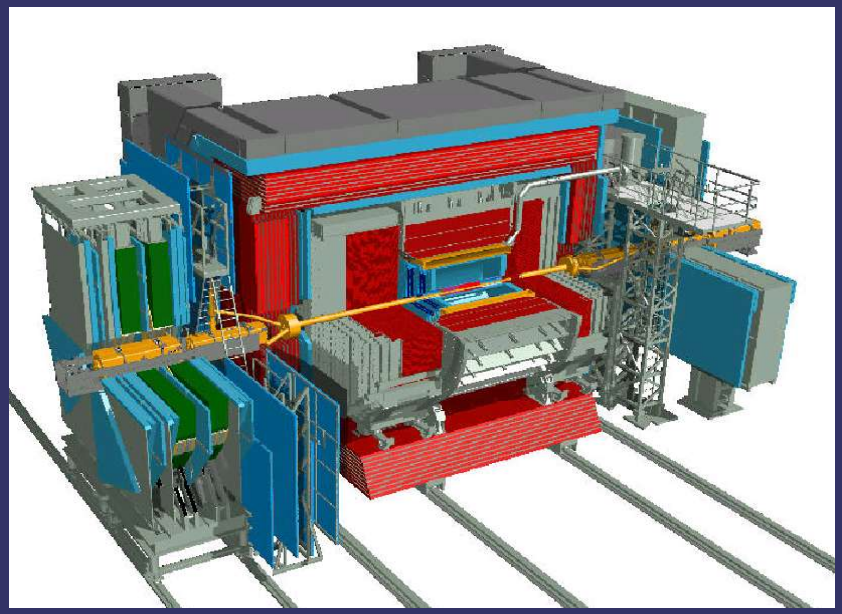
ZEUS status report - recent results

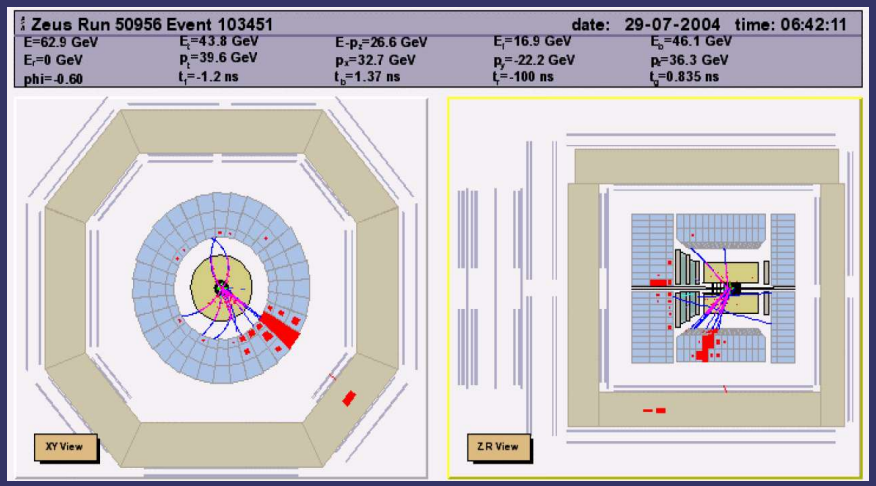
S.Chekanov (ANL)

for the ZEUS Collaboration

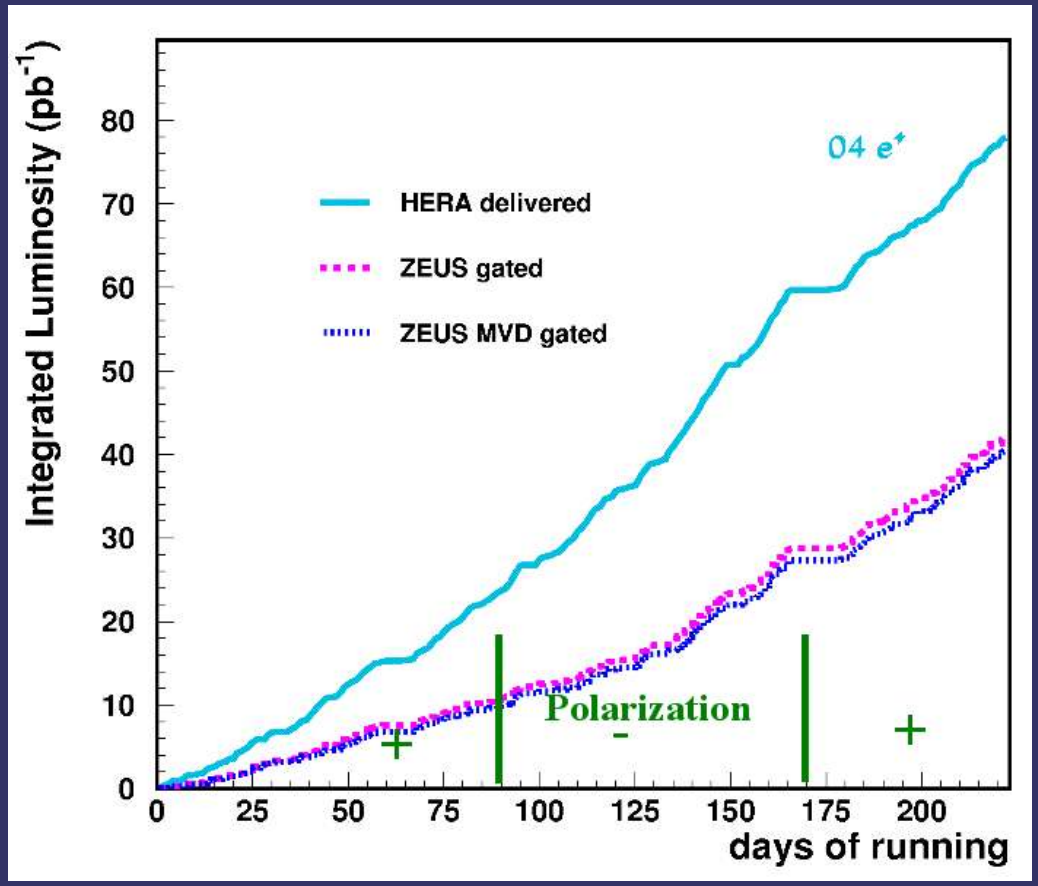
DESY PRC review (October 28, 2004)



- Data taking and running conditions
- Detector status
- Physics Highlights
- Summary



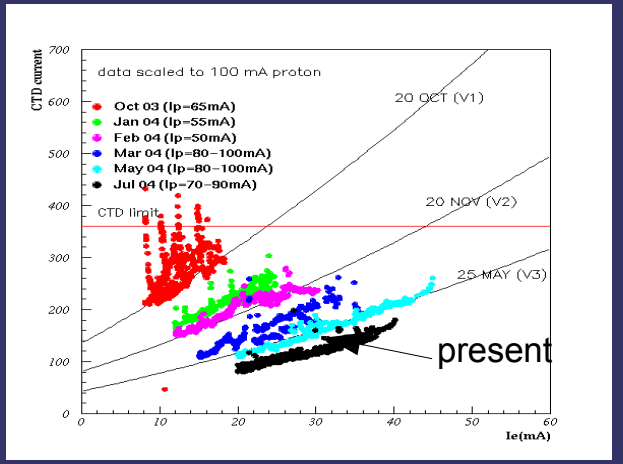
Data taking: 2003-2004



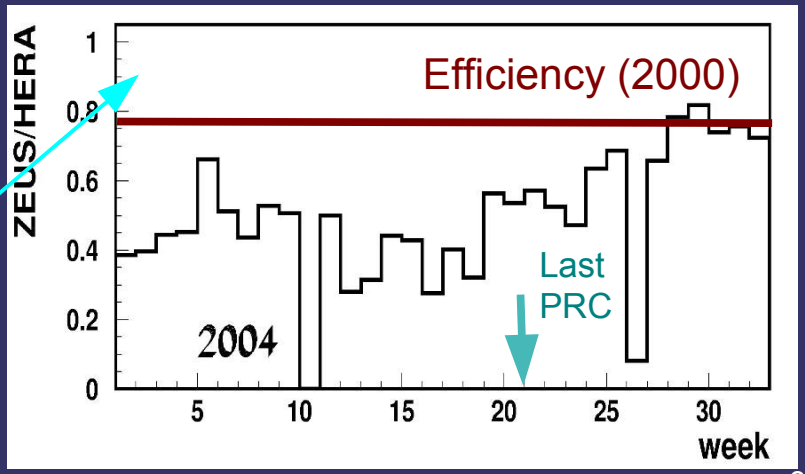
- Total gated: ~45 pb^{-1}
- Gated/HERA delivered ~ 54%
- Nearly all taken data can be used for physics
- All detectors are functional
  - Gated/MVD > 95%
  - Gated/STT > 95%

ZEUS data taking efficiency-I

- Significant improvements during July-August
- Efficiency went up since May due:
  - better beam conditions (better vacuum, less spikes)
  - improvements in DAQ/trigger
- Remaining inefficiency:
  - ~10% - HERA initial luminosity tuning
  - ~5-8% - HV trips in central tracking (CTD)
  - ~5-8% - DAQ problems
- Room for further improvements:
  - speed up run starts
  - reduce DAQ problems
  - reduce sensitivity to CTD HV trips



ZEUS real efficiency 80-90%

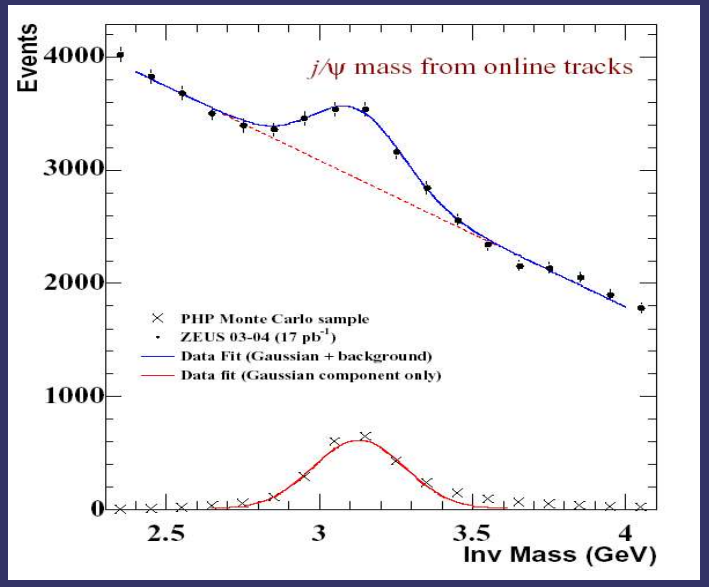


ZEUS data taking efficiency-II

- Typical trigger dead time was 5-10% in May (at last PRC):
  - removing very busy events due to beam gas collisions from the trigger chain
  - biggest improvement - regenerated pumps in June
    - vacuum was improved at least by a factor two

Current trigger dead time ~ 1-2% up to I_e~50 mA & I_p~100 mA

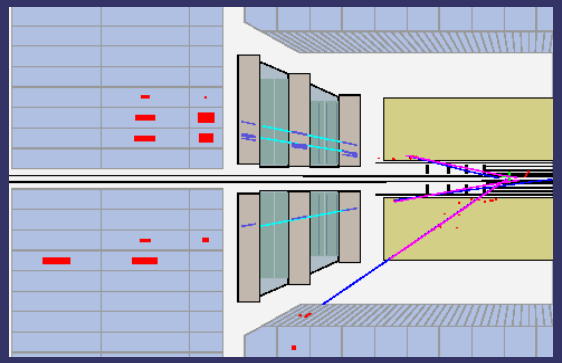
- Commissioning of Global Tracking Trigger (GTT) at second-level trigger finished:
  - includes information from CTD, STT & MVD:
    - better beam gas rejection and physics filters
    - extend to forward region
    - improve vertex resolution
    - potentially can reduce trigger rates by ~15-30%
  - some physics filters already use the GTT
    - allows heavy-flavor tagging on-line in the SLT
  - full operation for e^- running



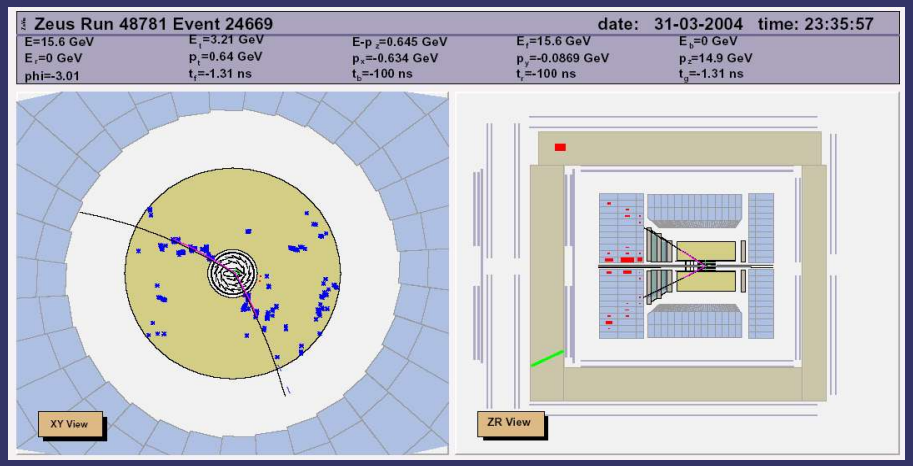
2003/2004 data taking

New components:

- Silicon Micro-Vertex-Detector (MVD)
- New forward tracking with STT
- New tracking trigger



Beauty candidate:
2 jets + 2 muons



J/Psi candidate

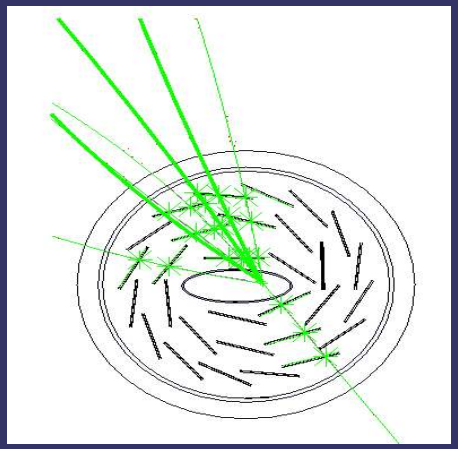
New data are already an important part of ongoing physics program (see ICHEP04)

→ will be discussed in context of particular physics topic

Status of MVD & Luminosity monitors

- 47 M events collected with MVD
- No big radiation dose during May-August
- Detector is in good shape
- Reliable detector operation

→ see physics results later

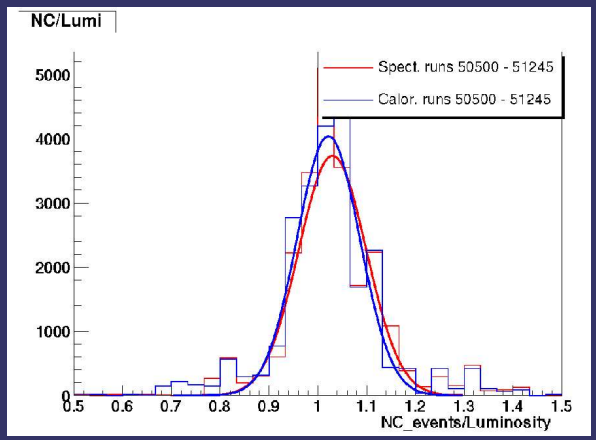


Lumi spectrometer

- Shielding upgrade + new set of radiation monitors

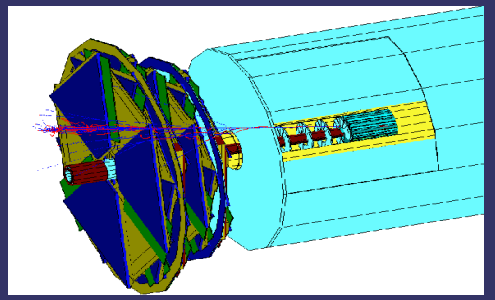
Lumi calorimeter

- Good agreement with Lumi spectrometer



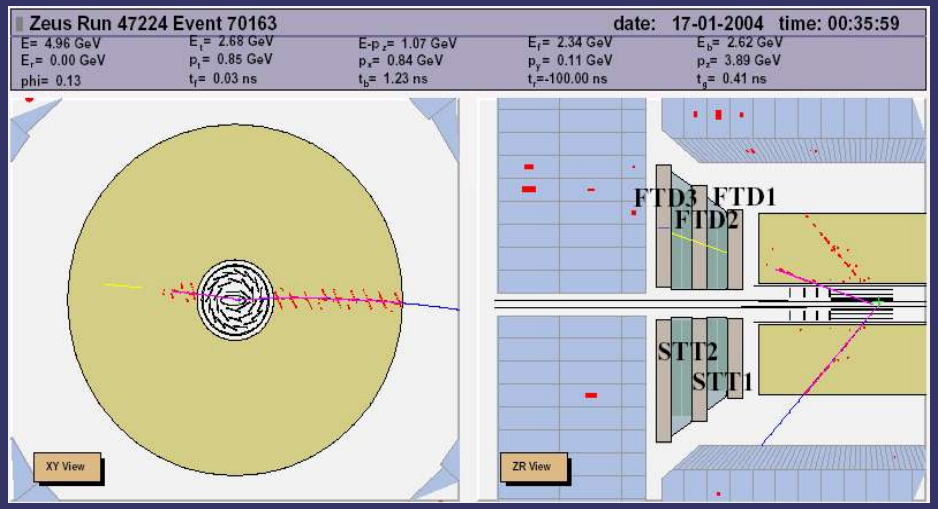
NC DIS(Q^2>200) / Lumi (nb-1)

Taking data with STT



- STT built to improve reliability and efficiency of tracking in forward direction
- STT/FRTD running at nominal HV during 2004 > 95% efficiency
- Angular coverage matches well with MVD and starts (θ < 23°) where CTD has low acceptance
- MVD/STT matching is in progress
  - With event vertex one can reach about 10% accuracy for 1-5 GeV
- STT was incorporated into GTT & TLT

  (software and hardware are ready)



Good STT-CTD-MVD matching:

90-95% efficiency for isolated tracks

Results of HERA shutdown (Aug-Sep)

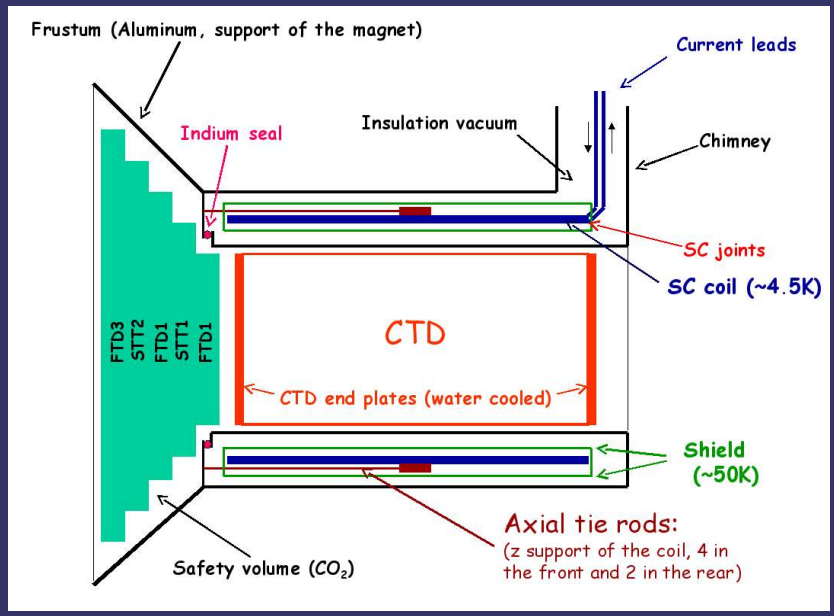
- General and preventive maintenance and detector repairs
- Calorimeter:
  - smallest number of UCAL bad channels for the last 6 years
- Lumi detectors:
  - Spectrometer: additional shielding against synchrotron radiation
  - Calorimeter: some electronics has been repaired
- Feedbox/Solenoid: monitoring was improved
- DAQ and trigger improvements

ZEUS is ready for data taking

Magnet heating by STT

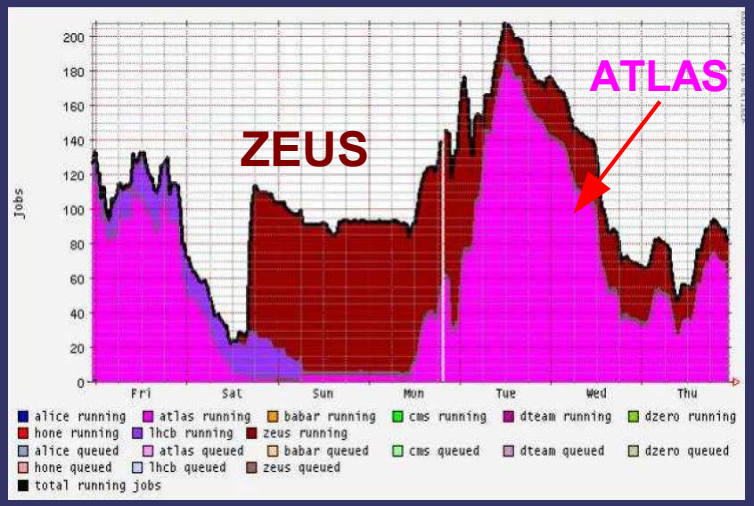
It was found that:

- STT electronics has insufficient cooling
- Operation of STT electronics can lead to temporary leaks in solenoid insulation vacuum
- A serious solenoid failure cannot be repaired in a short time
- STT stays off for now
- Investigations are on-going



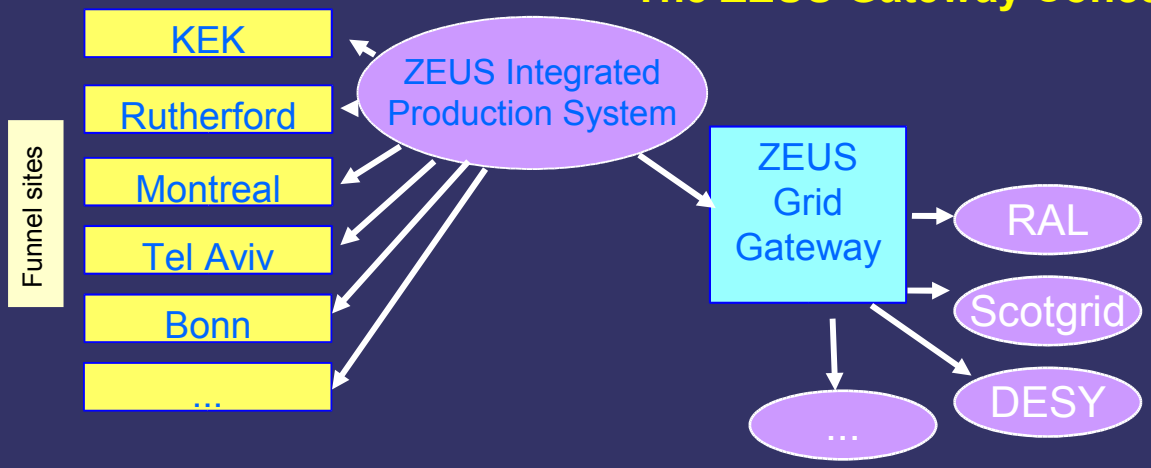
ZEUS Grid

- HERA-II data rates create strong increase of MC production demand
  - Need access to grid resources
  - At the same time, keep the "traditional" production sites (funnel)
- 0.6 M events already produced - samples pass standard DQM & are in use for physics analysis
- Transparent integration of traditional production system & grid



Jobs per VO (snapshot at RAL)

The ZEUS Gateway Concept

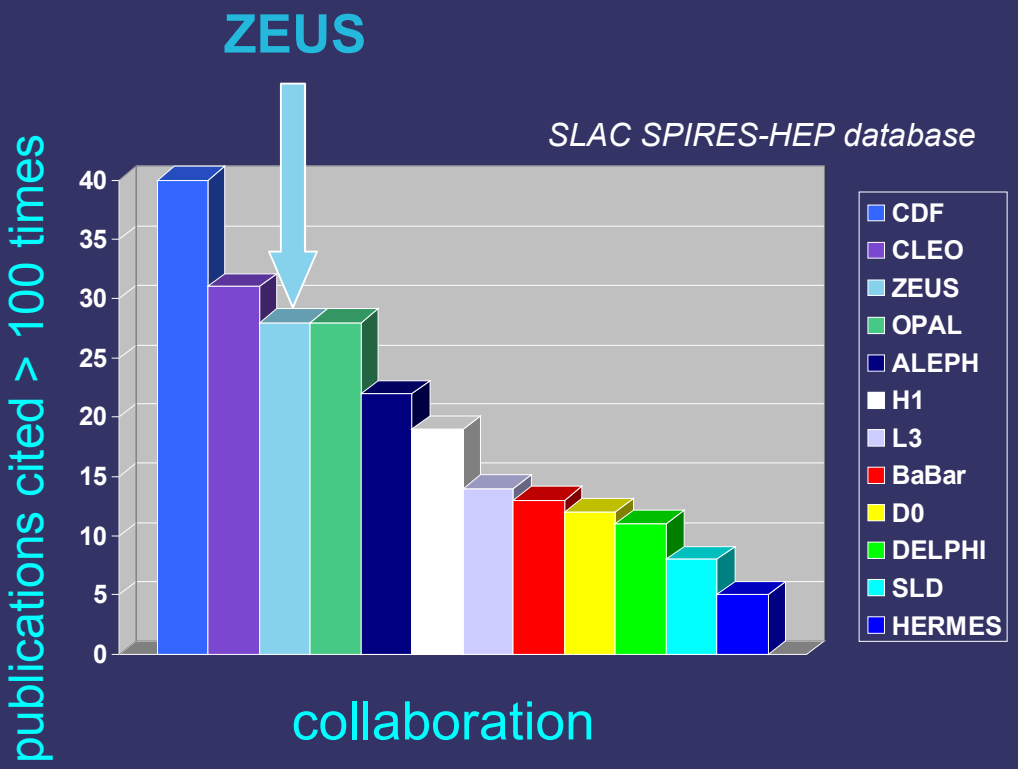


Physics output

45 papers submitted to ICHEP04

27 papers – new results

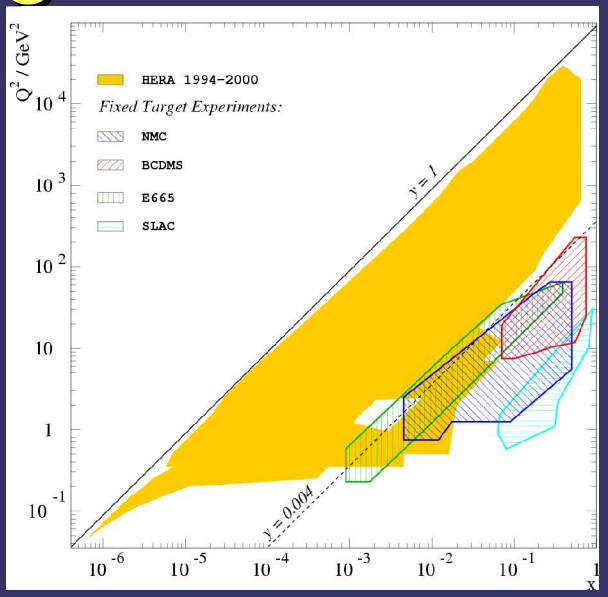
9 papers finished in 2004

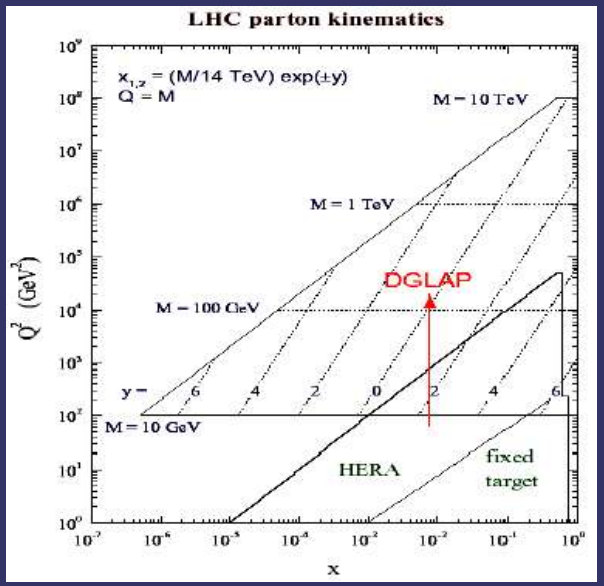


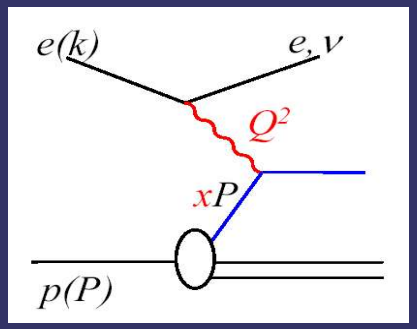
ZEUS papers are among most cited in literature

ZEUS physics program

- Proton structure, PDF
- Electroweak unification
- Jet production - QCD
  - α_s determination
  - photon structure
- Diffraction
- Heavy flavor physics (charm & beauty)
- Search for new physics
- Particle production
  - pentaquarks



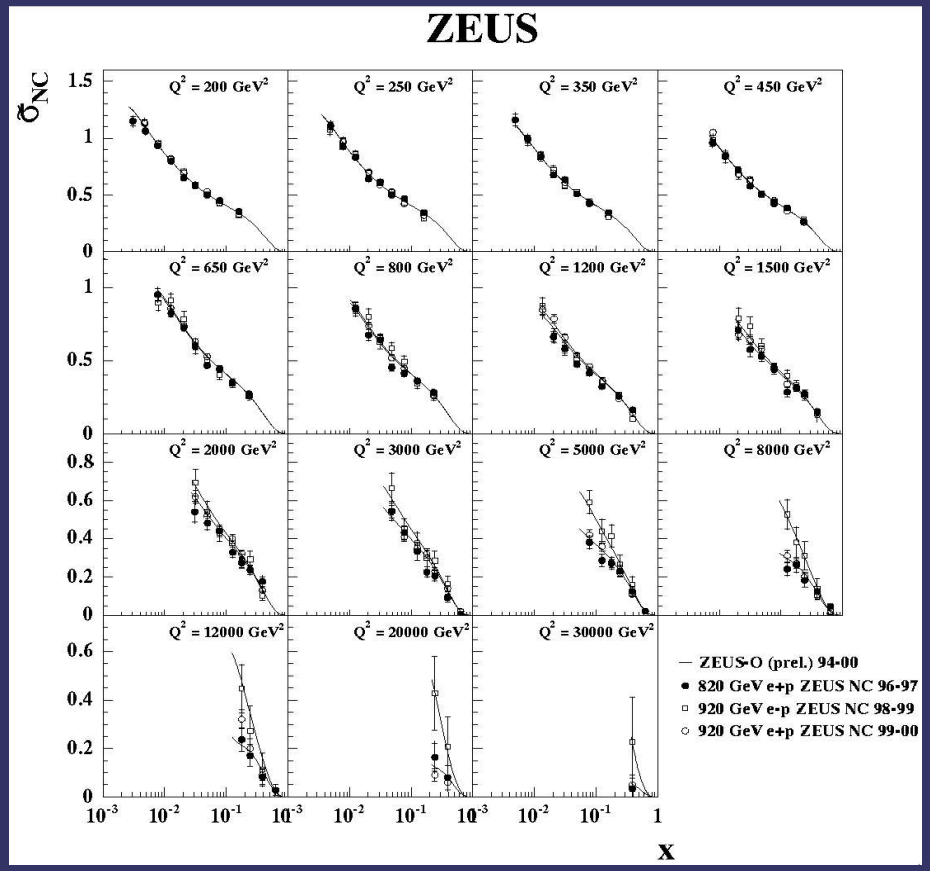


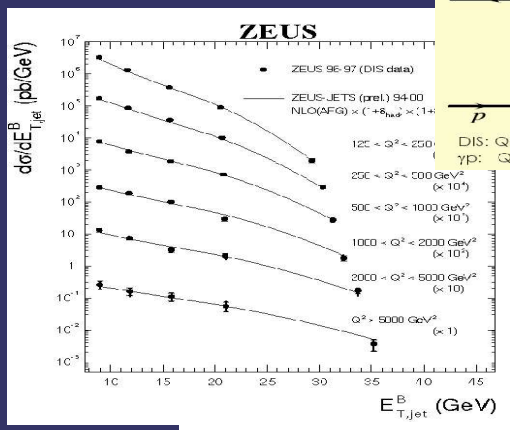


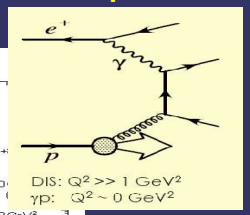
$Q^2 = -q^2$: 4-momentum transfer squared

x: fraction of proton momentum carried by quark

NLO QCD analysis and PDF

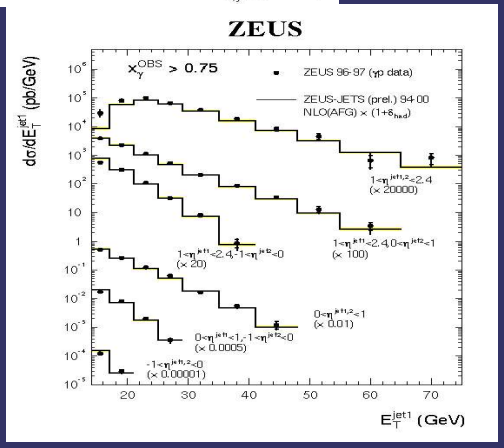






Inclusive DIS jets

Dijets in PHP

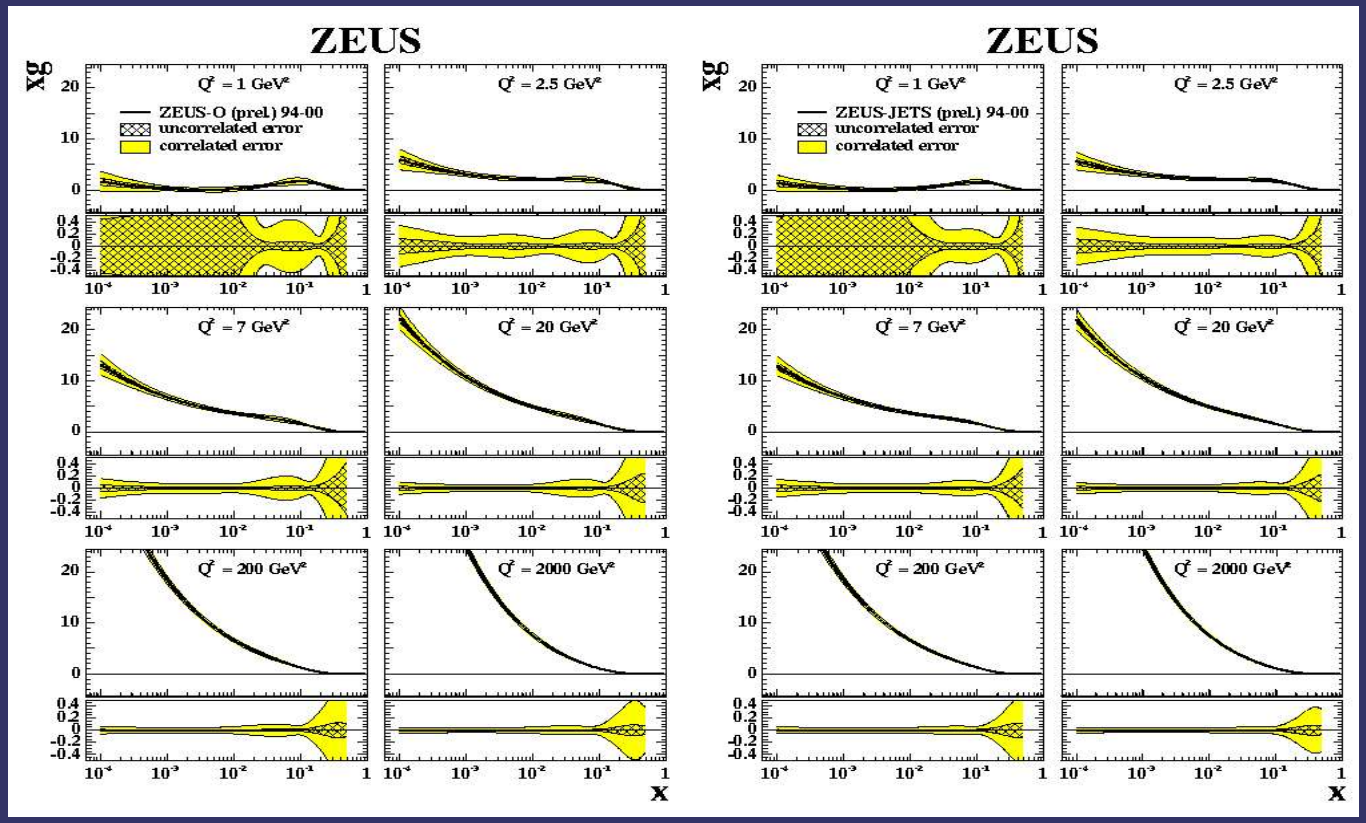


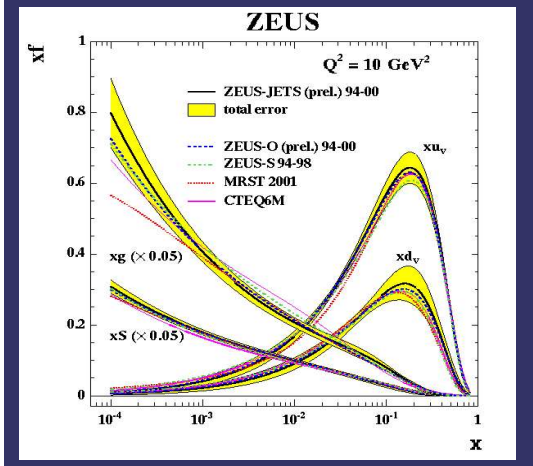
- HERA data at high x are still less precise than fixed-target experiments
- Fixed-target experiments suffer from systematic uncertainties and rigorous treatment of uncertainties is difficult
- Include jet observables measured at ZEUS
  - sensitive to gluon at x~0.01-0.1 through BGF process

ZEUS jets QCD analysis

ZEUS only fit

ZEUS + JETS fits

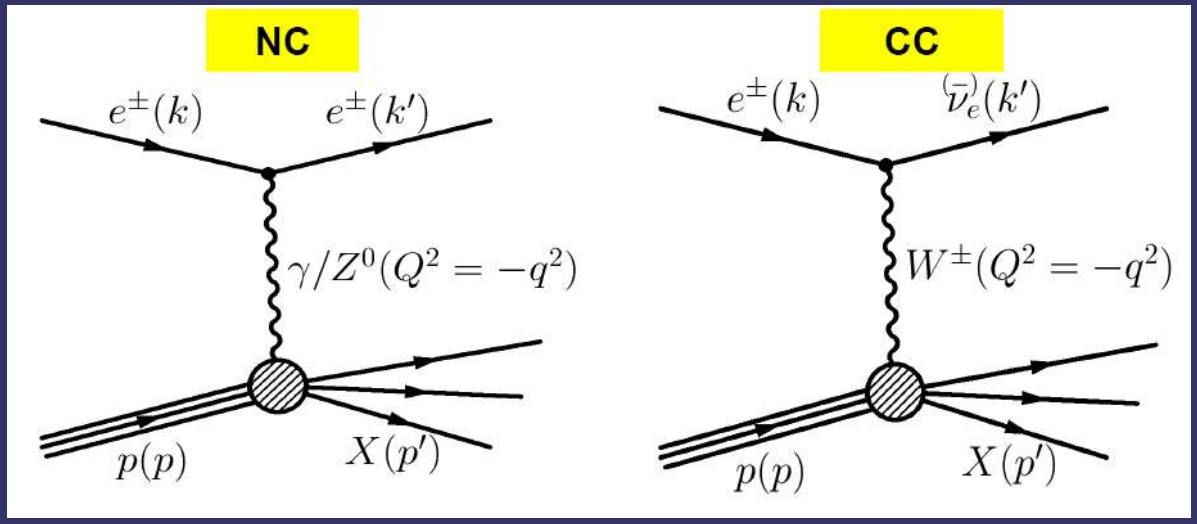




Improvement in determination of gluon densities at mid-to-high x

Rigorous treatment of uncertainties

DIS at HERAII: collisions with polarized leptons



NC DIS:

Z^0 couples differently to the left and right handed lepton

Contribution at high Q^2

(dependence of electroweak terms in the cross section)

CC DIS:

Linear dependence on polarization

Contribution to all Q^2

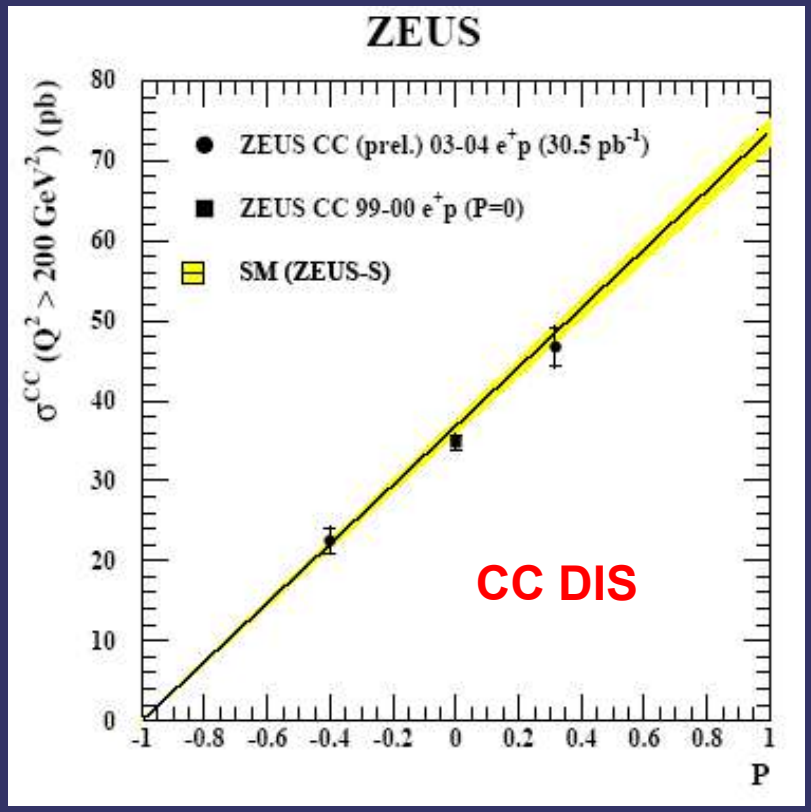
$$\sigma_{CC}^{\pm}(P) = (1 \pm P)\sigma_{CC}^{\pm}(0)$$

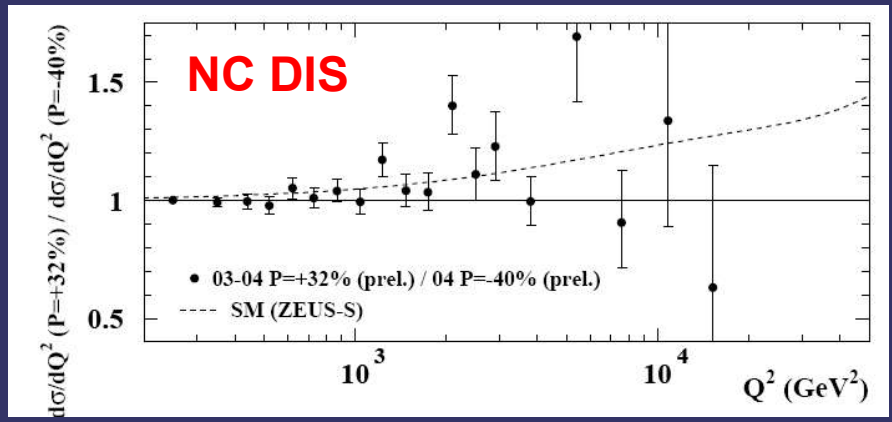
HERA II data: 16.4 pb^{-1} with P= -40.2%

14.1 pb^{-1} with P= 31.8%

S.Chekanov, DESY PRC review (Oct 2004)

Results on polarization. HERAII data



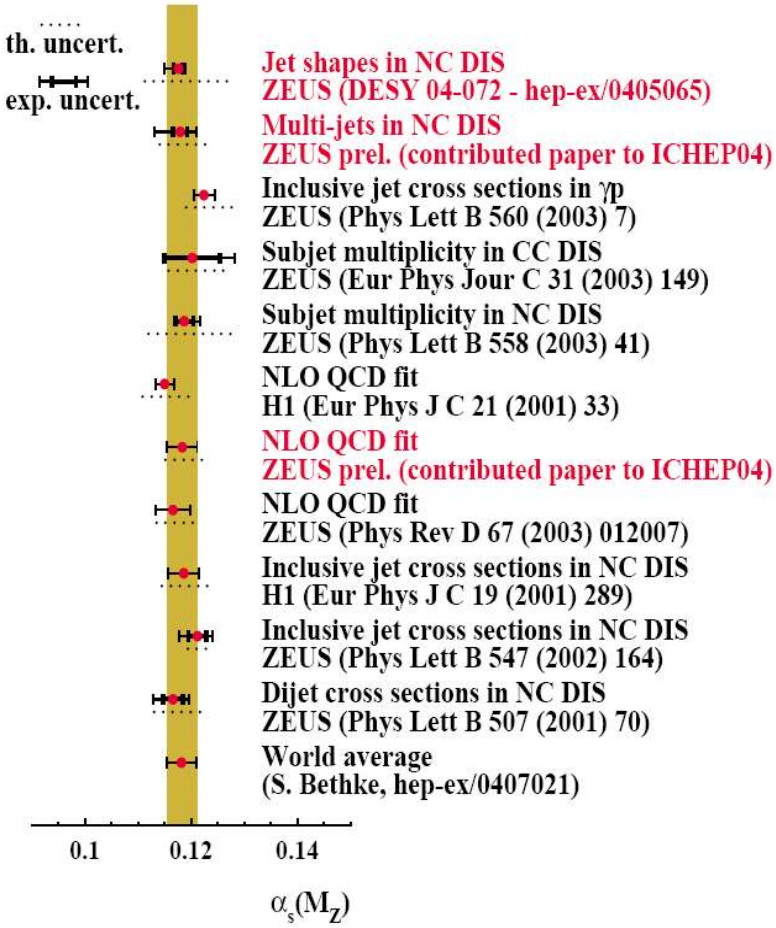


Polarization effect established in CC DIS

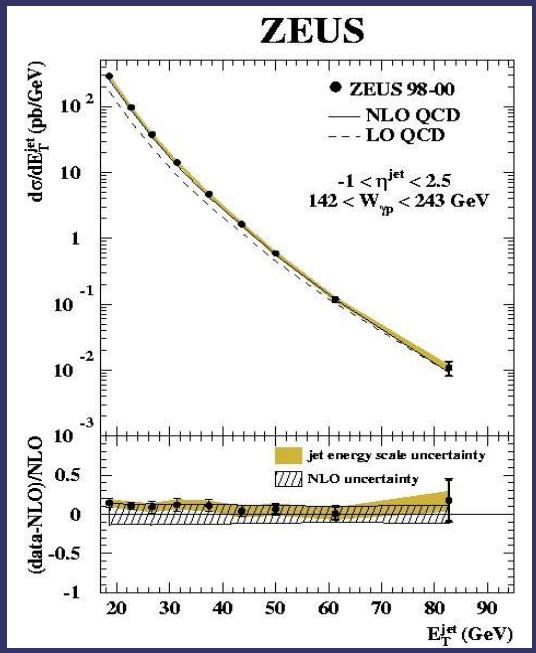
More data are needed for NC DIS

Agreement with the SM for both CC & NC DIS

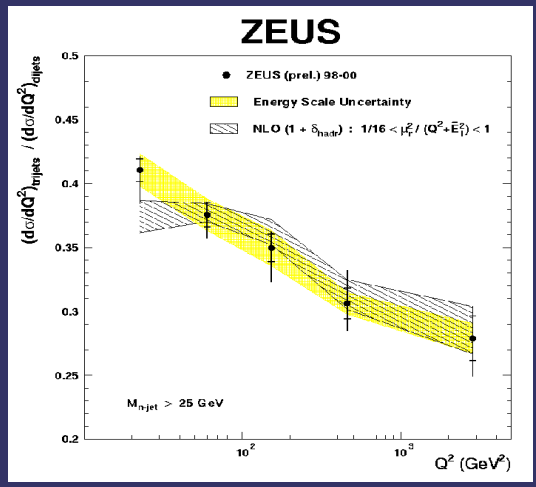
$\alpha_s(M_Z)$ determination



Most precise measurement from inclusive jets

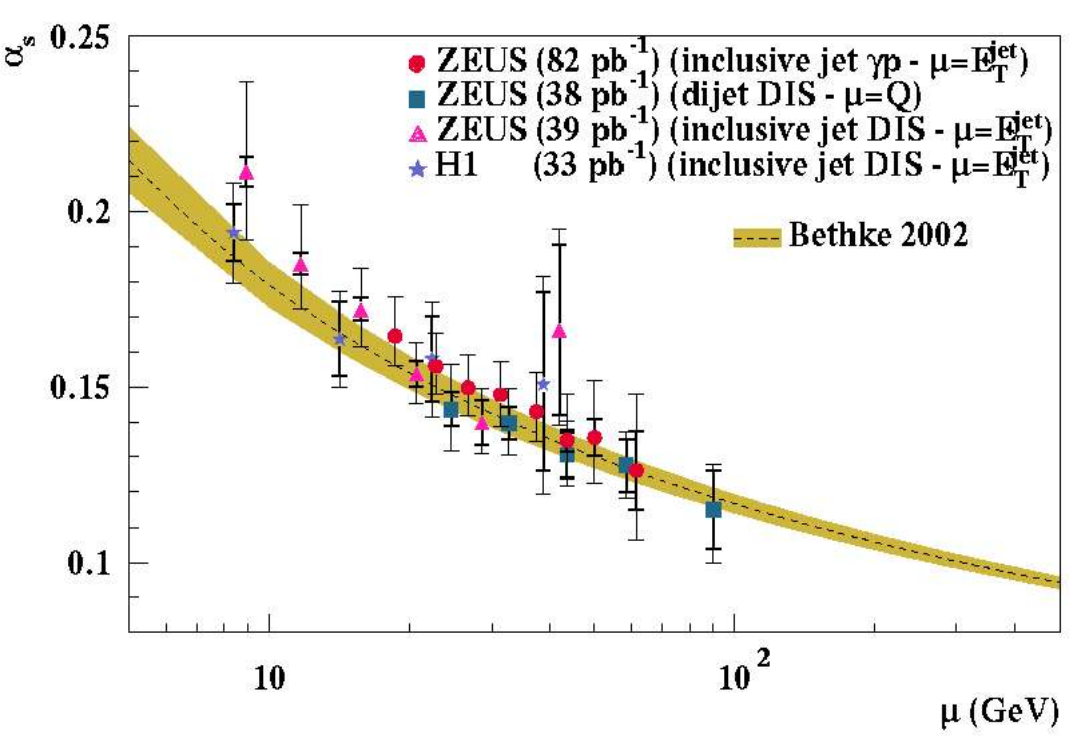


Most recent measurement from 3/2 jet ratio



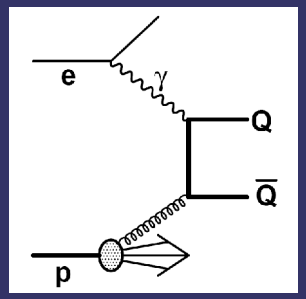
Competitive results
Theoretical uncertainties dominate
Influence on world average

Running α_s



- Covers significant range in energy scale
- Running of α_s in single experiment
- Theoretical uncertainties dominate - NNLO QCD is needed

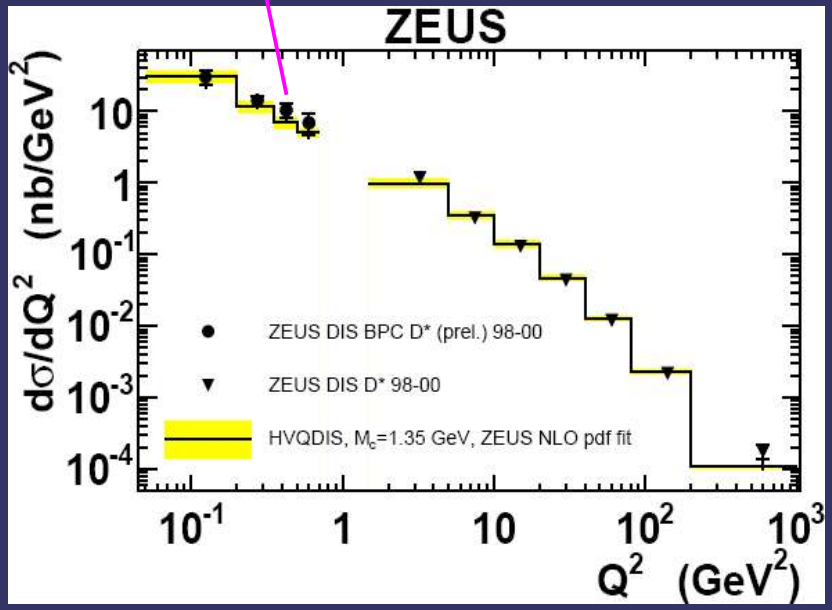
Charm production



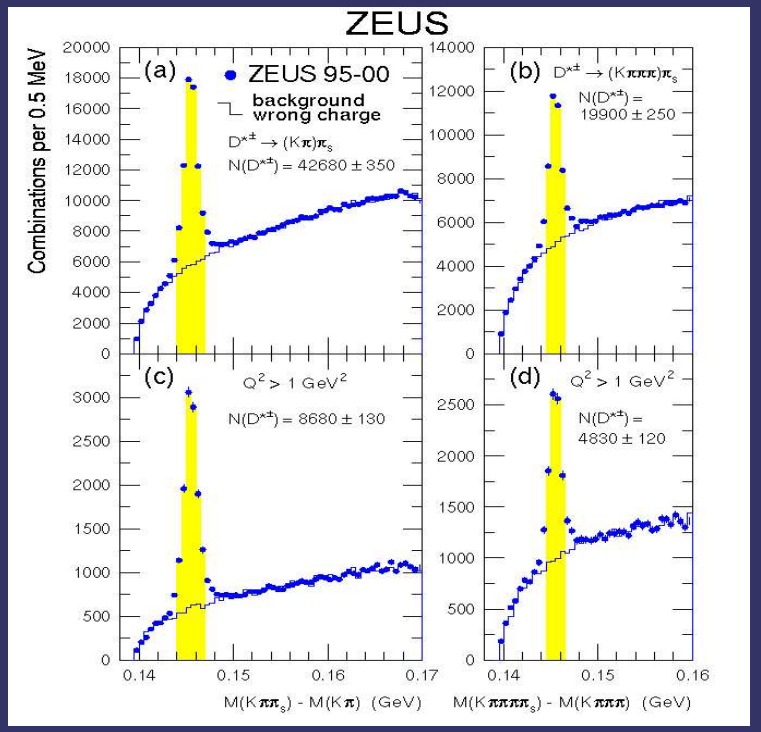
Charm production directly sensitive to gluon density in proton

Look at "golden" decay channel: $D^* \to D^0\pi \to K\pi\pi$

Low Q^2 with BPC



Agreement with NLO QCD for four decades in Q^2



Increase of statistics for heavy-flavor analyses relies on :

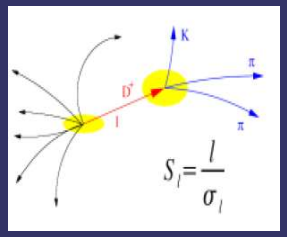
- extending the track acceptance to lower angles (MVD/STT)
- tagging with MVD

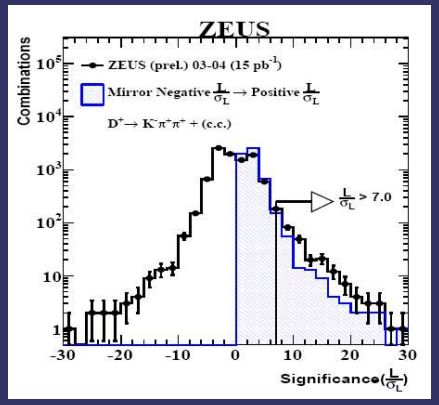
Charm studies using HERA II data

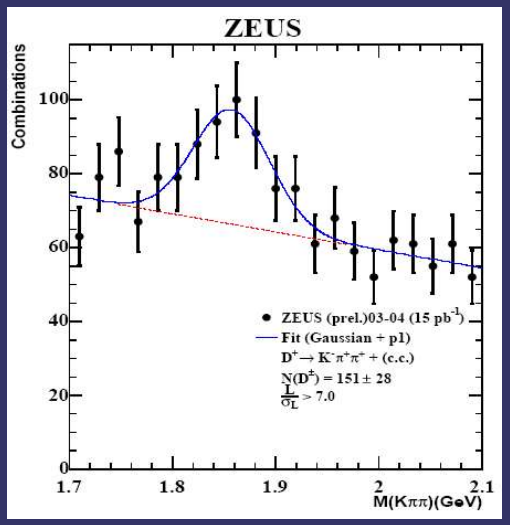
Charm tagging using decay length

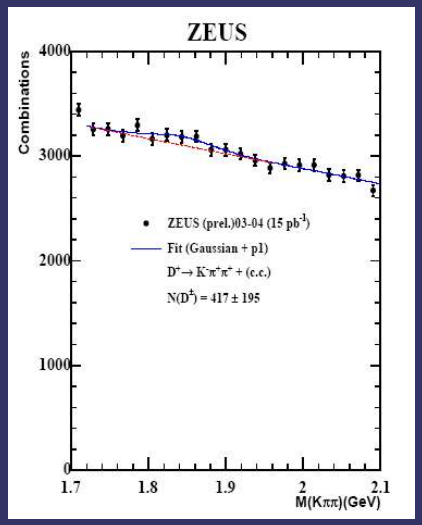
Use MVD detector

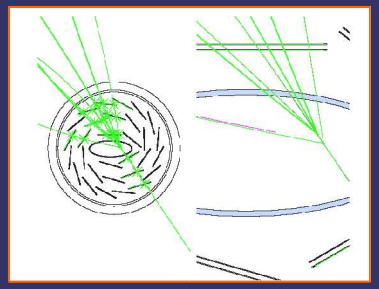
Decay length significance $S_l = l/\sigma_l$





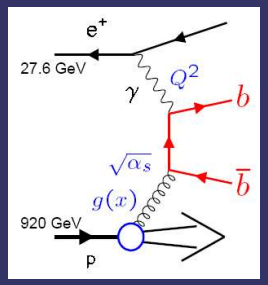






First look at HERA II data shows that lifetime tagging with MVD works as expected

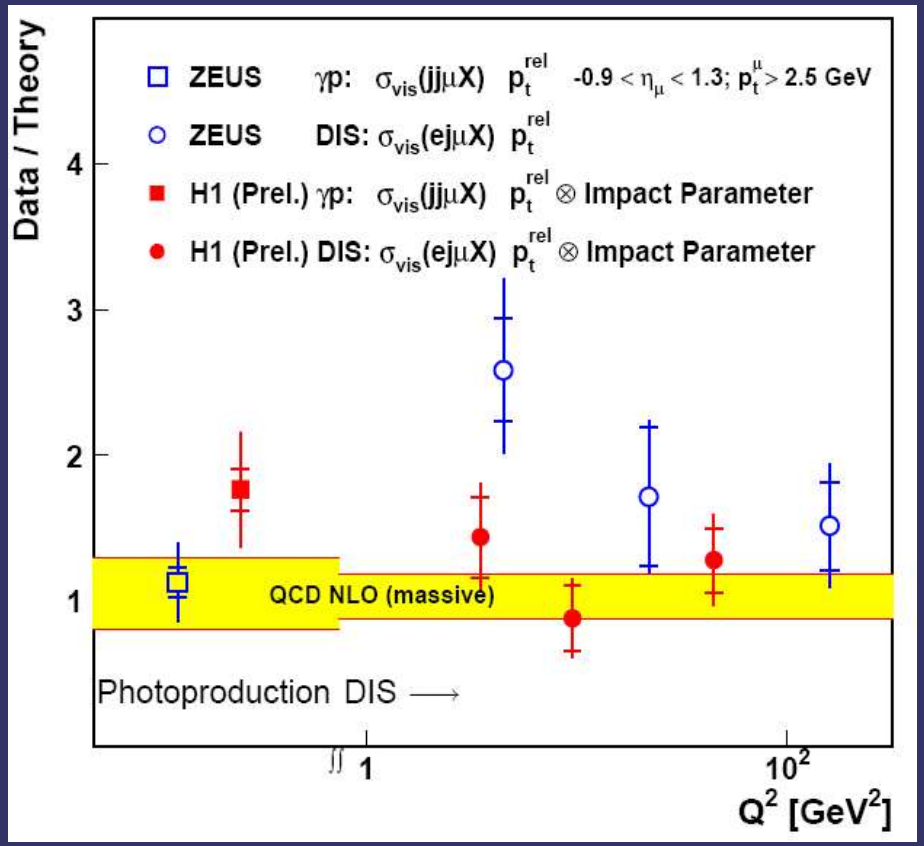
Large potential for the future



Beauty production

- Driven by gluons
- QCD calculations:
  - γp: FMNR (Frixione et al.)
  - DIS: HVQDIS (Harris, Smith)
- Multi-scale problem
  - m_b ~ 5 GeV

    hard scale ensures reliable QCD calculations
  - Q^2 (DIS)
  - P_T^b (PHP, DIS)

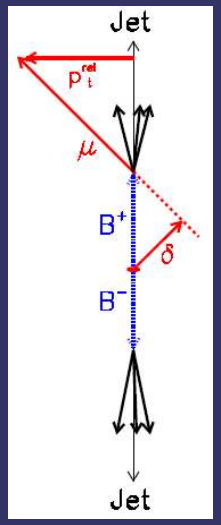


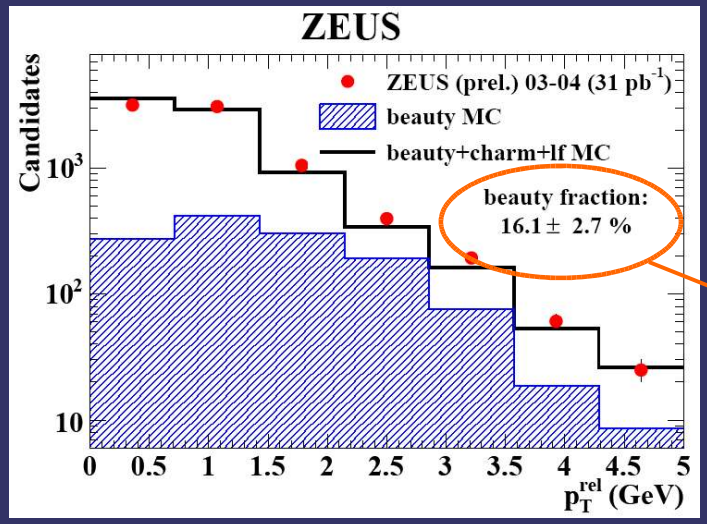
Data somewhat above massive NLO QCD

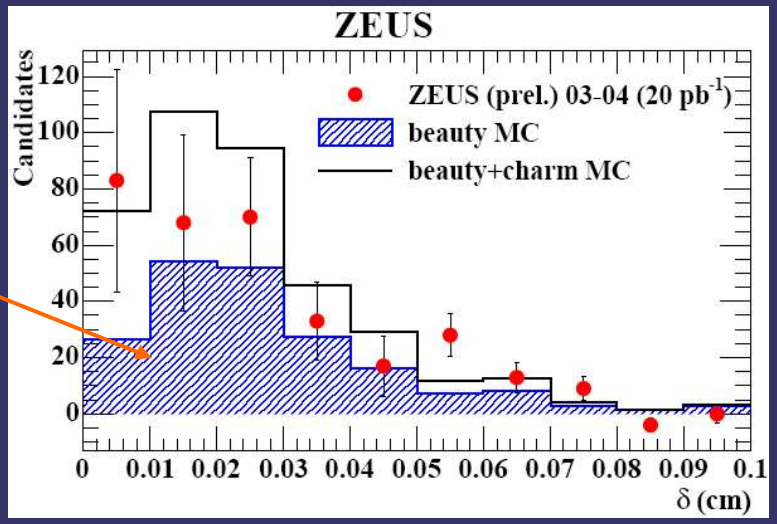
The Silicon Microvertex Detector for ZEUS Experiment

Beauty studies using HERA II data

- large mass leads to large p_t^{rel} of μ relative to jet axis
- large B-lifetime: use μ impact parameter δ from MVD



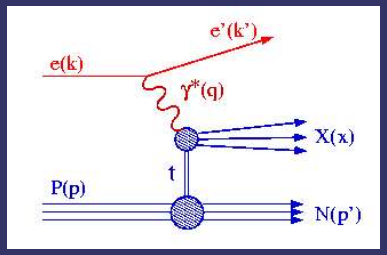




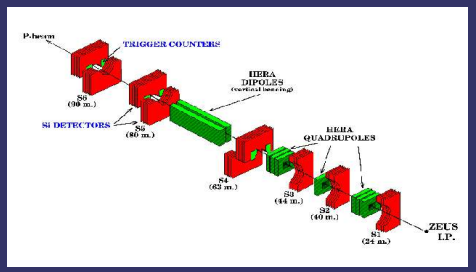
A beauty fraction 16.1 ± 2.7% extracted using p_t^{rel} method

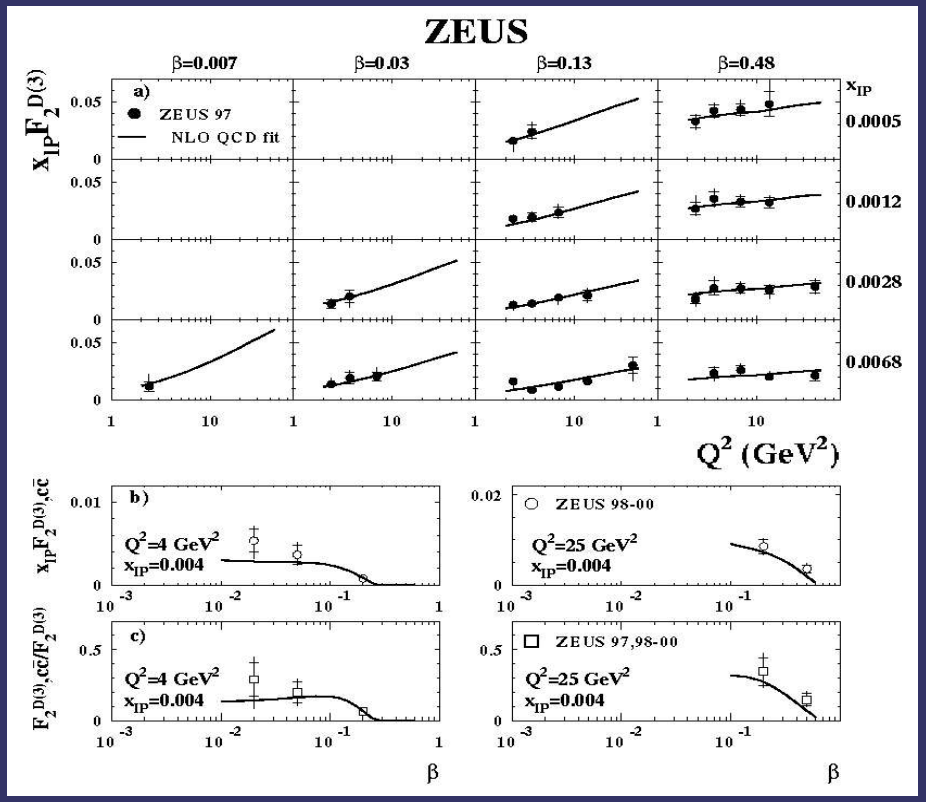
Gives consistent result with the impact-parameter method

Large potential for the future



Inclusive diffraction with LPS and charm data



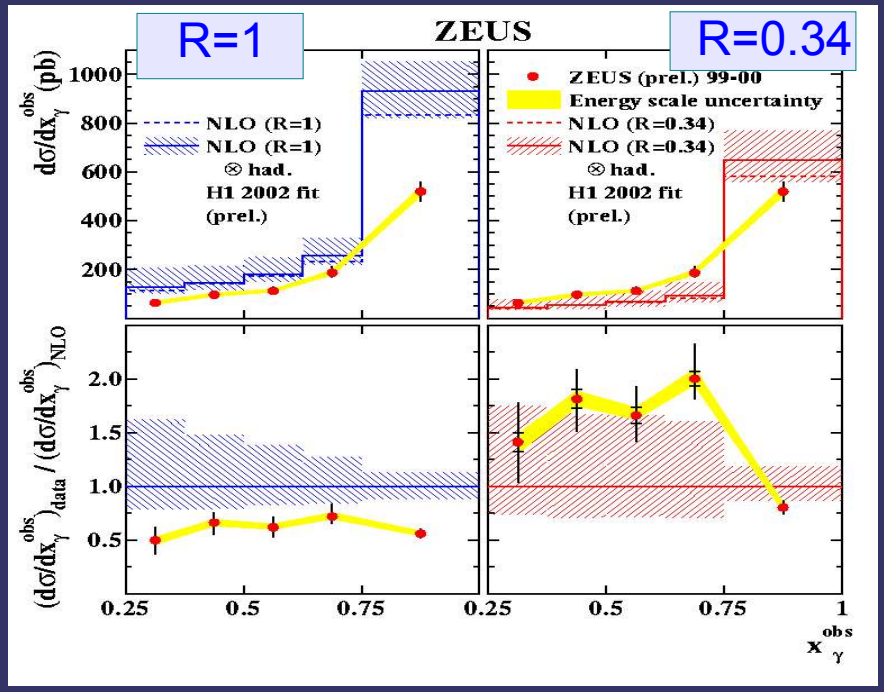


- Proton-tagging method with LPS
  - $x_L > 0.9$
  - $x_{IP} < 0.06$
  - high M_x accessible (up to 40 GeV!)
- NLO QCD fits include LPS & charm data

- Good description by the NLO QCD fit
- Fraction of t-channel momentum carried by gluons ~82% at initial scale (Q^2=2 GeV^2)

Diffractive dijet photoproduction

- QCD factorization:
  - central problem of hard diffraction
- Does not hold in pp
- CDF measurement is by factor 10 lower than NLO based on H1 diffractive PDF
  - need a suppression factor
- resolved contribution in diffractive photoproduction may require a similar correction (factorization breaking?)



LRG 3<η<5 (FPC region)

Comparisons with M.Klasen & G.Kramer

$$x_\gamma^{\mathrm{OBS}} = \frac{\Sigma_{jets} E_T^{jet} e^{-\eta^{jet}}}{2yE_e}$$

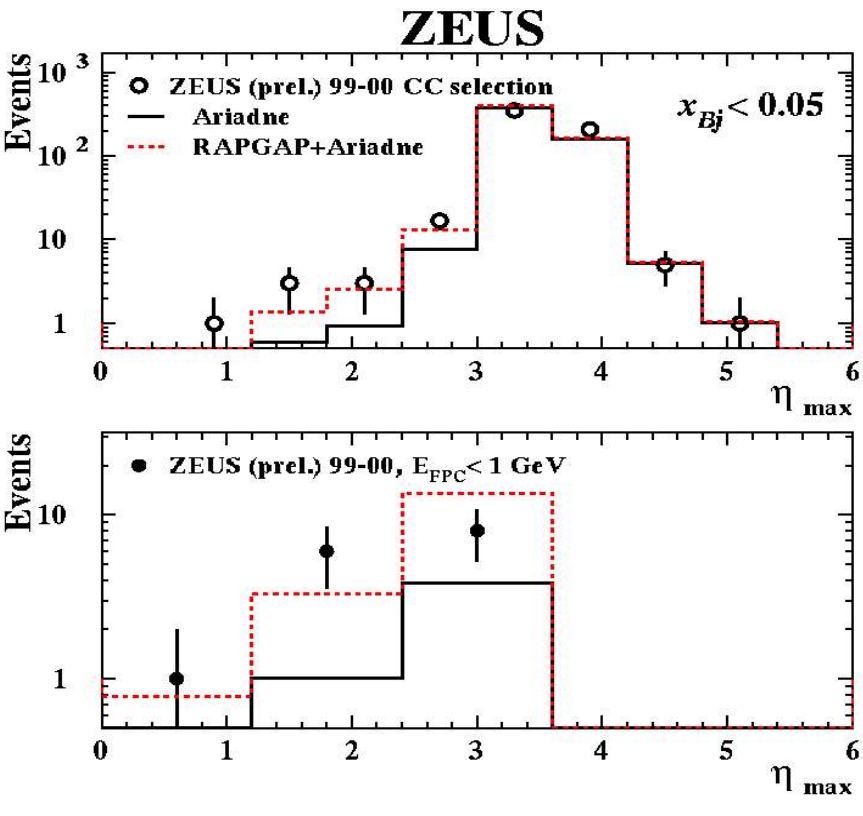
$x_\gamma^{\mathrm{OBS}} < 0.75 \rightarrow$ **"Resolved Enhanced"**

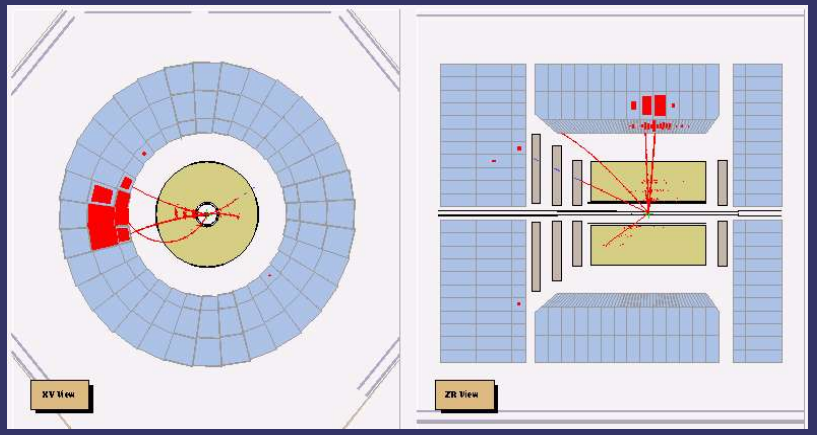
$x_\gamma^{\mathrm{OBS}} > 0.75 \rightarrow$ **"Direct Enhanced"**

- 30-fold increase in luminosity compared to previous ZEUS analysis
- Global suppression is more likely than a resolved photon suppression (see shapes)

Diffraction in CC DIS

Diffractive events - significant component of NC DIS
What about CC DIS - $e^+p \rightarrow \nu W^+ \rightarrow \nu X$?

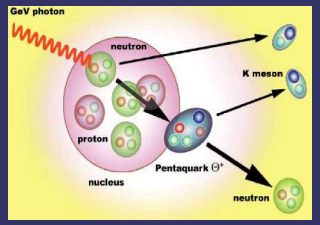




For $Q^2 > 200$ GeV^2 $\eta_{max} < 2.9$, $x_{IP} < 0.05$: using 99-00 data:

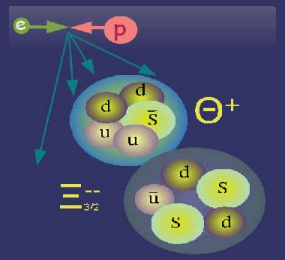
9 events with LRG
$\sigma = 0.49 \pm 0.2$ (stat) ± 0.8 (sys.) pb
agrees with RAPGAP CC (color singlet exchange between W^+ and proton)

$$\sigma^{diff}(e^+p \rightarrow \nu X p)/\sigma^{tot}(e^+p \rightarrow \nu X) = 2.9 \pm 1.2(\text{stat.}) \pm 0.8(\text{syst.})\ \%$$



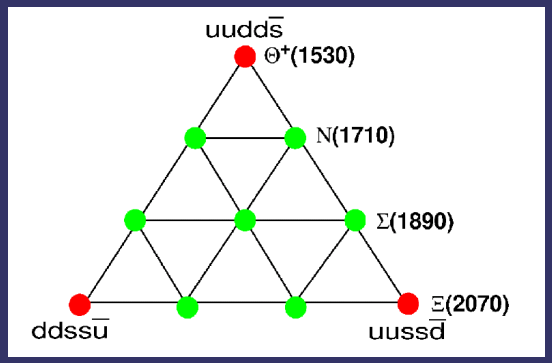
Pentaquarks

renaissance of hadron spectroscopy?



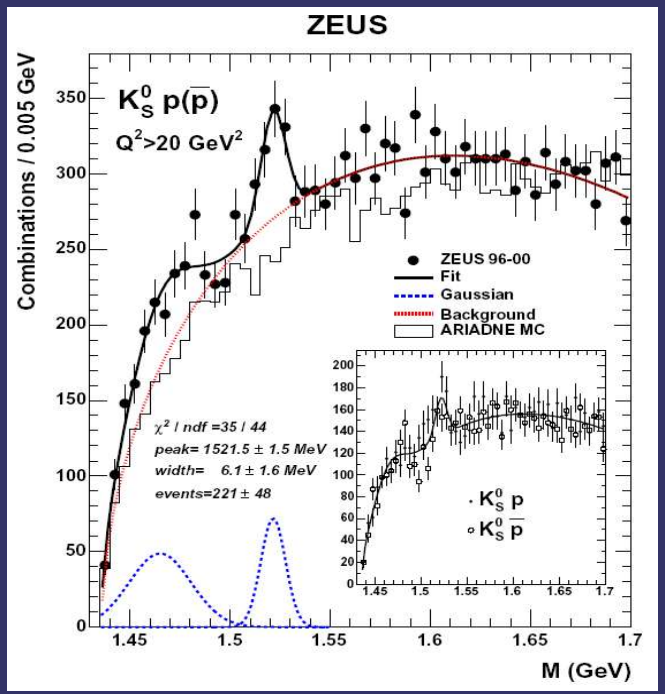
Constituent Quark model:

mesons $q\bar{q}$ baryons qqq



Does not predict more complicated states (but can accommodate them)

A number of fixed-target experiments observed a narrow baryonic state at 1530 MeV consistent with pentaquark predictions (Diakonov, Petrov, Polyakov)



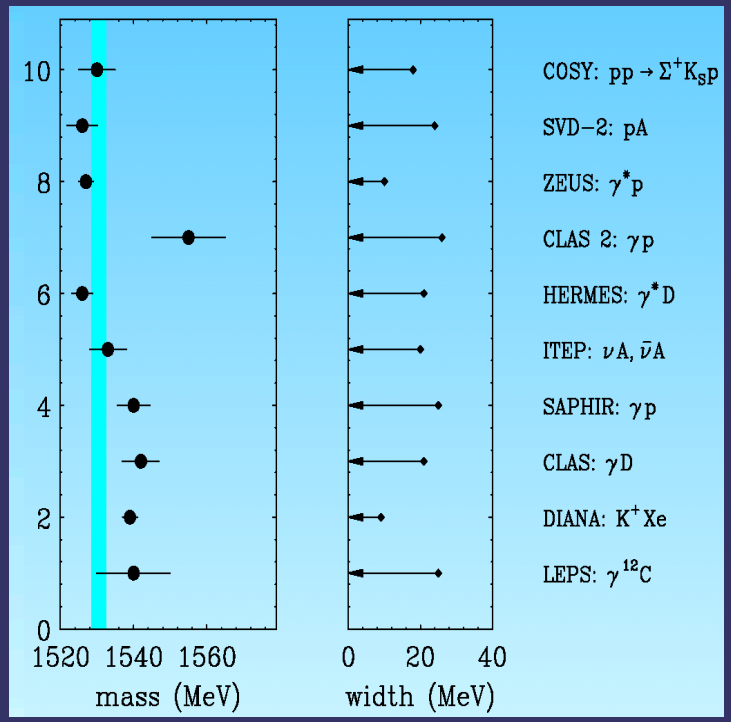
First evidence of θ^+:

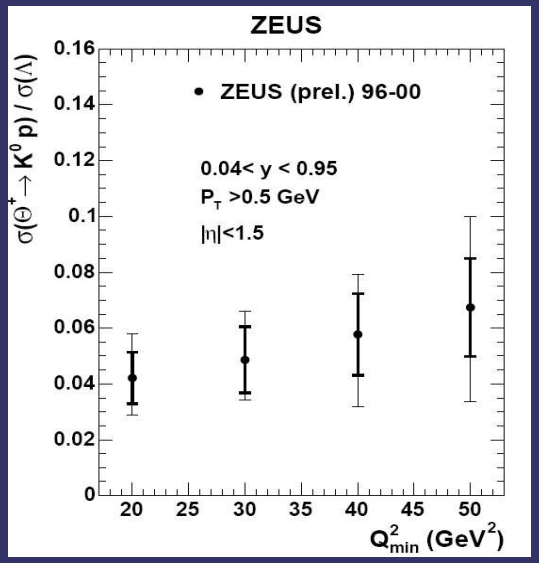
- in HEP colliding experiment
- for antipentaquark

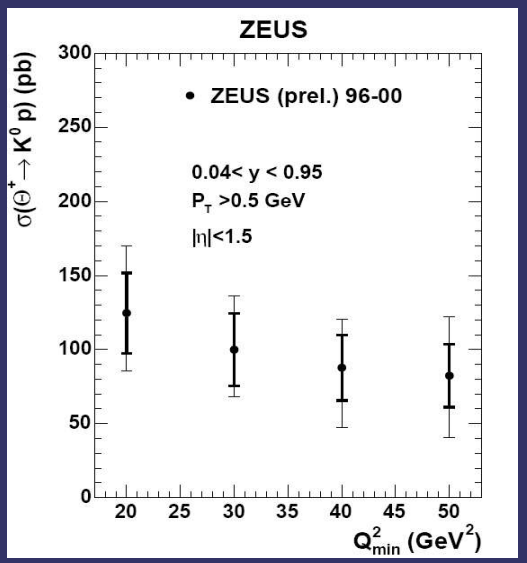
S.Chekanov, DESY PRC review (Oct 2004)

ZEUS measurement of θ⁺

summary of θ⁺ measurements



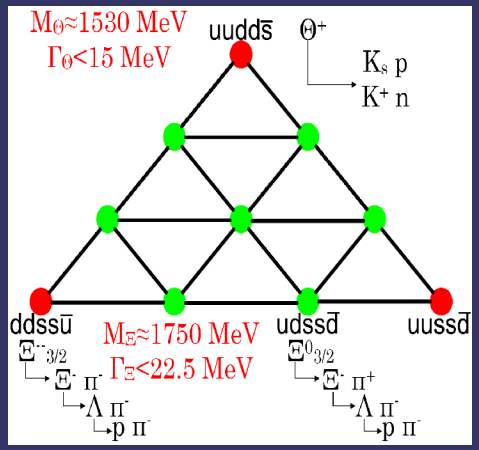




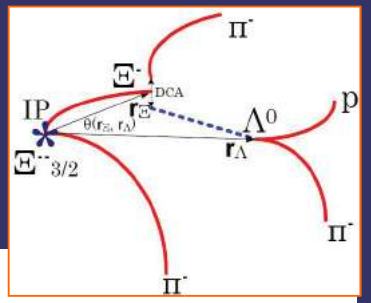
$$\frac{\sigma(ep \to e\theta^+ X \to eK^0 pX)}{\sigma(ep \to e\Lambda X)} = 4.2 \pm 0.9(stat)^{+1.2}_{-0.9}(syst)\%$$

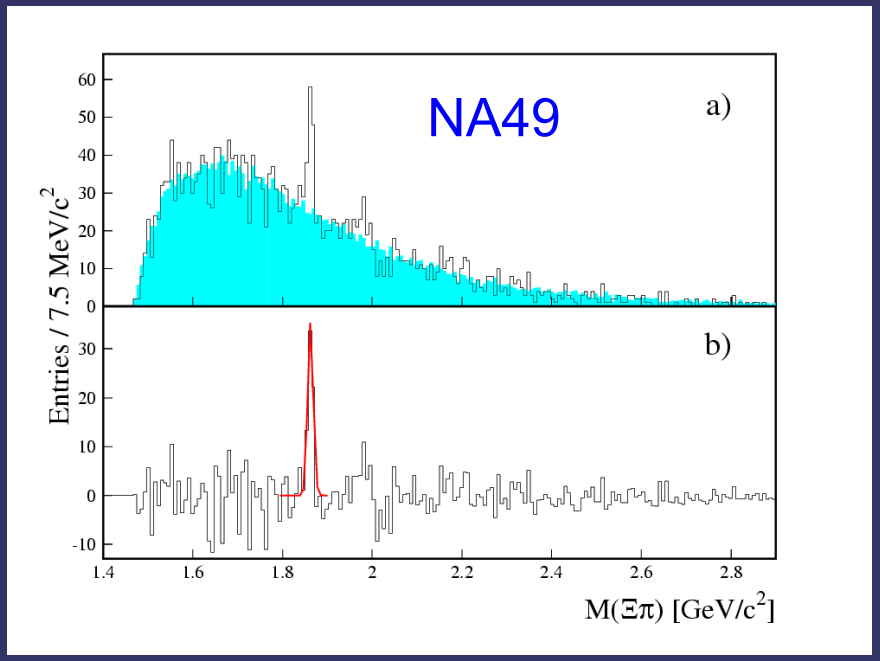
- One of the most precise measurements
- Significant impact on the world average m=1530 ±2 MeV
- First cross sections in DIS

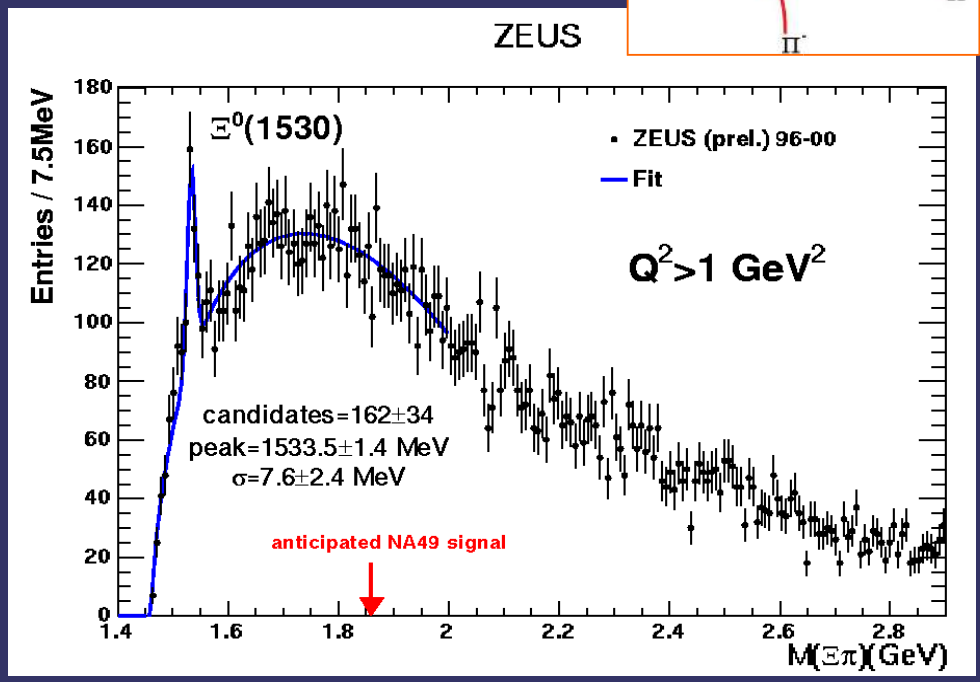
Search for heavy strange pentaquarks



NA49 observes $\Xi^-_{3/2}$ and $\Xi^0_{3/2}$ pentaquark states with mass 1862 MeV







Clean PDG $\Xi^0(1530)$ signal

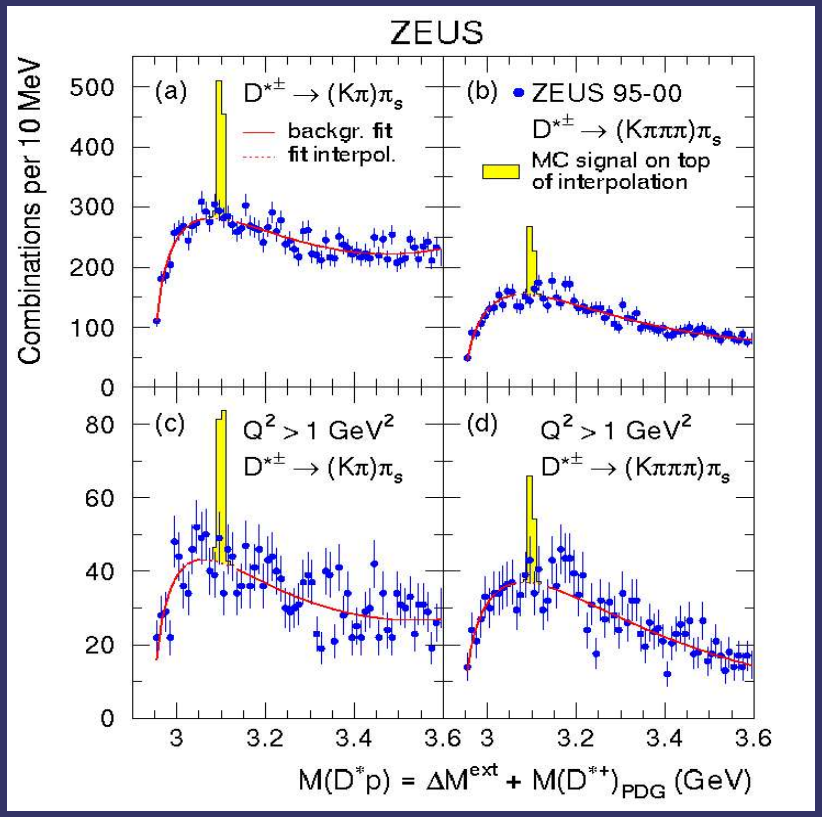
ZEUS does not observe the signal reported by NA49

Search for charm pentaquarks

If $\theta^+ = uudd\bar{s}$ exists, then $\theta^0_c = uudd\bar{c}$ can also exist

H1 reported a narrow signal at 3099 MeV (Phys. Lett. B588 (2004) 17)

final paper from this summer



H1 reports in their measured kinematic region (DIS):

$$R = N(\theta_c \to D^* p / D^*) \approx 1\%$$

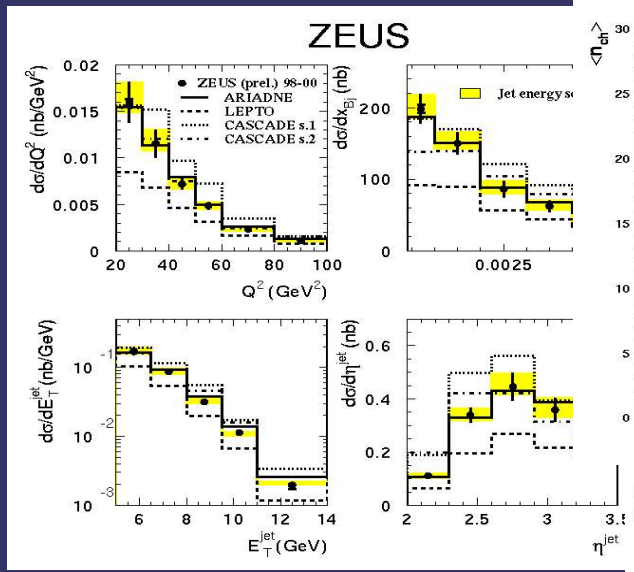
(consistent with photoproduction data)

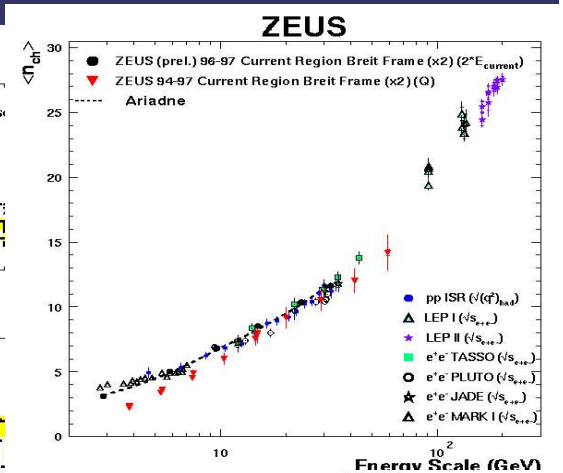
ZEUS excludes this fraction using larger D^* data sample:

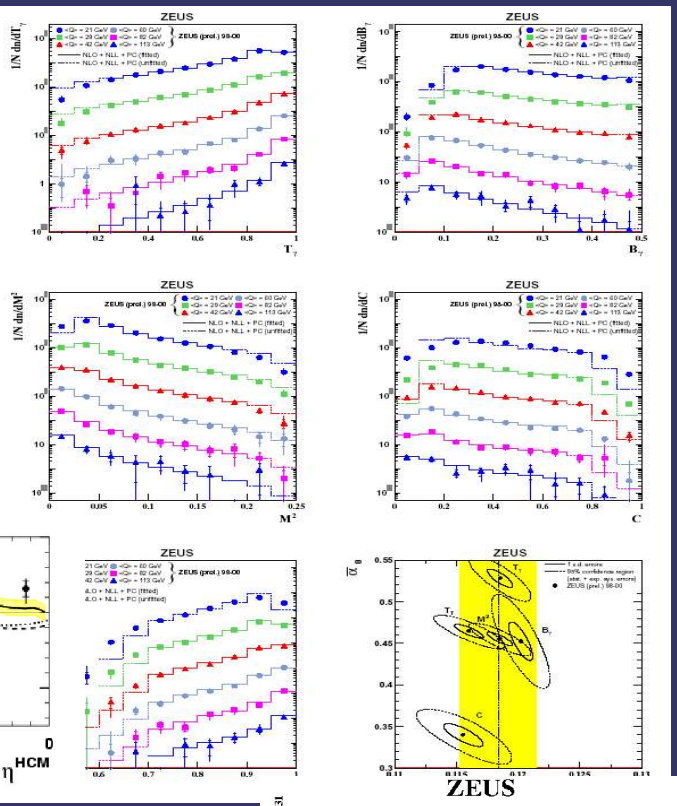
- at 9 σ in DIS and photoproduction
- at 5 σ in DIS (Q^2>1 GeV^2)

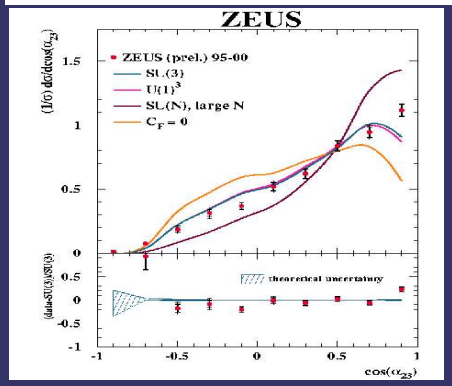
ZEUS data is in contradiction with H1 report

Many new results for ICHEP04









BFKL studies

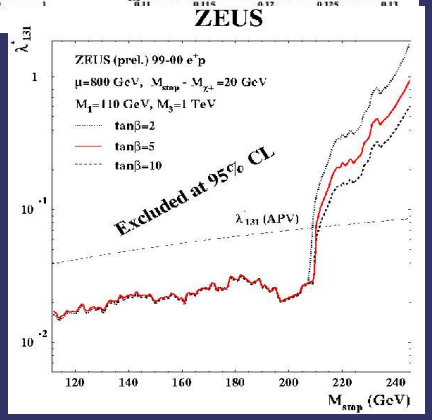
Azimuthal asymmetry

Event shapes

Color dynamics

Multiplicity measurements

A search for stop production



Summary

- Significant improvement in ZEUS data taking efficiency
- Data taken using new detectors:
  - MVD & STT
  - GTT at second-level trigger
- ZEUS detector is in good shape. STT problem is under investigation
- Only small fraction of results made public since May 2004 were shown
  - HERA II data are presented at ICHEP04
- Looking forward to more data