DIS 2005, Madison Wisconsin, 1 May 2005

Summary of Heavy Flavour WG

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R. Thorne: VFNS at NNLO

One more problem in defining VFNS. Ordering for $F_2^H(x,Q^2)$ different for n_f and n_f+1 regions.

	n_f-flavour	n_f+1-flavour
LO	$\frac{\alpha_S}{4\pi} C^{FF,1}_{2,Hg} \otimes g^{n_f}$	$C^{VF,0}_{2,HH} \otimes (h+\bar{h})$
NLO	$\left(\frac{\alpha_S}{4\pi}\right)^2 (C^{FF,2}_{2,Hg} \otimes g^{n_f} + C^{FF,2}_{2,Hq} \otimes \Sigma^{n_f})$	$\frac{\alpha_S}{4\pi}(C^{VF,1}_{2,HH} \otimes (h+\bar{h}) + C^{FF,1}_{2,Hg} \otimes g^{n_f+1})$
NNLO	$\left(\frac{\alpha_S}{4\pi}\right)^3 \sum_i C^{FF,3}_{2,Hi} \otimes f_i^{n_f}$	$\left(\frac{\alpha_S}{4\pi}\right)^2 \sum_j C^{VF,2}_{2,Hj} \otimes f_j^{n_f+1}$.

Switching direct from fixed order to same order when going from n_f to $nf+1$ flavours $\longrightarrow$ discontinuity.

Must make some decision how to deal with this.

Up to now ACOT have used e.g.

NLO $\quad \frac{\alpha_S}{4\pi} C^{FF,1}_{2,Hg} \otimes g^{n_f} \rightarrow \frac{\alpha_S}{4\pi}(C^{VF,1}_{2,HH} \otimes (h+\bar{h}) + C^{FF,1}_{2,Hg} \otimes g^{n_f+1})$,

i.e., same order of α_S above and below.

But LO evolution below and NLO evolution above. Slope discontinuous.

TR have used e.g.

LO
$$\frac{\alpha_S(Q^2)}{4\pi} C^{FF,1}_{2,Hg}(Q^2/m_H^2) \otimes g^{n_f}(Q^2) \rightarrow \frac{\alpha_S(M^2)}{4\pi} C^{FF,1}_{2,Hg}(1) \otimes g^{n_f}(M^2)$$
$$+ C^{VF,0}_{2,HH}(Q^2/m_H^2) \otimes (h+\bar{h})(Q^2),$$

i.e. freeze higher order α_S term when going upwards through $Q^2 = m_H^2$.

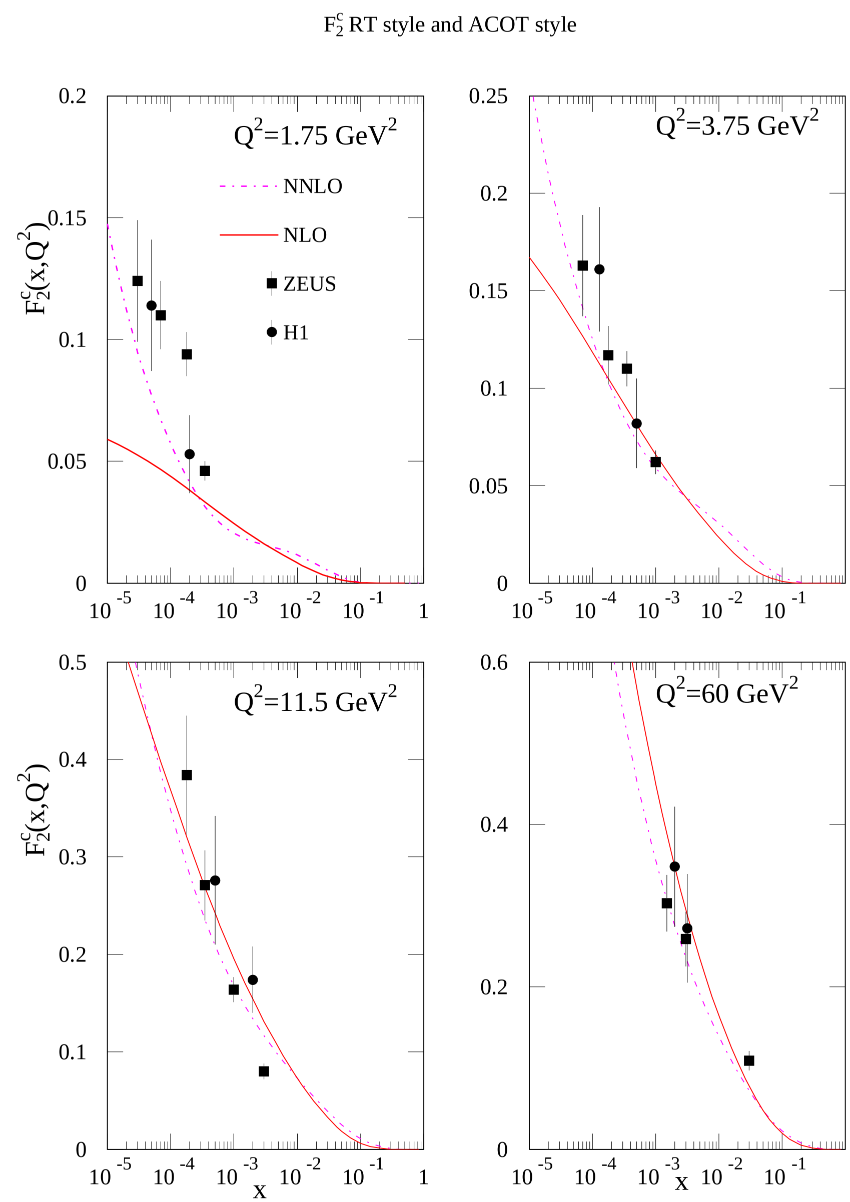
This difference in choice is extremely important at low Q^2 (if using $\mu^2 = Q^2$).

Can produce full NNLO predictions for charm with discontinuous partons, but continuous $F^H(x, Q^2)$.

Approximation in $\mathcal{O}(\alpha_S^3)$ heavy flavour coefficient functions for $Q^2 \leq m_H^2$ and frozen for $Q^2 > m_H^2$.

Results not very sensitive to choices in this, within sensible range.

Clearly improves match to lowest Q^2 data, where NLO always too low.



F. Olness: CTEQ HQ pdf

How do we deal with multiple scales???

Problem: Heavy Quark introduces new scale: $\log(\frac{Q^2}{\mu^2})$ $\log(\frac{M_H^2}{\mu^2})$

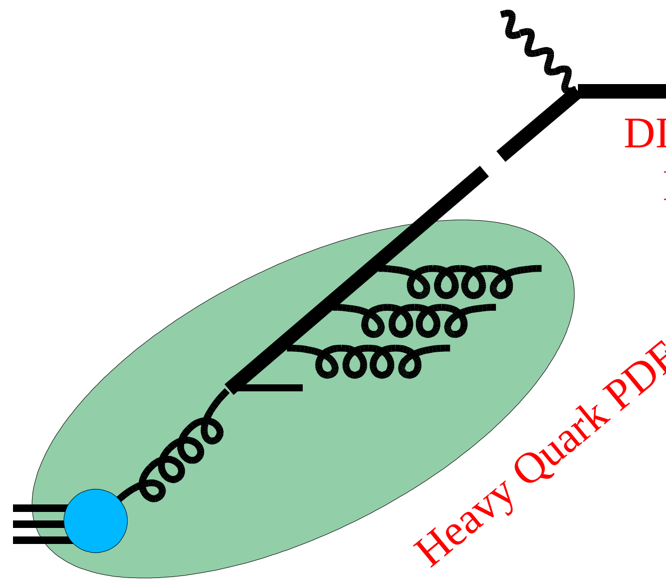
... life gets interesting.

Solution: Resum $Log(M_H)$ in the Heavy Quark PDF's:

... i.e., as in the ACOT renormalization scheme

ACOT, PRD 50, 3102

DGLAP equation
Resums iterative splittings
inside the proton

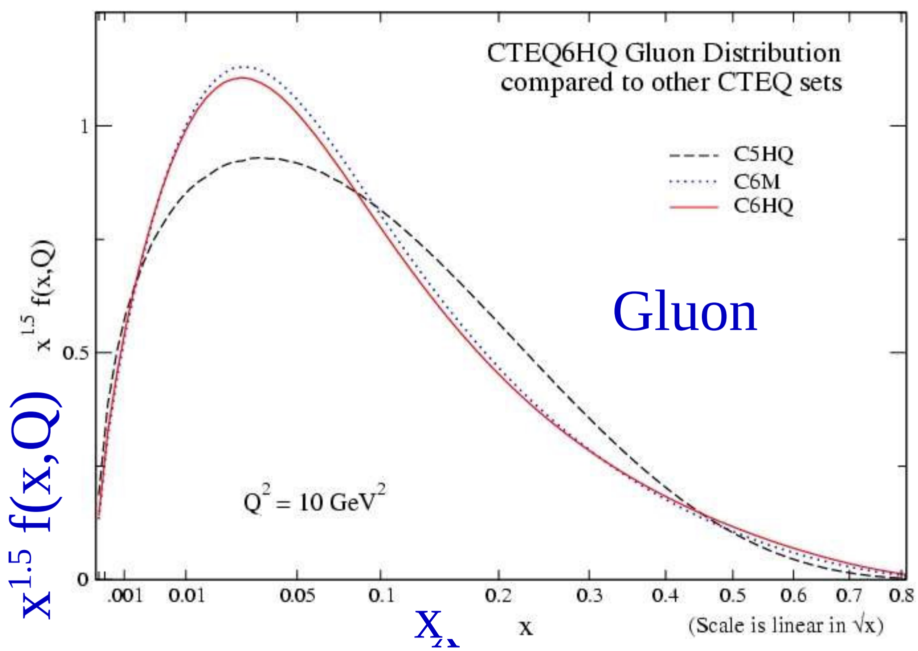


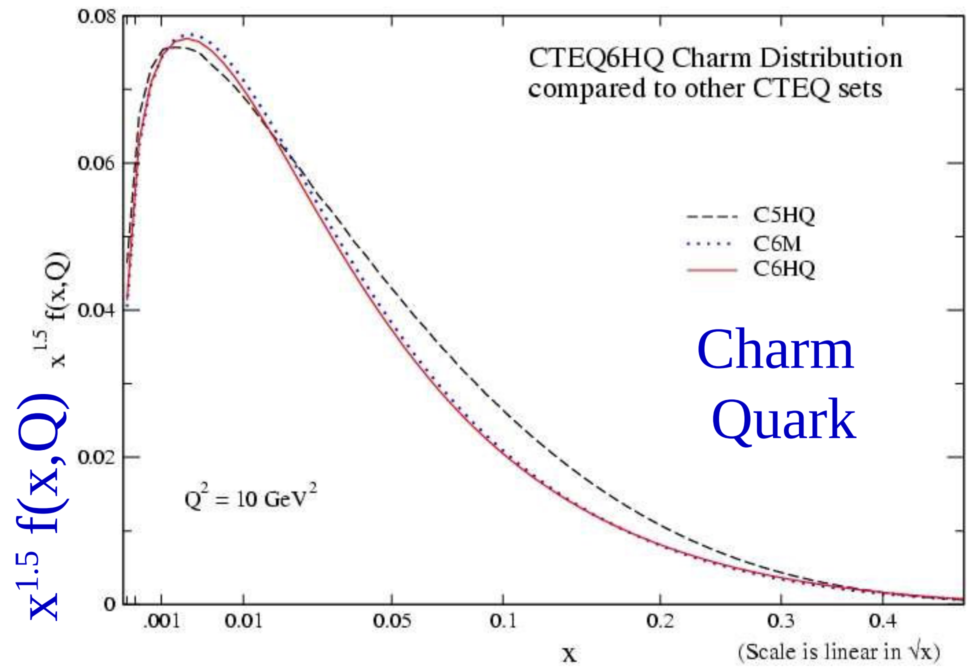
Result: We can describe the full kinematic range from low to high

implemented in the CTEQ6HQ PDF's with finite M_Q

CTEQ6HQ PDF's:

Compare: CTEQ6M, CTEQ6HQ, CTEQ5M





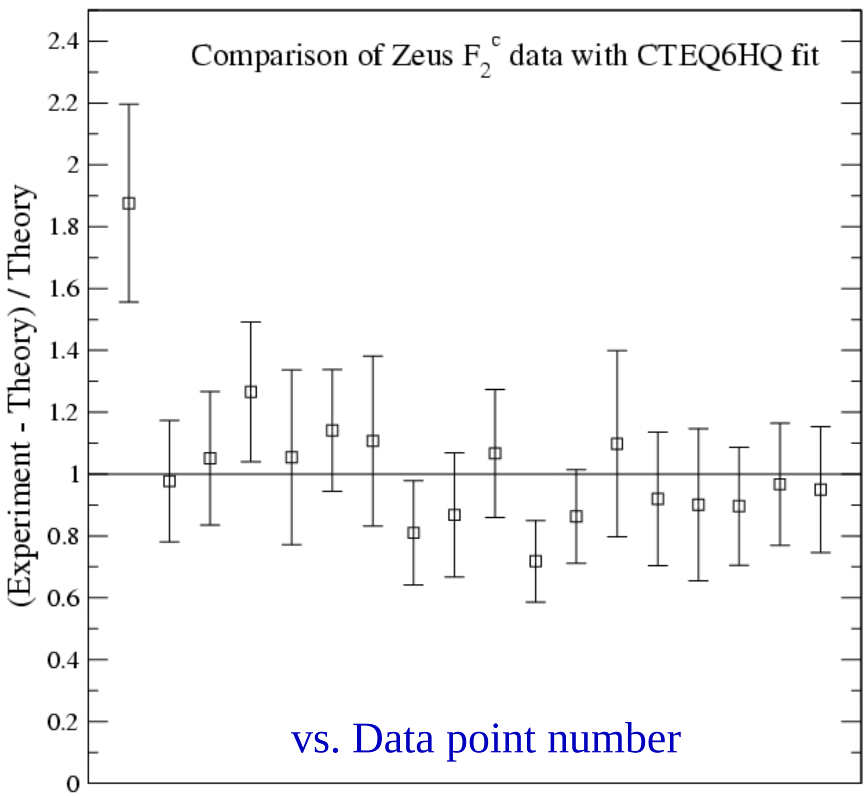
- Shift of Gluon for C5M to C6M is large *(New DIS & Jet data)*
- Charm PDF tied to gluon *($g \to cc$)*
- Small visual difference between C6M and C6H

Shift due to both scheme and uncertainty

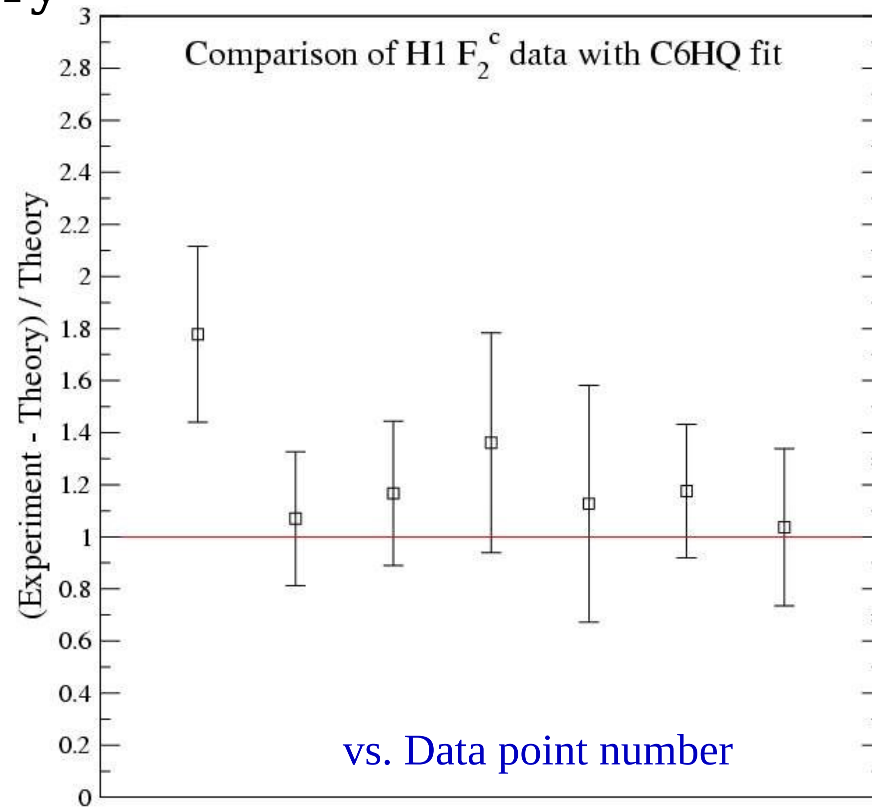
S. Kretzer, H.L. Lai, F. I. Olness and W.K. Tung. Phys.Rev.D69:114005,2004

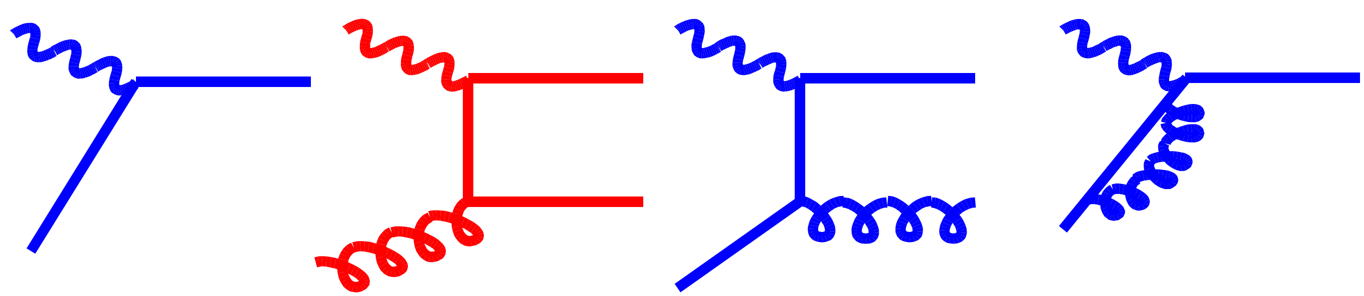
How does it do for the F_2^C data???

$$\frac{\text{Experiment} - \text{Theory}}{\text{Theory}}$$



(Exp -Theory)/Theory



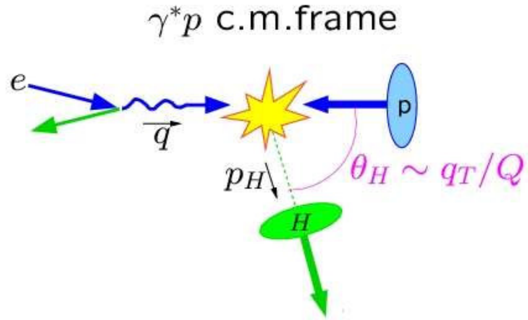


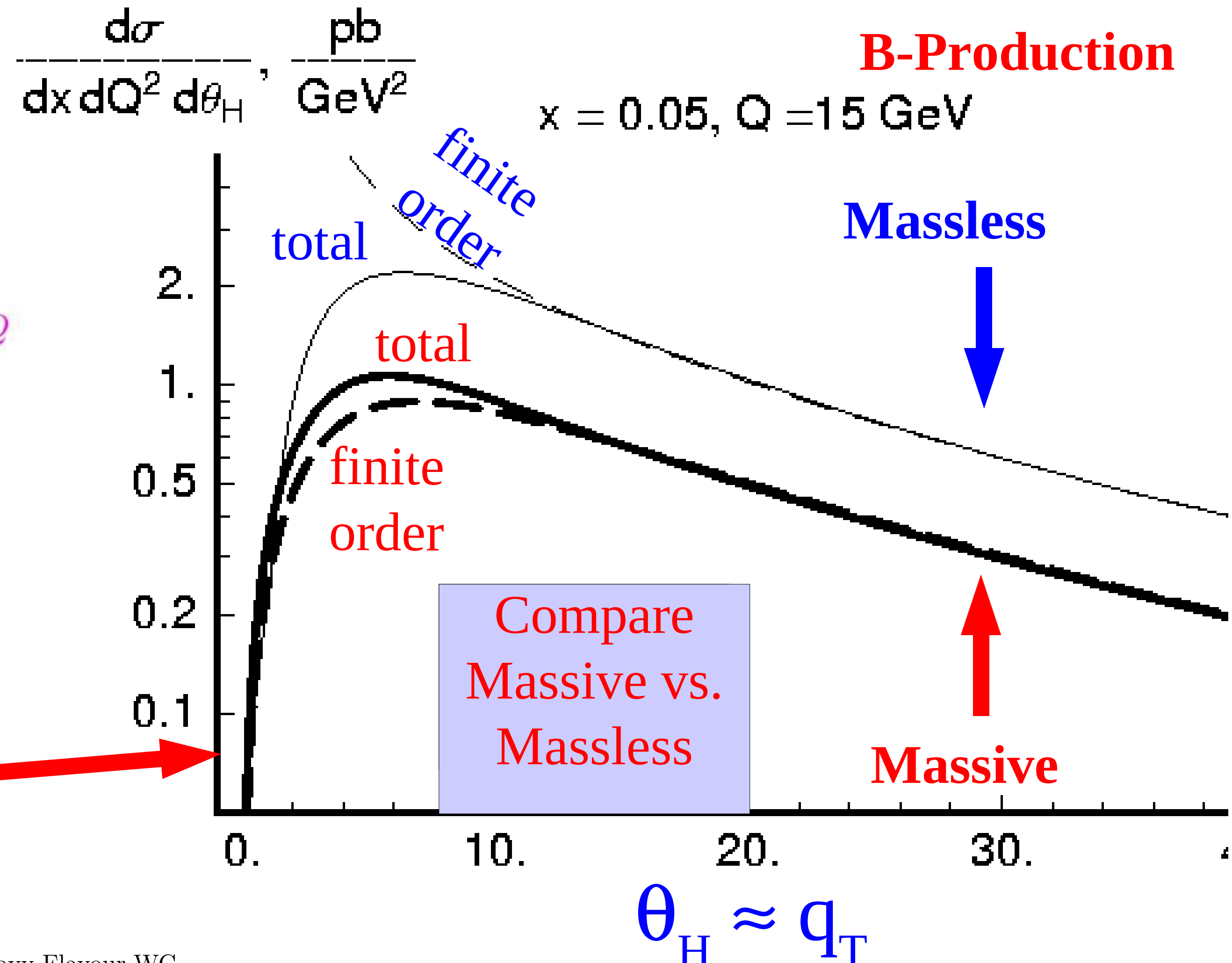
B-Production: Sudakov Resummation of Soft Gluon Radiation

Result of S-ACOT scheme

$$S_{ba}(b,Q,M_H)=\int \frac{d\mu^2}{\mu^2}\left\{A(\alpha_s,M_H)\ln\left(\frac{Q^2}{\mu^2}\right)+B(\alpha_s,M_H)\right\}+S_{Non-Pert}$$

0 0 0 *Due to finite quark mass*





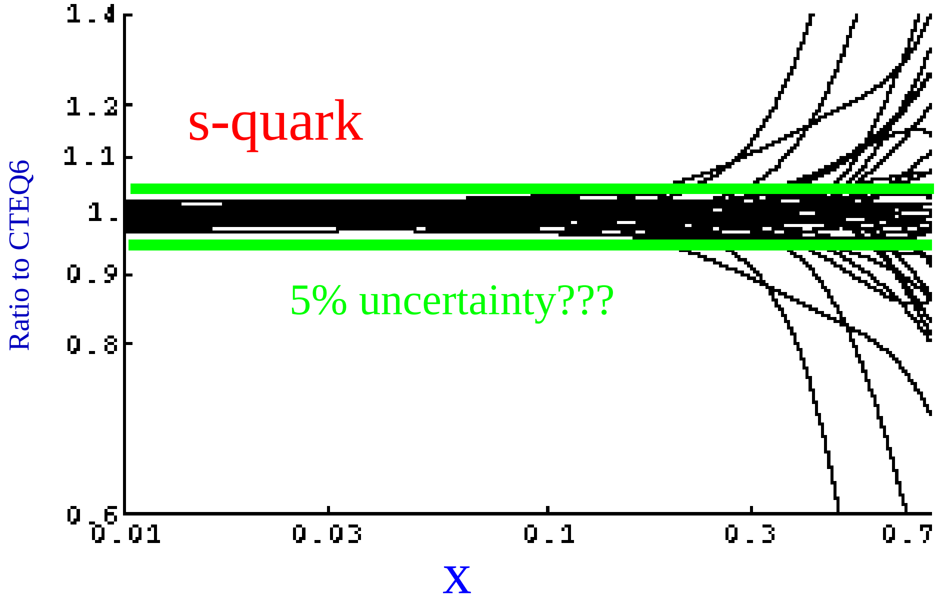
M$_H$ regulates collinear singularity

Compare Massive vs. Massless

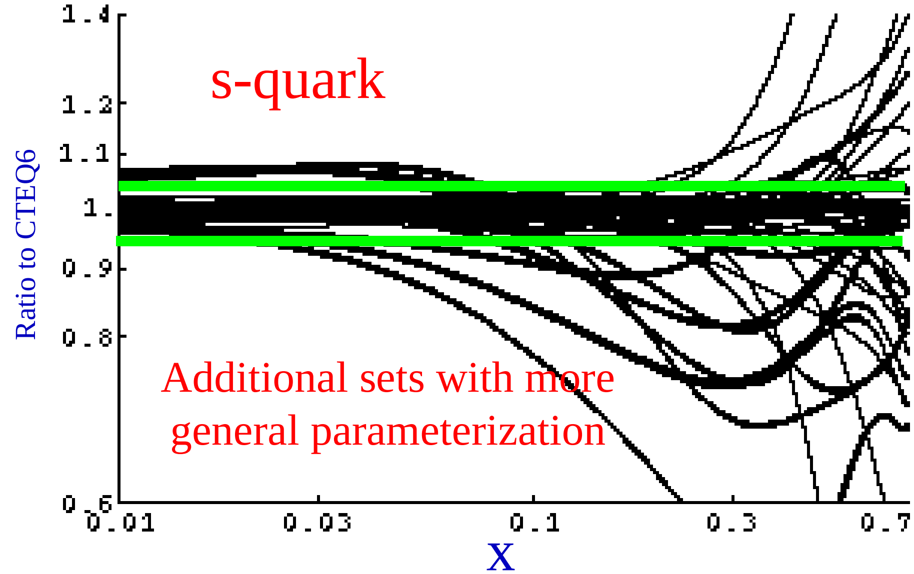
Nadolsky, Kidonakis, Olness, Yuan: PRD67:074015, 2003

What is true uncertainty on s-quark PDF???

40 CTEQ6M PDF sets



Closer to the true error



Curves shown are examples; this is not an exhaustive set

Warning: The Director General has determined the band of PDF's can greatly underestimate the true uncertainty

Global Fit: vary s(x) distribution

χ^2 / DOF	CTEQ6M	Constrained	Mixed	Free
CCFR Nu	1.02	0.85	0.79	0.72
CCFR Nu-bar	0.58	0.54	0.59	0.59
NuTeV Nu	1.81	1.70	1.55	1.44
NuTeV Nu-bar	1.48	1.30	1.15	1.13
BCDMS F2p	1.11	1.11	1.11	1.11
BCDMS F2d	1.10	1.10	1.10	1.11
H1 96/97	0.94	0.95	0.94	0.94
H1 98/99	1.02	1.03	1.03	1.03
ZEUS 96/97	1.14	1.14	1.14	1.15
NMC F2p	1.52	1.50	1.51	1.49
NMC F2d/F2p	0.91	0.91	0.91	0.91
NMC F2d/F2p $<Q^2>$	1.05	1.07	1.06	1.03
CCFR F2	1.70	1.71	1.81	1.88
CCFR F3	0.42	0.42	0.44	0.42
E605	0.82	0.82	0.82	0.83
NA51	0.62	0.61	0.52	0.52
CDF ℓ Asym	0.82	0.83	0.82	0.82
E866	0.39	0.40	0.39	0.38
D0 Jets	0.71	0.65	0.70	0.67
CDF Jets	1.48	1.48	1.48	1.47
TOTAL	2173	2144	2142	2133

Total of 1991 data points

CTEQ6: J. Pumplin, et al., JHEP 0207:012,2002

Reasonable χ^2 values

(CTEQ6 did not fit di-muon data)

More parameters,
lower value of χ^2

Only di-muon data is sensitive to s(x) !!!

$\therefore$

Idea: and -bar data
separately determine
s and s-bar distributions

A. Mitov: Soft Resummation for HQ in DIS

Interplay between soft logs and quark masses.

$$H^{soft}(z,\mu_F^2,\lambda) = 2C_F\left\{2\left(\frac{\ln(1-z)}{1-z}\right)_+ - \left(\frac{\ln(1-\lambda z)}{1-z}\right)_+ + \frac{1}{4}\left(\frac{1-z}{(1-\lambda z)^2}\right)_+ + \frac{1}{(1-z)_+}\left[\ln\frac{Q^2+m^2}{\mu_F^2} - 1\right]\right\}$$

$$\lambda = \frac{Q^2}{Q^2+m^2} \leq 1$$

$$z = \frac{\hat{x}}{\lambda} = \frac{Q^2+m^2}{2p\cdot q}\ , \quad 0 \leq z \leq 1$$

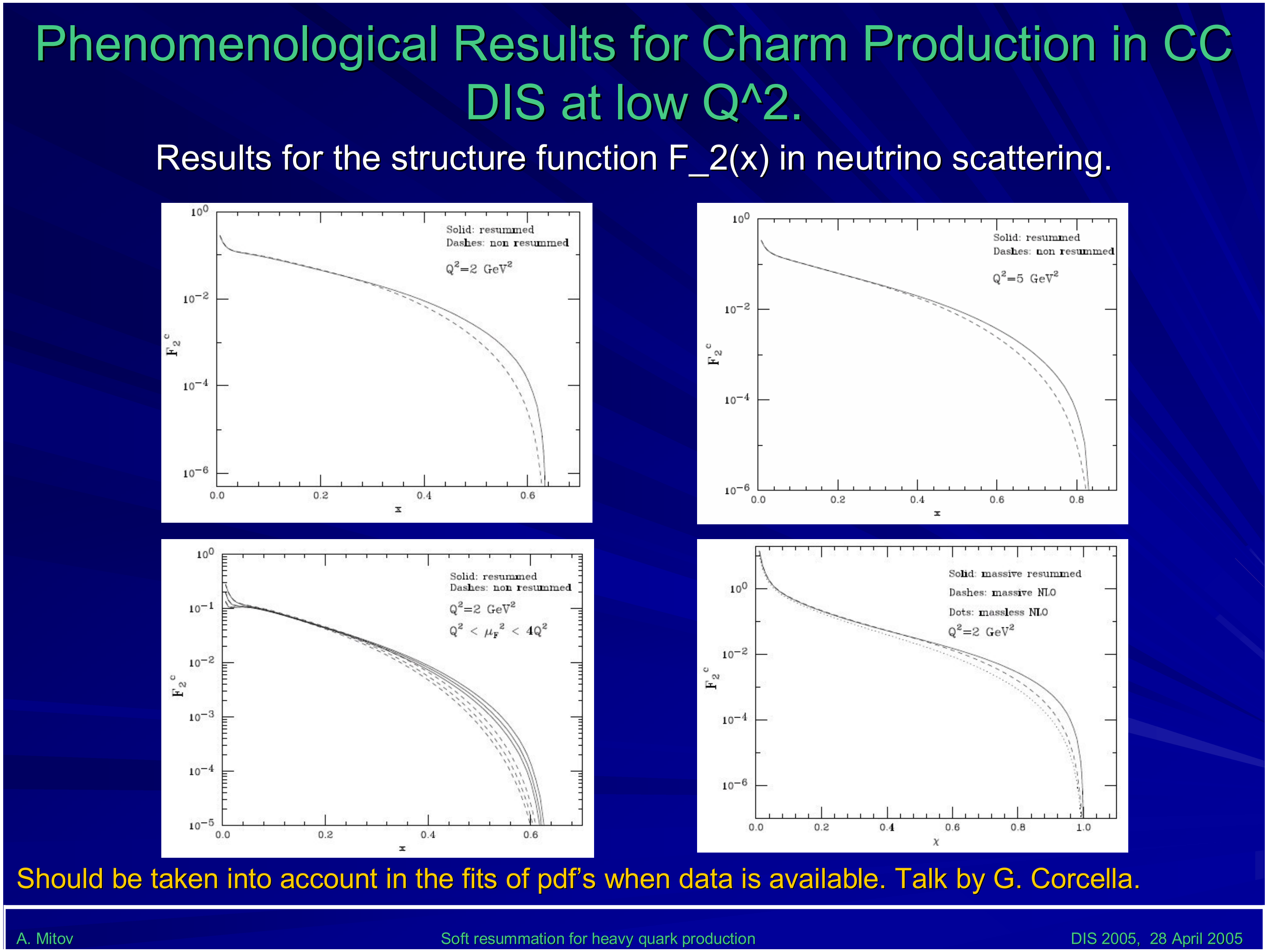
z – related to the partonic equivalent of the Bjorken variable.

However: the z->1 behavior depends very strongly on the value of the mass m (through λ).

Since z->1 effects become important also for moderate values of z (0.6 – 0.8), we divide the mass range into:

massive case: m/Q~1 , i.e. λ<<1,

massless case: m/Q<<1 , i.e. λ ≈1.


Phenomenological Results for Charm Production in CC DIS at low Q^2.
Results for the structure function F_2(x) in neutrino scattering.
Solid: resummed
Dashes: non resummed
Q²=2 GeV²
Solid: resummed
Dashes: non resummed
Q²=5 GeV²
Solid: resummed
Dashes: non resummed
Q²=2 GeV²
Q² < μ_F² < 4Q²
Solid: massive resummed
Dashes: massive NLO
Dots: massless NLO
Q²=2 GeV²
Should be taken into account in the fits of pdf's when data is available. Talk by G. Corcella.
A. Mitov
Soft resummation for heavy quark production
DIS 2005, 28 April 2005

A. Mitov: NNLO HQ Fragmentation Function

This way, all large logs are absorbed in the function $E_{ab}(\mu, \mu_0, z)$ and are resumed with the DGLAP equation to all orders in α_S.

Therefore to achieve resummation up to logarithmic order n, one needs the initial condition to order n and the splitting functions to the same order.

$$\begin{aligned} D^{\rm ini}_{a\to\mathcal{Q}}(\mu_0, m, z) &= \delta_{a\mathcal{Q}}\delta(1-z) + \frac{\alpha_s}{2\pi} d^{(1)}_{a\to\mathcal{Q}} + \left(\frac{\alpha_s}{2\pi}\right)^2 d^{(2)}_{a\to\mathcal{Q}} + \dots \\ &= \mathrm{LL} \quad + \quad \mathrm{NLL} \quad + \quad \mathrm{NNLL} \quad + \dots \end{aligned}$$

- $d^{(1)}$ - computed by Mele and Nason (1991).
- We have evaluated $d^{(2)}_{a\to\mathcal{Q}}$ for $a = \mathcal{Q},\ \overline{\mathcal{Q}},\ q, \bar{q}, \mathrm{gluon}$.

Collect all pieces:

$$d\sigma_H = (f_{\dots}) \otimes \widehat{d\sigma}_a(Q, \mu) \otimes E_{ab}(\mu, \mu_0) \otimes D^{\rm ini}_{b\to\mathcal{Q}}(\mu_0, m) \otimes D^{\rm n.p.}_{\mathcal{Q}\to H} + \mathcal{O}(m/Q)^p$$

Various components to PFF and the participating sub-processes at tree-level:

I. $D^{\rm ini}_{\mathcal{Q}\to\mathcal{Q}}$:

- $\mathcal{Q} \to \mathcal{Q} + g + g,$
- $\mathcal{Q} \to \mathcal{Q} + q + \overline{q},$
- $\mathcal{Q} \to \mathcal{Q} + \mathcal{Q} + \overline{\mathcal{Q}}.$

II. $D^{\rm ini}_{\overline{\mathcal{Q}}\to\mathcal{Q}}$:

- $\overline{\mathcal{Q}} \to \mathcal{Q} + \overline{\mathcal{Q}} + \overline{\mathcal{Q}}.$

III. $D^{\rm ini}_{q(\overline{q})\to\mathcal{Q}}$:

- $q(\overline{q}) \to \mathcal{Q} + \overline{\mathcal{Q}} + q(\overline{q}).$

IV. $D^{\rm ini}_{g\to\mathcal{Q}}$:

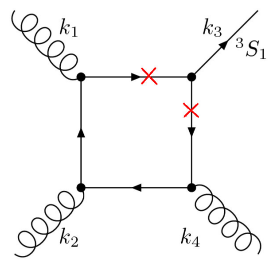
- $g \to \mathcal{Q} + \overline{\mathcal{Q}} + g\ .$

Our model

➯ Beyond the static approximation of the CSM:

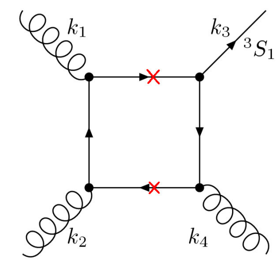
$$\int \psi(p_{rel})\mathcal{A}(p_{rel})dp_{rel} = \mathcal{A}(0)\phi(0) + \dots$$

➟We shall only consider here Disc $\mathcal{A}$; the hard part ($Q\bar{Q}$ production) is thus given by:



Typical diagram for CSM

↔

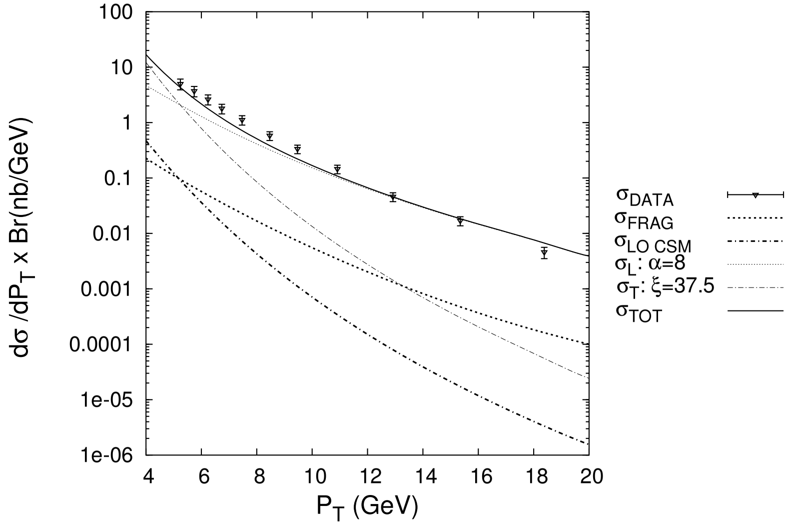


Typical diagram here

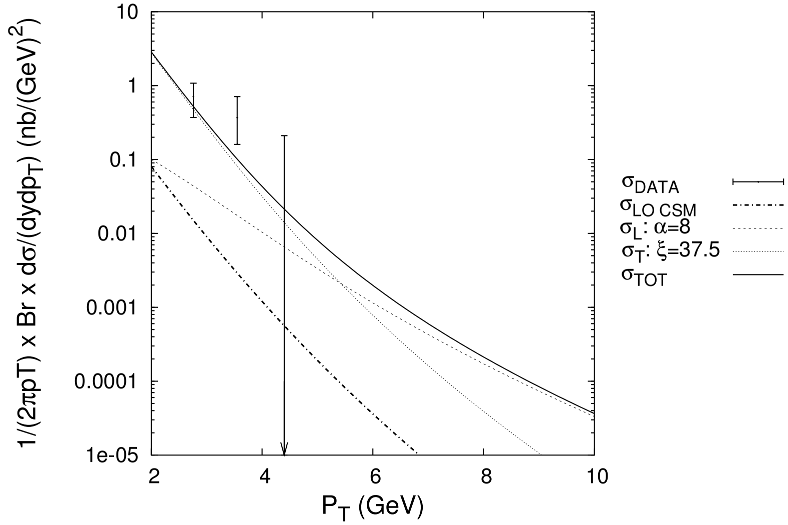
➟The soft part (non-perturbative), by a phenomenological vertex function:

$$\psi(p,P) = \frac{N}{(1-\frac{\vec{p}_{rel}^{\,2}}{\Lambda^2})^2} \text{ or } N\exp[\frac{-\vec{p}_{rel}^{\,2}}{\Lambda^2}] \quad \text{(in the CM frame)}$$

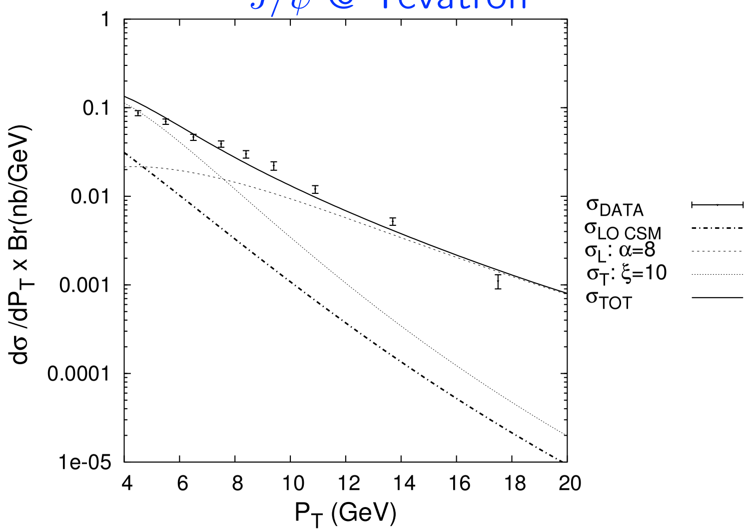
Our results



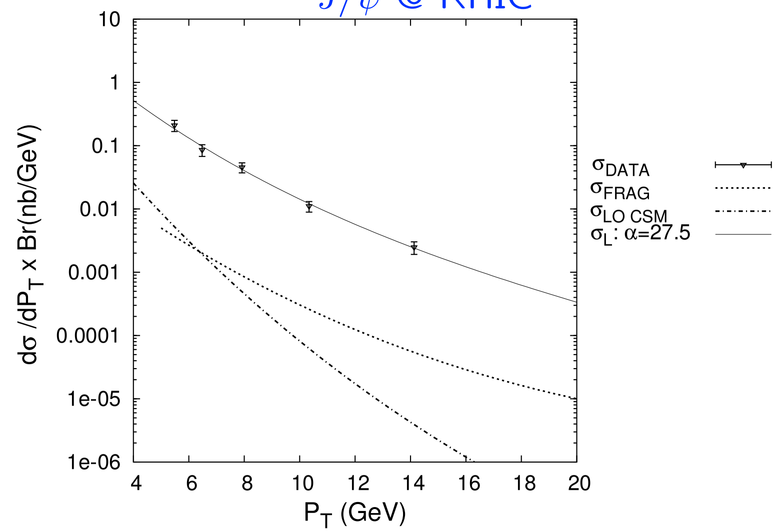
J/ψ @ Tevatron



J/ψ @ RHIC



Υ @ Tevatron



ψ' @ Tevatron

In each case, the longitudinal component dominates

What about fragmentation ?

➾ Our approach does not include fragmentation-like processes

a single parton emitted at large p_T evolves into a quarkonium

➾ We choose to consider this class of contributions through the COM

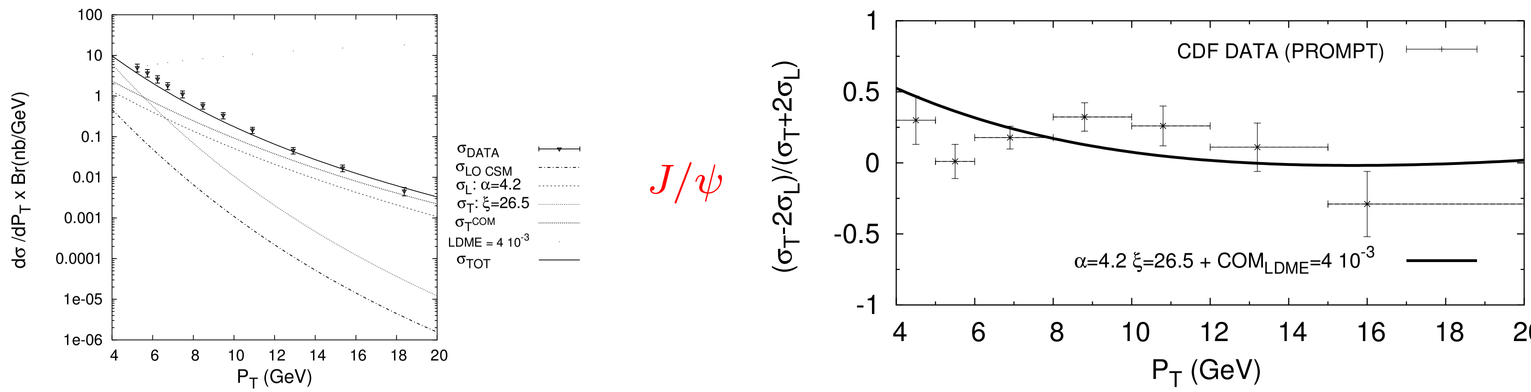
Leibovich

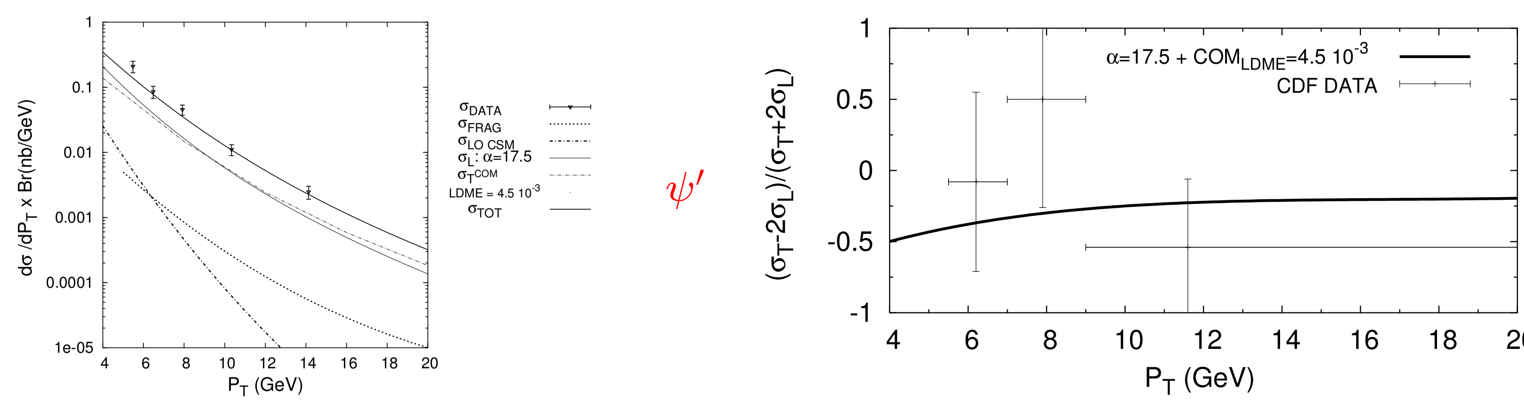
➾ We have seen that they give transverse contributions

might give unpolarised result with our contributions

➾ We combine the two contributions

with slightly modified values for the COM matrix elements





B. Kniehl: NLO Charmonium production in $\gamma\gamma$

Motivation for NLO:

- Reduction of renormalization and factorization scale dependence.
- Sizeable effects, e.g. due to opening of new partonic production channels.
- Ultimate test of NRQCD factorization by global NLO fit.
- High-statistics data from HERA II, Tevatron Run II, LHC, ILC.

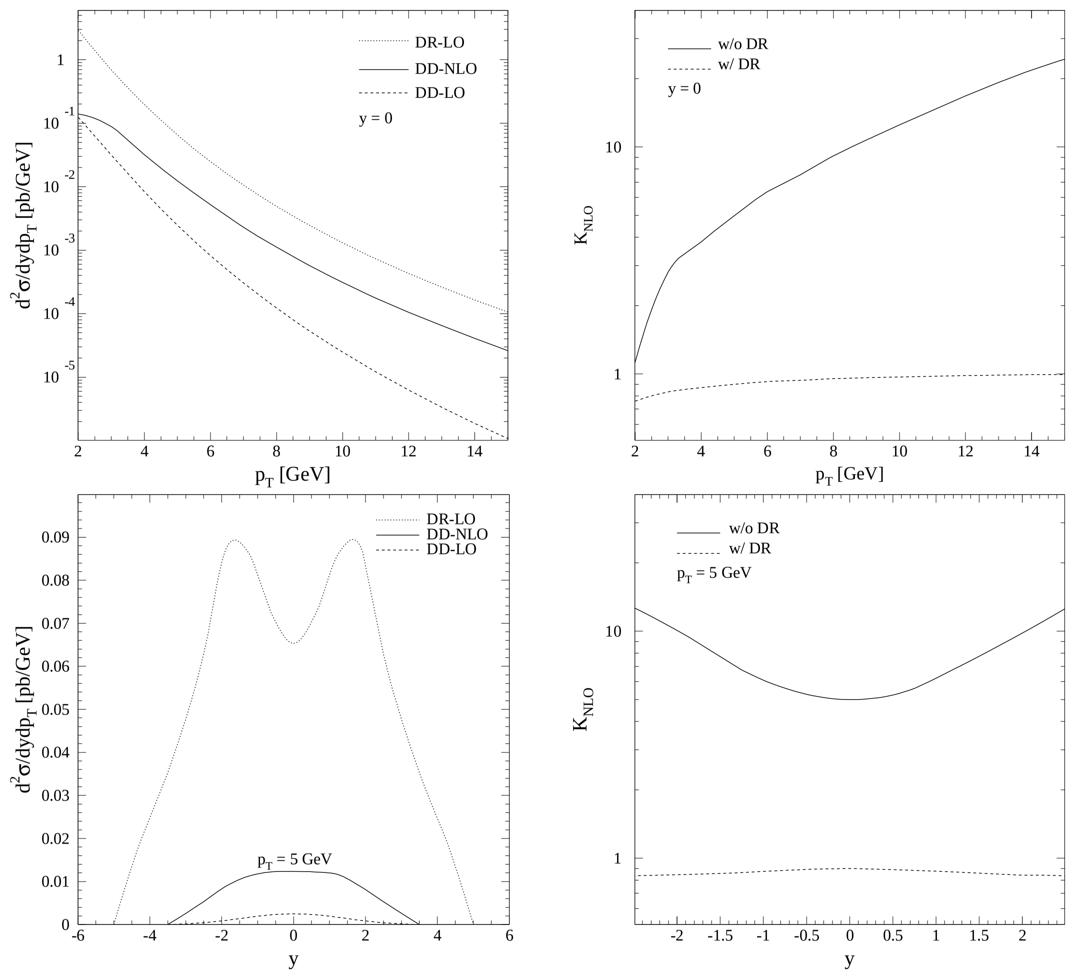
Previous NLO calculations:

- $\gamma p \to J/\psi + X$ w/ direct γ and J/ψ for $p_T > 0$ in CSM M. Krämer, J. Zunft, J. Steegborn, P.M. Zerwas, Phys. Lett. **B348** (1995) 657; M. Krämer, Nucl. Phys. **B459** (1996) 3.
- $\gamma p \to J/\psi + X$ w/ direct γ and J/ψ for $p_T = 0$ in NRQCD F. Maltoni, M.L. Mangano, A. Petrelli, Nucl. Phys. **B519** (1998) 361.
- $p\bar{p} \to J/\psi + X$ for $p_T = 0$ in NRQCD A. Petrelli, M. Cacciari, M. Greco, F. Maltoni, M.L. Mangano, Nucl. Phys. **B514** (1998) 245.

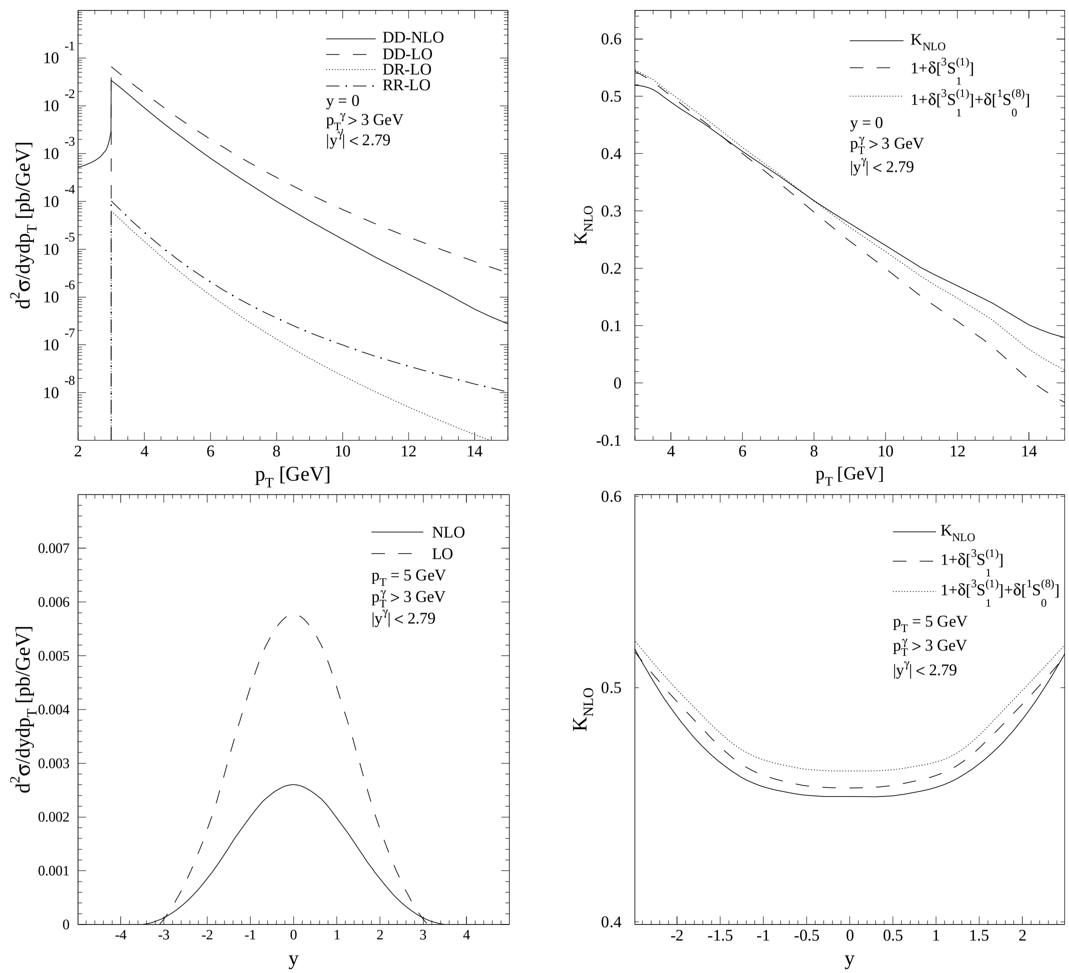
Here:

- $\gamma\gamma \to J/\psi + X$ w/ direct γ's and prompt J/ψ for $p_T > 0$ in NRQCD
- X purely hadronic: compensate μ_R dependence of LO single-resolved contribution
- X w/ prompt γ: direct photoproduction dominant

$\gamma\gamma \to J/\psi + j + X$



$\gamma\gamma \to J/\psi + \gamma + X$



I. Schienbein: Hadroproduction of D and B in Massive VFN

Overview

Subject of this talk:

- 1-particle inclusive hadroproduction of D mesons: $p\bar{p} \to (D^0, D^{*+}, D^+, D_s^+)X$
- Massive Variable Flavour Number Scheme (Massive VFNS): [1]
  - Collinear logarithms of the heavy quark mass $\ln \mu/m_h$ are subtracted and resummed
  - finite non-logarithmic m_h/Q terms are kept in the hard part/taken into account
  - Scheme based on the factorization theorem of Collins with heavy quarks [2]

Further applications:

- 1-particle inclusive hadroproduction of B mesons: $p\bar{p} \to BX$
- Completes earlier work on D meson production in $\gamma\gamma$ and γp collisions:
  - $\gamma\gamma \to D^\star X$: direct process [3]
  - $\gamma\gamma \to D^\star X$: single-resolved process [4]
  - $\gamma p \to D^\star X$: direct process [5]

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[1] B.A. Kniehl, G. Kramer, I.S.,H. Spiesberger, PRD71(2005)014018

[2] J. Collins, PRD58(1998)094002

[3] G. Kramer, H. Spiesberger, EPJC22(2001)289; [4] EPJC28(2003)495; [5] EPJC38(2004)309

List of Subprocesses

Calculation: $\overline{\mathrm{MS}}$-scheme, heavy quark: $m_Q = 0$ [1]

- Red: Heavy quark mass effects included
- Green: Heavy quark initiated: $m_Q = 0$
- Blue: only light lines involved

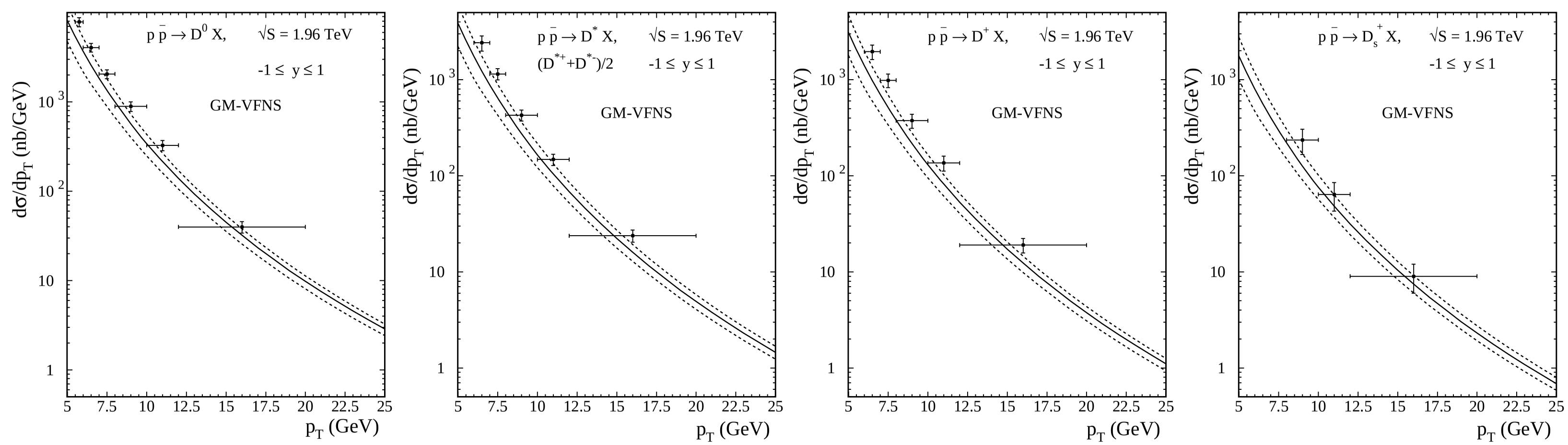
$gg \to qX$	$gg \to QX$	
$gg \to gX$		
$qg \to gX$	$Qg \to gX$	
$qg \to qX$	$Qg \to QX$	
$q\bar{q} \to gX$	$Q\bar{Q} \to gX$	
$q\bar{q} \to qX$	$Q\bar{Q} \to QX$	
$qg \to \bar{q}X$	$Qg \to \bar{Q}X$	
$qg \to \bar{q}'X$	$Qg \to \bar{q}X$	$qg \to \bar{Q}X$
$qg \to q'X$	$Qg \to qX$	$qg \to QX$
$qq \to gX$	$QQ \to gX$	
$qq \to qX$	$QQ \to QX$	
$q\bar{q} \to q'X$	$Q\bar{Q} \to qX$	$q\bar{q} \to QX$
$q\bar{q}' \to gX$	$Q\bar{q} \to gX$	$q\bar{Q} \to gX$
$q\bar{q}' \to qX$	$Q\bar{q} \to QX$	$q\bar{Q} \to qX$
$qq' \to gX$	$Qq \to gX$	$qQ \to gX$
$qq' \to qX$	$Qq \to QX$	$qQ \to qX$

$\oplus$ charge conjugated processes

[1] Aversa, Chiappetta, Greco, Guillet, NPB327(1989)105

Comparison with CDF II data for $p\bar{p} \to (D^0, D^{\star +}, D^+, D_s^+)X$ [1]

- $\mathrm{d}\sigma/\mathrm{d}p_T$ (nb/GeV), $|y| \le 1$, massive VFNS (GM-VFNS)
- Uncertainty band: independent variation of $\mu_R, \mu_F, \mu'_F = \xi m_T$, $\xi \in [1/2, 2]$



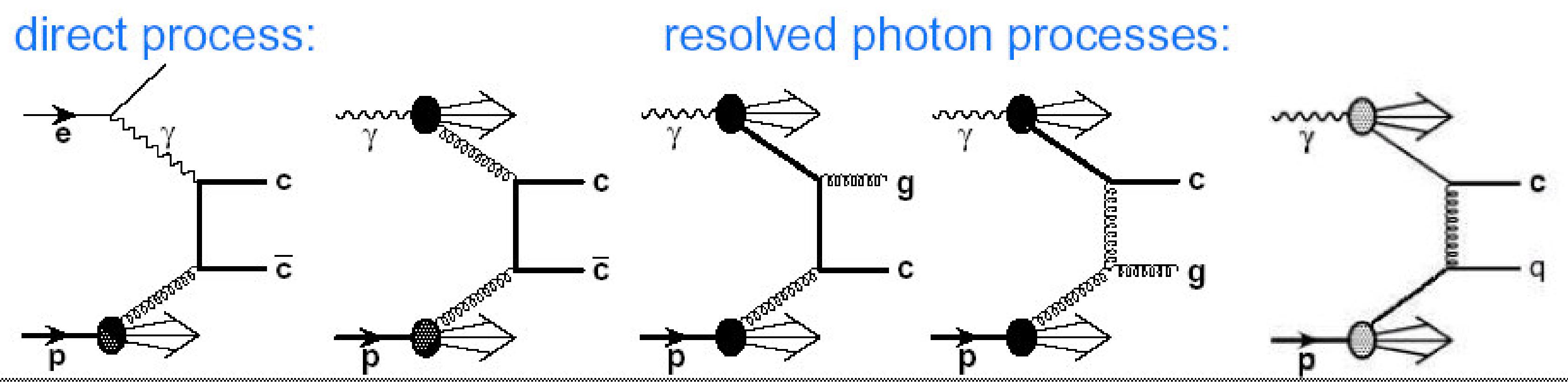
- Prompt charm (no secondary charm from B decay)
- Data and Theory compatible within errors
- Central values: Data/Theory $\simeq 1.5 - 1.8$

[1] Acosta et al, PRL91(2003)241804

Experimental part

Charm production

(LO massless scheme)



Inclusive D^* photoproduction in general agreement with NLO

New measurements try to be more exclusive:

- **D^*-jets: small fragmentation uncertainty**

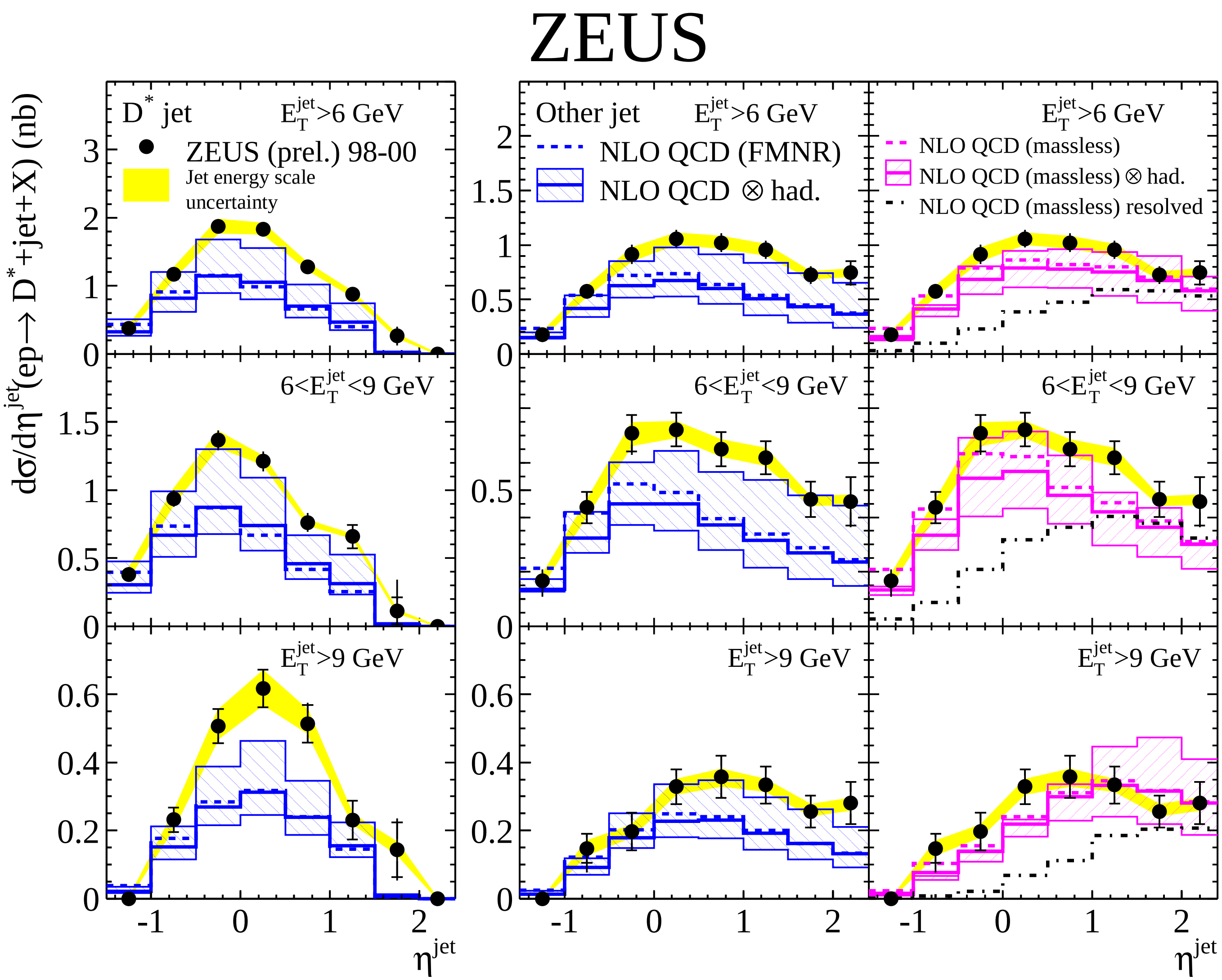
- **D^*+"other jet", D^*+dijets: further handle on parton dynamics wide acceptance for "other jet"**
- **study the c/g nature of the "other-jet" from jet shape**
- **Fragmentation fractions and fragmentation function:**
  test of fragmentation universality
  parameters needed for precise measurements of c production

T. Kohno: ZEUS D^* jets photoproduction

Events with a D^* and ≥ 1 jet ($E_T > 6$GeV)

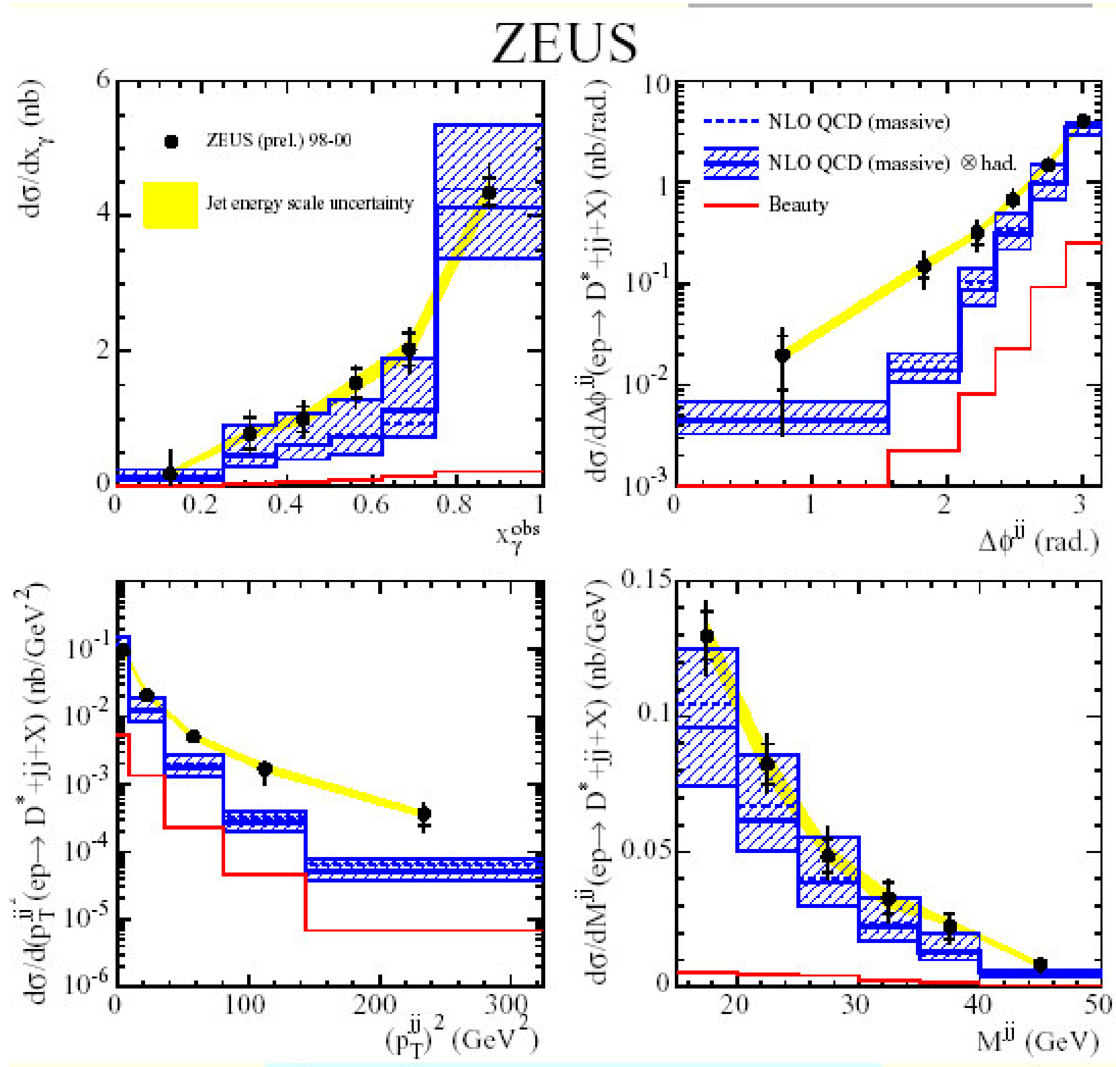
D^*-jet and "other"-jet distribution

Consistent with NLO massive (FMNR) and Massless calculations



T. Kohno: ZEUS D^* dijets

Dijet correlations, directly sensitive to NLO corrections

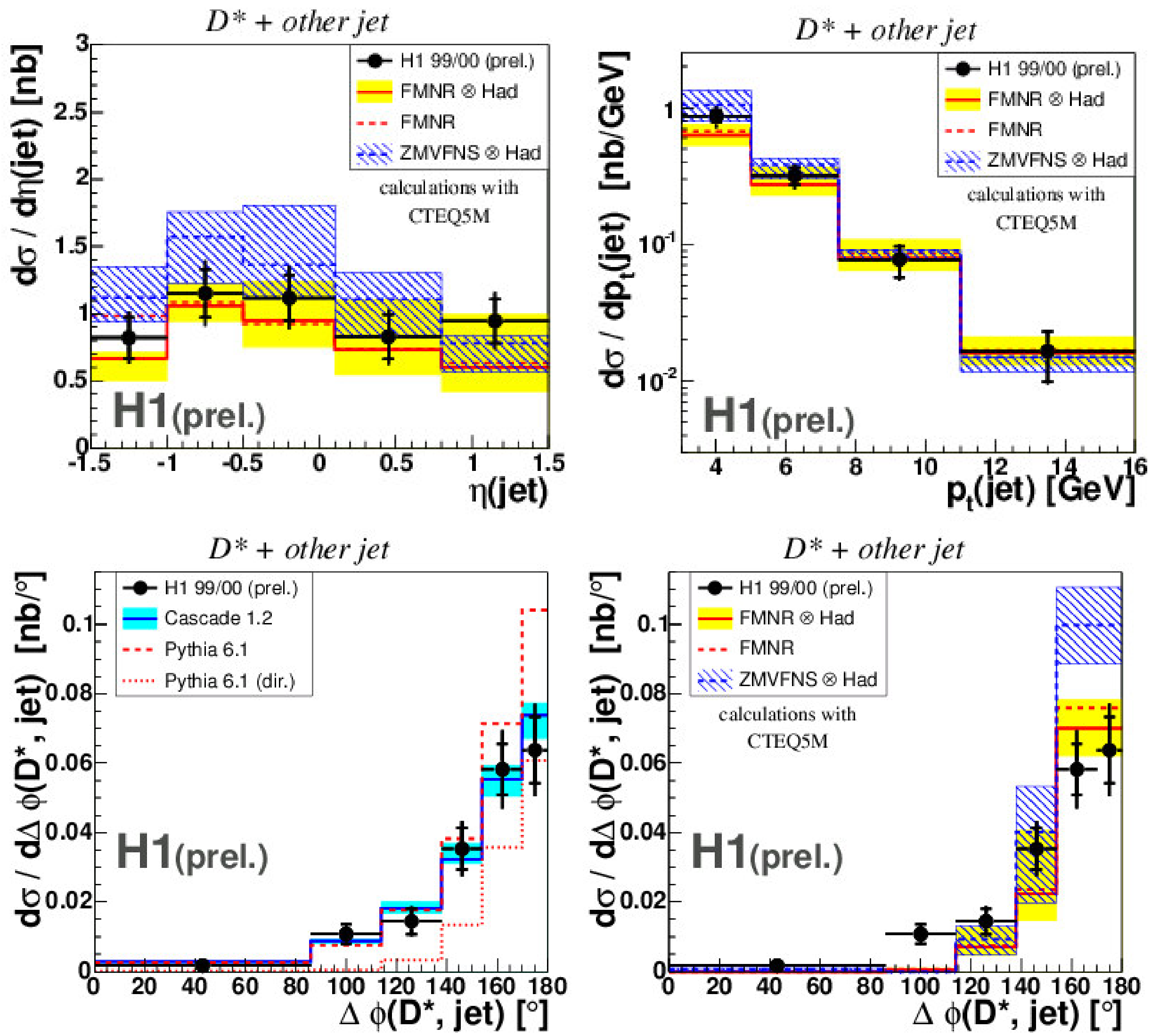


FMNR too low at large p_T^{jj} and low $\Delta\phi$

Need higher orders or matching with PS

G. Fluke: H1 Charm+jet photoproduction

D^* and "other"-jet $P_T > 3\text{GeV}$ (tagged PhP)

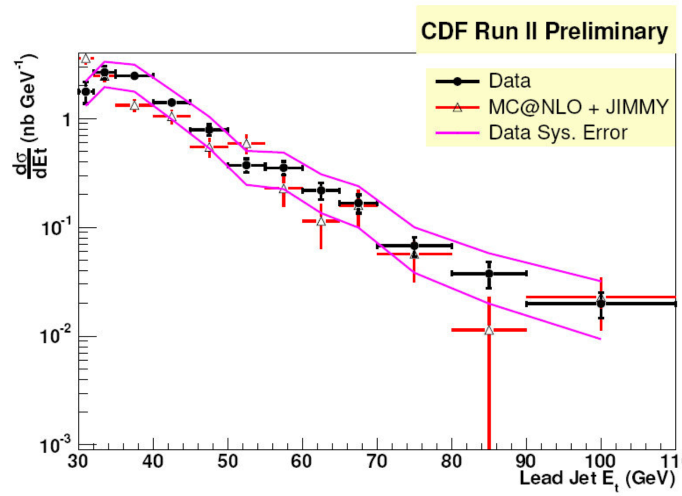


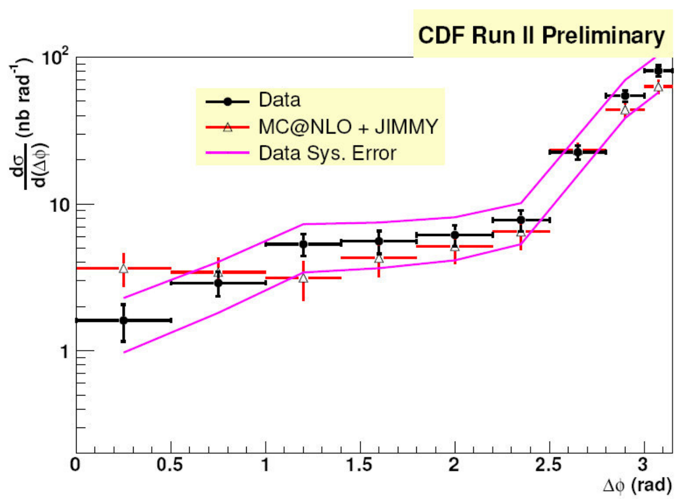
Δ_ϕ not well reproduce by massive and massless NLO

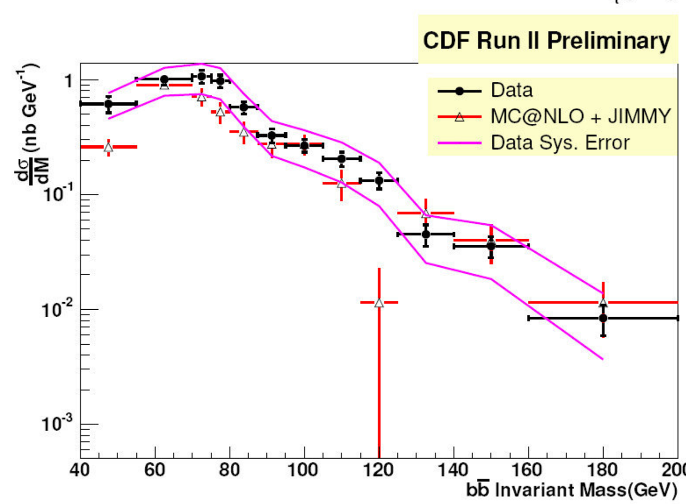
R. Lefevre: b-jets from CDF

Dijet b production

- Jet algorithm: JetClu with $R_{cone} = 0.7$
- Kinematical range
  - 2 b-jets within $|\eta| < 1.2$
  - $E_T^{1st\ b\text{-}jet} > 30$ GeV, $E_T^{2nd\ b\text{-}jet} > 20$ GeV
- Data sample: 65 pb^{-1}
  - Jet 20 only (prescaled trigger)
- Comparison to MC@NLO ⊕ JIMMY
  - Default JIMMY – Small MC sample







M. Martisikova: H1 Charm jet shape in photoproduction

Dijet photoproduction — One jet tagged as charm from muon

Look at the shape of the other jet, is it charm or gluon ?

Jet Shape - Detector Level Measurement

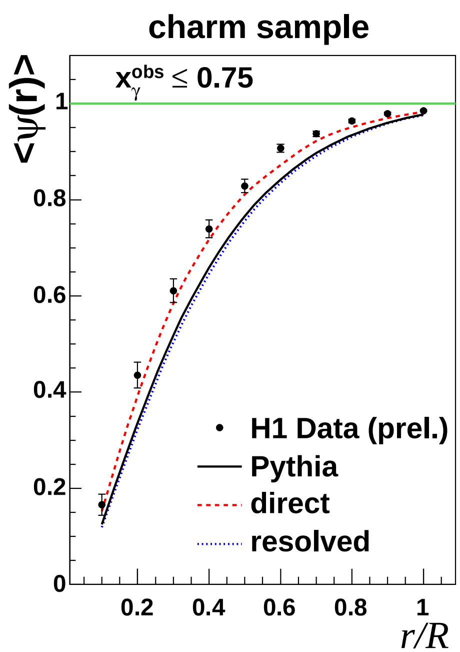
Fraction of E_γ entering the hard interaction:
$x_\gamma^{obs} = \frac{\sum_{jet1,2}(E-p_z)}{\sum_{HFS}(E-p_z)}$

Pythia: DGLAP evolution

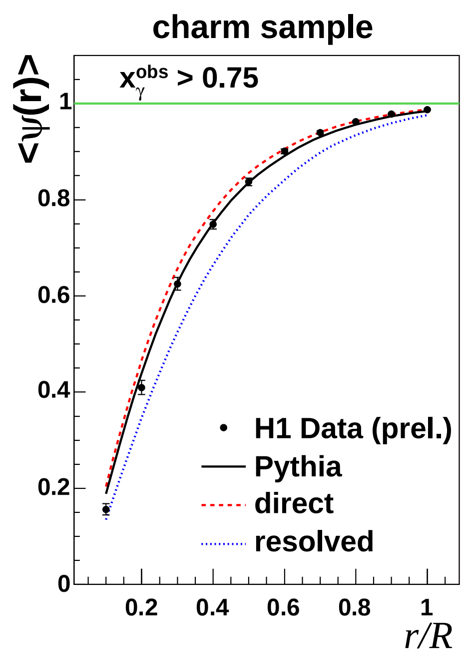
gen. in massles mode (excitation $\sim 35\%$)

Fragm.: lund string and Peterson ($\epsilon = 0.058$)

proton: CTEQ5L
photon: GRV-LO



resolved enhanced



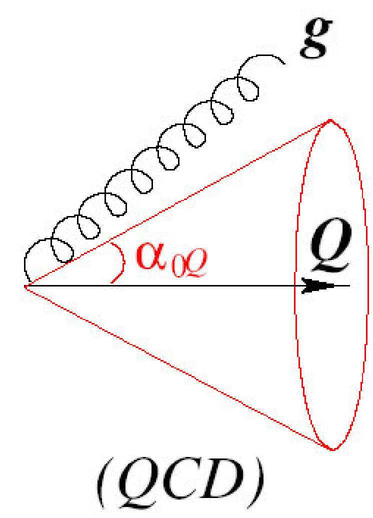
direct enhanced

Data suggest less gluon jets at low x_γ

Mária Martiš´ıková, DESY — DIS '05 - HFWG — 28 April 2005 — 7

A. Perieanu: H1 Charm jet shapes in DIS

$$\alpha_0 = \frac{m}{E}$$



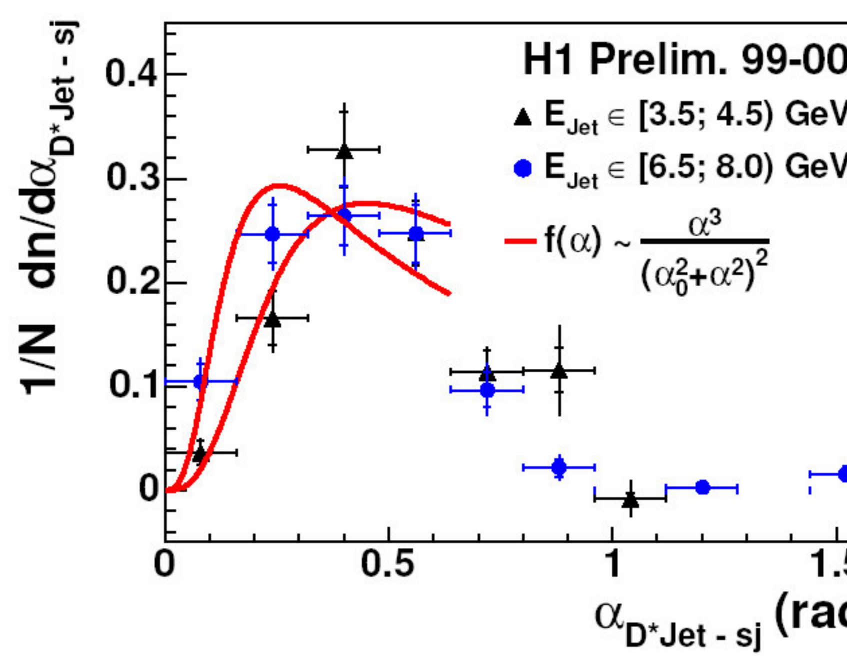
Shape of D^*-jet and "other"-jet studied in DIS

First attempt to measure the dead cone

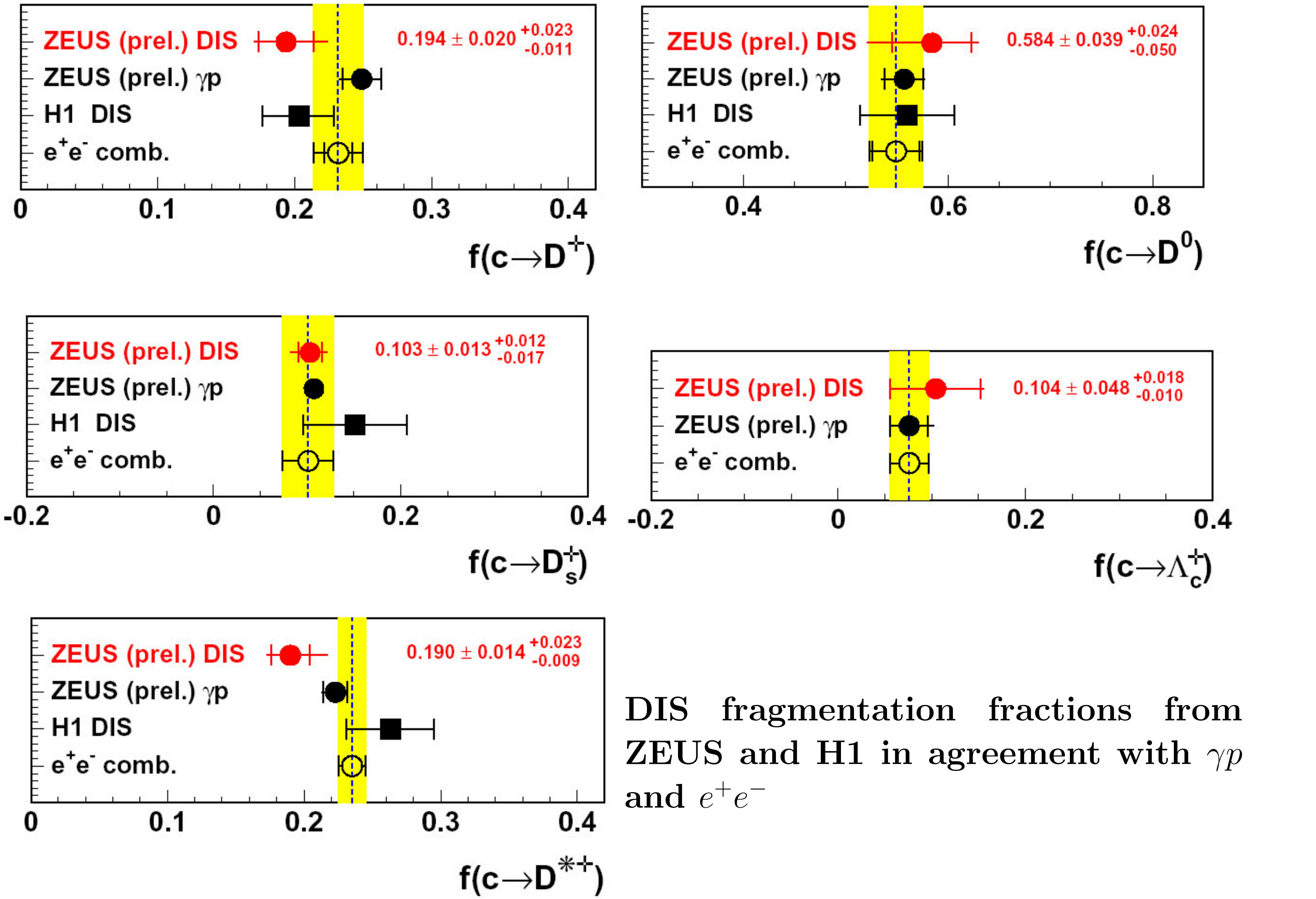
Measure angle between D^*-jet and first (non D^*) subjet

Shape consisten with dead cone effect but ...

similar shape also seen in light flavours



R.Walsh: ZEUS charm fragmentation fractions in DIS



DIS fragmentation fractions from ZEUS and H1 in agreement with γp and e^+e^-

Z. Rurikova: H1 Charm fragmentation function in DIS

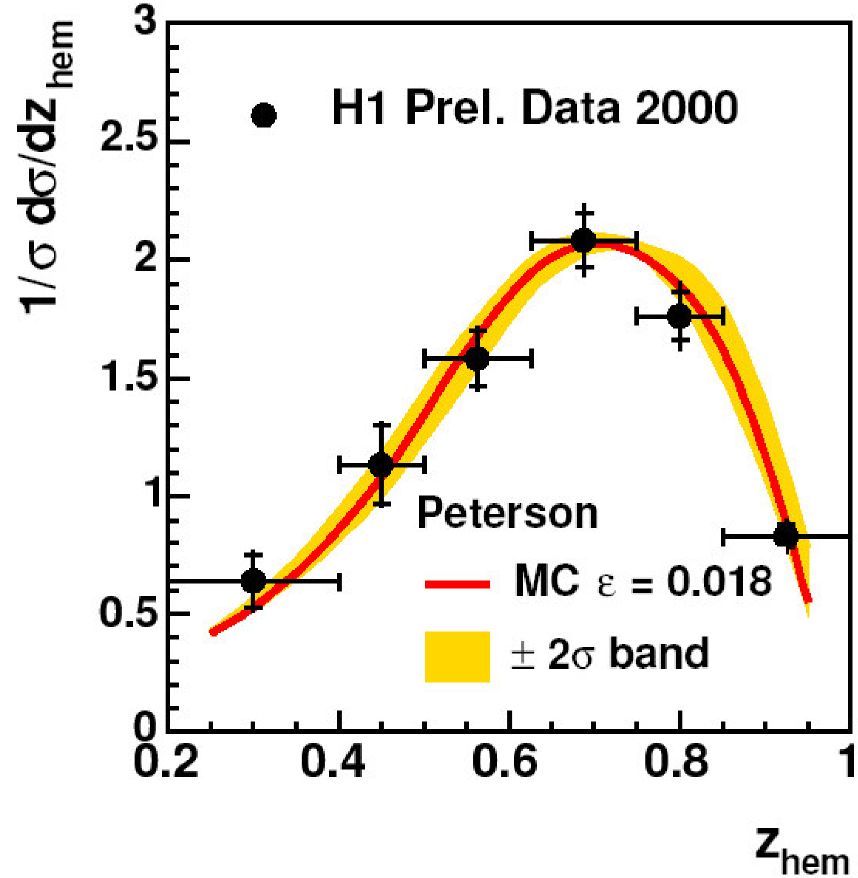
D^* **DIS data**

Z_{hem}: **fraction of hemisphere** $E + P$ **carried by the** D^*

Fit with Jetset with Peterson Fragmentation

$\epsilon = 0.018^{+0.004}_{-0.004}$

lower than ZEUS photoproduction result

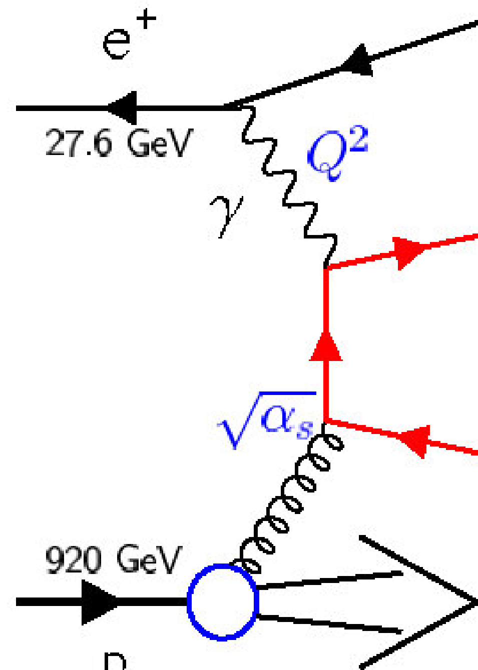


c and b production in DIS and HQ pdfs

c (and b) are a sizeable fraction of F_2

direct access to gluon pdf

b-pdf important for e.g. (MSSM) Higgs searches ($b\bar{b} \to H$)



Traditionally D^* production in DIS used by ZEUS/H1,
then extrapolated to full kinematics to get F_2^c
New measurements:

- H1 F_2^c/F_2^b measurement using inclusive track impact parameter
- NuTeV Charm production in CC
- ZEUS D^* at $0.05 < Q^2 < 0.7$GeV^2
- D0: b-pdf from $Z + b$
- ZEUS Charmonium production in DIS
- First ZEUS results from HERA-II data

T. Klimkovich: F_2^c and F_2^b using the H1 vertex detector

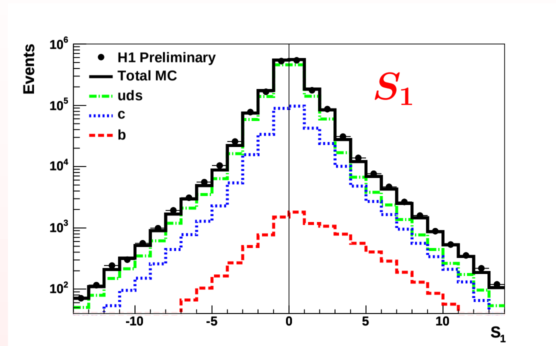
H1 measurement of F_2^c and F_2^b based on track impact parameter

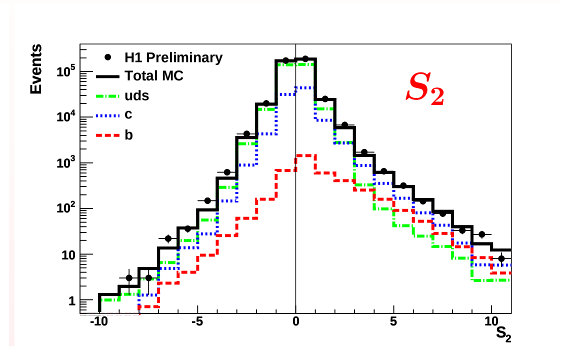
Extended to $Q^2 < 100\text{GeV}^2$

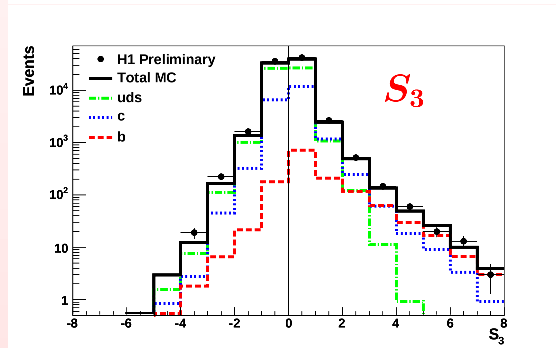
Large track acceptance: small extrapolation to F_2

$S = \delta/\sigma$
$\delta =$ signed track impact parameter sign given by jet or HFS direction

Significance (S_i) at Low Q^2







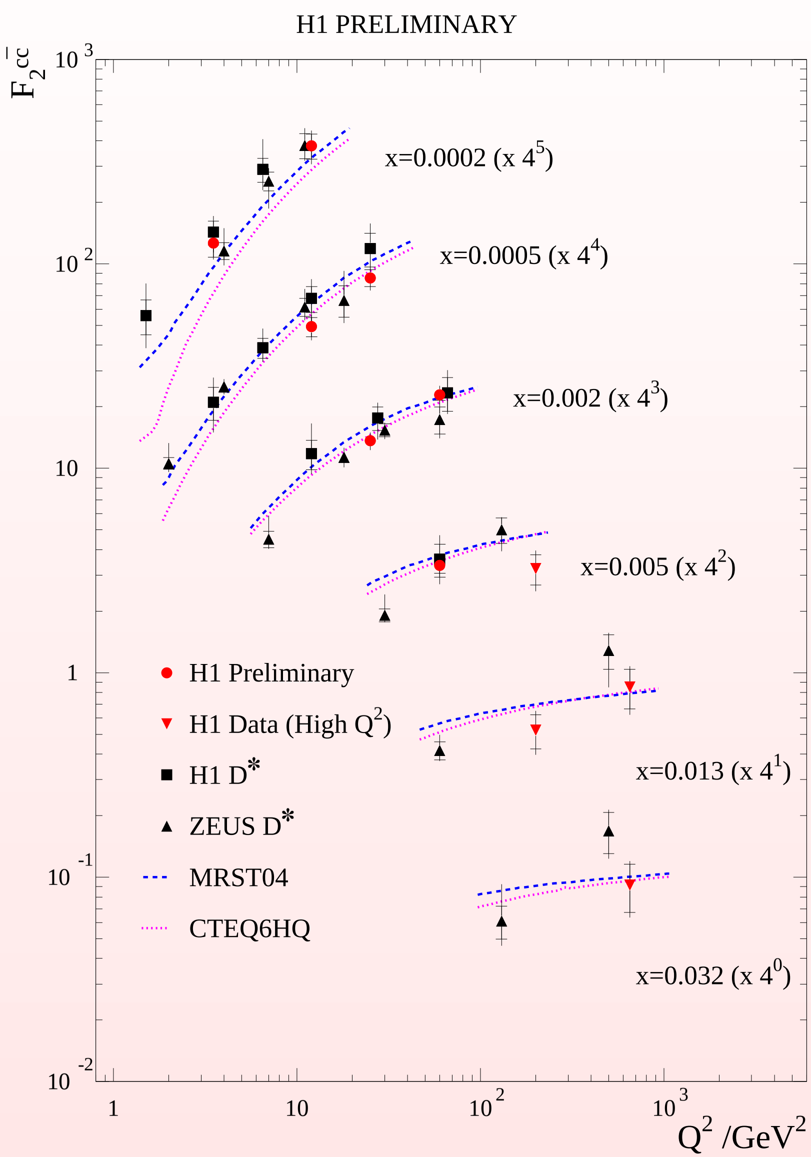
At low Q^2, beauty fraction is smaller. Need to do more to separate b and c

Define three distributions:

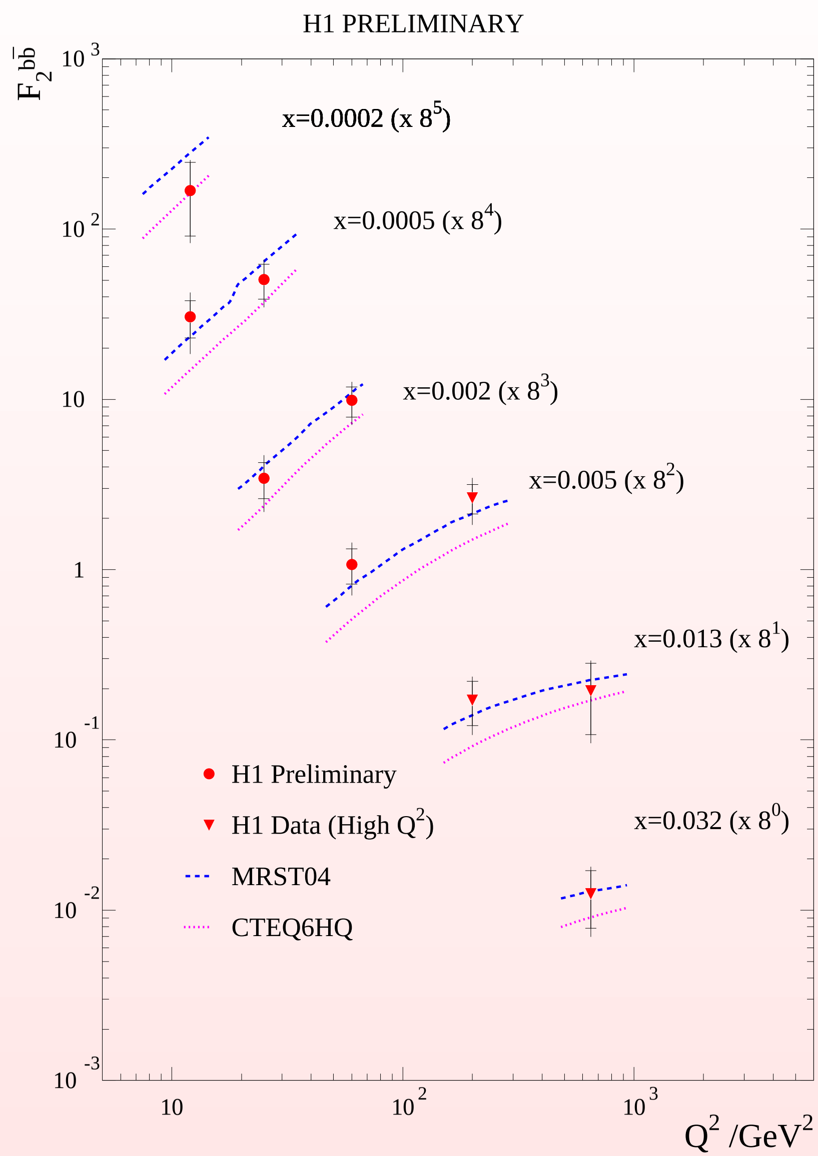
- S_1 highest significance track
- S_2 2nd highest significance track with same sign as S_1
- S_3 3rd highest significance track with same sign as S_1 and S_2

Tatsiana Klimkovich (H1 Collaboration) DIS 2005, Madison, Wiscon

$F_2^{c\bar{c}}$ vs Q^2

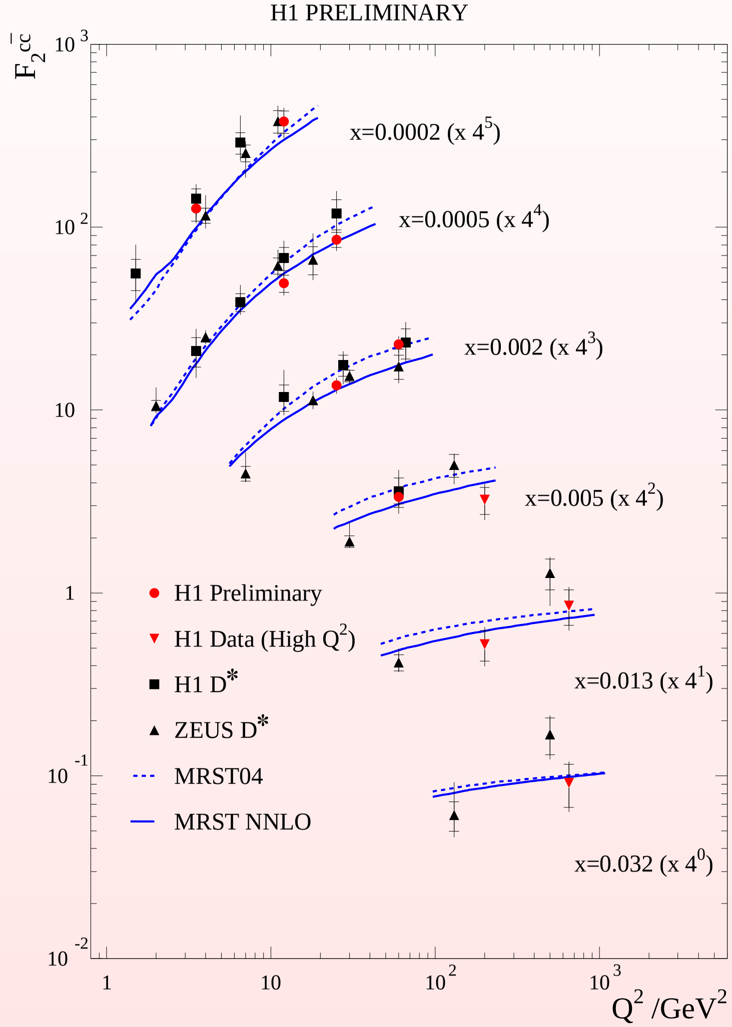


$F_2^{b\bar{b}}$ vs Q^2

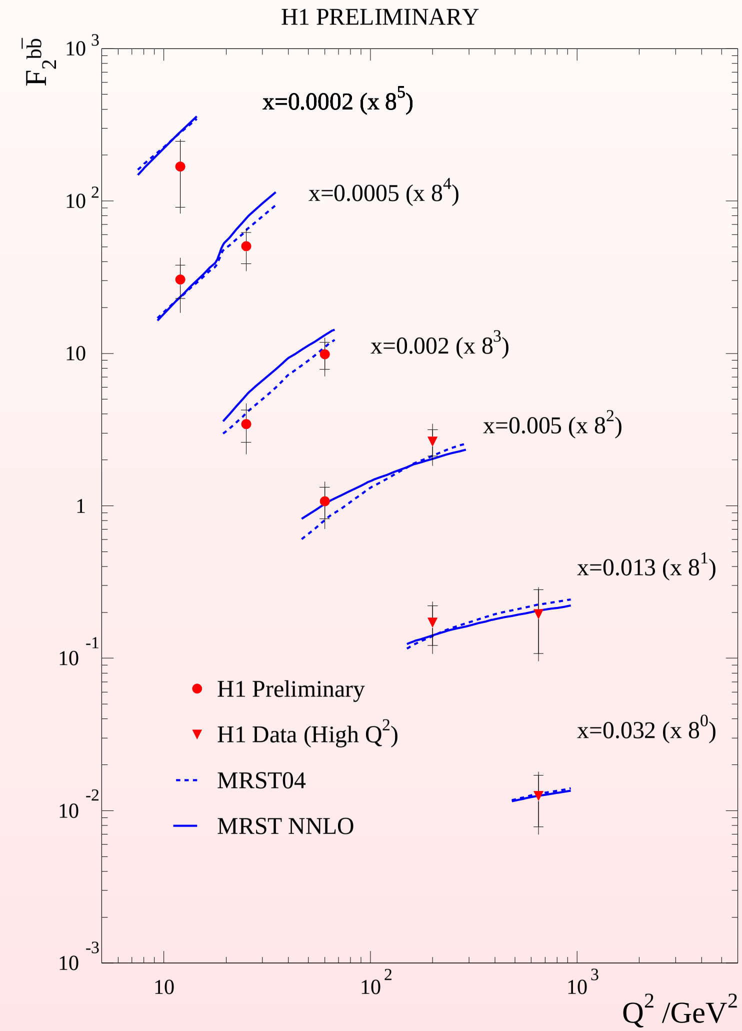


$F_2^{q\bar{q}}$ vs Q^2 MRST NNLO

$F_2^{c\bar{c}}$ vs Q^2



$F_2^{b\bar{b}}$ vs Q^2

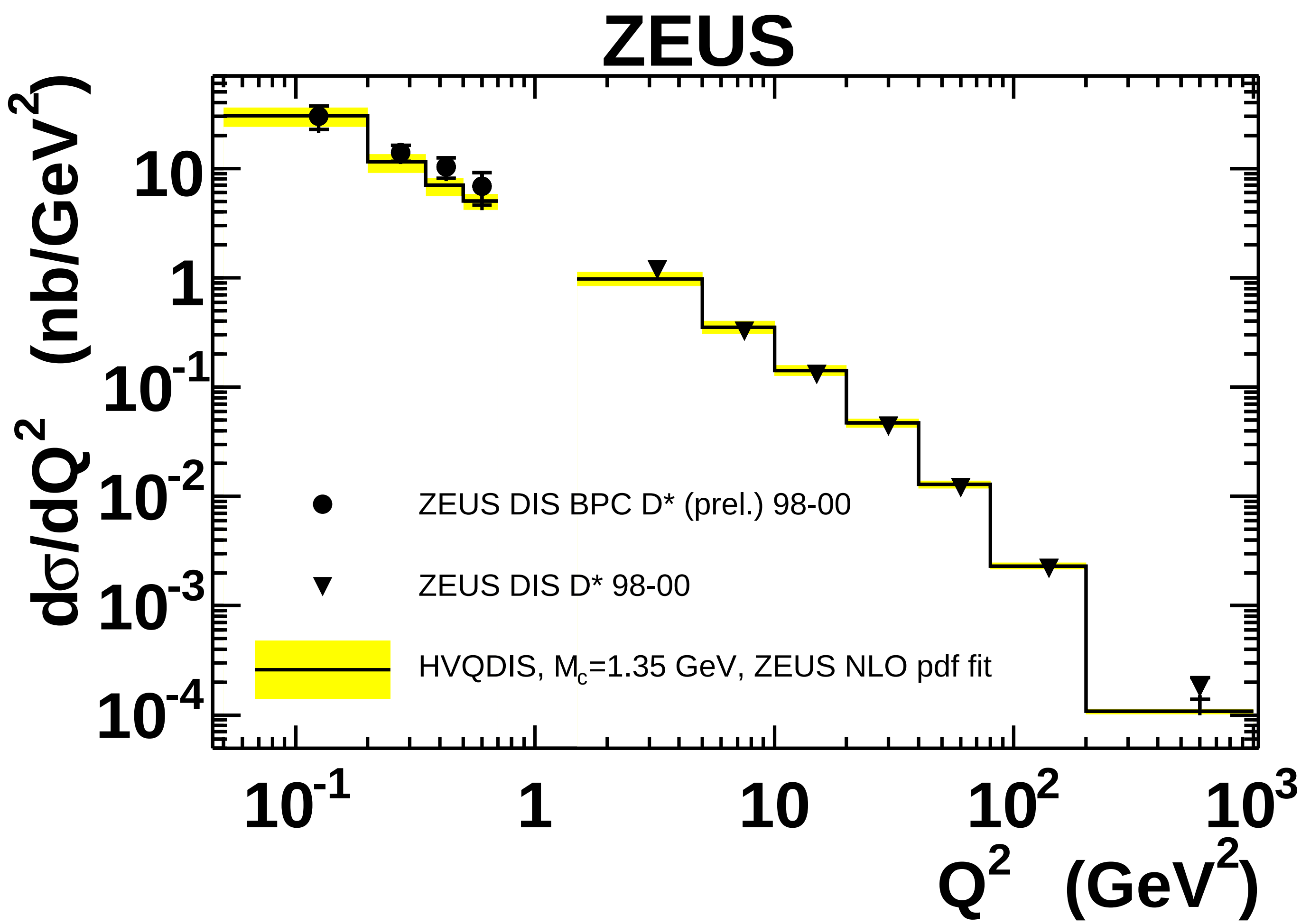


G. Aghuzumtsyan: Charm production at $0.05 < Q^2 < 0.7\mathbf{GeV}^2$

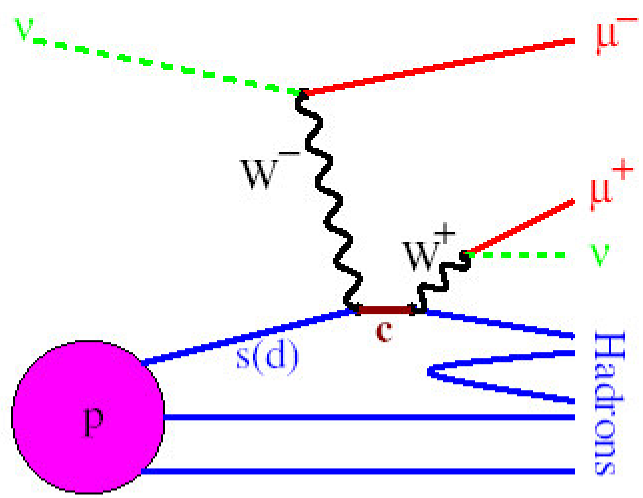
ZEUS beampipe calorimeter (BPC) tags events in the transition region DIS-Photoproduct

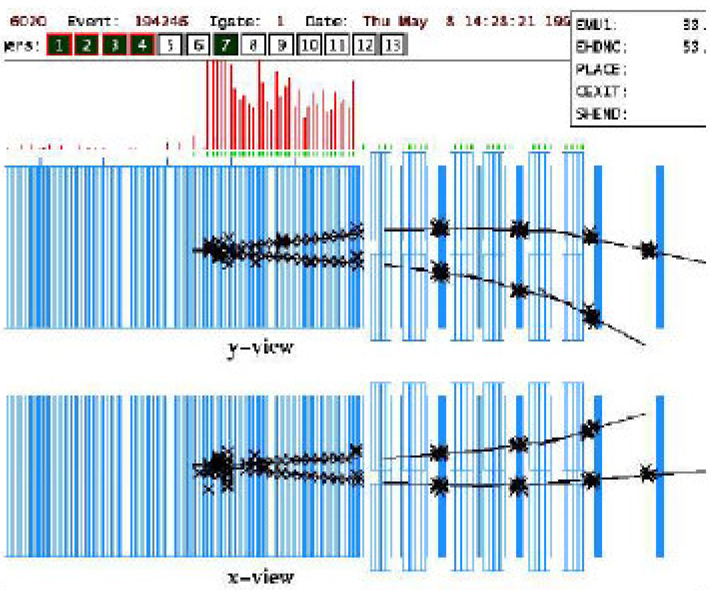
$0.05 < Q^2 < 0.7\mathbf{GeV}^2$ $0.02 < y < 0.085$ **(**< 0.085 **in the plot)**

98-00 data: $239 \pm 23 D^*$ **with** $p_T > 1.5\mathbf{GeV}$**,** $|\eta| < 1.5$



D. Mason: NuTeV $s/\bar{s}$ sea



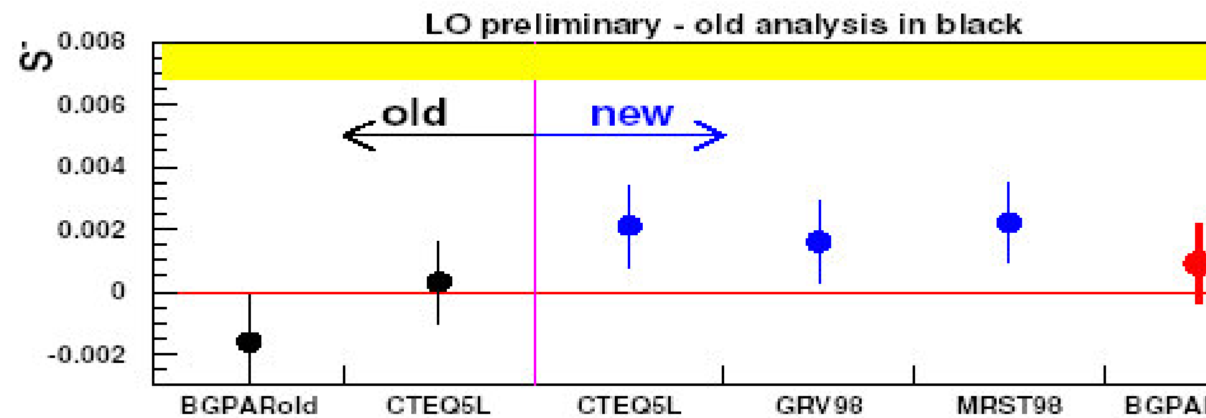


$\nu N \to \mu^- c(\to \mu^+)X$

Signed selected beam, look at $s(x)$ and $\bar{s}(x)$ independen

Complete data sample (20 times previous results)

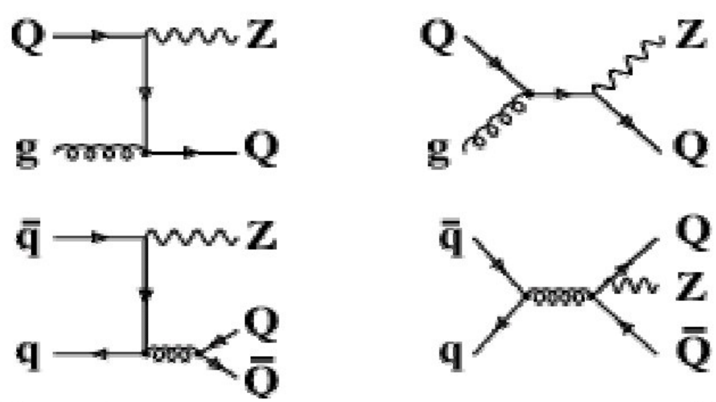
LO analysis, extract $S^- = \int dx\ x(s(x) - \bar{s}(x))$

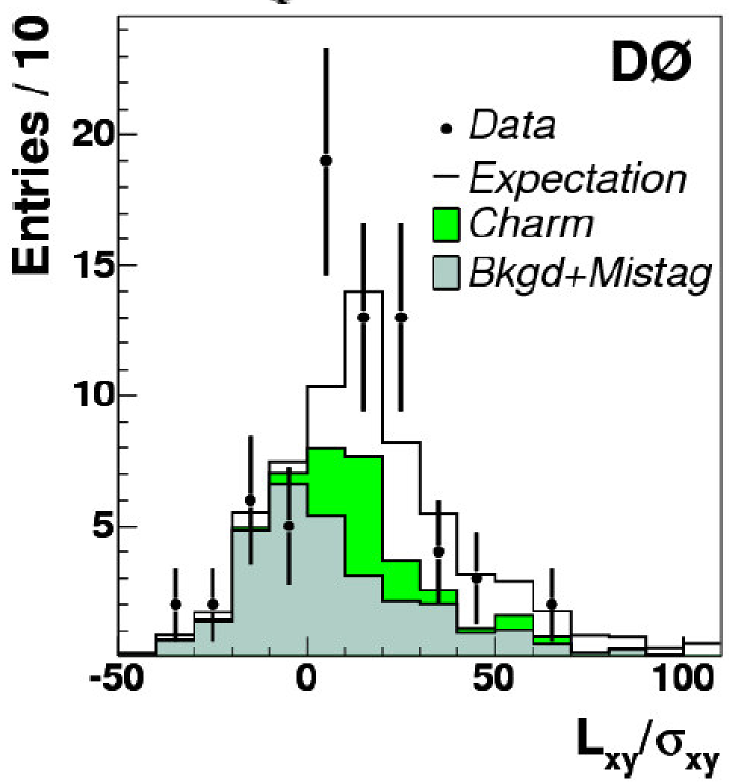


Strange asymmetry compatible with zero

$S^- = 0.0068$ **required to explain** $\sin^2\theta_W$ **anomaly**

N. Parua: $Z + (b - jet)$ from D0





$p\bar{p} \to Z + b$ **production sensitive to b-pdf**

180 pb^{-1} **of Run-II data** $\sim 5000\ Z(\to l^+l^-)$**+jet ev**

require a secondary vertex significance > 7

$\frac{\sigma(Z+bjets)}{\sigma(Z+jets)} = 0.021 \pm 0.004(\mathrm{stat.})^{+0.002}_{-0.003}(\mathrm{syst.})$

Theory: 0.018 ± 0.004 **(NLO+CTEQ6)**

A. Antonov: ZEUS J/ψ in DIS

Measurement of J/ψ production in DIS, $Q^2 > 2\mathrm{GeV}^2$

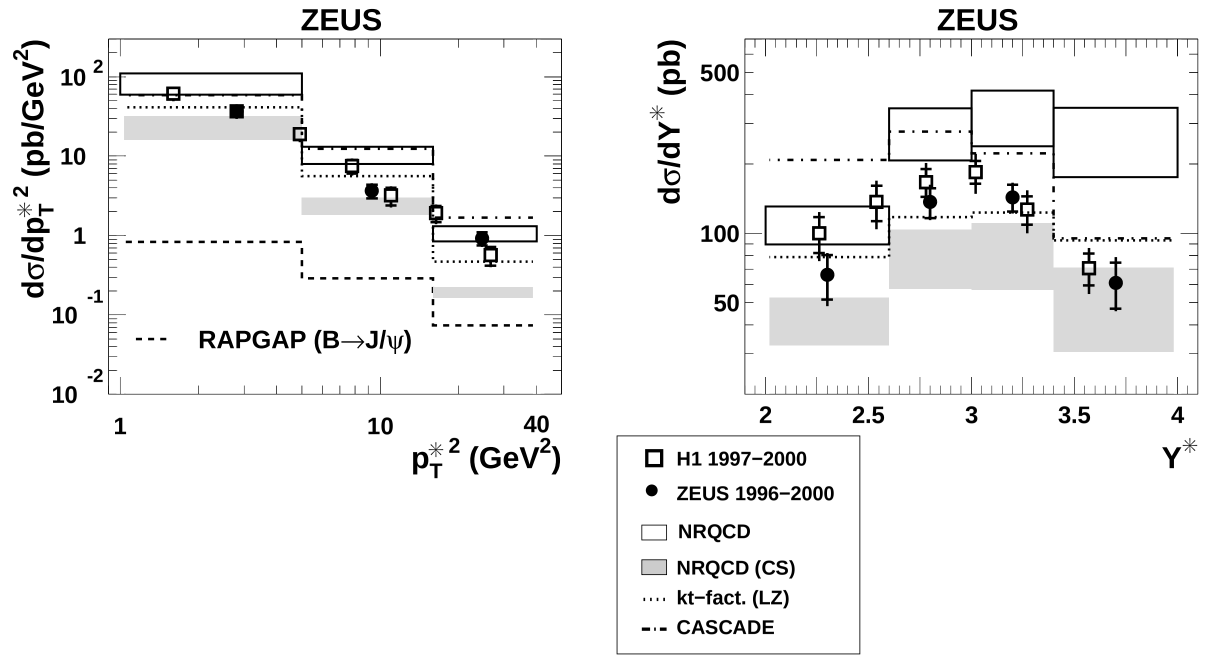
DIS 2005, Madison,Wisconsin April 27 - May 1,2005

Agreement with H1

LO NRQCD COM
too large
mostly excess at large z
resummation needed

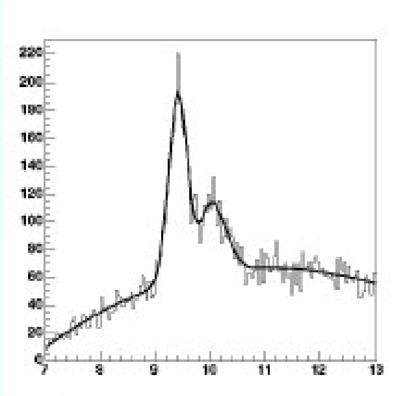
LO CSM slightly low

Comparison to H1 results $d\sigma/dp_T^{*2}$ and $d\sigma/dY^*$ in γp

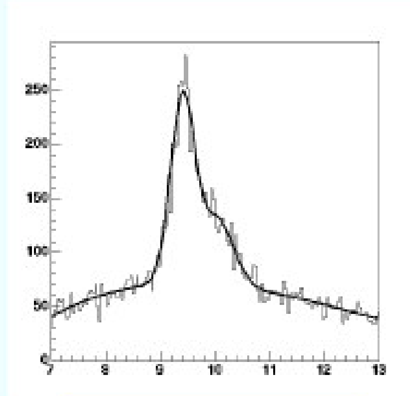


H.D. Wahal: Υ and μ-jets from D0

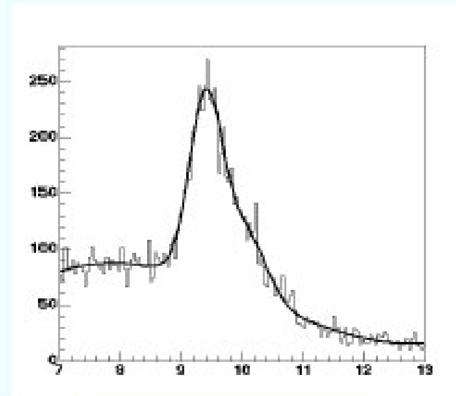
New measurement of Υ at D0 Agreement with CDF



$0 < |y^{\Upsilon}| < 0.6$

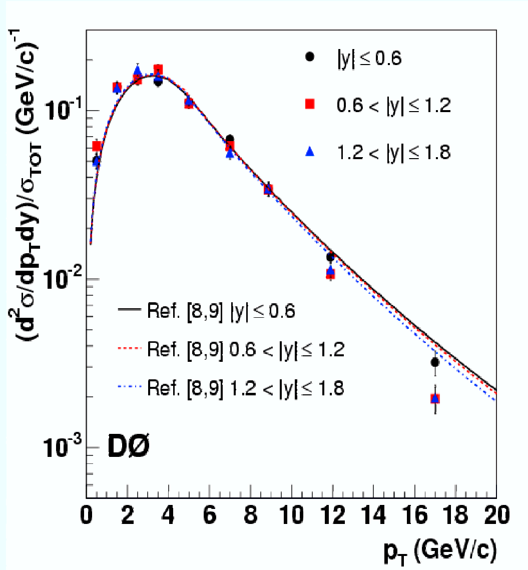


$0.6 < |y^{\Upsilon}| < 1.2$



$1.2 < |y^{\Upsilon}| < 1.8$

Normalized Differential Cross Section



- shape of the p_t distribution does not vary much with Υ rapidity
- Reasonable agreement with calculation of Berger, Qiu, Wang

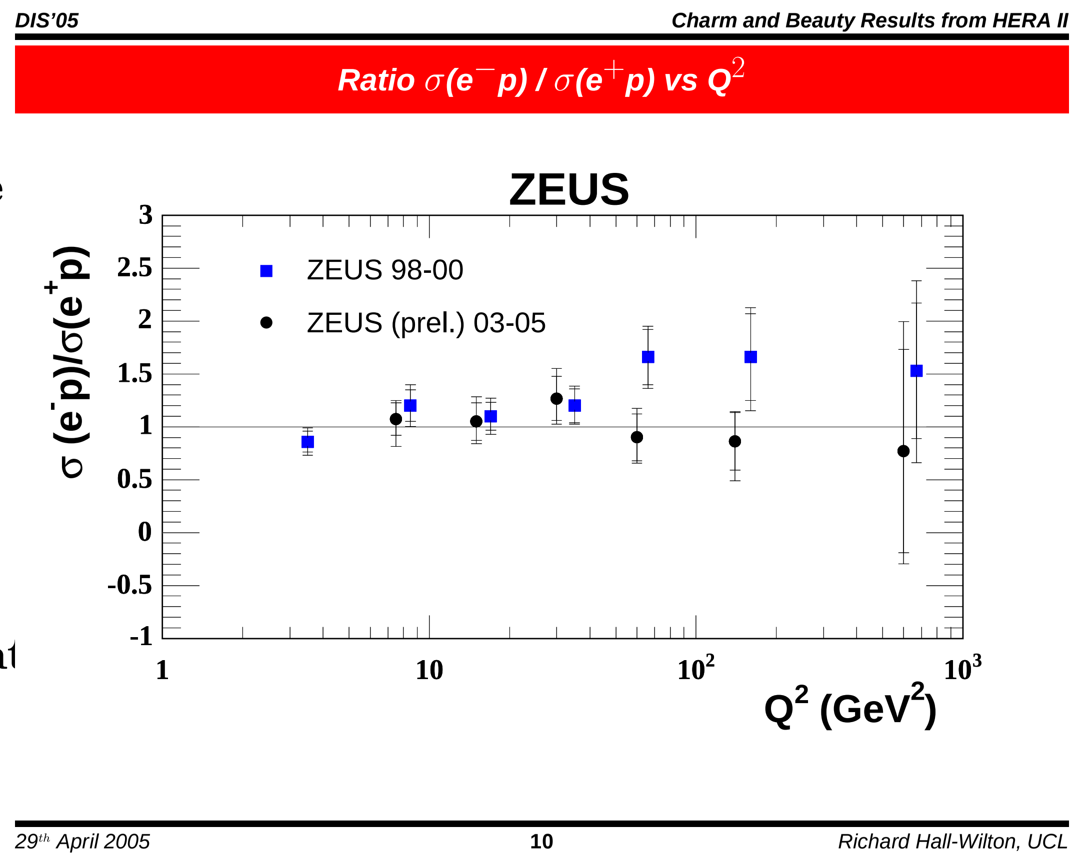
R. Hall-Wilton: ZEUS D^* production in DIS in 03-05 data

98-00: Hints for an excess in D^* rate at $Q^2 > 40$GeV^2 in e^-p collisions wrt e^+p

1998-2000:$17/65$**pb^{-1} of e^-/e^+ data**

2003-2005: $33/40$ **pb^{-1} of e^-/e^+ data**

First charm result from HERA-II dat



ZEUS muon impact parameter

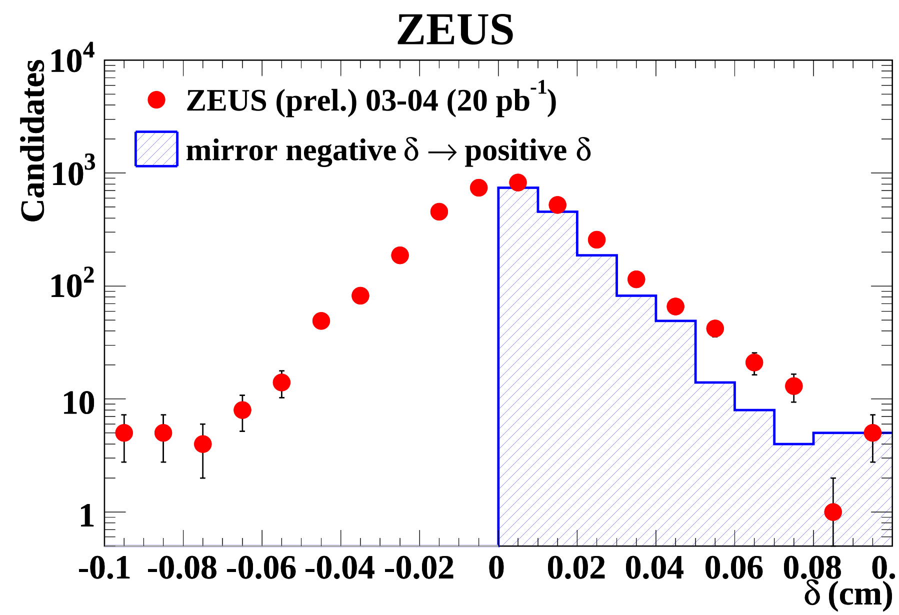
ZEUS has now a silicon microvertex detector (MVD) at HERA-II

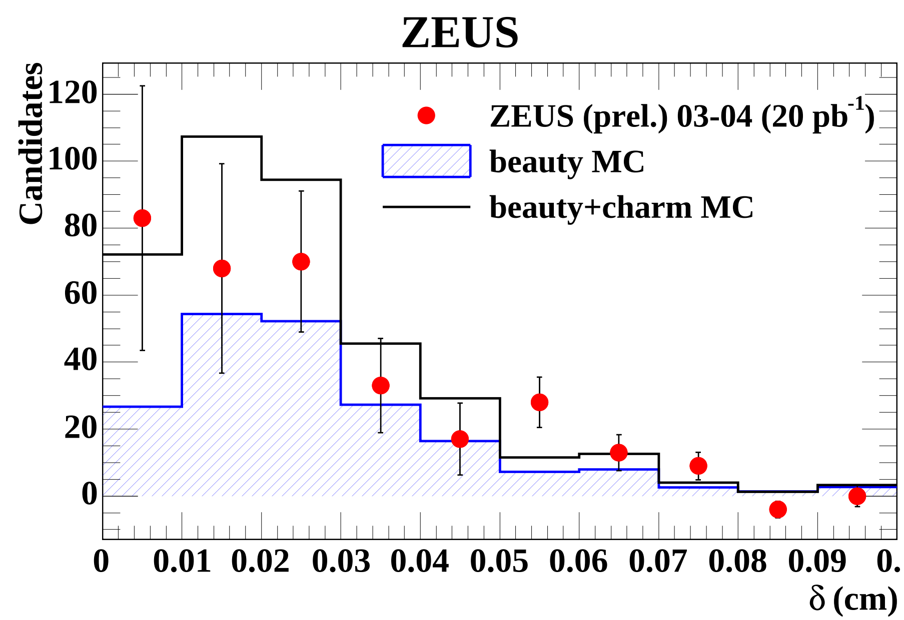
First results:

muon impact parameter (δ) from 03-04 data ($31\mathrm{pb}^{-1}$)

μ+dijets events

negative-positive subtracted δ distribution consistent with b and c from p_T^{rel}





b production

Though m_b is larger than m_c, b production has been more problematic

The beauty "puzzle" seems to be over:
Recent μ+dijet analyses from ZEUS and H1 don't confirm the large excess of early measurements

Is b production at HERA completely understood ?

New measurements:

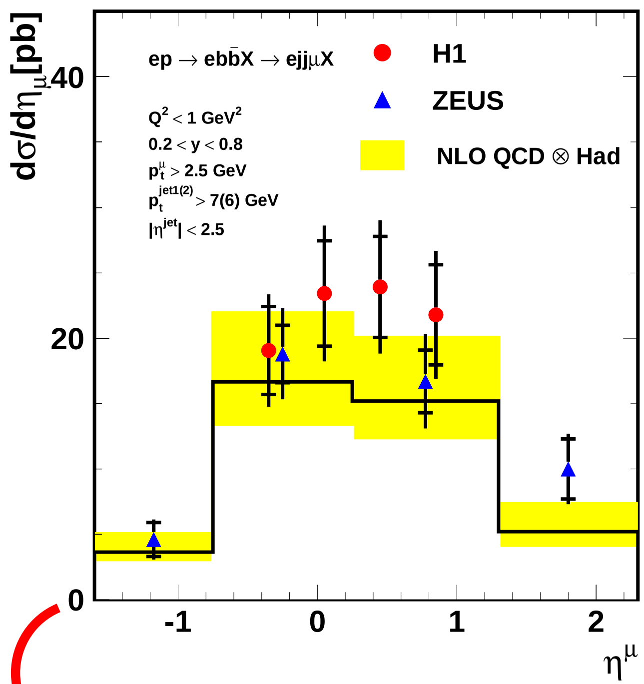
- **μ+jets H1 published final data**
- **H1 dijet photoproduction with inclusive impact par. tag**
- **analyses from μ correlations (ZEUS) and $D^*\mu$ correlations (H1) give access at low p_T**
- **HERA-b new results for hadroproduction**

O. Behnke: H1 b from μ+dijets Photoproduction

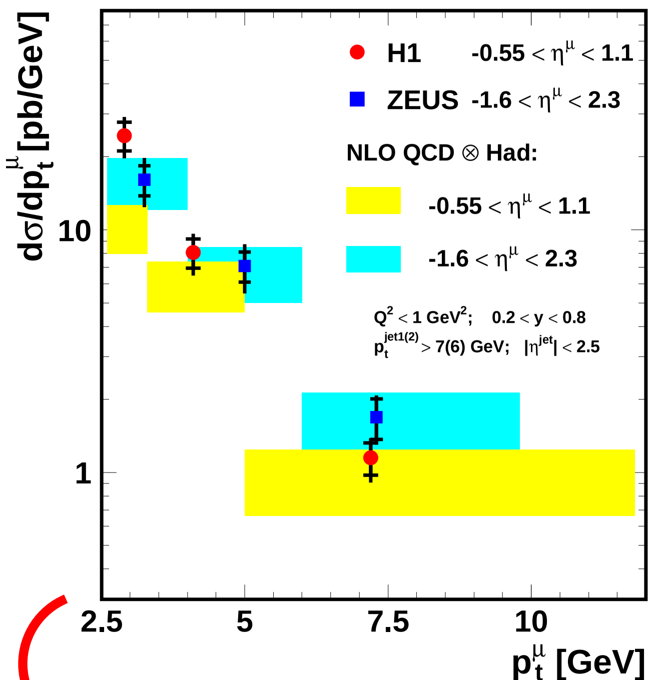
H1 recently published analysis of beauty production in dijet events with muons.

Muon impact parameter and p_T^{rel} to extract the b fraction

Comparison of H1 and ZEUS γp results



Good agreement H1 vs ZEUS



ZEUS: No excess at low p_t^{μ}

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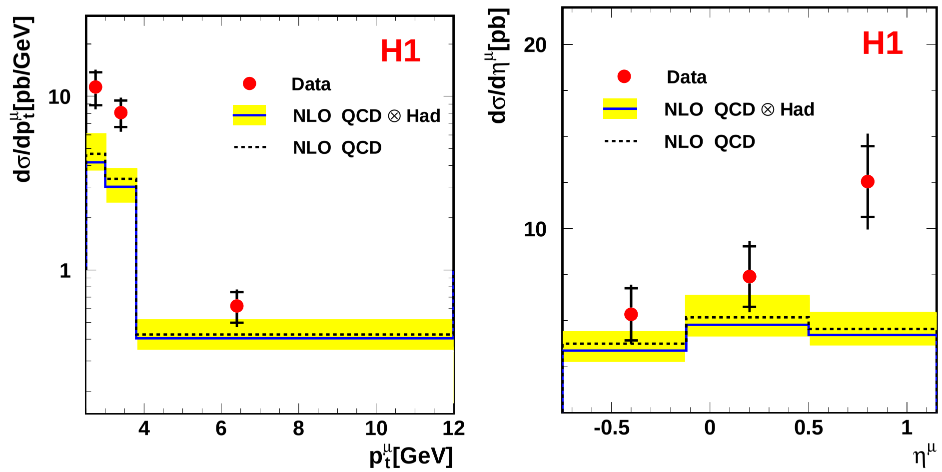
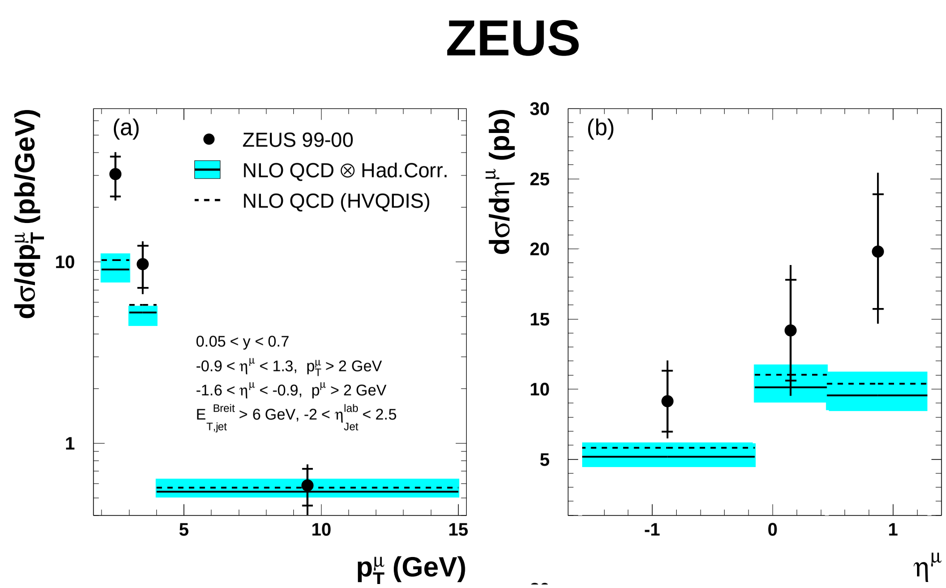
H1 b from μ+jet DIS

Beauty in DIS: Compare H1 and ZEUS results

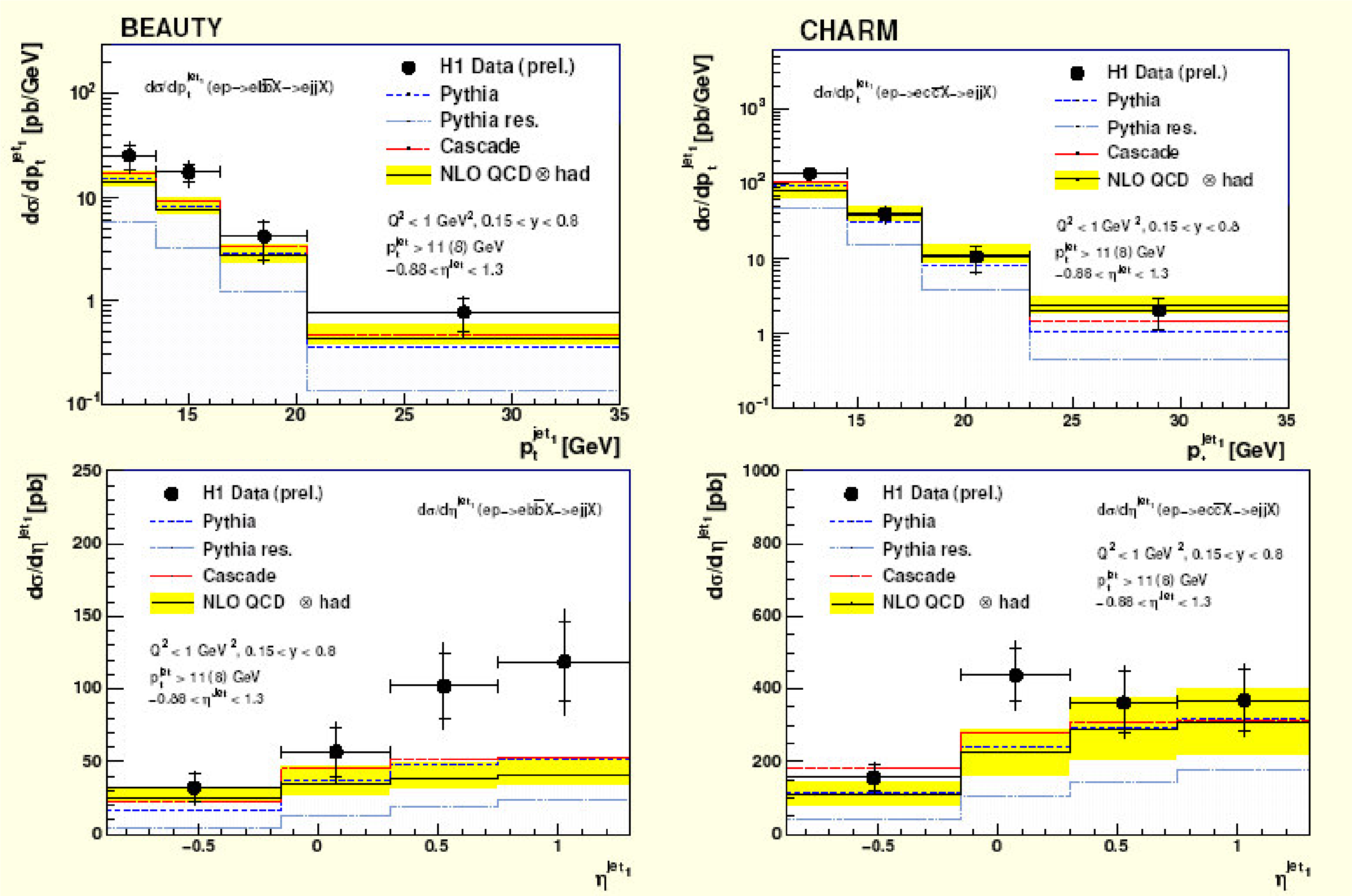




$\Rightarrow$ Good agreement

L. Finke: H1 b, c dijet photoproduction

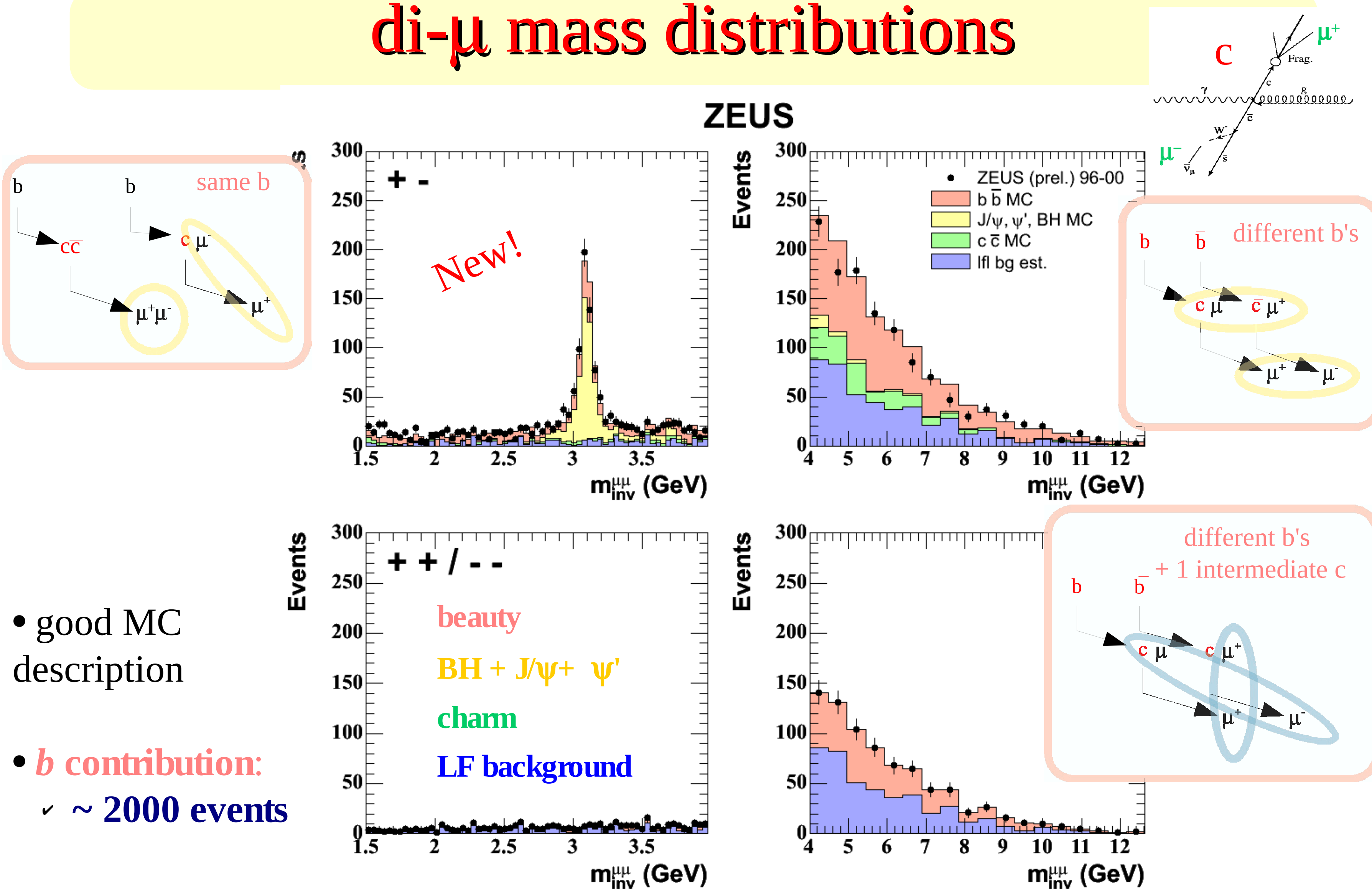
H1 results with inclusive IP tagging, general agreement with muon results



A. Longin: ZEUS b from dimuon

8

di-μ mass distributions



- good MC description
- *b* contribution:
  - ~ 2000 events
- signal and background normalisation: see next slides ↪

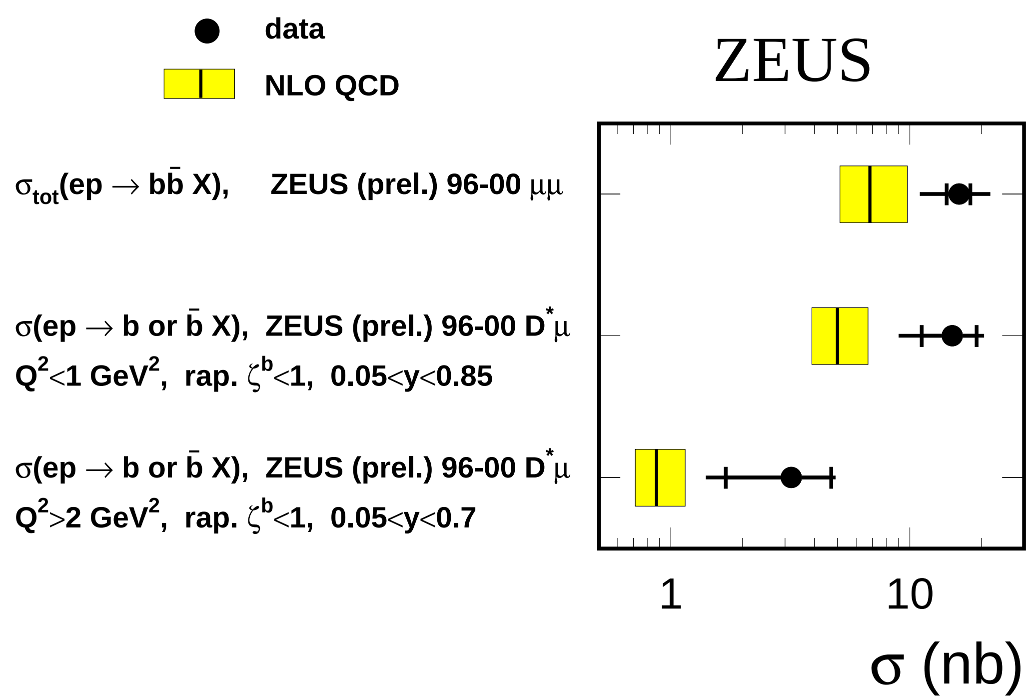
A.Longhin INFN Padova   ZEUS: *b* production with $\mu\mu$ correlations   DIS05 Madison (Wisconsin) 29/04/2005

ZEUS b from dimuon

Double muon tag, lower background, looser muon cuts:

$-2.2 < \eta^{\mu} < 2.5 \; p_t^{\mu 1} > 1.5\mathbf{GeV} \; p_t^{\mu 1} > 0.75 - 1.5\mathbf{GeV}$ **(depending on** η**)**

small extrapolation to full cross section

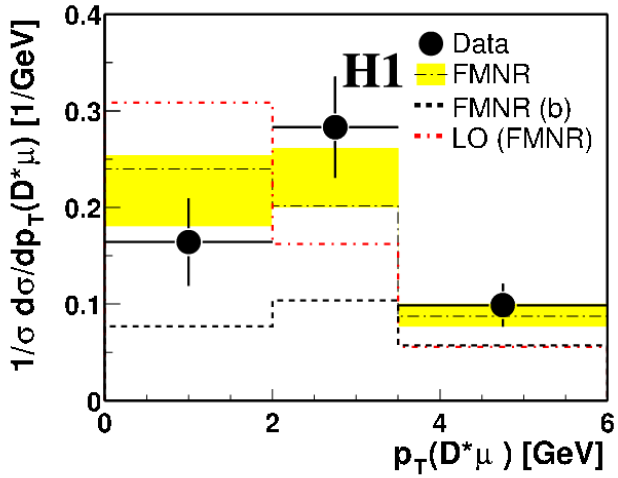


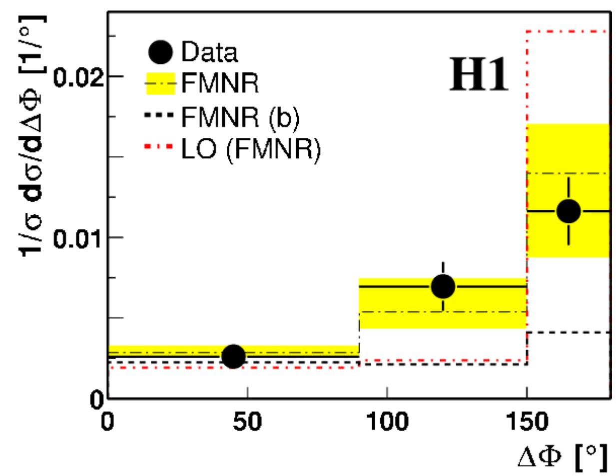
N. Malden, H1 c and b from $D^*\mu$ correlations

Recently published analysis from H1 Similar principle as dimuon analysis charm normalization compatible with NLO, b factor 4 larger, large errors

D*μ variables – (N)LO FMNR comparisons

$$p_T(D^*\mu) = |\vec{p}_T(D^*) + \vec{p}_T(\mu)|$$

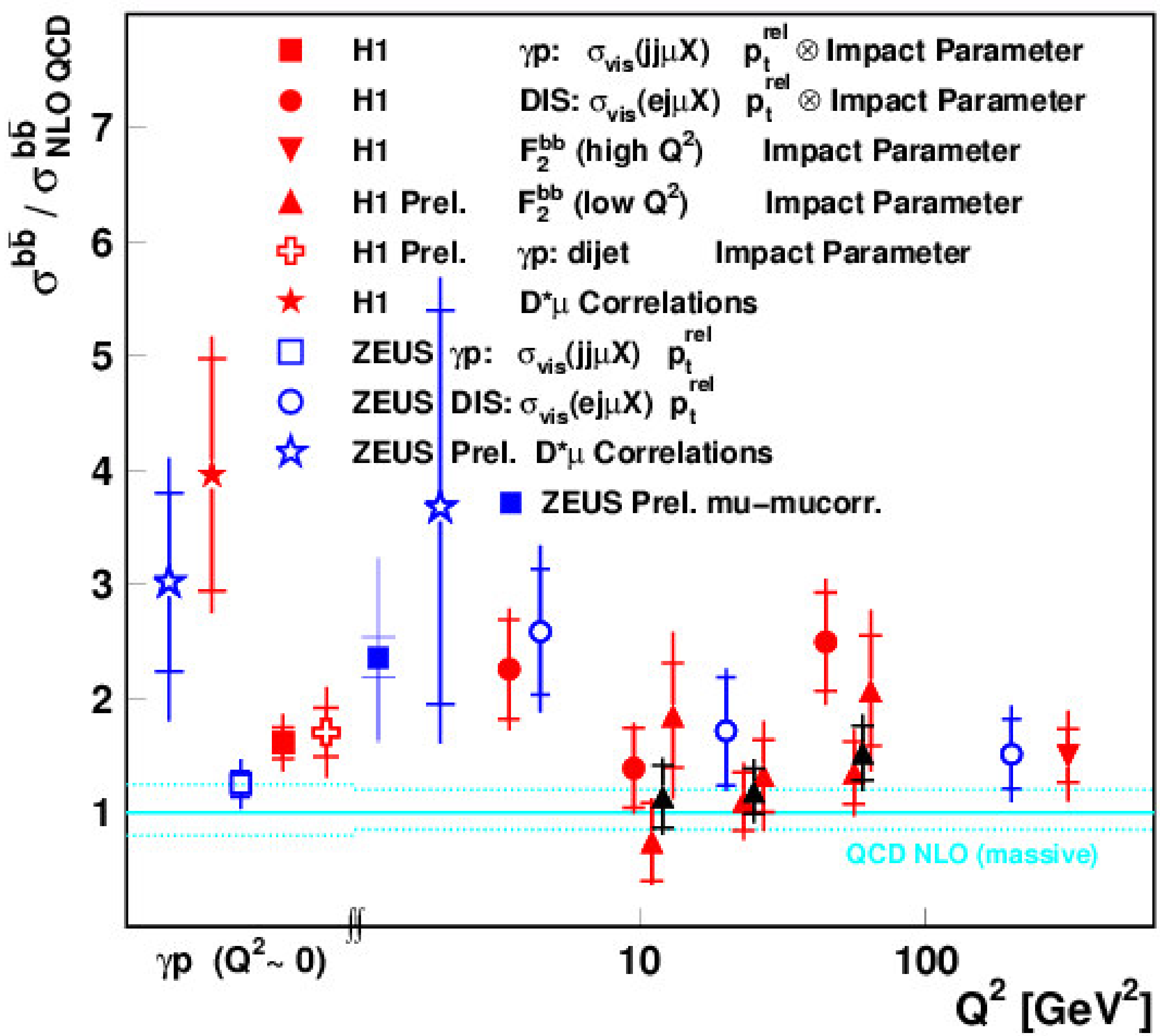




- **Expected deviations from LO due to higher order effects – flatter p_T distribution and broader ΔΦ peak.**

- **Good agreement with NLO calculation**

Latest version of the Summary plot



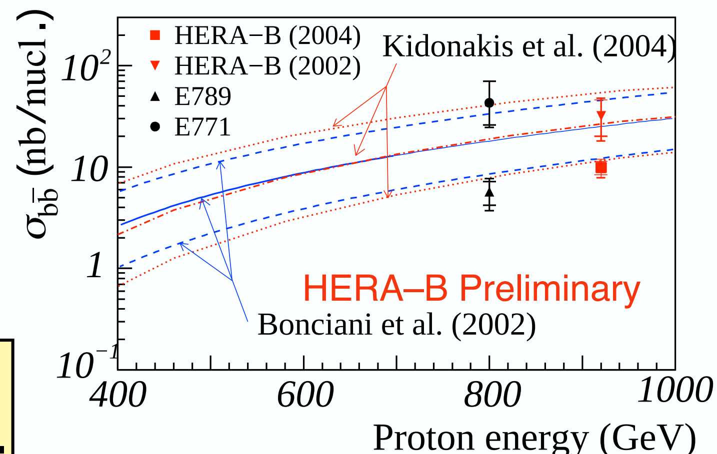
B Cross Section: Results

- Weighted average of results from 2000 and 2002/3 data-taking periods:

$$\frac{\sigma\sigma_{b\bar{b}}}{\sigma\sigma_{J/}} = 0.033 \pm 0.005\,(\text{stat.}) \pm 0.004\,(\text{syst.})$$

- Extrapolation to full cross section:
  - Extrapolation to full phase-space: theory
  - $\sigma_{J/} = 352\,\text{nb/nucl.}$ (average of E789 & E771, rather low, currently under investigation)

$$\sigma_{b\bar{b}} = 9.9 \pm 1.5\,(\text{stat.}) \pm 1.4\,(\text{syst.})\,\text{nb/nucl.}$$



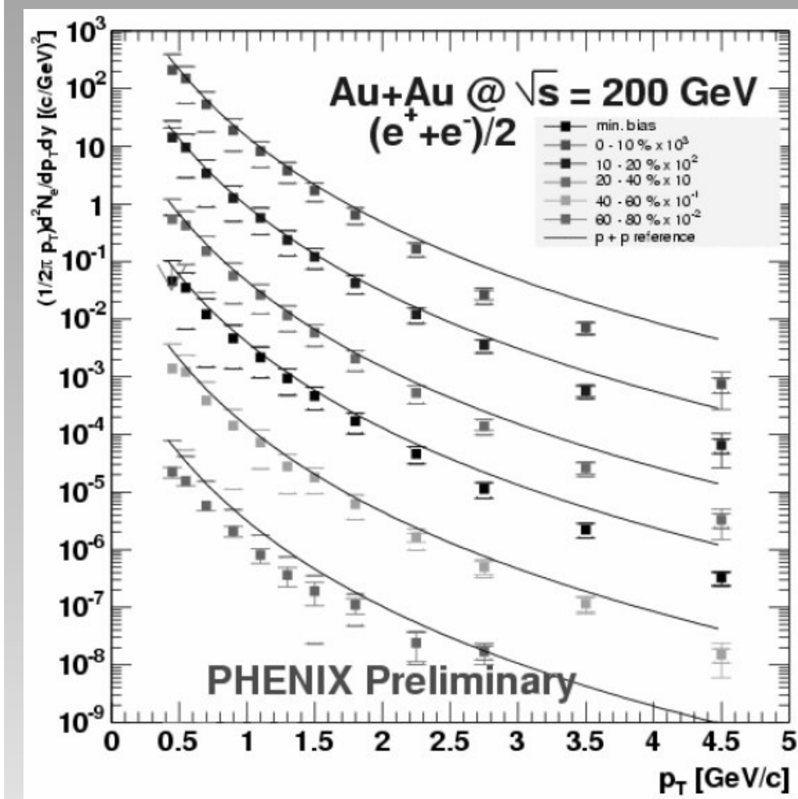
DIS2005 – U. Husemann: Charm and Beauty Production at HERA–B 16

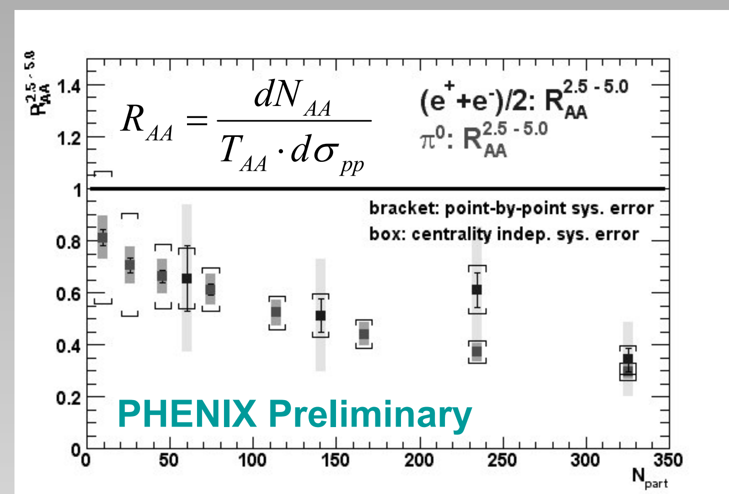
K. Read: PHENIX charm and charmonium

HQ as probe of dense matter **Open c tagged with leptons**

Heavy Flavor Production (electrons)

PHENIX Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV





Suppression at high p_T relative to scaled p+p results.
Spectral shape modified by medium.
Pattern consistent with models incorporating heavy quark energy loss.

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Charm Phisics at Belle (B. Yabsley) and BaBar (C. Chen)

Incredible amount of data on old and new charmed hadrons

Belle

summary

- I've left out most of our charm & charmonium studies
- $X(3872)$ observ^n & updated measurement of properties
  - no natural charmonium candidate has been found
  - $X \to \gamma J/\psi$ and $\omega J/\psi$ observations fix $C = +1$
  - angular and $M(\pi^+\pi^-)$ distributions favour $J^{PC} = 1^{++}$
  - decays & properties consistent with $D^0\overline{D}^{*0}$, but not χ'_{c1}
- $e^+e^- \to \psi\,\eta_c$ results (finally) confirmed by BaBar; disagreement with NRQCD [also open charm] still unexplained
- $X(3940) \to DD^*$ (not the $X(3872)$, not the $Y(3940) \to \omega J/\psi$) $\to$ publication this summer
- other spectroscopic contributions: D_{sJ}, $\Sigma_c(2880)$, . . .
- Θ^+ search [negative!]: QE formation limit by the summer
- D^0, D^+, D_s, Λ_c^+ fragmentation $\to$ publication at summer

DIS'05 29–Apr–2005 Unexplained results from Belle *Bruce Yabsley*

BaBar

- Semileptonic D^0 mixi
- Search $D^0 \to l^+ l^-$
- Search for $D_{sJ}(2632$
- $\Xi^0_c \to \Omega^- K^+$, $\Xi^0_c \to \Xi^- \pi^+$
- Λ_c mass measuremen

Conclusions

- **Great data on c,b in DIS and γp still coming from HERA- data**
- **Is there a problem in the description of beauty at low p_T ?**
- **Results on $s(x)$ from NuTeV**
- **waiting for HERA-II analyses**