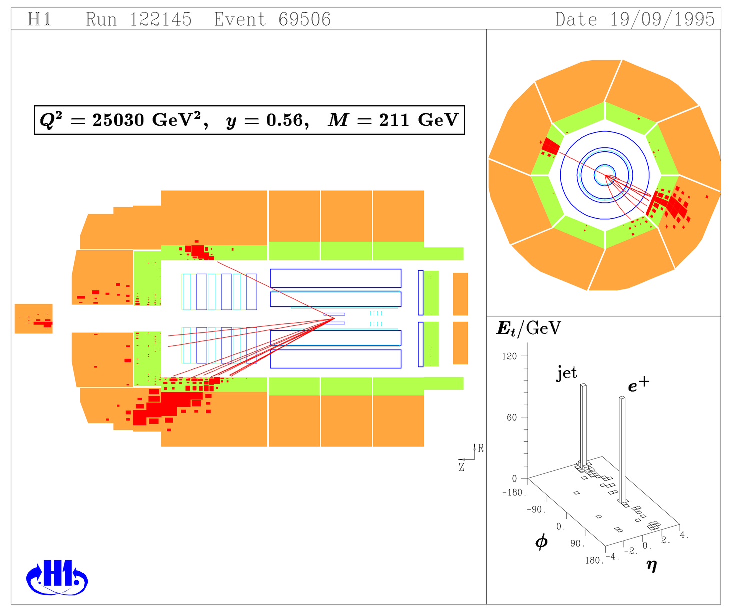
The HERA Experiments in the Year 2000

The Case for High Luminosity at HERA

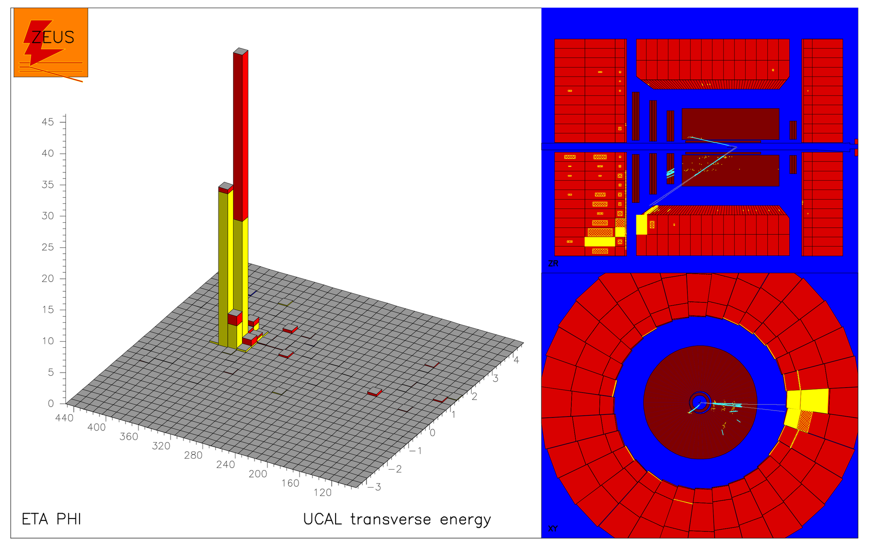
Example: Unexpectedly High Cross Section at High x and Q^2

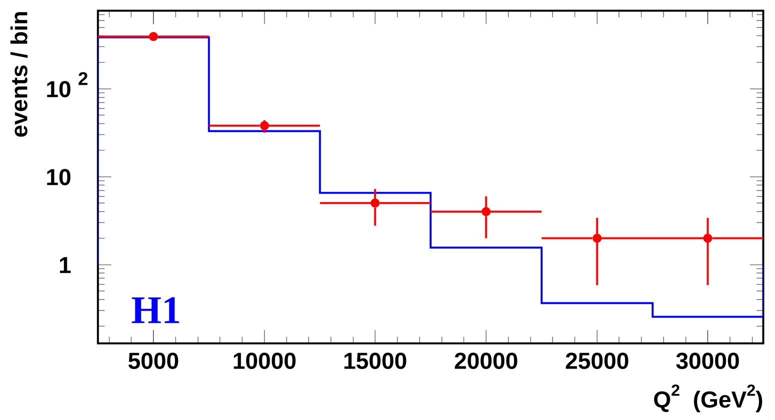
Candidate from NC sample

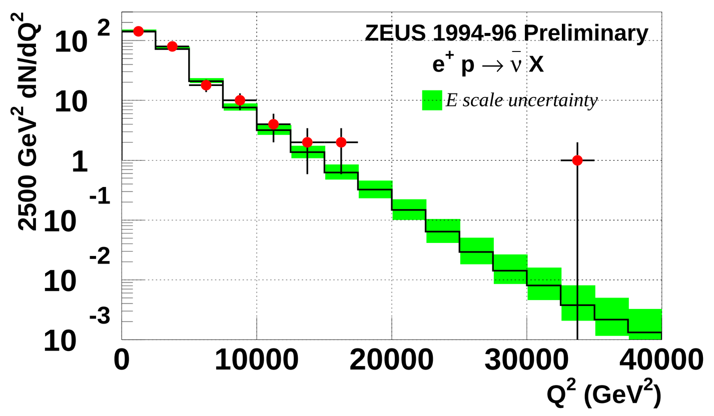


Candidate from CC sample

$Q^2 = 34000$ GeV^2, y = 0.65, x = 0.58







HERA is unique in probing the proton at smallest distances, via exchange of electro-weak gauge bosons: 4-momentum transfer squared Q^2 = 40,000 GeV^2 corresponds to a spatial resolution $\Delta r = 10^{-18}$ m.

At highest Q^2 (>15,000 GeV^2), more events than expected - based on our knowledge of structure functions at low Q^2 and on QCD - are observed by both H1 and ZEUS.

The signature of the events is the same as in "standard" deep inelastic scattering. The excess cannot be explained by experi-mental systematics or by uncertainties in the prediction. However, it could still be just a statistical fluctuation.

Only with higher statistics can the nature of the excess be clarified. Important additional constraints on possible explanations can result from e^- compared to e^+ scattering and from the use of polarized beams.

The broad physics potential of the HERA luminosity upgrade was studied in the **Workshop on "Future Physics at HERA",**

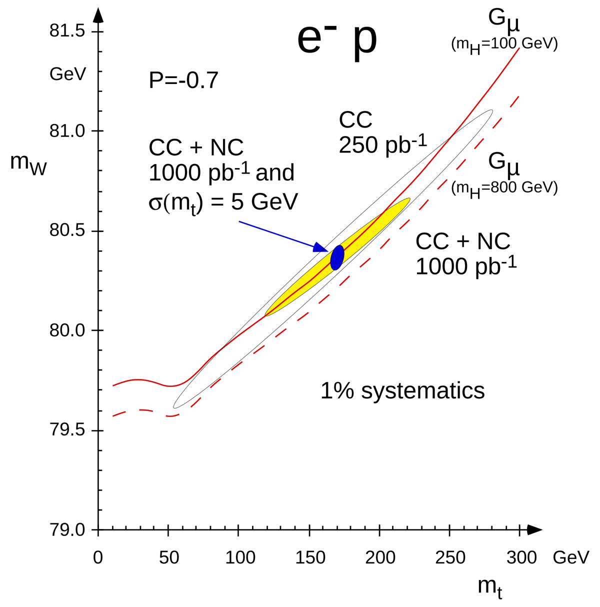
Proceedings: http://www.desy.de/heraws96

The HERA Spin Programme

Spin Rotators at H1 and ZEUS

Electro-weak Physics

Through the availability of all 4 charge and spin states of the electron, HERA combines the virtues of both μN and νN scat-tering experiments.
For each charge and spin state, the cross sections depend in a different manner on electro-weak parameters. HERA measurements are similar to a determination of the muon decay constant G_μ but probe the region of large space-like Q^2. They will put rather stringent constraints on m_t and m_W.



1σ confidence contours from e^-p scattering with 70% polarization - which is worth a factor of 4 in luminosity for the NC measurement. Together with direct top mass measurements, the allowed range of Higgs masses can be constrained.

A unique test of the Standard Model - with no equivalent in neutrino beam experiments - consists of the verification that

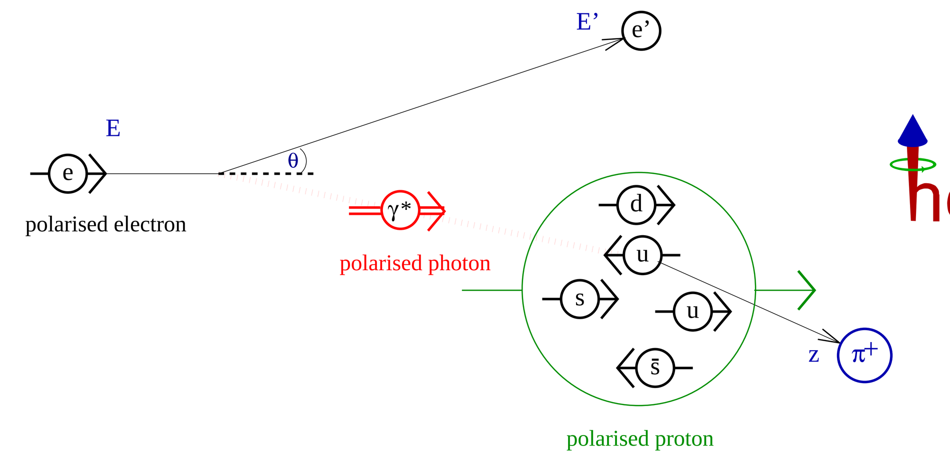
$$\sigma(e^-_{righthanded}\, p \to \nu X) = 0$$

HERMES

The Spin Structure of the Nucleon

$$s_z^N = \frac{1}{2} = \frac{1}{2}(\Delta u + \Delta d + \Delta s) + \Delta G + L_q + L_G$$

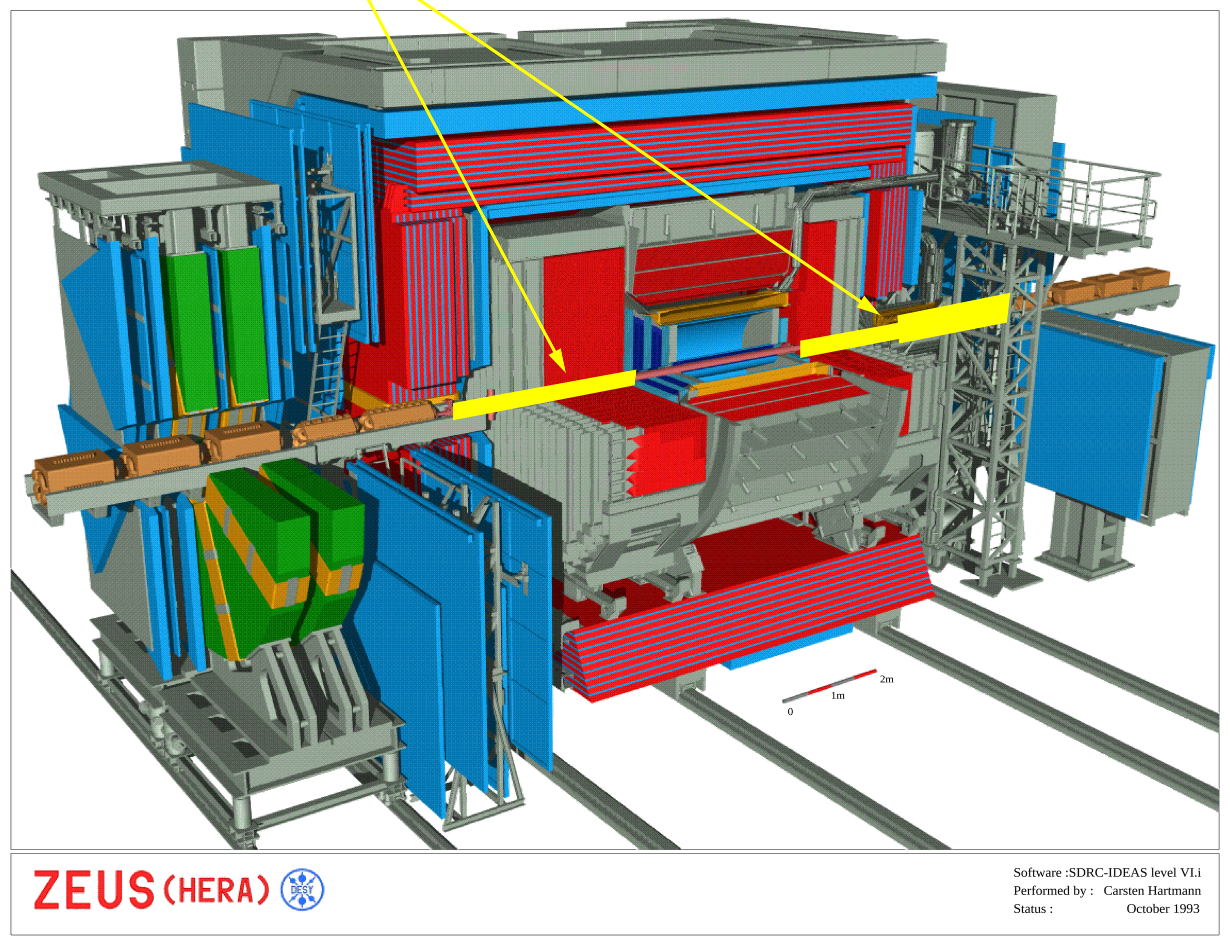
separate up, down, strange and gluon spin contributions



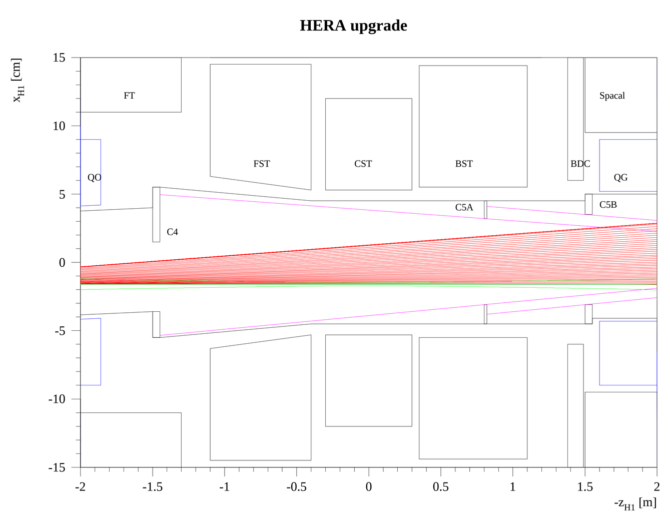
- probe quark spins in polarised nucleons by polarised (virtual) photons
- measure spin structure functions (inclusive cross section asymmetries, longitudinally and transversely polarised proton and neutron targets)
- observe final state hadrons (semi-inclusive spin asymmetries; select quark flavours by tagging leading hadrons)

H1 and ZEUS

HERA Magnets inside Experiments



Synchrotron Radiation Shielding



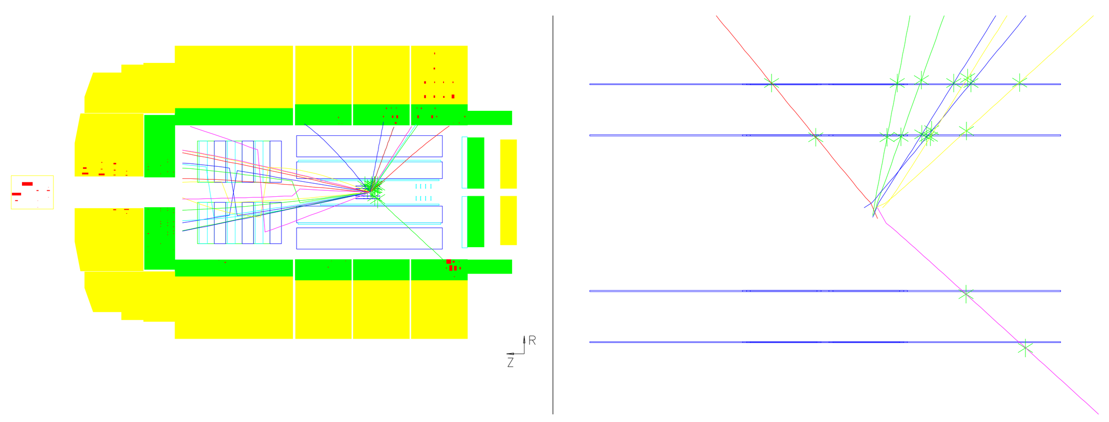
H1

Detector Upgrade Options

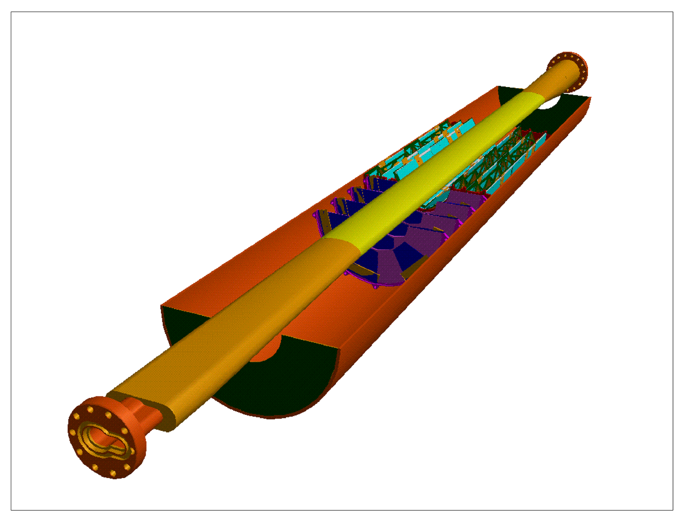
Robust z Vertex Chamber and Trigger

DAQ upgrade

Forward Tracking upgrade - complement existing Central & Backward Silicon Tracker



Forward and Central Silicon Tracker



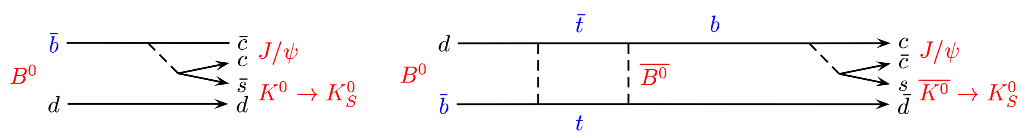
HERA-B - The CP Violation Experiment

Measure CP-violation in B-system

Measure asymmetry in the decay rates:

$$A_f = \frac{\Gamma(B^0\to f) - \Gamma(\bar{B}^0\to f)}{\Gamma(B^0\to f) + \Gamma(\bar{B}^0\to f)} = \sin(2\beta)\cdot\sin(xt/\tau)$$

CP-asymmetry occurs via interference of two decay amplitudes:



Try to fix two angles of the unitarity triangle with the decays:

$\sin 2\beta$: $B^0 \to J/\psi K^0_S$ $\quad$ $\sin 2\alpha$: $B^0 \to \pi^+\pi^-$

Need $4\cdot 10^{14}$ interactions (about 1 year of data taking) to detect 1500 events of the type $B^0 \to J/\psi K^0_S$.

Detector Principle