Beauty production at H1

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October 20, 2003

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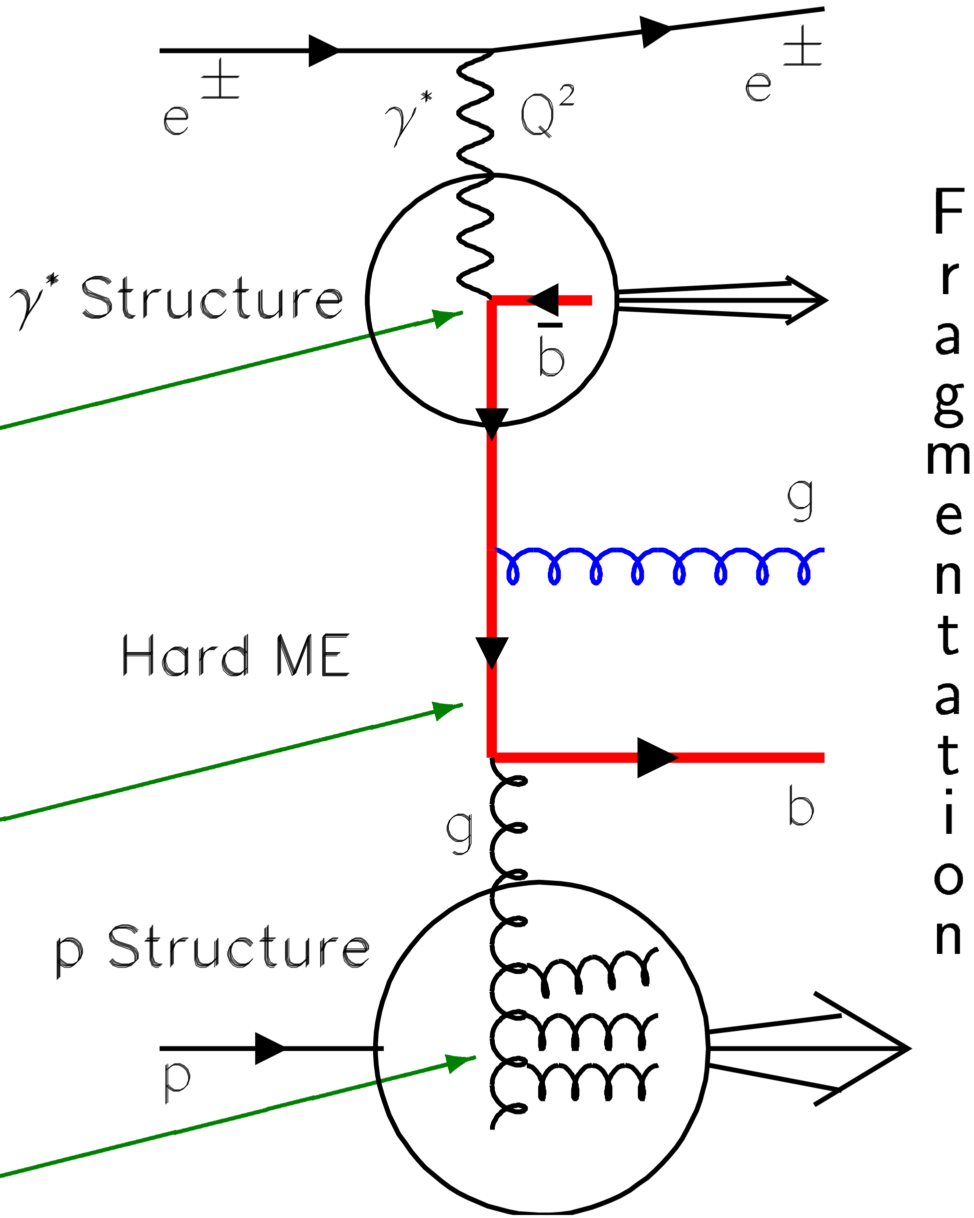
Beauty production in pQCD

Key questions:

Role of resolved photons for beauty production?

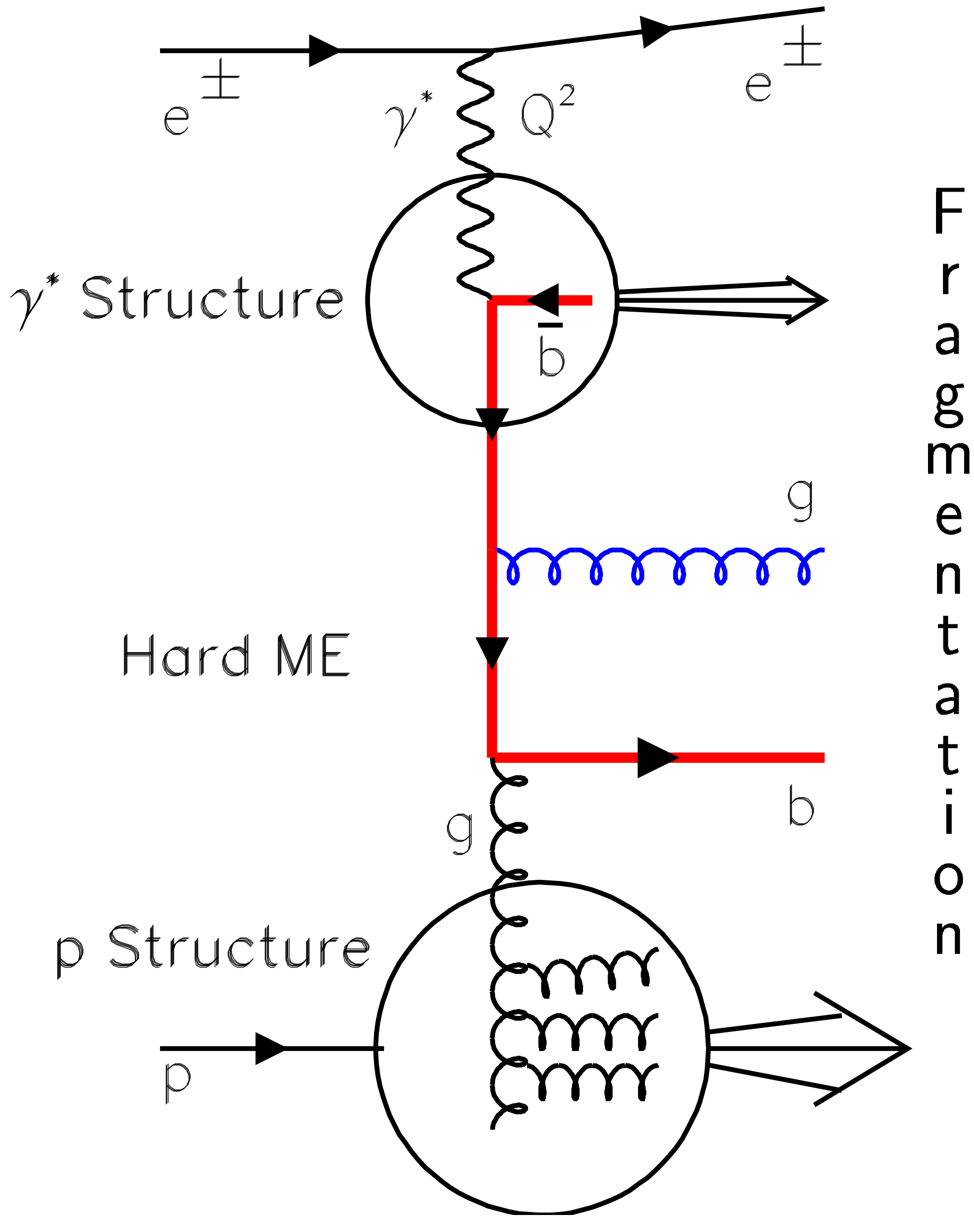
Use "massive" or "massless" b-quarks?

Test pQCD approximation for gluon radiations: DGLAP, CCFM, BFKL



QCD models compared to H1 data

- NLO $\mathcal{O}(\alpha_s^2)$ calculations:
  - γp: FMNR = "massive"
- LO $\mathcal{O}(\alpha_s)$ + Parton shower:
  - Pythia MC (DGLAP)
  - Cascade MC (CCFM)



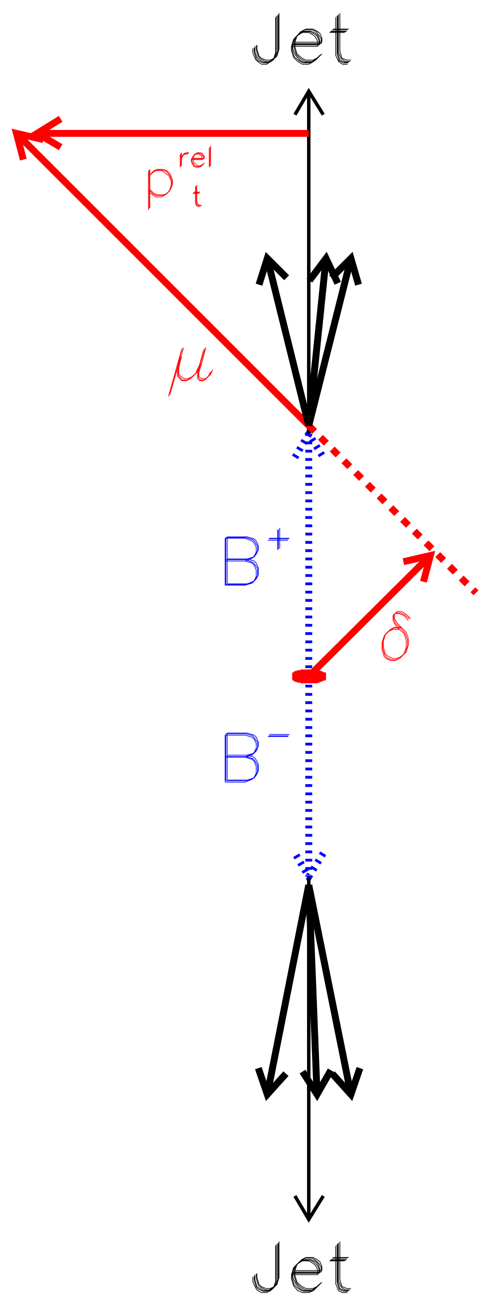
Beauty at H1: Topics of this talk

1. $B \to \mu X$ in γp $\leftarrow$ preliminary EPS 2003
2. $B \to \mu X$ in DIS $\leftarrow$ ongoing analysis
3. $D^* \mu$ correlations $\leftarrow$ preliminary DIS 2002
4. Inclusive vertex tagging $\leftarrow$ ongoing analyses

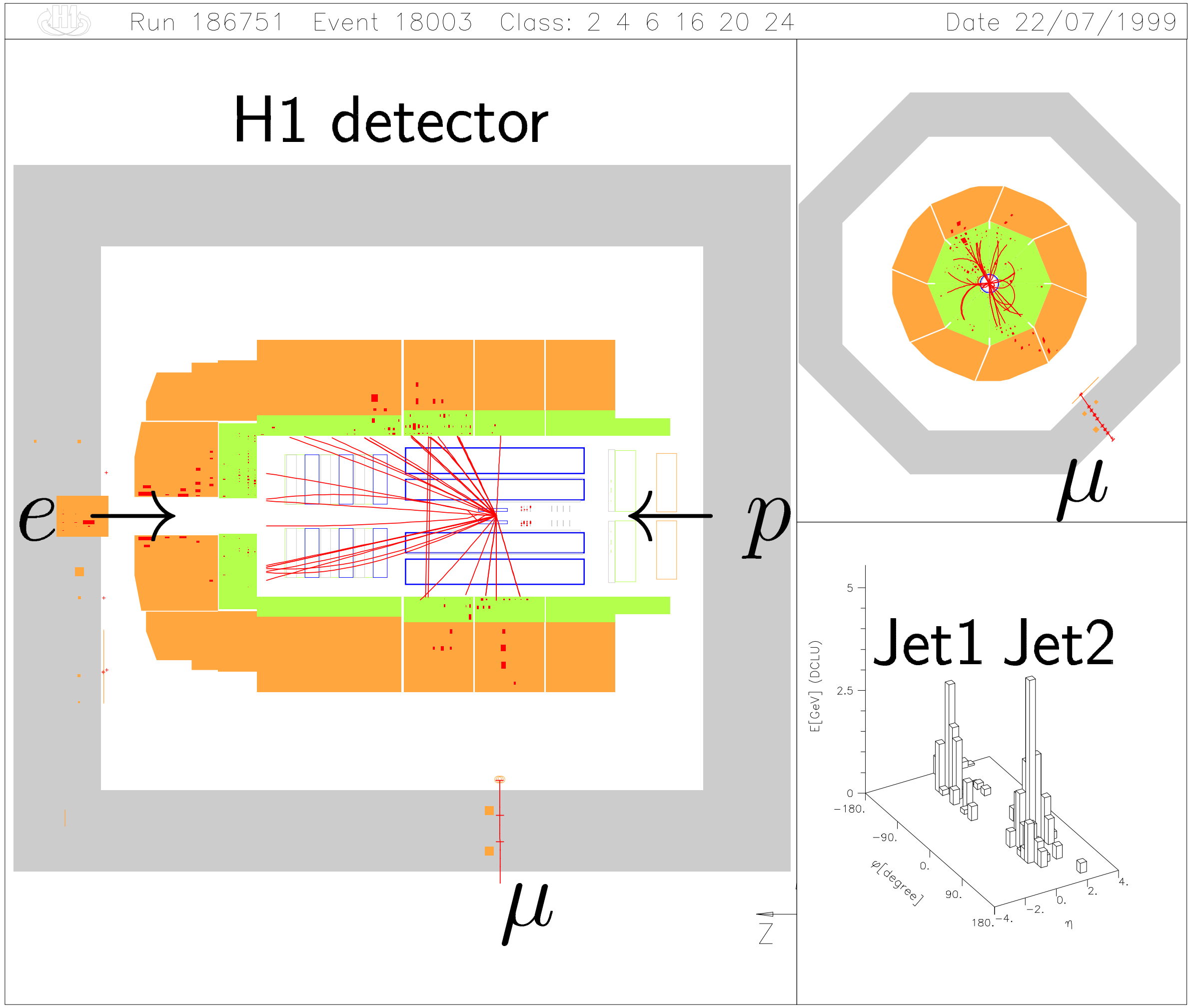
$B \to \mu X$ measurement technique

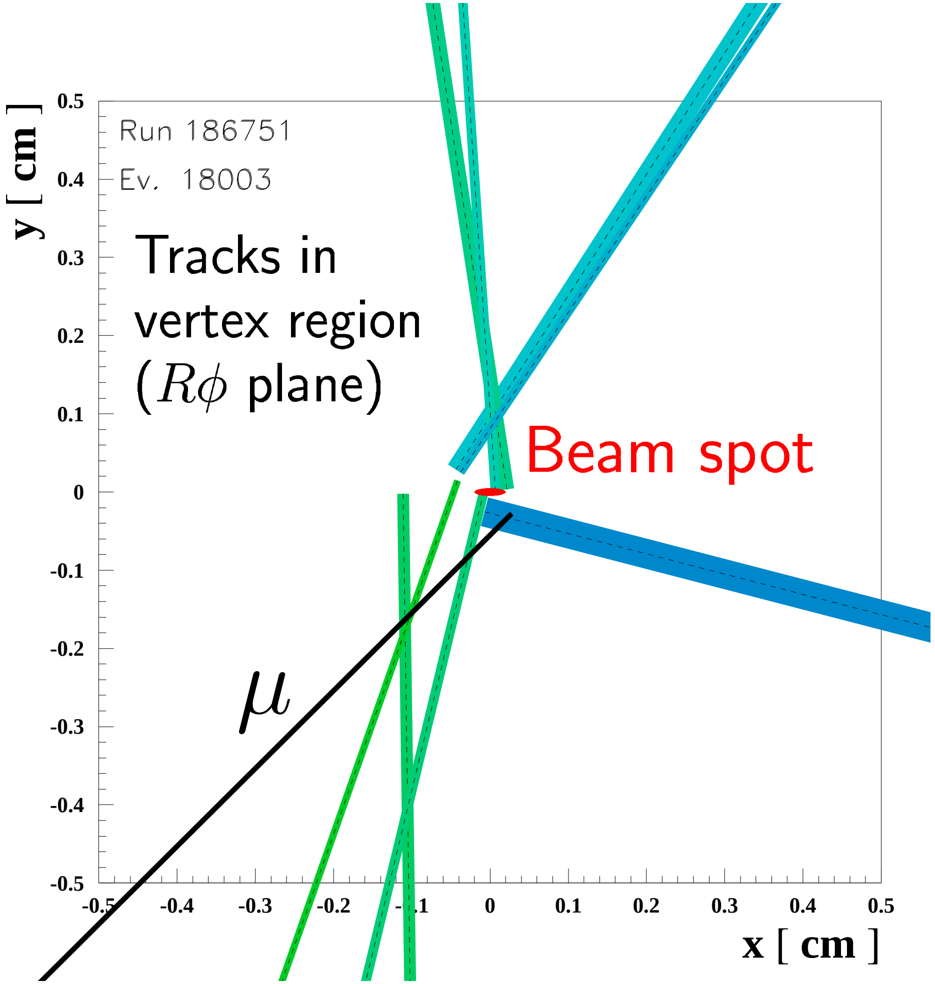
- Find muons from b,c-decays in dijet events

- For b,c and fake separation use:
  1. **Large b mass**
     $\Rightarrow$ **muon** p_T^{rel}
  2. **Long b lifetime**
     $\Rightarrow$ **muon signed impact-param.** δ



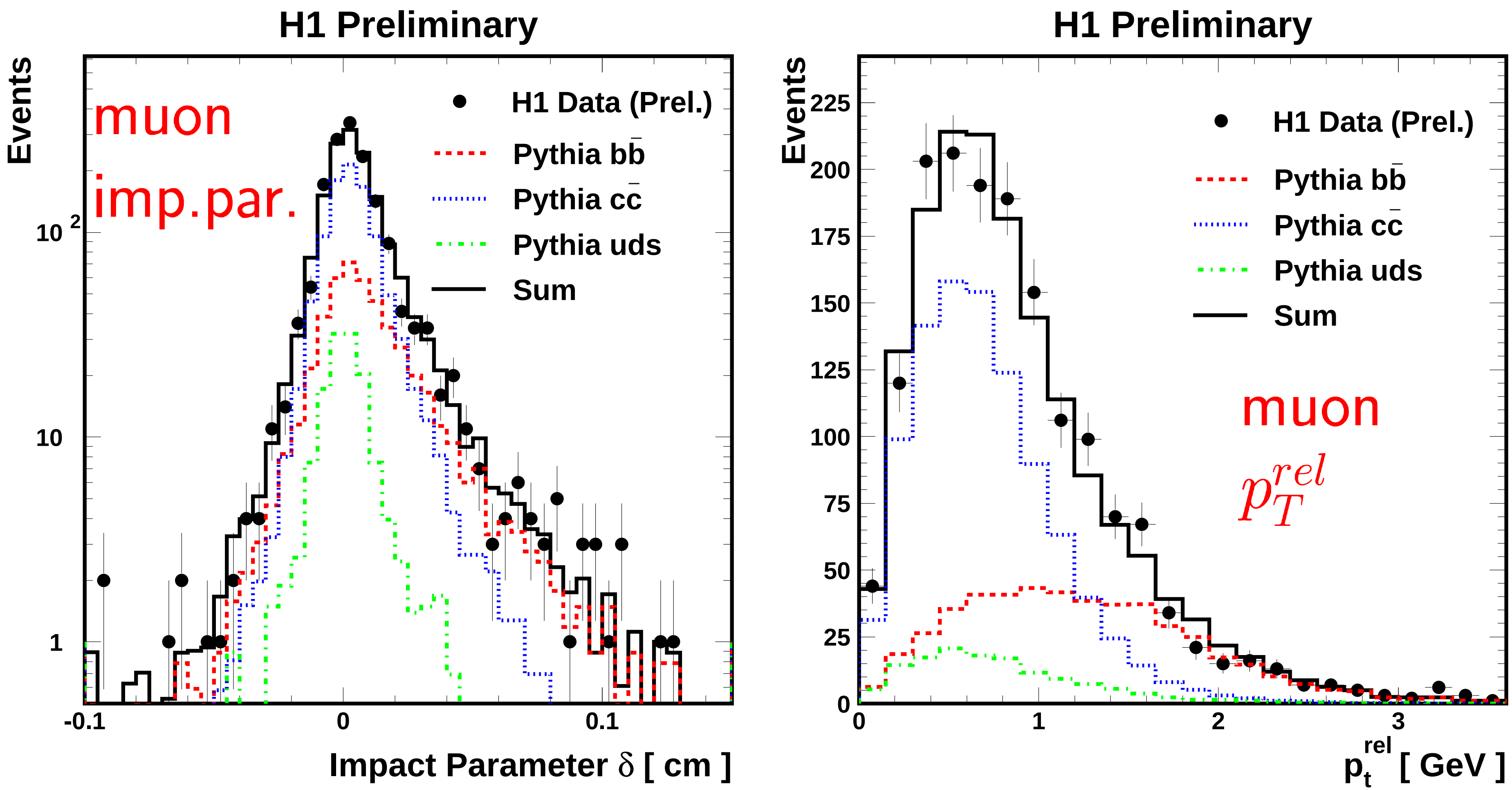
$B \to \mu X$ event candidate





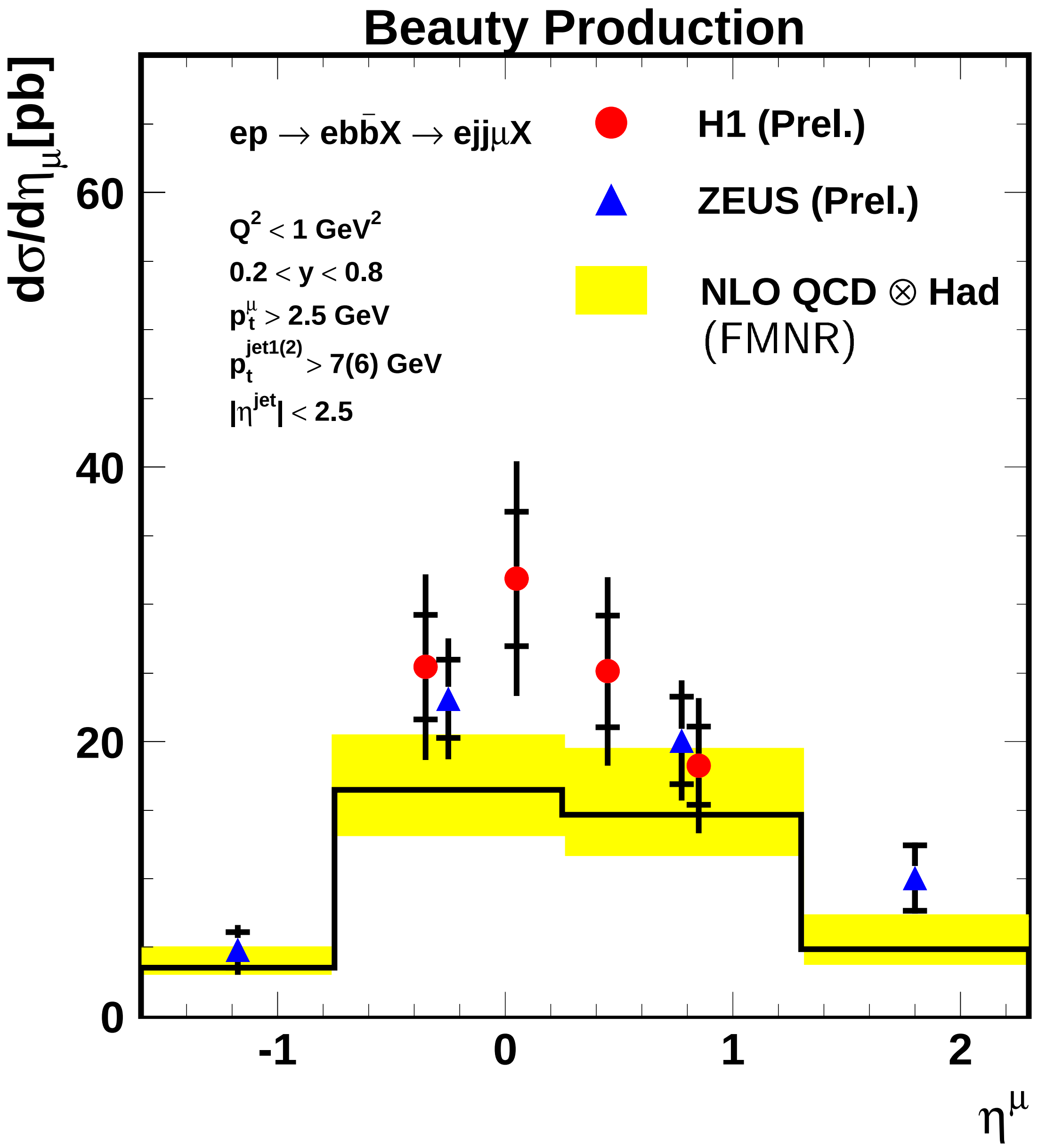
$B \to \mu X$ signal in γp

- Cuts: $Q^2 < 1$ GeV^2, $p_T^\mu > 2.5$ GeV, $p_T^{jet1(2)} > 7(6)$ GeV
- Data: 99/00 with L $= 48$ pb^{-1} $\Rightarrow \approx 1500$ events



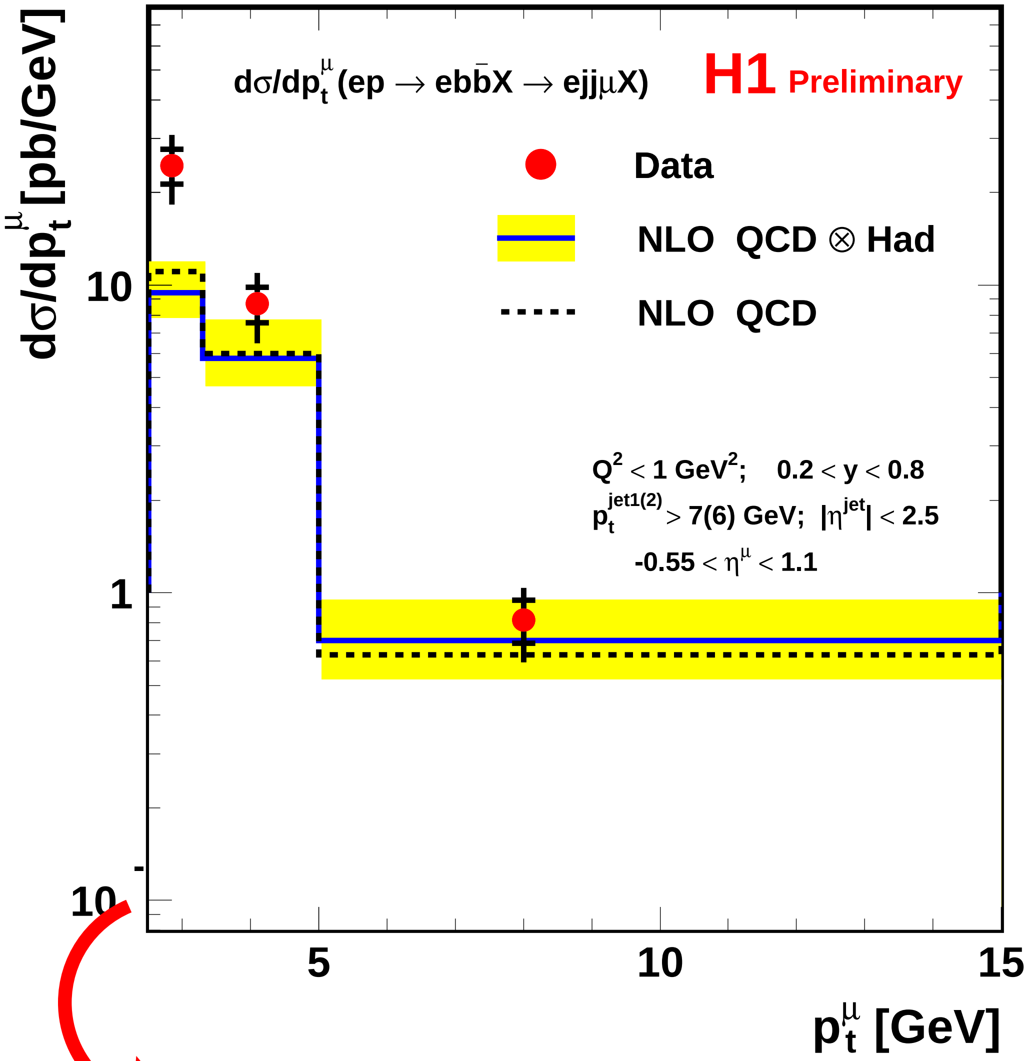
2-dim-Likelihood fit (δ, p_T^{rel}): $\to f_b = 31 \pm 3\%$

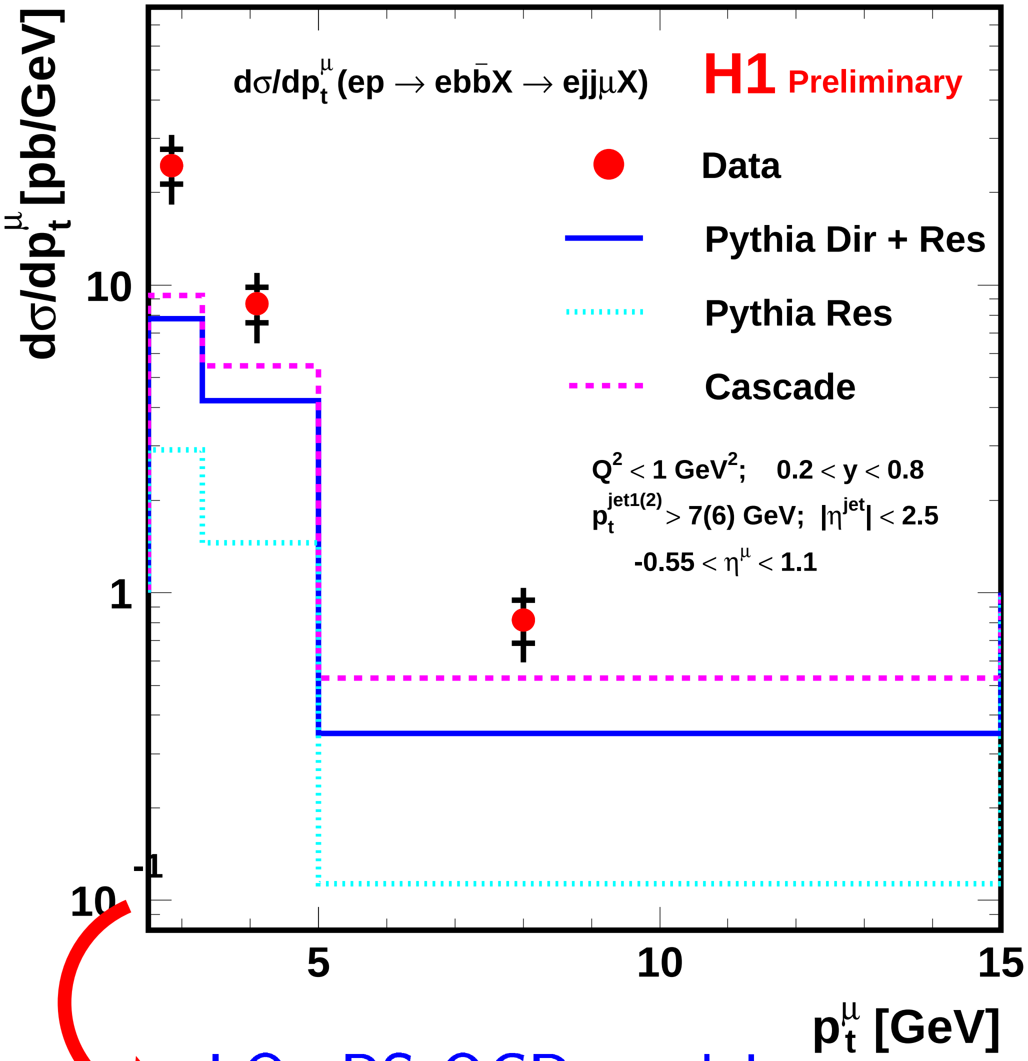
$B \to \mu X$ in γp $\to$ cross sections in bins of η^μ



- H1 and ZEUS agree
- All data points above NLO QCD
- Reasonable agreement of data and NLO QCD

$d\sigma/dp_T^\mu$ compared with QCD models

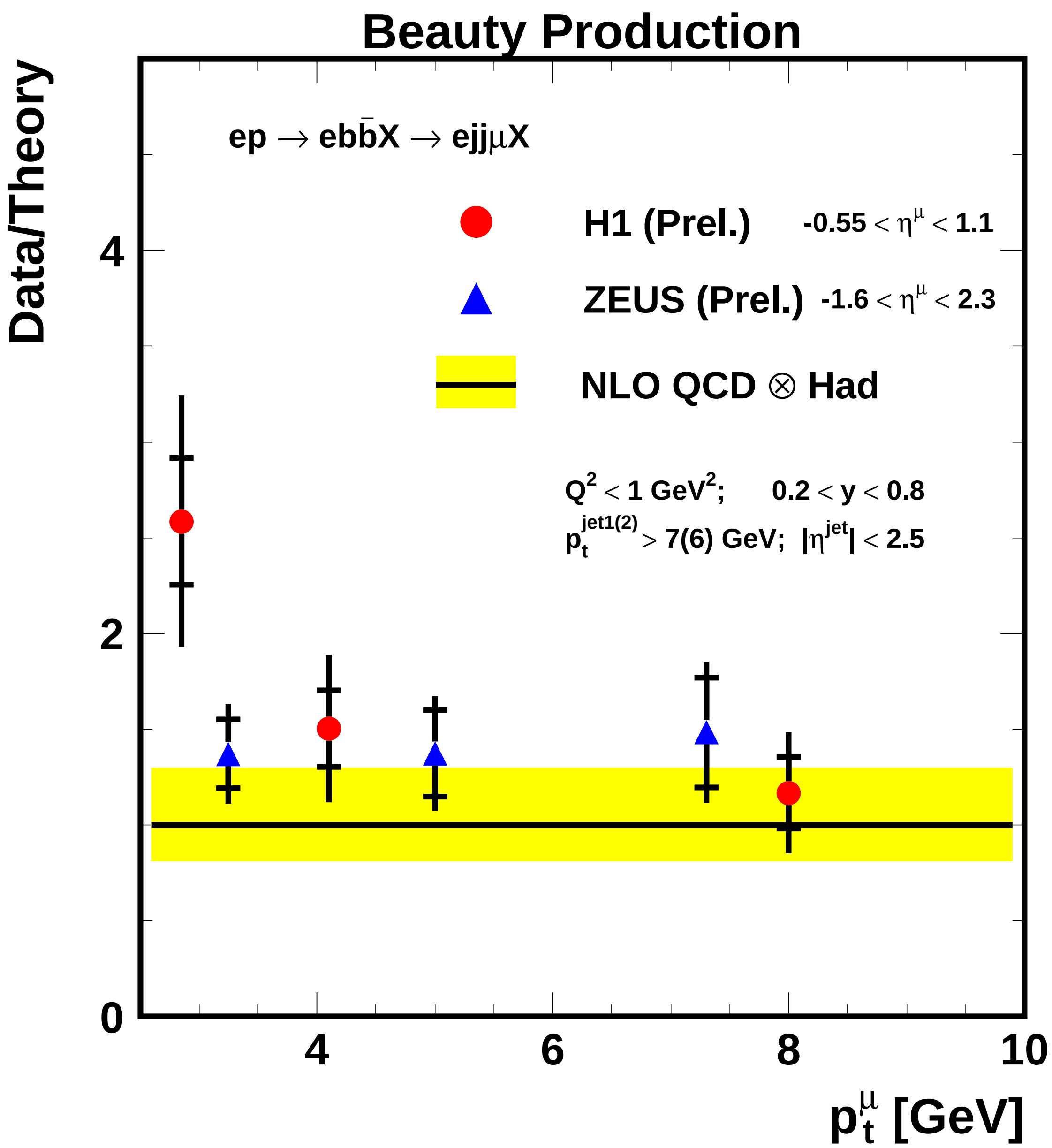




NLO QCD: Too low at low p_T^μ

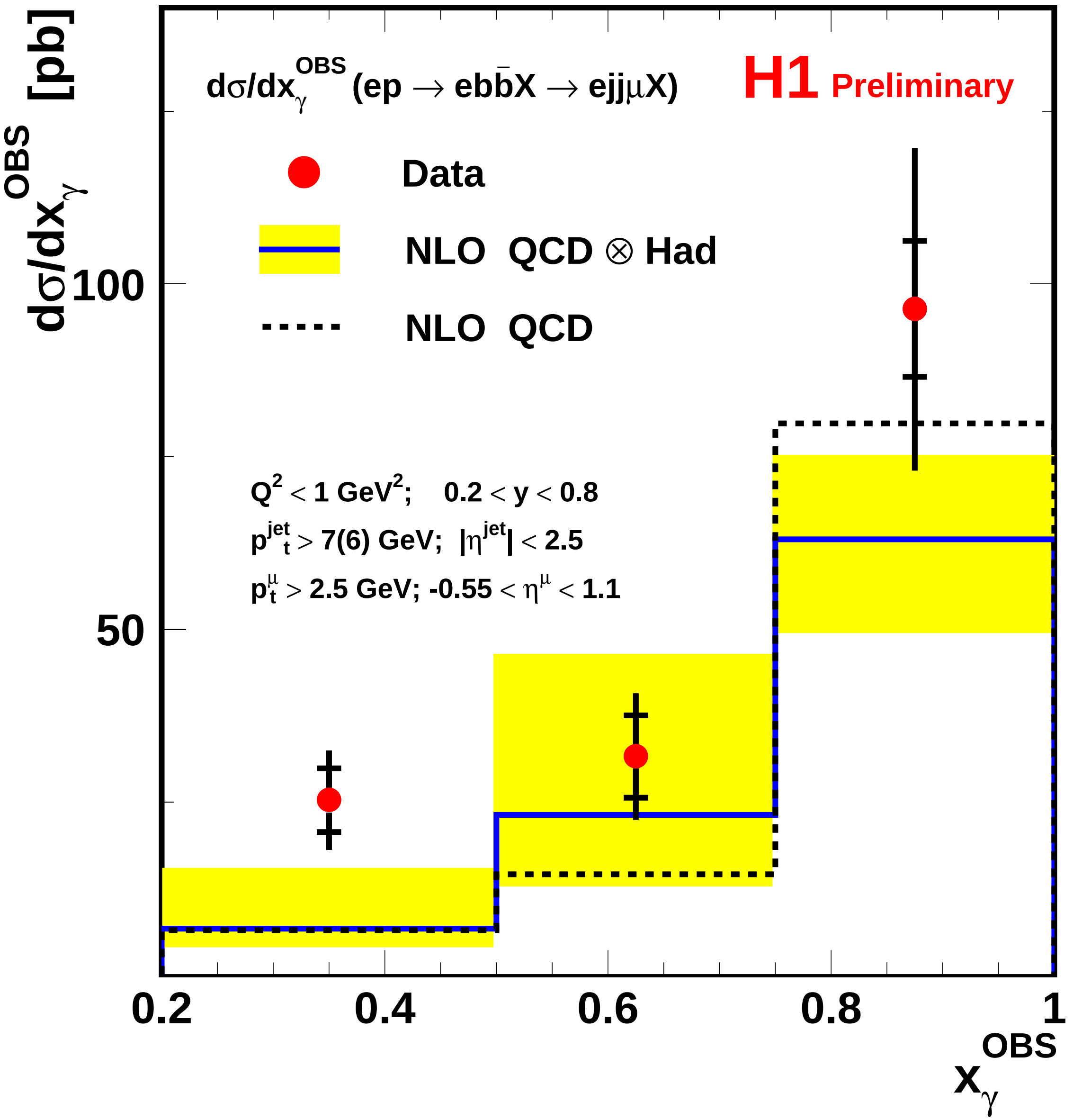
LO+PS QCD models:
Too low in normalisation

$\mathrm{d}\sigma/\mathrm{d}p_T^{\mu}$ Data/NLO QCD



- All data points above NLO QCD, but agreement within errors

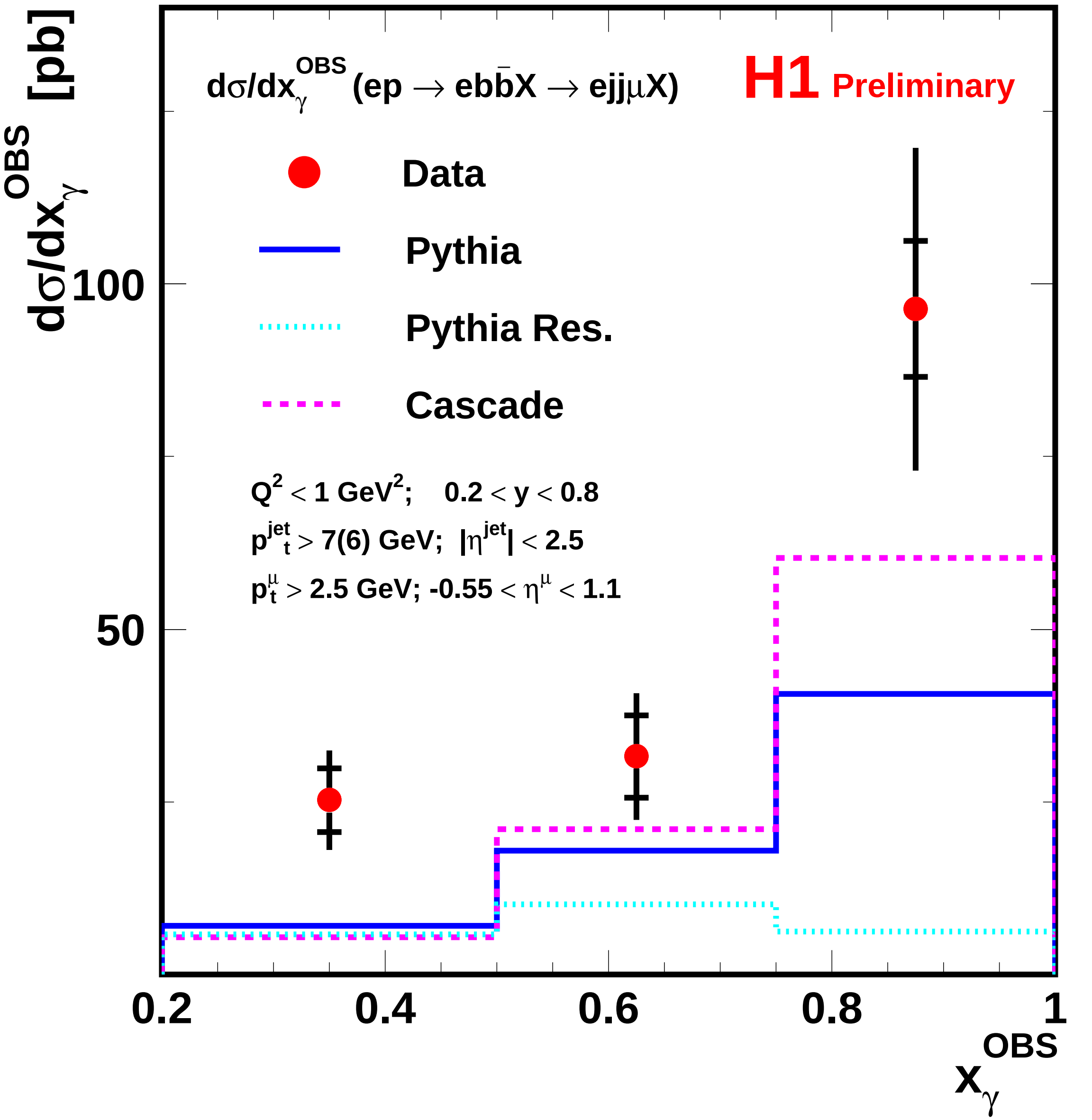
$d\sigma/dx_\gamma$ Data vs. NLO QCD



$$x_\gamma = \frac{\sum_{Jet1,2} E - P_z}{\sum_{All} E - P_z}$$

⇒ Large theoretical uncertainties!

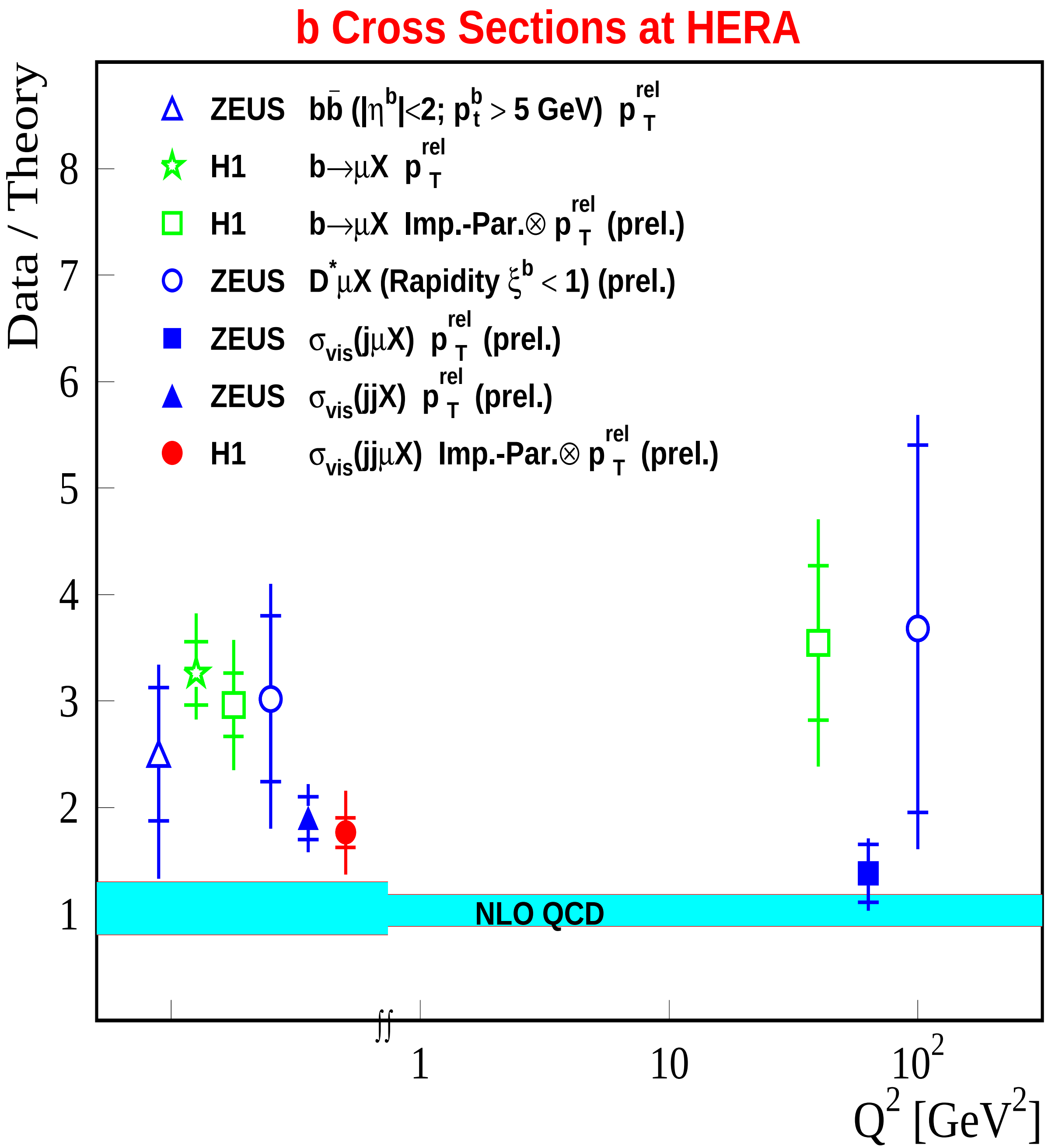
$d\sigma/dx_\gamma$ Data vs LO MC's



$$x_\gamma = \frac{\sum_{Jet1,2} E - P_z}{\sum_{All} E - P_z}$$

⇒ MC's predict too low normalisations

Beauty at HERA: Summary plot



$$\frac{\text{New H1-}\gamma p\text{ meas.}}{\text{NLO}} \approx 1.8$$

$$\frac{\text{Old H1-}\gamma p\text{ meas.}}{\text{NLO}} \approx 3$$

But data cross sections agree within 20%! How can that be?

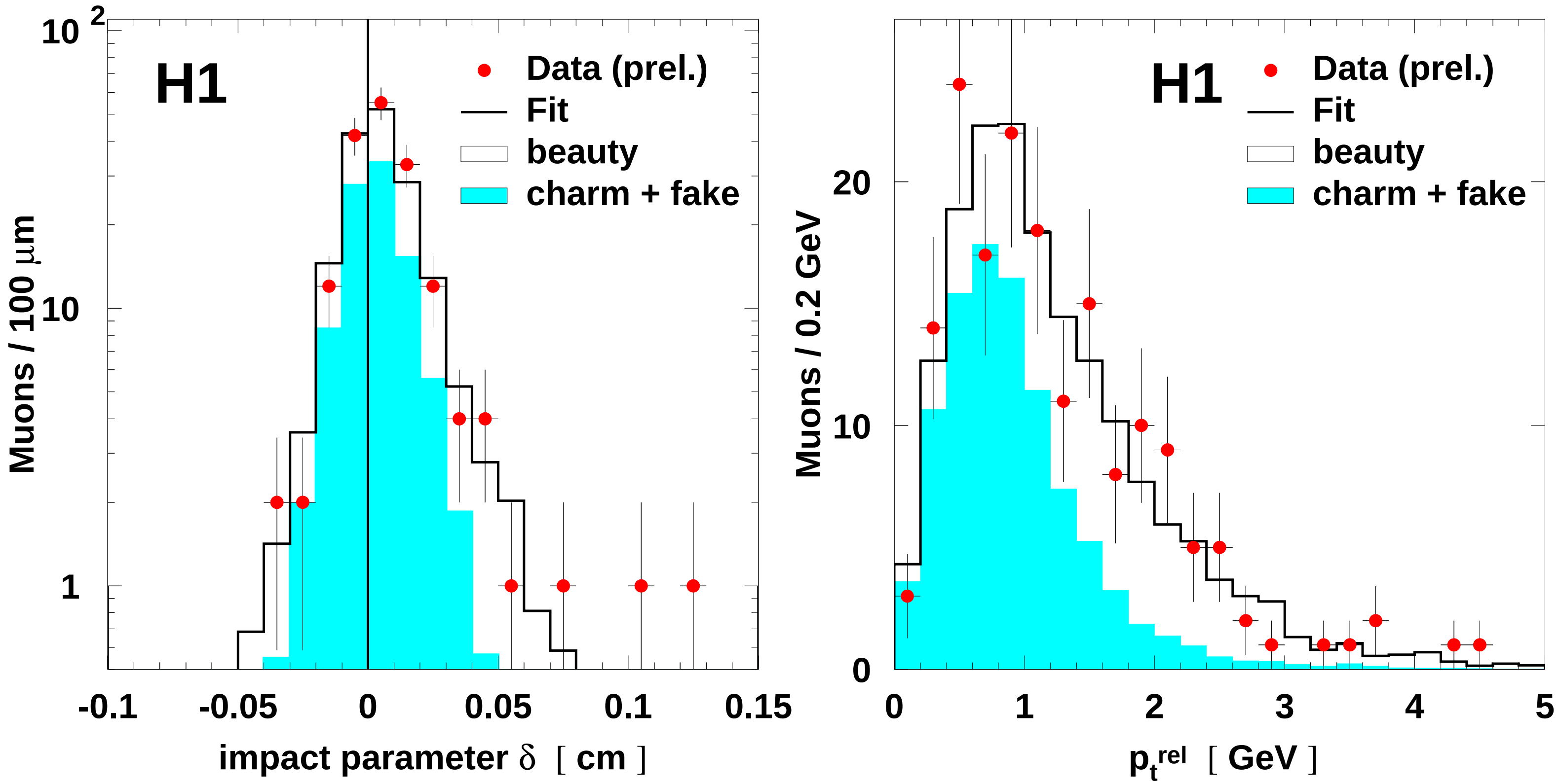
γp : H1 Data and NLO cross-sections

	Data	NLO calculation
$b \rightarrow \mu x$ old comp.	Extrapolate jj with using LO+PS MC (Aroma) $\sim$ 170 pb	NLO b-quark $\otimes$ Peterson fragmentation $\otimes$ $b \rightarrow \mu X$ p_T^μ spectrum $\otimes$ Br $\sim$ 56 pb
$b \rightarrow jj\mu x$ new comp.	$\uparrow$ $\sim$ 42 pb	$\downarrow$ • Run incl. k_T on outgoing partons $\rightarrow$ require $\geq$ 2 jets • Parton to Hadron corrections using LO+PS MC (Pythia) $\sim$ 24 pb

$\Rightarrow$ Extrapolation with LO $\neq$ Extrapolation with NLO! $\uparrow \neq \downarrow$

Beauty in DIS: First measurement

1997 data; 11 pb^{-1}
$p_T^\mu > 2$ GeV, $35^0 < \theta < 130^0$
≥ 2 jets; $E_T^{jets} > 5$ GeV
2 GeV$^2 < Q^2 <$ 100 GeV^2
$0.05 < y < 0.7$

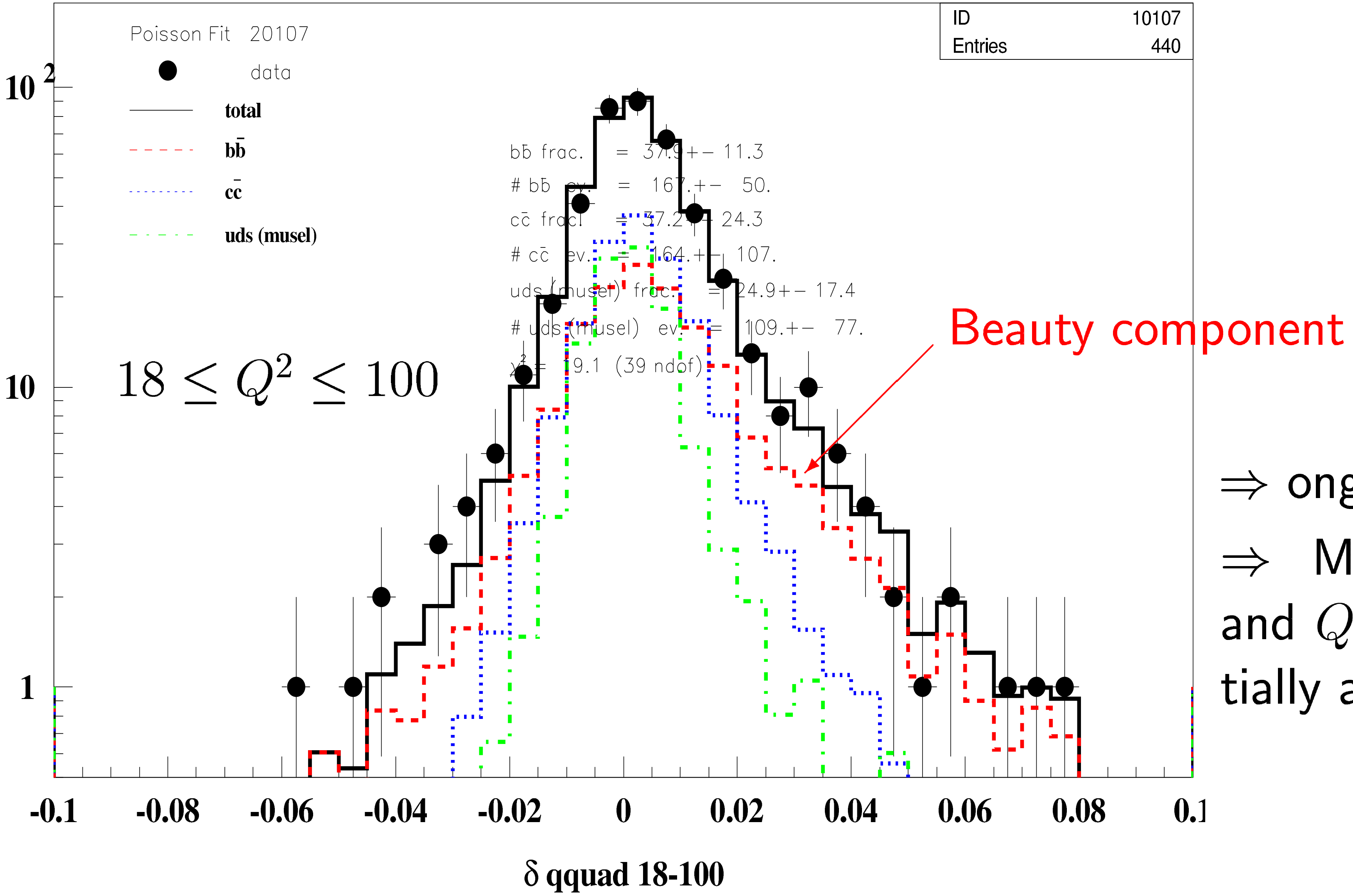


2-D-fit
(δ, p_T^{rel})
$f_b =$
$43 \pm 8\%$

Results	$\sigma_{kin.range}(e+p \to b\bar{b}X \to \mu^\pm X)$
H1 prel $= (39 \pm 8 \pm 10)$ pb	NLO (FMNR): 11 ± 2 pb CASCADE: 15 pb

$B \to \mu X$ in DIS: Analysis with 99/00 data

Example of beauty signal in muon impact parameter spectrum:

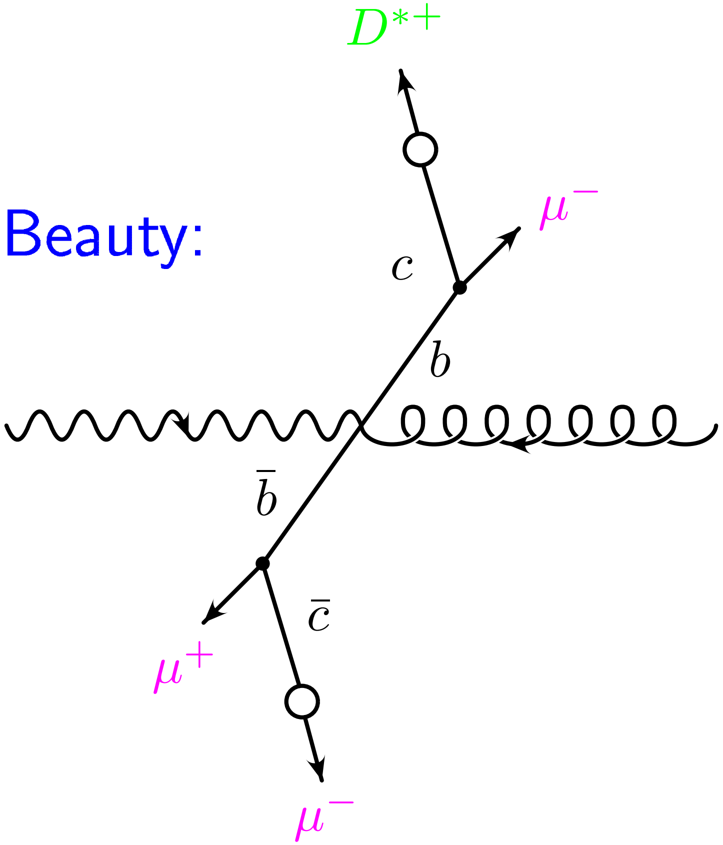


⇒ ongoing analysis

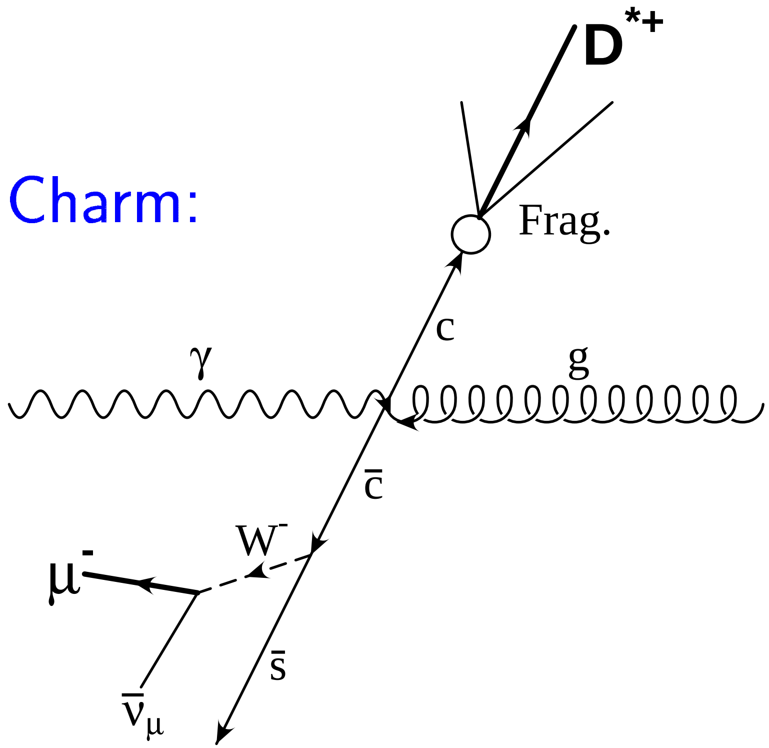
⇒ Measure in x and Q^2 as differentially as possible

$D^*\mu$ — Correlations in γp system

Beauty:



Charm:



$\Delta\Phi \approx 0^0 \quad Q(D^*) \neq Q(\mu)$

$\Delta\Phi \approx 180^0 \quad Q(D^*) \neq Q(\mu)$

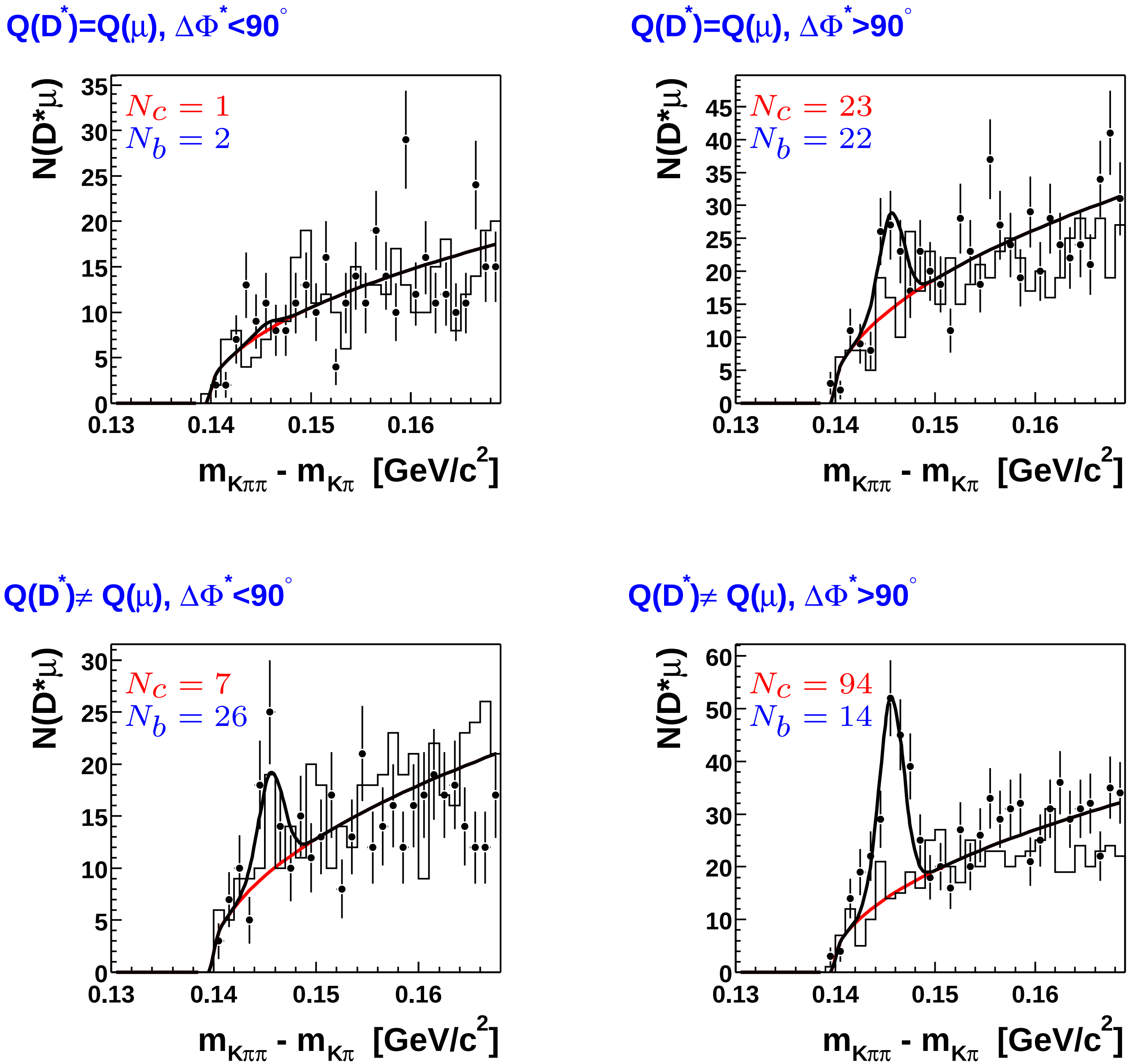
$\Delta\Phi \approx 180^0 \quad Q(D^*) = Q(\mu)$

$\Delta\Phi \approx 180^0 \quad Q(D^*) \neq Q(\mu)$

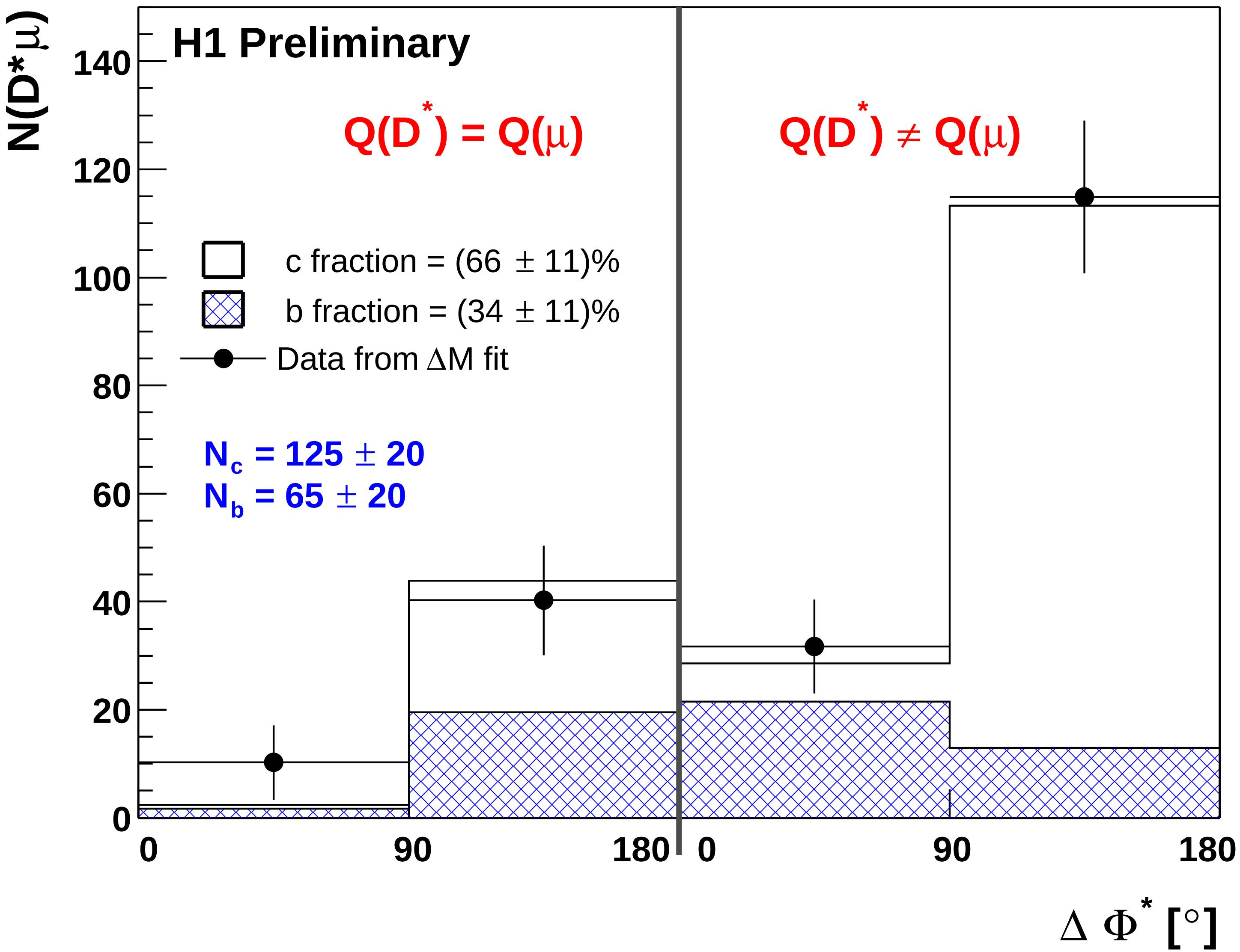
$\Rightarrow$ Separation of b and c via charge and angular correlations

$D^*\mu$ — Determination of b and c signal

b and c contr.
from simultaneous
fit to Δm versus
correl. region



$D^*\mu$ — 2 dim. Fit Results



→ Subtract fake muon background

c: $\approx 30\%$

b: $\approx 5\%$

$\Rightarrow \quad N_b = 62 \pm 19$

$\Rightarrow \quad N_c = 88 \pm 14$

$D^*\mu$ — Total b and c cross-sections

H1 data : 97-00 $\mathcal{L} = 91.2\ pb^{-1}$

Visible range:

$p_T(D^*) > 1.5$ GeV	$\lvert\eta_{D^*}\rvert < 1.5$
$p_T(\mu) > 1.0$ GeV	$20^\circ \leq \theta_\mu \leq 160^\circ$
$0.05 < y < 0.75$	no cut on Q^2

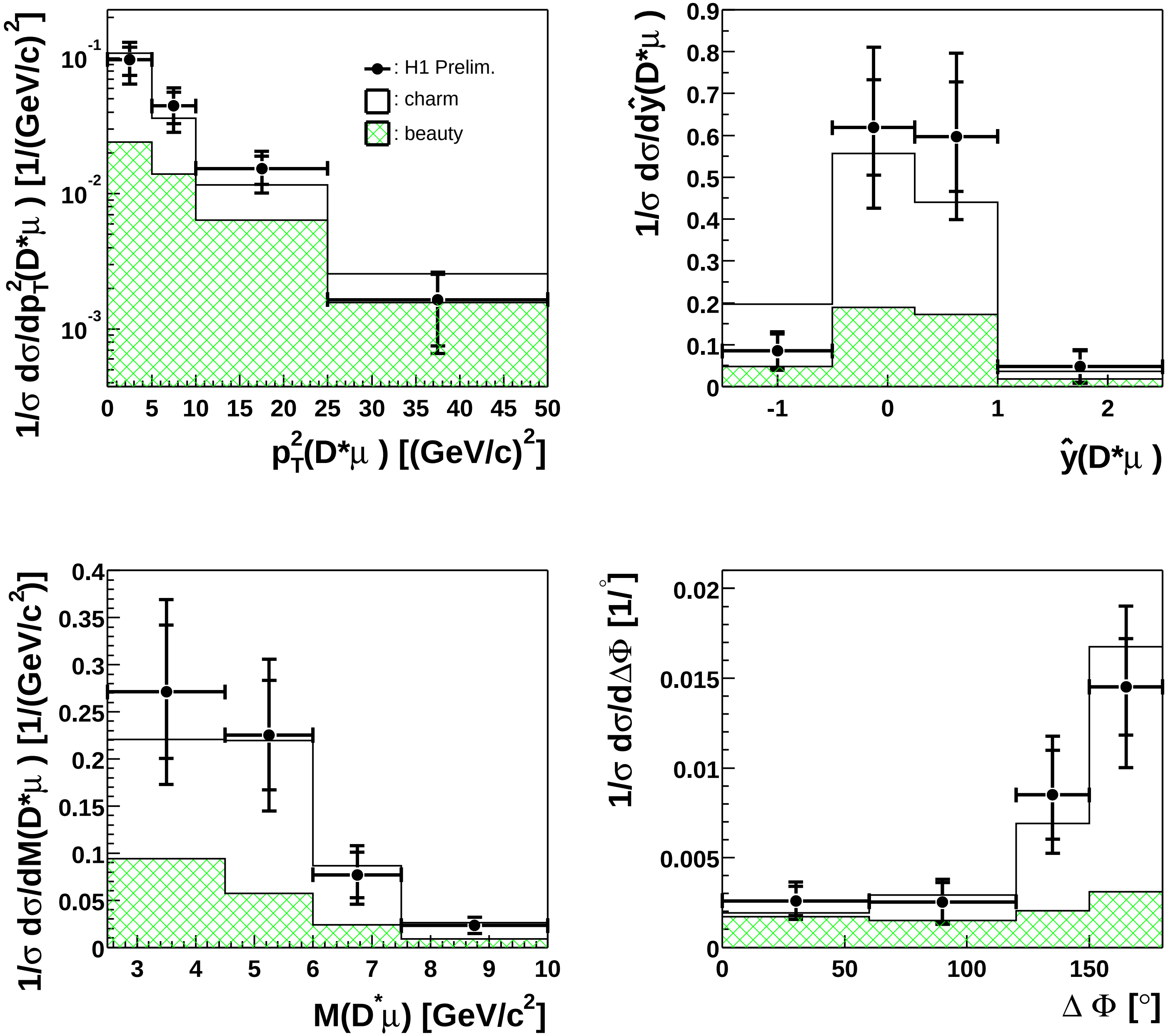
$$\sigma^{\mathbf{c}}_{\mathbf{vis}}(\mathbf{ep} \rightarrow \mathbf{eD}^*\mu\mathbf{X}) = (720 \pm 115 \pm 245)\text{pb}$$

$$\sigma^{\mathbf{b}}_{\mathbf{vis}}(\mathbf{ep} \rightarrow \mathbf{eD}^*\mu\mathbf{X}) = (380 \pm 120 \pm 130)\text{pb}$$

Comparison with LO direct prediction:

(AROMA) :
c: Data/MC = 1.8
b: Data/MC = 3.6

$D^*\mu$ — Differential cross sections

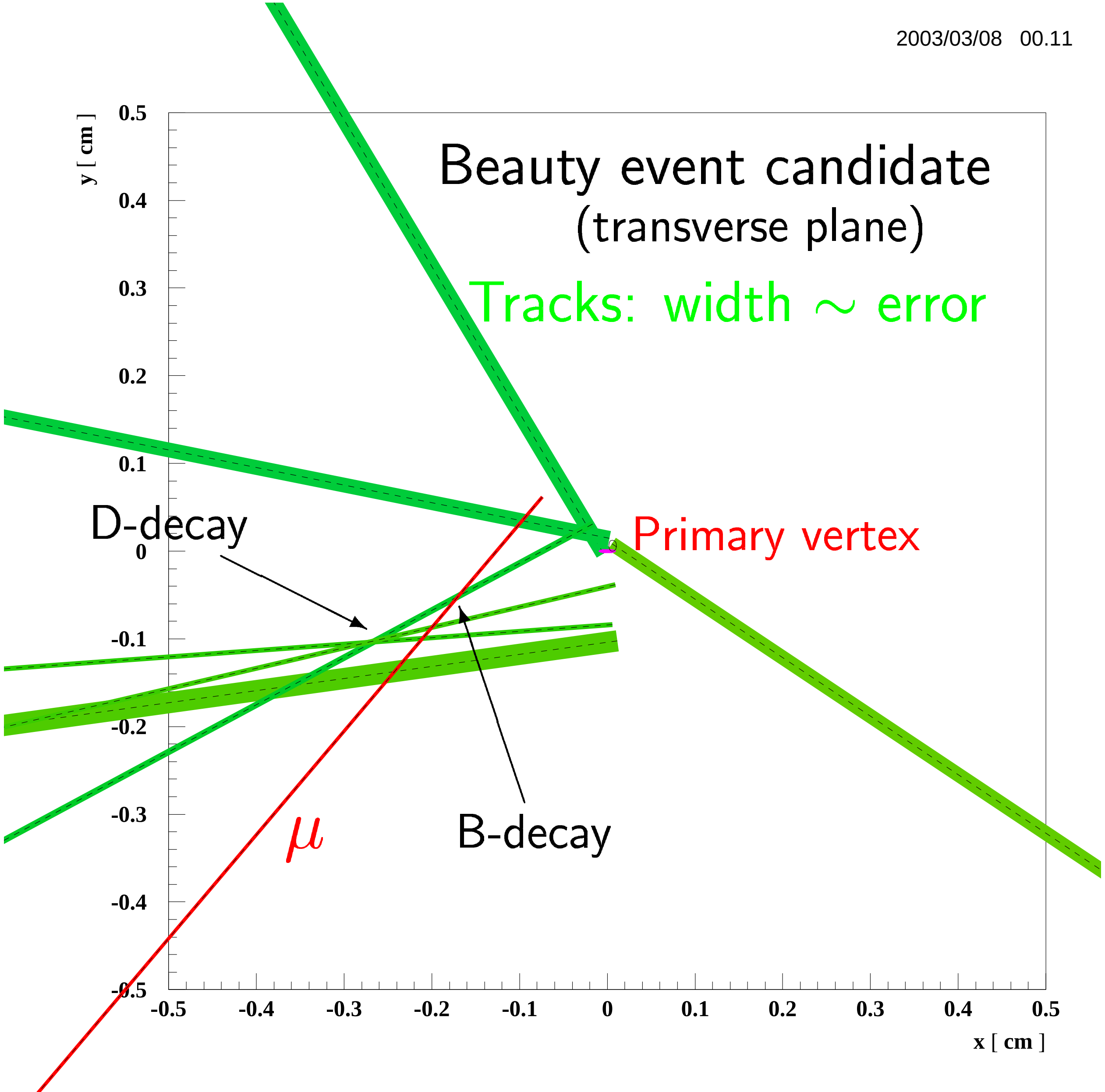


← Data vs.
(1.8 c-MC + 3.6 b-MC)

⇒ LO+PS (AROMA) describes the data shapes

HERA I results to come

⇒ Secondary vertexing analyses with Central Silicon Tracker



← This is one of the nicest H1 real data candidates with well resolved secondary vertices!

⇒ We can try inclusive sec. vertex tagging of charm and beauty in central region $30^0 < \theta_{c,b} < 150^0$

Inclusive Vertexing: Physics goals and methods

Goals with Beauty and Charm (examples):

- NC at high Q^2
- High p_T jets in γp
- Double tagging, e.g. can we separate $b\bar{b}$ from bg excitation processes?

Methods (example):

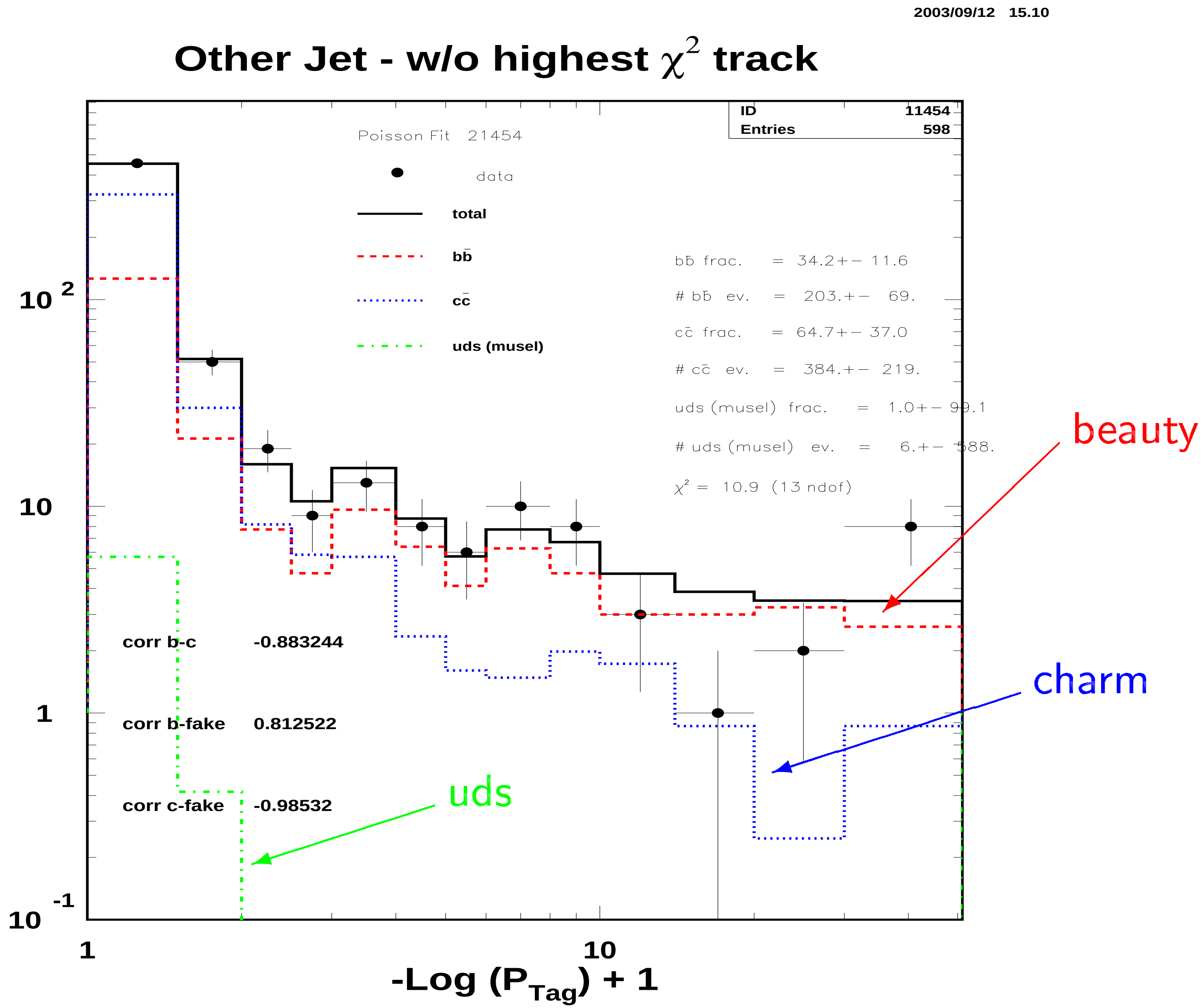
- Multi-impact parameter method:
  MIP $:=$ Combined probability that selected tracks all originate from primary vertex $\rightarrow$ **low** for b,c events.

Glimpse on ongoing double tagging analysis

Analysis channel:

$$Jet \longleftarrow \bar{b}b \longrightarrow \mu + Jet$$

Determine MIP separately for muon-jet and other jet



$\Rightarrow$ Nice separation of b and c from uds

Conclusions

- New differential $B \to \mu X$ results in photoproduction:
  - All measurements above NLO QCD predictions
  - Data/NLO discrepancies ≤ 1.5 sigma

- More HERA I results to come, e.g.
  - $B \to \mu x$ in DIS with 99-00 data
  - inclusive vertexing analyses:
    - $\to$ Extend the kinematic range (e.g. high Q^2)
    - $\to$ Double tagging

  $\Rightarrow$ Surprises not excluded!

- Outlook on HERA II $\to$ Felix Sefkows talk, 22/10 16:50