



63rd DESY PRC Meeting
10-11 May 2007, DESY Hamburg

H1 Status Report

Martin Wessels, DESY

- ▶ HERA and H1
- ▶ Reprocessing and Simulation
- ▶ Physics News and Highlights

HERA & H1

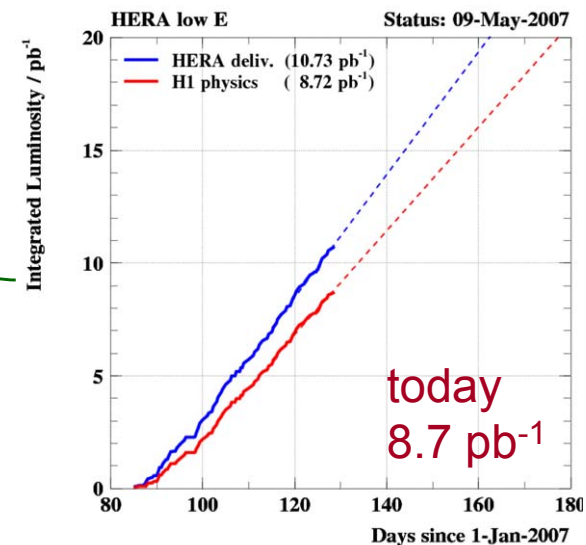
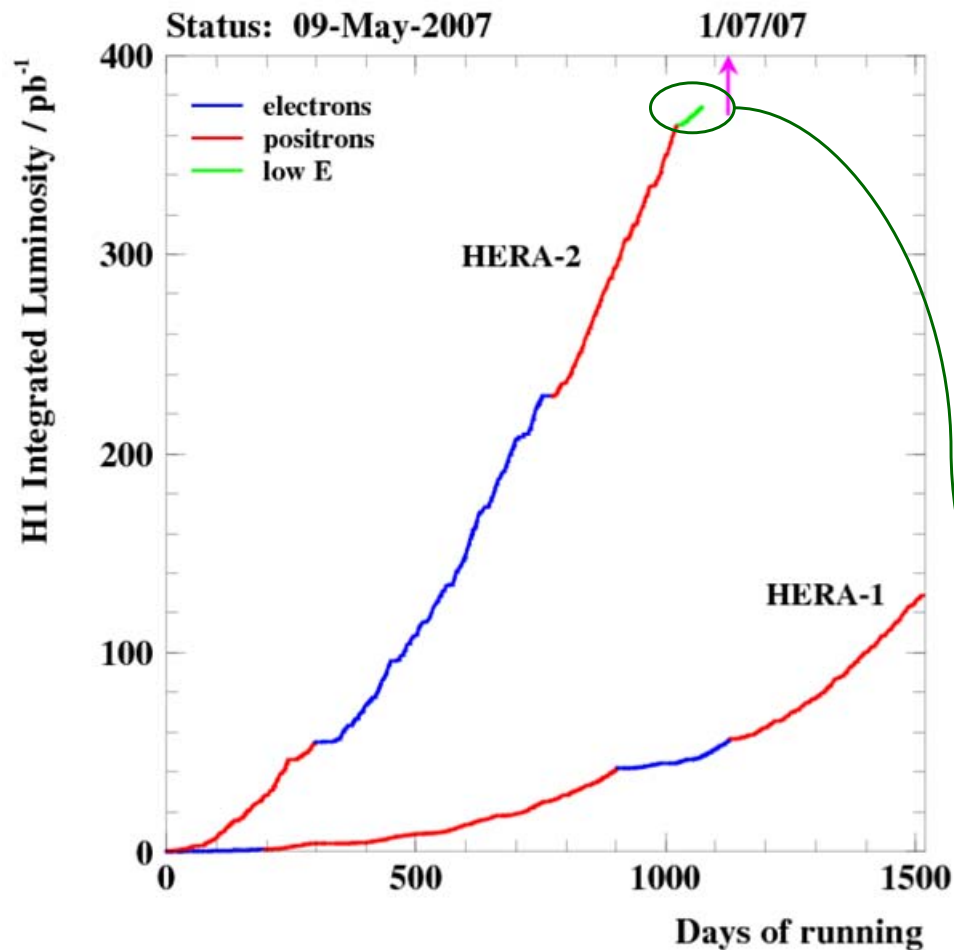
HERA high energy run came to an end on March 20th

50 pb⁻¹ good data added in 2007

H1 yield HERA I+II: 478 pb⁻¹

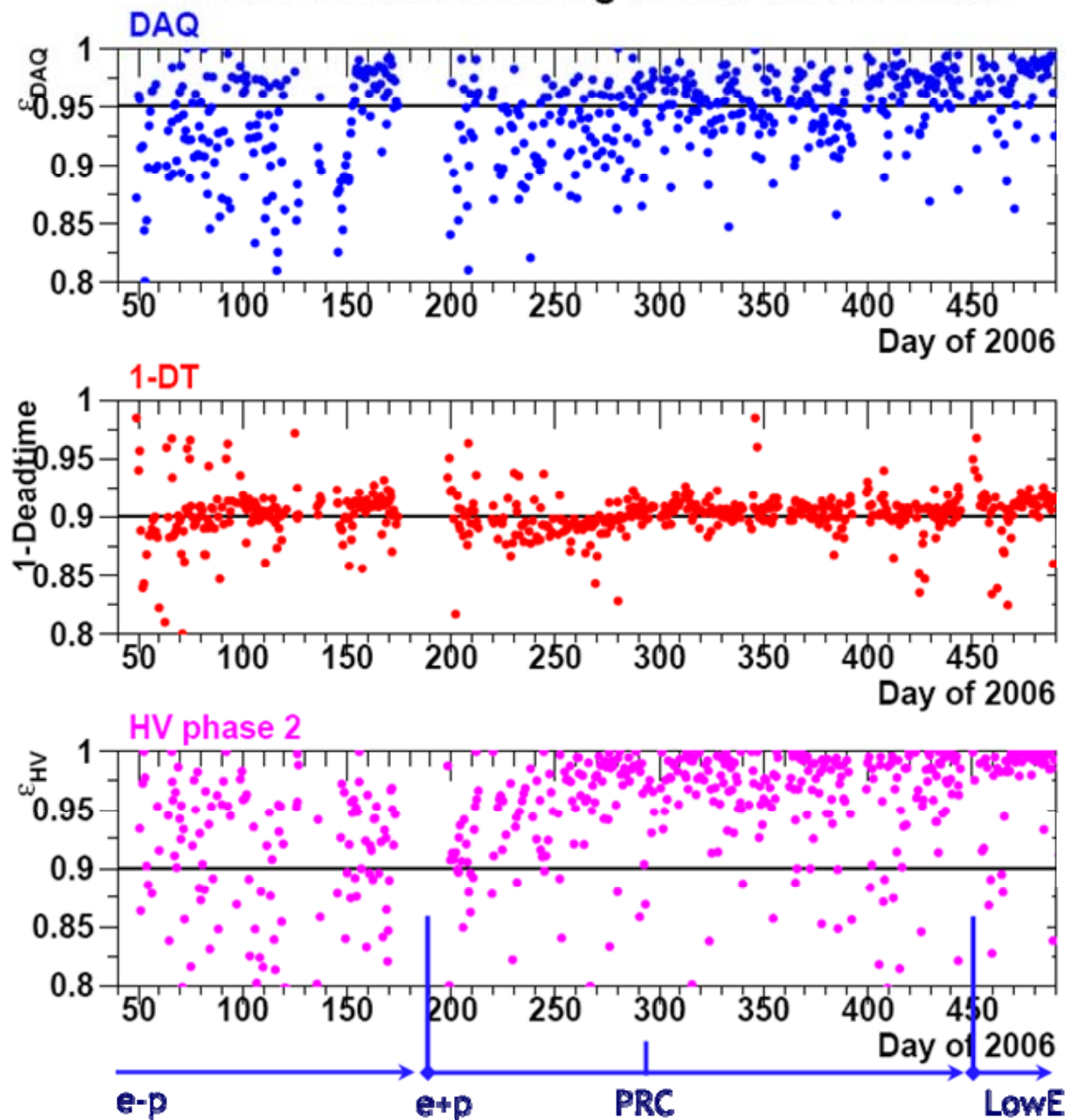
e-p: 184 pb⁻¹ e⁺p: 294 pb⁻¹

Low energy running @ E_p=460GeV started on March 26th



H1 Performance

H1 Efficiencies for Long Lumi Fills 2006/2007



successful running up to
the end of high energy run

trigger optimisation (Oct 06)
→ high and stable efficiencies

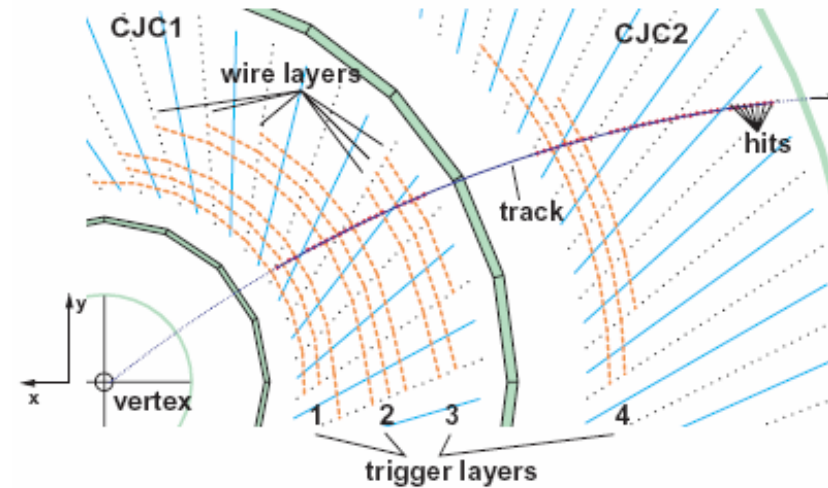
$$\left. \begin{array}{l} \epsilon_{\text{DAQ}} > 95\% \\ \epsilon_{\text{DT}} > 90\% \\ \epsilon_{\text{HV}} > 97\% \end{array} \right\} \epsilon_{\text{TOT}} > 80\%$$

efficient data taking
ongoing at low energy run

FTT Level 3

FTT: Fast Track Trigger in 3 levels

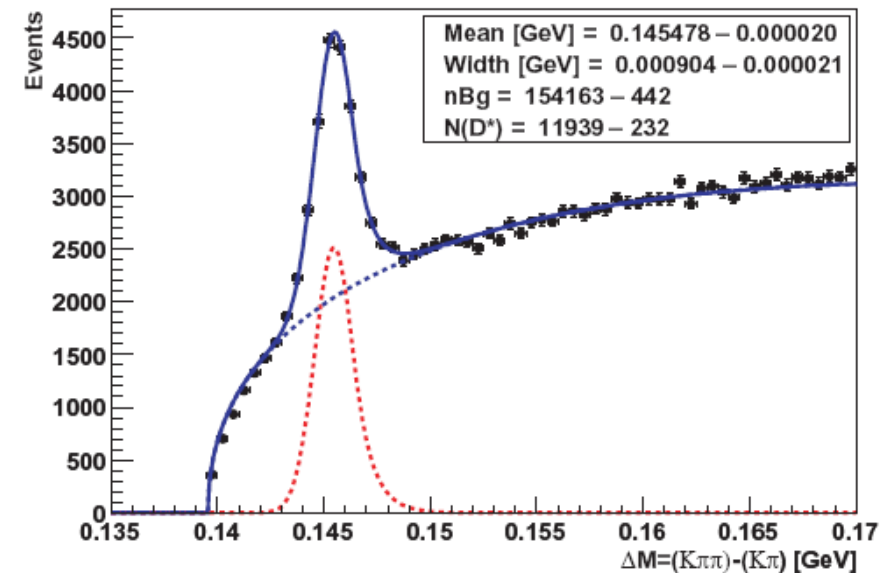
- L1 (2.3 μs): tracks in r-phi
- L2 (20 μs): up to 48 refined 3d tracks
- L3 (100 μs): particle id & inv. masses



FTT L3 activated autumn 2006

→ exclusive final states revived

decay channel	max. trigger rates [Hz]			L3 rate reduction
	L1	L2	L3	
$D^* \rightarrow K\pi\pi$ ($p_{t,D^*} > 1.5 \text{ GeV}$)	500	90	5 – 7	≈ 13
$b \rightarrow eX$	500	90	2 – 3	≈ 30
inelastic $J/\psi \rightarrow e^+e^-$ ($\mu^+\mu^-$)	400	90	5 – 7	≈ 13



D^* yield in γP increased by factor 10 wrt HERA I

Very Forward Proton Spectrometer

Tag and measure the diffractively scattered proton at low x_P and down to $t_{\min}$

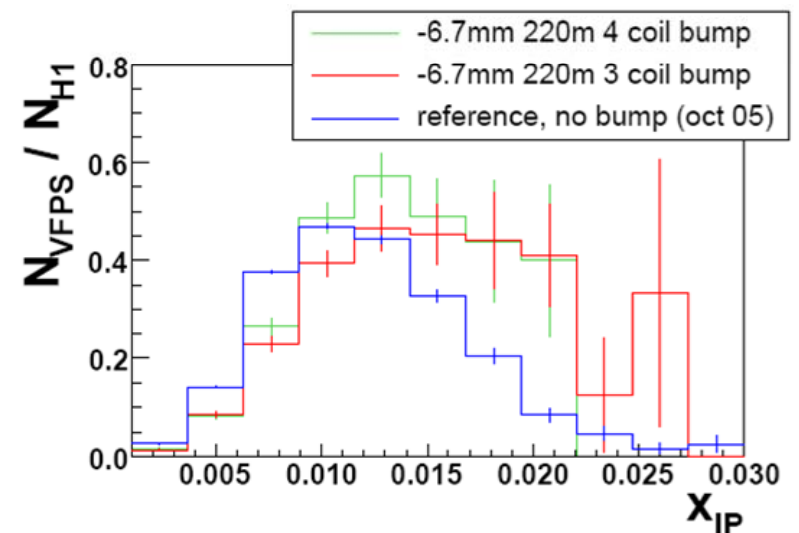
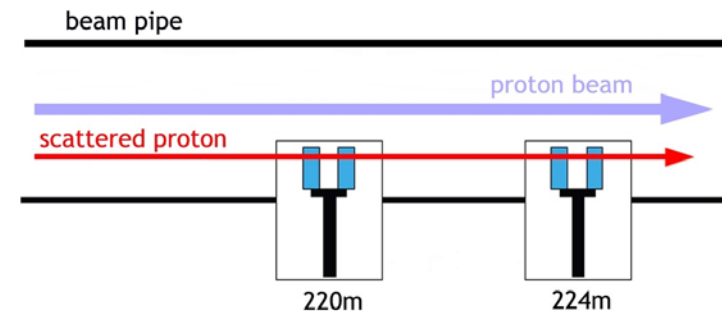
- two Roman Pot detectors
- successful regular operation 2006/07

VFPS: 130pb⁻¹ (in beam) **H1: 190pb⁻¹** [69%]
(data taking continues also for LowE running)

High x_P acceptance improved since autumn 06

Example physics yields with VFPS

- inclusive diffraction in DIS: ~880000 evts
- diffractive dijets in DIS: ~650 evts
- diffractive dijets in γP : ~6000 evts



Data Reprocessing

New reprocessing scheme

- “stripped raw data” files on disk, no tape access anymore
- factor ~ 4 gain in speed
- fast benefit of new calibrations and alignments

→ 4 data samples reprocessed since Oct 06 with improved reconstruction

Date	Sample	Lumi	Events	Rate	Time
Dec 06	2006 e ⁻ p	59 /pb	86.1 M	11 M/d	8 d
Jan 07	2006 e ⁺ p	79 /pb	152.4 M	12 M/d	13 d
Feb 07	2004 e ⁺ p	51 /pb	62.8 M	7 M/d	9 d
Feb 07	2003 e ⁺ p	4 /pb	19.5 M	7 M/d	3 d
May 07	2007 e ⁺ p	52 /pb	ongoing		

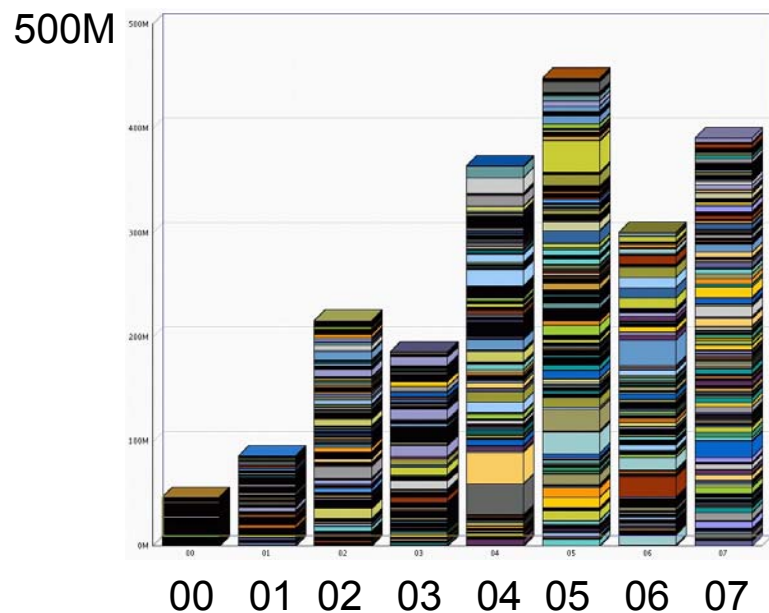
well aligned reprocessed full HERA II data sample
expected to be available for final analysis soon

Monte Carlo Simulation

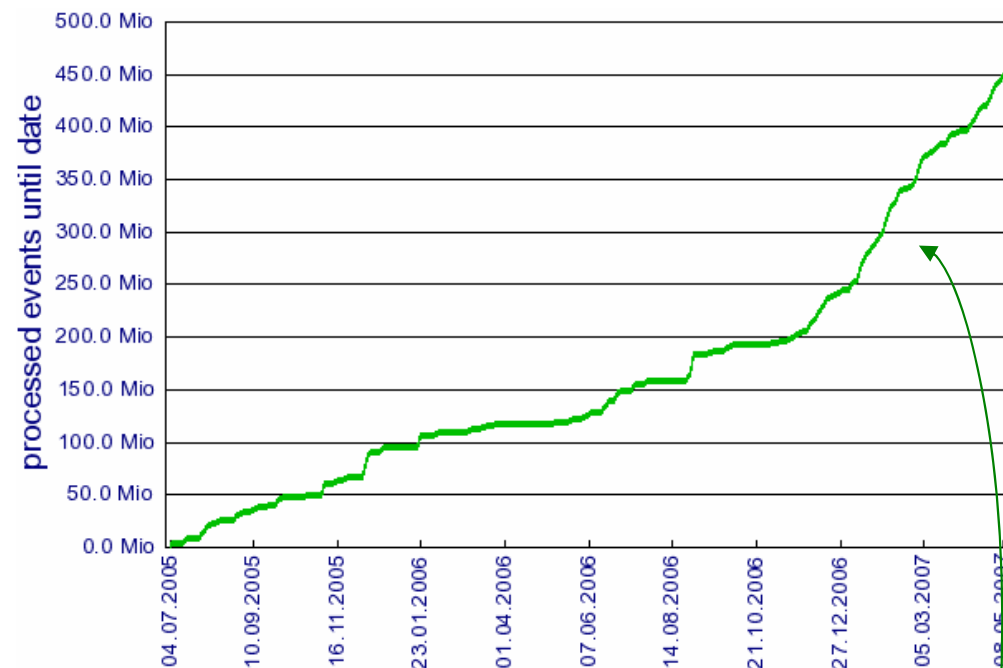
~800 M data events on tape

Huge MC samples needed

Total MC Production Per Year



H1 Monte Carlo GRID Production



New MC production group set up
to exploit full potential of GRID

Physics News & Highlights

Publications since Oct 2006		
Search for Lepton Flavour Violation in ep collisions at HERA		HERA I
Tests of QCD Factorisation in the Diffractive Production of Dijets in Deep-Inelastic Scattering and Photoproduction at HERA		HERA I
Search for Baryonic Resonances Decaying to Xi pi in Deep-Inelastic Scattering at HERA		HERA I
Production of D*-Mesons with Dijets in Deep-Inelastic Scattering at HERA		HERA I
Preliminaries DIS 2007		
Measurement of the Inclusive ep Scattering Cross Section at low Q2 and x at HERA	Inclusive	HERA I
Inclusive ep Scattering Cross Section at low Q2 and high y		HERA II
Combined Electroweak and QCD Fit of inclusive NC and CC Data with Polarised Lepton Beams at HERA		HERA II
A general search for new phenomena at HERA	Rare & Exotic	HERA II
Multi-lepton events at HERA		HERA I+II
Events with an Isolated Lepton (Electron or Muon) and missing transverse momentum at HERA		HERA I+II
Events with an Isolated Tau Lepton and missing transverse momentum at HERA		HERA I+II
A search for Excited Electrons in ep collisions at HERA		HERA I+II
A search for Excited Neutrinos in e-p collisions at HERA		HERA I+II
Beam charge azimuthal asymmetry in deeply virtual compton scattering at HERA II	Diffraction	HERA II
Minijet Production in Deep Inelastic Scattering at HERA	HFS & QCD	HERA I
Inclusive Prompt Photon Production in Deep Inelastic Scattering at HERA		HERA II
Inclusive Jet Production in Deep Inelastic Scattering at High Q2 at HERA		HERA I
Inclusive Jet Production in Deep Inelastic Scattering at low and medium Q2 at HERA		HERA I
Inelastic Electro-Production of J/Psi Mesons at HERA	Heavy Flavour	HERA II
D* Production in Deep Inelastic Scattering with the H1 Detector		HERA II

Isolated Leptons (e, μ) and P_T^{miss}

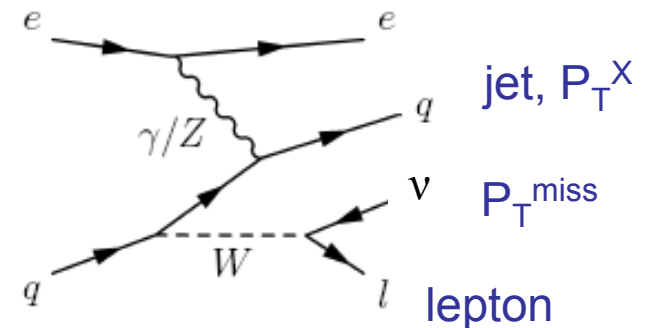
Reminder

- search for events with high P_T isolated lepton and missing P_T

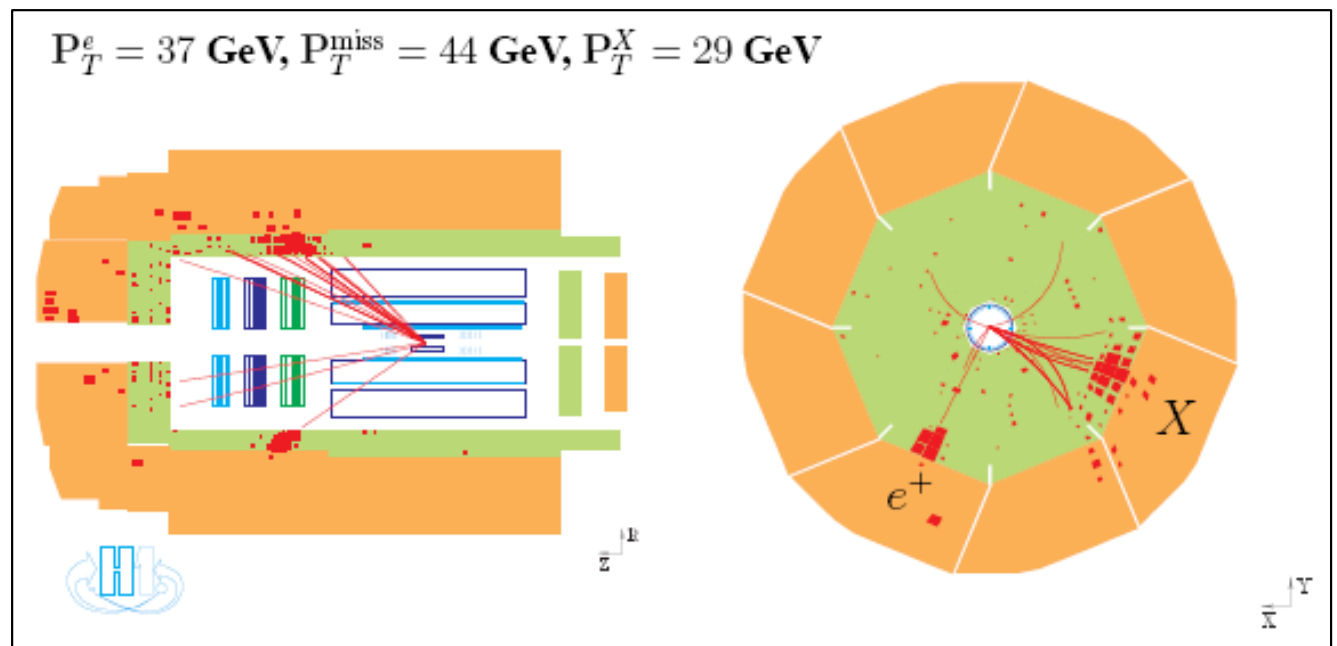
$$ep \rightarrow l + P_T^{\text{miss}} (+ \text{jet})$$

- SM: real W production with leptonic decay
→ soft hadronic system

$$ep \rightarrow l + W^\pm + X$$

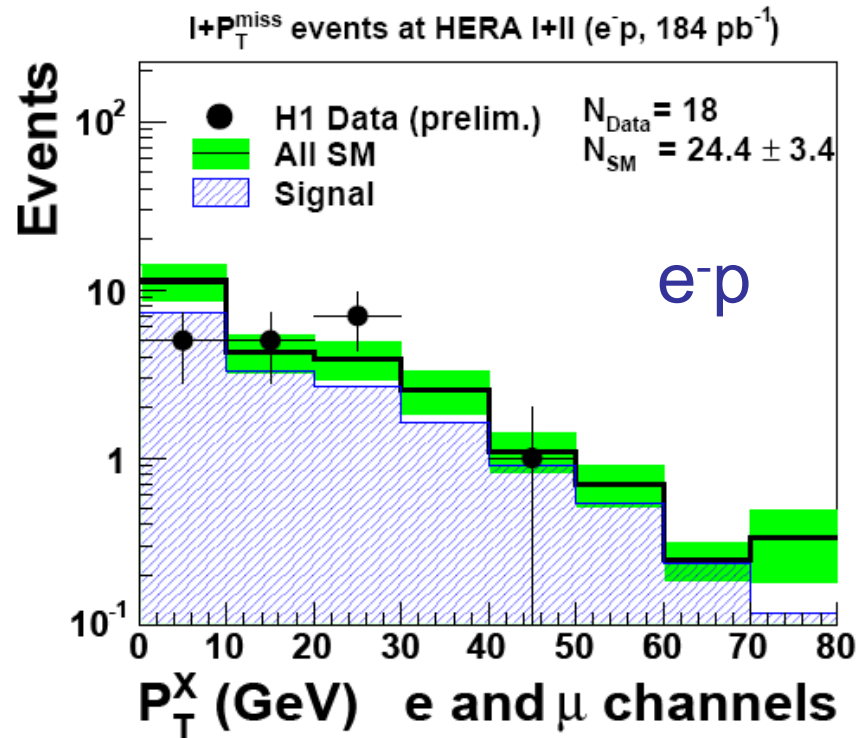


example of an atypical event with $P_T^X > 25$ GeV

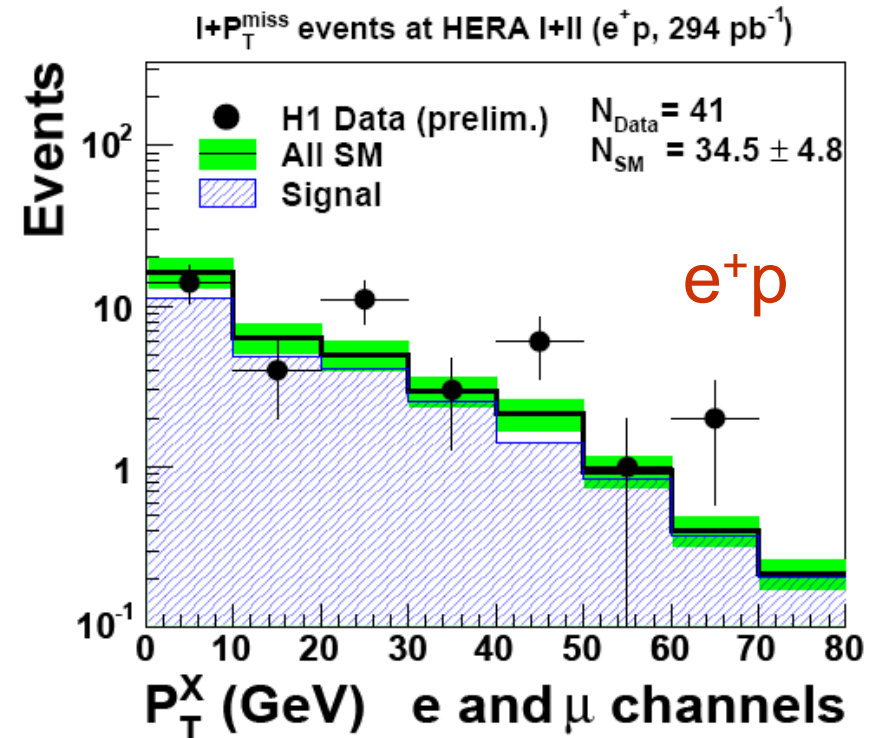


Isolated Leptons (e, μ) and P_t^{miss}

Full HERA I+II data set analysed: 478 pb⁻¹



e^-p : good agreement with SM

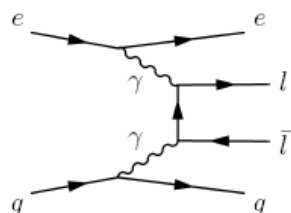


e^+p : excess at high P_T^X less pronounced than HERA I

► H1 excess remains at high P_T^X in e^+p data at 3.0 σ level

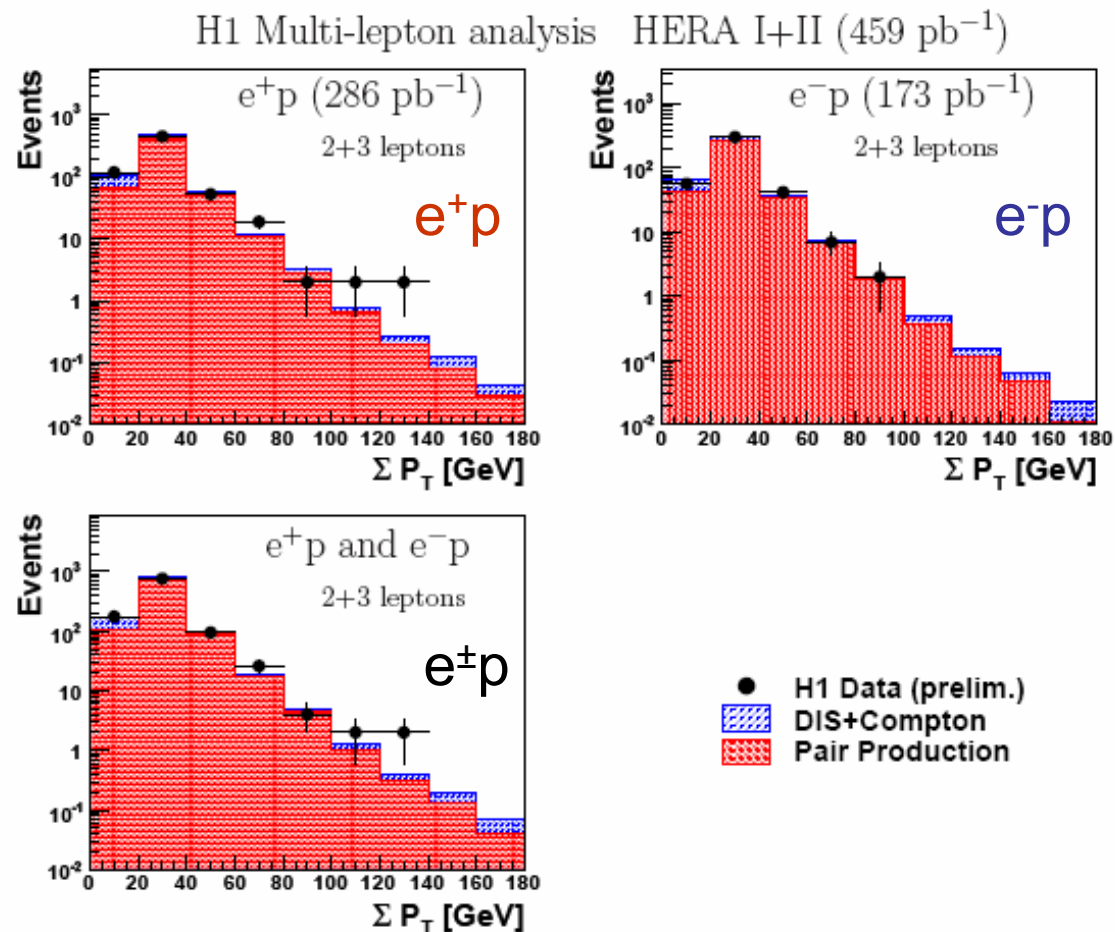
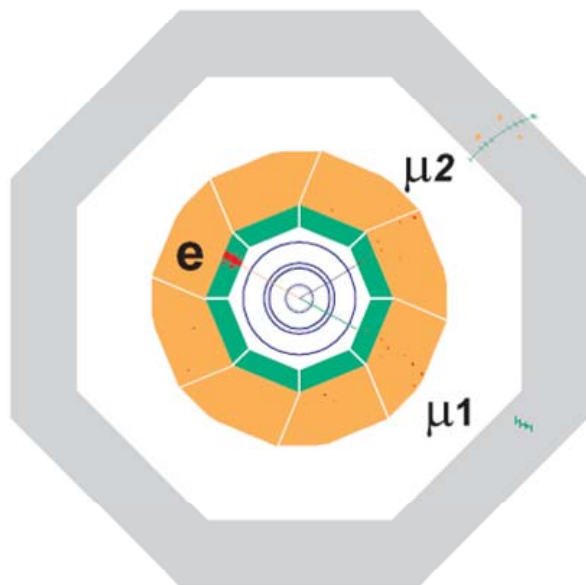
Multi Lepton Events (e, μ)

- search for events with at least 2 isolated high P_T leptons (e, μ)
- dominant SM contribution: two photon interaction



$$\gamma\gamma \rightarrow l^+l^-$$

ee, e μ , $\mu\mu$, eee, e $\mu\mu$
 ΣP_T : “hardness” of the events



Full HERA I+II data set analysed: 459 pb⁻¹

- ▶ overall good agreement with SM
- ▶ all 4 events with $\Sigma P_T > 100$ GeV in **e⁺p** data

General Search for New Phenomena

HERA II 337 pb⁻¹

investigate all final states at high P_T

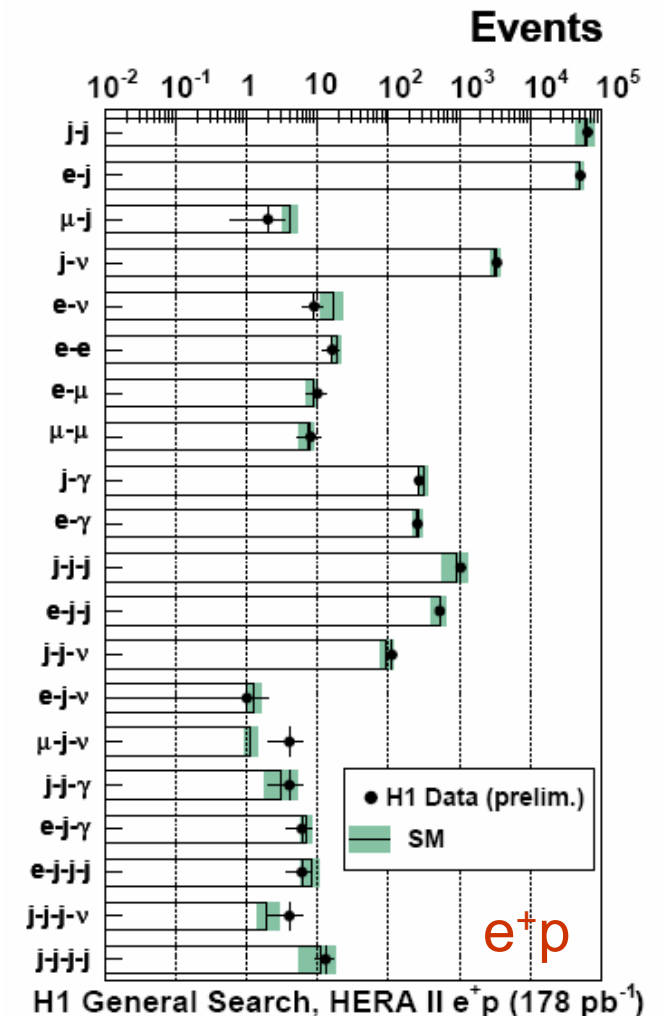
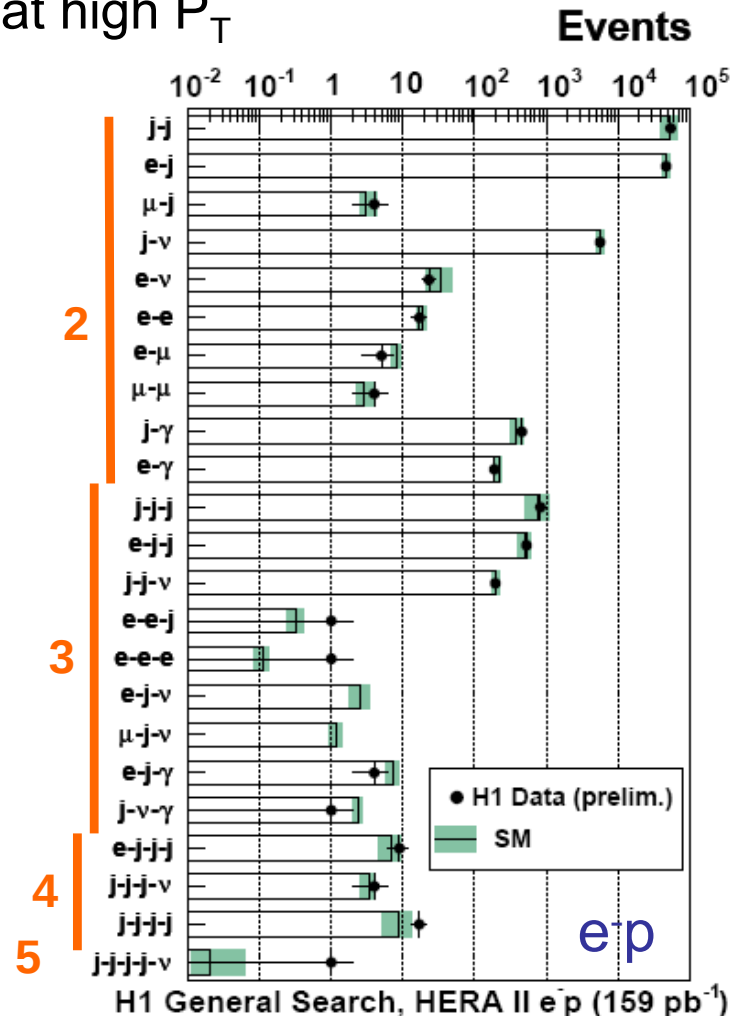
electrons, muons,
photons, jets, neutrinos

common phase space
 $P_T > 20$ GeV $10^\circ < \theta < 140^\circ$

investigate M_{all} and ΣP_T

systematic search
for deviations using
statistical analysis

overall good
agreement with SM

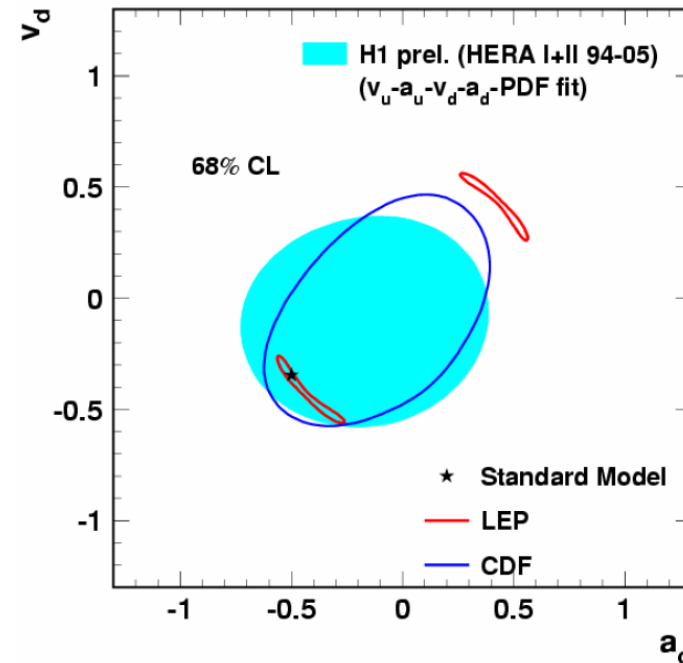
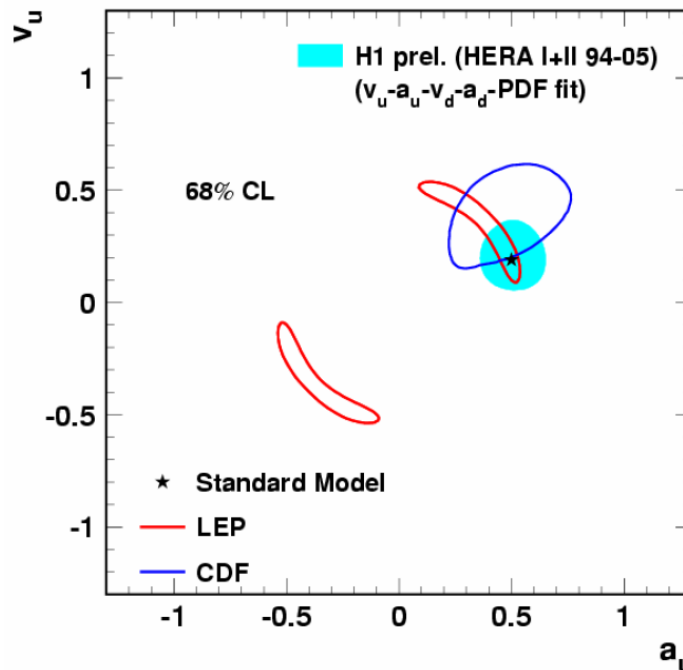
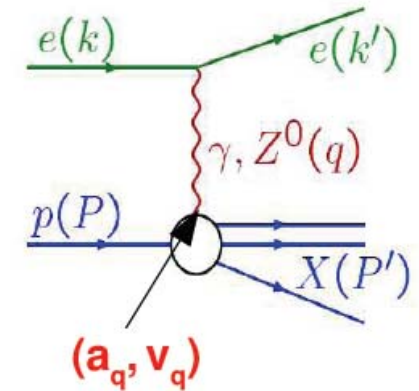


► broadest signature based search done at a collider

Determination of Electroweak Couplings

$$\frac{d^2\sigma_{\text{NC}}^{e^\pm p}}{dx dQ^2} = \frac{2\pi\alpha^2 Y_+}{xQ^4} \left[\tilde{F}_2(x, Q^2) \mp \frac{Y_-}{Y_+} x \tilde{F}_3(x, Q^2) - y^2 F_L \right]$$

HERA II → polarized e beam
additional sensitivity to couplings



- ▶ improved precision wrt HERA I (in particular for u-couplings)
- ▶ factor 2 increase of e^+p luminosity still to come

Inclusive ep Scattering at low Q^2 and x

Final inclusive cross section
measurement for low Q^2 at H1

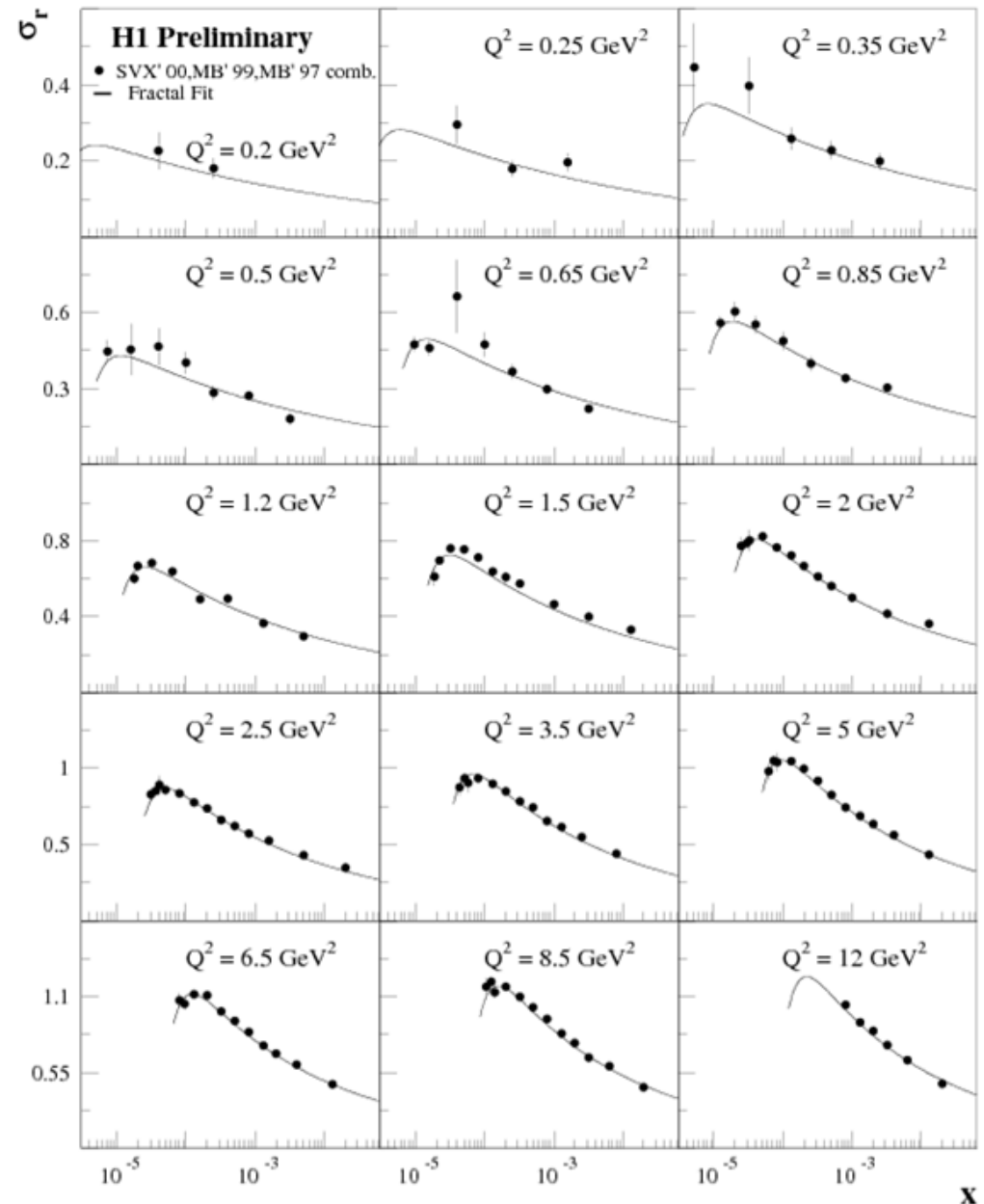
combination of all HERA I data sets
→ precision improved to 1.7 - 4%

$$0.2 \text{ GeV}^2 < Q^2 < 12 \text{ GeV}^2$$

$$4 \cdot 10^{-6} < x < 0.02$$

transition region
from soft to hard interaction

$$\sigma_r = F_2(x, Q^2) - \frac{y^2}{Y_+} \cdot F_L(x, Q^2)$$



Inclusive ep Scattering at low Q^2 and high y

HERA II 2003-06

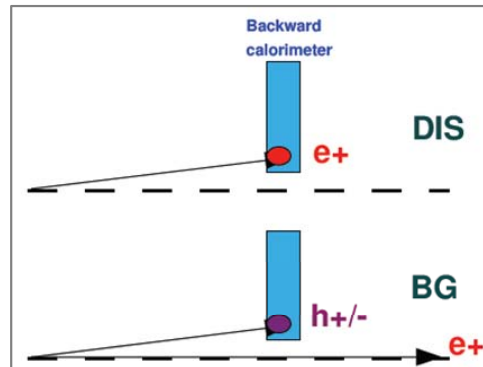
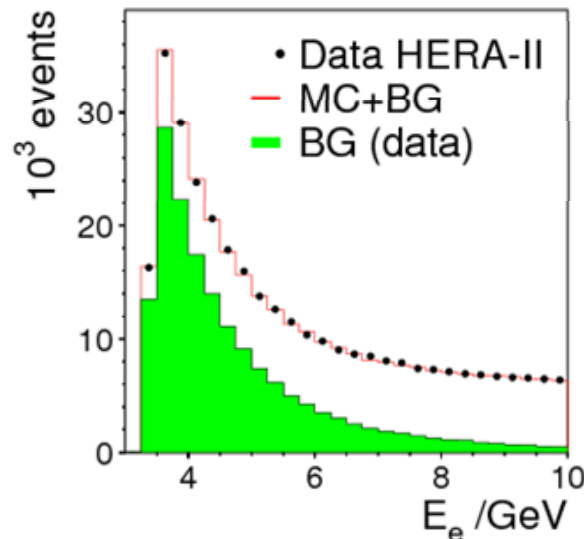
$$\sigma_r = F_2(x, Q^2) - \frac{y^2}{Y_+} \cdot F_L(x, Q^2)$$

Extraction of F_L

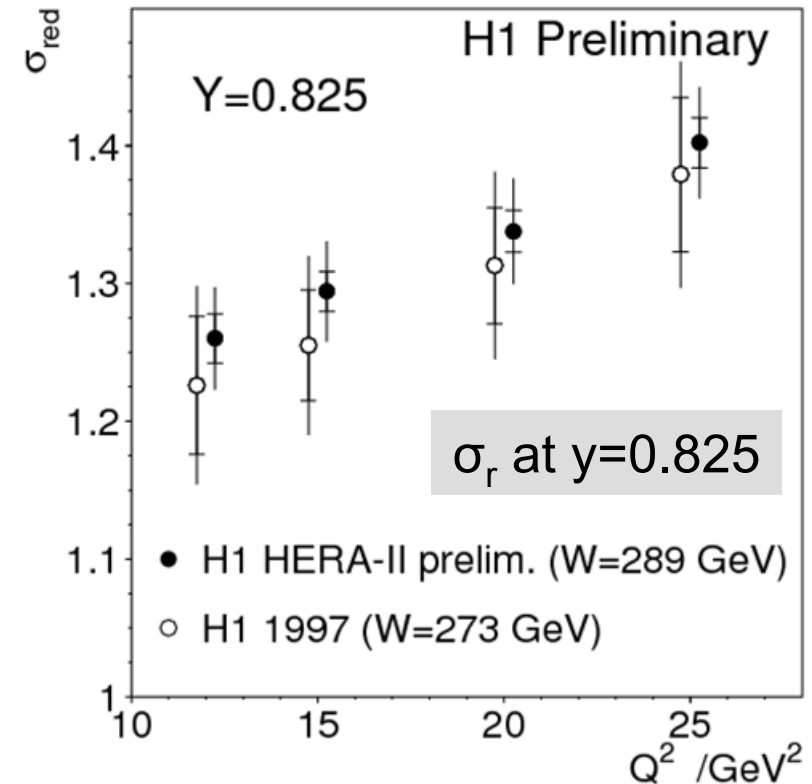
$$y = \frac{E_e - E_0}{E_0}$$

$$12 < Q^2 < 150 \text{ GeV}^2 \quad 0.75 < y < 0.9$$

- F_L contributes at high y (low E_e)
- experimental challenge similar to that of direct F_L measurement in low energy run



background subtracted using charge tag
 e^+p/e^-p samples complementary

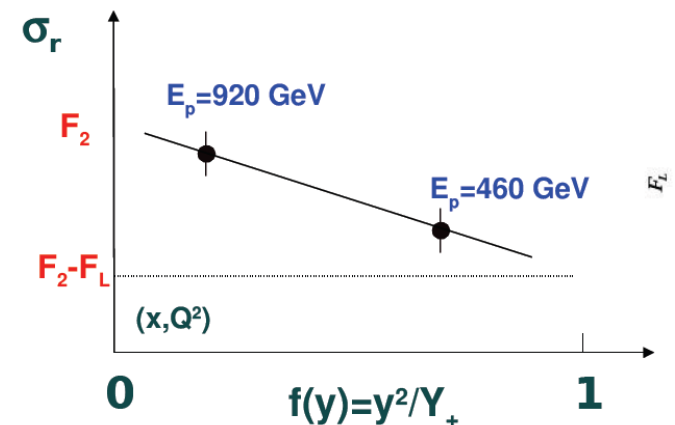


- precision improved by factor ~ 2
- systematic uncertainty 2-3%

Towards Direct F_L Measurement

$$\sigma_r \sim F_2(x, Q^2) - f(y) \cdot F_L(x, Q^2)$$

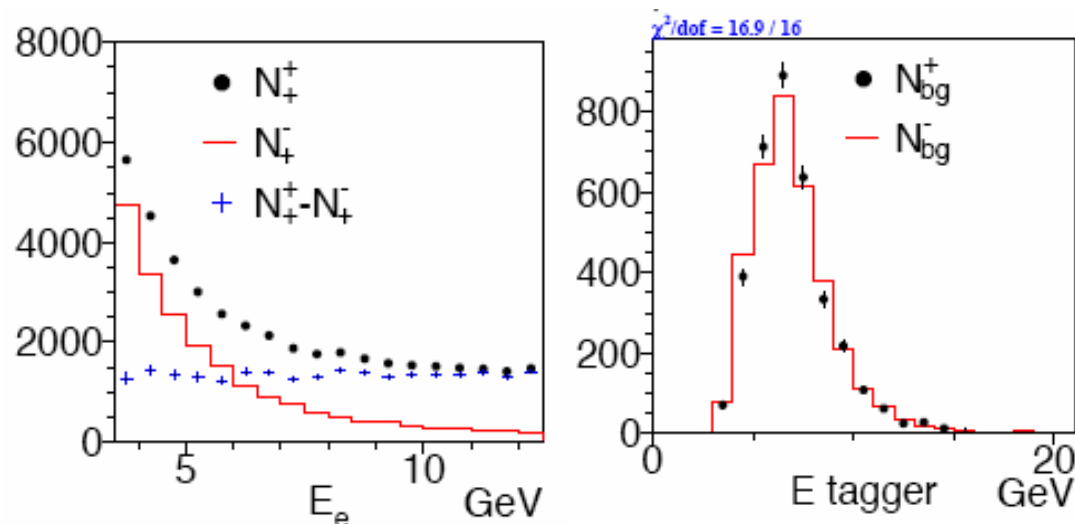
$$F_L(x, Q^2) \sim C(y) \cdot (\sigma(E_p^1) - \sigma(E_p^2))$$



$$y s = y' s' = Q^2/x$$

at low E_p same (x, Q^2) mean lower energy of electron

“Online” analysis of
recent Low Energy Run data



$N^{\text{tagged charge}}$
beam charge

Background subtraction using
Backward Silicon Tracker

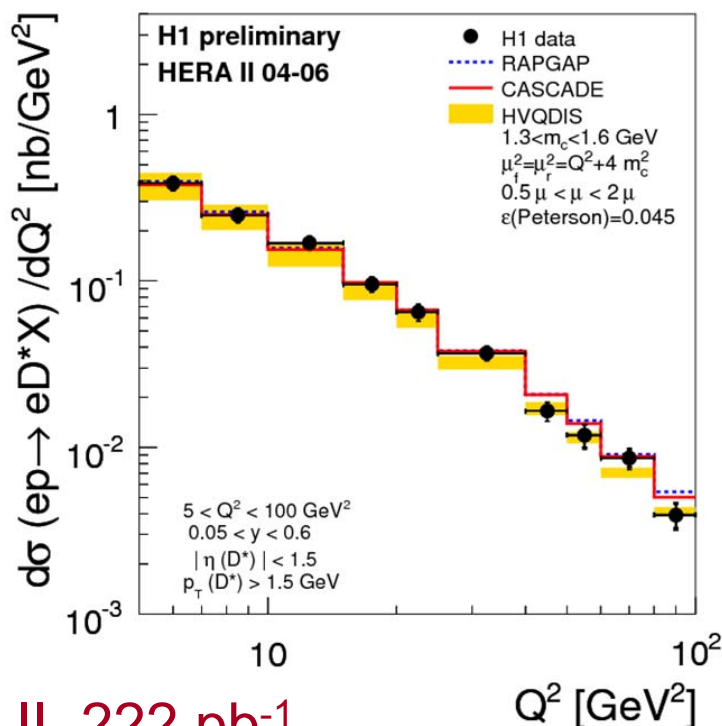
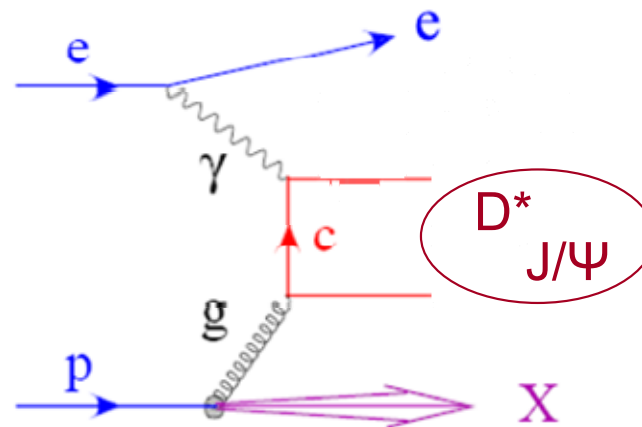
wrong charge background
well under control

Charm Production in DIS

Charm production at HERA

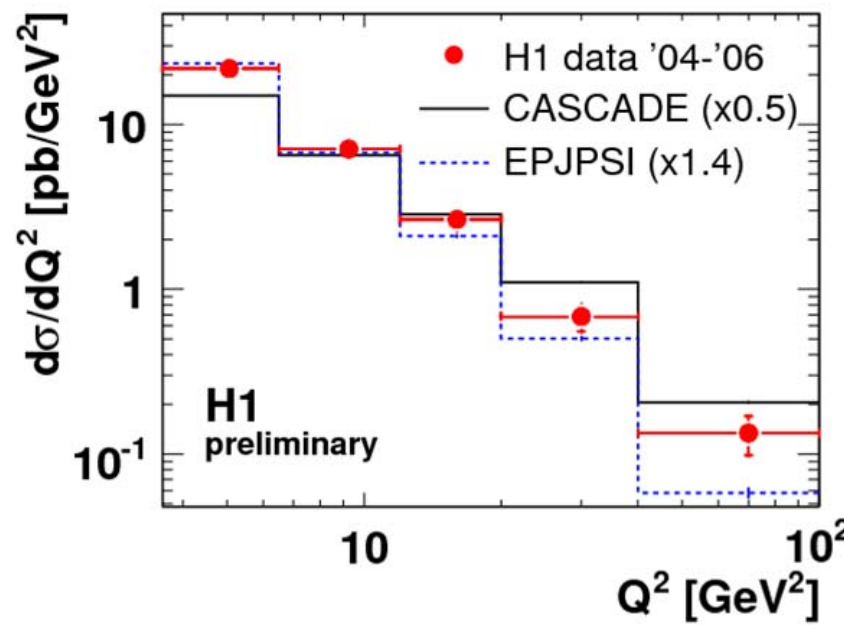
dominated by boson-gluon fusion

direct access to gluon



D^*

HERA II, 222 pb⁻¹



J/ψ

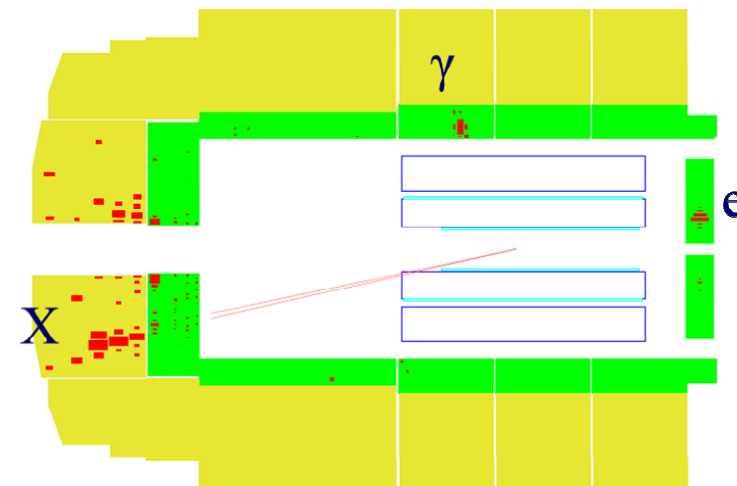
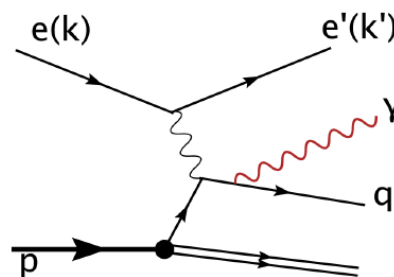
HERA II, 246 pb⁻¹

Prompt Photon Production in DIS

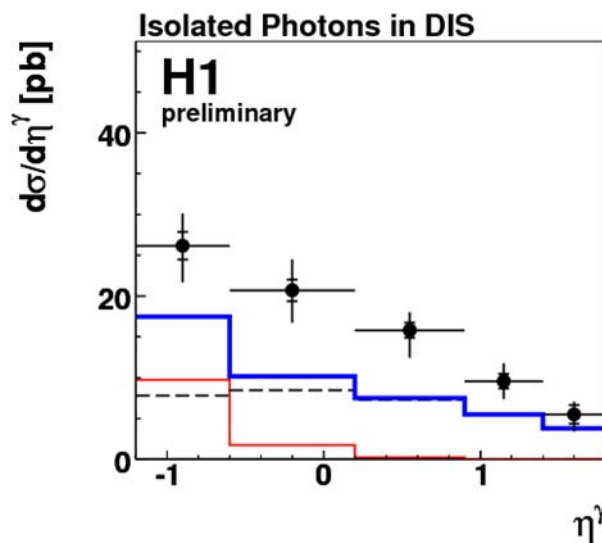
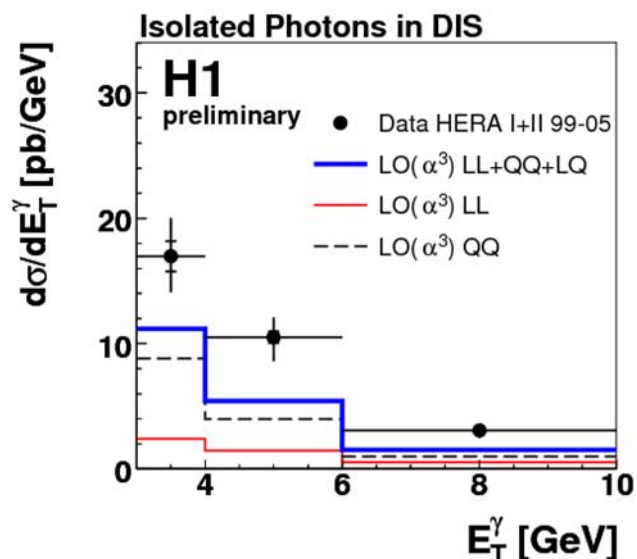
$$ep \rightarrow e\gamma X$$

radiation off the electron (LL)

radiation of the quark (QQ)



$$\text{DIS } 4 \text{ GeV}^2 < Q^2 < 150 \text{ GeV}^2$$



HERA I+II 226 pb⁻¹

- ▶ calculation low by ~50%
- ▶ shapes well described

Deeply Virtual Compton Scattering

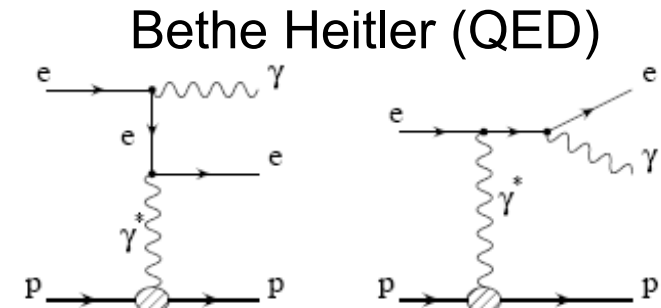
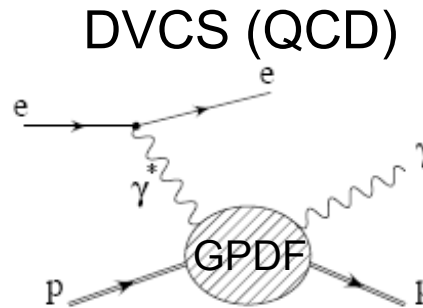
$$ep \rightarrow e\gamma p$$

$$6.5 \text{ GeV}^2 < Q^2 < 80 \text{ GeV}^2$$

HERA II

e^+p 145 pb⁻¹

e^-p 146 pb⁻¹

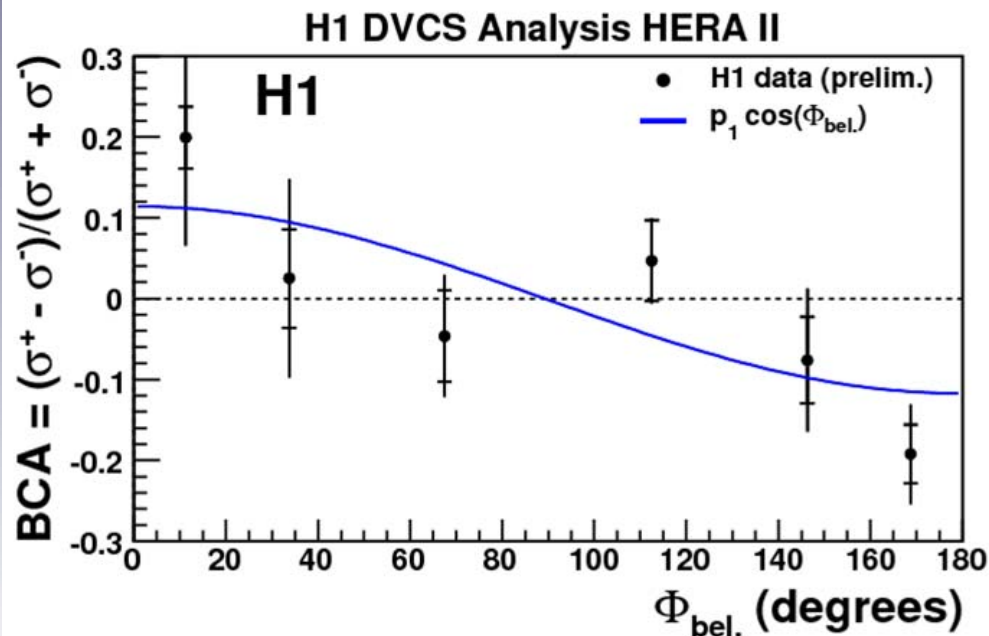


→ interference (beam charge asymmetry)

$$d\sigma_{ep \rightarrow e\gamma p} \simeq d\sigma^{DVCS} + d\sigma^{BH} + \underbrace{A^{BH} \text{Re} A^{DVCS}}_{\text{e-beam charge dependent}}$$

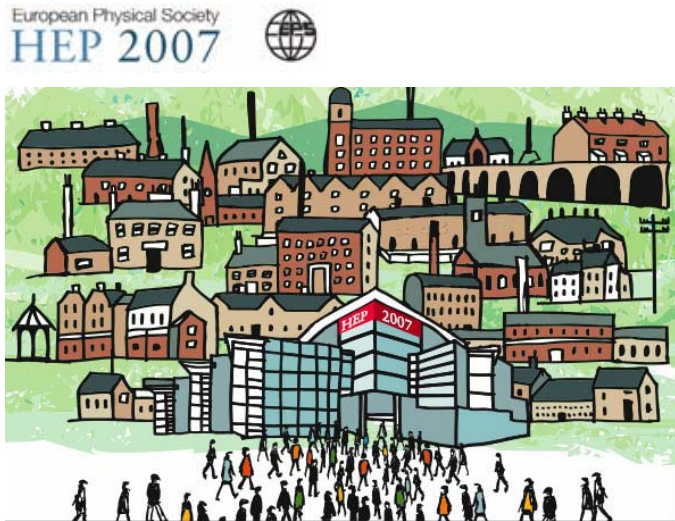
$$BCA = \frac{\sigma^{e^+p} - \sigma^{e^-p}}{\sigma^{e^+p} + \sigma^{e^-p}} \simeq \sum_{n=1,3} p_n \cos(n\Phi_{\text{bel}})$$

direct access to GPD's



First measurement of interference
BH/DVCS in collisions mode

H1/ZEUS Combinations



H1/ZEUS together: 1 fb⁻¹

H1/ZEUS combinations progressing
→ 4 abstracts submitted to EPS 2007

- isolated leptons and missing P_T
- multi-lepton events
- structure functions and contact interactions
- strong coupling from jets

Conclusions

HERA and H1 at high and low E_p

- successful end of high energy run: $\sim 0.5 \text{ fb}^{-1}$ collected
- promising progress of low energy run: $\sim 9 \text{ pb}^{-1}$ on tape already

Large flow of new physics results

- 4 papers published in 07
- 16 preliminaries at DIS

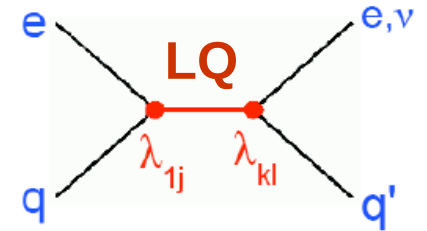
Entering an exciting period

- first final HERA results expected this year (eg. searches)
- HERA II precision analysis catching up in all domains
- H1+ZEUS combinations



Backup Slides

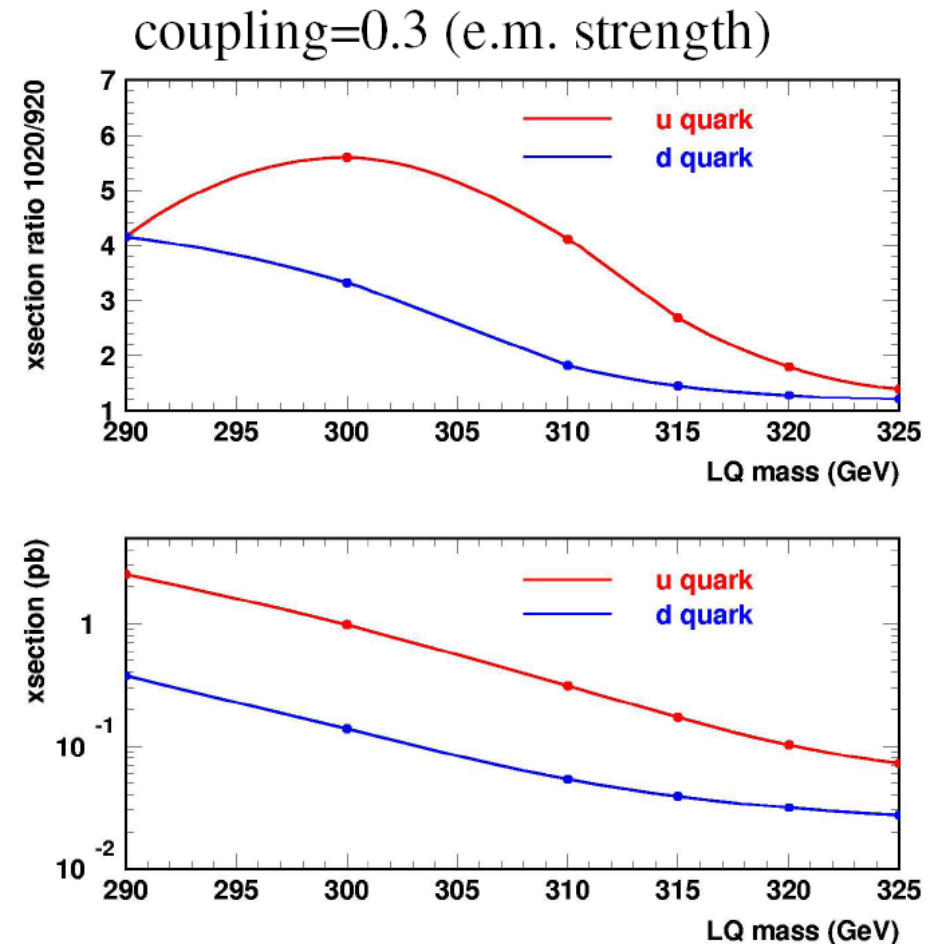
Last Month of HERA



HERA @ $E_p=1020 \text{ GeV}$ (10 pb^{-1})

- discovery potential for leptoquarks?
- not excluded $\lambda=0.3$, $M>310 \text{ GeV}$
- significant increase in cross section, but luminosity too small:
 $\sigma=0.3 \text{ pb} \rightarrow 3 \text{ events}$

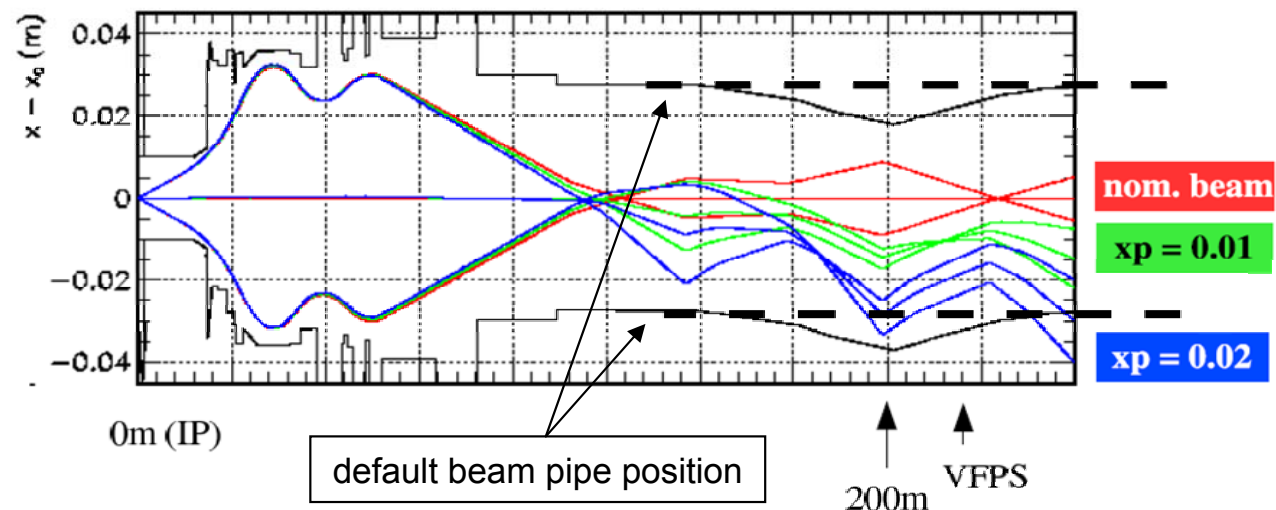
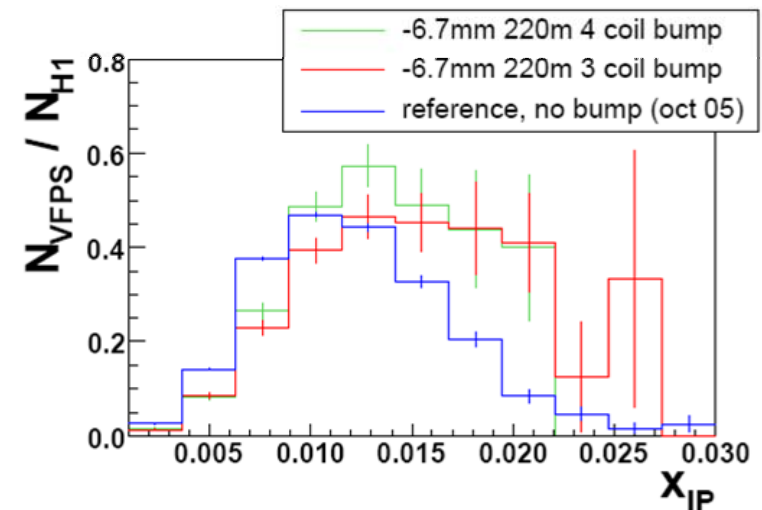
→ only weak discovery potential



Very Forward Proton Spectrometer

High $x_{\mathbb{P}}$ acceptance improved since autumn 06

- proton beam moved outwards HERA to overcome limitation by beam pipe aperture
- progress in understanding optics: acceptance close to expected



Inclusive ep Scattering at low Q^2 and x

Extraction of F_2

$$\sigma_r = \underbrace{C(Q^2)x^{-\lambda(Q^2)}}_{F_2} - \frac{y^2}{Y_+} \cdot F_L(x, Q^2)$$

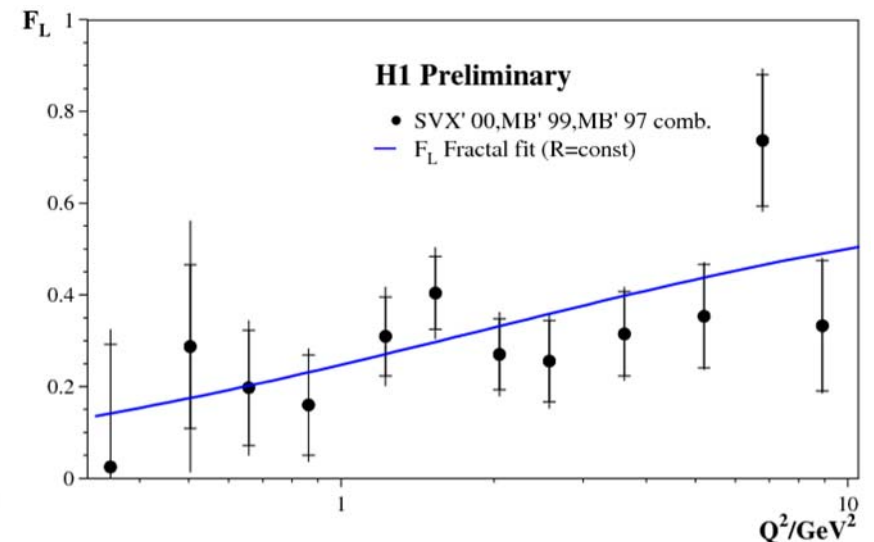
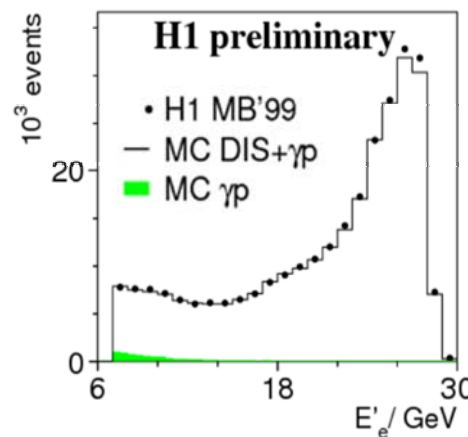
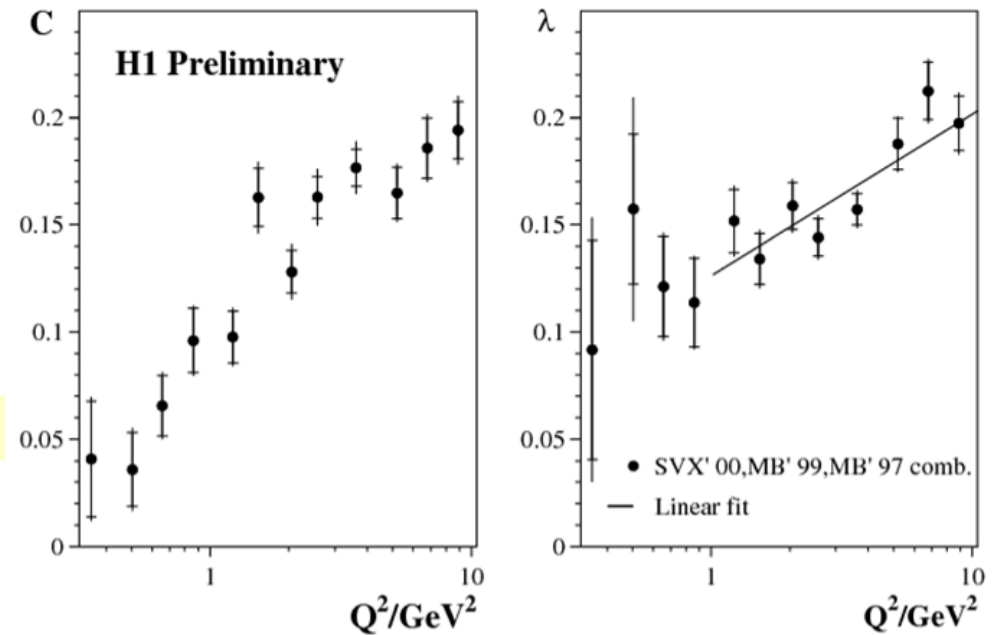
$F_2 \sim x^{-\lambda}$ at low x (< 0.01)

$$\lambda \sim \lg Q^2 \text{ for } Q^2 > 1 \text{ GeV}^2$$

Extraction of F_L

- $F_L \sim xg(x) \rightarrow$ gluon density function
- F_L contributes at high y only, i.e. low electron energies
- not ideal phase space for this analysis

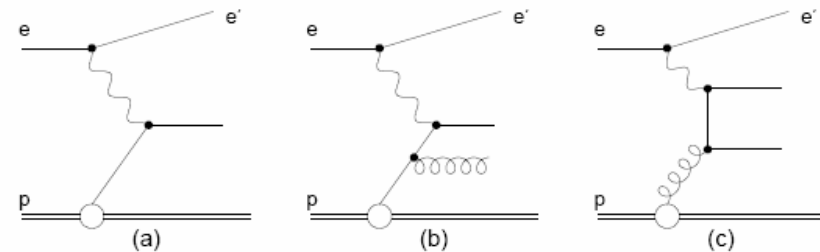
$\rightarrow$ new HERA II analysis at low y , medium Q^2



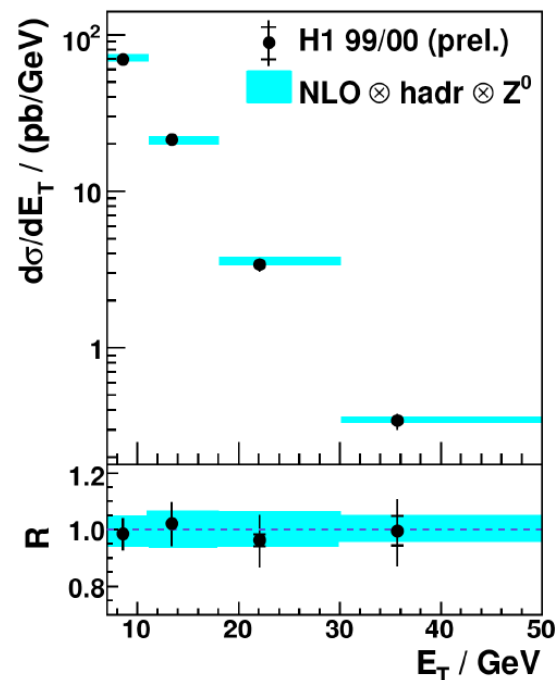
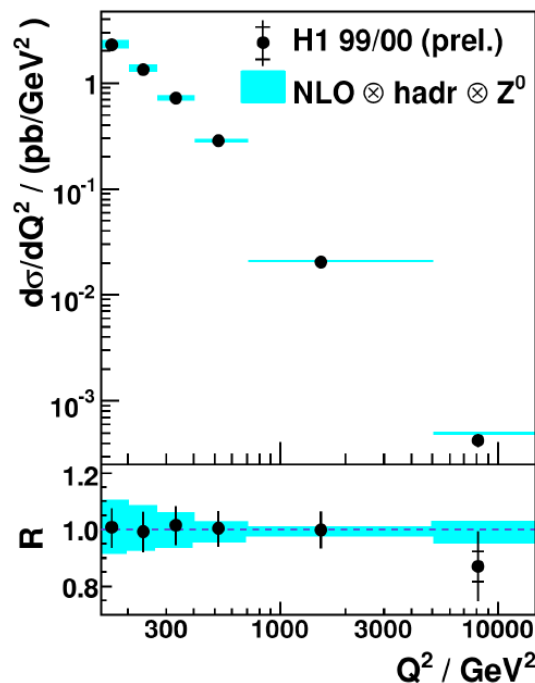
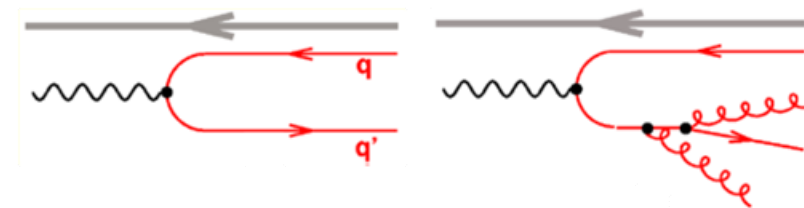
Jet Production in DIS at High Q^2

HERA I 99/00 e^+p : 65 pb $^{-1}$

- NC DIS: $150 < Q^2 < 15000 \text{ GeV}^2$
 $0.2 < y < 0.7$
- jets in Breit frame: $E_T > 7 \text{ GeV}$
- inclusive cross section:
each jet of an event contributes



Breit frame: virtual photon and proton collide head on



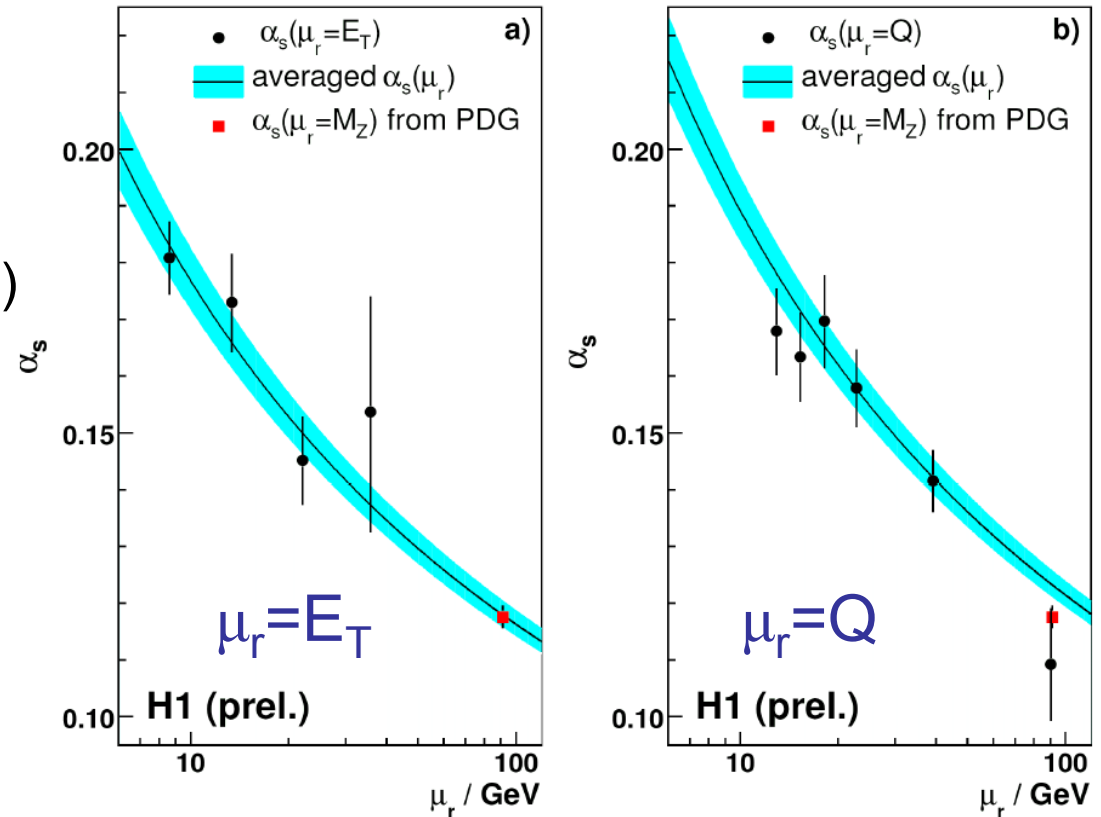
- ▶ cross sections well described by theory
- ▶ NLO prediction corrected for hadronisation
- ▶ Z exchange considered

Jet Production in DIS at High Q^2

Measurement of strong coupling

- average α_s from fits to double differential cross sections (Q^2 , E_T)
- two alternative scales used
- compatible with world mean

α_s from Inclusive Jet Cross Section



- most precise value obtained from fit to ratio $\sigma(\text{jets})/\sigma(\text{inclusive})$
- exp. error at 1% level, competitive and consistent with other determinations

$$\alpha_s(M_Z) = 0.1193 \pm 0.0014 (\text{exp.}) \quad {}^{+0.0046}_{-0.0032} (\text{th.}) \pm 0.0016 (\text{pdf.})$$