ZEUS Physics and Upgrade

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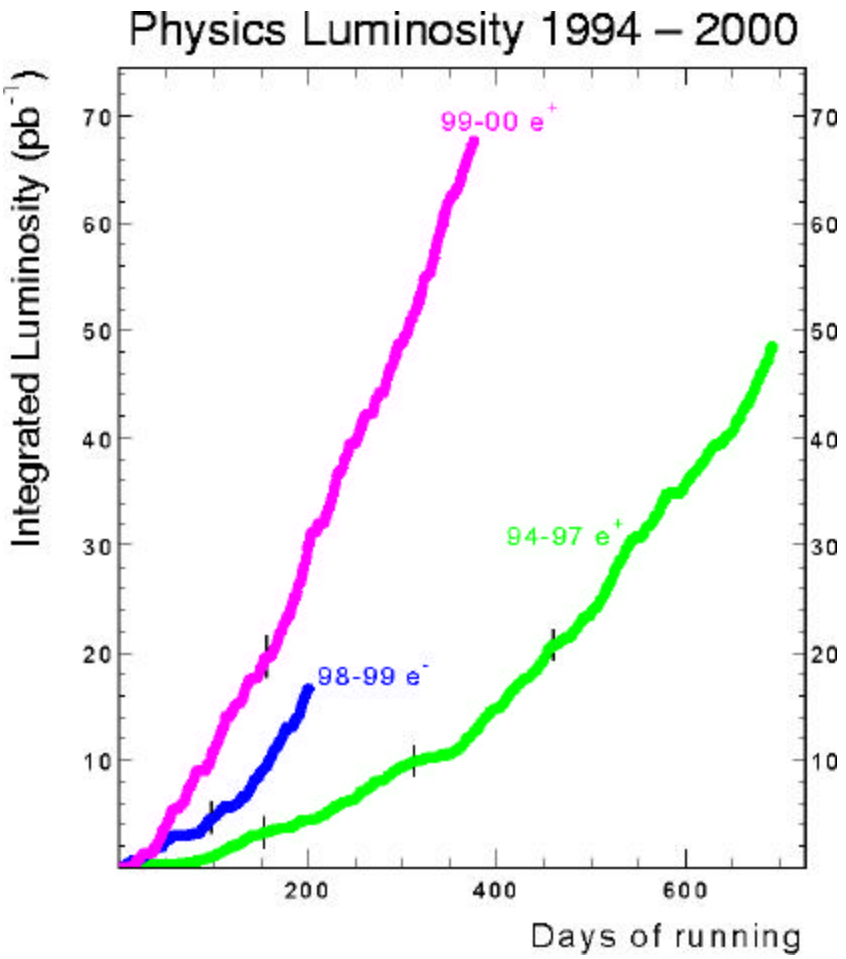
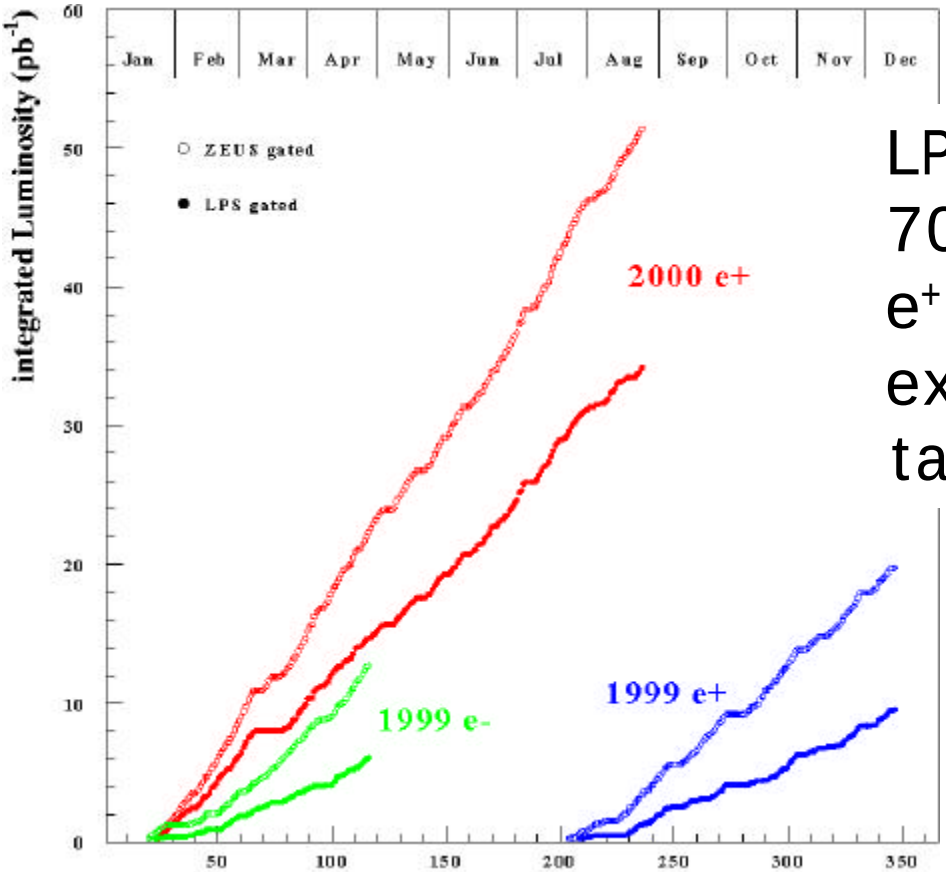
Data taking



Impressive HERA performance !

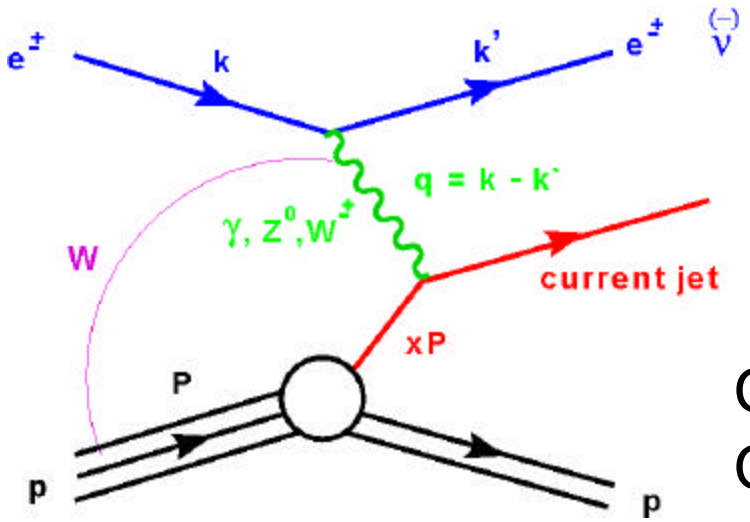
ZEUS collected for physics 1994-2000:
e^+ 116 pb^{-1};
e^- 17 pb^{-1}

(+FPC, BPC, BPT, LPS)



LPS:
70% efficiency
e^+ ~ 40 pb^{-1}
excellent data taking in 2000

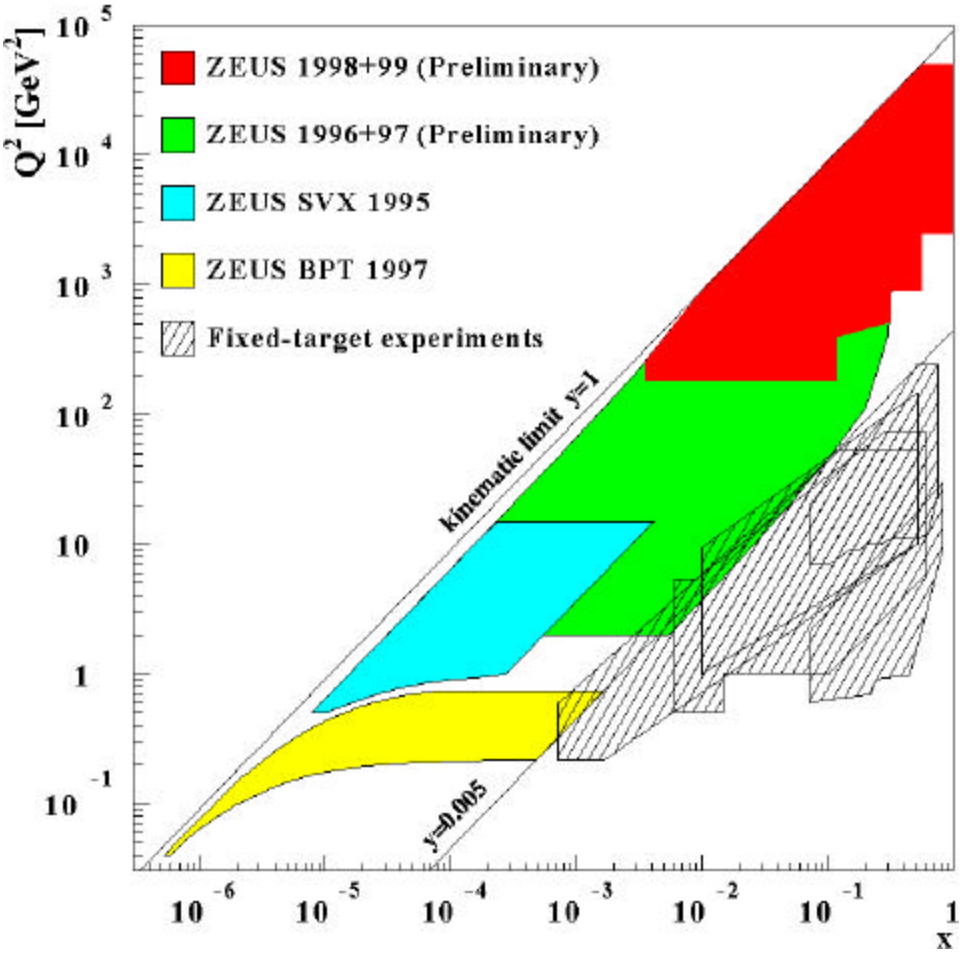
Experimental range



$Q^2 \sim 0$ GeV$^2 \rightarrow$ PHP

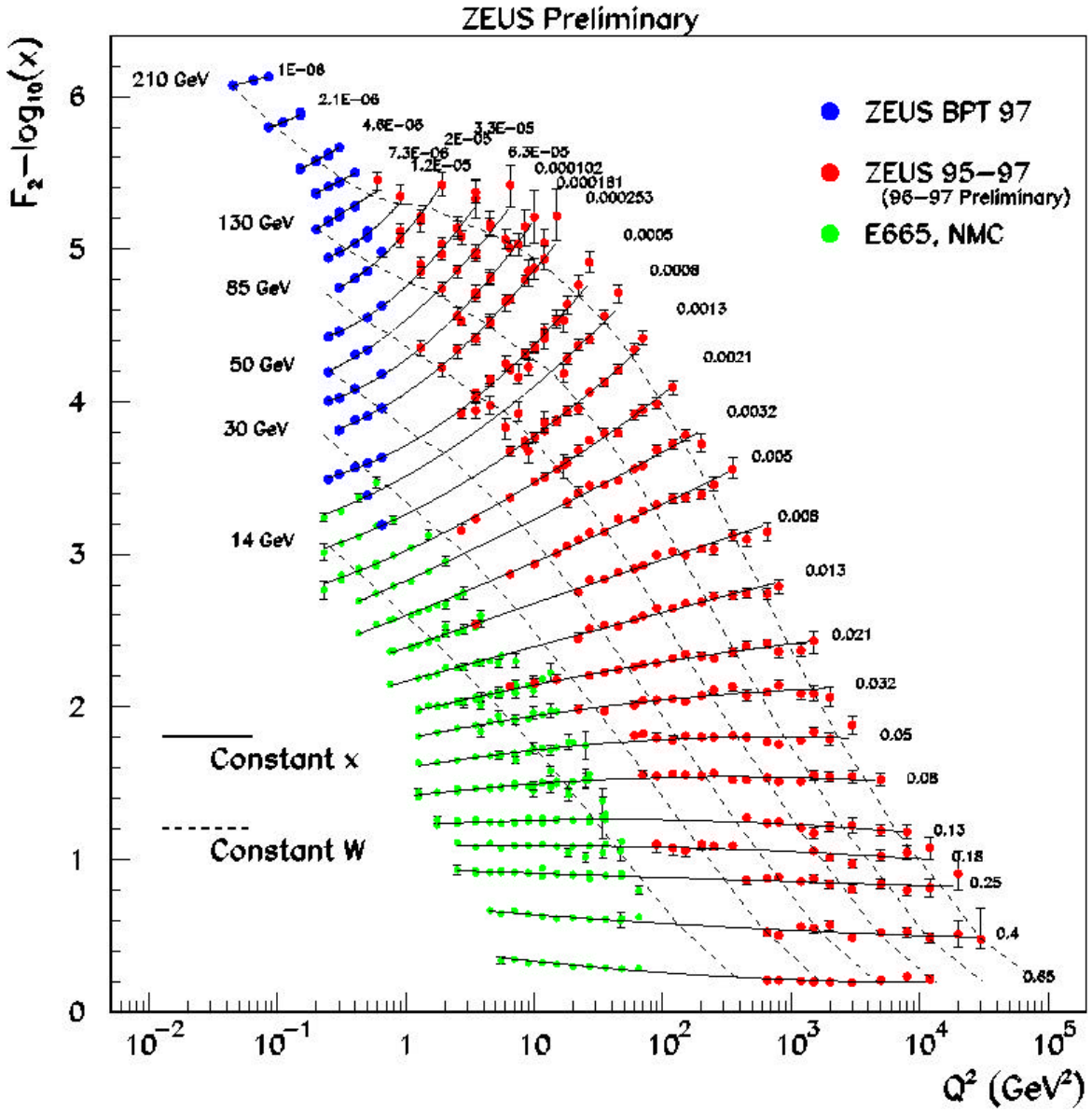
$Q^2 \gg 1$ GeV$^2 \rightarrow$ DIS

Large area covered:
span 6 orders of magnitude in x and Q^2.



High Q^2: EW, new physics;
low Q^2: non perturbative regime.

Scaling violation of F_2



1) F_2 offset is $\log_{10}(x)$

2) fit F_2 for each x value to

$$A(x) + B(x)\log_{10}Q^2 + C(x)(\log Q^2)^2$$

3) $x \sim Q^2/(Q^2+W^2) \rightarrow x \sim Q^2$ for fixed W

$W \rightarrow \gamma p$ CMS energy

The logarithmic Q^2 derivative of F_2

The changes in the F_2 dependence of F_2 (low x, low Q^2) can be looked at with

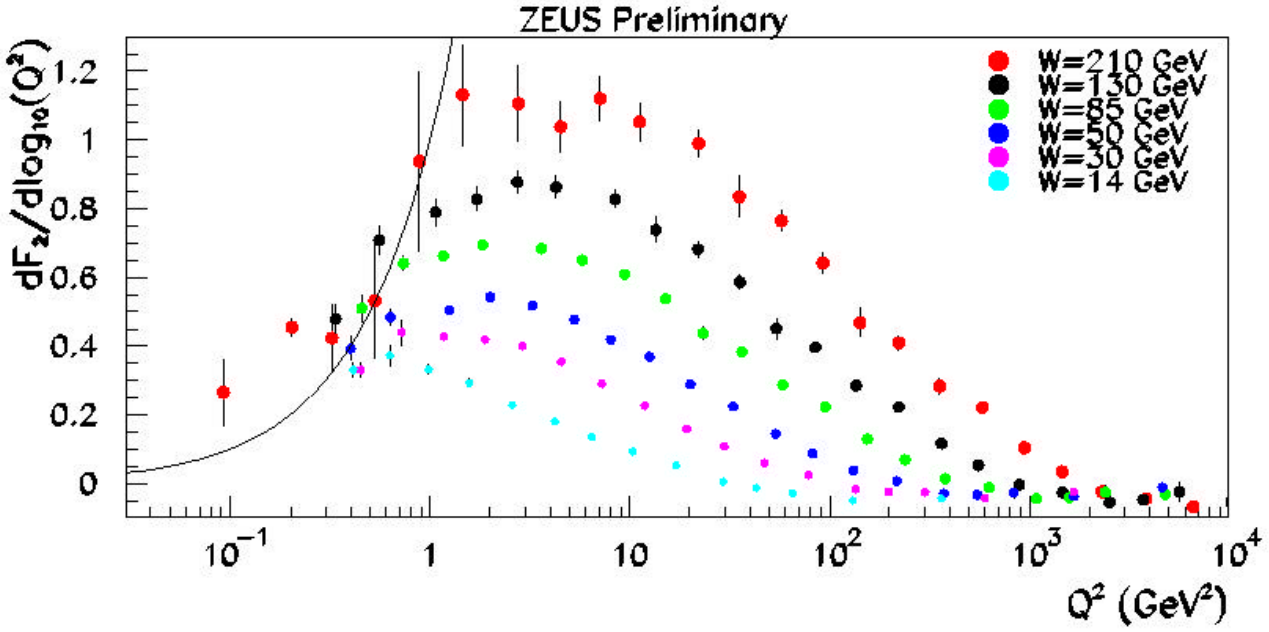
$$\frac{\partial F_2}{\partial \ln_{10} Q^2}\left(x, Q^2\right) = B(x) + C(x) log_{10} Q^2$$

(calculated for fixed x)

At low Q^2

$$(B)\quad \frac{\partial F_2}{\partial \ln_{10} Q^2}\left(x, Q^2\right) \propto Q^2 \sigma_0$$

(conservation of EM current $q_\mu W^{\omega\nu} = 0$)

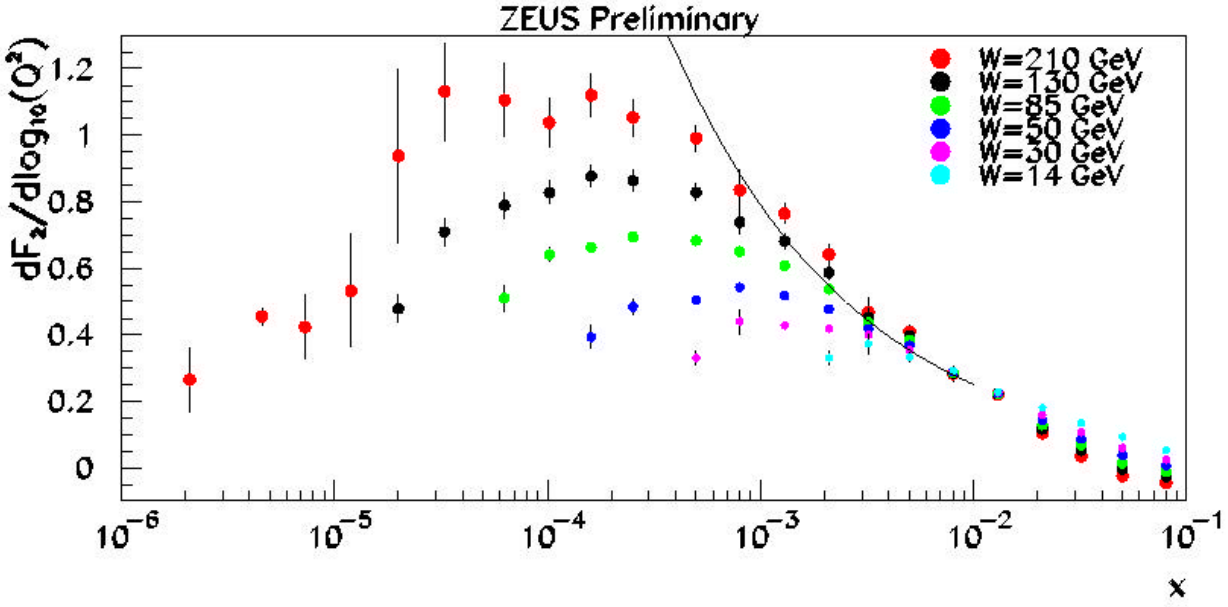


Line: $\sigma_0 * Q^2$ with $\sigma_0 = 1.0$

The logarithmic Q^2 derivative of F_2

In the low x limit and LO (DGLAP):

$$(A)\quad \frac{\partial F_2}{\partial \ln_{10} Q^2}\left(x, Q^2\right) \propto xG(x, Q^2) \sim x^{-\lambda}$$



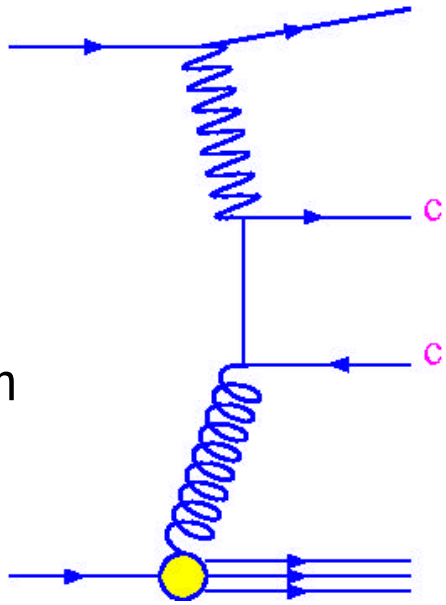
Line: $c*x^{-0.5}$ with C = 0.025

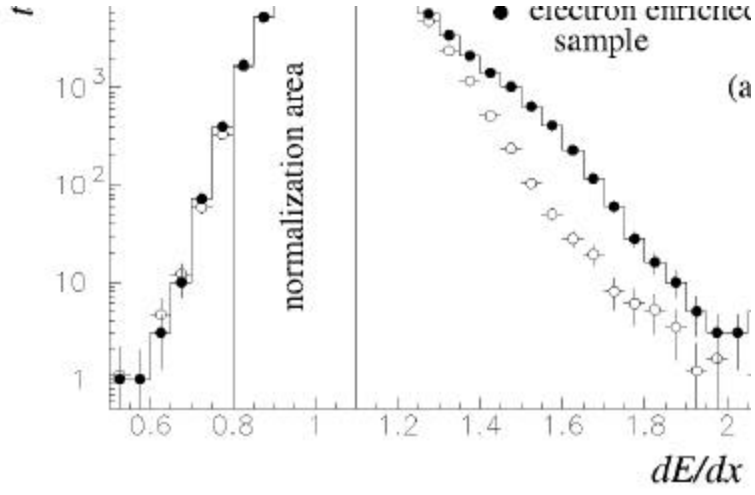
F_2^c via semileptonic decay
$c \rightarrow e \nu X$ ($\mu \nu X$)

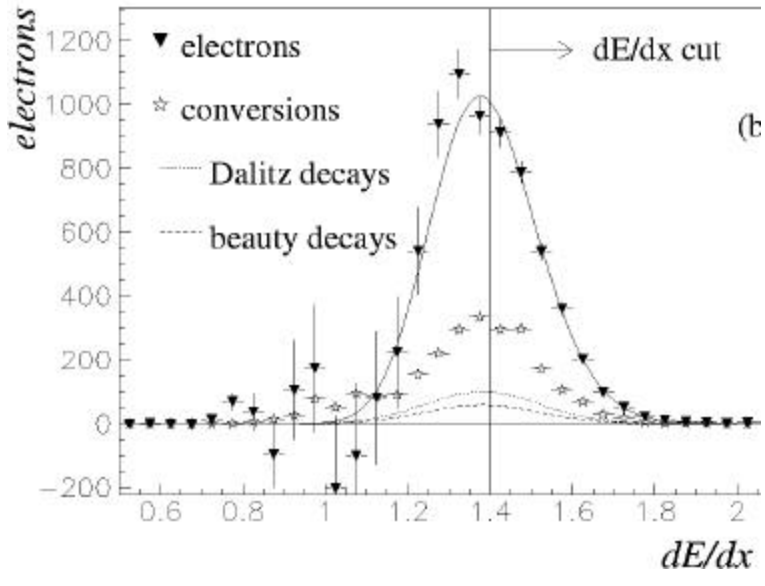
Directly sensitive to $xG(x,Q^2)$

New method:

- tracking (dE/dx) and CAL (E):
- Electron enriched: $E_{EMC}/E > 90\%$
- Hadron sample: $E_{EMC}/E_{CAL} < 40\%$
- Subtract statistically hadrons from electron enriched sample







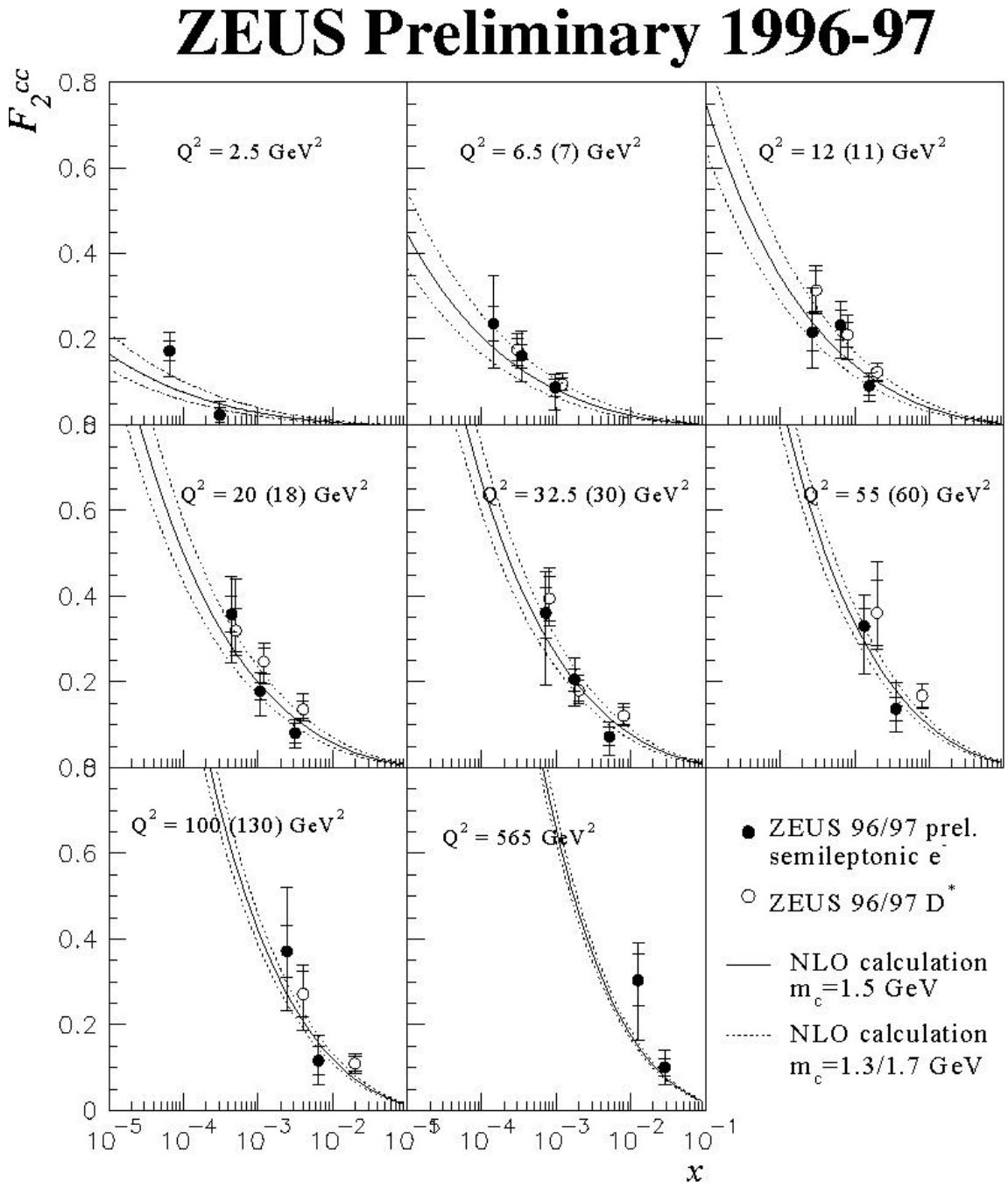
Clear signal seen !

Difficult background:

$\gamma \rightarrow e^+e^-$ (conversion)

$\pi^0 \rightarrow e^+e^-\gamma$ (Dalitz decays)

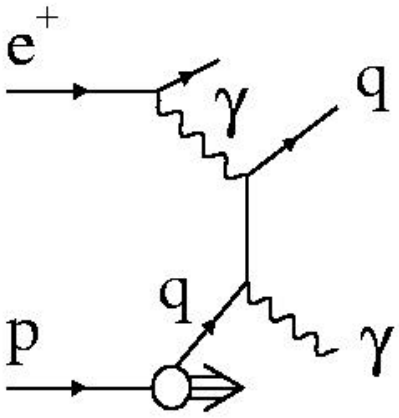
F_2^c (cont'd)



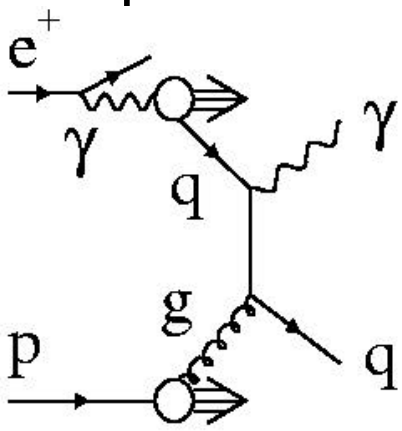
- fast rise at low x (steeper with higher Q^2);
- higher BR $\rightarrow$ extension to higher Q^2
- gluon from scaling violation of F_2 (ZEUS) describes perfectly the data.

Study of parton behavior using prompt-γ + Jet

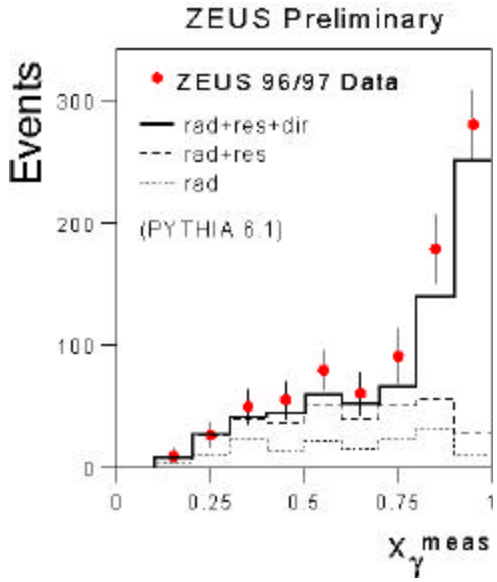
Events w/ hard γs in final state $\rightarrow$ sensitive to the quark densities in the proton.



(a) Direct Prompt γ

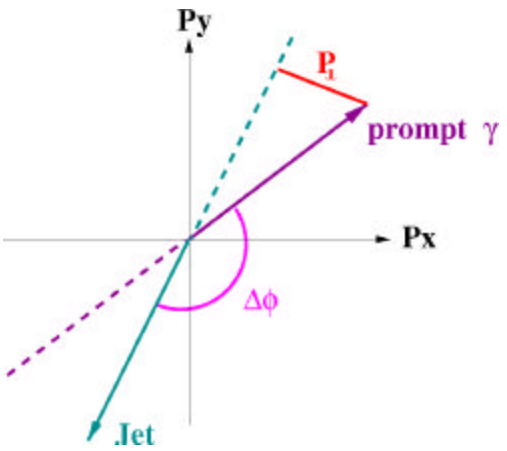


(b) Resolved Prompt γ



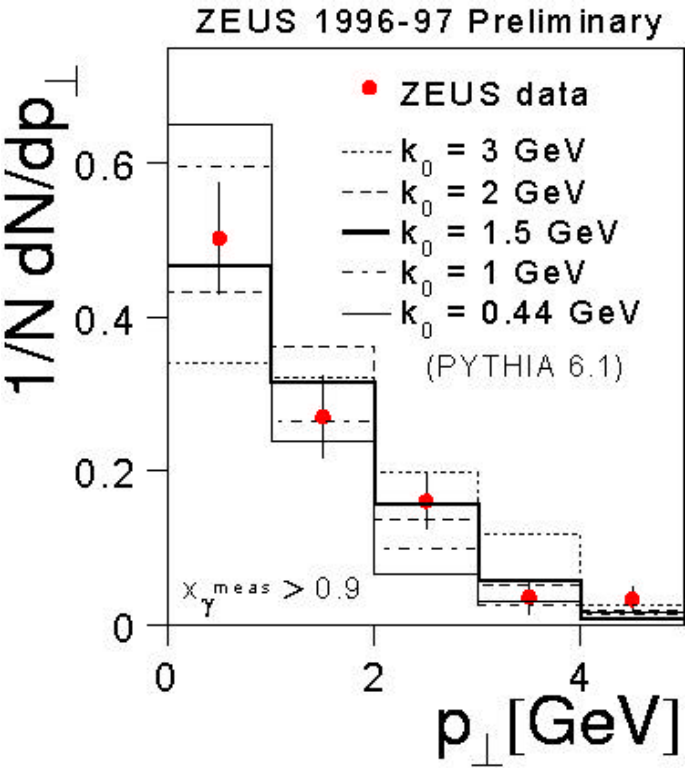
Select a clean sample of direct γ, require $x_\gamma > 0.9$

$$x_\gamma^{meas} = \sum_{\gamma,jet} \frac{E - p_z}{2E_e y_{JB}}$$

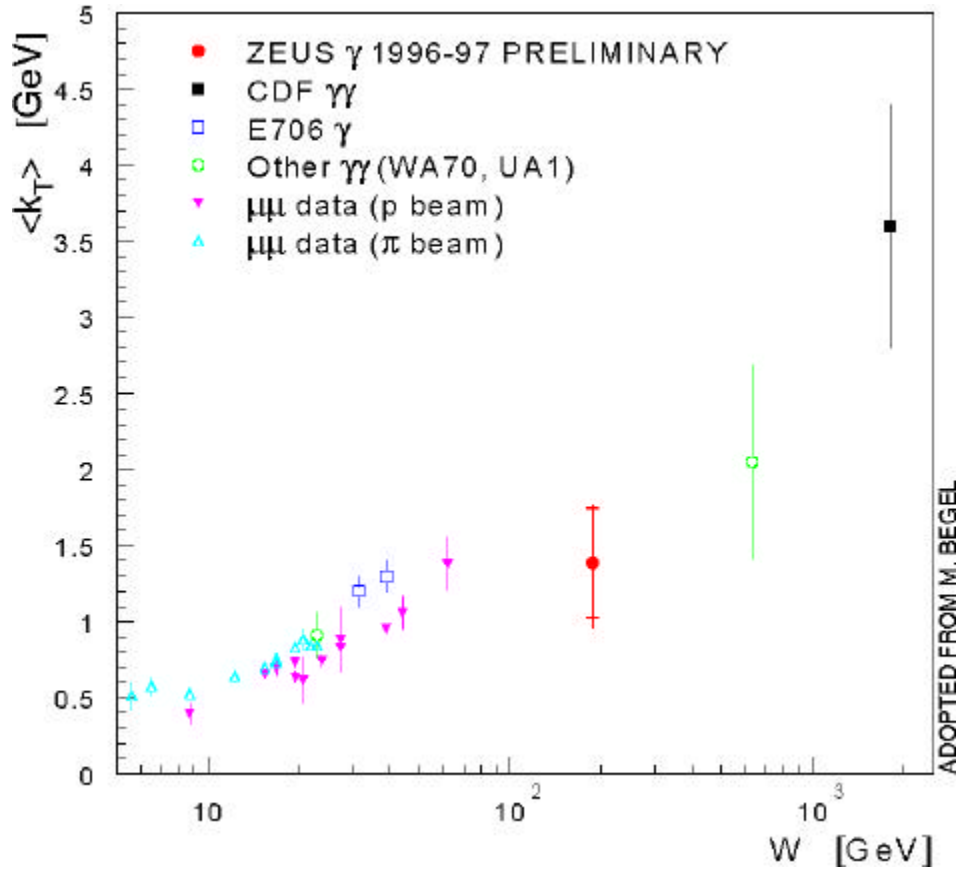


Sensitive to the initial state radiation pattern

prompt-γ + Jet (cont'd)

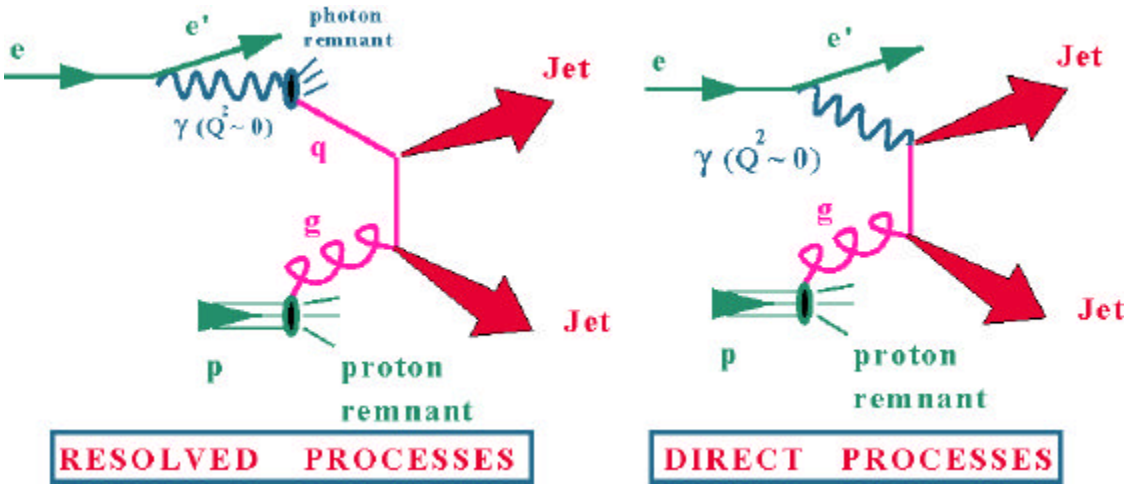


$\langle k_T \rangle$ from Fermi motion + possible gluon radiation $\Rightarrow$ modelled as intrinsic $\langle k_T \rangle$ in PYTHIA



Transverse momentum smearing of the partons due to gluon radiation increase with W

Dijet in Photoproduction



For $Q^2 \sim 0$, two dominant subprocesses:

$q_\gamma\, g_p \rightarrow q\, g$ and $\gamma\, g \rightarrow q\, q$

Study internal structure of jets and classify according to their size:

- "thick" jets expected from gluons;
- "thin" jets more likely from quarks.

Jets search w/ inclusive k_T algorithm.

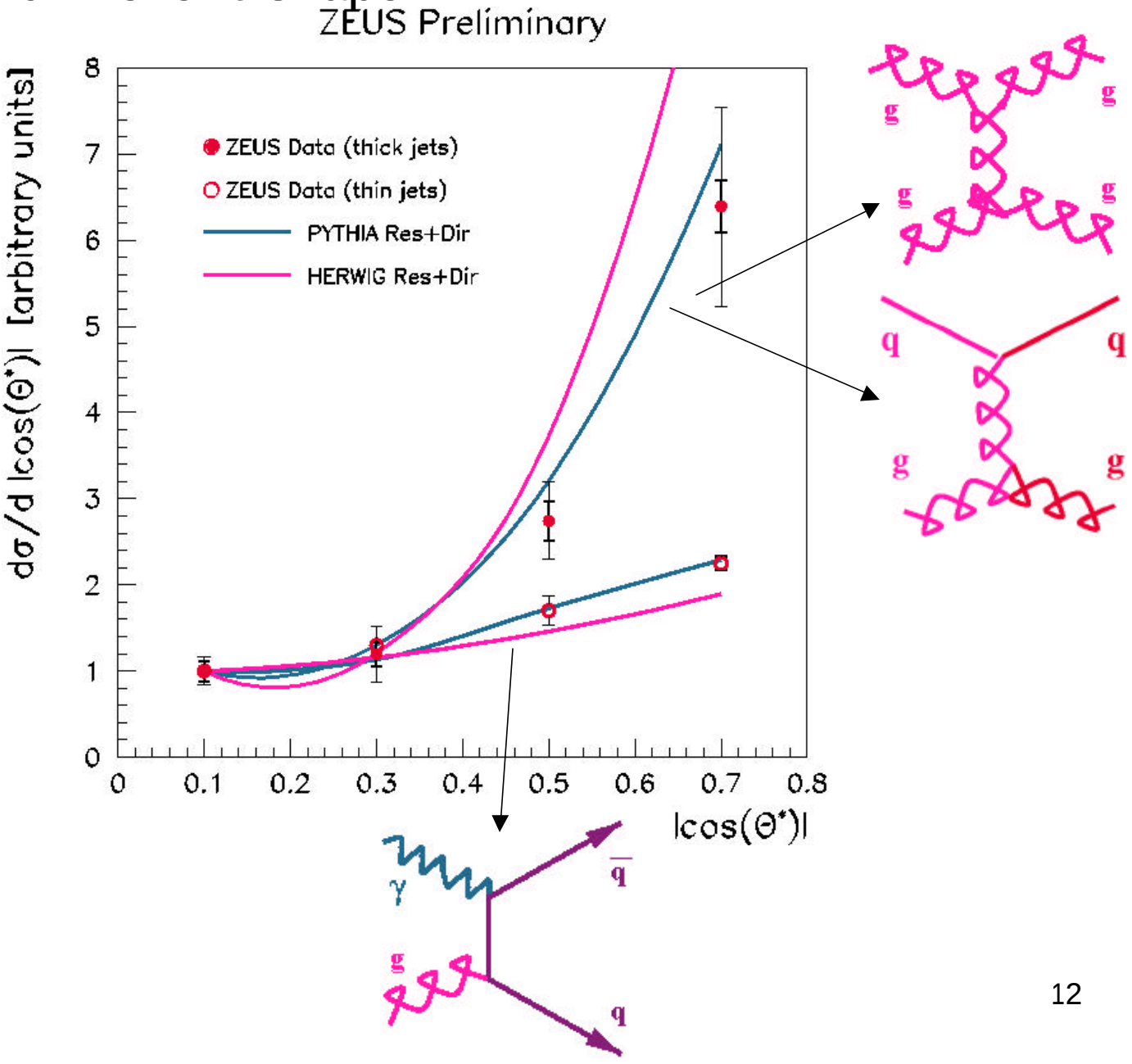
$0.2 < y < 0.85$ and $Q^2 < 1\ \mathrm{GeV}^2$

Dijet in Photoproduction (cont'd)

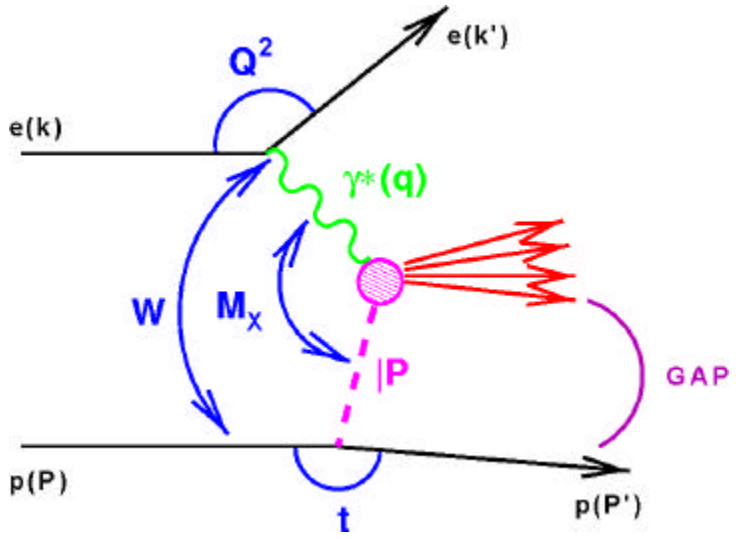
The $\cos\theta^*$ distribution sensitive to the parton dynamics:

- gluon exchange, $dN/d\cos\theta^* \propto (1-|\cos\theta^*|)^{-2}$;
- quark exchange, $dN/d\cos\theta^* \propto (1-|\cos\theta^*|)^{-1}$

$d\sigma/d\cos\theta^*$ for $M^{JJ} > 47$ GeV for samples of 2 "thick" and 2 "thin" jets exhibit a different shape:



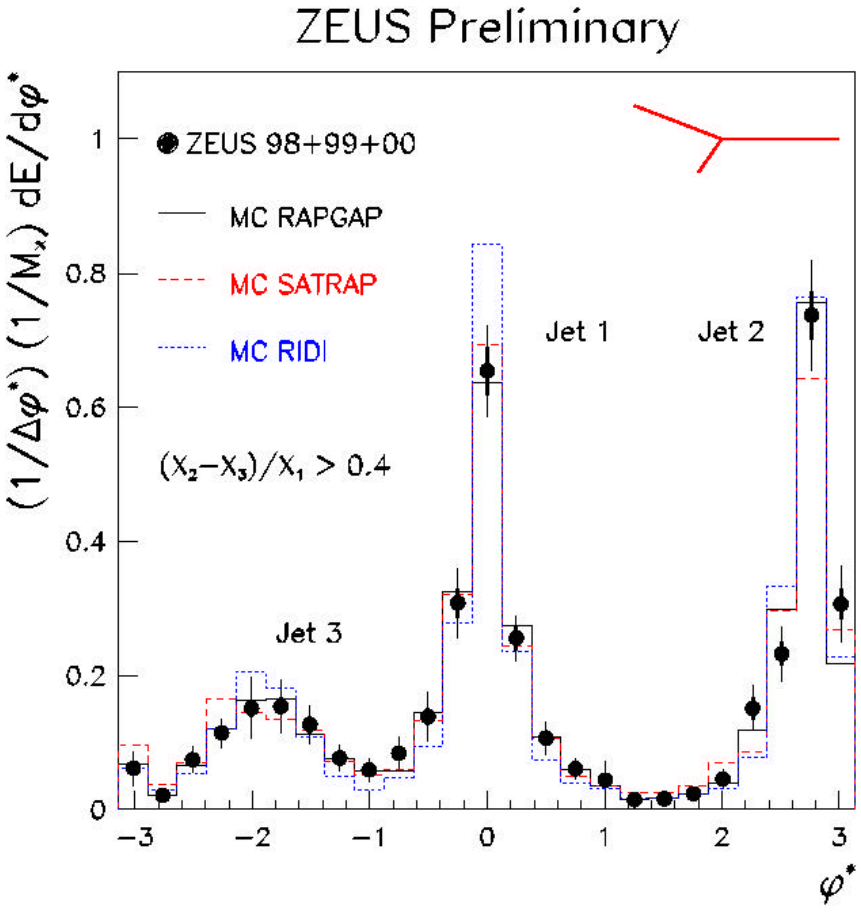
3-Jet production in Diffractive DIS



$5 < Q^2 < 100\ \mathrm{GeV}^2$
$200 < W < 250\ \mathrm{GeV}$
$x_{IP} < 0.025$
$23 < M_X < 40\ \mathrm{GeV}$
$\eta_{MAX}^{\mathrm{hadron}} < 3.0$

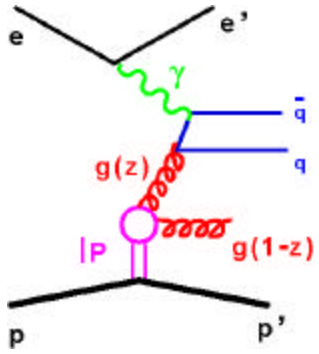
FPC extends M_X (and η) range.

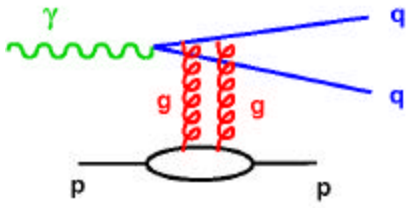
Three jet events were observed at PETRA in the range $29 \leq \sqrt{s} \leq 36$ GeV

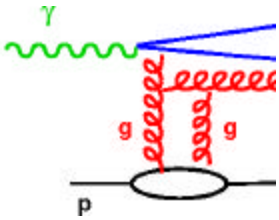


Evidence for three-jet events in LRG events!

3-Jet production in Diffractive DIS



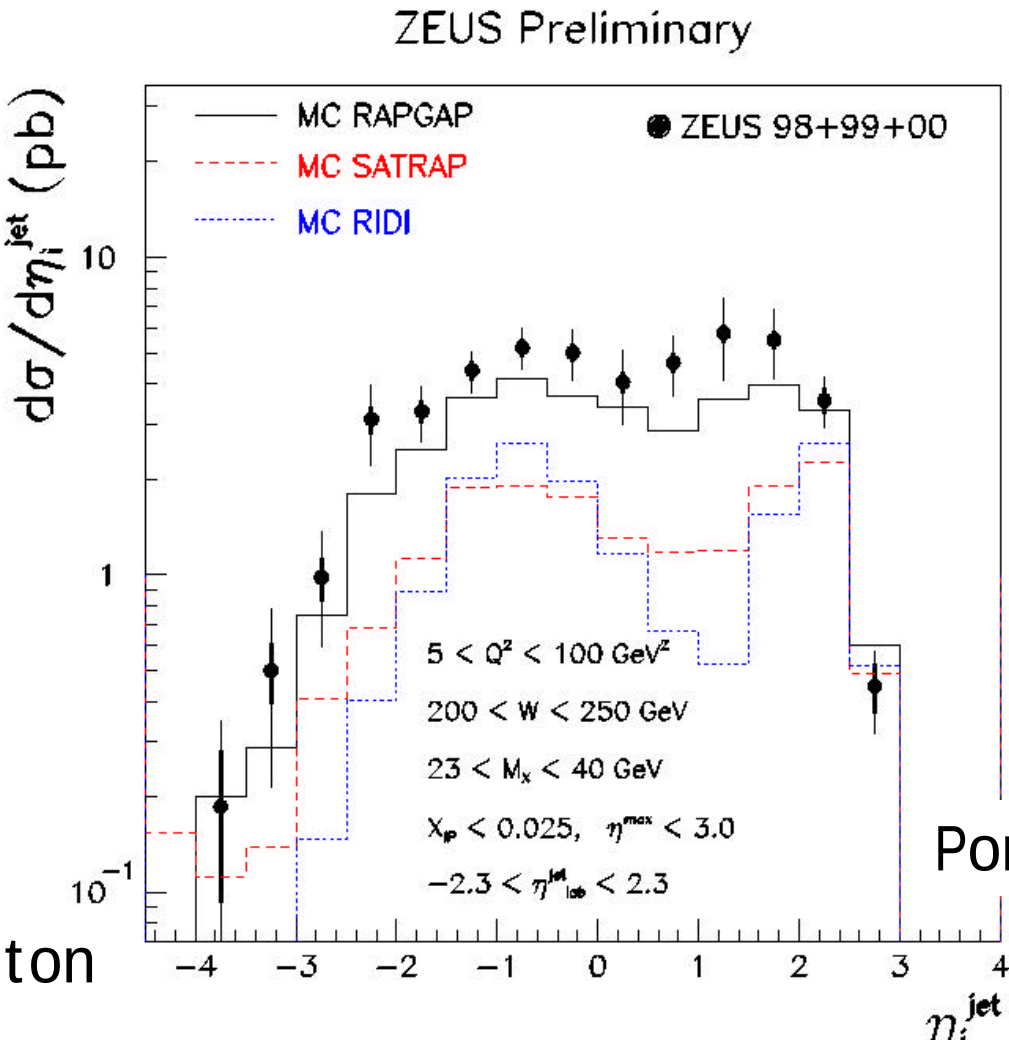




Factorize IP

pQCD inspired

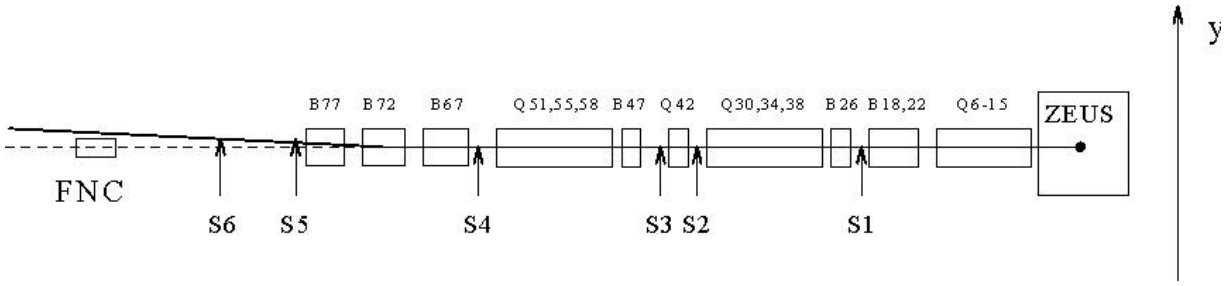
Tuned to inclusive diffraction.
pQCD inspired models dominated by jets aligned to γ–IP axis.
Gluon dominated Pomeron picture confirmed

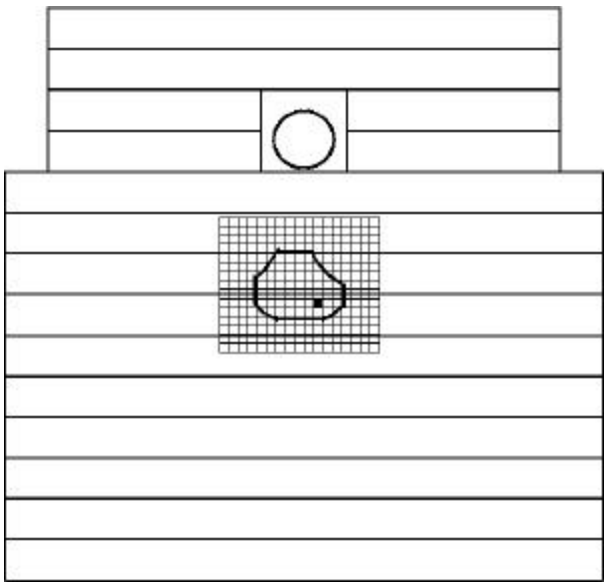


Pomeron

Photon

Leading Neutrons p_t distrib. in DIS



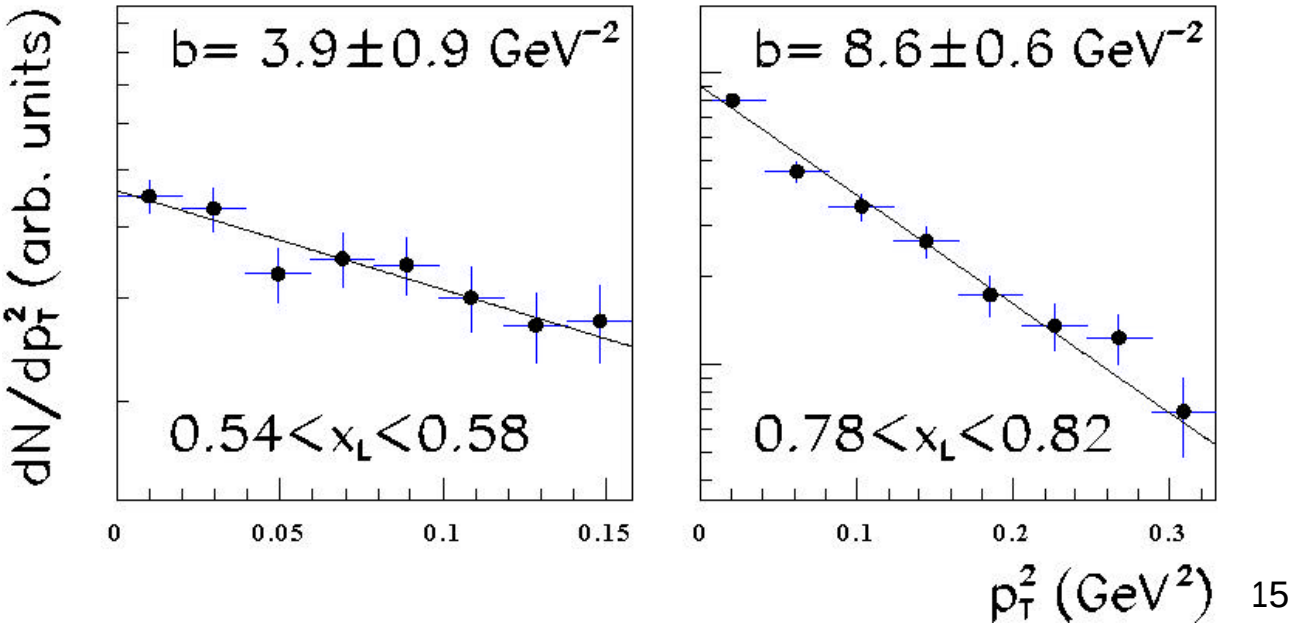


FNT installed in the FNC. Allows to measure the neutron p_t

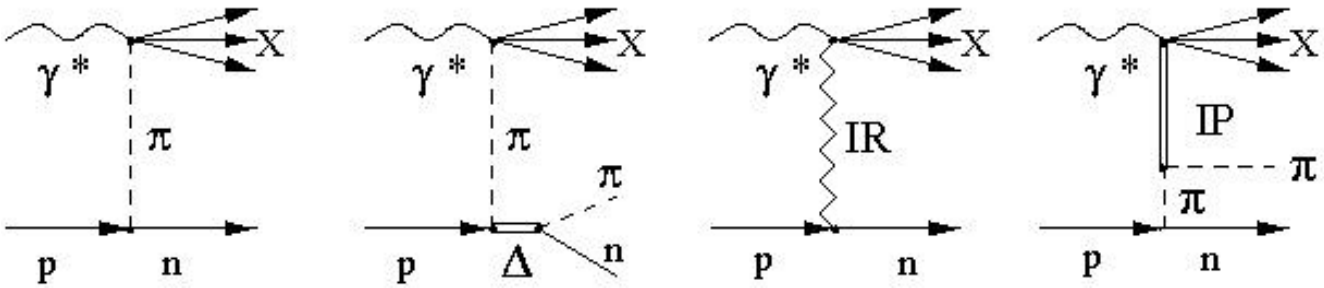
$x_L = E_n / E_{beam}$

Fit dN/dp_t^2 to a single exponential function ($\exp -b\, p_t^2$)

ZEUS PRELIMINARY 1999

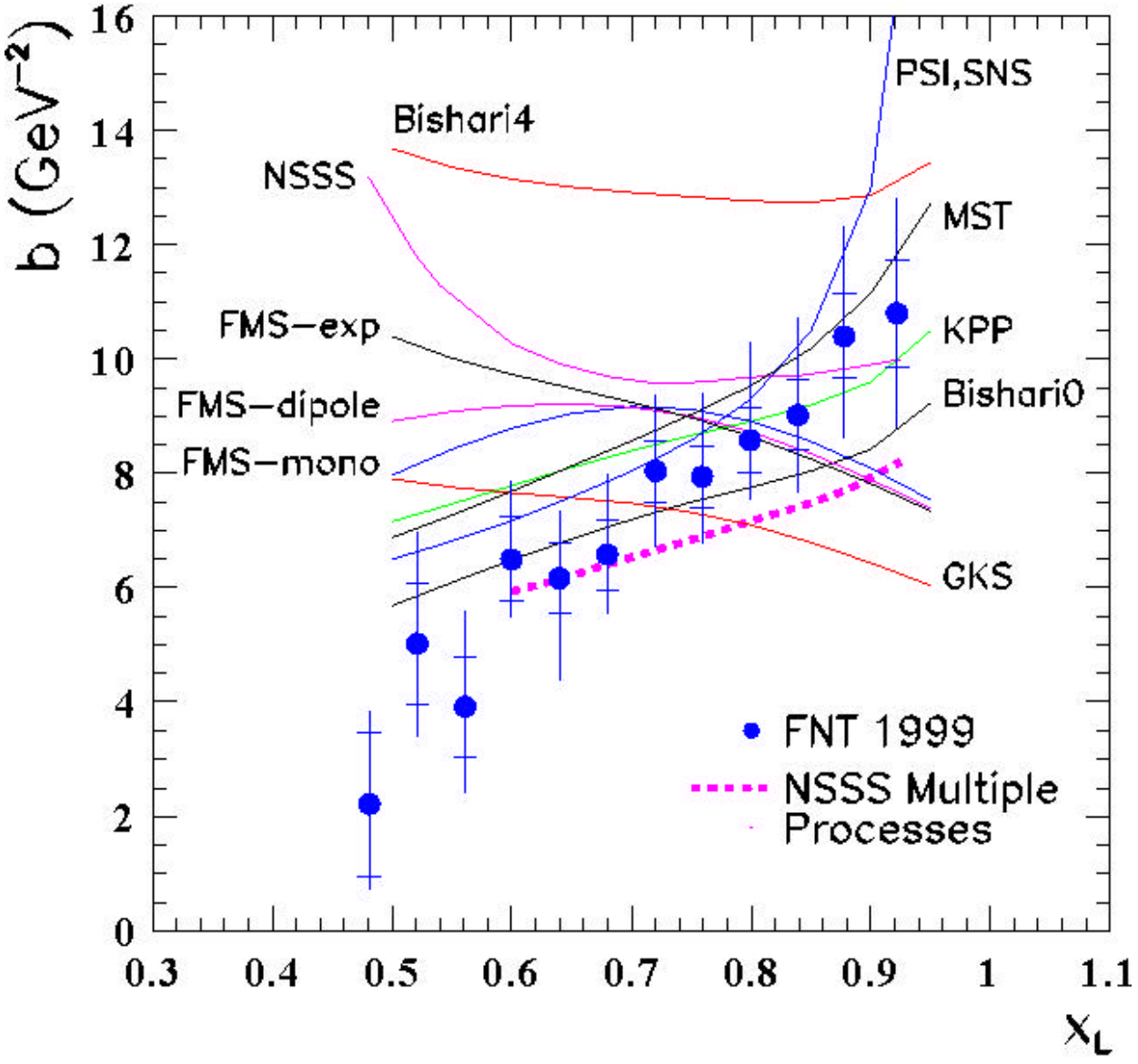


Leading Neutrons (cont'd)



P_t distribution (slope) sensitive to the nature of the exchanged object.

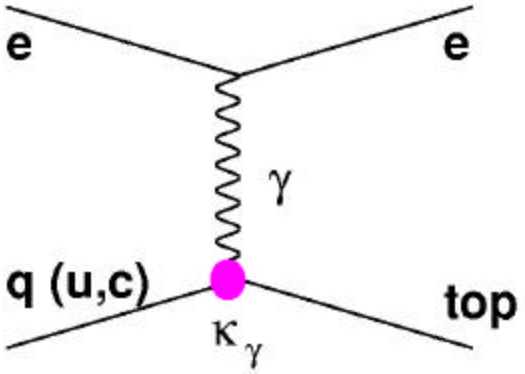
ZEUS PRELIMINARY 1999



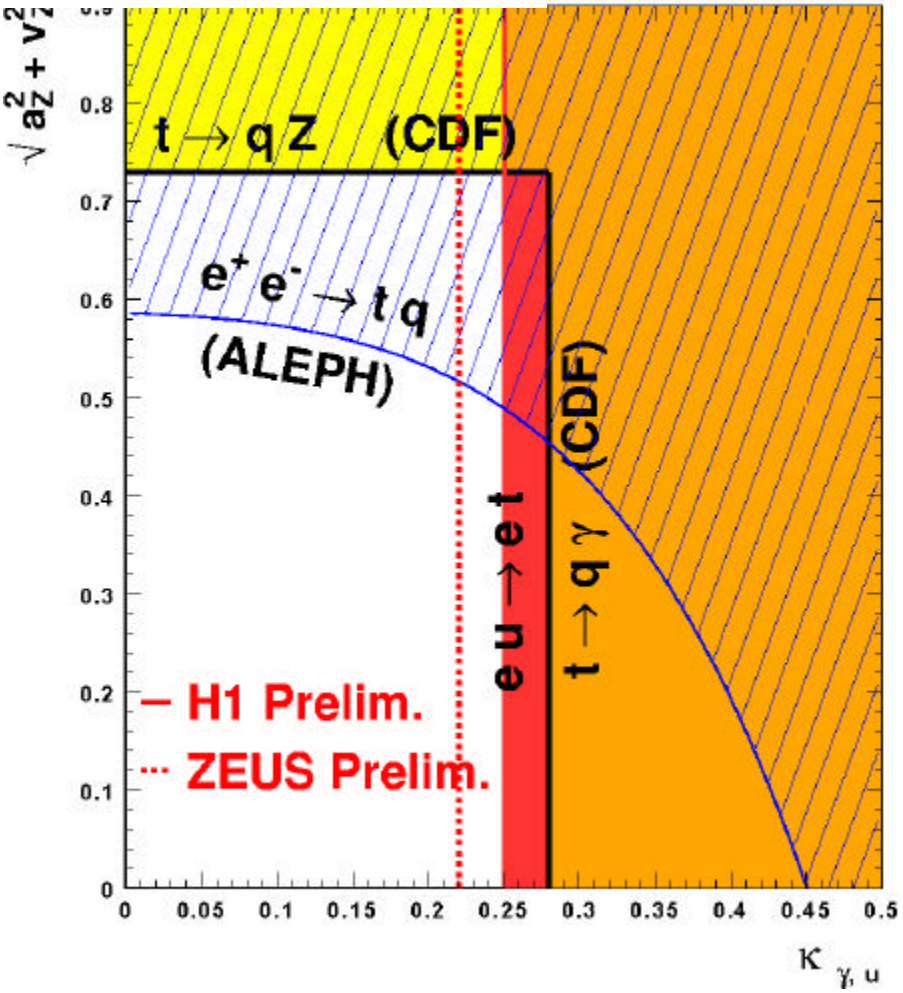
Search for single top production

High p_t leptons

	Electrons observed/expected (W)	Muons observed/expected (W)
Total 82 pb^{-1} preliminary	7 / 6.1±0.9 (1.9)	4 / 3.7±0.4 (0.8)



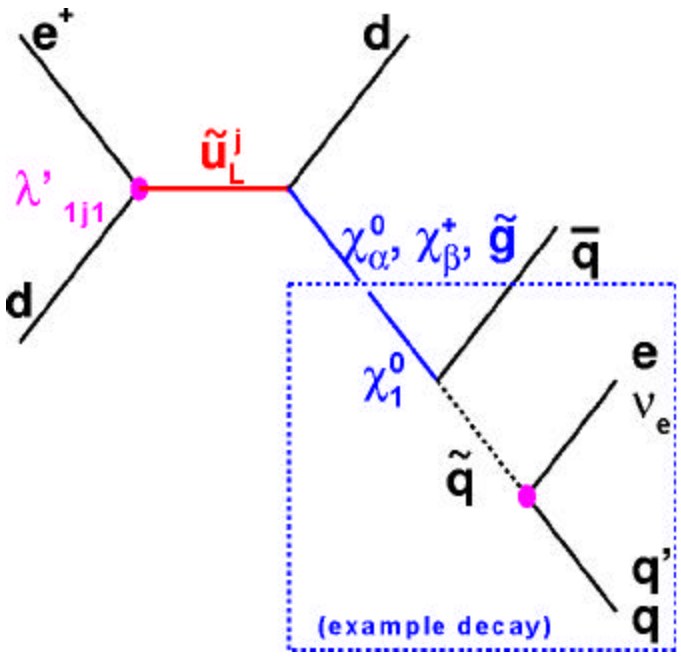
$t \rightarrow bW \rightarrow be\nu, b\mu\nu$
DATA: no events;
SM: expect 0.65



Best world limit on $\kappa_{tu\gamma}$:
$\kappa_{tu\gamma} < 0.22$
(95% CL)

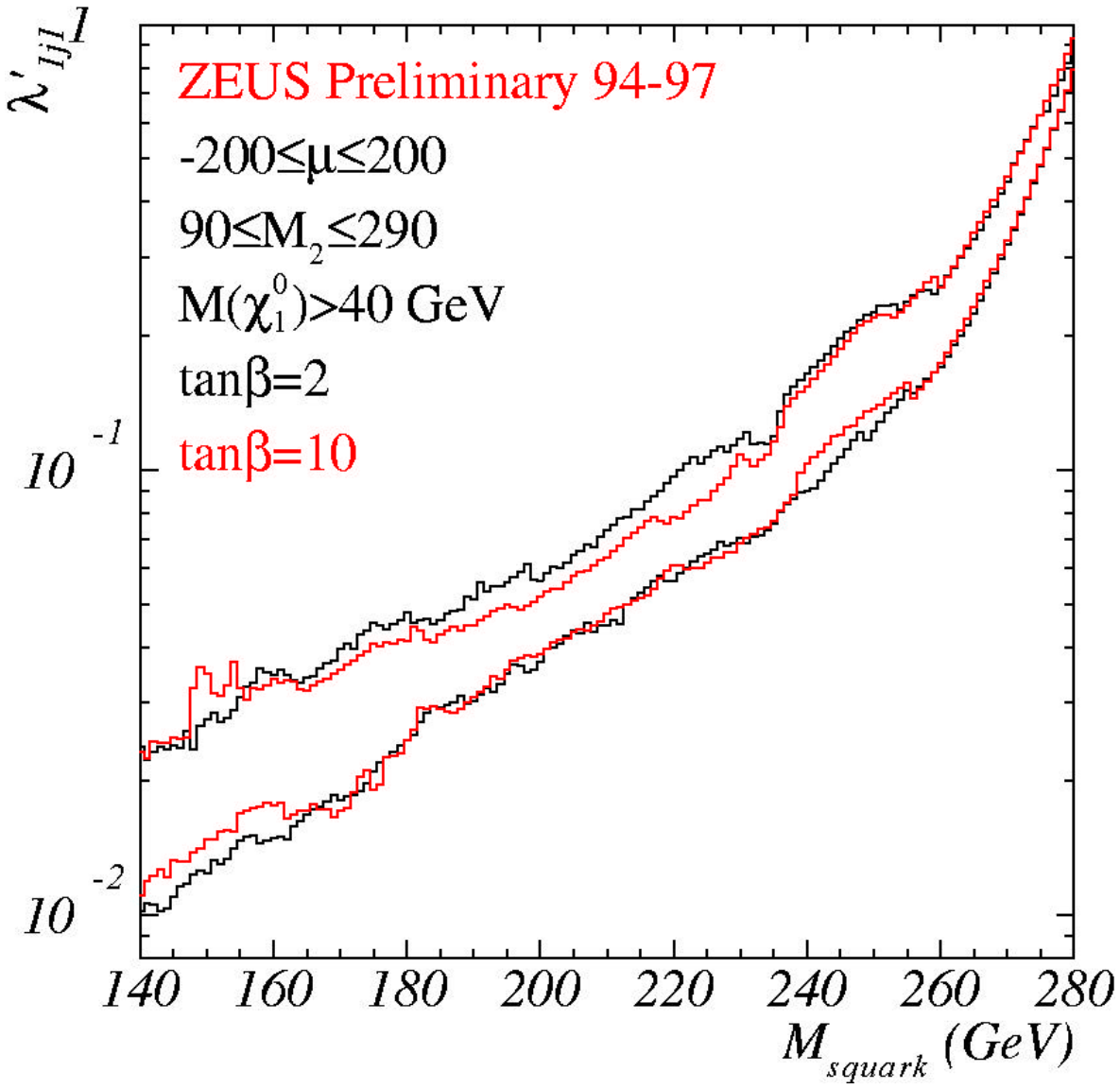
Limit at HERA obtained only for γ coupling,[17] and valid only for t-u FCNC.

Search for squark production in RPV SUSY

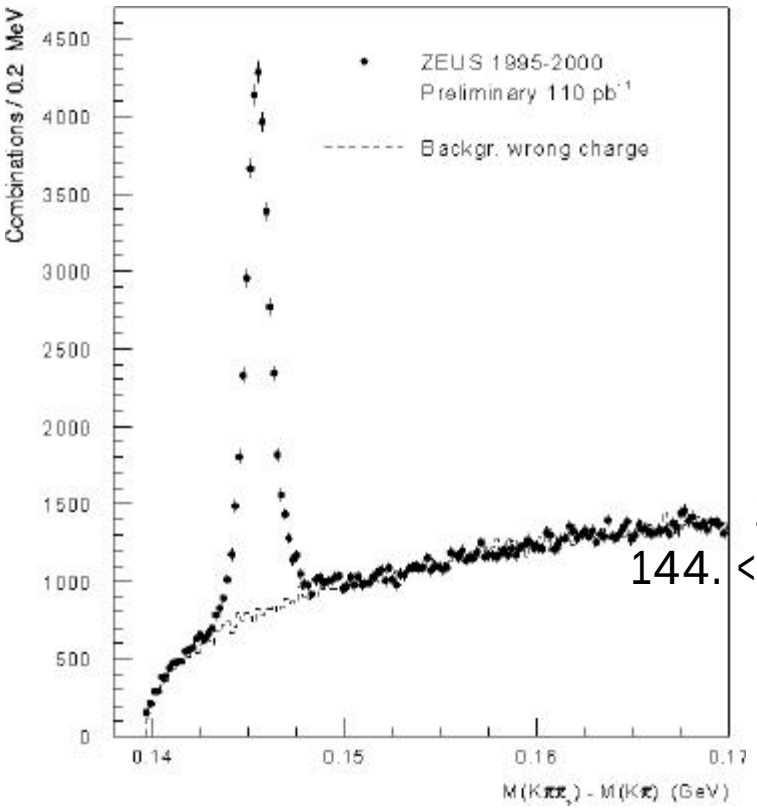


Simulation of the signal: large scan of the SUSY parameter space on M_2, μ, $\tan\beta$

DATA: 82 pb^{-1}



HERA as a charm factory ?



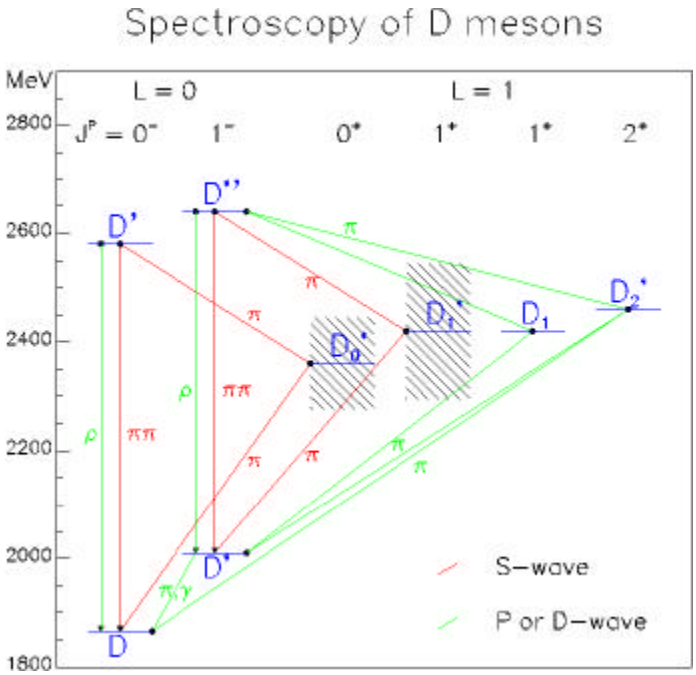
L = 110 pb^{-1} !
Combined high and low Q^2
$p_t^{D^*} > 2$GeV; $|\eta^{D^*}| < 1.5$

Mass window:
$1.83 < M(K,\pi) < 1.90$ GeV
$144. < M(K,\pi,\pi_s) - M(K,\pi) < 147$ MeV
$N(D^{*\pm}) \sim 30000$

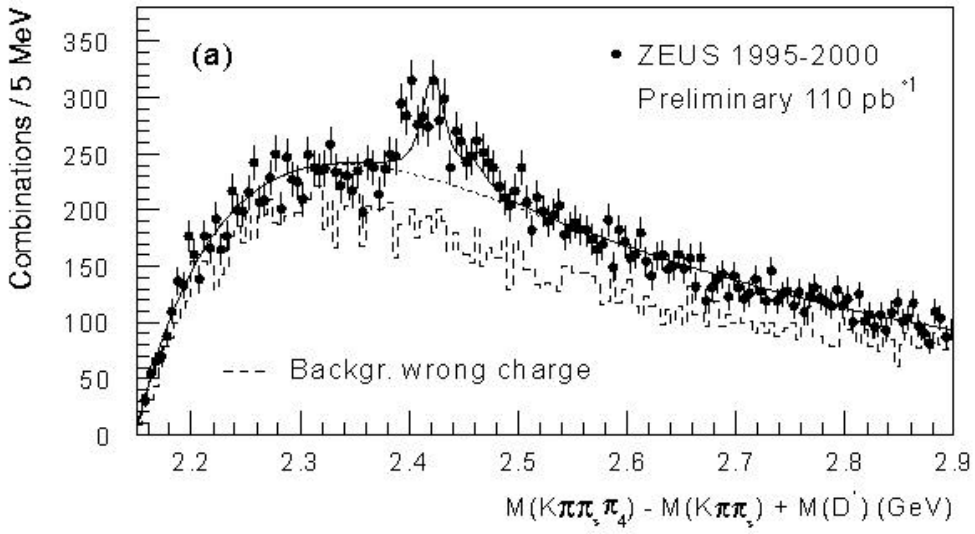
$$D^{*+} \rightarrow D^0\pi_s^+ \rightarrow K2\pi(K4\pi) + (c.c.);$$

2 orbital excited states:
- $D_1(2420)$
- $D_2^{*0}(2460)$

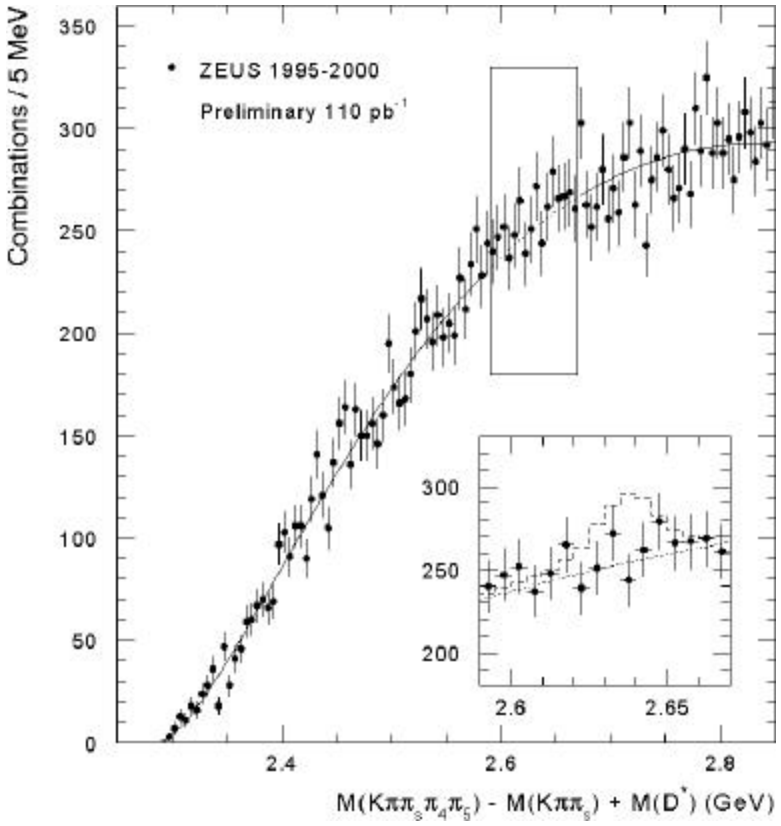
can decay in $D^*\pi$.
narrow (~ 20MeV)



Excited charm mesons



Fit D_1^0 and D_2^{*0} with Breit-Wigner folding in helicity spectra.

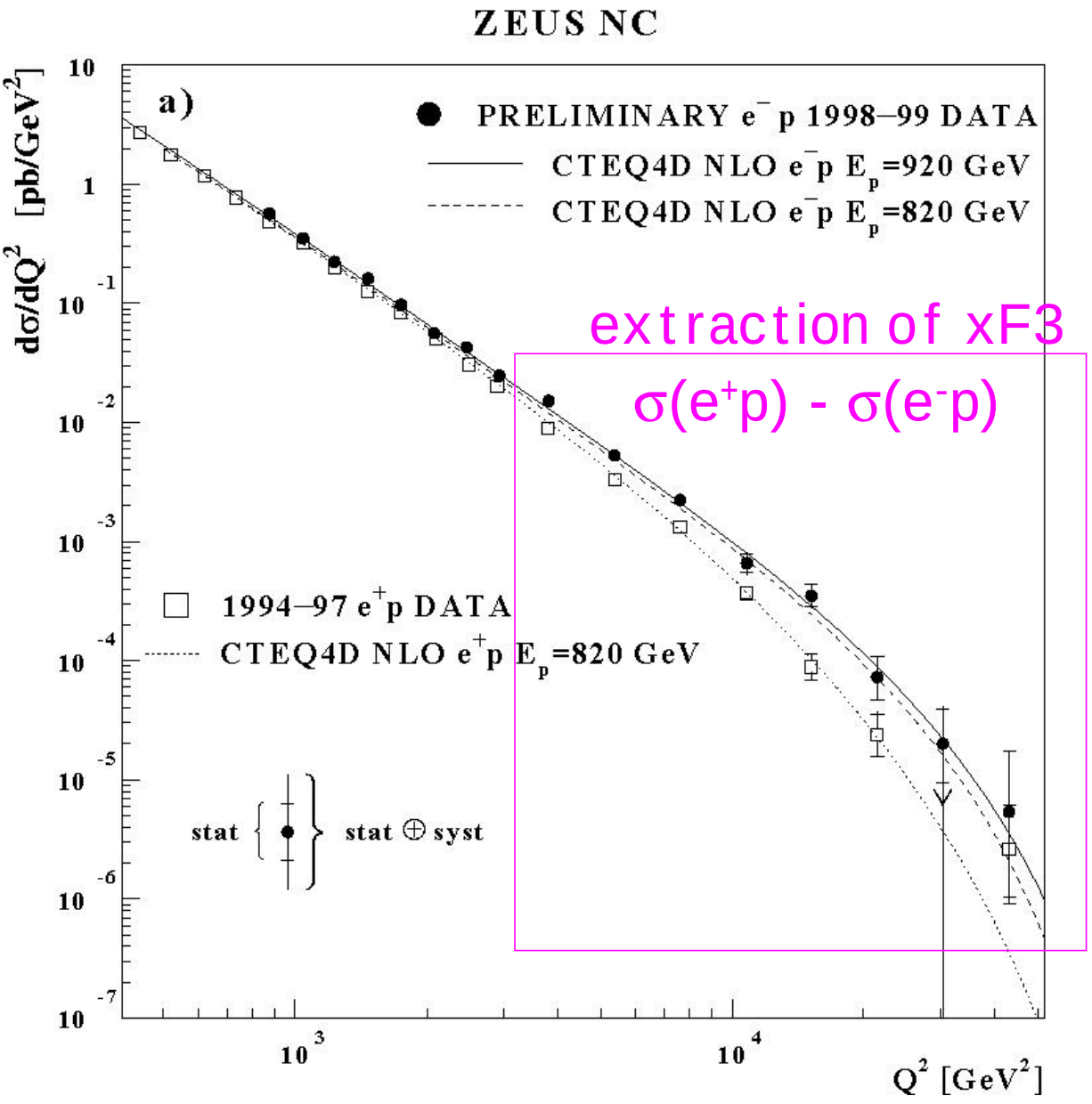


Search for radially excited D^*.
DELPHI sees a peak in $D^{*+}\pi^+\pi^-$ at M=2637 MeV.

ZEUS: no signal.

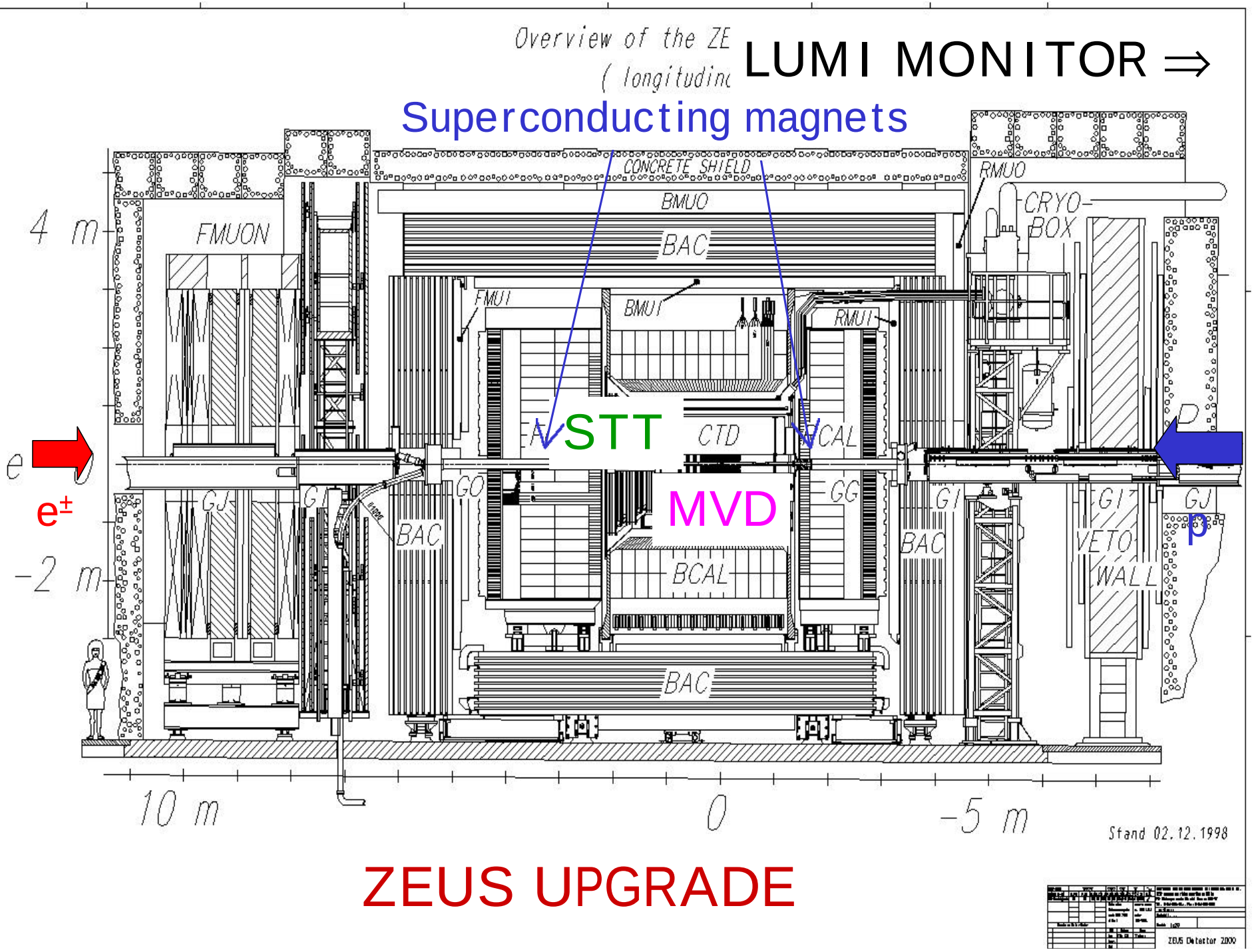
$$f\left(c \to D^{*`+}\right) \cdot B\left(D^{*`+} \to D^{*+}\pi^+\pi^-\right) < 0.7\% \text{ (95\% C.L.)}$$

Q^2 dependence of $\sigma(e^{\pm} p \rightarrow e^{\pm} X)$



- Impressive agreement w/ SM;
- Z exchange contributes differently to $\sigma(e^+p) - \sigma(e^-p)$.

High Q^2 region needs more (e^-p and e^+p data)

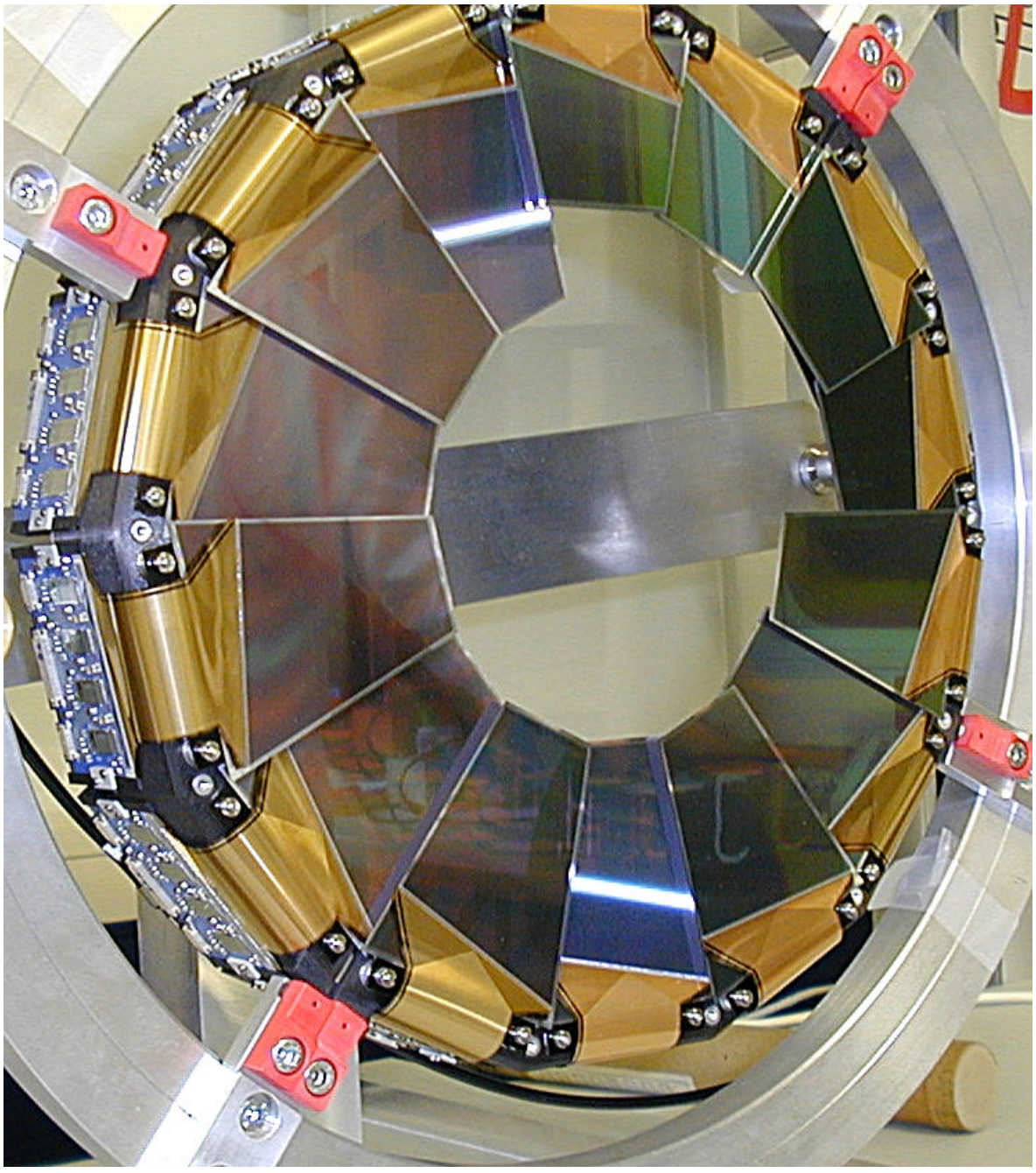

Overview of the ZE
(longitudin
LUMI MONITOR ⇒
Superconducting magnets
CONCRETE SHIELD
RMUO
BMUO
CRYO-
BOX
4 m
FMUON
BAC
FMUI
BMUI
RMUI
STT
CTD
BCAL
MVD
e
e±
GJ
GO
GG
GI
GIT
GJ
BAC
VETO
WALL
p
-2 m
BCAL
BAC
10 m
0
-5 m
Stand 02.12.1998
ZEUS UPGRADE
ZEUS Detector 2000

BMVD ladder production

Required: 30
Produced: 31
In production (spares): (4)

FMVD wheel assembly

Required: 4
Assembled: 1
To be asembled (spares): 3+(1)



MVD Status

Assembly MVD:
- support frames/tube ready
- laser alignment system installed
- 3D measurement of support points ladders/wheels done

In progress (now):
- install cabling for wheels
- cabling ladders

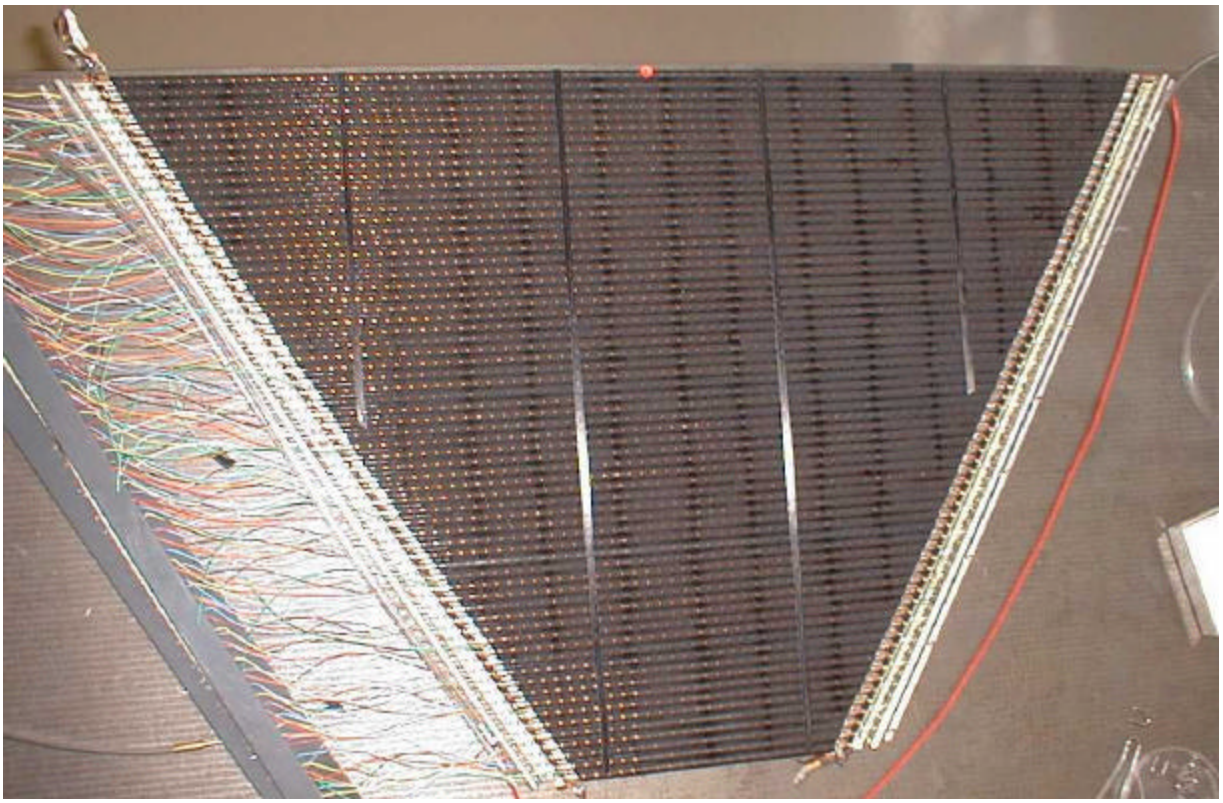
followed by the installation of wheels and ladders in the upper half of the MVD.

ADC, Patch-box, Clock and Control, LV and HV under control

$\Rightarrow$ complete readout chain (with one full Si-barrel module) working in the lab;

$\Rightarrow$ extend system to one complete ladder (5 modules) coming next week (all parts available)

STT Status



Mechanics:

- module assembly in progress in DESY, MePHI, York/Toronto, Freiburg;

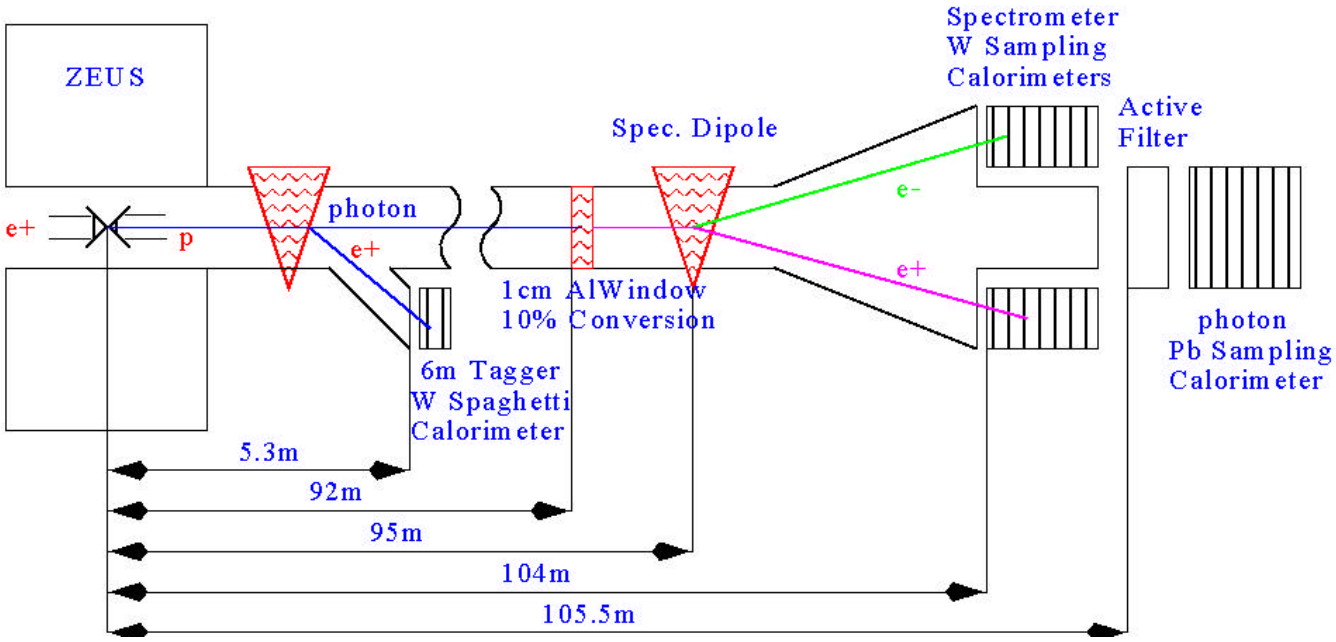
Electronics:

- design and production of boards finished (assembly on going in Argonne) [2 sets of electronics boards @ DESY]

Test beam (DESY electrons 1-6 GeV):

- measurement successful: straw by straw efficiency ~ 97% (as expected)

Luminosity monitor



Detector:

- 6m tagger: prototype (1/2) successfully tested;
- γ-CAL: final module ready and tested;
- spectrometer (ZEUS BPC): WLS replaced;

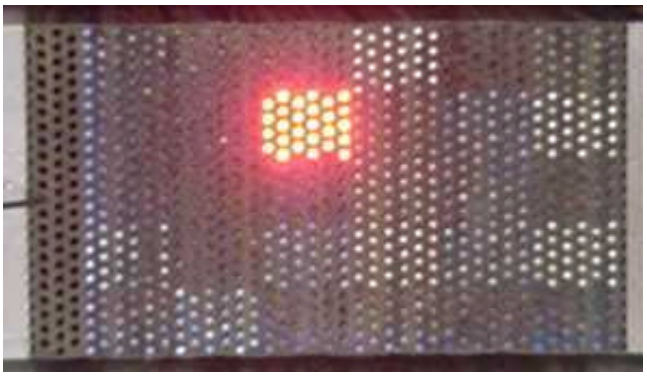
Mechanics:

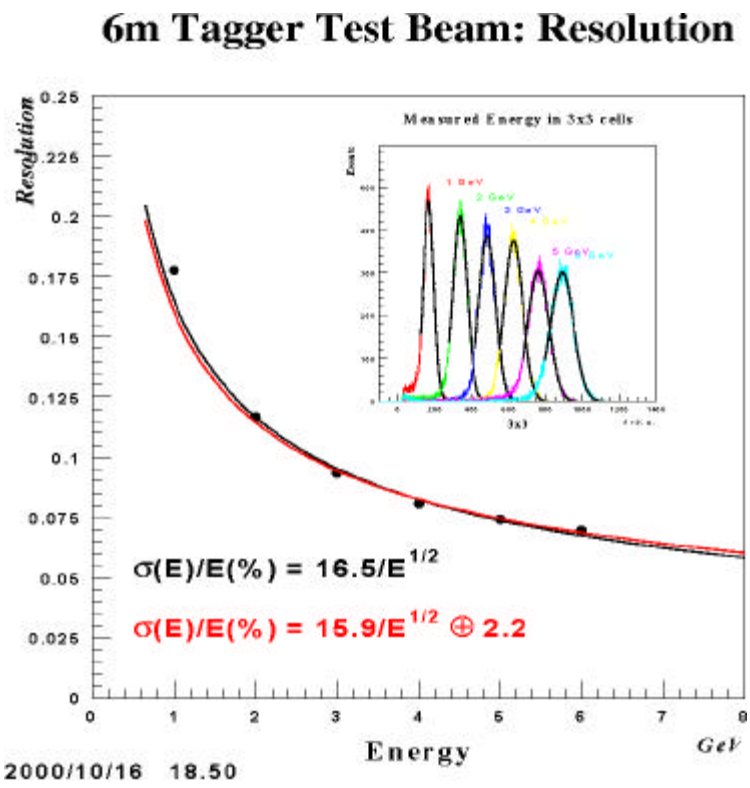
- new dipole: at DESY;
- new exit windows: designs ready;
- support structures: being designed.

Electronics (common):

- FEE prototypes tested;
- Integrator + FADC boards at design stage;
- Memory board in production';
- Trigger board in design stage

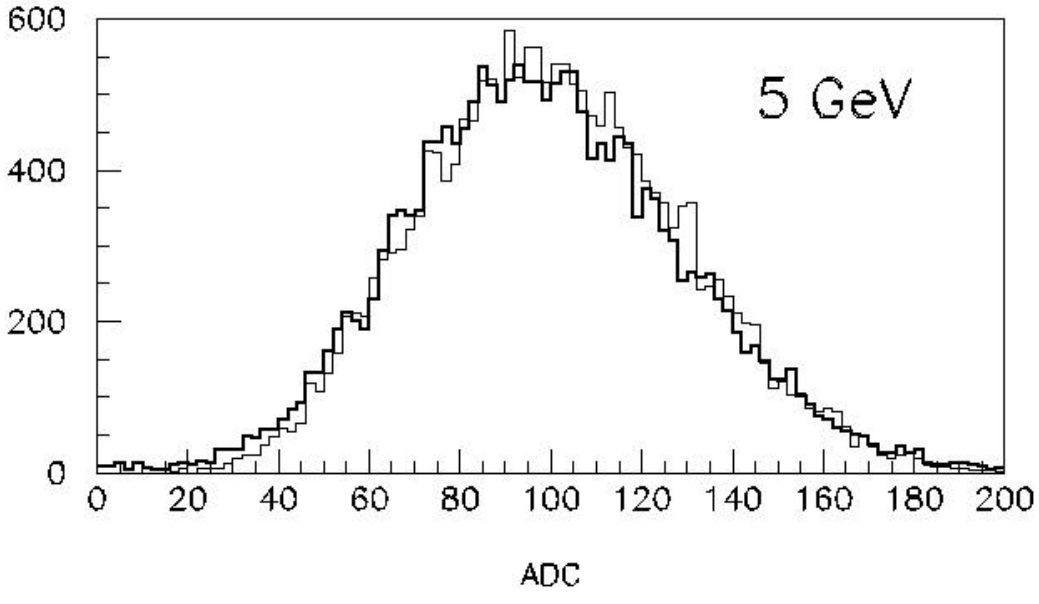
DAQ+Slow Control: work in progress





6m tagger and γ-CAL performance tests done at DESY with test-beam electrons (1-6 GeV)

γ-CAL + $4X_0$ filter data/mc



ZEUS Summary

- Excellent data taking . ZEUS has collected in HERA Run I 116 pb^{-1} ($e^{+}p$), 17 pb^{-1} ($e^{-}p$). FPC, BPC, BPT and LPS will not take part in the next run.

- The full statistic sample starts to be used in several analyses allowing to perform precise QCD measurements and set competitive limits on physics beyond the Standard Model.

- Preparation for HERA Run II:
  - MVD, STT and LUMI Monitor approaching the installation phase.
  - Upgraded tracking system with improved resolution will open new physics channels.
  - Offline is ready for the high luminosity data.