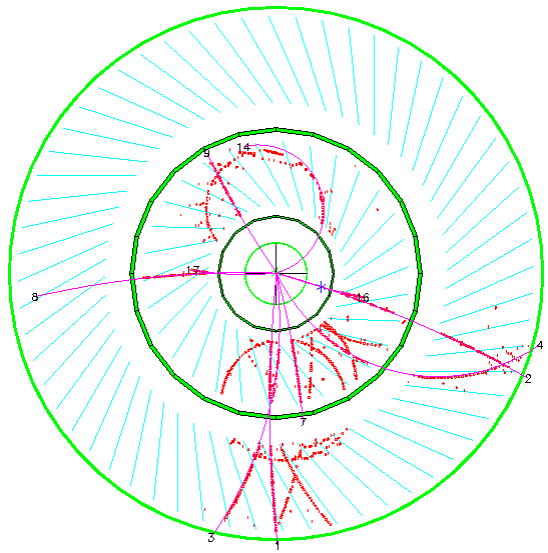
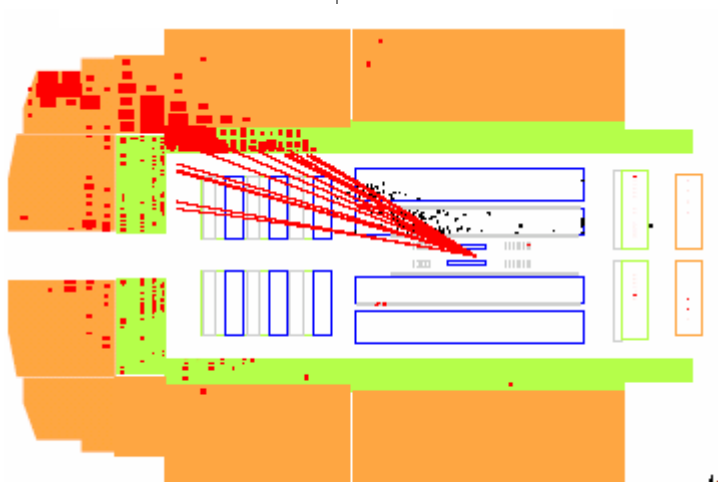
New Results from H1

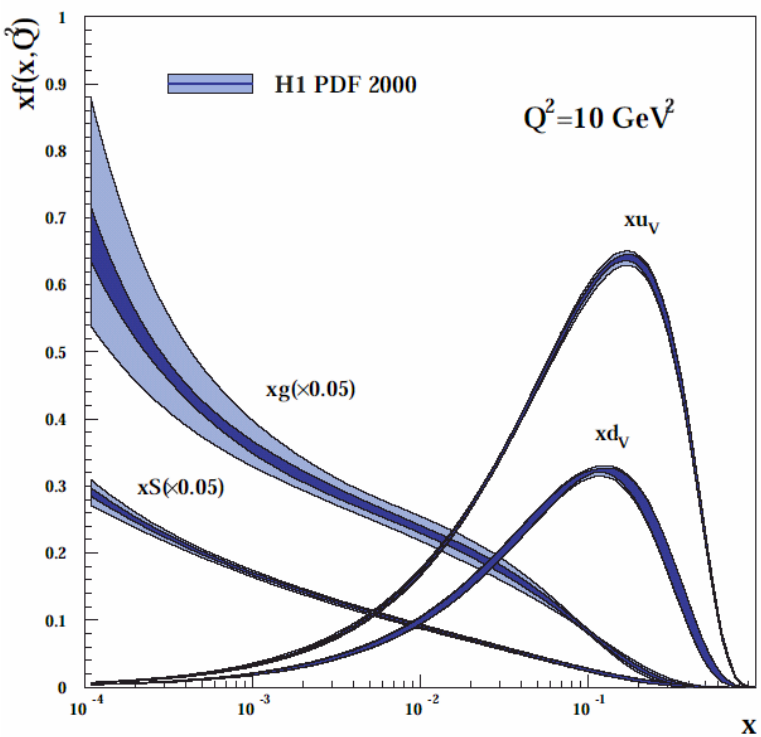
- New results from HERA I data:
  - Proton structure.
  - Heavy flavours.
  - The hadronic final state.
  - Diffraction.
  - Searches for new physics.
- First results with HERA II data:
  - Cross section measurements with polarised e^+.
  - Searches for new physics.
- Summary.

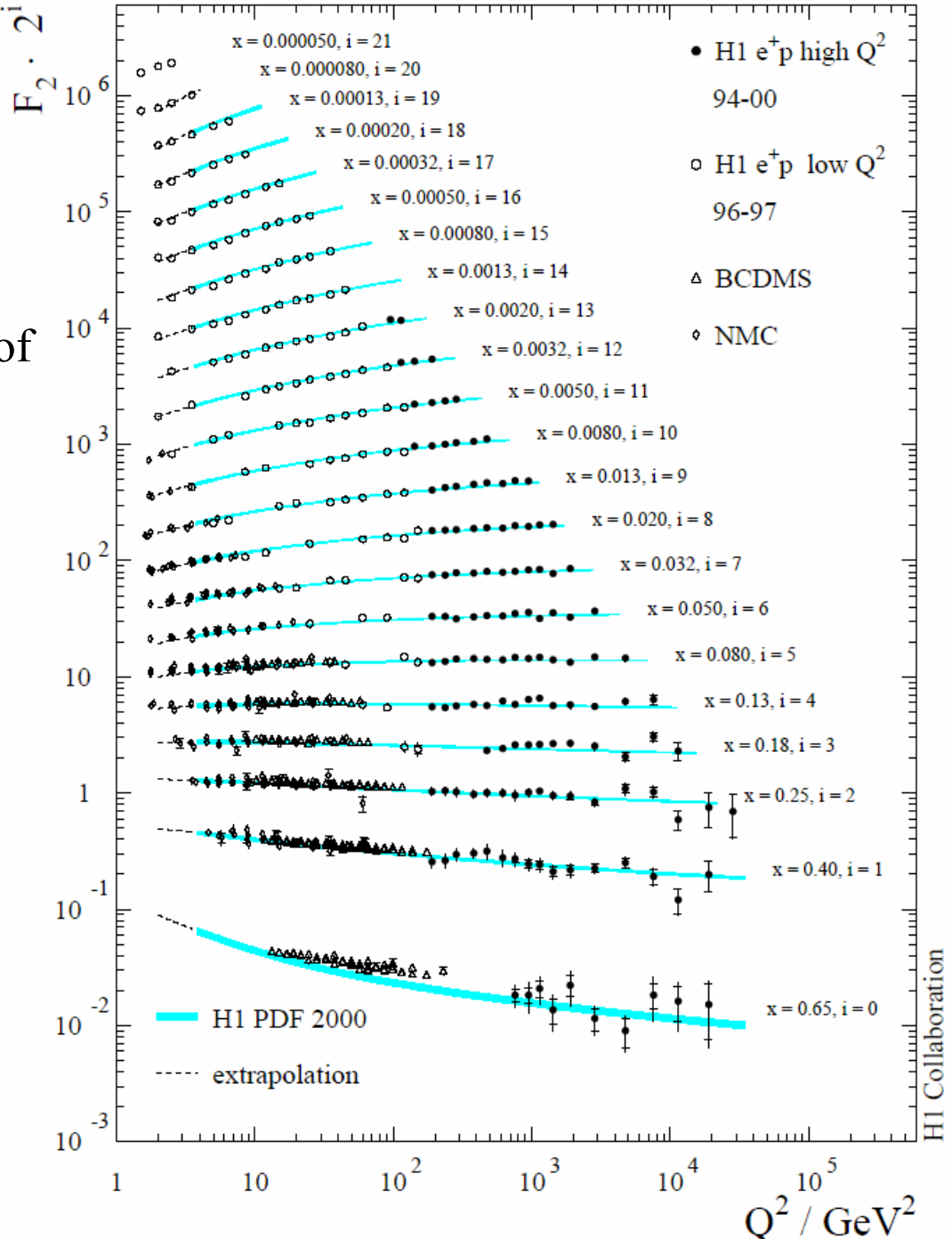




Structure function measurements

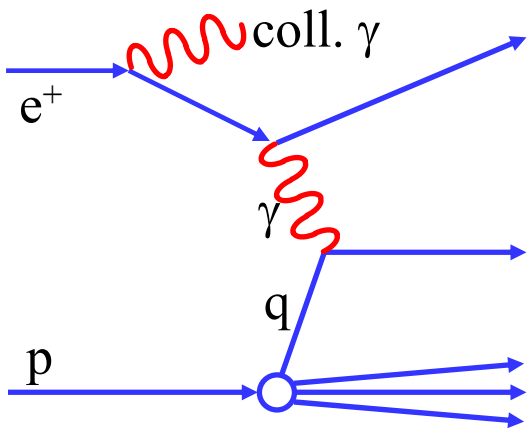
- H1 structure function data accurate to 2 to 3% over bulk of phase space.
- Hence extract NLO PDFs:



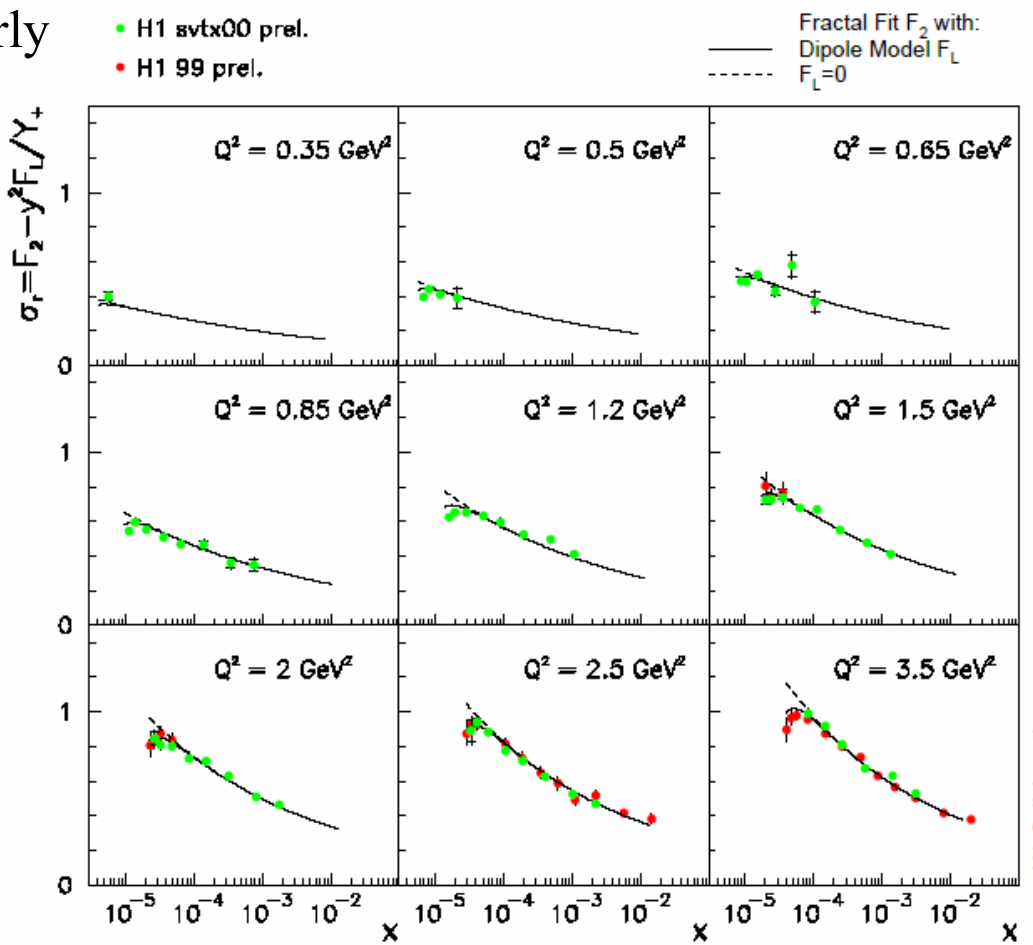


New cross-section measurements

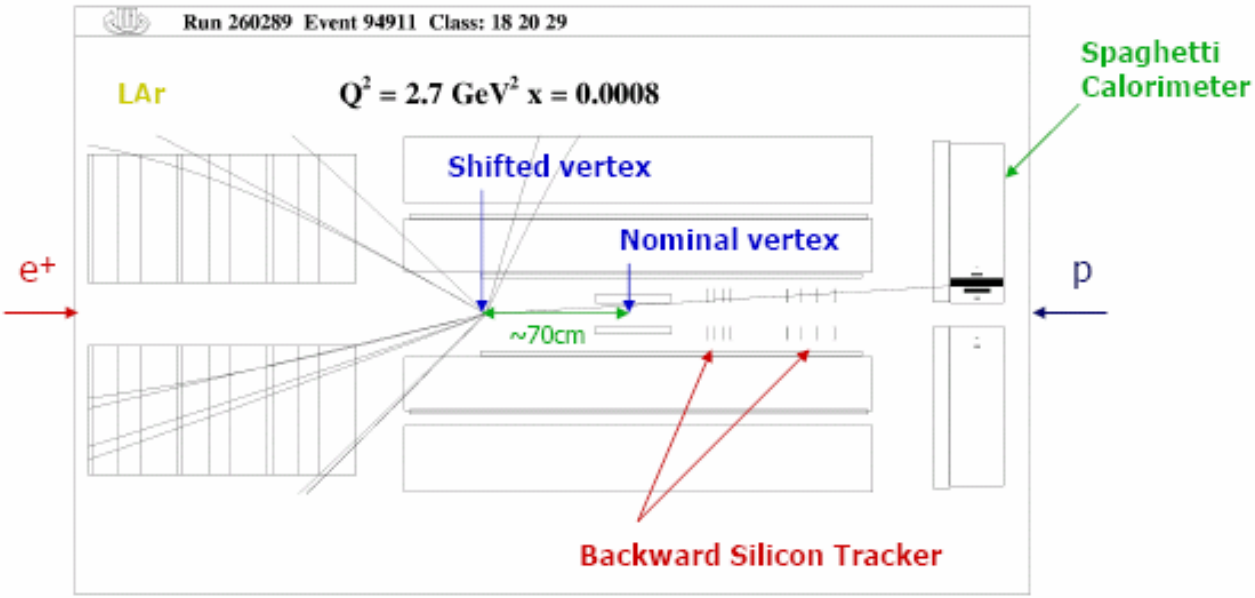
- Some regions of kinematic plane remain to be studied, particularly intermediate x at low Q^2.
- Radiative events, effective reduction in E_e.



- Access larger $x = Q^2/ys$ for given Q^2.



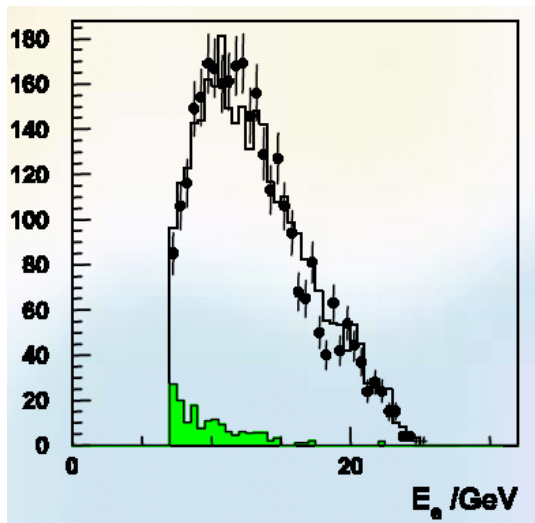
Cross-section at low Q^2



- Identify ISR events without tagging γ via:

$$\Sigma = \sum_{e+h} E - p_z$$
$$= 2E_e - 2E_\gamma$$

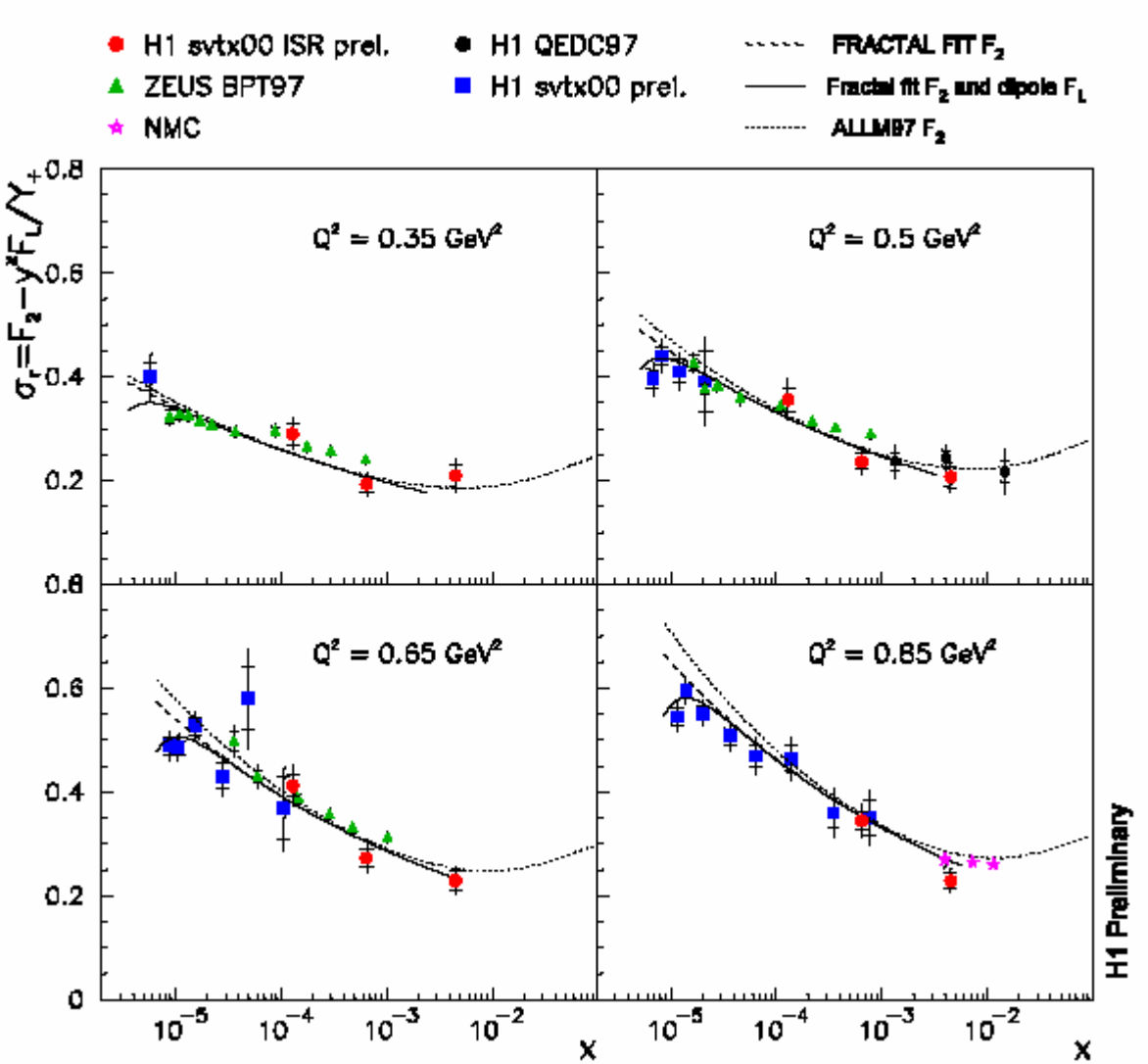
- Mean "E_{eff}" ~ 15 GeV, c.f. nominal value $E_e = 27.6$ GeV.



- Use shifted vertex data (low Q^2).
- BST and SpaCal necessary for measurement of scattered electron and rejection of photoproduction background.

Cross-section at low Q^2

- Cross-section from H1 ISR and QED Compton data (final results) in good agreement.
- Measurements consistent with other data in regions of overlap.



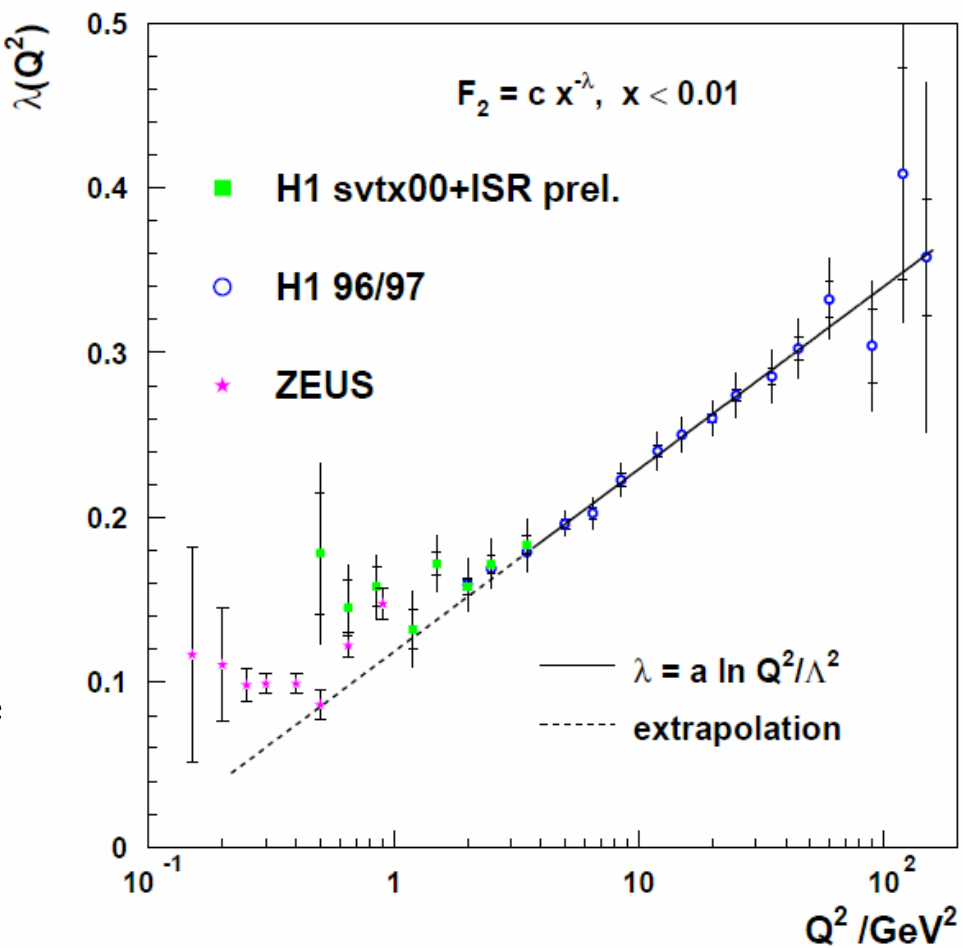
Behaviour of F_2 at low x

- Can parameterise structure function as

$$F_2\left(x,Q^2\right)=c\left(Q^2\right)x^{-\lambda\left(Q^2\right)}.$$

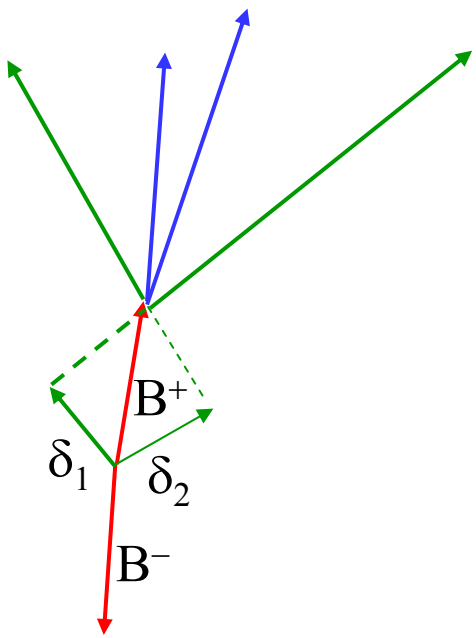
- Extract $\lambda(Q^2)$ by fitting F_2 as function of x at constant Q^2.
- Behaviour of $\lambda(Q^2)$ in "transition region" ($Q^2 \sim 1$ GeV^2) intriguing.
- Probing limits of perturbative QCD.
- Further investigation not possible at HERA II because of acceptance limitations introduced by new focussing magnets.

- Measurements of $\lambda(Q^2)$:

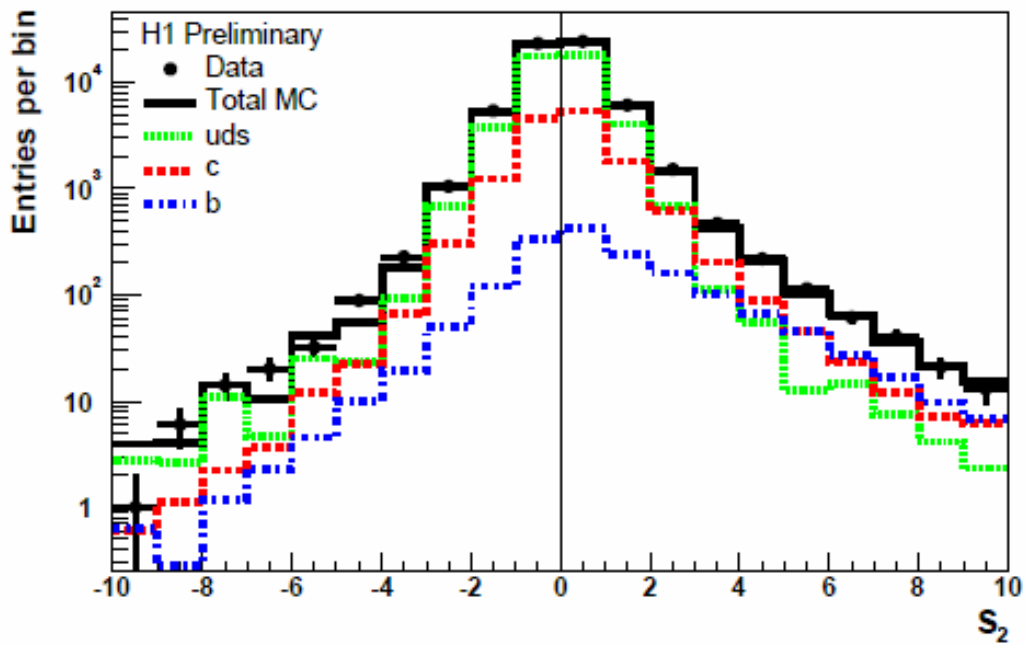


$F_2^{c\bar{c}}$ and $F_2^{b\bar{b}}$ at high Q^2

- Studies of beauty and charm production using H1 central silicon tracker (CST).
- Flavour identification using distance of closest approach of track to vertex δ.



- Determine significance $S = \delta/\sigma(\delta)$ for all CST tracks.
- Use 2 tracks with largest significance, S_1 and S_2
- Example, S_2 distribution:

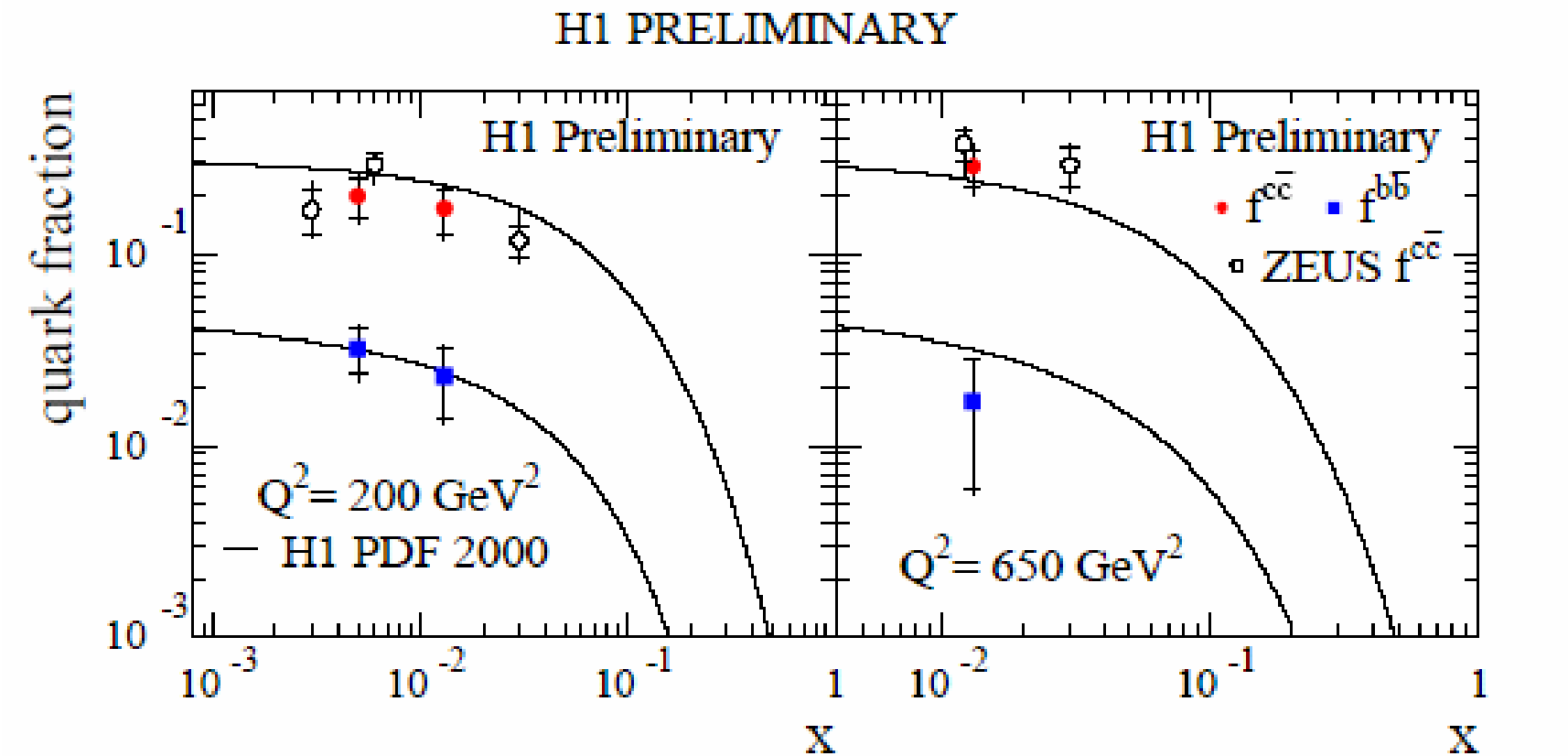


$F_2^{c\bar{c}}$ and $F_2^{b\bar{b}}$ at high Q^2

- Determine ratios

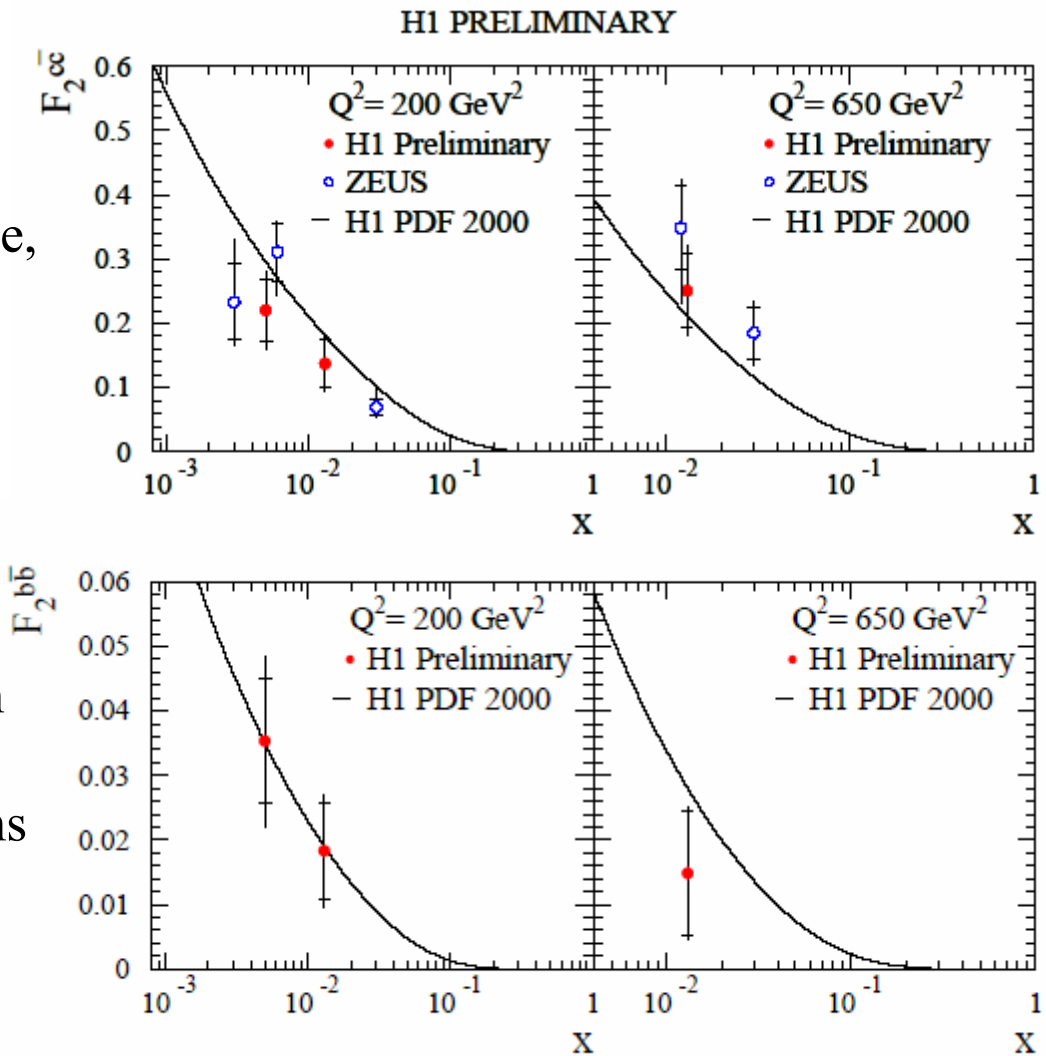
  $f^{c\bar{c}} = \frac{F_2^{c\bar{c}}}{F_2}$ and $f^{b\bar{b}} = \frac{F_2^{b\bar{b}}}{F_2}$

- $f_b \sim 2\%$, $f_c \sim 25\%$ in this region.



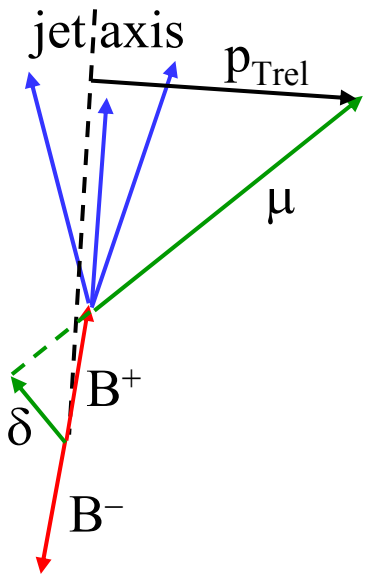
$F_2^{c\bar{c}}$ and $F_2^{b\bar{b}}$ at high Q^2

- Resulting $F_2^{c\bar{c}}$ (large acceptance, extrapolations small).
- First $F_2^{b\bar{b}}$ measurement, in good agreement with expectations from NLO calc. using H1 PDFs.



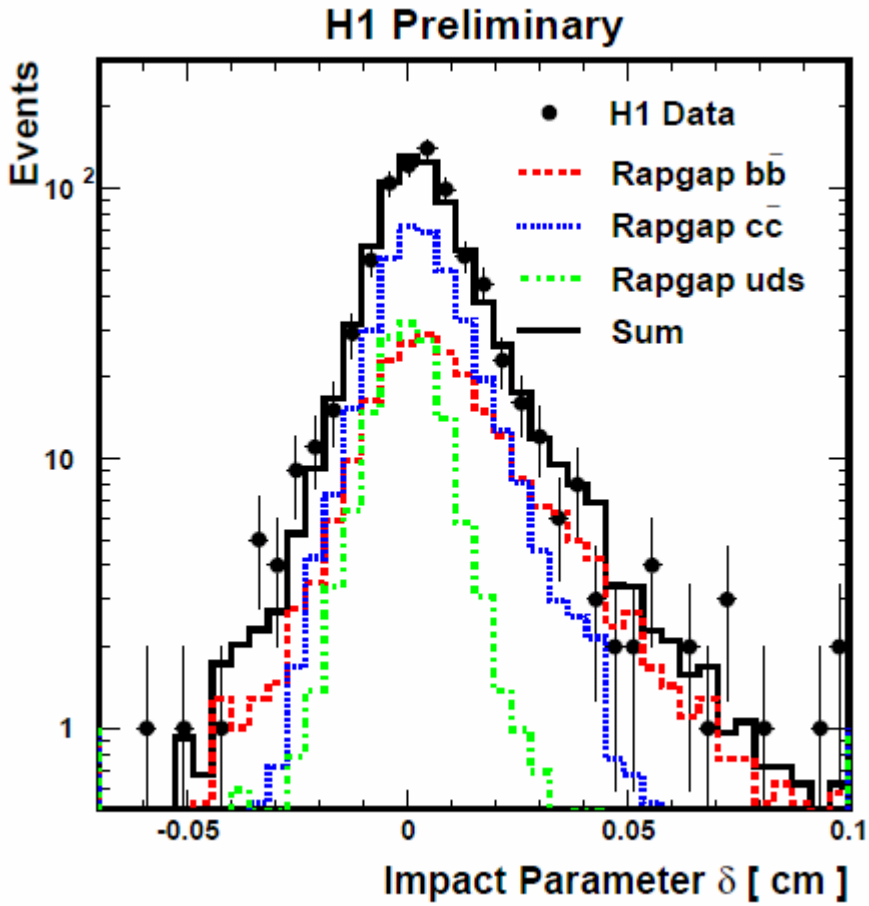
Beauty in DIS and photoproduction

- Identify semi-muonic beauty decays via p_{Trel} and impact parameter δ of muon.



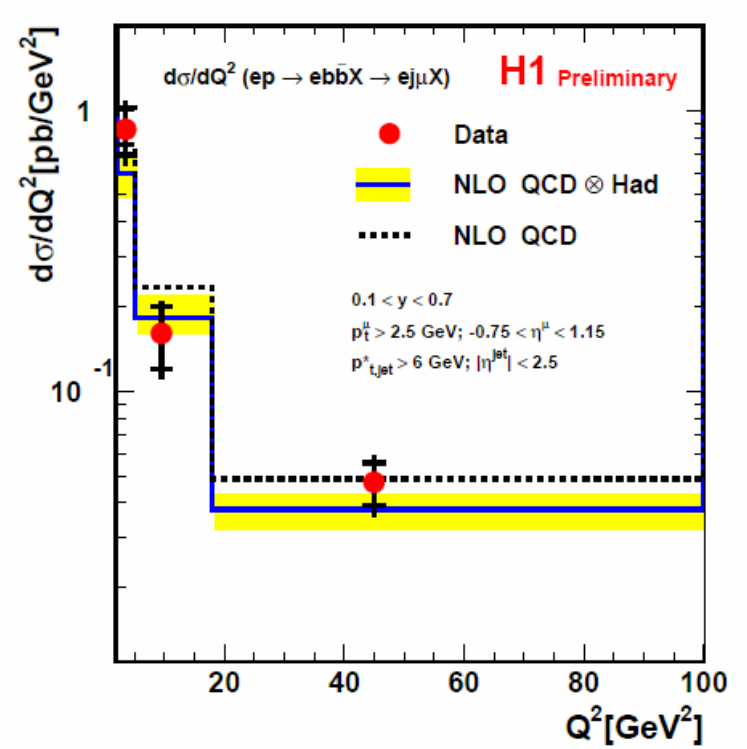
- Measure $e\,p \to e\,b\,\bar{b}\,X \to e\,jet\,\mu\,Y$ and $\gamma\,p \to b\,\bar{b}\,X \to jet\,jet\,\mu\,Y$.

- Data well understood, e.g. δ distribution in DIS:

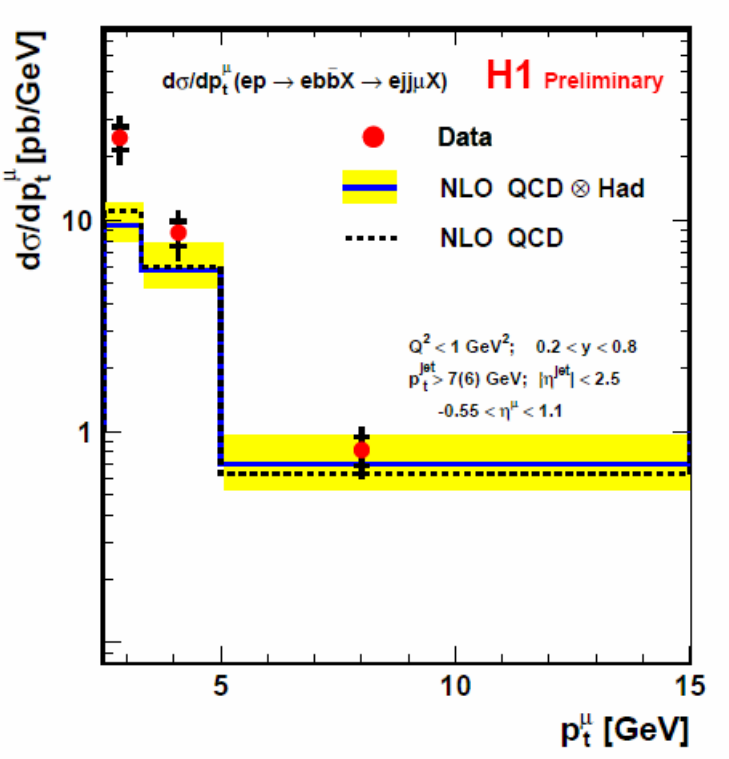


Beauty in DIS and photoproduction

- Fit 2D distribution in (δ, p_{Trel}) to obtain beauty contribution.
- DIS cross section well described by NLO QCD calc. (HVQDIS):

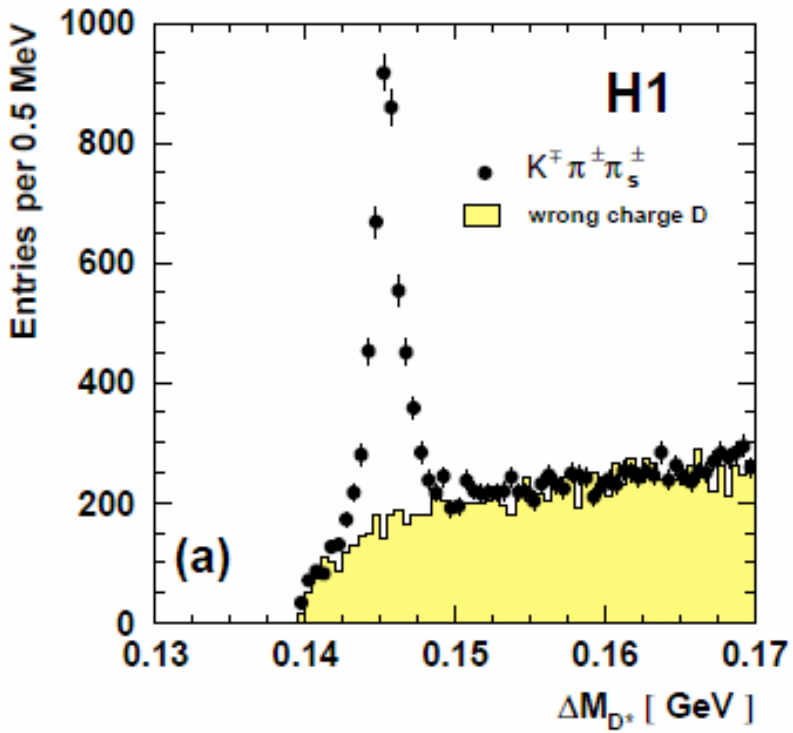


- NLO QCD calculations (FMNR) lie below photoproduction cross section at low muon p_T, agree at high p_T.



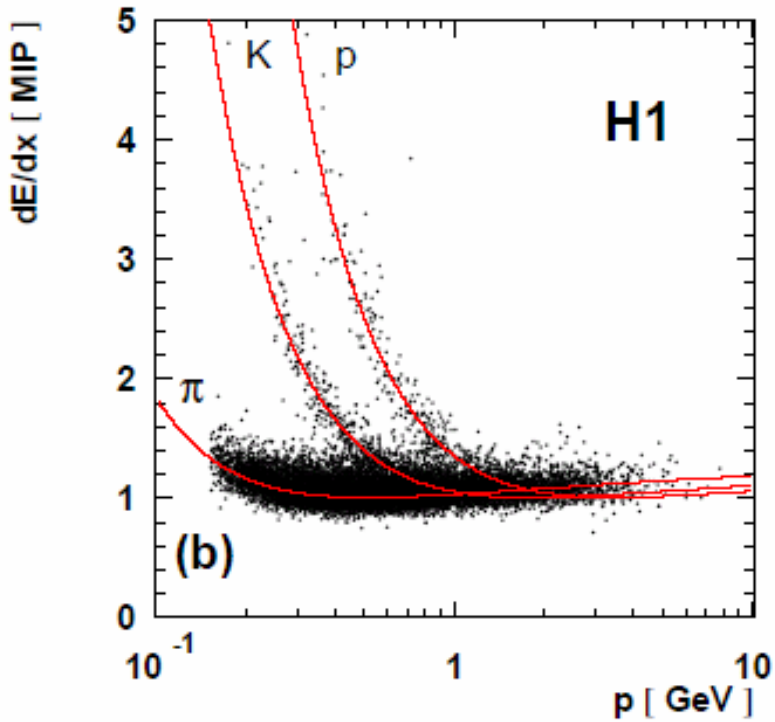
Evidence for a narrow anti-charmed baryon state

- Strange pentaquark ($uudd\bar{s}$) seen by many expts in channels $\Theta_s \rightarrow K^+ n$ and $\Theta_s \rightarrow K_S^0 p$.
- Search for equivalent charmed state, Θ_c ($uudd\bar{c}$).
- Look for narrow resonance in $D^* p$ mass spectrum.
- Use DIS D^* sample with selection that ensures good S/B ratio.
- $\Delta m_{D^*} = m(K^-\pi^+\pi_s^+) - m(K^-\pi^+)$.
- BG $m(K^+\pi^+\pi_s^+) - m(K^+\pi^+)$.



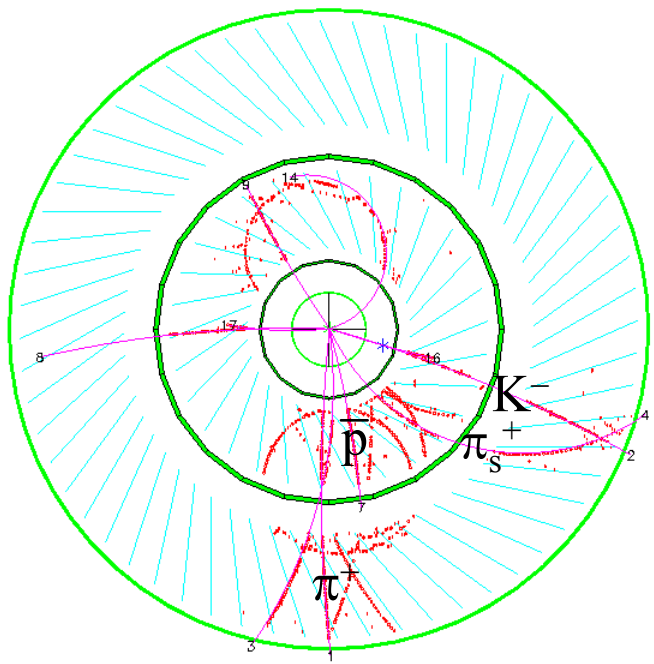
Evidence for a narrow anti-charmed baryon state

- Suppress non-proton BG using dE/dx measurements in H1 central jet chambers.



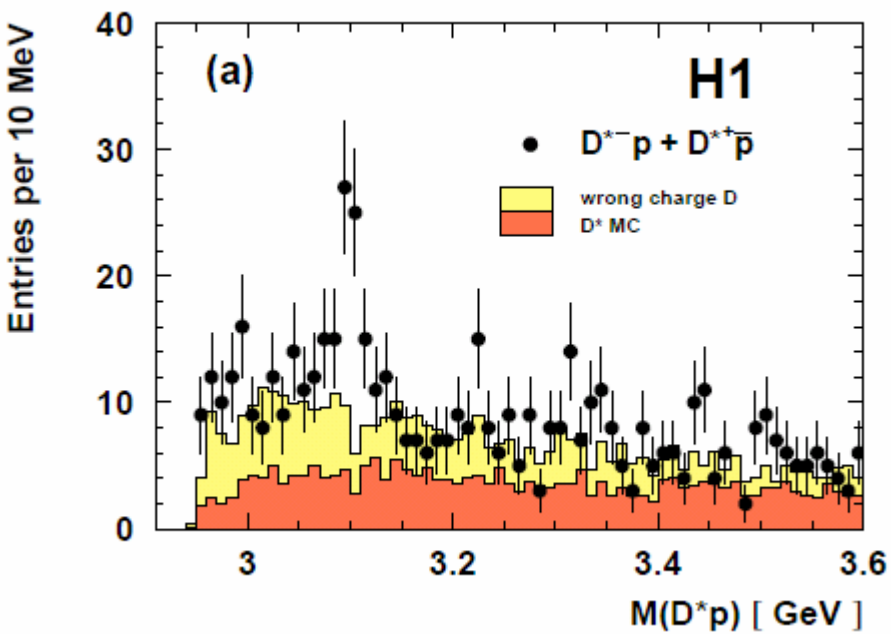
- Four particle mass resolution about 35 MeV.
- Use "Δm" technique to improve resolution near threshold, i.e.

$$m(K\pi\pi_s p) - m(K\pi\pi_s) + m(D^*)_{PDG}.$$



Evidence for a narrow anti-charmed baryon state

- Resulting mass spectrum:



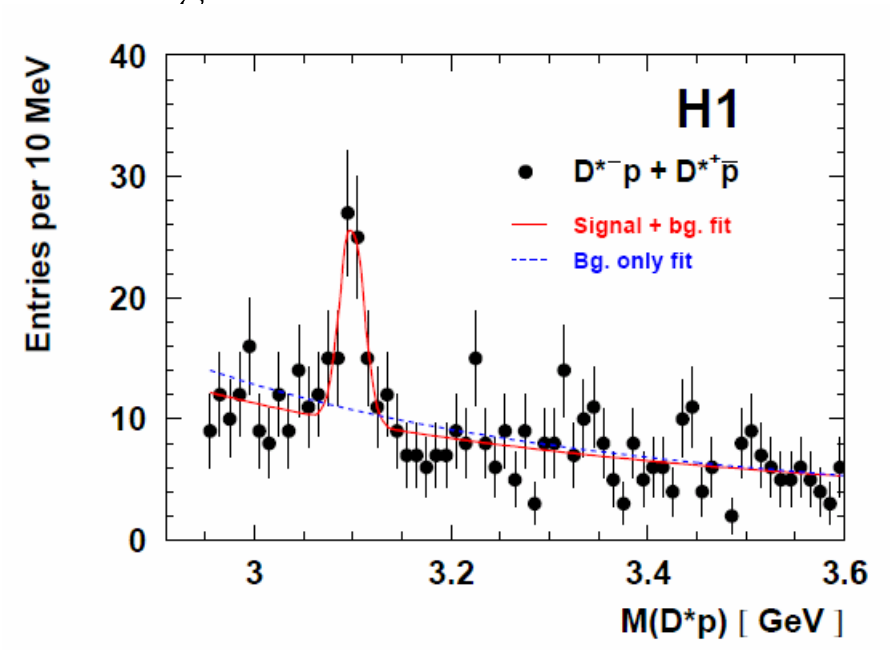
- BG described by "wrong charge D^0" sample + D^* MC (Rapgap).

- Peak seen in $D^{*-}p$ and $D^{*+}\bar{p}$ channels.
- Signal also present in γp data.
- Masses and widths (consistent with resolution) compatible in all data samples.

Sample	Mass (MeV)	Gauss width (MeV)	N_S
$D^{*-}p + D^{*+}\bar{p}$ (DIS)	3099 ± 3	12 ± 3	50.6 ± 11.2
$D^{*-}p$ (DIS)	3102 ± 3	9 ± 3	25.8 ± 7.1
$D^{*+}\bar{p}$ (DIS)	3096 ± 6	13 ± 6	23.4 ± 8.6
$D^{*-}p + D^{*+}\bar{p}$ (γp)	3103 ± 4	7 ± 3	43 ± 14

Evidence for a narrow anti-charmed baryon state

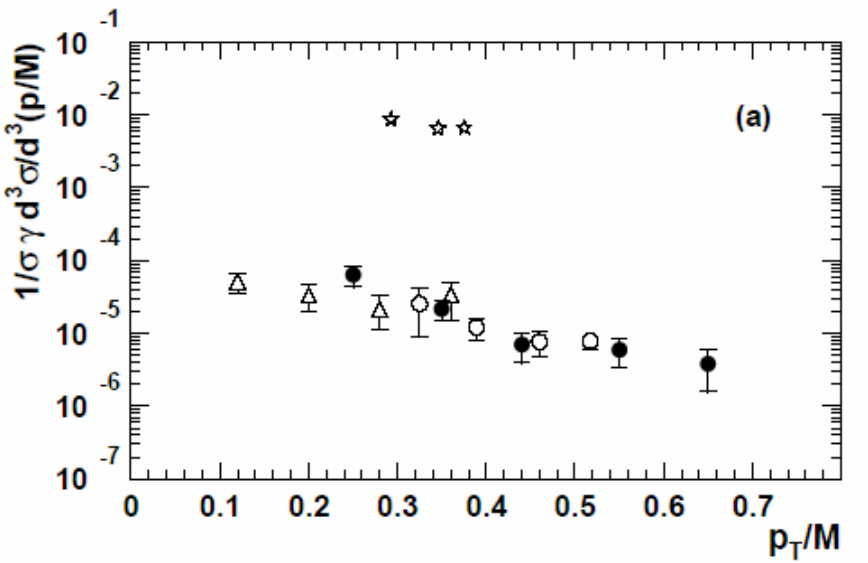
- Significance estimate.



- BG only fit gives $N_b = 51.7 \pm 2.7$ in signal region (within 2σ of mean peak position).
- Prob. that this BG fluctuates to produce signal is 4×10^{-8} (Poisson statistics).
- Corresponds to 5.4 Gaussian standard deviations.
- Difference between likelihoods for fit with and without signal corresponds to significance of 6.2σ.

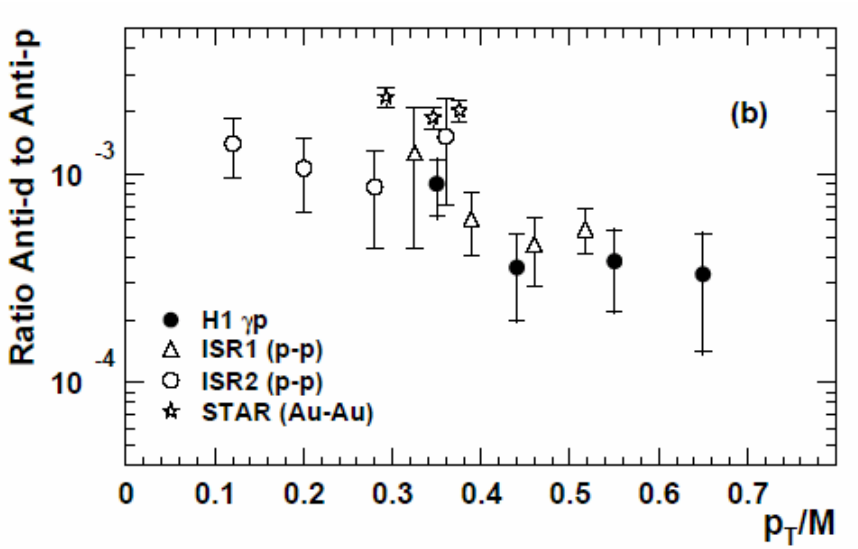
The photoproduction of anti-deuterons

- Identify anti-deuterons using dE/dx.
- Invariant x-sect. for anti-deuteron production:



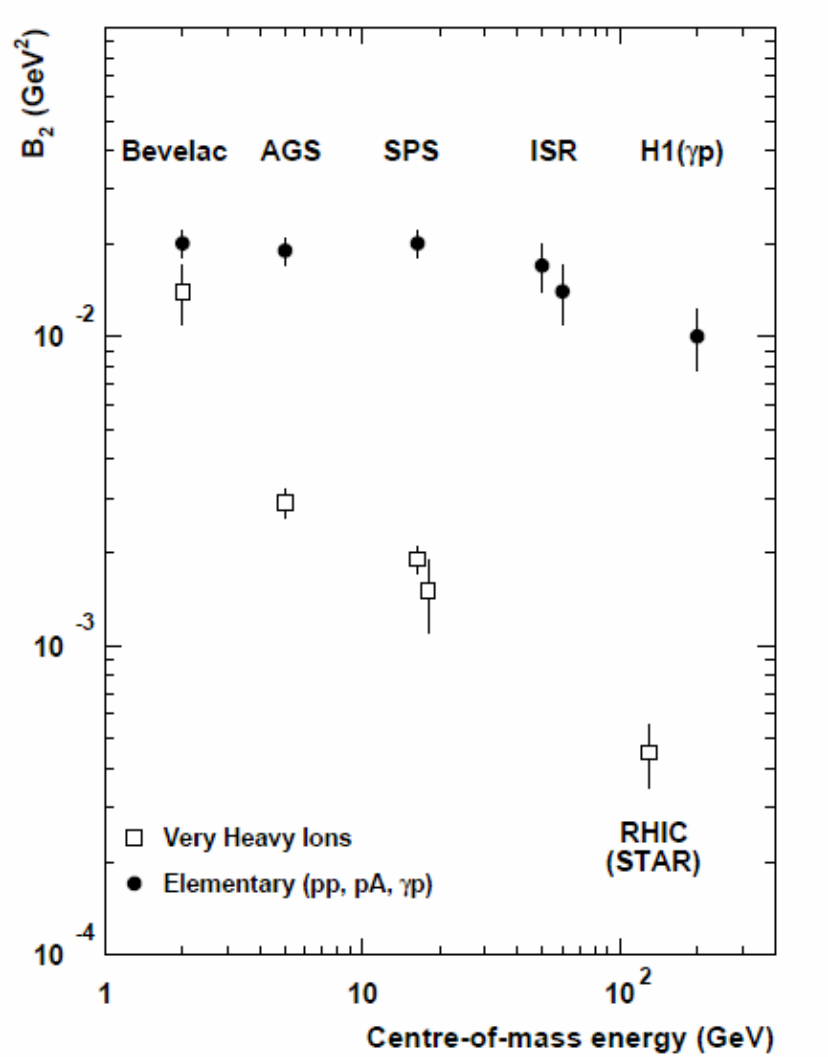
- Orders of magnitude larger in heavy ion than "elementary" collisions.

- Ratio of anti-d to anti-proton production only slightly smaller in elementary than in heavy-ion collisions:



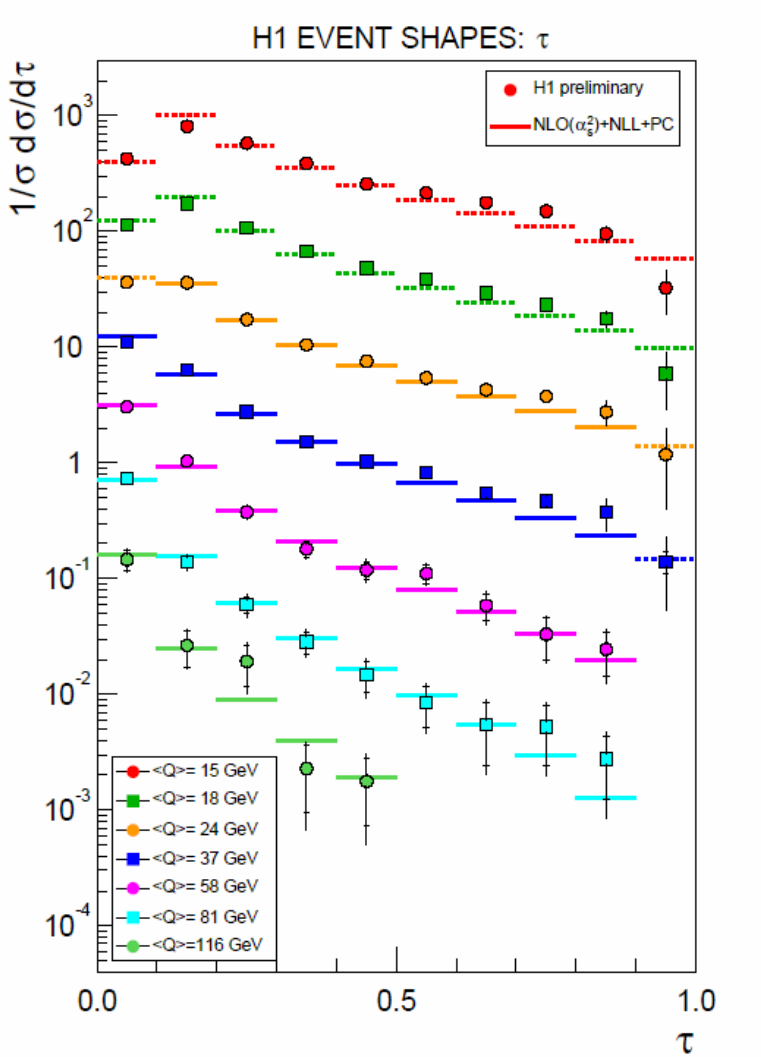
The photoproduction of anti-deuterons

- Compare coalescence model parameter B_2 for heavy-ion and "elementary" collisions.
- B_2 inversely proportional to size of interaction region at "freeze-out".
- Results suggest interaction region in "elementary" interactions smaller than in heavy ion collisions.



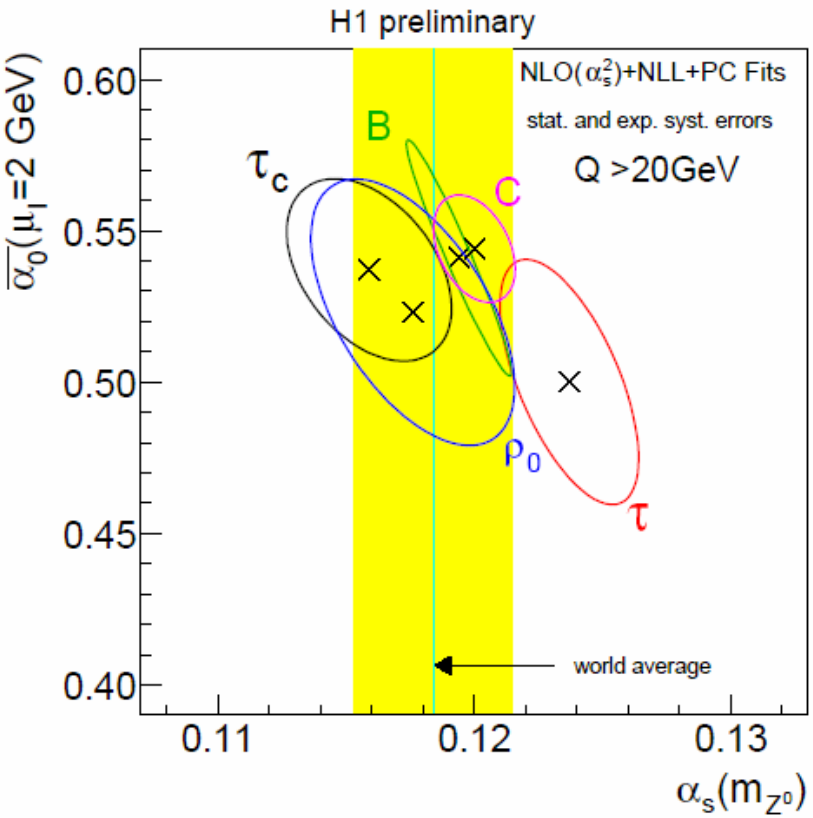
The hadronic final state – event shapes

- Measurements of hadronic final state allow further tests of perturbative QCD and ideas beyond perturbation theory.
- Example, description of $\tau = 1 - T$ spectra using pQCD plus "power corrections" (Dokshitzer, Webber...).
- Introduces parameter $\overline{\alpha}_0$.
- Fit using re-summed NLL calculations matched to NLO (Dasgupta, Salam) as convergence of pert. series poor at small τ.
- Obtain values of $\overline{\alpha}_0$ and $\alpha_s(M_Z)$.

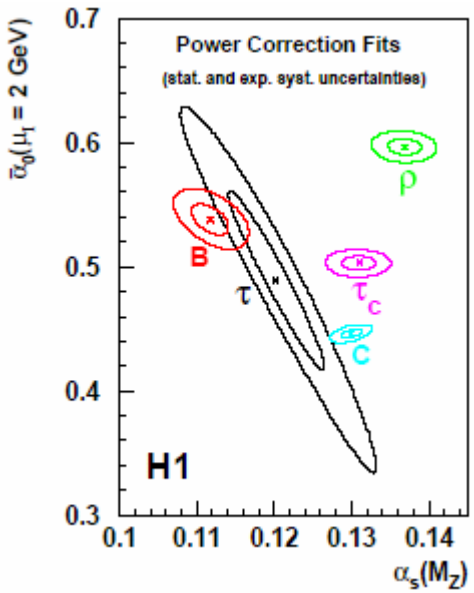


Event shape studies

- Repeat for further "two jet" variables.
- Resulting $\alpha_s(M_Z)$ and $\overline{\alpha}_0$ values:



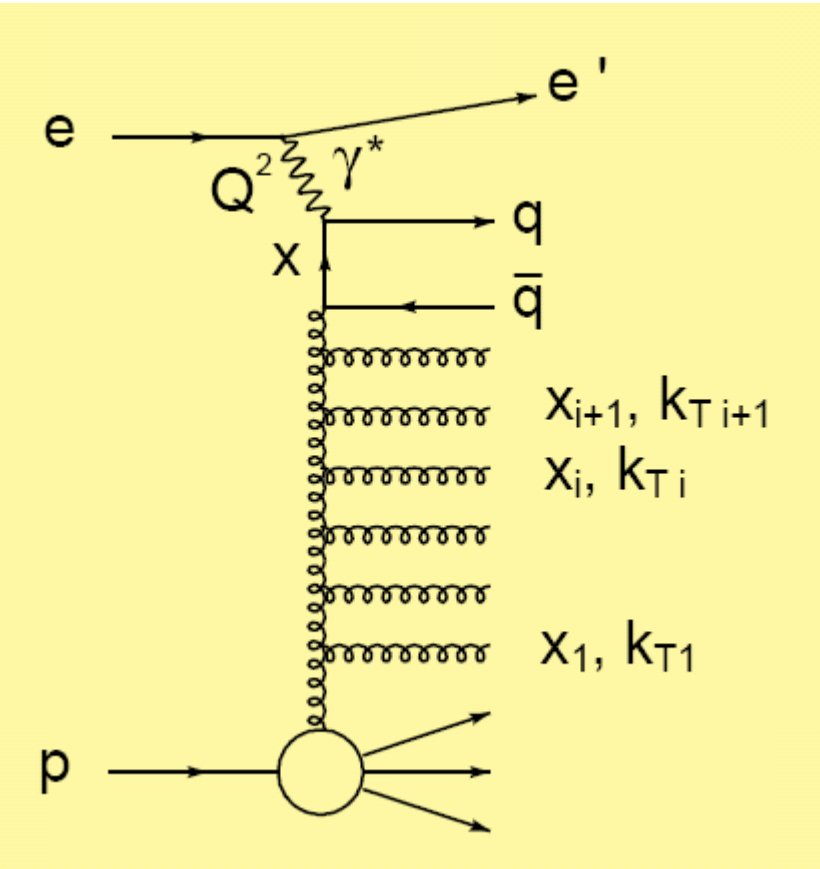
- Fitting spectra with NLO + NLL + power corrections results in improved consistency.



- Agreement with world average $\alpha_s(M_Z^2)$ and with $\overline{\alpha}_0$ as determined in e^+e^- analysis of mean event shapes.
- Measurements of 2, 3 and 4-jet event rates and of "three jet" event shape variables also made.

Forward jets

- Forward jet production sensitive to dynamics of parton cascade between proton and positron.



- Test applicability of QCD approximation schemes:

  DGLAP, $k_{T1} \ll k_{T2} \ll k_{T3} \cdots$

  BFKL, $x_1 \gg x_2 \gg x_3 \cdots$

  CCFM, $\theta_1 < \theta_2 < \theta_3 \cdots$

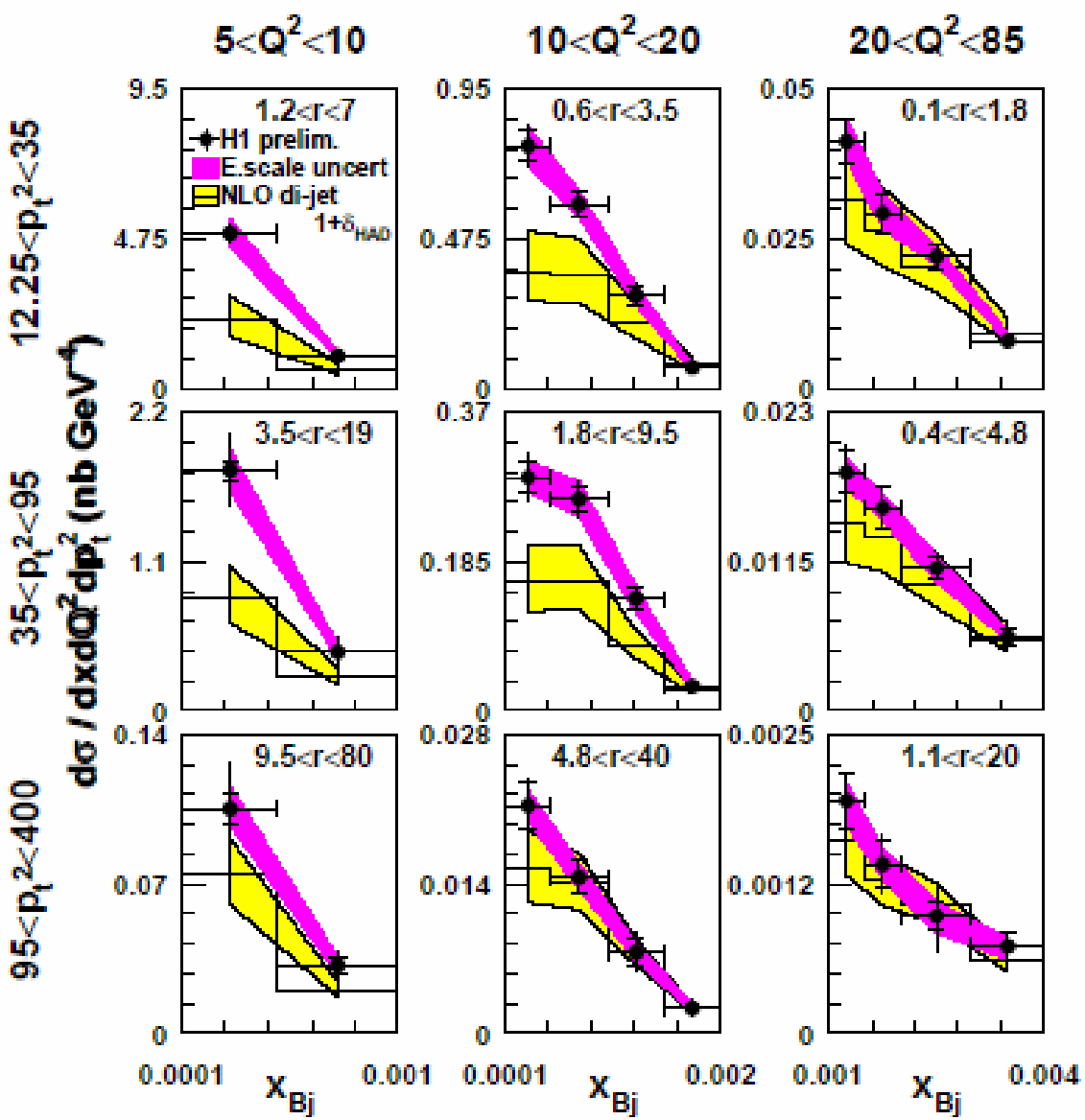
- Measure triple differential cross section for jets satisfying:

  $1.74 < \eta_{jet} < 2.79$

  $$x_{jet} = \frac{E_{jet}}{E_p} > 0.035$$

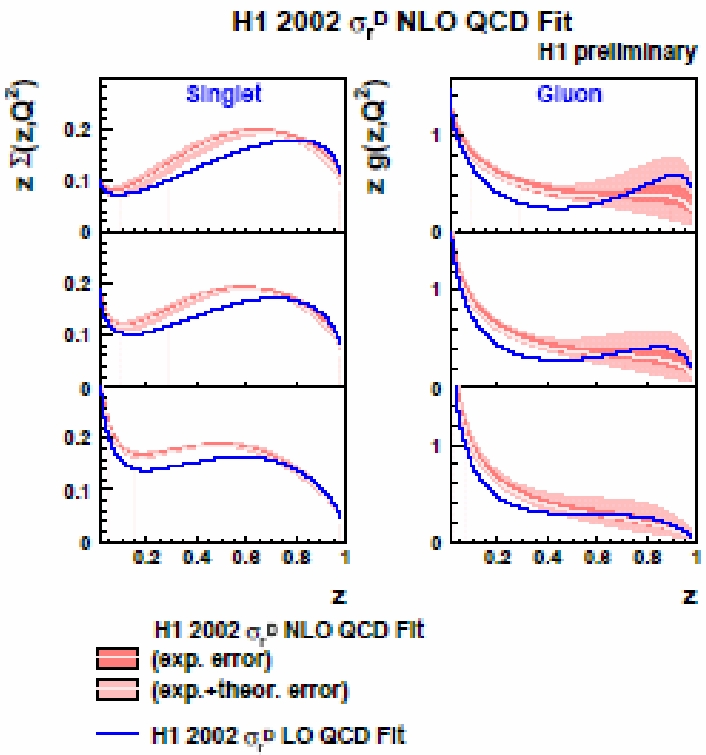
Forward jets and NLO QCD

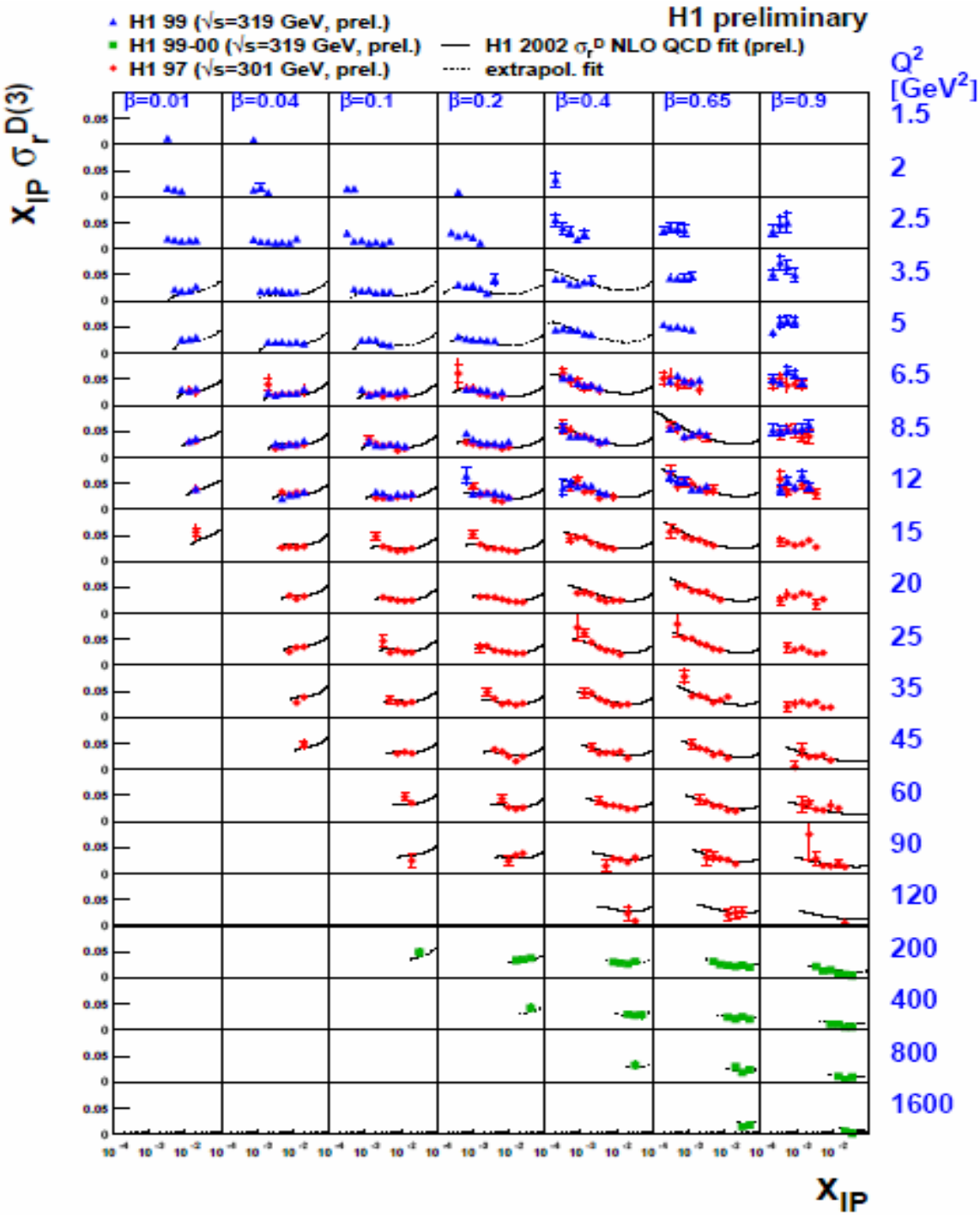
- Define $r = p_T^2/Q^2$.
- Data cover:
  - DGLAP-like region, $Q^2 > p_T^2$, $r < 1$.
  - BFKL-like region, $Q^2 \sim p_T^2$, $r \sim 1$.
  - γ^* region, $r > 1$.
- NLO QCD (Disent dijet) calculations adequate for moderate x and in DGLAP region.
- Poorer agreement at low x and in BFKL region.



The structure of diffraction

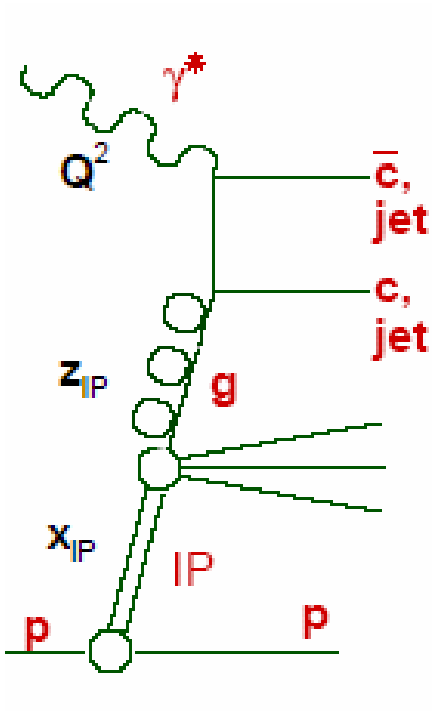
- H1 measurements cover complete kinematic range accessible at HERA I.
- NLO diffractive PDFs extracted from DGLAP fit.

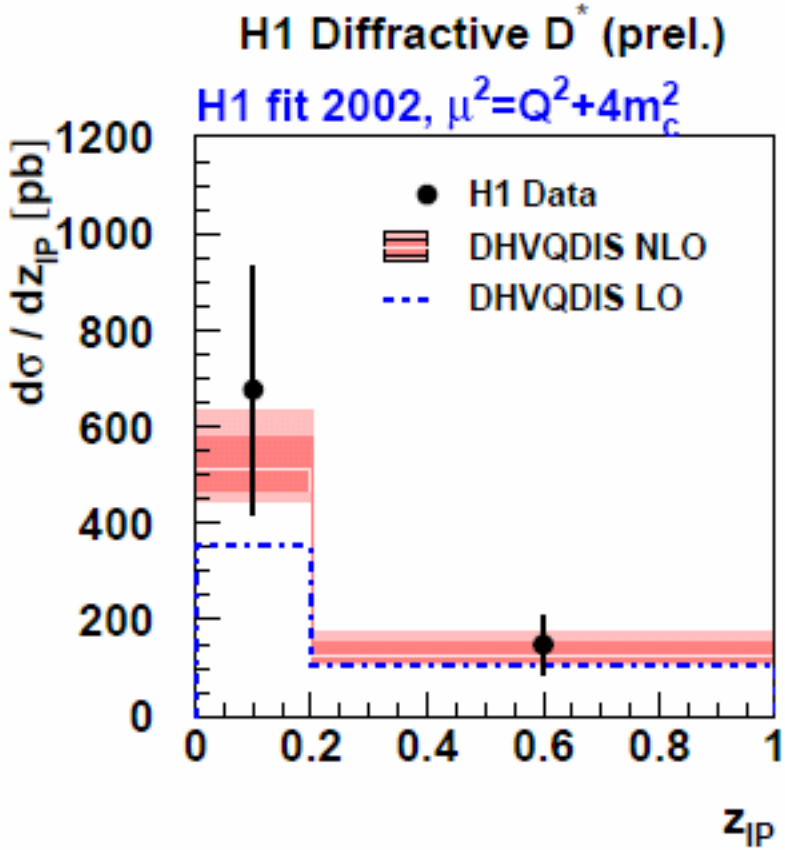




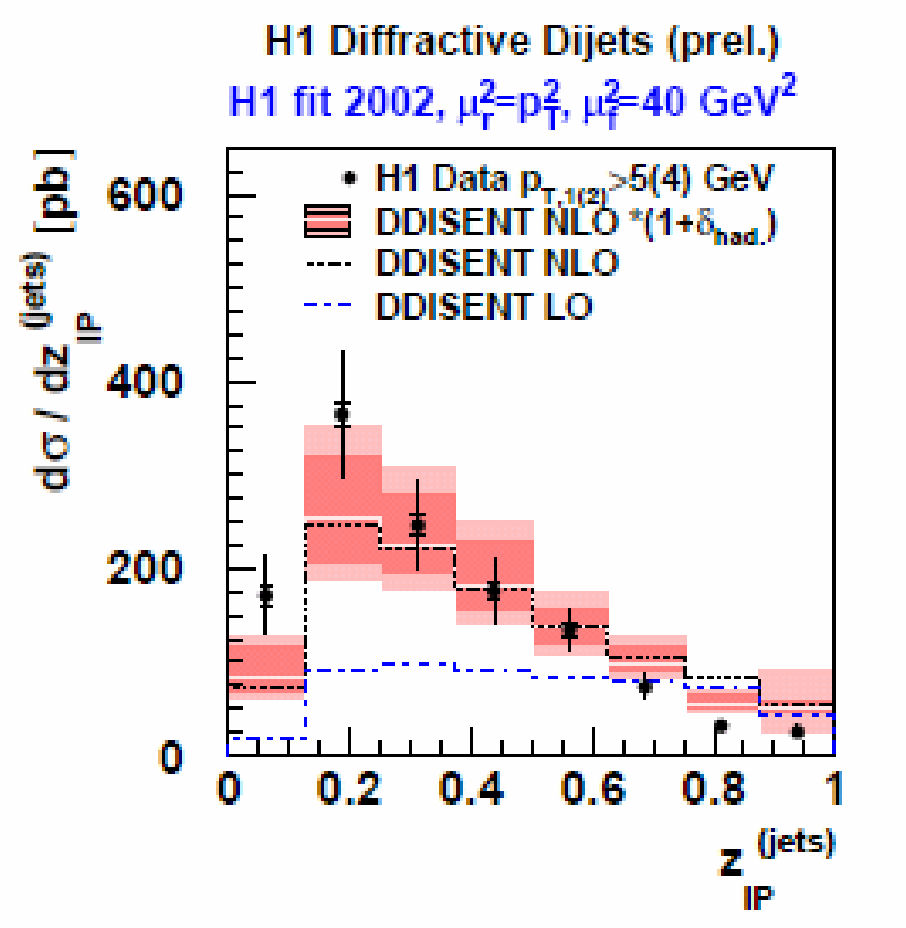
Compare diffractive final state measurements with NLO QCD predictions

- Study dijets in diffraction and the production of charm (tagged via D^*).





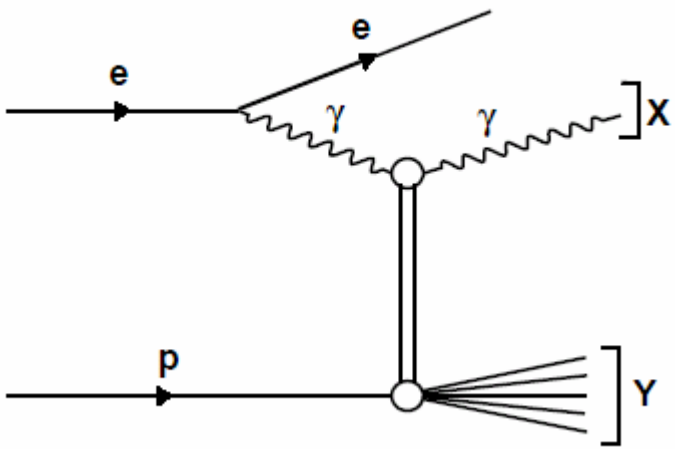
Compare diffractive final state measurements with NLO QCD predictions



- Hadronisation and scale uncertainties large as scales small.
- Data well described within these uncertainties.
- Consistent description of diffraction: factorisation works.

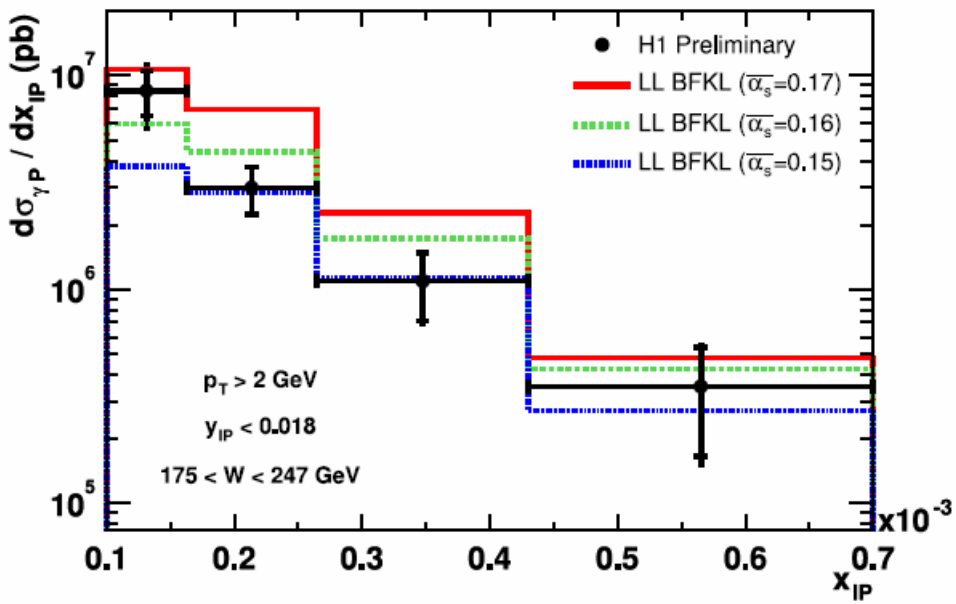
Diffractive photoproduction of high p_T photons

- First ever measurement of this particularly clean process for the study of diffractive dynamics.



- Compare with BFKL calculations in leading log approx. (Cox, Forshaw).

- Cross section as a function of $x_{\mathbb{P}}$:

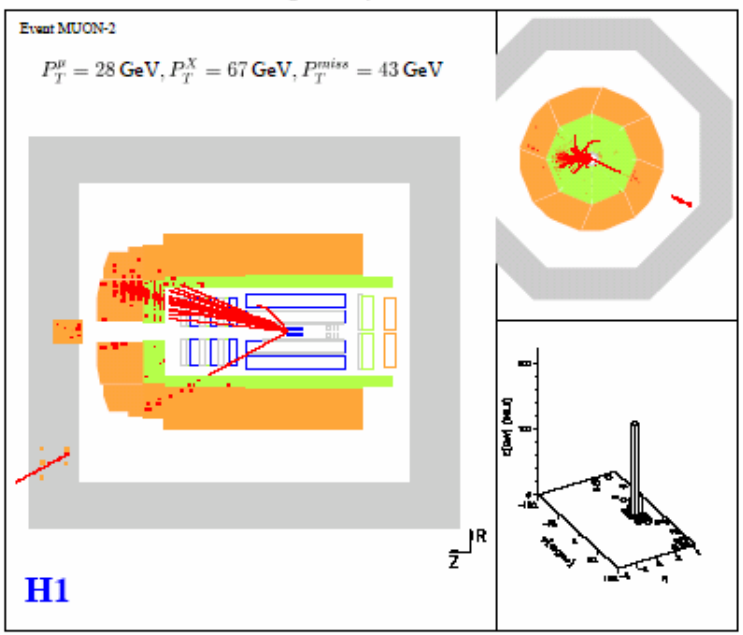


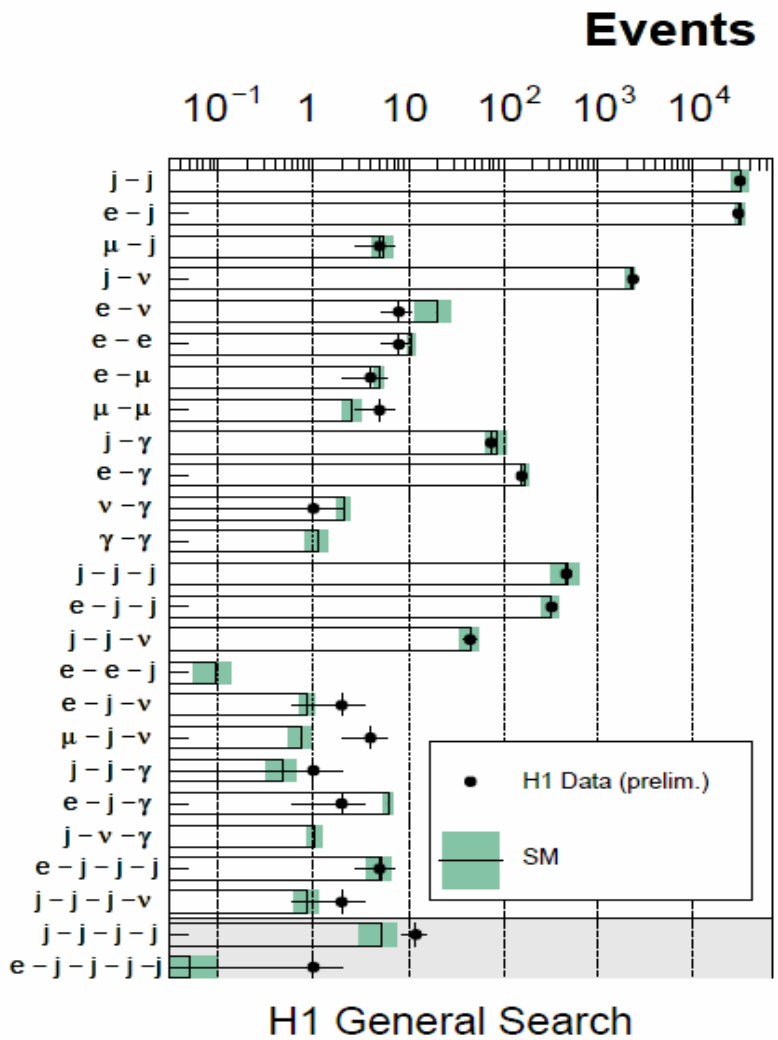
- Striking rise with energy $(1/x_{\mathbb{P}})$.
- Data consistently described with $\bar{\alpha}_s \sim 0.17$.

General search for new phenomena

- Investigate final states containing 2 or more isolated high p_T j, e, μ, γ, ν.
- Agreement with MC cocktail (LO QCD + PS) impressive.
- Most significant deviation isolated lepton events (hep-ex/0301030).

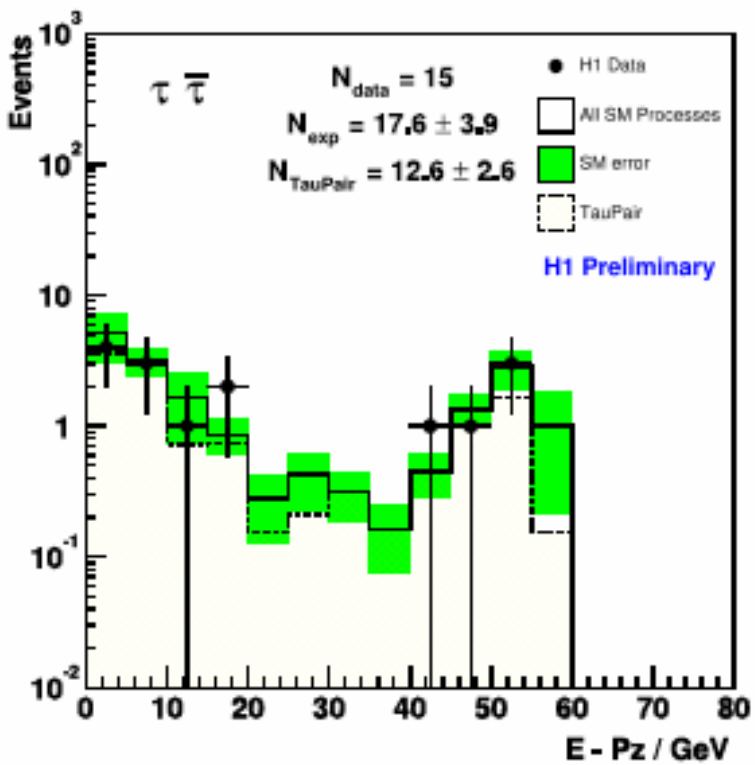
$e^+p \to \mu^+X$





Studies of τ leptons

- Extend studies of isolated lepton events.
- Algorithms for τ identification developed, $ep \rightarrow e\tau\bar{\tau}p$ events found.



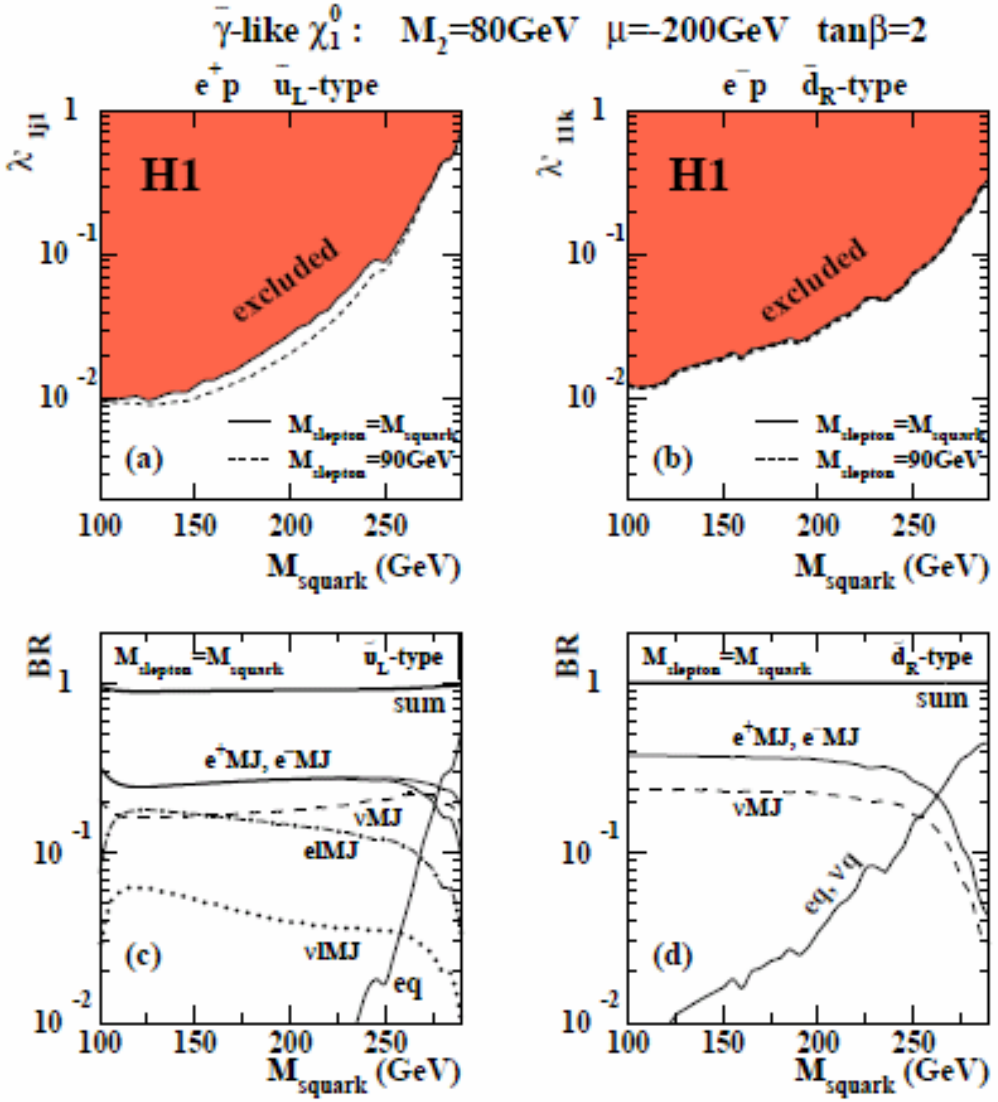
- Study isolated τ events.
- Look for hadronic decay modes, narrow "1 prong" jet $\tau \rightarrow \pi^{\pm}\nu, \rho^{\pm}\nu...$

- Results for $\mathcal{L} = 108\ pb^{-1}$:

	H1 Prel/SM
p_T^X above:	τ events
0 GeV	5/5.81
25 GeV	0/0.53
40 GeV	0/0.22

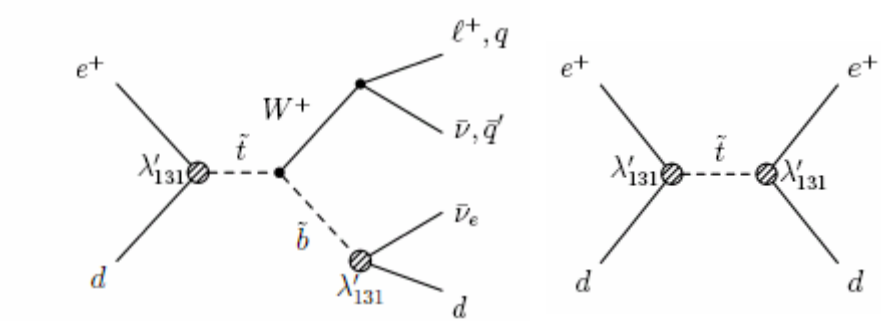
Search for R-parity violating SUSY

- Comprehensive search for event topologies associated with $\not{R}_P$ SUSY now published (hep-ex/0403027)
- Limits set on $\not{R}_P$ couplings and squark masses.
- Nearly all possible decay channels studied.
- Now augmented by search for bosonic stop decays.



Search for bosonic stop decays

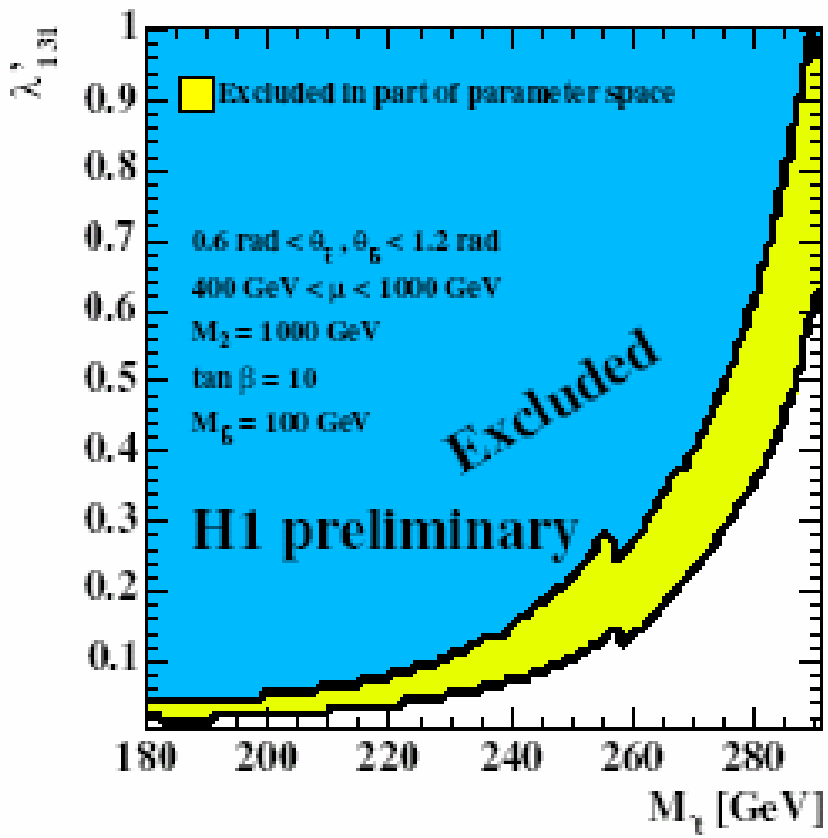
- Possible explanation for isolated lepton events:



- Search using all available e^+p data:

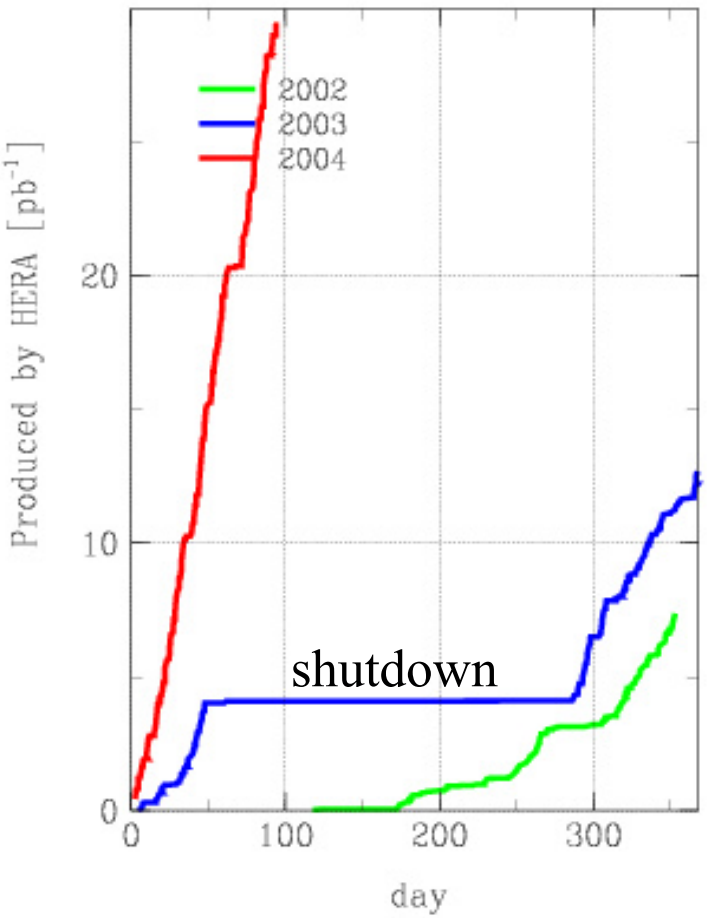
H1 preliminary		
Channel	all	
	data	SM expectation
$je\not{P}_\perp$	3	3.84 ± 0.92 (W: 1.55 ± 0.25)
$j\mu\not{P}_\perp$	8	2.69 ± 0.47 (W: 1.93 ± 0.31)
$jj\not{P}_\perp$	5	6.24 ± 1.74
ed	1100	1119.7 ± 131.3

- Derive limits on $\not{R}_P$ coupling λ_{131}' : and stop mass:



Current HERA running

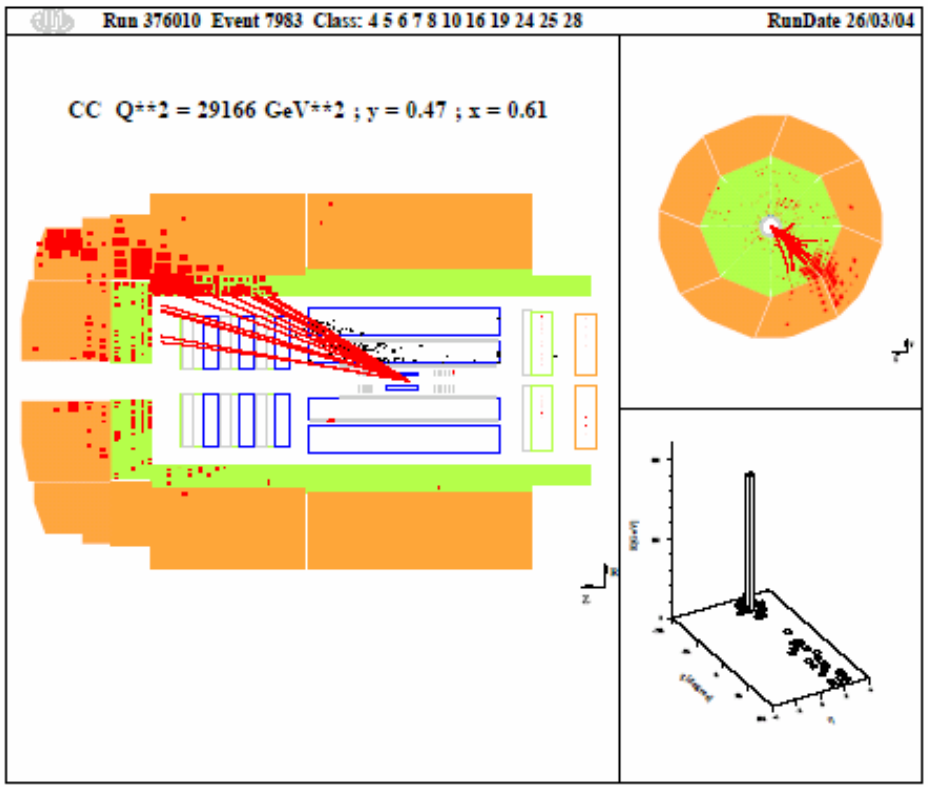
- $\mathcal{L}$ delivered by HERA:



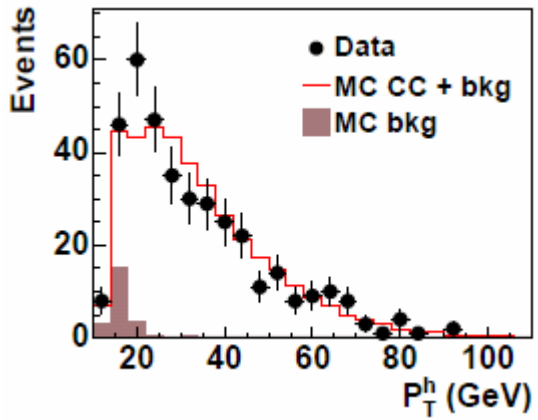
- Proton current typically 90% of design value of 100 mA.
- Electron currents up to 80% of design (50 mA) and increasing.
- Polarisation 30...40%.
- Specific luminosity two to three times HERA I value.
- Backgrounds tolerable.

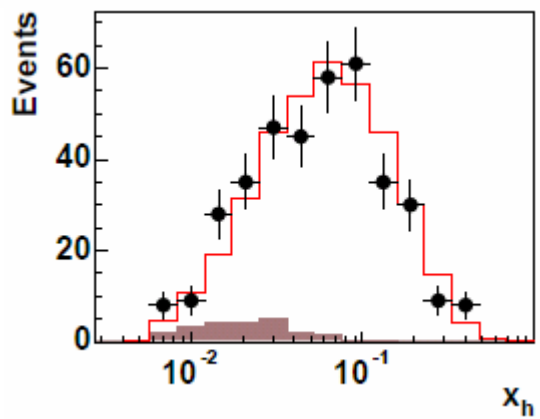
CC cross section as a function of polarisation

- Highest Q^2 H1 HERA II CC event recorded at end of March 2004.

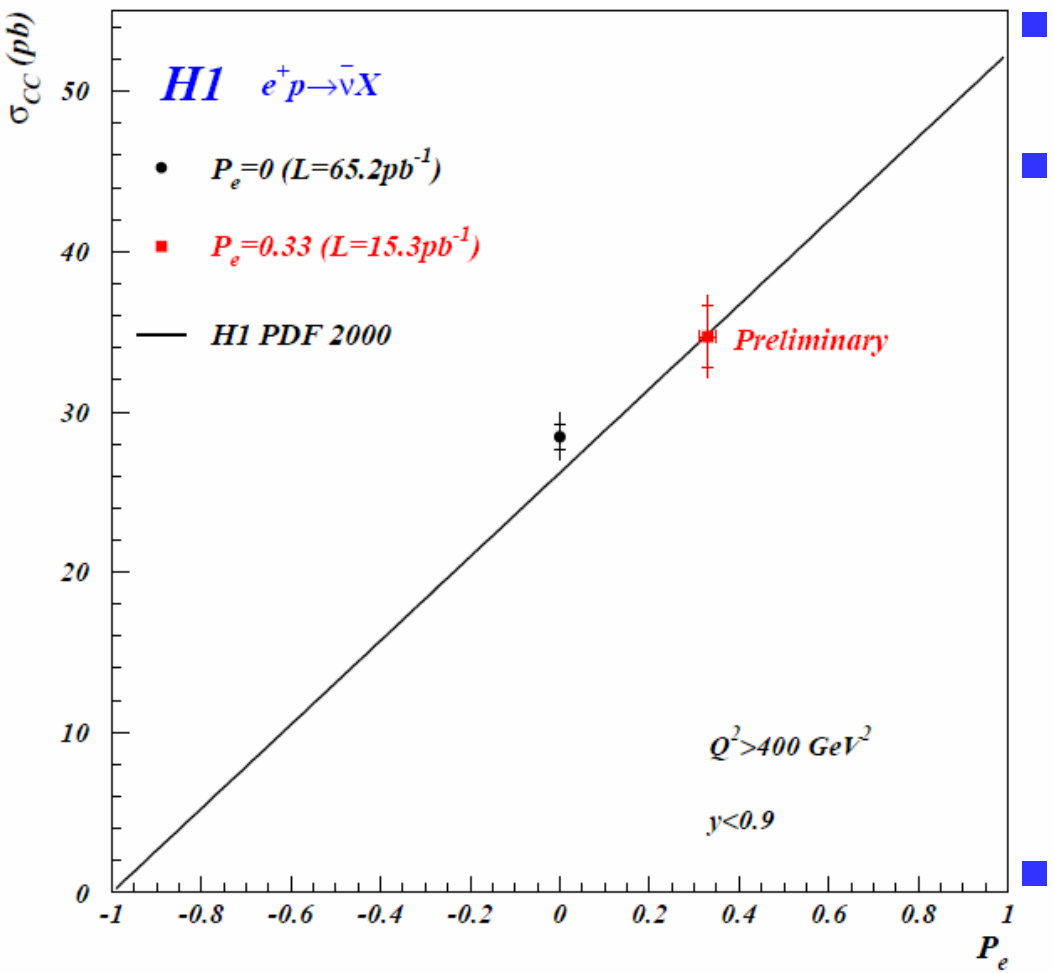


- Many upgrades made to detector.
- MC simulation modified and provides good description of data:

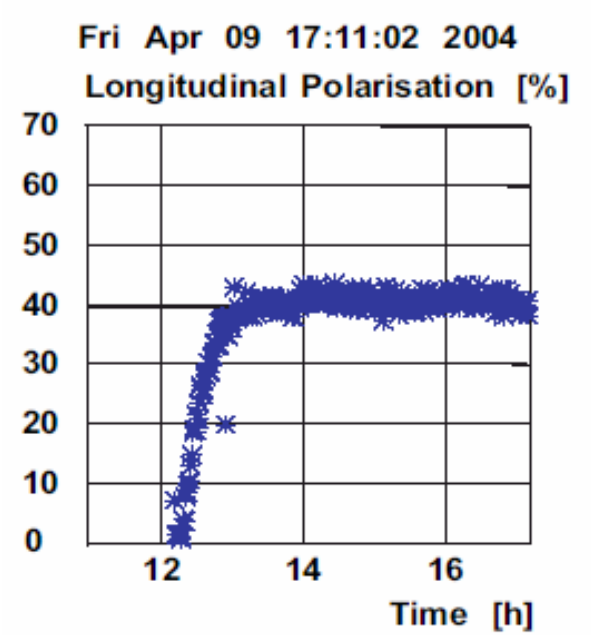




CC cross section as a function of polarisation

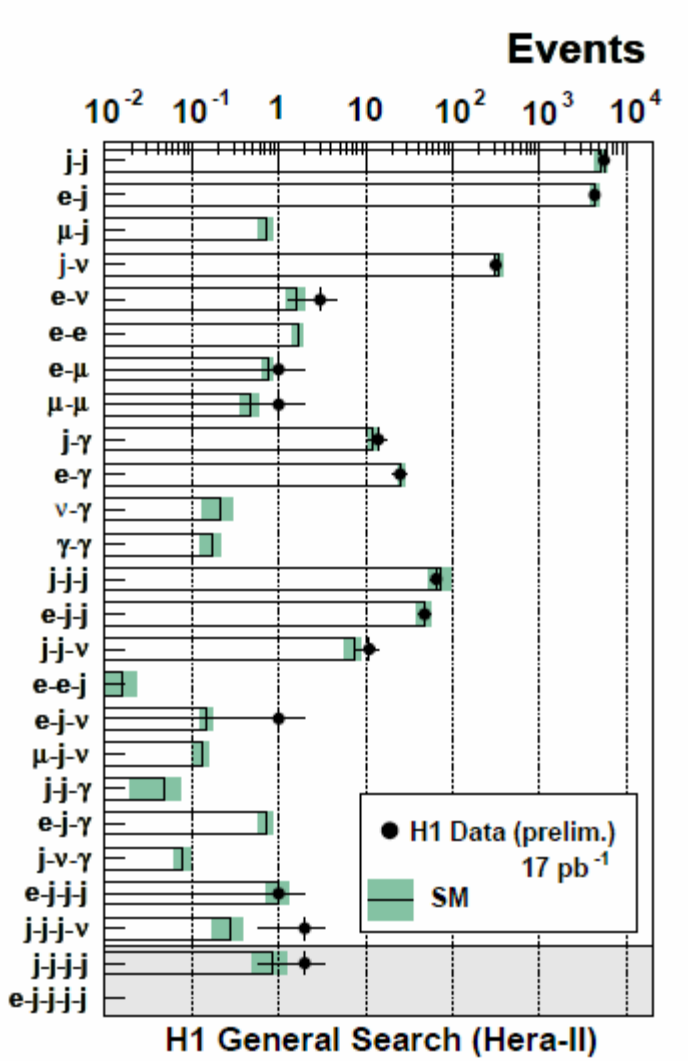


- Expected polarisation dependence confirmed with limited precision.
- Polarisation flipped early April.



- Eagerly await $\mathcal{L}$ with e^+_L.

General searches for new physics at HERA II

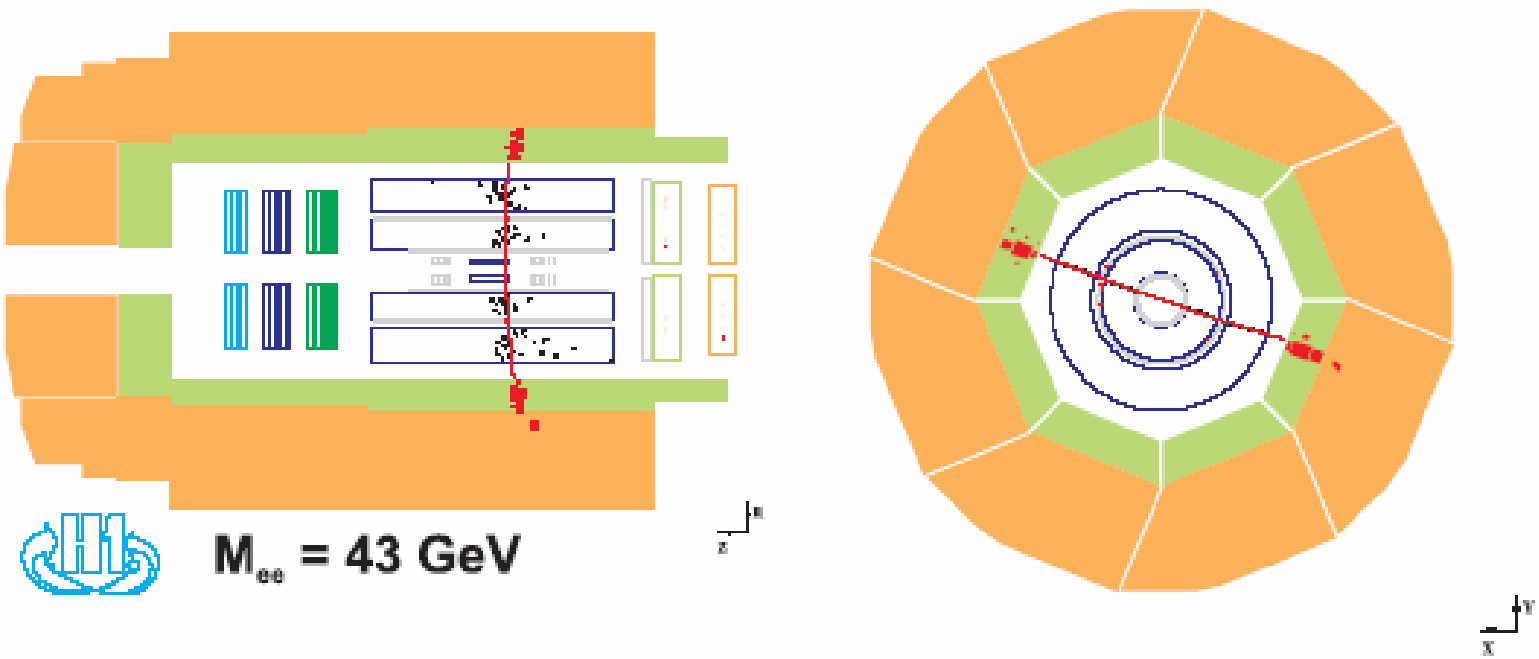


- Data well described by Monte Carlo cocktail.
- Study in detail anomalies seen in HERA I data:
  - Multi-electron events at high mass (hep-ex/0307015).
  - Isolated leptons.

Multi-electron events at HERA II

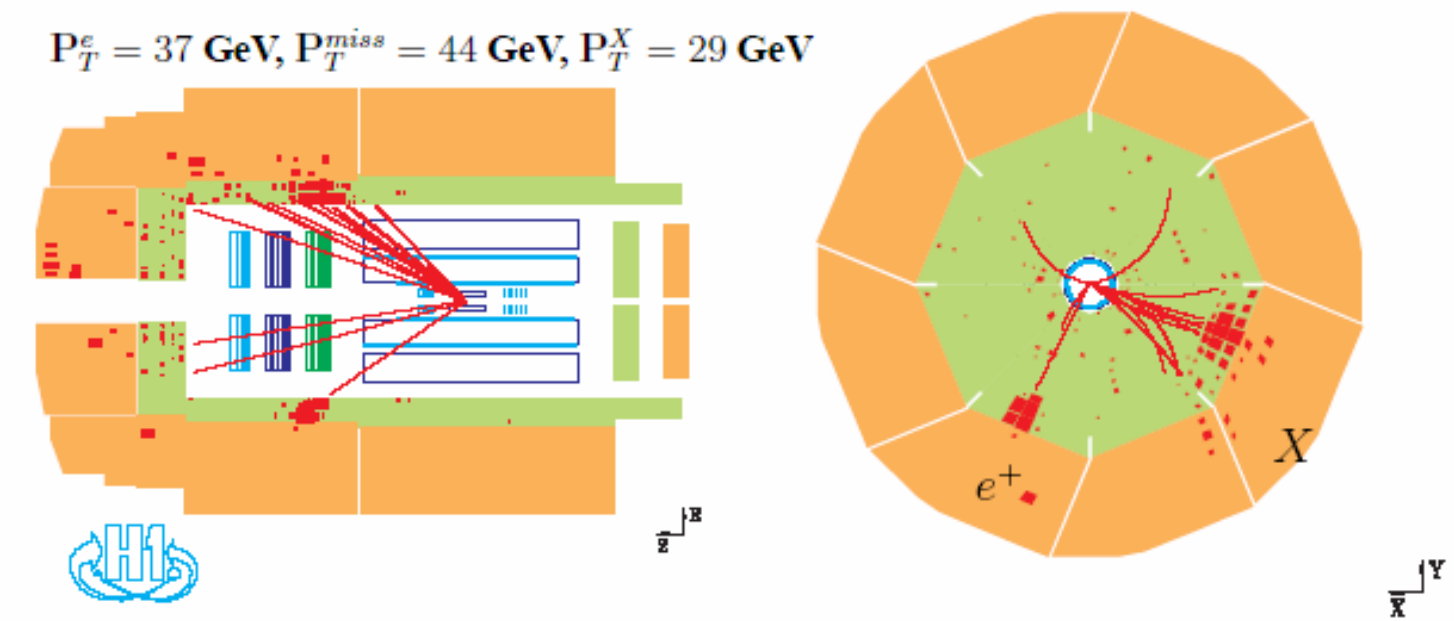
- H1 HERA II data, $\mathcal{L} = 17\ pb^{-1}$, contain multi-electron events:
- Rate compatible with SM.
- No events at high mass.

Selection	Data	SM	Pair Production (GRAPE)	DIS + Compton
"2e"	10	15.8 ± 1.7	13.5 ± 1.4	2.3 ± 0.5
"3e"	2	3 ± 0.4	3 ± 0.4	0



Isolated lepton events at HERA II

- Data contain isolated lepton events.
- Rate for isol. electrons above SM expectation for large p_T^X.



(Prel.) data/ SM	HERA I e (118 pb^{-1})	HERA I μ (118 pb^{-1})	HERA I τ (108 pb^{-1})	HERA II e (17 pb^{-1})	HERA II μ (17 pb^{-1})
Full sample	11/11.54	8/2.94	5/5.81	3/1.61	0/0.44
$p_T^X > 25$ GeV	5/1.76	6/1.68	0/0.53	2/0.34	0/0.29

Summary

- Analysis of HERA I data nearing completion.
- First fascinating glimpses of physics at HERA II emerging.
- Luminosity of 1 fb^{-1} is essential to clarify anomalies observed by H1 during HERA I running and to make EW measurements.
- This data will also allow detailed studies of exotic baryons and other states – a new branch of HERA physics.
- Low proton energy running required for precise measurement of partons at high x and F_L.
- Physics programme requires HERA operation beyond 2007.
- There is continued interest in HERA III electron-deuteron programme with H1 and further exploitation of HERA.

Summary of H1 results presented at DIS04

- Measurement of F_2 at low Q^2 and extension to the lowest Q^2 using ISR events (Alexey Petrukhin)
- Measurement of F_2 at low Q^2 in QED Compton scattering at HERA (Ewelina Lobodzinska)
- H1 QCD analysis of inclusive cross-section data (Benjamin Portheault)
- Deeply virtual Compton scattering (Laurent Favart)
- High $|t|$ photon production and J/ψ production at high $|t|$ (Jan Olsson)
- F_2^D measurements at low, intermediate and high Q^2 (Mikhail Kapushin)
- Status of the Very Forward Proton Spectrometer (Xavier Janssen)
- Comparison of diffractive final states with LO and NLO QCD predictions (Sebastian Schaetzel)
- Inclusive dijet production at low Bjorken-x in DIS (Roman Poeschl)
- Measurement of dijet production at low Q^2 at HERA (Kamil Sedlak)
- Studies of forward jet production in DIS (Albert Knutsson)
- Forward π^0 production in DIS (Lidia Goerlich)
- Event shapes in DIS (Wenbiao Yan)
- The photoproduction of anti-deuterons at HERA (Terry Sloan)
- Beauty in DIS and γp (Andreas Meyer)
- Charm and beauty measurements at high Q^2 using the H1 vertex detector (Paul Thompson)
- Anti-charmed baryon production in ep collisions (Sebastian Schmidt)
- General search for new phenomena (Matti Peez)
- Searches for squarks with H1 at HERA (Anja Vest)
- Search for superlight gravitinos at HERA (Nick Malden)
- H1 events with high p_T leptons and missing p_T and anomalous top production at HERA (David South)
- H1 events with several high p_T leptons (Emmanuel Sauvan)
- First inclusive measurements with polarised positron beams at HERA (Oliver Henshaw)
- Isolated τ events with missing p_T at HERA (Gerhard Brandt)