Charm Production in DIS at H1

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for

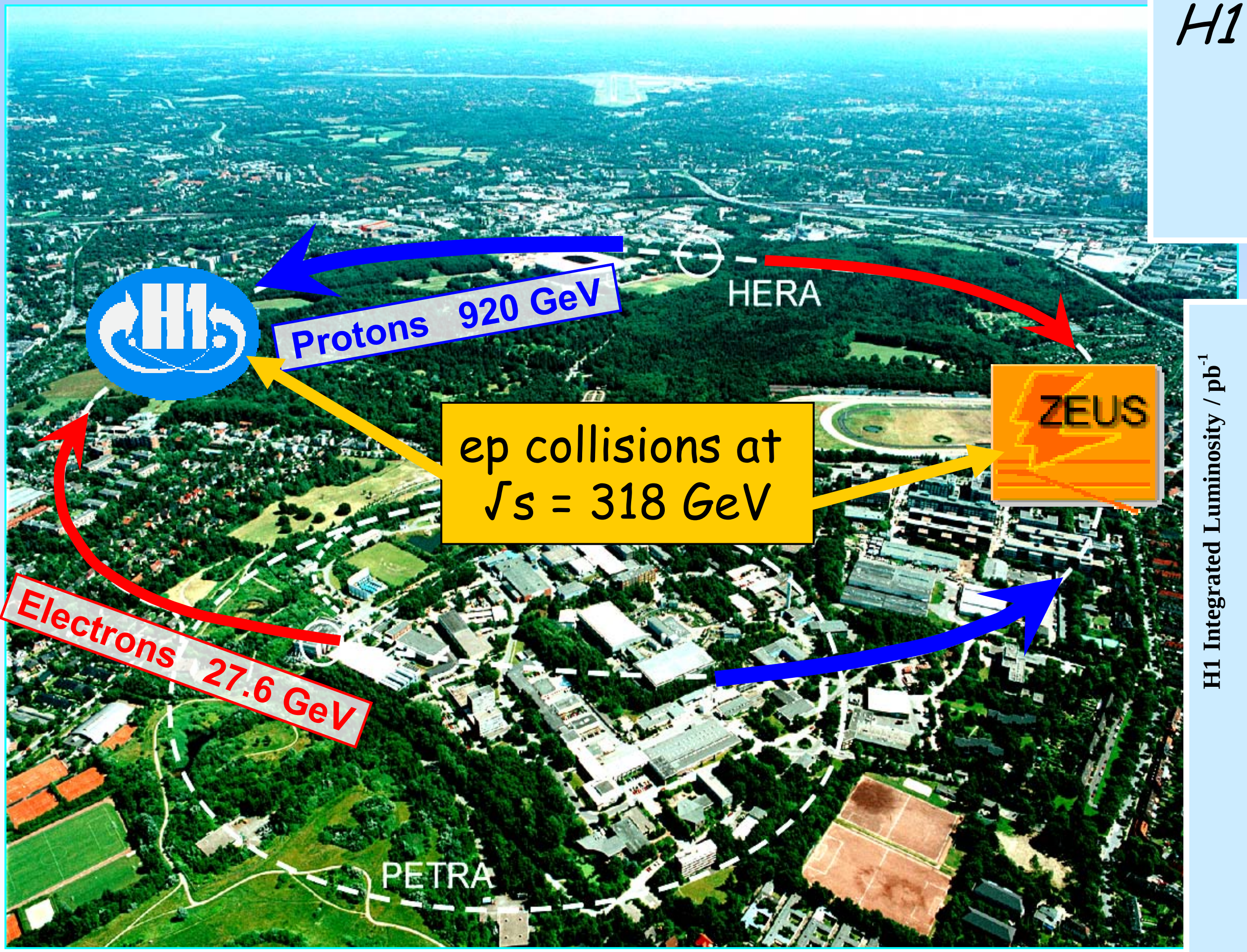
Collaboration

Based on HERA II data

DIS 2007 Munich

H1 experiment at HERA accelerator

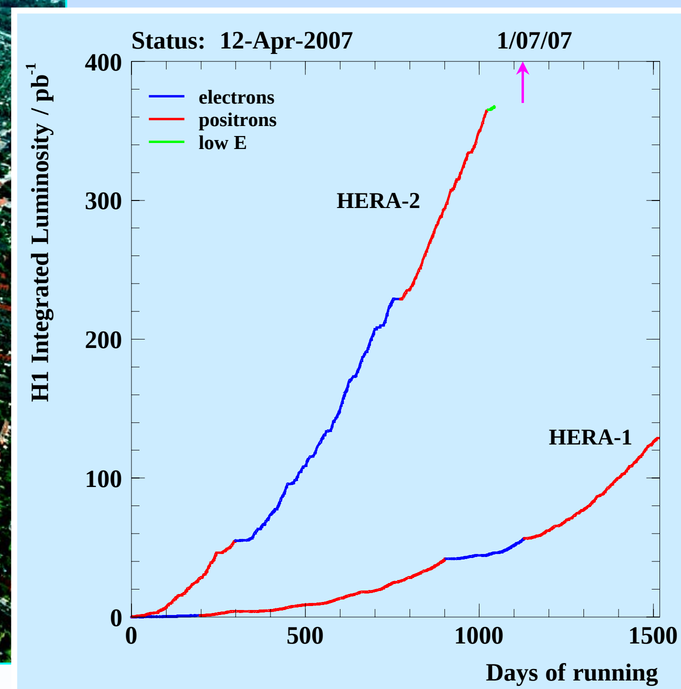
HERA storage ring at DESY (Hamburg, Germany)



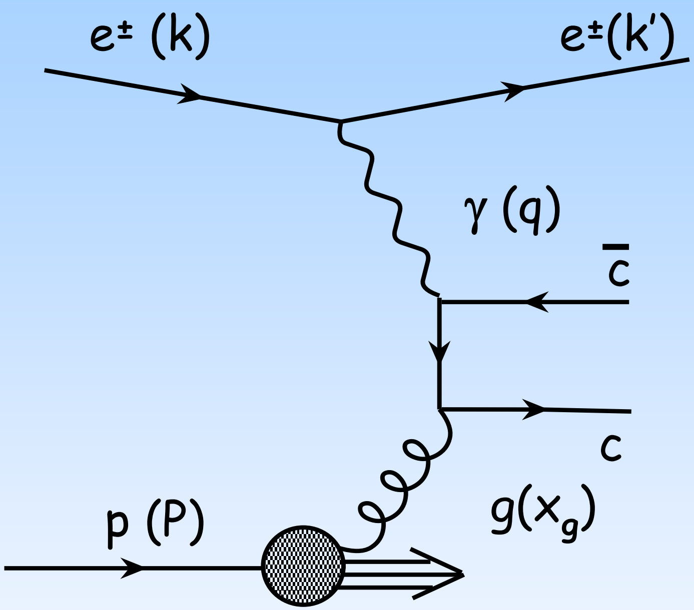
H1 Integrated Luminosity

HERA I 120 pb^{-1}

HERA II 350 pb^{-1}



Dominated by Boson – Gluon Fusion (BGF) in LO: $\gamma g \rightarrow c\bar{c}$ $(b\bar{b})$



ep kinematics: $\sqrt{s}$ = 318 GeV

- 4-momentum transfer squared $Q^2 = -q^2$;
- Bjorken scaling variable $x = Q^2/(2\, q\, P)$
- inelasticity $y = qP/kP$
- mass of the hadronic system $W^2 = (P + q)^2$

Kinematic range in this analysis

$5 < Q^2 < 100$ GeV^2 $\quad 0.05 < y < 0.6$

- charm mass – additional hard scale for tests of pQCD
- measure the charm contribution F^c_2 to proton structure function F_2
- gluon directly involved → constrain $g(x_g)$

Models of charm production

Data are compared to Monte-Carlo models and NLO calculation

Monte – Carlo models:

- **RAPGAP**
  - matrix element calculated in LO QCD
  - higher order contributions via parton showers
  - parton evolution in collinear approximation (DGLAP equations)
  - charm is massive in BGF
- **CASCADE**
  - gluon density unintegrated in gluon transverse momentum k_T
  - only gluons in proton
  - higher order contributions via initial state parton showers based on CCFM equations
  - charm is massive in BGF

Models of charm production: NLO calculation

NLO charm production in DIS (HVQDIS)

Features:

- Charm is massive (most appropriate for $Q^2 \sim m_c^2$)
- Fixed Flavour Number Scheme:
  - active partons in the proton are u, d, s
  - charm is produced in the hard process

Uncertainties:

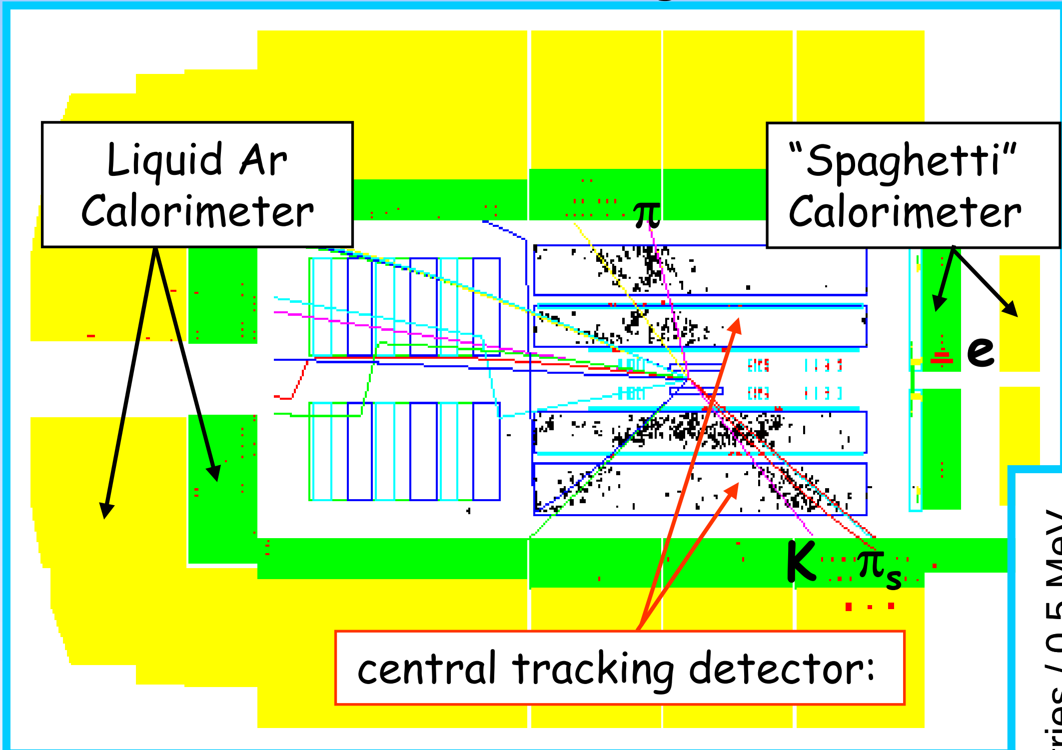
- choice of renormalization and factorization scales μ_r, μ_f
- charm mass m_c
- charm fragmentation

Used at H1 for this presentation:

- pdf: CTEQ5F3, $\mu^2_r = \mu^2_f = \mu^2 = (Q^2 + 4m^2_c)$,
- variations: $1.3 < m_c < 1.6$, $0.5\,\mu < \mu < 2\,\mu$
- fragmentation: Peterson, $\varepsilon = 0.045$

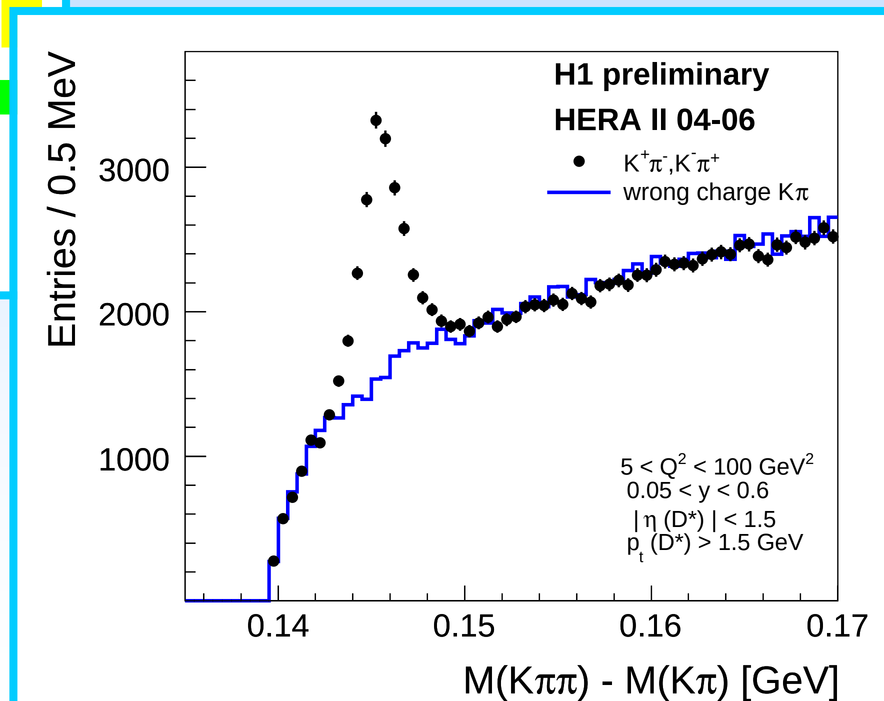
Charm tagging via D*-meson production at H1

D* reconstructed in golden channel: $D^{*+} \rightarrow D^0 \pi_s^+ \rightarrow K^- \pi^+ \pi_s^+$ (+ c.c.)



apply "mass difference method":

$$\Delta M(D^*) = M(K \pi \pi_s) - M(K \pi)$$



This analysis: L = 222 pb^{-1}

data of HERA II 2004-2006

$5 < Q^2 < 100$ GeV^2

$0.05 < y < 0.6$

Charm tagging via D*± at H1

Visible range defined by p_T and $\eta = -\ln \tan(\theta/2)$

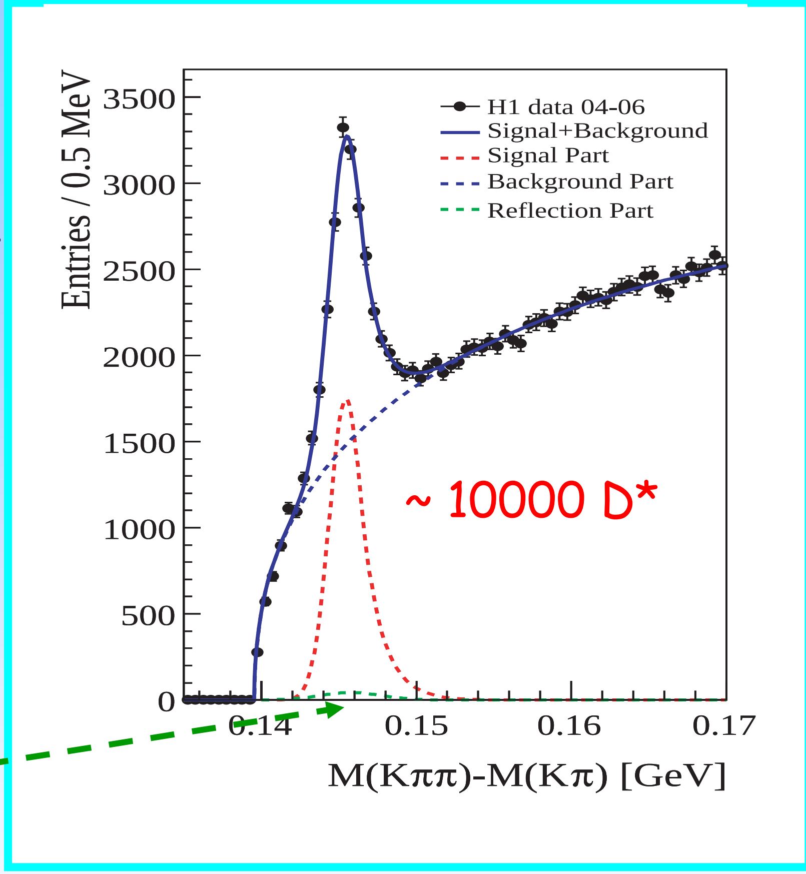
$p_T(D^*) > 1.5$ GeV, $|\eta(D^*)| < 1.5$

N(D*) defined from unbinned least likelihood fit

- Fit Function: Chrystall Ball:

$$x = \begin{cases} \dfrac{\left(\frac{n}{|a|}\right)^n \exp\left(-\frac{1}{2}a^2\right)}{\left(\frac{n}{|a|} - a - x\right)^n} & \text{if } x < -|a|, \\ \exp\left(-\frac{1}{2}\left(\frac{x-m}{\sigma}\right)\right)^2 & \text{if } x \geq -|a| \end{cases}$$

- contribution due to reflections 4%

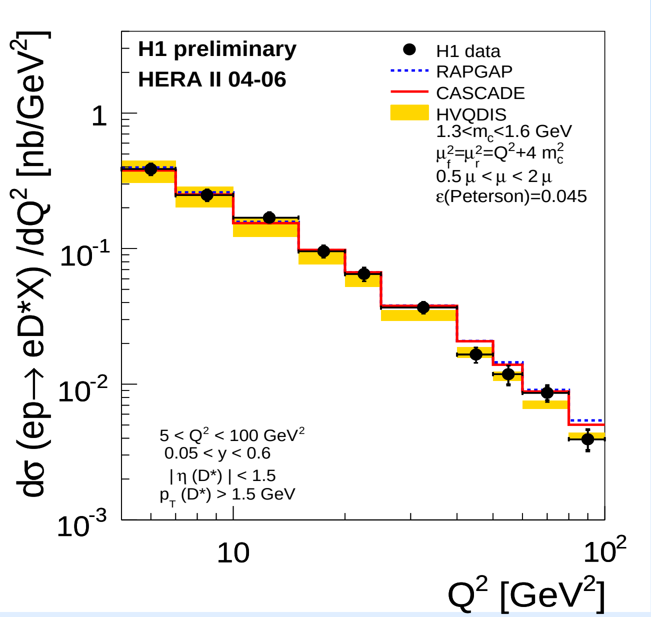


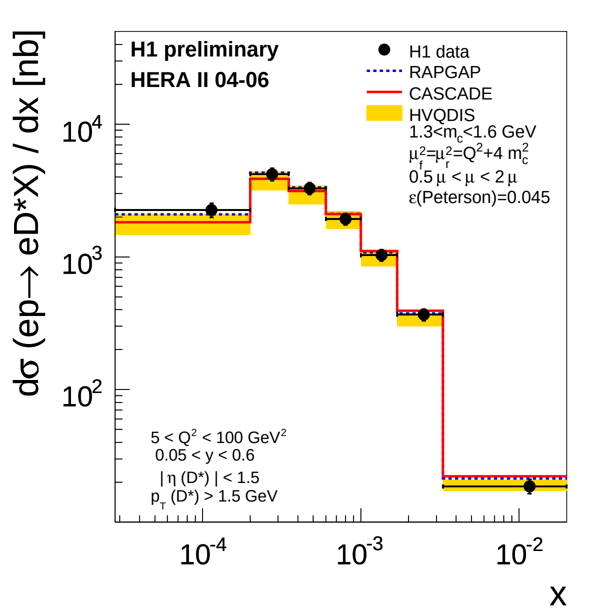
H1 Preliminary:

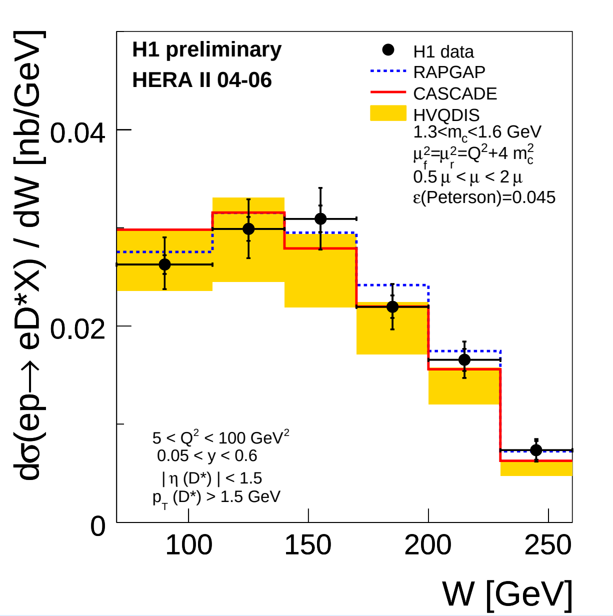
$5 < Q^2 < 100$ GeV^2, $0.05 < y < 0.6$
$p_T(D^*) > 1.5$ GeV, $|\eta(D^*)| < 1.5$

σ (ep → e' D* X) = 4.23 nb ± 0.09_{stat} ± 0.37_{syst}

Differential D* cross section vs DIS kinematics

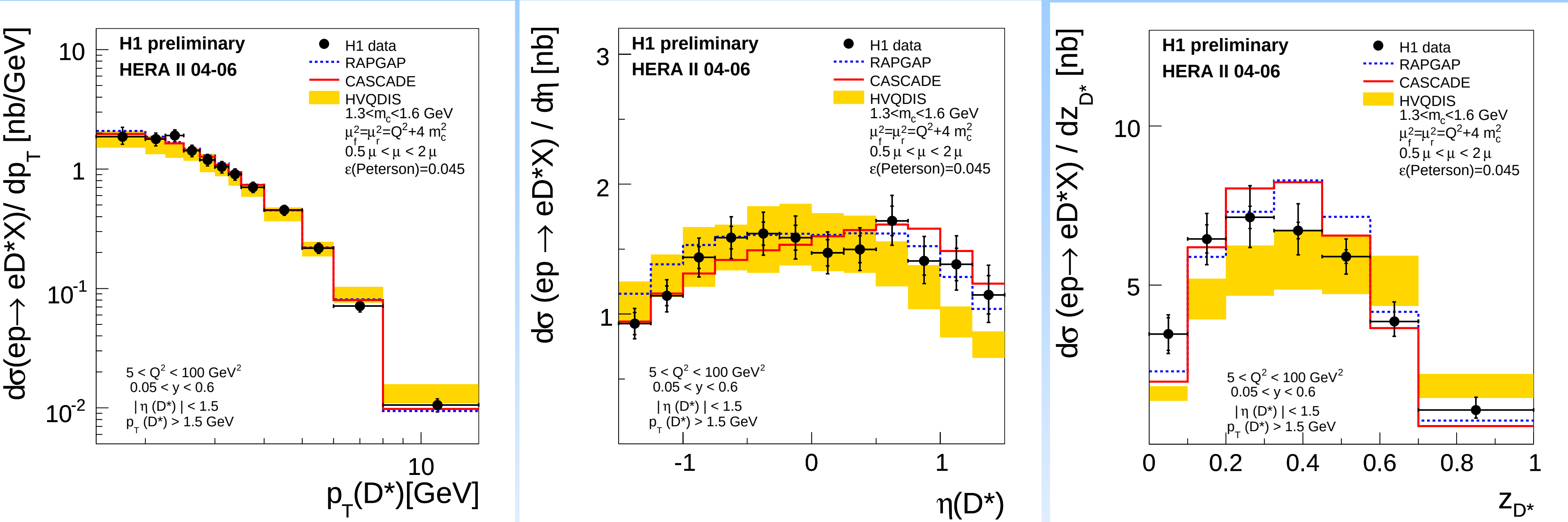






- The DIS kinematics equally well described by all the models
- NLO: large theory uncertainties due to mass and scale variation

Differential D* cross sections vs D* kinematics



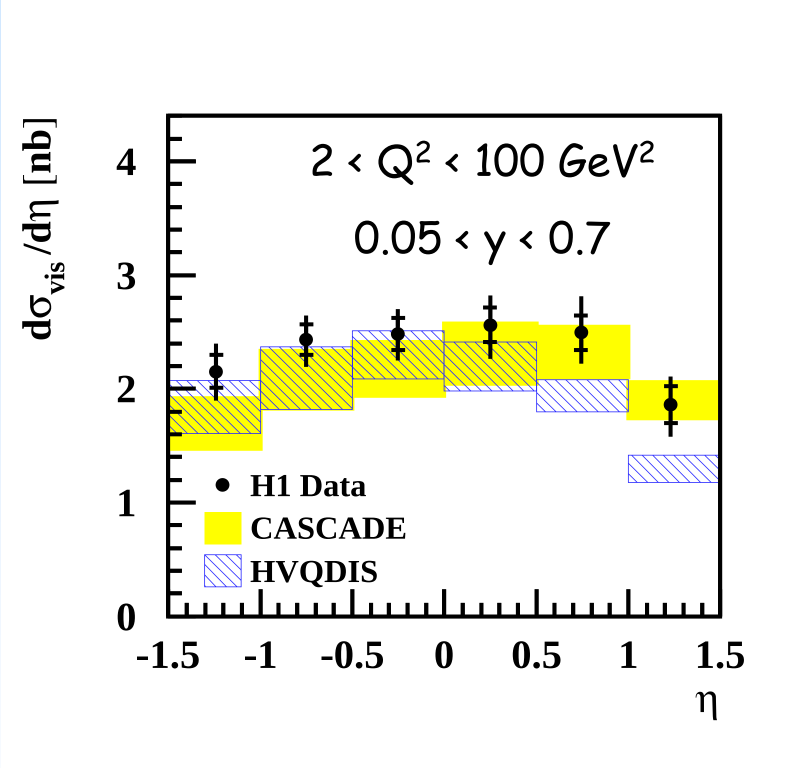
Models show deficits in describing the D* kinematics:

- forward η(D*) underestimated by the NLO calculation
- inelasticity $z_{D^*} = E(D^*)\text{-}p_z(D^*)\ /\ 2\ y\ E_e$ fairly described

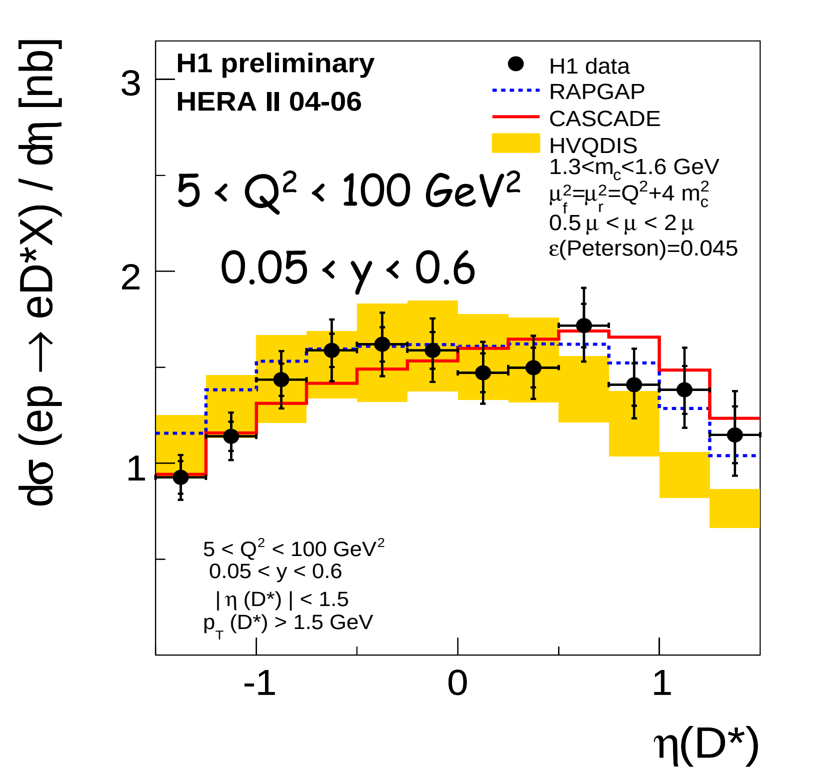
Same features have been observed in the previous measurements

D* cross section HERA I vs HERA II

HERA I



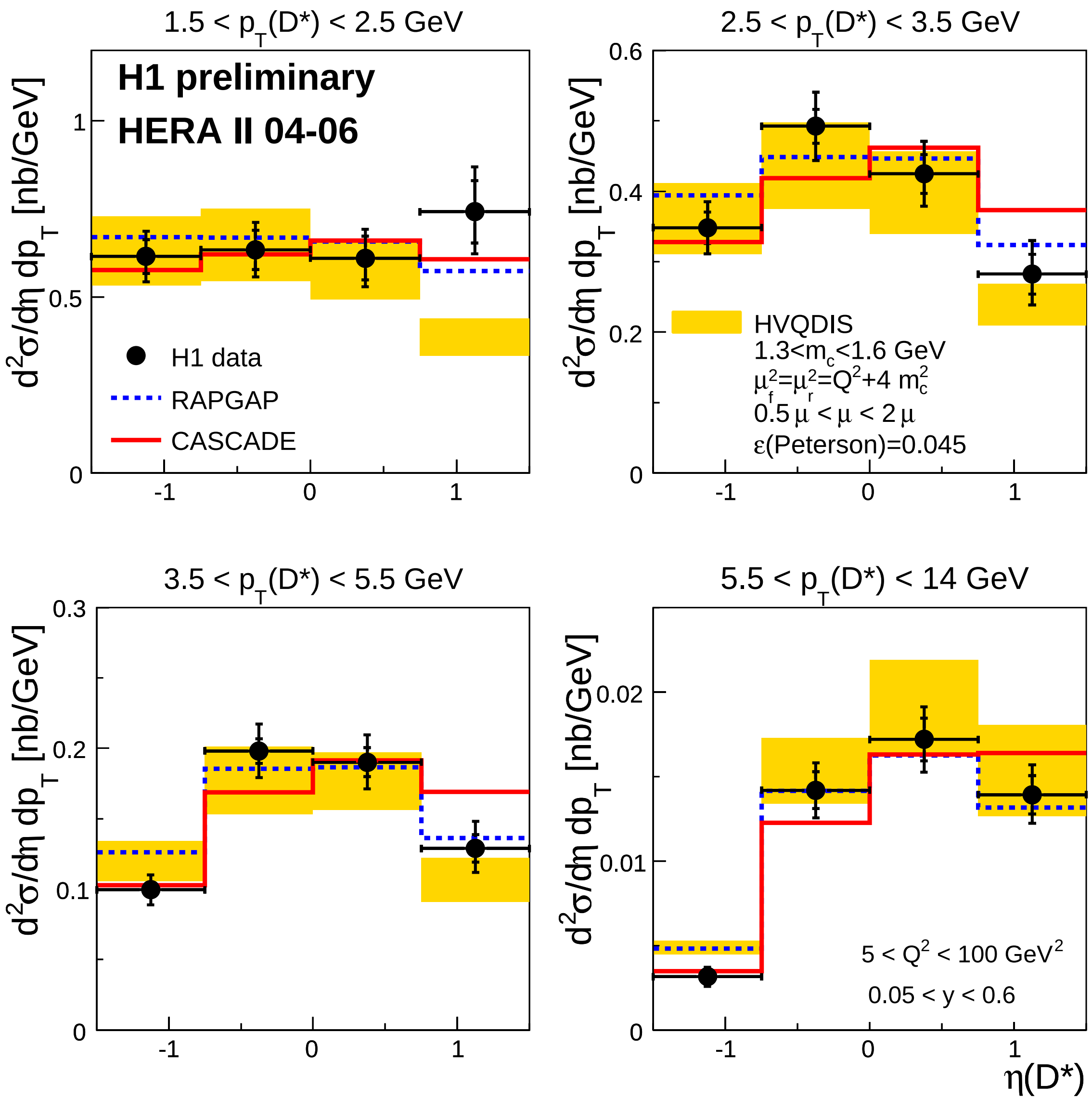
HERA II



Data of HERA I and HERA II consistent

Difference NLO - data in forward region more significant in HERA II

Double-differential D* cross sections



- models are consistent with data within uncertainties
- however models show deficits describing the data

- HVQDIS: deficits only at low p_T

  reduction of the theory uncertainty is feasible

- CASCADE: overshoot at high p_T and forward η

  gluon density too high at high x_g also visible in jet measurements

- RAPGAP: backward η underestimated

- still more precise measurements needed to differentiate between the models

Summary and Outlook

- Half of HERA II data is analyzed (5 x HERA I statistics at H1)
- Models confirmed with better precision
- Model deficits observed in certain kinematical regions become more visible
- Precision allows more double-differential cross sections studies

- More data are to come: all HERA II is being analyzed
- Systematic uncertainties will be reduced

- F^c_2 will be measured using the whole statistics of HERA I + HERA II
- significant increase of the visible phase space is foreseen

- Precise differential cross sections will be used to tune HVQDIS