Nicola Cabibbo a Roma I e II

DIPARTIMENTO DI FISICA

SAPIENZA
UNIVERSITÀ DI ROMA

Frascati 15 Dicembre 2020

He was the "father of flavor physics" and will be missed. Of course like all great physicists he will live on through the important contributions he has made to our understanding of nature

M. Wise on behalf of Caltech High Energy Physics

Fermi Constant

Dirac Equation

Goldstone boson

Cabibbo Angle

Cabibbo-Kobayashi-Maskawa mixing matrix

INFN Istituto Nazionale di Fisica Nucleare

UNIVERSITÀ DEGLI STUDI DI ROMA LA SAPIENZA

CKM 2006 Nagoya
Nicola Cabibbo, Makoto Kobayashi and (but for one) young italian physicists

Cecilia Tarantino, Nicola Cabibbo, G. M., Vittorio Lubicz


VIETATO FUMARE

A few relevant steps of Nicola Biography and Scientific Career

1. 1960-1962 LNF of INFN Frascati
2. 1962-1965 CERN, Lawrence Radiation Laboratory Berkeley and Harvard
3. 1965 Full Professor at L'Aquila, *1966 in Rome La Sapienza (from 84 for about 10 ys at Tor Vergata) then la Sapienza until his retirement in 2010*
4. In the \`70s & \`80s Institute for Advanced Study Princeton, Paris, New York, Syracuse, CERN
5. 1985-1993 INFN President
6. 1993-1998 ENEA President
7. Member of the Accademia Nazionale dei Lincei, National Academy of Science of United States of America
8. President of the Pontifical Academy of Sciences

The Particle Theory Group in the `70s

R. GATTO

NICOLA CABIBBO

+ Gallavotti + ….

G. ALTARELLI
L. MAIANI
G.PREPARATA

***Cabibbo Alumni**: It was for me a great privilege to study physics in Phys. Dept. of Rome at the beginning of the `70*

(the Nicola tobacco box)

M. TESTA

G. PARISI

R. PETRONZIO

G. MARTINELLI

F. RAPUANO

……

+ Zirilli + Benzi+ Allega+ ….

Nicola Cabibbo

Yearbook Accademia Pontificia 2008

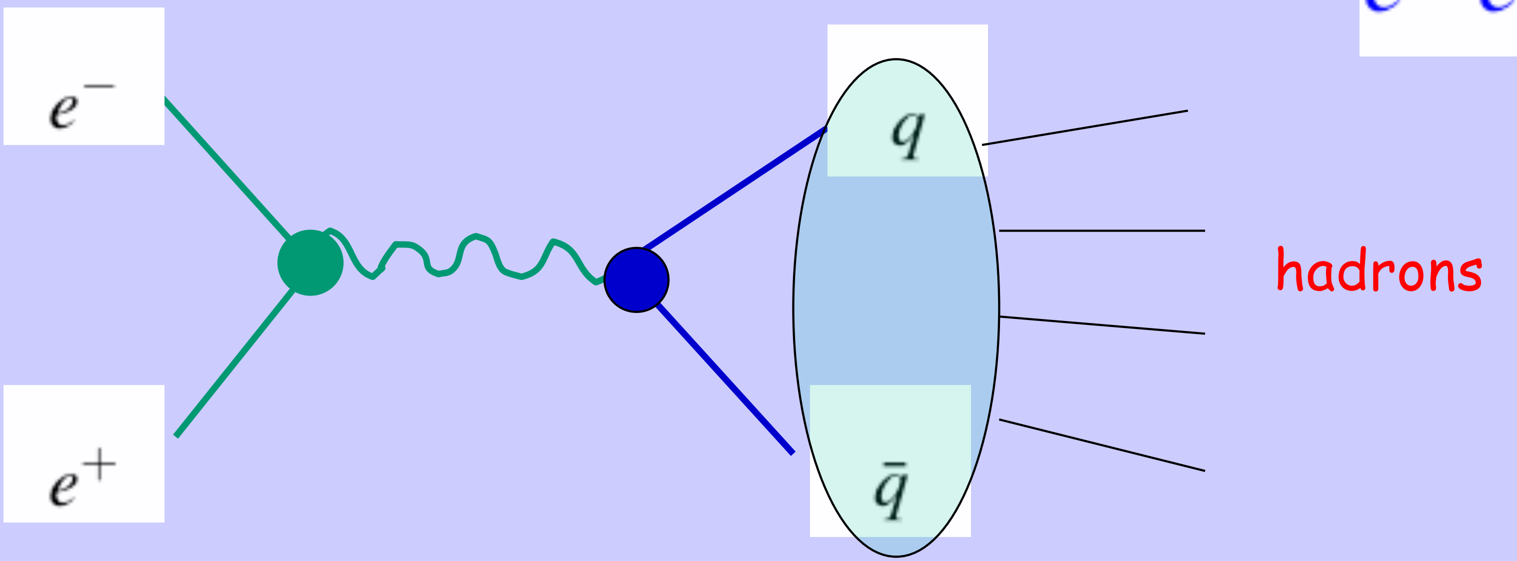
Main publications Cabibbo, N., Gatto, R., 'Electron-Positron Colliding Beam Experiments', *Physical Review*, 124, p. 1577 (1961); Cabibbo, N., 'Measurement of the Linear Polarization of g Rays by the Elastic Photoproduction of p 0 on He 4', *Physical Review*, 124, p. 1577 (1961); Cabibbo, N. and Gatto, R., 'Proton-Antiproton Annihilation into Electrons, Muons and Vector Bosons', *Il Nuovo Cimento*, 24, pp. 170-180 (1962); Cabibbo, N., 'Unitary Symmetry and Leptonic Decays', *Phys. Rev. Lett.*, 10, pp. 531-533 (1963); Cabibbo, N. and Maksymowicz, A., 'Determination of the Form Factors in $K\mu_3$ Decays', *Phys. Lett.*, 9, pp. 352-353 (1964); Cabibbo, N., 'Unitary Symmetry and Nonleptonic Decays', *Phys. Rev. Lett.*, 12, pp. 62-63 (1964); Cabibbo, N. and Radicati, L.A., 'Sum Rule for the Isovector Magnetic Moment of the Nucleon', *Phys. Lett.*, 19, pp. 697-699 (1966); Cabibbo, N., Parisi, G. and Testa, M., 'Hadron Production in $e^+ e^-$ Collisions', *Lettere al Nuovo Cimento*, 4, pp. 35-39 (1970); Altarelli, G., Cabibbo, N. and Maiani, L., 'The Drell-Hearn Sum Rule and the lepton Magnetic Moment in the Weinberg Model of Weak and Electromagnetic Interactions', *Phys. Lett.*, 40B, pp. 415-419 (1972); Bahcall, J.N., Cabibbo, N. and Yahil, A., 'Are Neutrinos Stable Particles?', *Phys. Rev. Lett.*, 28, pp. 316-318 (1972); Cabibbo, N. and Parisi, G., 'Exponential Hadronic Spectrum and Quark Liberation', *Phys. Lett.*, 59B, pp. 67-69 (1975); Cabibbo, N., 'Bag Models', *Proceedings of the International Neutrino Conference*, Aachen (1976); Cabibbo, N., 'Time Reversal Violation in Neutrino Oscillation', *Phys. Lett.*, 72B, pp. 333-335 (1978); Cabibbo, N., 'The Impact of Gauge Theory on Elementary Particle Physics', *Proceedings of the Thirteenth 'Gauge Theories Leptons' Rencontre de Moriond*, Vol. II, (J. Tran Thanh Van, ed.)(1978); Cabibbo, N., 'Parton Distributions and their Q2 Dependence', *The Whys of Subnuclear Physics*, Plenum Publishing

Corporation (1979); Cabibbo, N. and Maiani, L., 'The Vanishing of Order-G Mechanical Effects of Cosmic Massive Neutrinos on Bulk Matter', *Phys. Lett.*, 114B, pp. 115-117 (1982); Cabibbo, N. and Marinari, F., 'New Method for Updating SU(N) Matrices in Computer Simulations of Gauge Theories', *Phys.*

Lett., 119B, p. 387 (1982); Cabibbo, N., 'Gauge Theories and Monopoles' (A Modest Introduction) *Techniques and Concepts of High Energy Physics* (Thomas Ferbel, ed.), NATO ASI Series, Series B: *Physics*, vol. *99* (47) Plenum Press (1983), New York, *Proceedings of the Second NATO Advanced Study Institute*, Lake George (July 1982); Allega, M., Cabibbo, N., 'Acoustic Detection of Superheavy Monopoles in Gravitational Antennas', *Lett. Nuovo Cimento*, 38, pp. 263-269 (1983); Cabibbo, N., Martinelli, G. and Petronzio, R., 'Weak Interactions on the Lattice', *Nuclear Physics*, 244B, pp. 381-391 (1984); Cabibbo, N., 'Quark Mixing', Proceedings of the X Capri Symposium, *30 Years of Elementary Particle Theory* (May 1992).

$R_{e+e-}(S)$

$$e^+e^- \rightarrow \bar{q}q$$



$$R_{e^+e^-}(S) = \frac{\sigma(e^+e^- \rightarrow hadrons)}{\sigma(e^+e^- \rightarrow \mu^+\mu^-)}$$

At the dawn of the

Parton Model

Well before QCD

N. CABIBBO, *et al.*
4 Luglio 1970
Lettere al Nuovo Cimento
Serie I, Vol. 4, pag. 35-39

Hadron Production in e^+e^- Collisions (*).

N. CABIBBO
Istituto di Fisica dell'Università - Roma
Istituto Nazionale di Fisica Nucleare - Sezione di Roma

G. PARISI and M. TESTA
Istituto di Fisica dell'Università - Roma

(ricevuto il 30 Maggio 1970)

1. – The simple properties of deep inelastic electron-proton scattering has suggested models where these processes arise as interactions of virtual photons with an « elementary » component of the proton. These as yet unspecified elementary components of the proton have been given the name of « partons » by FEYNMAN (1). The model has been studied by BJORKEN and PASCHOS (2) and successively by DRELL, LEVY and TUNG MOW YAN (3) who gave a field-theoretical treatment of the parton model, and were able to recover some of the experimentally observed properties of this process. In this letter we wish to extend the method of ref. (3) to the study of the total cross-section of electron-positron annihilation into hadrons.

This treatment leads to an asymptotic (very high cross-section c.m. energy, $2E$) of the form

$$\sigma \to \frac{\pi\alpha^2}{12E^2}\left[\sum_{\text{spin }0}(Q_i)^2 + 4\sum_{\text{spin }\frac{1}{2}}(Q_i)^2\right], \tag{1}$$

where Q_i is the charge of the i-th parton in units of e. This is simply the sum of the contributions of the single partons considered as pointlike (4). Each parton contributes a different kind of events to the total cross-section. The typical high-energy event should consist in the production of a pair of virtual partons, each of which develops into a jet of physical hadrons.

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At the dawn of the

Parton Model

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2. – The total cross-section for hadron production is proportional ([8]) to the absorptive part of the two-point correlation function of the e.m. current

$$\sigma = \frac{\alpha^2 4\pi^3}{E^2} \Pi(4E^2). \tag{2}$$

where

$$\Pi(q^2)(q_\mu q_\nu - q^2 \delta_{\mu\nu}) = (2\pi)^3 \sum_n \delta^4(p_n - q) \langle 0|I_\mu(0)|n\rangle \langle n|I_\nu(0)|0\rangle . \tag{3}$$

Following the method of ref. ([3]) we employ the noncovariant perturbation expansion in the $P \to \infty$ frame. This limit is obtained by send
features of this limit, originated by FUBINI and FURLA
by WEINBERG ([9]).)

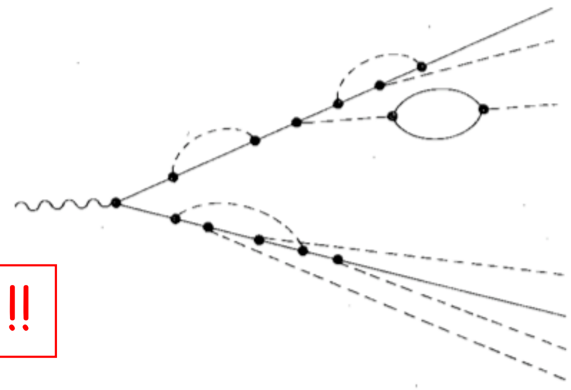


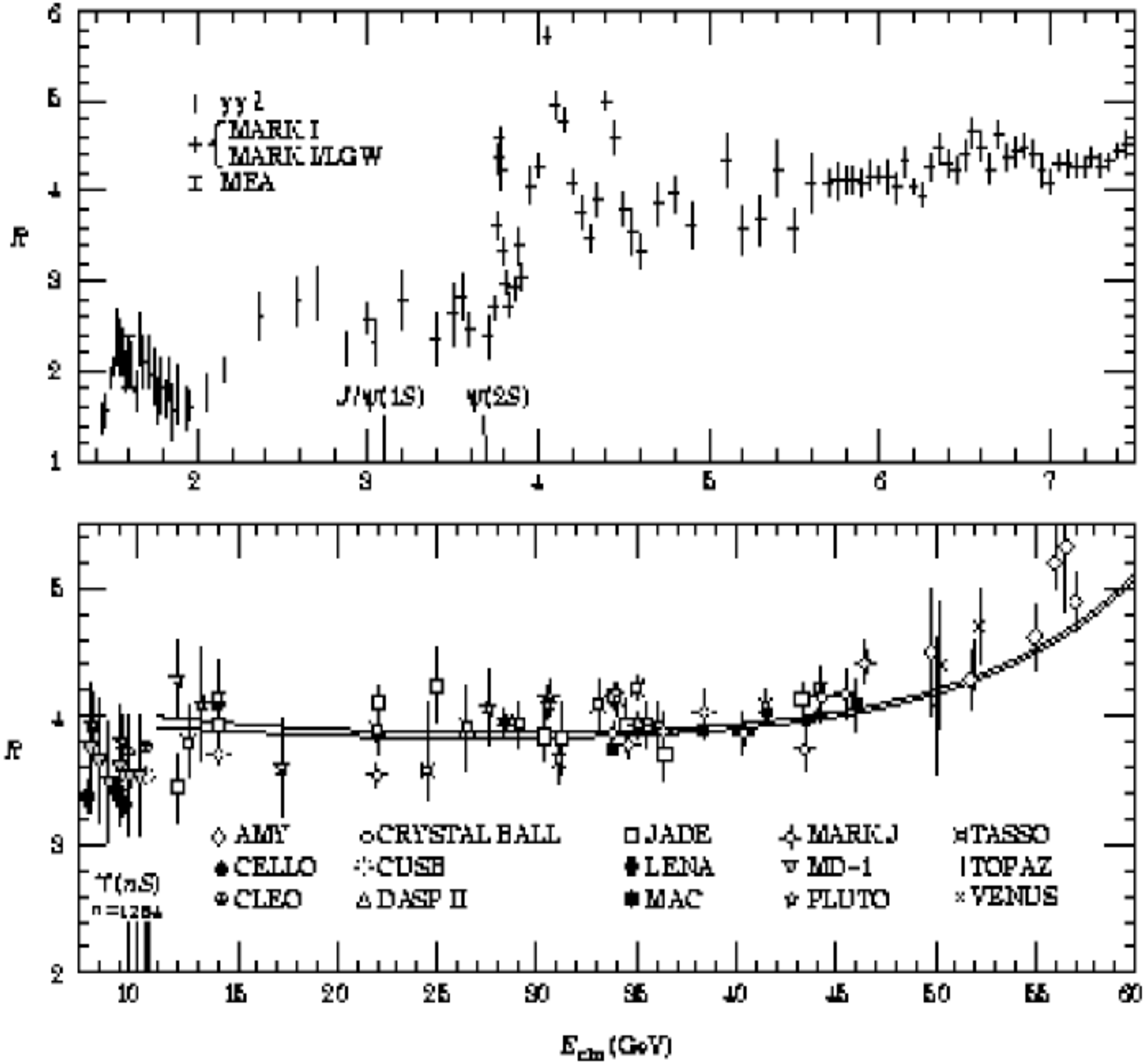
Fig. 1.

JET PHYSICS !!

$$\frac{1}{(2\pi)^4} \int d^4x \exp[iqx] \langle 0|j_3(x)\, j_3(0)|0\rangle . \tag{5}$$

Since j_μ is now the free current of the partons, this leads directly to eq. (1).

$R_{e+e-}(S)$



The data clearly support the existence of colour

Volume 59B, number 1 PHYSICS LETTERS 13 October 1975

EXPONENTIAL HADRONIC SPECTRUM AND QUARK LIBERATION

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Received 9 June 1975

The exponentially increasing spectrum proposed by Hagedorn is not necessarily connected with a limiting temperature, but it is present in any system which undergoes a second order phase transition. We suggest that the "observed" exponential spectrum is connected to the existence of a different phase of the vacuum in which quarks are not confined.

Following Hagedorn [1] we will impose the bootstrap condition:

$$\lim_{E\to\infty} \frac{\ln w(E)}{\ln \rho(E)} = 1. \qquad (8)$$

This relation can be satisfied if, for large E, $w(E) \to E^{\alpha-3} \exp(E\,\beta_c)$ with $\alpha < 2$ [1,8]. Under these hypothesis $F(\beta)$ will behave, for $\beta \approx \beta_c$, like ‡3

$$F(\beta) = A\,(\beta-\beta_c)^{2-\alpha} + \text{less singular terms}. \qquad (9)$$

Only if $\alpha \geqslant 1$ the internal energy density

$$U(\beta) = \frac{d}{d\beta} F(\beta)$$

becomes divergent at $\beta = \beta_c$ and $T_c = 1/k\beta_c$ is a limiting temperature.

For $\alpha < 1$ $U(\beta)$ reaches a finite limit at $\beta = \beta_c$. At greater temperature all thermodynamical quantities remain finite, but the integral representations, eqs. (2) and (5) are not any more valid.

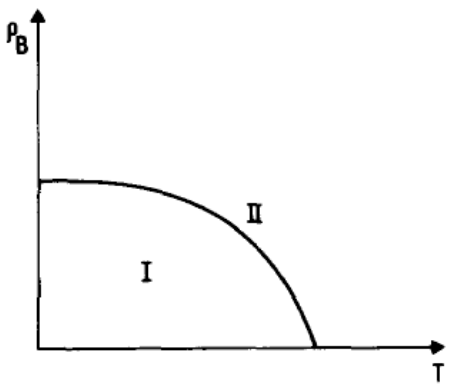

Fig. 1. Schematic phase diagram of hadronic matter. ρ_B is the density of baryonic number. Quarks are confined in phase I and unconfined in phase II.

Upper limits

Ref.TH.266

BOUNDS ON THE FERMIONS AND HIGGS BOSON MASSES
IN GRAND UNIFIED THEORIES

N. Cabibbo
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INFN - Laboratori Nazionali di Frascati

and

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$$8\pi^2 \frac{dh^2}{dt} = \left(\frac{9}{4}h^2 - 16\pi\alpha_s\right)h^2 \qquad (3.2)$$

The quark mass is :

$$M_f = h(\eta^2)\cdot\eta \qquad (3.3)$$

In writing Eq. (3.2), terms of order α_w and α have been neglected.

stability condition

$$h^2(\eta^2) > \frac{64}{9}\pi\alpha_s \qquad (4.1)$$

corresponding to $M_f > 250$ GeV. Clearly, in the vicinity of the singular point, Eq. (3.2) does not describe the correct behaviour of h^2, in that higher order corrections become significant. The presence of a singularity in the solution of Eq. (3.2), for a certain value of q^2, is simply a signal that, at that energy scale, the interaction becomes strong. This should not happen for q^2 smaller than M_U^2, and this condition leads to an upper bound for the initial value, $h^2(\eta^2)$. We note that the stronger condition that $^2(q^2)$ remains small for $q^2 < M_U^2$, leads essentially to the same bound. his is due to the fact that L_U is very large, and that the solution to q. (3.2) varies very rapidly near the singular point. We shall therefore dopt the weaker bound discussed above.

We have determined the upper bound of $h^2(\eta^2)$ by solving numerically q. (3.2). In the case $N=3$, Eq. (4.1) is sufficient to describe the ariation of α_s with q^2. For $N=8$, we have taken into account the two oop corrections to the evolution of α_s, computed in Ref. 11). Using $_s(\eta^2) \approx 0.1$, we find :

$$M_f < 200 \text{ GeV} \quad (N=3)$$

In the framework of GUT, the requirement that no interaction becomes strong and no vacuum instability develops up to the unification energy, is shown to imply upper bounds to the fermion masses as well as upper and lower bounds to the Higgs boson mass. These bounds are studied in detail for the case of the unifying groups SU(5) or O(10)

12 June 1979

Upper limits

$$32\pi^2 \frac{d\lambda}{dt} = 4\lambda^2 + 12\lambda h^2 - 3\lambda(3g^2 + g'^2) - 36h^4 + \frac{9}{4}\left[2g^4 + (g^2 + g'^2)^2\right] \quad (3.5)$$

$$M_H^2 = \frac{2}{3}\lambda(\eta^2)\eta^2 \quad (4.3)$$

The resulting bound on M_H, as a function of the heavy quark mass, is shown in Fig. 1, for the case $N = 3$, and i

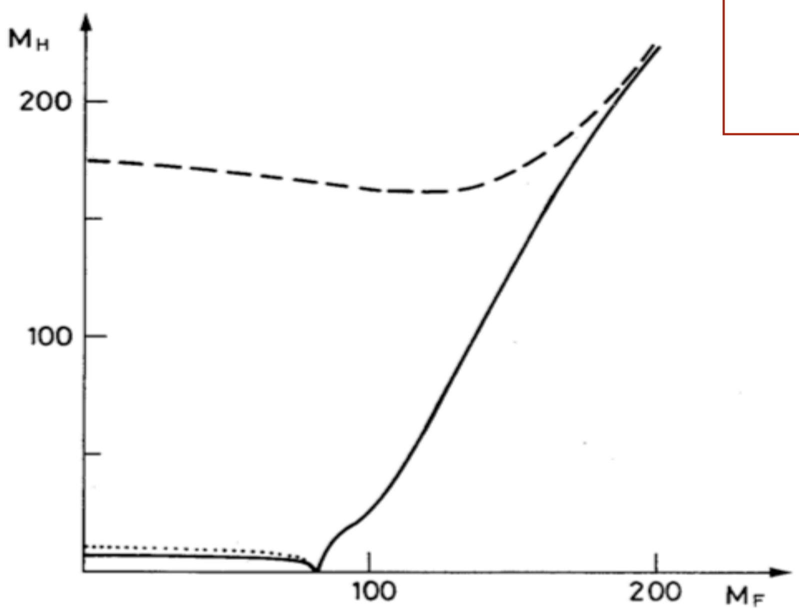

FIG. 1

$$\langle\phi\rangle \equiv \eta = \frac{1}{2^{3/4} G_F^{1/2}} \sim 176 \text{ GeV}$$

Lower limits given by the stability of the potential

Looking back at Eq. (3.5), we see that $\lambda(q^2)$ can be driven to negative values if the Yukawa coupling dominates the r.h.s. The situation is easy to analyze if we neglect the q^2 dependence of h, g and g^2. If :

$$36\,h^4 - \frac{g}{4}\left[2g^4 + (g^2+g'^2)^2\right] \propto \qquad (5.2)$$
$$\propto 12 M_f^4 - 3(2M_W^4 + M_Z^4) > 0$$

the r.h.s. of Eq. (3.5) has one negative and one positive root : $\lambda_- < 0 < \lambda_+$. The negative root λ_- is an ultra-violet stable fixed point. Under these conditions, for any initial value in the region :

$$0 \le \lambda(\eta^2) \le \lambda_+ \qquad (5.3)$$

λ becomes negative at some finite value of q^2. A lower bound for $\lambda(\eta^2)$ can thus be obtained, by requiring that this does not happen for q^2 less than M_U^2. In the more complicated case where h, g and g' evolve with q^2 according to Eqs. (2.1) and (3.2), the lower bound can be obtained numerically. The corresponding lower bound on M_H is displayed in Figs. 1 and 2, for N = 3 and 8 respectively *), as a function of the fermion mass, i.e., $h(\eta^2)$.

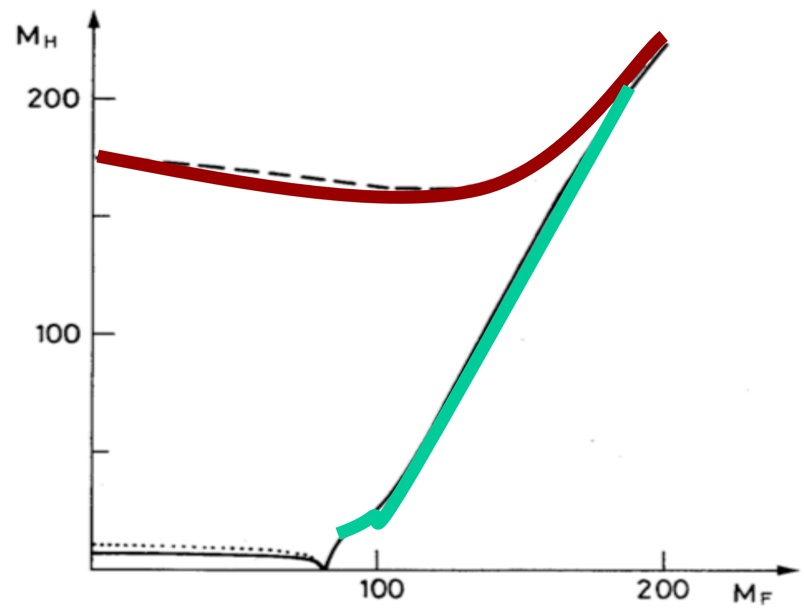

FIG. 1

G. Altarelli & G. Isidori

Coleman-Weinberg Effective Potential approach

LOWER LIMIT ON THE HIGGS MASS IN THE STANDARD MODEL: AN UPDATE

$$V_0^{1-loop}[\phi] = -\frac{1}{2}m_0^2\phi^2 + \frac{1}{24}\lambda_0\phi^4 + \frac{1}{16\pi^2}\left[\frac{1}{4}H^2\left(\ln\frac{H}{\mu_0^2}-\frac{3}{2}\right)+\frac{3}{4}G^2\left(\ln\frac{G}{\mu_0^2}-\frac{3}{2}\right)+\frac{3}{2}W^2\left(\ln\frac{W}{\mu_0^2}-\frac{5}{6}\right) + \frac{3}{4}Z^2\left(\ln\frac{Z}{\mu_0^2}-\frac{5}{6}\right)-3T^2\left(\ln\frac{T}{\mu_0^2}-\frac{3}{2}\right)\right]$$

where

$$H = -m_0^2 + \lambda_0\phi^2/2, \qquad G = -m_0^2 + \lambda_0\phi^2/6,$$
$$W = g_{10}^2\phi^2/4, \qquad Z = (g_{10}^2 + g_{20}^2)\phi^2/4,$$

requirement that the running coupling $\lambda(\Lambda)$ never becomes neg
larger than all mass scales in the theory the one-loop potential
as:

$$V_0^{1-loop}[\phi] \simeq +\frac{1}{24}\phi^4\left\{\lambda_0 + \left[\beta_\lambda(\lambda_0, g_{i0}) - 4\lambda_0\gamma(\lambda_0, g_{i0})\right]\ln\left(\frac{\phi}{\mu_0}\right.\right.$$

[**For present developments Talk by Gian Giudice this afternoon at 4.30 pm**]()

This is just the expansion of the quartic term in the RG improved potential:

$$V_{RG}^{1-loop}(\phi) \simeq +\frac{1}{24}\lambda(t)[\xi(t)\phi]^4 + O(\lambda(t)^2, g_i(t)^2), \tag{4}$$

where

$$\xi(t) = \exp\left(-\int_0^t \gamma(\lambda(t'), g_i(t'))dt'\right), \qquad t = \log(\Lambda/\mu_0), \tag{5}$$

$$\frac{d\lambda(t)}{dt} = \beta_\lambda(\lambda, g_i), \qquad \frac{dg_i(t)}{dt} = \beta_i(\lambda, g_i), \tag{6}$$

$$\lambda(0) = \lambda_0 \qquad g_i(0) = g_{i0}. \tag{7}$$

Nuclear Physics B208 (1982) 365-380
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LEPTONIC DECAY OF HEAVY FLAVORS: A theoretical update

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Received 29 June 1982

The spectrum of charged leptons in semileptonic B and D decays is reanalyzed. Special emphasis is given to the behaviour near the end point which is of importance for the determination of the $b \to u$ versus $b \to c$ couplings. In particular the effects of soft gluons are studied and their contribution is resummed in leading double logarithmic approximation. This effect determines the end-point behaviour for the decay of a heavy quark into massless quark and leptons, such as $b \to u e^- \bar{\nu}_e$. Bound-state corrections to the parton picture are treated in a model which satisfies all kinematical constraints. A comparison of predictions for charm decay with experimental data is also presented.

The ``naive" ancestor of the HQET shape function for semileptonic and radiative decays

It contains, however, up to a redefinition of the non perturbative parameters, the main features of the modern theory

Fit of the parameters from
The lepton spectrum of D decays

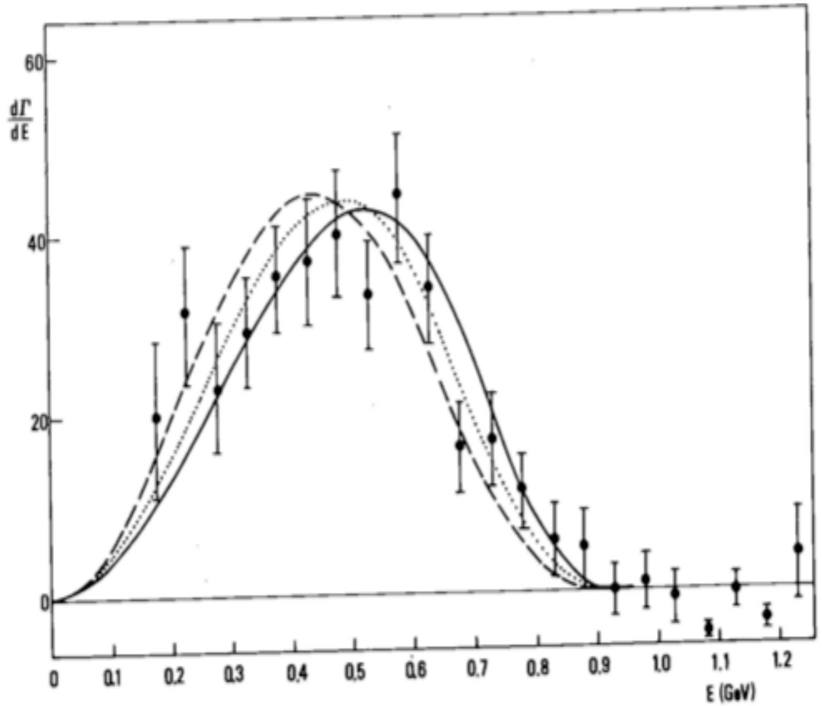
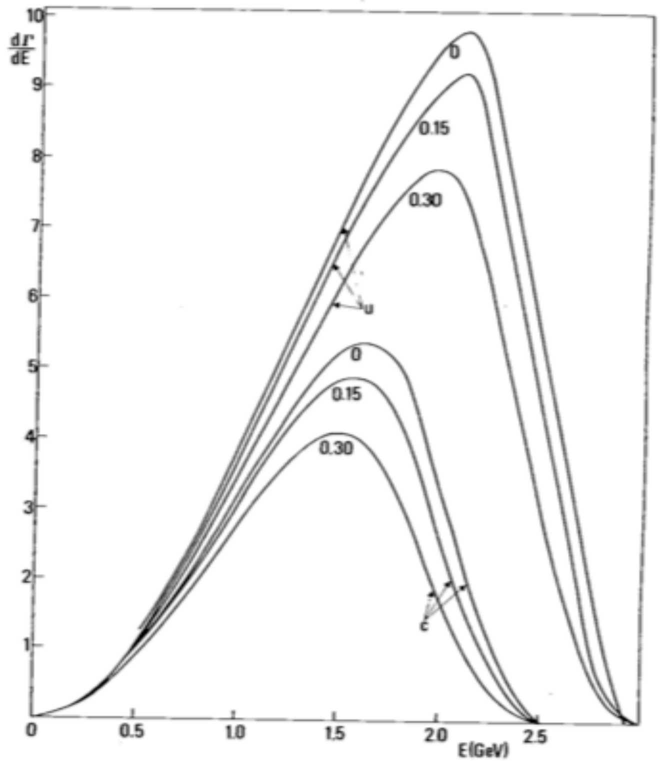


Fig. 3. Charged lepton spectrum in D decay for $M_D = 1.866$ GeV, $m = 0.3$ GeV, $m_{sp} = 0.15$ GeV, $\alpha_s = 0.38$, $P_B = 0.26$ GeV and $P_F = 0$ (solid), $P_F = 0.15$ GeV (dotted), $P_F = 0.3$ GeV (dashed). The normalization is fixed to the number of events.



6. $d\bar{\Gamma}_{c,u}/dE$ for B meson decay for $M_B = 5.218$ GeV, $m_u = 0.15$ GeV, $m_c = 1.7$ GeV, $m_{sp} =$ GeV, $\alpha_s = 0.24$, various values of P_F as indicated (in GeV) and $P_B = 0.76$ GeV. The absolute scale is arbitrary, but the relative normalizations are correct.

comparing our predictions with the spectra obtained in $e^+e^- \to \Upsilon''' \to B\bar{B}$, the est uncertainty, at present, seems to arise from the poor determination of the B mass, i.e. of the B momentum at a given value of the beam energy. The present bounds on the B-meson mass are [14]

$$5.162 \text{ GeV} \leq M_B \leq 5.275 \text{ GeV}, \quad (42)$$

5279.17 ± 0.29 PDG FIT

Prediction of the spectrum in B decays for b -> c and b -> u

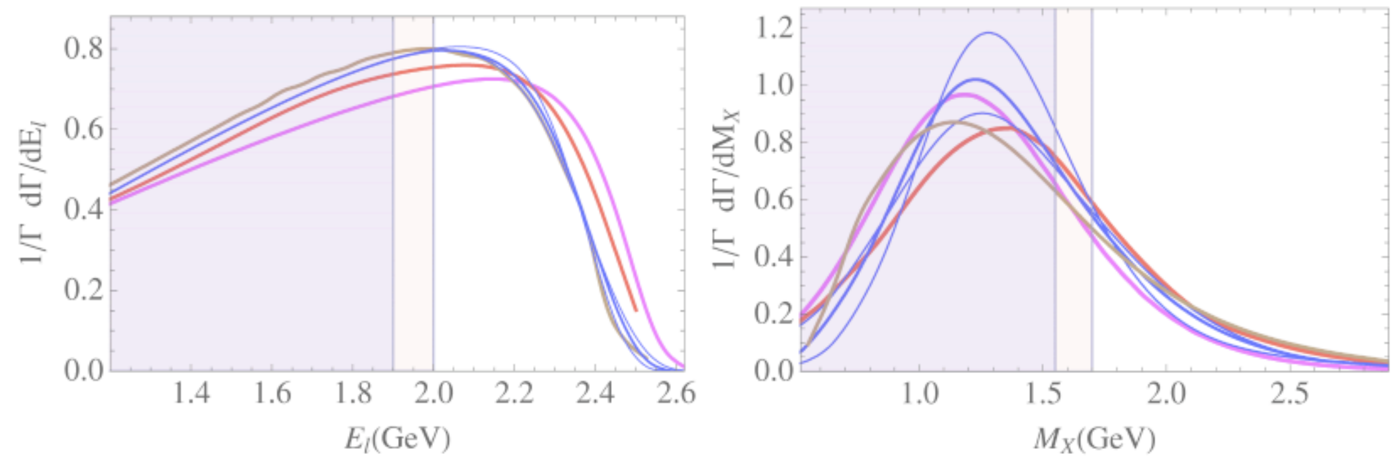


Fig. 38. Comparison of different theoretical treatments of inclusive $b \to u$ transitions: (a) E_l spectrum; (b) M_X spectrum. Red, magenta, brown and blue lines refer, respectively, to DGE, ADFR, BLNP, GGOU with a sample of three different functional forms. The actual experimental cuts at $E_l = 1.9, 2.0\,\text{GeV}$ and $M_X = 1.55, 1.7\,\text{GeV}$ are also indicated.

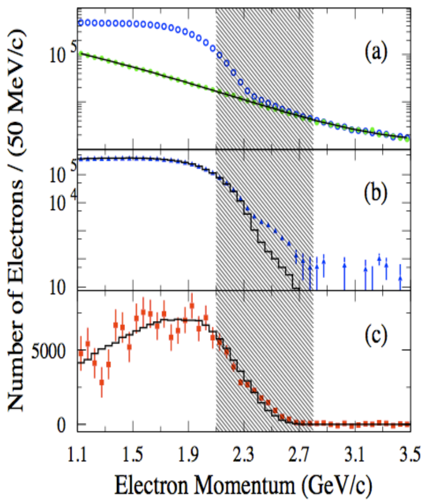


Fig. 40. The inclusive electron energy spectrum [594] from BaBar is shown for (a) on-peak data and q^2 continuum (histogram); (b) data subtracted for non-$B\overline{B}$ contributions (points) and the simulated contribution from B decays other than $b \to u\ell\nu$ (histogram); and (c) background-subtracted data (points) with a model of the $b \to u\ell\nu$ spectrum (histogram).

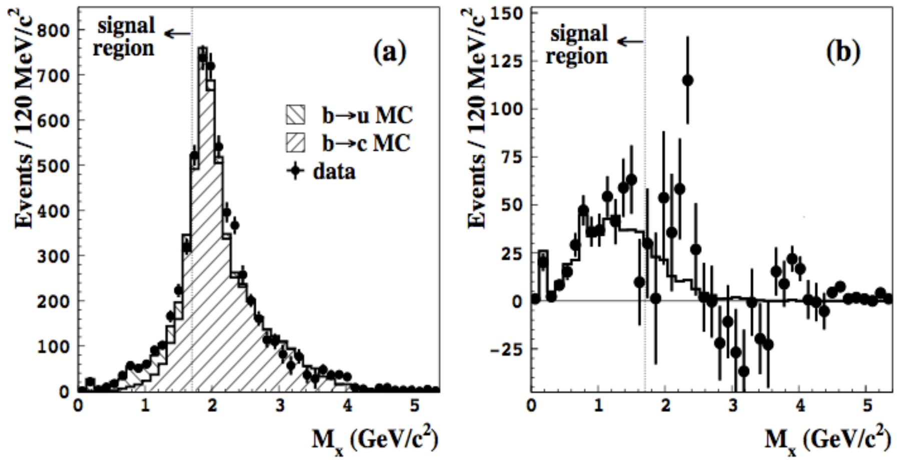


Fig. 41. The hadronic invariant mass spectrum [595] in Belle data (points) is shown in (a) with histograms corresponding to the fitted contributions from $b \to c\ell\nu$ and $b \to u\ell\nu$. After subtracting the expected contribution from $b \to c\ell\nu$, the data (points) are compared to a model $b \to u\ell\nu$ spectrum (histogram) in (b).

V_{cb} and V_{ub}

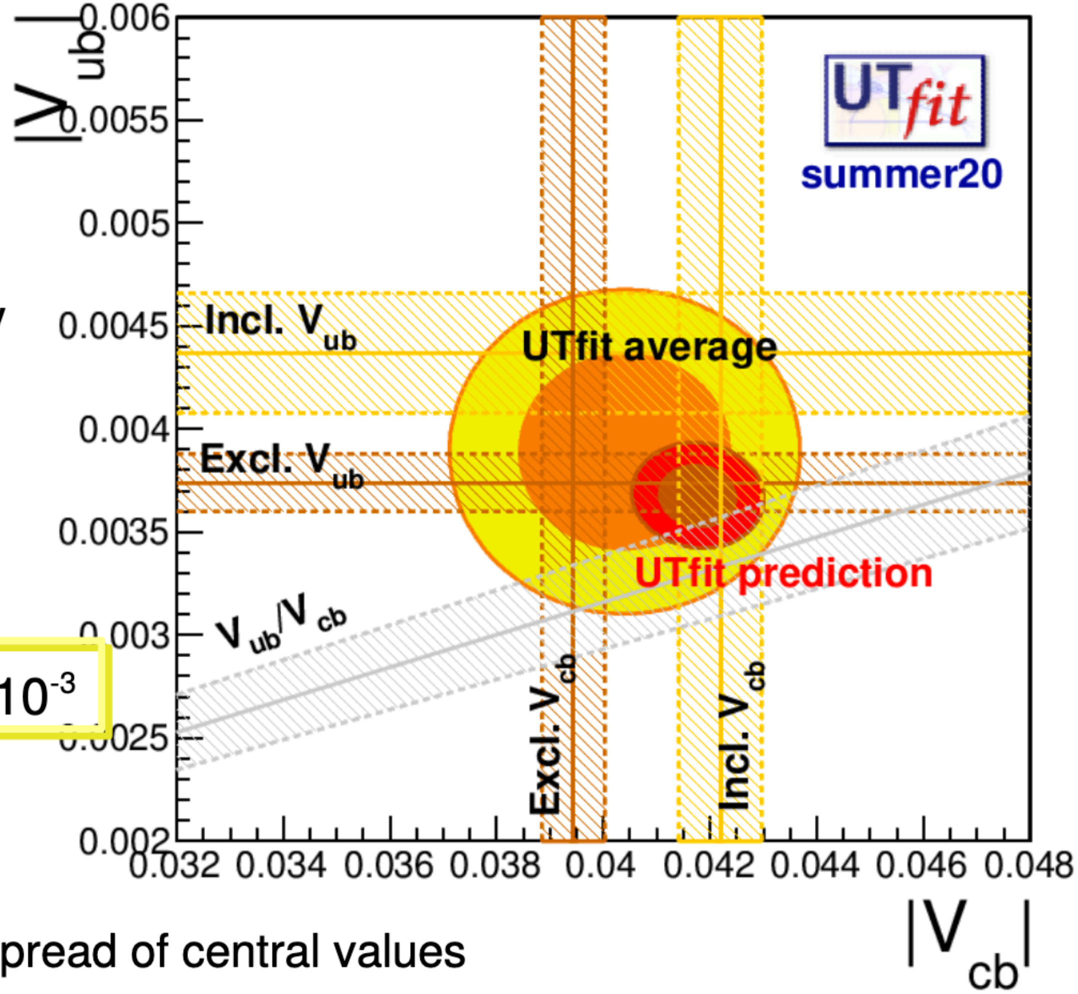
from FLAG

$|V_{cb}|$ *(excl)* = $(39.44 \pm 0.59)\ 10^{-3}$

$|V_{cb}|$ *(incl)* = $(42.19 \pm 0.78)\ 10^{-3}$

~2.8σ discrepancy

from HFLAV



from FLAG

$|V_{ub}|$ *(excl)* = $(3.74 \pm 0.14)\ 10^{-3}$

$|V_{ub}|$ *(incl)* = $(4.37 \pm 0.25 \pm 0.26$ *[flat]*$)\ 10^{-3}$

~1.9σ discrepancy

from HFLAV adding a flat uncertainty covering the spread of central values

$|V_{ub} / V_{cb}|$ *(LHCb)* = $(7.9 \pm 0.6)\ 10^{-2}$

see talk by Gino Isidori this afternoon at 3 pm

Volume 119B, number 4,5,6 PHYSICS LETTERS 23/30 December 1982

A NEW METHOD FOR UPDATING SU(N) MATRICES IN COMPUTER SIMULATIONS OF GAUGE THEORIES

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and

Enzo MARINARI
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Received 12 July 1982

We present a new method for updating SU(N) matrices in lattice gauge theories simulations. The new method has been found for the case of SU(3) to be about three times more efficient than the Metropolis method.

In this paper we propose a new method for updating SU(N) matrices which is a natural extension of the Creutz method for SU(2).

Tests executed on a 4^4 lattice in SU(3) indicate that the method is more efficient that the Metropolis method: the new method led to a 40% saving in the computer time used for one iteration, and the thermalization is achieved faster, as indicated by a flatter hysteresis cycle during fast thermal excursions.

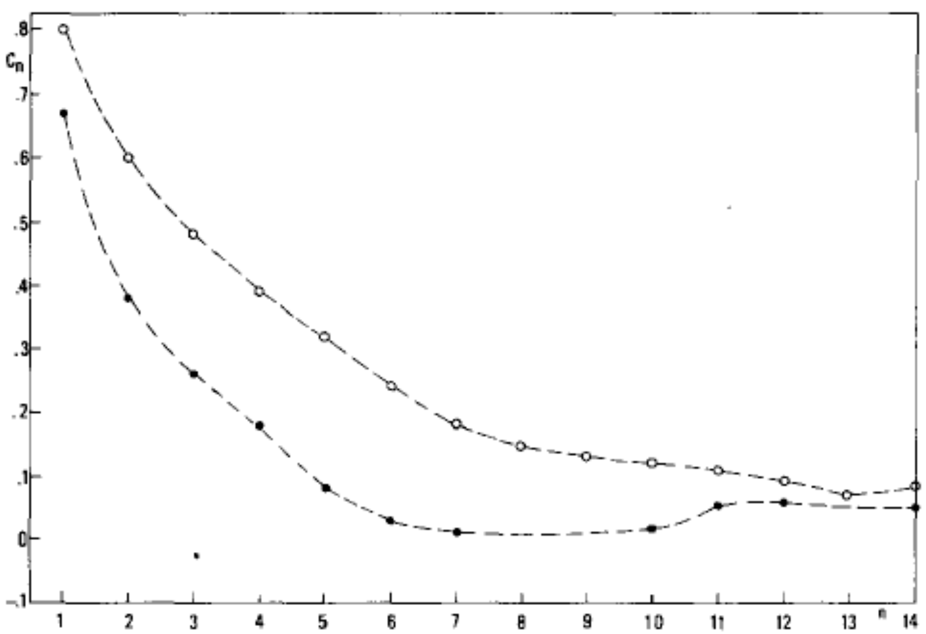

Fig. 3. Correlation function C_n [see eq. (17)]. Black dots: new method. Open circles: Metropolis.

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研図書室

Published in Nucl.Phys.B244:381-391,1984.

mid-August holiday paper !!

WEAK INTERACTIONS ON THE L

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and

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CERN -- Geneva

ABSTRACT

We show that lattice QCD can be used to evaluate the matrix elements of four fermion operators which are relevant for weak decays. A first comparison between the results obtained on the lattice and other determinations is also presented.

Calculation Of Weak Transitions In Lattice Qcd.
Richard C. Brower, Guillermo Maturana, (UC, Santa Cruz) , M. Belen Gavela, (Brandeis U.) , Rajan Gupta, (Harvard U.)
Phys.Rev.Lett.53:1318,1984.

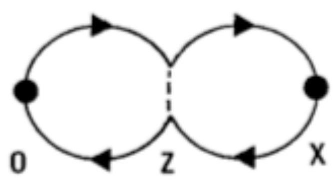


fig.1a

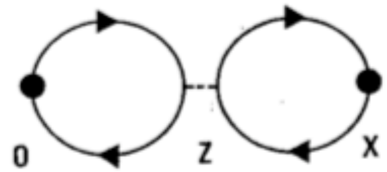


fig.1b

As a second test we have evaluated the $K_0 - \bar{K}_0$ matrix element:

$$\langle K^0 | (\bar{s}\gamma^\mu(1-\gamma_5)d)(\bar{s}\gamma_\mu(1-\gamma_5)d) | \bar{K}^0 \rangle = (4a^2)(10 \pm 1)\,10^{-2}$$

$B_K \sim 0.9\,(1 \pm 0.3)$

$[\sim 7.7\ 10^{-2}]$

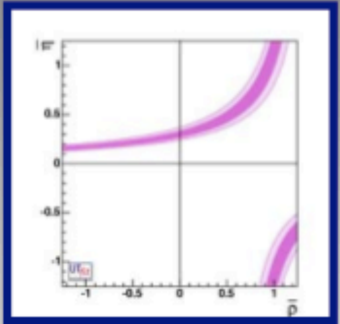
This result is in good agreement in sign and magnitude with the vacuum insertion value of Ref. /10/, but about 3 times larger than the estimate of Ref. /11/.

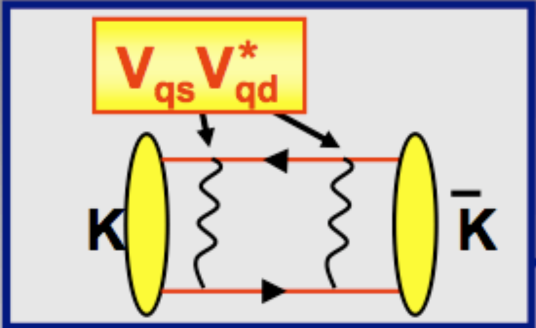
J Donoghue Phys. Lett. 119B (1982) 412

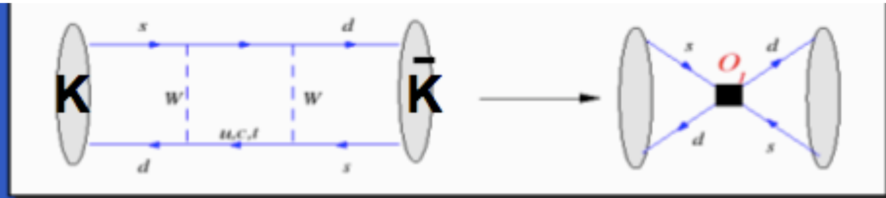
We were opening the Pandora box of Weak Interactions on the lattice (chiral symmetry, power diver. and renormalization, FSI etc.)

K^0-$\bar{K}^0$ mixing: B_K

V. Lubicz SuperB meeting nov. 2009







$$\langle \bar{K}^0 | Q(\mu) | K^0 \rangle = \frac{8}{3} f_K^2 m_K^2 B_K(\mu)$$

$\hat{B}_K = 0.90 \pm 0.03 \pm 0.15$

S.Sharpe@Latt'96 — 17%

$\hat{B}_K = 0.86 \pm 0.05 \pm 0.14$

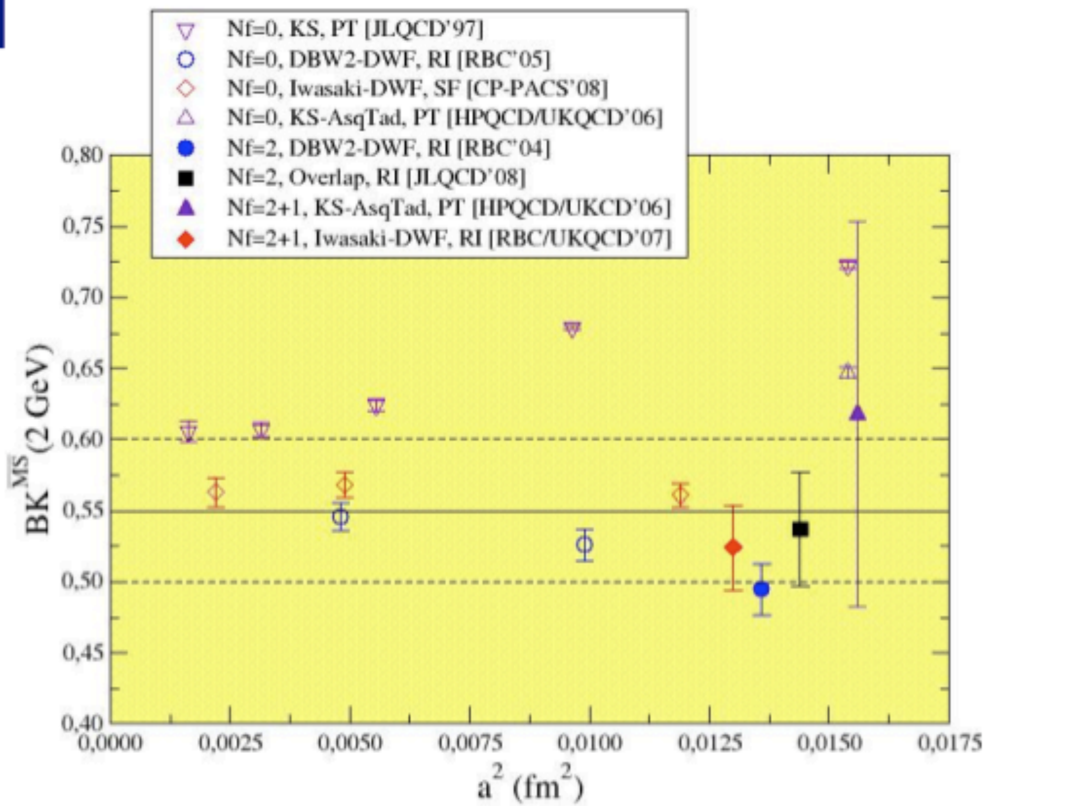
L.Lellouch@Latt'00 — 17%

$\hat{B}_K = 0.79 \pm 0.04 \pm 0.08$

C.Dawson@Latt'05 — 11%

$\hat{B}_K = 0.723 \pm 0.037$

L.Lellouch@Latt'08 — 5%



[VL, C.Tarantino 0807.4605]

All unquenched calculations until last year at fixed (and rather large) lattice spacing

lattice QCD inputs

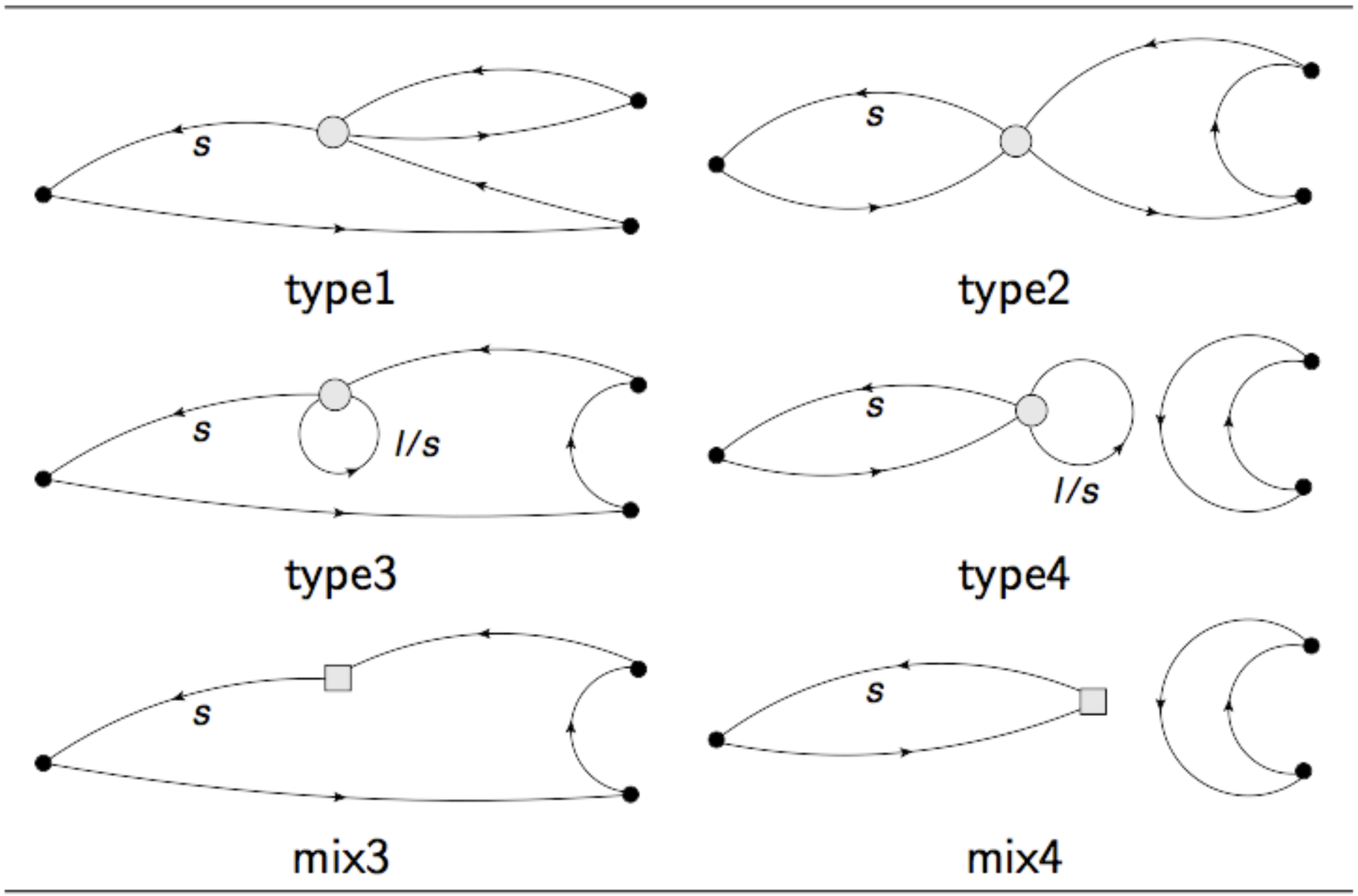
updated in early 2020

Observables	Measurement	
B_K	0.756 ± 0.016	2.1 %
f_{Bs}	0.2301 ± 0.0012	
f_{Bs}/f_{Bd}	1.208 ± 0.005	
B_{Bs}/B_{Bd}	1.032 ± 0.038	
B_{Bs}	1.35 ± 0.06	4.4 %

FLAG 2019 suggests to take the most precise between the Nf=2+1+1 and Nf=2+1 averages.

We quote, instead, the weighted average of the Nf=2+1+1 and Nf=2+1 results with the error rescaled when chi2/dof > 1, as done by FLAG for the Nf=2+1+1 and Nf=2+1 averages separately

$K^0 \to \pi\pi(I=0)$ contractions



Nicola attention for new projects

An exceptional result that took about 15 years of the Columbia Group+C. Sachrajda +A. Soni + several tens of PhD students and Post Docs, need to be checked by a second group

Direct *CP* violation and the $\Delta I = 1/2$ rule in $K \to \pi\pi$ decay from the standard model

R. Abbott,[1] T. Blum,[2,3] P. A. Boyle,[4,5] M. Bruno,[6] N. H. Christ,[1] D. Hoying,[3,2] C. Jung,[4] C. Kelly,[4] C. Lehner,[7,4] R. D. Mawhinney,[1] D. J. Murphy,[8] C. T. Sachrajda,[9] A. Soni,[4] M. Tomii,[2] and T. Wang[1]

We present a lattice QCD calculation of the $\Delta I = 1/2$, $K \to \pi\pi$ decay amplitude A_0 and ε', the measure of direct CP violation in $K \to \pi\pi$ decay, improving our 2015 calculation [1] of these quantities. Both calculations were performed with physical kinematics on a $32^3 \times 64$ lattice with an inverse lattice spacing of $a^{-1} = 1.3784(68)$ GeV. However, the current calculation includes nearly 4 times the statistics and numerous technical improvements allowing us to more reliably isolate the $\pi\pi$ ground state and more accurately relate the lattice operators to those defined in the standard model. We find $\mathrm{Re}(A_0) = 2.99(0.32)(0.59) \times 10^{-7}$ GeV and $\mathrm{Im}(A_0) = -6.98(0.62)(1.44) \times 10^{-11}$ GeV, where the errors are statistical and systematic, respectively. The former agrees well with the experimental result $\mathrm{Re}(A_0) = 3.3201(18) \times 10^{-7}$ GeV. These results for A_0 can be combined with our earlier lattice calculation of A_2 [2] to obtain $\mathrm{Re}(\varepsilon'/\varepsilon) = 21.7(2.6)(6.2)(5.0) \times 10^{-4}$, where the third error represents omitted isospin breaking effects, and $\mathrm{Re}(A_0)/\mathrm{Re}(A_2) = 19.9(2.3)(4.4)$. The first agrees well with the experimental result of $\mathrm{Re}(\varepsilon'/\varepsilon) = 16.6(2.3) \times 10^{-4}$. A comparison of the second with the observed ratio $\mathrm{Re}(A_0)/\mathrm{Re}(A_2) = 22.45(6)$, demonstrates the standard model origin of this "$\Delta I = 1/2$ rule" enhancement.

February 2006 Inauguration of the APENEXT LAB (INFN-La Sapienza)

Breve Storia del progetto APE

Nicola Cabibbo

Dipartimento di Fisica
Università di Roma “La Sapienza”

8 Febbraio 2006

see talk by Giorgio Parisi this afternoon at 2 pm

L'impatto di APE

- Scientific, technological and social impacts:
  - APE is standard "de facto" in European LQCD computing area
  - Huge number of scientific and technological (HW, SW, Architecture) papers
  - Establishment of an international computing facility fully dedicated to scientific numerical computing
    - Laboratorio di Calcolo apeNEXT: 12 TFs installed, opening on February, 8th
  - Strategic opportunities to increase national(European) industry capability
    - Eurotech
      - INFN collaboration -> HPC division, market expansion, international visibility
    - Finmeccanica/QSW
  - Training, dissemination and establishment of spin-off companies
    - Atmel/Ipitec
    - Nergal
    - Digital Video
    - Venere

SPIN OFF OF THE APE PROJECT

Cabibbo as smart manager
as INFN and ENEA President

see talk by Piergiorgio Picozza
At 12:15

Other papers that I do not have time to discuss

Volume 40B, number 3 PHYSICS LETTERS 10 July 1972

THE DRELL-HEARN SUM RULE AND THE LEPTON MAGNETIC MOMENT IN THE WEINBERG MODEL OF WEAK AND ELECTROMAGNETIC INTERACTIONS

G. ALTARELLI
Istituto di Fisica dell'Università, Roma, Italy

N. CABIBBO
Istituto di Fisica dell'Universita, Roma, Italy
and Istituto Nazionale di Fisica Nucleare, Serione di Roma, Italy

and

L. MAIANI
Istituto Superiore di Sanità, Roma, Italy
Istituto Nazionale di Fisica Nucleare, Sottosezione Sanità, Roma, Italy

1) DETERMINATION OF THE A0 - A(2) PION SCATTERING LENGTH FROM K+ ---> PI+ PI0 PI0 DECAY.
By Nicola Cabibbo (CERN),. CERN-PH-TH-2004-073, May 2004. 8pp.
e-Print Archive: hep-ph/0405001

see talk by Patrizia Cenci this afternoon At 2:30 pm

Nicola was keen to teach and continued to do it until very recently.

He was able to find simple arguments, and arrive to classical results with original and intuitive demonstrations, to explain difficult concepts.

His students were fascinated by his simplicity, gentle modes and sense of humour. So we did, all of us we who had the privilege to be his collaborators and friends. (L. Maiani)


VIETATO FUMARE

Before the end….

Nicola will remain a reference for those who had the privilege to interact with him, and for the future generations of young researchers who will share with him the passion for physics and in general the love for the investigation of the misteries of Nature.

We are all grateful to him for the example that he gave as a scientist, as a teacher and as a manager of impeccable moral integrity.