# First Measurement of the Charged Current Interactions with Polarised Leptons at



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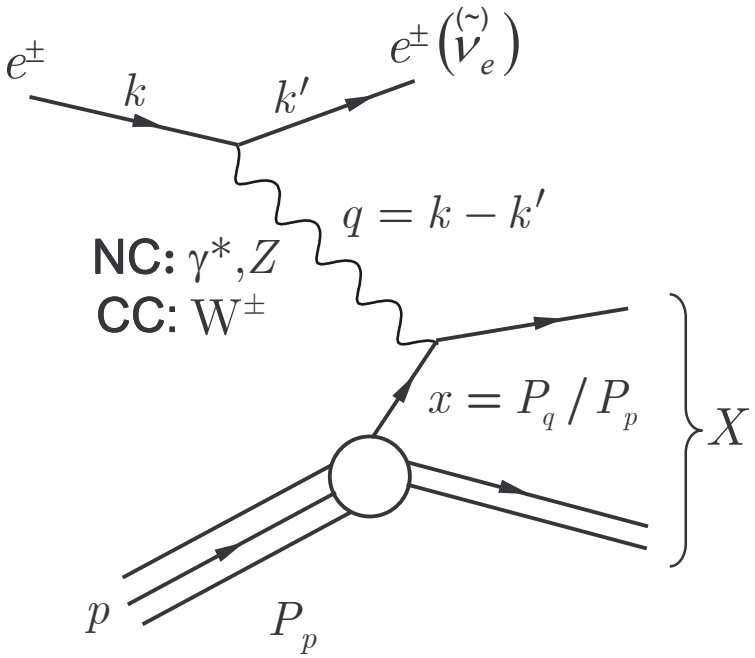
- Deep Inelastic Scattering and Charged Current
- HERA and H1 experiment
- HERA I results
- HERA II:
  - Charged Current analysis
  - First measurement of the polarisation dependence on the CC cross section
- Summary and outlook

# Deep Inelastic Scattering




## Kinematics of inclusive scattering:

4-momentum transfer squared:

$$Q^2 = -q^2$$

Bjorken scaling variable:

$$x = Q^2 / (2P \cdot q)$$

Inelasticity:

$$y = q \cdot P / (k \cdot P)$$

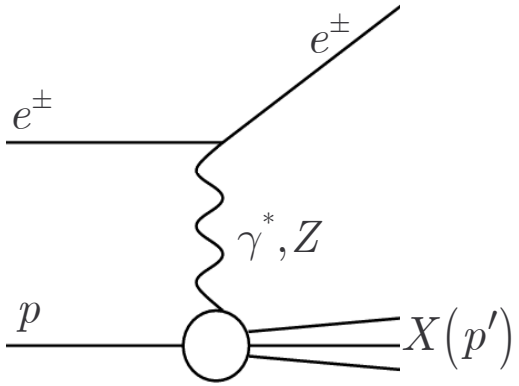
where: $Q^2 = xys$

$\sqrt{s}$ - center of mass energy

NC: kinematics from $e^{\pm}$

CC: kinematics from hadronic final state

# NC $ep \to eX$




$$\phi^{\pm}_{NC} = \left[ Y_{+} \tilde{F}_{2}\left(x,Q^{2}\right) - y^{2} \tilde{F}_{L}\left(x,Q^{2}\right) \mp Y_{-} x \tilde{F}_{3}\left(x,Q^{2}\right) \right]$$

$$Y_{\pm} = 1 \pm (1-y)^{2}$$

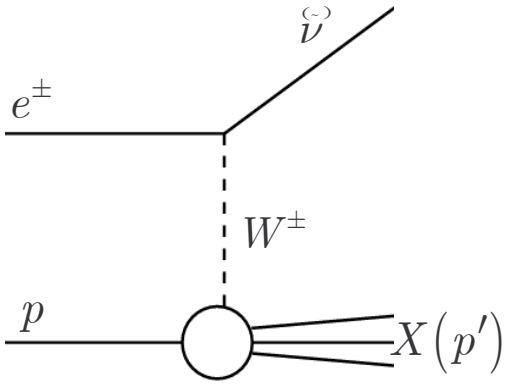
$$\frac{d^{2}\sigma^{e^{\pm}p}_{NC}}{dxdQ^{2}} = \frac{2\pi\alpha^{2}}{x}\left[\frac{1}{Q^{2}}\right]^{2} \phi^{\pm}_{NC}$$

Generalised structure functions:

$$\tilde{F}_{2} \sim \sum x\{q + \bar{q}\}$$

$$x\tilde{F}_{3} \sim \sum x\{q - \bar{q}\}$$

# CC $ep \to \nu X$

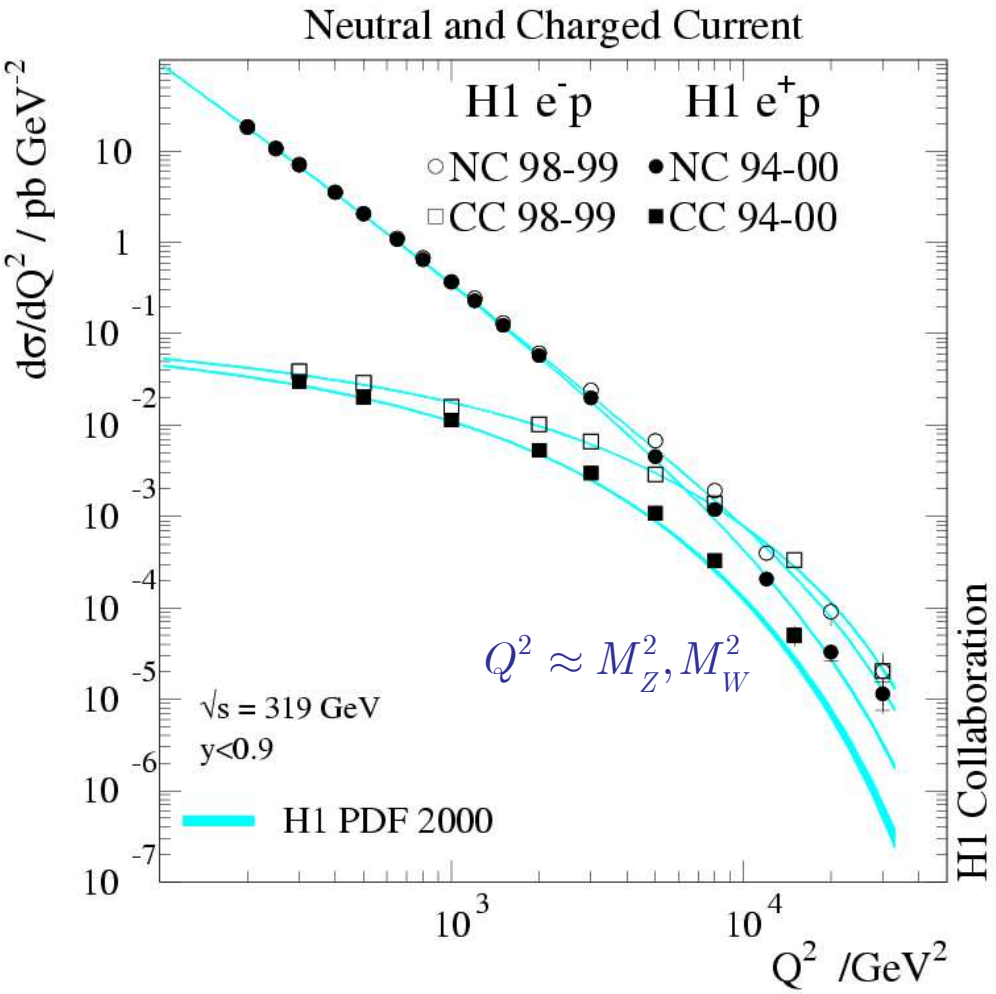



$$\frac{d^{2}\sigma^{e^{\pm}p}_{CC}}{dxdQ^{2}} = \frac{G_{F}^{2}}{2\pi x}\left[\frac{M_{W}^{2}}{Q^{2}+M_{W}^{2}}\right]^{2} \phi^{\pm}_{CC}$$

$$\phi^{+}_{CC} = x[\bar{u} + \bar{c}] + (1-y)^{2} x[d + s]$$

$$\phi^{-}_{CC} = x[u + c] + (1-y)^{2} x[\bar{d} + \bar{s}]$$

# NC and CC: high $Q^2$ electroweak unification




**NC:**

$$\frac{d^2\sigma_{NC}^{e^{\pm}p}}{dxdQ^2} = \frac{2\pi\alpha^2}{x}\left[\frac{1}{Q^2}\right]^2 \phi_{NC}^{\pm}$$

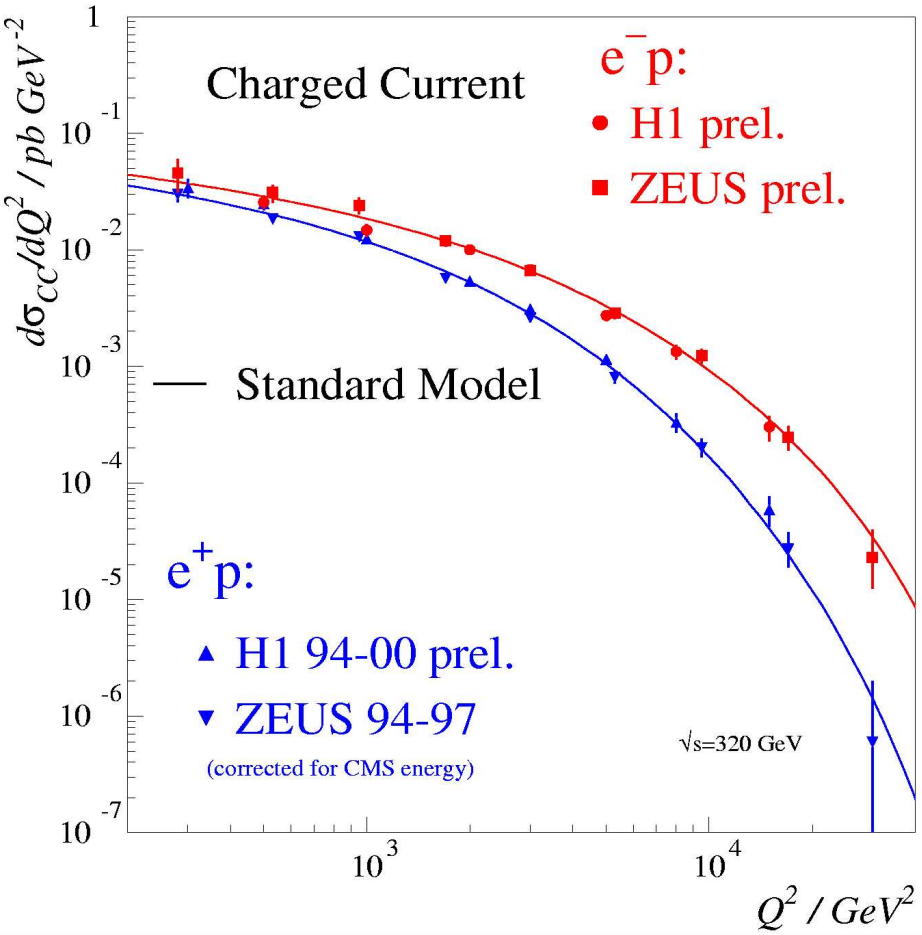
**CC:**

$$\frac{d^2\sigma_{CC}^{e^{\pm}p}}{dxdQ^2} = \frac{\pi\alpha^2}{4x\sin^4\Theta_W}\left[\frac{1}{Q^2+M_W^2}\right]^2 \phi_{CC}^{\pm}$$

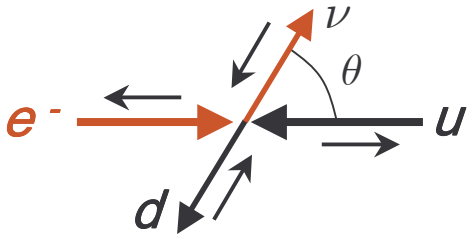
**Unification of weak and electromagnetic forces**

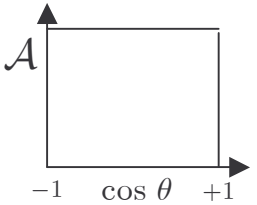
# CC Cross Section at high $Q^2$ and the valence quarks

**$e^+$ and $e^-$ cross sections are different !**

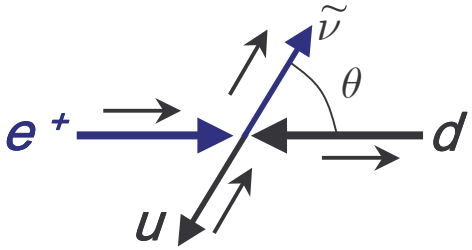


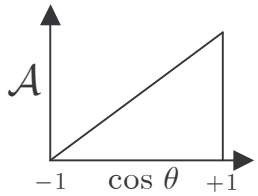

$$\sigma_{CC}(e^- p) \sim \left(\frac{M_W^2}{M_W^2 + Q^2}\right)^2 \left[(1-y)^2(\bar{d} + \bar{s}) + (u + c)\right]$$



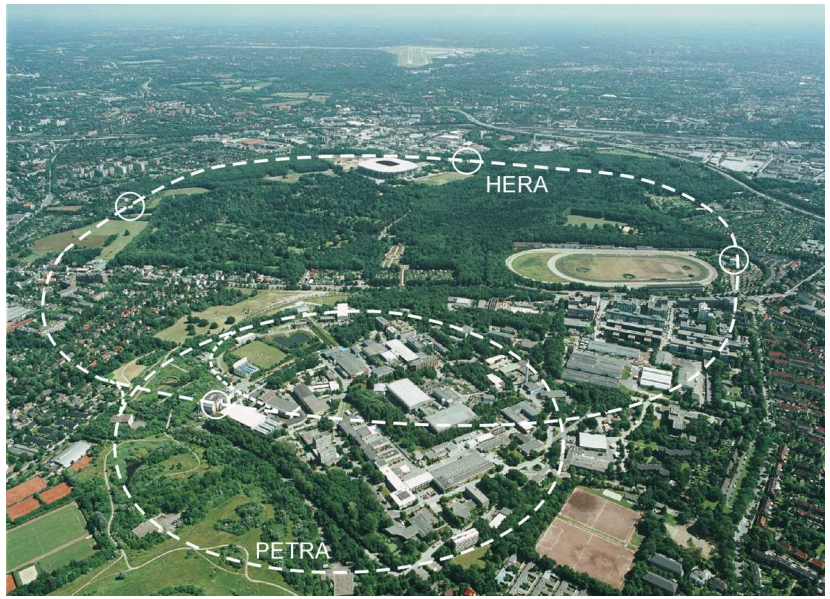

$$\sigma_{CC}(e^+ p) \sim \left(\frac{M_W^2}{M_W^2 + Q^2}\right)^2 \left[(1-y)^2(d + s) + (\bar{u} + \bar{c})\right]$$

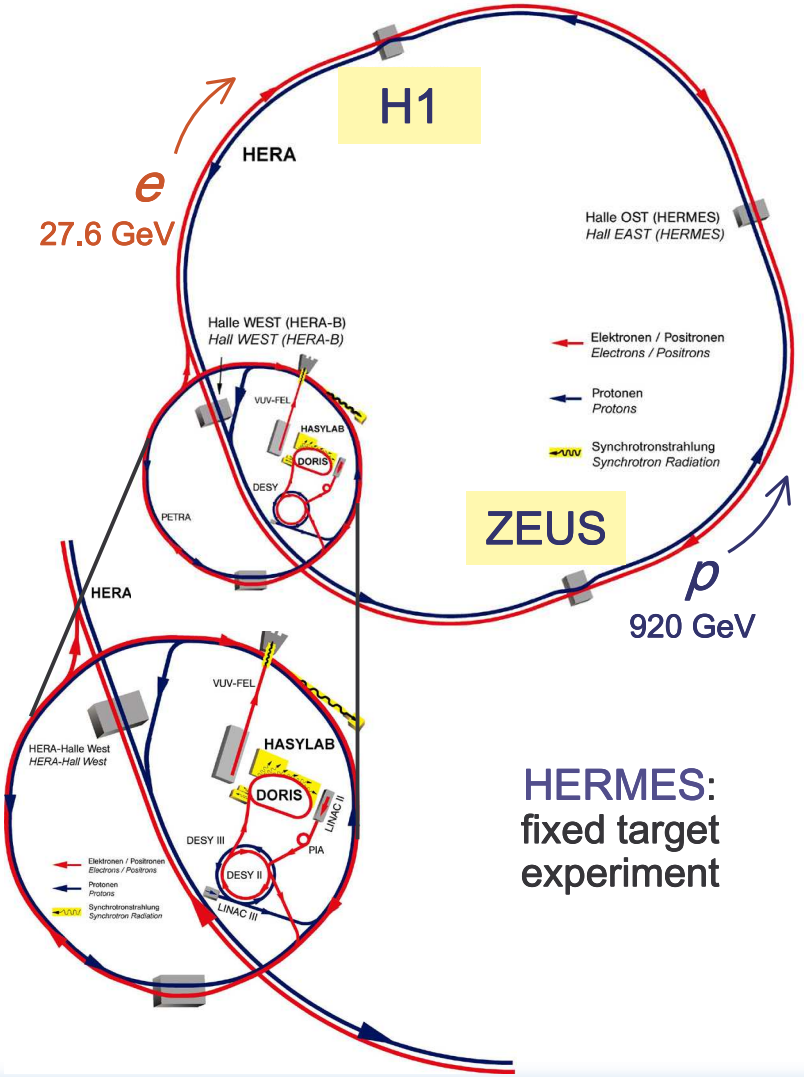


# DIS: *ep* scattering above 1 GeV$^2$ of $Q^2$
## both contributions NC and CC - measured at HERA:

HERA (Hadron Electron Ring Anlage)
DESY 1992, Hamburg: 6.3 km circumference



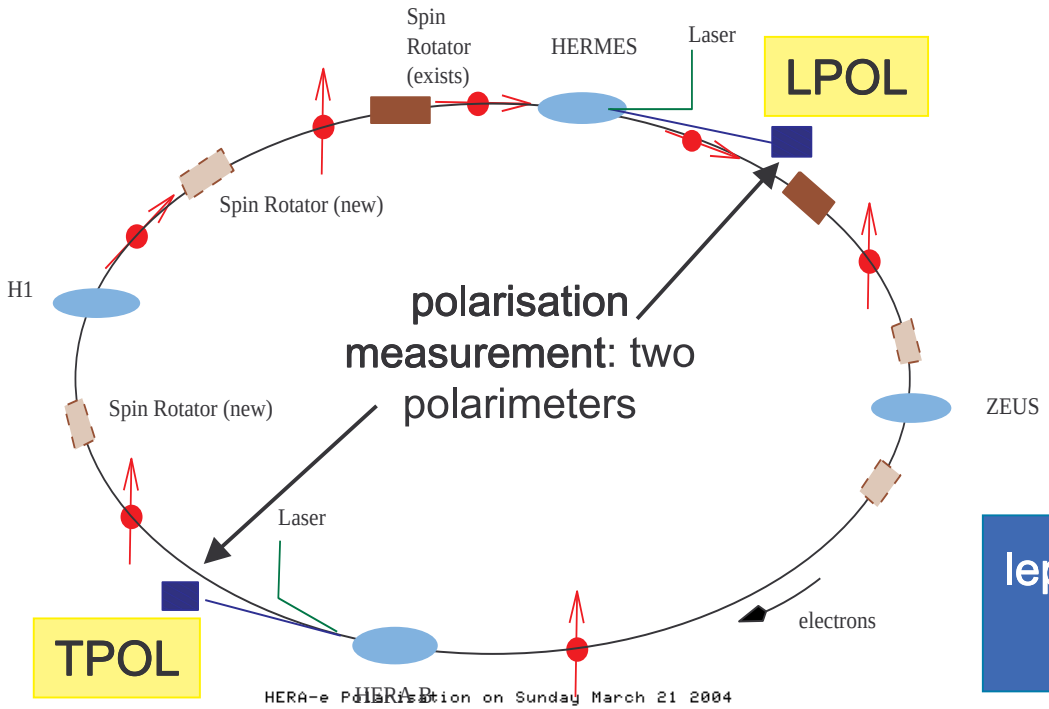

H1 and ZEUS: experiments to investigate high-energy *ep* collisions

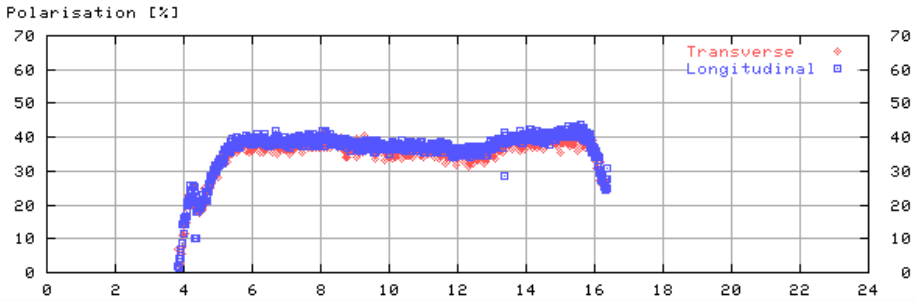
HERMES: fixed target experiment

# HERA II: polarized leptons

## Longitudinally polarized lepton beam →

study of electroweak interactions, spin structure functions, physics beyond the SM



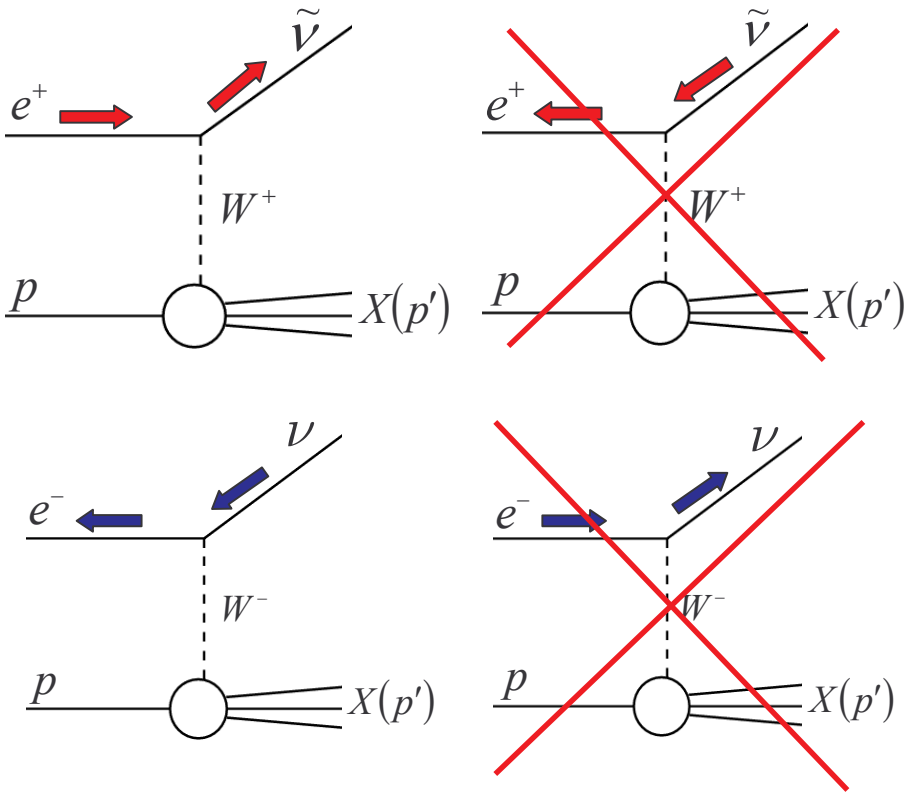

## Polarization:

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

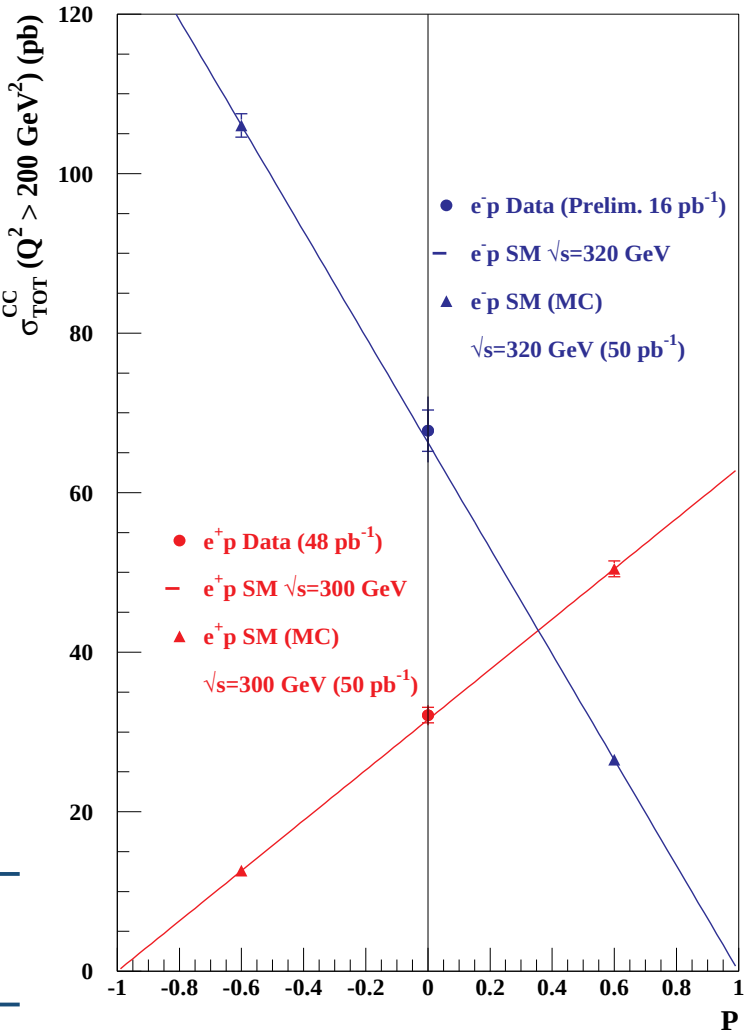
leptons are naturally transversely polarized in a storage ring

longitudinal polarisation: spin rotators

# HERA II: polarized leptons

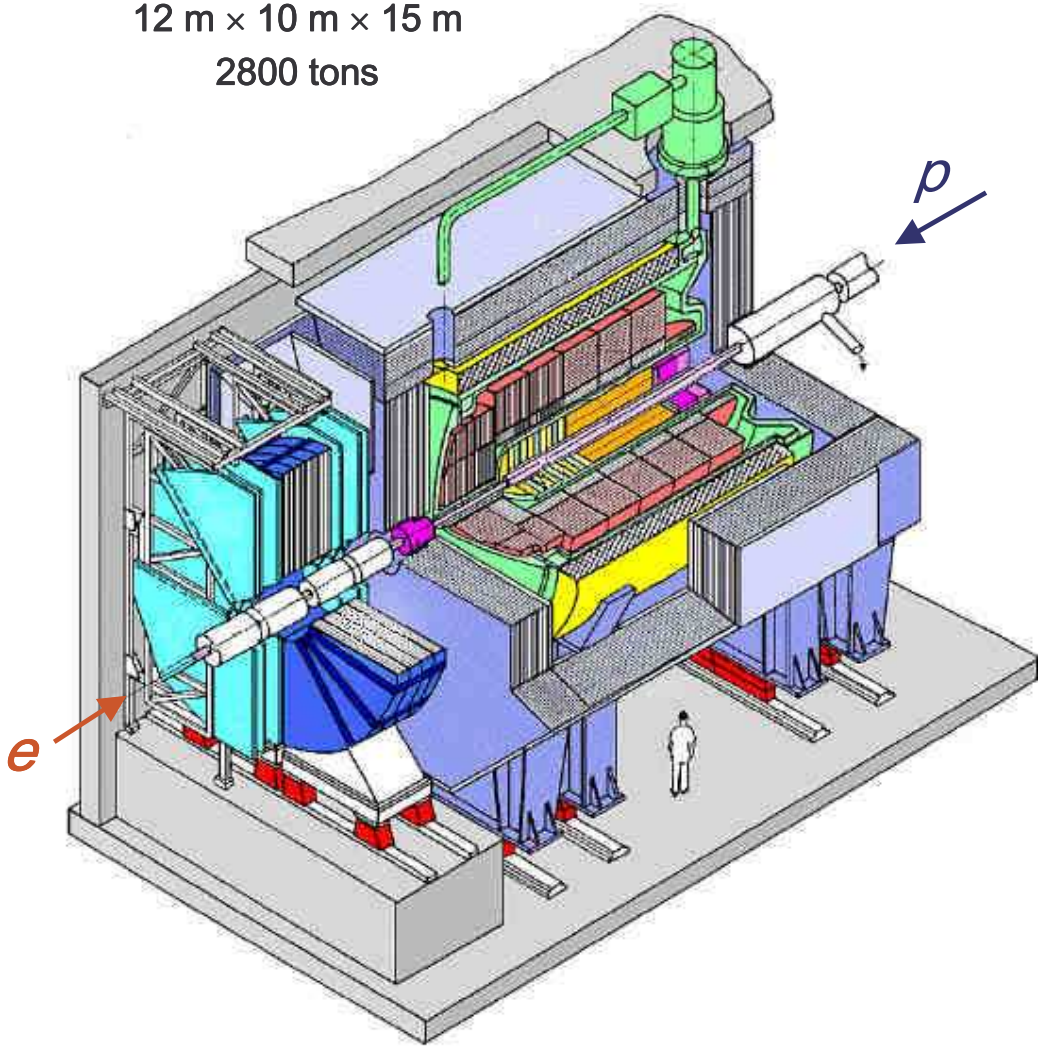



$$\sigma_{CC}(e^{\pm}p \to \nu X) = (1 \pm P)\sigma^{L}_{CC}(e^{\pm}p \to \nu X)$$



# H1 detector

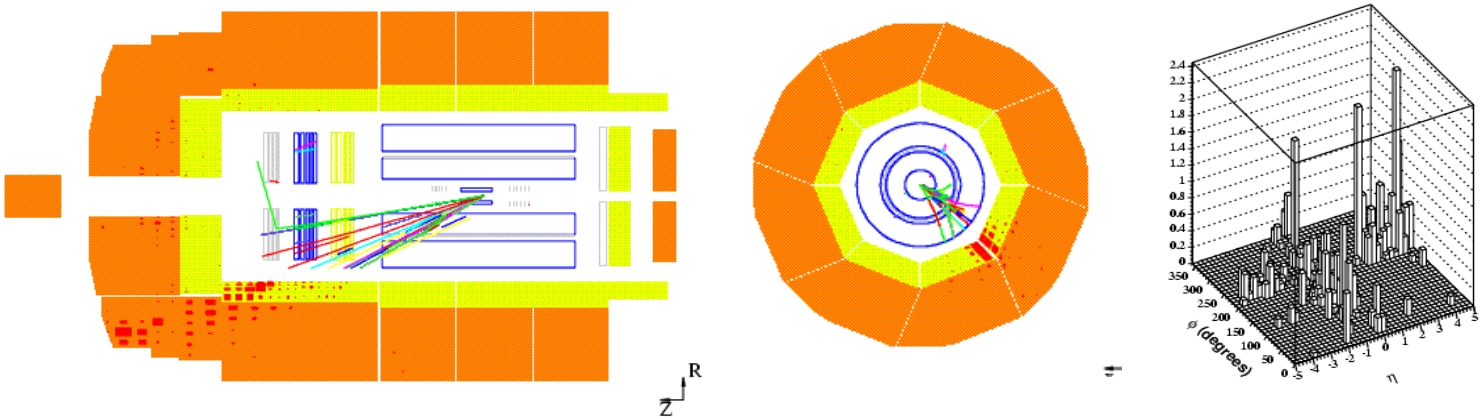
12 m × 10 m × 15 m
2800 tons



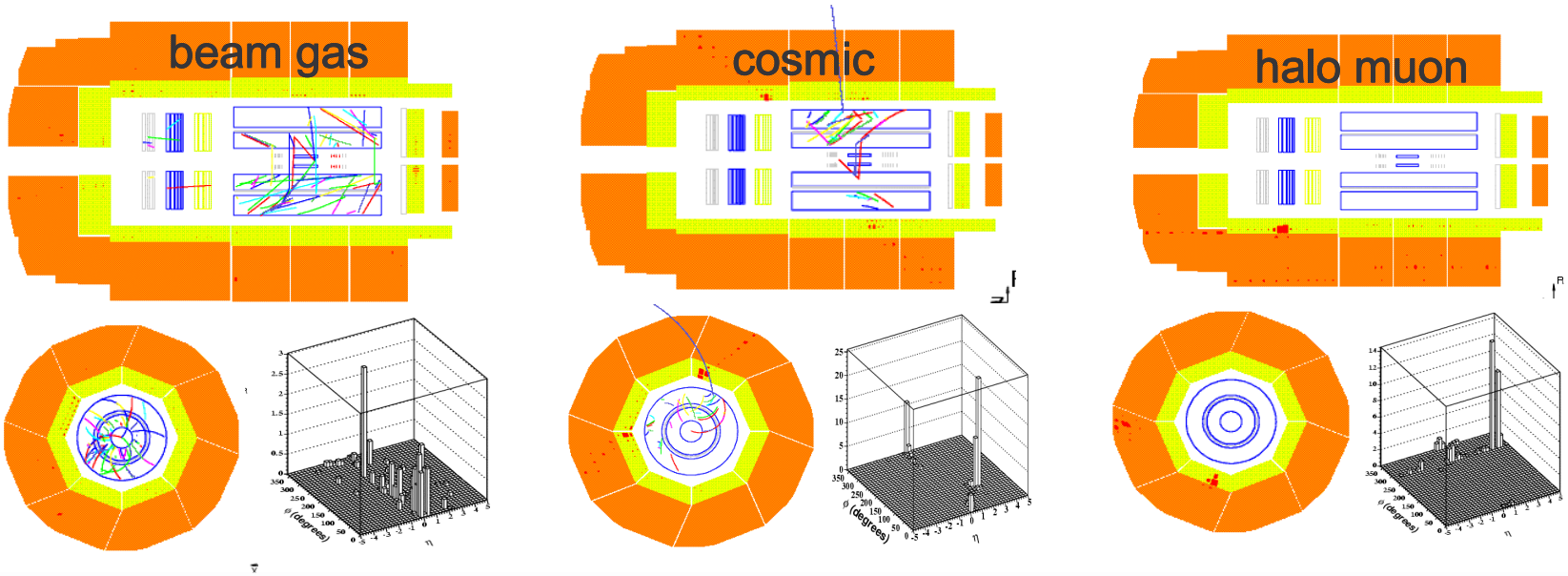

## main components:

- forward, central, backward tracking detectors
  (momenta and trajectories of charged particles)
- calorimeters (LAr, Spacal, Plug, TC, FNC)
  (energy, angle of charged/neutral particles)
- superconducting coil
  ("transfers momentum" of charged particles)
- muon system
- luminosity system

# Charged Current Events …



# … and background



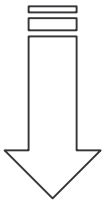
# Charged Current analysis

## HERA II

3.4.2004 -19.6.2004

$L$ = 23.6 pb$^{-1}$

$P$= -40%



Left handed

241 events

**CC selection cuts:**

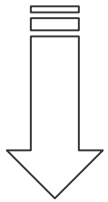
1. luminosity runs with HV
2. LAr CC specific triggers
3. $-35<Z_{vtx}<35$ cm
4. $P_T^{miss} > 12$ GeV
5. background rejection
6. collision (T0) timing
7. $V_{ap}/V_{par}= 0.35$
8. anti photoproduction 2D cut
9. anti neutral current cuts
10. $Q^2 > 220$ GeV$^2$
11. $0.03 < y < 0.85$

visual scanning of the rest events (~4%)

13.10.2003 -1.4.2004

$L$ = 20.1 pb$^{-1}$

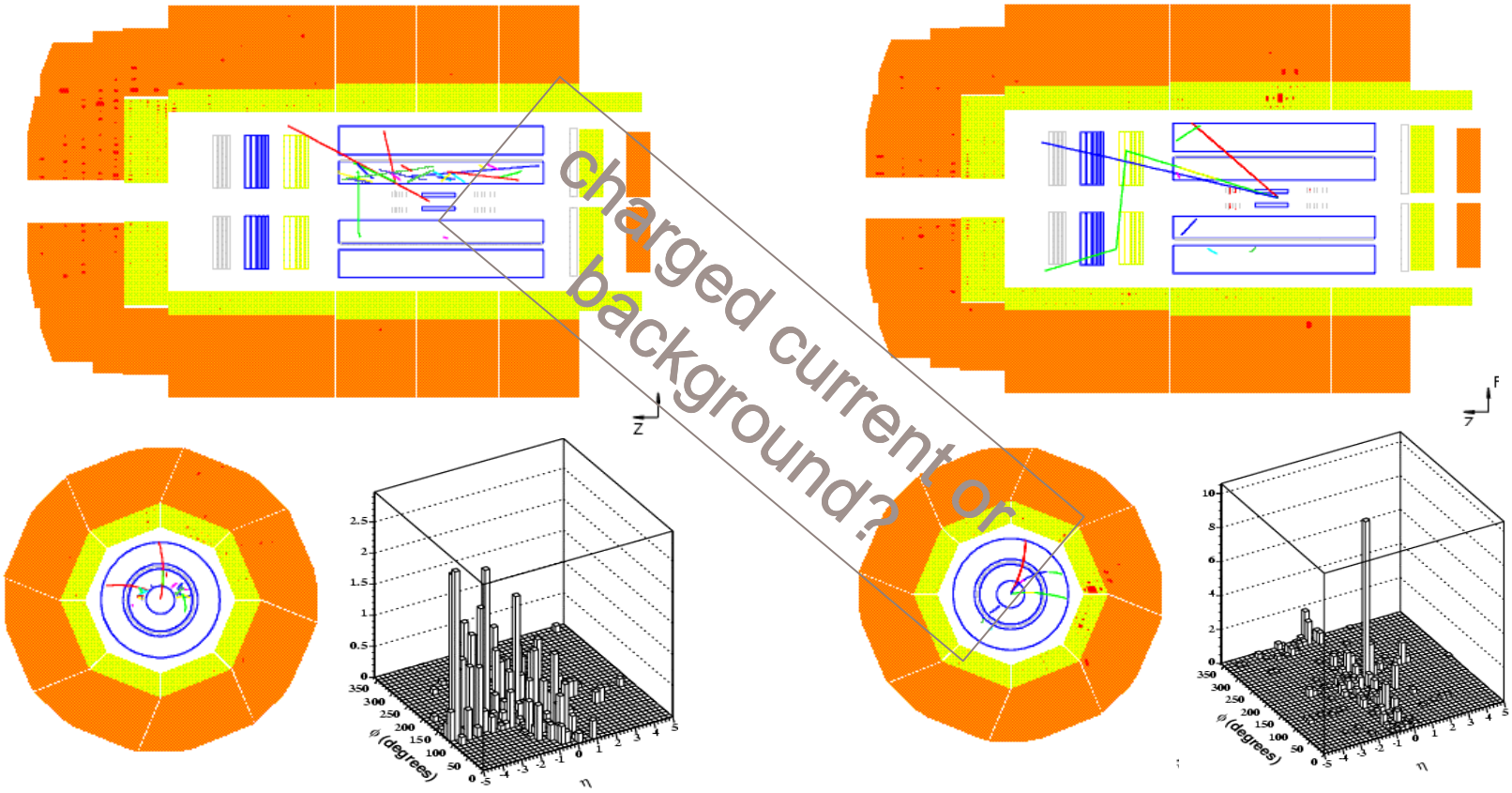
$P$ = +33%



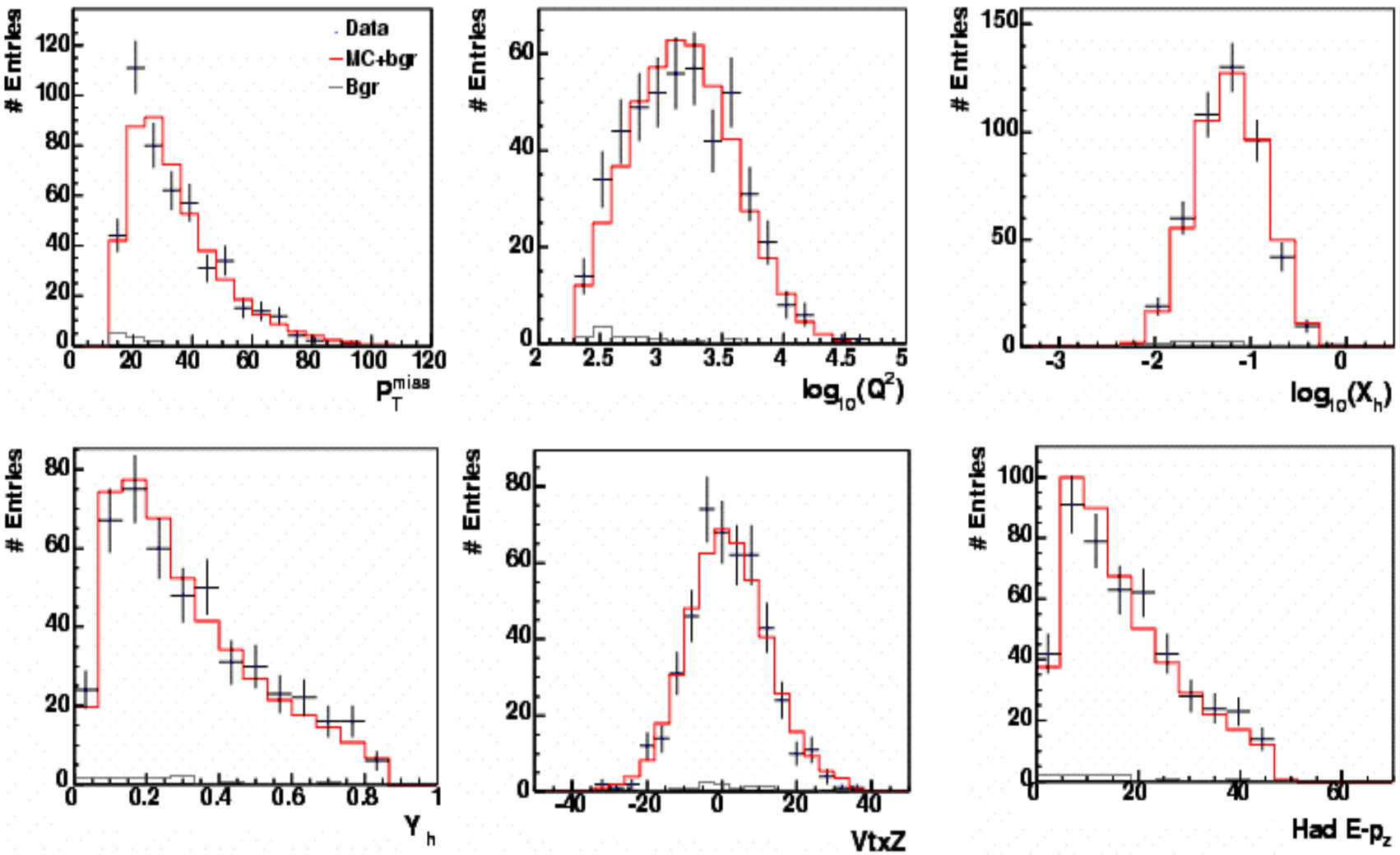
Right handed

472 events

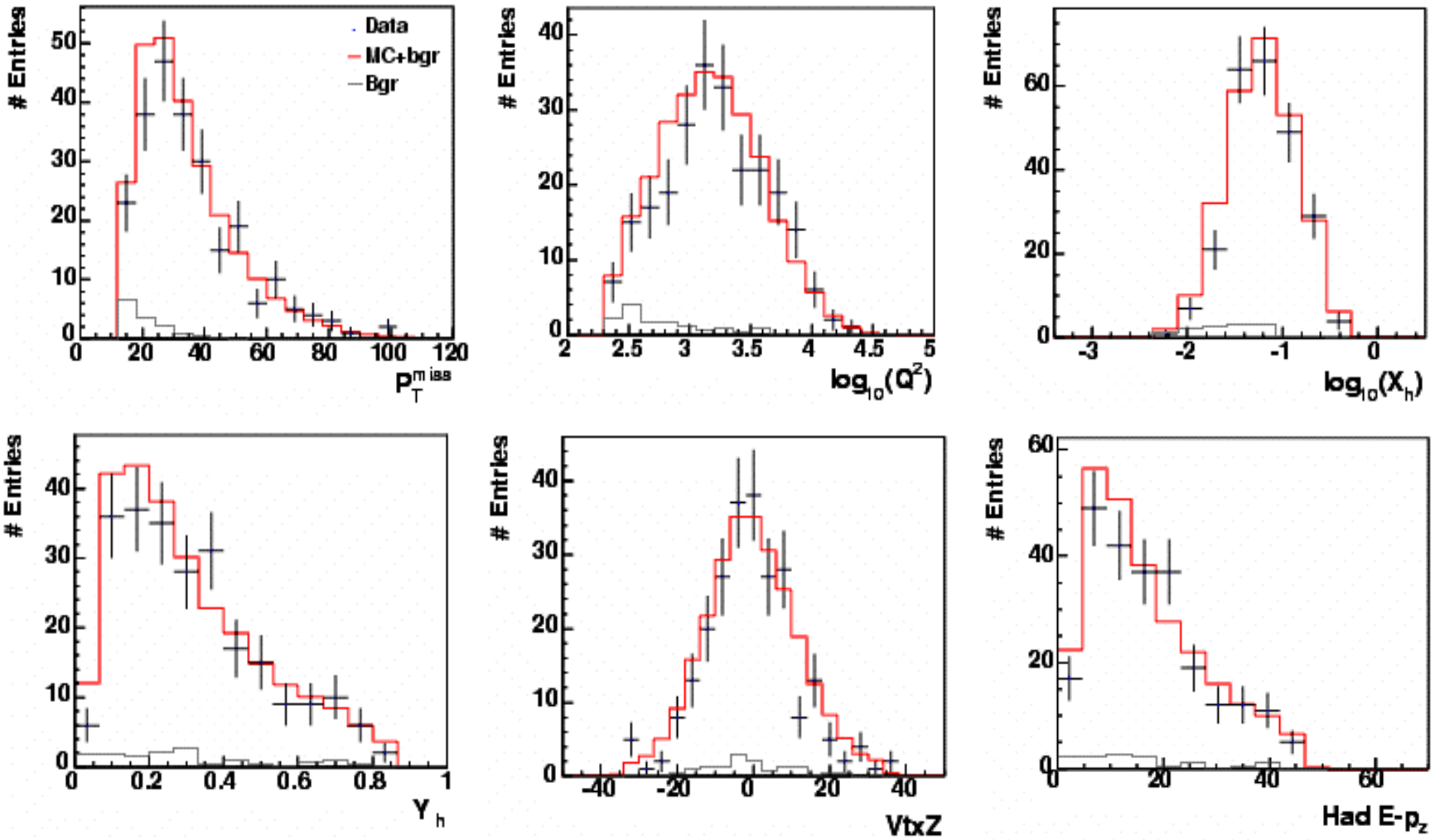
# Scanning of Charged Current Events



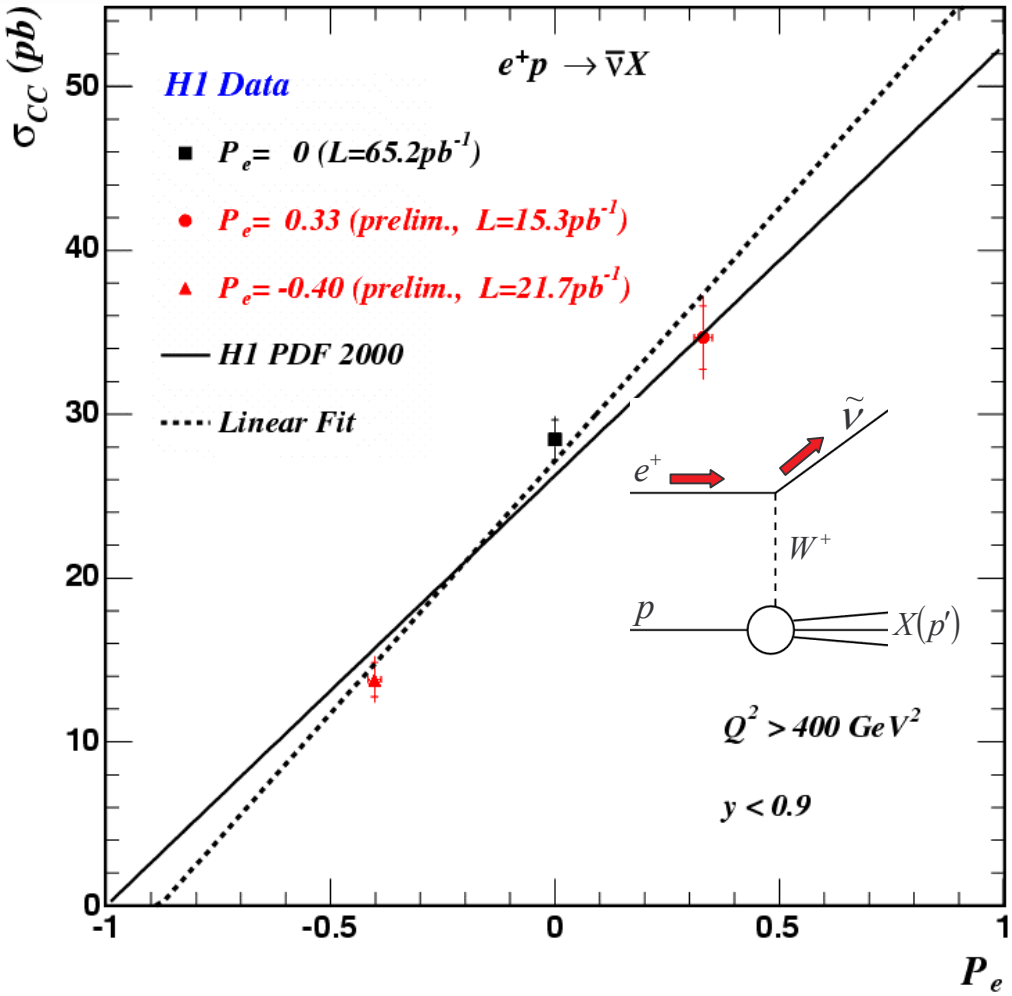
# Right-handed Charged Current Events (472)



# Left-handed Charged Current Events (241)



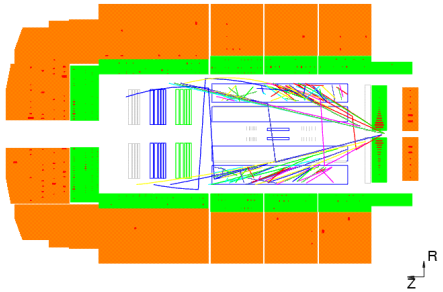
# First measurement of the polarisation dependence of the CC cross section

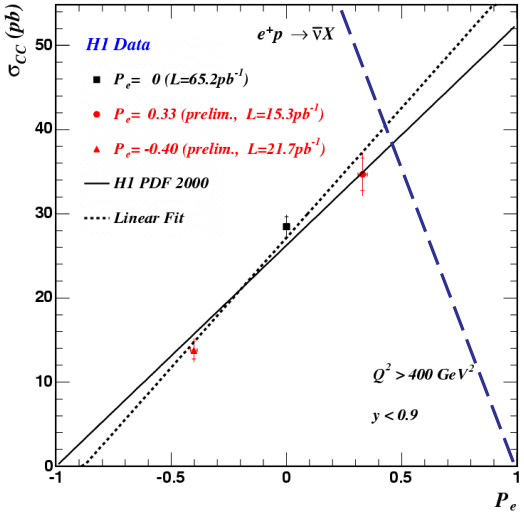



$$\sigma_{CC}(e^{\pm}p \to \nu X) = (1 \pm P)\sigma^{L}_{CC}(e^{\pm}p \to \nu X)$$

# Summary and Outlook

1. charged current analysis:
   1. first measurement of the polarisation dependence of the CC cross section (will be published till Christmas)
   2. background finders can be improved






→ CC cross sections from polarised $e^+$ of both helicities

→ coming: CC cross sections from polarised $e^-$