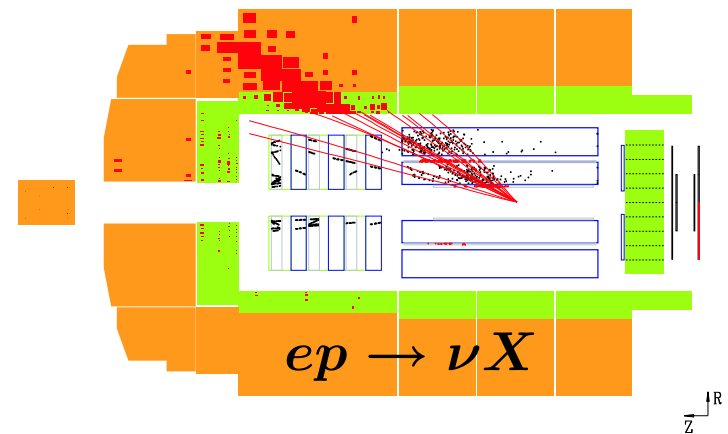
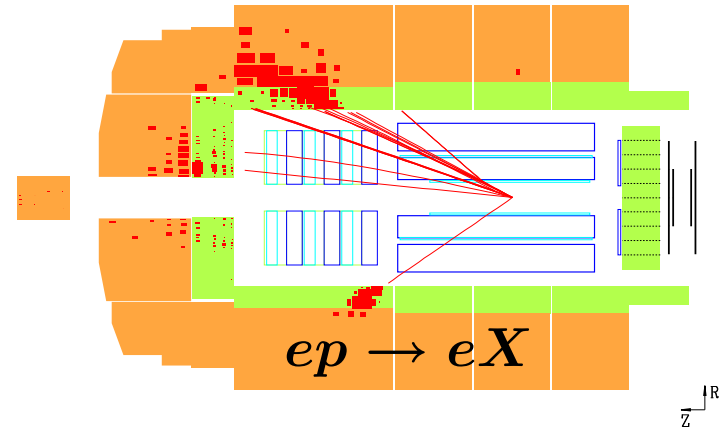


H1 Status and Prospects, May 2004

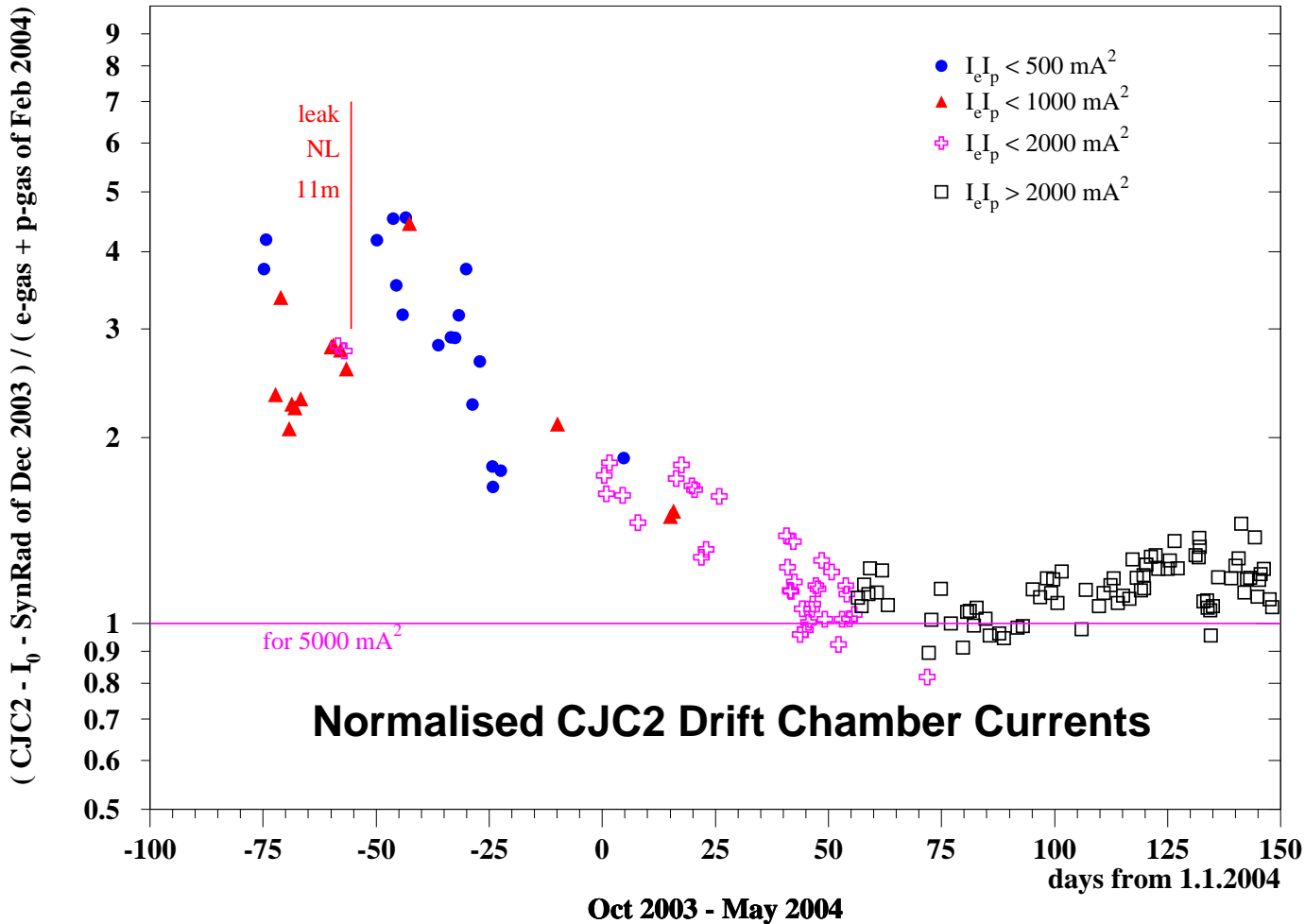
Paul Newman Birmingham University



- *Data Taking*
- *Recent Physics Results*
- *Physics Status and Aims*



HERA-II Data Taking: Backgrounds



Steady improvement after last vacuum leak (November 2003) ... pumping takes time

H1 able to run with recent high currents (\sim design) ... acceptable limits for trackers adjusted

Still suffer from 'spikes' in backgrounds

Background conditions remain "harsh" and cause radiation damage ... FST now inoperational

HERA-II Data Taking: Luminosity

Big improvement on 2003!

$> 15 \text{ pb}^{-1}$ taken with each lepton polarisation state

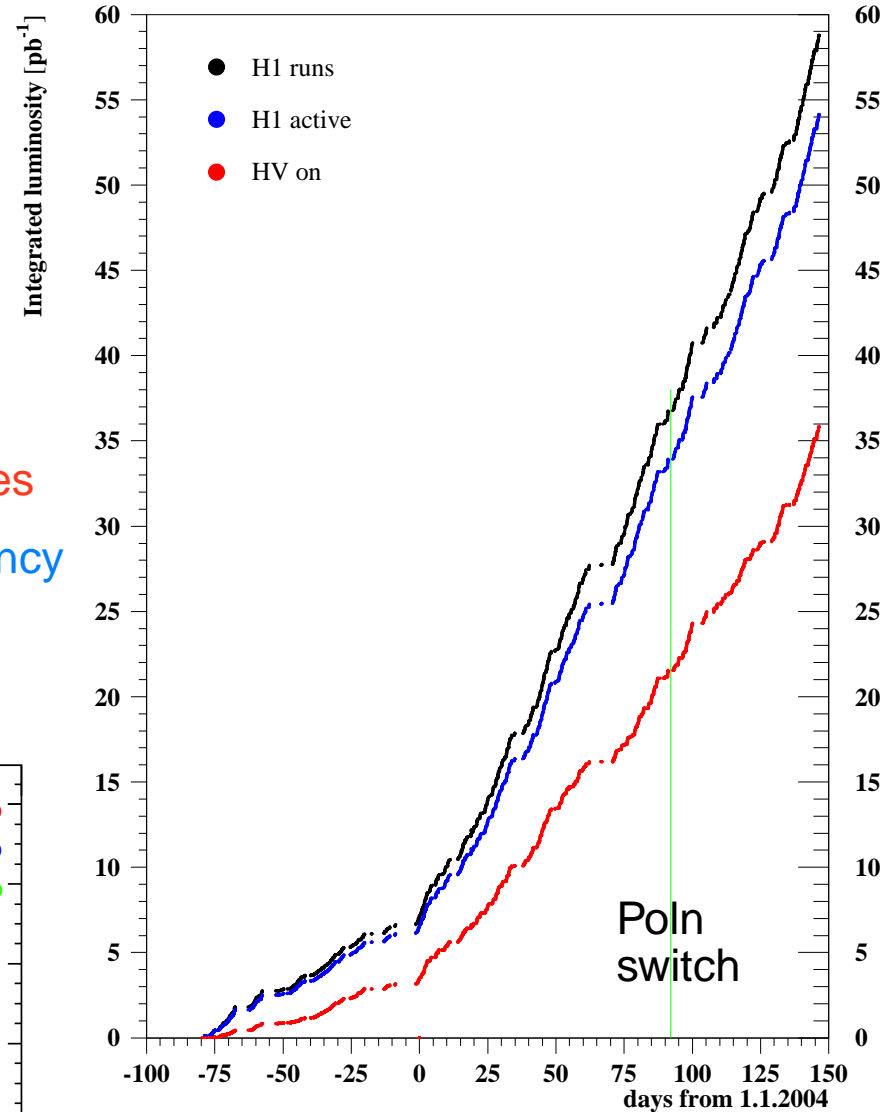
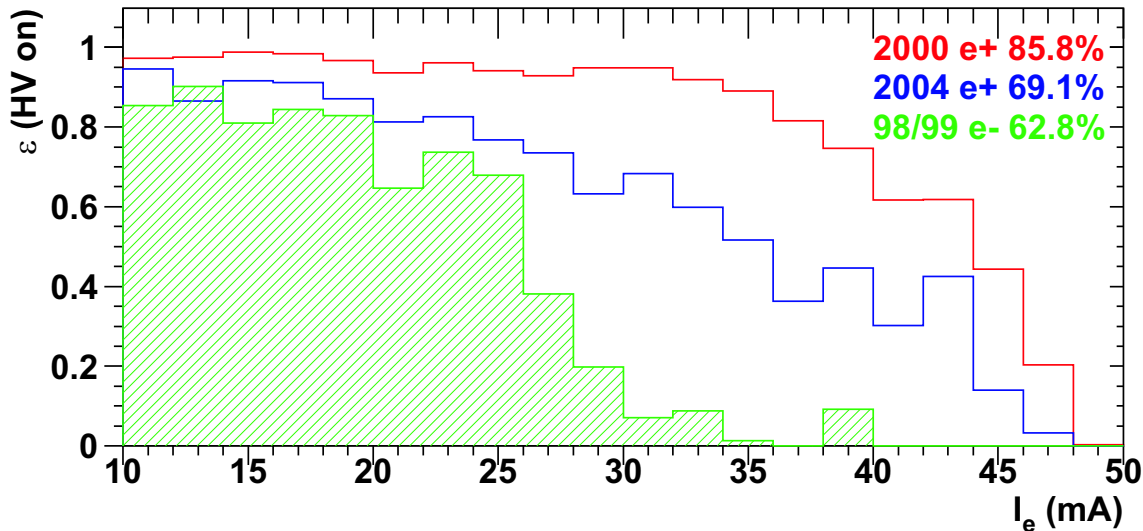
Polarisation typically 30 – 40%

Small data acquisition deadtimes (H1 active)

Significant HV inefficiencies due to backgrounds / spikes

Only recently reached 2000 level of 85% HV-on efficiency

HV efficiency vs I_e



Recent H1 Papers

8 papers released since October 2003 PRC ...

- DESY-03-159 (11/03): Muon Pair Production in ep Collisions
- DESY-03-206 (01/04): Measurement of Dijet Production at Low Q^2
- DESY-04-025 (03/04): Search for Squark Production in R-Parity Violating Supersymmetry
- DESY-04-032 (03/04): Measurement of Anti-Deuteron Production
- DESY-04-038 (03/04): Evidence for a Narrow Anti-Charmed Baryon State
- DESY-04-051 (04/04): Forward π^0 Production and Associated Transverse Energy Flow
- DESY-04-083 (05/04): Measurement of F_2 at low Q^2 in QED Compton Scattering
- DESY-04-084 (05/04): Search for bosonic stop decays in R-parity violating supersymmetry

Recent and Forthcoming Conferences

At **DIS04** there were 30 talks by H1 members

summarising work in last year, including newly released data on ...

- Polarised $\sigma(CC)$ from HERA-II
- High p_T Particle Production at HERA-II
- F_2 at low Q^2 , high x from ISR events
- τ production
- Forward Jet Production
- $b \rightarrow \mu X$ in low Q^2 DIS
- F_2^b and F_2^c at Large Q^2

(Almost) all on completely original and new topics!

Preparations for **ICHEP04** summer conference are well underway

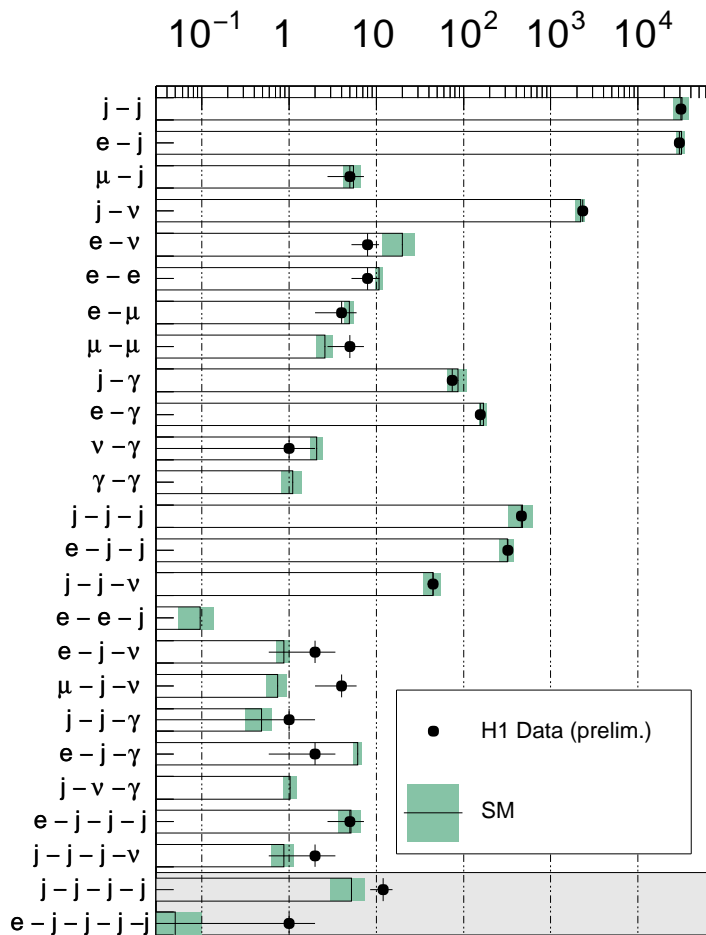
54 abstracts submitted, summarising work of past two years

Systematic Searches For Anomalies in High p_T Data

Investigation of all final states with isolated j, e, μ, γ, ν ($p_T > 20$ GeV, $10^\circ < \theta < 140^\circ$)

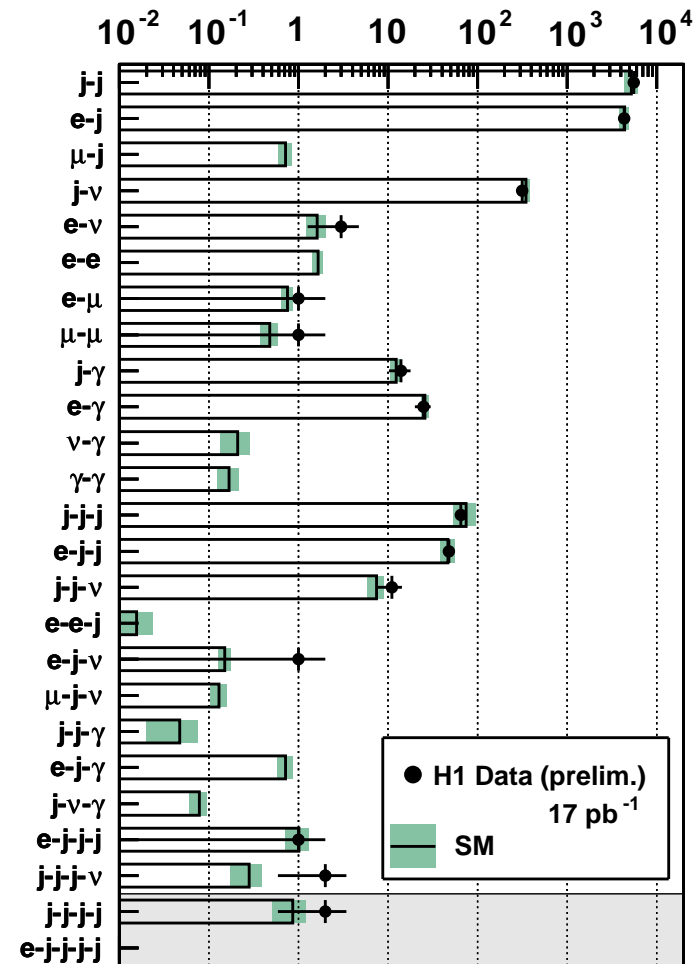
Overall highly impressive agreement with Standard Model predictions ... but $\mu j \nu, e j \nu$?

HERA-I Events



H1 General Search

HERA-II Events



H1 General Search (Hera-II)

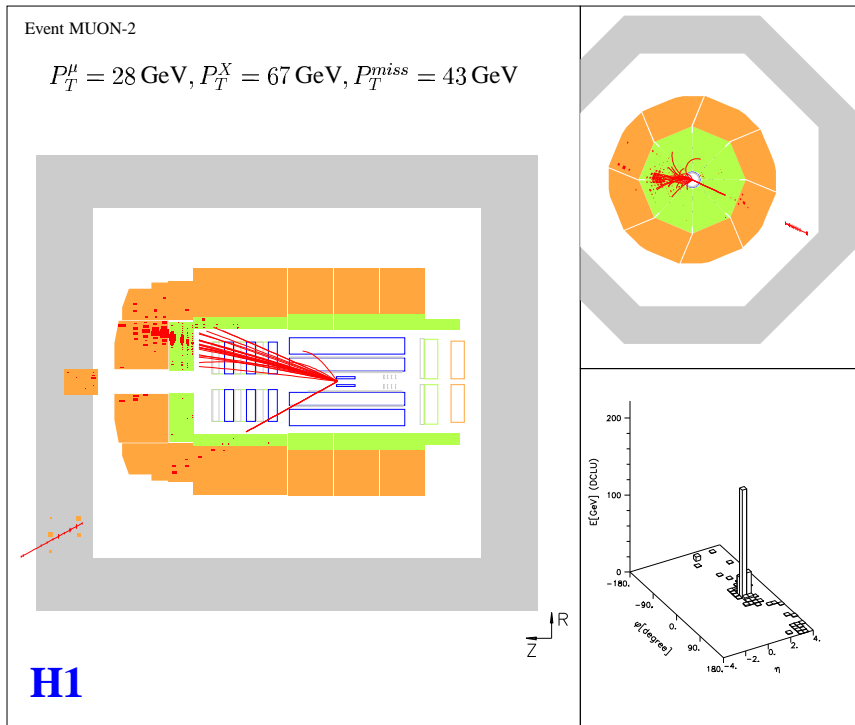
Dedicated Studies of Isolated Leptons with Missing p_T

Study events with isolated high p_T μ , e or τ , missing p_T and large hadronic p_T^X in e^+p data

Events observed and expected in Standard Model ...

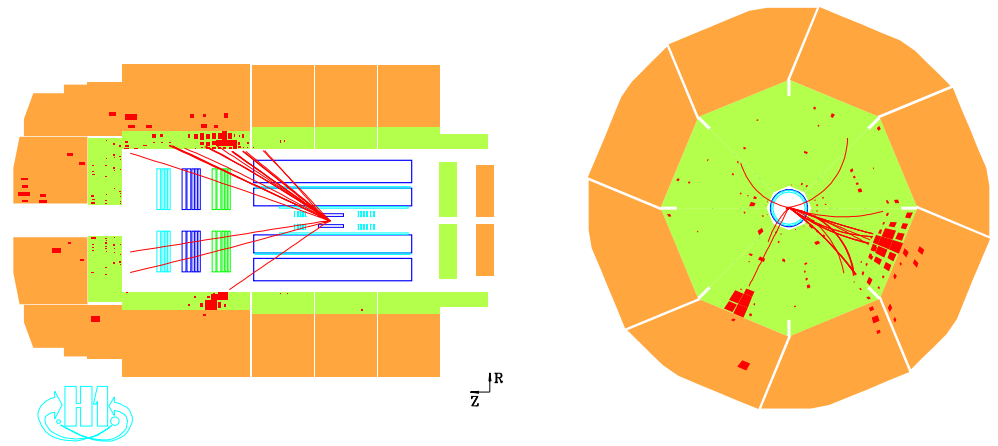
	HERA-I (110 pb ⁻¹)			HERA-II (17 pb ⁻¹)	
	μ	e	τ (prel)	μ (prel)	e (prel)
$p_T^X > 25$ GeV	6 / 1.44	4 / 1.48	0 / 0.53	0 / 0.29	2 / 0.34

$$e^+p \rightarrow \mu^+ X$$



$$\text{HERA-II } e^+p \rightarrow e \cancel{p}_T X$$

$$p_T^e = 37 \text{ GeV}, p_T^{miss} = 44 \text{ GeV}, p_T^X = 29 \text{ GeV}$$



Possible Interpretations?

W radiation is dominant SM process ...

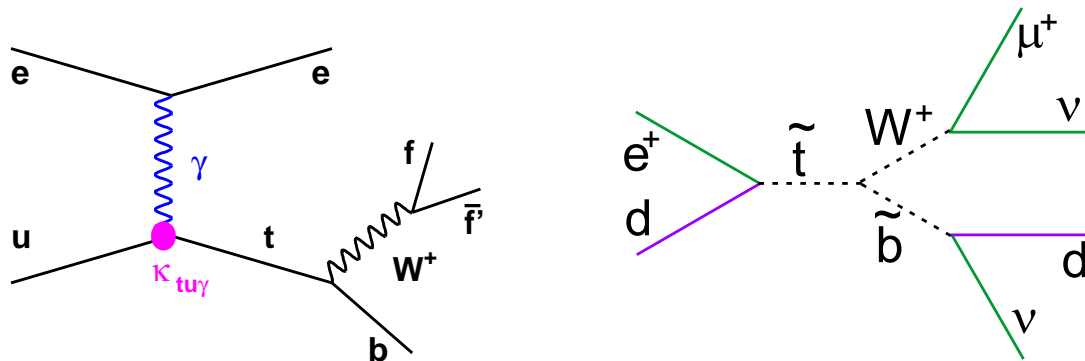
Excess in HERA-I $e + \mu$ is $\sim 10^{-3}$ fluctuation

Beyond the Standard Model ...

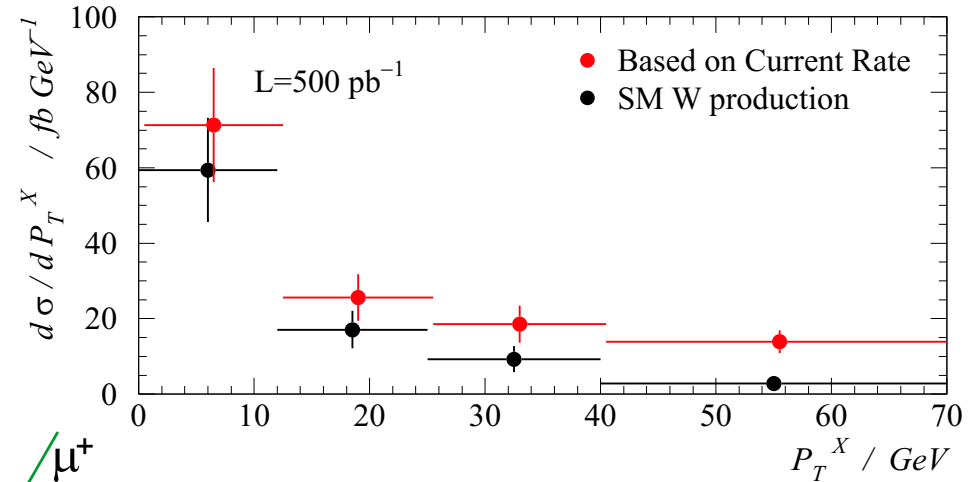
Anomalous single top production?

$R_p \tilde{t}$ production with $\tilde{t} \rightarrow \tilde{b}W$?

... dedicated searches published



Simulated Cross Sections and Errors



This anomaly can only be clarified with large increases in e^+p luminosity

If current event rate persists, 5σ "discovery" possible with 500 pb^{-1}

See also anomalously high H1 yields of multi-electron events in e^+p scattering

R_p SUSY at HERA-I

Search programme with HERA-I data nearing completion

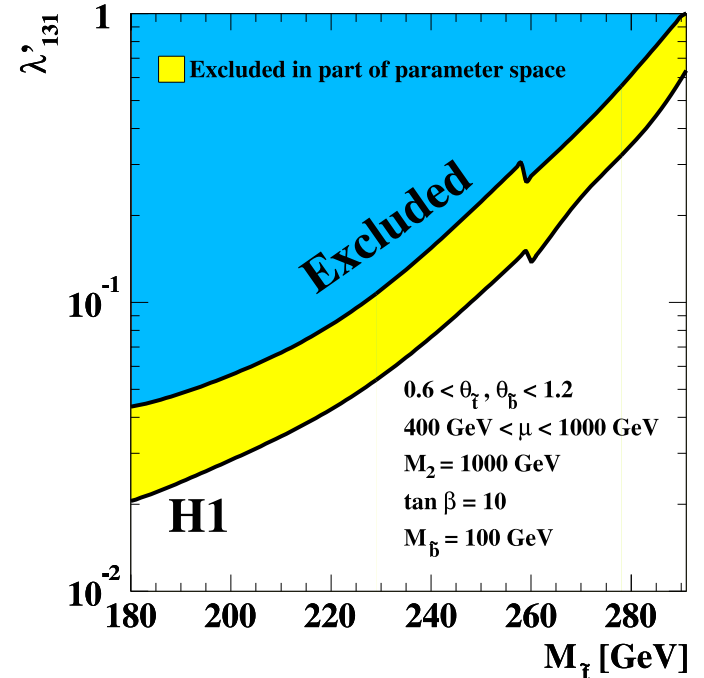
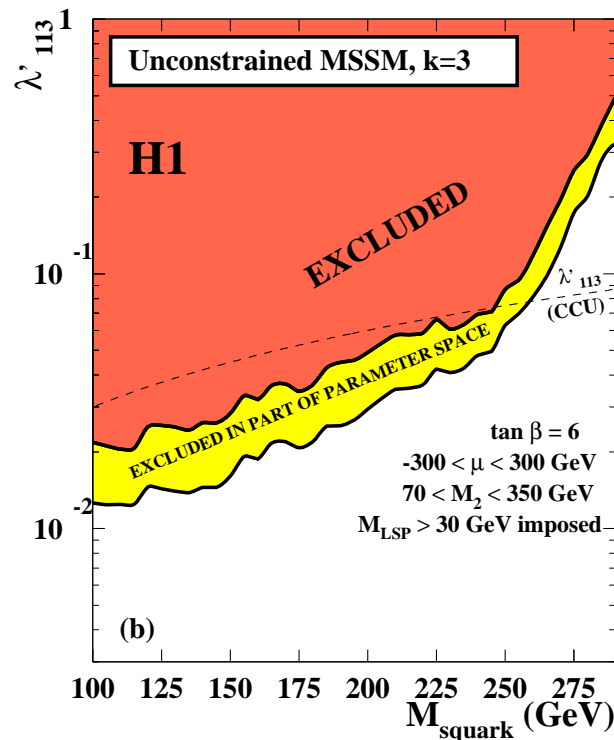
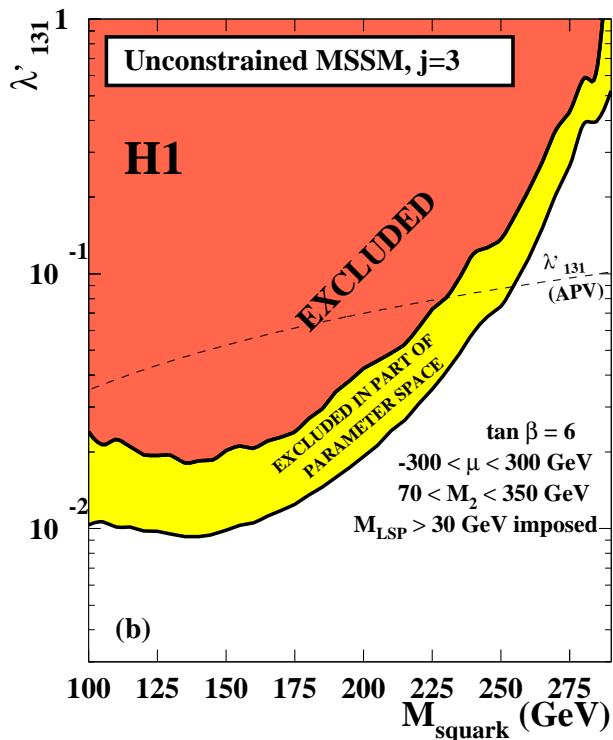
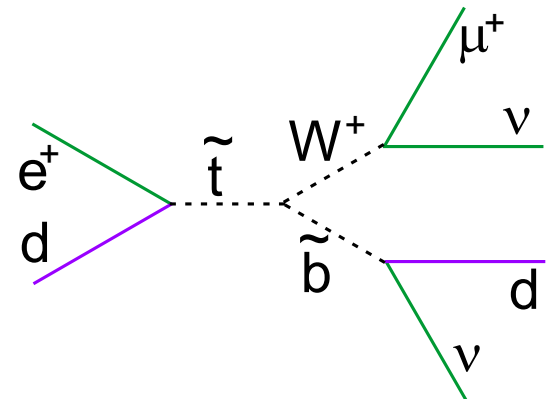
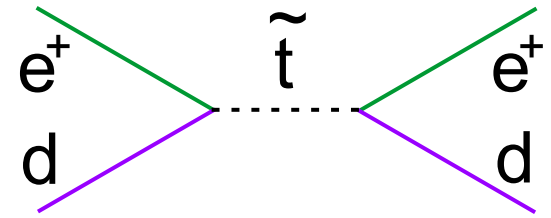
e.g. Recent searches for R_p SUSY \tilde{q} production

Search for e.g. $e^+ d \rightarrow \tilde{t}$ via λ'_{131} , $e^- u \rightarrow \tilde{b}$ via λ'_{113}

Consider R_p and \tilde{R}_p decays covering most of BR for all $m(\tilde{q})$

Also consider for first time $\tilde{t} \rightarrow \tilde{b}W$

Limits: e.g. $m(\tilde{t}) > 275$ GeV for λ'_{131} of em strength



Search Prospects at HERA-II

HERA has unique discovery potential for some time to come in several areas

e^+ or e^-

Anomalous $tu\gamma$

q radius / form factor

Contact Interactions

Double charged Higgs

Large Extra Dimensions

e^*

q^*

e^+

$F = 0$ LQ / LFV

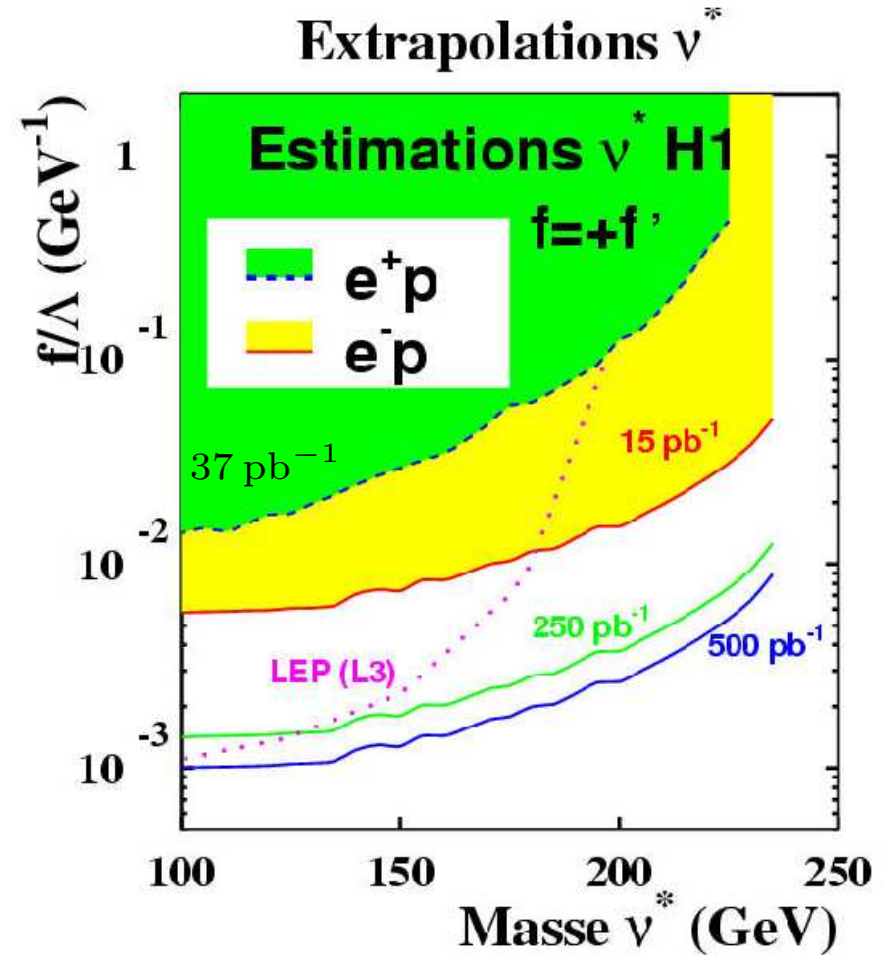
\tilde{t} (& \tilde{c}, \tilde{u})

e^-

$F = 2$ LQ / LFV

\tilde{b} (& \tilde{s}, \tilde{d})

ν^*

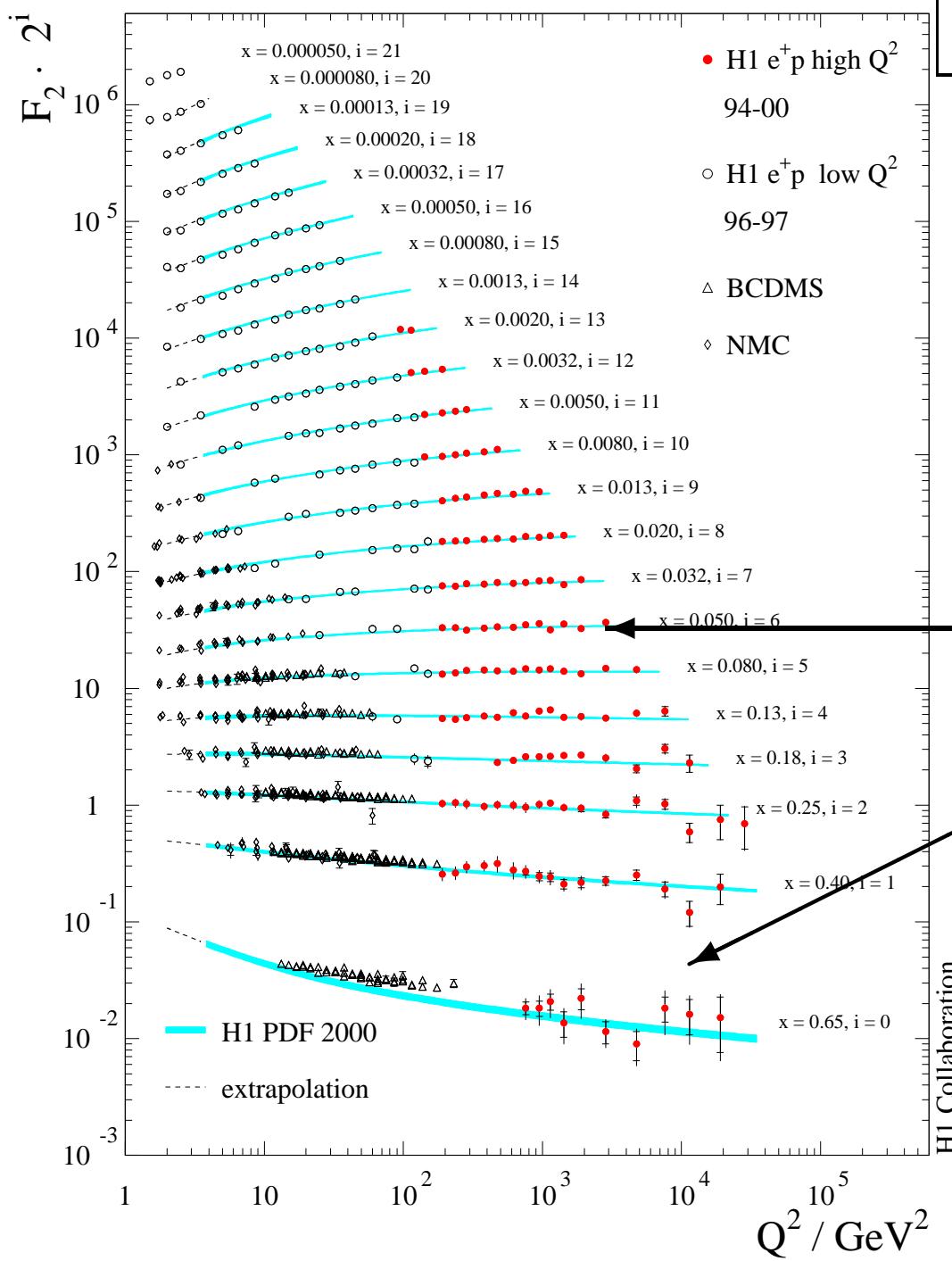


Improvements on current sensitivity require large increases in \mathcal{L}

... top priority to optimise overall search programme

e^+p and e^-p complementary in some areas, both interesting

$F_2^{\text{em}}(x, Q^2)$ and u at high x



$$\tilde{\sigma}_{\text{NC}}^{\pm} = F_2 \mp \frac{Y_-}{Y_+} xF_3 - \frac{y^2}{Y_+} F_L$$

$$F_2^{\text{em}}(x, Q^2) = x \sum_q e_q^2 (q + \bar{q})$$

... dominates in most of phase space

Measured over huge kinematic range

well matched to LHC predictions via DGLAP

2-3% precision in bulk of phase space

Highest x region requires much more luminosity (e^+ or e^-) and / or reduced $E_p \rightarrow$ high x , moderate Q^2

Beautifully described by QCD fits

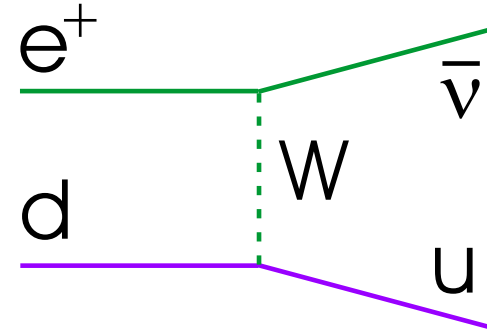
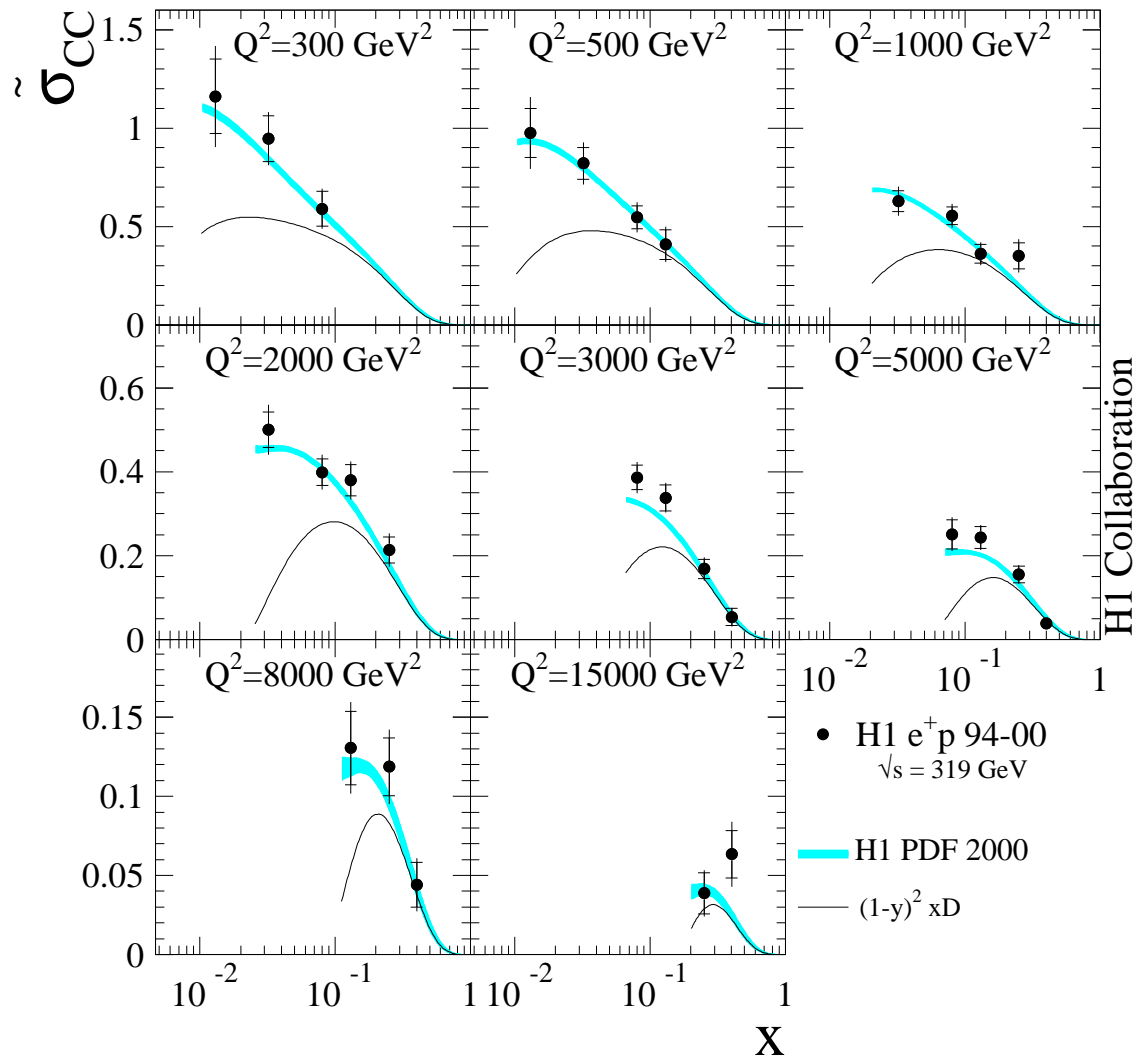
\rightarrow strongest constraint on u, \bar{u}

Constrains gluon and α_s

via $\frac{\partial F_2}{\partial \ln Q^2} \sim \alpha_s x g(x)$ (LO QCD)

e^+p Charged Current Cross Section and d at "high" x

Charged Current (e^+p , 65 pb^{-1})

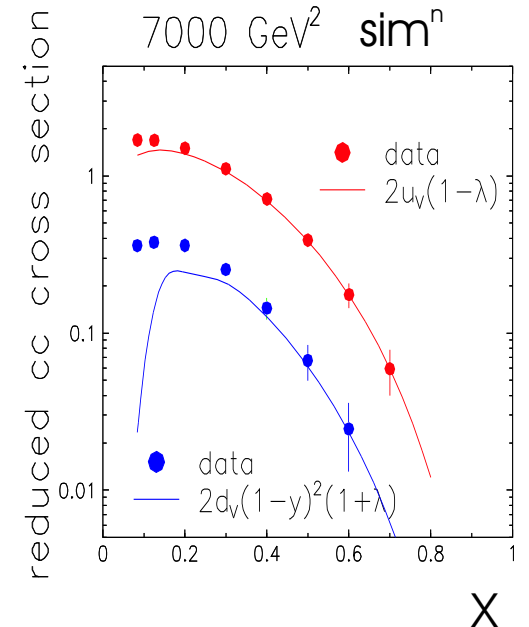


$$\tilde{\sigma}_{CC}^+ \sim x(\bar{u} + \bar{c}) + (1-y)^2 x(d + s)$$

Promising for d density at $x \sim 0.3$

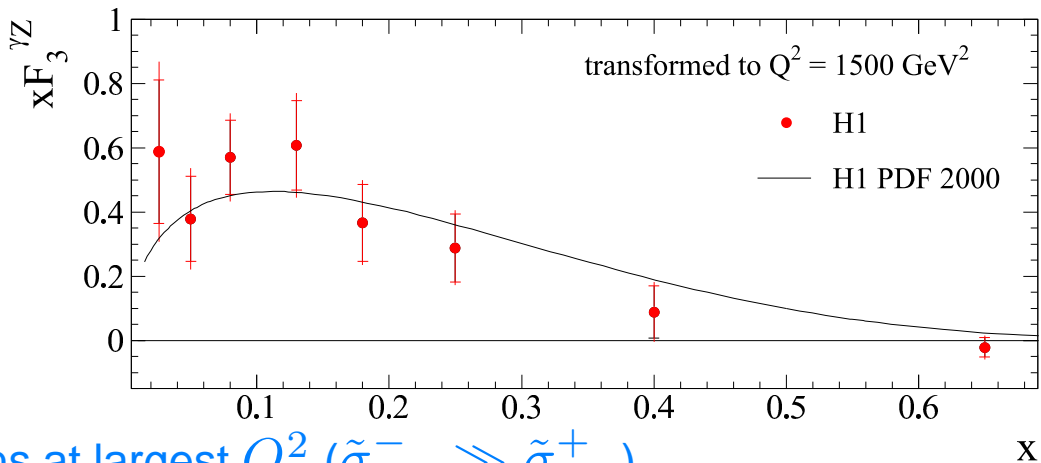
Higher x Suppressed by $(1-y)^2$ factor

250 pb^{-1}
 e^\pm



$x F_3(x, Q^2)$ and u_v, d_v

$$x F_3 = \frac{1}{2y(1-y)} (\tilde{\sigma}_{\text{NC}}^- - \tilde{\sigma}_{\text{NC}}^+) \\ \sim 2u_v + d_v$$



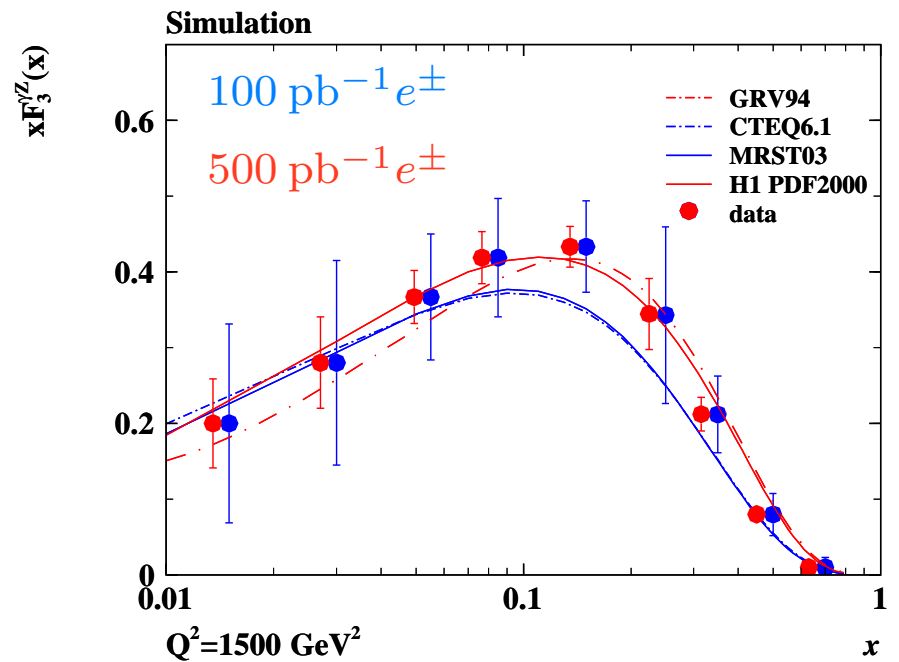
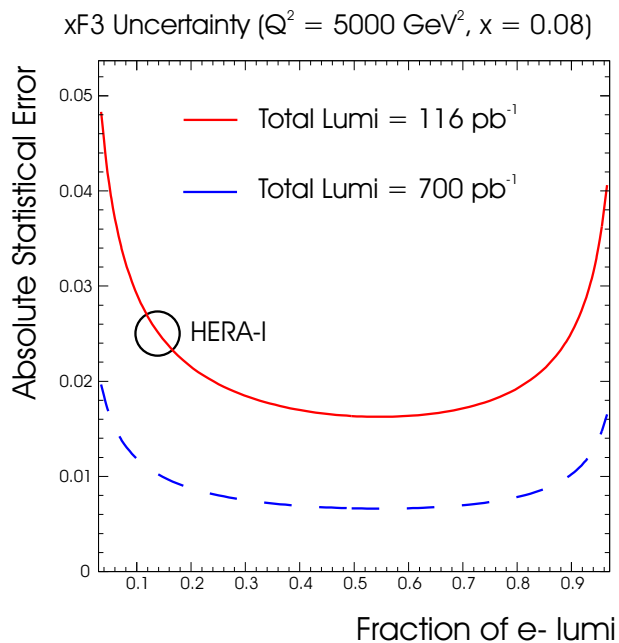
Assumption-free access to valence distributions at largest Q^2 ($\tilde{\sigma}_{\text{NC}}^- \gg \tilde{\sigma}_{\text{NC}}^+$)

y factors suppress highest x , kinematics suppress lowest x , potentially competitive for $x \sim 0.1$

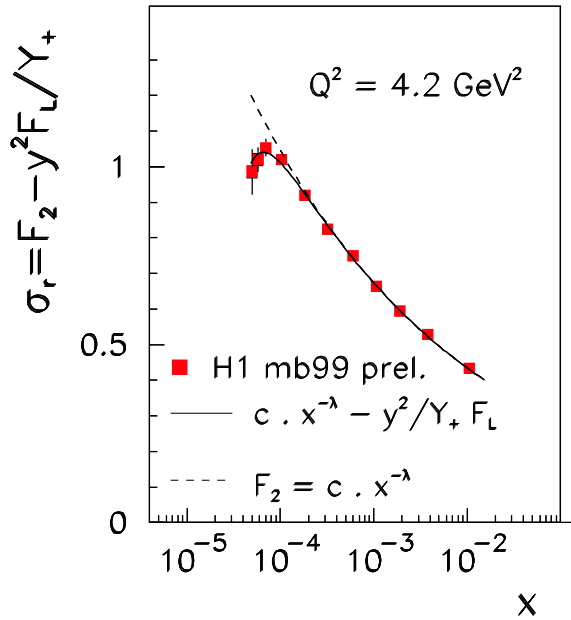
First “exploratory” HERA-I extractions agree well with predictions

Errors rather insensitive to exact e^+/e^- sharing within reasonable limits

Total e^+ and e^- luminosity most important for significant progress



F_L and the Gluon at Low x



Gluon only indirectly determined in DGLAP fits

Important to test with jets, charm, $F_L \dots \sim \alpha_s x g(x)$ (LO QCD)

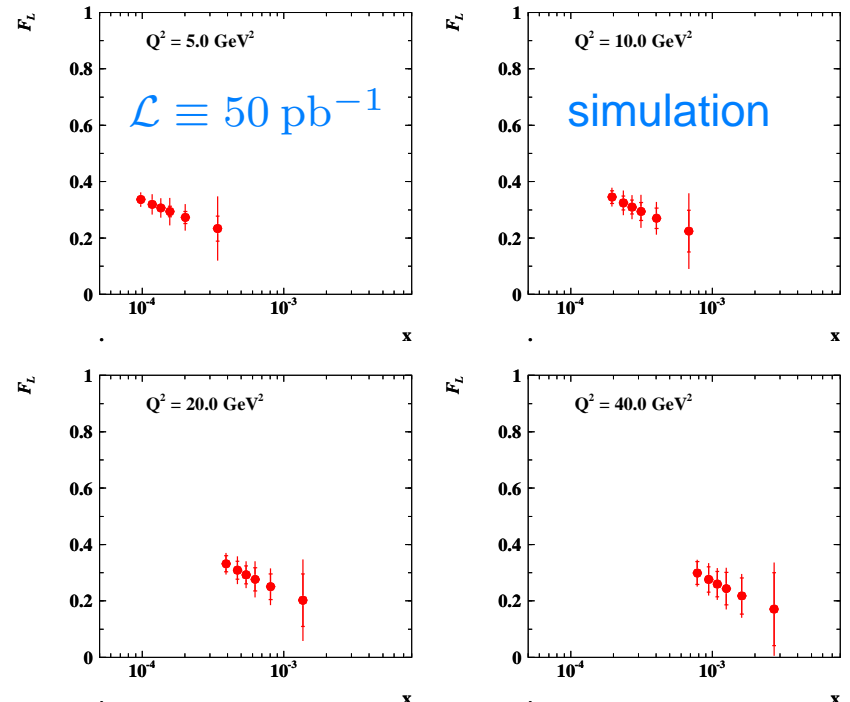
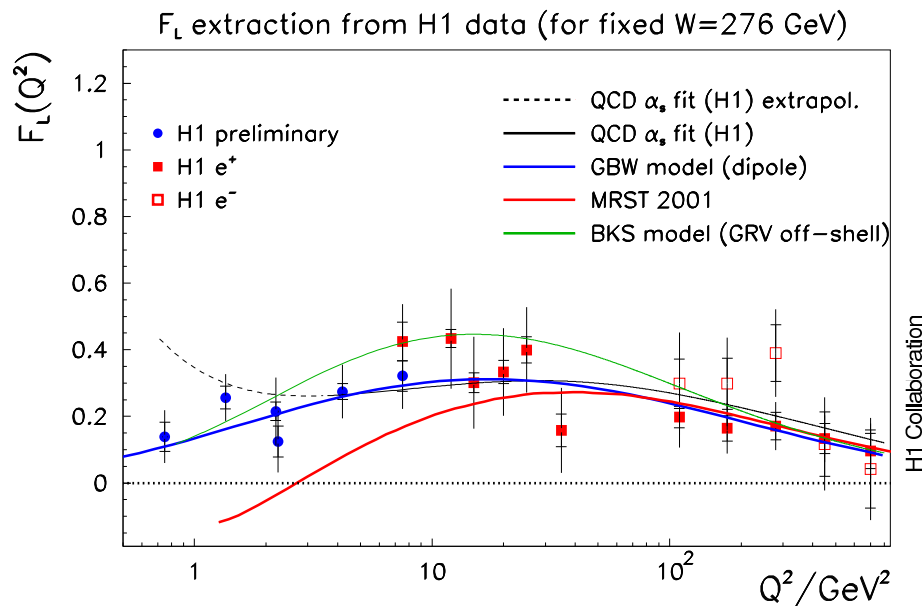
$$\tilde{\sigma} = F_2 - (y^2 / Y_+) F_L$$

Sensitivity at highest $y \rightarrow 0.9$ ($E'_e \rightarrow 3 \text{ GeV}$)

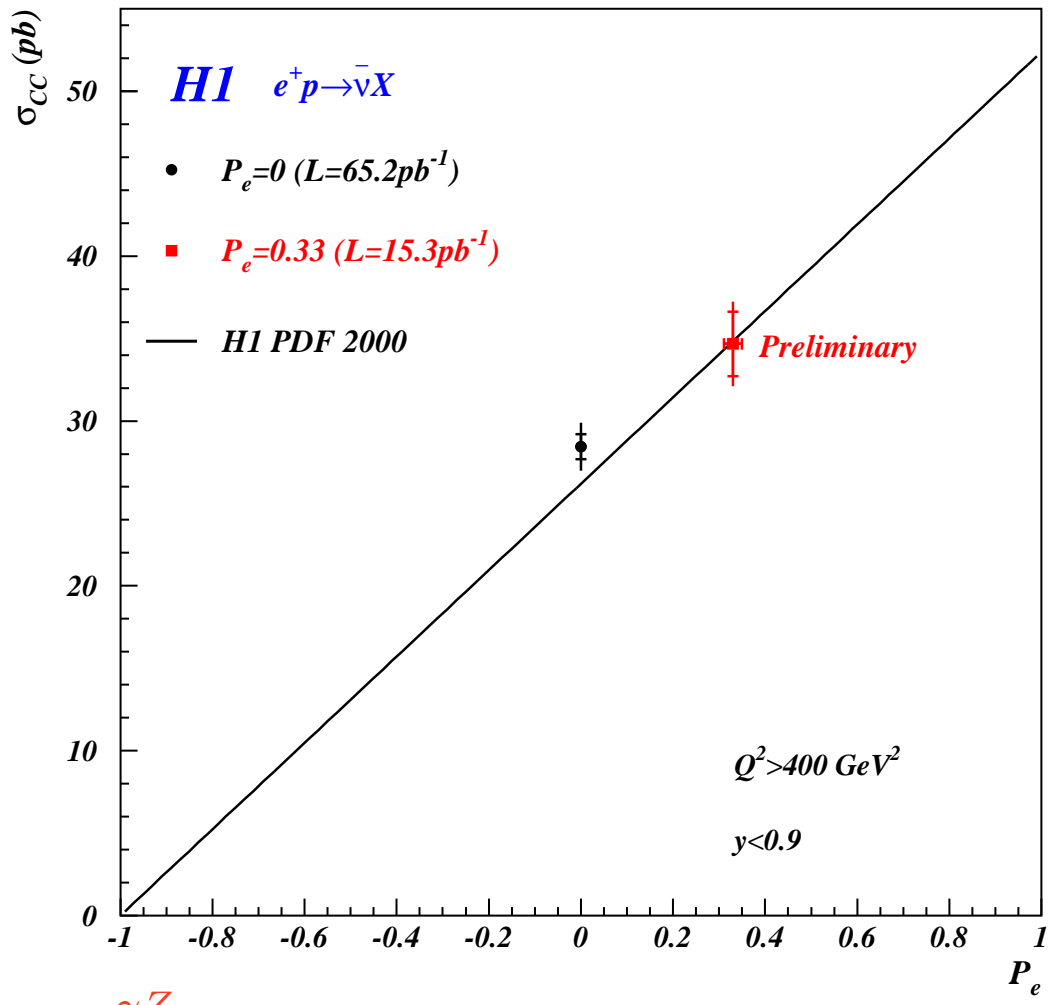
F_L determination spans 3 orders of magnitude in Q^2

Distinguishes between DGLAP and other approaches at low Q^2

Better measurements from reduced E_p running \rightarrow relax F_2 assumptions and see x dependence



Polarisation and HERA-II



CC cross section has linear dependence on polarisation in Standard Model

First measurement of influence of lepton helicity on CC interactions in ep scattering

Polarisation $\sim 30\%$, Luminosity $\sim 15 \text{ pb}^{-1}$

Effect established at $\sim 2.3\sigma$ level

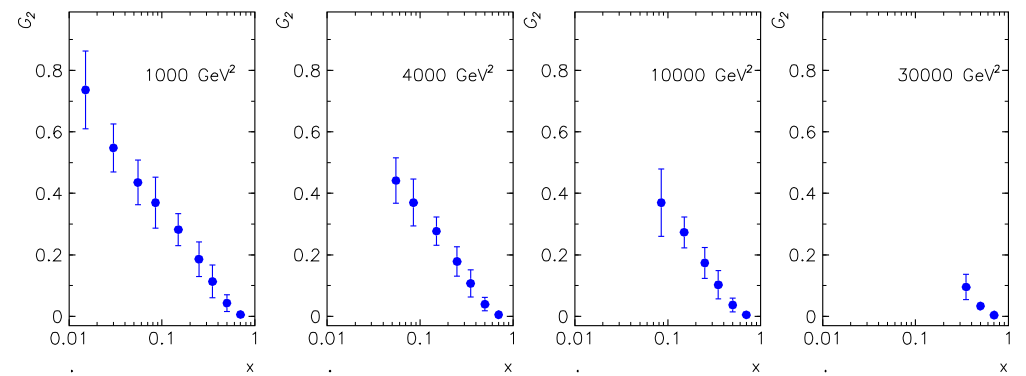
Similar luminosity collected with opposite helicity and $\sim 40\%$ polarisation

With larger luminosities, sensitivity to PDFs and electroweak couplings

eg $F_2^{\gamma Z}$ from NC polarisation asymmetry (e^+ or e^- , asymmetry $\propto P_e$)

$$F_2^{\gamma Z} \sim \frac{1+d/u}{4+d/u}$$

Simulation with $\mathcal{L} = 200 \text{ pb}^{-1}$, $P_e = \pm 0.5$



Hadronic Final State Studies and QCD

Bulk of H1 physics programme concerned with understanding QCD through hadronic final state measurements (89/130 physics papers so far)

- Jet production and properties
- Open charm production
- Open beauty production
- Forward physics & QCD cascade dynamics
- Fragmentation
- Energy flow and particle spectra
- Diffractive cross sections / final states
- Tagged leading protons and neutrons
- Inclusive and exclusive vector mesons, DVCS
- Hadron spectroscopy ...

Many of these measurements are statistically limited thus far

Theoretical progress → most observables can be compared with NLO calculations

Improvements require **highest possible \mathcal{L}** , independently of beam charge or polarisation

Evidence for a Narrow Anti-charmed Baryon State

Following recent observation of θ^+ pentaquark in $K_s^0 p$ and $K^+ n$, search for charmed analogue

Use 'golden' charm decay channel $D^{*-} \rightarrow \bar{D}^0 \pi_s^- \rightarrow K^+ \pi^- \pi_s^-$ & c.c.

Combine with proton candidates from dE/dx to form $M(D^* p)$

Clear signal with mass 3099 ± 3 (stat.) ± 5 (syst.) MeV ... observed in γp and DIS

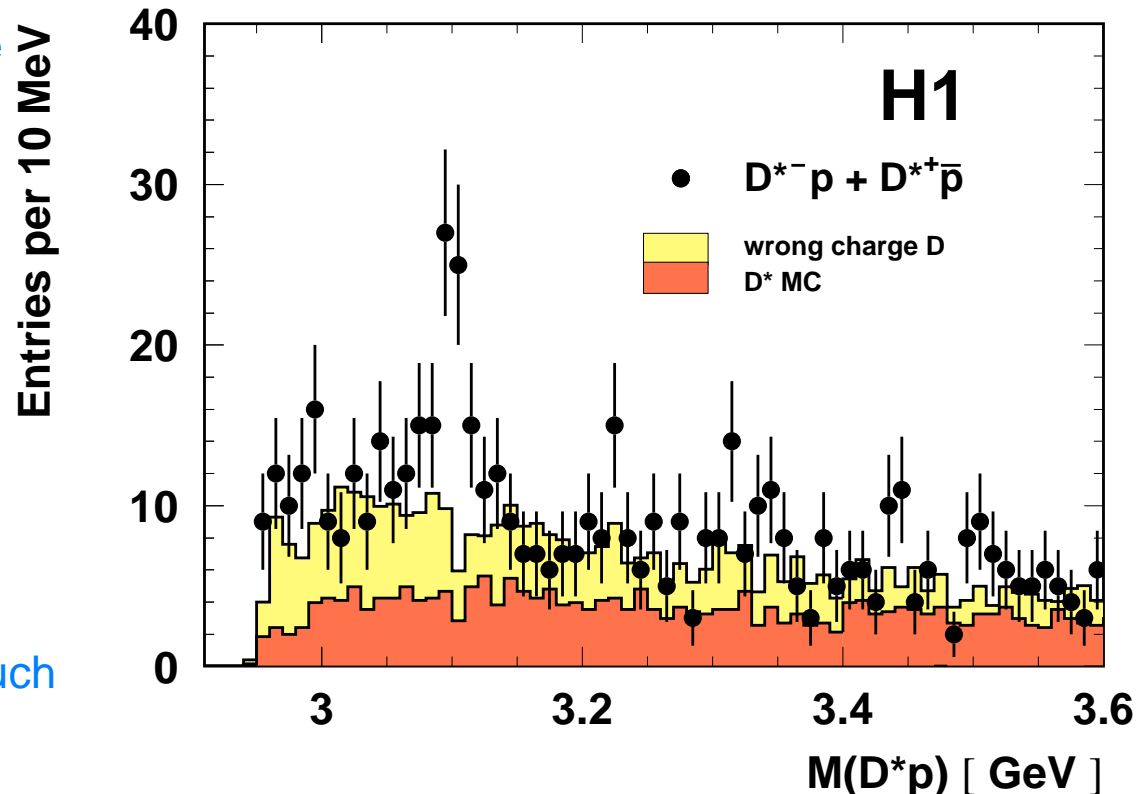
Background well modelled by wrong charge
 $K^\pm \pi^\pm$ combinations and D^* Monte Carlo

51 ± 11 events (75 pb^{-1})

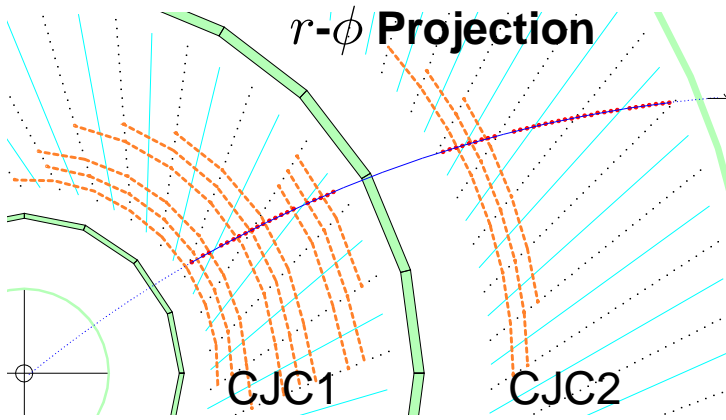
Compatible yields in $D^{*-} p$ and $D^{*+} \bar{p}$

As in strange case, width compatible with
experimental resolution (~ 7 MeV)

Minimal constituent quark composition of such
a state is $uudd\bar{c}$... charmed pentaquark?



Fast Track Trigger Status



Required for continued triggering of interesting low p_T final states with track based signatures at high \mathcal{L}

L1: 2.3 μ s

QT analysis,
Track-Segment-Finding

L2: 25 μ s

Track-Segment-Linking,
momenta,
momentum sums

L3: $\approx 100 \mu$ s

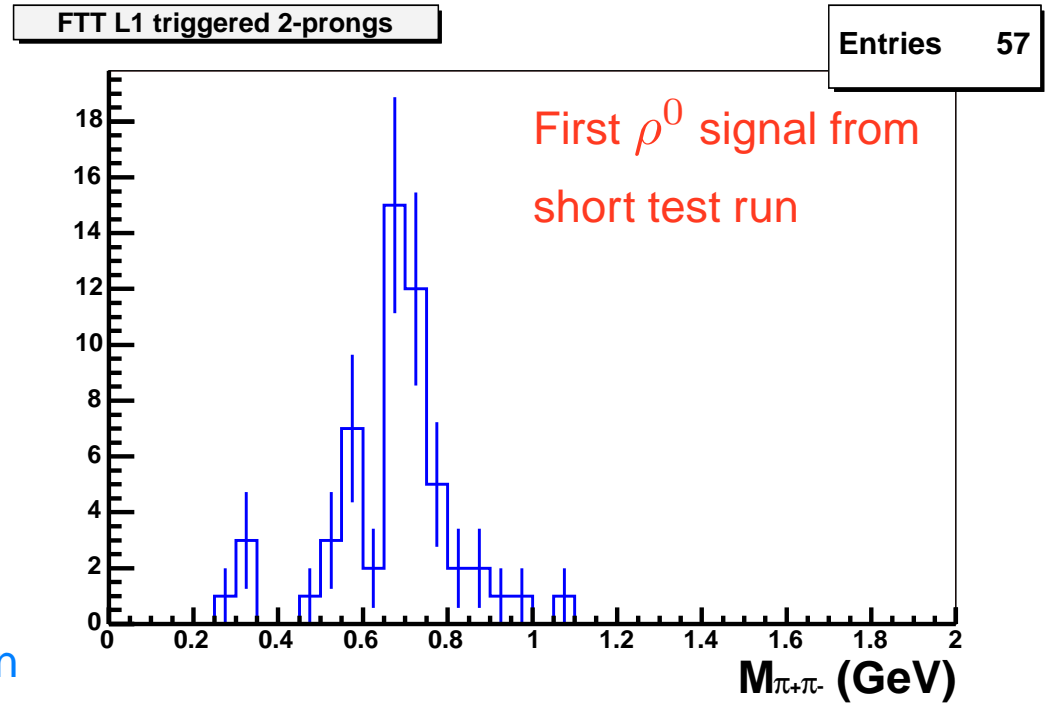
event reconstruction,
jets, invariant masses, $\Delta m \dots$

Level 1

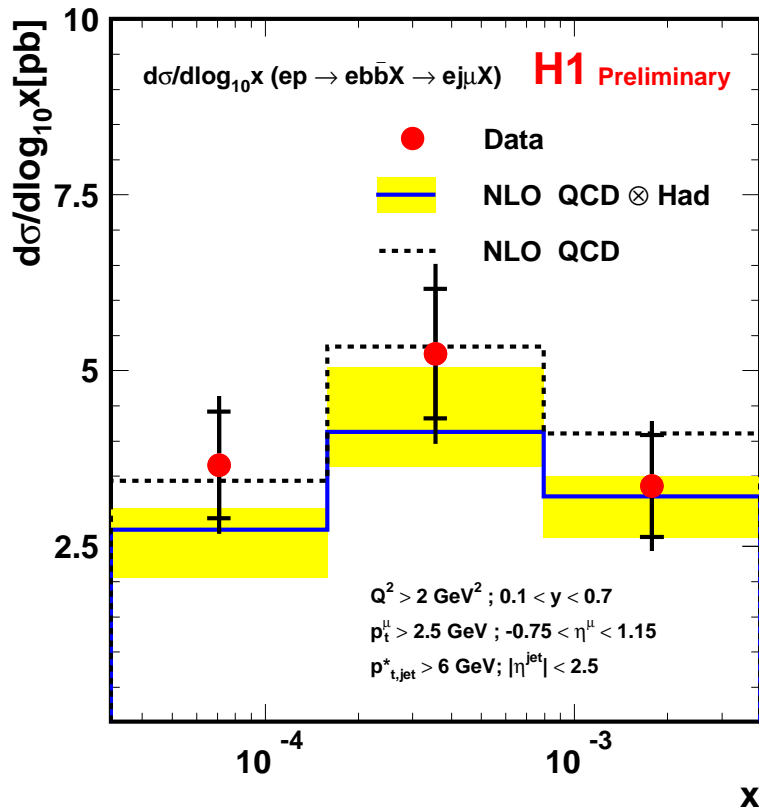
- Hit finding with 95% efficiency
- Track segment finding operational
- Coarse segment linking to form tracks
- First L1 trigger implemented for exclusive vector mesons in events with no tagged electron

Level 2/3

- Later stages of trigger being finalised
- Aiming for full commissioning before shutdown



Recent Progress in Beauty Cross Sections



$\sigma(ep \rightarrow ebb\bar{X} \rightarrow e\mu jX)$ in DIS

Use sample with muons associated with jets

Evaluate beauty contribution using 2D fit to ...

... muon impact parameter (silicon detector)

... p_T^{rel} of muon relative to jet

Results consistent with NLO QCD

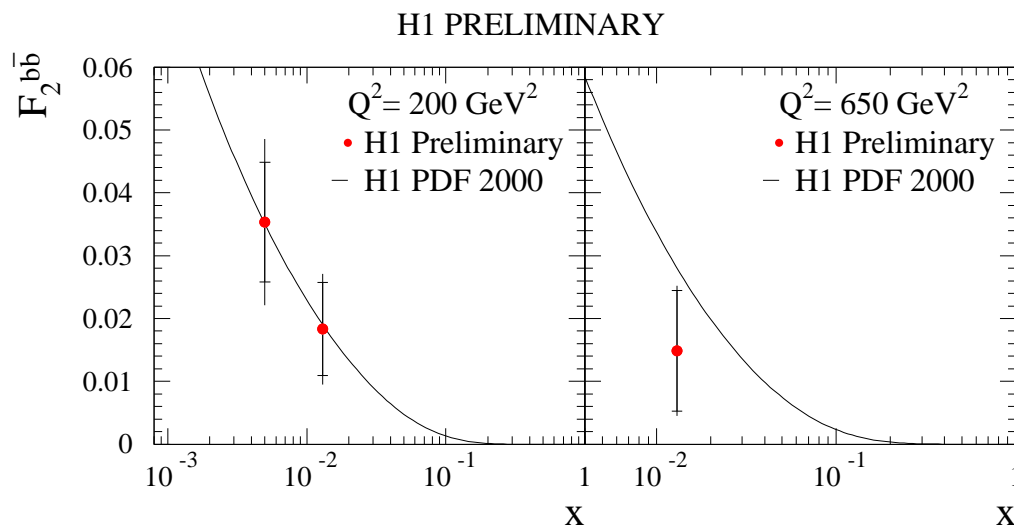
Inclusive F_2^b (and F_2^c) in high Q^2 DIS

Inclusive secondary vertex sample from silicon

b, c contributions from fits to signed impact parameter distribution

For $Q^2 \gtrsim 100 \text{ GeV}^2$, minimal extrapolation to inclusive b cross section

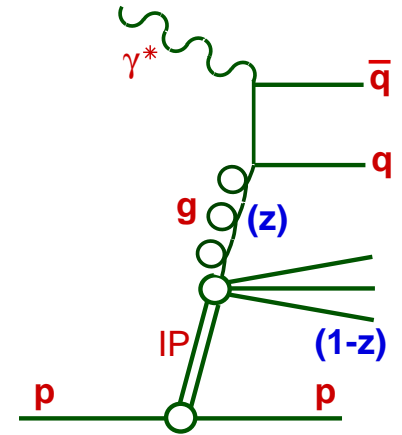
New technique!... First F_2^b measurement



Diffraction final states and NLO QCD

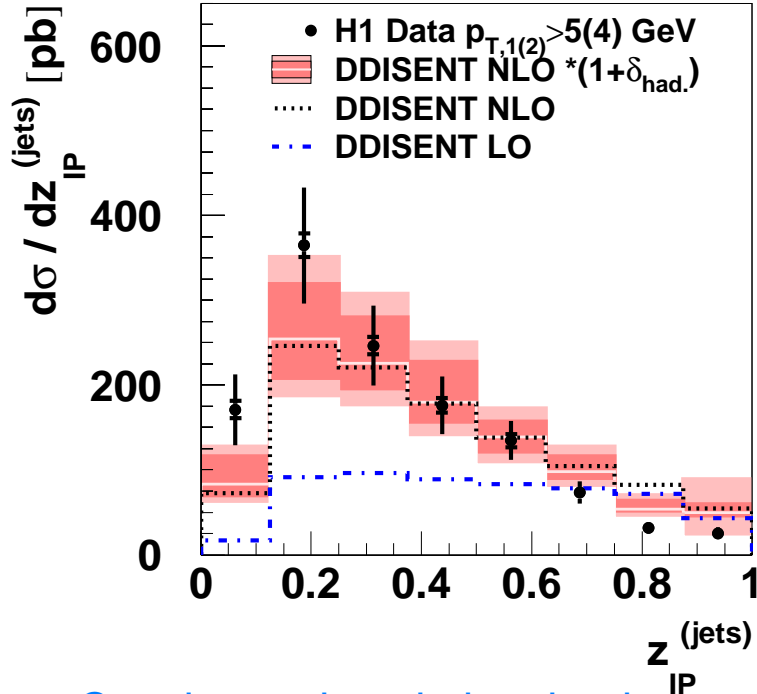
Overlaps between different final state signatures give new sensitivities

e.g. test semi-inclusive QCD factorisation by predicting diffractive dijet and charm rates at NLO using diffractive parton densities from F_2^D



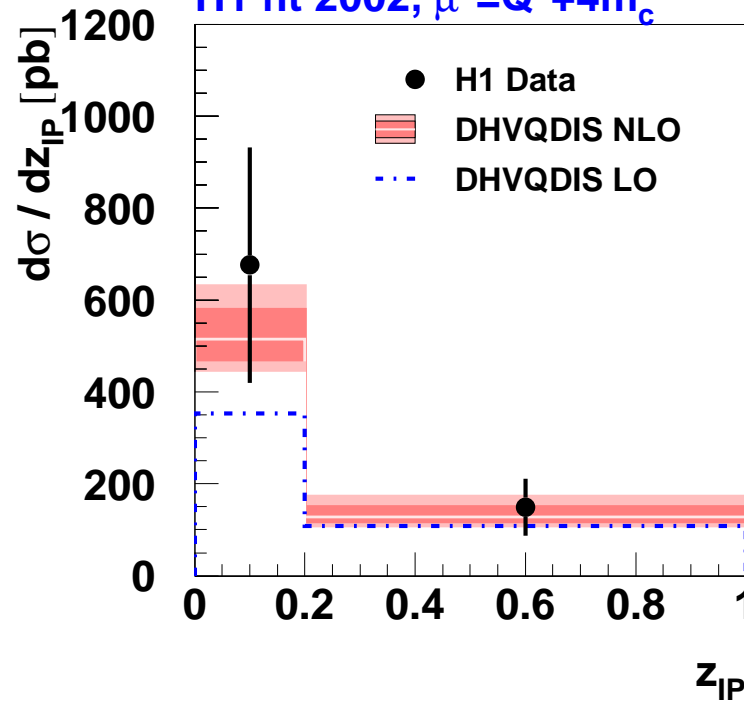
H1 Diffractive Dijets (prel.)

H1 fit 2002, $\mu_r^2 = p_T^2$, $\mu_f^2 = 40 \text{ GeV}^2$



H1 Diffractive D^* (prel.)

H1 fit 2002, $\mu^2 = Q^2 + 4m_c^2$

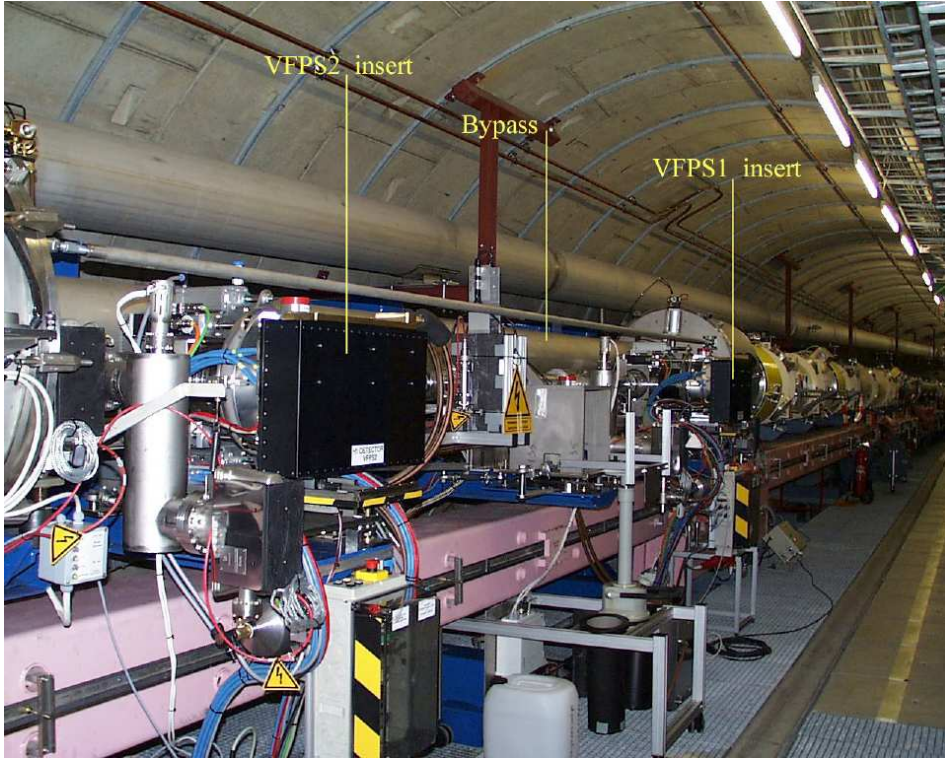


Consistent description, but large experimental and theoretical errors

Further progress needs high statistics data at fixed x_{IP} and better systematics

Also improved theoretical errors ... Relax "Regge" factorisation assumption, go to higher scales

Status of Very Forward Proton Spectrometer



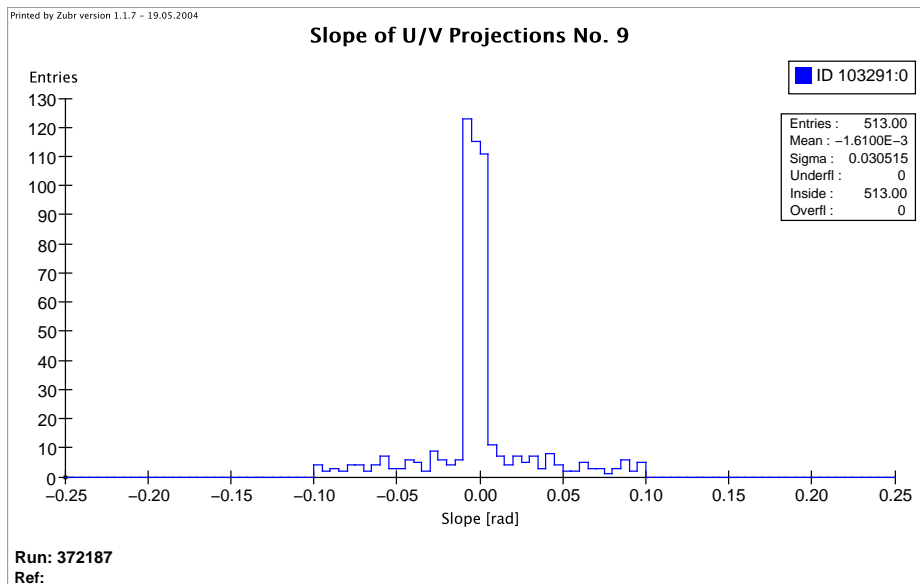
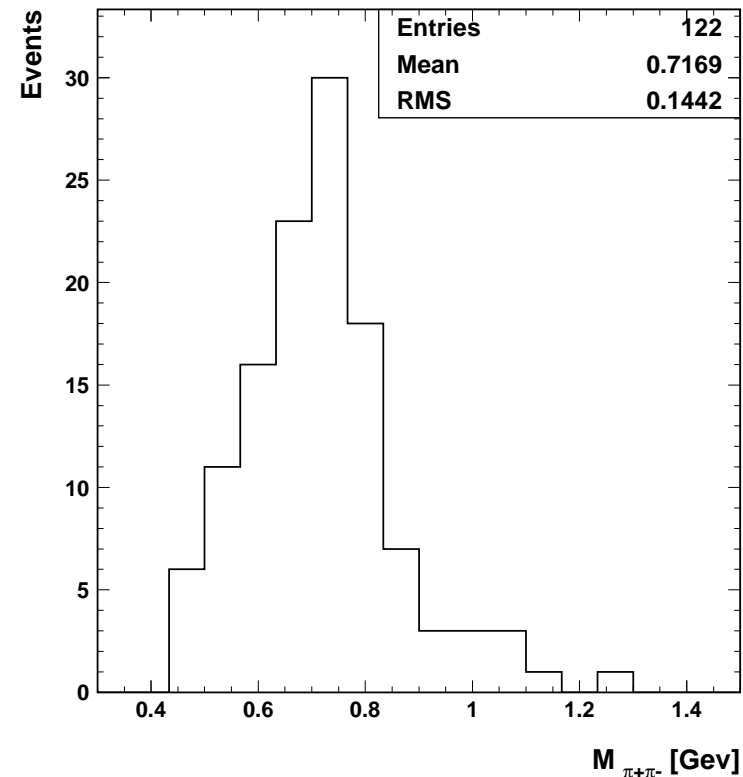
2 Roman pot stations near $z = 220$ m

... Efficient triggering and measurement of leading protons in interesting region $|t| < 1 \text{ GeV}^2$, $x_P \sim 0.01$

Track reconstruction working ... clear forward peak

First level 1 trigger implemented

Clear ρ peak (untagged γp) from short test run



Summary

- **Ongoing analysis of HERA-I data**

 - ... Many new measurements and techniques

- **Detector in good shape and taking high quality HERA-II data**

 - ... First physics results obtained with polarised leptons

- **Top future priority is highest possible luminosity as soon as possible**

 - ... New level of precision in broadest range of physics topics

 - Can be realised with e^+ running, also necessary to clarify high p_T anomalies

 - e^- data of interest for some searches and electroweak physics

 - Reduced E_p running required for F_L , high x , moderate Q^2 and W dependences

- **H1 Collaboration remains firmly committed to full HERA-II programme**