From D* cross section to the F_2^c: extrapolation issues

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Experimental and theoretical issues

of open charm production at HERA.

Meeting 08 August 2008

$F_2^{c\bar{c}}$ extraction from D* cross sections

$$F_2^{c\bar{c}}(\exp) = \frac{\sigma_{vis}(\exp)}{\sigma_{vis}(theory)} F_2^{c\bar{c}}(theory)$$

Visible cross section: pt(D*)>1.5 GeV, |η(D*)|<1.5

Problem: detector sees only 30% of the phase space for c→D*

→ strong model dependence due to large extrapolation factors

Extrapolation problems:

1) Different extrapolation models

2) Unknown parameters within a single model: extrapolation errors

Extrapolation problem 1: different models

Extrapolation Models:

- NLO: Riemersma et al: integrated form; HVQDIS: differential form,
  fixed order massive calculation, Nf=3, FFNS, evolution: DGLAP

- CASCADE: massive LO ME + Parton showers,
  proton structure: gluons only, evolution: CCFM

Model parameters

HVQDIS:

PDFs: MRST04F3, m_c = 1.43 GeV , $\mu_r=\mu_f=\mu=\sqrt{Q^2+4m_c^2}$

Fragmentation:

shat-dependent fragmentation (talk by Karin Daum):

$\hat{s}<70$ GeV^2: α_{Kart} =6.0, otherwise α_{Kart}=3.3

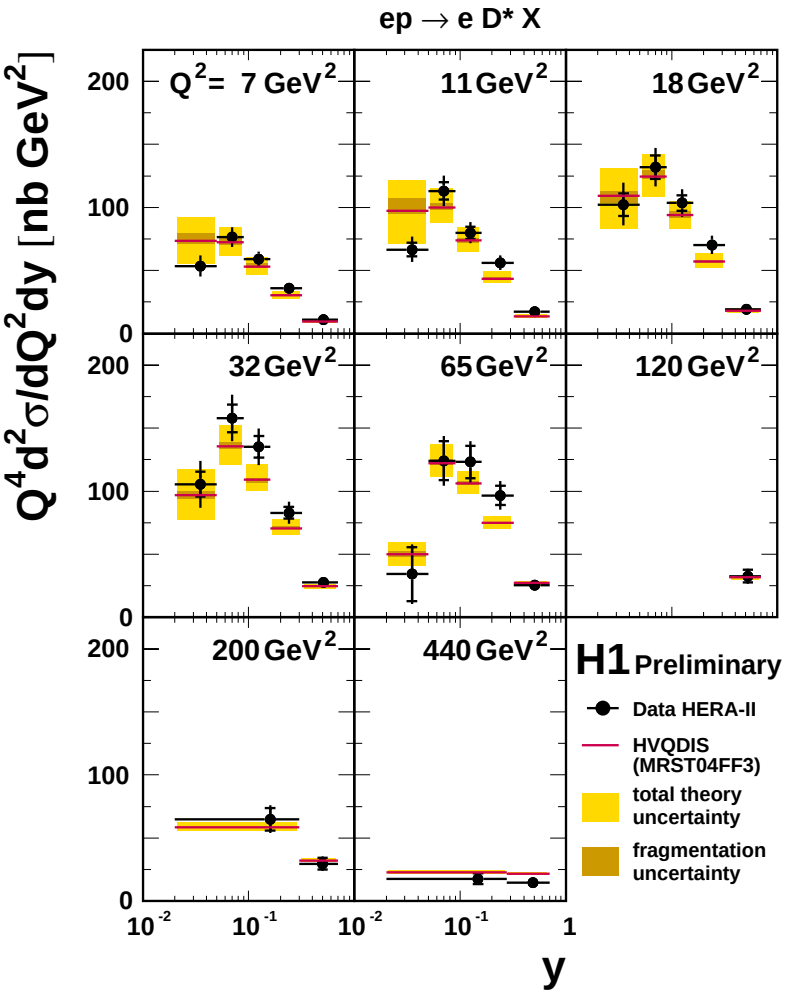
CASCADE:

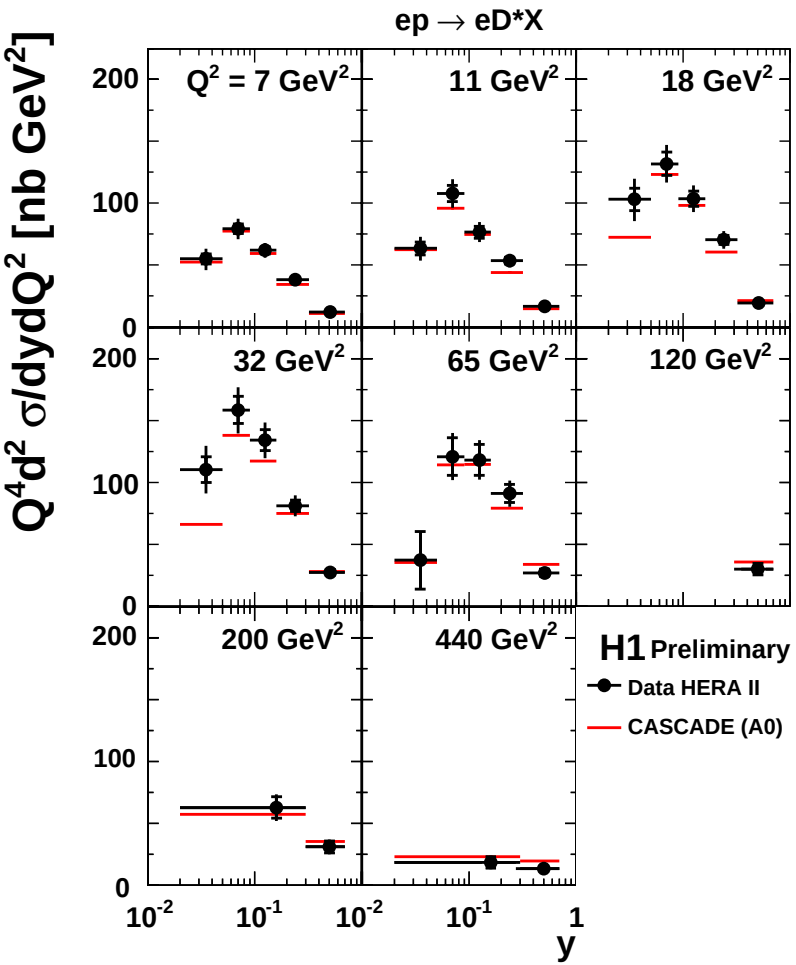
PDFs: A0, m_c = 1.43 GeV, $\mu_r=\mu_f=\mu=\sqrt{Q^2+4m_c^2}$

Fragmentation:

$\hat{s}<70$ GeV^2; α_{Kart} = 8.2, otherwise α_{Kart} = 4.3

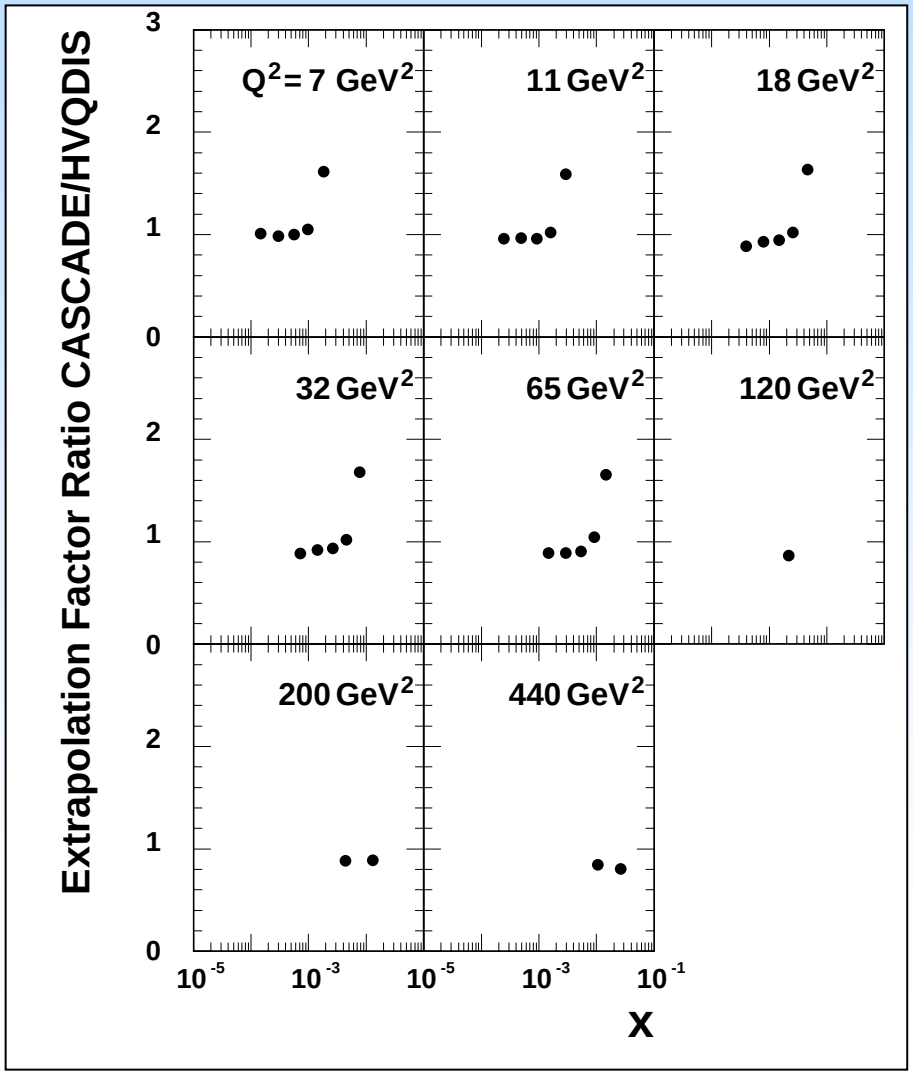
Cross sections vs NLO and CASCADE





Lowest y (highest x) overestimated by NLO, underestimated by CASCADE

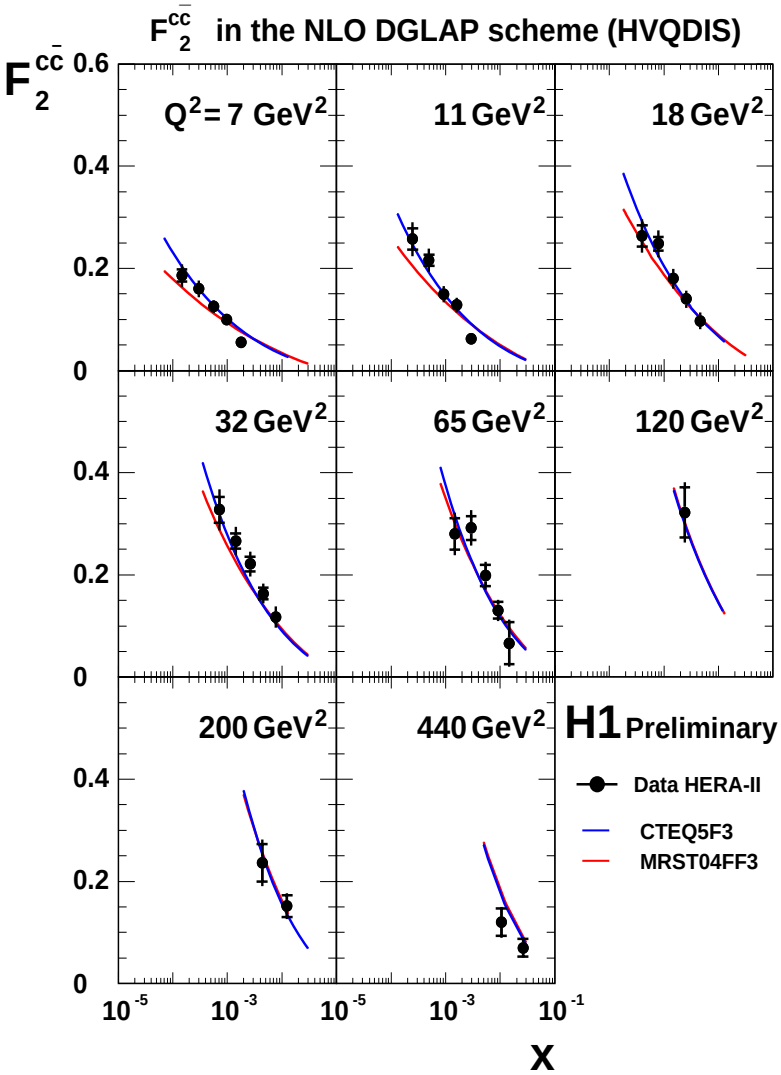
Extrapolation factors: NLO and CASCADE

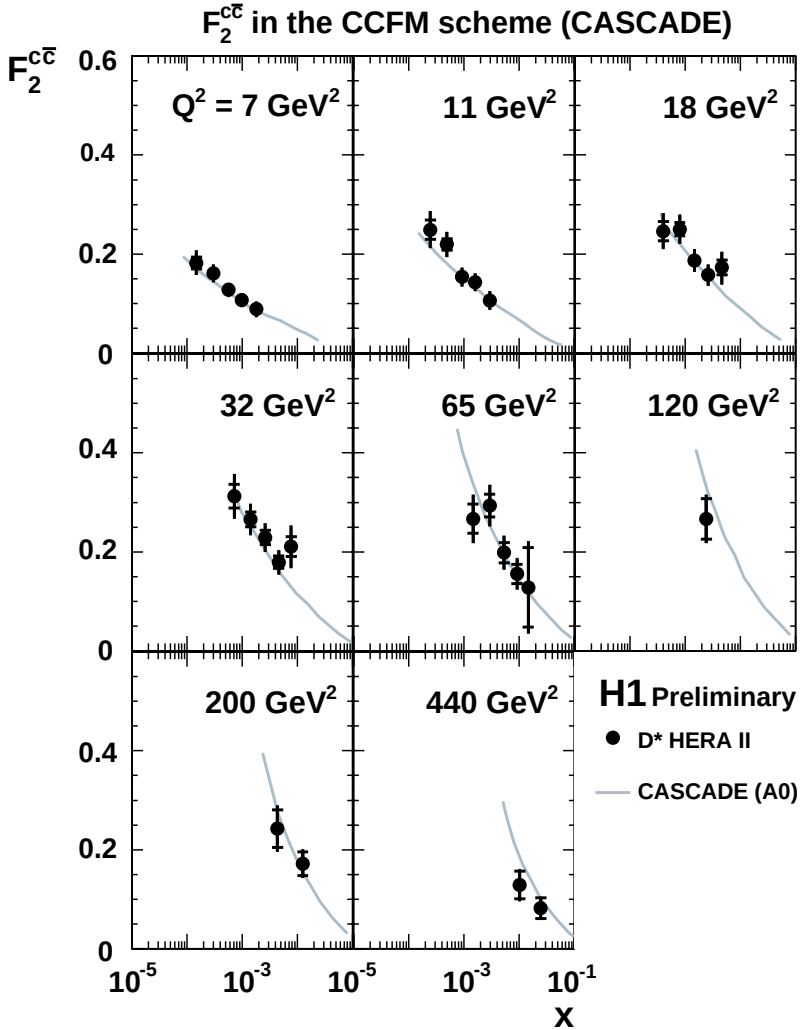


Extrapolation factors ($\sigma_{tot}/\sigma_{vis}$) differ in NLO vs CASCADE:

30% (low x) -100% (high x)

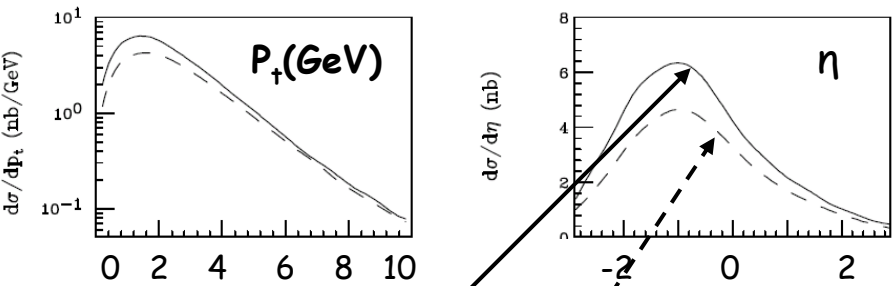
H1 Preliminary: 2 results on F_2^c



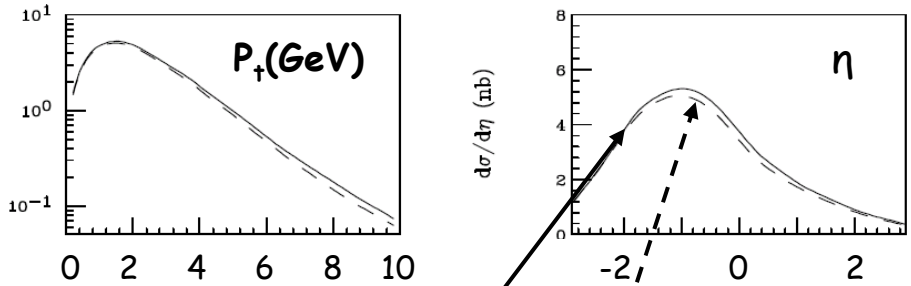


Extrapolation of D* cross section to F2c

Extrapolation Problem 2: unknown model parameters

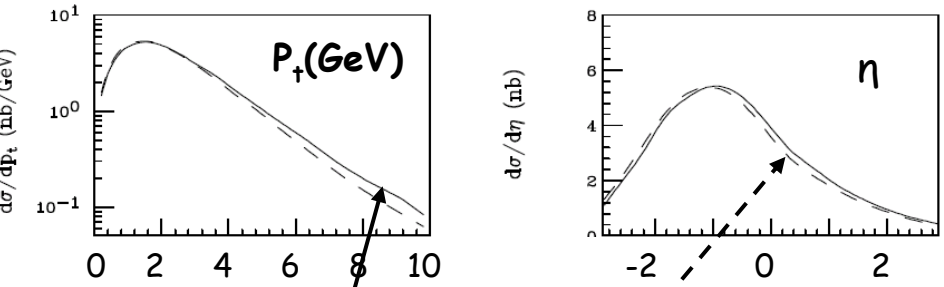


m_c=1.35 m_c=1.65



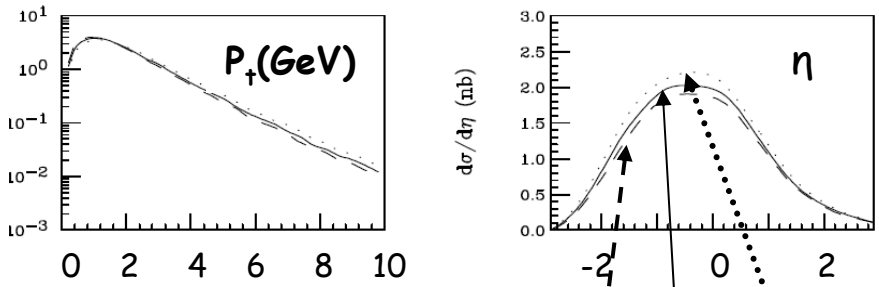
PDF: CTE4f3, GRV94

charm cross section: varied scales



scales: $\mu^2=4m_c^2$, $\mu^2=4(Q^2+4m_c^2)$

visible D* cross section at HERA



fragmentation Peterson ε=0.03, 0.06, 0.09

m_c, scales, pdf, fragmentation change both normalization and the shape of kinematics!

Extrapolation uncertainty: workaround

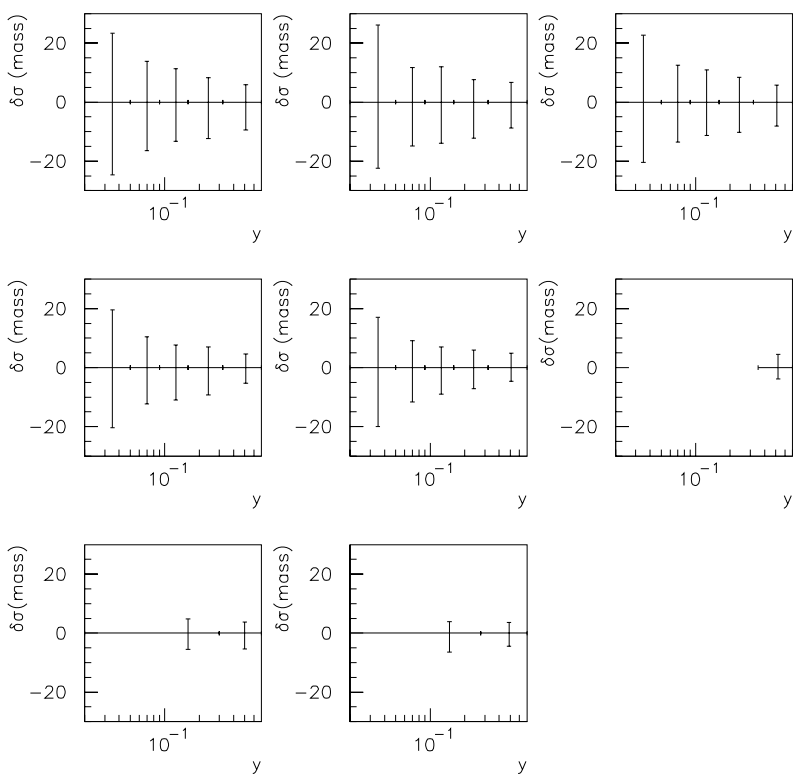
Idea:

estimate the extrapolation uncertainty via variation of model parameters

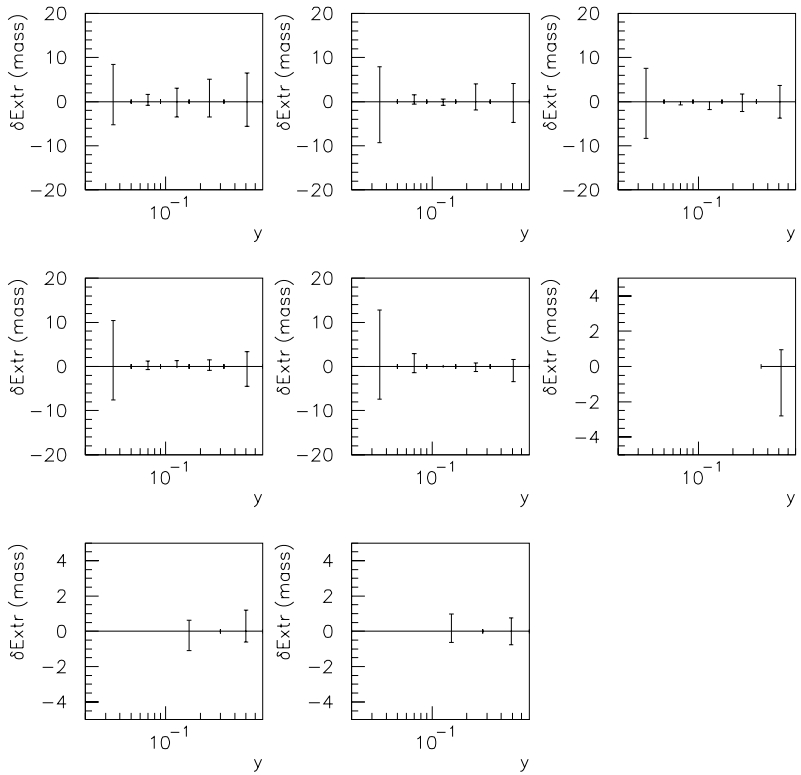
- charm mass: $1.3 < mc < 1.6$ GeV
- renormalization/factorization scales:
  - simultaneously $0.5\ \mu < \mu_r = \mu_f < 2\ \mu$
  - independent $0.5\ \mu < \mu_r, \mu_f < 2\ \mu$, $0.5 < \mu_r / \mu_f < 2$
- fragmentation model (s-dependent Kartwelishvili parameterization):
  - variation of $\hat{s}$ – cut off
  - variation of α_{Kart}
- Vary PDF

Variation of the charm mass in NLO

relative error on the cross section



relative error on the extrapolation: F^c_2/σ_{vis}

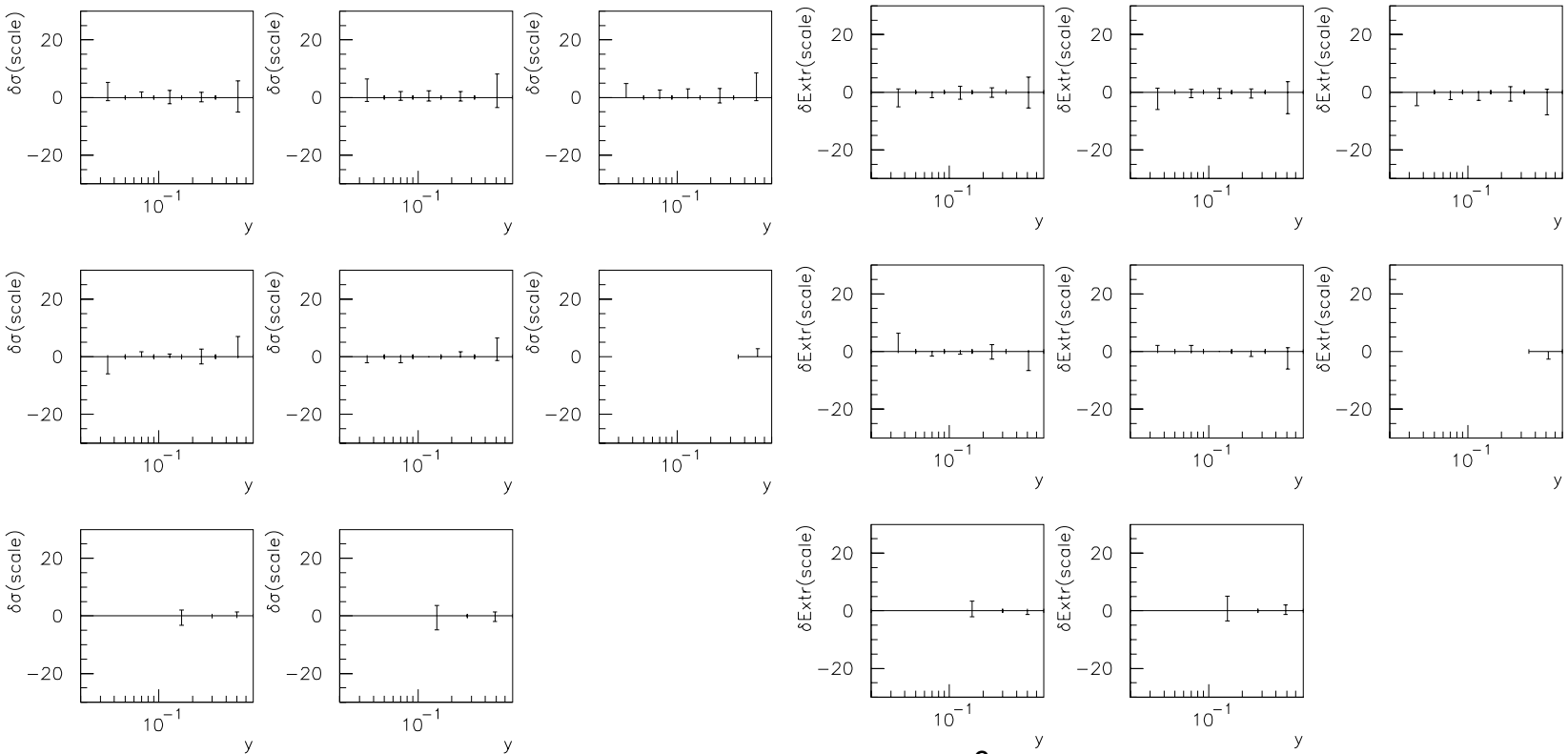


Most differences due to mass variation in σ_{vis} and F^c_2(NLO) cancel in the ratio

Variation of the scales in NLO, $\mu_r=\mu_f$

relative error on the cross section

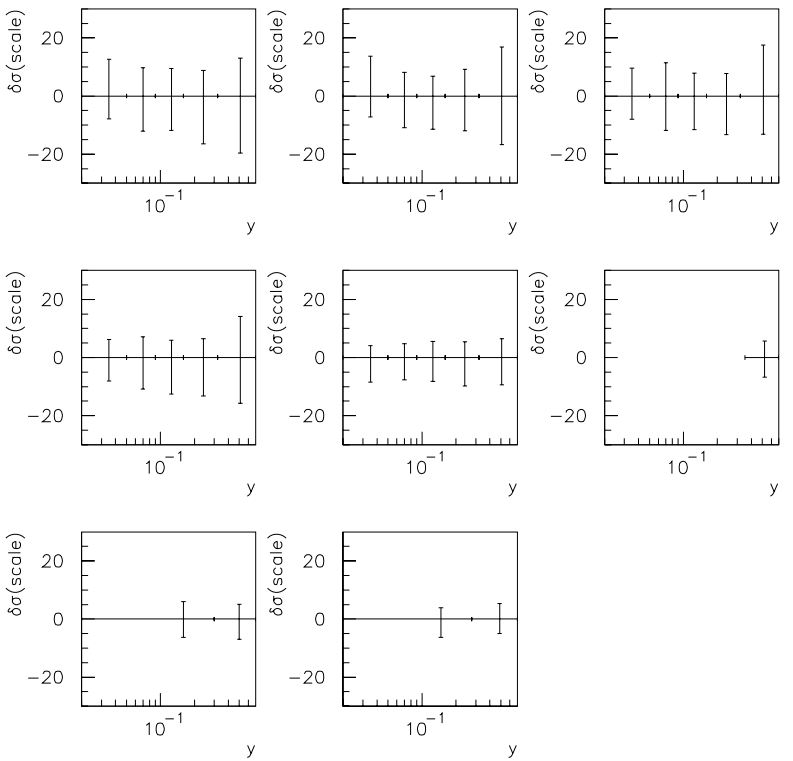
relative error on the extrapolation: F^c_2/σ_{vis}



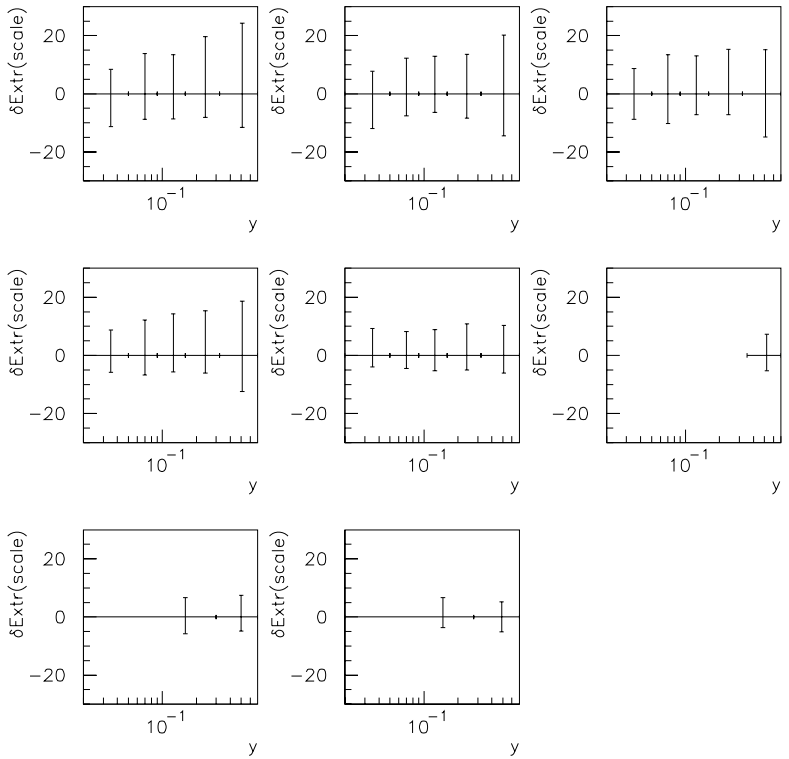
Differences due to scale variation in σ_{vis} and F^c_2(NLO) don't cancel in the ratio but are rather small

Variation of the scales in NLO, $\mu_r \neq \mu_f$

relative error on the cross section



relative error on the extrapolation: F^c_2/σ_{vis}



Differences due to scale variaton in σ_{vis} and F^c_2(NLO) don't cancel in the ratio

large uncertainties up to 20%

Variation of mass and the scales in NLO

Warning 1:

- Varying m_c the gluon distribution should be also changed
- Workaround (plans):
  - Get (appropriate for the used model!) PDFs @ variable m_c
  - Fit NLO @ variable m_c to the data

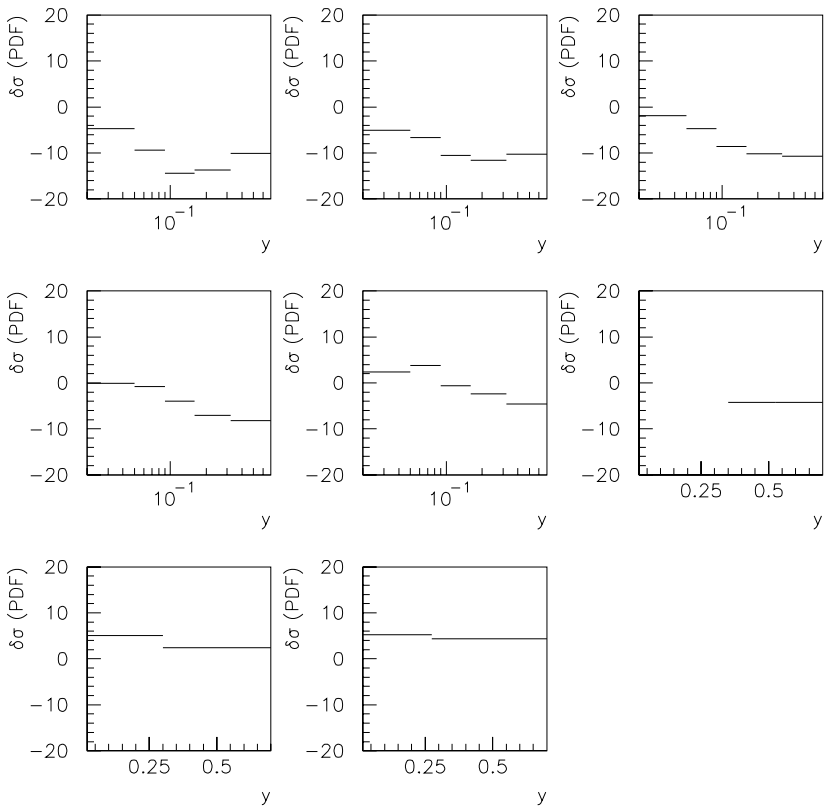
Warning 2:

Not yet proved that the scales indeed treated (technically) independent

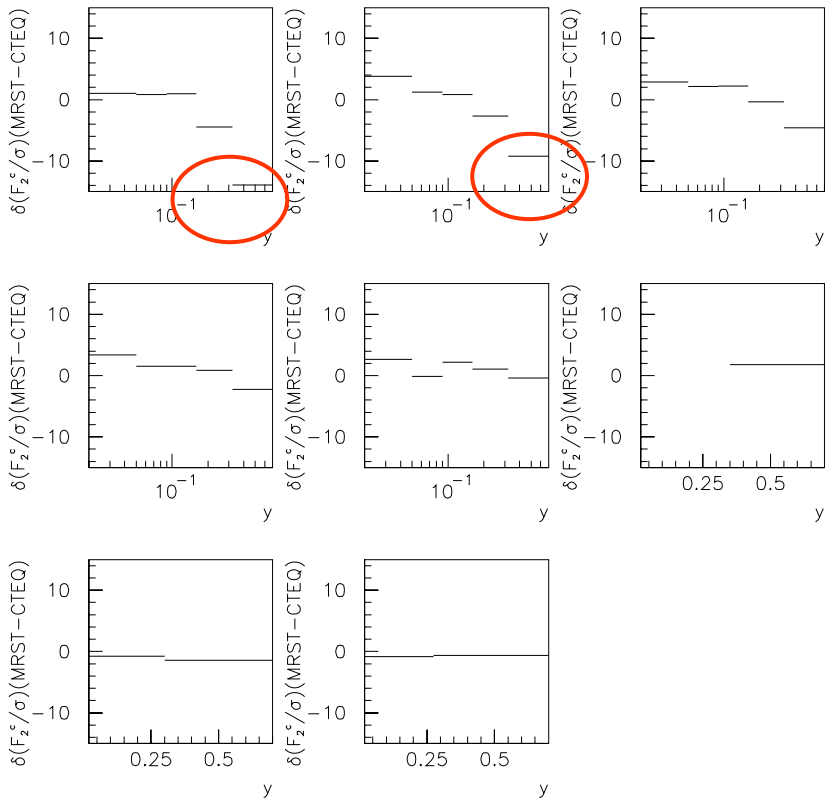
- To be checked!

Variation of the PDF: mrst vs cteq

relative error on the cross section



relative error on the extrapolation: F^c_2/σ_{vis}



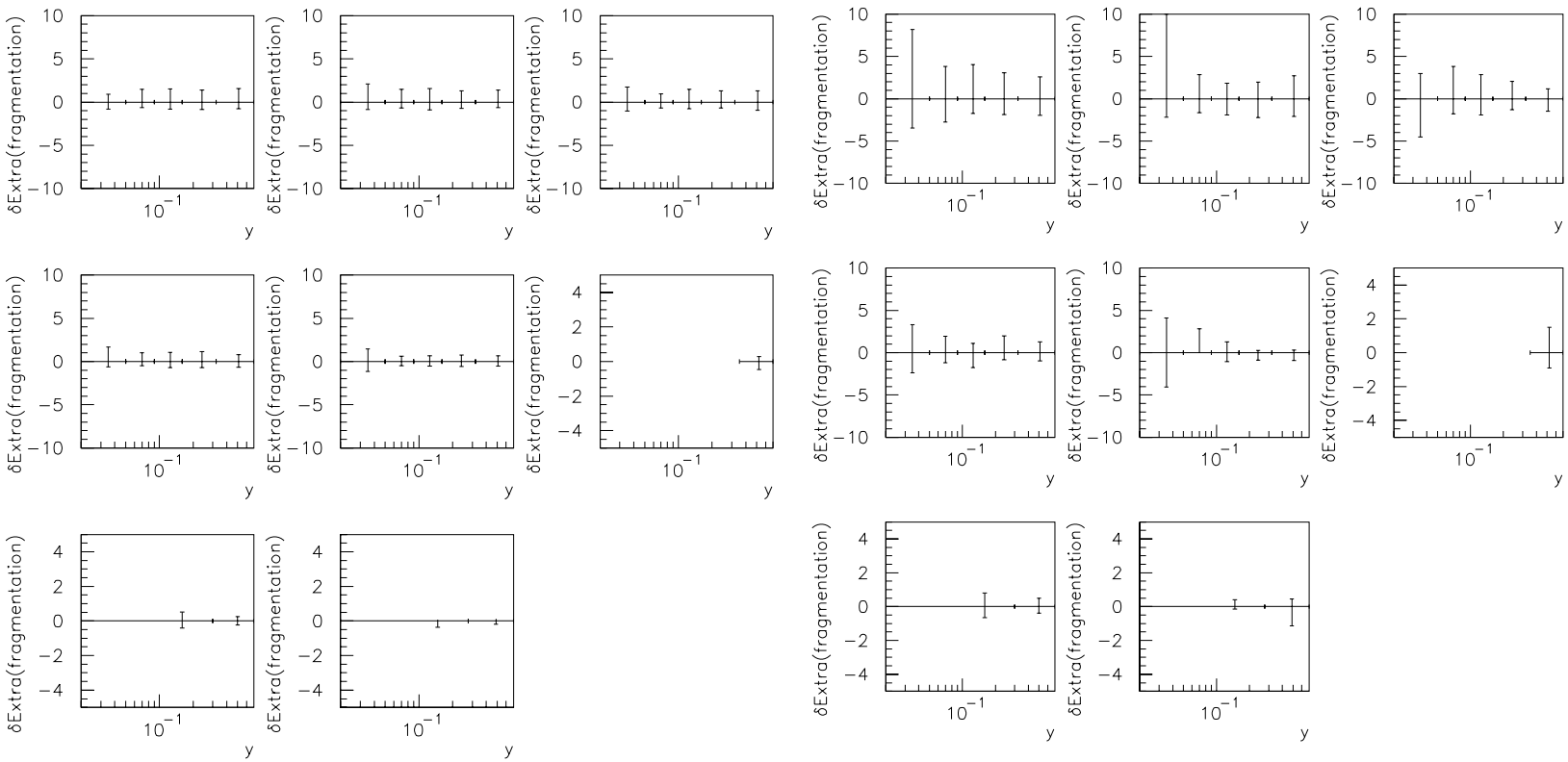
F^c_2: sizable differences only at low Q^2 & low x – 2 bins, in average 2%

Uncertainties on the fragmentation in NLO

Extrapolation uncertainty due to fragmentation model

variation of cross over in $\hat{s}$

variation of α_{Kart}



Significant uncertainty due to the fragmentation model

Discussion

Experimental measurements of D* cross section get very precise

Extrapolation to the full phase space model dependent

Model uncertainties larger than experimental errors

Experimental needs: to come in the next 2-3 years

- Enlarge phase space: possible at H1
- Decrease experimental uncertainty (combination of different methods)

Theory needs:

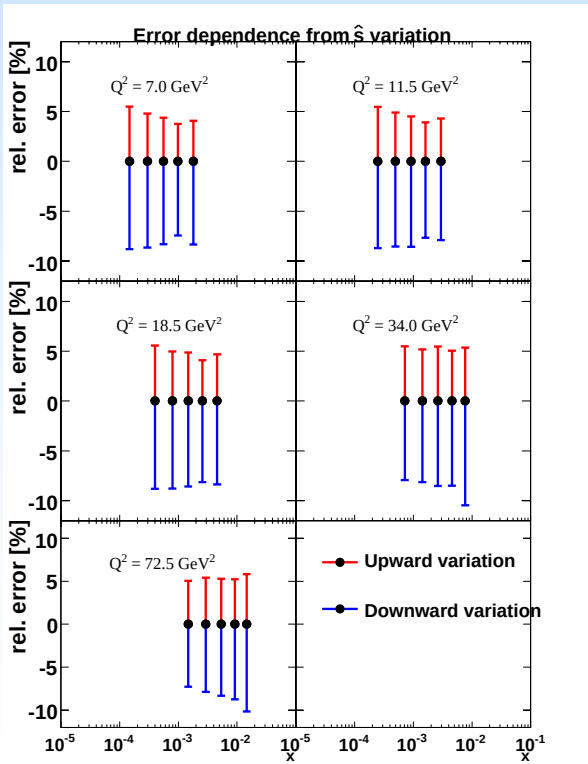
- Proper theory (treatment):
  - Consistent parameters in the models
  - NLO + PS : MC@NLO – to come in the next 1-2 years, GMVFNS?
  - NNLO?
  - NLO vs PS, Fragmentation : Workshop in November at DESY

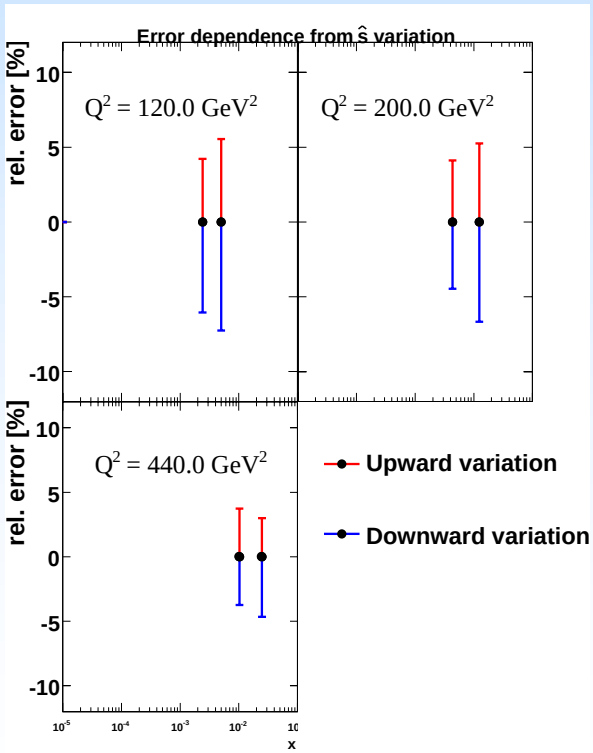
BACKUP

Fragmentation uncertainties (CASCADE)

Fragmentation model: $s<70\ \mathrm{GeV}^2$; $\alpha = 8.2$, otherwise $\alpha = 4.3$,

Uncertainties in the extrapolation: cross over varied by ± 20 GeV^2

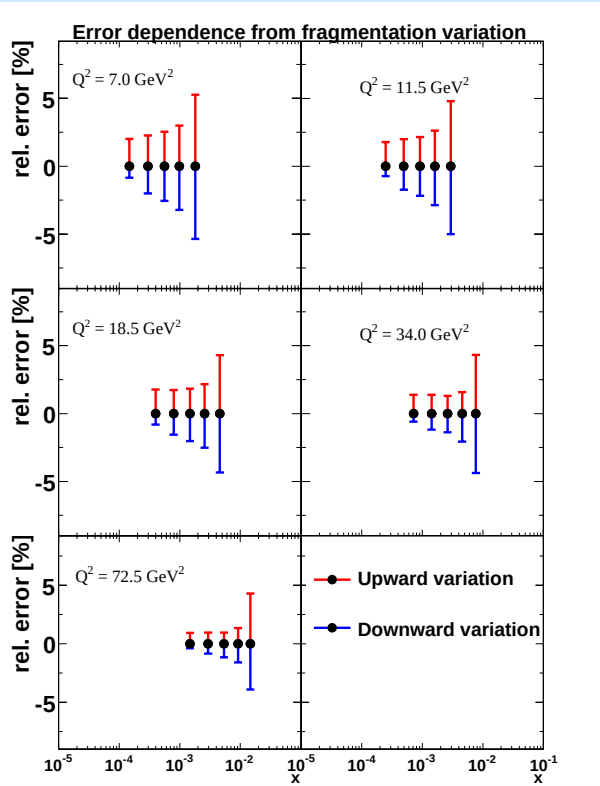


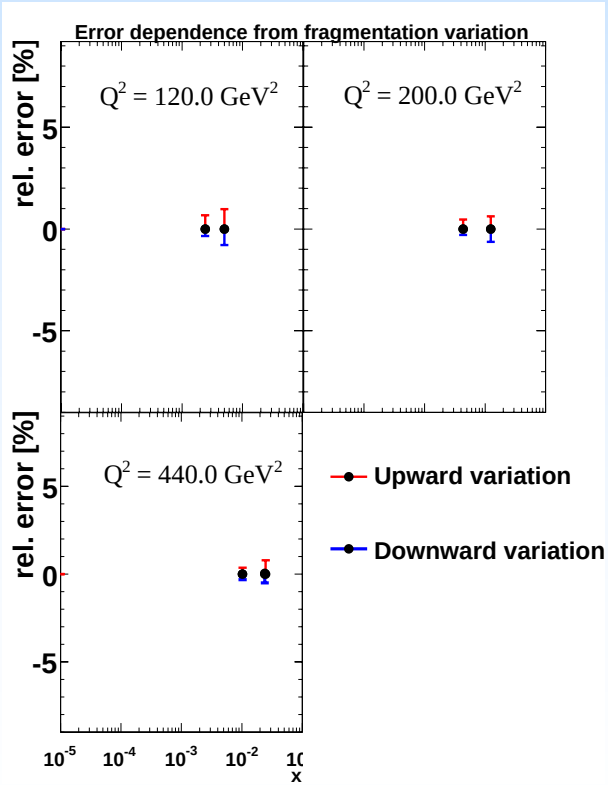


Fragmentation uncertainties (CASCADE)

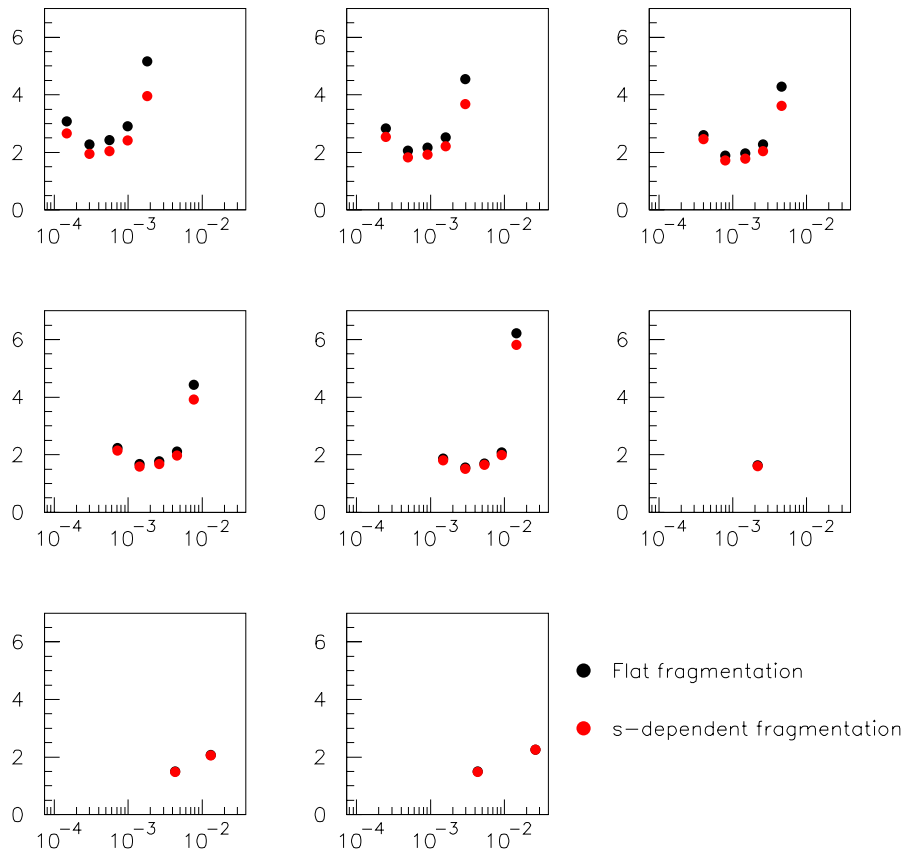
Fragmentation model: s<70 GeV^2; α = 8.2, otherwise α = 4.3,

Uncertainties in the extrapolation: variation of α

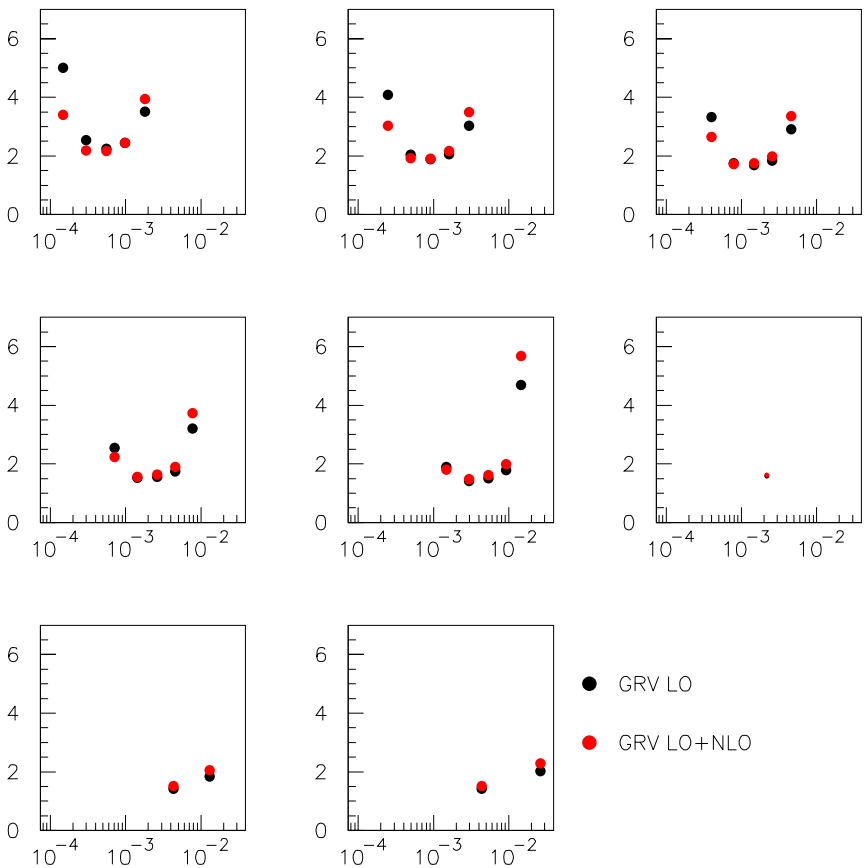




Extrapolation factors in HVQDIS

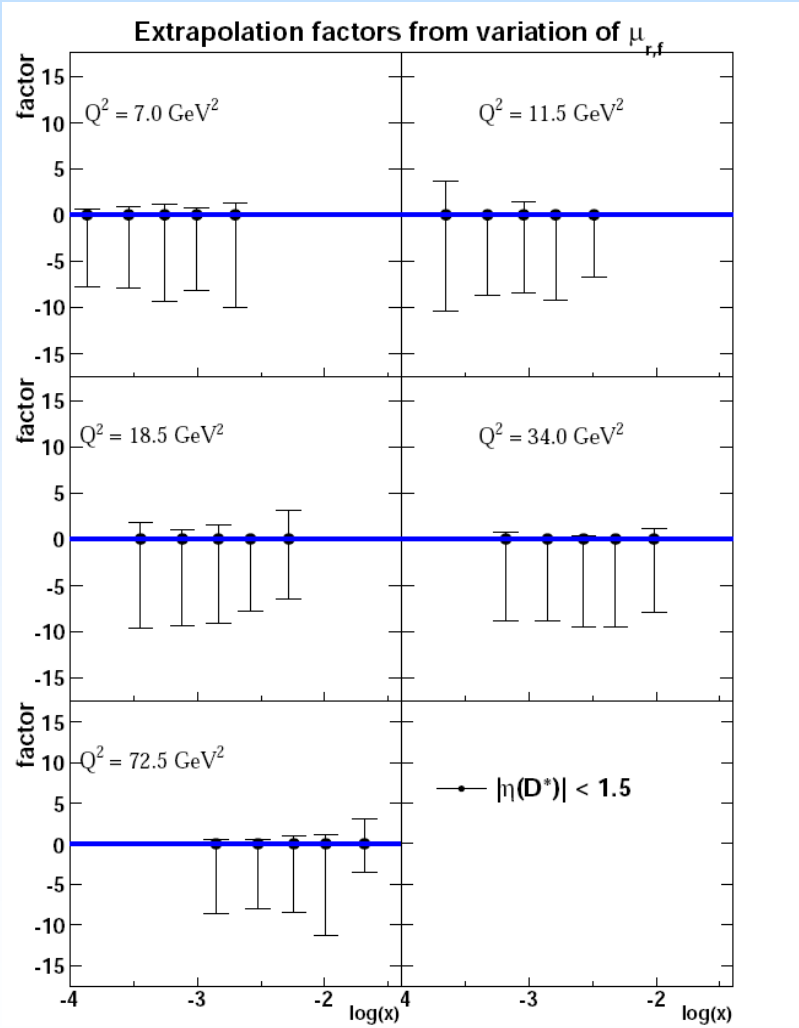


Extrapolation factors in HVQDIS

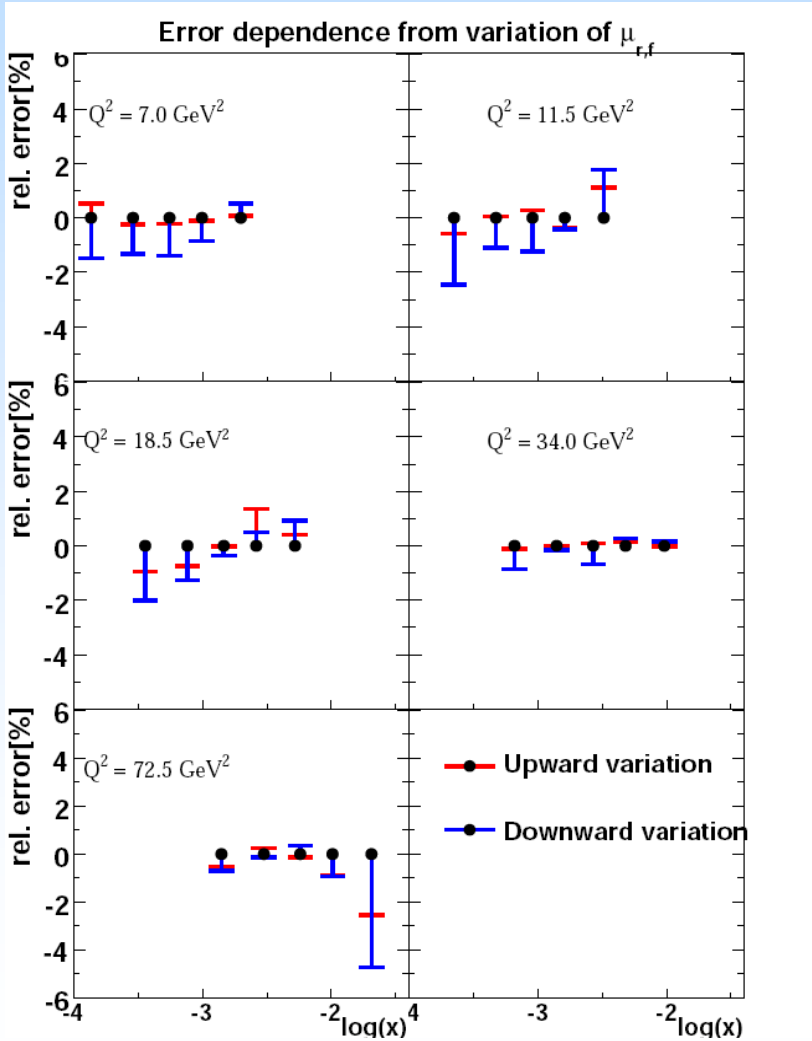


Scale variations in Cascade

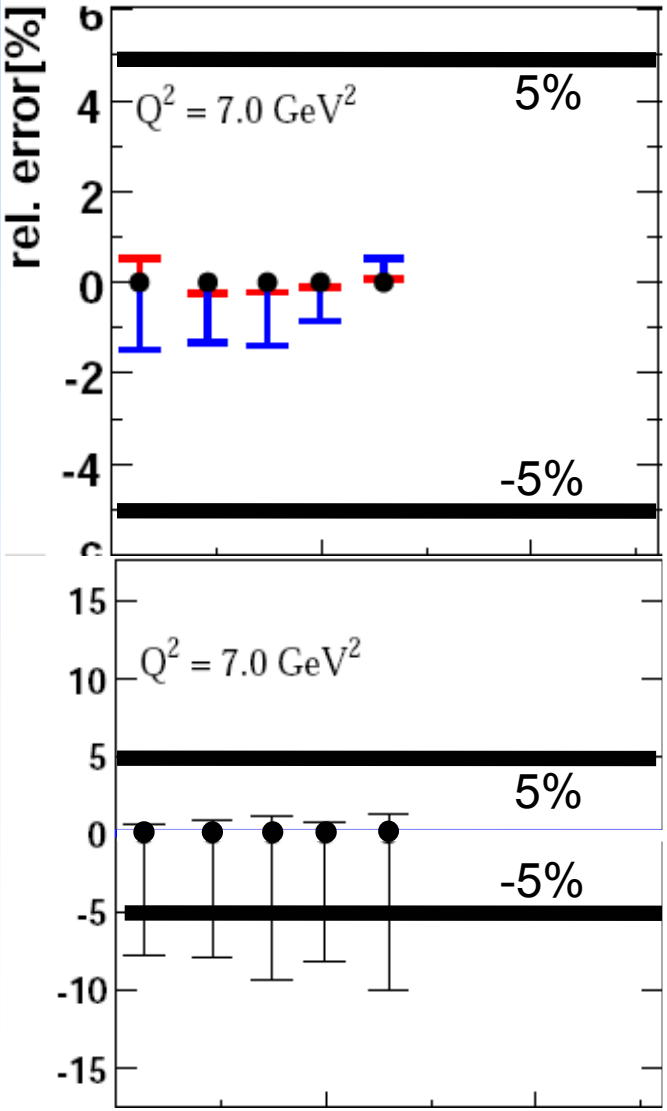
$0.5 < \mu_r/\mu_0 < 2$ same PDF A0



$0.5 < \mu_r/\mu_0 < 2$, appropriate PDFs



Scale variations in Cascade



Using wrong PDF leads to wrong uncertainties:

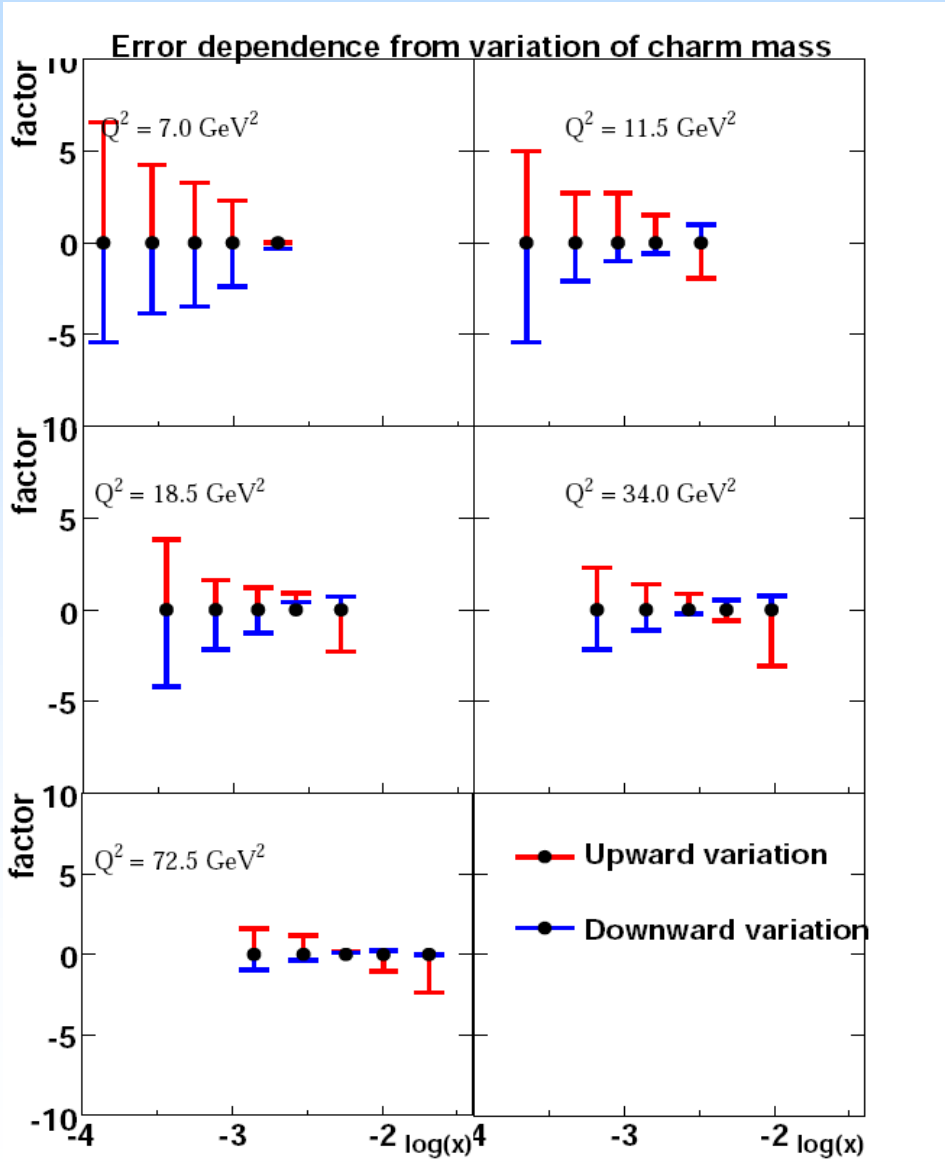
Overestimated by a factor of 5!

Recall mass/scale variations in HVQDIS:

don't have appropriate PDFs:

- expect large mass effects
- possible inconsistencies in μ_r

Mass variations in Cascade



Same mass variation:

$1.3 < m_c < 1.6$ GeV

Smaller uncertainty