Constraining parton density functions using HERA data

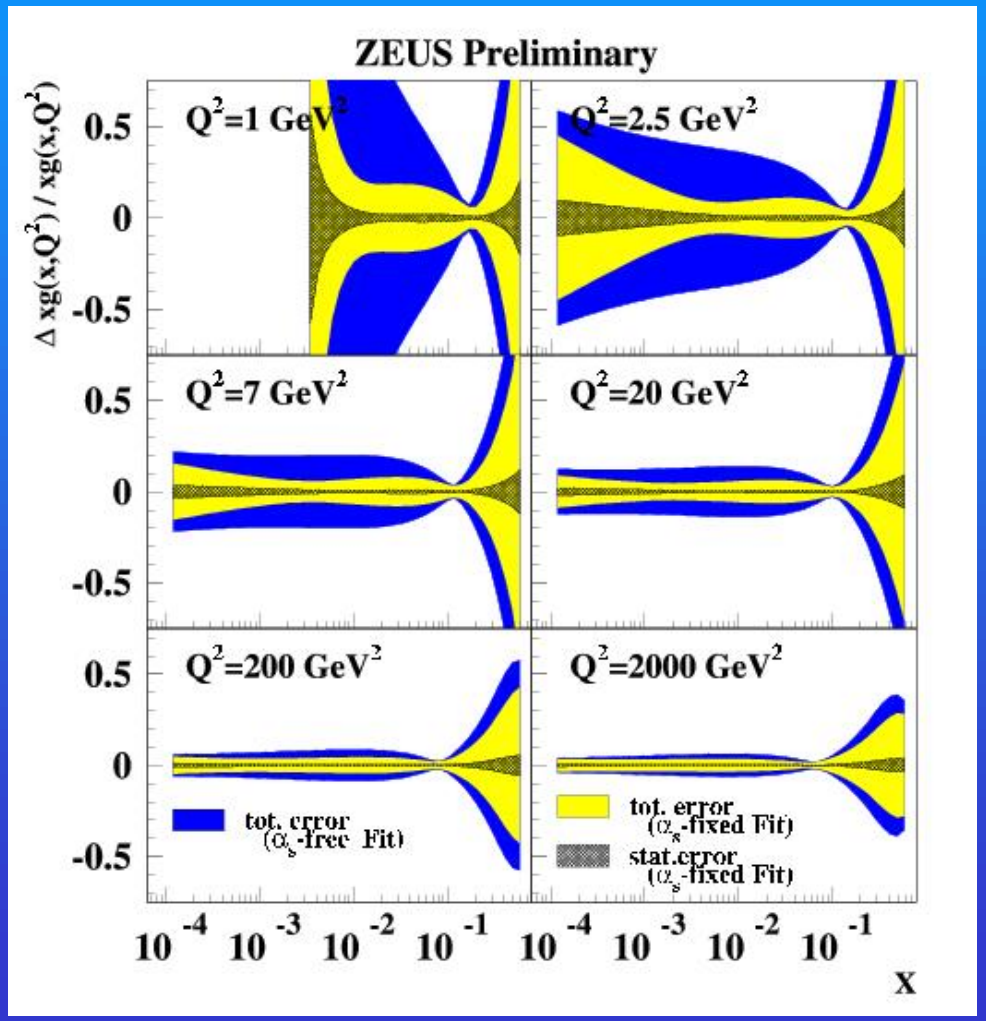
Alex Tapper (Imperial College London)

- Introduction
- Status of PDFs from HERA
- Status of other data and future prospects
  - Charged current DIS - valence quarks and strange
  - Heavy flavours - charm and beauty
  - Jet data
- Summary

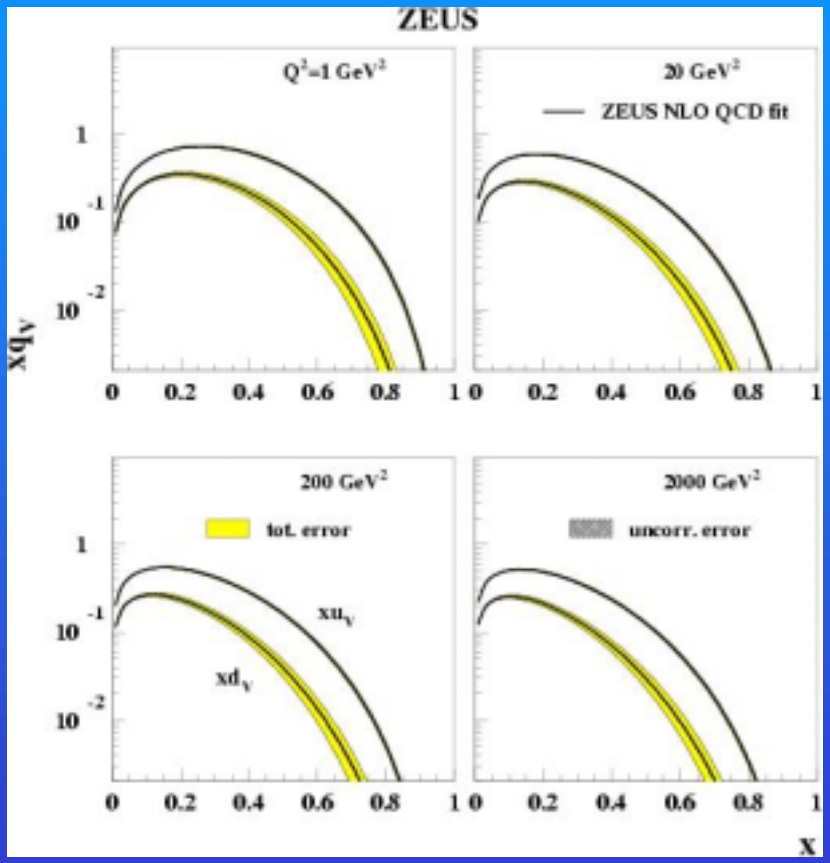
Introduction

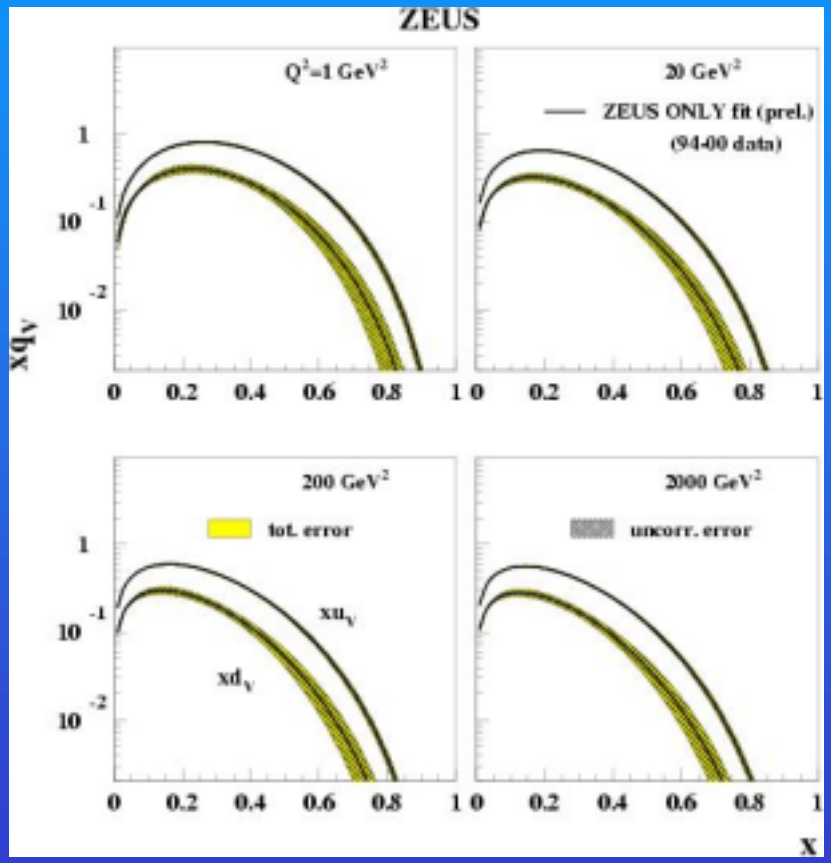
- Have seen the effect of HERA I F_2 data and prospects for HERA II F_2 data
- What other measurements at HERA give information on PDFs?
- What is the status of these measurements now from HERA I data?
- What can we expect from HERA II?

Status of PDFs from HERA

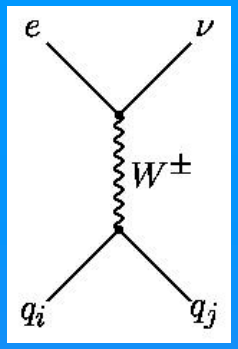


Status of PDFs from HERA





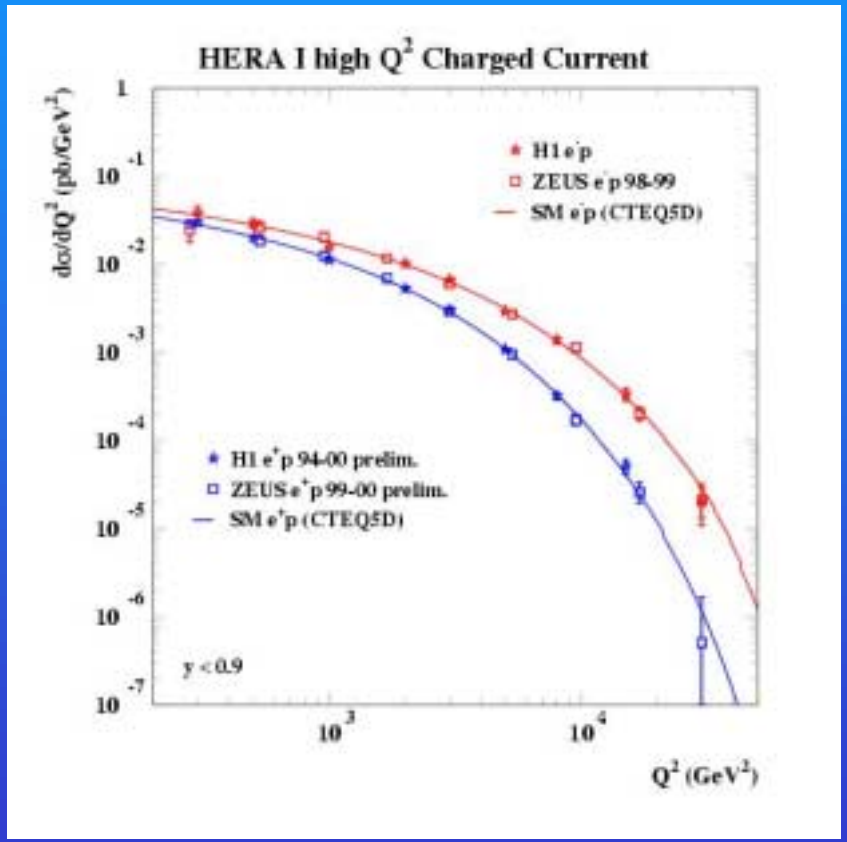
Charged current DIS



- $W^{\pm}$ exchange
- Sensitivity to quark flavour

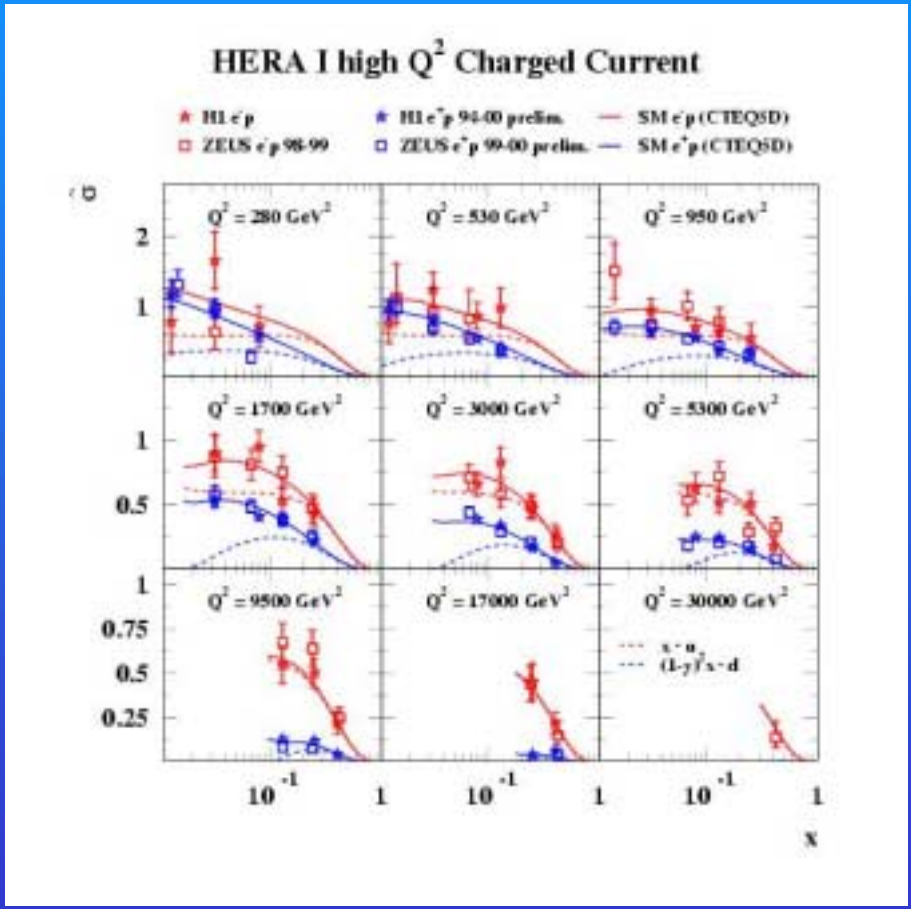
$$\sigma(e^- p) \propto \left[u + c + (1-y)^2(\bar{d} + \bar{s})\right]$$
$$\sigma(e^+ p) \propto \left[\bar{u} + \bar{c} + (1-y)^2(d + s)\right]$$

- e^+p sensitive to $d(x,Q^2)$
- e^-p sensitive to $u(x,Q^2)$



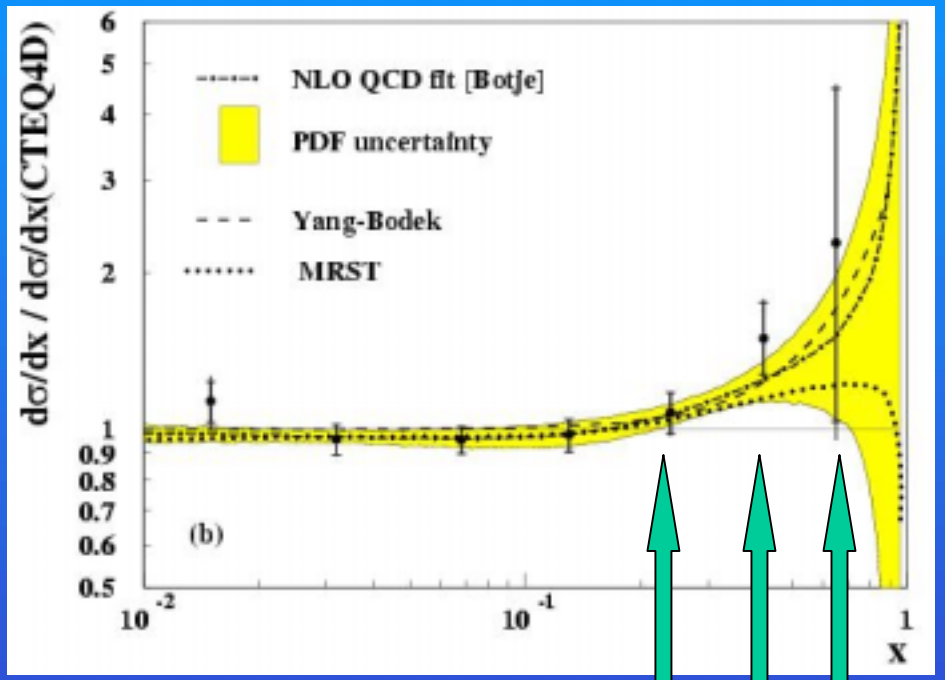
Charged current DIS

- HERA I cross section measurements
- See areas in x where valence quarks dominate cross section
- Input to fits now!
- Constrain valence quarks almost as well as fixed target data
- Statistics dominated
- Room for improvement at HERA II



Charged current DIS

- Behaviour of d/u as x->1
- x<0.3 well constrained by CDF and NMC data
- 0.3<x<0.7 NMC data but with large nuclear corrections
- x>0.7 little information
- No nuclear corrections necessary for HERA data
- d-quark density at high x only from charged current
- Factor of 10 more luminosity



x= 0.24 0.42 0.65

$50\ pb^{-1}\ e^{+}p$

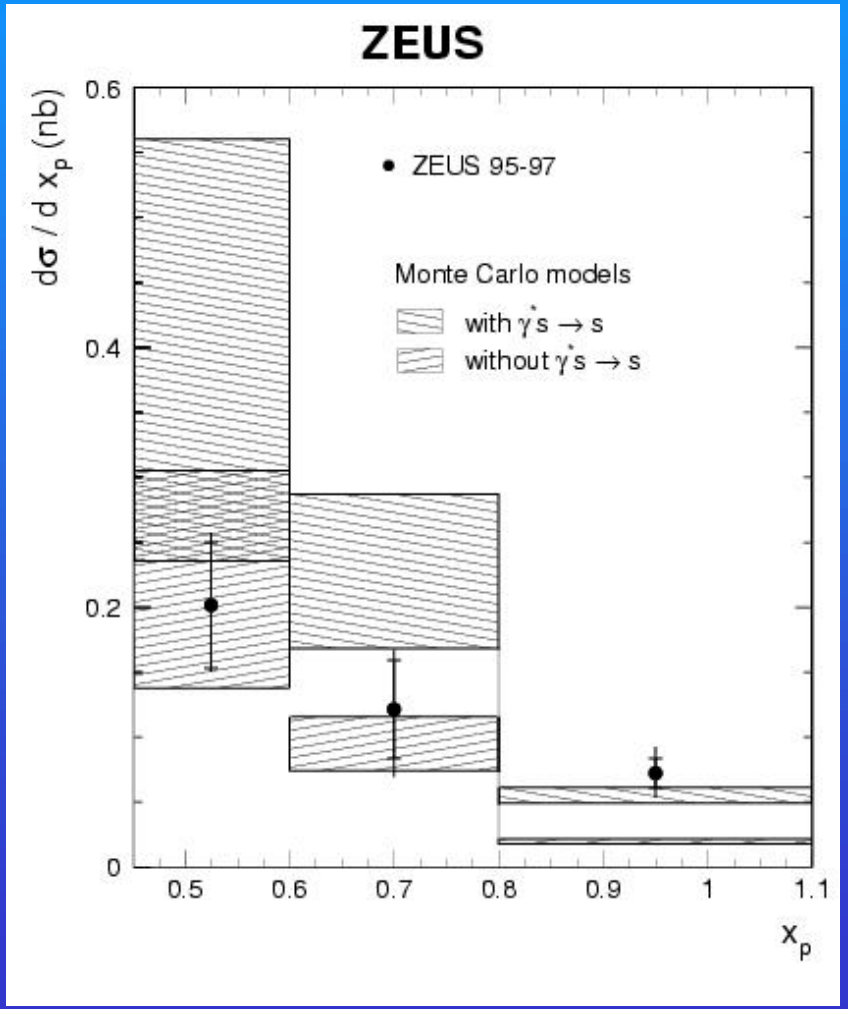
δ=10% 20% 100%

Strange

- Current HERA data from ϕ meson production
- First direct observation of strange sea at HERA
- Level of comparing different MC models of strange quarks

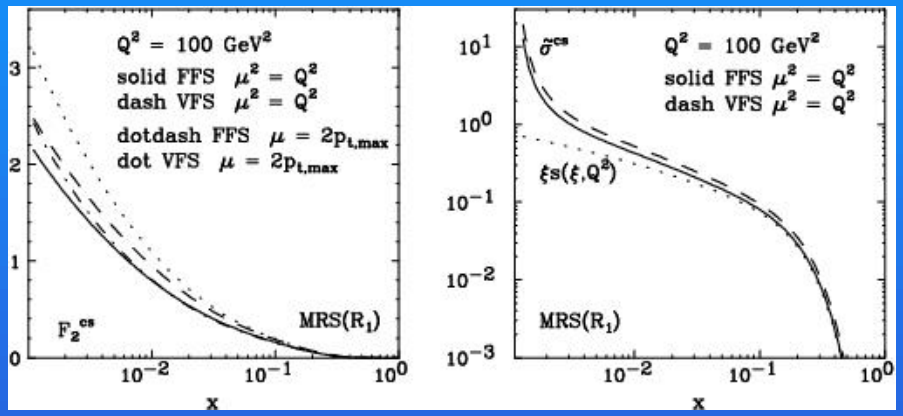
- Collect a large sample of high-P_T ϕ events at HERA II
- Constraint on strange sea?

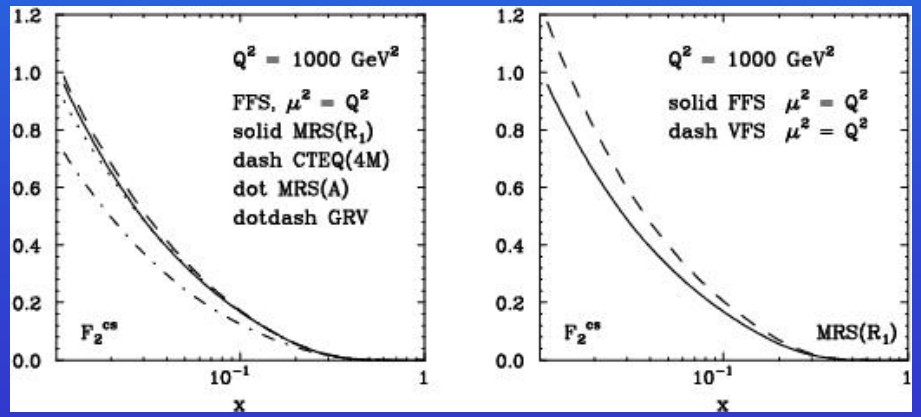
50 pb^{-1}



Strange

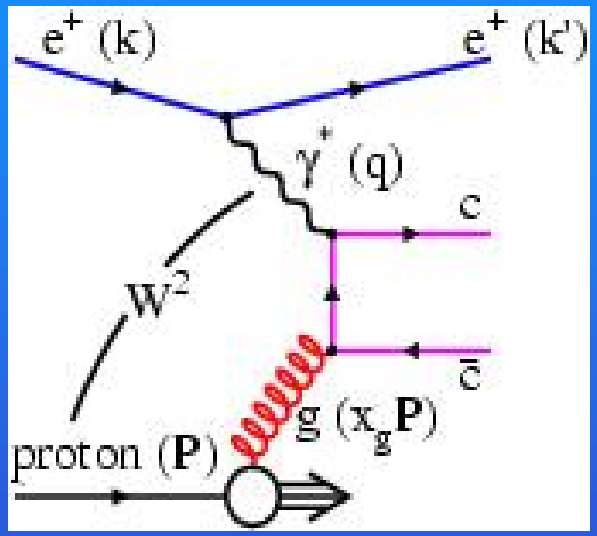
- Direct access to strange sea also possible through tagging charm in charged current DIS
  - Low cross section
  - Low charm tagging efficiency
- Only a handful of D^* events in HERA I CC data
- Will be a challenge at HERA II
- Use maximum number of decay channels
- Strange-quark density error 15-30% at HERA II





Charm

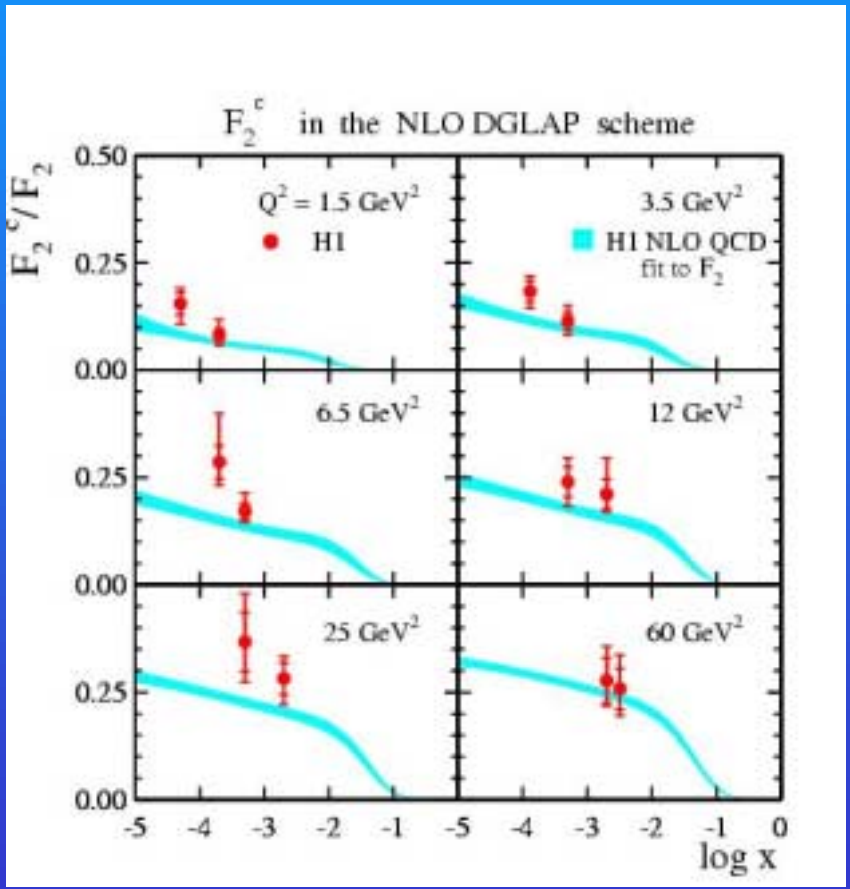
- Fixed flavour number scheme
  - Charm generated only through BGF
  - Measurements provide constraints on gluon density
  - Should break down when $Q^2 >> m_c^2$
- Charm density in proton for higher Q^2/P_T



Charm

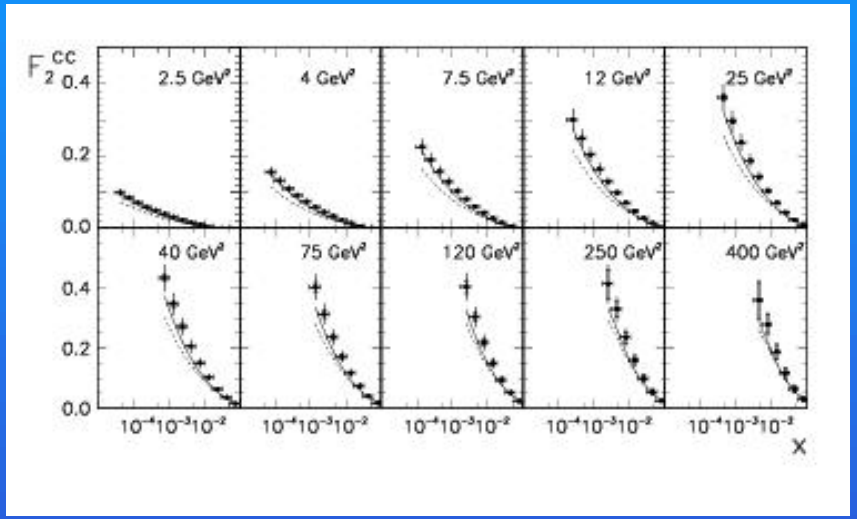
- Charm measurements in DIS
- Measure cross sections and extrapolate to F_2^c
- Visible cross section ~30% of total
- Fraction of charm >25% at higher values of Q^2
- Uncertainties from m_c, hard scale, fragmentation…
- $5.10^{-5}<x<3.10^{-3}$

20 pb^{-1}



Charm

- What can be expected from HERA II?
- Increased luminosity and tagging efficiency will lead to much improved precision
- At some point uncertainty in m_c will limit precision
- x range up to 0.1
- May observe charm acting like a parton?

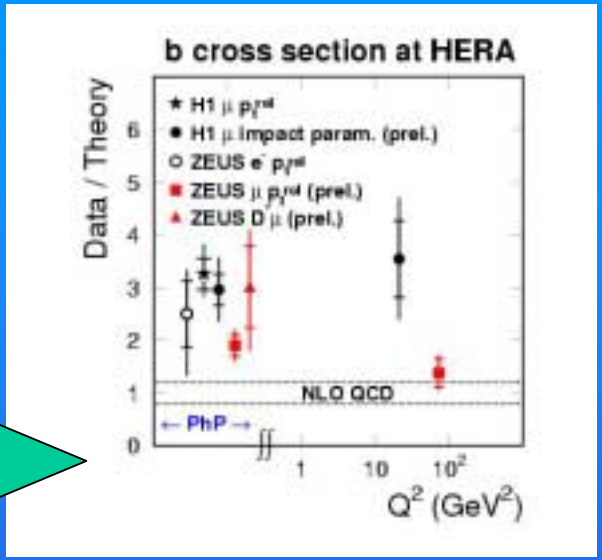


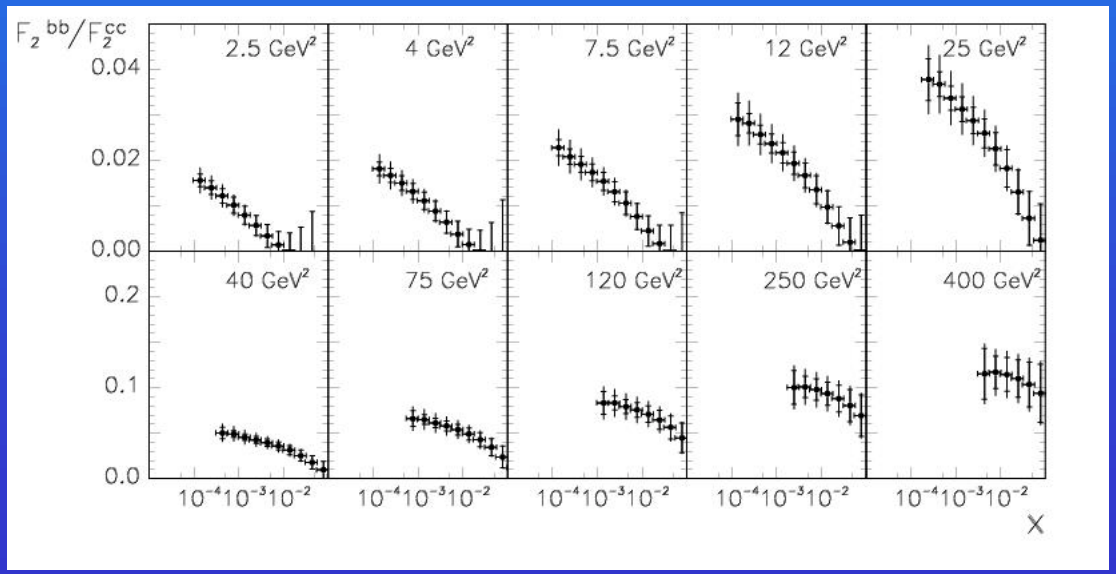
500 pb^{-1}

- Conclusion: Increases in precision through higher luminosity and improved tagging will benefit gluon density extraction

Beauty

- Essentially similar story to charm
- Higher quark mass
- Smaller cross section
- Much to understand in current measurements





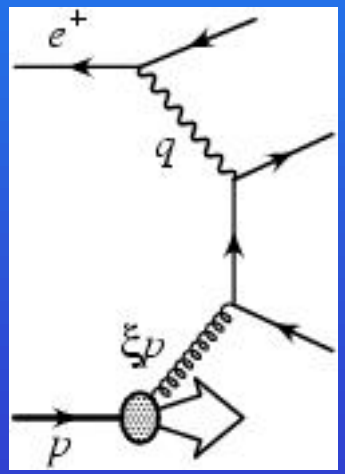
500 pb^{-1}

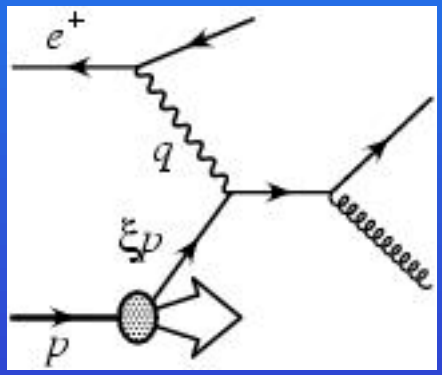
- Precision to compare charm and beauty contributions to proton
- Probably not to constrain PDFs

Jet measurements

- Jets in NC DIS sensitive to quark distributions in the proton
- Directly sensitive to gluon distribution through subprocess

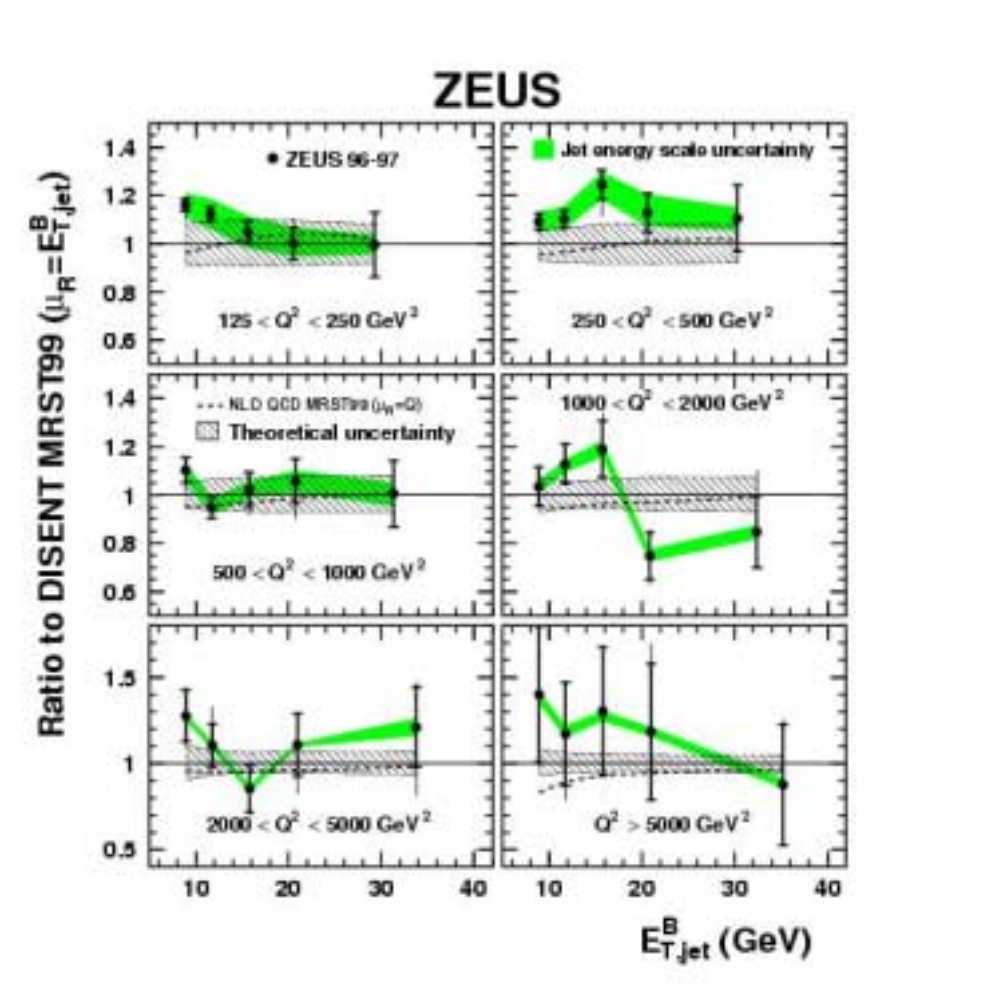
BGF





QCDC

Jet measurements

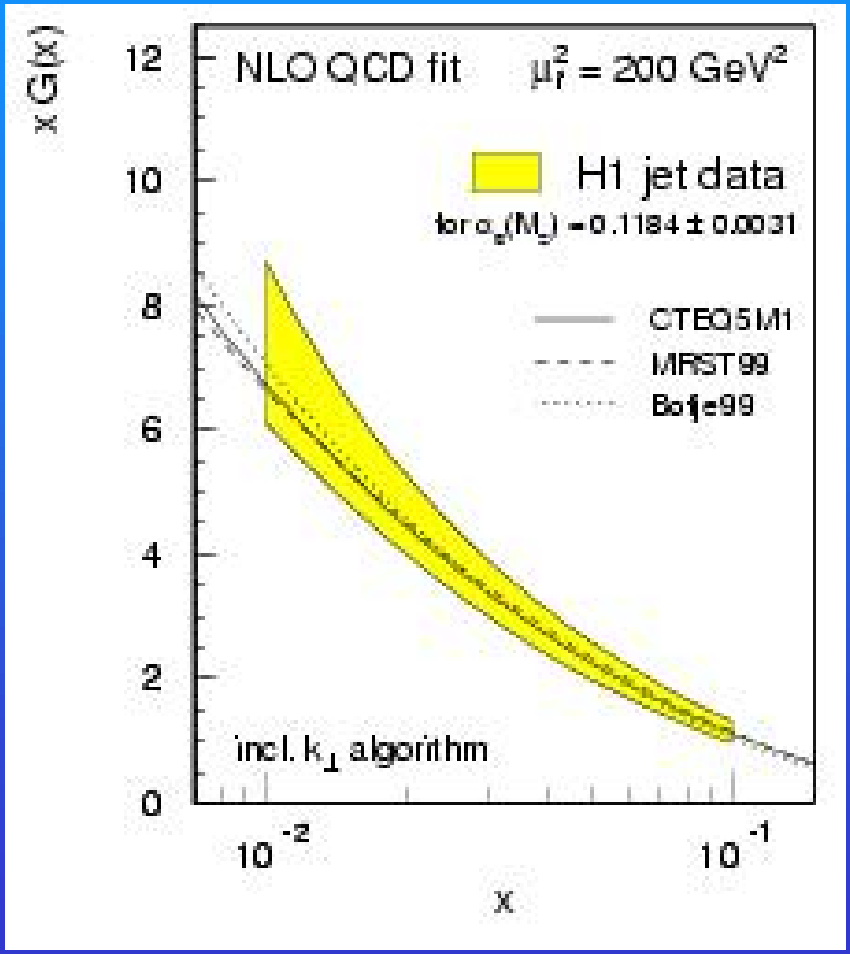


- Ratios of measured cross sections to theory
- At higher E_T and Q^2 values theoretical uncertainties and systematic uncertainties are smaller
- Can we use this to constrain the gluon and quark PDFs in future?

30 pb^{-1}

Jet measurements

- Gluon extraction
- Including jet and inclusive data
- α_S fixed
- 0.01<x<0.1
- Consistent with global fits

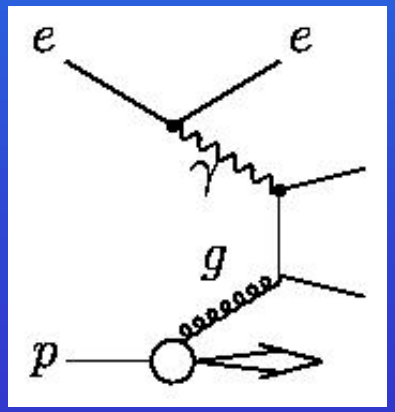


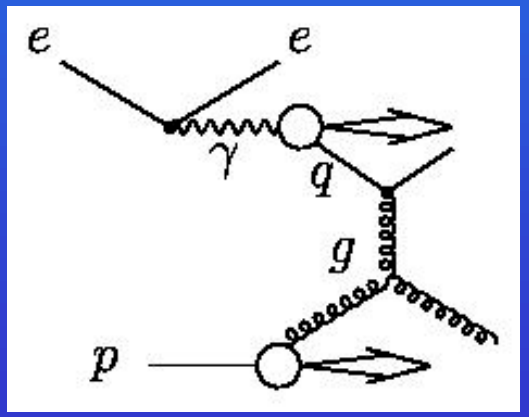
30 pb^{-1}

Jet measurements

- Jets in photoproduction
- Direct and resolved processes
- Both directly sensitive to the gluon density
- Easier to consider direct process when considering proton PDFs

DIRECT

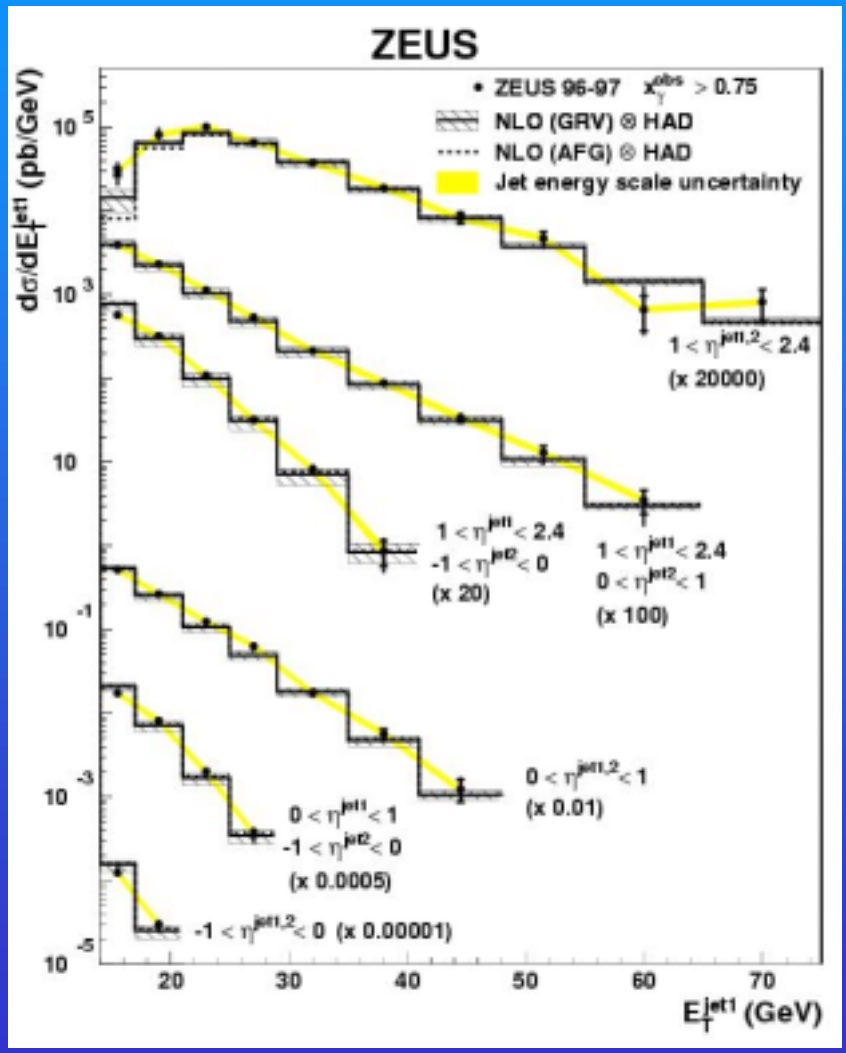




RESOLVED

Jet measurements

- Current status of PhP di-jets
- $x_\gamma^{obs} > 0.75$
  - direct process enriched
- x range from 0.01 to 0.5



30 pb^{-1}

Summary

- Status of HERA I measurements that give information on PDFs
  - Still data left to analyse
  - Expect improvement in precision at high Q^2/E_T
- Prospects for these and other measurements at HERA II
  - Higher statistics
  - Extend kinematic reach
  - Flavour specific measurements
- Measurements do offer information on PDFs but in many cases challenging to utilise as input to fits effectively
- Best possible knowledge of PDFs and QCD relevant to future experiments