AmZeus Program

DOE Presentation

Wesley H. Smith, *U. Wisconsin*
Chair, AmZeus

March 11, 2004

Outline:

AmZeus overview- W. Smith
DESY plans: Zeus & HERA, US Role - R. Klanner
Zeus Physics Overview - R. Yoshida
ANL Role in ZEUS - J. Repond

This talk is available on:
http://www.hep.wisc.edu/wsmith/zeus/DOE04/AmZeusDOE-Mar04.ppt

AmZeus Membership

(January, 2004)

S. Chekanov, M. Derrick, J.H. Loizides*, S. Magill, S. Miglioranzi*,
B. Musgrave, J. Repond, R. Yoshida,
Argonne National Laboratory,
M. Helbich*, Y. Ning*, Z. Ren*, W.B. Schmidke, F. Sciulli
Columbia University
N. Brummer, B. Bylsma, L.S. Durkin, T.Y. Ling
Ohio State University,
E.A. Heaphy, F. Metlica, B.Y. Oh, J.J. Whitmore
Pennsylvania State University,
A. Everett*, L.K. Gladilin, D. Kcira, S. Lammers*, L. Li*,
D.D. Reeder, M. Rosin*, P. Ryan*, A.A. Savin, W.H. Smith
University of Wisconsin, Madison,
S. Dhawan (Yale University), M. Mattingly (Andrews U.)

23 Ph.D. Physicists +
10 Ph.D. Students

All Zeus: 241 Ph. D. Physicists + 84 Students
(Belgium, Canada, Germany, Greece, Israel, Italy. Japan, Kazakhstan,
Korea, Netherlands, Poland, Russia, Spain, UK, USA)

HERA

HERA: an electron-proton collider at DESY in Hamburg, Germany

2 collider experiments
--> H1 and ZEUS
2 fixed target experiments
--> HERA-B and HERMES

HERA I: 1992-2000

~130 pb^{-1} taken by ZEUS, H1

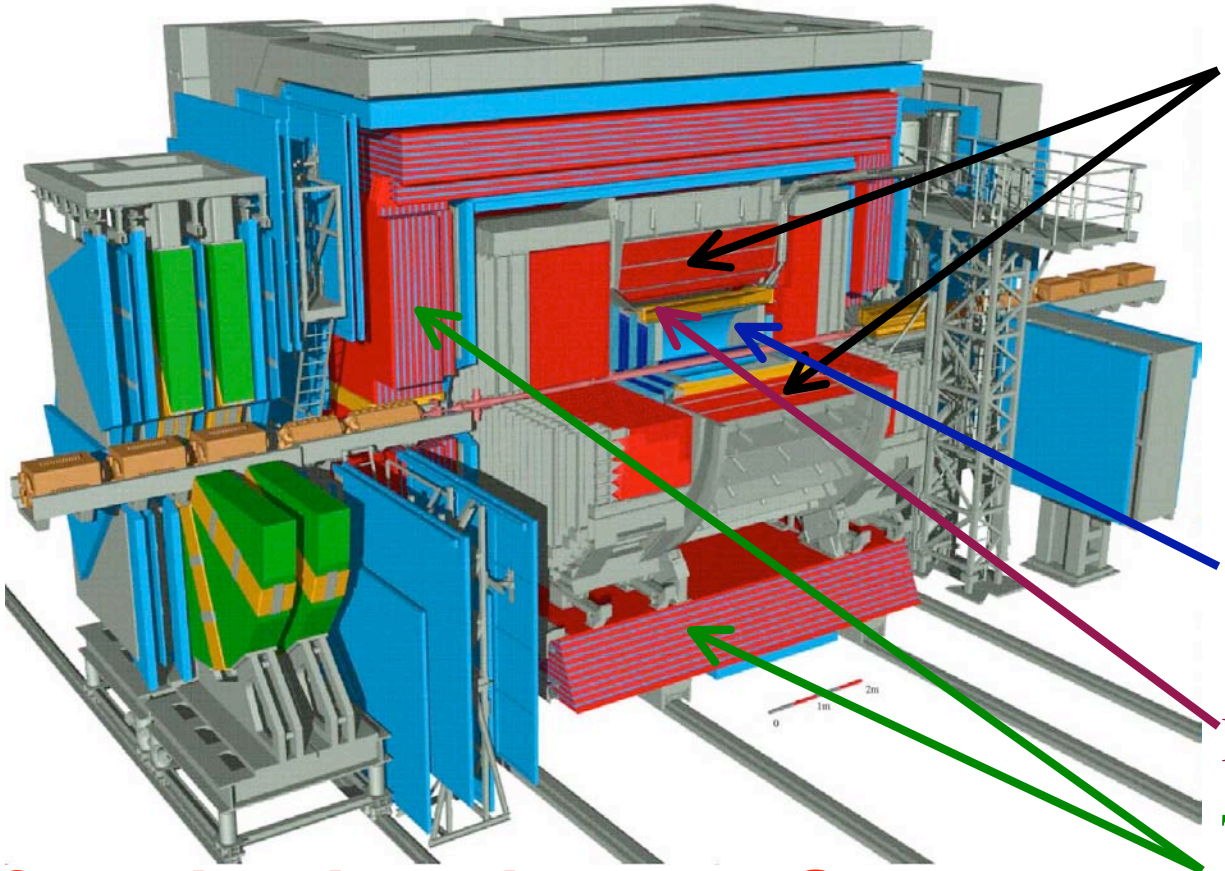
- 920 GeV protons (820 before1998)
- 27.5 GeV $e^{\pm}$
- 300/318 GeV c.o.m. energy
- 220 bunches, 96ns. crossing time
- 90 mA protons,40 mA positrons
- Instantaneous luminosity: $1.8 \times 10^{31} cm^2 s^{-1}$

2000-2002 Luminosity Upgrade

HERA II: 2003-2007

Luminosity Goal : 750 pb^{-1}

US Contributions to ZEUS



Uranium-Scintillator Barrel Calorimeter & its electronics/readout & calibration systems

First Level trigger for entire calorimeter

Small Rear Tracking Detector Electronics

Barrel Presampler

Toroidal Iron Magnet design & coils built

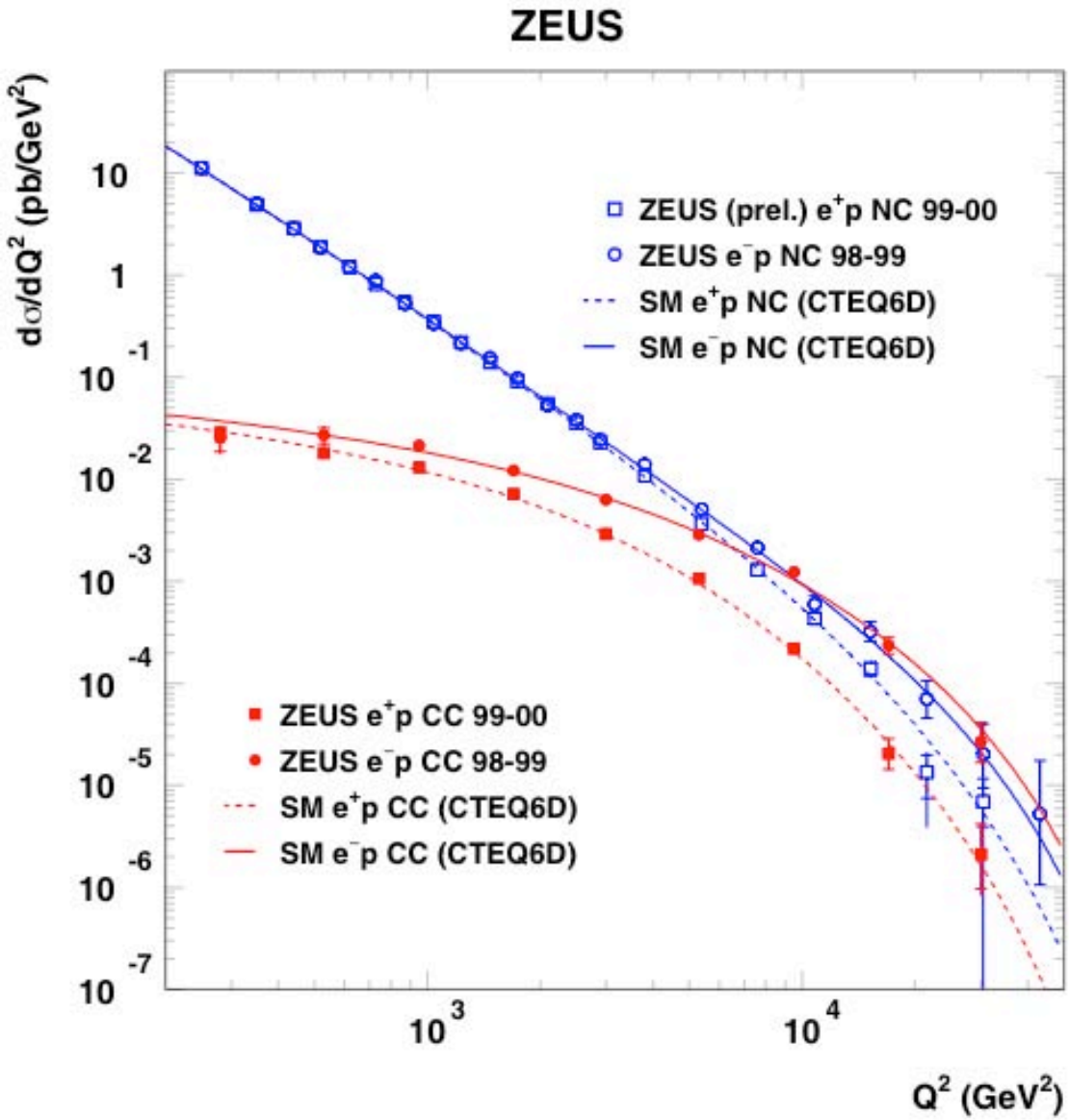
Plus upgrades for HERA-II (next slides)

Contributions incl. M&O support

Obligation to exploit investment

- **Reap the rich physics harvest**

HERA I Electroweak Unification



Charged & Neutral Current σ's

- Protons on electrons and positrons

$Q^2 < 1000$ GeV^2

- $\sigma^{NC} >> \sigma^{CC}$ due to γ vs. W propagator

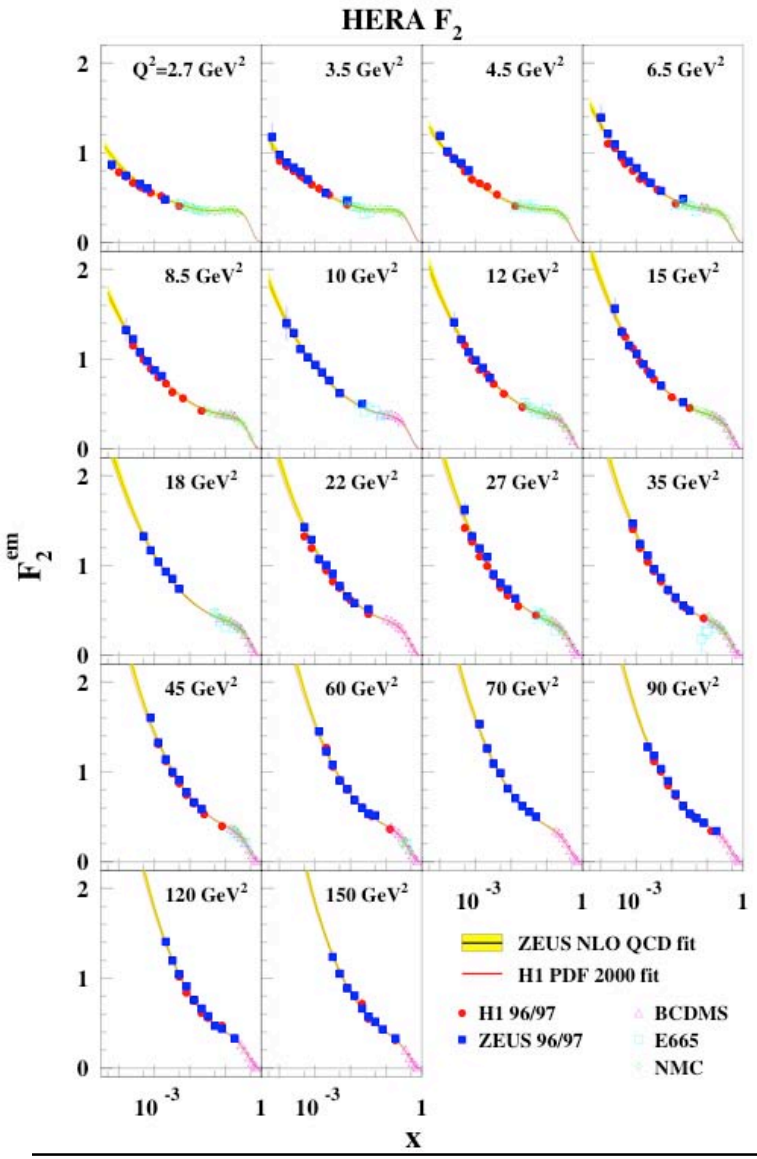
$Q^2 \geq 10000$ GeV^2

- Unification of weak & EM forces

Standard Model

- Excellent description of data

HERA I Structure Functions

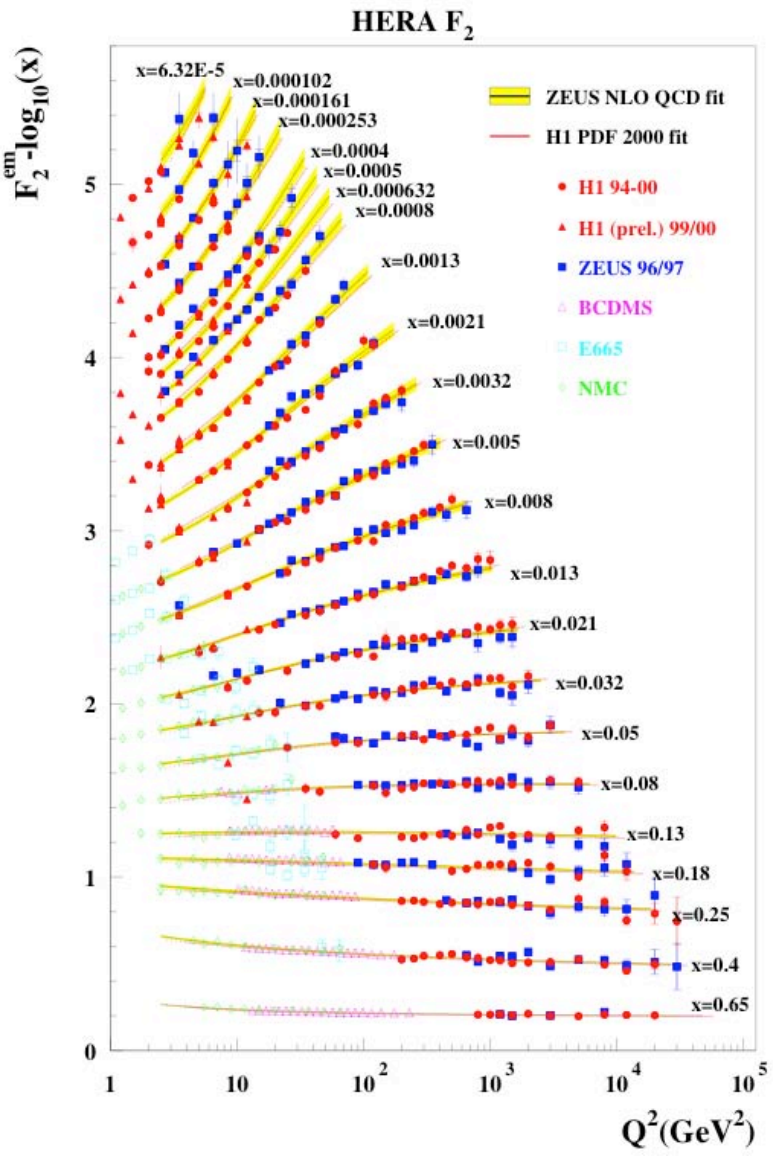


←F_2 vs. x

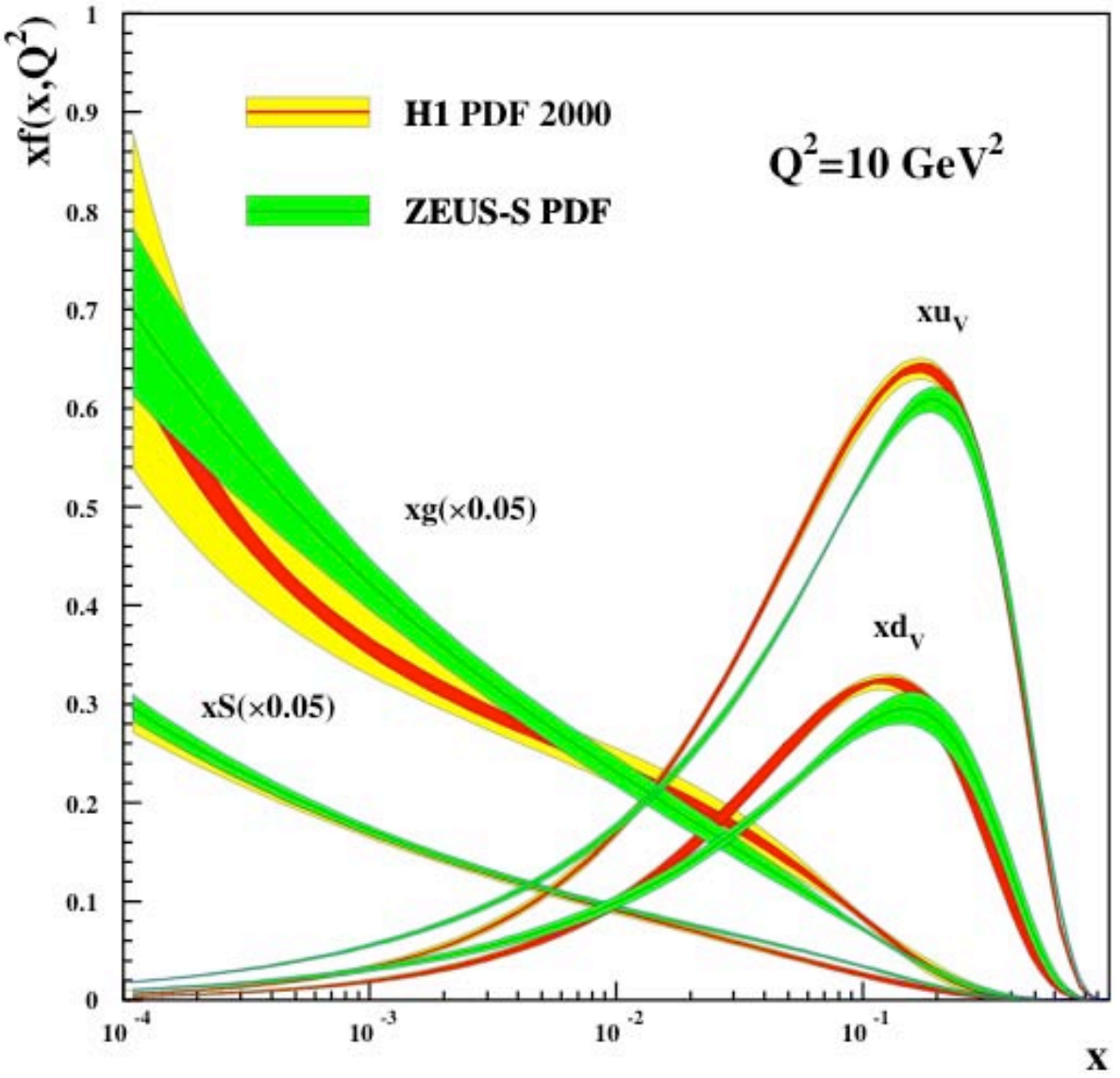
- Rapid rise of F_2 as x→ 0
- No slow down of F_2 rise seen yet

F_2 vs. Q^2→

- Data span 4 decades of Q^2
- +/- scaling violations
- SM gives excellent description



HERA I Parton Distributions



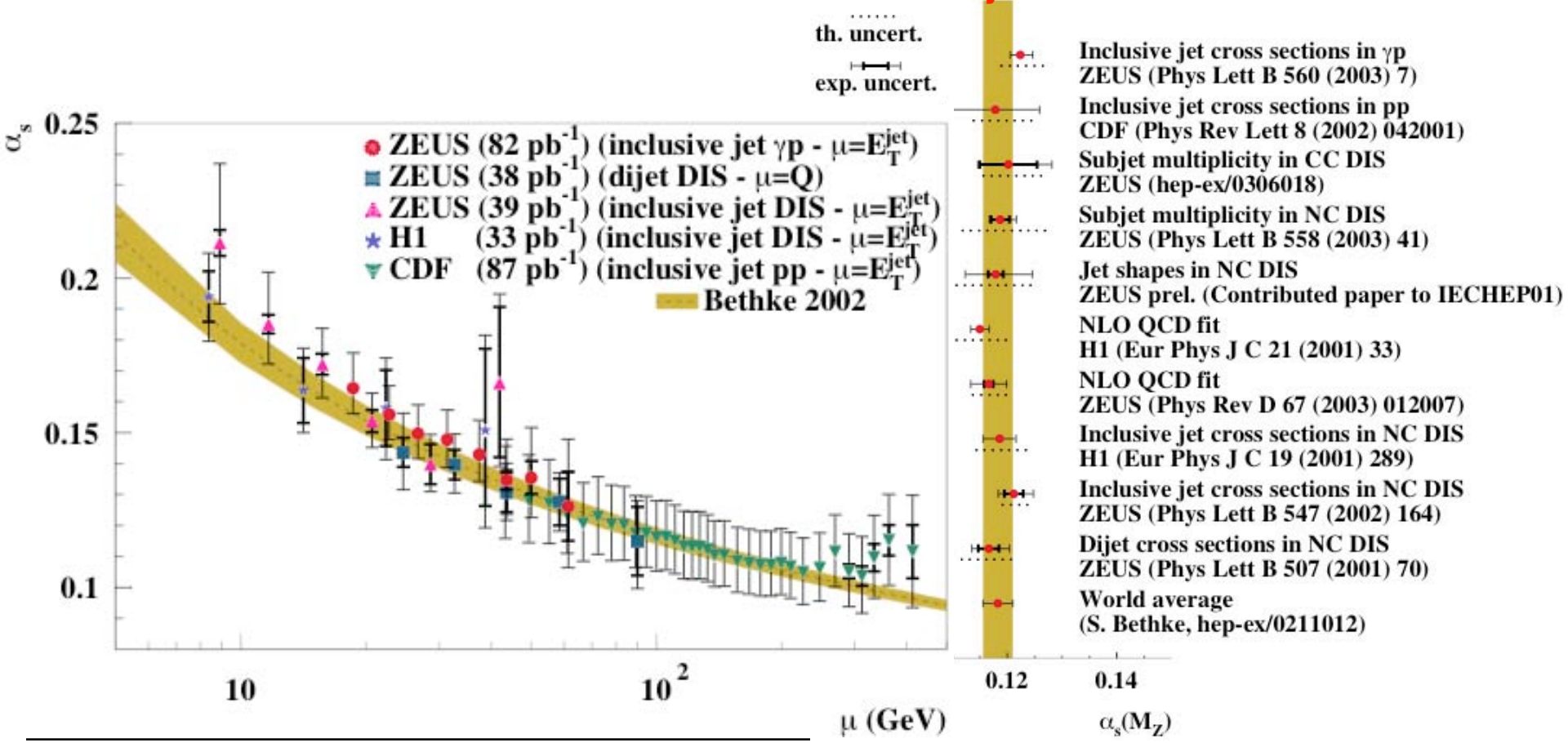
- Good agreement btw. quark & gluon densities from ZEUS & H1
- Rapid rise of gluon density as $x \rightarrow 0$
- Implications for LHC
  - Particle production from gluons

HERA I Jets & α_s

HERA data clearly show running of α_s

α_s values are as precise as other measurements

Zeus is doing precision Jet Physics (σ_{syst} down to 2%):



Other HERA - I Physics

Competitive & Complementary Search for New Physics:

- Large Extra Dimensions (new paper ~ Tevatron)
- Single Top Production (best limit)
- Leptoquarks (best limit)
- R-Parity violating SUSY (best limit)
- Instantons (unique)

Heavy Quark Contribution to F_2

- $F_2^{CC}/F_2 \sim (4/3)/(13/3)$

Observed transition from partonic to hadronic behavior

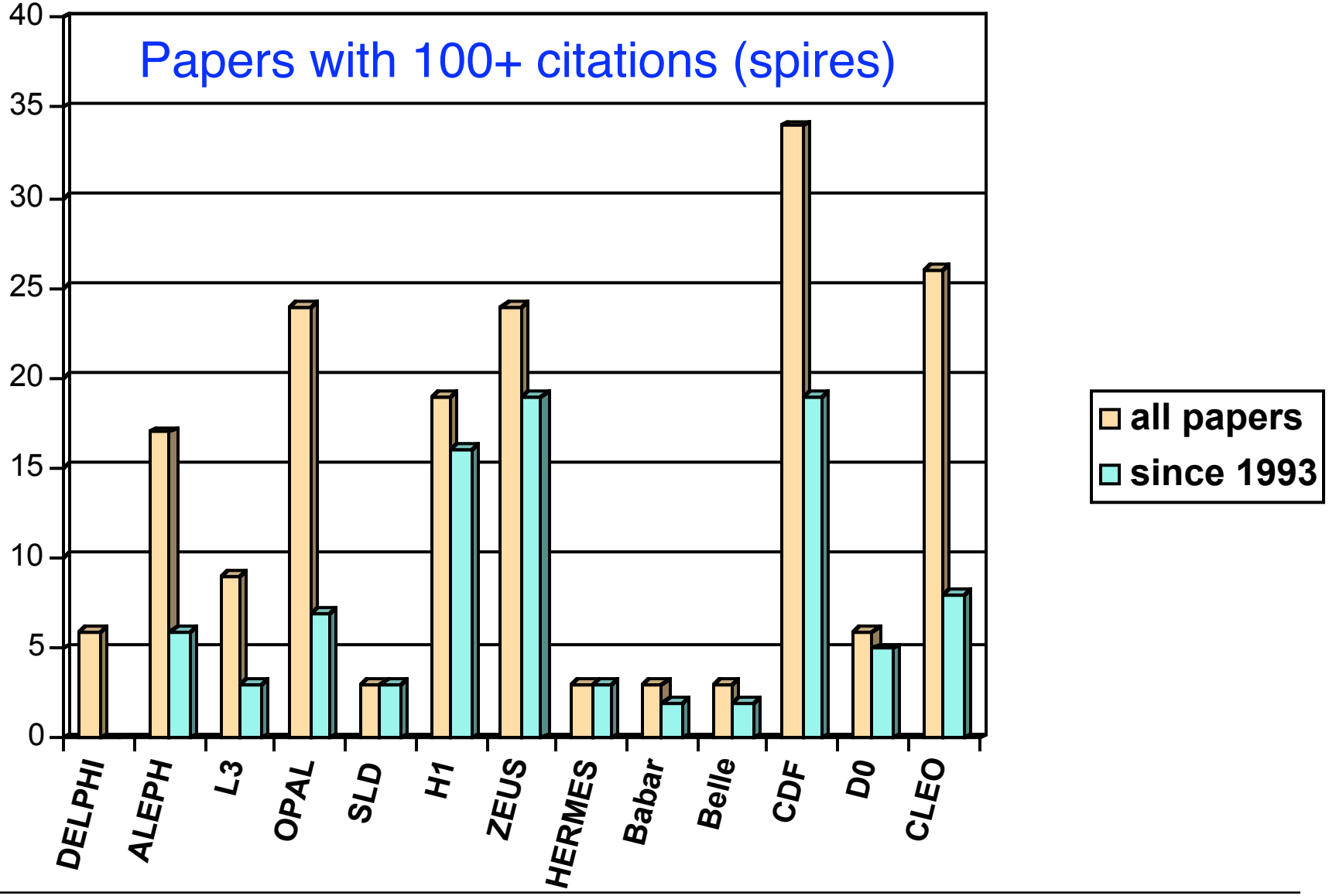
- F_2 transition around $Q^2 \sim 3 \rightarrow 0.4$ GeV^2

Diffraction:

- Deep Inelastic Virtual Compton Scattering: W- & Q^2- dependence
- Vector Meson production
- Inclusive: t-, M_X,Q^2 & W- dependence, substantial part of DIS

For more, see talk by R. Yoshida

HERA - I Impact

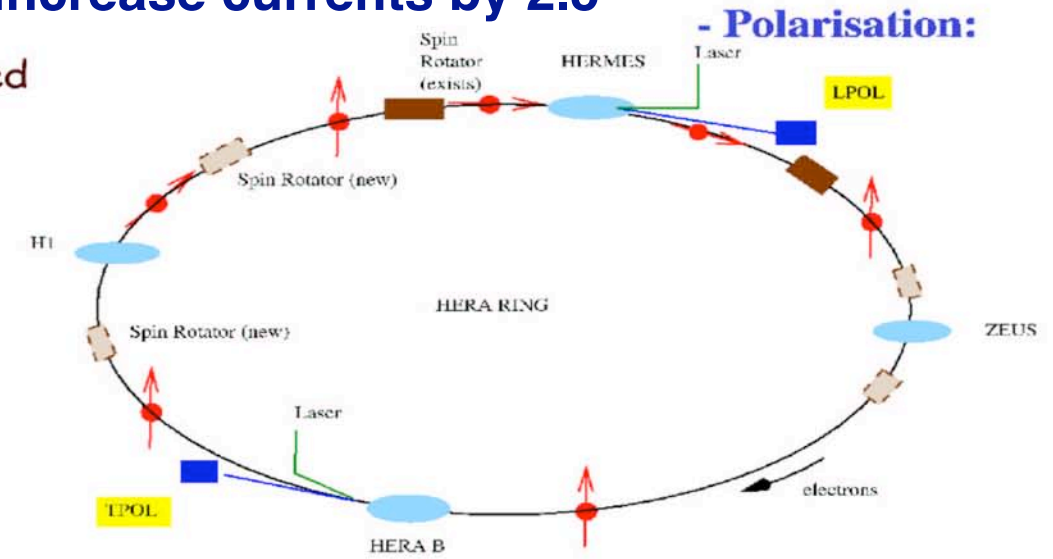


HERA - II Upgrades

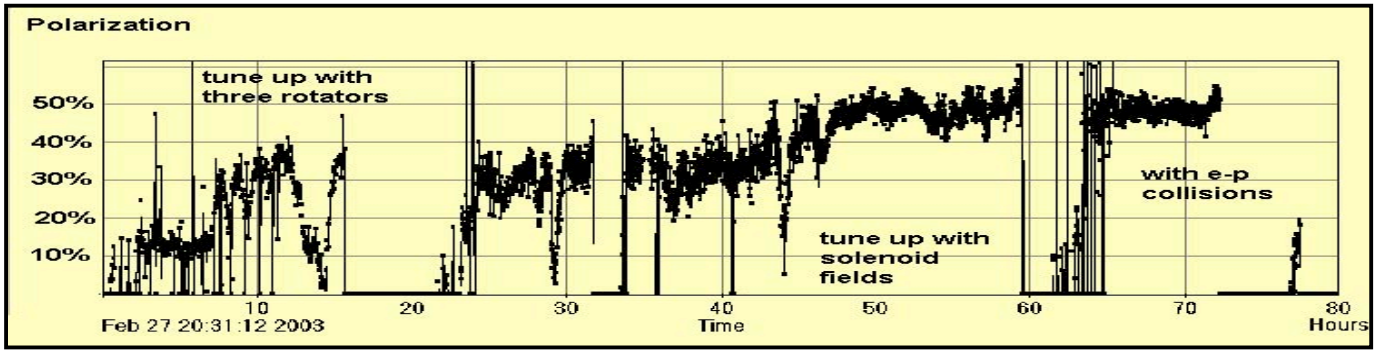
Luminosity x 5 & Polarization ~ 50%

- Reduce beam σ by 2.5 & increase currents by 2.5

A final focusing magnet being installed



Spin Rotators successfully implemented

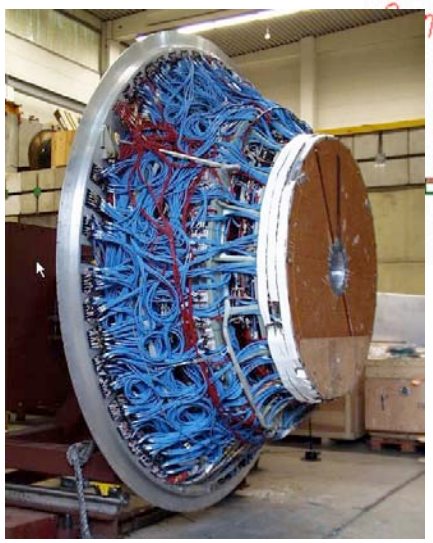


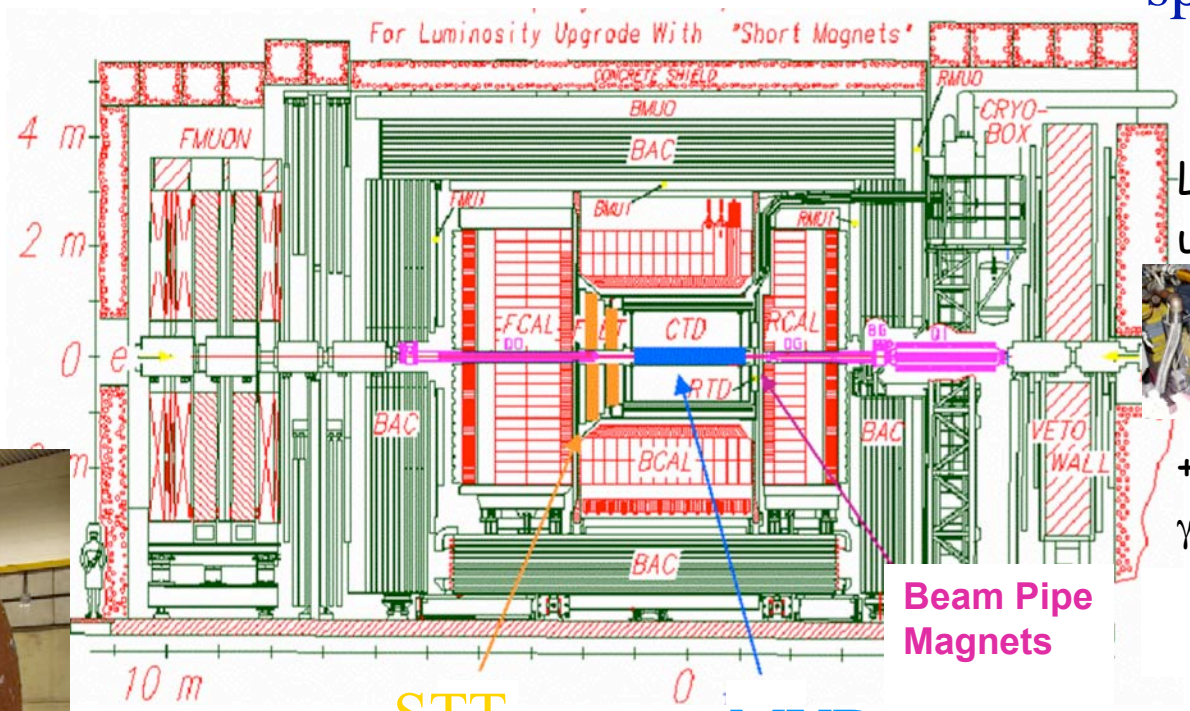
Significant Polarimeter upgrades implemented

ZEUS HERA-II Upgrades

US contributes Readout Electronics

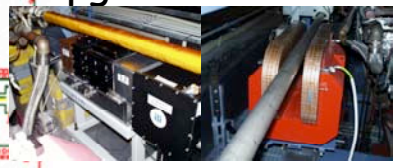
Straw Tube Forward Tracker





US builds spectrometer

Lumi detector upgrades

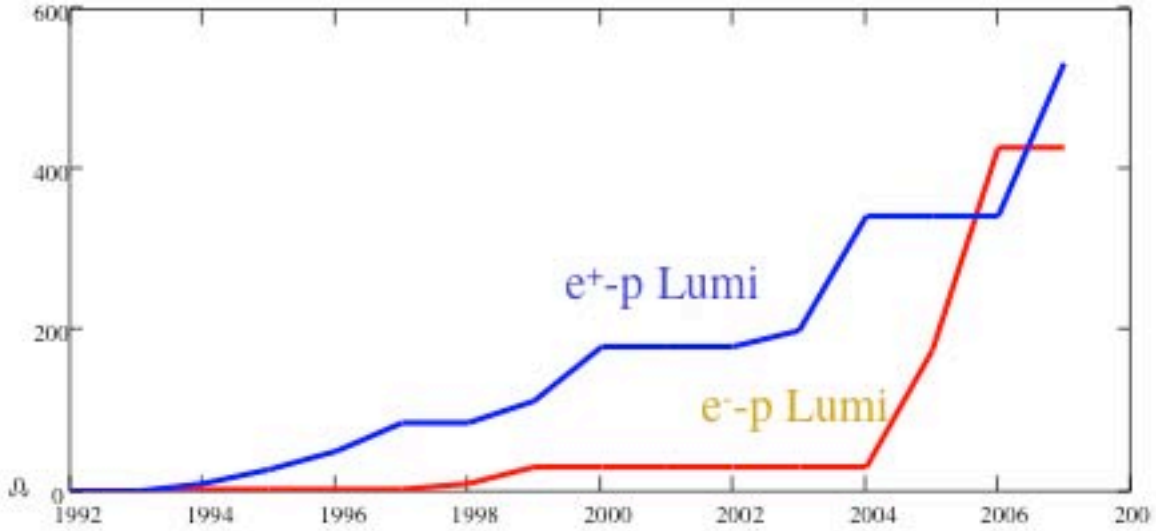


+ beam counters, γ tagger

Micro Vertex Detector

US contributes to Second Level Tracking Trigger

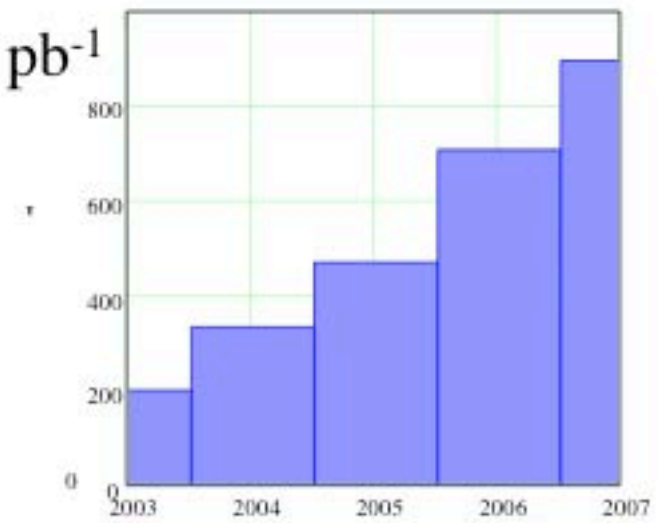
HERA - II Projected Performance



Planned accumulation of electron-proton and positron-proton luminosities at HERA

1992-2007

total luminosity at HERA accumulated between 1992-2007



Latest News:

- **Beam-related background problems solved**
- **HERA is going for full currents: new luminosity record!**

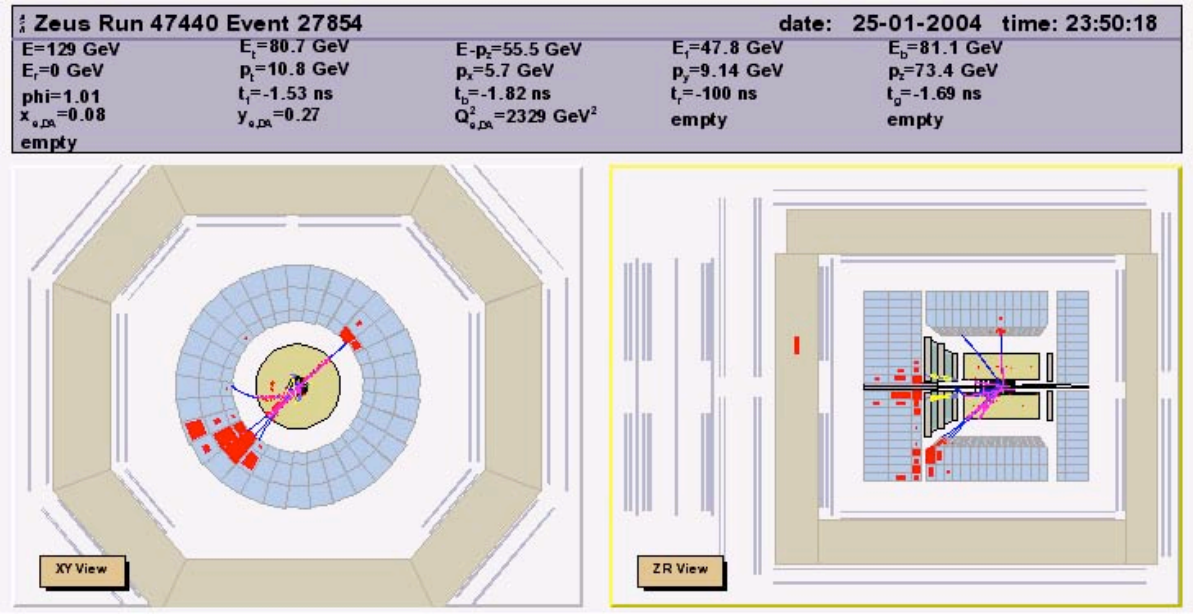
HERA - II Events

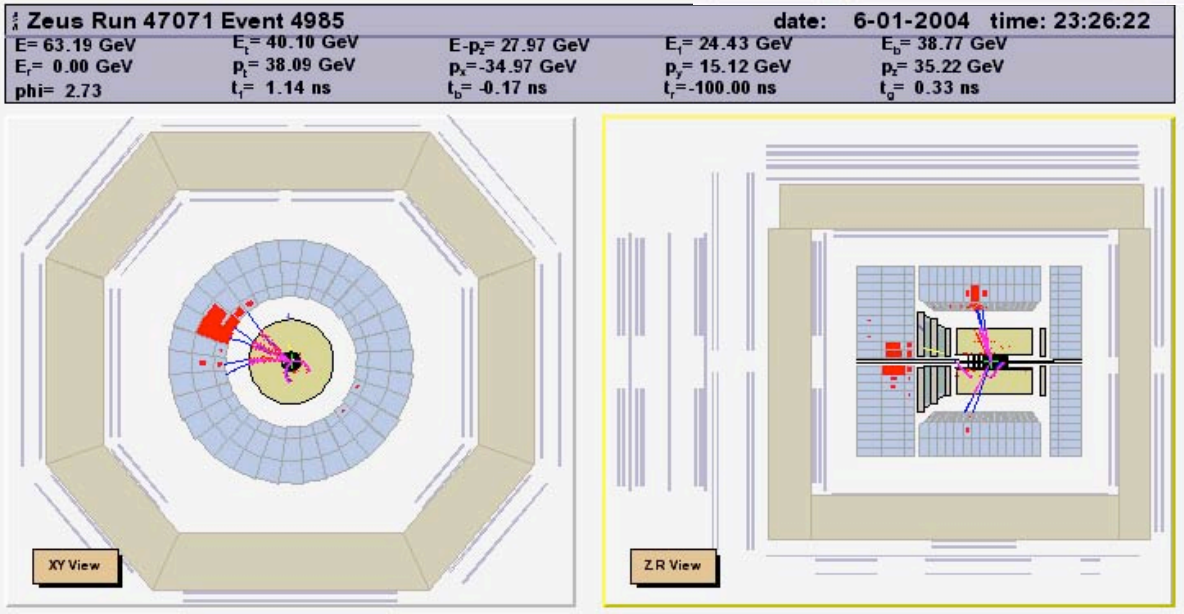
Neutral Current DIS

$e^{\pm} p \rightarrow e^{\pm} X$ (γ,Z^0 exchange)

$Q^2 = 2325$ GeV^2

$x = 0.08$





Charged Current DIS

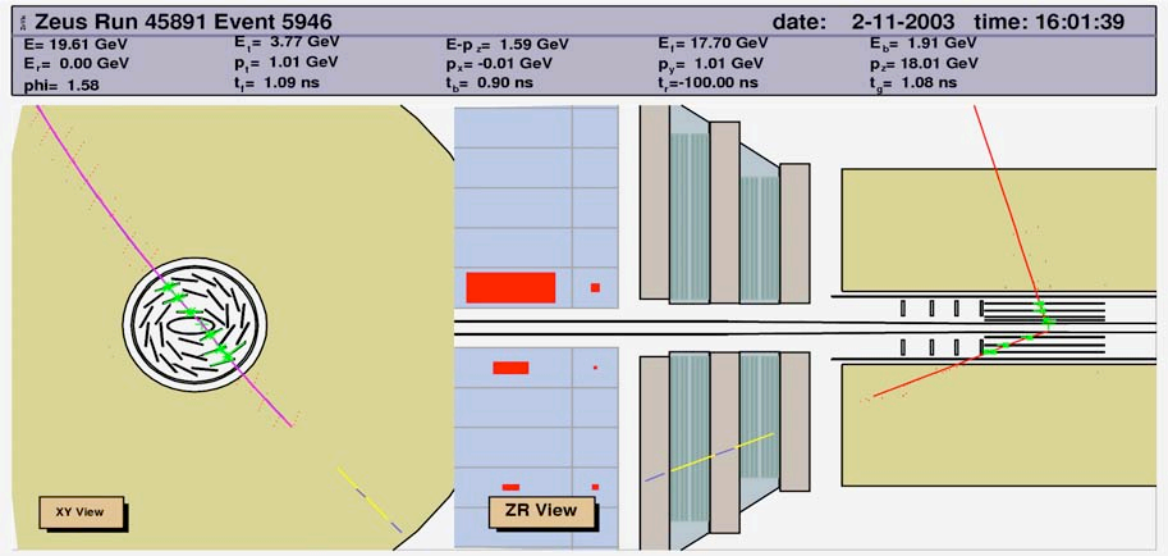
$e^{\pm} p \rightarrow \nu X$ ($W^{\pm}$ exchange)

$Q^2 = 2800$ GeV^2

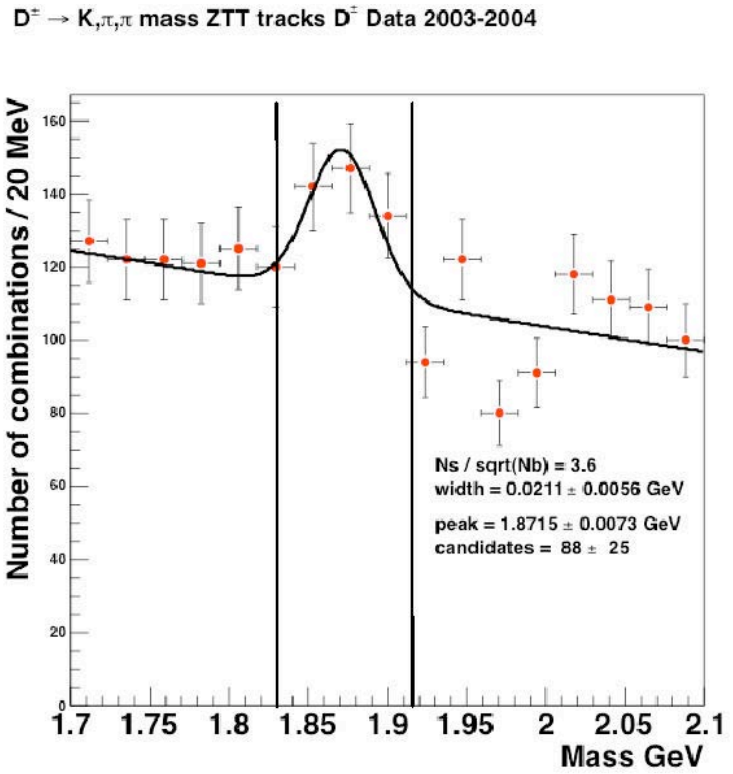
$p_T = 38$

New Zeus Tracking for HERA - II

MVD and STT:



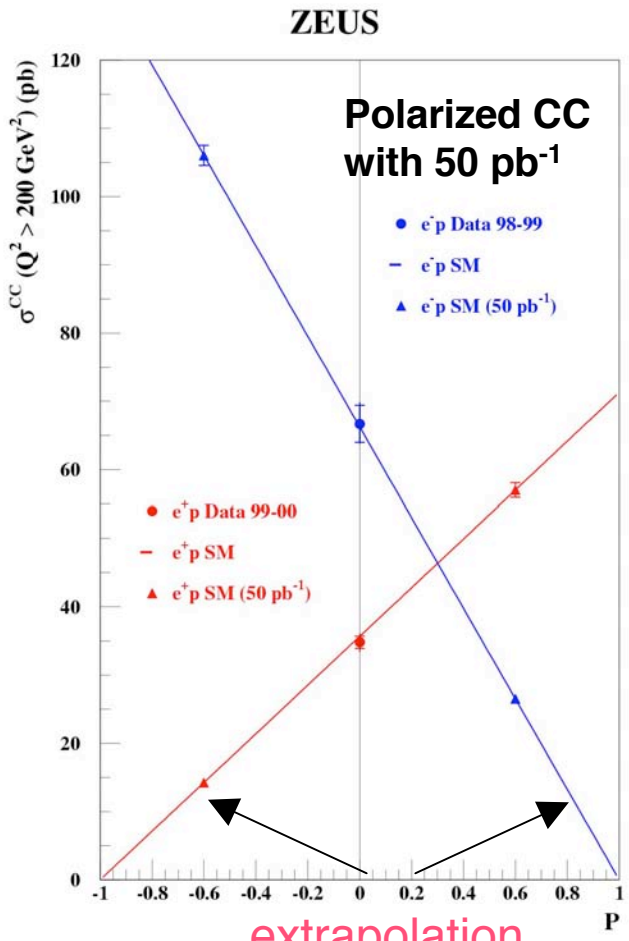
D* from MVD:



HERA - II Analyses

Structure Function Measurements:

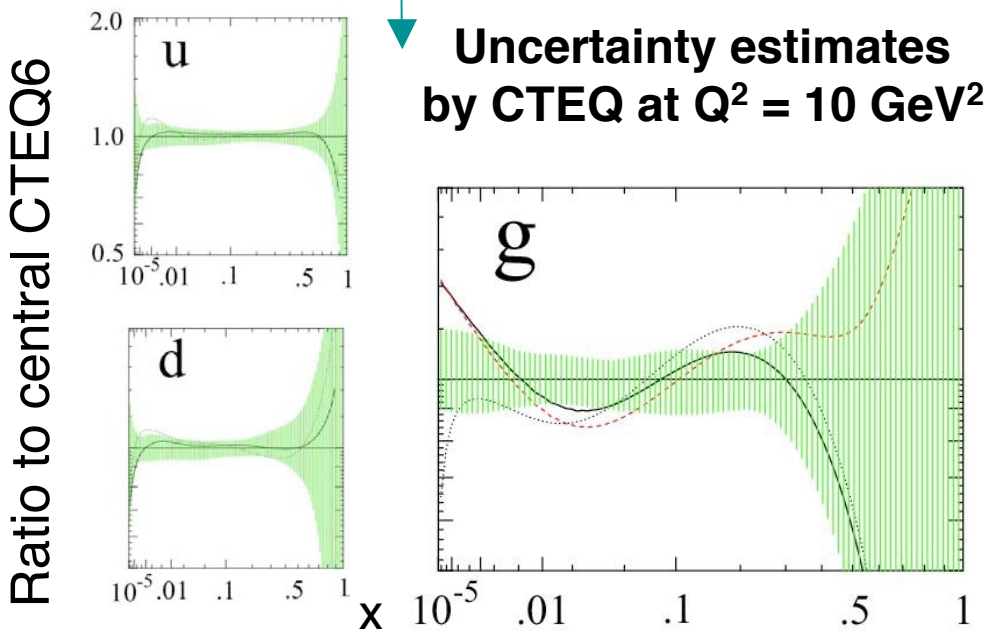
- more accurate CC, NC xF_3, F_L
- polarized cross section
- charm, bottom contributions
- parton density functions



extrapolation

sensitivity to new physics

Uncertainty estimates by CTEQ at $Q^2 = 10$ GeV^2



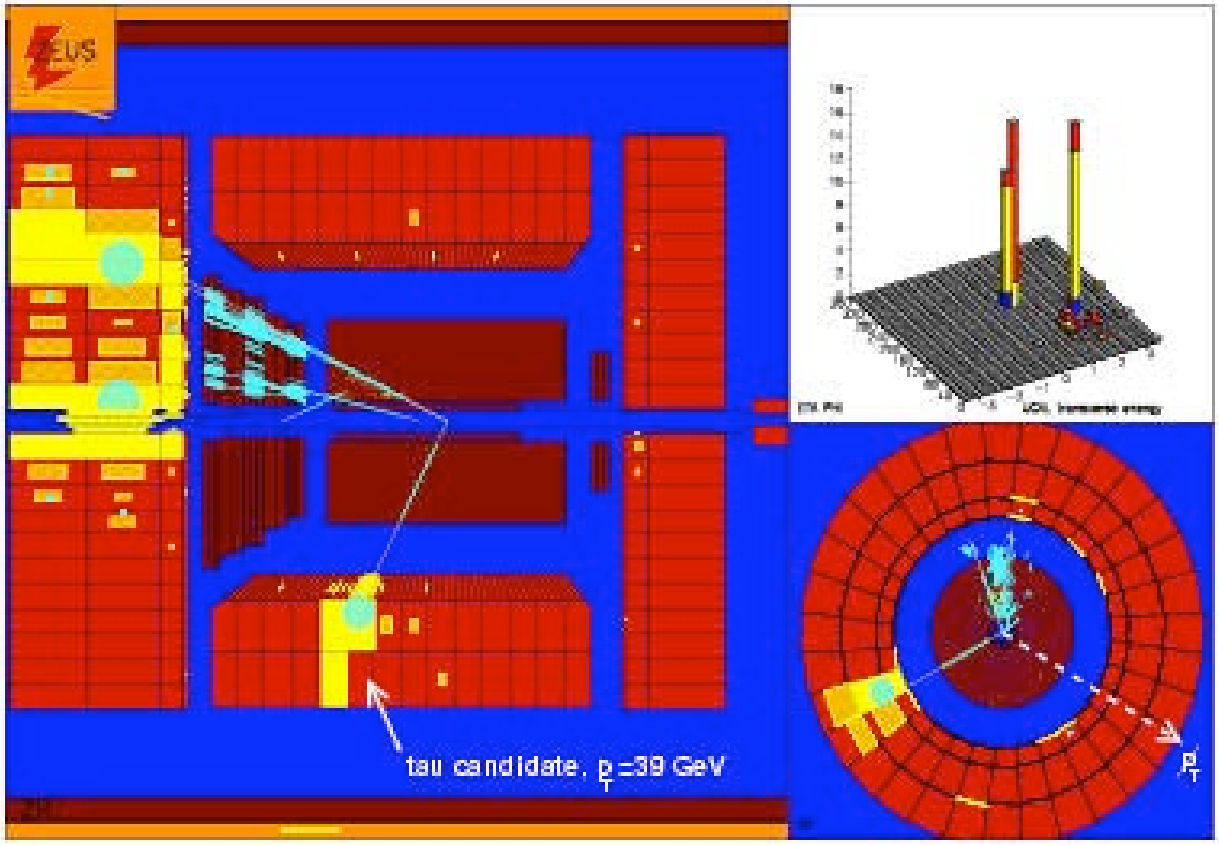
u density most constrained

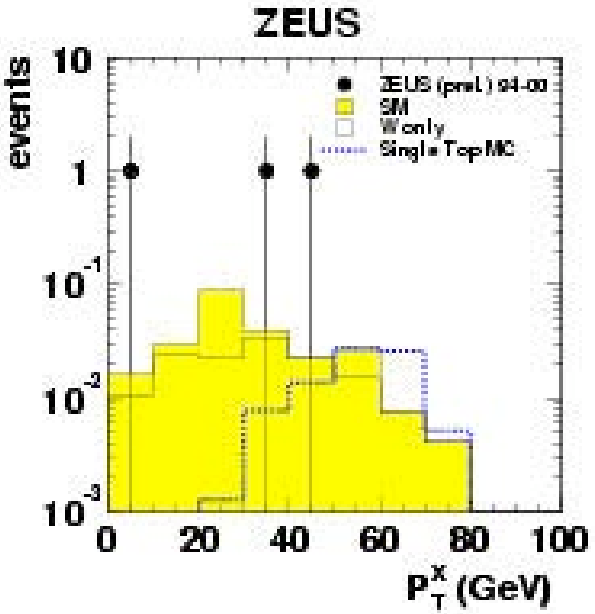
gluon density poorly constrained at high x

HERA- II Searches for Physics Beyond Standard Model

HERA-I Isolated τ's & missing P_T

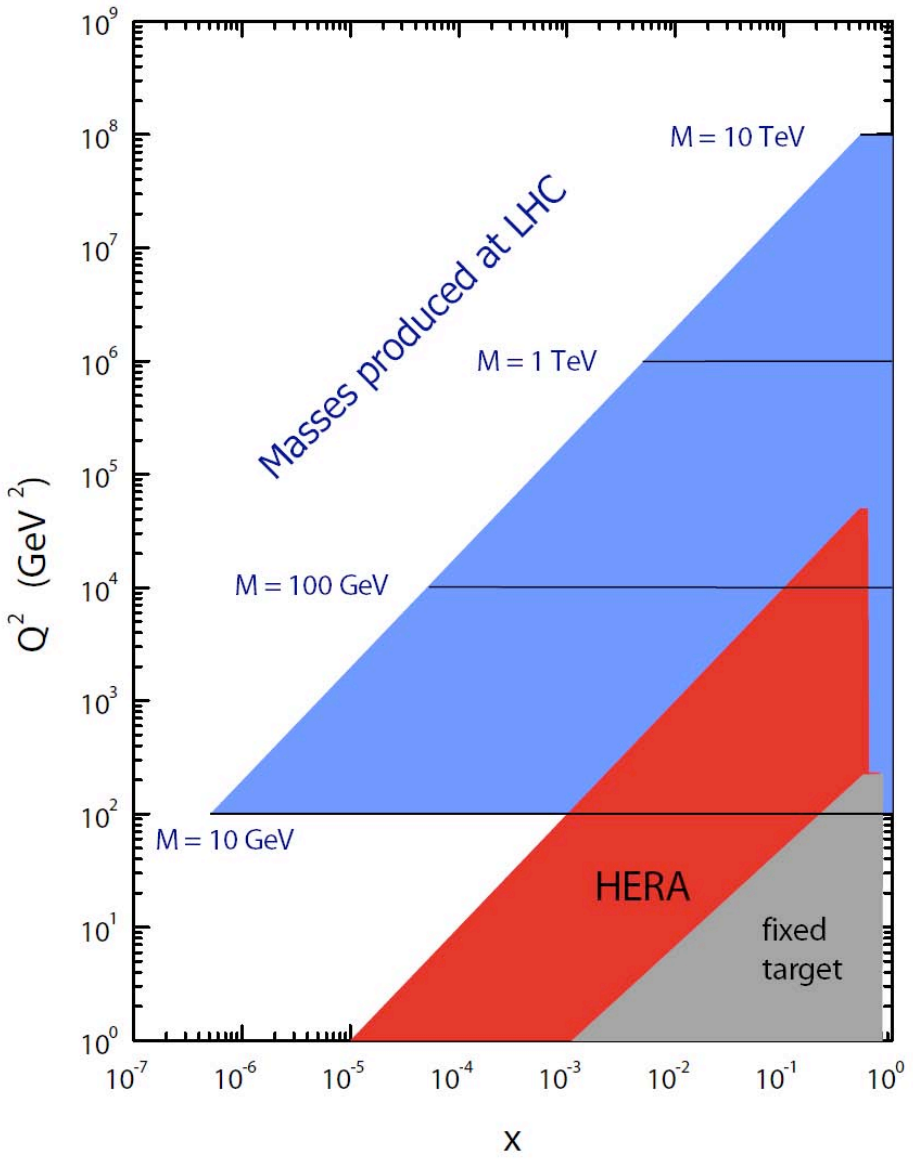
- Excess > SM expectation -- resolve with HERA - II





P_t^X cut	observed	expected
none	3	0.23 ± 0.06
25 GeV	2	0.12 ± 0.02
40 GeV	1	0.06 ± 0.01

HERA → LHC



HERA densities extrapolate into LHC region

DGLAP parton densities, QCD knowledge from HERA

↓

LHC measurements

HERA measurements crucial for understanding signal + background at LHC!

HERA/LHC workshop, starting this month and continuing for the next year will study the use of HERA measurements for LHC

AmZeus Leadership Role

US totals (& DOE only)

Number of physics coordinators: 15 (10)

Number of coordinators of a technical task (e.g. calorimeter, trigger, etc): 7 (7)

Number of people in upper management:

- Physics chair (appointed): 2 (1)
- Deputy spokesmen (elected) : 2 (1)
- Spokesmen (elected) : 2 (1)

AmZEUS members currently in ZEUS management positions:

- Spokesman: R.Yoshida (Argonne)
- Trigger Coordinator: W. Smith (Wisconsin)
- Physics Coordinators: S. Chekanov (Argonne),A. Savin (Wisconsin)

AmZeus HEP Leadership:

- DIS '97 hosted by ANL (J. Repond)
- DIS '05 hosted by U. Wisconsin (W. Smith)

AmZeus Maintenance

Calorimeter (All)
- All: only US responsibility shared with other countries

Calorimeter readout electronics
- Columbia)

Calorimeter first level trigger
- Wisconsin

Calorimeter fast-clear
- Ohio state

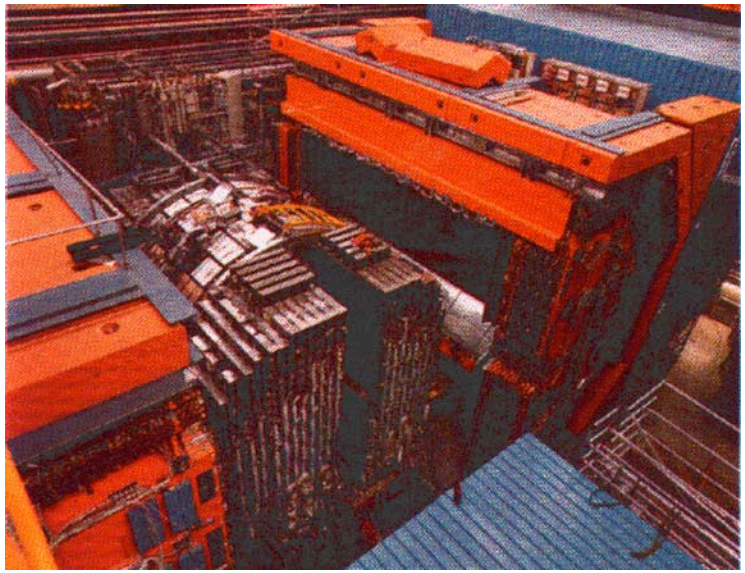
Calorimeter first level trigger processor
- Argonne

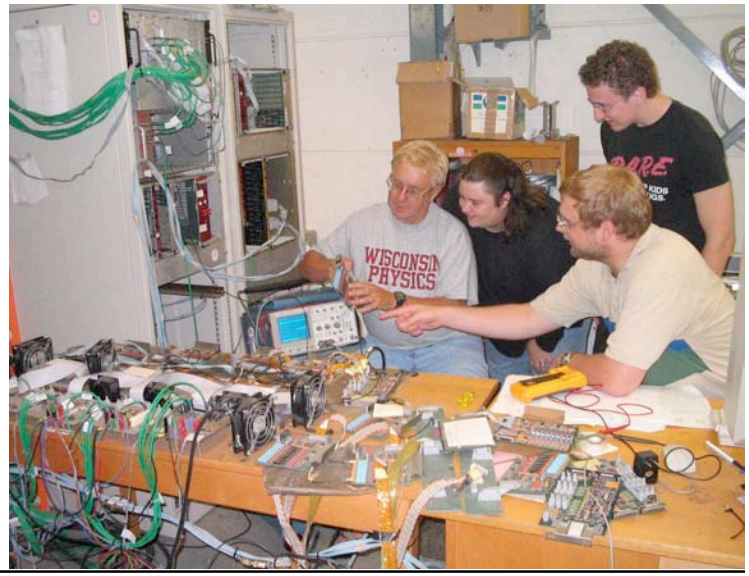
Barrel Presampler
- Argonne

Straw Tube Tracker readout electronics
- Argonne

Small Angle Rear Tracker trigger
- Argonne

Luminosity monitor spectrometer
- Columbia





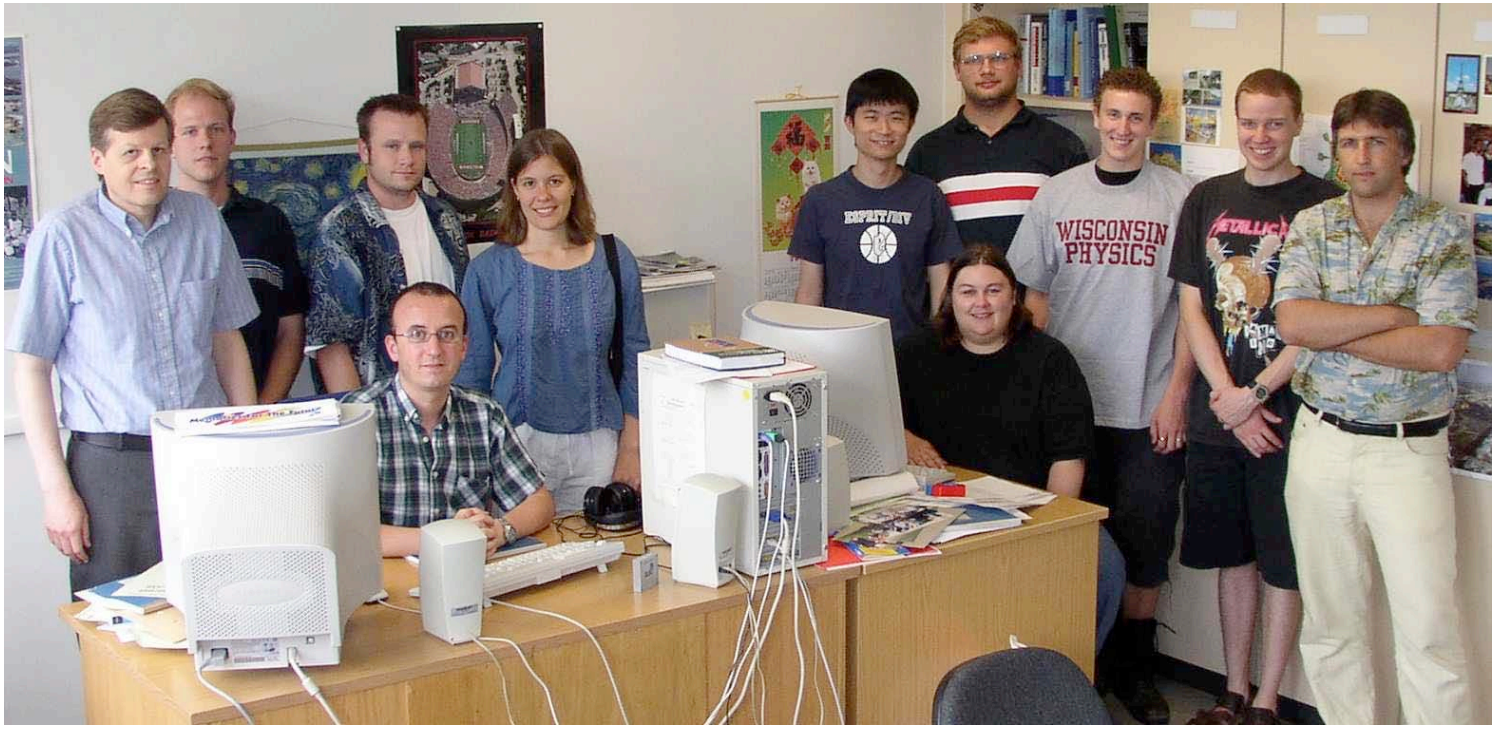
AmZeus Students

Total number of PhDs given thus far: 38 (21)

Current number of PhD students: 11 (7)

Many former students are now postdocs working on the Tevatron program

Prof. Smith (left), Drs. Kcira (seated), Savin (right) & Wisconsin students working on Zeus at DESY July '03



AmZeus Budget

YEAR (CY,FY) Actual or Request	ZEUS Common Costs (CY, k$)	DOE Operations Budget (FY,k$)	DOE Equipment Budget + ANL match (FY, k$)	€ /$ on Aug. 1 (Bill date)
2000	138	18* bal.	50 + 50	0.93
2001	101	177	50 + 50	0.88
2002	96	160	45 + 45	0.98
2003	144	130	45 + 45	1.12
2004	175†	100	30 + 30	1.25 now
2005	190†	155§	40 + 40§	1.25?
2006	205†	155§	35 + 35§	1.25?
2007	110†	155§	25 + 25§	1.25?
2008	20?†	110§	0§	1.25?
Totals	1159 (1179)	1160		

† Estimate

§ Assuming no additional FY2004 funds

* $18K is the balance left in FY 2000 funds after paying CY 1999 bills

AmZeus Expenses

ZEUS Common Costs:

- **ZEUS (only) Gases, Electricity, Helium Refrigeration, Common Maintenance & Repairs, Central Computing, Polarimeter Operation: CY03: 1020 K€**
  - Risks: Electricity costs & currency fluctuations
- **ZEUS Central Data Acquisition, Analysis Facility Operation & Upgrade: CY03: 320 K€**
- **US Share is 23 Ph.D./245 Ph.D. = 9.4%**

AmZeus Equipment:

- **Technician: Cathy Farrow**
  - $60k/year from AmZeus & $30k/year from DESY
- **Computing Equipment & Supplies**
  - $20k/year reducing to $10k in 2006

AmZeus Summary

HERA - II is a great opportunity for great physics

- Precision measurements & discovery potential
- Rich dividend from investment of DOE funding and personnel
- Exciting new physics program amidst shrinking HEP spigots

Have done great physics with HERA-I data

- Demonstrates the potential of the new HERA-II data

AmZeus is a leading group in the ZEUS detector management, operation & physics analysis

ZEUS cannot operate without the US Groups

"poster child" for an international role for US HEP

- a model for future international collaborations (Linear Collider)

Producing top-notch physicists

- Experienced in sophisticated hardware & software

Extremely Cost -Effective program

- Highest ratio of physics, papers & Ph.D.s per dollar spent.