DE BALLONS Château-d'Oex

Pioneers of Cosmic Rays

Hans Peter Beck, Universities of Bern and Fribourg, Switzerland; and CERN 25 January 2020

LUI

Early 1900's



1896 — Discovery of radioactivity



Antoine Henri Becquerel

* 15. Dezember 1852 in Paris † 25. August 1908 in Le Croisic

Nobel Prize 1903

"in recognition of the extraordinary services he has rendered by his discovery of spontaneous radioactivity "

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Early 1900's — Study of radioactivity

Radioactivity was discovered by **Becquerel** in **1896**, and studied further by **Marie Curie** and many others.

Earth is recognised as a radioactive ball.

Radioactivity measured in the atmosphere should get less when going further away from Earth.



Measuring radioactivity in the early 1900's



With an electrometer, measuring discharge between two charged wires, radioactivity was measured in that time. Painstakingly !

Pioneers of the detection of cosmic rays



Karl Bergwitz (1875-1958), Germany Decrease of radioactivity at 1300 m to 24%

Balloon flights in 1909



Albert Gockel (1860-1927), Professor in Fribourg No decrease, maybe increase of radioactivity at 4500m. Introduced the term 'cosmic radiation'

25 January 2020

No hydrogen for Gockel to go higher

At that time, gas balloons were used.

With methane, maximum altitude is limited.

With hydrogen, high altitudes were possible.

Gockel was first promised, then refused the hydrogen.



Herrn Professor Gockel. Freiburg.Schweiz Sehr geehrter Herr Professor! Sochen erhalte ich durch den Präsidenten unseres Vereins die höchst bedauerliche Nachricht, dass die Generaldirektion in Paris nun die Zusage der Umfüllung des Wasserstoffgases in unsern Ballon plötzlich zurückgezogen hat. Wir sind erbost, aber es Wir verfügen nun immer noch über eine Leuchtgasfüllung wenn Ihnen also mit Höhen bis zu etwa 4500 m noch gedient ist. bleibt diese Fahrt Ihren Zwecken reserviert und würde dann, ordentliches Wetter vorausgesetzt, von Zürich-Schlieren aus gegen Ende dieser Woche stattfinden; sonst würde eie zu andern Zwecker Es tut mir leid, Ihnen von dieser Veränderung der Verhaltnisse, an denen wir natürlich nicht schuld sind, berichten Hochach tungavol1 Thr ganz ergebenert

Zürich, den 10.0ktober 15

Pioneers of the detection of cosmic rays



Victor Hess (1883-1964) Professor in Graz reached 5300 m in 1912



Werner Kolhörster (1887-1945) Professor in Berlin reached 9300 m in 1914

Detection of cosmic rays



lonisation of air increases with altitude.



Victor Hess with his device Nobel prize in 1936.

Albert Gockel died already in 1927 and could not be awarded.

Ballon flight today with modern equipment

















Taking a Geiger Counter on board of an airplane

20 times higher background radiation in standard cruising altitude than at ground level.

ca 6 µS/h

Fukushima radiation map https://jciv.iidj.net/map Comparable to the hot zones. E.g. Ōkuma is evacuated and has ca 4.5 µS/h MAD --> LHR Geiger counter data 01-08-2015



Where do cosmic rays come from?

Earth is constantly hit by particles.

Most come from the **sun**. They have moderately **low energies**.

Active galactic nuclei, neutron stars, supernovae, deep in the Milky Way and in far away galaxies, create particles at <u>extremely high energies</u>.



Aurora Borealis

The sun's **solar wind is composed of particles** protons, electrons, helium nuclei,...

As the energy of these is moderately low, the **Earth's magnetic field deflects** them — except in the polar regions.

When the sun is ejecting a **solar flare**, it becomes visible with the naked eye in the polar regions.





Earth's magnetic field deflects the solar wind



Aurora Borealis (North Pole) and Australis (South Pole)



High energetic particles hit Earth everywhere

Active galactic nuclei, neutron stars, supernovae, deep in the Milky Way and in far away galaxies, create particles at extremely high energies.

Some of these are also hitting the Earth.



Why study Cosmic Rays ?

The **Universe** is emitting **light** - which we see with the **naked eye** and through **telescopes**.

Fascinating humankind since ever.

The **Universe** is also emitting **particles**, giving a **broader view** and **new insights**.



Fascinating even more. Particle physics is also cosmology.

Studying Cosmic Rays — the early days



Carl David Anderson Discovered **anti-matter in 1932** (the positron, which is the anti-electron) Nobel Prize 1936



High altitude research station at the Jungfraujoch 3500m Since the mid 1920's.

Studying Cosmic Rays — still today

On ground

3000 km² array in Malargüe, Mendoza prov., Argentina



Studying Cosmic Rays — still today

In space

On the international space station



Studying Cosmic Rays — still today

Below ground

In the ice at the South Pole



Understanding particle collisions



- as cosmic rays collide with the atmosphere
- gives insight in the inner forces of matter

25 January 2020

120 years of accelerating particles



1897 Accelerating electrons

Cathode ray tube J.J. Thomson

> 1931 First circular accelerator Ernest O. Lawrence & M. Stanley Livingston





1940

28 42nd International Balloon Festival Château-d'Oex

25 January 2020

LHC

CERN — Large Hadron Collider



CERN Préves



CMS

LHC ring: 27 km circumference -ALICE

ALICE

CERN Meyrin



The structure of matter revealed



If an atom's radius would be as large as the distance from CERN to Copenhagen, the LHC could still resolve millimetre scale objects.

The evolution of the Universe



$$egin{aligned} \mathcal{L} = -lashleft _{\mu
u}\mathcal{F}^{\mu
u} \ &+ i \overline{\psi} \, \mathcal{D} \psi \ &+ \psi_i y_{ij} \psi_j \phi + h.c. \ &+ \left| \mathcal{D}_\mu \phi
ight|^2 - \mathcal{V}(\phi) \end{aligned}$$

The Standard Model of Particle Physics

Balloons played an important role in the beginning on the way to deeply understand the Universe, and with it, who we are, where we are coming from, and where we are going to. Medical Application as an Example of Particle Physics Spin-off Combining Physics, ICT, Biology and Medicine to fight cancer



Accelerating particle beams ~30'000 accelerators worldwide ~17'000 used for medicine

Hadron Therapy



Leadership in Ion Beam Therapy now in Europe and Japan

>100'000 patients treated worldwide (45 facilities)
>50'000 patients treated in Europe (14 facilities)



Detecting particles



g pet

Clinical trial in Portugal, France and Italy for new breast imaging system (ClearPEM)









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Balloon museum



Original items to show





Through the opening of the exhibition:

Guided tours Lectures Junior Scientist booklet https://www.espace-ballon.ch/copie-de-exposition-temporaire







Explaining Cosmic Rays



Explaining Particles







Thank you for listening

25 January 2020

"Art&Science" - Chateau d'Oex/ CH Balloon Museum April 2019 – March 2022 Balloon Festival January 25th Febriary 2nd 2020









