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EARLY HISTORY OF COSMIC RAY STUDIES

Personal Reminiscences with Old Photographs

Edited by Yataro Sekido and Harry Elliot

VOLUME 118

D. REIDEL PUBLISHING COMPANY

DORDRECHT / BOSTON / LANCASTER

COSMIC RAY STUDY IN NISHINA LABORATORY

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1.

The cosmic ray research in Japan was initiated by Dr. Yoshio Nishina in 1931. In the summer of that year, he was nominated chief of a new laboratory (Nishina Laboratory) of The Institute of Physical and Chemical Research (I.P.C.R.). There, R. Sagane soon started to make Geiger-Müller counters. The first counter was made of a copper tube 5 cm in length and 2 cm in diameter. Both ends of the tube were shielded by ebonite plugs, and a steel wire was stretched between the plugs as a central electrode. This counter was of the shape that two "Spitzen Zähler"s were connected facing each other. Fortunately the discharge characteristics of this counter showed a plateau as large as 50 volts, and it was primarily used to measure the intensity of radiation in the laboratory, When the center of a typhoon passsed through Tokyo area in the fall of this year, it was found that the counting rate varied with decreasing atmospheric pressure, and later returned to the normal rate when the typhoon had gone. Apparently there was a significant correlation between the counting rate and the atmospheric pressure.

While this kind of preliminary experiment was continued, we concentrated our effort to make larger G.M. counters of different type. One of these counters had such a structure that a brass tube and a steel wire were sealed in a glass tube, which was then filled with a low pressure air. In those days the good counter with a 50 – 100 v plateau could be obtained only by trial and error, as the discharge mechanism of G.M. counter was not clear.

In 1932, we started a cloud chamber study of cosmic rays; we planned to measure the energies of cosmic ray particles in a magnetic field. In the beginning, however, nobody in the laboratory was convinced whether cosmic ray tracks could be obtained in the cloud chamber.

The first cloud chamber we made was expanded by a horizontally moving piston, and was mounted in a magnetic field of 2000 Gauss, which was generated by a Helmholtz coil. At the end of 1932, we succeeded in taking photographs of cosmic ray tracks. The counter controlled method for cloud chamber operation was invented by R. Sagane, and was applied to this experiment as mentioned in November 1932 at the meeting of I.P.C.R. The next year, we found that the Blackett group had also invented similar method and applied it to cosmic ray experiment, when their publication of March 1933 arrived at our laboratory.

One of the photographs thus taken showed a pair of circular tracks emitted from a point where a straight track crossed the inner surface of the glass wall. Another interesting photograph demonstrated the simultaneous incidence of multiple tracks with different raddi of curvature.

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Y. Sekido and H. Elliot (eds.), Early History of Cosmic Ray Studies, 137–143.

In March of 1933, Blackett published the result obtained by the counter controlled cloud chamber in a magnetic field (Blackett and Occhialini, 1933). Their experiment was similar to ours, but with a stronger magnetic field. Having read this paper, we found that the pair of circular tracks in our photograph of 1932 was nothing but a pair creation and that the picture with multiple tracks showed a shower phenomenon. However, we could not but conclude that our apparatus was not good enough to continue further experiments on energy spectrum, and that a larger cloud chamber in a stronger magnetic field was necessary for the future study of high energy cosmic ray particles. Thus we decided to suspend the cloud chamber experiment for a while.

2.

At the end of 1933, The Japan Society For The Promotion of Science* started "The 10th subcommittee" to promote cosmic ray study in Japan. The subcommittee soon discussed what would be fruitful research projects, and the first project they chose was an observation of cosmic ray intensities by ionization chambers. Later, the G.M. counter experiment was added.

As Dr. Nishina was a member of this subcommittee, he decided to start this project in the Nishina Laboratory. At first, C. Ishii and other members constructed the ionization chambers of the Compton type. In 1935, for a measurement of altitude variation of cosmic ray intensities, the Compton type ionization chamber was taken up to Mt. Fuji to observe the intensity at mountain altitude, which was then compared with the sea level intensity measured at Tokyo by F. Yamasaki. In June 1936, on the occasion of the solar eclipse, Y. Nishina, C. Ishii, and Y. Sekido observed the cosmic ray intensity at Mt. Syari in Hokkaido. In the fall of that year, the observation of underground burst was carried out in Shimizu tunnel by the Neher type ionization chamber (Nishina and Ishii, 1936).

According to the progress of research activity in those days, two cosmic ray groups started in the Nishina Laboratory. One was to observe cosmic ray intensities by ionization chambers and by G.M. counters. The other group (Takeuchi and others) was to carry out the cloud chamber experiment. As the history of the former group will be

* Japan Society for the Promotion of Science: This society was established in 1931 by the Japanese government primarily in response to strong demands by famous Japanese scientists, and later the discussion made at the National Diet.

The aim of this society was to promote academic research activities in Japan: aiming at the development of culture and industry, the repletion of national defence, and the contribution to nations prosperity and benefit of the human being. The programms that the society carried out in the beginning were to offer financial support to scientists, to organize the committee for investigation of research projects, to issue academic publications, and to recommend its support to important scientific projects.

The society was first organized as a foundation supported by the Japanese government, the royal family, and a rich company. The first president was Prince Chichibu, the first chairman the Prime Minister, and the first director was Prof. Joji Sakurai, who was later replaced by Prof. Hantaro Nagaoka (Fujioka, 1973).

Since its establishment, the society had continued its activity for 36 years. In 1967, the society was reorganized according to a law passed by the Diet, and placed under the supervision of the Minister of Education.

described by Dr. Y. Sekido in this book, I shall give a brief outline of the history of the cloud chamber group.

3.

In 1935, Dr. Nishina planned to make a large cloud chamber and a strong magnet; according to his plan, at first I made a model magnet with the size 1/10 of the proposed magnet, and studied the shape of pole pieces that could generate a magnetic field as uniform as possible over the whole effective volume of the cloud chamber. Finally I was able to find the best shape for the pole pieces.

In the meantime, I constructed a cloud chamber of disc shape of 40 cm diameter in collaboration with the engineering staff of I.P.C.R.. This chamber was expanded by moving an aluminum plate, which is supported by a rubber sheet connected to the outer structure of the chamber. The plate was moved by taking in and out the pressurized air. The light source was composed of an arc light and a parabolic mirror of 50 cm diameter with a focal length of 10 cm.

The magnet was manufactured by Tokyo Shibaura Electric Co. The maximum diameter of the pole pieces was 70 cm, and one of the pole pieces had a cone shaped hole for photographing (Fig.1). Each unit of the magnetic coil was made of dual layers of swirling copper tube, which was cooled by letting water flow inside the tube. All units were connected in series electrically and the tubes in parallel for cooling. When a current of 1000 A was passed through the coil, a magnetic field of 16500 Gauss was obtained with a 3 percent uniformity over the whole volume of the cloud chamber (Fig.1).

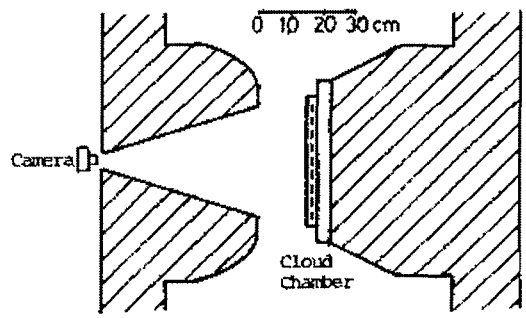

Fig. 1 (a). The cloud chamber apparatus in Nishina Laboratory, I.P.C.R.

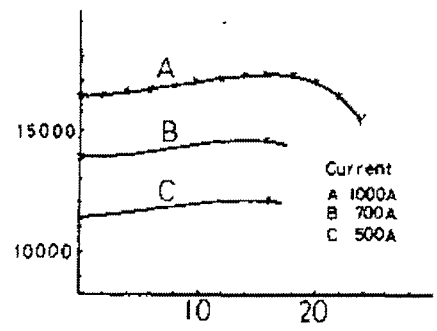

Fig. 1 (b). The magnetic field along the broken line shown in Fig. 1 (a) (average position of tracks).

Next a large D.C. generator that could generate a D.C. power as large as 300 – 400 kw was needed for the operation of this magnet. Because we could not find such a powerful generator in our institute, we asked the Japanese Navy to help us. Eventually the Navy permitted us to use their generator which had been used to charge submarine batteries. They agreed to let us use the generator at Yokosuka Naval Arsenal only when they were not using it.

Then Takeuchi and Ichimiya moved to Yokosuka with the cloud chamber in the spring of 1936, and for about one year we carried out our experiment. The purpose of this experiment was to measure the energy spectrum of cosmic ray particles. In 1937 Blackett published his result on the energy spectrum obtained by his cloud chamber again prior to our publication (Blackett, 1937). We found that our result agreed completely with his result, and presented our result only orally at the meeting of I.P.C.R., but did not published it.

4.

After that we started an experiment to measure the energy loss of cosmic ray particles putting a lead plate of 3.5 cm or 5 cm thickness inside the cloud chamber.

In 1937, Neddermeyer and Anderson published their observation on the energy loss of cosmic ray particles through an 1 cm platinum plate, and suggested the existence of a particle with a mass heavier than that of an electron (Neddermeyer and Anderson, 1937). Other papers also indicated the evidences of such particles that were apparently not protons but did not create electron pairs when they passed through the absorbing material (Street and Stevenson, 1937; Crussard and Leprince-Ringuet, 1937a, b). These papers were published in May, however, Nishina had heard some news of them from N. Bohr who visited Japan in April via United States. As we were doing a similar experiment, we tried to estimate the masses of the observed particles. M. Kobayashi then calculated, using the Bloch's equation, the energy losses in lead of charged particles with several different masses, and showed us a graph of energy loss – momentum relation which was used for our analysis. In August we found a particle

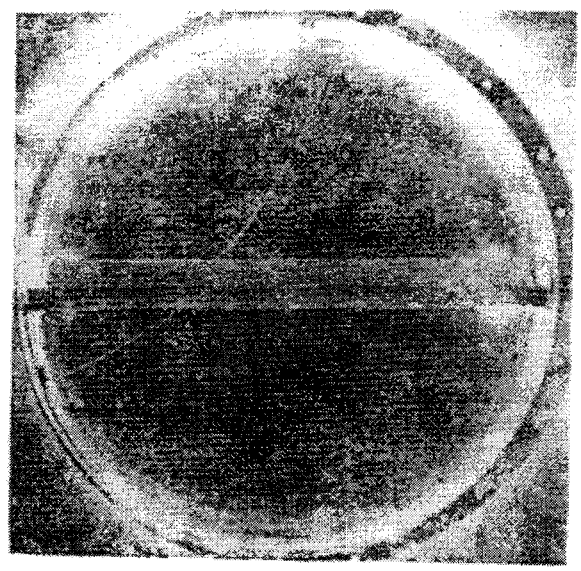

Fig. 2

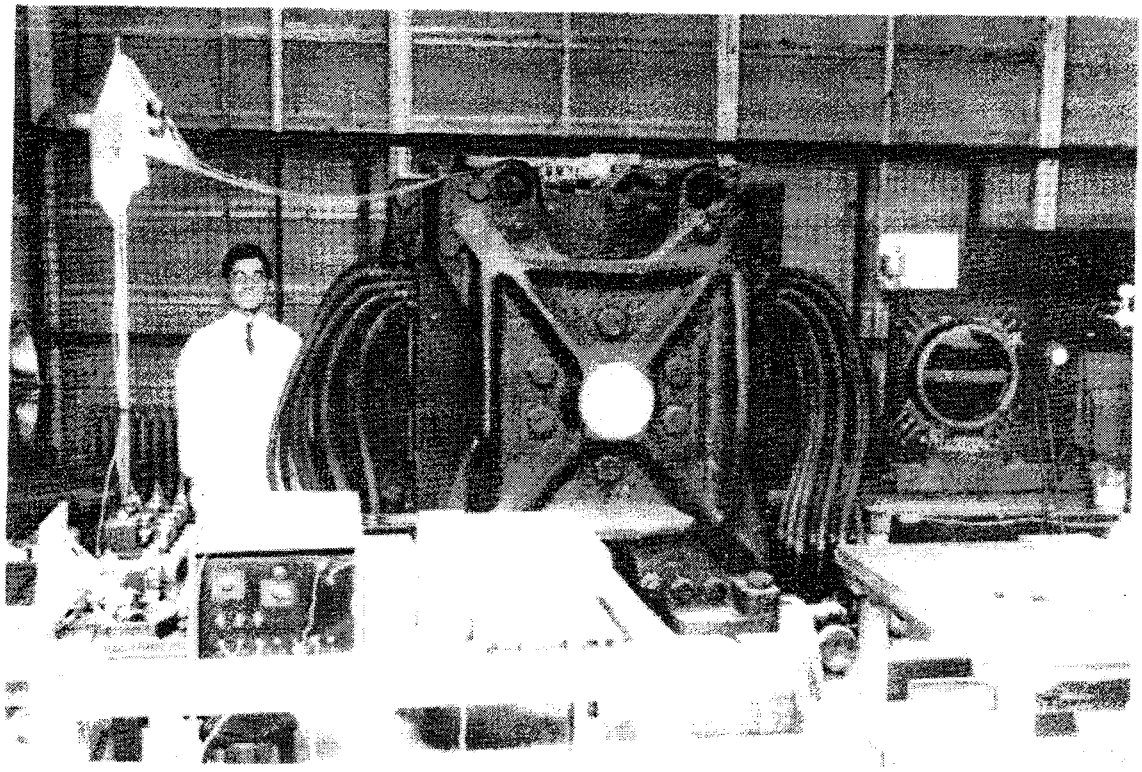

Fig. 3. The author and the large magnet in Nishina Laboratory. (November 22, 1938)

(Fig. 2) with a mass 1/7 – 1/10 of that of a proton (Nishina *et al.*, 1937). This paper was received by the Physical Review on August 28 and was published on December 1 after shortening the description, while Street and Stevenson's estimation of mass was reported in their letter to the Editor on October 6 which was published on November 1.

In 1938 we returned to the campus of I.P.C.R., and continued our cloud chamber experiment (Fig.3). At that time a large generator was introduced in our campus for the cyclotron project, and could also be used for our experiment. In those days, our interest turned towards the measurement of the mass of the mesotron. At the end of this year, we obtained an another example of a particle with an intermediate mass (Nishina *et al.*, 1938).

5.

Since then we went forward to measure the ionization density of particles in the cloud chamber, and planned to determine the mass of the particles by the simultaneous measurement of momentum ($H\rho$) and ionization density (I). In the meantime we obtained an interesting event in which $H\rho = 1.2 \times 10^6$ Gauss.cm and $I = 3$ times minimum ionization which corresponds to twice the ionization density of an electron with the same momentum (Fig. 4). We estimated the mass of this particle to be a half of that of a proton, and reported this result at the meeting of I.P.C.R. However the existence of such a particle was not predicted at that time, and furthermore some people had doubts about the accuracy of our measurement of ionization density. As we observed only one such event, we did not publish it.

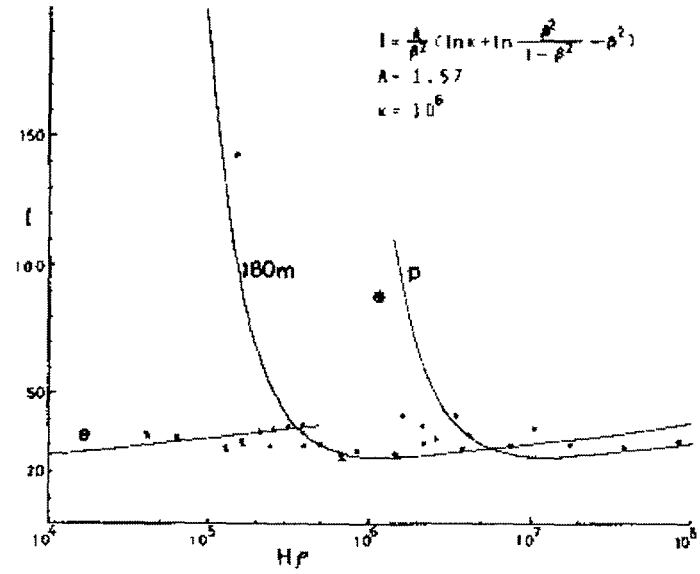

Fig. 4. The Result of observations of momentum and ionization density. The median mass event is shown by a double circle.

Then we decided to use two cloud chambers for further work; the idea was to separate the ionization measurement from the momentum measurement. Actually a large cloud chamber of 40 cm diameter was mounted in a magnet, and a small cloud chamber of 15 cm diameter was placed above the magnet on top of the large chamber. Aiming at improving the accuracy of momentum measurement, the large chamber was expanded immediately when the triggering pulse was accepted to get sharp and long tracks. On the contrary, the expansion of the small chamber was a little delayed to diffuse ions to obtain the accurate ionization densities.

We started this experiment in 1941. However the intensity of cosmic rays which passed simultaneously through both chambers was too low. Before long we realized that it was hopeless to get a sufficient number of tracks with high ionization densities within a reasonable time, and finally we gave up continuing this experiment.

6.

In 1941 we planned to take cloud chamber photographs of cosmic rays at aeroplane altitude; we intended to do this experiment on a military fighter. Since we could not get on board with our apparatus, and since the fighter's cabin was not pressurized at that time, the airborn apparatus should function automatically under the low temperature and low atmospheric pressure. Takeuchi then tried to develop an automatic cloud chamber photographing device. We built a model apparatus, and repeated the test experiment in the low temperature – low pressure room at The Central Research Institute of Aeronautical Science. However, after some time we had to discontinue this experiment owing to the war.

7.

Thus the cloud chamber study of cosmic rays had continued for about ten years in the Nishina Laboratory, and we could accumulate quite a number of photographs of

Fig. 5. Y. Nishina.

high energy cosmic ray particles. Unfortunately these photographs and most of the records of experiments were burned together with the experimental apparatus by the air raid on Tokyo on April 13 in 1945, and only a few documents were left in my hand.

This report was written on refferring to the small amount of documents that escaped damage and to my memory (July, 1980).

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