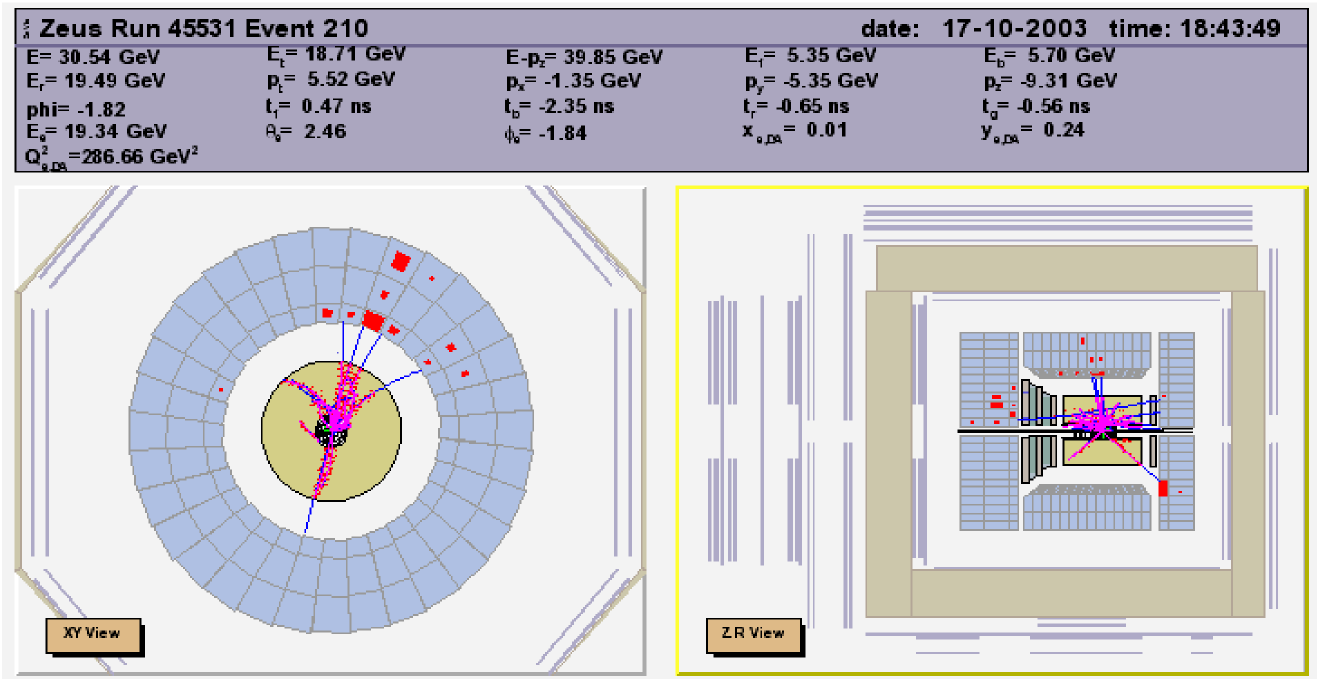
# Recent results and progress from ZEUS

Matthew Wing (Bristol University)

- Look at the latest data
- Detector and running conditions
- Recent physics highlights
- Summary and outlook



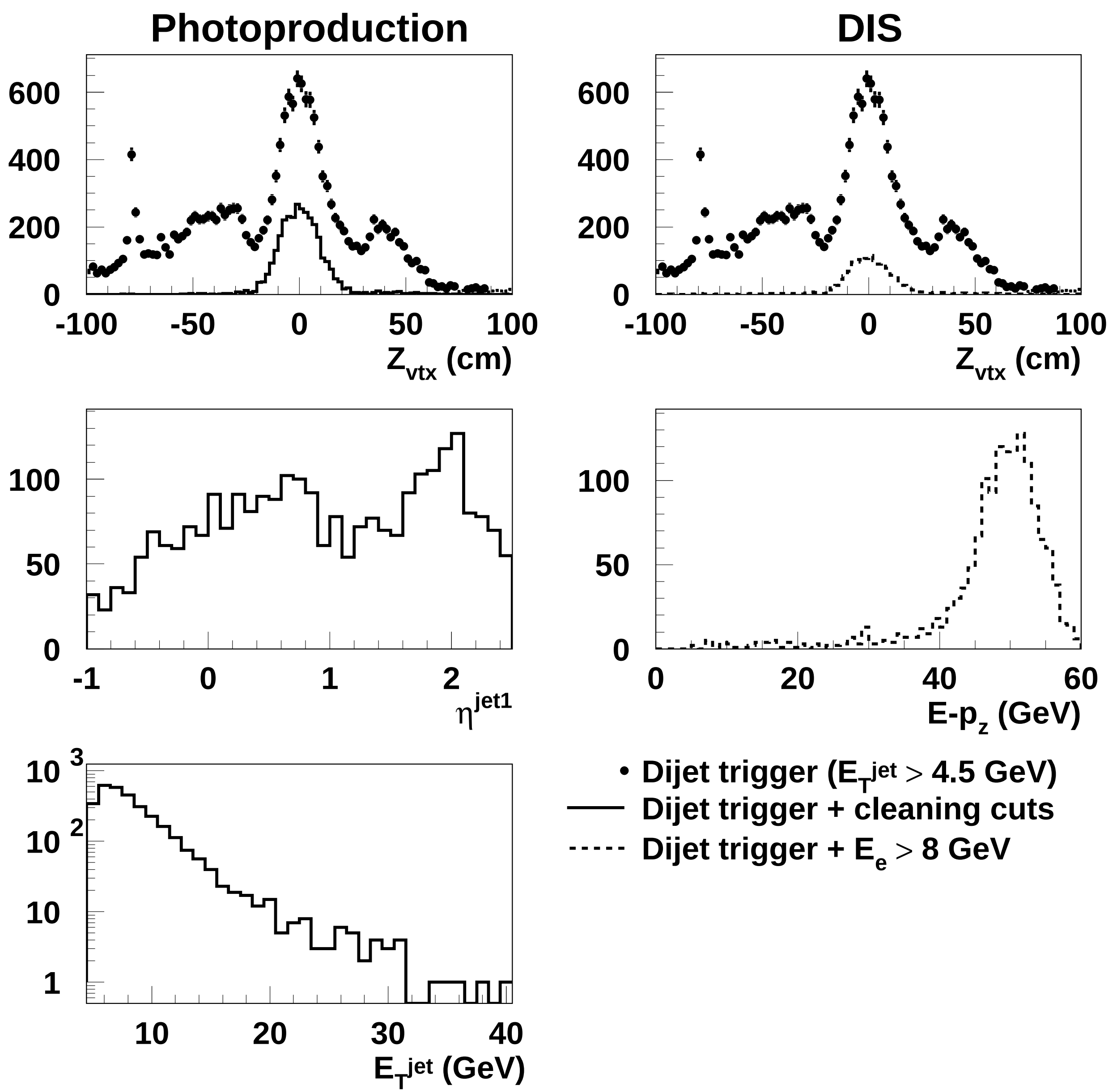
# Look at last week's data

Have $\sim$ 0.5 $\mathrm{pb}^{-1}$ of data since the shutdown

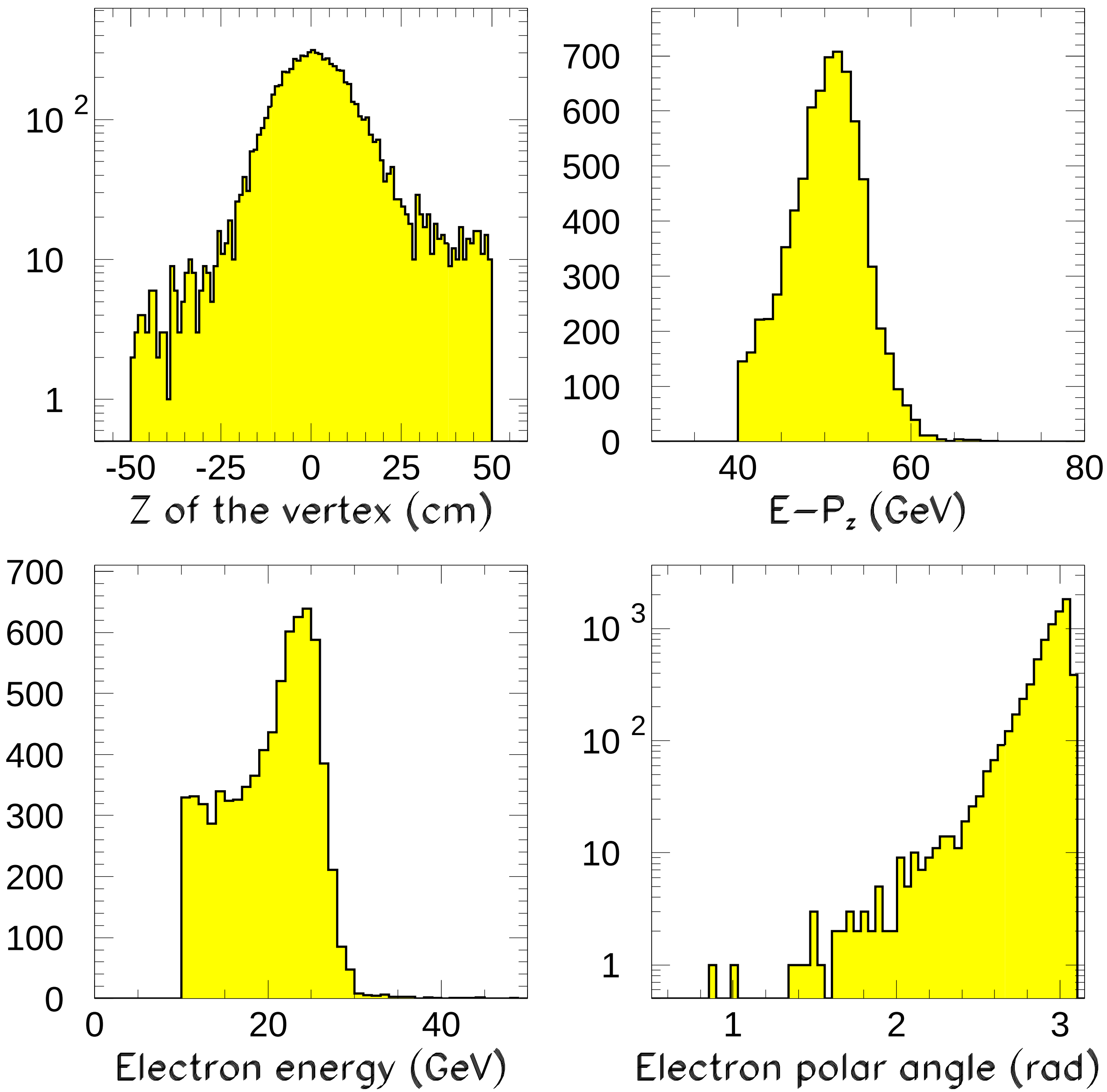
**Photoproduction:**

- **Simple cleaning cuts**
- **Increased $E_T^{\mathrm{jet}}$**

**Clear physics events seen**

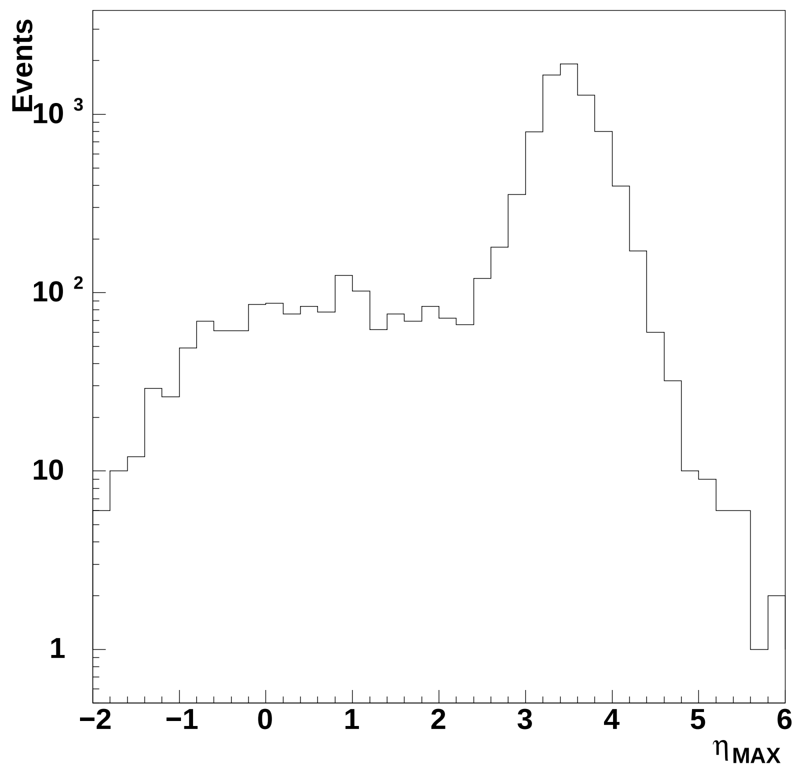


# More new data



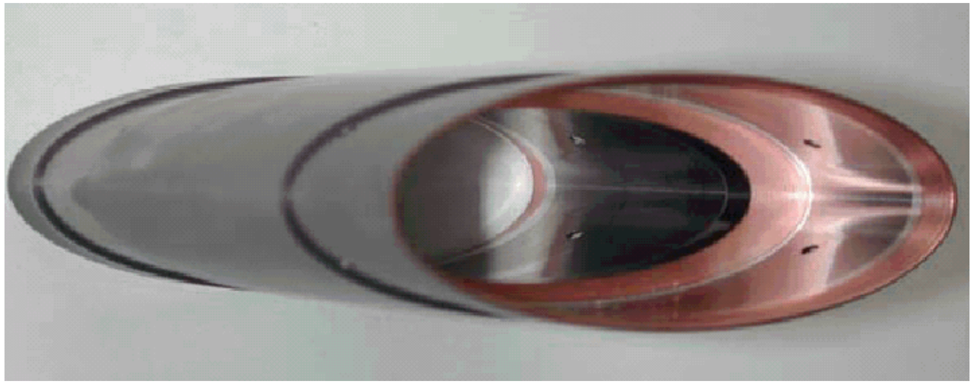

**Reasonably clean DIS events**

**With diffractive events there**



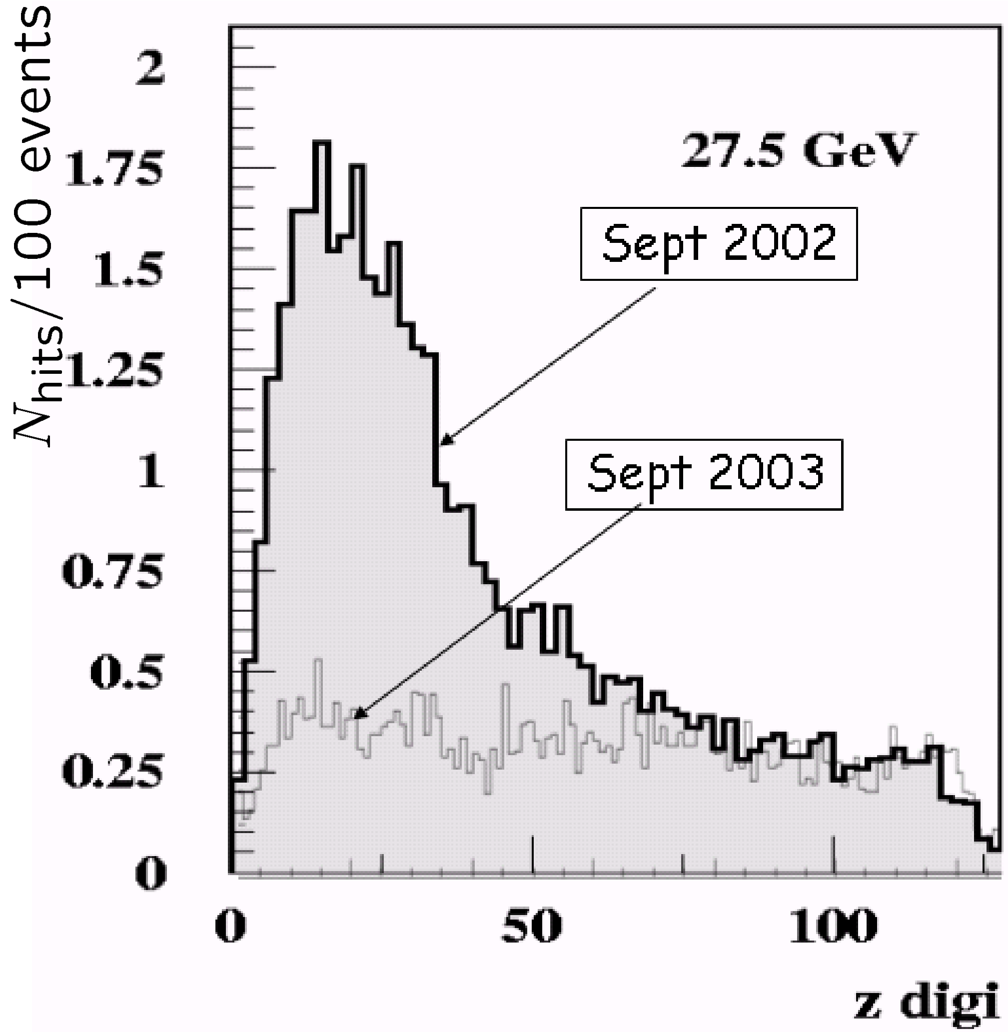
# Background reduction

Redesign of C5a collimator during shutdown



Synchrotron radiation drastically reduced

(Not) seen in central tracker



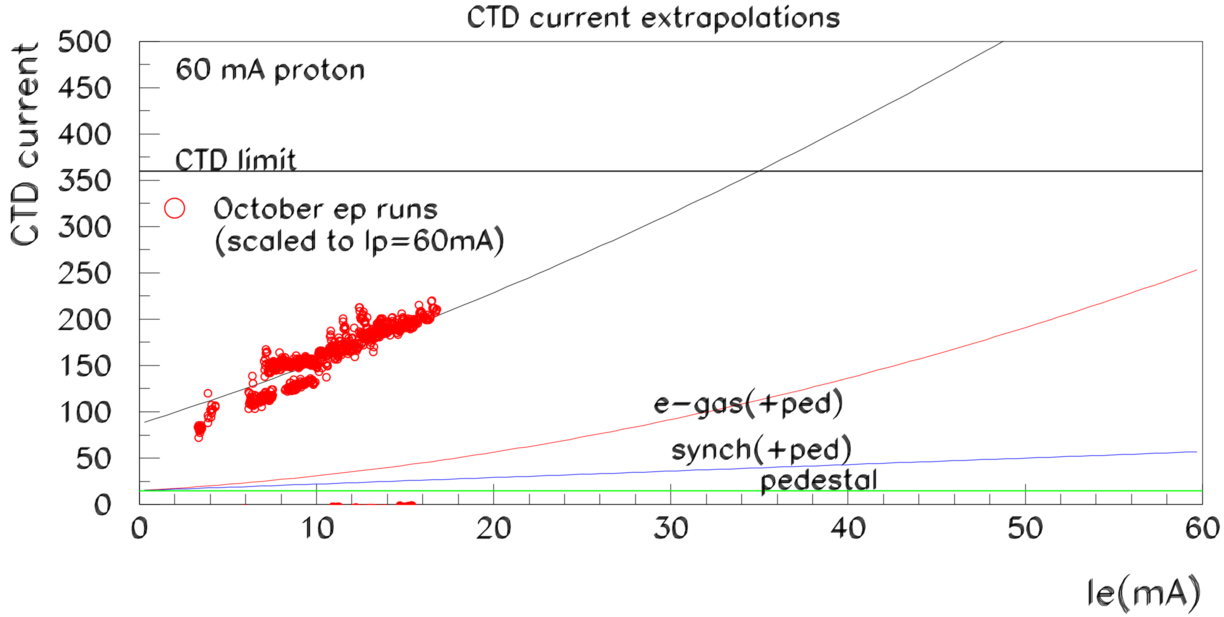
# Running conditions

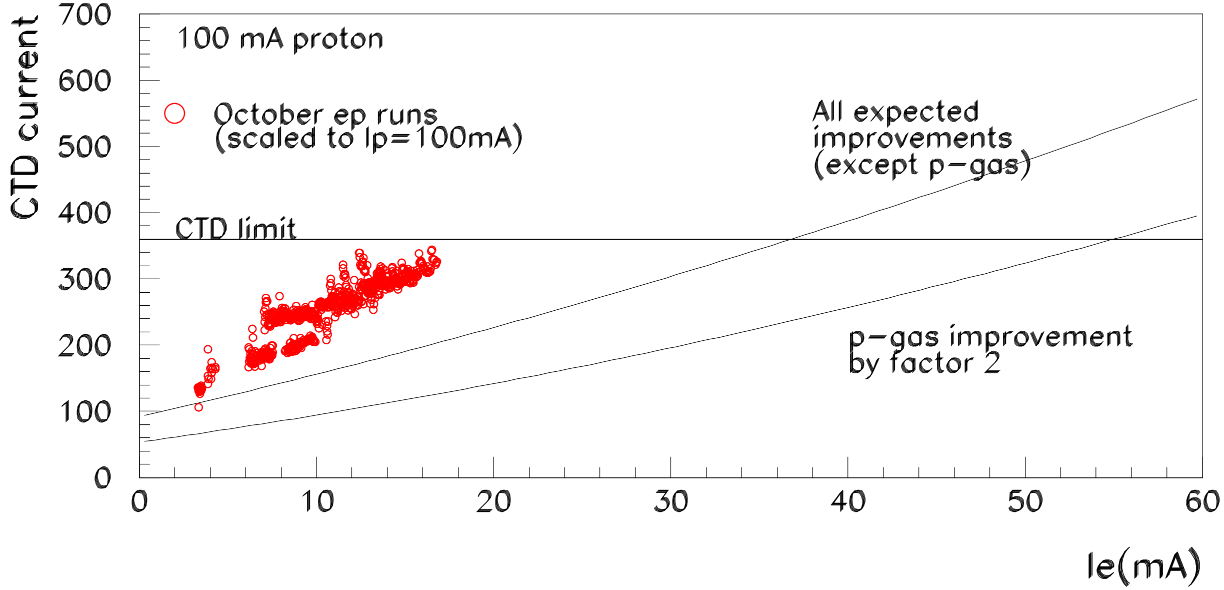
Need to run below safe CTD current limit

Can run up to highest expected currents for this year

Improvement in background to pre-shutdown level $\Rightarrow$ can run at $100 \times 35$ mA

Improved pumping and gradual cleaning of the beam will allow us to run at the maximum currents

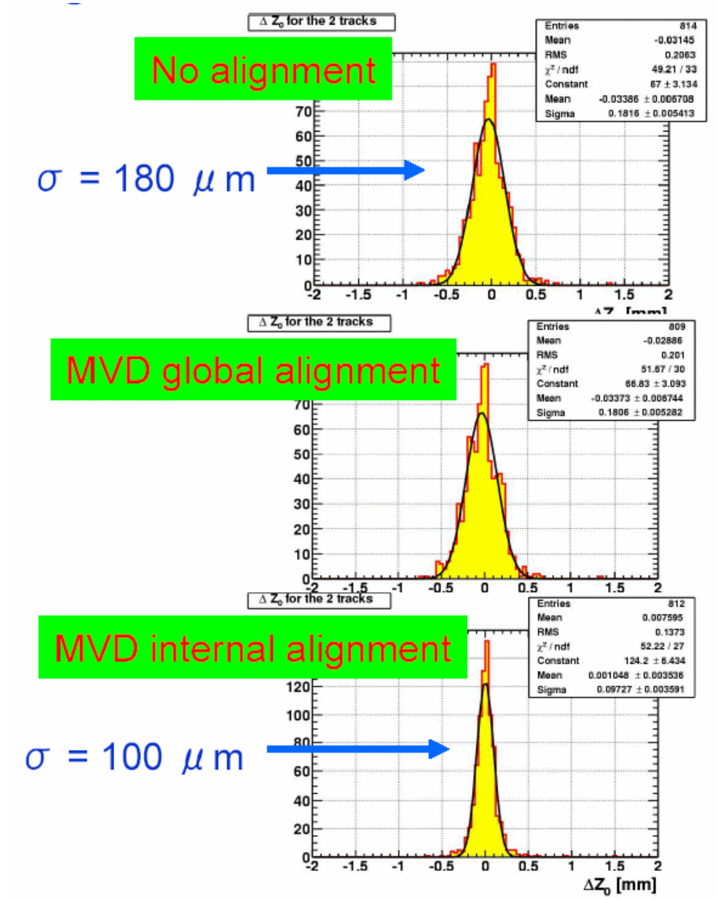


# State of the detector

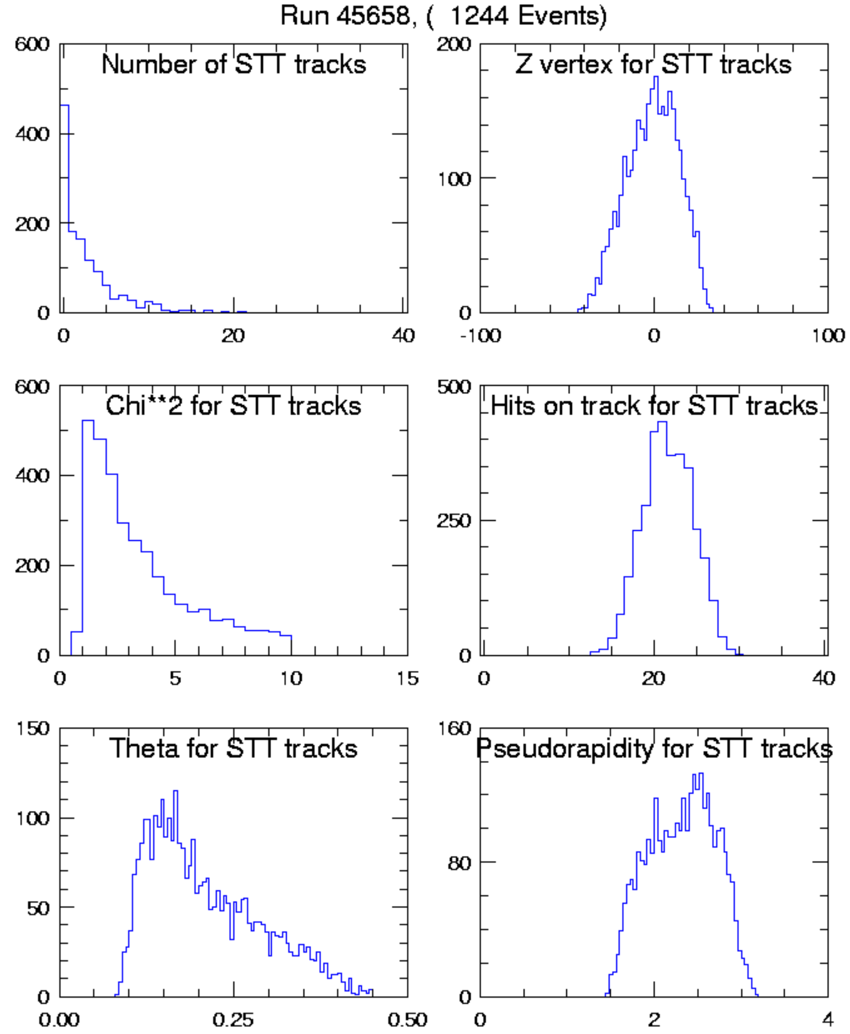
**MicroVertex Detector:**

- **Rate of radiation damage currently within limits**
- **No. bad channels $< 2\%$**
- **MVD being aligned**




**Straw Tube Tracker:**

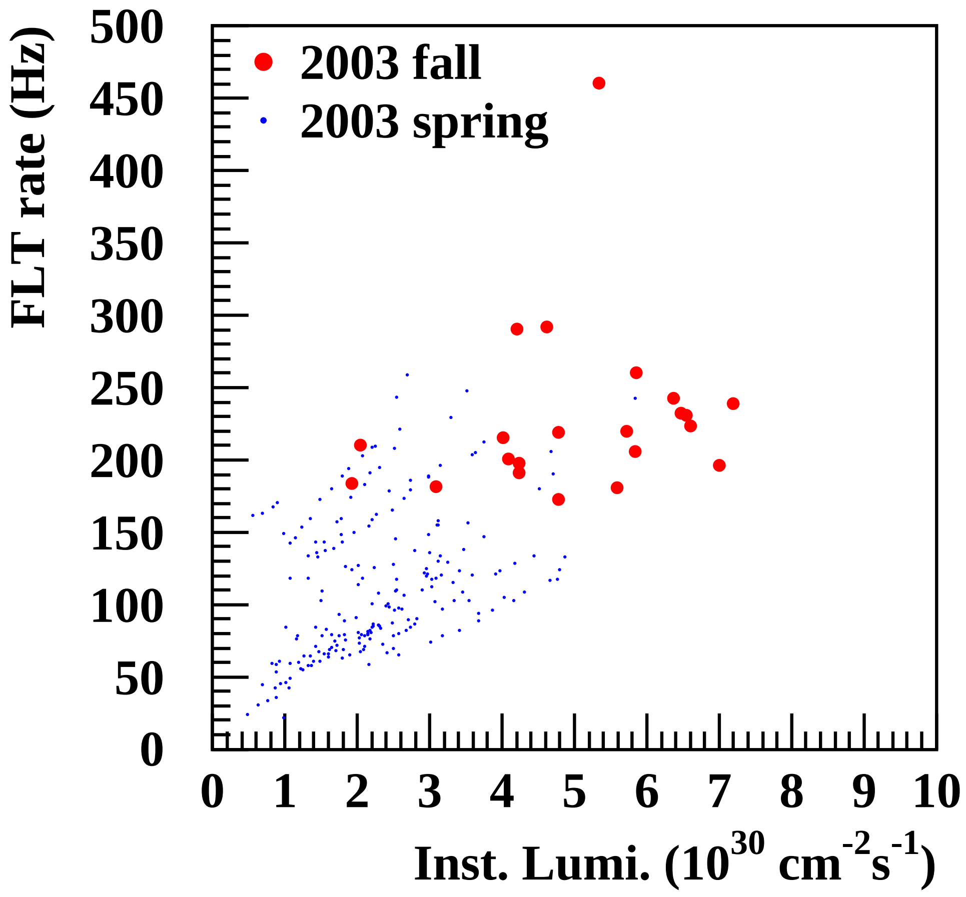
- **repairs have been successful**
- **first data coming in**

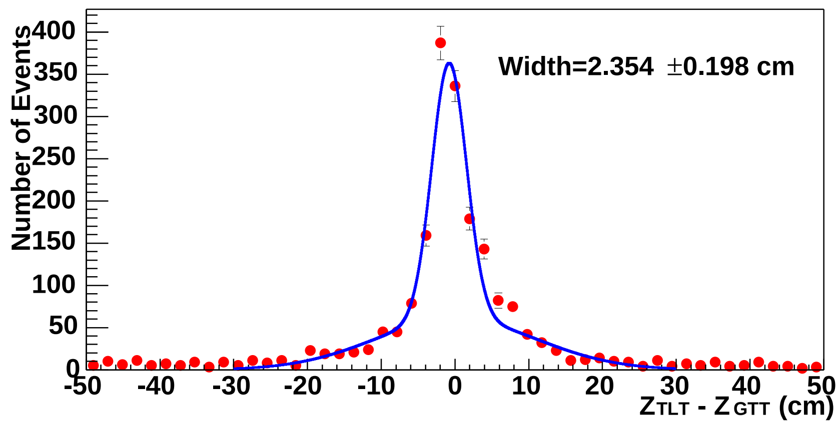


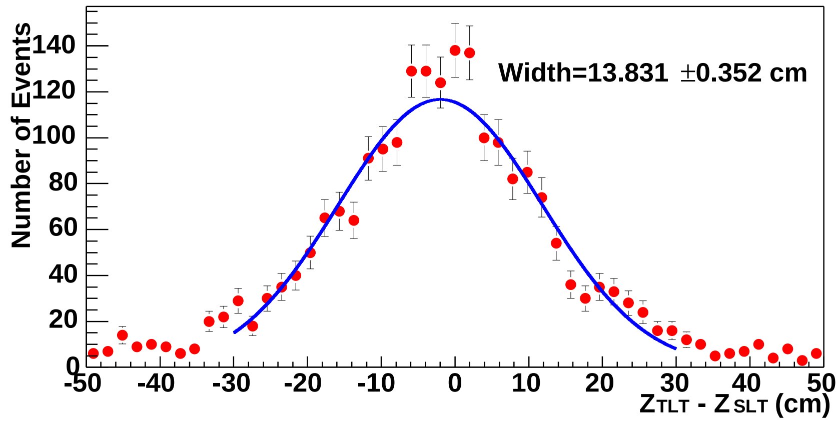
# Triggering

FLT rate about 200 Hz

SLT and TLT rates also okay




Global Tracking Trigger (GTT) will give improved triggering

Comparison with previous SLT (NB. real data, online algorithm, no MVD so far)

Resolution improved by factor $\sim$ 6

# Physics results

**Have produced 6.25 papers since the last PRC:**

- **Measurement of high$-Q^2$ charged current cross sections in $e^+p$ deep inelastic scattering at HERA**
- **Measurement of $D^{*\pm}$ production in deep inelastic $e^\pm p$ scattering at HERA**
- **Measurement of the open-charm contribution to the diffractive proton structure function**
- **Bose-Einstein correlations in one and two dimensions in deep inelastic scattering**
- **Observation of $K_s^0 K_s^0$ resonances in deep inelastic scattering at HERA**
- **Isolated tau leptons in events with large missing transverse momentum at HERA**
- *Addendum:* **Search for single-top production in $ep$ collisions at HERA**

# Charged current reactions in e+p DIS

**CC reactions provide flavour-specific probes of the PDFs**

$$\tilde{\sigma}(e^+p \to \bar{\nu}_e X) = x\left[\bar{u} + \bar{c} + (1-y)^2 (d+s)\right]$$

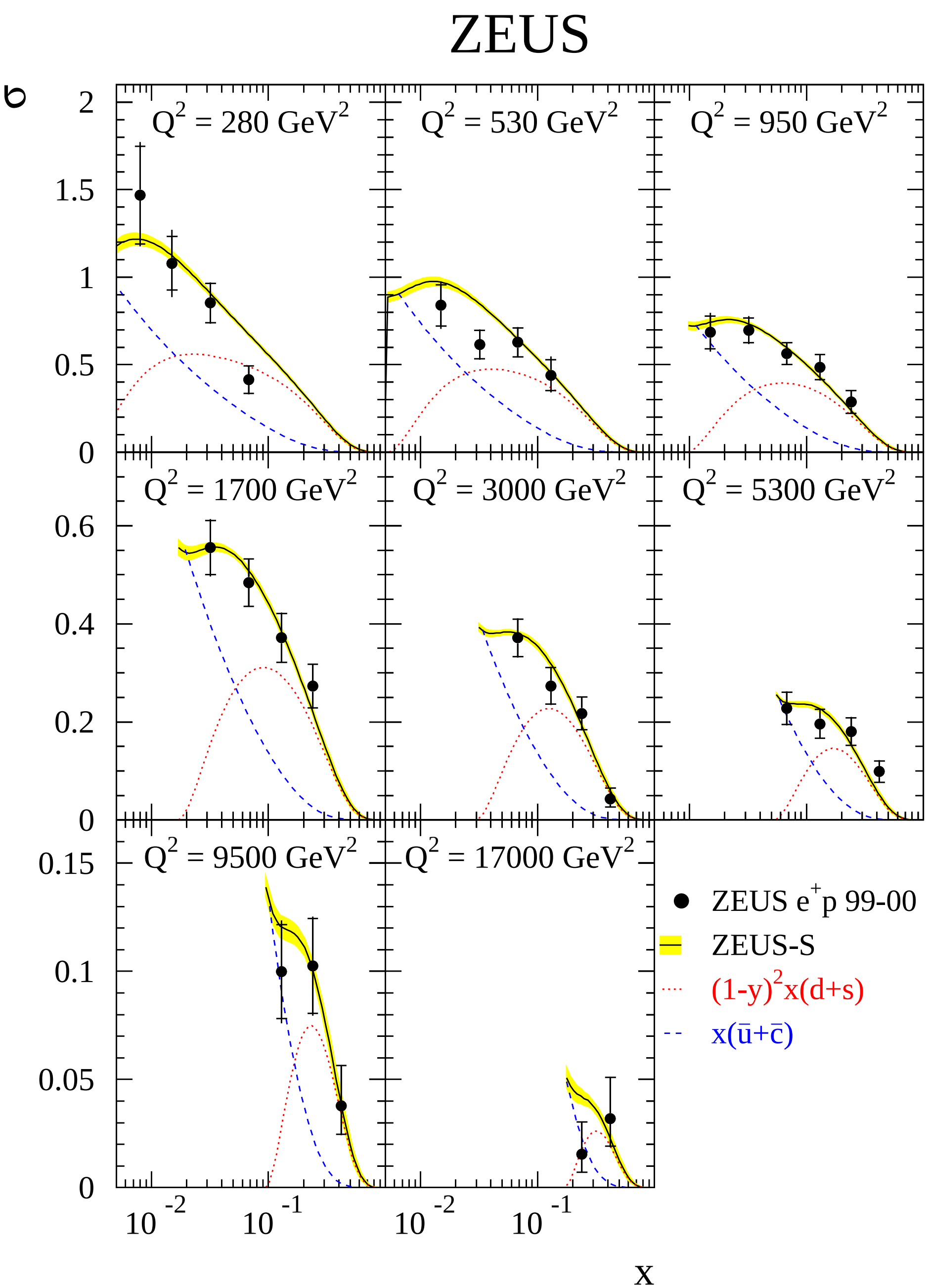
**Excellent description of the data by the Standard Model**

**Fixing $C_F$ and using:**

$$d\sigma/dQ^2 \propto M_W^4/(Q^2+M_W^2)^2$$

$\Rightarrow M_W$ **= 78.9 $\pm$2.0 (stat.) $\pm$ 1.8 (syst.) $^{+2.0}_{-1.8}$(PDF) GeV**

**In agreement with the more precise measurements in time-like region**



# Charge current structure function

**Combine with $e^-p$ data for structure function**

$$F^{CC}_{2,e^+p} = x[d(x,Q^2)+s(x,Q^2) + \bar{u}(x,Q^2)+\bar{c}(x,Q^2)]$$

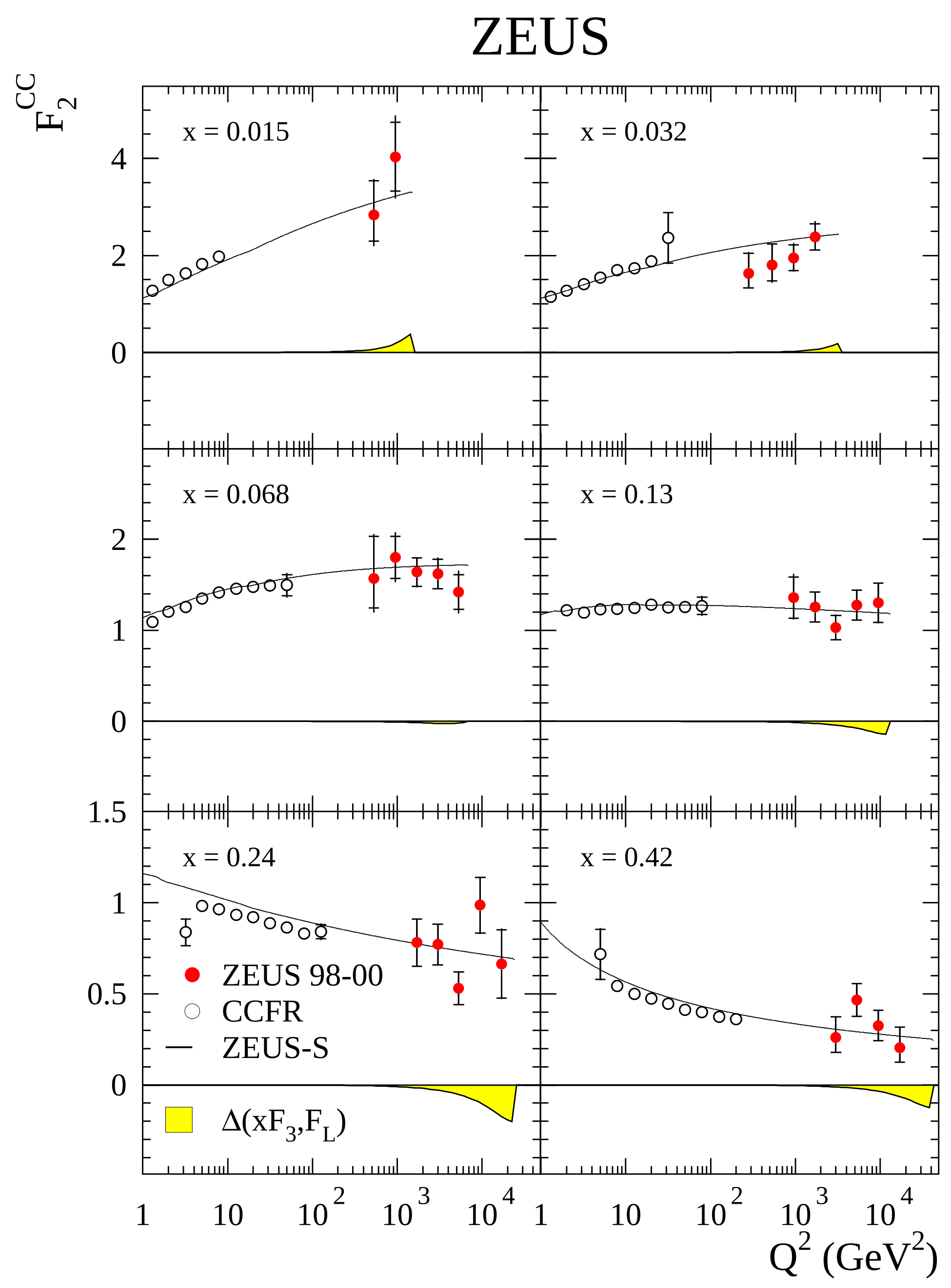
$$F^{CC}_{2,e^-p} = x[u(x,Q^2)+c(x,Q^2) + \bar{d}(x,Q^2)+\bar{s}(x,Q^2)]$$

$$F^{CC}_{2} = \tilde{\sigma}^{CC}_{\text{Born}}(e^+p)+\tilde{\sigma}^{CC}_{\text{Born}}(e^-p) + \Delta(xF_3,F_L)$$

**Reasonable agreement of NLO fit with data**

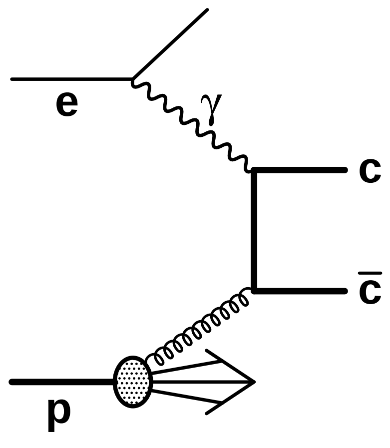
**Large potential for new data**

**Final inclusive measurement ($e^+p$ NC) to come soon**



# D* production in DIS

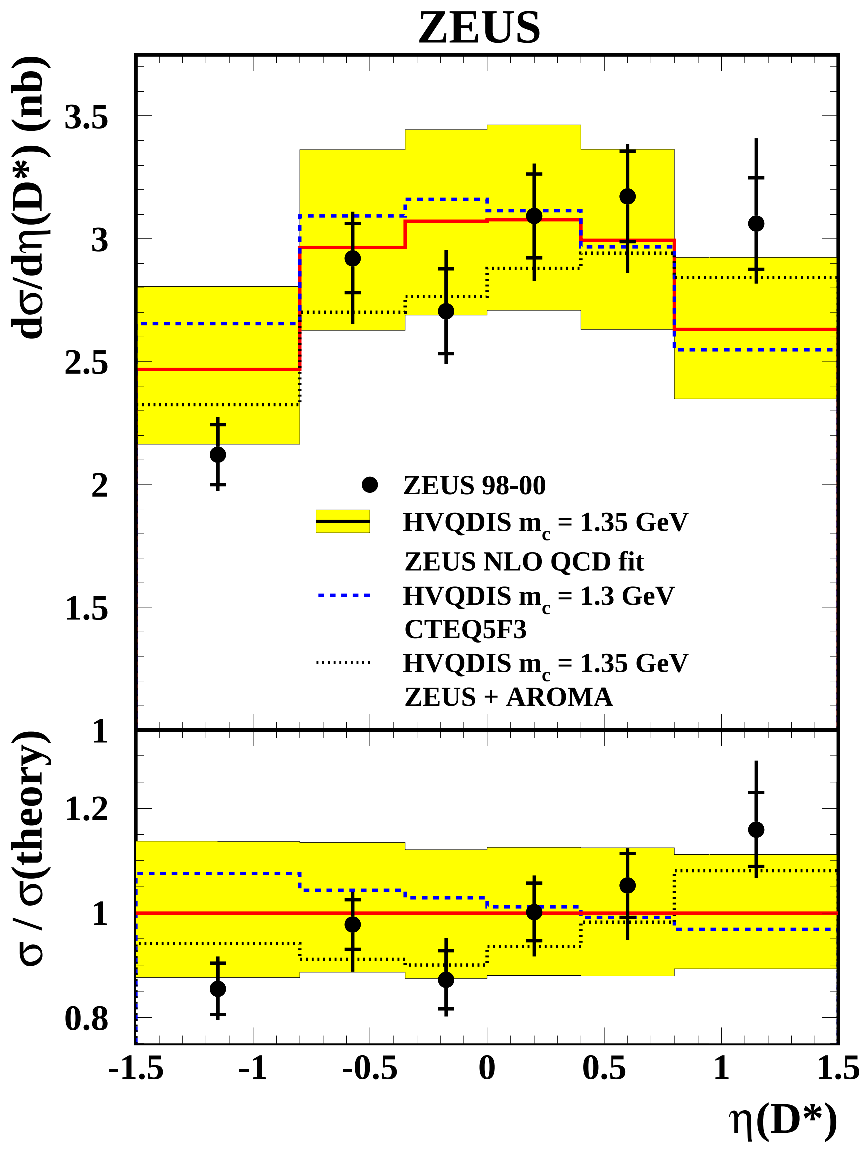
Direct sensitivity to the gluon in the proton




Have about 5500 $D^*$ mesons for analysis

Good description by NLO QCD

Some difference in shape; can the PDF be fitted to describe the data?



# D* production in DIS

$$F_{2,\text{meas}}^{c\bar{c}}(x_i, Q_i^2) = \frac{\sigma_{i,\text{meas}}(ep \to D^* X)}{\sigma_{i,\text{theo}}(ep \to D^* X)} \times F_{2,\text{theo}}^{c\bar{c}}(x_i, Q_i^2)$$

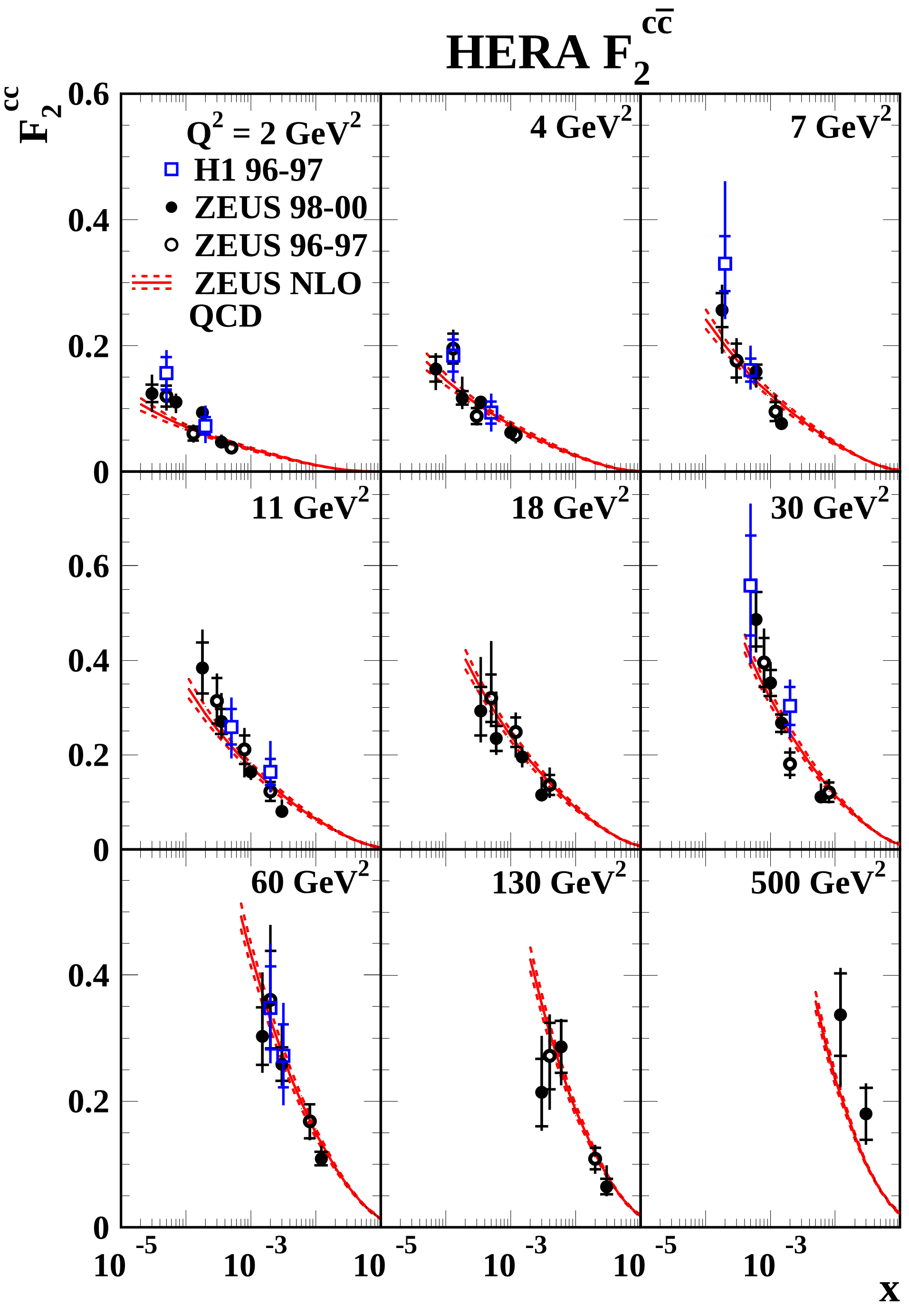
Recently added extra 31 points, extending up to $Q^2 = 500$ GeV$^2$

Have good(ish) precision up to 30 GeV$^2$

Reasonable description by NLO QCD fit

Steeper rise of data to low $x$ with increasing $Q^2$ indicative of large gluon density

At lowest $Q^2$, data and theory uncertainty comparable $\Rightarrow$ data can be used as additional constraint



# D* production in diffractive DIS

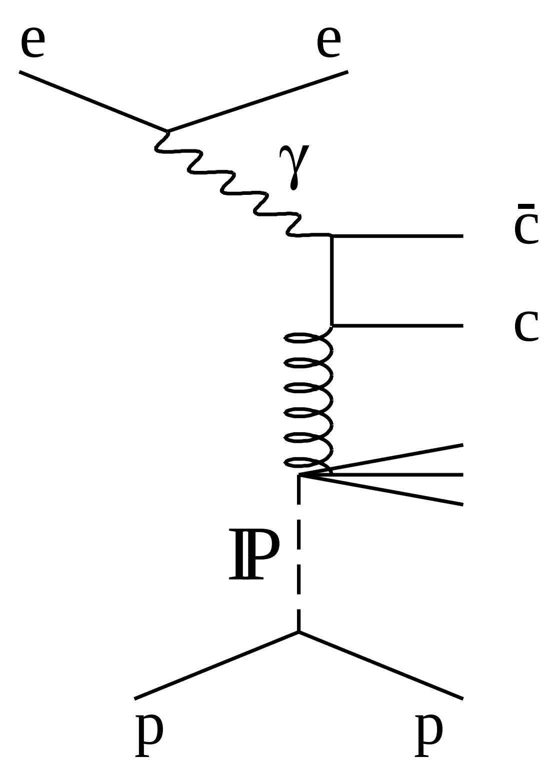
Diffractive processes contribute $\sim 10\%$ to the total DIS cross section

Events have clear experimental signature - large rapidity gap

QCD factorisation has been proven (Collins) for these class of events $\Rightarrow$ can measure "diffractive parton distributions"

Evolution with $Q^2$ according to DGLAP equations

Extract parton densities and predict charm production



# D* production in diffractive DIS

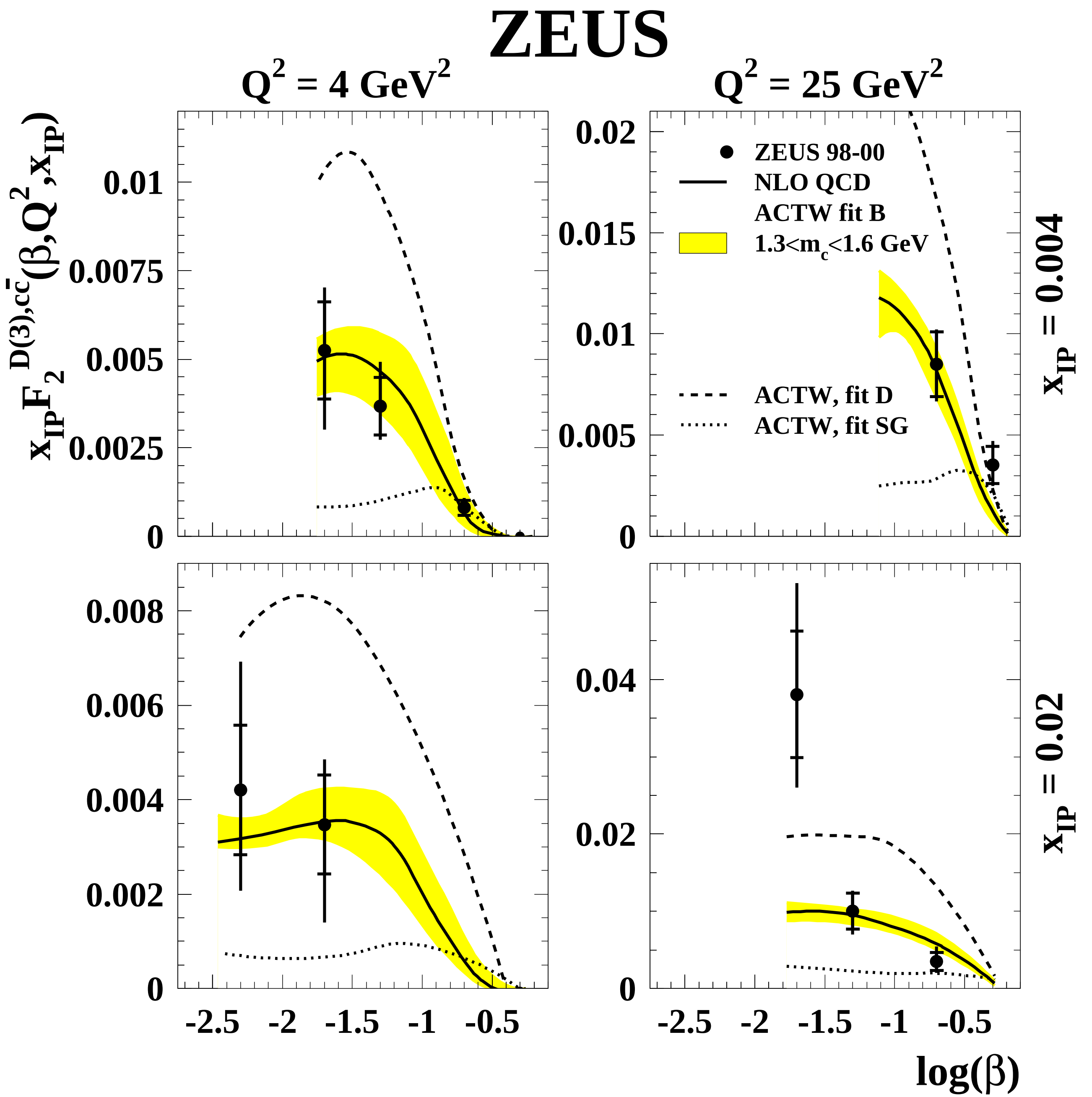
Data show sensitivity to parton density parametrisations

Some parametrisations are ruled out

One parametrisation consistent with data

Factorisation approach works

Data can be used in future PDF fits



# Bose-Einstein correlations

**BE correlations are related to the spatial dimensions of the production source**

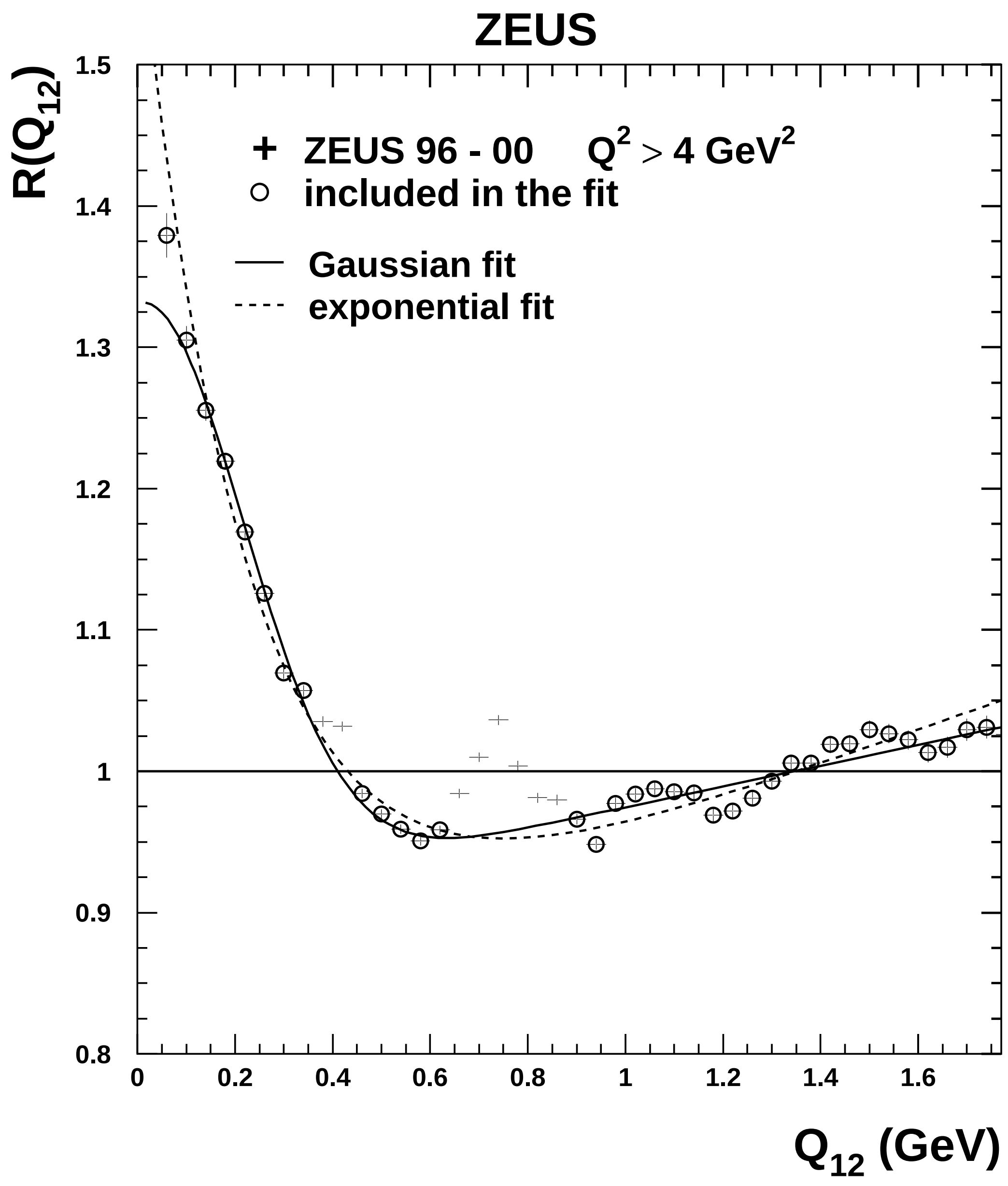
**Use BE correlations to get handle on size and shape of hadronisation region**

$R(Q_{12})$: **ratio of particle densities**

$Q_{12}$: **4-momentum separation**

**Dependence on $r$ and $\lambda$ on the hard process?**

**Change partonic-interaction size; what happens to hadronic-source size?**



# Bose-Einstein correlations

$r = 0.666 \pm 0.009(\text{stat.})^{+0.022}_{-0.036}(\text{syst.})$ fm

*cf* LEP1:

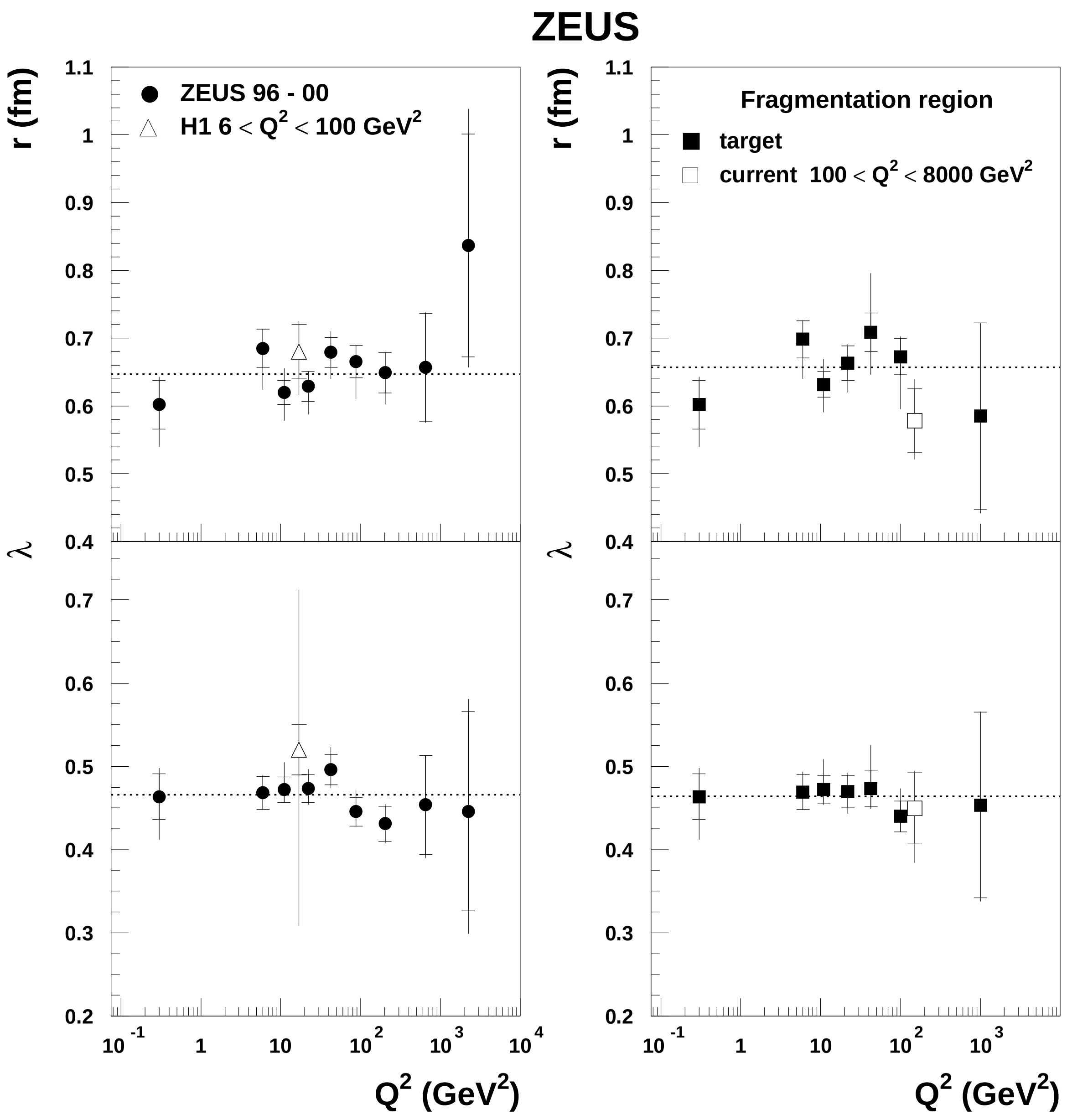
$r = 0.78 \pm 0.01(\text{stat.}) \pm 0.16(\text{syst.})$ fm

**Not the same as in hadronic and heavy-ion collisions**

**No dependence on $Q^2$**

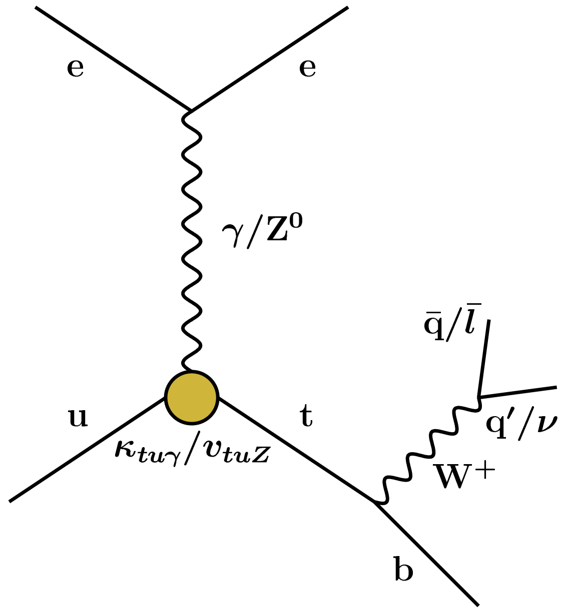
**Same in the current and target regions of the Breit frame**

**The size of the pion production region does not depend upon the size of the quark scattering region**

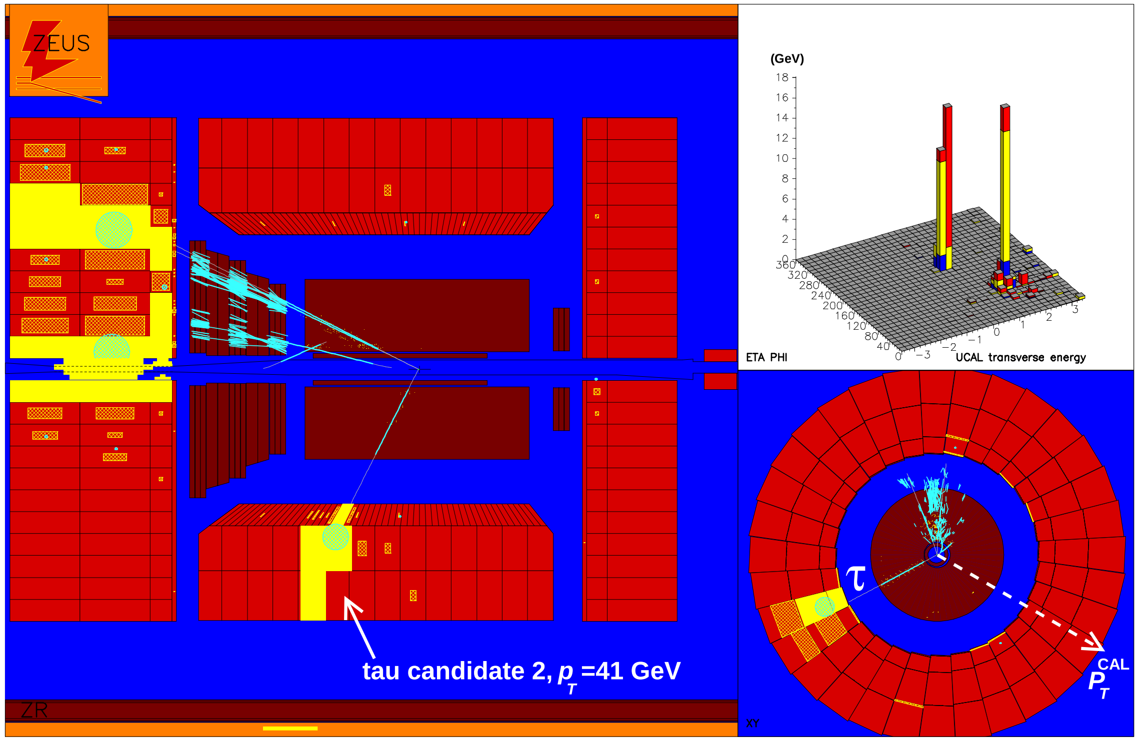


# Isolated tau leptons

Search for flavour-changing neutral current processes




and other processes beyond the Standard Model




Clear experimental signature

Have looked in positron, muon and hadronic channels

Multivariate method used to extract high $p_T$ tau leptons

# Isolated leptons

| ZEUS<br>1994-2000 $e^{\pm}p$<br>$\mathcal{L} = 130.1\text{pb}^{-1}$ | Electron<br>obs./exp.<br>($W^{\pm}$ contribution) | Muon<br>obs./exp.<br>($W^{\pm}$ contribution) | Tau<br>obs./exp.<br>($W^{\pm}$ contribution) |
|---|---|---|---|
| $p_T^{\text{had}} > 25\text{GeV}$ | 2 / 2.90 $^{+0.59}_{-0.32}$ (45%) | 5 / 2.75 $^{+0.21}_{-0.21}$ (50%) | 2 / 0.20 $^{+0.05}_{-0.05}$ (49%) |
| $p_T^{\text{had}} > 40\text{GeV}$ | 0 / 0.94 $^{+0.11}_{-0.10}$ (61%) | 0 / 0.95 $^{+0.14}_{-0.10}$ (61%) | 1 / 0.07 $^{+0.02}_{-0.02}$ (71%) |

**An excess of $\tau$ events seen**

**1 $\tau^+$ and 1 $\tau^-$ where only $\tau^+$ expected from single top and SUSY models**

**Production of isolated leptons consistent with Standard Model**

**Look forward to more data and better tagging (of heavy flavours) at HERA II**

# Search for single top production

Final combination of muon, positron and hadronic channels

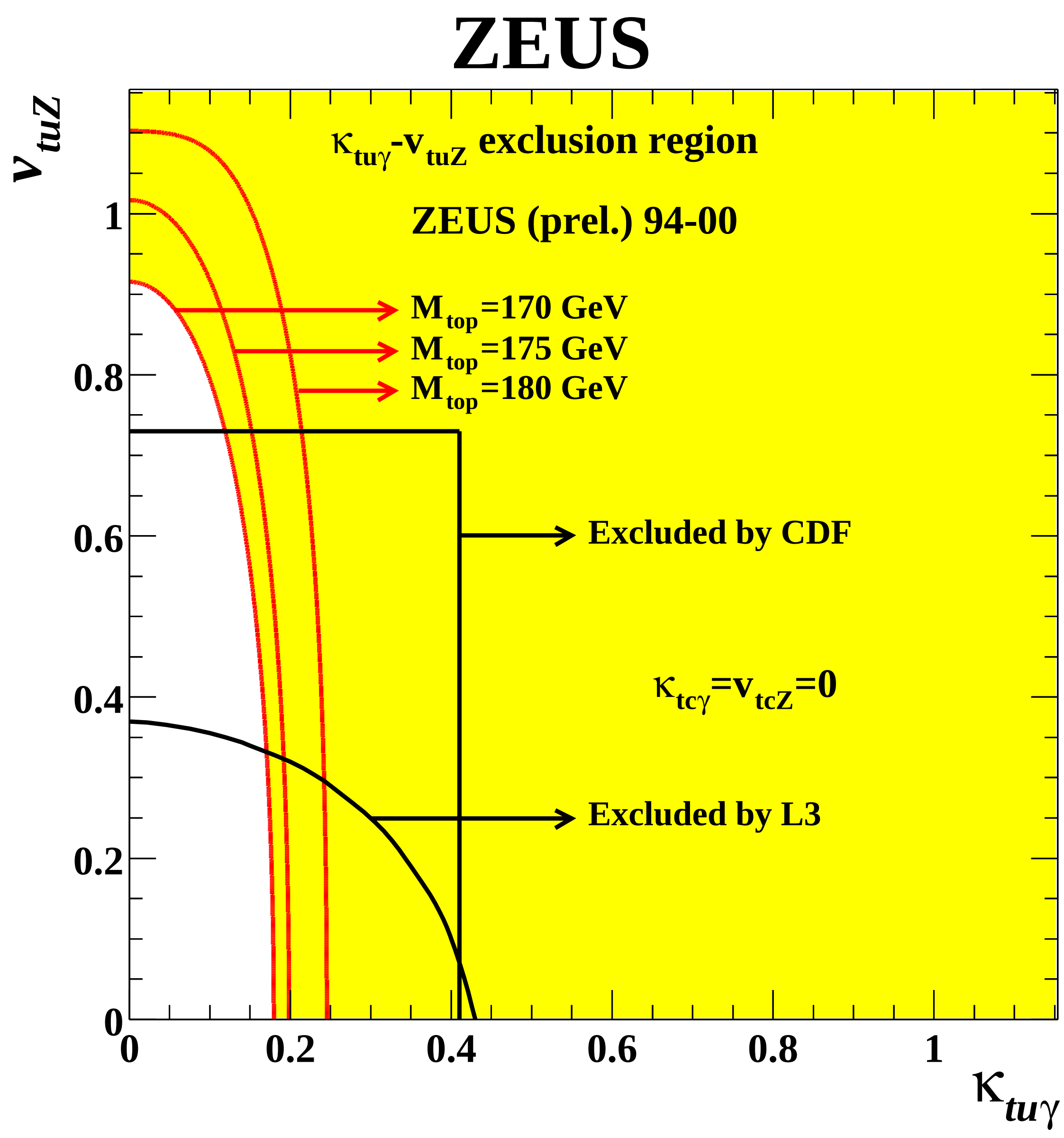
Assuming $\nu_{tuZ} = 0$:

$\kappa_{tu\gamma} < 0.174$ **at 95% CL**

Improved simulation of $Z$-exchange process $\rightarrow \nu_{tuZ}$

ZEUS providing competitive limits; substantial region excluded

(To be published as addendum soon)



# Summary and outlook

**ZEUS physics output is high, producing a wealth of new results**

**Ready for lots more data like:**