The Passage from Cosmic Rays to Subatomic Physics

James W Cronin
Rosnerfest
University of Chicago
April 1, 2011

ELEMENTARY PARTICLE PHYSICS IN THE SECOND HALF OF THE TWENTIETH CENTURY

Val L Fitch and Jonathan L Rosner

9.1. Introduction

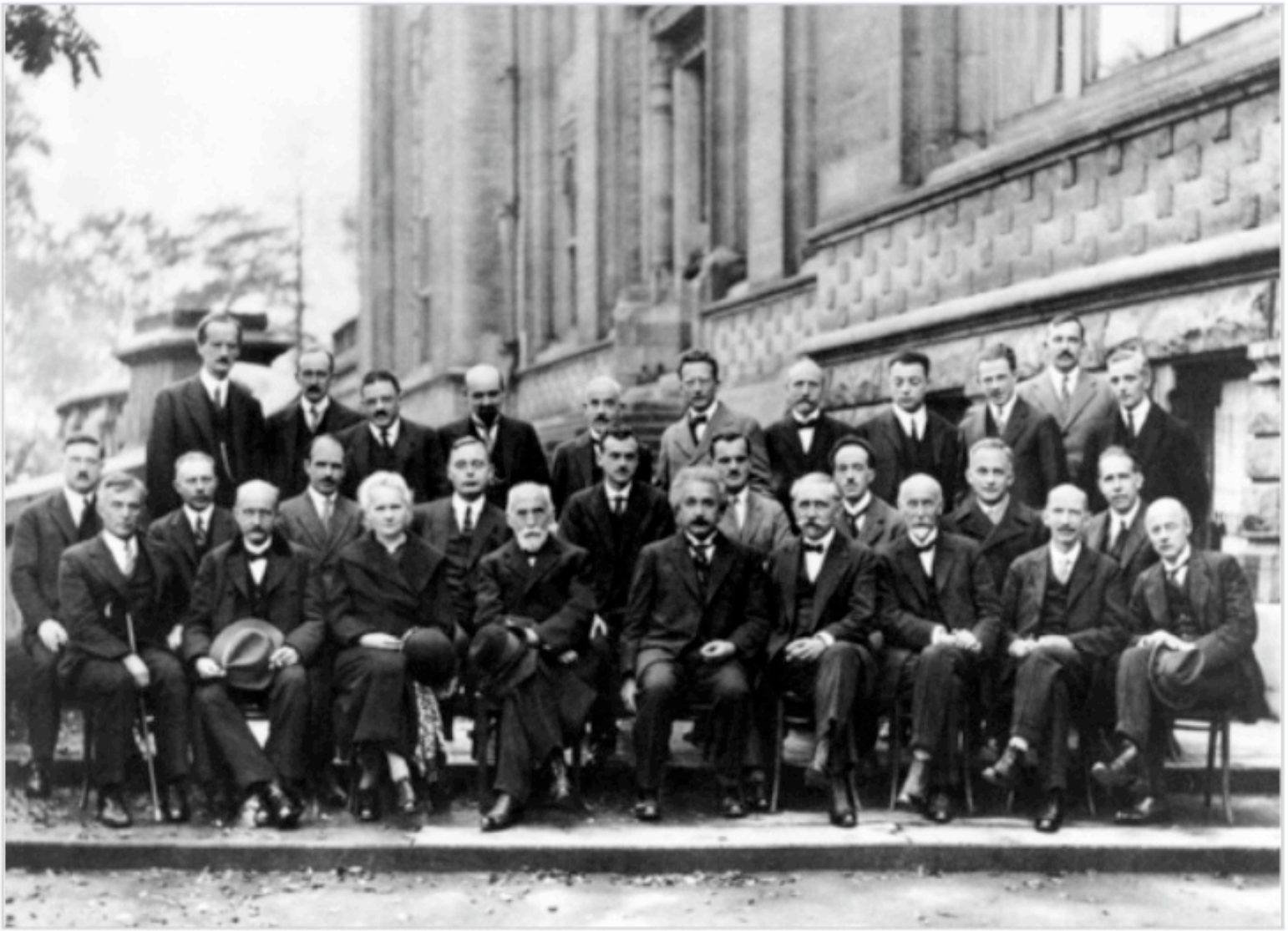
The past 50 years of elementary particle physics have witnessed an explosion of data, followed by simplifications based on classification and solid theory. Attempts to describe the fundamental interactions from a more unified point of view have borne fruit in a combined theory of weak and electromagnetic interactions based on self-interacting quantum fields and a similarly based theory of the strong interactions.

The understanding of the periodic table of the elements bears some similarity to the story of particle physics. An initial systematization of data was followed by firmer theoretical efforts, culminating in the advent of quantum mechanics. The vast variety of atoms and isotopes could be understood in terms of fundamental protons, neutrons and electrons interacting via electromagnetic (well understood) and strong (poorly understood) forces.

In the 1960s, a scheme for classifying the strongly interacting particles based on the group SU(3) began to make sense of the rapidly proliferating spectrum. Eventually, the success of SU(3) and related symmetries was traced to the existence of a few constituents—the *quarks*. Now we are confronted with a proliferation of quarks and *leptons* (the electron, muon, tau and their respective neutrinos) for which a deeper explanation is still lacking. These are summarized in table 9.1.

As more and more fundamental building blocks of matter were being uncovered, the way in which fundamental forces were described also

1927 Solvay Congress



A. Piccard, E. Henriot, P. Ehrenfest, Ed. Herzen, Th. De Donder, E. Schrödinger, J.E. Verschaffelt, W. Pauli, W. Heisenberg, R.H. Fowler, L. Brillouin;
P. Debye, M. Knudsen, W.L. Bragg, H.A. Kramers, P.A.M. Dirac, A.H. Compton, L. de Broglie, M. Born, N. Bohr;
I. Langmuir, M. Planck, M. Curie, H.A. Lorentz, A. Einstein, P. Langevin, Ch. E. Guye, C.T.R. Wilson, O.W. Richardson
Fifth conference participants, 1927. Institut International de Physique Solvay in Leopold Park.

1947 Shelter Island Conference

Richard Feynman explains a point during the 1947 Shelter Island Conference. Standing (from left to right) are Willis Lamb, [illegible], Victor Weisskopf, George Uhlenbeck, Robert Marshak, Julian Schwinger, and David Bohm. Seated are Robert [illegible]heimer, Abraham Pais, Feynman, and Herman Feshbach. (Courtesy of National Academy of Sciences.)

CONGRÈS INTERNATIONAL SUR LE RAYONNEMENT COSMIQUE

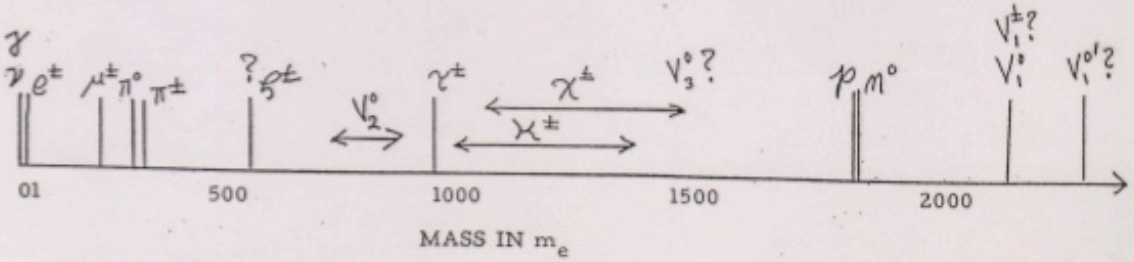
BAGNÈRES-DE-BIGORRE, 6-12 Juillet 1953 Photo ALIX

3rd Rochester Conference 1952

December

Appendix VI: THE UNSTABLE "ELEMENTARY" PARTICLES OR MEGALOMORPHS

Particle	Products	Observed by	Lifetime (sec.)	Q	Mass	Statistics	Spin	Parity
? $V_1^{0\prime}$	$\to p + \pi^-$	c. c.	$> V_1^0$	~75 Mev	$2270 m_e$?	F. D.	n/2?	-
V_1^0	$\to p + \pi^-$	c. c.	3.5×10^{-10}	37 Mev	$2190 m_e$	F. D.	n/2?	-
? $V_1^\pm$	$\to p + (?)^0$	c. c.	?	?	?	?	?	?
m^0	$\to p + e^- + \nu$	Spectrograph & counters	740	783 Kev	$1837 m_e$	F. D.	1/2	-
V_3^0	$\to K^- + \pi^+$	c. c.	?	?	$M_p > m_{V_3^0} > m_n$	?	?	?
K	$S^\pm, \chi^\pm, V^\pm \to \pi^\pm + (?)^0$	c. c.	2×10^{-8}					
	$m_0 \sim 800 m_e$	c. c. & emul.	$\sim 2 \times 10^{-9}$	115 Mev	$1400 m_e$	B. E.	0?	S?
	$\chi^\pm, V^\pm \to \mu^\pm + ? 2\nu$	emul. c. c.	?	?	$1100 m_e$	F. D. ?	1/2?	-
$\tau^\pm$	$\to \pi^\pm + \pi^+ + \pi^-$	emul. & c. c.	10^{-8} $\sim 10^{-9}$	75 Mev	$975 m_e$	B. E.	0?	PS?
V_2^0	$\to \pi^+ + \pi^-$	c. c.	$\sim 10^{-10}$	210 Mev	$850 m_e$	B. E.	0?	S?
? $S^\pm$	$\to \pi^\pm + (?\pi^0)$	emul.	$? 10^{-11}$	40 Kev $< Q <$ 6 Mev	$552 m_e$	B. E.	0?	S?
$\pi^\pm$	$\to \mu^\pm + \nu$	counters	2.3×10^{-8}	5.9 Mev	$276 m_e$	B. E.	0	PS
π^0	$\to 2\gamma$ $\to e^+ + e^- + \gamma$	counters emul. & counters	$\lesssim 5 \times 10^{-15}$	135 Mev	$266 m_e$	B. E.	0	PS
$\mu^\pm$	$\to e^\pm + 2\nu$	counters	2.15×10^{-6}	105 Mev	$212 m_e$	F. D.	1/2	-

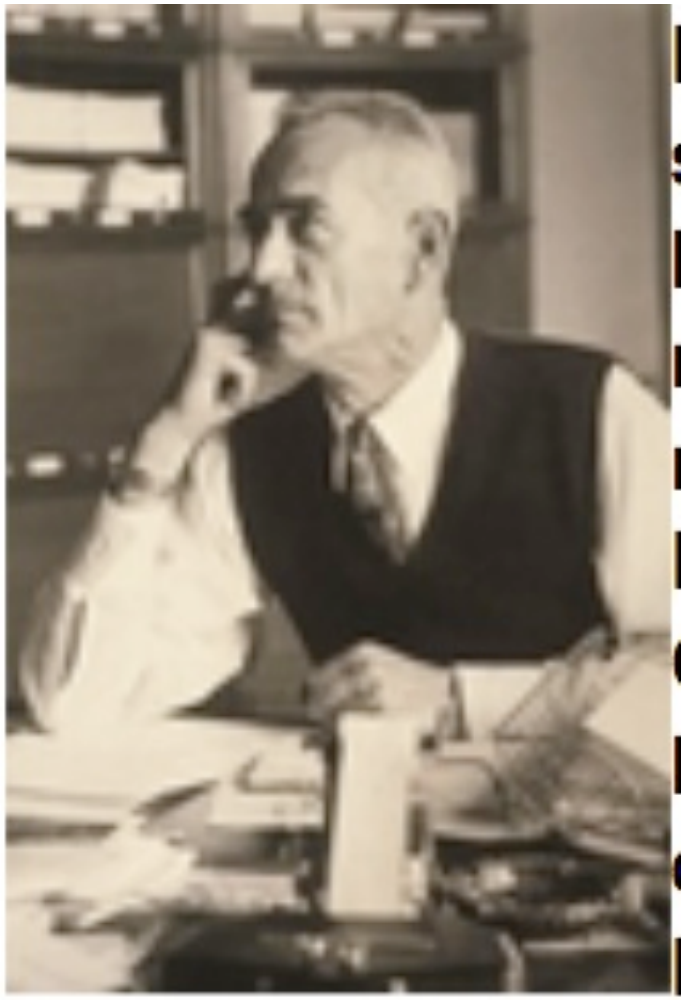


Charles Peyrou testimony on Bagneres de Bigorre

(Colloquium on history of particle physics 1980)

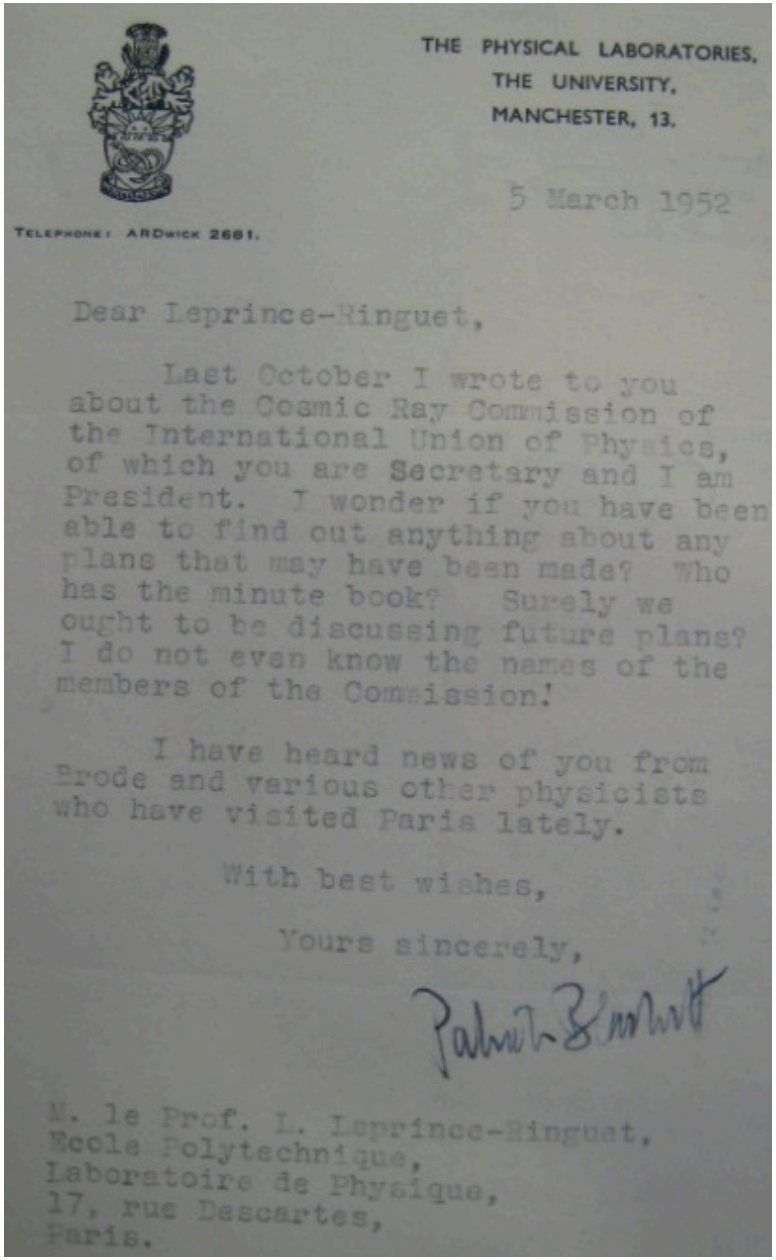
The Bagnères meeting was the regular cosmic ray conference held every odd year. The organizing committee decided that the main weight of the conference should be on new particles (i.e. strange in modern language). In fact, on 6 full days of conference only one morning was devoted to other topics and the cosmic aspect of cosmic rays was amost completely neglected. The last one and a half days were entirely devoted to a resumé of the situation as coming out of the preceeding days. All participants, young or old, remember the conference as the best of their lives. Indeed, it is there that a coherent picture of the new particle physics began to emerge from many partial works. The exitence of many particles with well defined properties was firmly and definitely established here, the Λ^0, the $\theta^0(K_1^0)$, the Ξ^-. Unsolved problems were at least clearly stated: the nature of K^+ decays, the absence of K^- captures etc. but I should not anticipate too much. In short it is very much due to this conference (and to the first Rochester conferences) that the physics of new (strange) particles began to be considered seriously by "serious" physicists (Serious having, as usual, the sense of either theorists or people busy with classical antiquities and especially physicists combining the two qualities c,f. Gell Mann's talk at this colloquium).

Blackett



Leprince-Ringuet

Blackett to Leprince-Ringuet March 5 1952



THE PHYSICAL LABORATORIES,
THE UNIVERSITY,
MANCHESTER, 13.

TELEPHONE: ARDWICK 2681.

5 March 1952

Dear Leprince-Ringuet,

Last October I wrote to you about the Cosmic Ray Commission of the International Union of Physics, of which you are Secretary and I am President. I wonder if you have been able to find out anything about any plans that may have been made? Who has the minute book? Surely we ought to be discussing future plans? I do not even know the names of the members of the Commission!

I have heard news of you from Brode and various other physicists who have visited Paris lately.

With best wishes,

Yours sincerely,

P. M. S. Blackett

M. le Prof. L. Leprince-Ringuet,
Ecole Polytechnique,
Laboratoire de Physique,
17, rue Descartes,
Paris.

Dear Leprince-Ringuet,

Last October I wrote to you about the Cosmic Ray Commission of of the International Union of Physics, of which you are the Secretary and I am President. I wonder if you have been able to find out anything about any plans that may have been made? Who has the minute book? Surely we we ought to be discussing future plans? I do not even know the names of the members of the Commission!

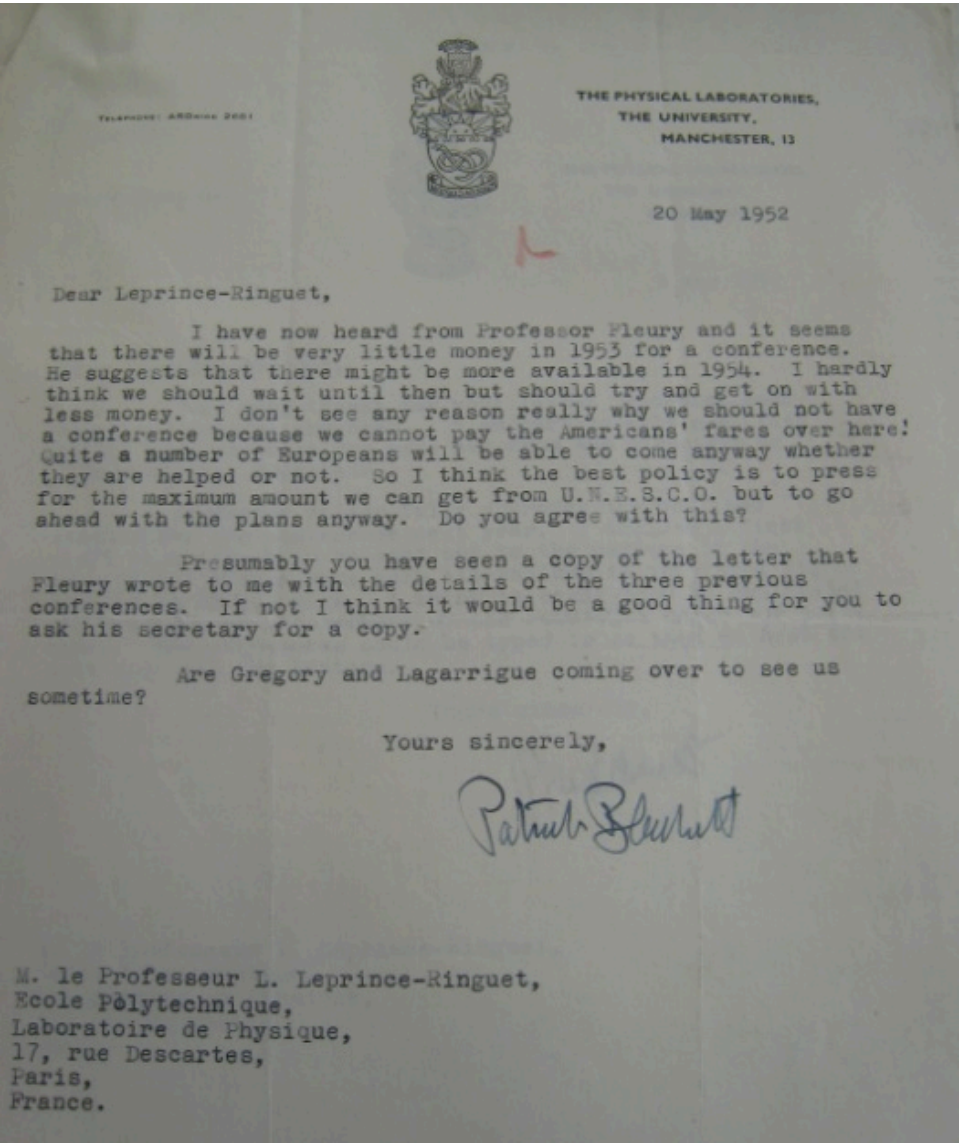
Letter from Blackett and Leprince-Ringuet to IUPAP cosmic ray commissioners planning Conference at Bagneres de Bigorre July 1953

19 May 1952

C. D. Anderson	United States
M. S. Vallarta	Mexico
H. J. Bhabba	India
G. Bernardini	Italy

We feel that the whole field of cosmic rays is now too wide to be dealt with in a single conference, and it would be therefore better to limit the subject to certain lines of special contemporary interest. The general subject would be 'Interactions at Ultra Relativistic Energies' including the creation of V, K, τ, and ξ particles, cosmic ray phenomena underground, the primary spectrum, and any recent results related to the general definition given above. You will notice that we have excluded in the main the geophysical aspects of cosmic rays, since we feel that these are of sufficient importance to justify being made the subject of another conference, perhaps in 1955,

Ultimately the conference was restricted to discussion only of the heavy unstable particles over six days



THE PHYSICAL LABORATORIES,
THE UNIVERSITY,
MANCHESTER, 13

20 May 1952

Dear Leprince-Ringuet,

I have now heard from Professor Fleury and it seems that there will be very little money in 1953 for a conference. He suggests that there might be more available in 1954. I hardly think we should wait until then but should try and get on with less money. I don't see any reason really why we should not have a conference because we cannot pay the Americans' fares over here! Quite a number of Europeans will be able to come anyway whether they are helped or not. So I think the best policy is to press for the maximum amount we can get from U.N.E.S.C.O. but to go ahead with the plans anyway. Do you agree with this?

Presumably you have seen a copy of the letter that Fleury wrote to me with the details of the three previous conferences. If not I think it would be a good thing for you to ask his secretary for a copy.

Are Gregory and Lagarrigue coming over to see us sometime?

Yours sincerely,

Patrick Blackett

M. le Professeur L. Leprince-Ringuet,
Ecole Polytechnique,
Laboratoire de Physique,
17, rue Descartes,
Paris,
France.

Seeking funds from UNESCO for expenses outside of France

Fluery is head of IUPAP

I have now heard from Professor Fluery and it seems that there will be very little money in 1953 for a conference. He suggests that there might be more available in 1954. I hardly think we should wait until then but should try and get on with less money. I don't see any reason really why we should not have a conference because we cannot pay the Americans' fares over here! Quite a number of Europeans will be able to come anyway whether they are helped or not. So I think the best policy is to press for the maximum amount we can get from UNESCO but to go ahead with the plans anyway. Do you agree with this?

TENTATIVE SCIENTIFIC PROGRAMM

I

Study of very high energy nuclear phenomena in cosmic radiation, with special emphasis on the new unstable heavy particles (detailed experimental studies, discussion of results, possible interpretations).

II

A small auxiliary meeting may be held for workers in the field of Geomagnetic phenomena, in order to lay the foundations for a standardization of methods.

TENTATIVE TIME-SCHEDULE

This programme is subject to modification. The final schedule will be communicated at the beginning of the Congress.

JULY 1953

SATURDAY 4

Beginning of Registrations.

SUNDAY 5

Arrival of guests.
9 p. m., Reception.

MONDAY 6

Morning. — Opening session.
Afternoon. — Scientific papers.

TUESDAY 7

Morning and afternoon. — Scientific papers.
9 p. m., Entertainment provided by the Town of Bagnères-de-Bigorre (regional songs and dances).

WEDNESDAY 8

Morning and afternoon. — Scientific papers.

THURSDAY 9

Morning or afternoon. — Visit to the Observatoire du Pic du Midi. — Lourdes (Sanctuary, Museum of the Pyrénées).

FRIDAY 10

Morning and afternoon. — Scientific papers.
Evening. — Toro de fuego (Basque Fireworks).

SATURDAY 11

Morning. — Scientific papers.
Afternoon. — Final session.
8 p. m., Supper provided by the University of Toulouse.

SUNDAY 12

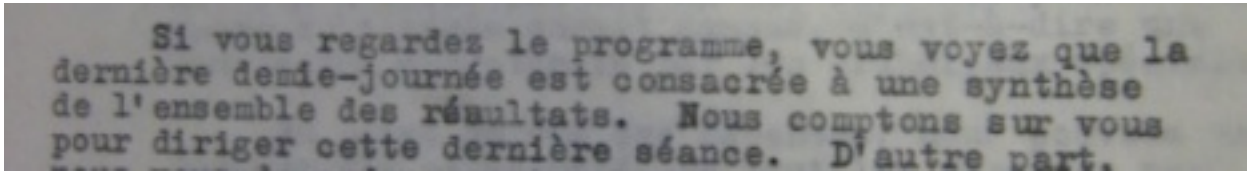
EXCURSION :
Lourdes, Gavarnie, lunch at Barèges, Pic d'Ayré (cable-railway), Tourmalet, return to Bagnères.

DIVERSIONS NOT INCLUDED IN GENERAL PROGRAMME

The Committee hopes to obtain free entrance to the *Casino Municipal* for the members of the Congress and their families, and also to the *Museum*, to the *Municipal swimming-pool*, to the *Tennis Courts of the Club Sportif de la Bigorre*.

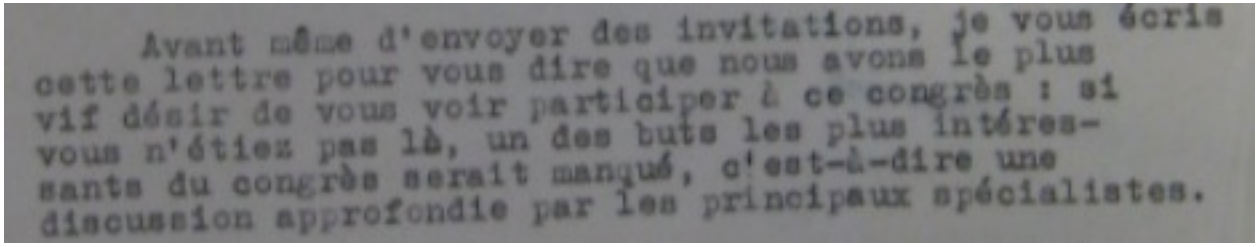
Trout-fishing and mountaineering are also possible.

Extract of letter from Leprince to Rossi March 10, 1953


Si vous regardez le programme, vous voyez que la
dernière demie-journée est consacrée à une synthèse
de l'ensemble des résultats. Nous comptons sur vous
pour diriger cette dernière séance. D'autre part,

If you look at the program you can see that the last half-day is dedicated to the synthesis of all the results. We count on you to direct this last session.

Extract of letter from Leprince to Powell December 10, 1952


Avant même d'envoyer des invitations, je vous écris
cette lettre pour vous dire que nous avons le plus
vif désir de vous voir participer à ce congrès : si
vous n'étiez pas là, un des buts les plus intéres-
sants du congrès serait manqué, c'est-à-dire une
discussion approfondie par les principaux spécialistes.

Before sending the invitations, I am writing you this letter to tell you we have the strongest desire that you participate in this congress: if you were not to attend one of the most interesting goals of the of the conference will be lacking, that is to say an in depth discussion led by the real experts.

Half-day discussions were to be led by Powell and Fretter on all the emulsion and cloud chamber results respectively

Leprince wanted to use this conference to demonstrate the revival of physics in France after World War II he sent letters of invitation to a number of prestigious physicists as well as the Soviet scientists. The invitations went to:

Gregor Wentzel
Werner Heisenberg
Enrico Fermi
Hans Bethe
Oreste Piccioni
Maurice Goldhaber
Robert Oppenheimer
John Wheeler
and others

None attended but there were in most cases polite responses. Some of these follow:

Professor L. Leprince-Ringuet
Ecole Polytechnique
Laboratoire de Physique
17 Rue Descartes,
Paris, France

Dear Leprince-Ringuet:

I am very sorry to answer only now your kind invitation to the Congress of the International Union of Physics next July. I am afraid that I will not be able to come because I have agreed to visit Brookhaven at about that same time. I am sorry that this is the case, because the conference that you are organizing will certainly be of great interest and I would like very much to have this opportunity to visit the installations at the Pic du Midi.

I was very happy to see you in Rochester. With best regards,

Sincerely yours,

Enrico Fermi

EF:vr

April 3, 1953

Professor L. Leprince-Ringuet
Directeur du Laboratoire de Physique
de l'Ecole Polytechnique
17, Rue Descartes
Paris, France

Dear Professor Leprince-Ringuet:

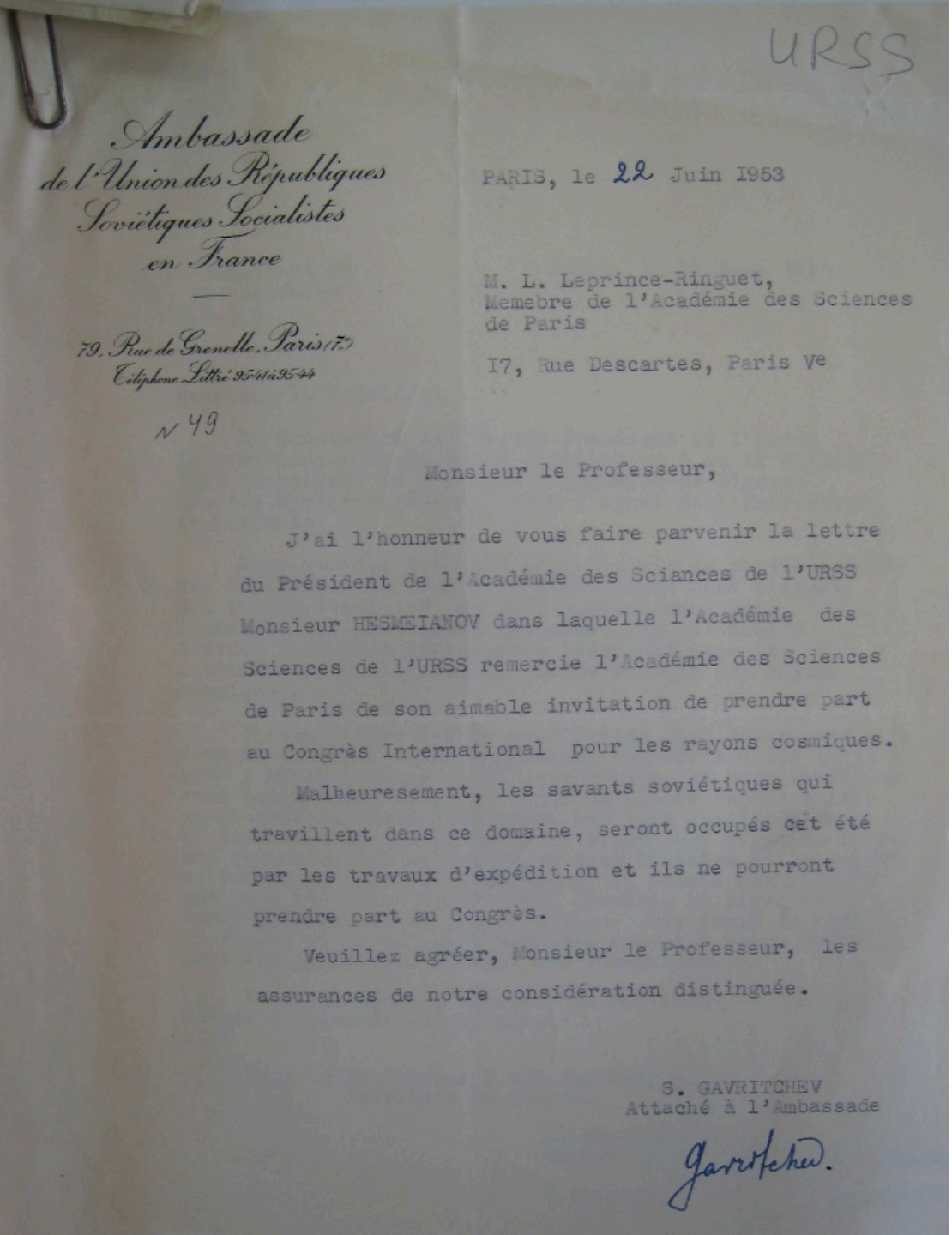
It was extremely kind of you to invite me to your forthcoming cosmic ray conference. Unfortunately, I shall not be able to come to Europe this year. I hope that Dr. R. P. Shutt from this laboratory will be able to attend. He, together with Fowler, Thorndike, and Whittemore have observed the first V particle produced by the cosmotron, in a diffusion cloud chamber. He should have some interesting things to tell. Perhaps you will be good enough to send him an invitation.

I would appreciate receiving a more detailed program or the proceedings of the conference when they are available.

Wishing you all success with your conference and with best regards to you and Dr. Gregory, I remain,

Yours cordially,

M. Goldhaber



URSS

Ambassade
de l'Union des Républiques
Soviétiques Socialistes
en France

79, Rue de Grenelle, Paris (7e)
Téléphone Littré 95-44 à 95-44

N 49

PARIS, le 22 Juin 1953

M. L. Leprince-Ringuet,
Memebre de l'Académie des Sciences
de Paris

17, Rue Descartes, Paris Ve

Monsieur le Professeur,

J'ai l'honneur de vous faire parvenir la lettre du Président de l'Académie des Sciances de l'URSS Monsieur HESMEIANOV dans laquelle l'Académie des Sciences de l'URSS remercie l'Académie des Sciences de Paris de son aimable invitation de prendre part au Congrès International pour les rayons cosmiques.

Malheuresement, les savants soviétiques qui travillent dans ce domaine, seront occupés cet été par les travaux d'expédition et ils ne pourront prendre part au Congrès.

Veuillez agréer, Monsieur le Professeur, les assurances de notre considération distinguée.

S. GAVRITCHEV
Attaché à l'Ambassade

Gavritchev.

Dear Professor ((Leprince-Ringuet)

I have the honor to pass a letter from the president of the Academy Of Sciences of the USSR, Mr Hesmeianov in which the Academy of Sciences of the USSR thanks the Academy of Sciences of Paris for the kind invitation to take part in the International Congress for cosmic rays.

Unfortunately, the Soviet scientists who work in this area will be occupied this summer with an expedition and they will not be able to take part in the Congress.

S. Gavritchev,

Attache to the embassy

Some inquiries

THE INSTITUTE FOR ADVANCED STUDY
PRINCETON, NEW JERSEY

SCHOOL OF MATHEMATICS

June 14

Dear Le Prince Ringuet

Thanks so much for your letter.
Am leaving for Holland in few days.
Address (mail reaches me there 'til June 27)

Hotel Noordzee
Koningin Wilhelmina blvd 8
Noordwijk Holland.

Am attending Lorentz conf. Leiden. Had planned to sail back July 10. Will reconsider due to your very kind invitation. Dont know whether I can make it.

Can I get transport flight Amsterdam South of France and return paid?
Am in great hurry now. Sending all good wishes

Yours
A. Pais

P.S. I hope all K-particles have spin zero.
I hope $\tau \to 3\pi$
$\kappa \to \mu + \nu + \gamma$
$\chi \to \pi + 2\gamma$

Pais did not attend

DEPARTMENT OF MATHEMATICAL PHYSICS.

THE UNIVERSITY,
EDGBASTON,
BIRMINGHAM, 15.

Telephone
SELLY OAK 1181

28th April, 1953.

Professor L. Leprince-Ringuet,
Secretary,
Congres de Bagneres,
17 Rue Descartes,
Paris Ve.

Dear Sir,

I enclose a card applying for an invitation to the Cosmic Ray conference at Bagneres this July. I wish to contribute to the second part of the conference a theoretical paper entitled "The modes of decay of the τ-meson" to occupy 15 minutes.

Yours sincerely,

R. H. Dalitz

R. H. Dalitz.

HOTEL NEW WESTON
MADISON AVENUE AT 50TH STREET
NEW YORK 22, N.Y.

envoyer Dandin

11 June 1953

Dear M. Lepinay-Ringuet,

We enjoyed your all too short visit in Chicago. Betty was thrilled with your interesting book. We shall be in Paris July 3 and 4 before going on to the Congress. We hope to see you in Paris so I shall call your laboratory at that time.

It was not clear from the announcement whether or not abstracts were required for the auxiliary meeting. In case a program is to be arranged I have enclosed three different abstracts for the auxiliary meeting so that the program committee may choose the topics they prefer.

With our best wishes to you,

John Simpson

And some amusing letters:

Cunard Line
R.M.S "Queen Mary"

15 June 1953

Dear Monsieur Lephince-Ringuet:

I hope you have returned well and safely to France after an enjoyable visit to U.S.A.

I think you have charged someone else with the details of the Bagnères conference: but as I have left the documents at home, I beg you to transmit the following questions:

(1) At what hotel in Bagnères shall my wife and I be staying? (I must send this information to my secretary in New York?).

(2) ~~Is~~ Is it possible to reserve two seats, first class, in the day train of July 5 from Paris to Bagnères?

Please reply to
KARL K. DARROW
Brown's Hotel
London W. 1
Angleterre.

We look forward very much to meeting you!

Sincerely yours
Karl Darrow

K K Darrow executive secretary of APS
(used to luxury)

UNIVERSITY OF MINNESOTA
COLLEGE OF SCIENCE, LITERATURE, AND THE ARTS
MINNEAPOLIS 14

DEPARTMENT OF PHYSICS

January 19, 1953

L. Leprince Ringuet
École Polytechnique
Laboratoire de Physique
17 Rue Descartes
Paris, France

Dear Petit Prince:

I received your letter concerning exposing of plates in Texas. Unfortunately we do not plan to fly the oriented gondola there and consequently will be unable to orient your plates. John Winckler has already left for Texas to start the operation and I plan to go down in a week. If everything goes well we should be done before the middle of February. Because the time is rather short it perhaps does not make sense to have the plates delivered from England. I have spoken to Phyllis Freier about this and she agreed to put some plates on for you. She will write to you directly about this.

I would like very much to attend the conference in the Pyrenees in July and I believe that people that are invited to this conference will be allowed to pay their way out of their government contracts. It would be very good if I could locate some little French girl to teach me the language before I come over. I am looking forward to seeing your "charming" scanners.

Best regards,

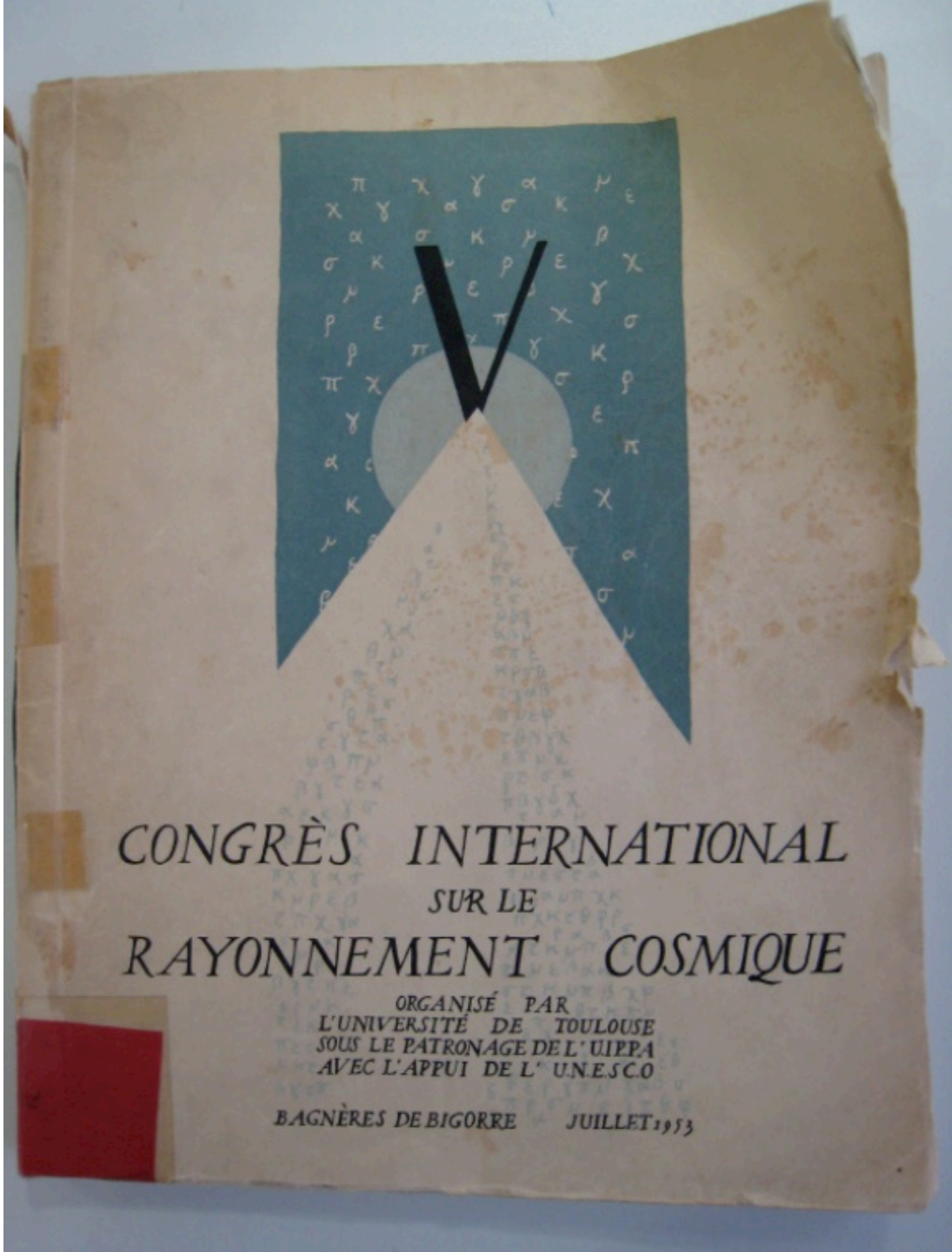
Ed Ney

Edward P. Ney
Associate Professor of Physics

EPN/mb

Preface

The particles described in this conference are not entirely fictitious and every analogy with the particles really existing in nature is not purely coincidental.



10 July 1953

Vendredi (après - midi) - Président de séance : C.F. POWELL

Rédapitulation et discussion.

1) Introduction.

2) Direct mass measurements of heavy charged mesons;
   a) slow particles
   b) fast particles

3) Evidence for the nature of the secondary particles ;
   a) μ-mesons
   b) π-mesons
   c) γ-rays

4) Distribution in energy of secondary particles from
   a) Charged V-particles
   b) S- particles
   c) K- particles

5) Nuclear capture of negative K-particles

6) The τ - mesons

7) Contradiction "The modes of decay of the τ -meson."

R.H. DALITZ · Birmingham/15'

11 July 1953

Samedi matin - Président de séance : W.B. FRETTER

A - Light neutral V's decaying into two light mesons with Q about 210 Mev.

40 min. 1. Evidence for two-body decay.

2. Nature of secondaries.

3. Q - values and masses

4. Lifetime

B - Other light neutral V's.

30 min. 1. Q - values.

2. Modes of decay

C - V_1^o events

40 min. 1. Decay scheme and Q - values

2. Possible existence of high Q - values

3. Lifetime.

4. Production
   a) Rate of production.
   b) Energy required for production.
   c) Possibility of pair production.

5. Angular distribution of secondaries

6. V_1^o - particles in nuclear fragments.

D. - Super - protons.

30 min. 1. Evidence for proton secondaries.

2. Evidence for meson secondaries

3. Q - values.

20 min. E. - Cascade decays.

10 min. F. - Theoretical suggestions (given by Chew)

Rossi nomenclature

APPENDIX

NOMENCLATURE MORE FREQUENTLY USED DURING THE CONFERENCE

A. GROUPS OF PARTICLES

1) L-mesons : symbol L : pi-mesons, mu-mesons, any other possible lighter meson.
2) K-mesons : symbol K : particles with mass intermediate between those of the pi-meson and the proton.
3) H-particles (hyperons) : symbol H : particles with mass intermediate between those of the neutron and the deuteron (this definition to be revised if "fundamental" particles heavier than the deuteron are found).

B. PHENOMENOLOGICAL DESCRIPTION

1) V-event : phenomenon which can be interpreted as the decay in flight of a heavy meson or an hyperon. Subclasses : V^0 and $V^{\pm}$.
2) S-event : phenomenon which can be interpreted as the decay or the nuclear capture of a heavy meson or a hyperon at rest.

C. CHRISTIAN NAMES FOR MODES OF DECAYS

Use small Greek letter for mesons; use capital Greek letters for H-particles.

Examples :

$\tau \rightarrow 3\pi$

$\mu \rightarrow \mu$ + (2 neutral particles)

$\chi \rightarrow \pi$ + (neutral particle)

$\theta^0 \rightarrow \pi^{\pm}$ + ($L^{\mp}$) ($Q \sim 200$ Mev)

Rossi's masterful summary:

All the heavy particle physics derived from the cosmic radiation was correct with exception of lambda production.

The other question is whether the V°-particles are formed individually or in pairs. I would like to precise the meaning of this question : the important thing is not to know whether occasionally or even often, they are made in pairs, the question is to know whether they can be made singly at all, because the theorists would like to think in order to account for the comparatively long mean-life of the V_1^o-particle that they can only be produced in pairs.

As far as I can see the only possibility for such pair production would be :

$$\pi^- + P + N \longrightarrow V_1^o + V_1^o$$

Concluding remark:

Before concluding my remarks there is one point which I would like to make which was made already in the course of the conference: it is the very close similarity, between the masses of two of the best established particles, I mean the charged tau-particle with a mass of 970 and θ^o-particle with a mass of 971. This looks hardly like an accident, and on the other hand it is very difficult to see how the θ^o-particle could be the neutral counterpart of the tau-particle.

Leprince-Ringuet's remarks at the closure of the conference

One can no doubt say that that the future of cosmic radiation in the domain of nuclear physics depends on the machines especially with the development more or less quickly of "strong focusing". But probably this point of view should be tempered by the fact that we have the uniqueness of some phenomena, quite rare it is true, for which the energies are much larger (than present machines) and we have a bit of protection in that our techniques will be well developed to keep ahead of the rapid growth of the energy of the machines. We are - I believe - a bit in the position of a group of alpinists who are climbing a mountain, this mountain is very high, perhaps infinitely high, and we are climbing it under conditions more and more difficult. But we cannot stop to take a rest, to sleep because coming from below a sea is surging, an inundation, a flood which progressively grows, forcing us to climb higher and higher. It is evident that this is a position which is not very comfortable, but is it not a situation extremely exciting and of magnificent interest?

Leprince gradually moved his group from Pic du Midi to CERN. His brilliant students and colleagues, Gregory, Muller, Astier, Armenteros, Peyrou and Lagarrigue performed extraordinary experiments at CERN.

Cosmic ray research led to the correct interpretation of the heavy unstable particles in advance of the accelerators

A. Pais	associated production	1952
M. Gell-Mann	strangeness scheme	1953
R. Dalitz	tau – theta puzzle → parity violation	1954

THE
PHYSICAL REVIEW

A journal of experimental and theoretical physics established by E. L. Nichols in 1893

SECOND SERIES, VOL. 86, NO. 5 JUNE 1, 1952

Some Remarks on the *V*-Particles*

A. PAIS
Institute for Advanced Study, Princeton, New Jersey
(Received January 22, 1952)

It is qualitatively investigated whether the abundance of *V*-particle production can be reconciled with their long lifetime by using only interactions of a conventional structure. This is possible, provided a *V*-particle is produced together with another heavy unstable particle (Sec. II). Two distinct groups of interactions are needed: for one, the coupling is strong (II); for the other, it is very weak (III). Two kinds of *V*-particles are considered, Fermions of mass $\sim 2200m$ and Bosons ($\sim 800m$). The arguments are somewhat different, according to whether the latter are nonpseudoscalar (III) or pseudoscalar (V). The competition with processes involving μ-mesons is discussed (IV). Possible connections with the τ-meson are commented on in Sec. V. The preliminary nature of the present analysis is stressed (VI).

Isotopic Spin and New Unstable Particles

M. GELL-MANN
Department of Physics and Institute for Nuclear Studies, University of Chicago, Chicago, Illinois

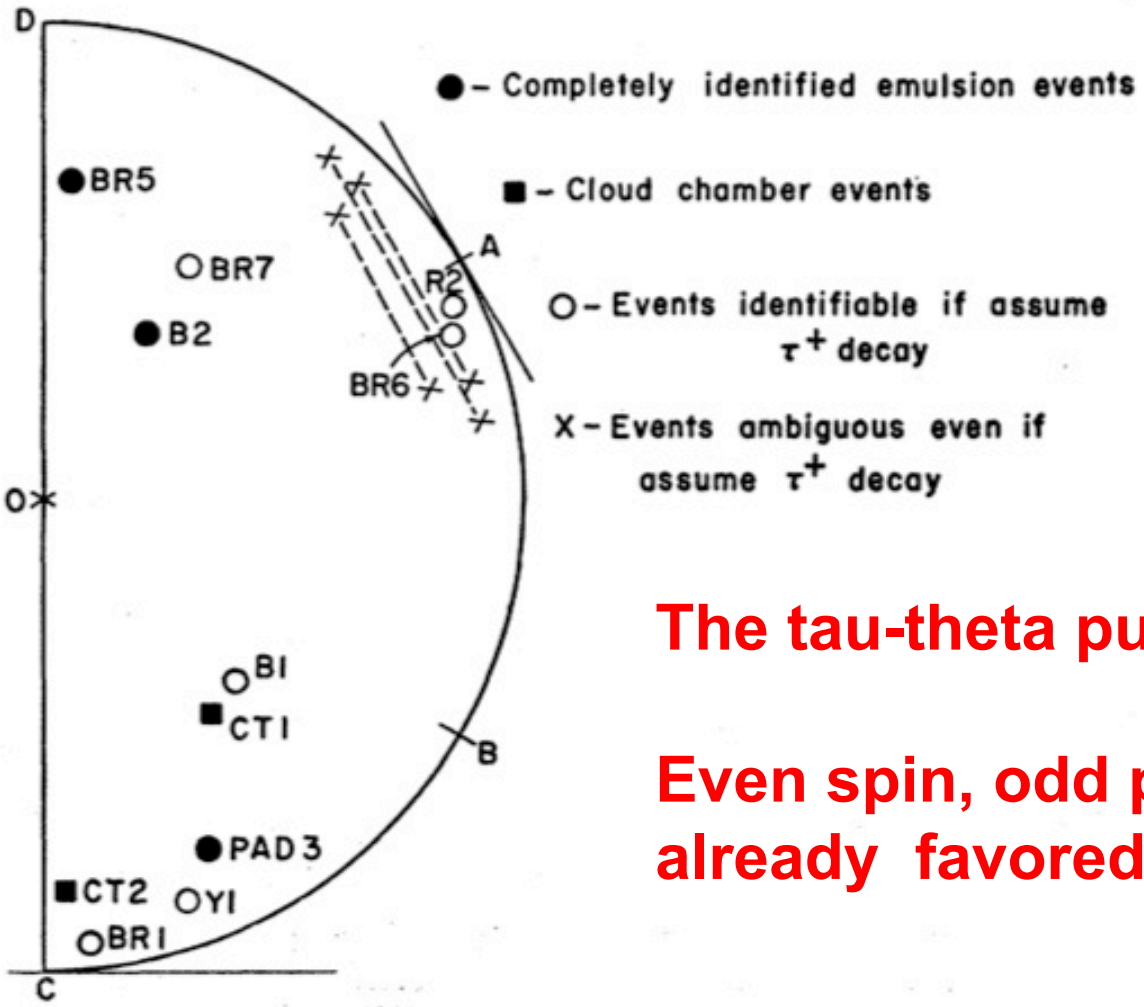
(Received August 21, 1953)

Finally, like the antiproton and antineutron. Thus we see that the reactions $\pi^-+p\rightarrow V_1^0+\tau^0$ and $\pi^-+p\rightarrow V_1^-+\tau^+$ are allowed, while the reactions $\pi^-+p\rightarrow V_1^0+[\tau^0]$ and $\pi^-+p\rightarrow V_1^++[\tau^+]$ are forbidden, although all four are allowed by conservation of charge. In order to produce anti-τ's it would be necessary to resort to a reaction like $\pi^-+p\rightarrow n+\tau^++[\tau^+]$ or $\pi^-+p\rightarrow n+\tau^0+[\tau^0]$.

In a similar fashion, all reactions of the form nucleon+nucleon$\rightarrow$ V_1+V_1 and all reactions of the form τ+nucleon$\rightarrow V_1+\pi$ are forbidden, while reactions such as nucleon+nucleon$\rightarrow V_1+\tau$+nucleon or $[\tau]$+nucleon$\rightarrow V_1+\pi$ are allowed.

Decay of τ Mesons of Known Charge*†

R. H. Dalitz‡
Laboratory of Nuclear Studies, Cornell University, Ithaca, New York
(Received February 9, 1954)



The tau-theta puzzle

Even spin, odd parity already favored

FIG. 3. The data on τ-meson decay events in which the signs of π-meson charges are established.

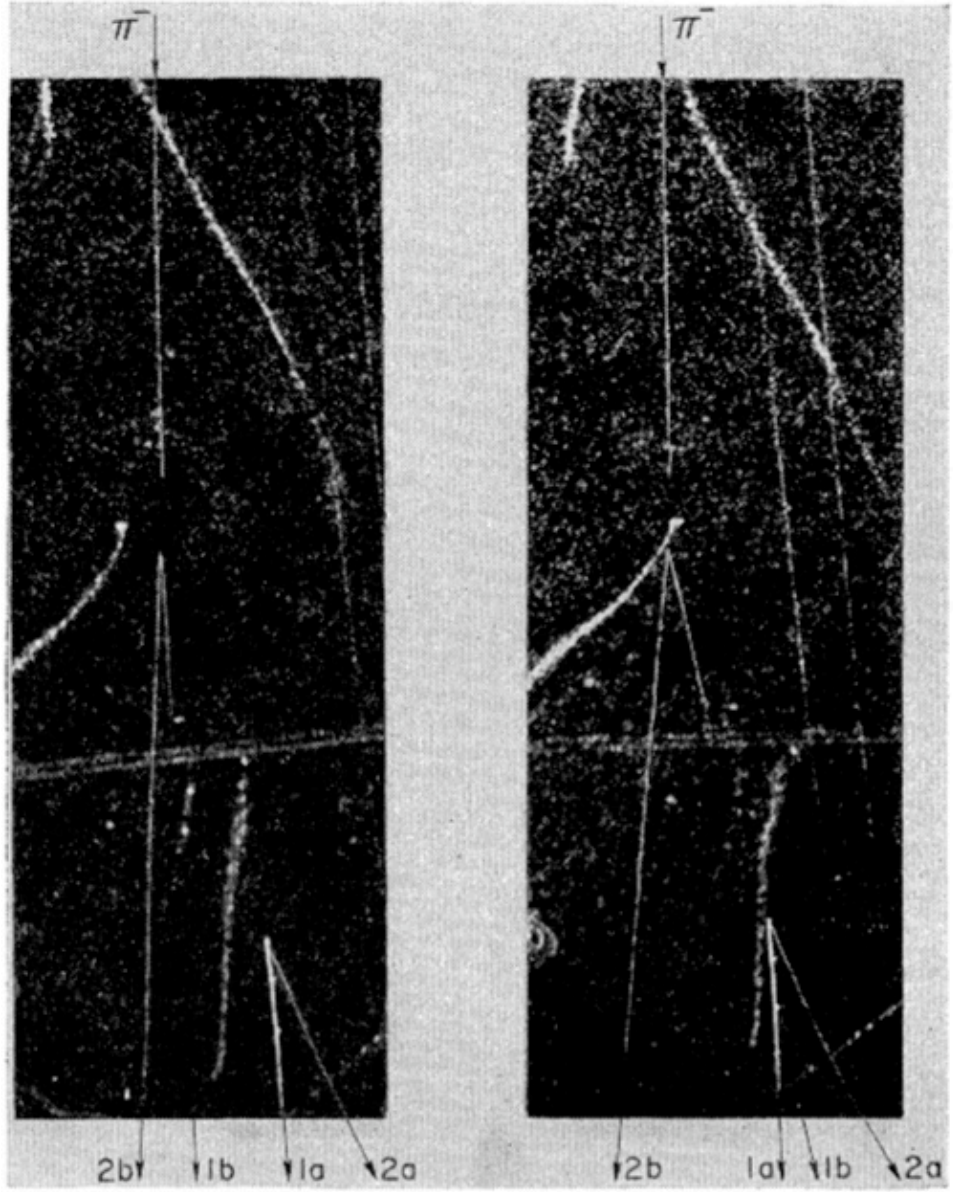
Production of Heavy Unstable Particles by Negative Pions*

W. B. Fowler, R. P. Shutt, A. M. Thorndike, and W. L. Whittemore
Brookhaven National Laboratory, Upton, New York

(Received November 10, 1953)

Associated Production

Brookhaven 3 BeV Cosmotron



END

Dalitz testimonial on Bagneres de Bigorre

The International Cosmic Ray Conference for 1953 was arranged to concentrate on the new particles, and this was a major event in the lives of all the physicists who took part in it. It was held 6-12 July at Bagnères-de-Bigorre, in the Basque country on the northern slopes of the Pyrenees. During this conference, it became clear that there was a substantial consensus concerning the subject matter of all this widespread cosmic ray work. Previously it had seemed as if a new decay mode, or perhaps a known decay mode for a new parent mass, was being reported almost every month, but now it was seen that the most frequent decay modes were quite limited in number and were associated with fairly definite mass values. Previously, the $V_1^0 \rightarrow p\pi^-$ particle was the only well established V^0 particle, known to us as the $\Lambda(1115)$ hyperon; now, the painstakingly precise work of Thompson had established the existence of the $V_2^0 \rightarrow \pi^+\pi^-$ particle, also known as the θ^0 meson, with mass 496±5 MeV, comparable with that for the τ^+ meson. Of course, the cloud chamber work still left some further neutral events, labelled $V_3^0, V_4^0, \ldots$, and some charged $V^\pm$ events to be sorted out, the latter still to be related with the at-rest decay events reported from the emulsion work. The new techniques for using layered emulsion blocks were being perfected and it was becoming possible to follow charged secondaries through many layers and so to identify them uniquely and to measure their energies from their range. In committee, rules were drawn up for the formal specification of any new particles or new decay modes. It was an exciting time, as if the mists were lifting and we could at last look ahead.