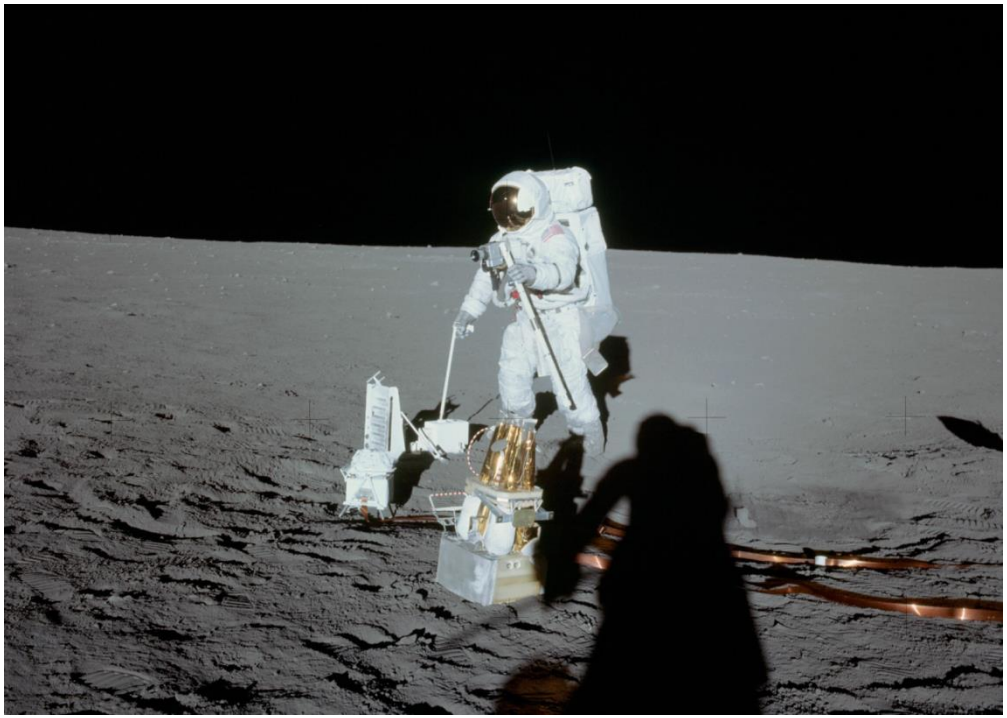
Radiation hazards for astronauts: the part of cosmic rays.



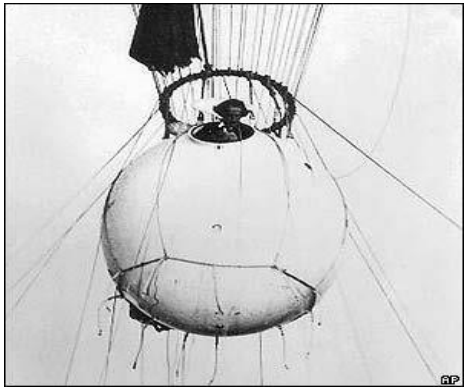
- History
- Apollo
- ISS and current Mars missions.
- Future

Christian Muller

Cosmic Rays: first space discovery

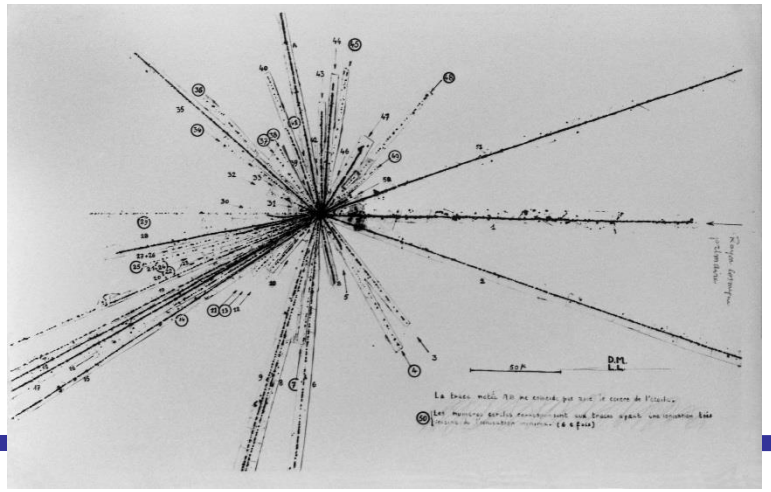
- 1910-1912: Victor Hess by flying electroscopes up to 11000 m. discovers that the radiation responsible for spontaneous ionisation phenomena observed by previous physicists could not originate from the earth nor from the sun.
- Victor Hess shared the 1936 Nobel prize with Carl Anderson who had identified the positron in cosmic radiation.

1931: Professor Picard reaches the stratosphere with clear scientific objectives: the study of cosmic rays, this flight has already two aspects of manned flight: cabin pressurization and in flight oxygen production.



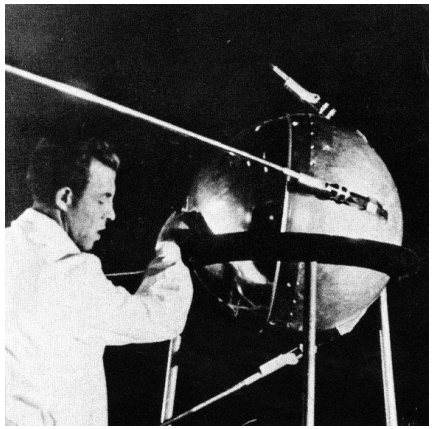
Human decisions were everywhere in this flight where nothing ran as expected (rotating gondola ..).

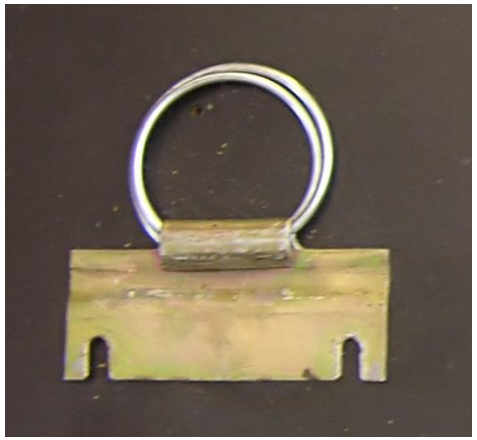
Photographic techniques were essential, before the development of accelerators, the secondary particles produced by the collisions of cosmic rays with atoms were the essential sources of particle physics discovery.



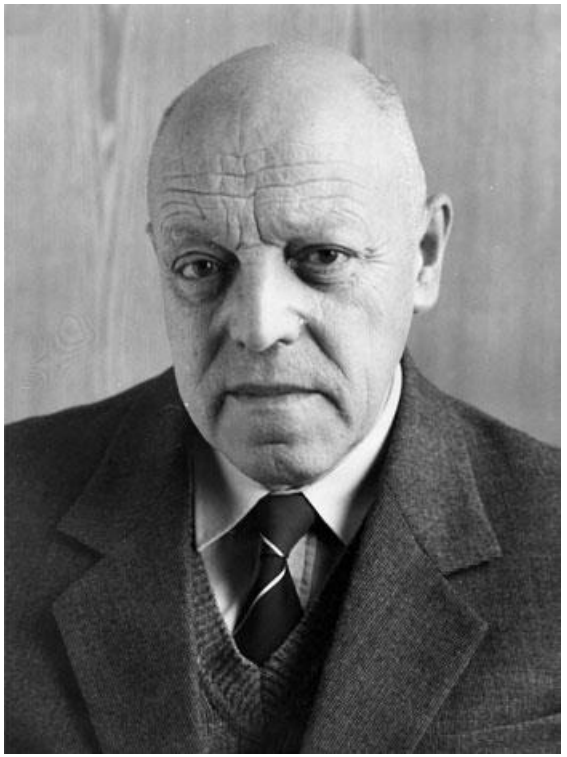
1957: launch of the first artificial satellites, first scientific results on the ionosphere and space plasma layers.

James Van Allen came from sounding rockets.





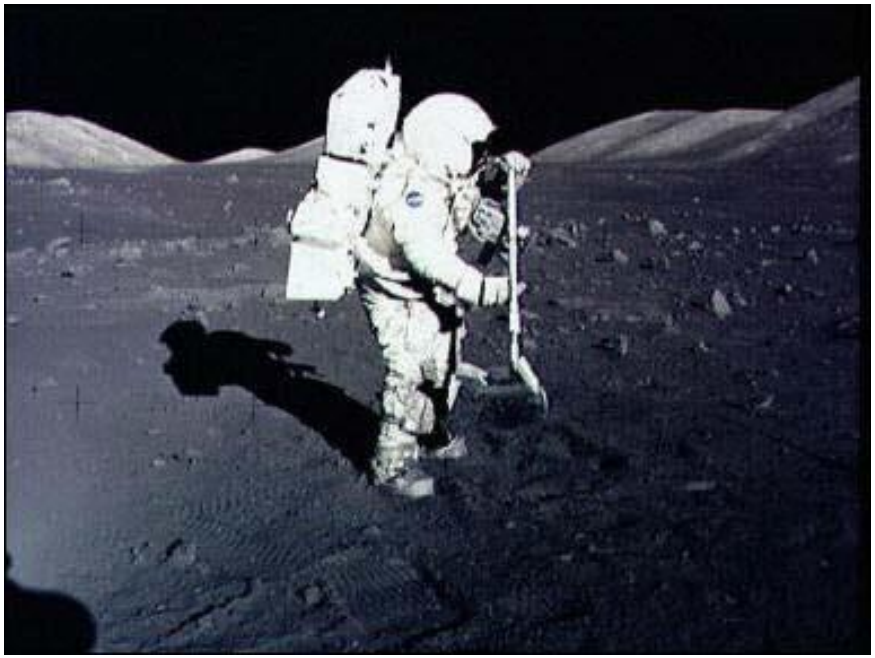
Konstantin Gringauz choose the transmitter frequency of Sputnik 1 and switched it on the launch pad.



Effect of cosmic rays during Apollo operations

- Apollo astronauts had about once every 3 seconds visual flashes out of the magnetosphere.
- Cause: Cherenkov radiation created as the cosmic ray particles pass through the vitreous humour of the astronauts' eyes, direct interaction with the optic nerve, or direct interaction with visual centres in the brain?
- Apollo 16 and Apollo 17 flew the ALFMED Experiment and demonstrated the relation of these flashes to cosmic rays.

No specific astronaut morbidity: very small cohort.



1969: plans for a 100 persons station

Unfortunately, less than 600 people travelled in space to this date.

NASA's Longitudinal Study of Astronaut Health

- NASA matched a group of 336 astronauts with NASA employees.
- “Overall mortality has been significantly higher for the astronaut group in every analysis. Data presented to the committee in January 2003, just prior to the loss of the space shuttle Columbia and its crew of 7, showed 29 deaths among the 312 astronauts in the LSAH database and only 17 deaths among the 912 comparison participants. Accidental deaths, including 8 in spacecraft losses, accounted for 20 of the astronaut deaths (versus only 2 in the comparison group). The groups did not differ significantly in mortality from any other cause.”

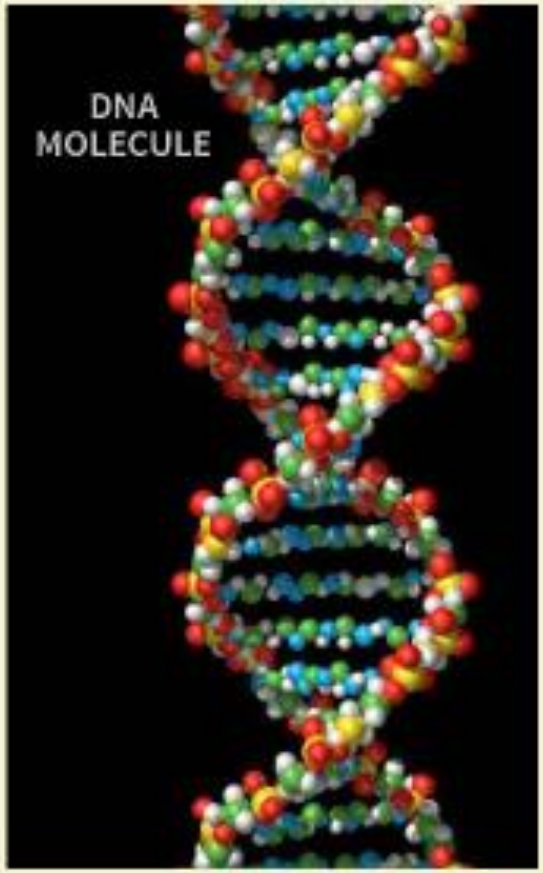
NASA's Longitudinal Study of Astronaut Health

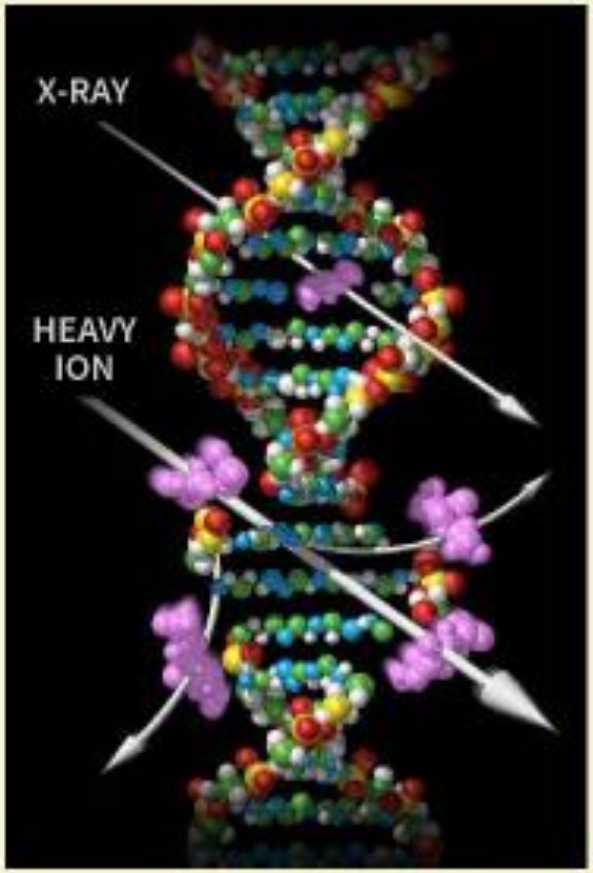
- "Because of the known association of some cancers with radiation exposure, surveillance of astronauts for malignancies was planned from the beginning of the LSAH. Craig Fischer briefed the committee on the comparison of cancer incidence among the astronauts (Fischer, 2003), the LSAH comparison participants, and an age- and sex-matched sample of the National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) database. Fourteen cases of cancer (excluding 33 cases of non-melanoma skin cancer) were diagnosed among the 312 astronauts followed from 1959 to the present. This is 59 percent higher than the comparison group per person/year (not statistically significant), but 46 percent lower per person/year than the SEER data (statistically significant)."
- Other studies underway: problem of choosing a control group.

How Radiation Harms the Human Body

Radiation in space takes the form of **subatomic particles** from the sun as well as from sources in the Milky Way galaxy and beyond. These high-speed particles **tear through DNA** molecules, splitting them or damaging the instructions they have encoded for cell reproduction. The damaged DNA can lead to cancers or other diseases.

Radiation exposure can be **acute** (a high dose in a short period of time) or **chronic** (low levels of radiation over a long time).

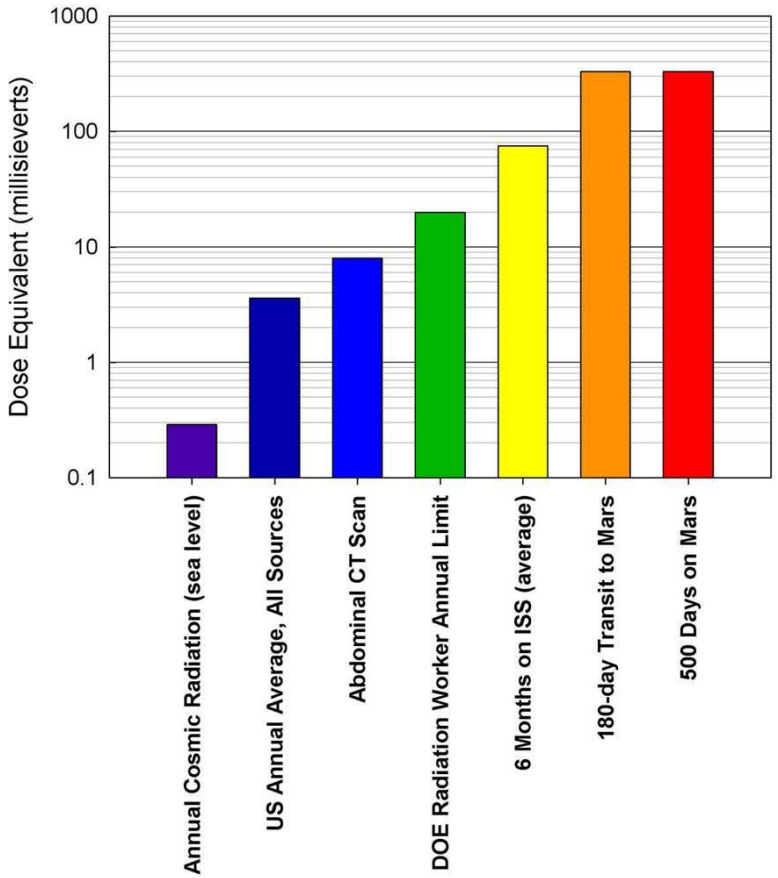




Repartition of energetic particles

- Galactic cosmic rays (GCRs) consist of high energy protons (85%), helium (14%) and other high energy nuclei.
- Solar energetic particles consist primarily of protons accelerated by the Sun to high energies via proximity to solar flares and coronal mass ejections.
- GCR create secondary particles on light shielding.

Actual RAD results on MSL



During the MSL-curiosity cruise to Mars, the following radiation doses were measured and are compared with other doses.

The dose on 1 Sievert causes 5.5 % increase in cancer probability.

2 Sievert correspond to symptoms of radiation poisoning.

4 Sievert can be fatal, 8 Sievert cannot be treated by current medical procedures.

Conclusions

- The Mars trip is possible but dangerously close to the toxic limit.
- Protective action: shielding with non metallic hydrogen or oxygen rich layers: water, polyethylene. On Mars: underground habitat? Ice or concrete layering. Magnetic shielding during the cruise?