DESY - Zeuthen
- klein@ifh.de -

1 THERA: Electron–Proton Scattering at $\sqrt{s} \sim 1\text{TeV}$

A Contribution to the TESLA Technical Design Report
13. Feb. 2001

[THY - H1 - ZEUS - Exp - Dir · remarkable experience]

H. Abramowicz[41], S.P. Baranov[21], J. Bartels[17], W. Bialowons[13], R. Brinkmann[13], O. Çakır[4], A. Caldwell[12], V. Chekelian[32,31], A.K. Çiftçi[4], J.G. Conteras[14], M. Corradi[7], J.A. Crittenden[8], J. Dainton[23], K. Daum[45], A. Deshpande[46,39], D. Eckstein[13], E. Elsen[13], B. Foster[9], L. Frankfurt[41], E. Gabathuler[23], J. Gassner[38], U. Gensch[13], I. Ginzburg[33], L. Gladilin[44], M. Glück[14], N. Gogitidze[21], K. Golec-Biernat[17], E. Gotsman[41], T. Greenshaw[23], V. Guzey[2], P. Jankowski, U. Jezuita-Dabrowska[42], H. Jung[13], U.F. Katz[8], R. Klanner[13,17], M. Klasen[17], M. Klein[13], B. Kniehl[17], H. Koru[5], P. Kostka[13], H. Kowalski[13], M. Krawczyk[42], T. Kurča[20], M. Kuze[19], P. Landshoff[10], T. Laštovička[37], B. Levchenko[30], E. Levin[41], A. Levy[41], K. Long[24], L. Lönnblad[25], U. Maor[41], M. McDermott[23], K. Nagano[19], T. Naumann[13], W. van Neerven[22], P. Newman[6], N. Nikolaev[18], C. Pascaud[34], E. Perez[40], D. Pitzl[13], B. Pötter[32], G. Rädel[1], V. Ravindran[3], I. Redondo[26], E. Reya[14], A. De Roeck[11], E. Rondio[43], J. Ruan[15], W. Schäfer[18], S. Schlenstedt[13], P. Schleper[13], U. Schneekloth[13], S. Söldner-Rembold[16,11], H. Spiesberger[27], U. Stösslein[13], M. Strikman[36], S. Sultansoy[5], K. Tuchin[41], W.K. Tung[29], R. Wallny[47], D. Waters[35], P. Wesolowski[13], F. Willeke[13], M. Wing[28], Ö. Yavaş[4], M. Yılmaz[5], A.F. Żarnecki[42], A. Zembrzuski[42], A. Zhokin[31], V. Zoller[31], N.P. Zotov[30]

92 authors
43 institutes.

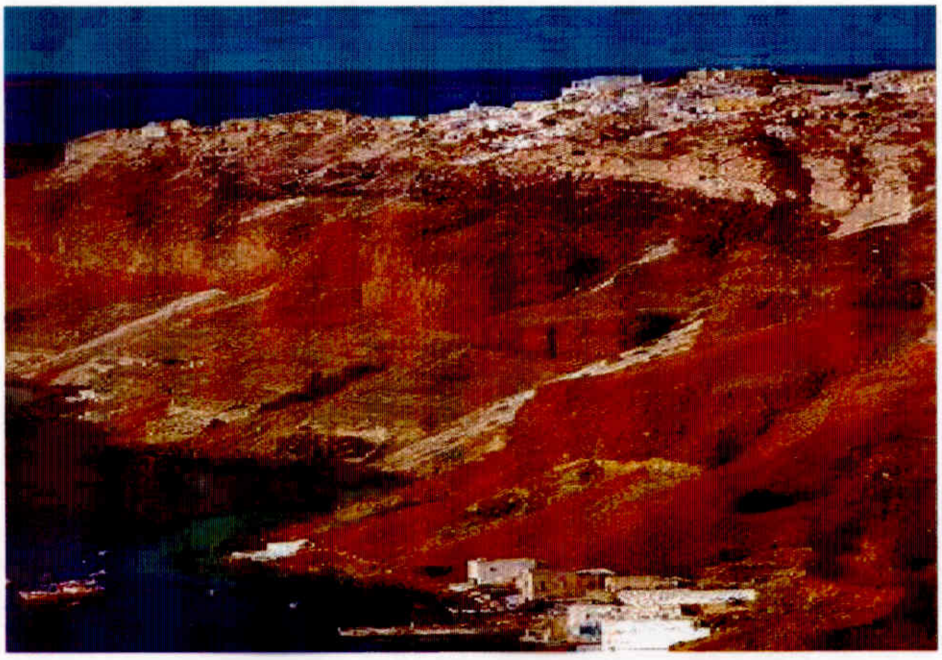
editors.

4meetings 2000/01.

www.ifh.de/thera
all talks ...

THERA

founded 3000 years ago by Thera in doric period on
mountain Messavouno, 369m high
anciently known as *Kalliste* - most beautiful
today known as Santorini



1. Introduction

2. HERA

3. low x

4. further QCD tests

5. high Q^2

6. Experimentation at THERA

Σ

The Higgs Particle is certainly not - despite much loose talk to the contrary the origin of mass ... Most of the mass of ordinary matter is concentrated in protons and neutrons .. Their mass mostly arises from pure energy, associated with the dynamics of confinement in QCD.

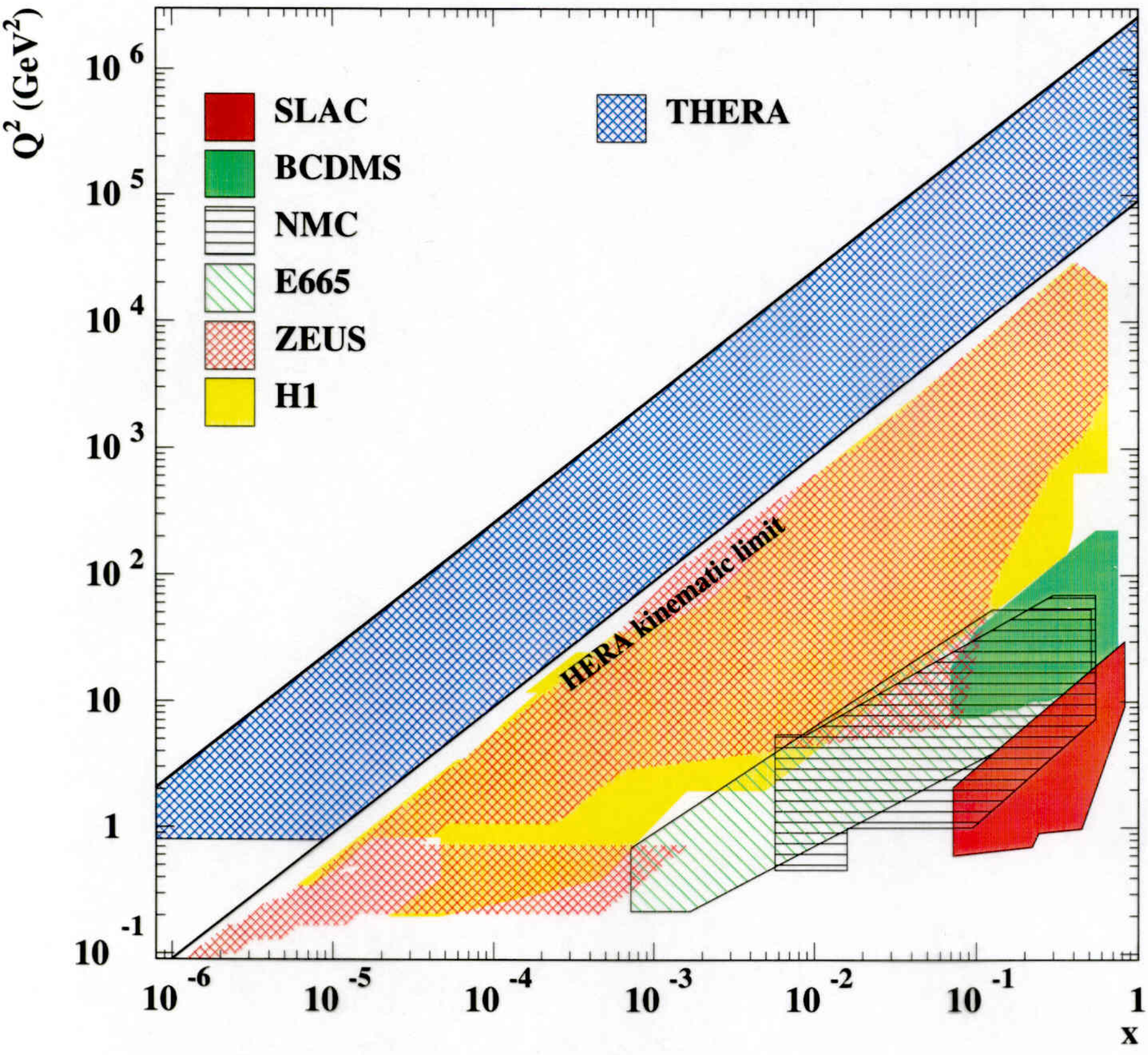
F. Wilczek

"future summary" - LEPfest [hep-ph/0101187]

THERA 250 … 800 E_e

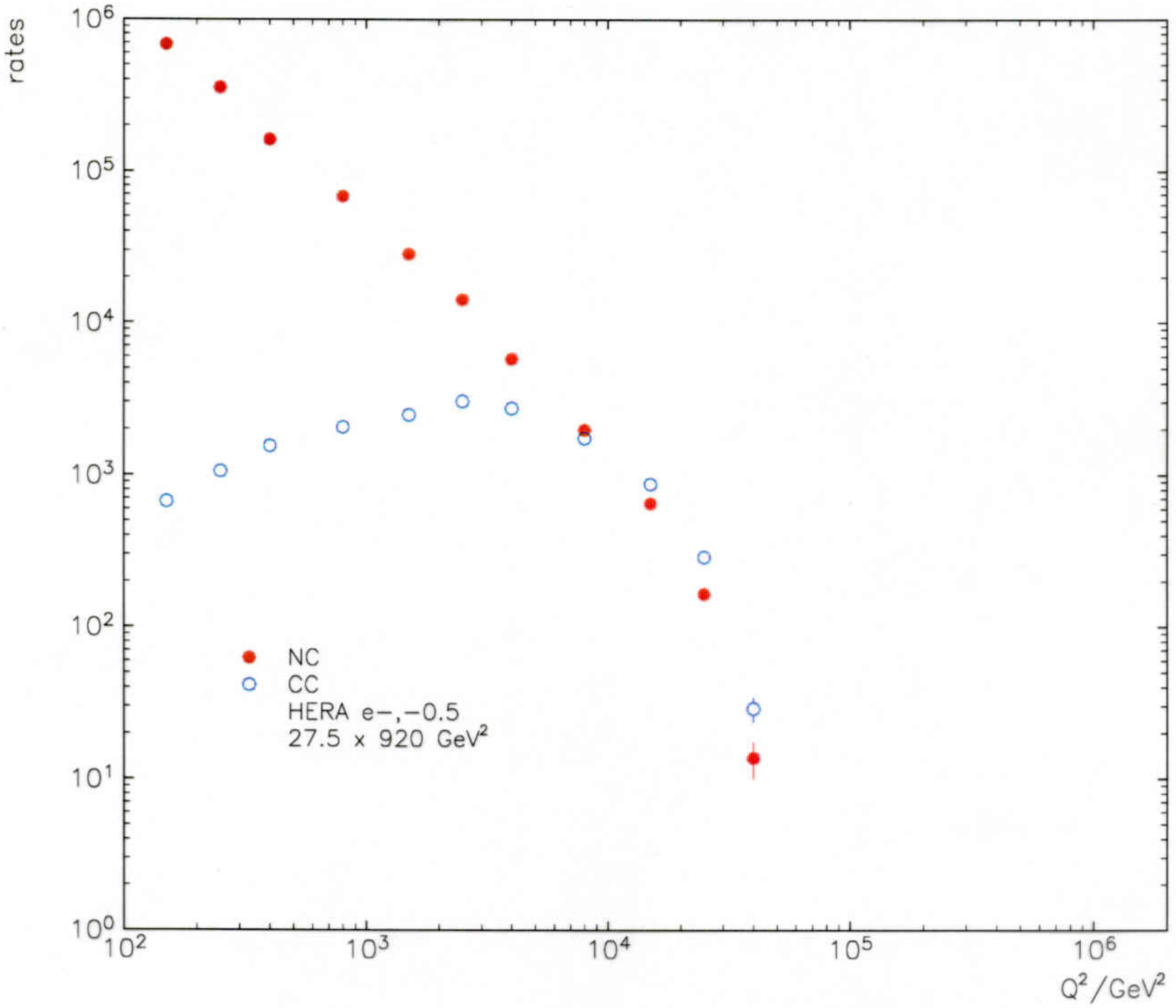
300 … 1000 E_p

GeV



low x :=

lower than previously

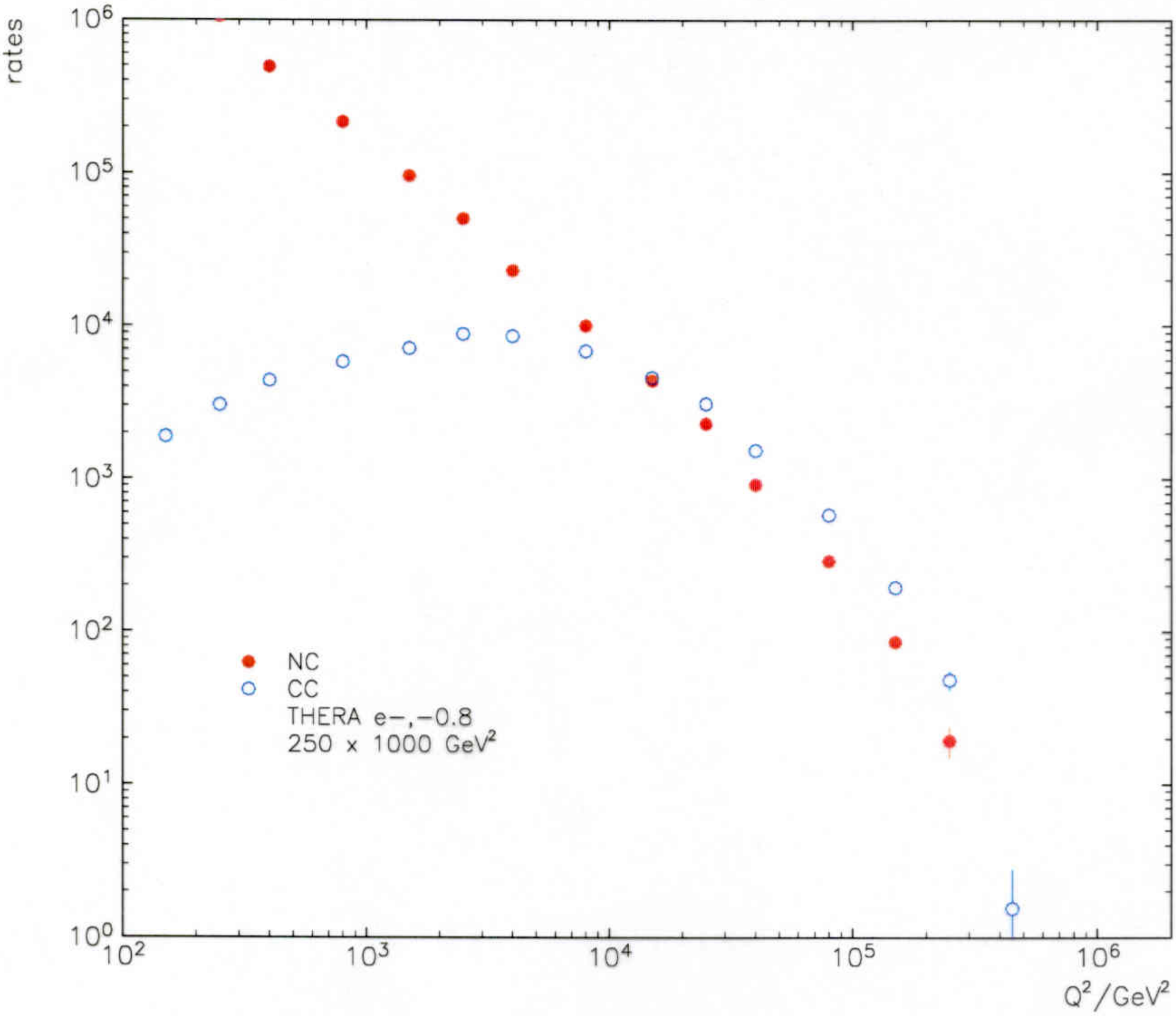


● HERA 200pb⁻¹
○ simulation!

$$\text{rates} = \int dx\, N(x,Q^2) = f(Q^2). \quad e^-$$

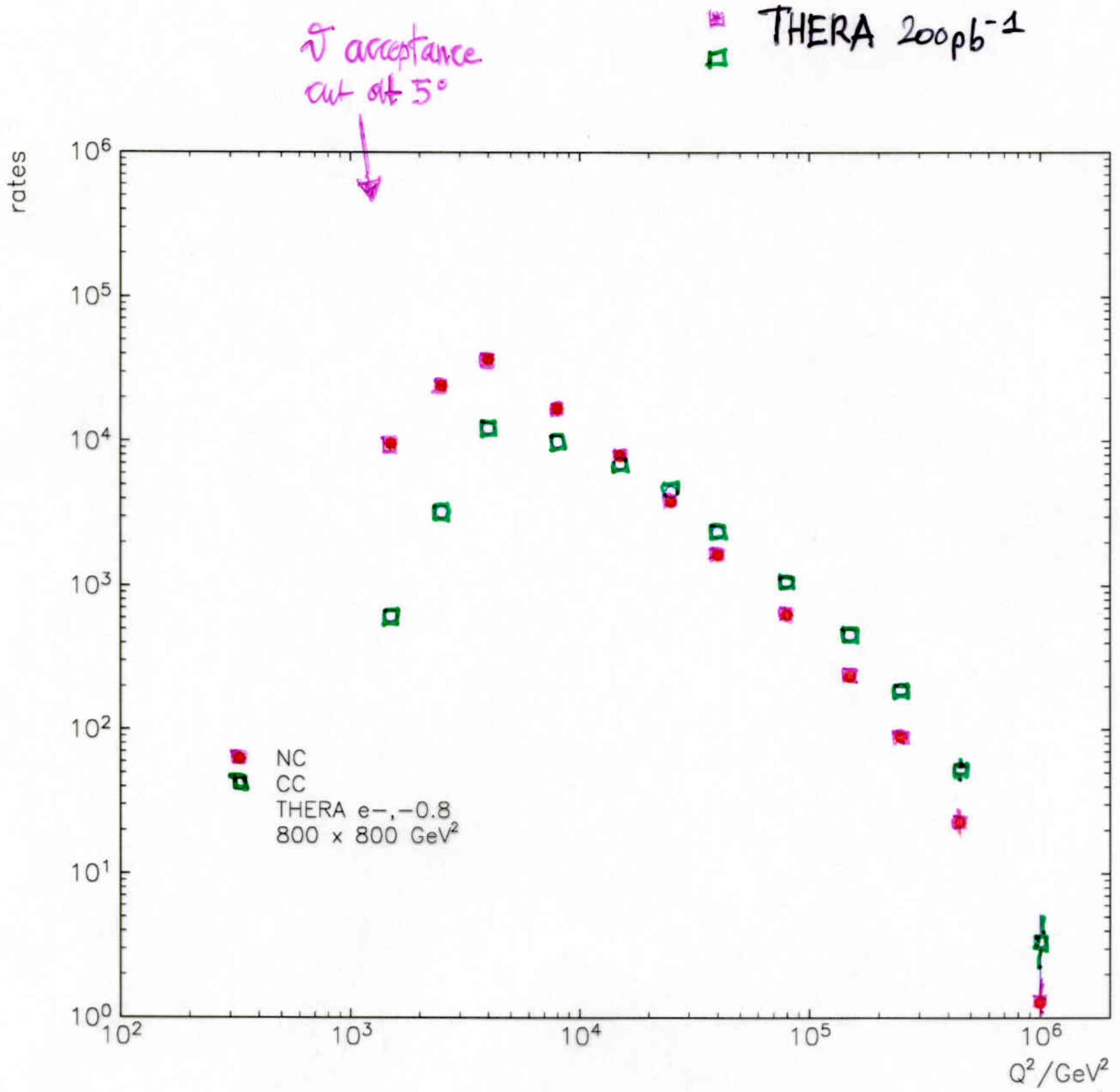
low x

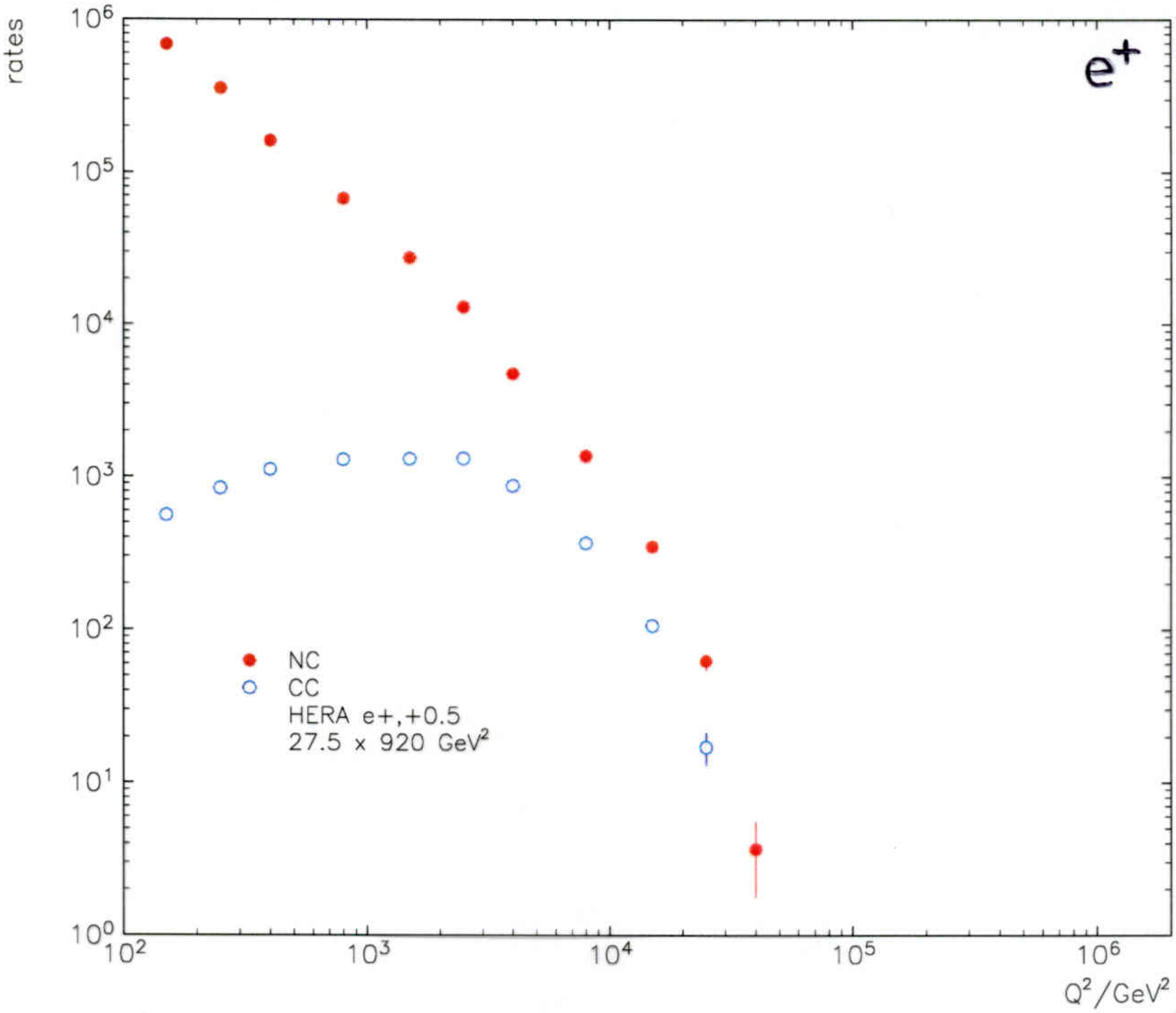
huge NC rate



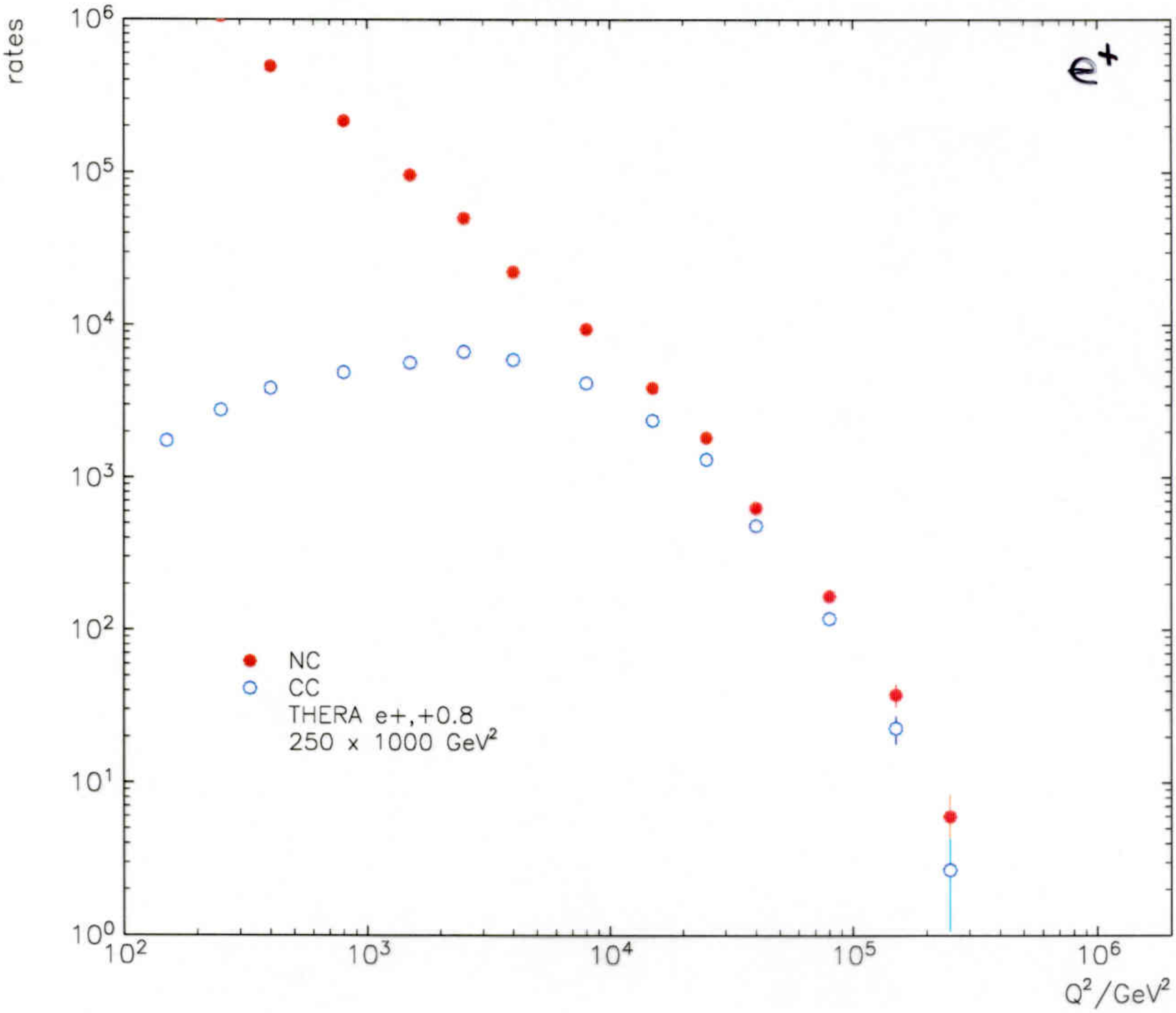
$\mathcal{L} = 200 pb^{-1}$

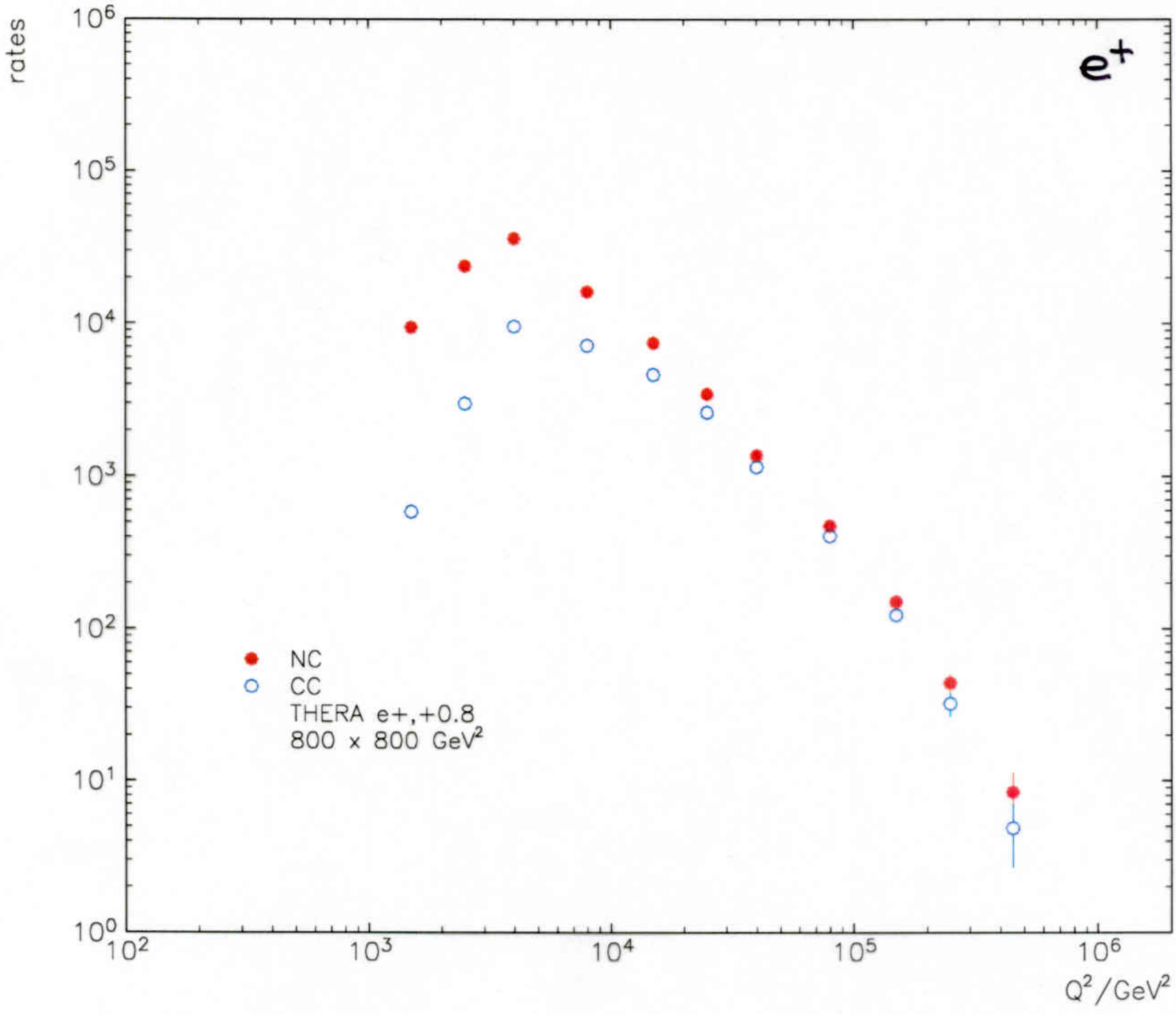
$< 50 pb^{-1}$
ok for low x


THERA 200pb-1
ϑ acceptance cut at 5°
rates
NC
CC
THERA e−,−0.8
800 x 800 GeV²
Q²/GeV²



rates
e+
NC
CC
HERA e+,+0.5
27.5 x 920 GeV²
Q²/GeV²


rates
e+
NC
CC
THERA e+,+0.8
250 x 1000 GeV²
Q²/GeV²


rates
e+
NC
CC
THERA e+,+0.8
800 x 800 GeV²
Q²/GeV²

The THERA Book

contents status instructions for authors

www.ifh.de/thera

soon to appear
- book
- CD
- hep-ex

Current version (April 24)

DESY-LC-Rev-2001-062

gzip'ed postscript (2.8 MB), PDF (10.7 MB)

Contents

- **Beyond the Standard Model**
  - **Search for Excited Fermions**
    M. Kuze
  - **Contact Interactions, Large Extra Dimensions and Leptoquarks**
    A.F. Zarnecki
  - **Charged-Current DIS**
    K. Nagano
  - **MSSM Sparticle Pair Production**
    M. Corradi
- **Photon Structure**
  - **Kinematics of Photoproduction**
    M. Krawczyk, S. Söldner-Rembold and M. Wing
  - **Jet Photoproduction**
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  - **Inclusive Dijet Photoproduction and the Resolved Photon**
    M. Wing
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- **Electron-Nucleus Collisions** M.W. Krasny M5
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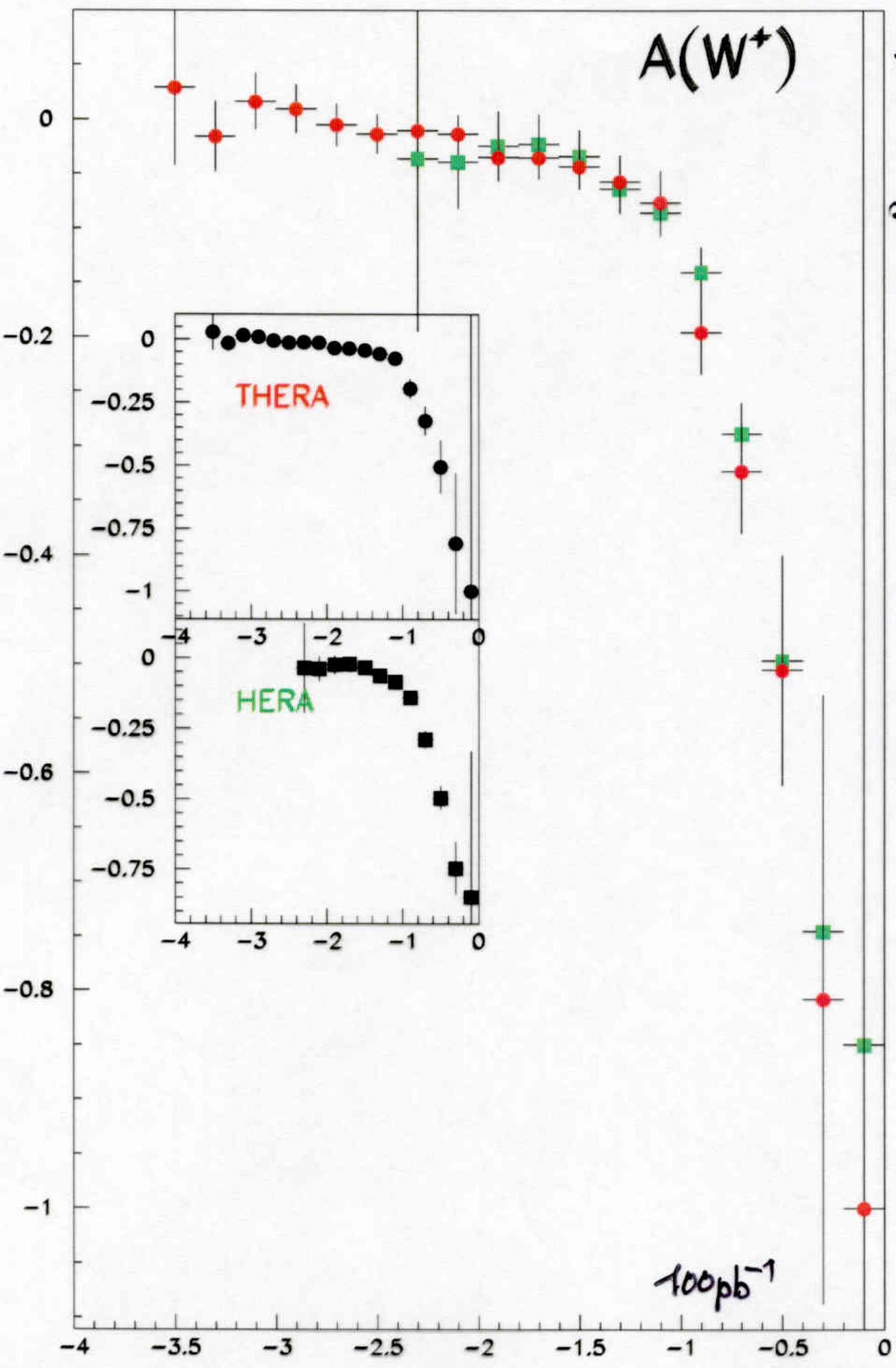
- **Real Photon-Proton Collisions**
  - **gamma-p and gamma-A Collisions at THERA**
    A. Ciftci et al.
- **Polarised Protons**
  - See HERA workshops A De Roeck - this session

$e^+ p \to \bar{\nu} X$

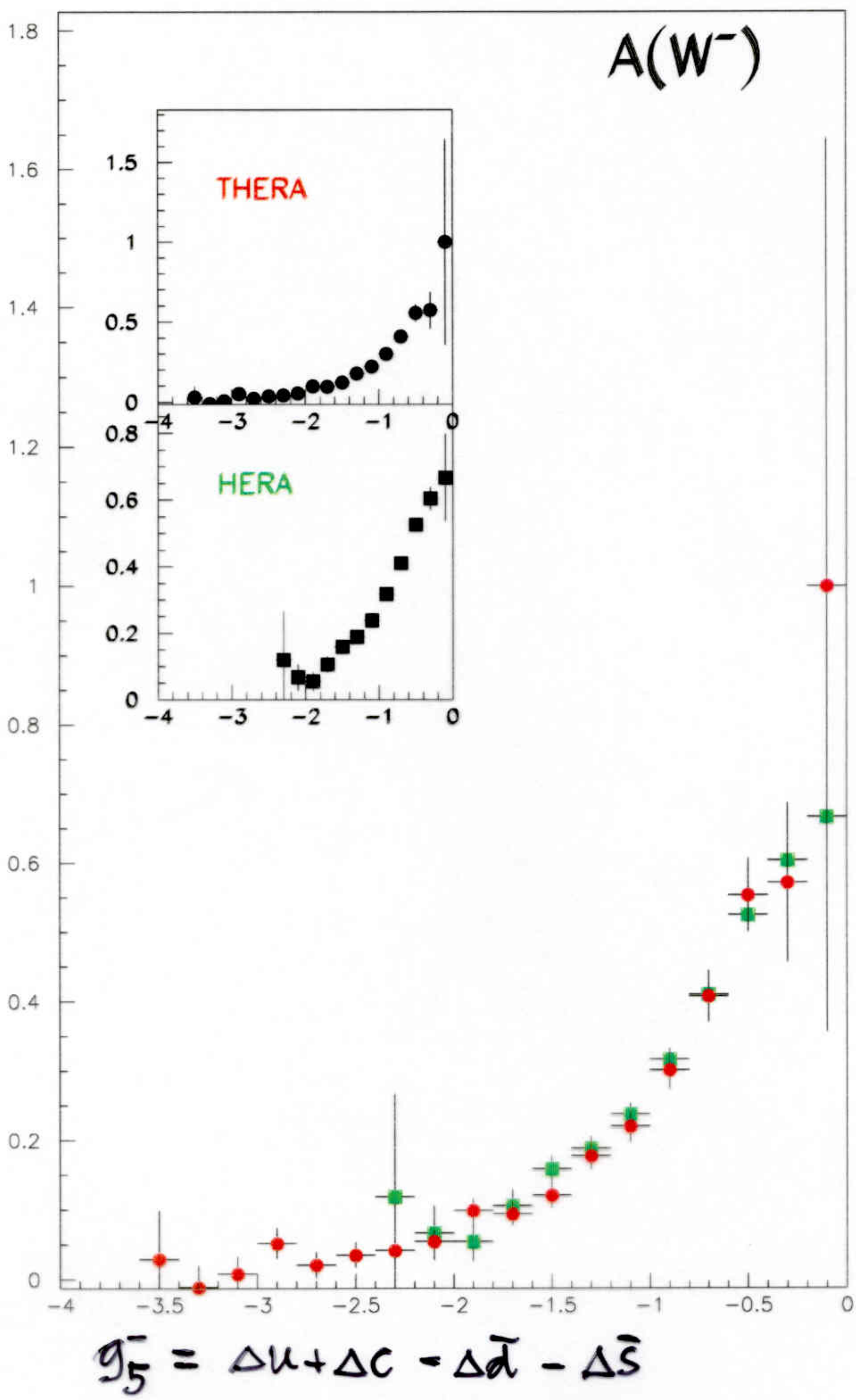


$$= \frac{\sigma_{\uparrow\downarrow} - \sigma_{\uparrow\uparrow}}{+} \approx \frac{g_5^+}{F_1^+}$$

$$g_5^+ = \Delta d + \Delta s - \Delta\bar{u} - \Delta\bar{c}$$

• sum rules: hep-ph/0102280 V. Ravindran, W. Neerven

Spin flavour decomposition with charged currents. high Q^2


A(W⁻)
THERA
HERA
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−4
−3.5
−3
−2.5
−2
−1.5
−1
−0.5
0
$g_5^- = \Delta u + \Delta c - \Delta \bar{d} - \Delta \bar{s}$

2. HERA

$E_e = 27.5\ \text{GeV}$

$E_p = 920\ \text{GeV}$

$\sqrt{s} \simeq 300\ \text{GeV}$

B. Wiik.
G. Voss
et al.!

HERA proposal : Juli 1981

" This machine is planned to come into operation around 1990".

$E_e = 12\,GeV$ $E_p = 480\,GeV$ $\mathcal{L} = 1.03 \cdot 10^{26}\,cm^{-2}s^{-1}$

$ep \rightarrow ep\gamma$

Spätschicht 19.10.

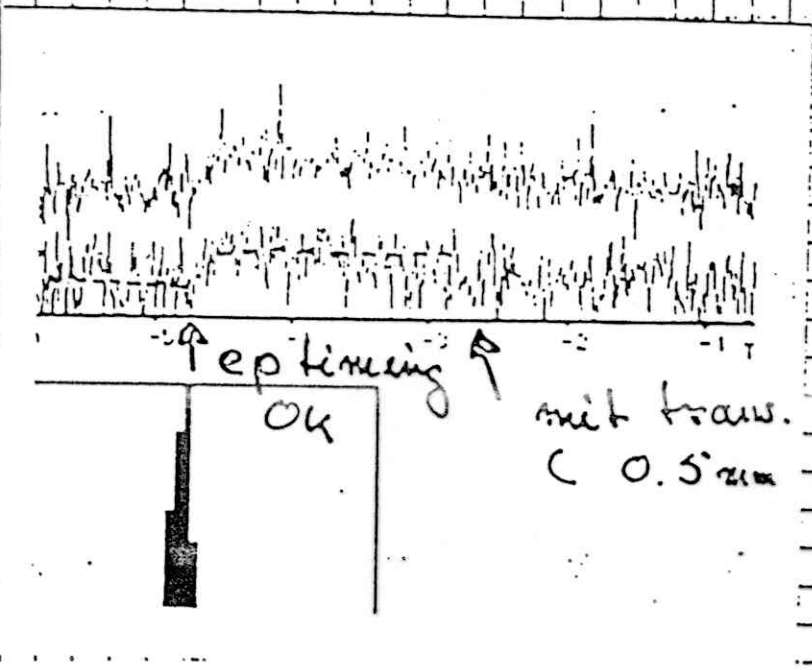
Protonen Strahl ~ 72 µA ≃ 10^{10}

Elektronen Strahl ~ $2 \cdot 10^{9}$

Elektronen und Protonen ~~vertikal~~ transversal mit den ± 7 mm Positionmonitore auf die richtige Lage gebracht. Timing abgeglichen so dass die beiden Bunche sich im WWD-Nord treffen => Zunahme der eγ Koinzidenz Rate um ein Faktor 2!

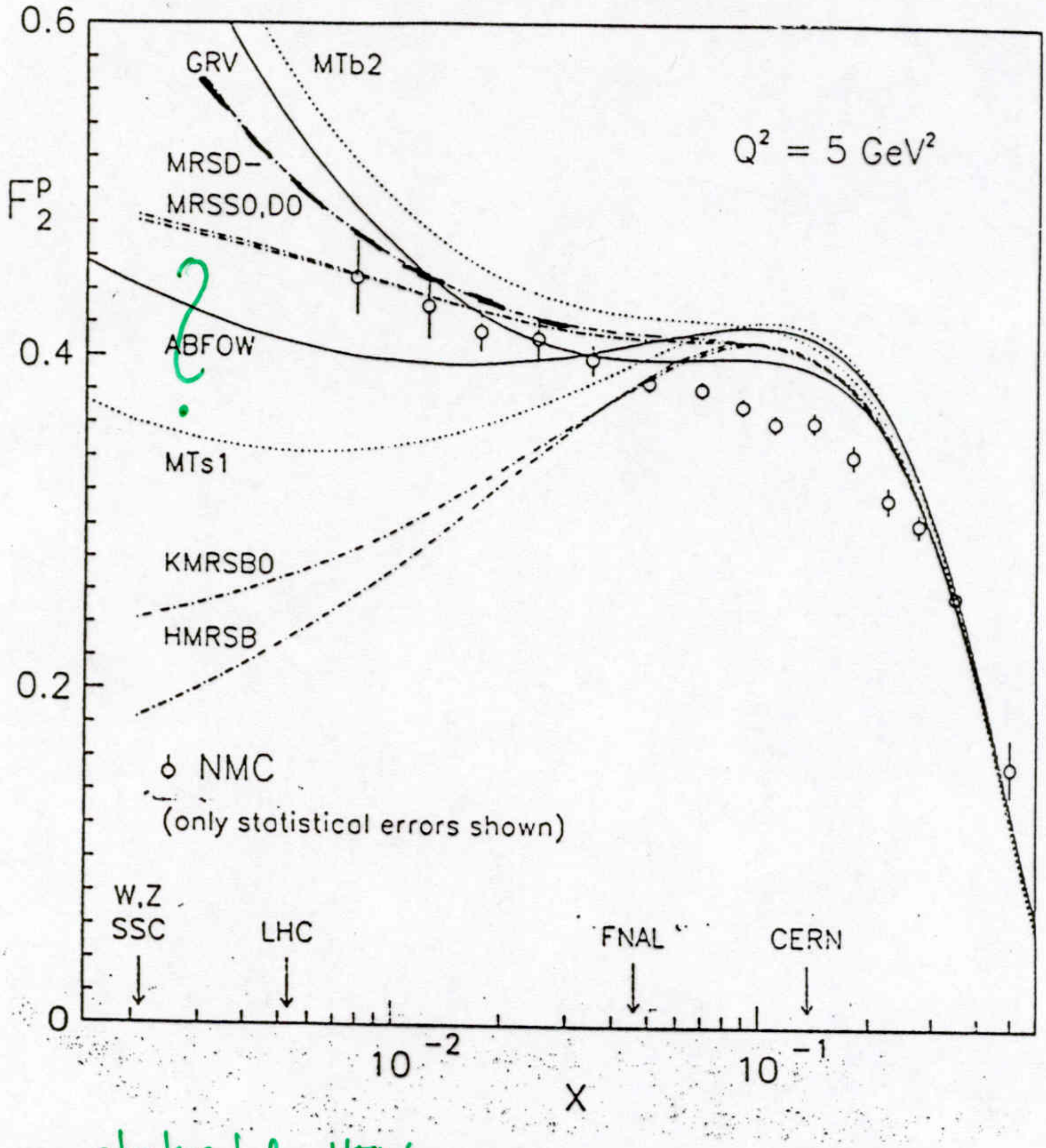
=> erste e-p Kollisionen in HERA

19.10.91 um 18^{50}



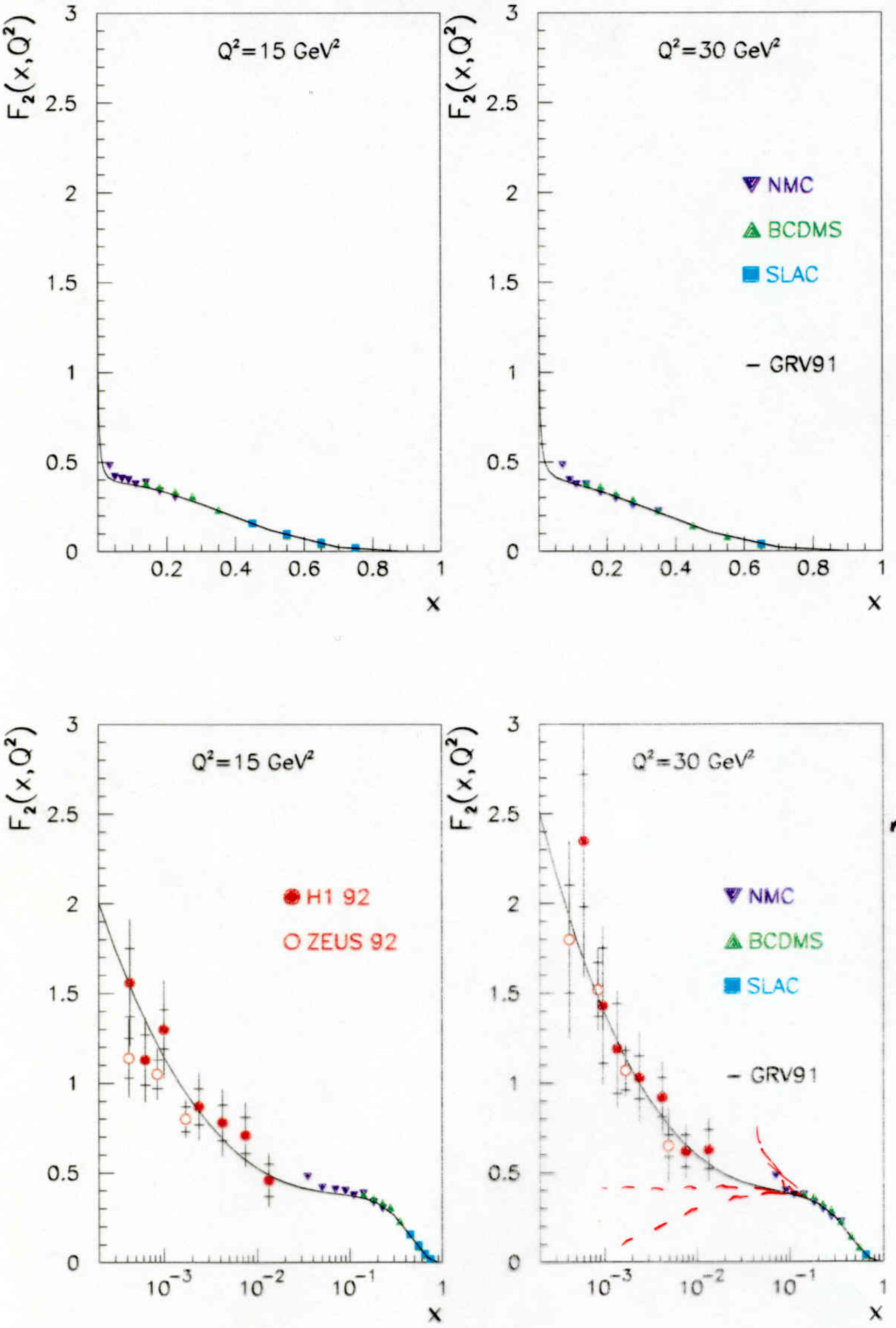
mit transv. Beule gebraucht
< 0.5 mm vertikal getrennt

Parton Density Functions of the Nucleon



status before HERA

- great confusion -
thy freedom.



~200nb^{-1} !

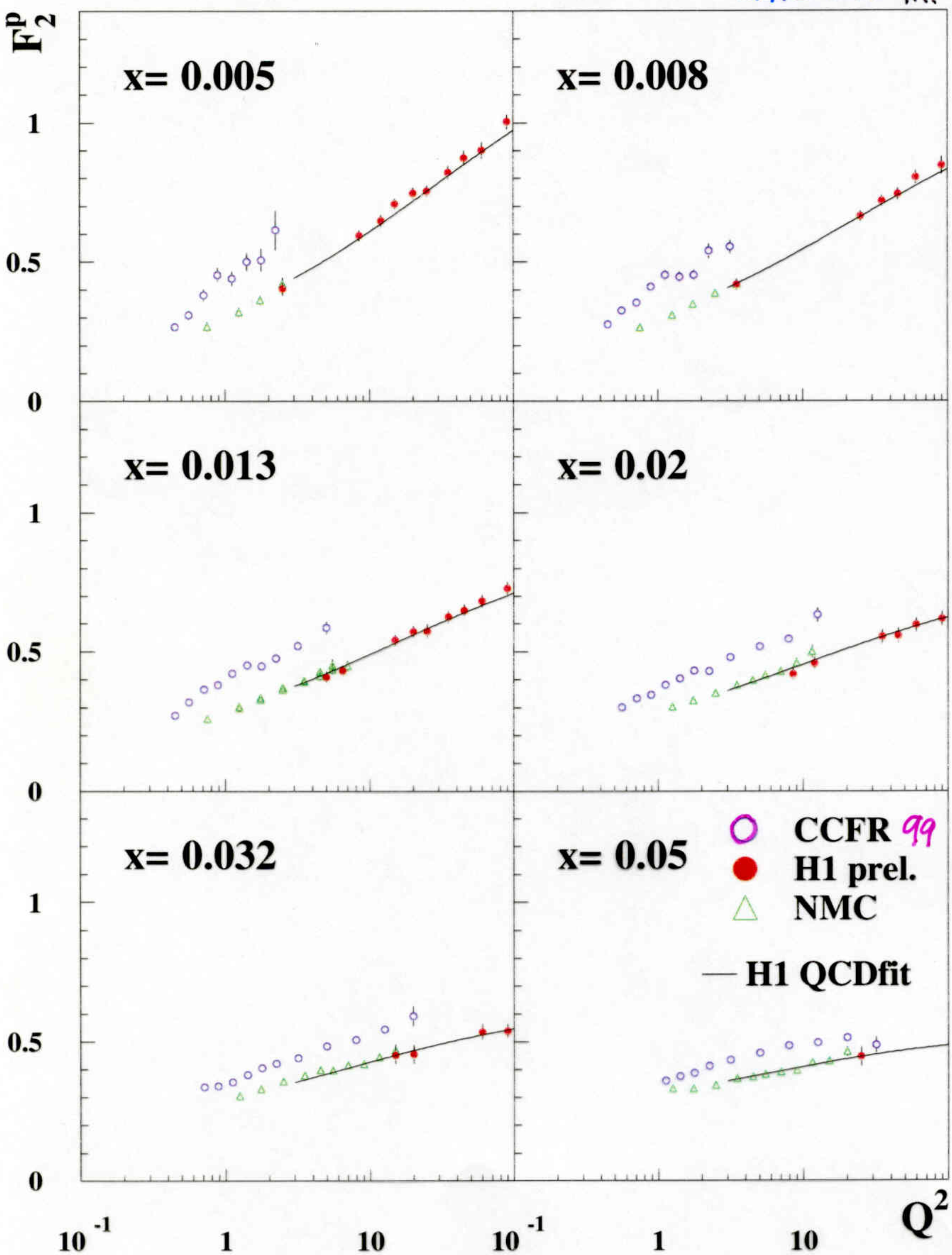
A de Rujula et al
Possible non-Regge behaviour of F_2
PR D10 (74) 1649

GRV
Z Phys C53 (92) 127
dynamical partons
$Q_0^2 \sim 0.4$ GeV^2

Parisi, Petronzio, UTϕ, GR. 76

somehimes you need three measurements of 1 quantity

Lγ symposium SLAC 1999. MK.



CCFR has re-analyzed their data: F_2, xF_3 changed charm!

HERA I

1991 – 2000 $\int \mathcal{L} dt \sim 100\,pb^{-1}$

- $F_2(x, \underline{Q}^2)$ rises for $x < 0.01$ towards low x

- DIS comprises a hard diffractive component

- precision measurement F_2 : $\delta\alpha_s \approx \langle \delta\alpha_s \rangle_{world}$
  +BCDMS

- heavy flavours : $\gamma g \to c\bar{c}$ is 20% of σ
  and $\sigma_{b\bar{b}}$ is (too) large

- unification of NC and CC at $Q^2 \approx 10^4\,GeV^2$

- partonic structure of the photon

⋮

⇒ uncomparable development of strong i.a. gauge field theory

- LQ's preferred to vanish. Large $p_\perp$ isolated leptons not (yet)?

Wiik / Llewellyn-Smith DESY 77/38 preparation for CHEEP, HERA

Any new facility should give access to a large unexplored kinematical region with sufficient luminosity to investigate what now seem to be the most profound problems in particle physics. With an electron-proton colliding beam facility one can attack questions such as:

- What is the structure of the weak interaction ?
- What mechanism, if any, will damp the rising weak cross section at high energy ?
- Do the intermediate vector bosons – $W^{\pm}$ and Z^{0} – exist ?
- How will the neutral current affect the scattering of charged leptons ?
- Are the weak and electromagnetic interactions different manifestations of a single force ?
- To what extent does the point-like behaviour of hadrons revealed by deep inelastic ν, μ and e experiments persist at higher energies ?
- Do scaling violations have the characteristic features expected if the strong interactions are described by a gauge theory ?
- Are there additional heavy leptons ?
- Are there further hadronic degrees of freedom beyond charm ?

most of these questions were answered when HERA was approved . :

HERA II

2001 – 200? $\int \mathcal{L} dt \sim 1 fb^{-1}$ $E_p \simeq 300 \cdots 1$ TeV.

new machine, upgraded detectors, rotators $\lambda_{e^\pm}$

- high precision cross-section measurements to $\lesssim 1\%$
- $\delta\alpha_s < \langle\delta\alpha_s\rangle_{world}$ ≈ 0.0010 $\alpha_s = ?$
- F_2^c in extended x range to 5-10%. F_2^b F.C.B ST's
- $F_L(x, Q^2)$ to 5-10%
- charged currents: d_v/u_v to high x, r.h. cc?
- electroweak (NC) structure functions $xF_3^{\gamma Z} = xG_3$ $(q-\bar{q})$
  $F_2^{\gamma Z} = G_2$ PV singlet.
- competitive searches

HERA III ?

- 200? – 20??
- deuterons for unfolding partons, low x. n,p tagging
- nuclei. saturation enhanced by $A^{1/3}$
- spin physics at low(er) x and high(er) Q^2.
  ↑ asymmetry ↑ $\mathcal{L}$.

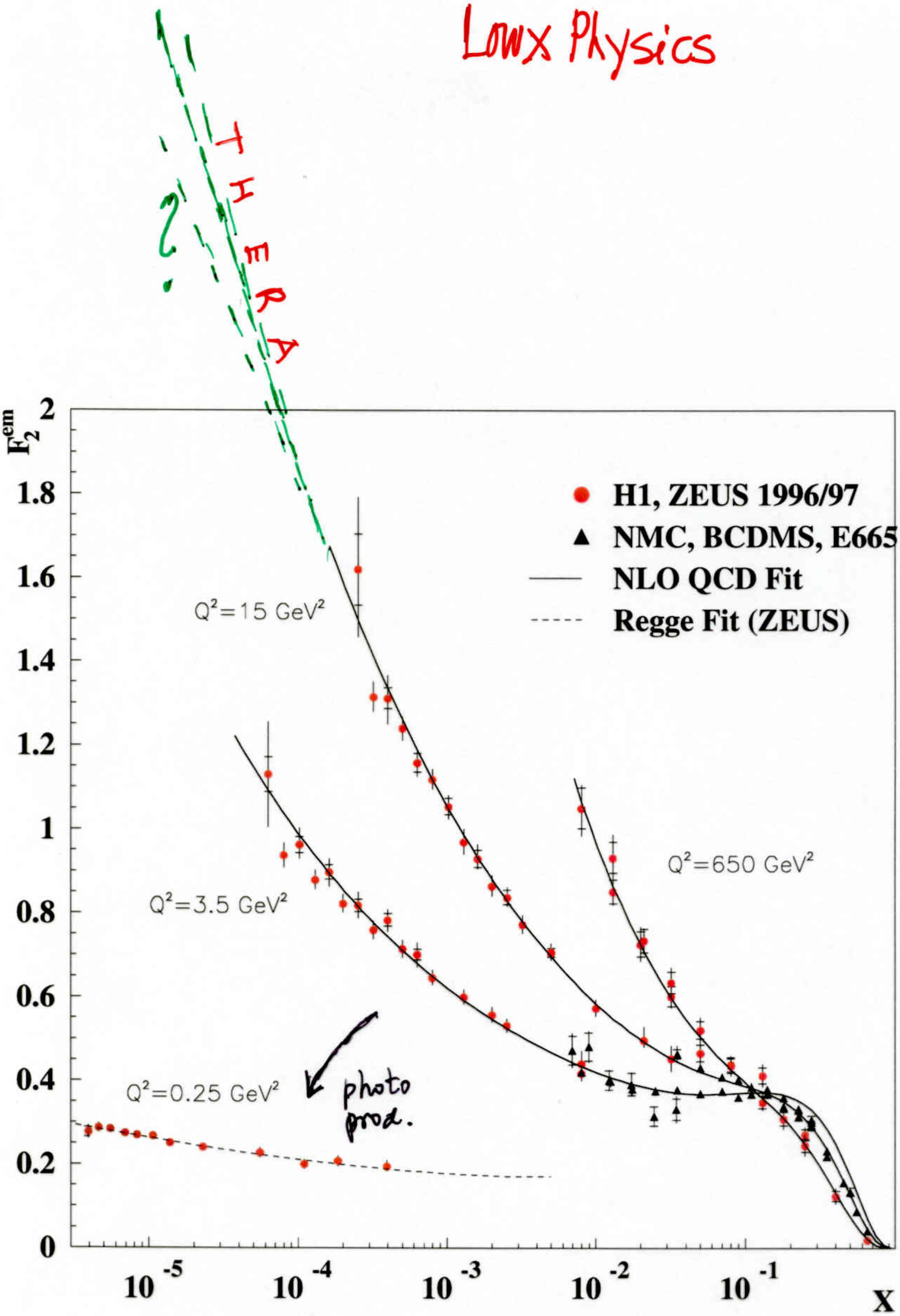
$\vec{d}$ w/o snake?
Skrinsky
Derbenev.

3. low x

$$x = Q^2 / sy \gtrsim 10^{-5}$$

for $Q^2 \gtrsim 1\ \mathrm{GeV}^2$

Low x Physics

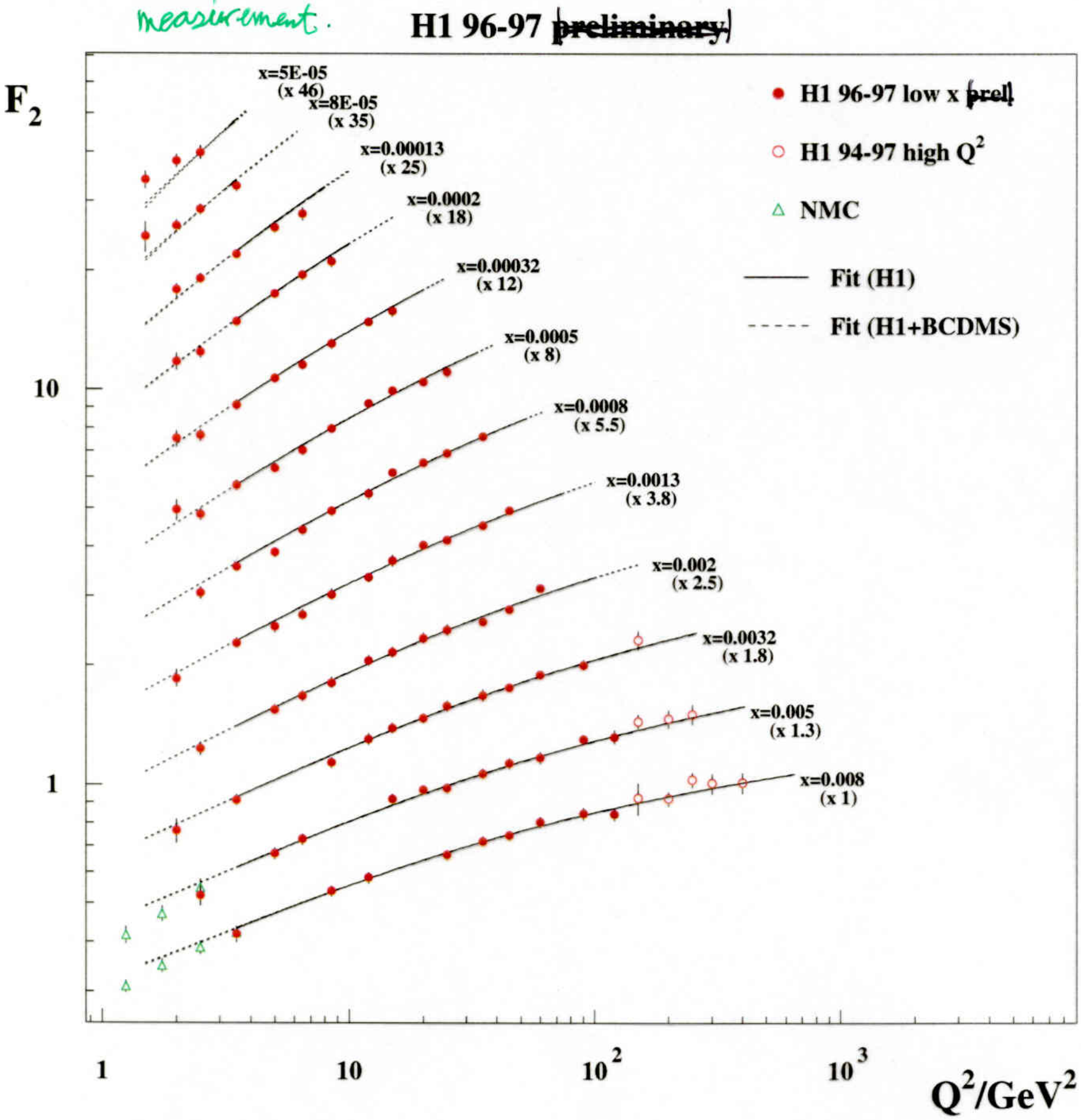


$\mathcal{L}_{H1} = 20 pb^{-1}$

- ν astrophysics $x \approx 10^{-8}$ earth ν tomography
- LHC

DGLAP, NLO ($\overline{MS}$), heavy flavour (c,b) QCD analysis of H1 ep (and BCDMS μp) data.

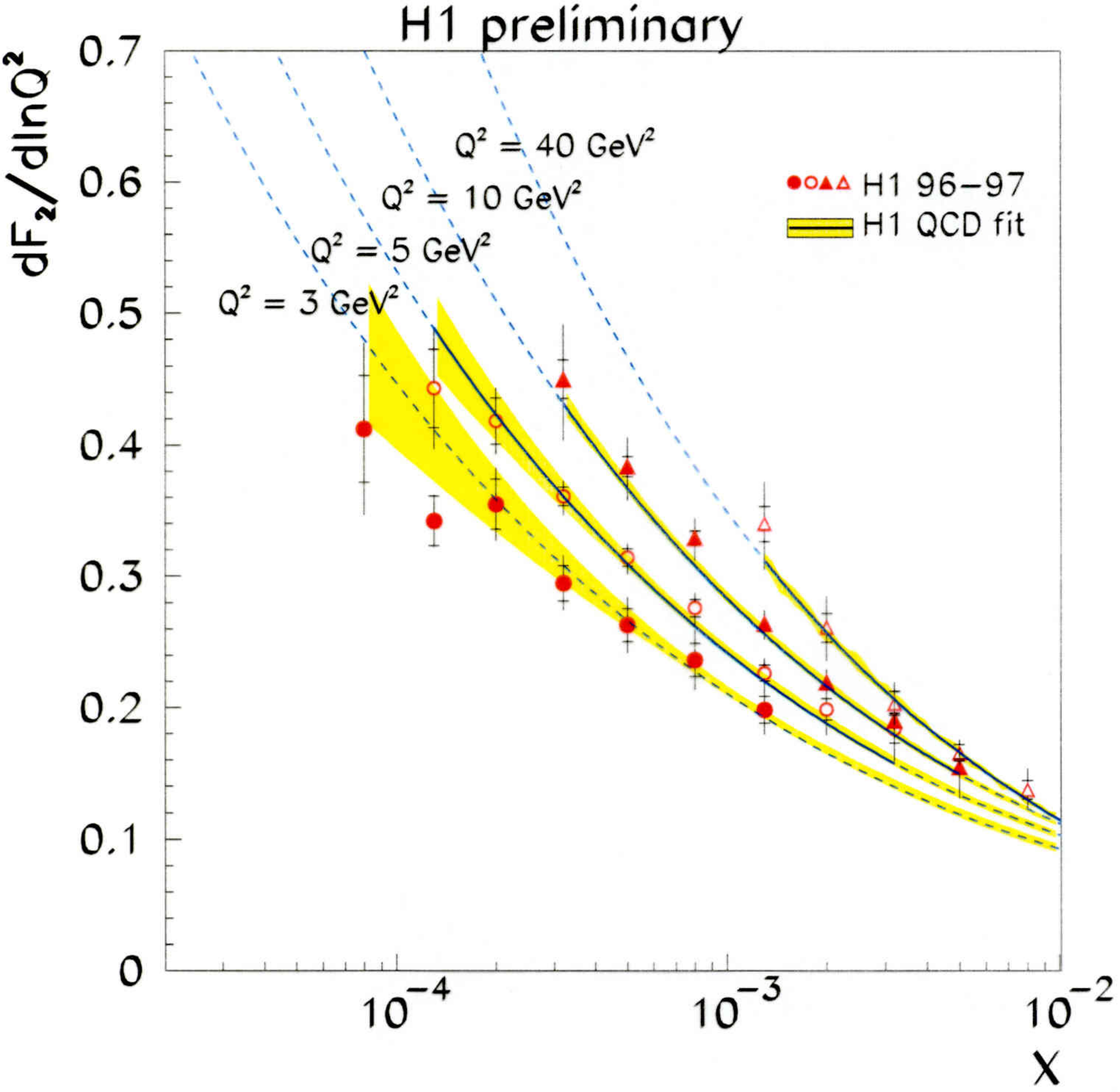
3% precision measurement.



$\alpha_s \cdot \ln 1/x \gtrsim 1$

$\sigma_r = F_2 - \frac{y^2}{Y_+} F_L$ use $F_L^{QCD}(\alpha_s^2)$ and $y < 0.6$ to get F_2

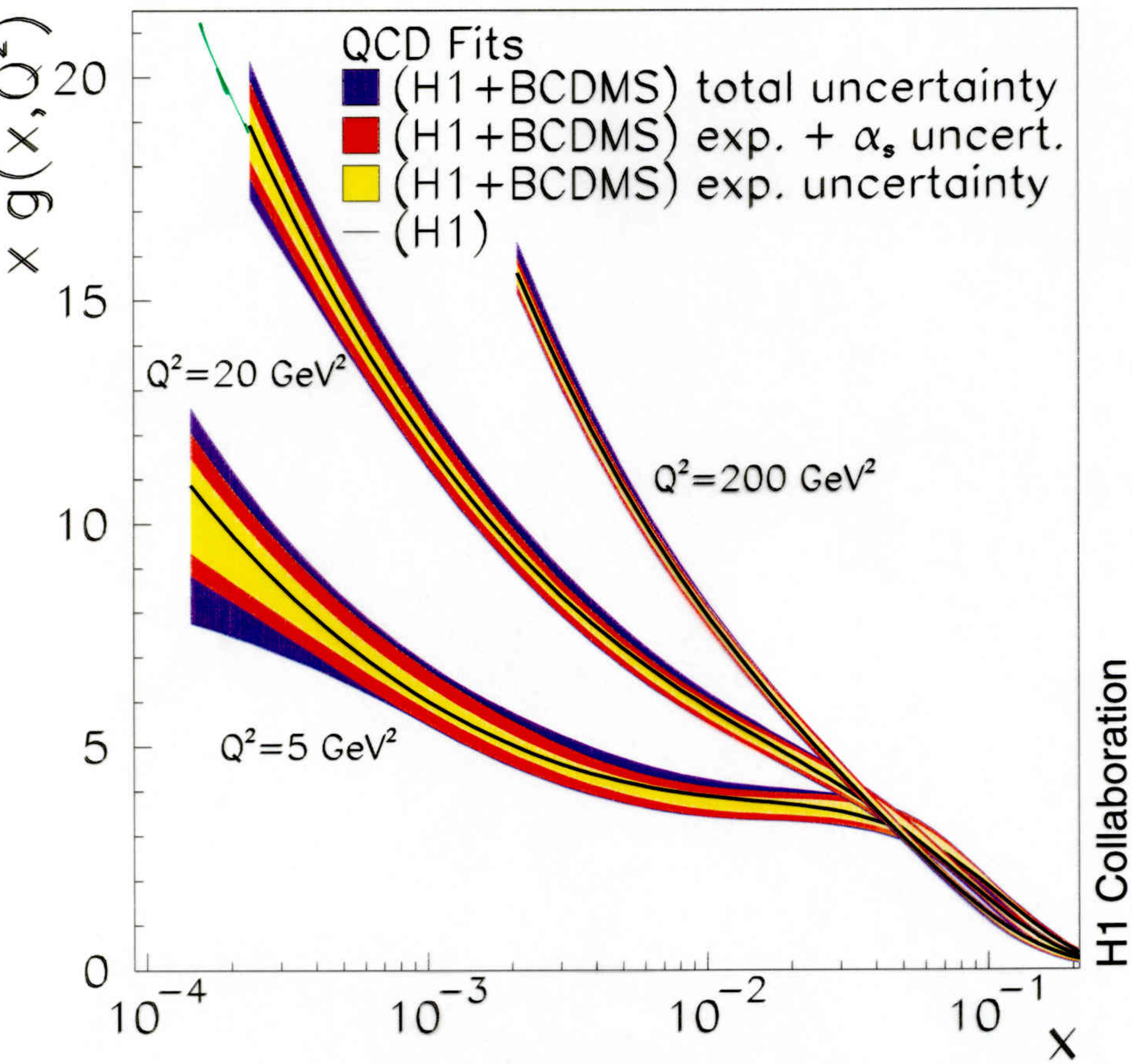
$\partial F_2 / \partial \ln Q^2 \approx \alpha_s \cdot xg$ at low x, $Q^2 \gtrsim 3\ \text{GeV}^2$



$\partial F_2 / \partial \ln Q^2$: PW Johnson PR D16 (1977) 2769
Wu Ki Tung

?

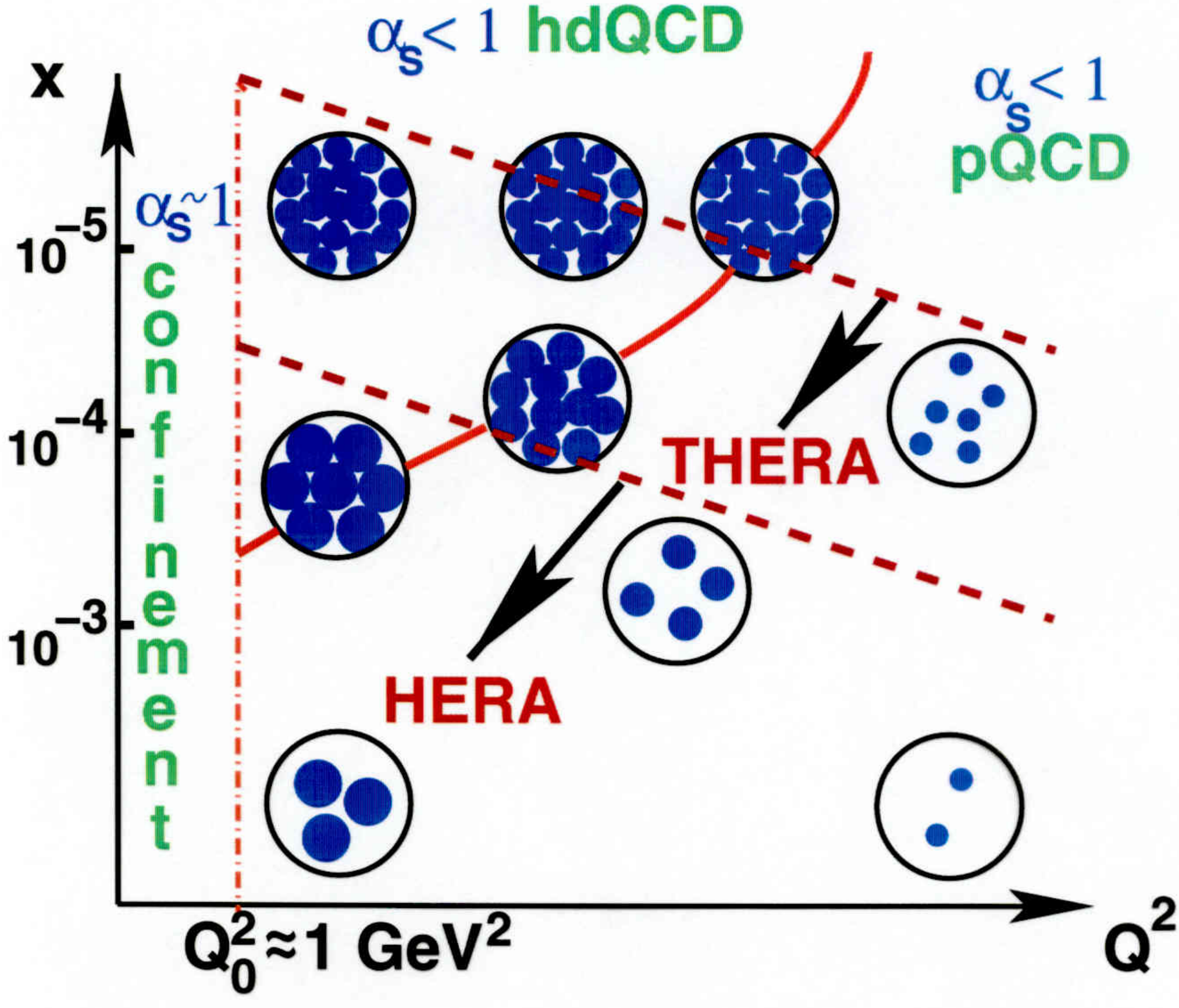
- precision, precision, precision – 3x patience
  E Gabathuler
- saturation : limitation of gluon phase space density
  $xg \lesssim \frac{1}{\pi N_c \alpha_s} \cdot Q^2 \cdot r_p^2 \simeq Q^2/\alpha_s$
- DGLAP & BFKL are linear ev. equ's . no parton rescattering
  exp. growth of xg with ln 1/x ÷ Froissart bound (?)



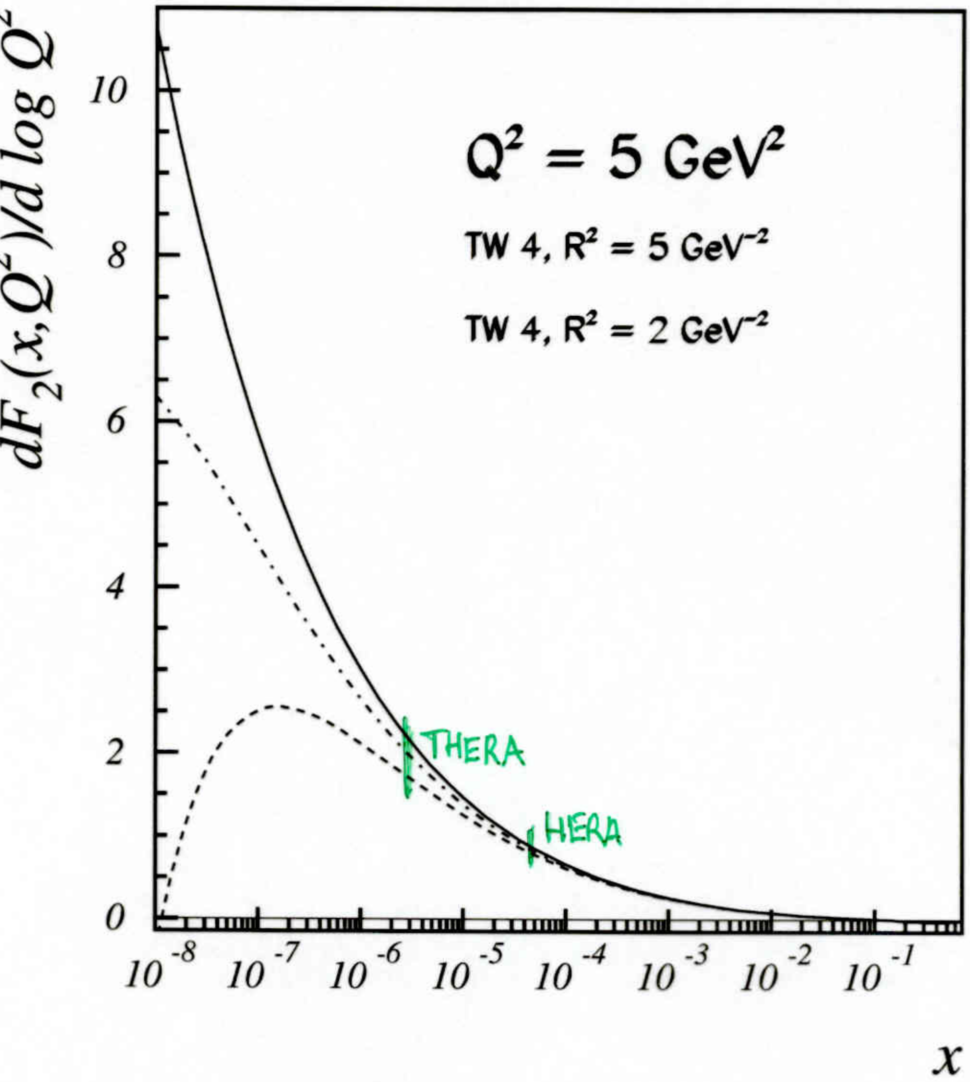
- effective QCD. high density QCD (physics-math. ?)
- pert. thy breaks down although α_s is small.

[• raise E
• and density.]

(T)HERA
eIC

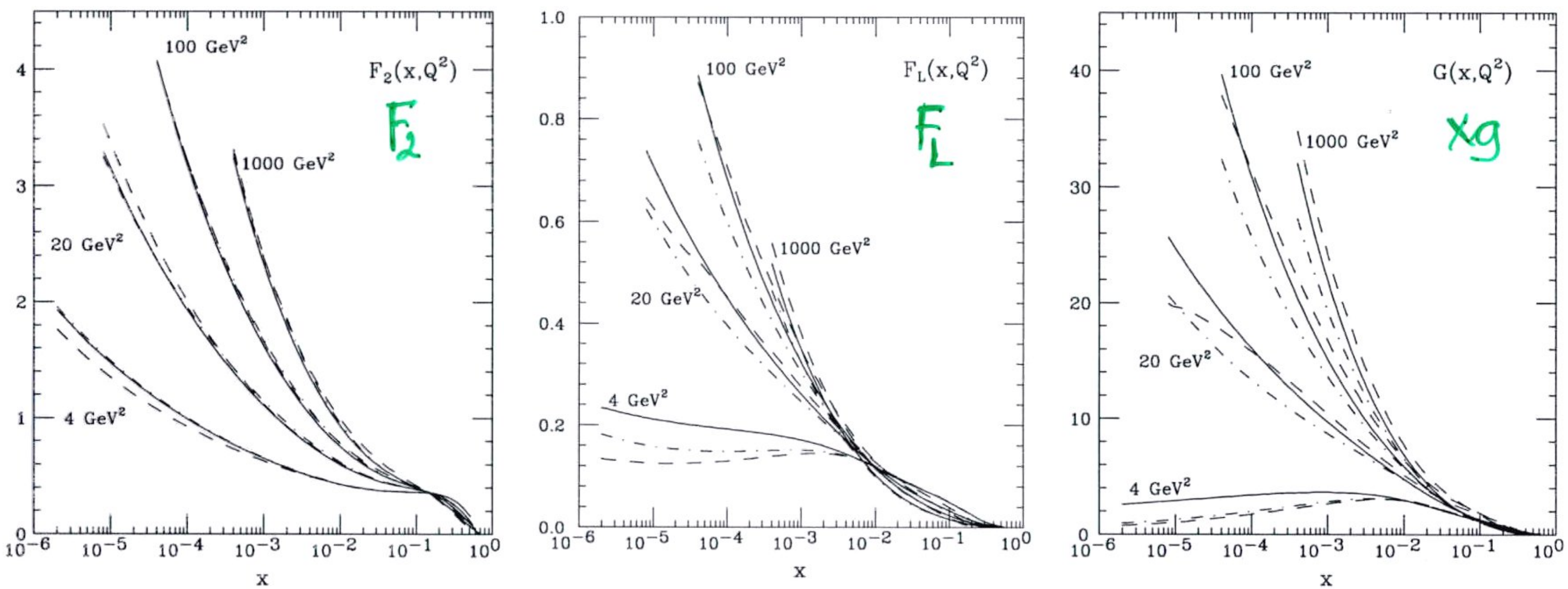


$\alpha_s < 1$ hdQCD
x
$\alpha_s < 1$
pQCD
$\alpha_s \sim 1$
confinement
10^{-5}
10^{-4}
10^{-3}
THERA
HERA
$Q_0^2 \approx 1$ GeV^2
Q^2



" twist-4 restores unitarity "

J. Blümlein et al hep-ph/0102025 (2000).



ln x- resummation

— unresummed

-·- double asy.sc. S resum.

-- power res. R resum.

G. Altarelli, R. Ball, S. Forte

[thera. book. 2001. hep-ph/]

questions

- Will it remain sufficient to use the leading twist DGLAP evolution equation (to a given accuracy in logarithms in Q^2) or will it become necessary to resum [28–30] the large logs in energy that appear at each order in the perturbative expansion (i.e. for the regime in which $\alpha_s(Q^2)\ \ln(x_0/x) \sim \mathcal{O}(1)$) ?

- Does diffusion in parton transverse momenta lead to a breakdown of (collinear) factorization for leading twist pQCD, and a non-trivial mixing of perturbative and non-perturbative effects, in a kinematic regime in Q^2 which is assumed to be safe at higher x ?

- Will the increase of the parton distributions lead to an experimentally-accessible new pQCD regime, where the coupling constant is small but the interaction is strong ? If so, how can one distinguish between this new regime and the standard one in which the LT DGLAP equations are applicable ?

- Will the structure functions and cross sections of hard exclusive processes continue to increase with energy or will their growth be tamed to avoid violation of unitarity of the S-matrix (applied to the hard interactions of the hadronic fluctuations of the photon) ?

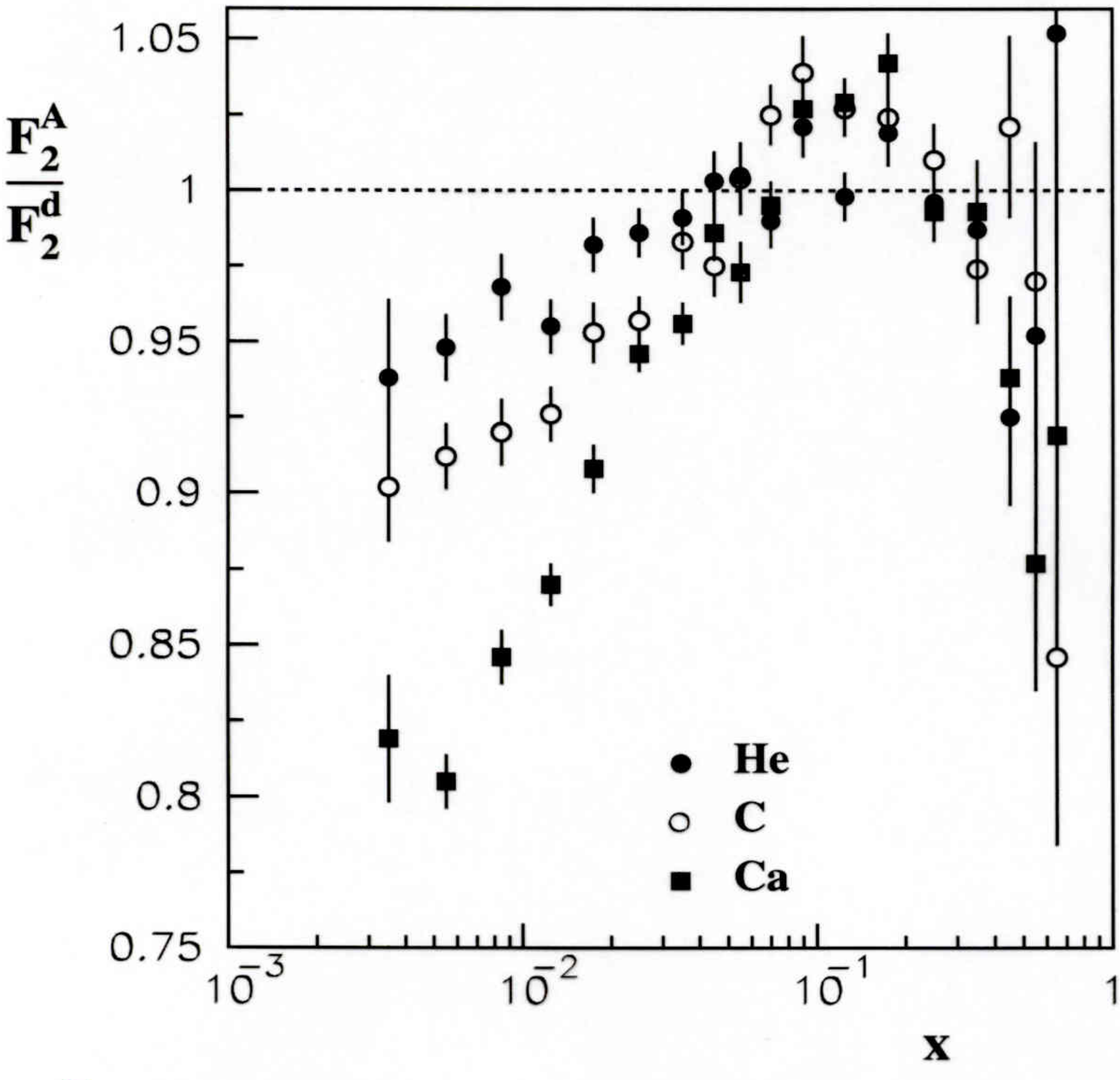
- Since the same QCD factorization theorems which lead to successful description of hard processes predict a rapid increase of HT effects with increasing energy, how important will the latter effects be for the interpretation of the small-x data ?

- no exp. information in DIS for $x < 10^{-2}$

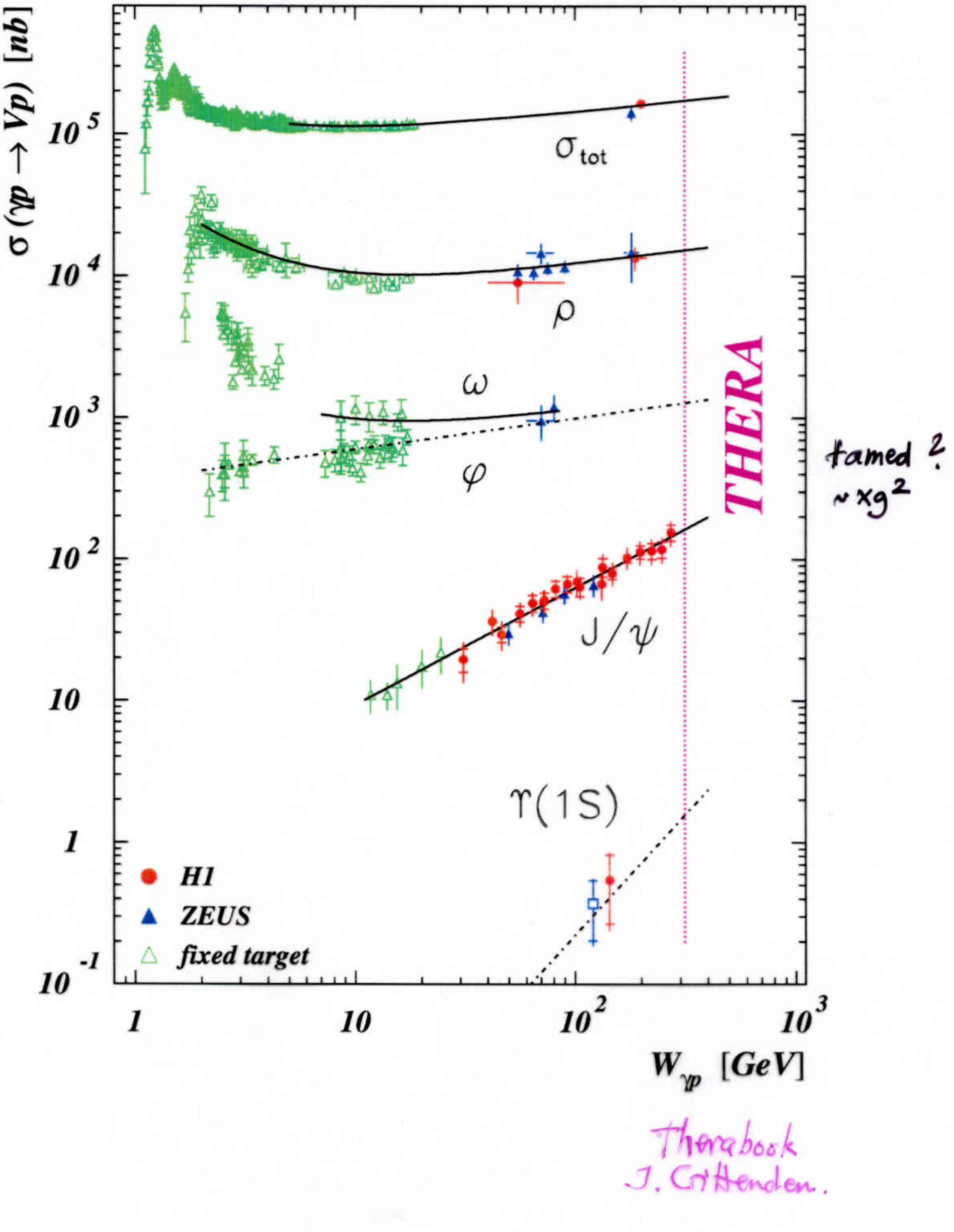
- $\dfrac{g_A}{\pi r_A^2} \Big/ \dfrac{g_p}{\pi r_p^2} = A^{1/3} \cdot \dfrac{g_A}{A \cdot g_p}$ as $r_A \sim A^{1/3}$

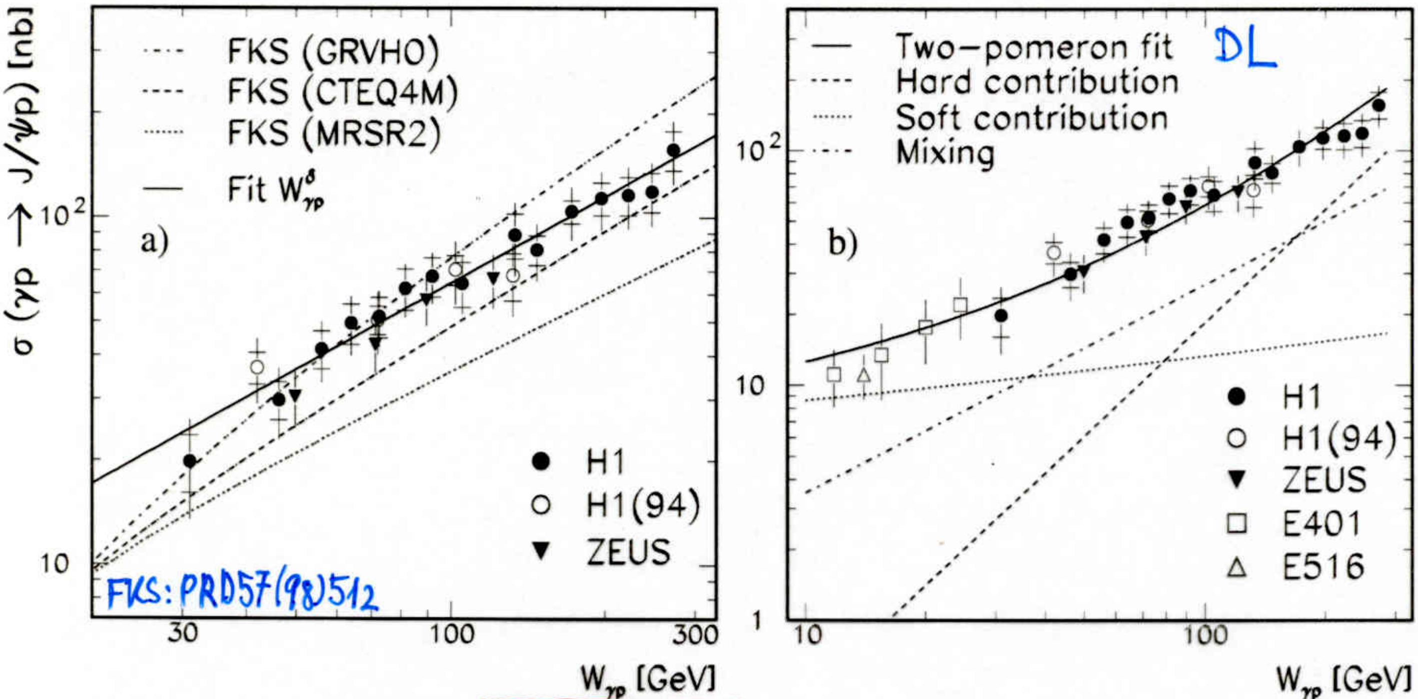
  $A^{1/3}$: 1.3 for A = 2; 3.4 for 40; 5.7 for 200

  density enhanced.



[cf. Therabook "eA collisions at THERA"
L. Frankfurt, V. Guzey, M McDermott, M. Strikhman


σ (γp → Vp) [nb]
W_γp [GeV]
σ_tot
ρ
ω
φ
J/ψ
ϒ(1S)
THERA
H1
ZEUS
fixed target
tamed ?
~ xg²
Therabook
J. Crittenden..



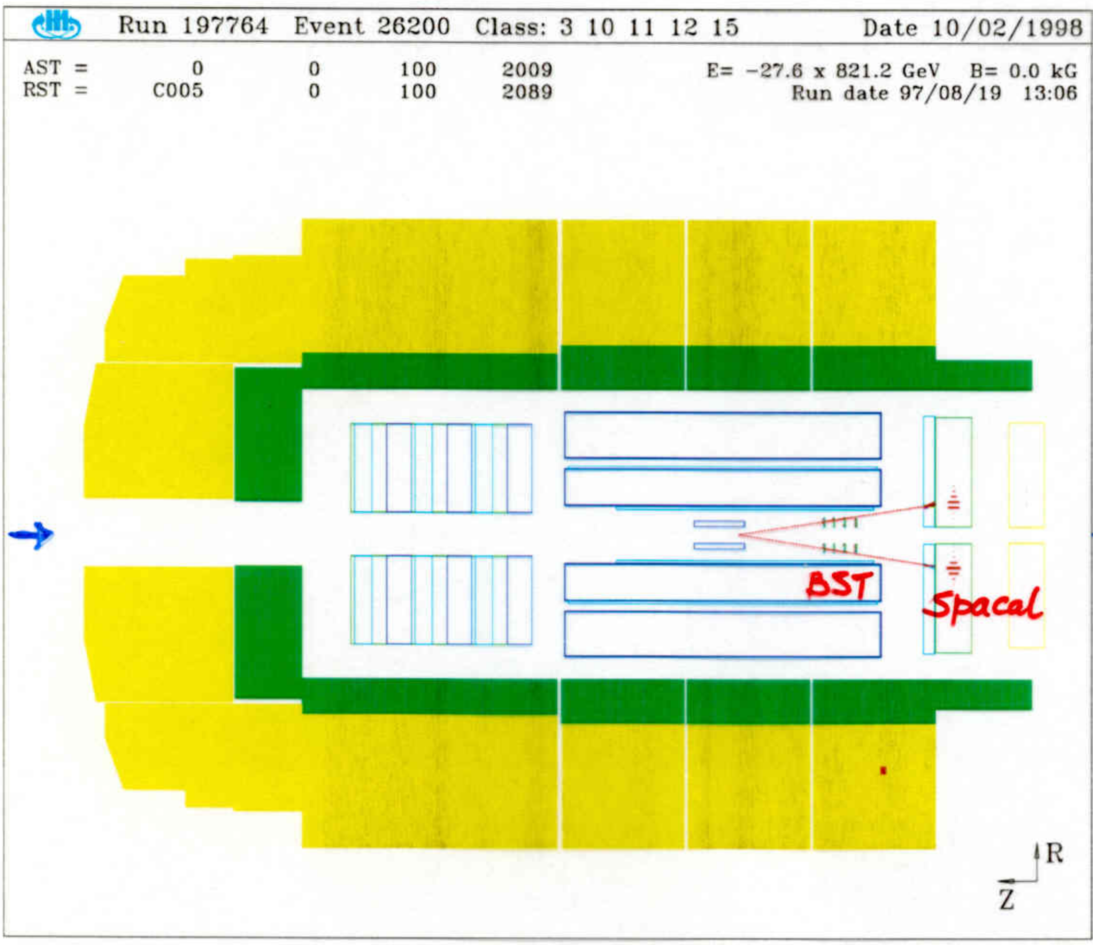
$$\frac{d\sigma}{dt} \sim (\alpha_s \cdot xg)^2$$

$$x = m^2_{J/\psi} / W^2$$

W^{δ}, $\delta = 4(\alpha - 1)$

$\delta = 0.83 \pm 0.07$
H1 data

$ep \to e\, J/\psi\, p$
$\quad \hookrightarrow e^+e^-$

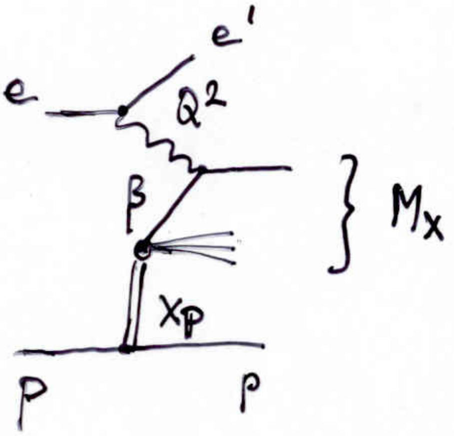


e →

← p

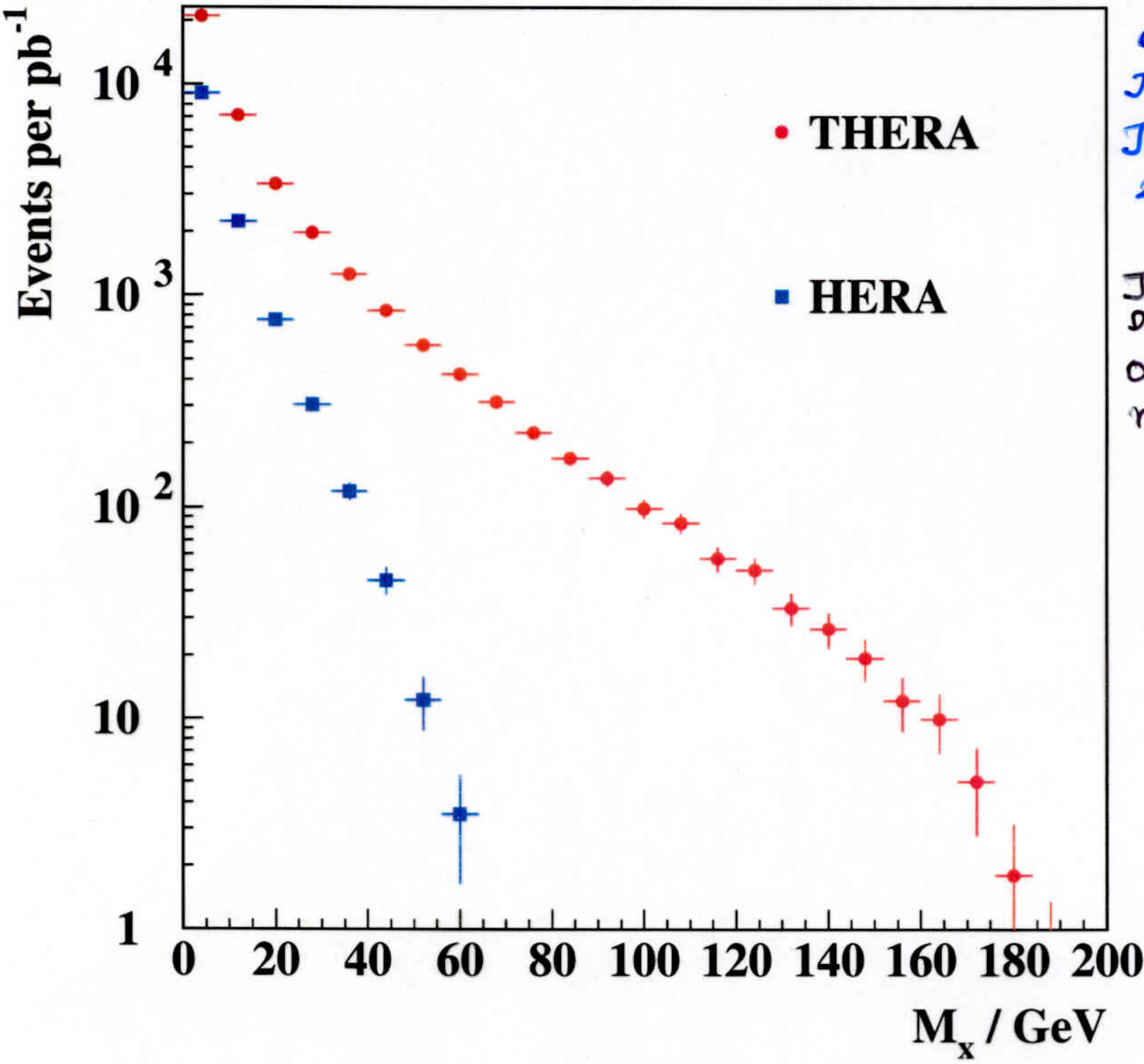
low x:
backward J/ψ

Diffraction



2g exchange ?
Saturation ?

[small x F_2 ↔ high energy behaviour of fwd sc T of $\gamma^* p_{el}$.] optical theorem.



cf. e.g. J. Bartels JPhysG NPP. 26 (2000) 481

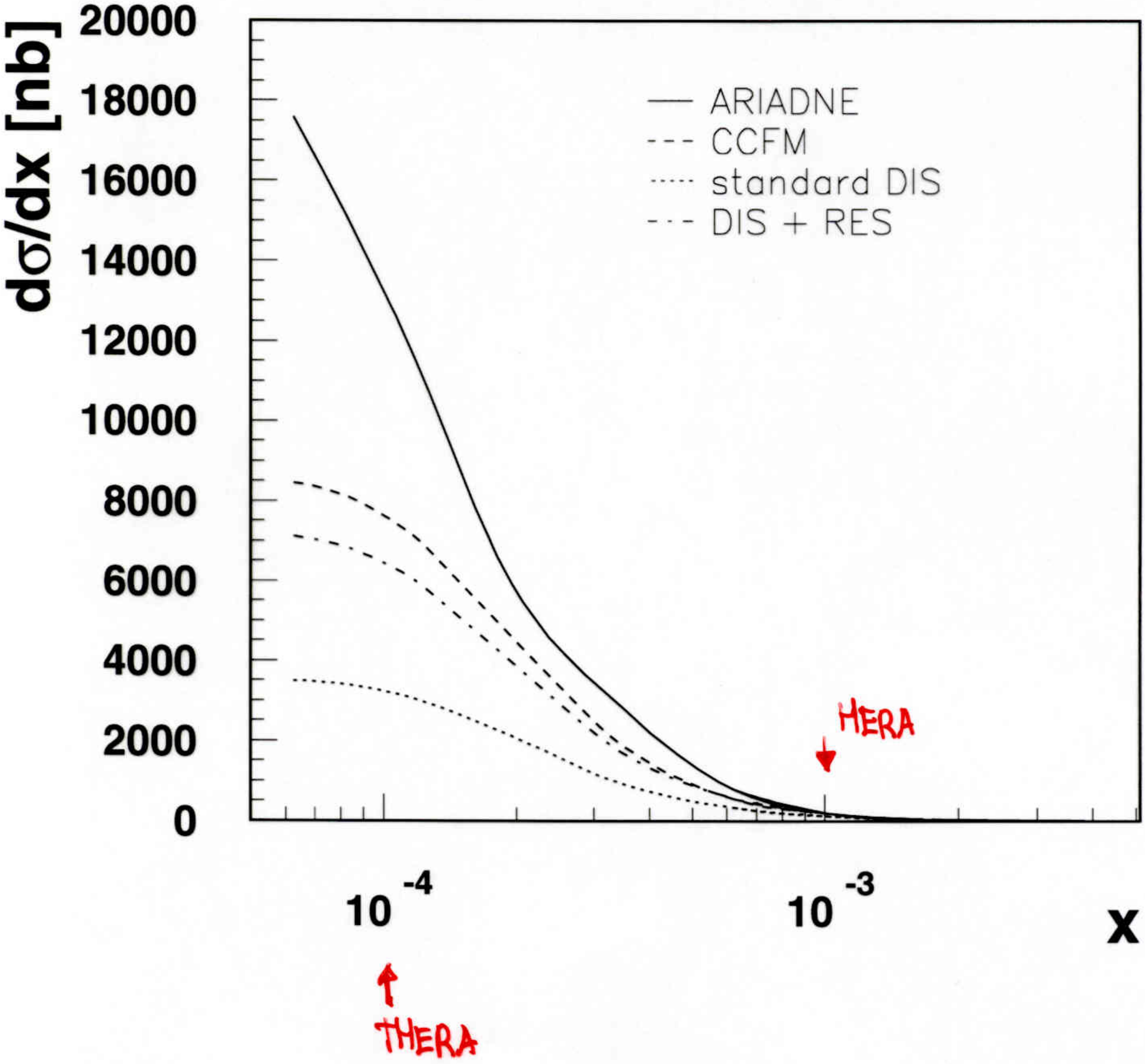
J. Blümlein D. Robaschik. OPE - diffr. recently.

- diffractive parton densities at fixed $x_{I\!P}$: $F_2^{D_3}$ hi $p_\perp$ jets.. diffractive c, b
- $\beta < 0.05$ poorly explored at HERA
- eA : 50% diffraction ?

factorisation J. Collins.

forward jets

- final state production – new evolution eq. @ low x ?
  (non) $k_\perp$ ordered emission of gluons. hotspots ?
  unintegrated parton distributions accessible.



- crucial: ϑ_{jet} as small as possible ~2° !

jets: B. Pötter
Th. book partonshowers hadronisation... !

Thbook: H. Jung, L. Loemblad

4. QCD Tests

α_s

c, b

resolved γ

α_s

- large Q^2. $\Delta\alpha_s(M_Z^2) \simeq 0.001$ 3 loop
- scaling violations (HERA, THERA) [illegible])

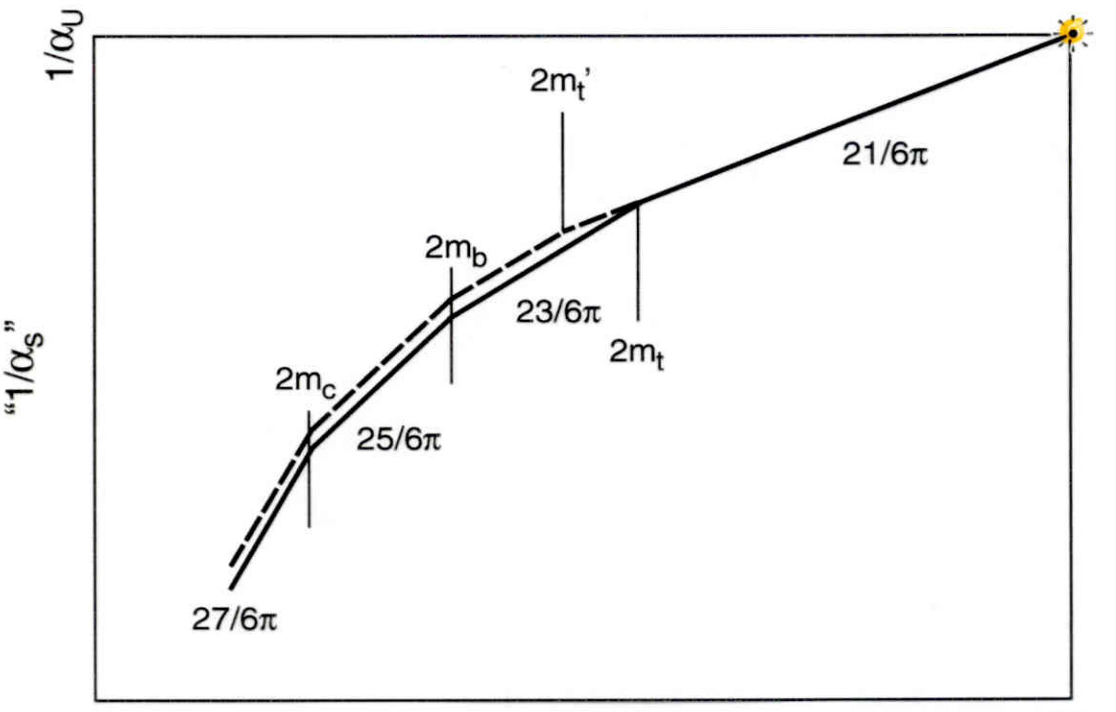
$\delta\alpha_s \simeq 0.0005$ (exp) prel.* ! CC ! $\delta\alpha_s^{\text{HERA alone}} \approx 0.0020$ / 15

precise α_s, free of final state effects

low x ↔ hi x.

* MK. C Pascaud R Wallny Therabook .soon.

$$1/\alpha_s(Q^2) = 1/\alpha_u + \frac{21}{6\pi} \cdot \ln(Q/M_u)$$ unification



- accuracy of α_s much worse than α, G_F, $\sin^2\theta_W$.

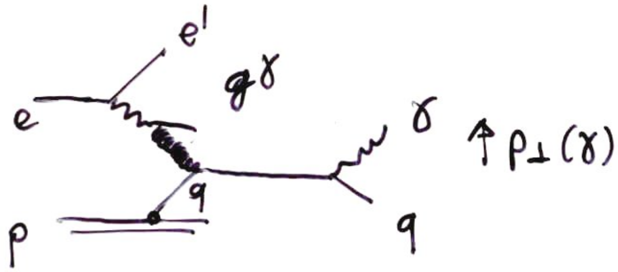
huge efforts for precision $g-2$, $\sin^2\theta_W$ in particular!

- hi x gluon in DIS lower than jets

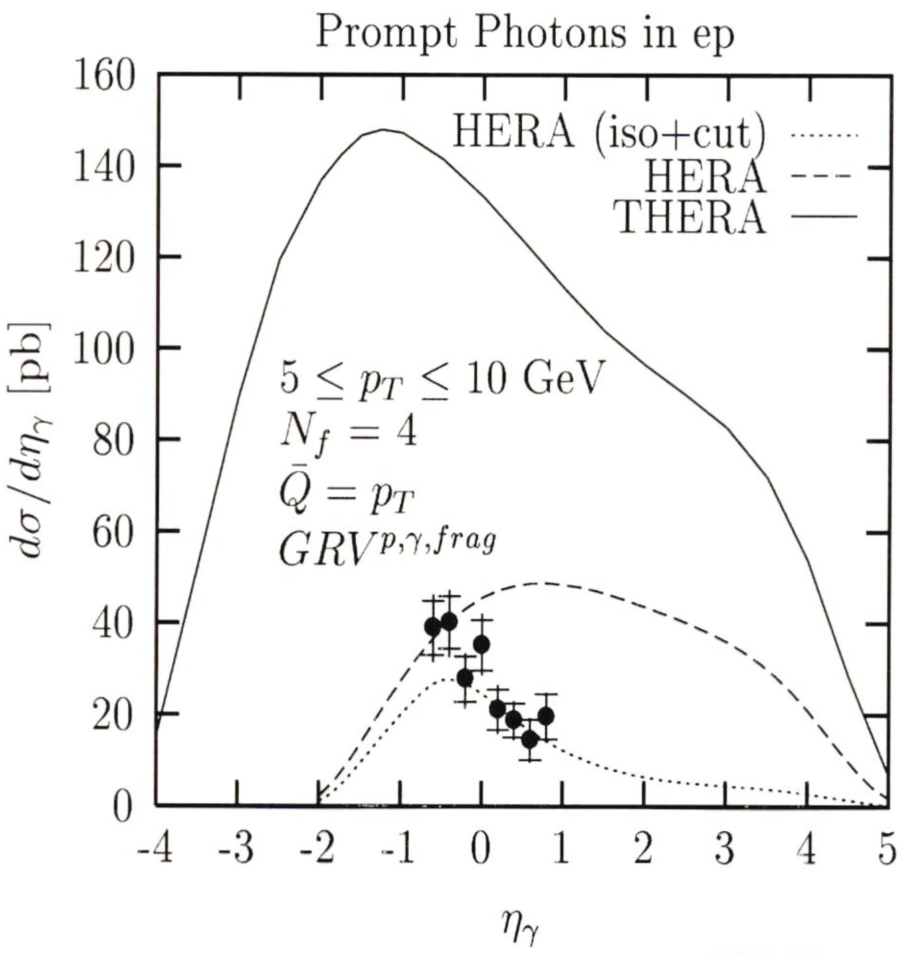
α_s DIS lower than LEP, TeV [or directγ] ? $\tilde{g}$ light.

PRECISION! low Ep @ HERA.

partonic structure of the photon



photoprod. $Q^2 \simeq 0$



Therabook
M. Krawczyk
A. Zembrzuski

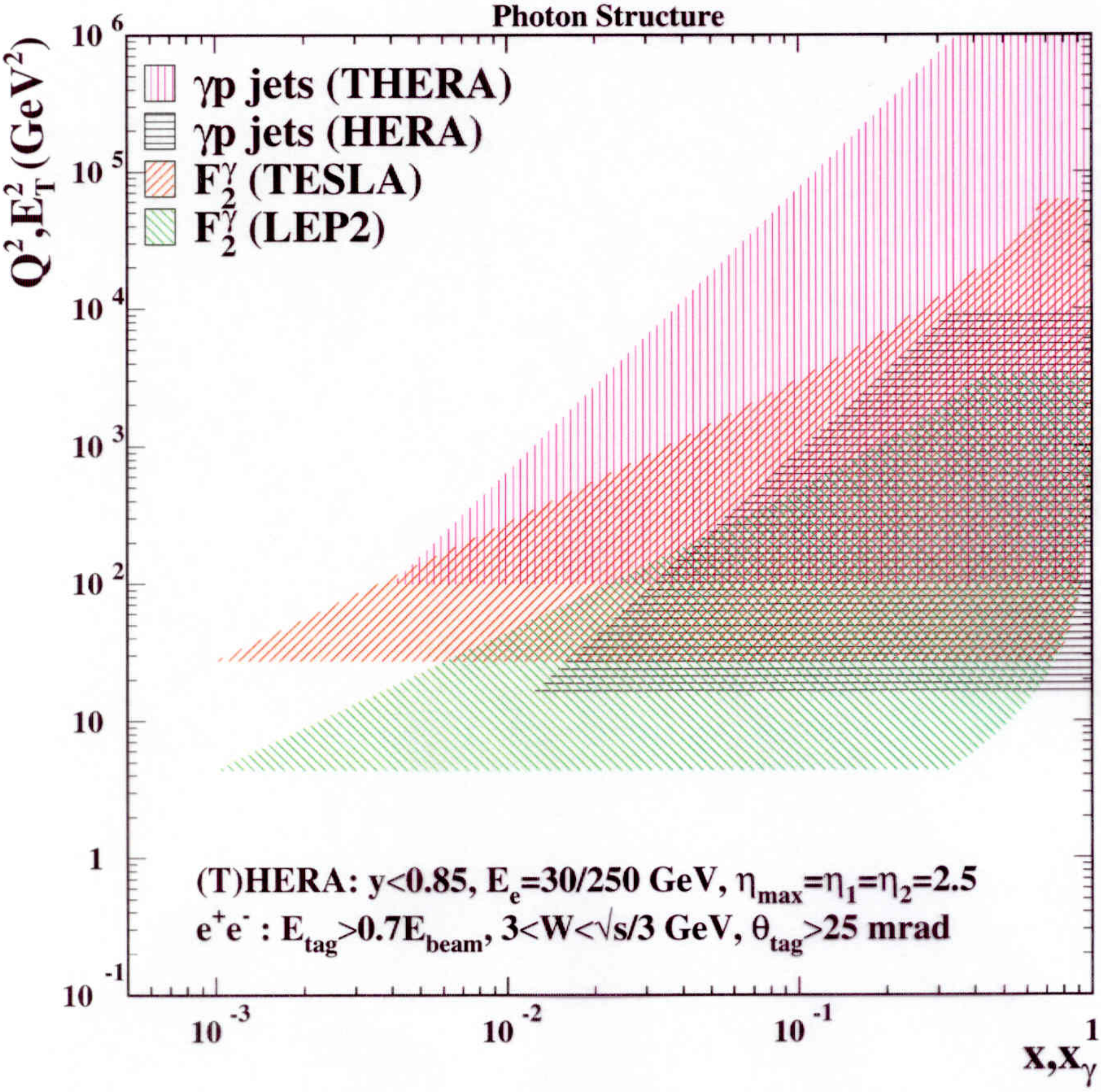
$\eta_\gamma \gtrsim 0$ (fwd) : gγ.q dominant.

study gluonic content of γ

[~ 100 years after Einstein]

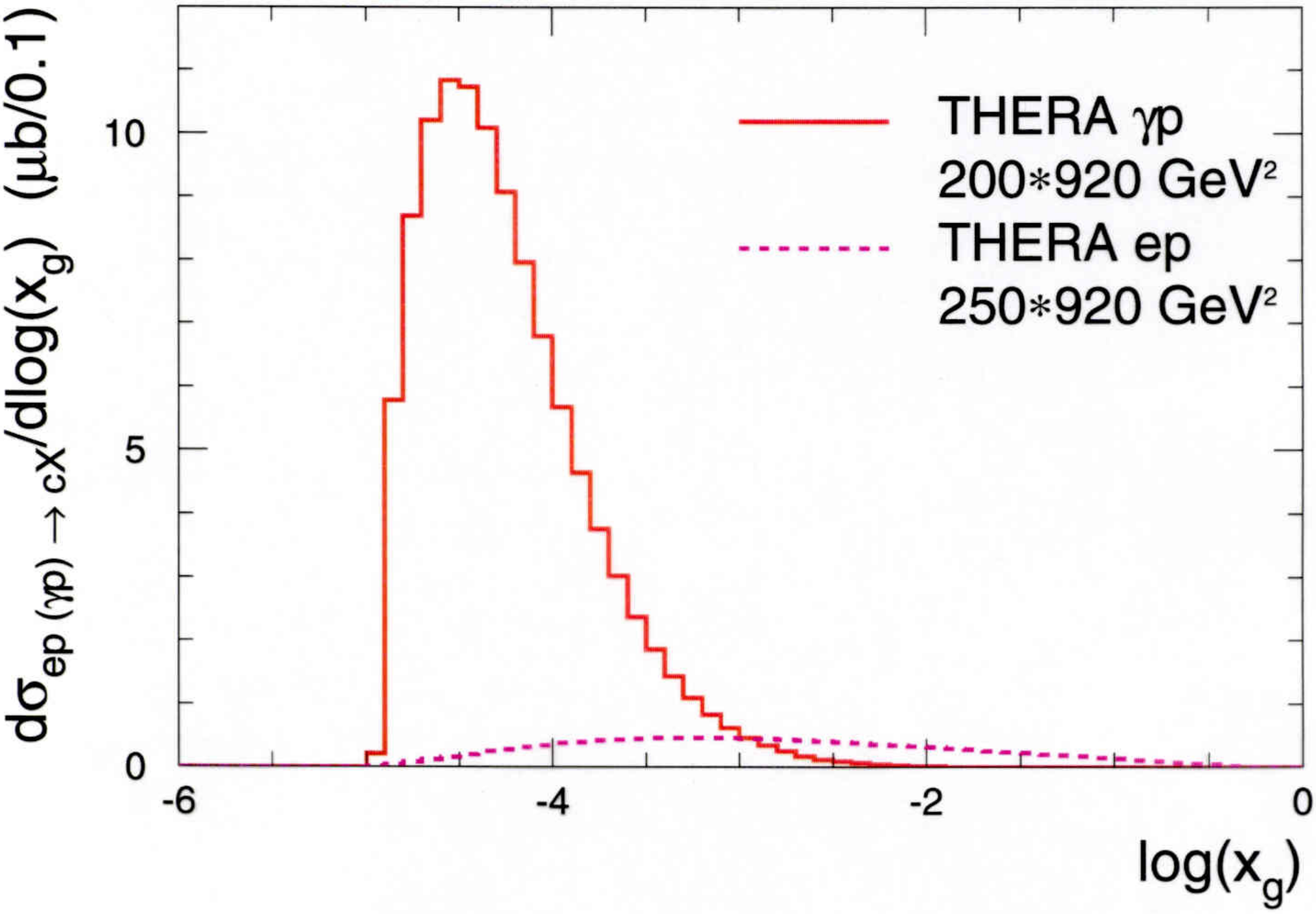
for γ structure THERA - TESLA complementary

as HERA - LEP



- notice γγ for TESLA and γp for THERA

[backscattered laser light] cf. Therabook A. Gftri et al

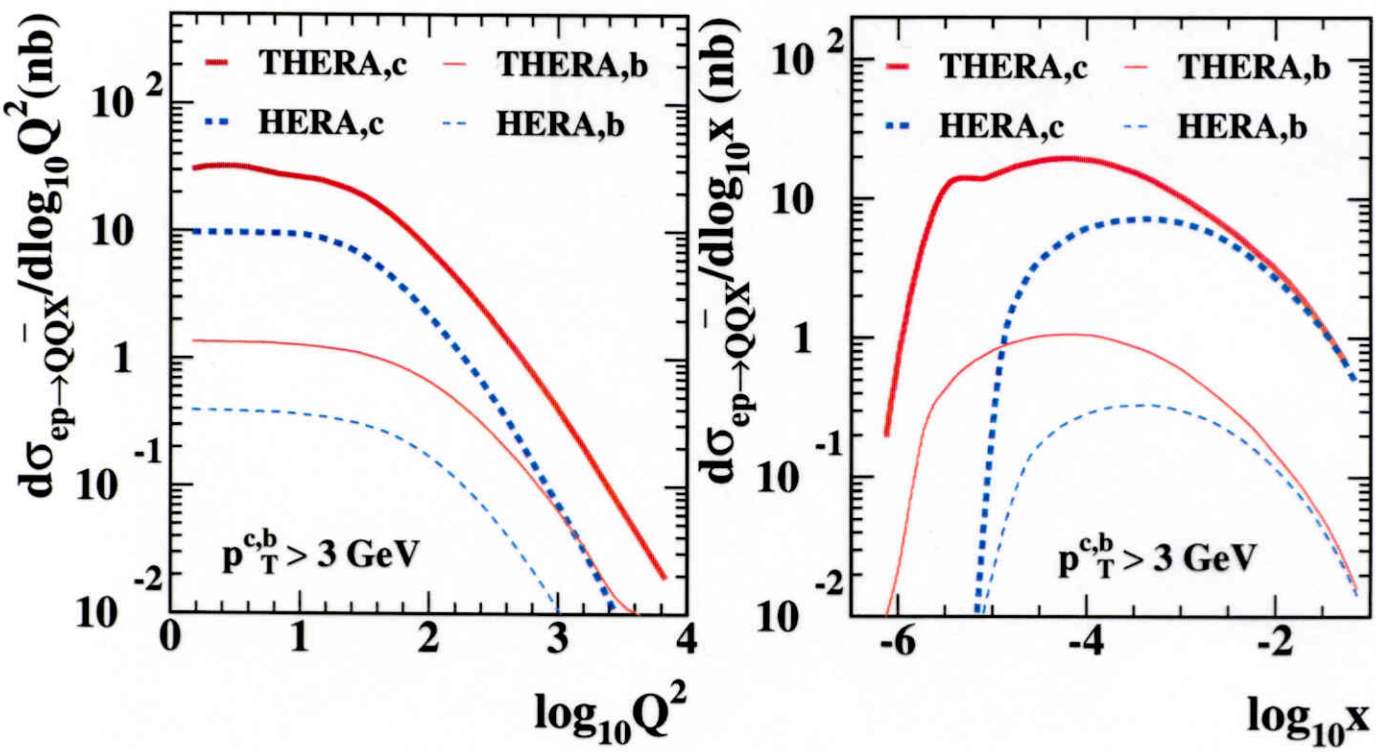


• c, b cross sections much enhanced in real γ over virtual γ p scattering.

heavy flavour electroproduction

L. Gladilin
I. Redondo
(Therabook)

DIS



- enlarged range and cross section in DIS + photoproduction
- large fraction of inclusive cross section ~30% / α_s
- photon-gluon fusion ⇒ xg complementary
- strange in CC
- intrinsic charm at large x ?
- $m_c = ?$ 100 MeV ↔ $\delta\alpha_s = 0.0005$

A NEW FIELD SINCE HERA LOW x.

WE EXPECT THAT THE SAME FEATURES OF CHARM PRODUCTION AT HERA WILL PERSIST FOR BOTTOM PRODUCTION AT THERA

[W.v. Neerven Dec. 2000. thera webpage]

CONCLUSIONS

1. ELECTROPRODUCTION OF HEAVY FLAVOURS IS THE BEST TESTING GROUND OF QCD

   THIS PHENOMENON IS DUE TO THE LIGHT CONE DOMINANCE FOR $F_{k,c}$, $F_{k,b}$

2. BECAUSE OF THE NON-RESUMMABLE $\ln \frac{s}{m^2}$ TERMS IN PHOTO AND HADRO PRODUCTION, NNLO CORRECTIONS WILL NOT CLOSE THE GAP BETWEEN PERT QCD AND DATA (TOO LARGE K-FACTORS)

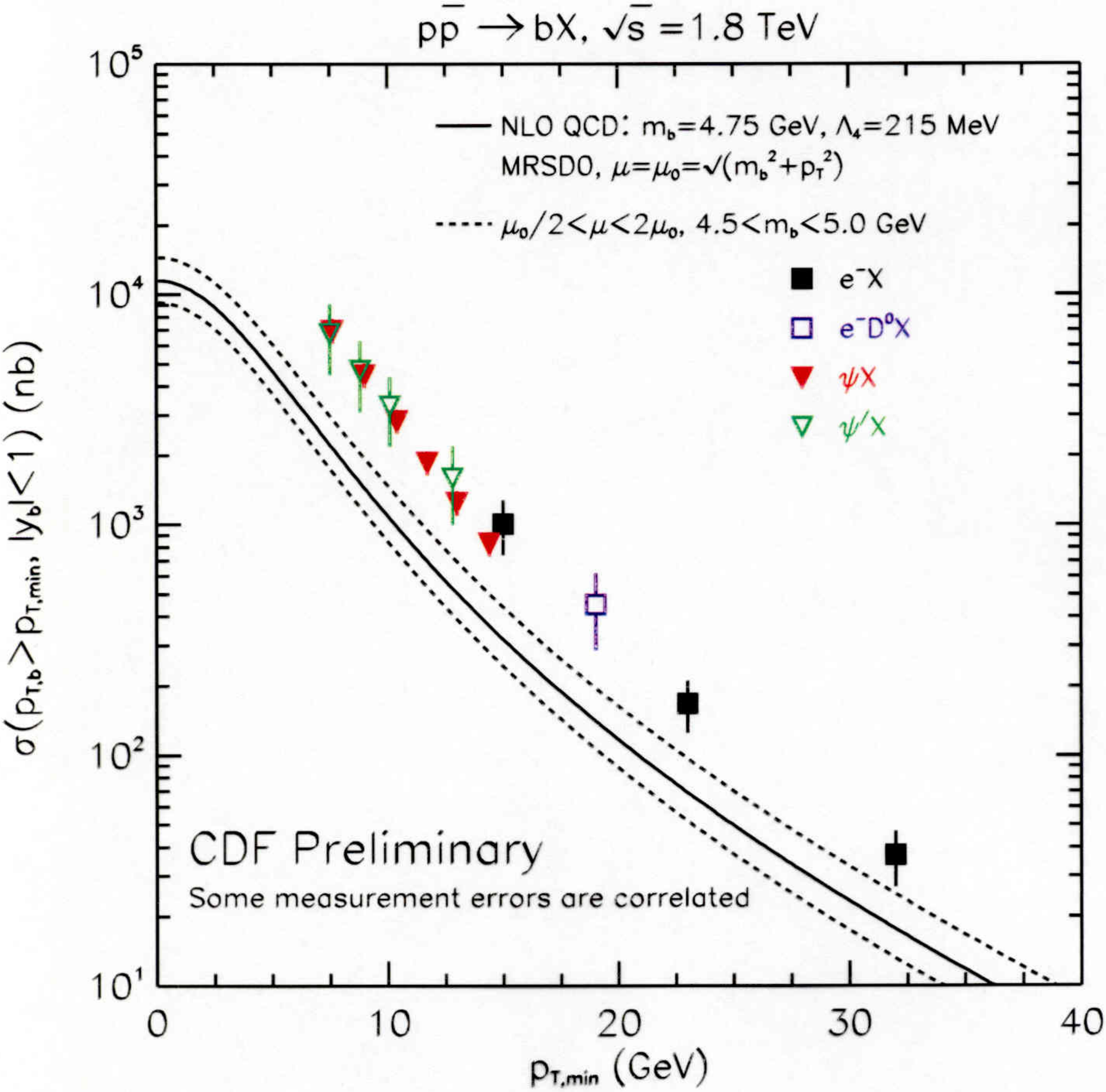
3. STRUCTURE FUNCTIONS AND e^+e^- COLLINEAR SAFE OBSERVABLES ARE THE BEST OBJECTS TO TEST PERT. QCD.

" an embarrassment for PQCD

[gluon diagram] $b\bar{b}$ is suspect "

Tung.

Beauty ?



H1. $\sigma_{vis}(ep \rightarrow b\bar{b}X \rightarrow \mu X) = (170 \pm 25)$ pb

Osaka 00 $\sigma_{NLO\,QCD} = (104 \pm 17)$ pb

impact parameter analysis using CST.

$\delta_{\mu Z}$ 500 μm

5. high Q^2

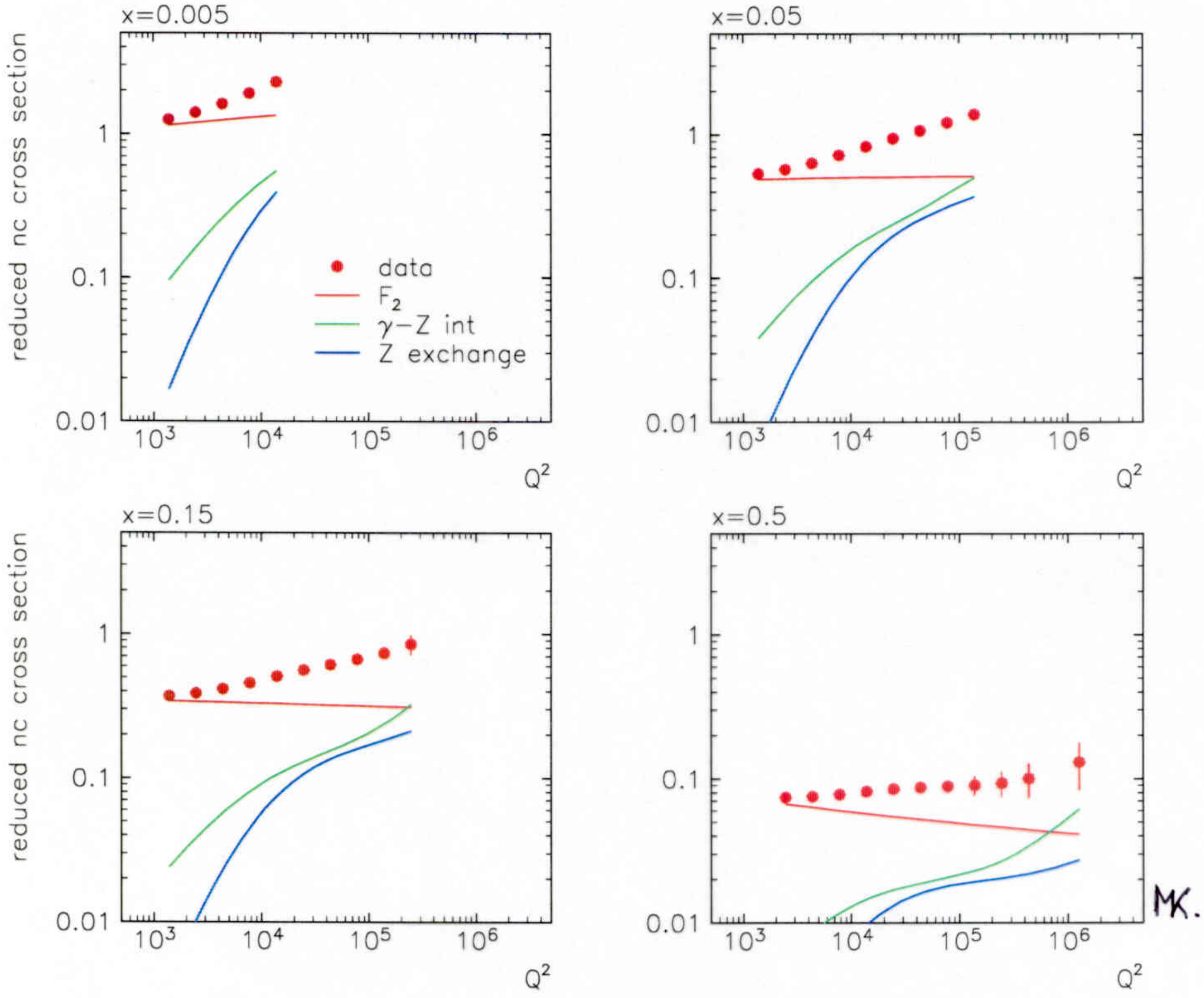
$$Q^2 = sxy < 4 E_e E_p$$

$$Q^2_{max} \sim 1.000.000 \, GeV^2 = 1 \, TeV^2$$

NC, CC

searches

high Q^2



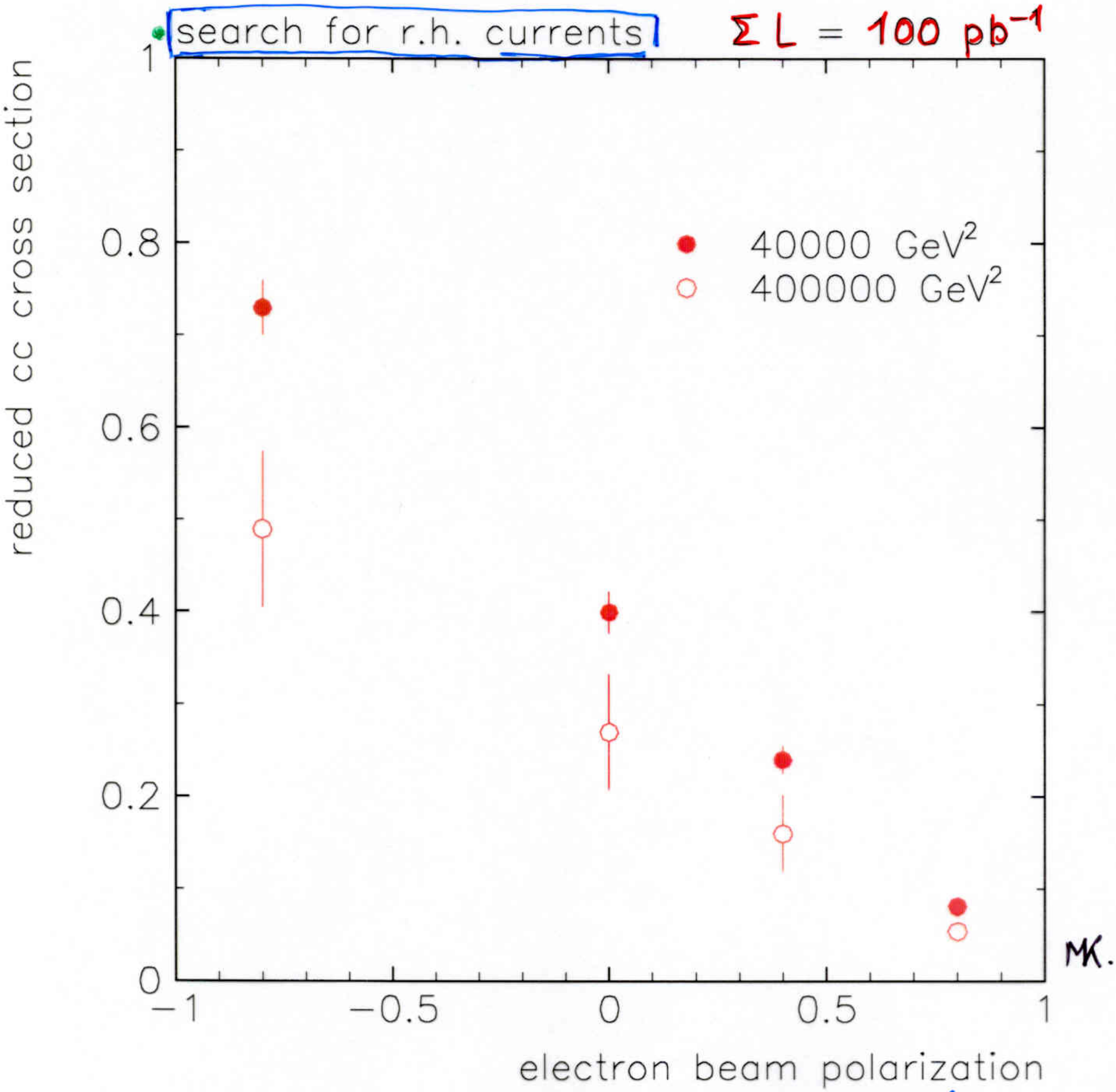
stat + syst
simulation.

+ high precision : α_s pp physics.
+ truely electroweak : light q couplings / not investigated.
+ partons u/d at high x (NC, CC)

$\alpha_s \to 0$ predictable in pQCD. / does not have to be right.

$$\frac{d^2\sigma_{cc}^{\pm}}{dx\,dy} = \frac{G_F^2}{2\pi}\left(\frac{M_W^2}{Q^2+M_W^2}\right)^2 \cdot s\ \frac{1\pm\lambda}{2} \cdot \left[Y_+ W_2^{\pm} \mp Y_- x W_3^{\pm}\right]$$

- high precision measurement of CC for $Q^2 \gtrsim 10.000\ GeV^2$
- complete flavour decomposition with NC, CC.
- search for r.h. currents



high TESLA polarisation !!

cf. K. Nagano Thera book

Searches & spectroscopy.

- Leptoquarks

SM   F=2   0 e^-q

        0   2 e^+q

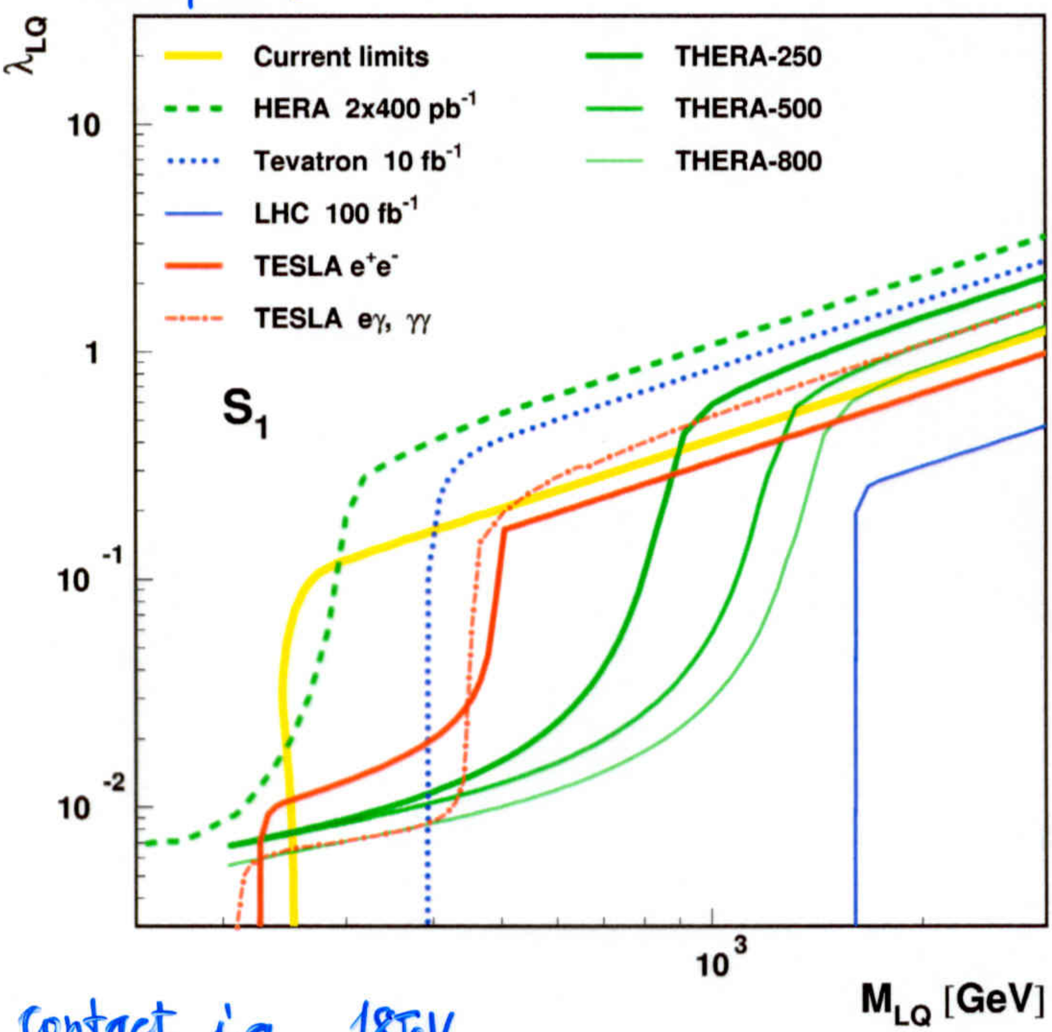
S,V ϑ of final state lepton

F   compare e^+/e^-

chirality λ_e

14 states.

(also squarks in R_p SUSY)



$S_1: F=2$

$Q=-4/3$ $e_L d$.

$-1/3$ $e_L u$, νd

BRW model

- contact i.a. 18 TeV
- extra dimensions 2.8 TeV

if LQ exist with M < 1 TeV
THERA ideal. spectroscopy
needs large $\mathcal{L} \gg 100\,pb^{-1}$

A.F. Zarnecki
Therabook
(E. Perez, M. Kuze, M. Corradi)

6. experimentation

kinematics

interaction

detector(s).

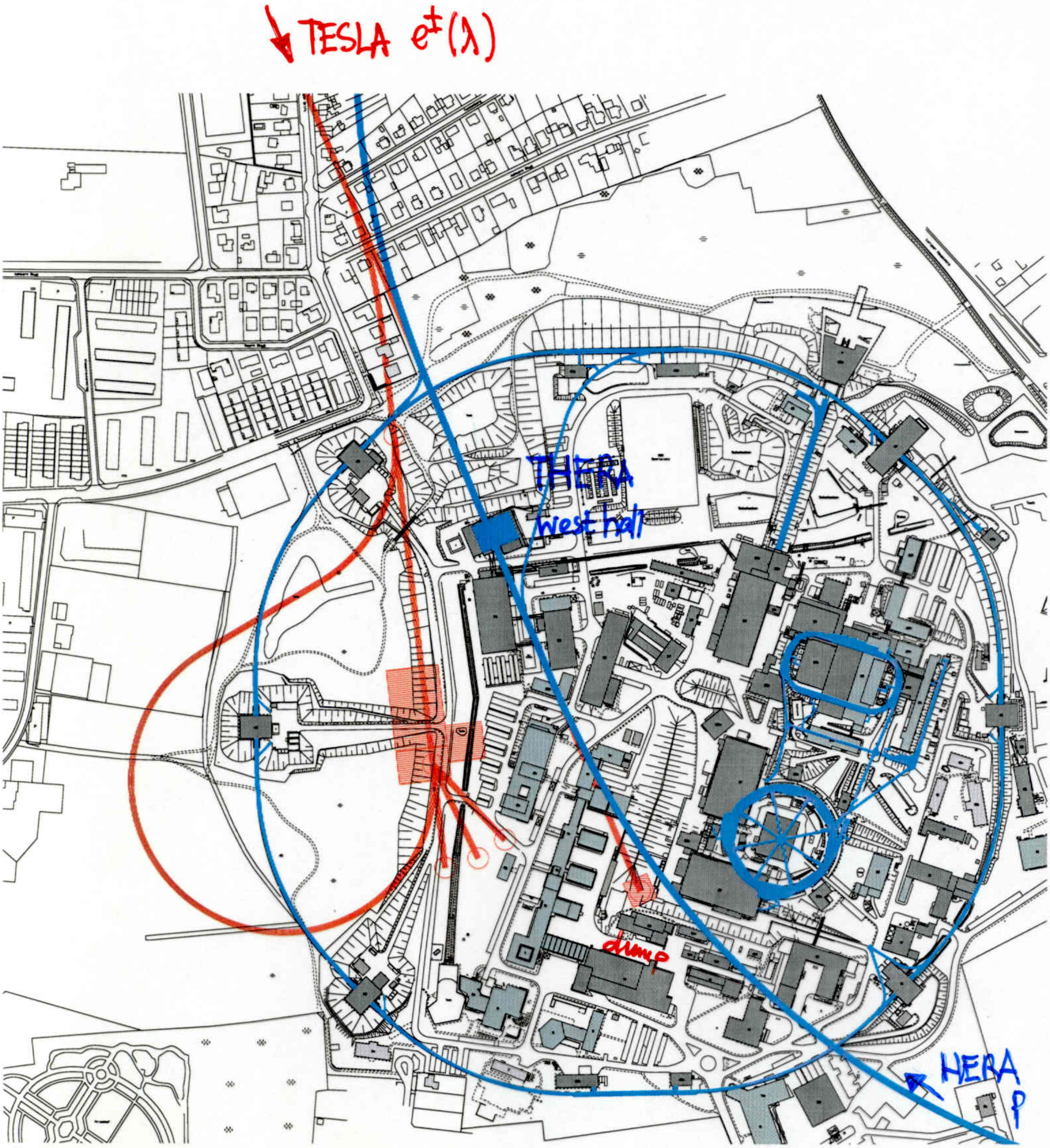
single arm: 250 GeV * 1 TeV low x . Ee/Ep<1 40 pb^{-1}/y

double arm: 500 GeV * 500 GeV high $\mathcal{L}$ 250 pb^{-1}/y

power upgrade: 800 * 800 GeV/2 high Q^2 160 pb^{-1}/y

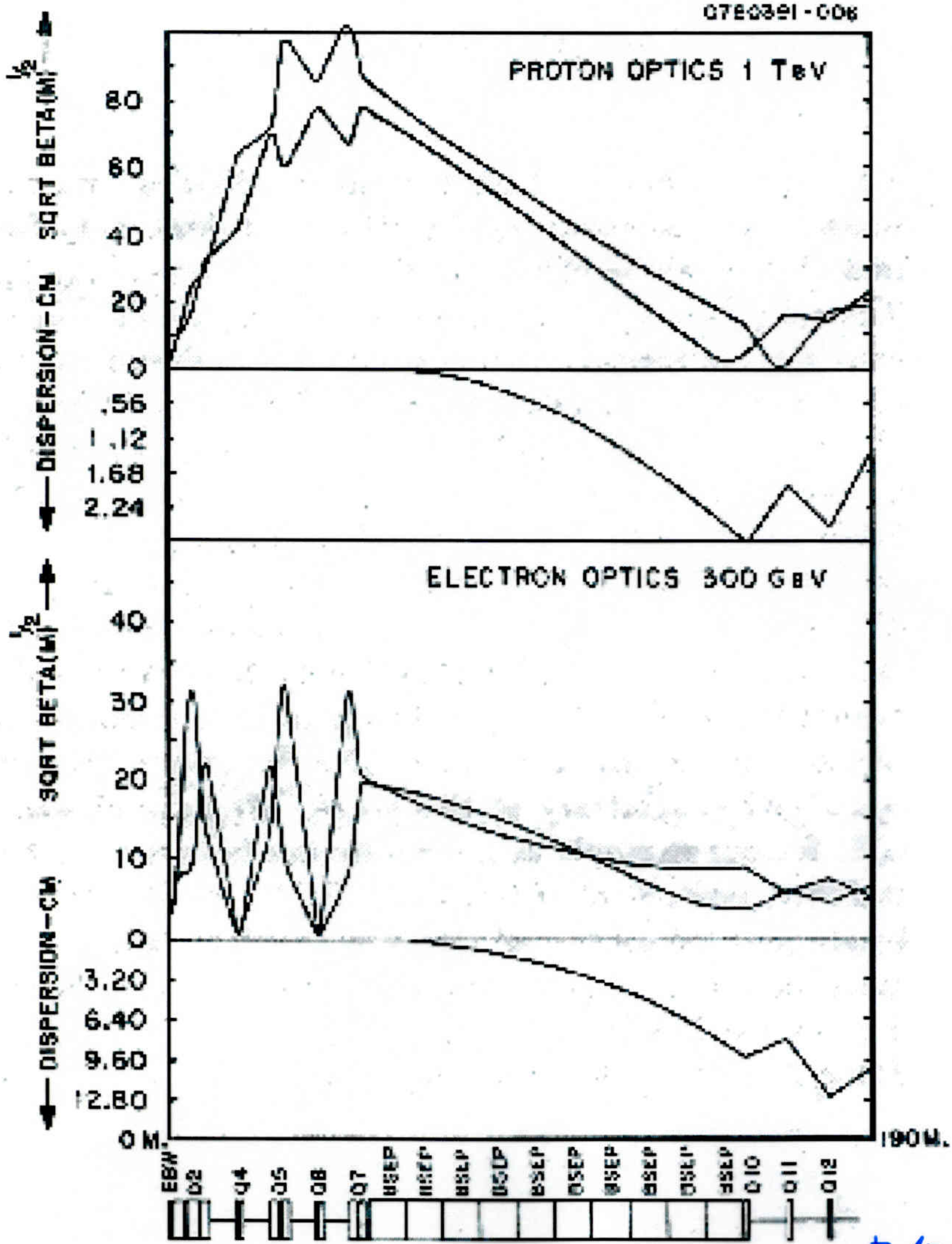
y = 200 d ε = 60%

Ie const. in time!



possible THERA interaction region

F. Willeke



Ee/Ep 1... 1/4.

Wiik, Willeke, Tigner
IEEE S.Fr. 90

R. Brinkmann
Ankara Wshop 96

M. Dohlus
DESY M 95-11.

THERA Machine Parameters

electron beam parameters	
electron energy	$E_e = 250\,\mathrm{GeV}$
number of electrons per bunch	$N_e = 2 \times 10^{10}$
bunch length	$\sigma_{se} = 0.3\,\mathrm{mm}$
invariant emittance	$\varepsilon = 100 \times 10^{-6}\,\mathrm{m}$
beta function at IP	$\beta_{x,y} = 0.5\,\mathrm{m}$
electron tune shift	$\Delta\nu_y = 0.228$
disruption	$D = 0.02$
bunch spacing	$t_{be} = t_{bp} = 211.37\,\mathrm{ns}$
RF frequency	$f = 1301\,\mathrm{MHz}$
accelerating gradient	$g = 23.4\,\mathrm{MV/m}$
beam pulse length	$T_p = 1.19\,\mathrm{ms}$
number of bunches	$56 \times (94 + 6$ empty bunches$)$
duty cycle	$d = 0.5\%$
repetition rate	$f_r = 5\,\mathrm{Hz}$
beam power	$P_b = 22.6\,\mathrm{MW}$
proton beam parameters	
proton energy	$E_p = 1\,\mathrm{TeV}$
number of protons per bunch	$N_p = 10^{11}$
number of bunches	$N_{pb} = 94$
beam current	$I_p = 71\,\mathrm{mA}$
bunch length	$\sigma_p = 10\,\mathrm{cm}$
beta functions at IP	$\beta^*_{xp} = 10\,\mathrm{cm}$
normalised emittance	$\varepsilon_p = 1 \times 10^{-6}\,\mathrm{m}$
IBS growth time transv./long.	$\tau_s = 2.88\,\mathrm{h}, \tau_x = 2.0\,\mathrm{h}$
collider parameters	
hourglass reduction factor	$R = 0.9$
crossing angle	$\theta = 0.05\,\mathrm{mrad}$
luminosity	$L = 4.1 \times 10^{30}\,\mathrm{cm^{-2}\,s^{-1}}$

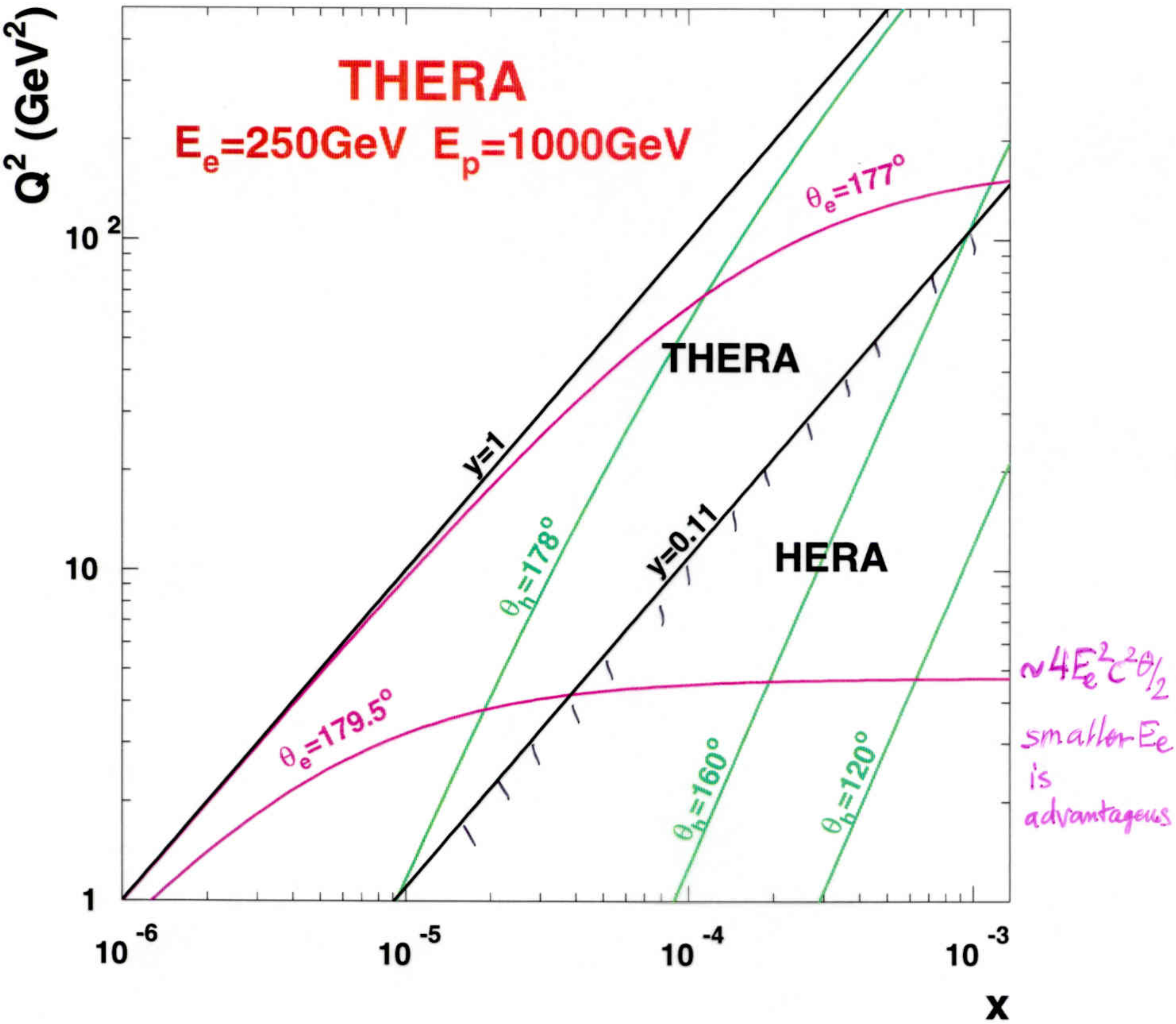
may need cooling in PETRA * 2-3

beam sep in long defoc. quadrupole
no upstream synchr. rad. , pipe radius 2cm
detector short in z !

low x at THERA

$E_e' \simeq (1-y) \cdot E_e$ large

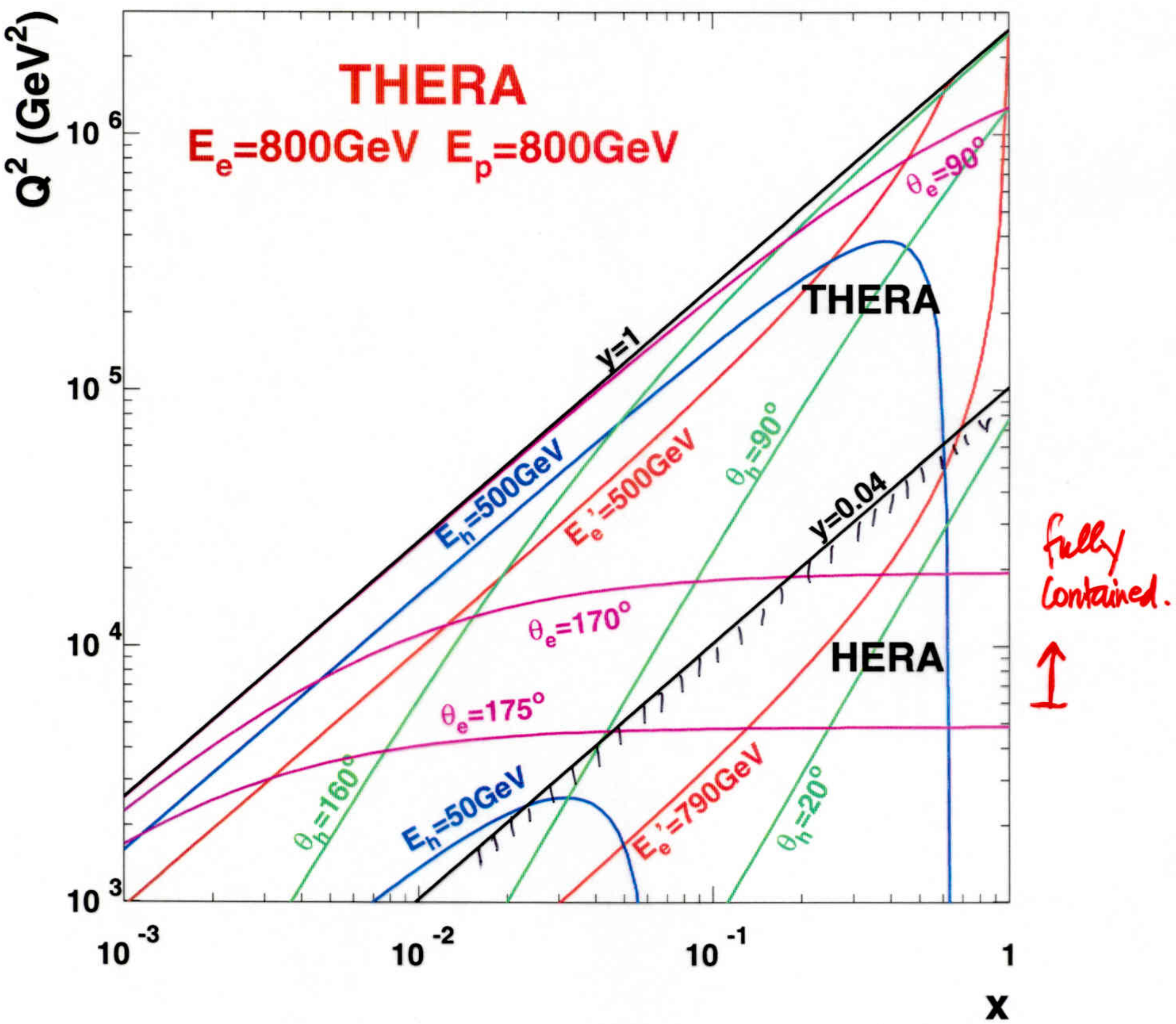
$E_h \simeq y \cdot E_e$ large



tracking & calorimeter near pipe

MC & resolution studies made

hi Q² kinematics.

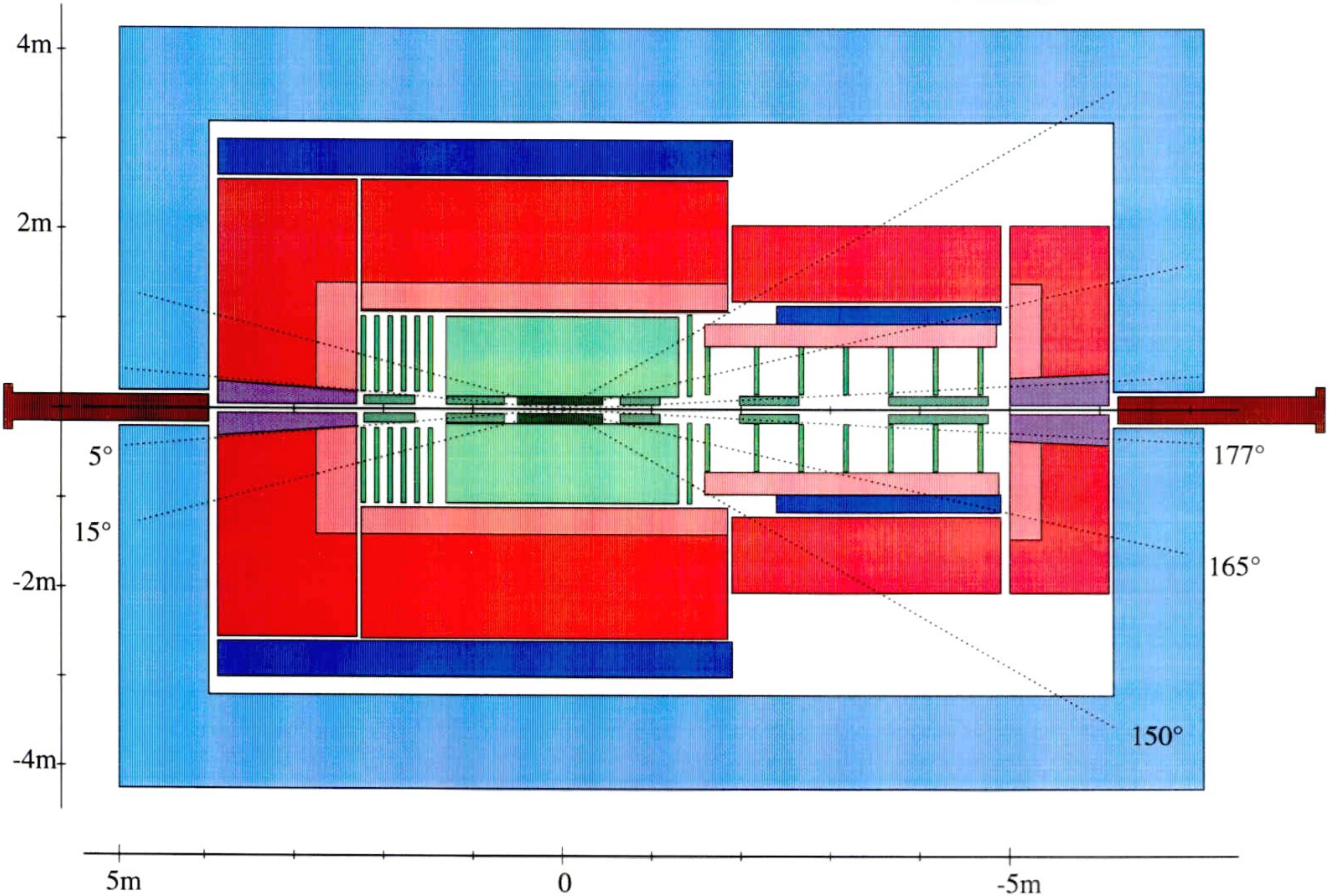


no kinem. peak

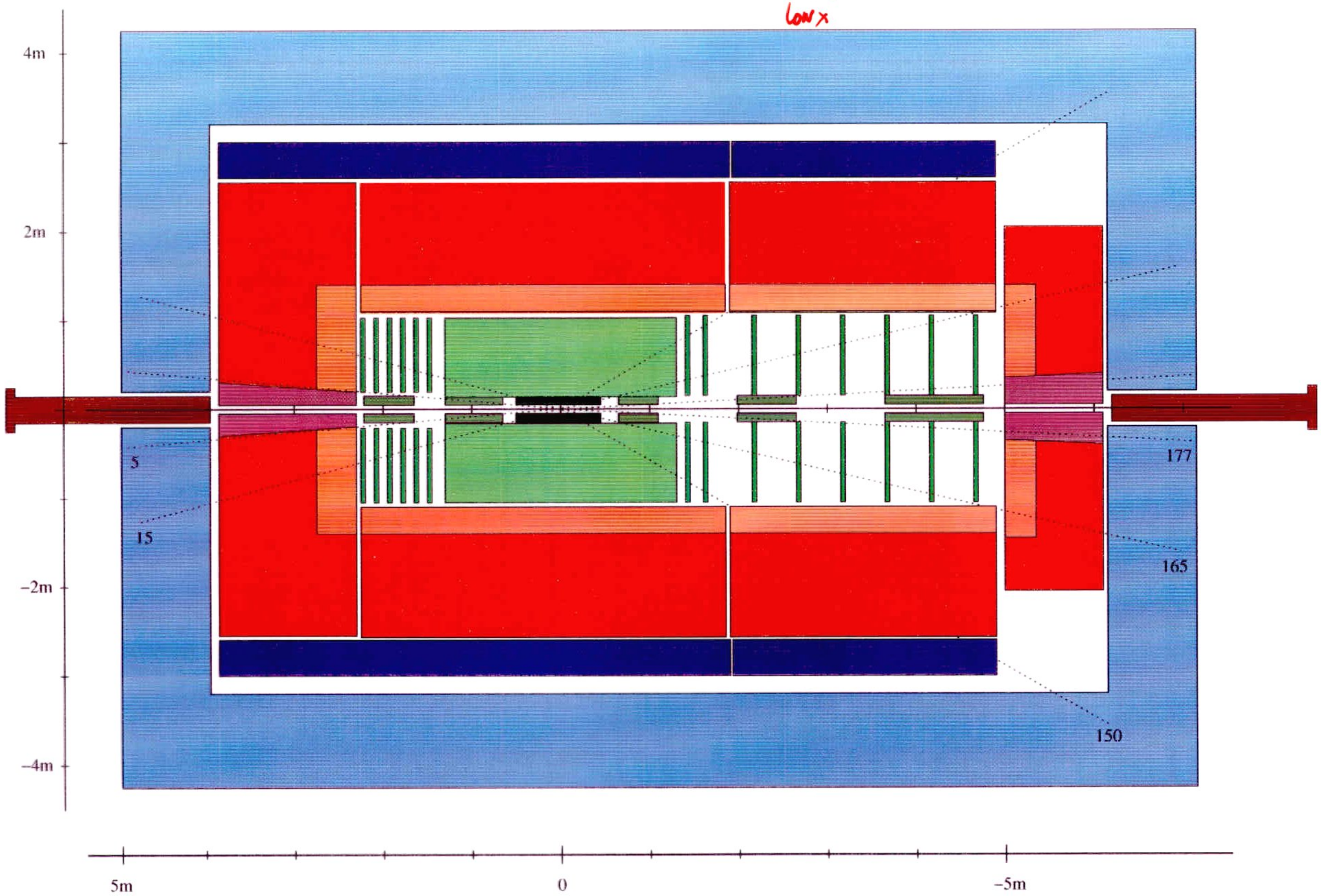
max. energies at HERA ≤ E_p

H1 calo fwd, central ?

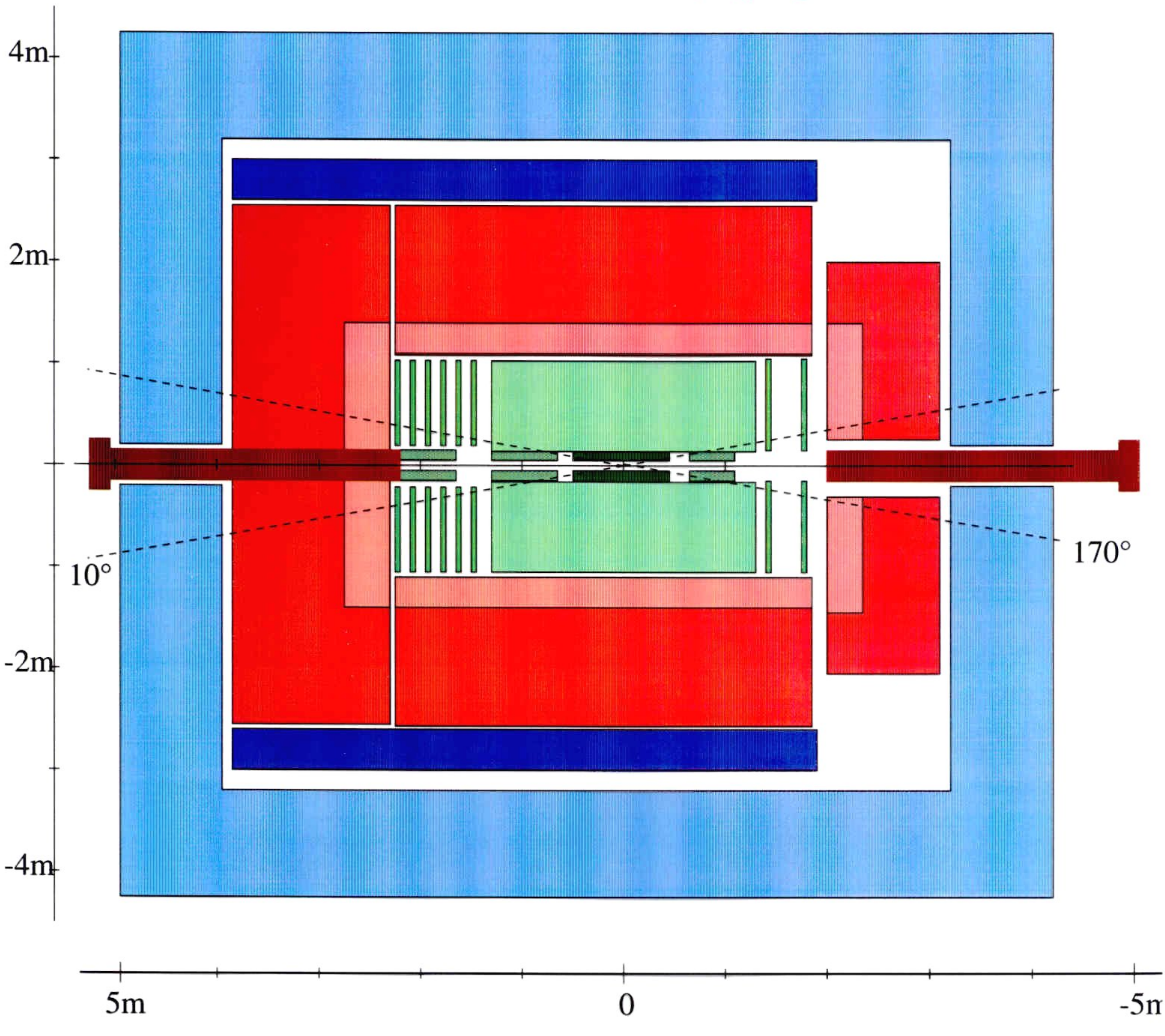
THERA DETECTOR, low x Y1. TDR.



THERA DETECTOR V2.
low x



THERA DETECTOR, high Q^2



- TESLA & HERA match in i.a. space
  & collision time

thus

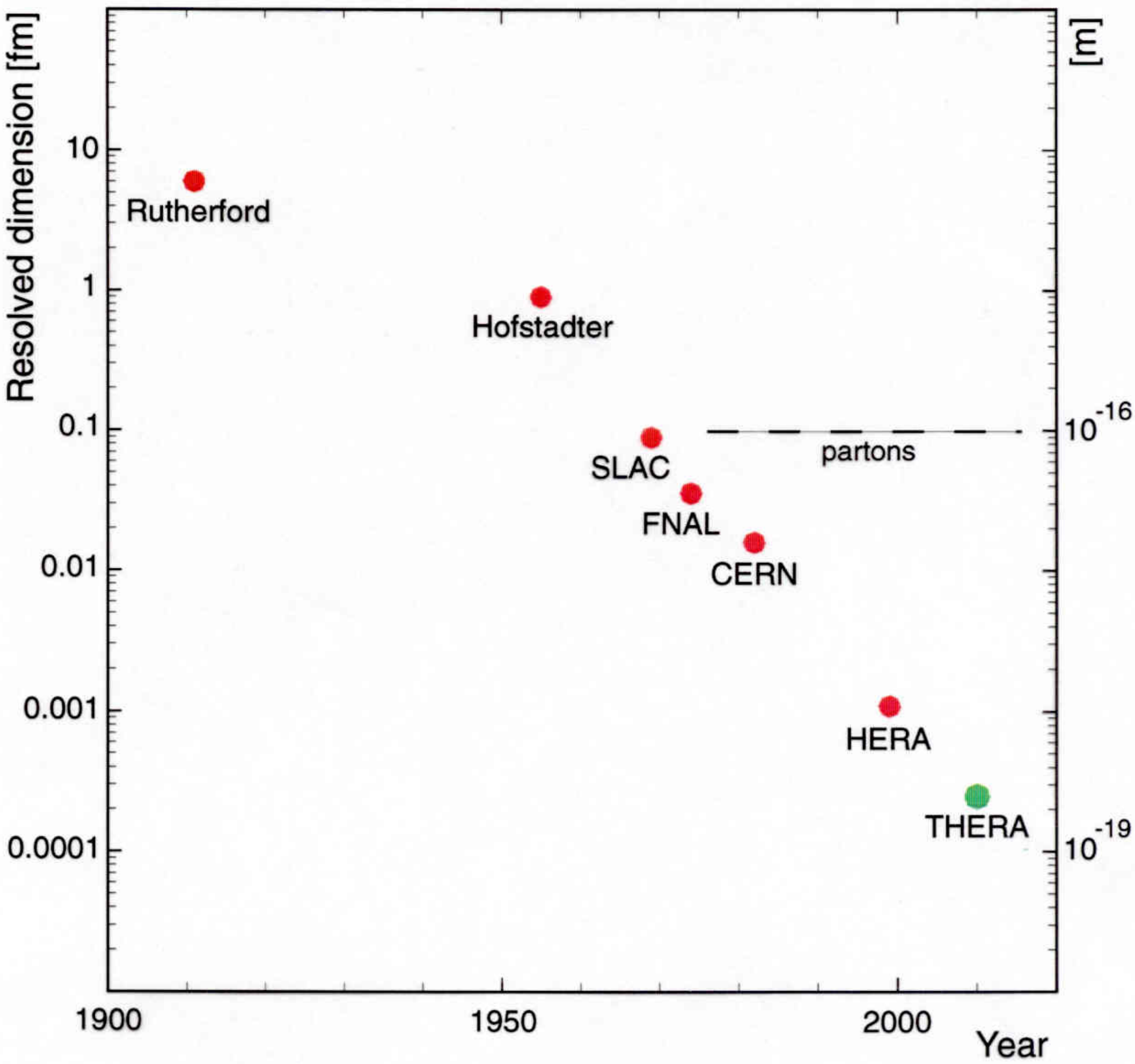
- THERA unique, cost effective facility
  for investigating matter structure
  down to 10^{-19} m

- a rich, broad research programme
  - strong i.a. at high parton densities
  - precision tests of QCD in small + large dimensions
  - exploration of new phenomena

- attractive complement to pp & e^+e^- at $\sqrt{s} \sim 1$ TeV
  and the natural successor of HERA

- including its options $\vec{e}\vec{p}$, eA
  and (new) real γ N scattering.

- its realization requires courage
  and dedicated proton accelerator R&D.


Resolved dimension [fm]
[m]
10
1
0.1
0.01
0.001
0.0001
10^-16
10^-19
Rutherford
Hofstadter
SLAC
FNAL
CERN
HERA
THERA
partons
1900
1950
2000
Year