The High Mountain Research Stations : a scientific heritage


Lomnick Stit, 2634m slm Slovakia


Capanna Margherita, 4559m slm Italie


Pyramid, 5050m slm
Nepal


Sonnblick, 3106 m slm
Austrie


Jungfraujoch, 3580m slm
Suisse


Chacaltaya, 5230m slm Bolivie


BEO Mussala, 2925m slm Bulgarie


Testa Grigia, 3480m slm Italie


Dome Concordia – 3233 m asl
Antartide


Pic du Midi, 2887 m slm France

The role of the HMO's at the end of 1800

In 1800, the mountain adventure was at the beginning: the conquest of the first Alpine Peaks (*Mont Blanc on 1786, Jungfrau on 1811, Monte Rosa on 1855, Eiger on 1858, Matterhorn on 1865)* opened the off-limits adventure, the extreme challenge.

The first scientific interest was aimed at man, to his capability of endurance: physiologists like *Angelo Mosso* (1846-1910) , biologists and botanists as *Joseph Vallot (1*854-1925) were the first researchers climbing the mountains with a scientific interest. Metereologists as *Joseph Tyndall* and astronomers as Pierre J*anssen* followed.

In the first half of 1900

with the cosmic rays discovery , the extraordinary epopee of the «cosmicians» begun .

All the most important discoveries in strange particles and high energy physics were carried out at HMO's.

Many of these scientists were awarded with the Nobel Prize.

Poets and artists, the first mountain climbers

In 1336 **Francesco Petrarca** (1304-1374) climbed with his brother the Mont Ventoux (m 1912) in Provence. He describe his adventure in poetic words *«L'ascesa al Monte Ventoso»*

At the beginning of 1500 **Leonardo da Vinci** (1452-1519) climbed athe **Monboso** (Monterosa) to investigate the effects of the light refraction at high altitude

"l'aria (è) tenebrosa e il sole più luminoso qui assai che nelle basse pianure".

Scientific research at high altitude

Blaise Pascal (1623-1662

Blaise Pascal nel 1648 al Puy de Dome (1464 m) studied the atmospheric pressure with the altitude **«** *Traité de l'equilibre des liqueurs et de la pesanteur de la masse d'air-Paris,1663 »*

Geminiano Montanari

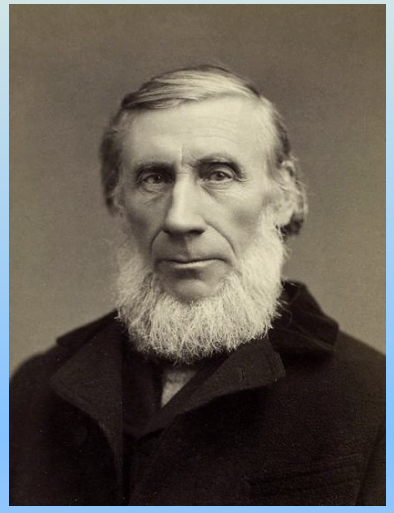
In 1671, Geminiano Montanari. was the first in Italy, that applied the barometer to altimetry, on the top of Monte Cimone He repeated the same experiment that Pascal had done on Puy de Dome, 23 years before.

Pascal with the barometre at Puy de Dome

Horace Benedict De Saussure 1740-1799

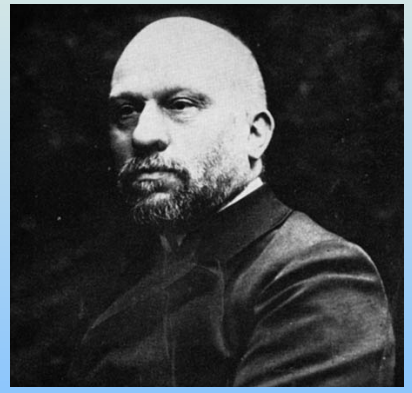
Bearers on the Mont Blanc with De Saussure expedition 1787 for research in biology and botany

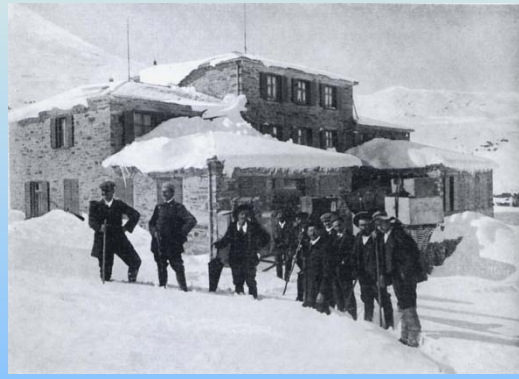
The Pioneers



John Tyndall in many expeditions on Matterhorn (1866) and Mont Blanc studied the absorption of infrared radiation in atmosphere (First studies on the green-house effect)

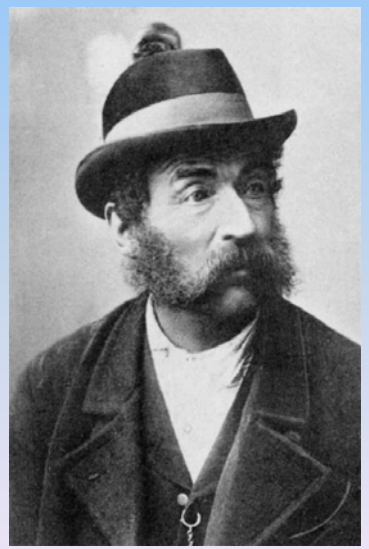
John Tyndall (1820-1893)





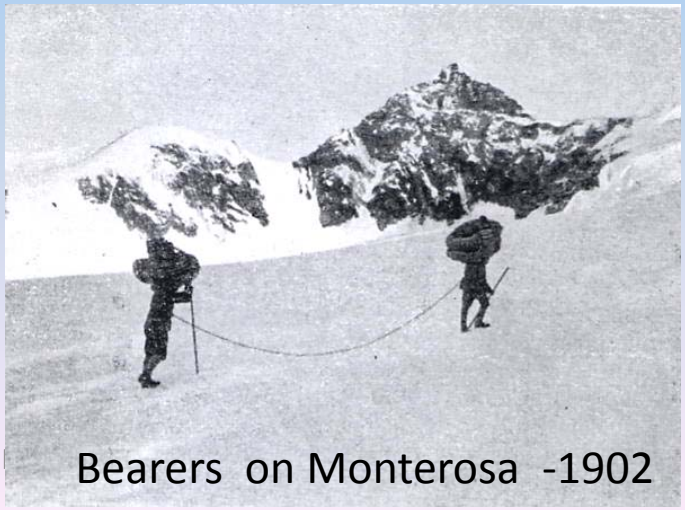
Angelo Mosso (1846-1910)

Professor at Torino University, was a pioneer in the human physiology studies at high altitude and the founder of two high mountain laboratories, at Capanna Margherita on Monte Rosa (4557 m), and at Col d'Olens (3000 m)



Simon Neumayer, meteorologist at Sonblick(3106 m) -1900

Room for the scientist to work, live and sleep.
Only little changes were undertaken from 1886 to the late 1980.



Bearers on Monterosa -1902

Phyisiology experiments at Capanna Margherita (1900)

Sfingmometre for blood pressure measurements

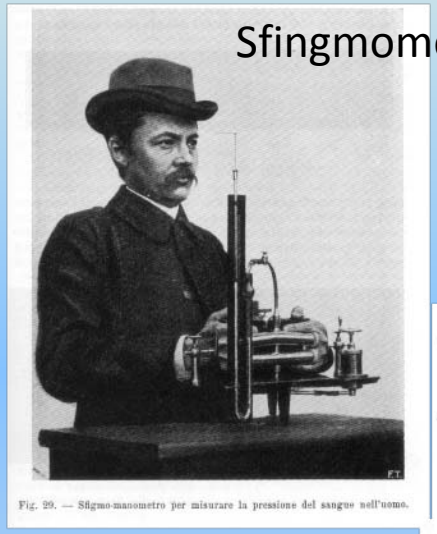


Fig. 29. — Sfigmo-manometro per misurare la pressione del sangue nell'uomo.

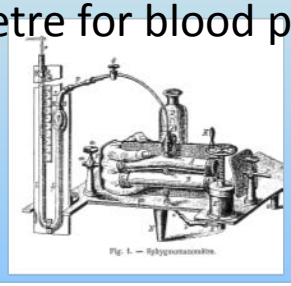
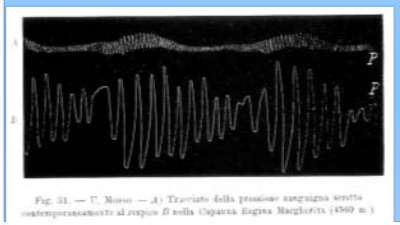
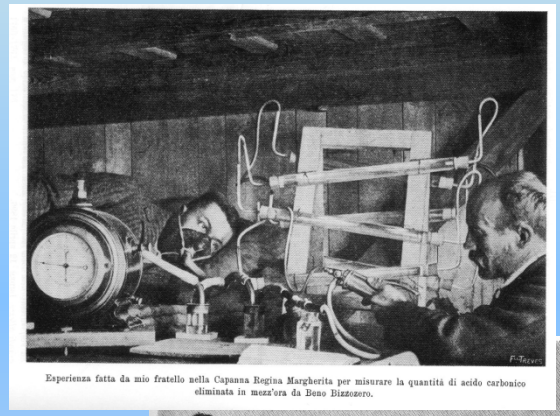


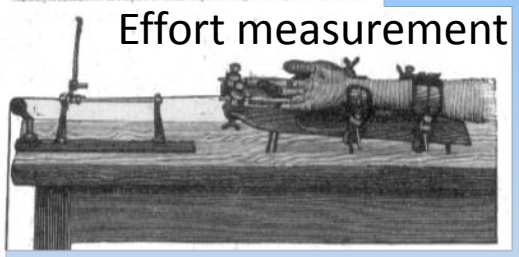
Fig. 1. — Sphygmomanometre.





Esperienza fatta da mio fratello nella Capanna Regina Margherita per misurare la quantità di acido carbonico eliminata in mezz'ora da Beno Bizzozero.

Effort measurement



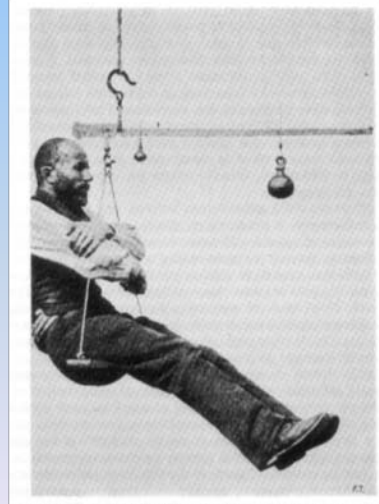


Fig. 61. — Stadera che portammo nella spedizione al Monte Rosa.

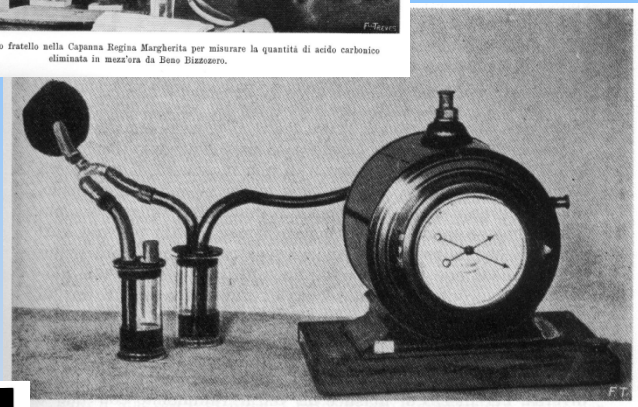


Fig. 16. — Contatore colle valvole e la maschera di guttaperca per misurare la quantità di aria inspirata.

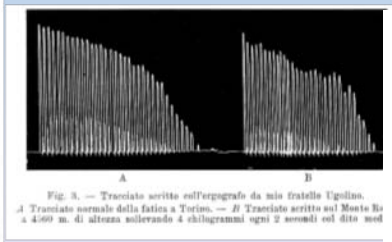


Fig. 3. — Tracciato scritto sull'ergografo da mio fratello Ugolino.

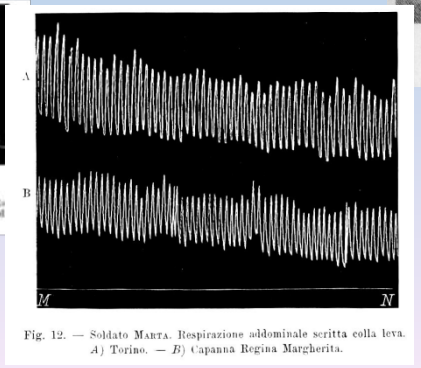


Fig. 12. — Soldato Marta. Respirazione addominale scritta colla leva. A) Torino. — B) Capanna Regina Margherita.

Weight variation at high altitude

Today similar experiment are being performed at ISS (International Space Station)!

The Vallot Hut and Janssen Observatory On Monte Bianco

Joseph Vallot (1892)

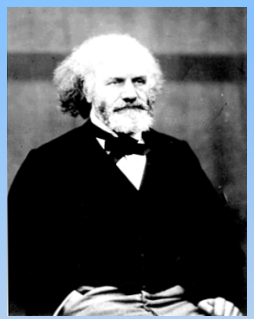
The Vallot Observatory

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!

Janssen on the Mont Blanc

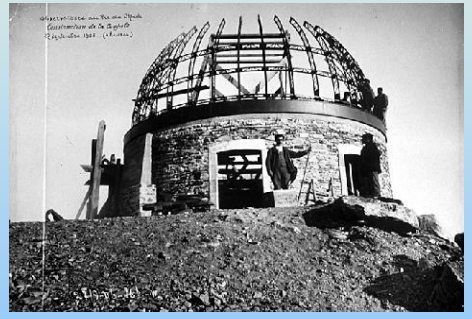
In 1893 , after two years of work under incredible conditions, the new Observatory was installed on top of the highest mountain in Europe, using a system of pylons fixed into the glacier ice.
Finally Janssen (69 years old at that time) could carry out his research in the best conditions!
The Observatory 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 meteorological tower is falling in the glacier (1909)

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 first Laboratories

1873 France
Pic du Midi
2887 m asl
Astronomy



1894 Capanna Regina Margherita 4559 m asl Italie
Physiology Meteorology

1886 Austria
Sonnblick
3106 m asl
Meteorology

1912 Thien-Shan 3340 m asl Kazakhistan
Astronomy

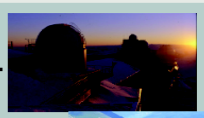
1890 (France)
Vallot Hut
Mont Blanc 4350 m asl
Biology Astronomy

1893 France
Observatoire Jannsen
Mont Blanc 4807 m asl
Astronomy

1926Jungfraujoch
3454 m asl Suisse
Astronomy
Astrophysica

When?
Quando?

Pic du Midi
2887m asl
France
1873



Sonnblick
Laboratory
3106 m asl
Austria
1886

Capanna
Regina Margherita
4559 m asl
Italy
1894

Istituto
Angelo Mosso
2901 m asl
Italy
1907

Thien-Shan
Laboratory
3340 m asl
Kazakhistan
1912

Jungfraujoch
Laboratory
3454 m asl
Switzerland
1926

Echo Lake
Laboratory
3200 m asl
USA
1930

Lomnick Stit
2634 m asl
Slovakia
1940

Chacaltaya
Laboratory
5230 m asl
Bolivia
1942

ASEC, Aragats
3200 m asl
Armenia
1943

Terskol Peak
Laboratory
3100 m asl
North Caucasus
Russia
1944

Pamir
Laboratory
4380 m asl
Kyrgyzstan
1946

Osservatorio
astronomico
Campo Imperatore
2150 m asl
Italy
1947

1947
Testa Grigia
Research Station
3480 m asl
Italy

1951
White Mountain
Research Stations
USA

1953
Norikura
Observatory
2770 m asl
Japan

1959
BEO Moussala
2925 m asl
Bulgaria

1960
Gornergrat
Laboratory
3012 m asl
Switzerland

1961
Mauna Kea
Observatories
4200 m asl
USA

1988
LNGS (INFN)
Italy

1990
Yangbajing
Laboratory
4300 m asl
Tibet
P.R. China

1990
Pyramid
Laboratory
5050 m asl
Nepal

1995
Dome Concordia
Station
(summer station)
3233 m asl
Antarctica

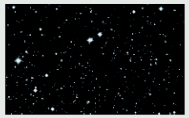
1996
Ottavio Vittori
Laboratory
2165 m asl
Italy

1997
Mount Hermon
2020 m asl
Israel

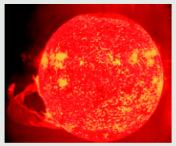
1998
Schneefernerhaus
Laboratory
2650 m asl
Germany

Which science?
Quale scienza?

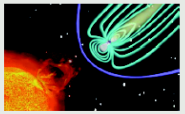
Space Science
Scienza dello spazio



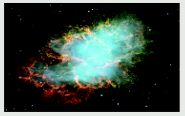
Astronomy
Astronomia



Solar Physics
Fisica Solare



Space weather forecast
Previsioni del tempo spaziale

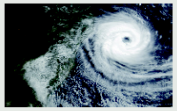


Astrophysics
Astrofisica

Cosmic Rays Physics
Fisica dei raggi cosmici

Atmosphere Science
Scienza dell'atmosfera

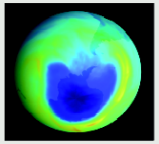
Atmospheric Chemistry
Chimica dell'atmosfera



Atmospheric Physics
Fisica dell'atmosfera

Clouds formation
Formazione di nubi

Lightning & thunderstorm
Fulmini e temporali

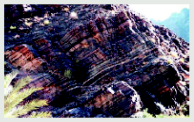


Ozone depletion
Buco dell'ozono

Earth Science
Scienza della Terra

Paleoclimatology
Paleoclimatologia

Seismology
Sismologia



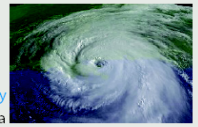
Geology
Geologia

Glaciology
Studio dei ghiacci

Which science?
Quale scienza?

Climatology
Climatologia

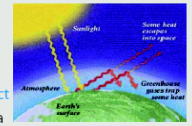
Climate changes
Cambiamenti climatici



Meteorology
Meteorologia

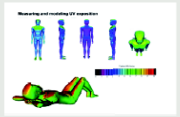
Pollution monitoring
Monitoraggio dell'inquinamento

Weather forecast
Previsioni del tempo

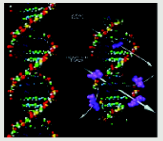


Greenhouse effect
Effetto serra

Medicine and Biology
Medicina e Biologia



UV exposure
Esposizione ai raggi UV



Radiobiology
Radiobiologia

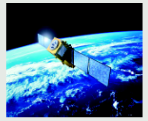
Human life in extreme conditions & Sport Medicine
Vita umana in condizioni estreme e medicina sportiva

Pollutants effect on life and food chain
Effetto di inquinanti sulla vita e sulla catena alimentare

Physiology and Biophysics
Fisiologia e Biofisica

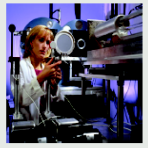
and more...
e inoltre...

Telecommunication
Telecomunicazioni



Satellite data validation
Validazione dei dati da satellite

Ecological tourism
Turismo ecologico



Instruments calibration
Calibrazione di strumenti

Science divulgation & Education
Divulgazione scientifica & Educazione

Environmental protection
Protezione ambientale

High altitude astronomy

The high altitude sites for astronomy observation guarantee:

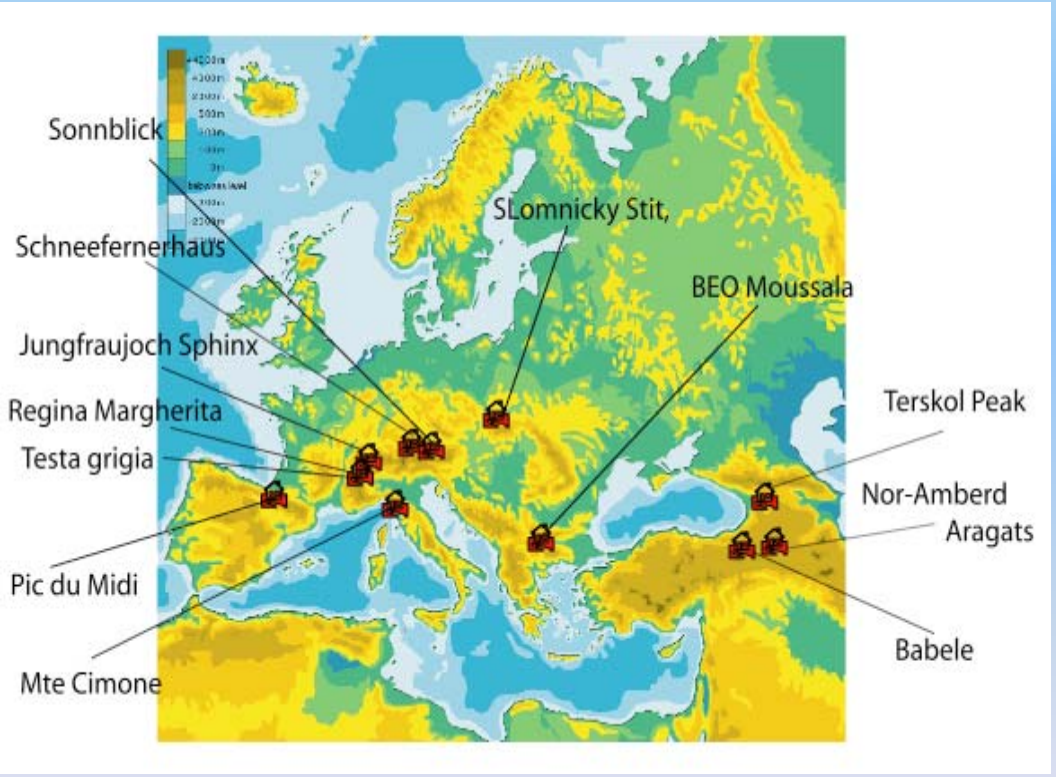
- No light pollution
- Reduced atmosphere layer
- Historical progress in astronomical observations are strictly related to the increasing altitude of observatories.

In the course of years higher observational sites have been used

1873 Pic du Midi 2887 m
1893 Janssen Observatory 4300 m Mont Blanc
1904 Mount Wilson USA 1700 m
1912 Tien Shan Kazakhsta 3340 m
1928 Mount Palomar USA 1900 m
1946 Pamir Kyrgyzstan 4380 m
1937 Jungfraujoch (Switz.) 3500 m
1950 Gornergrat (Switz 3135 m)
1958 Kitt Peak USA 2300 m

1969 La Silla Spain 2400 m
1980 Mauna Kea Hawai 4200 m
2007 Atacama Chile 5000 m
2010 DomeC Anctarctic 3200 m

High Mountain Laboratories in Europe



Pic du Midi	2887 m asl	France
Testa Grigia	3480 m asl	Italy
Regina Margherita	4559 m asl	Italy
Angelo Mosso	2901 m asl	Italy
Ottavio Vittori	2165 m asl	Italy
LNGS Gran Sasso	2150 m asl	Italy
Pic du Midi		France
Jungfraujoch Sphinx	3454 m asl	Switzerlan
Gornergrat	3012 m asl	Switzerlan
Schneefernerhaus	2650 m asl	Germany
Sonnblick	3106m asl	Austria
Lomnicky Stit	2634 m asl	Slovakia
BEO Moussala	2925 m asl	Bulgaria
ASEC Aragats	3200 m asl	Armenia
Nor Amberd	2000 m asl	Armenia
Terskol Peak	3100m asl	Russia

High Mountain Laboratories in the world

Chacaltaya 5.400 m Bolivia

Yangbajing 4.300 m, Tibet

Tian-shan 3.340 m, Kazakhistan

Dome Concordia 3.200 m, Antarctic

Mauna Kea 3.058 m, Hawaii

Norikura 2.770 m, Japan

Mount Hermon 2.025 m, Israel

INCA 5.400 m Chile

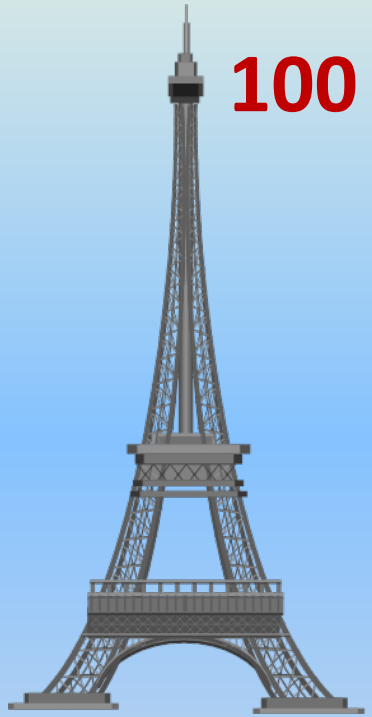
Huanacayo 4.300 m, Peru

White Mountain 3.340 m, U.S.A

Everest Pyramid 5050 m, Nepal

1912-2012

100 years from the cosmic rays discovery



30th of March 1911

The Jesuit Priest Theodore Wulf, Physics Professor at Valkenburg (Netherland) with a new electroscope invented by himself, first discovered the "radiation from outside" on the top of Tour Eiffel (312 m)

7° of August 1912

Balloon flight Praga –Berlin 5000 m asl

Victor Franz Hess 1883-1964

"The results of experiments could be explained with a high penetrating radiation incoming from the top of the atmosphere".

Victor Hess, *Physikalische Zeitschrift*, novembre 1912

Cosmic Rays Research

- High Mountain Observatories played a crucial role in cosmic ray (CR) physics, high energy and particle physics.
- Before the construction of particle accelerators, the observation of CRs at high altitudes was the only way to study high energy interaction mechanisms.

- The first High Mountain Observatories (HMOs) were witnesses to an extraordinary period in which the most important physicists (many of them Nobel Prize awarded) introduced new detection techniques and discovered new particles, establishing the foundations of modern astrophysics and cosmology

- In 1928 initiated their experiments in Perù ***R. Millikan and A.H. Compton*** (**Huancayo Observatory**, 3350 ma.s.l.) in order to assess the characteristics of cosmic rays (electromagnetic radiation or particles)

- ***E. Fermi and E. Amaldi*** (Rome), ***G.D. Rochester, P.M.S. Blackett*** (Manchester) and ***C.F.Powell*** (Bristol) and ***P. Auger*** (Paris) were involved in CR research at **Testa Grigia** (3480 m a.s.l.) in Italy, at **Pic du Midi** (2887 m a.s.l.) in France and at **Jungfraujoch** (3454 m a.s.l.) in Switzerland.

- The American Physics School, lead by ***B. Rossi and C. Anderson*** worked at **Echo Lake on Mt. Evans** (3200 m a.s.l.) and at **White Mountain** (3200 m a.s.l.) in USA.

- ***C.M.G. Lattes and G. Occhialini*** did their research at **Mt. Chacaltaya** (5230 m a.s.l.) in Bolivia.

Strange particles discovery

The discovery of ‘‘**strange particles**” started at HMOs.

- At Mont Blanc (4300 m a.s.l.), ***L. Leprince-Ringuet*** first observed several strange tracks in a nuclear emulsion (1944);
- From 1948 to 1950 evidence of this phenomenon was obtained at Pic du Midi also, with the cloud chamber used by the Manchester group (***C.C. Butler, R.Armenteros and K. Barker*).**
- During the same period, ***C.Anderson*** observed the same tracks with nuclear emulsions on top of White Mountain,
- ***B. Rossi*** at MIT carried out a study of these particles, analyzing the nuclear interactions produced in a cloud chamber at Echo Lake: the existence of the V particle, with the typical double track, was confirmed.

- Furthermore, the K particle, with its typical three-charged particle decay, was discovered by ***C. Powell*** at Jungfraujoch.
- The discovery of the p meson with nuclear emulsions was performed by ***C.F. Powell, Lattes and Occhialini.*** at Chacaltaya in Bolivia

The HMOs . . . 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

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

12° of June 1914 , Wulf and Hess experiments were confirmed by measurements performed by **Werner Kolhörster on** balloon flight at 9000 m .

The measured ionization level was 12 times greater than on ground

1922 Robert Millikan performed measurements both in high mountain and onboards of balloons at 15000 m

Robert Millikan (Nobel Prize 1923)
Preaparing a balloon launch

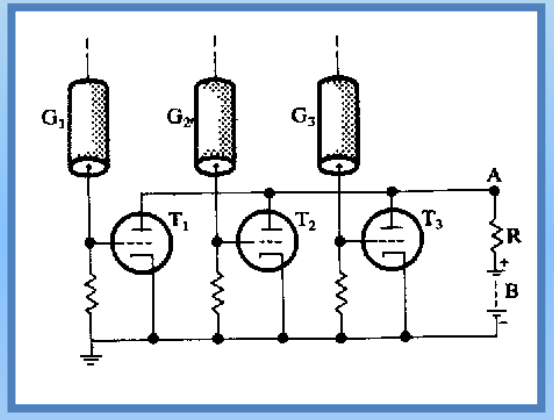
Millikan and collaborators on
Mount Whitney 1925

New Instruments

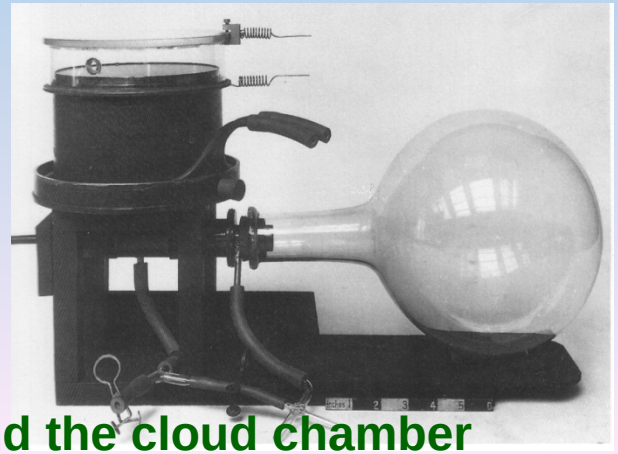
- New measurements techniques as the **Geiger counter** , the **coincidence detector** of Bruno Rossi , the Wilson **cloud chamber** allowed a better comprehension of the cosmic rays characteristics

Hans Geiger

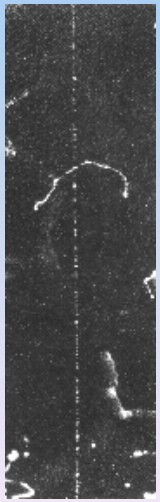
Bruno Rossi at Padua University



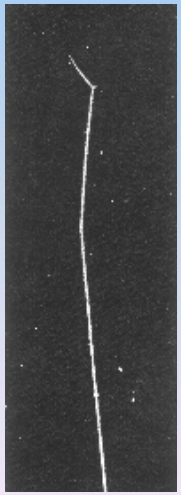
The coincidence detector



1911- **C.T.R.Wilson and the cloud chamber**



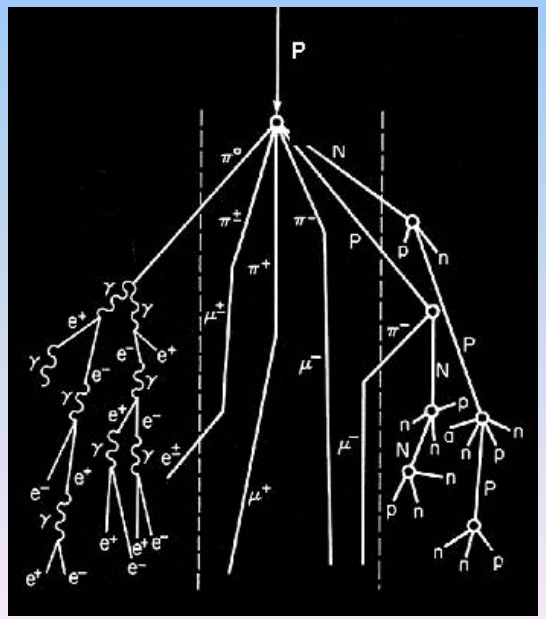
e – track



alfa+ track

Gabriele D'Annunzio

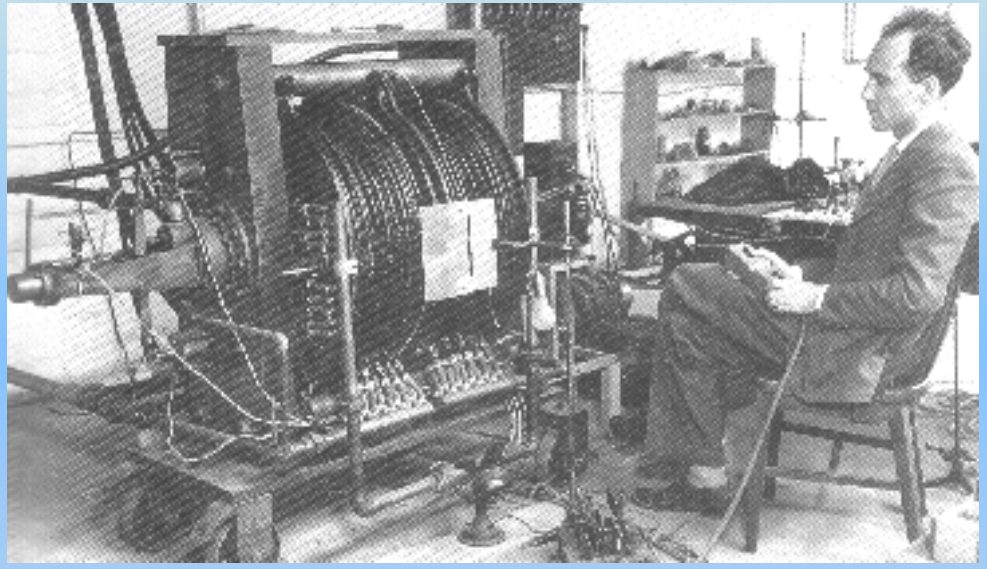
In 1931 Auguste Piccard , using a pressurized cabin , reached the 15000 m altitude, with an electroscope.
The italian poet Gabriele D'Annunzio was fascinated by these extreme experiments and proposed his participation to the next flight, disposed to be launched down if necessary, happy to die for scientific research!!!



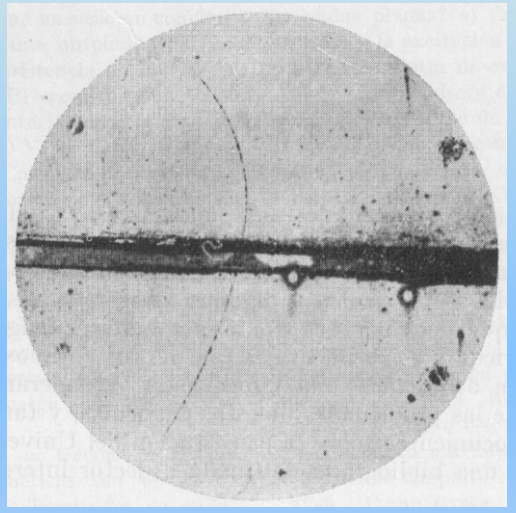
Cosmic ray shower

Finally in 1932 Compton (Nobel Prize) after a wide measurement campaign funded by Carnegie Institute in Washintongt, established the corpuscular nature of the cosmic rays, previously considered composed only of energetic gamma rays

Antimatter



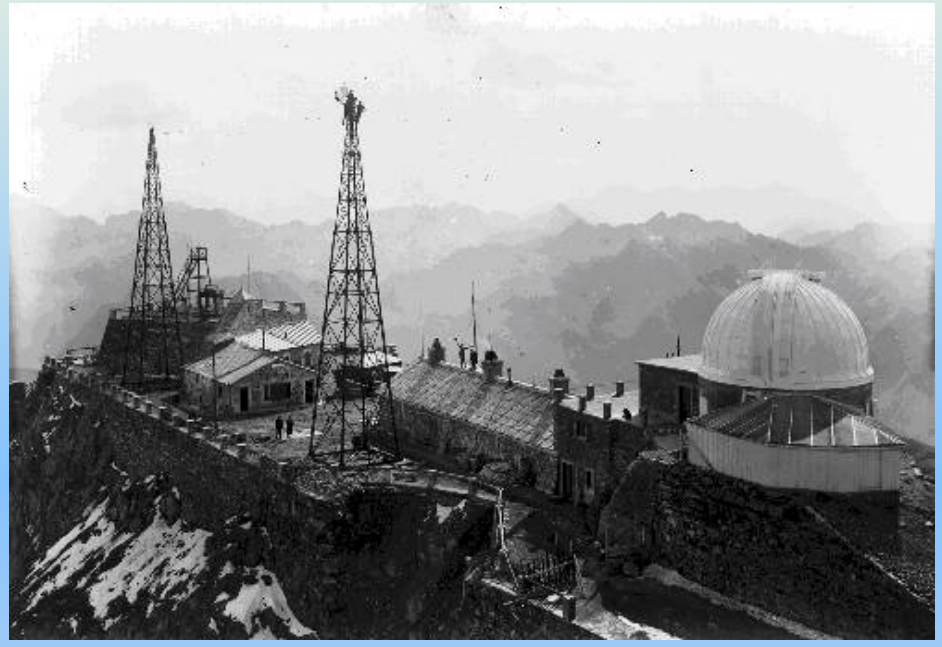
C.D. Anderson at Caltech laboratory



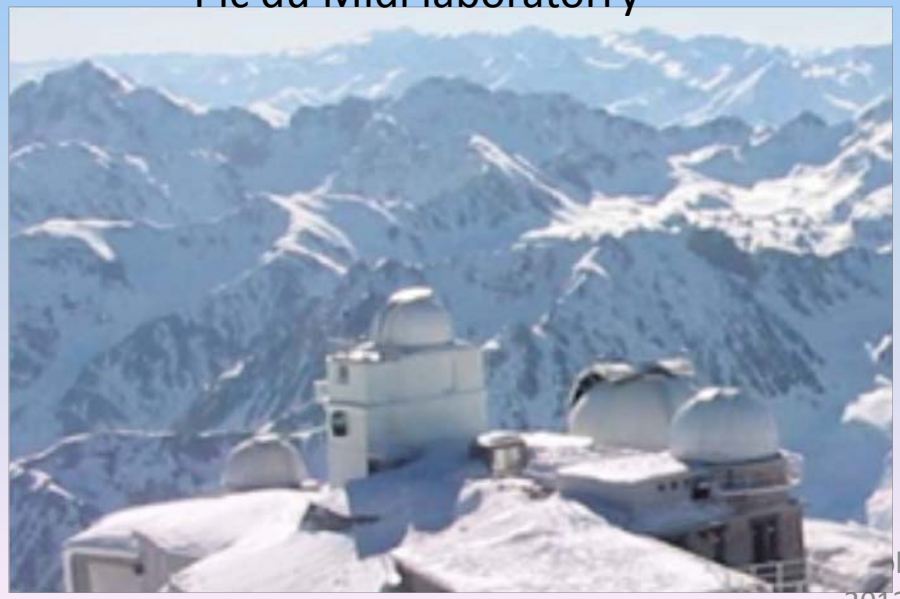
The positron track. The lead layer change the track curvature

1932 Carl D. Anderson (Nobel prize 1936), at Caltech Institute, using a cloud chamber in a magnetic field,
detected a track similar to the electron one, but with an opposite curvature
He discovered the first anti-particle , the positron, confirming the Paul A.Dirac theoretical prevision.
The discovery was confirmed at Pic du Midi.

Pic du Midi Laboratory 2887 m France



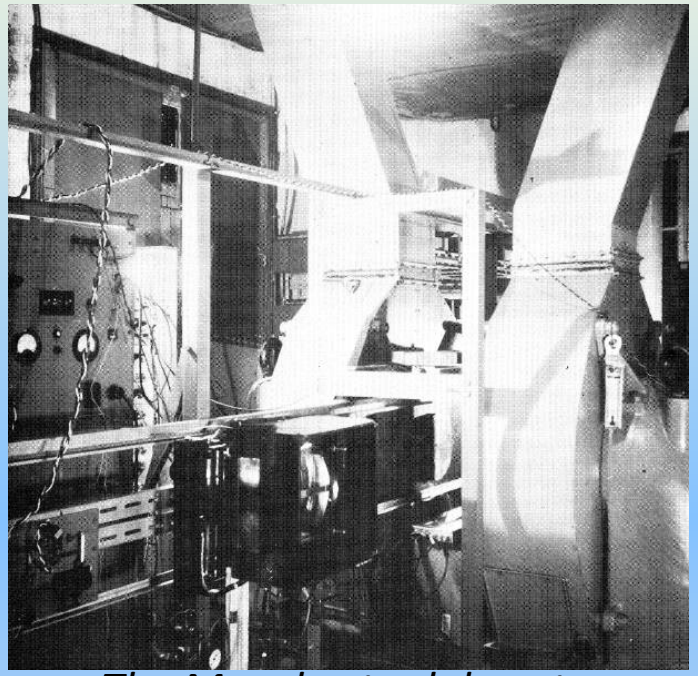
Pic du Midi laboratorry



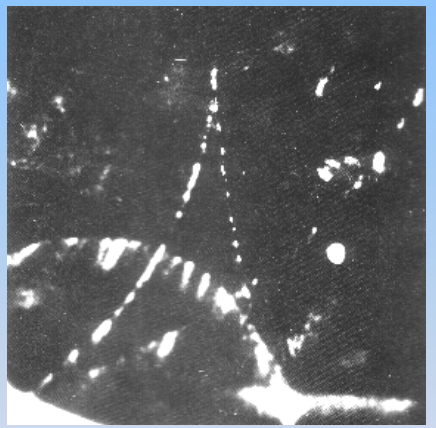
Beppo Occialini and Patrick Blackett at Pic du Midi 1947

The positron dicovery was confirmed after two weeks at Pic du Midi by **P. Blackett e G. Occhialini**. Pfor this experiment Occhialini introduced an electronic trigger to select the nuclear events to be analized.

Rosch, Butler, Blackett, Barneoud, Pic du Midi (1950)



The Manchester laboratory



An image of e+ e- produced by Compton effect in a cloud chamber with magnetic field. The two particles have opposite curvature

Transport of the Manchester electromagnet at Pic du Midi (1950), to be employed with the cloud chamber of Blackett e Occhialini. To install the electromagnet (only the base weight was 4 tons!), a slope 220 m , 42°, was manufactured .

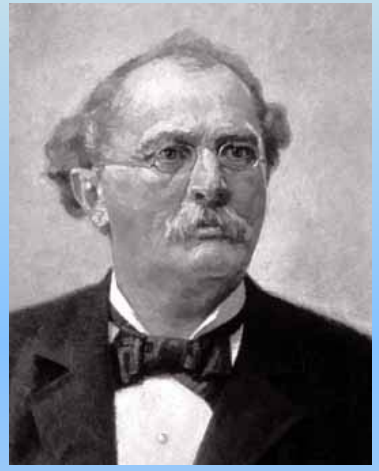
The decay of the Iperon Λ^0 in proton p and pion π, detected at Pic du Midi by C.Armenteros.

The international congress at Bagnère de Bigorre 1953

The monument to Iperon at Bagnère de Bigorre

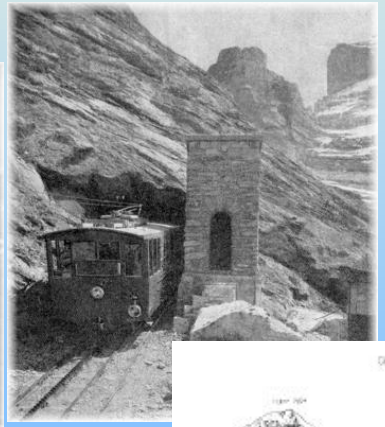
B. Rossi,G.Bernardini,E.Fermi

Jungfraujoch Sphinx 3454 m asl Switzerland

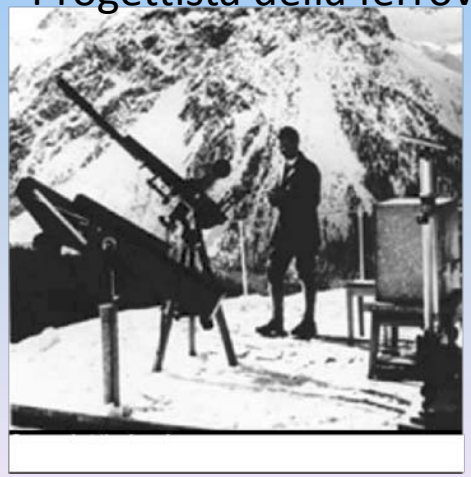


Adolf Guyer-Zeller
Progettista della ferrovia

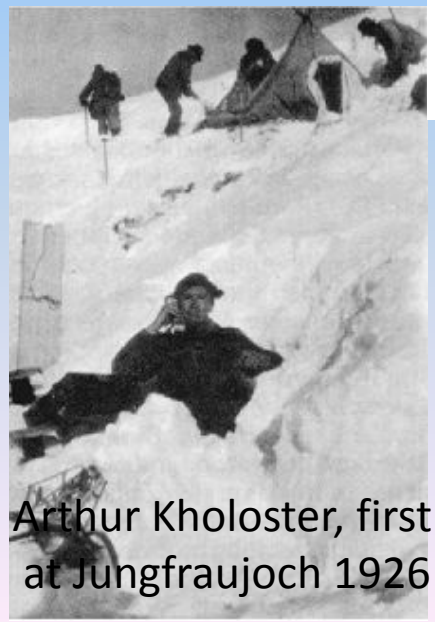
Railway to laboratory (1912)



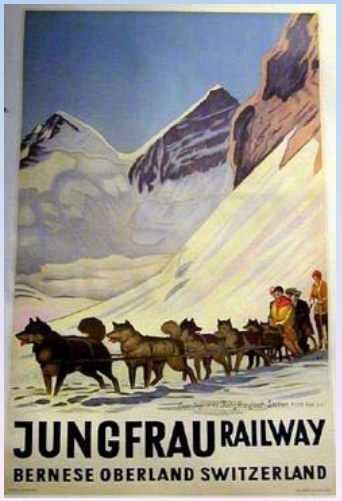
The Jungfrau railway project Guyer-Zeller.



The astronomer Daniel Chalonge
Observing at Jungfraujoch 1938

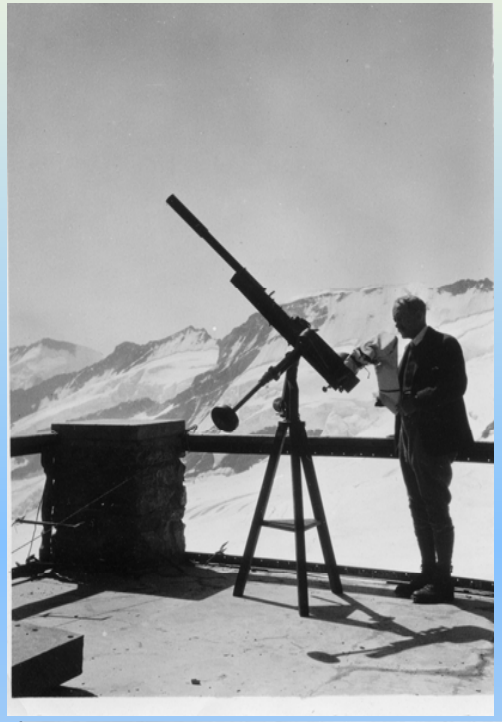


Arthur Kholoster, first researcher at Jungfraujoch 1926

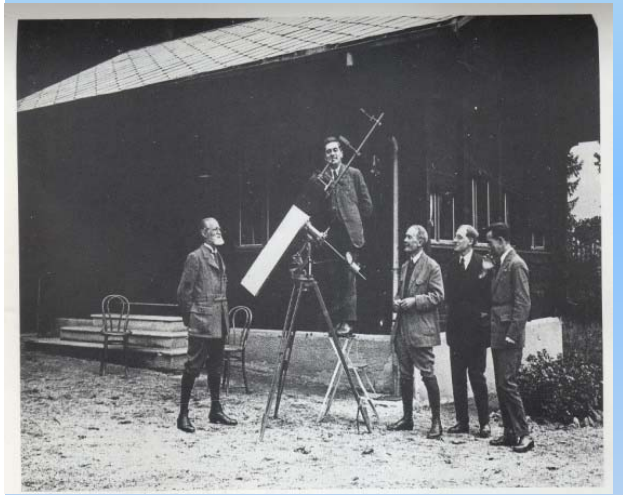


Daniel Chalonge (1895-1977), astronomer of the Observatoire de Paris and one of the founders of the Institut d'Astrophysique de Paris, dedicated hislife at two passions: the scientific research and the mountains.

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



trographe Chalonge sur la terrasse du Berghaus au Jungfraujoch.
ut : Emmanuel Dubois, Léon Bloch, René Maus, Eugène Bloch,
rice Richard, Pierre-Émile Lambert et assis, Maurice Lambrey.
Au fond, les crêtes de la Jungfrau (8 août 1928)



At Vallot Hut with Joseph Vallot

Observation at Jungfraujoch

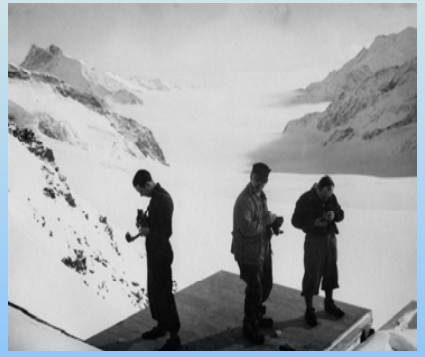
Observation at Vallot Hut

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

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

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

Daniel Chalonge

Daniel Chalonge at Jungfraujoch transporting the spectrograph on the slope to the Sphinx observatory

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

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

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

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

Testa Grigia Laboratory 3480 m asl Italy

Testa Grigia laboratory
Plateau Rosa Cervino

Research in Cosmic Ray Physic

Enrico Fermi designed the laboratory for the cosmic rays study and for high energy physics' The Testa Grigia Laboratory was built in 1947 by the Study Center for Nuclear Physics of CNR (National Council of Research). On behalf of the Institute of Physics in Rome, headed by Edoardo Amaldi, the project and realization were due to Gilberto Bernardini, Claudio Longo and Ettore Pancini.

Enrico Fermi, Franco Rasetti, Nello Carrara.

E. Amaldi, G. Bernardini, E. Pancini, Laboratorio Testa Grigia 1947.

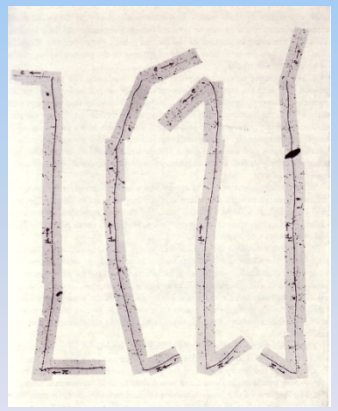
Enrico Persico (1950

Chacaltaya laboratory 5400m Bolivia

- The laboratory was founded in the september 1942 by Ismael Escobar, initially as a meteorological station. The pions was discovered in 1947 trought the method of nuclear emulsion by Cesare Lattes, Giuseppe Occhialini e Cecil Powell (Nobel prize 1950) confirming the theory of Yukawa (Nobel prize *1949);*

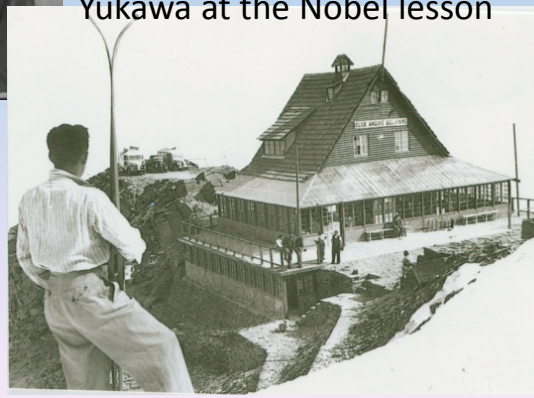
Yukawa at the Nobel lesson

Cesare Lattes a Chacaltaya (1950).



The historical image of decay tracks of the meson π. in nuclear emulsion ; π decays in the meson μ , that decays in electron and neutrinos

(π → μ → e+ν).



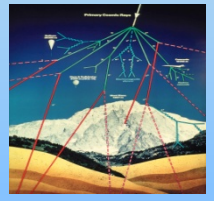
G.Handel at the Club Andino Boliviano 1947

In the High Altitude Research Stations there are optimal conditions for scientific research

No light pollution
Assenza di inquinamento luminoso

No anthropogenic pollution
Assenza di inquinamento antropogenico

High UV intesity
Alta intensità UV

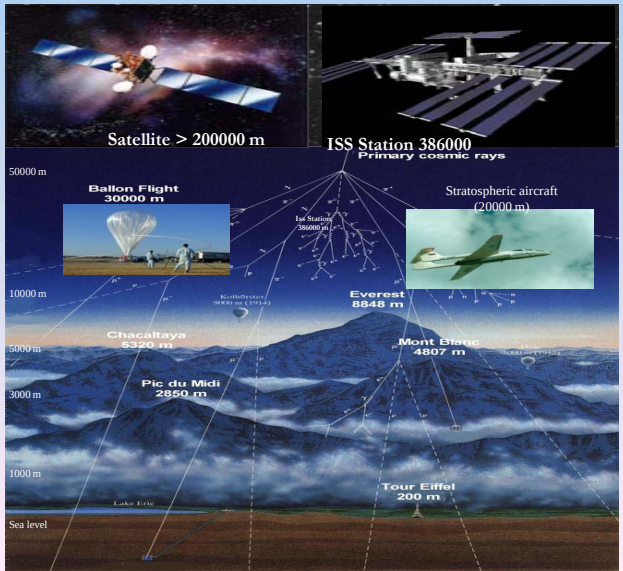


High cosmic ray flux
Alto flusso di raggi cosmici

Millenarian glaciers
Ghiacciai millenari

Extreme conditions for human life
Condizioni estreme per la vita umana

Integration in Earth Observation



The High Mountain Research Stations, worldwide distributed, allow to perform contemporary investigation on the “Earth System” at various altitudes and latitudes, in different conditions of atmospheric shielding and geomagnetic field.

The Laboratories represent essential ground–based facilities, integrated in the system of Earth observation:

- high altitude aircraft for scientific flights ~ 20 Km
- stratospheric ballons ~ 30 km
- Low Earth Orbit (LEO) satellites ~ 200Km
- International Space Station (ISS) - 386 Km

Integration in Earth Observation

The High Mountain Research Stations are integrated in some World-Wide Network Monitoring.

WMO

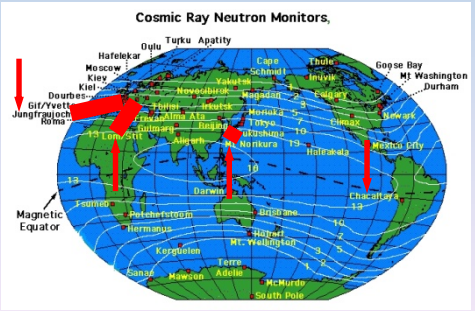
Atmosphere Monitoring

The World Meteorological Organization **(WMO),** an intergovernmental organization with a membership of 187 Member States and Territories, is the specialized agency of the United Nations for meteorology (weather and climate), operational hydrology and related geophysical sciences..

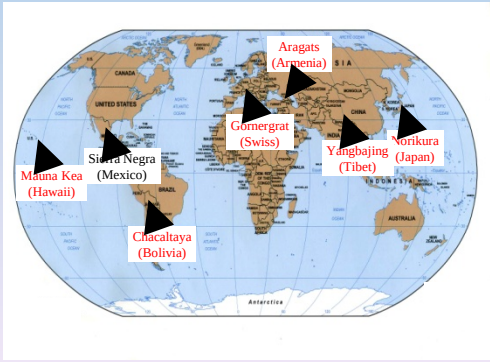
GAW

The Global Atmosphere Watch **(GAW)** programme coordinates the effort of 22 global and some 300 regional atmospheric monitoring stations to produce data that are relevant to climate change.

Cosmic Rays monitoring



Monitoring of variability of cosmic ray intensity on Earth



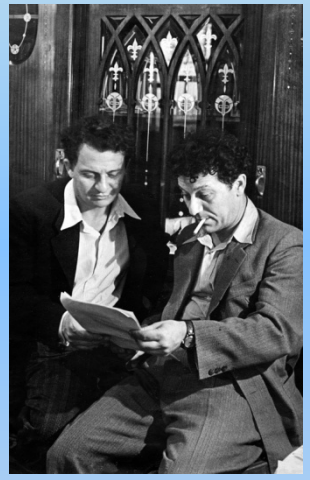
Neutron monitor Network

Space Weather Forecast (Solar Neutron Telescope)

Aragats Observatory Armenia

- **Cosmic Ray research at the high altitude station on Mt. Aragats was initiated by Alikhanyn brothers, the famous Armenian physicists, in 1943.**

The Aragats Laboratory today



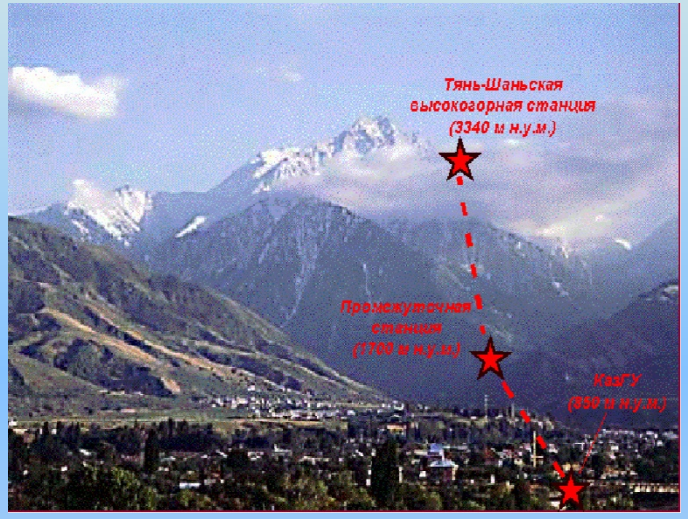
First researchers at Aragats 1945

Cosmic Ray detector

Carrying the instrumentation at the Laboratory 1945

Tien-Shan 3340 m asl Kazakhstan 1961

Research: Astronomy , Cosmic ray physics



Observation at Tien-Shan

ATHLET (Almaty Three Level Experimental Techrique)

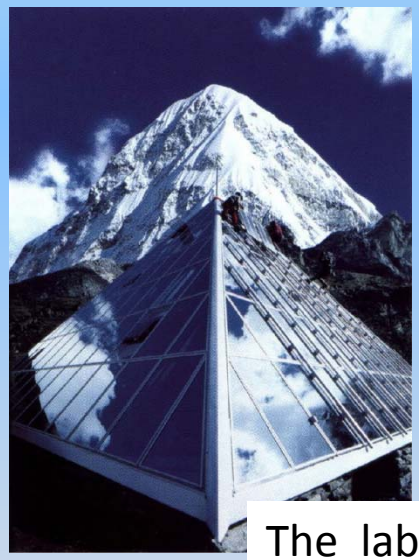
Cosmic Ray detector

Neutron calorimeter

Vladimir Yakolev (on the right) director of the laboratory with the Nobel Prize winner I.M.Frank visiting the station in 1972.

Everest Pyramid 5050 m, Nepal

Research activity: High altitude Physiology and Medicine, Metereology, Climate change



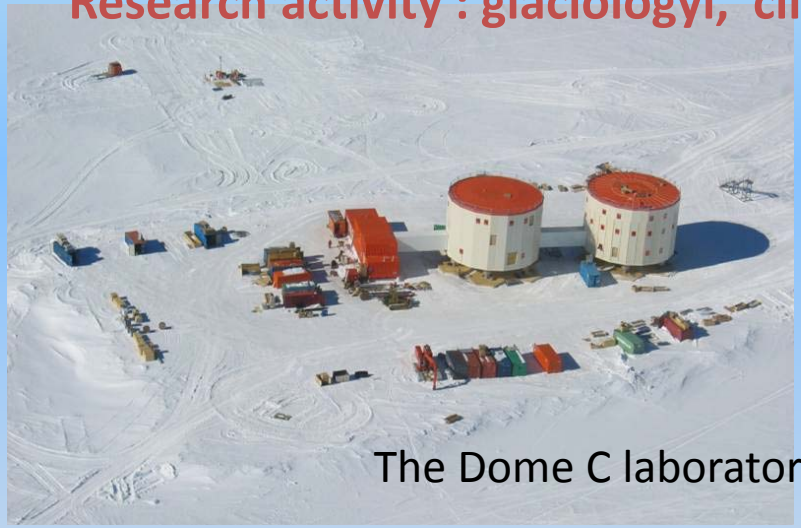
The laboratory ; on the back the Everest Peak

In March 2008 a metereologicl sta
has been installed at the Everest
Colle Sud at 8000 m asl.

Phyisiology experiments

Dome Concordia 3.200 m, Antarctic

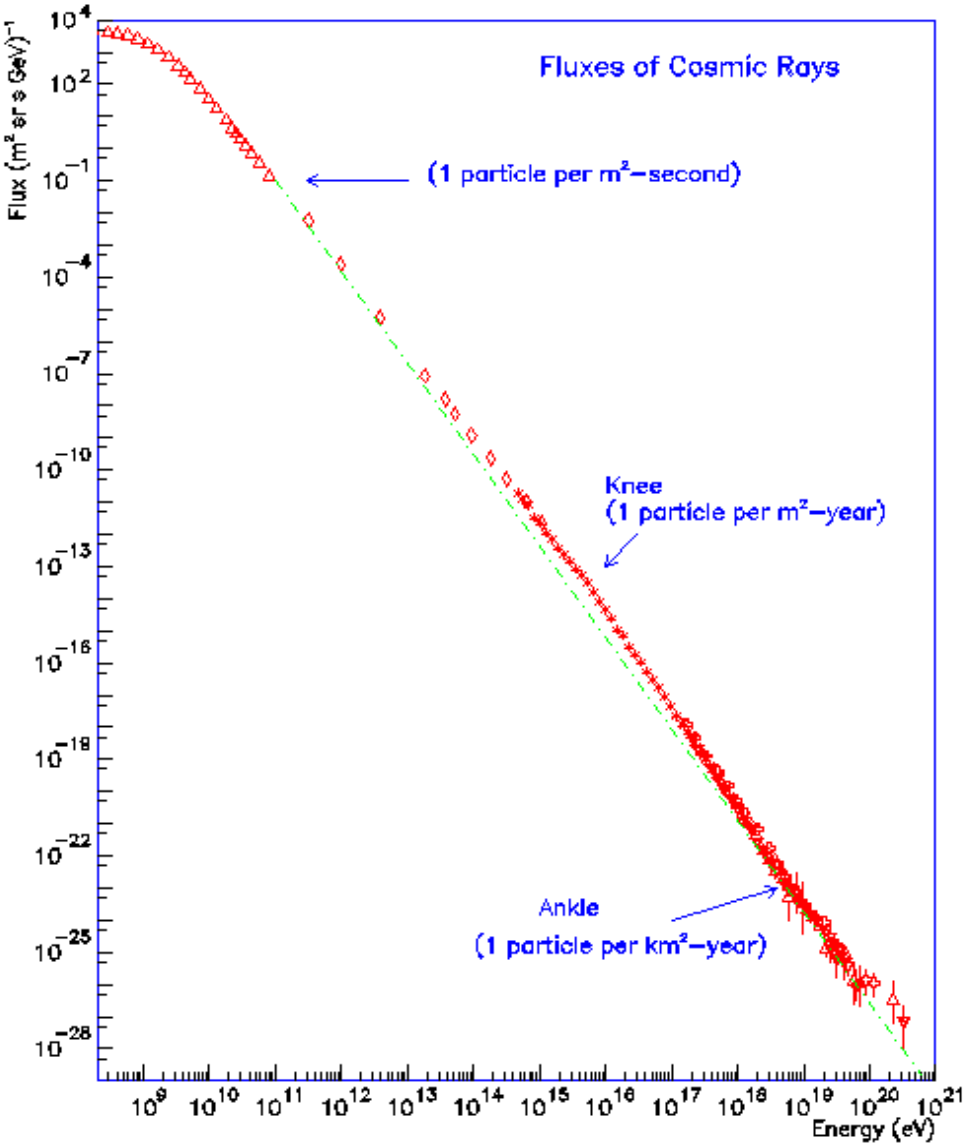
Research activity : glaciologyi, climate change Atmosphere physics



The Dome C laboratory (3200 m asl, Italy-France collaboration)

Ice sample to be analyzed

The cosmic rays studies today

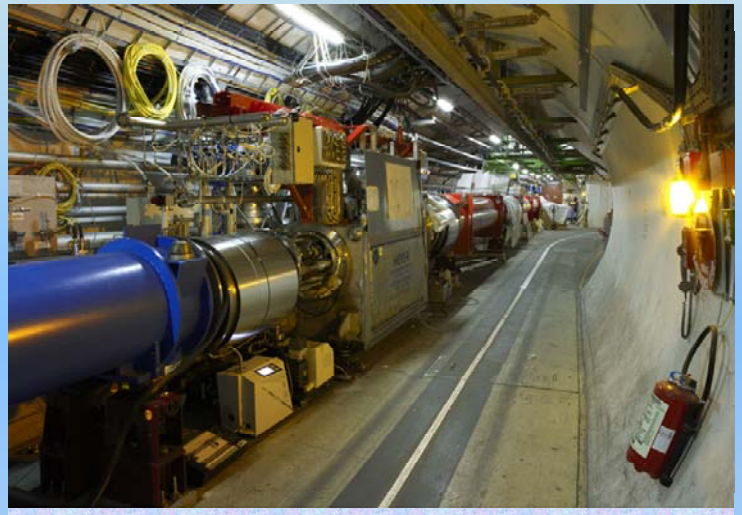


The main interest the very high energy range, (10^{20}eV with a flux<1/km^2/100 years) both for corpuscular and electromagnetic radiation.

Many experiments are performed both at HMO and on satellite and ISS

- Study of Gamma ray burst
- Research for antimatter
- Research for relict particle
- Research for dark matter
- Research for MWB

High Energy Physics



Large Hadron Collider CERN Geneva

- ***Before the construction of the first particle accelerators (about 1950) the high energy physics was experimentally studied only at high altitude research stations, by interaction of cosmic rays with atmosphere nuclei***

- ***Until today, the cosmic ray energies are much more higher that those obtained at particle accelerators***

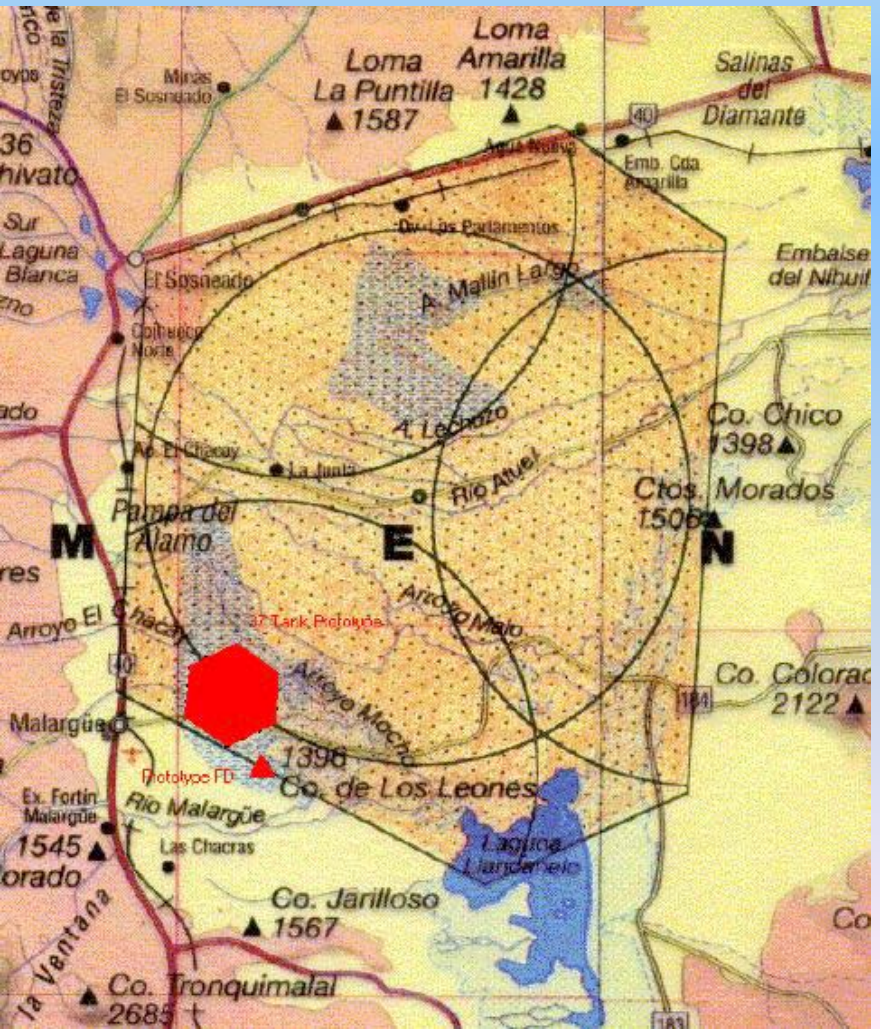
Yang Baj Jing Tibet 4300m Cosmic ray observatory

Esperimento per la rivelazioni
di sciami di raggi cosmici
ARGO dell'INFN
a Yangbjing in Tibet a 4500m di altitudine.

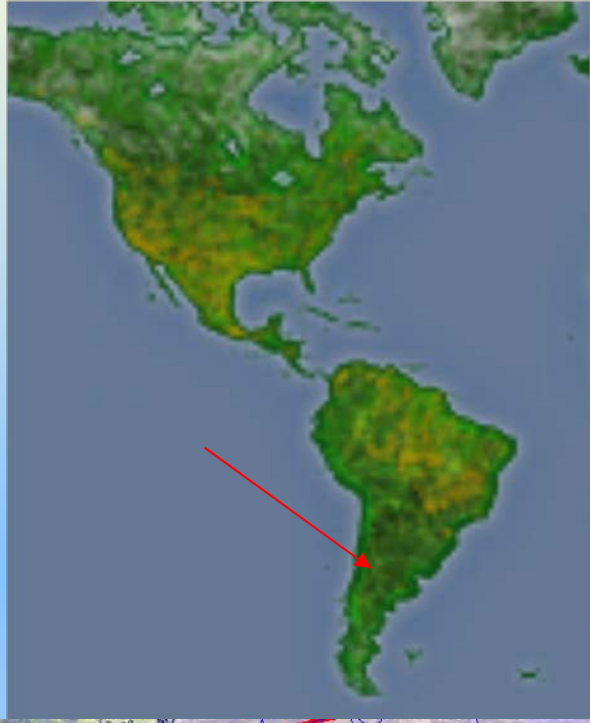
Laboratorio sotterraneo dell'INFN sotto al Gran Sasso

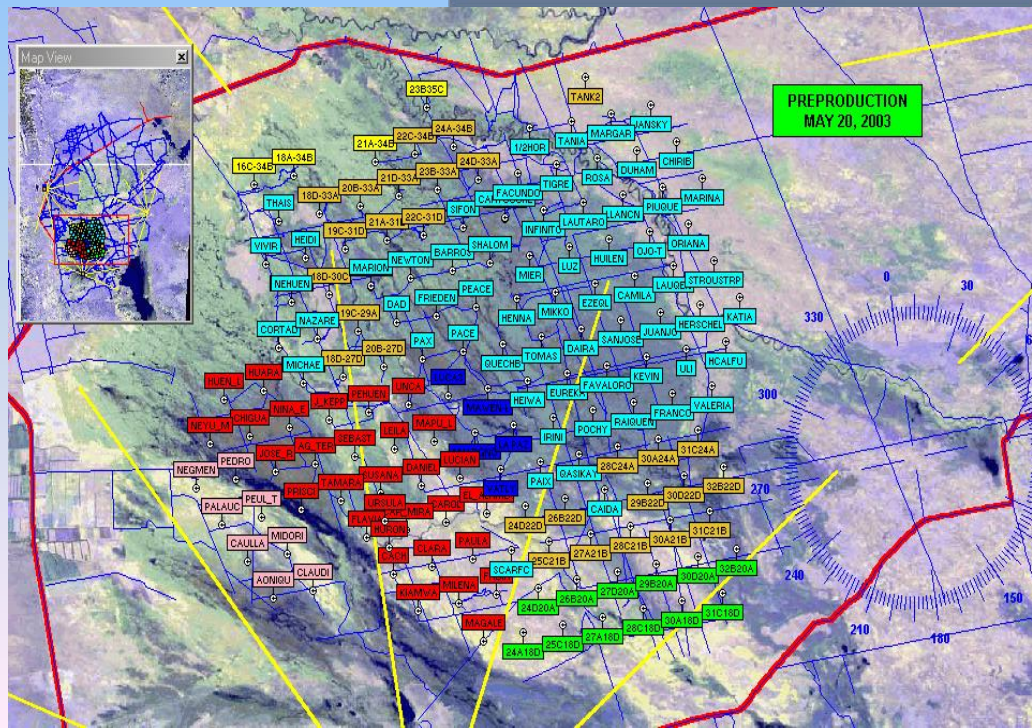
Pierre Auger Project

3000 km^2 coperti



Malargue
Mendoza
Argentina



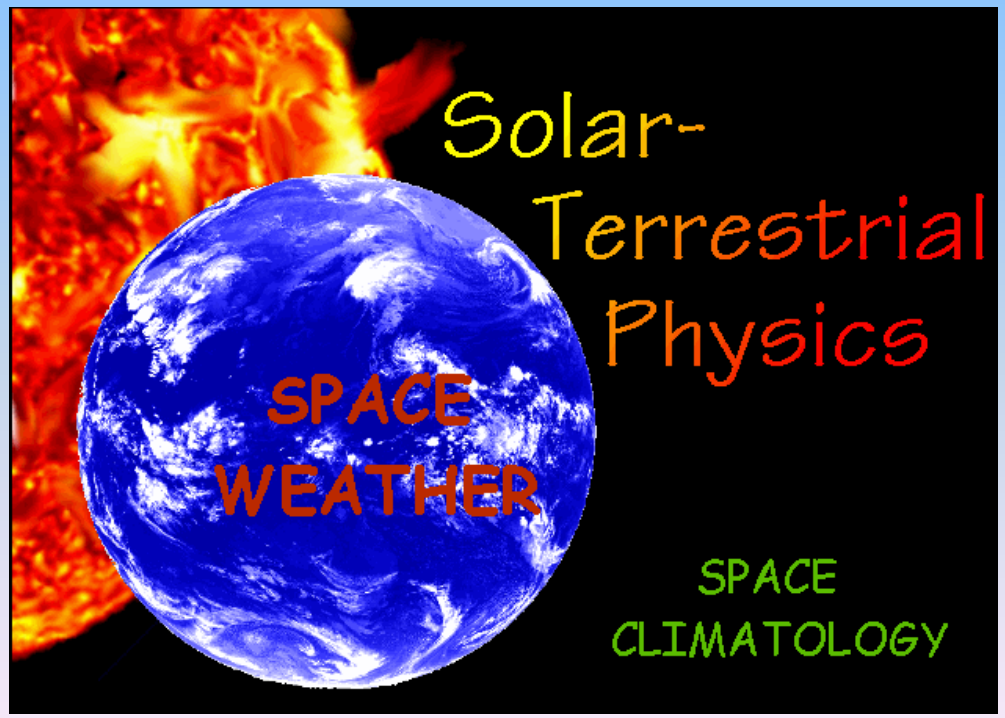


The Cherenkov telescopes

The Magic telescopes at La Palma 2250 m

The Cherenkov telescopes in Arizone

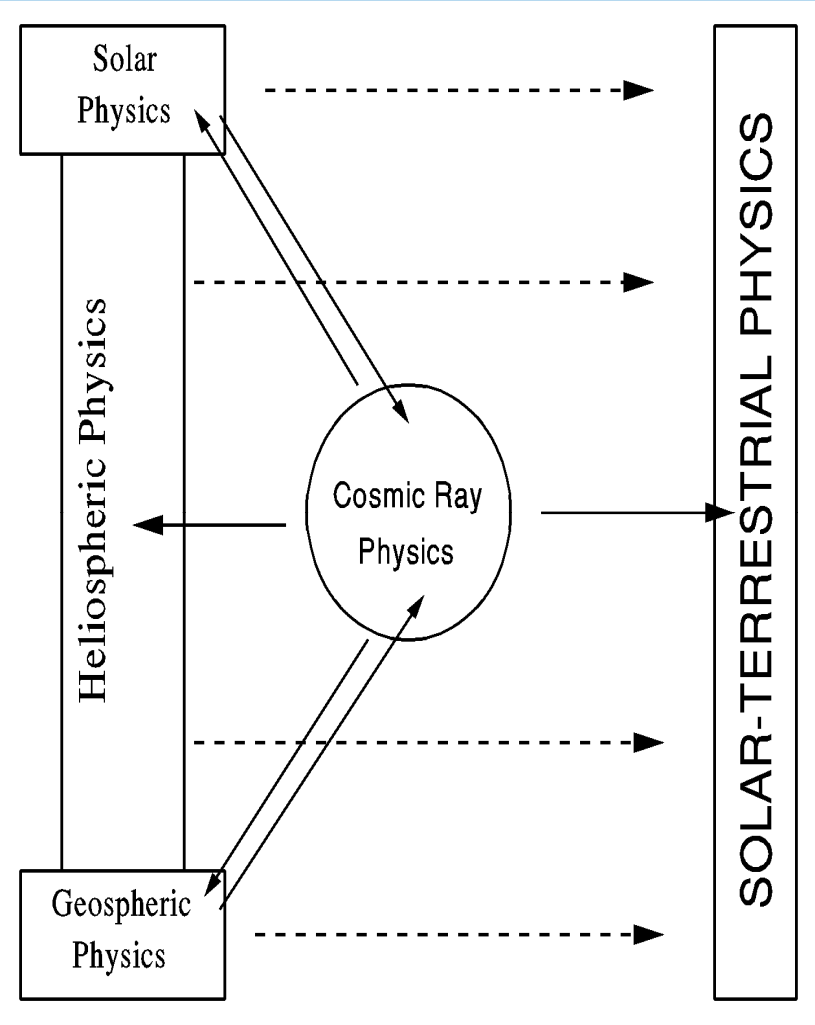
ASTRONOMY



Radiotelescopes

COSMIC RADIATION SECTOR

WHY CR RECORDS ?



WHY HMO LABORATORIES

- **SOME ISSUES INVOLVED :**
- (Direct CR-data use)
  - **Navigation & radio communications**
  - **Hazards flying electronic device**
  - **Radiobiological damages**
  - **Atmospheric ozone depletion**
  - **Weather and Climatology**
- (Indirect CR-data use)
  - **Clinic pathologies & Biosphere**
  - **Catastrophic effects in electric power lines & oil pipelines**
  - **Geomagnetic activity level**
  - **Aurorae and associated effects**
  - **Atmospheric Ozone dynamic**
  - **Ionospheric Research**

COSMIC RADIATION SECTOR

- **CR TASKS**
- Prompt data for Space Weather
- Revised data for Space Climatology
- Tools for high-speed solar wind streams identification
- Identification of Earth's induced effects on cosmic radiation (air mass, atmospheric temperature, electric fields, geomagnetic and latitude dependences, north-south differences, secular variations, jerks, geomagnetic anomalies, …)
- Data files in the international formats for the World-Wide Network of detectors
- Study of solar and galactic cosmic rays and their relation with modulation phenomena (short-, medium- and long-term basis)
- Cosmic ray induced effects in the terrestrial environment

EXPERIMENTAL WORK FOR NEW COUNTERS


Mountains , not only for sport activities, but privileged sites for scientific research
Thak you for your attention