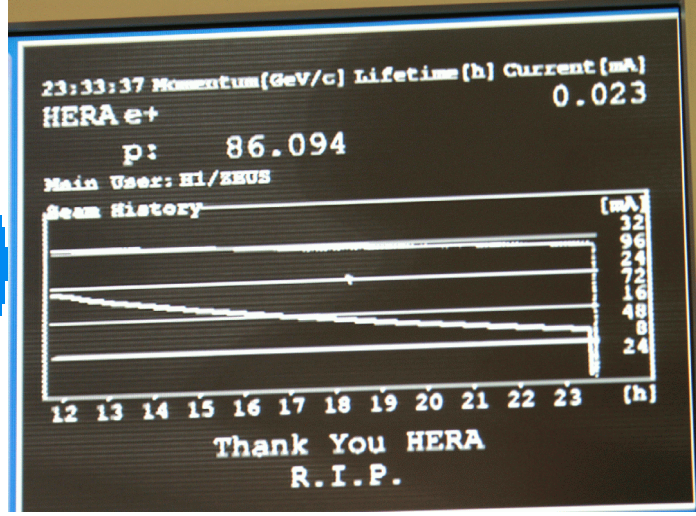


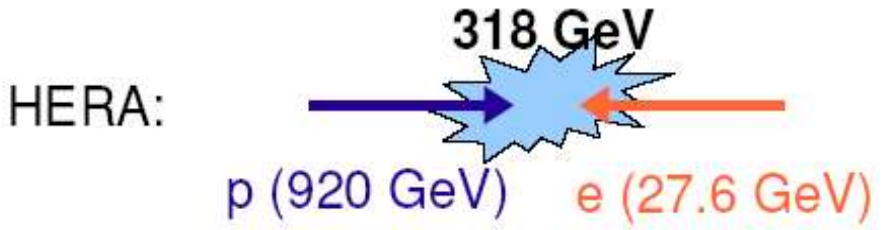
H1 Summer Conferences Results

Cristinel DIACONU

Centre de Physique des Particules de Marseille

and Deutsches Elektronen Synchrotron Hamburg

H1 and the HERA program



- **HERA 1: 1992-2000 ~120 pb^{-1}/expt**
- **HERA 2: 2003-2007 luminosity upgrade**

End of High Energy run
March 20 2007

H1 Harvest at HERA 1+2: ~478pb^{-1}

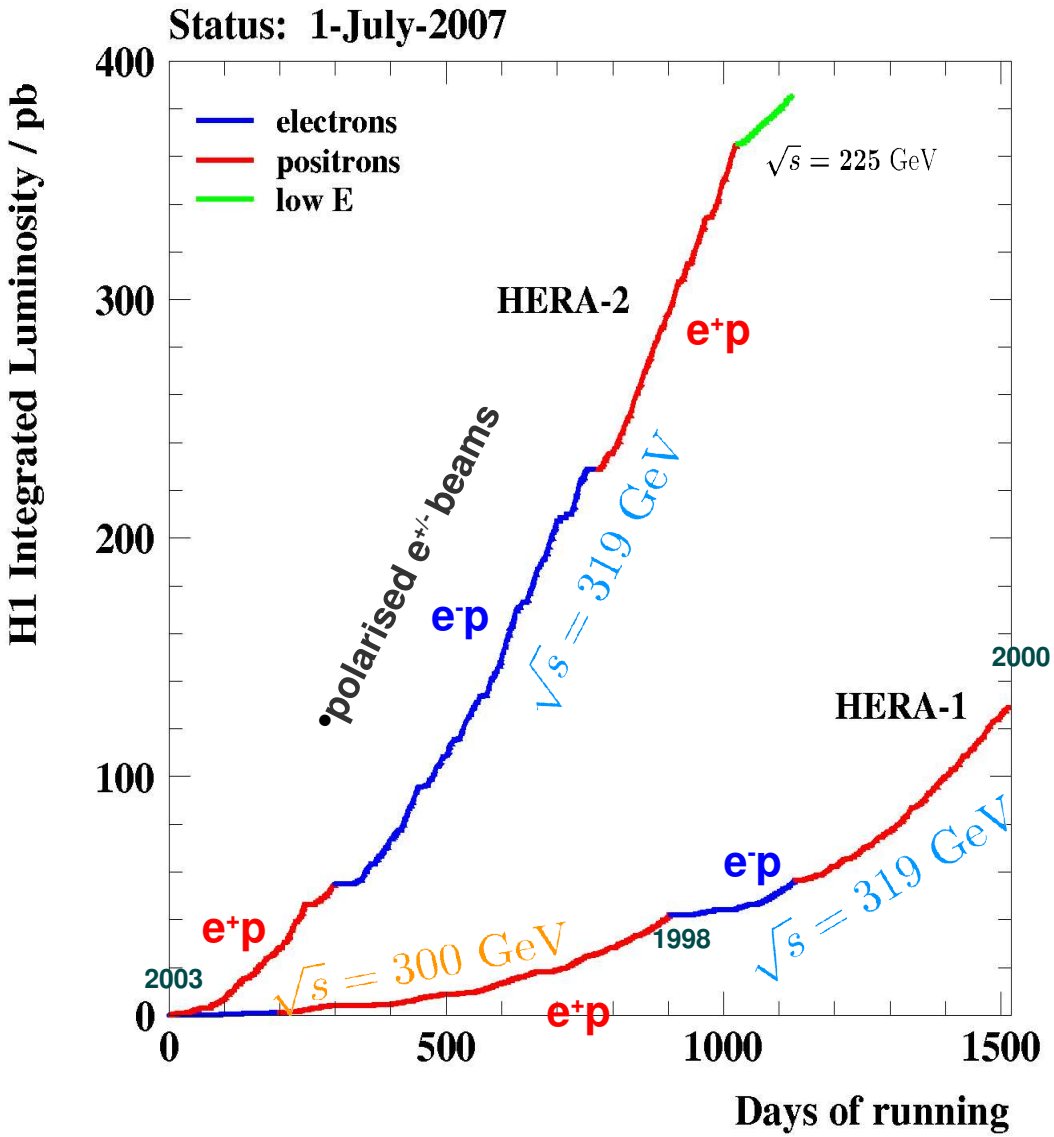
- **~184 pb^{-1} e$^-$p**
- **~294 pb^{-1} e$^+$p**

Since April 2007: Low Energy Run

E_p=460 GeV, 12.5 pb^{-1}

575 GeV, 6.5 pb^{-1}

HERA program entering
an exciting period: final analyses



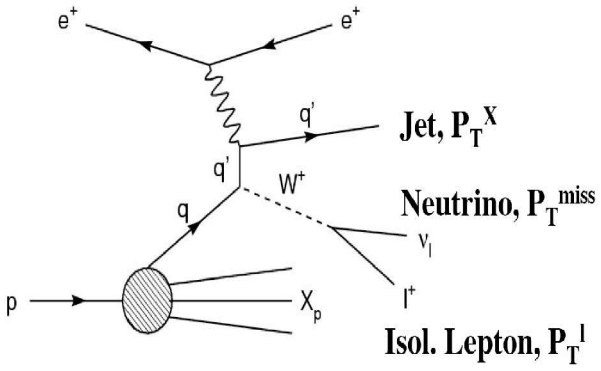
Outline

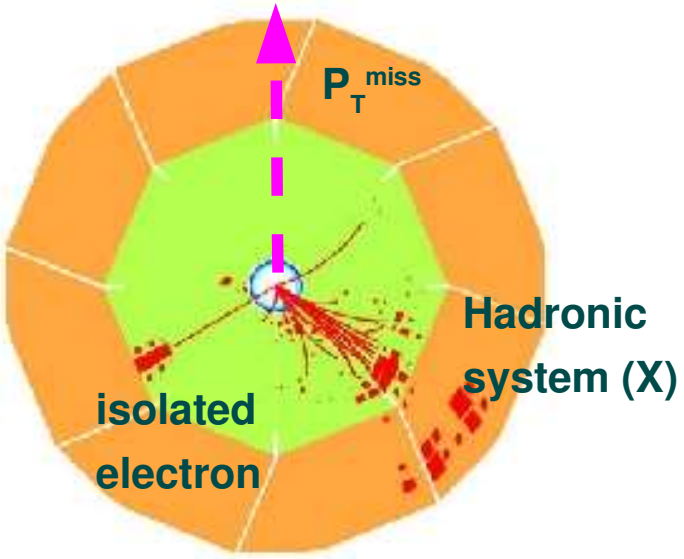
- **Searches for the new physics: HERA as a frontier collider**
  - **Rare processes with σ≤1pb and BSM**
  - **Electroweak fits**
- **Proton structure measurements: HERA as a proton imaging device**
  - **Best precision low Q2 and high Q2 (high y)**
- **QCD studies in a clean high energy laboratory: HERA as a QCD machine**
  - **Exclusive final states: α_s from jets, charm, photons, jets in diffraction, DVCS**

Event with isolated e or μ and P_T^{miss}

SM W: Total Cross Section ~1.3 pb

=> ~5 events/100pb^{-1}with e or μ

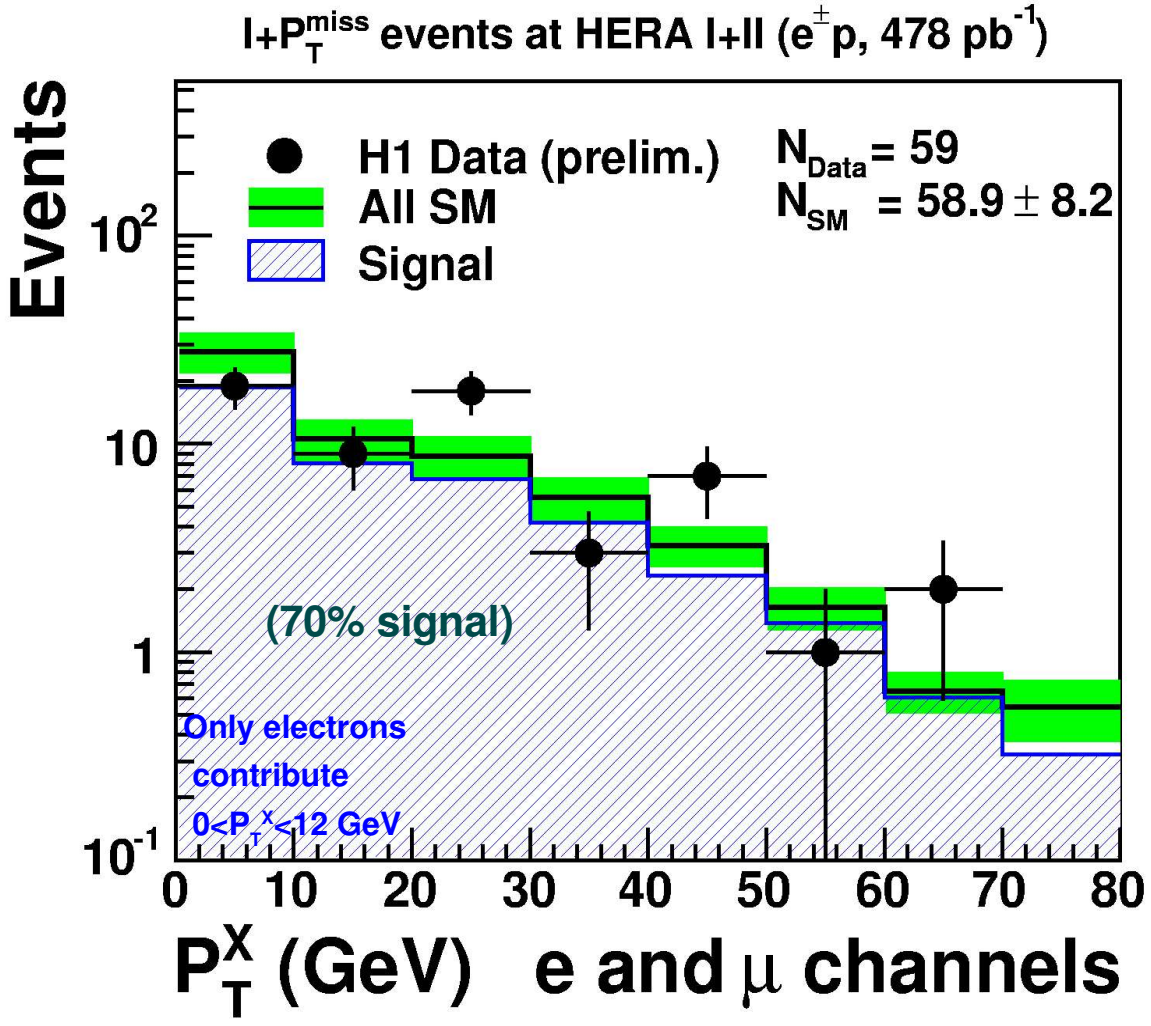




H1 HERA 1 (118 pb^{-1}, mainly e$^+$p)

P_T^X>25 GeV 11 (Data) / 3.5±0.6 (SM) (3σ)

Full HERA Luminosity

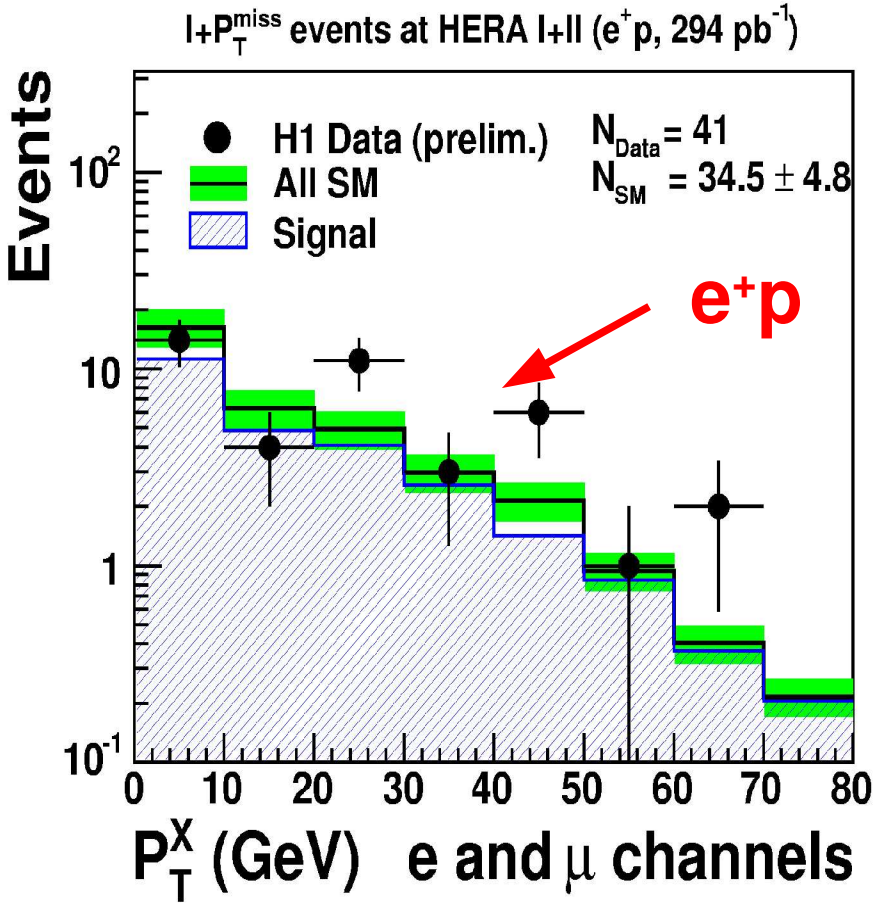


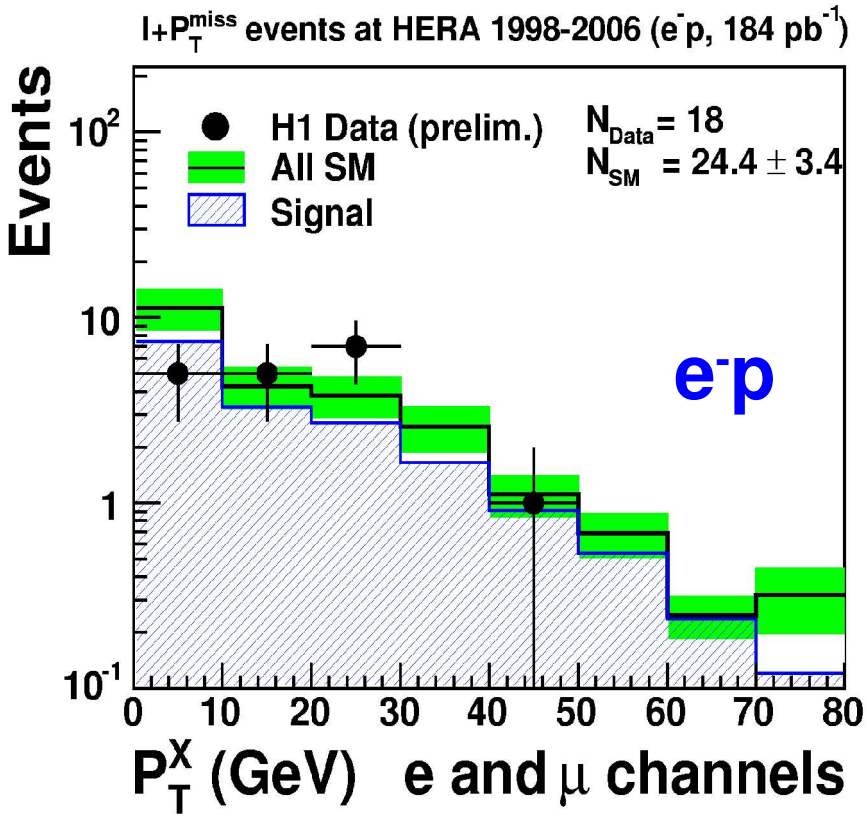
Evidence for W production at HERA

Continue to observe events at high P_T^X

=>Look more differentially in e$^+$p/e$^-$p data samples

H1 Results (e and μ) e^+p vs. e^-p data





e^+p H1 observation: 21/8.9±1.5 (3.0σ)

not clarified with HERA II data

no events in excess observed by ZEUS

e^-p Agreement with SM (H1 and ZEUS)

H1-ZEUS combination

Common Phase Space:

P_t^{lep}>10 GeV 15°<θ_{lep}<120°

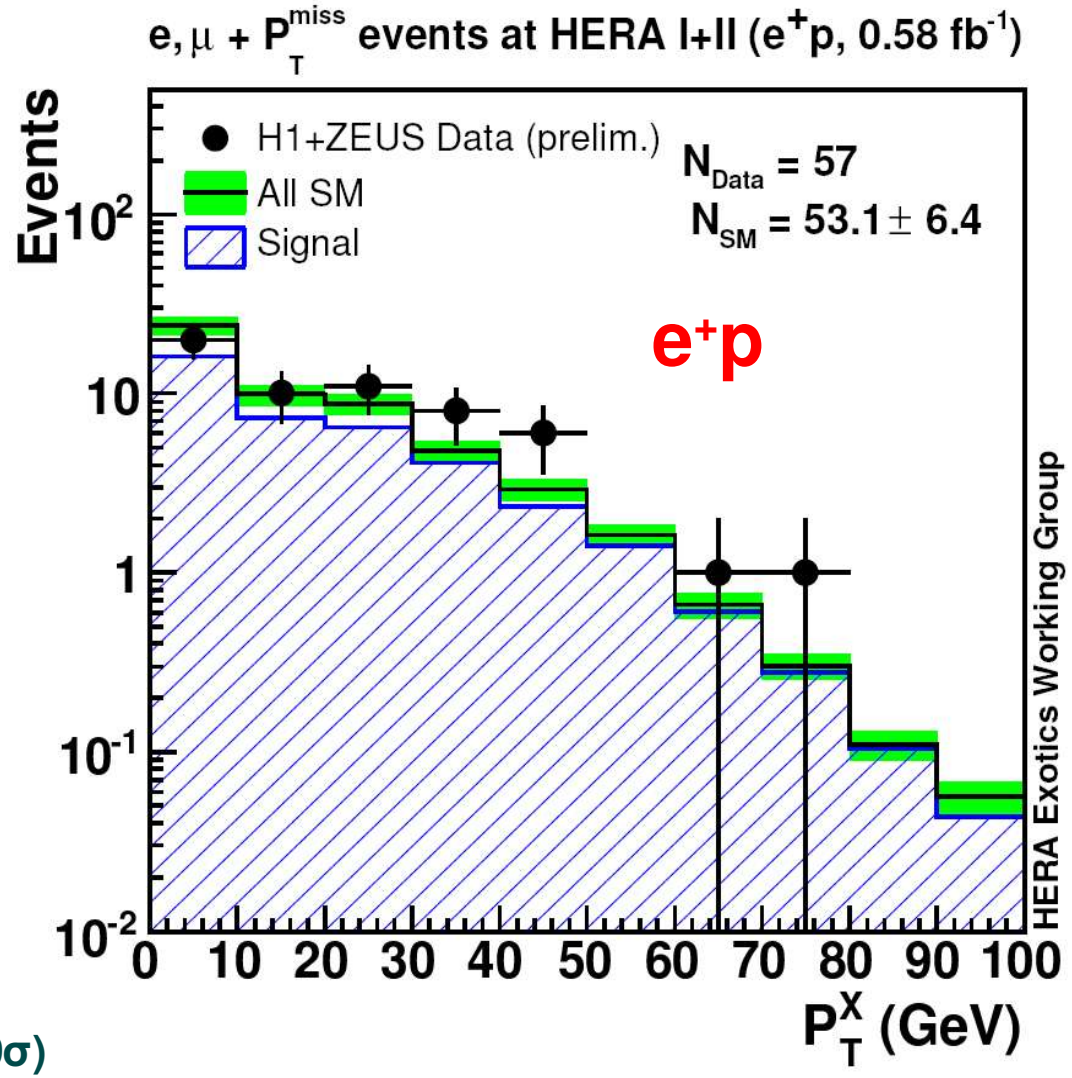
all background rejection cuts harmonised

ZEUS: new analysis for EPS2007

sees good agreement e+p/e-p

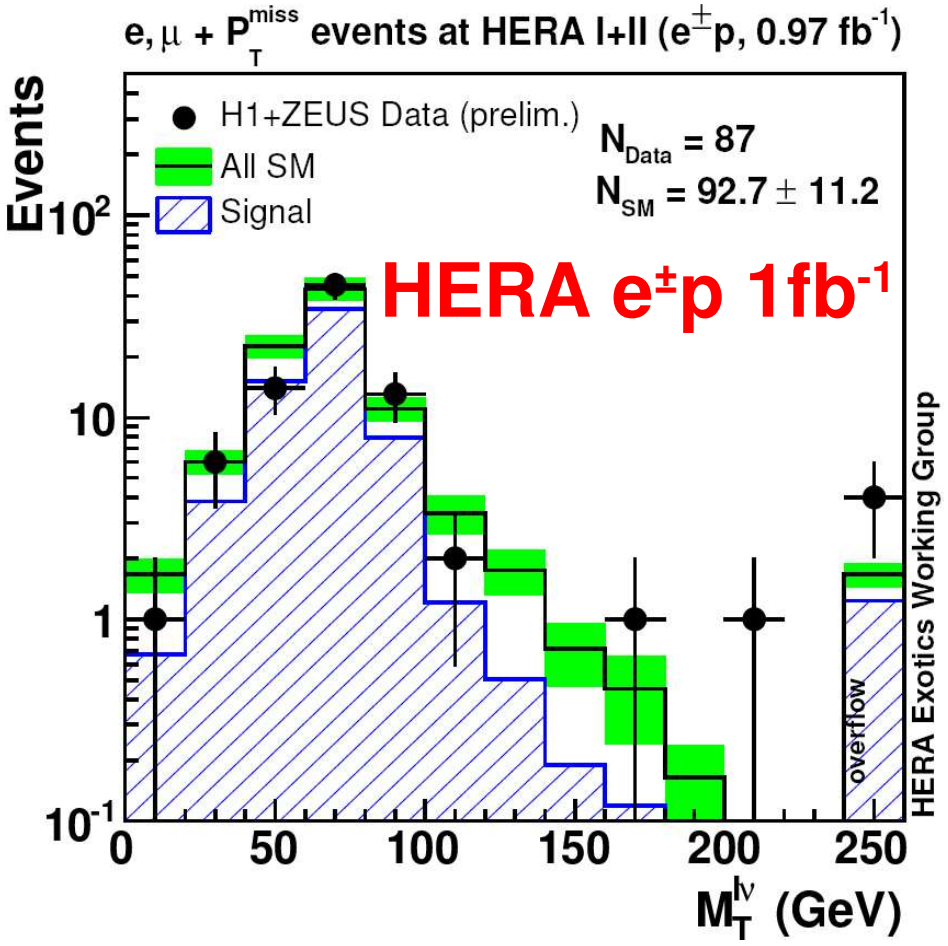
H1 excess e+p: the same level (2.9σ)

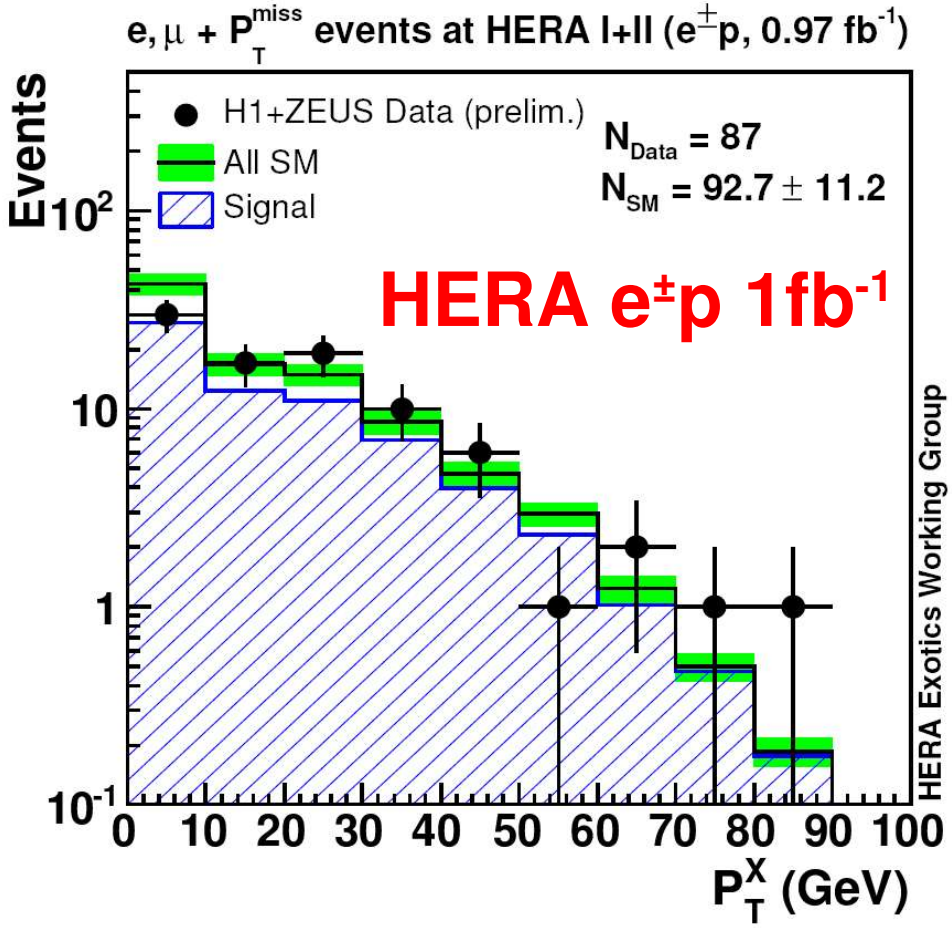
H1 vs. ZEUS compatibility @ 2σ



P_T^X> 25 GeV		e+μ Data/SM	
H1	0.29 fb^{-1}	17/7.1±0.9	(2.9σ)
ZEUS	0.29 pb^{-1}	6/7.5±1.1	
H1+ZEUS	0.58 fb^{-1}	23/14.6±1.9	(1.8σ)

Isolated leptons+P_T^{miss} at HERA





Large statistics to measure and investigate W production

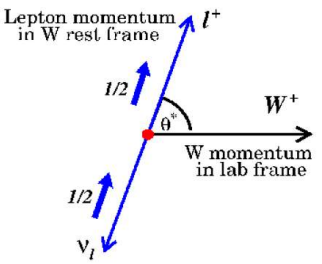
W production and W helicities

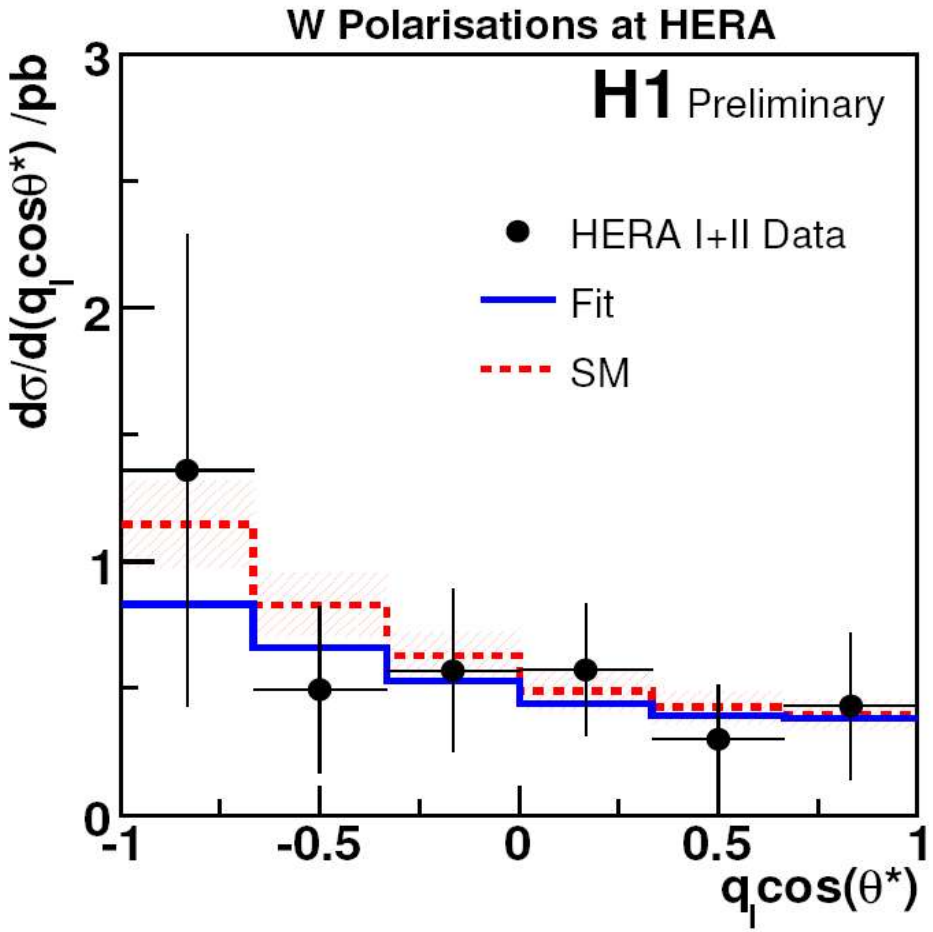
Cross section measurements (e+μ)

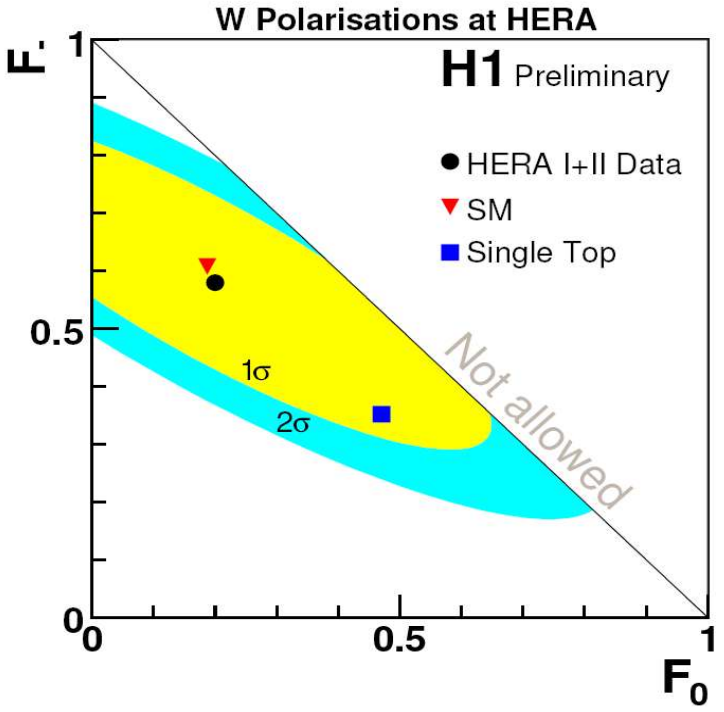
(NLO QCD)

H1	HERA I+II Data	SM
$\sigma_{\sigma_{\ell+\not{p}_T}}$	$0.24 \pm 0.05\,(\text{stat}) \pm 0.05\,(\text{sys})$	$0.26 \pm 0.04\,(\text{th.sys})$
σ_W	$1.23 \pm 0.25\,(\text{stat}) \pm 0.22\,(\text{sys})$	$1.31 \pm 0.20\,(\text{th.sys})$

$$\frac{dN}{dcos\,\theta^*} \propto (1 - F_- - F_0) \cdot \frac{3}{8}(1 + cos\,\theta^*)^2 + F_0 \cdot \frac{3}{4}\left(1 - cos^2\theta^*\right) + F_- \cdot \frac{3}{8}(1 - cos\,\theta^*)^2 .$$







H1	HERA I+II Data	SM
F_-	$0.58 \pm 0.15\,(\text{stat}) \pm 0.12\,(\text{sys})$	$0.61 \pm 0.01\,(\text{stat})$
F_0	$0.15 \pm 0.21\,(\text{stat}) \pm 0.09\,(\text{sys})$	$0.19 \pm 0.01\,(\text{stat})$

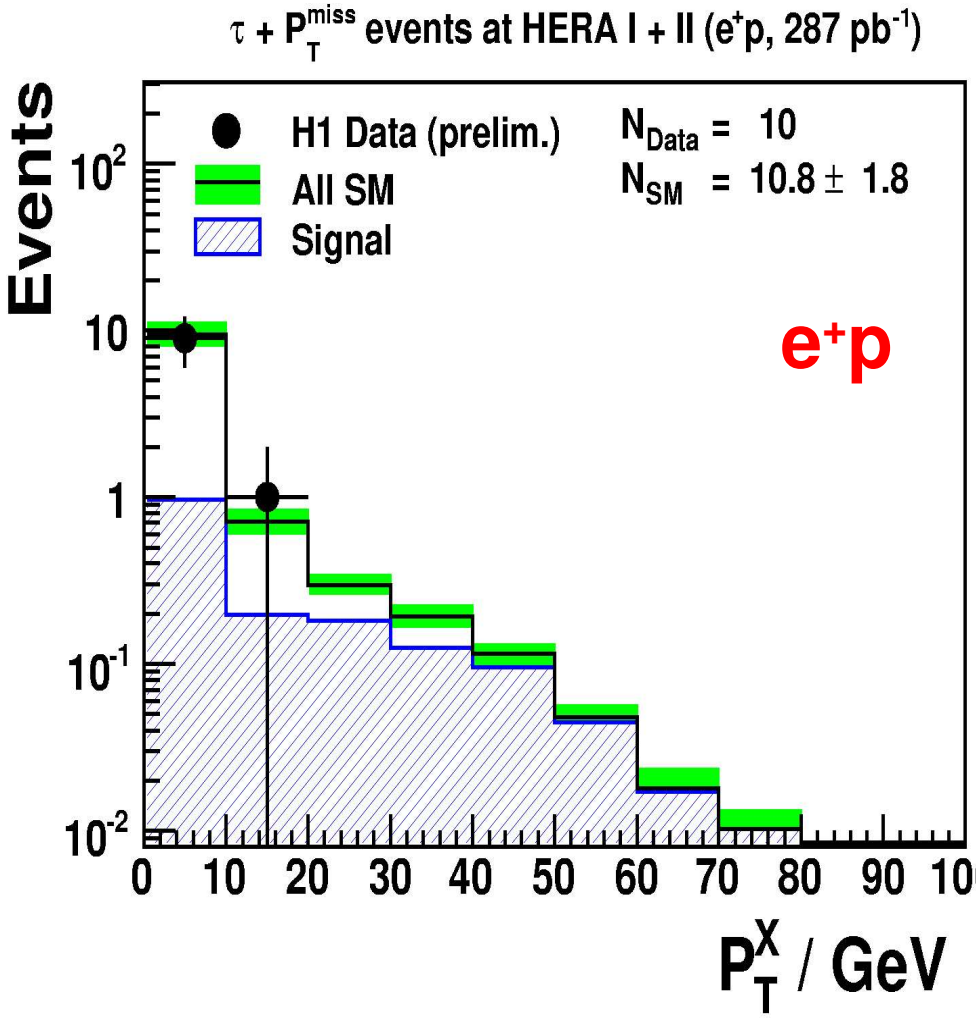
New Result

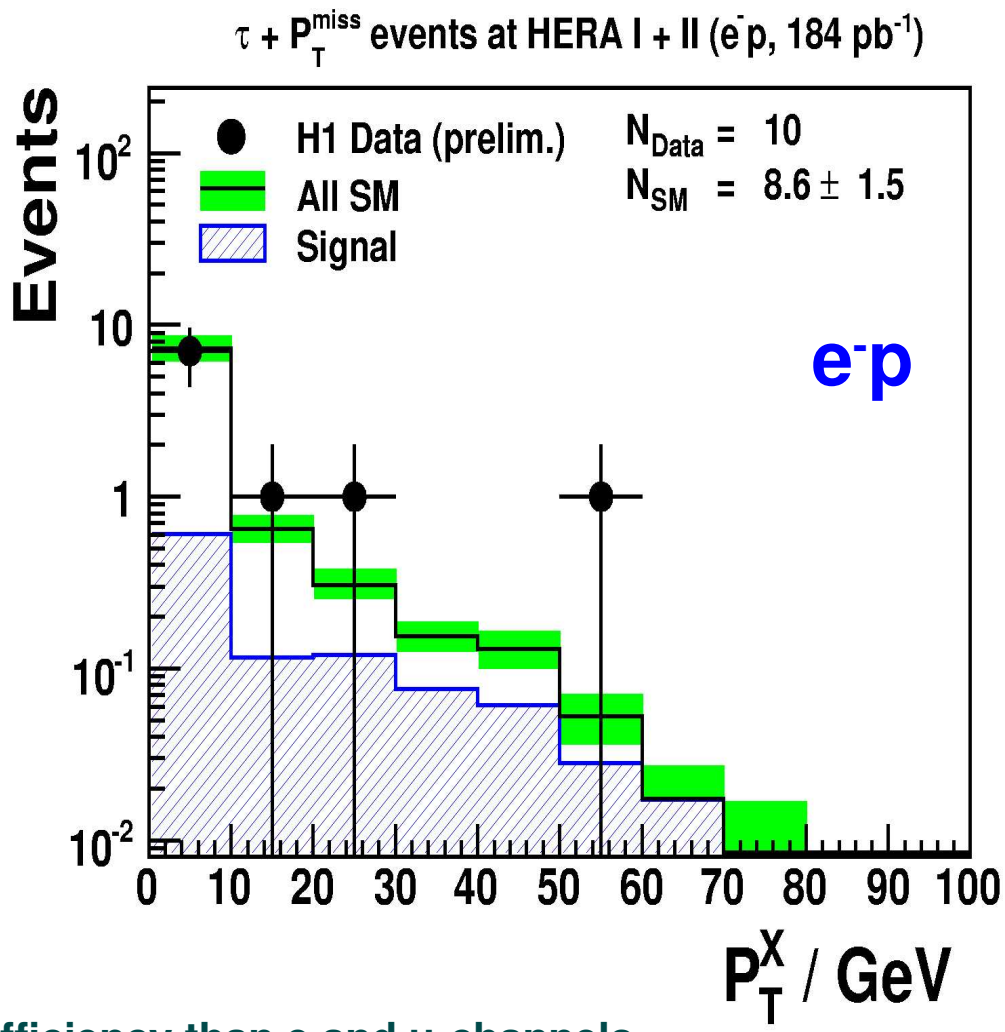
Full HERA statistics

$\tau + P_T^{miss}$ e^+p vs. e^-p data

τ leptons identified in the hadronic (one-prong) decay channel

Jets with single tracks in CC events





Large background (CC), much lower efficiency than e and μ channels

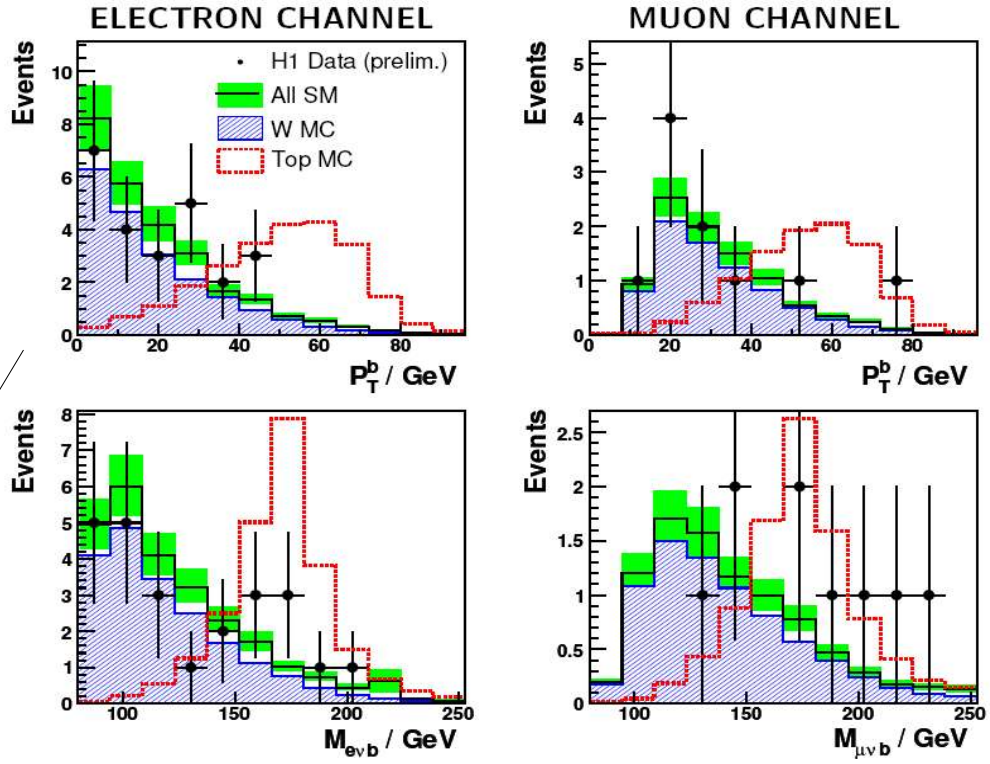
- No excess detected in e^+p and e^-p.

Search for anomalous top production

FCNC

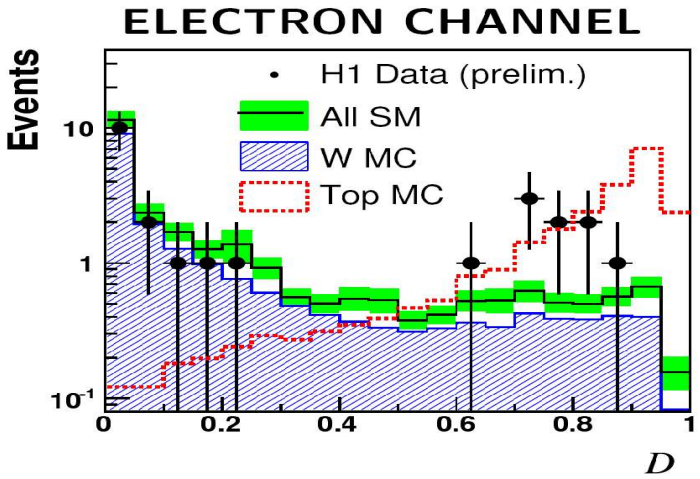
$$e^{\pm}\, u \rightarrow e^{\pm} t \rightarrow \ell^{+}\, P_T^{miss}\, \mathrm{jet}$$

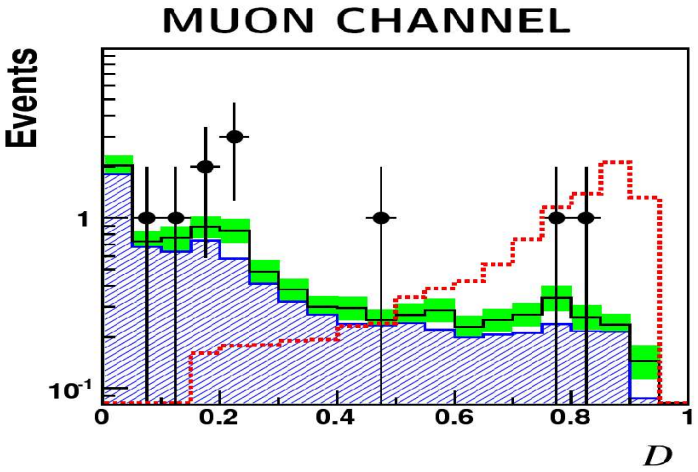
Full HERA Luminosity



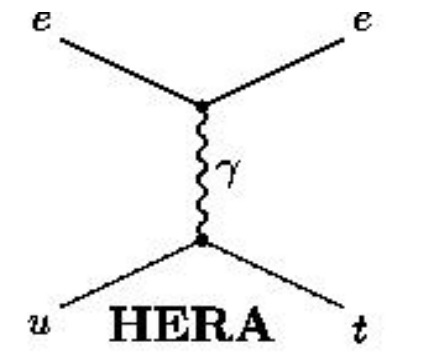
Multivariate Analysis

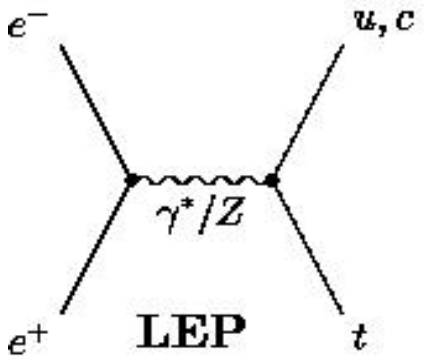
M_{top}, P_t^b, θ*

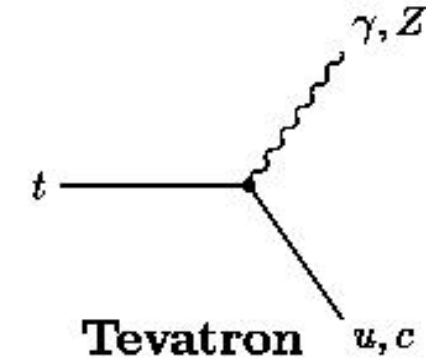


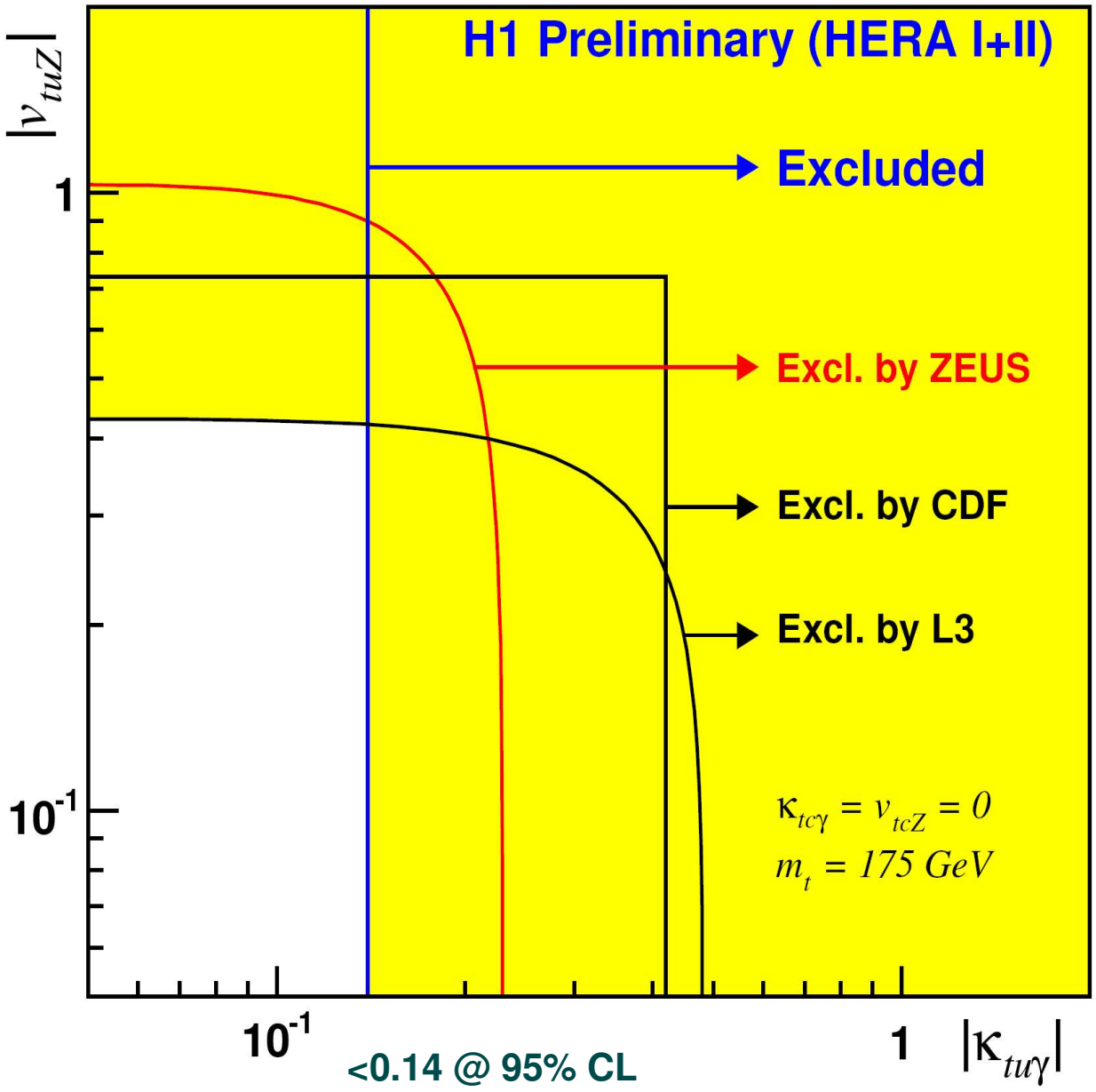


Search for anomalous top production









New Result
Full HERA statistics

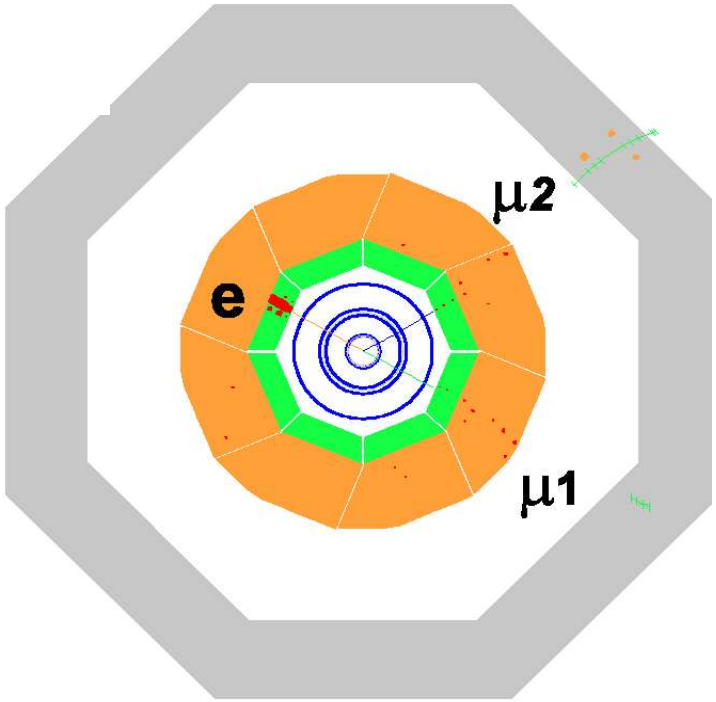
Multilepton events

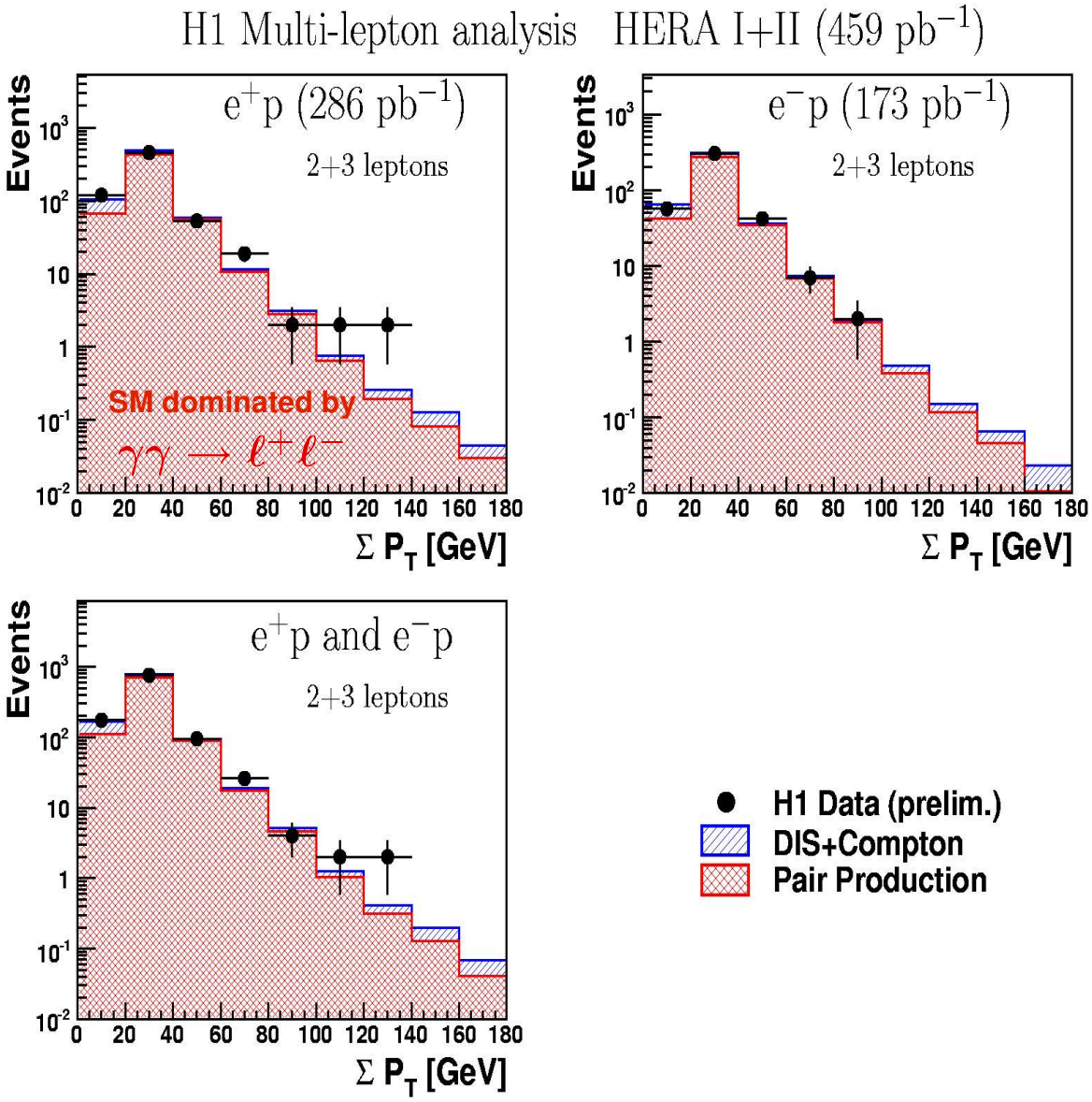
H1/HERA I: observation of multi-electrons at high mass

Include muons; combinations:

ee, eμ, μμ, eee, eμμ

ΣP_T: "hardness" of the events





For ΣP_T>100 GeV, e^+p data: 4/1.2±0.

combination with ZEUS ongoing

General Searches

New result
Full HERA II

- Search for isolated particles at high P_T
- Electrons ,Photons, Muons, Hadronic Jets, Neutrinos

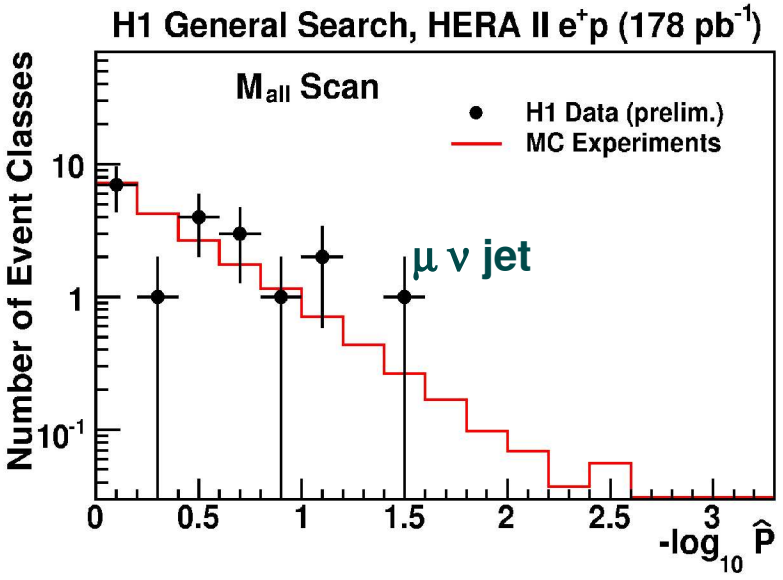
- Unique phase space:

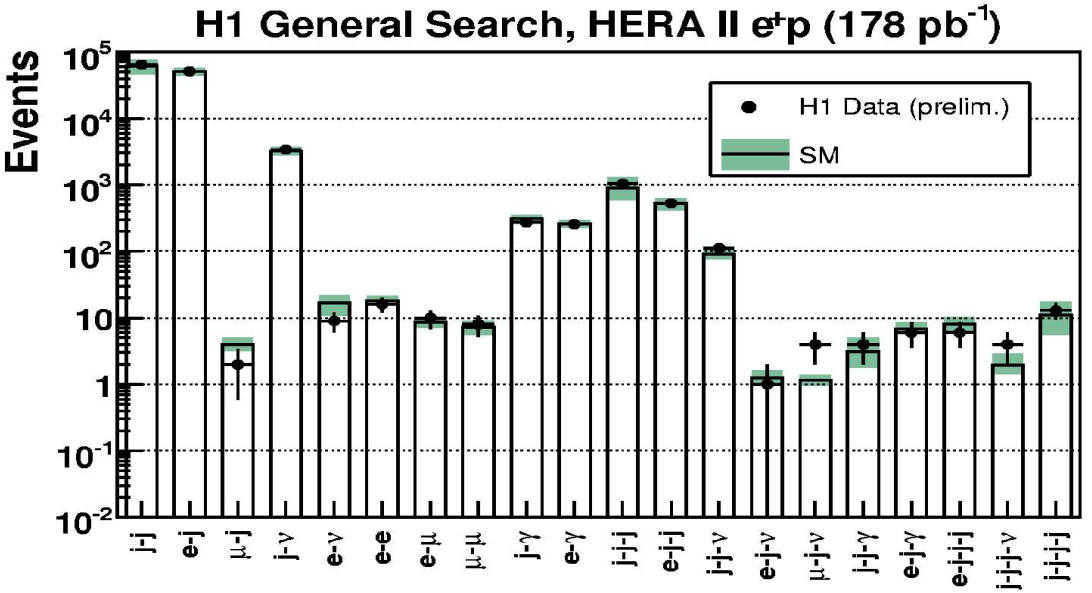
P_T >20 GeV

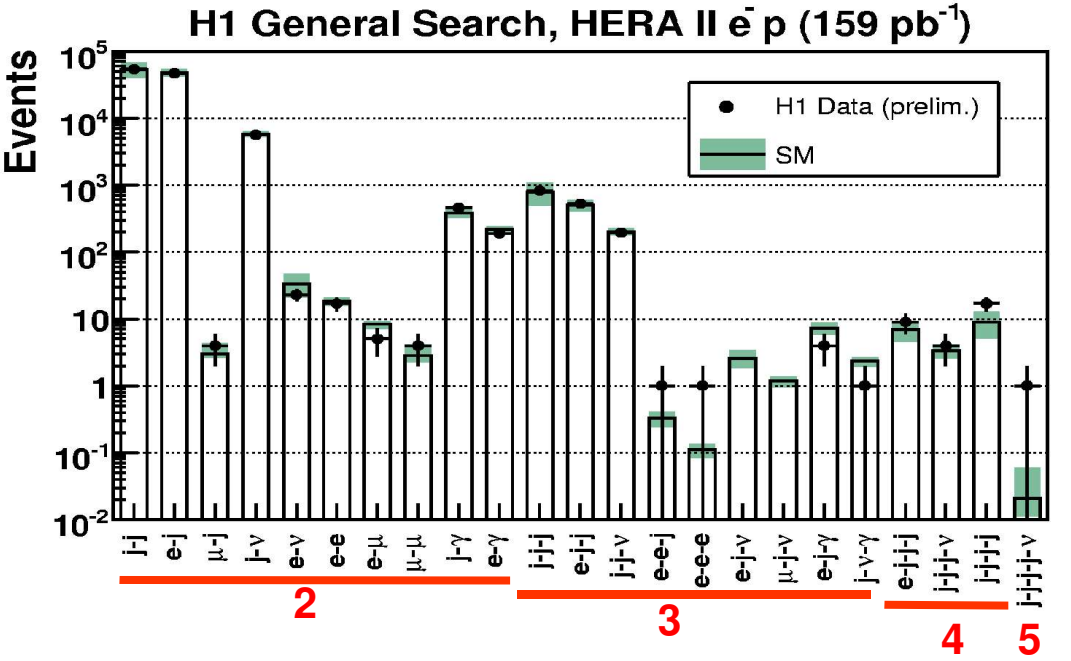
$10^o<\theta<140^o$

D0, PRD64, 012004 (2001)
H1, Phys Lett B602 (2004) 14

- Investigate Mass and ΣP_T
- Statistical Analysis (search for deviations)





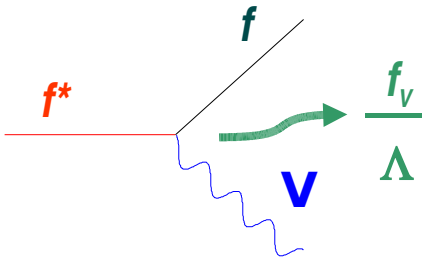


Search for lepton-boson resonances

Unambiguous signature for matter substructure:

direct observation of excited states

full HERA E_{cm}=320 GeV luminosity



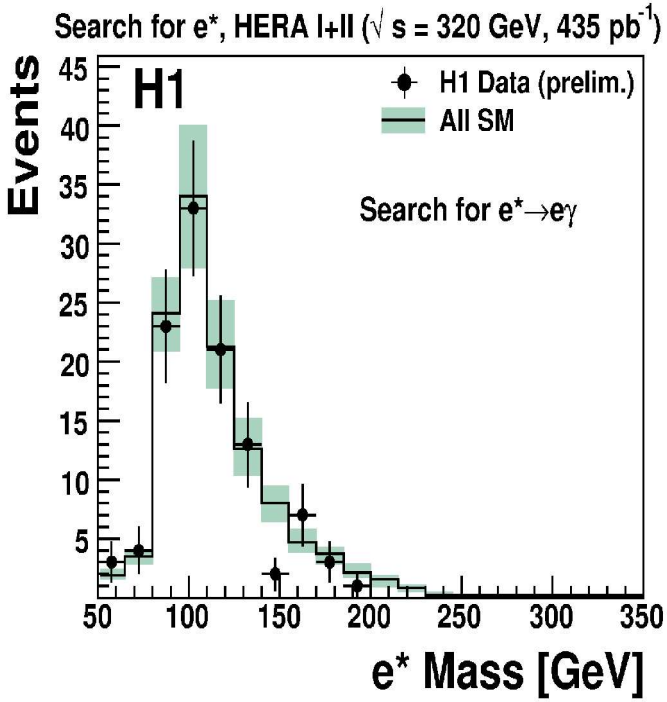
$\Lambda \approx$ compositeness scale

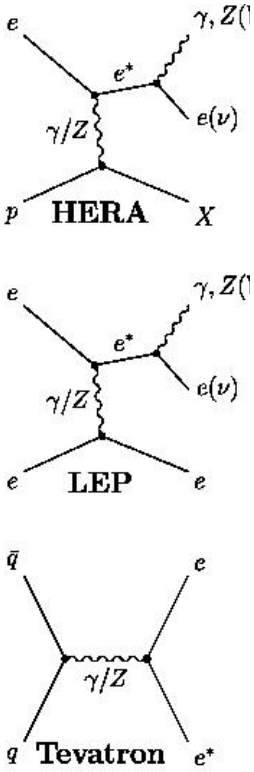
Relative strength γ, Z,g :

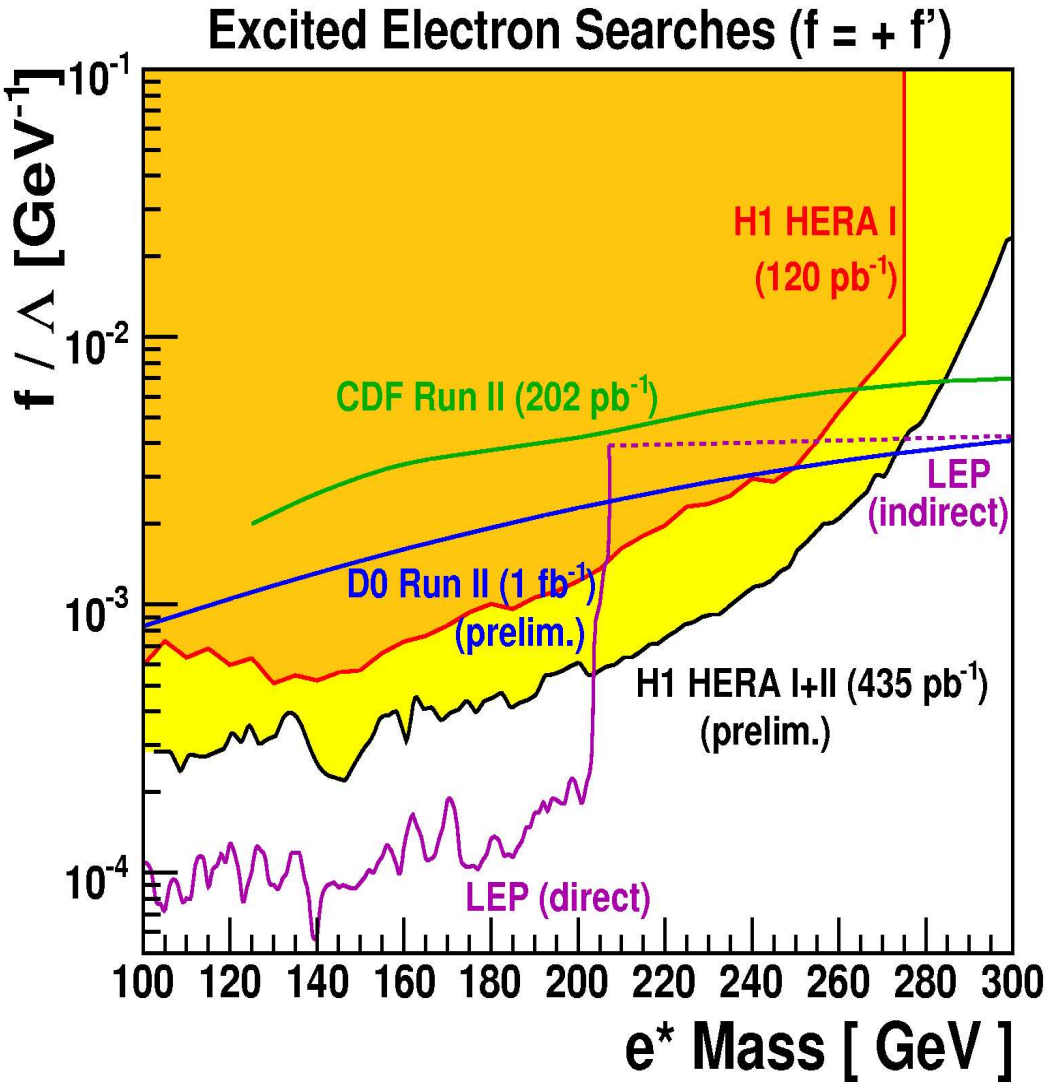
couplings f, f ', f_s

Lepton-Boson Resonances

eγ, νW, eZ



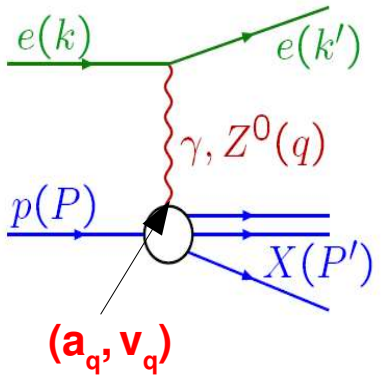




$f/\Lambda = 1/M_{e*}$

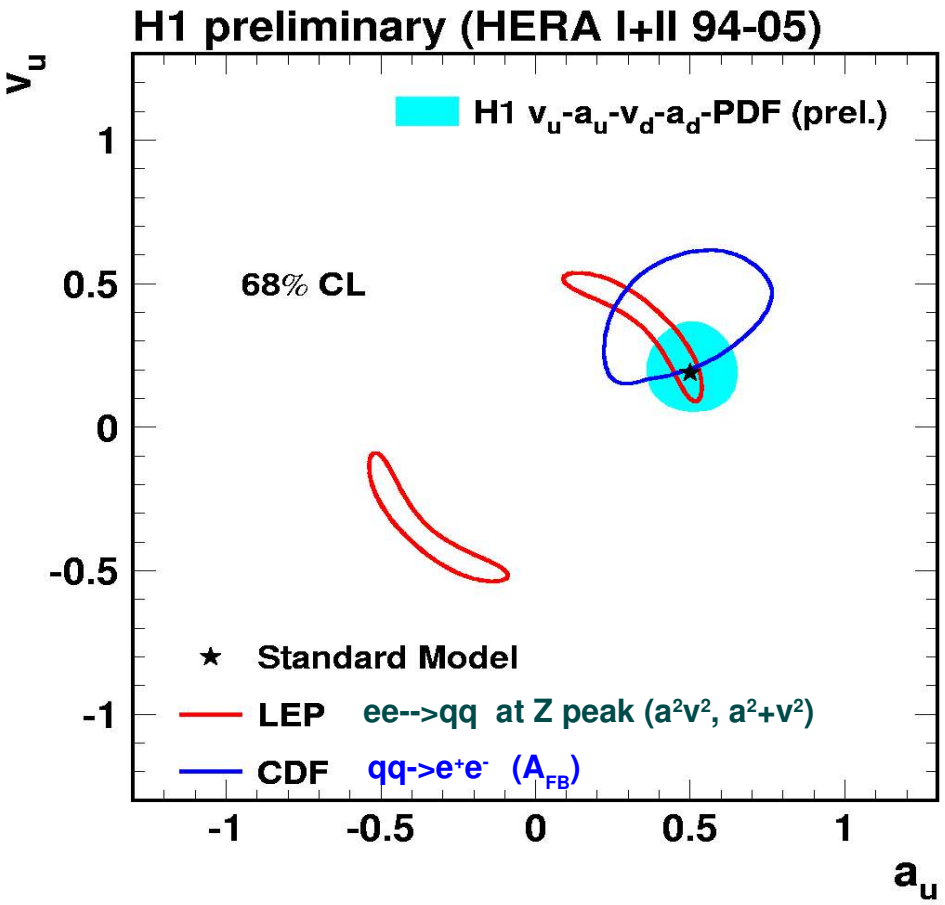
$M_{e*} < 273$ GeV excluded @ 95% C.L.

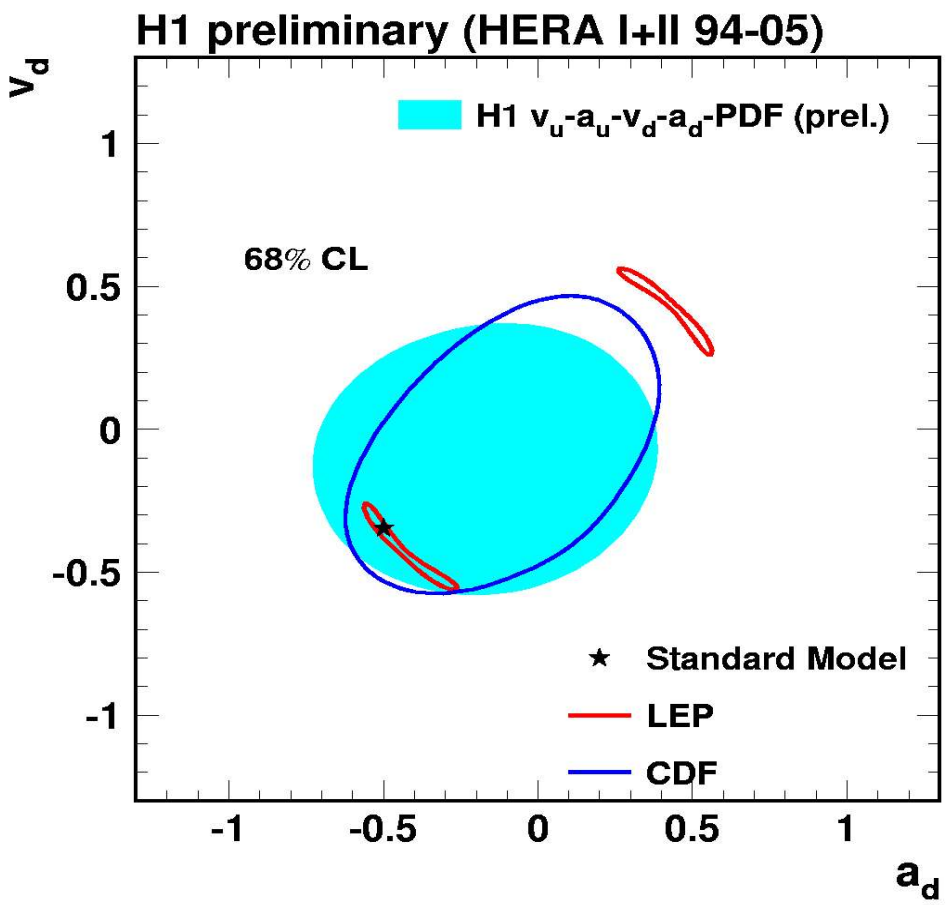
Light quark couplings to Z



NC/CC data=> full QCD/EW Fit: PDF's+light quarks couplings

Now taking advantage of polarisation @HERA II : new fit





Best precision for u-couplings (factor 2 improvement wrt HERA 1)

A factor 2 increase in (e^+p) luminosity still to go

Low Q^2 measurements

High precision in the low Q^2 regime obtained via special runs

MB minimum bias (high trigger rate)

SVX shifted collision vertex

(increase acceptance at lowest Q2)

Q^2: 0.2 – 12 GeV^2

x:4•10^{-6} – 0.02

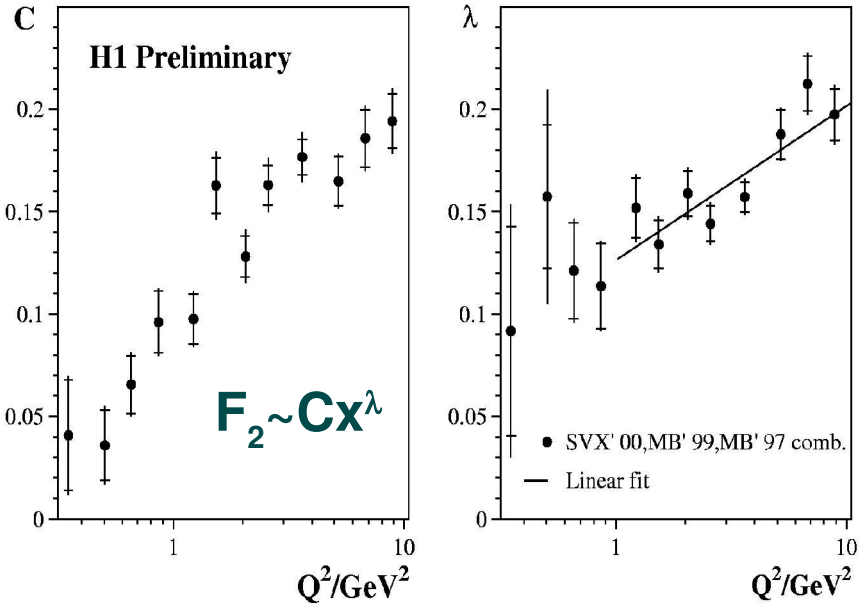
New: datasets combined

2-3% precision (systematics limited)

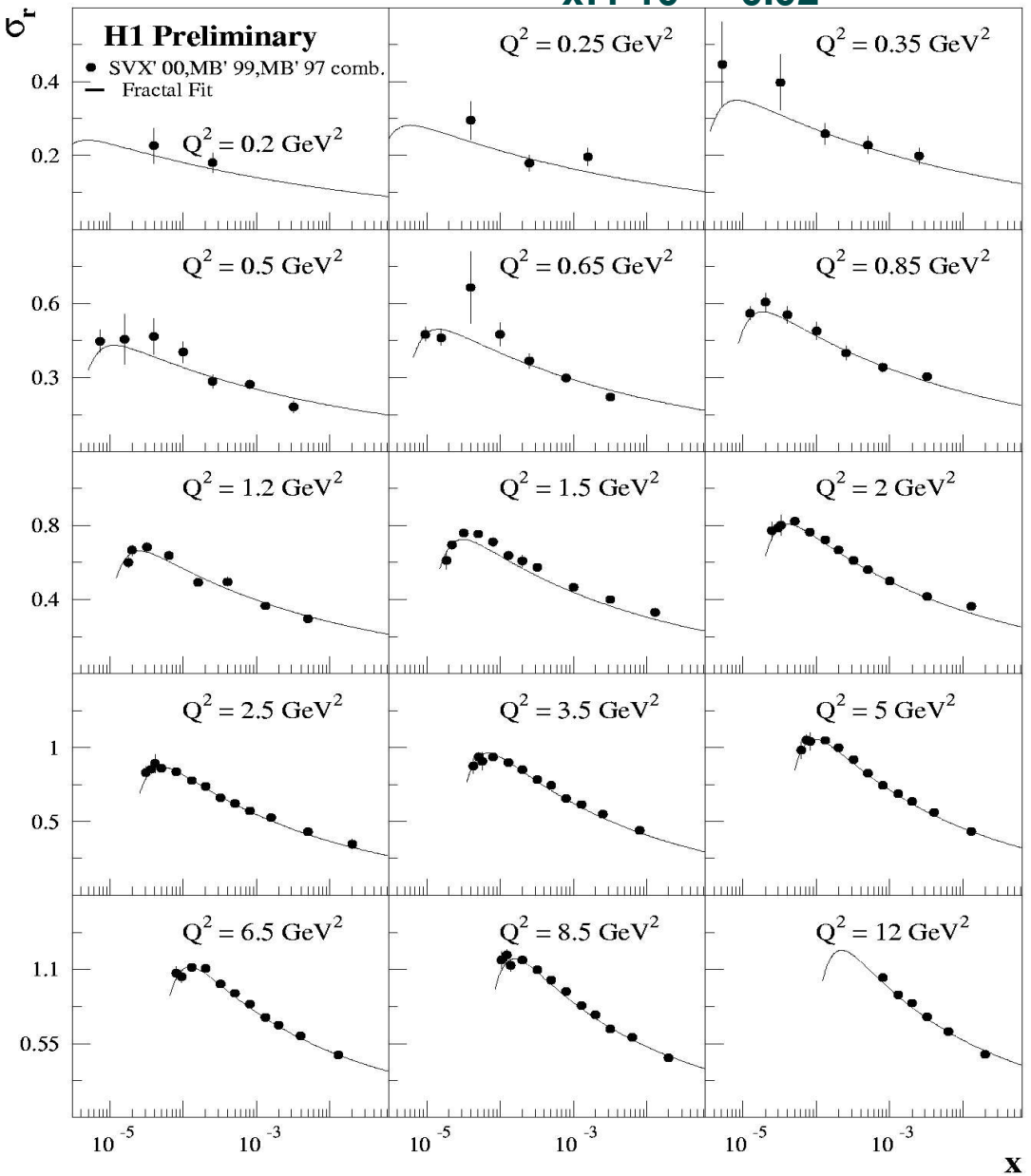
$$\sigma_r = F_2(x,Q^2) - \frac{y^2}{Y_+}\cdot F_L(x,Q^2)$$

Soft hadronic to DIS transition

F2: empirical predictions: fractal fit, power law...



...and F_L



High y regime and F_L

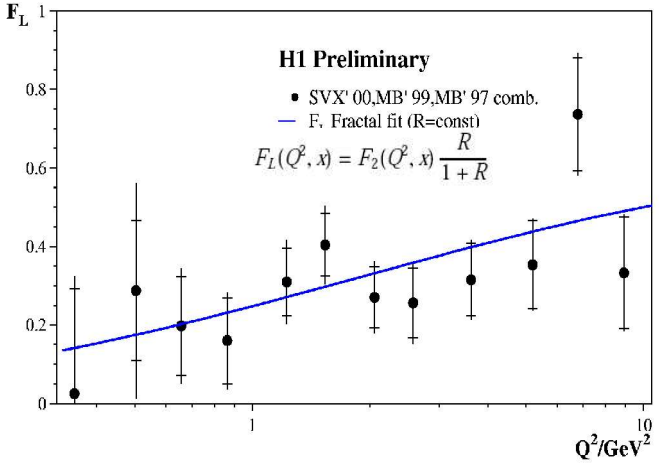
$$\sigma_r = F_2(x,Q^2) - \frac{y^2}{Y_+}\cdot F_L(x,Q^2)$$

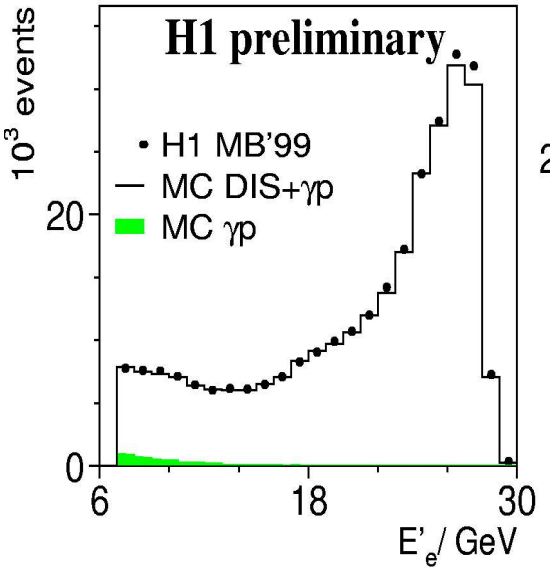
$$F_L(x,Q^2) \sim \alpha_s x g(x,Q^2)$$

To extract F_L

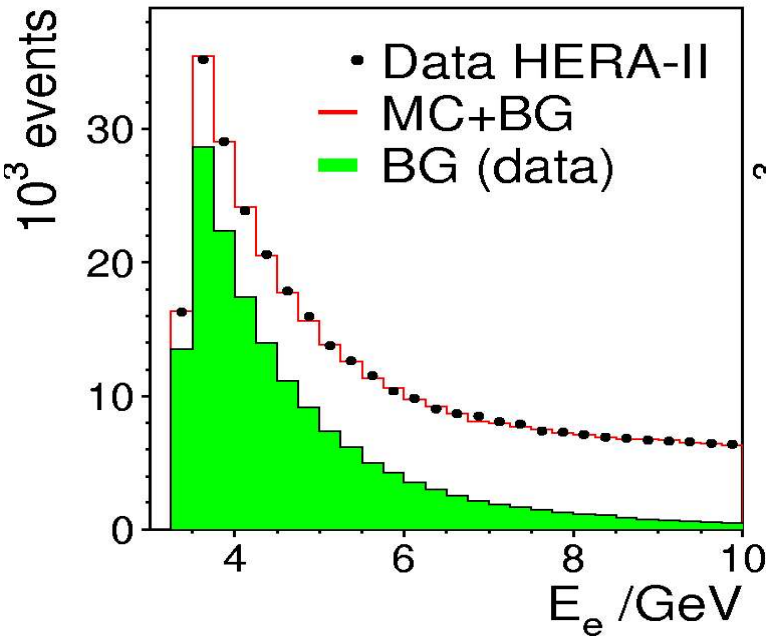
$$\sigma_r(Q^2,x) = c(Q^2)\,x^{-\lambda(Q^2)} - \frac{y^2}{Y_+}F_L(Q^2)$$

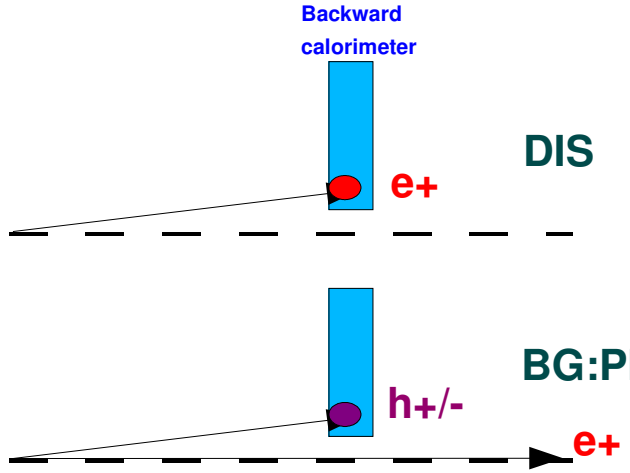
$$y \simeq \frac{E_e - E_e^0}{E_e}$$ **high y = low E_e**





New analysis (HERA II) e^+p/e^-p Data



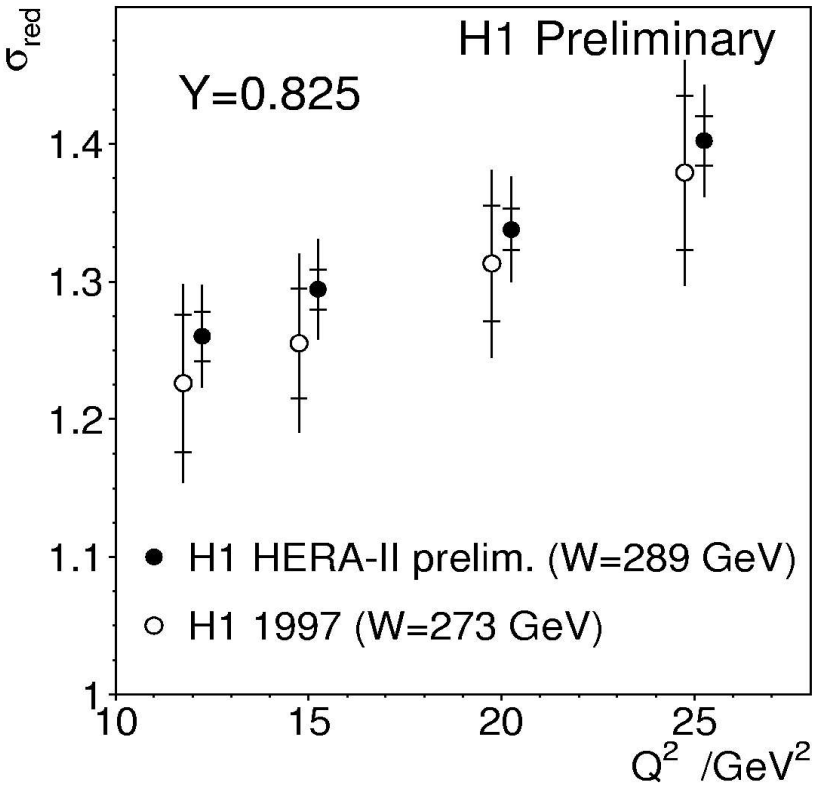


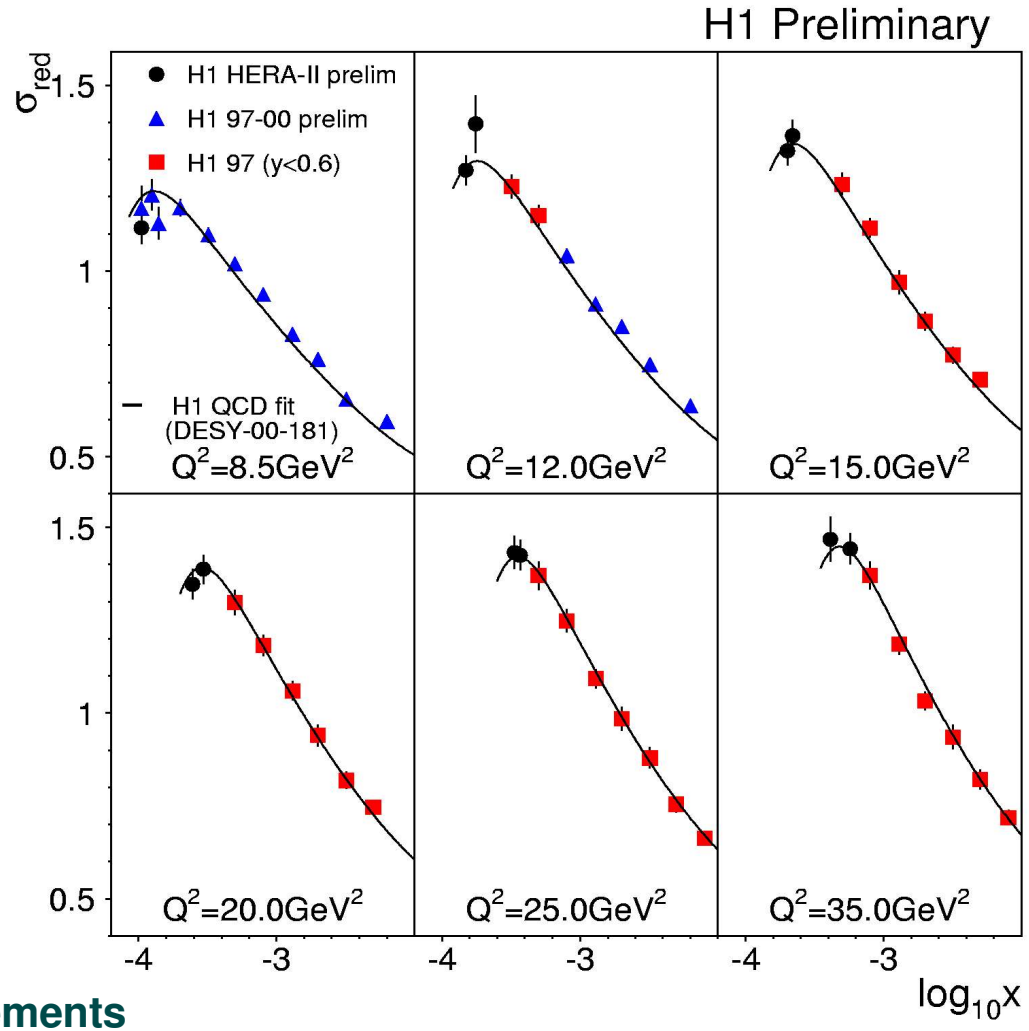
Background subtracted using charge tag

e^+p/e^-p samples complement/compare

High y measurement for Q^2=8.5 – 35 GeV^2

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



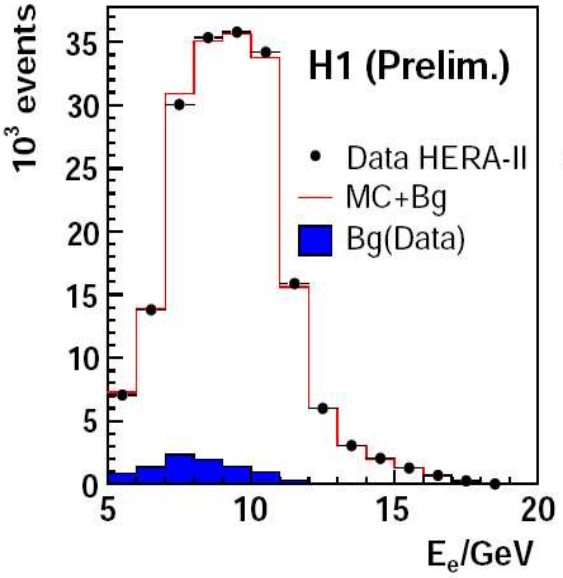


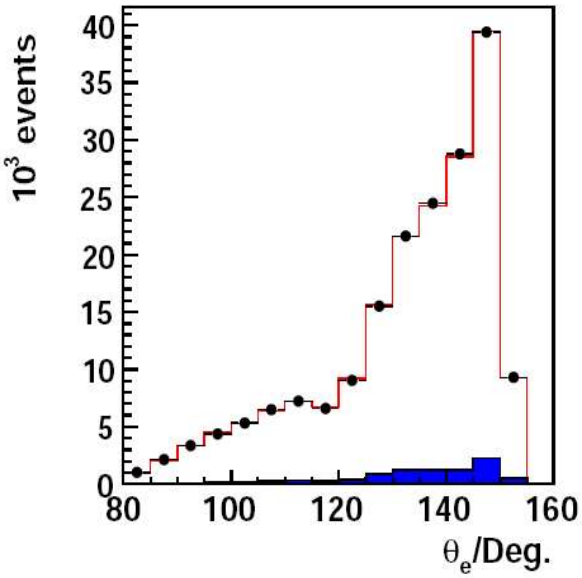
HERA II data used in precision measurements

Uncertainties divided by a factor of 2

High y measurement at high Q2

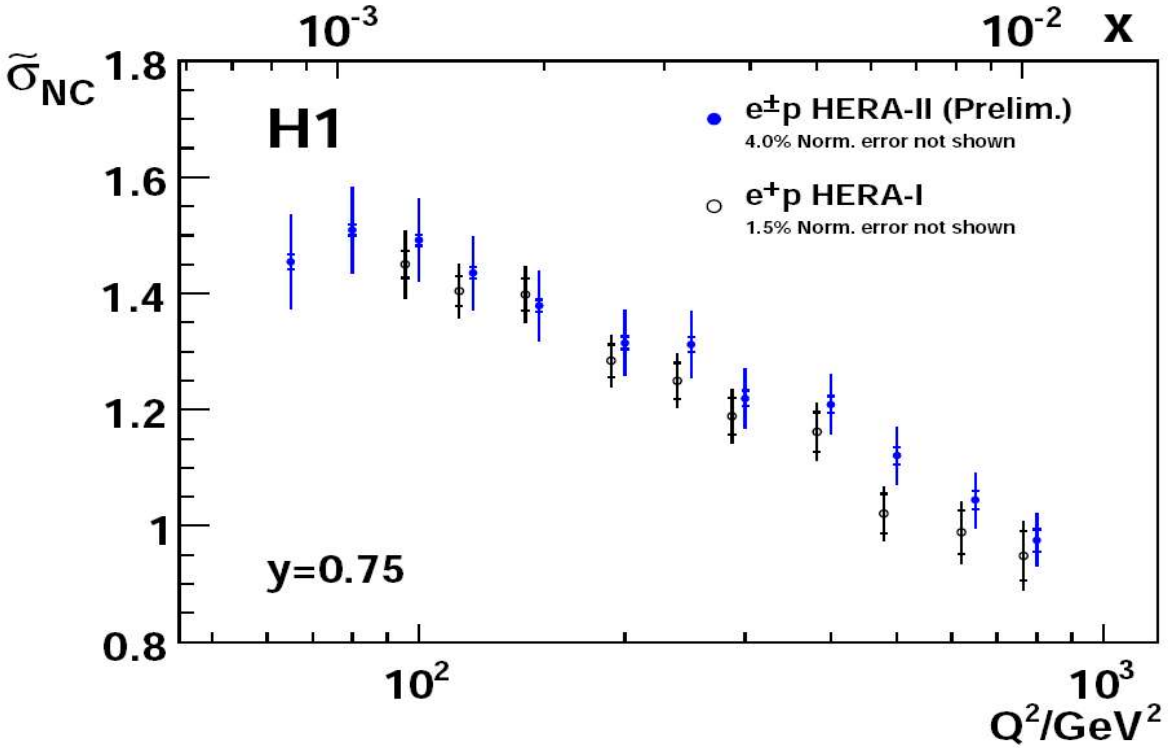
Electrons at low energy
in the calorimeter



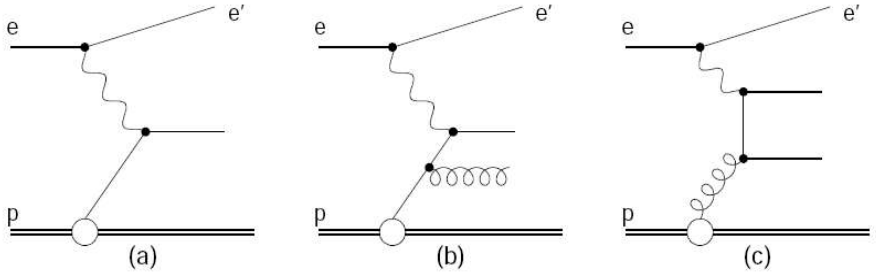


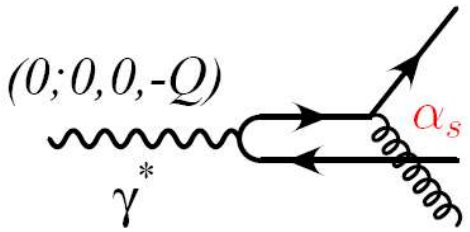
Improvement in statistics,
and phase space extension

Good prospects for final precision

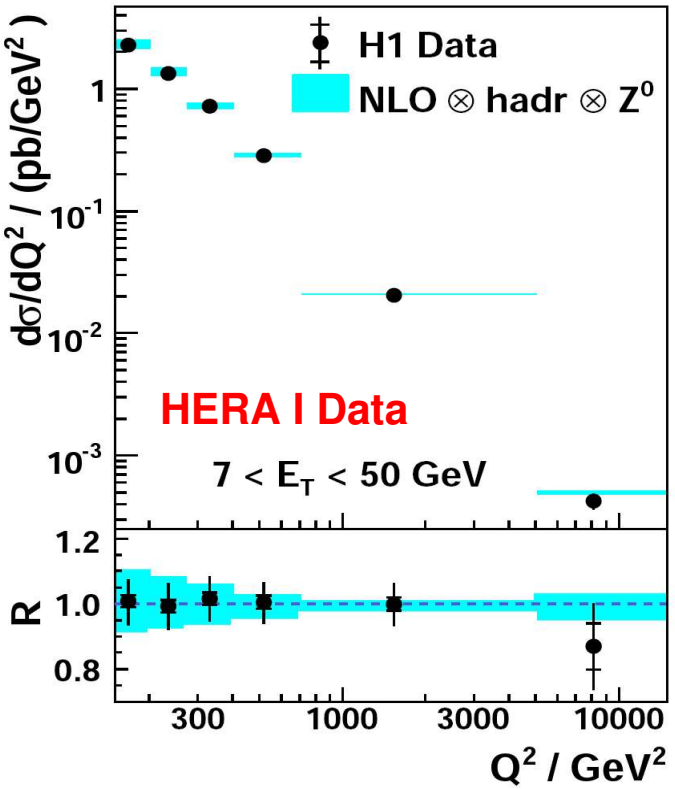


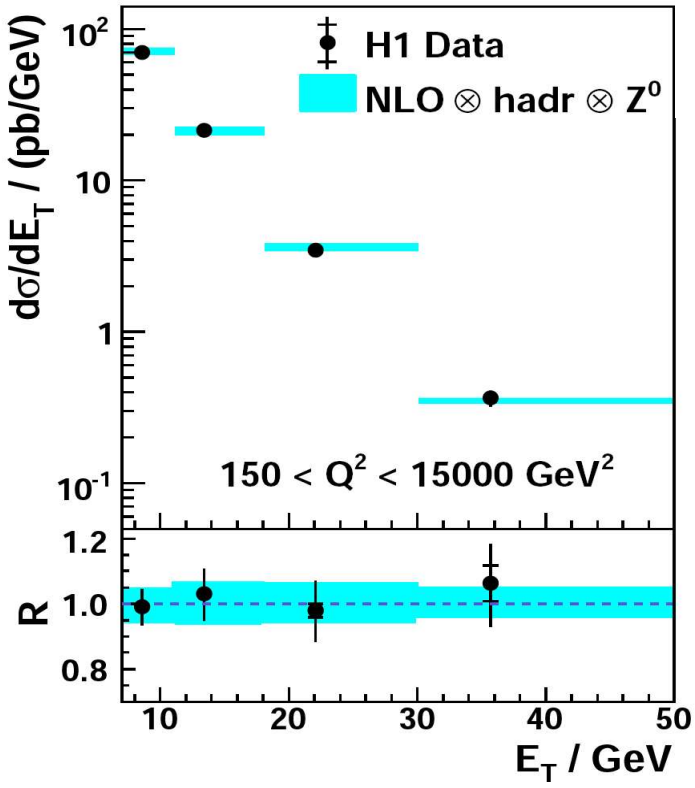
Jet production in DIS: high Q^2





Inclusive Jet Cross Section





$$150 < Q^2 < 15000 \text{ GeV}^2 ,$$

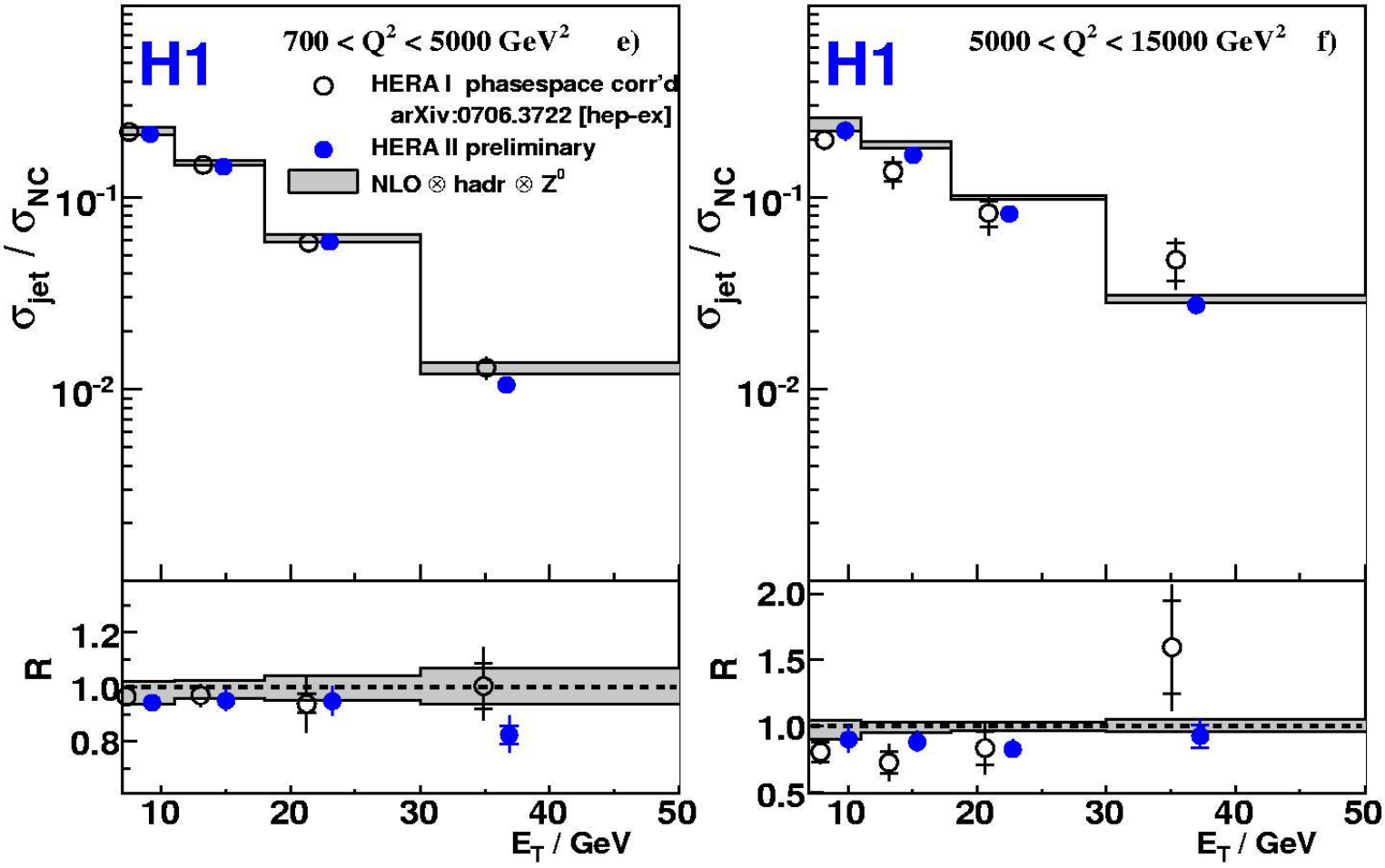
$$0.2 < y < 0.7 ,$$

First H1+ZEUS combined α_s determination [Monica's talk]

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

Inclusive jets measurements at high Q^2 HERA II

Full HERA II Data

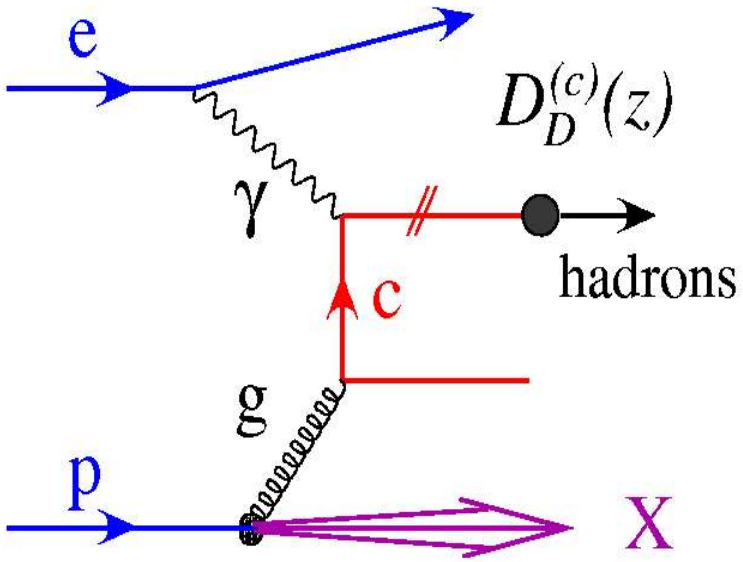


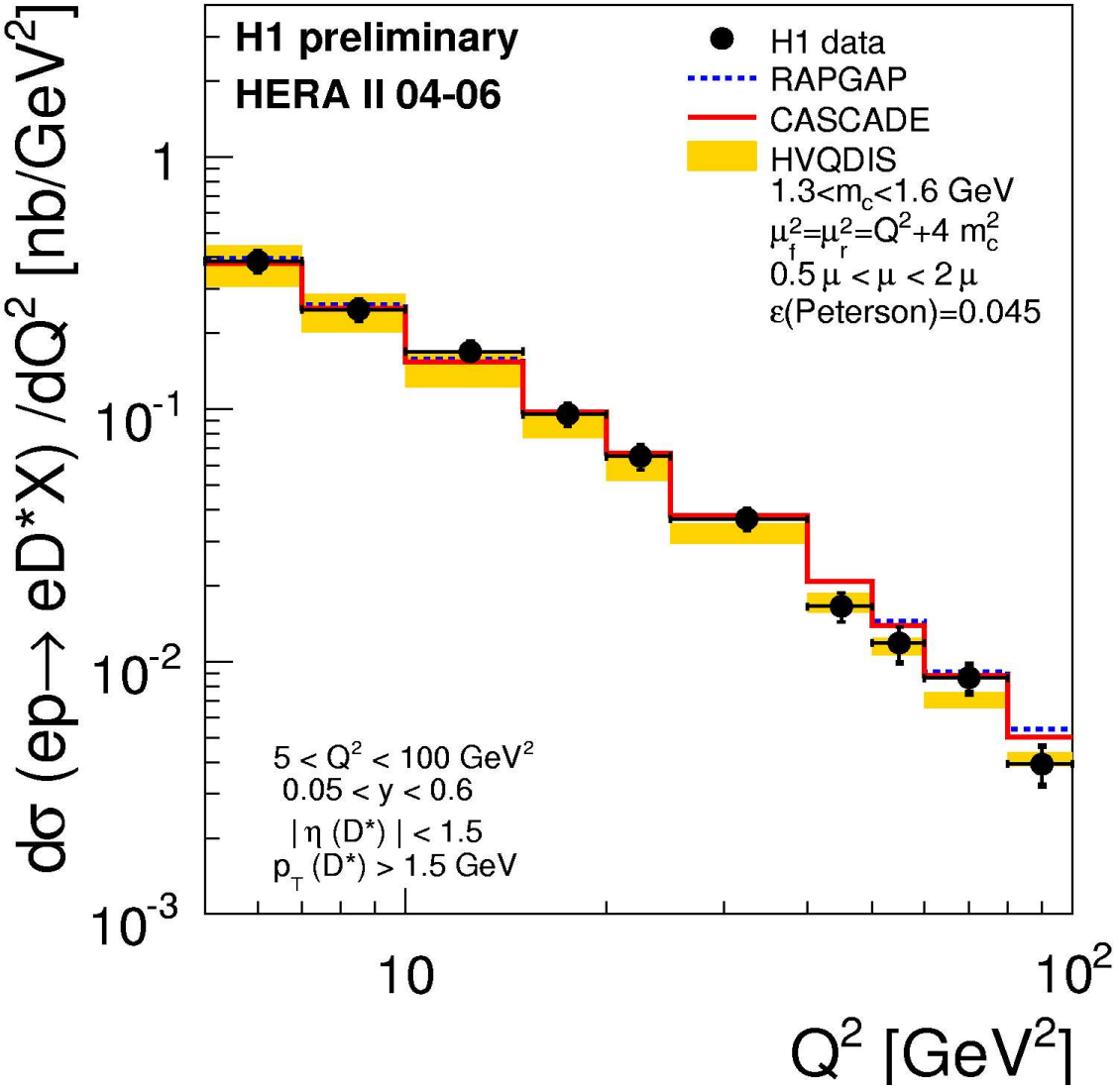
Clear improvement in precision, bright future for QCDs studies and α_S

Charm Production in DIS

HERA II data

L=222 pb^{-1}



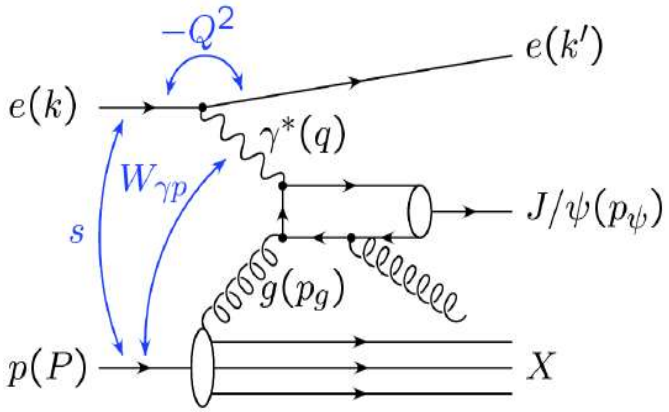


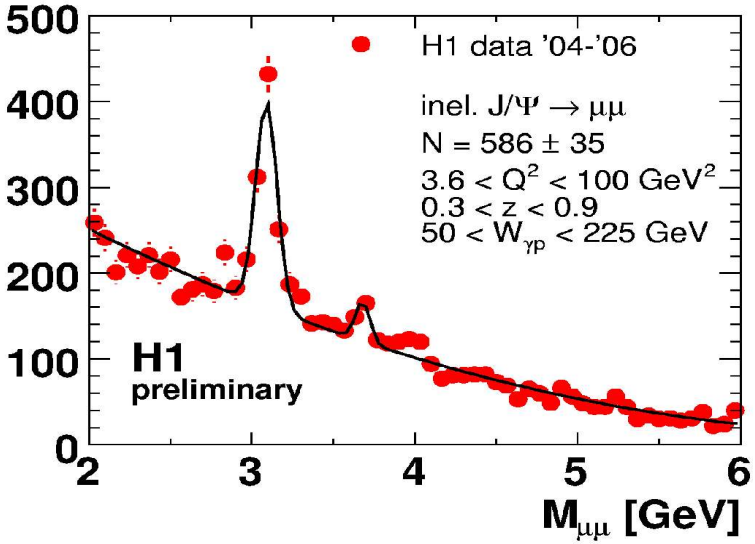
High precision measurements

test QCD and is sensitive to the gluon

J/Psi electroproduction

HERA II data
L=260 pb^{-1}

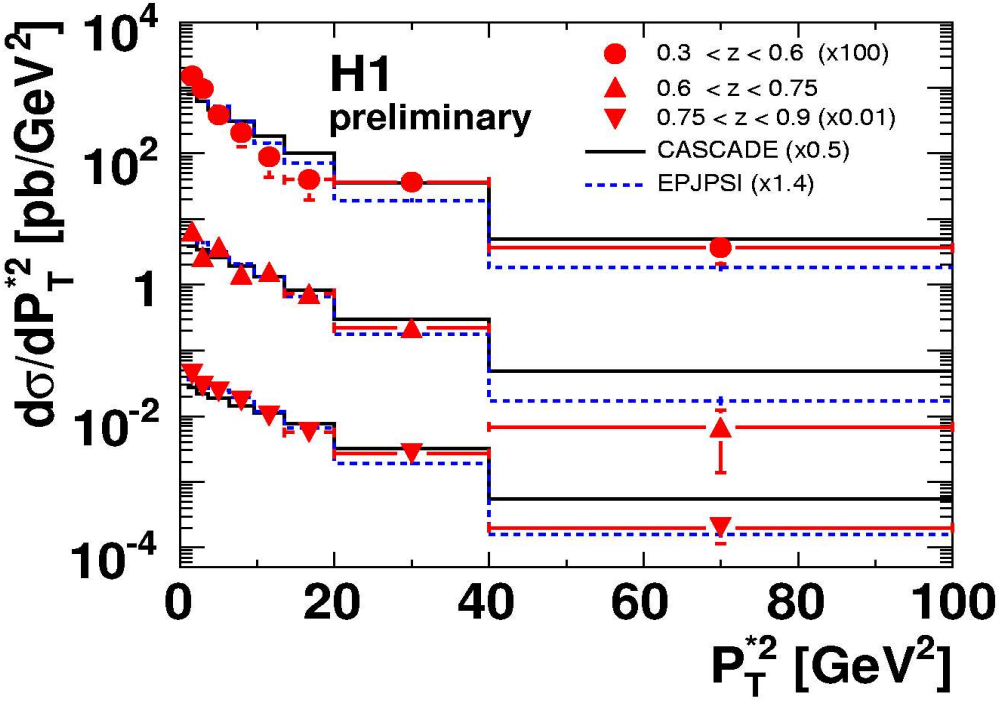




J/ψ→e⁺e⁻
also used

short distance(Q^2) ⊗ long distance(J/Psi)

$$z = \frac{p_\psi \cdot P}{q \cdot P} = \frac{E^*_\psi}{E^*_\gamma} \text{ in } p \text{ rest frame}$$

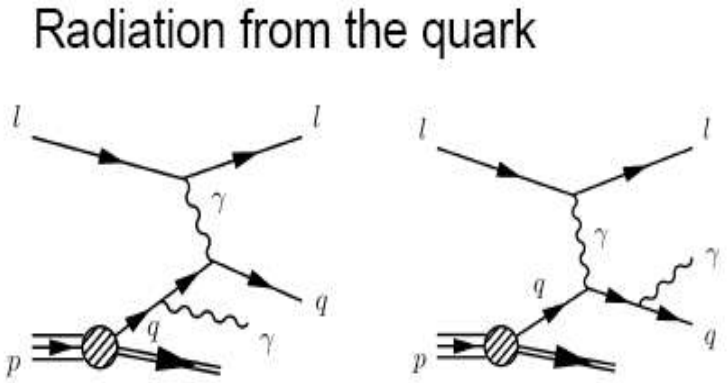


MC programs fail to describe data
New, precise measurement ready
to confront with theory

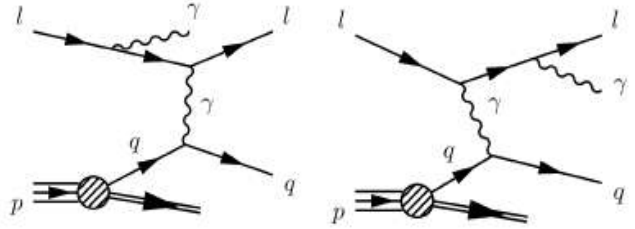
Isolated photon production

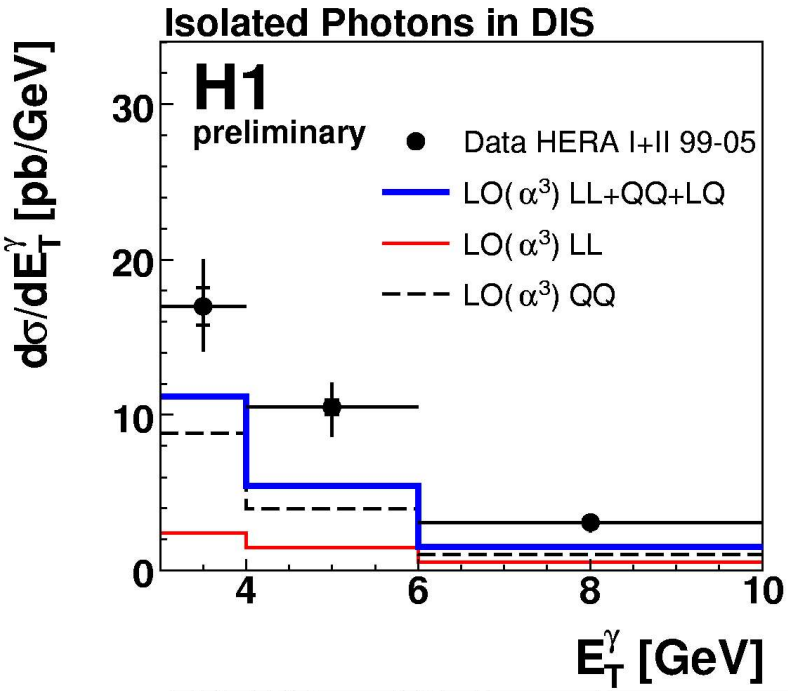
HERA I+II Data
226 pb^{-1}

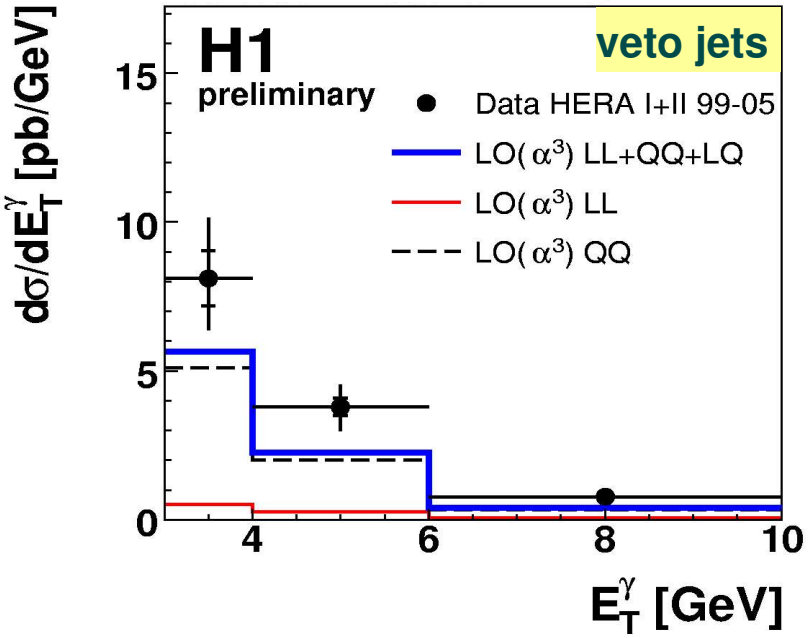
QQ



LL







QQ contribution enhanced (inelastic production)

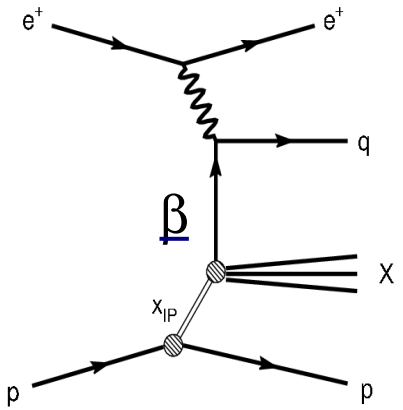
LO calculation underestimates the measurements

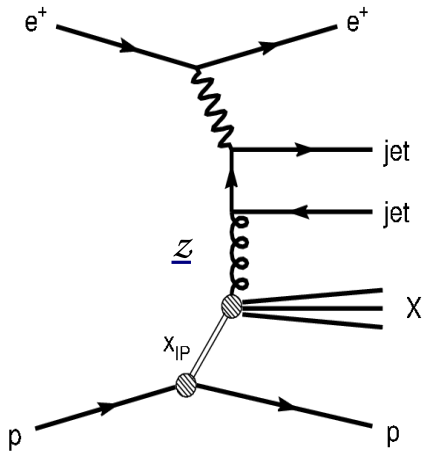
NLO needed

Diffractive PDF's from inclusive+jets

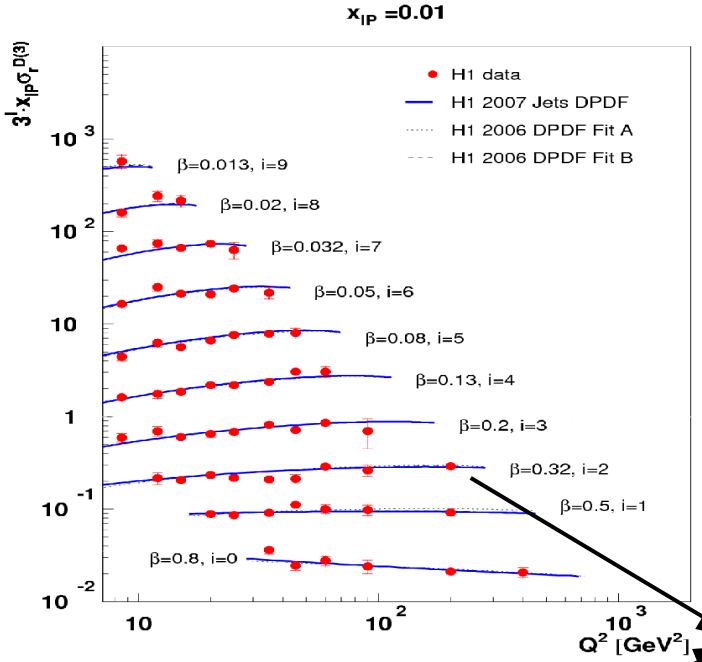
final HERA I

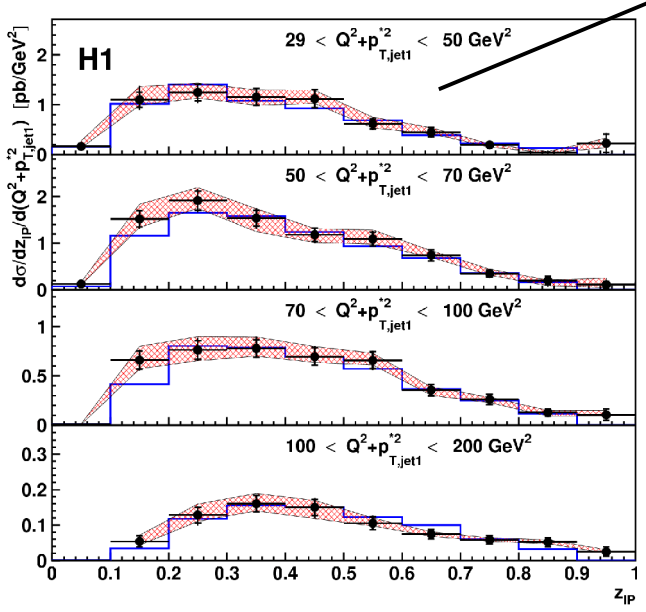
Inclusive diffr.



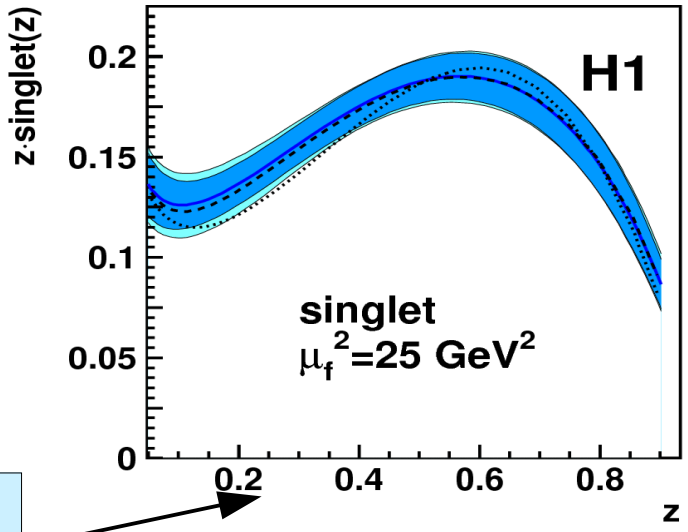


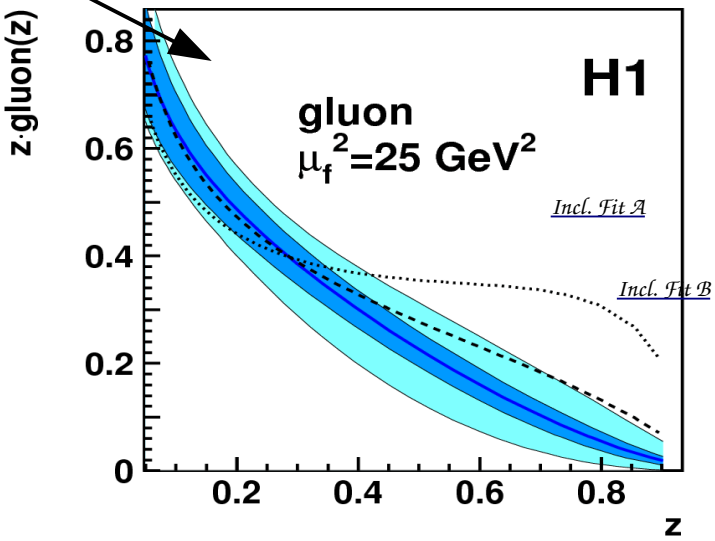
Diffractive dijets





NLO FIT





Consistent picture

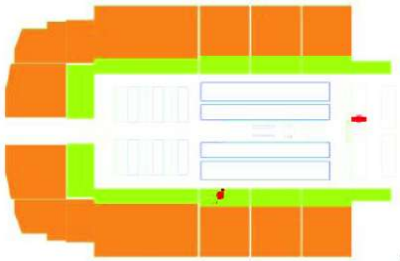
Improved gluon density

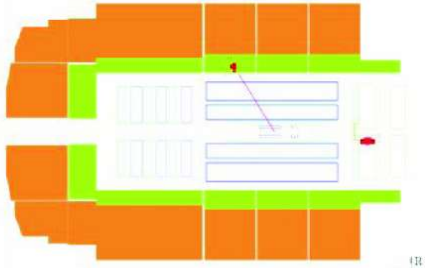
Deeply Virtual Compton Scattering

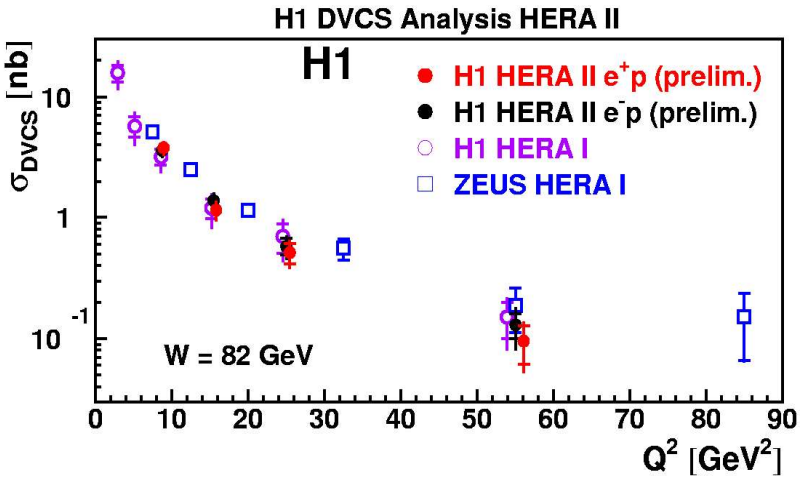
HERA II
e^+p 145 pb^{-1}
e^-p 146 pb-1

Deeply Virtual Compton Scatering

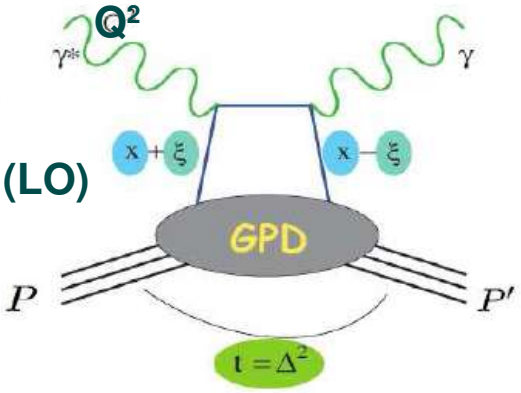
Bethe-Heitler

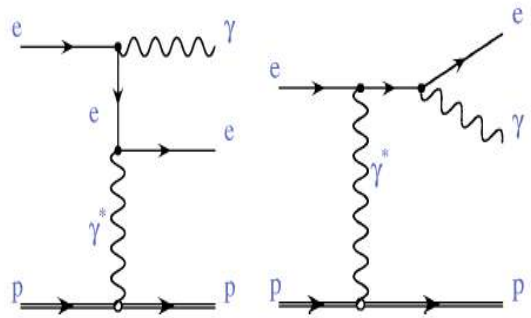




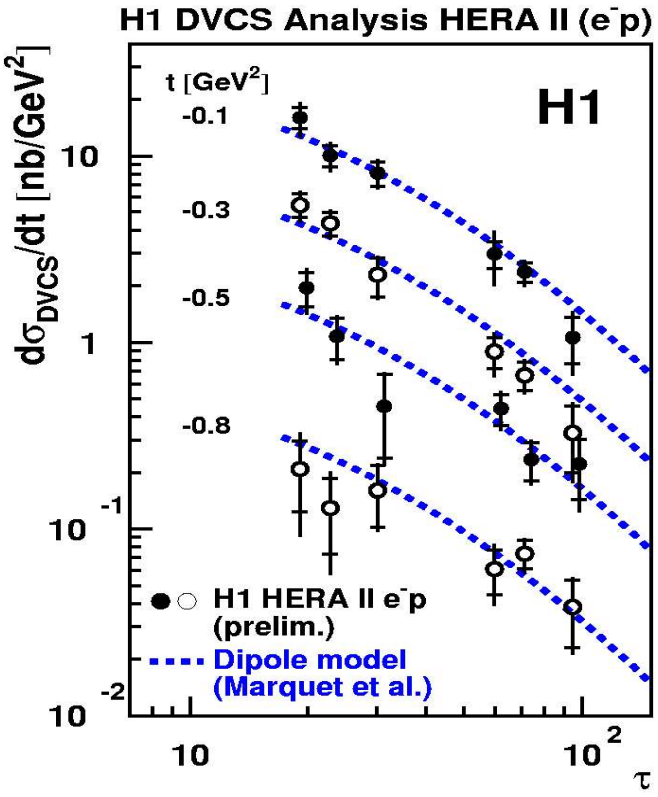


(LO)





$W=E_{cms}(\gamma^* p)$



Access the GPD's

Investigate soft interactions (color dipole model)

$$\sigma(\gamma^* p \to \gamma p)(x, Q^2) = \sigma(\gamma^* p \to \gamma p)(\tau = Q^2/Q_s^2(x)).$$

geometric scaling

DVCS: e^+p/e^-p asymmetry

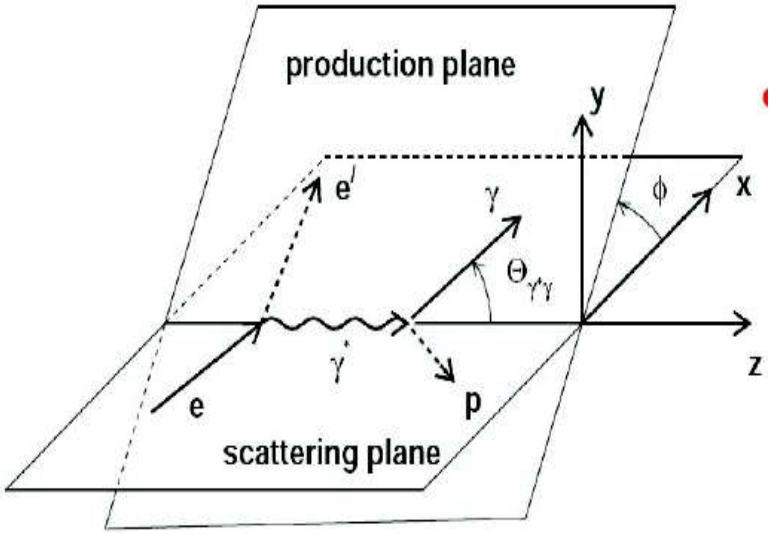
Interference as "extractor" of new effects

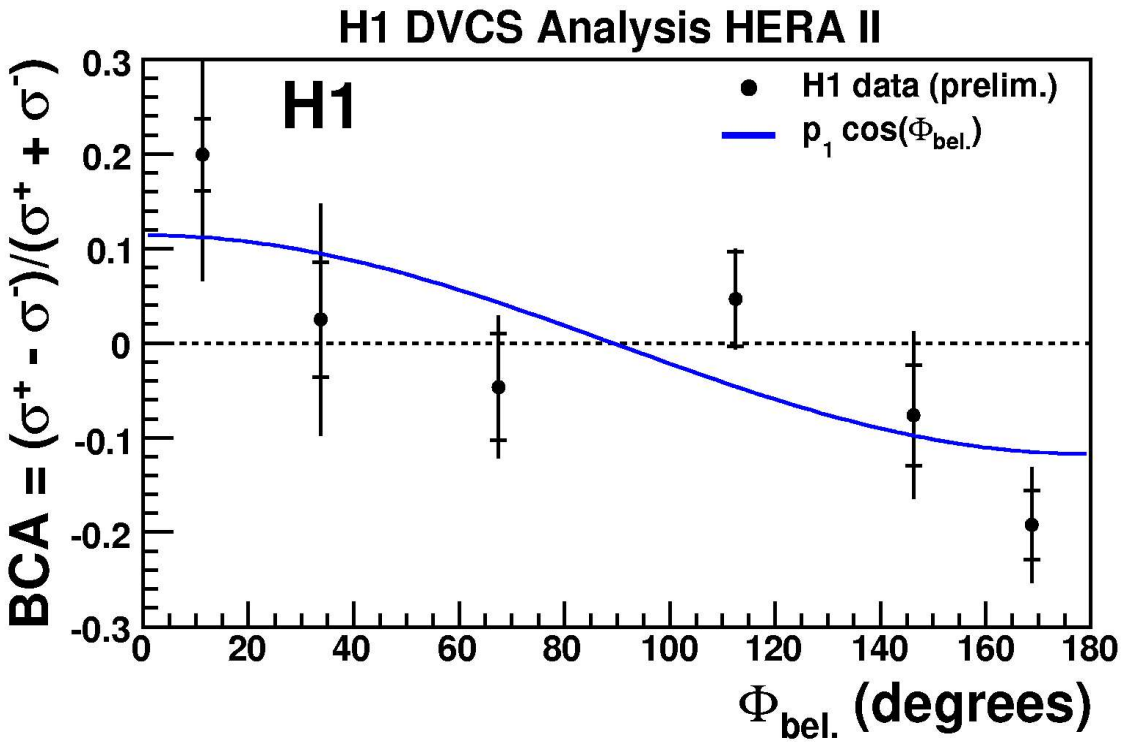
$$d\sigma_{ep\to ep\gamma} \simeq d\sigma^{BH} + d\sigma^{DVCS} + A^{BH} Re A^{DVCS}$$

e-beam charge dependent component

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

Complementary information, direct access to GPD's





First measurement in collision mode at HERA

Rare and Exotics

REX H1prelim-07-161 Measurement of W production and W polarisations at HERA
REX H1prelim-07-163 Search for single top production at HERA
REX H1prelim-07-061 A general search for new phenomena at HERA
REX H1prelim-07-062 Multi-lepton events at HERA
REX H1prelim-07-063 Events with an Isolated Lepton (Electron or Muon) and missing transverse momentum at HERA
REX H1prelim-07-064 Events with an Isolated Tau Lepton and missing transverse momentum at HERA
REX H1prelim-07-065 A search for Excited Electrons in ep collisions at HERA
REX H1prelim-07-066 A search for Excited Neutrinos in e⁻p collisions at HERA
REX H1prelim-06-061 A search for Leptoquarks in e-p collisions at HERA
REX DESY-06-029 Tau Lepton Production in ep Collisions at HERA
REX DESY-06-038 Search for Doubly-Charged Higgs Boson Production at HERA
REX DESY-07-009 Search for Lepton Flavour Violation in ep collisions at HERA

Inclusive

ELAN H1prelim-07-144 Inclusive ep Scattering Cross Section at high Q² and high y
ELAN H1prelim-07-041 Combined Electroweak and QCD Fit of inclusive NC and CC Data with Polarised Lepton Beams at HERA
ELAN H1prelim-07-042 Inclusive ep Scattering Cross Section at low Q² and high y
ELAN H1prelim-07-045 Measurement of the Inclusive ep Scattering Cross Section at low Q² and x at HERA
ELAN H1prelim-06-142 Electroweak Neutral Currents at HERA
ELAN H1prelim-06-041 High Q2 Charged Current in polarised ep collisions
ELAN H1prelim-06-042 High Q2 Neutral Current in polarised ep collisions

Diffraction

DIFF H1prelim-07-011 Beam charge azimuthal asymmetry in deeply virtual compton scattering at HERA II
DIFF H1prelim-06-014 Measurement of Inclusive Diffractive Deep-Inelastic Scattering at HERA (99-04 data)
DIFF H1prelim-06-016 Diffractive parton densities from a combined analysis of dijets and inclusive data in diffractive DIS
DIFF DESY-06-023 Diffractive Photoproduction of Rho Mesons with Large Momentum Transfer at HERA
DIFF DESY-06-048 Diffractive Deep-Inelastic Scattering with a Leading Proton at HERA
DIFF DESY-06-049 Measurement and QCD Analysis of the Diffractive Deep-Inelastic Scattering Cross Section at HERA
DIFF DESY-06-164 Diffractive Open Charm Production in Deep-Inelastic Scattering and Photoproduction at HERA
DIFF DESY-07-018 Tests of QCD Factorisation in the Diffractive Production of Dijets in Deep-Inelastic Scattering and Photoproduction at HERA

Hadronic Final States

HAQ H1prelim-07-131 Inclusive Jet Production at high Q2 (HERA II)
HAQ H1prelim-07-032 Minijet Production in Deep Inelastic Scattering at HERA
HAQ H1prelim-07-033 Isolated Photon Production in Deep Inelastic Scattering at HERA
HAQ H1prelim-07-035 Inclusive Jet Production in Deep Inelastic Scattering at low and medium Q2 at HERA
HAQ H1prelim-06-032 Azimuthal correlations in dijet events at low Q2 DIS
HAQ H1prelim-06-034 3-jet cross sections at low x and Q2
HAQ DESY-05-135 Forward Jet Production in Deep Inelastic Scattering at HERA
HAQ DESY-05-225 Measurement of Event Shape Variables in Deep-Inelastic Scattering at HERA
HAQ DESY-06-020 Photoproduction of Dijets with High Transverse Momenta at HERA
HAQ DESY-06-044 Search for a Narrow Baryonic Resonance Decaying to $K^0_s p$ or $K^0_s \bar{p}$ in Deep Inelastic Scattering at HERA
HAQ DESY-07-045 Search for Baryonic Resonances Decaying to Xi pi in Deep-Inelastic Scattering at HERA
HAQ DESY-07-065 Charged Particle Production in High Q² Deep-Inelastic Scattering at HERA
HAQ DESY-07-073 Measurement of Inclusive Jet Production in Deep-Inelastic Scattering at High Q^2 and Determination of the Strong Coupling

Heavy Flavours

HF H1prelim-07-071 Inelastic Electro-Production of J/Psi Mesons at HERA
HF H1prelim-07-072 D[*] Production in Deep Inelastic Scattering with the H1 Detector
HF DESY-05-161 Elastic J/Psi Production at HERA
HF DESY-06-039 Measurement of Charm and Beauty Dijet Cross Sections in Photoproduction at HERA using the H1 Vertex Detector
HF DESY-06-110 Inclusive D*-Meson Cross Sections and D*-Jet Correlations in Photoproduction at HERA
HF DESY-06-240 Production of D*-Mesons with Dijets in Deep-Inelastic Scattering at HERA

Conclusions and outlook

- H1 collected ~0.5 fb^{-1} at E_{cm} ~320 GeV
  - Searches for new physics ongoing, full statistics exploited
    - 3σ effect on isolated leptons remains
    - First significant W cross section measurement and W polarisations study
  - High Q^2 measurements: PDF constraints and EW effects from fits
  - Low Q2: best precision approached using now HERA II data
  - QCD studies: HQ production, jets, α_s, diffraction...
- New step in HERA program: end of collisions 07/2007
  - plethora of new results expected from HERA in the next years
    - improvements in statistics, systematics challenges
    - H1+ZEUS combination
- Rich legacy to LHC and beyond is being built now