Probing the Intrinsic Charm in the nucleon at EIC

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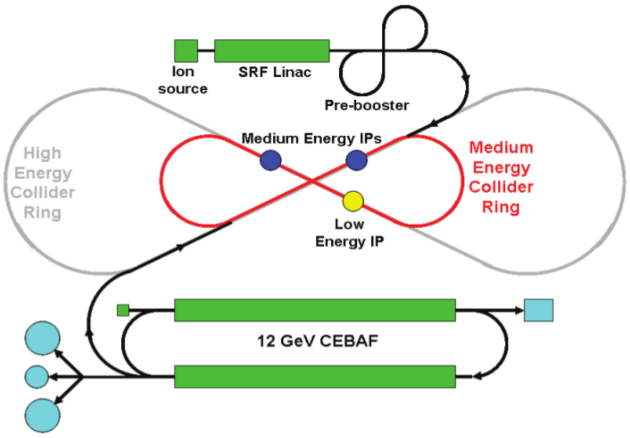
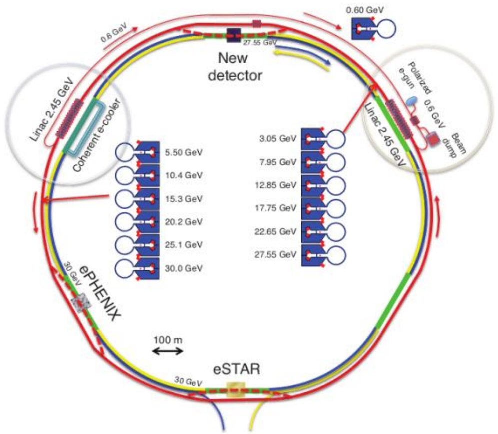




Outline

- Motivation
- Extraction of Intrinsic charm component from D meson electroproduction
- Pythia simulation
- Projection
- Conclusion

Motivation

- A complete map out of the proton structure in terms of its quark constituents.

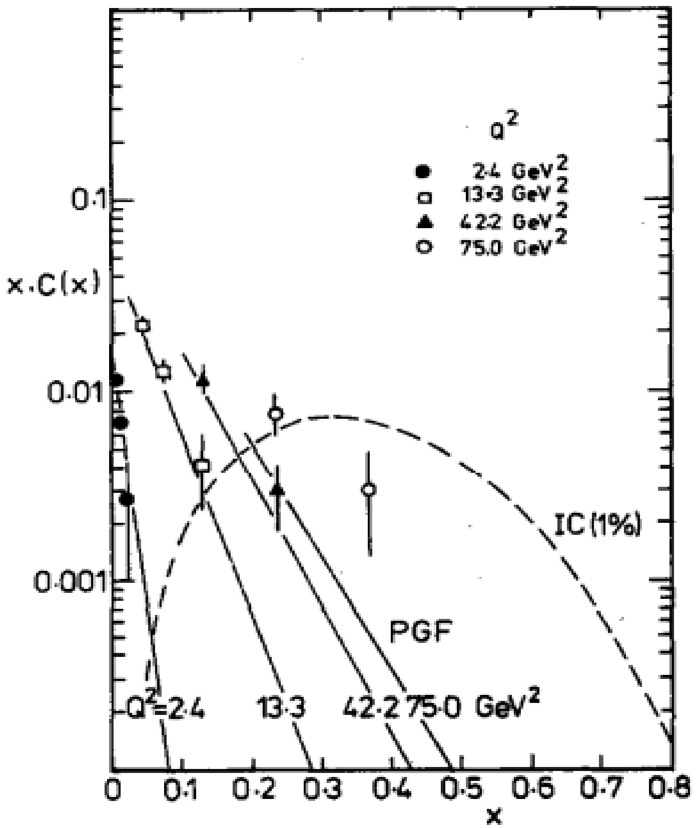
- Charm mesons lepto-production is one of the main sources of information on the nucleon's gluon distribution

- Tagging charm in neutrino and antineutrino scattering allows one to probe the strange and anti-strange quark densities in the nucleon.E770 and E744 experiments. **Phys. Rev. Lett. 70 (1993)**

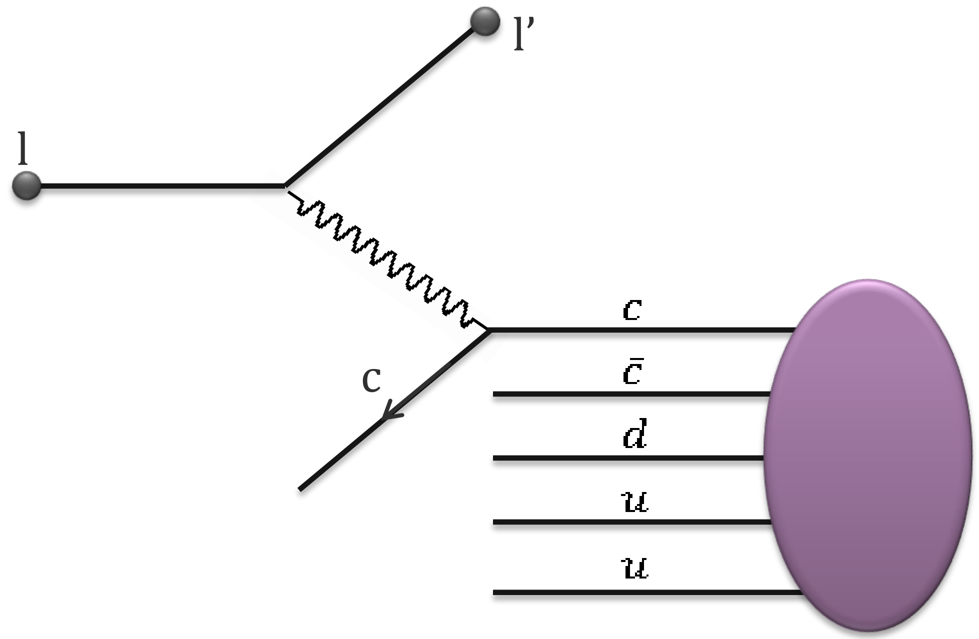
- **Investigate the existence of intrinsic charm component in the proton introduced by Brodsky et al. S.J.Brodsky, P.Hoyer, C.Peterson, and N.Sakai, Phys. Lett. B 93 (1980)**

Intrinsic charm

First evidence of intrinsic charm was observed in the di-muons production EMC experiment at CERN



J.J. Aubert et al., Nucl. Phys. B 213 (1983)



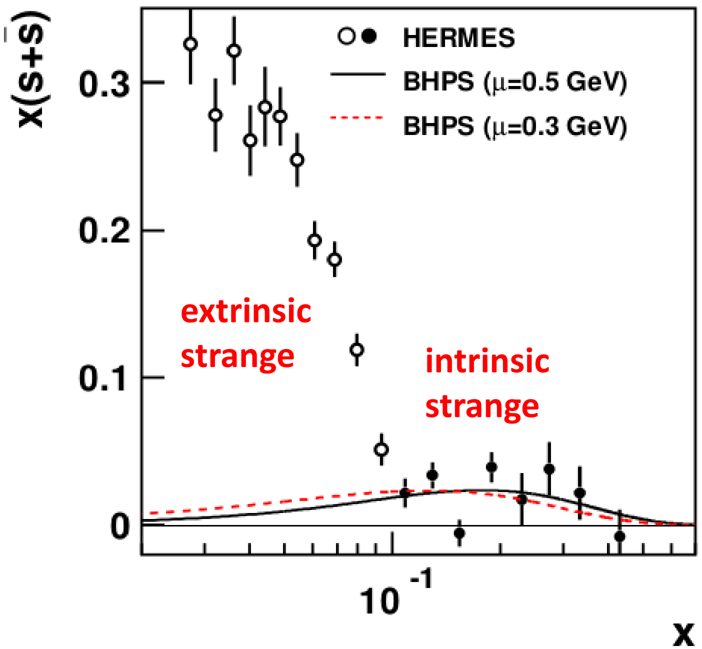
- IC can be generated $gg \to c\bar{c}$ fluctuation inside the proton where the gluons are coupled to the valence quarks

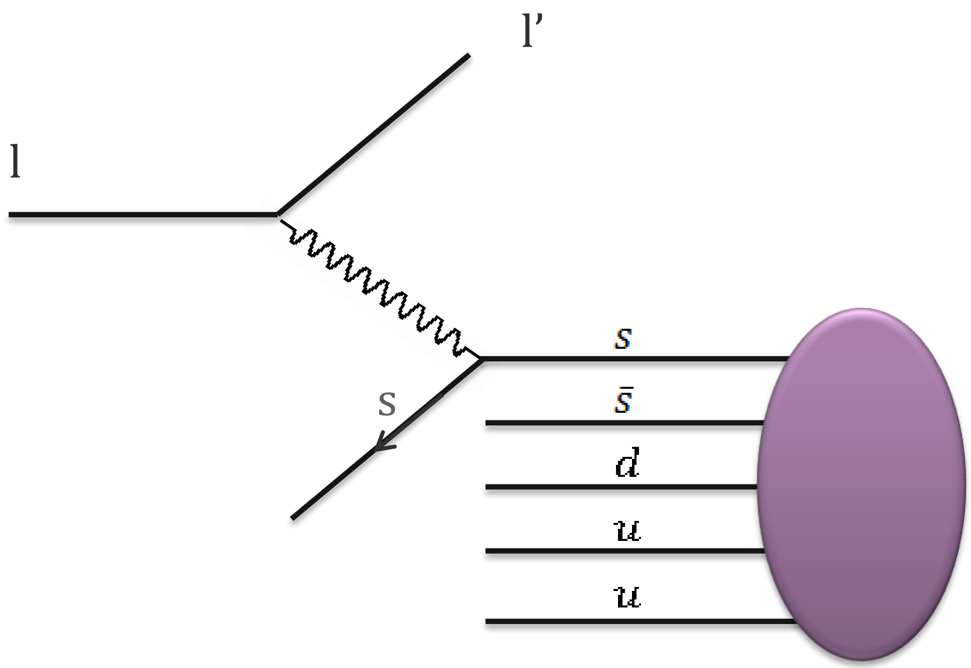
- Existence of IC component provides an evidence for a five-quark state $|\mathbf{uudc}\ \bar{\mathbf{c}}\rangle$ contribution to the nucleon wave function.

Intrinsic strangeness

HERMES data shows a clear evidence for the existence of intrinsic strangeness component in the proton

W.C. Chang and J.-C. Peng Arxiv:1105.2381





$$S(x,Q^2) = S_{int}(x,Q^2) + S_{ext}(x,Q^2)$$

Access the five-quark state $|uuds\bar{s}\rangle$ contribution to the proton wave function

Measurement of IC and EC

Lepto-production of charm mesons from SIDIS off deuteron provides access to

- charm mesons multiplicities → fragmentation functions
- Access the charm distribution in the nucleon

Particle data group

D meson	Mass (GeV)	Hadronic decay mode	BR
D^0	1.864	$K^-\pi^+$	3.9%
D^+	1.869	$K^-\pi^+\pi^+$	9.4%
D^-	1.869	$K^+\pi^-\pi^-$	9.4%
D^{*0}	2.007	$D^0\pi^0 \to K^-\pi^+\gamma\gamma$	62%
D^{*+}	2.010	$D^0\pi^+ \to K^-\pi^+\pi^+$ $D^+\pi^0 \to K^-\pi^+\pi^+\gamma\gamma$	67.7% 30.7%
D^{*-}	2.010	$D^0\pi^- \to K^-\pi^+\pi^-$ $D^-\pi^0 \to K^+\pi^-\pi^-\gamma\gamma$	67.7% 30.7%

Formalism

$$\frac{dN^h(x,Q^2,z)}{dN^{DIS}(x,Q^2)} \approx \frac{d\sigma^h(x,Q^2,z)/dx\,dQ^2dz}{d\sigma^{DIS}(x,Q^2)/dx\,dQ^2} = \frac{\sum_q e_q^2\, q(x,Q^2) D_q^h(z,Q^2)}{\sum_q e_q^2\, q(x,Q^2)}$$

Integrating over z for a deuteron target, $h = D^{*+} + D^{*-} \equiv D^*$

$$\frac{Q(x,Q^2)\int D_{NS}^{D^*}(z,Q^2)dz + S(x,Q^2)\int D_S^{D^*}(z,Q^2)dz + \boldsymbol{C(x,Q^2)}\int D_C^{D^*}(z,Q^2)dz}{5Q(x,Q^2) + 2S(x,Q^2) + 8\boldsymbol{C(x,Q^2)}}$$

$$Q(x,Q^2) = u(x,Q^2) + \bar{u}(x,Q^2) + d(x,Q^2) + \bar{d}(x,Q^2)$$

$$S(x,Q^2) = s(x,Q^2) + \bar{s}(x,Q^2) \quad C = c(x,Q^2) + \bar{c}(x,Q^2)$$

$$c(x,Q^2) = \frac{Q\int D_{NS}^{D^*}(z,Q^2)dz + S\int D_S^{D^*}(z,Q^2)dz - M(x,Q^2)[5Q + 2S]}{8M(x,Q^2) - \int D_C^{D^*}(z,Q^2)dz}$$

$M(x,Q^2)$ is the measured multiplicity

PDF input:

- S,Q pdf from CTEQ6 parametrization

FF input:

- FF from KKKS08 parameterization

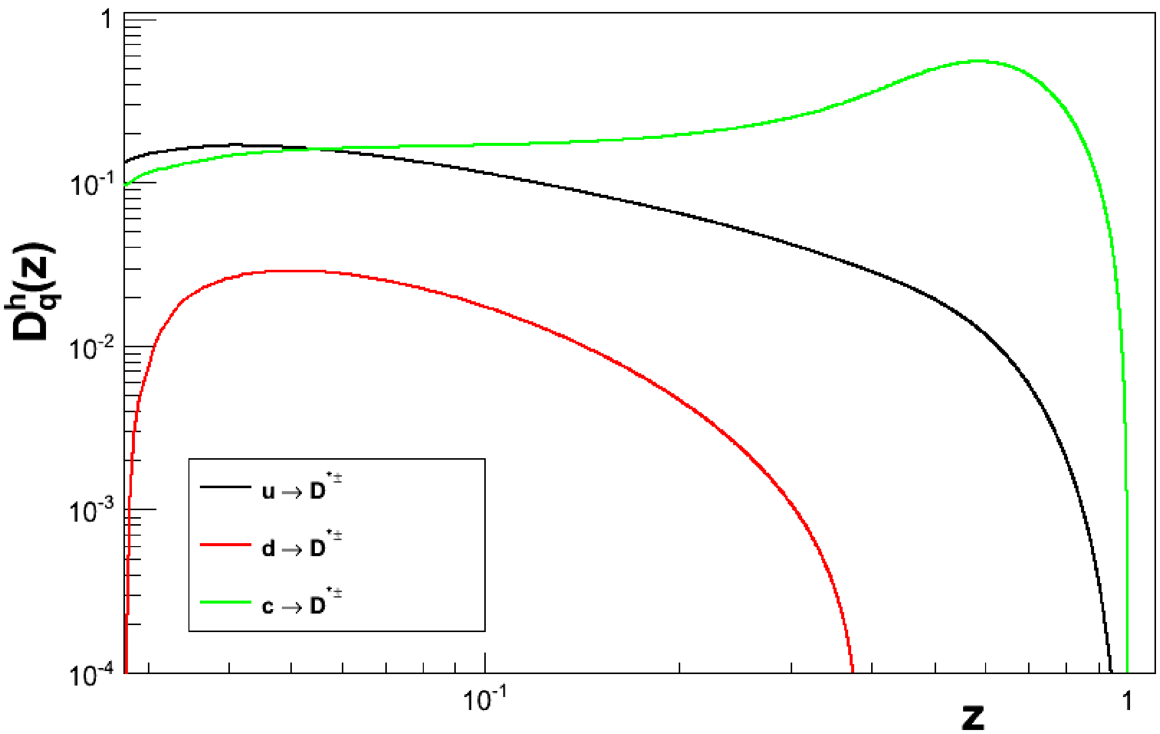
$D^{*\pm}$ Fragmentation Function

KKKS08 parametrization:

- Fit to experimental data from BELLE, CLEO, ALEPH and OPAL are used to determine fragmentation function for D^0, D^+ and D^*

T. Kneesch, B.A. Kniehl, G. Kramer, and I. Schienbein, Nucl. Phys. B799 (2008)

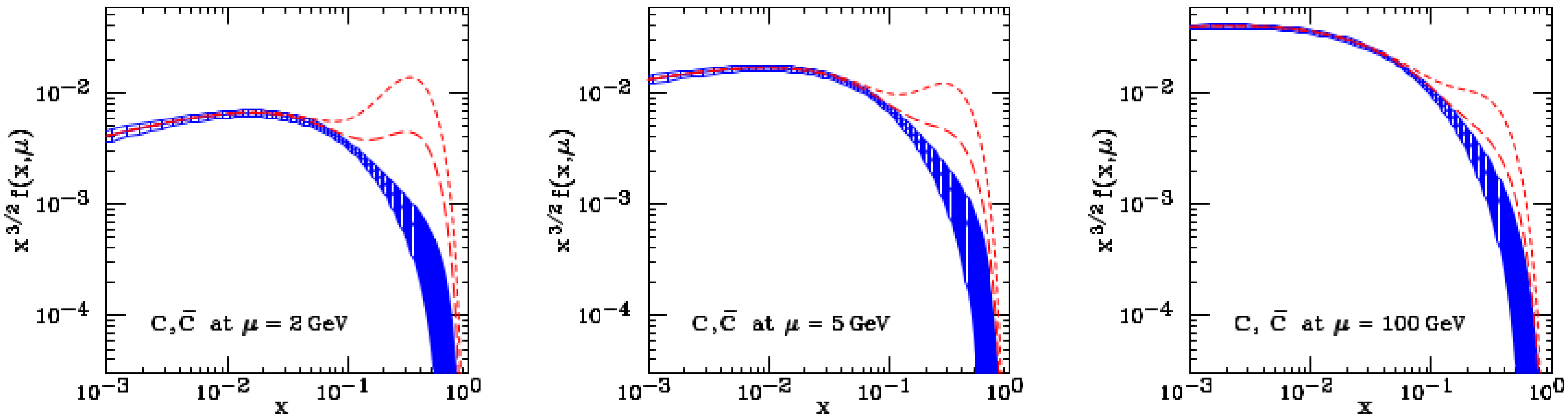
$10^{-4}<z<1$, $2.25\ GeV^2<Q2<10^6\ GeV^2$



Pythia Simulation

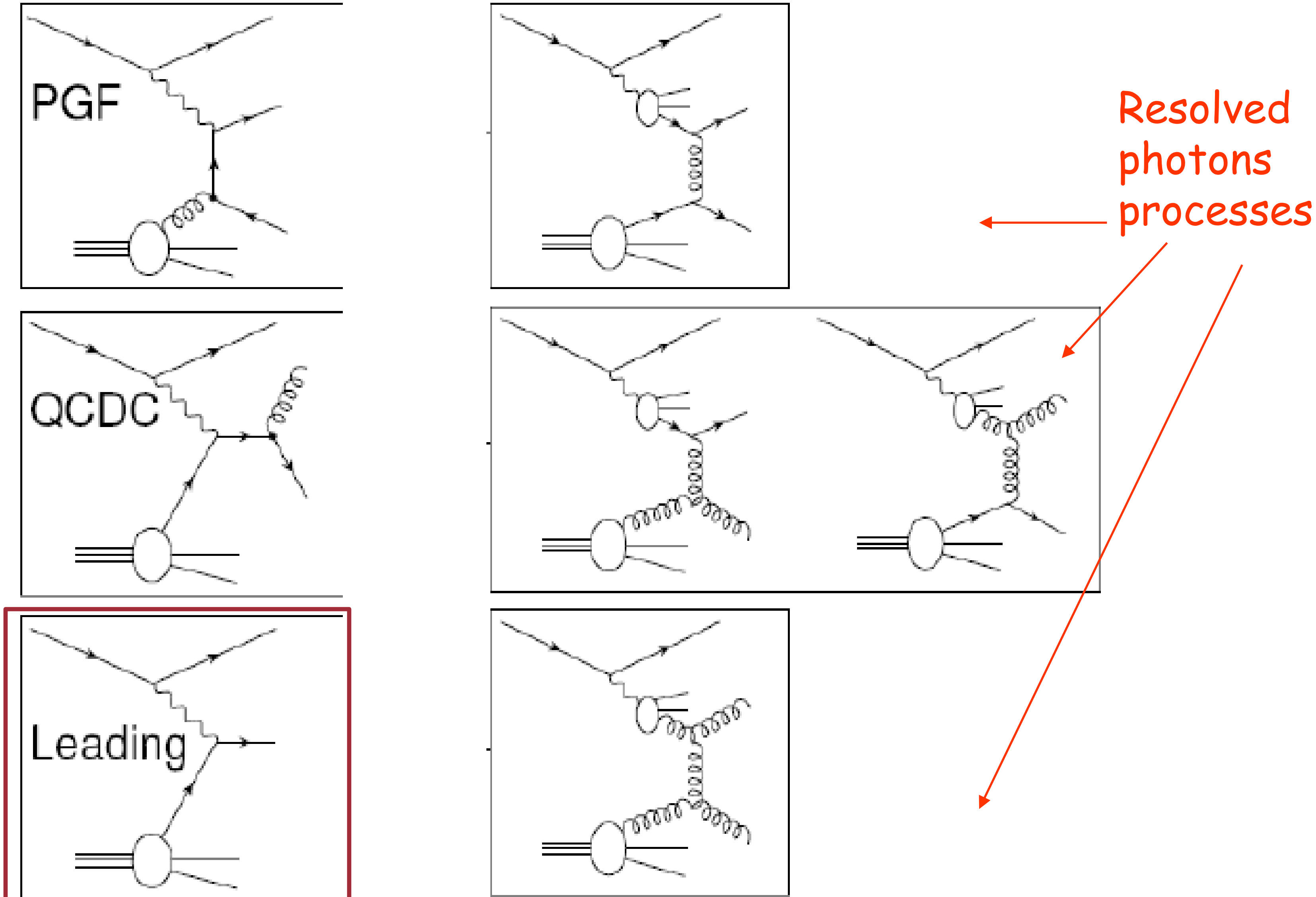
Pythia event generator is used to determine the $D^{*\pm}$ multiplicities

- e- beam energy 11 GeV
- p beam energy 50, 250 GeV
- pdf: cteq65 + BHPS model to include the intrinsic charm component
- Change Active flavor number to 4

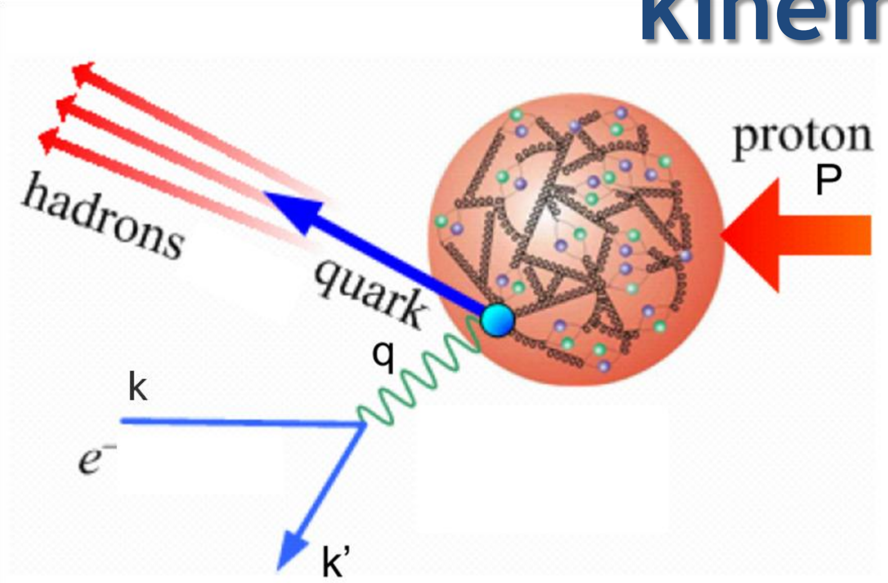


J. Pumplin, H.L. Lai, and W.K. Tung, Phys. Rev. D75 (2007)

Background Processes



kinematics

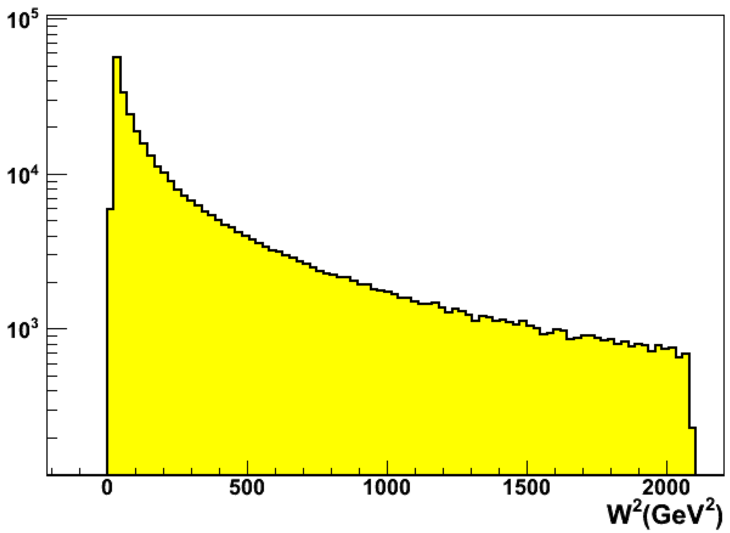


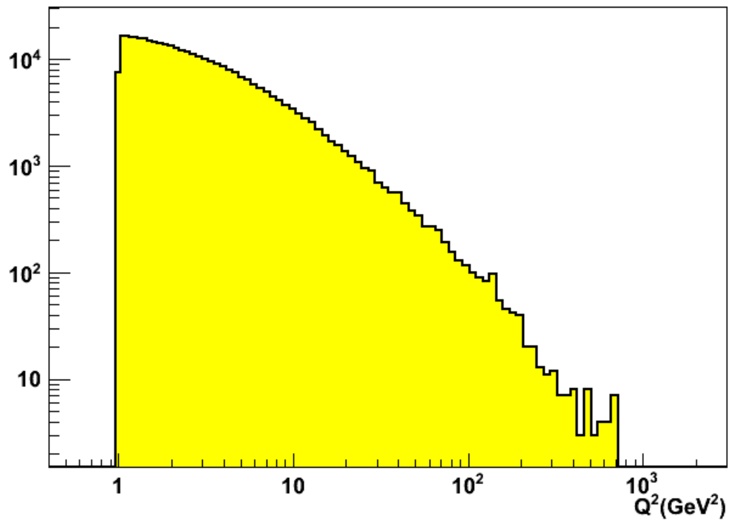
$$Q^2 = -(k - k')^2$$

$$W^2 = (P + q)^2$$

$$x = \frac{Q^2}{2\,(Pq)}$$

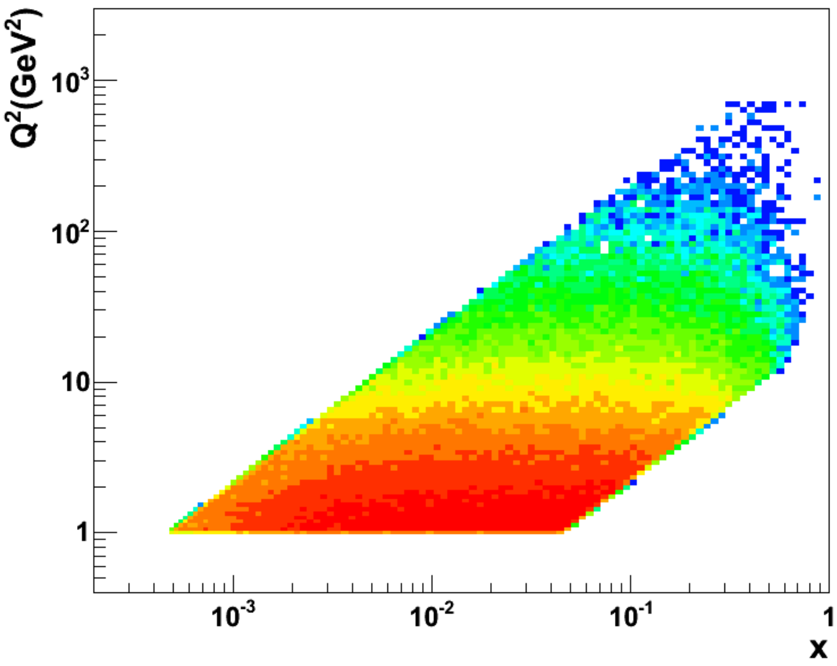
$$s = (P + k)^2$$





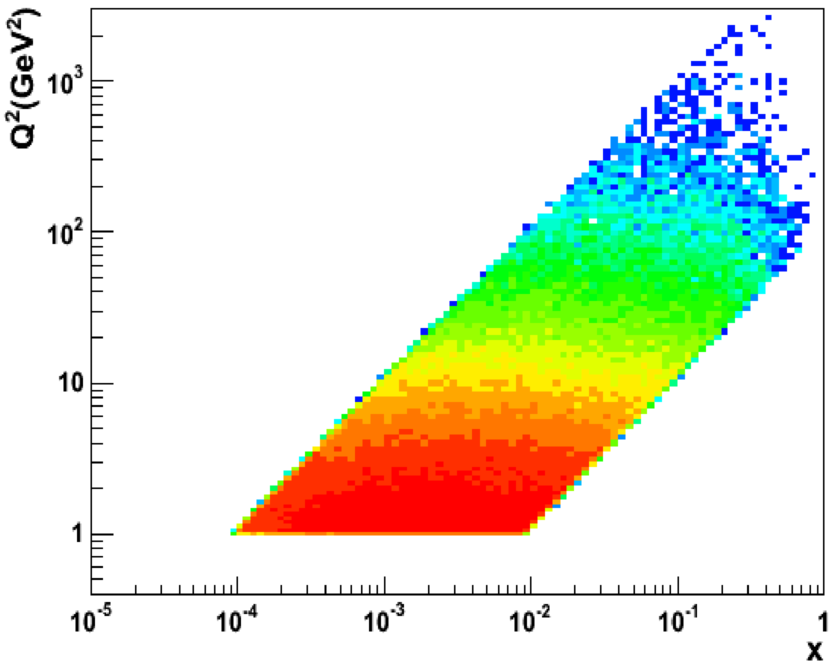
Q^2 versus x

$\sqrt{s} = 45\ GeV$



large x coverage

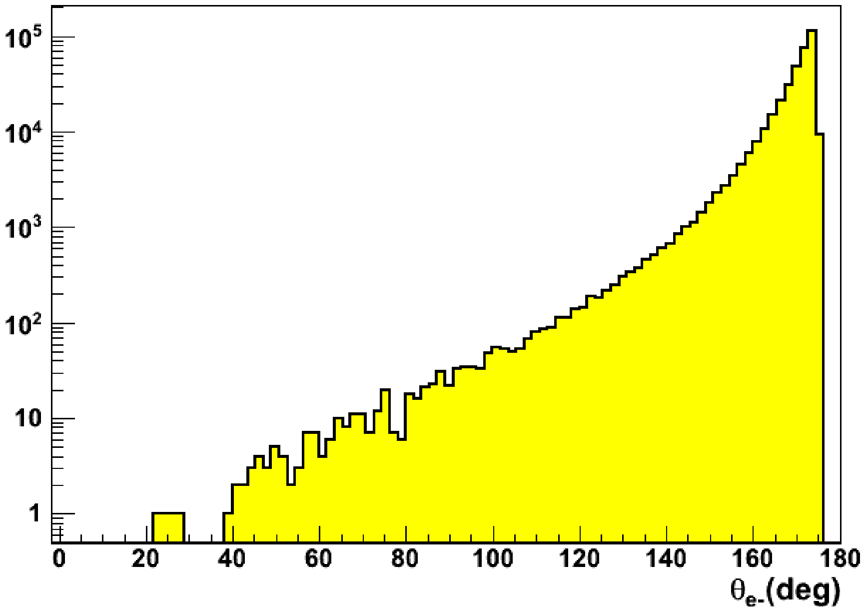
$\sqrt{s} = 105\ GeV$



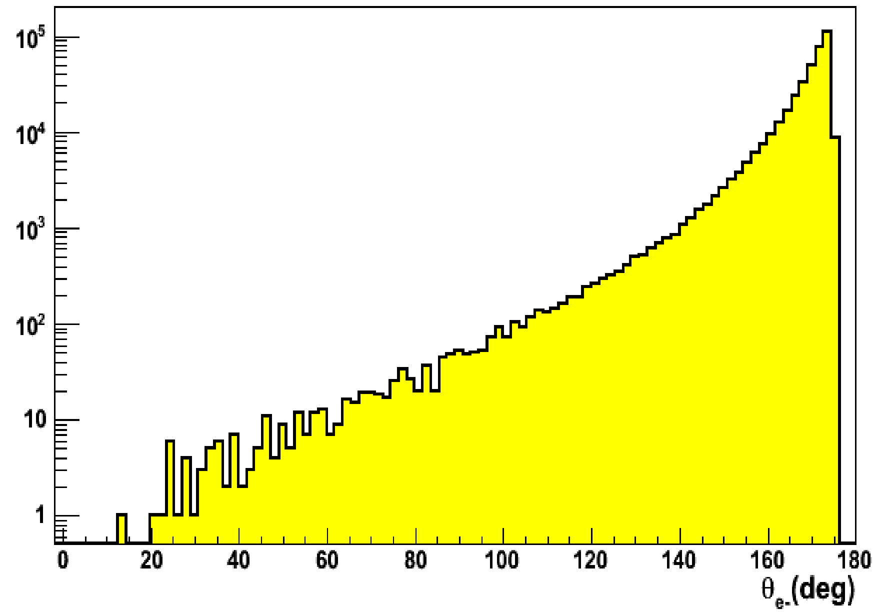
low x coverage

Angular distribution of scattered electron

$\sqrt{s} = 45\ GeV$

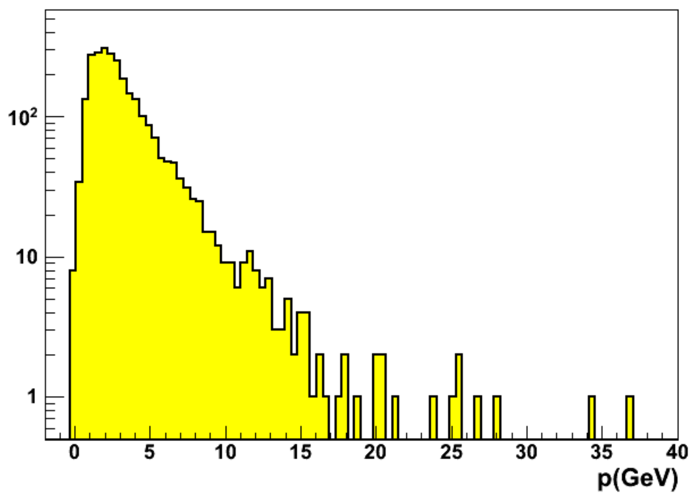


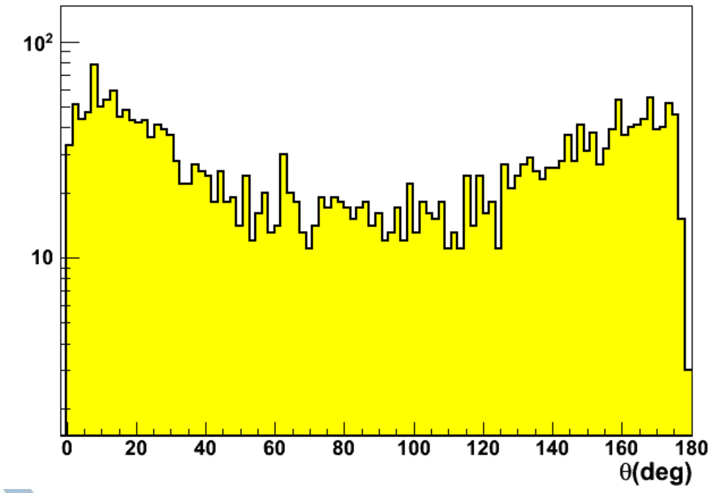
$\sqrt{s} = 105\ GeV$



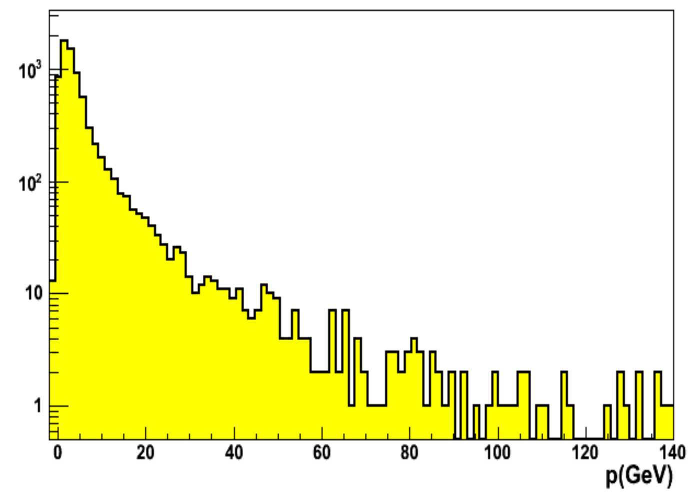
Angular and mometun distributions of D^{*+} meson

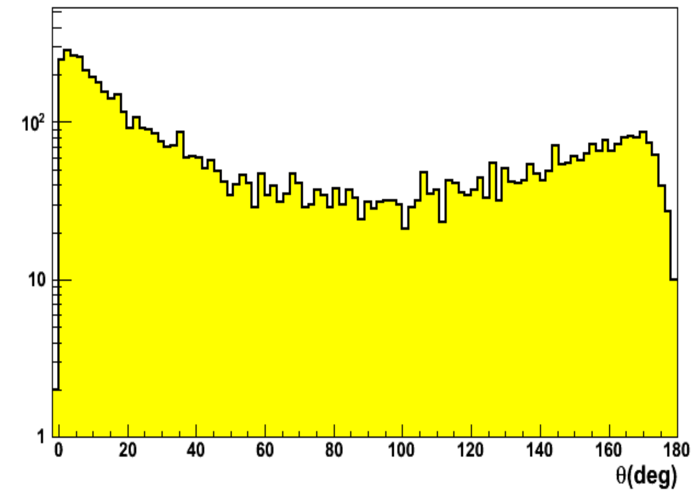
$\sqrt{s} = 45\ GeV$





$\sqrt{s} = 105\ GeV$

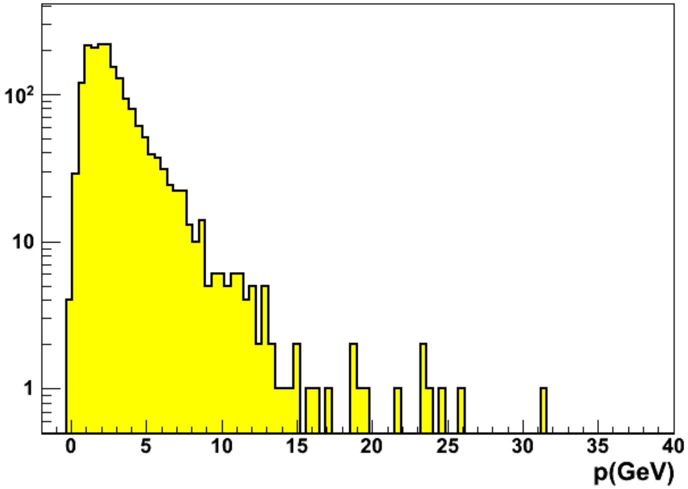


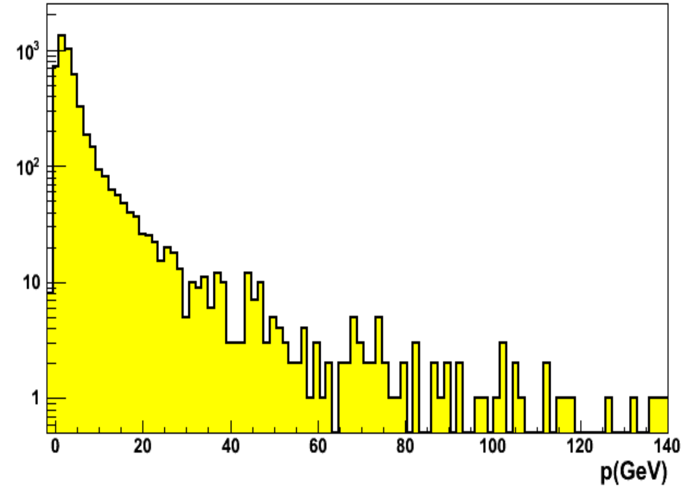


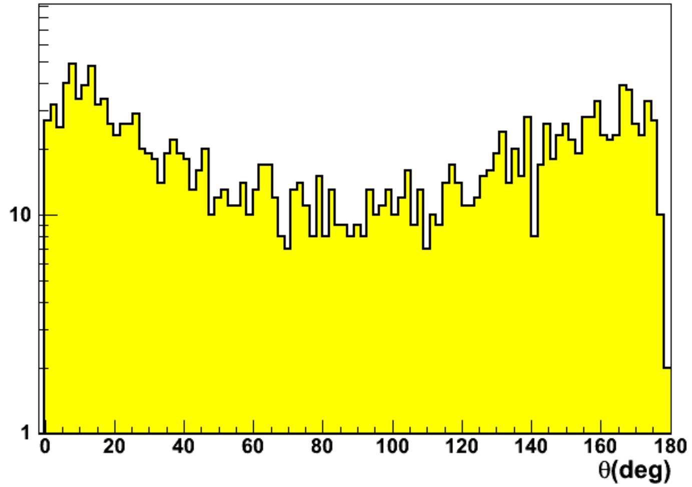
Angular and mometun distributions of D*- meson

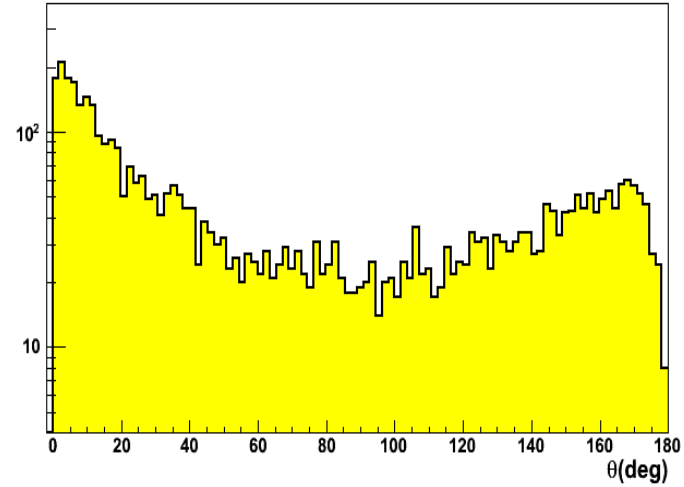
$\sqrt{s} = 45\ GeV$

$\sqrt{s} = 105\ GeV$



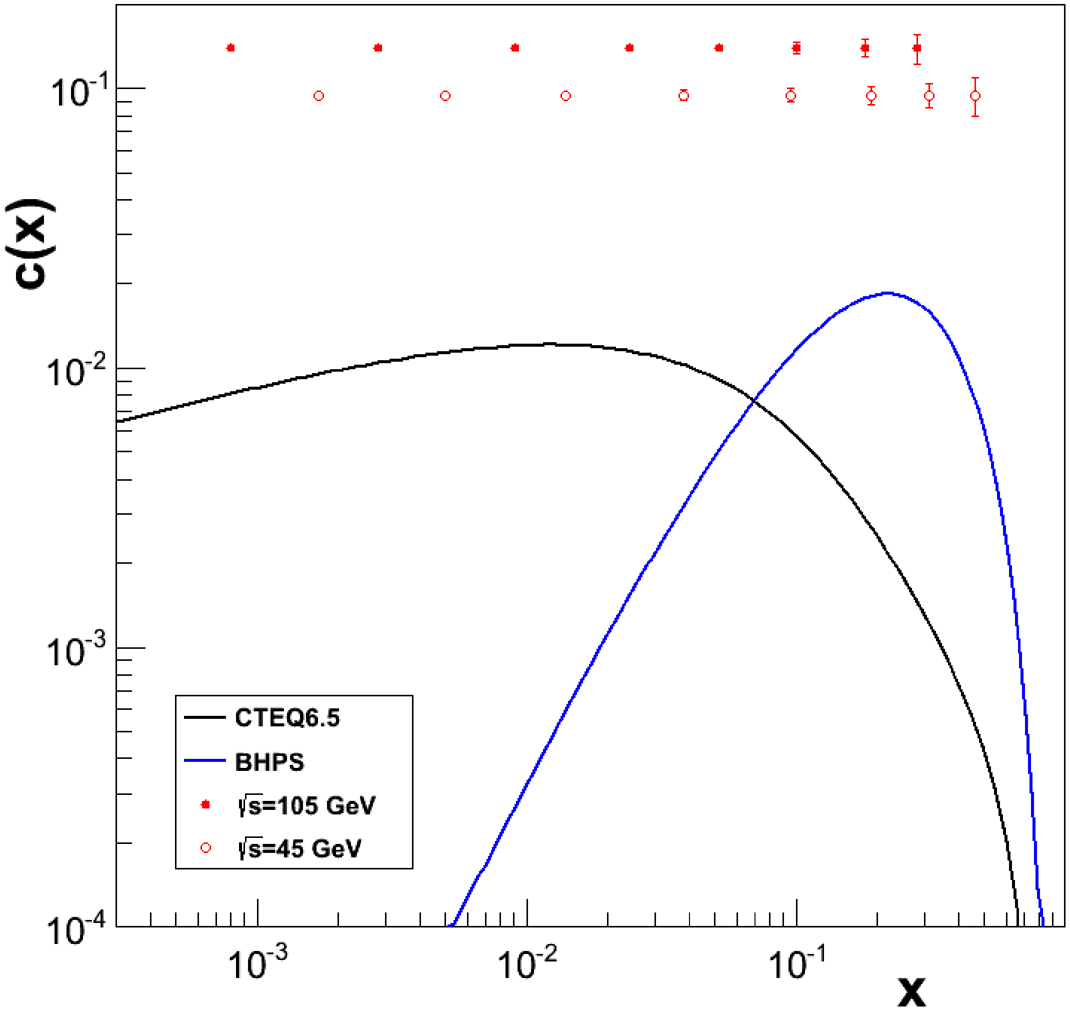






Projection

- Two years of running at luminosity 10^{33} cm^{-2} s^{-1}
- Overall 90% detection efficiency is assumed



Conclusion

- Electroprodction of $D^{*\pm}$ mesons at EIC offers an opportunity to access the extrinsic and intrinsic charm density in the nucleon.
- Extraction of $D^{*\pm}$ meson multiplicities will provide an input the fragmentation function database
- Sytematic uncertainties related to parton distribution function and fragmentation function are under study
- multi binning analysis to determine charm pdf as function of x and Q^2