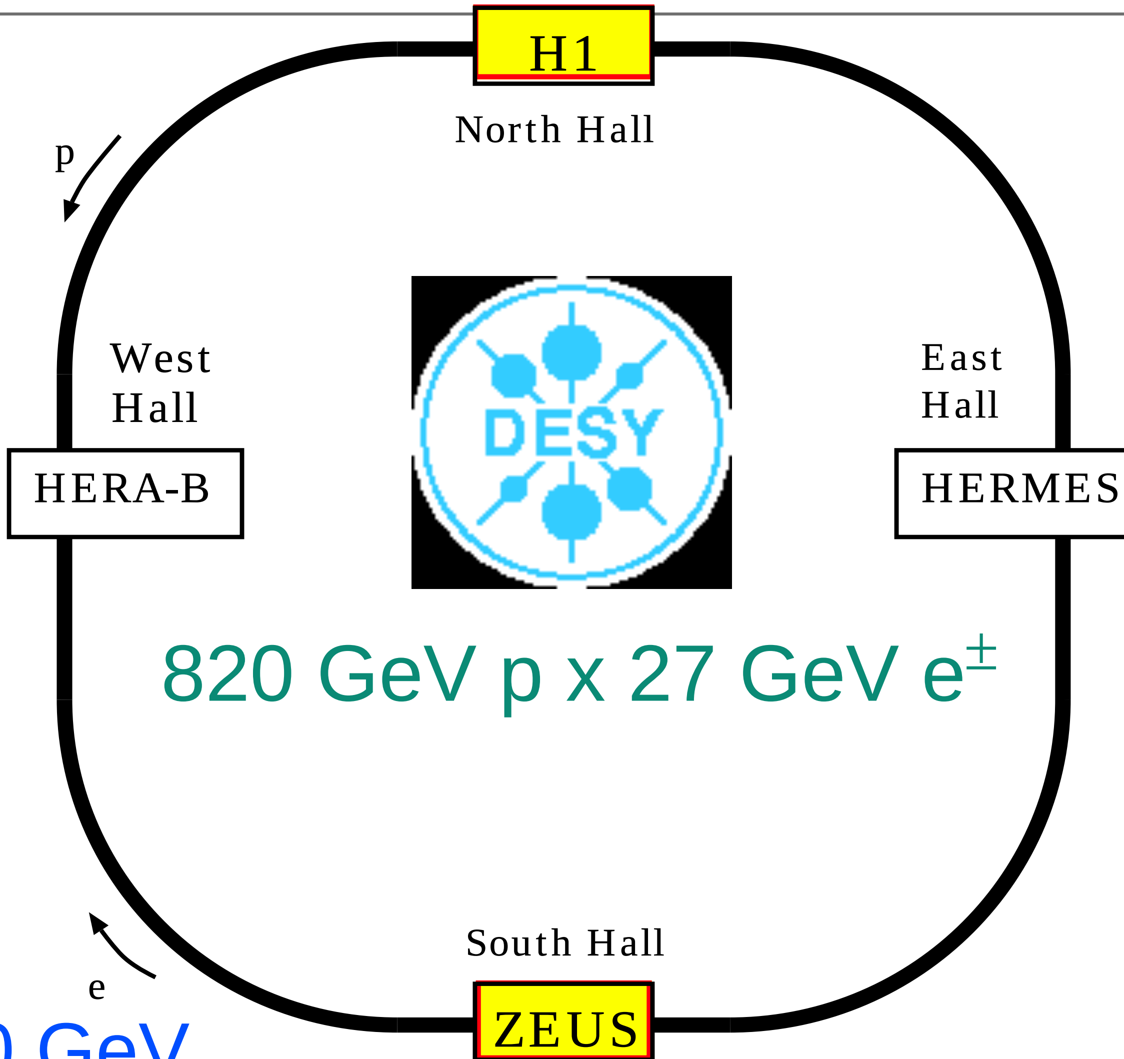
Presentation to HEPAP Subpanel

U. Chicago, August 11, 1997

Wesley Smith,
U. Wisconsin,
Chair, U.S. Institutes on Zeus

HERA



Collider:

- √s= 300 GeV
  - **Equivalent to 47 TeV fixed target**

Experiments:

- 2 general purpose detectors
  - **H1 & Zeus**
- Dedicated Fixed Target
  - **HERMES:**
    - Polarized electrons on polarized H target
  - **HERA-B**
    - Proton Halo on wire target

ZEUS Collaboration

Manitoba, McGill,Toronto, York
CANADA
Bonn, DESY, DESY-Zeuthen, Freiburg,Hamburg I,
Hamburg II, Julich, Siegen
GERMANY
Tel Aviv, Weizmann
ISRAEL
Bologna, Cosenza, Florence, Frascati-Rome, Padua,
La Sapienza-Rome, Turin
ITALY
Tokyo-INS, Tokyo-Metropolitan
JAPAN
Seoul
KOREA
NIKHEF-Amsterdam
The NETHERLANDS
Cracow, Warsaw
POLAND
Moscow
RUSSIA
Madrid
SPAIN
Bristol, London(I.C.), London(U.C.),
Oxford, Rutherford
UNITED KINGDOM
Andrews, Argonne, Brookhaven, Columbia, Iowa,
Louisiana*, Ohio State, Pennsylvania State,
U.C. Santa Cruz, Virginia Tech*, Wisconsin, Yale+
(DoE & NSF) U.S.A. (50 Scientists & 20 Students)
50 Total Institutions
420 Total Physicists

*recently left

+recently joined

US ZEUS History

TASK: Depleted Uranium Barrel Calorimeter

Responsibilities: (a sample)

Argonne ....Module Assembly & Test, Trigger Processor, Project Management
Columbia ....Readout Electronics
(6K ch.Pipelined Switched Capacitor Array S/N ~ 40,000:1, 96 nsec sampling)
U. Iowa ....Analysis Software
Louisiana ....Scintillator & Waveshifter
Ohio State ....Scintillator & Waveshifter, Trigger Fast Clear, Source Test
Penn State ....Laser Calibration System
Virginia Polytech.....Cockroft-Walton Bases
(Invention of new type of PMT base)
Wisconsin ....PMT Testing, DU Manufacture, Slow Control, Cooling, Calorimeter Trigger
(Deadtimeless pipelined isolated electron-finding and energy sums at 96ns (80 MHz))

Organization:

Executive Board.......1 per institute & elected rotating chair
Project Manager.......located at Argonne
(B. Musgrave)

History:

Formed in 1984-85
Received ~ $ 20M from DoE and ~ $ 2M from NSF
Test Beam at FNAL (E790) 1990 - 1991
Data-taking began in June, 1992 w/ fully operating calorimeter.
More than 50 journal physics publications.
More than 20 U.S. Ph.D. Theses.

US Experimental Activities

Detector Operation/Upgrade

- BCAL Maintenance & Calibration -- All
- BCAL Presampler -- ANL, Iowa, Penn
- Beampipe Cal -- Columbia, Iowa & Wisc.
- CAL First Level Trigger -- Argonne & Wisc.
- CAL Trigger Fast Clear -- Ohio St.
- Forward/Rear CAL Presampler -- Iowa
- Leading Proton Spect. -- UC Santa Cruz
- Small Rear Tracking Det. -- ANL & Penn St.

Common Tasks by US Zeus members

- Zeus CPU cluster Coordination
- Monte Carlo Generation
- Run Control Maintenance
- Analysis File Production & Maintenance
- Graphics Software
- Calorimeter Data Quality Monitoring

US Experimental Leadership

- Spokesman: Allen Caldwell '97-'99
- Deputy Spokesmen:
  - J. Whitmore, Penn St.,'93-'95
  - A. Caldwell, Columbia, '95-'97
- Physics Group Leaders:
  - **Physics Chairman:**
    - J. Whitmore, Penn St., '93-'94
  - **Hard Photoproduction:**
    - C. Foudas, Wisc. '95-'97
    - J. Butterworth, Deputy, Penn St., '95-'96
    - J. Whitmore, Penn St. '94-'95
  - **Exotics & High Q^2**
    - B. Straub, Columbia, '96-'97, Deputy '93-'96
    - D. Krakauer, Argonne, '94-'95
    - K. Honscheid, Ohio St., '93-94
  - **Structure Functions:**
    - Q. Zhu, Columbia, '96-97
    - D. Krakauer, Argonne, '93-'94
- Run Coordinators:
  - R. Talaga, Argonne, '93
  - S. Kartik, Louisiana, '95
- Trigger:
  - **Coordinator:** W. Badgett, Wisconsin, '96-'97
  - **Co-convenor:** W. Smith, Wisconsin
- 76 Talks at Major International Conferences

Construction & Operation

Lessons from Construction

- Lab & University Synergism
  - **National Lab Role - Argonne**
    - Construction of DU Calorimeter
    - Could not be done at University
    - Project Management
  - **University Role**
    - Electronics
      - Most technically advanced in pre-LHC era
    - Scintillator, Wave Shifters, High Voltage
    - Testing & Commissioning

Lessons From Operation

- University groups take leading roles
  - **Physics & experimental leadership**
- Long term responsibilities
  - **Major construction responsibilities mean major maintenance responsibilities for the duration of the experiment**
    - Need to plan for support

Overseas Operations

US Groups treated well by DESY

- Offices
- Network and Computing Support
- Voice in Laboratory decisions
- Video Conference Facilties
- Visa/Housing Assistance

Additional Expenses

- Shipping
- Cost of Living DIfferential
- Travel
- Computing Facilities

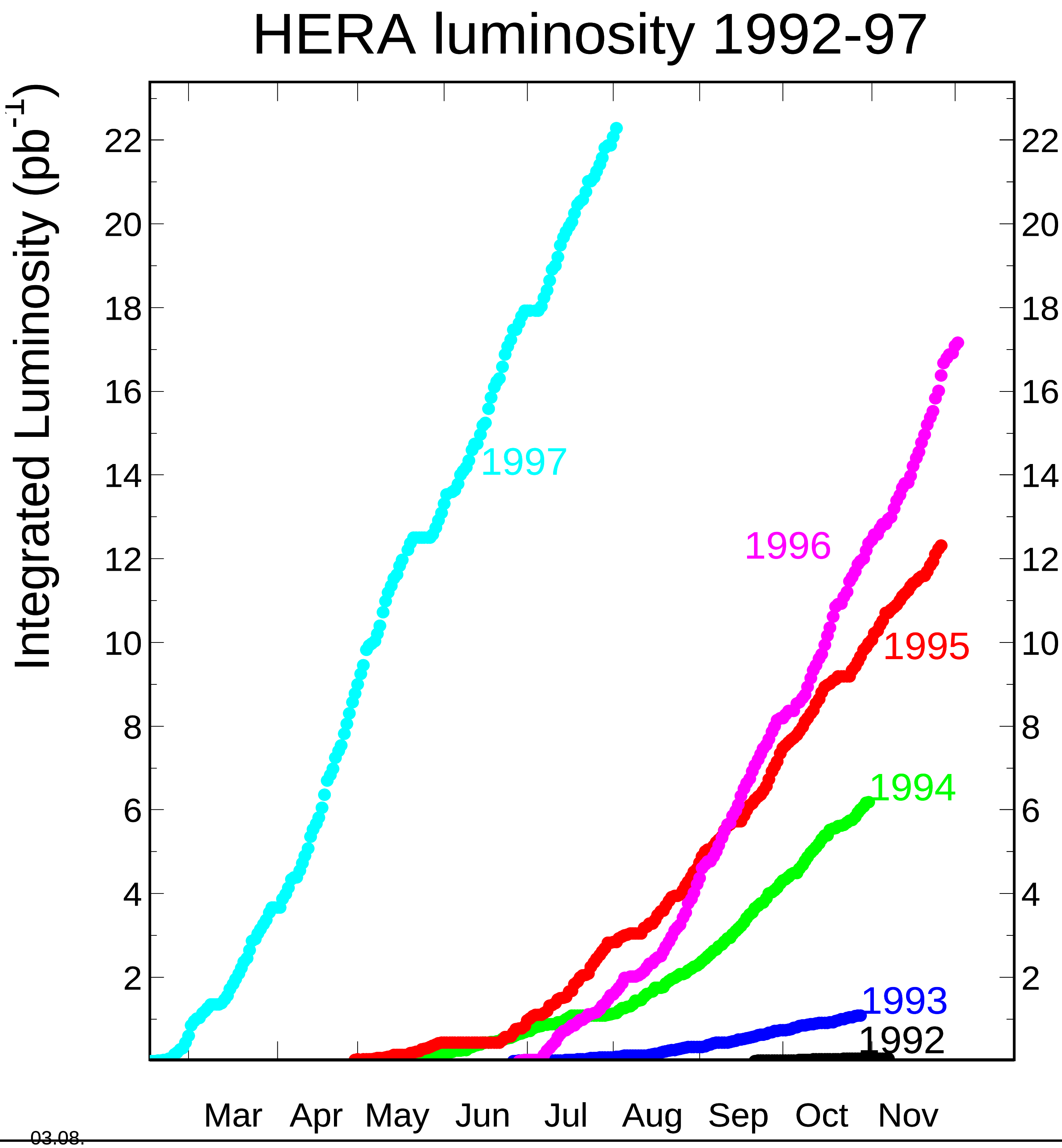
Communications

- Network Performance is Critical
  - **Present connections are good**
    - If have a good connection to ESNet
  - **Will this continue in the future?**
- Video Conference facilties
  - **Weekly group meetings important**

HERA Data Runs

ZEUS Data Samples:

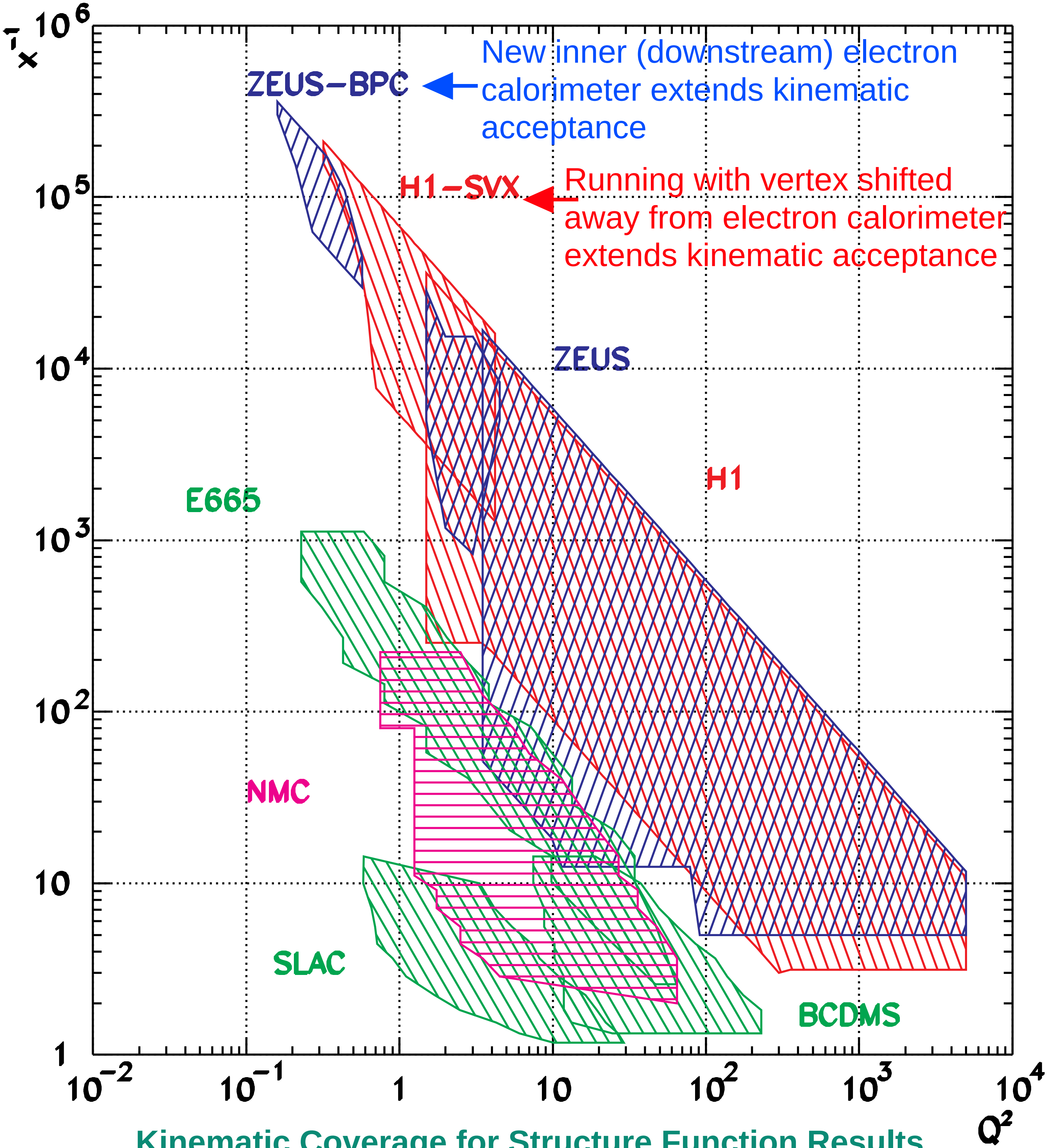
- 1 pb^{-1} e^-p (1993-1994)
- 22 pb^{-1} e^+p (1994-1996)
- 1997: 17.1 pb^{-1} e^+p (thru Aug. 3)



Kinematic Range

HERA: x below 10^{-5} and Q^2 above 10^4 GeV^2

Natural extension of FT experiments into unexplored kinematic regions



Kinematic Coverage for Structure Function Results

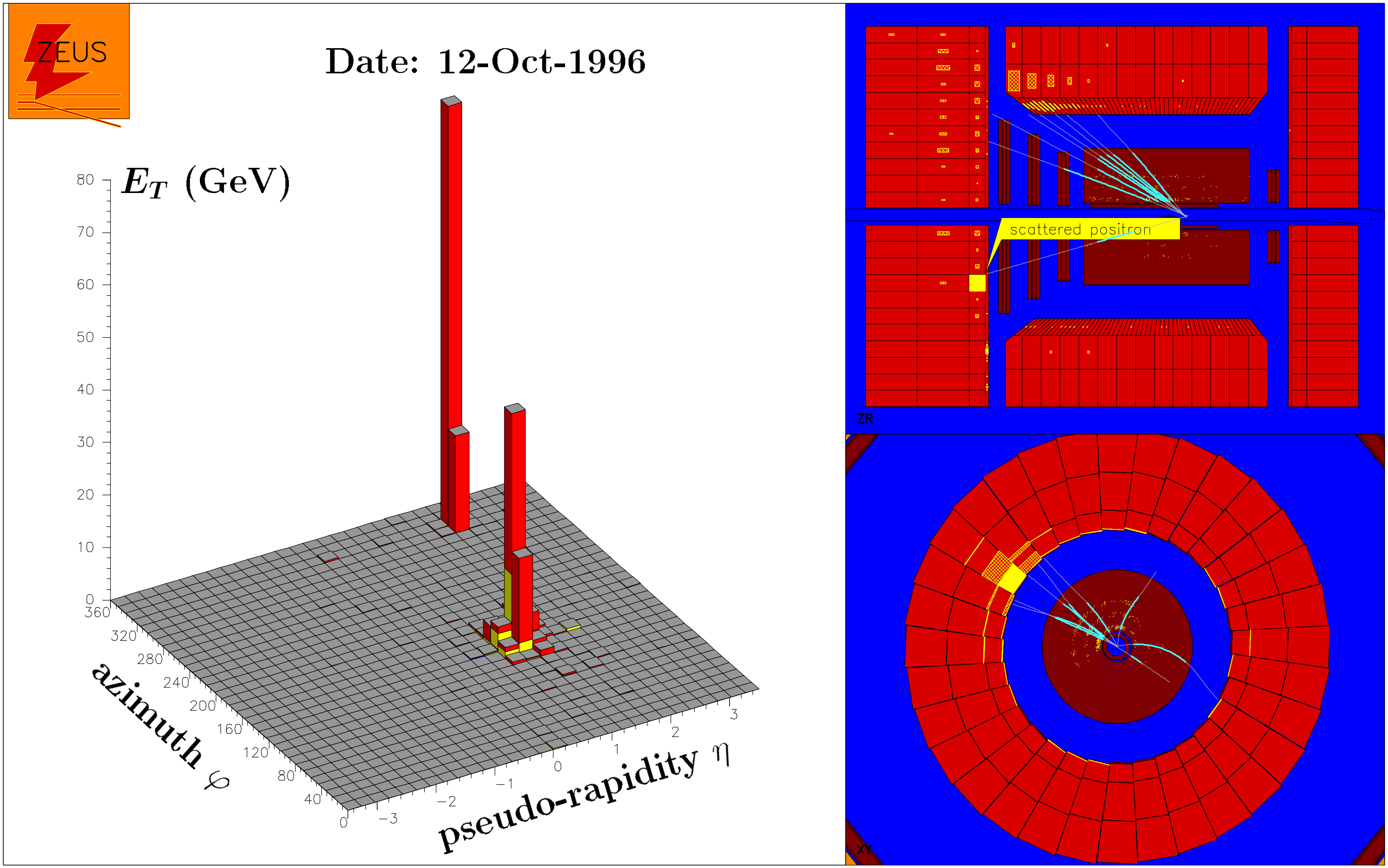
$E_t = 204\ GeV \quad E - p_Z = 50.2\ GeV \quad \gamma = 38.6^\circ$

$p_t = 2.2\ GeV \quad E'_e = 380\ GeV \quad \theta_e = 15.4^\circ$

$x_{DA} = 0.709 \pm 0.034 \quad x_e = 0.605 \pm 0.060$

$y_{DA} = 0.721 \pm 0.008 \quad y_e = 0.752 \pm 0.021$

$Q^2_{DA} = 46100 \pm 1600\ GeV^2 \quad Q^2_e = 41000 \pm 3000\ GeV^2$



High-x & Q^2

(from B. Straub, 1997 Lepton-Photon)

Preliminary H1 and ZEUS results on high Q^2 $ep \to eX$ and $ep \to \nu X$ scattering for 1994-1997 data sample.

Charged Current ($ep \to \bar{\nu}_e X$):

- **Tendency for the data to be above Standard Model DIS expectations at large Q^2. For $Q^2 > 10^4$ GeV^2, H1 and ZEUS observe 28 events where 17.7±4.3 are expected.**

Neutral Current ($ep \to eX$):

- **H1 observes 8 events with $y > 0.4$ and mass between 187.5 GeV and 212.5 GeV, where 1.5±0.3 events are expected. In this region, ZEUS observes 3 events and expects 2.9±0.24.**
- **ZEUS observes 5 events with $x > 0.55$ and $y > 0.25$, where 1.51±0.13 are expected. In this region, H1 observes 1 event and expects 0.75±0.30.**
- **The excess events observed at high x (M) are unlikely to be due to a single narrow resonance.**
- **Combined H1 and ZEUS cross sections for Q^2 cuts between 5000 and 30000 GeV^2 have been presented.**

Q^2_{min}	σ_{comb}	σ_{SM}
15000 GeV^2	$0.71^{+0.14}_{-0.12}$ pb	0.49 pb
30000 GeV^2	$0.098^{+0.059}_{-0.042}$ pb	0.023 pb

Other Physics Highlights

Structure Functions

- Dramatic rise w/ decreasing x at low-x
- Extraction of Gluon Distribution
- Low-Q^2 transition to pert. QCD

Photoproduction

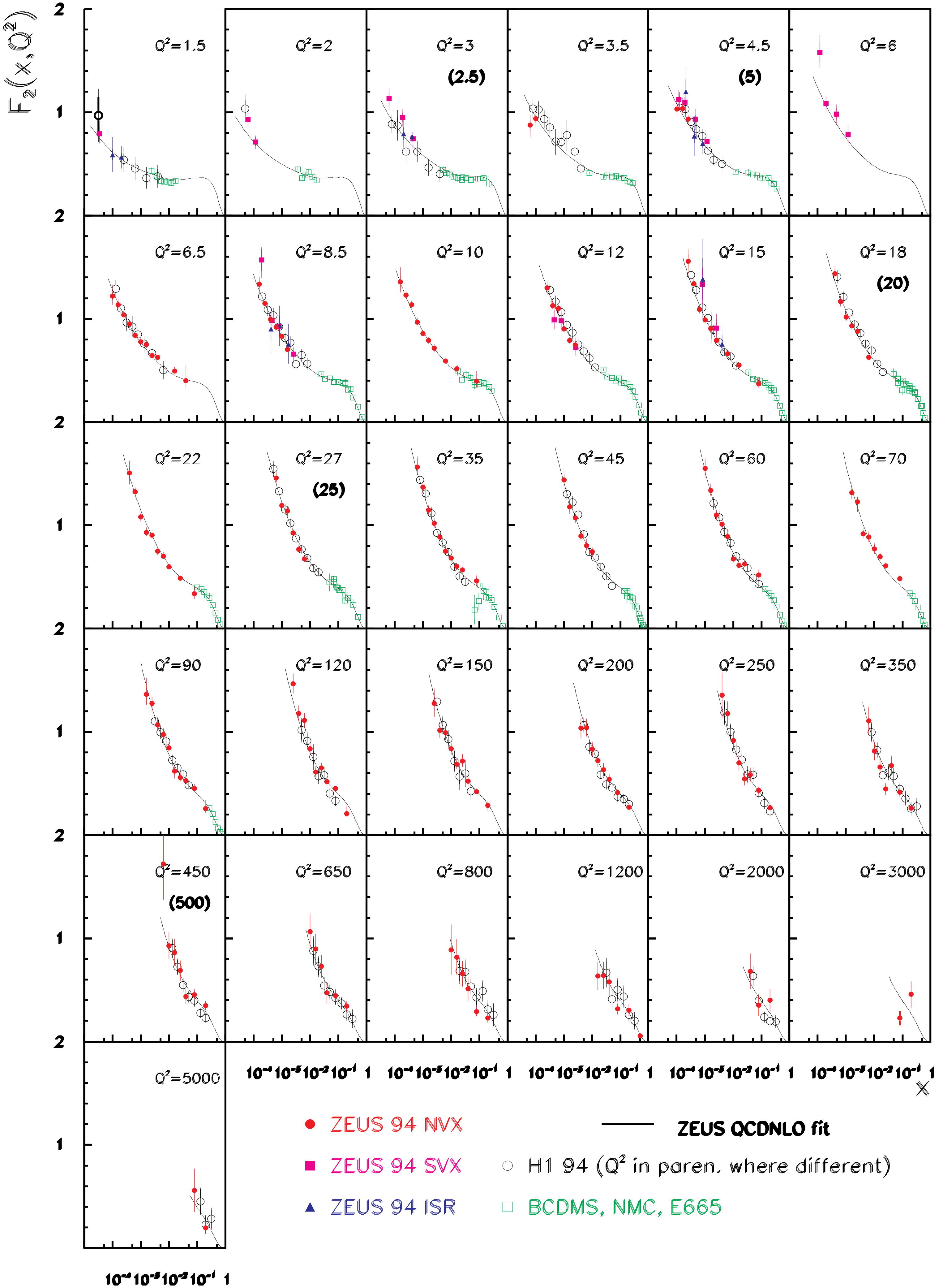
- Structure of Photon
- Separation of quark & gluon exch.

Diffraction

- Striking signal -- clear identification
- Structure of Pomeron

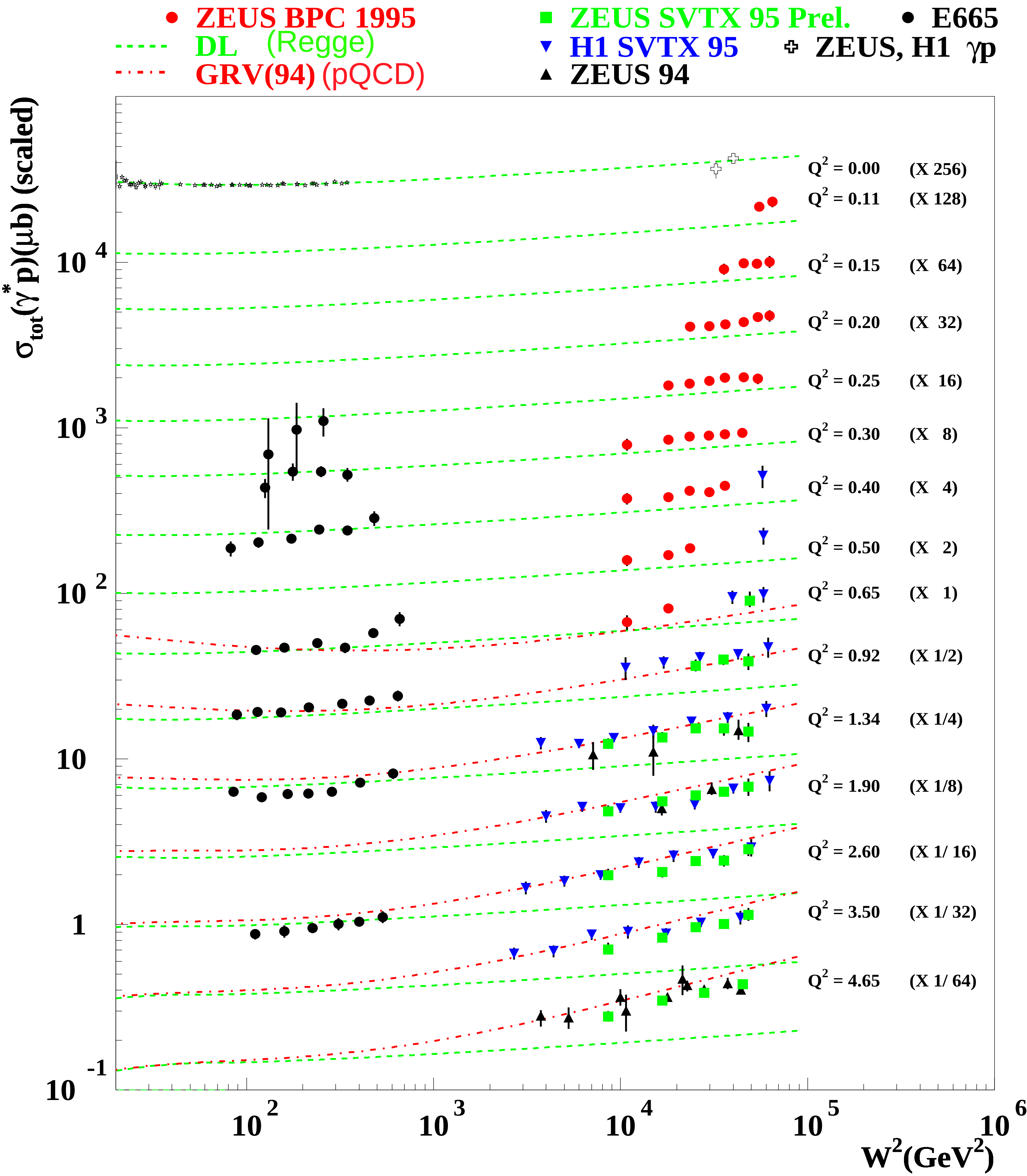
Vector Mesons

- Elastic & Deep Inelastic
- QCD Laboratory



$F_2(x,Q^2)$
Q^2=1.5
Q^2=2
Q^2=3
(2.5)
Q^2=3.5
Q^2=4.5
(5)
Q^2=6
Q^2=6.5
Q^2=8.5
Q^2=10
Q^2=12
Q^2=15
Q^2=18
(20)
Q^2=22
Q^2=27
(25)
Q^2=35
Q^2=45
Q^2=60
Q^2=70
Q^2=90
Q^2=120
Q^2=150
Q^2=200
Q^2=250
Q^2=350
Q^2=450
(500)
Q^2=650
Q^2=800
Q^2=1200
Q^2=2000
Q^2=3000
Q^2=5000
10^{-4} 10^{-3} 10^{-2} 10^{-1} 1
x
ZEUS 94 NVX
ZEUS 94 SVX
ZEUS 94 ISR
ZEUS QCDNLO fit
H1 94 (Q^2 in paren. where different)
BCDMS, NMC, E665

Pert. QCD - Non-Pert. QCD



Future Outlook

1997:

- Take data until October (e^+p)
- Expect to double 1994-96 e^+p statistics

1998-1999:

- Modifications to HERA
- e^-p running
- Expect similar luminosity as e^+p

2000-2005:

- Major HERA upgrade
- Factor of 7 increase in luminosity
  - 1×10^{31} to 7×10^{31}
- Possibility to run with polarized $e^{+/-}$
- Goal of 1 fb^{-1} by 2005

Physics expectations by 2005:

- $\alpha_s(M_z)$ measured to .001
- $xg(x)$ measured to 1%
- Does the rise at low-x continue?
- Quark couplings from NC, CC polarized $e^{+/-}$
- $WW\gamma$ couplings
- Leptoquarks?

Physics Results & Outlook

HERA Physics

- Phenomena at low & high Q^2
- Perturbative & Non-Perturbative QCD
- Comparison of NC & CC

US Institutions

- Play a leading role in physics analysis
- Continue to harvest good physics from initial DoE/NSF investment

Future Program

- Major investment by DESY & experiments
- US groups have played an important role in shaping the future HERA program
- US program will benefit from new physics with little additional investment
- US participation is critical for continued Zeus operation
- Exciting long-term future until 2005