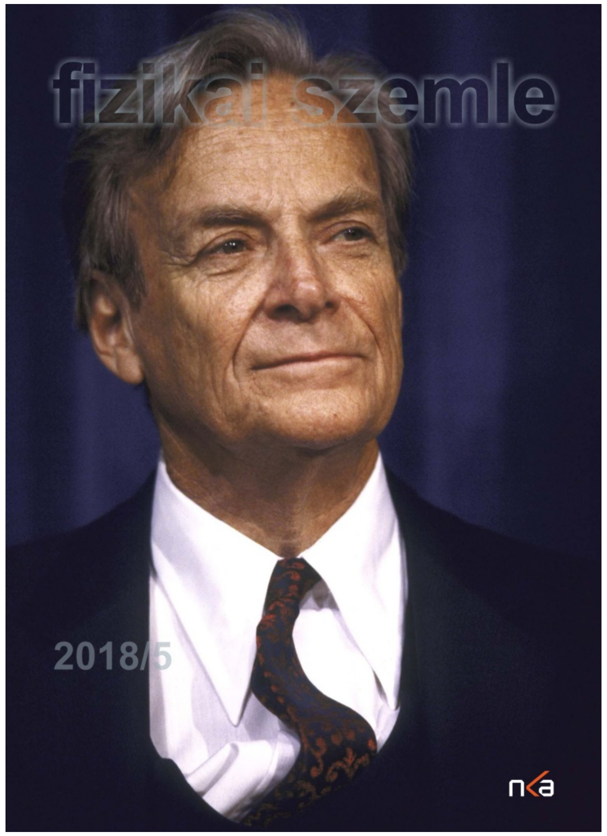
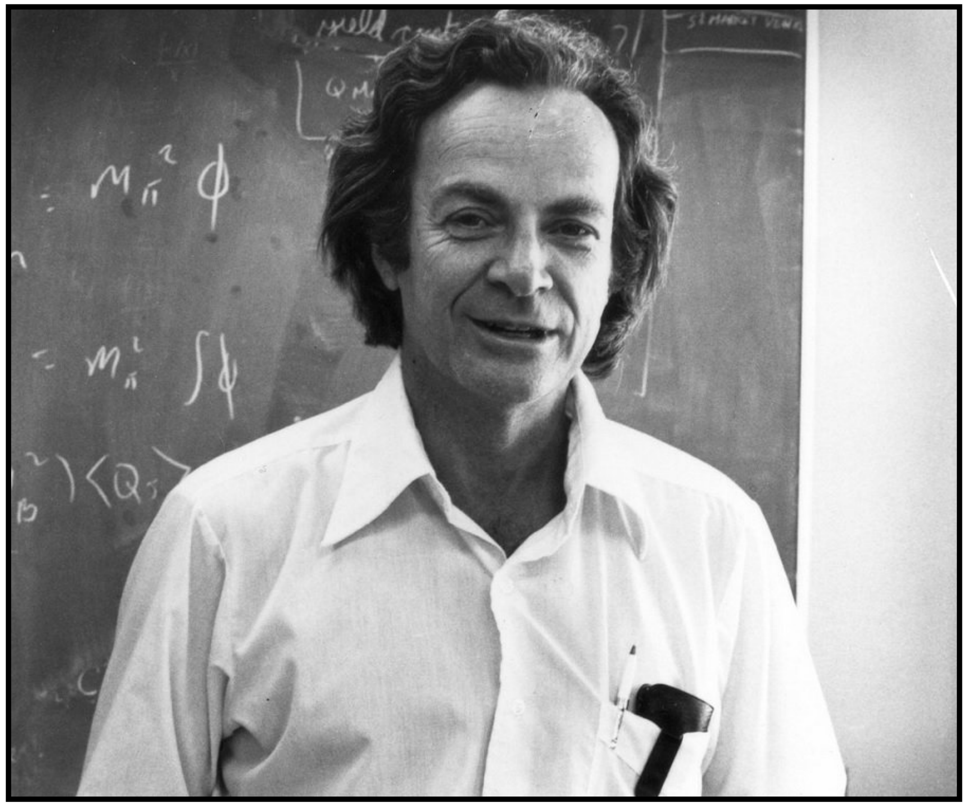
Feynman 100 and the Neutrino `72 , Balatonfüred





Feynman 100 at CALTEC, May 11, 2018

Welcome

Thomas F. Rosenbaum President, Caltech; Sonja and William Davidow Presidential Chair and Professor of Physics

Being Feynman's Curious Sister

Joan Feynman, Jet Propulsion Lab (Retired)

The Shuttle Accident & Other Man-made Disasters

Freeman Dyson, Professor Emeritus at the Institute for Advanced Study in Princeton

Dick's Tricks

Leonard Susskind, Felix Bloch Professor in Physics, Stanford

Bill Gates Remembers Richard Feynman

Bill Gates, Co-founder, Microsoft and Co-chair, Bill & Melinda Gates Foundation

Video courtesy of the office of Bill Gates

Feynman at Caltech

John Preskill, Richard P. Feynman Professor of Theoretical Physics, Caltech

and

Kip Thorne, Nobel Prize, Physics 2017; Richard P. Feynman Professor of Theoretical Physics, Emeritus, Caltech

The Art of Physics

Robbert Dijkgraaf, Director and Leon Levy Professor at the Institute for Advanced Study in Princeton; Professor, University of Amsterdam

Black Hole Blues

Janna Levin, Claire Tow Professor of Physics and Astronomy at Barnard College of Columbia University; Guggenheim Fellow

Growing Up Feynman

Michelle Feynman, Daughter of Richard P. Feynman

Closing

James Gleick: *Genius. Life and Science of Richard Feynman*
Pantheon Book New York (1992) 531pages

“Architect of QFT, brash young leader on the atomic bomb project, inventor the ubiquitous Feynman diagram, ebullient bongo player and storyteller, R.P. Feynman was the most brilliant, iconoclastic, and influential physicist of modern times… He had a lightening ability to see into the heart of the problem nature posed… It was permitted in connection with Feynman to use the word ***genius****. … He was the enemy of pomp, convention, quackery, and hypocrisy.”*

Richard Phillips Feynman(May 11, 1918 – February 15, 1988).
American theoretical physicist, know for

- The Dirac-Feynman path integral formulation of QM,
- The theory of QED,
- The physics of the superfluidity of supercooled liquid helium,
- Quantization QFT of gravity and YM theories
- The V-A form of the weak current of the "Fermi theory of weak interaction".
- The parton model interpretation of deep inelastic electron nucleon scattering.
- He has also been credited with the pioneering concepts of nanotechnology and quantum computing.

Perhaps he is most famous contribution is

- the diagrammatic approach to the mathematical expressions for the terms appearing in the perturbative expansion of QFT amplitudes (Feynman diagrams, Feynman integrals).

For his contributions to the development of QED, he received the Nobel Prize in Physics in 1965 (jointly with J.Schwinger and S.Tomonaga).

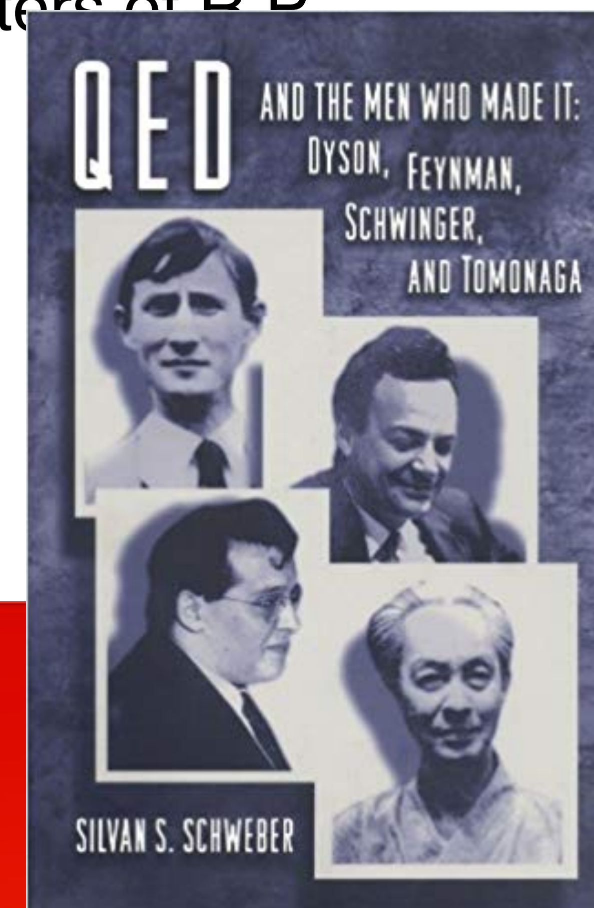
He held the R.C.Tolman professorship in theoretical physics in CALTECH (1950-1988). ***He was a keen populariser of physics through both books and lectures***

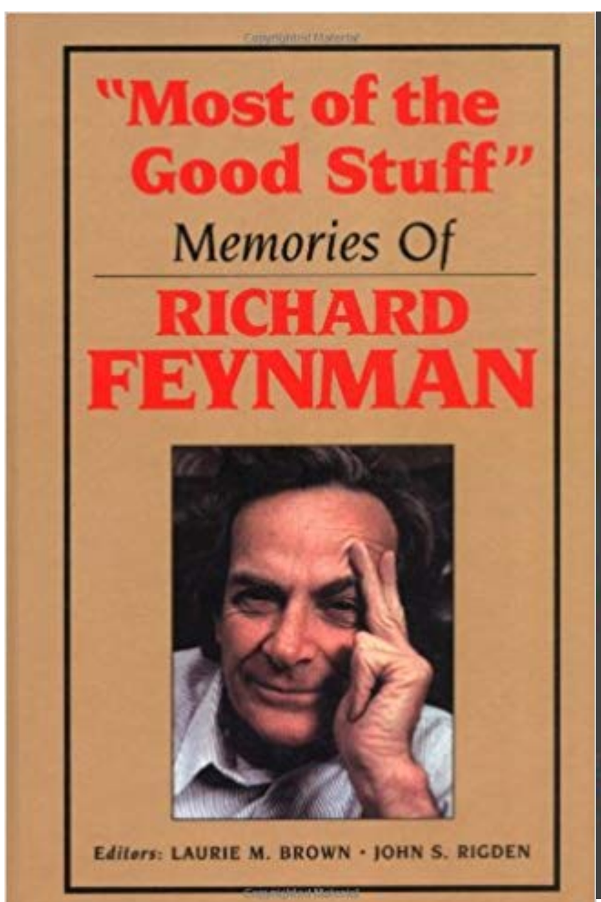
Books written by Feynman

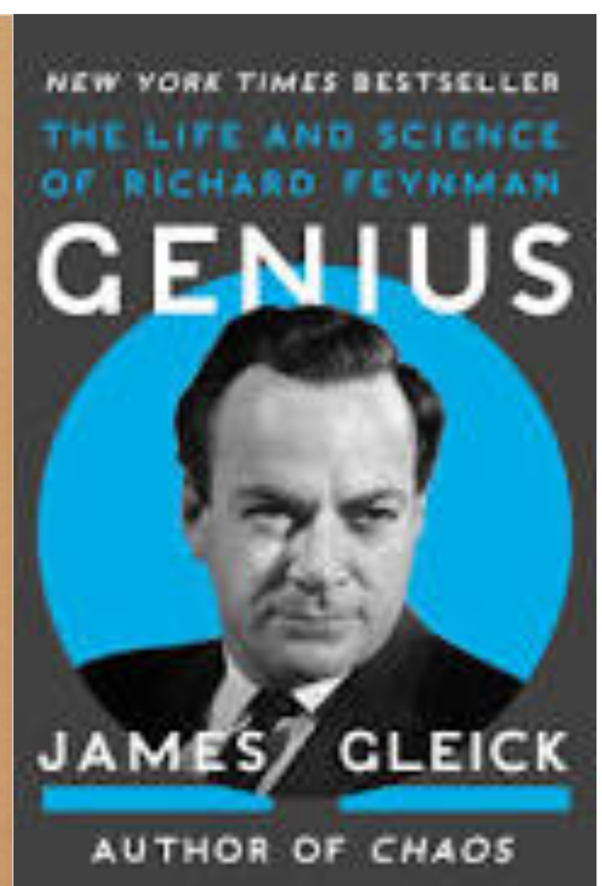
- Theory of Fundamental Processes, 1961
- Quantum Electrodynamics, 1961
- The Feynman Lectures on Physics, (with Leighton,R.B and Sands,M),1963
- The Character of Physical Law, 1965
- Quantum Mechanics and Path Integrals (with Hibbs,A.R.), 1965
- Photon-Hadron Interactions, 1972
- Statistical Mechanics: A Set of Lectures, 1972
- Surely you're joking Mr. Feynman, 1985
- QED the Strange Theory of Light and Matter, 1985
- What Do You Care What Other People Think?, 1988
- The Pleasure Finding Things Out
- *The Feynman Lectures on Gravitation (Moringo,F.B. and Wagner,W.G.),1995*
- *Feynman Lectures on Computation (Hey,A.J.G and All,RF.W.), 2000*

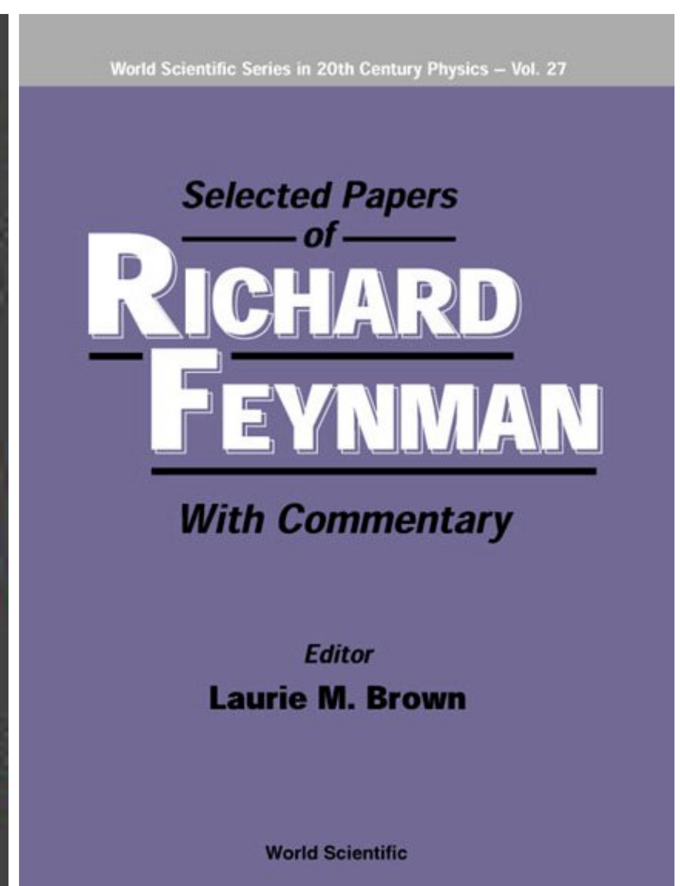
Books written about Feynman

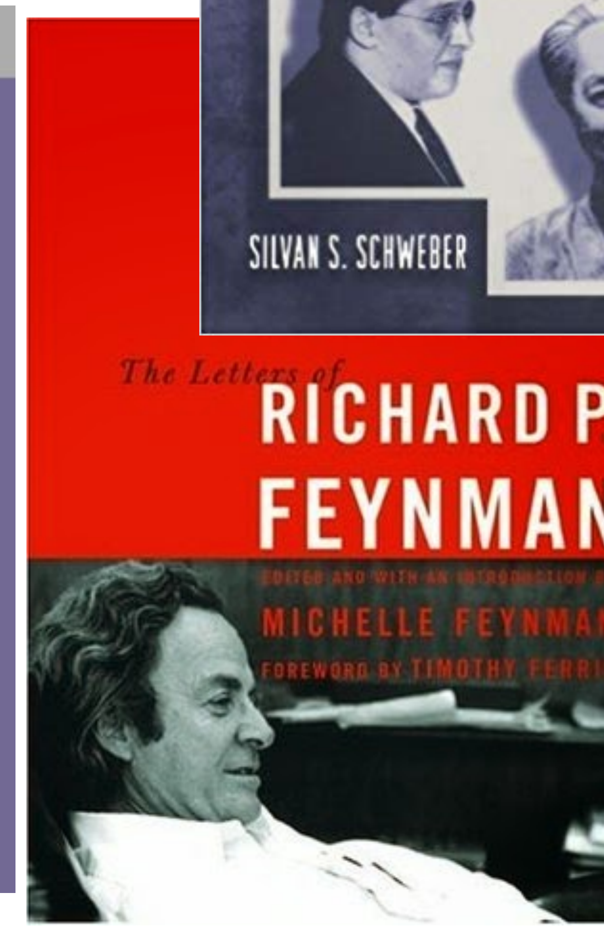
- QED and the man who made it (S.S. Schweber, 1994)
- Most of the Good Stuff: Memories of R.P. Feynman. (Brown,L and Rigden,J), 1993
- Selected Papers of Richard Feynman, (Brown,L)2000
- Perfectly Reasonable Deviations from the Beaten Track: The Letters of R.P. Feynman, (ed. Michelle Feynman),1993
- Quantum Man (L.M.Krauss)2012











Public figure

Feynman also became known through his semi-autobiographical books

Surely You're Joking, Mr. Feynman!

What Do You Care What Other People Think?

and books written about him such as

Tuva or Bust! (by R. Leighton)

Genius: The Life and Science of Richard Feynman (by J. Gleick.)

He assisted in the

development of the atomic bomb during World War II

became known to a wide public (1986-1988) as a member of the

Rogers Commission, the panel that investigated

the Space Shuttle *Challenger* disaster..

In a 1999 poll of 130 leading physicists worldwide by the British journal *Physics World* he was ranked as one of the ten greatest physicists of all time


Seeing Things

Path Integral

Space–time approach to non-relativistic quantum mechanics. *Rev. Mod. Phys.* **20** (1948): 367–387.

QED

The theory of positrons. *Phys. Rev.* **76** (1949): 749–759.

Space–time approach to quantum electrodynamics. *Phys. Rev.* **76**: 769–789. (1949)

With Laurie M. Brown. Radiative corrections to Compton scattering. *Phys. Rev.* **85** (1952): 231–244.

Liquid Helium

Mathematical formulation of the quantum theory of electromagnetic interaction. *Phys. Rev.* **80** (1950): 440–457.

Atomic theory of the lambda transition in liquid helium. *Phys. Rev.* **91** (1953): 1291

Atomic theory of liquid helium near absolute zero. *Phys. Rev.* **91** (1953): 1301

V-A interaction

With M. Gell-Mann. Theory of the Fermi interaction. *Phys. Rev.* **109** (1958): 193–198

Quantisation QFT of gravity and YM theories

The quantum theory of gravitation. *Acta Physica Polonica* **24** (1963): 697–722.

The Dirac-Feynman path integral

Dirac: The Lagrangian in Quantum Mechanics (1932) Phys. Zeit. der Sowjetunion 3 (1933), 64

Dirac, "The Principles of Quantum Mechanics", p124 to 126. (Oxford 1935)

Thesis - 1942 - Feynman

FEYNMAN, R.P.
Principles of least
action in quantum
mechanics.

Two page citation from Dirac

mechanics. These remarks bear so directly on what is to follow and are so necessary for an understanding of it, that it is thought best to quote them in full, even though it results in a rather long quotation. Speaking of the transformation function (q_t'/q_T') connecting

[1] P. A. M. Dirac, *The Principles of Quantum Mechanics* (The Clarendon Press, Oxford, 1935), second edition, Section 33; also, Physik. Zeits. Sowjetunion 3, 64 (1933).
[2] P. A. M. Dirac, Rev. Mod. Phys. 17, 195 (1945).

The Dirac-Feynman path integral

Dirac: The Lagrangian in Quantum Mechanics *Phys. Zeit. der Sowjetunion 3 (1933),*

What corresponds in quantum theory to the Lagrangian method of the classical theory ?

Advantages: Equations of motions are given by stationary property of the action
Easily expressed relativistically.
Easily generilized to suitable flied quantities

$$<q_{t+\epsilon}|q_t> = \exp\frac{i}{\hbar}\int_t^{t+\epsilon} Ldt$$

$$<q_t|q_T> = \int < q_t|q_m > dq_m < q_m|q_{m-1} > dq_{m-1}... < q_2|q_1 > dq_1 < q_1|q_T >$$

Feynman worked out the formalism

QED: graphical rules and renormalizability

Space–time approach to quantum electrodynamics. *Phys. Rev.* **76**: 769–789. (1949)

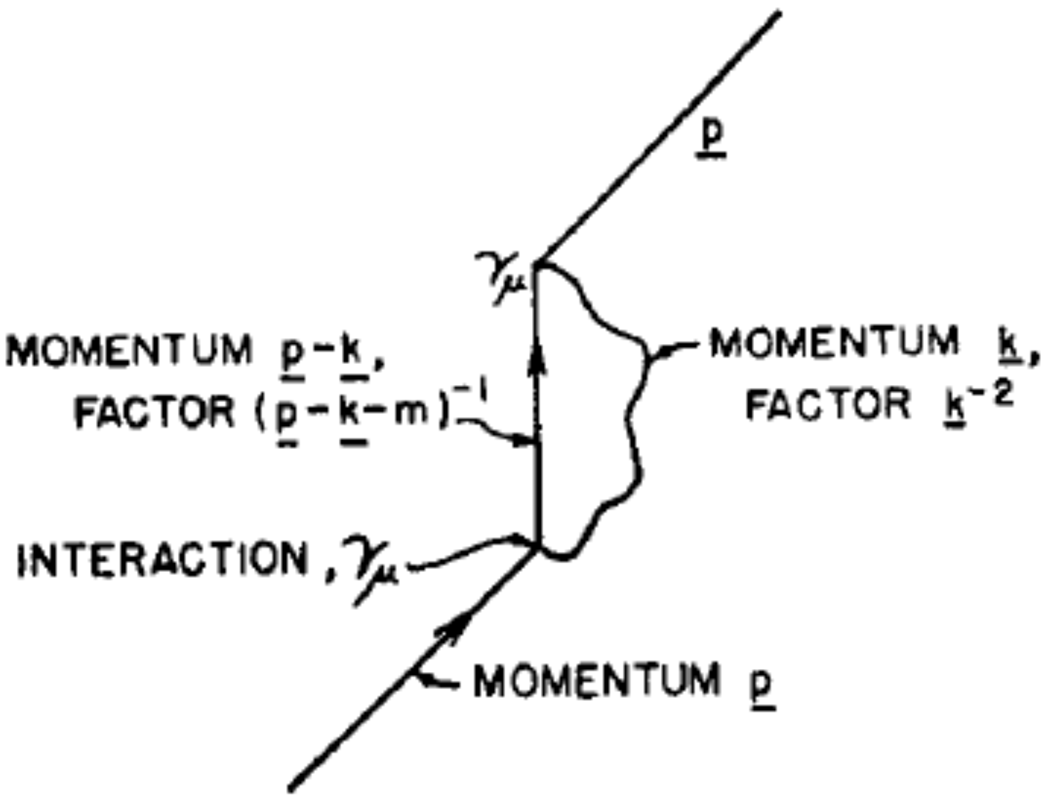


FIG. 3. Interaction of an electron with itself. Momentum space, Eq. (11).

His most famous and perhaps most important contribution is the diagrammatic approach to QED

With Tomanaga,Schwinger and Dyson he invented quantum field theory where QM and special relativity fit together,

Derivation of Feynman rules and Feynman diagrams without path integral

Schwinger: "Feynman brought QFT to the masses: "

learn Feynman diagrams without understanding QFT

QUANTUM THEORY OF GRAVITATION*

BY R. P. FEYNMAN

(Received July 3, 1963)

My subject is the quantum theory of gravitation. My interest in it is primarily in the

The quantum theory of gravitation. *Acta Physica Polonica* **24** (1963): 697–722.

Fadeev-Popov Ghost

Feynman's tree theorem

Berezin integrals over fermions

Berezin, F.A.: The method of second quantization. "Nauka", Moscow (1965). English translation Academic Press, New York (1966)

A roaring come-back of the path integral method

Quantisation QFT of gravity and YM theories

The quantum theory of gravitation. *Acta Physica Polonica* **24** (1963): 697–722.

My subject is the quantum theory of gravitation. My interest in it is primarily in the relation of one part of nature to another. There's a certain irrationality to any work in gravitation, so it's hard to explain why you do any of it; for example, as far as quantum effects are concerned let us consider the effect of the gravitational attraction between an electron and a proton in a hydrogen atom; it changes the energy a little bit. Changing the energy of a quantum system means that the phase of the wave function is slowly shifted relative to what it would have been were no perturbation present. The effect of gravitation on the hydrogen atom is to shift the phase by 43 seconds of phase in every hundred times the lifetime of the universe! An atom made purely by gravitation, let us say two neutrons held together by gravitation, has a Bohr orbit of 10^8 light years. The energy of this system is 10^{-70} rydbergs. I wish to discuss here the possibility of calculating the Lamb correction to this thing, an energy, of the order 10^{-120}. This irrationality is shown also in the strange gadgets of Prof. Weber, in the absurd creations of Prof. Wheeler and other such things, because the dimensions are so peculiar. It is therefore clear that the problem we are working on is not the correct problem; the correct problem is what determines the size of gravitation? But since I am among equally irrational men I won't be criticized I hope for the fact that there is no possible, practical reason for making these calculations.

Yang-Mills and Gravitation

1. B. S. DeWitt, *Phys. Rev.*, **162**, 1195, 1239 (1967).
2. B. S. DeWitt, *Phys. Rev. Letters*, **12**, 742 (1964).
3. V. N. Popov and L. D. Faddeev, "Perturbation Theory for Gauge Invariant Fields," preprint I.T.Ph., USSR, Kiev (1967).
4. S. Mandelstam, *Phys. Rev.*, **175**, 1580, 1604 (1968).
5. S. Mandelstam, *Ann. Phys.* (New York), **19**, 25 (1962).

Yang-Mills only

1. L. D. Faddeev and V. N. Popov, *Phys. Letters*, **25B**, 29 (1967).
2. L. D. Faddeev, *Theo. and Math. Phys.*, **1**, 1 (1969).

Canonical approach (Hamiltonian)

1. P. A. M. Dirac, *Can. J. Math.*, **2**, 129 (1950).
2. P. A. M. Dirac, *Proc. Roy. Soc.* (London), **A246**, 326, 333 (1958).
3. P. A. M. Dirac, *Phys. Rev.*, **114**, 924 (1959).
4. R. Arnowitt, S. Deser and C. W. Misner, "The Dynamics of General Relativity," *Gravitation, an Introduction to Current Research*, L. Witten, ed. (New York: Wiley, 1962).
5. B. S. DeWitt, *Phys. Rev.*, **160**, 1113 (1967).
6. J. Schwinger, *Phys. Rev.*, **152**, 1219 (1966); **158**, 1391 (1967); **173**, 1264 (1968).

Canonical Derivations of the Feynman-DeWitt Rules

1. I. B. Khryslovich, *Yadernaya Fizika*, **10**, 409 (1968); English translation: *Sov. J. Nucl. Phys.*, **10**, 235 (1970).
2. A. M. Altukhov and I. B. Khryslovich, *Yadernaya Fizika*, **11**, 902 (1970).
3. E. S. Fradkin and I. V. Tyutin, *Phys. Letters*, **30B**, 562 (1969); *Phys. Rev.*, **D2**, 2841 (1970).
4. P. Hasenfratz and P. Hrasko, *Phys. Rev.,* **D13**, 2235 (1976)

The Parton Model: Quarks and Gluons

From parity revolution to the problem of composite strongly interacting hadrons

Very high-energy collisions of hadrons. Phys. Rev. Lett. 23 (1969)1415-1417.

The behavior of hadron collisions at extreme energies. In High Energy Collisions London, Gordon and Breach (1969), pp. 237-256.

Partons. In The Past Decade in Particle Theory. London, Gordon and Breach (1971), pp. 773-813.

What neutrinos can tell us about partons. In Proc. Neutrino '72 Europhysics Conference Vol. 11. Budapest: OMKD Technoinform, pp. 75-96.

Photon-Hadron Interactions. Reading, Massachusetts: W.A. Benjamin., 1972 296 pages

NEUTRINO '72

EUROPHYSICS CONFERENCE

BALATONFÜRED, HUNGARY,

11-17 JUNE 1972

organized by

THE HUNGARIAN PHYSICAL SOCIETY

PROCEEDINGS VOLUME II.

A. FRENKEL
G. MARX
Editors

1968-1972

Detailed experimental information on DIS at SLAC
Parton Model

1971
Significant development in weak interaction theory

1972
Measurement of Neutrino-nucleon scattering at high energy, CERN and Fermilab is started or just starting

1973:
Discovery of natural currents
Discovery of asymptotic freedom

QCD is the theory of strong interactions ?

HUNGARY

G.Benkó
E.Dénes
A.Frenkel
É.Gajzágó
T.Gombosi
G.Györgyi
K.Hajdú
P.Hasenfratz
M.Huszár
P.Király
D.Kiss
J.Kóta
I.Lovas
B.Lukács
I.Manno
J.Szücs
E.Nagy
J.Nyiri
Z.Perjés
G.Pintér
Á.Sebestyén
A.Somogyi
C. Szegő
F.Telbisz
J.Zimányi
A.Kónya

D.Berényi
A.Vatai
I.Farkas
L.Gálfi
J.Harnad
Z.Horváth
F.Károlyházi
K.Nagy
K.L.Nagy
F.Niedermayer
T.Nagy
G.Pócsik
Z.Rácz

P.Gnädig
Z.Kunszt
J.Kuti
G.Marx
A.Patkós
A.S.Szalay

UNITED STATES OF AMERICA

J.Bahcall
R.P.Feynman NP,1965
B.C.Barish NP,2017
G.L.Cassiday
C.L.Cowan NP,1995

R.Davis Jr. NP,2002
K.Lande
T.D.Lee NP,1957
R.E.Marshak
F.Reines NP,1995
V.L.Telegdi
V.F.Weisskopf

SWITZERLAND

C.Baltay
J.S.Bell
R.Gastmans
B.Lautrup
P.Musset
S.Natali

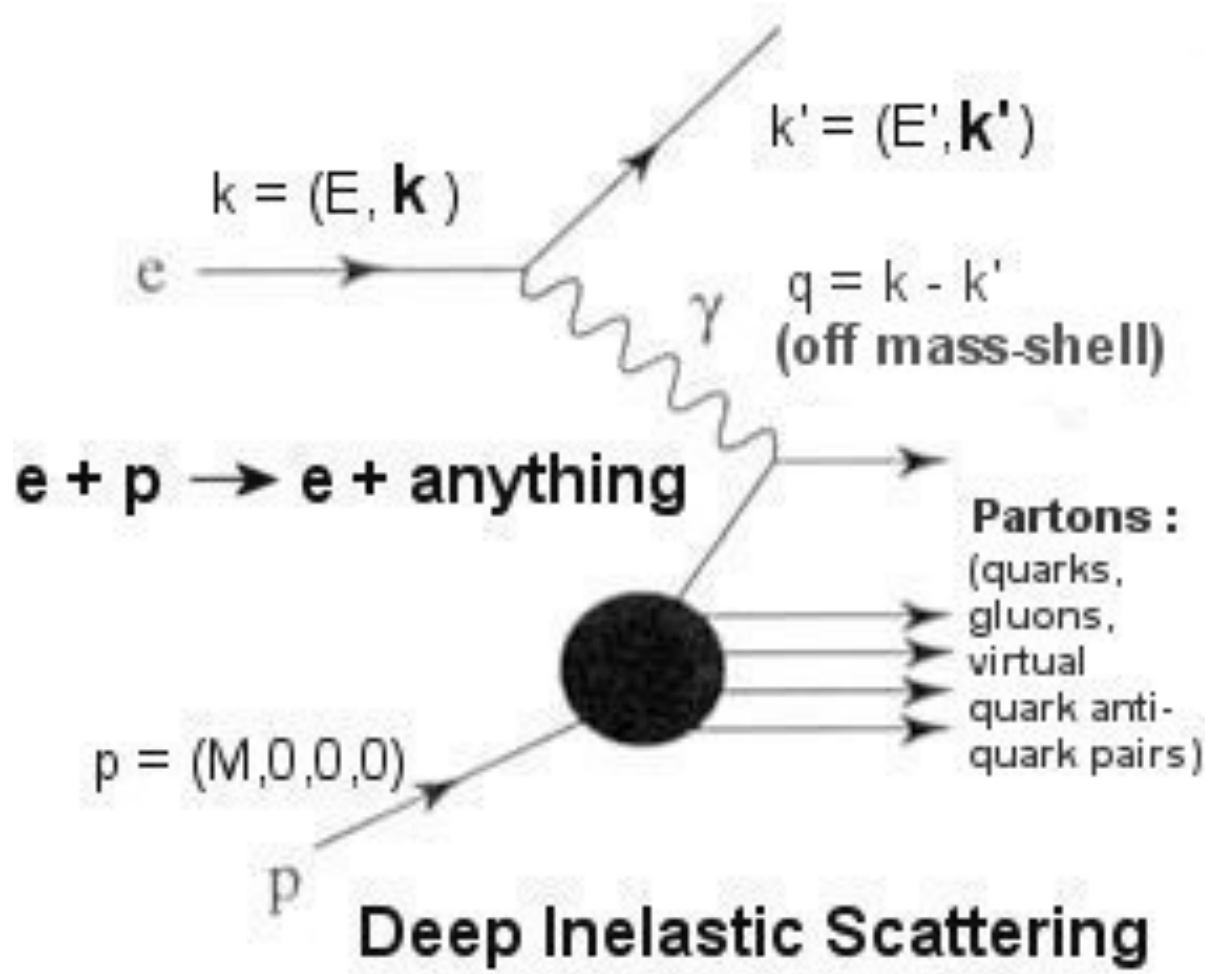

72
BALATON

Feynman’s talk: What neutrinos can tell us about partons

The wave function for a proton moving with a large momentum P is supposed to be large only when the transverse momenta of the proton is finite. When we scatter a high energy lepton from such a proton it scatters from a particular parton allowing for energy-momentum conservation. The spectrum of the scattered lepton determines the longitudinal momentum distribution of the parton in a manner analogous to the way the frequency distribution of radar scattered from a swarm of bees determines the velocity distribution of the bees inside the swarms.

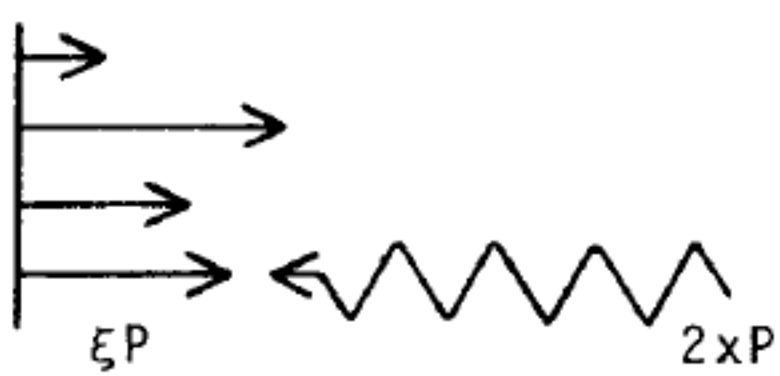
Riordan reported that when Feynman visited SLAC in August 1968 and saw the experimental results on deep inelastic scattering,“Feynman had an epiphany” when he realized that the observations measured “in some way the momentum distribution of his parton!”

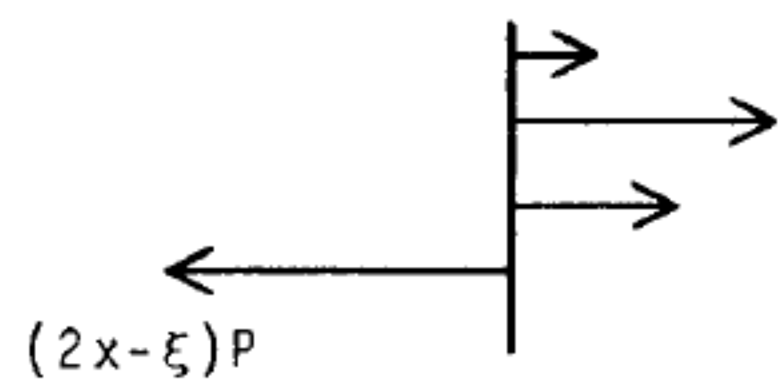
The parton picture of deep inelastic scattering



$p = (P, 0, 0, P)$

$q = (0, 0, 0, -2Px)$





Q: Why have not quarks and partons been produced at SLAC?

Feynman: I am so much used to the idea that quarks are not produced that I forgot to mention that there is a paradox: is it possible that quarks only have interactions for finite relative momenta and yet do not get isolated, they cannot get separated? I do not understand that I am happy with that. I like paradoxes…that is the fun.

Q: .. you said neutral quarks probably also exist. Where did they come from?

Feynman:
Not neutral quark, I said neutral partons. I have not found anyway by electron and neutrino scattering to tell us more about these neutral partons except their existence, induced by the fact that the conservation of momentum does not work with the charged quarks.

Q: Do you think that the reason we do not see quarks is they posses very large masses and interact strongly with each other in peculiar ways?

Feynman:
This is a completely different direction, but not the direction I am going. If the quark masses are high… then the whole thing goes haywire…
My quarks have small masses, and they do not come apart because of something I 'll tell you about 25 years from now. The masses that I want are so law that we would have absolutely and definitely seen them. Thus perhaps the whole thing is nonsense, and the experiment will tell you very soon. Or if it is right then this is very exiting, because we are approaching a paradox, and the hope of physics is to find a paradox. This is the real way of making a revolution. We have to find a place where we are shocked. I thinks we are getting near to one.

What would be the effect of introducing partons with quantum numbers different from those of normal quarks?

Feynman:
Another system of partons with other quantum numbers (such as the triplet quark model and other models) definitely have a big effect.

Talk by Kuti: Deep Inelastic Lepton Nucleon Scattering

Important work in Budapest on spin dependent DIS

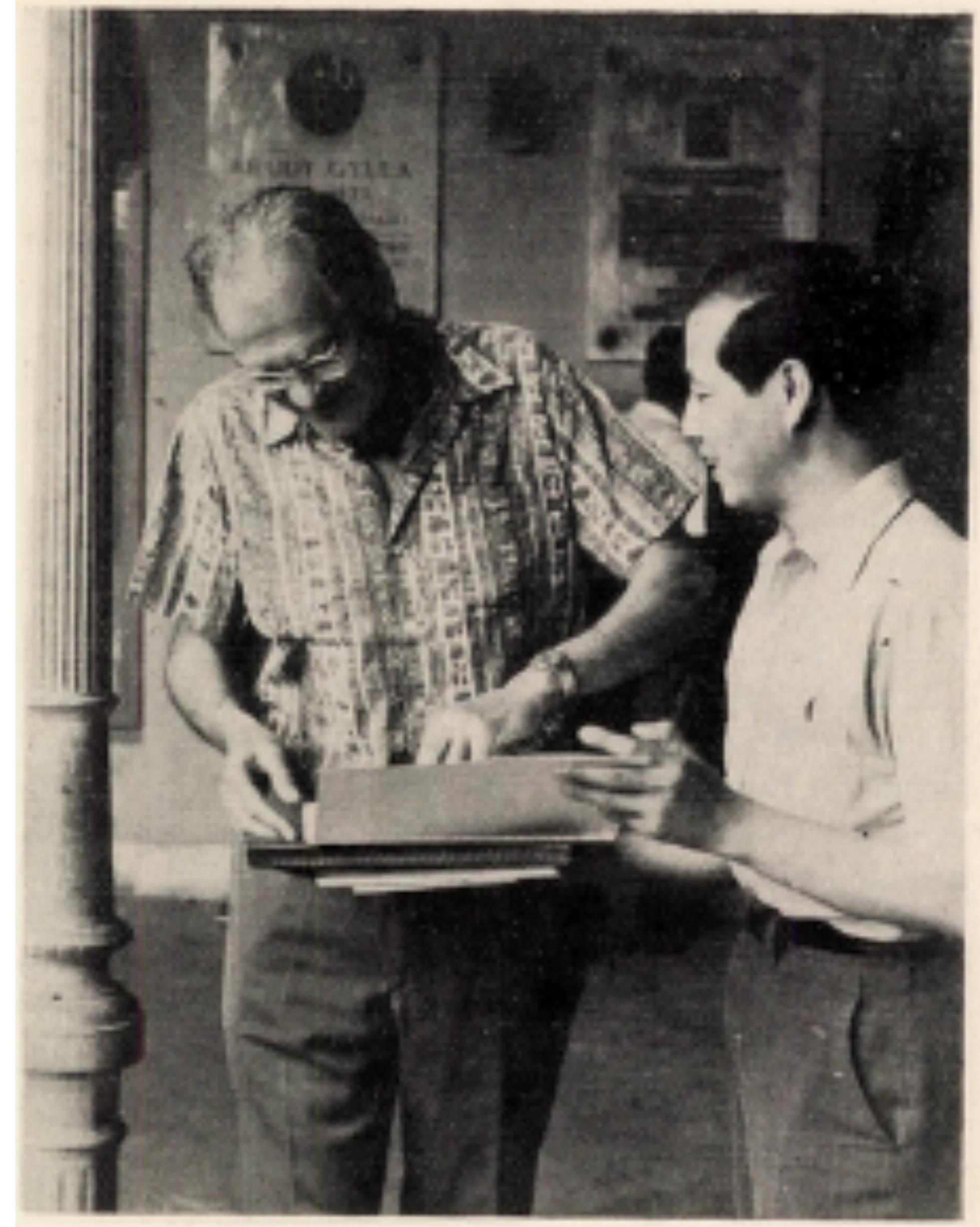
I

Finn Ravndal:

During that term Feynman went to Hungary to take part in a neutrino conference at Balatonfüred. He came back fired up with the first quantitative experimental confirmation of the parton model and the fractional quark charges. This was the measurement of the famous factor of 5/18 which related the deep inelastic electron scattering cross section to the corresponding cross section with neutrinos. Around this time he had started to think that the charge of a single quark could be measured directly by summing up the charges from the jet fragments in the final state. This possibility caught the attention of Glennys Farrar and Jon Rosner[21]. In the fall I travelled to Fermilab with Feynman where we among others met Stan Brodsky who also had considered this proposal in his collaboration with Farrar. He argued convincingly that such a measurement would not be possible. Feynman realized that he had been wrong and was visibly shaken afterwards.

T.D. Lee : critics of the parton model

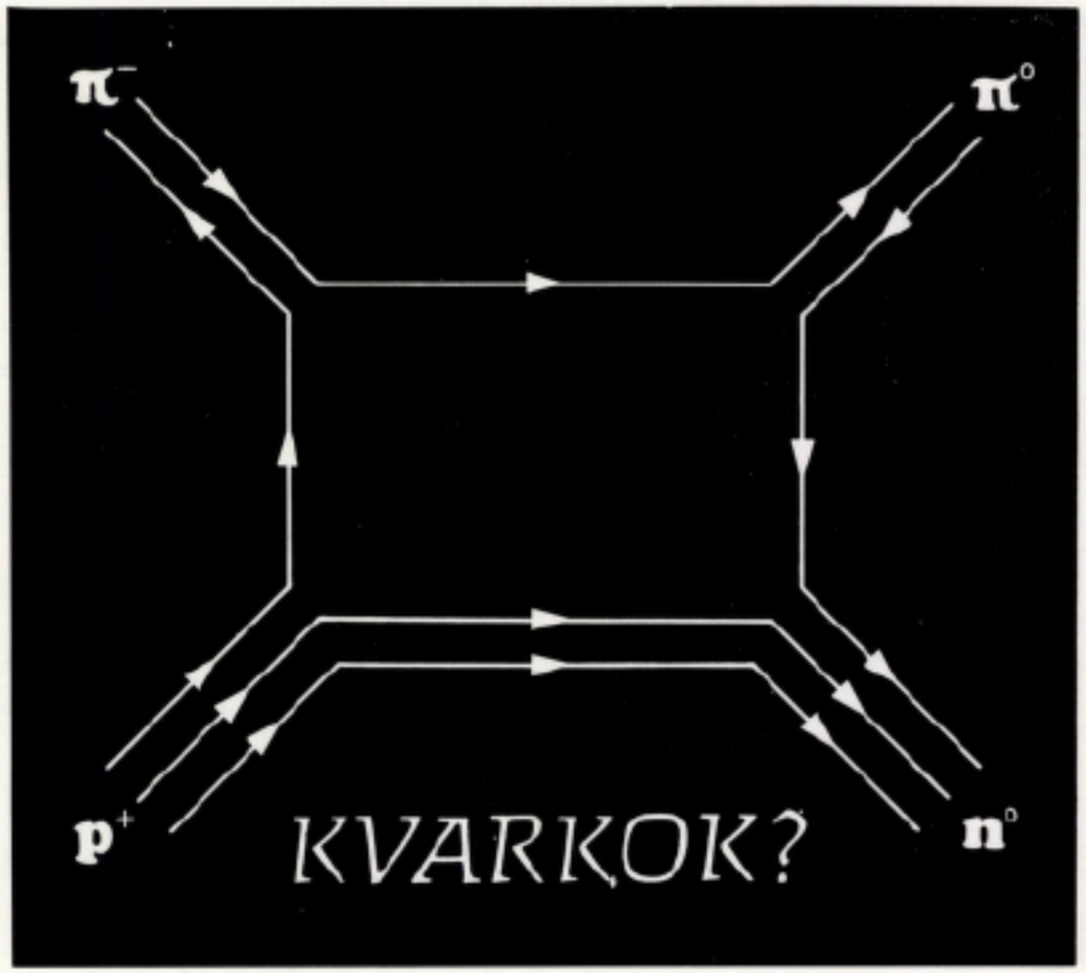
The important role of the infinite momentum frame in the formulation of the model may be in conflict with relativistic invariance. The kinematical conditions are only consistent with light quarks much lighter than the protons. This appears to be rather unphysical.



Victor Weisskopf és Tseng Dao Lee Balatonfüreden

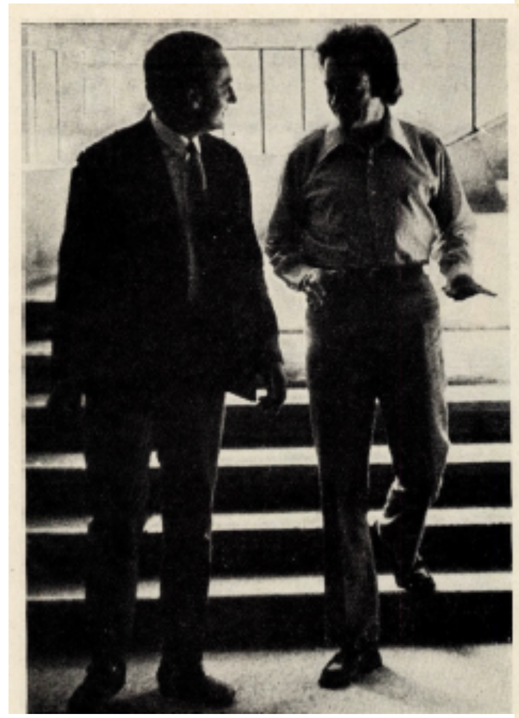
fizikai szemle

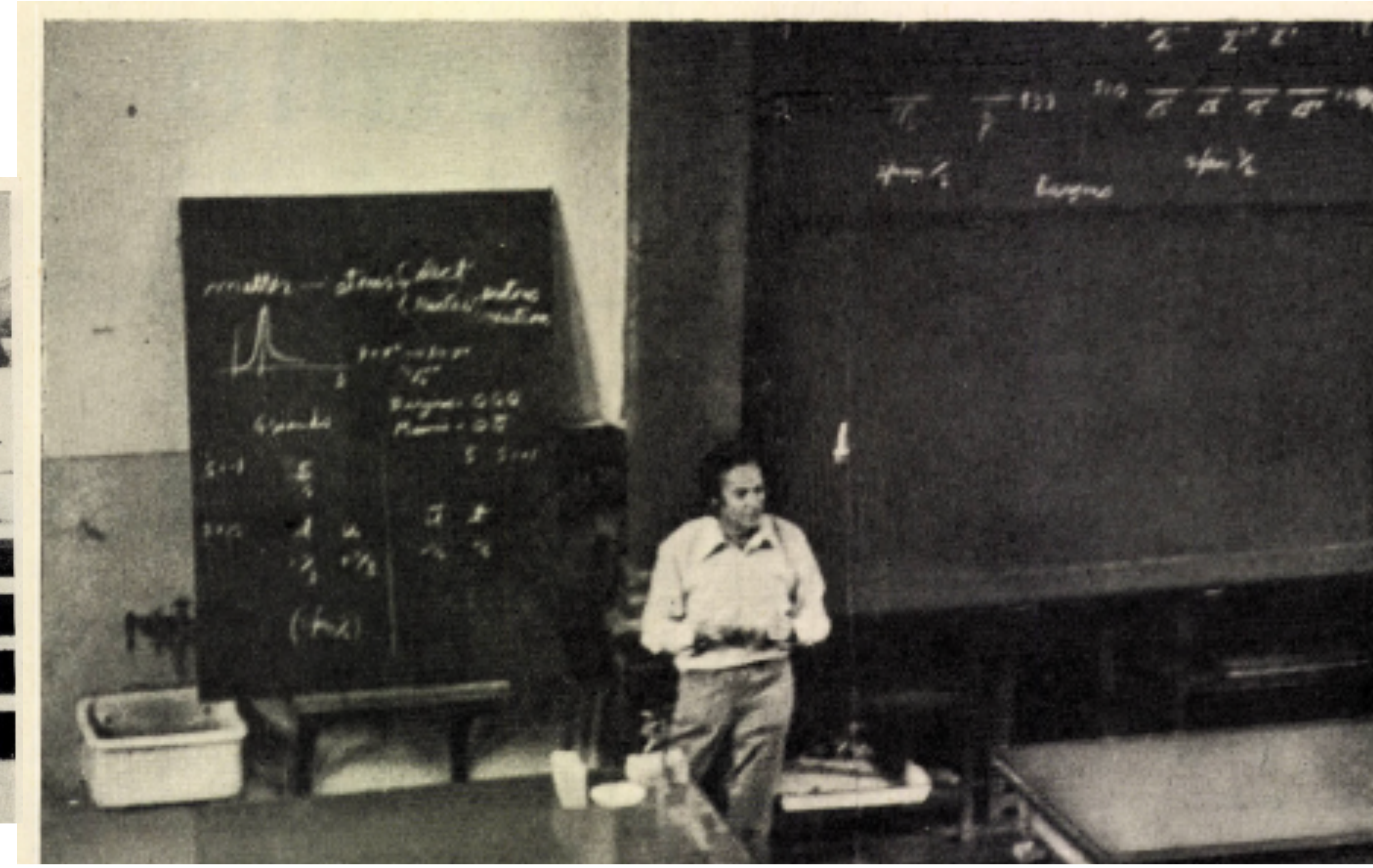
Az Eötvös Loránd Fizikai Társulat lapja



1973|1

Feynman's talk : Quarks





1972

[88] *Statistical Mechanics*; a set of lectures. Reading, Massachusetts: W.A. Benjamin.
[89] *Photon–Hadron Interactions*. Reading, Massachusetts: W.A. Benjamin.
[90] What neutrinos can tell us about partons. In *Proc. Neutrino '72 Europhysics Conference*, Vol. II. Budapest: OMKD Technoinform, pp. 75–96.
[91] *Fisica de Altas Energias: Cursos de Verano 1972*. Mexico: COPAA-SEDICT.

1973

[92] Quarks. *Fizikai Szemle* **23**: 1–7.

I

Finn Ravndal:

Back at Caltech in the fall we in the younger generation realized that renormalization and the calculation of Feynman diagrams would be necessary in order to participate in the exploration of the new QCD. But this was a direction of particle physics for which we were not prepared, in spite of having Feynman and Gell-Mann around us on a daily basis. There had been very little or no quantum
field theory in standard courses with the weight
instead on more phenomenological aspects. In one of his Wednesday seminar Gell-Mann wanted to discuss the renormalization group and its use in QCD. It was not of much help and we felt disappointed, expecting more from one of the originators of this fundamental method.

QCD is the correct theory of strong interactions

Late in the spring 1973 the beta-function for QCD had been calculated and found to be negative, implying asymptotic freedom. Feynman showed little or no interest in this result.

That was surprising since his parton model now had a field-theoretic formulation. One reason was the unsettling situation with the total e+e- cross section for which the latest experiments at the Cambridge accelerator still gave values much larger than expected. The factor of three due to the new colours didn't seem to be the solution.

The younger generation realized that renormalization and the calculation of Feynman diagrams would be necessary in order to participate in the exploration of the new QCD

First corrections to scaling in DIS has been calculated using Wilsons operator product expansion. How to apply it to hadron processes was not clear. The parton model lost Its importance.

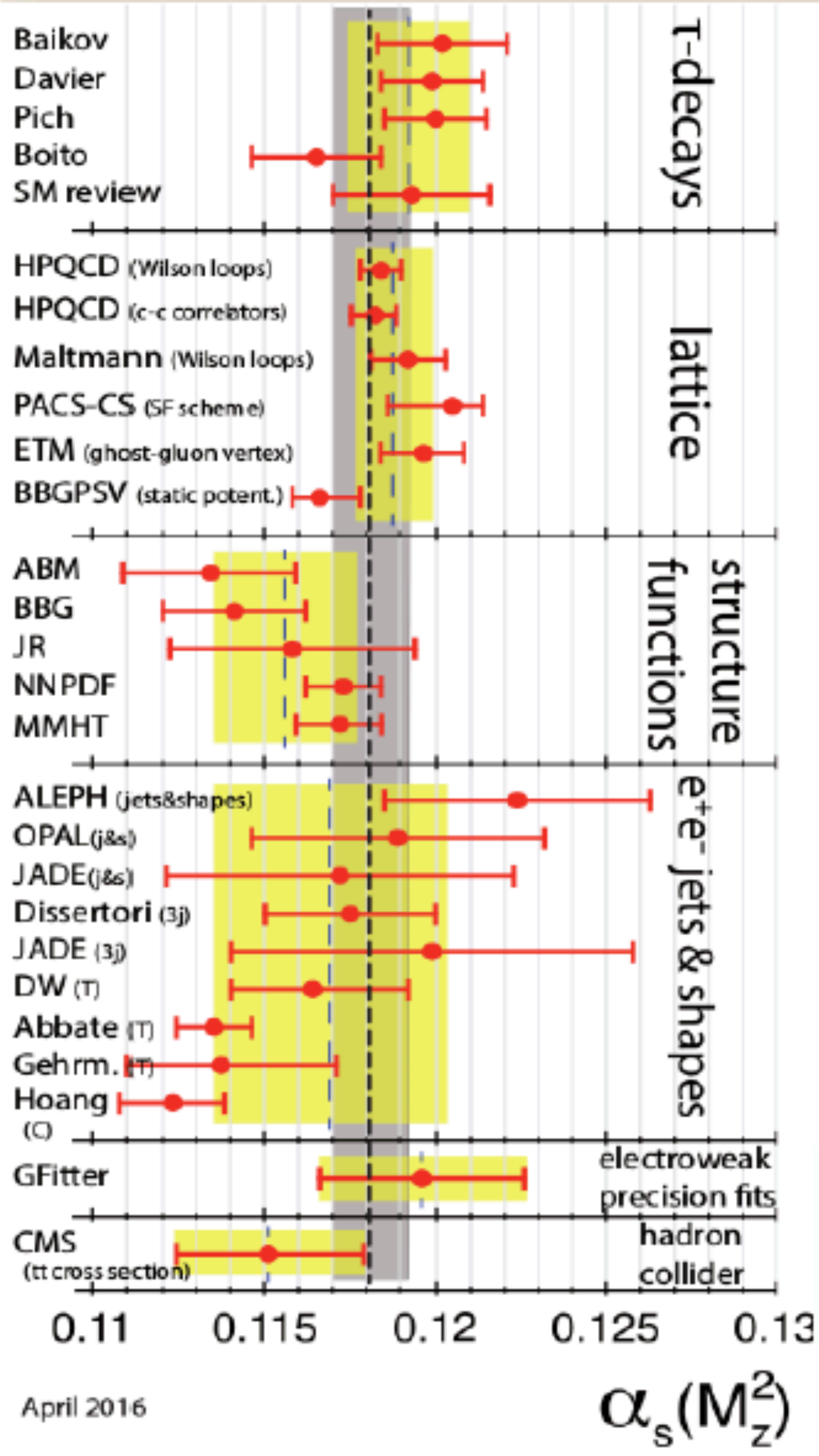
Altarelli-Parisi DGLAP evolution equations

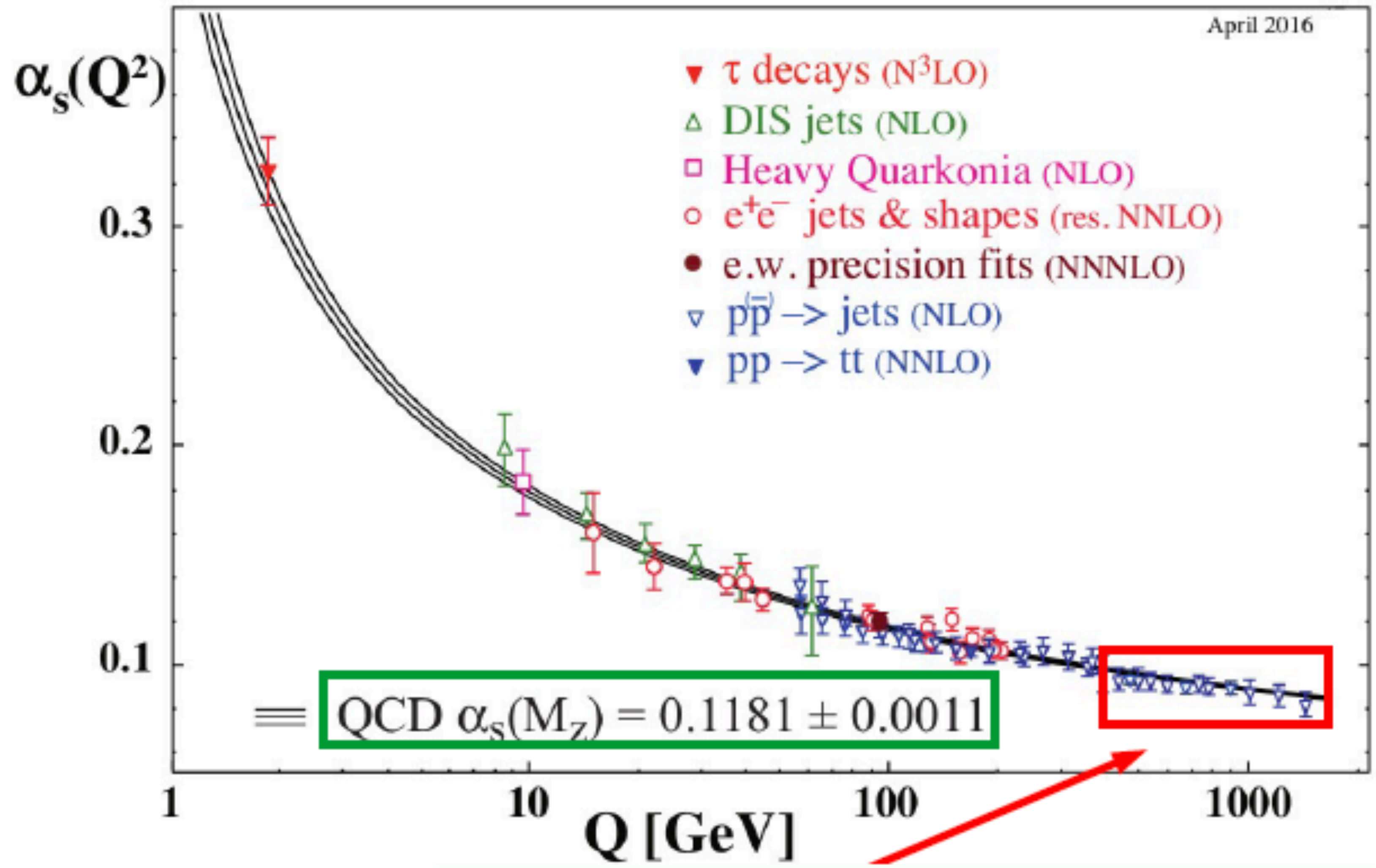
Factorization and cancellation theorem

Perturbative QCD: high precision tool for predicting values of observables measured in high energy scattering experiments

$$\sigma(s,\tau) = \sum_{AB} \int dx_1 dx_2 p_{1A}(x_1, Q^2) p_{2B}(x_2, Q^2) \sigma_{AB}(x_1 x_2 s, \tau)$$

Lattice gauge theory for low energy





not included in average:
LHC data, but only NLO theory

dominated by lattice

$$\frac{\Delta\alpha_S(M_Z)}{\alpha_S(M_Z)} = 0.9\%$$

PDG, Chin. Phys. C40 (2016) 100001

PDG 1992: 2.4%

Feynman and the subtraction method

THE PERTURBATIVE CALCULATION OF JET STRUCTURE IN e^+e^- ANNIHILATION*

R.K. ELLIS[1], D.A. ROSS[2] and A.E. TERRANO

California Institute of Technology, Pasadena, California 91125, USA

Received 4 July 1980

The structure of this paper is as follows. In sect. 2 we calculate the differential cross section for processes involving three particles in the final state. Representing this as $\sigma^{(3)}$ we obtain the distribution in C:

$$\frac{d\sigma^{(3)}}{dC} = \int d\sigma^{(3)}\,\delta(C - C^{(3)})\,, \tag{1.17}$$

where $C^{(3)}$ is the expression given by eq. (1.13). The above expression contains divergences due to the emission of soft and collinear particles. In sect. 3 we calculate the contribution to the cross section due to the production of four partons

We are pleased to acknowledge useful discussions with R. P. Feynman, R. D. Field, T. Goldman, Z. Kunszt, H. D. Politzer, and S. Wolfram. We thank the MATHLAB at MIT for the use of MACSYMA.

in the final state. This may be schematically written as

$$\frac{\mathrm{d}\sigma^{(4)}}{\mathrm{d}C} = \int \mathrm{d}\sigma^{(4)}\,\delta(C - C^{(4)})\,, \tag{1.18}$$

where $C^{(4)}$ is given by eq. (1.14). Eq. (1.8) also contains singularities in the three-jet region. Thus the total contribution is given by,

$$\begin{aligned}\frac{\mathrm{d}\sigma}{\mathrm{d}C} &= \frac{\mathrm{d}\sigma^{(4)}}{\mathrm{d}C} + \frac{\mathrm{d}\sigma^{(3)}}{\mathrm{d}C} \qquad C \neq 0 \\ &= \mathrm{d}\sigma^{(4)}\,\delta(C - C^{(4)}) + \mathrm{d}\sigma^{(3)}\,\delta(C - C^{(3)})\,.\end{aligned} \tag{1.19}$$

As a calculational device it is convenient to deal only with finite quantities. Hence we evaluate the terms in $\mathrm{d}\sigma^{(4)}$ which contain singularities in the region in which four jets masquerade as three:

$$\mathrm{d}\sigma^{(4)} \overset{\substack{\text{singular}\\ \text{region}}}{\rightarrow} \mathrm{d}\sigma^{(s)}\,. \tag{1.20}$$

We thus rewrite eq. (1.19):

$$\frac{\mathrm{d}\sigma}{\mathrm{d}C} = \left[\mathrm{d}\sigma^{(4)}\,\delta(C - C^{(4)}) - \mathrm{d}\sigma^{(s)}\,\delta(C - C^{(3)})\right] + \left[(\mathrm{d}\sigma^{(s)} + \mathrm{d}\sigma^{(3)})\delta(C - C^{(3)})\right]. \tag{1.21}$$

Each of the terms in square brackets is now finite in the three-jet region [but still

Feynman and Field

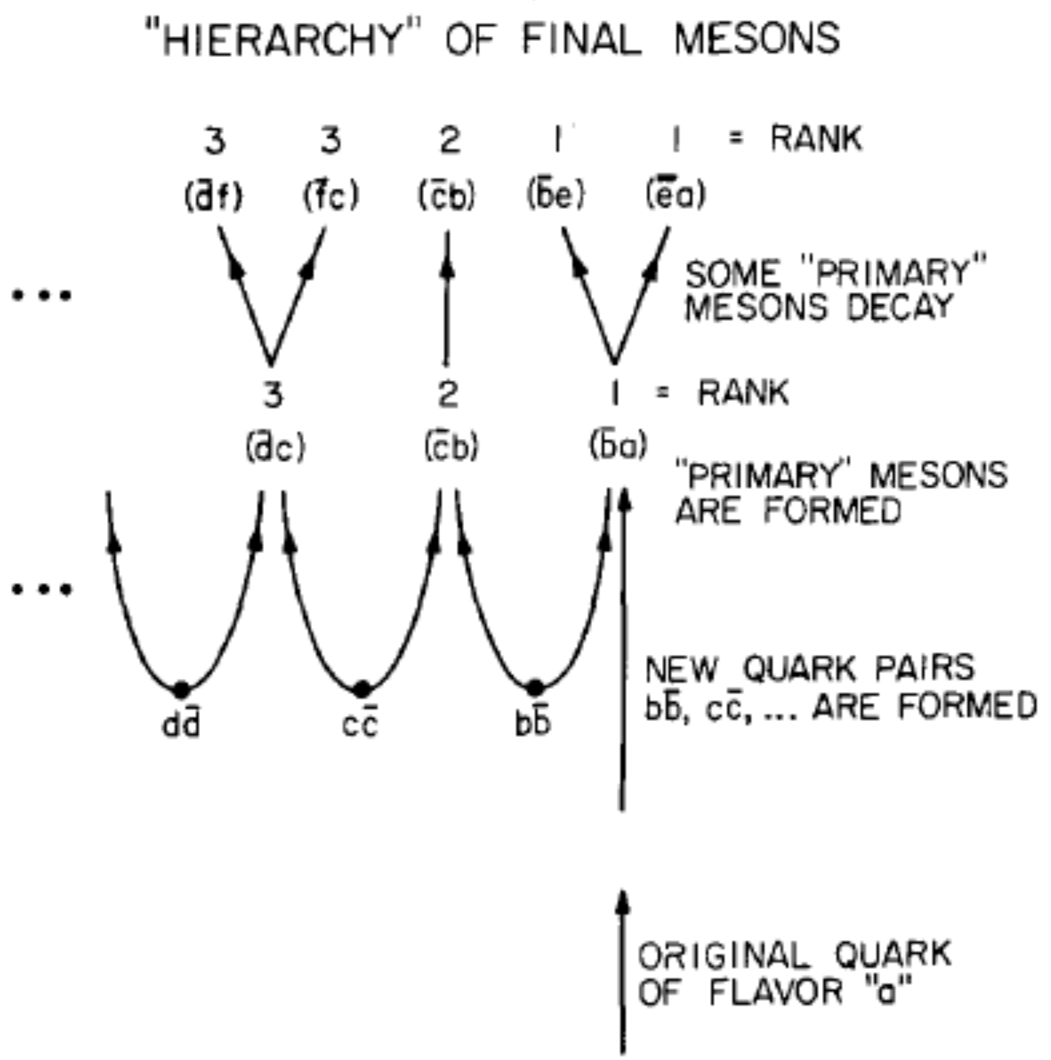


Fig. 1. Illustration of the "hierarchy" structure of the final mesons produced when a quark of type "a" fragments into hadrons. New quark pairs b$\bar{b}$, c$\bar{c}$, etc., are produced and "primary" mesons are formed. The "primary" meson $\bar{b}$a that contains the original quark is said to have "rank" one and primary meson $\bar{c}$b rank two, etc. Finally, some of the primary mesons decay and we assign all the decay products to have the rank of the parent. The order in "hierarchy" is *not* the same as order in momentum or rapidity.

G. Marx and Feynman's tree at Balatonfüred

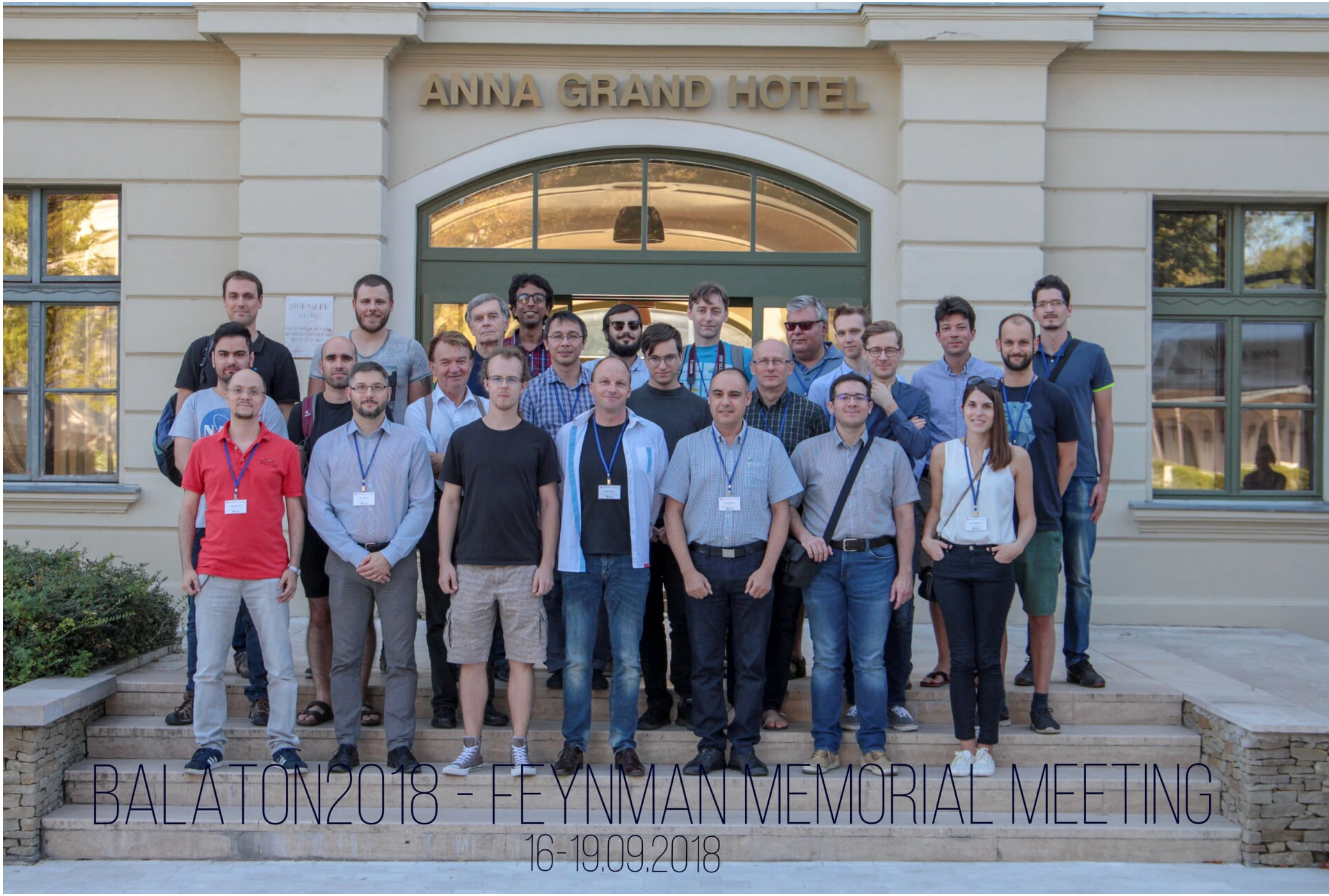
After 10 years of dark period that followed the crushing of the revolution in 1956 the he communist Hungary a satellite country of the Soviet Union started to open itself for scientific collaboration. Also the sputnik in 1961 triggered interest for scientific collaboration also in the US and Western Europe. Hungarian scientist could go to visit US universities and one was allowed to organise international conferences . The Hungarian Particle physicist have been lucky having a charismatic young Professor George Marx who could brilliantly live with the new possibilities. He was an excellent physicist, brilliant speaker, high spirited, genuinely interested in the emerging revolutionary developments in particle physics.

The Neutrino '72 Conference in Balatonfured was a part of this effort. G. Marx made a brilliant organisation. Neutrino physics was an emergent field and Marx also worked on neutrino physics . He had already visited US universities and had excellent personal contact with the leading particle physicist in Europe and in the US.

G. Marx had holiday house in Balatonfured. Rabindranath Tagore planted the first tree. A group of indian trees is formed.(NP 1913). Much later Salvatore Quasimodo also planted a tree.(NP 1953). The tradition that if a Nobel-Prize laureat visits Balatonfüred he or she oughto plant a tree.

He suggested that Feynman as Nobel-prize holder should also plant a tree. But one had to have balance between East and West, so Bruno Pontecorvo has been asked to plant a tree. It happened on June 13.

Later Frank, Wigner, Dirac also followed.


ANNA GRAND HOTEL
BALATON2018 - FEYNMAN MEMORIAL MEETING
16-19.09.2018

TWO MAJOR DISCOVERIES:

HIGGS-BOSON

DETECTION OF GRAVITATIONAL WAVES

How to proceed?