Towards a Letter of Intent for Future eN Scattering Measurements with H1 at HERA

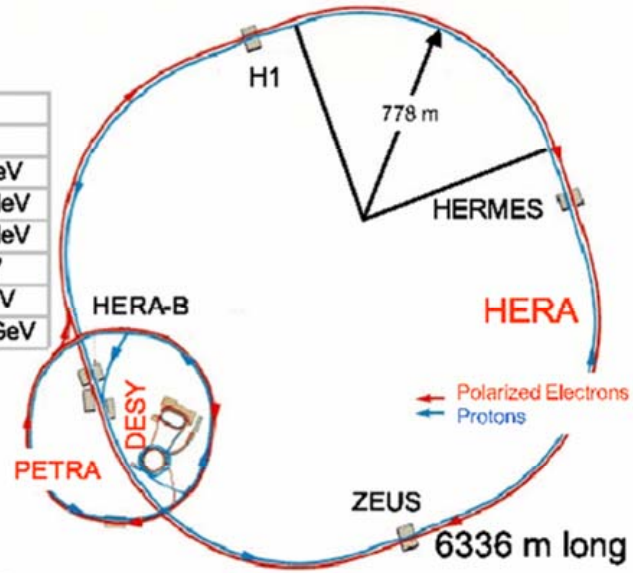
Max Klein (H1)

- The H1 Experiment
- Physics in the „HERA2" Phase
- Electron-Deuteron Scattering at HERA
- Low x ep in the „Transition Region"
- eA and High Density QCD
- Deep Inelastic Spin Physics

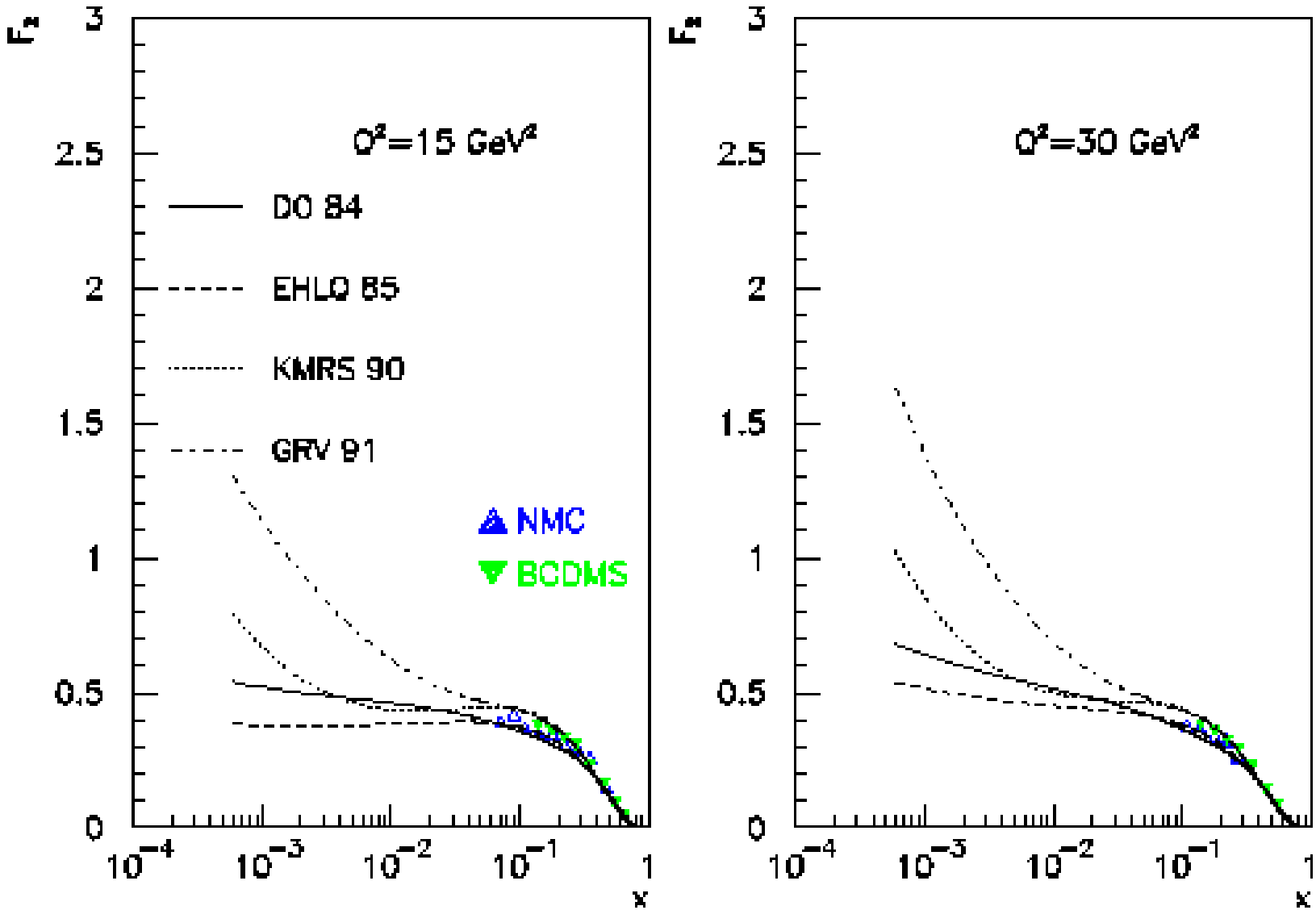
Part of Summary of HERA3 DESY-Zeuthen Workshop, March 14th, 2003

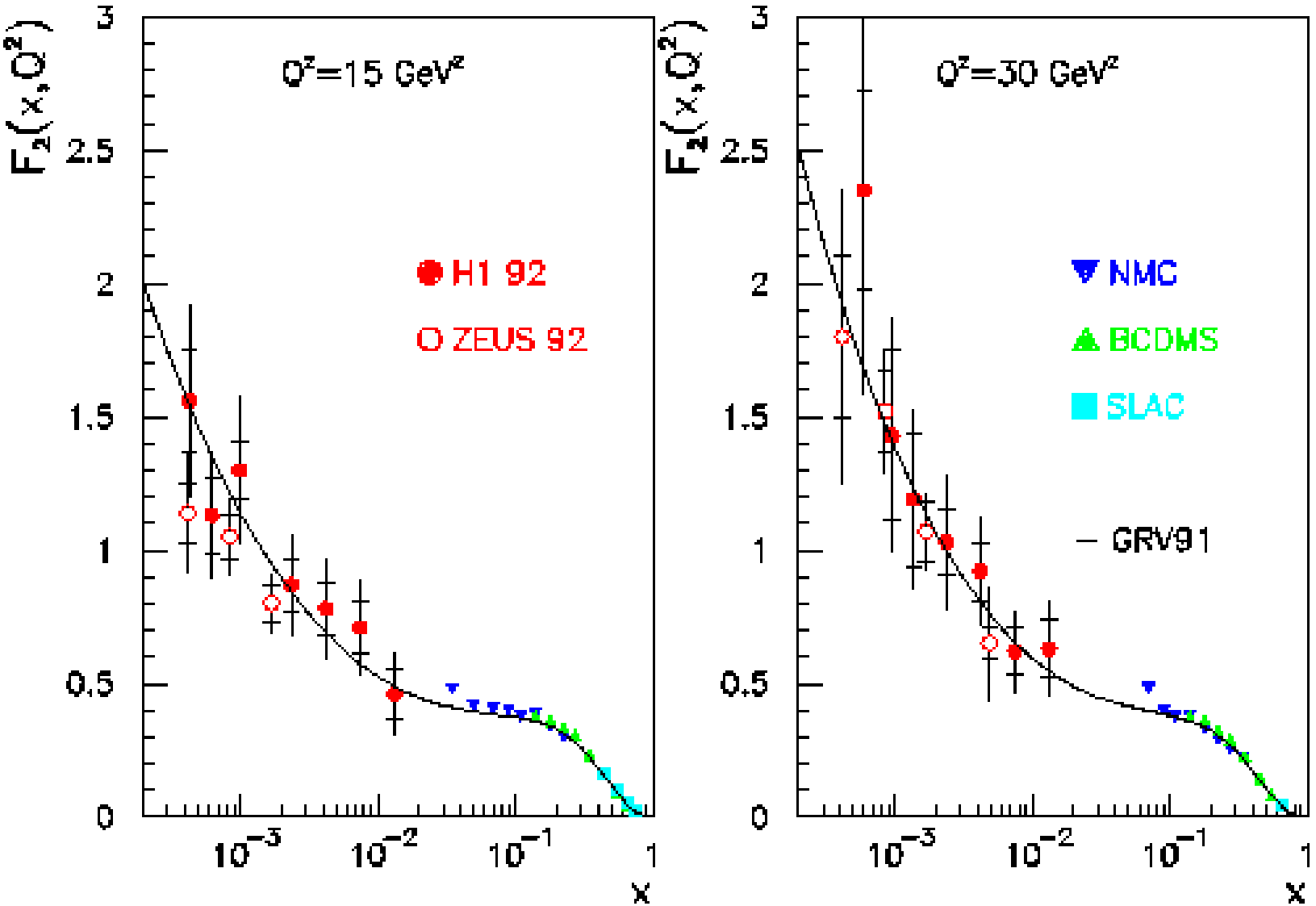
HERA and its Pre-Accelerator Chain

	Protons	Electrons	
20 keV	Source	Source	150 keV
750 keV	RFQ	Linac II	450 MeV
50 MeV	Linac III	Pia	450 MeV
8 GeV	DESY III	DESY II	7 GeV
40 GeV	PETRA	PETRA	12 GeV
920 GeV	HERA-p	HERA-e	27.5 GeV

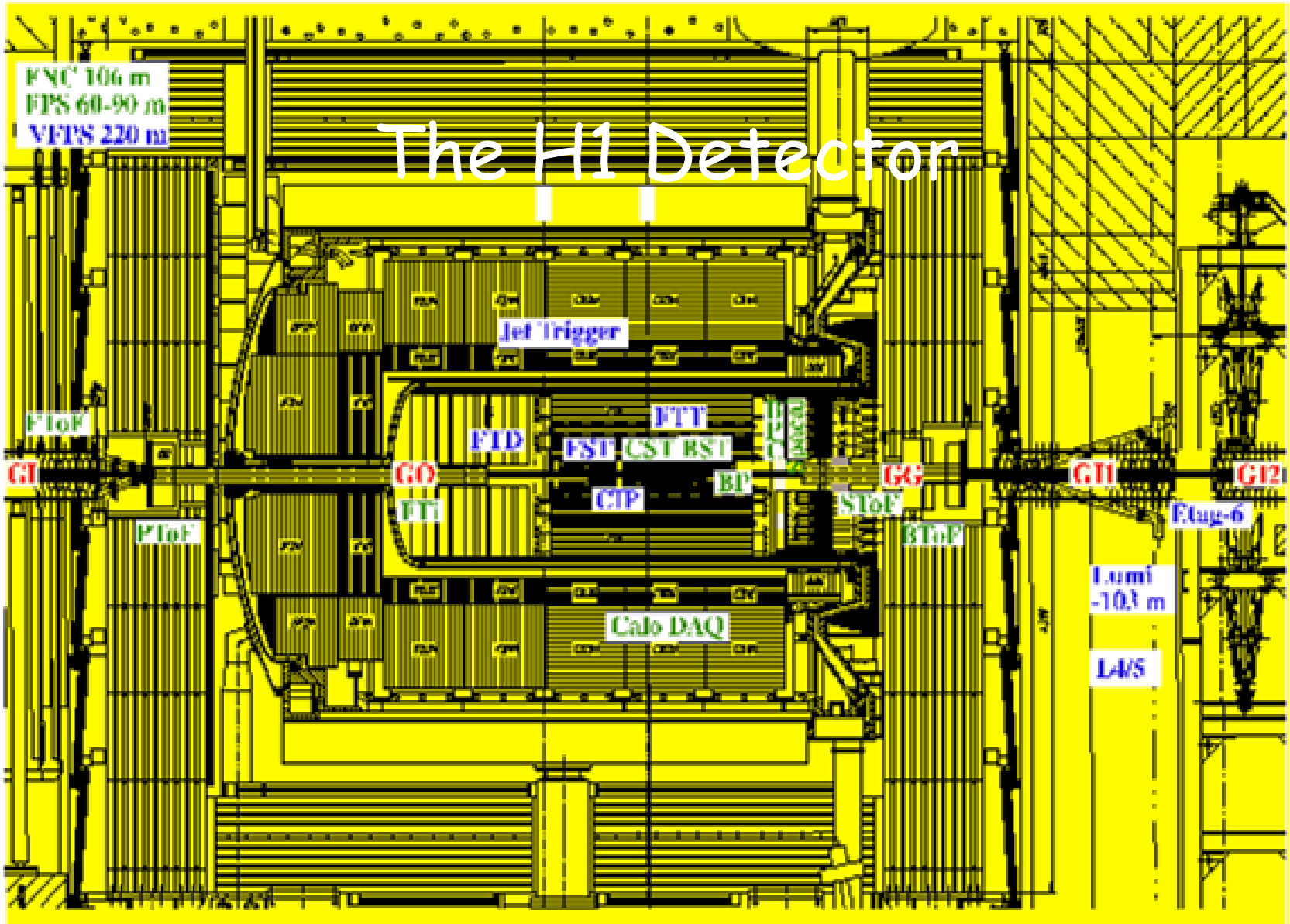


F2 and x range before HERA

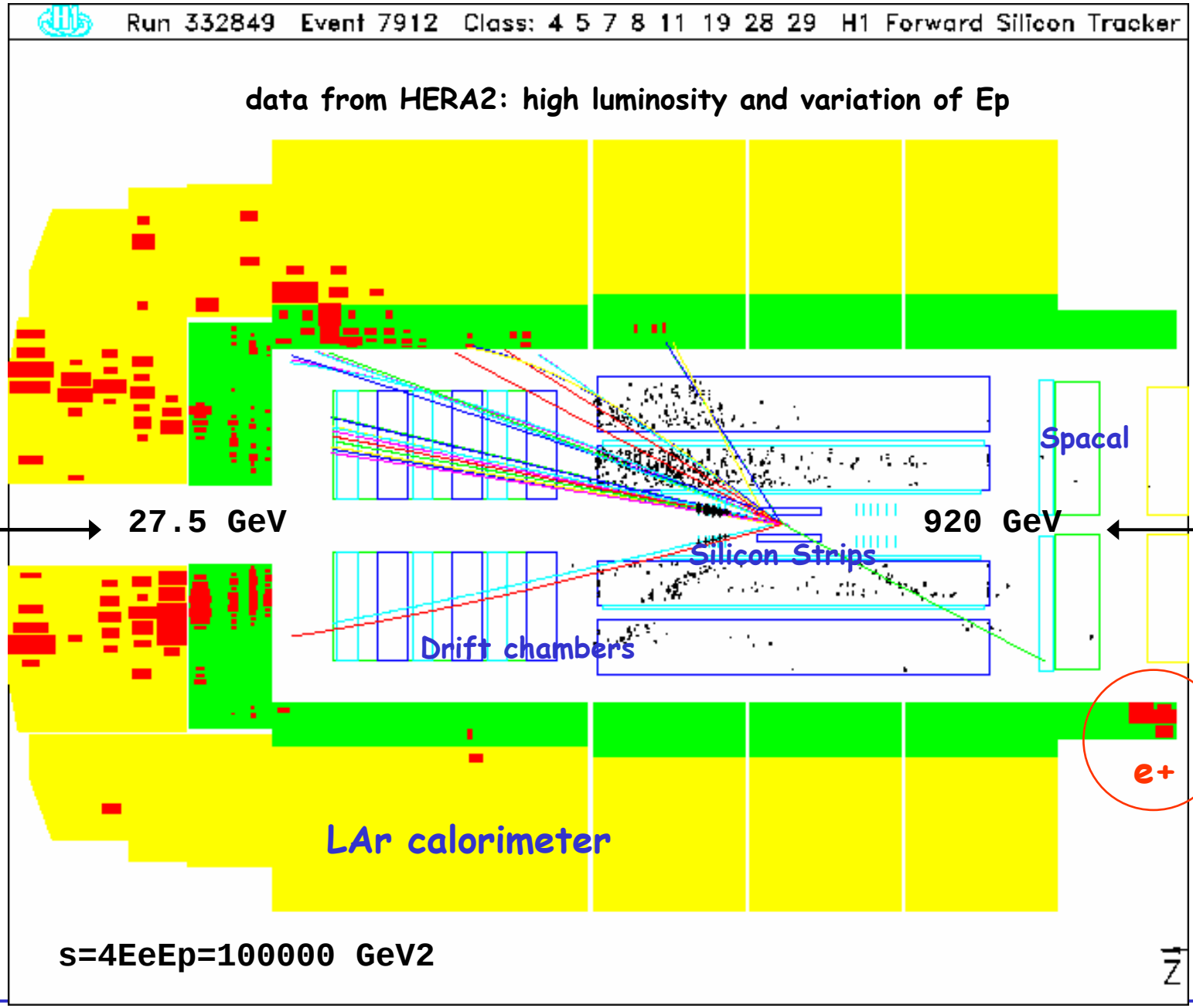




HERA opened low x physics of high parton densities (with 20 nb-1)



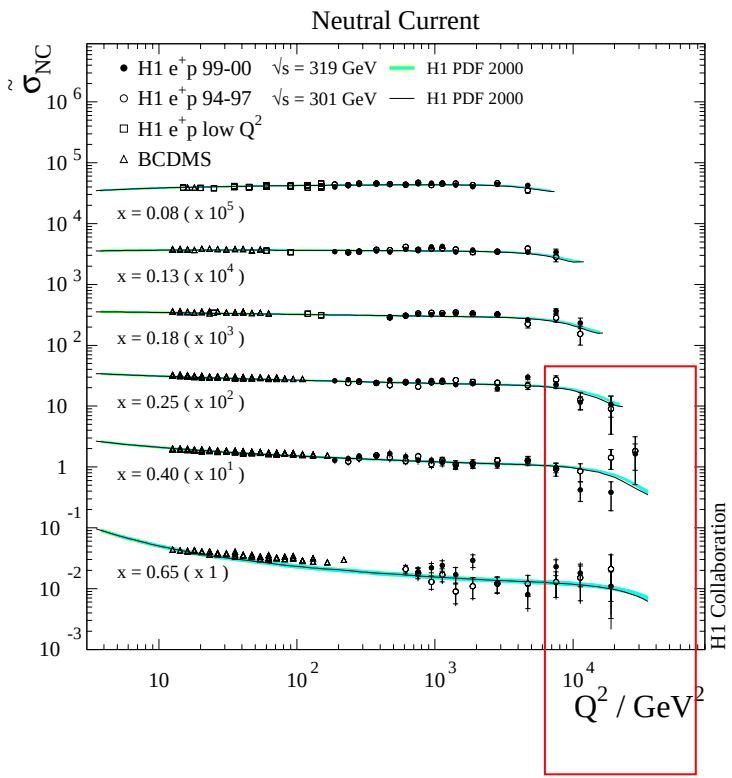
designed in 1985, built in 1990, upgraded in 2000, → 2010 ??

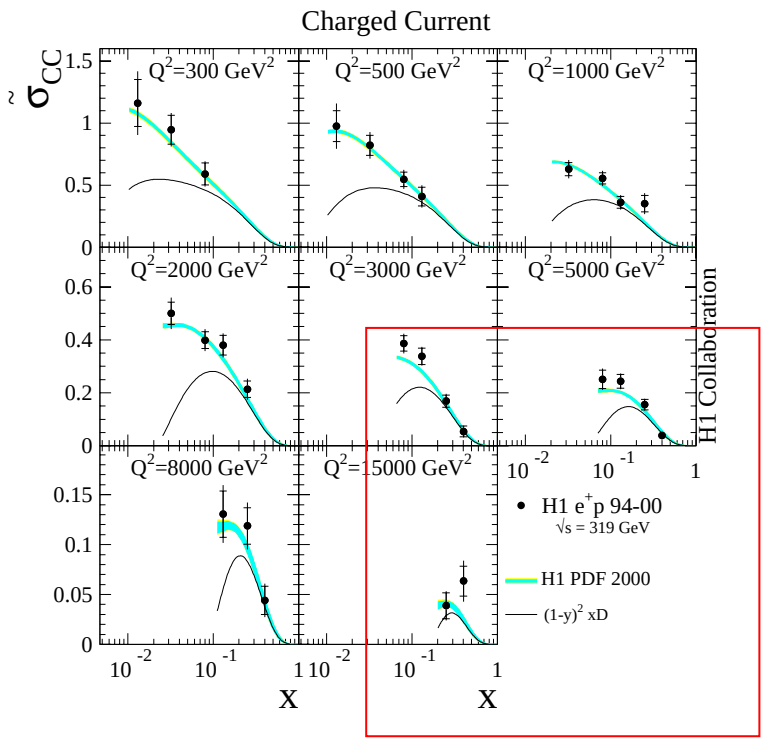

Run 332849 Event 7912 Class: 4 5 7 8 11 19 28 29 H1 Forward Silicon Tracker
data from HERA2: high luminosity and variation of Ep
e
27.5 GeV
920 GeV
p
Spacal
Silicon Strips
Drift chambers
e+
LAr calorimeter
s=4EeEp=100000 GeV2
Z

H1 and ZEUS so far obtained 100pb-1 (e+) and 15 pb-1 (e-) at sqrt(s) of ~300 GeV in running period from 1992 to 2000 → luminosity upgrade (3y) and polarisation

Measurement and QCD Analysis of NC and CC Cross Sections at HERA (1)

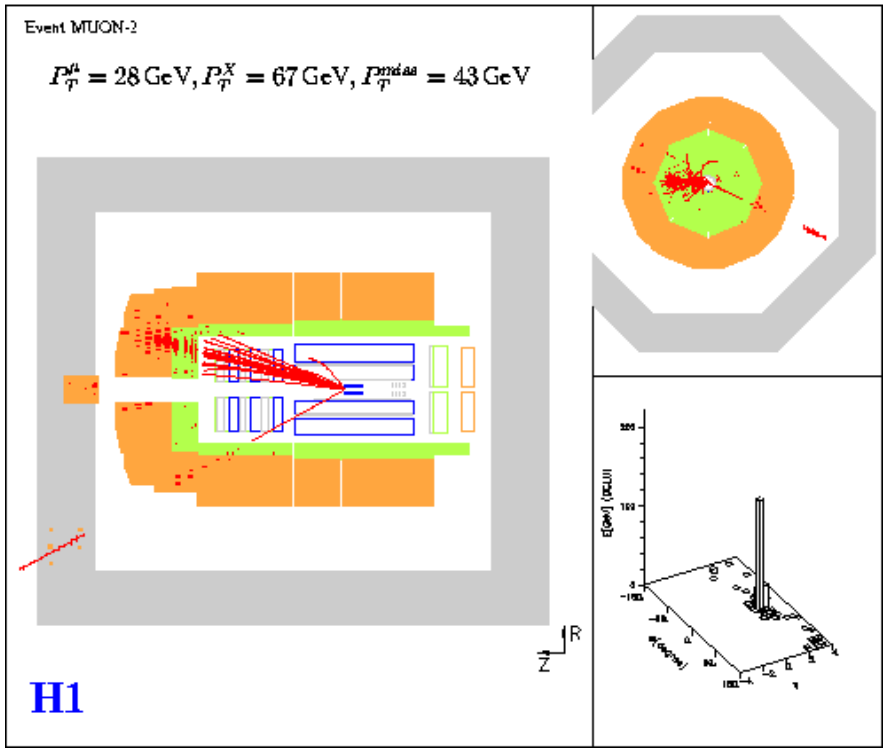
65.2 pb-1, 99/00 and combinations with 94-97, xF3, FL, parton distributions





needs luminosity increased by a big number! (10) - four states of different charge and polarisation

$$e^+p \to \mu^+X$$



Isolated Electrons and Muons with missing pt
H1 DESY 02-224 (subm to Phys.Lett.B)

for pt > 25 GeV find 10 against 2.9+-0.5

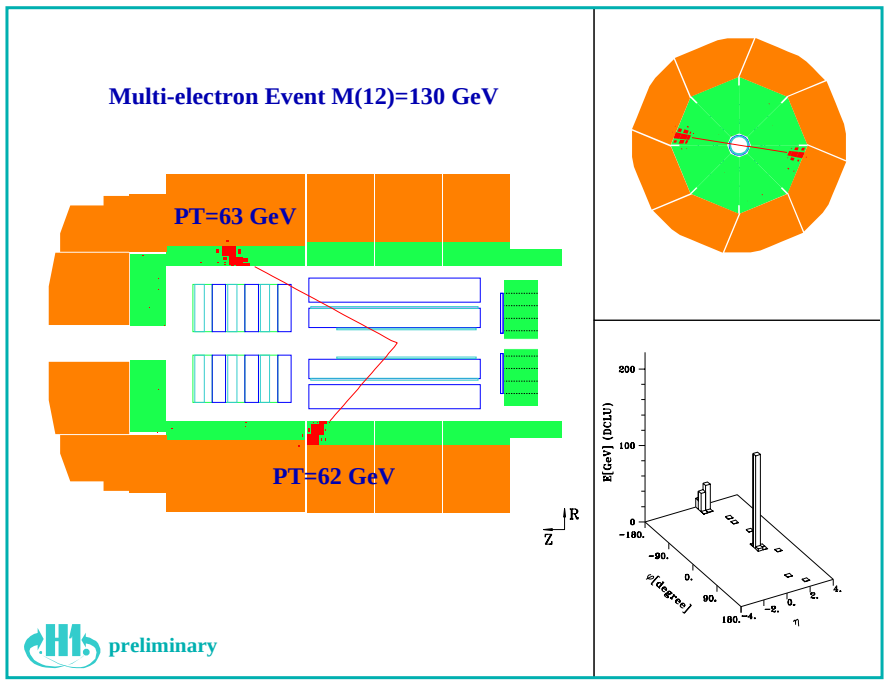
using 13.6 pb-1 e- & 104.7 e+

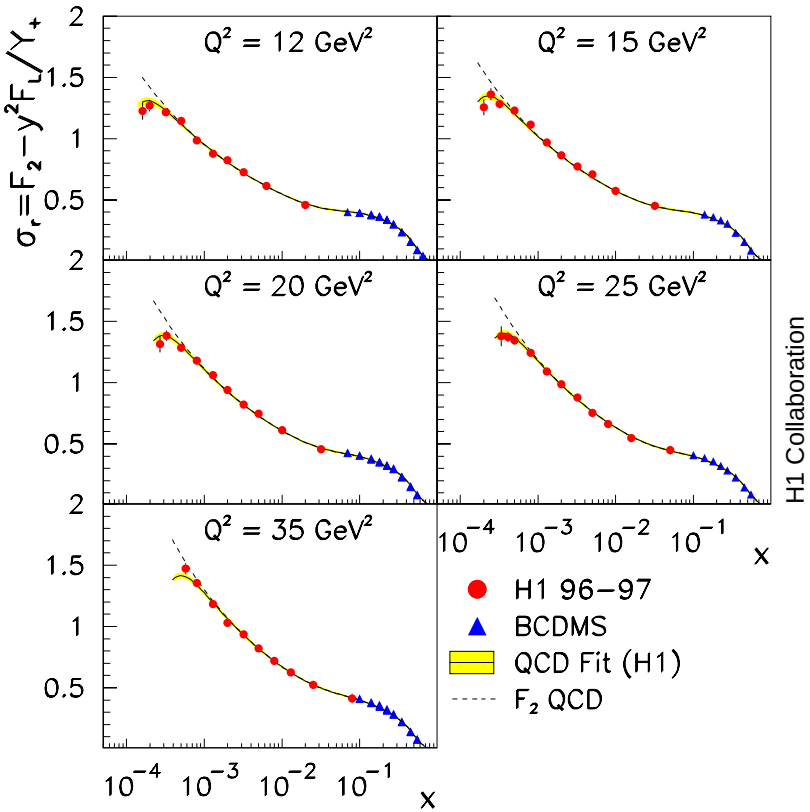
?

Multielectron Production (H1 prel.)

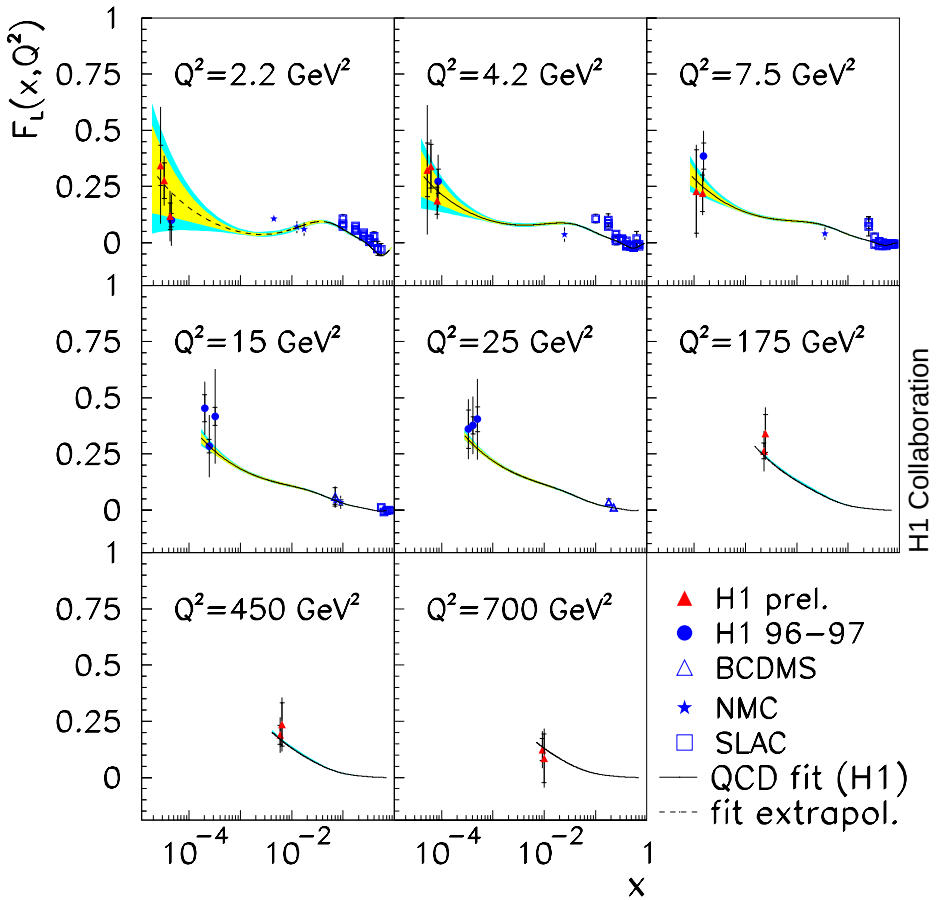
M(ee) > 100 GeV

	events	SM (eq →eeeq)
2e	3	0.25 +- 0.05
3e	3	0.23 +- 0.04





$$\sigma_r = F_2 - y^2 F_L / [1 + (1-y)^2]$$



with fixed beam energy can only access highest (lowest x=Q2/sx) kinematic region

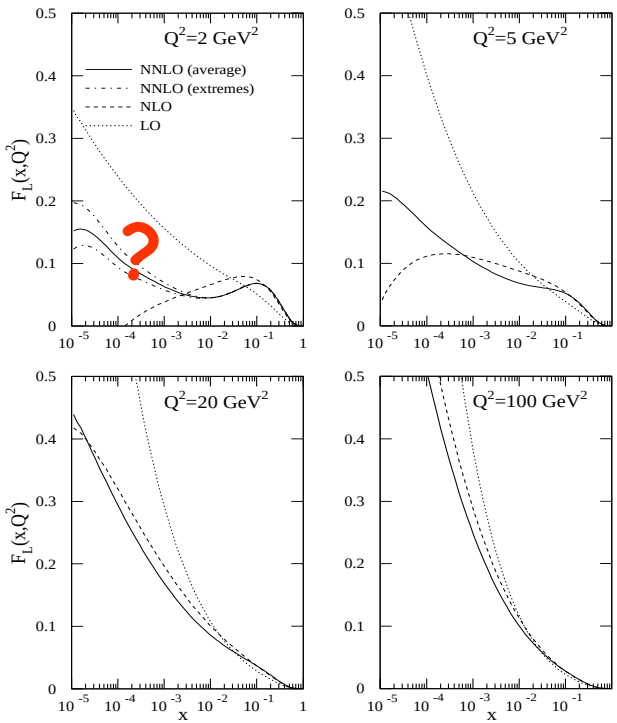
needs extrapolation of F2

y=1-Ee'/Ee → exp. challenge: eID to 3 GeV

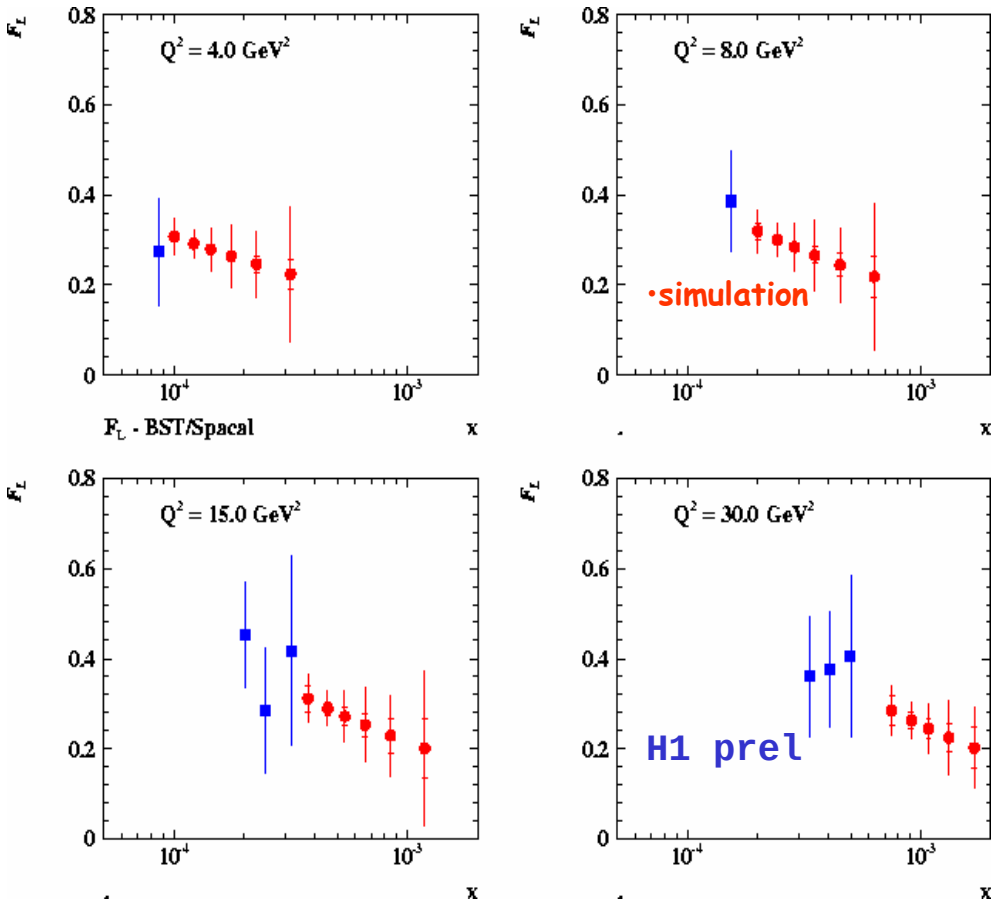
Longitudinal structure function

$$F_L \propto \alpha_s \cdot xg$$

ho QCD test requires F2 AND FL
to determine the gluon density



R.Thorne



require(s) variation of Ep, e.g. here:
920, 400, 500 GeV with about 200, 50, 10pb-1

precision (1%): FL(x), and high x (alphas) at HERA

sc quads limit HERA2 acc (!) to Q2 > 3 (7) GeV2 at high (low) y

PETRA

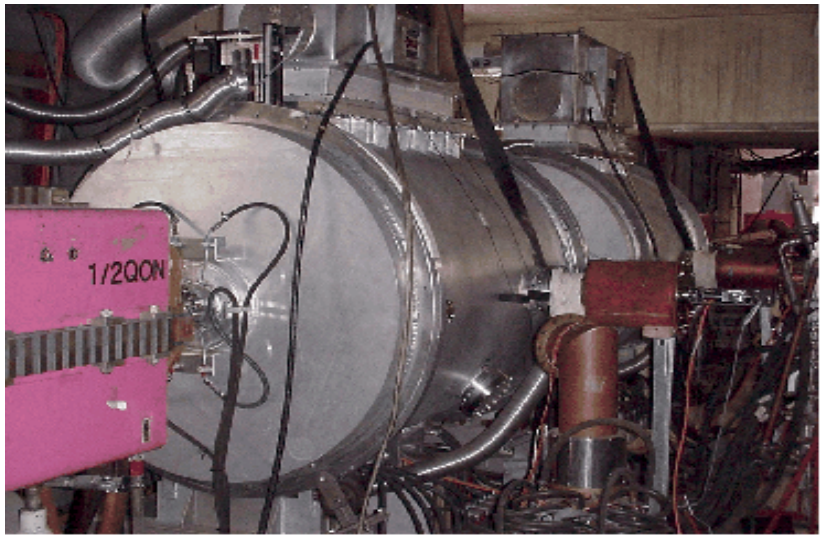


Abb. 3: Die Protonen-Cavities mit ihrem Durchmesser von 1.40 m und ihren Anschlüssen führt zu einer deutlichen Einschränkung in der Positionswahl für den neuen Ring.

Abb. 4: Die wegen der PETRA-II-Elektronen-Ejektion an die Tunneldecke verlegten Stromschienen reduzieren den vertikal zur Verfügung stehenden Platz um 35 cm.

Workshops on the future of DIS beyond the canonical ep

1968 → 2008

s from 10 GeV2 to 100.000 GeV2

is there a next step, which one?

References

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"THERA: Electron-Proton Scattering at $\sqrt{s} \sim 1$ TeV", TESLA TDR, DESY 2001-011, ECFA 2001-209, part VI, Appendices, pp. 99-160, Ed.s R. Klanner, U. Katz, M. Klein and A. Levy, March 2001;
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[6] "ELFE: The Electron Laboratory for Europe", TESLA TDR, DESY 2001-011, ECFA 2001-209, part VI, Appendices, pp. 191-207, Ed.s R. Klanner, E. DeSanctis, J.-M. Laget and K. Rith.

A Letter of Intent for High Statistics eD Scattering

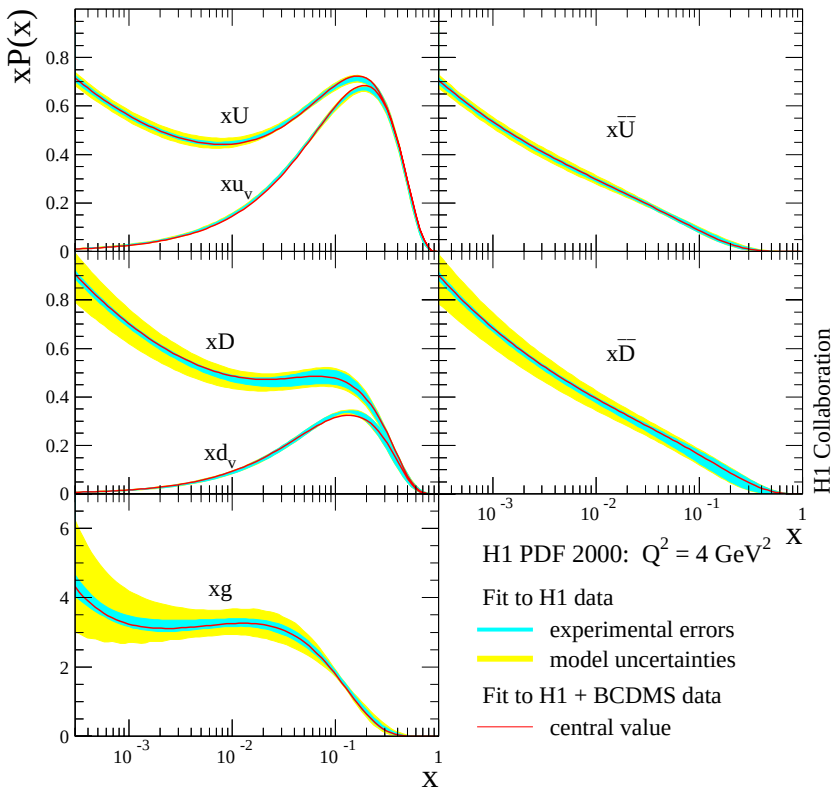
describe baryonic matter (Hofstatter → QPM)
determine neutron structure at high Q2 and low x
unfolding of pdf's (low x – superhigh E neutrino physics)

much richer at HERA than at fixed target experiments due to

tagging of spectators (measuring p(p_s) get en → eX)
diffraction which is related to shadowing
charged currents at high Q2

supported by majority of H1 institutes and open for new groups and individuals

parton distributions at low x



$$F_2^{\,p} = x[e_u{}^2\bar{u} + e_d{}^2\bar{d}] + HQ$$

cannot predict neutrino N scattering from ep

→measure dbar, ubar and heavy flavour (c, b)

higher x: s-c, dv/uv

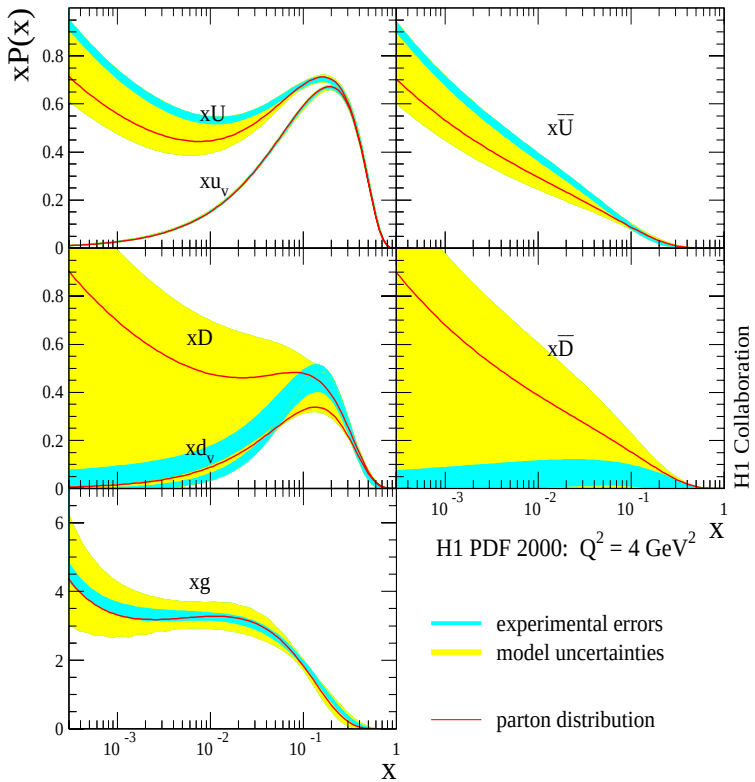
$$xP = A_P x^{B_P} (1-x)^{C_P} f(x) \rightarrow A_P x^{B_P}$$

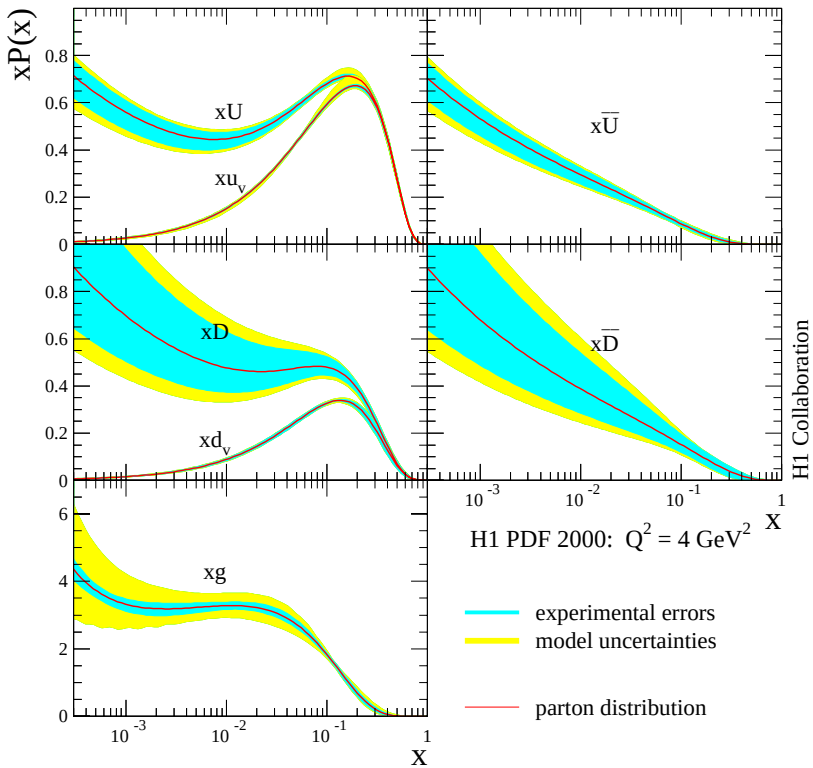
usually assume $\bar{u} = \bar{d}$ at low x

but

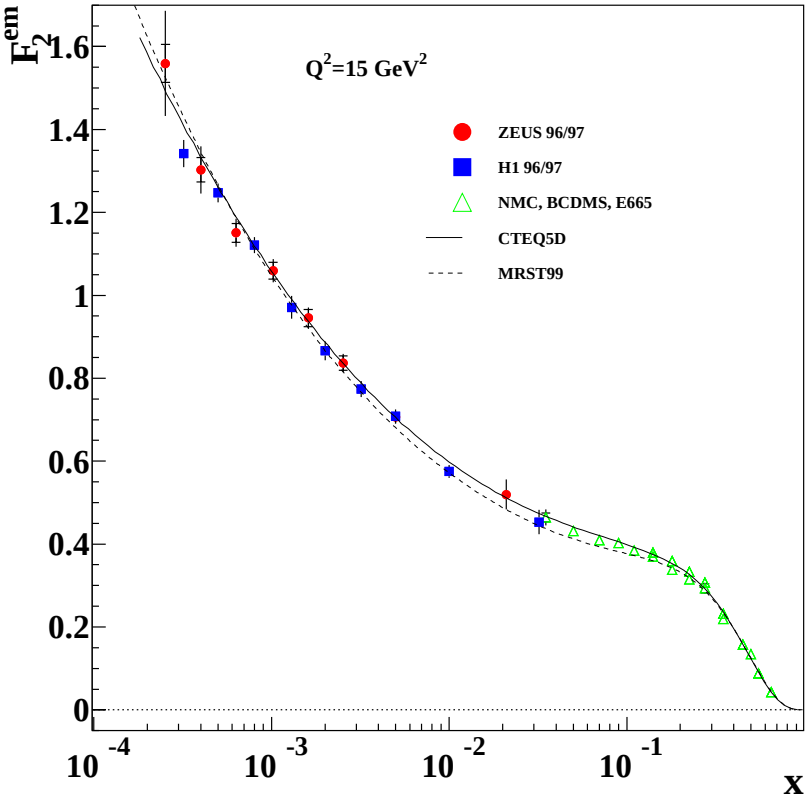
slopes B may differ

normalisations A differ



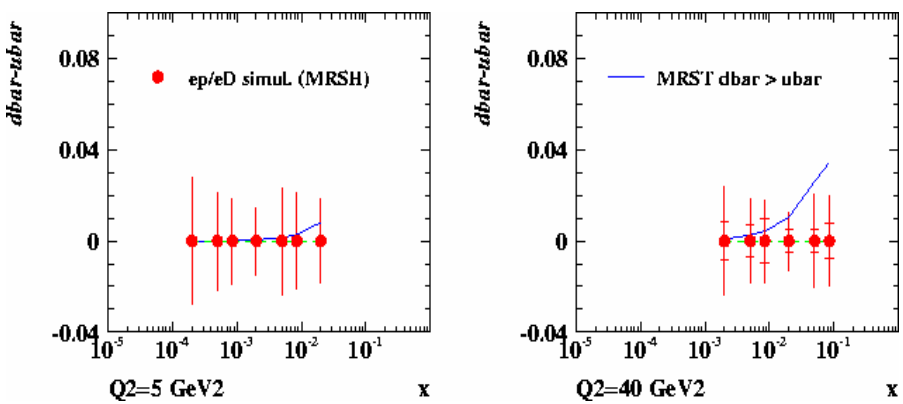


fit to H1 data

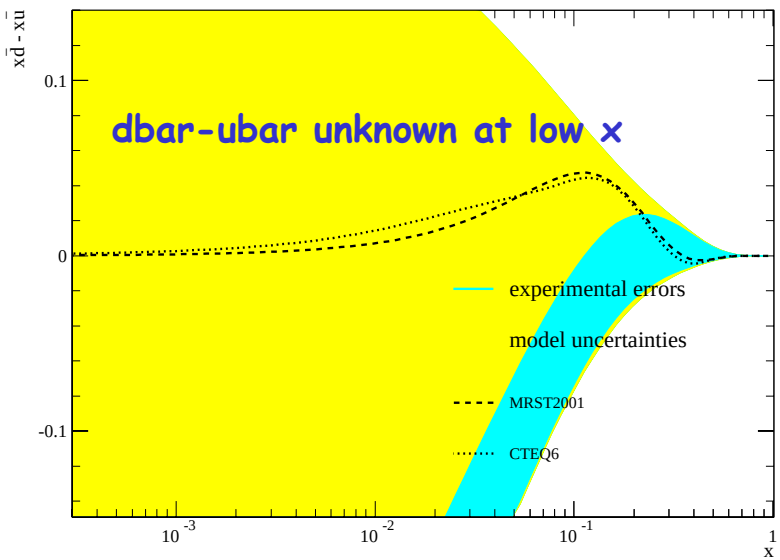


what determines the rise of F2 ?

Pauli blocking, confinement, pion cloud :
do NOT expect dbar=ubar

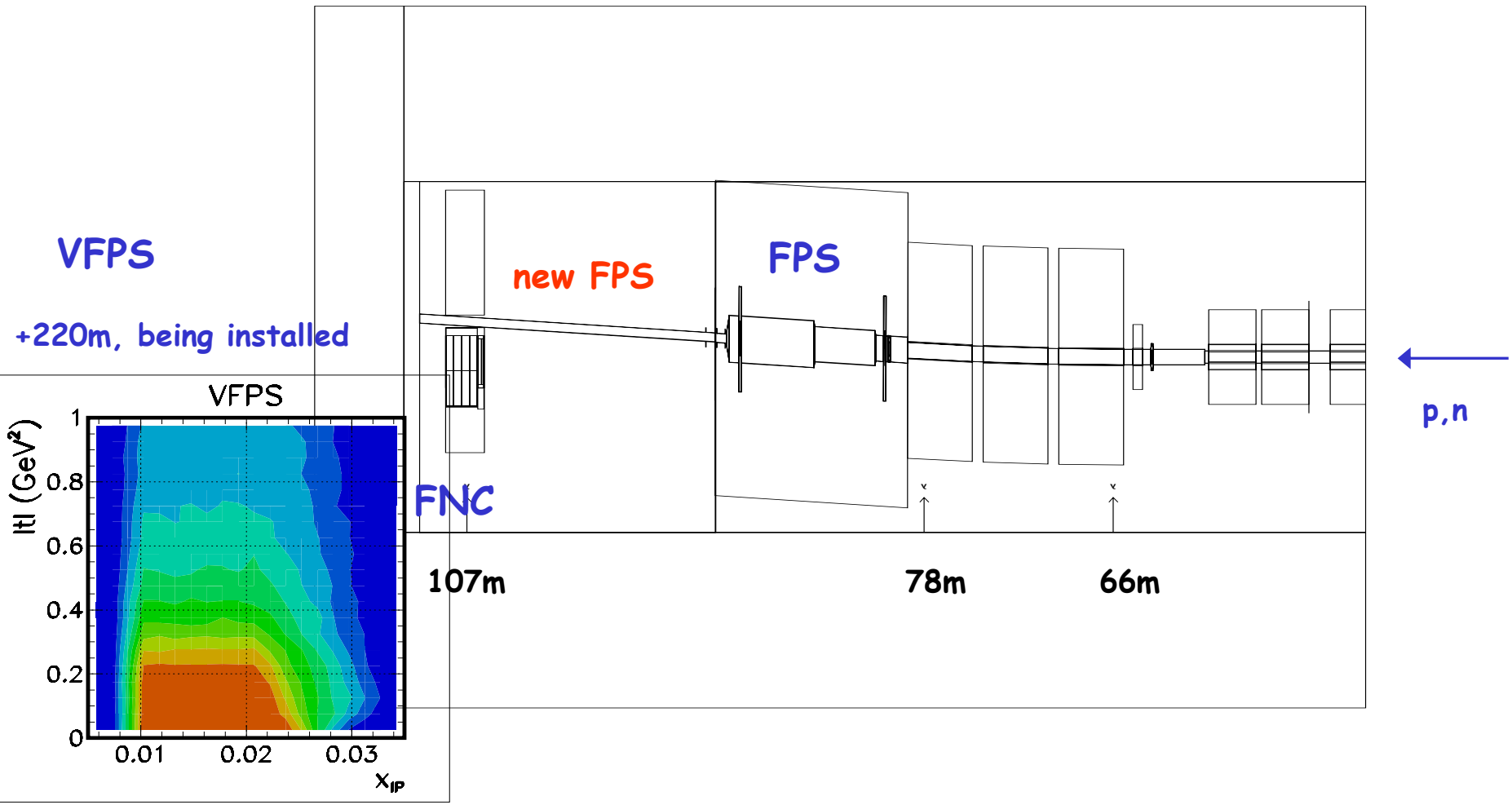


simulated accuracy (20pb-1 eD, 40 ep)



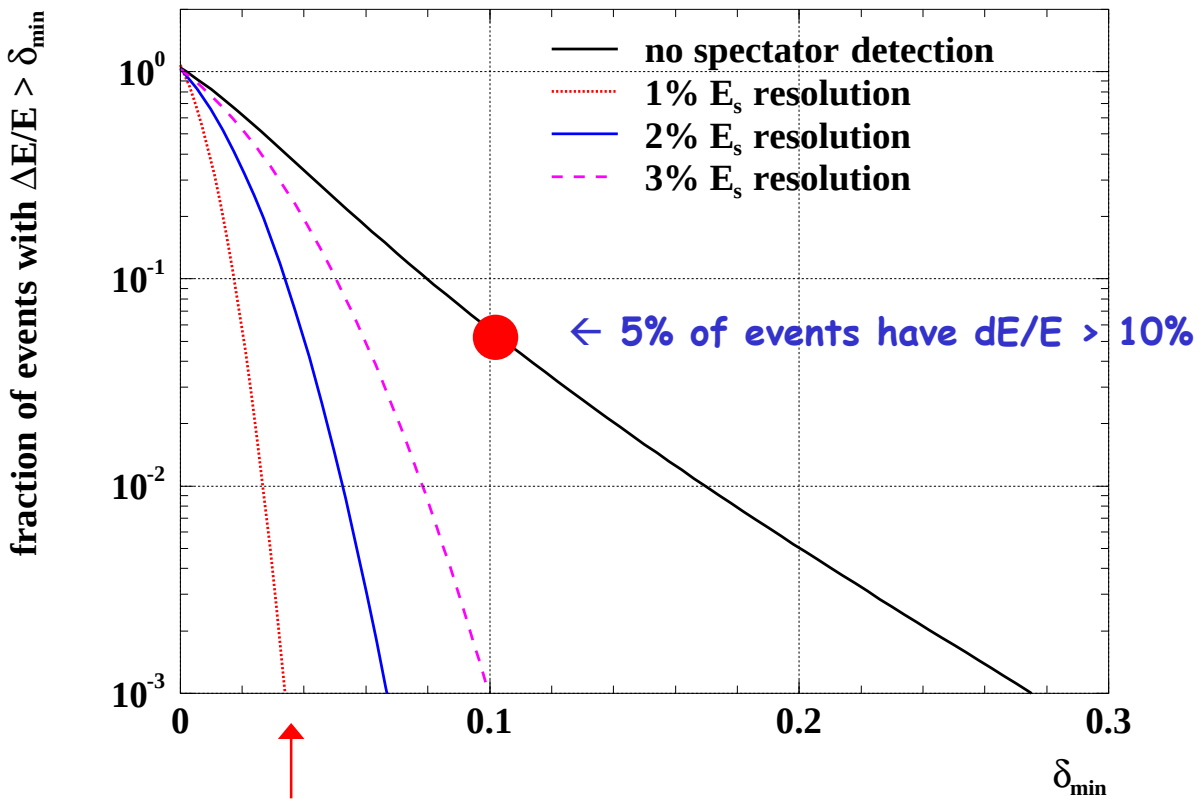
unconstrained fit (H1 data) : dbar small

Tagging Spectrometers of H1



Tagging of p,n,D

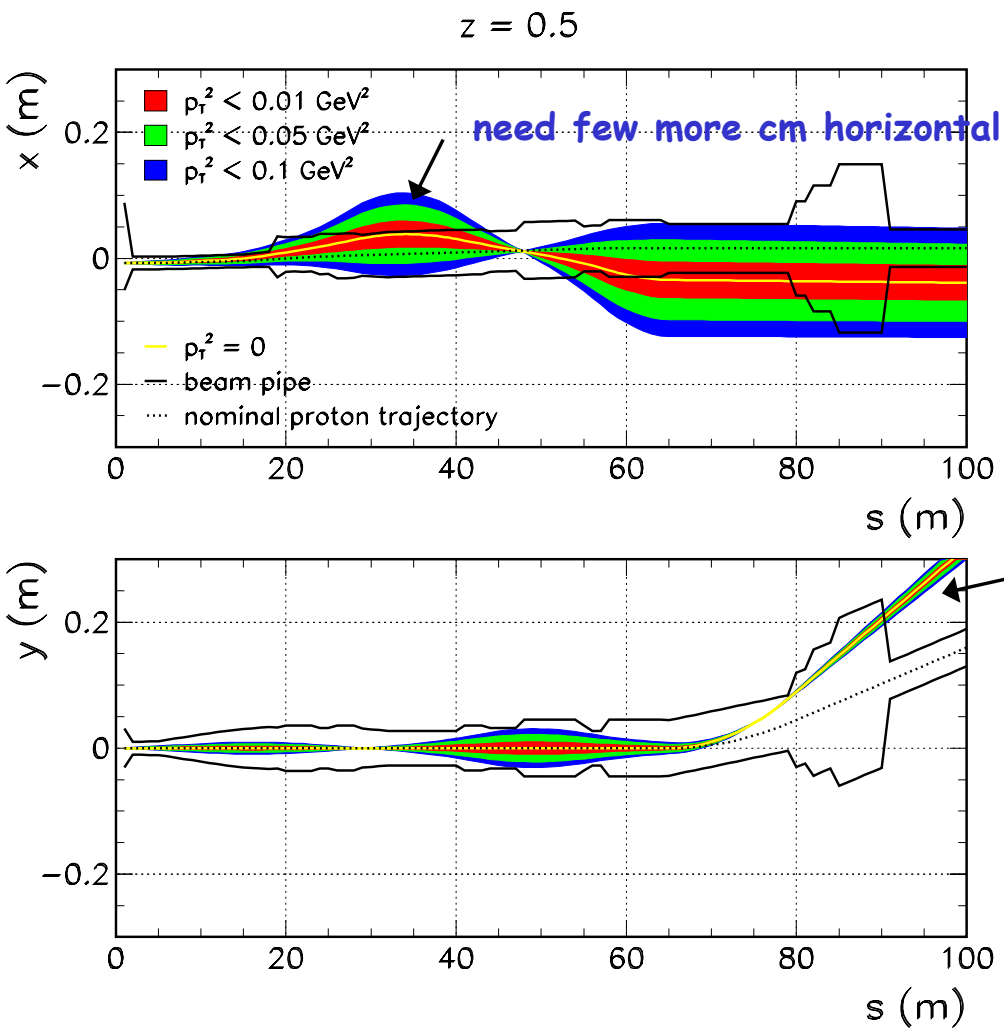
reconstruct en kinematics (reduce Fermi motion) by measuring spectator proton



aim for 1% momentum resolution

calibration with kinematic peak at p=E/2 and resonances in central detector

optics: from VFPS and FPS



need few more cm horizontal aperture

30% of diffractive events
appear as background to
p spectator tagged events

nFPS, not moveable

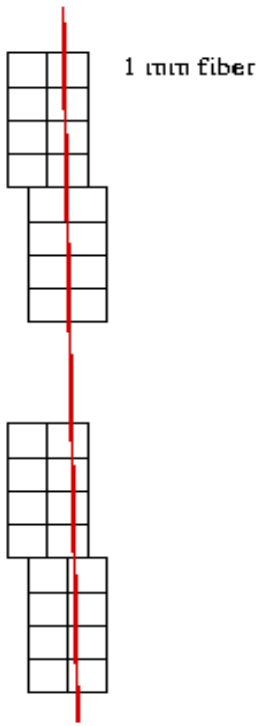
2 stations between 85 and 105m

re-use electronics from present FPS

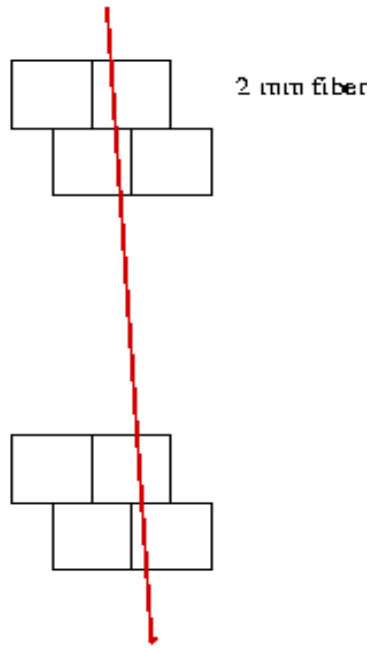
full simulation of beam line (NL)

Possible Spectator Proton Detector
(2 stations between 85m and 105m from IP)

For 6.5 cm detector size



For 13 cm detector size



–> 1% energy resolution for HERA–2 optics

tentative design
done this week!

track efficiency reconstruction $\geq 90\%$
Number of channels: 16 PSPM $\times$ 64 channels
cost estimate: $\mathcal{O}(100k\$)$

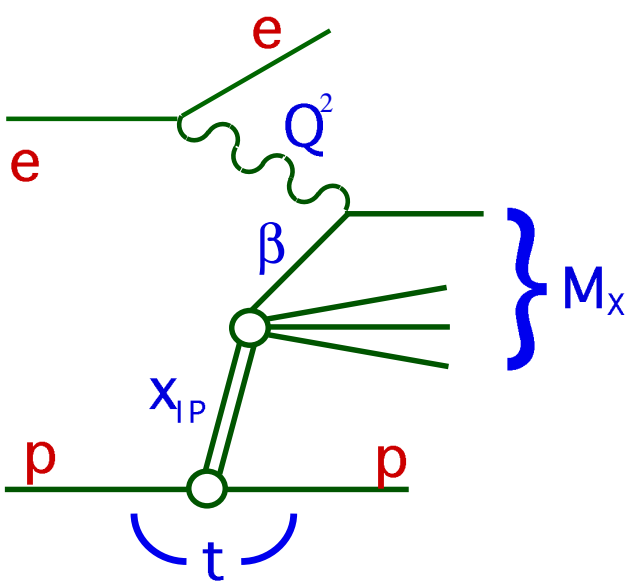
Diffraction

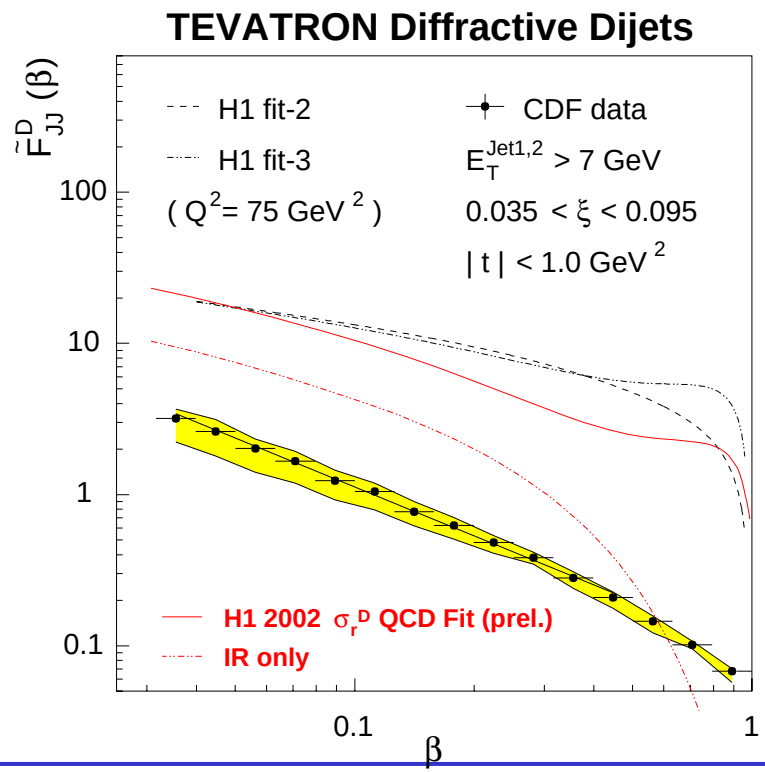
diffraction (F2D) – confinement: p smashed in DIS but remains intact in diffraction

the Pomeron a mystery and a field theoretical challenge – two gauge bosons xchanged

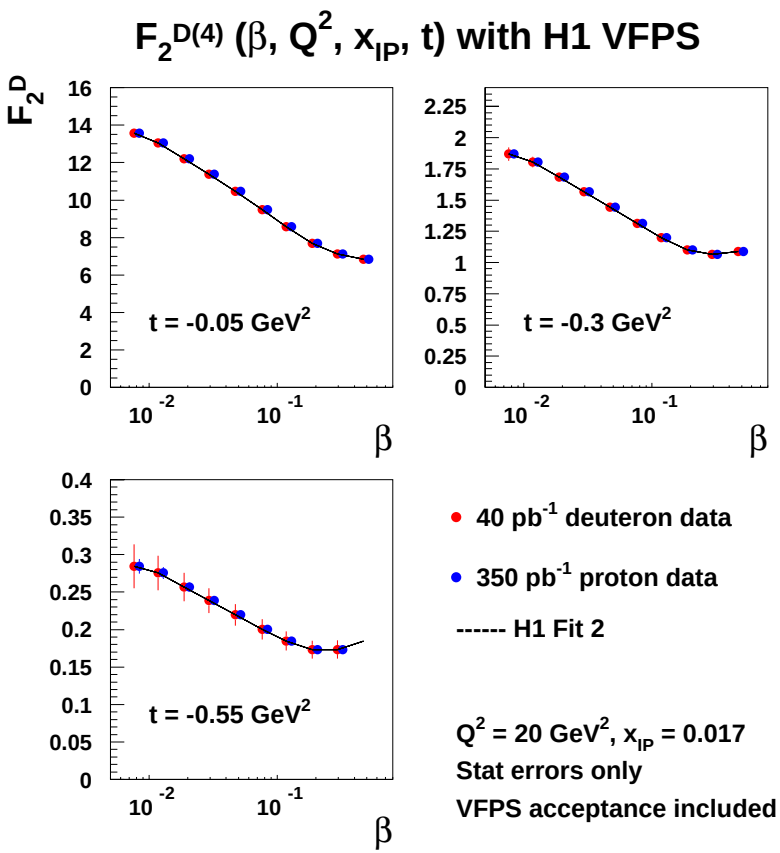
Higgs production via PP scattering – very clean channel at LHC

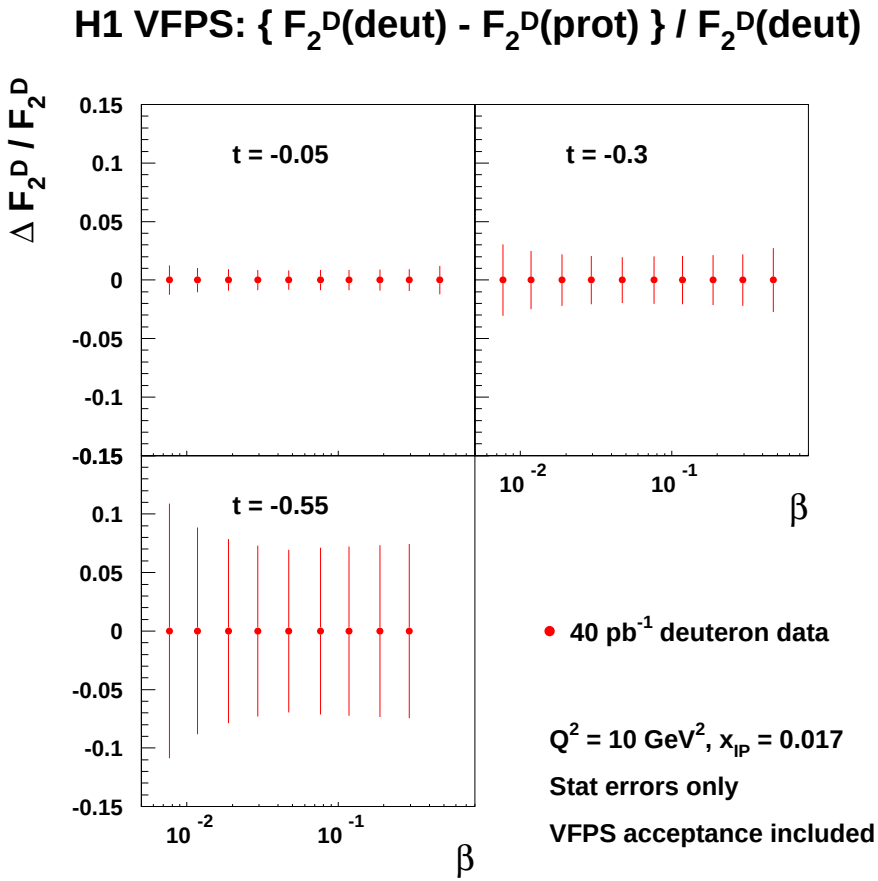
Pdfs → dijet rate in pp BUT dpdf's cannot describe diffractive pp (Tevatron data)





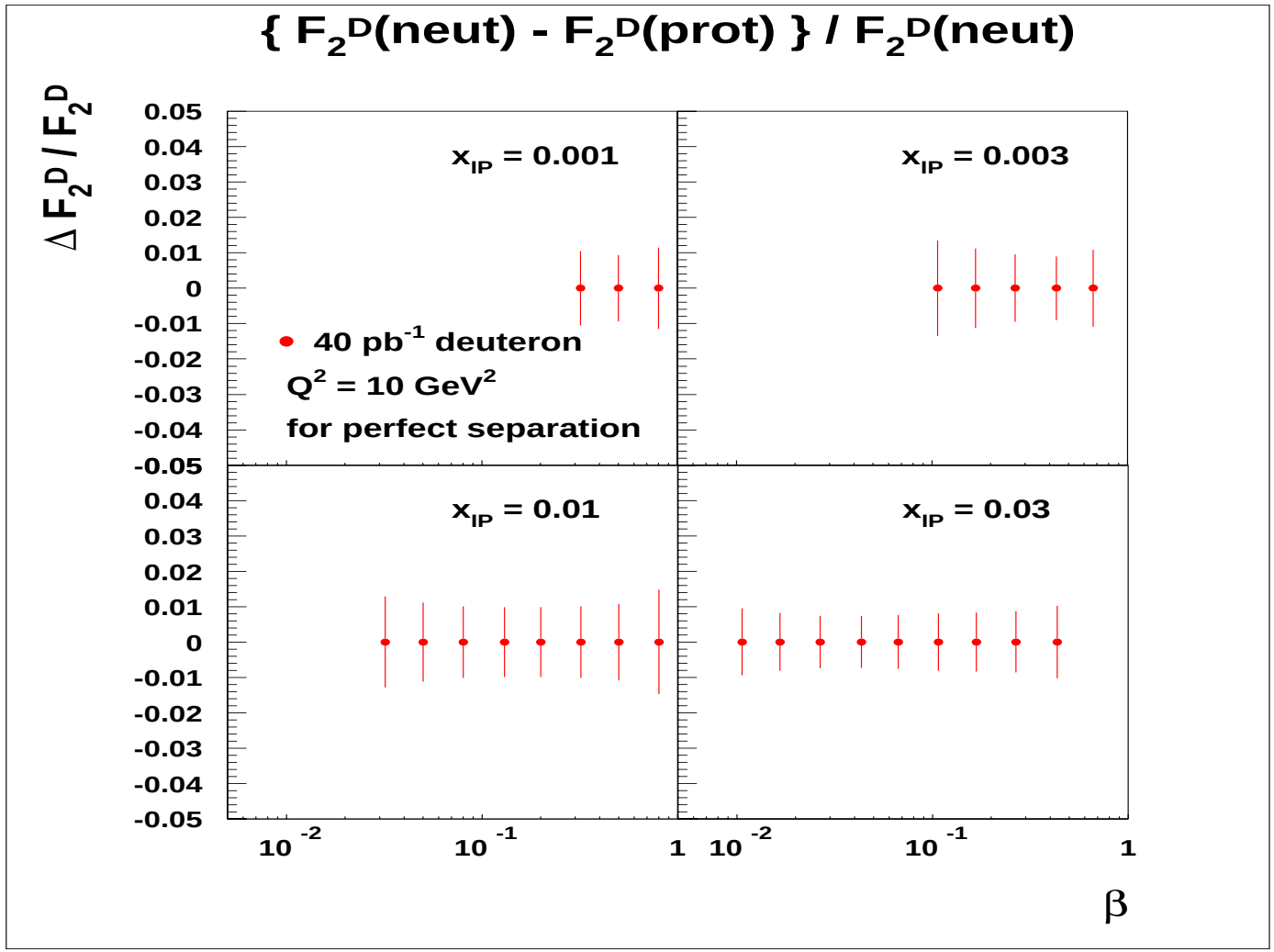
diffraction on either p, n or D (coherent)





- is isospin conserved?
- expect increasing fraction of diffraction with larger A (bbl)

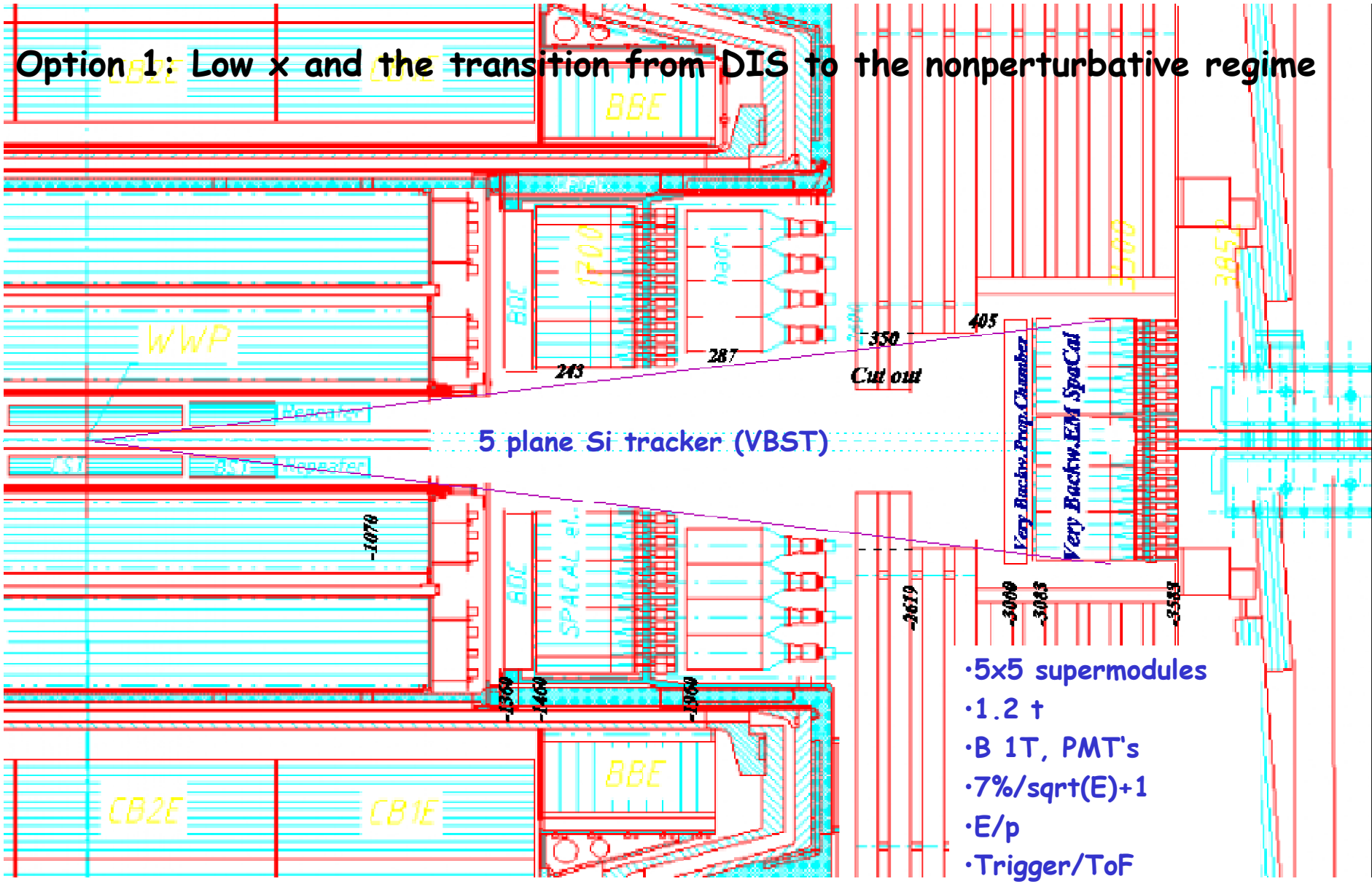
diffraction on either p or n



compare with xP F2D ~ 0.02…0.04

will be very interesting with vector mesons (t)

Option 1: Low x and the transition from DIS to the nonperturbative regime



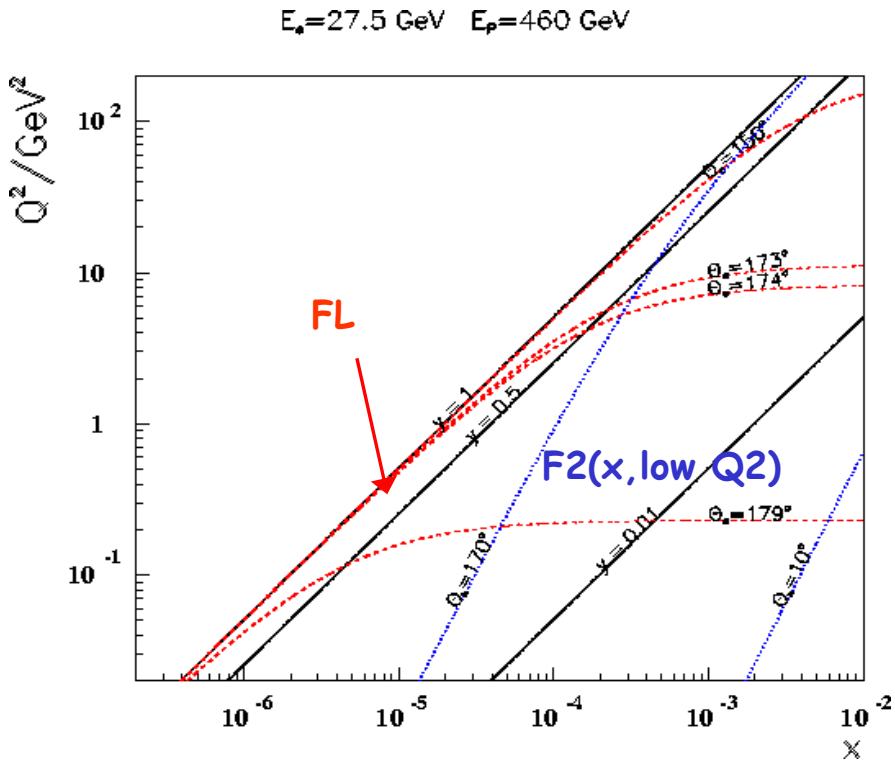
- 5x5 supermodules
- 1.2 t
- B 1T, PMT's
- 7%/sqrt(E)+1
- E/p
- Trigger/ToF
- Resonances (high W)

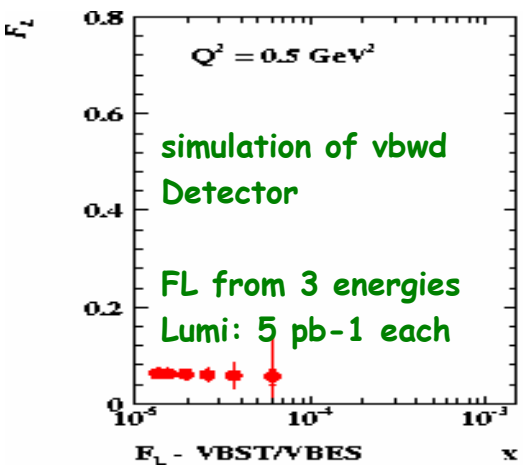
replace the cold magnets (GG and GO) by backward and fwd (under study) spectrometers

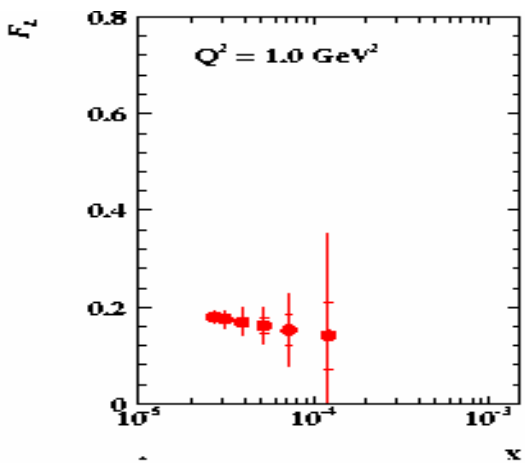
FL in the transition region gluon density and NLO ?

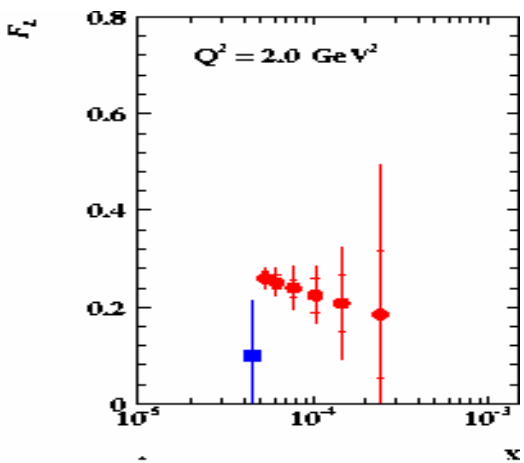
high precision (also for F2):

yp statistically subtracted (99 BST data)
lumi via Bethe Heitler in same detector
efficient tracking
VBPC for alignment of VBST …

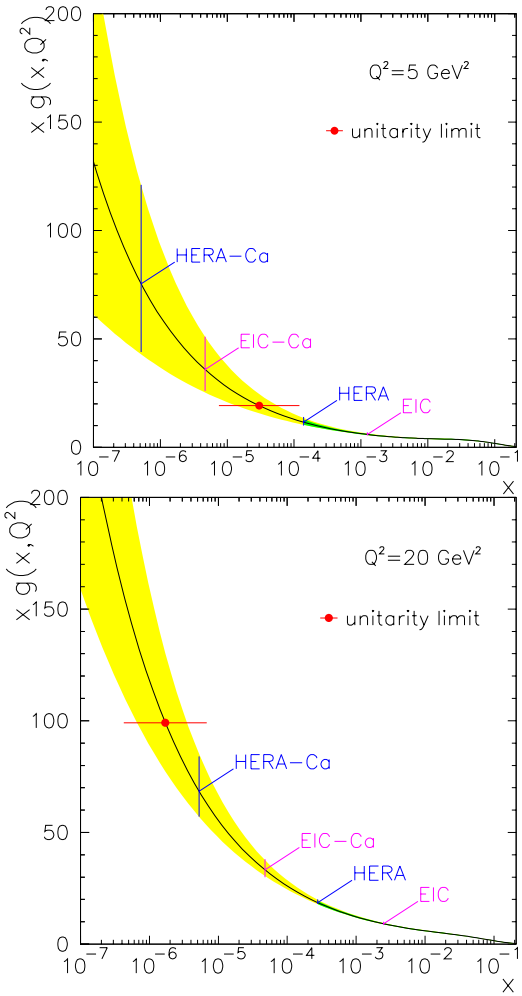








Option 2: eA scattering (low x)



$$\frac{g_A/\pi r_A^{\,2}}{g_p/\pi r_p^{\,2}} = A^{1/3}\frac{g_A}{A g_p}$$

- low x - field strength high, large Q2 – coupling weak
  → unitarisation effects
  → new phase of matter
- deconfinement
- nuclear parton distributions (RHIC, Alice)
- bj → black body limit
  - $F_2 \propto Q^2 \ln(\delta / x)$
  - large diffractive cross section
  - no colour transparency
  - $\sigma\,(J/\psi)[A]_x$

laser (FEL!) cooling (Bessonov)

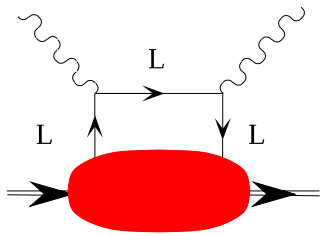
- $d, \vec{d}, {}^{16}O, {}^{40}Ca, Hg$ with $5\,pb^{-1}/A$

exploratory at lowest x - unique due to high beam energies

Option 3: Luminous polarised e – polarised N Scattering

bizarre behaviour of quantum number 1/2=f(q,g,L)
sum rules (low x, hi Q2), hard scale, spin at low x?, GPD's and L

f1(g1)



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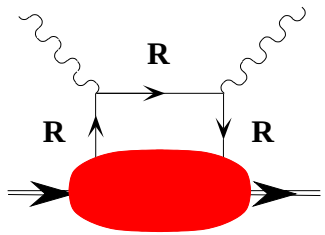
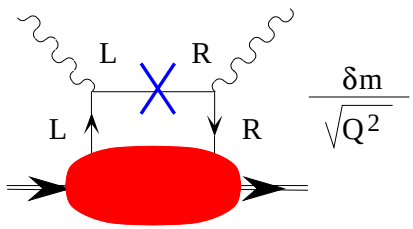
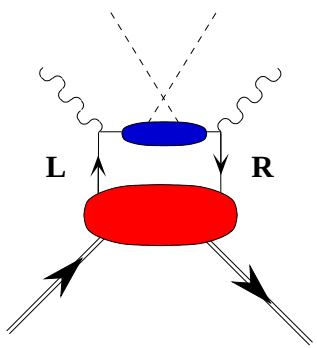


Hard QCD spin physics

h1



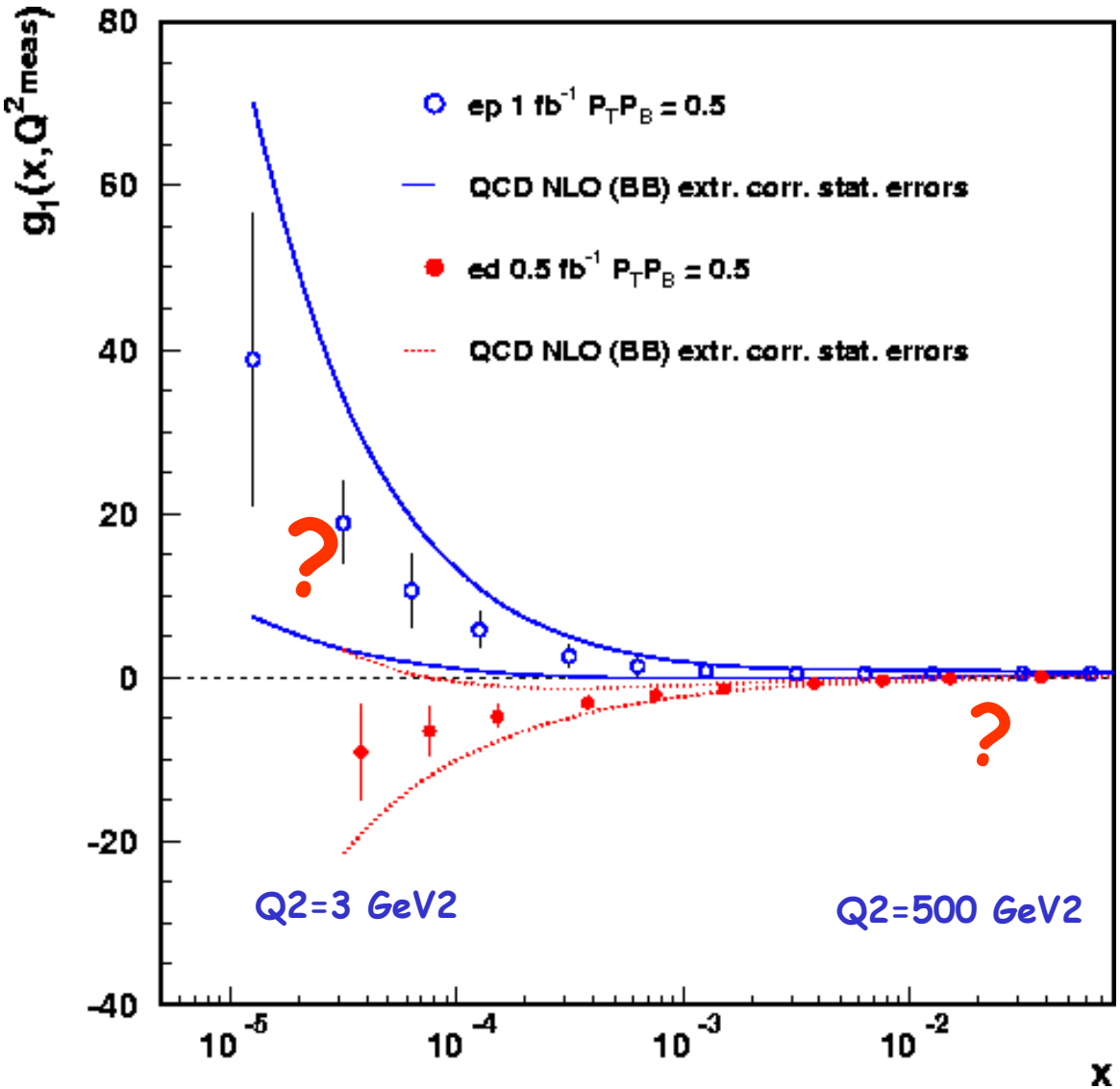
suppressed in DIS (chiral odd)



semi-inclusive scattering: measure
azimuthal asymmetry of pion distributions
from ep↑ – ep↓ (or deuteron) asymmetry

azimuth: angle between ly and hy plane

access to transverse quark polarisation



longitudinal ep (D) polarisation in colliding mode

measurement at high y
Q2 dependence only via combination of experiments

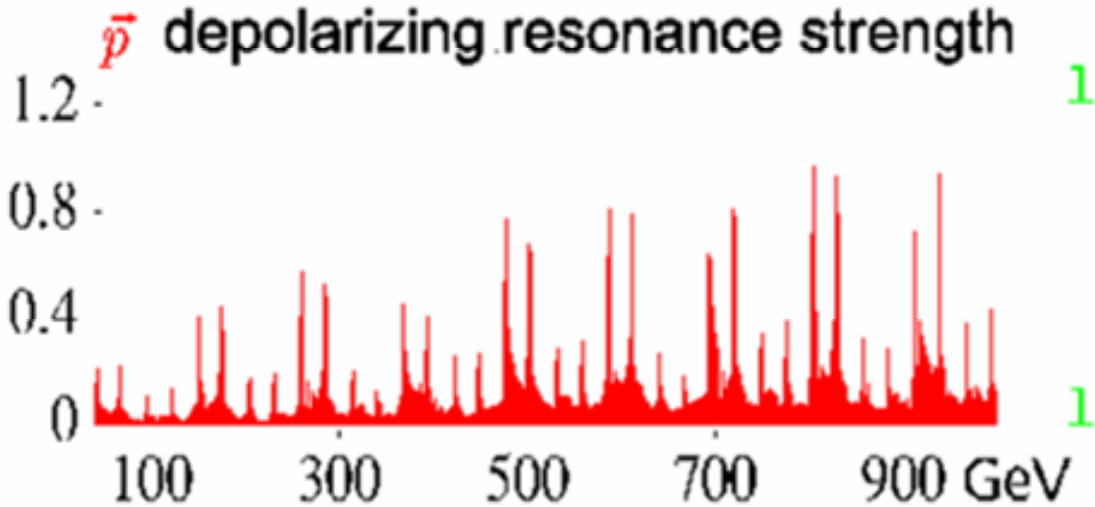
requires huge statistics
→ Sources
→ HERA Lumi upgrade

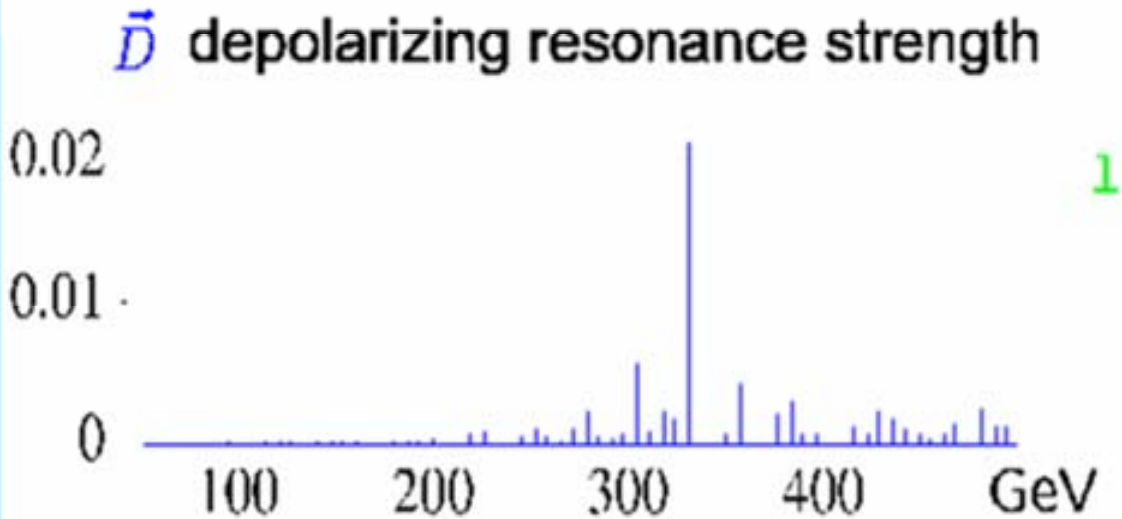
large asymmetries in CC
(also interesting for Transversity cf R.Jakobs MPI workshop Dec 02)

heavy flavour
diffraction
Searches

high rate to trigger

Polarized Deuterons





- Resonances are 25 times weaker and 25 times rarer for D than for p
- Transverse polarization could be achieved without Siberian Snakes
- Transverse RF dipoles could be used to rotate and stabilize longitudinal polarization

September 2001:

Directorate decides „to transform PETRA into a dedicated synchrotron light source, starting in January 2007, after the completion of the HERA II programme…
The basic assumption was that the future of DESY lies in the TESLA LC and XFEL."

December 2001

Durham workshop on the future of HERA → hep-ex/0204032

10. April 2002

„Decision on the Technical Study to transform PETRA into a SLS"
one ring less than wished by the extended scientific council

21. April 2002

„HERA Running and the Future Use of PETRA", statement of the H1 Collaboration

April 2002 DIS2002 at Cracow

Directorate requests letters of intent for the future use of HERA for May 2003

August 2002: International Steering Committee for HERA III (exp's)

December 2003: Workshop at MPI (MPI web, transparency book)

January 2003: German BMBF endorses XFEL and PETRA SLC („ab 2007")

March 10-14, 2003: →Draft Letters of Intent, Meeting at Zeuthen ← here we are

May 7, 2003: PRC intends to discuss the future programme of HERA

Summary

- Searches, hi x, highest precision, high rate semiinclusive measurements (e.g. b)
- HERA 2 needs high luminosity and energy variation
- tight/impossible till end of 2006

- neutron structure: tagged eD scattering (2 x 100pb-1) pdf-diff-shadowing

- rebuild i.a. region to precisely measure in transition region and low x

- ep,eA – high density QCD (eA backgrounds, cooling)

- spin physics in HERA region may dramatically change view from fixed target perspective (high luminosity, current IR, deuteron spin easier than p?)

HERA is a unique collider and can remain to be unique for more than a decade with a fundamental HEP program leading to a new level of understanding partonic matter and interactions