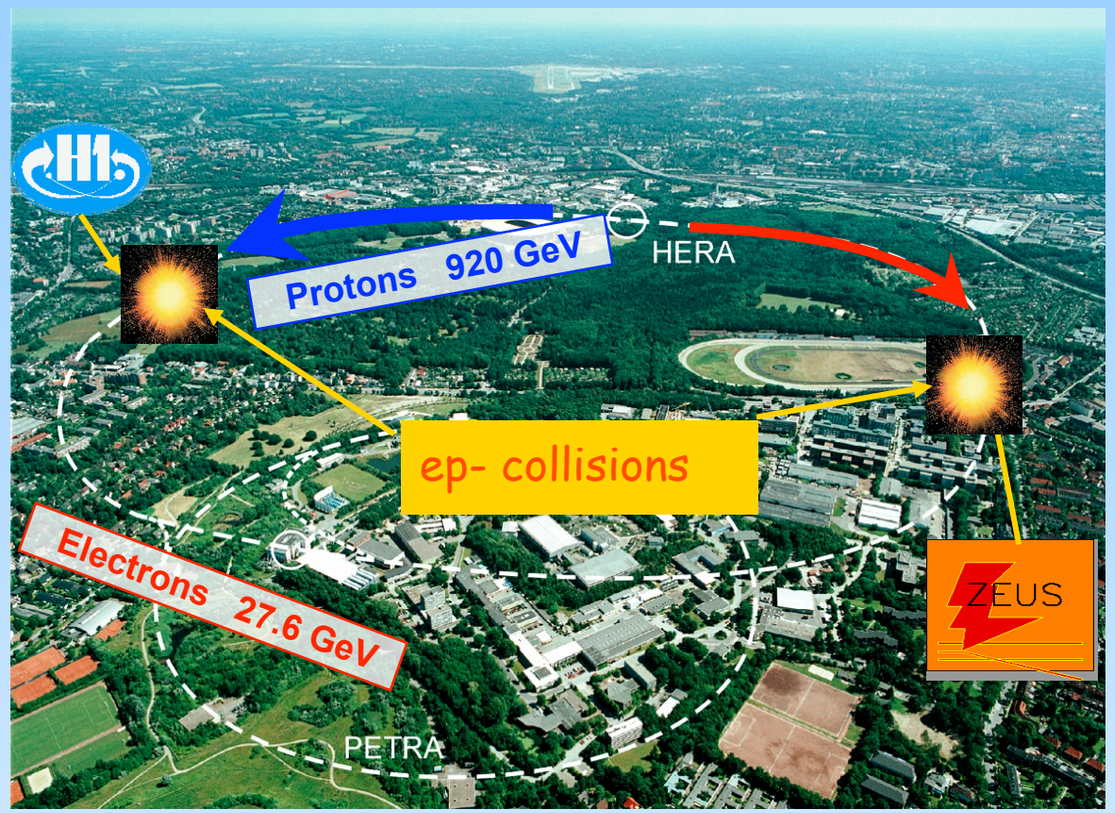
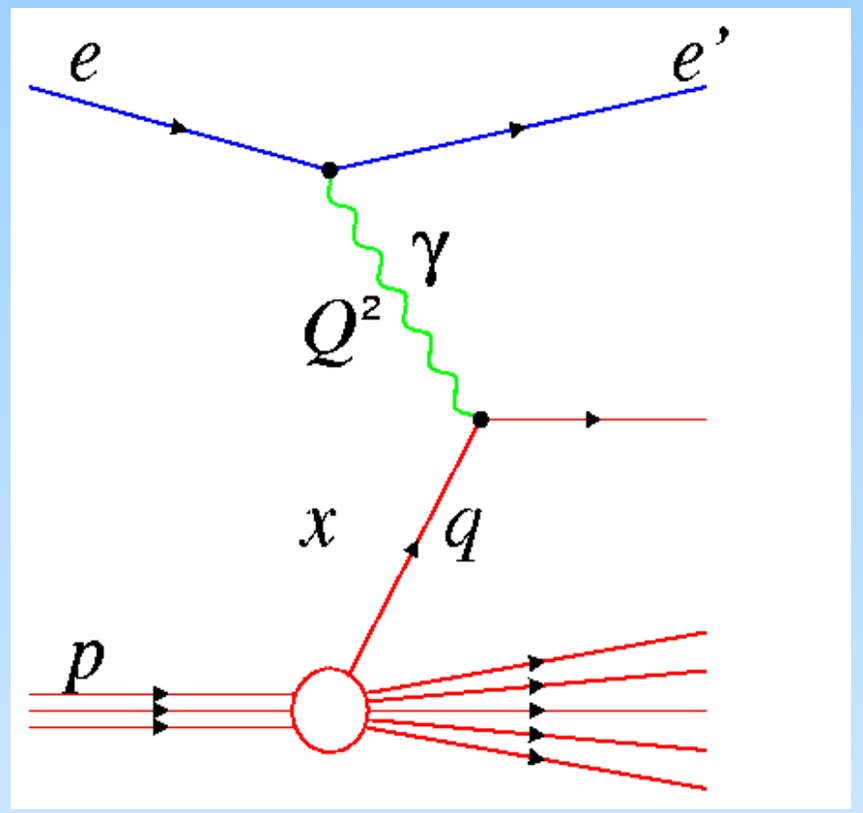
XXIst International Workshop on Deep-Inelastic Scattering and Related Subjects

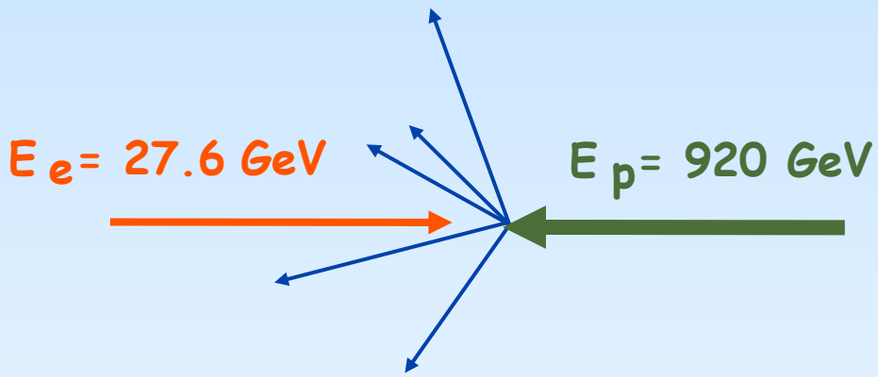
Charm and Beauty Photoproduction at HERA Using Semi-Leptonic Decays

Karin Daum -Wuppertal/DESY
on behalf of the H1 collaboration

ep-scattering at HERA







$\sqrt{s} \approx 320$ GeV

Q^2	photon virtuality
x	Bjorken scaling variable
y	Inelasticity in proton rest frame

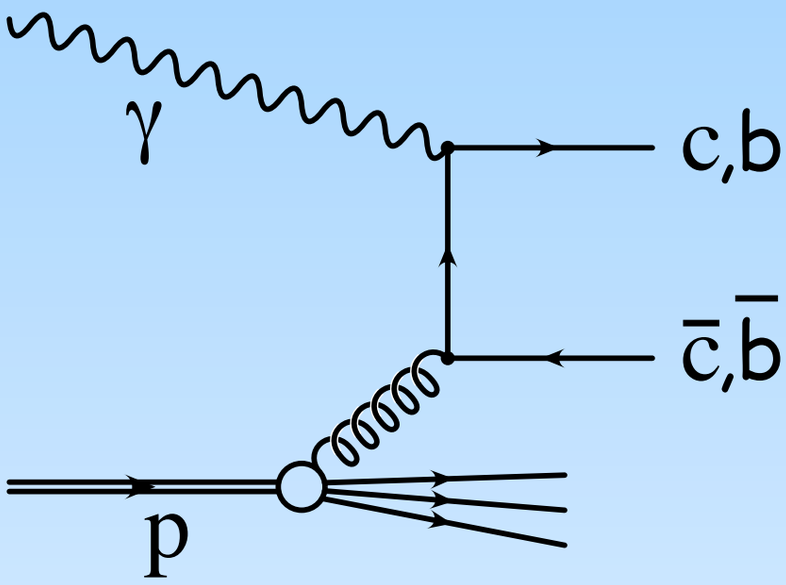
2 kinematic regimes :

$Q^2 \cong 0$ GeV^2 : **Photoproduction (γp)**

$Q^2 > 1$ GeV^2 : **DIS**

Open heavy flavour photoproduction at HERA

predominantly:
boson-gluon-fusion



Heavy quark mass provides hard scale
⇒ perturbative QCD applicable

however: "Battle of scales"

$m_c(m_b)$, p_T and Q^2

⇒different theoretical approaches

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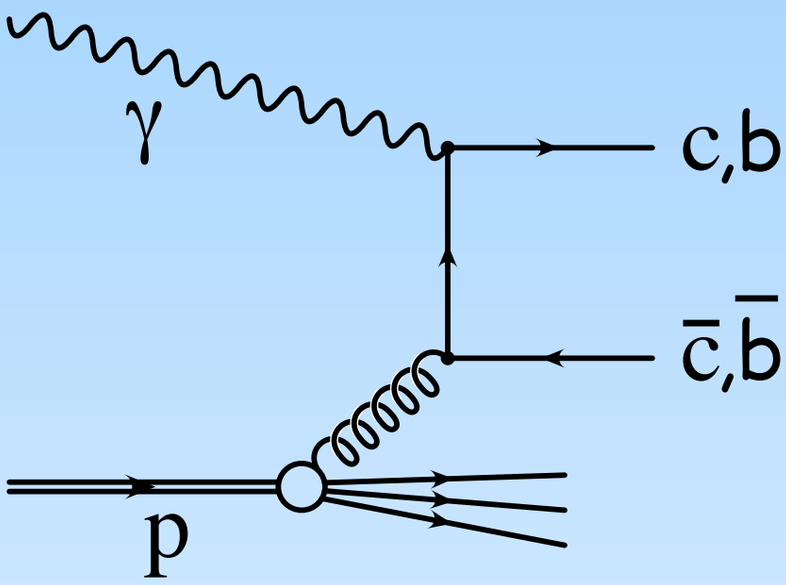

direct process

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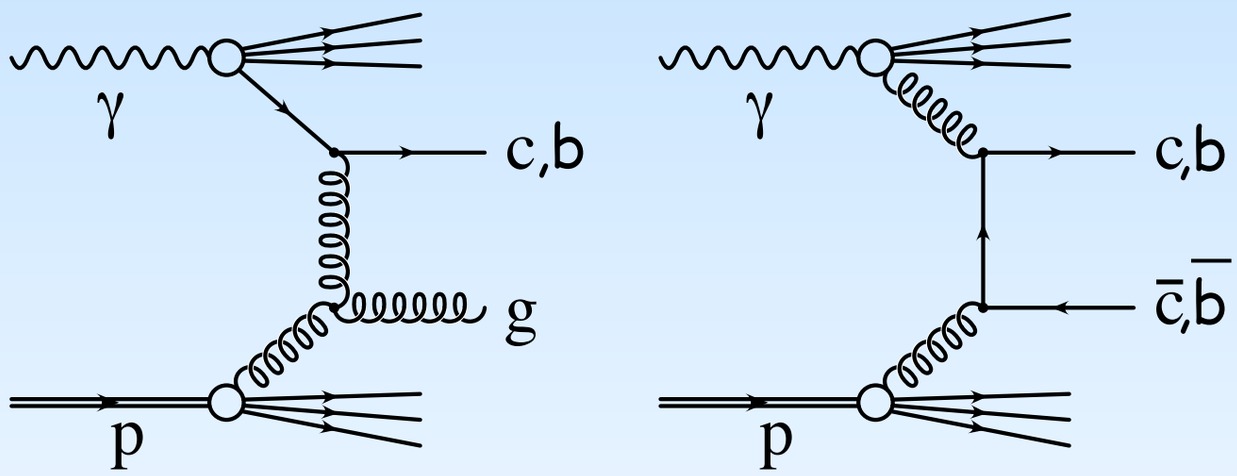
Photoproduction:scattering off quasi-real γ's
⇒ γ has a hadronic structure



resolved processes

Open heavy flavour photoproduction at HERA

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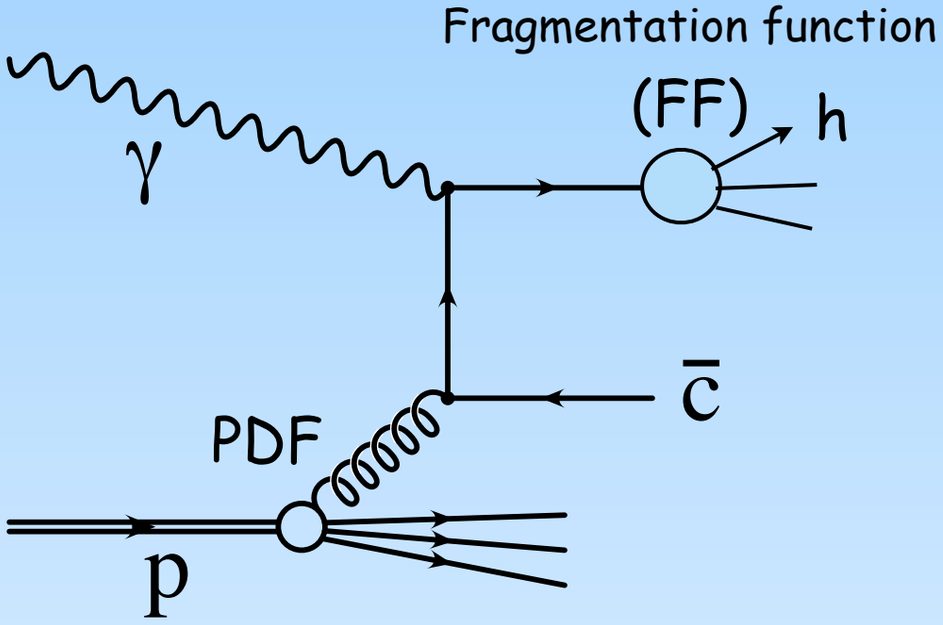

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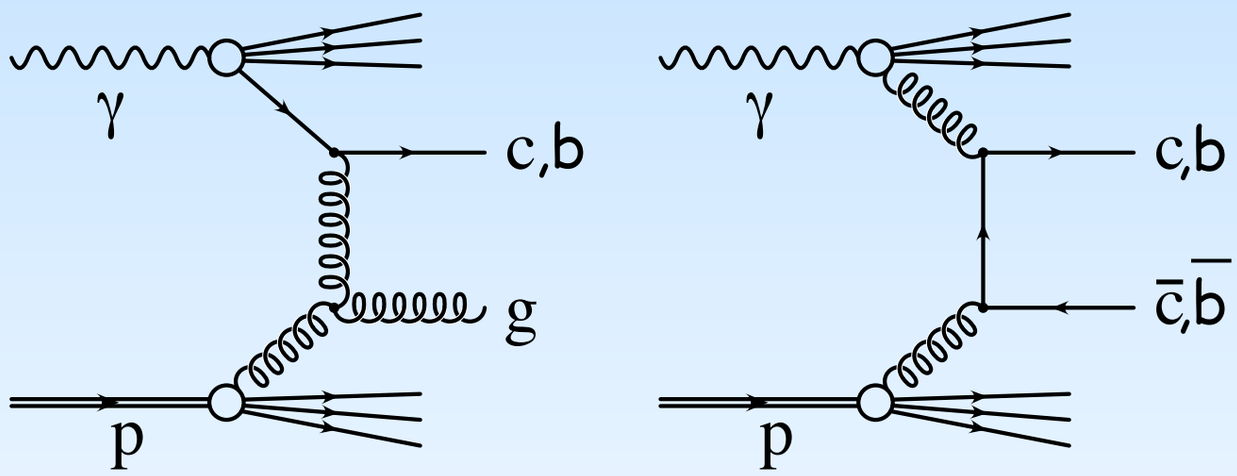
Factorisation:

$\sigma^h = PDF \otimes M.E. \otimes FF$



resolved processes

Theory approch for photoproduction

Massive fixed order QCD calculation, FFNS

- heavy flavours generated dynamically via BGF
- correct threshold treatment
- valid for $\mu^2 \approx O(m_c^2), O(m_b^2)$
- expected to fail at some scale $\mu^2 >> m_c^2, m_b^2$

$\Rightarrow$ appropriate for heavy flavour photoproduction it p_T small enough

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QCD LO + Parton shower Monte Carlo generators:

- PYTHIA: DGLAP evolution + Lund string fragmentation
- HERWIG:DGLAP evolution + cluster fragmentation
- CASCADE:CCFM evolution + Lund string fragmentation

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QCD NLO programs:

- FNMR + hadronisation corrections
- MC@NLO: full NLO MC generator: FNMR + cluster fragmentation

Heavy quark tagging

Tagging via semi-leptonic profits from from high branching fractions

≈ 10+10 % for beauty, ≈ 8 % for charm

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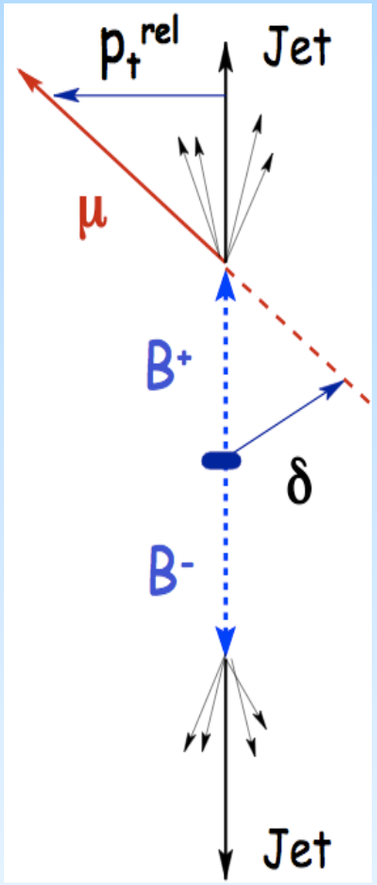
Above HQ threshold

μ + di-jets



Use in addition:

longevity: impact parameter

heavy mass: p_T^{rel}

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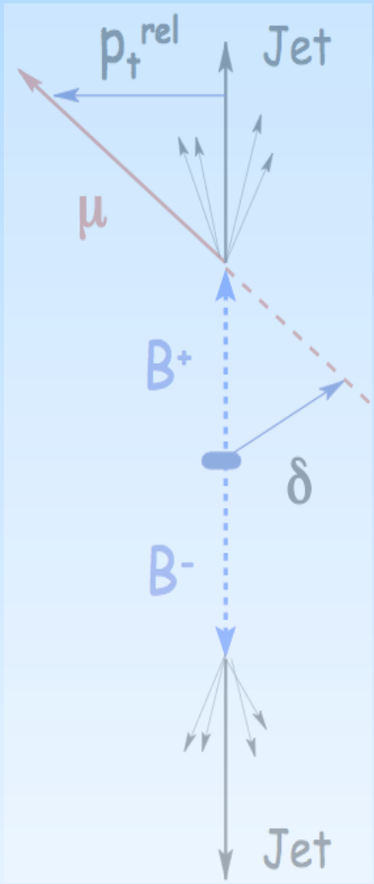

Use in addition:

longevity: impact parameter

heavy mass: p_T^{rel}

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Close to beauty threshold

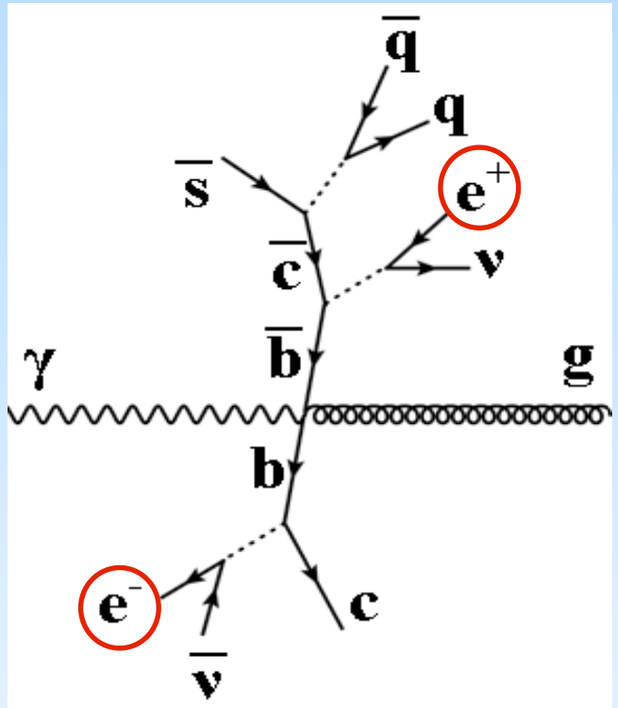
low p_T di-electrons

Use in addition:

angular correlation $\otimes$ charge:

$q_1 q_2 \Delta\phi$

heavy mass: m_{ee}



(one out of three possibilities)

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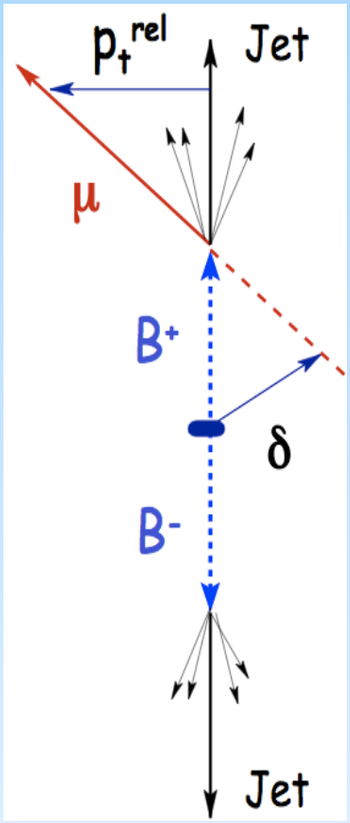
Charm and beauty from μ + di-jets

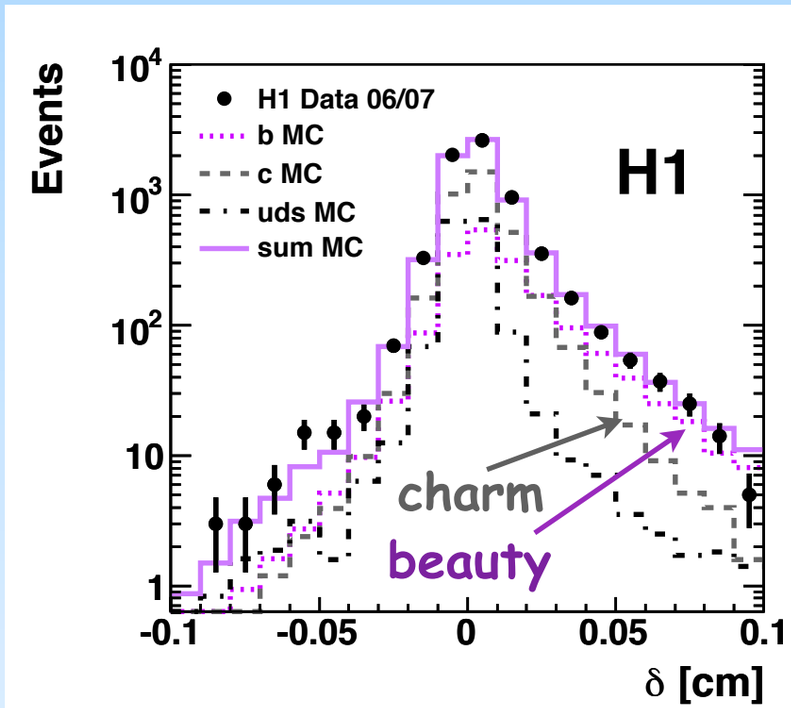
Phase space
Q^2<2.5 GeV^2, 0.2<y<0.7
p_T^{μ}<2.5 GeV, -1.3<η^{μ}<1.5

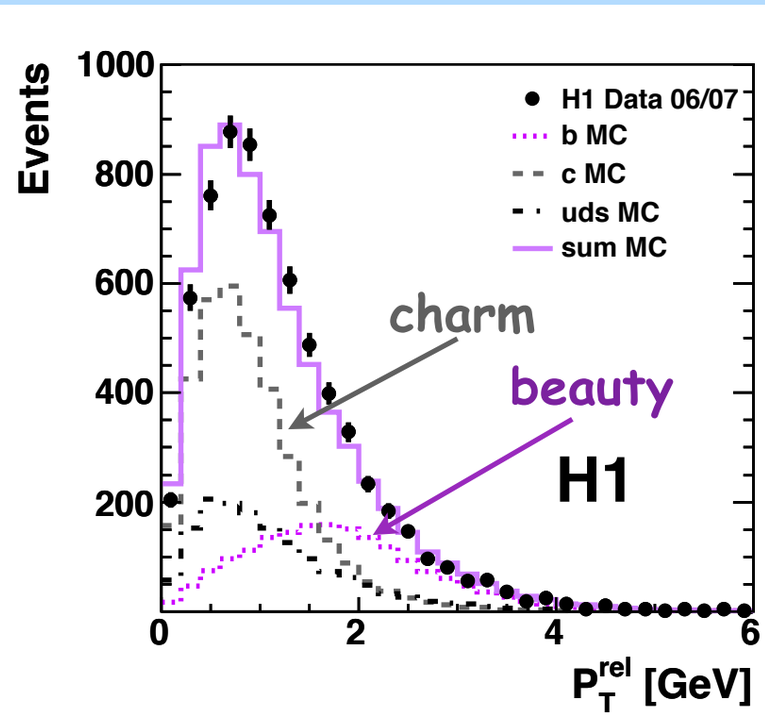
p_T^{jet1},p_T^{jet2}>7, 6 GeV
-1.5<η^{jet}<2.5



2d-Template fit in p_T^{rel} and δ

simultaneous determination of charm and beauty cross section





	H1 Data	PYTHIA	CASCADE	HERWIG	MC@NLO
charm [pb]	$81.3\pm4.3_{stat}\pm8.5_{syst}$	94.3	76.8	58.6	$58.6\ ^{+29.5}_{-11.2}$
beauty [pb]	$43.3\pm2.1_{stat}\pm4.5_{syst}$	35.3	29.0	20.6	$33.4\ ^{+7.1}_{-9.2}$

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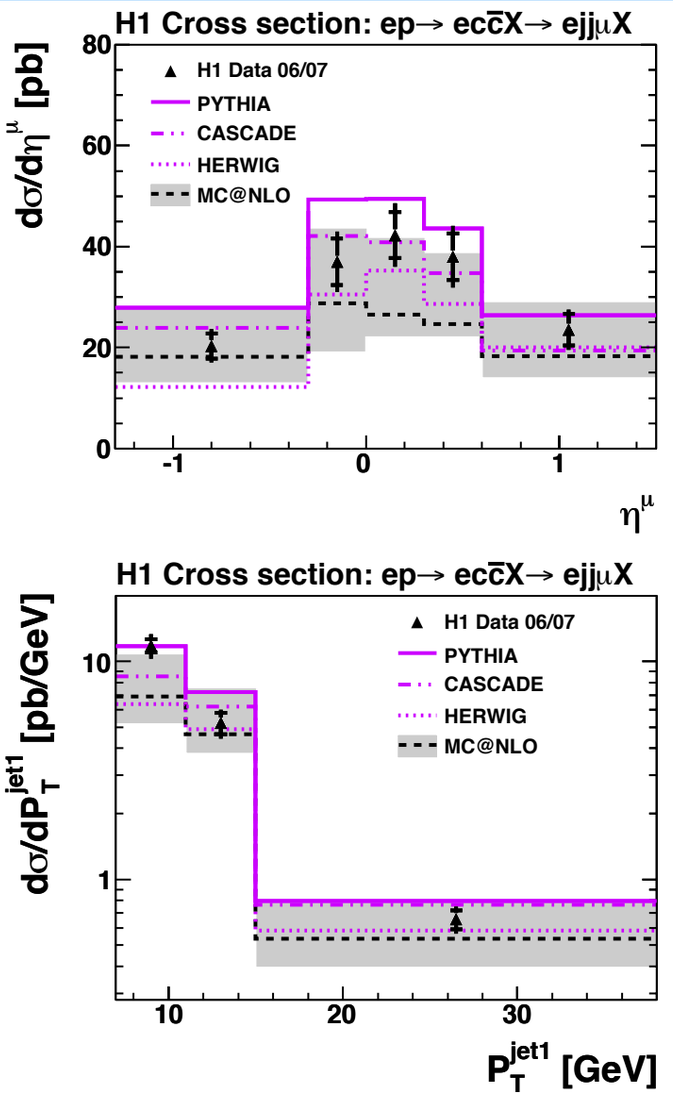
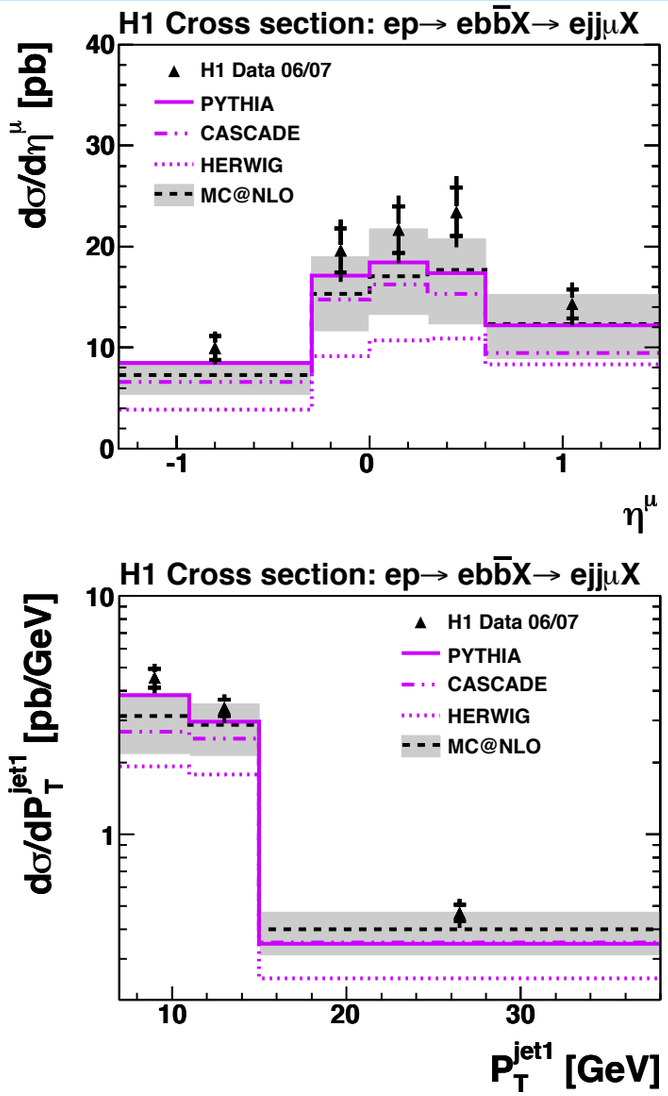
Cross sections differential in η^{μ} and p_T^{jet}

Charm



Beauty



Charm: reasonably described by all models - MC@NLO large uncertaintes

Beauty: reasonably described - except by HERWIG (too low)

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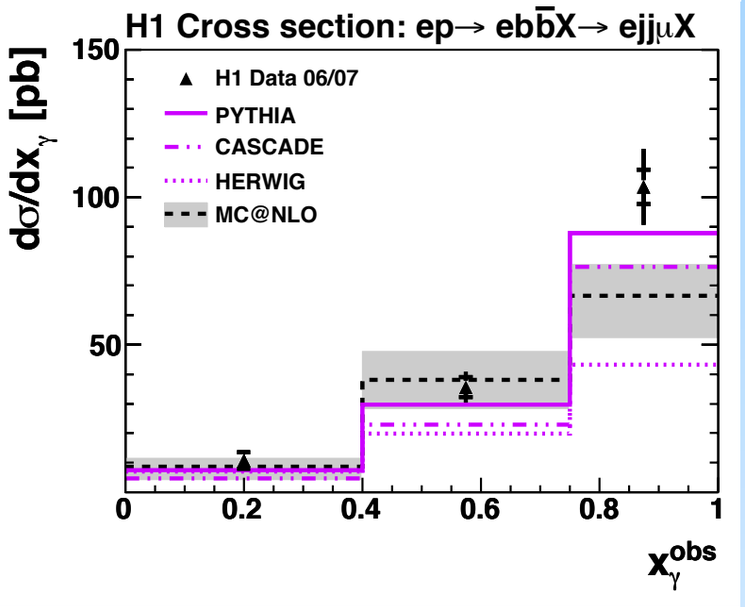
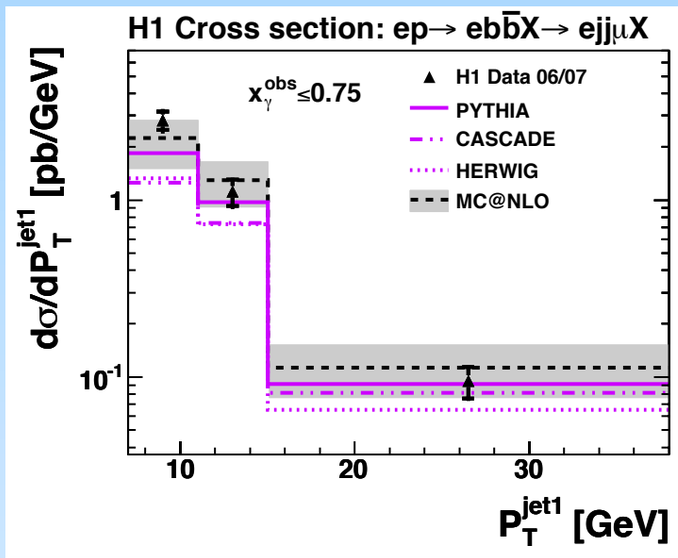
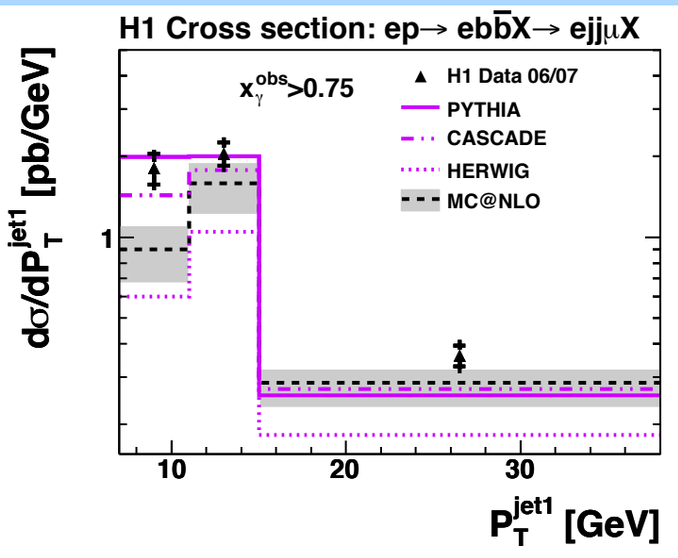
Beauty: direct & resolved contribution

$$x_\gamma^{obs} = \frac{\sum_{jet1}(E - P_z) + \sum_{jet2}(E - P_z)}{\sum_{all}(E - P_z)}$$



resolved enriched direct





- Significant resolved contribution for beauty
- All LO models describe the shapes of the distributions
- MC@NLO significantly below the data at low pTjet in the direct regime

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Beauty photoproduction near threshold

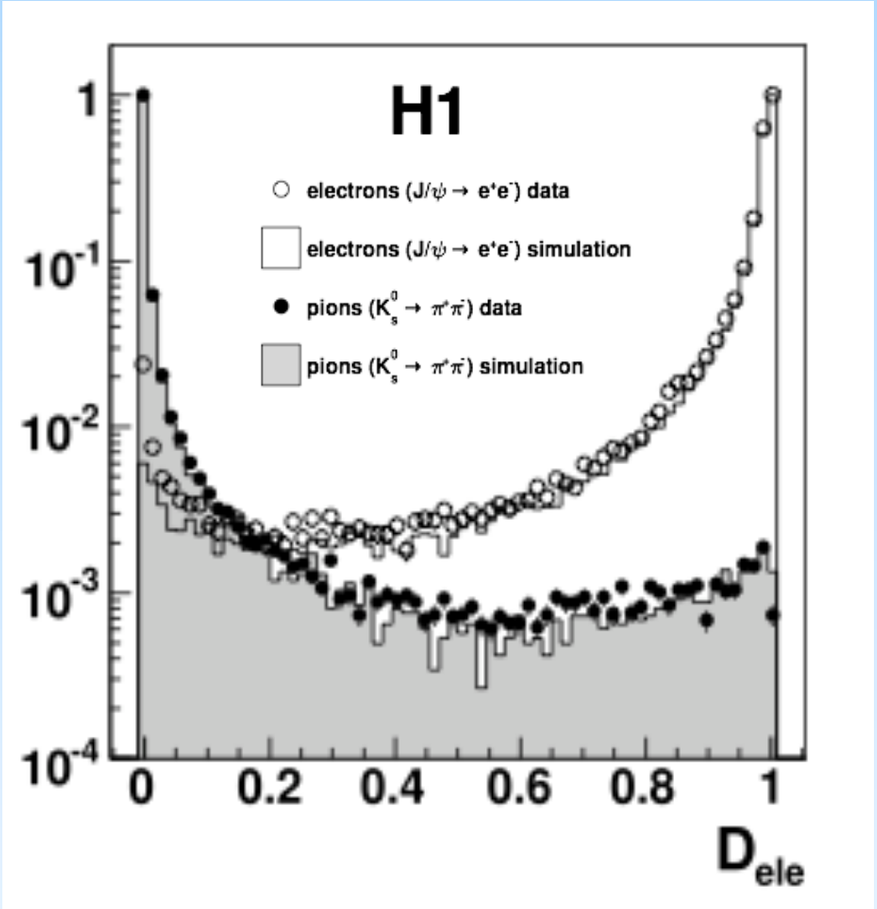
Phase space
$Q^2<1\ GeV^2$, $0.05<y<0.65$
$|\eta(b)|, |\eta(\bar{b})|<2$

$$ep \to eb\bar{b}X \qquad b\bar{b} \to eeX'$$

Threshold region accessible due to:
- dedicated low p_T electron trigger
- excellent low p electron identification
  (shower shape + dE/dx)
  >90% electron efficiency and
  >99% hadron rejection

Pions from $K^0 \to \pi^+\pi^-$

Electrons from $J/\psi \to e^+e^-$



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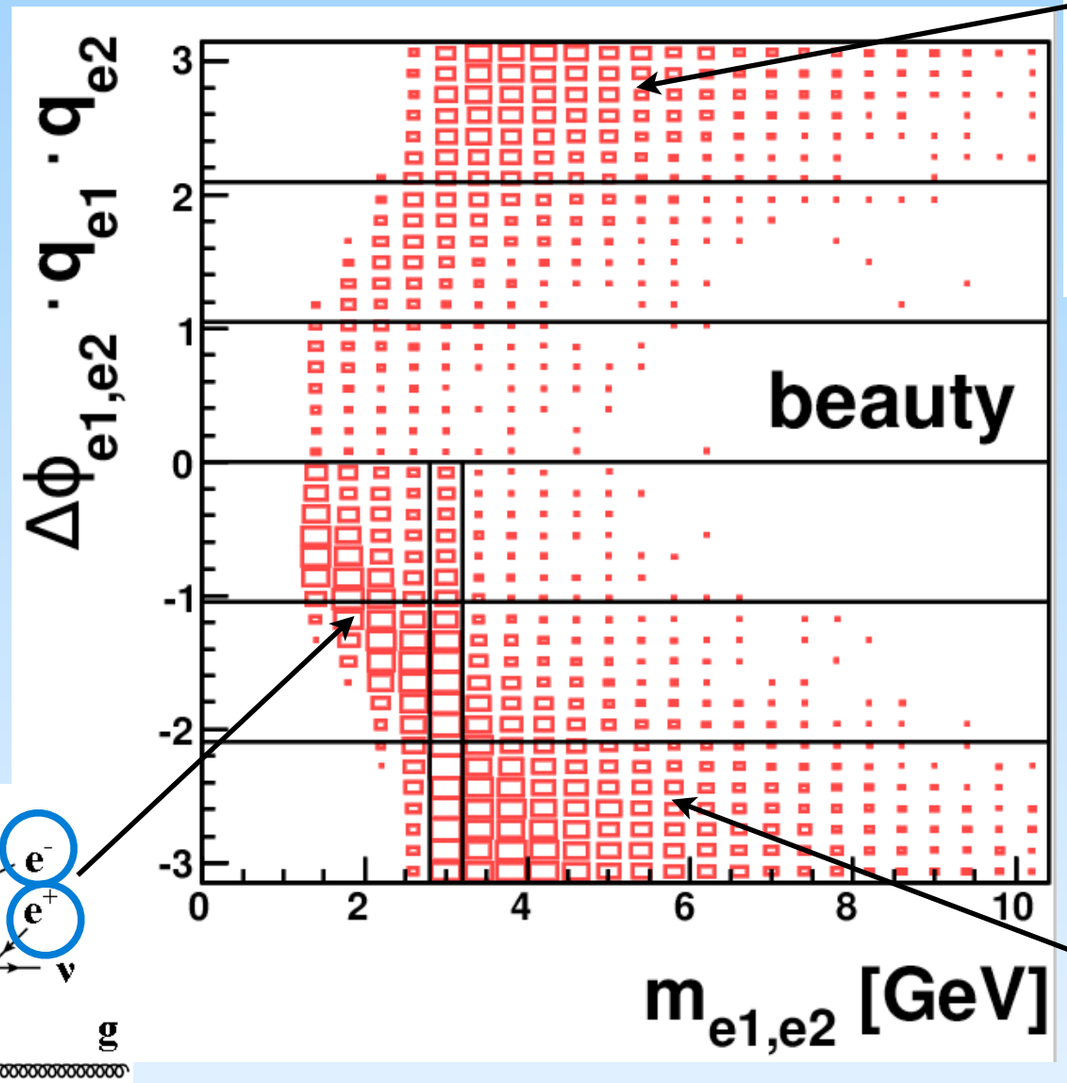
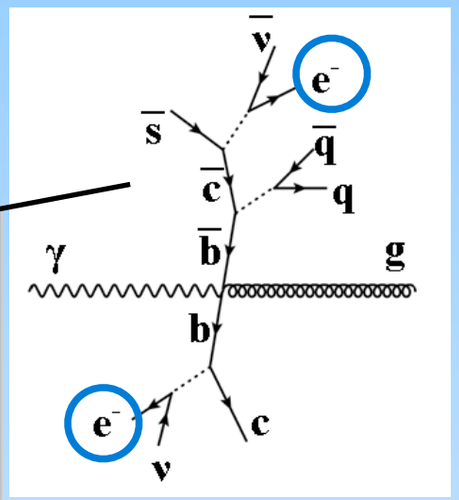
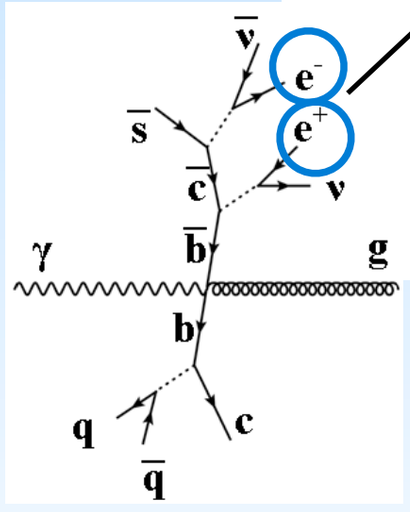
Beauty photoproduction near threshold

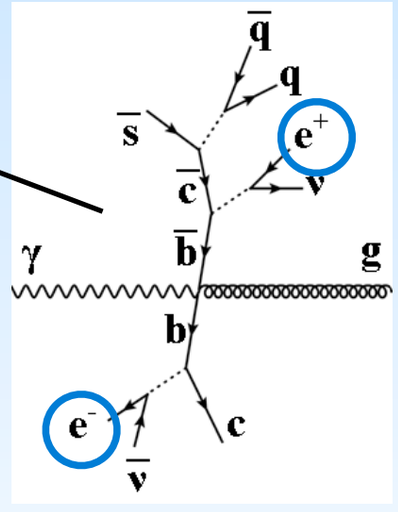
Use di-electron correlations:

- Invariant mass: m_{ee}
- Azimuthal angle: $\Delta\phi_{ee}$
- Charge: q(e1)*q(e2)



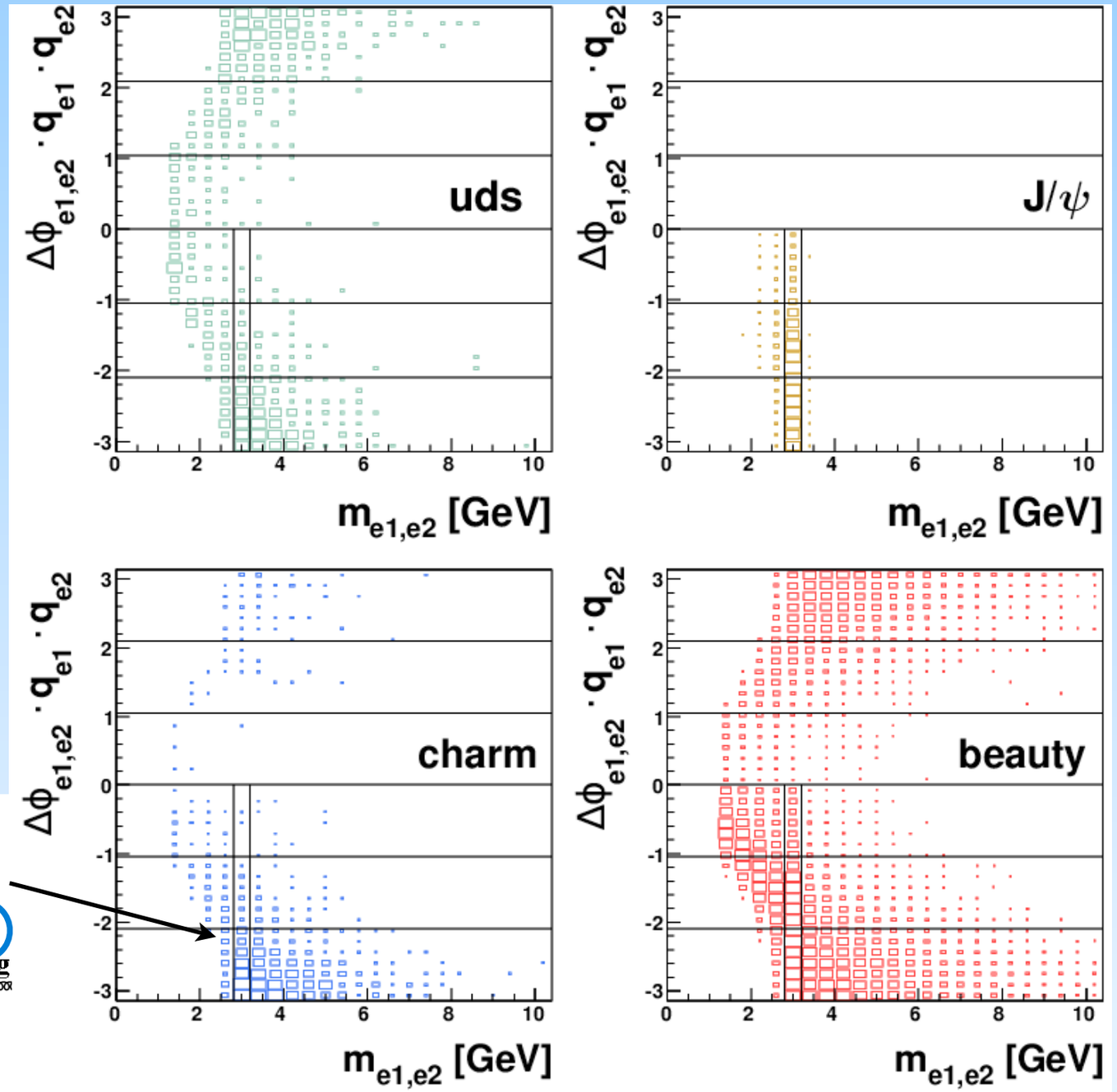


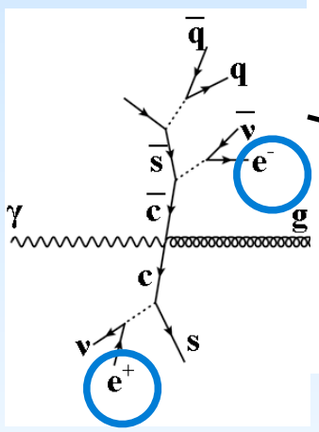




Beauty photoproduction near threshold

- Additional constraints on uds background from non-electron sample
- Regularised unfolding of the differential beauty cross section





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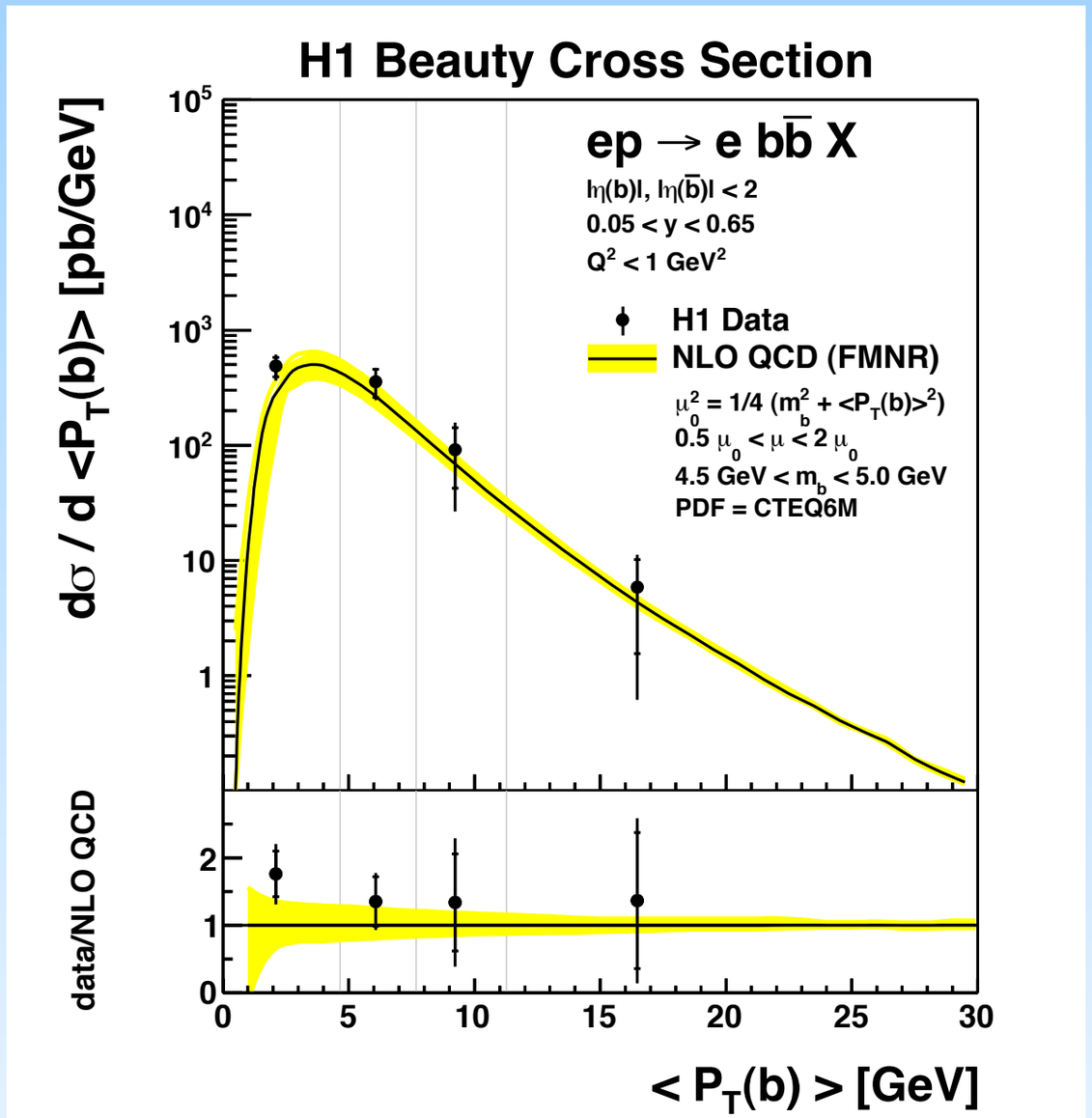
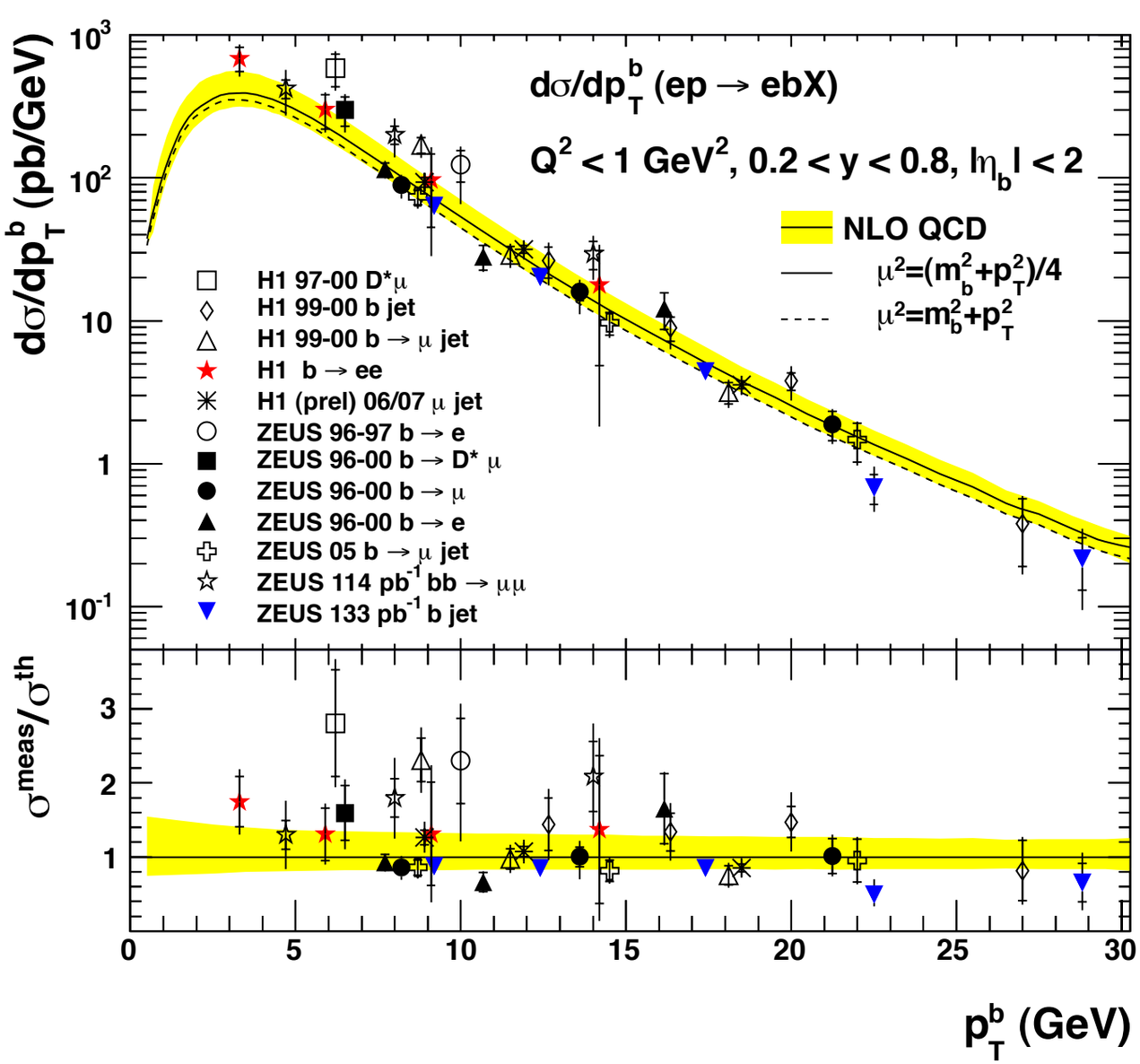
Beauty photoproduction near threshold

Differential beauty cross section as a function mean transverse b-quark momentum



- Access to lowest $p_T(b)$ values ever measured in ep
- NLO agree with data within uncertainties

Summary on Beauty Photoproduction



NLO QCD in good agreement with data

Conclusions

- New results on charm and beauty photoproduction in ep scattering from H1 using semi-leptonic decays
- Data are used to test different LO and NLO QCD models
- Charm production with high p_T dijets is well described by all models - albeit NLO QCD with very large uncertainties
- Beauty production with high p_T dijets is well described by LO models - MC@NLO underestimates the direct contribution
- Beauty production near threshold measured for the first time
- In general good agreement between data and NLO QCD