THE HIGH MOUNTAIN RESEARCH STATIONS: WINDOWS ON THE UNIVERSE

Ecole Internationale Daniel Chalonge
13th Paris Cosmology Colloquium 2009

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INFN Istituto Nazionale di Fisica Nucleare Sezione di Torino

l'Observatoire de Paris

UNESCO United Nations Educational, Scientific and Cultural Organization

Centro UNESCO di Torino

The Mountain and the Science

The High Mountain Research Stations are widely distributed in the mountain regions all around the word –in Alps, Caucasus, Carpathians, Andes, Rocky Mountains, Anctartic, always placed in spectacular, breathtaking places.

An European scientific heritage

High Mountain Research Stations were established in Europe at the beginning of modern science (end of 1800) in order to provide the most adventurist scientists suitable and unique places to carry out research in various fields, from astronomy, to solar physics, to physiology.

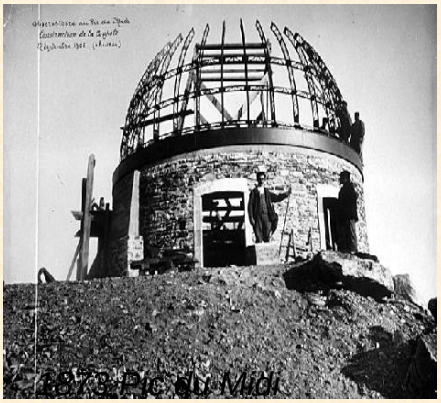
In the course of time, the High Mountain Research Stations became important laboratories for the European Scientific Community, witnesses of scientific progress and site of historical data collections.

The strategic role of the High Mountain Research Stations is still today crucial for:

- **long term observation and data collection in many scientific fields**
- **Earth and space observation system,**
- **instrument calibration**

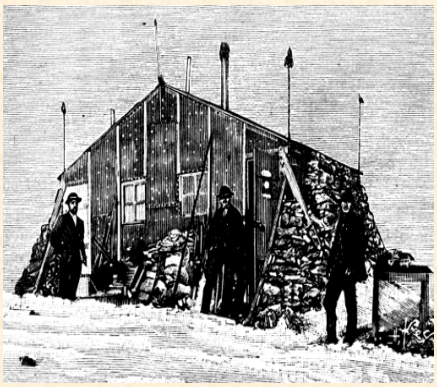
integration of data from satellite experiments.

The Beginning: the first Laboratories



1873 Pic du Midi
2887 m asl , France
Astronomy

1886 Sonnblick
3106 m asl Austria
Metereology



1890 Vallot Hut
Mont Blanc 4350 m asl, France
Biology, Natural Sciences

1893 Observatoire Jannsen
4807 m asl Mont Blanc France
Astronomy

1894 Capanna Regina
Margherita 4559 m asl Italy
Physiology, Metereology

1912 Thien-Shan
3340 m asl Kazakhistan
Astronomy

1926 Jungfraujoch
3454 m asl Suisse
Astronomy, Astrophysics

1940 Lomnick Stit
2634 m asl Slovakia
Cosmic Ray and solar physics

The pioneers

Astronomy

Pierre Janssen
(1824-1907)

P. Janssen transported at the Mont Blanc

Biology

Joseph Vallot
(1854-1925)

The Vallot Hut in a vintage design.

The “salon chinois”

Physiology

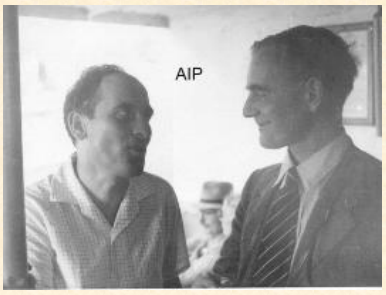
Angelo Mosso
(1846-1910)

An experiment on Monte Rosa

Astrophysics

Daniel Chalonge

(1895 - 1977)



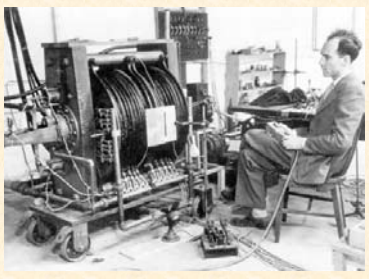
G. Occhialini, C. Lattes
Nobel Prize in 1950 for pion discovery

Carl David Anderson

(1905 - 1991)

Daniel Chalonge at Jungfraujoch (1932)

Cesare Lattes at Chakaltaya (1945)



Carl David Abdersen During an experiment (1932)

The Vallot Hut and Janssen Observatory On Monte Bianco

The Vallot Observatory

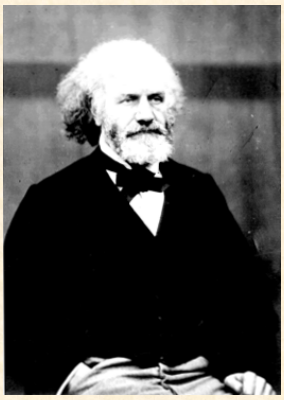
Joseph Vallot (1892)

Joseph Vallot (1854-1925), a rich Parisian gentleman fond of science and self-taught in botany, biology, meteorology, built in 1890 the Vallot Observatory at 4350 m asl on the Mont Blanc.
Later he established a more comfortable mountain hut, with also a "salon chinois", following the exotic taste at the end of 1800!
Here he carried out studies on high altitude adaptation.
In 1913, with experiments on squirrels, he established for the first time the reduction of physical capacity caused by high altitude.

The Vallot Hut.

Transport of instrumentation at Vallot Hut.

The Janssen Observatory*



Pierre Janssen

Pierre Janssen (1824-1907), astronomer at the Paris Observatory, during his studies of spectroscopy, discovered that several lines of absorption due to Earth atmosphere disturb the solar spectrum.
What's the solution? To perform his research at very high altitude … on top of the Mont Blanc, at 4807 m asl!

P. Janssen transported on the Mont Blanc

The meteorological tower is falling in the glacier (1909)

In 1893 , after two years of work under incredible conditions, the new Observatory was installed on top of the highest mountain in Europe, using a system of pylons fixed into the glacier ice.
Finally Janssen (69 years old at that time) could carry out his research in the best conditions!
The Observatory however fell in a crevasse in 1909, two years following Janssen death. Conserved in the museum of Chamonix, the meteorological tower is the last witness to this incredible adventure.

* The information about P. Janssen comes from news item of Piero Bianucci (TuttoScienze 4 Gennaio 2006)

Vallot and Janssen represent the extreme example of heroism and madness in the name of science: living conditions at altitudes of about 5000 m were prohibitive in that time. Vallot suffered from rheumatic fever, Janssen limped and had to be taken to the top of mountain in a sedan-chair or in a sledge. It was impossible to stay for a long time in the observatories, due to altitude related damages. However, both these scientists (Janssen was almost 70 years old!) climb tirelessly up and down the mountain, in absolute, visionary and grand dedication to science.

The High Mountain Research Stations
Windows on the Universe

Mountains are majestic, fascinating, mysterious…

Mountains are related to sport, to art, to travel, but their contribution to modern science is almost unknown.

In the nineteenth century the peaks of the Alps were conquered first by alpinists, and then by scientists, who shared the same passion, the love for challenge, the spirit of sacrifice.

The High Mountain Research Stations provided a crucial contribution to the scientific knowledge from 1800 until today.

In the course of time, the High Mountain Research Stations became important laboratories for the European Scientific Community, witnesses of scientific progress and site of historical data collection.

Daniel Chalonge at Jungfraujoch

Daniel Chalonge is a pioneer of the high altitude research. His love for the alpinism (the Peak Chalonge is named from him) contributes to the enthusiasm in climbing the mountains at Mont Blanc, at Pic du Midi, at Jungfrau, in Pamir, to find the optimal conditions for spectrometry and astrophysics research.

La vie veritable c'est la vie libre, c'est l'action sous toutes ses formes.
La science est une forme de lutte.
Un' autre plus immediate, plus eclatante pour le corp c'est l'alpinisme…"
Daniel Chalonge

In the same years, all around the words many important scientists carried out advanced research in astrophysics and particle physics at HMO's

Enrico Fermi, Franco Rasetti, Nello Carrara.

"The HMO… became in these years the meeting points for young physicists from many countries. The common life in the mountain huts … open the way to wide and ambitious scientific collaborations … " (Edoardo Amaldi).

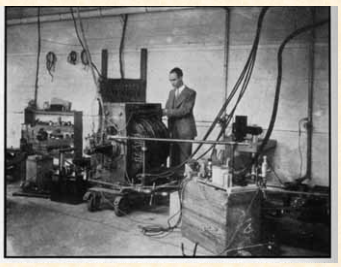
Cosmic Rays : Discovery of new particles

In the first half of 1900 the High Mountain Observatories were unique locations for the study of cosmic rays and high energy physics, before the construction of the first particle accelerators.
Most of new elementary particles was discovered in high altitude experiments.

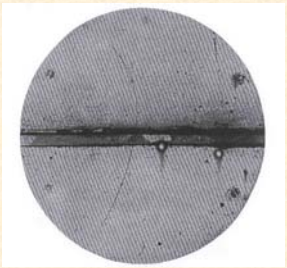
Table 1: Early discoveries in elementary particle physics

Particle	Year	Discoverer (Nobel Prize)	Method
e^-	1897	J.J. Thomson (1906)	Discharges in gases
p	1919	E. Rutherford	Natural radioactivity
n	1932	J. Chadwick (1935)	Natural radioactivity
e^+	1933	C.D. Anderson (1936)	Cosmic Rays
$\mu^\pm$	1937	S. Neddermeyer	Cosmic Rays
$\pi^\pm$	1947	C.F. Powell (1950)	Cosmic Rays
$K^\pm$	1949	C.F. Powell (1950)	Cosmic Rays
π^0	1949	R. Bjorklund	Accelerator
K^0	1951	R. Armenteros	Cosmic Rays
Λ^0	1951	R. Armenteros	Cosmic Rays
Δ	1952	C.D. Anderson (1936)	Cosmic Rays
Θ^-	1952	R. Armenteros	Cosmic Rays
$\Sigma^\pm$	1953	A. Bonetti	Cosmic Rays
p^-	1955	O. Chamberlain (1959)	Accelerators
		E. Segré (1959)	
anything else	>1955	various groups	Accelerators
ν oscillations	1998	SuperKamiokande	Cosmic Rays

•Positron (1933) *Carl David Anderson (Nobel Prize 1936)*

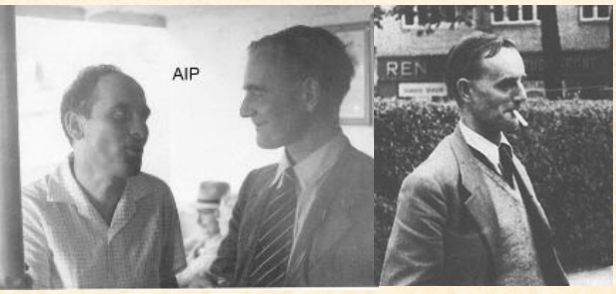


The giant magnet with which cosimic ray particles were detected and their energies measured. Carl D. Anderson is adjusting the apparatus.



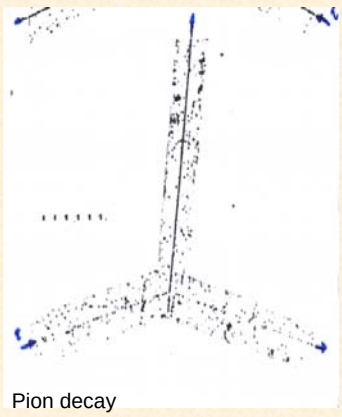
Cloud chamber photograph by C.D. Anderson of the first positron ever identified.

•Pion (1947) *Cecil Powell (Nobel Prize 1950), Giuseppe Occhialini, Cesare Lattes*



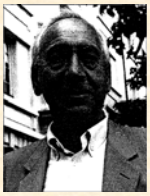
Cesare Lattes, Giuseppe Occhialini and Cecil Powell

Chacaltaya Laboratory



Pion decay

•Hyperon Λ^0 (1951) *Rafael Armenteros*



Rafael Armenteros

Pic du Midi Laboratory

Hyperon monument at Pic du Midi

Hyperon decay

Daniel Chalonge

Daniel Chalonge (1895-1977), astronomer of the Observatoire de Paris and one of the founders of the Institut d'Astrophysique de Paris, dedicated his life at two passions: the scientific research and the mountains.

He was a pioneer in the research at High Altitude Observatories, at Pic du Midi, Vallot Hut and Jungfraujoch in the '30.

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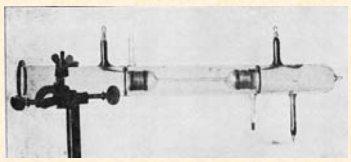
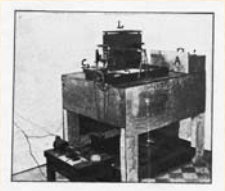
He gave his name to astrophysics instruments -the microphotometer and the spectrographe Chalonge- and to a peak in the Alps -the Peak Chalonge-.

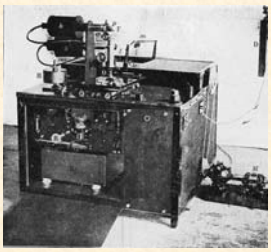
Today the International School of Astrophysics Daniel Chalonge, directed by Professor Norma Sanchez -Observatoire de Paris- is named after him.

He was a precursor in astrophysics studies, for his experimental and theoretical works and for the conception and construction of new instruments, like the hydrogen tube and the microphotometer



The hydrogen tube 1927





The Microphotometres Chalonge-Lambert 1926-1928

Daniel Chalonge at Jungfraujoch transporting the spectrograph on the slope to the Sphinx observatory, probably because of the stop of the 120 m lift

Transport of the prisme objectif on the Aletsch glacier (1933)

" …Les efforts qu'exige l'etude des etrange phenomenes qui se deroulent aux confins de notre terre et les immense services que peuvent rendre les observations de haute montagne…"

"…The efforts required for studying the strange phenomena at the extreme border of the Earth and the great services provided from the high mountain observation…"

Daniel Chalonge, La Montagne et l'alpinisme n.245, 1933

Observation at Jungfraujoch

Observation at the Vallot Hut in 1924

The spectrograph Chalonge at Jungfraujoch

At Jungfraujoch with the 25 cm telescope

En quelques heures de marche sur les sentiers des Alpes, parmi les neiges et les rochers, je vis plus, je recueille plus d'impressions, plus de souvenirs que en six mois de la vie…

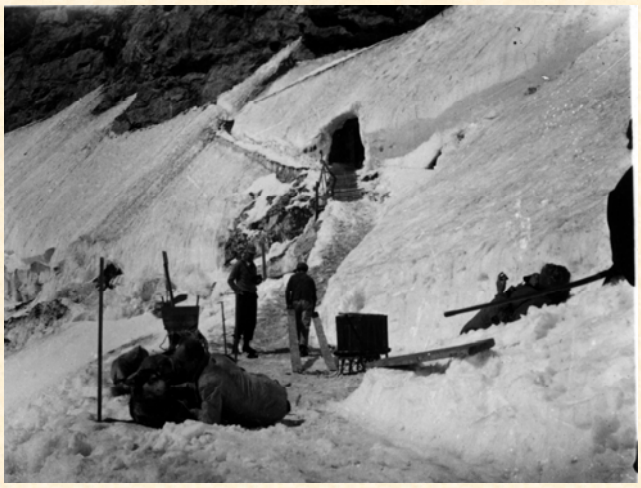
Daniel Chalonge

In few hours of walking on the alps tracks, between the snow and the rocks, I collect more emotions, more memories than in six months of normal life…

At that time -first half of 1900- also the scientific research was more intense and more effective in the High Mountain Observatories.

Daniel Chalonge : scientist and alpinist

Daniel Chalonge was at the same time fond of science and alpinism



Daniel Chalonge and others researchers in front of Aletsch glacier

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Daniel Chalonge

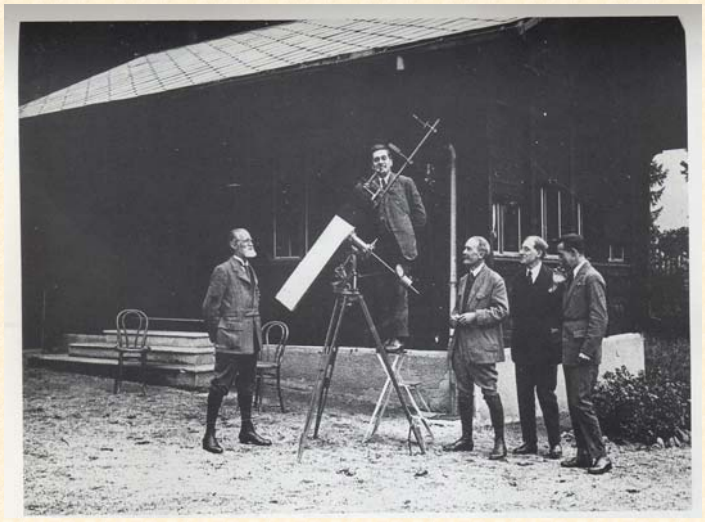
The scientific caravan climbing to the laboratory; on the back of the sixth holder the spectograph Chalonge

Transport of the prisme objectif on the Aletsch glacier (1933)

Arrival at Vallot Hut Laboratory (4362m) (1924)

Daniel Chalonge at Mountain Observatories

Observation at the Vallot Hut (France)



Chamonix, 1924. The Vallot Hut and Chalonge spectrograph. From left to right: J.Vallot, C.Fabry, P.E. Lambert, G Déjardin, D. Chalonge

The Chalonge spectrpgraph on the terrace of Vallot Observatory in 1924

Observation at the Jungfraujoch (Germany)

At Jungfraujoch with the 25 cm telescope

The 0,80m telescope at Jungfraujoch

The spectrograph Chalonge at Jungfraujoch

Observation at Abisko (Sweden)

Chalonge et Barbier at Abisko

Measurements of tropospheric ozone between low and high altitude sites or in the polar regions to understand overall observed changes. Several missions take place: simultaneously in Lauterbrunnen to Jungfraujoch and or in Lapland Swedish Abisko during the polar winter.

" …Les efforts qu'exige l'etude des etrange phenomenes qui se deroulent aux confins de notre terre et les immense services que peuvent rendre les observations de haute montagne…"

"…The efforts required for studying the strange phenomena at the extreme border of the Earth and the great services provided from the high mountain observation…"

Daniel Chalonge, La Montagne et l'alpinisme n.245, 1933

Daniel Chalonge at the Astrophysics Institut in Paris

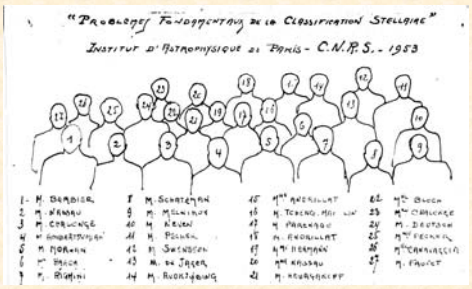
D. Chalonge and D. Barbier at the Observatoire de Paris (1936)

The Spectrograph Chalonge and the coronograph Lyot

The Chalonge Medal was designed by the famous French sculptor Madeleine Pierre Quérolle and coined by the Hôtel de la Monnaie (the French Mint).

Paris 1949

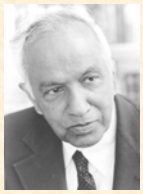
Paris 1953



Scientists awarded with the Chalonge Medal

The Daniel Chalonge astrophysics school school awarded only three scientists in its 18-year history. The first medal was awarded in 1991 to astrophysicist and Nobelist Subramanyan Chandrasekhar (1910-1995), who was a great friend of Daniel Chalonge and delivered the school's inaugural lecture. The second medal was awarded in 1992 to the distinguished high-energy physicist Bruno Pontecorvo (1913-1993), a pioneer of neutrino physics and a major supporter and lecturer at the school. The third medal was awarded in 2006 to Nobel prize winner George Smoot, frequent lecturer at the school.

Chalonge Medal in 1991



Subramanyan Chandrasekhar (Nobel Prize in 1983)

Chalonge Medal in 1992

Bruno Pontecorvo

Chalonge Medal in 2006

George Smoot with the Daniel Chalonge Medal

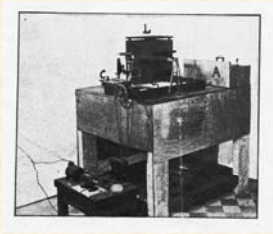
Nobel Prize in 2006

Daniel Chalonge and the Instruments

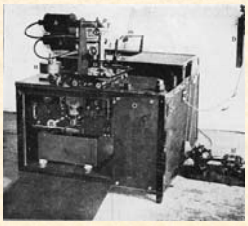
The microphotometer

Quantitative spectrophotometry requires the use of a high quality recorder microphotometre. That is why Chalonge and Lambert developed in physics laboratory at the Sorbonne, the first microphotometer in 1926.

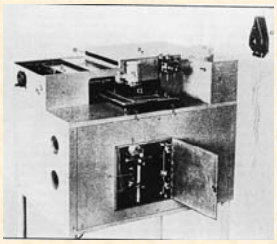
Daniel Chalonge was the inventor of many new instruments,which allowed exceptional improvements in reliability and repeatability of experiments.



First microphotometer: ~1926



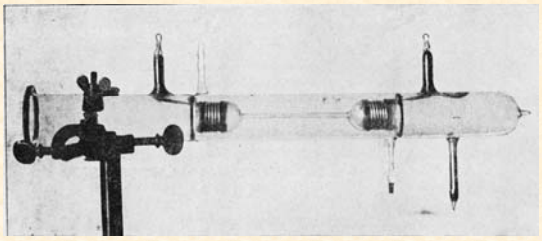
The second : 1931



The third, 1938,.

The hydrogen lampe

Arosa en 1930



The calibration of photographic plates requires a very stable source whose intensity does not vary too much in the spectral range where the plate is used. The continuous molecular hydrogen UV lamp developed by Chalonge is so stable that allows a good calibration, until then unknown in this spectral range.

THE SPECTROGRAPH CHALONGE

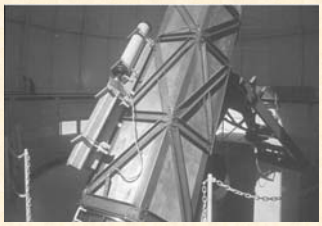
It is built to be used at the Cassegrain focus of a reflector. The spectrum broadening is accomplished by small oscillations of the plateholder in its plane: this method allows to obtain spectra narrower in the UV than in the red, hence to reinforce the short wavelenghts. Behind the slit, an adjustable rotating sector permits to reduce in a known proportion the light entering the slit and to make easier the comparison between the spectra of stars with different magnitudes. The spectrograph can be rotated around the collimator axis so that the plane determined by this axis and the slit remainsalways vertical: thus avoid the disturbing effects of the atmospheri refraction

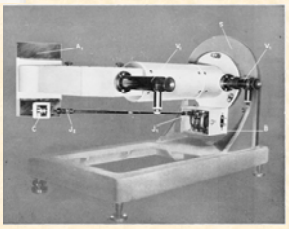
The spectrogaphe on the terrace of the Pic du Midi de Bigorre in 1930

Installation at Jungfraujoch

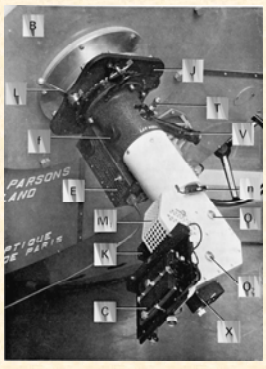
A Abisko en 1935

Derrière le télescope Chalonge en utilisant le T120 de l'OHP comme table équatoriale en 1942 ?





Première version en 1952



Au T80 de l'OHP
(2ième version du spectrographe)