Beauty Production at HERA using the H1 Experiment

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H1 Collaboration

- Motivation
- Experimental Techniques
- Beauty dijets in photoproduction
- Inclusive beauty cross section in DIS

Motivation

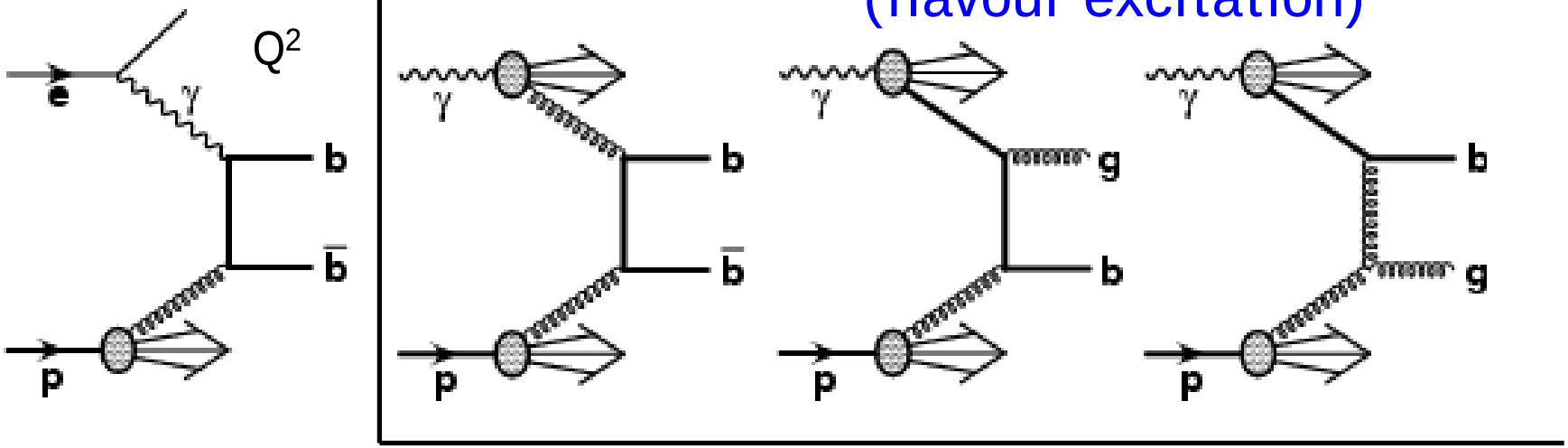
DIS

Photoproduction (γp)

Direct γ

Resolved γ

(flavour excitation)



Test of perturbative QCD: multi-scale problem (Q^2, m_b^2, p_t^2)

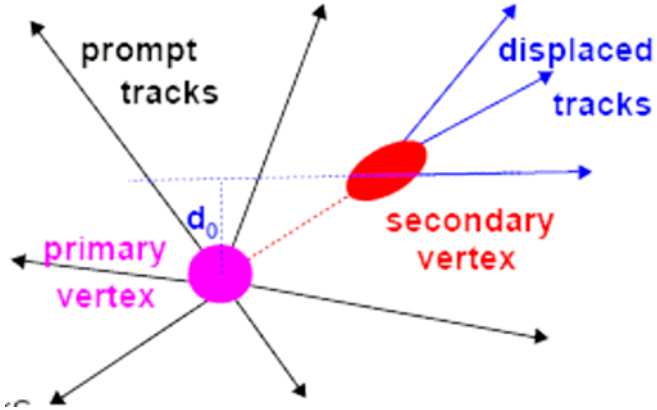
Theoretical approaches: massless, massive(FFNS) and general mass(GM-VFNS) flavour number schemes.

PDFs: F_2^{bb} measurements at high Q^2 important for LHC e.g. *bb->H*

LO (α_s)+Parton shower: DGLAP (PYTHIA/RAPGAP), CCFM (CASCADE)

NLO (α_s^2) calculations: Fixed order (FMNR/HVQDIS) , GM-VFNS PDFs

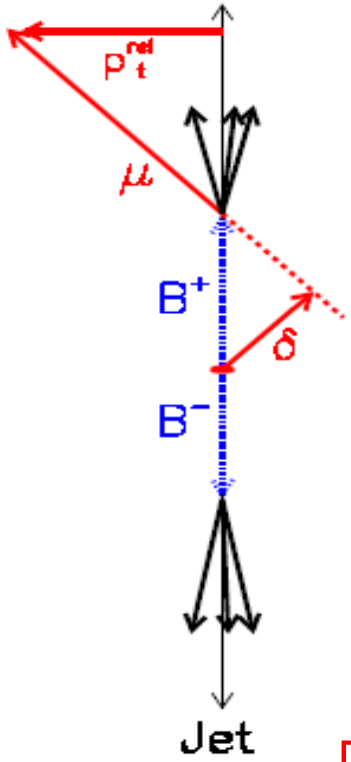
Experimental Techniques



Displaced tracks

Measure impact parameter back to primary vertex. Higher efficiency than explicit secondary vertex.

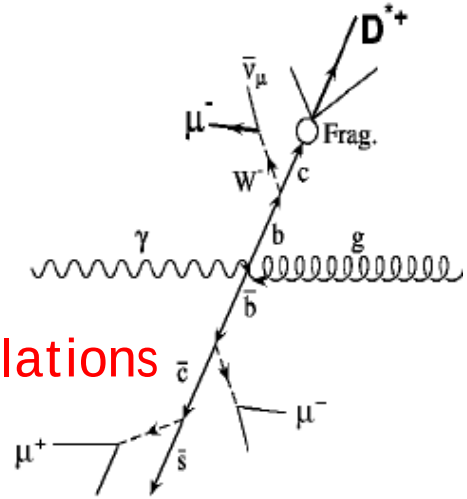
Focus on results using this method



Muons and jets

Use μ impact parameter combined with p_t^{rel}.

hep-ex/0502010



D*-μ correlations

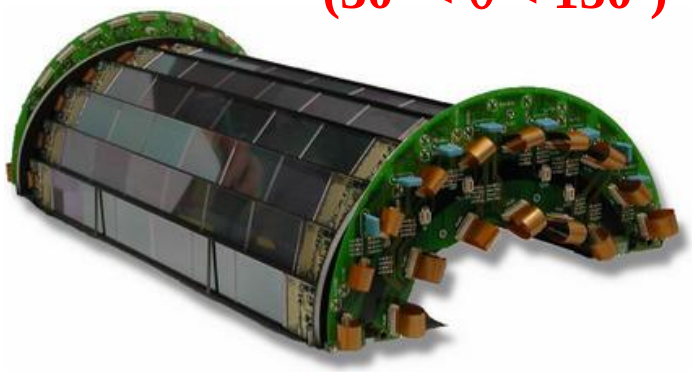
Use correlations of hemispheres and charges to reduce background and separate *c*/*b*.

hep-ex/0503038

H1 Vertex Detector

CentralSiliconTracker

($30^o < \theta < 150^o$)

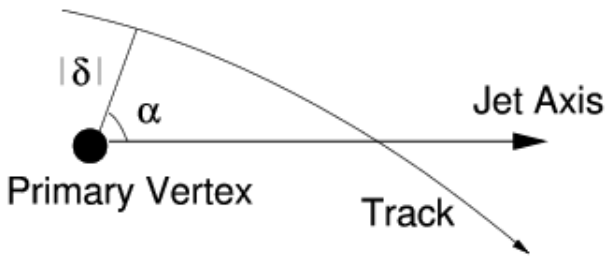


- Double layer double sided strips
- Precise determination of impact parameter in transverse plane
- Resolution of $|\delta|$ for hits in both layers;

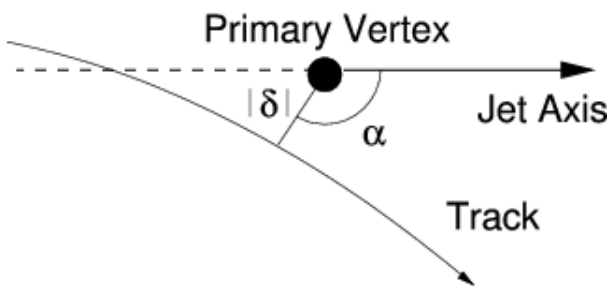
$$33\mu m \oplus \frac{90\mu m}{P_T}[GeV]$$

Signed impact parameter δ

$\alpha < 90^o \rightarrow \delta = +|\delta|$

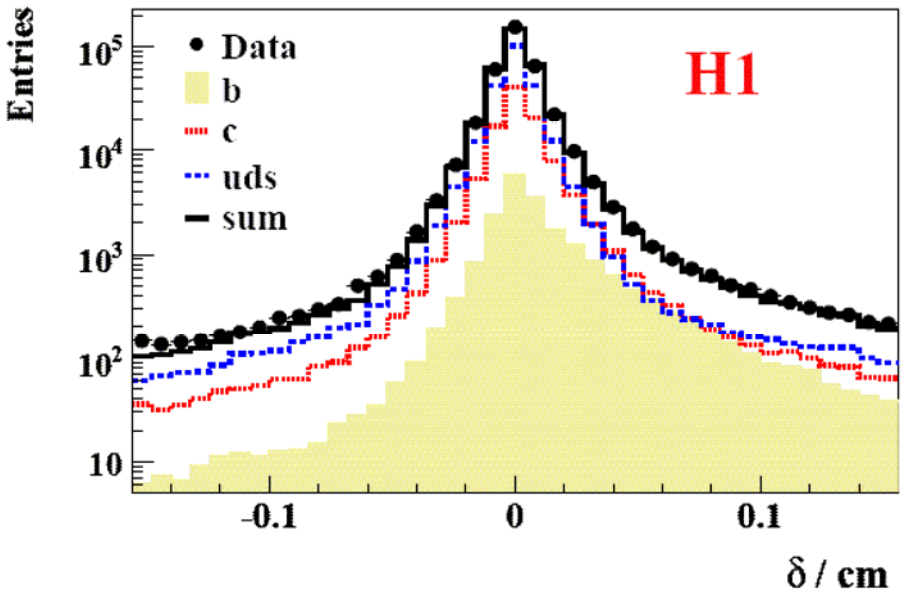


$\alpha > 90^o \rightarrow \delta = -|\delta|$

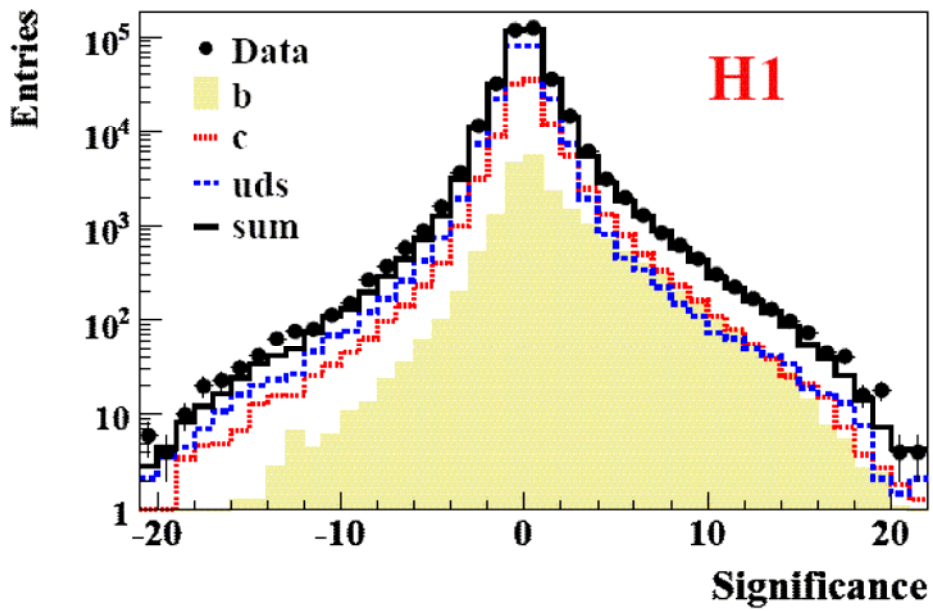


Displaced Track Method

Signed Impact parameter δ



Significance

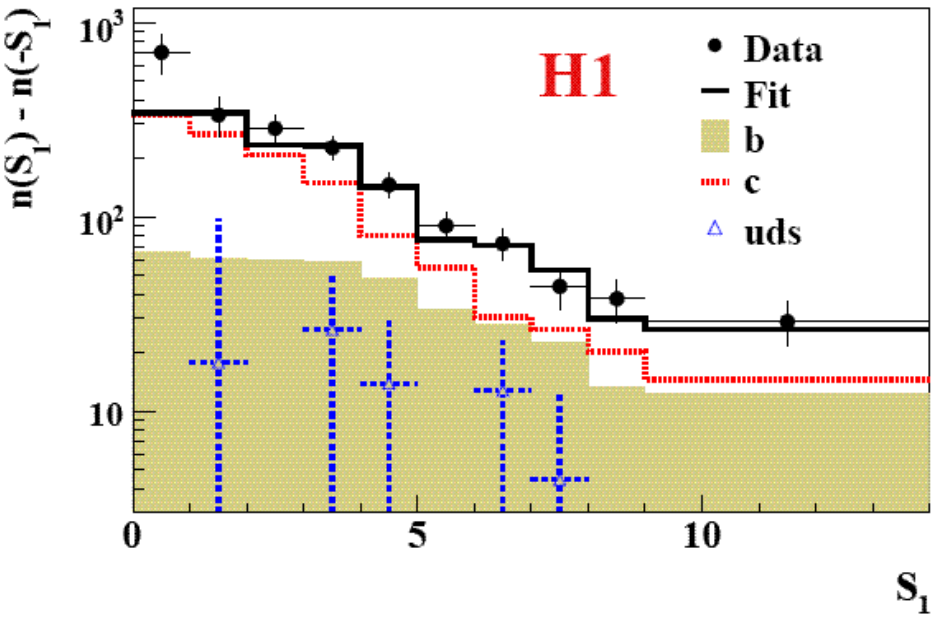


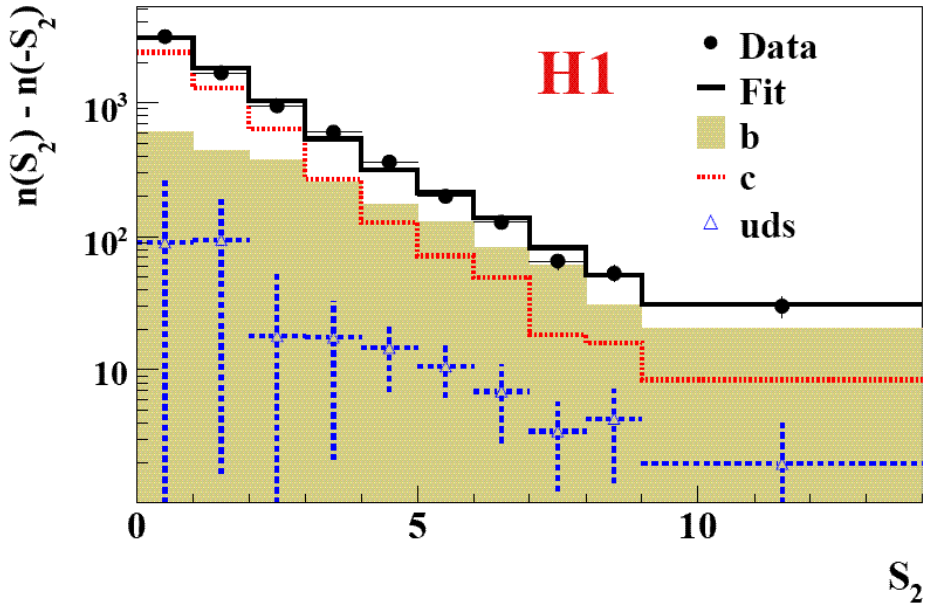
Charm and beauty asymmetric due to lifetime

Light flavours mostly symmetric

$$Significance = \delta / \sigma(\delta)$$

Signal Extraction





Define two significance distributions

S_1 significance of highest significance track (1 track events)

S_2 significance of second highest significance track (> 1 track events)

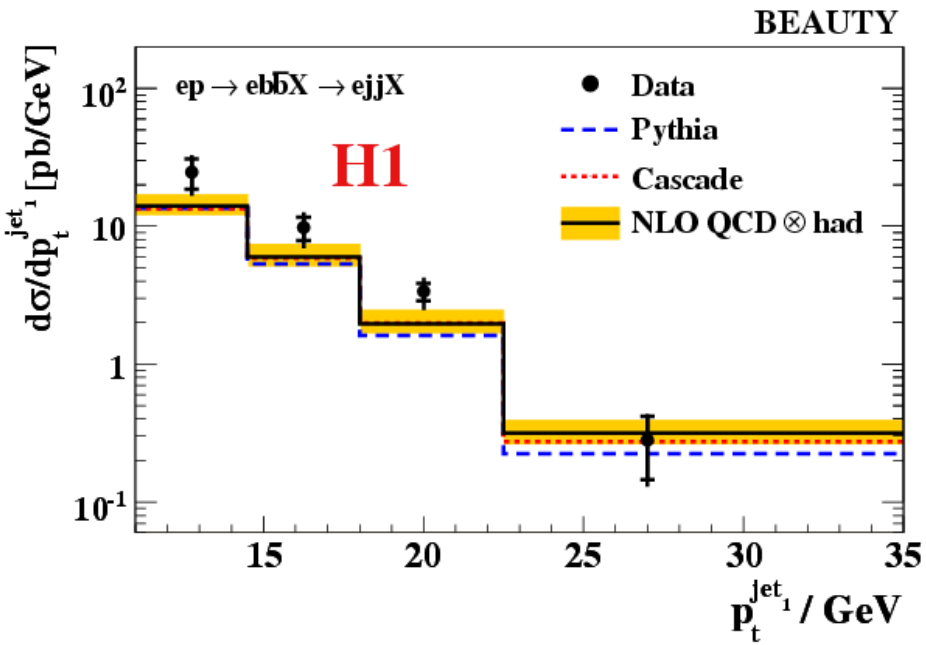
Subtract –'ve from +'ve bins to reduce resolution uncertainty

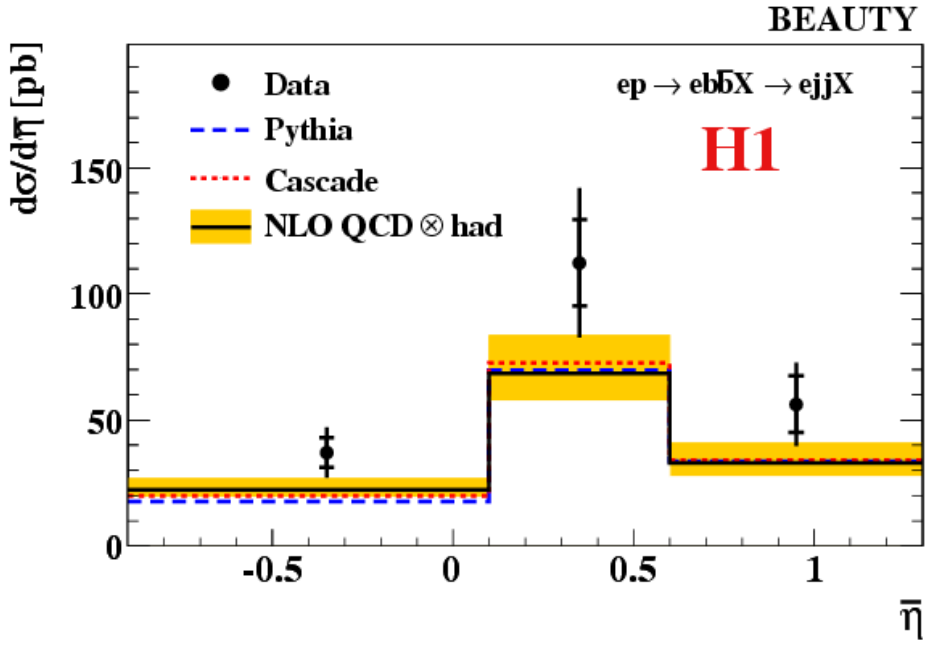
Fit S_1, S_2 and total number of events with MC templates for *c*, *b*, *uds*

Beauty Dijets in Photoproduction

H1 Final, Eur. Phys. J. C47 (hep-ex/0605016)

$Q^2<1\ GeV^2,\ 0.15<y<0.8,\ p_t^{jet}>11(8)\ GeV,\ -0.9<\eta^{jet}<1.3$



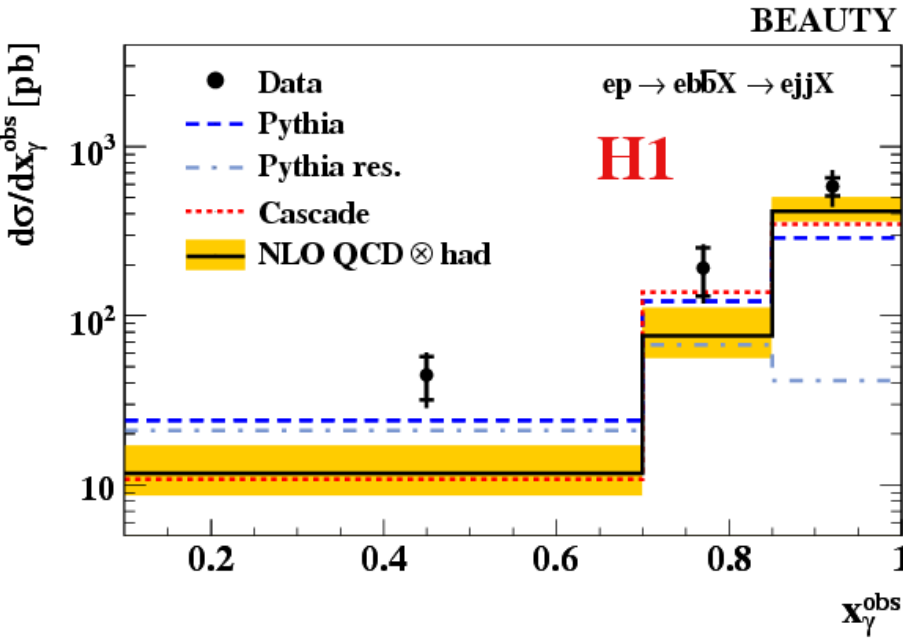


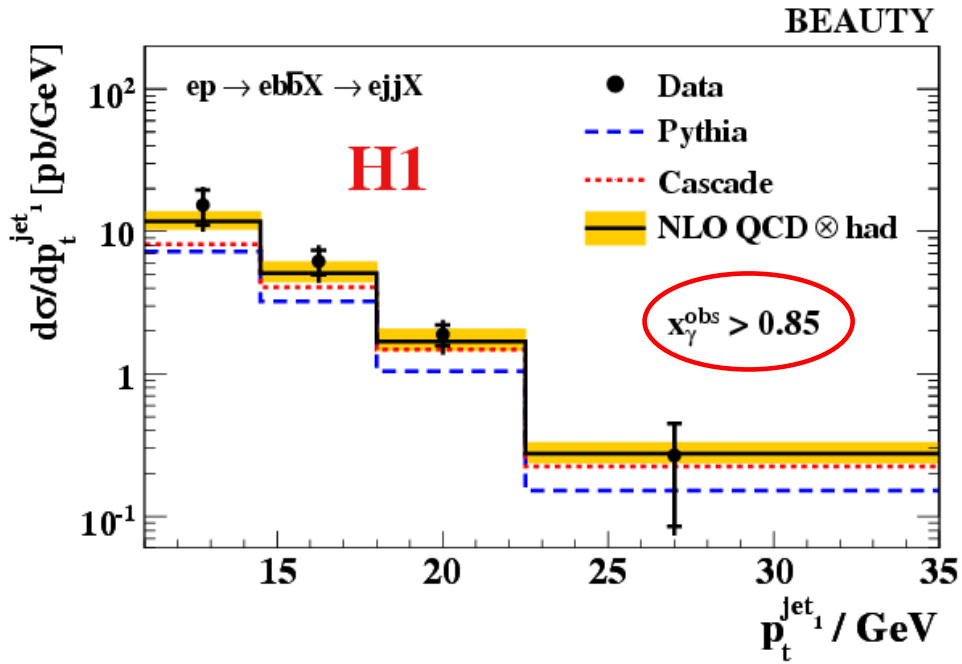
Highest p_t region measured for beauty jets at HERA

Data above, but consistent with, QCD models (MC, NLO QCD)

NLO QCD = massive scheme (FMNR)

Dijets and x_γ





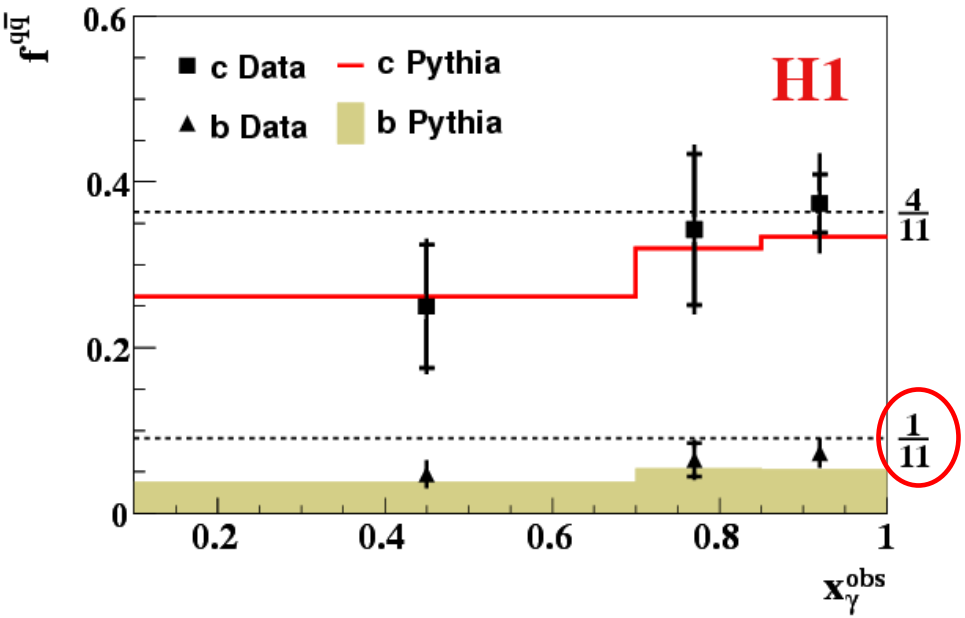
x_γ = fraction of γ's momentum entering hard interaction

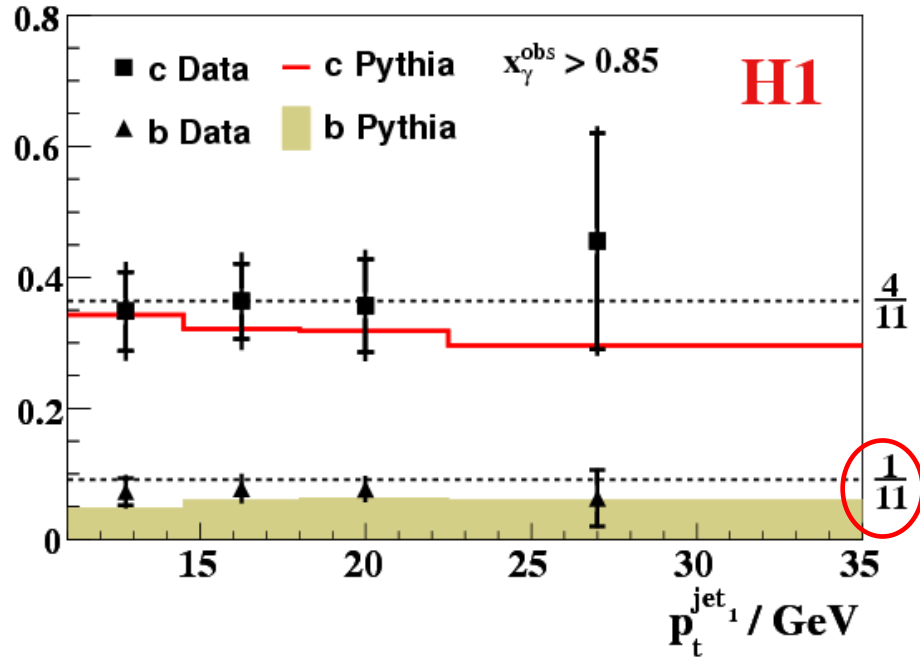
Shape best described by PYTHIA with resolved γ contribution

CASCADE/NLO QCD low at small x_γ

p_t^{jet1} for $x_\gamma > 0.85$ better described by NLO

Dijet Quark Fractions



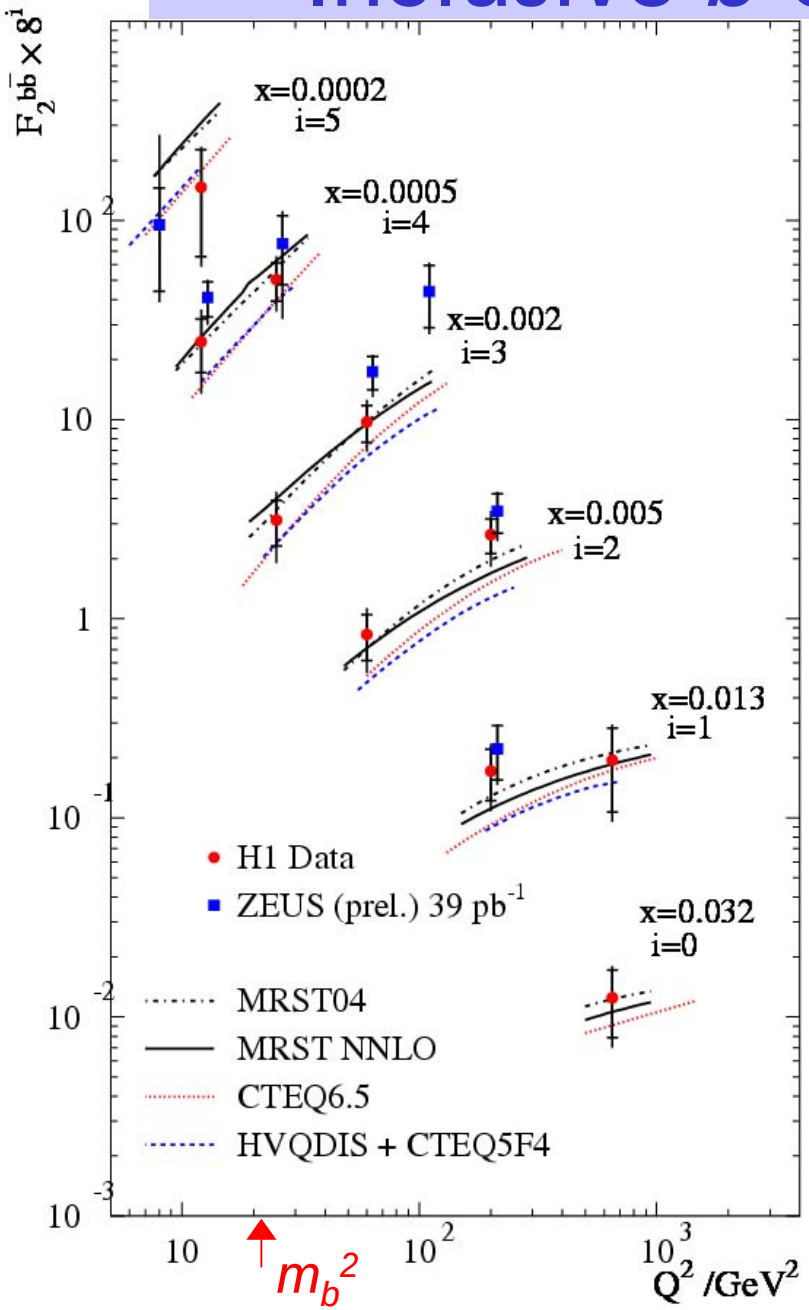


Cross section fraction $f_b = \sigma_b / \sigma_{udscb}$

b fraction higher for large x_γ (direct processes)

Approaching expectation of massless limit (quark charge counting)

Inclusive *b* cross section in DIS



H1 data (HERA-I) obtained using displaced track method.

$p_t^{track} > 0.5$ GeV reduces extrapolations to full cross section and allows to measure inclusive $\sigma_{bb} \sim F_2^{bb}$

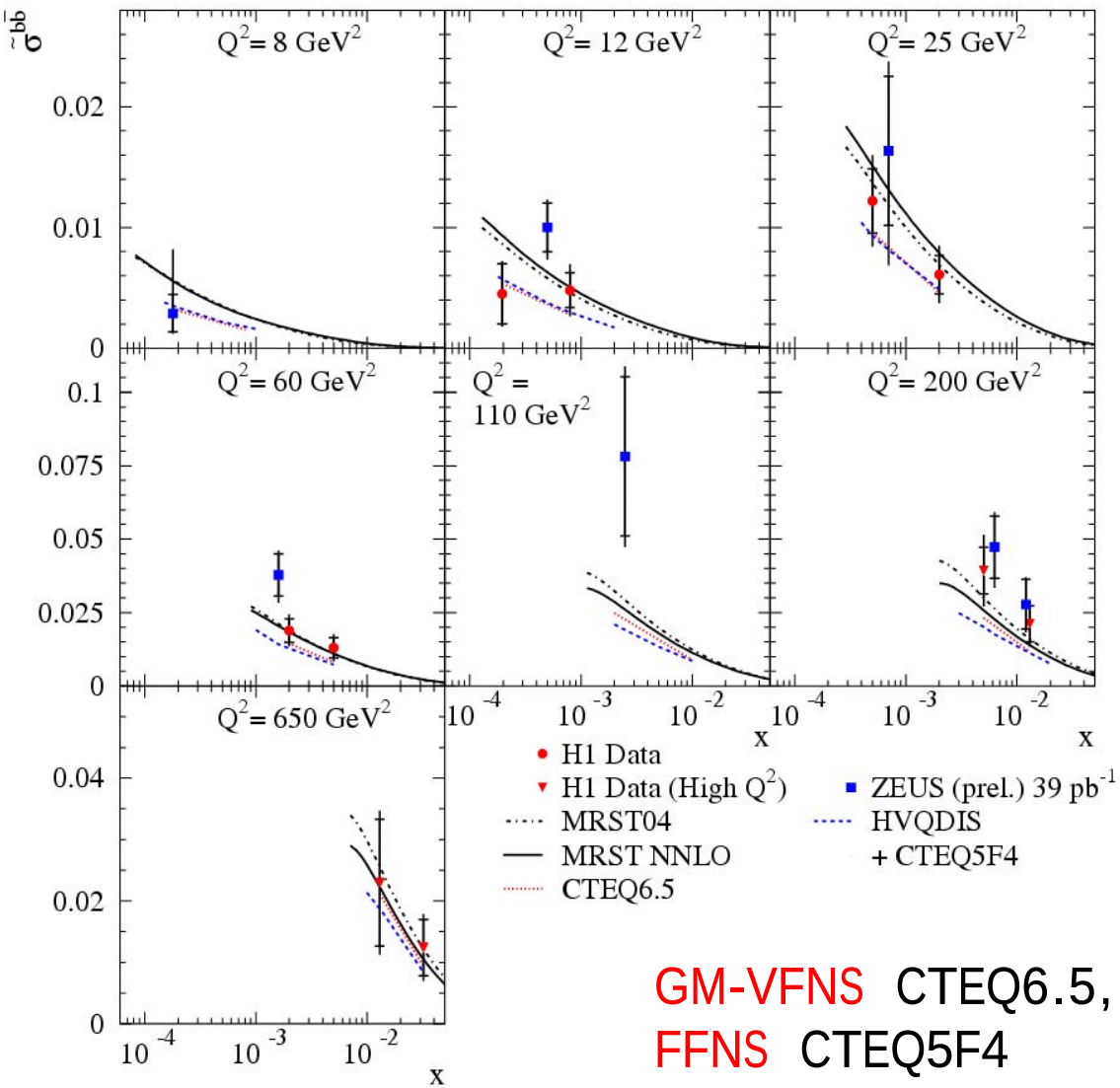
Region $Q^2 <= m_b^2$ challenging $f^{bb} = 10^{-3}$. Need S_1,S_2 *and* S_3.

Data described by QCD

GM-VFNS CTEQ6.5, MRST04, MRST NNLO
FFNS CTEQ5F4

Eur. Phys. J. C40 (2005) 349 (hep-ex/0411046)
Eur. Phys. J. C45 (2006) 23 (hep-ex/0507081)
e^+p data 1999-2000, L_{int} = 57.4 pb^{-1}

Inclusive *b* cross section in DIS



Large *b* mass means x_g probed for $x_g > 10^{-3}$.

b also tests perturbative scales and QCD prescription

Large differences in predictions for $Q^2 <= m_b^2$

Not enough data to distinguish yet

GM-VFNS CTEQ6.5, MRST04, MRST NNLO
FFNS CTEQ5F4

Conclusions

- Beauty cross sections measured using number of techniques at H1
- Provide a stringent test of perturbative QCD
- Data so far well described by pQCD (NLO, NNLO)
- Forthcoming HERA-II data (~3 more than HERA-I) will help further to constrain heavy flavour PDFs and reduce uncertainties for future colliders e.g. LHC