

**FESTIVAL INTERNATIONAL
DE BALLONS**
Château-d'Oex



Pioneers of Cosmic Rays

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

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“

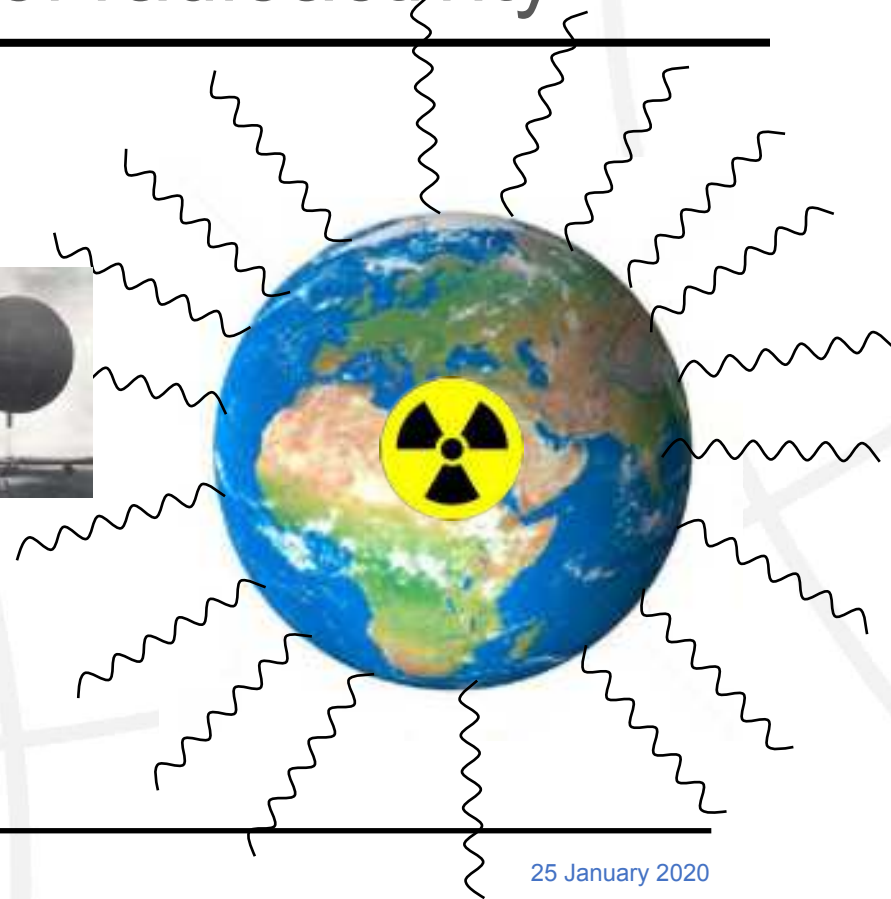


Early 1900's — Study of radioactivity

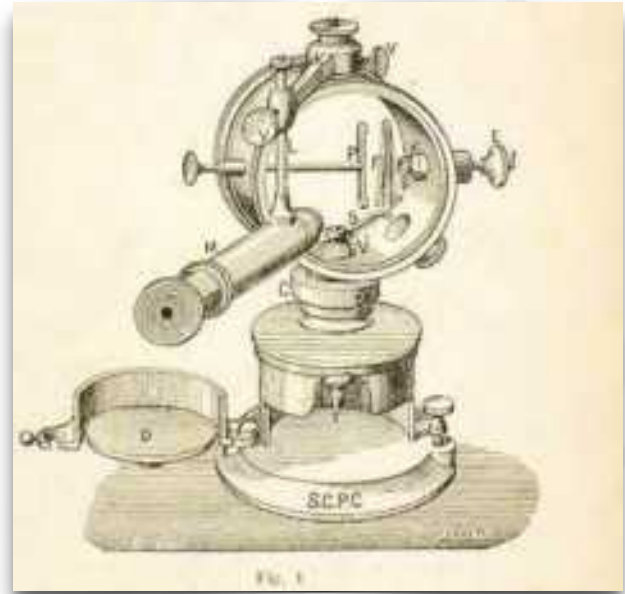
Radioactivity was discovered by **Becquerel** in **1896**, and studied further by **Marie Curie** and many others.

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



Balloon flights in 1909

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



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



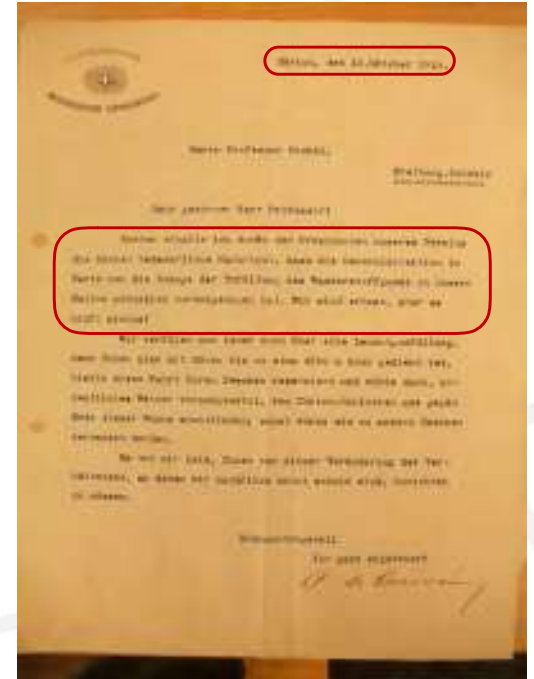
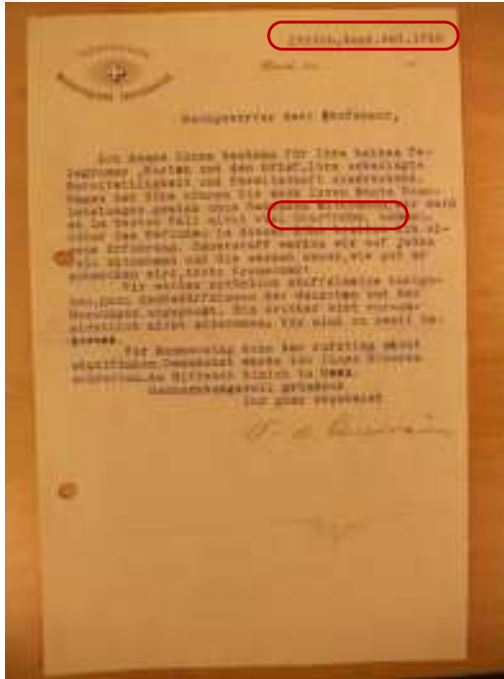
No hydrogen for Gockel to go higher

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.



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

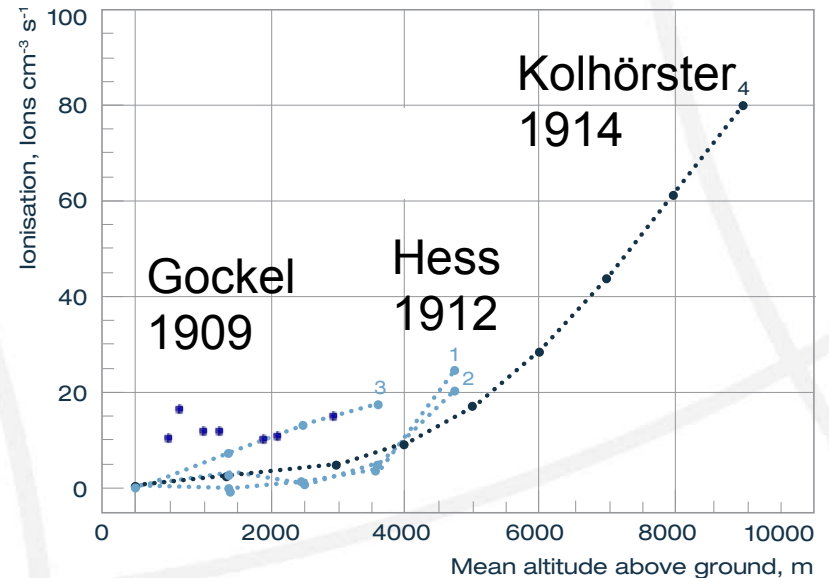
Detection of cosmic rays



Victor Hess with his device
Nobel prize in 1936.

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

Ionisation of air increases with altitude.



Commemorative balloon flight 25 January 2020

Ballon flight today with modern equipment



CAEN  Electronic Instrumentation

2. General Description

The Cosmic Hunter - SP5620CH, as shown in Fig. 2.1, is composed of two Detection Units - SP5622 and one Coincidence Module - SP5621.



Fig. 2.1: Cosmic Hunter, the educational system to detect the cosmic rays.

Commemorative balloon flight 25 January 2020



Commemorative balloon flight 25 January 2020

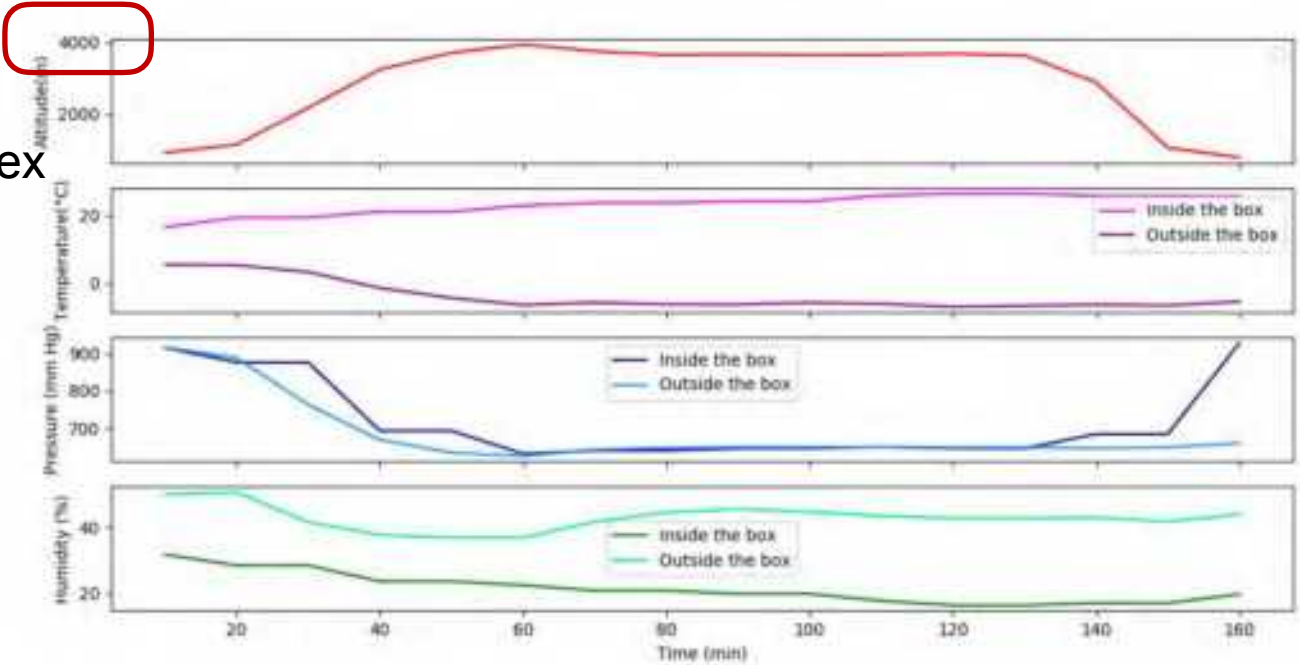


Commemorative balloon flight 25 January 2020



Commemorative balloon flight 25 January 2020

Flight Environment Parameters



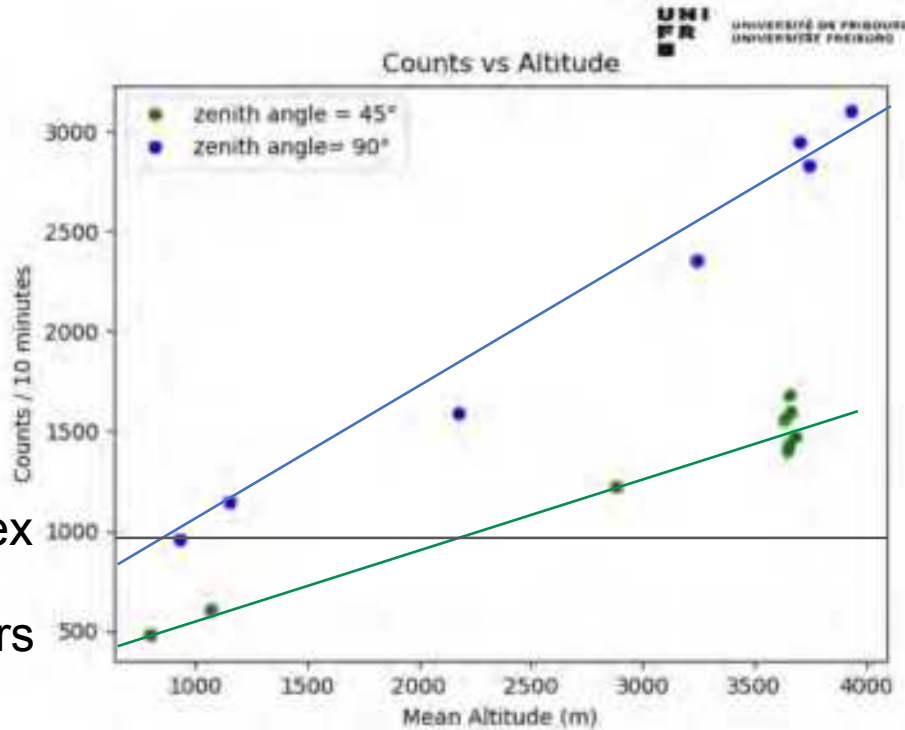
Chateau-d'Oex

11h40

Giffers

14h15

Commemorative balloon flight 25 January 2020



Chateau-d'Oex

Giffers

cosmic rays from the top

3 times higher rate at 4000m
than at 1000m

cosmic rays at 45°

1.5 times higher rate at 4000m
than at 1000m

Taking a Geiger Counter on board of an airplane

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

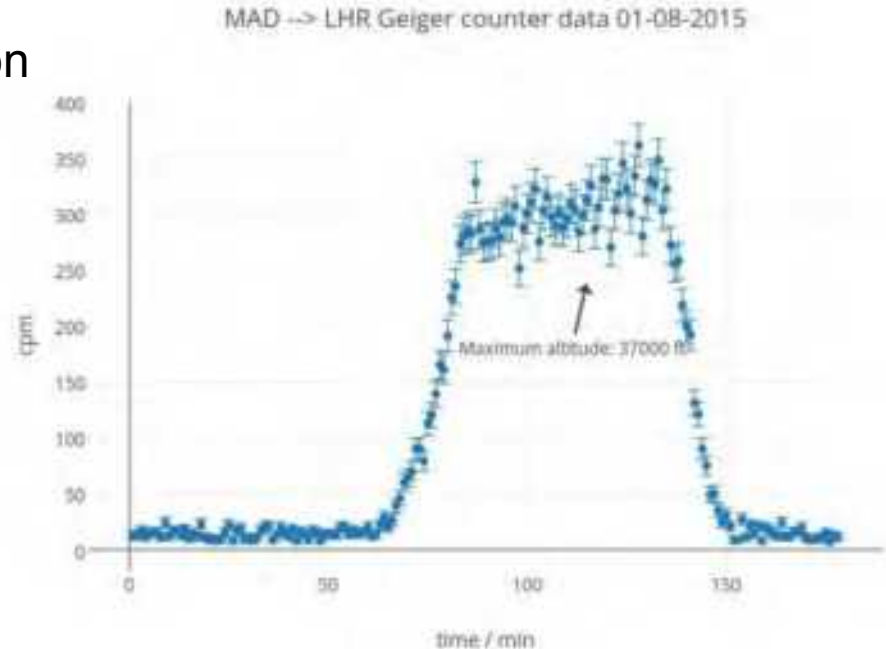
ca 6 $\mu\text{S}/\text{h}$

Fukushima radiation map

<https://jcion.iidj.net/map>

Comparable to the hot zones.

E.g. Ōkuma is evacuated and has ca 4.5 $\mu\text{S}/\text{h}$



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 **extremely high energies**.



Aurora Borealis

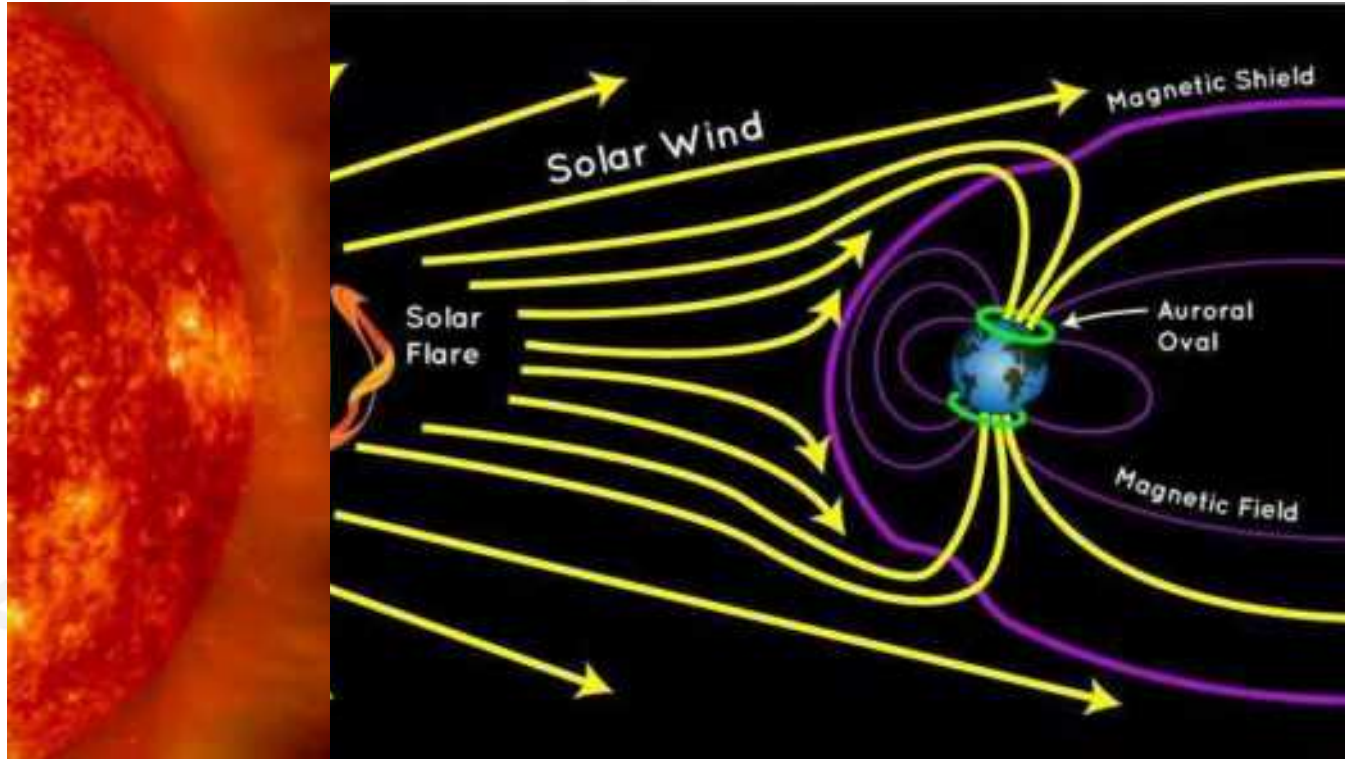
The sun's **solar wind** is composed of particles protons, electrons, helium nuclei,...

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 Jungfrauoch 3500m
Since the mid 1920's.

Studying Cosmic Rays — still today

On ground

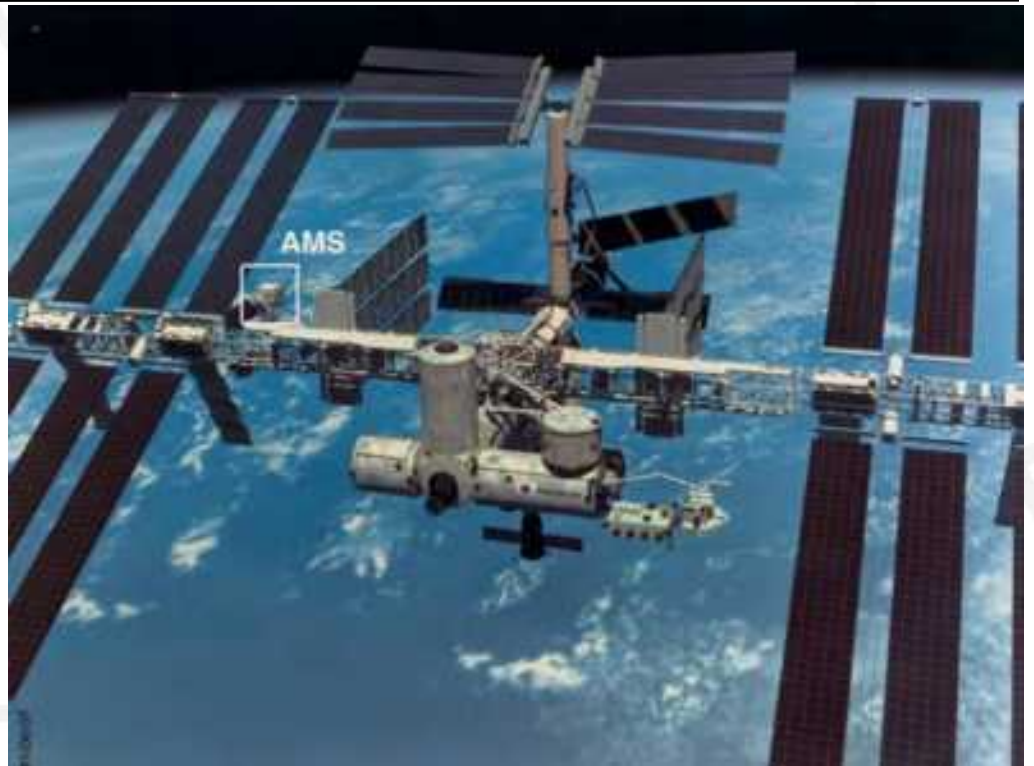
3000 km² array
in Malargüe,
Mendoza prov.,
Argentina



Studying Cosmic Rays — still today

In space

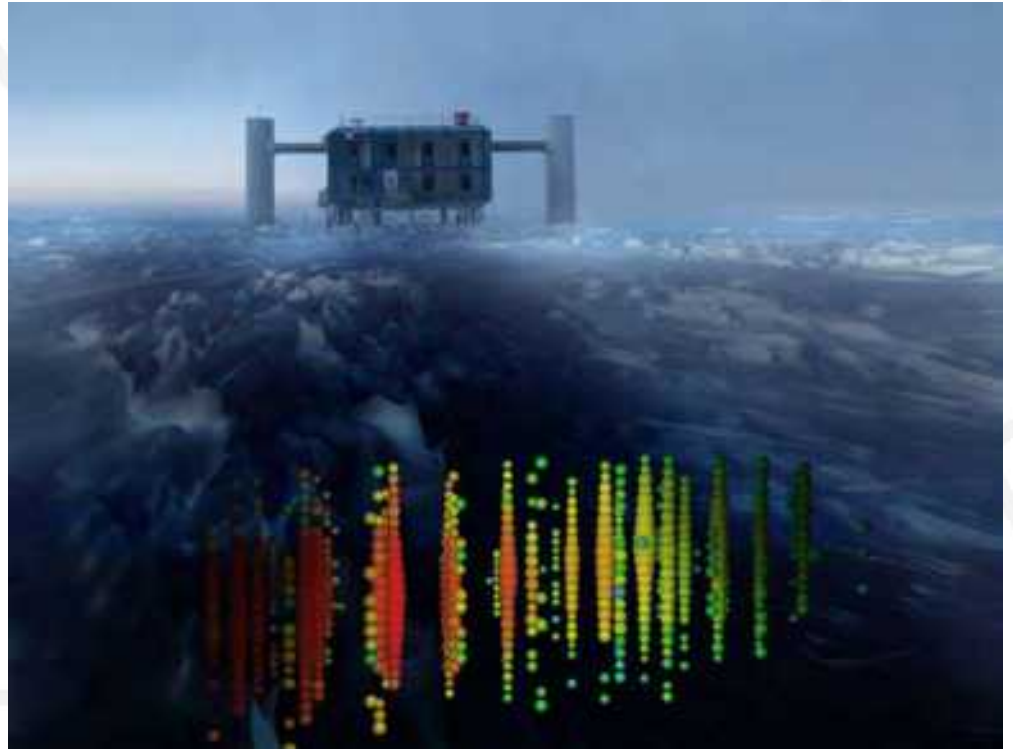
On the
international
space station



Studying Cosmic Rays — still today

Below ground

In the ice at the
South Pole



Understanding particle collisions



At **CERN**, particles are brought to collisions

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

120 years of accelerating particles



1897 Accelerating electrons

Cathode ray tube

J.J. Thomson

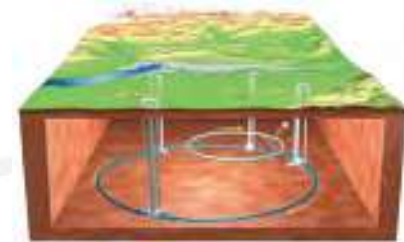


1931 First circular accelerator

Ernest O. Lawrence & M. Stanley Livingston



1940



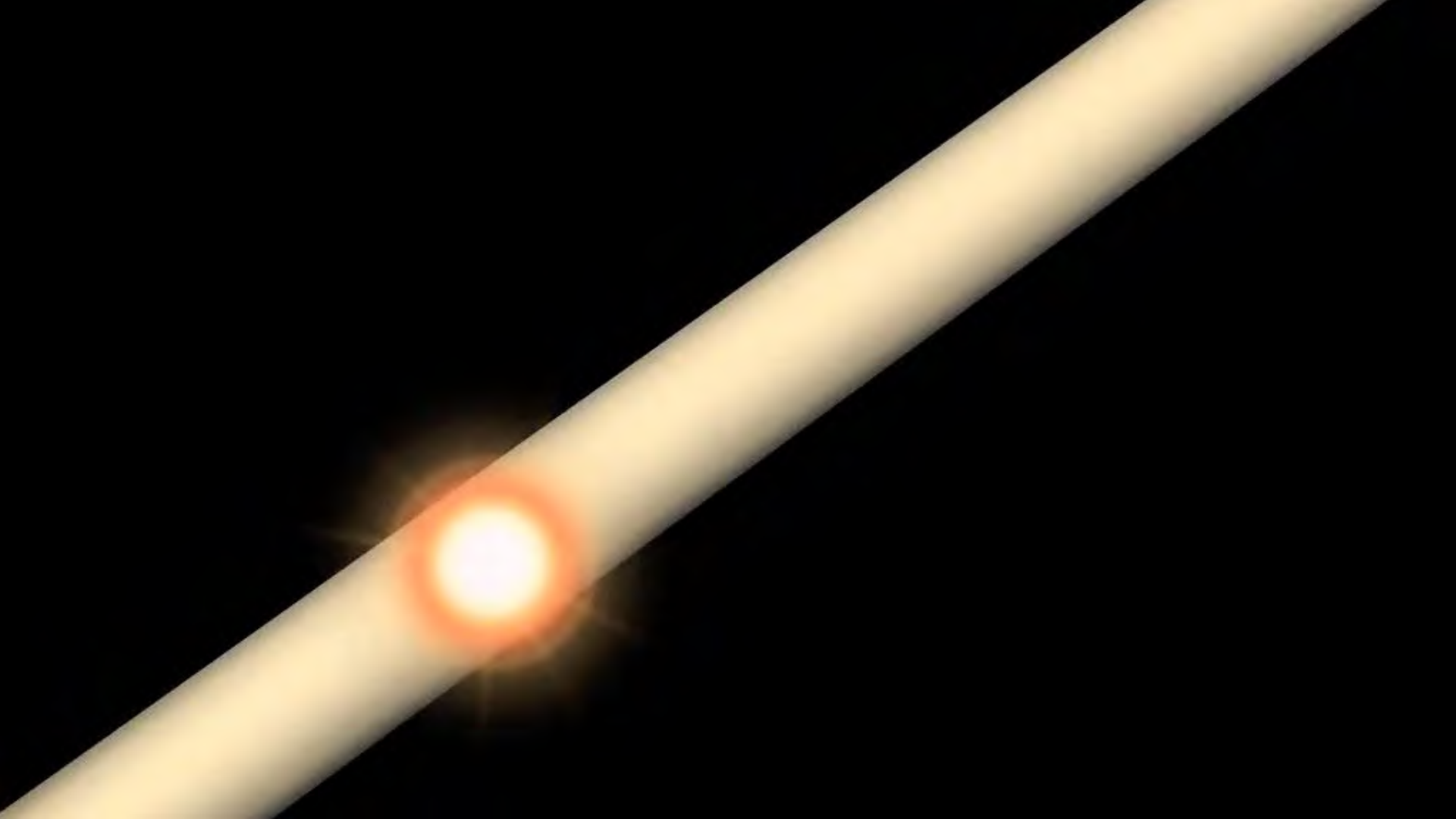
**Today:
LHC**

CERN — Large Hadron Collider

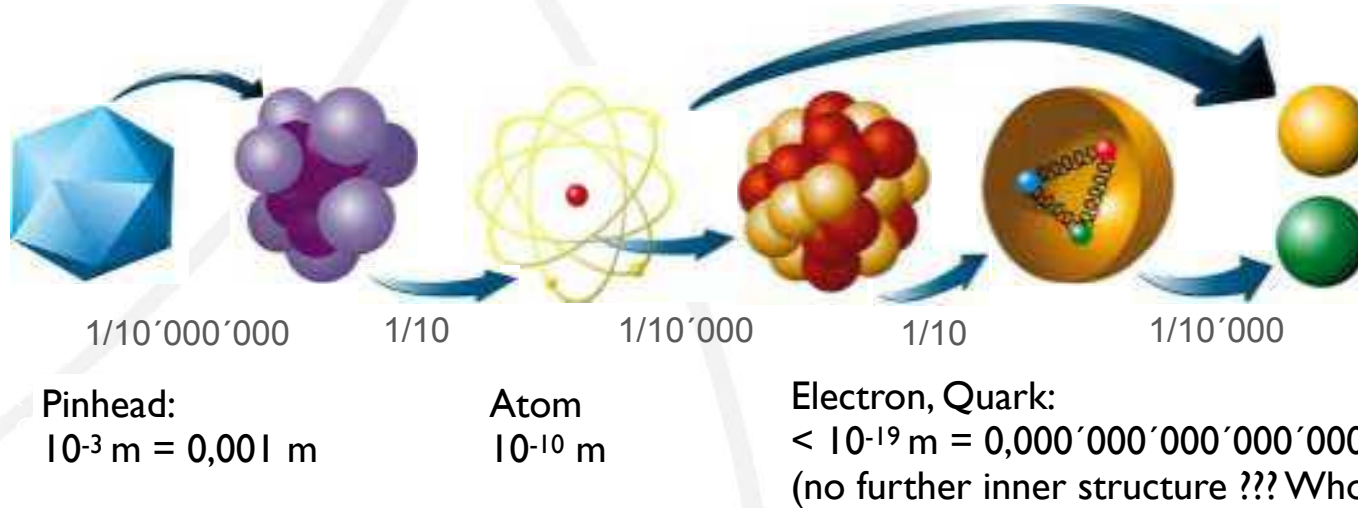


Exploration of a new energy frontier
in p-p and Pb-Pb collisions



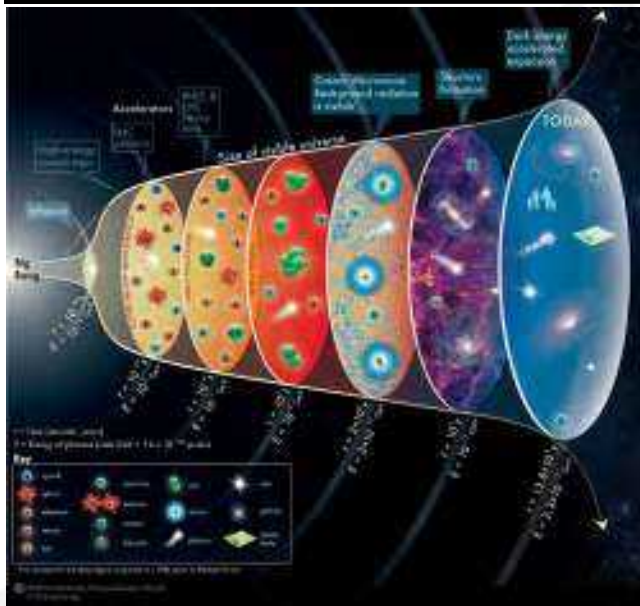


The structure of matter revealed



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



$$\begin{aligned}\mathcal{L} = & -\frac{1}{4}\mathcal{F}_{\mu\nu}\mathcal{F}^{\mu\nu} \\ & + i\bar{\psi}\mathcal{D}\psi \\ & + \psi_i y_{ij}\psi_j\phi + h.c. \\ & + \left|\mathcal{D}_\mu\phi\right|^2 - \mathcal{V}(\phi)\end{aligned}$$

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**.

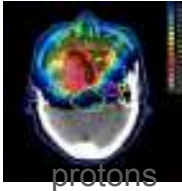
Medical Application as an Example of Particle Physics Spin-off

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)



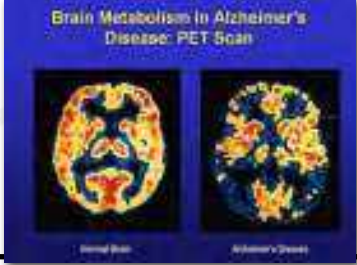
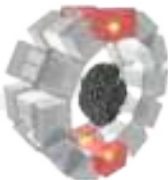
Detecting particles

Imaging

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



PET Scanner



Balloon museum



espace
BALLON



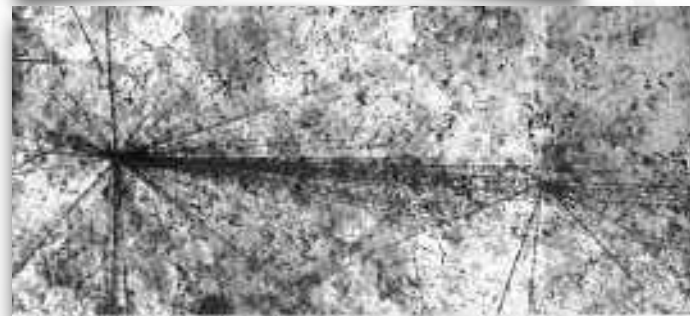
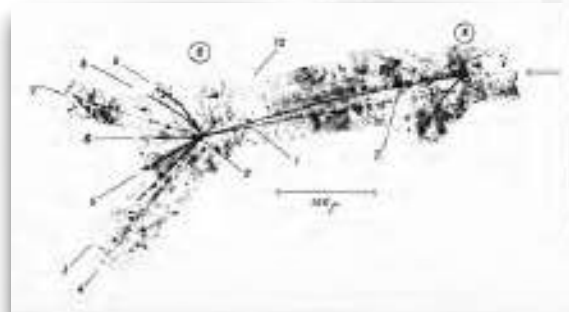
Original items to show



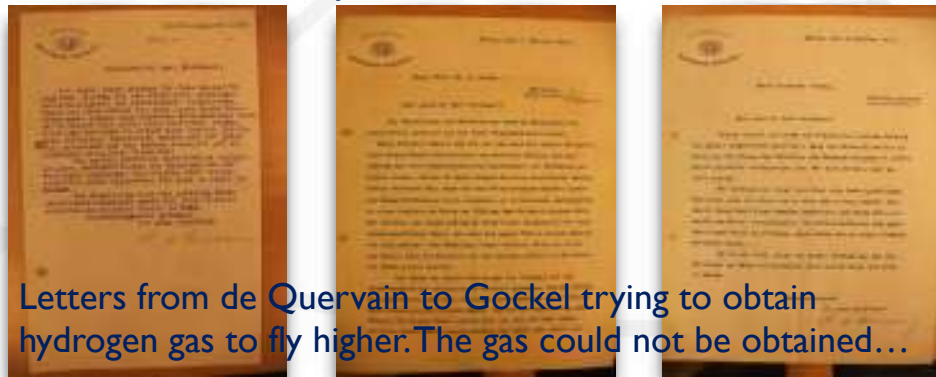
Electrometer used by Gockel around 1910



Sparkchamber



Emulsion plates from mid 1950's taken at Jungfraujoch



Letters from de Quervain to Gockel trying to obtain hydrogen gas to fly higher. The gas could not be obtained...

“Art&Science”

Through the opening of the exhibition:

Guided tours

Lectures

Junior Scientist booklet

<https://www.espace-ballon.ch/copie-de-exposition-temporaire>



Explaining Cosmic Rays

What are Cosmic Rays Was ist Kosmische Strahlung Que sont les Rayons Cosmiques



Two panels of the aurora borealis in green and blue.


1 Cosmic rays are high-energy particles that come from outer space. They are made up of protons, neutrons, and electrons. They travel at nearly the speed of light and can penetrate deep into the Earth's atmosphere. When they hit the atmosphere, they create a cascade of secondary particles, including muons, pions, and neutrinos. These particles can then reach the ground and be detected by various instruments.

2 Cosmic rays are a natural part of the environment. They are constantly hitting the Earth, and we are exposed to them every day. However, the amount of radiation we receive from cosmic rays is very small compared to other sources of radiation, such as radon gas and medical X-rays. Despite this, cosmic rays can still cause damage to living organisms, particularly in the form of DNA damage. This damage can lead to mutations, which can increase the risk of cancer and other diseases.

3 Cosmic rays are also a source of information about the universe. By studying the composition and energy of cosmic rays, scientists can learn about the processes that create them and the conditions in the regions where they originate. For example, the study of cosmic rays has helped us understand the structure of the Milky Way galaxy and the nature of the interstellar medium.



Discoveries with Cosmic Rays Entdeckungen mit Kosmischer Strahlung D couvertes avec des Rayons Cosmiques



Four panels showing cosmic ray particles and aurora borealis.

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Particle Detection Teilchendetektoren D tecteurs de Particules

Historic Technologies



Three panels showing historical particle detection technologies: bubble chamber, cloud chamber, and Geiger counter.

Modern Technologies



Three panels showing modern particle detection technologies: silicon detector, scintillator, and superconducting magnet.

Today's Technologies



Three panels showing modern particle detection technologies: Large Hadron Collider, ATLAS detector, and CMS detector.

Particle Physics Spin-off



Three panels showing spin-off technologies from particle physics: medical imaging, space exploration, and material science.

Explaining Particles

Particle Accelerator
Teilchenbeschleuniger
Accélérateur de Particules



1 Particules accélérées à l'aide d'un champ électromagnétique oscillant. Les électrons sont accélérés dans un tube à vide par un champ électrique alternatif. Les électrons accélérés produisent des rayons X. Les électrons accélérés produisent des rayons X. Les électrons accélérés produisent des rayons X.

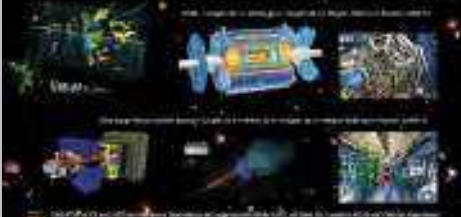
2 Les électrons sont accélérés dans un tube à vide par un champ électrique alternatif. Les électrons accélérés produisent des rayons X. Les électrons accélérés produisent des rayons X. Les électrons accélérés produisent des rayons X.

3 Les électrons sont accélérés dans un tube à vide par un champ électrique alternatif. Les électrons accélérés produisent des rayons X. Les électrons accélérés produisent des rayons X. Les électrons accélérés produisent des rayons X.

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Modern Particle Detectors
Moderne Teilchendetektoren
Détecteurs de Particules Actuels

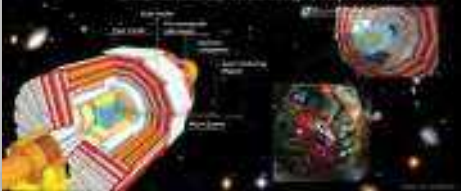


1 Les détecteurs de particules modernes sont capables de mesurer la trajectoire, l'énergie et l'identité des particules. Ils sont utilisés pour étudier les interactions fondamentales de la nature.

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Particles & Interactions
Teilchen & Wechselwirkungen
des Particules & des Interactions



1 Les particules interagissent entre elles à l'aide de forces fondamentales. Les interactions sont gouvernées par des théories de jauge.

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The Big Bang & evolution of the Universe:

$$E = -Mc^2 \gamma^2 + mc^2$$

$$+ \frac{1}{2} m v^2$$

$$+ \frac{1}{2} m v^2 + \frac{1}{2} m v^2$$

$$+ \frac{1}{2} m v^2 + \frac{1}{2} m v^2$$


Thank you for listening

“Art&Science” - Chateau d’Oex/ CH

Balloon Museum April 2019 – March 2022

Balloon Festival January 25th February 2nd 2020





photos of the CMS experiments by Michael Mach







"Atlas - ATLAS Detector" 2012



"CMS - ATLAS" 2012



"CMS - ATLAS" 2012

