

# On the way to $F_2^c$ at H1

$F_2^c$  extraction from charm events tagged via  $D^*$  in DIS

- method
- problems
- prospects

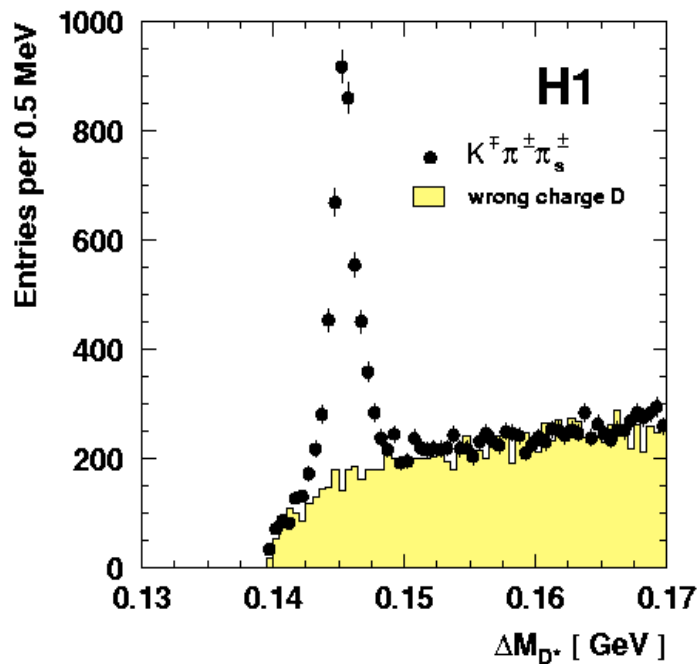
Alternative: lifetime tag

Katerina Lipka

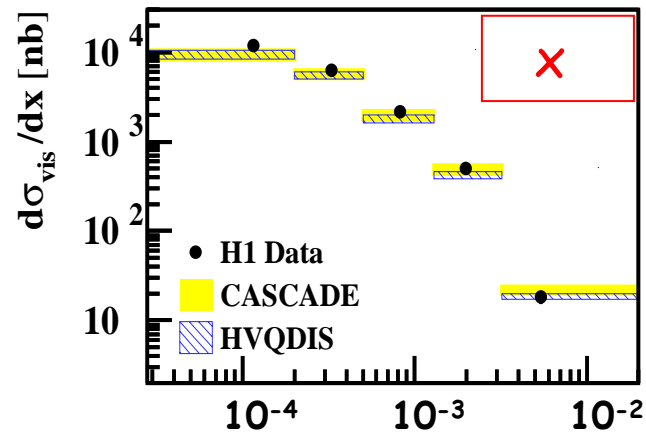
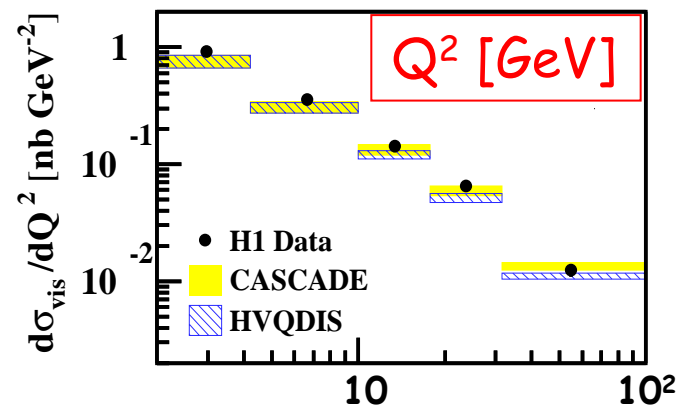
HERA-LHC Workshop March 2007 DESY

# Open charm tagging: $D^*$ in DIS

- tag charm in "golden" channel:  $D^{*+} \rightarrow D^0 \pi_s^+ \rightarrow K^- \pi^+ \pi_s^+$  (+ c.c.)
- apply "mass difference method":  $\Delta M(D^*) = M(K \pi \pi_s) - M(K \pi)$
- DIS:  $2 < Q^2 < 100 \text{ GeV}^2$ ,  $0.05 < y < 0.7$ , HERA I,  $\mathcal{L} = 47 \text{ pb}^{-1}$



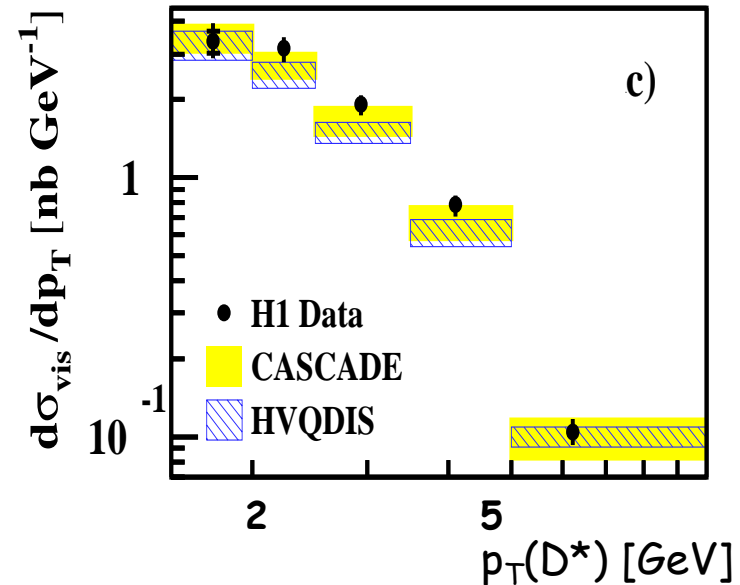
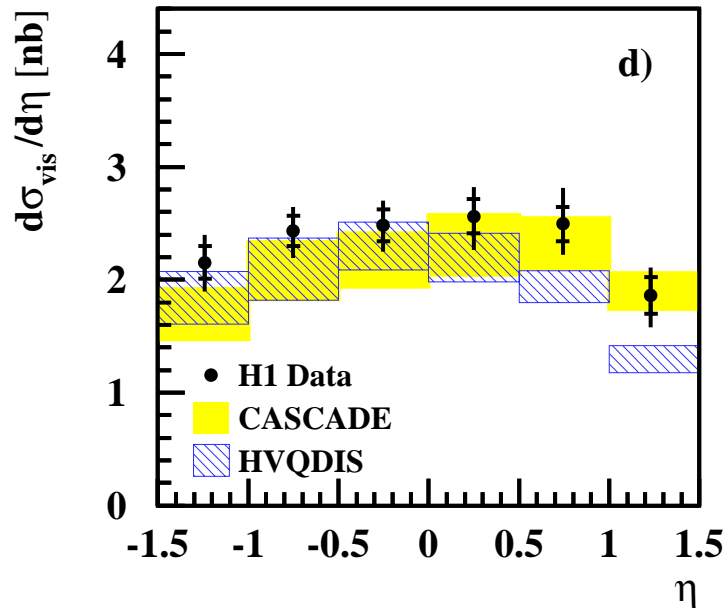
"wrong charge D" : fake  $D^0 (K^+ \pi^+ / K^- \pi^-) + \pi_s$



# Open charm tagging: $D^*$ in DIS, visual cross sections

$D^*$  cross section measured in "visible" range: HERA-1  $|\eta(D^*)| < 1.5$ ,  $p_T(D^*) > 1.5$  GeV

Need extrapolation to the full phase space !



- CASCADE: LO + parton showering, CCFM evolution
- HVQDIS: massive full NLO calculation, DGLAP evolution

Extrapolation factor (e.g. HVQDIS) 3.4 (only 30% of the phase space accessible)

Large model uncertainties:  $m_c$ , fragmentation, scales, pdf

# From the $D^*$ visible cross section to $F_2^c$

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- $c\bar{c}$  cross section in HVQDIS:

full NLO ME calculation, works in Fixed Flavour Number Scheme

PDF: e.g. CTEQ 5F3

$$\mu_r = \mu_f = \sqrt{Q^2 + 4m_c^2}$$

- $\sigma(c\bar{c})$  transformed into  $\sigma(D^*)$  via fragmentation in lab frame

$c \rightarrow D^*$  fraction 0.257, fragmentation via Peterson/Karvelishvili

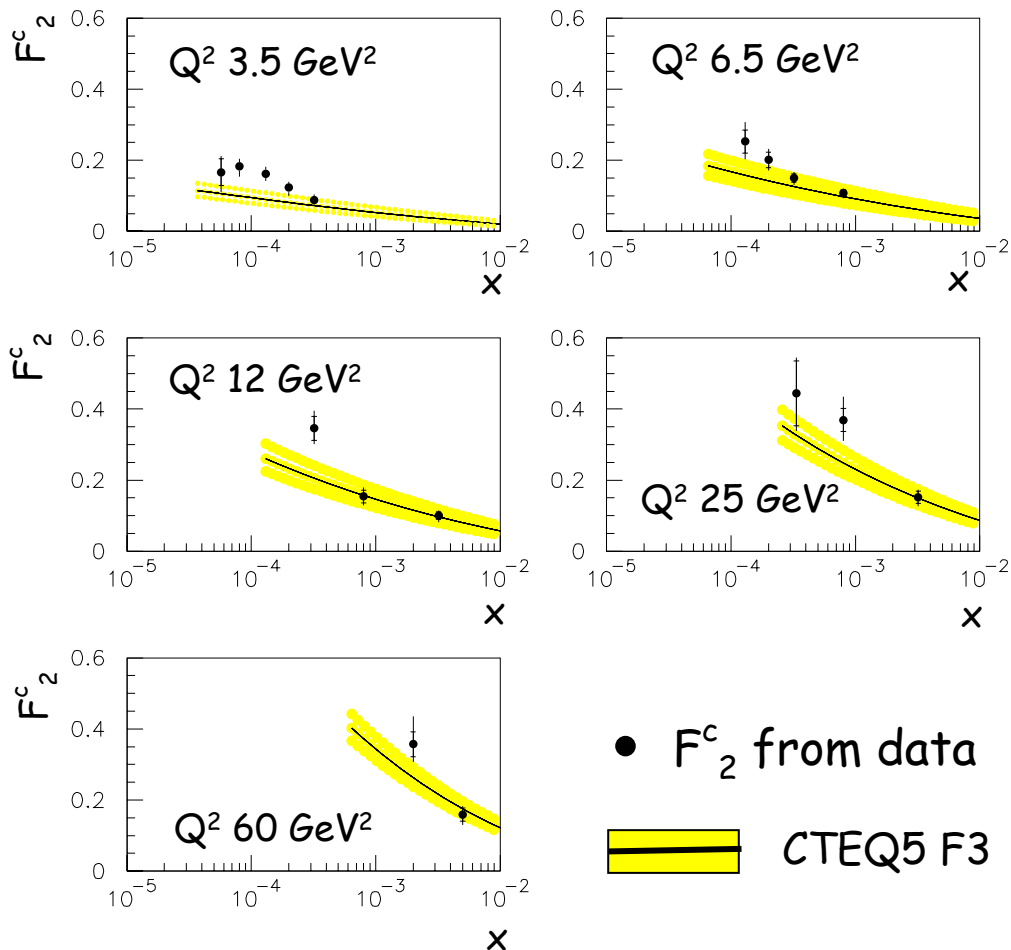
- Uncertainties: 10% fragmentation, 10%  $m_c$ , 5% scale variation

$$F_2^c(\text{exp}) = \sigma_{\text{vis}}(\text{exp}) / \sigma_{\text{vis}}(\text{theory}) \times F_2^c(\text{theory})$$

$F_2^c(\text{theory})$ : calculated in NLO (S. Riemersma et al)

# From the $D^*$ visible cross section to $F_2^c$

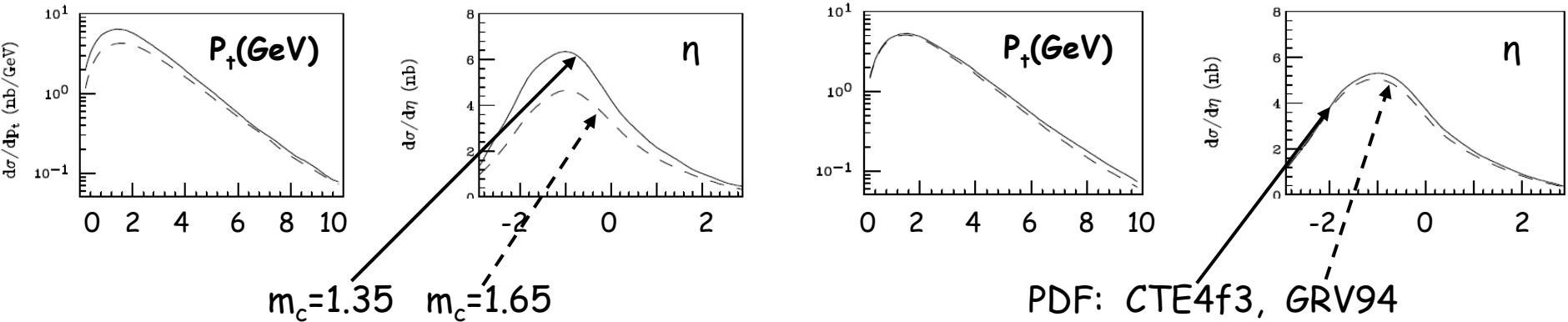
Example of  $F_2^c$  extracted from H1  $D^*$  cross sections (hep-ex/0701023)



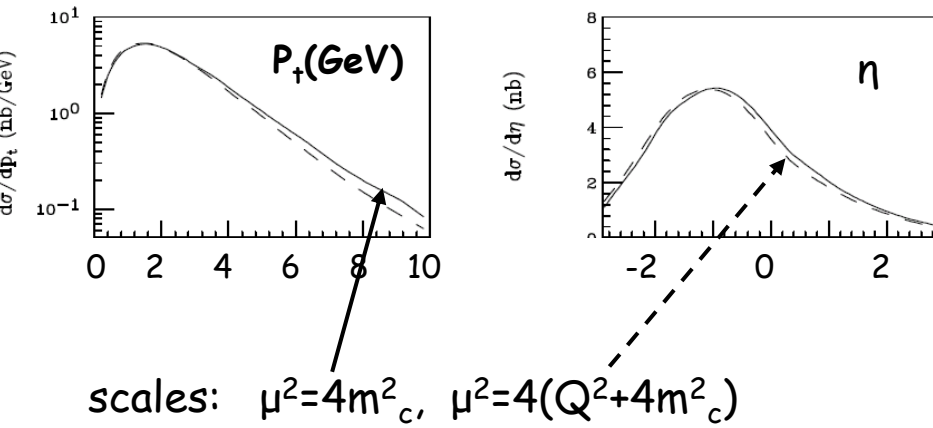
- experimental and model uncertainties of similar size
  - model uncertainties due to variation of  $m_c$  1.3-1.5 GeV, fragmentation (10%)
  - no scale variation
  - no extrapolation uncertainties
  - data compared to  $F_2^c$
- pdf: CTEQ5F3;  $m_c$  1.2-1.6 GeV

# From the cross section to $F_2^c$ : Extrapolation uncertainties

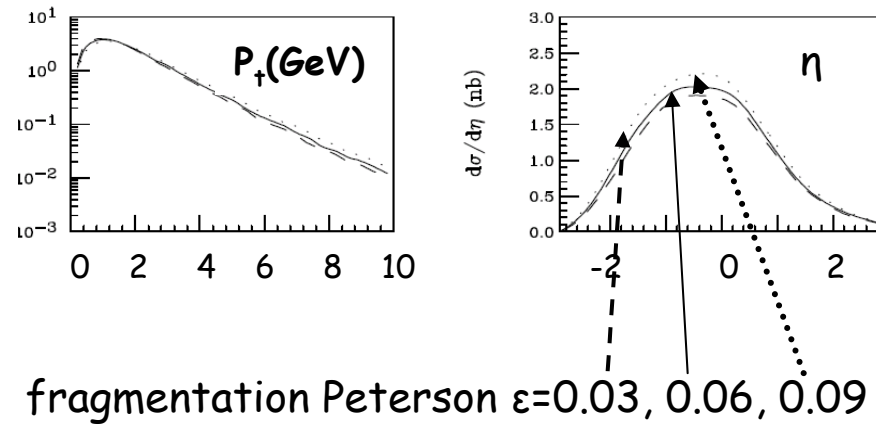
## Charm cross section: influence of $m_c$ , PDF



## charm cross section: varied scales



## visible $D^*$ cross section at HERA



# From the $D^*$ visible cross section to $F_2^c$

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## HERA I Analysis done : Problems

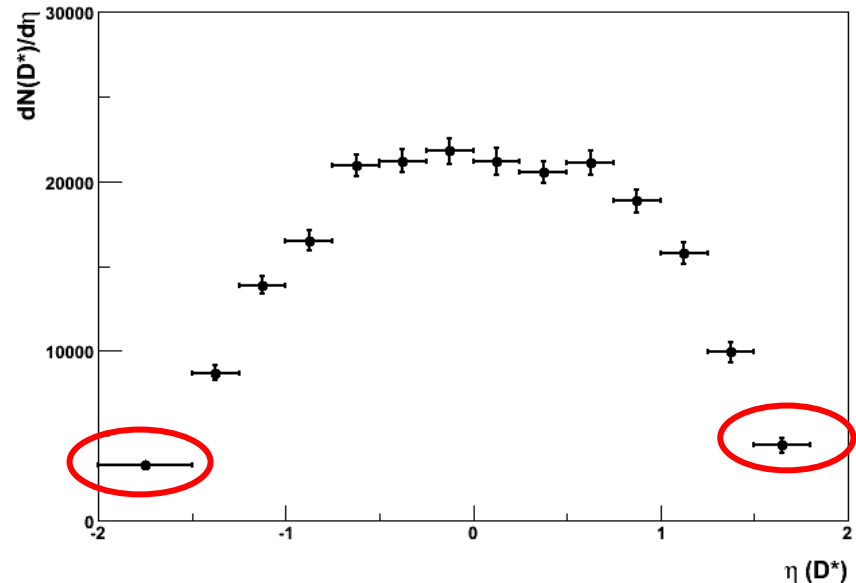
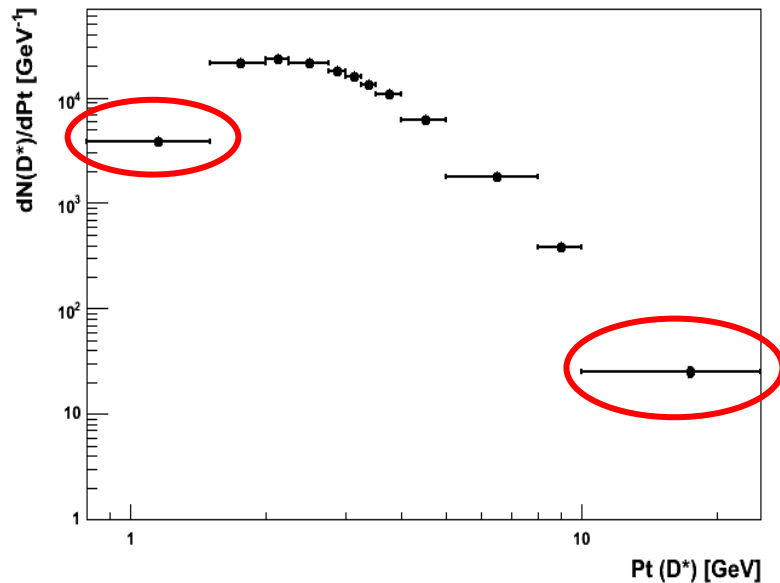
1. Large experimental uncertainties
2. Large extrapolation (only 30% of the full phase space is visible)
3. Large model uncertainties due to
  - charm mass
  - fragmentation
  - PDF
  - renormalization/factorization scales

## HERA II Analysis to come : Solutions

- 10 x statistics: a series of systematic studies allowed
- Detector upgrades: new phase space regions to explore
- Systematic studies on model parameters using data

# H1 $F_2^c$ prospects for HERA II

New phase space regions in  $p_T(D^*)$ ,  $\eta(D^*)$



HERA I  $|\eta| < 1.5$ ,  $p_T(D^*) > 1.5$  GeV, average extrapolation factor 3.4

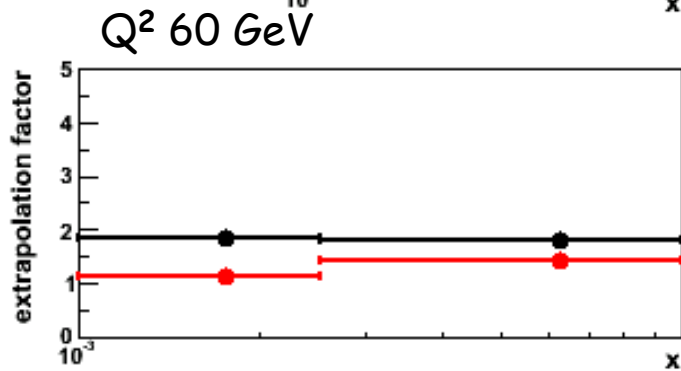
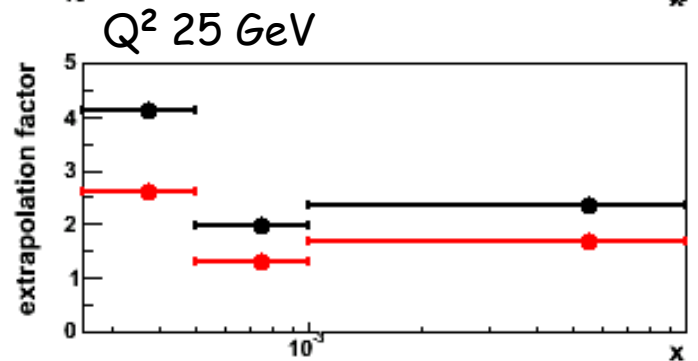
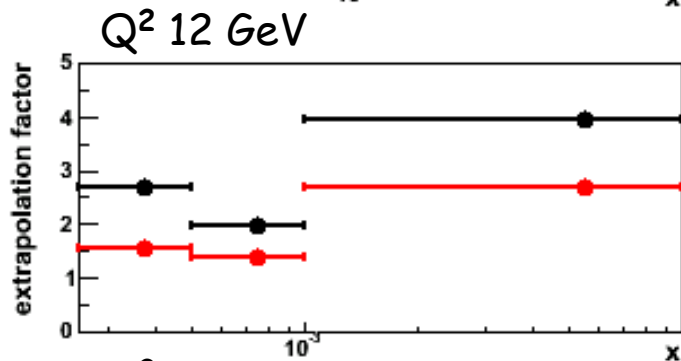
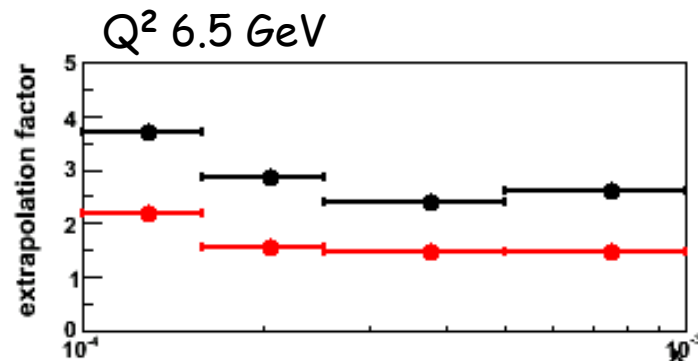
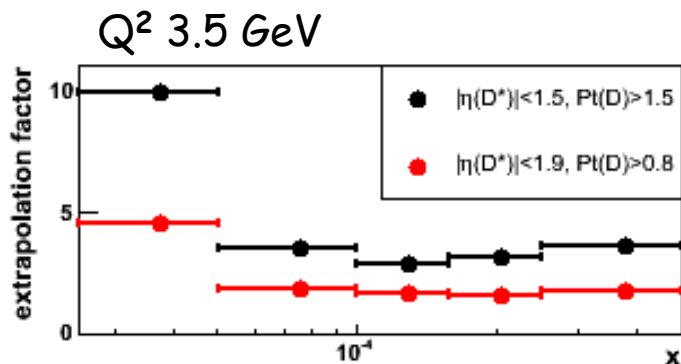
HERA II  $p_T(D^*) > 0.8$  GeV,  $|\eta| < 1.9$  (central detector) average extrapolation 1.9

+ Backward Silicon Tracker  $-2.75 < \eta < 1.9$  average extrapolation 1.6

Increase of visible range used in analysis from 30% to 60%

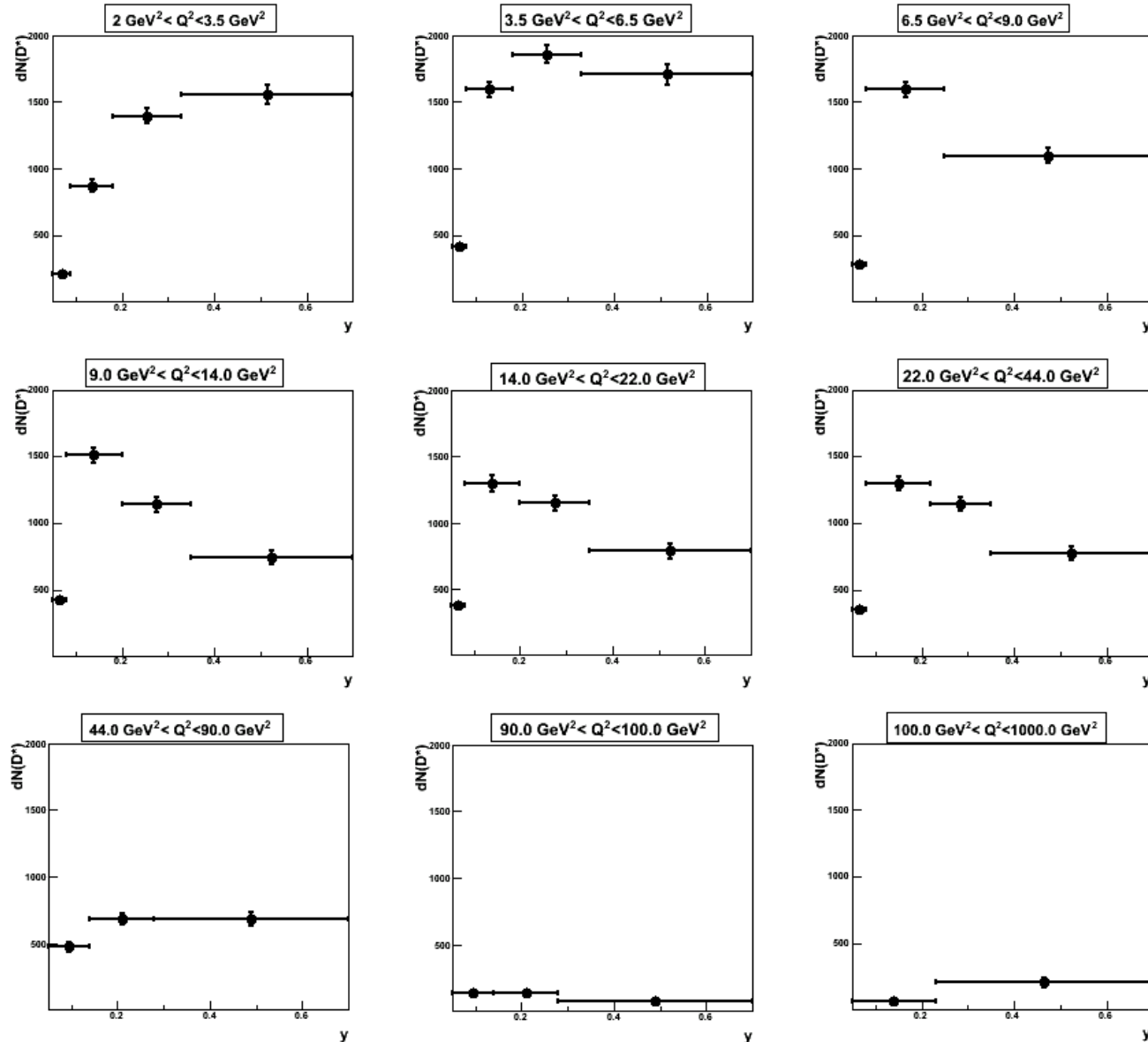


# $F_2^c$ prospects for HERA II: lower extrapolation



Much lower extrapolation at low  $Q^2$ , low  $x$   
( $Q^2, x$  bins from HERA I analysis)

# $F_2^c$ prospects for HERA II: finer binning



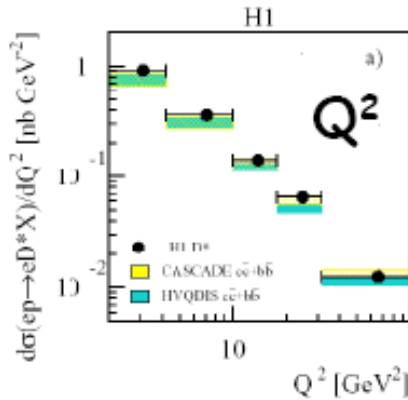
# Reduction of the model uncertainties: prospects

HERA I analysis: model uncertainties 10% : Studies by Karin Daum

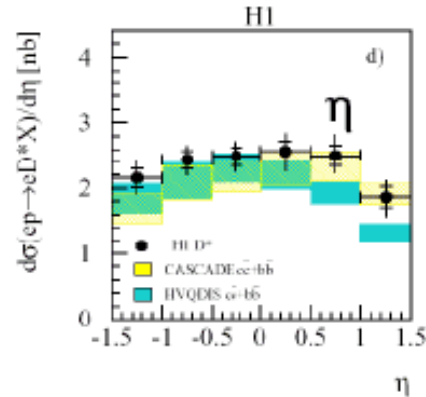
Use :

$$\sigma_{\text{vis}}(D^*)$$

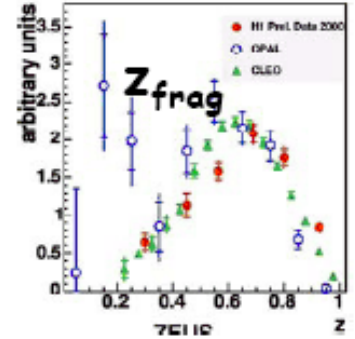
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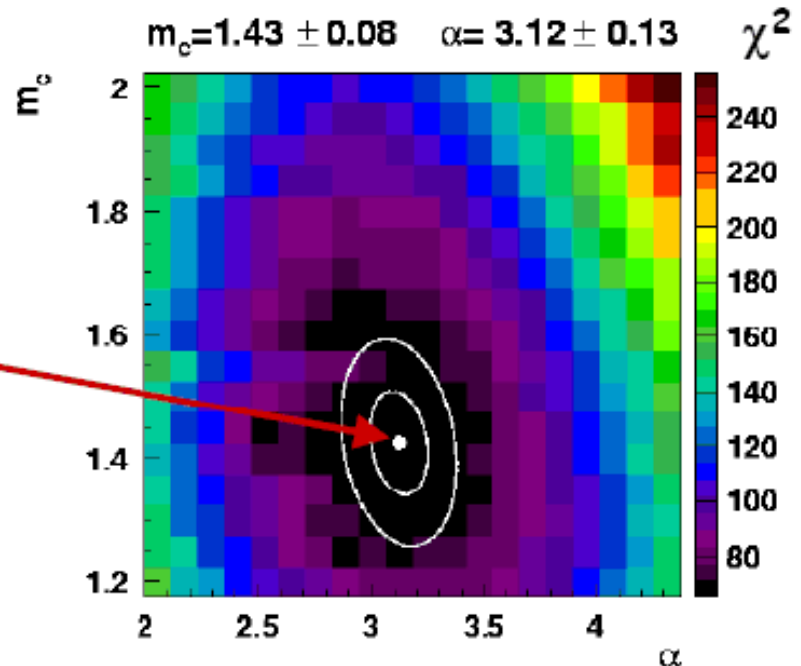


Do a fit in NLO (HVQDIS)

Get this

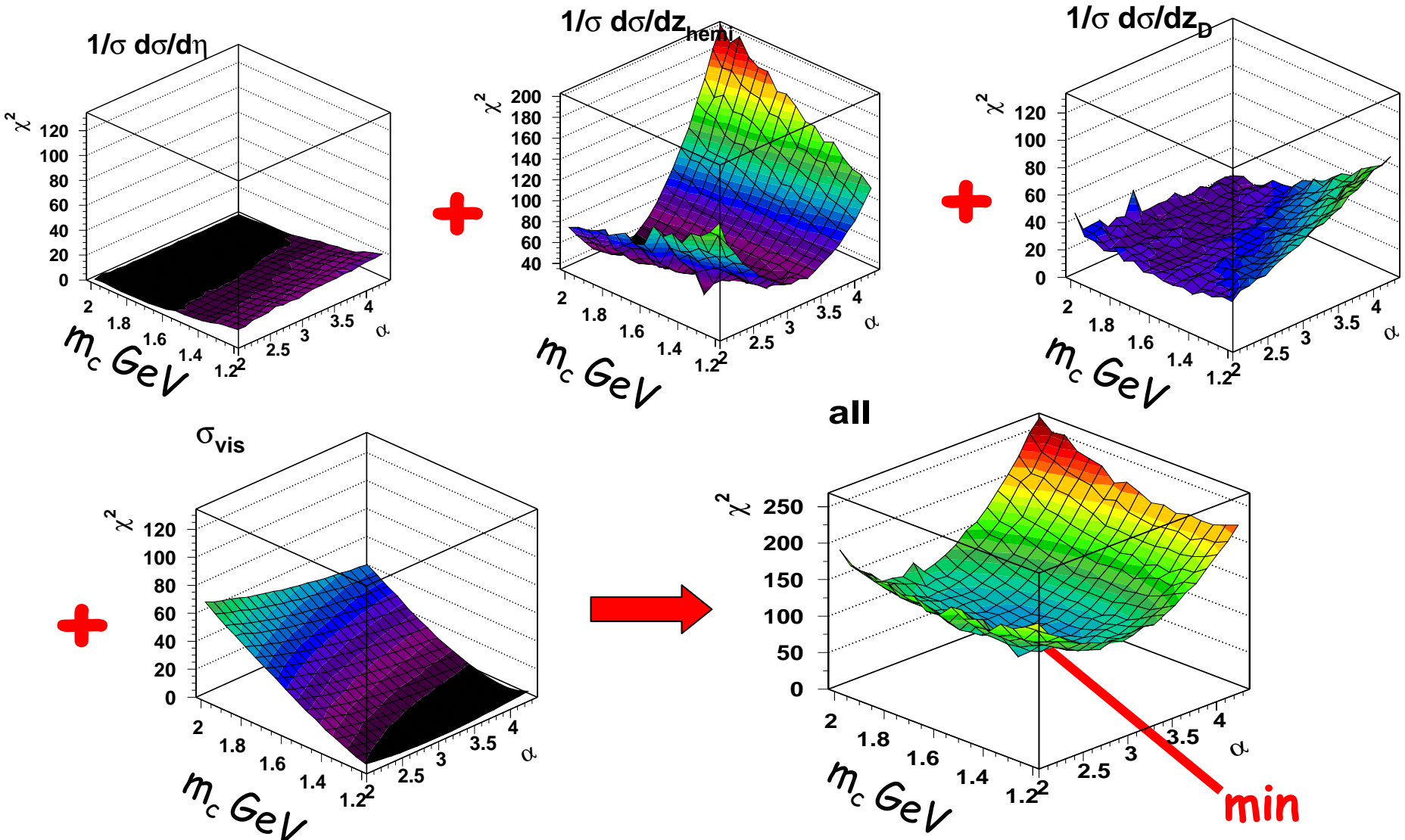
(3D fit:  $\mu_f = \mu_r$  in addition)

Example only, 200-250 pb<sup>-1</sup> assumed

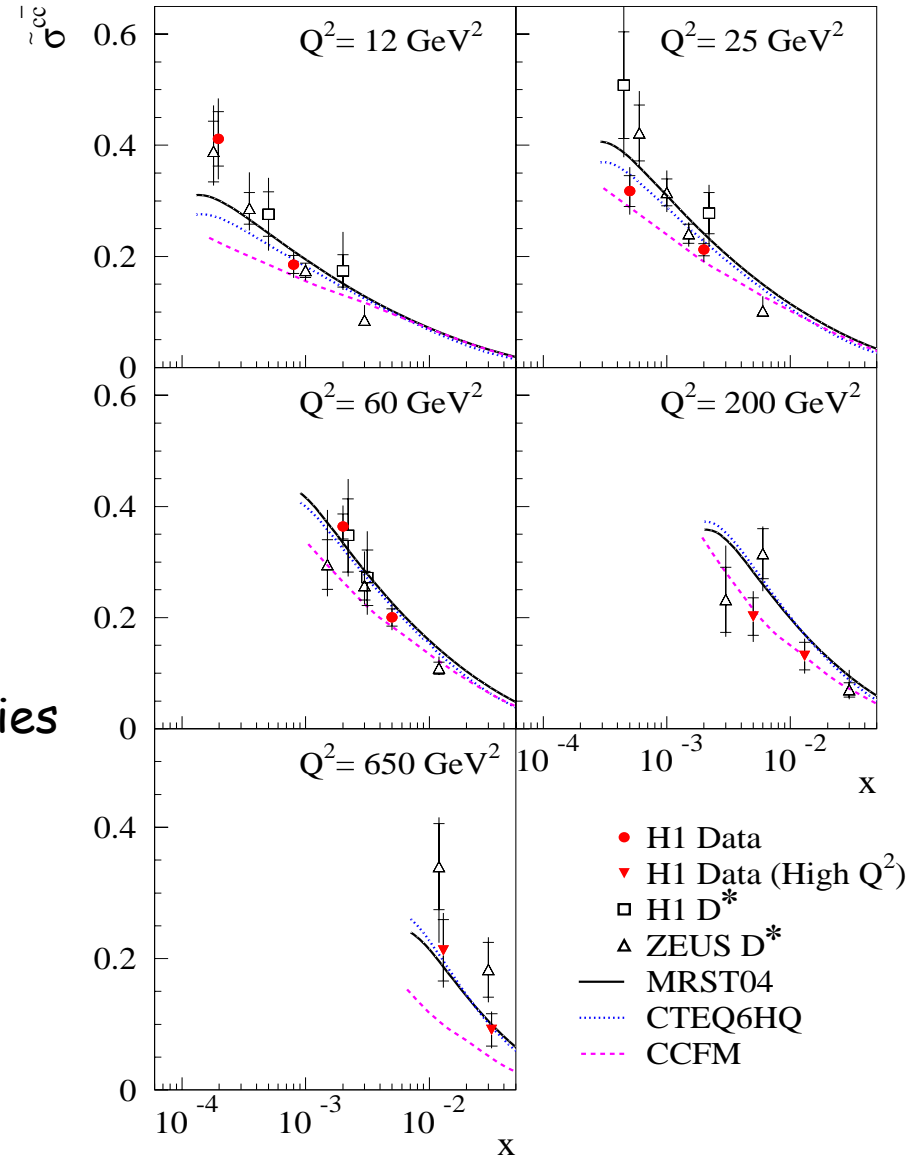
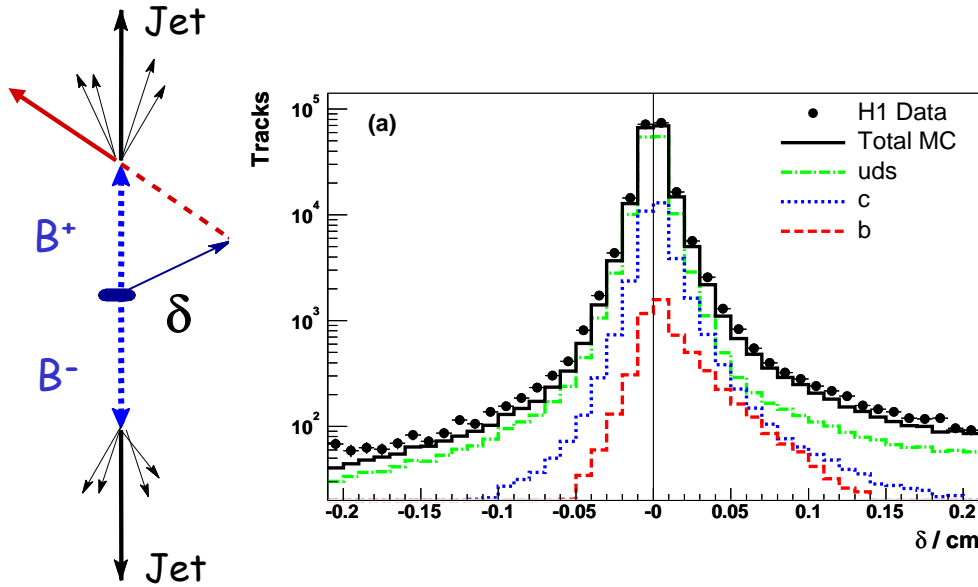


# HVQDIS fit to 3-fold cross sections

Studies by Karin Daum



# Open charm (beauty) tagging: Lifetime



Different extrapolation  
 Different sources of systematic uncertainties  
 Use as an alternative method  
 $F_2^c$  extracted with the same model  
 (presented last workshop)

# Outlook & Goals

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- high statistics and improved systematics at HERA 2
- studies of model parameters using data -
- constrain  $m_c$ , fragmentation in HVQDIS
- use lifetime tag as orthogonal method
- combine H1 and ZEUS data

➔ precision measurement of  $F_2^c$  at HERA  
include in a global Fit, extract  $g(x)$