DVCS measurements at EIC

Niveditha R

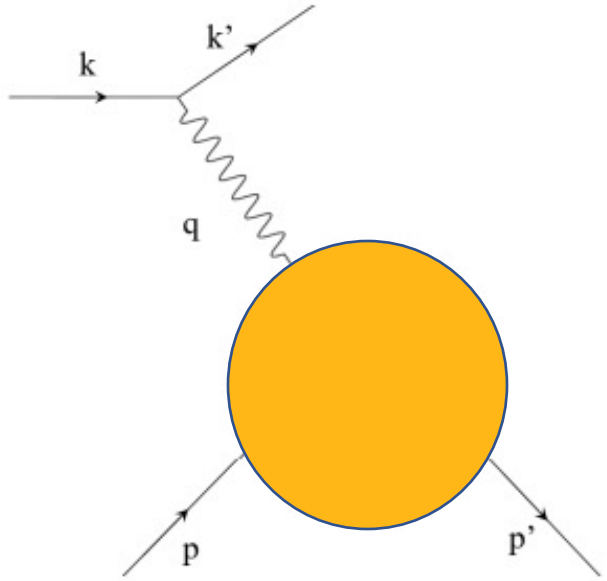
23/07/2023

Electron-Ion Collider User Group Meeting

Understanding the structure of nucleon

Elastic Scattering

$$Q^2 = 4EE' \sin^2\left(\frac{\theta}{2}\right).$$



- gives access to transverse spatial distribution of partons
- Cross-section of this scattering, considering an extended nucleon is given by

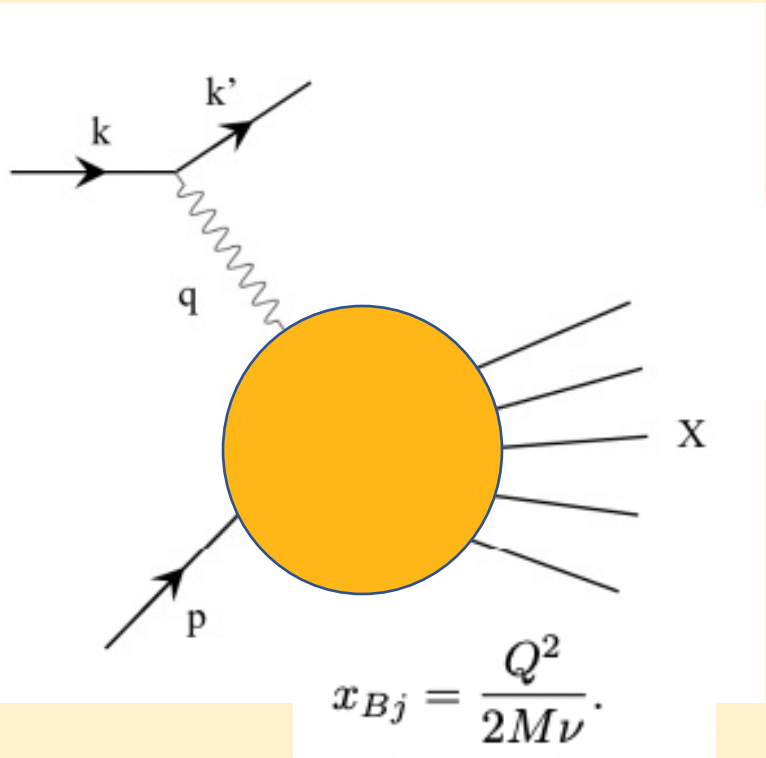
$$\left(\frac{d\sigma}{d\Omega}\right)_{Rosenbluth} = \left(\frac{d\sigma}{d\Omega}\right)_{Mott} \left\{F_1^2(Q^2) + \frac{Q^2}{4M^2}\left[F_2^2(Q^2) + 2\left(F_1(Q^2) + F_2(Q^2)\right)^2 \tan^2\left(\frac{\theta}{2}\right)\right]\right\}$$

F1 and F2 are Dirac and Pauli form factors which give the distribution of electric charge and current inside a nucleon.

Understanding the structure of nucleon

Deep-Inelastic Scattering (in briet frame)

$$Q^2 = 4EE' \sin^2\left(\frac{\theta}{2}\right).$$



$$x_{Bj} = \frac{Q^2}{2M\nu}.$$

- gives access longitudinal momentum distribution of partons
- Cross-section of this scattering is given by

$$\frac{d^2\sigma}{d\Omega dE'} = \frac{\alpha^2 \cos^2\left(\frac{\theta}{2}\right)}{4E^2 \sin^4\left(\frac{\theta}{2}\right)} \left(\frac{F_2(x_{Bj}, Q^2)}{\nu} + \frac{2}{M} F_1(x_{Bj}, Q^2) \tan^2\left(\frac{\theta}{2}\right) \right).$$

F1 and F2 here are the structure functions of a nucleon and they depend on x and Q2.

Understanding the structure of nucleon

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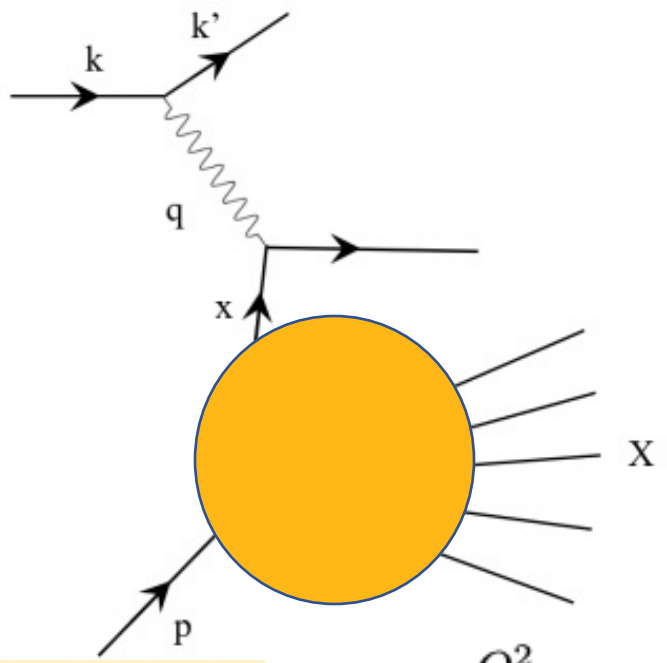


- The virtual photon can be thought of to scatter off of a single parton carrying longitudinal momentum fraction x
- Cross-section is the

$$\frac{d^2\sigma}{d\Omega dE'} = \{\text{Cross-section of e over parton i}\}\{\text{Density of parton with momentum fraction x}\}$$

$$x_{Bj} = \frac{Q^2}{2M\nu}. \qquad x \approx \frac{Q^2}{2M\nu} = x_{Bj}.$$

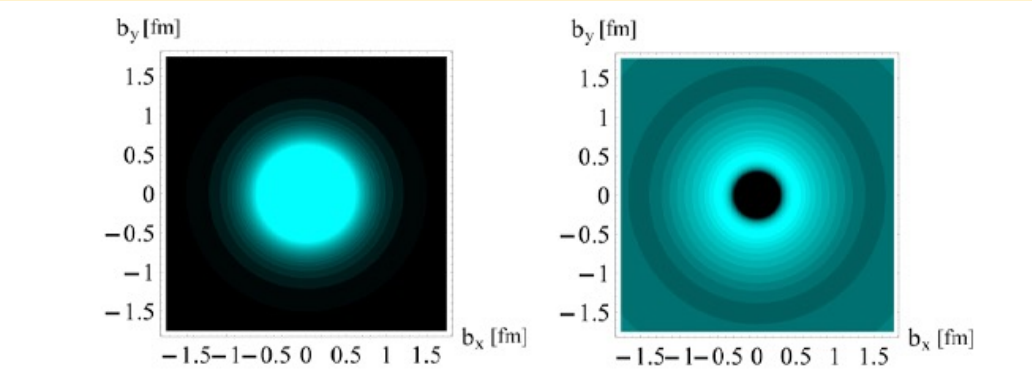
$$F_2(x_{Bj}) = x_{Bj} \sum e_i^2 q_i(x_{Bj}),$$

where e_i is the charge of the parton i, in units of the proton charge, and qi(x_{Bj}) is the density of partons i with longitudinal momentum fraction x_{Bj} . These functions qi are called Parton Distribution Functions (PDFs).

Elastic Scattering

Form Factors

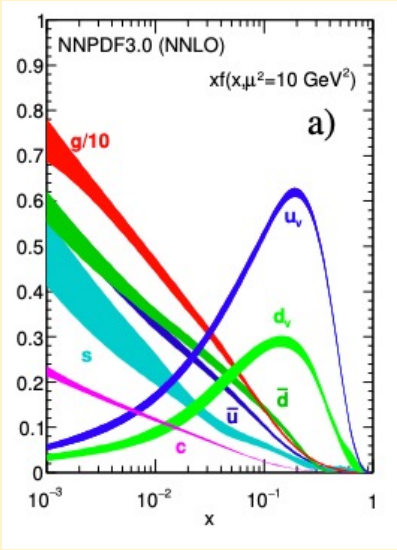
Transverse spatial distribution of partons



Deep Inelastic Scattering

Parton Distribution Functions

Longitudnal momentum distribution of partons



Elastic Scattering

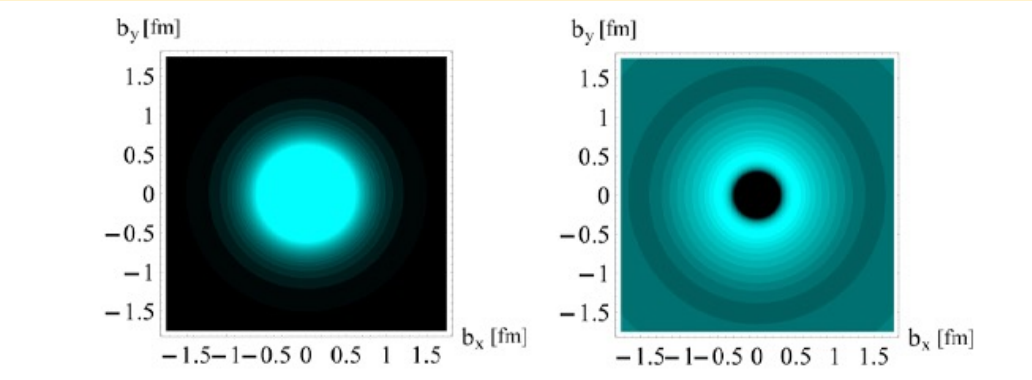
Deep Inelastic Scattering

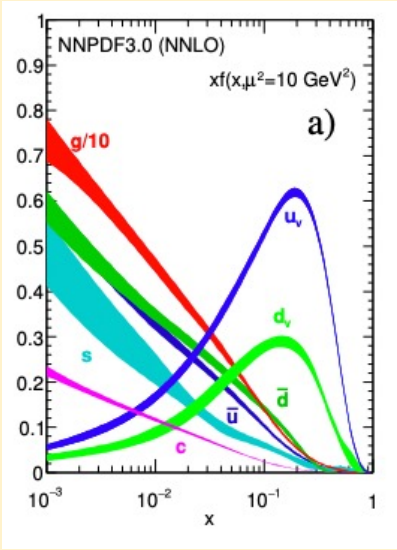
Form Factors

Parton Distribution Functions

Transverse spatial distribution of partons

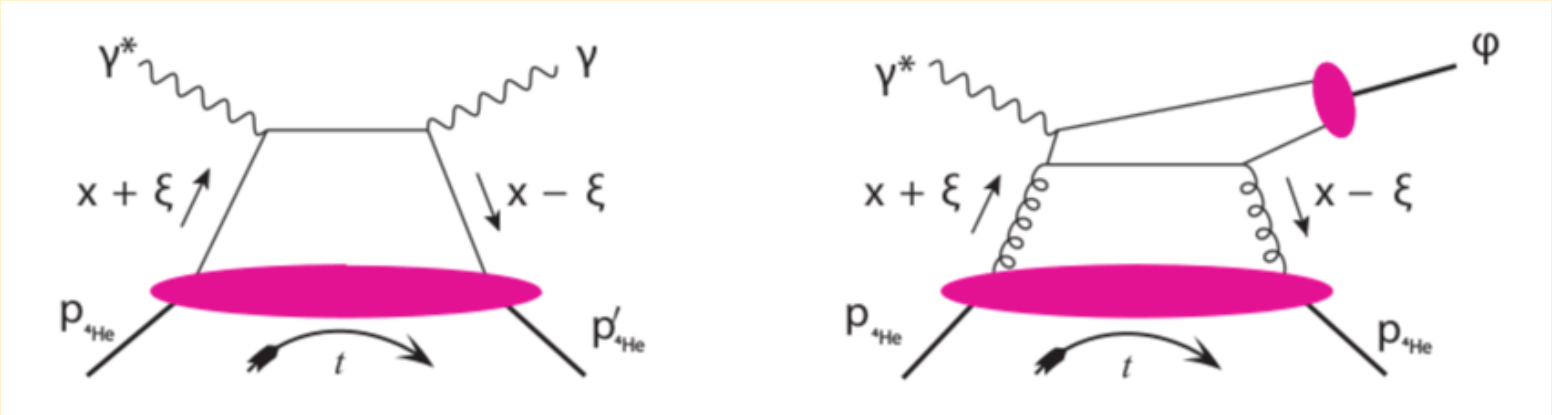
Longitudnal momentum distribution of partons



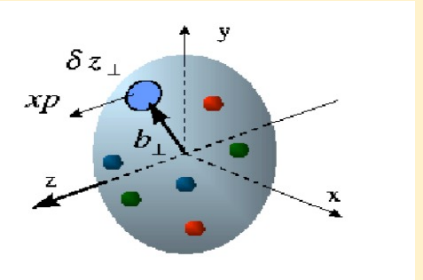


Genralised Parton Distributions

Hard Exclusive Processess



GPDs gives us the probability to find a quark which carries longitudinal momentum fraction *x* at a transverse position $\mathbf{b}_\perp$ in a nucleon



Genralised Parton Distributions

Form Factors

Parton Distribution Functions

Transverse spatial distribution of partons

Longitudnal momentum distribution of partons

longitudinal momentum fraction *x* at transverse position $\mathbf{b}_\perp$

Genralised Parton Distributions

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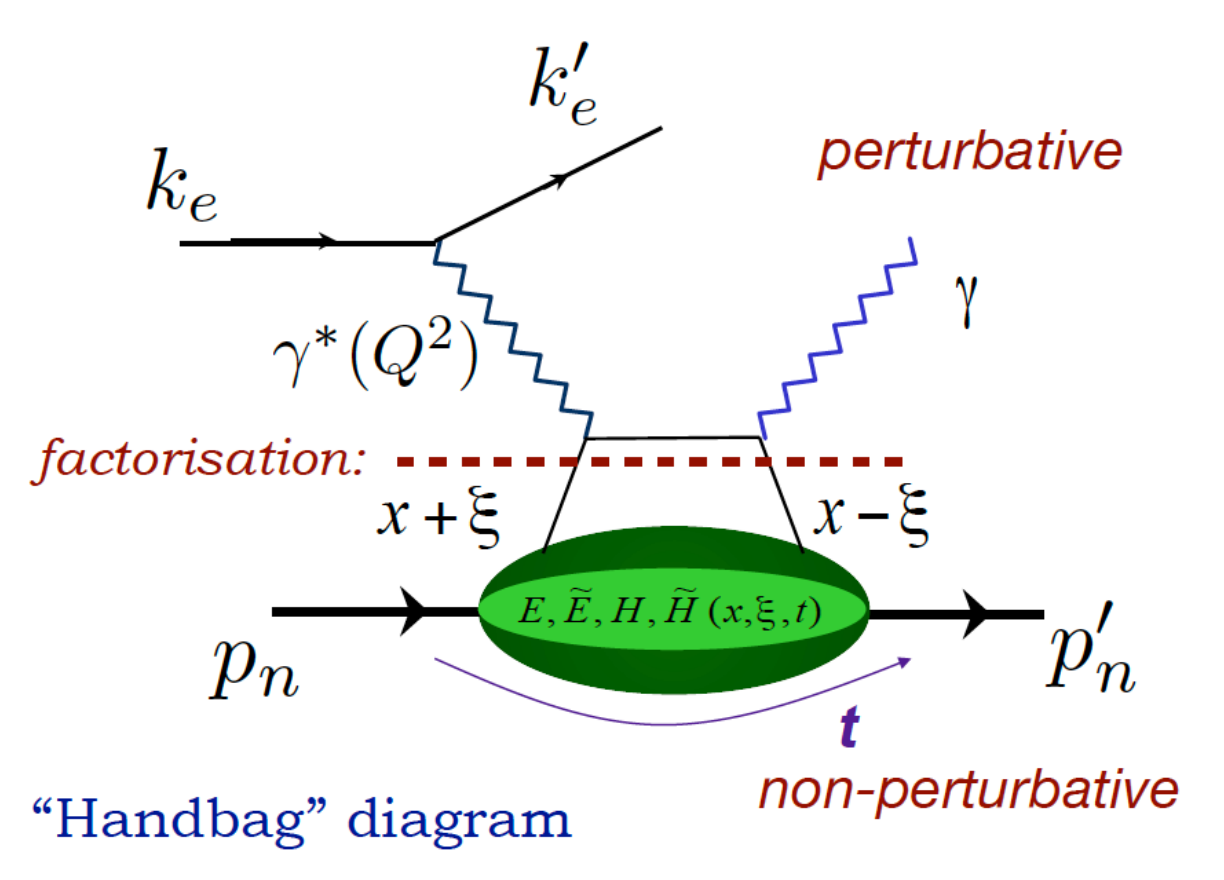
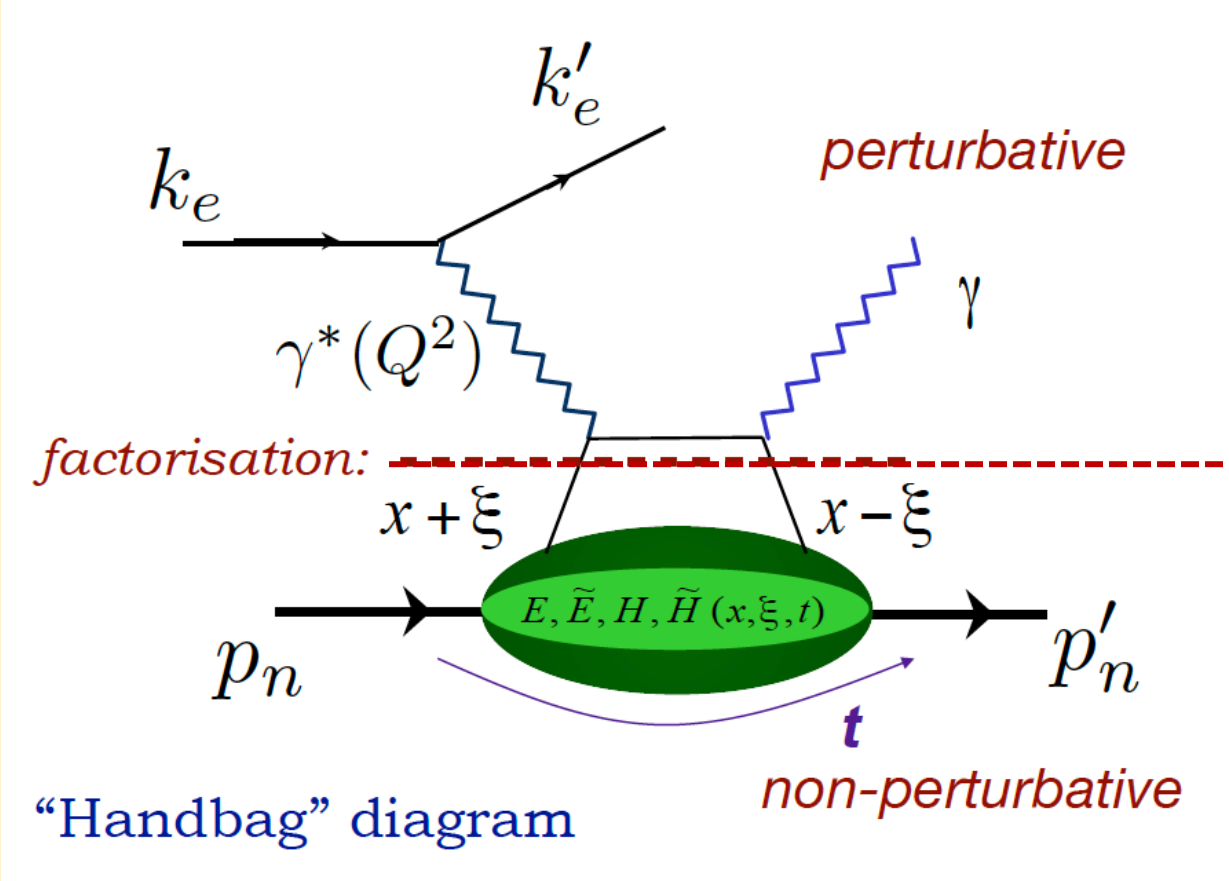
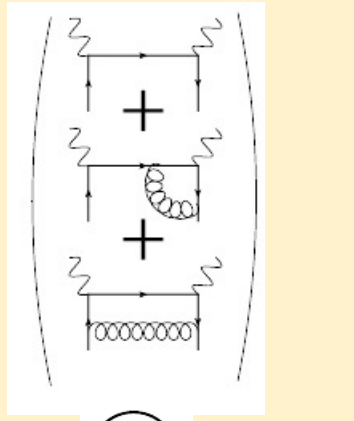
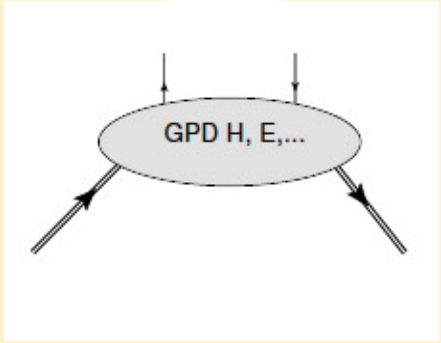


- interactions where the struck nucleon remains intact and final state particles are detected
- In such analysis, the final state particles are the deflected electron, deflected nucleon and other particles of interest (γ , π 0 , φ).

Hard Exclusive Processess

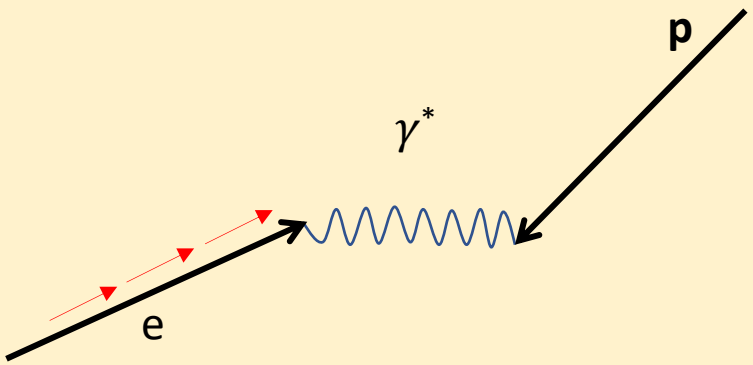






❖In the limit of high energy and high momentum transfer, these can be factorized into (i) calculable cross-section of interaction between the virtual photon and quark and (ii) the nucleon itself described by GPDs.

Studying DVCS process



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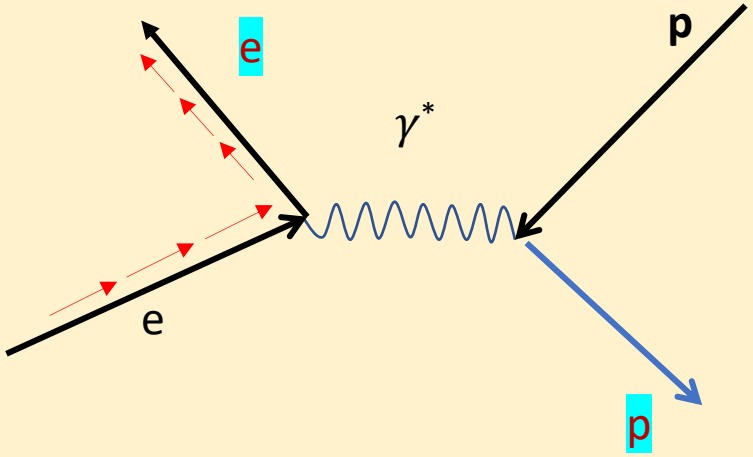

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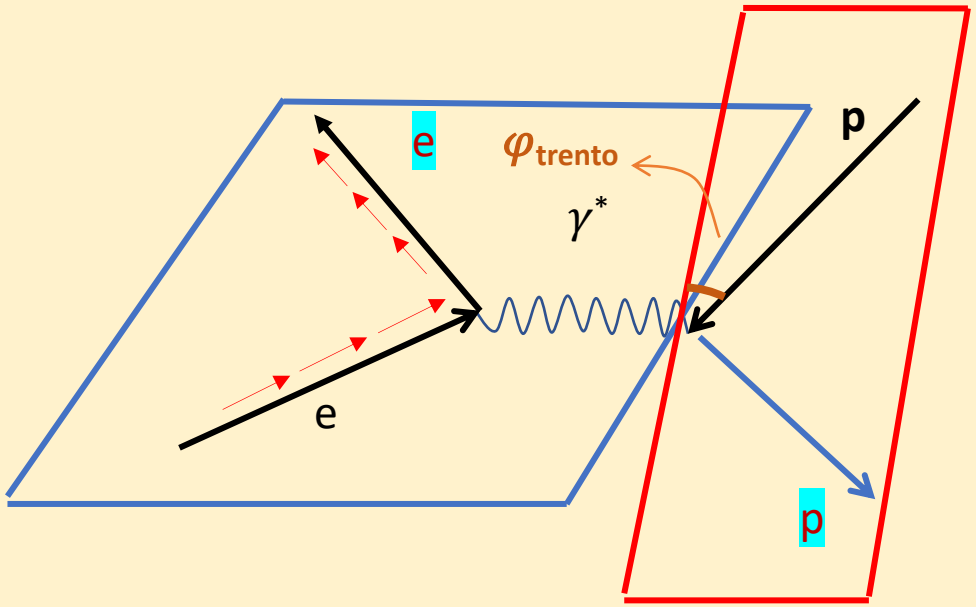
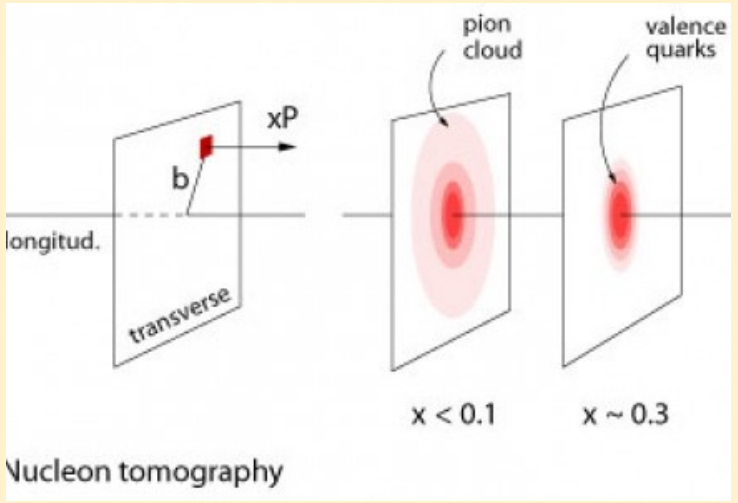


Beam Spin Assymmetry

$$\frac{N_{\varphi}^{\rightarrow} - N_{\varphi}^{\leftarrow}}{N_{\varphi}^{\rightarrow} + N_{\varphi}^{\leftarrow}}$$

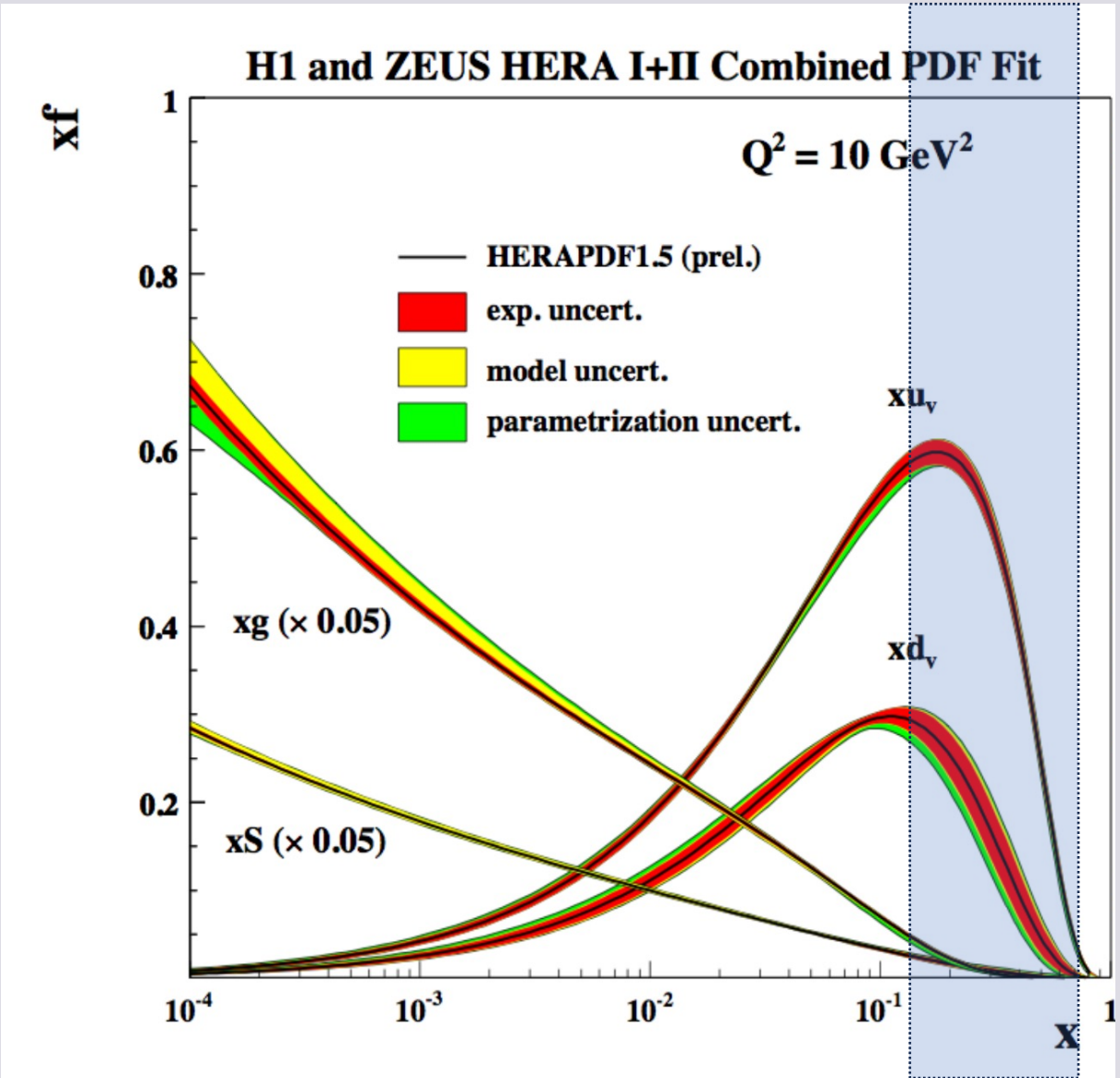


φ_{trento} = Angle between electron plane (electron and virtual photon) and hadron plane (neutron and phi)

Plotting this in bins of φ_{trento}

Modulation in BSA gives access to the spatial distribution of Quarks and Gluons in a nucleon

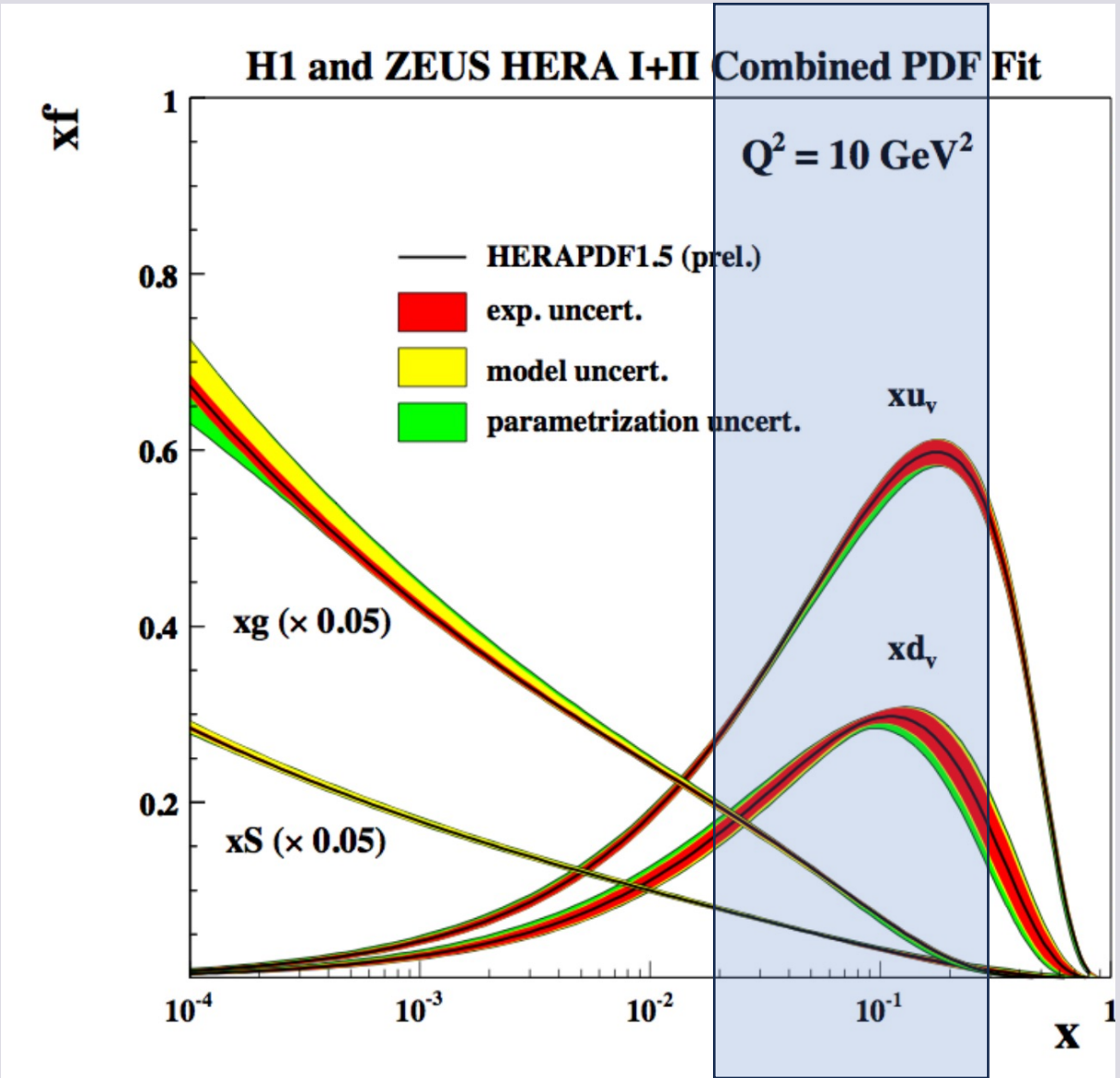
Acessing DVCS process through different experiments



JLAB

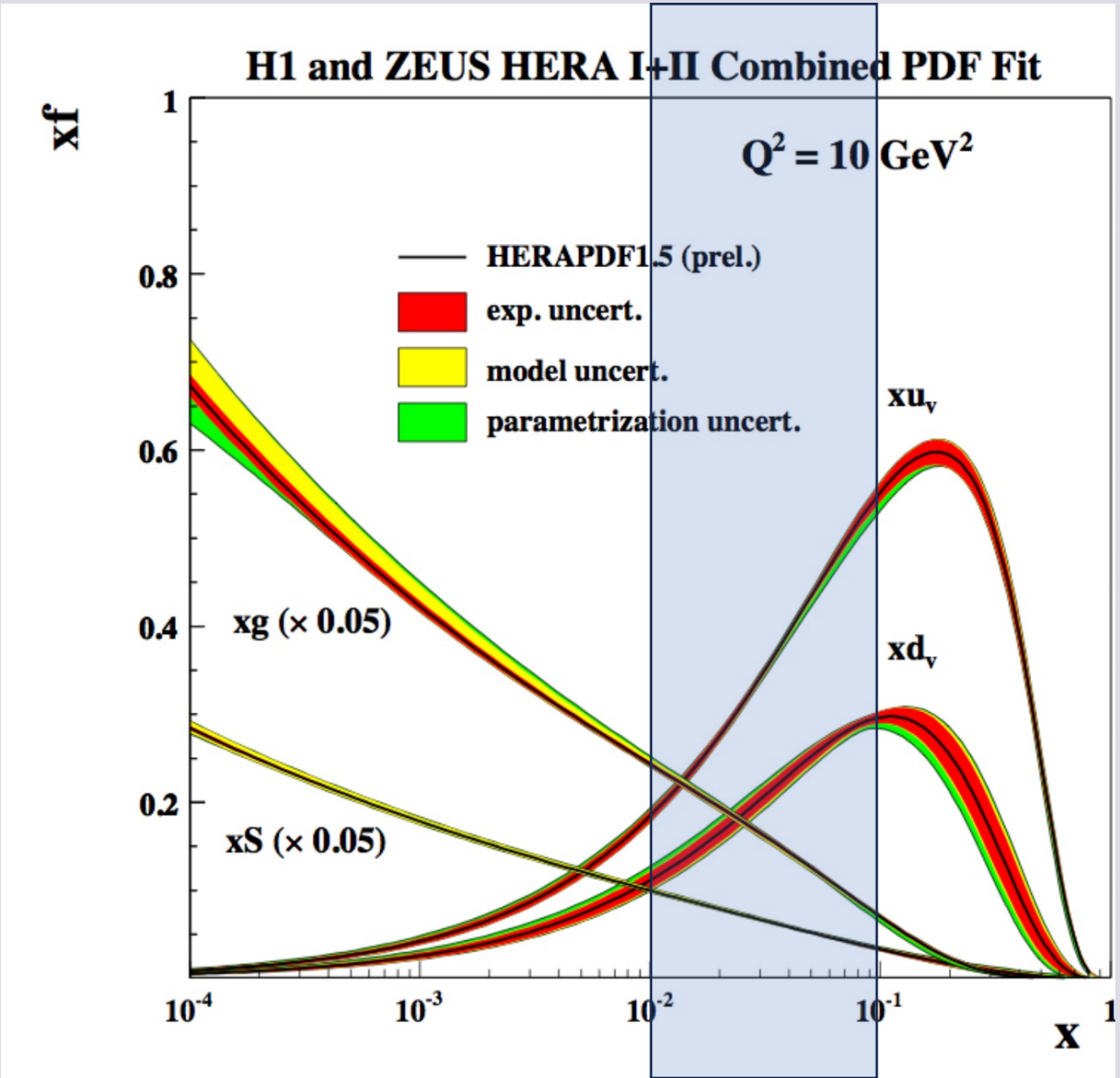
$0.1 < x_b < 0.7$

Acessing DVCS process through different experiments



JLAB	$0.1 < x_b < 0.7$
HERMES	$0.02 < x_b < 0.3$

Acessing DVCS process through different experiments



JLAB	$0.1 < x_b < 0.7$
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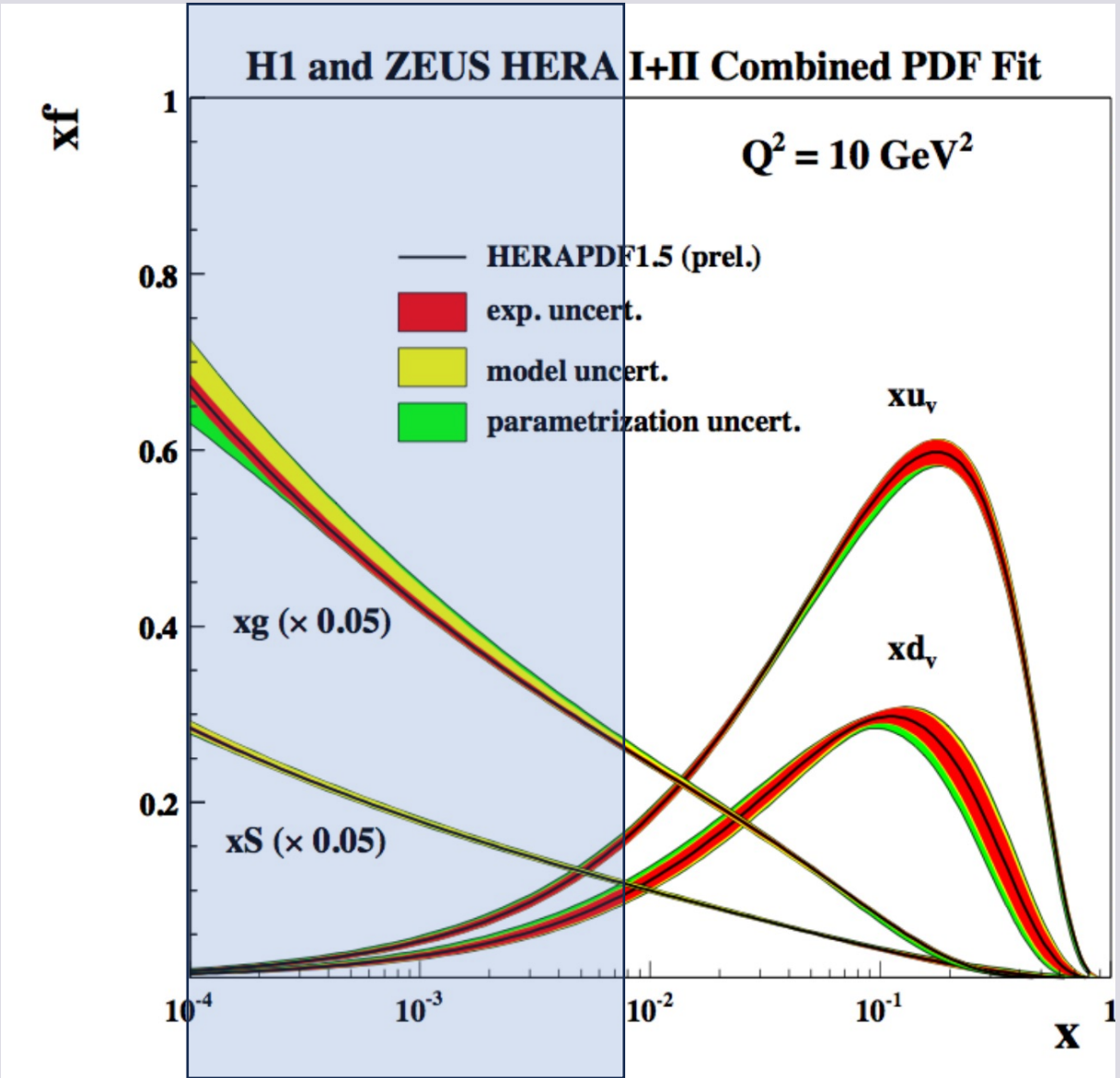

JLAB	$0.1 < x_b < 0.7$
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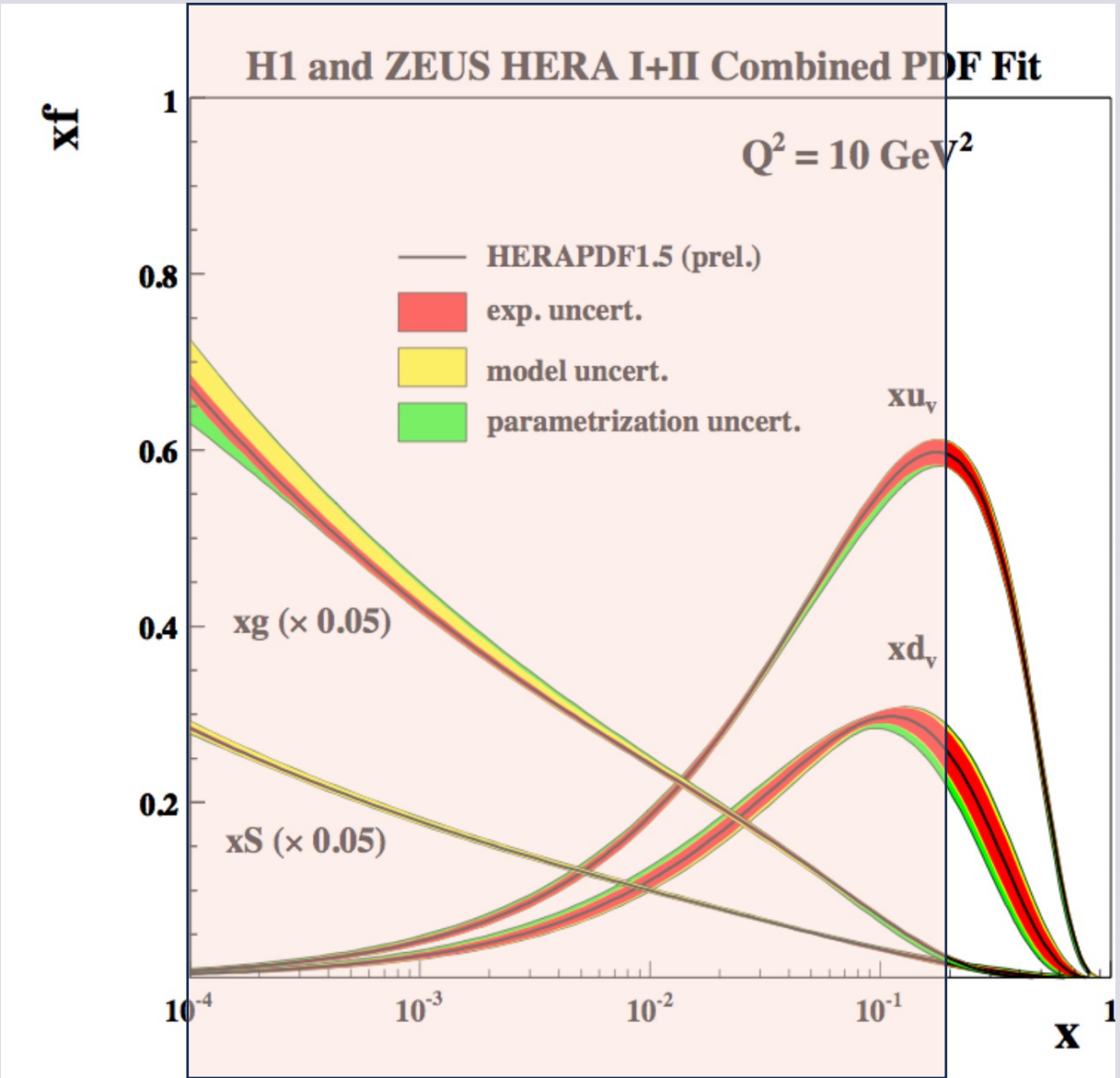
ZEUS/H1	$10^{-4} < x_b < 0.02$

Acessing DVCS process through different experiments



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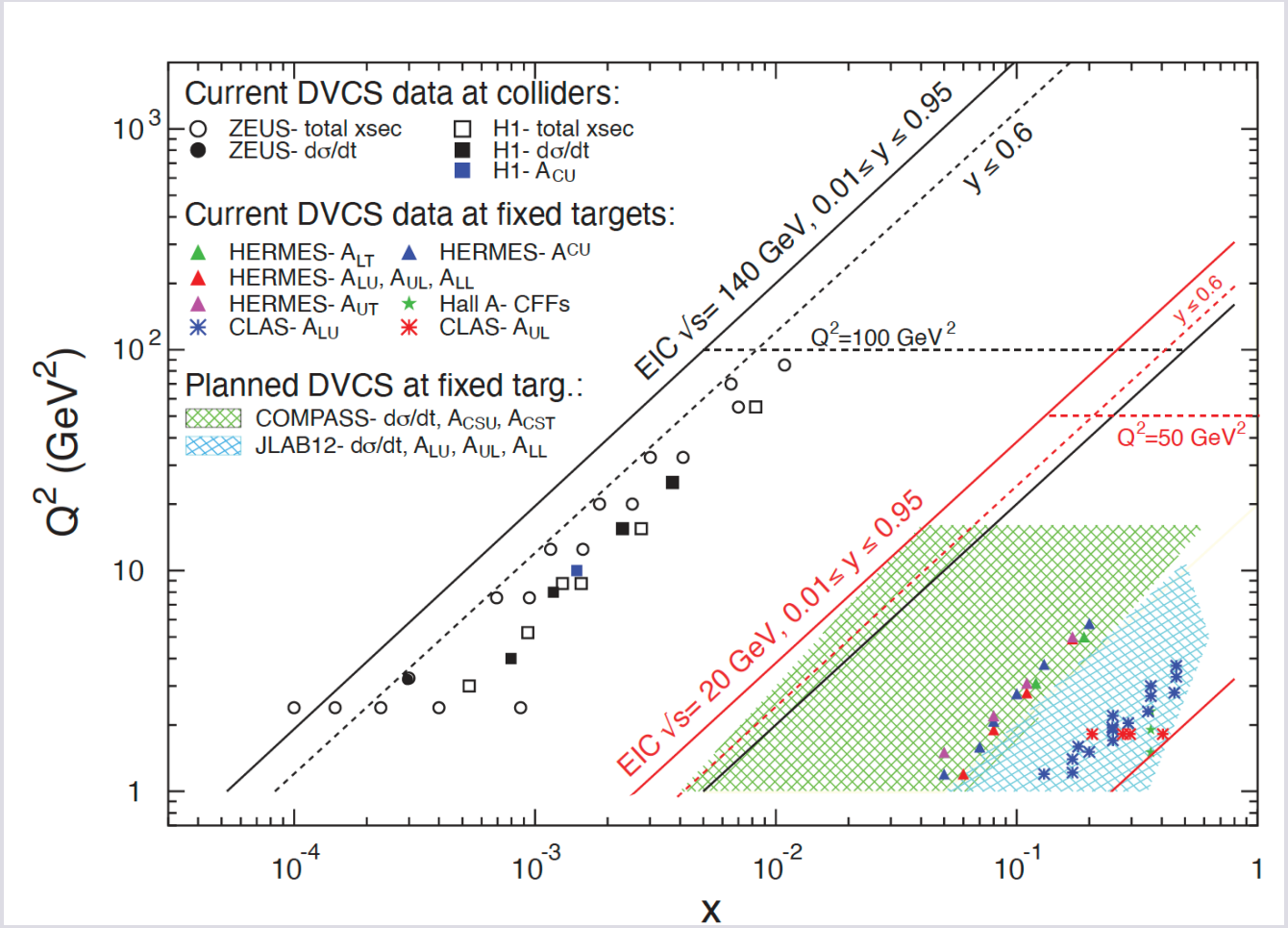
EIC	$10^{-4} < x_b < 0.2$ 100-1000 times luminosity of HERA

Acessing DVCS process through different experiments



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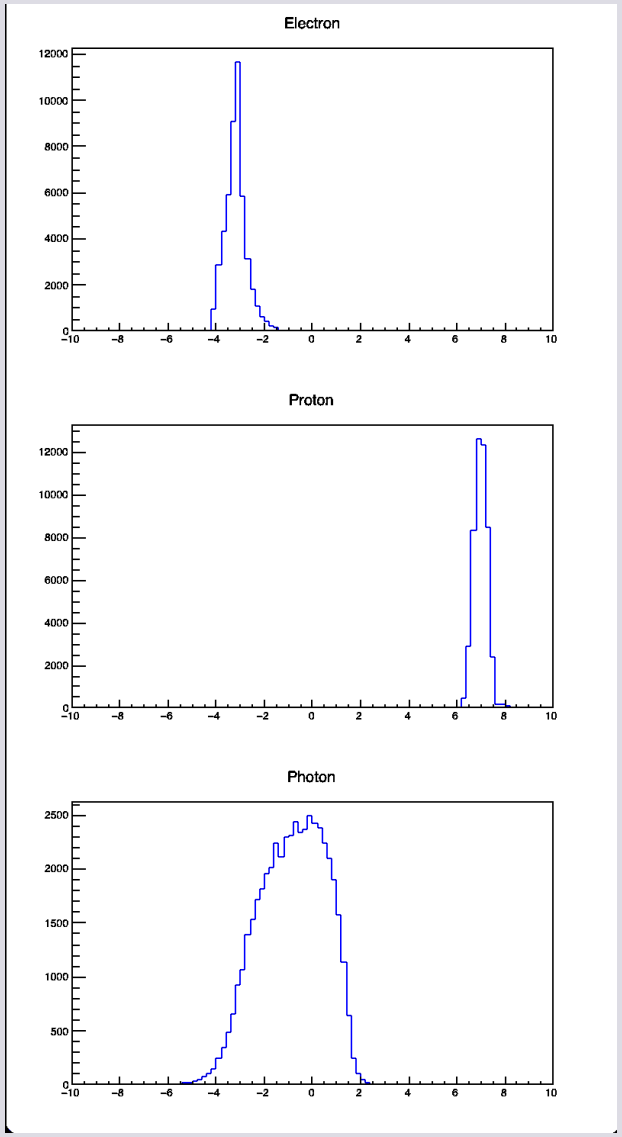
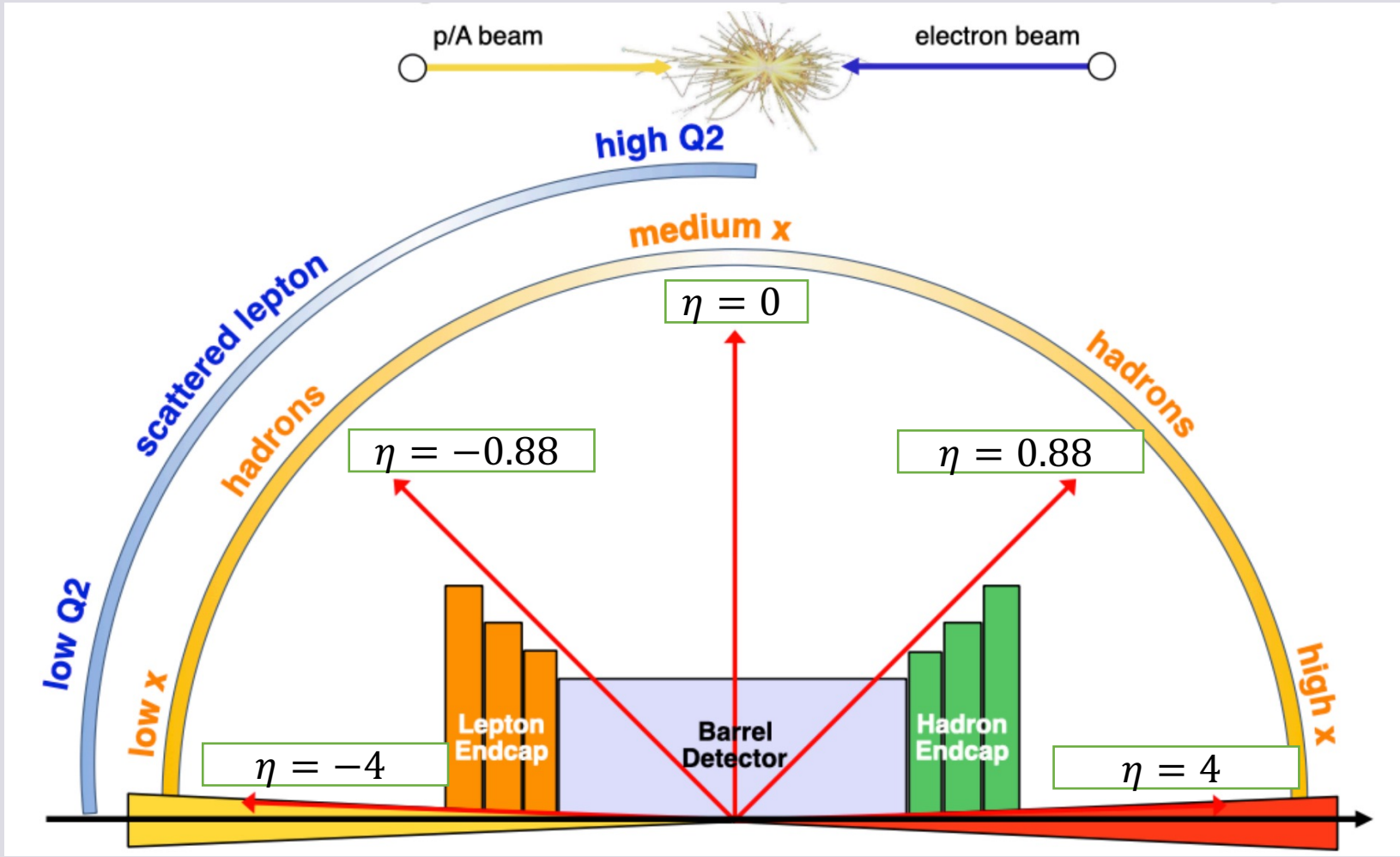
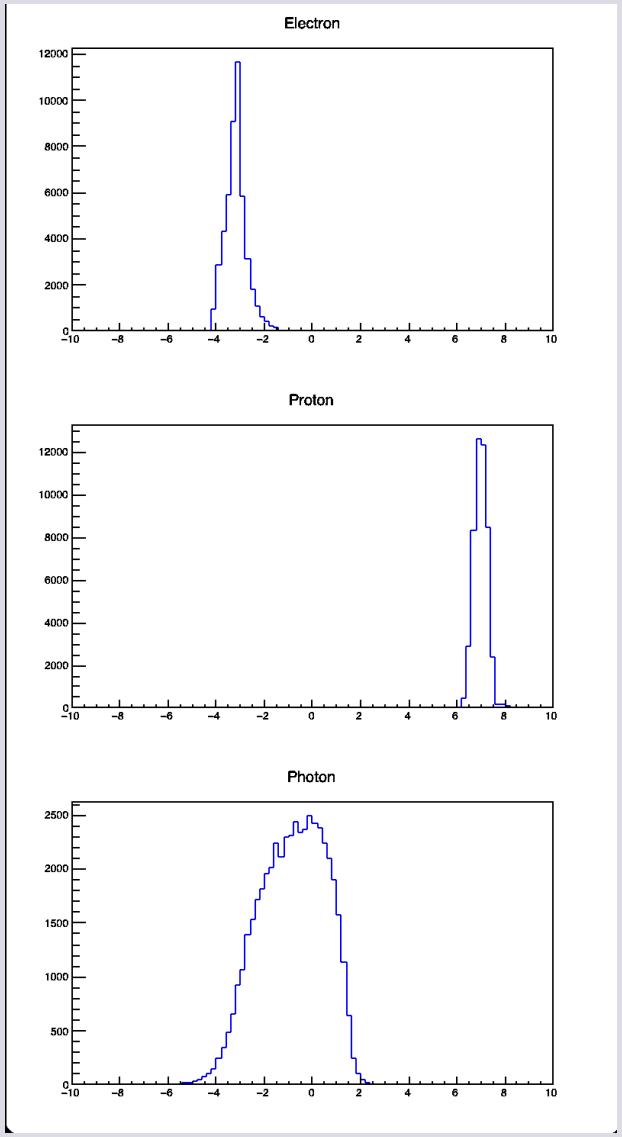
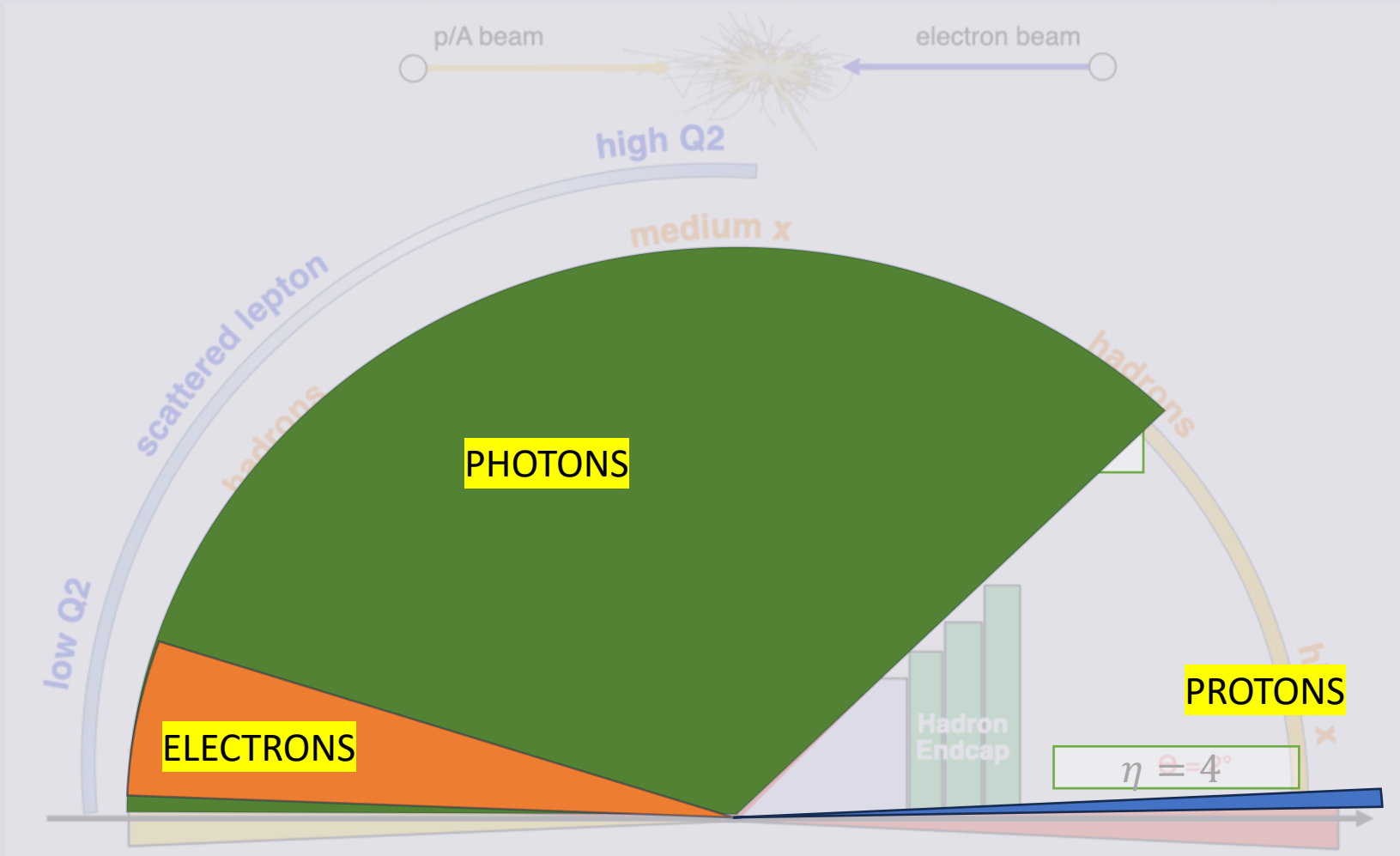
Spatial topology of DVCS at EIC and ePIC detector





Spatial topology of DVCS at EIC and ePIC detector





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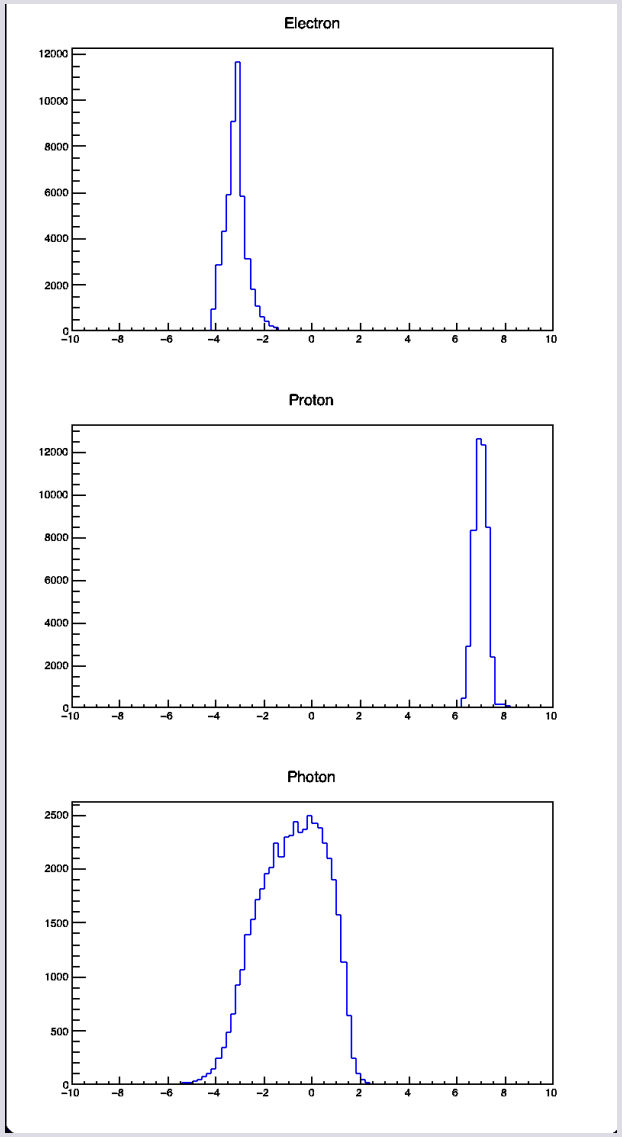
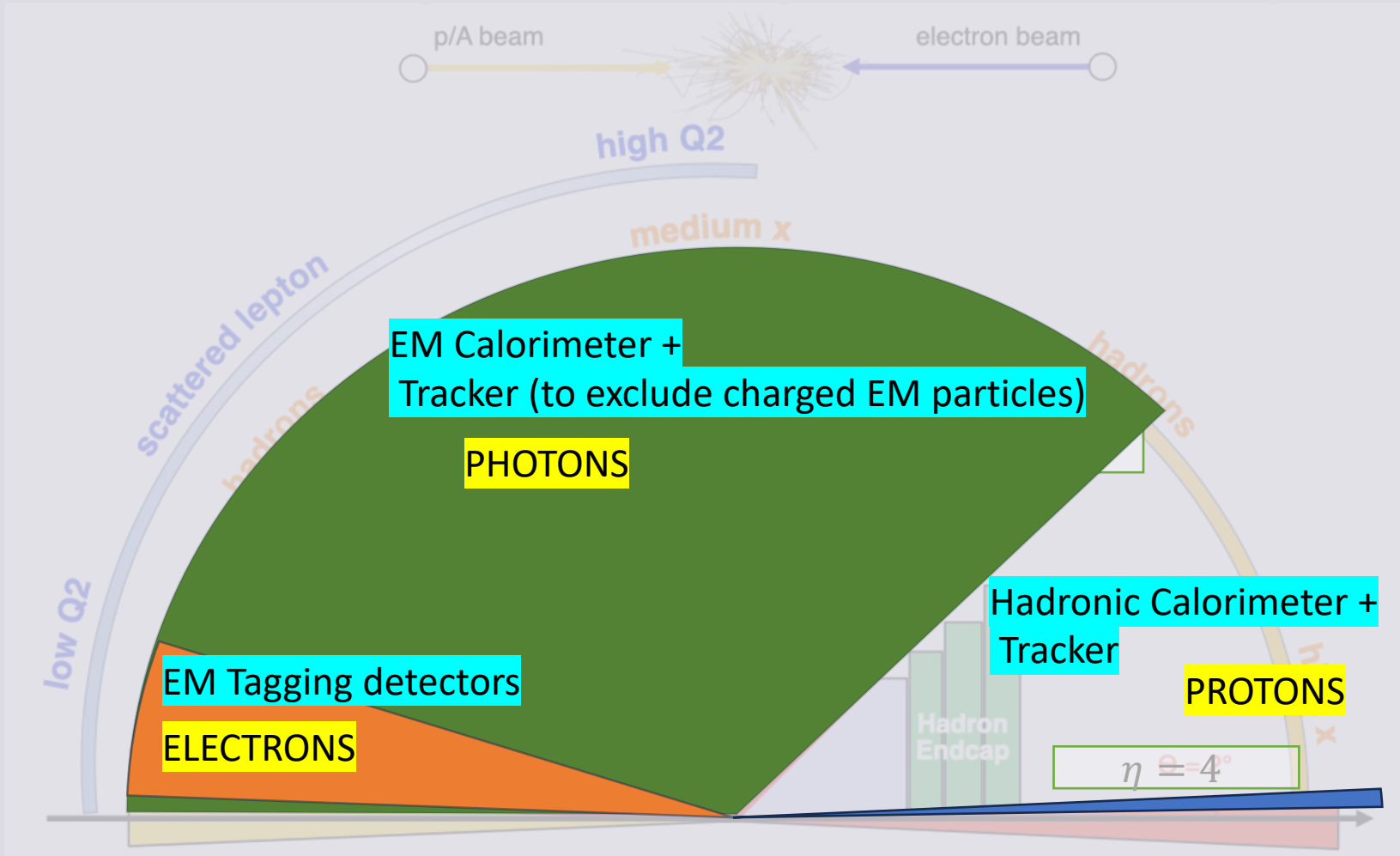
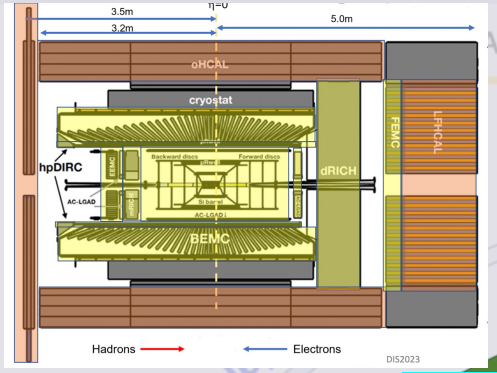






Detector
Sci Glass EMCal
Si MAPS Tracker
MPGD Tracker

EM Calorimeter +
Tracker (to exclude charged EM particles)

PHOTONS

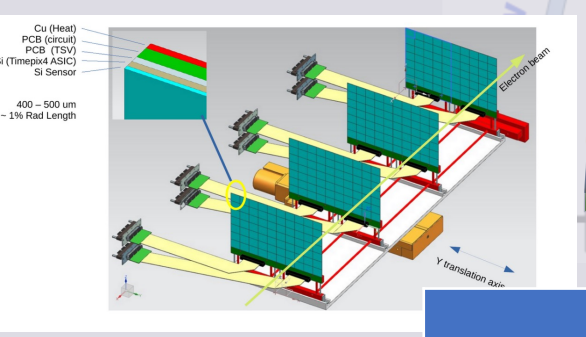
EM Tagging, Calorimetry and
Tracking detectors

ELECTRONS

Hadronic Calorimeter + Tracker

PROTONS

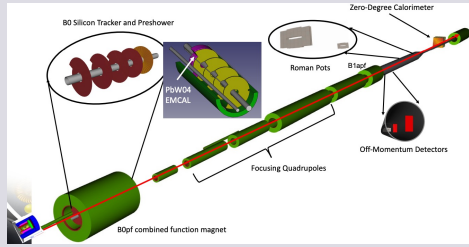
$\eta = 4$



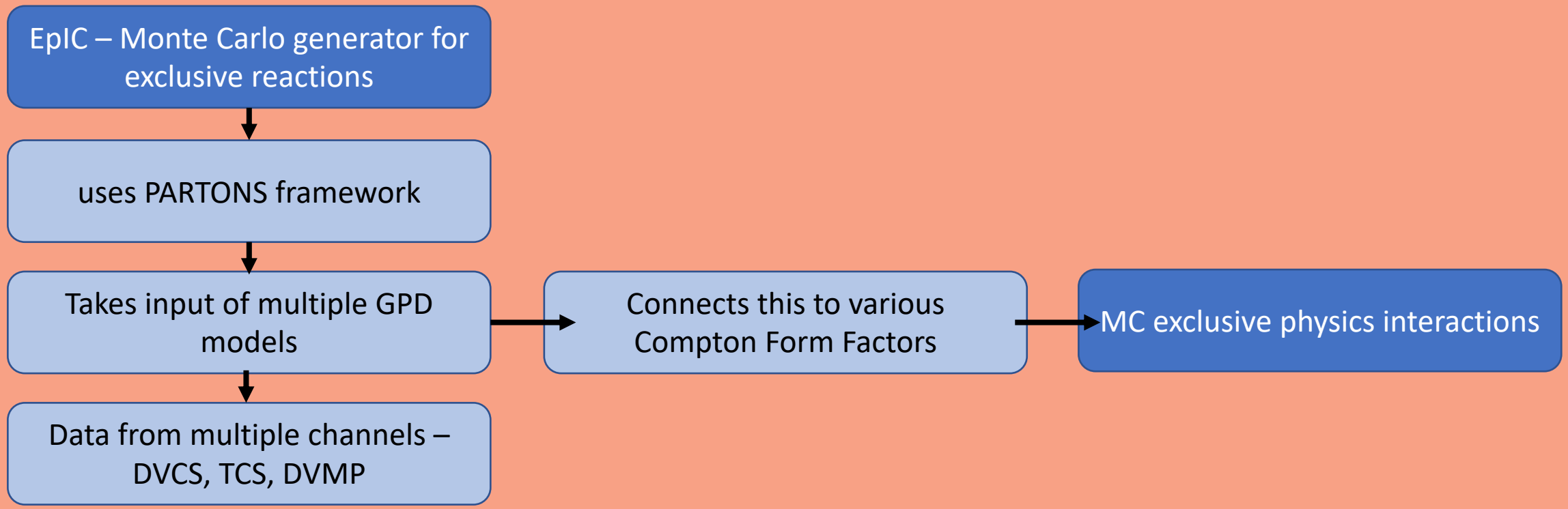
Detector
Luminosity Monitoring
Q2 Tagging

[Alec Jentsch Talk : Link to full detailed information.]

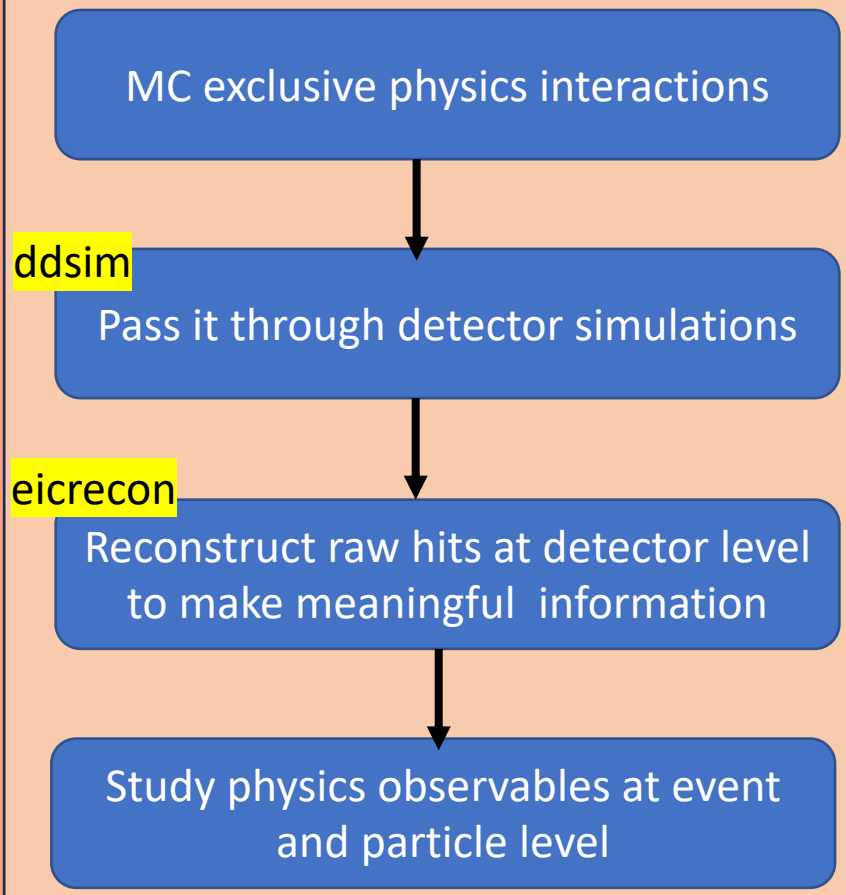
Detector
Zero-Degree Calorimeter (ZDC)
Roman Pots (2 stations)
Off-Momentum Detectors (2 stations)
B0 Detector



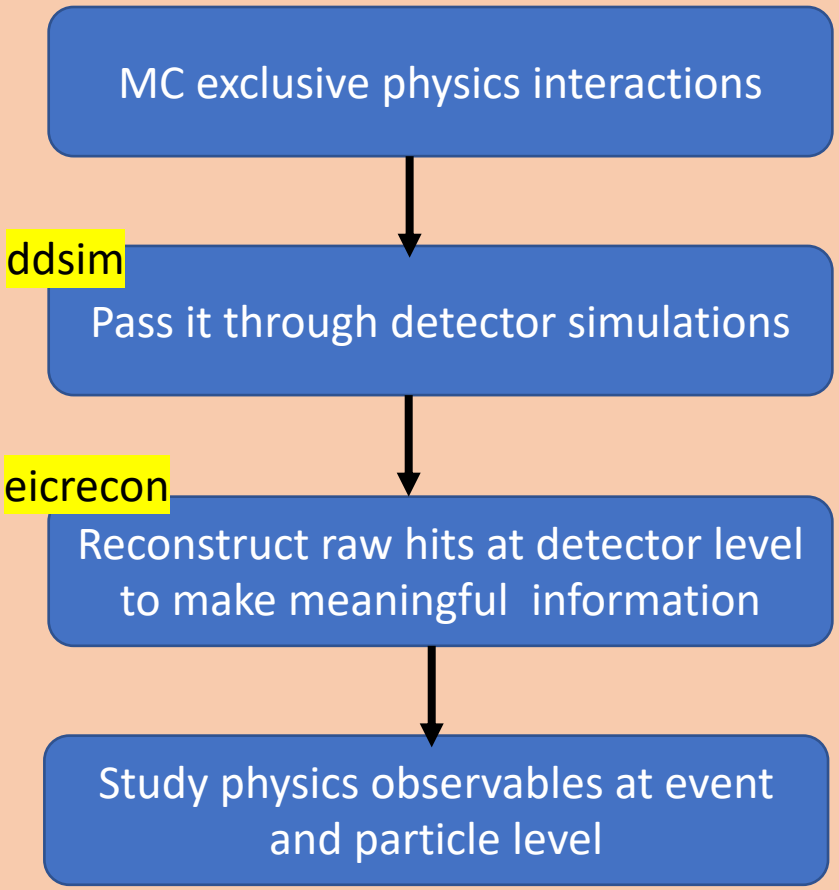
How do I get this typical topology? From a generator which has inputs from data available thus far.



Studying excluisve physics observables



For anyone here interested in starting to contribute to EIC project somewhere….



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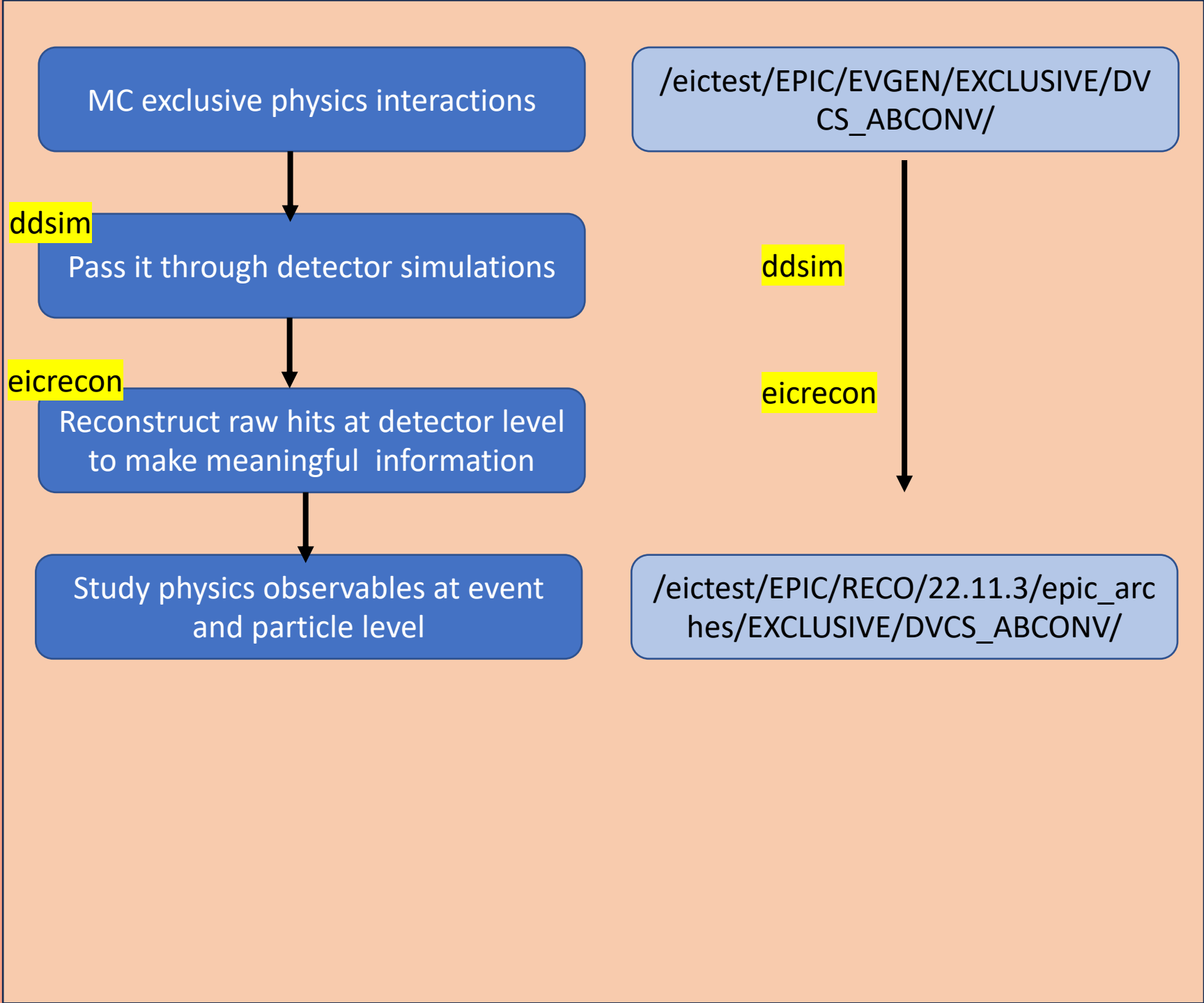


For anyone here interested in starting to contribute to EIC project somewhere….

MC exclusive physics interactions

/eictest/EPIC/EVGEN/EXCLUSIVE/DVCS_ABCONV/

ddsim

Pass it through detector simulations

ddsim

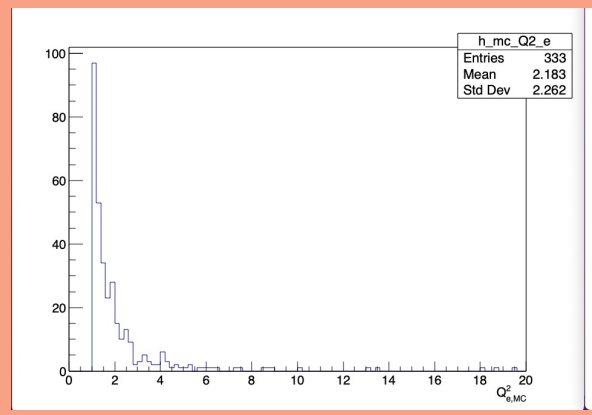
eicrecon

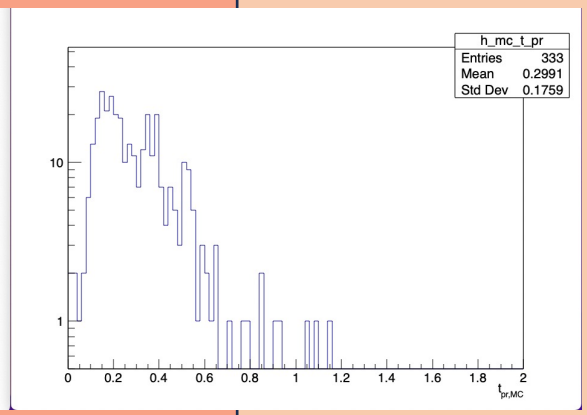
Reconstruct raw hits at detector level to make meaningful information

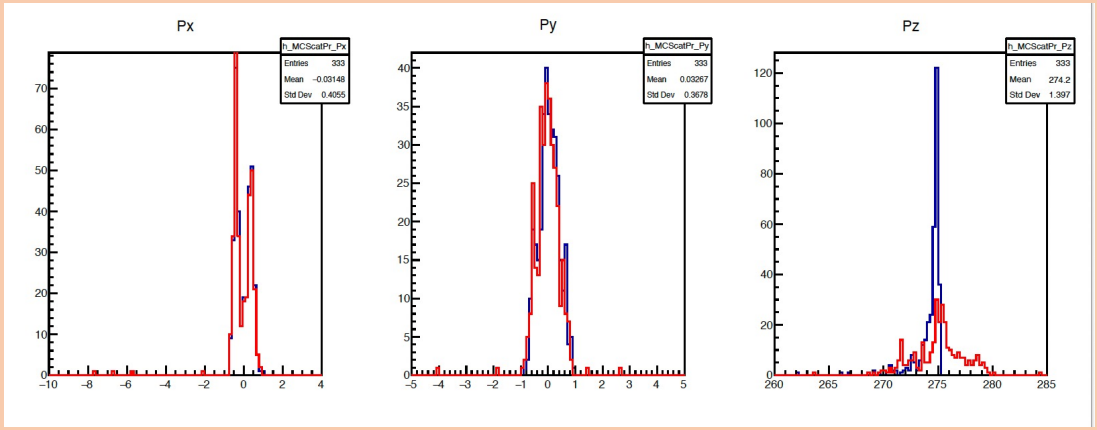
eicrecon

Study physics observables at event and particle level

/eictest/EPIC/RECO/22.11.3/epic_arches/EXCLUSIVE/DVCS_ABCONV/







For anyone here interested in starting to contribute to EIC project somewhere….

Contact me – nivram@cea.fr

Join eA Study group

Join Exclusive physics working group

Thank you for your attention….