

# ELECTROWEAK RESULTS at HERA

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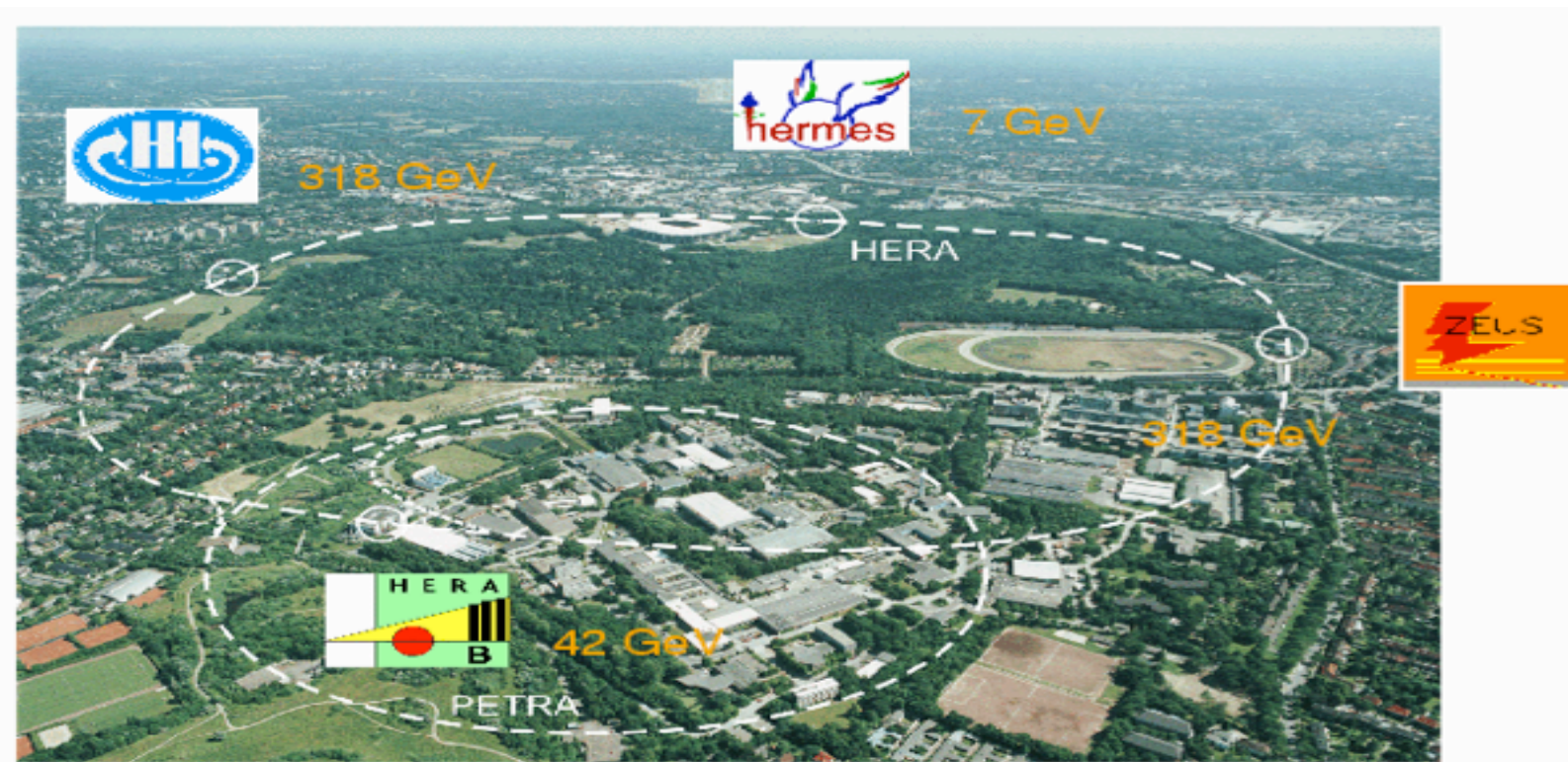
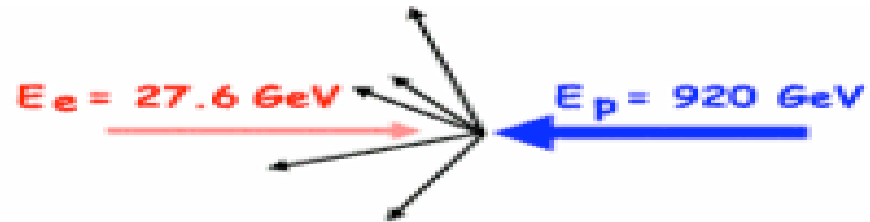
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# OUTLINE

HERA and Experiments  
Structure Function Data  
EW-STM + pdf`s  
W-Mass in CC  
U,d-quark couplings to Z  
Spin dependent Xsections  
High Pt unbalanced lepton events  
Limit on TOP with FCNC

# $E_p$ COLLIDER and EXPERIMENTS

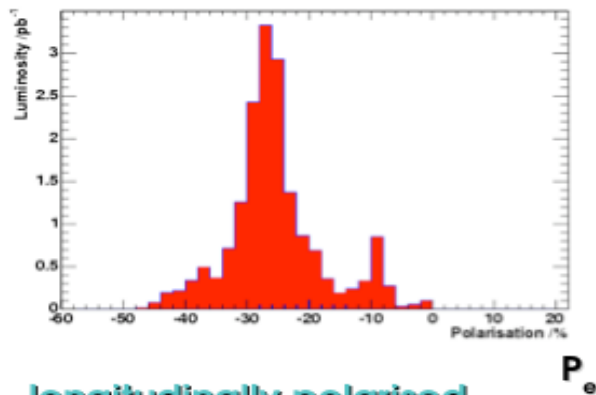


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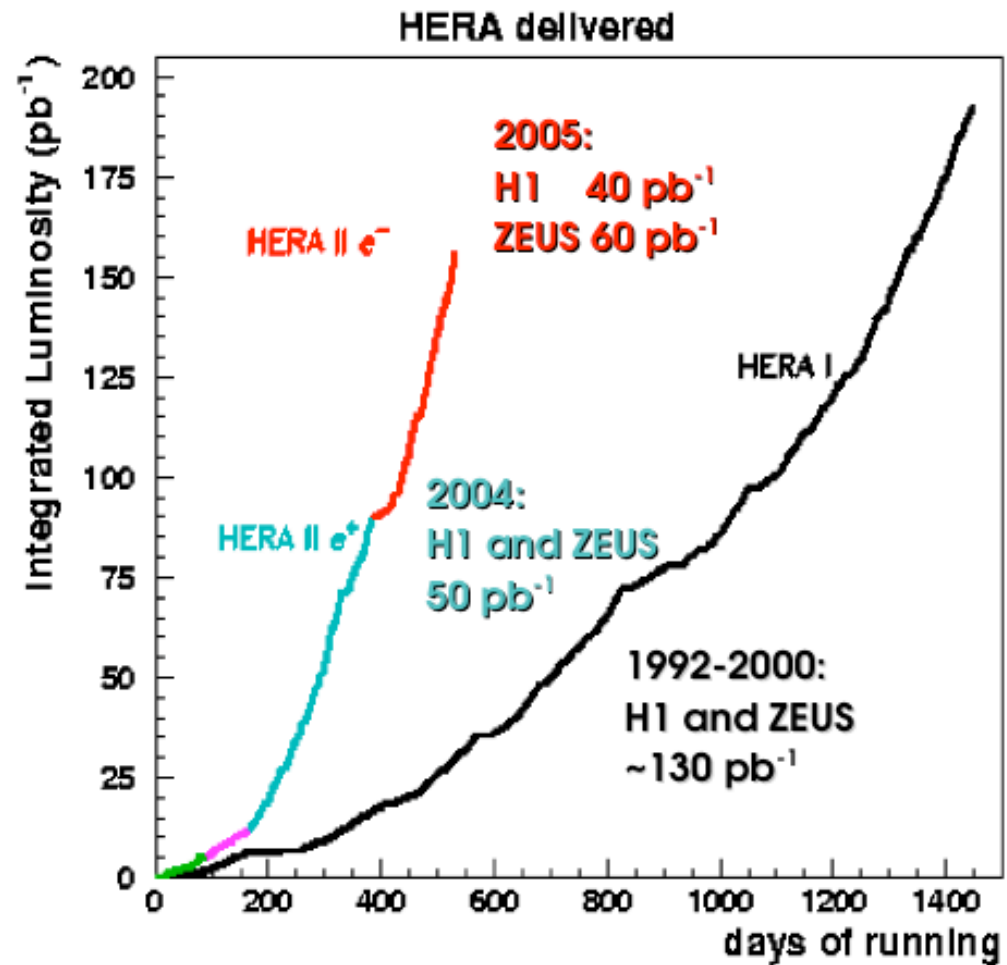
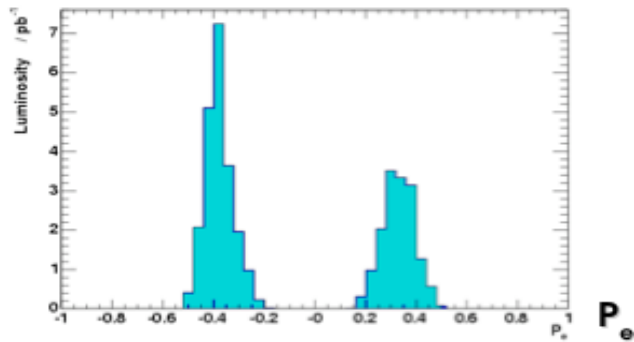
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# LUMINOSITY and POLARISATION

longitudinally polarised  
electron beam



longitudinally polarised  
positron beam

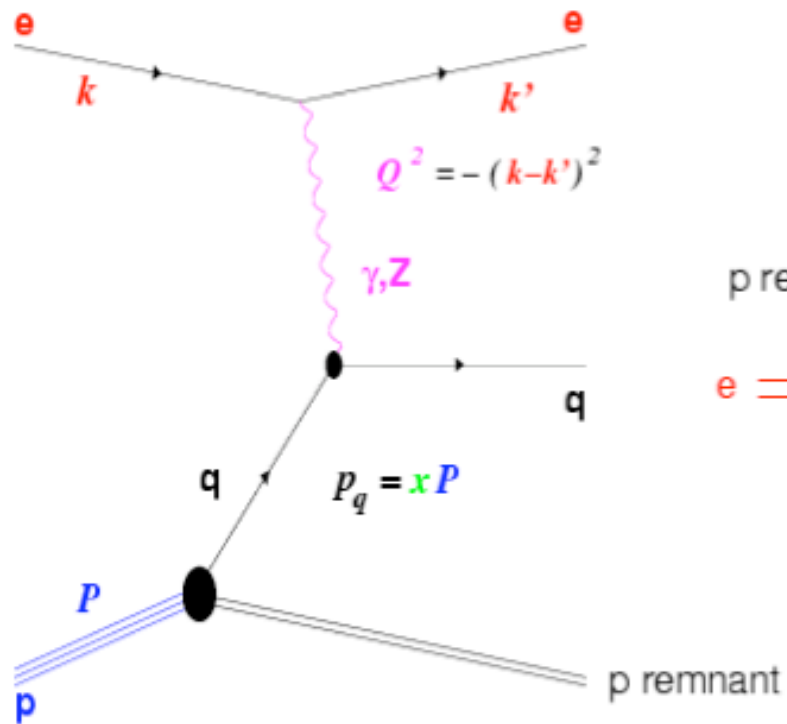


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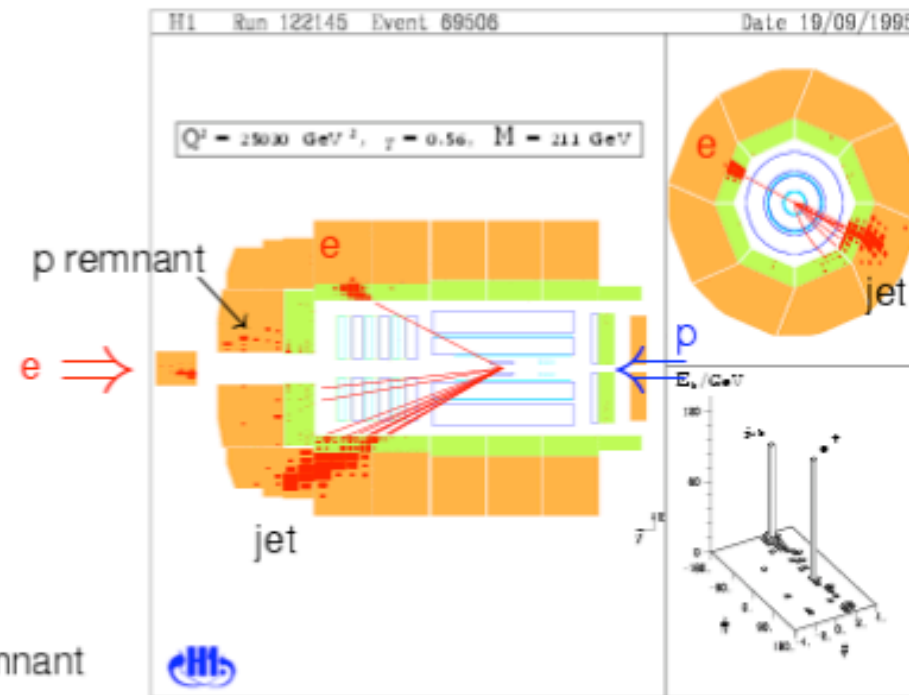
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# NEUTRAL CURRENT SCATTERING

deep inelastic scattering (DIS):

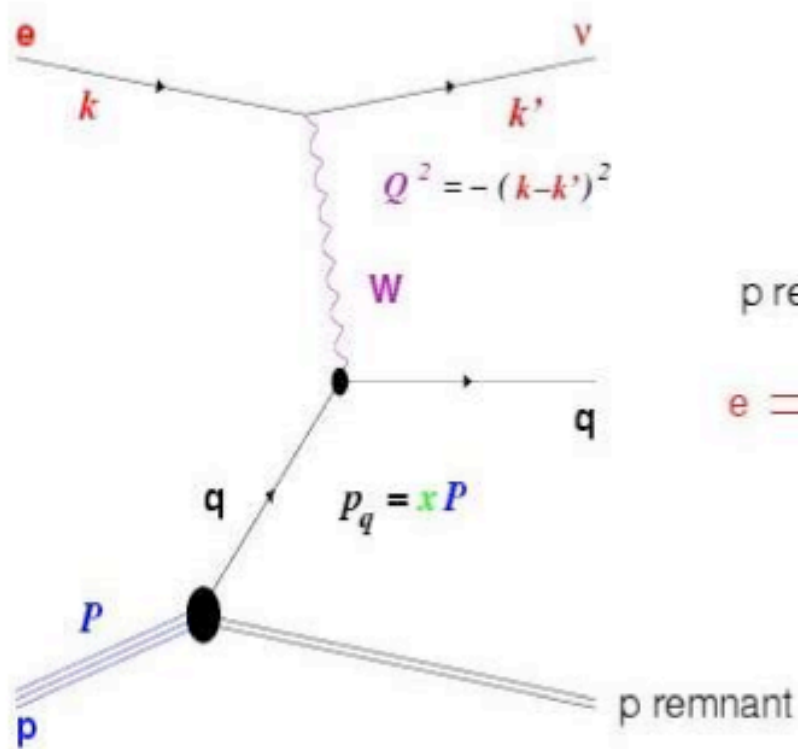


H1 detector

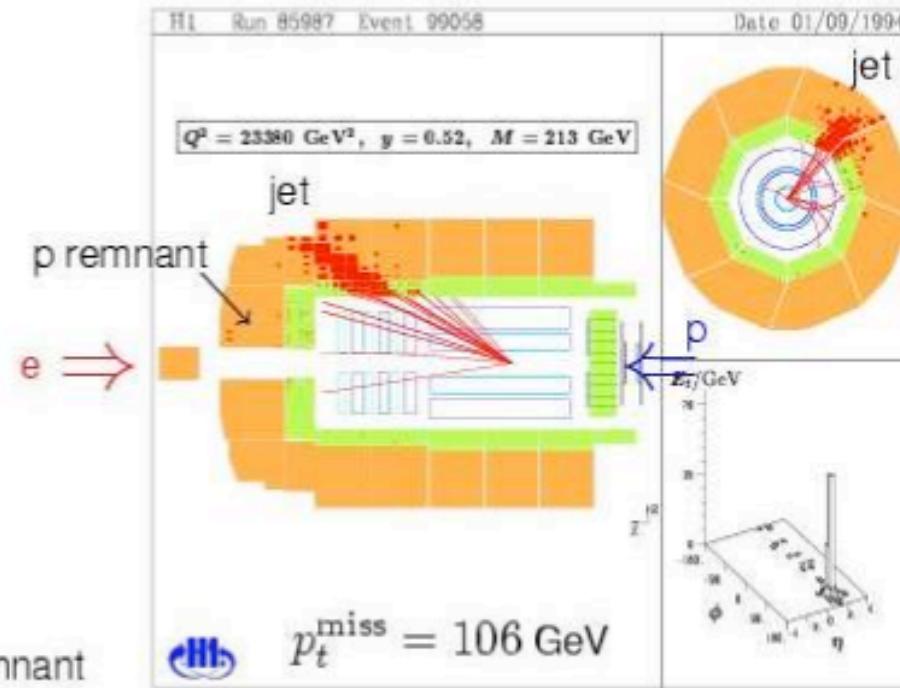


# CHARGED CURRENT SCATTERING

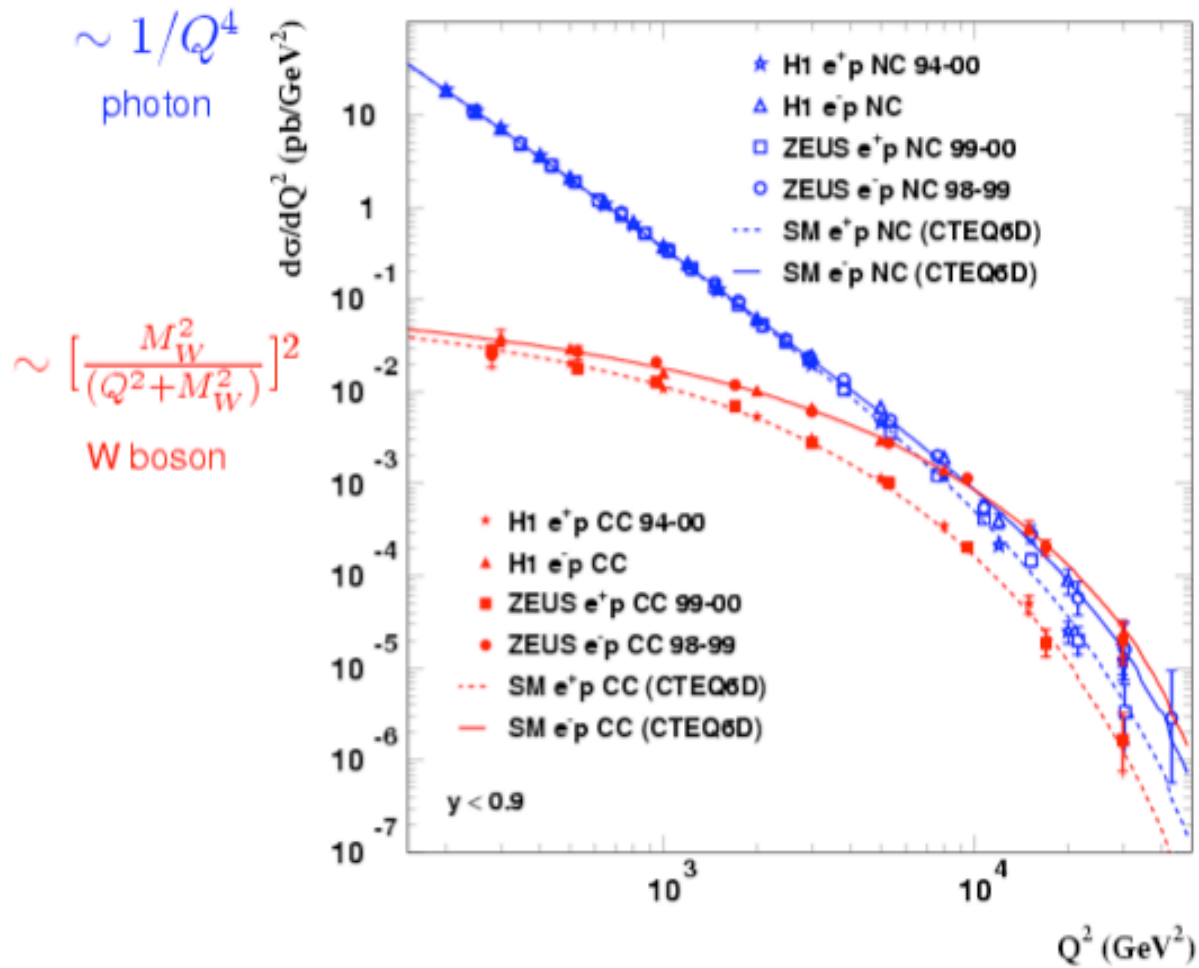
deep inelastic (DIS) scattering:



H1 detector

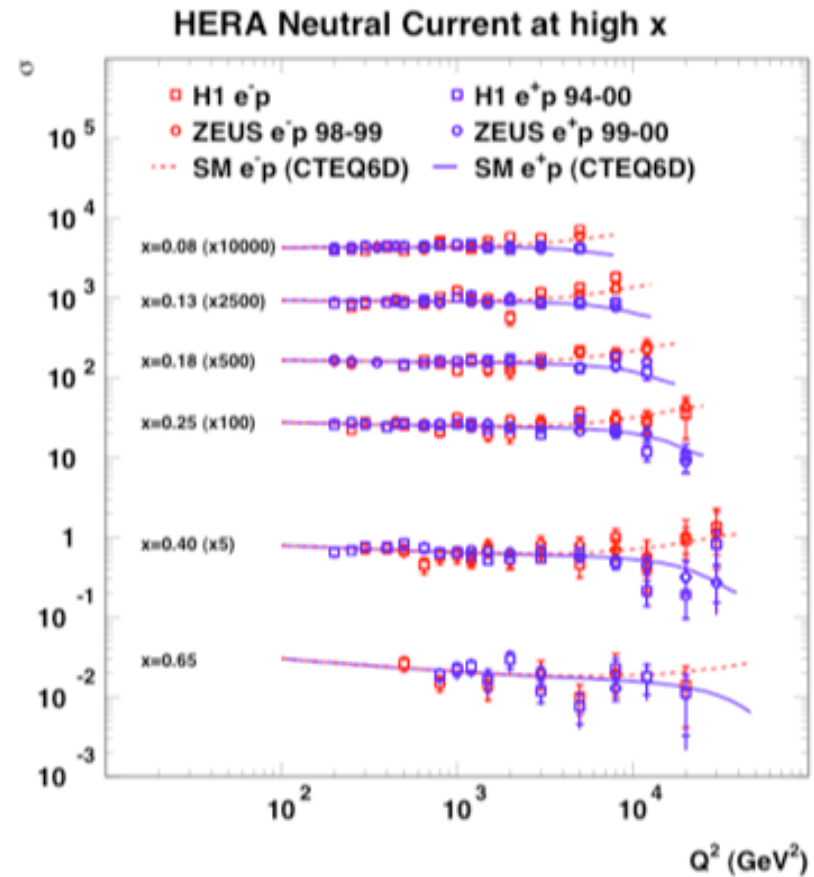
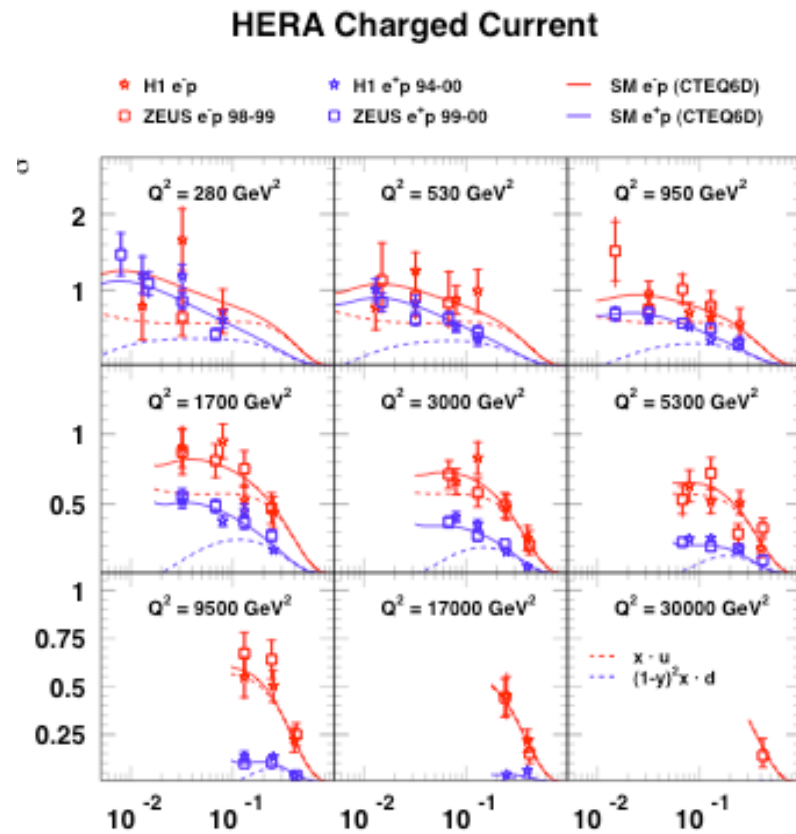


# CC and NC SCATTERING XSECTION



unification of  
 electromagnetic and  
 weak interactions

# HERA CC and NC DATA





# CC XSECTION + STANDARD MODEL

$$\frac{d^2\sigma_{cc}^{\pm}}{dx dQ^2} = \frac{G^2}{2\pi} \cdot \left( \frac{M_W^2}{Q^2 + M_W^2} \right)^2 \cdot \Phi^{\pm}(pdfs)$$

$M_W$  is propagator mass (enters in  $Q^2$  dependency)  
Fermi constant  $G$  includes most of the radiative corrections

$$\frac{d^2\sigma_{cc}^{\pm}}{dx dQ^2} = \frac{\pi\alpha^2}{4M_W^4 \left(1 - \frac{M_W^2}{M_Z^2}\right)^2} \cdot \frac{1}{|1 - \Delta r|^2} \cdot \left( \frac{M_W^2}{Q^2 + M_W^2} \right)^2 \cdot \Phi^{\pm}(pdfs)$$

OMS scheme :  $M_W$  also enters in normalization  
Radiative correction  $\Delta r$  computed in SM framework

# W Propagator Self Energy

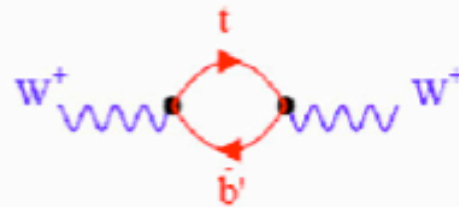
$$\Delta r = \Delta\alpha - \frac{c_W^2}{s_W^2} \Delta\rho + \Delta r_{rem}$$

$\Delta\alpha_{lept}$   
Computable

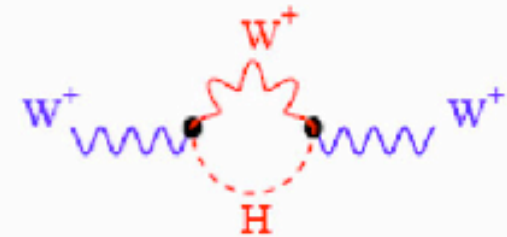
$\Delta\alpha_{quarks}$

Hadronic photon  
Vacuum polarization  
Not computable  
Parameterized with  
e+e- data

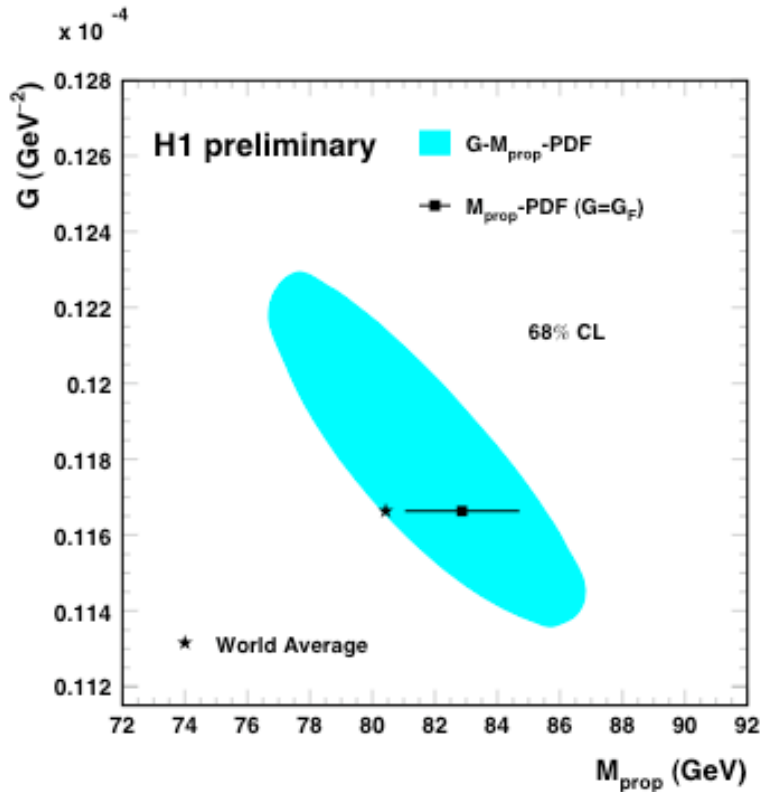
$\Delta\rho^{top} \propto M_{top}^2$



$\Delta r_{rem}^{Higgs} \propto \ln M_{Higgs}$



# W-MASS from PROPAGATOR



*G-Mprop-QCD fit*

➔ fix  $G_F$  to the SM value and fit propagator mass with pdfs

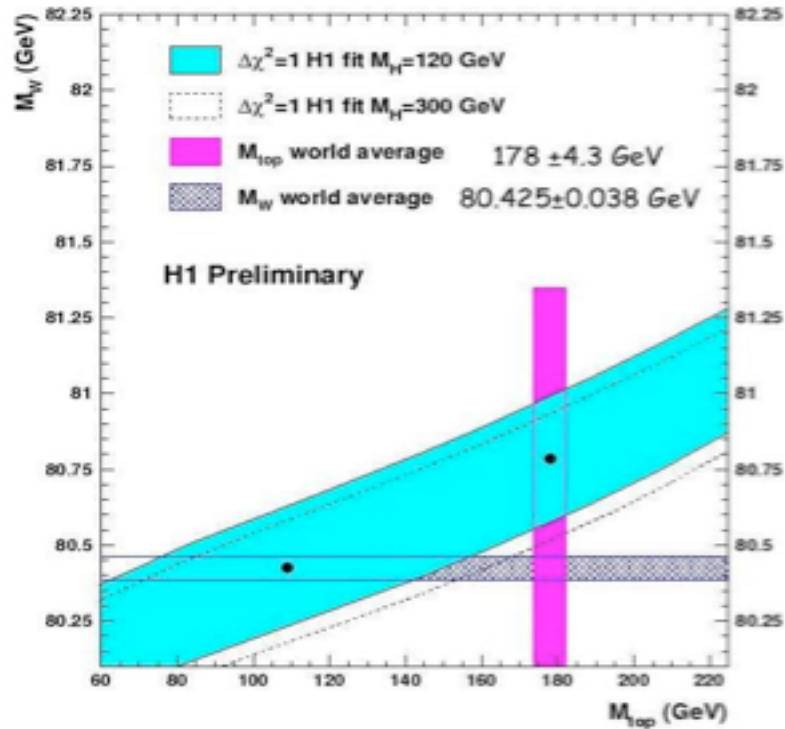
Pdfs fixed to H1PDF2000 fit  
 $M_w = 82.370 \pm 1.572 \text{ GeV}$

Fit of pdfs +  $M_w$  (as the propagator mass)

$$M_W = 82.87 \pm 1.83 (\text{exp})^{+0.30}_{-0.16} (\text{mod}) \text{ GeV}$$

Model uncertainties ( $\alpha_s, Q_0^2, \dots$ )

# STANDARD MODEL OMS SCHEME



$$M_W = 80.786 \pm 0.207(\text{exp})^{+0.048}_{-0.029}(\text{mod}) \pm 0.025(\text{top})$$

$$\pm 0.033(\text{th}) - 0.084(\text{Higgs}) \text{ GeV}$$

(120 → 300 GeV)

$$\Rightarrow \sin^2 \theta_W = 0.2151 \pm 0.0040(\text{exp})^{+0.0019}_{-0.0011}(\text{th})$$

# QUARK COUPLINGS to Z and DIS



$$\frac{ig}{\cos\theta_W} \gamma^\mu \frac{v_q - a_q \gamma^5}{2}$$

$$a_q = I_3^L \quad \text{Axial coupling, } I^3 = +1/2 \text{ for u, } -1/2 \text{ for d}$$

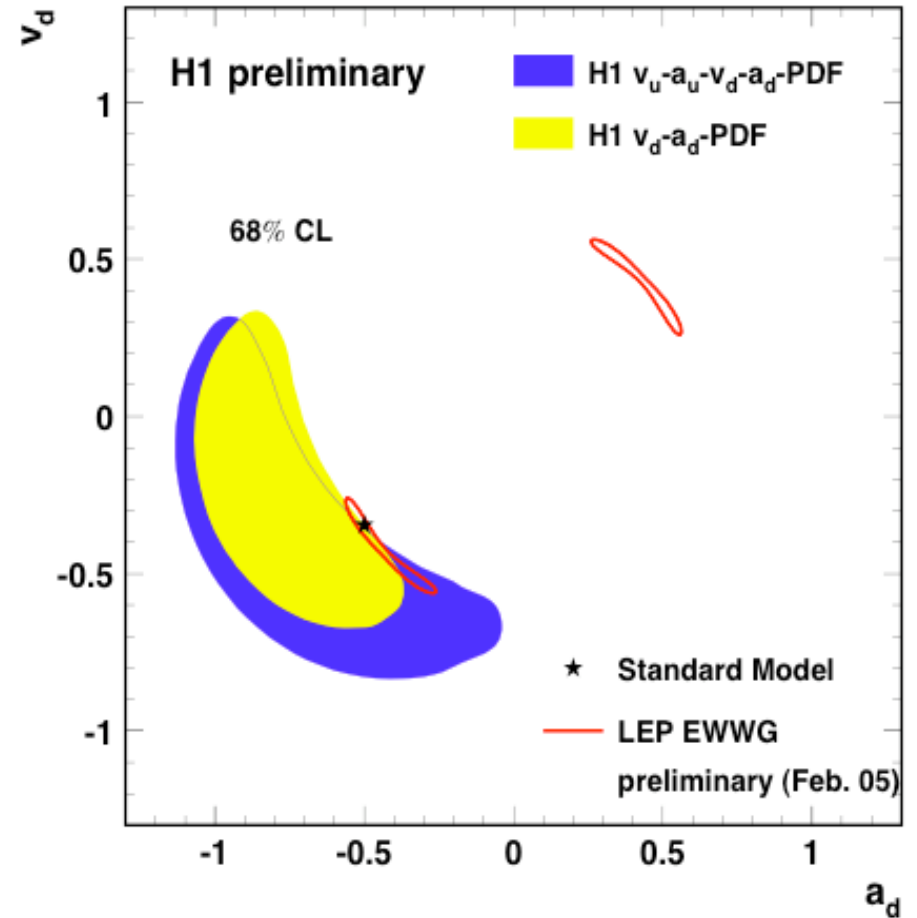
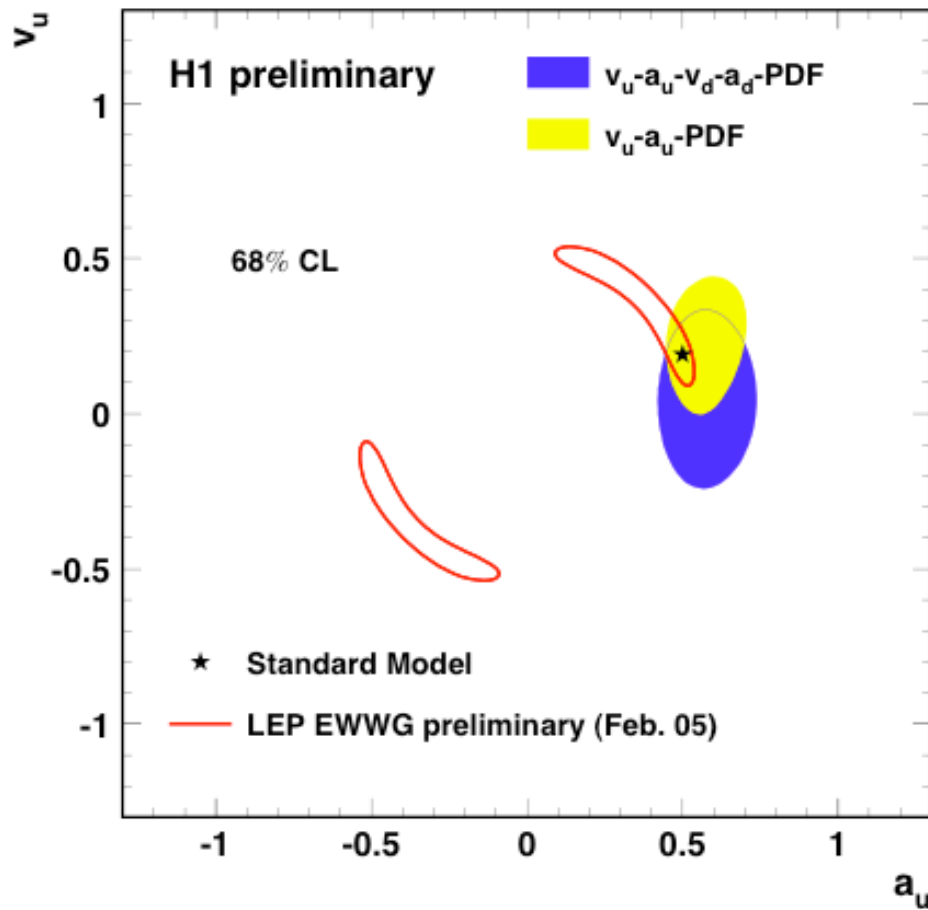
$$v_q = I_3^L - 2e_q \sin^2 \theta_W \quad \text{Vector coupling}$$

$$F_2 = \sum_q \left[ e_q^2 - 2e_q v_q v_e \chi_Z + |v_q^2 + a_q^2| |v_e^2 + a_e^2| \chi_Z^2 \right] x(q + \bar{q})$$

$$xF_3 = \sum_q \left[ -2e_q a_q a_e \chi_Z + 4v_q a_q v_e a_e \chi_Z^2 \right] x(q - \bar{q})$$

➡ Determination of the four  $a_U, v_U, a_D, v_D$

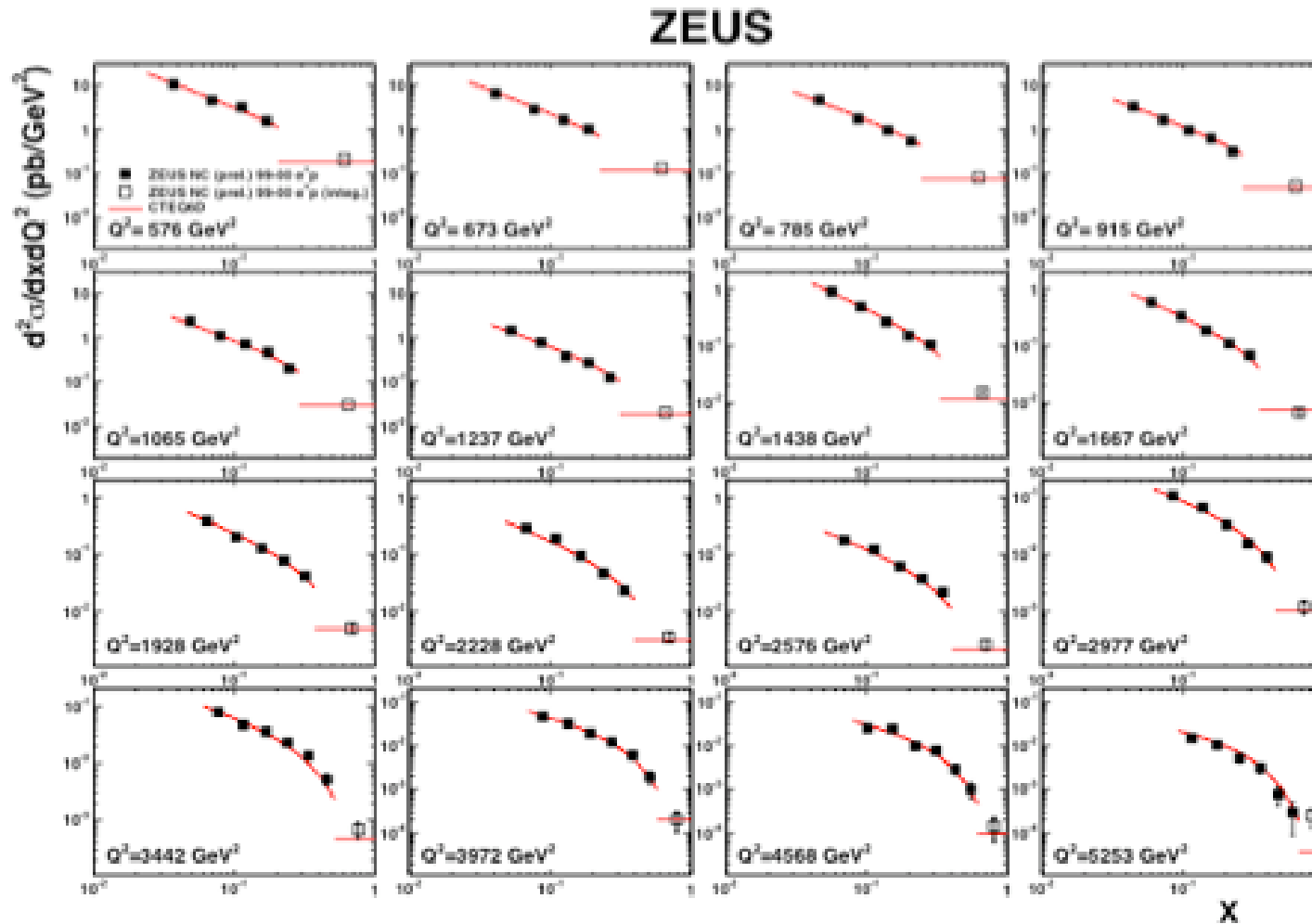
# RESULTS on U and D QUARKS



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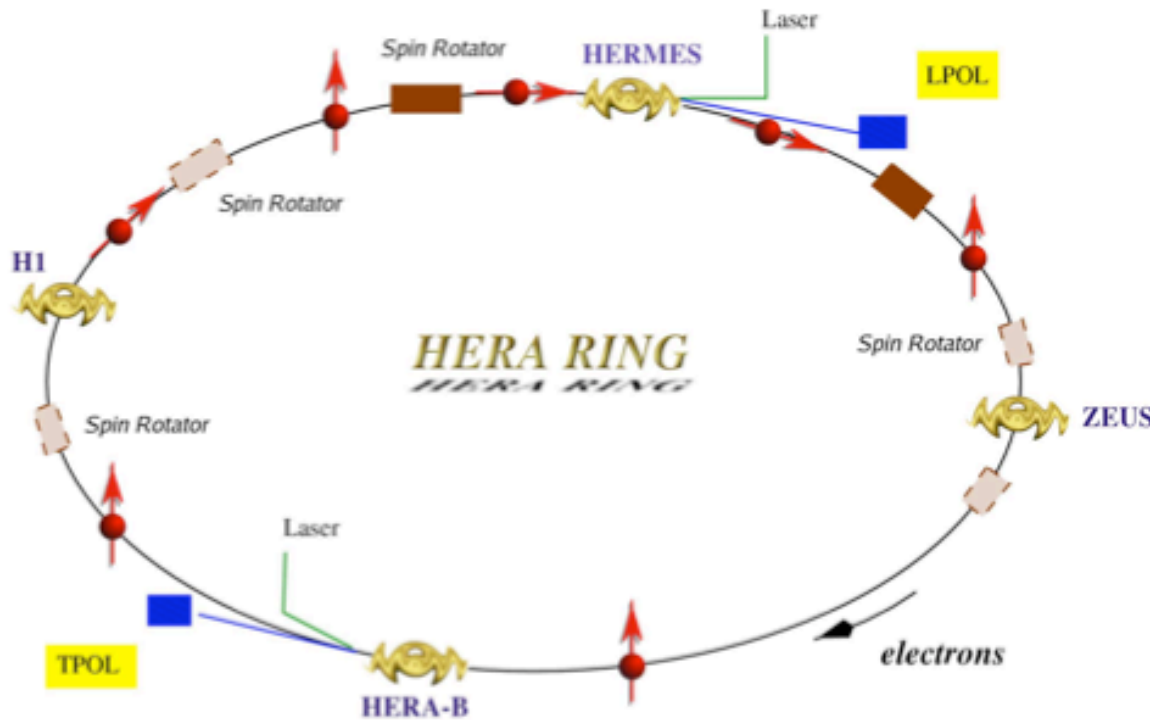
# NC at large X Improvement ZEUS



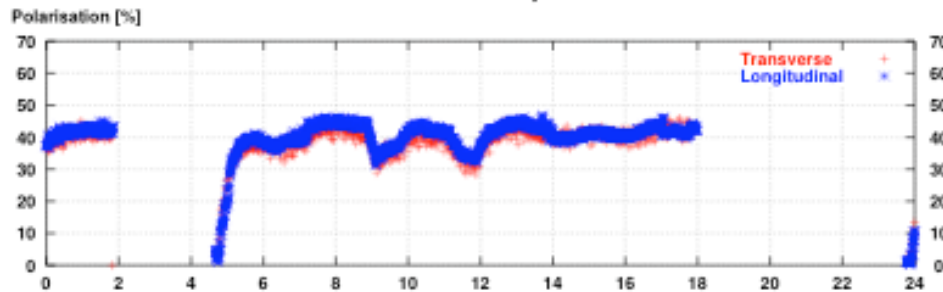
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# POLARISATION at HERA



HERA-e Polarisation on Saturday November 29 2003



- Sokolov-Ternov effect  
→ Lepton beam has transverse polarisation

- Spin rotator before/after the HI/ZEUS/HERMES detectors

Polarisation:

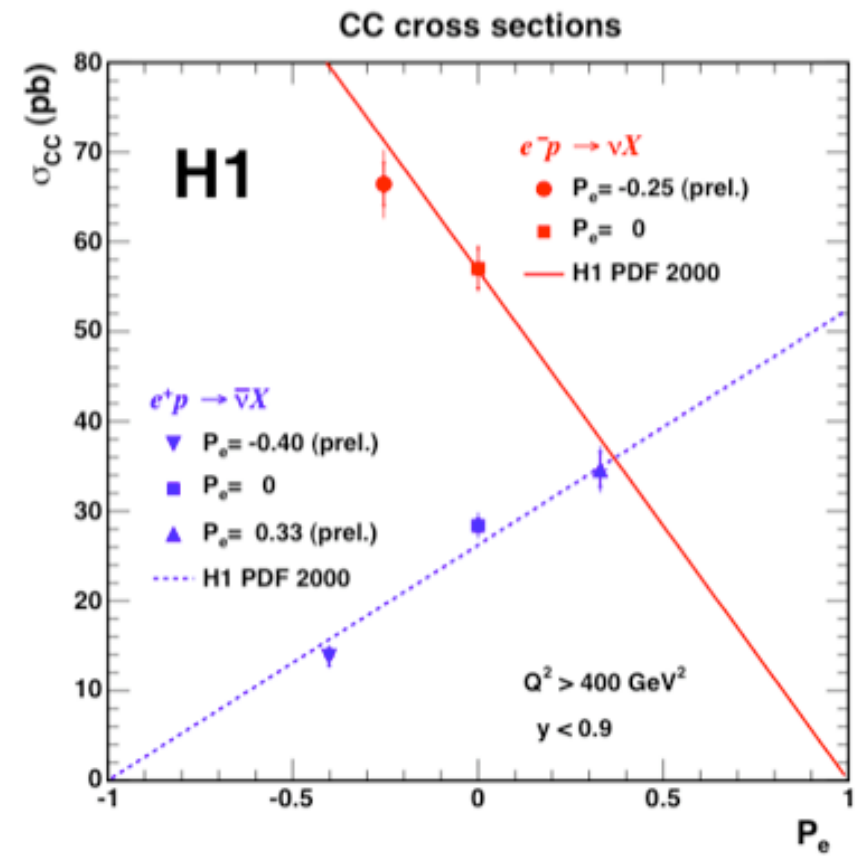
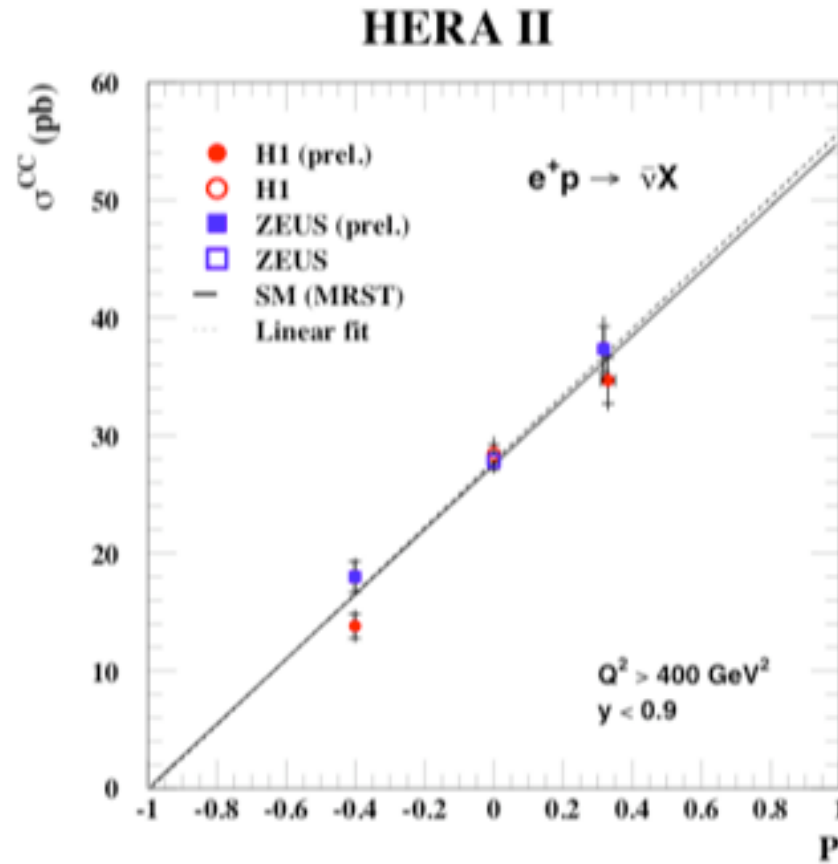
$$P = \frac{N_{RH} - N_{LH}}{N_{RH} + N_{LH}}$$

- Typical HERA II polarisation is 40%, built-up time 30 minutes

- Monitoring by two independent Compton polarimeters

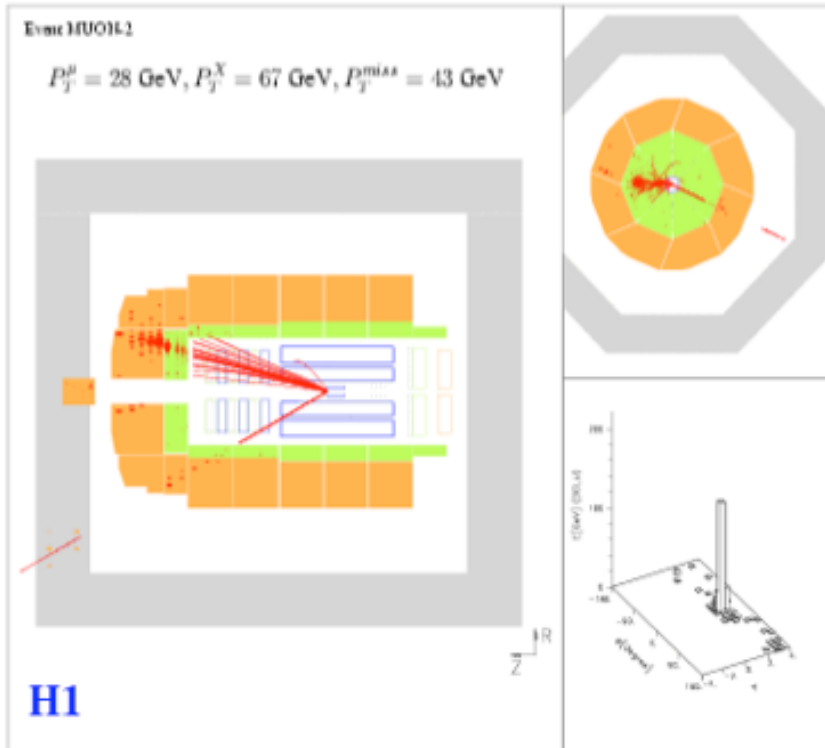


# HERA SPIN DEP. XSECTION



# HIGH Pt unbalanced LEPTON Events

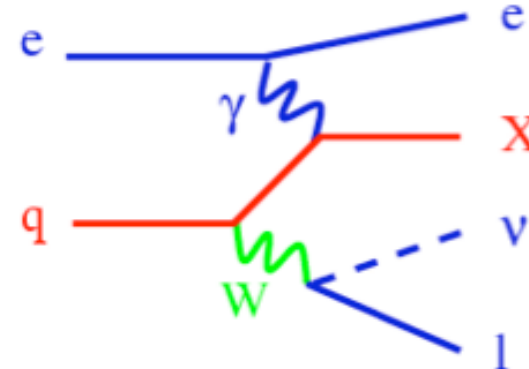
$$e^+p \rightarrow \mu^+X + PT_{miss}$$



- isolated lepton (e or  $\mu$ )
- high hadronic  $p_T$
- missing calorimeter  $p_T$

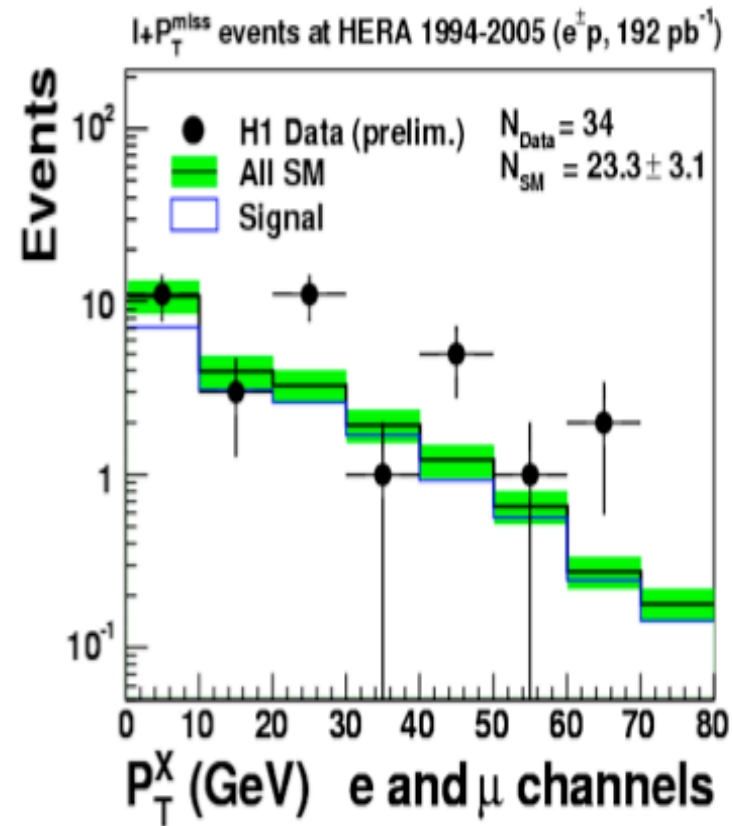
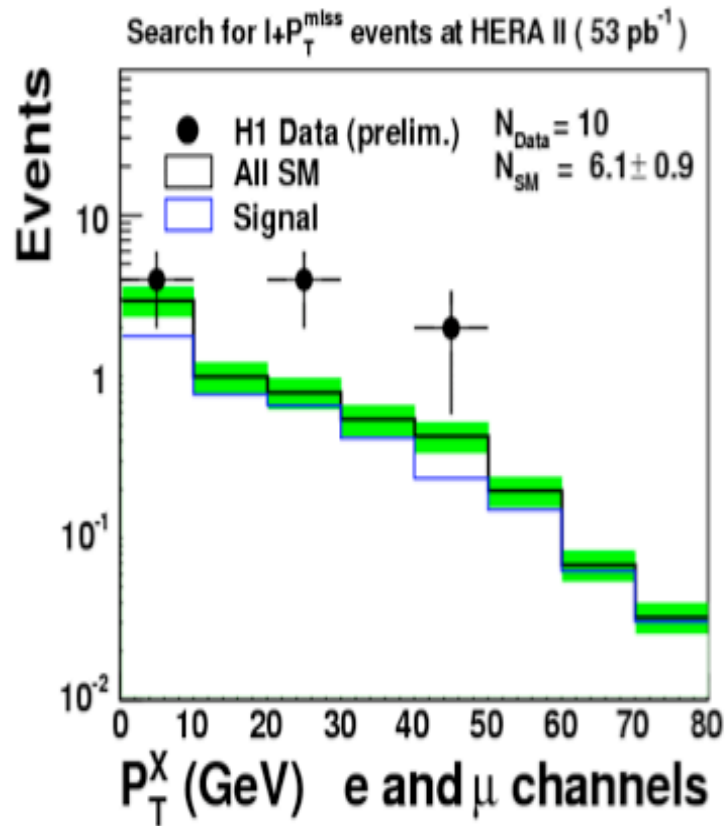
Standard Model:

dominated by W production



**in NLO-QCD: Diener, C.S., Spira**  
**Eur. Phys. J C 25 (2002) 405**

# Unbalanced LEPTON EVENTS



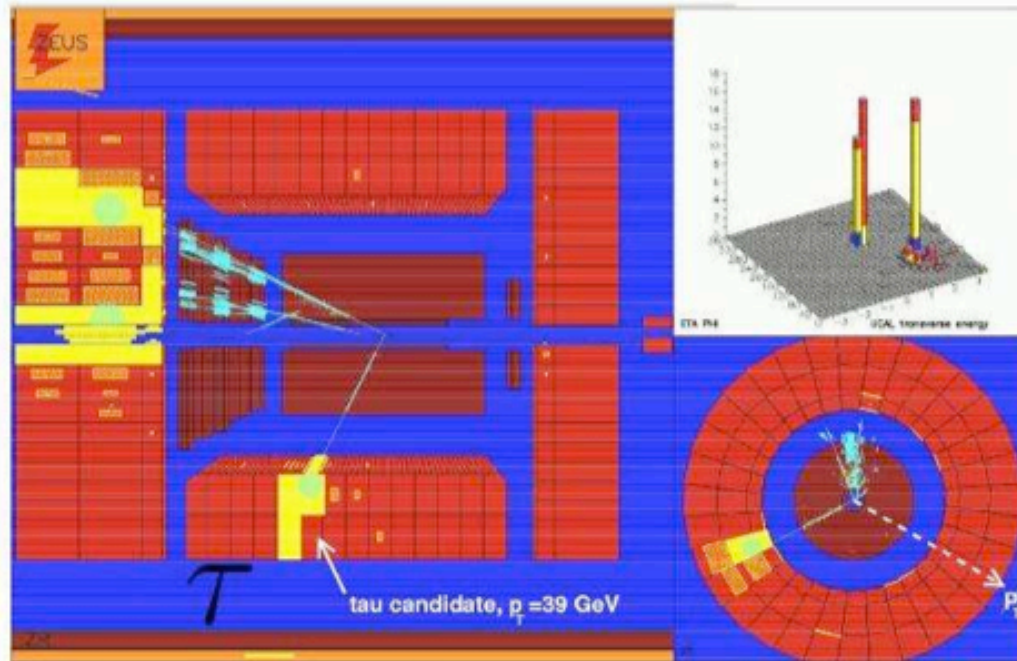
# H1 and ZEUS RESULTS

<b>H1 1994-2005</b> $\mathcal{L}(e^\pm p) = 192 \text{ pb}^{-1}$	Electron obs./exp.	Muon obs./exp.	Tau <sup>prel.</sup> obs./exp.	$W$ contrib. $e\mu(\tau)$
Full sample	25/18.4 $\pm 2.5$	9/4.9 $\pm 0.8$	5 / 5.81 $\pm 1.36$	$\approx 75(15)\%$
$P_T^X > 25 \text{ GeV}$	11/2.9 $\pm 0.6$	6/2.9 $\pm 0.6$	0 / 0.53 $\pm 0.10$	$\approx 85(50)\%$

<b>ZEUS 1994-2000</b> $\mathcal{L}(e^\pm p) = 130 \text{ pb}^{-1}$	Electron obs./exp.	Muon obs./exp.	Tau obs./exp.	$W$ contrib. $e\mu(\tau)$
Full sample	24 / 20.6 $\pm 3.2$	12 / 11.9 $\pm 0.6$	3 / 0.4 $\pm 0.12$	$\approx 17(48)\%$
$P_T^X > 25 \text{ GeV}$	2 / 2.9 $\pm 0.46$	5 / 2.75 $\pm 0.21$	2 / 0.2 $\pm 0.05$	$\approx 50(50)\%$

# ZEUS Tau EVENT

## Example of Tau Candidate

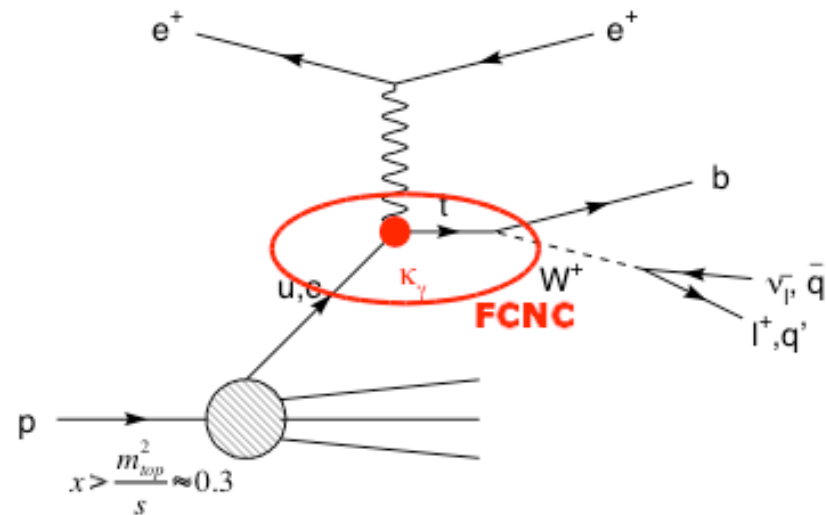


$$P_T^{CAL} = 39 \text{ GeV} \quad P_T^X = 37 \text{ GeV} \quad M_\tau = 68 \text{ GeV}$$

$\tau$  jet: collimated "pencil like"

# Single TOP PRODUCTION?

Motivation: explains the large hadronic Transverse Momenta observed in the “Isolated Lepton” Events as  $P_T$  of b-Jets resulting from  $t \rightarrow bW$  Decays



- SM single top Production highly suppressed ( $\sigma < 1\text{fb}$ )
- **Flavour-Changing Neutral Current** (FCNC) Interactions may yield observable Cross-Sections

# LIMITS on FCNC TOP

## Semi-leptonic Channel

$$\sigma = 0.41^{+0.29}_{-0.19} \text{ pb}$$

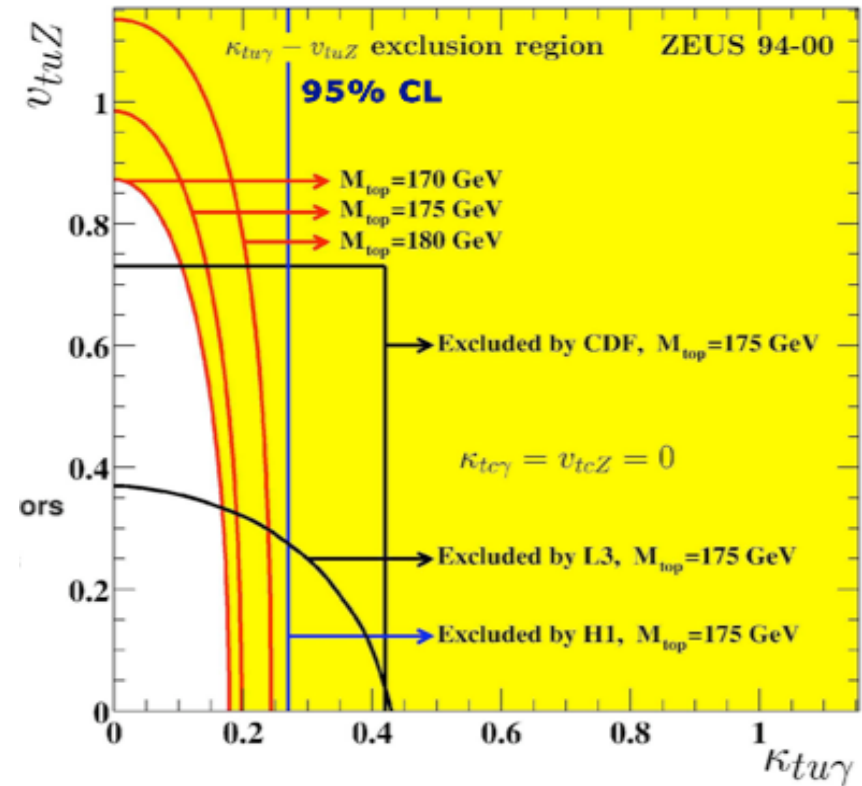
## Hadronic Channel

$$\sigma = 0.04^{+0.27}_{-0.23} \text{ pb}$$

## Combined Channel.

$$\sigma = 0.29^{+0.15}_{-0.14} \text{ pb}$$

$$K_{tu\gamma} = 0.20^{+0.05}_{-0.06}$$



→ These Limits do not exclude the Interpretation of the “Isolated Lepton” Events as resulting from Decays of single top Quarks produced by FCNC Interactions

# SUMMARY

Pdf determination at HERA + EW

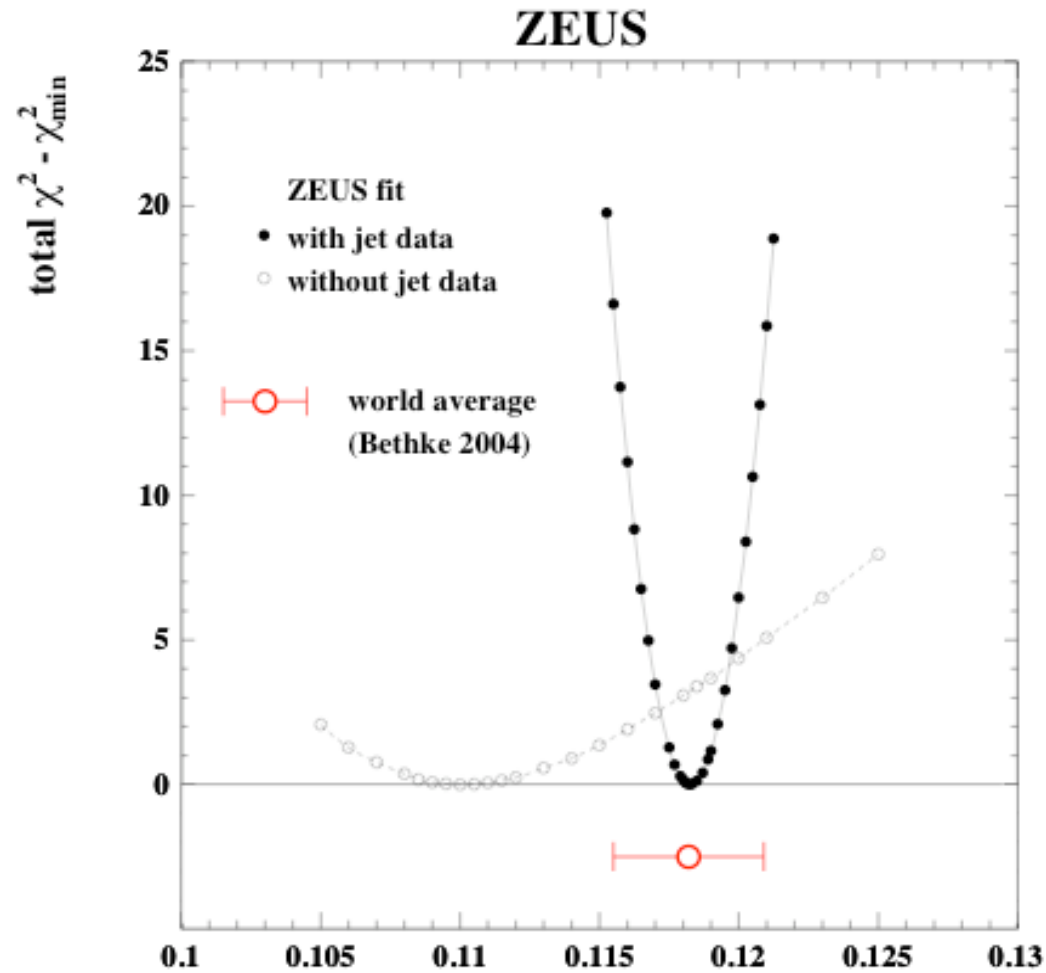
QCD part and EW fitted together

Polarisation will help to improve

Low rate unbalanced lepton events  
are still coming in



# Alpha-S Determination



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