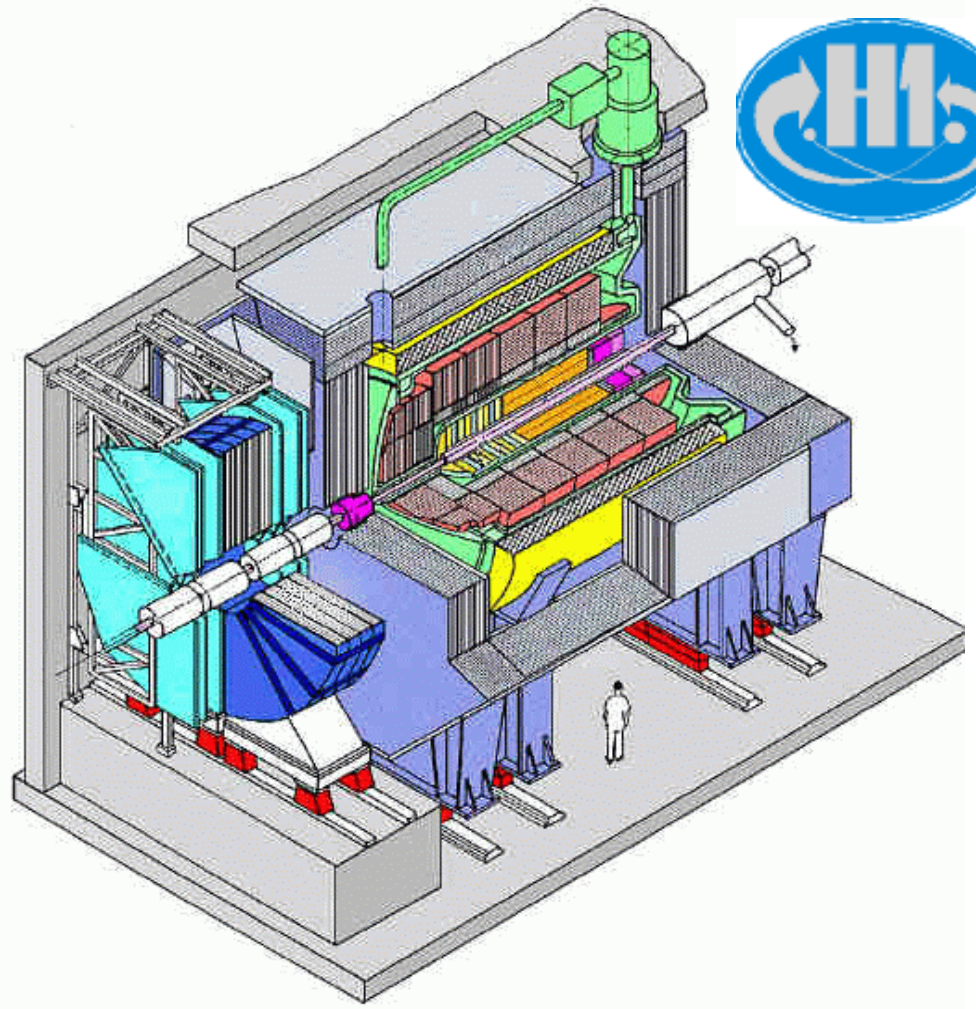
H1 Project Review



Alexei Raspereza for MPI-H1 Group

MPI Project Review Meeting 2007/12/18

Outline

- HERA Performance
- H1 MPI Group
- Hardware Activities
  - Jet trigger
  - L2NN trigger
- Physics Analyses
  - Inclusive NC/CC measurements
  - Inclusive jet cross section measurements
  - Charm production with dijets
- Prospects : direct $F_L(x,Q^2)$ measurement

HERA I+II Running

ZEUS

HERA:

E(p) = 820, 920, 460, 575GeV
E(e) = 27.6GeV

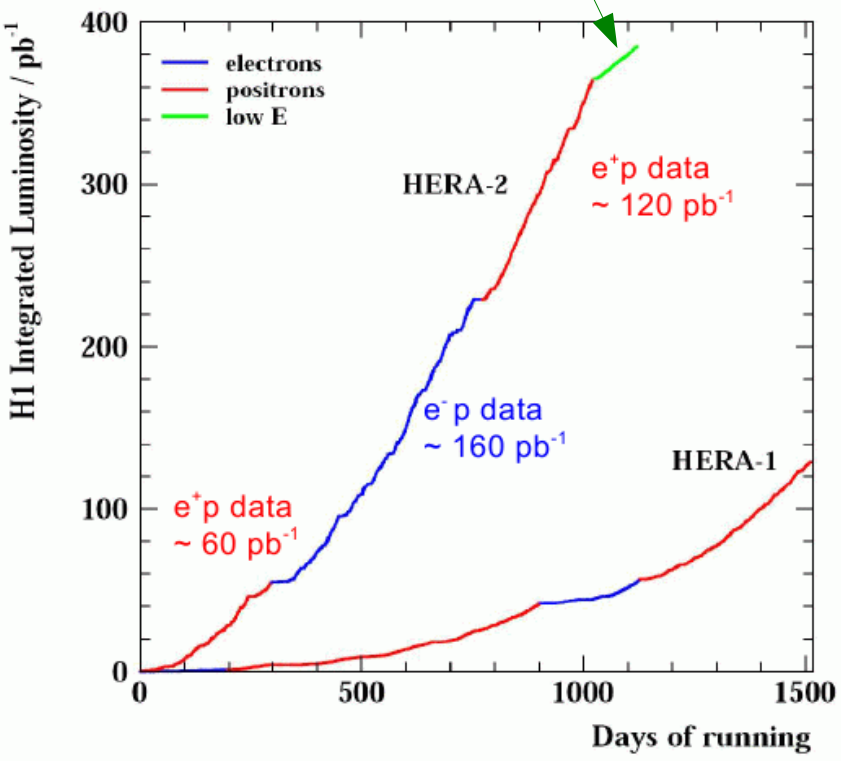
	HERA I	HERA II
e^+p	$\simeq 100 pb^{-1}$	$\simeq 200 pb^{-1}$
$e^- p$	$\simeq 20 pb^{-1}$	$\simeq 180 pb^{-1}$

in total 0.5 fb^{-1}

Dedicated low/medium proton energy run

- Ep = 460 GeV $\simeq 12 pb^{-1}$
- Ep = 575 GeV $\simeq 7 pb^{-1}$

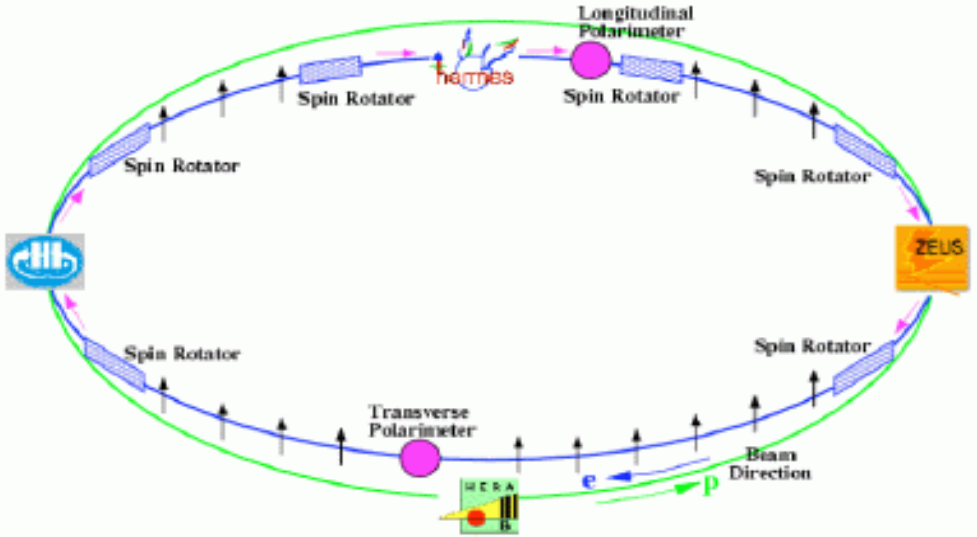
$\Rightarrow$ direct F_L measurement

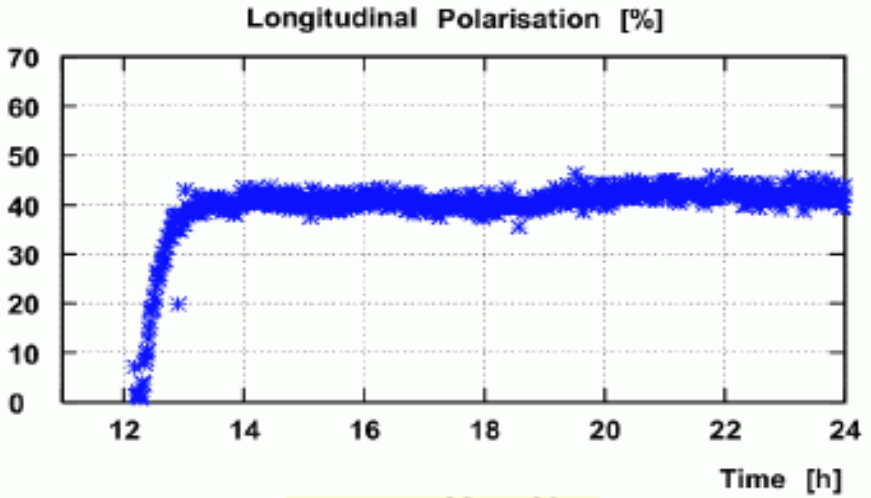


Longitudinally Polarised Lepton Beams @ HERA II

Synchrotron radiation off lepton beam induces transverse polarisation
(Sokolov-Ternov effect)

Newly installed spin rotators flip transverse and long. polarisation





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

⇒ <u>considerably extended physics potential</u>

- polarisation dependence of σ^{CC}
- γZ – interference at high Q^2 NC DIS

➔ classical tests of the Standard Model

MPI Group within H1 Collaboration

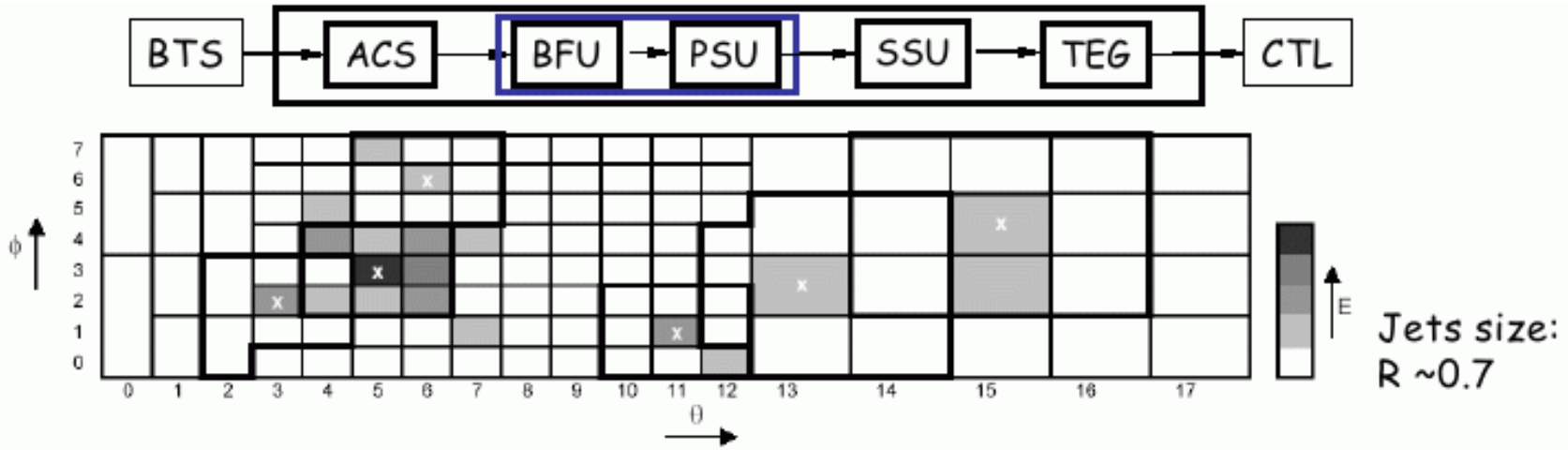
- Responsible director
  - A.Caldwell
- Staff scientists
  - C.Kiesling (project leader)
  - V.Chekelian (EC-member)
  - G.Grindhammer (WG-convener)
- Post-docs
  - B.Olivier, A.Raspereza, J.Bracinik
- Guest scientist
  - A.Dubak
- Support
  - F.Rudert, M.Schaber
- PhD students
  - A.Liptaj, S.Shushkevich, R.Kogler, A.Dossanov
- Diploma student
  - S.Schmitt
- Engineers
  - M.Fras, W.Haberer, M.Modjesch, A.Wassatsch
- Alumni members – Ph. Doctors brought up in H1 MPI Group last year
  - R.Placakyte, B.Antunovic, A.Nikiforov, Z.Rurikova

Responsibilities & Activities

- Hardware
  - LAr trigger : C.Kiesling, J.Bracinik, A.Liptaj, A. Nikiforov + engineers
  - Jet trigger : C.Kiesling, B. Olivier, A.Dubak + engineers
  - L2NN trigger : C.Kiesling, R.Placakyte + engineers
- Physics Analyses
  - Inclusive NC/CC measurements, including F_L: V.Chekelian, A.Raspereza, A.Dubak, S.Shushkevich, A.Nikiforov, B.Olivier, R.Placakyte, S.Schmitt
  - QCD Fits : C.Kiesling, B.Olivier
  - charm physics : G.Grindhammer, Z.Rurikova, A.Liptaj, J.Bracinik
  - inclusive jets : G.Grindhammer, J.Bracinik, A.Dossanov, R.Kogler
  - New phenomena : B.Olivier

Hardware Activities

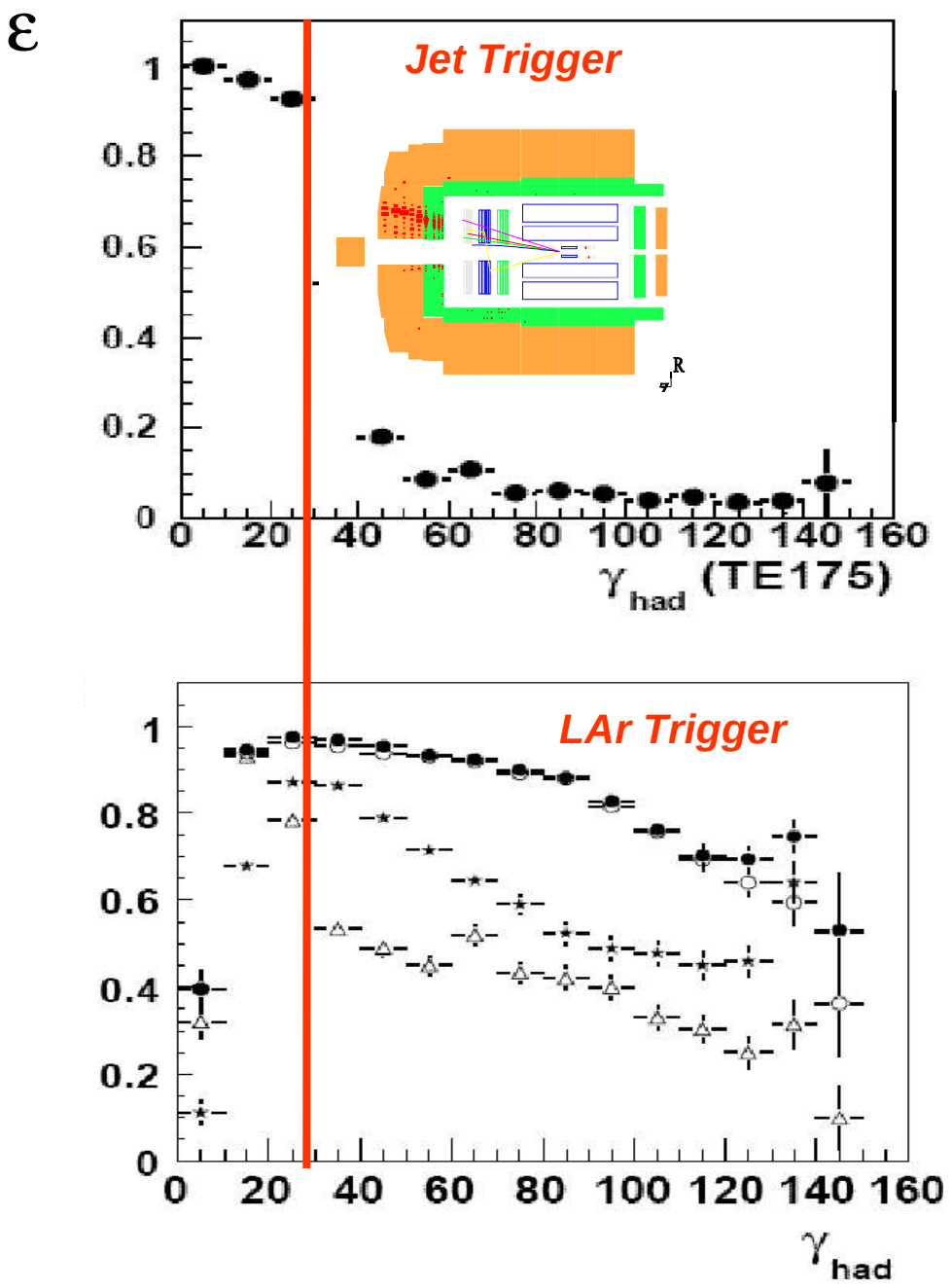
Jet Trigger



- **Adc Calculation Storage:** digitise then sum towers-low coherent noise
- **Bump Finder Unit:** jet algorithm in 100ns! - less energy sharing
- **Primary Sorting Unit:** 16 energy sorted jets:
- **Secondary Sorting Unit:** leading jets physics, last jets noise
- **Trigger Element Genarator:** global conditions ETmiss, ETrans
  conditions on individual jets E_T, θ
  topological conditions on $\Delta\theta$, $\Delta\phi$

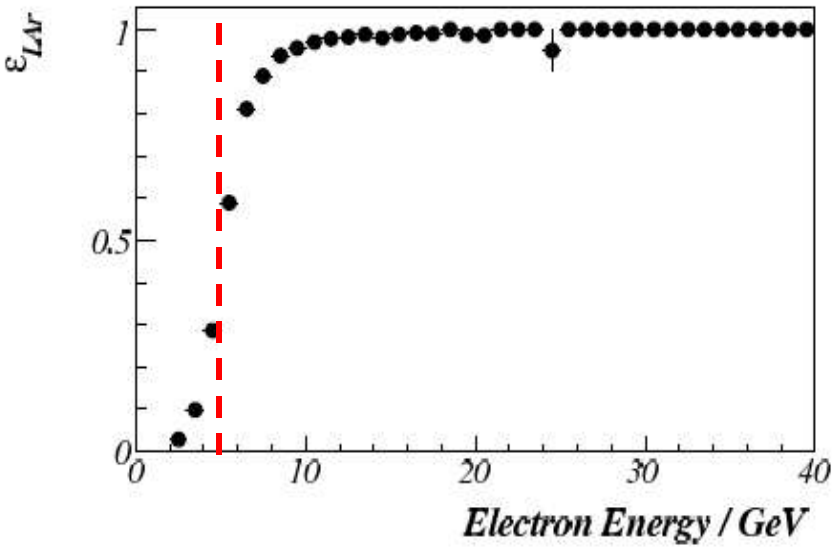
80 pb^{-1} of data collected with jet trigger

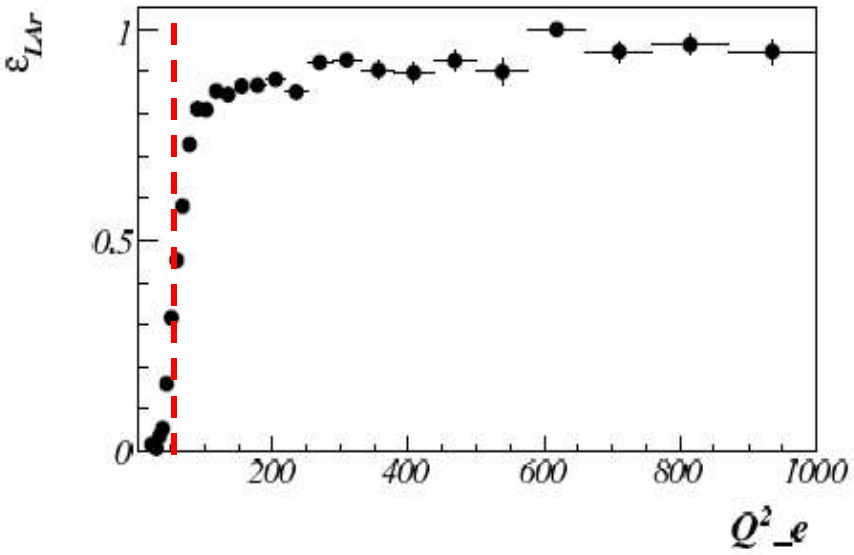
Jet Trigger && CC – Forward Jets



- *LAr Trigger: CC analysis suffers from low efficiency at low jet angle*
- ***Jet Trigger opens new phase space: single jet <30°***
- *1Hz at E_T(jet) > 8 GeV*
- *50pb^{-1} accumulated*
- *Efficiency 90-100%*

Nominal Energy Run (0607 e+) – Old LAr Trigger in NC

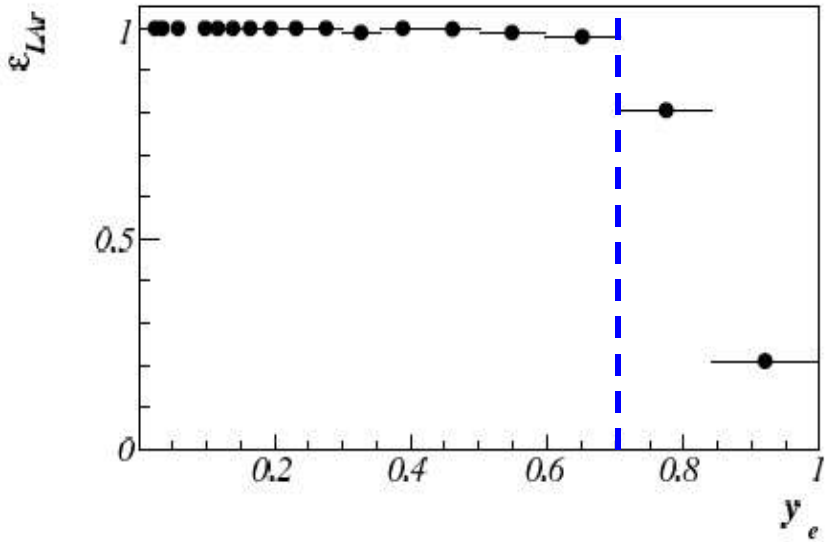




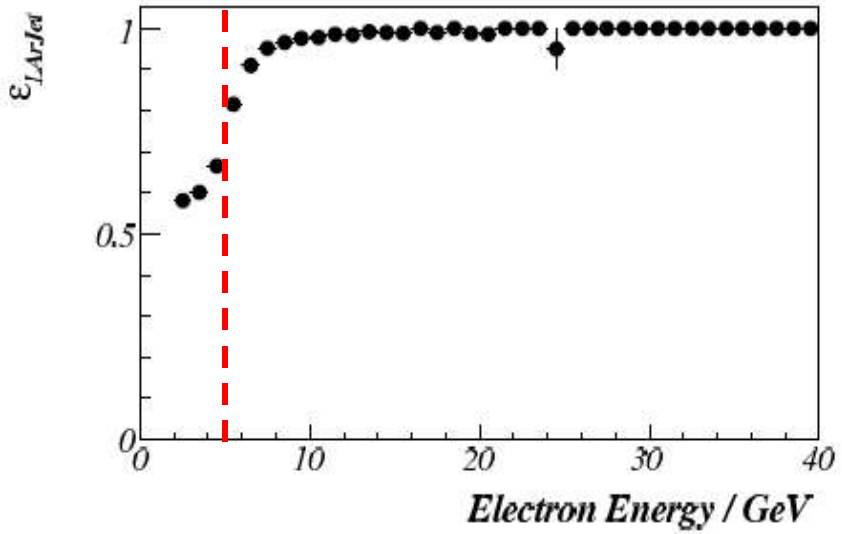
Strongly decreasing efficiency for low E_e

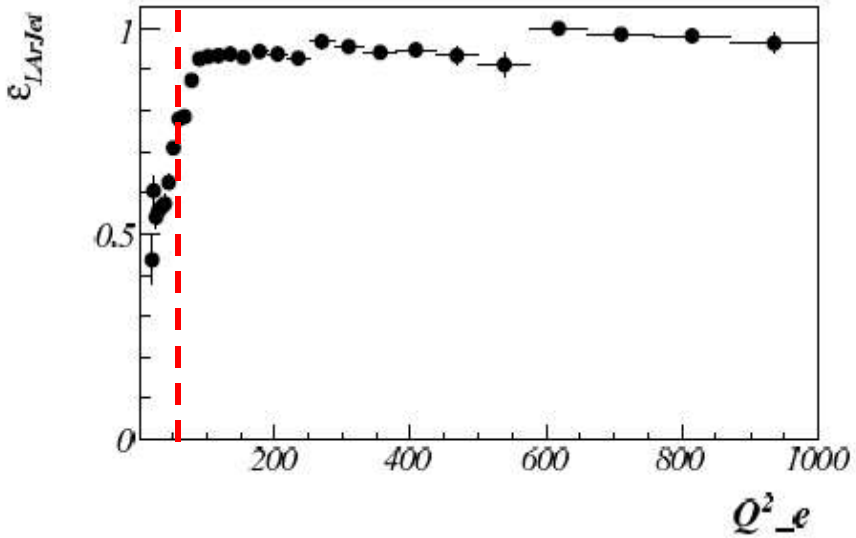
-> cut *E_e > 5 GeV:*

- *Q^2 > 50 GeV^2,*
- *limits statistics at the highest y*



Nominal Energy Run – Old LAr + Jet Trigger in NC

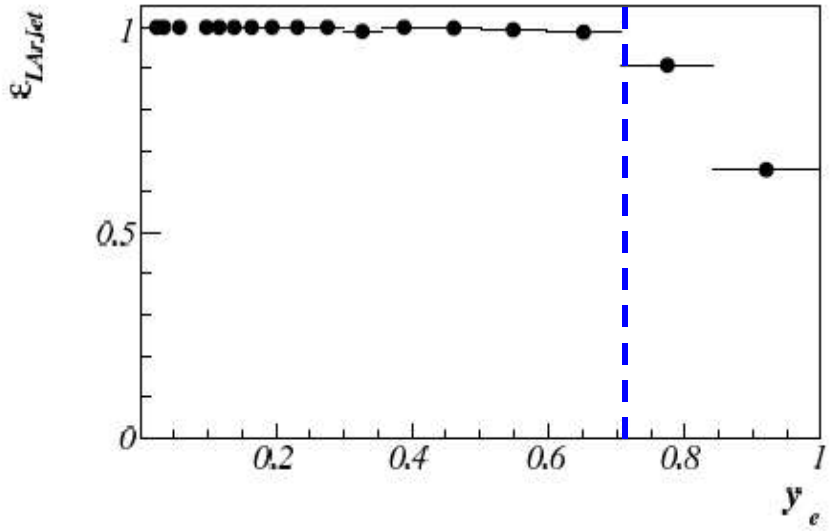




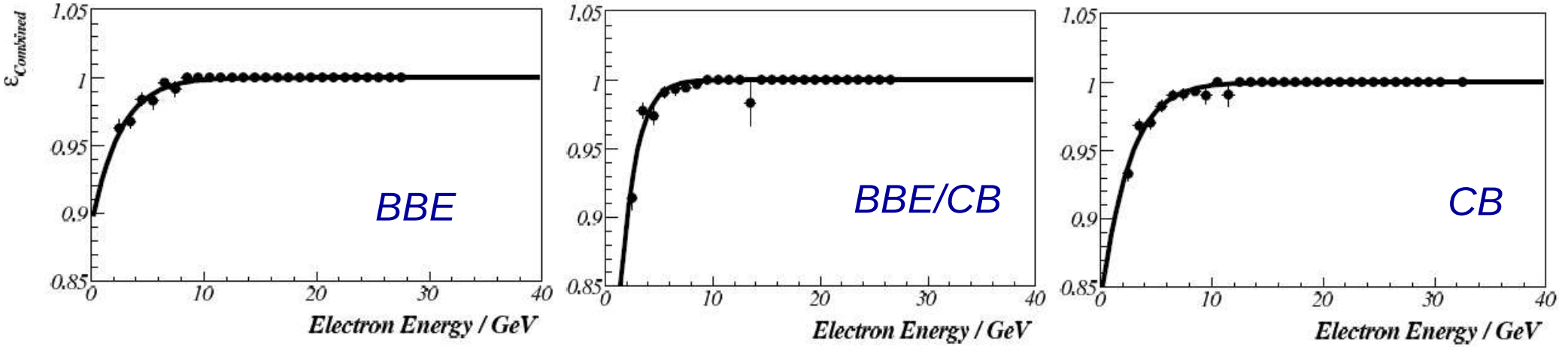
Combine Old LAr trigger with New Jet+Track trigger:

Significant increase in efficiency at low E_e

Luminosity collected for nominal E run with JT active: ~ 60 pb^{-1}

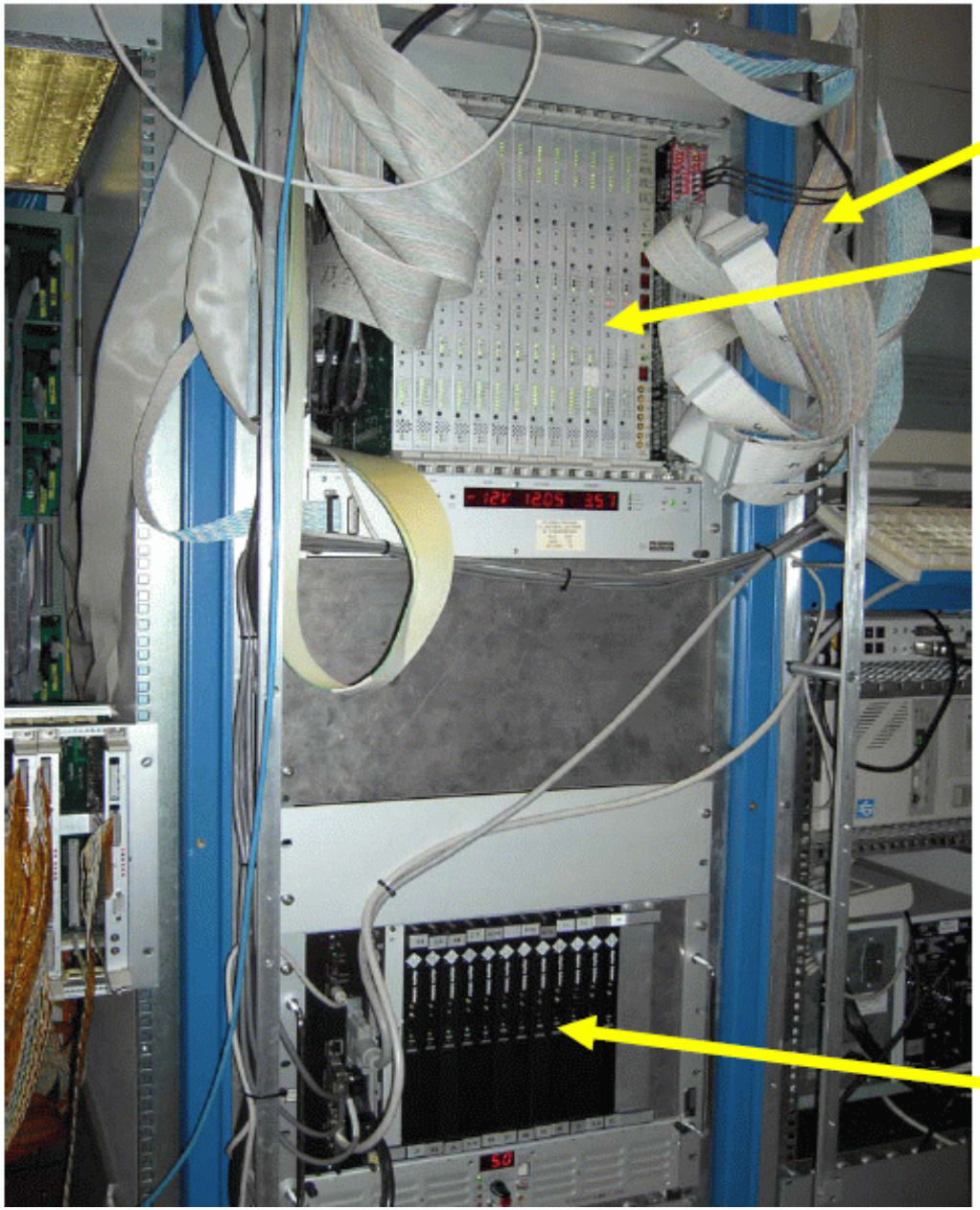


Jet Trigger in NC Analysis of Low/Medium Energy Data (Example : Ep=460GeV)



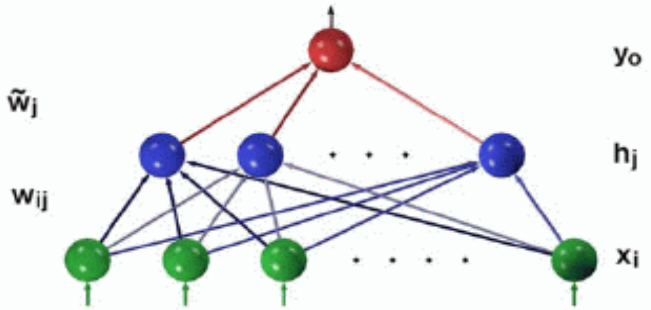
- Combined trigger efficiency 92-100% (E_e =2-10 GeV)
- Trigger is highly efficient in the whole $(\theta,\phi)_e$ phase space
- Access to high y domain ⇒ crucial for F_L measurement

Neural Network Trigger @ Level 2 (L2NN)



data from the level 1 processors

selection & preprocessing of input data



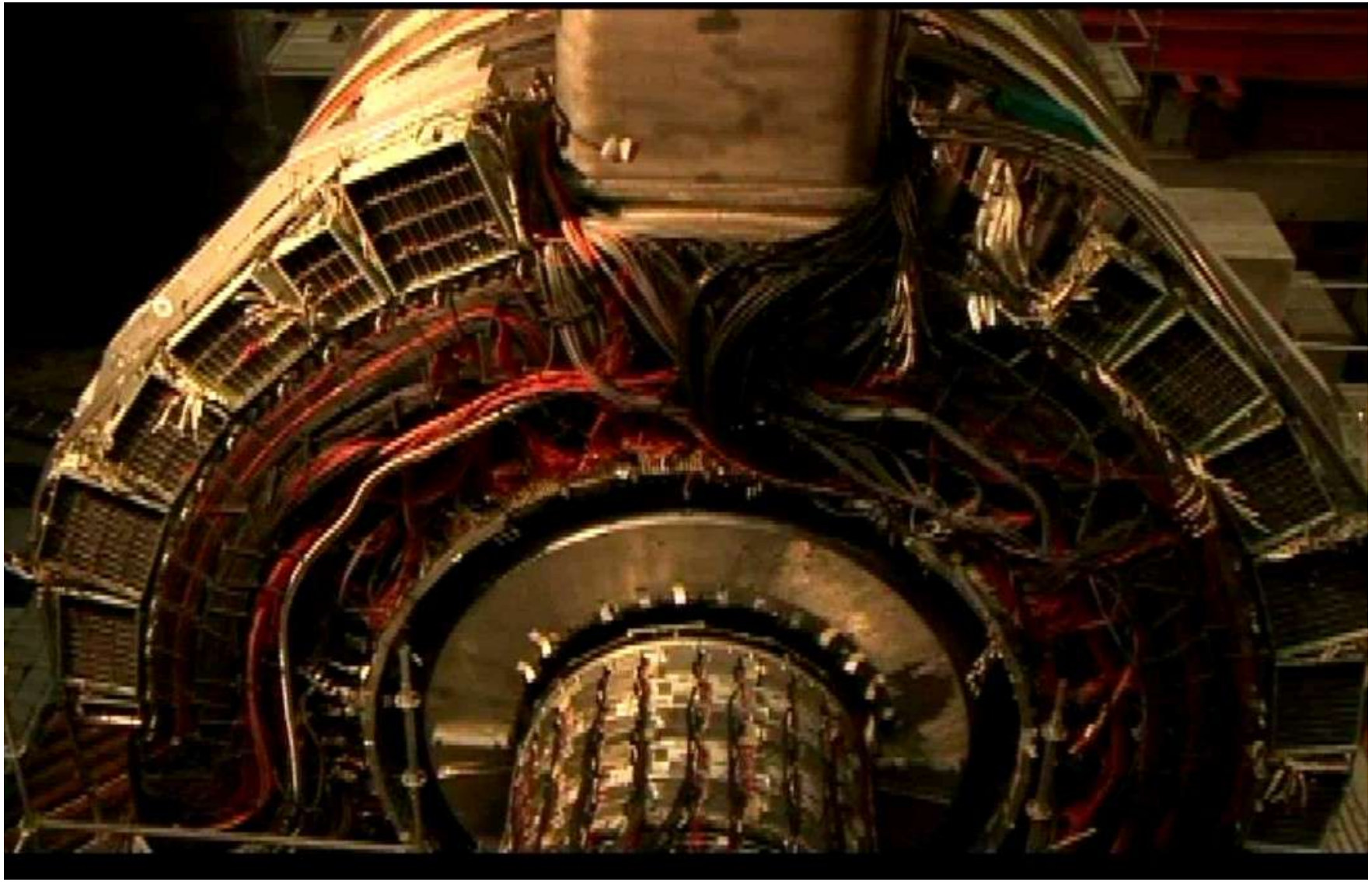
12 networks for specific physics, e.g.

- untagged and tagged D*
- DVCS
- elastic J/Ψ and Υ production
- photoproduction dijets

neural network processors

Dismantling of H1

… started July 3, 2007



LAr stacks built by MPI will go out in February 2008 …

Electronic Hut, LAr Electronics

readout electronics
already taken out

MPI Electronics being disassembled

Horst Brettel taking apart what he put together 16 years ago ...

Calorimeter Stacks built by MPI („Forward Barrel“) will come out by February 2008

Physics Analyses in H1
MPI Group

Physics at HERA

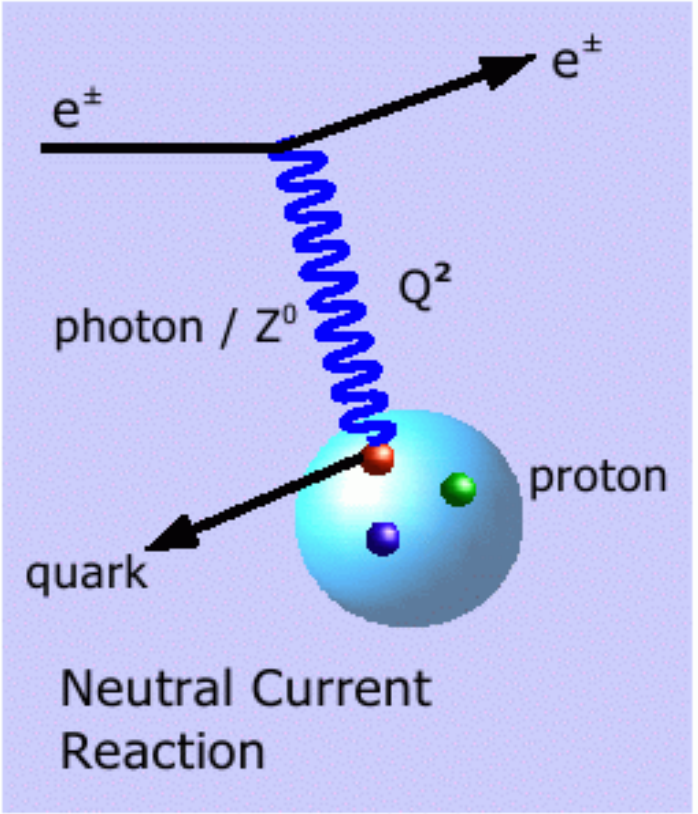
HERA performs measurements at Q^2 up to and beyond EW scale

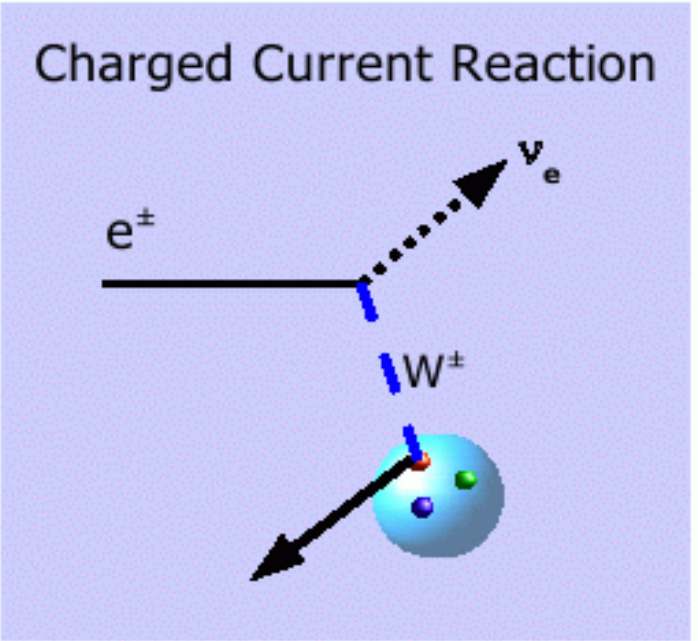
HERA collides e and p
study strong, electromagnetic & weak forces through Deep Inelastic Scattering

At fixed √s: two kinematic variables: x & Q^2
$Q^2 = s \times y$

Q^2 = "resolving power" of probe
High Q^2 : resolve 1/1000th size of proton

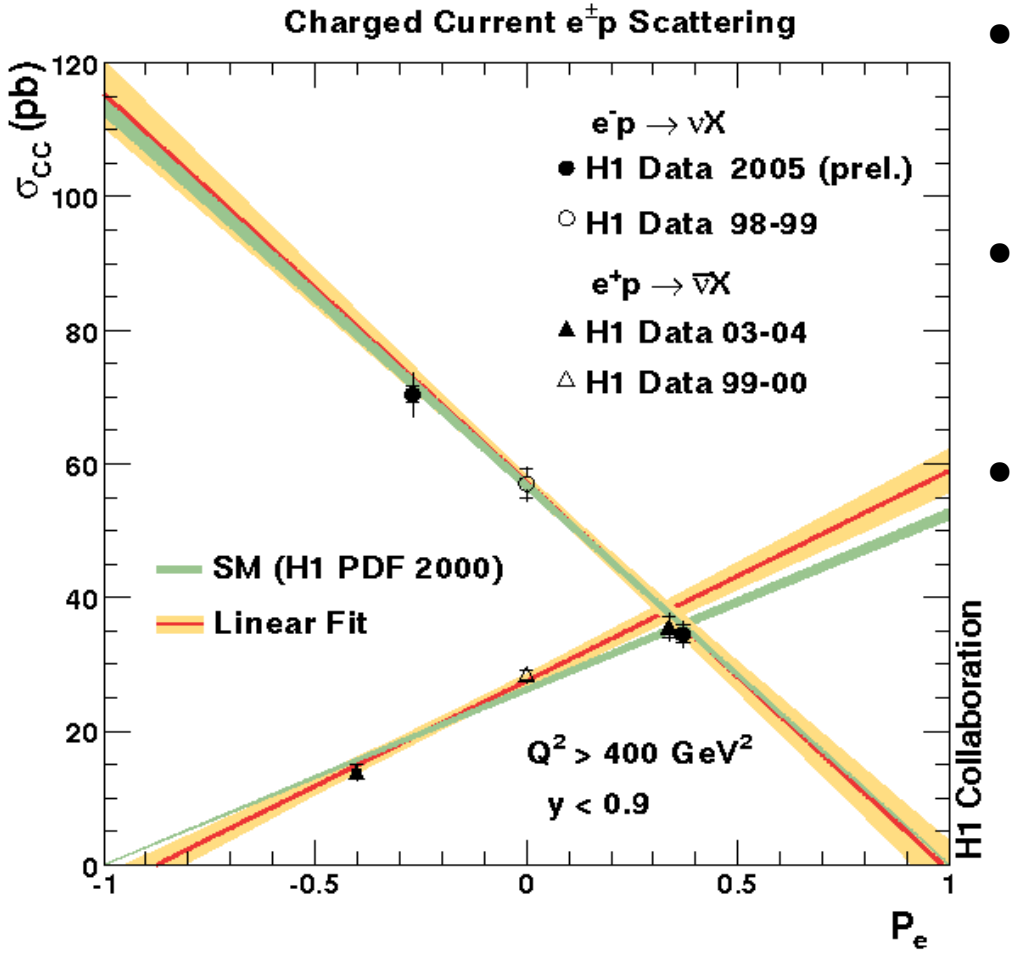
x = momentum fraction
of proton carried by quark
HERA: ~10^{-6} - 1





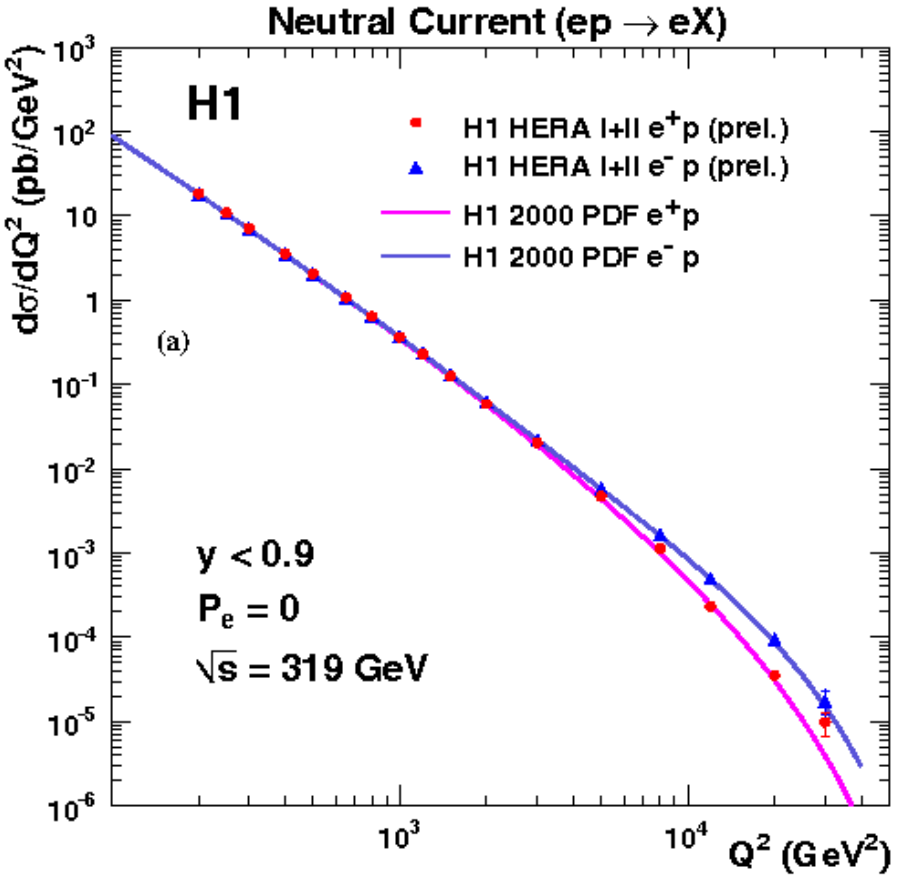
Polarization Dependence of σ_{CC}

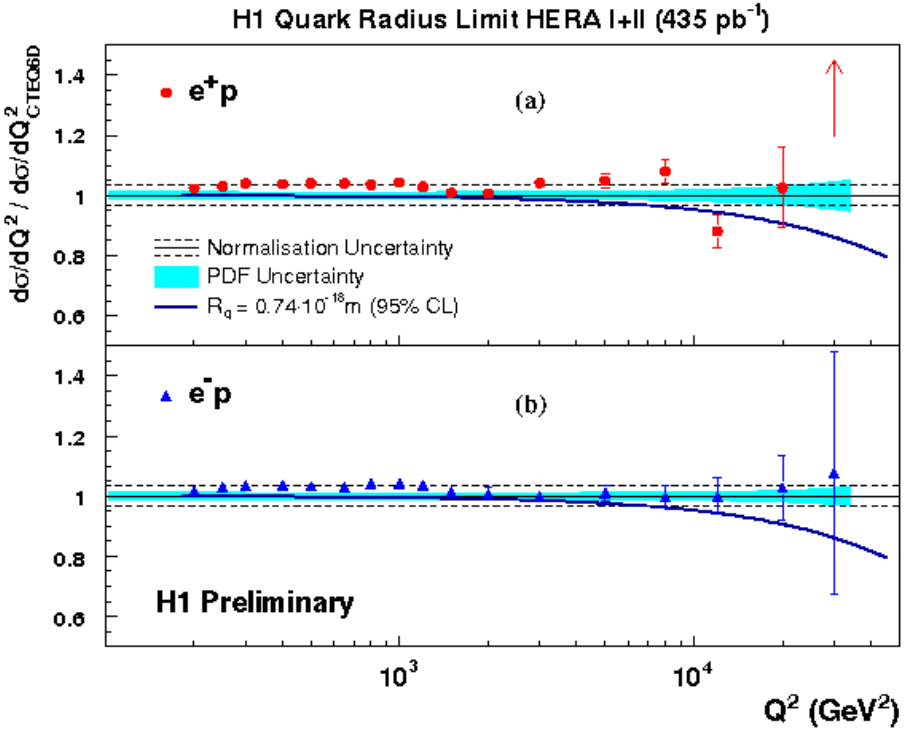
Classical Test of SM



- Polarisation dependence clearly seen : $\sigma_{CC}^{\pm} \propto (1 \pm P_e)/2$
- Data consistent with SM prediction of no e^-_R e^+_L CC
- Constraints on mass of W_R assuming $g_L = g_R$ and $m(\nu_R) = 0$
  - **e^+p data $m(W_R) > 208$GeV**
  - **e^-p data $m(W_R) > 186$GeV**

$d\sigma^{NC}/dQ^2$ HERA I+II Data Limits on Quark Radius





$$\frac{d\sigma}{dQ^2} = \frac{d\sigma^{SM}}{dQ^2}\left(1 - \frac{1}{6}R_q^2 Q^2\right)^2$$

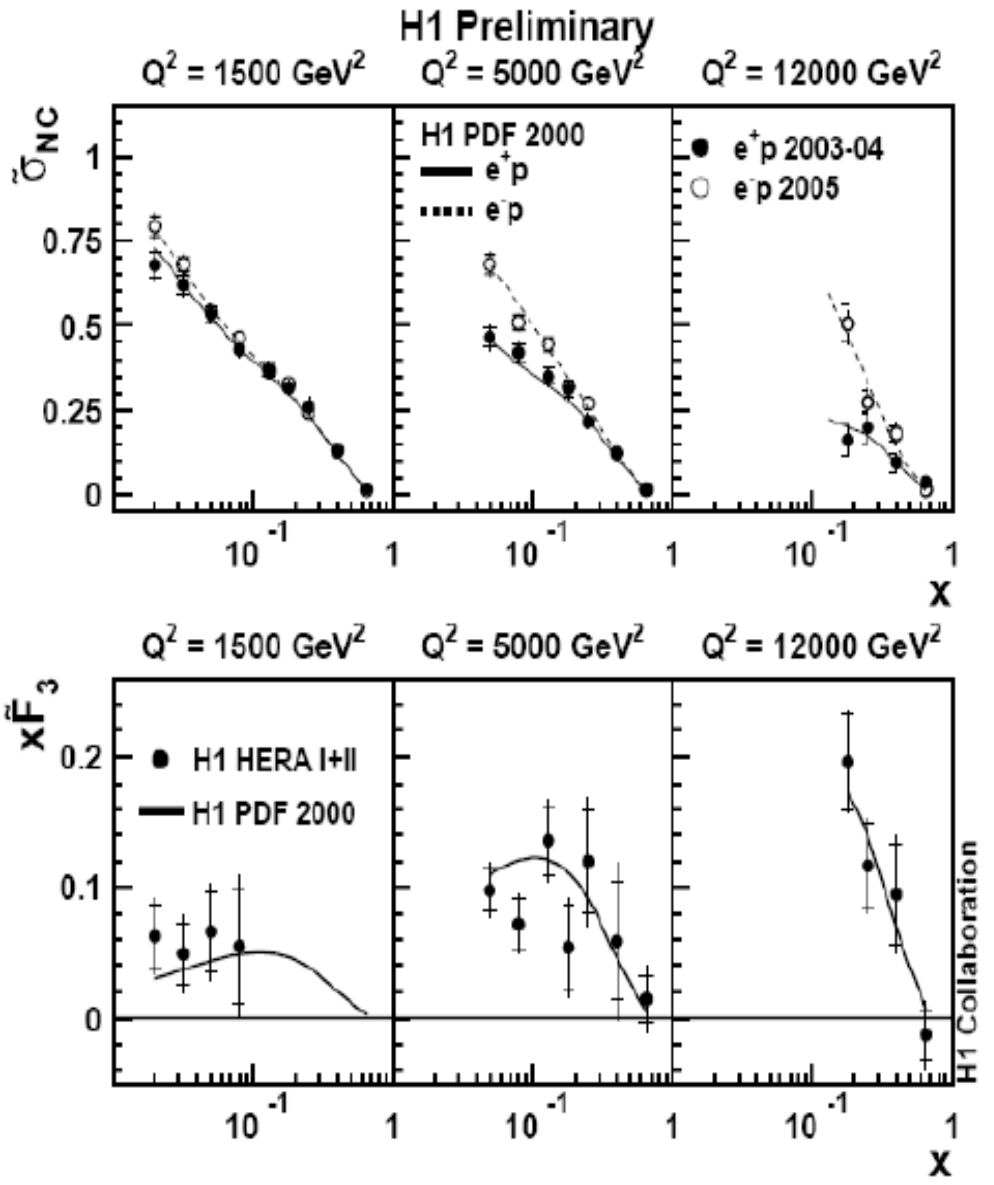
$R_q < 0.74 \cdot 10^{-18}$ m @ 95%CL

Structure function xF_3 in NC

- Unpolarised case (neglecting F_L)

$$\tilde{\sigma}^{\pm}_{NC} \approx \tilde{F}_2 \mp \frac{Y_-}{Y_+} x\tilde{F}_3 \quad \Rightarrow$$

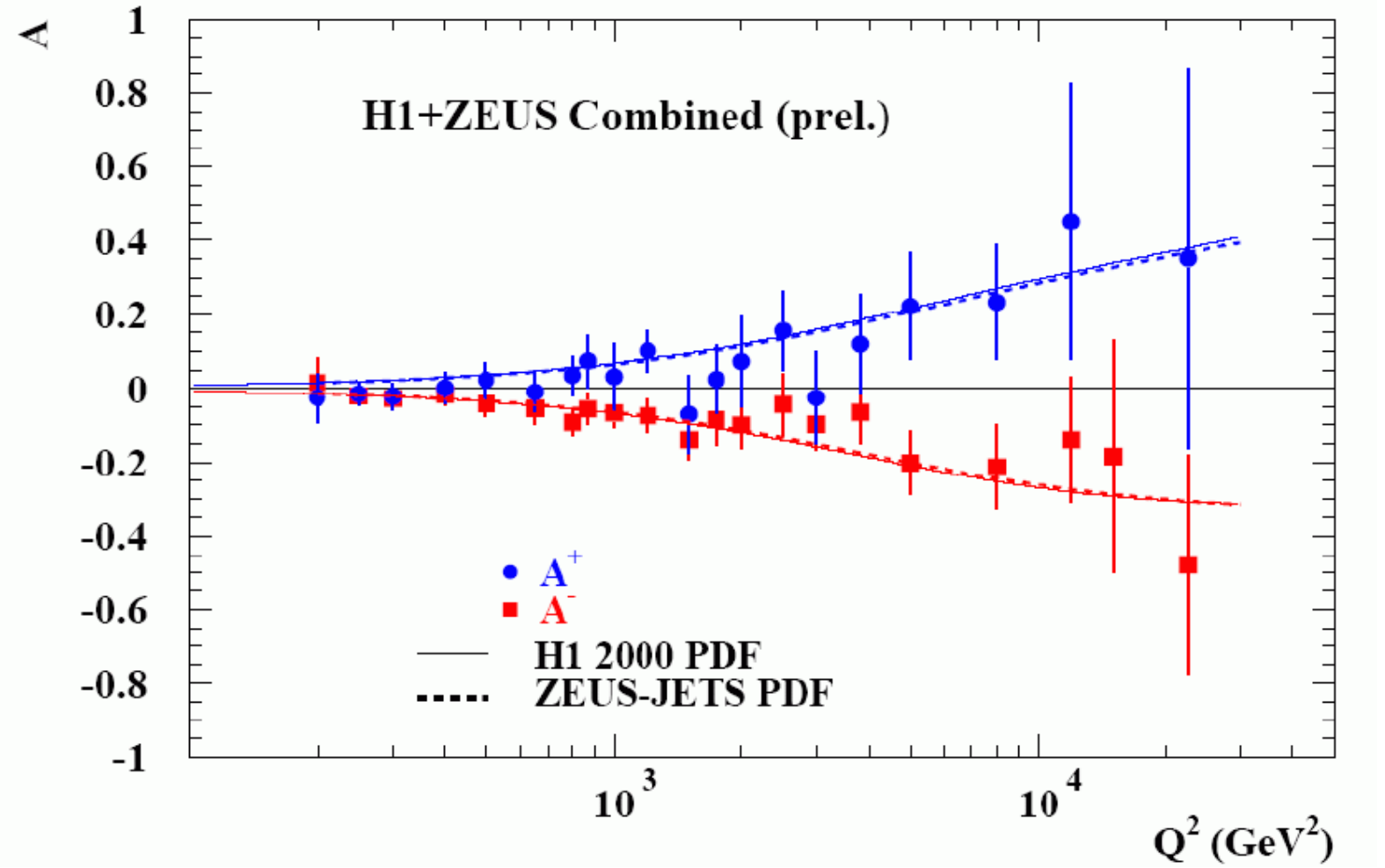
$$x\tilde{F}_3 = \frac{Y_+}{2Y_-}(\tilde{\sigma}^-_{NC} - \tilde{\sigma}^+_{NC}) \approx a_e \chi_Z x F_3^{\gamma Z}$$



NC Polarisation Asymmetry

- Direct measure of parity violation

$$A^{\pm} = \frac{2}{P_R - P_L} \cdot \frac{\sigma^{\pm}(P_R) - \sigma^{\pm}(P_L)}{\sigma^{\pm}(P_R) - \sigma^{\pm}(P_L)} \approx \chi_Z a_e \frac{F_2^{\gamma Z}}{F_2}$$

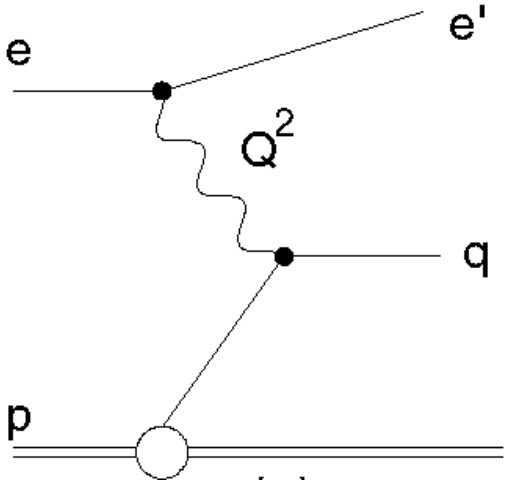


Inclusive Jet Production in DIS

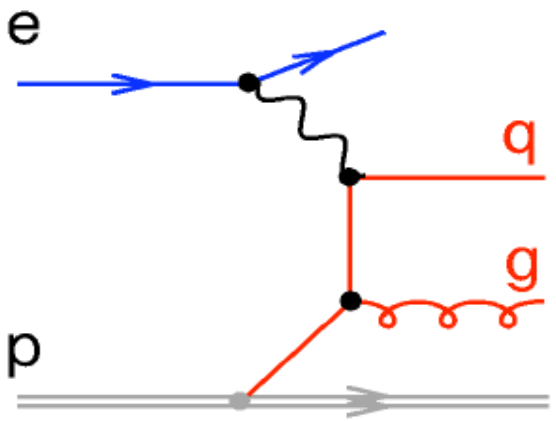
- Born level diagram

  $\Rightarrow E_T^{Jet} \rightarrow 0$ in Breit frame

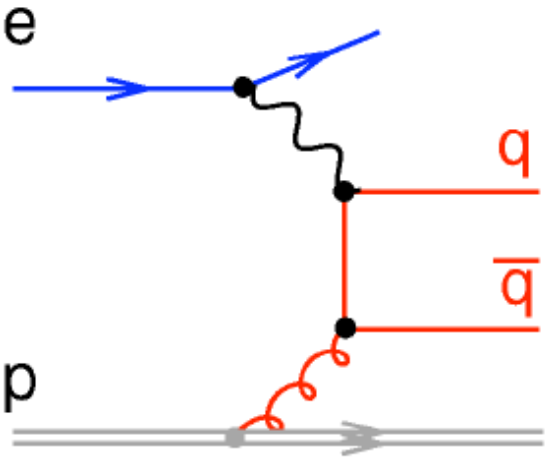
  (boson-quark head-on)



- Leading order in α_S



QCD Compton

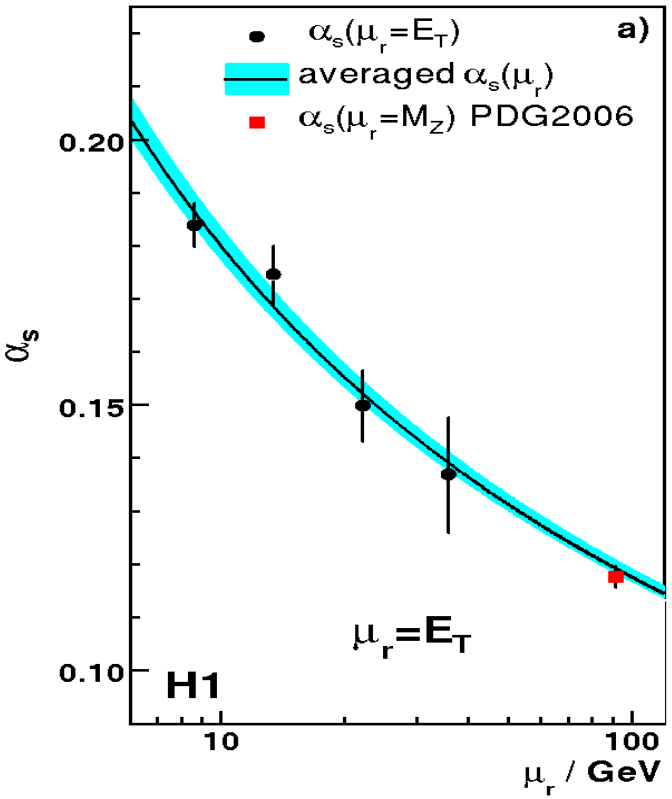


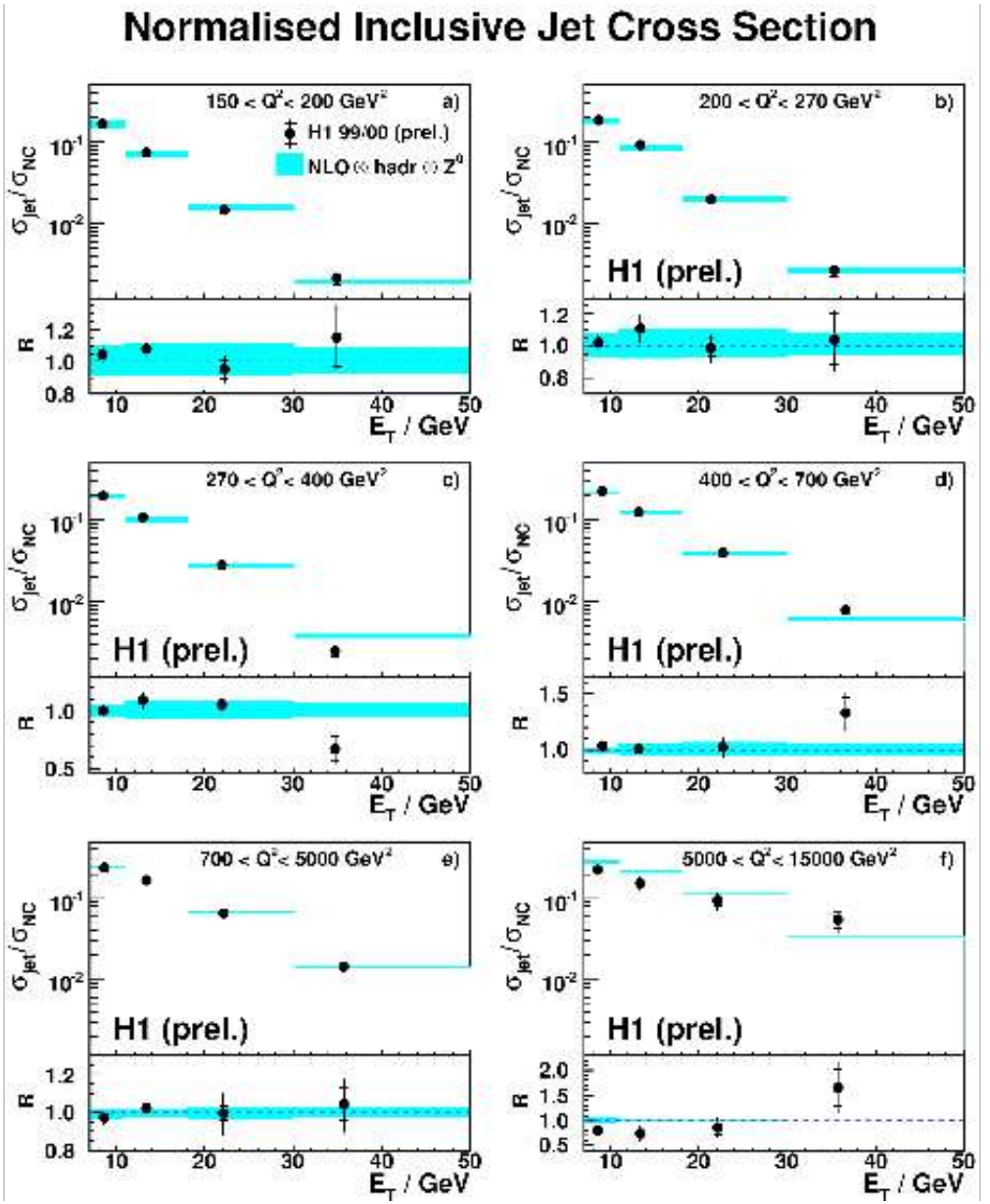
Boson-gluon fusion

- Jets with transverse momentum in BF
- Direct sensitivity to $\alpha_S \Rightarrow$ test of QCD

Normalised Inclusive Jet Cross-Section

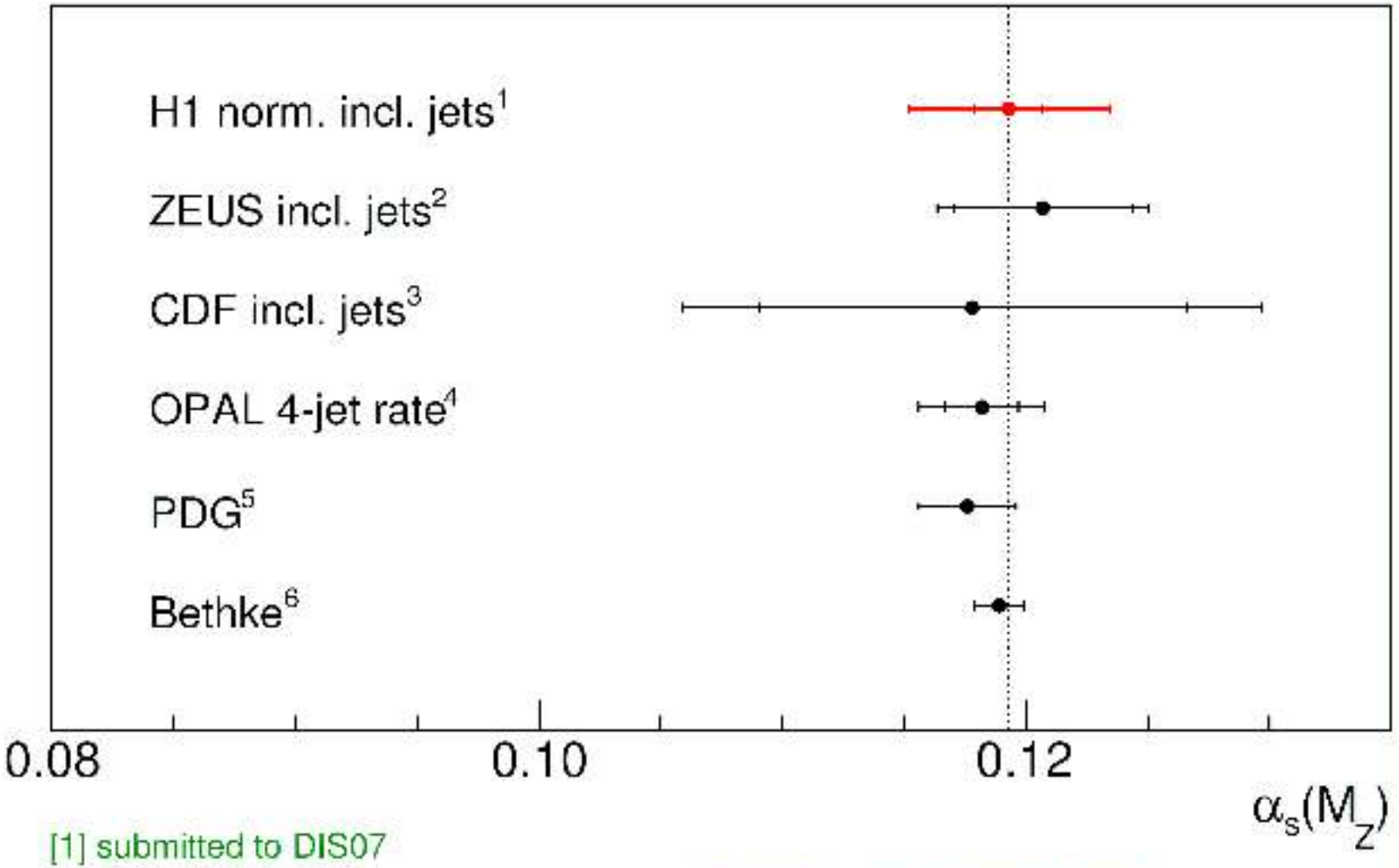
- HERA I data sample (L=65.4 pb^{-1})
- Use #jets / #DIS events (normalised inclusive jet cross section) ⇒
  - Lumi uncertainty cancels
  - Exp. sys. reduced
  - PDF uncertainty reduced





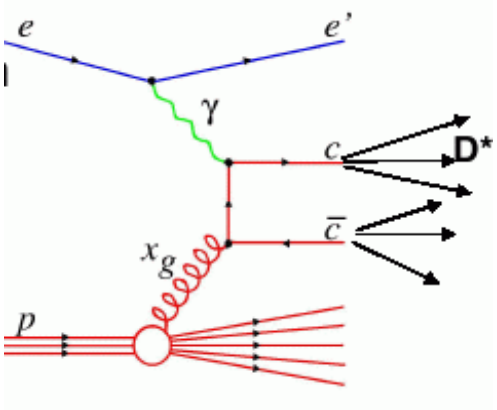
$$\alpha_s(M_Z) = 0.1193 \pm 0.0014\,(\text{exp.}) \,^{+0.0046}_{-0.0032}\,(\text{th.}) \pm 0.0016\,(\text{pdf.})$$

Comparison of α_s Measurements



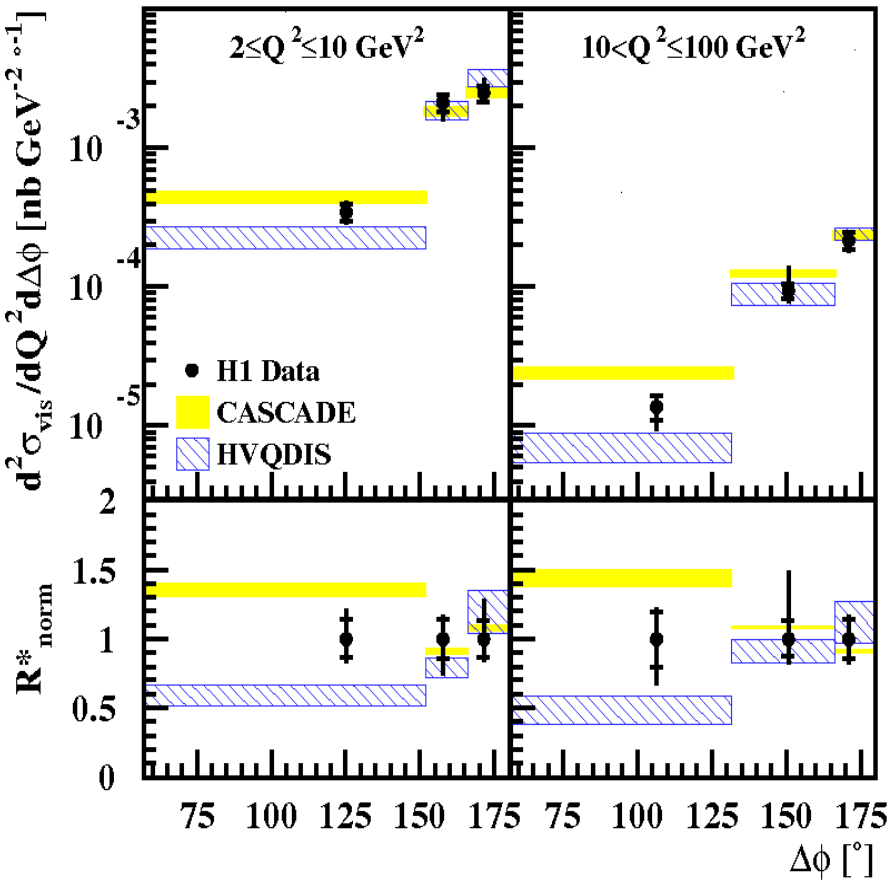
[1] submitted to DIS07
[2] hep-ex/0701039
[3] Phys.Rev.Lett.88:042001,2002
[4] Eur.Phys.J. C47(2006)295-307
[5] J.Phys.G33:1-1232,2006.
[6] Prog.Part.Nucl.Phys.58:351-386,2007.

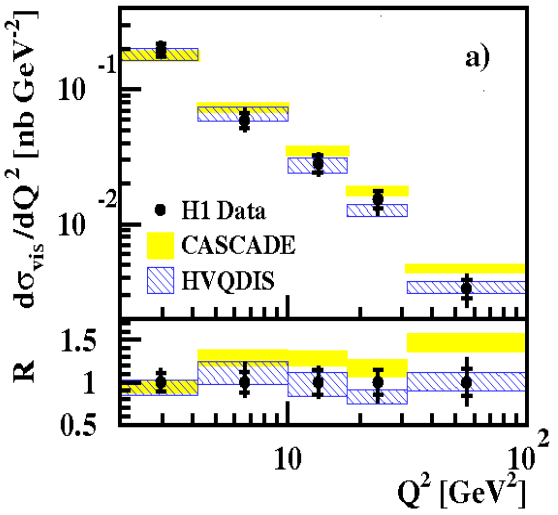
D^* mesons + Dijets in DIS

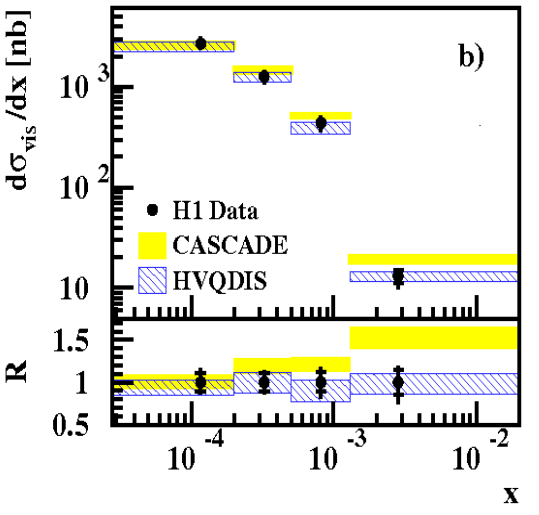


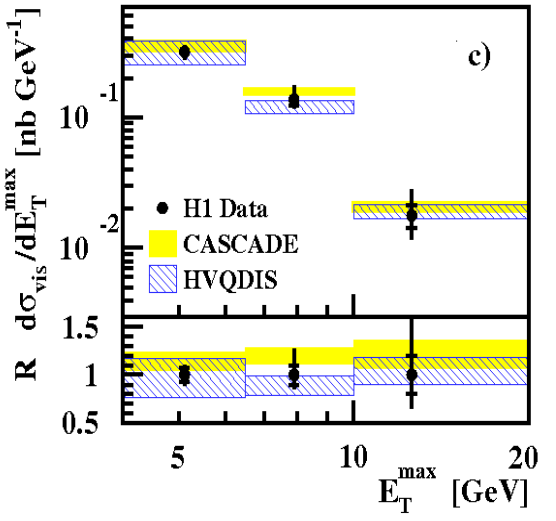
- three scales involved : heavy charm mass, Q^2, E_T^{Jet}
- reasonable description of data by HVQDIS (collinear factorisation) and CASCADE (k_T-factorisation)

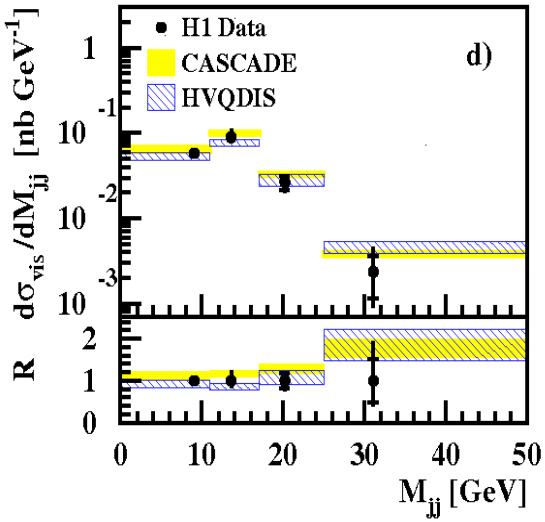
H1 $ep \rightarrow eD^{*\pm}jjX$











Direct F_L Measurement

$$\sigma_r = \frac{Q^2 x}{2\pi\alpha^2 Y_+}\frac{d^2\sigma}{dxdQ^2} = F_2(x,Q^2) - f(y)F_L(x,Q^2)$$

$$Y_+ = 1 + (1-y)^2$$

$$f(y) = \frac{y^2}{Y_+}$$

dominant

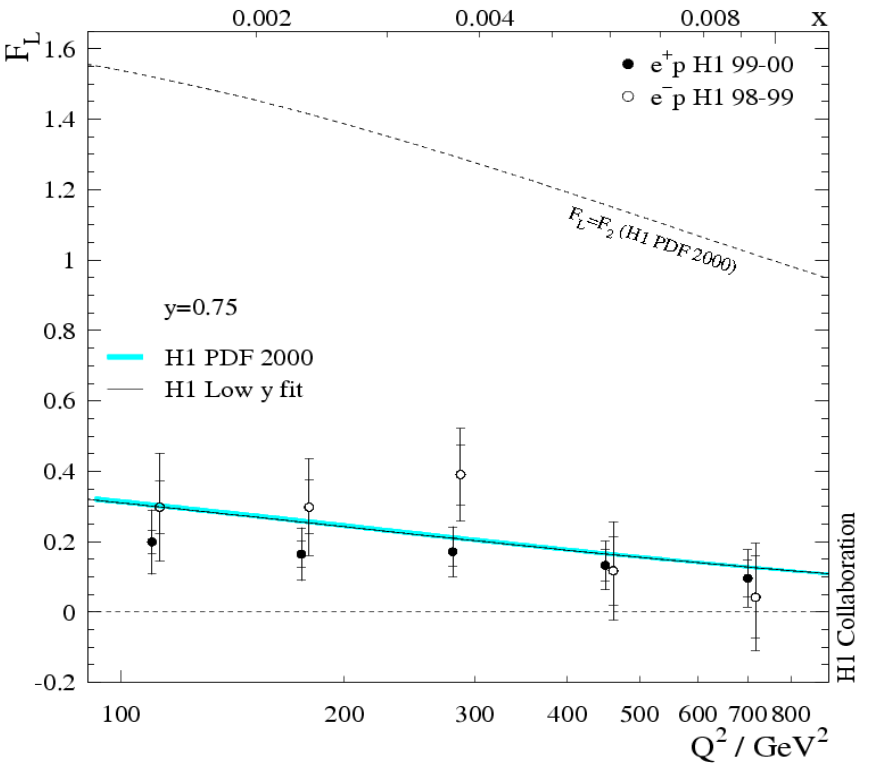
sizable at high y

- Measurement of F_L has a value on its own
  - consistency check of DGLAP which is used for PDFs
  - complete probe of the proton structure (including gluon density)

⇒ implication for LHC

  - Prediction for the Higgs production cross section via gluon fusion
  - Better knowledge of QCD bkgd

Published "determination" of F_L by H1

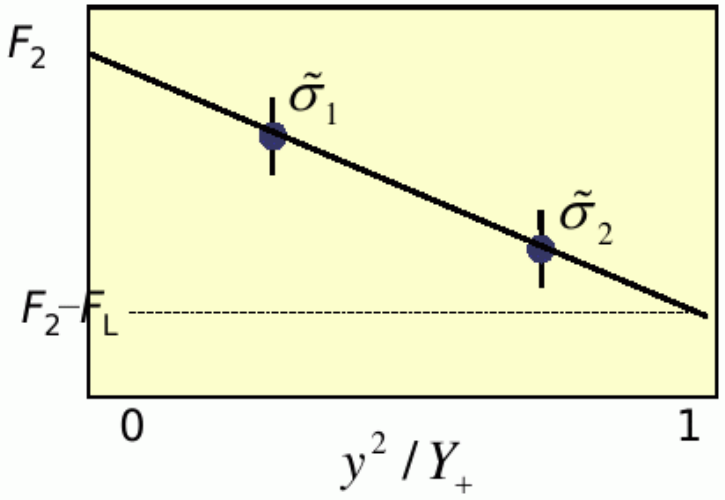


Direct F_L Measurement

Main Idea

Reduced cross-section $\sigma = F_2 - f(y)F_L$

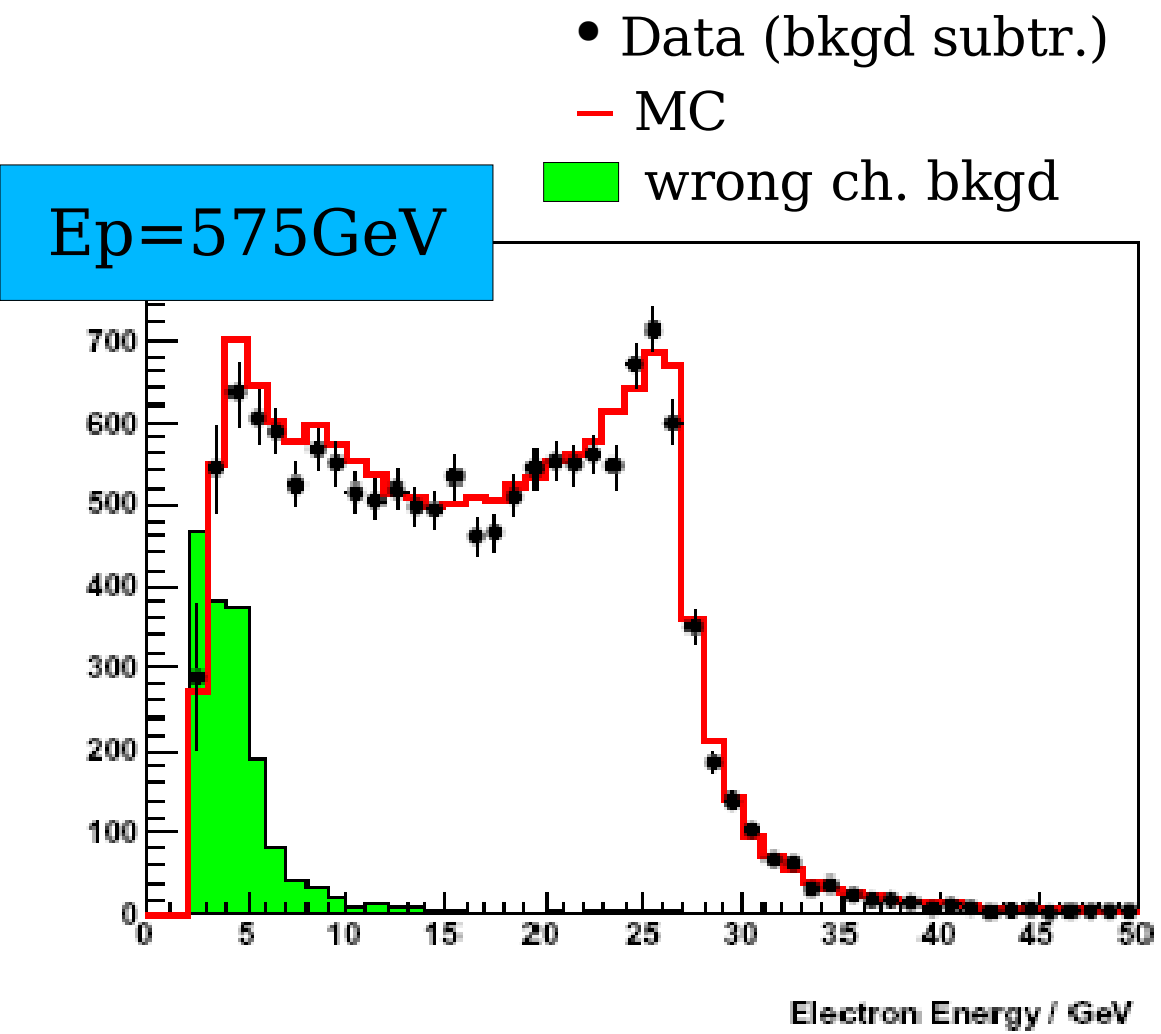
In order to separate F_2 and F_L cross section measurement at the same x and Q^2, but different y (i.e. different s, different beam energies) is needed.



$$F_L(x,Q^2) = \frac{\sigma_1(x,Q^2,y_1) - \sigma_2(x,Q^2,y_2)}{f(y_2) - f(y_1)}$$

Larger y difference ⇔ higher accuracy of F_L .

Towards F_L Measurement
Low/Medium Energy Run Data



- Ep=460,575 GeV data are of good quality
- Access to low E_e (2GeV)
  ⇒ high y domain ⇒ F_L
  - Merit of jet trigger
- Bkgd subtraction exploiting charge of lepton candidate

Summary

- After 15 years of service to science the HERA ep machine was shut down (July 2007)
- 0.5 fb^{-1} of high quality data delivered per experiment
- Data-taking ended, but analysis of data is still ongoing (for 4-5 upcoming years)
- Many interesting physics results have been obtained and are still to come, allowing to:
  - test SM of EW interactions
  - study QCD
  - probe proton structure
- MPI group was active participant in design/construction of H1 detector, operation and monitoring of hardware and is active participant in analysis of the collected data