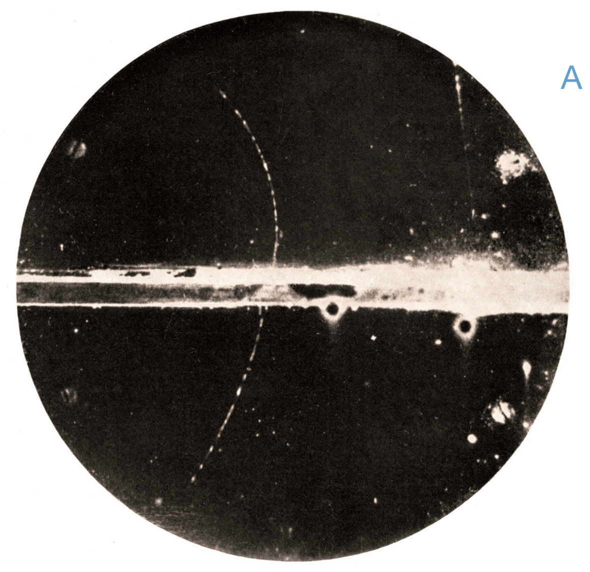
100 Years of Cosmic Rays

1933—1947 Birth of Particle Physics

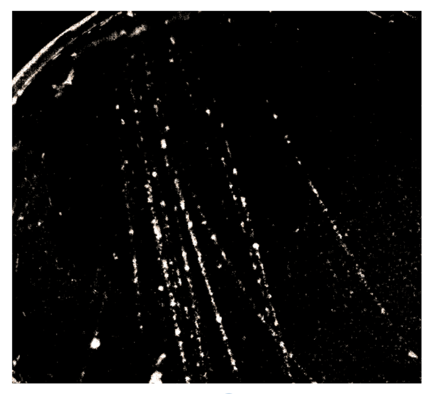
1932 — CD Anderson: Discovery of the positron

In 1931, with a cloud chamber operating in a strong magnetic field, Anderson observed cosmic ray tracks with negative and positive charges, which were interpreted as electrons and protons. Since many positive tracks had the same ionisation as the electrons, Anderson introduced a 6mm-thick lead plate into the chamber. In photographs from 1932, he found tracks with the ionisation and track length observed for electrons, but with a positive charge. This anti-electron (positron) had been predicted two years earlier by PAM Dirac.



A positron with an energy of 63MeV entering the lead plate from below and leaving the plate with an energy of 23MeV. For a proton, the track length would be ten times shorter.

1933—1935 — B Rossi, PMS Blackett, G Occhialini: Particle showers



Cloud chamber photograph of a particle shower with about 16 tracks. The divergence of the tracks points to an interaction in the magnet coil.

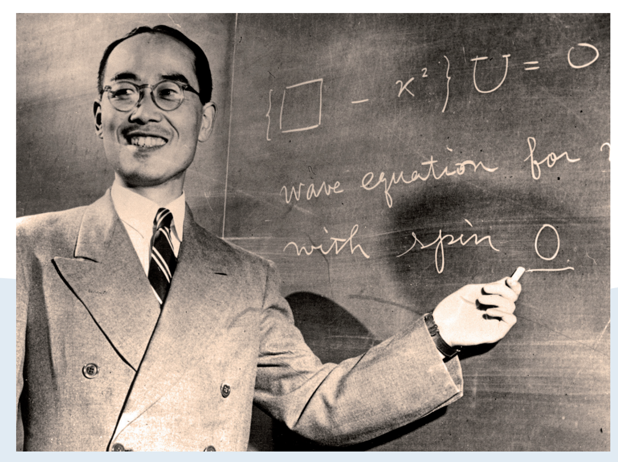
Rossi performed measurements with three Geiger-Müller counters in coincidence with and without lead shielding on top. The coincidence rate increased with the shielding, even though the opposite had been expected. The explanation was the shower production by an incoming cosmic particle.
Blackett and Occhialini demonstrated the shower production visually with cloud chamber photographs.

1934 — W Baade, F Zwicky: Supernovae as possible sources of cosmic rays

By investigating photographic plates taken over the past 30 years, about 13 short flaring, extremely bright objects were identified. Zwicky and Baade called them supernovae. Based on the estimated energy release, they concluded that supernovae are sources of cosmic rays. This hypothesis is still valid, but not completely confirmed.

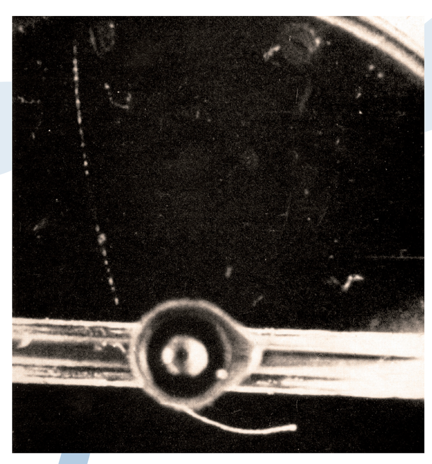
1935 — H Yukawa: Prediction of the pion

Yukawa formulated a theory to explain the dense packing of protons and neutrons in the nucleus of an atom. The short-ranged field needed a carrier with a mass inversely proportional to the range. He estimated a particle mass of about 100MeV and predicted that these particles could be produced in cosmic particle interactions.



H Yukawa, 1949

1936 — SH Neddermeyer, CD Anderson: Discovery of the muon

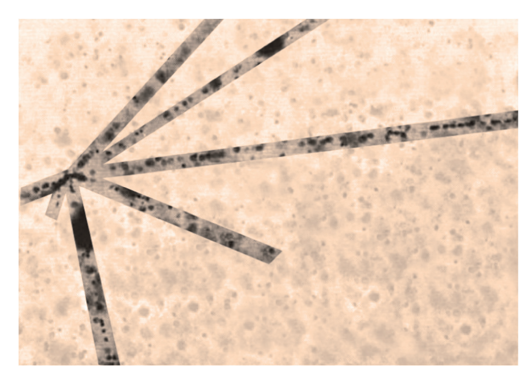


Stereographic photograph of a cloud chamber exposure. A muon enters the chamber from above and comes to rest below.

In a cloud chamber exposure with a 1cm-thick platinum plate in the centre, 6000 photographs were taken. Anderson and Neddermeyer found about 25 events where the energy loss in the platinum absorber was much smaller than measured for electrons or positrons. Since the mass should be between the electron and proton masses, they first called it the mesotron.
For several years, it was assumed that this particle was the predicted Yukawa particle.

1937 — M Blau, H Wambacher: First cosmic ray nuclear interaction in a photo emulsion

The photo-emulsion technique was developed by M Blau. In 1937 a five-month exposure to cosmic particles was performed at Hess's Hafelekar cosmic ray station at an altitude of 2300m. The discovery of a so-called star was a breakthrough of this detection technique. A cosmic particle interacted with an atom of the emulsion, producing eight tracks.



A “star” produced in a photo emulsion by a cosmic particle

1938 — P Auger: Extensive air showers

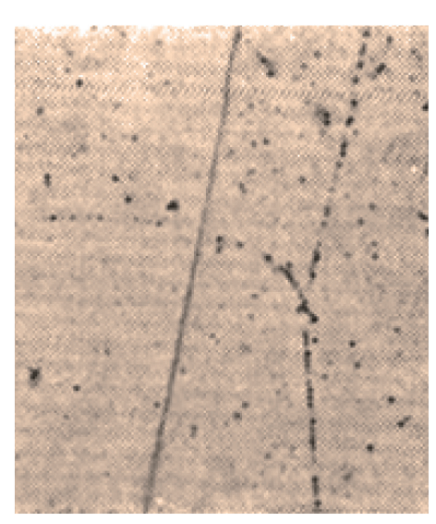
With two Geiger-Müller counters in coincidence, Auger and his colleagues, Maze and Robley, detected extensive air showers. They measured the rate at up to 300m of counter distance and estimated the energy of the primary cosmic particles to be about 10^{15}eV.

1942 — I Lange, SE Forbush: Solar cosmic particles

In February 1942, a large solar flare appeared. Lange and Forbush measured an increase in the cosmic particle rate of about 15%. They concluded that this additional fraction is caused by charged particles emitted by the solar flare.

1947 — DH Perkins, GPS Occhialini, CF Powell: Discovery of the pion

The pion event identified by Perkins. Tracks B and C are protons; D is a tritium nucleus. The short track E is a recoil nucleus. The grain density and scattering of track A correspond to a particle with a mass of about 100MeV.



In 1938 Yukawa and Sakata predicted the lifetime of the Yukawa particle to be about 10^{-8} seconds, which was 100 times shorter than the measured lifetime of the muon.
The problem was solved with the discovery of the pion in photographic emulsions in 1947. Perkins found one event, and two months later Occhialini and Powell identified 25 pion interactions.
In Britain, the emulsion technique was improved by Powell, Perkins and others, in cooperation with the Ilford company.

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