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Thomas Jefferson National Accelerator Facility

Charm production rate

Sergey Furletov

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Charm in HVQDIS, Herwig, Pythia

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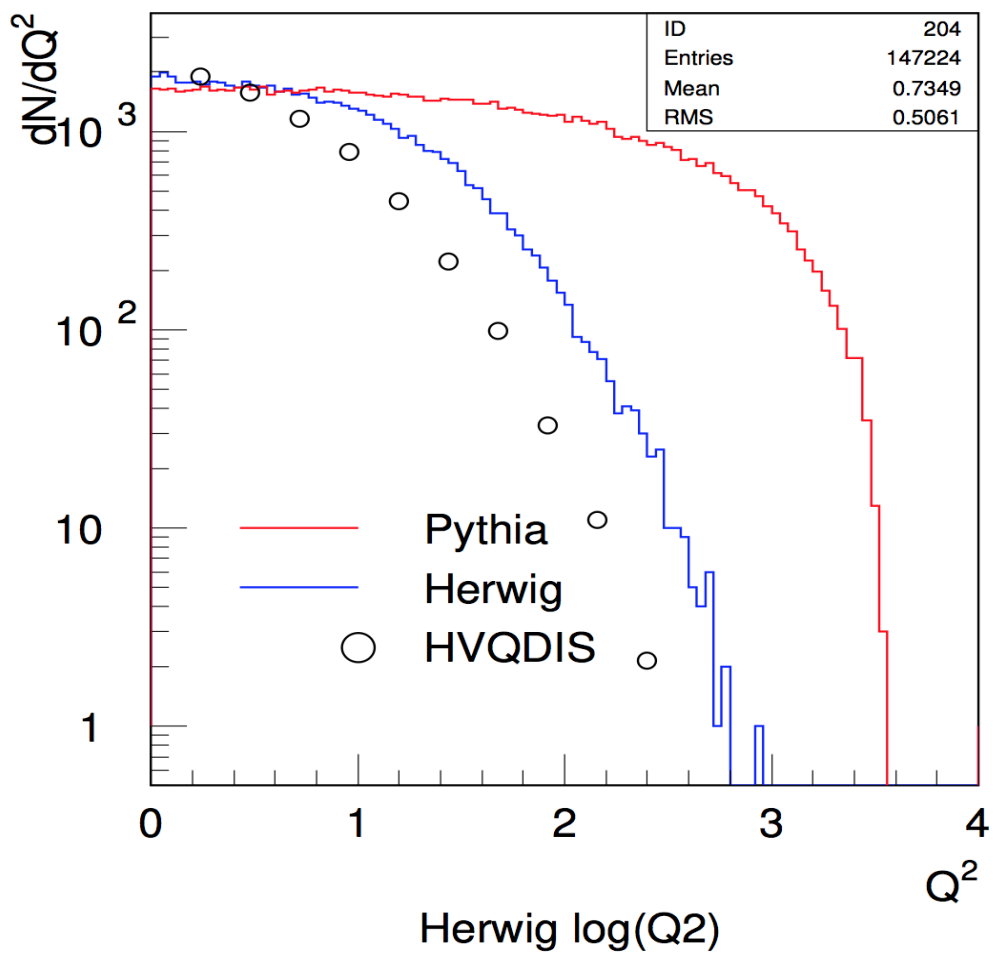
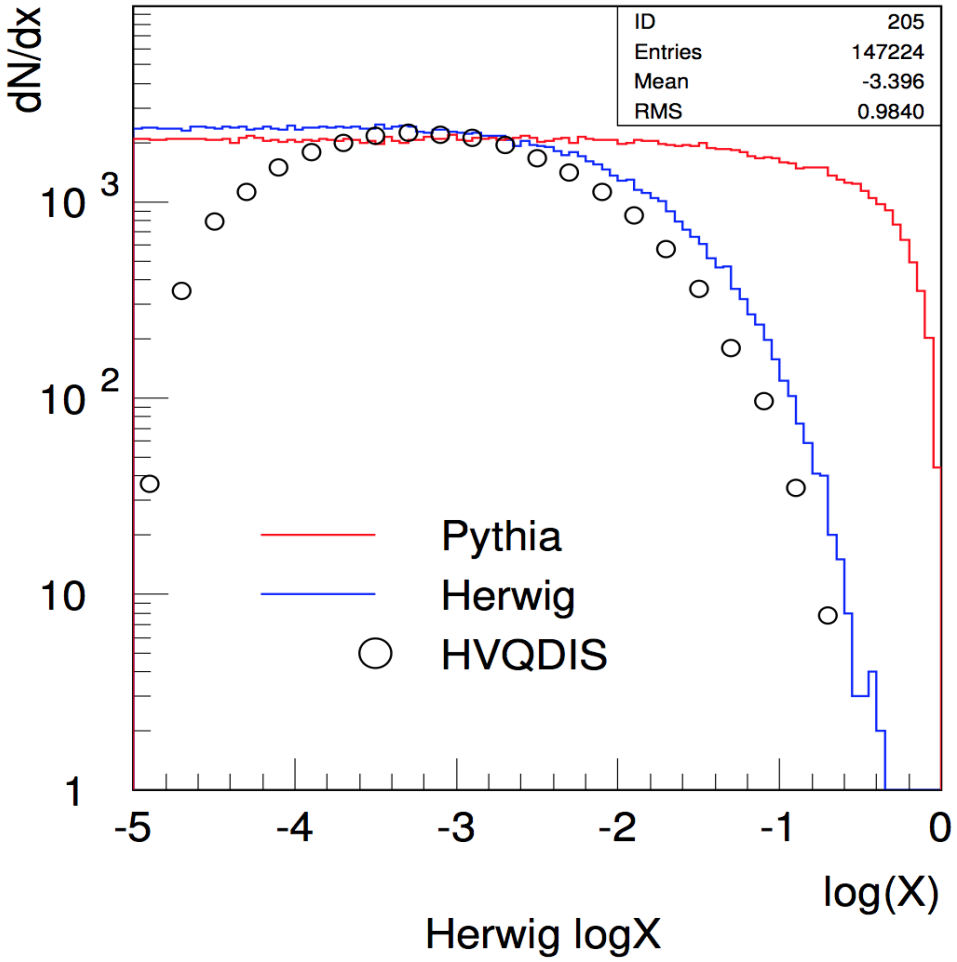
$\sqrt{s}$=63 GeV





Charm cross section

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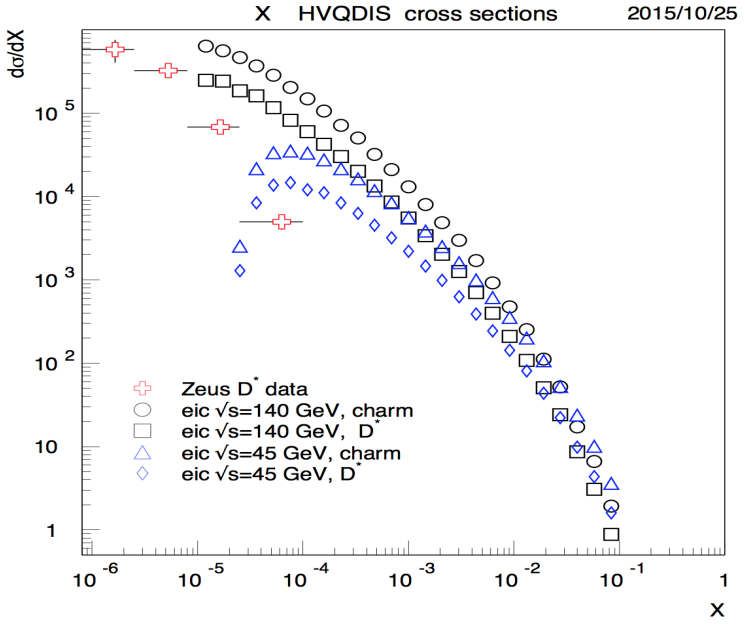
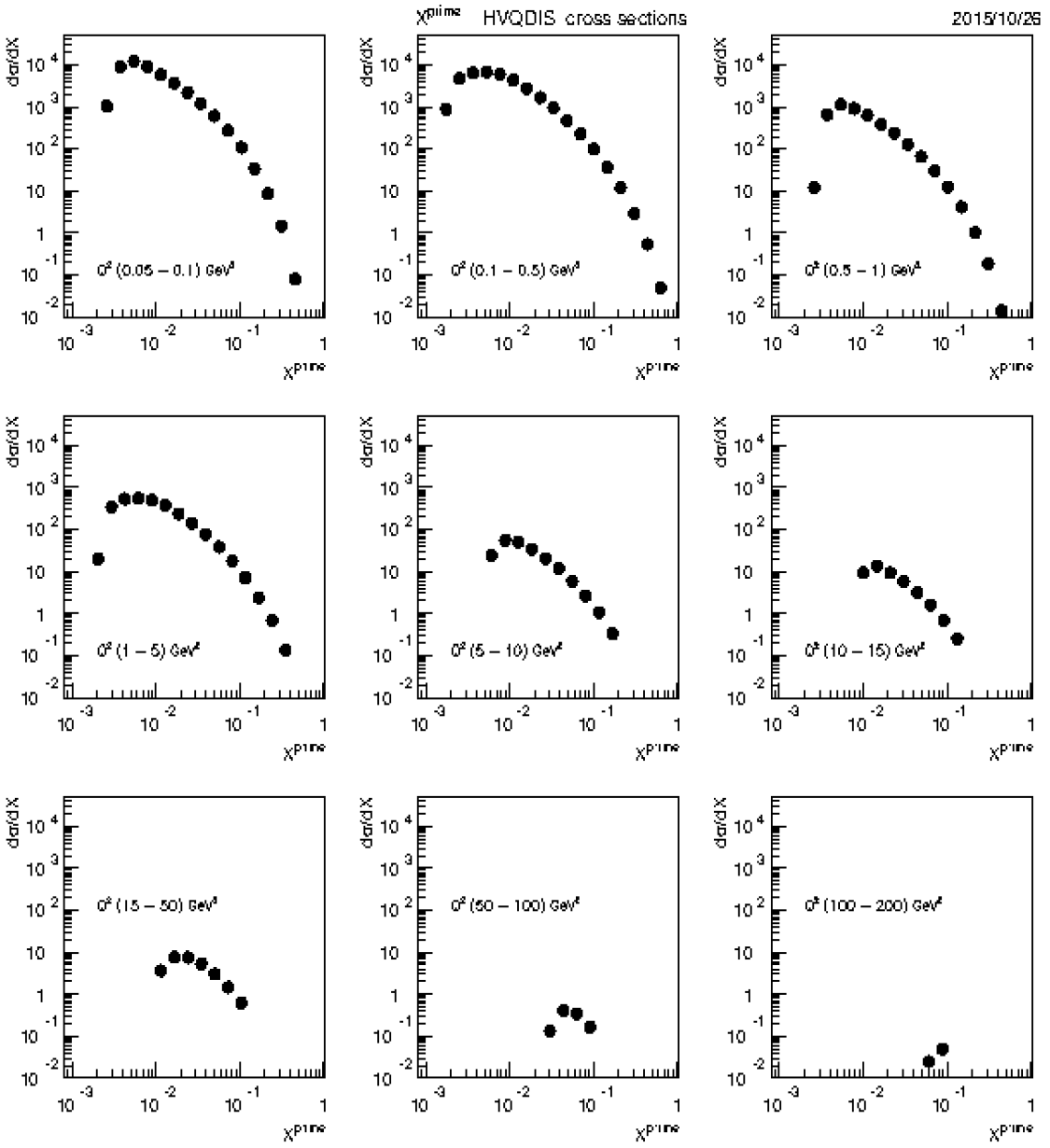
$\sqrt{s}$ = 63 GeV

400K events	Cross section	Cross section x>0.1	N evt x>0.1	Cross section NLO
Pythia	100 nb	5.2 nb	20806	120 nb
Herwig	7.17 nb	0.008 nb	494	--
HVQDIS	31 nb	0.04 nb	--	49 nb

Backup Slides

HVQDIS for *ep* at EIC





- *BGF process probes the gluon density in the target at light-cone momentum fractions :*

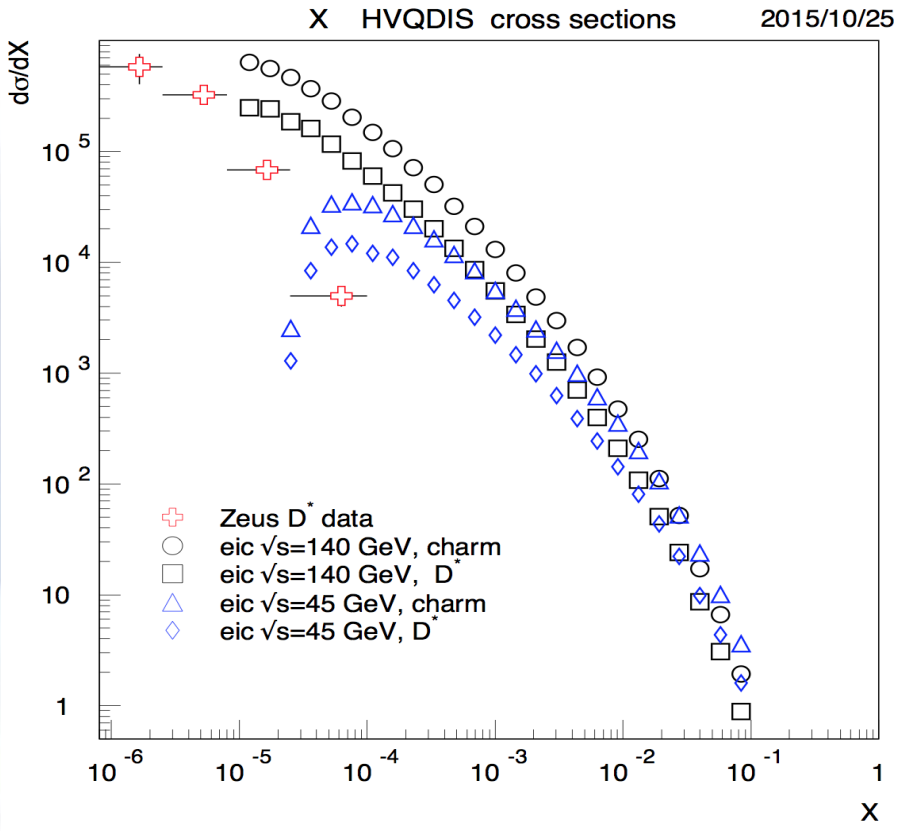
  $x' > x\,(1 + 4\,Mc^2/Q^2)$

  where x is the Bjorken variable and Mc^2 the heavy quark mass.

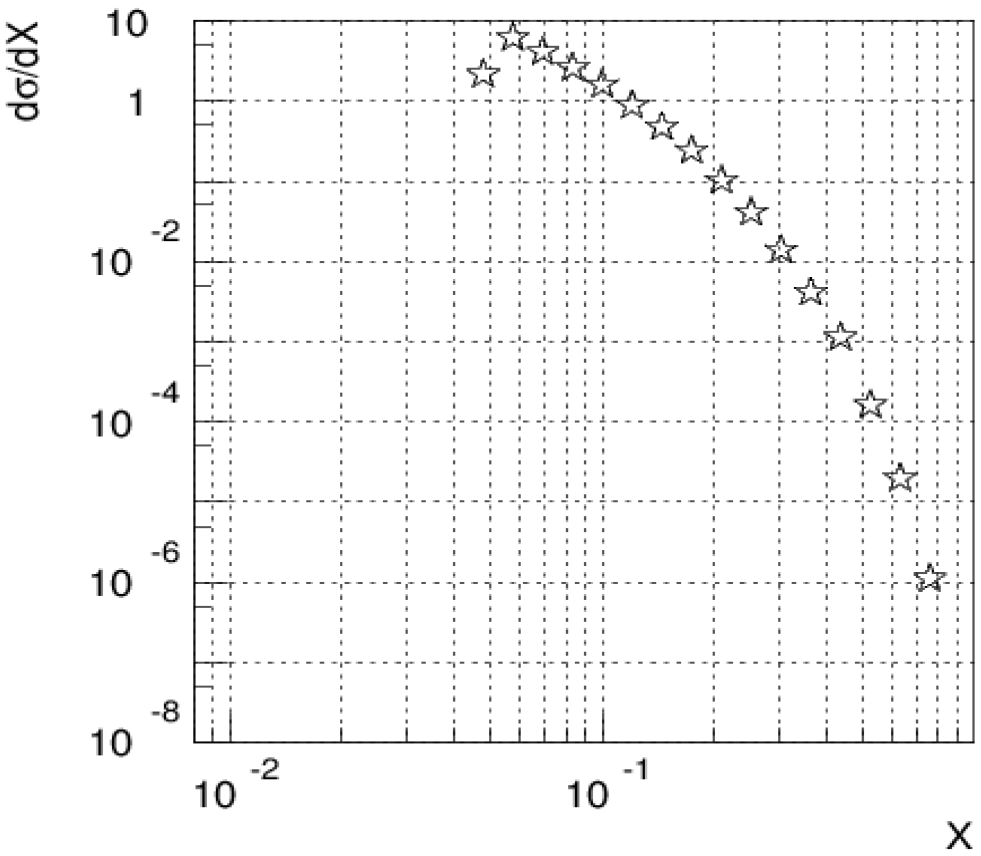
- *Calculation for dσ/dx is done for x'*

- *The results show good sensitivity to the gluon density even at x' > 0.1.*

Pythia and HVQDIS



Q2>10 x>0.05



Pythia and HVQDIS

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For 100 fb-1 luminosity, and Acc = 1

	Pythia cross section	N charm	N D*	HVQDIS cross section
all	140 nb	56×10^9	$\sim 320 \times 10^6$	67 nb
Q2 > 10	20 nb	4×10^9	$\sim 22 \times 10^6$	2.5 nb
X > 0.05	6.7 nb	1.3×10^9	$\sim 7 \times 10^6$	0.3 nb

Pythia D* rate

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$$D^{*+} \rightarrow D^o \pi_s^+ \ , \ D^o \rightarrow K^- \pi^+$$

- *Branching : BR ~2.5 %*
  - 67.7.% $D^{*+} \rightarrow D^0 \pi^+$
  - 3.88 % $D^0 \rightarrow K^- \pi^+$
- *Acceptance (Zeus) : Acc ~11%*

$$N = \sigma \times \mathcal{L} \times BR \times Acc$$

For 100 fb-1 luminosity, and Acc = 1

	Pythia cross section	N charm	N D*	HVQDIS cross section
all	140 nb	56 x 10^9	~320 x 10^6	
Q2 > 10	20 nb	4 x 10^9	~22 x 10^6	
X > 0.05	6.7 nb	1.3 x 10^9	~7 x 10^6	0.25 nb

Pythia init

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CTEQ 5D

```
 ******************** PYINIT: initialization of PYTHIA routines ******************

 *****  CERN Computer Program Library     -     Reference:  W5051  *****
 *****  PDFLIB Version:  8.04  Released on  2000-04-17  at  12.24  *****
 PDFLIB  : TMAS value
 Warning : NON standard settings, TMAS value =    175.00000000000000        set

 ============================================================================
 I                                                                          I
 I      PYTHIA will be initialized for gamma/e- on p+ user configuration    I
 I                                                                          I
 I                    px (GeV/c)   py (GeV/c)   pz (GeV/c)      E (GeV)     I
 I        gamma/e-       0.000        0.000      -10.000       10.000      I
 I        p+             0.000        0.000      100.000      100.004      I
 I                                                                          I
 I           corresponding to     63.253 GeV center-of-mass energy          I
 I                                                                          I
 ============================================================================


 Nucleon PDFs :  CTEQ Set 5D (DIS) Structure Functions
                 Ngroup =           4 ,   Nset =          47
```

Pythia, kinematic plot x

Charm
MSEL=4
xsec=140nb

```
 1********* PYSTAT:  Statistics on Number of Events and Cross-sections *********

 ==========================================================================
 I                                  I                                I           I
 I           Subprocess             I     Number of points           I    Sigma  I
 I                                  I                                I           I
 I----------------------------------I--------------------------------I    (mb)   I
 I                                  I                                I           I
 I N:o Type                         I    Generated          Tried    I           I
 I                                  I                                I           I
 ==========================================================================
 I                                  I                                I           I
 I   0 All included subprocesses    I      1000000      31900774     I 1.397D-04 I
 I  84 g + gamma -> Q + Qbar, mass  I      1000000      31900774     I 1.397D-04 I
 I                                  I                                I           I
 ==========================================================================
```

Pythia, kinematic plot x

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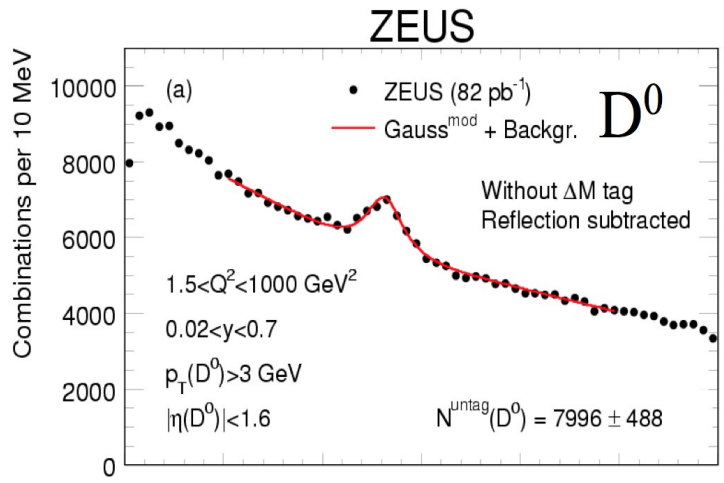
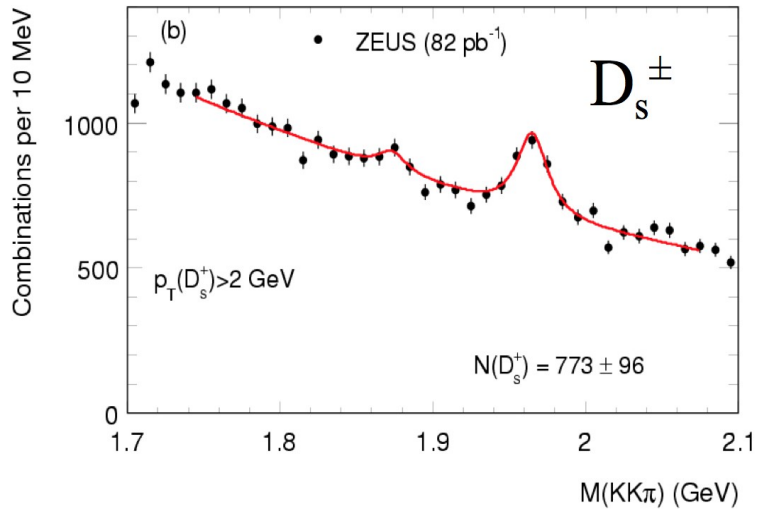
BG
MSEL=2
xsec=36000nb
250x

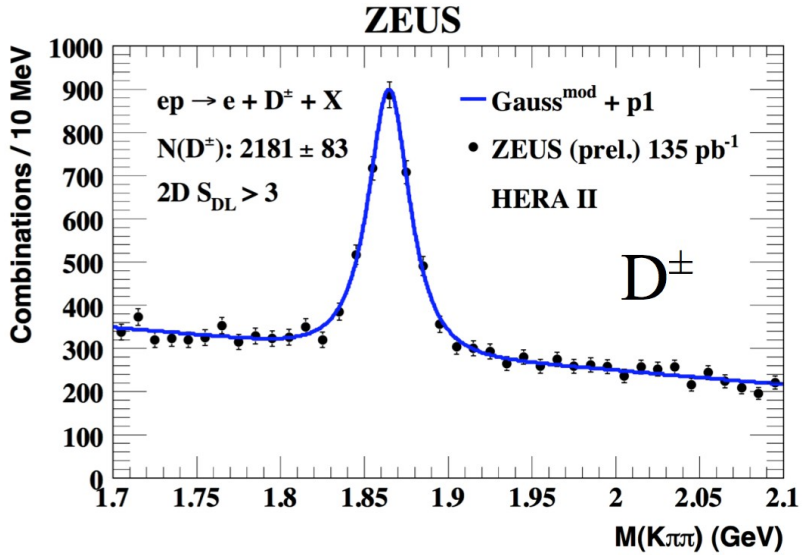
1********* PYSTAT: Statistics on Number of Events and Cross-sections *********

N:o	Type	Generated	Tried	Sigma (mb)
0	All included subprocesses	1000000	382794191	3.611D-02
11	f + f' -> f + f' (QCD)	72086	0	3.824D-03
12	f + fbar -> f' + fbar'	1597	0	8.498D-05
13	f + fbar -> g + g	2285	0	1.222D-04
28	f + g -> f + g	182779	0	9.721D-03
53	g + g -> f + fbar	2402	0	1.303D-04
68	g + g -> g + g	112041	0	6.099D-03
91	Elastic scattering	159249	643177	3.915D-03
92	Single diffractive (XB)	73026	360314	1.787D-03
93	Single diffractive (AX)	62499	296362	1.533D-03
94	Double diffractive	30825	273947	7.499D-04
95	Low-pT scattering	370	865198	4.160D-06
99	q + gamma* -> q	266548	2356665	7.212D-03
131	f + gamma*_T -> f + g	14347	183942	3.878D-04
132	f + gamma*_L -> f + g	73	10346	1.840D-06
135	g + gamma*_T -> f + fbar	19544	490665	5.317D-04
136	g + gamma*_L -> f + fbar	329	80690	8.756D-06
1	VMD * hadron	660984	378131926	2.691D-02
2	direct * hadron	34293	765643	9.301D-04
3	anomalous * hadron	38175	1539957	1.055D-03
4	DIS * hadron	266548	2356665	7.212D-03

Other charmed mesons







D* rate

$$D^{*+} \to D^o \pi_s^+ \ , \ D^o \to K^- \pi^+$$

- *Branching : BR ~2.5 %*
  - 67.7.% $D^{*+} \to D^0 \pi^+$
  - 3.88 % $D^0 \to K^- \pi^+$
- *Acceptance (Zeus) : Acc ~11%*

$$N = \sigma \times \mathcal{L} \times BR \times Acc$$

$$N = \sigma \times 100 fb^{-1} \times 0.0257 \times 0.1 \sim \sigma[nb] \times 10^6 \times 0.282$$

	Cross section	N D*
$\sqrt{s}$ = 45	11 nb	~3x10^6
$\sqrt{s}$ = 145	38 nb	10^7
$\sqrt{s}$ = 45, x>0.01	3.3 nb	10^6

HVQDIS for *ep* at EIC

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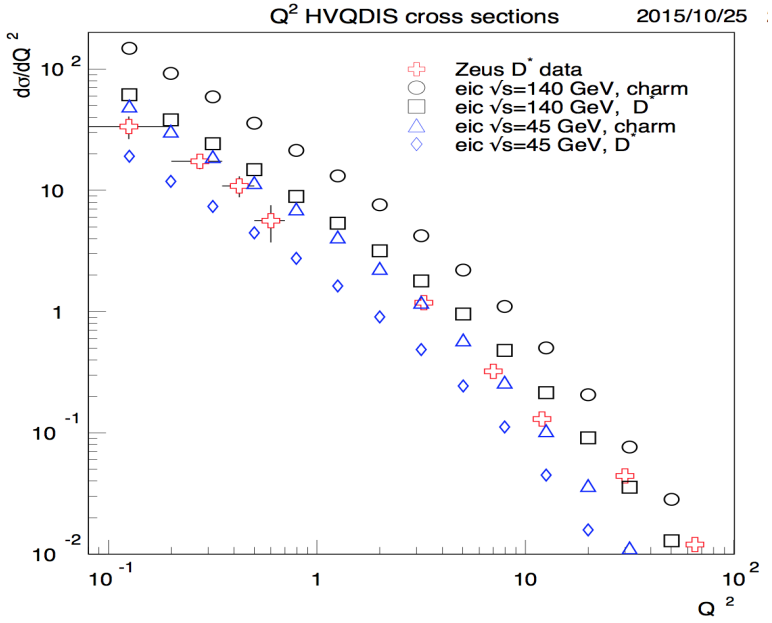
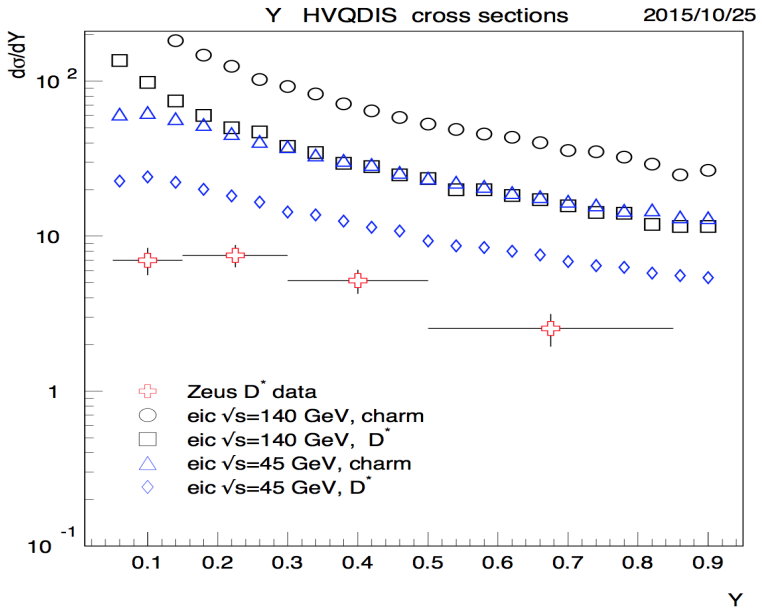
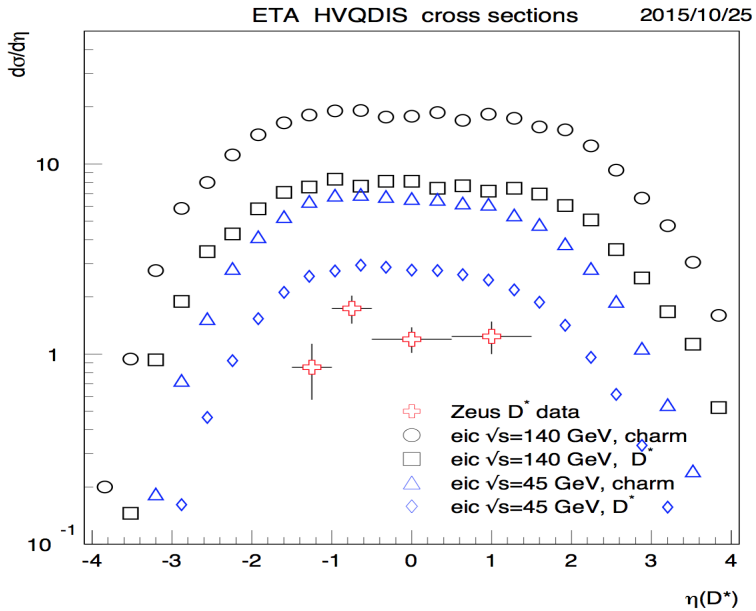
Calculation is done for 2 ep energies of EIC:

- *Ee=10 GeV , Ep=50 GeV :*
  - Total charm cross section : 28 nb
  - Total D* cross section : 11 nb
- *Ee=20 GeV , Ep=250 GeV :*
  - Total charm cross section : ~93 nb
  - Total D* cross section : ~38 nb
- *Zeus data are shown for different kinematic region :*
  - for estimation only







H1 and ZEUS combined data

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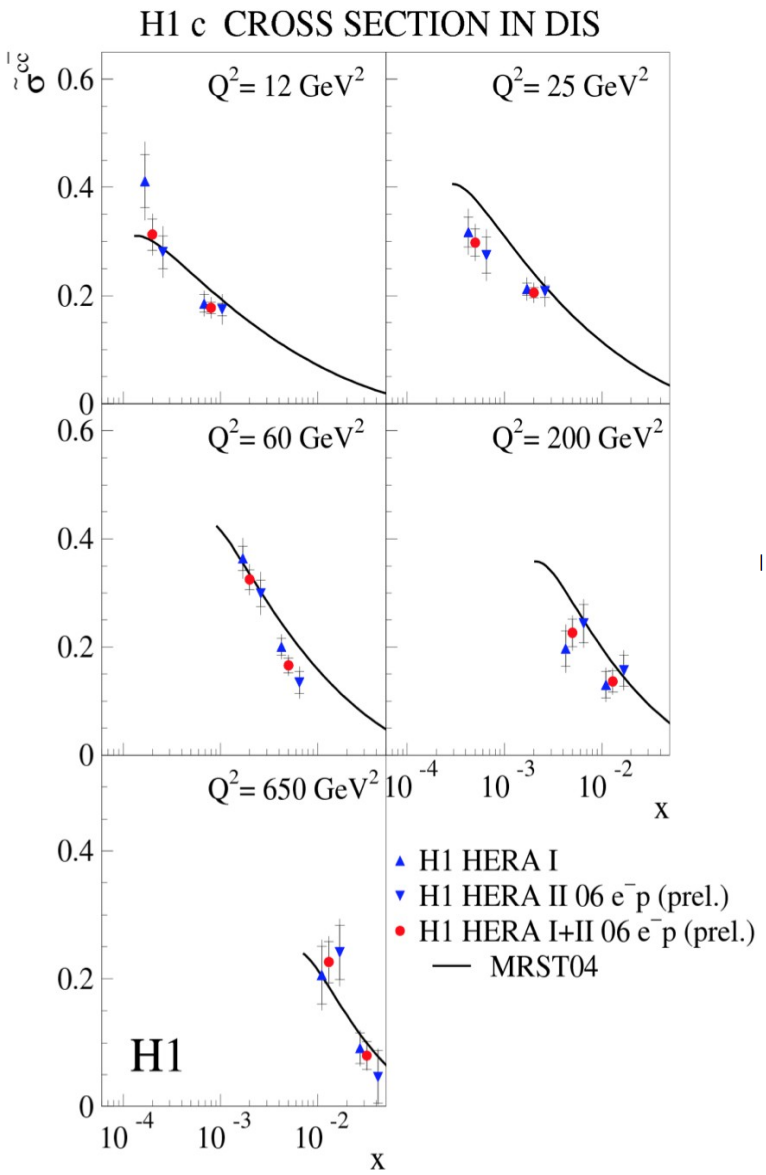
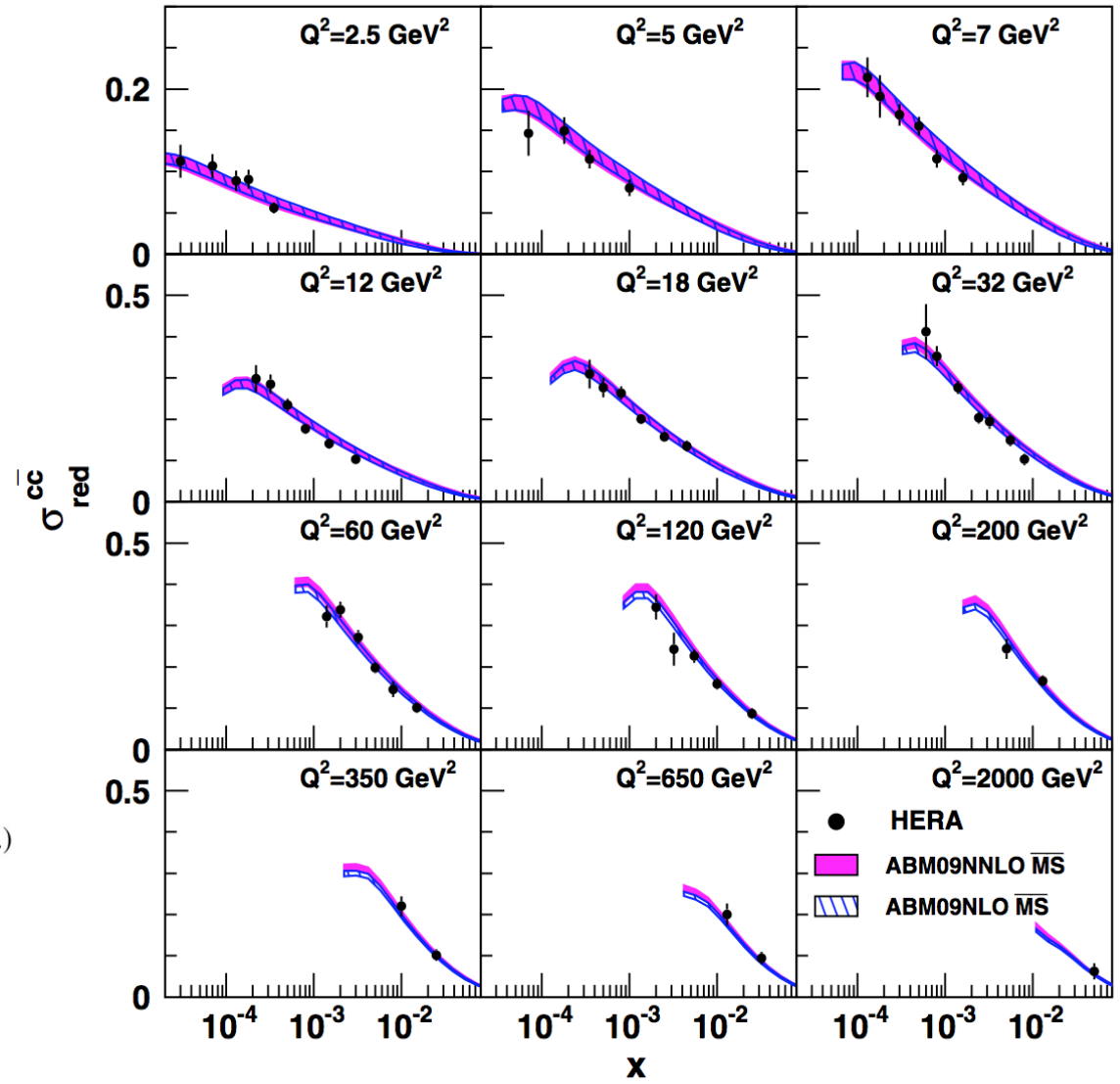
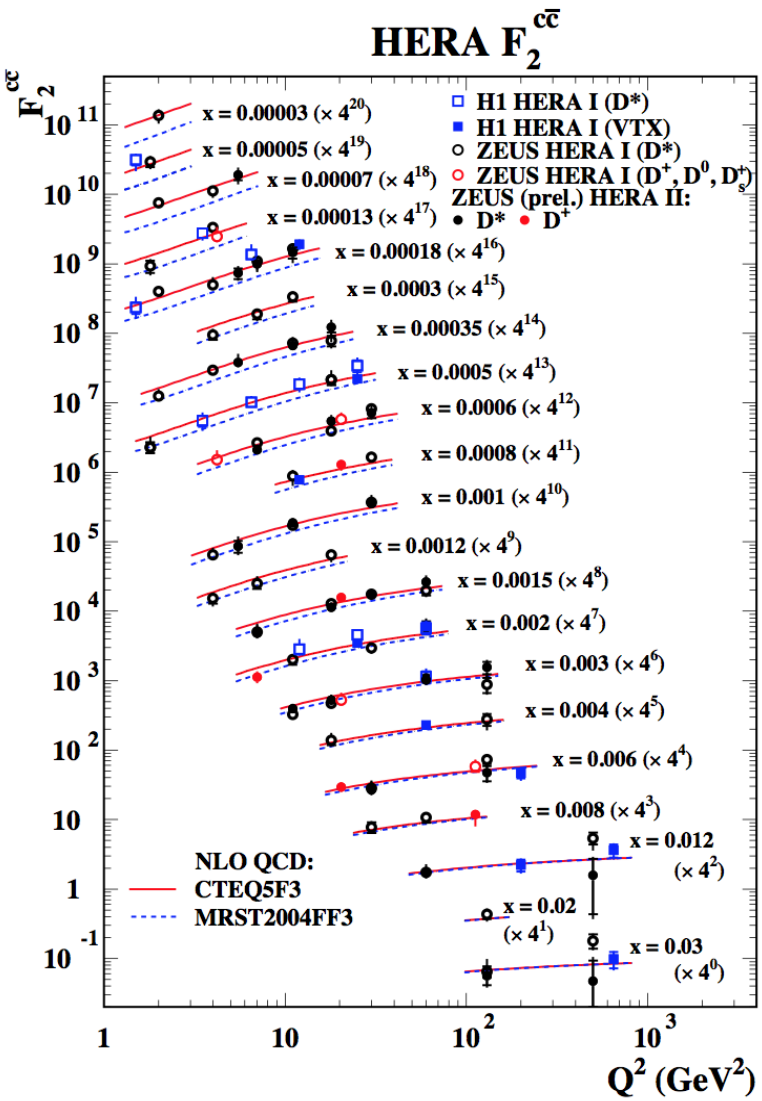
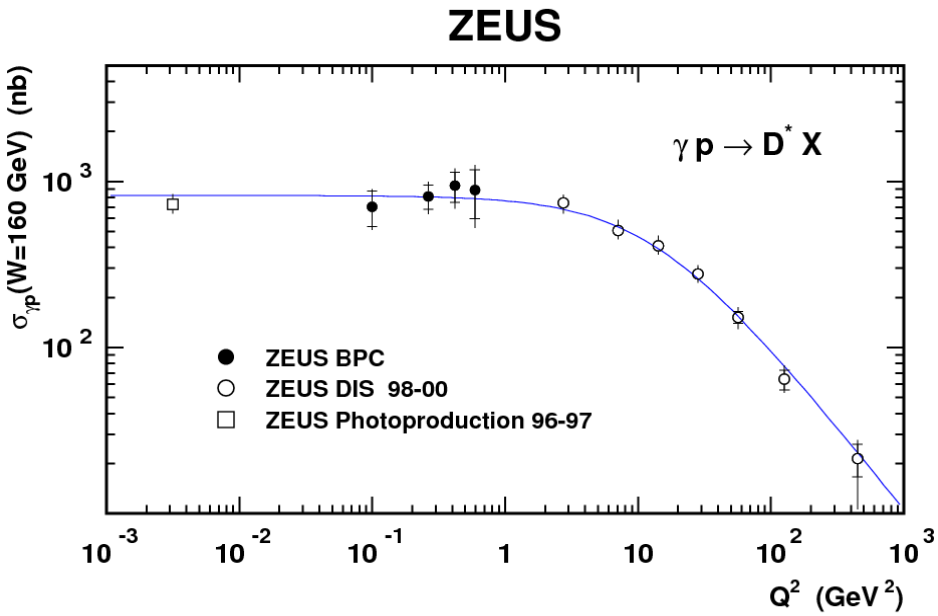
Rev. Mod. Phys., Vol. 86, No. 3, July–September 2014





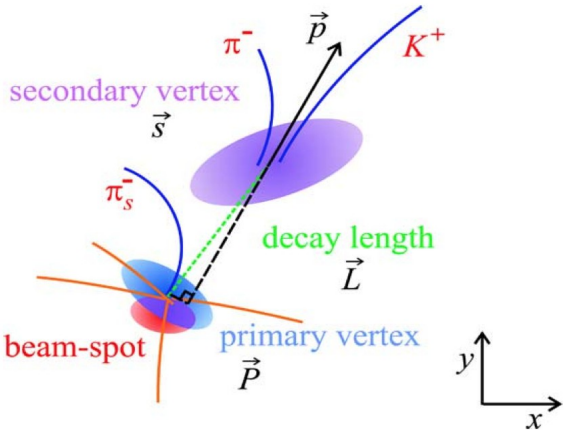
Charm production in ep scattering at HERA

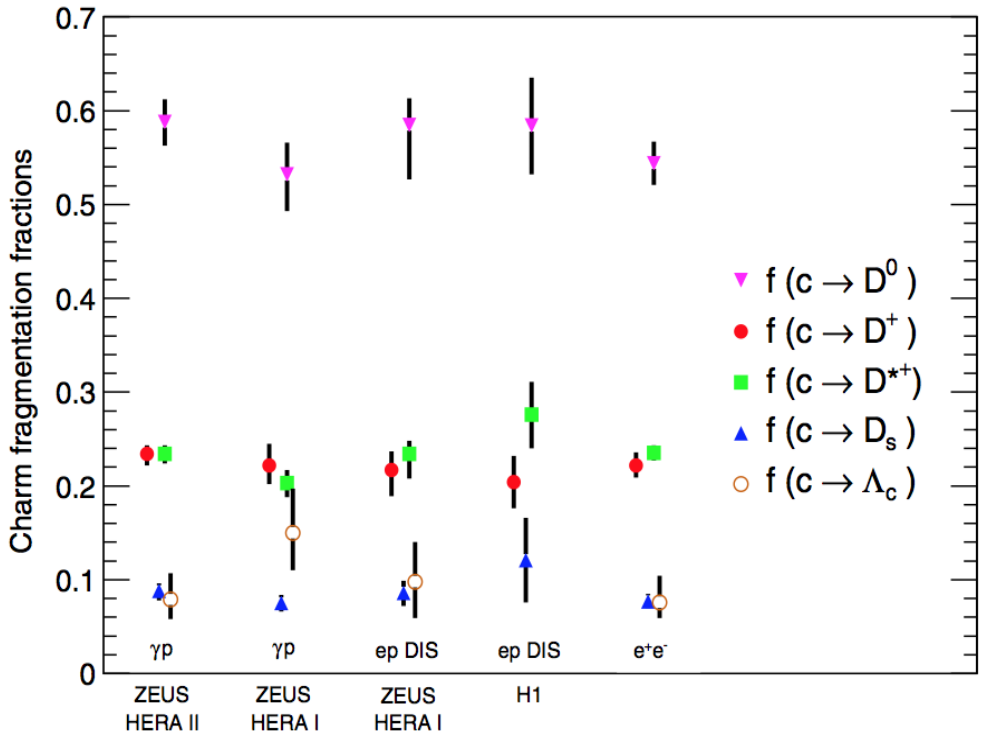




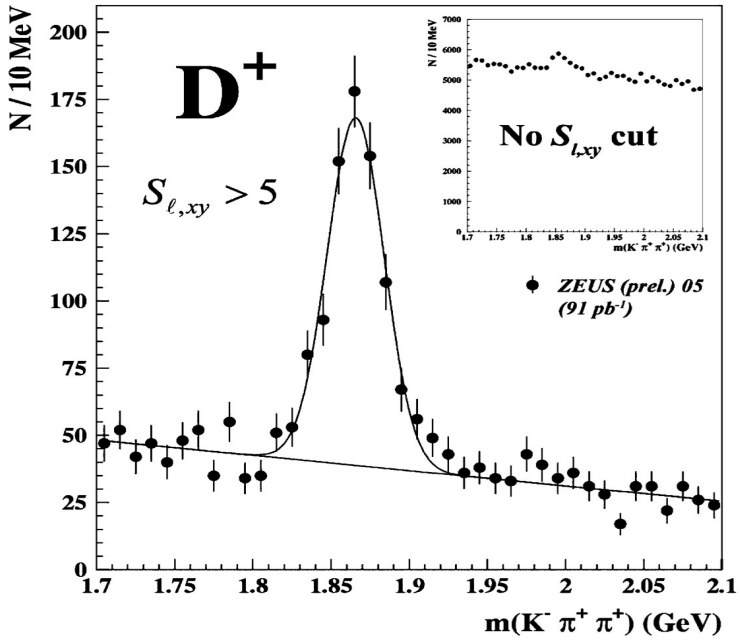
Other charmed mesons

- *Charm fragmentation to other mesons is measured.*
- *However reconstruction most of them require microvertex to resolve primary and secondary vertices.*
- *Right-bottom plot shows reconstruction of D+ with microvertex and without.*



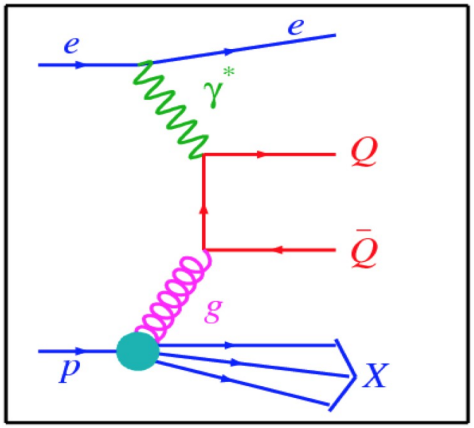


Abramowicz, H., et al. (ZEUS Collaboration), 2013b, J. High Energy Phys. 09, 058.

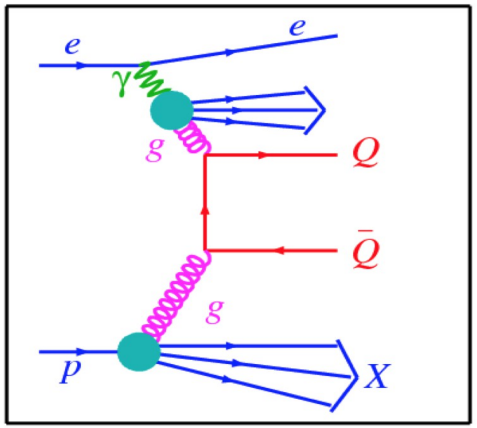


N. Coppola, IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 54, NO. 5, OCTOBER 2007

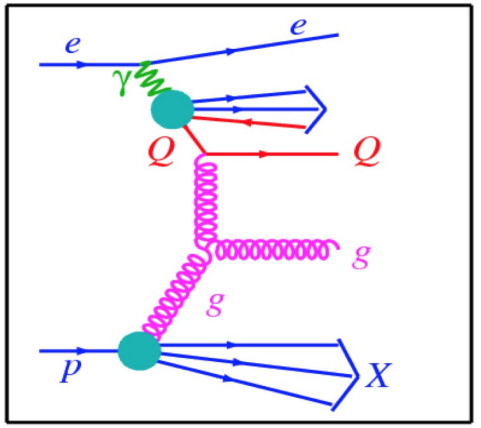
Charm production at HERA



Direct



Resolved



Excitation

ZEUS detector