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Geneva, 13th January 1955

EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH

RESEARCH PROGRAMME FOR CERN IN GENEVA 1955

presented by the Director - General to the Scientific Policy Committee.

GENERAL REMARKS

While the design and construction of the big accelerating machines in Geneva is well under way and progressing satisfactorily, it is clear that at least three years will pass before even the first of them can be used for research. It seems imperative not to wait until that time but to initiate a research programme at the earliest opportunity. This idea was informally discussed among the members of the Nominations Committee and the Director-General, previous to his appointment, and its validity was recognized within this group. Based upon this recognition the first steps toward realization have already been taken.

With the final organization of CERN now being in force, a resolution by the Council is called for to support a vigorous research programme previous to the completion of the machines. While the pursuit of research in a scientific organization would hardly seem to demand a justification, it may be useful to clarify its relation to the construction and the use of the big accelerators. For this purpose we propose the following general considerations:

1. Although it is foreseen that a substantial part of the scientific manpower will come to Geneva on short contracts, it is important to create at Geneva a school and a strong standing tradition. In order to have a scientific atmosphere well established by the time the first machine works, it is not too early to start some research activities here and now.

2. Experience has shown that there exists a mutually profitable relation between the problems of basic research and those, encountered in engineering. Far from detracting from the construction of the big machines it can be confidently foreseen that there will be a most fruitful cross-stimulation between the men, engaged in research and those who are primarily engaged in design and construction.

3. An appropriation, comprised between half a million and one million Swiss frs./year would already be quite sufficient to initiate and support a worthwhile research programme. It would be a rather improbable coincidence if it turned out that it is the spending of this comparatively inconsiderable amount which would ultimately upset the present budget.

134 For this year three research activities are contemplated and shall now be separately discussed:

A. THEORY

1. Outline

The need for theoretical work at CERN has already been recognized by establishing the Theoretical Group which is at present working under the direction of Møller in Copenhagen. It is felt, however, that a complete geographic separation of the Theory in Copenhagen on one hand, and the experimental work in Geneva on the other hand, is not desirable. Therefore it is planned to have a small group of theoreticians working at Geneva; their selection is proposed to be primarily governed by the consideration that their field of interest bears upon that of the experimentalists in Geneva.
Men working in the theory of meson physics are therefore most desirable, but a man working in another field who proves stimulating and interesting to other members of CERN, should certainly not be excluded.

2. Manpower

For the coming year we hope to obtain 2 well-qualified theoreticians to work full-time at Geneva and possibly another one to work on part-time basis. Therefore the manpower will be:

2 L3/4
½ L3/4

3. Budget for 1955

Staff expenses	50,000	Swiss francs
General expenses	5,000	" "
Capital expenses	5,000	" "
	60,000	Swiss francs

B. RESEARCH IN NUCLEAR MAGNETISM

1. Outline

Following the explicit recommendation of the various bodies of the provisional CERN, it was decided to establish in Geneva a small group working on problems of nuclear magnetism, using mainly the equipment on loan from the Stanford University. It is proposed to include this work in the programme under discussion.
The work consists of the study of nuclear magnetic resonance under conditions of extremely high resolution (1 part in 100 million). Under this condition it is possible to study the very fine feature of the spin-spin interaction of different nuclei in a molecule which are of particular interest in organic liquids. While there exist no direct relation between this type of research and that dealing with

high energy physics, there can be no question about its intrinsic scientific value. By bringing this type of work to Geneva it can be hoped that it may stimulate similar work in other laboratories in Europe.

Furthermore, it may be pointed out here that this work requires the art of electronics on a very high level and there is little doubt that the presence of this highly-qualified personnel will help CERN to attain a high level of competence in the electronics field so essential both for the accelerators and for the experimental apparatus.

2. Manpower

The 2 men who have taken up their work here on October 1, should certainly be kept on for its continuation and besides we want to foresee at least one more collaborator to join them at an earlier opportunity with a small supporting technical staff and possibly, the use of one further part-time man; the manpower will be therefore:

3 L3/4
2 T2/3
½ L3/4

3. Budget for 1955

Staff expenses	120,000	Swiss francs
General expenses	35,000	" "
Capital expenses	25,000	" "
	180,000	Swiss francs

C. COSMIC-RAYS

1. Outline

Cosmic-rays research is explicitly mentioned in the Convention (Art.II, para. 3a) as one of the fields prescribed for CERN's activities. Apart from its intrinsic value, such research is highly important, especially during the initial years, for the following reasons:

1) It constitutes the most appropriate training ground for young physicists who will have to use the machines later on; it introduces them to the basic concepts of high-energy physics and to experimental skills which can be transferred to the accelerator work almost without any further adaptation. The immediate availability of this source of radiation at or near Geneva helps to create the required scientific atmosphere.

2) By starting immediately the development of apparatus usable in advanced cosmic-ray research, we insure the availability, at the time needed, of instrument-making personnel and facilities, and even of some general-purpose items of equipment, which will facilitate the starting-up and the development of the experimental programme around the accelerators.

A first exchange of views between the Secretary General and various cosmic rays experts took place in the course of spring and summer 1954, both by letter and in discussions held on the occasion of various international meetings. Blackett, Leprince-Ringuet and Powell were among the persons interested in these talks. As a conclusion it was thought that, at least for the moment, it did not seem useful for CERN to start a Group to work with nuclear emulsion technique in Geneva. This type of work is already going on in a very satisfactory way in many European Universities and CERN could continue, as during the past two years, to function as the organizing centre of a wide co-operation taking care of the organization, and possibly of part of the expenses involved in balloon flights expeditions, and in the development and improvements of processing and measurements techniques. About this last point, a programme is expected to be sent to CERN by Powell and Rotblat.

On the other hand, it was felt highly desirable to start as soon as possible a research programme based on the use of fast counter and cloud chambers techniques.

In order to keep the cosmic-rays programme within very narrow limits in respect of budget and personnel requirements, two sorts of activities have been planned:

1) an experiment devoted to the measurement of the mean life of K mesons in which cloud chambers and millimicrosecond techniques are combined. ~~A detailed report on what has been done until now in this field and a description of CERN experiments is given in the Annex~~. It is felt that this experiment will offer a convenient starting point for the instrumentation activities in these two fields and that its intrinsic interest will introduce the necessary sense of urgency.

2) The prosecution of the activities of the Jungfraujoch Group working with the cloud chamber of 54 x 54 x 24 cm^3 on the V events produced by cosmic rays at mountain altitudes. In fact CERN has received from Professor Blackett, authorized by the D.S.I.R. to whom the instrument belongs, the very generous offer to take over the new cloud chamber operated by Newth and his team at the Jungfraujoch. The transfer will be according to the following schedule:

   <u>October 1954 - October 1955</u>: two young physicists to be appointed by CERN will join the Jungfraujoch team. One could be appointed immediately, the second in a few months. They will learn to operate the instruments and the related techniques.

   <u>October 1955</u>: It is hoped that Newth can obtain a leave of absence from the Manchester University in order to join CERN, possibly with some of his collaborators. The scientific direction and financial support would be entirely by CERN. If Newth stays in Manchester, however, the scientific and financial support will be shared.

October 1956: CERN will take over all responsibility.
All details concerning this transfer will be arranged by Amaldi and Blackett.

2. Manpower

The personnel required for experiments 1) is the following:

1 L3	from	July 1, 1955
1 L4	"	January 1, 1955
1 L5	"	January 1, 1955
2 L5	"	April 1, 1955
1 T3	"	January 1, 1955

Of the above-mentioned 6 people, 2 must be electronic experts and 2 cloud chamber experts.
Since it is proposed to establish a close link between this experiment and the instrumentation proper, some of the personnel listed above will be provided by the Instrumentation Section, possibly on a time-sharing schedule.

The personnel required for experiments 2) is the following:

2 L3	from	October 1955
2 L4	"	October 1955
1 L5	"	November 1954
1 L5	"	March 1955

The personnel required must be composed, at least partly, of cloud chamber experts; Newth is included in this scheme.

3. Budget for 1955

Experiment 1)

Staff expenses	100,000 Swiss francs
General expenses	50,000 " "
	150,000 Swiss francs

Experiment 2)

Staff expenses	82,000 Swiss francs
General expenses	8,000 " "
	90,000 Swiss francs

No Capital Expenses are foreseen in either case, since the capital expenditure of the Experiment 1) will be borne by the Instrumentation Section, and that of the Experiment 2) will be supplied by the donor.

ANNEX

Observations on the proposed experiment on long lived K - particles, using fast timing cloud chamber techniques (1).

1. Previous experiments.

1.1 Keuffel Mezzetti experiments (KM) - (Phys. Rev., 1 Aug. 1954).

We have measured the decay curve of stopped unstable cosmic ray particles using liquid scintillators and directional Cerenkov counters (2). Auxiliary information is provided by Geiger counters, connected to an 80-channel hodoscope. The apparatus is shown in Fig.1. Each Cerenkov counter is a hollow lucite box filled with water, painted black on the bottom and viewed from above by an RCA C7157 photomultiplier. The measured efficiency is 90 percent for fast μ-mesons travelling towards the photomultiplier end, and 0.4 percent for particles traversing the counter in the opposite sense. The experimentally verified Cerenkov velocity threshold for water corresponds to $E/mc^2 = 0.52$.

The apparatus was designed to select events of the following type. A charged unstable particle produced in the generating layer of Pb passes through the scintillator S and stops near or inside one of the Cerenkov counters $\check{C}$. There it decays at rest into an upward-going relativistic secondary which is detected in $\check{C}$ unobscured by downward-going shower particles. The time delay is measured with a 17-channel chronotron-type timing circuit (2,3). The triggering requirements included the firing of any two counters in the G_2 bank. We also later rejected, by examining the hodoscope pictures, events where an extension

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1) This Annex is mainly based on the report presented by Mezzetti and Ballario to the Meeting on Cosmic Rays held in Geneva on the 9th and 10th September 1954.

2) J. Winckler and K. Anderson, Rev. Sci. Inst. 23 765 (1952).

tray and/or tray G_1 indicated an air shower and certain other events discussed below.

Our results are shown in Fig.2. The time distribution shows a central peak and a well-defined exponential "tail" beginning at about 12.4 mμsec. If the lags greater than 12.4 μsec are analysed by the method of Peierls on the basis of a single exponential, the mean life is 8.7 ± 1.0 mμsec. The systematic error is probably no larger than the statistical error quoted. The rate of such events, extrapolated to zero time, is 3.5 hr^{-1}.

Instrumental timing errors were studied in detail by inverting the Cerenkov counters and triggering on fast μ-mesons and soft showers. The timing error distributions were consistent with the shape of the central peak in Fig.2, but could not possibly account for the exponential tail. We found, however, that large pulses in the <u>scintillator</u> - as indicated by a high multiplicity in a hodoscoped Geiger tray below it - produced a shift of 3 to 5 mμsec in the direction of apparent lags in the Cerenkov counters (1). For this reason, we rejected events in the actual run where more than six counters were discharged in trays G_2 or G_3.

Time lags might arise from differences in time of flight of two associated particles. We tested this possibility by displacing the Cerenkov counters 50 cm to one side, but still maintaining similar thickness of Pb above and around it. The rate of lags greater than 12.4 mμsec decreased by a factor of 20 under these conditions. (See "KB", Fig.2). Such a sharp decoherence cannot be associated with particles from a distant origin. We also verified with a neutron source that the Cerenkov counters had a negligible response to neutrons.

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1) Pulse heights could not be measured directly in this experiment because of amplifier saturation.

The delayed events are most reasonably interpreted in terms of bona fide decays. Many short-lived unstable particles are known, but we wish to re-emphasize that we detect only those which produce relativistic secondaries. Thus τ-mesons can be detected only by the materialization of γ rays from the (relatively infrequent) alternative mode of decay $\tau' \rightarrow \pi + 2\pi^0$ while the π-μ-e process will be detected only by the decay electrons. These are distributed in time over a 2.2 μsec mean life and are very inefficient in triggering the apparatus compared to long-range μ-mesons from K-decay.. A small number of lags in the microsecond range were indeed observed, but it was not possible in the present experiment to analyse these into 2.2 μsec and flat random noise components; we can only say that the background from such events is at most about 0.5 counts per channel in Fig.2. (If this background were doubled it would decrease the mean life by only 0.25 mμsec.).

The fact that we considered only lags greater than 12.4 mμsec in the analysis biases us strongly against processes with mean lives less than about 4 mμsec. Our results should be compared particularly with the results of the Paris cloud chamber group (1), where the minimum time of flight to the lower chamber is 5 mμsec. These investigators found a predominant K-process $K_\mu \rightarrow \mu + \nu$, with a unique secondary momentum 223 Mev/c, and it appears likely that we are observing this particle. The Paris group (2) estimates the K_μ mean life as 28 mμsec, but this value is not considered inconsistent with ours because of their small statistical sample. Earlier cloud-chamber mean life estimates gave lower and upper bounds of 4 and 10 mμsec (3) (4). In addition to the K_μ's, these estimates probably involved

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1) Gregory, Lagarrigue, Leprince-Ringuet, Muller and Peyrou, N.Cim.11, 292 (1954).

2) B. Gregory, Padua Conference on Heavy Mesons. April, 1954.

3) Astbury, Buchaman, Chippindale, Millar, Newth, Page, Rytz and Sahiar, Phil. Mag. 44 242 (1953).

4) Bridge, Peyrou, Rossi and Safford, Phys. Rev. 90 921 (1953).

other K-particles with mean lives short enough not to show up after 12.4 mμsec.

Our rates appear to be consistent with cloud chamber and emulsion rates, but large uncertainties are involved in the comparison.

1.2 Hyams' experiment. (H). The following discussion and the sketch of the arrangements used are based on the Report of the Conference of Bagnières de Bigorre, pag. 14.

C_1 and C_2 are water-filled Cerenkov counters with white walls, used as velocity indicators. C_1 is in anticoincidence, so the particle crossing it must have $\beta \leq \beta_c$; since the total range has to be greater than a certain amount R_o, its mass must be $\geqslant m_o$ (f.i. $m_p > m_o > m_\mu$). (Fig.3). C_2 is in coincidence so that the secondary particle has to be relativistic $\beta_s > \beta_c$. To trigger the chamber a coincidence of the type S $\bar{C}_1$ $G^{\geq n}$ C_2 is required; the delay between the pulses of S and C_2 is measured. The information associated with each picture can be summarised as follows :

a) a ionising particle (pulse in S and G) slow and unaccompanied by any fast particle ($\bar{C}_1$), enters the chamber;
b) the particle is seen to stop in a Pb plate; this, in connection with (a), gives a lower limit m_o for the mass of the particle;
c) a secondary ionising particle is seen to be emitted from the point where the primary stops; in most cases a change of direction will be observed;
d) the secondary particle is fast, as indicated by the Cerenkov pulse in C_2 ("change of velocity" criterion);
e) in most cases it will be possible to check the change of velocity between the primary and the secondary by comparing the relative ionisation densities of the two tracks on the picture;
f) the time-lag between the stopping of the primary and the emission of the secondary is measured.

The C_1-anticoincidence requirement is probably the most severe from the point of view of the rates. The chance of the primary being unaccompanied by other fast particles when crossing C_1 has to be reasonably large; consequently the shower producing layer has to be sufficiently far from C_1, and the useful solid angle will be correspondingly small. It is important to notice that the same holds also for C_2, in order to be able to use its pulse for the "change of velocity" criterion and for the measurement of the time lag (it is difficult to obtain good time resolution with multiple pulses from the same photomultiplier).

An a-priori estimate of about 1 observation per day was reported by Hyams at Bagnières, but the actual rate is probably lower. A rate between 0.2 and 0.5/day would not be inconsistent with KM's rate. So far about 10 events have been obtained (private communication, running time not given), in 5 of which positive identification of the event as an S - particle was possible from the analysis of the cloud chamber picture; the associated time lags were approximately 25, 9, 7, 3, 3 mμs (average 9.4 mμsec).

2. <u>List of interesting questions about long lived charged K - particles.</u>

A number of interesting questions can be investigated by means of an experiment using the directional Cerenkov triggering technique in connection with other devices (possibly one or two cloud chambers).

a) <u>Possible existence of more than one mean life time,</u> in the range between, say, 2 and 50 mμs.

This requires a very accurate analysis of the shape of the decay curve, and a high intensity experiment would therefore be desirable.

b) <u>Nature of the secondary particle</u> (π or μ)

One way to do this would be to look for "cascade" decay processes (f.i. $K \to \pi \to \mu \to e$), detecting them by means of "multiple timing". If the secondary particle is a π^+ and is brought to rest within the sensitive volume of a scintillation counter, the pulses from the incoming π and that from the secondary μ can be separated in a good fraction of the cases, even if the scintillation counter is rather large;

the pulse from the decay electron will be separated in almost all cases. If the secondary particle is a π^- in a good fraction of the cases it will give rise to a nuclear star, recognisable from a big undelayed pulse in the counter; μ^+ and μ^- will give the same pattern of pulses, the stopping material being of low Z.

Another possibility, of course, would be to make direct mass measurement on the secondary particles by scattering-range (?) if a multiplate cloud chamber is used, or by momentum range if also a magnetic chamber is available. The first method is probably too inaccurate to allow a distinction between π and μ, the second is probably not practically feasable because of cost and reduction of useful solid angles.

c) Charge (+ or -) of the secondary particle. If the secondary is a π meson, the charge can be identified from the appearance of the pulses at the stopping, as described above in (b).

If, instead, the secondary is a μ-meson, its sign can be inferred from the Z - dependence of the $\mu \rightarrow e$ decay meanlife; this requires the substitution of the low - Z (organic) scintillation counter with a high - Z one (it will probably be possible to "load" a liquid (organic) scintillation with some transparent high - Z material without spoiling its fluorescence).

Of course, the sign of the secondary (as well as of the primary) can be seen directly if one uses a cloud chamber with a sufficiently strong magnetic field; if only the sign and not the momentum is required a strong non uniformity of the field could be tolerated, which would make the problem creating such field easier and less costly.

d) Nuclear interaction properties of the K mesons. By changing the atomic number of the material in which the K mesons are brought to rest, the Z dependence of the apparent mean life time of the K^-'s can be studied. This will come out in a much cleaner way if the sign of the particle is known in advance.

e) Energy spectrum of the secondaries. The range - spectrum would be studied best by using a cloud chamber arrangement, which allows the reconstruction of both the decay - point of the primary and of the stopping point of the secondary particle. A large multiplate chamber would be necessary for this. The energy spectrum itself can be derived only when the nature of the secondary is established.

3. Proposal for a purely electronic (without C.C.) high intensity experiment (Fig.4).

The delay between S_1 and $\check{C}$ is measured; in addition, the pulses from S_2 are displayed on a fast scope (resolving time of the order of 10^{-8} s) Master : $\bar{S}_4\ S_1\ \check{C}\ S_2$. The whole apparatus is high above the floor, in order to prevent decays happening in the floor to be counted. Estimated rate of "true" triggerings (based on KM) : $\sim 1\ h^{-1}$.

4. Proposal for experiment including cloud chambers to be made at CERN (Fig.5).

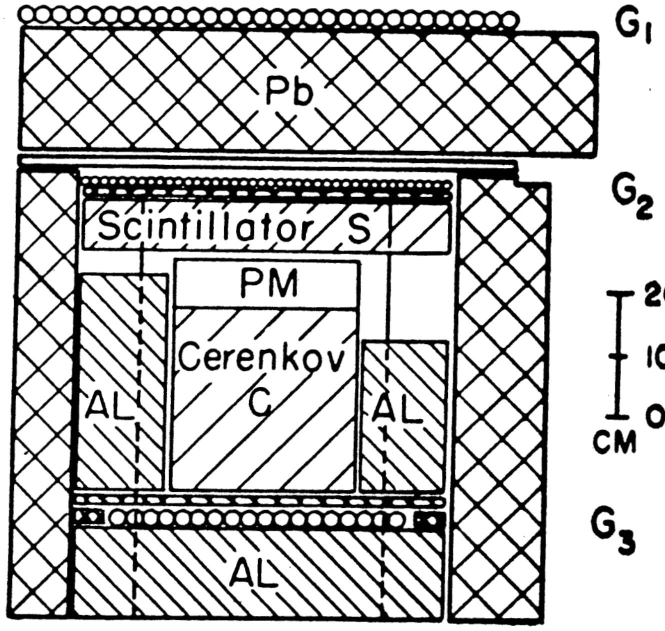
The following events will be studied:

A high-energy particle P produces in the plates of the lower cloud chamber a K-meson and a penetrating shower which discharges the scintillation counter below the chamber, giving an indication of zero time for the millimicrosecond time measurement. The K-meson comes to rest in another plate of the cloud chamber and its range can be measured. With a certain delay the K-meson decays in a fast upward going particle, which gives a pulse in the Cerenkov counter if the energy exceeds the Cerenkov threshold. This is the case for the charged light mesons emerging from the decay of $K_{\pi 2}$ and $K_{\mu 2}$ and part of the $K_{\mu 3}$, which occur not too far down in the lower chamber. Other events which will be recorded are those where the Cerenkov counter is triggered by upwardgoing electron pairs, associated with γ-rays from the decay of neutral π^0 mesons, produced in the decay of $K_{\pi 3}$ and $K_{\pi 2}$ or with γ-rays emitted directly in the decay of the K-meson.

In all these cases the upward going particles will produce a pulse in the Cerenkov counter which is delayed with respect to the zero-time pulse from scintillation counter S_1, the delay giving the mean-life of the stopped K-meson. The decay particle will after traversing the Cerenkov counter stop in one of the plates of the upper cloud chamber, so that its range can be measured.

The experiment, which was originally proposed by Mezzetti is essentially a derivation from Hyams experiment with cloud chambers to identify the event, but using the directional properties of a Cerenkov counter to select only events with an upward going particle as in Mezzetti's experiment. Since this requirement is less restrictive than the triggering scheme used by Hyams the rate of true events is expected to be larger. Rough estimates indicate that with a Cerenkov counter surface of 0,5 m^2 about 50 K-mesons per day should be recorded by the electronic system at 3500 meters. Even at Geneva altitude 2-5 events should occur per day. It is however not known whether the triggering requirement based on the directional sensitivity of the Cerenkov counter is restrictive enough to reduce the background to a level which makes the operation of the cloud chambers possible, without excessive waste of measuring time. This problem is being studied.

FIG. 1. Experimental arrangement. G_1 and G_3 are trays of GM counters of diameter 1 in. and sensitive length 24 in.; G_2 is a tray of ½-in. GM counters of the same length. All the elements in the array are approximately square except for S, which is 11 in. by 24 in. There are two Čerenkov counters, one behind the other, each 1 ft square by 6 in. thick.



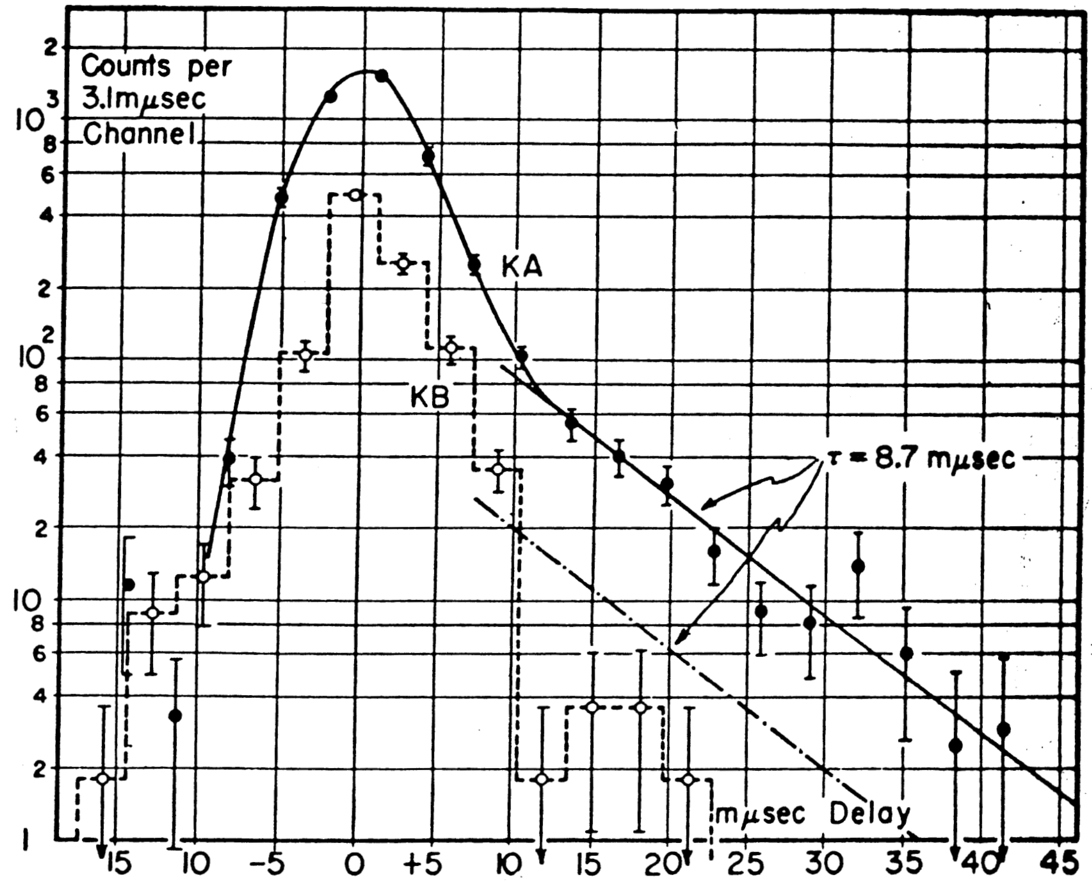


FIG. 2. Time lag distributions. *KA*: regular run, disposition as in Fig. 1, running time 230.7 hr, total rate 19.8 hr^{-1}. *KB*: test for lags due to time of flight. Čerenkov counters displaced 50 cm. Normalized to same running time as *KA*, so that differences in *absolute* rate of lags are significant.

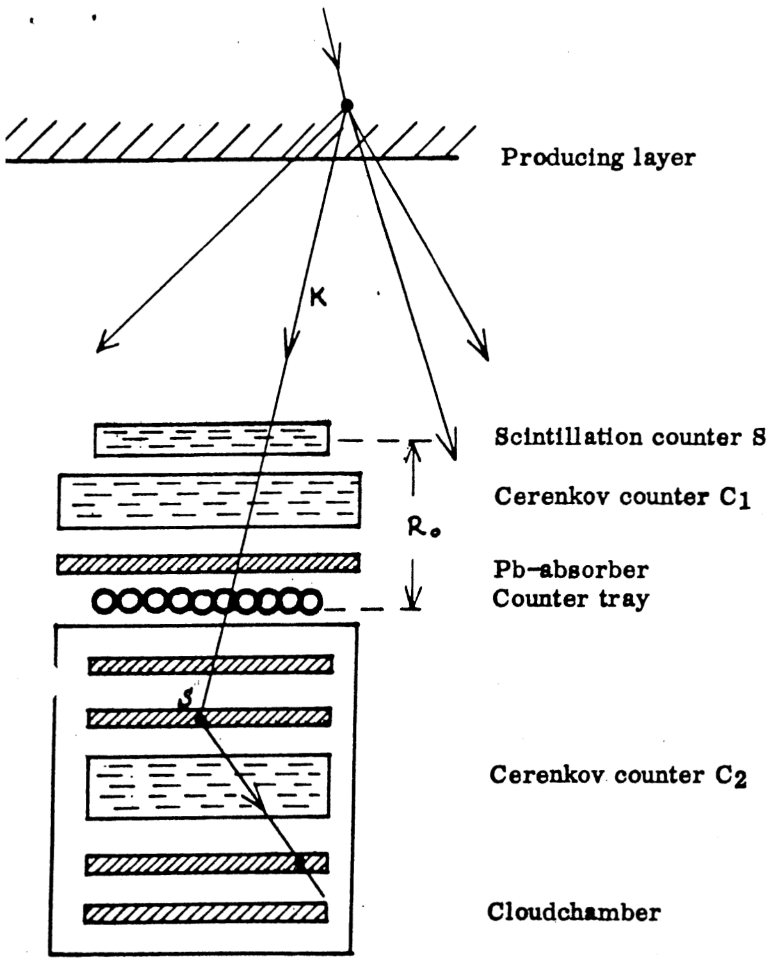


Fig. 3

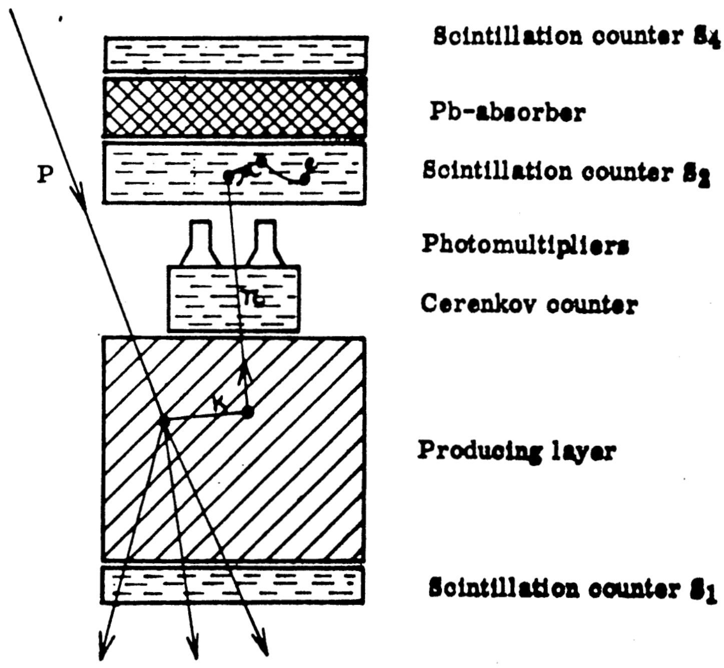


Fig. 4

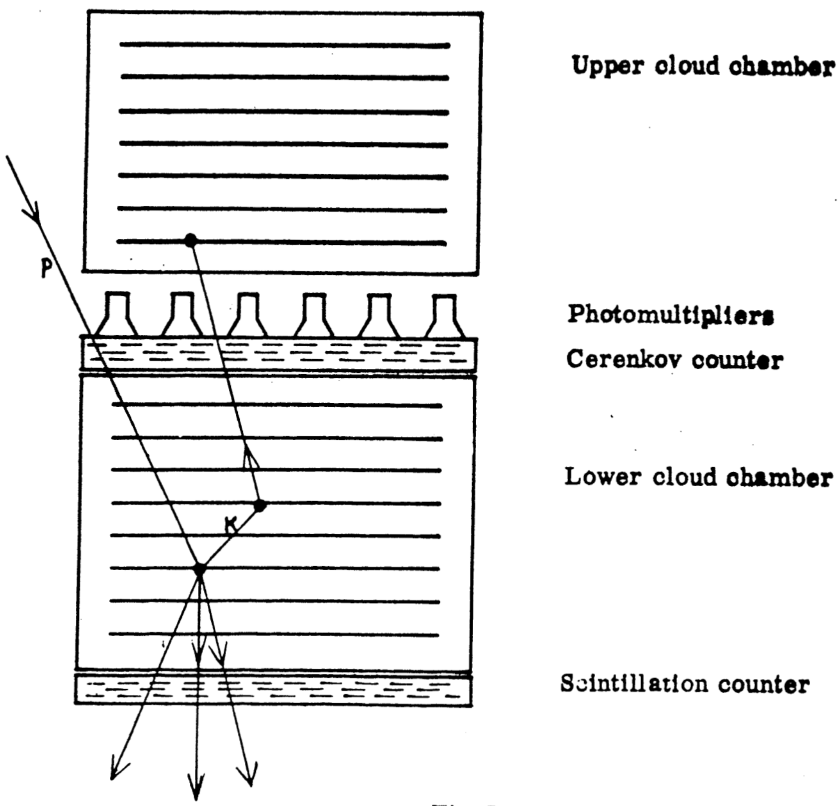


Fig. 5