Introduction to High P_T and Q^2 Physics at HERA

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Speaking at the
H1 Student Seminar Cross Talk

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Contents

- Introduction to the high P_T/Q^2 group
- Examples of physics analyses
- Future Prospects

Only brief introduction given here.

For theorectical background and detailed H1 results see students talks in this session.

HIP group

The high P_T/Q^2 (HIP) group remit is to make quantitative measurements of phenomena in ep scattering with a high P_T signature.

Topics of concern to the HIP group include:

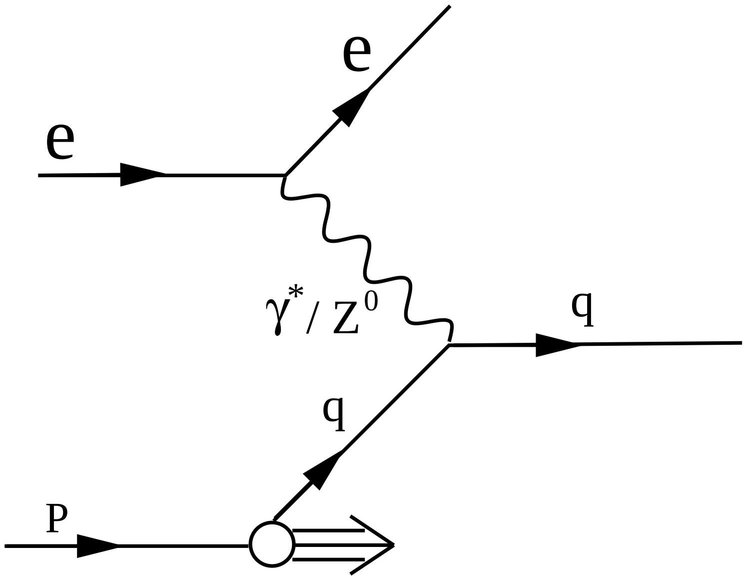
- Neutral Current (NC) cross sections for e^+p and e^-p scattering
- Charged Current (CC) cross sections for e^+p and e^-p scattering
- QCD fits to the NC and CC data
- Search for events with isolated leptons and missing transverse energy
- W and Z production
- Measurement of high P_T jet cros sections
- High P_T dilepton cross sections
- Flavour tagging at high Q^2
- Precision calibration of calorimeters
- Good understanding of trackers
- Fast checking and analysis of data

High P_T and Q^2 at HERA

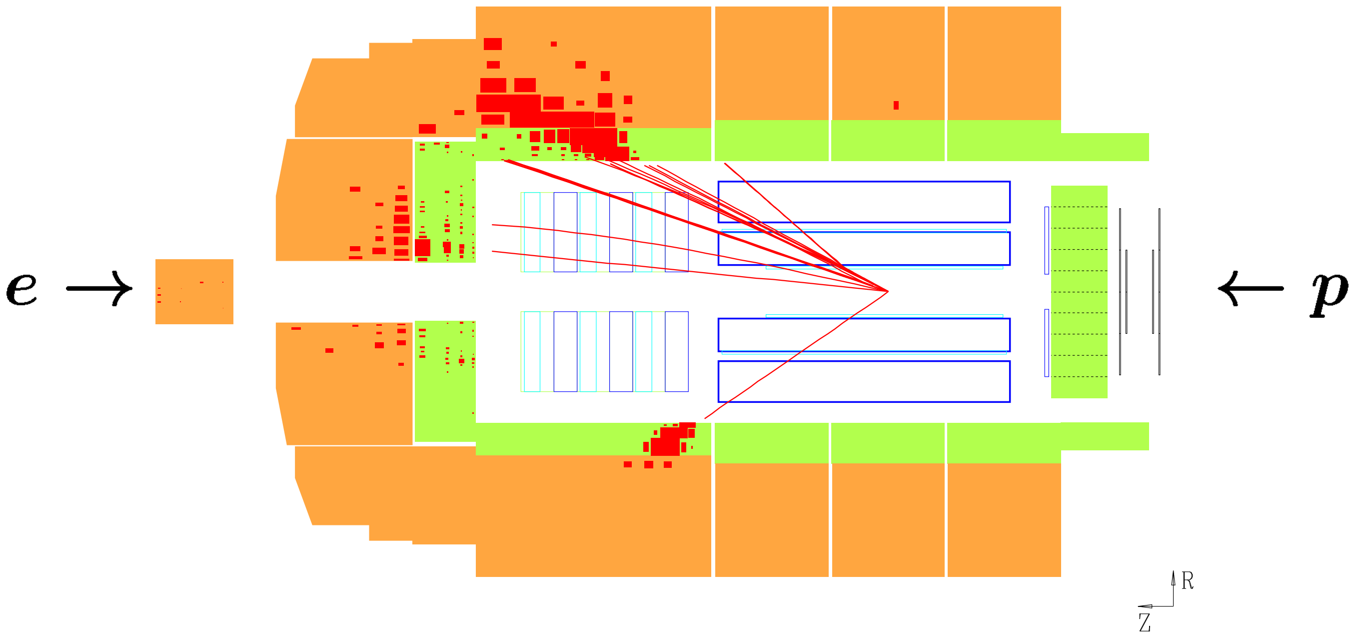
- At High Q^2 exchange of W and Z^0 bosons becomes important enabling:
  - Measurement of W mass (direct and indirect)
  - Measurement of axial-vector and vector quark couplings
- At High Q^2 or high P_T very small distances ($< 10^{-18}$ cm) can be probed
  Deviations from QCD/EW expectation can indicate:
  - quark substructure
  - production of exotic s-channel resonances
  - Heavy exchange bosons
- Not forgetting QCD !
  Extending the Q^2 range increases sensitivity to:
  - gluon distribution
  - α_s
  - valence quark distributions
  - Non-standard resummation effects (BFKL)

  High P_t jets give access to:
  - structure of photon
  - gluon at high x

Inclusive Neutral Current DIS Measurements



$\boxed{Q^2 = 16950\ \mathrm{GeV}^2, \quad y = 0.44, \quad M = 196\ \mathrm{GeV}}$

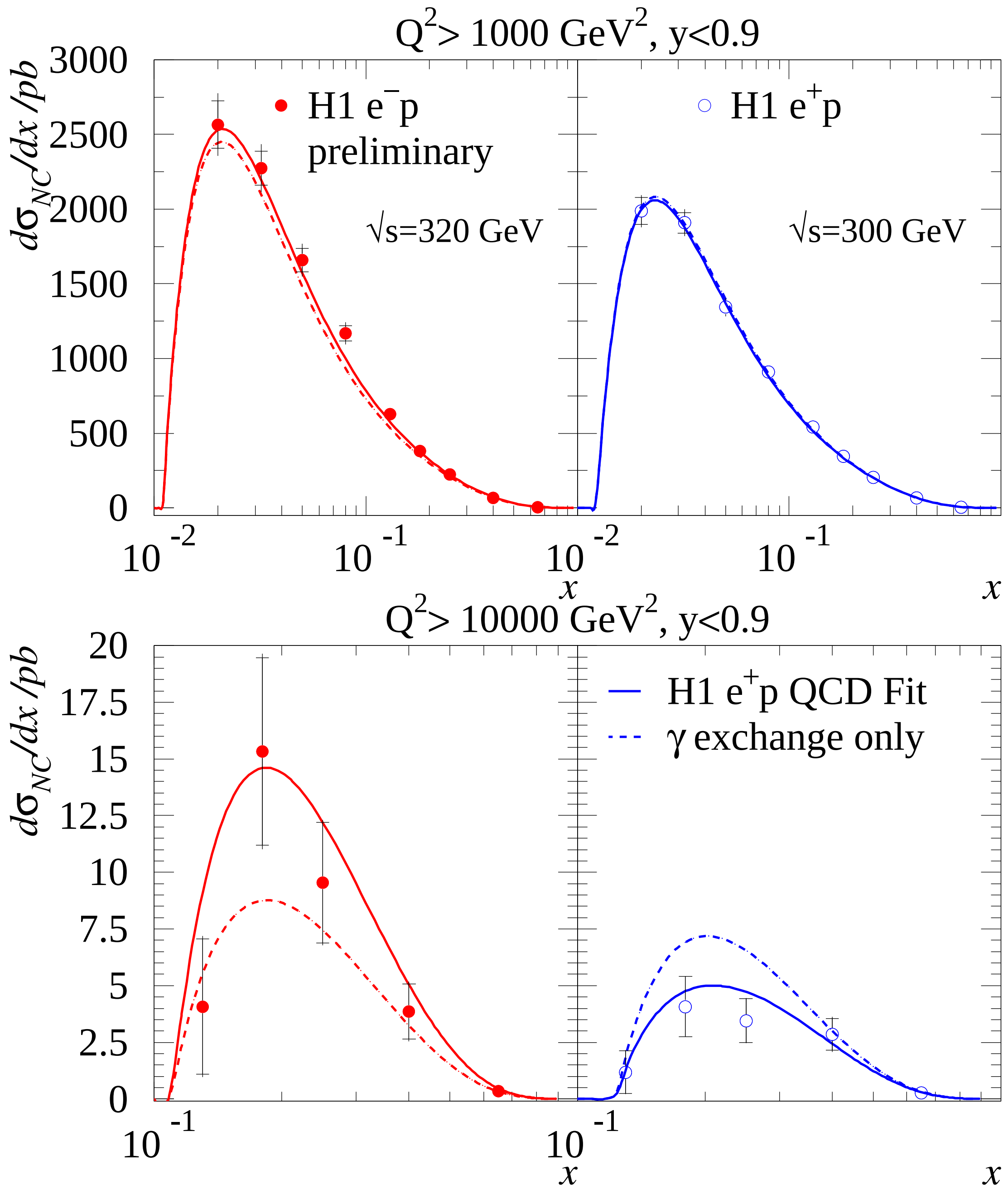


Neutral Current Deep Inelastic Scattering

- Precision test of QCD. DGLAP evolution is now tested over >3 orders of magnitude
- Investigation of γZ^0 interference $\Rightarrow$ plot
- Helps constrain parton densities. Main constraint on gluon, u valence quark and sea.
- Constraints on anomalous couplings
- Tests for physics beyond the Standard Model $\Rightarrow$ plot

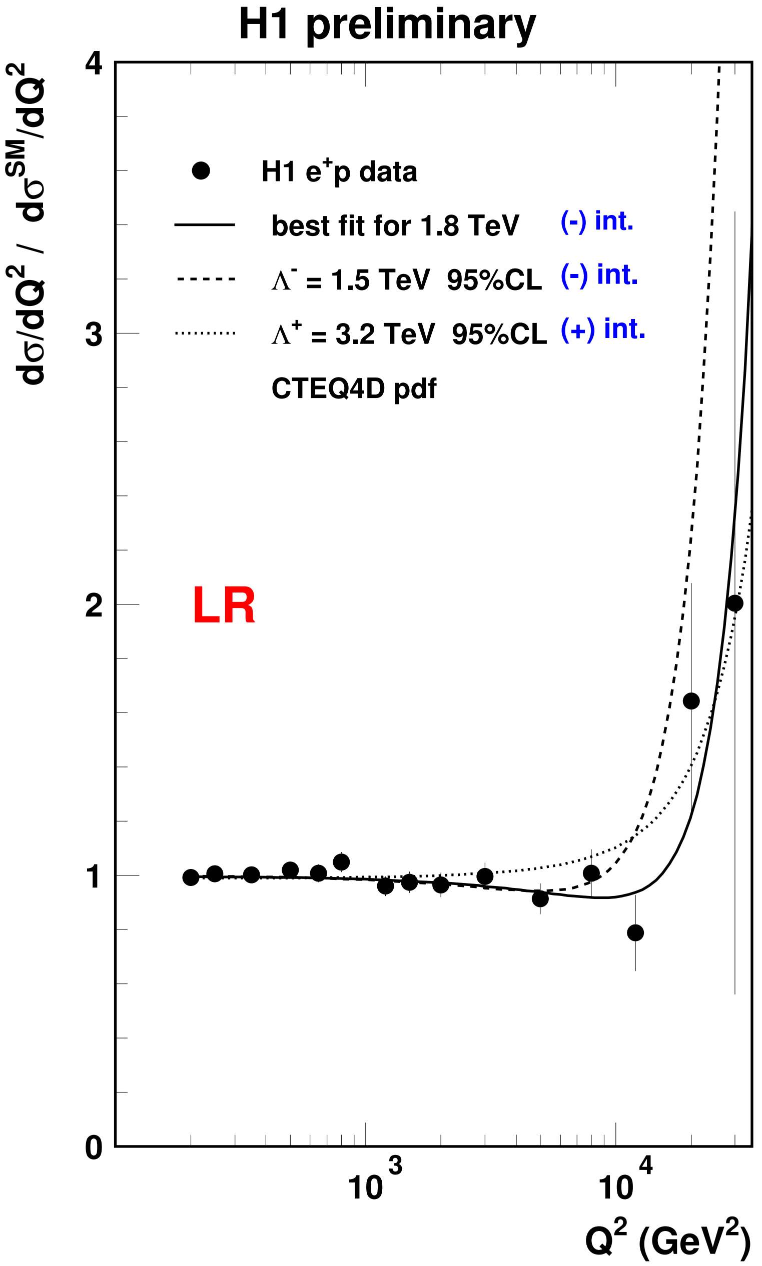
For details see talk by Anna Burrage

Parity Violation in the NC Cross Section



The effects of γZ^0 interference causes an increase in the NC cross section in e^-p scattering and a decrease in e^+p scattering.

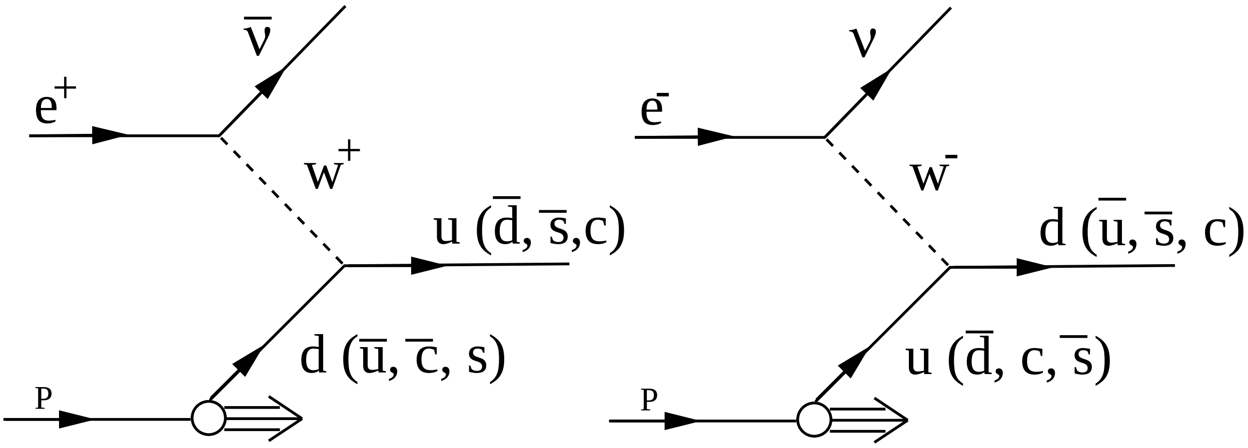
NC Cross Section Probing New Physics

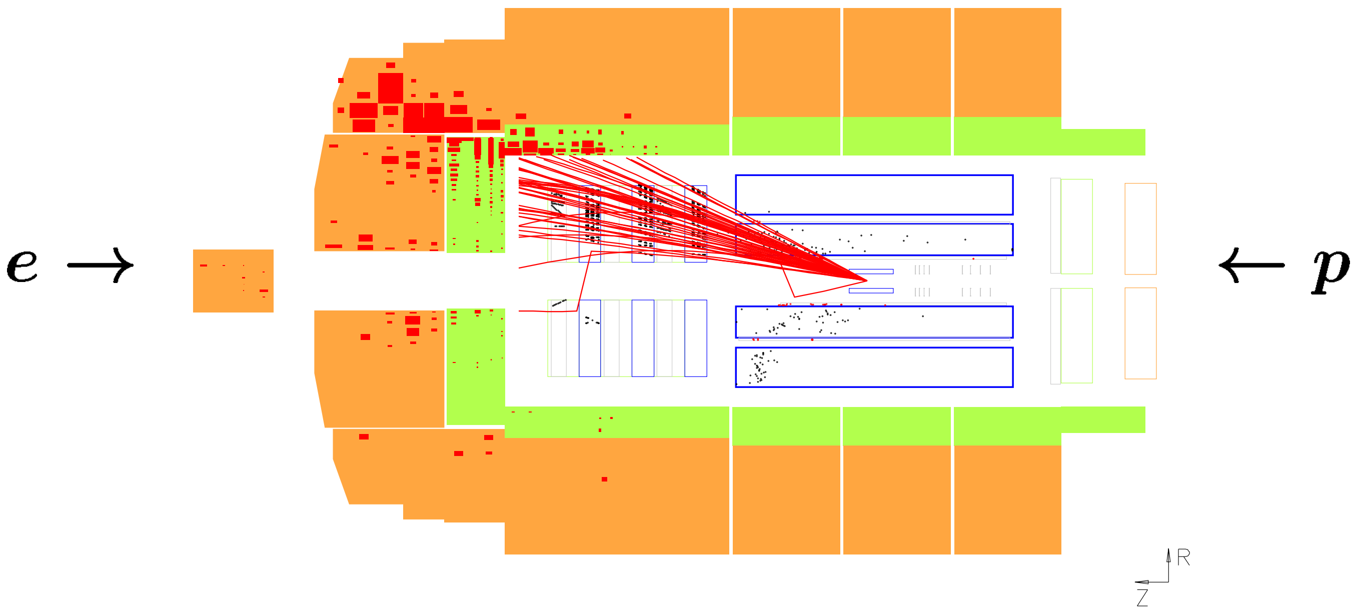


- Contact interactions lead to a rise in the NC cross section at high Q^2
- Data not yet precise enough to rule in or out scenarios shown

For details see talk by Juergen Scheins

Charged Current DIS



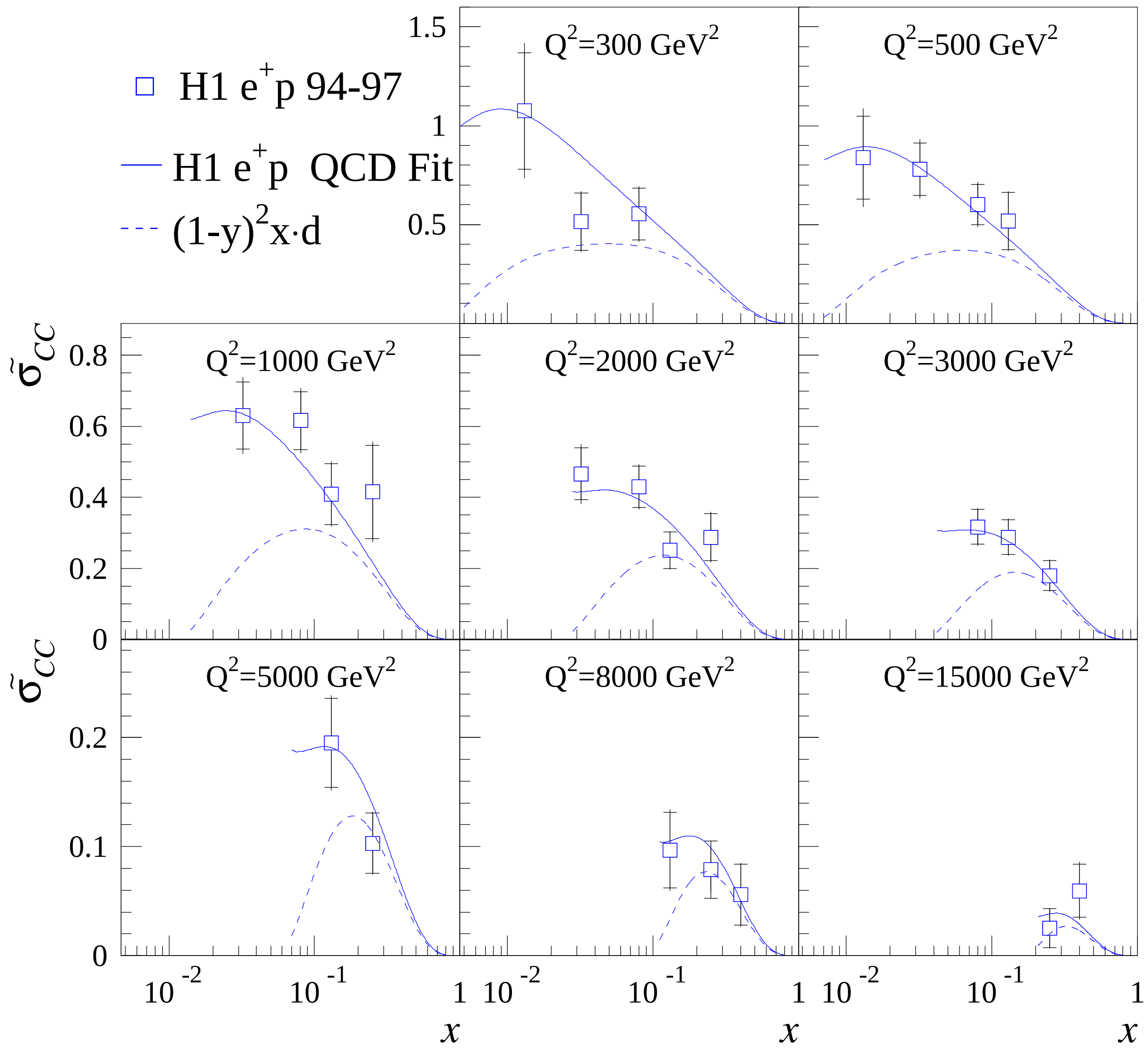


Charged Current Deep Inelastic Scattering

- Parton densities. Best method at HERA to probe d-quark density and individual components of sea $\Rightarrow$ plot
- Propagator W mass determination
- Constraints on anomalous couplings
- Tests for physics beyond the Standard Model

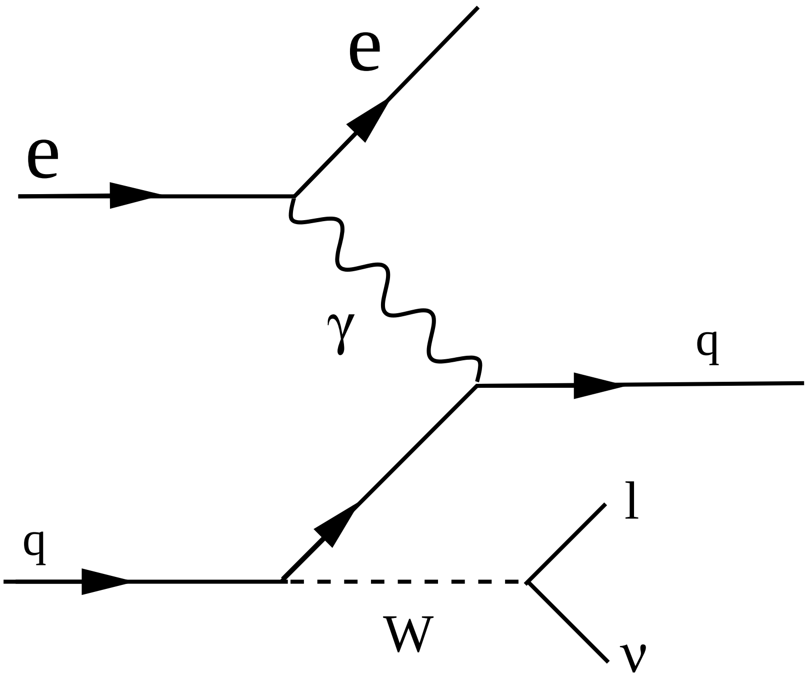
For details see talk by Anna Burrage

CC Reduced Cross Section



- At high x CC cross section is mainly sensitive to the d quark density of the proton.
- At lower x $\bar{u}$ quark density is the biggest contribution.

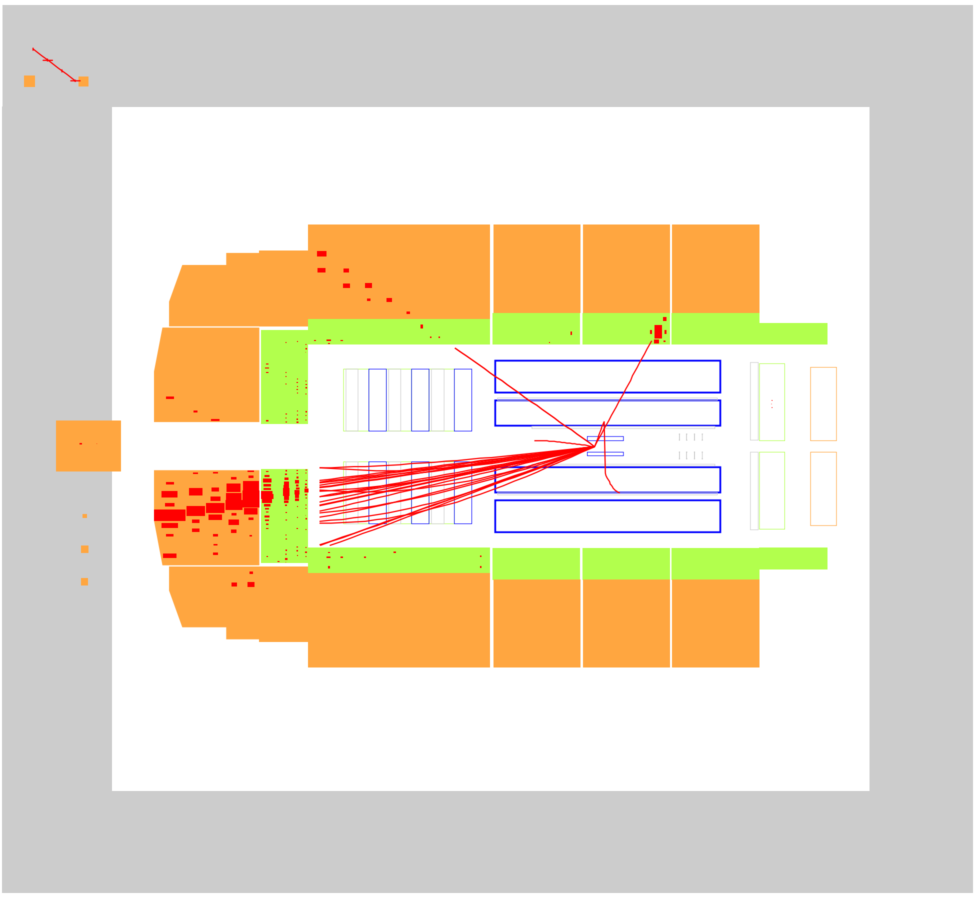
W Production and Isolated Leptons



$P_T^\mu = 39\,\mathrm{GeV}, P_T^X = 27\,\mathrm{GeV}, P_T^{miss} = 42\,\mathrm{GeV}$

$M_{\mu\nu} = 82\,\mathrm{GeV}$ $\quad W^- \to \mu^- \nu \quad Candidate$

$\boldsymbol{e} \rightarrow$



$\leftarrow \boldsymbol{p}$

W Production

- Small cross section ($\sim 1\ \mathrm{pb}^{-1}$), but interesting physics
- Gives contraints on anomalous $WW\gamma$ couplings
- Gives a direct mass measurement
- Many new physics scenarios produce a W in their decay chain.

Electron	Data	SM expectation	W
$P_T^X > 0$ GeV	3	3.12 $\pm$0.70	2.24 $\pm$0.67
$P_T^X > 12$ GeV	1	1.15 $\pm$0.25	0.78 $\pm$0.23
$P_T^X > 25$ GeV	0	0.50 $\pm$0.12	0.38 $\pm$0.11
$P_T^X > 40$ GeV	0	0.16 $\pm$0.04	0.14 $\pm$0.04

Table 1: **Observed and predicted event rates in the electron decay channel for e^+p data.**

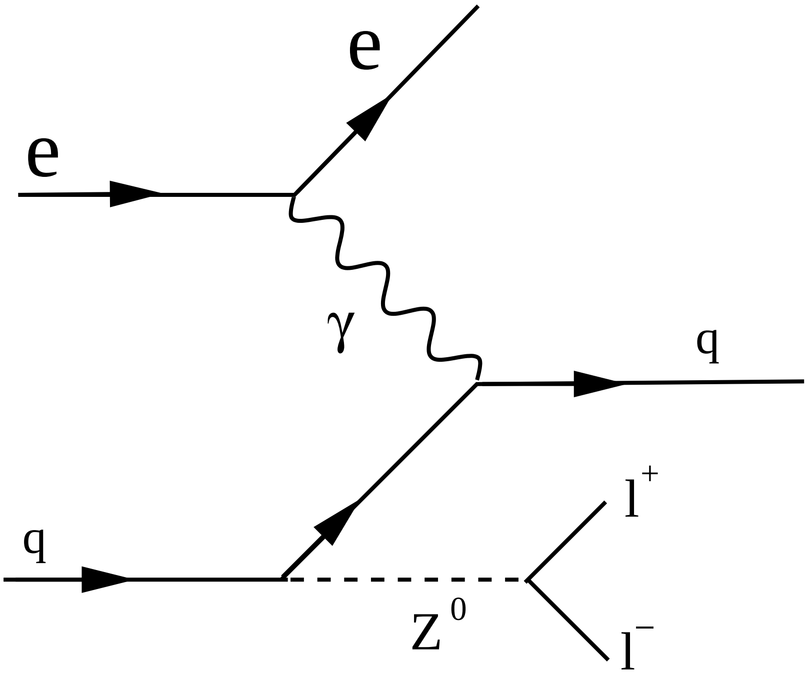
Muon	Data	SM expectation	W
$P_T^X > 12$ GeV	5	1.01 $\pm$ 0.28	0.87 $\pm$ 0.26
$P_T^X > 25$ GeV	5	0.56 $\pm$ 0.15	0.49 $\pm$ 0.15
$P_T^X > 40$ GeV	3	0.21 $\pm$ 0.06	0.19 $\pm$ 0.06

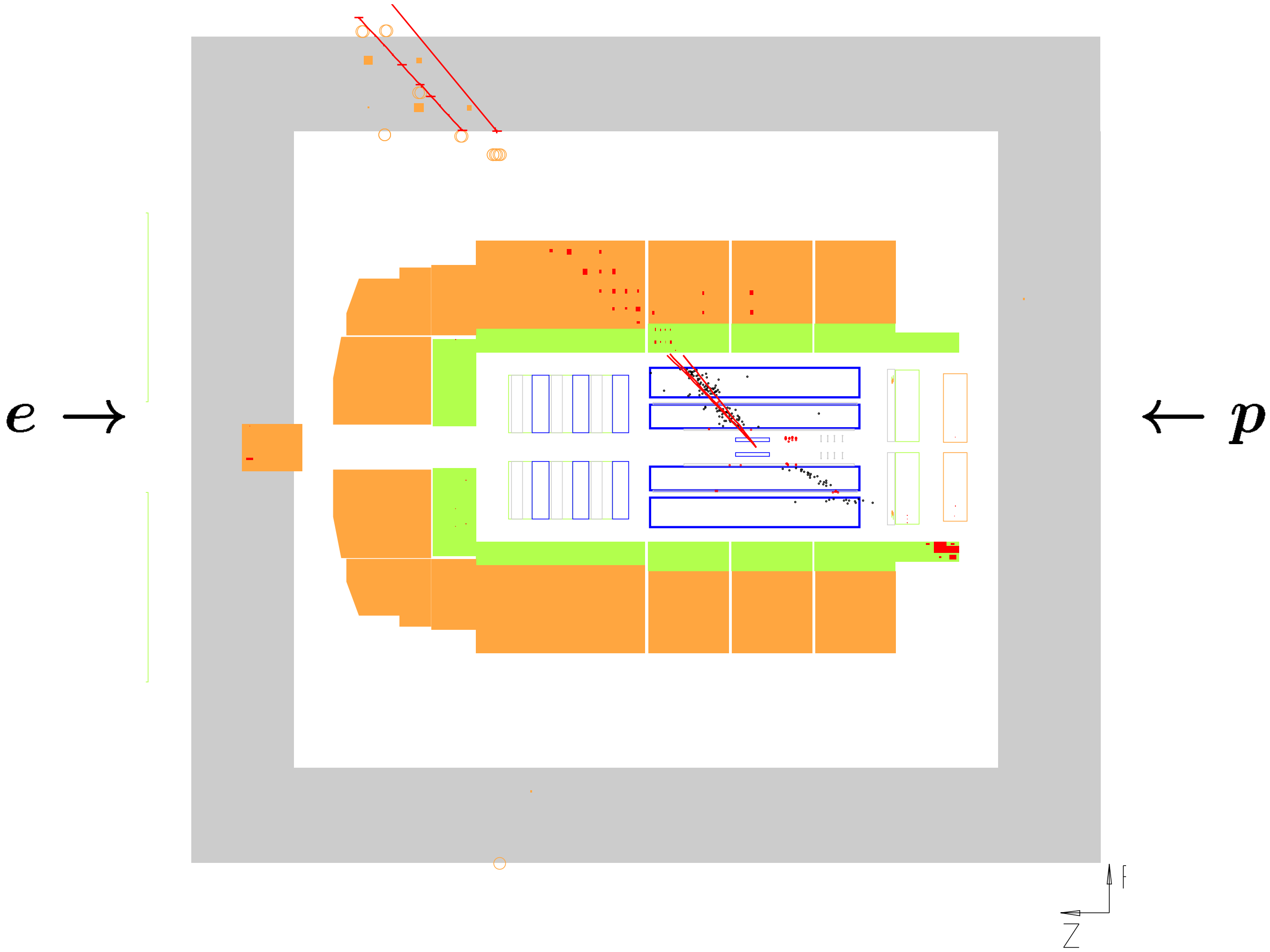
Table 2: **Observed and predicted event rates in the muon decay channel for e^+p data.**

With more data the excess observed at high P_T^X could lead to an exciting discovery

For details see talks by Nick Malden and Boris Leissner

Z^0 and l^+l^- Pair Production



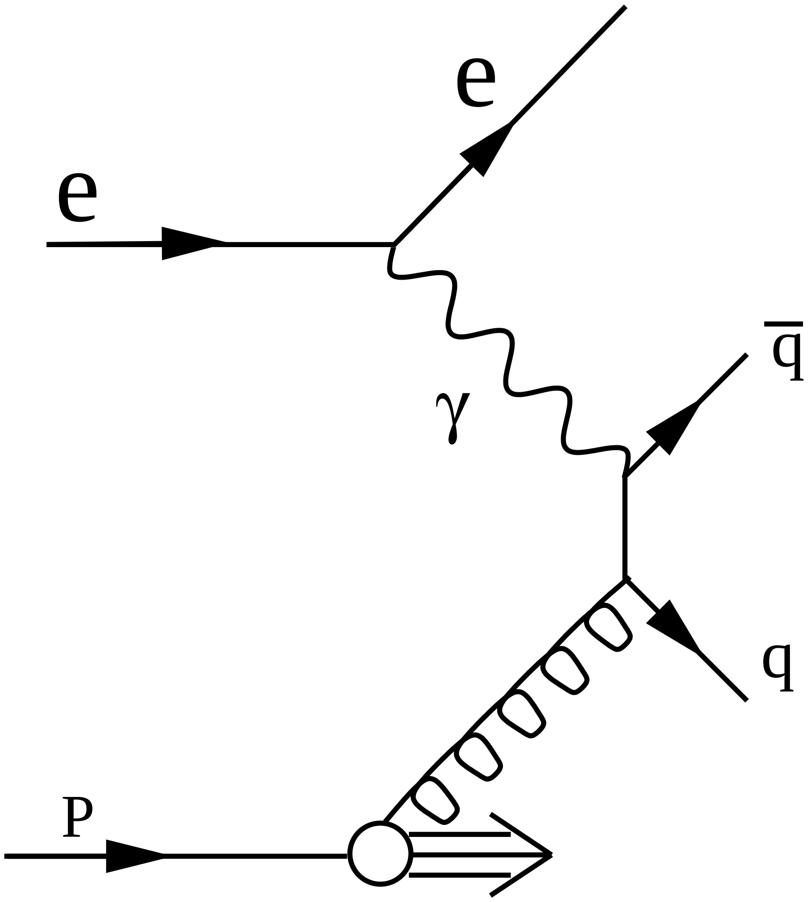


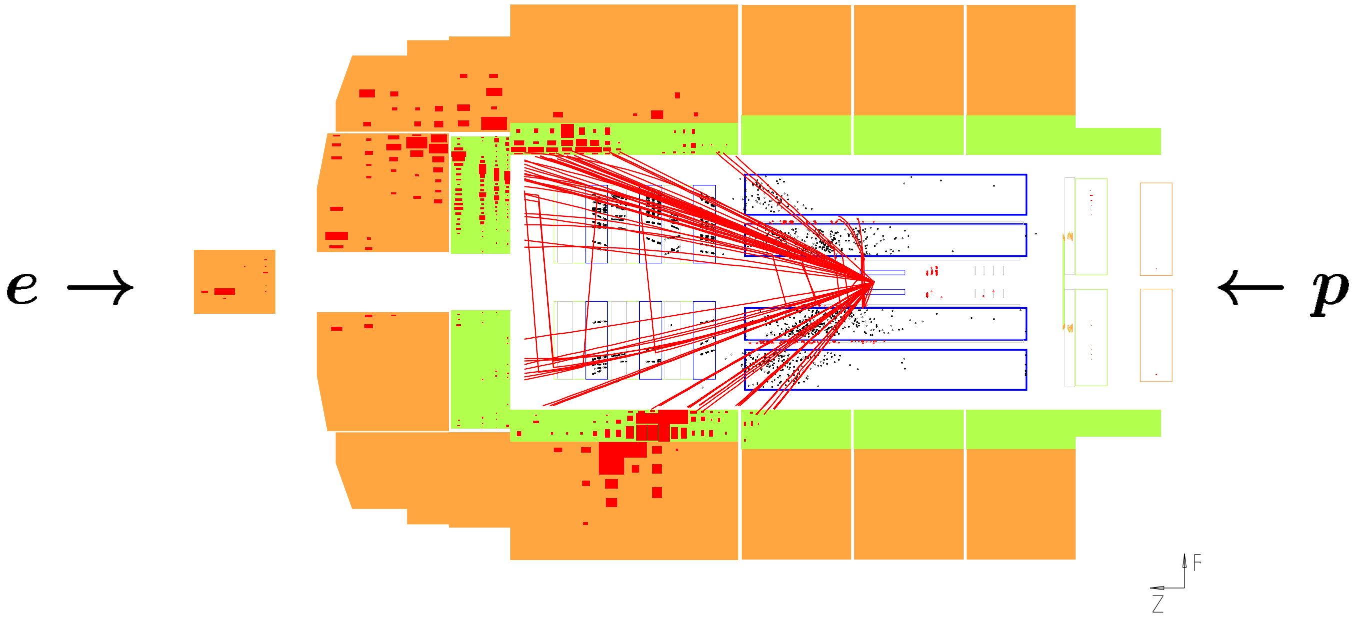
Lepton Pair and Z^0 Production

- Standard Model Z^0 cross section very small (~ 0.1 pb^{-1})
- Interesting to observe. An excess could point to new physics.
- Lepton pair production can put constraints on new heavy resonance production.
- An important background to W and Z^0 production. Needs to be understood

For details see talk by Boris leissner

Jet Production at High P_T

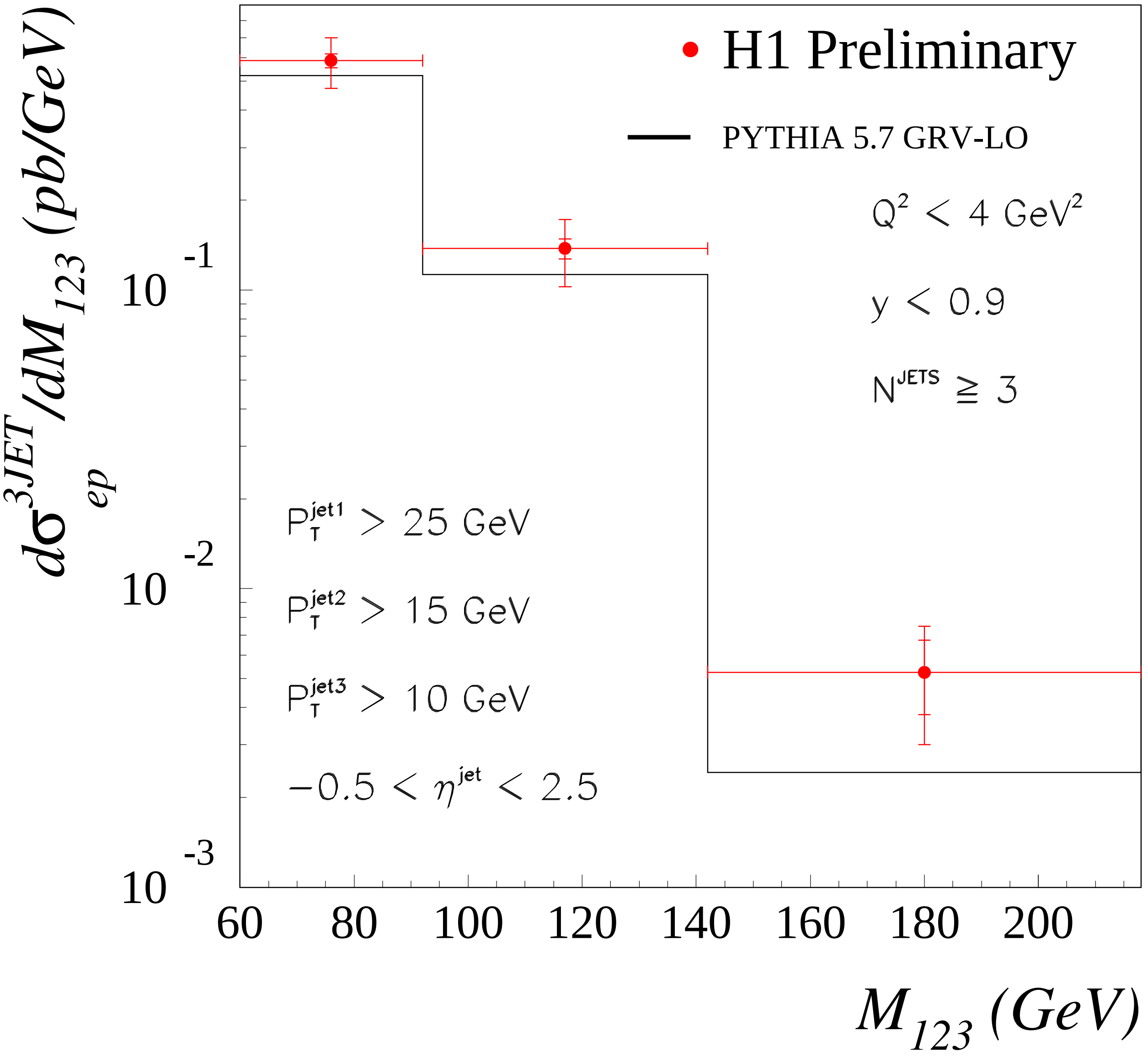




High P_T Jet Production

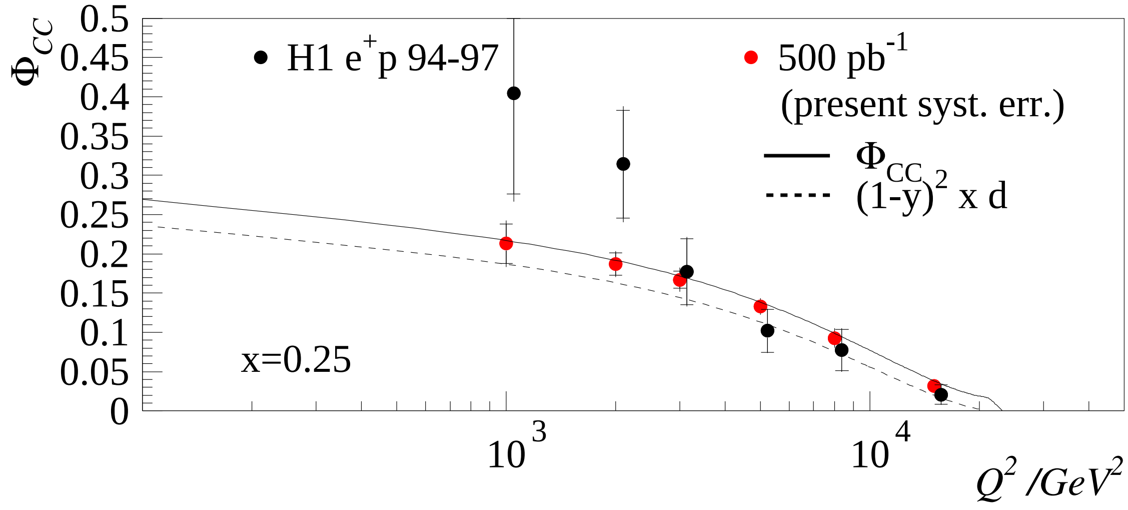
- Inclusive cross sections put constraints on new physics eg contact interactions $\Rightarrow$ plot
- Help constrain the gluon in the proton and pdfs of the photon
- More exclusive measurements can be used to search for resonaces eg. W, top or excited quarks

Three Jet Invarient Mass Cross Section

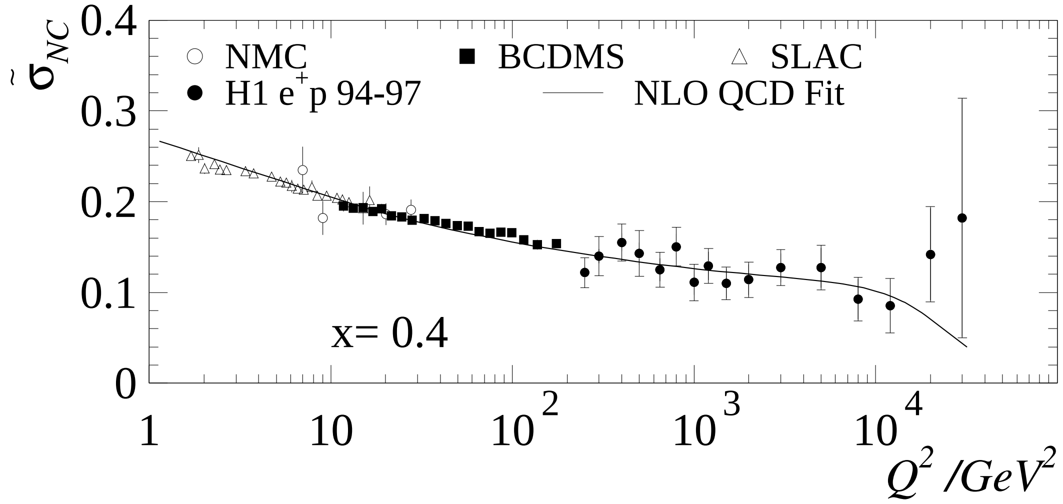


HERA Has a Bright Future

- 2000 $\rightarrow$ HERA runs with $L = 300$ pb^{-1} per year (luminosities for H1+ZEUS together)
- eg. State of CC Measurement in year 2003



- eg. NC cross section measured better than 10% up to $Q^2 = 20000$ GeV^2 (Verifying or refuting excess seen in 94-97 data).



- eg. 40 to 100 W events.

High P_T/Q^2 physics has only just begun !