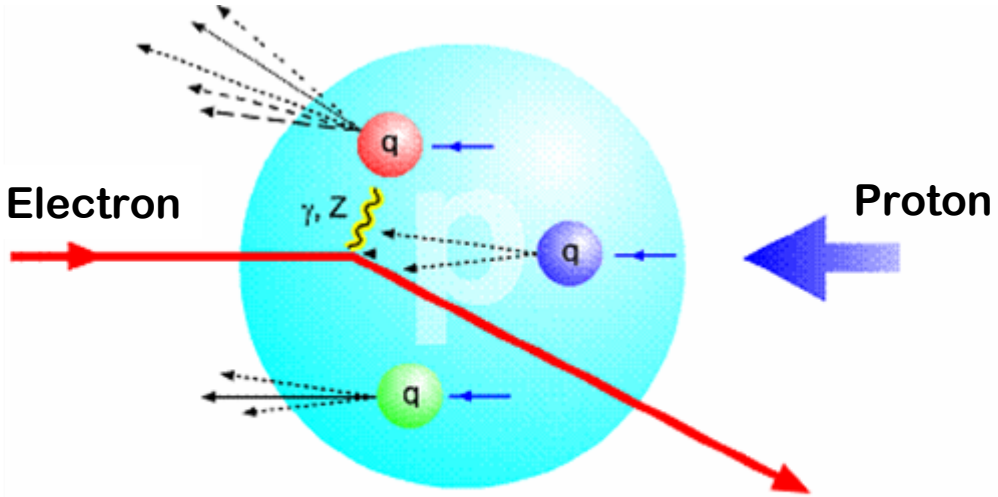
ZEUS

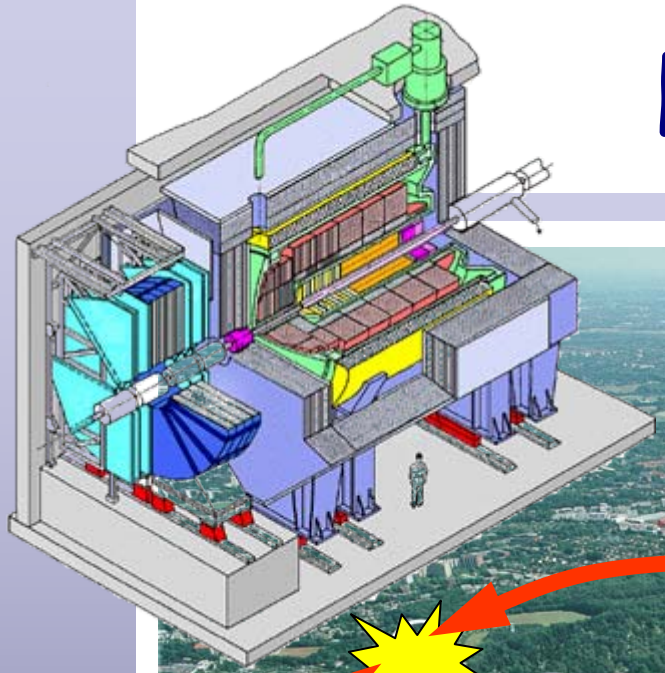
Status Report

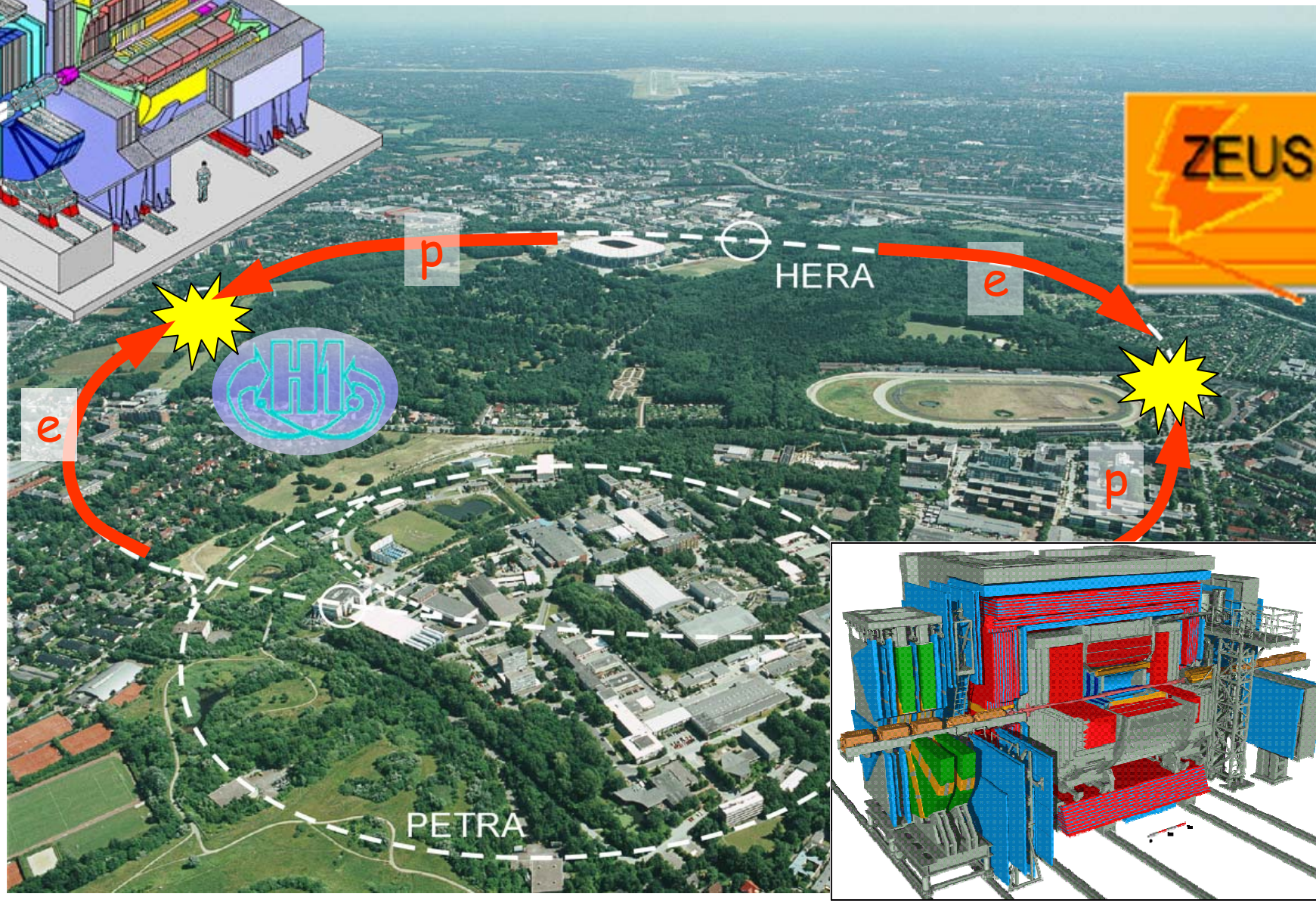


Burkard Reisert

MPI Project Review
December 17 - 18, 2007

HERA Accelerator



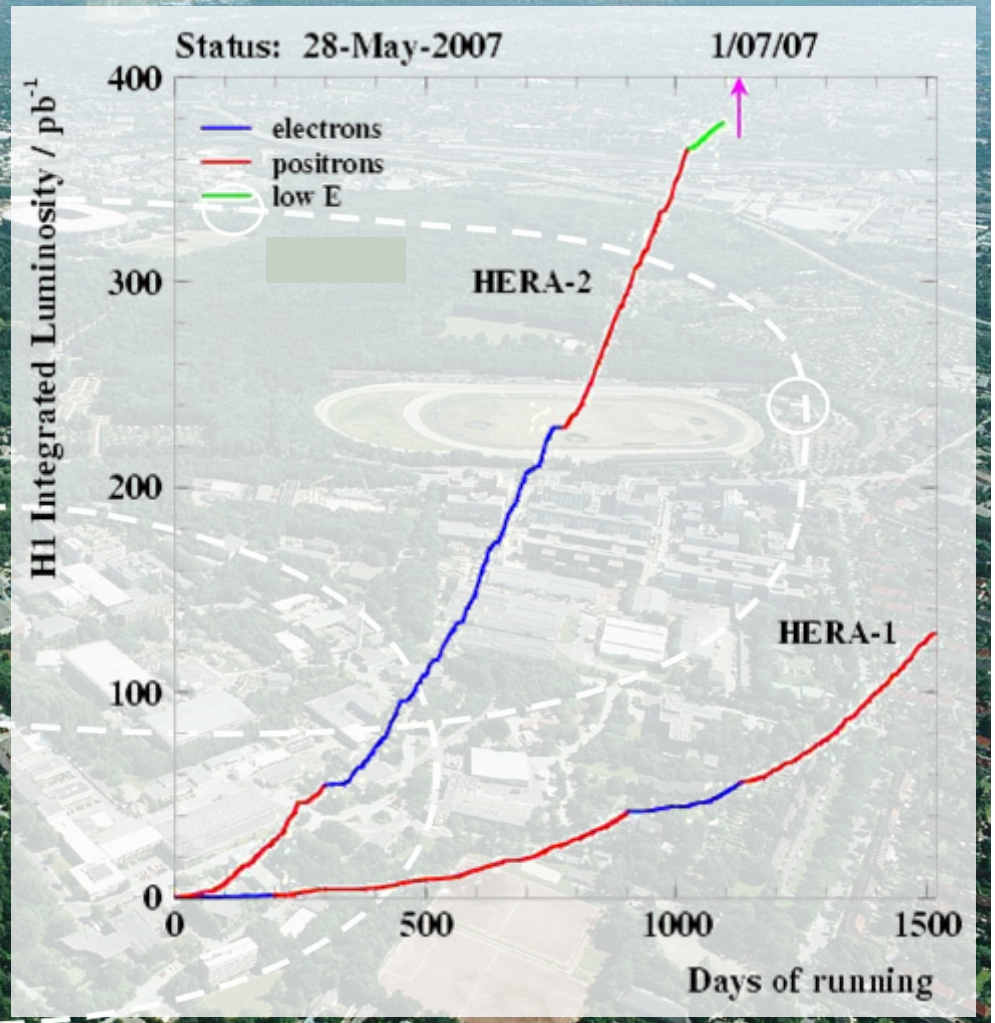


MPI Munich
Burkard Reisert
MPI Project Review 2007

HERA Performance

HERA High Energy Run
E_e=27.5GeV →←E_p =920GeV
Concluded March 21st

HERA-1 & HERA-2 combined integrated Luminosity L = 0.5 fb^{-1} per experiment



Special runs until June 30th
HERA Low Energy Run
E_e=27.5GeV →←E_p=460 GeV
.. and ←E_p=575 GeV

The MPI ZEUS Team

Responsible Director: Allen Caldwell

Project Manager: Iris Abt

Research Associates: Daniel Kollár, Burkard Reisert, William Schmidke

Guests/Associates:

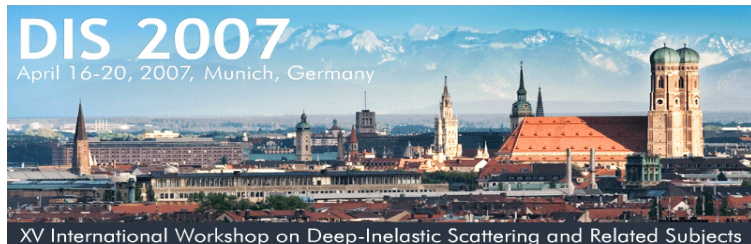
Vladimir Drugakov (DESY Hamburg), Prabhdip Devgun (U Punjab), Julia Grebenyuk (U Hamburg), Manjit Kaur (U Punjab), Wolfgang Lohmann (DESY Zeuthen), Jason Schwarz (McGill U), Frank Sciulli (Columbia U), Shima Shimizu (U Tokyo), Inderpal Singh (U Punjab), Amir Stern (Tel Aviv U)

Functions within ZEUS collaboration:

D. Kollár: Convener FL-Group;
I. Abt: Convener High Q^2 & Exotics
I. Abt: Designated ZEUS Physics Coordinator

Local Organizing Committee of DIS 2007

XV Workshop on Deep Inelastic Scattering
Combined effort of H1 and ZEUS groups



Responsibilities & Analysis

Hardware Responsibilities:

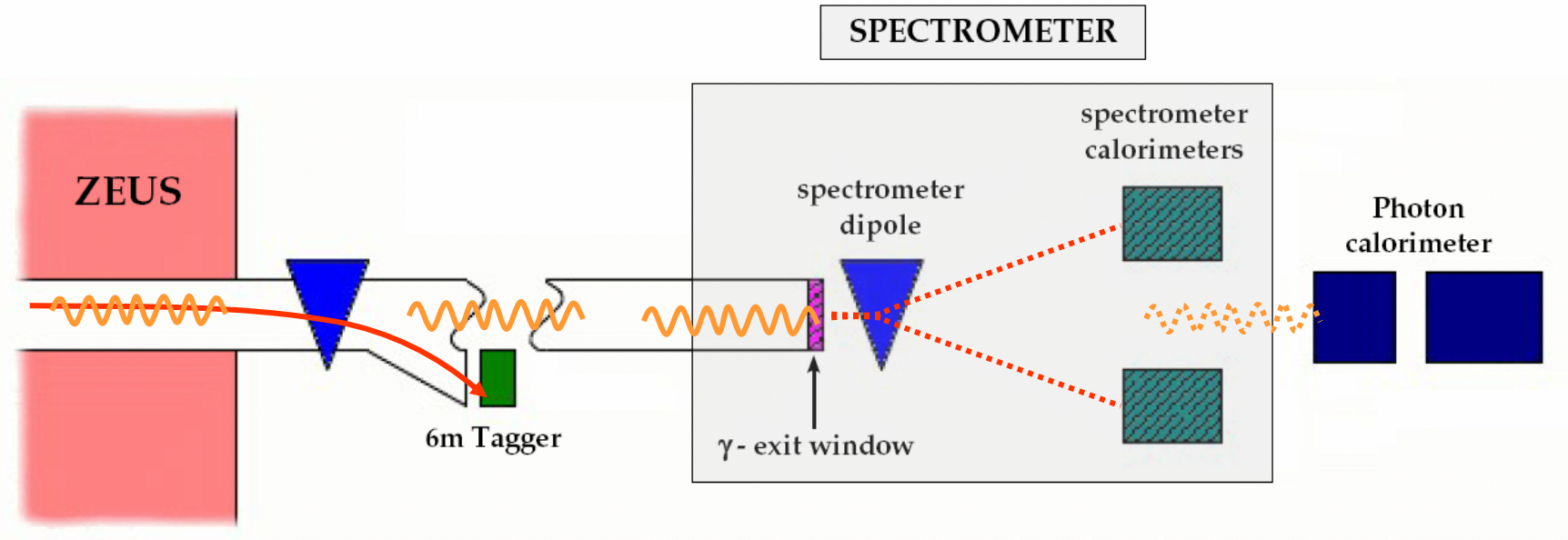
- Luminosity Spectrometer — W. Schmidke, V. Drugakov
- CAL Readout — W. Schmidke

ZEUS detector is being decommissioned

Analyses:

- Luminosity Measurement — V. Drugakov
- F2 at high y (HERA High Energy Run) — D. Kollár, B. Reisert
  → preliminary for DIS07, ongoing
- F2 at high y and FL (HERA Low Energy Runs — B. Reisert, D. Kollár
  → ongoing, aiming for preliminary for DIS08
- Photon-proton total cross sections — W. Schmidke
  → new analysis, ramping up
- Inclusive Leading Neutrons in DIS and γp — W. Schmidke
  → published in Nucl. Phys. B, July 2007
- Di-jets in γp with leading neutron tag — W. Schmidke
  → editorial board process started

Luminosity Spectrometer



Technique

Process: ep→e'pγ

- Accurately calculable cross-section
- Sufficient rate for real-time monitoring

Method: γ-measurement downstream

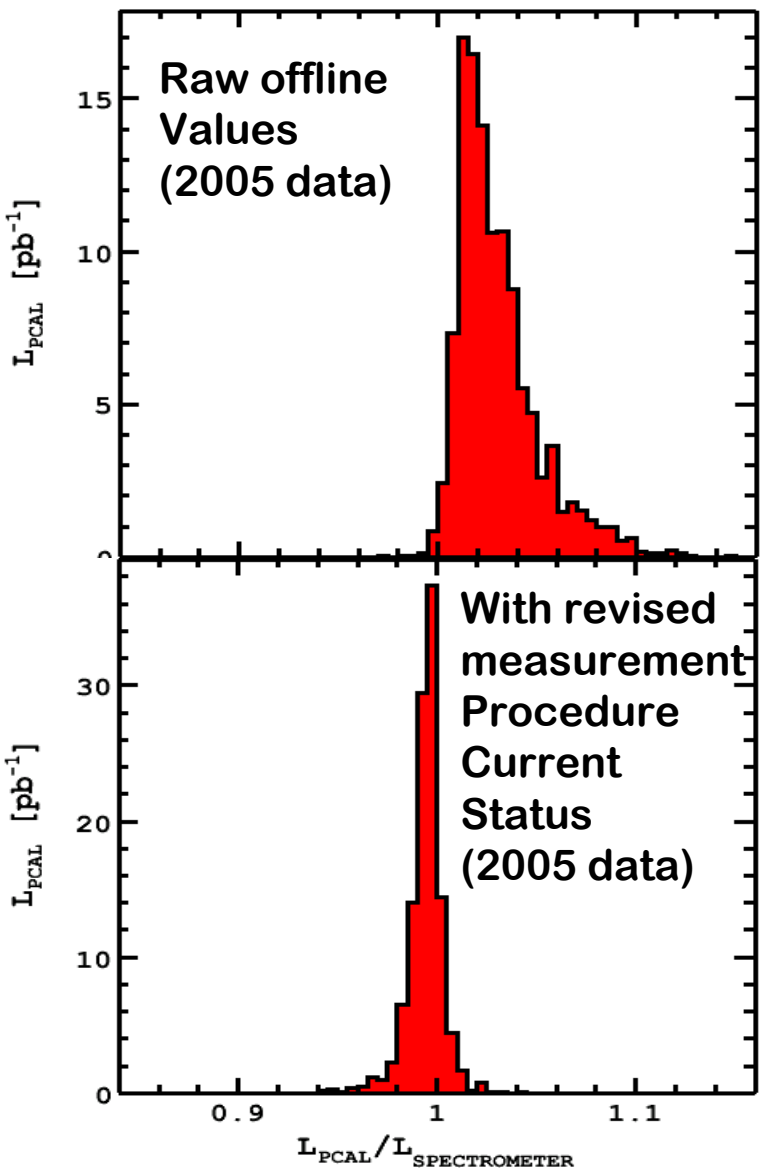
- Photons follow electron direction
- e are magnetically separated

Experimental Setup

- Detects e^+e^- -pairs from photon conversions in γ-exit window (~9%)
- Away from synchrotron radiation plane
- Away from bremsstahlung photons

- Alternative measurement of γ in photon calorimeter

Luminosity Measurement



Two independent luminosity monitors:
Luminosity Spectrometer (since 2003)
& photon calorimeter

Dedicated study to understand numerous systematic effects:

theory
- 0.5% (working with theorists on update)

aperture and detector alignment
- 1% (will profit from ongoing acceptance study

window conversion
- 2% (will profit from ongoing acceptance study)

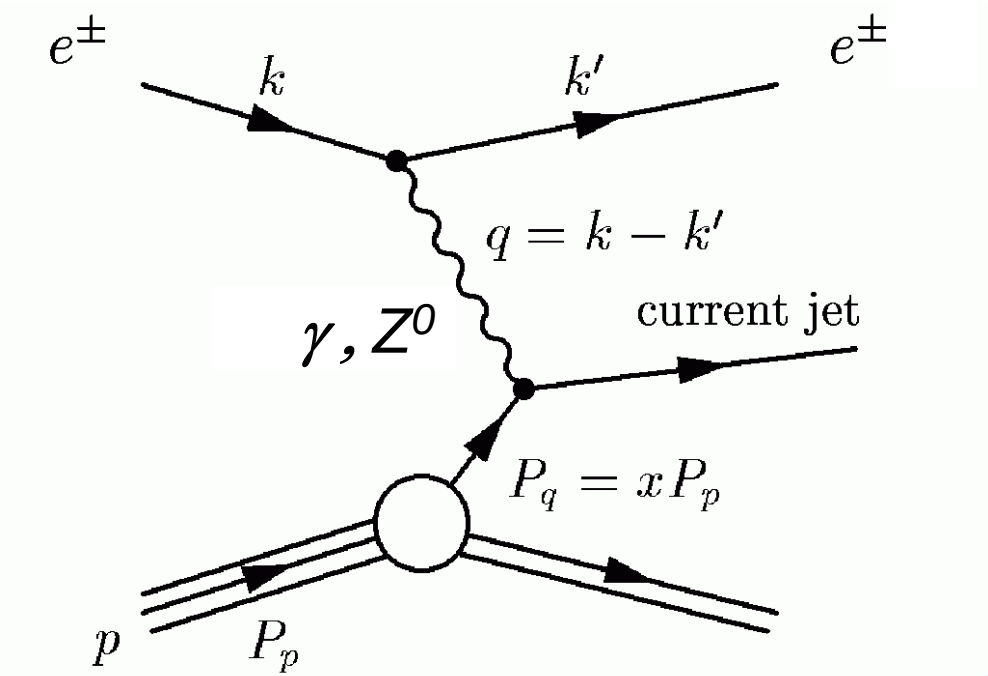
correction
- 0.5%

X-position
- 1.2% (will profit from ongoing acceptance study)

all other systematics checked
- negligible

Total error on Zeus luminosity: 2.6 %
good prospects for further improvements

Deep Inelastic Scattering



Kinematic Variables

- **4-momentum transfer resolving power**
  $$Q^2 = -q^2 = -(k - k')^2$$
- **Bjørken scaling variable *x* momentum fraction of struck parton**
  $$x = \frac{Q^2}{2p \cdot q}$$
- **Inelasticity:**
  $$y = \frac{p \cdot q}{p \cdot k}$$

Center of mass energy $\sqrt{s}$: $s = (k + p)^2$ **relation for fixed s:** $Q^2 = sxy$

- **Neutral current DIS cross section expressed by structure functions:**

$$\frac{d^2\sigma^{e^{\pm}p \to e^{\pm}X}}{dxdQ^2} = \frac{2\pi\alpha^2}{xQ^4}\underbrace{\left(1+(1-y)^2\right)}_{Y_{\pm}=1\pm(1-y)^2}\cdot\left(F_2\left(x,Q^2\right) - \frac{y^2}{Y_+}F_L\left(x,Q^2\right) \mp \frac{Y_-}{Y_+}xF_3\left(x,Q^2\right)\right)$$

High Q^2 only

$\tilde{\sigma}$: Reduced cross section

Structure Functions

- **Proton Structure Function F_2**

$$F_2 = \sum_q A_q\left(Q^2\right)\left[xq + x\bar{q}\right], \quad \text{at low } Q^2\text{: } A_q\left(Q^2\right) = e_q^2$$

$A_q\left(Q^2\right)$: Electro weak coefficient function

F_2 is directly sensitive to quark densities,

gluons are accessible only through scaling violations

- **Longitudinal Structure Function F_L**

Quark Parton Model (spin ½ partons only): $F_L = 0$

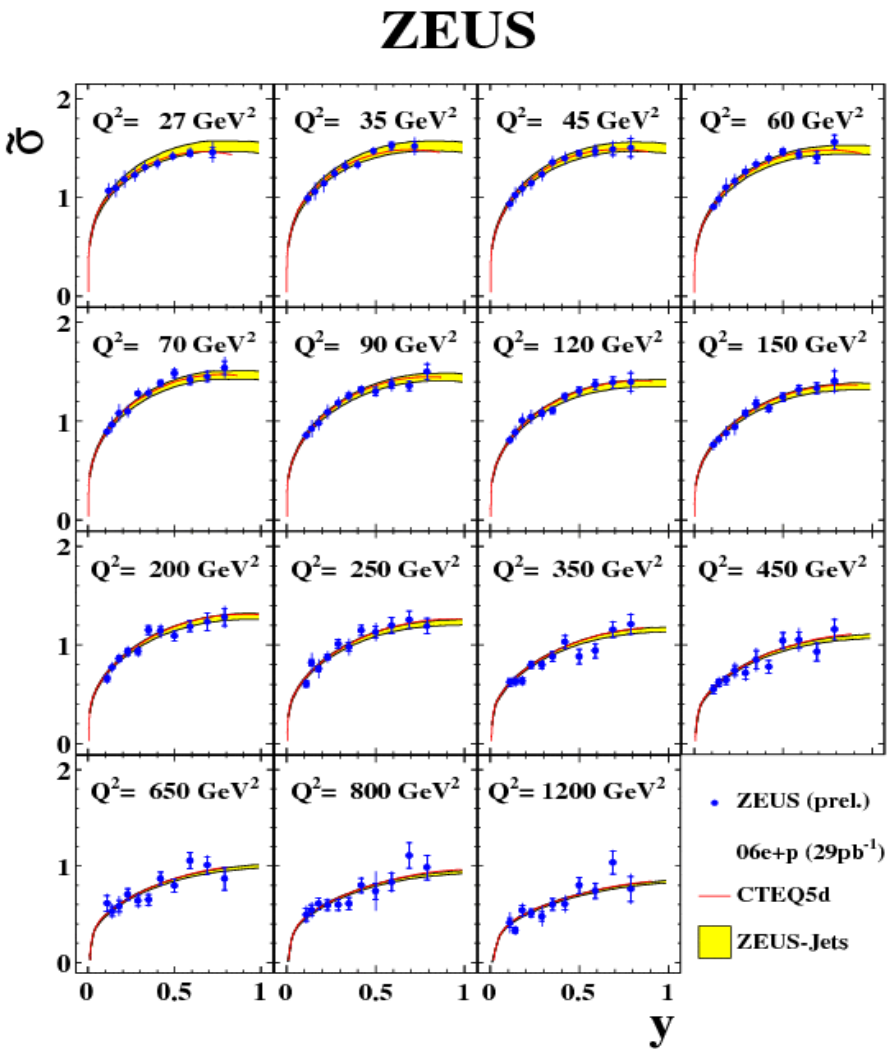
QCD: (NLO)

$$F_L = \frac{\alpha_s}{4\pi} x^2 \int_x^1 \frac{dz}{z^3}\left[\frac{16}{3}\underbrace{\sum_q e_q^2\left(xq + x\bar{q}\right)}_{F_2} + 8\sum_q e_q^2\left(1 - \tfrac{x}{z}\right)zg\right]$$

Direct sensitivity to gluon

Sizable contribution of F_L only at high y

Reduced Cross Section vs. y



Measured reduced cross sections compare to SM predictions with

- CTEQ5D
- ZEUS Jets PDF Fit

→ measurement well described by predictions

Systematic checks

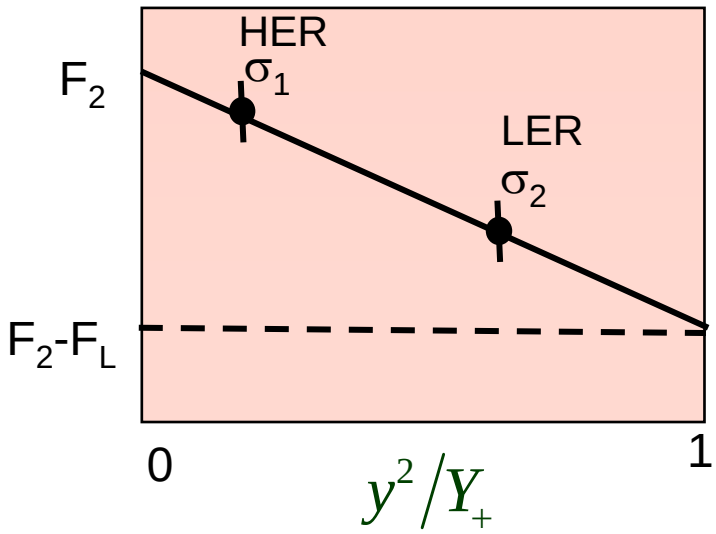
Electron energy scale	2%
γp background estimate	10%
Electron finding inefficiency	10%
Variation of E-Pz threshold	2 GeV

Proof of principle that we can measure at high *y* ,i.e. low E_e'
Preliminary result presented at DIS 2007

Direct measurement of F_L

- Measurement of F_L will give access to gluon: $F_L \propto \int_x^1 \frac{dz}{z^3}\left[\sum_q e_q^2\left(1-\frac{x}{z}\right) zg\right]$
- Measure cross section $\sigma_r = F_2\left(x,Q^2\right) - \frac{y^2}{Y_+} F_L\left(x,Q^2\right)$

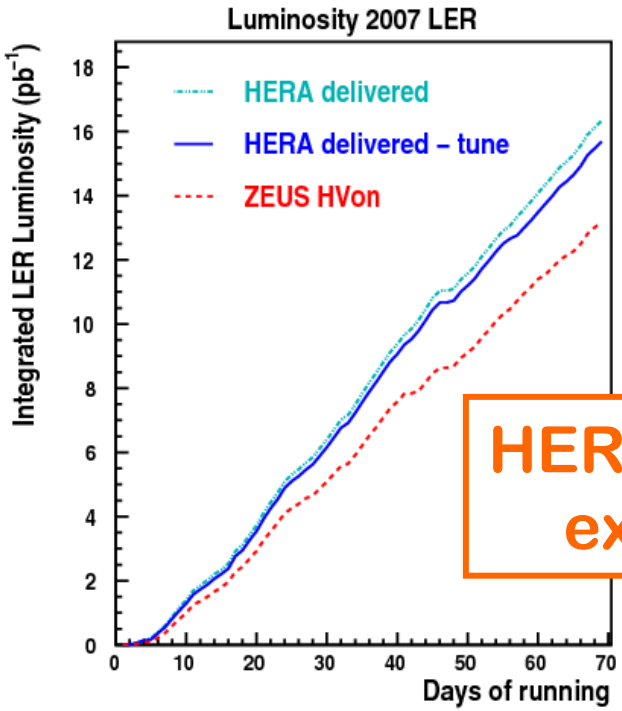
  at same *x* and Q^2 but different y, i.e. different centre-of-mass energy



- Change proton beam energy to change cms energy
- Large level arm in y^2/Y_+
- measure at high *y* in LER

Feasibility study: Will need ~10pb^{-1} for measurement of F_L

HERA Dedicated Runs for F_L



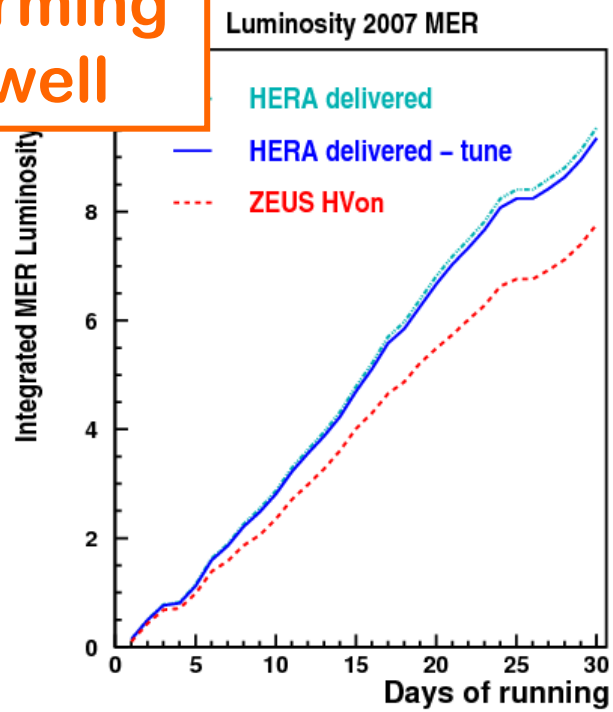
Low Energy Running

E_p=460 GeV, $\sqrt{s}$ = 225 GeV

(24 Mar 2007 – 31 May 2007)

ZEUS gated: 14pb^{-1}

HERA was performing exceptionally well



Medium Energy Running

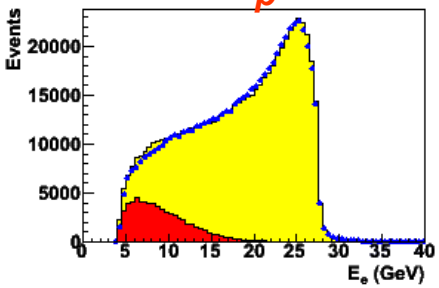
E_p=575 GeV, $\sqrt{s}$ = 252 GeV

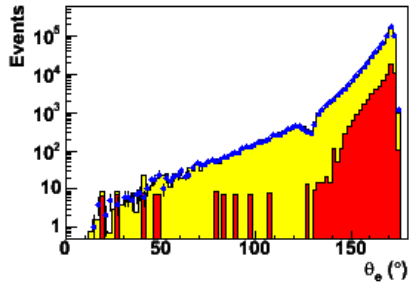
(1 Jun 2007 – 30 Jun 2007)

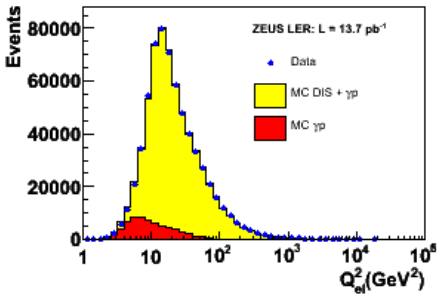
ZEUS gated: 7pb^{-1}

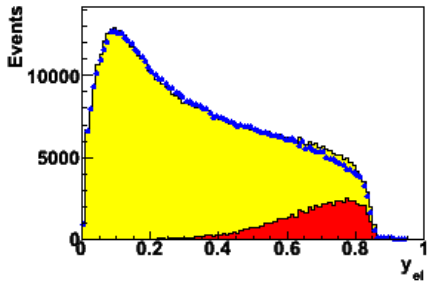
Towards Measurement of F_L

LER: E_p=460 GeV, $\sqrt{s}$ = 225 GeV



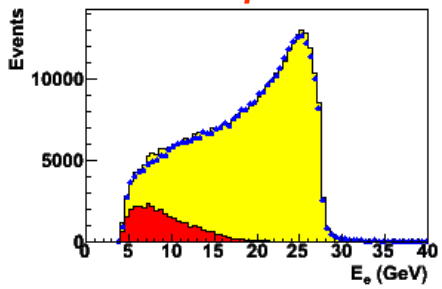


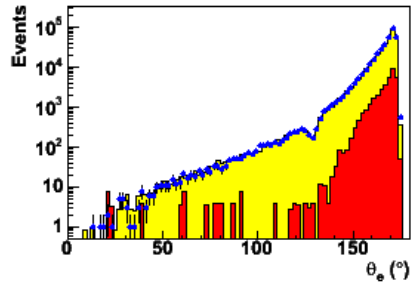




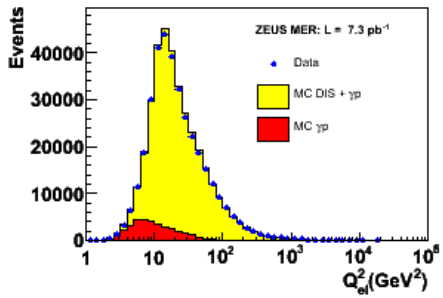
Data collected during LER and MER together with HER cross sections will allow first direct measurement of F_L at low x

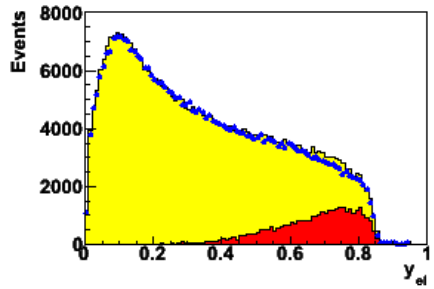
MER: E_p=575 GeV, $\sqrt{s}$ = 252 GeV





Ongoing detailed studies of
- electron identification
- electron energy calibration
- background rejection
- …

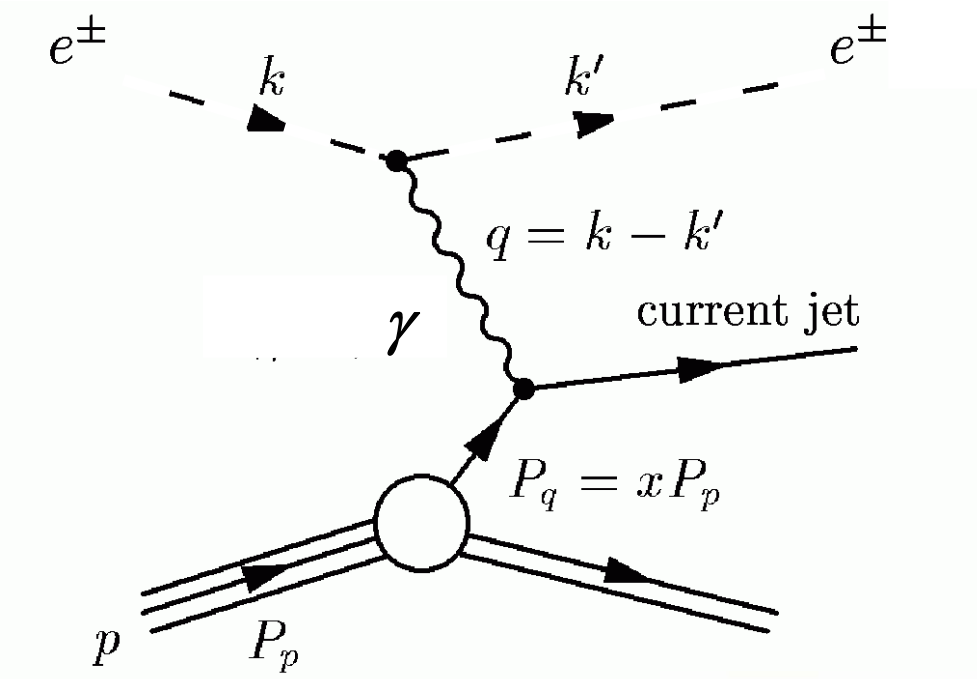




Note MC F_L was put to 0

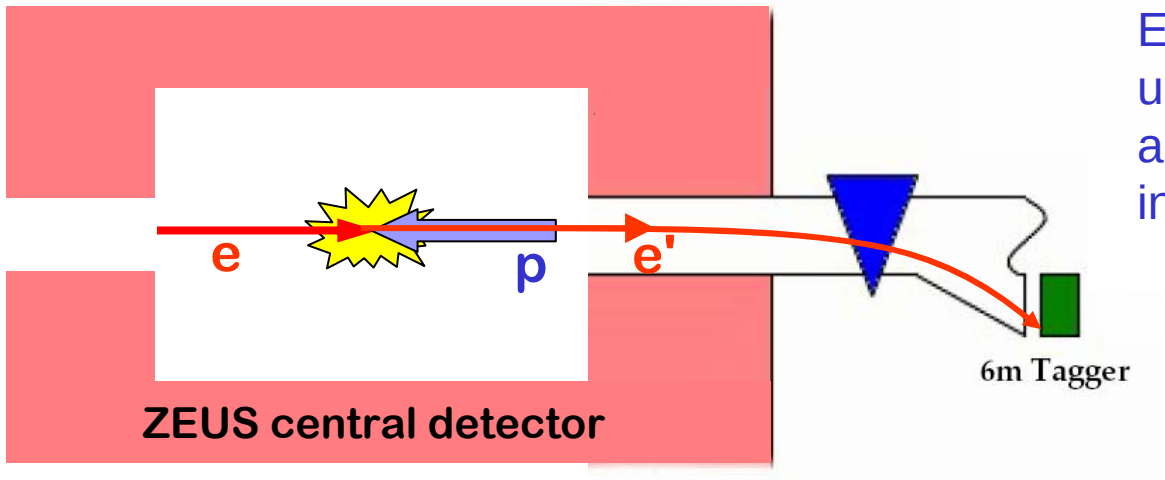
Aiming for preliminary measurement of F_L for DIS2008

Photon Proton Scattering



- The same process may be interpreted as scattering of a virtual photon off a proton
- Photon Proton centre-of-mass energy:

$$W_{\gamma p}^2 \equiv -(P+q)^2 = ys - Q^2$$

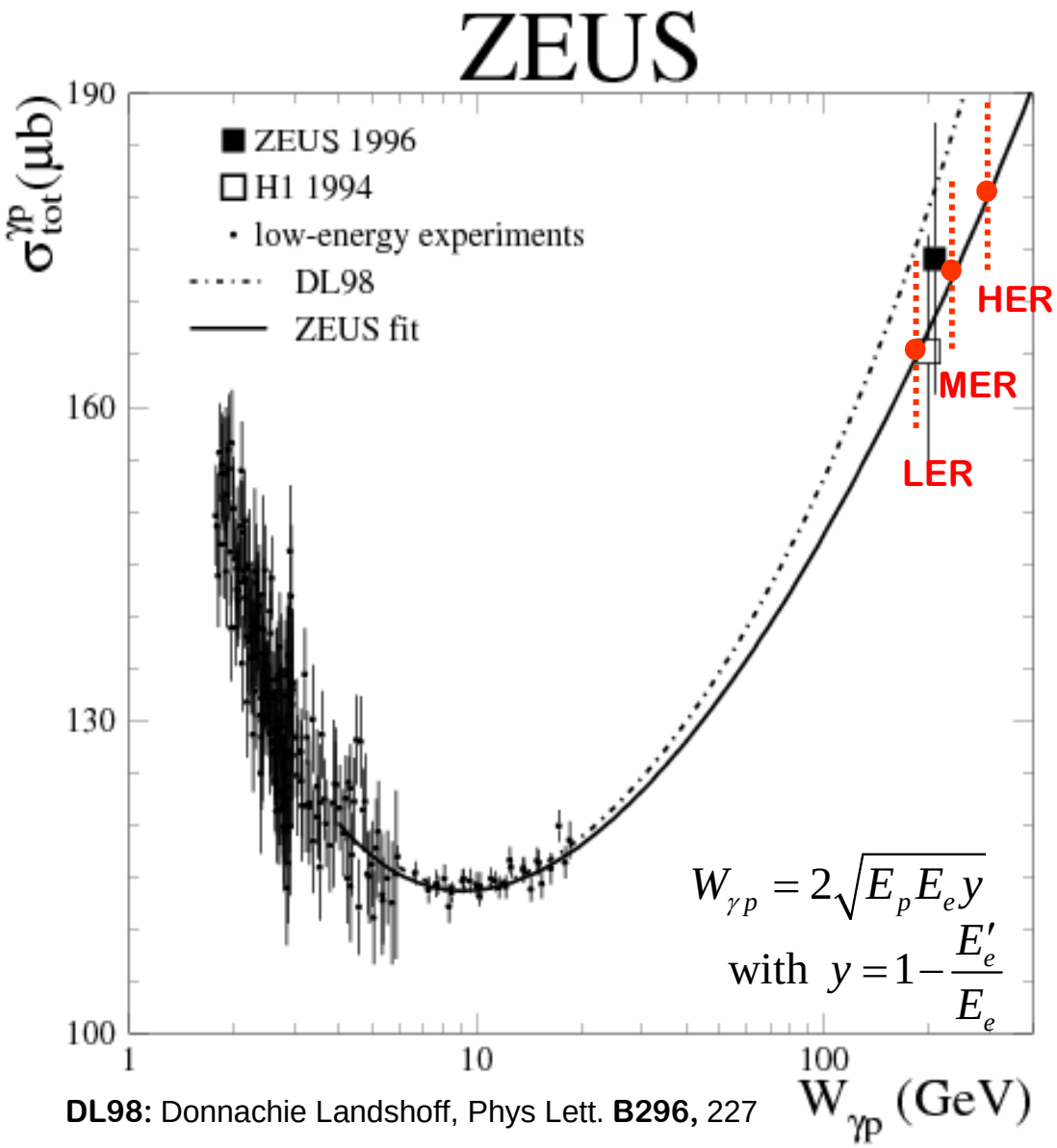


Electrons scattered under very small angles are measured in 6m Tagger

$$W_{\gamma p} = 2\sqrt{E_p E_e y}$$

$$\text{with } y = 1 - \frac{E'_e}{E_e}$$

Photon-Proton Cross Section



DL98: Donnachie Landshoff, Phys Lett. **B296,** 227

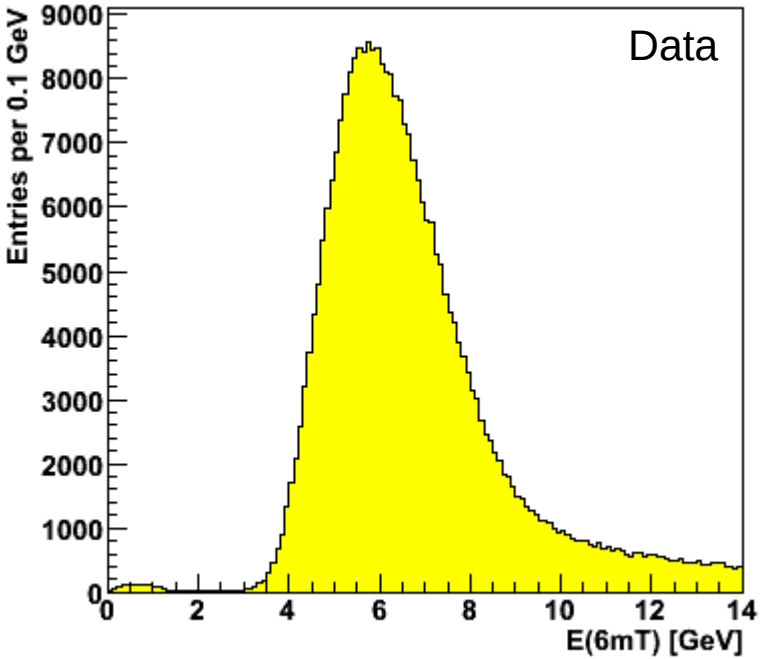
Energy dependence of total hadronic cross sections (pp, $p\bar{p}$, Kp, πp) by exchange of Regge trajectories. Same functional form expected for γp ($\gamma\gamma$) due to soft hadronic behavior of γ (Vector Dominance Model)

$$\sigma_{tot} = A \cdot W_{\gamma p}^{2\varepsilon} + B \cdot W_{\gamma p}^{-2\eta}$$

- Projection of new measmnt using 6mTagger in HER, MER and LER
  - Reduced systematic errors thanks to large acceptance of 6mT, some syst. err. cancel LER vs. MER vs. HER
  - → Well measured slopes

Towards Measurement of $\sigma_{tot}^{\gamma p}$

Energy spectrum of e' in 6mTagger

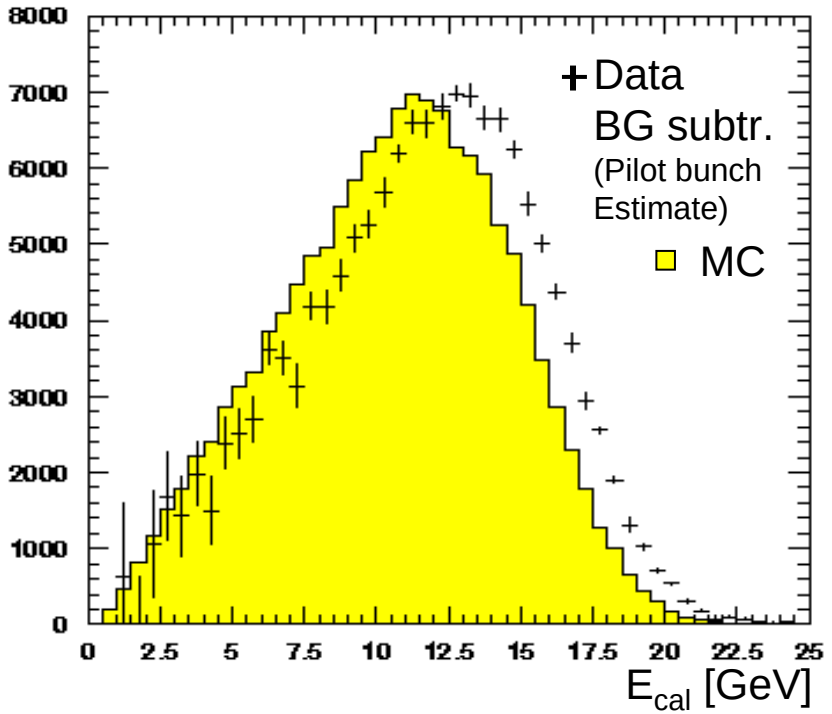


Analysis ramping up, work on

- Signal extraction
- 6mTagger calibration
- 6mTagger acceptance
- Trigger (in-)efficiencies
- Background estimates
- …

First look at data

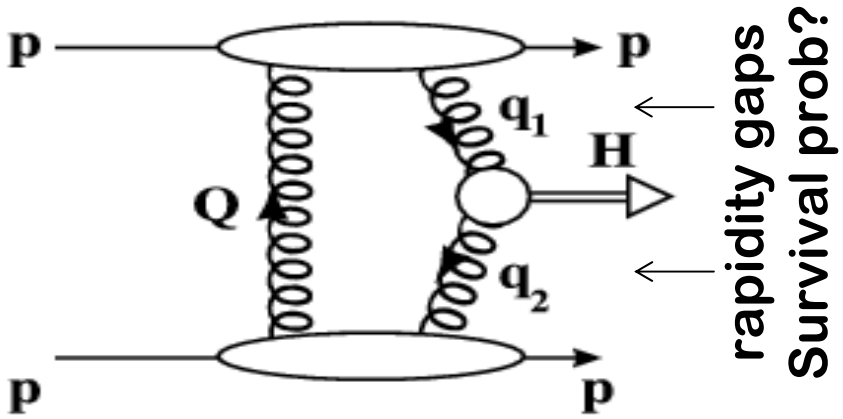
Energy spectrum in Central detector



… DIS08: aiming for preliminary measurement of slope of $\sigma_{tot}^{\gamma p}$

Leading Neutrons: Motivation

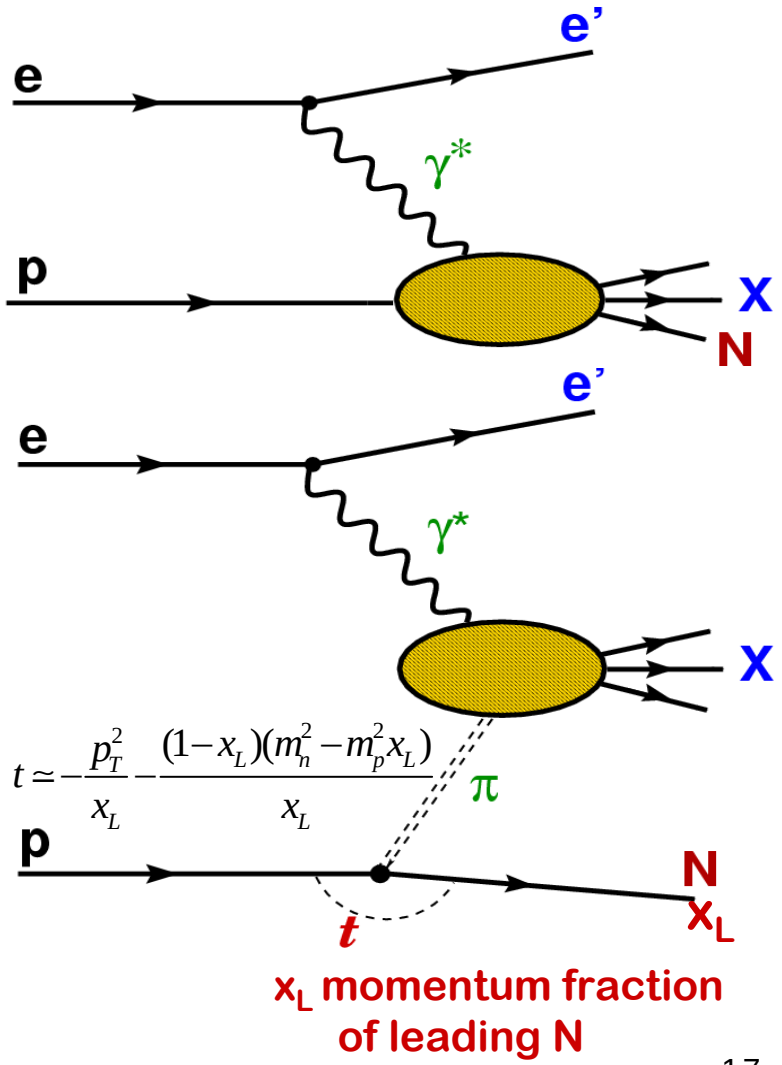
Central exclusive Higgs production@LHC



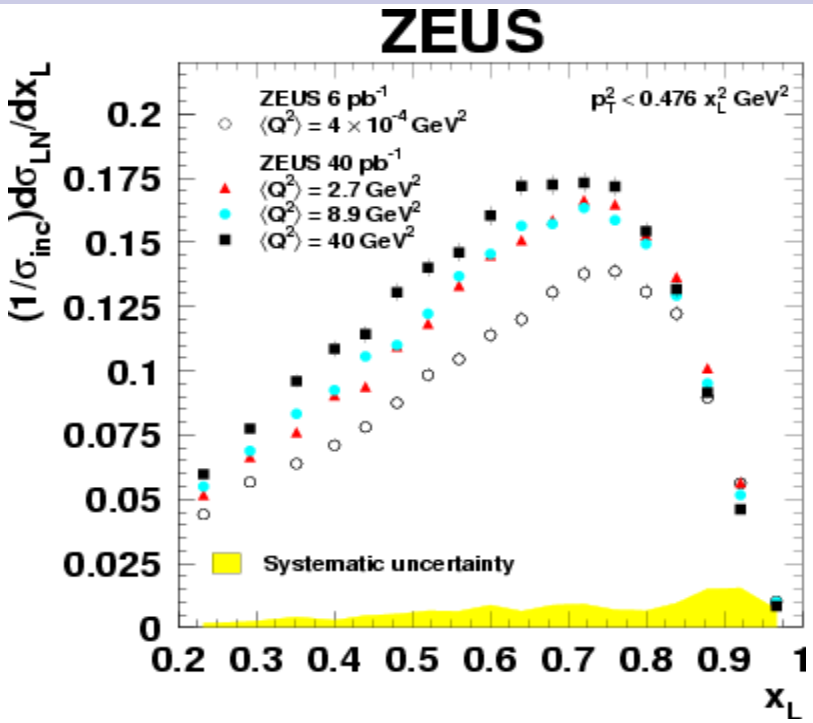
Attractive for Higgs studies
(e.g. Khoze, Ryskin, Sterling hep-ph/0607134)

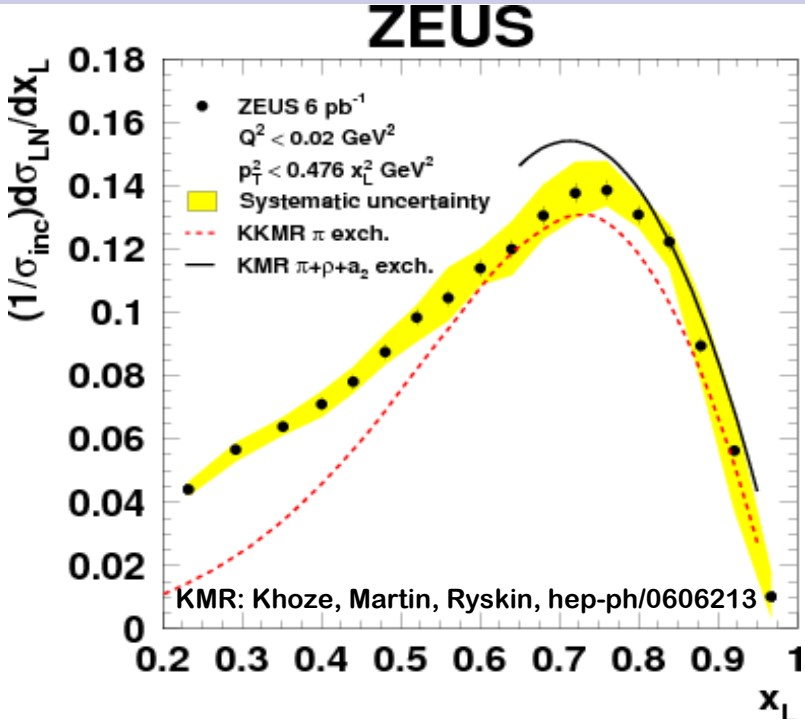
- Outgoing p's intact, small scattering angles →known QN (J_z=0, CP-even selection rule)
- Energy loss of outgoing protons directly related to mass of central system → potentially excellent mass resolution, irrespective of decay mode of produced particle
- Signal-to-background ratio of $\mathcal{O}$ 1 is advertised

Such models are tuned/tested on leading nucleon data in ep-collisions

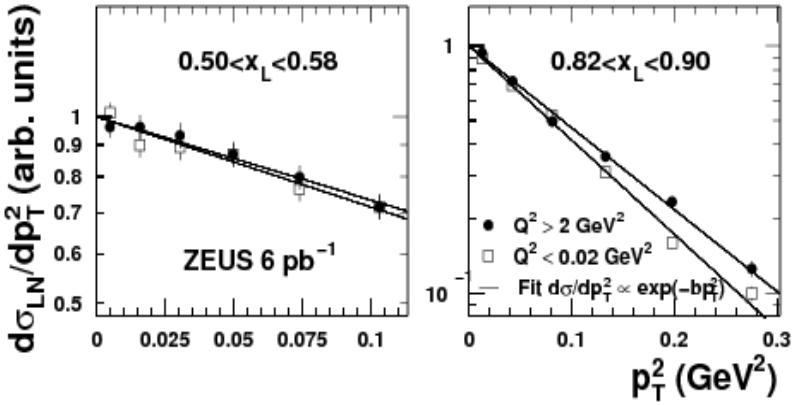


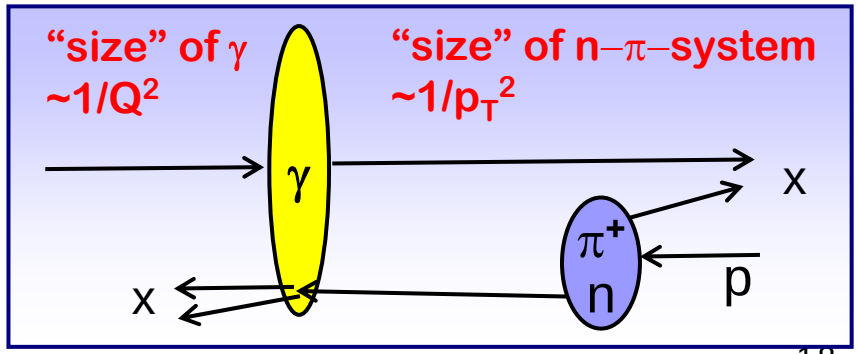
Leading Neutron in DIS & γp



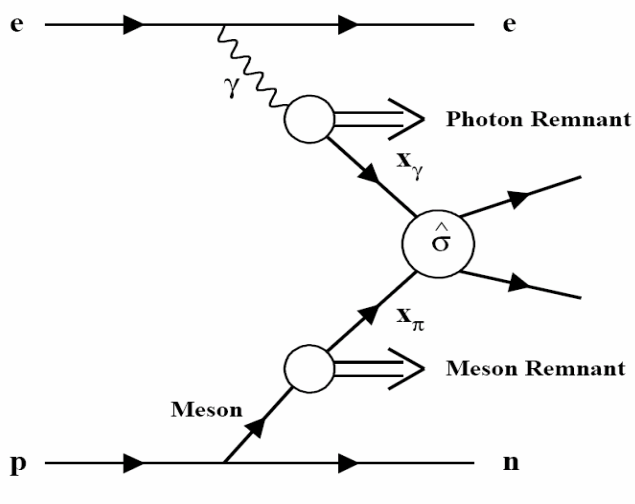


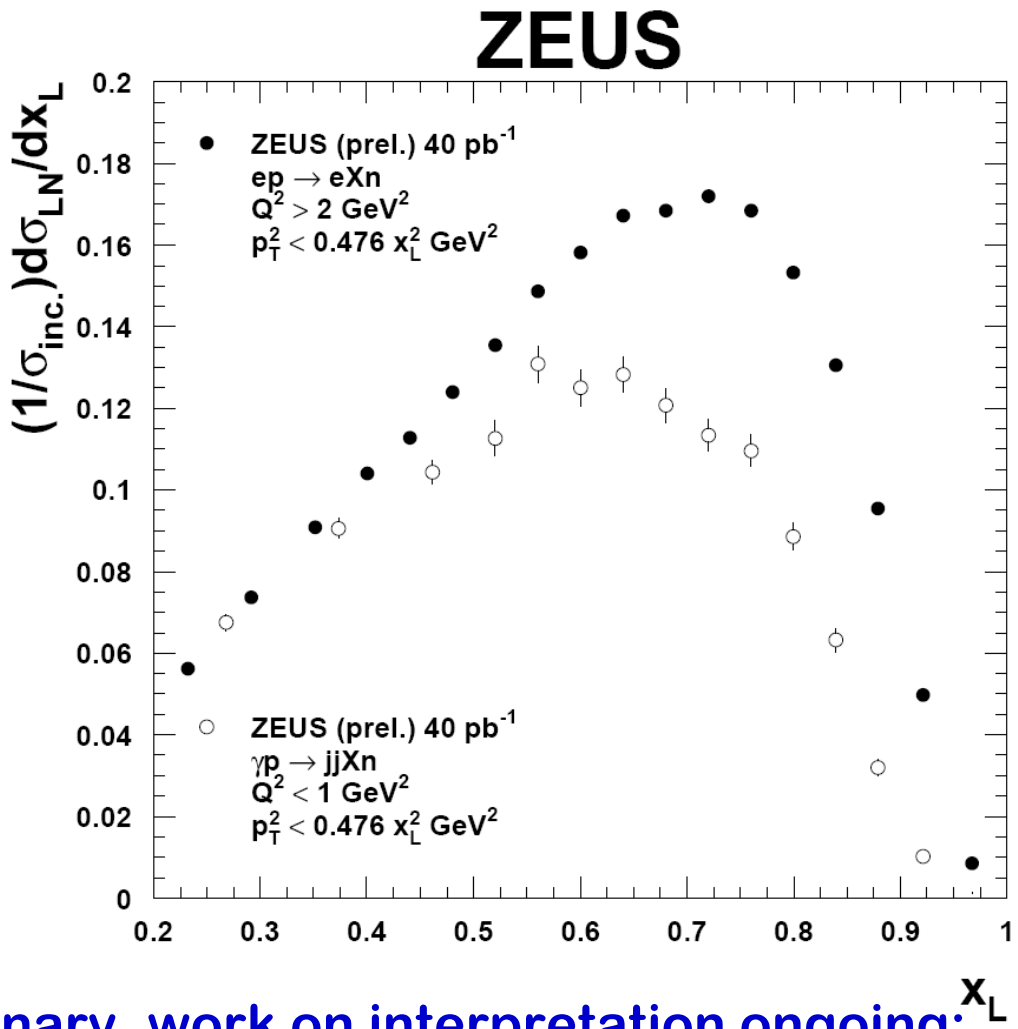
Suppression of n-production by re-absorption





Leading Neutron & Dijets





Add on analysis: identify dijets in γp with leading neutron tag

E_T of jet-system provides scale (instead of Q^2)

Measurement made preliminary, work on interpretation ongoing: Suppression due to n-absorption or reduced phase space (need to produce jets)?

Conclusions

- MPI Zeus group is a small but visible group, has its impact within the Zeus Collaboration
- Main focus will be to make the direct measurement of F_L preliminary for DIS08
- Slope for photon-proton total cross section aiming for preliminary for DIS08
- Data acquisition at HERA has finished, the ongoing analysis will define the rich legacy of HERA