Charm and Beauty Measurements at High Q^2 using the H1 Vertex Detector

- Motivation
- Method
- Results

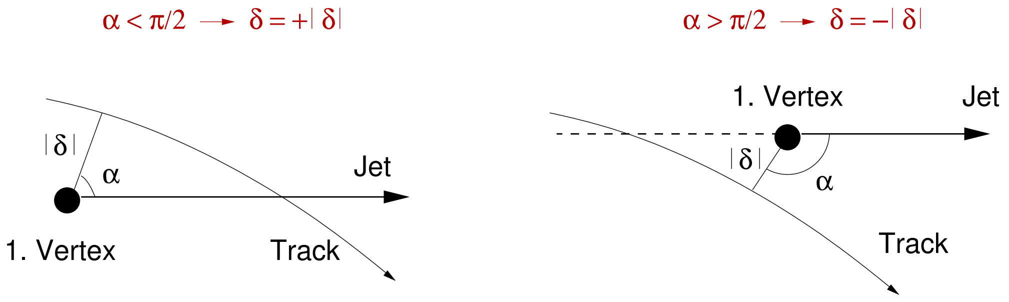
Paul Thompson (H1)

Motivation

- Aim for measurement of $F_2^{c\bar{c}}$ and $F_2^{b\bar{b}}$ at high Q^2
- Test the PDFs obtained from QCD fits to inclusive cross section
- At high Q^2 ($Q^2 > 110\ \mathrm{GeV}^2 >> m_{c,b}^2$) expect to be in the massless regime
- Exclusive measurements D^*, μ may suffer from low statistics and involve model dependent extrapolations in e.g. p_T
- Use inclusive impact parameter method for all events with tracks precisely measured by the silicon tracker

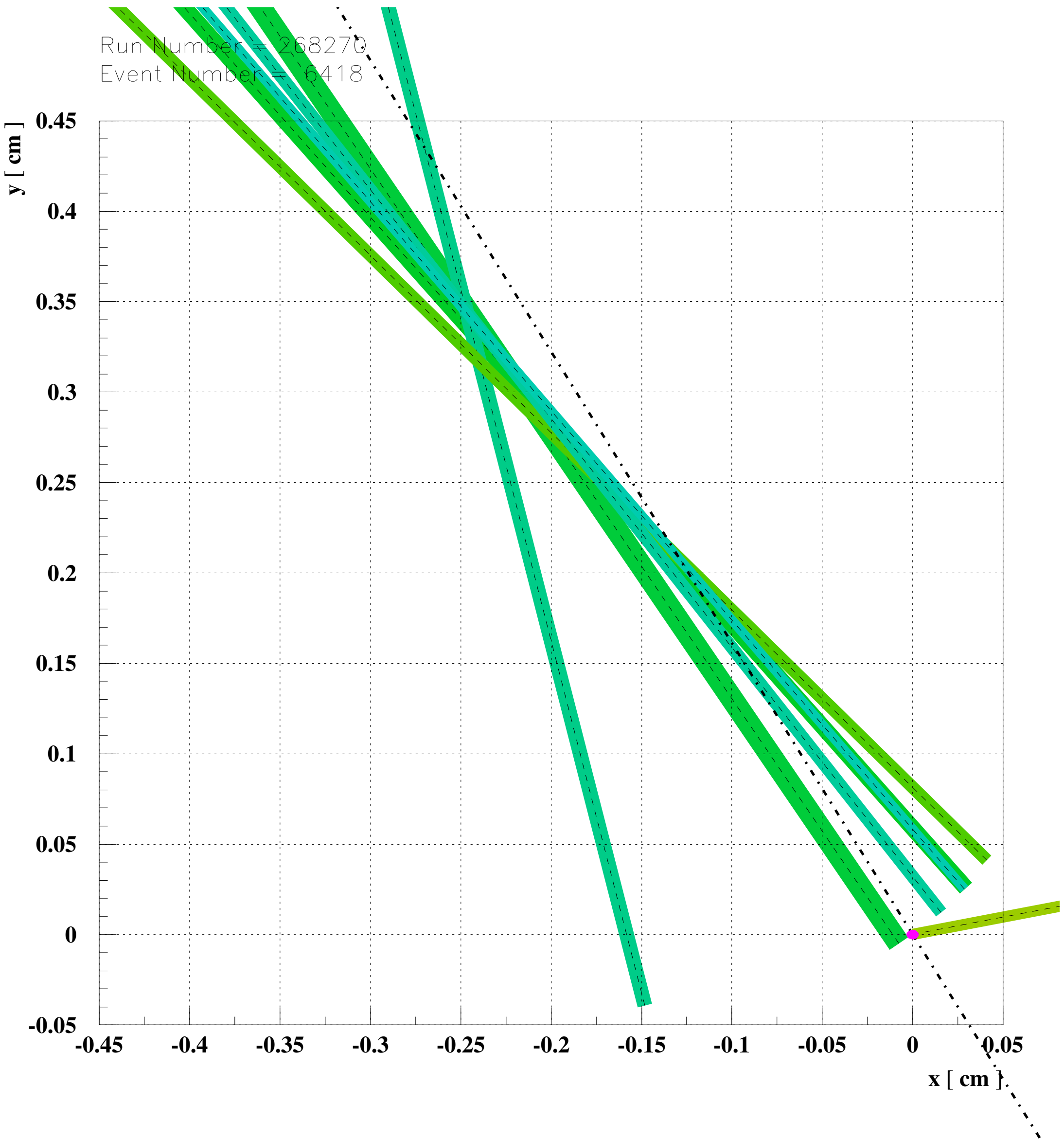
Technique

Look at the signed impact parameter for all tracks with precise measurement from central silicon tracker (CST)

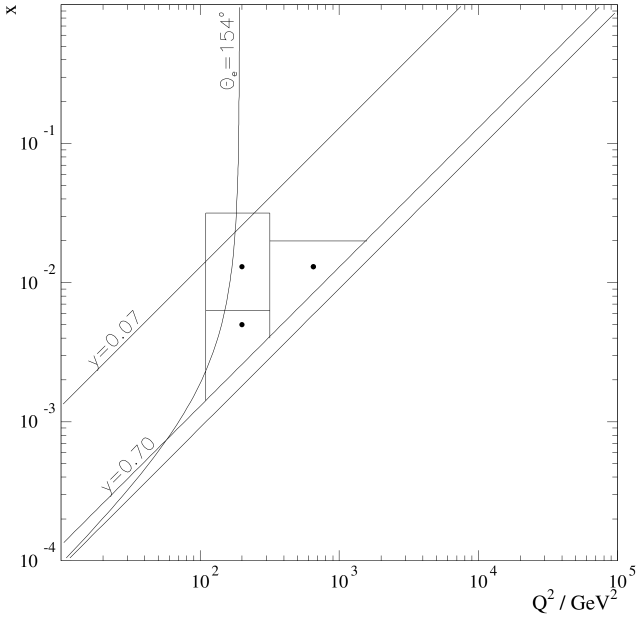


- Events with secondary vertex decays from heavy flavour particles will have large positive impact parameter
- Light flavour primary decays will have small negative and positive impact parameter due to resolution effects

Sample Event

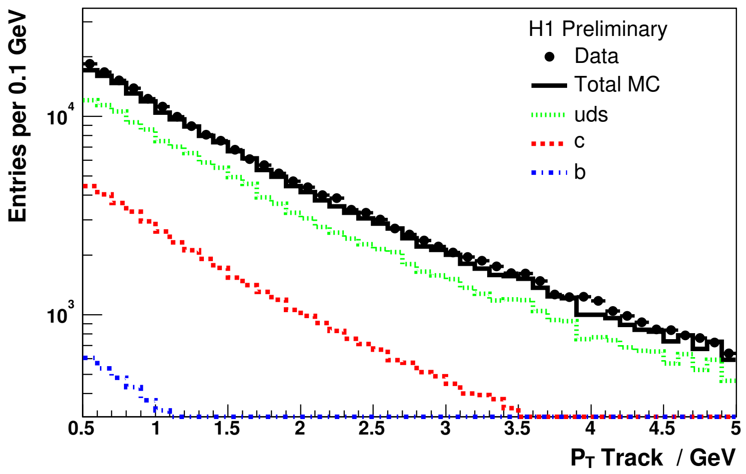


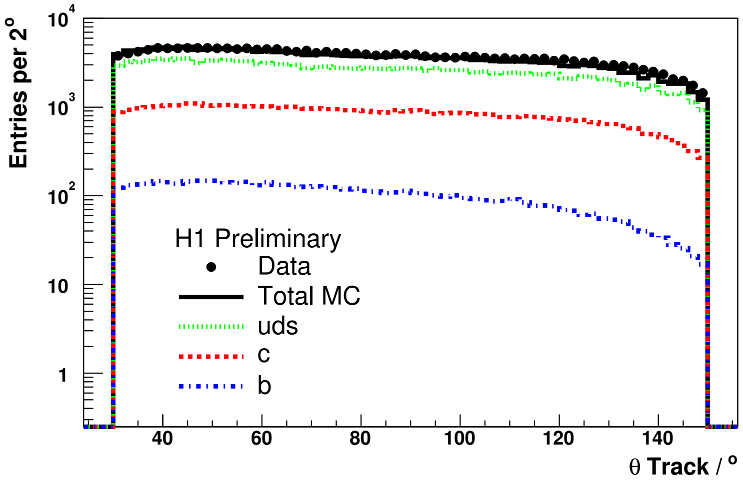
x and Q^2 Binning



- 99/00 HERA-I data $\mathcal{L} \simeq 57~\mathrm{pb}^{-1}$
- $Q^2 > 110~\mathrm{GeV}^2$, $0.07 < y < 0.7$
- 3 differential measurements and one integrated measurement
- Silicon angular acceptance corresponds to these regions in x, y and Q^2
- Model extrapolations small $<< 10\%$

Track Selection



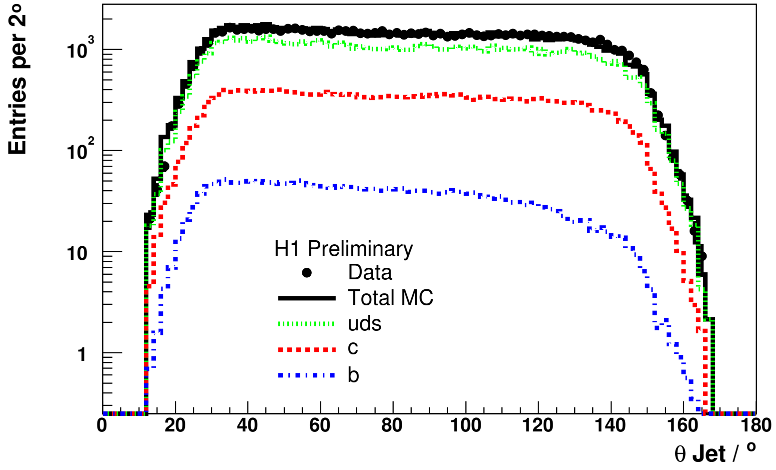


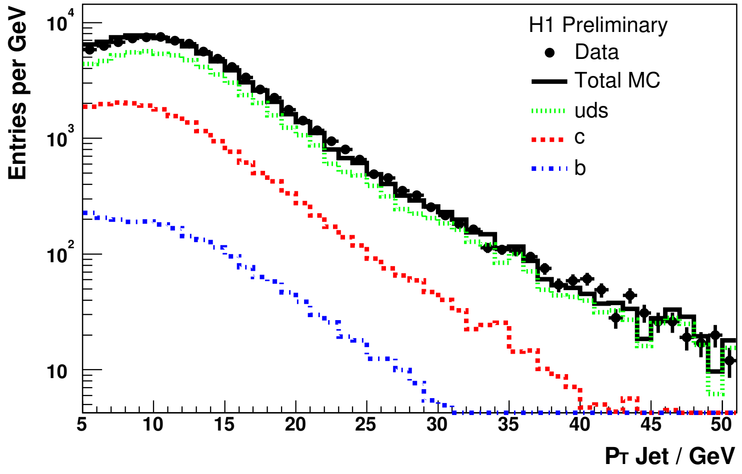
Selection for CST tracks used in vertex analysis

- $p_T > 500$ MeV, $30 < \theta < 150^{\circ}$
- $N_{\mathrm{CST}} > 1$, $\mathrm{Prob}_{\mathrm{link}} > 0.1$
- $R_{\mathrm{start}} < 50$ cm, $L_{\mathrm{track}} > 10$ cm

Jet Axis Selection

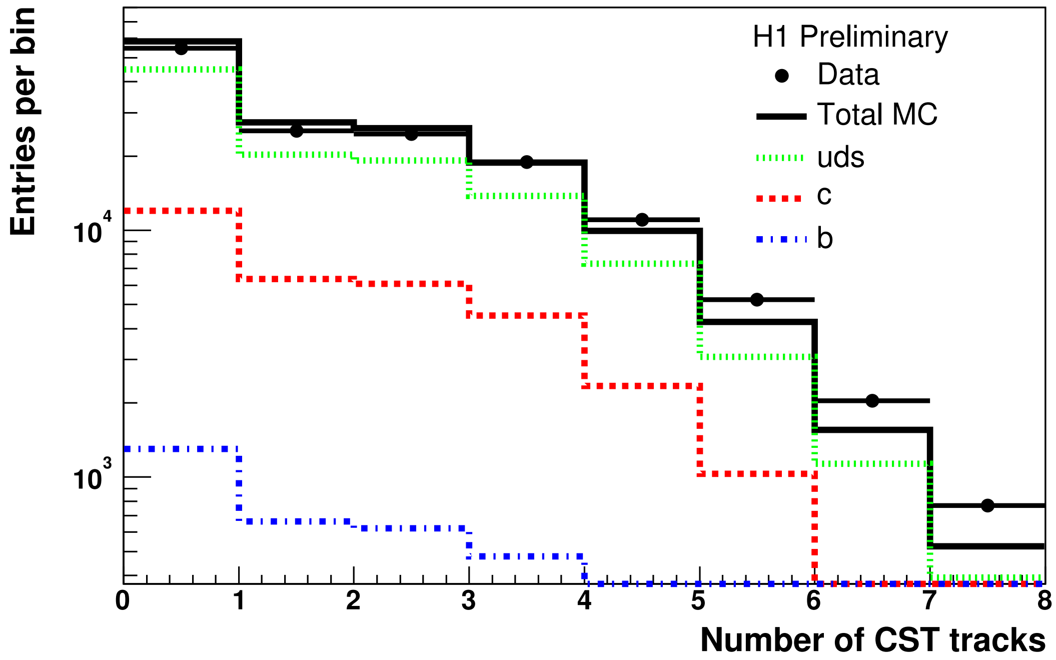
Jet axis given either by jet (inclusive k_T algorithm in the lab.) with $p_T > 5$ GeV else hadronic final state





Majority of events at high Q^2 contain a jet

CST tracks per Jet

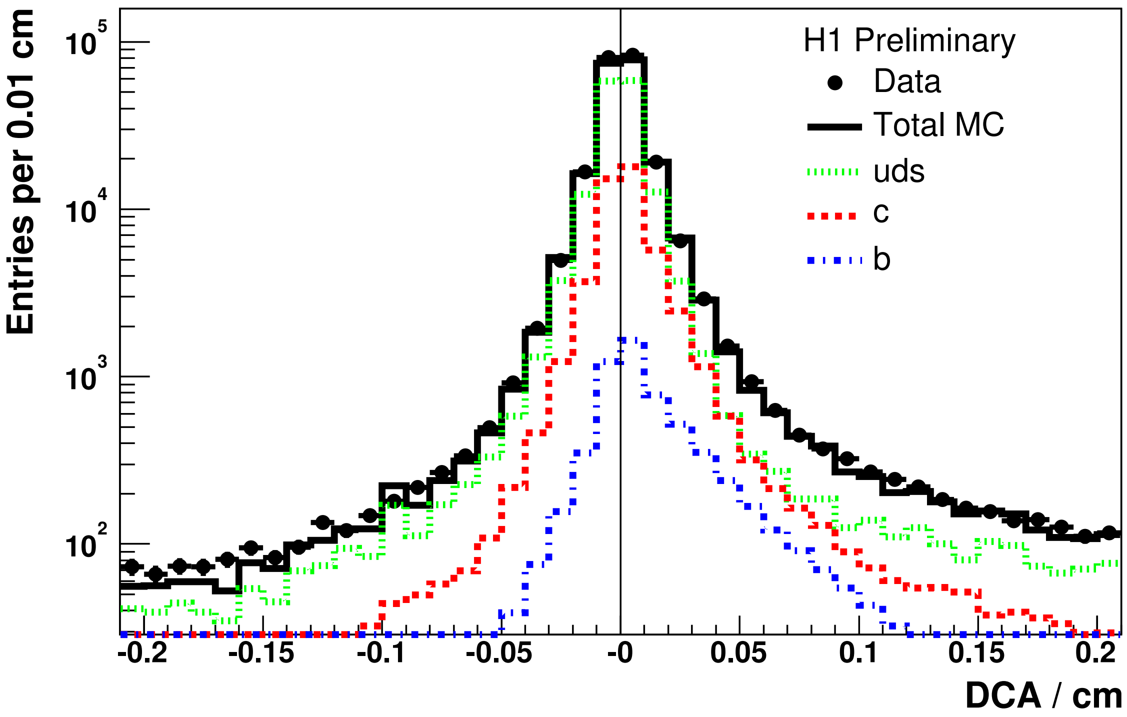


Tracks matched to jet witihin $\Delta R < 1$

Inefficiencies due to e.g. track-jet matching, CST hit inefficiency ($\sim 50\%$)

DCA (δ)

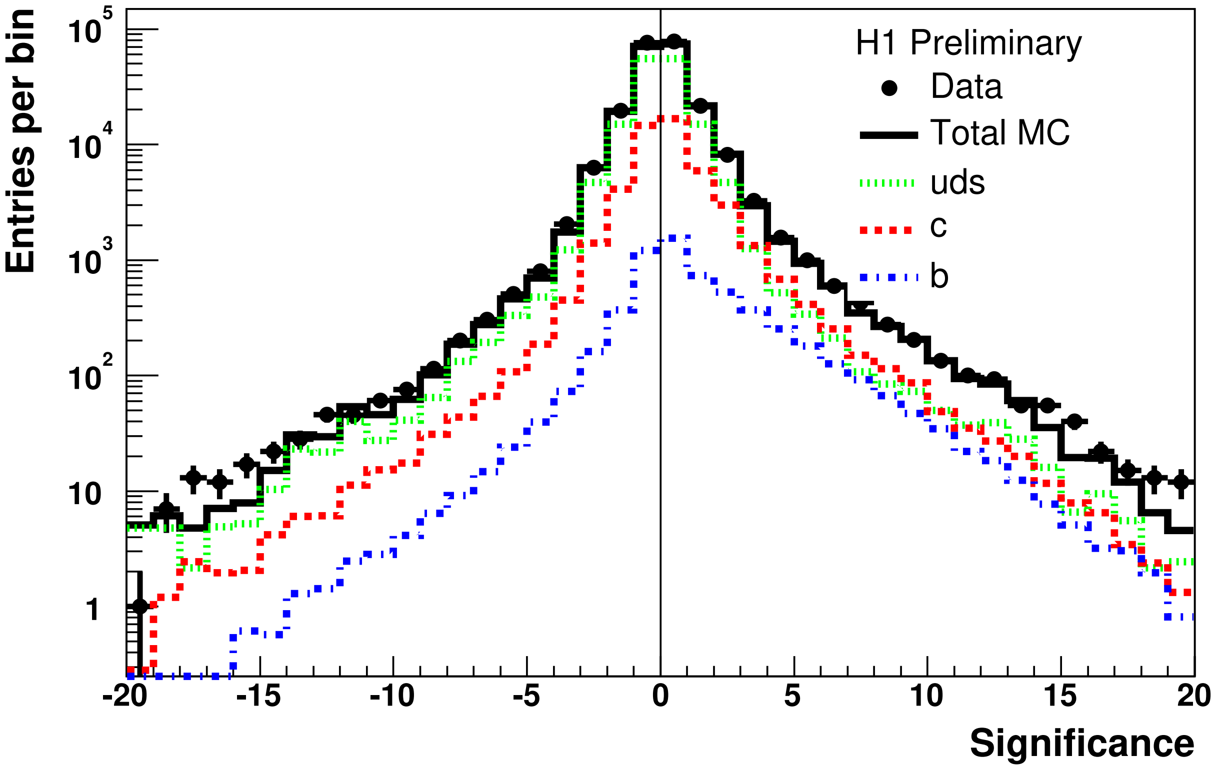
For each track within each jet, plot DCA in $r\phi$ plane (δ)



Tracks required to have $|\delta| < 1$ mm (remove e.g. K0s).

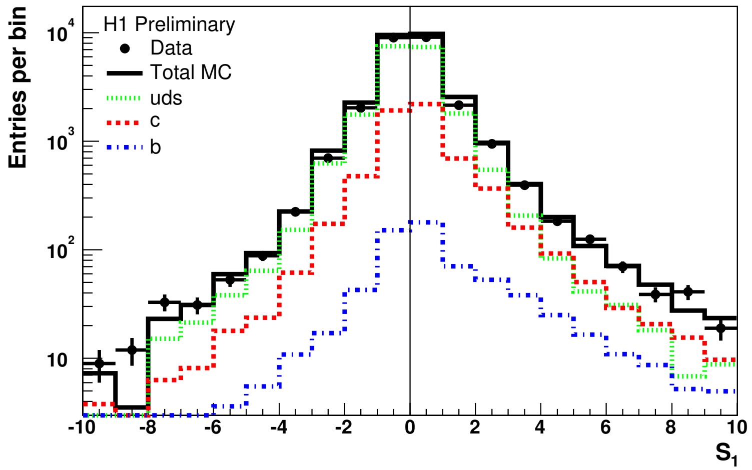
Significance (S_i)

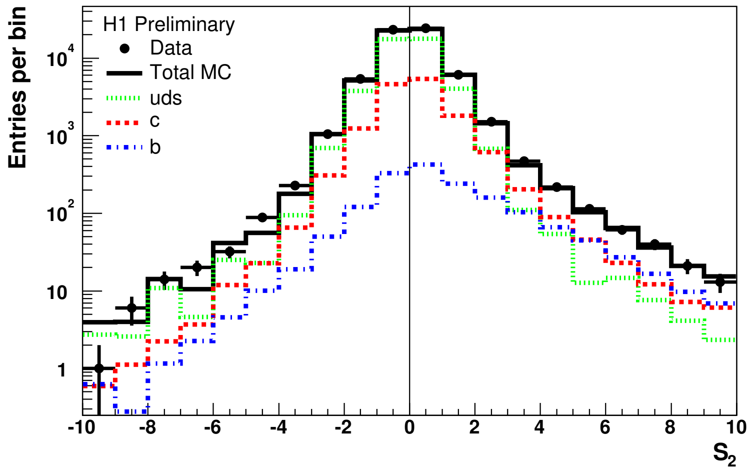
Significance of each track given by $S_i = \frac{\delta}{\sigma(\delta)}$



S_1 and S_2

Define 2 independent S_i distributions:





S_1 Highest significance track for 1 track events

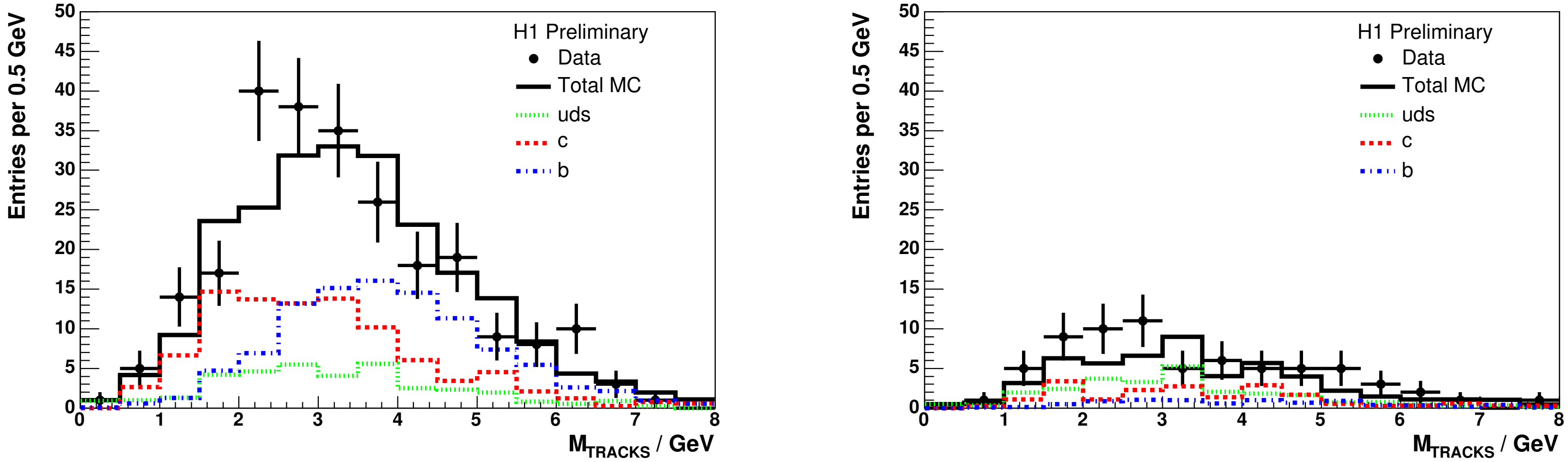
S_2 2^{nd} highest significance track for > 1 track events

S_1 More sensitive to charm and aids statistics

S_2 more sensitive to beauty due to higher multiplicity. Choosing the 2^{nd} highest significance track reduces contamination from light quark background

Track Jet Mass

Look at mass of jet from all tracks for events in range $5 < S_2 < 10$ and $-10 < S_2 < -5$



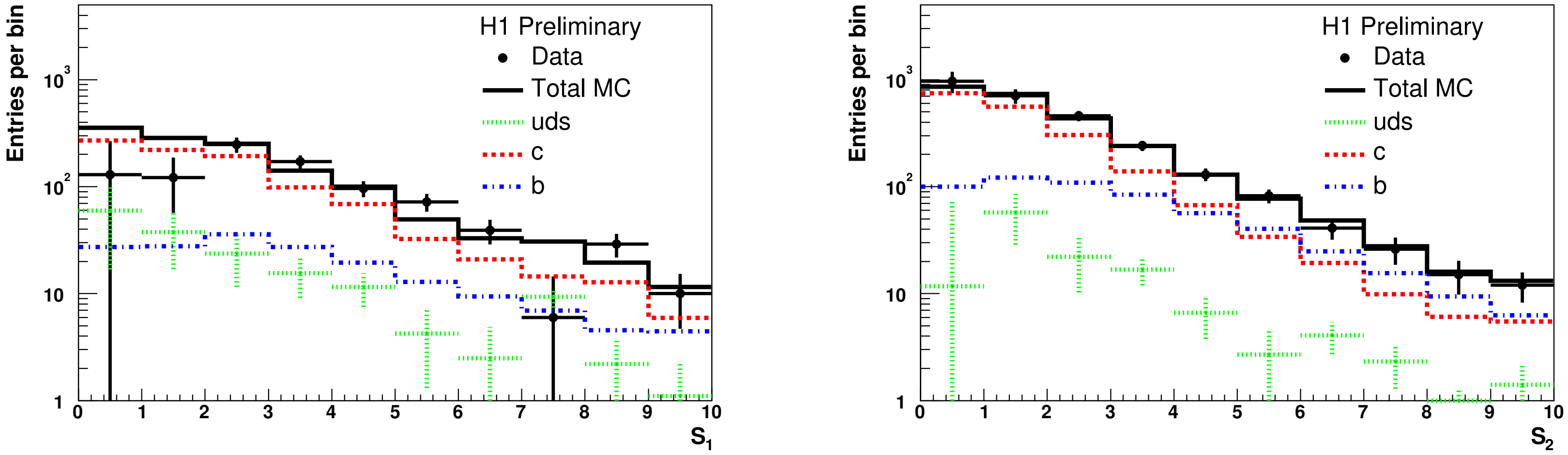
c and b contributions dominate positive significance and have distinguishable distributions

uds contribution only important for negative significance

N.B. We do not fit this distribution only significance distributions

Negative Subtraction for S_i

Subtract the negative S_i bins from the positive for both data and MC to reduce sensitivity to resolution of light quarks



Asymmetry mainly in 1 track sample, and small

Light quarks included in fit

Conversion to $F_2^{c\bar{c}}$ and $F_2^{b\bar{b}}$

Perform three parameter fit to S_1, S_2 and number of DIS events in x,Q^2 bin

- P_0 - MC scale factor for uds
- P_1 - MC scale factor for c
- P_2 - MC scale factor for b

Obtain fraction of events in bin with charm or bottom
$f^{c\bar{c}} = \frac{P_1 N_c}{P_0 N_{uds} + P_1 N_c + P_2 N_b}$
where N_c etc. are the generated number of events in this bin.

Obtain c,b cross section from total

$F_2^{c\bar{c}}(x, Q^2) = F_2^{\text{meas.}} \cdot f^{c\bar{c}}$

Integrated Cross Section

Cross sections measured over kinematic range $Q^2 > 150\ \mathrm{GeV}^2, 0.1 < y < 0.7$

$\sigma_{c\bar{c}} = 431 \pm 59 \pm 69\ \mathrm{pb}$

$\sigma_{b\bar{b}} = 45 \pm 11 \pm 11\ \mathrm{pb}$

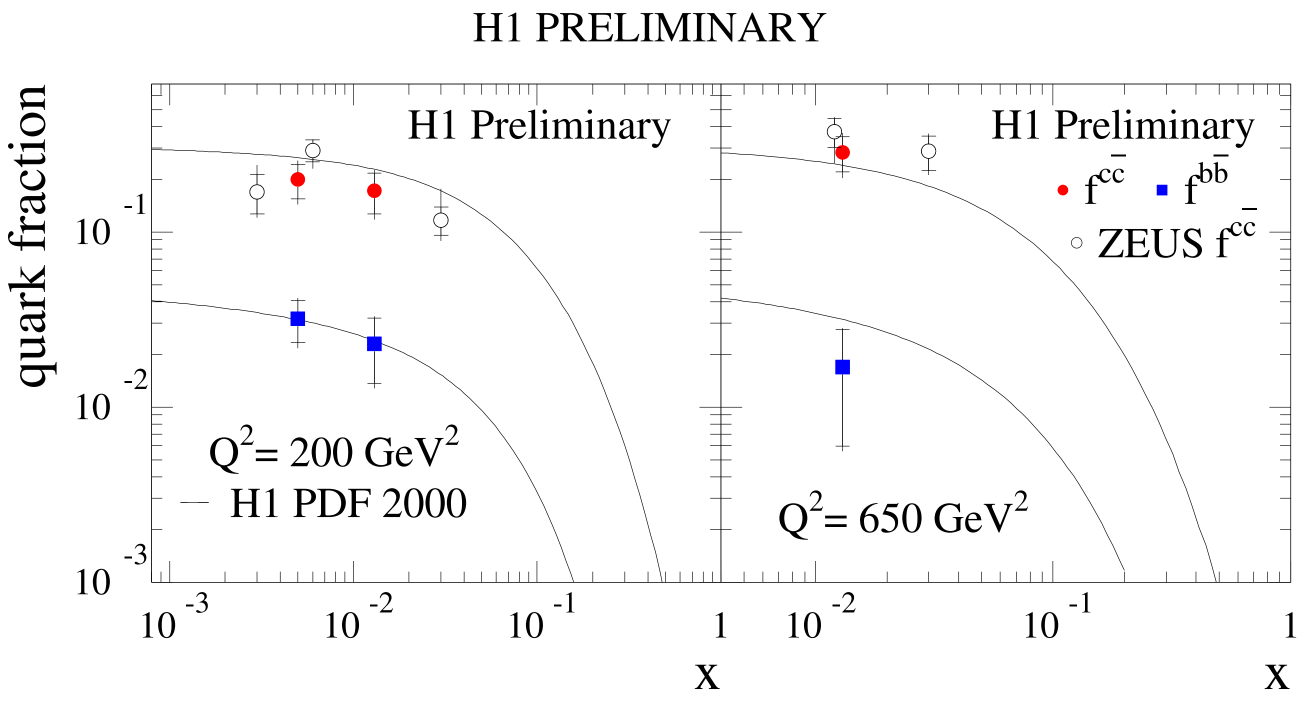
Comparison with H1 NLO Fit 2000

H1 NLO QCD Fit to all H1 HERA-I low Q^2 and high Q^2 NC/CC data sets. Treatment of heavy flavours is massless approach with $xb(x, Q^2) = 0$ for $Q^2 < m_b^2$.

$\sigma_{c\bar{c}} = 455\ \mathrm{pb}$

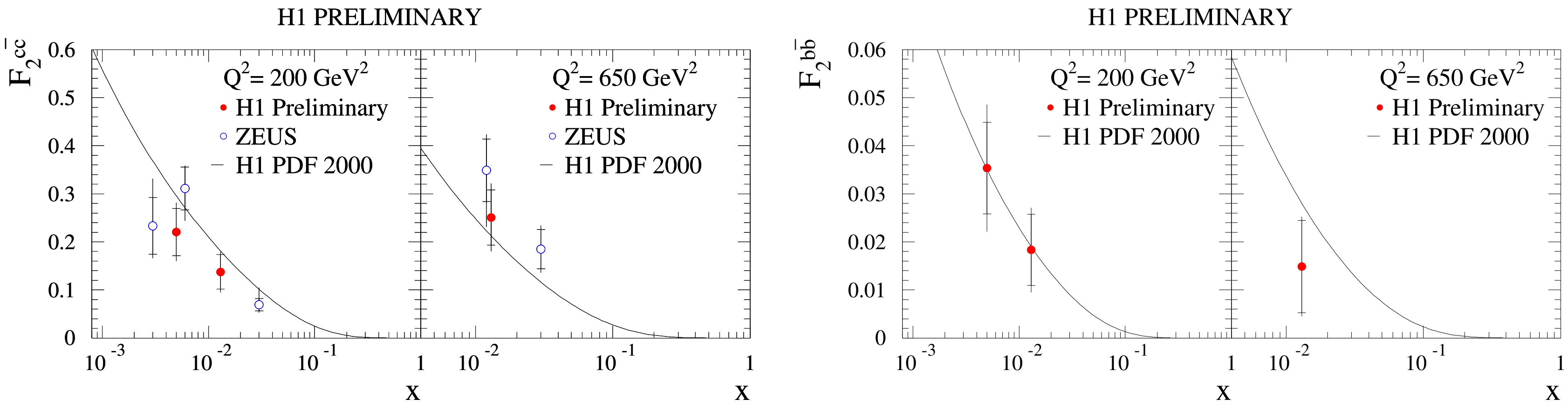
$\sigma_{b\bar{b}} = 51.8\ \mathrm{pb}$

Quark Fractions



Compatible with H1 massless NLO QCD Fit and ZEUS D^* measurements

$F_2^{c\bar{c}}$ and $F_2^{b\bar{b}}$



Extending measurements of b cross section to higher Q^2

Summary

Summary of method

- Inclusive method for tagging heavy flavour decays using significance of CST tracks from primary vertex
- Inclusive selection of all events with a CST track (no large extrapolations!)

Results

- Measurements of $F_2^{c\bar{c}}(x,Q^2)$ and $F_2^{b\bar{b}}(x,Q^2)$ at high Q^2
- Consistent with NLO massless QCD fit "H1 PDF 2000"

Outlook

- Just the beginning!
- Exciting extensions using low Q^2 samples, improving separation using higher multiplicity events, studies of final state details etc.