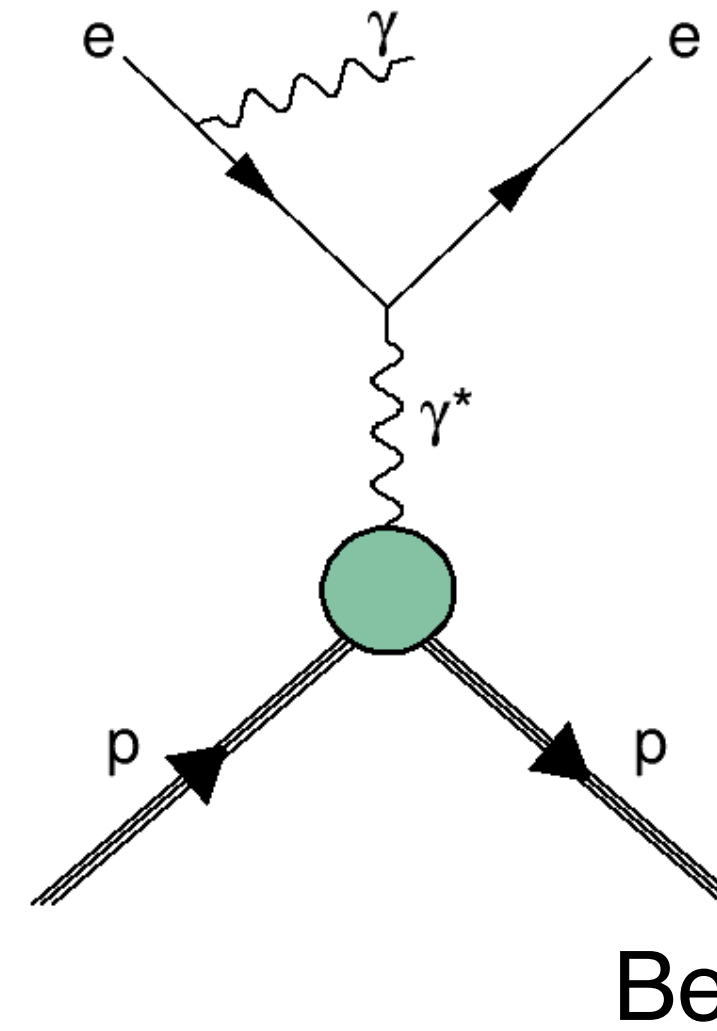
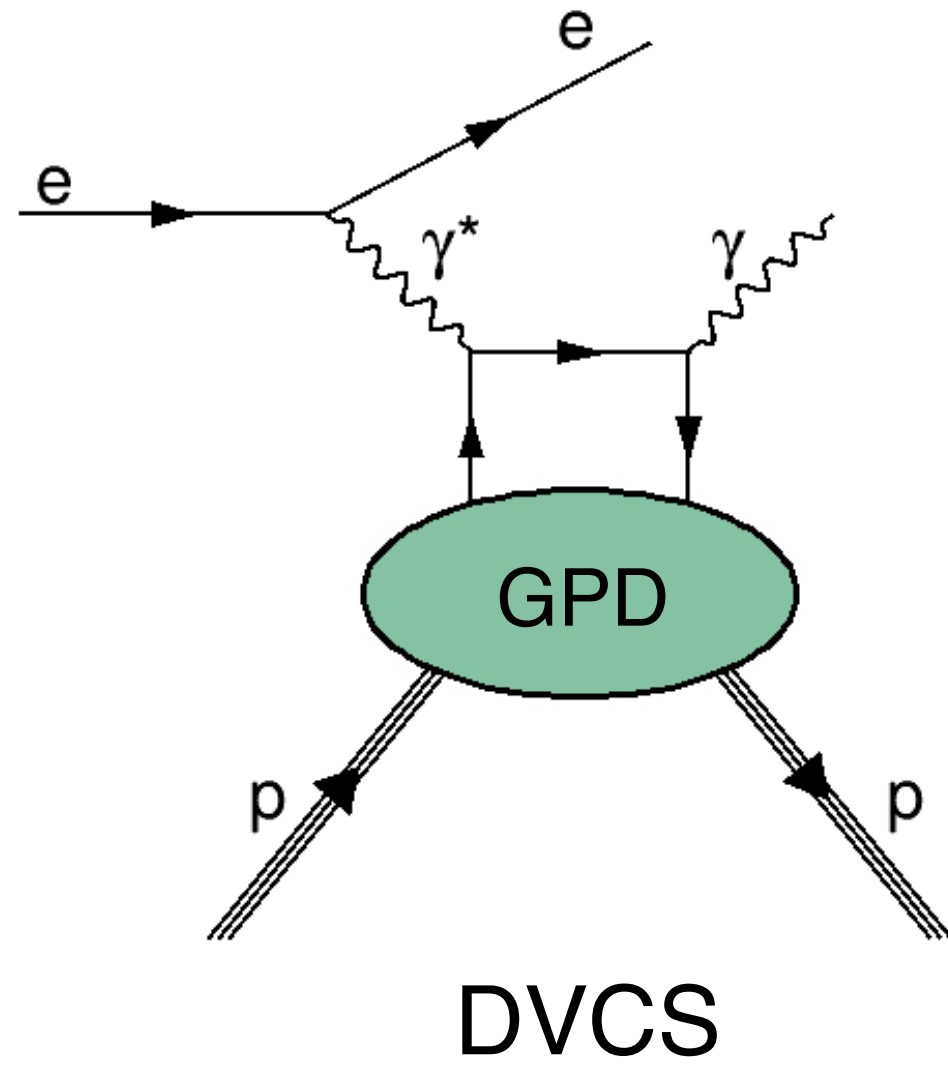


down to $x_B=10^{-5}$ at LHC in pA
 $x_B=10^{-6}$ at LHC in pp

Deeply Virtual Compton Scattering

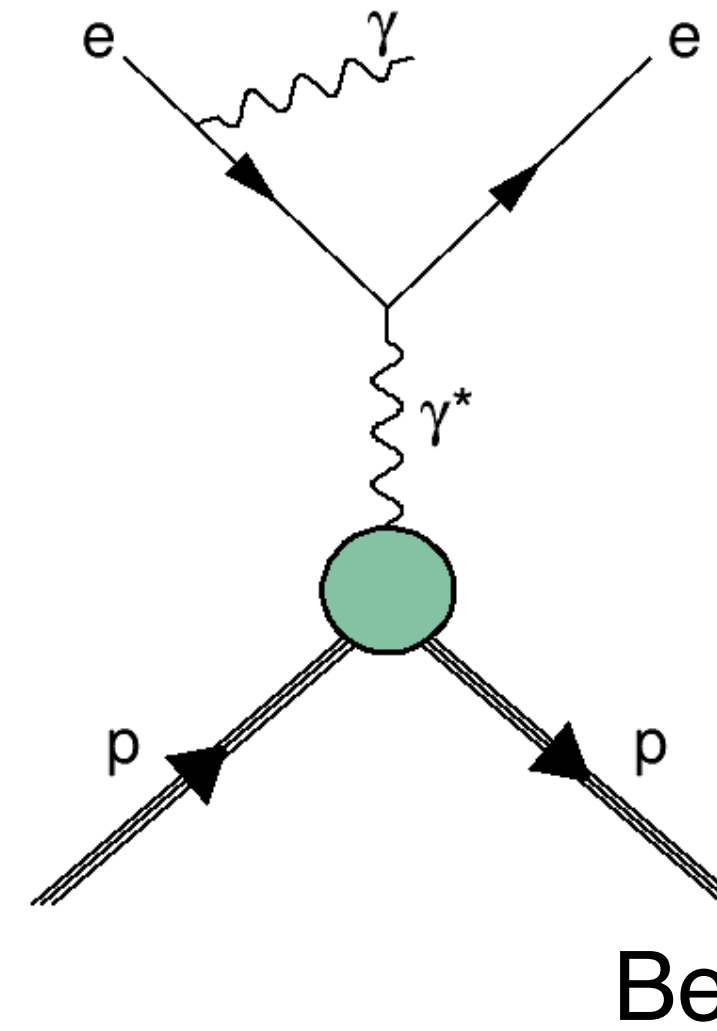
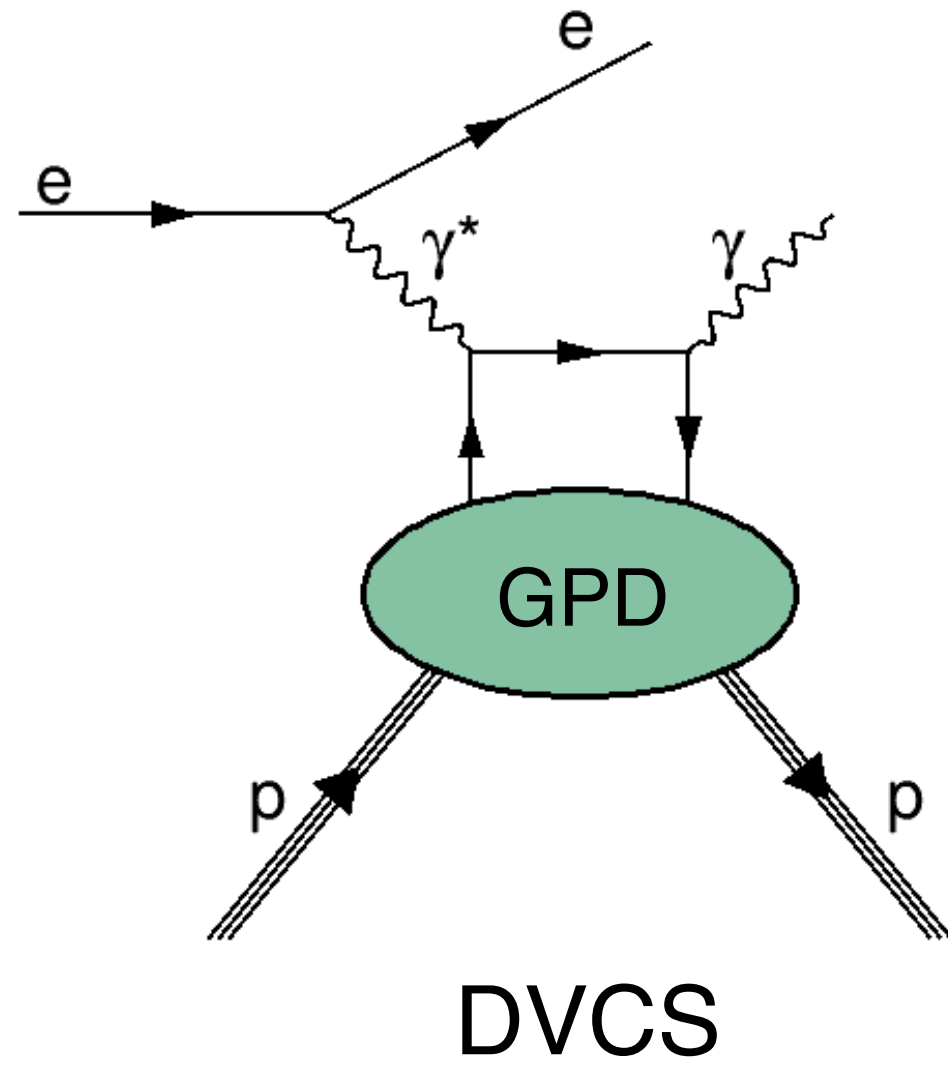


Deeply Virtual Compton Scattering



$$d\sigma = |\tau_{BH}|^2 + |\tau_{DVCS}|^2 + \tau_{DVCS}\tau_{BH}^* + \tau_{DVCS}^*\tau_{BH}$$

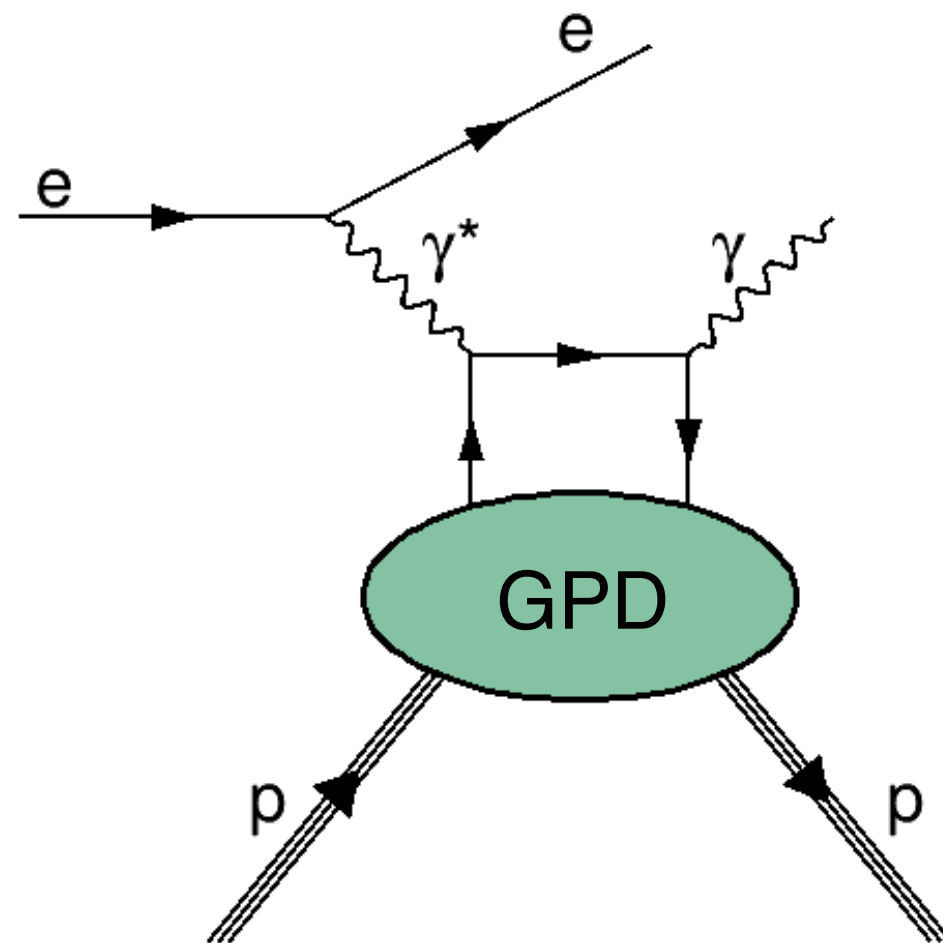
Deeply Virtual Compton Scattering



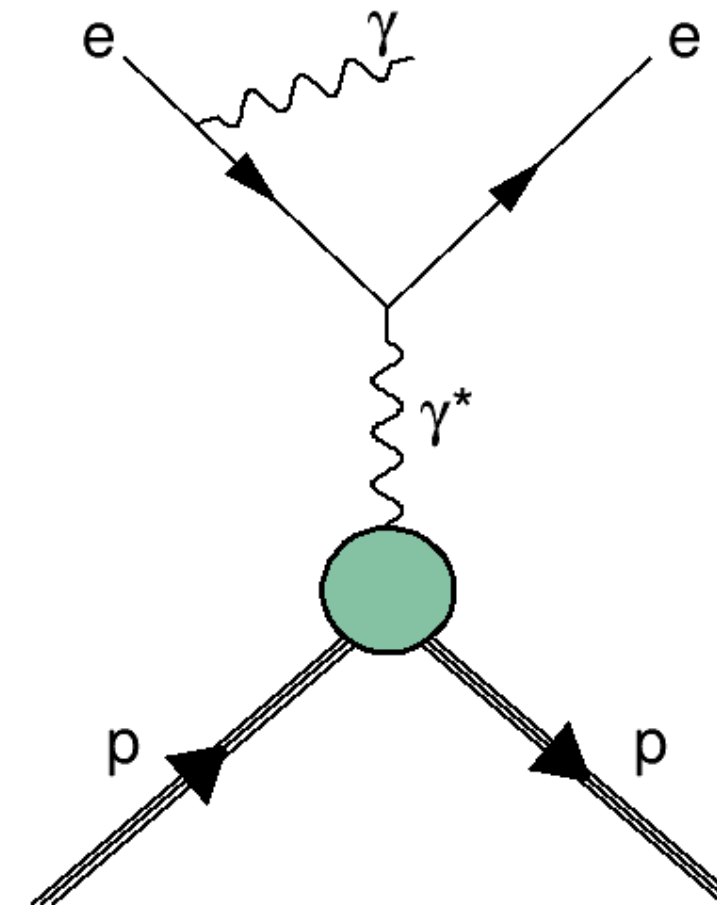
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calculable
with knowledge
form factors

Deeply Virtual Compton Scattering



DVCS



Bethe-Heitler

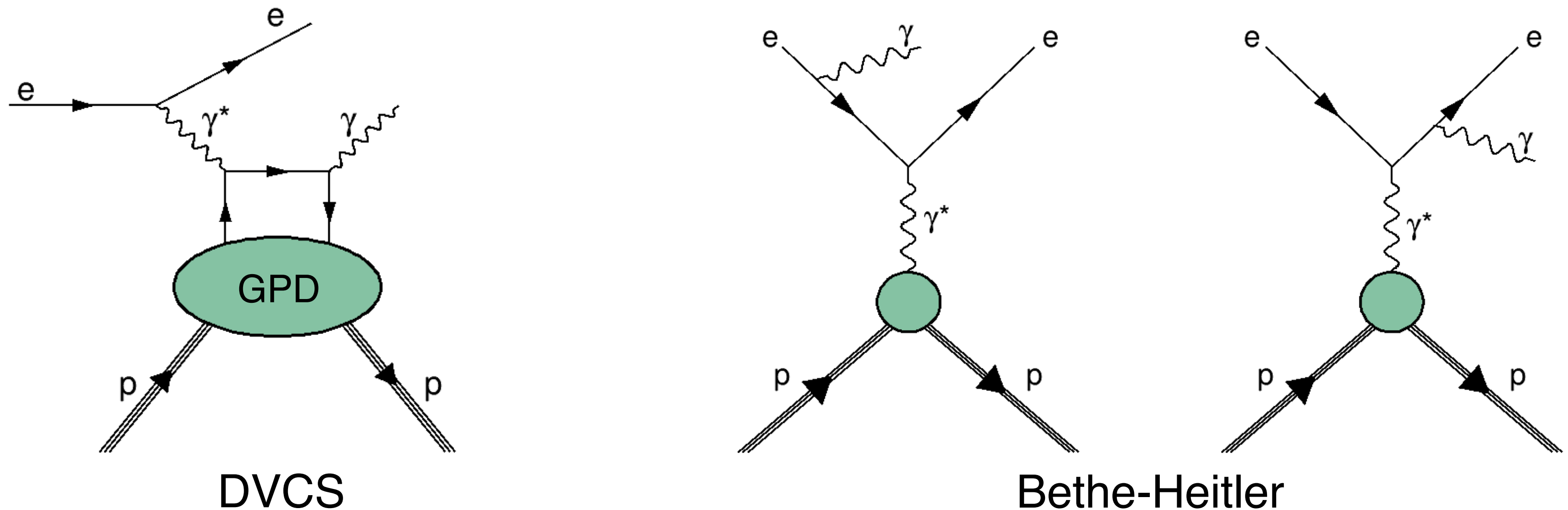
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calculable
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form factors

$\sim$ Compton Form Factors (CFFs)

$$\sim PV \int_{-1}^{+1} \frac{\text{GPDs}(x, \xi, t)}{x \pm \xi} dx \pm i\pi \text{GPDs}(\pm\xi, \xi, t) + \dots$$

Deeply Virtual Compton Scattering



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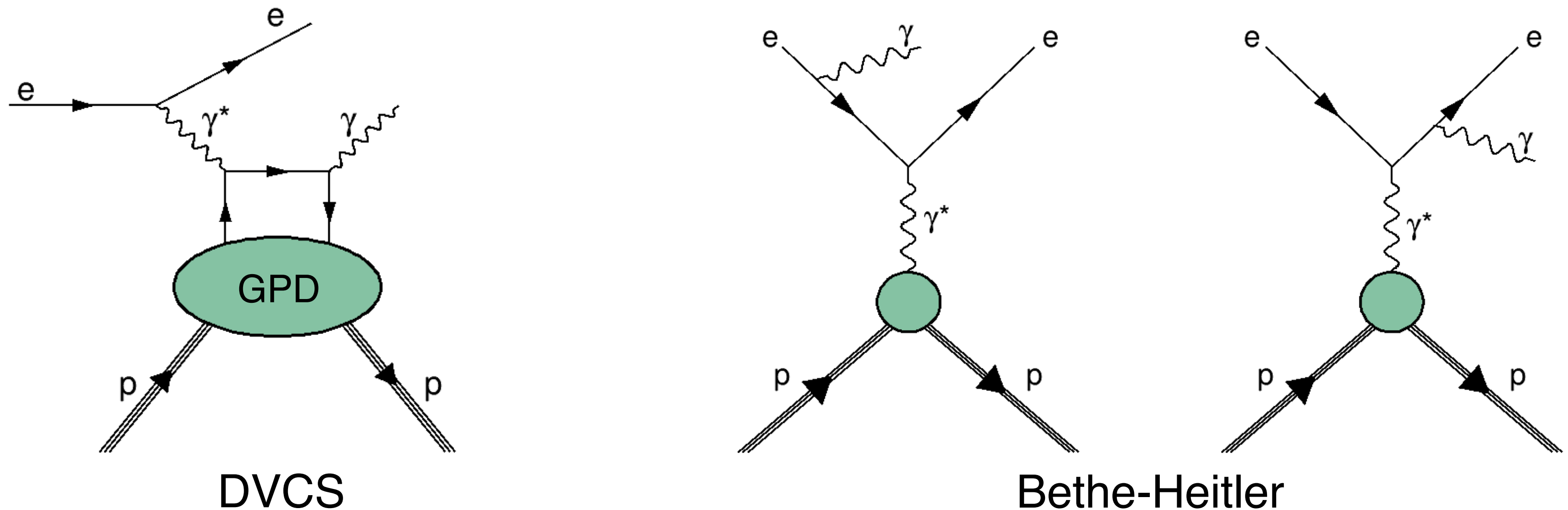
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Cross sections
Beam-charge asymmetries
Double-spin asymmetries

Deeply Virtual Compton Scattering



$$d\sigma = |\tau_{BH}|^2 + |\tau_{DVCS}|^2 + \tau_{DVCS}\tau_{BH}^* + \tau_{DVCS}^*\tau_{BH}$$

calculable
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~ Compton Form Factors (CFFs)

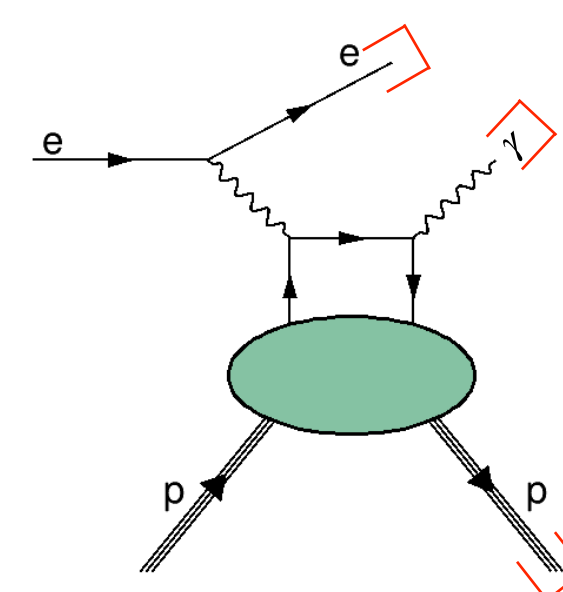
$$\sim PV \int_{-1}^{+1} \frac{\text{GPDs}(x, \xi, t)}{x \pm \xi} dx$$

Cross sections
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Double-spin asymmetries

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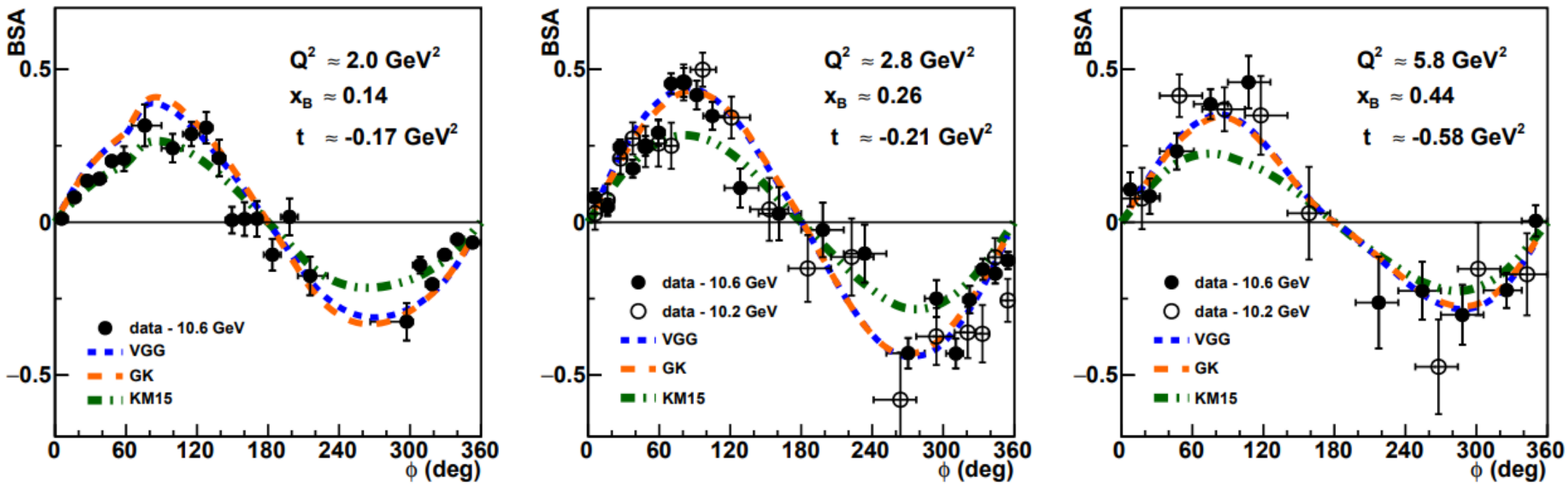
single-spin
asymmetries

DVCS off the proton



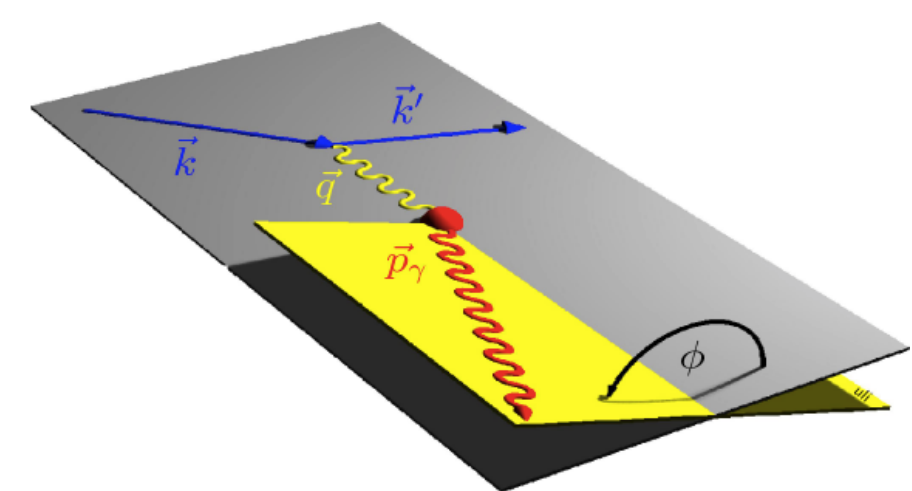
Beam-spin asymmetry

CLAS, Phys. Rrev. Lett. **130** (2023), 211902

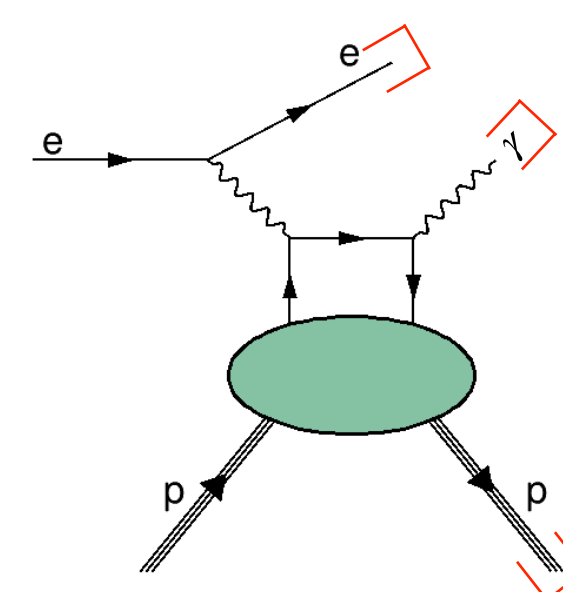


Vast extension of statistics: 64 bins in x_B, Q^2, t

$$\Im m \left[F_1 \mathcal{H} + \xi (F_1 + F_2) \tilde{\mathcal{H}} - \frac{t}{4M_p^2} F_2 \mathcal{E} \right]$$

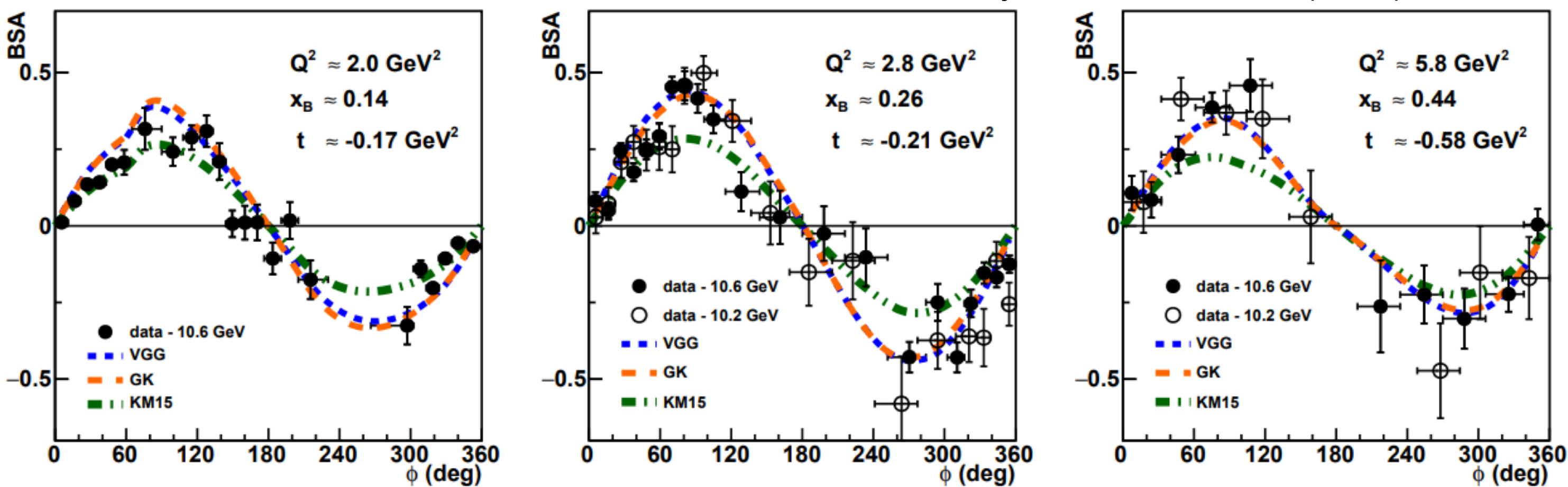


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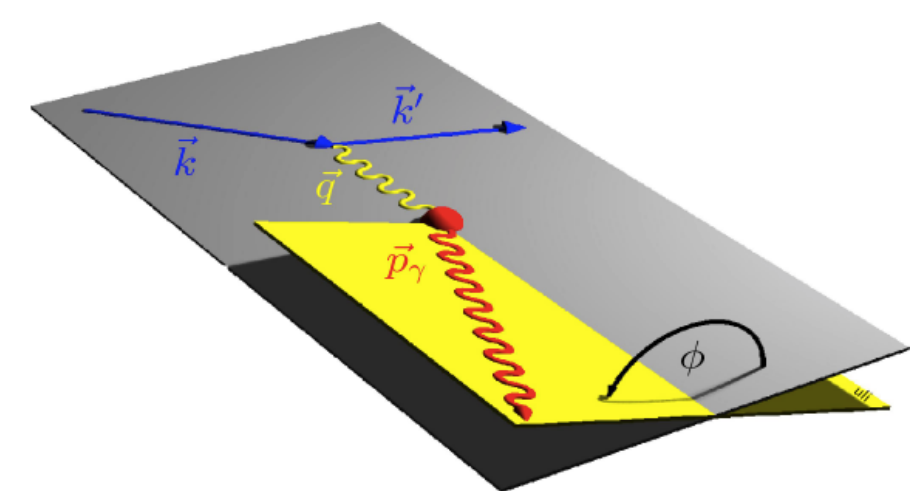
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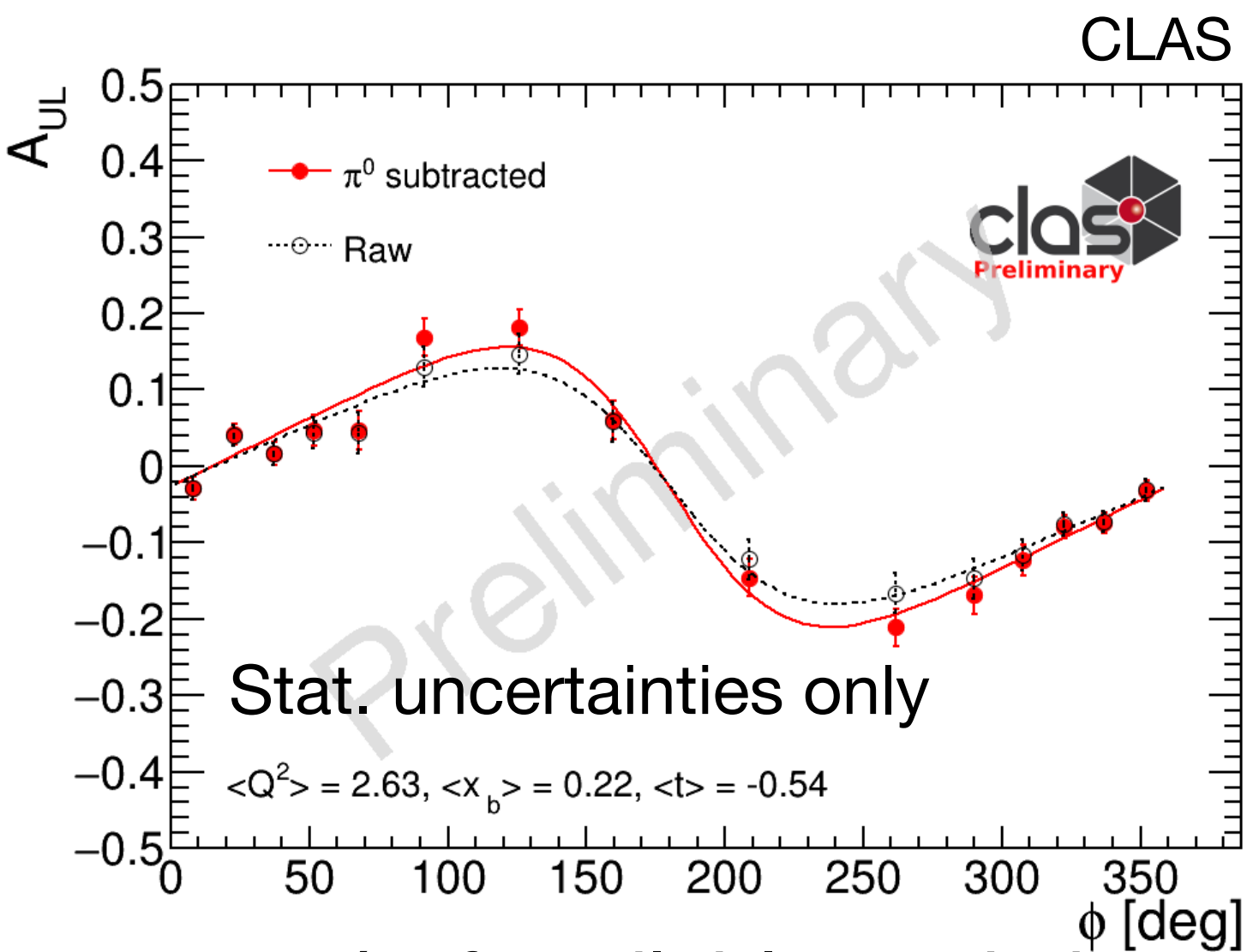


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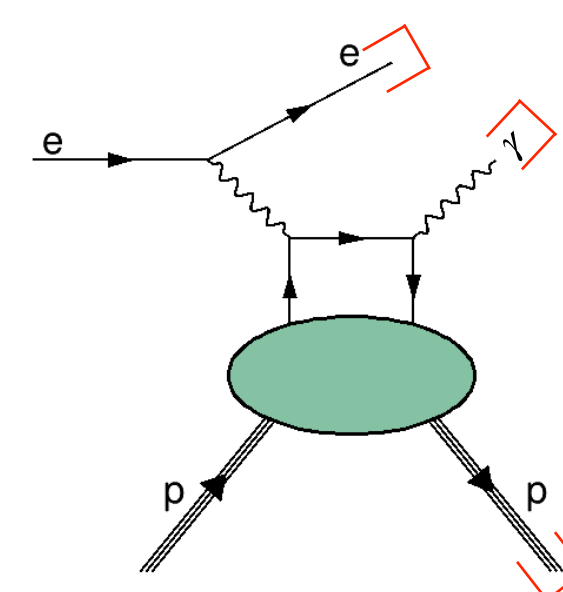
Longitudinal target-spin asymmetry



50% of available statistics

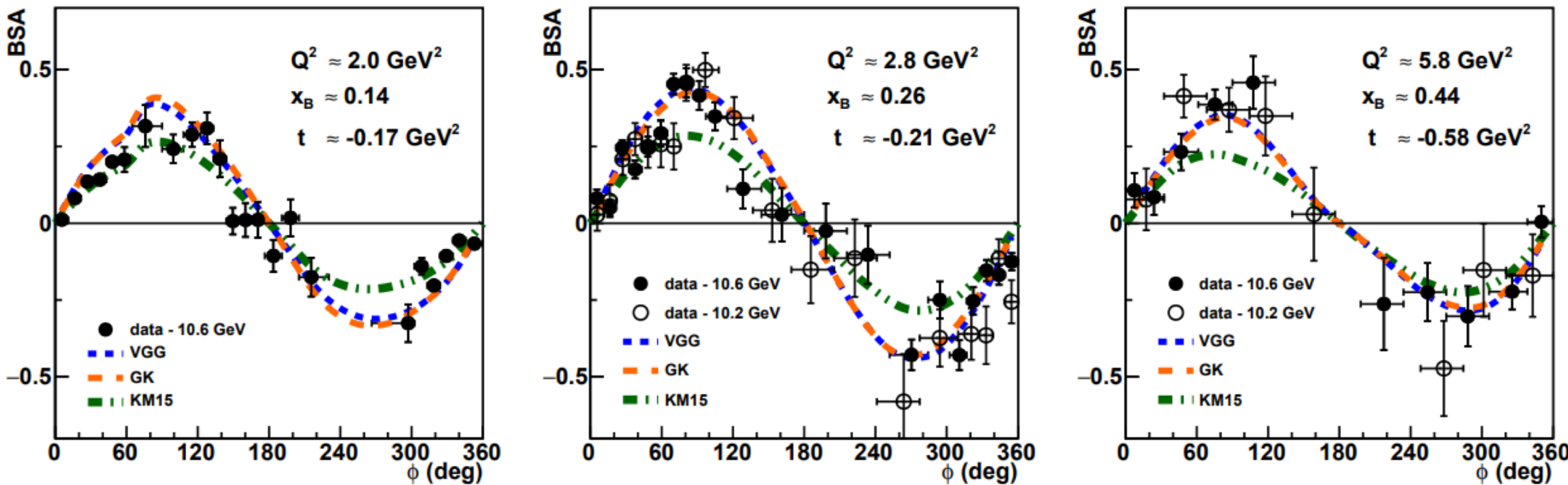
$$\Im m \left[F_1 \tilde{\mathcal{H}} + \xi (F_1 + F_2) \left(\mathcal{H} + \frac{x_B}{2} \mathcal{E} \right) - \xi \left(\frac{x_B}{2} F_1 + \frac{t}{4M_p^2} F_2 \right) \tilde{\mathcal{E}} \right]$$

DVCS off the proton

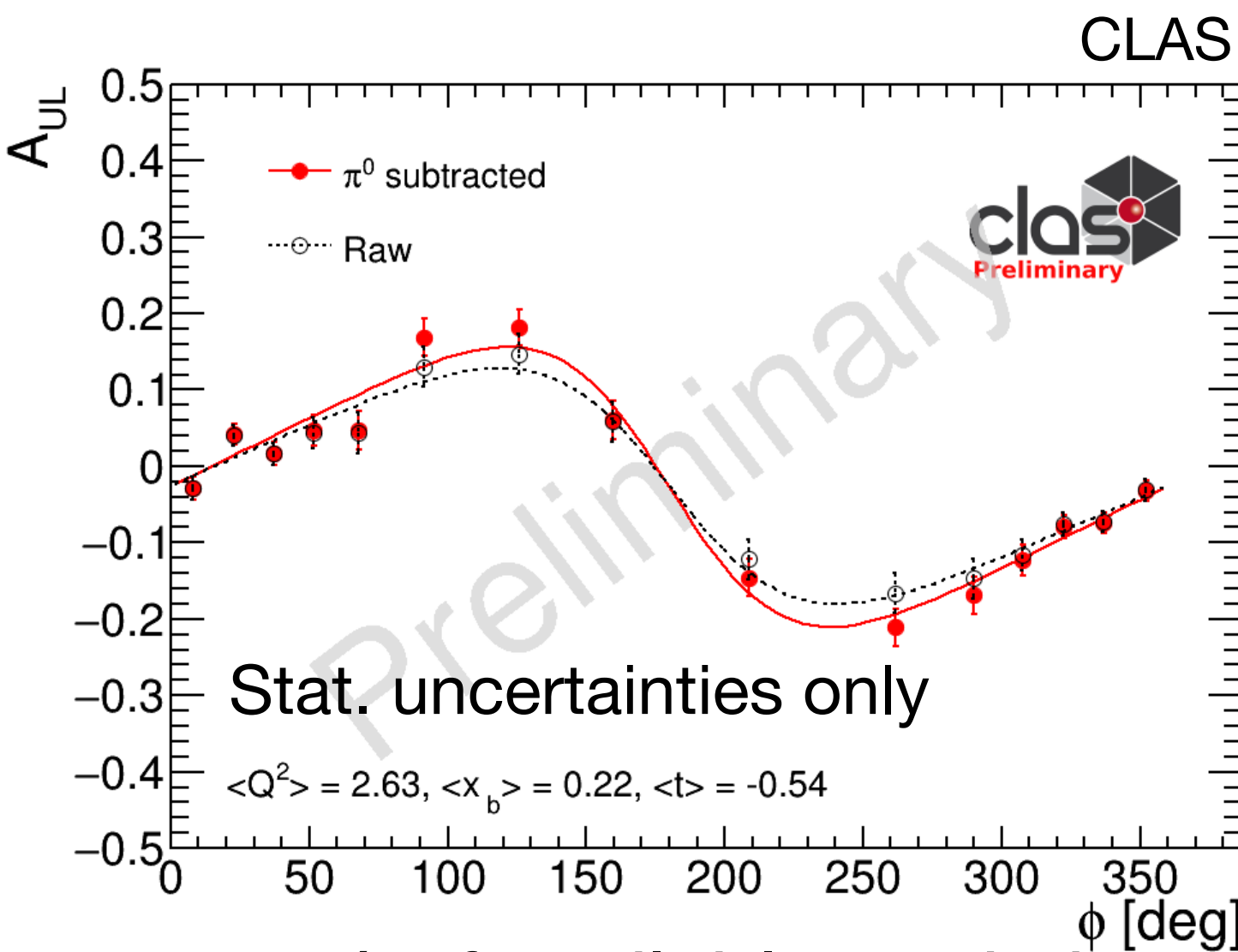


Beam-spin asymmetry

CLAS, Phys. Rrev. Lett. **130** (2023), 211902

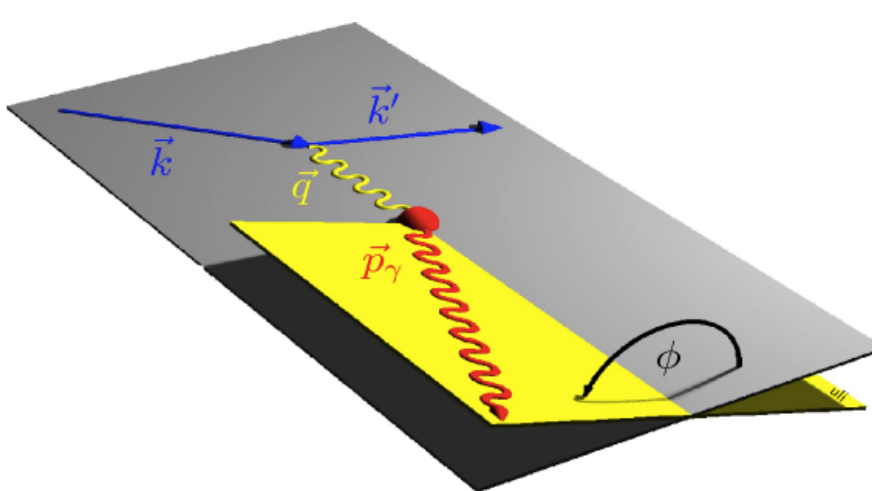


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Vast extension of statistics: 64 bins in x_B, Q^2, t

$$\Im m \left[F_1 \mathcal{H} + \xi(F_1 + F_2) \tilde{\mathcal{H}} - \frac{t}{4M_p^2} F_2 \mathcal{E} \right]$$

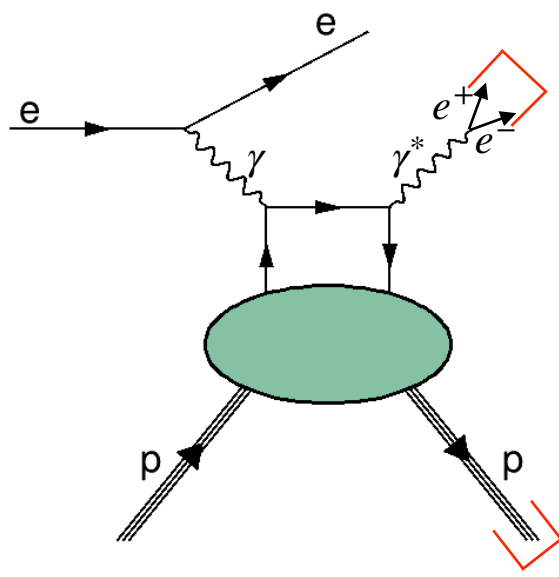


Combination:
clean separation of
 $\Im m \mathcal{H}$ and $\Im m \tilde{\mathcal{H}}$

50% of available statistics

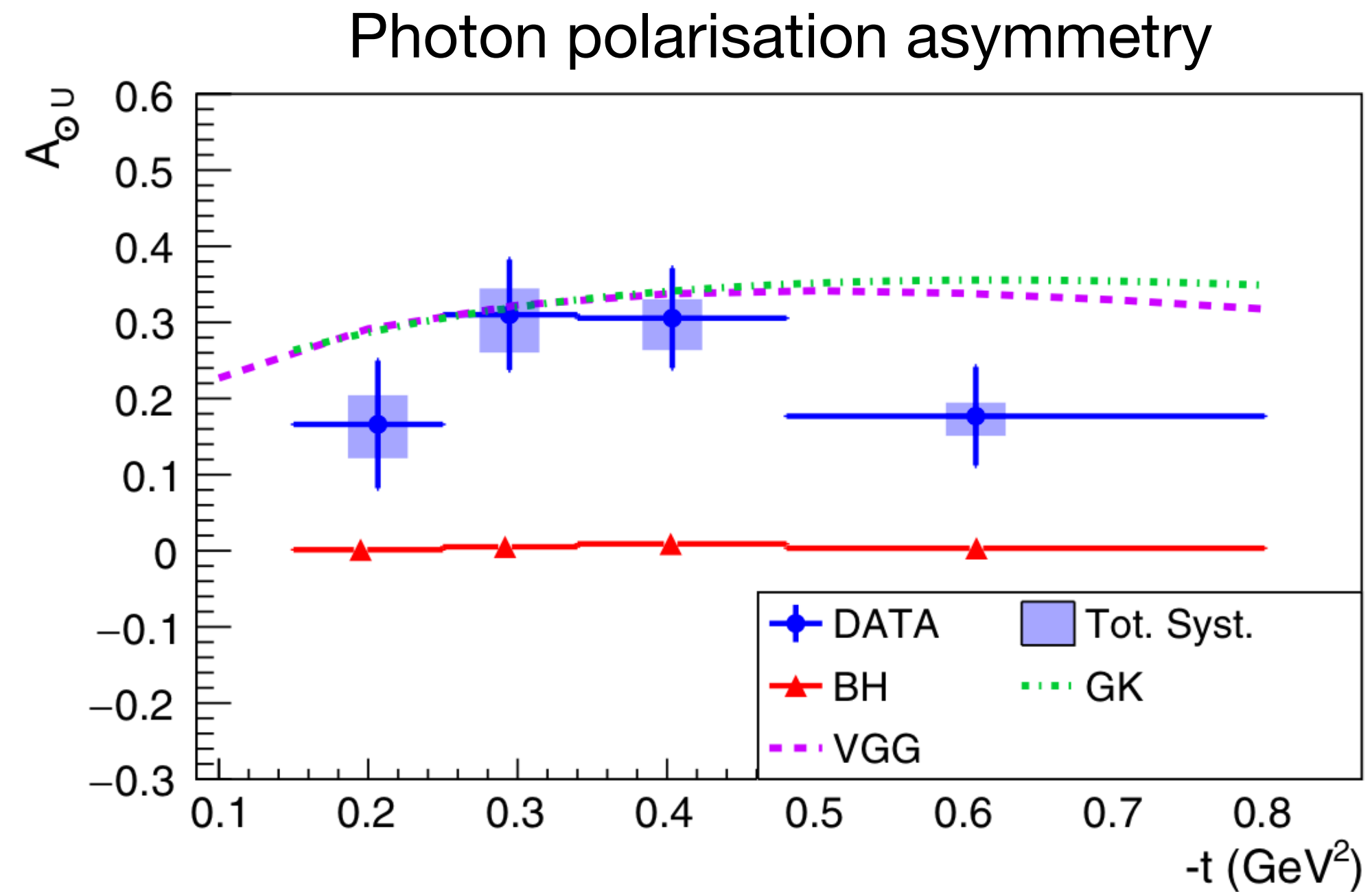
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TCS off the proton



First measurement

CLAS, Phys. Rev. Lett. **127** (2021) 262501

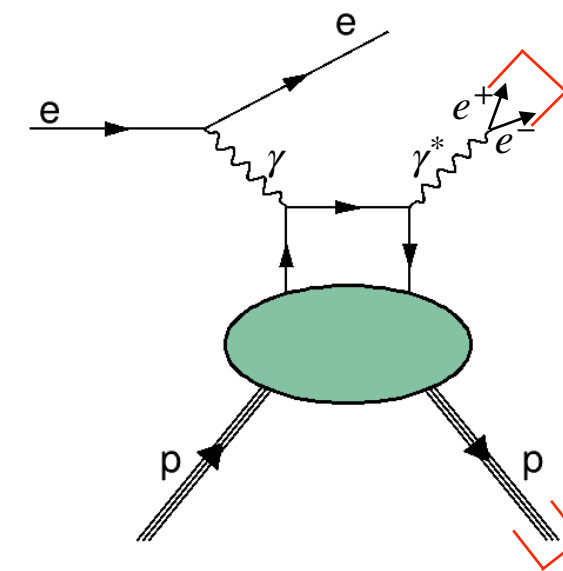


$\sim \text{Im}\mathcal{H}$: same information as DVCS at LO

Comparison with DVCS:

- test of universality
- understanding of QCD corrections

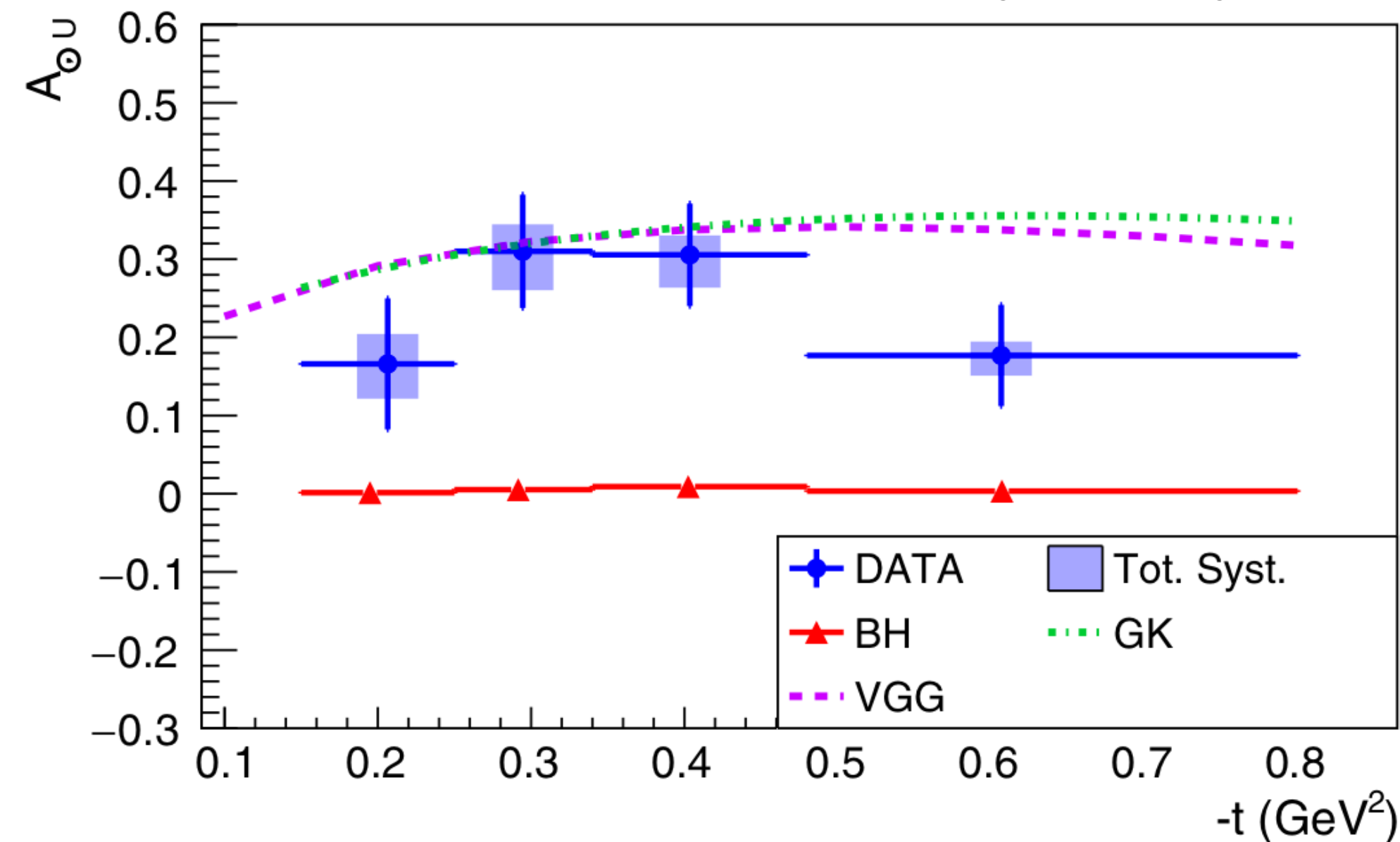
TCS off the proton



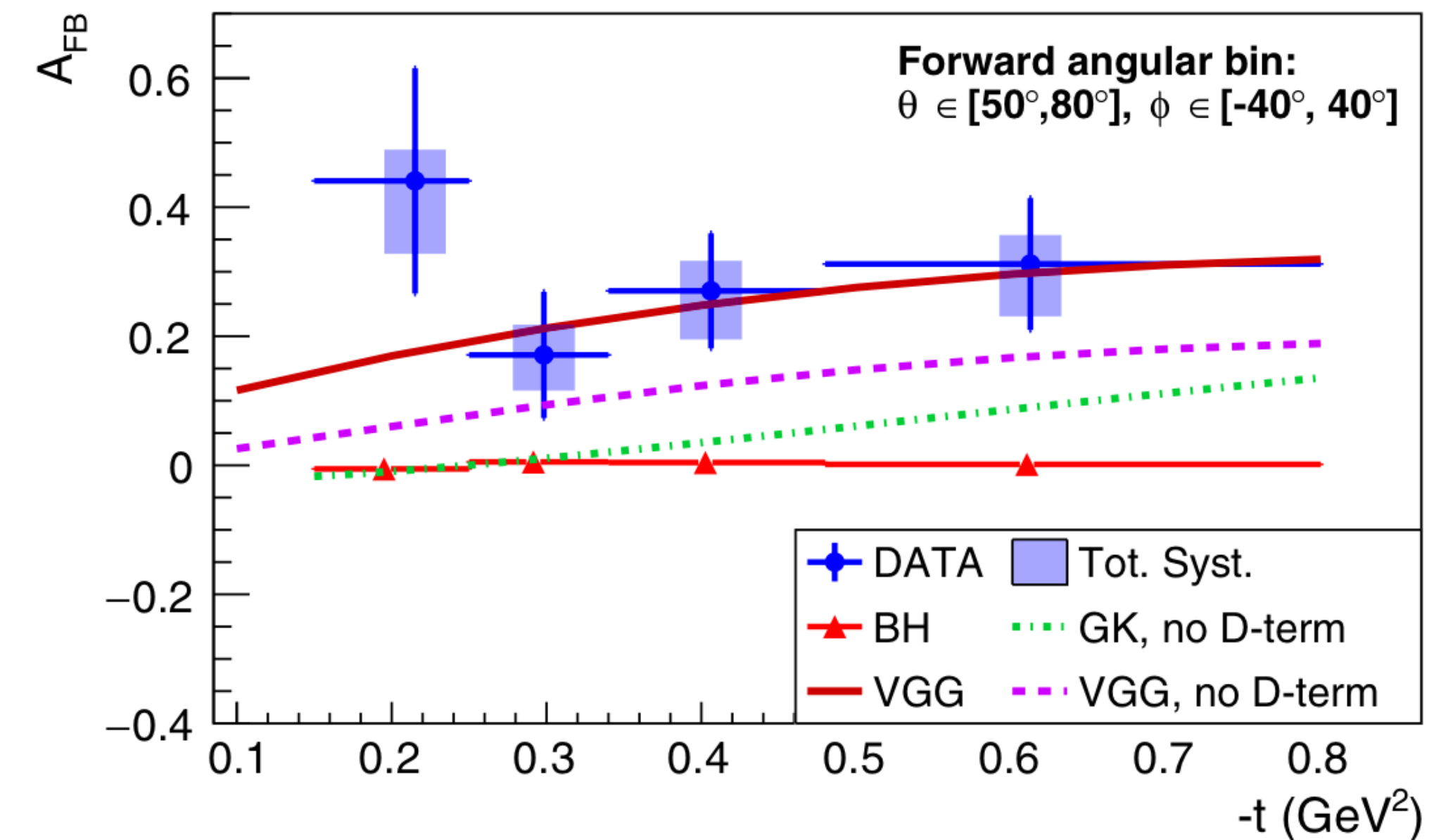
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Photon polarisation asymmetry



Forward-backward asymmetry



$\sim \text{Im}\mathcal{H}$: same information as DVCS at LO

Comparison with DVCS:

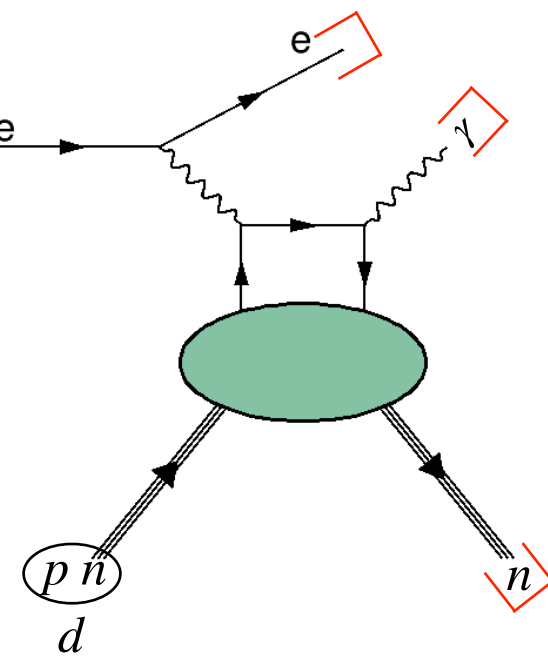
- test of universality
- understanding of QCD corrections

$$A_{\text{FB}}(\theta, \phi) = \frac{d\sigma(\theta, \phi) - d\sigma(180^\circ - \theta, 180^\circ + \phi)}{d\sigma(\theta, \phi) + d\sigma(180^\circ - \theta, 180^\circ + \phi)}$$

$\sim \text{Re}\mathcal{H}$

DVCS off the neutron

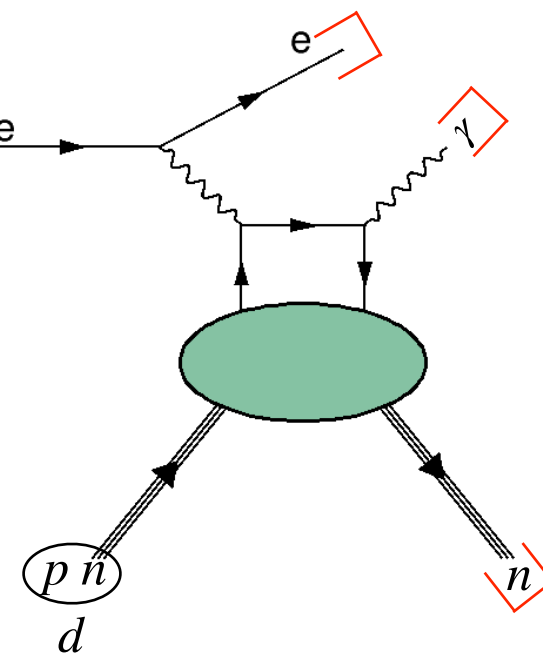
$$\vec{e} + d \rightarrow e + \gamma + n$$



DVCS off the neutron

Quark-flavour separation of GPDs

$$\vec{e} + d \rightarrow e + \gamma + n$$



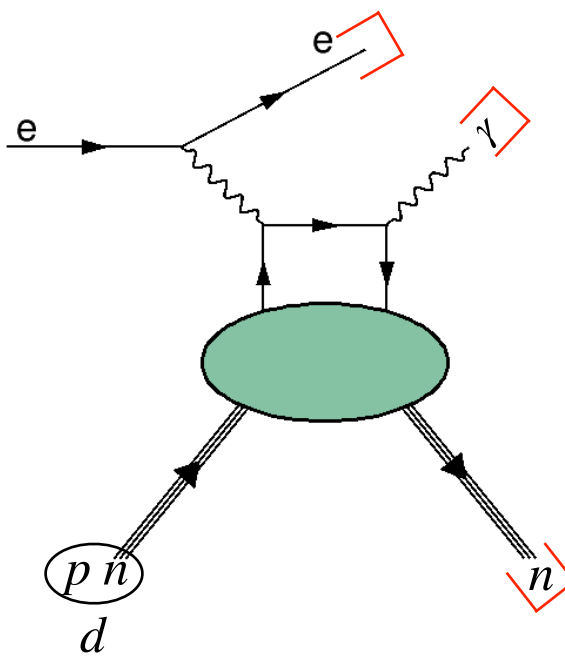
DVCS off the neutron

Quark-flavour separation of GPDs

Beam-spin asymmetry

$$\Im m \left[F_1 \mathcal{H} + \xi (F_1 + F_2) \tilde{\mathcal{H}} - \frac{t}{4M_p^2} F_2 \mathcal{E} \right]$$

$$\vec{e} + d \rightarrow e + \gamma + n$$



DVCS off the neutron

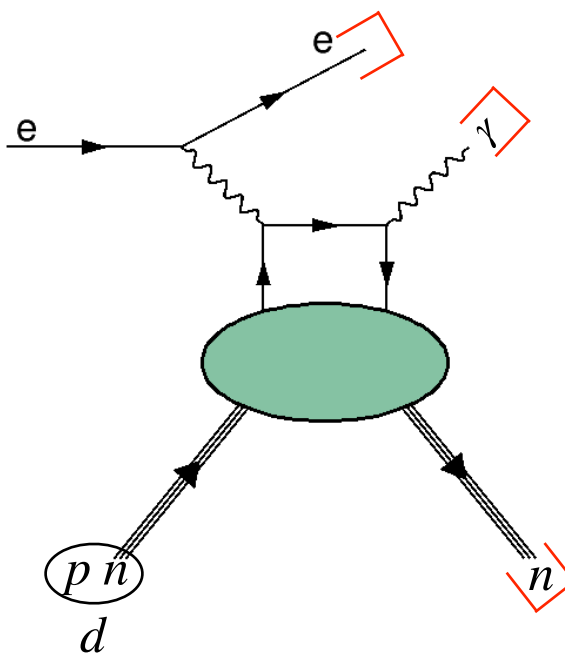
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proton target

$$\vec{e} + d \rightarrow e + \gamma + n$$



DVCS off the neutron

Quark-flavour separation of GPDs

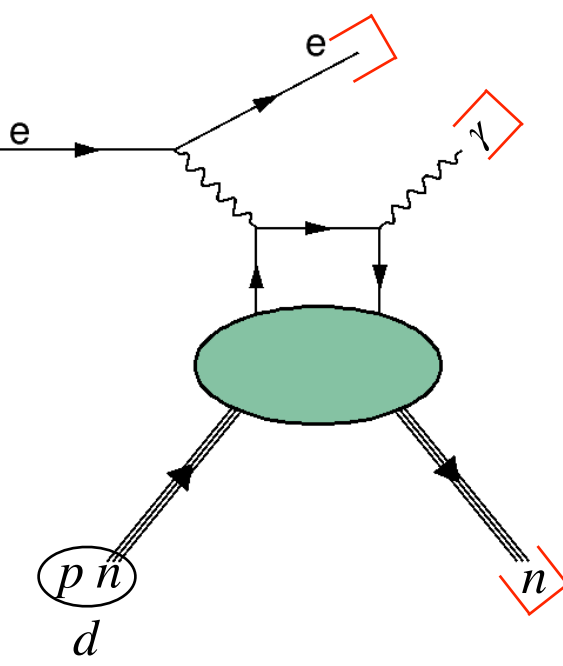
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proton target

neutron target : high sensitivity to GPD E

$$\vec{e} + d \rightarrow e + \gamma + n$$



DVCS off the neutron

Quark-flavour separation of GPDs

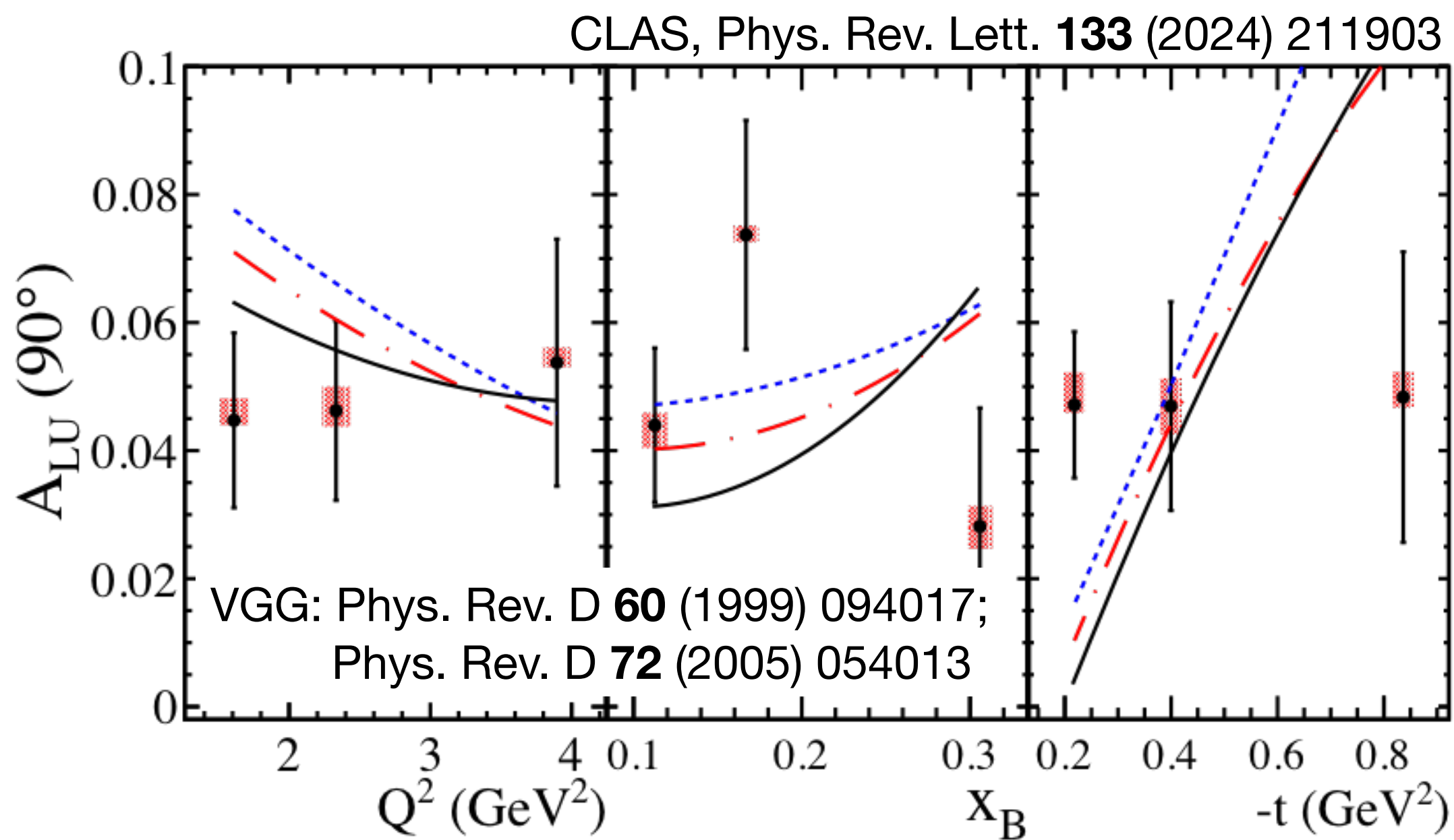
Beam-spin asymmetry

$$\Im m \left[F_1 \mathcal{H} + \xi(F_1 + F_2) \tilde{\mathcal{H}} - \frac{t}{4M_p^2} F_2 \mathcal{E} \right]$$

proton target

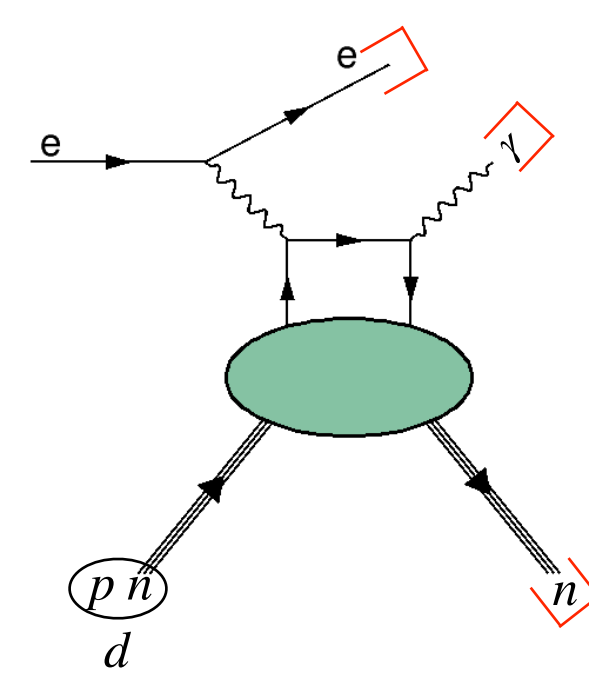
neutron target : high sensitivity to GPD E

First measurement with active detection of neutron, by CLAS.



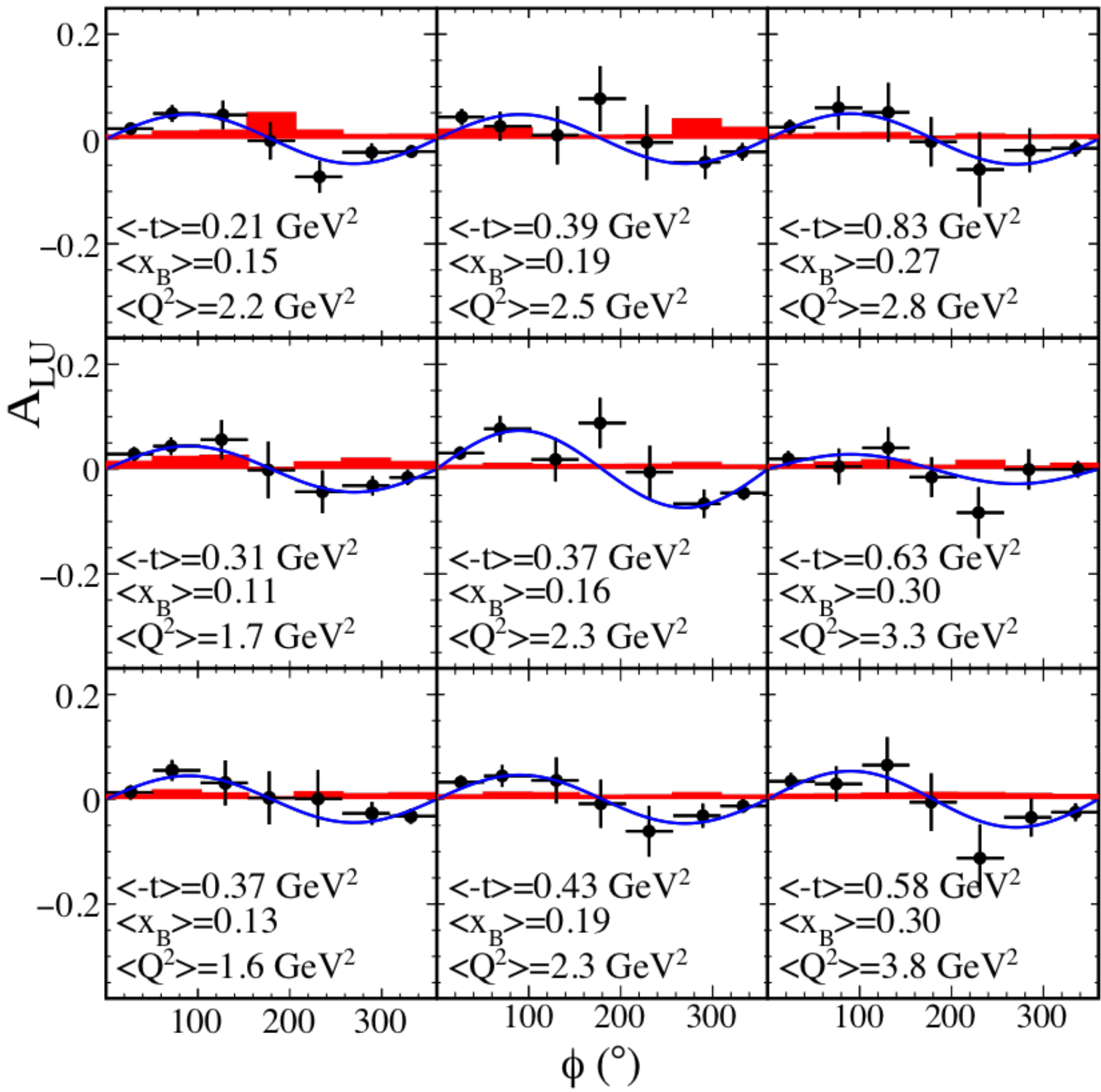
Data favour $0.0 < J_d < 0.2$

$$\vec{e} + d \rightarrow e + \gamma + n$$

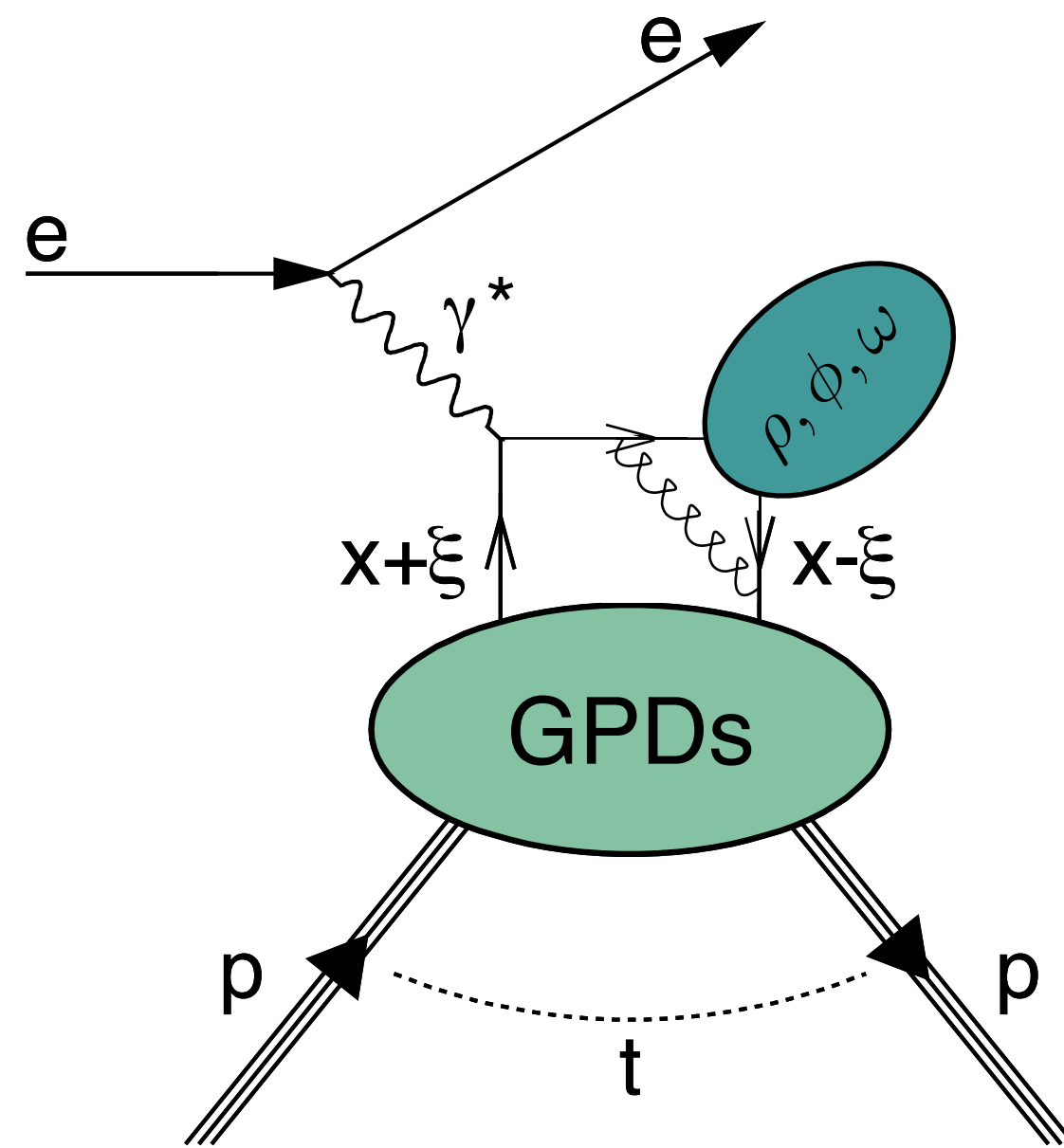


Beam-spin asymmetry

CLAS, Phys. Rev. Lett. **133** (2024) 211903



Exclusive vector-meson production



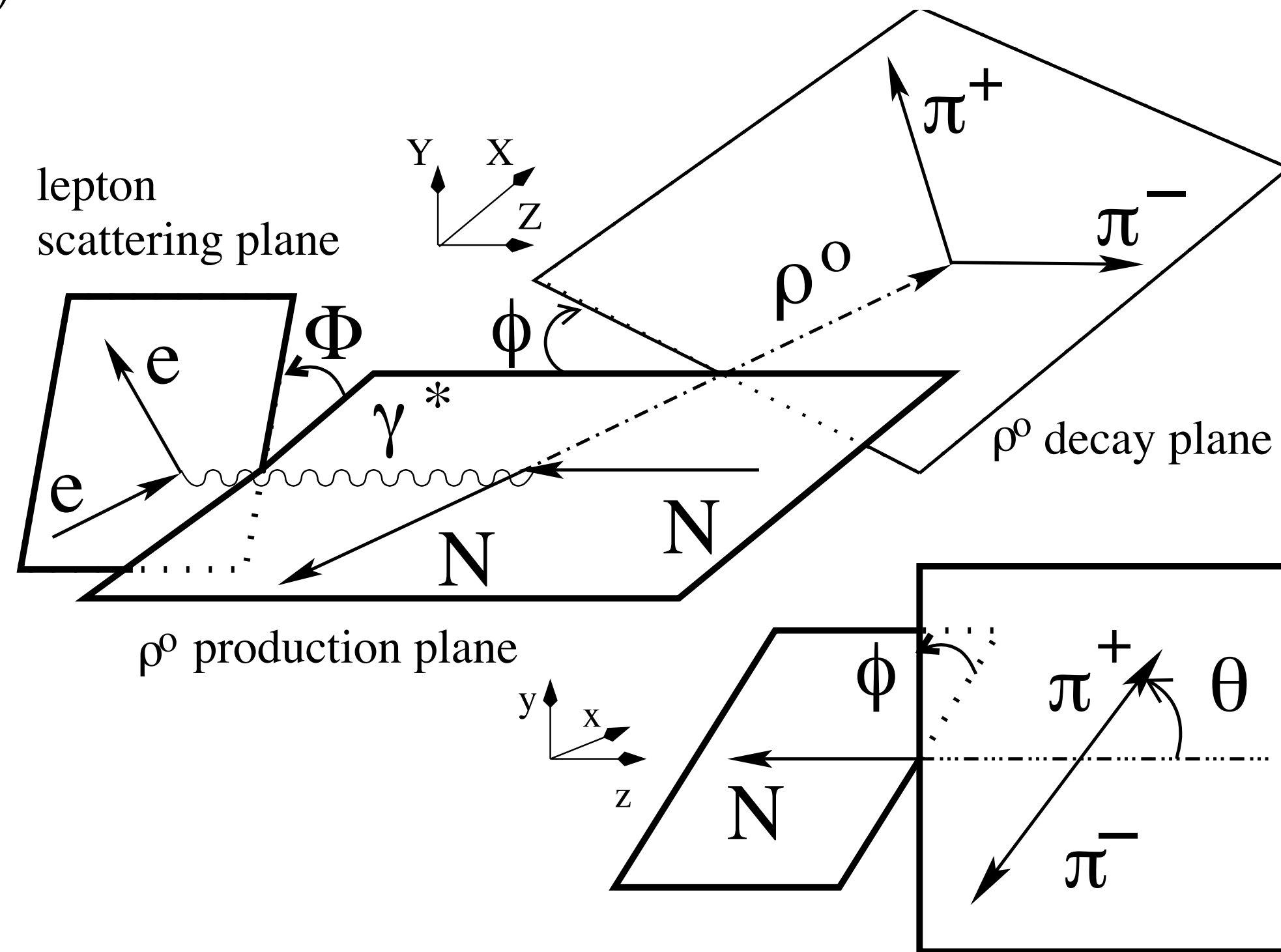
Access to GPDs

$$H, E, H_T, \bar{E}_T = 2\tilde{H}_T + E_T$$

$$\tilde{H}, \tilde{E}$$

Angular distributions

$$l + p \rightarrow l + p + \rho^0 (\rightarrow \pi^+ + \pi^-)$$

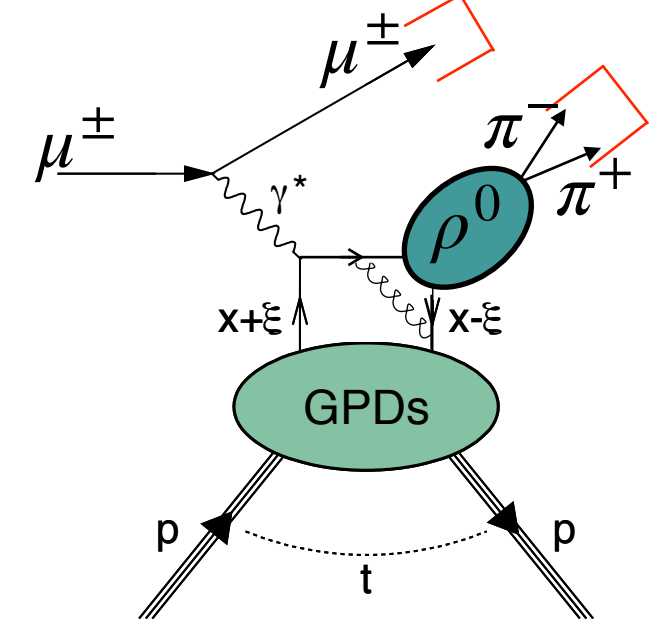


Fit angular distribution of decay pions $\mathcal{W}(\Phi, \phi, \Theta)$ and extract either Spin Density Matrix Elements (SDMEs) or helicity amplitude ratios

Exclusive ρ^0 production : SDMEs

COMPASS: EPJC **83** (2023) 924

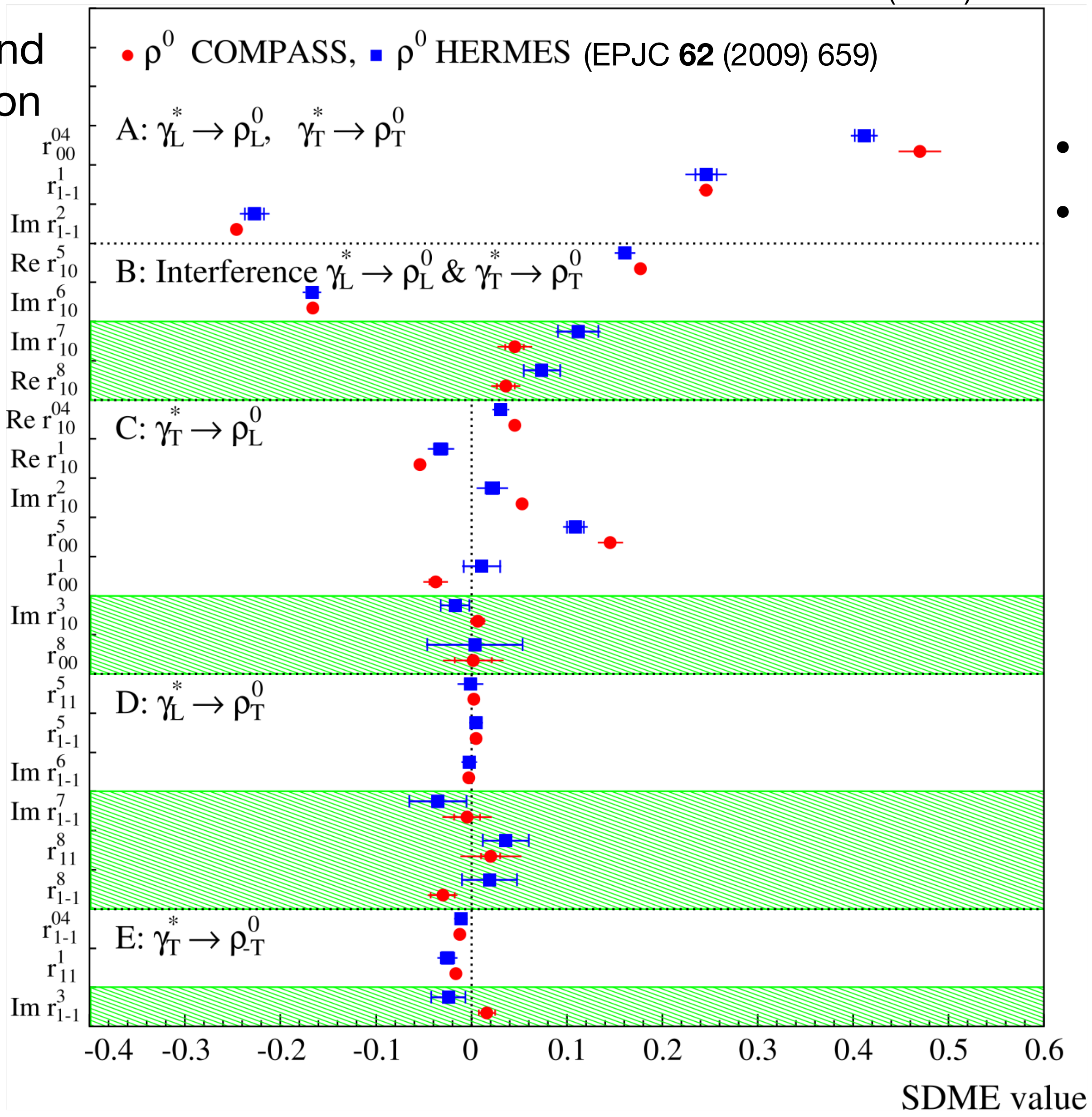
Unpolarised proton target and longitudinally polarised lepton beam



- 5 classes of SDMEs
- unpolarised and polarised SDMEs

HERMES:
 $\langle Q^2 \rangle = 1.96 \text{ GeV}^2$
 $\langle W \rangle = 4.8 \text{ GeV}^2$

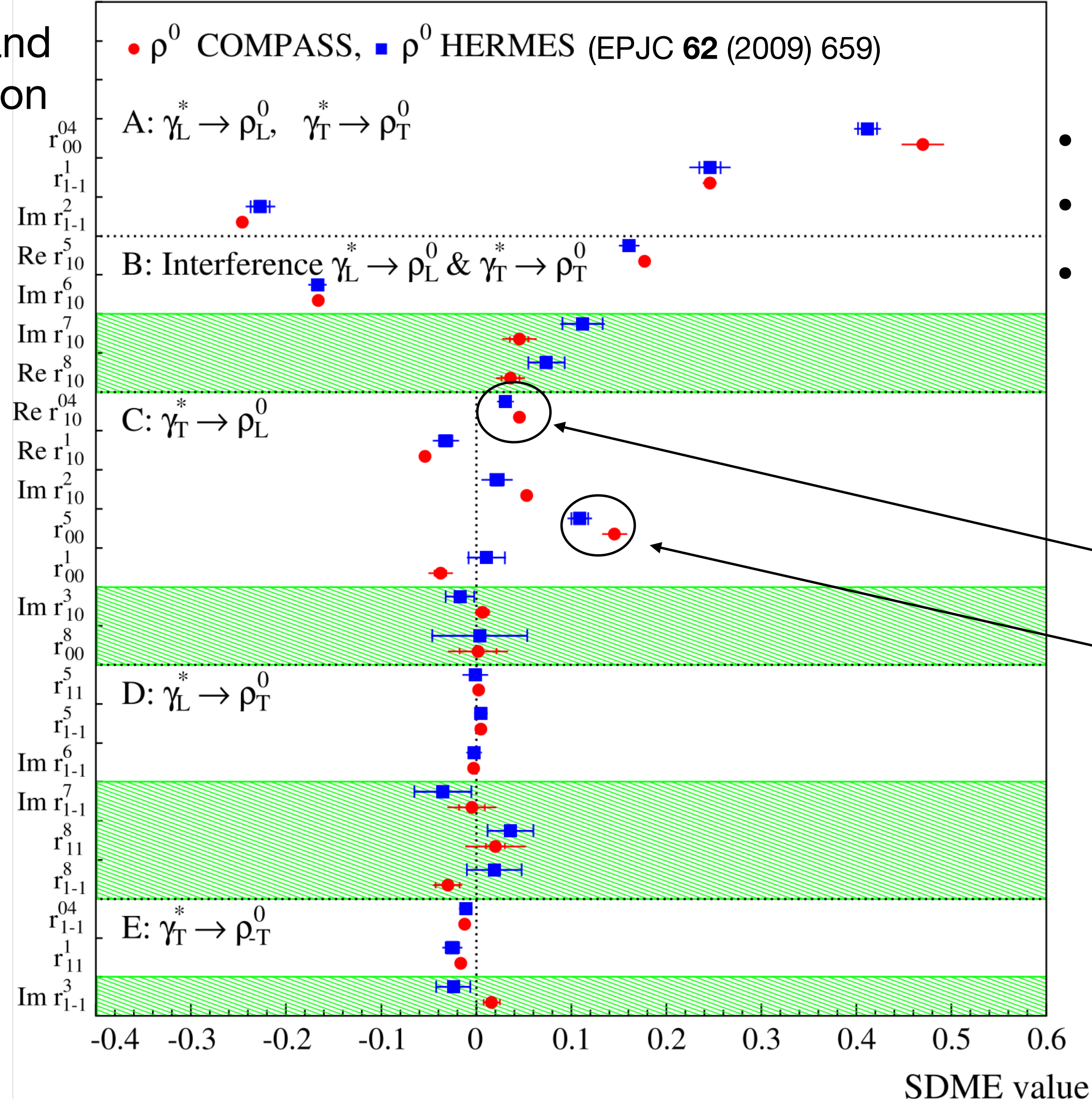
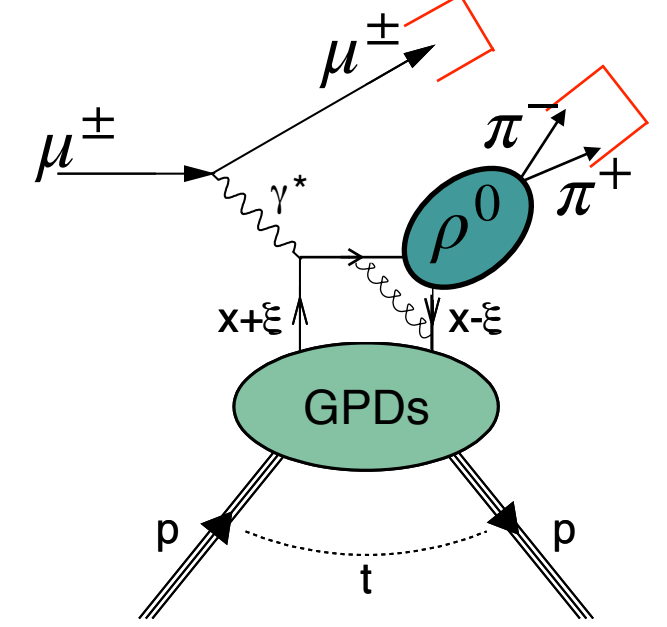
COMPASS:
 $\langle Q^2 \rangle = 2.40 \text{ GeV}^2$
 $\langle W \rangle = 9.9 \text{ GeV}^2$



Exclusive ρ^0 production : SDMEs

COMPASS: EPJC **83** (2023) 924

Unpolarised proton target and longitudinally polarised lepton beam



- 5 classes of SDMEs
- unpolarised and polarised SDMEs
- s-channel helicity conservation ($\lambda_{\gamma^*} = \lambda_{\rho^0}$):
 - fulfilled for class A & B
 - class C - strong violation:

$$\Re r_{10}^{04} \neq 0 \text{ by } > 4\sigma$$

$$\Re r_{00}^5 \neq 0 \text{ by } > 9\sigma$$

$$H_T, \bar{E}_T = 2\tilde{H}_T + E_T$$

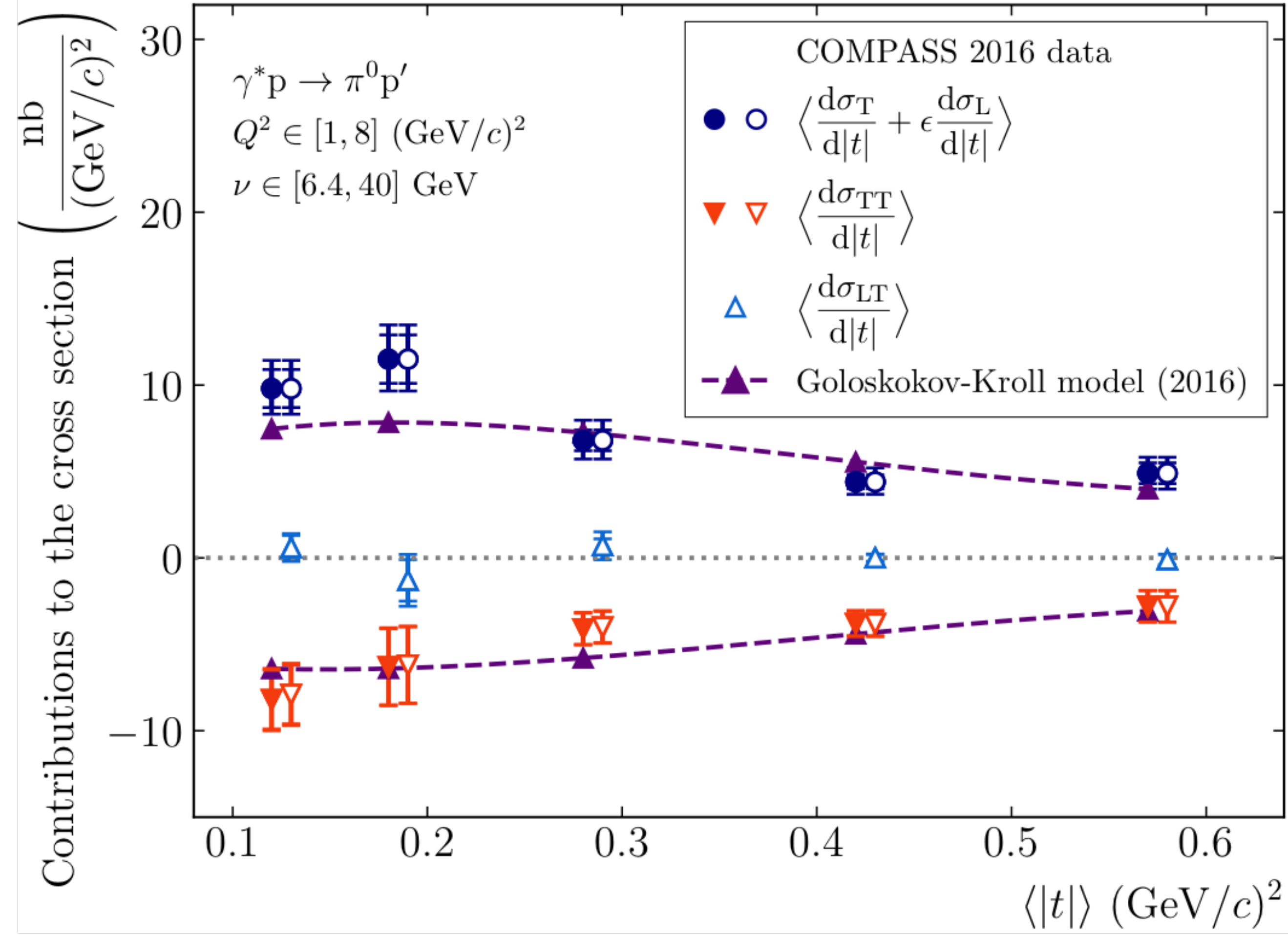
(In Goloskokov-Kroll model:
 $k_\perp$ factorisation assumed)

HERMES:
 $\langle Q^2 \rangle = 1.96 \text{ GeV}^2$
 $\langle W \rangle = 4.8 \text{ GeV}^2$

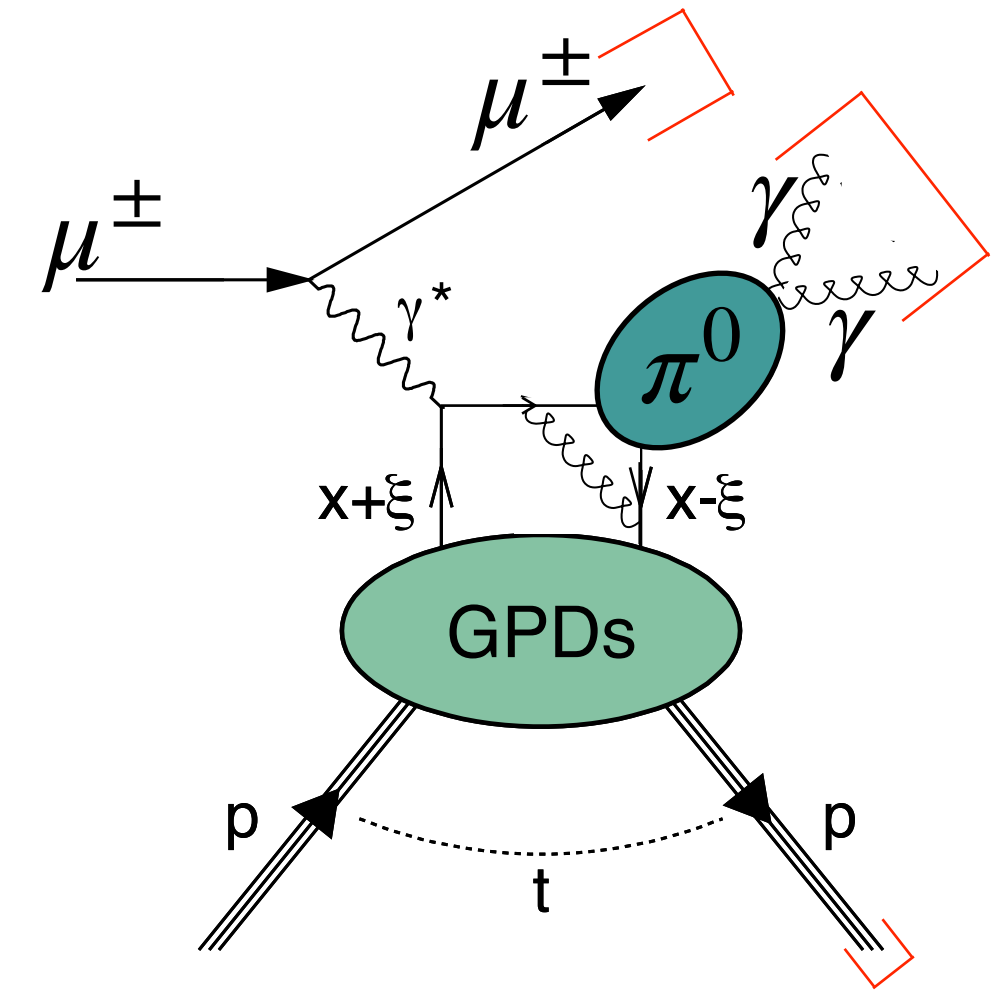
COMPASS:
 $\langle Q^2 \rangle = 2.40 \text{ GeV}^2$
 $\langle W \rangle = 9.9 \text{ GeV}^2$

Exclusive π^0 production

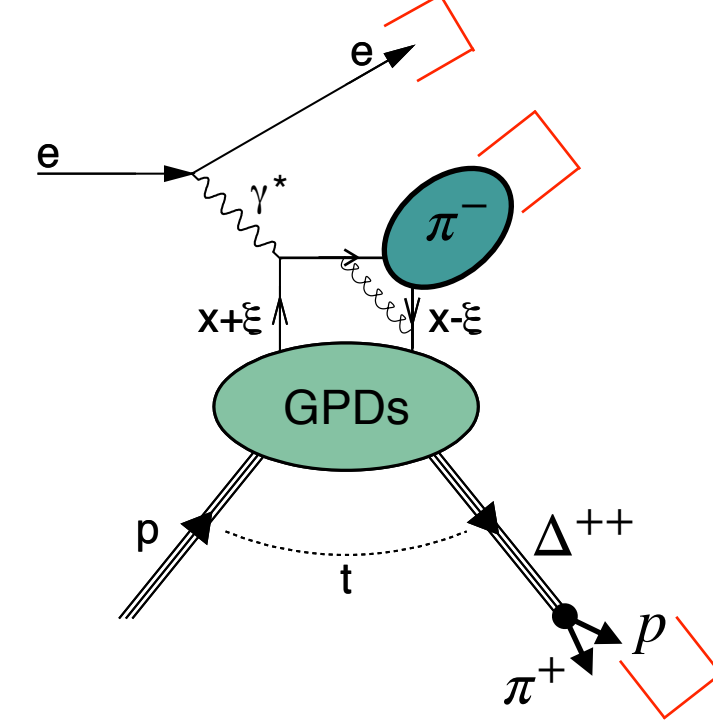
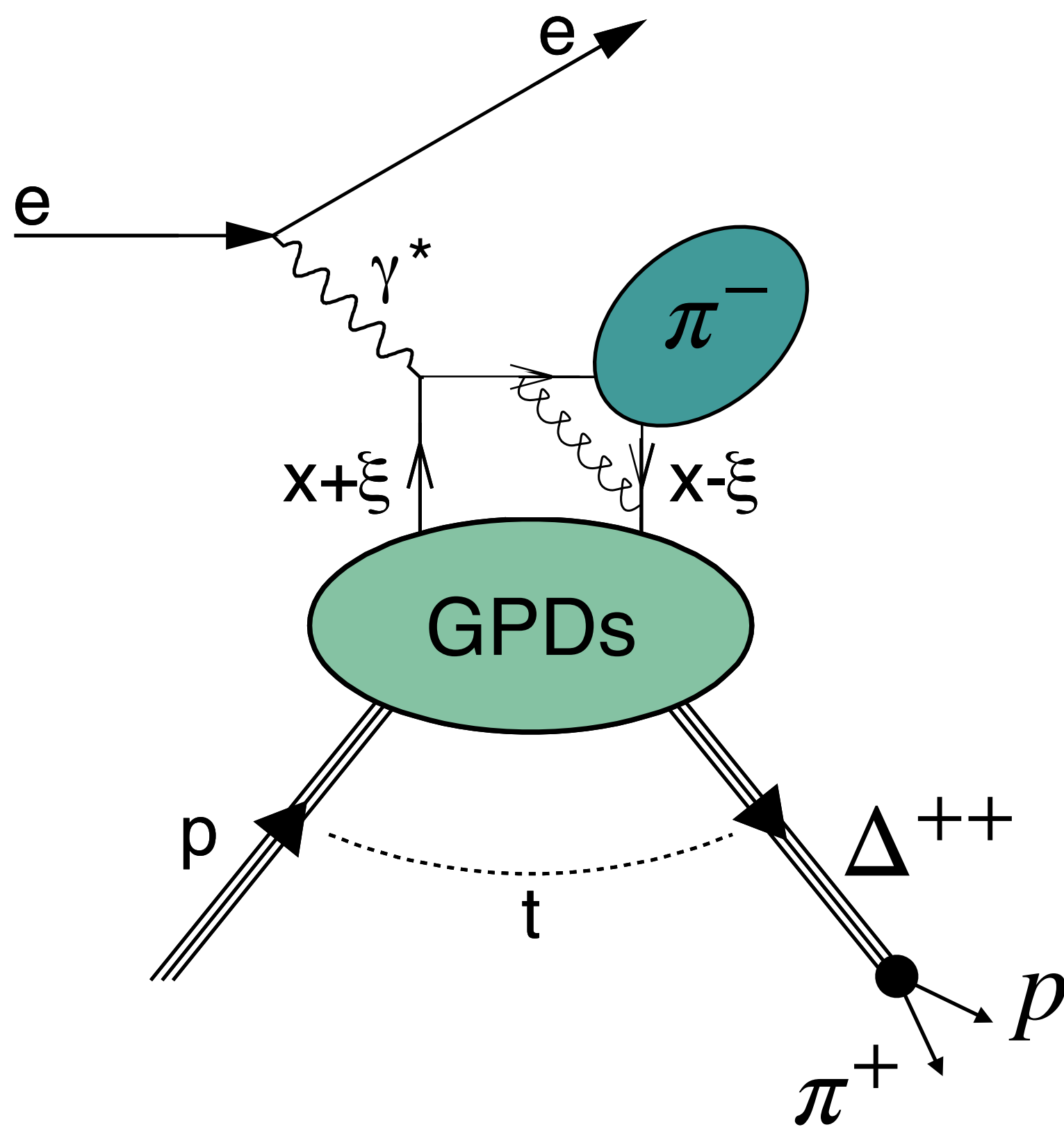
COMPASS, Phys. Lett. B (2025) 139832
arXiv:2412.19923



$\longrightarrow \tilde{H}, \tilde{E}, H_T, \bar{E}_T$
 $\longrightarrow H_T, \tilde{E}$
 $\longrightarrow \bar{E}_T = 2\tilde{H}_T + E_T$

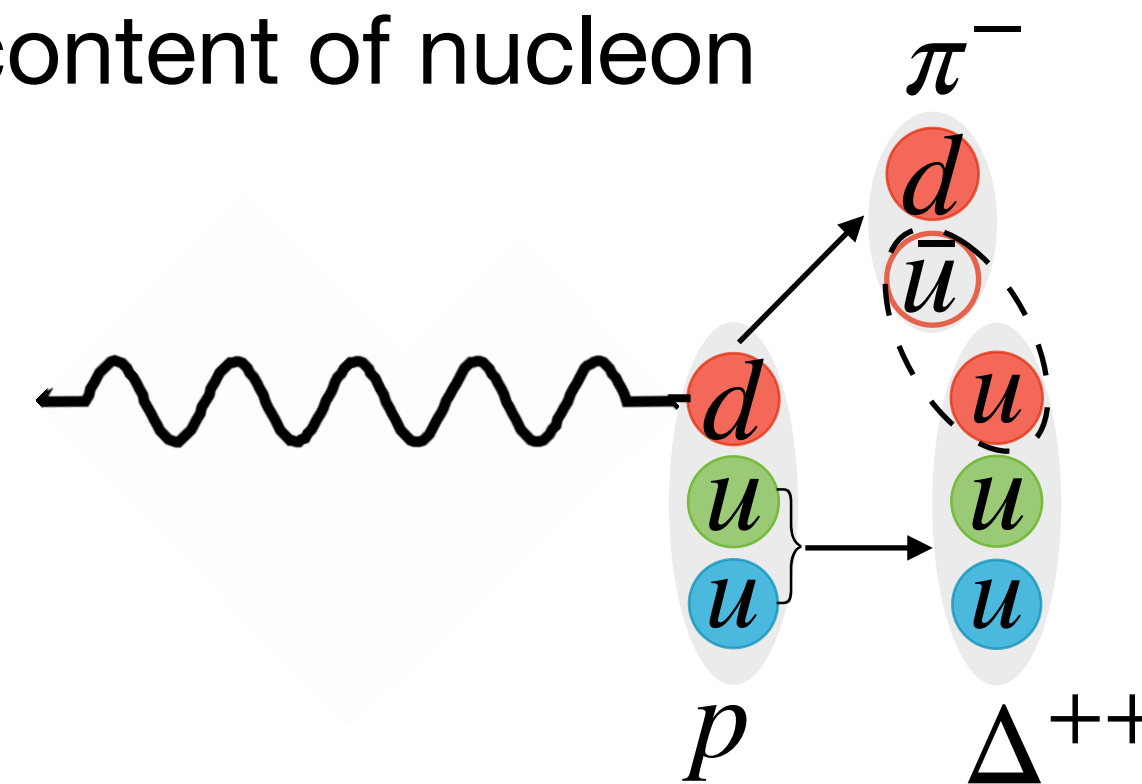


Access to transition GPDs



First measurement of $\vec{e} + p \rightarrow e + \pi^- + \Delta^{++}$ in DIS

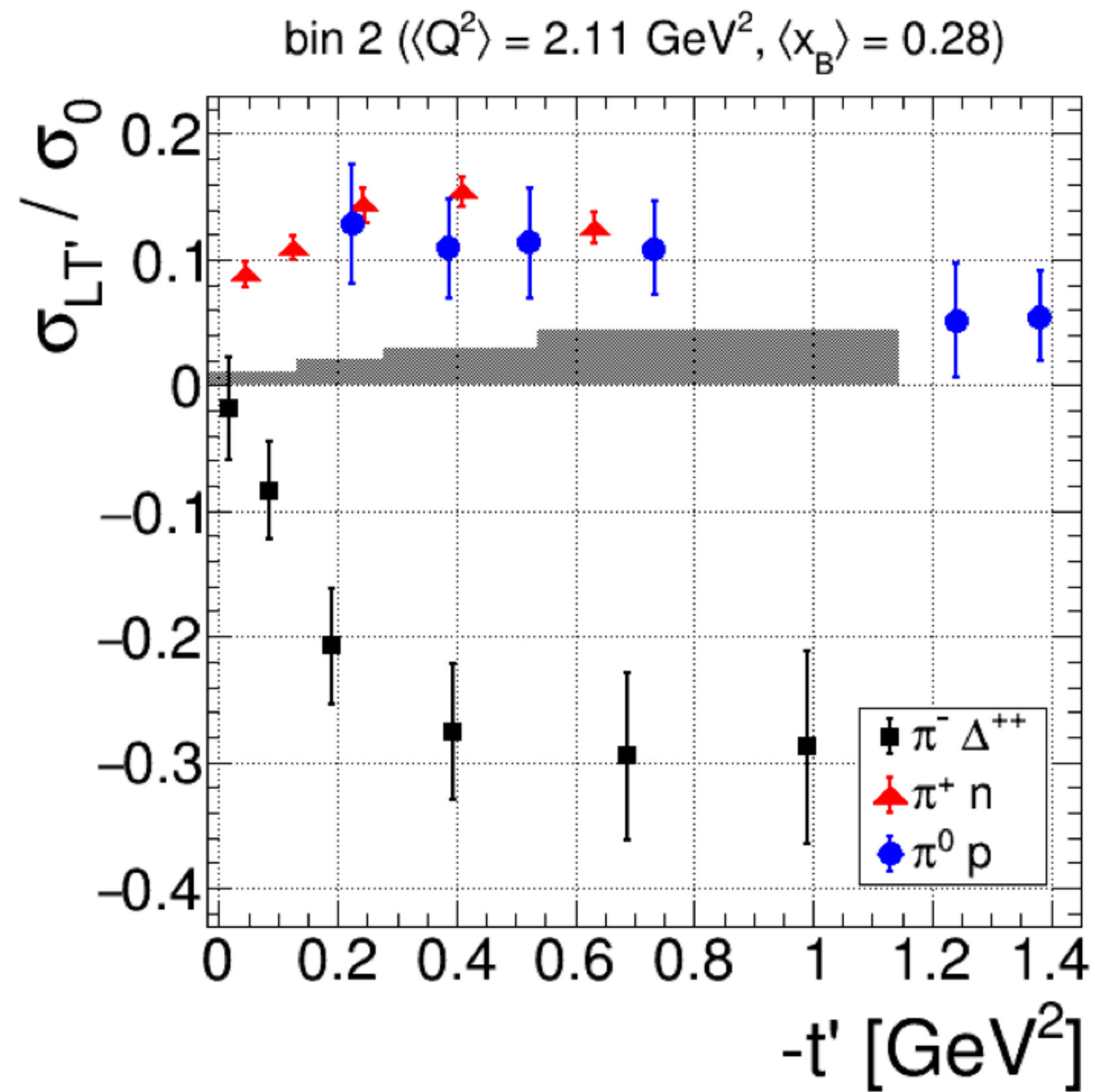
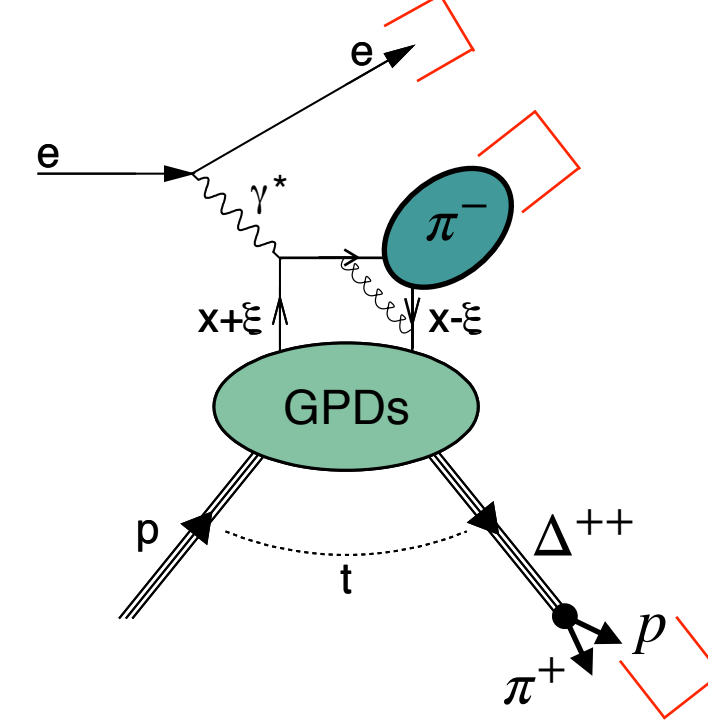
- clean, high-statistics access to transition GPDs
- probing d-quark content of nucleon



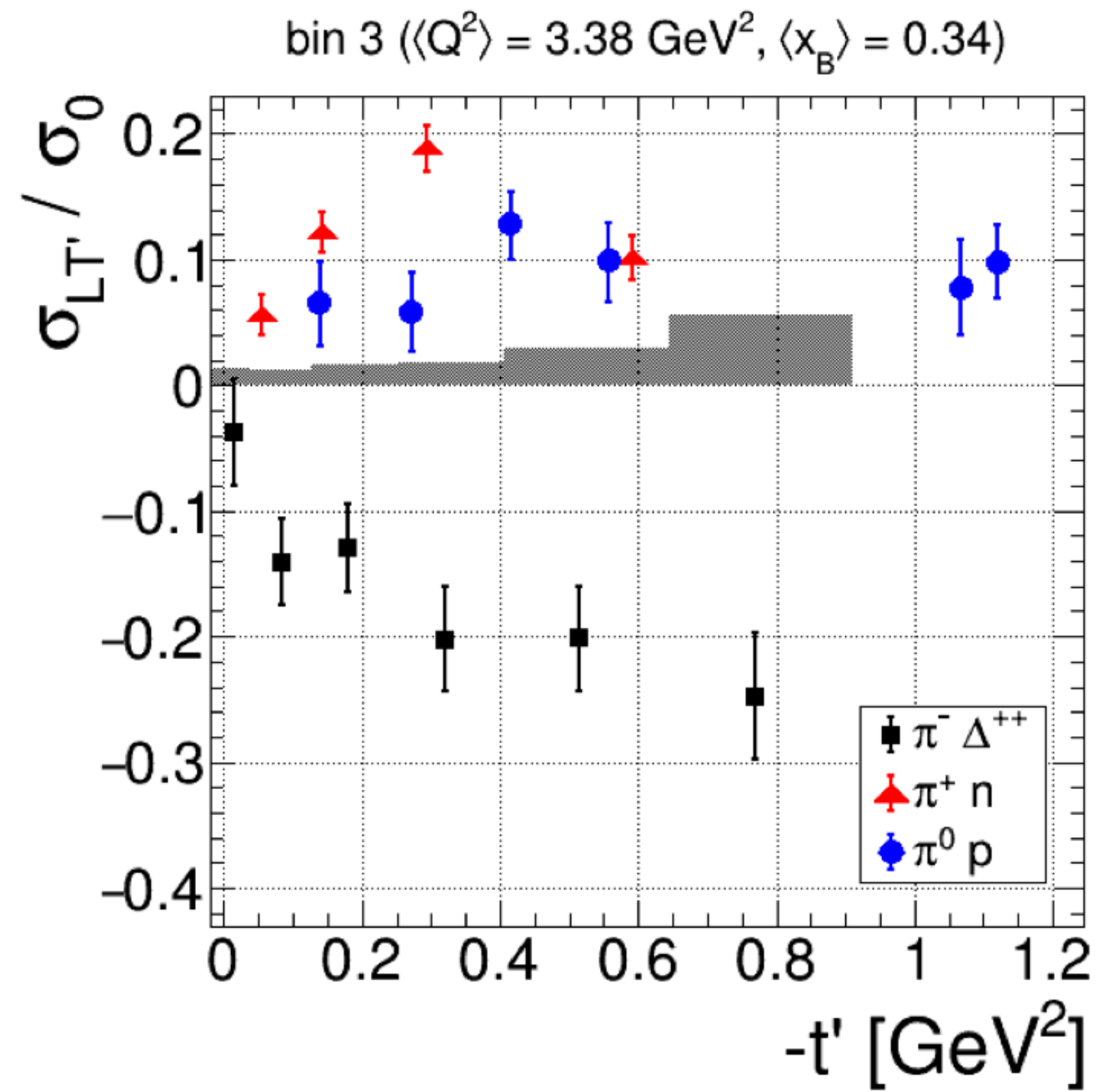
- first measurement sensitive to transversity transition GPDs

Access to transition GPDs

Beam-spin asymmetry $\propto \sigma_{LT}/\sigma_0 \sin \phi$



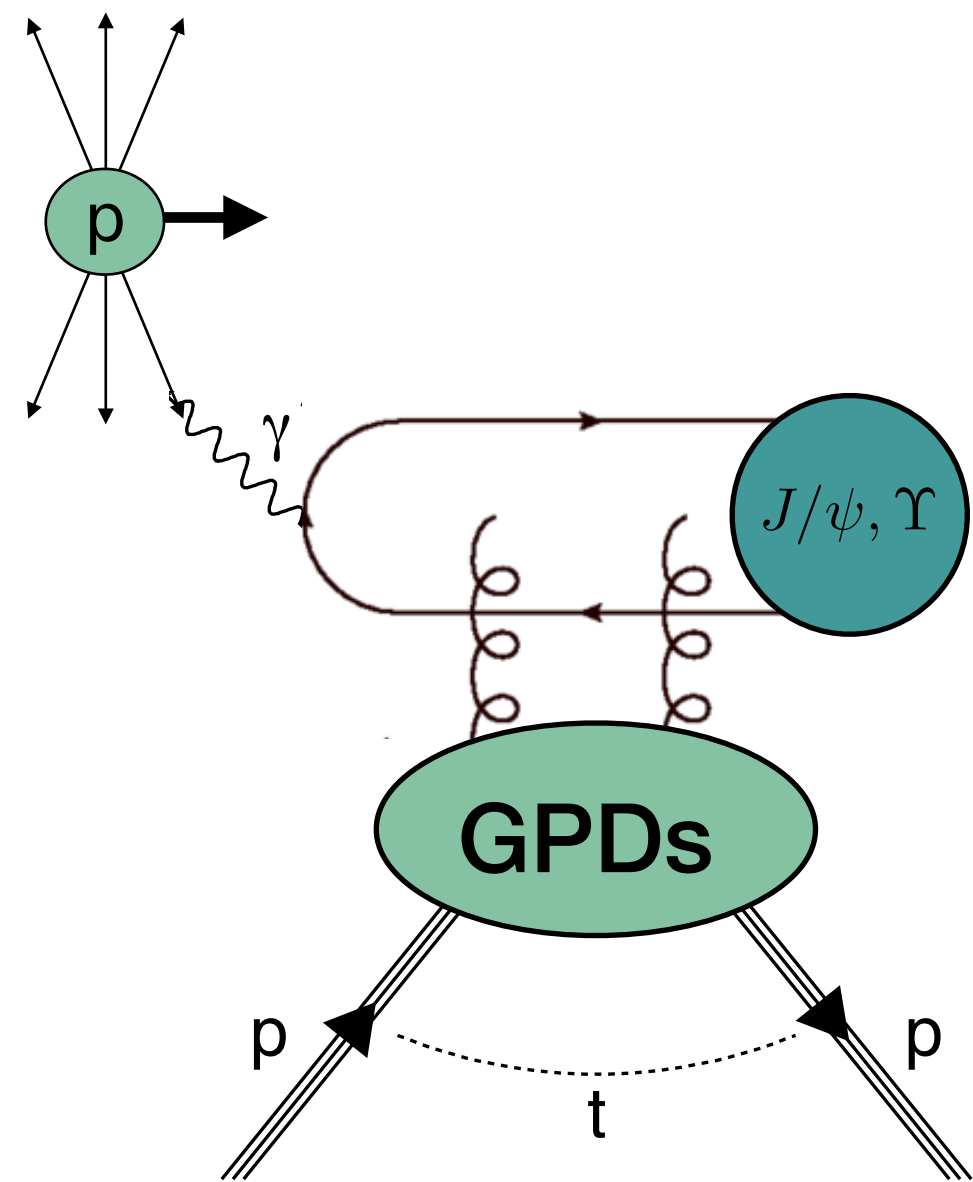
CLAS PRL **131** (2023) 021901



$\blacktriangle \pi^+ n$: CLAS, Phys. Lett. B **839** (2023) 137761 $\rightarrow H_T$

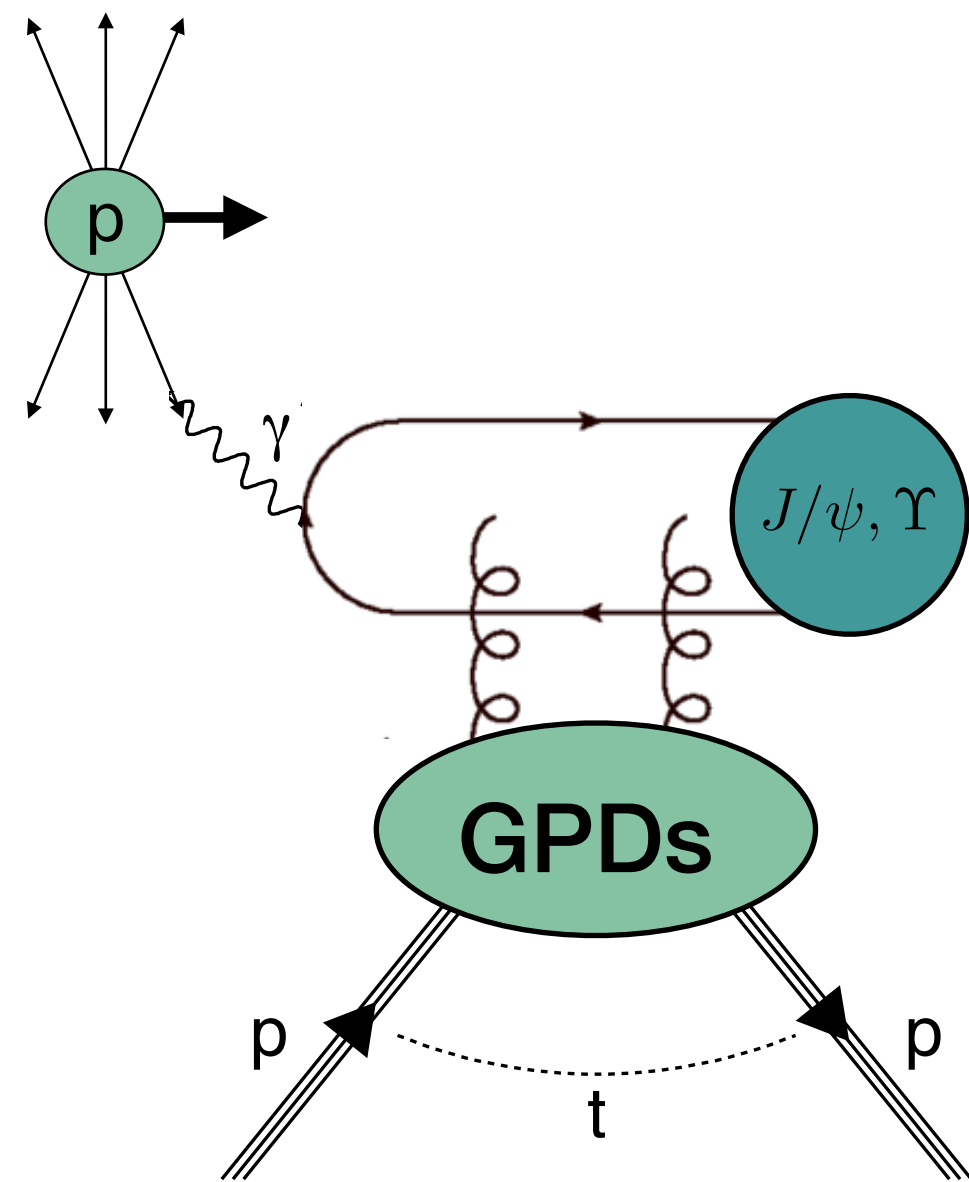
$\bullet \pi^0 p$: CLAS, Phys. Lett. B **849** (2024) 138459 $\rightarrow \bar{E}_T = 2\tilde{H}_T + E_T$

Ultra-peripheral hadron-hadron collisions

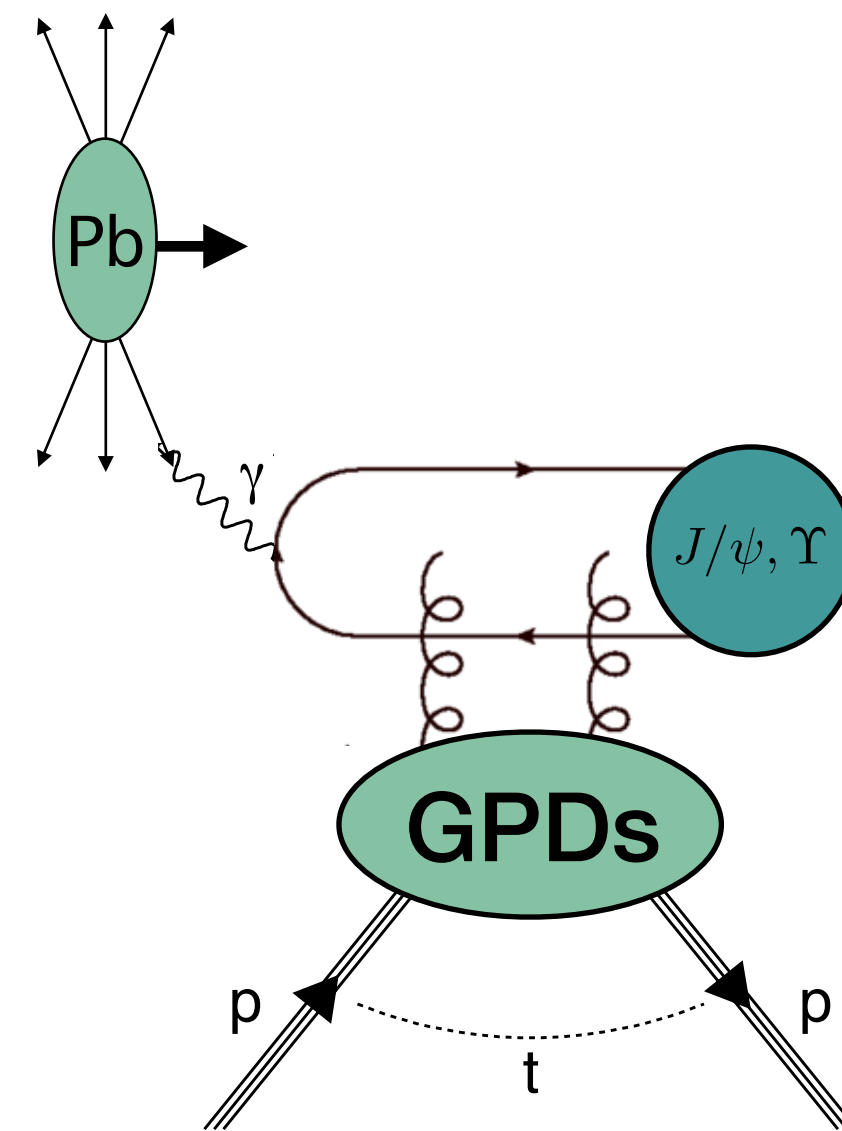


pp: ambiguity in ID of photon emitter

Ultra-peripheral hadron-hadron collisions

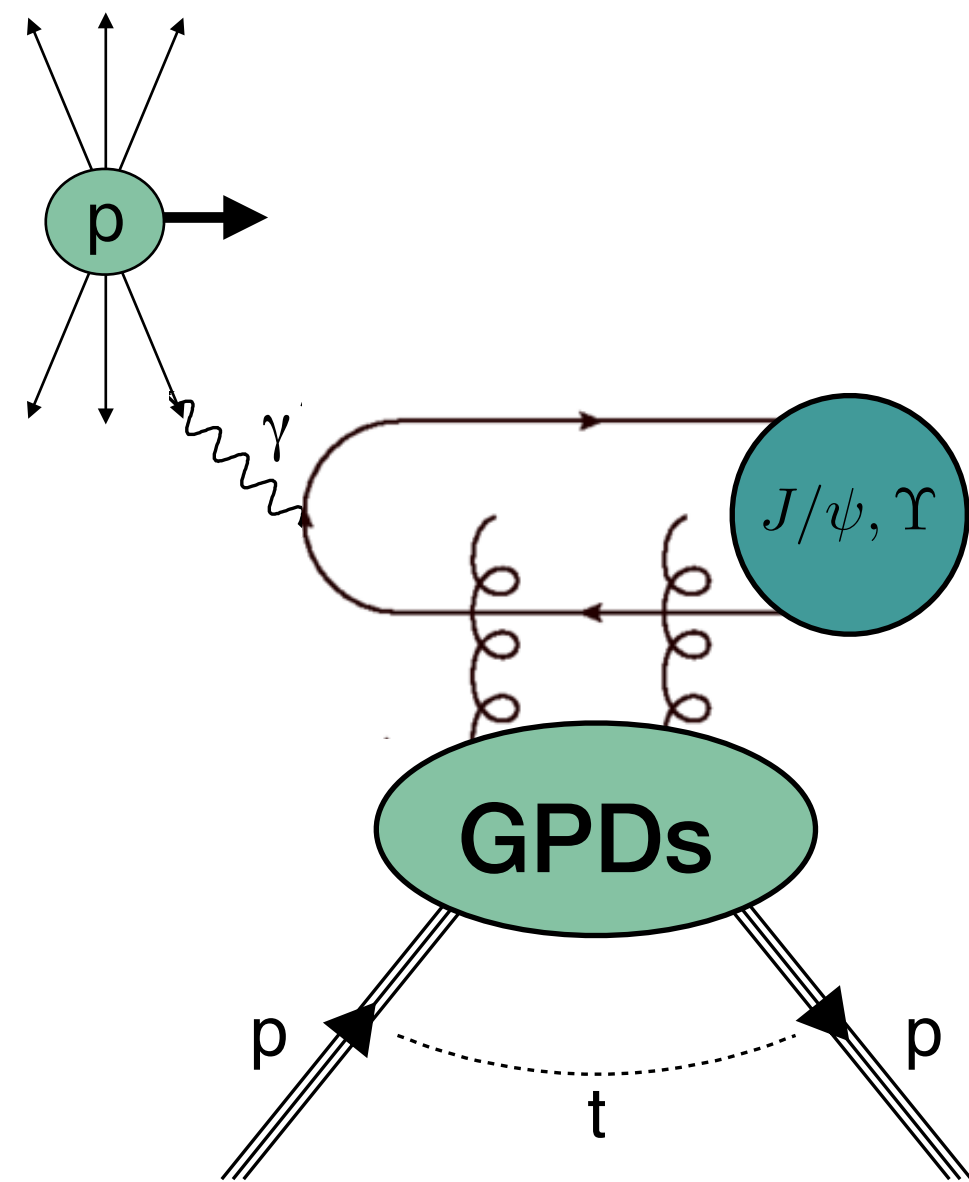


pp: ambiguity in ID of photon emitter

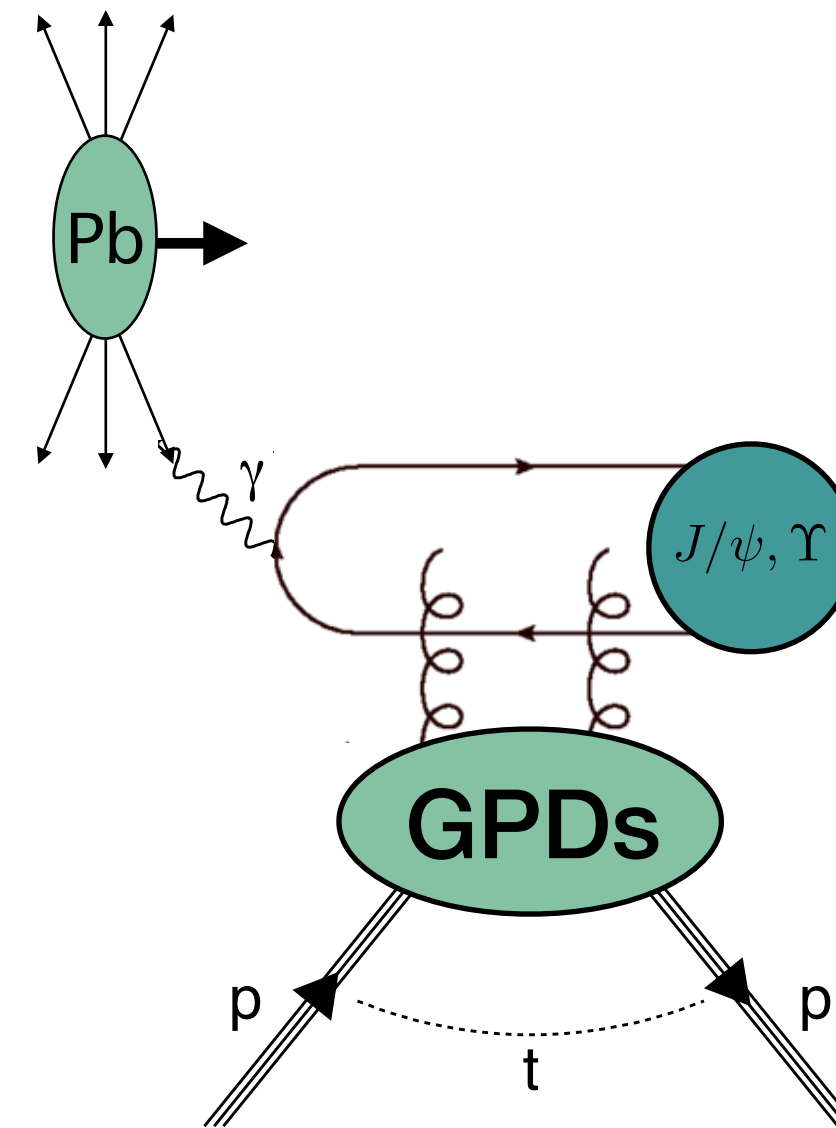


pPb: use Z^2 dependence of photon flux
→ Pb is predominantly photon emitter

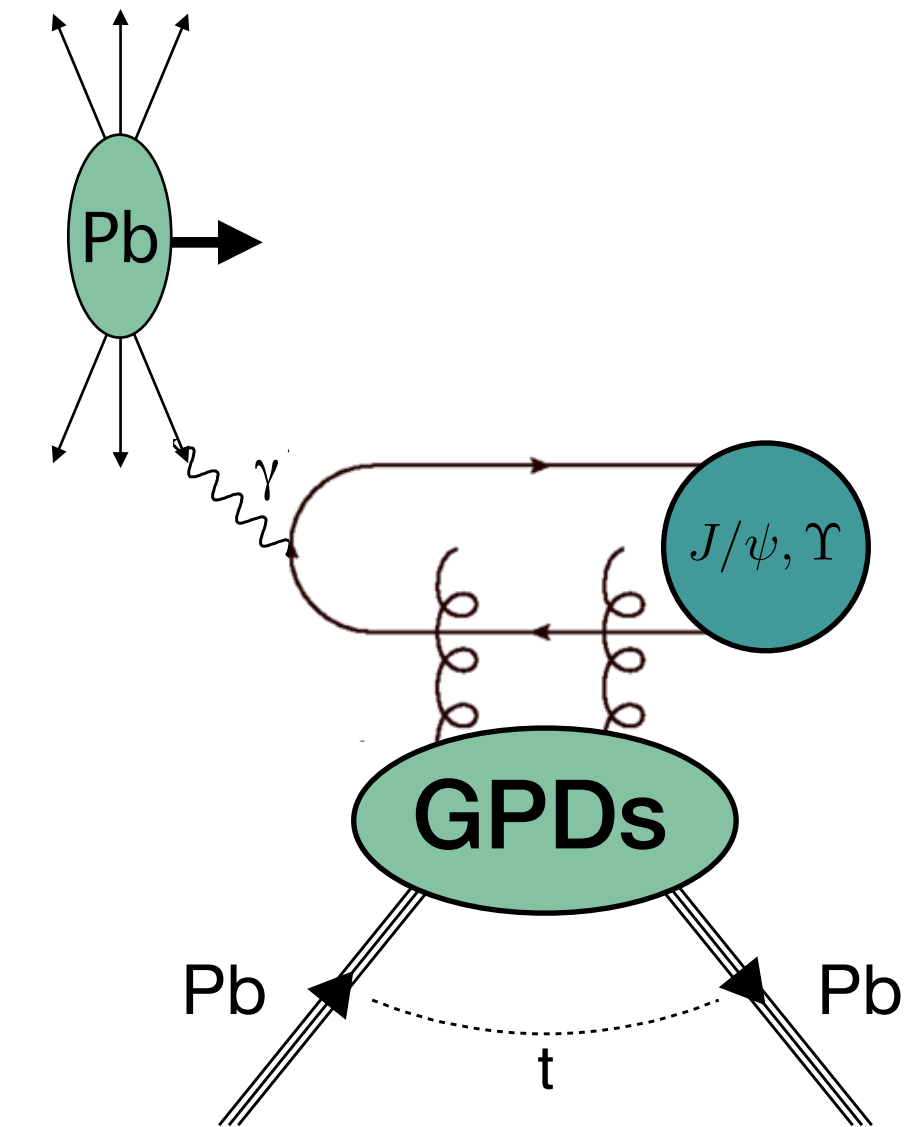
Ultra-peripheral hadron-hadron collisions



pp: ambiguity in ID of photon emitter

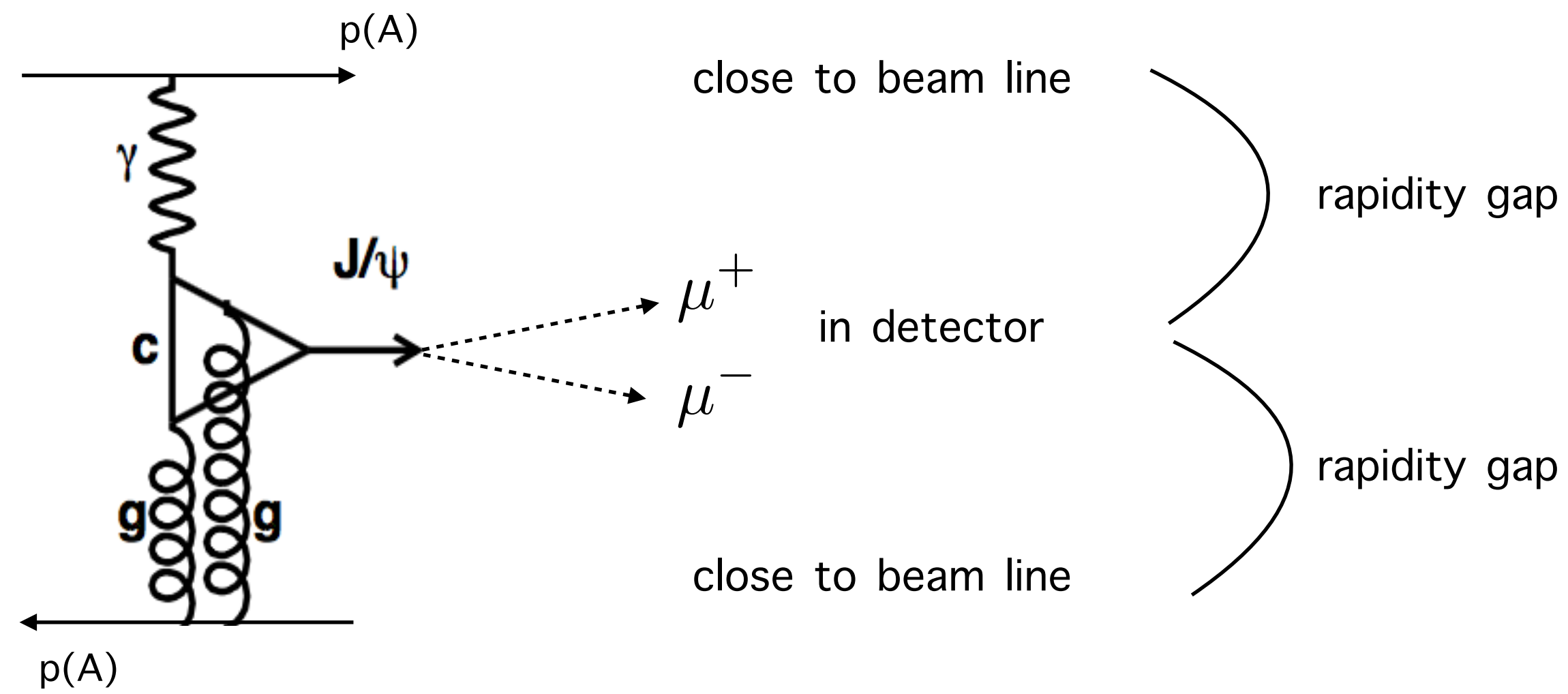


pPb: use Z^2 dependence of photon flux
 $\rightarrow$ Pb is predominantly photon emitter



PbPb: probing nuclear GPDs
 Ambiguity in ID of probed ion
 can be lifted with ZDCs

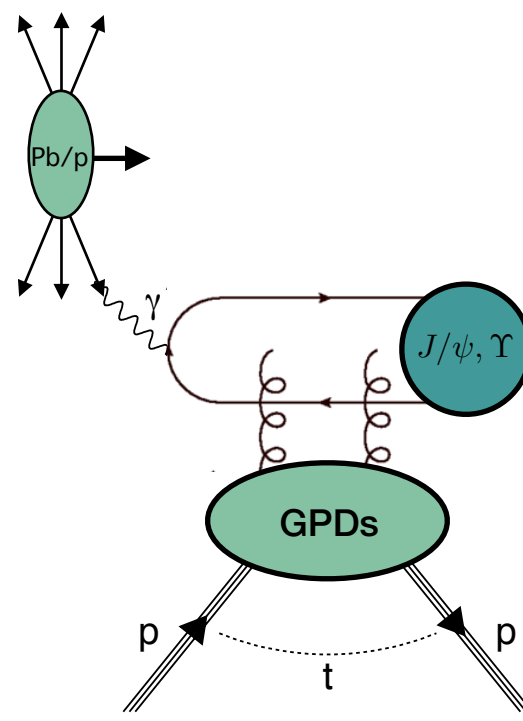
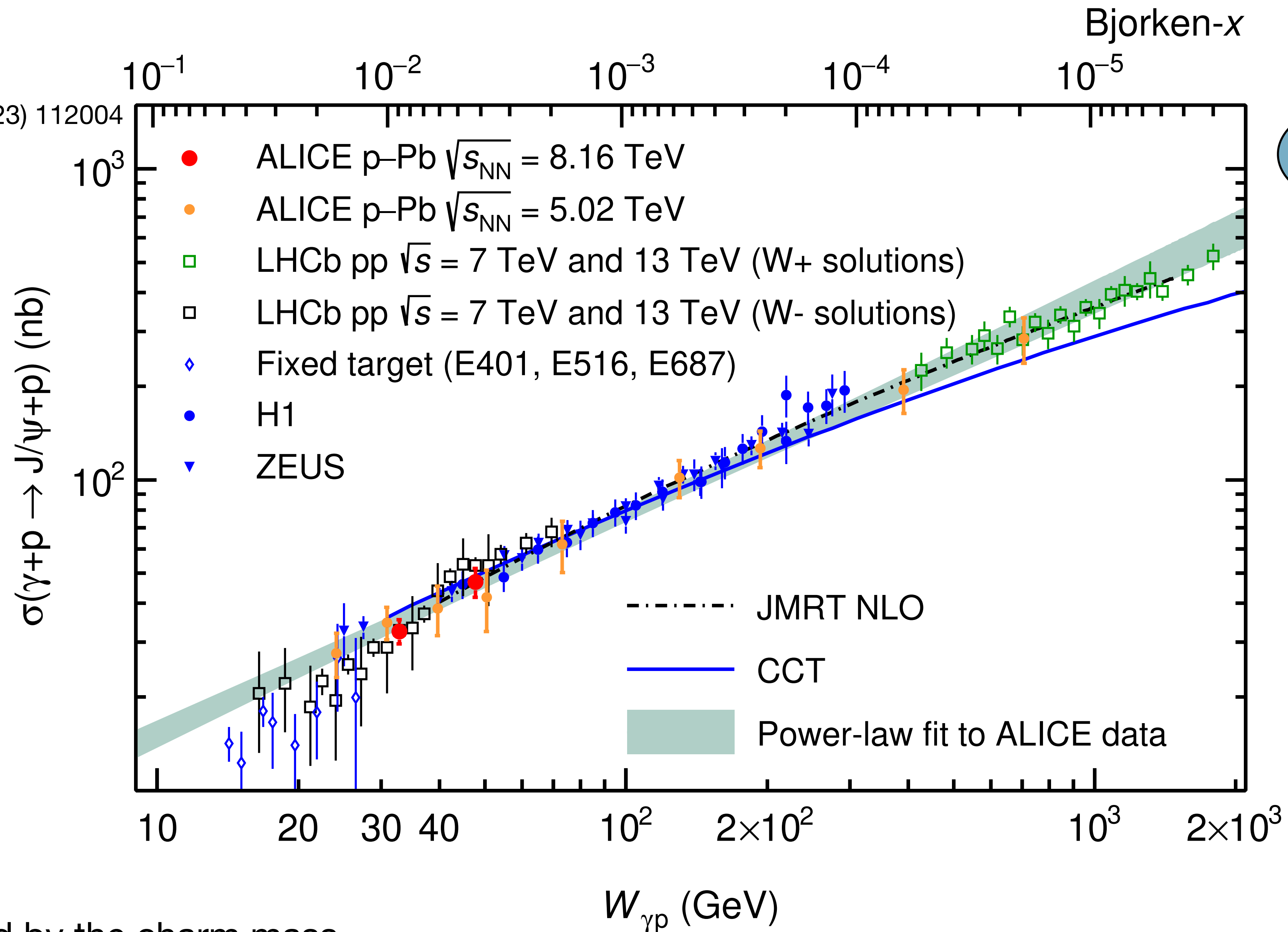
Experimental signature



$$-t \approx p_{T,\mu\mu}^2$$

J/ψ photoproduction cross section off the proton at the LHC

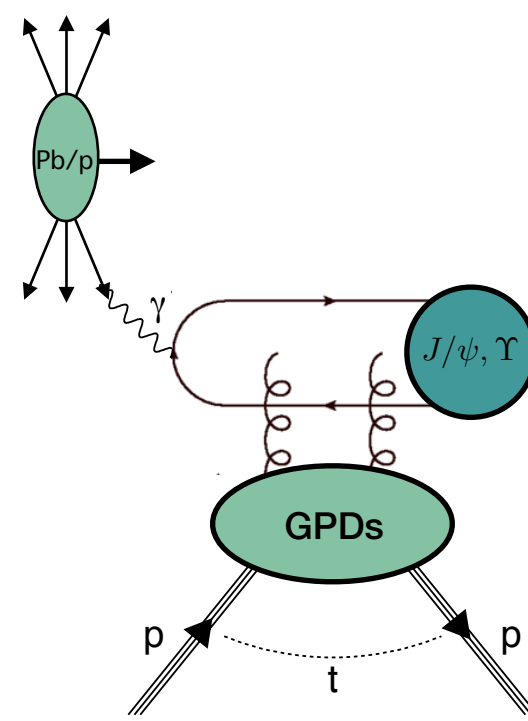
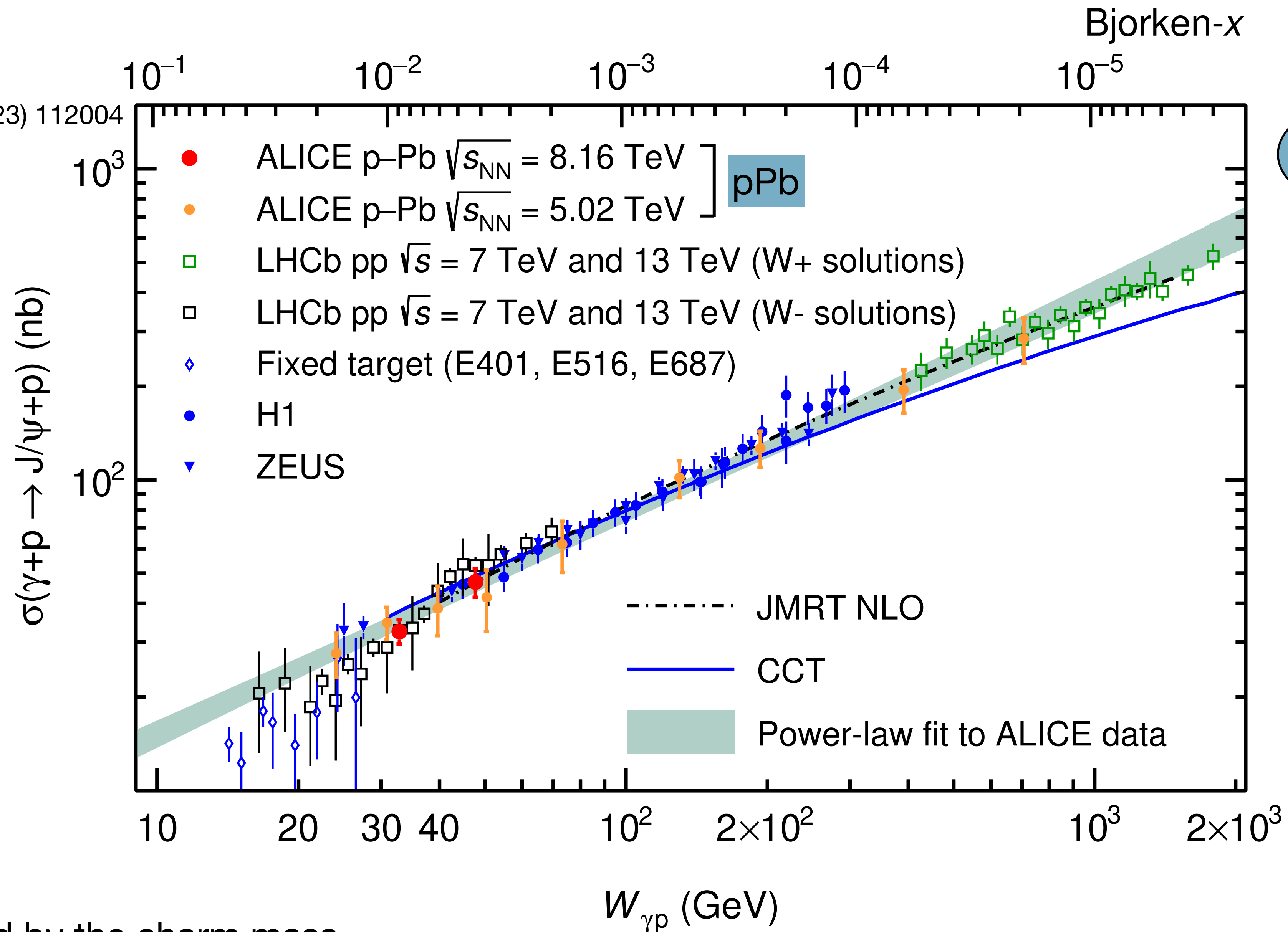
Phys. Rev. D **108** ('23) 112004



Hard scale: fixed by the charm mass

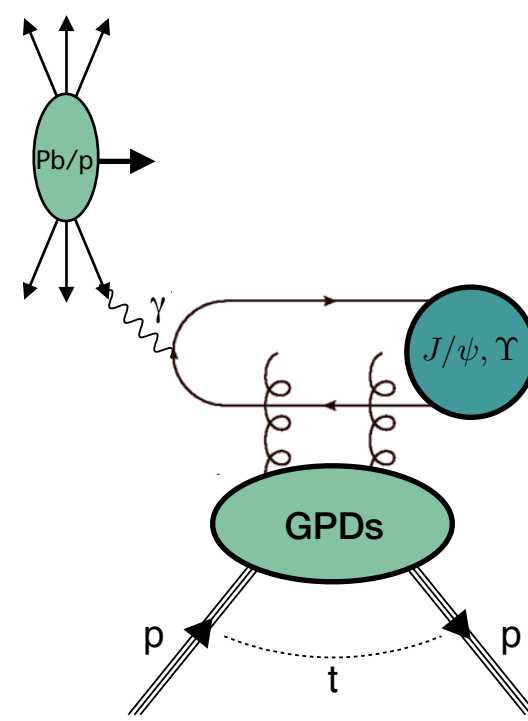
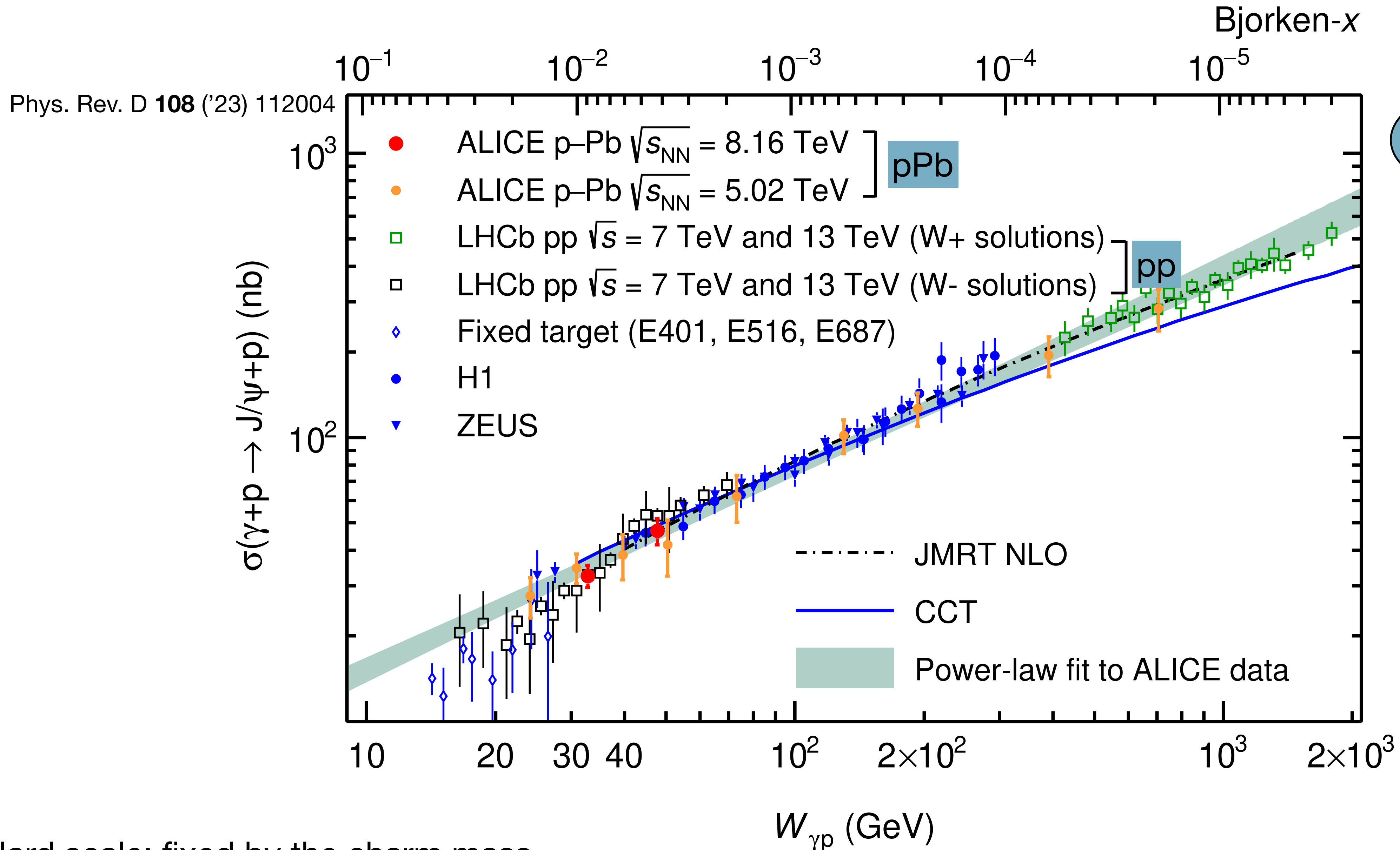
J/ψ photoproduction cross section off the proton at the LHC

Phys. Rev. D **108** ('23) 112004



Hard scale: fixed by the charm mass

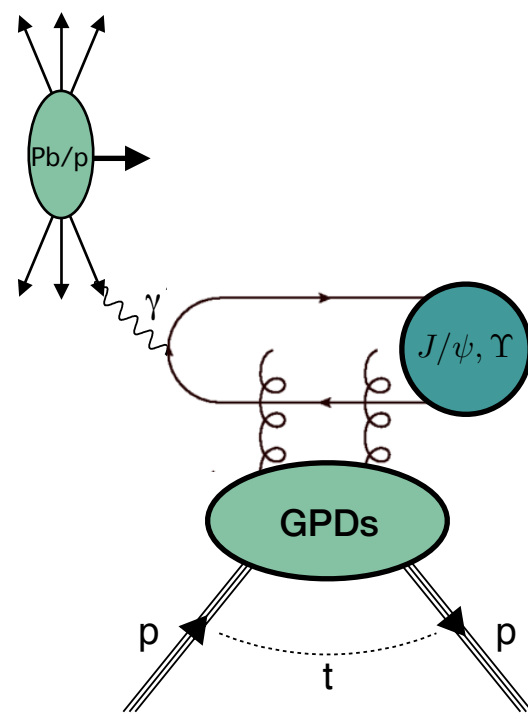
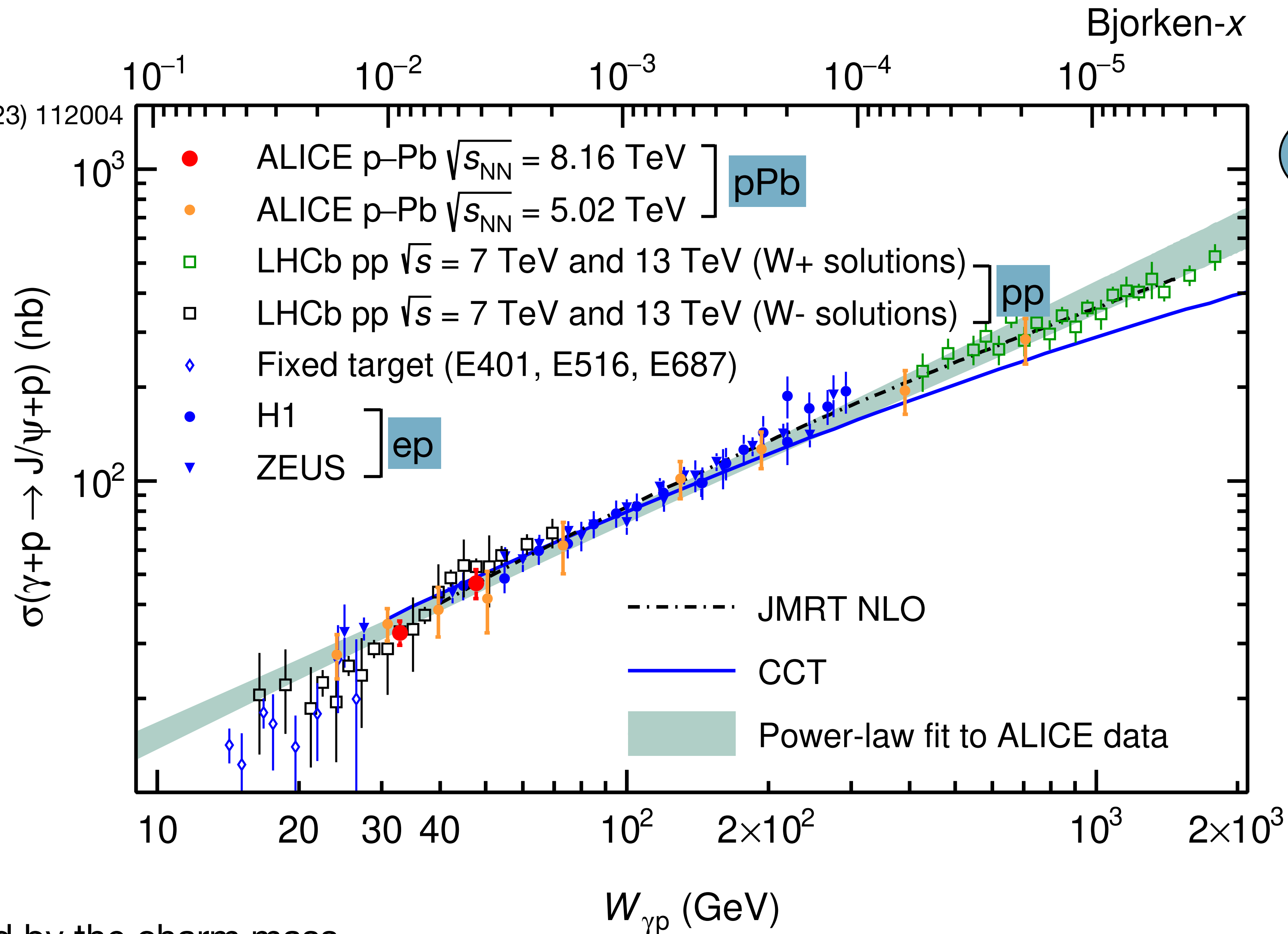
J/ψ photoproduction cross section off the proton at the LHC



Hard scale: fixed by the charm mass

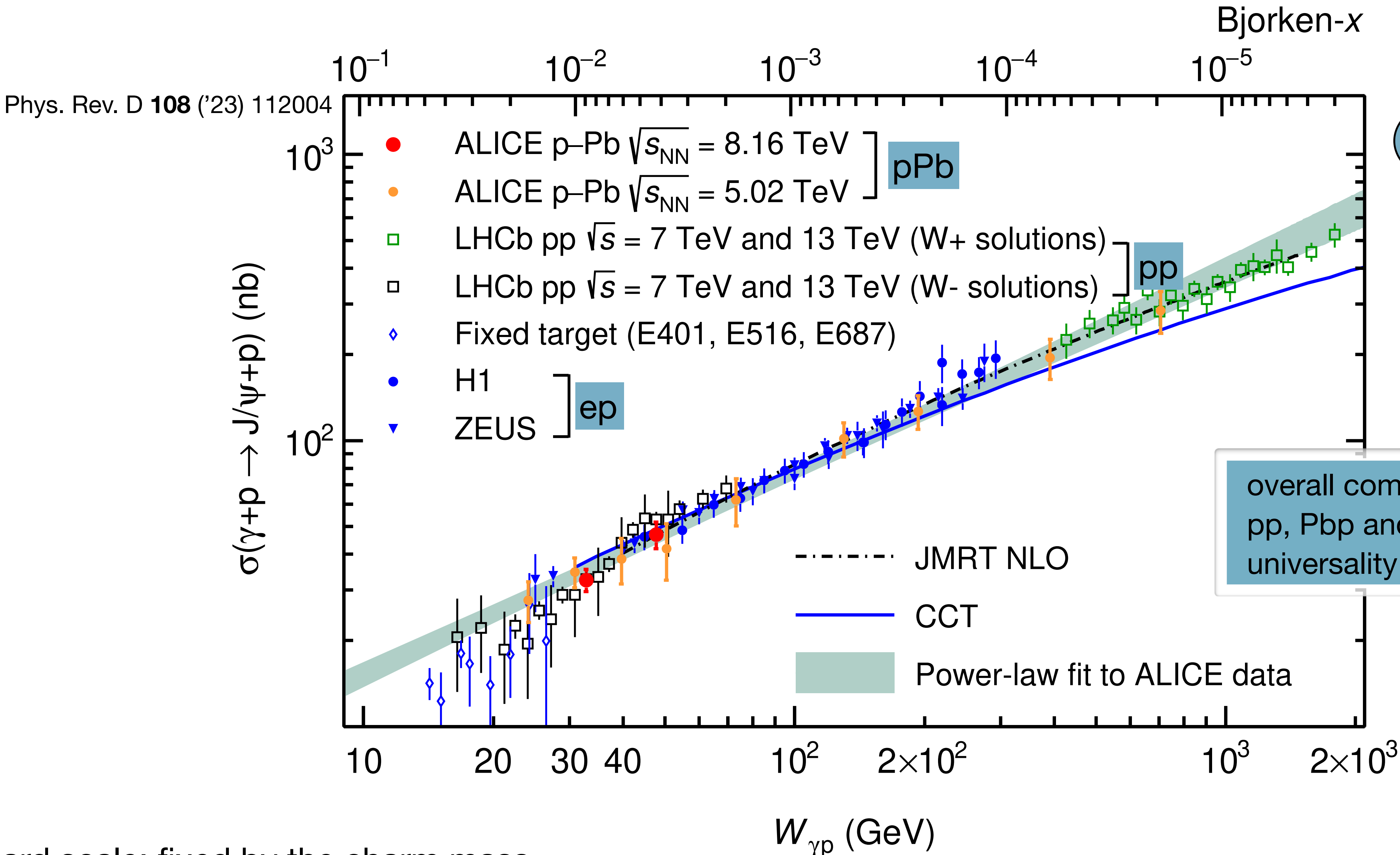
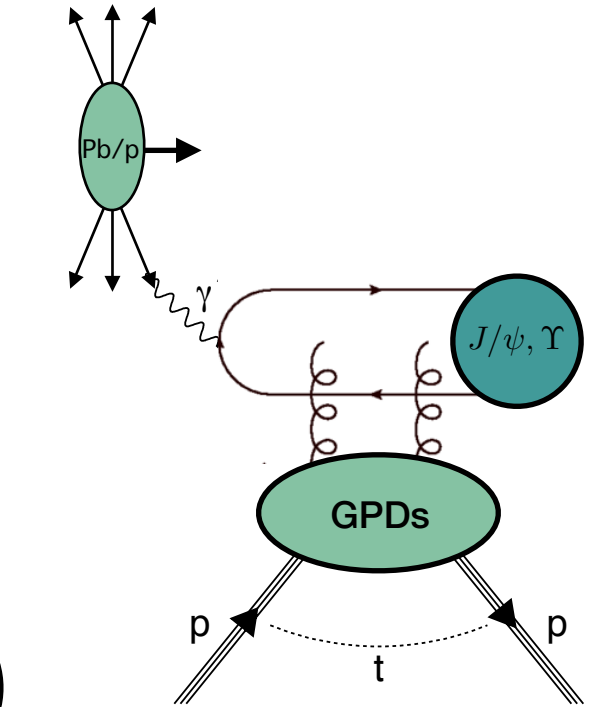
J/ψ photoproduction cross section off the proton at the LHC

Phys. Rev. D **108** ('23) 112004



Hard scale: fixed by the charm mass

J/ψ photoproduction cross section off the proton at the LHC

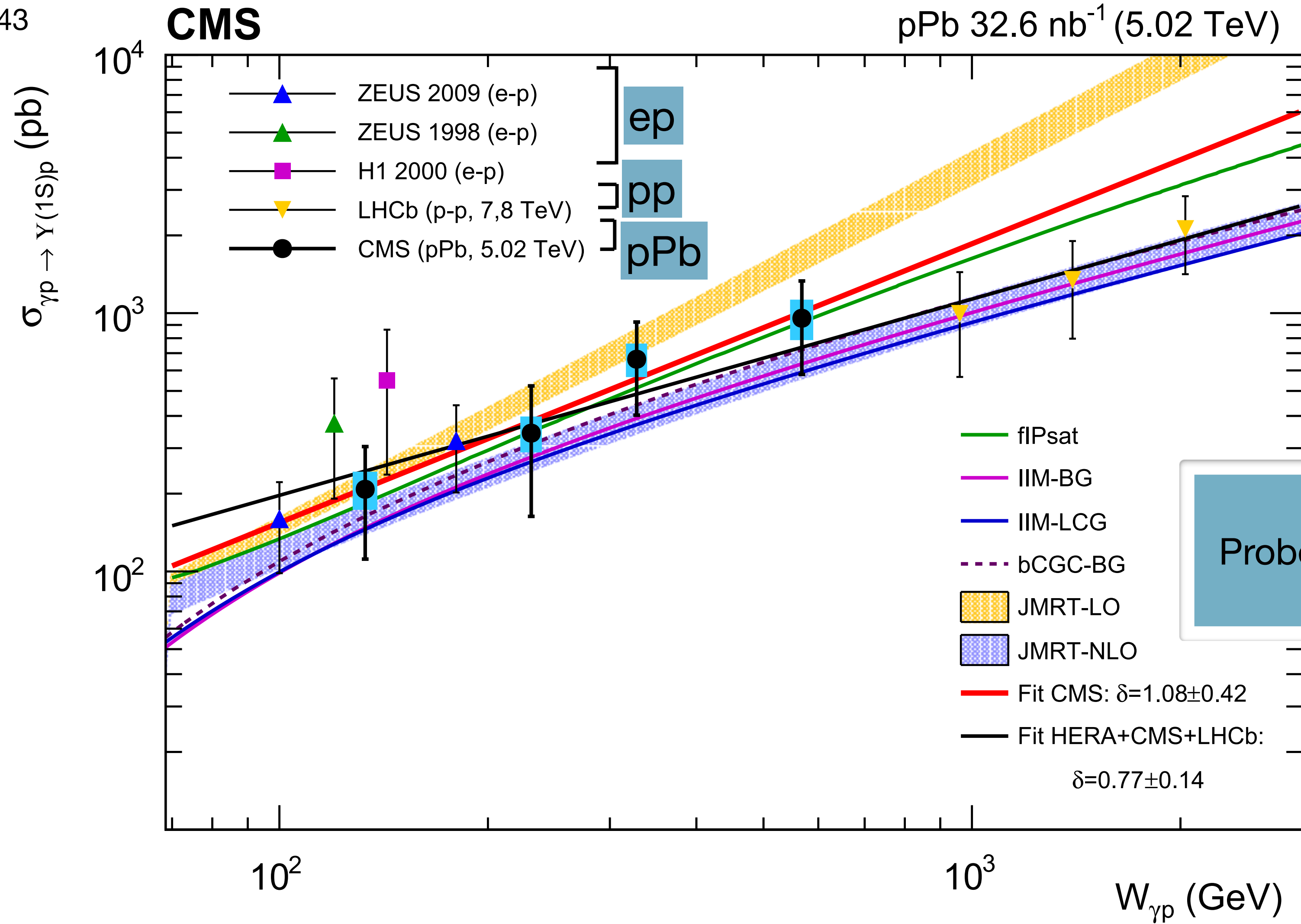


Hard scale: fixed by the charm mass

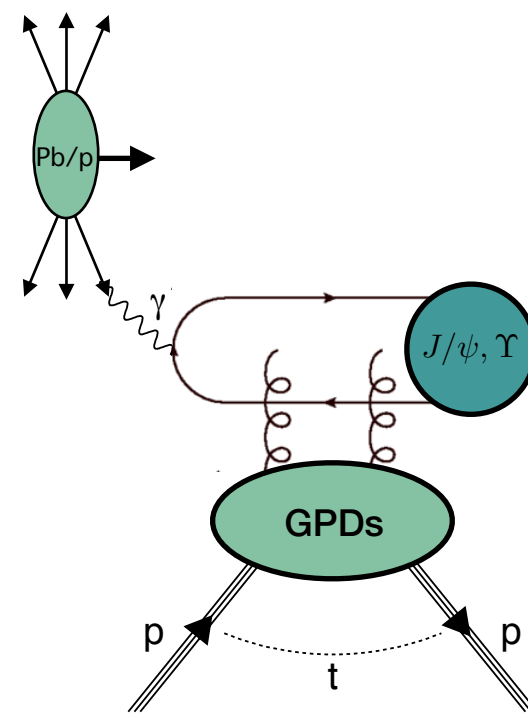
Υ photoproduction cross section

Eur. Phys. J. C **79** (2019) 277

Eur. Phys. J. C **82** (2022) 343

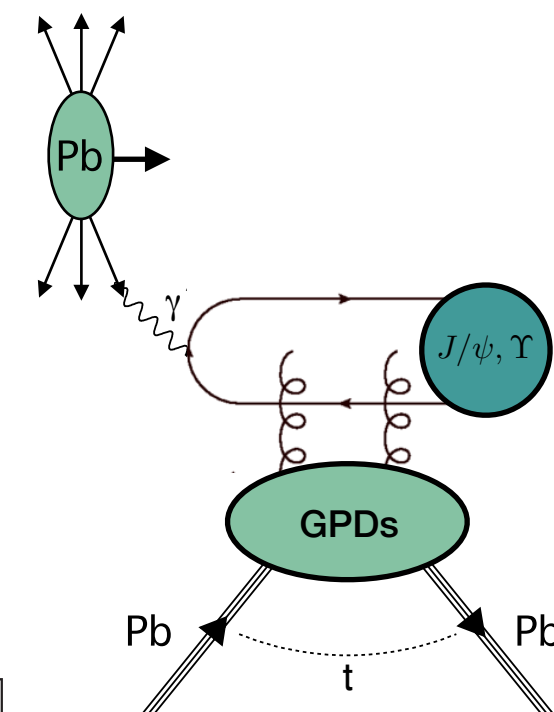
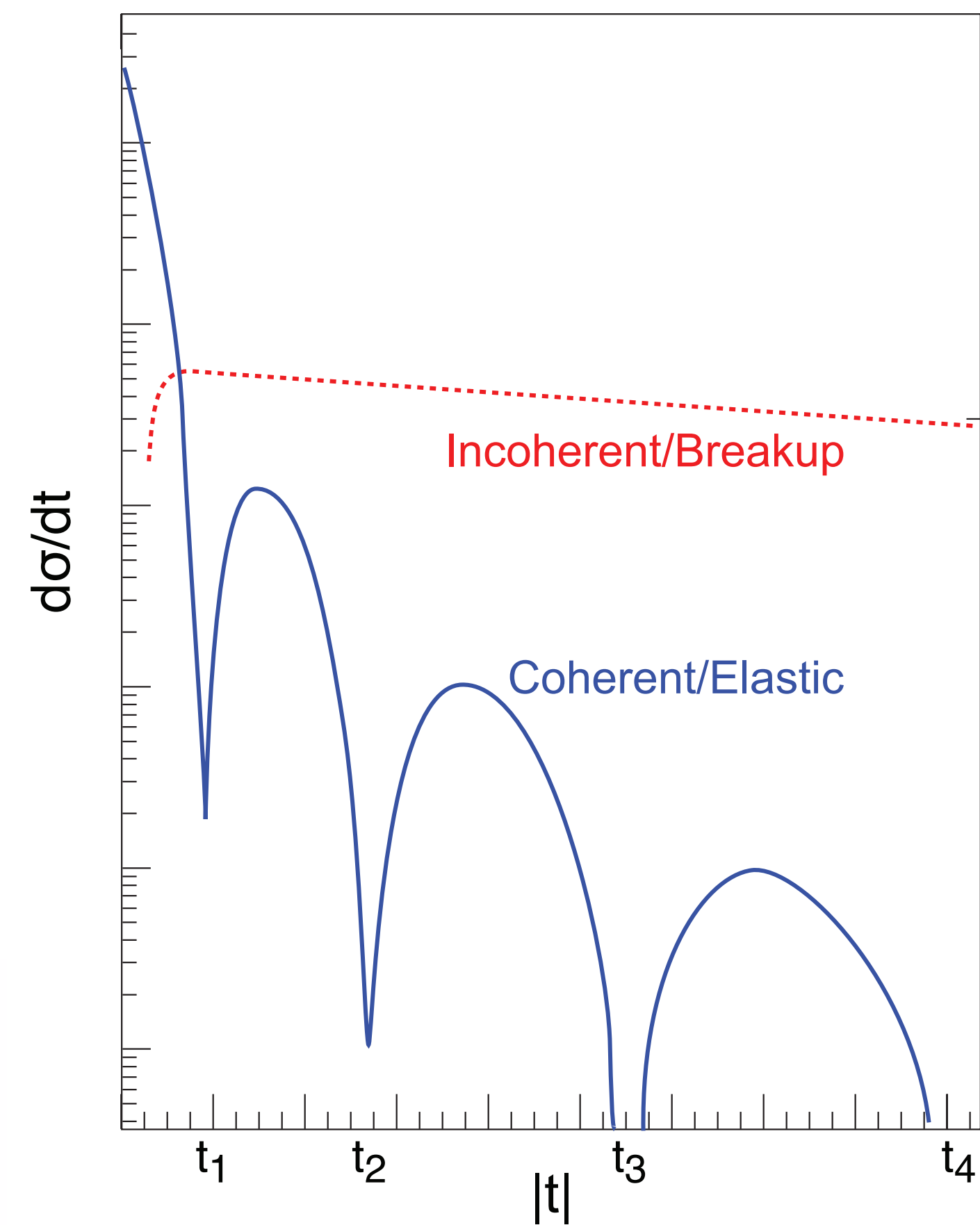
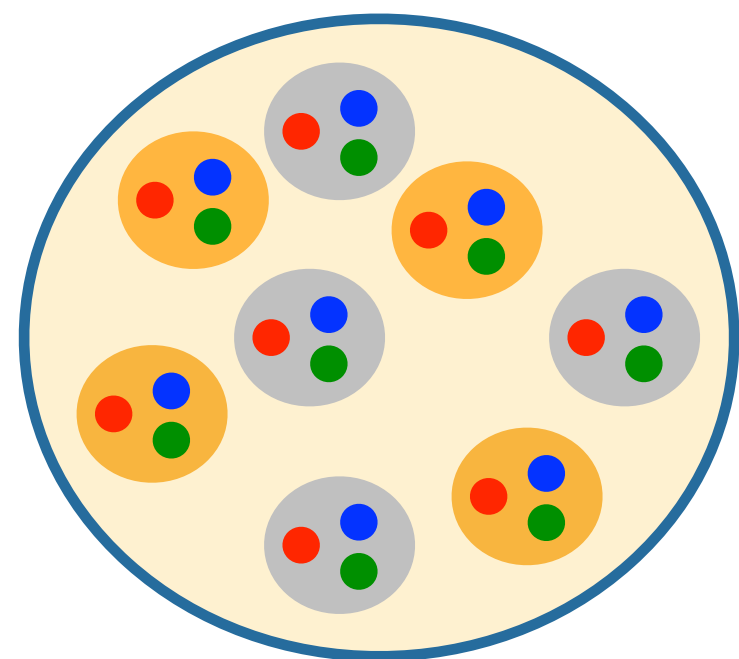


GPD H



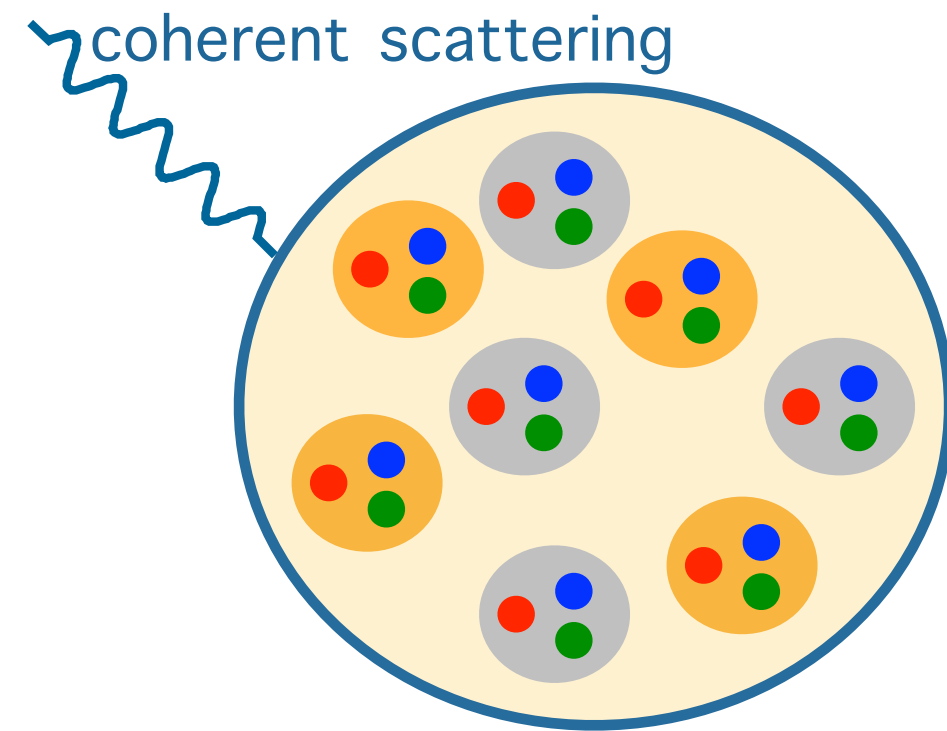
Ultrapерipheral PbPb collisions

What object are we probing?

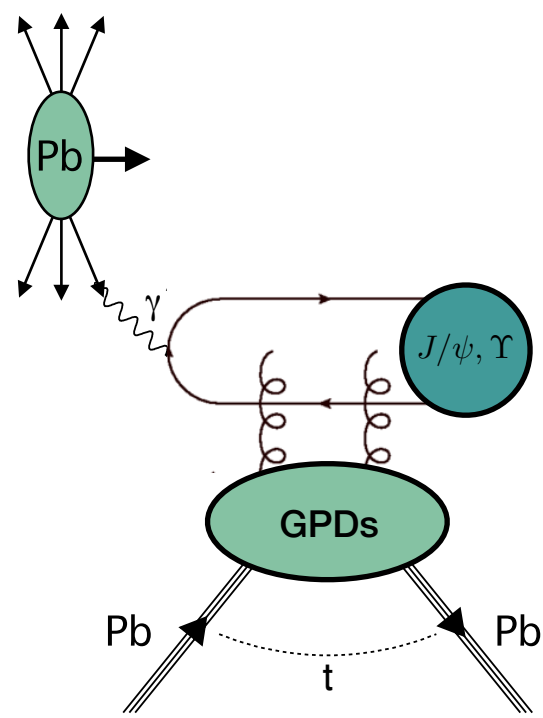
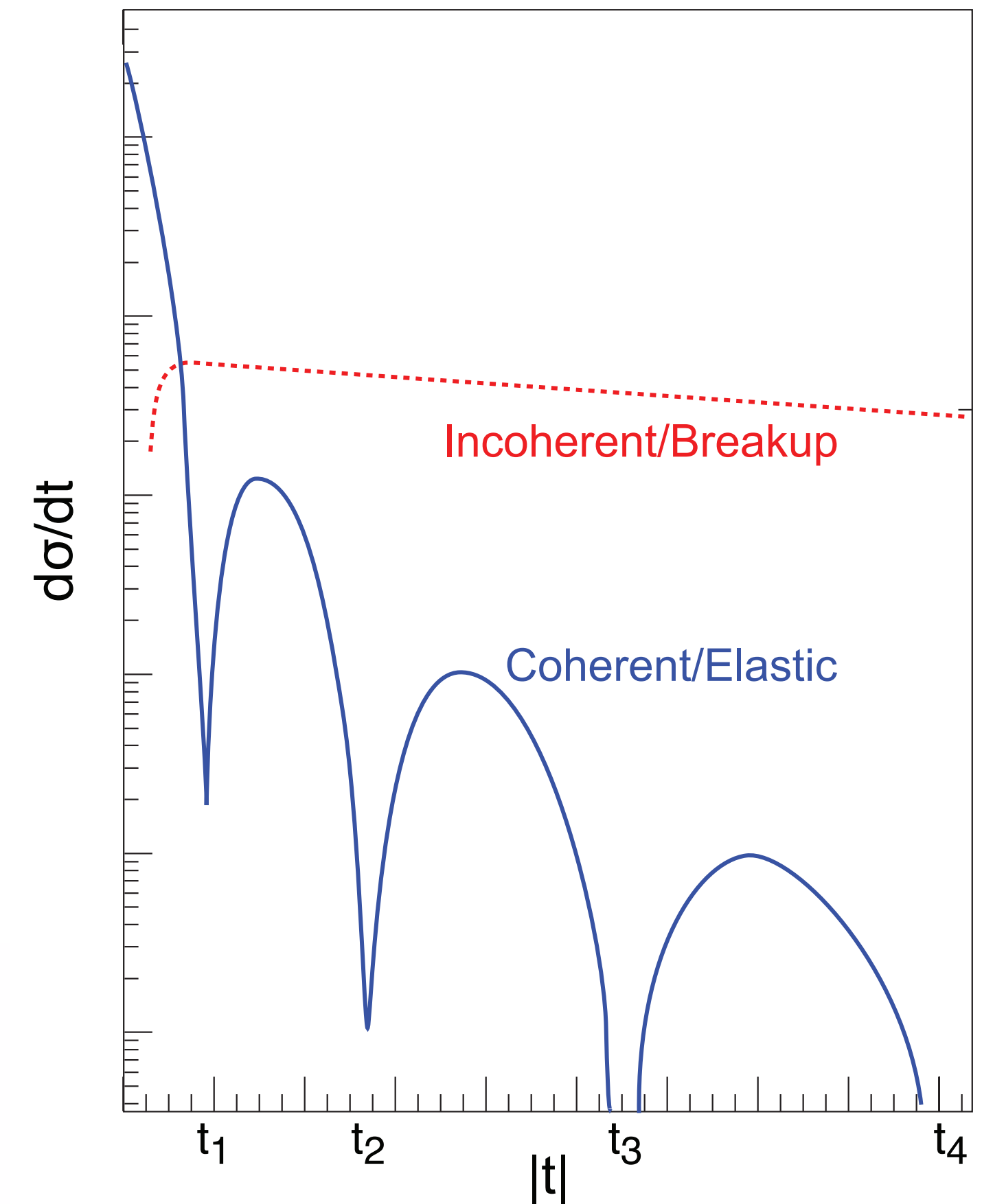


Ultrapерipheral PbPb collisions

What object are we probing?

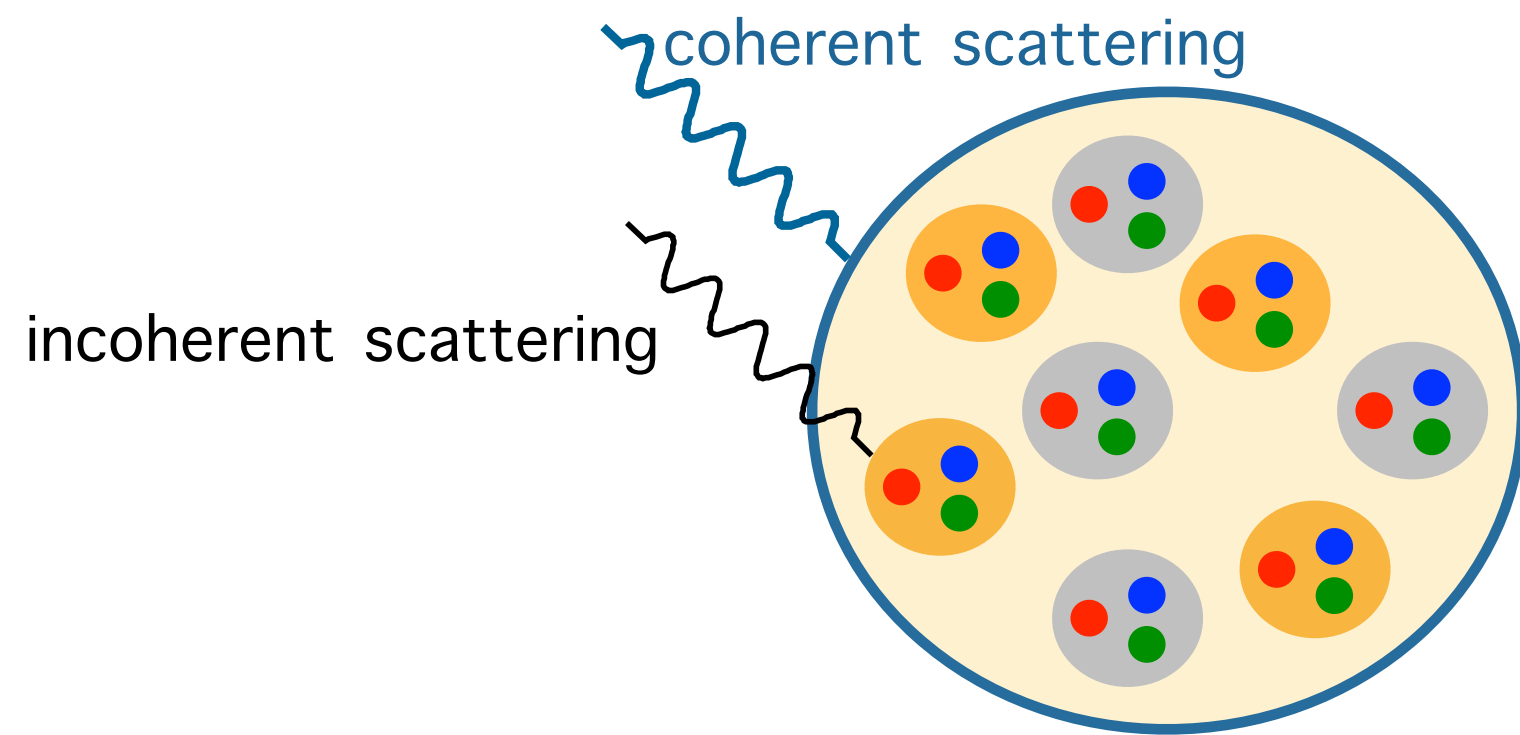


Coherent interaction: interaction with target as a whole.
~ target remains in same quantum state.



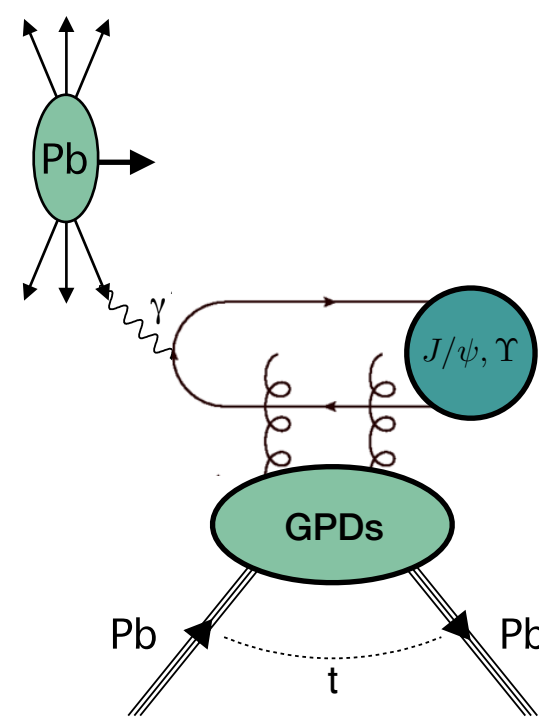
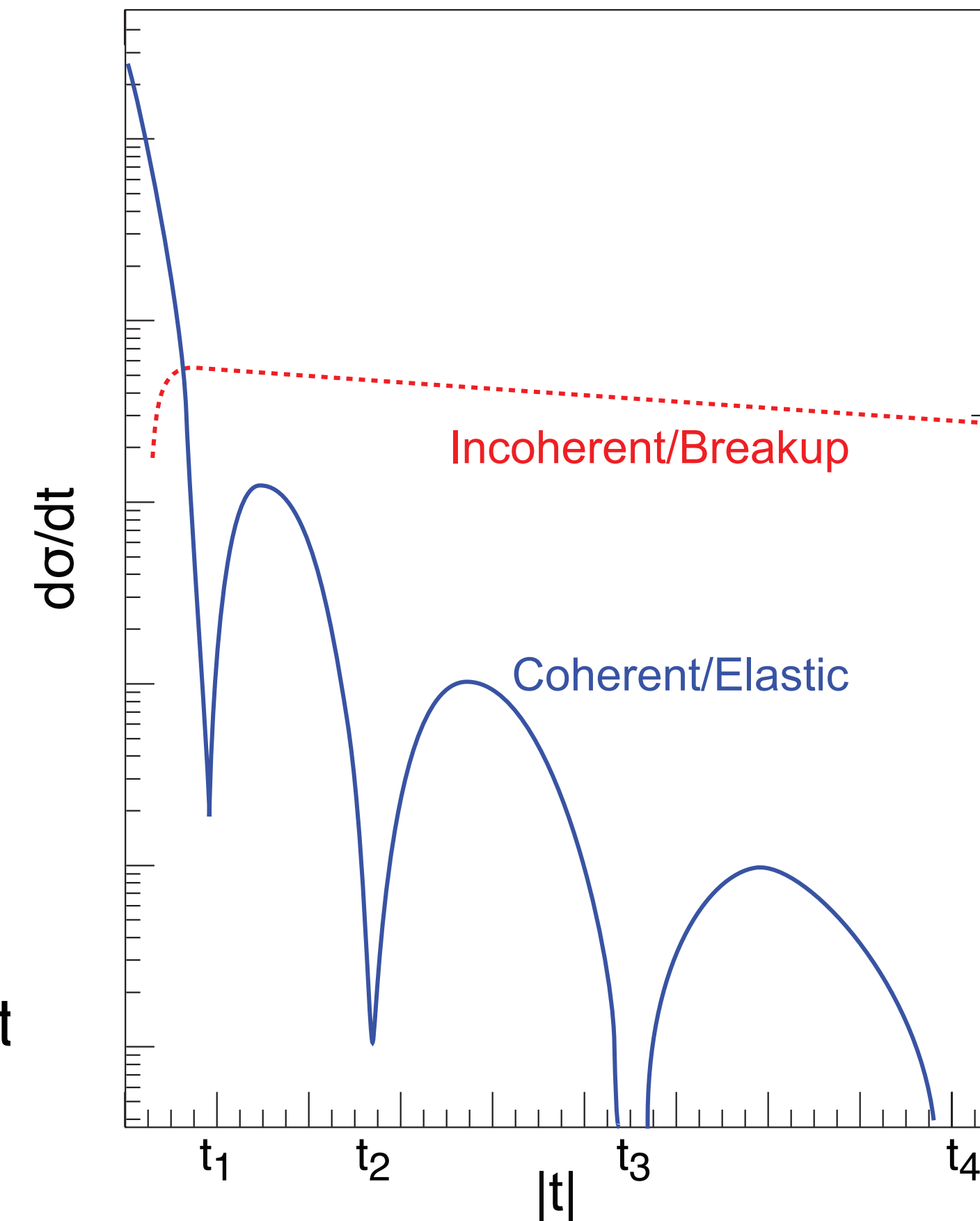
Ultrapерipheral PbPb collisions

What object are we probing?



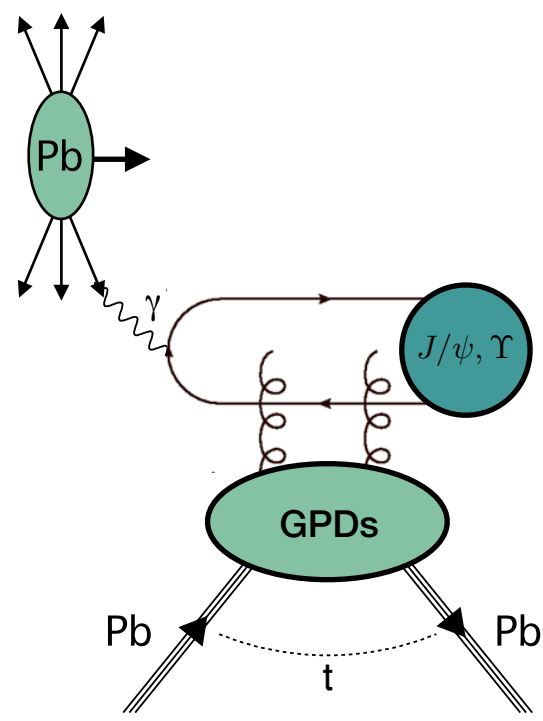
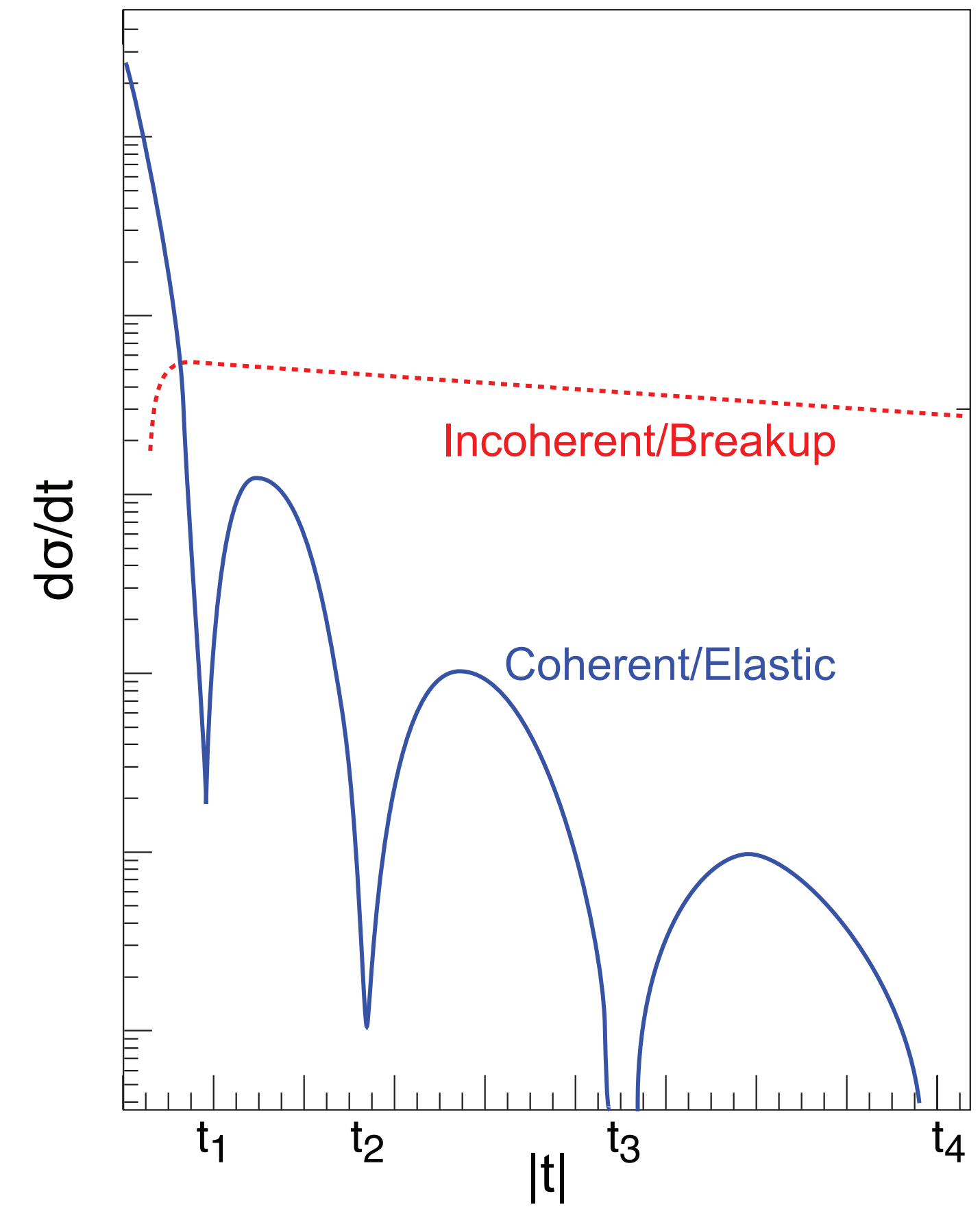
Coherent interaction: interaction with target as a whole.
~ target remains in same quantum state.

Incoherent interaction: interaction with constituents inside target
~ target does not remain in same quantum state.
Ex.: target dissociation, excitation



Experimentally important points

- Good separation of coherent and incoherent production: not easy!



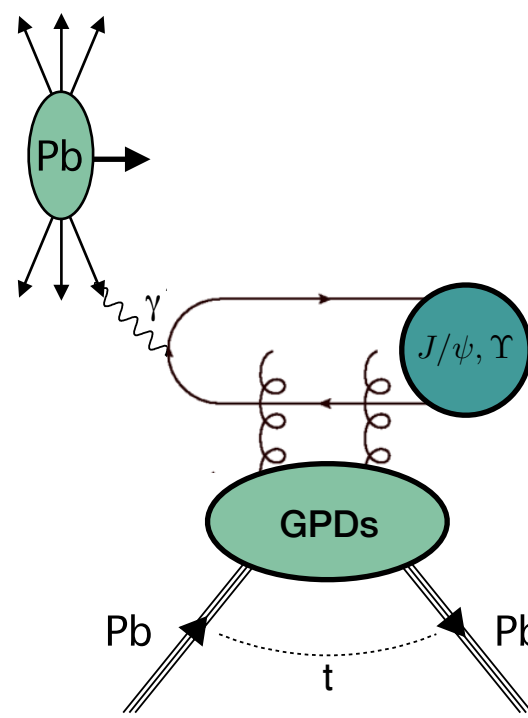
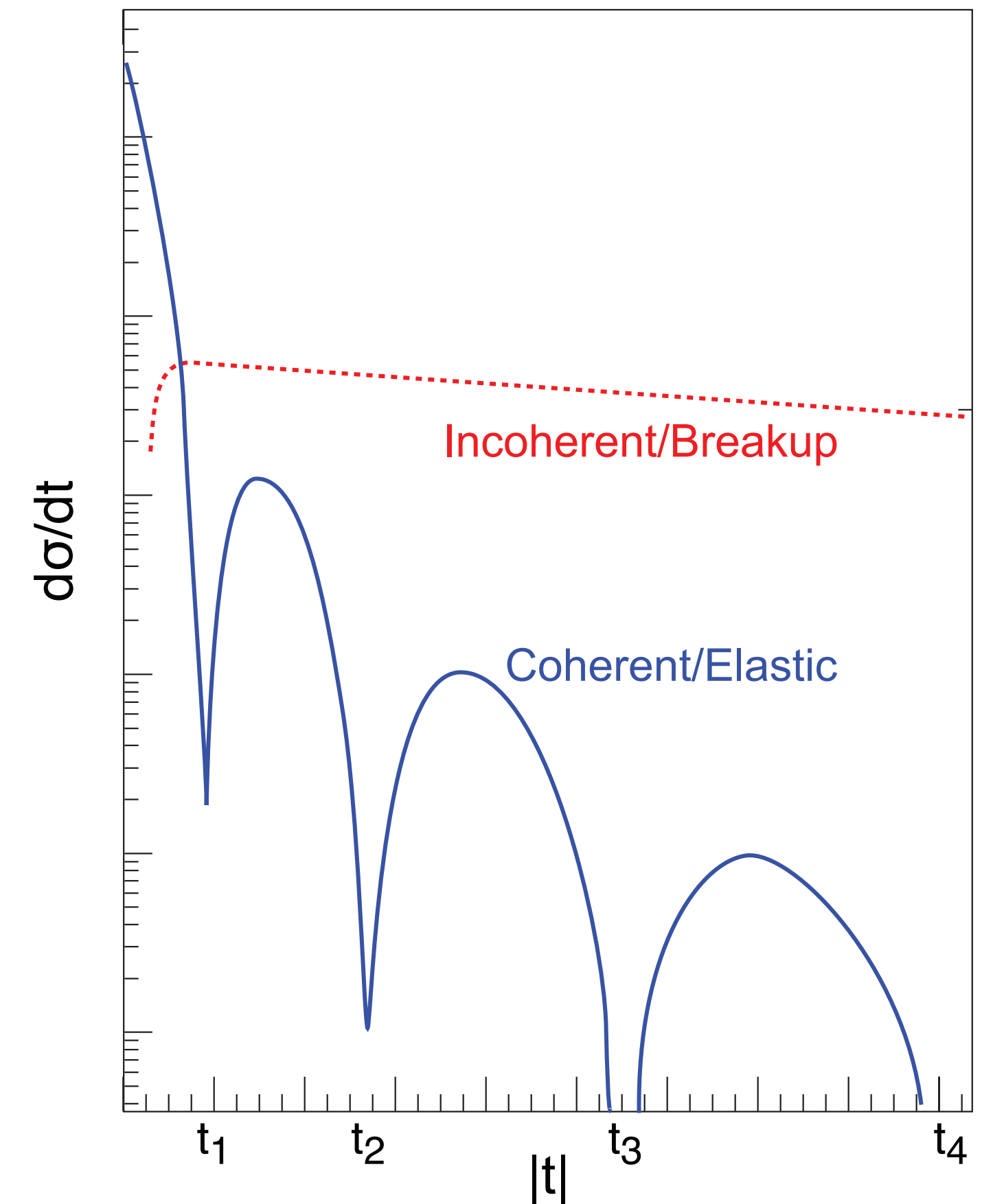
Experimentally important points

- Good separation of coherent and incoherent production: not easy!

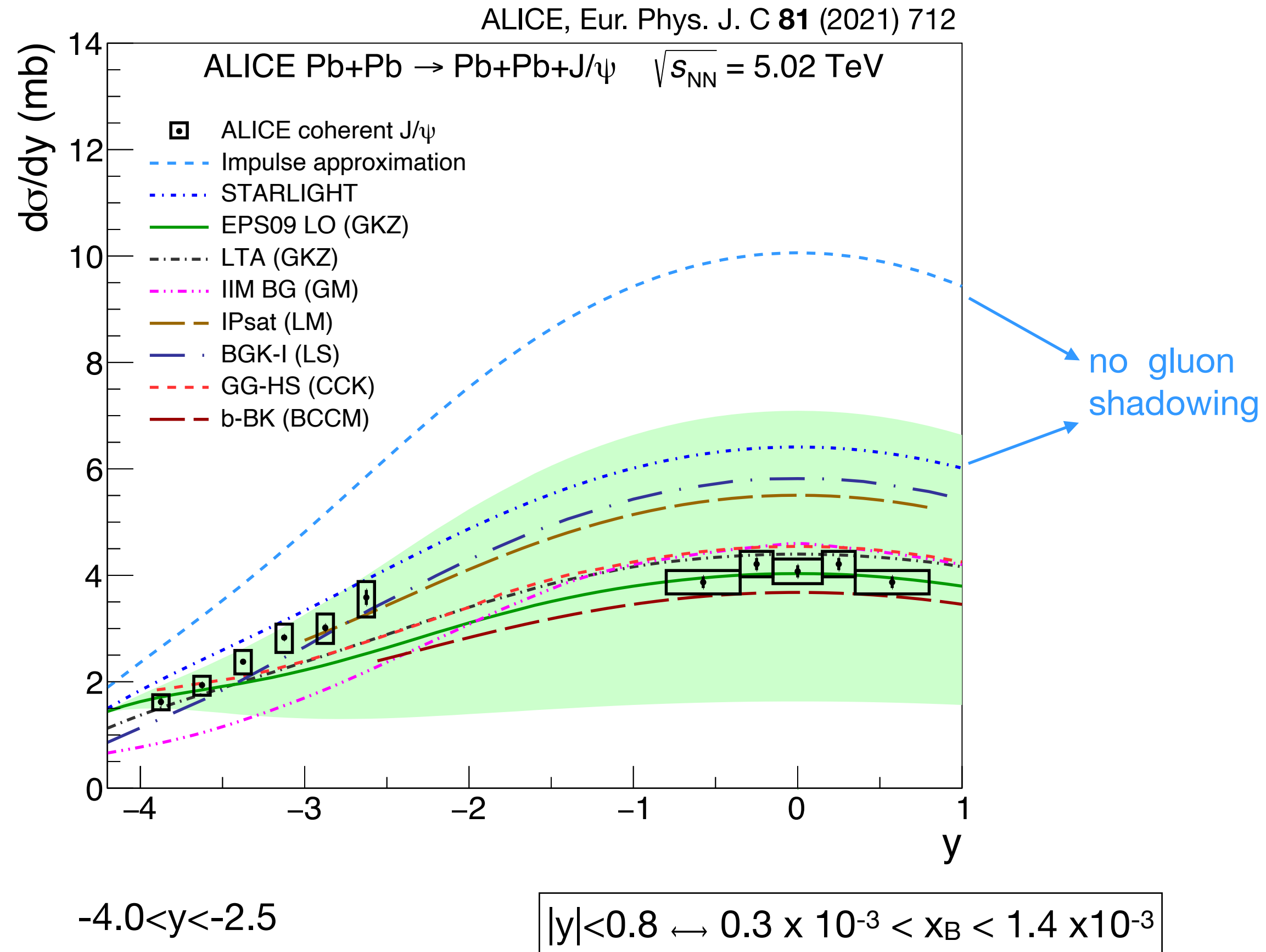
- Coherent production: measurements up to large t :
 - 3D or 2D (x independent) transverse position

$$\int_0^{\infty} d\Delta_{\perp} \text{GPD}(x, 0, \Delta_{\perp}) e^{-ib_{\perp} \Delta_{\perp}}$$

Experimentally limited by maximum transverse momentum.
Need to extend p_{T} range as much as possible in measurement.
~third diffractive minimum.



Coherent production in PbPb at ALICE

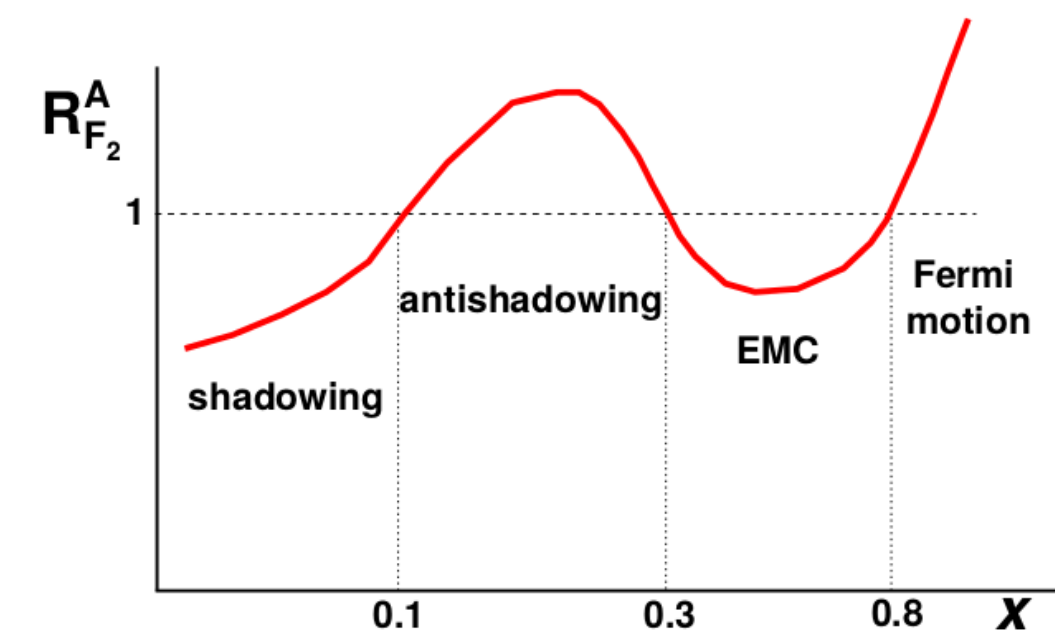
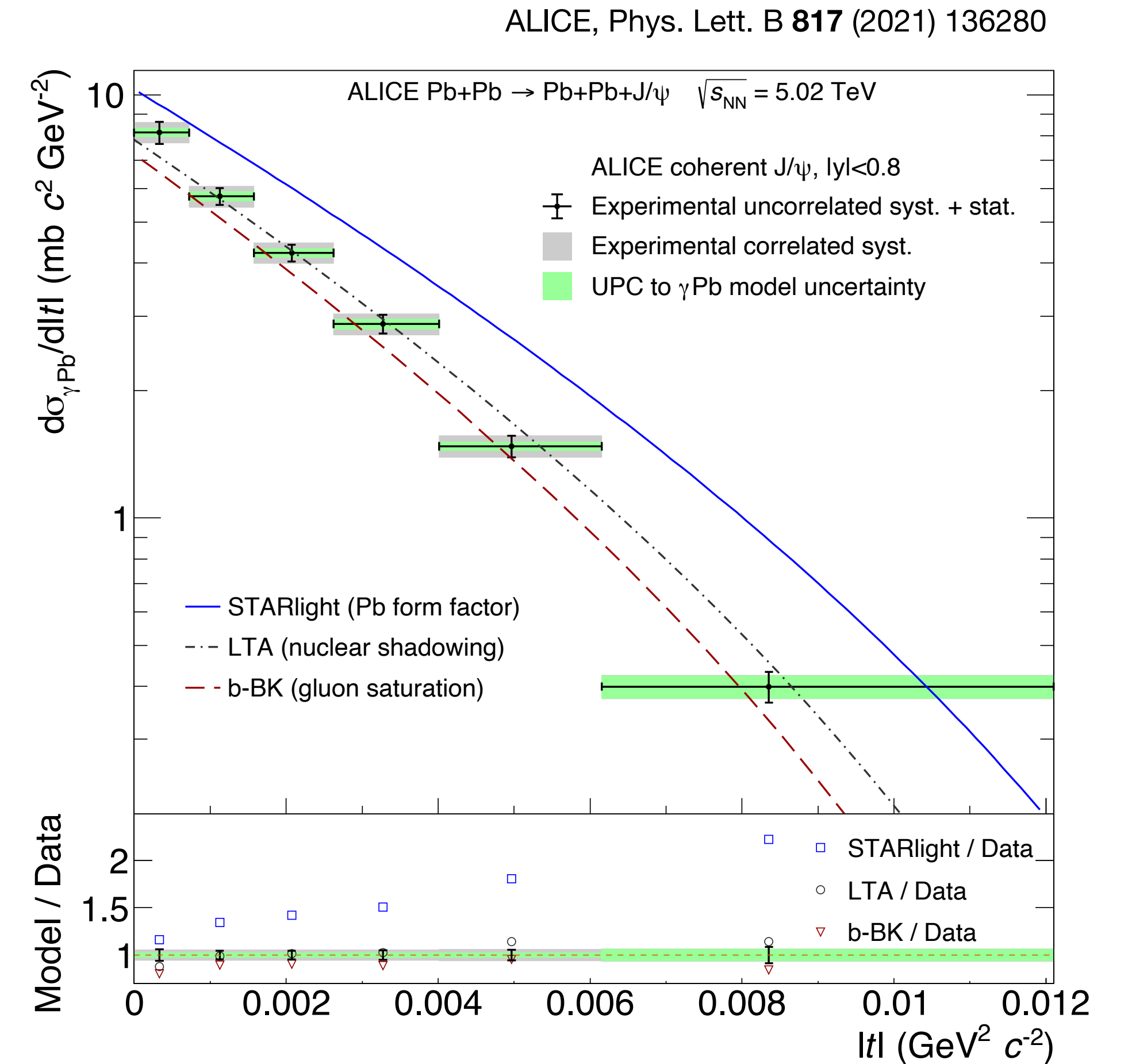


$0.7 \times 10^{-2} < x_B < 3.3 \times 10^{-2}$ (dominant)

$1.1 \times 10^{-5} < x_B < 5.1 \times 10^{-5}$

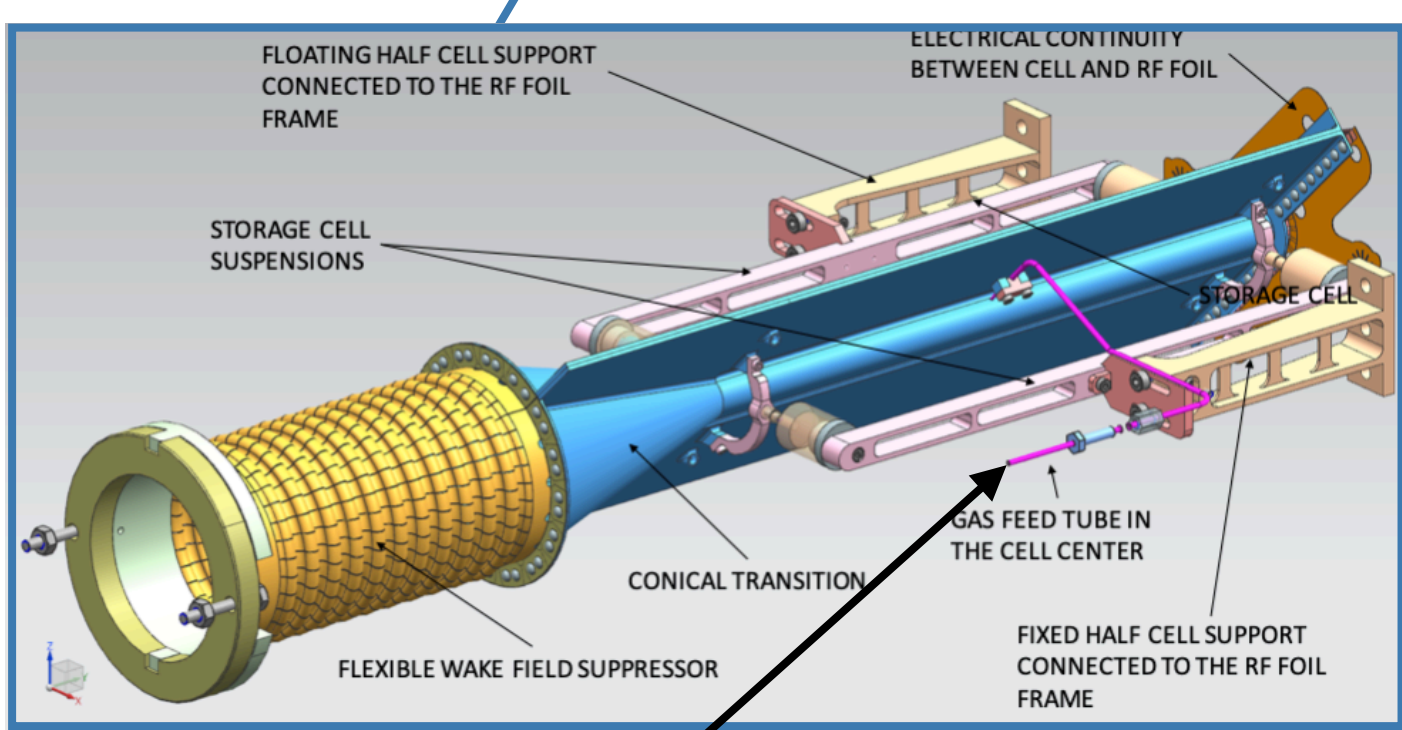
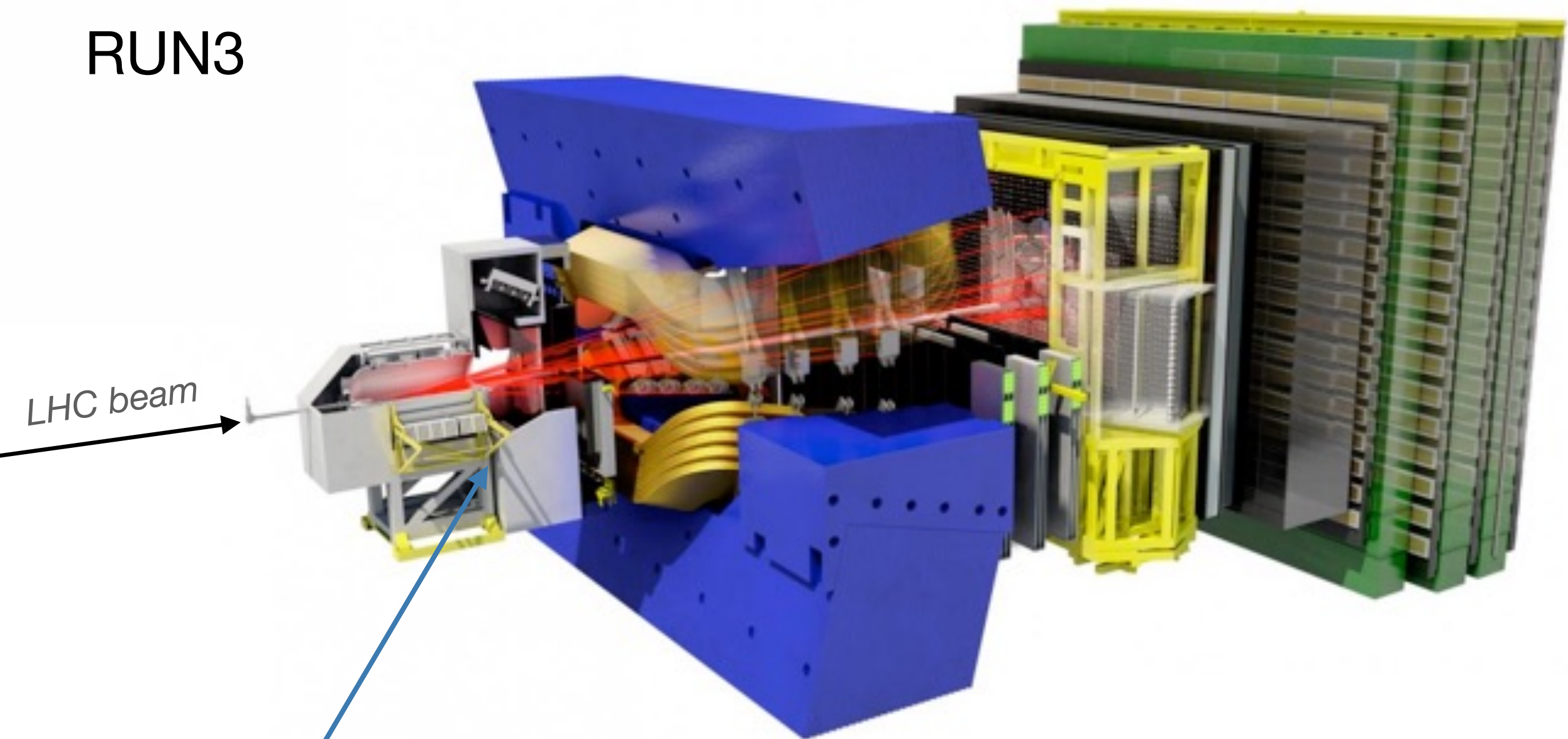
Results indicate shadowing in gluon PDF:

$$R_g = \frac{g^{Pb}}{A g^p} \approx 0.65 \text{ at } x \approx 10^{-3}$$

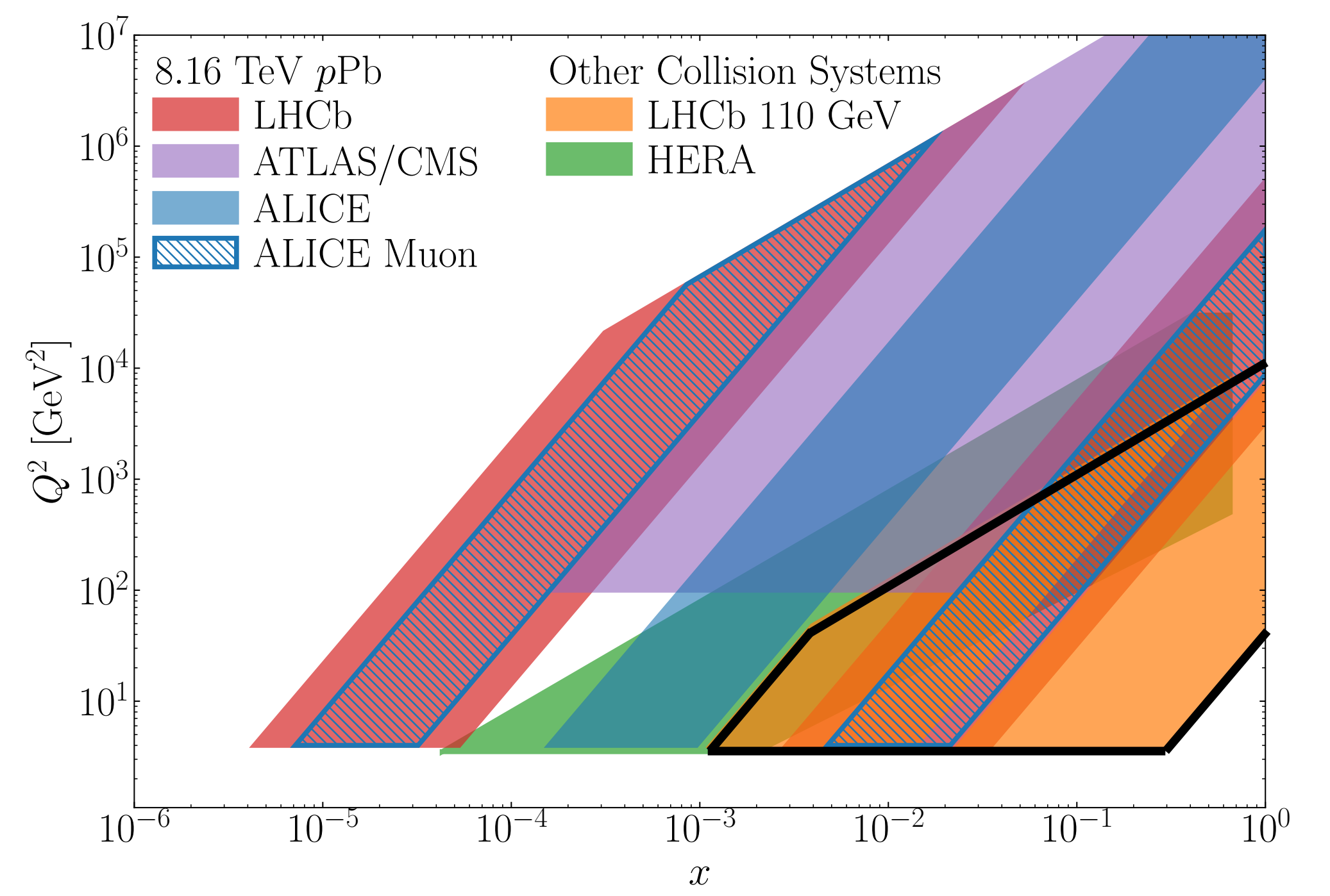


Fixed target at LHCb

RUN3

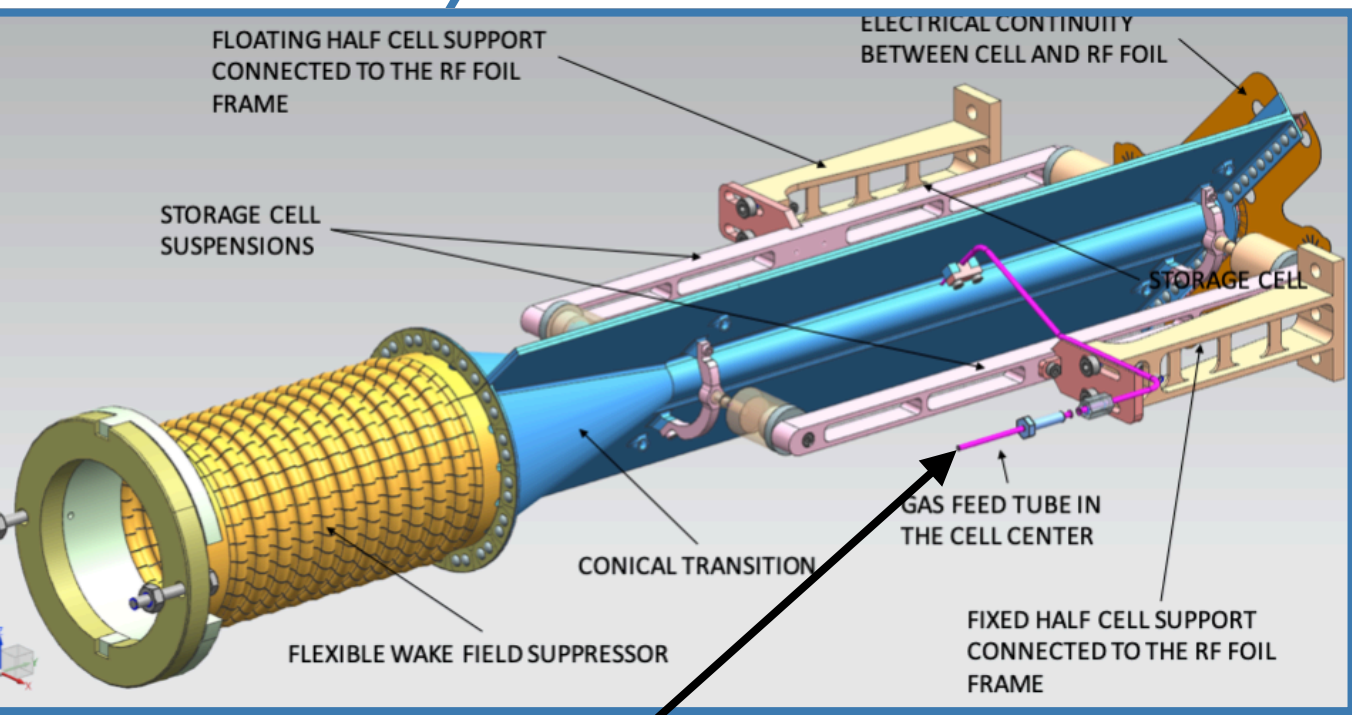
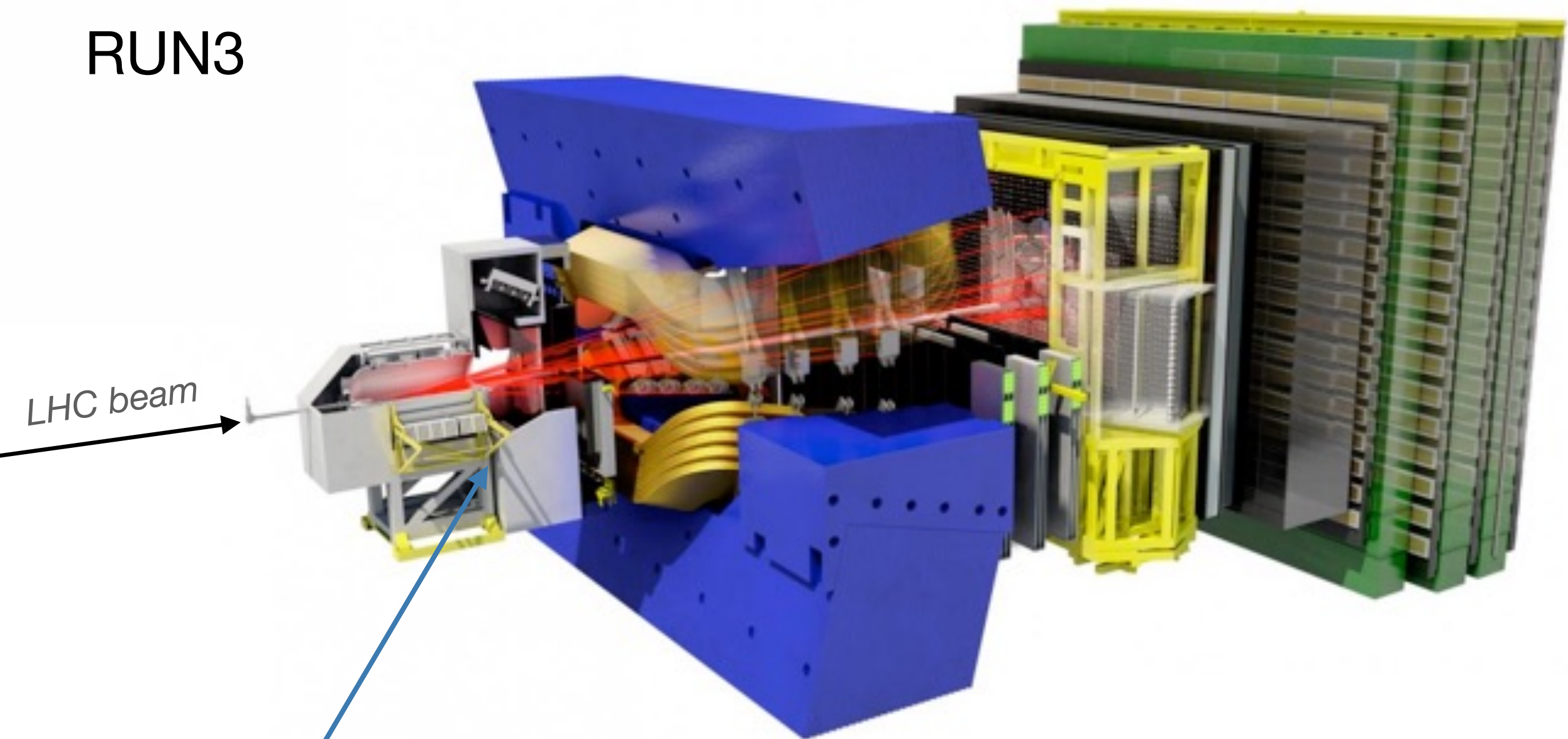


inject gas: He, Ne, Ar, and H₂, D₂

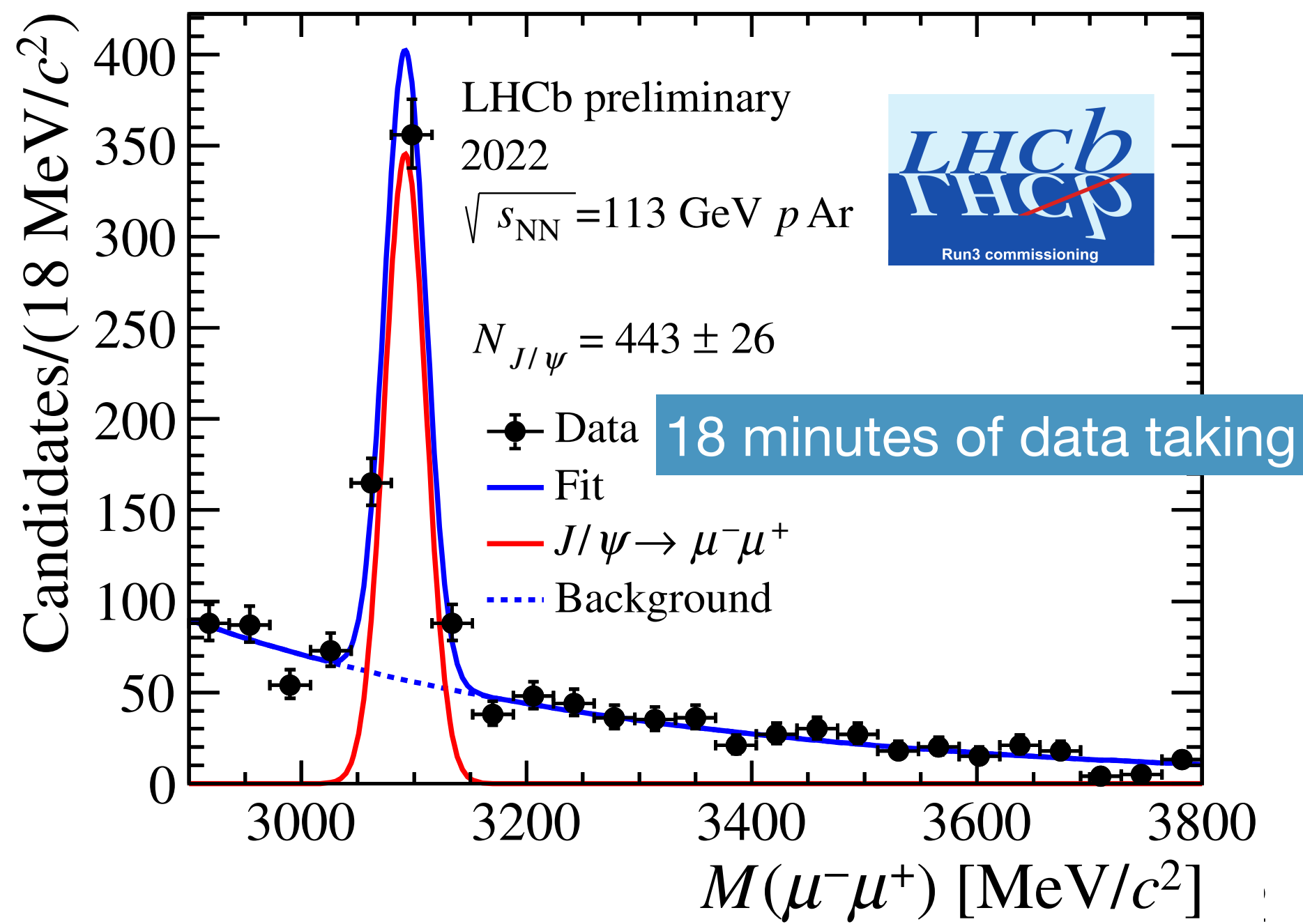
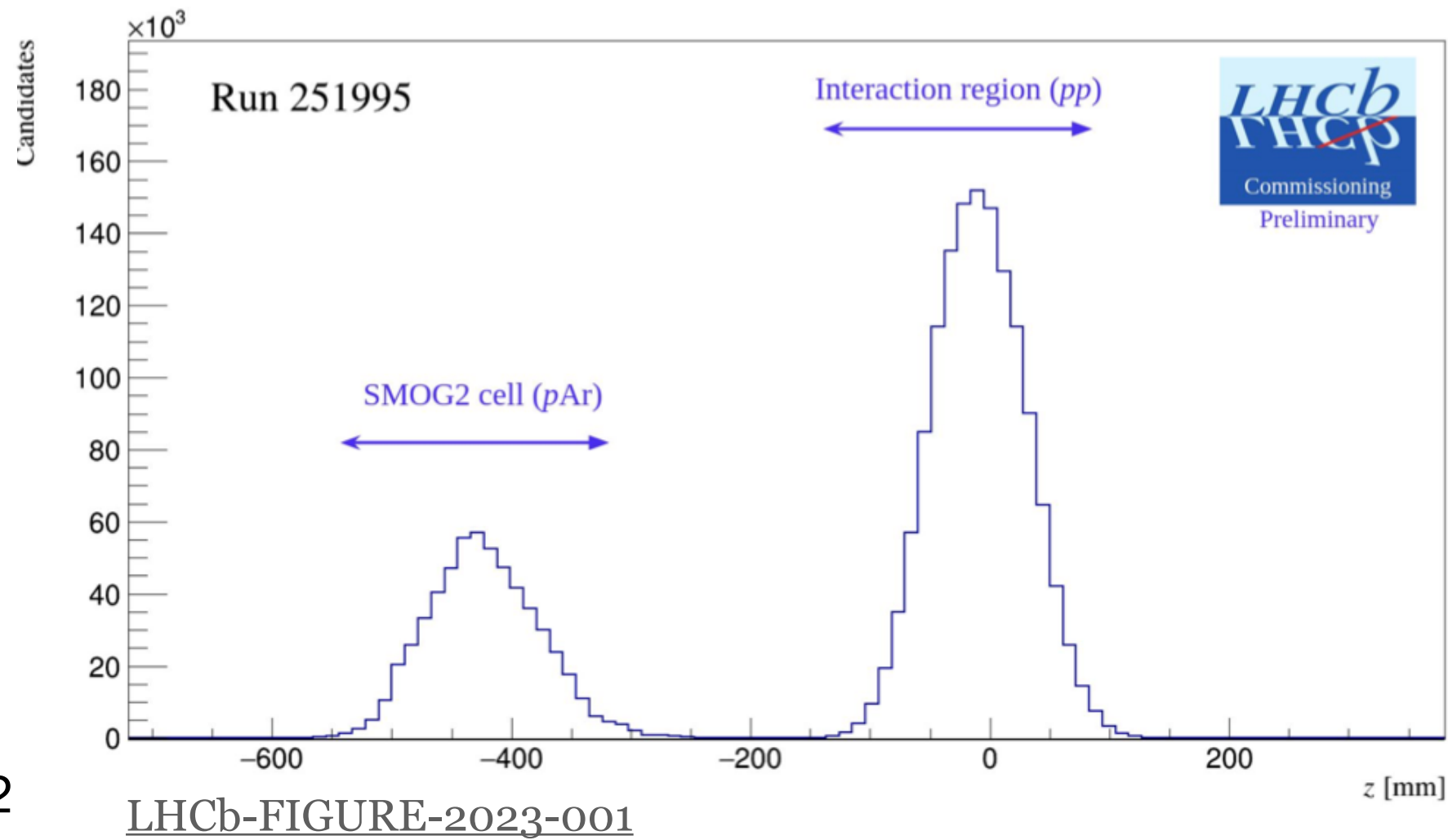
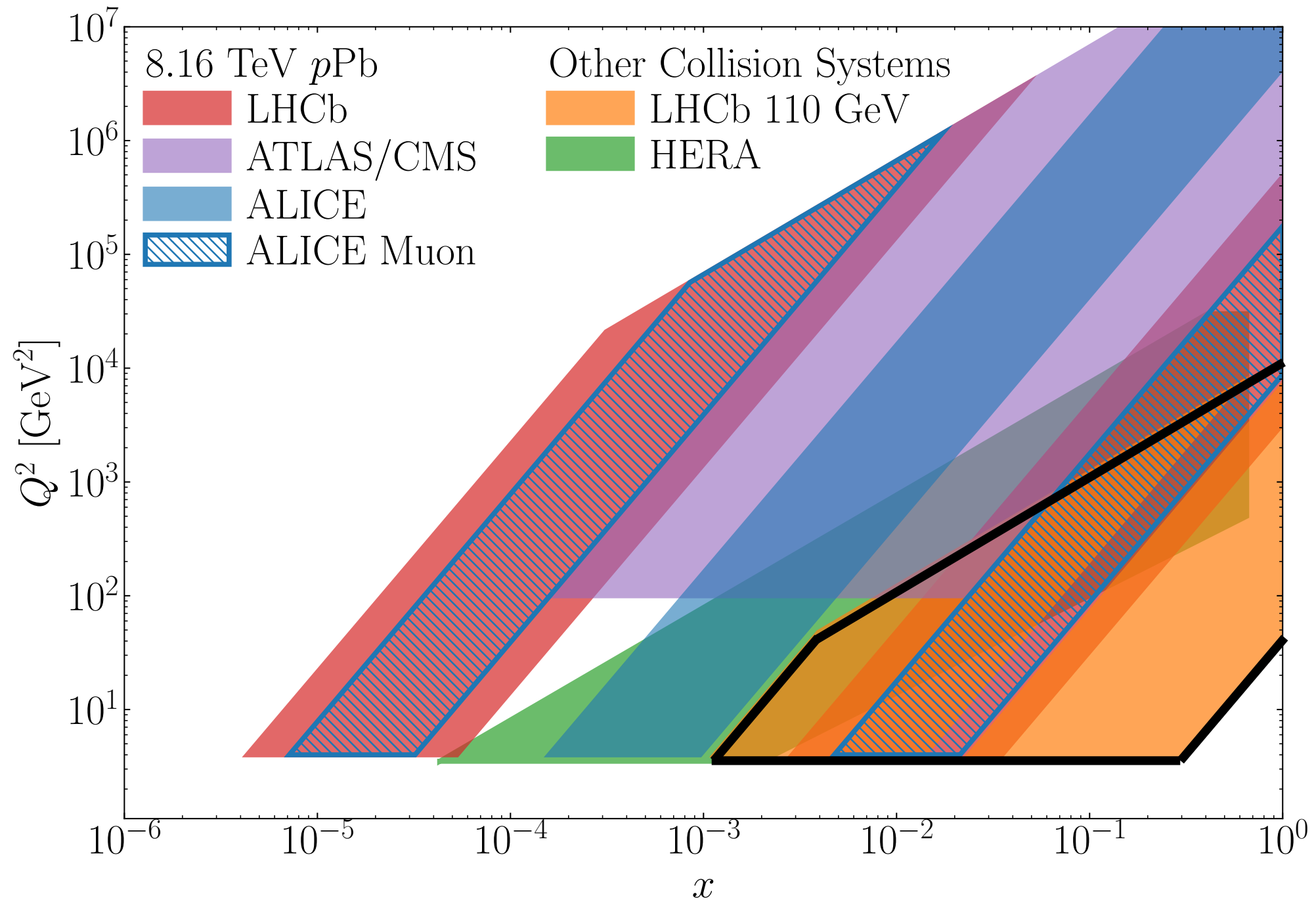


Fixed target at LHCb

RUN3



inject gas: He, Ne, Ar, and H₂, D₂

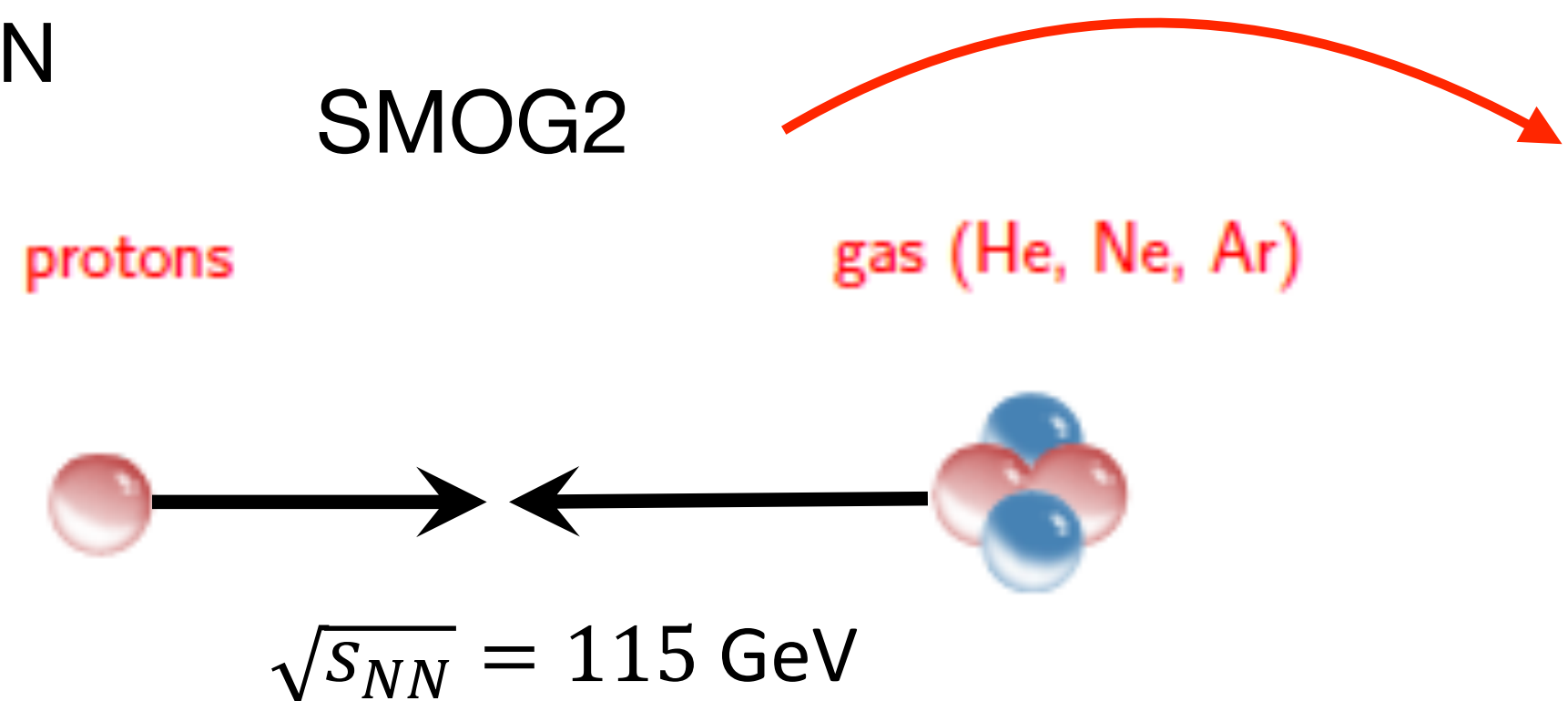


Upcoming experiments probing GPDs

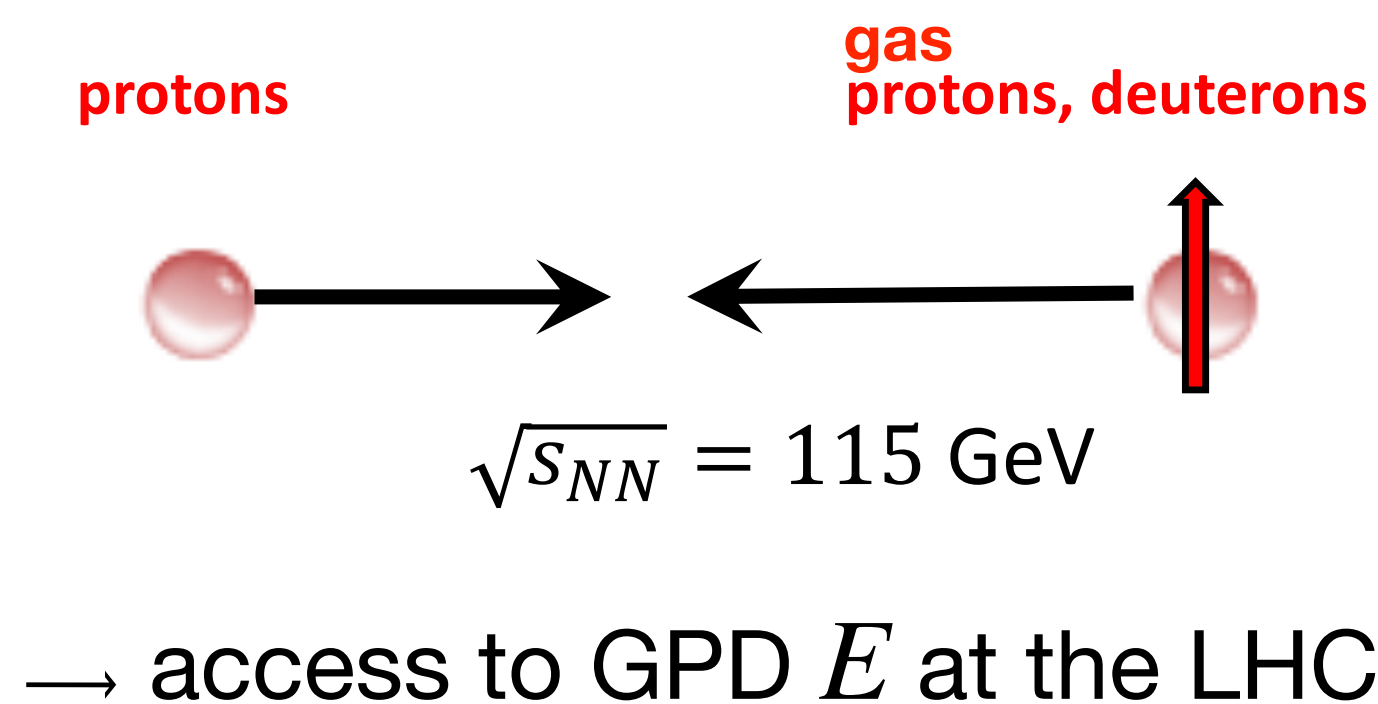
- Jefferson Lab:

- ▶ ALERT at CLAS (analysis ongoing): DVCS and meson production on ^4He : spin-0 target $\rightarrow$ only 1 GPD
- ▶ Addition of neutral spectrometer at Hall C: DVCS, exclusive π^0 off proton (analysis ongoing)
- ▶ Transverse target at CLAS approved (~ 4 years) $\rightarrow$ access to GPD E
- ▶ Double DVCS at CLAS approved ($\sim 5\text{--}6$ years) and at Hall A with SoLID (C1 approved) $\rightarrow$ access to GPDs at $x \neq \xi$
- ▶ Additional proposals:
 - ▶ Positron beam at Jefferson Lab $\rightarrow$ access to $Re\mathcal{H}$ through beam-charge asymmetry
 - ▶ Upgrade to JLab at 22 GeV

- LHCSPIN

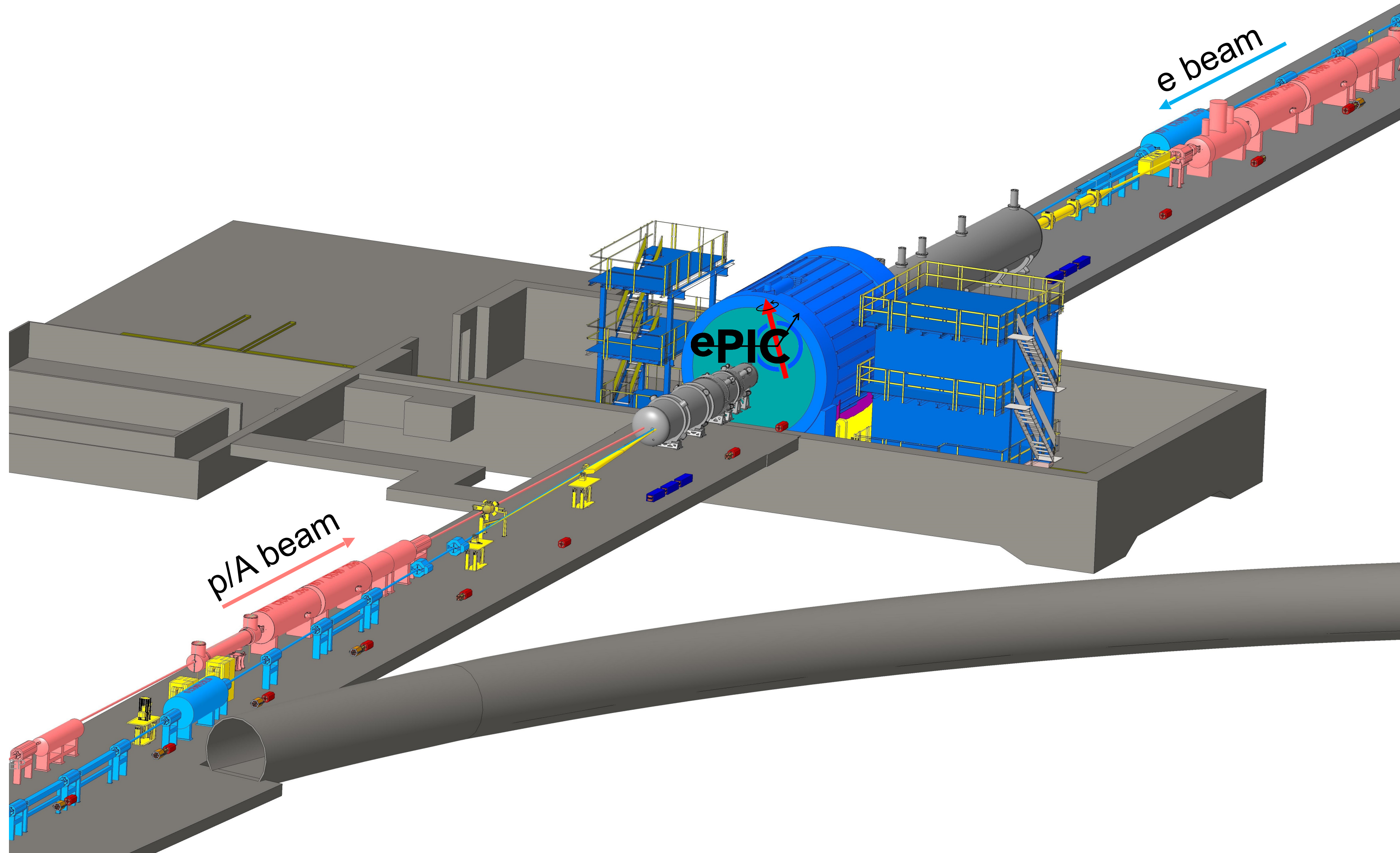


Proposal for Run 5:
LHCSPIN: transversely polarised gas target at LHCb

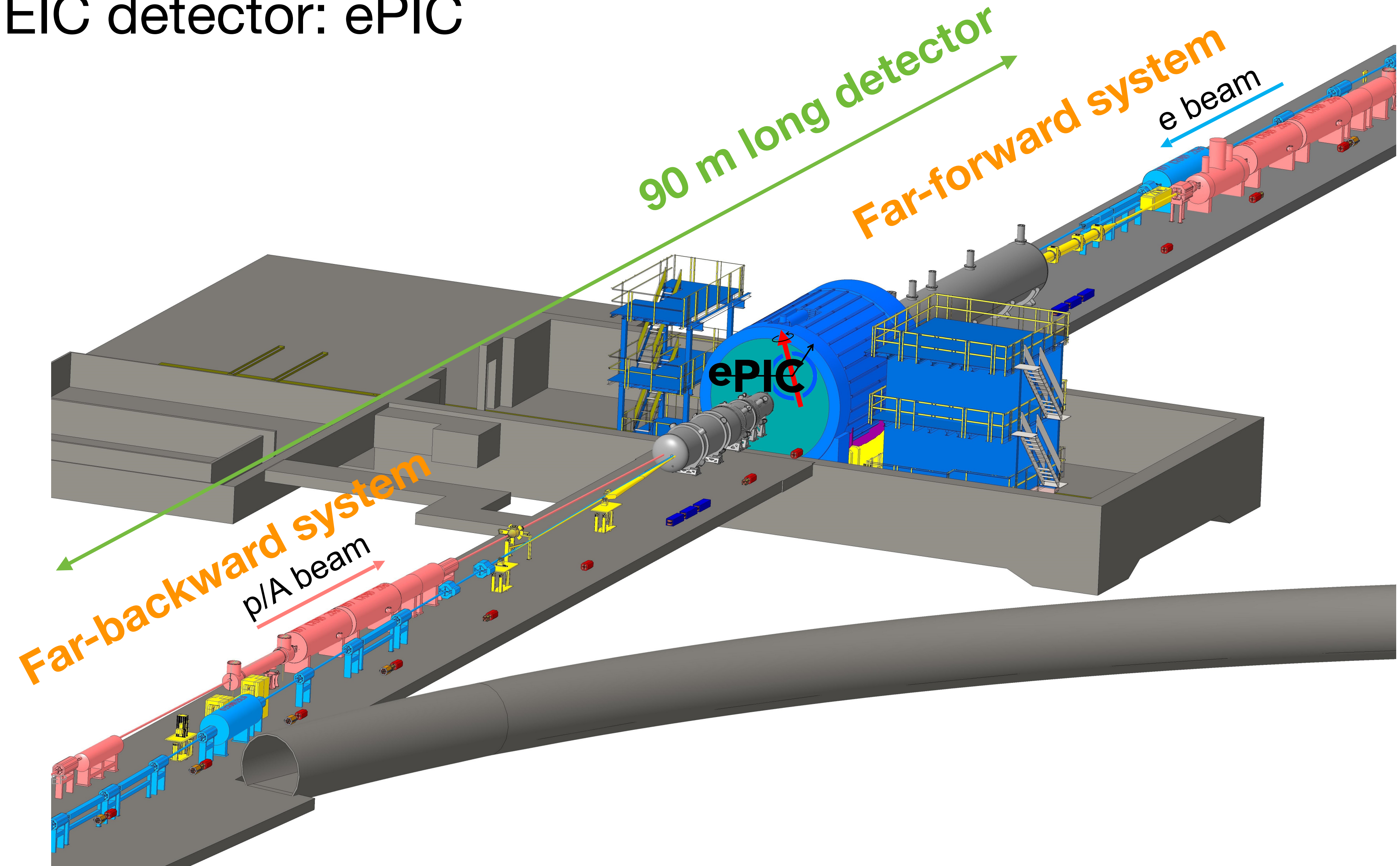


- EIC

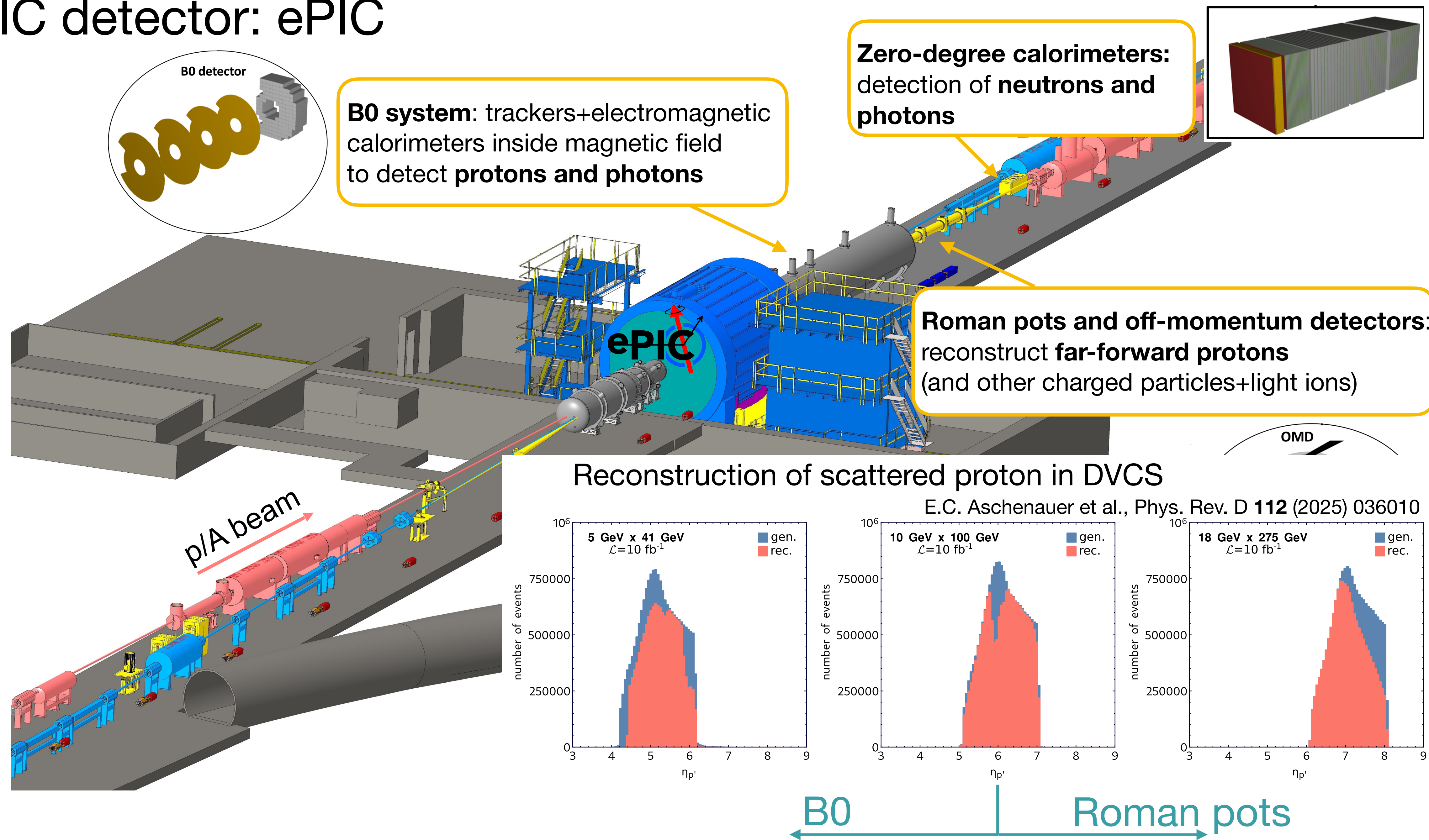
First EIC detector: ePIC



First EIC detector: ePIC



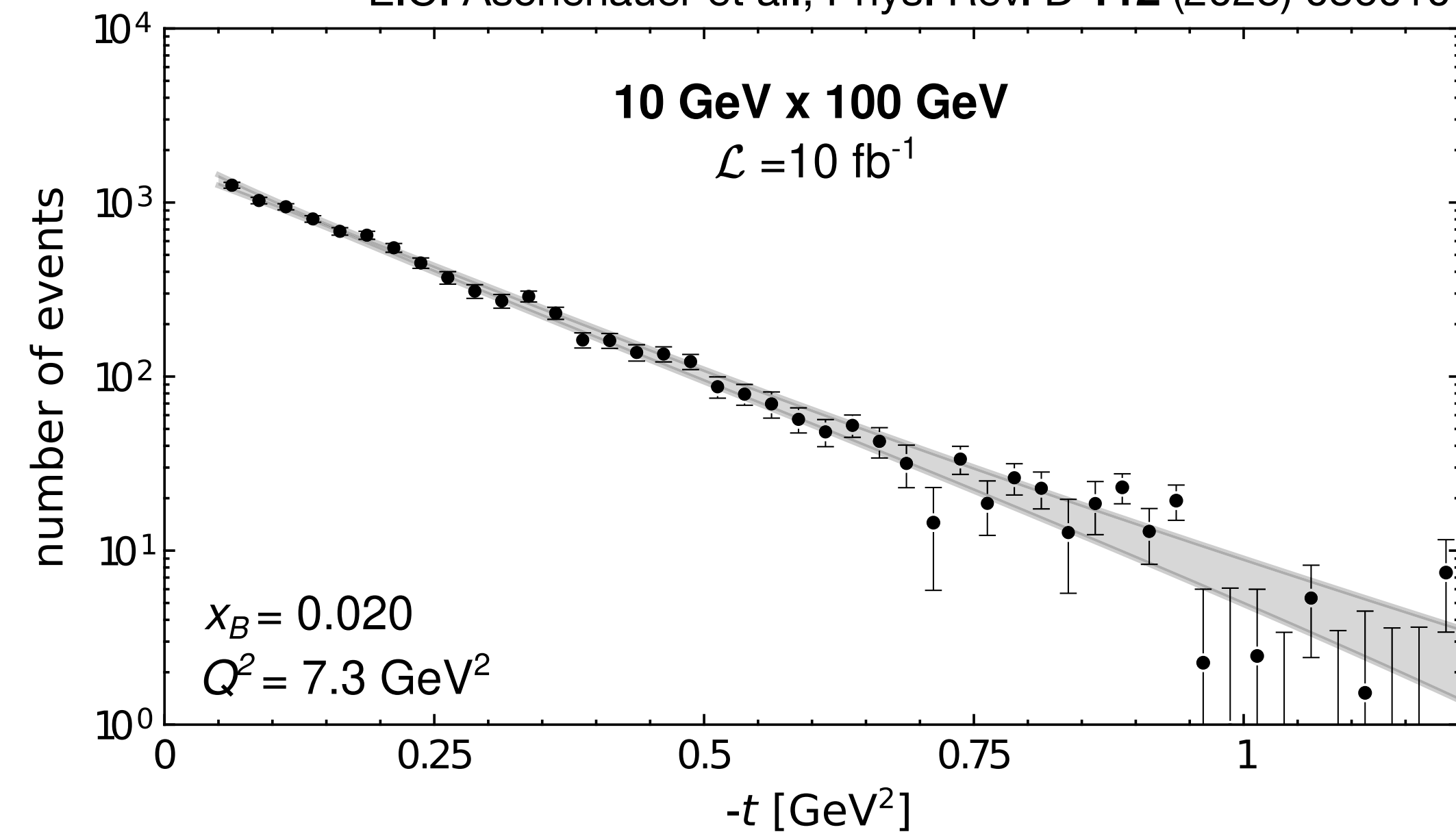
First EIC detector: ePIC



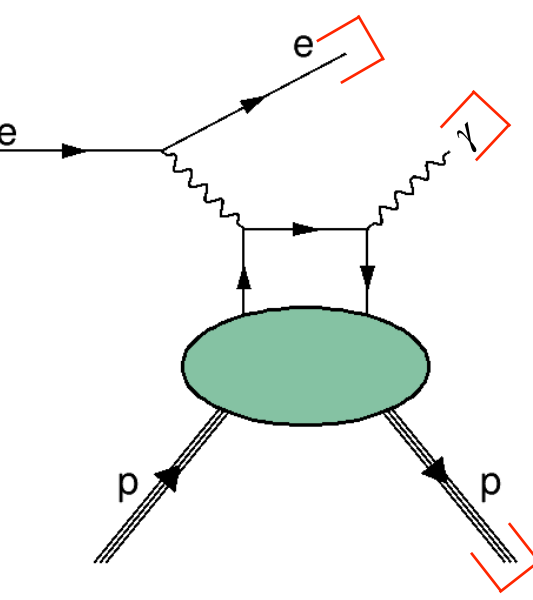
DVCS and impact on determination of CFFs in ePIC

DVCS after efficiency and acceptance corrections

E.C. Aschenauer et al., Phys. Rev. D **112** (2025) 036010



DVCS and impact on determination of CFFs in ePIC

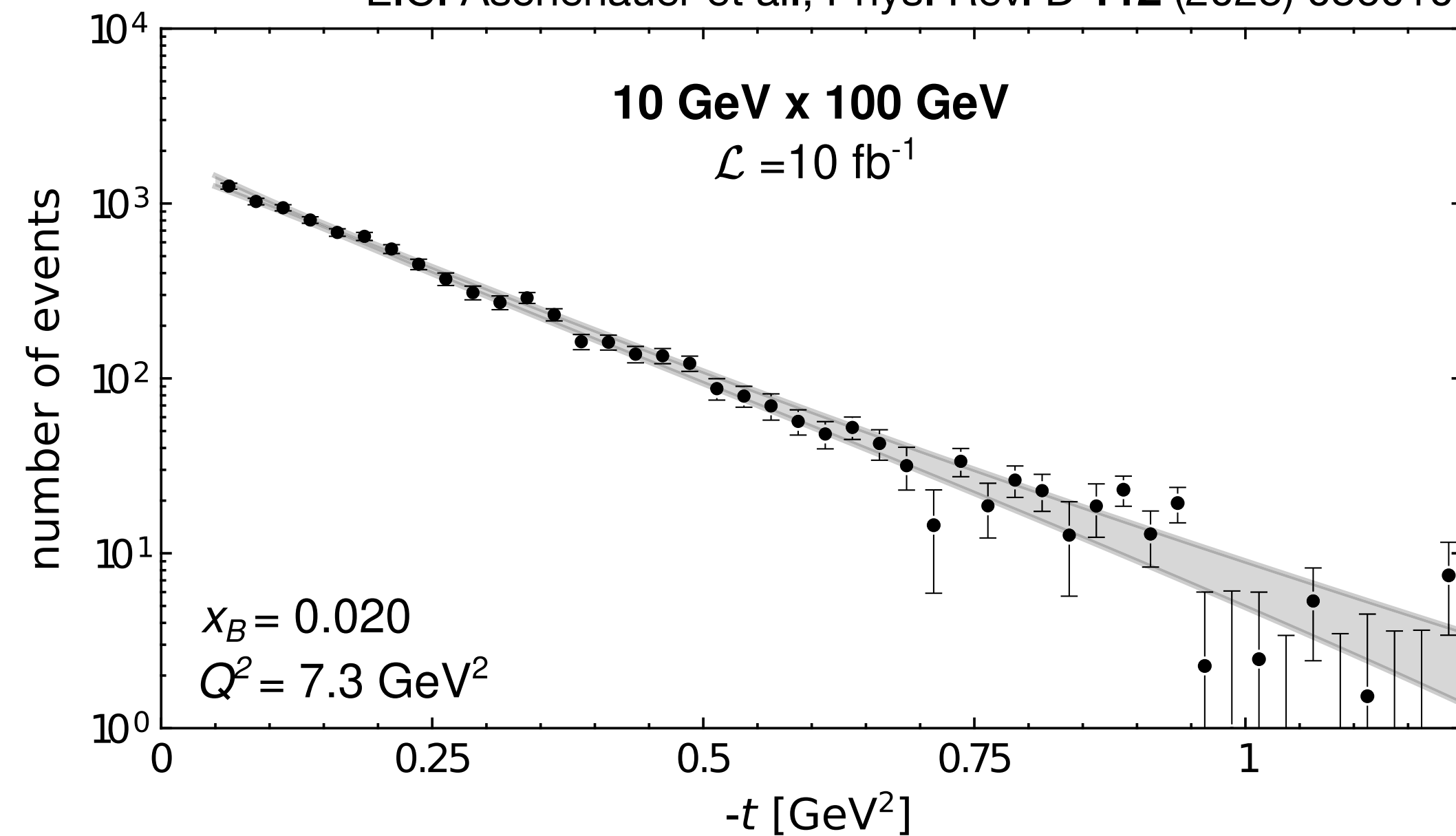


DVCS after efficiency and acceptance corrections

E.C. Aschenauer et al., Phys. Rev. D **112** (2025) 036010

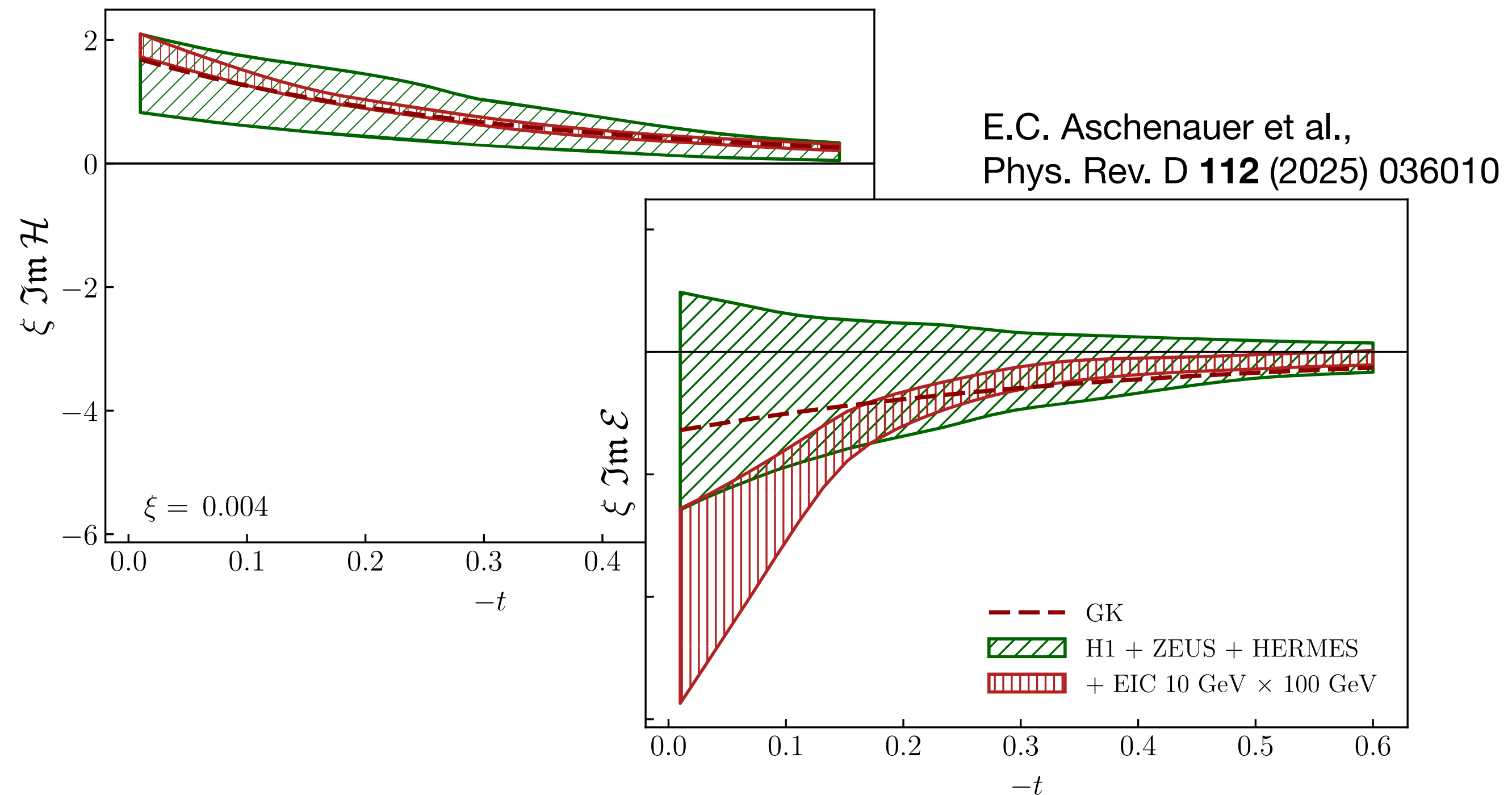
10 GeV x 100 GeV

$\mathcal{L} = 10 \text{ fb}^{-1}$



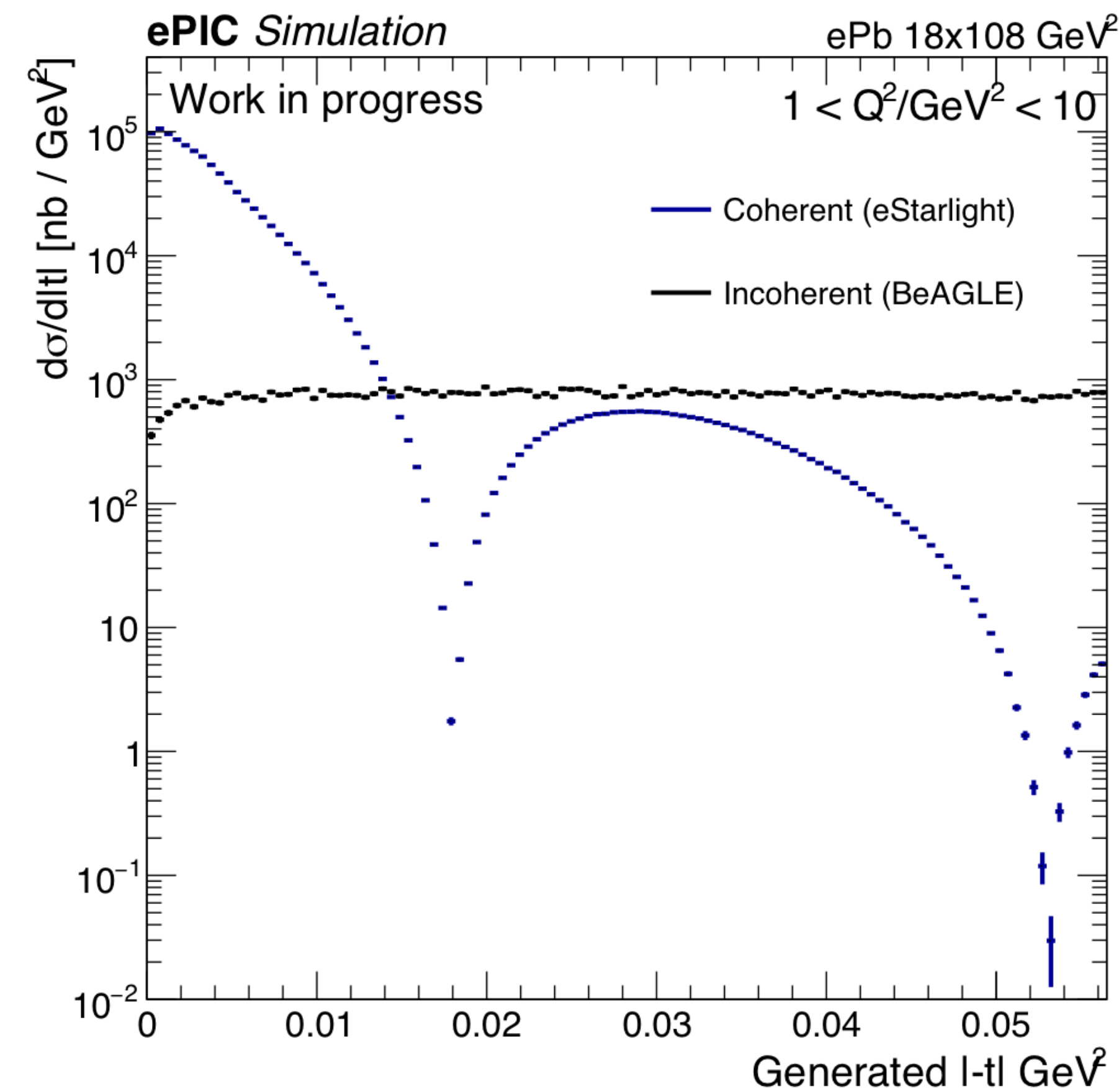
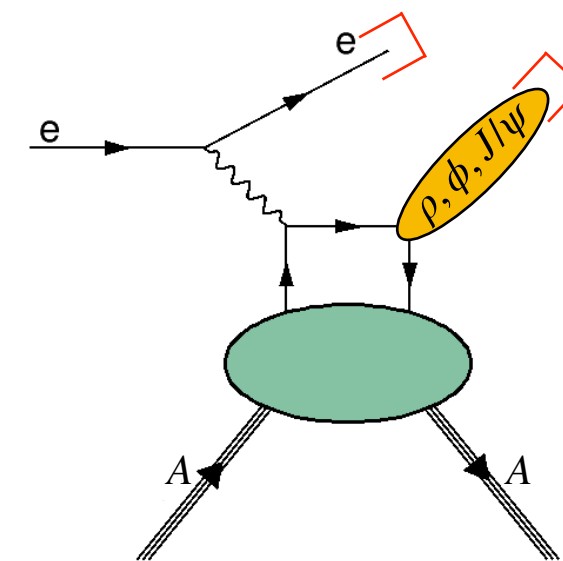
Lepton-beam helicity asymmetry

$$\rightarrow \Im m \left(F_1 \mathcal{H} + -\frac{t}{4m^2} F_2 \mathcal{E} + \dots \right)$$



Exclusive vector-meson production off nuclei in ePIC

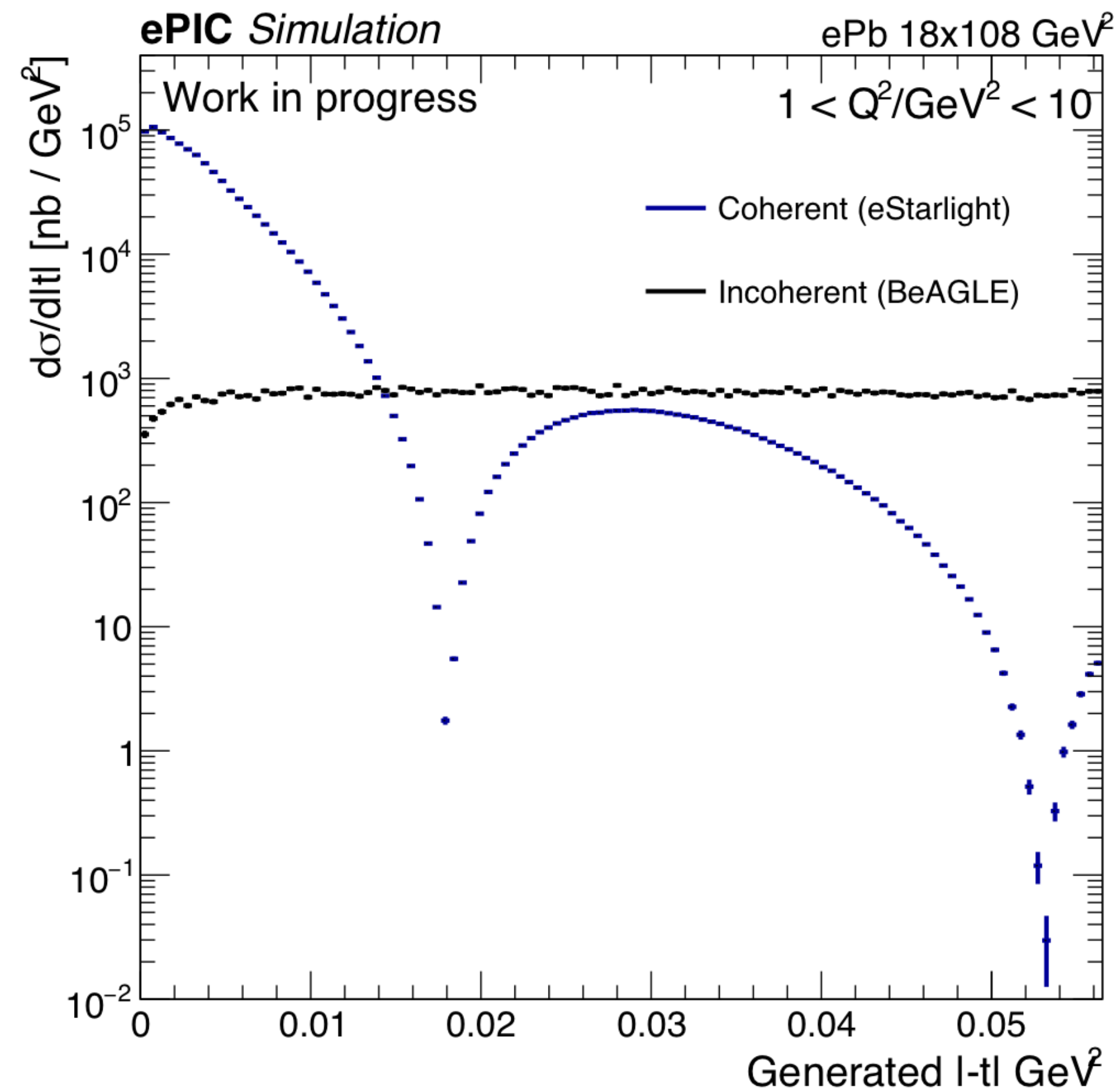
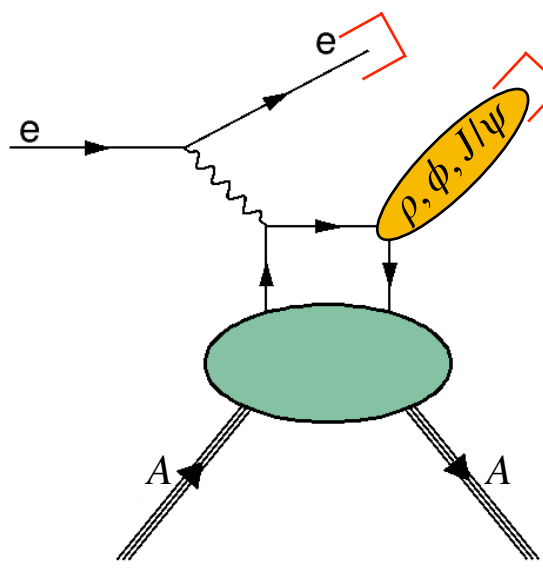
Separation of coherent and incoherent signal



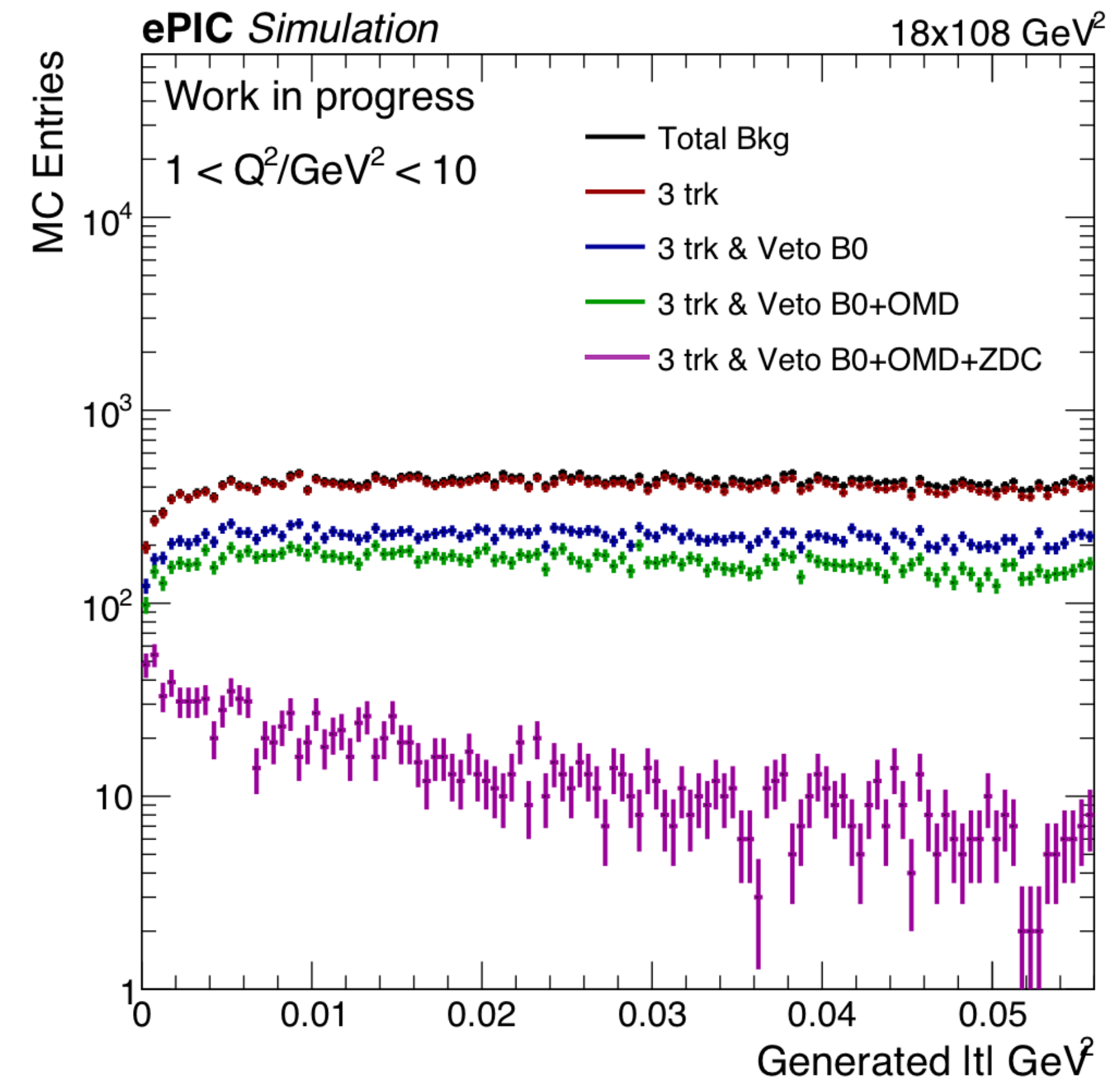
Simulated **coherent** and incoherent signal

Exclusive vector-meson production off nuclei in ePIC

Separation of coherent and incoherent signal



Simulated **coherent** and incoherent signal



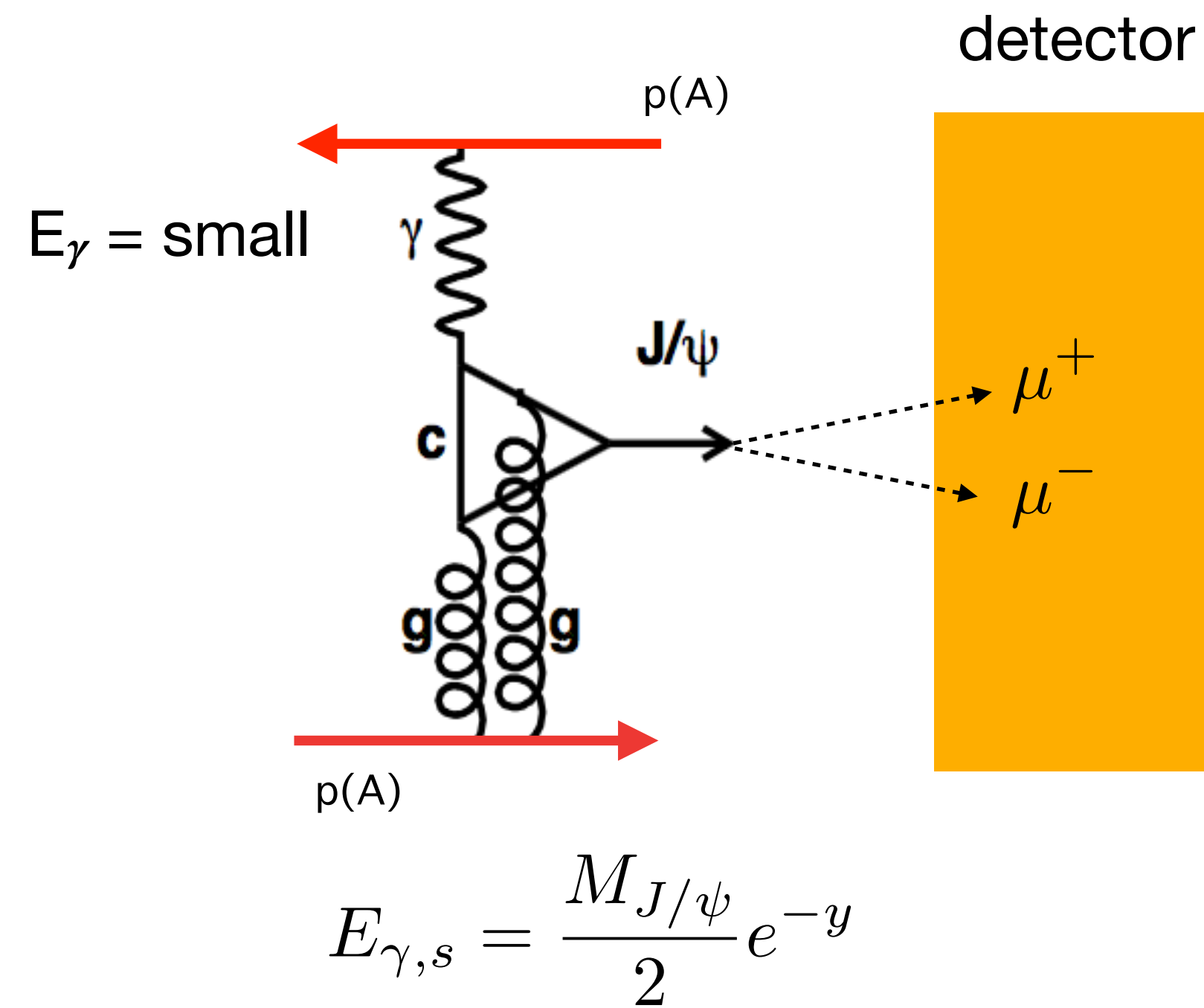
Suppression of incoherent signal using detector system

Summary

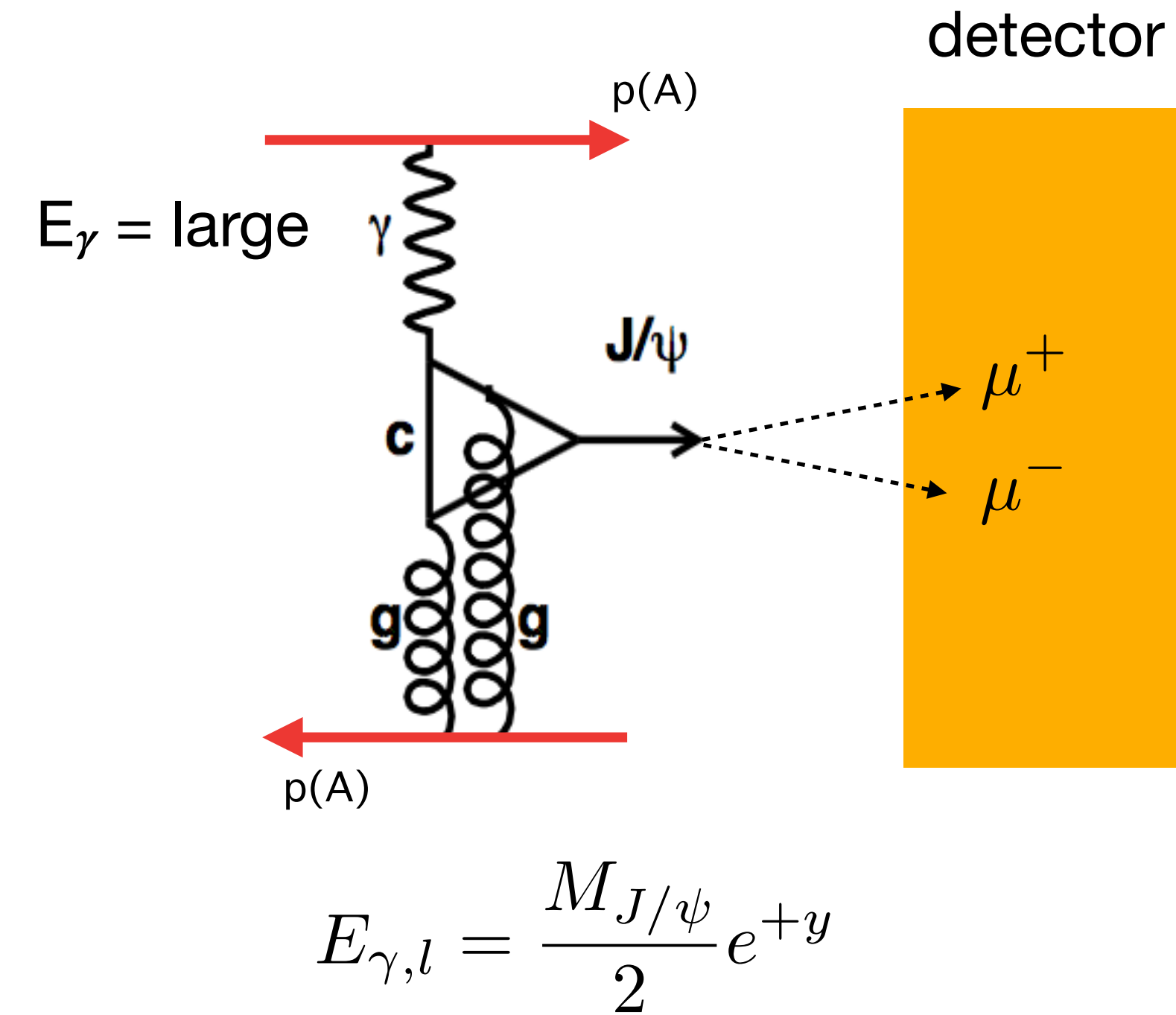
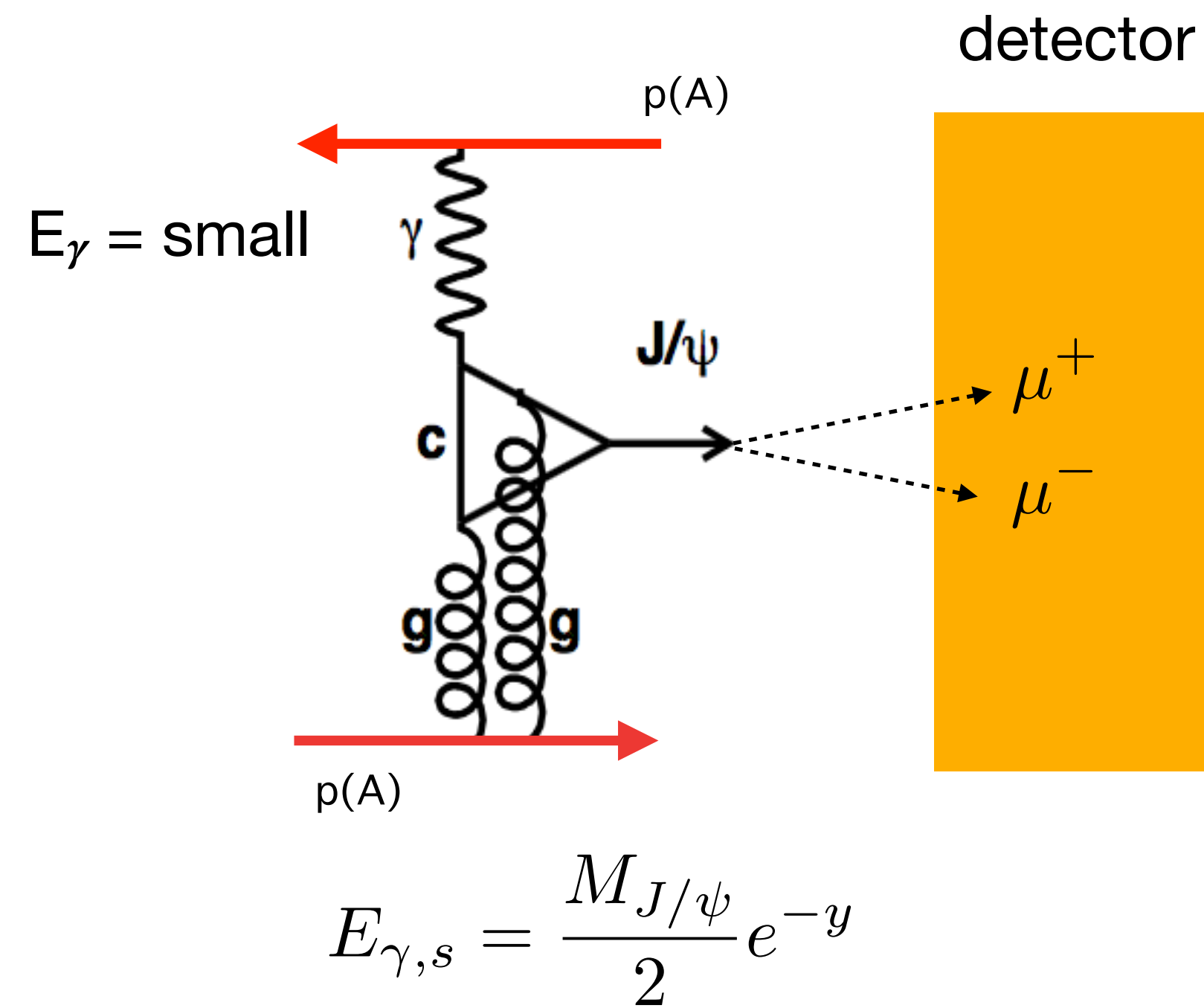
- Valence region at Jefferson Lab: full GPD programme at high precision to extract chiral-even and chiral-odd GPDs using polarised electron beam and unpolarised, longitudinally and transversely polarised proton targets as well as light nuclei.
- Sea-quarks at COMPASS: measurements of DVCS and hard exclusive meson production off unpolarised proton are ongoing.
- Sea-quarks and gluons at the EIC: full GPD programme, at unrivalled precision down to $x_B=10^{-4}$, using polarised electron beam and polarised nucleons as well as entire series of unpolarised nuclei.
- LHC:
 - Spin-independent, highest-energy measurements with proton and lead ions: test of universality of GPDs and access to lowest region in x_B , down to 10^{-6} .
 - Fixed target with proton and noble gasses for high- x_B region. Plans for transversely polarised target.

Back up

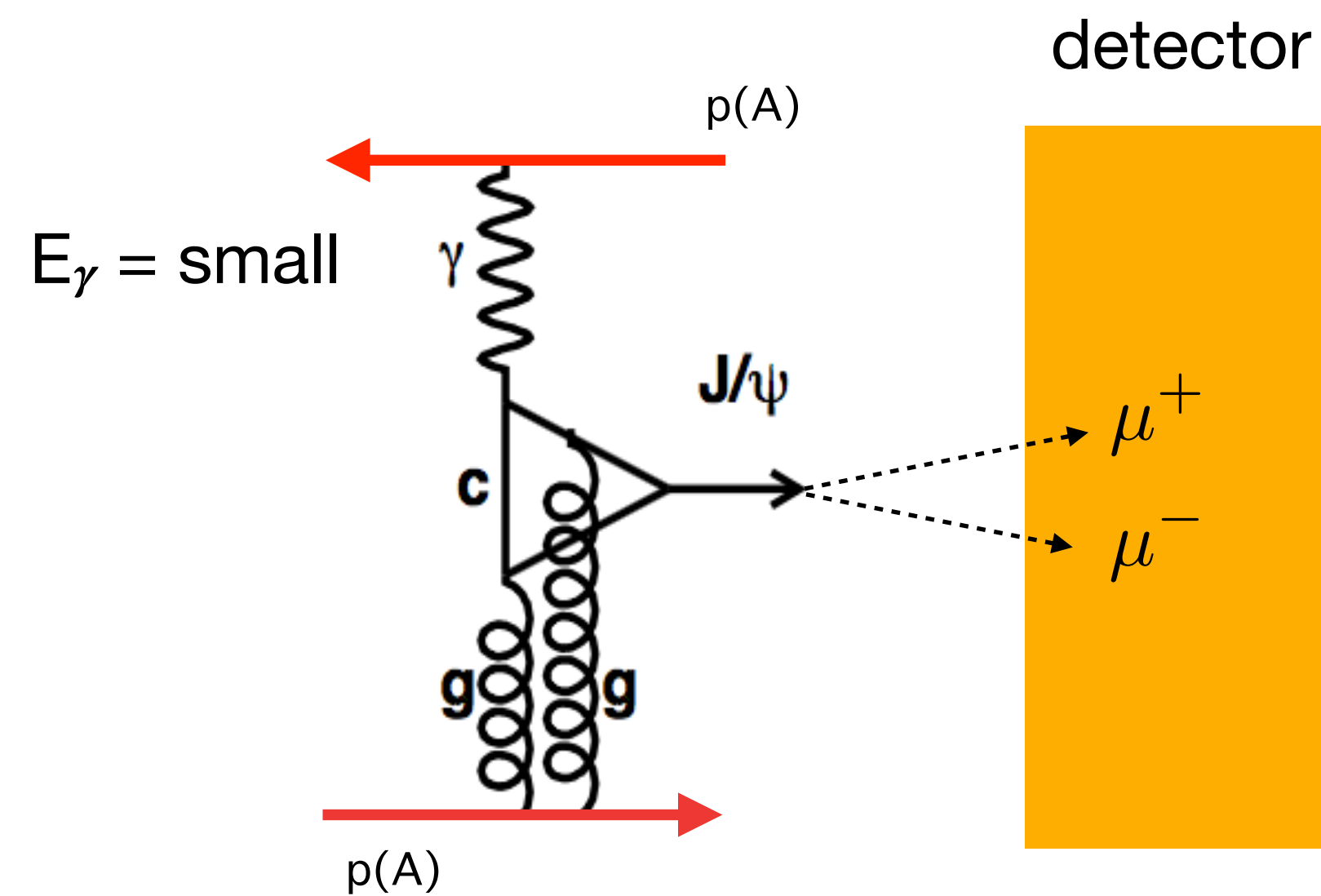
Disentangling the ambiguity on the ID of the γ emitter



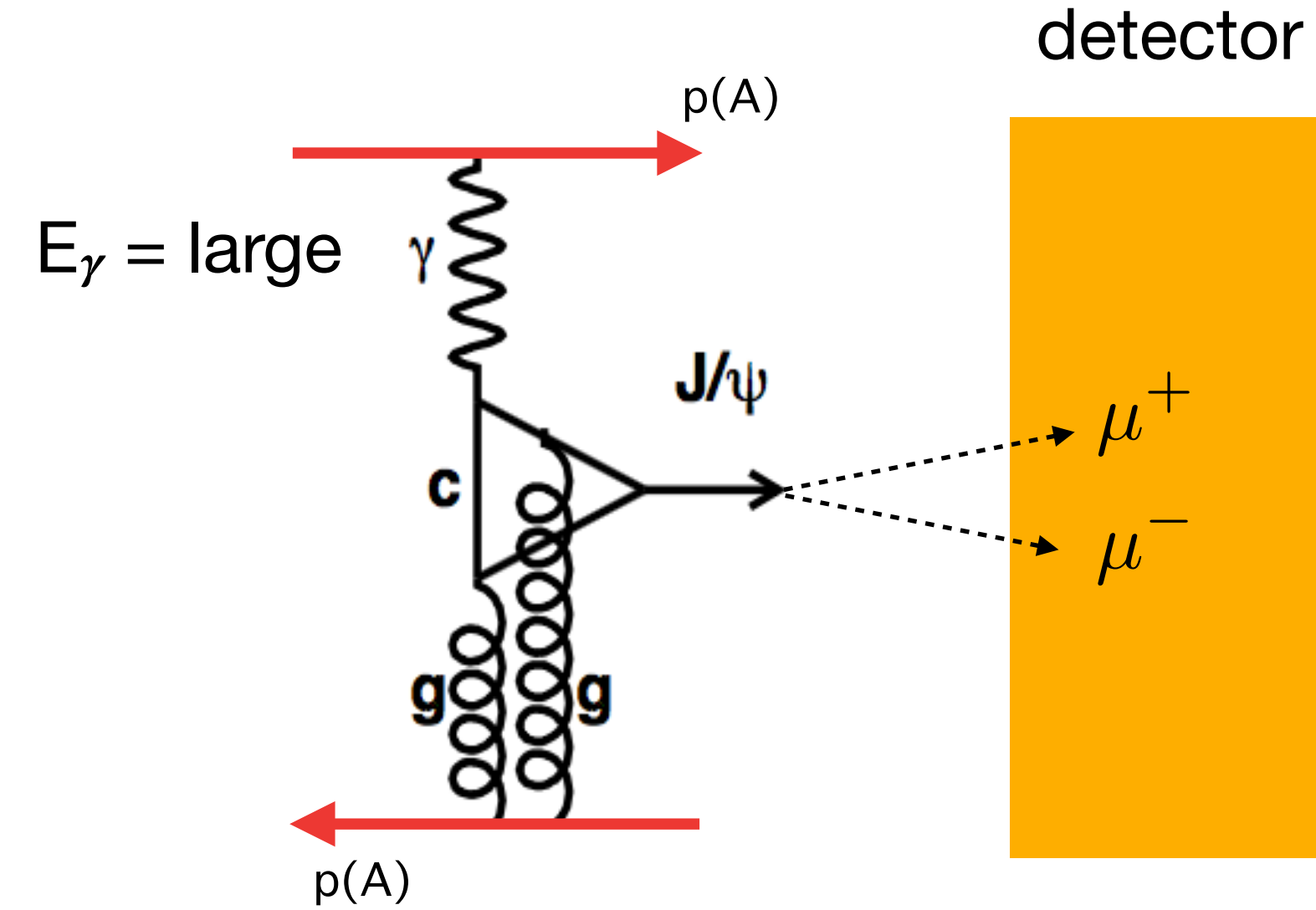
Disentangling the ambiguity on the ID of the γ emitter



Disentangling the ambiguity on the ID of the γ emitter



$$E_{\gamma,s} = \frac{M_{J/\psi}}{2} e^{-y}$$



$$E_{\gamma,l} = \frac{M_{J/\psi}}{2} e^{+y}$$

$$\sigma(y) = N_{\gamma/A}(E_{\gamma,s}) \sigma_{J/\psi}(E_{\gamma,s}) + N_{\gamma/A}(E_{\gamma,l}) \sigma_{J/\psi}(E_{\gamma,l})$$

Disentangling the ambiguity on the ID of the γ emitter

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Disentangling the ambiguity on the ID of the γ emitter

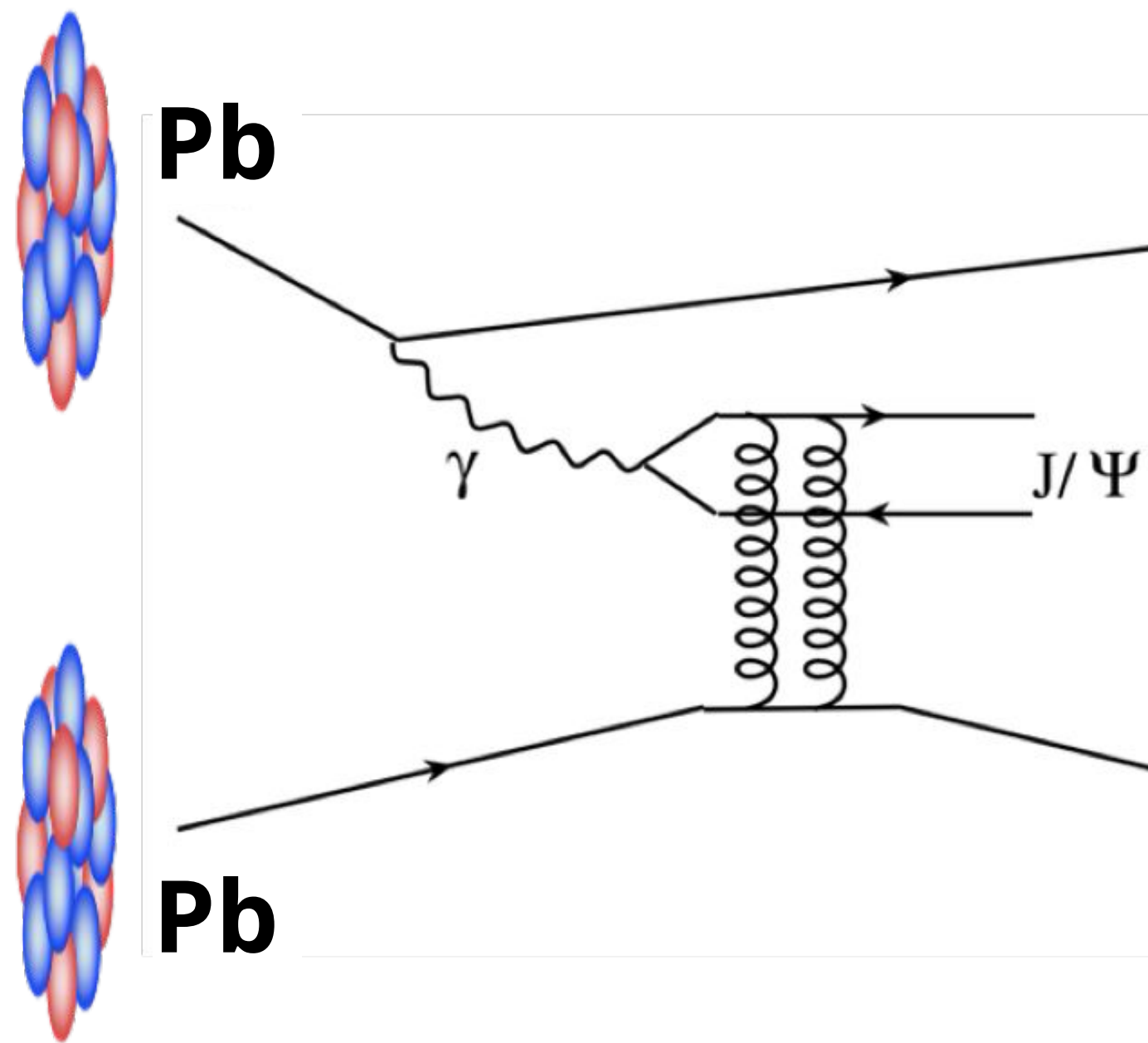
$$\sigma(y) = N_{\gamma/A}(E_{\gamma,s}) \sigma_{J/\psi}(E_{\gamma,s}) + N_{\gamma/A}(E_{\gamma,l}) \sigma_{J/\psi}(E_{\gamma,l})$$

Photon flux $N_{\gamma/A}(E_{\gamma})$ is function of impact parameter:
enhanced for large E_{γ} at small impact parameter.

Disentangling the ambiguity on the ID of the γ emitter

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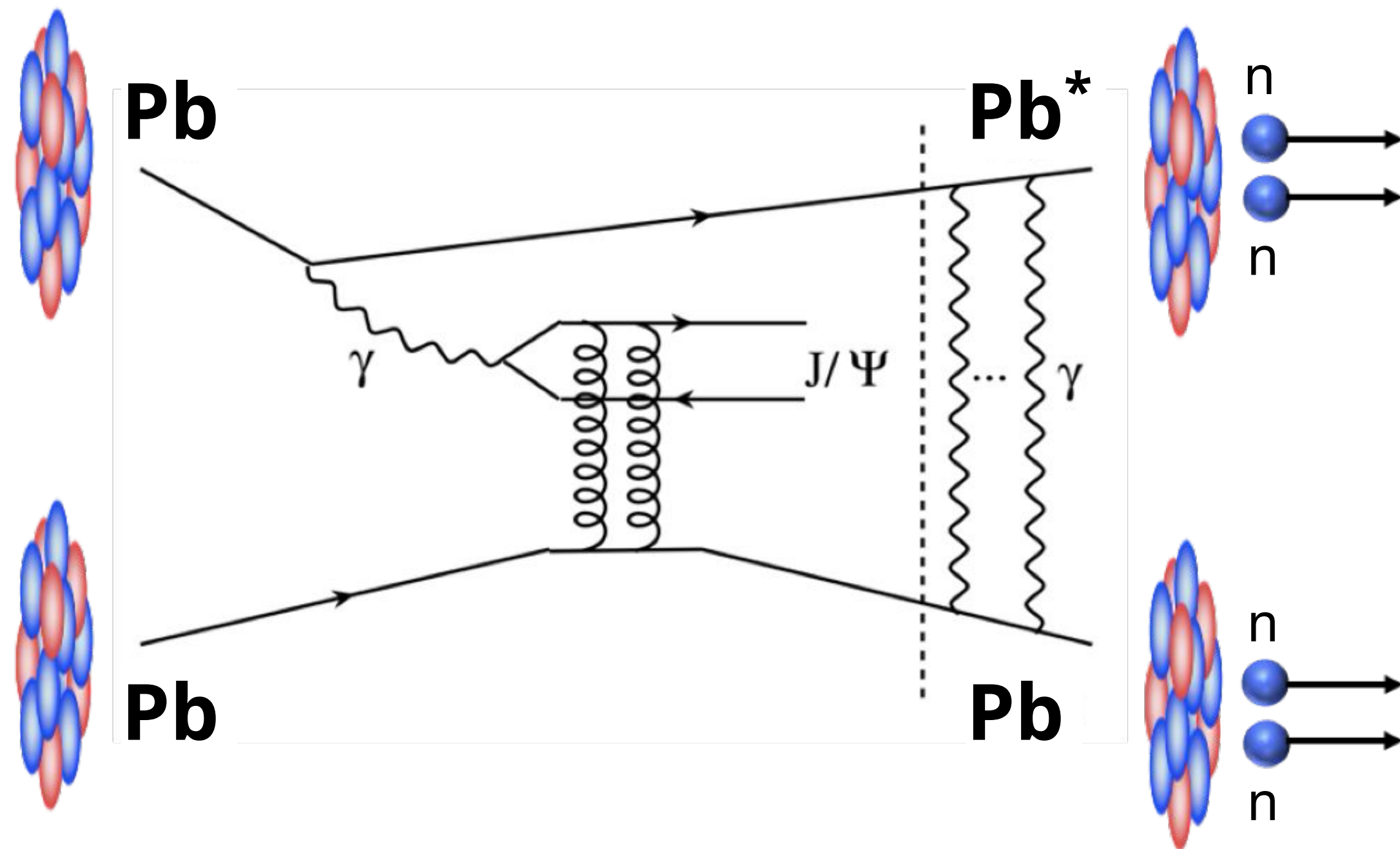


Disentangling the ambiguity on the ID of the γ emitter

$$\sigma(y) = N_{\gamma/A}(E_{\gamma,s}) \sigma_{J/\psi}(E_{\gamma,s}) + N_{\gamma/A}(E_{\gamma,l}) \sigma_{J/\psi}(E_{\gamma,l})$$

Photon flux $N_{\gamma/A}(E_{\gamma})$ is function of impact parameter:
enhanced for large E_{γ} at small impact parameter.

Small impact parameter, $b \longrightarrow$ higher probability for exciting ($\propto 1/b^2$) $\longrightarrow$ higher probability to emit neutrons.

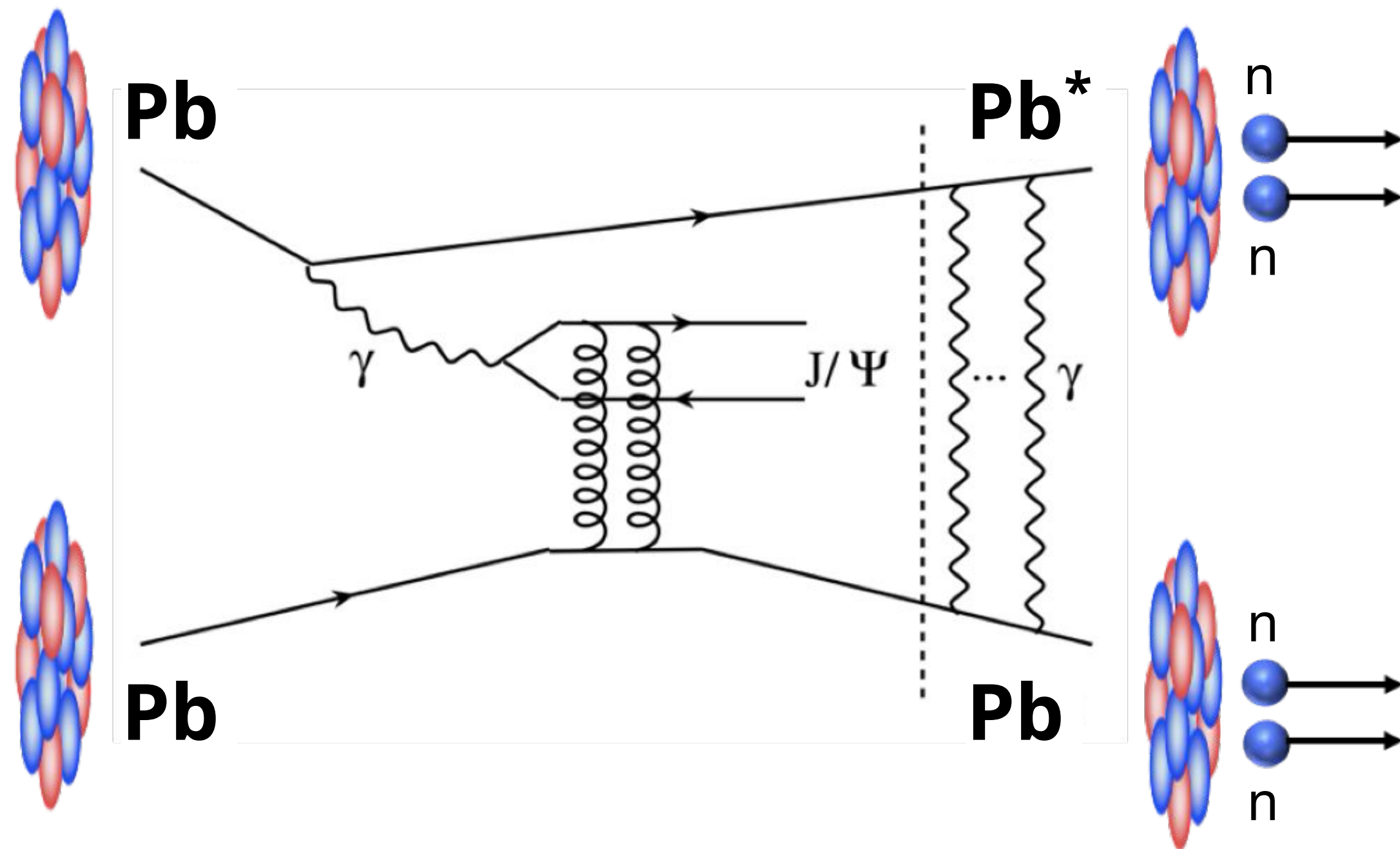


Disentangling the ambiguity on the ID of the γ emitter

$$\sigma(y) = N_{\gamma/A}(E_{\gamma,s}) \sigma_{J/\psi}(E_{\gamma,s}) + N_{\gamma/A}(E_{\gamma,l}) \sigma_{J/\psi}(E_{\gamma,l})$$

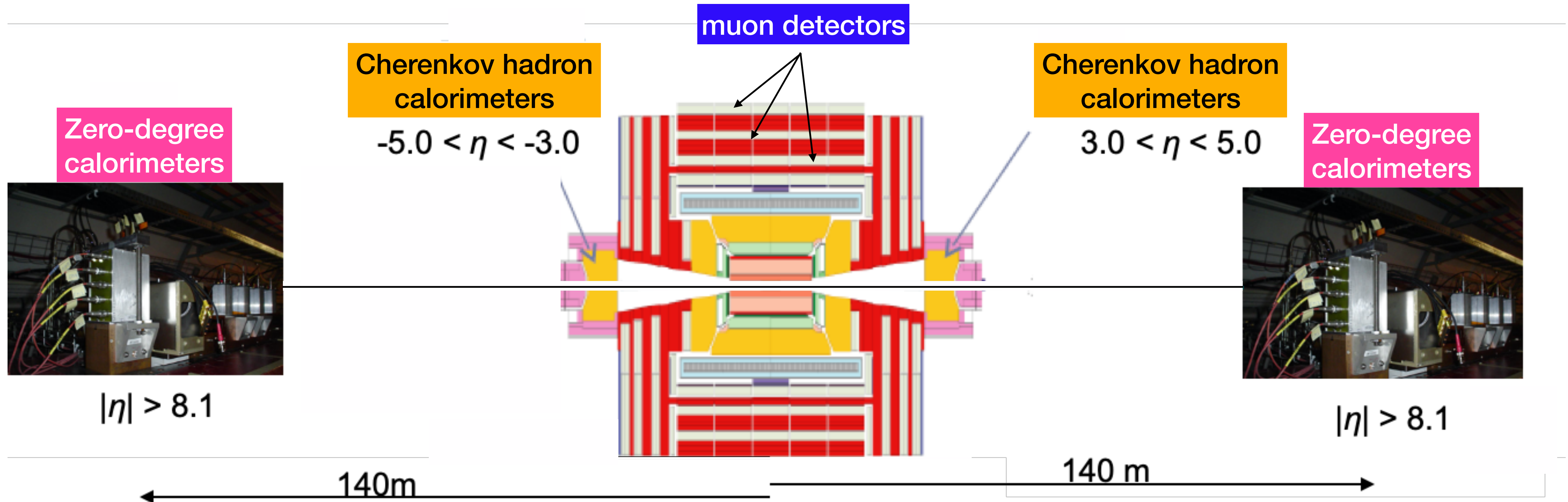
Photon flux $N_{\gamma/A}(E_{\gamma})$ is function of impact parameter:
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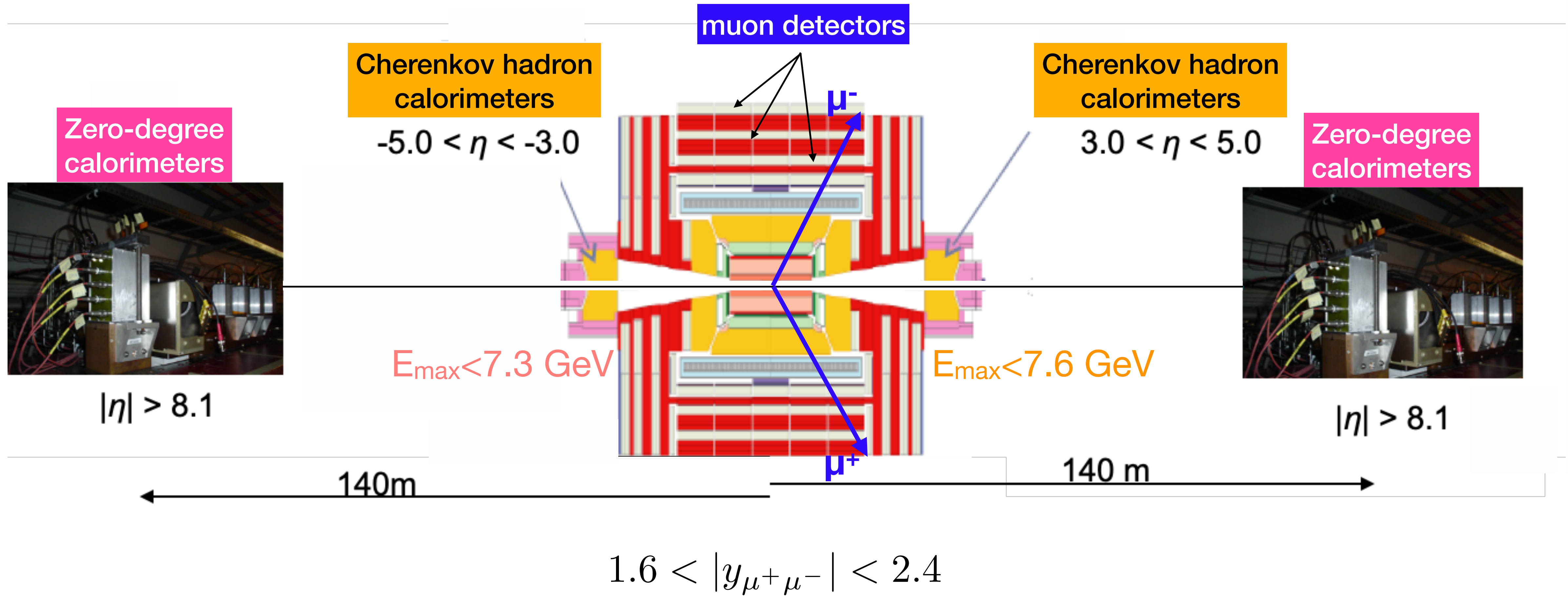


Make measurement with
possibility to detect neutrons

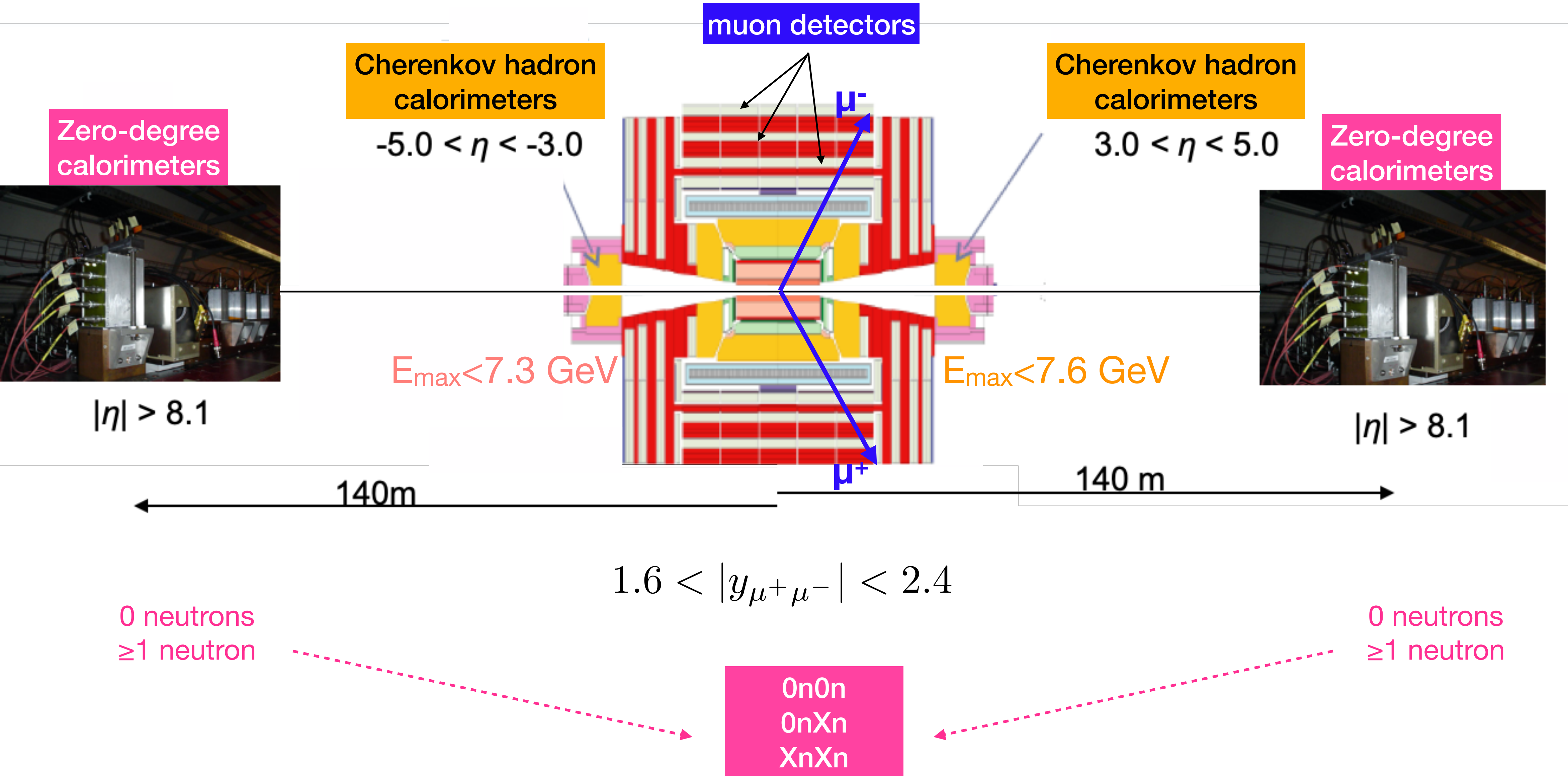
CMS central detector and the (far-)forward region



CMS central detector and the (far-)forward region



CMS central detector and the (far-)forward region



Disentangling the ambiguity on the ID of the γ emitter

$$\sigma^{0n0n}(y) = N_{\gamma/A}^{0n0n}(E_{\gamma,s}) \sigma_{J/\psi}(E_{\gamma,s}) + N_{\gamma/A}^{0n0n}(E_{\gamma,l}) \sigma_{J/\psi}(E_{\gamma,l})$$

$$\sigma^{0nXn}(y) = N_{\gamma/A}^{0nXn}(E_{\gamma,s}) \sigma_{J/\psi}(E_{\gamma,s}) + N_{\gamma/A}^{0nXn}(E_{\gamma,l}) \sigma_{J/\psi}(E_{\gamma,l})$$

$$\sigma^{XnXn}(y) = N_{\gamma/A}^{XnXn}(E_{\gamma,s}) \sigma_{J/\psi}(E_{\gamma,s}) + N_{\gamma/A}^{XnXn}(E_{\gamma,l}) \sigma_{J/\psi}(E_{\gamma,l})$$

measured

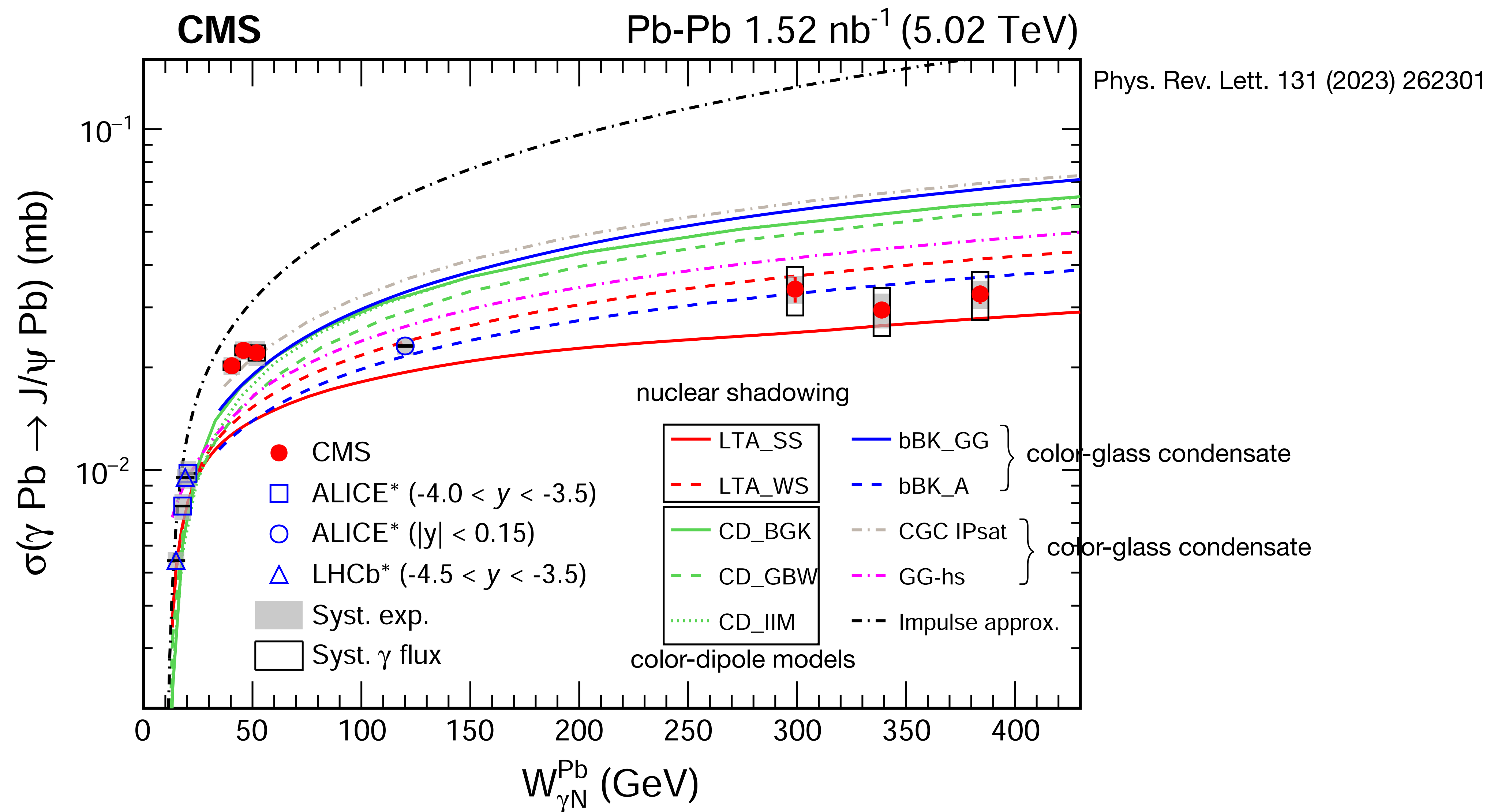
Disentangling the ambiguity on the ID of the γ emitter

$\sigma^{0n0n}(y)$	=	$N_{\gamma/A}^{0n0n}(E_{\gamma,s}) \sigma_{J/\psi}(E_{\gamma,s})$	+	$N_{\gamma/A}^{0n0n}(E_{\gamma,l}) \sigma_{J/\psi}(E_{\gamma,l})$
$\sigma^{0nXn}(y)$	=	$N_{\gamma/A}^{0nXn}(E_{\gamma,s}) \sigma_{J/\psi}(E_{\gamma,s})$	+	$N_{\gamma/A}^{0nXn}(E_{\gamma,l}) \sigma_{J/\psi}(E_{\gamma,l})$
$\sigma^{XnXn}(y)$	=	$N_{\gamma/A}^{XnXn}(E_{\gamma,s}) \sigma_{J/\psi}(E_{\gamma,s})$	+	$N_{\gamma/A}^{XnXn}(E_{\gamma,l}) \sigma_{J/\psi}(E_{\gamma,l})$
measured		computed (StarLight)		computed (StarLight)

Disentangling the ambiguity on the ID of the γ emitter

$\sigma^{0n0n}(y)$	=	$N_{\gamma/A}^{0n0n}(E_{\gamma,s})$	$\sigma_{J/\psi}(E_{\gamma,s})$	+	$N_{\gamma/A}^{0n0n}(E_{\gamma,l})$	$\sigma_{J/\psi}(E_{\gamma,l})$
$\sigma^{0nXn}(y)$	=	$N_{\gamma/A}^{0nXn}(E_{\gamma,s})$	$\sigma_{J/\psi}(E_{\gamma,s})$	+	$N_{\gamma/A}^{0nXn}(E_{\gamma,l})$	$\sigma_{J/\psi}(E_{\gamma,l})$
$\sigma^{XnXn}(y)$	=	$N_{\gamma/A}^{XnXn}(E_{\gamma,s})$	$\sigma_{J/\psi}(E_{\gamma,s})$	+	$N_{\gamma/A}^{XnXn}(E_{\gamma,l})$	$\sigma_{J/\psi}(E_{\gamma,l})$
measured		computed (StarLight)	extracted		computed (StarLight)	extracted

CMS: γ Pb cross section, energy dependence



ALICE: γ Pb cross section, energy dependence

