SIDIS Production in EIC

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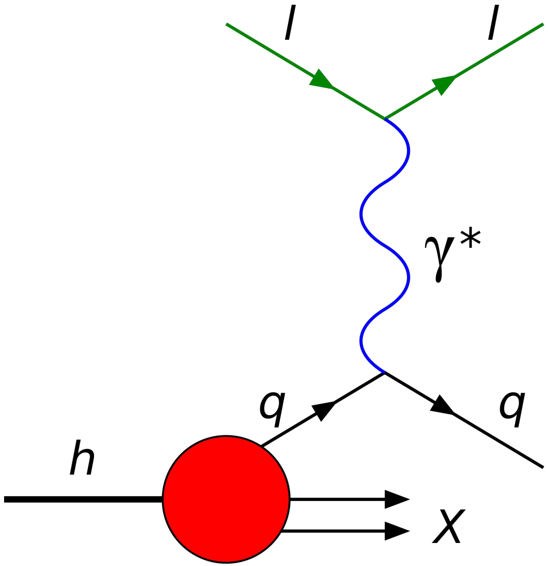
Background: Semi-Inclusive Deep Inelastic Scattering

In DIS, a probing lepton exchanges a virtual photon with a parton, releasing a shower of hadronic material.

In semi-inclusive DIS, the final states of the scattered lepton and the leading hadron are detected.

The measured hadron is sensitive to the transverse momentum of the parton that the lepton interacted with.



Background: Proton spin crisis

The naïve model of protons stated that proton spin is a simple sum of the spins of the particle’s three valence quarks.

Particle physics experiments have discovered that these quarks carry only a fraction of the proton’s spin.

The other components of proton spin are gluon and sea quark polarization and parton angular momenta.

Background: Parton distribution function

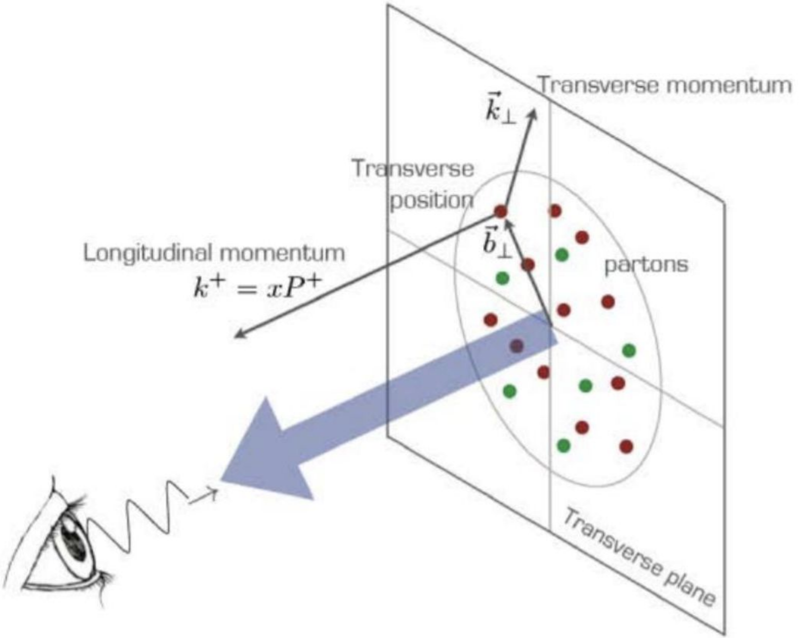
Parton distribution functions describe the number density for finding a parton inside a hadron carrying a specific fraction of the hadron’s longitudinal momentum.

Traditional PDFs describe the internal structure of protons in a one-dimensional picture.

Background: Transverse momentum dependent PDFs

TMDs introduce parton transverse momentum in addition to longitudinal momentum fraction.

TMDs provide full information of parton motion within a proton.

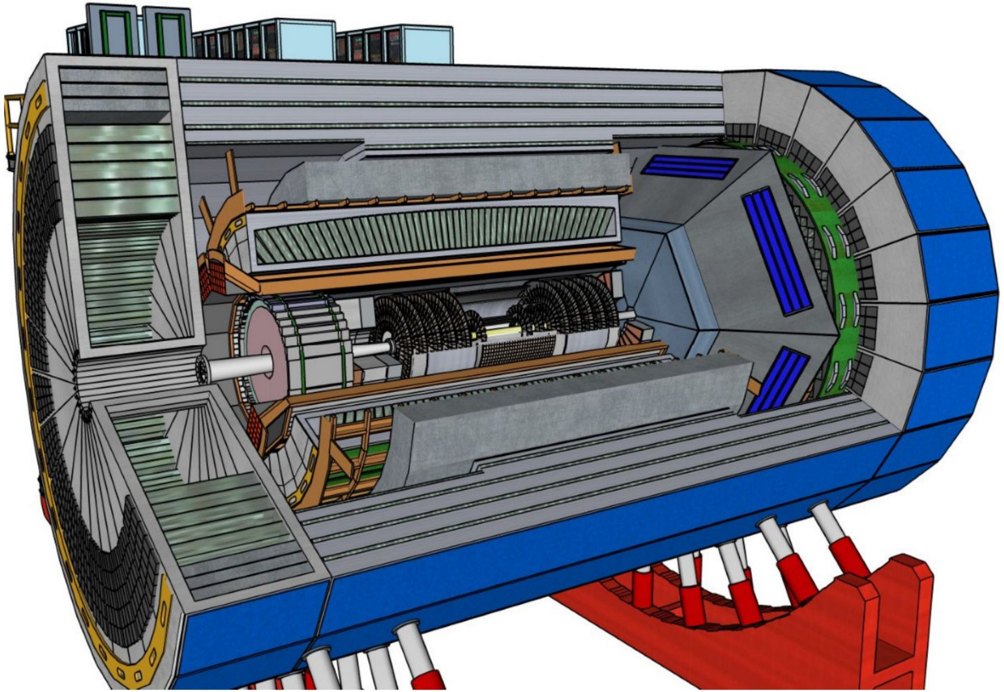


A. Bacchetta, 2016

Background: Transverse momentum dependent PDFs

TMDs via SIDIS		Quark Polarization		
		Unpolarized (U)	Longitudinally Polarized (L)	Transversely Polarized (T)
Nucleon Polarization	U	$F_{UU} \propto f_1 \otimes D_1$ *Unpolarized*		$F_{UU}^{\cos(2\phi_h)} \propto h_1^\perp \otimes H_1^\perp$ *Boer-Mulders*
	L		$A_{LL} \propto g_1 \otimes D_1$ *Helicity*	$A_{UL}^{\sin(2\phi_h)} \propto h_{1L}^\perp \otimes H_1^\perp$ *Long-Transversity*
	T	$A_{UT}^{\sin(\phi_h-\phi_S)} \propto f_{1T}^\perp \otimes D_1$ *Sivers*	$A_{LT}^{\cos(\phi_h-\phi_S)} \propto g_{1T} \otimes D_1$ *Trans-Helicity*	$A_{UT}^{\sin(\phi_h+\phi_S)} \propto h_1 \otimes H_1^\perp$ *Transversity* $A_{UT}^{\sin(3\phi_h-\phi_S)} \propto h_{1T}^\perp \otimes H_1^\perp$ *Pretzelosity*

ECCE Detector



O. Hen et al., 2021

Kinematic reconstruction: Electron method

$$Q^2 = 2E_e E'_e(1+\cos\theta_e)$$

$$y = 1 - \frac{E'_e}{2E_e}(1-\cos\theta_e)$$

$$x = \frac{Q^2}{sy}$$

Electron method only requires measurement of the scattered electron.

Scattered electron is identified with charged particle tracks.

H. Abramowicz & A. Caldwell, 1999

Kinematic reconstruction: Hadron (Jacquet-Blondel) method

Hadron method requires measurement of every final state hadron.

Final state hadrons are identified from charged particle tracks and hadron calorimeter clusters.

$$\delta_{had} = \sum_{i=1}^{\#hadrons} E_i(1-\cos\theta_i)$$

$$= E_{had} - p_{z\ had}$$

$$y = \frac{\delta_{had}}{2E_e}$$

$$Q^2 = \frac{p_{t\ had}^2}{1-y}$$

$$x = \frac{Q^2}{sy}$$

H. Abramowicz & A. Caldwell, 1999

Kinematic reconstruction: Double angle method

Double angle method requires measurement of the electron and the final state hadrons.

This method does not rely on scattered electron energy.

$$\cos\gamma = \frac{p_{t\ had}^2 - \delta_{had}^2}{p_{t\ had}^2 + \delta_{had}^2}$$

$$Q^2 = 4E_e^2 \frac{\sin\gamma(1+\cos\theta_e)}{\sin\gamma + \sin\theta_e - \sin(\theta_e+\gamma)}$$

$$x = \frac{E_e}{E_p}\frac{\sin\gamma + \sin\theta_e + \sin(\theta_e+\gamma)}{\sin\gamma + \sin\theta_e - \sin(\theta_e+\gamma)}$$

H. Abramowicz & A. Caldwell, 1999

Plan: Check resolution of DIS kinematics reconstruction

Compare reconstructed kinematic variables to truth values using different reconstruction methods in different kinematic regions.

Determine resolution of kinematic variables Q^2, y, x, z, ϕ from the full detector simulations.

Plan: Dihadron events

Specifically look at dihadron SIDIS events.

Calculate the phi-modulated asymmetry for unpolarized electron/transversely polarized proton collisions.

This asymmetry is proportional to the transversity function convolved with the dihadron interference fragmentation function.

Provide pseudodata and projection of uncertainty in EIC experiments.