

## Charm production rate

Sergey Furletov

8 June 2016

# Pythia init

```
***** 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 PYTHIA will be initialized for gamma/e- on p+ user configuration 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 corresponding to 63.253 GeV center-of-mass energy I
I
=====

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

# Pythia, kinematic plot x

Charm  
MSEL=4  
xsec=140nb

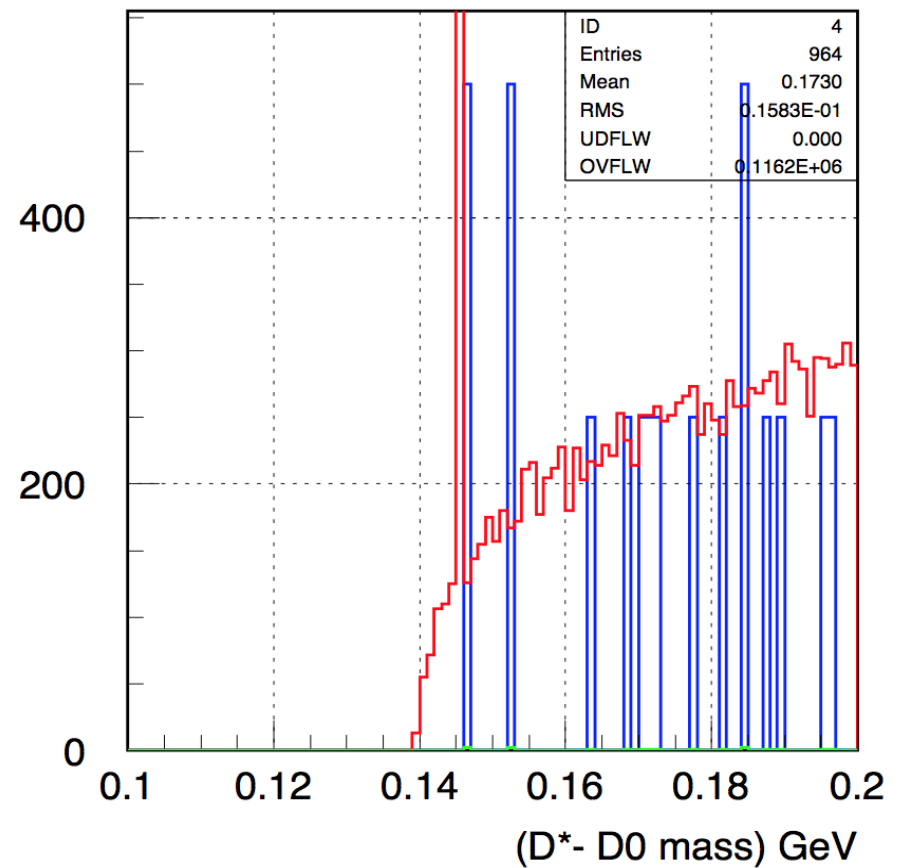
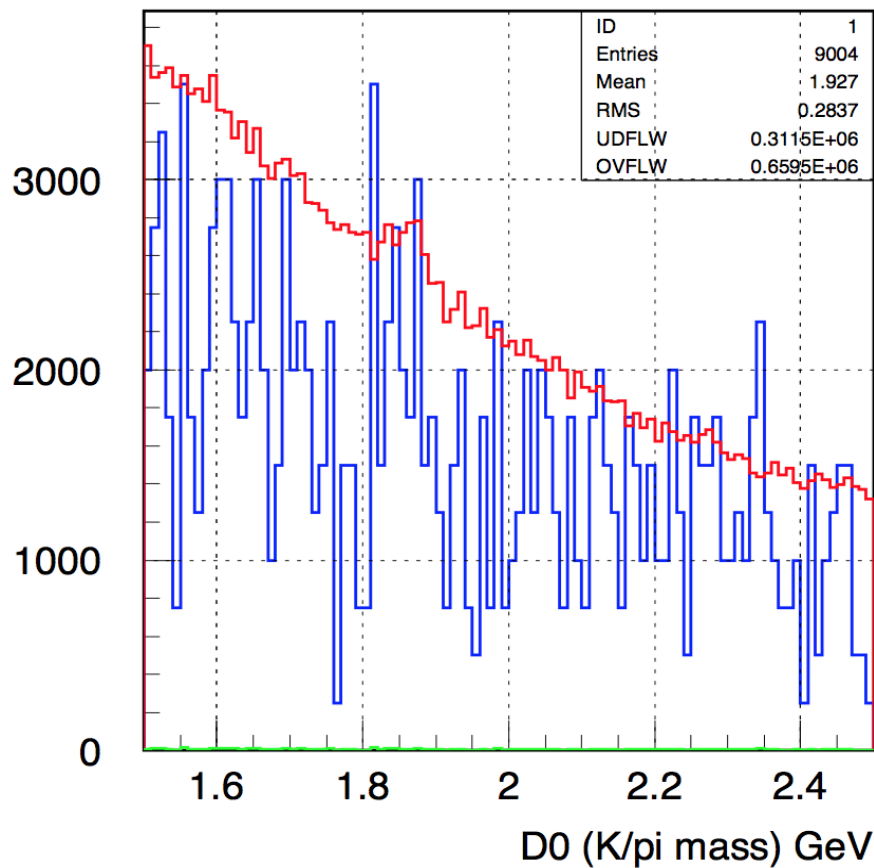
```
***** PYSTAT: Statistics on Number of Events and Cross-sections *****
=====
I          I          I          I
I          Subprocess          Number of points          Sigma          I
I          I          I          I
I          I          I          I
I-----I-----I          (mb)          I
I          I          I          I
I N:o Type          Generated          Tried          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
=====
```



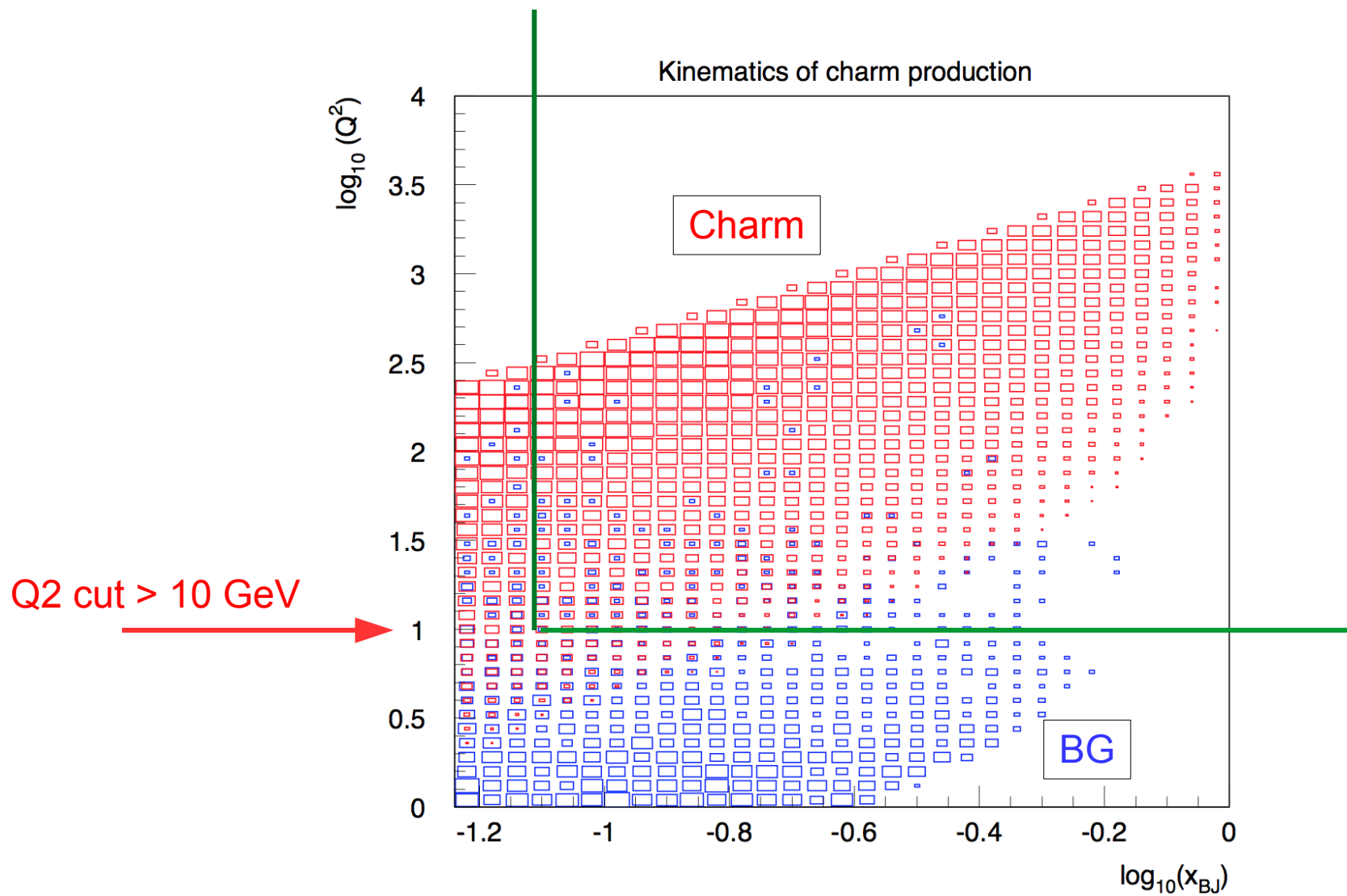
# Pythia, D\* reconstruction

$Q^2 > 10$  GeV,  $0.05 < x < 0.2$

Kinematics of charm production (Pythia) file=MSEL\_4\_1Mb\_cuts\_py



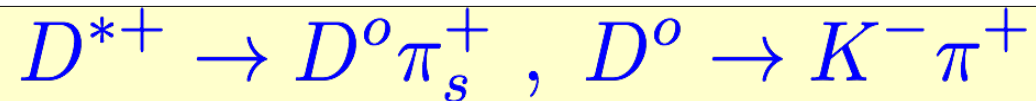
# Pythia, kinematic plot $x-Q^2$



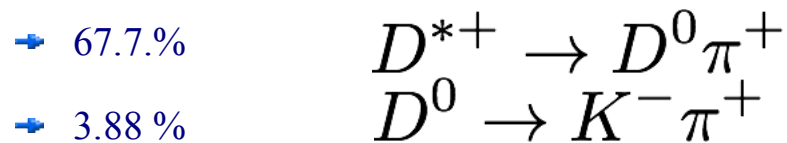
# Pythia MSEL=4

1M events	Cross section	N charm	N D*	%%
No cuts	140 nb	2M	7000	0.7%
Q2>10	20 nb	280k	1500	0.15%
Q2>10 0.05<x<0.2	6.7 nb	90k	400	0.04%

# Pythia D\* rate



- Branching :  $BR \sim 2.5 \%$



- Acceptance (Zeus) :  $Acc \sim 11\%$

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

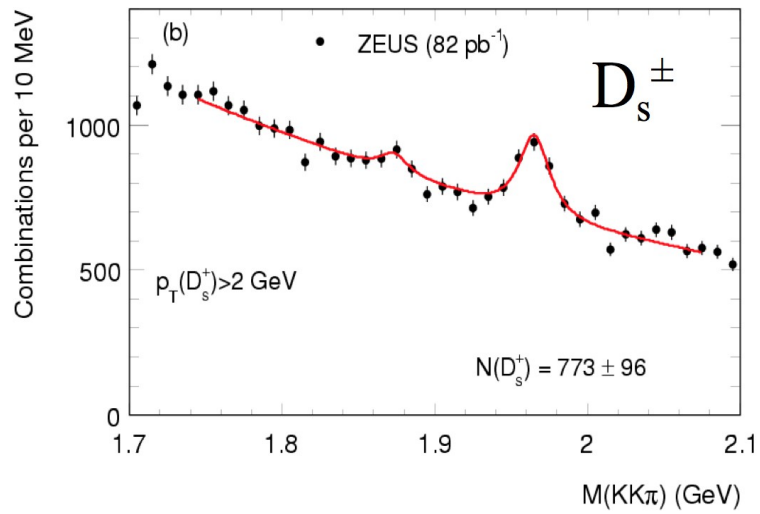
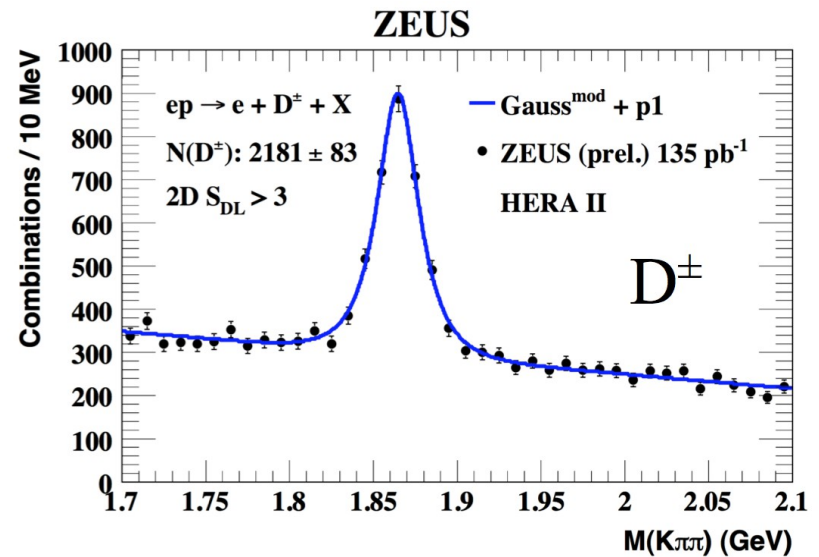
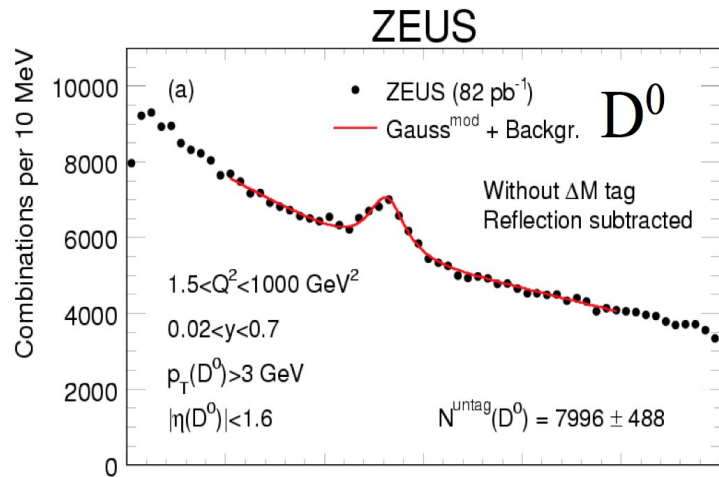
For 100 fb-1 luminosity, and  $Acc = 1$

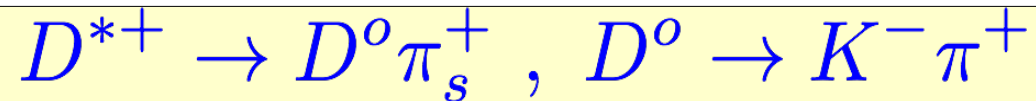
	Cross section	N charm	N D*
all	140 nb	$56 \times 10^9$	$\sim 320 \times 10^6$
Q2 > 10	20 nb	$4 \times 10^9$	$\sim 22 \times 10^6$
X > 0.05	6.7 nb	$1.3 \times 10^9$	$\sim 7 \times 10^6$



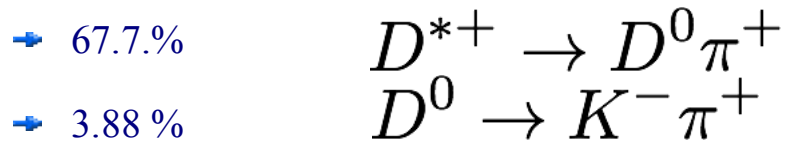
# Backup Slides

# Other charmed mesons





- Branching : BR ~2.5 %



- Acceptance (Zeus) : Acc ~11%

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

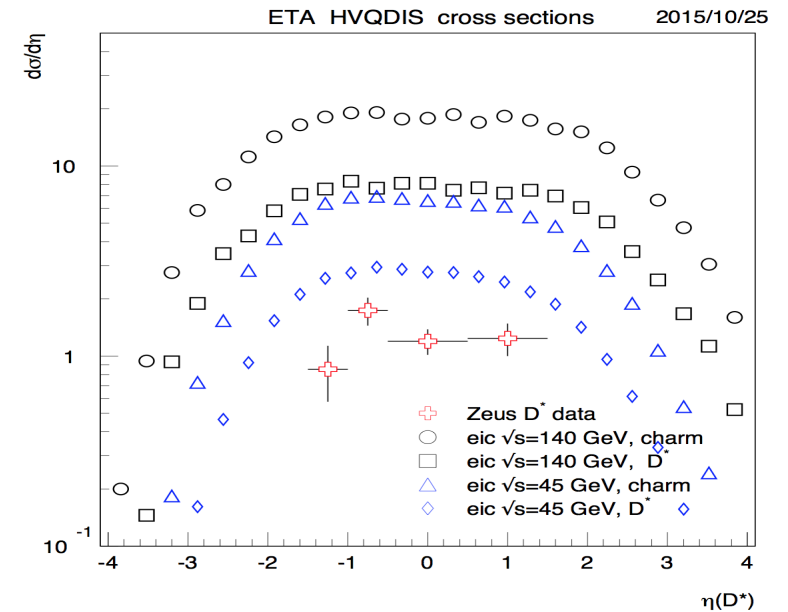
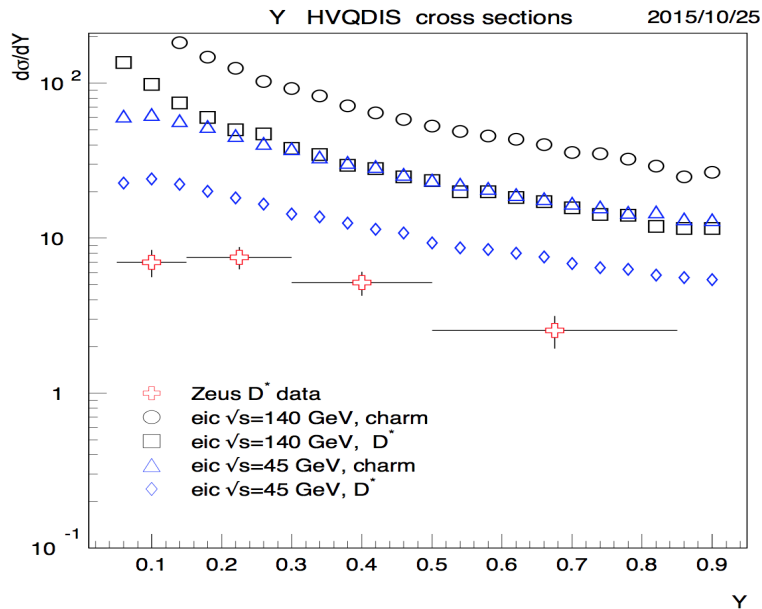
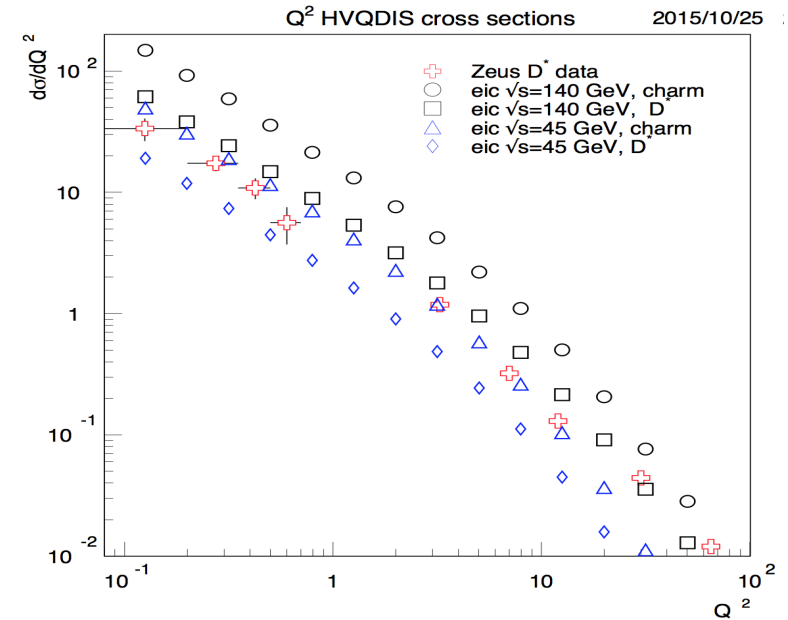
$$N = \sigma \times 100 fb^{-1} \times 0.0257 \times 0.1 \sim \sigma [nb] \times 10^6 \times 0.282$$

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

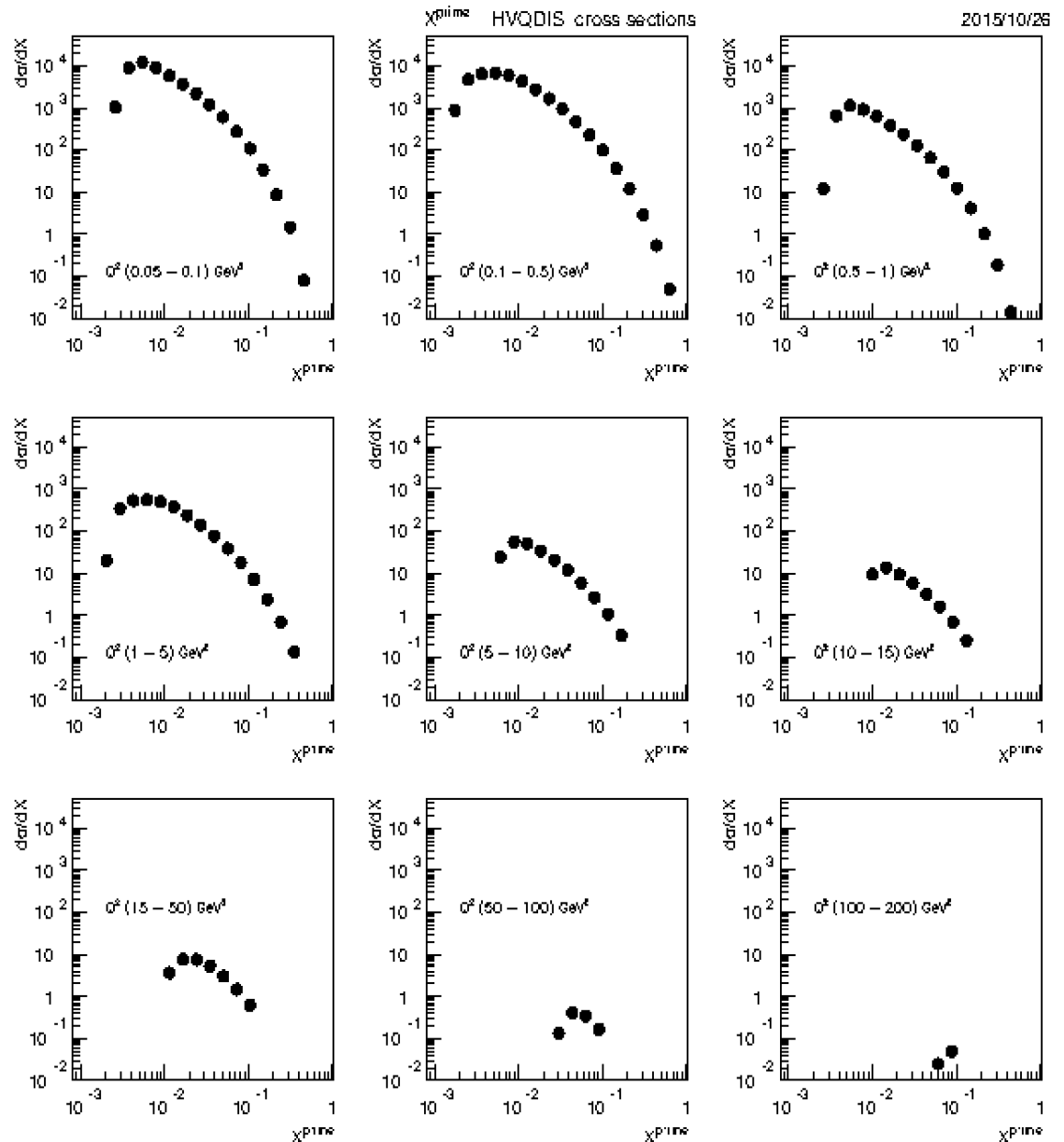
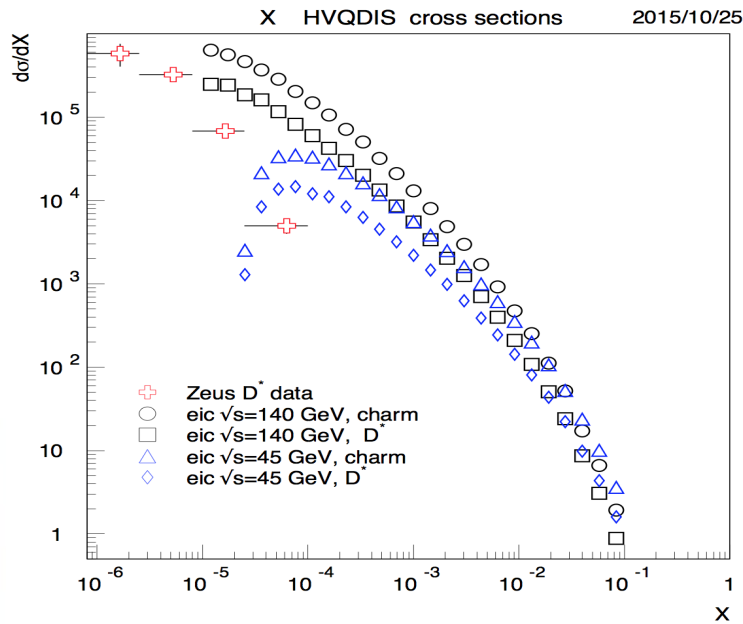
# HVQDIS for $ep$ at EIC

Calculation is done for 2  $ep$  energies of EIC:

- $E_e=10\text{ GeV}$ ,  $E_p=50\text{ GeV}$ :
  - ➔ Total charm cross section : 28 nb
  - ➔ Total  $D^*$  cross section : 11 nb
- $E_e=20\text{ GeV}$ ,  $E_p=250\text{ GeV}$ :
  - ➔ Total charm cross section :  $\sim 93\text{ nb}$
  - ➔ Total  $D^*$  cross section :  $\sim 38\text{ nb}$
- Zeus data are shown for different kinematic region :
  - ➔ for estimation only



# HVQDIS for $ep$ at EIC



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

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

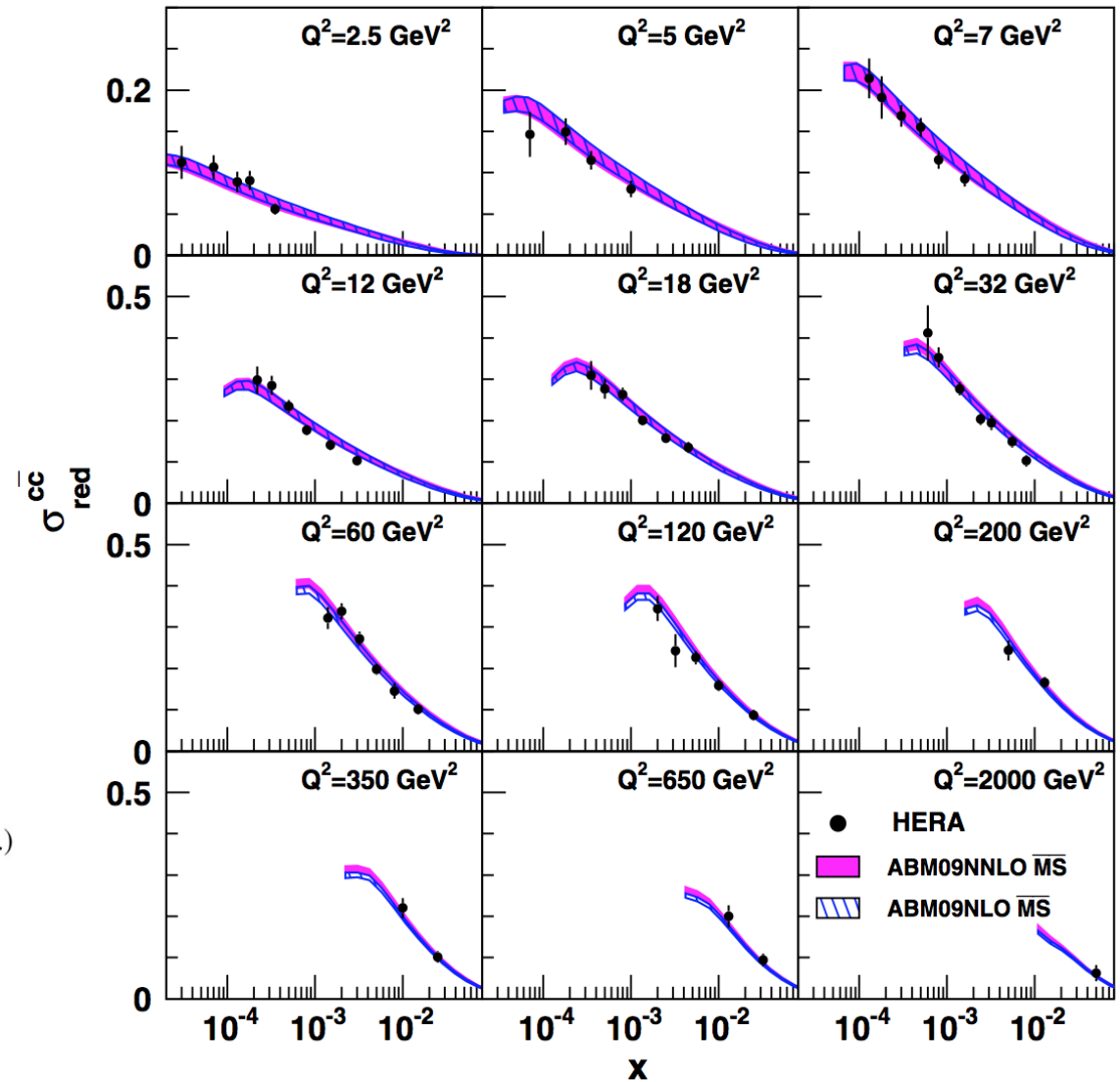
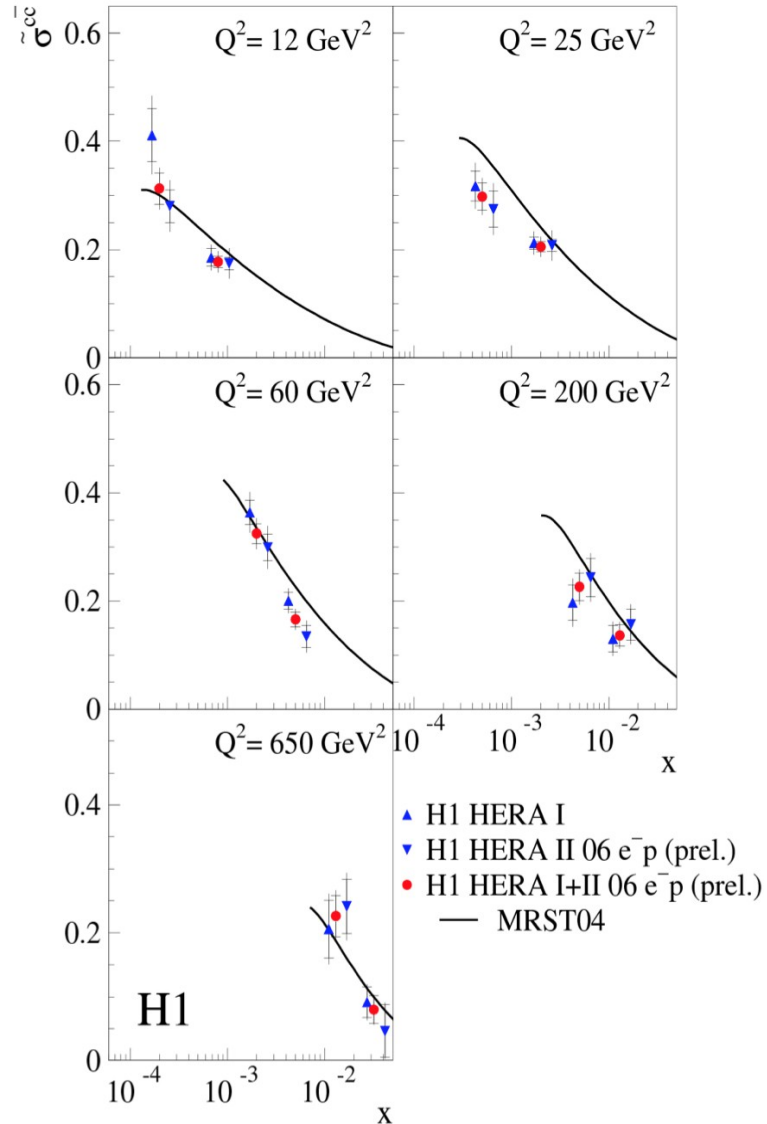
*where  $x$  is the Bjorken variable and  $Mc^2$  the heavy quark mass.*

- *Calculation for  $d\sigma/dx$  is done for  $x'$*
- *The results show good sensitivity to the gluon density even at  $x' > 0.1$ .*

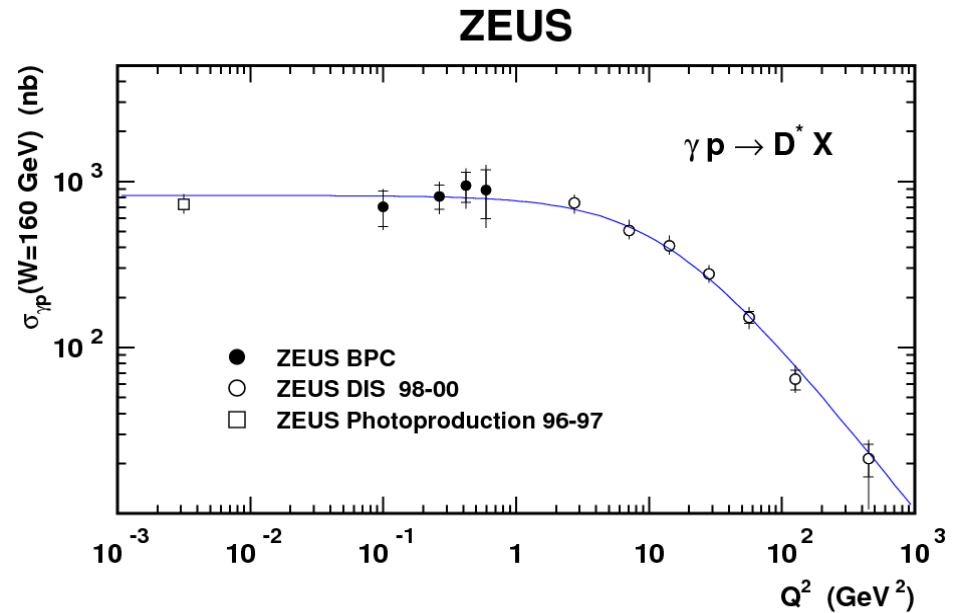
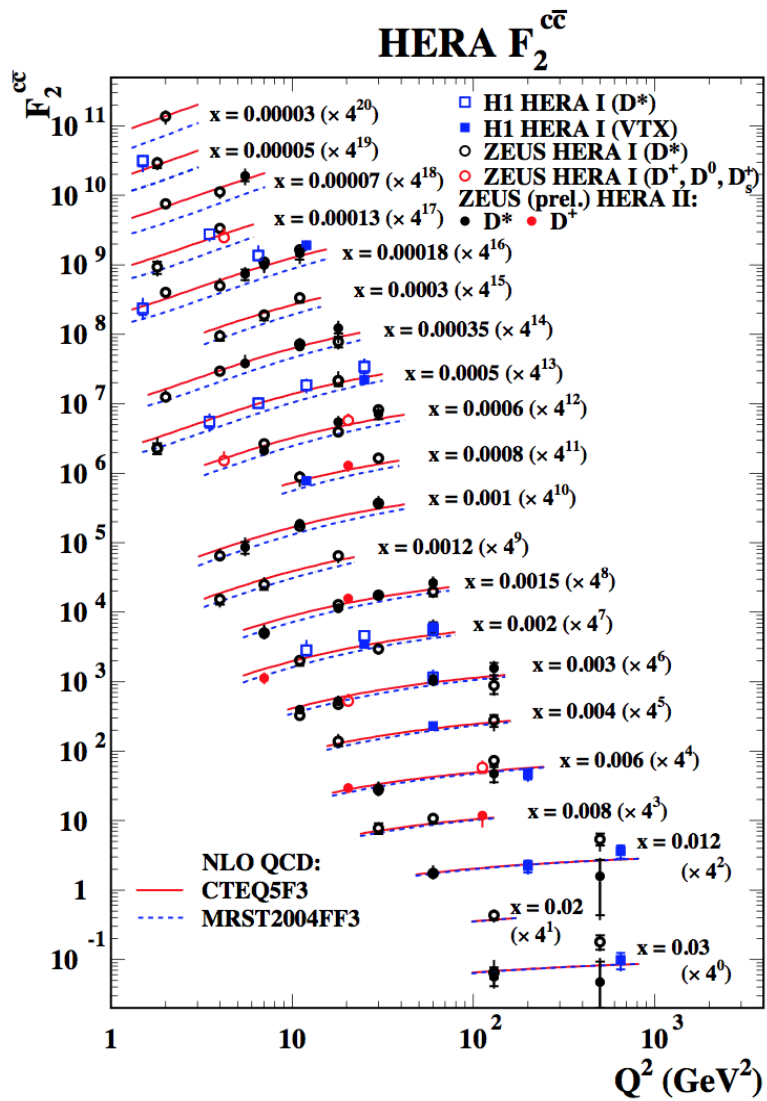
# H1 and ZEUS combined data

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

H1 c CROSS SECTION IN DIS

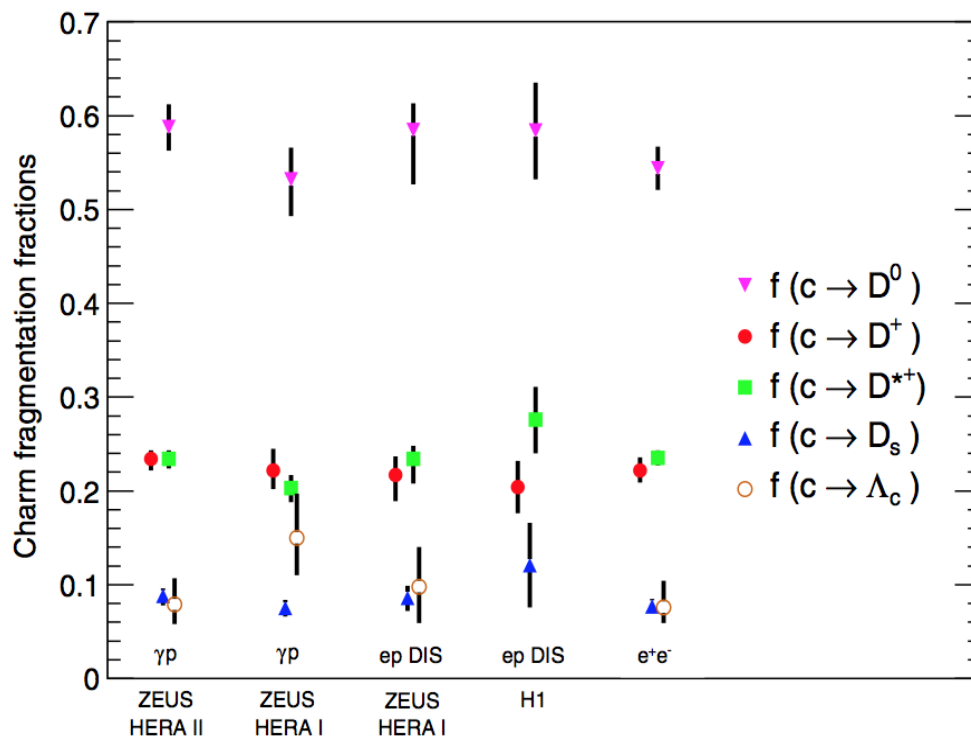
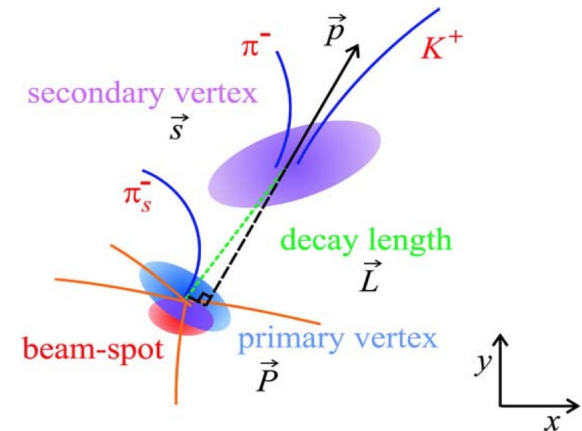


# Charm production in ep scattering at HERA

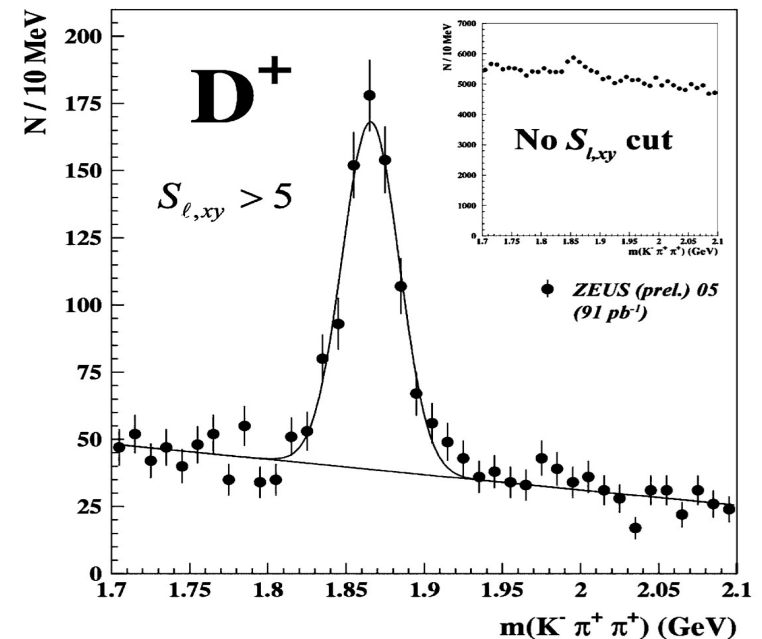


# Other charmed mesons

- 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.



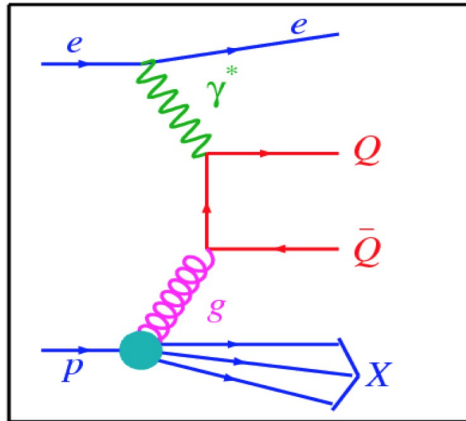
Abramowicz, H., et al. (ZEUS Collaboration), 2013b, J. High Energy Phys. 09, 058.



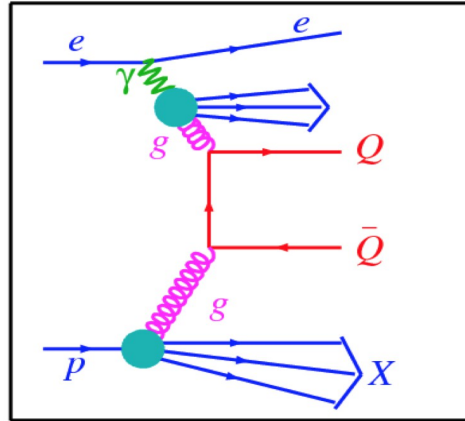
N. Coppola, IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 54, NO. 5, OCTOBER 2007



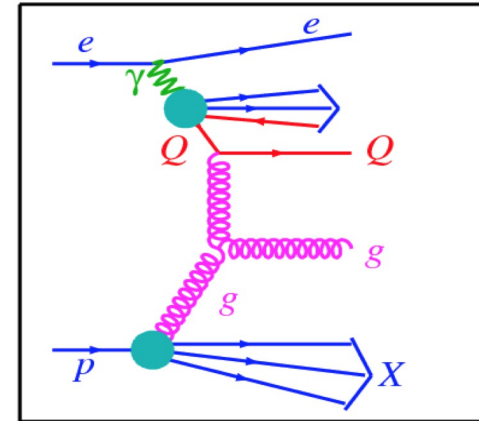
# Charm production at HERA



Direct



Resolved



Excitation

# ZEUS detector

<b>Zeus Run 47350 Event 135</b>		<b>date: 21-01-2004 time: 23:08:17</b>		
$E = 32.22 \text{ GeV}$	$E_T = 8.55 \text{ GeV}$	$E-p_z = 16.80 \text{ GeV}$	$E_T = 21.86 \text{ GeV}$	$E_b = 1.91 \text{ GeV}$
$E_r = 8.45 \text{ GeV}$	$p_T = 1.05 \text{ GeV}$	$p_x = -1.04 \text{ GeV}$	$p_y = 0.17 \text{ GeV}$	$p_z = 15.42 \text{ GeV}$
$\text{phi} = 2.98$	$t_T = -1.02 \text{ ns}$	$t_b = -3.20 \text{ ns}$	$t_r = -1.29 \text{ ns}$	$t_g = -1.19 \text{ ns}$

