

Probing Nuclear Structure and Dynamics at the Electron-Ion Collider

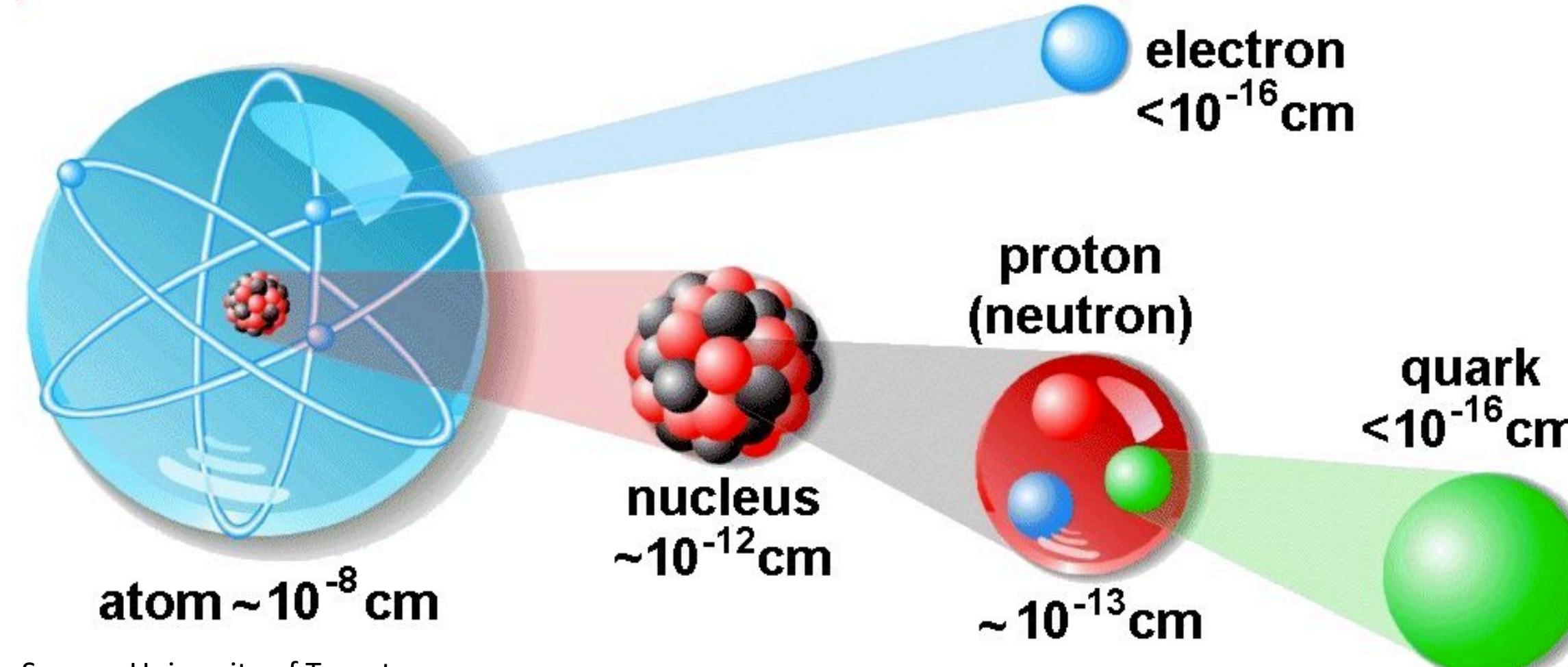


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Particle Physics

Particle physics is the study of the elementary constituents of matter and the interactions between them.

Particle physics aims to answer the ambitious question: What is the Universe made of?



Particle Colliders

Particle physics unravels the structure of matter through particle collisions.

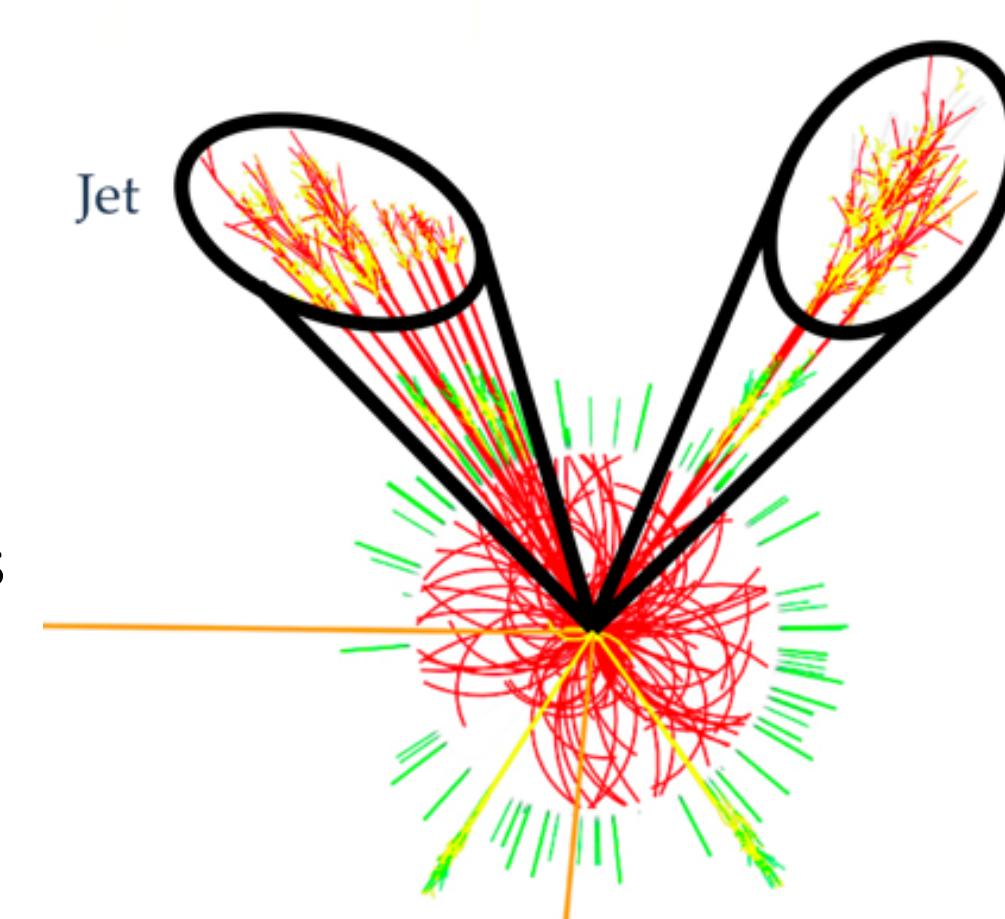
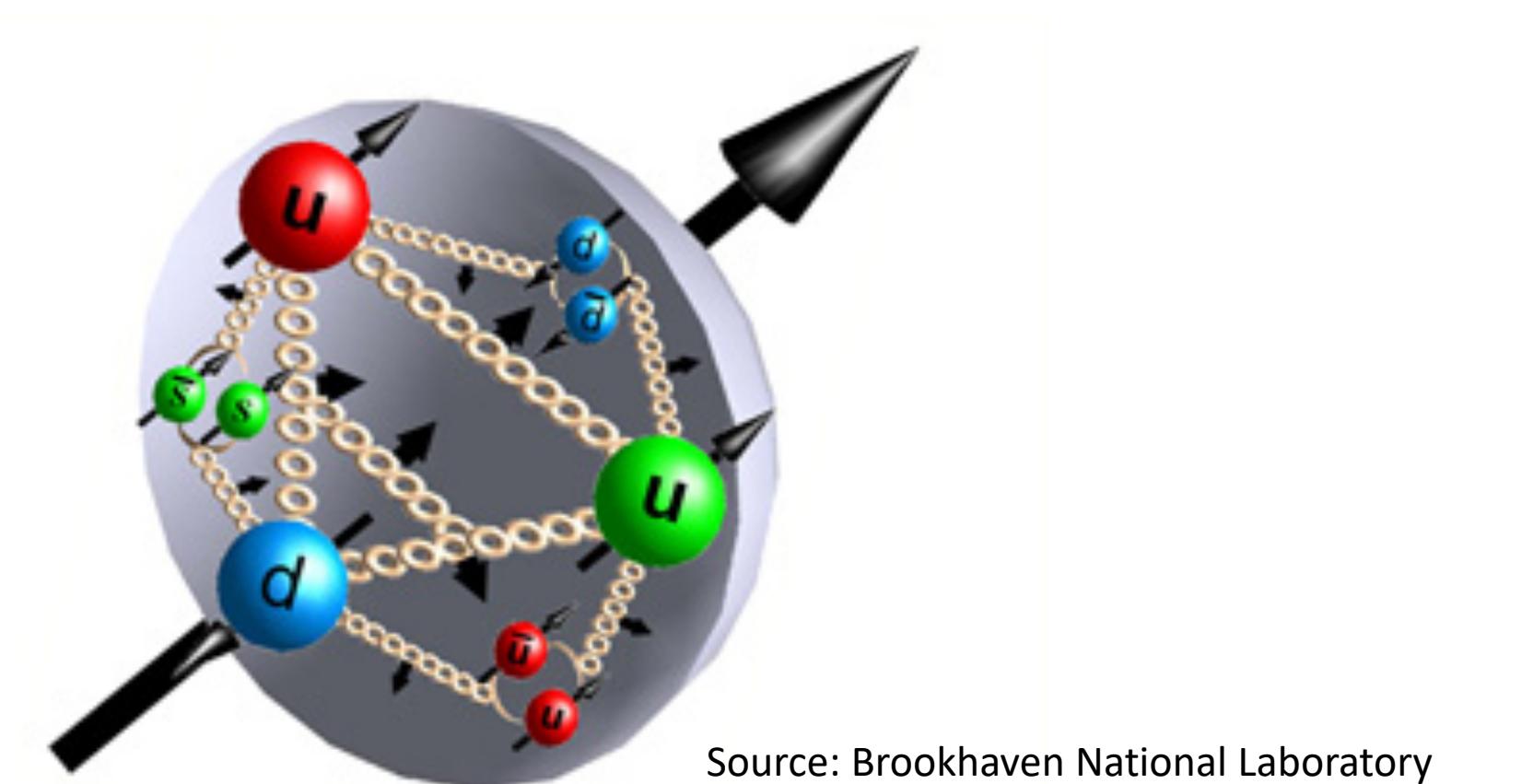


Source: Jefferson National Laboratory

The Electron-Ion Collider (EIC)

The Brookhaven National Laboratory will be the home of the newest particle accelerator facility, the Electron-Ion Collider.

The EIC will smash electrons into protons and other heavier atomic nuclei to study the quarks and gluons within the protons and neutrons.



What is a jet?

Because quarks and gluons cannot be observed individually, the collision debris is measured.

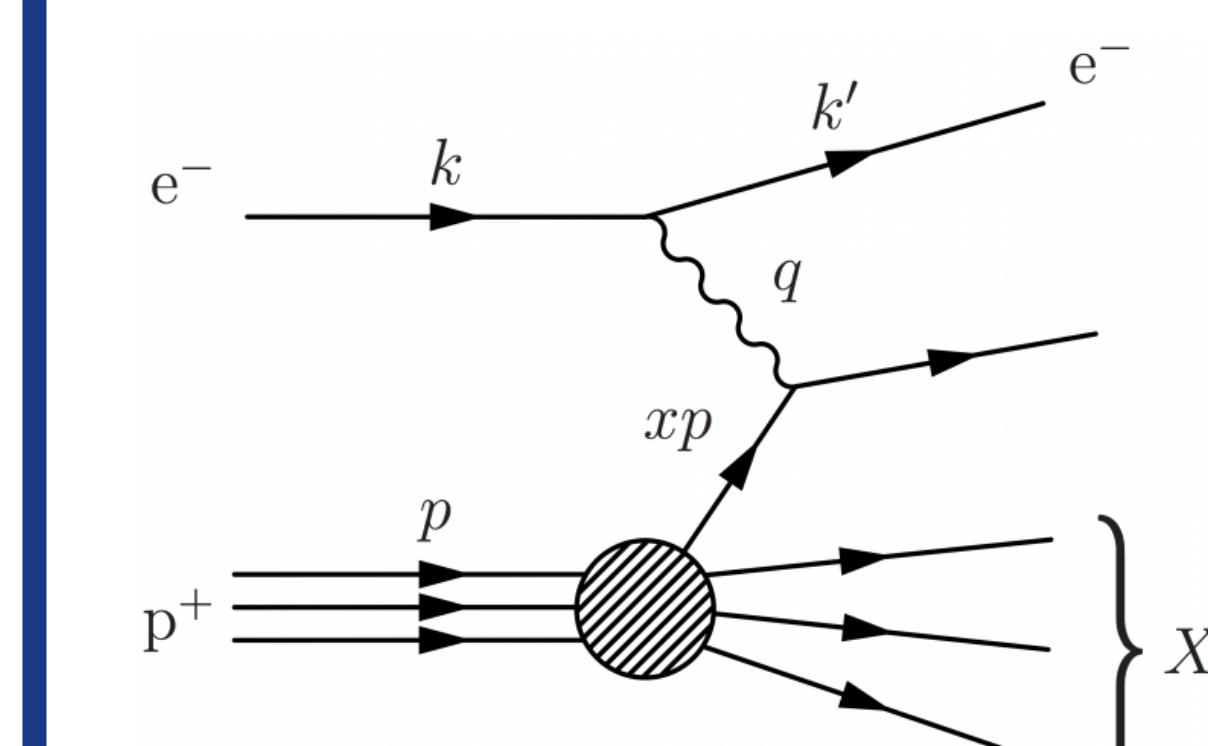
Jets are collections of collimated debris which allows us to work backwards from the collisions to study the structure and dynamics of the quarks and gluons within protons and neutrons.

References:

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- Z. B. Kang, X. Liu, S. Mantry and J. W. Qiu, Phys. Rev. D 88, 074020
- D. Kang, C. Lee and I. W. Stewart, Phys. Rev. D 88, 054004,
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- T. Sjöstrand, et. al., Comput. Phys. Commun. 191 159

Deep Inelastic Scattering (DIS)

$$e^- + N_A \rightarrow J + X$$



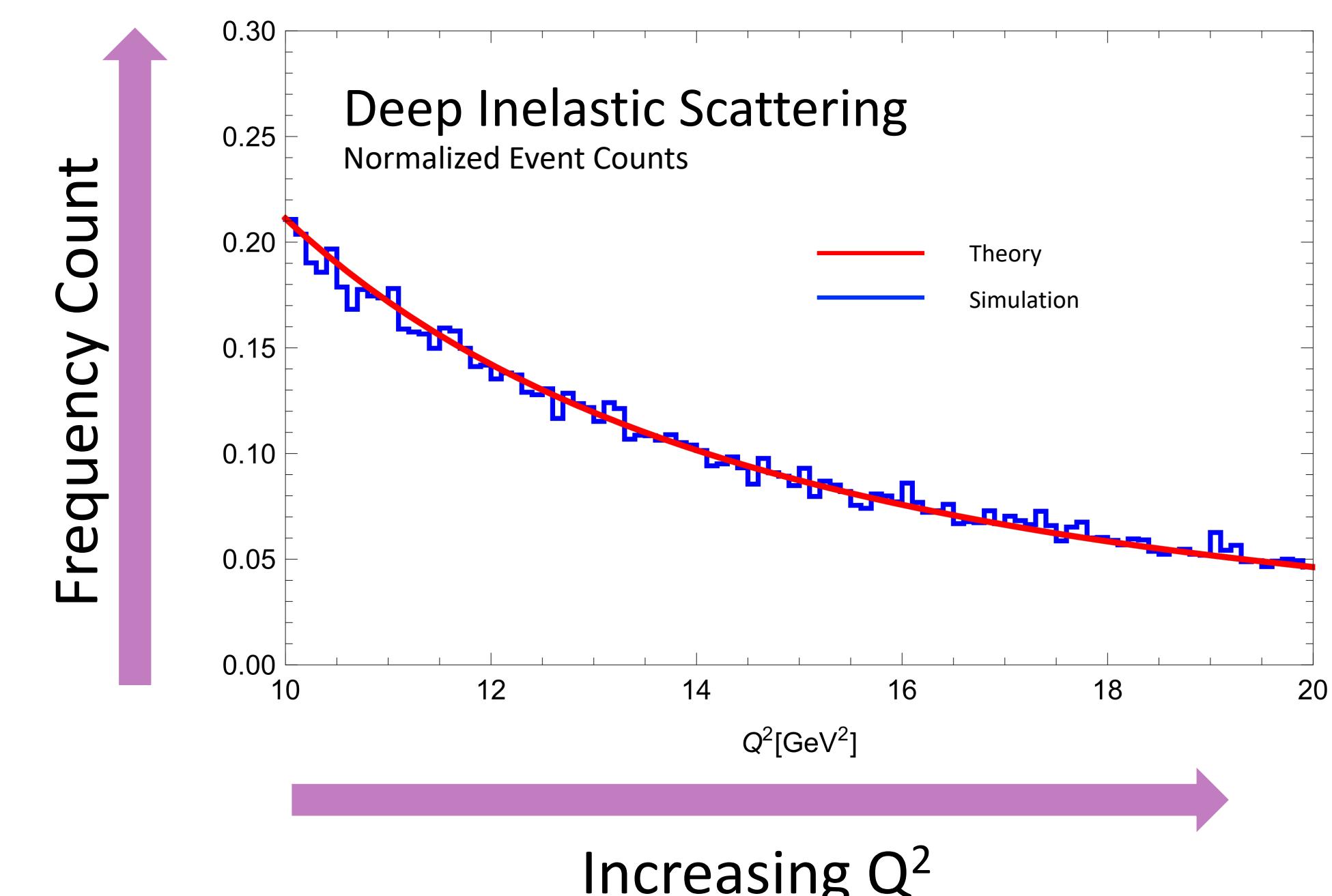
$$Q^2 \equiv q^2 = -(k - k')^2$$

Q^2 measures energy and angle of the scattered electron.

$$x = \frac{Q^2}{2p \cdot q}$$

x measures the momentum of the struck quark.

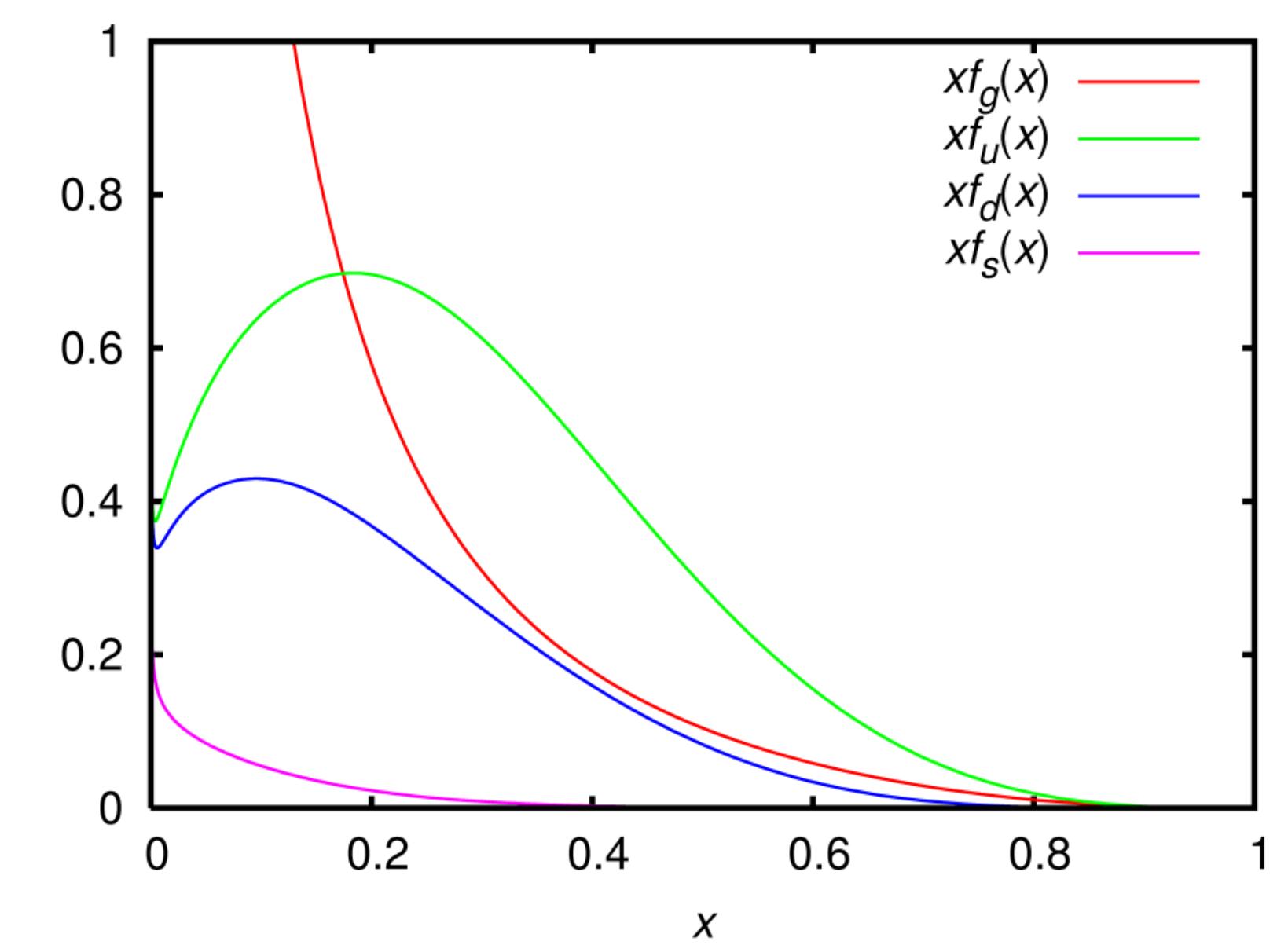
DIS Q^2 Distribution



Simulation Program:

- Pythia8.240
- Number of simulated events: 100,000
- Center of Mass collision energy: 90GeV

Proton Structure Functions (PDFs)

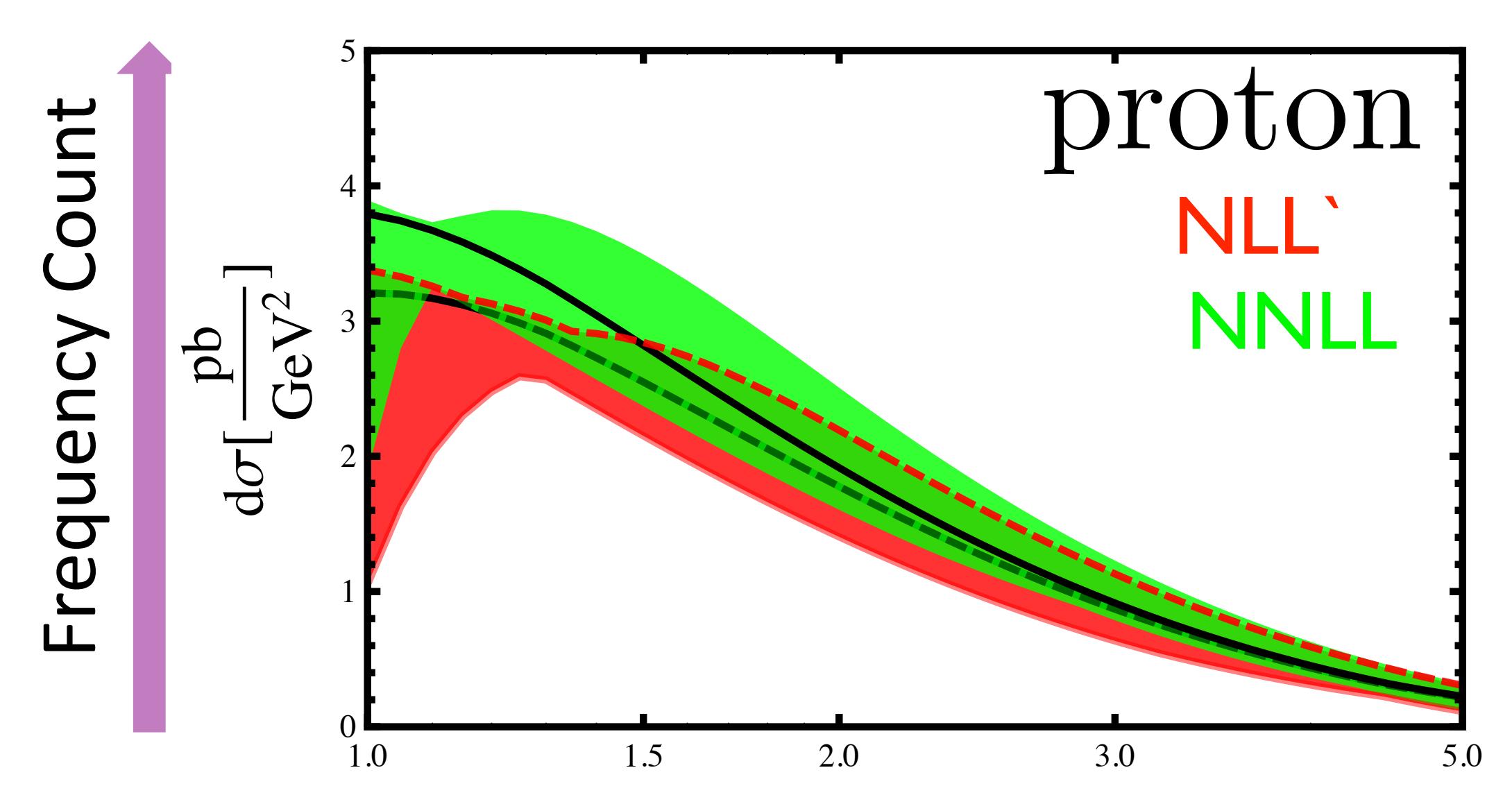
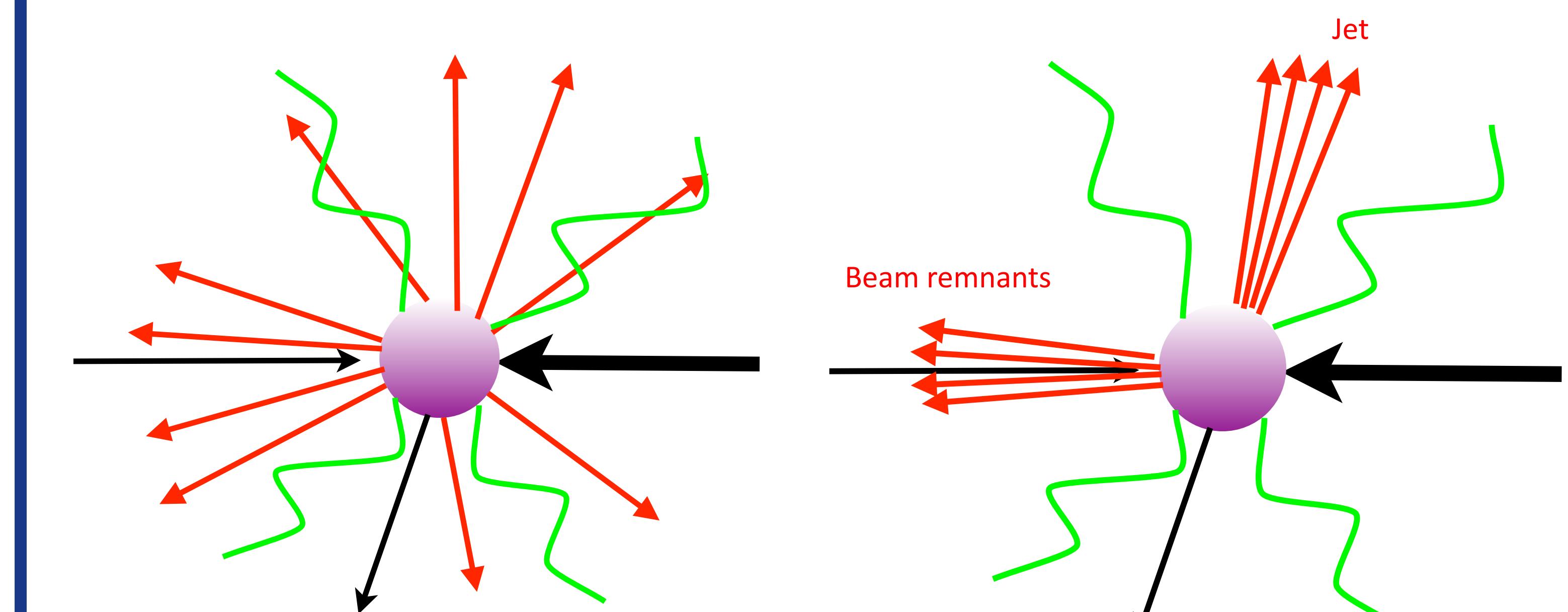


Parton Distribution Functions (PDFs) describe the momentum distribution, revealing information about the behavior of the quarks and gluons within protons and neutrons.

Nuclear PDFs tell us how these momentum distributions of the quarks and gluons are effected when the protons and neutrons are inside various types of nuclear environments.

The 1-Jettiness Distribution

$$\text{The 1-Jettiness definition: } \tau_1 = \sum_k \min \left\{ \frac{2q_A \cdot p_k}{Q_A}, \frac{2q_J \cdot p_k}{Q_J} \right\}$$



The 1-jettiness observable will serve as a probe of nuclear physics at the EIC and allow for studies such as:

- Jet distributions in e-A collisions
- Nuclear Parton Distribution Functions
- Parton propagation through cold nuclear matter
- Nuclear medium effects