

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



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DIS 2009



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- Summary

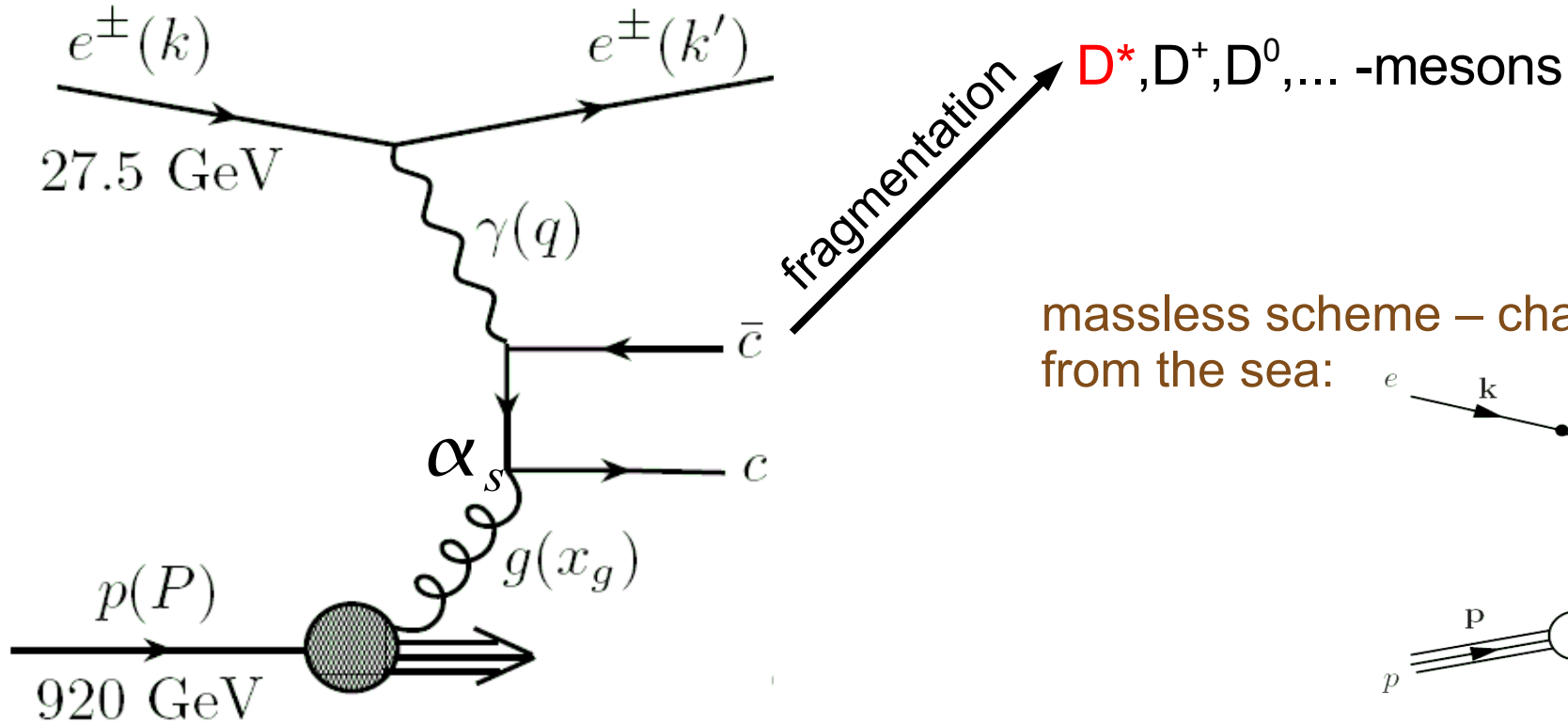
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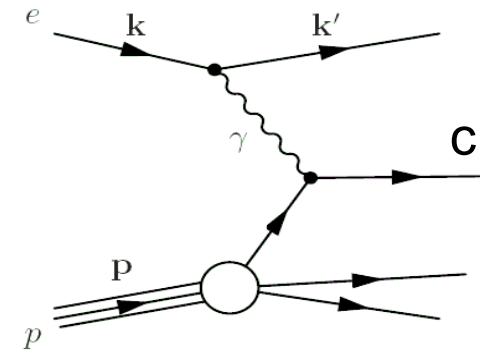
Federal Ministry
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and Research

Charm production at HERA

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



massless scheme – charm directly from the sea:



Charm cross section in QCD factorisation:

$$\sigma^{\text{charm}} = \text{protonstructure (gluons)} \otimes M(\gamma p \rightarrow qq) \otimes \text{fragmentation}$$

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

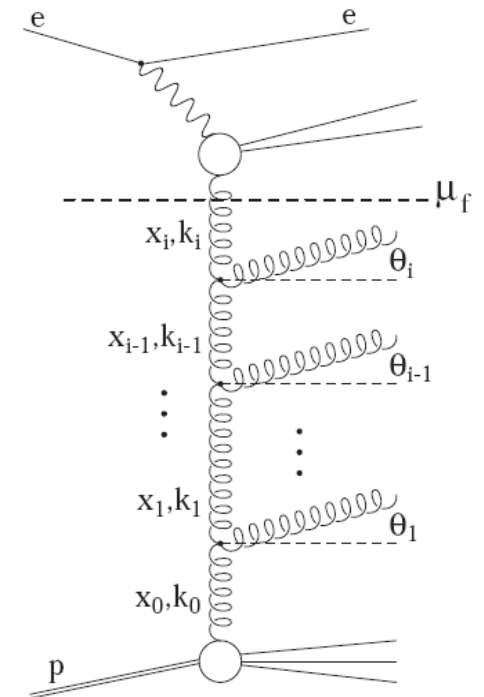
Models for charm production

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

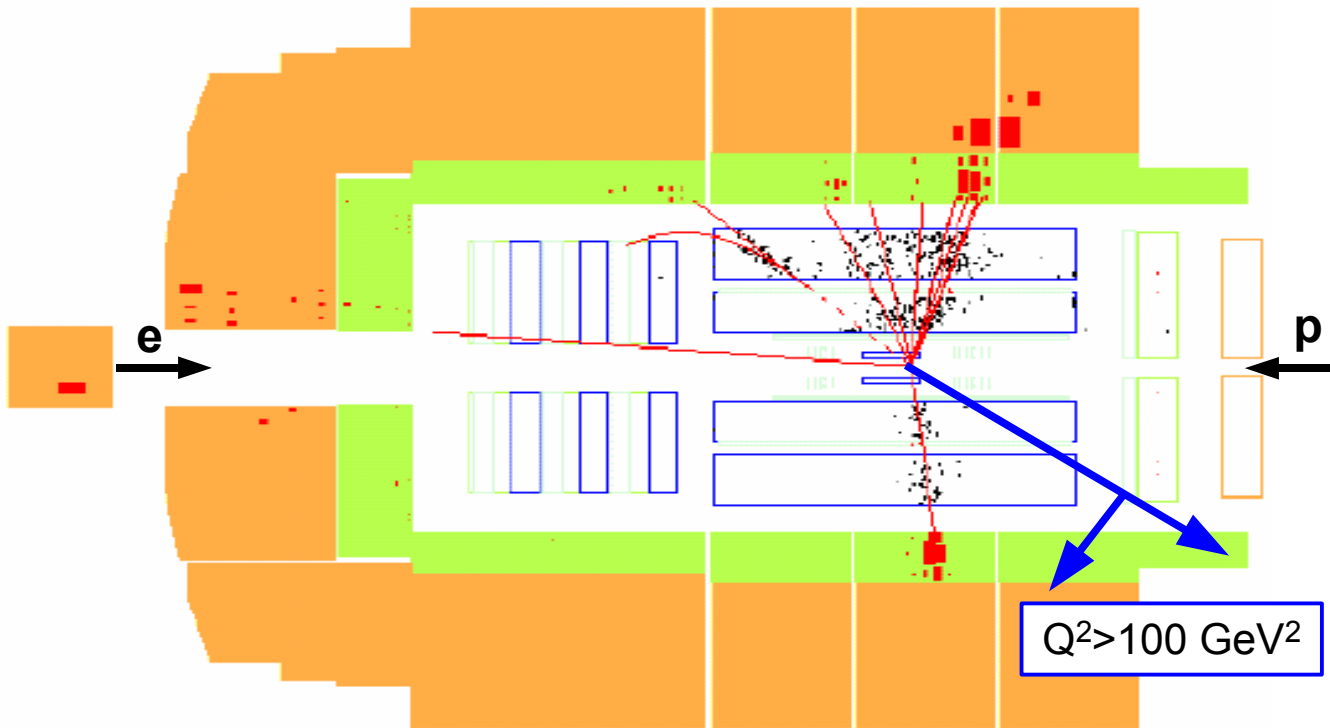
Monte-Carlo: LO + Parton Shower

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

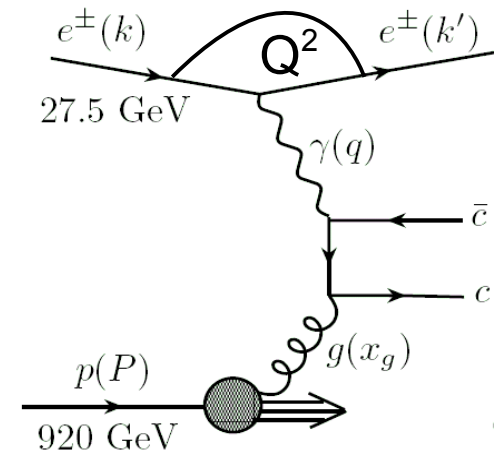


Kinematics

$Q^2 > 100 \text{ GeV}^2$: 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:

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

inelasticity:

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

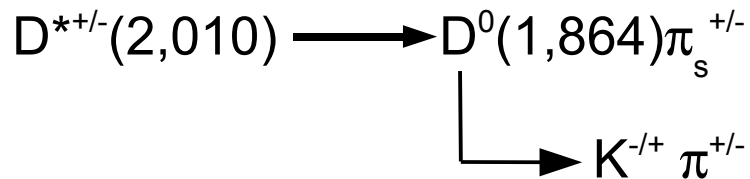
Bjorken-Scale Variable:

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

D* reconstruction

- HERAII data, $\mathcal{L}_{\text{int}}=351\text{pb}^{-1}$

- Select D* in decay channel:



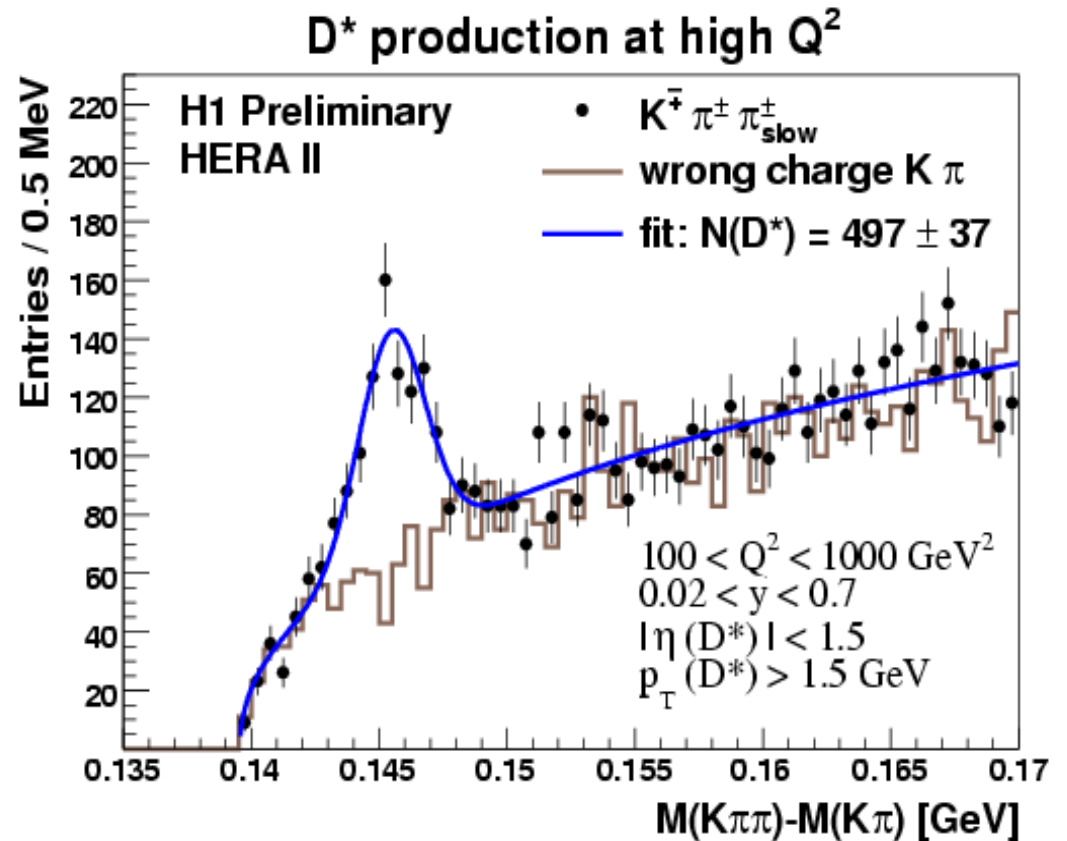
- Branching ratio BR=2.57%

- Use mass difference method:

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

- 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**: $100 < Q^2 < 1000 \text{ GeV}^2$, $0.02 < y < 0.7$

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

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

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

Model Input parameters:

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

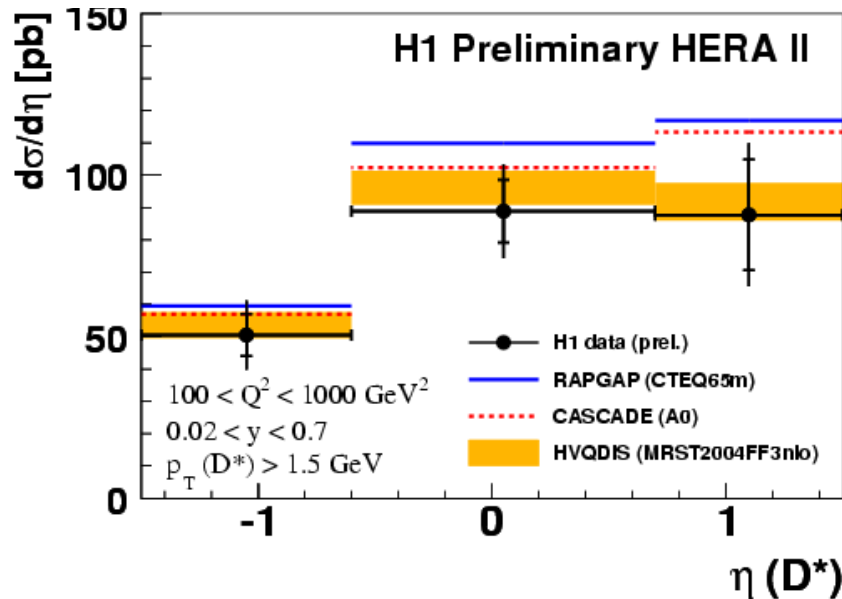
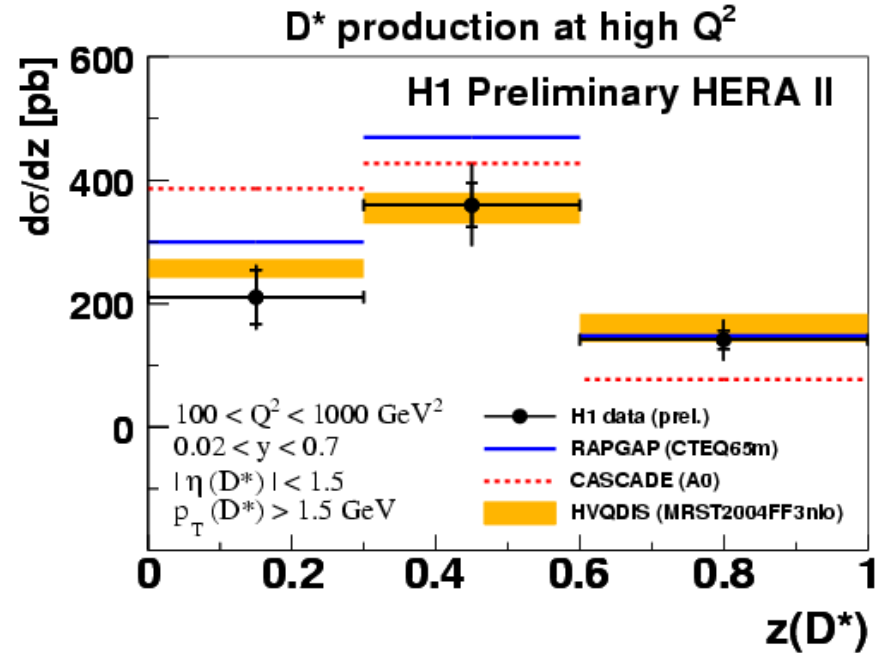
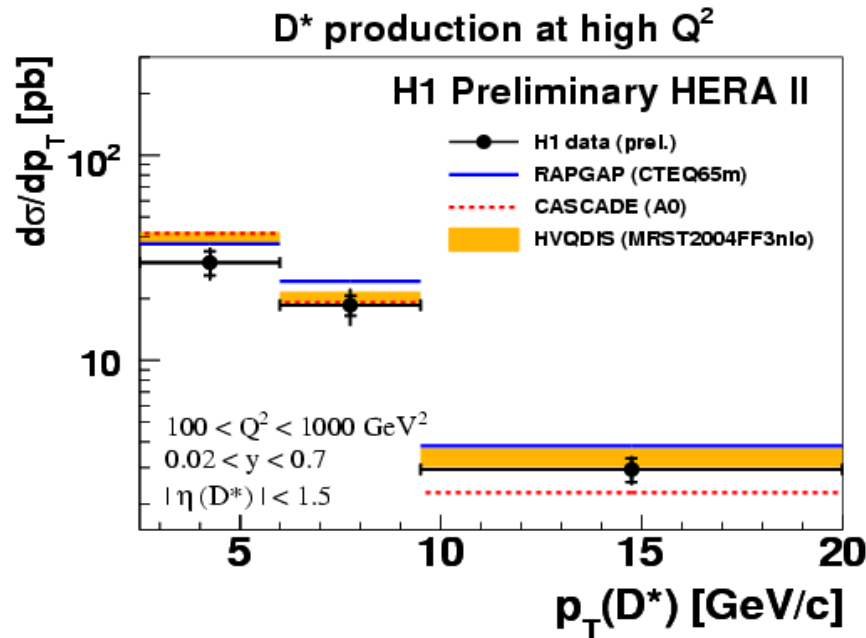
Ref. EPJC 59 (2009) 589, details see talk A.Jung

$$\alpha = 6.0^{+1.1}_{-1.3} \text{ for } \hat{s} < 70 \text{ GeV}^2$$

$$\alpha = 3.3^{+0.4}_{-0.4} \text{ for } \hat{s} > 70 \text{ GeV}^2$$

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

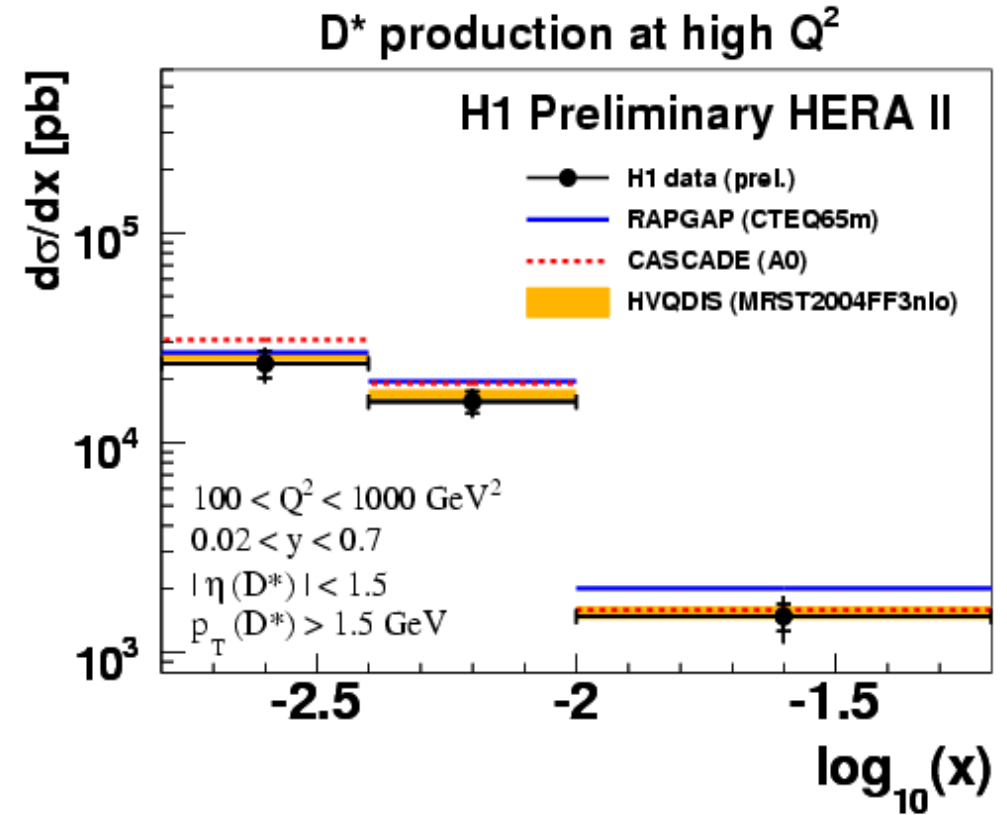
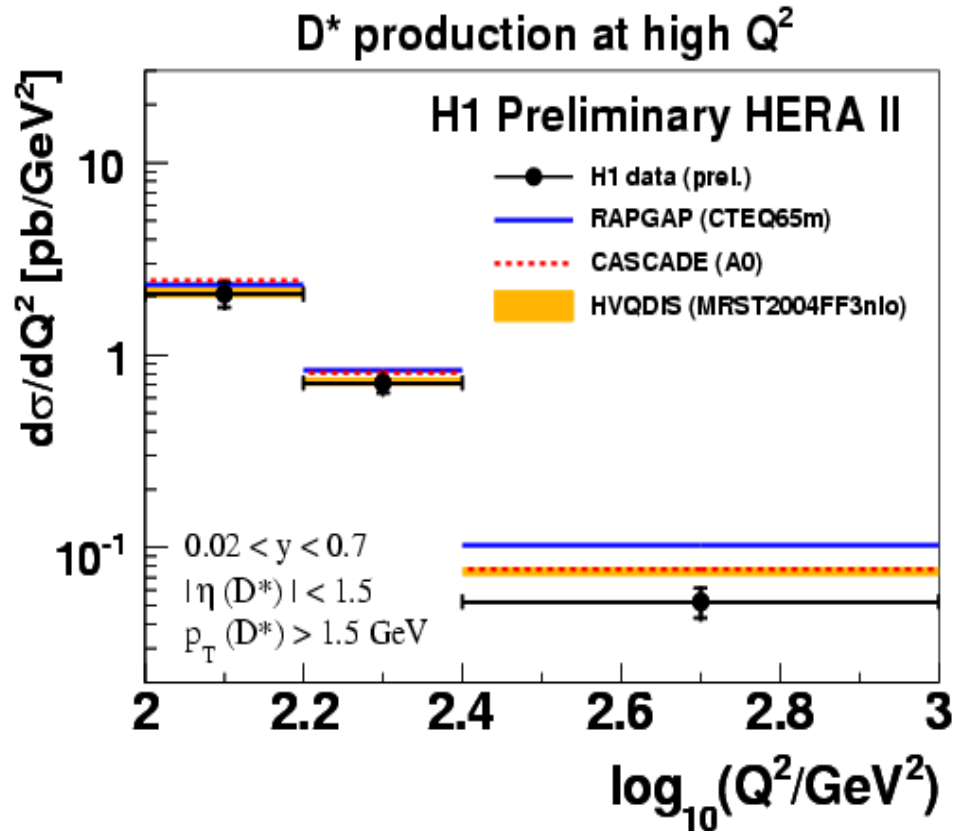
Results: single differential cross sections



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

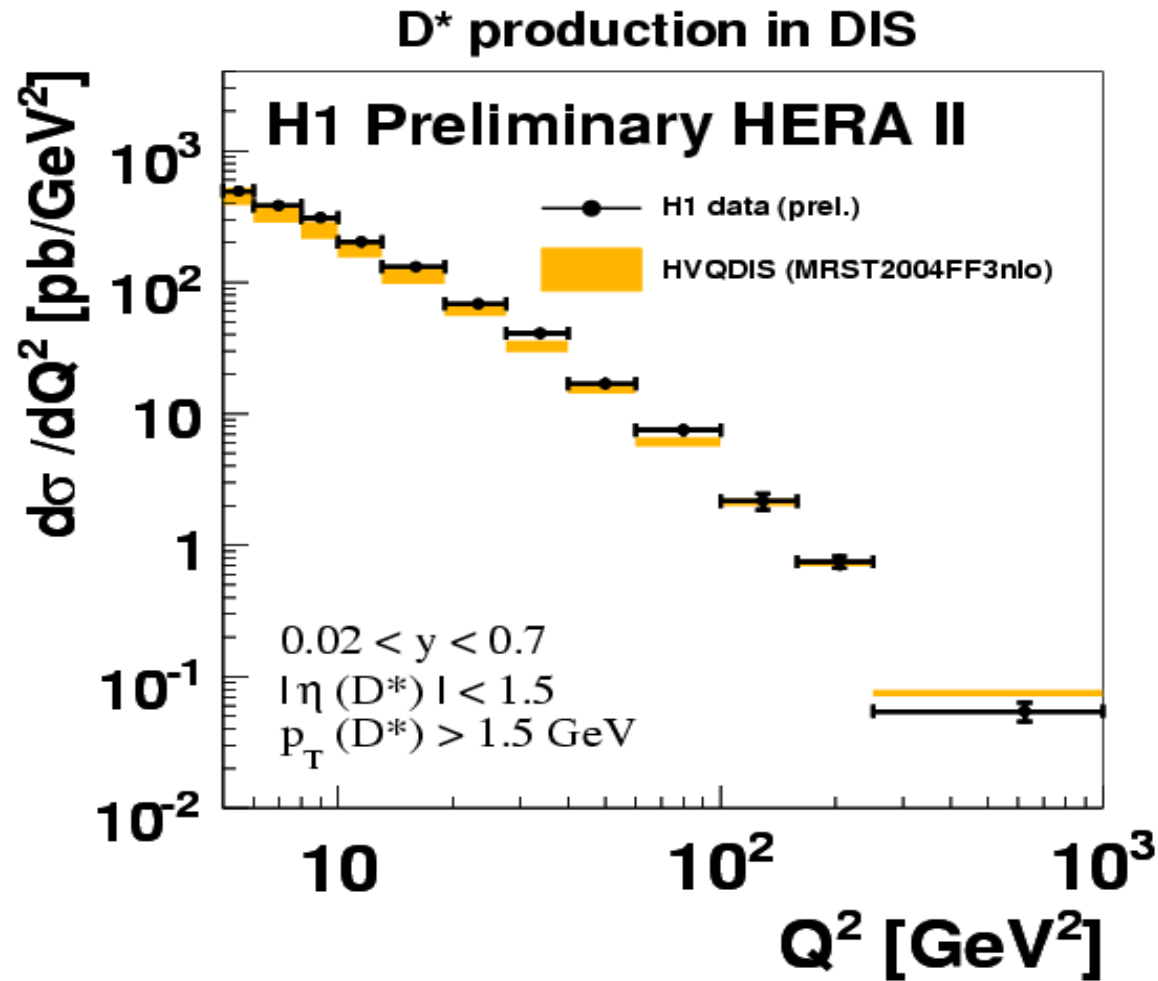
- Good agreement with HVQDIS
- RAPGAP/CASCADE don't describe the shape of $p_T(D^*)$ and $z(D^*)$

Results: single differential cross sections



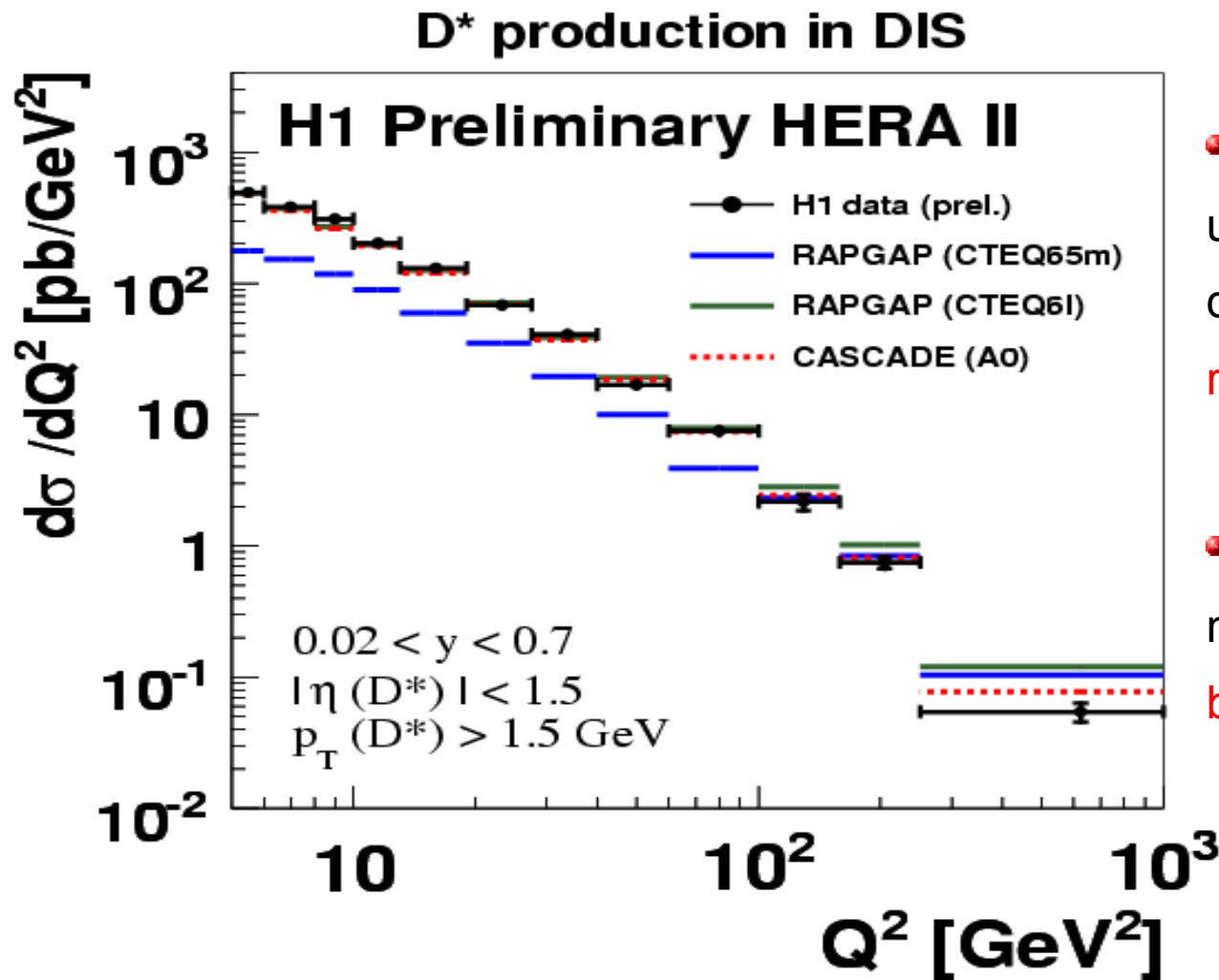
- Reasonable description by HVQDIS
- RAPGAP/CASCADE describe data worse

Results: cross sections in full Q^2 range



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

Results: cross sections in full Q^2 range

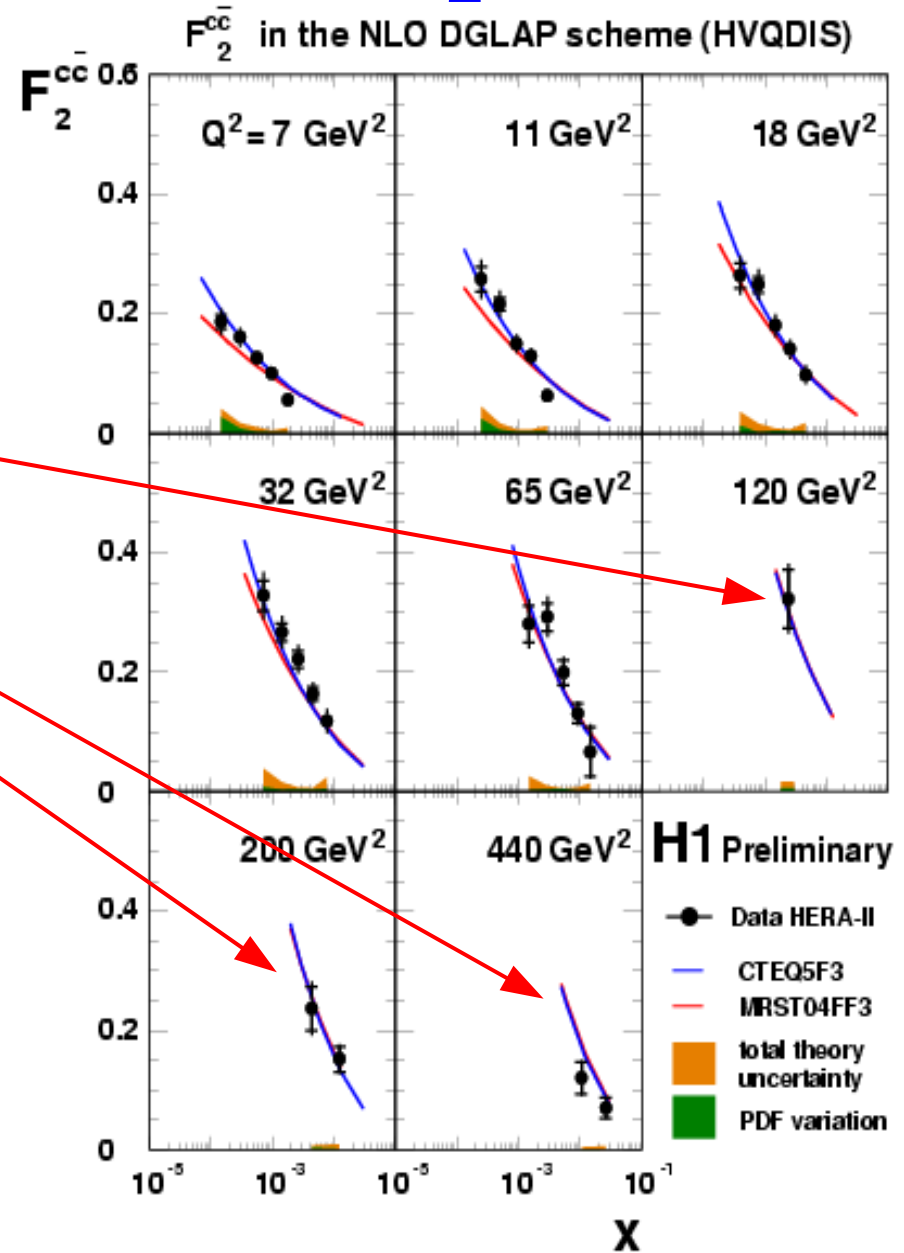


- CASCADE (LO+PS CCFM):
uses consistently
determined PDF (set A0)
reasonable description of the data
- RAPGAP (LO+PS DGLAP):
no consistent PDF set available
both PDFs don't describe data well

Results: extraction of F_2^c

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

- 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 $100 < Q^2 < 1000 \text{ GeV}^2$
- 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 $Q^2 \gg m_c^2$.