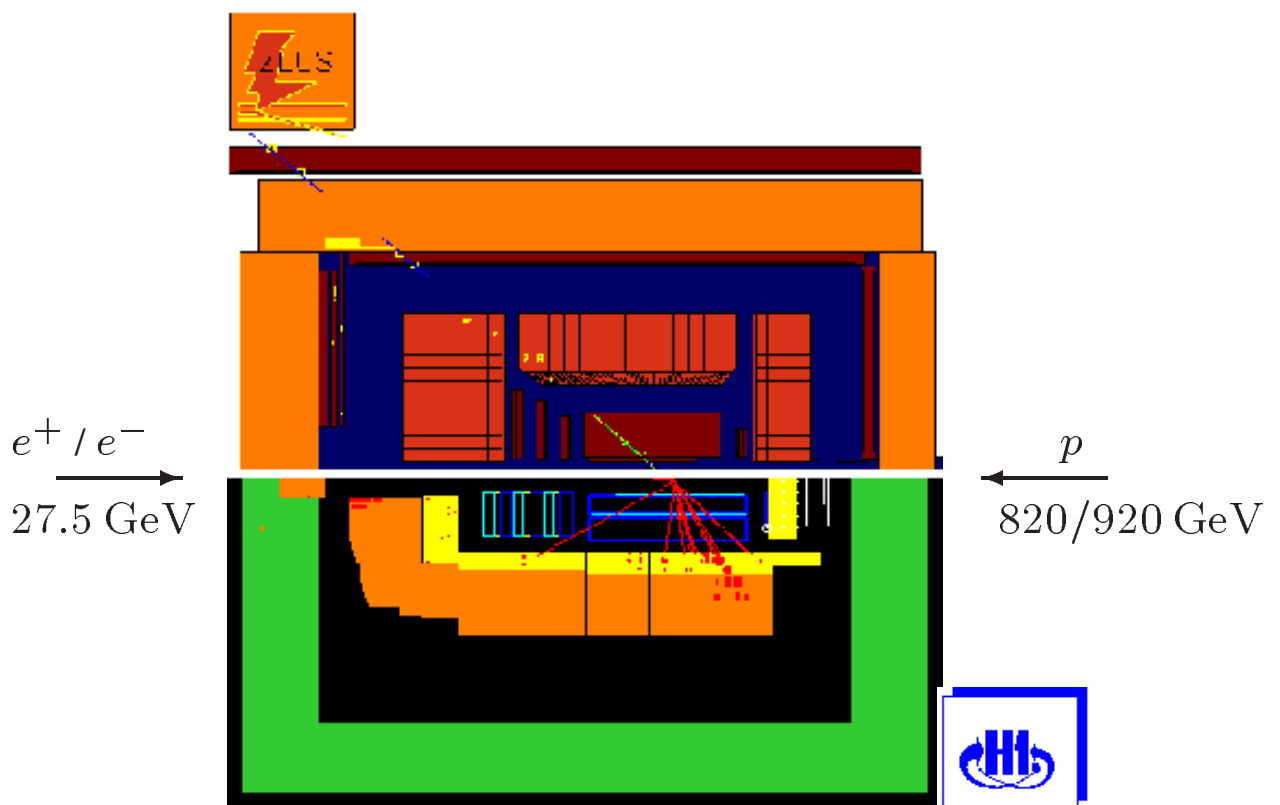


HERA Status Report, November 2000

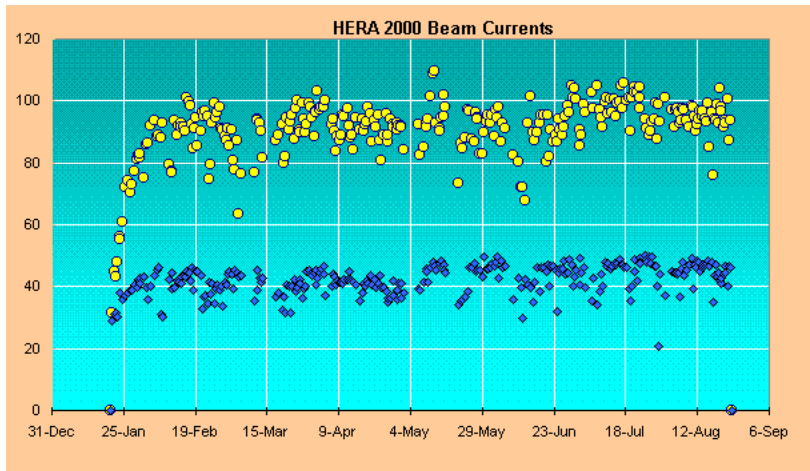
Paul Newman, Birmingham University



- HERA-1 Performance
- HERA-1 Physics Results
- Upgrade Projects
- Physics at HERA-2

HERA Performance

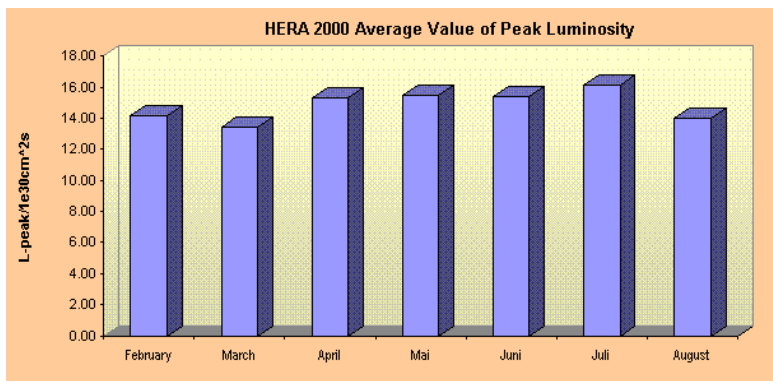
HERA running near to design parameters in 2000



Design $I_p = 150$ mA

Design $I_e = 58$ mA

65% electron polarisation achieved.

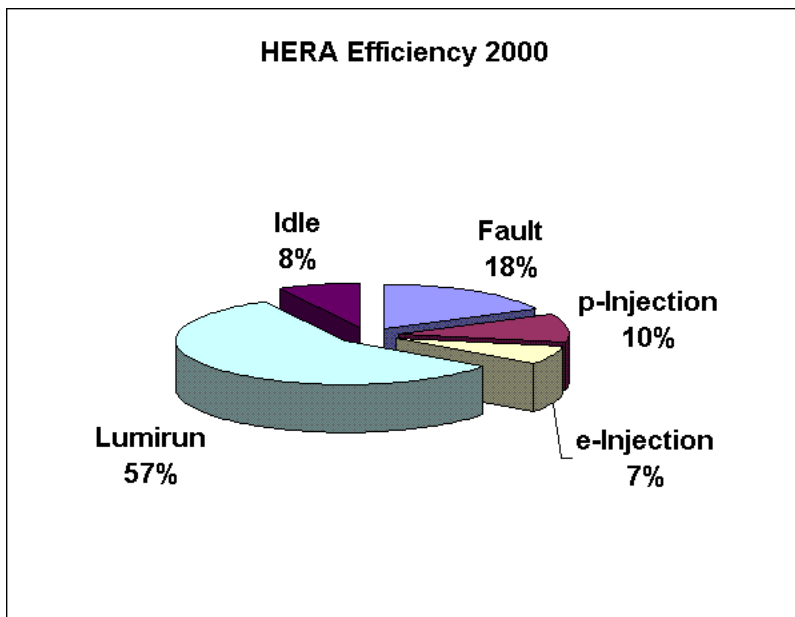


Design peak luminosity

$1.5 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$

67 pb^{-1} delivered in 8 months in 2000.

Design was 35 pb^{-1} per year

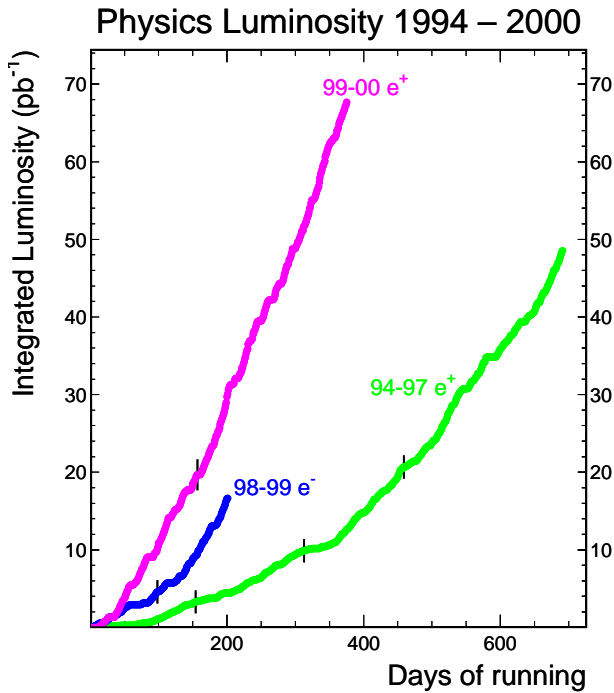


HERA operation efficiency 57%

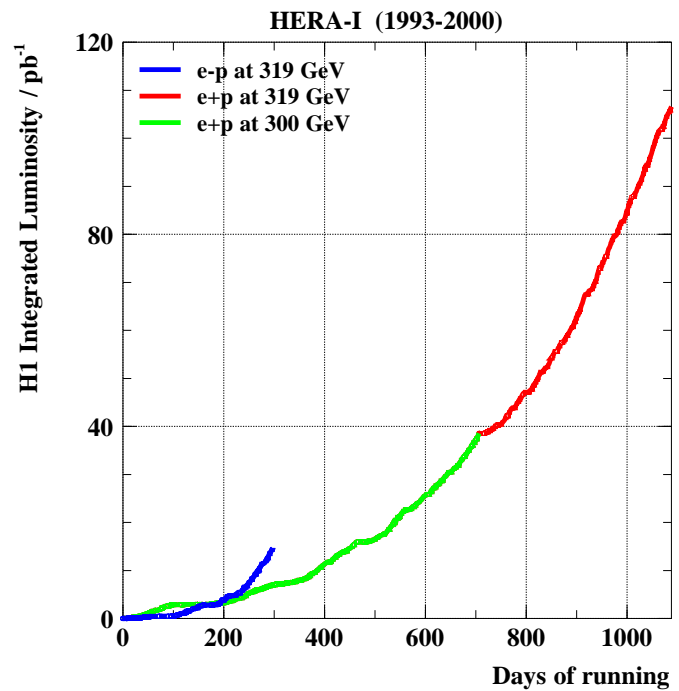
H1 / ZEUS typically use 70% for analysis.

Final HERA-1 Samples

ZEUS



H1



e^+p : $\sim 120 \text{ pb}^{-1}$ for

H1 / ZEUS

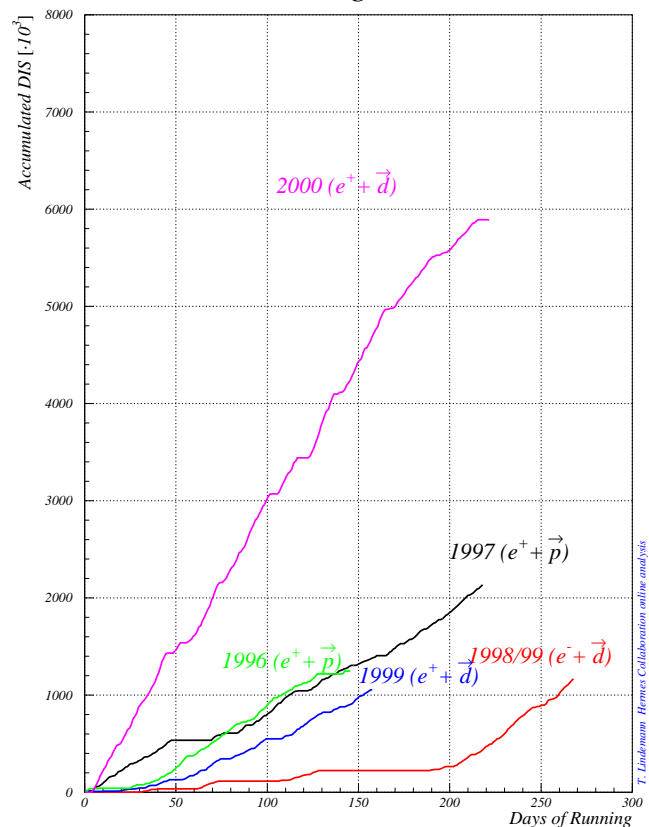
e^-p : $\sim 16 \text{ pb}^{-1}$ for

H1 / ZEUS

Special samples (e.g. SV)
to study low Q^2 / transition
to photoproduction

Successful longitudinal
polarisation achieved for
HERMES in 2000

Hermes Running 1996-2000



Highlights from HERA-1

H1 / ZEUS have ~ 180 papers published in refereed journals.

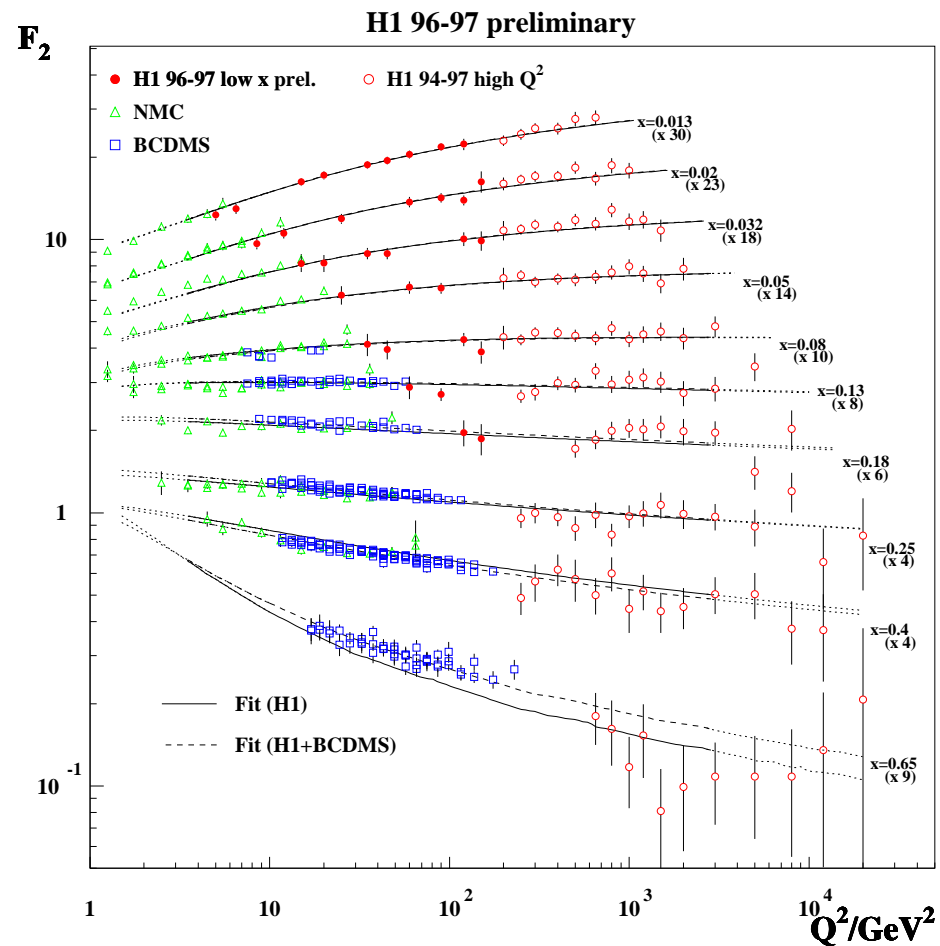
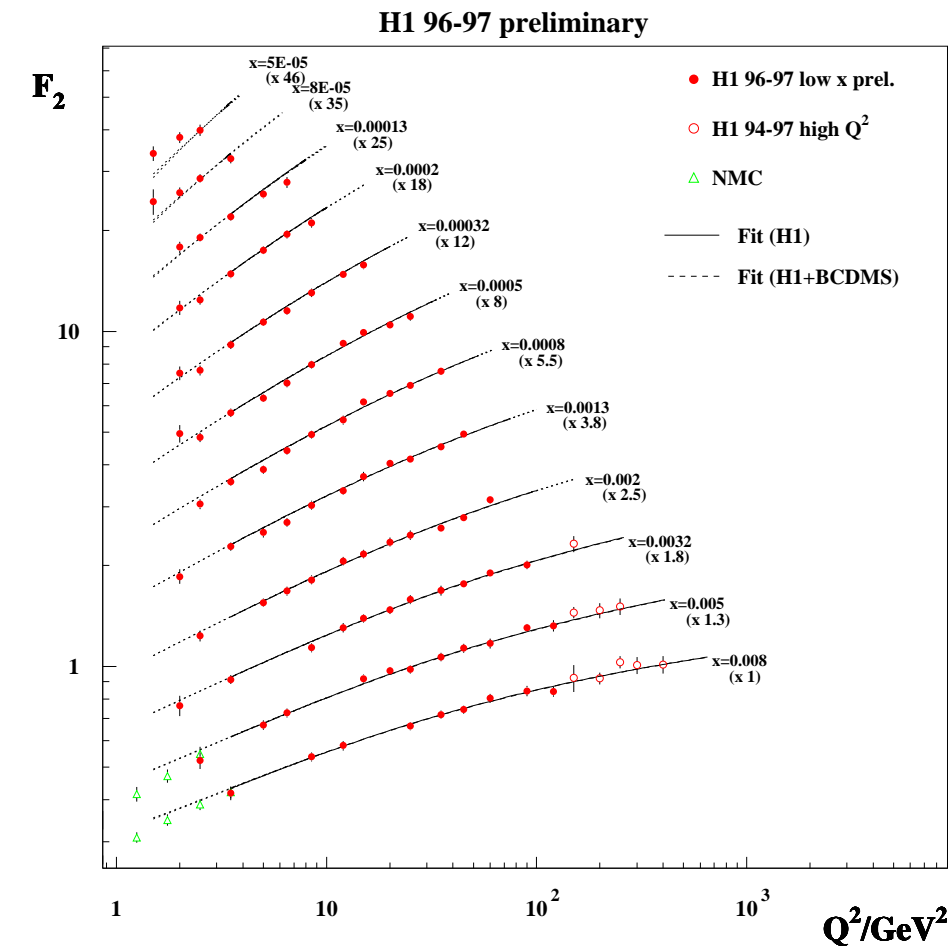
64 NEW Preliminary Results presented at ICHEP2000.

Lots more results expected from HERA-1 data.

Some Highlights so far ...

- Competitive limits on leptoquarks, \mathcal{R}_p -SUSY, l^* , contact int^n s, large extra dimensions from almost all HERA-1 data.
- $\sigma(CC)$ & $\sigma(NC)$ from almost all e^+p , e^-p HERA-1 data.
- Measurements of $xF_3(x, Q^2)$ - γ^*Z interference
- Extractions of F_L at low x
- Determination of M_W in space-like region
- Flavour decomposition e.g. $xu_v(x)$, $xd_v(x)$ from CC data.
- Measurements of charm structure function F_2^c
- Dijet Cross Sections in both CC and NC
- Diffractive F_2^D and final state data \rightarrow structure of \mathbb{P}
- Real and virtual photon structure.
- Final state searches for novel QCD dynamics (e.g. BFKL).

Precision F_2 Data



F_2 measured in
huge phase space.

$< 1\%$ (stat) \oplus 3% (syst)
precision in some
regions.

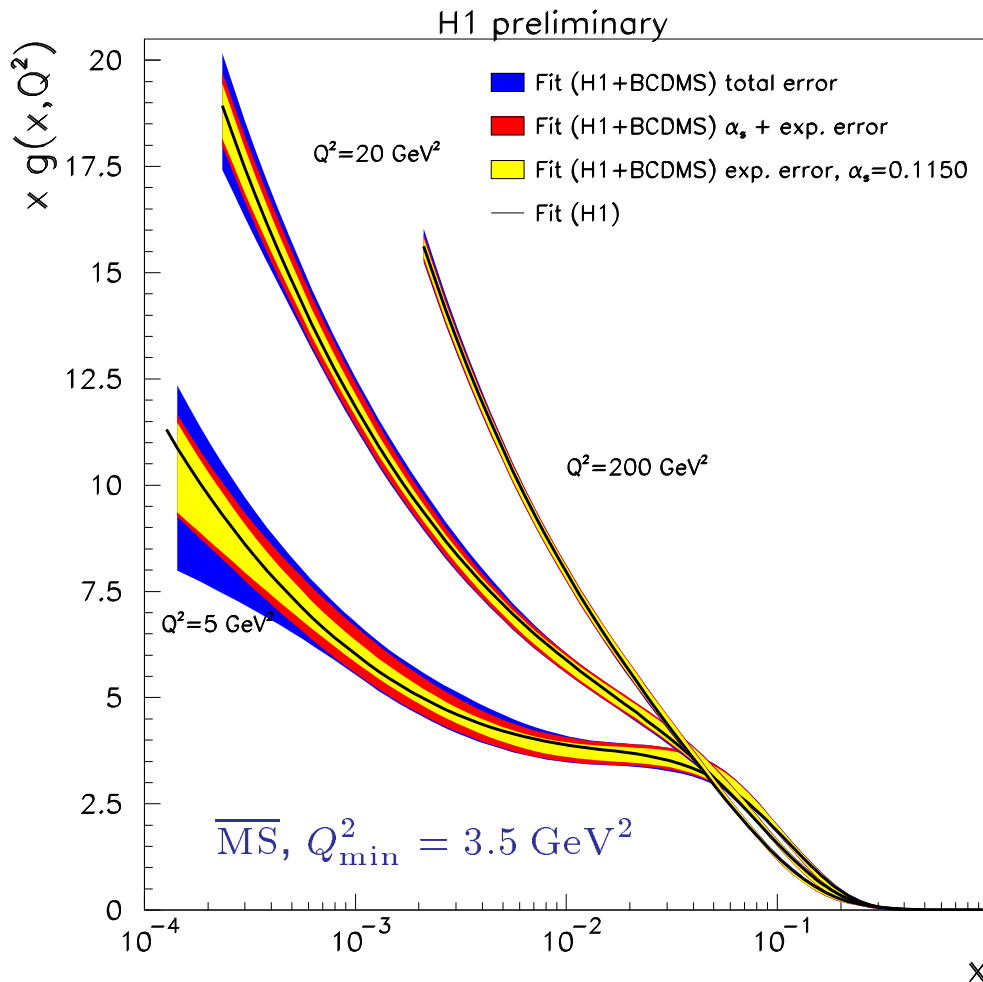
Data remain statistically
limited for $Q^2 \gtrsim 2000 \text{ GeV}^2$

Gluon and α_s from Inclusive Data

Simultaneous extraction of α_s and $xg(x, Q^2)$

NLO DGLAP analysis of H1 data with $1.5 \leq Q^2 \leq 3000 \text{ GeV}^2$ (1994-7) and BCDMS high x data.

Full correlated error treatment.



$$\alpha_s(M_Z^2) = 0.1150 \pm 0.0017 (\text{exp.}) {}^{+0.0011}_{-0.0012} (\text{model})$$

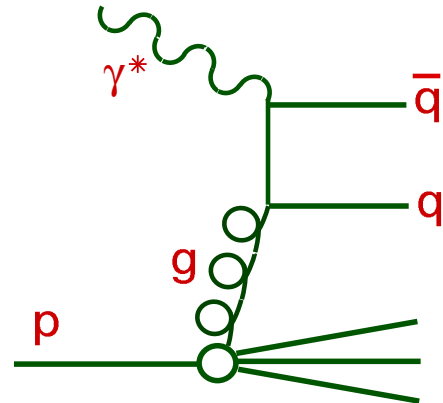
Additional uncertainty ~ 0.005 (renormalisation & factorisation scales) - will decrease when NNLO formulae available.

QCD Tests in the Final State

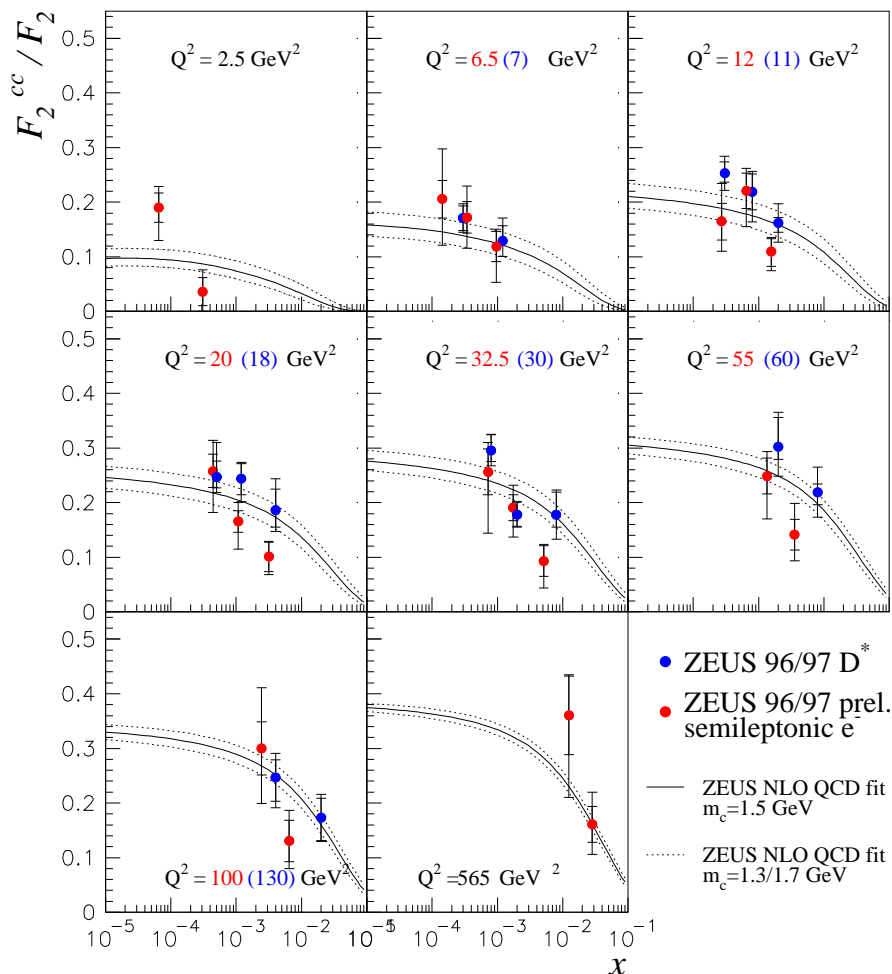
Hadronic Final State analyses →

- Consistency checks with extractions from DGLAP fits.
- Tests of QCD Factorisation Theorem.

e.g. Final states containing charm or dijets are sensitive to $xg(x, Q^2)$ and α_s through Boson Gluon Fusion.



ZEUS Preliminary 1996-97

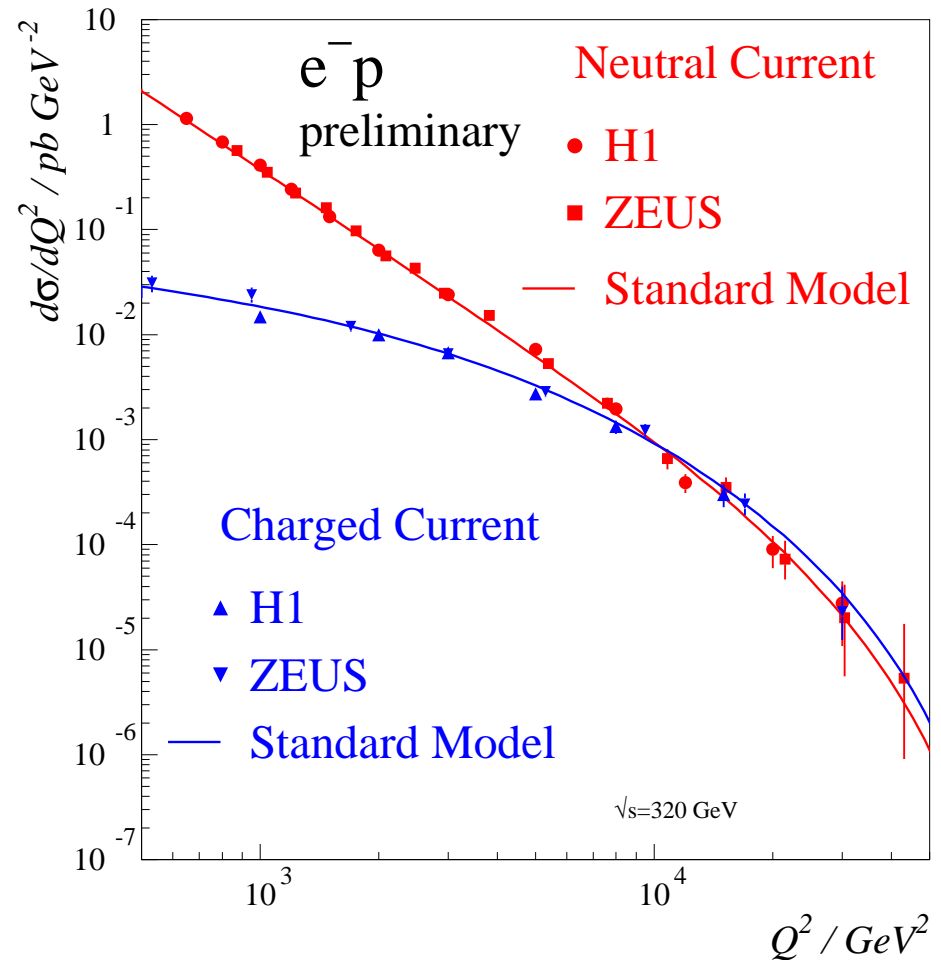
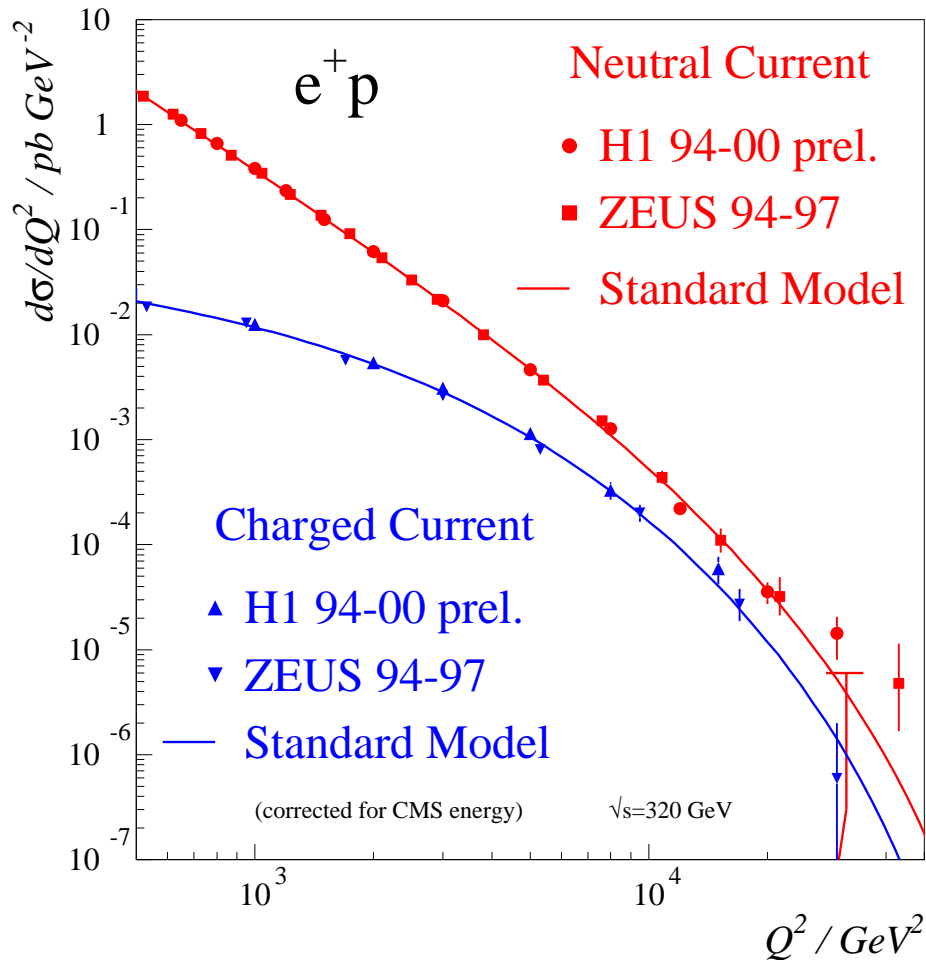


Measured from D^* and semi-leptonic decays.

Dotted lines show uncertainty from m_c

Increasingly precise data, but much more needed for detailed tests of theory.

High Q^2 Cross Sections

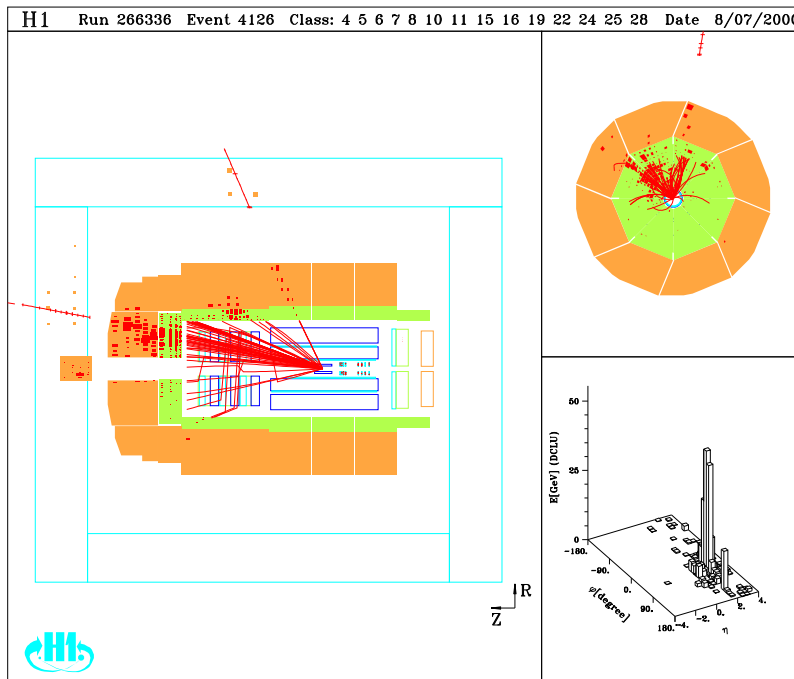


NC, CC e^+ , e^- Cross Sections measured with almost all pre-upgrade data.

Nice illustration of electroweak unification at high Q^2

Tantalising signals

- No evidence for high Q^2 excess (1994-6 data) in 1997-2000 data → attributed to statistical fluctuation.



- In e^+p , H1 observe isolated leptons with missing p_T (W signature) appearing faster than expected at high p_T of hadronic recoil.

H1 94-00 e^+p 82 pb^{-1} Preliminary	H1 Prelim Data ($e + \mu$)	Standard Model Expectation
$P_T^X > 0$ GeV	14	8.16 ± 1.97
$P_T^X > 12$ GeV	12	4.07 ± 1.03
$P_T^X > 25$ GeV	9	2.26 ± 0.57
$P_T^X > 40$ GeV	6	0.79 ± 0.22

No events found in 13.6 pb^{-1} of e^-p data.

ZEUS data in this channel consistent with Standard Model.

HERA Status and Plans

Summary of Schedule

- September 2000: Shutdown began
- May 2001: Restart with beam - technical tests
- August 2001: Colliding beams - tests
- November 2001: Production lumi (expect $\sim 30 \text{ pb}^{-1}$ in 2001)

Superconducting magnets to reduce β of intersections at H1 / ZEUS made at Brookhaven

Two undergoing tests at DESY

Two still to be delivered

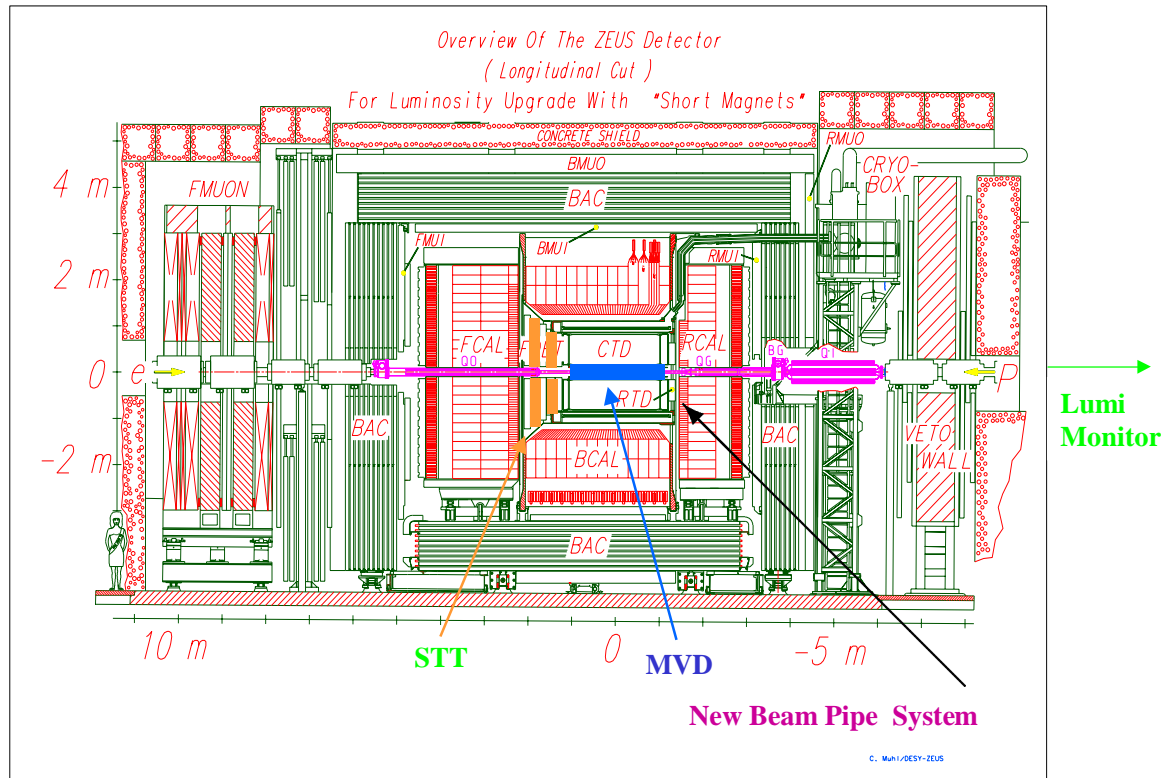
SC magnet schedule tight but not yet critical.

Experiments currently on target to meet schedule.

Longer Term Plans (speculative)

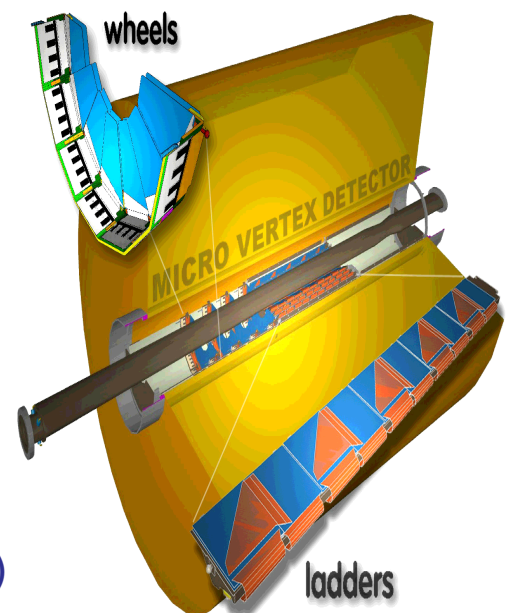
- 2002-2005: One year for each of e^+ , e^- left / right handed.
- 2006 ... Deuterons / heavy ions?

ZEUS Upgrade Projects

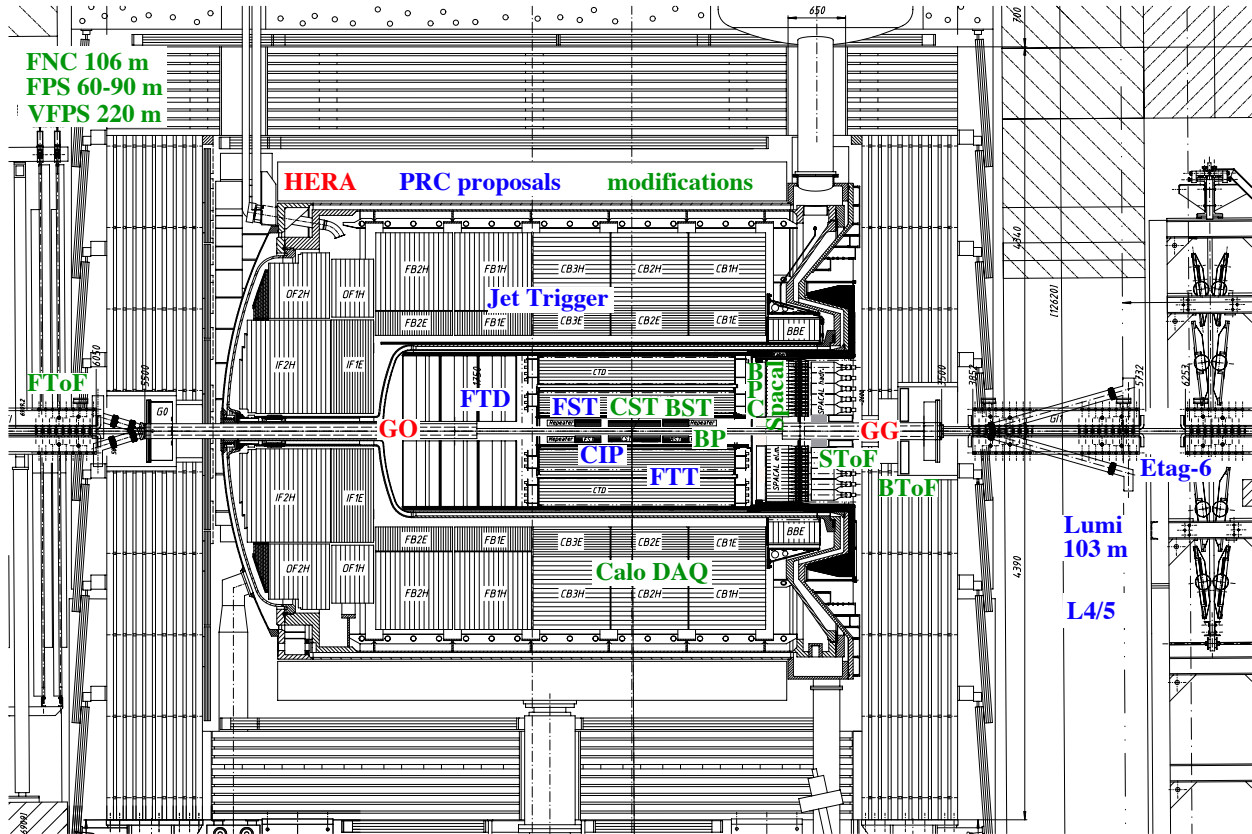


Main UK Involvement in Silicon Microvertex Detector (MVD)

- Secondary vertices for HF tagging
- Improved track resolution / acceptance
- Improved triggering (global track trigger)



H1 Upgrade Projects



Main UK Projects are Forward Tracker and Fast Track Trigger

Forward Tracker: more planar chambers →

- $> 90\%$ reconstruction efficiency in very messy environment
- Electrons and hadrons in very high x events
- Charm at high x , Forward Jets ...

Track Trigger Upgrade: selected Central Jet Chamber wires →

- Much improved track p_T thresholding / multiplicity, topology information at trigger L1-3
- Resonance searches (eg $D^* \rightarrow K\pi\pi_{\text{slow}}$) inside $100 \mu\text{s}$

Physics at HERA-2

Luminosity to increase by factor of 5

- Much improved precision on high x , Q^2 cross sections.
- Improved measurements of statistically limited exclusive channels at low x .
- Studies of electroweak sector reach maturity (e.g. $\Delta M_W \sim 80 \text{ MeV}$ after 1 year.)
- Completely new areas . . . , polarisation, b sector . . .
- Full Flavour Decomposition of Structure Functions
- Improved limits from searches

Examples of HERA-2 Physics Potential

Compare $e^+, e^- \sigma(\text{NC}) \rightarrow$

Much improved $x F_3$ data (Z^0)

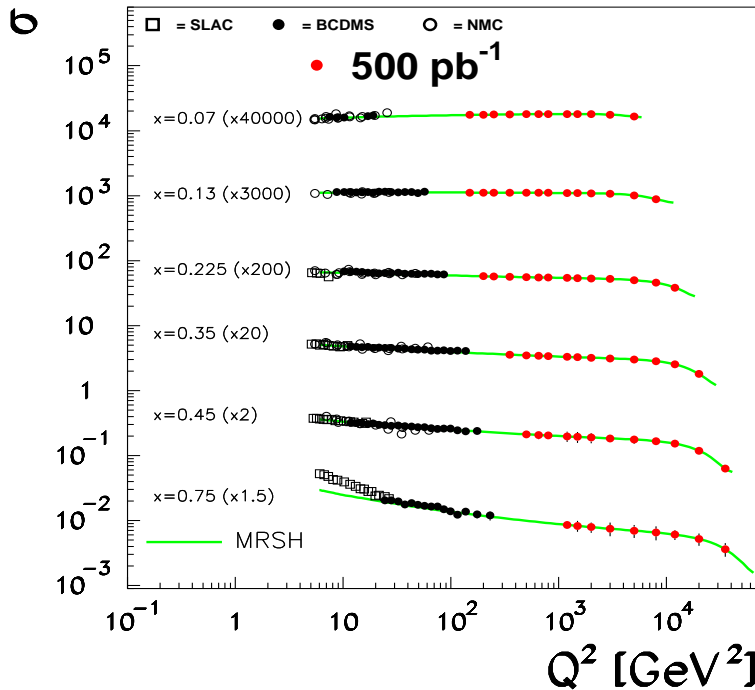
Vary beam energies \rightarrow

Much improved F_L data (gluon)

DGLAP fits to precision data

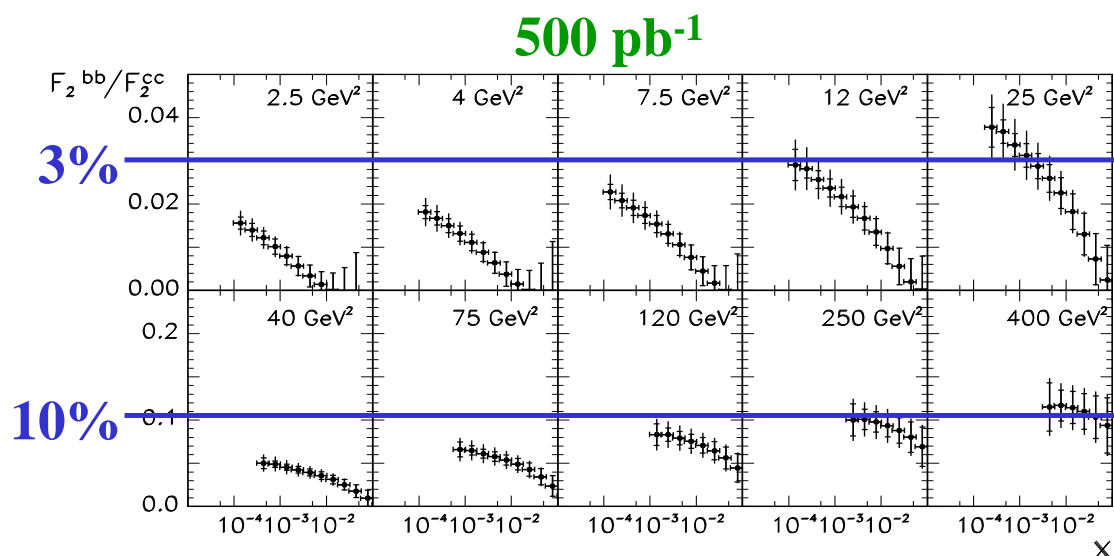
at all $Q^2 \rightarrow$

e.g. $\frac{\Delta[xg(x)]}{xg(x)} \sim 3\%$

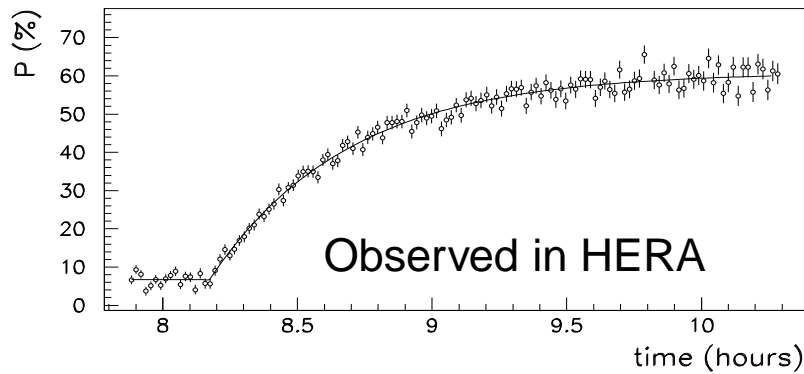


Precision charm physics as tool for QCD tests.

Sensitivity to beauty contribution to F_2



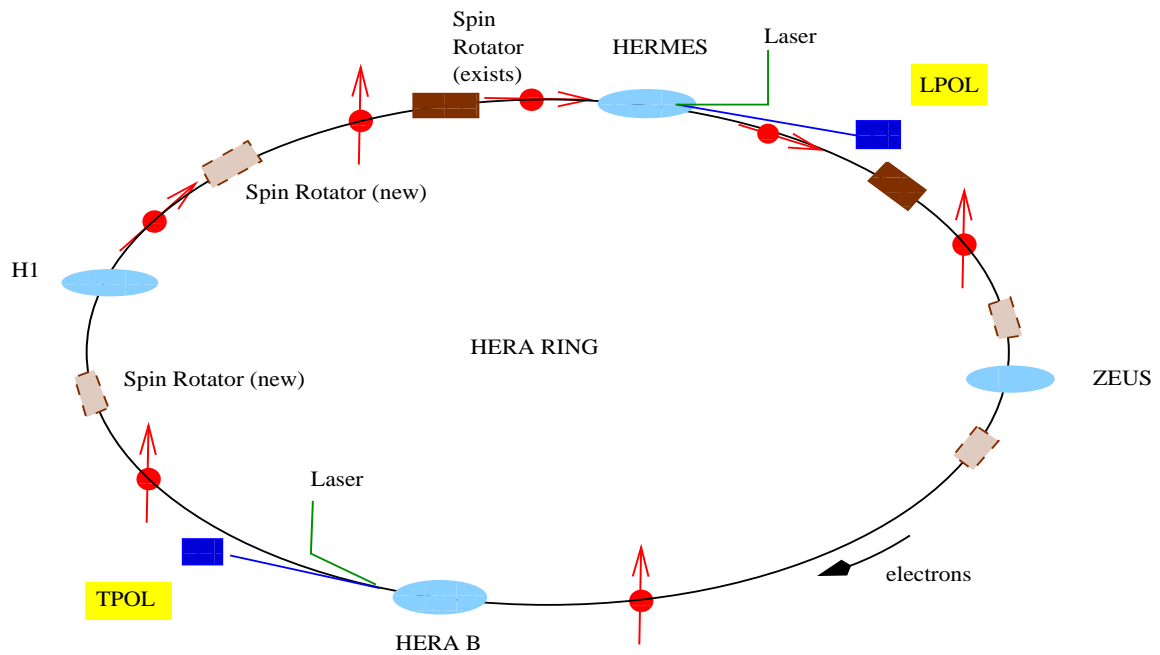
Lepton Polarisation at HERA



Design goal is 70%

50-60% pol'n routinely achieved for HERMES (40 min rise time)

→ spin structure functions, polarised quark distributions.

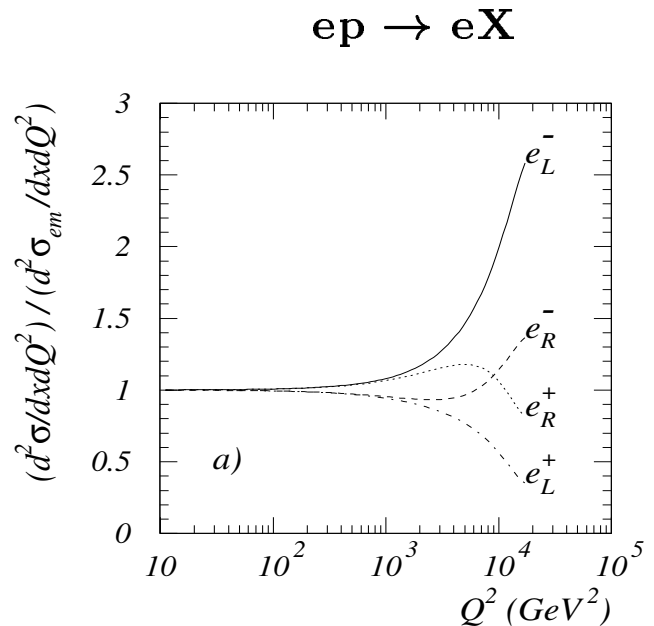
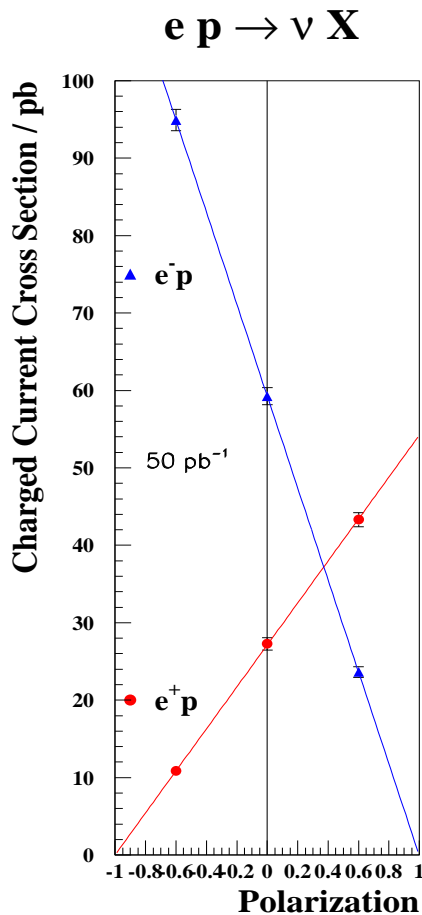


Spin rotators to be installed for H1 / ZEUS.

Upgrades to TPOL, LPOL polarimeters.

1% polarisation precision expected post upgrade (4% so far).

Physics with Polarised Leptons



Chiral structure of Standard Model
results in strong polarisation
dependence of CC & NC cross sections
where W and Z exchanged.

Run with left and right polarised e^+ and e^-

- Turn SM processes off to enhance search sensitivity
e.g. RH CC exclusion limit $M_W(R) > 400 \text{ GeV}$ (1 year).

- u and d quark vector and axial vector couplings
e.g. estimated precision with 250 pb⁻¹ for each of $e_{L,R}^\pm$
 $\Delta v_u \sim 13\% \quad \Delta a_u \sim 6\% \quad \Delta v_d \sim 17\% \quad \Delta a_d \sim 17\%$

Low x Physics at HERA-2

Many final state analyses still highly statistically limited.

e.g. HF channels, vector mesons, inclusive diffraction . . .

Not possible to take all low x data at HERA-2

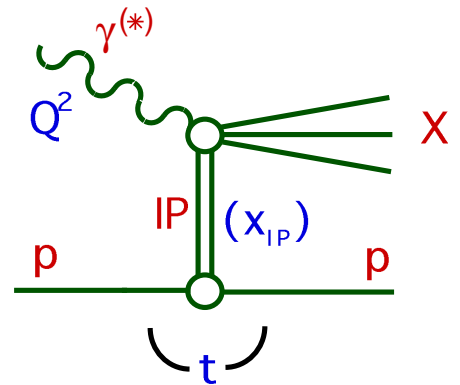
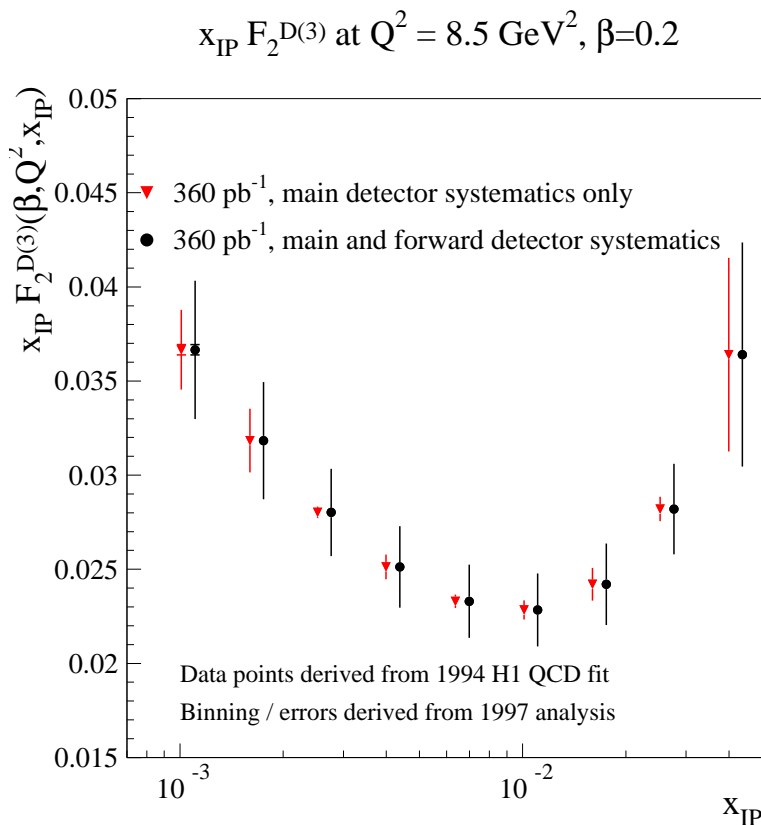
ep physics rate > 1 kHz

Crucial to trigger e.g. D^* , J/ψ efficiently!

→ ZEUS track trigger with CTD / MVD, H1 FTT

Diffraction data limited by 'Rapidity Gap' Selection method.

→ H1 Very Forward Proton Spectrometer



• High acceptance
 allowing precision
 studies of $ep \rightarrow eXp$
 at HERA-2.

Summary

- HERA-1 was highly successful
 - Spectacular machine performance in 1999-2000
 - Many significant physics contributions made
 - Lots more results expected in near future
- Accelerator and experiments on schedule for HERA-2
 - Many exciting upgrade projects
 - Looking forward to high precision at high Q^2 and p_T
 - Polarised leptons add a new dimension
 - Final state measurements at low x still require more data to develop full understanding of QCD