GEGENWÁRTIGE TENDENZEN DER ELEMENTARTEILCHENPHYSIK

JB 3/88

1. $SU_{3C} \times SU_{2L} \times U_{1Y}$ STANDARDMODELL:

   THEORIE VS. EXPERIMENT

2. JENSEITS DES STANDARDMODELLS: (SEL. TOPICS)
   - THEORIE (HAUPTRICHTUNGEN)
   - EXPERIMENTE (BESCHLEUNIGER, DETEKTOREN)

3. TIEF INELASTISCHE LEPTON-HADRON REAKTIONEN
   $[Q^2 \lesssim 5 \cdot 10^4\ GeV^2,\ x \gtrsim 5 \cdot 10^{-5}]$

1. STANDARDMODELL

$$SU_{3C} \times SU_{2L} \times U_{1Y}$$

SU_{3C} ↓ QCD

$SU_{2L} \times U_{1Y}$ ↓ GWS

QCD:

- GELL-MANN '72
  FRITZSCH, LEUTWYLER
- GROSS, WILCZEK, '73
  POLITZER

GWS:

GLASHOW	'62
WEINBERG	'67
SALAM	'67
T'HOOFT	'72
GIM	'70

A. THEORIE :

$\mathcal{L}_{eff}$

ψ ⟶ $e, \mu, \tau, \nu_e, \nu_\mu, \nu_\tau$; u, d, s, c, b, t — FERMIONEN $s = 1/2$

A ⁓⁓› $\gamma, W^{\pm}, Z^0, g_{\alpha\beta}$ — BOSONEN $s = 1$

η — BOSONEN $s = 0$

$$\mathcal{L}_{eff} = \mathcal{L}_F + \mathcal{L}_V + \mathcal{L}_H + \underline{\mathcal{L}_{int}}$$

$$\mathcal{L}_F = \sum_\alpha \bar{\psi}_\alpha (i\partial\!\!\!/ - m_\alpha)\psi_\alpha$$

$$\mathcal{L}_V = -\frac{1}{4}\left(W_{\mu\nu}W^{\mu\nu} + B_{\mu\nu}B^{\mu\nu}\right) + \frac{1}{2}m_W^2\left(W_1^2 + W_2^2\right) + \frac{1}{2}m_Z^2 Z^2$$

$$(m_\gamma = 0,\ m_g = 0) \qquad - \frac{1}{4} G_{\mu\nu}G^{\mu\nu}$$

$$\mathcal{L}_H = \partial\eta\partial\eta - m_H^2\eta^2$$

YANG - MILLS FELDSTÄRKEN:

$$F^a_{\mu\nu} = \partial_\mu A^a_\nu - \partial_\nu A^a_\mu - g\, C^a{}_{bc} A^b_\mu A^c_\nu$$

- $m_W,\ m_Z,\ m_H,\ m_{\psi_i}\big|_{i=1}^{6}(q),\ m_{\ell_i}\big|_{i=1}^{3}(\ell) \quad \left(m_{\nu_i}\big|_{i=1}^{3}(\nu)\right).$

  12 (15) PARAMETER

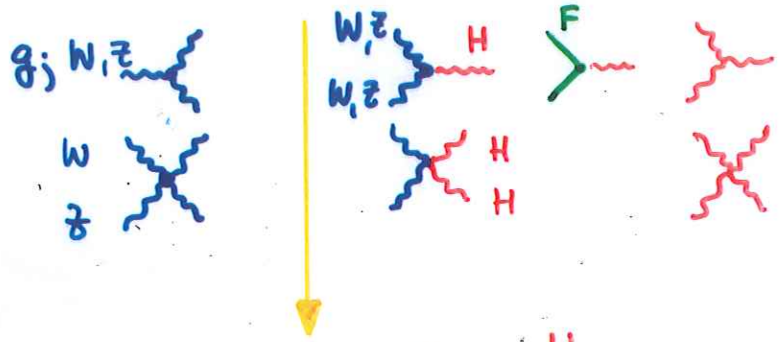
- $g(U_Y),\ g(SU_2),\ g(SU_3)$ + 2 PARAMETER

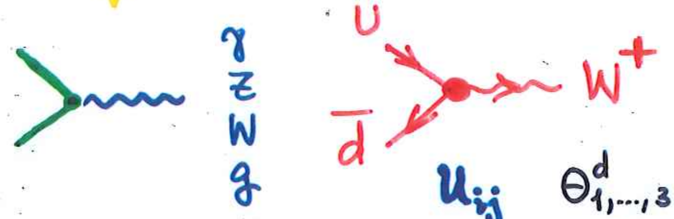
  $\downarrow$ e $\quad$ $\downarrow$ $(\sin^2\theta)$ $\quad$ $\downarrow$ Λ_{QCD}

  nicht neu

  $\cos^2\theta = M_W^2 / M_Z^2$

$$\mathcal{L}_{int} = \mathcal{L}_{VV} + \mathcal{L}_{VF} + \mathcal{L}_{HV} + \mathcal{L}_{HF} + \mathcal{L}_{HH}$$





U_{ij} $\Theta^{d}_{1,\dots,3}, \delta^{d}$

Kobayashi-Maskawa Matrix

$(\Theta^{\nu}_{1,\dots,3}, \delta^{\nu})$

- 4 Parameter $(q_d's)$
- (4 " $(\nu's)$)

---

18 PARAMETER ($\leq$25 PARAMETER WENN $\forall \nu, m_\nu > 0$.)

↑ ZU VIELE ! ↑

KENNTNISSE ÜBER :

A: FERMIONEN

SPIN: 1/2 (DIRAC 20ies / PAULI 1942

m_f ?

θ_i^d, δ^d ?

ν's ?!

B: BOSONEN

m_B ?, KOPPLUNGEN ?

⟶ e ?

KOPPLUNGSRELATIONEN ≘ EXP.

- DAS STANDARDMODELL PARAMETRISIERT EINEN WEITEN ERKENNTNISBEREICH.

- PROBLEME : ∃ GENERATIONEN
  ∃ d-q . u-ℓ (?) MIXING
  MASSENSEQUENZEN

2. JENSEITS DES STANDARDMODELLS

$SU_{3C} \times SU_{2L} \times U_{1Y}$

↓

(1) **UNIFICATION ≥** (TOE's
GUT's /
KKT's

(2) ERWEITERUNG (≥) VON TEILEN DES SM
(AXIGLUE)

(3) „BESSERE" FUNDIERUNG (A LA **TC**)
→ SSB

(4) "TIEFERE" EBENEN $\Lambda_{QCD} < \Lambda_{EW} < \Lambda_{PR}$
(PREONEN)

- ALLE THEORIEN SIND EICHTHEORIEN. (HEP)
- BASIC - THEORIEN SOLLEN RENORMIERBAR SEIN.
- 'MORE-BASIC' THEORIEN MÜSSEN EINFACHER SEIN (WENIGER WW'S, FERMION-FELDER), UMFASSEN MEH PHYSIK BEI $\Lambda << \Lambda_{TH}$, ...

THEORY OF EVERYTHING [TO BE ACTUALIZE WEEKLY.

1974 GUT (SU_5) SUSY-GUT
1984 (SUSY) KKT ... SEVERAL DIM'S
1988 SUPERSTRING.

Λ_{TOE} $10^{14} \dots 10^{18}$ GeV ← HEP & UNIVERS

DESERT ?

Λ_{ACC} $10^{2} \dots 10^{4}$ GeV

WIR HABEN NOCH VIEL ZU LERNEN, UM ZU VERSTEHEN WAS Λ_{TOE} WIRKLICH IST.

QCD × QED — ORDINAR WORLD.

EINIGE CHARAKTERISTIKA:

(1) **GUT**: $SU_5 \supset SU_3 \times SU_2 \times U_1 \supset SU_3 \times U_1$

SU_{3C} $\quad SU_{2L} \times U_{1Y}$ $\quad U_1^{em}$!

SSB

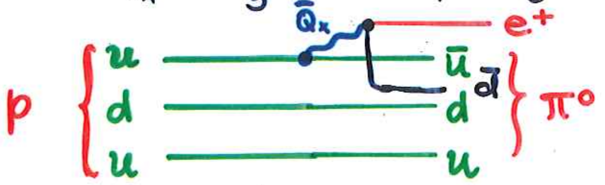
DIVERSE HIGGS-FELDER MÜSSEN EINGEFÜHRT WERDEN: $(\phi) \longrightarrow \begin{pmatrix} \vec{0} \\ v \end{pmatrix}$

SU_5 - EICHSEKTOR:

$$5^2 - 1 = 24 = (8,1) + (1,3) + (1,1) + (3,2) + (3^*,2)$$

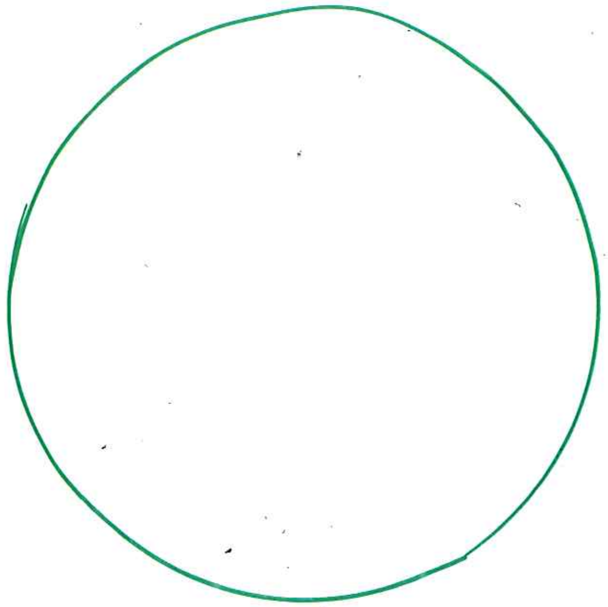
$(8,1)$	$(1,3)$	$(1,1)$	$(3,2)$	$(3^*,2)$
G_α^β	SU_2-FELDER	B (U_{1Y})	(X,Y)	$\begin{pmatrix} X \\ Y \end{pmatrix}$

$Q_X = -\frac{4}{3}$, $\quad Q_Y = -\frac{1}{3}$ $\quad$ LEPTOQUARKS ($m_{X,Y} \sim 4 \cdot 10^{14}$ GeV … $\approx$ 640 pg



$p \rightarrow e^+ \pi^0$

p : zu stabil $\tau_p^{exp} > \tau_p^{theo}$!



SYMMETRY

DIE WÜSTE LEBT.

WAHRSCHEINLICH :

ES IST

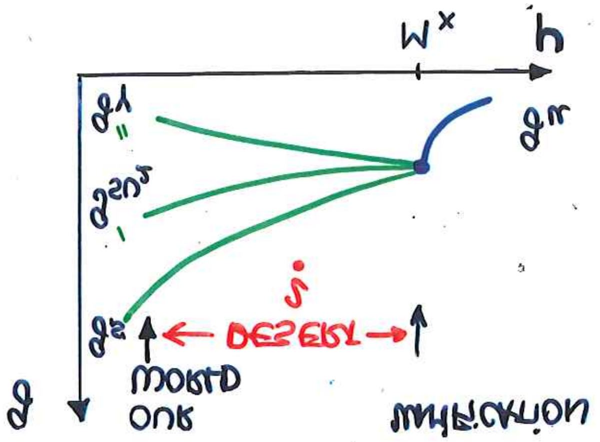
$$\sin^2\theta = \frac{1}{6} + \frac{5\,\alpha(\mu)}{9\,\alpha_s(\mu)}$$

$$= \frac{3}{8} + \varphi \cdot \ln\left(\frac{M_X}{\mu}\right)$$

(Exp.)

1986 ! ≠ SU5

$$\sin^2\theta = g'^2 / (g''^2 + g'^2) \xrightarrow{M_X} \frac{3}{8}$$



$$\frac{d\,g_n}{d\ln\mu} = -\,b_n\,g_n^3$$

RGE's

(4) PREONEN:

VIELE IDEEN ⟷ (NOCH) KEINE EVIDENZ FÜR NEUE EBENEN.

40'ies, 50'ies: $\pi^{\pm}, \pi^{0}, \rho^{\pm}, \rho^{0} \ldots$

$p, n, \ldots$

KLASSIFIKATION:

$|u\bar{d}\rangle$ π^{+}

$|d\bar{u}\rangle$ π^{-}

$\frac{1}{\sqrt{2}}|u\bar{u} + d\bar{d}\rangle$ π^{0}

} SU_2 STARKER ISOSPIN (HEISENBERG, IWANENKO)

$|uud\rangle = p$ $|ddu\rangle = n$

→ BOUND-STATES ? WIE ?

BSP.: QCD

QHD

ABBOTT
FRITZSCH d

$\mathbb{W} = \left(\begin{matrix} q \\ q \end{matrix} \right.$

⋮

etc.

EMPIRISCHE ZUSTÄNDE

$|H^{\pm 0}\rangle$: π, p, Λ, K, J/ψ ...

↓

KLASSIFIKATION DES FERMIONINHALTES

$\binom{u}{d}_L^i \quad u_R^i \quad d_R^i$

u d s c b t ...

↓

EINFÜHRUNG VON BINDUNGSFELDERN
YANG-MILLS GLUE

$G_\alpha^\beta \; (SU_{3c})$

↓

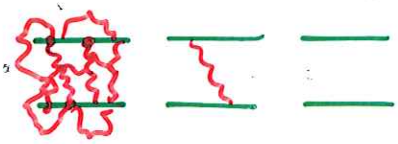
EVTL.: ASYMPTOTISCHE FREIHEIT IN DER BINDENDEN EICHTHEORIE

$$\frac{4\pi}{\left(\frac{11}{1} - \frac{2}{3}N_f\right)\ln\frac{Q^2}{\Lambda^2}} \xrightarrow[Q^2\to\infty]{} 0$$

↓

FREIE KONSTITUENTEN BEI HOHEM Q^2

Q^2 (t) →



↓

BS-FRAGMENTATION

← $-Q^2$ (s)

BESCHLEUNIGER

- COLLIDER $p, \bar{p}, e^{\pm}$  $p, \bar{p}, e^{\pm}$

- FIXED TARGET MACHINES p 

TARGET Fe, … → π, K, n, p; $\nu_e\ \nu_\mu,\ \nu_\tau$

SC-MAGNETS

DETEKTOREN

4π : (IM MAGNETFELD)

KOORDINATENDET.	DC, PC, TEC	} TRACKS	θ_i, p_i
KALORIMETER	BGO, SCINT.		$\sum_i E_i$
ABSORBER	Fe, Al, …		

μ - KAMMERN

e - KALORIMETRIE $e, \gamma \leftarrow \pi^0$ etc.

h - — · —

VORWÄRTS-DETEKTOREN ~ $\nu, \bar{\nu}$ N (FIXED TARGET)
BEAM DUMP

BC & ELEKTRON. DETEKTOREN

⟶ ν_τ (UNK)

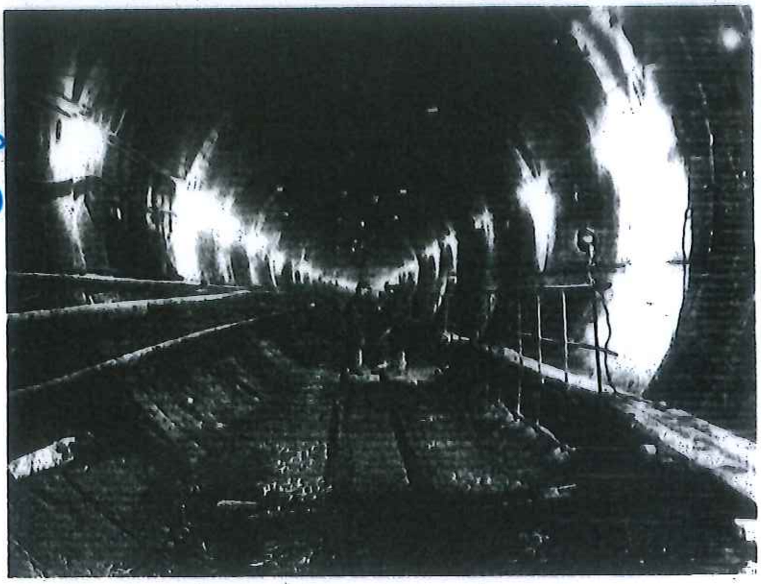
⟶ p-ZERFALL : UNDERGROUND DETECTORS

ν-ASTRONOMIE : — " —

БАЙКАЛ (USSR)

DUMAND (HI)

UNK PROTVINO (SERPUKHOV) (USSR)



A section of the tunnel for the UNK machine being built at the Soviet Serpukhov Laboratory. The 21 km tunnel is expected to be complete in 1990.

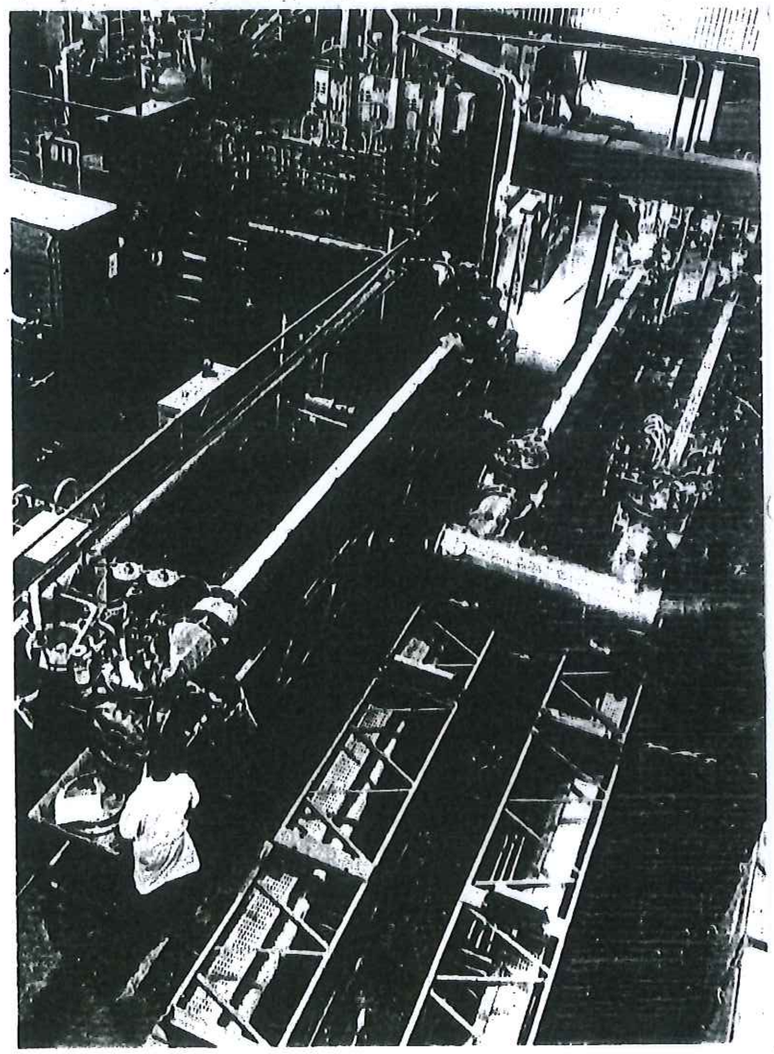
SERPUKHOV UNK underway

The 'Accelerator and Storage Complex' (better known by its Russian initials, UNK) at Serpukhov, USSR, advanced with some 3 km of tunnelling completed in 1986 and a mber of superconductiong magnets successfully tested.

The initial plans for UNK are to build a conventional magnet ring to reach 600 GeV (400 GeV in the storage ring mode) and a superconducting magnet ring to reach 3 TeV. This complex will be fed by the existing 76 GeV proton synchrotron currently providing 10^{13} protons per pulse and being upgraded to 5×10^{13}.

The two rings will be located in the same tunnel, with the conventional ring above the superconducting, so that collisions between vertically crossing proton beams can be obtained. Alternatively the storage of antiprotons also in the TeV ring (space has been left available in the site design specifically for the possible addition of an antiproton accumulator) would obviously allow proton-antiproton collisions up to a combined energy of 6 TeV.

Several 6 m superconducting magnets of the warm-iron Fermilab Tevatron type have been built and tested. They trained rapidly to 6.2 T with good field quality; this is comfortably above the design value of 5 T. The cold-iron solution, such as is being used at DESY for HERA, is being considered with the particular aim of reducing the heat load. This could enable the



Superconducting magnets for UNK under test

(Photos Serpukhov)

TEVATRON (USA)

BATAVIA, IL (CHICAGO)

During the previous 800 GeV fixed target run, experiments were serviced by existing beamlines upgraded to transport 800 GeV beam, as none of the major new Tevatron facilities were ready.

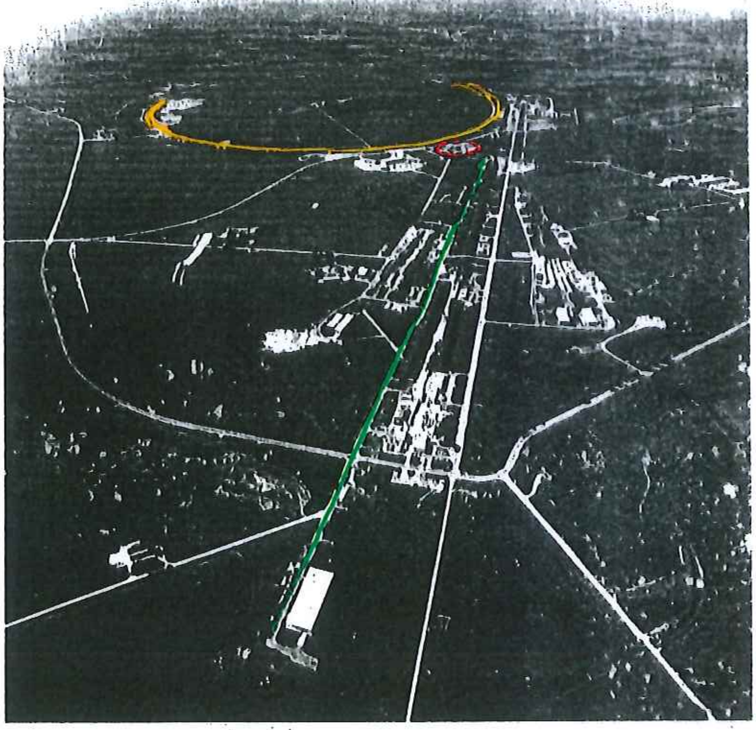
Two highlights of this present run are the increased efficiency of the Tevatron and the commissioning and data taking of three big fixed target beamlines and detectors in the new Muon, Wideband, and Meson West Areas.

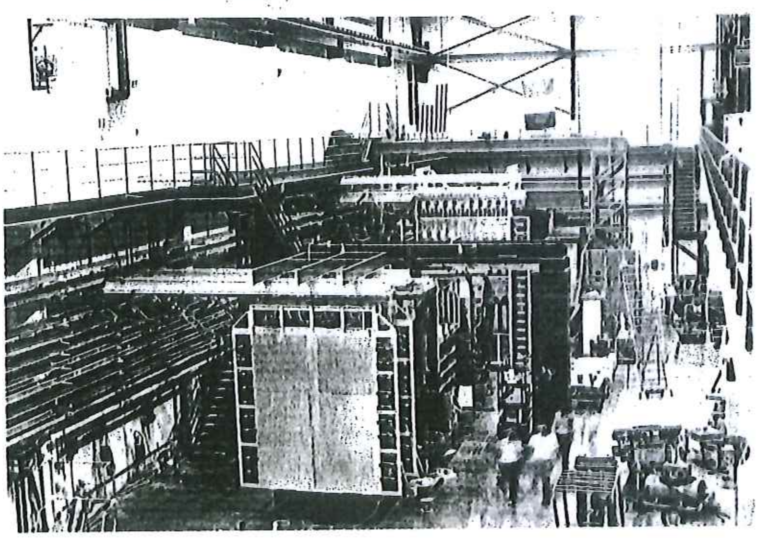
During the first nine weeks of running, the accelerator surpassed the peak intensity record from the previous run, reaching more than 1.7×10^{13} protons per pulse. Compared with the start-up of the previous run, twice as many protons per week have been accelerated this time, with the highest accumulated weekly proton intensity reaching 1.06×10^{17}. In addition, a record 127 hours of beam was reached during one week.

One of the three new beams leads to the Muon Experimental Hall and Experiment 665, studying muon interactions at energies of up to 750 GeV in a variety of targets, looking at the hadrons recoiling from violent muon collisions in hydrogen and heavy nuclei, and measuring the quark content (structure functions) of these targets. It involves a collaboration Argonne, California (San Diego), Fermilab, Freiburg, Harvard, Illinois (Chicago), Poland, Maryland, MIT, the Max Planck Institute (Munich), Washington, Wuppertal and Yale.

The second new major experiment is E687 in the Wideband Beam, looking at the photoproduction of charm and beauty especially photo-excited states containing

The beamlines fanning out from Fermilab's Tevatron ring.





Experiment 687 in the Tevatron Wideband Beam looking at the photoproduction of states containing heavy quarks includes a large Italian contingent.

LEP physics

(CH/F) GENEVA

LEP TUNNEL BREAK-THROUGH '86

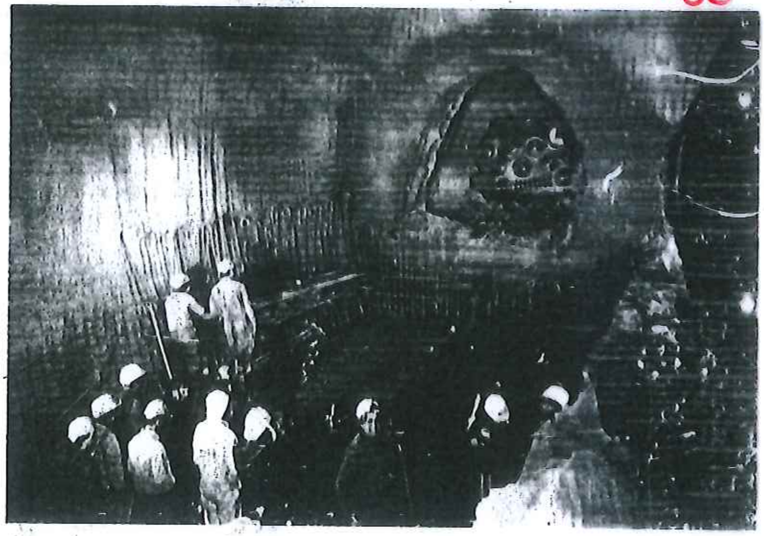
Construction of the 27 km LEP electron-positron Collider at CERN pushes relentlessly forward. Less evident, but just as vital, is the work for the four big detectors which will be ready to intercept LEP's first colliding beams towards the end of 1988 (see May issue, page 1). Despite these day-to-day preoccupations of construction and preparation, the ultimate aim of this mammoth project is to do new physics.

The possibilities for opening up new areas of physics for exploration and measurement were spelled out in detail before the project was accepted by CERN Council in 1981. However in the meantime the W and Z particles, the carriers of the weak nuclear force, were discovered at CERN in 1983, providing dramatic confirmation of electroweak unification.

At CERN and elsewhere, evidence continues to accumulate in favour of the Quantum Chromodynamics (QCD) picture of inter-quark forces. Together, electroweak unification and QCD are the twin pillars of the 'Standard Model' of today's physics.

Electron-positron collisions at presently available machines at the German DESY Laboratory in Hamburg and at Stanford in the US have revealed no sign of the long-awaited sixth 'top' quark, the big missing link in the Standard Model. However some clues are provided by the UA1 experiment which benefits from the higher energies at CERN's proton-antiproton Collider.

Meanwhile theorists have continued their efforts to extend the Standard Model. No evidence for any of these new ideas, some of them very appealing, has been found, but they will stand or fall by what is found at LEP.



(Photo CERN 612.5.86)

Another breakthrough for the LEP electron-positron Collider at CERN.

Günther Wolf, then chairman of the LEP Experiments Committee, suggested to John Ellis and Roberto Peccei, the two theorists on the Committee, that the time was ripe for a further survey of the physics possible with the new machine. Five main areas were identified, and working groups were set up containing experimenters from the four LEP collaborations and theorists.

The five areas are — precision studies around the Z (the carrier of the electrically neutral part of the weak nuclear force); so-called 'toponium' consisting of a top quark bound to its antiquark; searches for new particles; high energy LEP running beyond the foreseen initial level of around 50 GeV per beam; and QCD and heavy quark physics.

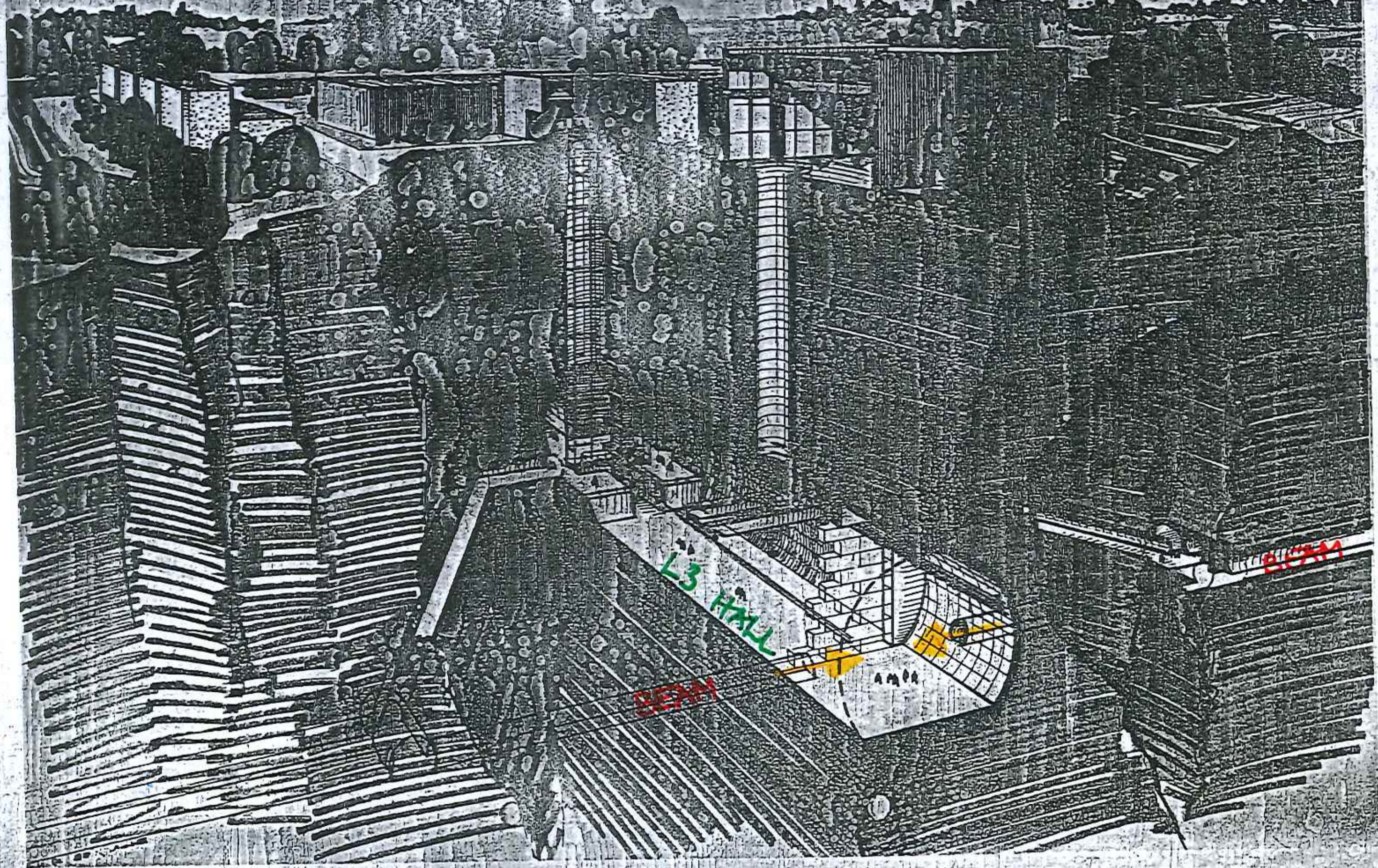
Called 'Physics at LEP', the findings of the working groups have now been published in two weighty tomes which should serve as a useful handbook for the experimentalists once the data starts to roll in.

Z physics

The working group commissioned to look at physics around the Z came to number of definite conclusions:

- the mass and width of the Z peak should be easily measurable at LEP;
- the use of polarized (spin oriented) beams is seen as a 'natural' requirement;
- inferring the number of types of neutrino should be easy;
- any new heavy particles (fermions) coming from additional quark families should have detectable effects;
- the elusive Higgs boson (the source of mass in the electroweak theory) might remain so if the particle is heavier than about 50 GeV;
- the delicate forward-backward asymmetries in this sector should give important precision measurements.

L3 AT LEP



Around the Laboratories

HERA HAMBURG (FRG)

DESY
HERA progress

At the end of April, the first magnets for the 30 GeV electron storage ring were installed in the underground tunnel being excavated for the HERA electron-proton collider at the German DESY Laboratory in Hamburg. These magnets are mounted in 12 metre modules, and a hundred modules are needed to fill the curved part of each quadrant of the ring. Meanwhile the superconducting magnets (dipoles, quadrupoles and correction coils) for the 820 GeV proton ring have been ordered.

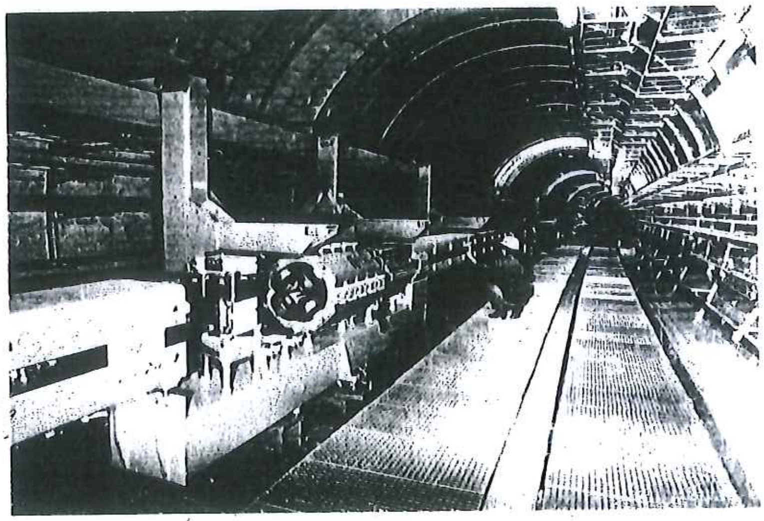
The electron injection tunnel from the PETRA pre-accelerator to HERA is being completed and first beam tests are imminent. The proton line from PETRA to HERA has already been tested (with positrons — see May issue, page 18) with particles being ramped from 7 to more than 12 GeV in PETRA.

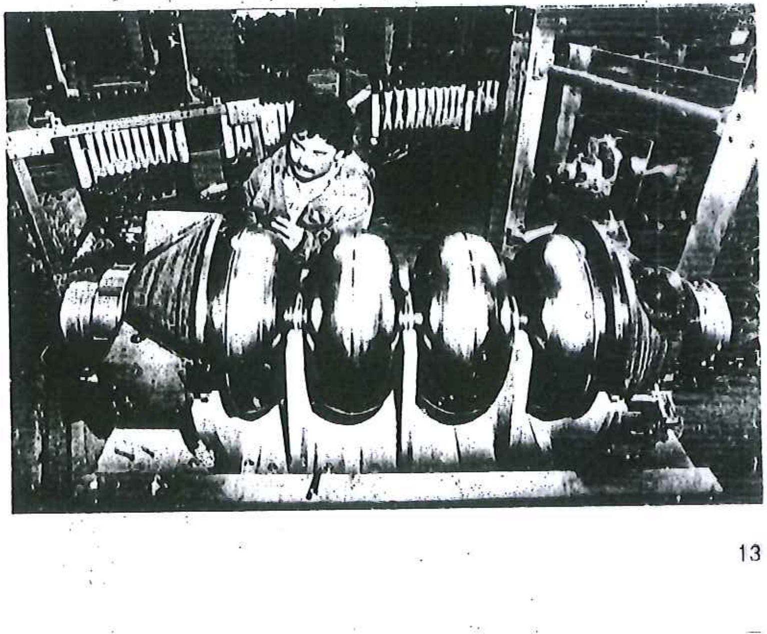
After progress with the new linac to provide HERA's protons, work is getting underway for the 40 GeV proton acceleration system for the PETRA pre-accelerator. The Canadian TRIUMF and Chalk River Laboratories are collaborating closely with DESY in this work.

HERA's cryogenic plant has now been installed. As well as being the biggest in Europe, its constructors claim it to be the most efficient cooling system of its type ever made. It comprises three independent compressor and cooling lines each of 6.4 kW at 4.3 K. The first was tested in April and produced 1500 litres of liquid helium. Two lines will be sufficient to run HERA, leaving one in reserve.

This cryogenic plant also provides the cooling power for the big magnet test hall, now ready for series tests of all industrial magnets arriving. In a separate hall provided with an independent 900 W cooling plant, systematic tests of a chain of three dipole and two quadrupole magnets began in April.

Installation of the magnets is getting underway for the electron ring of the 6.3 km HERA eletron-proton collider at the German DESY Laboratory in Hamburg.





▼ *The electron ring for the HERA electron-proton collider being built at the German DESY Laboratory envisages 30 GeV beams, requiring superconducting radiofrequency accelerating cavities in addition to conventional equipment. 500 MHz four-cell niobium units such as this built by industry have performed well in tests at DESY. Beam tests (in the PETRA ring) should begin soon.*

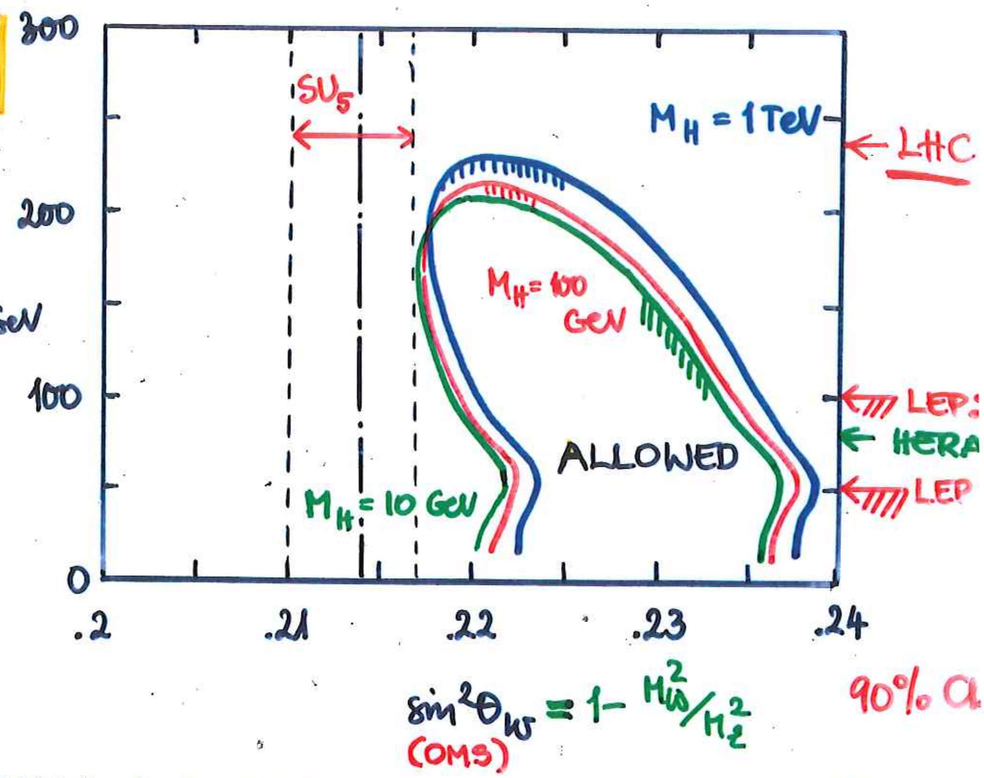
(Photos DESY)

REAKTION	BESCHLEUNIGER	$\sqrt{s}$ / GeV	START	LAND	DDR BETLG.
e^+e^- COLLIDER	● PETRA	46	~ 10 yr	FRG	
	● PEP, CESR	— " —	~ — " —	USA	
	TRISTAN	60	'87	JAPAN	
	LEP I/II	100/200	'89	CERN	×
	SLC	100	'88	USA	
	● LINAC 1 (3 km)	10^3	?	USSR	
eN COLLIDER	HERA	300	'90	FRG	×
	● LHC (AFTER pp!)	1400	~'95	CERN	
	● UNK & LINAC	3500	?	USSR	
$p\overset{(-)}{p}$ COLLIDER	UNK	6000	'93	USSR	DISK.
	● LHC	$1.4 \cdot 10^4$	~ 95'	CERN	
	● SSC (SITE DEC. NOV '88)	$4 \cdot 10^4$	'94 (96)	USA	
FIXED TARGET ($\overset{(-)}{\nu}N$, $K^{\pm}N$, BEAM DUMPS)	UNK	75	'93	USSR	×
	● SPS	35	~ 10 yr.	CERN	VIK
	○ TEVATRON	43	'86	USA	

WISSEN WIR SCHON OB WIR IRGEND ETWAS JENSEITS VON W & Z ENTDECKEN?

JA.

m_t :



AMALDI et al. UPR 0331T May 87 : PR D '87

1 dim. 90% CL : $m_t < 180$ GeV.

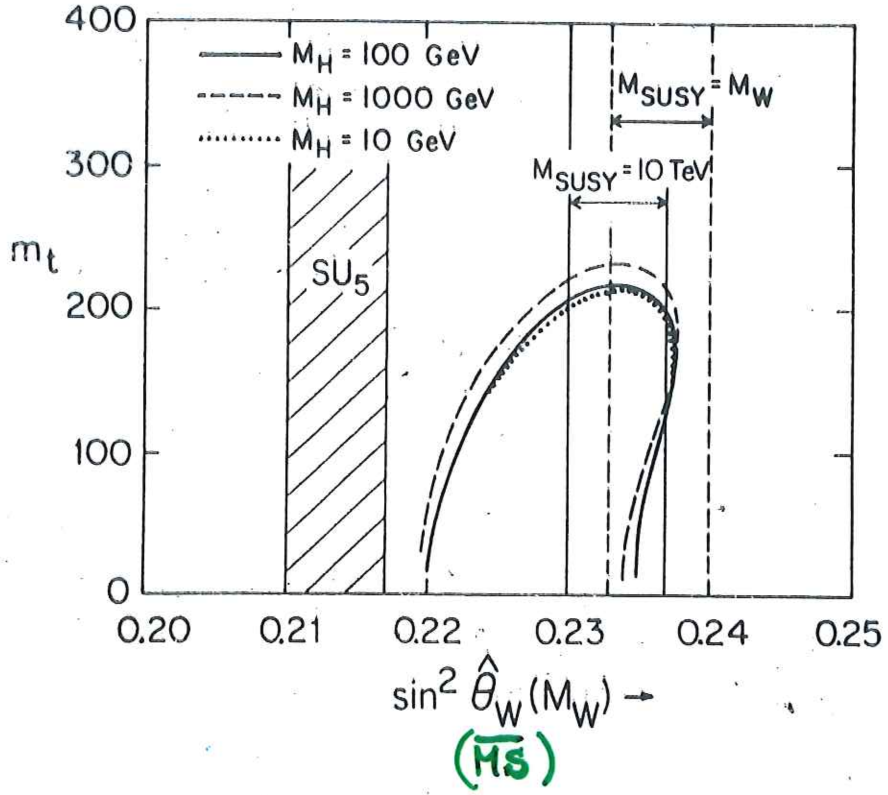
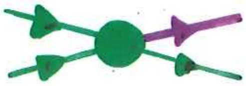


Figure 2: Allowed regions (90% c.l.) in $\sin^2 \hat{\theta}_W(M_W)$ and m_t for fixed values of M_H. Also shown are the predictions of ordinary and supersymmetric GUTs, assuming no new thresholds between M_W or M_{SUSY} and the unification scale.

EXPERIMENTELLE ZIELE

NEUE TEILCHEN

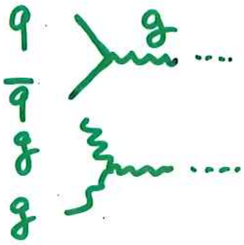
s 

• e^+e^-

$\sqrt{s}$ - TUNING

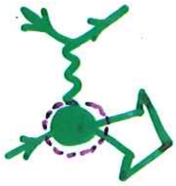
• pp

HOHES $\sqrt{s}$



Z'; W'; LQ's; $H^{\pm 0}$;
t; TC's; AG's
SUSY's
(t, ν_τ; ℓ^*, q^*, IVB*)

NEUE STRUKTUREN

t 

• $\overset{(-)}{\nu} N$

• $e^\pm N$ (hohes $\sqrt{s}$) (hohes Q^2)

→ HERA (BSP.)

TIEF-INELASTISCHE $e^{\pm}p(N)$-STREUUNG

(HERA)

STANDARDMODELL-TESTS:

BSP.:

- STRUKTURFKT.
- QUARKVERTEILUNGEN $Q^2 \sim O(10^3 \ldots 10^4 \, GeV^2)$
- α_s, Λ_{QCD}, xG
- m_t; ‚FREE' TOP

JENSEITS DES STANDARDMODELLS

BSP.:

- SUSY-EFFEKTE & STR.FKT.
- FERMION COMPOSITENESS
- LEPTOQUARKS: $m_{LQ} \sim O(100 \, GeV)$

KINEMATIK:

BJORKEN - VARIABLEN:

$$x_B = Q^2 / S y_B$$

$$y_B = E_J / E \,\big|_{LAB} \quad (p \text{ AT REST})$$

$$S = (p_e + p_p)^2 = m_e^2 + m_p^2 + E_e E_p - \vec{p}_e \vec{p}_p$$

$$\approx 4 E_e E_p$$

$$-Q^2 = (p_e - p_{e'})^2$$

:

$$0 < x_B < 1$$

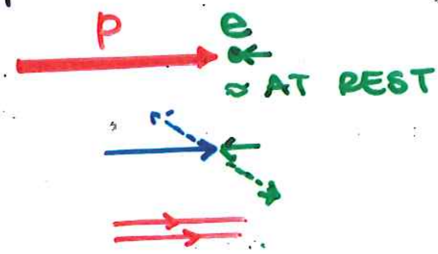
$$0 < y_B < 1$$

HERA

$E_p = 820$ GeV, $E_e = 30$ GeV

VORHER :

NACHHER :



$$\frac{d^2\sigma^{NC}}{dx\,dQ^2} = \frac{4\pi\alpha^2}{xQ^4}\left[\frac{1}{2}Y_+ F_2 + \ldots_{\gamma Z,\, Z^2}\right]$$

$\uparrow |\gamma|^2$-Prop.

$\downarrow$

$$F_2 = \sum_i e_i^2 \left(x\bar{q}_i + xq_i\right)$$

$$\frac{d^2\sigma^{CC\, e^\pm}}{dx\,dQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left(\frac{Q^2}{Q^2+M_W^2}\right)^2 \frac{1}{s_\theta^4}\,\frac{1+|\lambda|}{2}\left[Y_+ W_2^\pm \mp Y_- xW_3^\pm\right]$$

$$W_2^- = 2\sum_i \left(xu_i + x\bar{d}_i\right)$$

$$W_2^+ = 2\sum_i \left(xd_i + x\bar{u}_i\right)$$

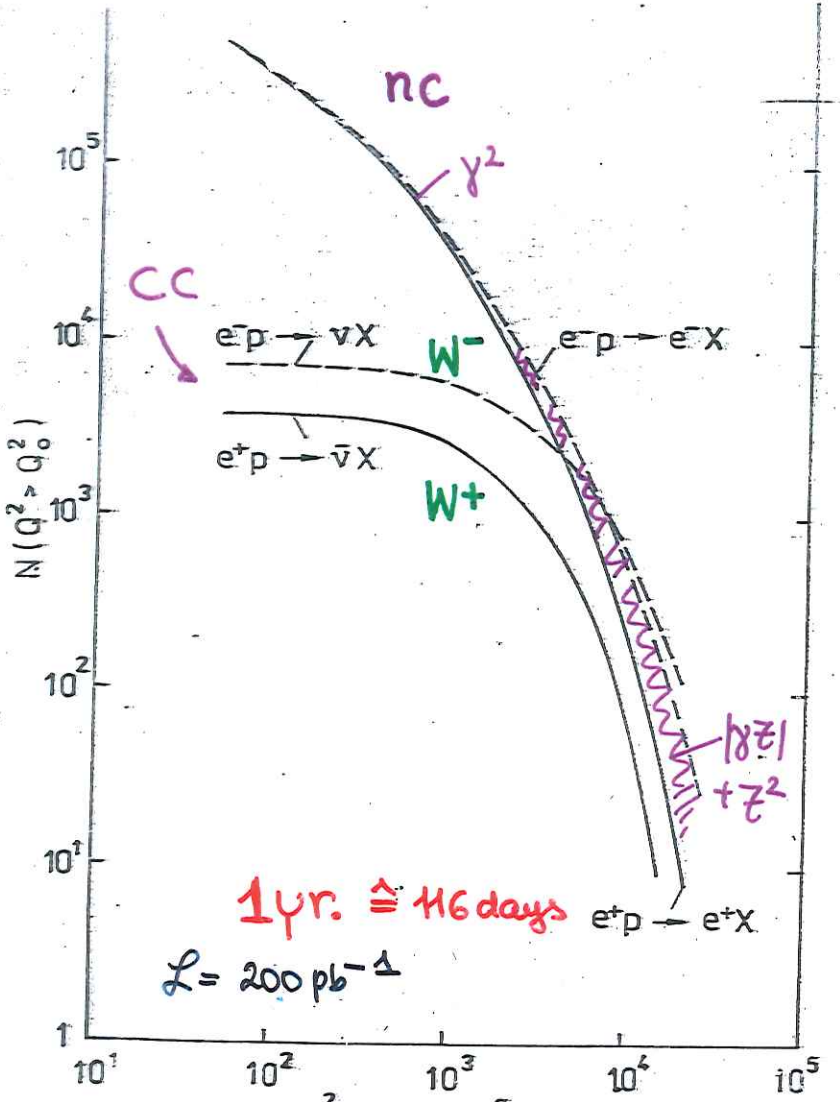

nc
γ^2
CC
$e^-p \to \nu X$
W^-
$e^-p \to e^-X$
$e^+p \to \bar{\nu} X$
W^+
$|Z\gamma|$
$+Z^2$
1yr. ≙ 116 days
$e^+p \to e^+X$
$\mathcal{L} = 200\,pb^{-1}$
$N(Q^2 > Q_0^2)$
$Q_0^2 / (GeV/c)^2$
10^1
10^2
10^3
10^4
10^5
1

Fig. 1

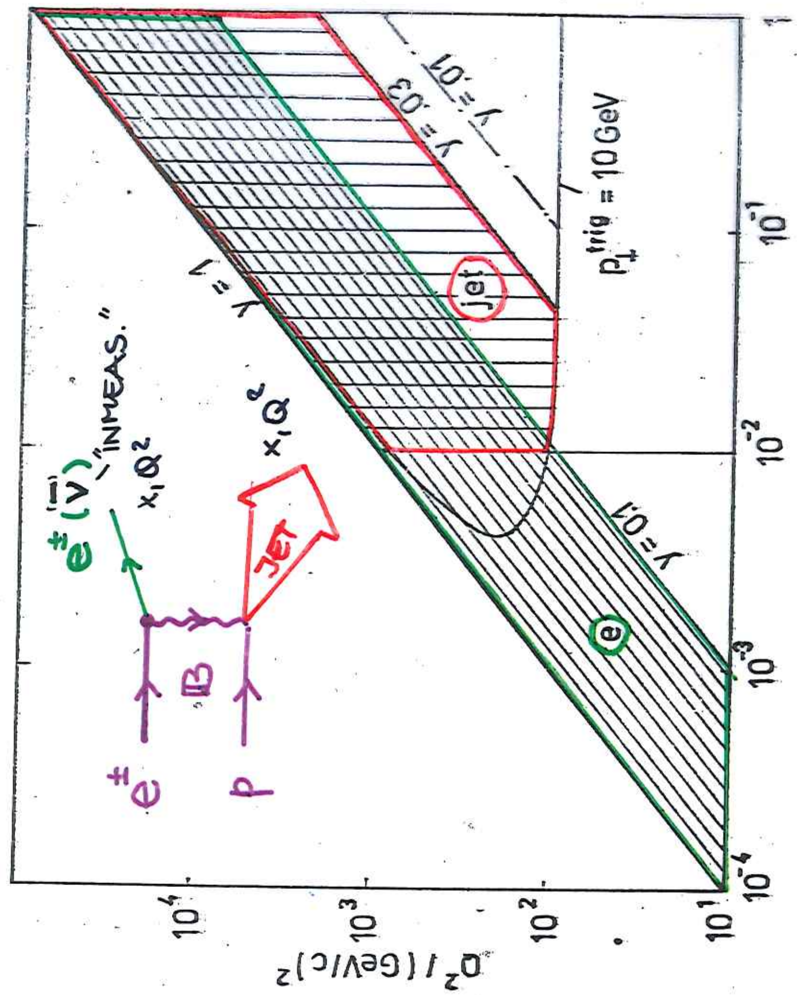
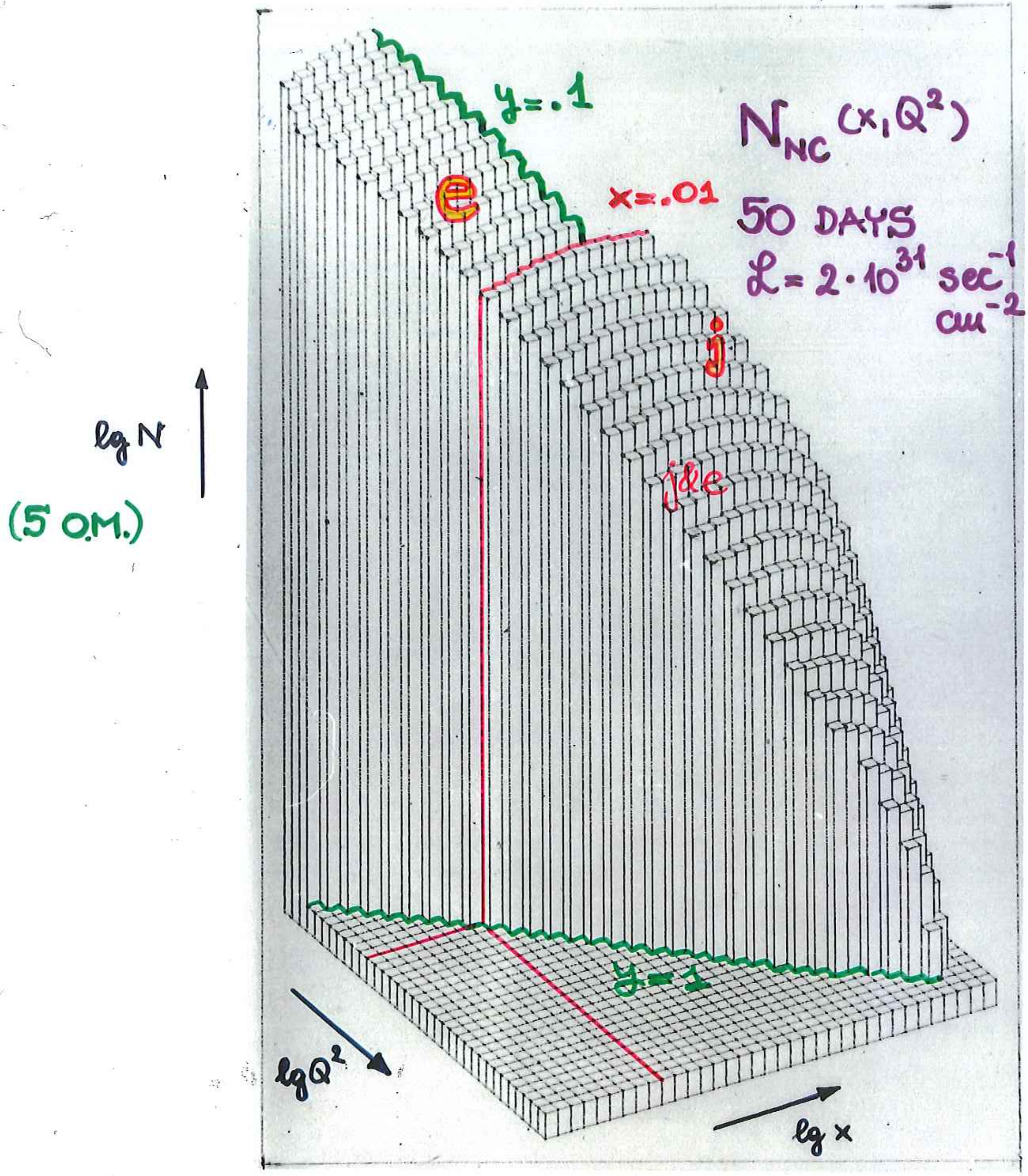
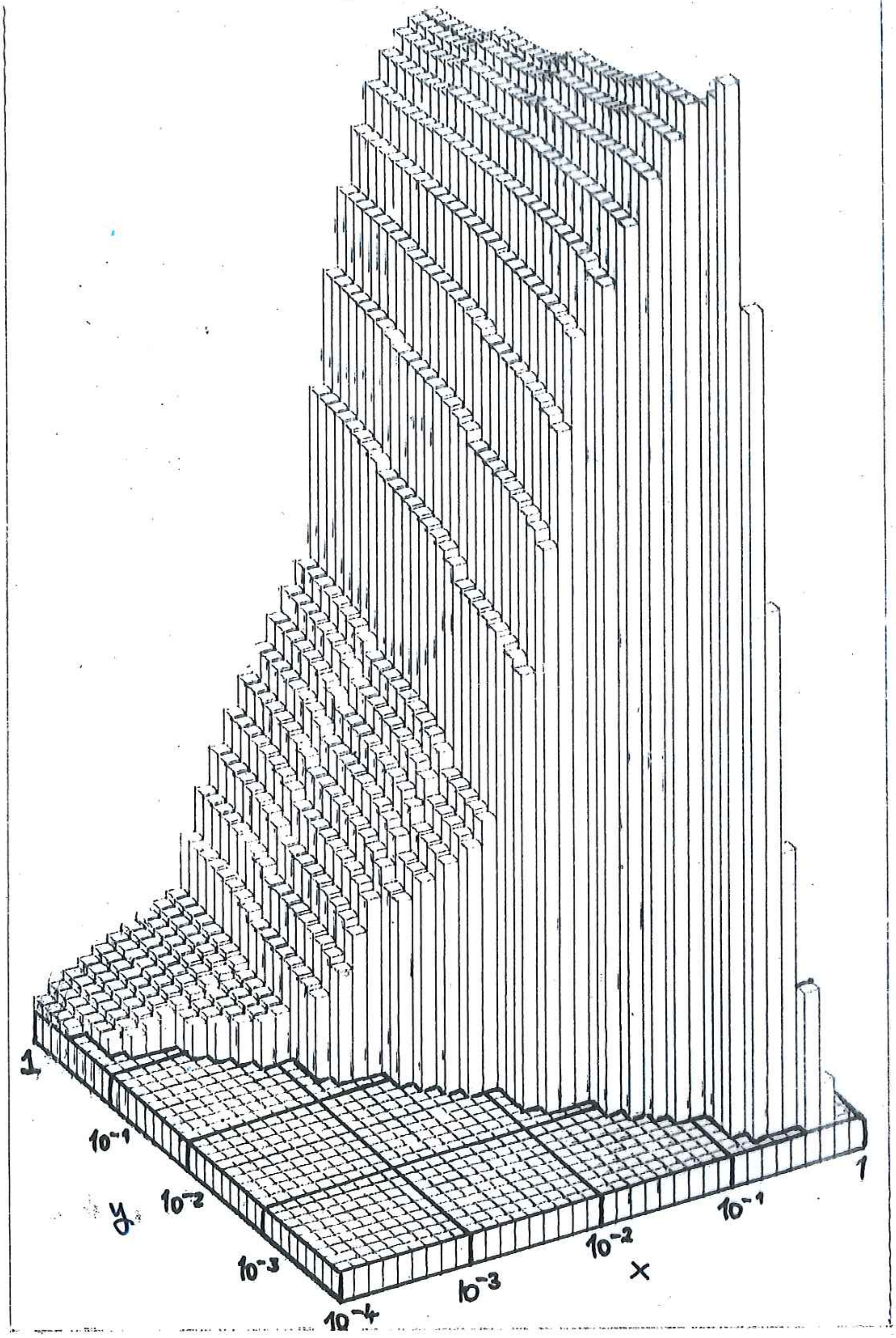

$e^{\pm}$
p
B
$e^{\pm}(\bar{\nu})$
"UNMEAS."
x, Q^2
JET
x, Q^2
y = 1
y = 0.1
y = .03
y = .01
jet
e
$p_\perp^{trig} = 10\,GeV$
$Q^2 / (GeV/c)^2$
x
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10^1
10^2
10^3
10^4

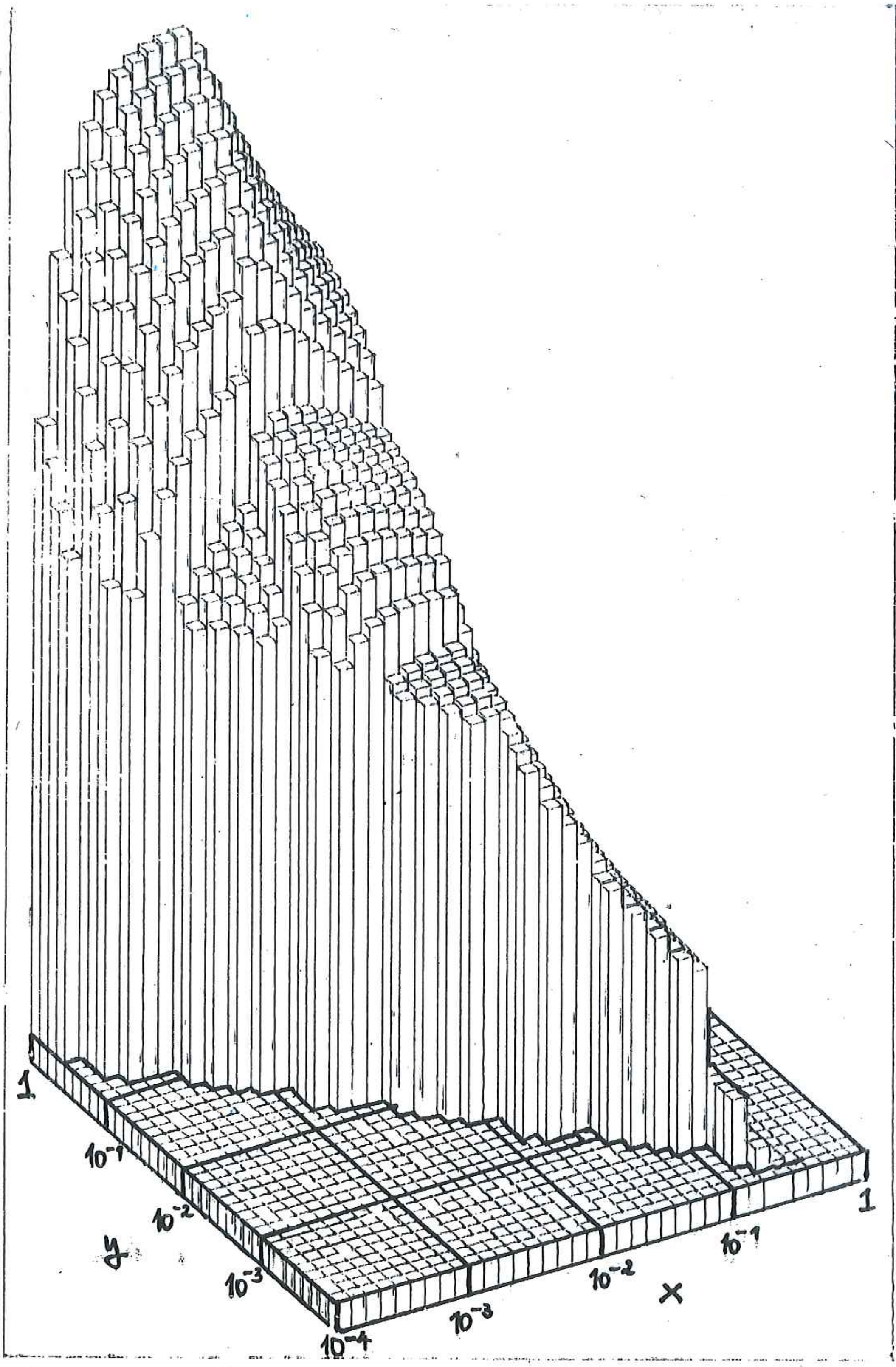
Fig. 2



$$d^2\sigma_{NC}/dx\,dQ^2 \propto Q^{-4}x^{-1}$$



$x d_v$, $Q^2 > 5\ \mathrm{GeV}^2$, $S = 98400\ \mathrm{GeV}^2$



$xs = xu_s$, $Q^2 > 5\ GeV^2$, $S = 98400\ GeV^2$

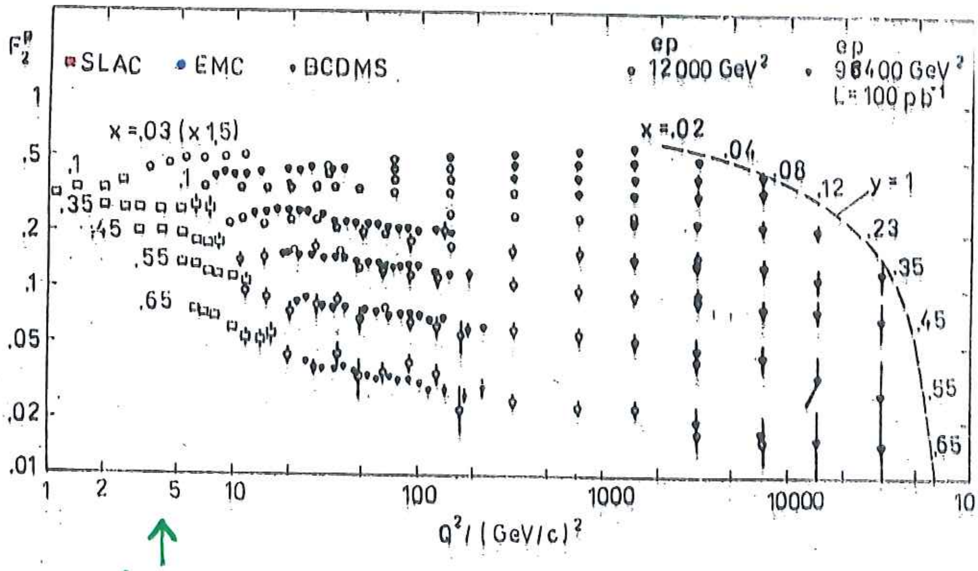


Fig. 7

≤'78 ≤'87 HERA

$S \sim 10^4$ GeV² $s = 10^5$ GeV²

! 90ies

Q^2:

5 ORDERS OF MAGNITUDE.

ENTFALTUNG VON QUARKVERTEILUNGEN

JB et al., Hadron Struc. '86, Nov. 86
R. Rückl, G. Ingelman, DESY Oct. 87

$$\begin{pmatrix} \sigma_{nc}^{-} \\ \hline \sigma_{nc}^{+} \\ \sigma_{cc}^{-} \\ \sigma_{cc}^{+} \end{pmatrix} = \| A_{ij} \| \otimes \begin{pmatrix} q_1 \\ \hline q_2 \\ q_3 \\ q_4 \end{pmatrix}$$

TREE : MATRIXGLEICHUNG

...+ 1LOOP : INTEGRALGL. SYST. (JB, in prep.)

(MELLIN CONV. TYPE) → ALGEBRAISIERBAR (JAN. 88)

↓ REIHEN VON LAGUERRE FKT., VERALLG. ζ-FKT. etc.

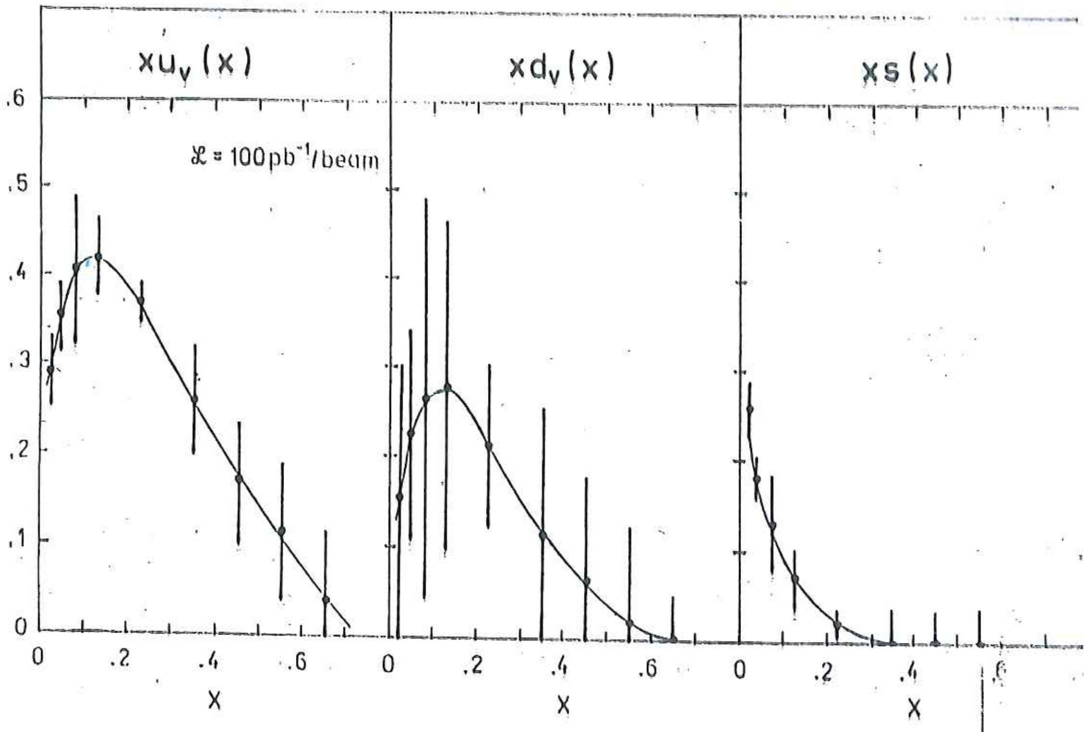

$xu_v(x)$
$xd_v(x)$
$xs(x)$
$\mathcal{L}$ = 100 pb^{-1}/beam
.6
.5
.4
.3
.2
.1
0
0
.2
.4
.6
x
x
x

Fig. 15

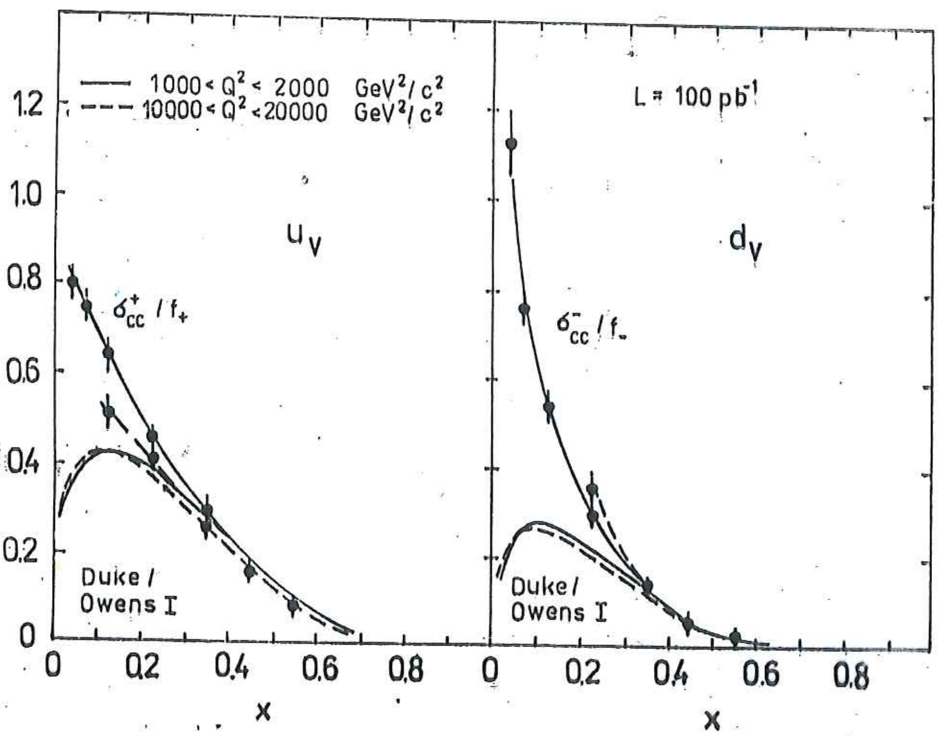

1000 < Q^2 < 2000 GeV^2/c^2
10000 < Q^2 < 20000 GeV^2/c^2
L = 100 pb^{-1}
u_v
d_v
σ^+_{cc} / f_+
σ^-_{cc} / f_-
Duke / Owens I
Duke / Owens I
1.2
1.0
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
x
x

Fig. 16

QCD - TEST

RUNNING α_s ?

Λ_{QCD} ?

→ LÖSUNG DER A-P-GLN. (2 LOOP)

(Integrodifferentialgln., algebraisierbar)

⟼ MULTIPARAMETERFIT : Λ

$xG(Q_0^2)$, $F_2^{Q_0^2}$, $\Sigma \bar{q}^{Q_0^2}$

(Anfangswertproblem)

$$\alpha_s(Q^2) = \frac{12\pi}{33-2N_f} \frac{1}{\ln(Q^2/\Lambda^2)}$$

STATISTISCHE PRÄZIS. F. Λ_{QCD}

(MAR'88)

$\delta\Lambda$ / MeV

S	$x > .25$	$x > 10^{-2}$	$x > 10^{-4}$
98400 GeV^2	230	110	40
12000 GeV^2	110	60	35
BEIDE OPTIONEN	90	40	20

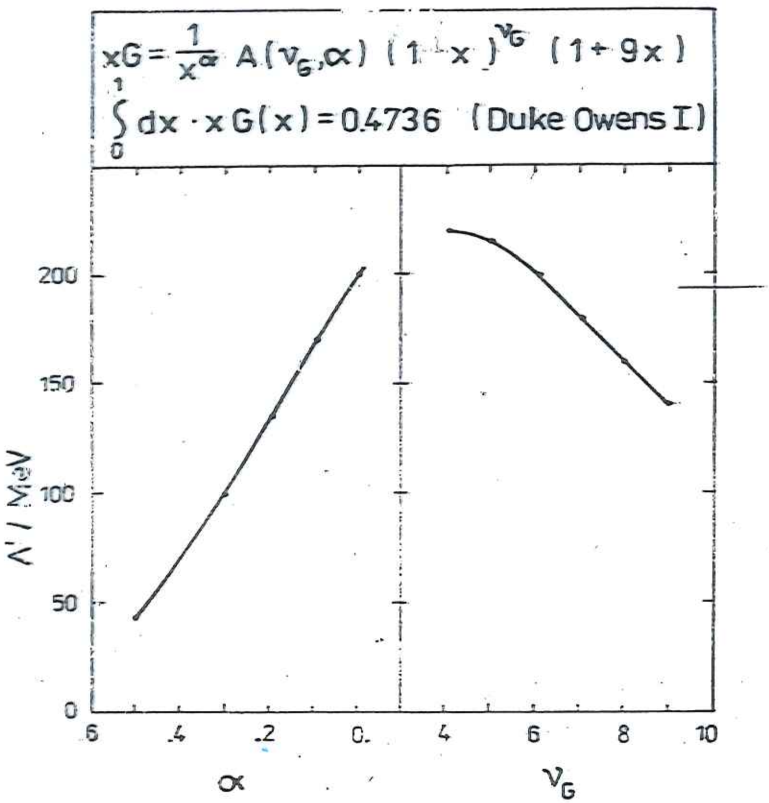
$\times G_{fix}$

NS ↑

SINGLET FIT: $\delta\Lambda = 160$ MeV $x > 10^{-2}$ ← !

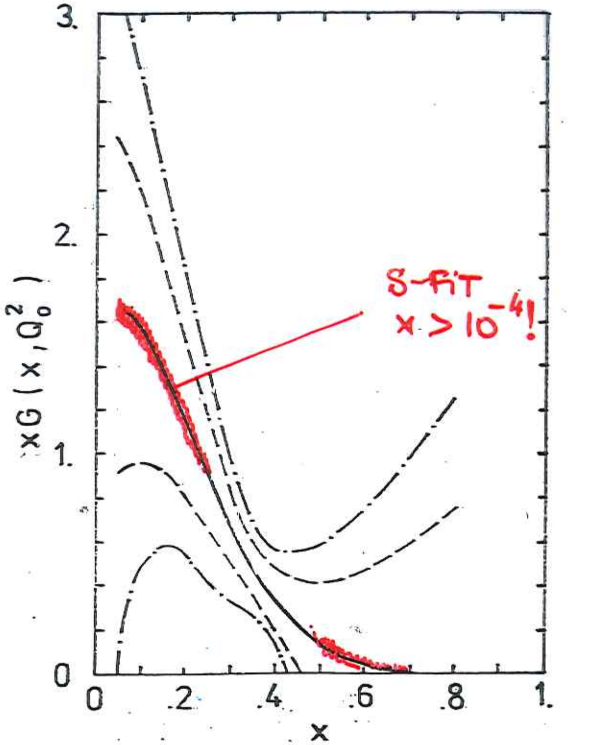
$\delta\Lambda = 20$ MeV $x > 10^{-4}$

→ SENSITIVITÄTSMASS



$xG = \frac{1}{x^{\alpha}} A(\nu_G, \alpha)\ (1-x)^{\nu_G}\ (1+9x)$
$\int_0^1 dx \cdot xG(x) = 0.4736$ (Duke Owens I)
Λ' / MeV
α
ν_G

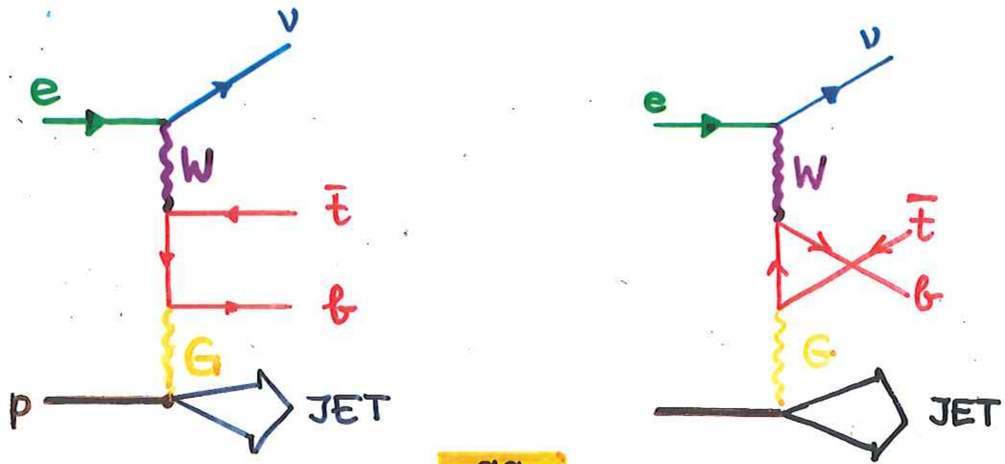
Fig.19



$xG(x, Q_0^2)$
x
S-FIT
$x > 10^{-4}$!

Fig.20

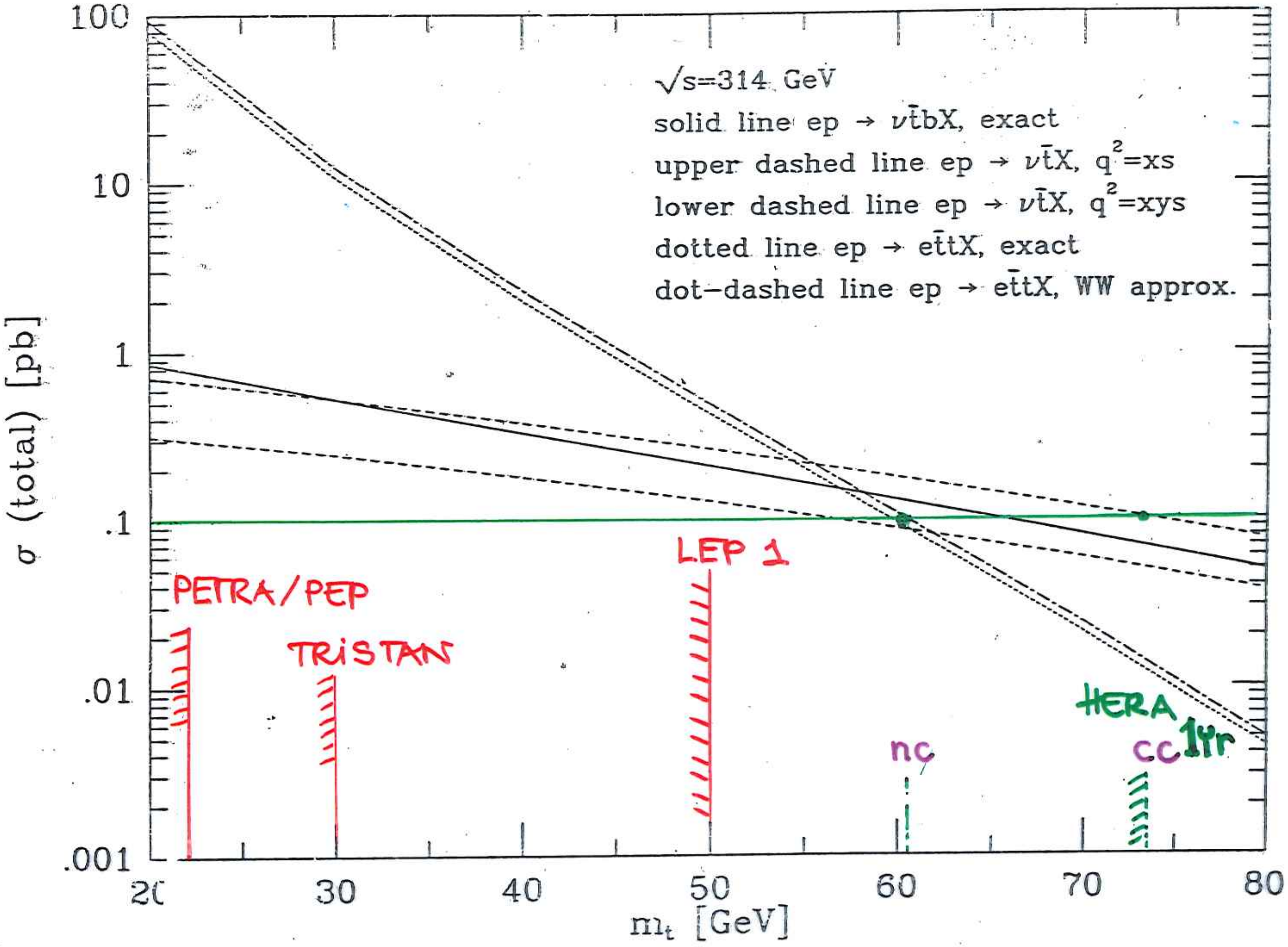
t - PRODUKTION



CC

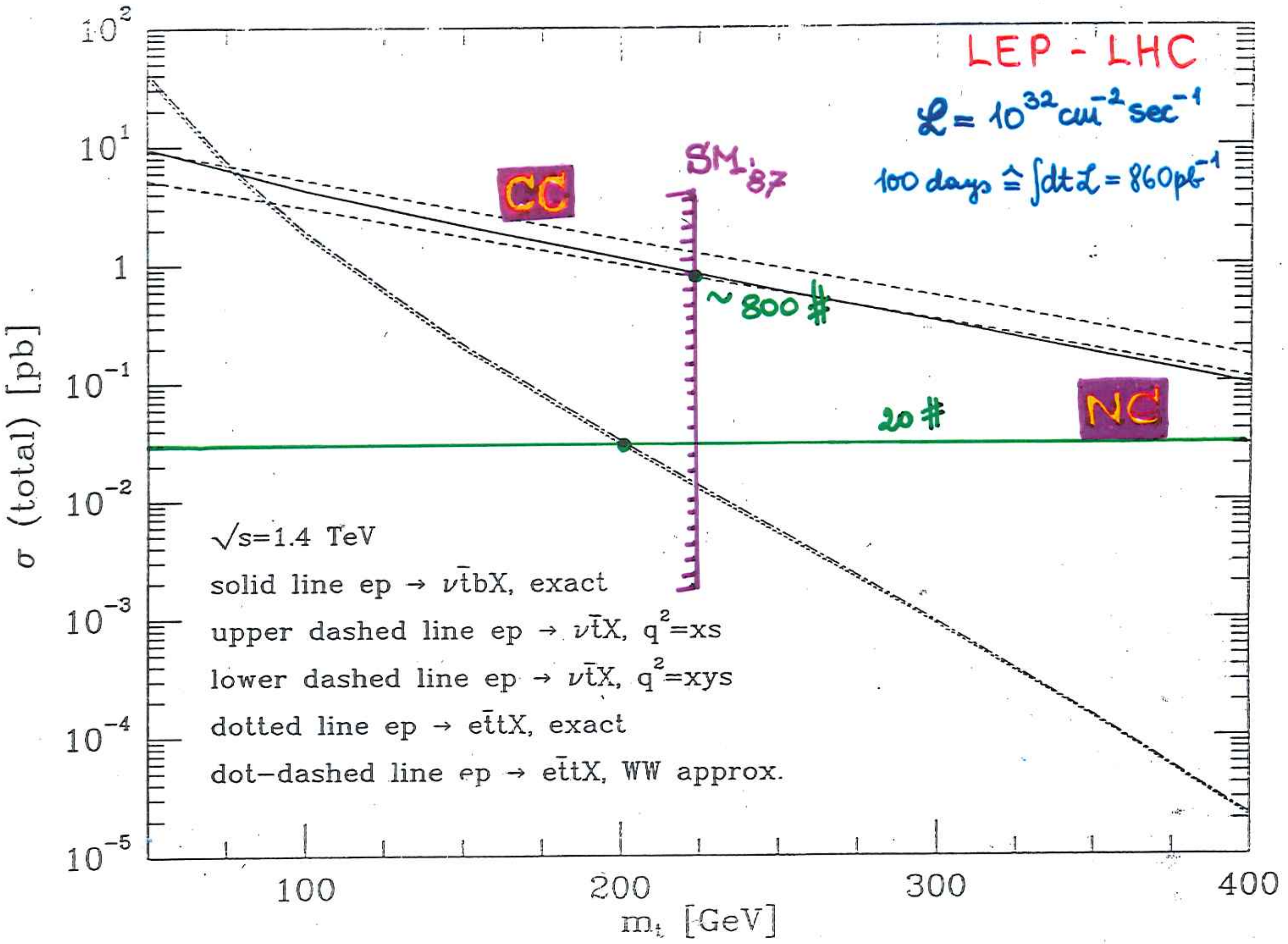
NC

$$\sim \begin{cases} b \to t \\ W \to \gamma, Z \\ \nu \to e \end{cases}$$



√s=314 GeV
solid line ep → ν t̄ b X, exact
upper dashed line ep → ν t̄ X, q²=xs
lower dashed line ep → ν t̄ X, q²=xys
dotted line ep → e t t̄ X, exact
dot-dashed line ep → e t t̄ X, WW approx.
σ (total) [pb]
100
10
1
.1
.01
.001
20
30
40
50
60
70
80
m_t [GeV]
PETRA/PEP
TRISTAN
LEP 1
HERA
nc
cc
1yr

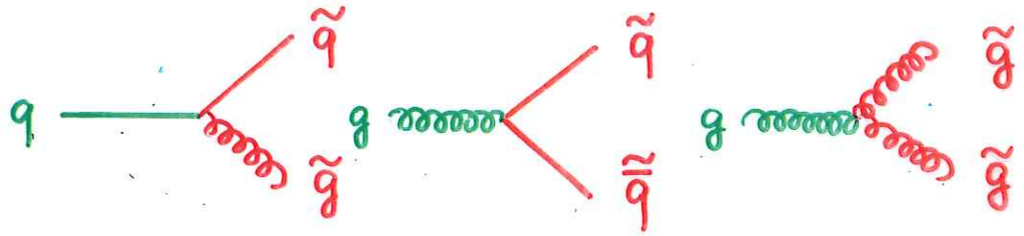
Fig. 2

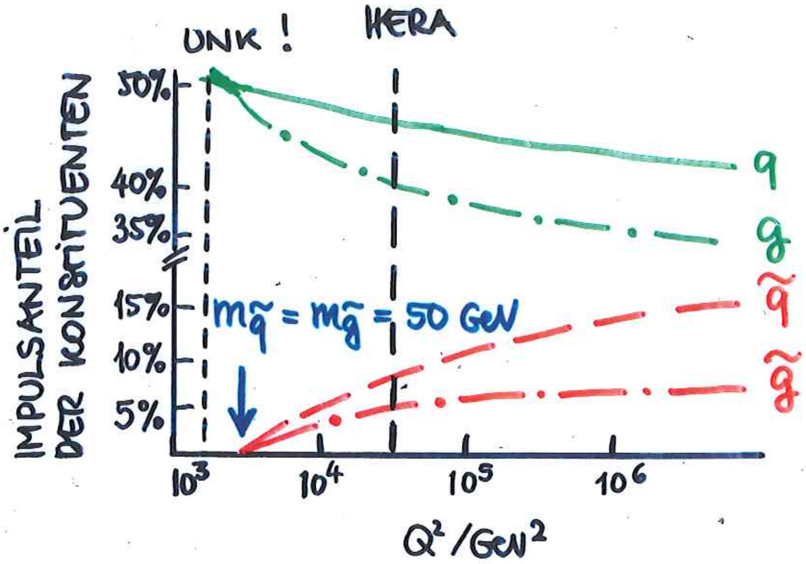


LEP - LHC
ℒ = 10^32 cm^-2 sec^-1
100 days ≙ ∫dt ℒ = 860 pb^-1
CC
NC
SM '87
~800 #
20 #
√s=1.4 TeV
solid line ep → ν t̄ b X, exact
upper dashed line ep → ν t̄ X, q²=xs
lower dashed line ep → ν t̄ X, q²=xys
dotted line ep → e t̄ t X, exact
dot-dashed line ep → e t̄ t X, WW approx.
σ (total) [pb]
m_t [GeV]

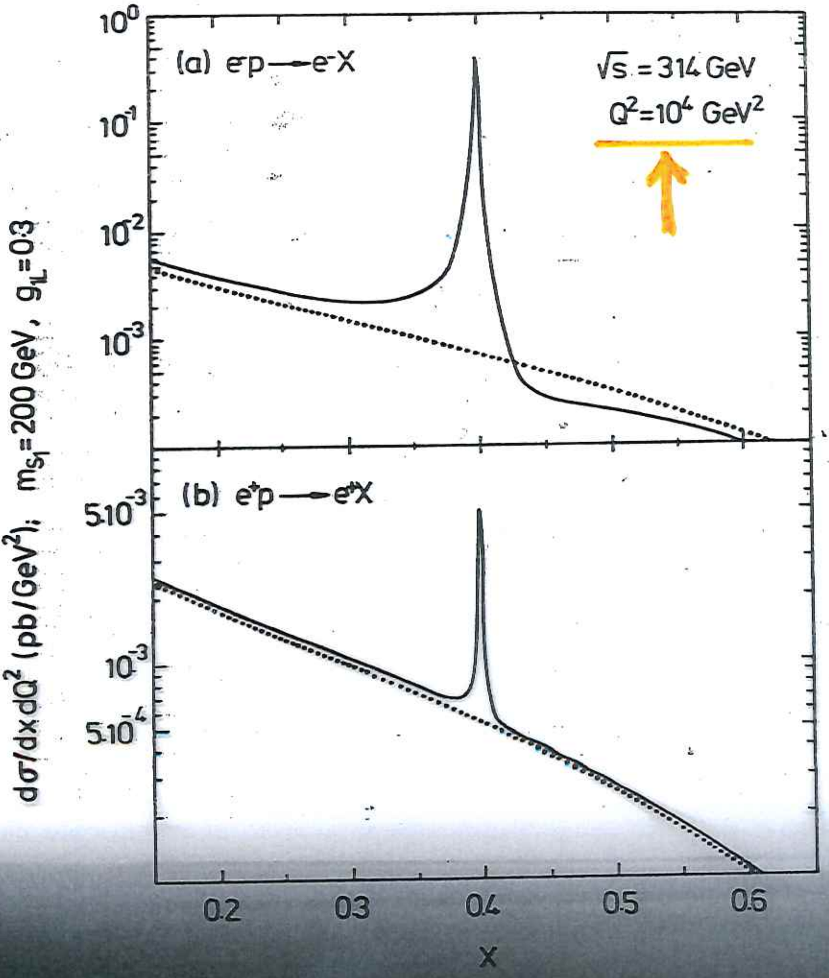
Fig. 5

STRUKTURFUNKTIONEN UND SUSY-EFFEKTE





LEPTOQUARKS



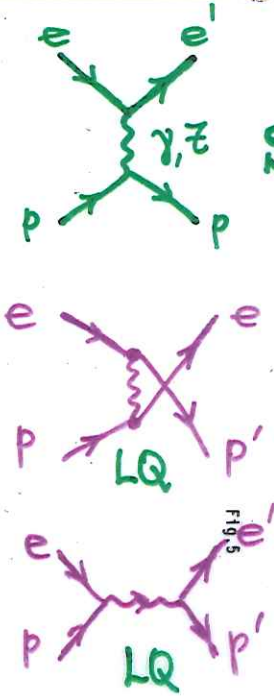
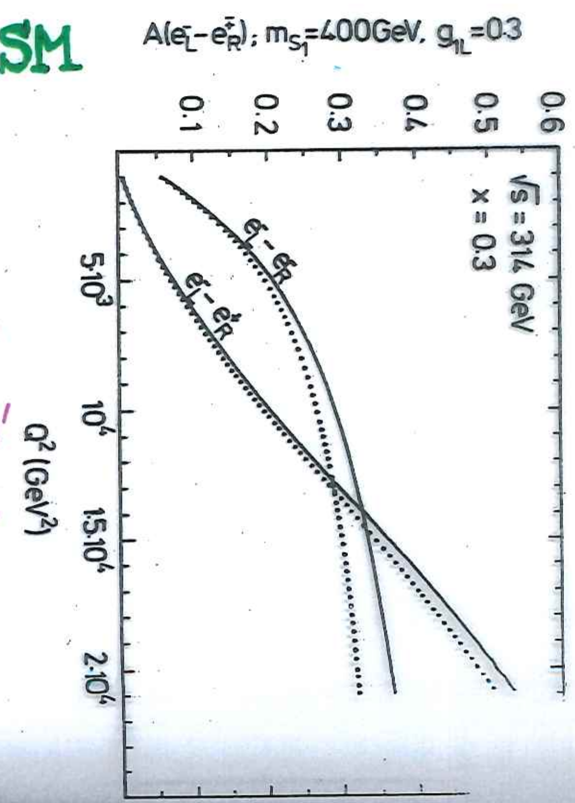


Fig. 5



FERMION - COMPOSITENESS

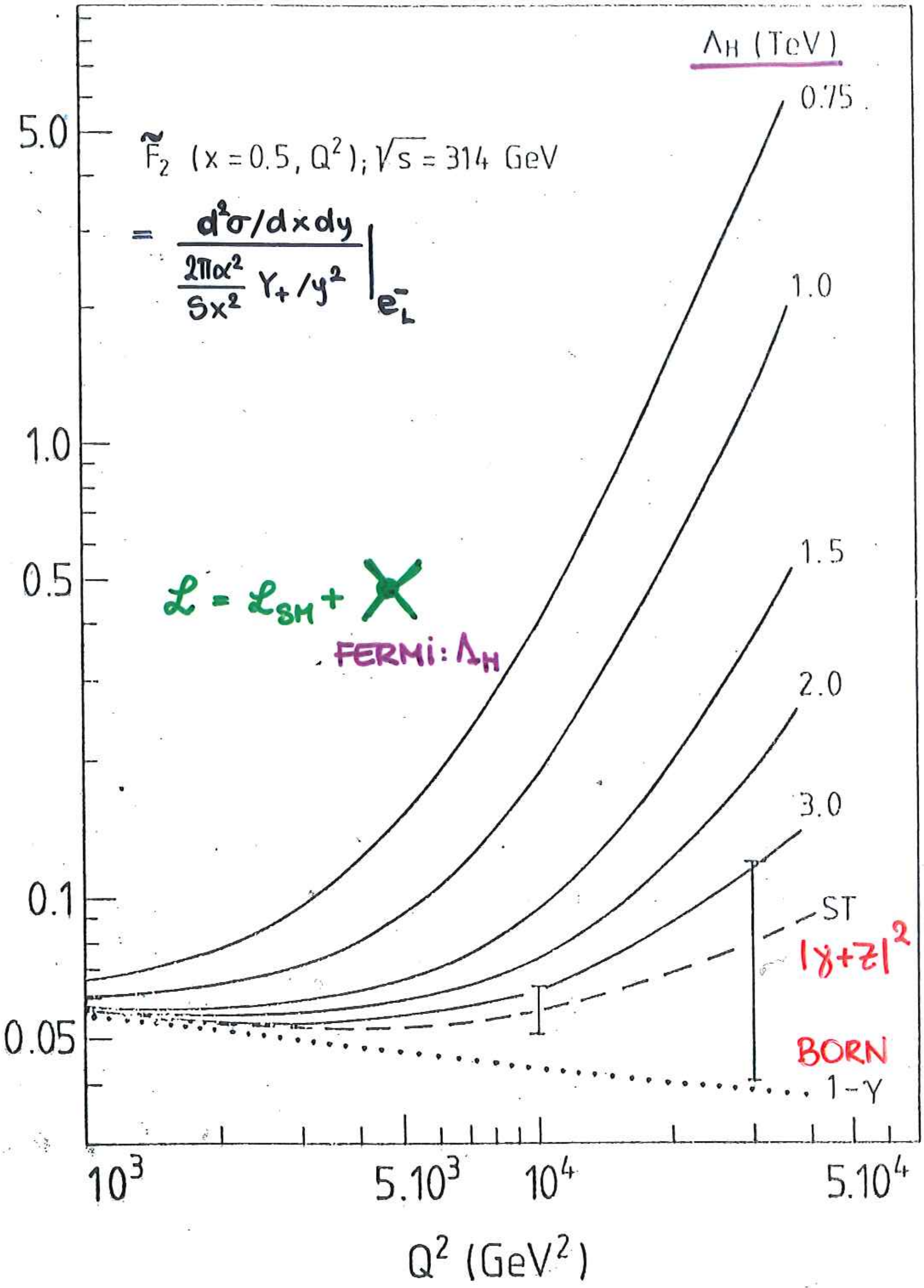


Fig. 5.4. $F_2(x,Q^2)$ as a function of Λ, Q^2 for a $(V-A)_e \times (V-A)_q$ residual interaction.

ge Fields

moment.

(12.168)

(12.169)

(12.170)

(12.171)

CODA

There was a lady from Squantum
Who had incredible momentum.
She shook off the glue
That colored her blue
And got asymptotic freedom.

There's a boson they call Goldstone
That's very hard to disown.
You try electrocution,
You get a transmutation:
The photon comes off the light-cone.

A theorist shows me how to mix
Technicolor $SU(6)$.
Should you find in the stew
A funny quark or two.
Just sweep them under the Higgs.

A mathematician named Anatole
Stepped on a magnetic monopole.
He struggled with the string
Dirac had tied to the thing,
And so became one fiber bundle.

And now my dear for change of pace
Take imaginary holidays
Where the metric is good,
No $i\varepsilon$'s intrude,
In the realm of Euclidean 4-space.

(by K. HUANG)

CONCLUSIONS

- UNK ν - PHYS. (DIS) AND HERA - DIS ARE SUPPLEMENTORY
  - KIN. RANGE

  HERA → NC   UNK → CC

- $\lesssim 1500$ #/h ; $10^6\ \nu_\mu^- D$, $2 \cdot 10^5\ \bar{\nu}_\mu^+ D$ / 30 days.
  (NC: 6 modules HC → $2 \cdot 10^5\ \nu_\mu N$)

- $\overset{(-)}{\nu} D$, $\overset{(-)}{\nu} p$ $\xrightarrow[CC]{}$ u_v, d_v, sea
  difficult at HERA, low CC stat

- Syst. save $xG(Q_0^2, x)$ measurement
  → HERA $xG(x, Q^2)$ meas low x
  otherwise unconstr. fit, (no h

- R (UNK) higher x   R (HERA) very low x