Beauty & Charm Physics at HERA

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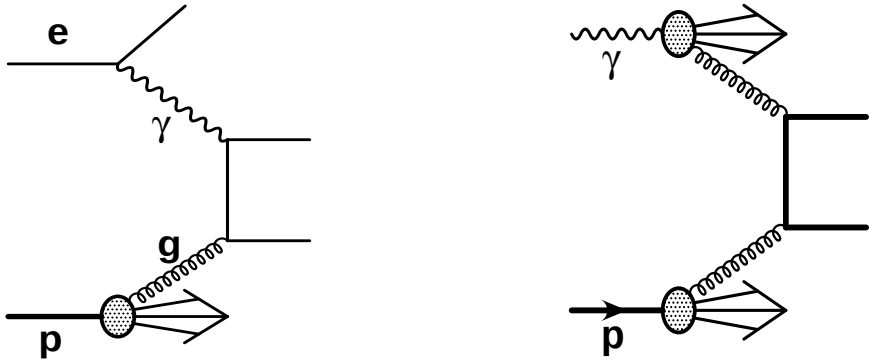
On behalf of the ZEUS & H1 Collaborations

Introduction: Heavy Flavour Production at HERA

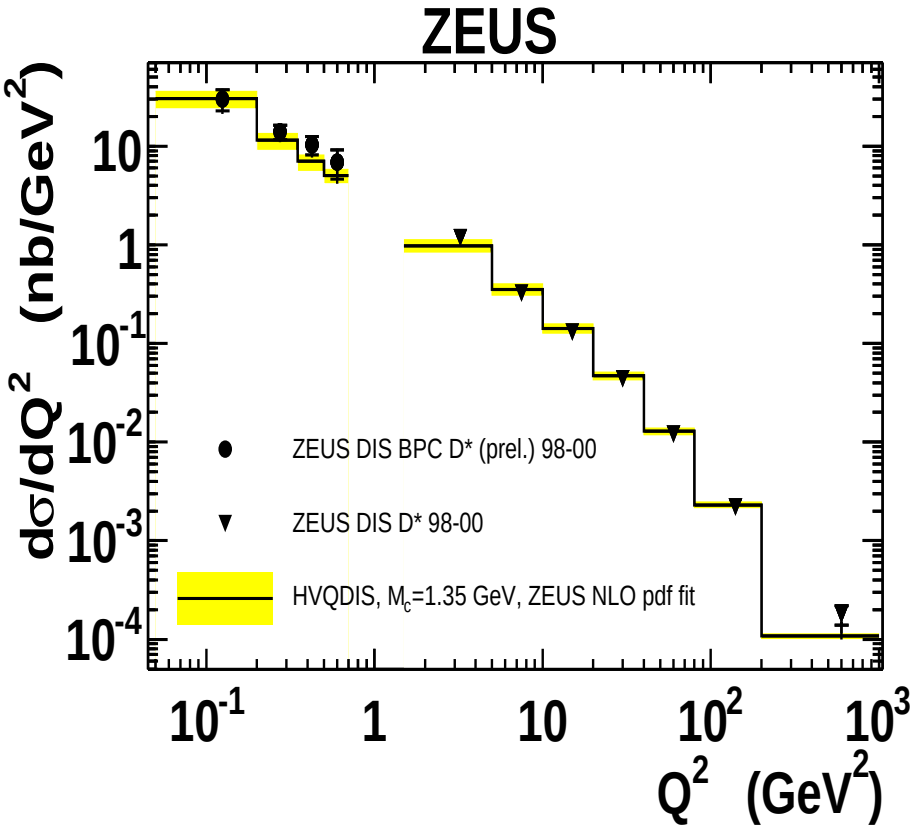
- HERA collides 920 (820) GeV p with 27.5 GeV $e^{\pm}$; ZEUS & H1 colliding experiments.
- Heavy quark production dominated by Boson Gluon Fusion at LO, ($\gamma g \rightarrow q\bar{q}$).

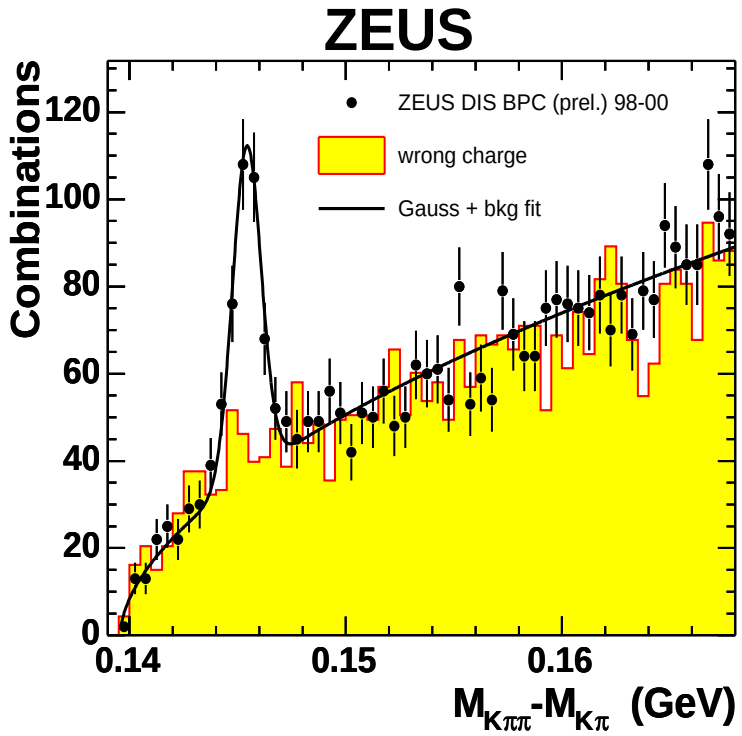


- Two kinematic regimes:
  - Deep Inelastic Scattering (DIS), $Q^2 > 1$ GeV^2 – direct process is dominant.
  - Photoproduction (γp), $Q^2 \simeq 0$ GeV^2 – resolved processes are important.
- Test of pQCD – study gluon density in proton and hadronic components of photon.
- Compare to NLO QCD calculations: FMNR, ZMVFNS for γp, HVQDIS for DIS.
- LO + parton shower MCs used: Pythia, Herwig, Cascade, Rapgap.

D^* Cross Section at Low Q^2

- Test of NLO for charm production in transition region from DIS to γp.
- Low Q^2 values reached by measuring the scattered electron in the Beam Pipe Calorimeter (BPC).

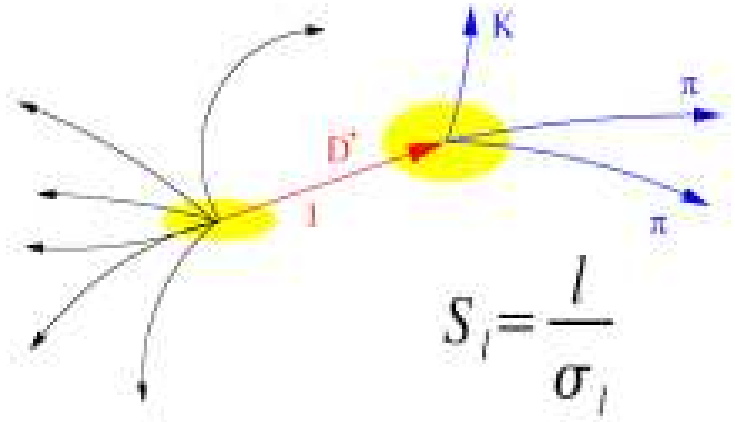


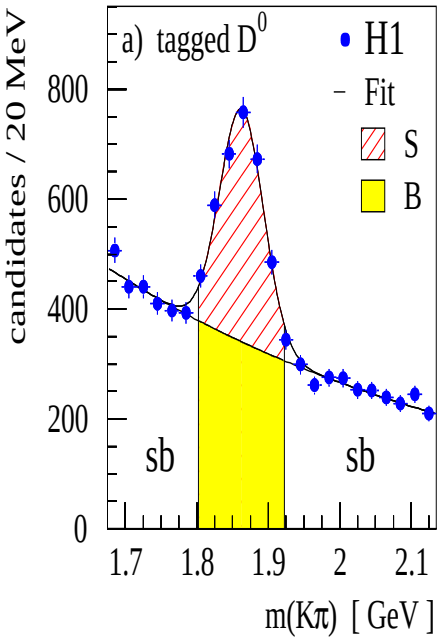


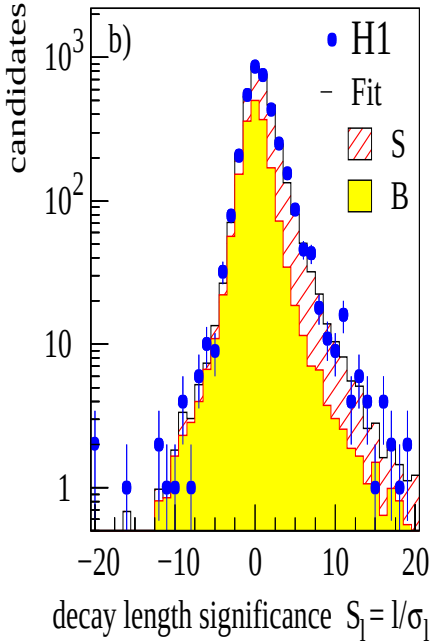
- $0.05 < Q^2 < 0.7\ \mathrm{GeV}^2$
- $0.02 < y < 0.85$
- $1.5 < p_T(D^*) < 9.0\ \mathrm{GeV}$
- $|\eta(D^*)| < 1.5$

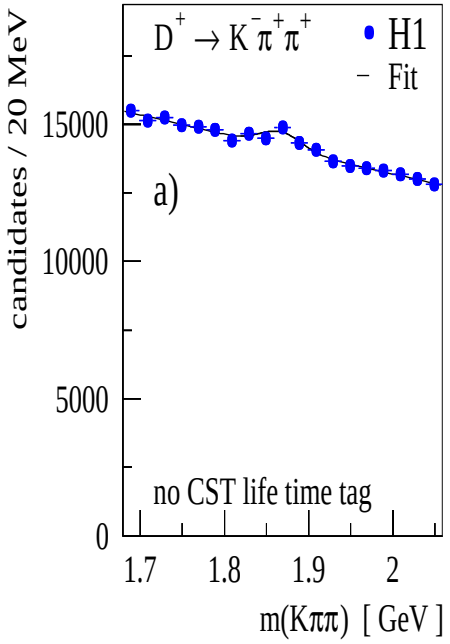
D Meson Production

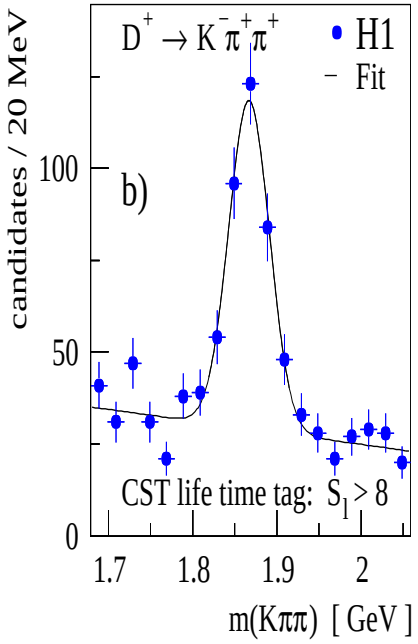
- D mesons have long lifetimes, tagged via displaced secondary vertices.
- Cutting on decay length significance (S_l) greatly improves signal purity.
- For $S_l > 8$, D^+ signal to background ratio improves by factor 50, keep 20% of signal.





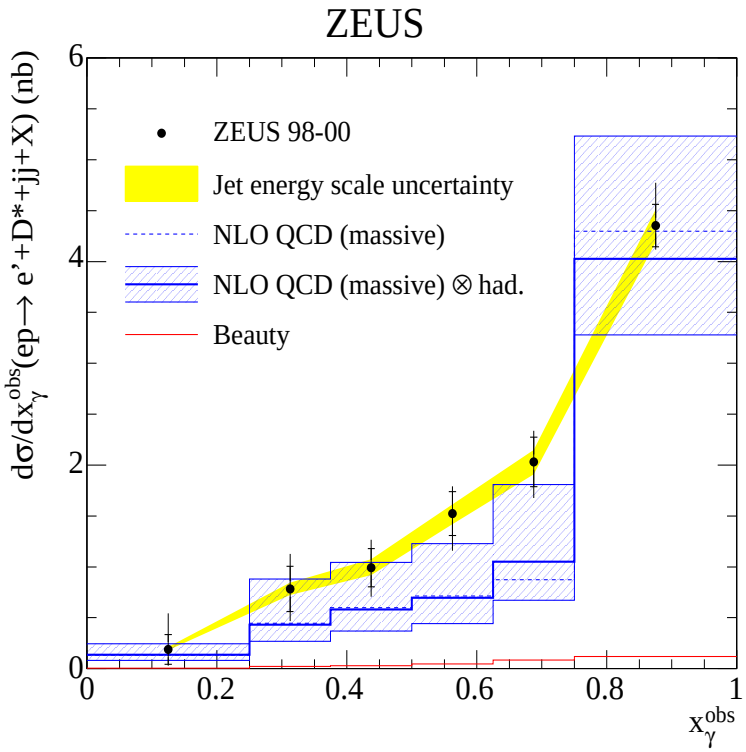


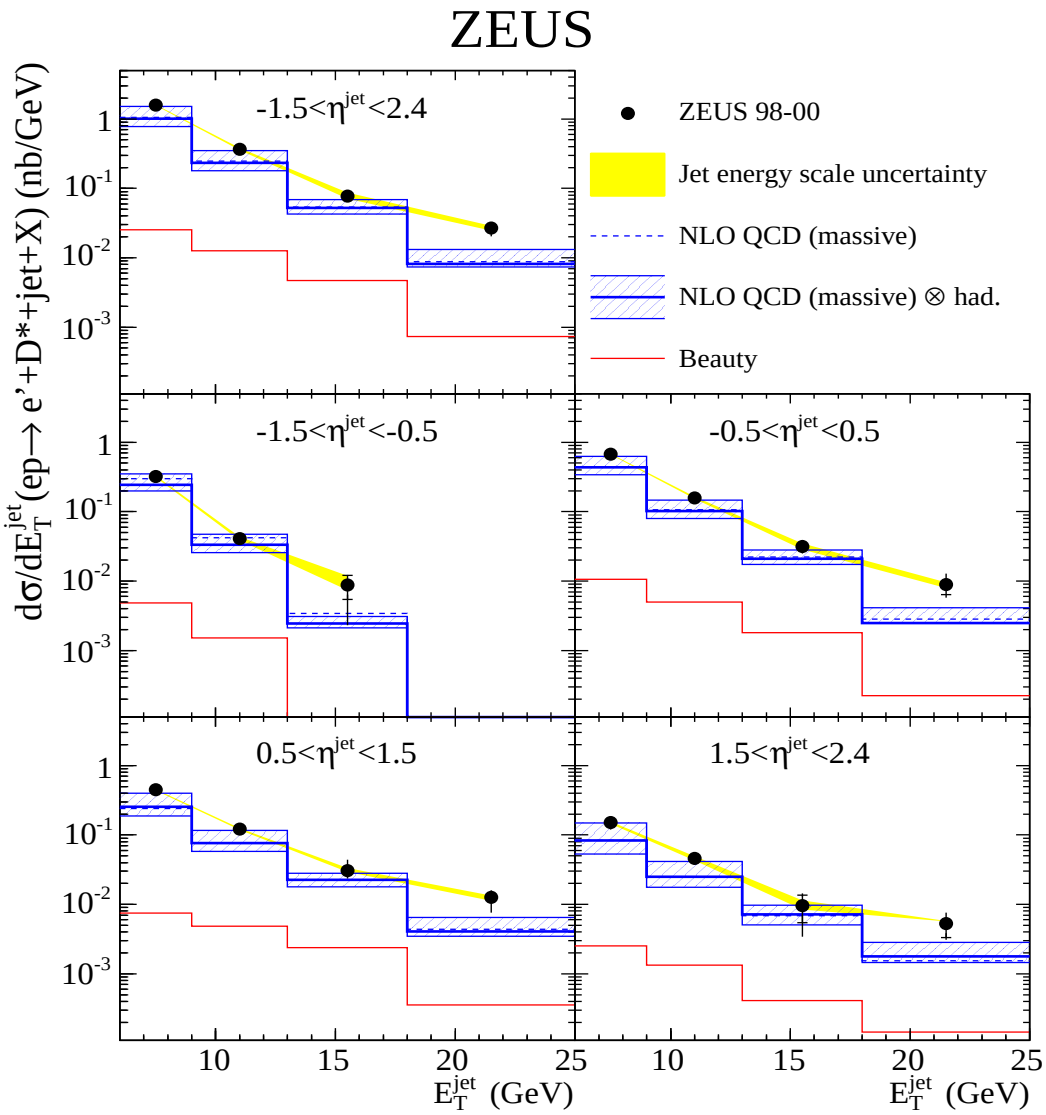




Dijet Correlations in D^* Photoproduction

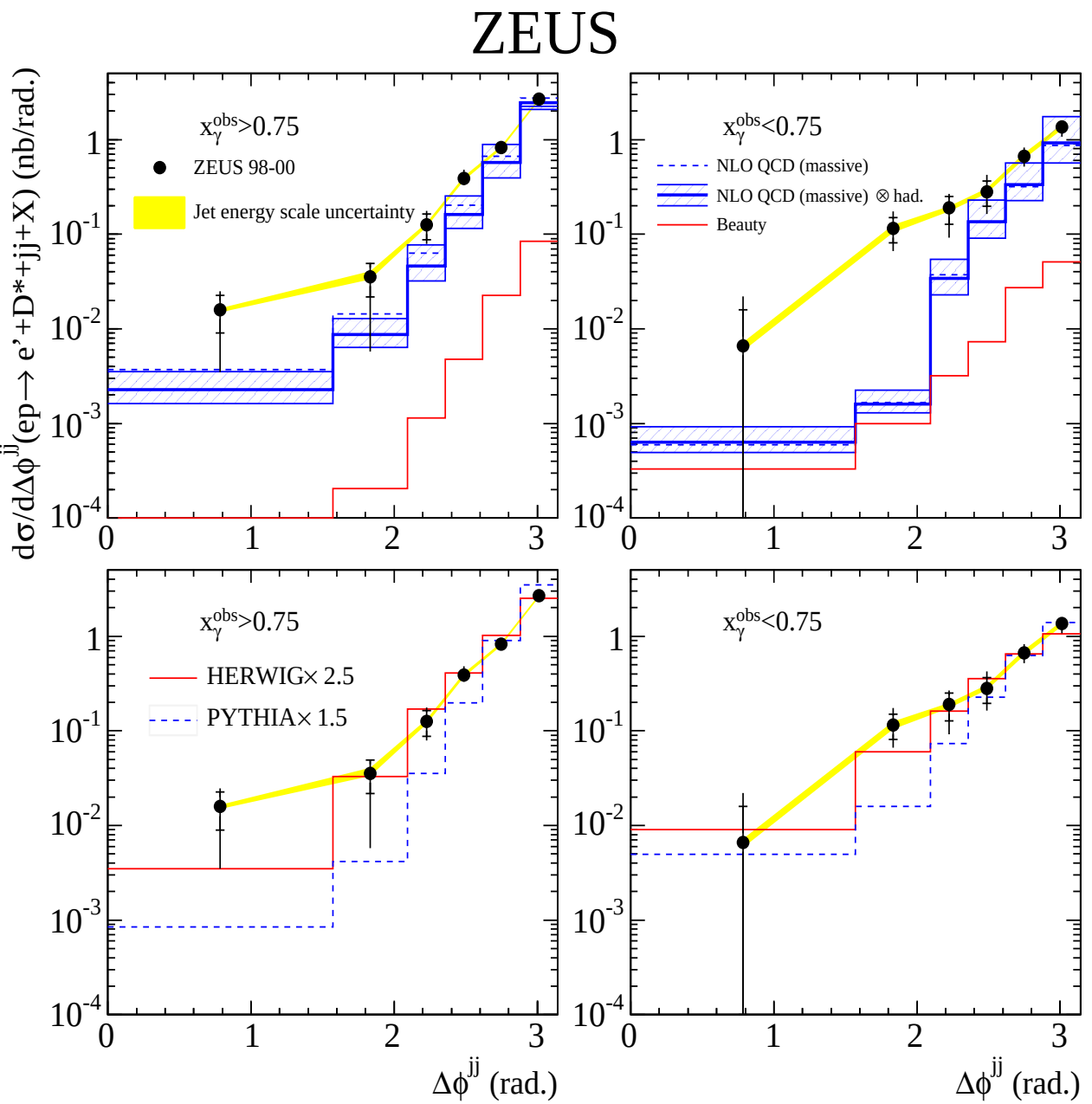
- x_γ^{obs} used to distinguish between direct and resolved γp dijets.
- Good agreement with NLO for inclusive jet cross sections.





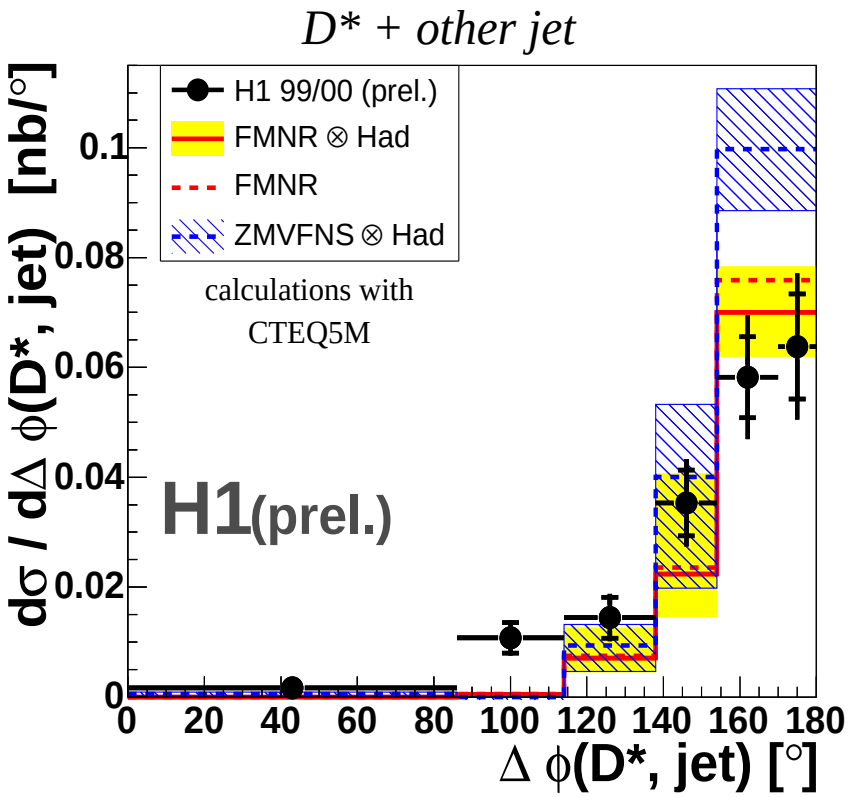
Dijet Correlations in D* Photoproduction

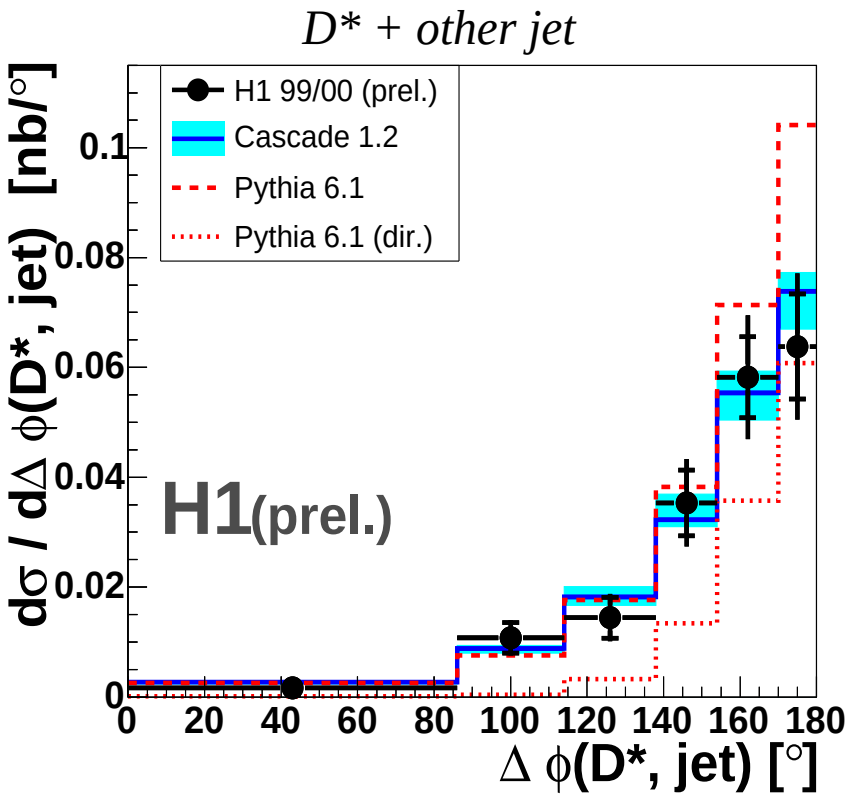
- NLO describes shape of data for direct γp, data favours lower charm mass.
- Shape poorly described by NLO for resolved γp, need higher order corrections.
- LO + parton shower particularly HERWIG fits data well for both direct and resolved.



D^* Jet Correlations in Photoproduction

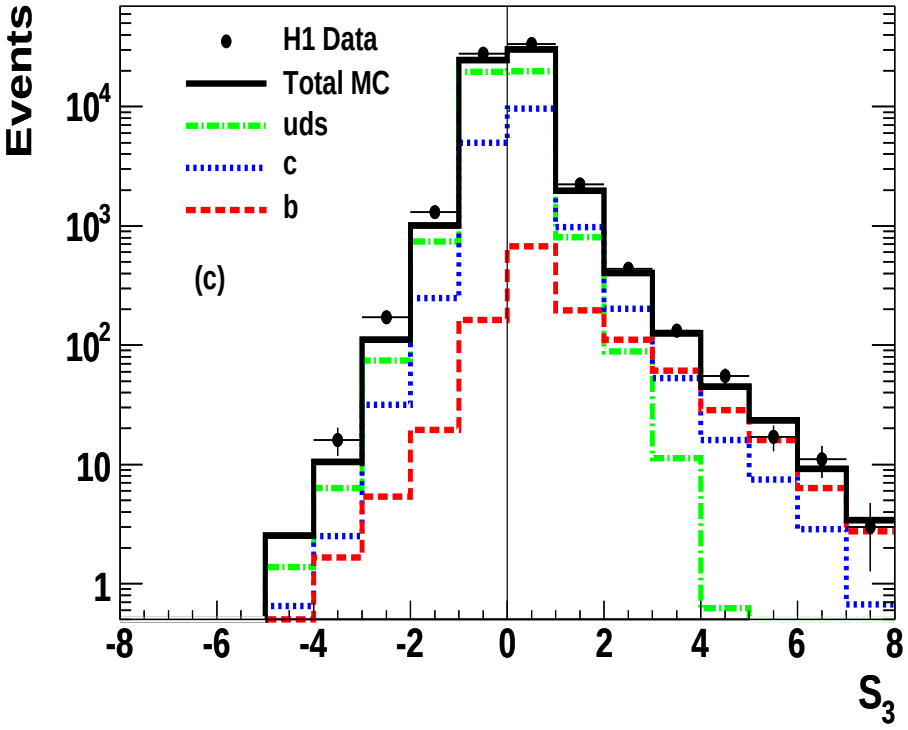
- Similar results found for γp events with D^* and jet not containing the D^*.
- Again data described better by LO + parton shower MCs than NLO.
- NLO massive scheme (FMNR) gives better description than massless scheme (ZMVFNS).

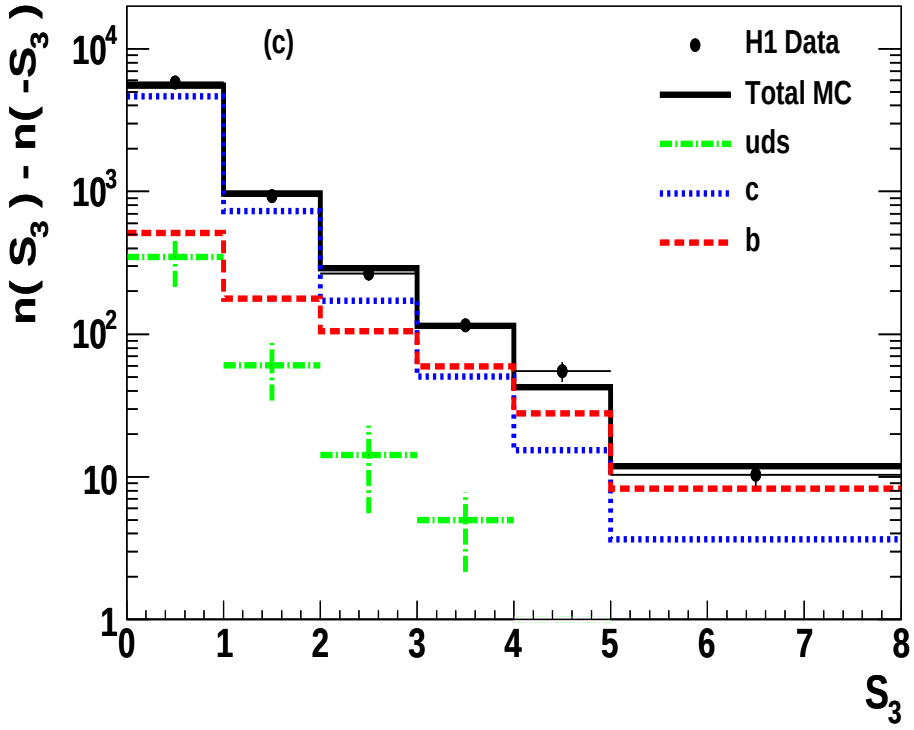




$F_2^{c\bar{c}}$ & $F_2^{b\bar{b}}$ from Impact Parameters

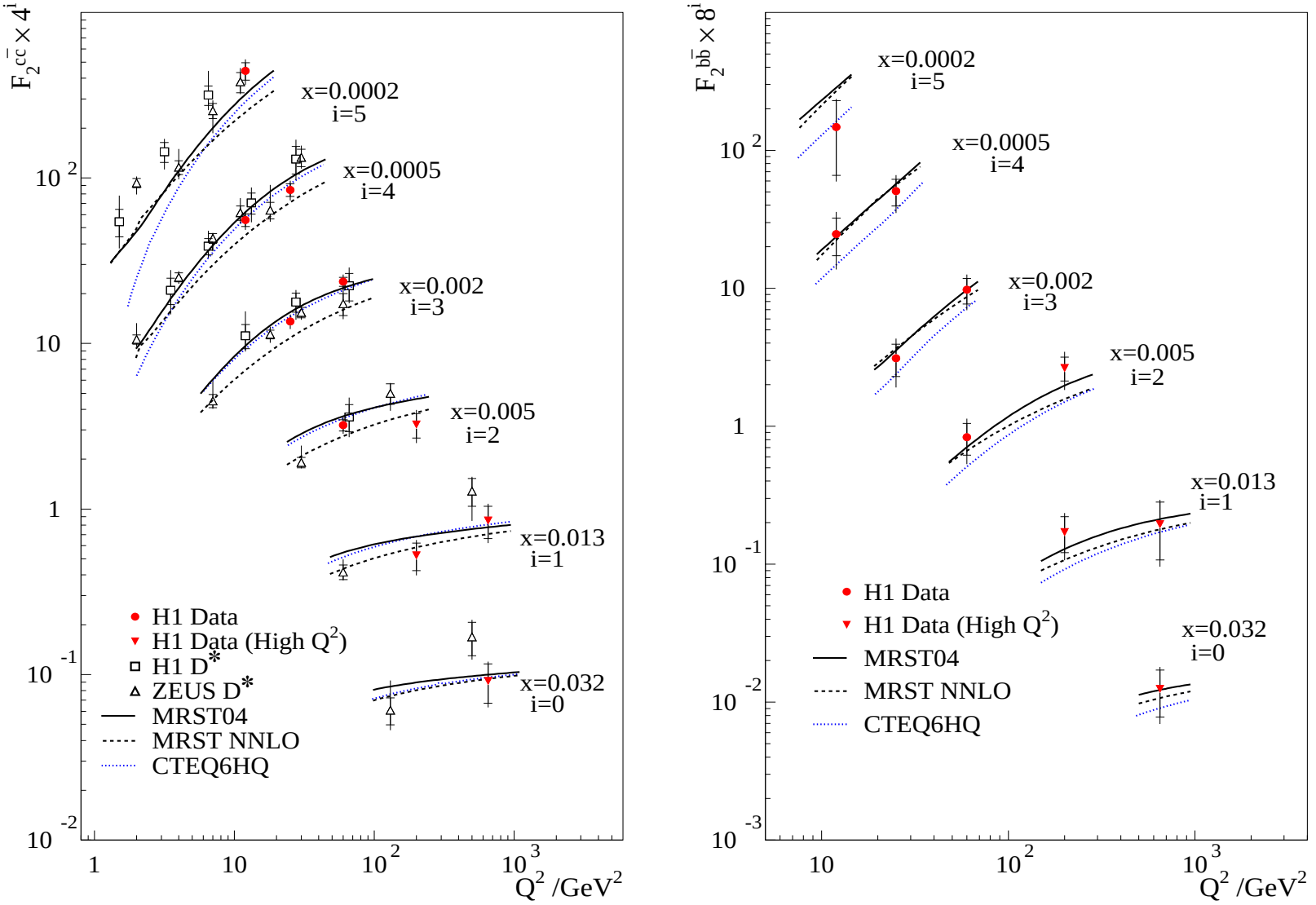
- Using impact parameter significance (S) of tracks, charm and beauty fractions calculated by fitting distributions in different x-Q^2 intervals.
- Differential cross sections measured, structure functions determined.





- For track with third highest S, beauty and charm fractions large at large S.

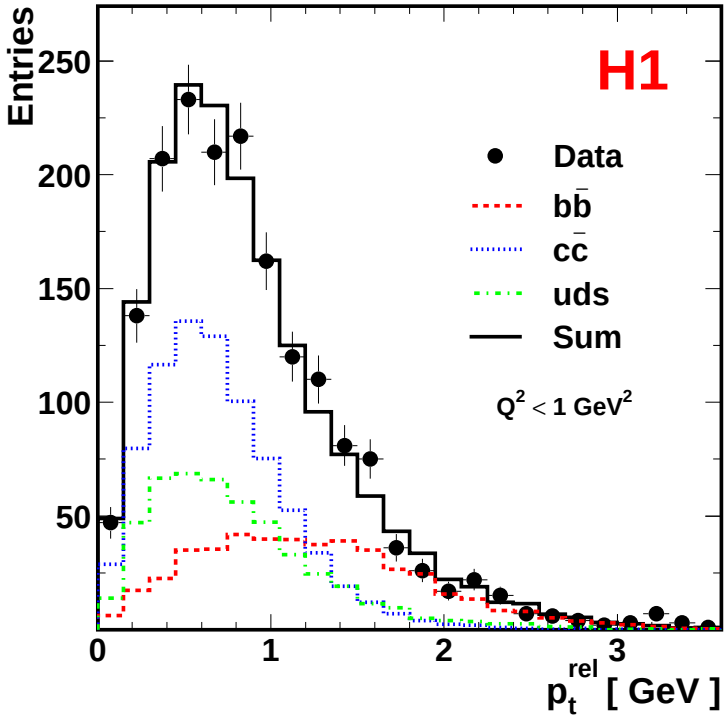
$F_2^{c\bar{c}}$ & $F_2^{b\bar{b}}$ from Impact Parameters

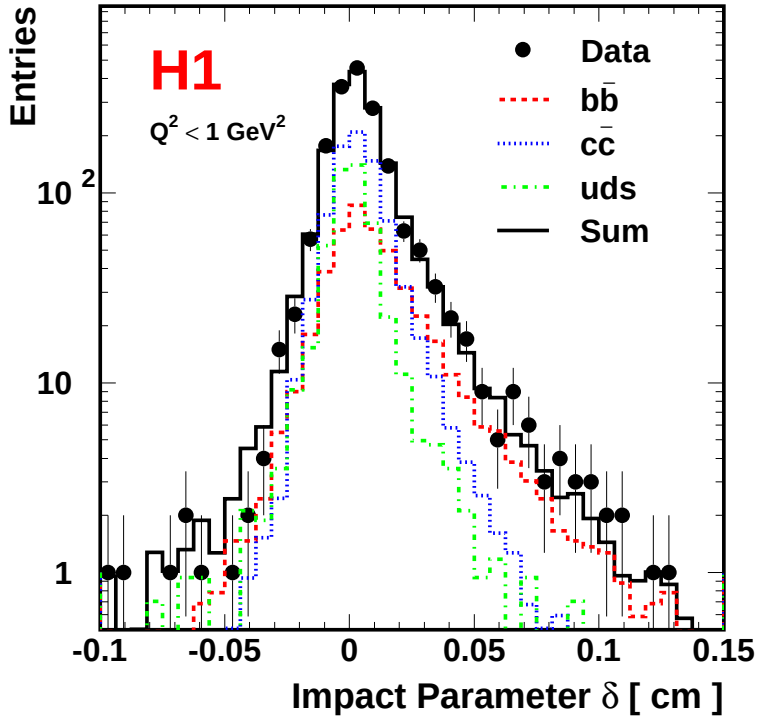


- QCD calculations fit the data reasonably well; NNLO calculations now available.
- Scaling violations apparent at low x.

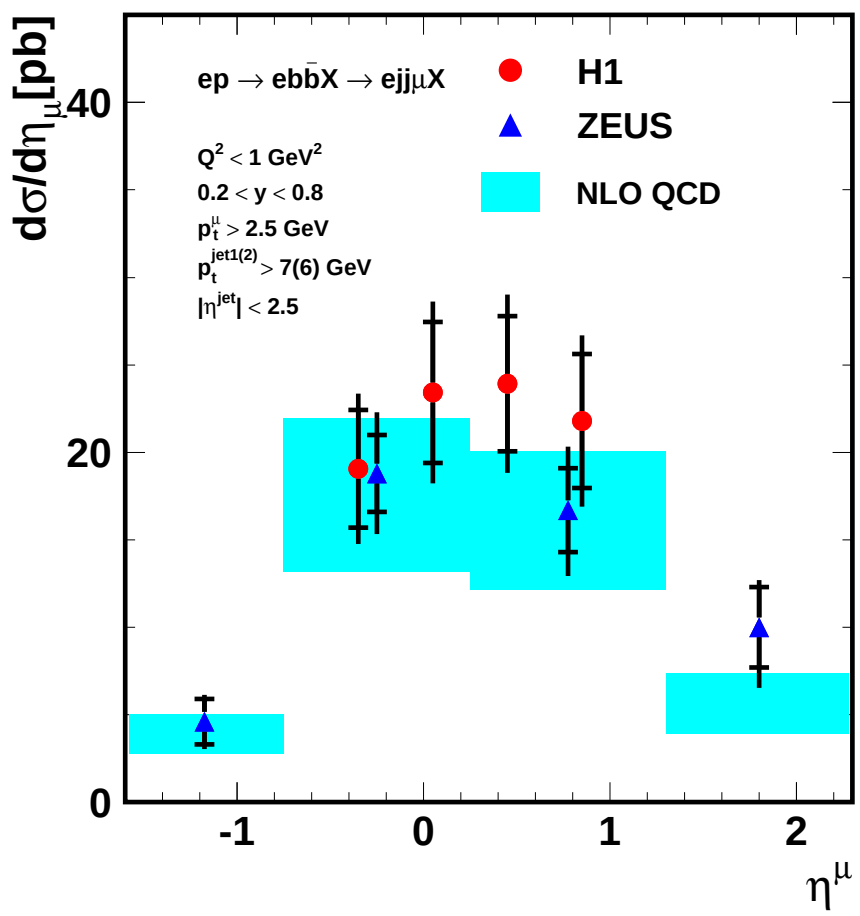
Beauty Tagging Using a Muon & Jets in Photoproduction

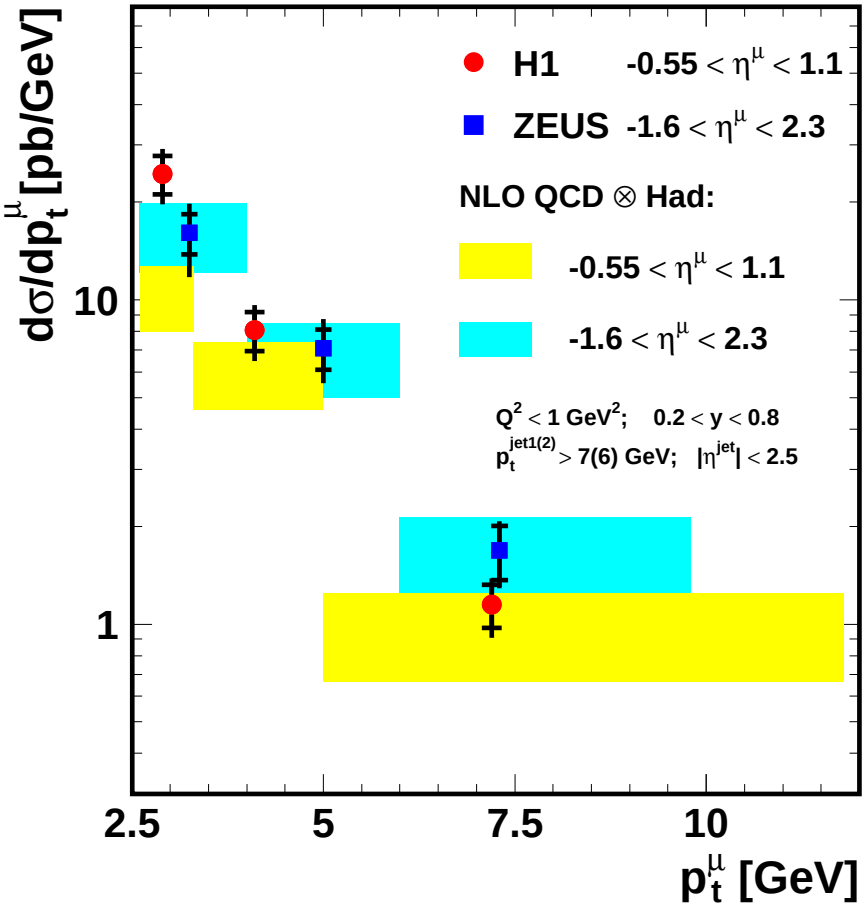
- Semileptonic decay of B meson to muon with accompanying jets.
- Separate beauty from charm and light flavours by exploiting high mass and long lifetime of B meson:
  - Relative transverse momentum (p_T^{rel}) of muon to axis of associated jet.
  - Impact parameter (δ) of muon in transverse plane.
- Simultaneously fit δ and p_T^{rel} to extract beauty fraction.





Beauty Tagging Using a Muon & Jets in Photoproduction

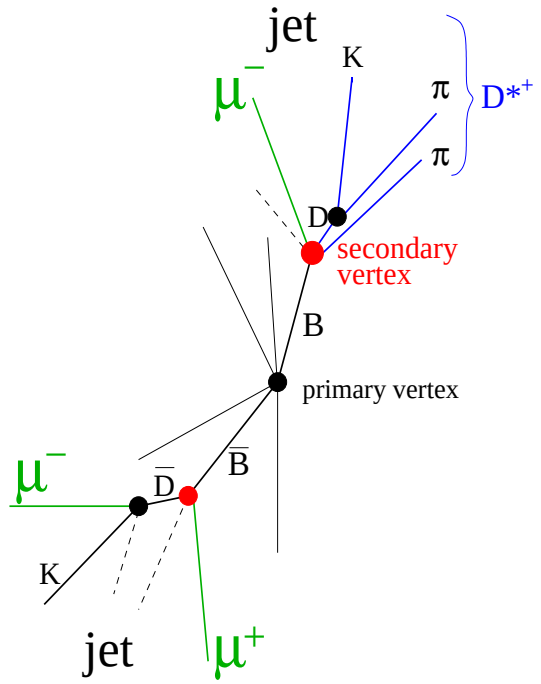


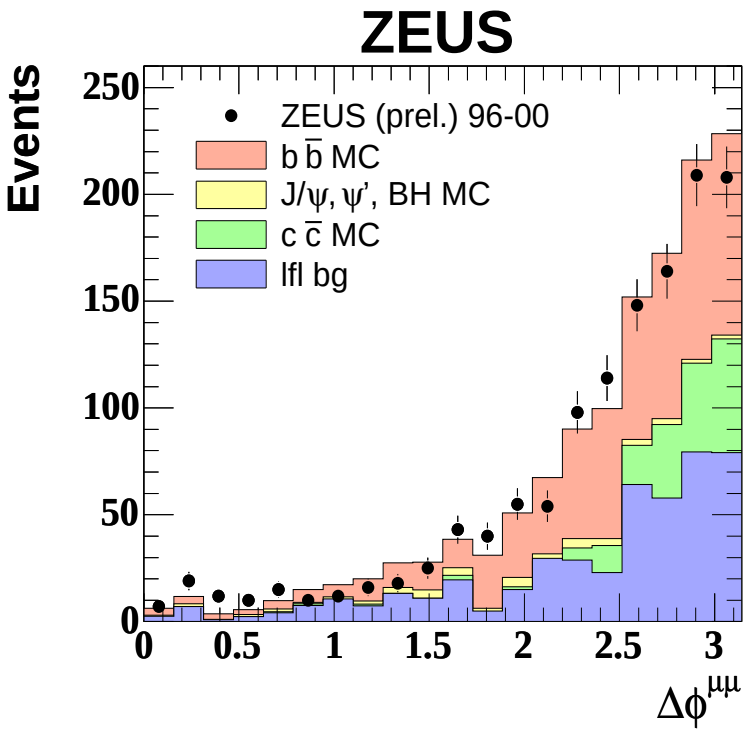


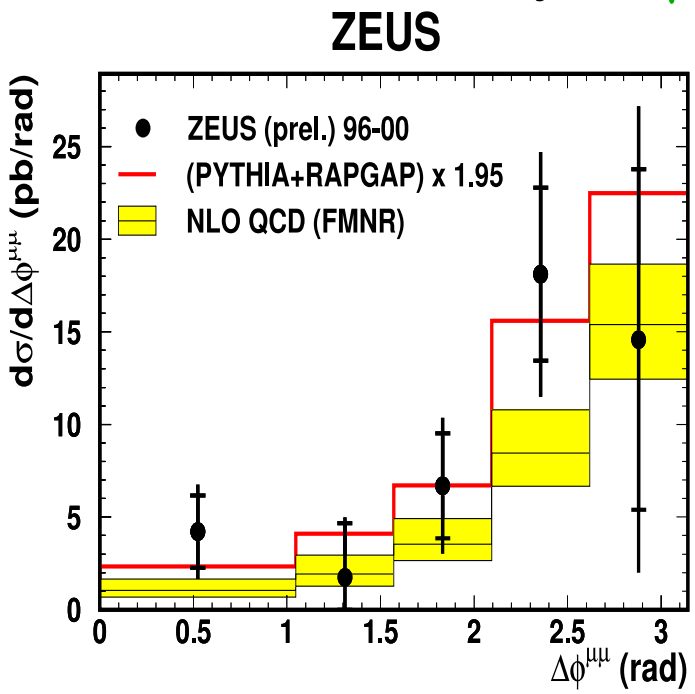
- NLO describes the data reasonably well.
- H1 have excess of events at low p_T^μ

Beauty in Dimuon Events

- Events with two muons suppresses background from charm and light flavours.
- Separating sample into high and low mass, isolated and non-isolated, like and unlike sign further constrains background.

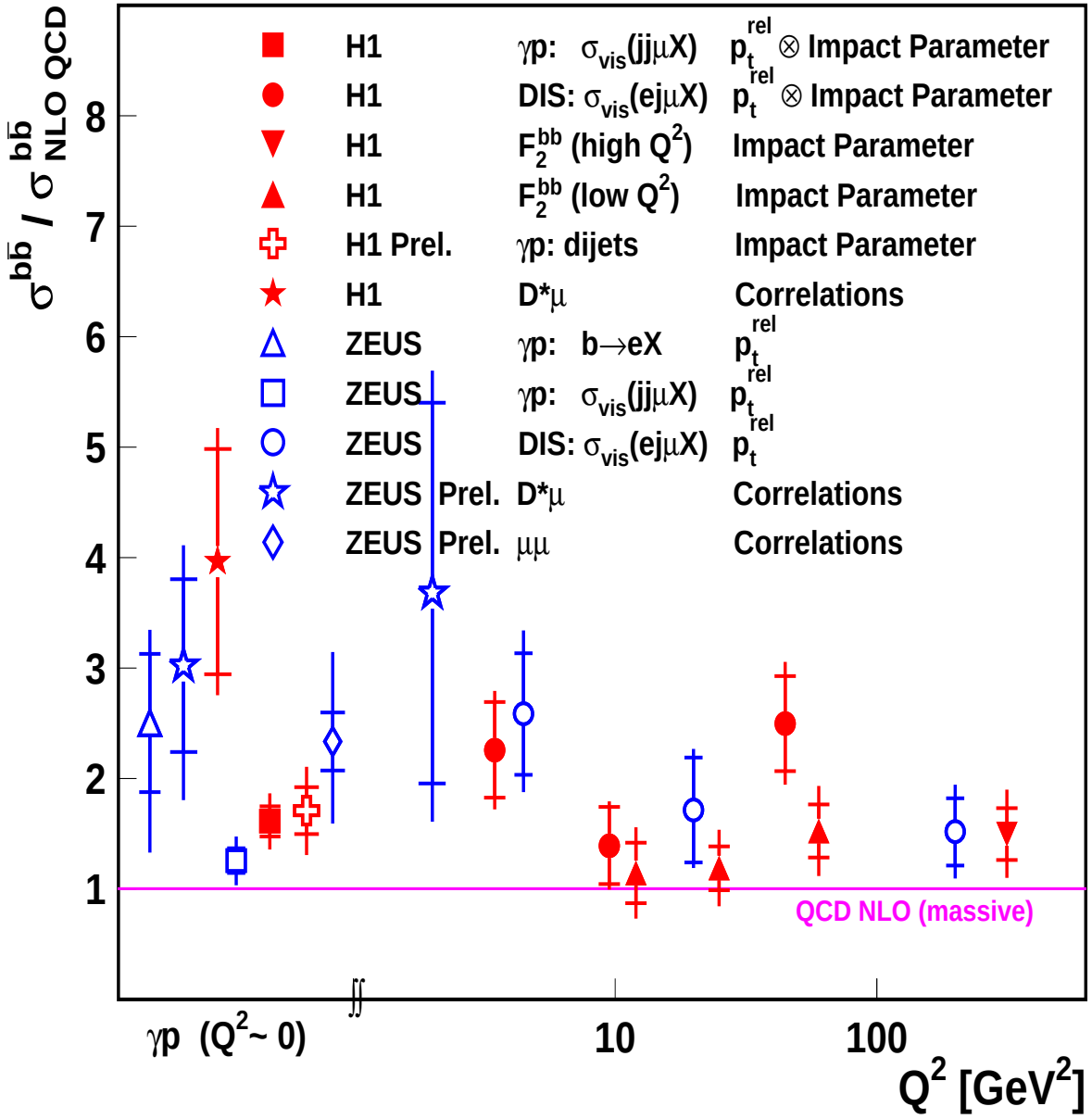






Summary of Beauty Results

- Good coverage of measurements.
- Tendency of data to lie above NLO prediction.
- Measurements with smaller errors closer to theory.
- Improved theoretical understanding needed to include higher orders.



Summary

- Charm results in good agreement with NLO QCD.
- Beauty results indicate higher order theory calculations needed.
- HERA-II luminosity now exceeds HERA-I, hopefully 700pb^{-1} accumulated by end of running (2007).
- HERA now delivering polarised beams, detectors upgraded, e.g. ZEUS MVD, improved analysis of data – first HERA-II results now out!