H1/ZEUS Review 2004

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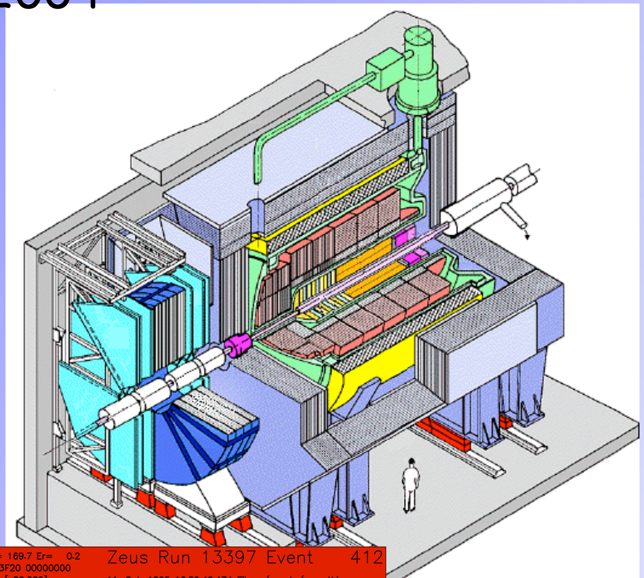
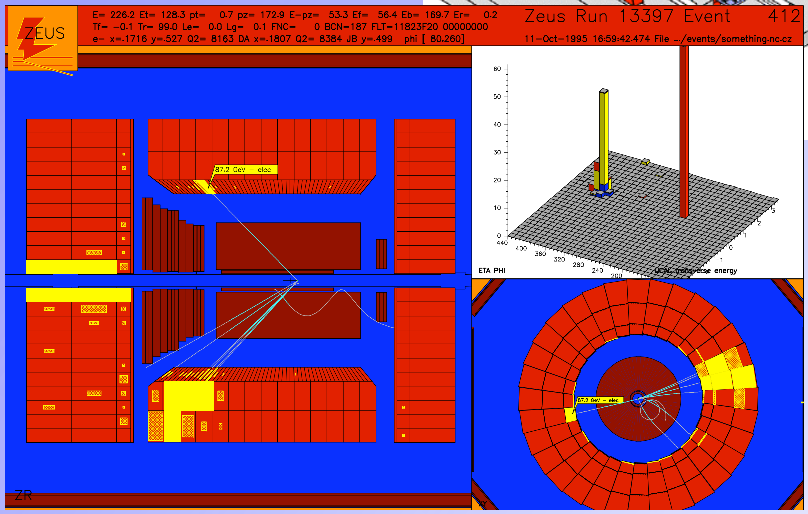
MPI für Physik, München, Dec. 14, 2004

- Comment to Nobel Prize
- HERA/H1/ZEUS performance
- MPI detector subsystems
- Physics Highlights
- Activities
- Summary



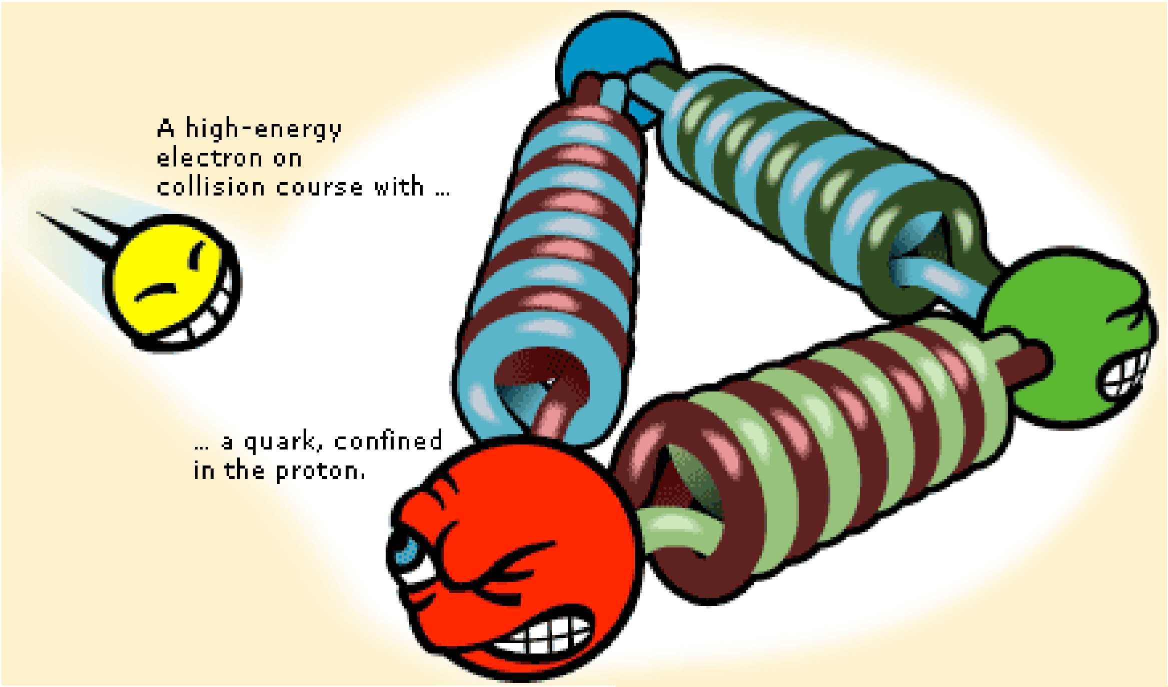
H1



ZEUS NC Event

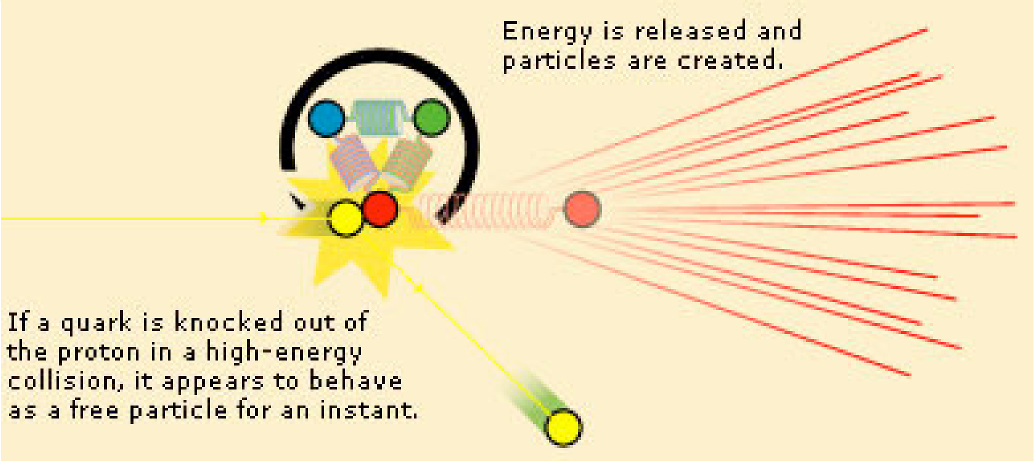
An e-p Collision as viewed by RSAS

The Nobel Prize in Physics 2004



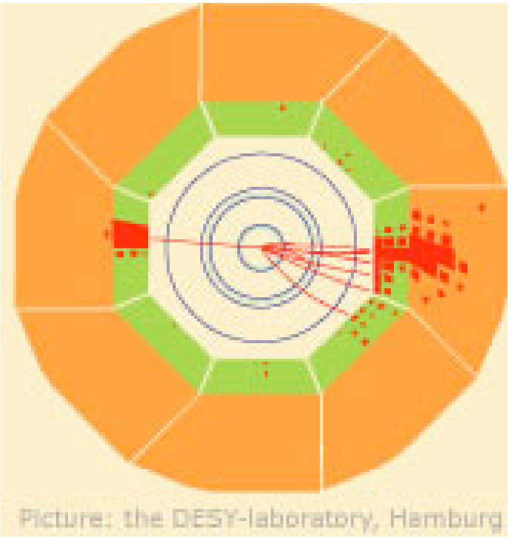
Inside the proton

The three quarks within the proton are held together by the powerful force mediated by the gluons, depicted here as coiled springs. As the distance between the quarks increases, so does the force between them.



A NC Event as seen by H1

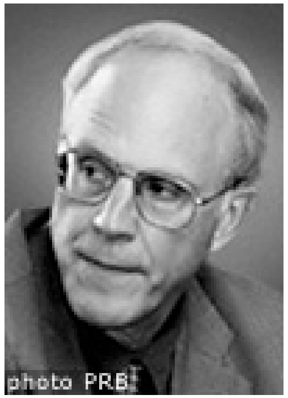
The Nobel Prize in Physics 2004

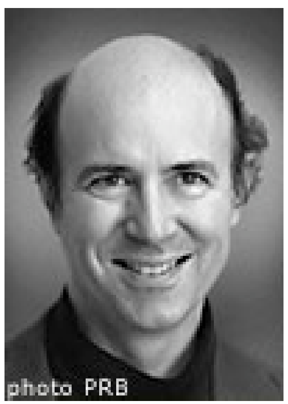


The theory shows its true colours

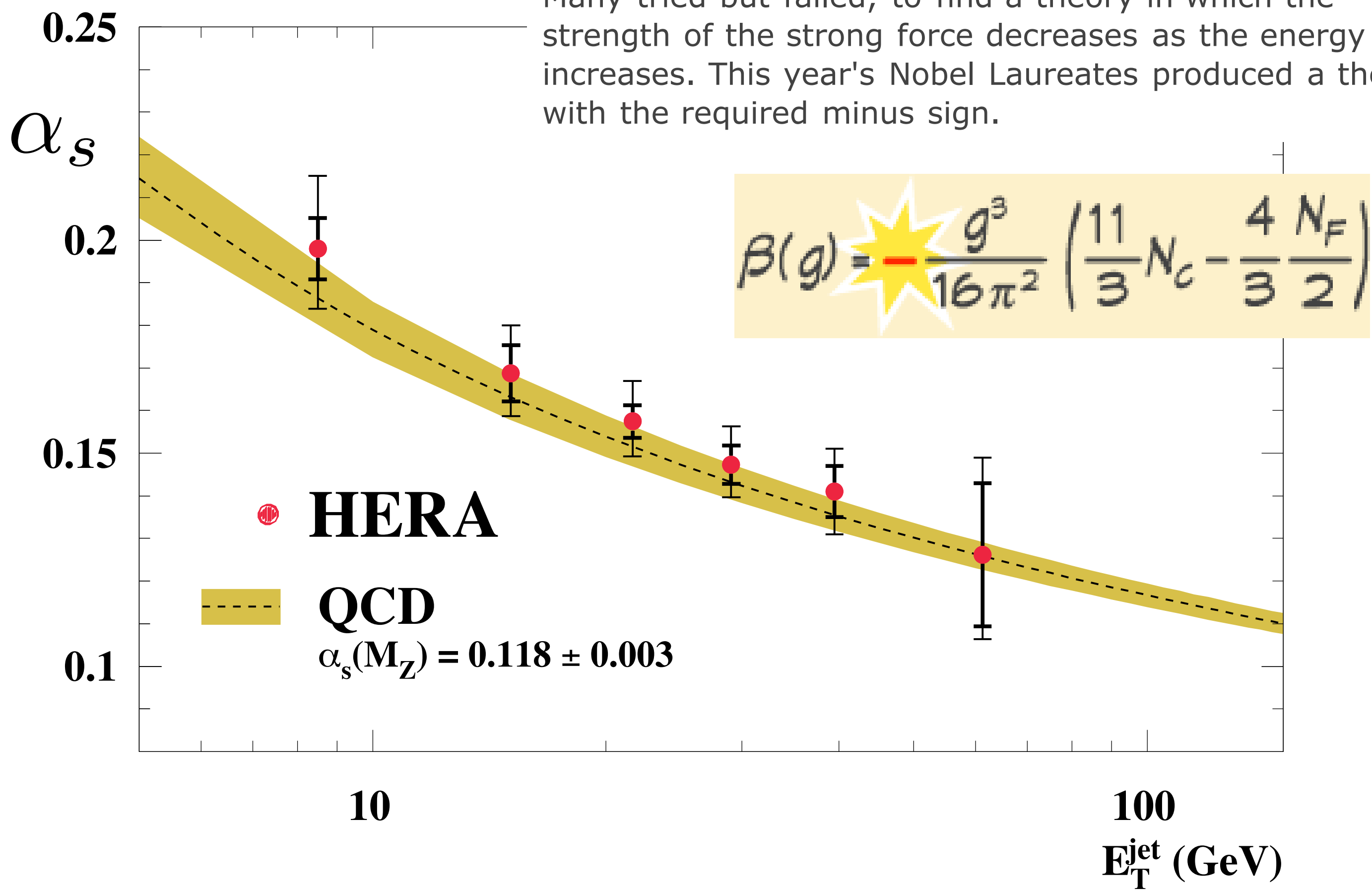
The aftermath of a high-energy collision between a proton and an electron, as seen by the H1 experiment at the DESY laboratory in Hamburg. The experiment is shown in cross-section, perpendicular to colliding beams of protons and electrons. The electron has struck one of the quarks in a proton. An impressive shower of particles - providing information about the struck quark - is spontaneously produced from the energy strored in the gluon force-field. The charged particles in the shower bend in the experiment's strong magnetic field.

The Nobel Winners and HERA Jets





Many tried but failed, to find a theory in which the strength of the strong force decreases as the energy increases. This year's Nobel Laureates produced a theory with the required minus sign.

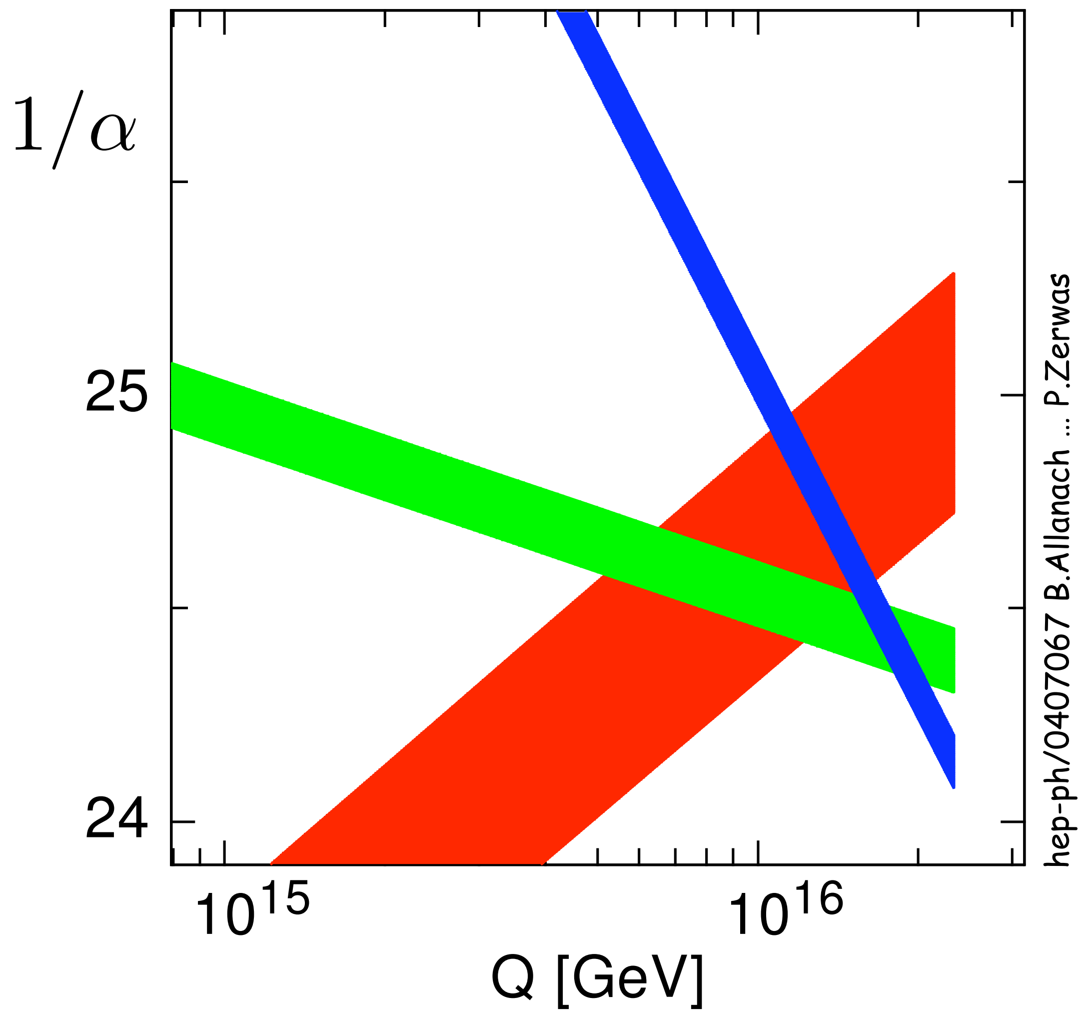


No doubt, it runs !

But what precisely is the coupling ?

And what about the gluon field ?

Unification Scale



$\alpha_s(\mathrm{M}_Z) = 0.118 \pm 0.003$

From measurements of F_2

H1:

$$\alpha_s(\mathrm{M}_Z) = 0.1160 \quad \pm 0.0016 \text{ (exp)} \quad \pm^{0.0058}_{0.0046} \text{ (thy)}$$

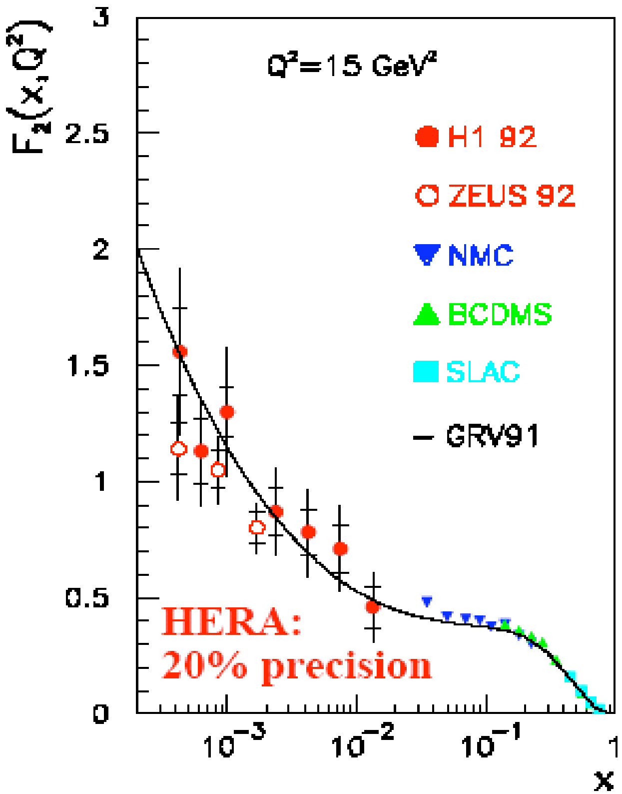
ZEUS:

$$\alpha_s(\mathrm{M}_Z) = 0.1209 \quad \pm 0.0015 \text{ (exp)} \quad \pm^{0.0048}_{0.0049} \text{ (thy)}$$

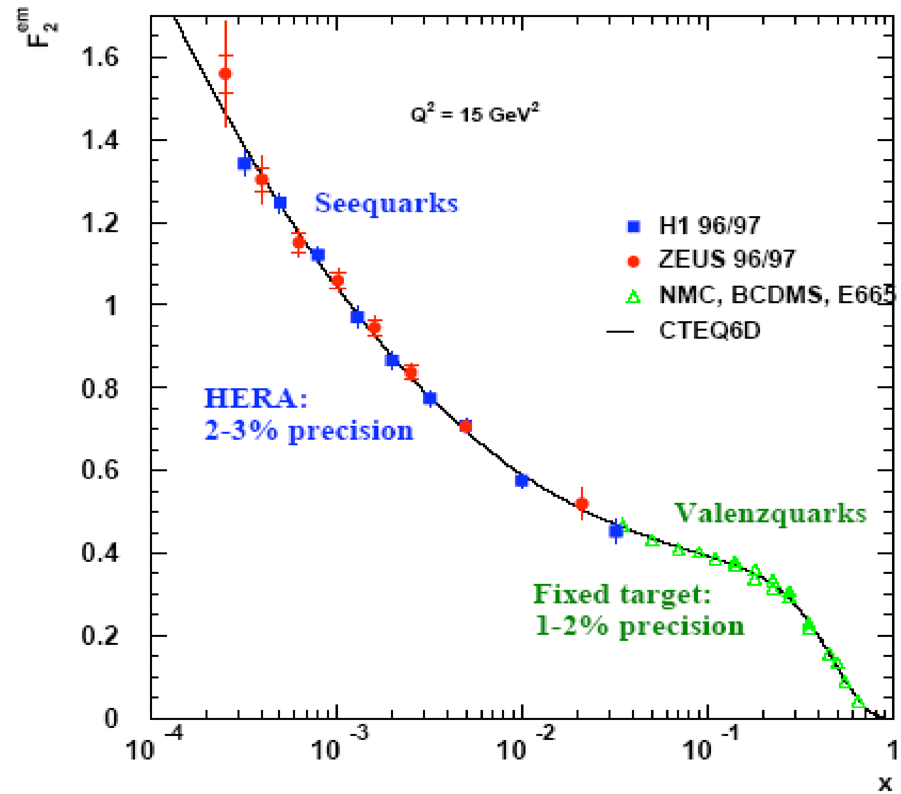
What is α_s ?

Low x at HERA

1992 data ~30 nb-1



1997 data ~30 pb-1



- F. Wilczek: ... further experimental consequences, regarding the pointwise evolution of structure functions, were derived. The most dramatic of these, that protons viewed at ever higher resolution would appear more and more as field energy (soft glue), was only clearly verified at HERA twenty years later.

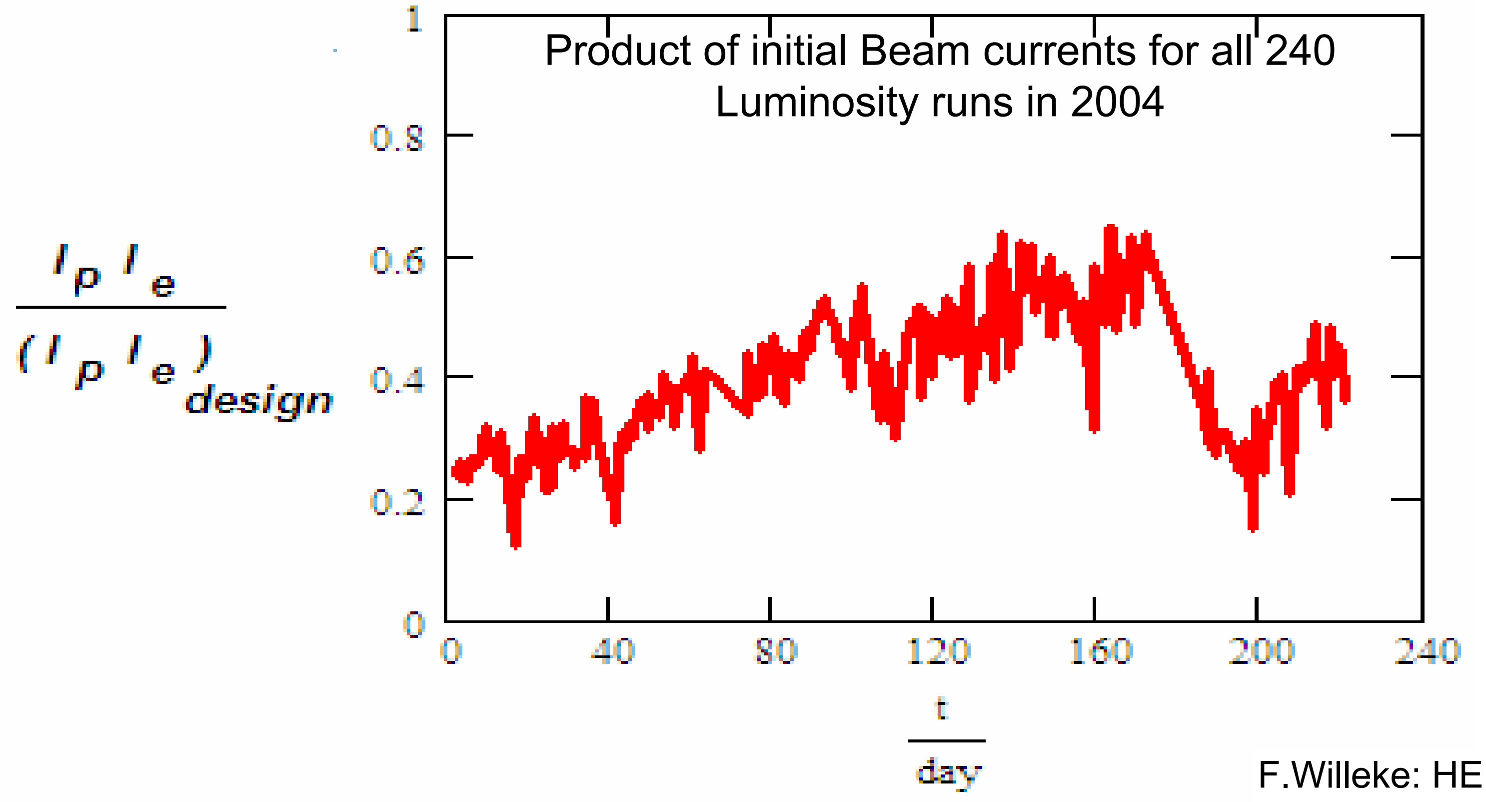
HERA Performance

- 2004 was a promising start of HERA e^+ running
- the luminosity improved as planned (spec. L ~ 75% design)
- longitudinal (LH/RH) polarization routinely delivered
- backgrounds in general acceptable (coasting beam, vacuum leaks, proton rf, ...)
- operational efficiency and availability of HERA not yet satisfactory (BU-coils, vacuum leaks at flanges, beam-pipe overheating, ...)
- many improvements in fall shutdown
- just now started with e^- beam and continuing in 2005

HERA Beam Currents in 2004

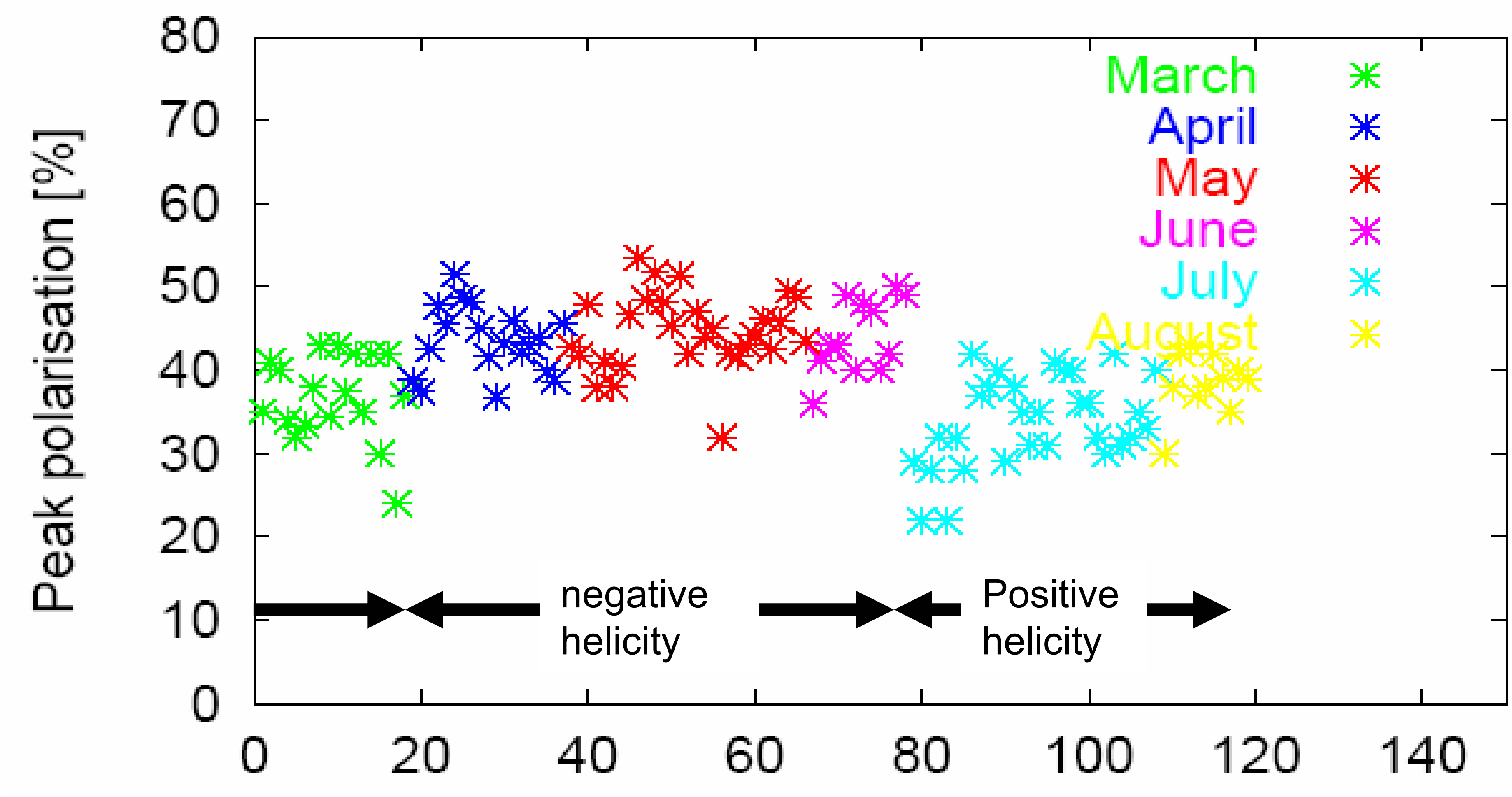
Since February 2004: No beam current limitations due to experimental backgrounds: Beam currents raised as planned to Y 2000 level reaching ~60% of original HERA Design

I_p^{max} = 106mA, I_e^{max} = 48 mA n_b=180



F.Willeke: HERA, 58th PRC

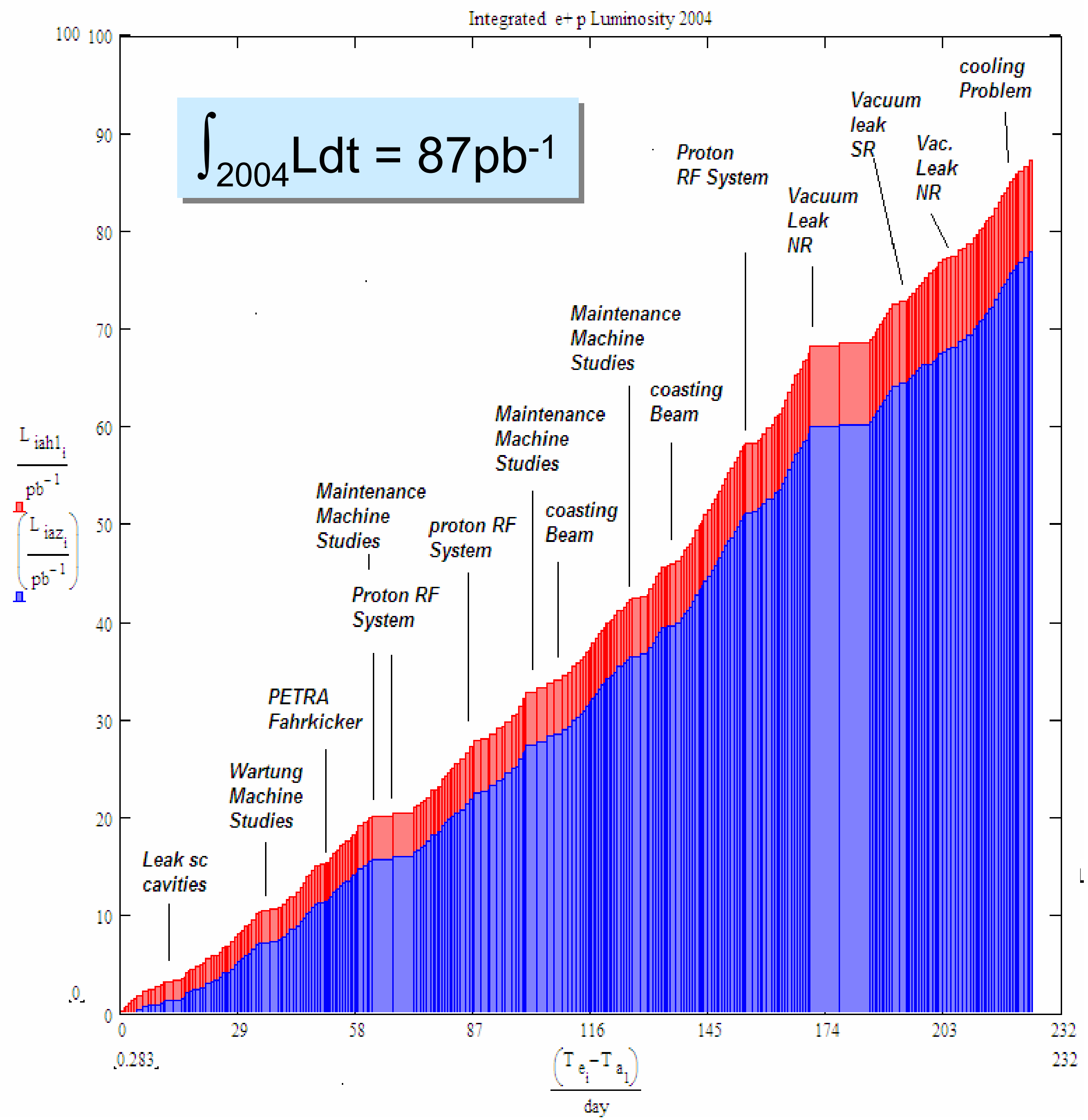
Longitudinal Polarization



HERA run #

F.Willeke: HERA, 58th PRC

2004 Luminosity Accumulation



Peak luminosity ➔ 1.2 $pb^{-1}d^{-1}$
Best week 0.9 $pb^{-1}d^{-1}$
2004 Average 0.4 $pb^{-1}d^{-1}$

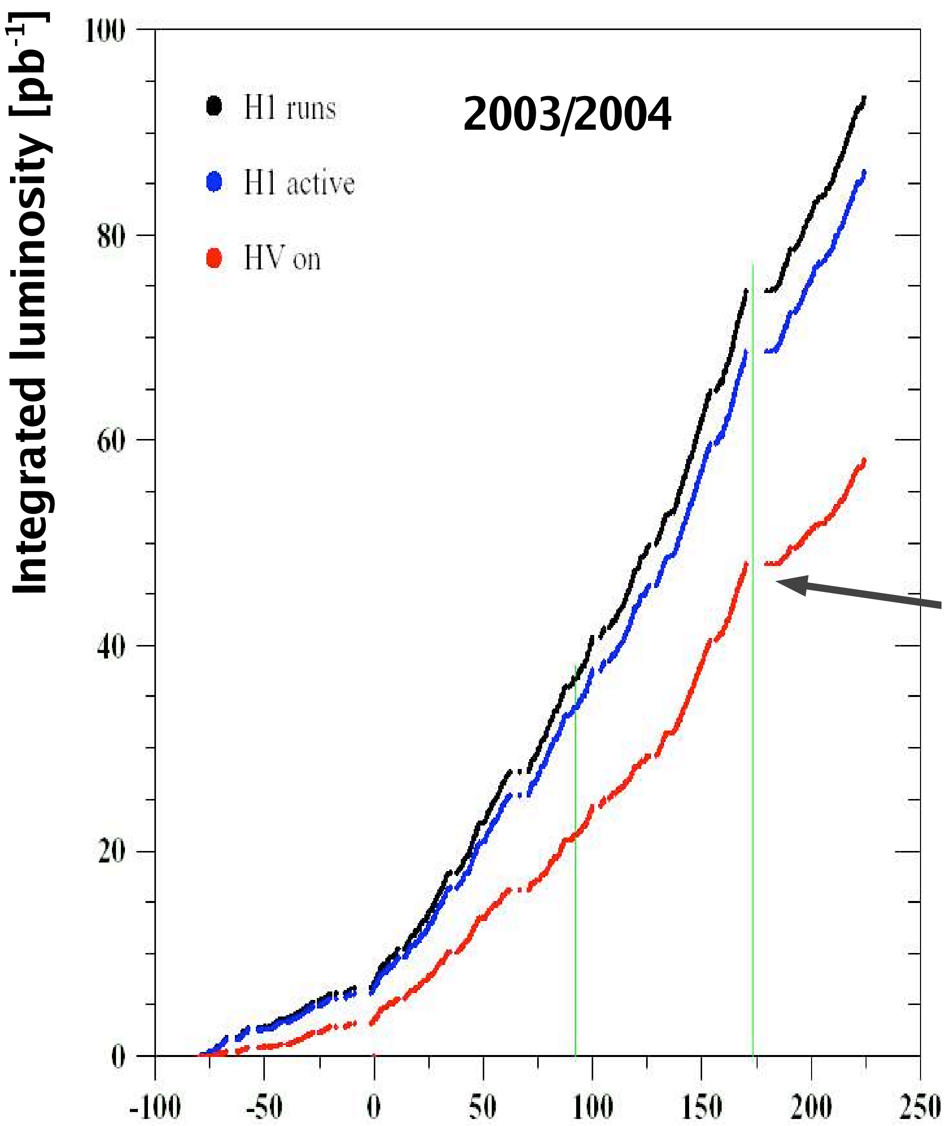
~50 days of operations lost

Due to major technical failures ➔

Operational efficiency needs to be improved

F.Willeke: HERA, 58th PRC

H1: Luminosity 2003/2004



99 pb^{-1}	HERA delivered
93 pb^{-1}	H1 + DAQ
0.946	average DAQ eff.
86 pb^{-1}	H1 + pipeline active
0.08	average deadtime
58 pb^{-1}	H1 + tracker HV on
0.67	average HV eff.
98 M EVENTS ON TAPE	
Two helicities	

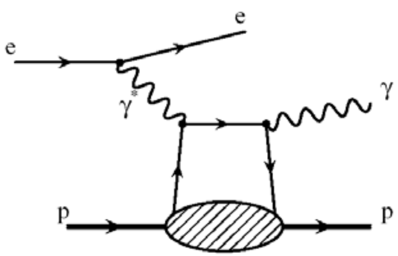
Low HV eff. due to bad background:
vacuum leaks
"coasting" p-beam

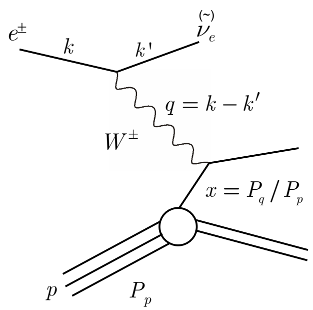
2004 as successful as the best HERA I year and with e^+ polarized

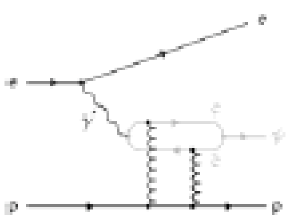
LAr Level 1 Trigger System

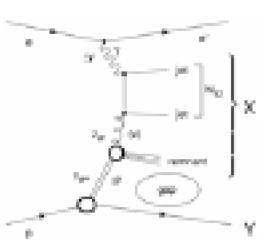
- It worked successfully. It provides the main trigger for NC and CC events at high Q^2.
- It worked, but required a significant effort in manpower and time, mainly because of aging of the electronics and unpredictable external noise sources:
  - problems with capacitors and fans of different PSs, about 1000 capacitors have been replaced so far
  - read-out problems, in part related to bad contacts
  - keep trigger rates acceptable by identifying and disabling pads which pick-up external noise, for some period of time (50 pads out of 4000 in 2004)
  - and more ...

Level 2 Neural Net (L2NN) Trigger





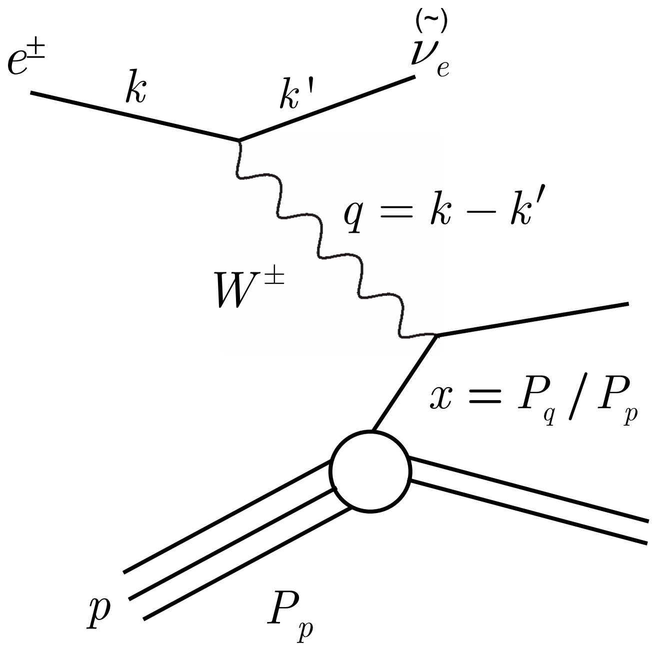




TE	L1ST	Physics
*00	78	Charged Current old
01	68	Phi K+K-
02	52,54	J/Psi ee
03	83	DiJet
04	54	J/Psi $\mu\mu$
05	32	D* untagged
06	40	Spacal back2back
07	78	Charged Current
08	33	J/Psi ee TC (1999)
09	41	DVCS
10	83	D* tagged
*11	33	J/Psi ee TC (2004)
12	15	J/Psi $\mu\mu$ inelastic

- L2NN working well & stable
- new physics channels & nets
- old nets retrained
- predicted rate reductions & efficiencies found to be correct

Charged Current Cross Section and Polarization (MPI: H1/ZEUS)



LO:

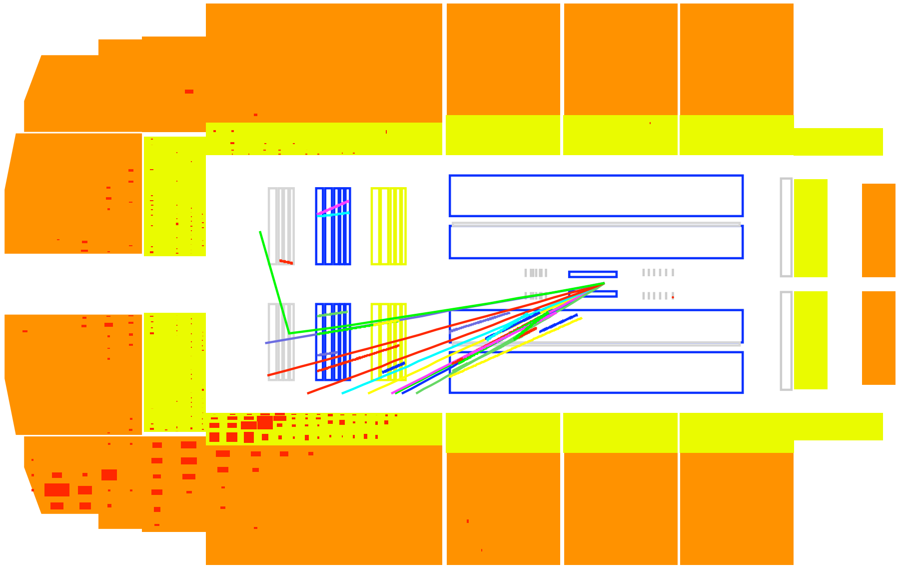
$$\frac{d^2\sigma^{\pm}_{cc}}{dx dQ^2} = (1 \pm P_e)\frac{G_F^2}{2\pi x}\left(\frac{M_W^2}{M_W^2 + Q^2}\right)^2 \Phi^{\pm}_{cc}$$

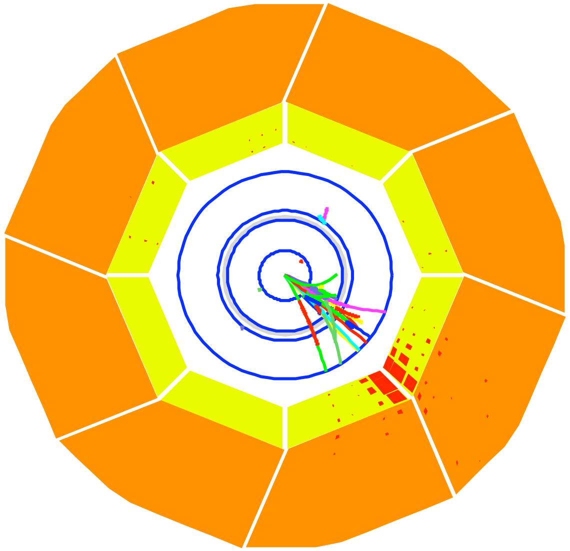
$$\Phi^{+}_{cc} = x[(\bar{u} + \bar{c}) + (1 - y^2)(d + s)]$$

$$P_e = \frac{N_R - N_L}{N_R + N_L}$$

- linear dependence on P_e
- SM: $\sigma^{+}_{cc}(P_e = -1) = 0$

Selection of CC-Events



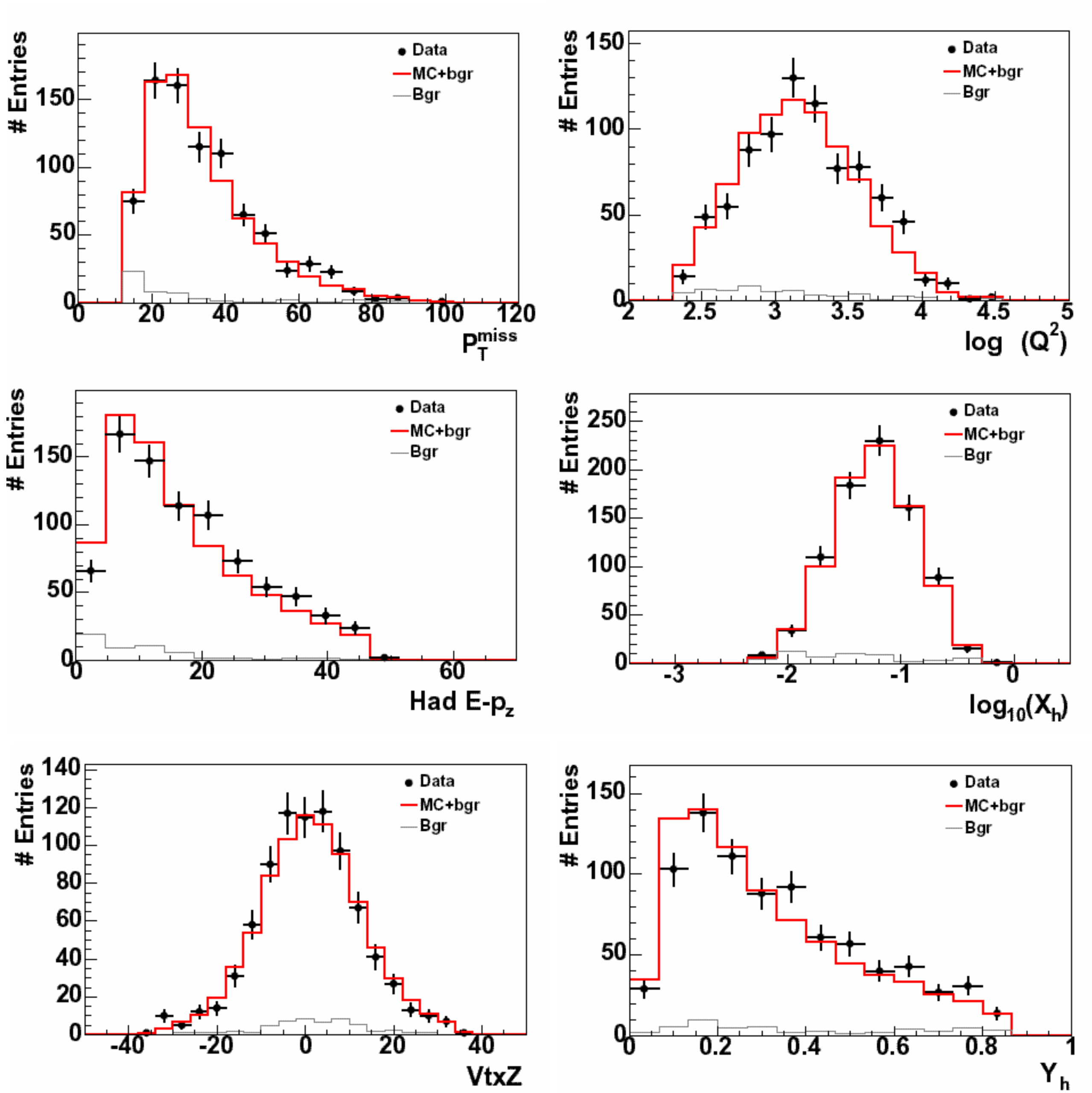


$$Q_h^2 = \frac{p_{T,h}^2}{1 - y_h}$$

$$y_h = \frac{(E - p_z)_h}{2E_e}$$

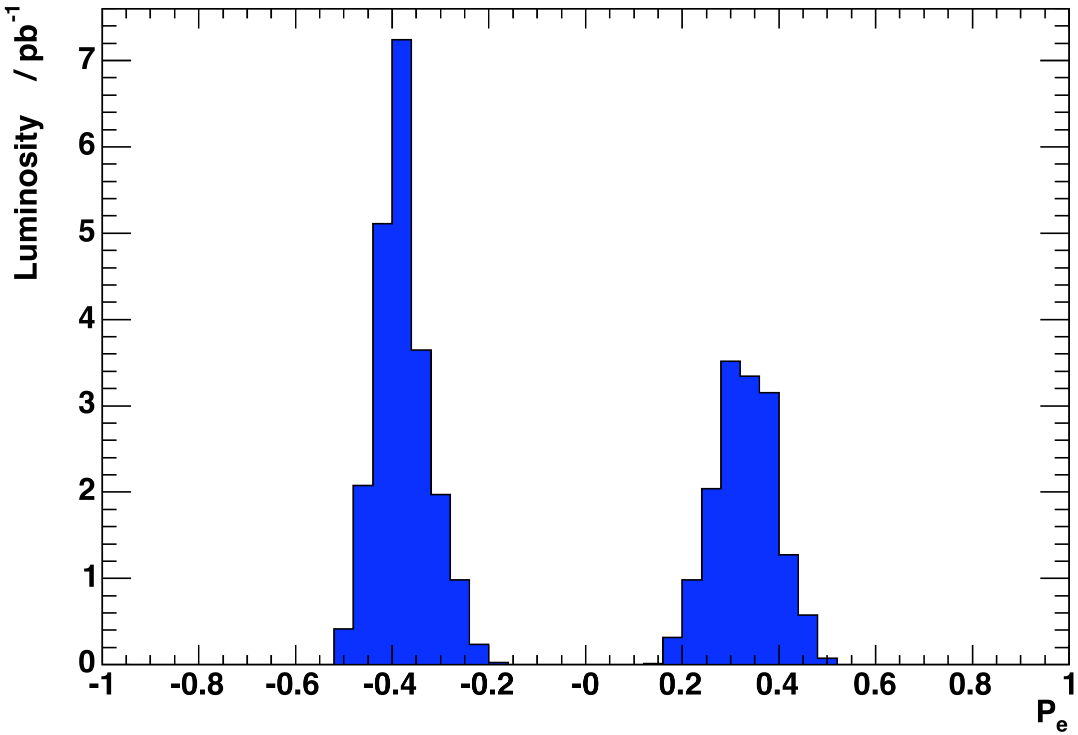
- CC-candidates are selected:
- $p_{T,h} > 12 \text{ GeV}$
- $Q^2 > 400\text{GeV}^2 \; y < 0.9$

CC-Data and MC-Simulations



Polarization and Luminosity

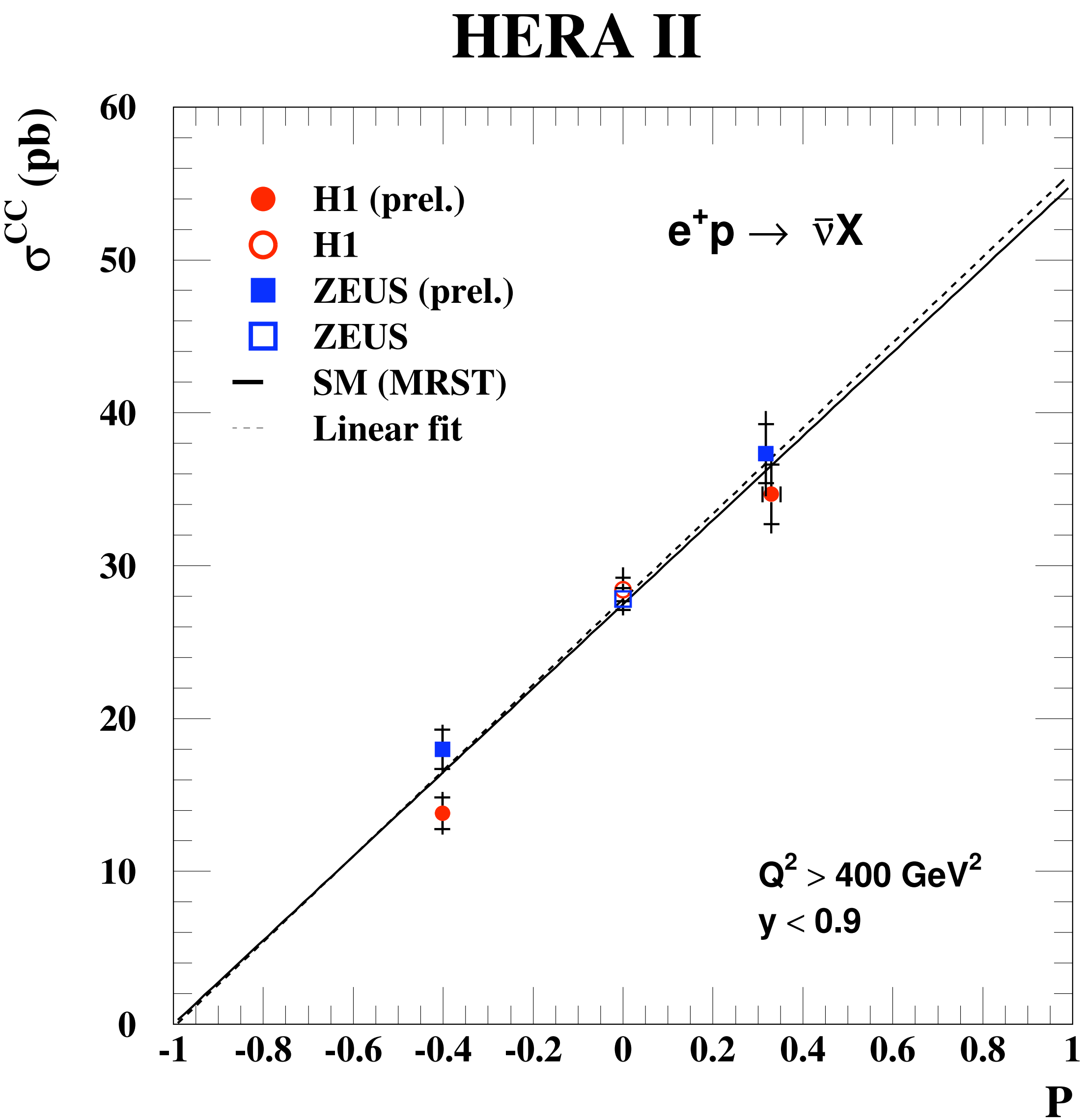
- transverse polarization of positron beam due to sync. radiation
- longitudinal polarization with spin rotators on both sides of IR
- measurement of polarization with 2 independent polarimeters



$$< P_e >= -40.2 \pm 1.5\ \% \qquad < P_e >= 33.0 \pm 2.0\%$$

$$\mathrm{L} = 21.7 \pm 0.6\ \mathrm{pb}^{-1} \qquad \mathrm{L} = 15.3 \pm 0.4\ \mathrm{pb}^{-1}$$

Dependence of $\sigma_{cc}(e^+p)$ on Polarization



H1/ZEUS preliminary for ICHEP 2004

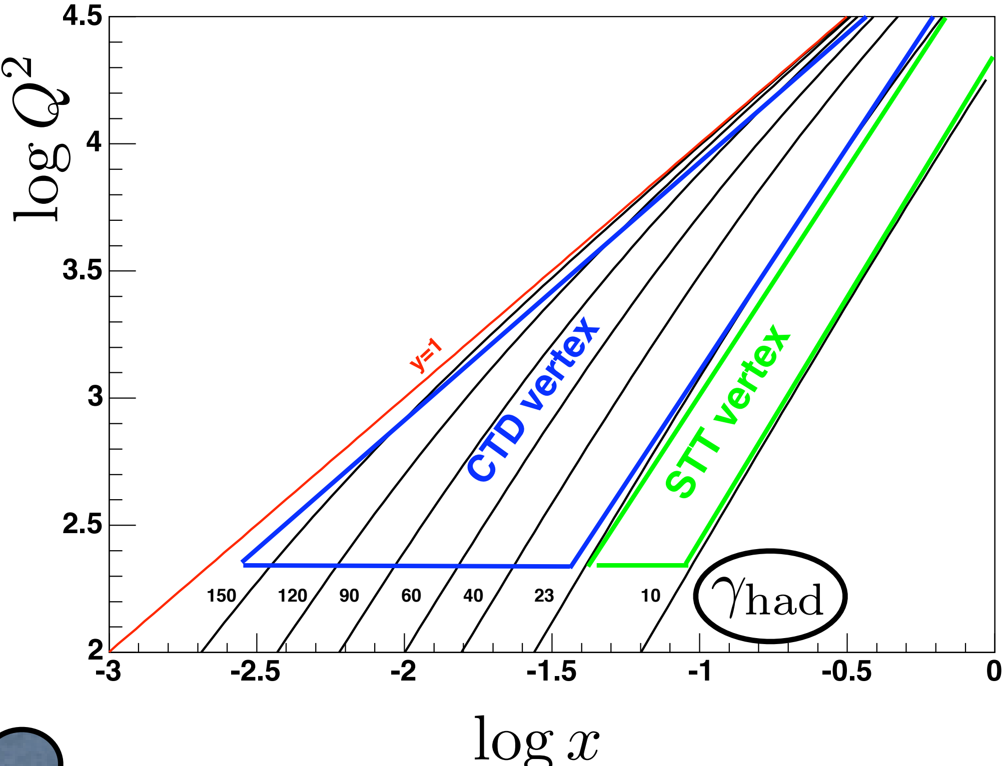
- data consistent with SM
- Linear fit to H1 and ZEUS data yields

$$\sigma_{CC}(P_e = -1) = \quad 0.2 \pm 1.8 \text{ (stat)} \pm 1.2 \text{ (sys) [pb]}$$

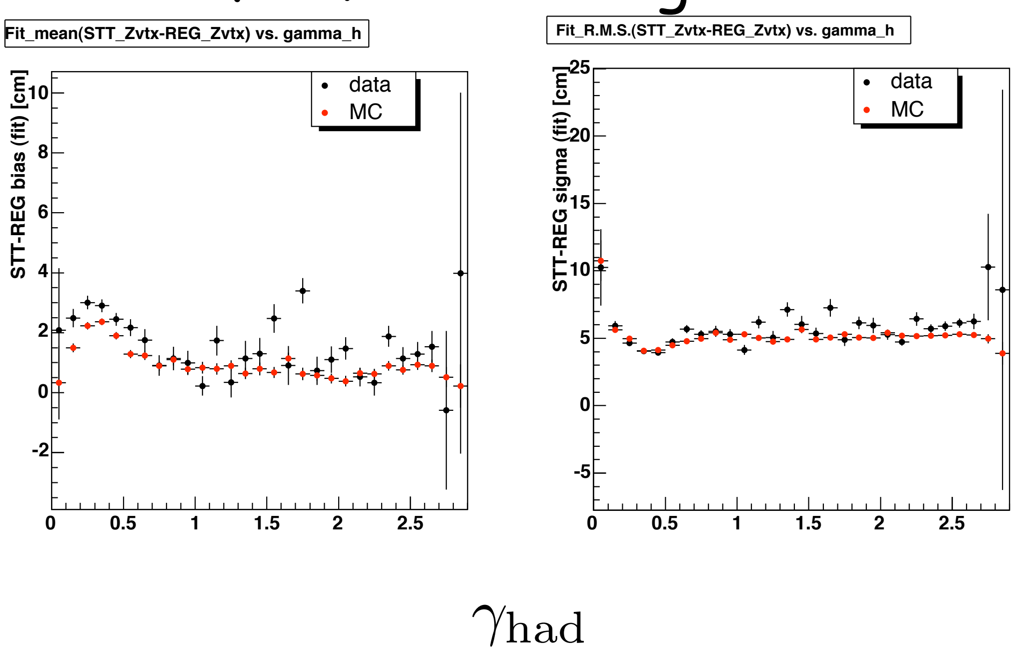
No indication for RH currents

ZEUS: STT in CC Analysis

- Straw-Tube-Tracker (STT) designed to improve track reconstr. in fwd. region
- In CC high x events, where the hadronic system is very fwd., STT can be used to find event vertex. Without SST the time difference between FCAL and RCAL signals can be used to find z-vtx.
- STT performs better than CTD for γ_{had} < 23°



bias & resolution of z-vtx from SST using NC



D* and D*+Dijet Production in DIS

☑ Thesis of Sebastian Schmidt

- DIS phase space:

  $2 < Q^2 < 100\ GeV^2,\ 0.05 < y < 0.7$

- tag D* using "golden" channel:

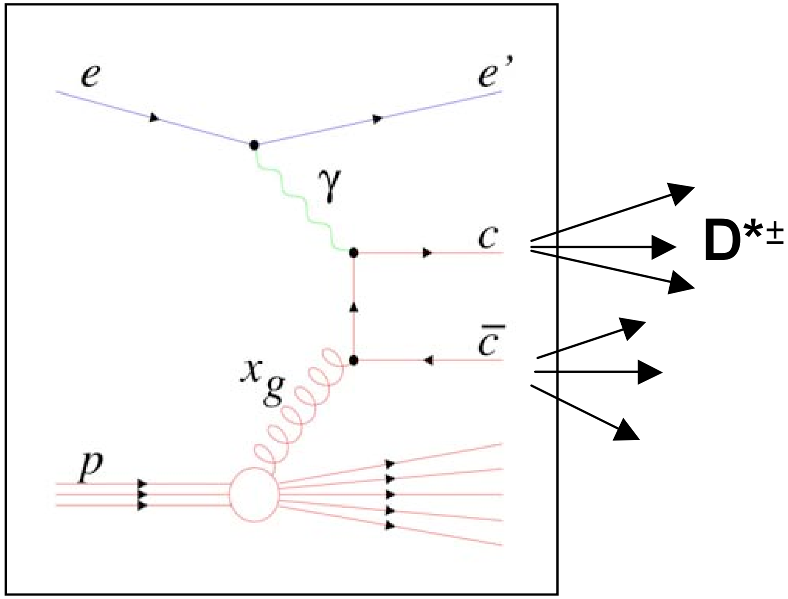
  $D^{*\pm} \to D^0 \pi_s^\pm \to K^\mp \pi^\pm \pi_s^\pm$

- D* phase space:

  $p_T(D^*) > 1.5\ GeV,\ |\eta(D^*)| < 1.5$

- 2 k_t-jets in Breit-frame:

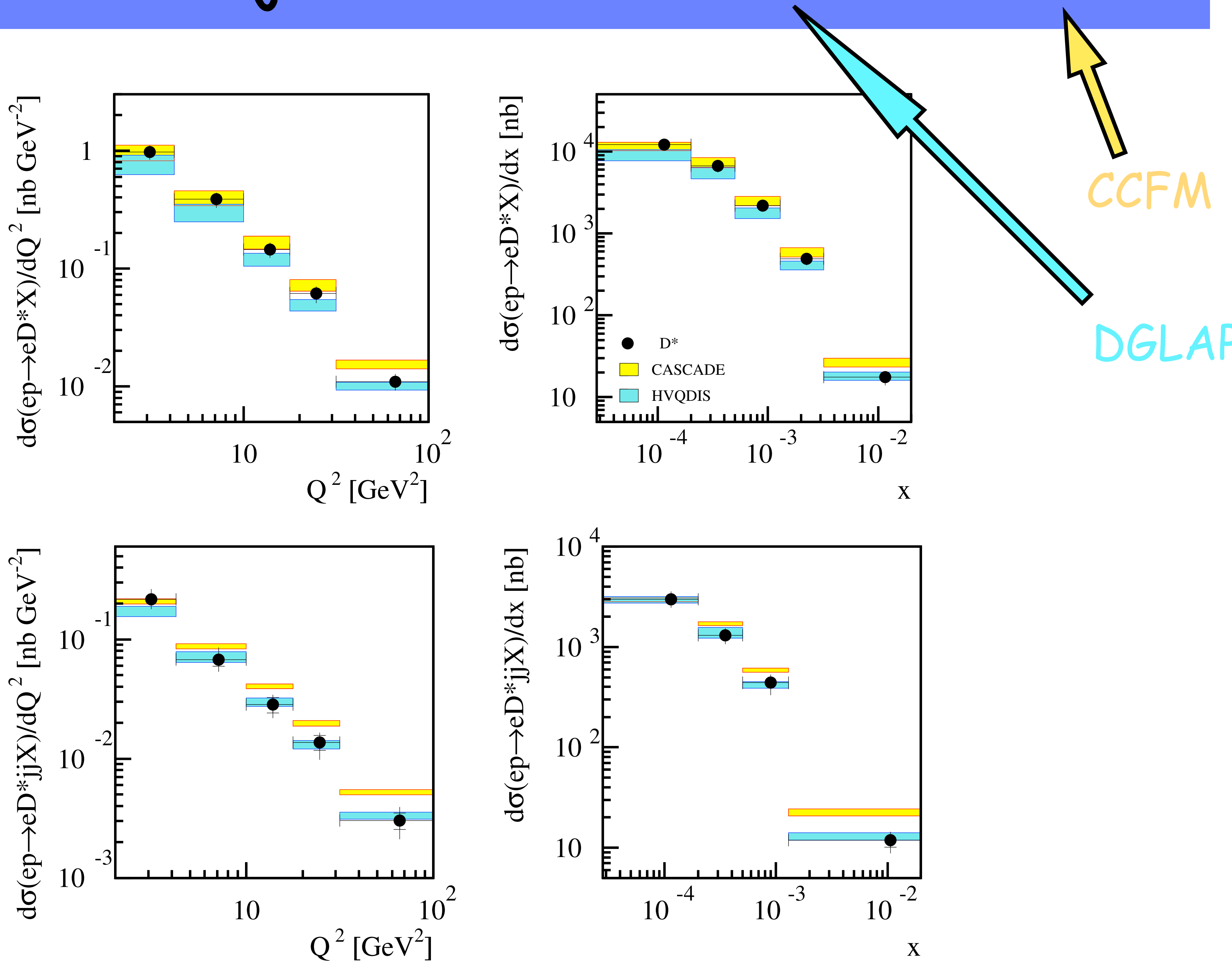
  $E_T > 4$ and $> 3\ GeV,\ -1 < \eta_{lab} < 2.5$



D* and D*+Dijets: Data vs. NLO/Cascade

D*

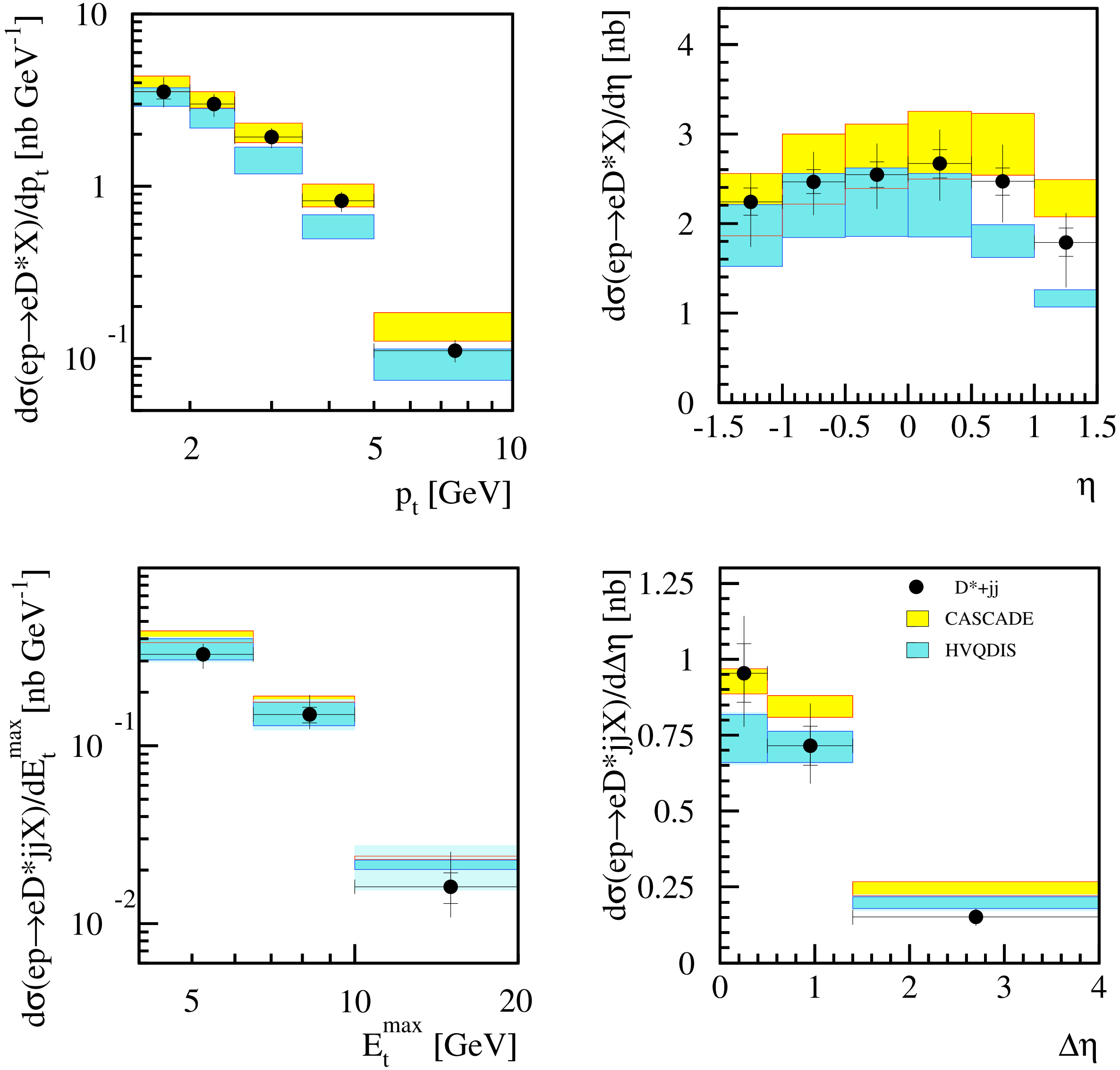
D*+jj



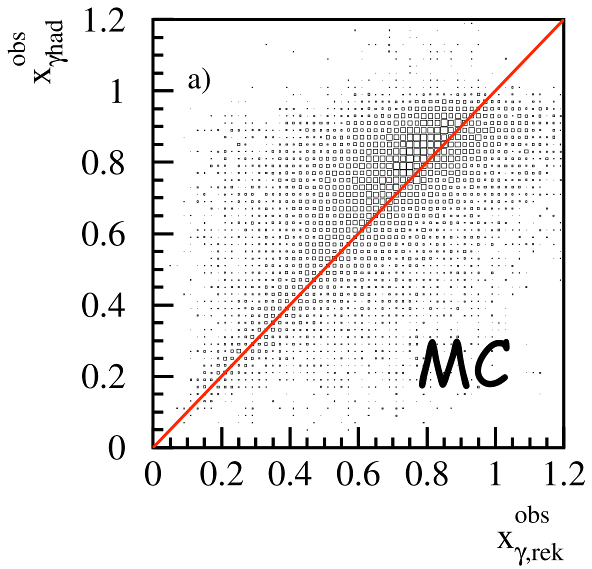
D* and D*+Dijets: Data vs. NLO/Cascade

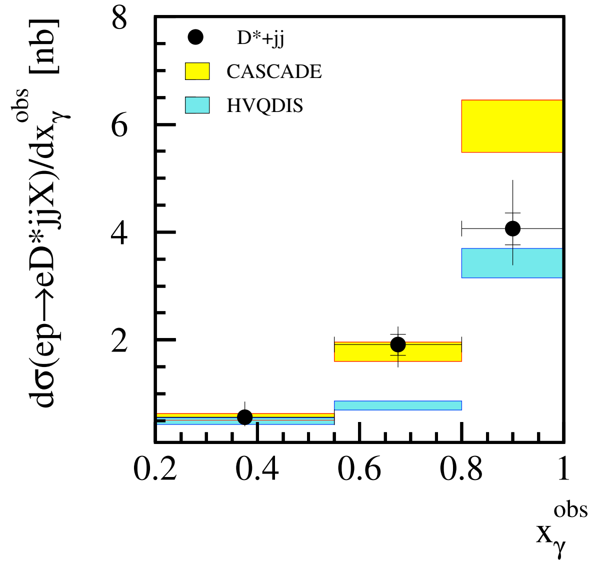
D*

D*+jj



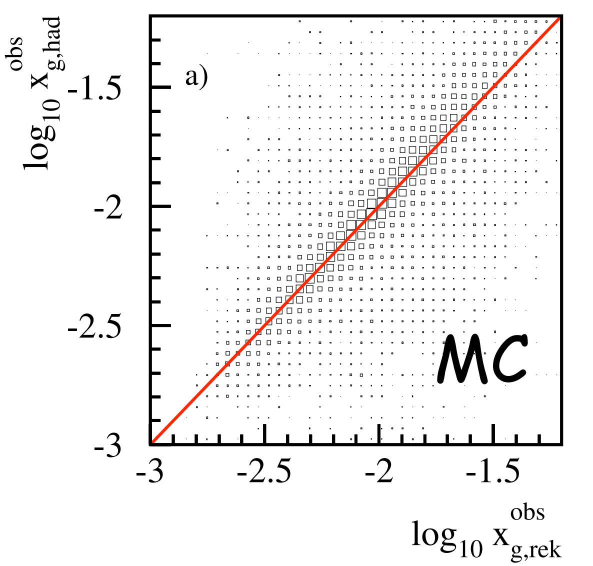
D*+ Dijets: Data vs. NLO/Cascade

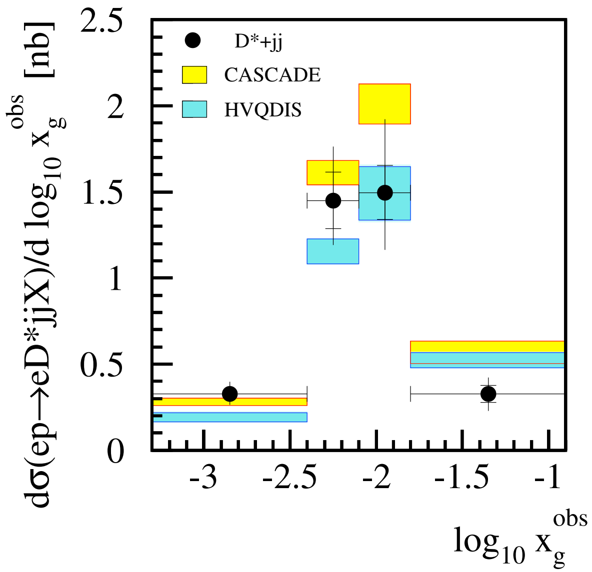




- x_γ fractional momentum of the parton from the photon entering the hard process (direct/resolved)

$$x_\gamma^{\rm obs} = \frac{\sum E_{\rm T,jet} \exp(-\eta_{\rm jet})}{2yE'_e}$$



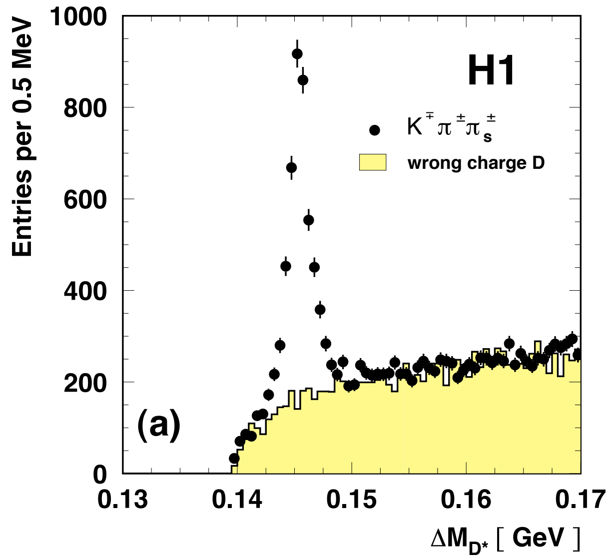


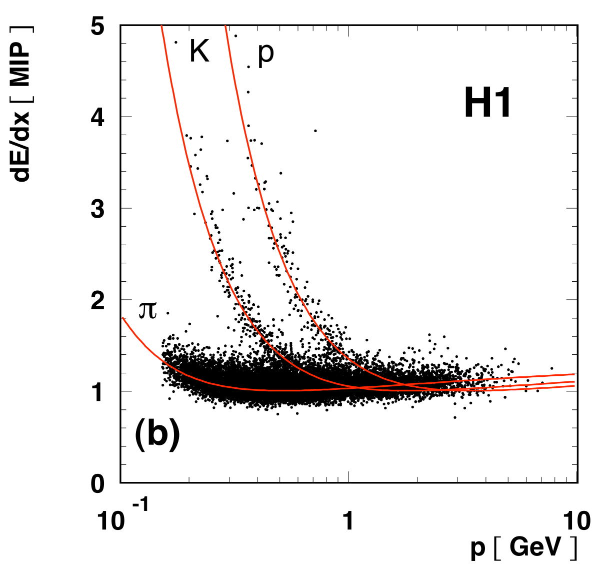
- x_g fractional momentum of the gluon from the proton entering the hard process (gluon density)

$$x_g^{\rm obs} = \frac{\sum E_{\rm T,jet} \exp(\eta_{\rm jet})}{2E_p}$$

Work on H1 paper on-going

The "Charming" Pentaquark at H1





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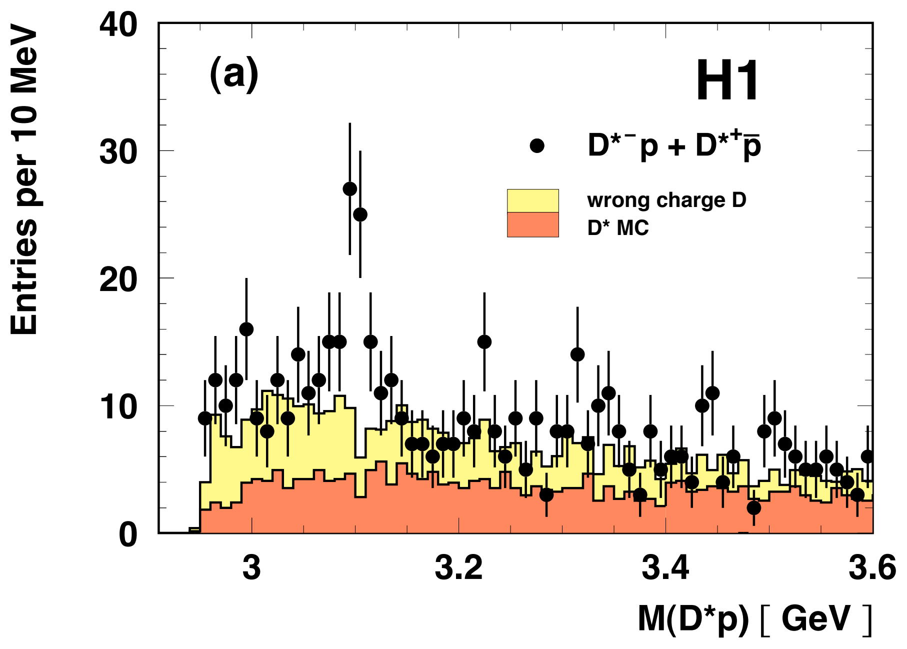
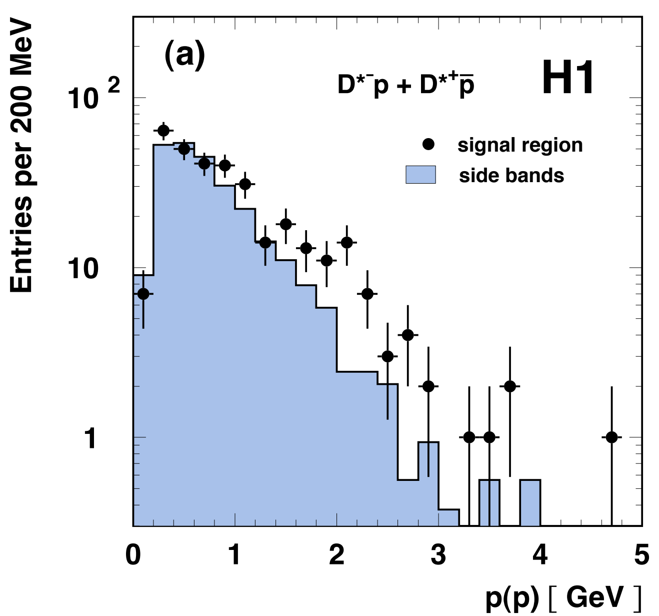
$\boldsymbol{D^0}$	$p_{\mathrm{T}}(K) > 500$ MeV $p_{\mathrm{T}}(\pi) > 250$ MeV $p_{\mathrm{T}}(K) + p_{\mathrm{T}}(\pi) > 2$ GeV $\lvert m(K\pi) - m(D^0)\rvert < 60$ MeV
$\boldsymbol{D^*}$	$p_{\mathrm{T}}(\pi_s) > 120$ MeV $\lvert \Delta M_{D^*} - m(D^*) + m(D^0)\rvert < 2.5$ MeV $p_{\mathrm{T}}(D^*) > 1.5$ GeV $-1.5 < \eta(D^*) < 1$ $z(D^*) > 0.2$
$\boldsymbol{p}$	$p_{\mathrm{T}}(p) > 120$ MeV $L_p > 0.3$ for $p(p) < 2$ GeV $L_p > 0.1$ for $p(p) > 2$ GeV

- $\theta^+(1540) \rightarrow K^+n$ (udud $\bar{s}$)
- look for udud $\bar{c}$ in $D^{*-}p\,(D^{*+}\bar{p})$
- clean D* in golden channel ($Q^2 > 1$ GeV^2, $0.05 < y < 0.7$)
- identified proton (dE/dx)

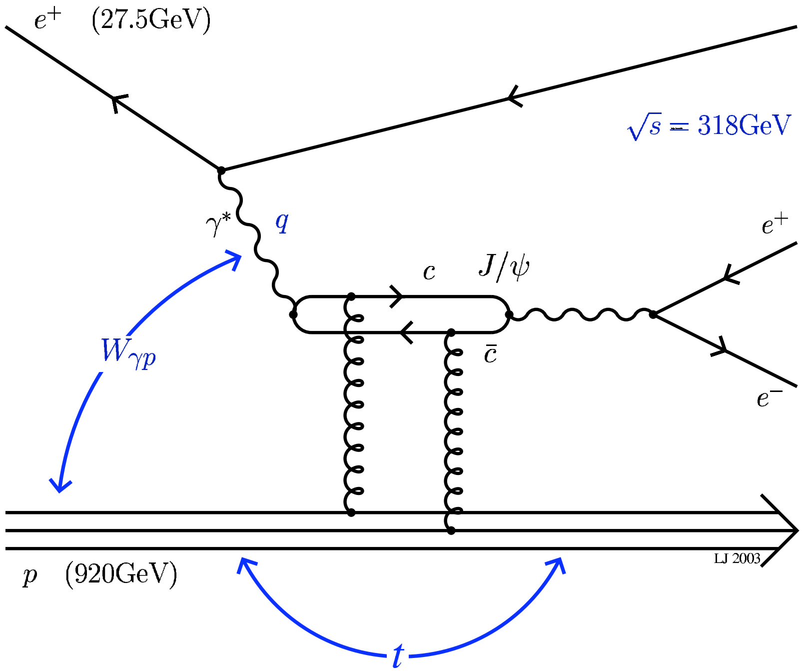
D*p Signal & Background

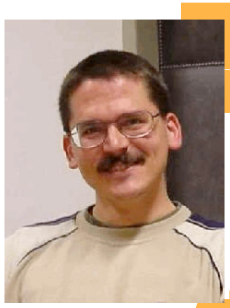


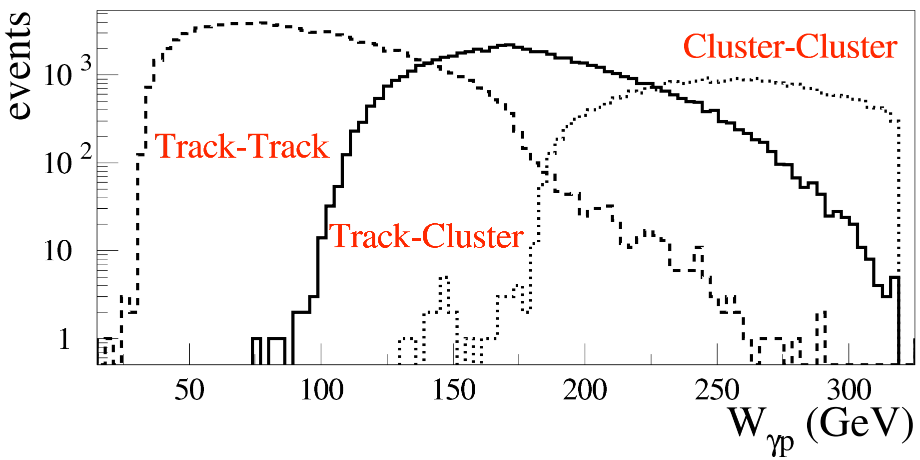


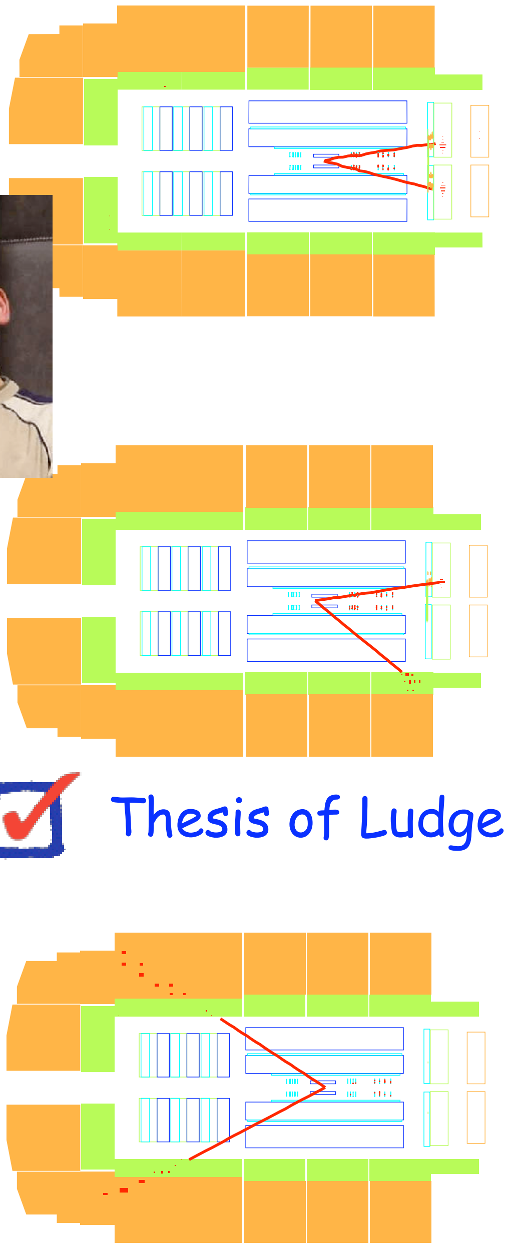
- peak at 3099±3±5 MeV
- width 12 MeV (exp. resol.)
- no signal
  - in background
  - when selecting side bands of D* or D° candidates + p
- reflections were studies, e.g. excited D_1 and D_2 mesons
- D*p signal yields more D*s than D*p side bands
- proton momentum spectrum (no dE/dx) from signal region harder than from side bands
- observation of D*p signal depends on IR (i.e. not seen by ZEUS)

Elastic J/ψ Photoproduction at large W

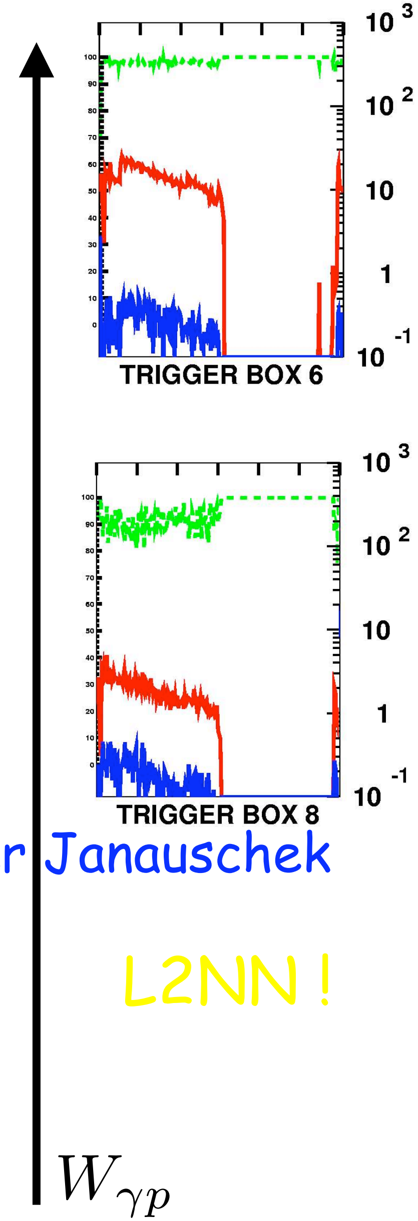








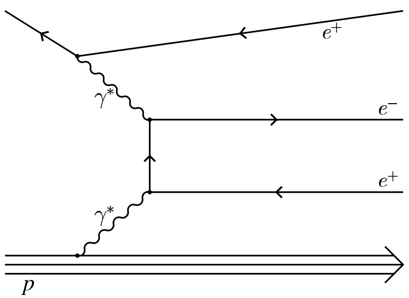
Thesis of Ludger Janauschek



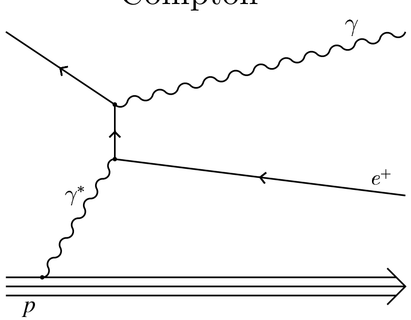
L2NN !

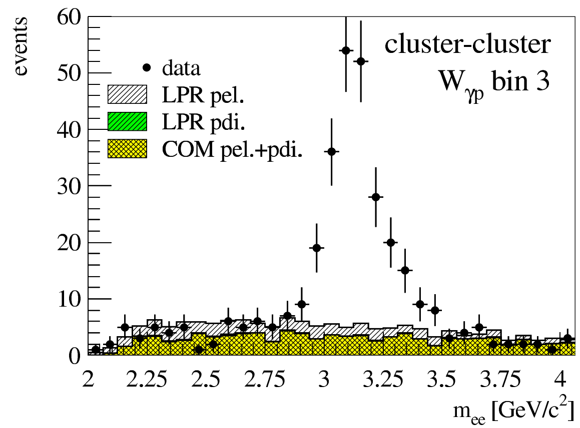
Backgrounds and Signal Extraction

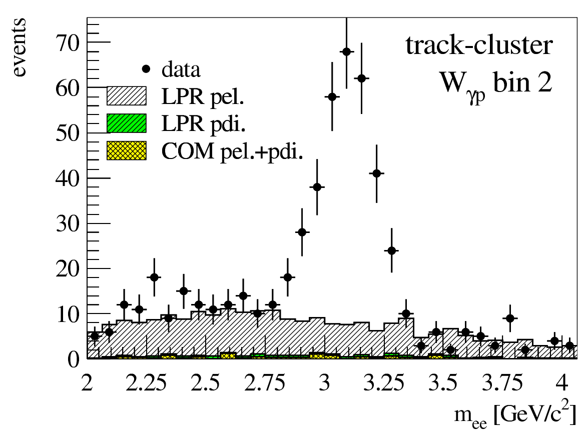
Lpair



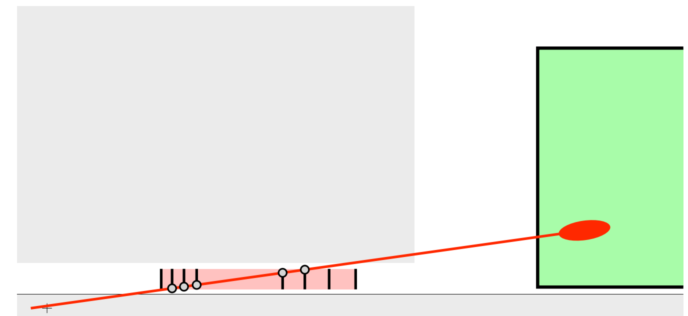
Compton

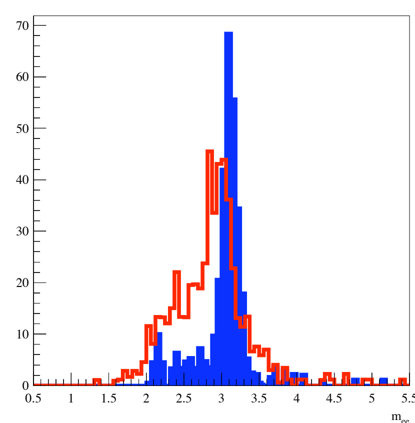




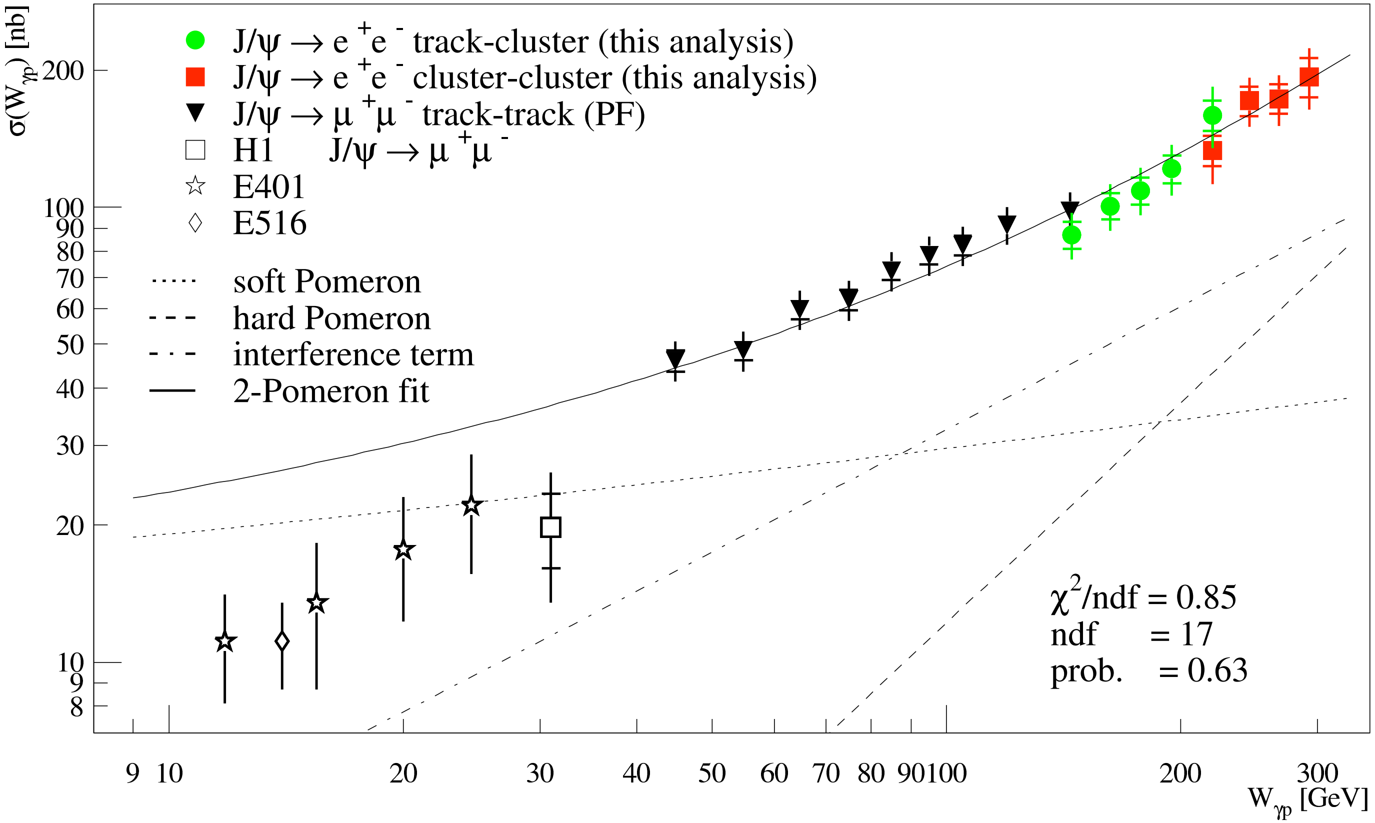


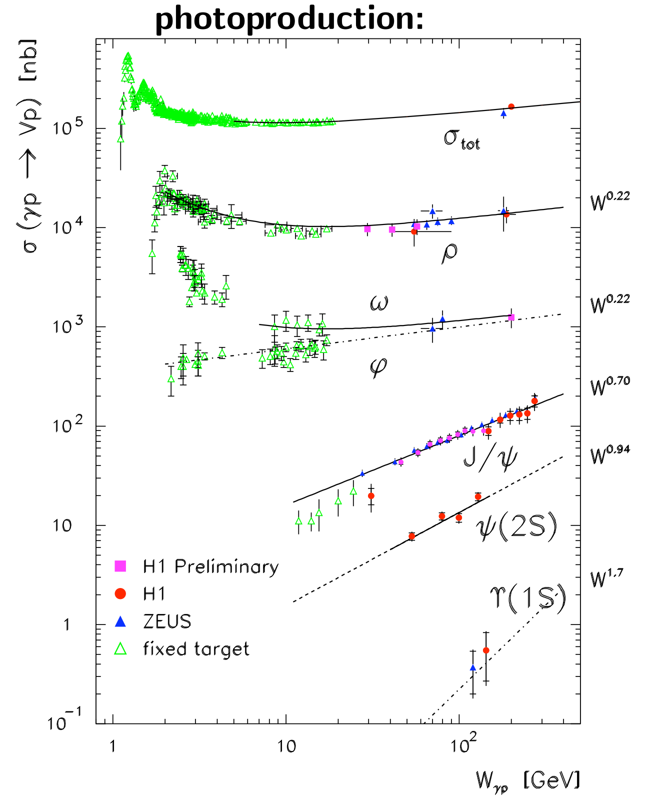
Improving mass resolution for CC using the BST





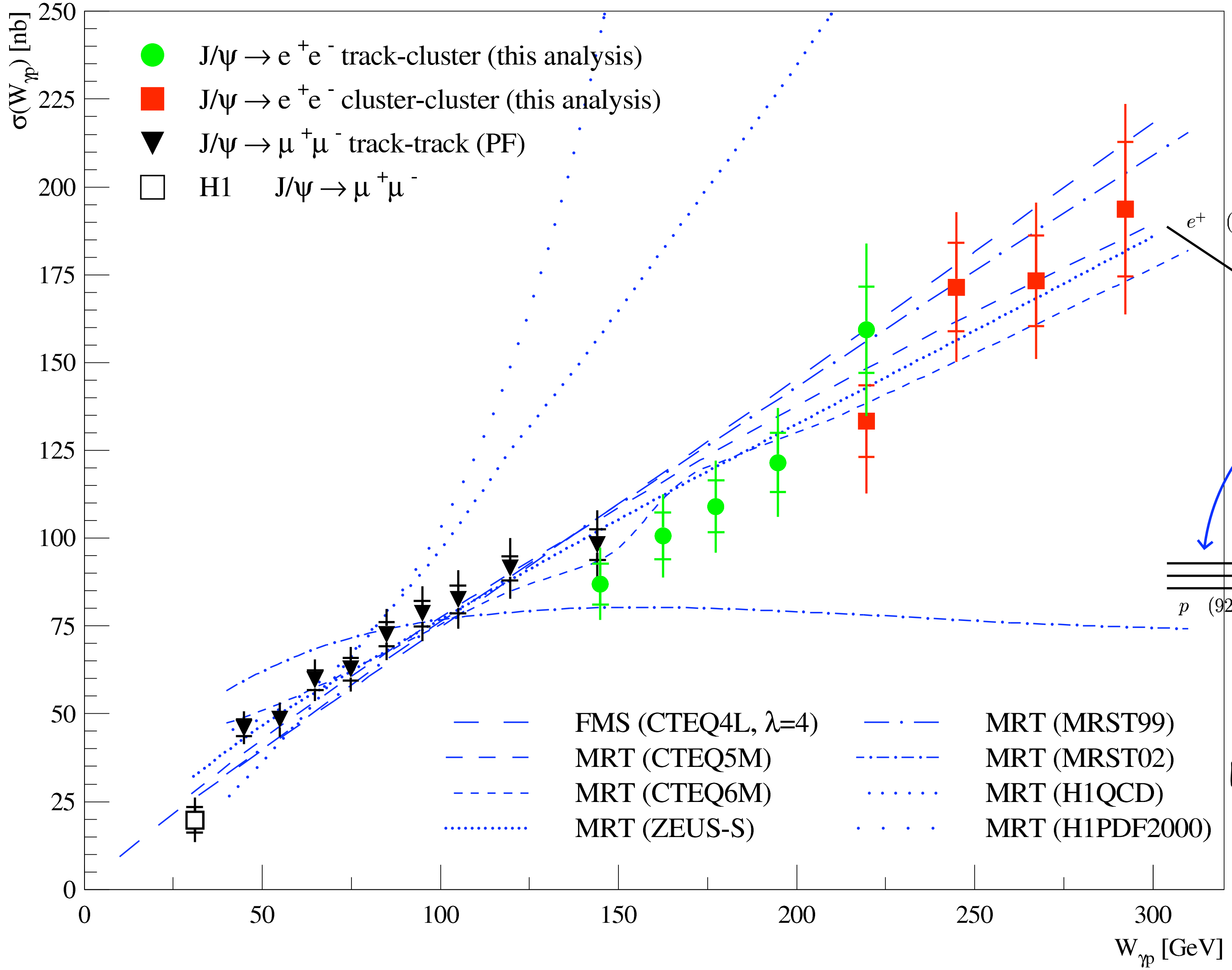
$\sigma(W_{\gamma p})$: Pomeron Fits

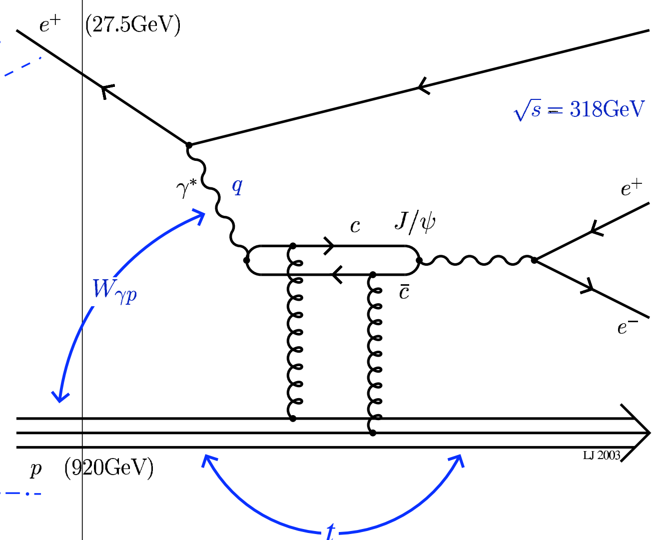




- for J/ψ need to fit a soft and a hard Pomeron
- good fit in HERA energy range
- How seriously should one take the low energy data ?

QCD Fits Using Different Gluon Densities

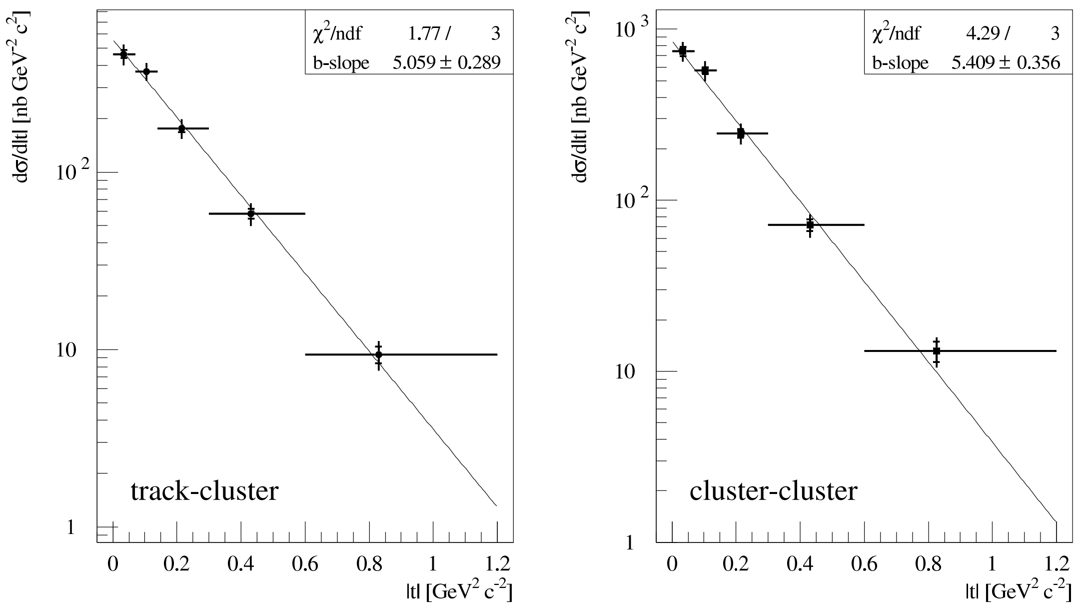




normalization free !

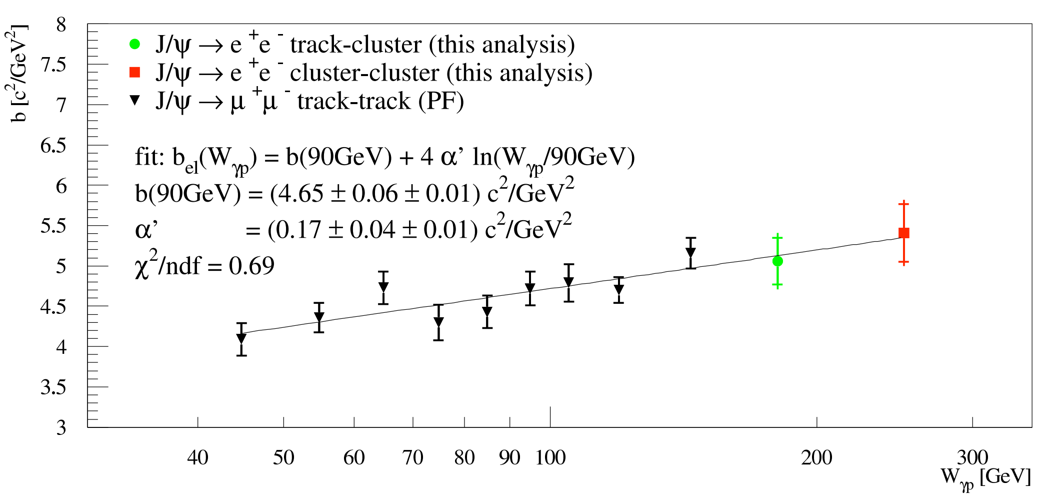
- Great sensitivity, but can we trust the theory ?

$$\frac{d\sigma}{dt}(t) \propto \exp(b(< W_{\gamma p} >)t)$$



fit data, assuming only one effective Pomeron

$$b_{\mathrm{TC}}(135\,\mathrm{GeV} < W_{\gamma p} < 235\,\mathrm{GeV}) = (5.1 \pm 0.3 \pm 0.2)\,\mathrm{GeV}^{-2}\,\mathrm{c}^2$$
$$b_{\mathrm{CC}}(205\,\mathrm{GeV} < W_{\gamma p} < 305\,\mathrm{GeV}) = (5.4 \pm 0.4 \pm 0.2)\,\mathrm{GeV}^{-2}\,\mathrm{c}^2$$

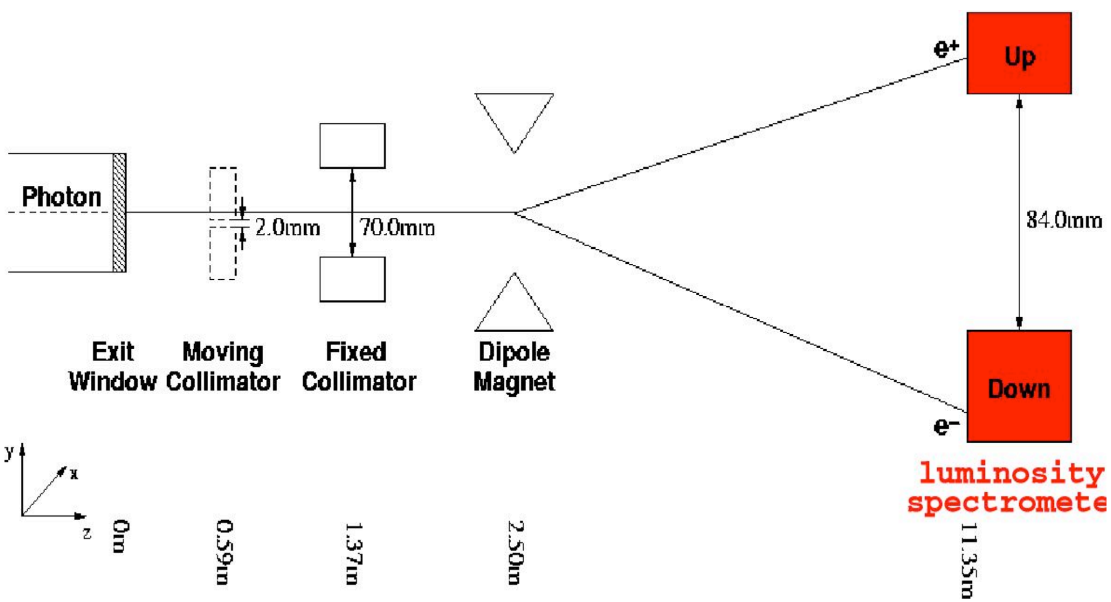


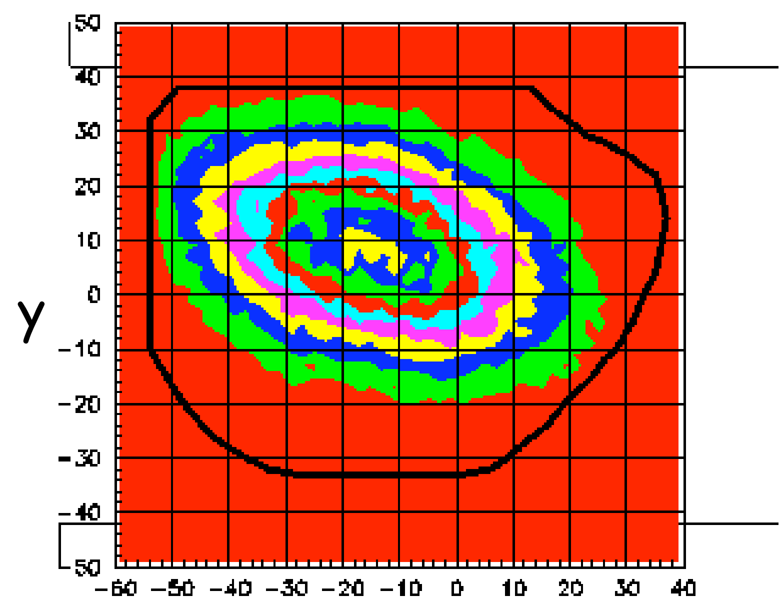
- and more in LJ's thesis (eff. Pomeron trajectory)
- H1 paper in progress

ZEUS: Luminosity Spectrometer

- Some BH-photons convert in exit window of beam-pipe; e^+e^- pairs are bent into 2 calorimeters. In addition large backgrounds due to sync. radiation.

- to calculate acceptance need to know the profile of the BH-photons and the geometrical acceptance of the beam-line.
  - reweight the profiles from GEANT to the data - for every 16 s period of data - get an acceptance for every 16 s ⇒ expect most precise luminosity!

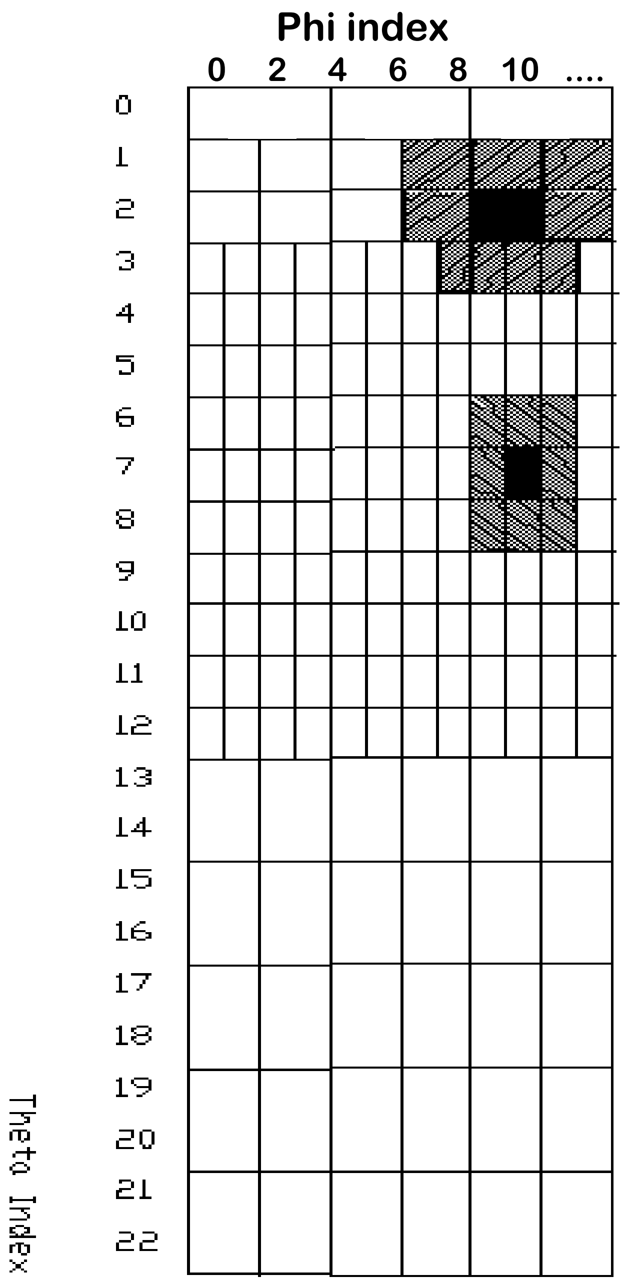




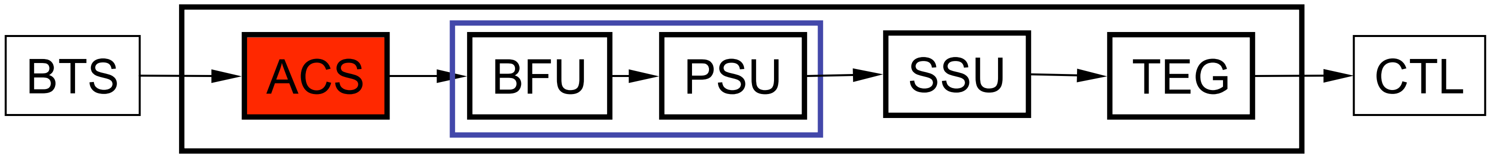
~ 100m from IR

x [mm}

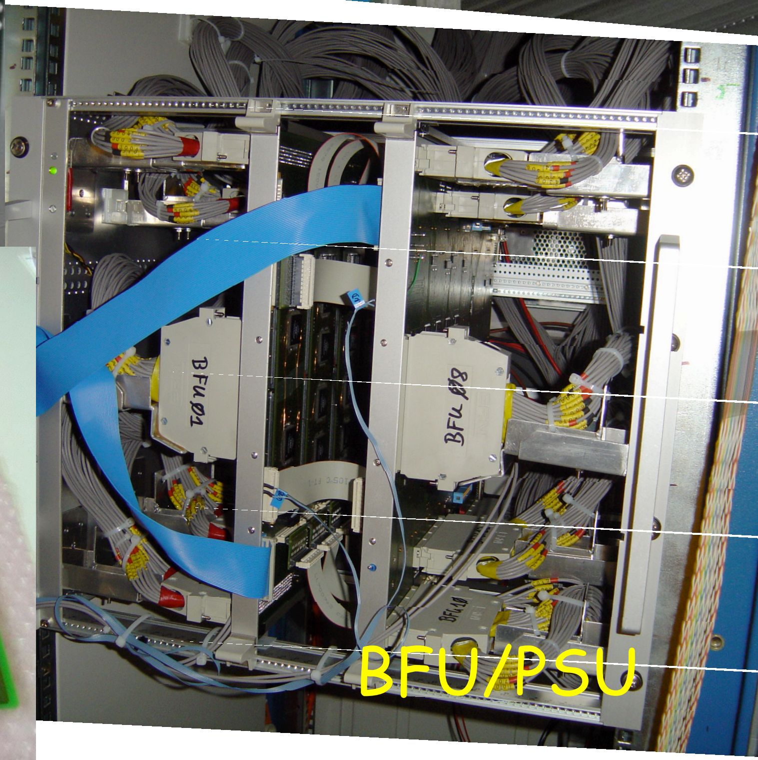
LAr JetTrigger

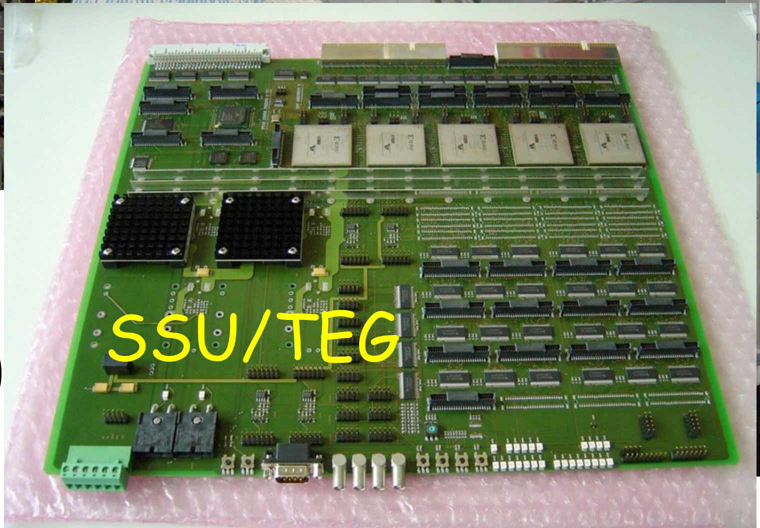


- ACS digitize analog TT-signals and sum
- BFU search for local maxima, sum energies of immediate neighbors
- PSU/SSU sort jets by transverse energy (list of up to 16 ordered jets)
- TEG build trigger elements fulfilling cuts
- ACS production (48 boards B) finished, installed, and mostly tested
- BFU/PSU 2 MBs installed, tested & working
- SSU/TEG 2 boards installed
- JetT timing tested, signal within 8 BCs



LAr JetTrigger Installation





PostDoc position advertised this month for JetT

Group Members: H1/ZEUS

Boss: Allen Caldwell

Staff:

- Iris Abt (Zeus)
- Christian Kiesling (PL)
- Vladimir Chekelian
- Günter Grindhammer
- Gerd Buschhorn (emeritus)

PostDocs:

- Claudia Büttner (Zeus)
- Juraj Bracinik
- Ana Dubak

Guest:

- Alexej Babaev
- Katerina Tzamariudaki

Secretarial Support:

- Ursula Grenzemann
- Marlene Schaber

PhD Students:

- Ludger Janauschek (finishing)
- Andrei Nikiforov
- Ringaile Placakyte
- Zuzana Rurikova
- Sebastian Schmidt (finished/Desy)
- Juraj Sutiak (Zeus)
- Biljana Vujicic
- (Jens Zimmermann)

Engineers:

- Charles Braquet
- Markus Fras
- Werner Haberer
- Josef Huber
- Miriam Klug
- Andreas Wassatsch

Activities

- Hardware
  - LAr L1: A.Babaev, J.Bracinik, C.Kiesling, A.Nikiforov, Z.Rurikova, B.Vujicic
  - JetT: A.Dubak, C.Kiesling, A.Nikiforov, B.Vujicic, Engineers
  - L2NN: L.Janauschek, C.Kiesling, R.Placakyte, J.Zimmermann
- Analyses
  - Inclusive NC, CC: V.Chekelian, C.Kiesling, A.Nikiforov, R.Placakyte, B.Vujicic
  - Charm: J.Bracinik, G.Grindhammer, Z.Rurikova, (K.Tzamariudaki)
  - Elastic J/ψ: L.Janauschek, C.Kiesling
  - Jets: G.Grindhammer
- Misc.
  - Physics Coord.: V.Chekelian
  - CB-Member: C.Kiesling

Summary

- LAr L1 and L2NN are running well, but require a lot of effort
- JetT is being installed and tested, still much work ahead
- HERA is expected to provide lumi close to design with first e^- beam (later e^+) and polarization
- We are involved in exciting mainly QCD topics
  - understanding proton structure at low and large x
  - what is the gluon density ?
  - understanding heavy quark production
  - precision measurement of the strong coupling
- New students to mine the rich data are veeery welcome !