Bibha Chowdhuri was a particle physicist, known for her work studying cosmic rays and for the discovery of the meson. She was the first woman particle physicist in India and is likely the first Indian woman to earn a Ph.D. in physics.

Image: Wikipedia

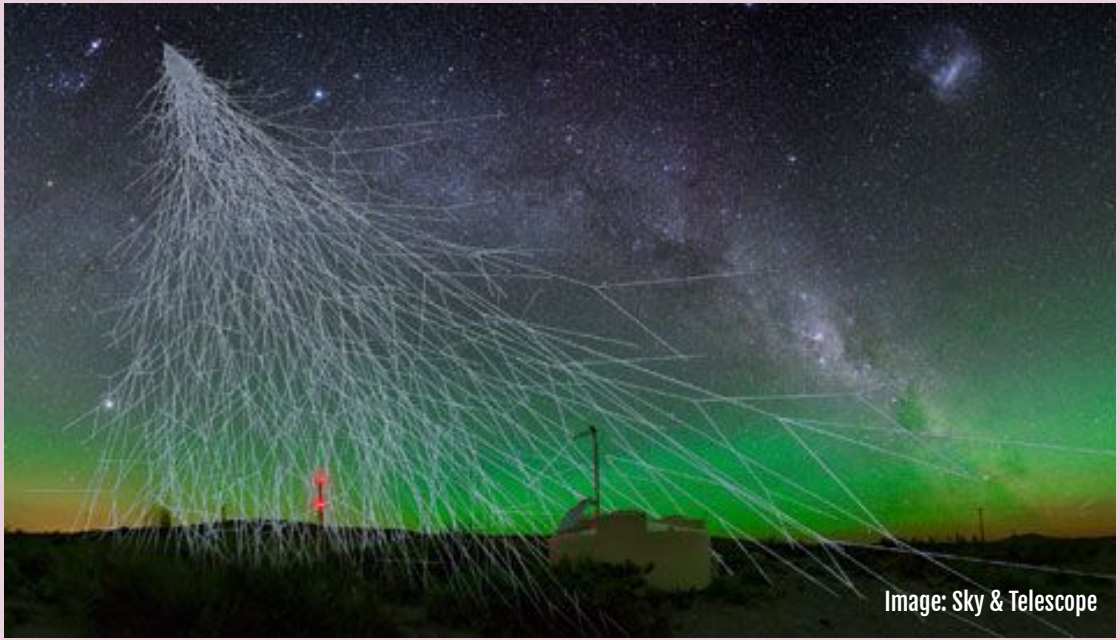
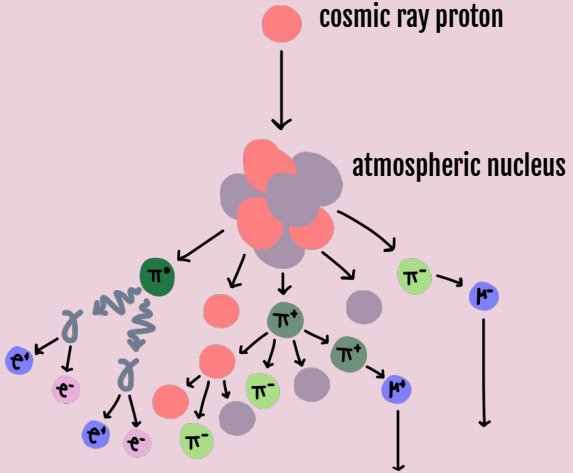


Image: Sky & Telescope

Cosmic rays

Cosmic rays are charged particles (mostly protons and nuclei) that were discovered in the early 1900s by experiments which found that ionizing radiation increased with height above the Earth's surface.

In the 1930s, when Bibha Chowdhuri was studying particle physics during her MSc, cosmic rays were the easiest way to study high energy interactions and look for new particles, since particle accelerators were just starting to be invented.

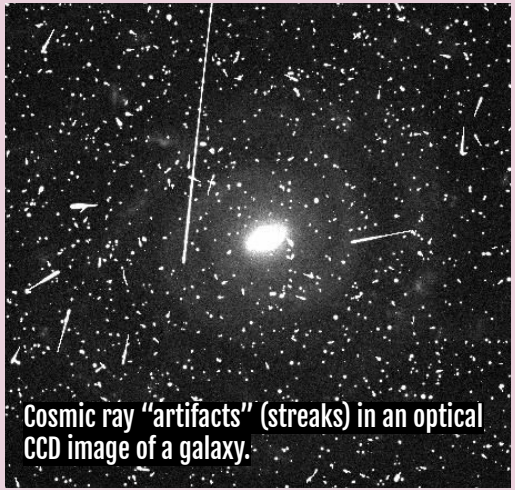


When cosmic rays enter the atmosphere, they interact with atmospheric nuclei and produce showers of particles, called **air showers** . The shower itself and the particles it contains tells us about the composition, energy, and direction of the original cosmic ray. Additionally, the interactions of secondary, tertiary, etc. particles can be studied as the shower descends toward Earth's surface.

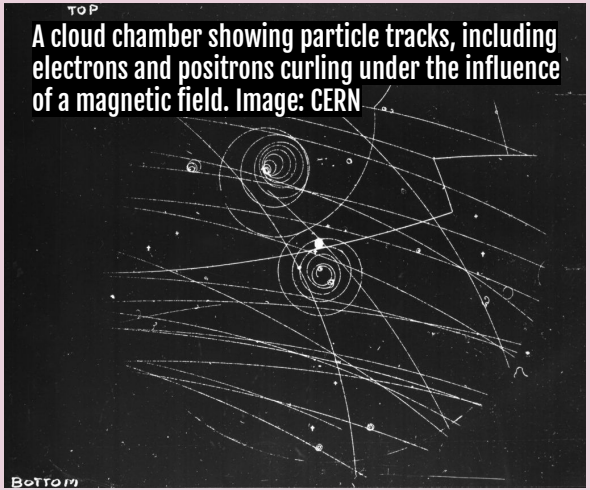
Detecting cosmic rays

Before Chowdhuri, cloud chambers had been used to observe the condensation tracks left by ionizing particles travelling through supersaturated vapour. Particles leave tracks that are unique to their charge and mass, allowing for the fluxes of a given particle to be determined, for interactions between particles to be seen, and for new particles to be identified.

The challenge with cloud chambers was that it was not possible to image the particle tracks at the time, so Chowdhuri's work focused on using photographic plates to image and preserve the interactions of cosmic rays with the plate material, much like the cosmic ray streaks in CCD images that we consider to be noise in astronomical data today!



Cosmic ray "artifacts" (streaks) in an optical CCD image of a galaxy.

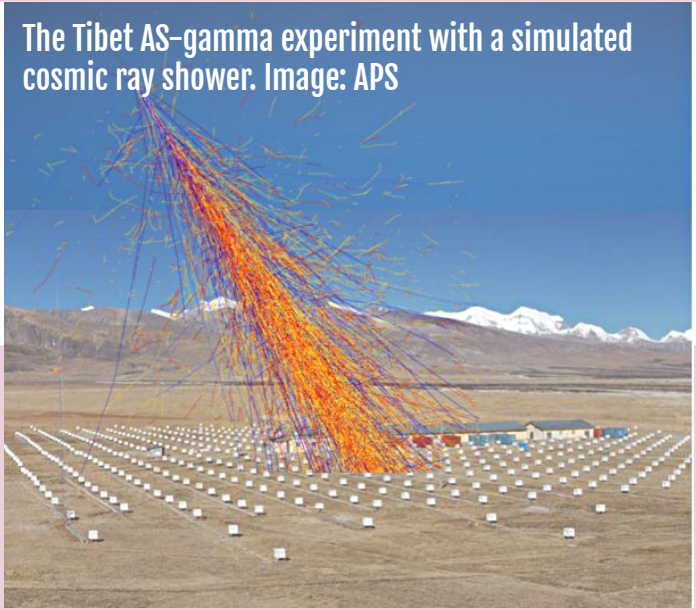


A cloud chamber showing particle tracks, including electrons and positrons curling under the influence of a magnetic field. Image: CERN

Detecting cosmic rays

Cosmic ray air showers hit their maximum number of particles at a few thousand kilometers above sea level, depending on the original cosmic ray's energy. Below this altitude, the particles have lost significant energy and can no longer create more shower particles, losing the remainder of their energy through ionization and excitation of atmospheric particles.

To get sufficient cosmic ray flux for their photographic plate observations during her MSc, Chowdhuri and her supervisor (Debendra Mohan Bose,) travelled by camel up to altitudes of 4300m in the Himalayas. They placed detectors at different altitudes to study how flux changed with altitude



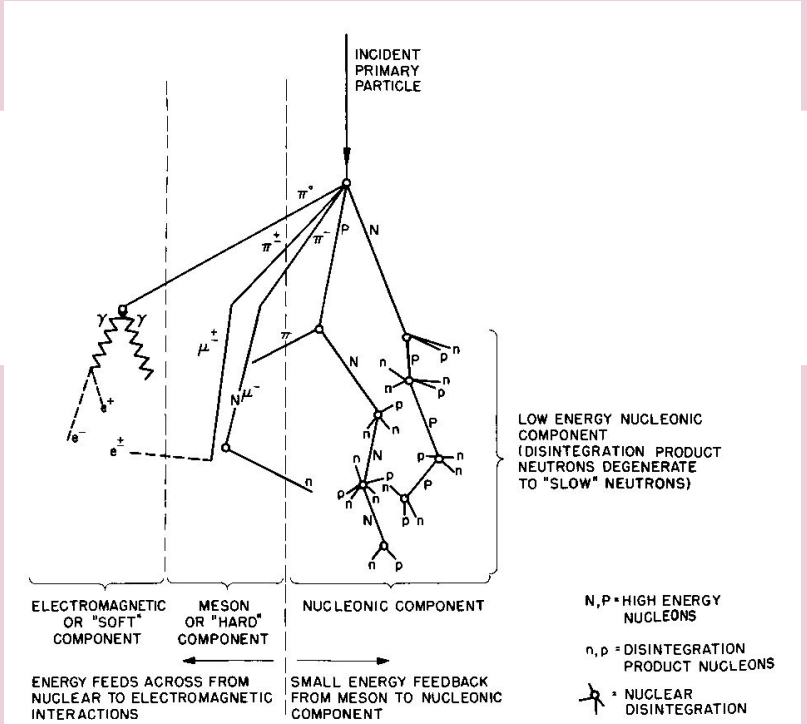
The Tibet AS-gamma experiment with a simulated cosmic ray shower. Image: APS

Current generation cosmic ray detectors also directly detect particles from cosmic ray air showers and are found at similar altitudes. The **Tibet AS-gamma** experiment is located at a similar altitude in the Himalayan mountains in Tibet.

Discovering mesons

Mesons are hadronic (composite) subatomic particles, which consist of a **quark and antiquark** bound together by the **strong interaction** .

They are **unstable** particles, produced naturally in cosmic ray interactions, which quickly decay into lighter mesons or stable particles, such as electrons, neutrinos, and photons, or can sometimes interact with other particles to produce muons or neutrinos.



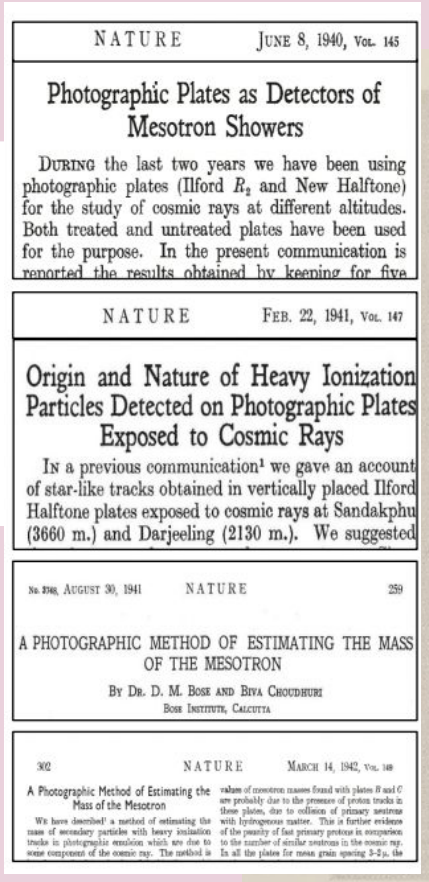
Schematic Diagram of Cosmic Ray Shower

Meson	mass (MeV)	quark Flavor	Generation	Hadronic Products	Mean life (sec.)
π^+	140	$u\bar{d}$	1	-	$2.6 \cdot 10^{-8}$
K^+	494	$u\bar{s}$	2	pions	$1.24 \cdot 10^{-8}$
D^+	1870	$c\bar{d}$	2	kaons	10^{-12}
B^+	5279	$u\bar{b}$	3	D mesons	$1.6 \cdot 10^{-12}$

Discovering mesons

Chowdhuri and Bose found anomalous tracks in their photographic plate data, which they linked to the newly theorized ***mesotron*** (later meson), leading to four publications in *Nature*. However, they were unable to obtain an accurate mass measurement with the plates used in their initial setup.

During WWII, an embargo on the export of photographic plates from India made it impossible for Chowdhuri and Bose to repeat the experiment with more sensitive plates. Later, Cecil Powell would replicate this experiment, which led to the Nobel Prize in 1950 for the discovery of the **pion**.



NATURE JUNE 8, 1940, VOL. 145

Photographic Plates as Detectors of Mesotron Showers

DURING the last two years we have been using photographic plates (Ilford R_2 and New Halftone) for the study of cosmic rays at different altitudes. Both treated and untreated plates have been used for the purpose. In the present communication is reported the results obtained by keeping for five

NATURE FEB. 22, 1941, VOL. 147

Origin and Nature of Heavy Ionization Particles Detected on Photographic Plates Exposed to Cosmic Rays

IN a previous communication[1] we gave an account of star-like tracks obtained in vertically placed Ilford Halftone plates exposed to cosmic rays at Sandakphu (3660 m.) and Darjeeling (2130 m.). We suggested

No. 3788, AUGUST 30, 1941 NATURE 259

A PHOTOGRAPHIC METHOD OF ESTIMATING THE MASS OF THE MESOTRON

BY DR. D. M. BOSE AND BIVA CHOUDHURI
BOSE INSTITUTE, CALCUTTA

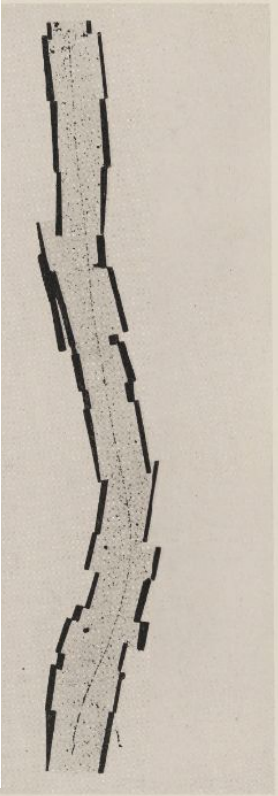
302 NATURE MARCH 14, 1942, VOL. 149

A Photographic Method of Estimating the Mass of the Mesotron

WE have described[1] a method of estimating the mass of secondary particles with heavy ionization tracks in photographic emulsion which are due to some component of the cosmic ray. The method is

values of mesotron masses found with plates B and C are probably due to the presence of proton tracks in these plates, due to collision of primary neutrons with hydrogenous matter. This is further evidence of the paucity of fast primary protons in comparison to the number of similar neutrons in the cosmic ray. In all the plates for mean grain spacing 3·2 μ, the

PLATE XLIII

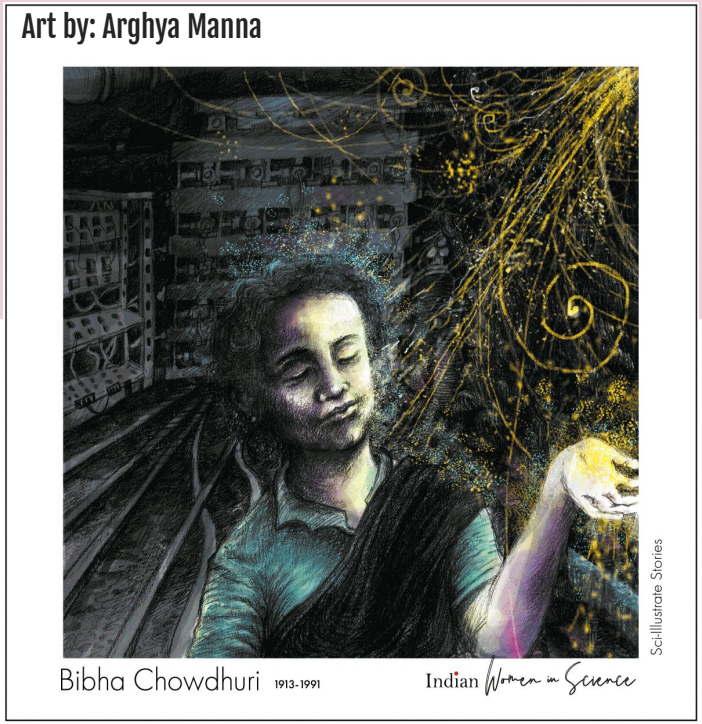


← - - - - 100 μ - - - - →

Meson Track

Mosaic of photo-micrographs of the track of a meson which enters the emulsion at the top of the figure and ends in the emulsion at the bottom. Note the frequent changes in direction, giving the appearance of a general curvature, and the 'thinness' of the track along most of the trajectory. The increase of ionization at the end of the range is clearly visible.

Chowdhuri went on to pursue a PhD at the University of Manchester and submitted her thesis **“Extensive Air Showers associated with Penetrating Particles”** shortly after Blackett won the Nobel Prize for his discovery of the pion.



Chowdhuri continued to study and teach physics for the rest of her life in India, France, and the USA. Though Blackett acknowledged her work in contribution to his Nobel Prize, she received no recognition in India and was completely overlooked in particle physics history as a prominent physicist.

Though she was overlooked during her life, Bibha Chowdhuri is now finally gaining recognition for her work and has been recognized in a German-language biography and in an article written by the **Cherenkov Telescope Observatory** – an upcoming observatory that will detect gamma-rays through the air shower techniques that Chowdhuri pioneered.

Further reading

CTAO article: https://www.ctao.org/news/building-from-diversity-article-bibha-chowdhuri/

BOSE, D., CHOUDHURI, B. A PHOTOGRAPHIC METHOD OF ESTIMATING THE MASS OF THE MESOTRON. *Nature* 148, 259–260 (1941). https://doi.org/10.1038/148259a0 (https://www.nature.com/articles/148259a0)

Amazing Women in History article: https://amazingwomeninhistory.com/bibha-chowdhuri-indian-physicist/

Wikipedia page: https://en.wikipedia.org/wiki/Bibha_Chowdhuri