$D^{*\pm}$ production at high Q^2 with the H1 detector

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- Charm production
- D^* at high Q^2
- Results
- Summary

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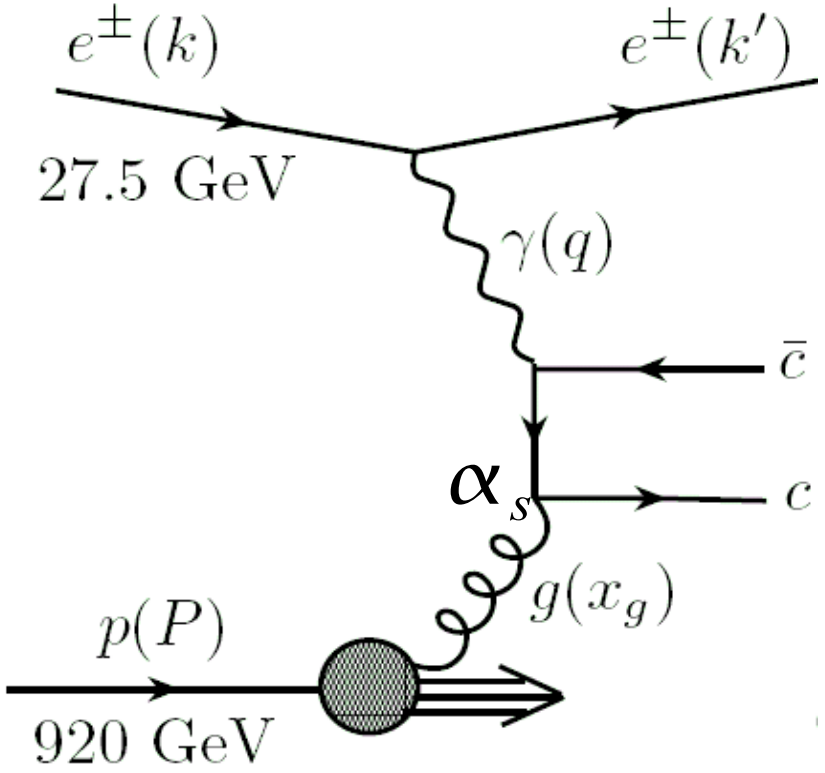
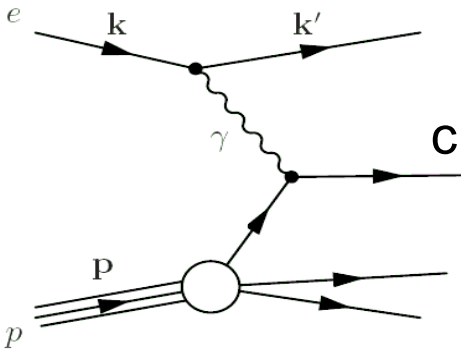
Charm production at HERA

dominant mechanism in the massive scheme:
Boson Gluon Fusion (BGF)



fragmentation → D*,D⁺,D⁰,... -mesons

massless scheme – charm directly from the sea:



Charm cross section in QCD factorisation:

σ^{charm} = protonstructure (gluons) $\otimes$ M(γp→qq) $\otimes$ fragmentation

Test the reliability of the massive scheme for $Q^2 >> m_c^2$

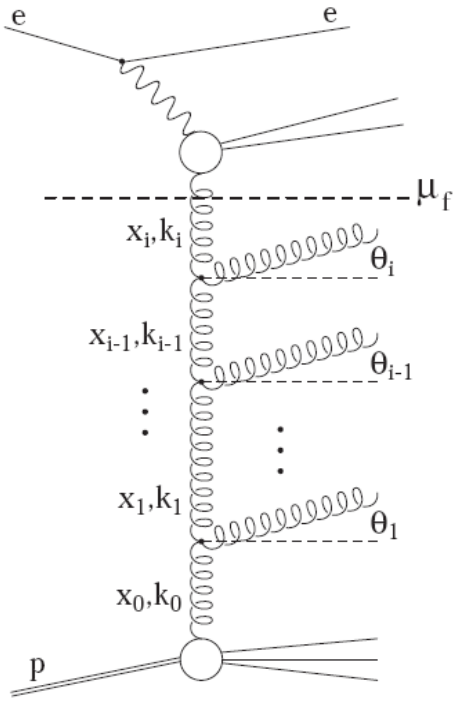
Models for charm production

NLO calculation in Fixed Flavour Number Scheme (FFNS)

- **HVQDIS**: Fixed order, **massive scheme** (BGF) with three active flavours in the proton (n_f=3)
- **DGLAP** evolution
- Uses independent fragmentation

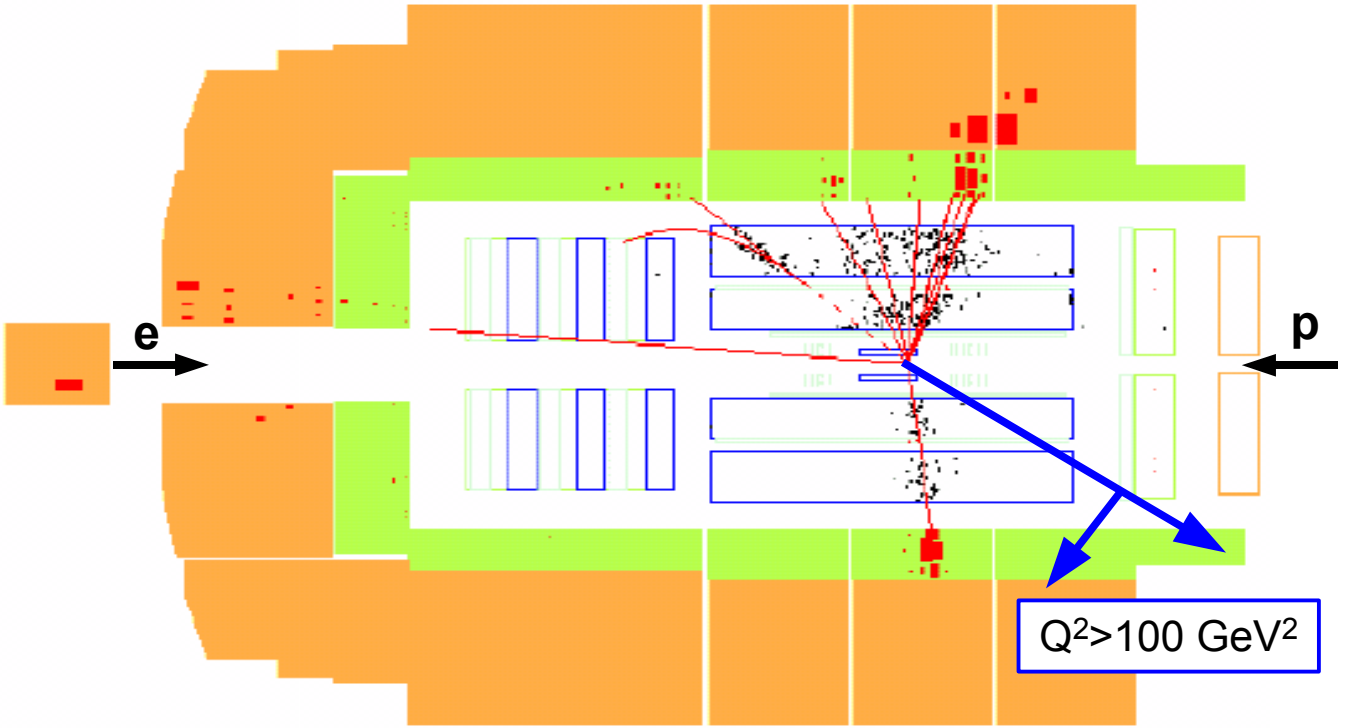
Monte-Carlo: LO + Parton Shower

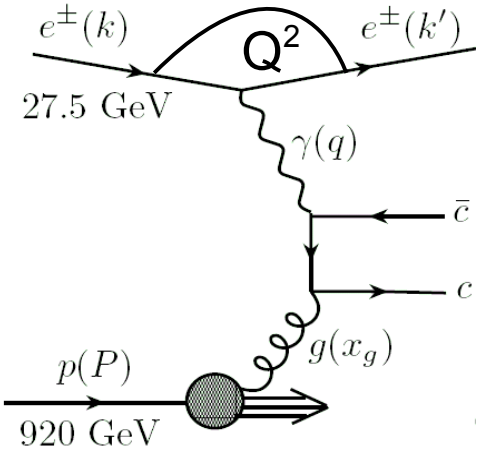
- **RAPGAP**: collinear factorisation, **DGLAP** evolution
- **CASCADE**: k_T factorisation, **CCFM** evolution
- Fragmentation:
  - Light Quarks (uds) : Lund string model
  - Heavy Quarks : Bowler parametrisation



Kinematics

Q^2>100 GeV^2: Unexplored region for D* analyses at H1





- Electron detected in central calorimeter (LAr)
- Decay particles of the D* detected in the central tracker

photon virtuality:

$$Q^2 = -\mathrm{q}^2 = -(\mathrm{k} - \mathrm{k}')^2$$

inelasticity:

$$y = \frac{\mathrm{p} \cdot \mathrm{q}}{\mathrm{p} \cdot \mathrm{k}}$$

Bjorken-Scale Variable:

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

D* reconstruction

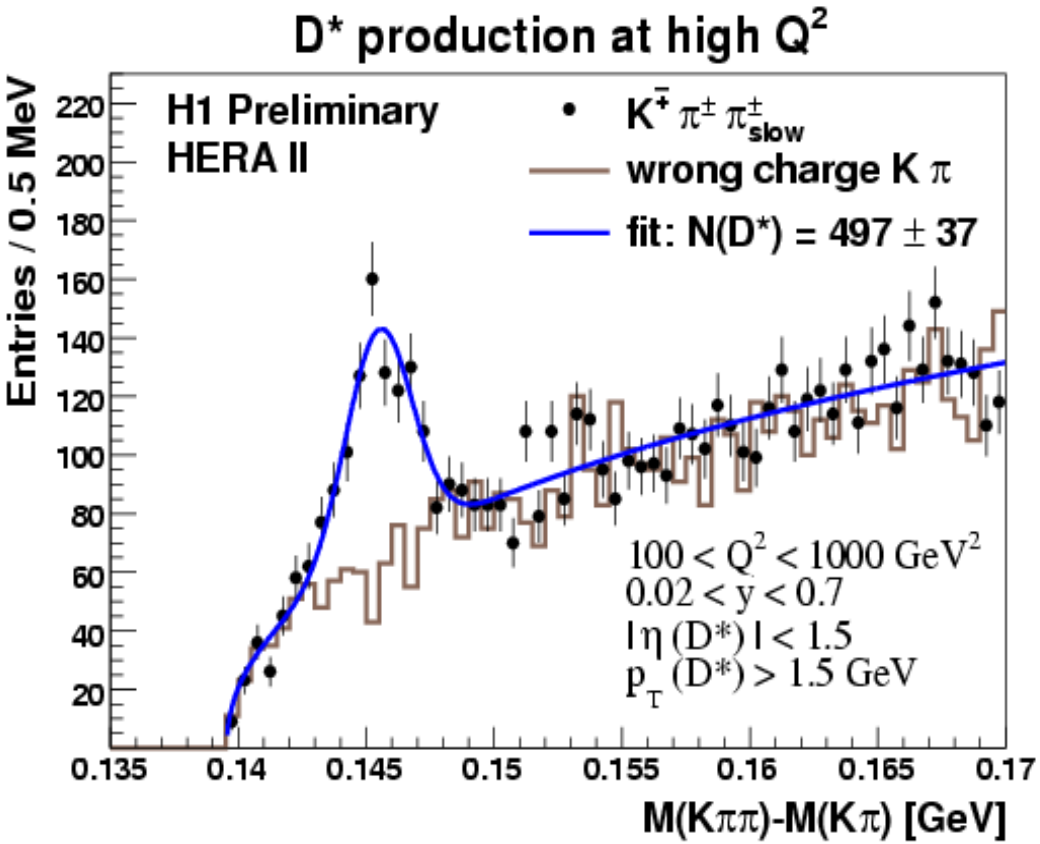
- HERAII data, $\mathcal{L}_{int}$=351pb^{-1}
- Select D* in decay channel:

$$D^{*+/-}(2{,}010) \longrightarrow D^{0}(1{,}864)\pi_s^{+/-}$$
$$\hookrightarrow K^{-/+}\ \pi^{+/-}$$

- Branching ratio BR=2.57%
- Use mass difference method:

$$\Delta m(D^*) = M_{inv}(K\pi\pi_s) - M_{inv}(K\pi)$$

- Combinatorial background via "wrong charge D" ($K^+\ \pi^+/K^-\ \pi^-$)



- Signal extraction: simultaneous fit to signal and background

Cross section measurement

Total cross section in the visible range: $100<Q^2<1000\ \mathrm{GeV}^2$, $0.02<y<0.7$

$p_T(D^*)>1.5$ GeV, $-1.5<\eta(D^*)<1.5$

$$\sigma_{tot}\,(ep\rightarrow D^* X) = 243 \pm 18_{stat} \pm 25_{syst}\ [pb]$$

Data Compared to HVQDIS prediction: $\sigma_{tot}^{theo} = 251\ ^{+6}_{-7}$ [pb]

Model Input parameters:

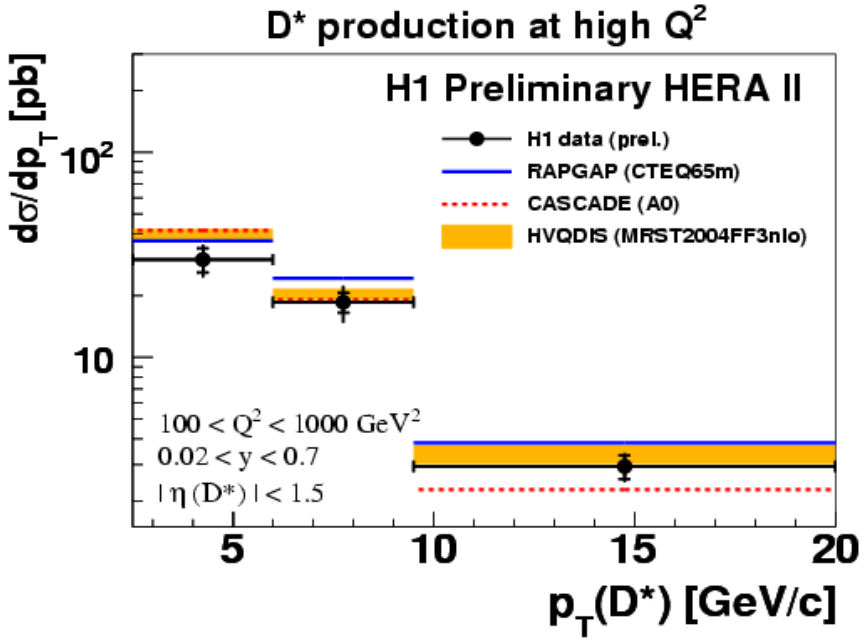
- PDF MRST2004FF3; $1.3 < m_c < 1.7$ GeV; $0.5\mu < \mu_r = \mu_f < 2\mu$, $\mu=\sqrt{Q^2+4m_c^2}$
- Threshold dependent fragmentation via Kartvelishvili parameterization:

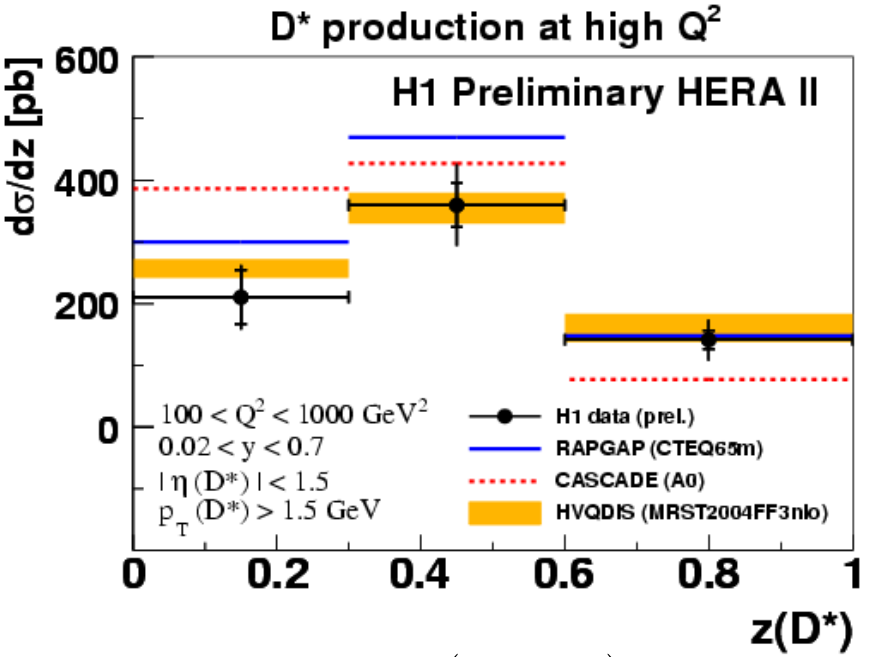
  Ref. EPJC 59 (2009) 589 , details see talk A.Jung

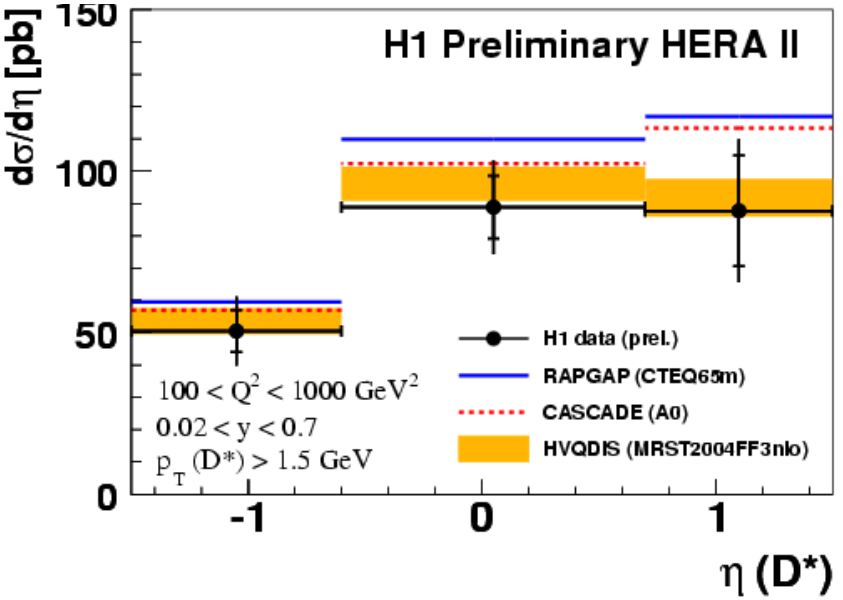
$$\alpha = 6.0^{+1.1}_{-1.3} \quad for\ \hat{s} < 70\ \mathrm{GeV}^2$$
$$\alpha = 3.3^{+0.4}_{-0.4} \quad for\ \hat{s} > 70\ \mathrm{GeV}^2$$

$\hat{s}$ - center of mass energy of the hard process

Results: single differential cross sections



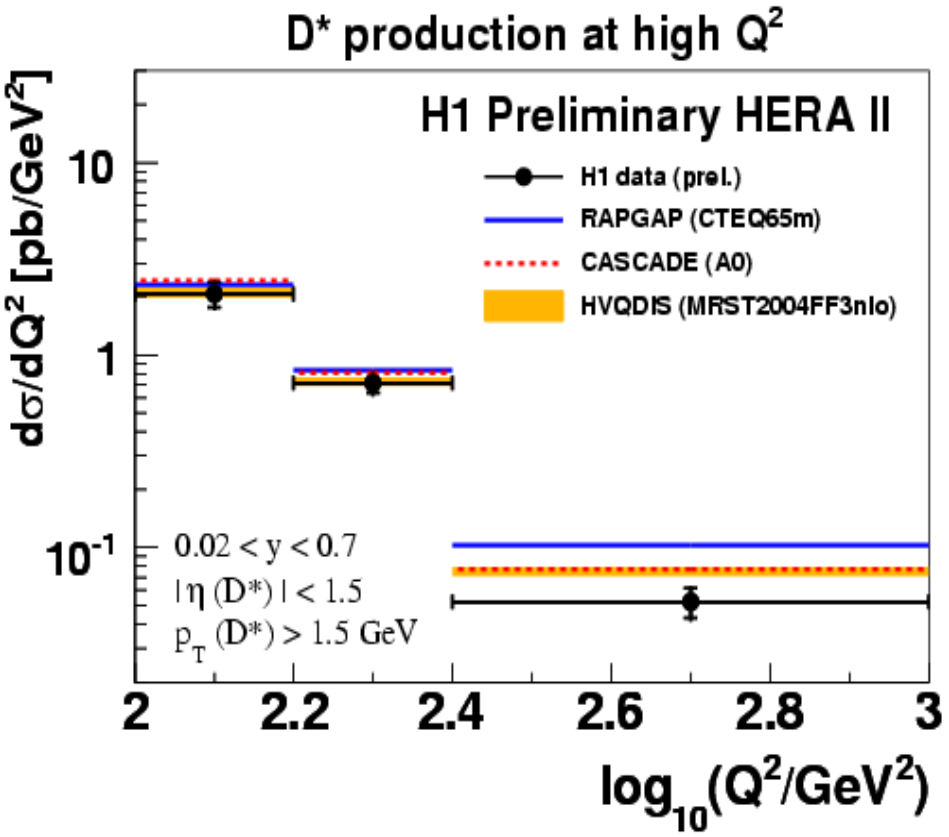


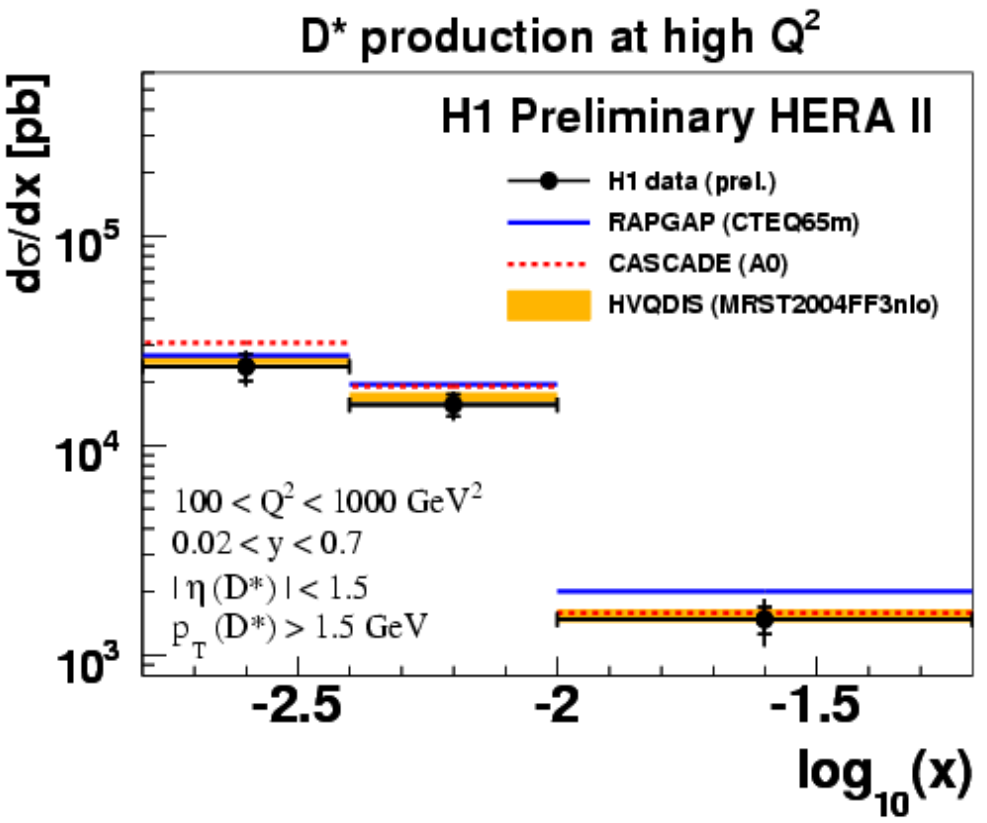


$$z(D^*) = \frac{(E - p_z)_{D^*}}{2\ y\ E_e}$$

- Good agreement with HVQDIS
- RAPGAP/CASCADE don't describe the shape of $p_T(D^*)$ and $z(D^*)$

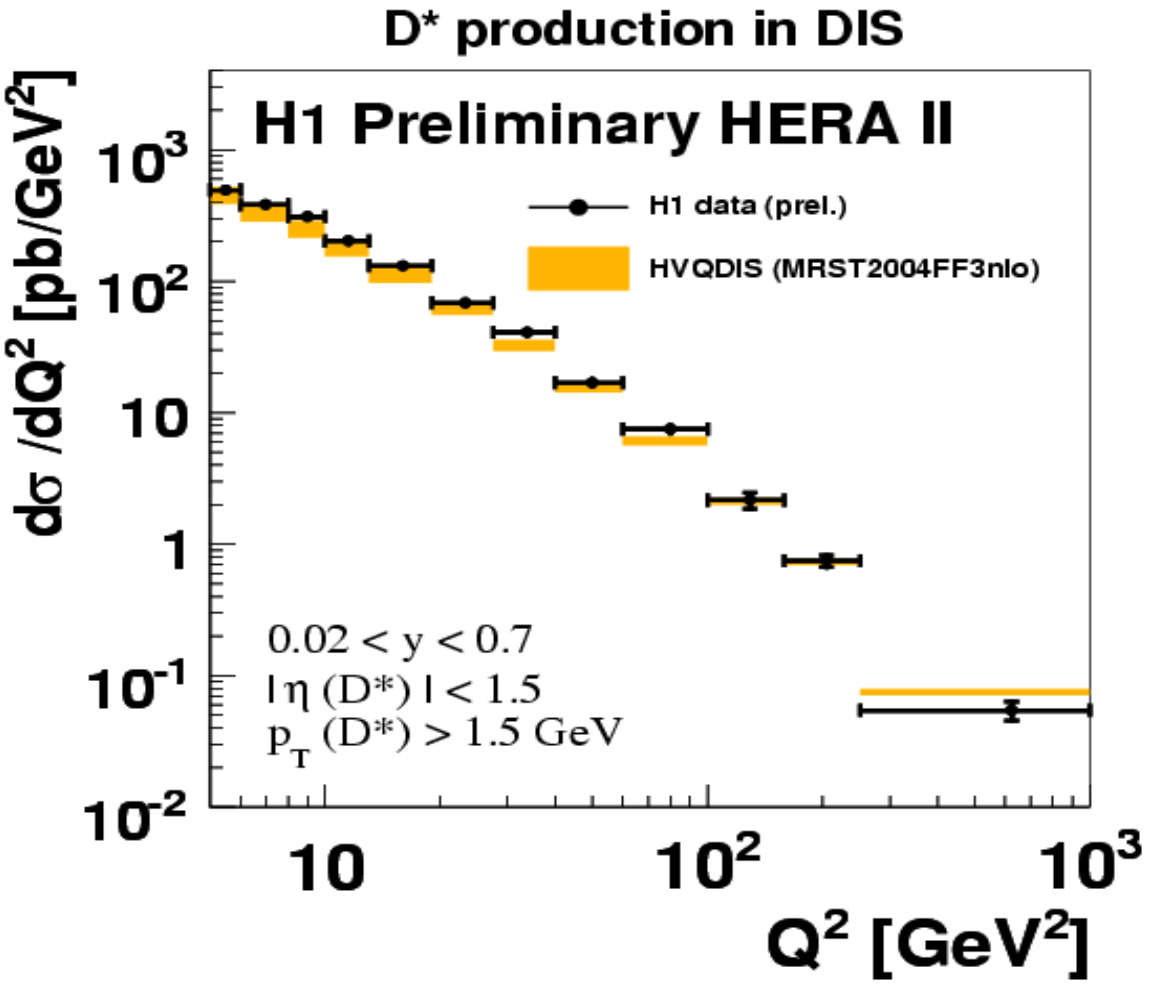
Results: single differential cross sections





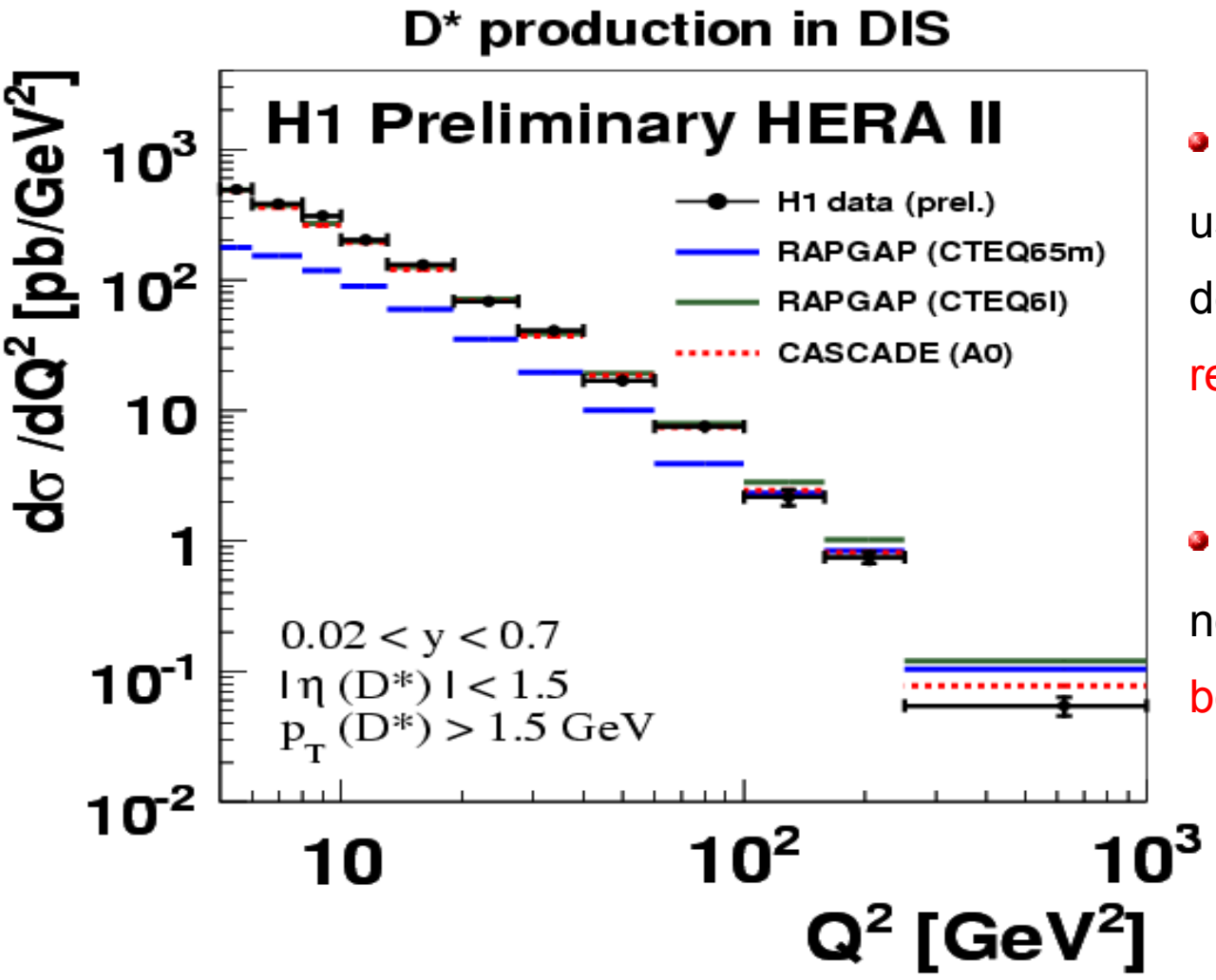
- Reasonable description by HVQDIS
- RAPGAP/CASCADE describe data worse

Results: cross sections in full Q^2 range



Reasonable description of Q^2 slope by the massive calculation HVQDIS for $5<Q^2<1000$ GeV^2

Results: cross sections in full Q^2 range



- CASCADE (LO+PS CCFM):

uses consistently

determined PDF (set A0)

reasonable description of the data

- RAPGAP (LO+PS DGLAP):

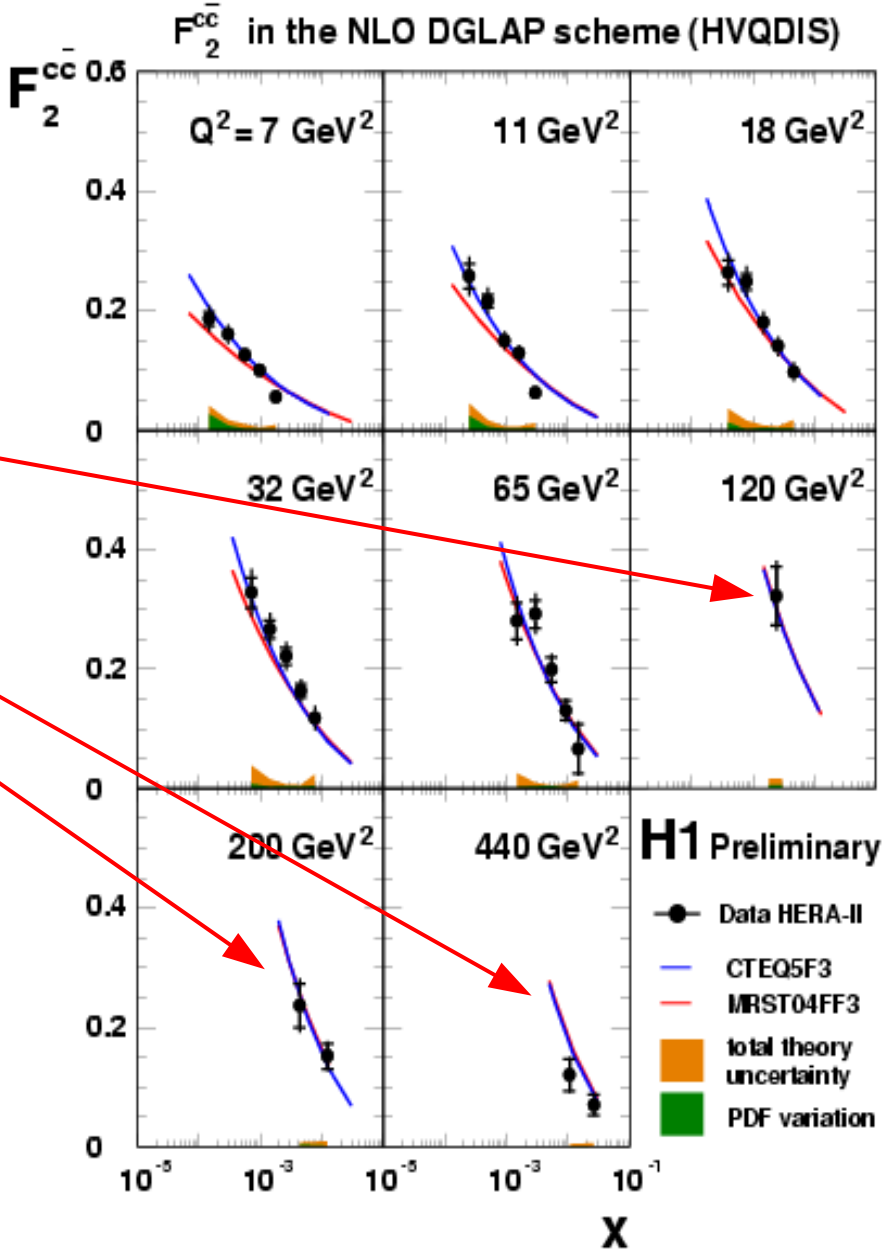
no consistent PDF set available

both PDFs don't describe data well

Results: extraction of F_2^c

$$\frac{d^2\sigma^{c\bar{c}}}{dxdQ^2} = \frac{4\pi\alpha_{em}^2}{xQ^4}\left[\left(1-y+\frac{y^2}{2}\right)F_2^{c\bar{c}} - \frac{y^2}{2}F_L^{c\bar{c}}\right]$$

- This analysis
- Extrapolation to full phase space using HVQDIS
- Lower theory uncertainties at large Q^2
- Good agreement with FFNS calculation



Summary

- D* production cross sections measured at $100<Q^2<1000\ GeV^2$
- Good agreement with NLO calculation in the massive scheme
- LO + PS Monte-Carlo event generators don't agree well with data
- F_2^c at high Q^2 extracted from double-differential cross sections using massive FFNS calculation
- Calculations in the massive scheme describe charm production well at large energy scales $Q^2>>m_c^2$.