National Institute for Laser, Plasma and Radiation Physics

INFLPR

Biology 4 Space

Workshop

27/4/2023

CENTER FOR ADVANCED LASER TECHNOLOGIES

cetal

CETAL-PW CETAL-LaMP CETAL-PhIL

Agenzia Spaziale Italiana

AMS-02

INFN Istituto Nazionale di Fisica Nucleare

AMS@INFN Roma-Sapienza: Current Activities & Future Perspectives

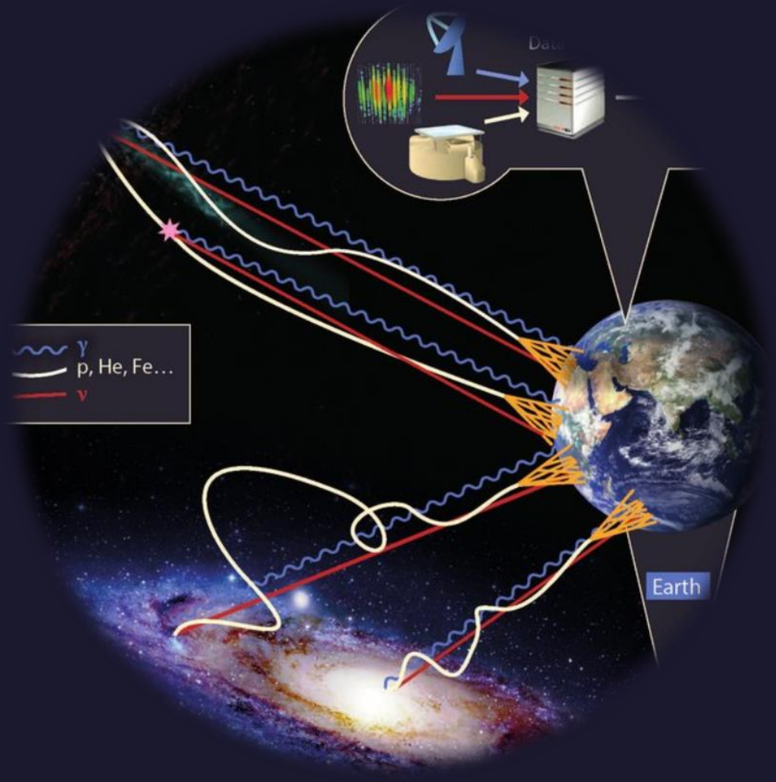
Alessandro Bartoloni
On behalf of the AMS Roma Sapienza group
Italian Institute for Nuclear Physics (INFN)

I gratefully acknowledge the strong support from the AMS collaboration, from the INFN Scientific Committee CNS2 and from the Italian Space Agency (ASI) within the agreement ASI-INFN n. 2019-19-HH.0

Outline & Keywords

- The AMS Roma Sapienza Group
- Space Radiation Characterization
- AstroParticle Experiments
- Enabling Research @ AMS Roma Group

AMS02
(Space Cosmic Ray Detectors)



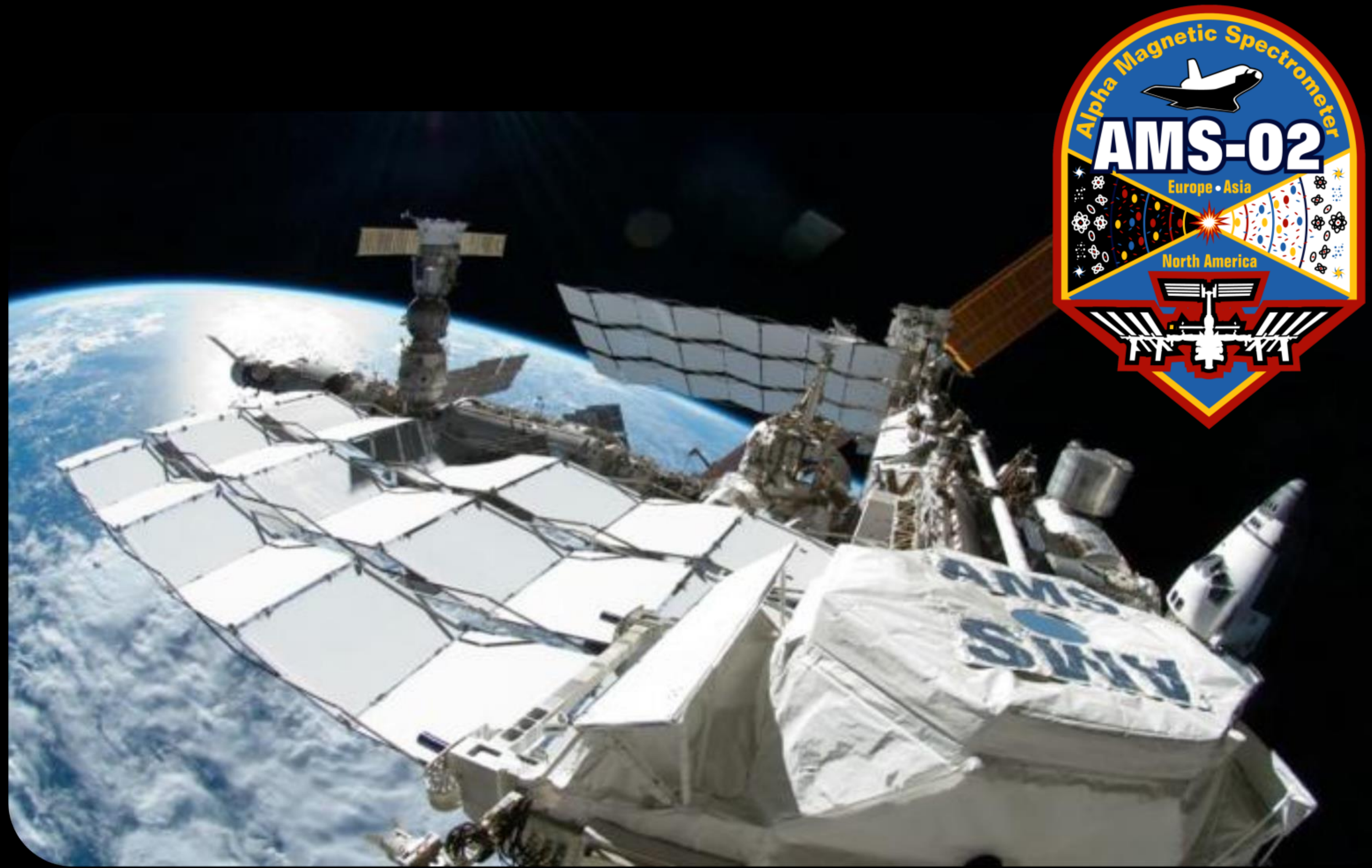
Space Radiation & Radiobiology

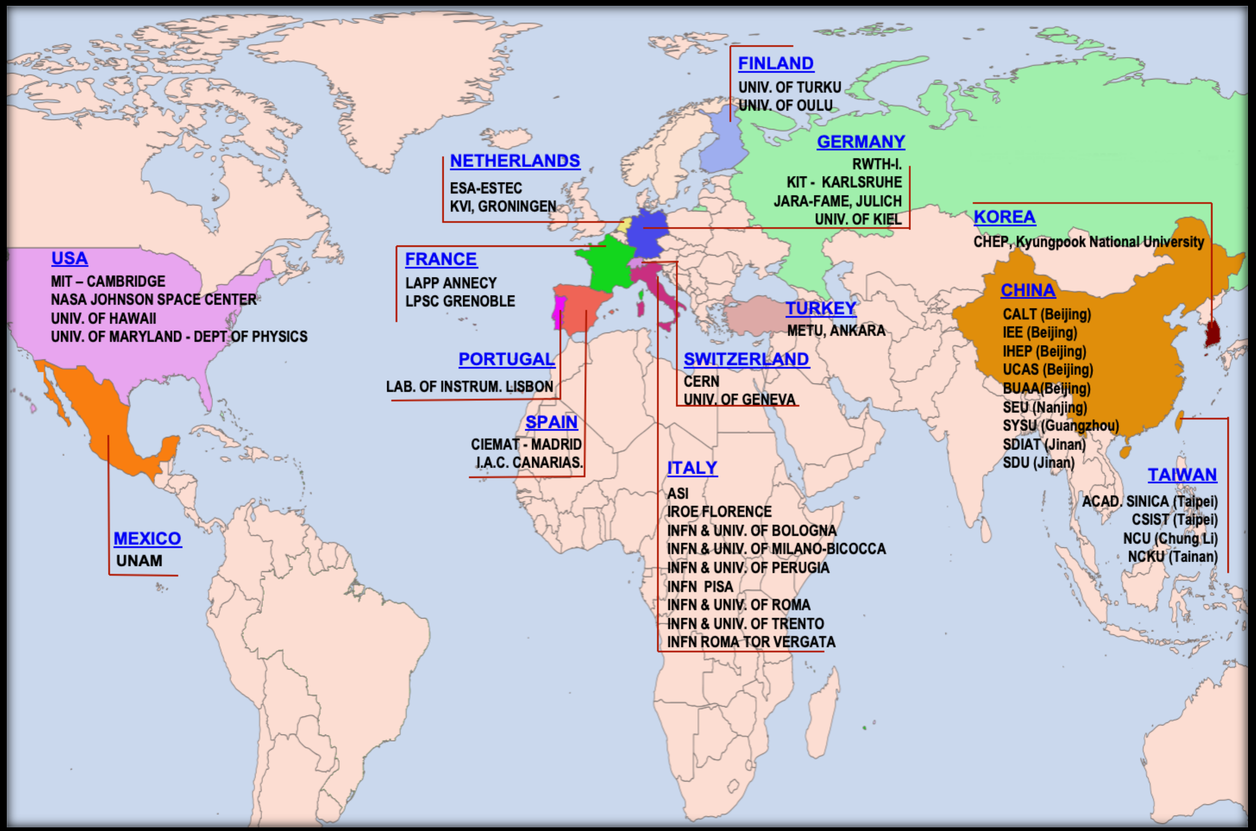
Human Space Exploration

The AMS Roma Sapienza Research Group

Alpha Magnetic Spectrometer AMS02

AMS is a particle detector measuring Galactic Cosmic Ray fluxes.
It was installed on the International Space Station (ISS) on May 19, 2011





The AMS collaboration

(http://ams02.space)

An international collaboration made of 44 Institutes from America, Asia and Europe

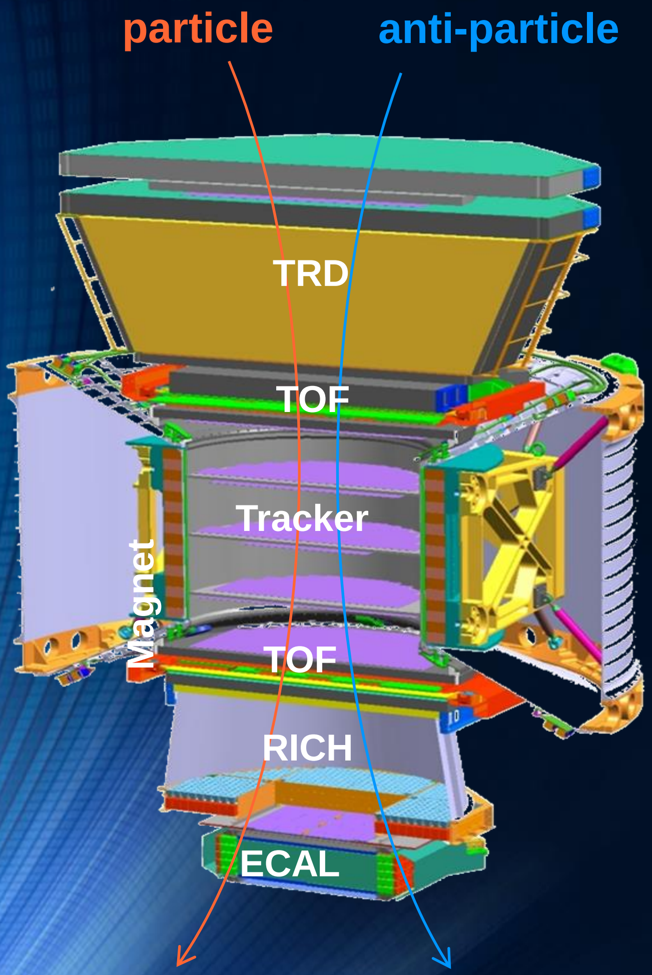
It uses the unique environment of space to study the universe and its origin by searching for antimatter, dark matter while performing precision measurements of cosmic rays' composition and flux.

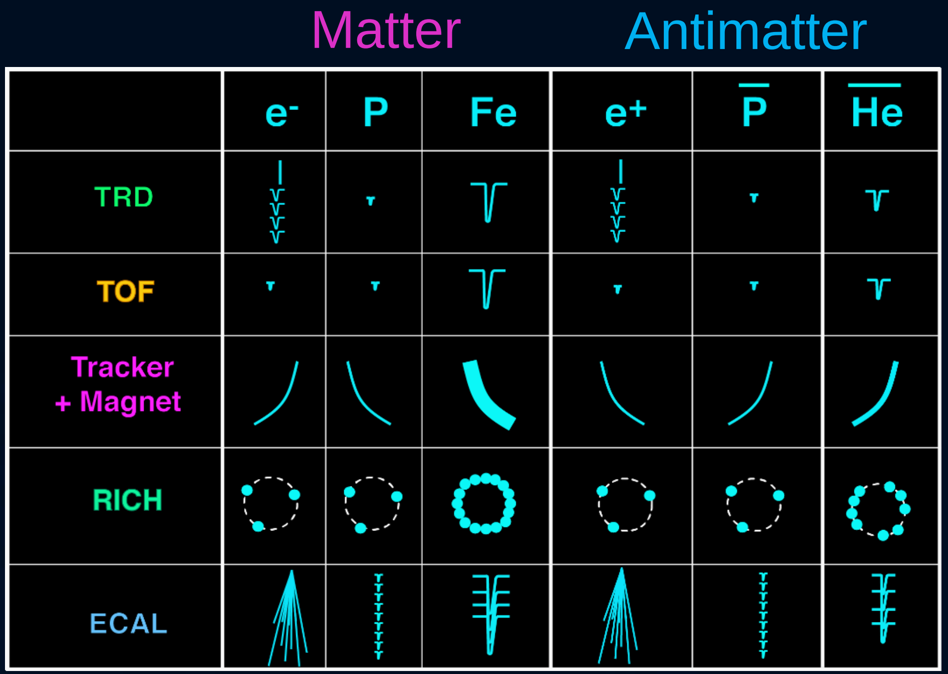
The AMS Payload Operation Control Center at CERN operates 365 days year h24

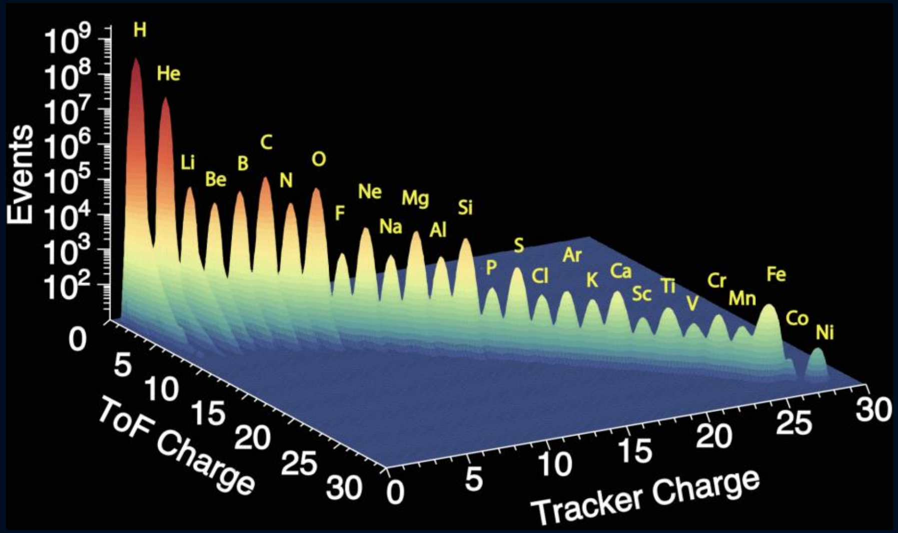
The AMS02 detector has collected so far more than **200 billion** Cosmic Rays events.

More Info in the AMS-02 webpage:
https://ams02.space

AMS is a space version of a precision detector used at accelerators





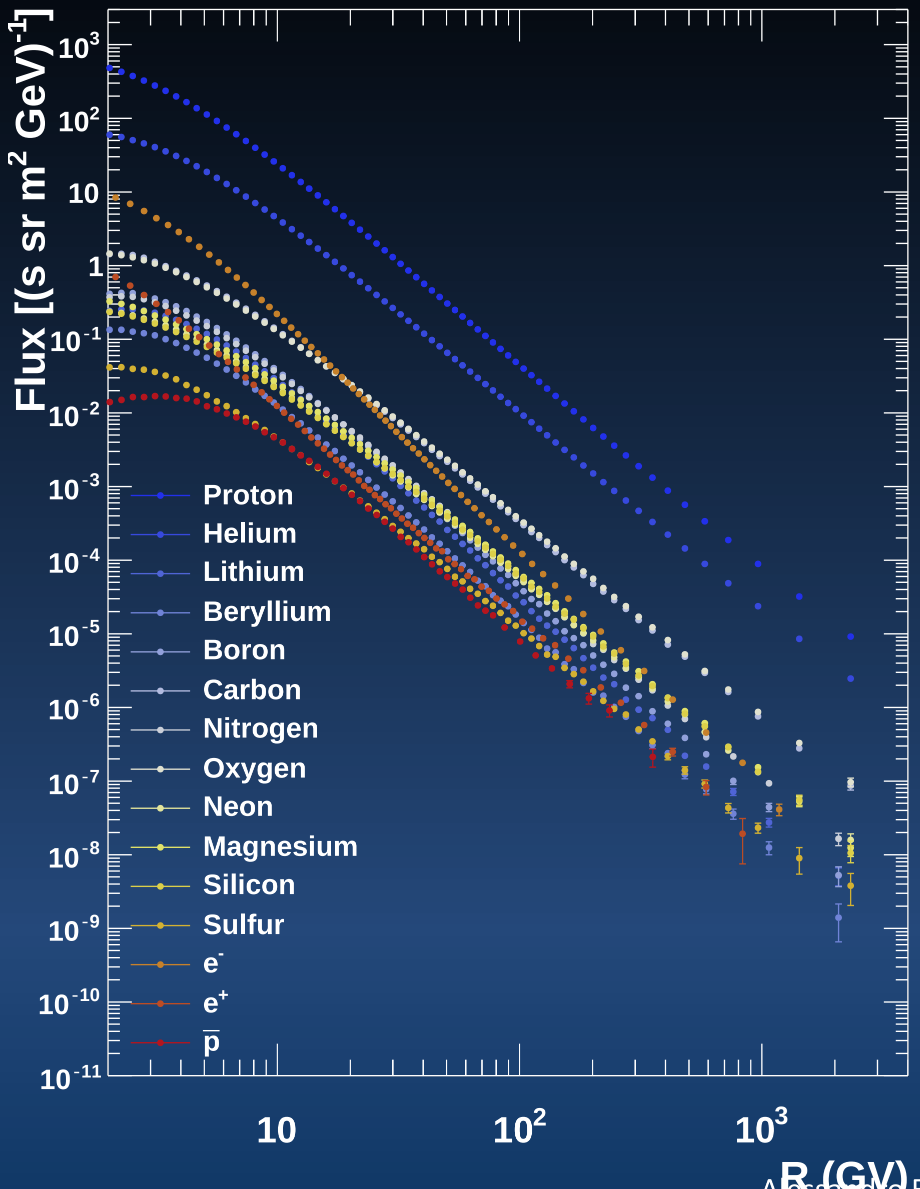


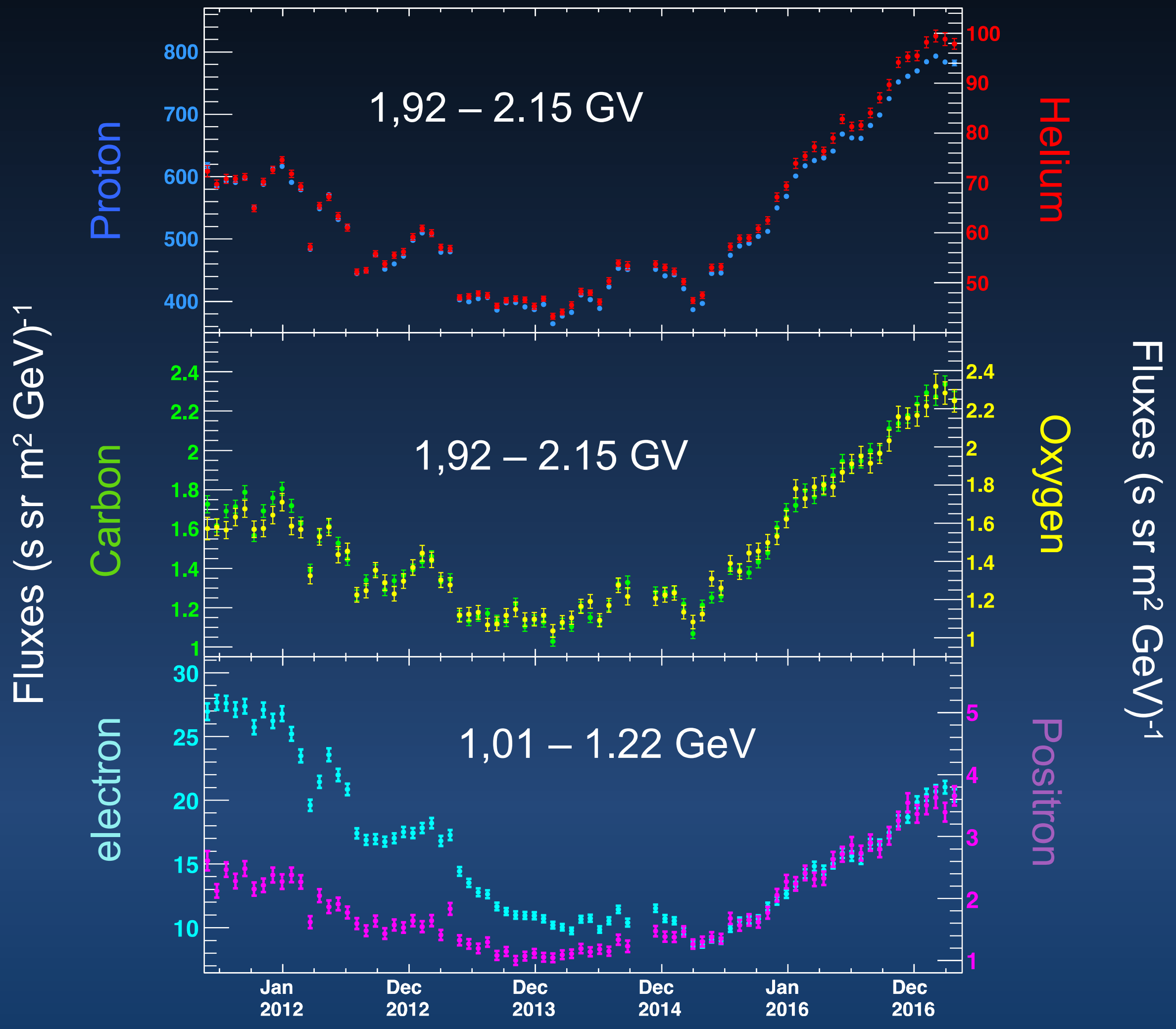
Cosmic-ray properties

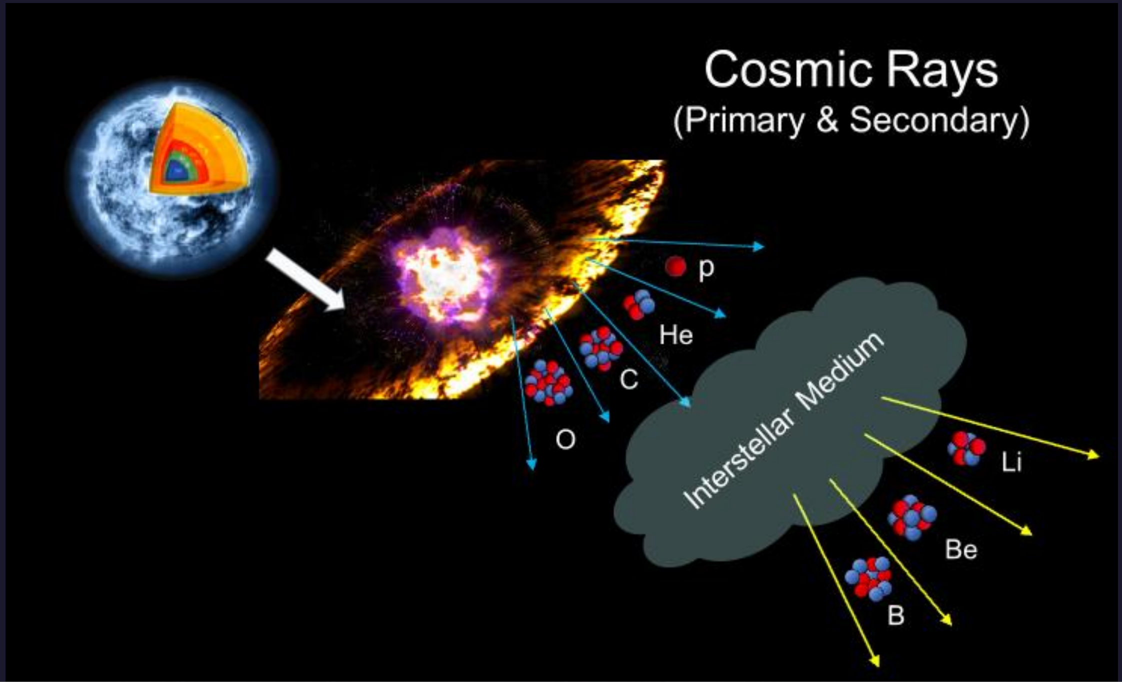
Dark Matter searches

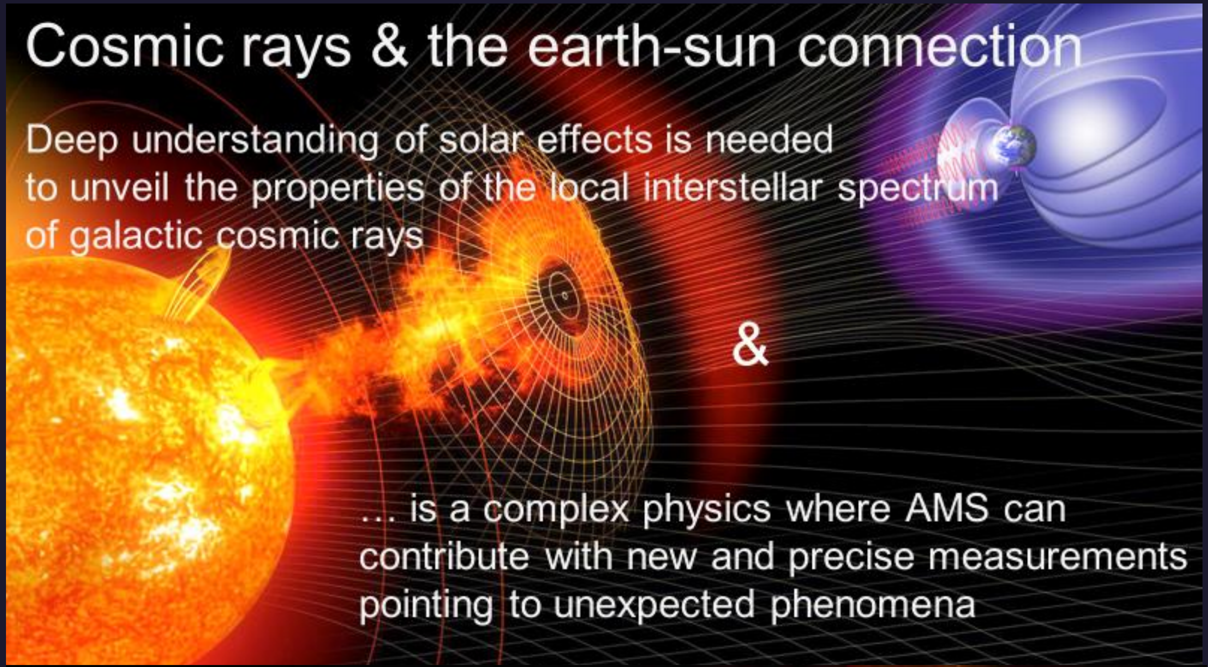
Primordial antimatter searches

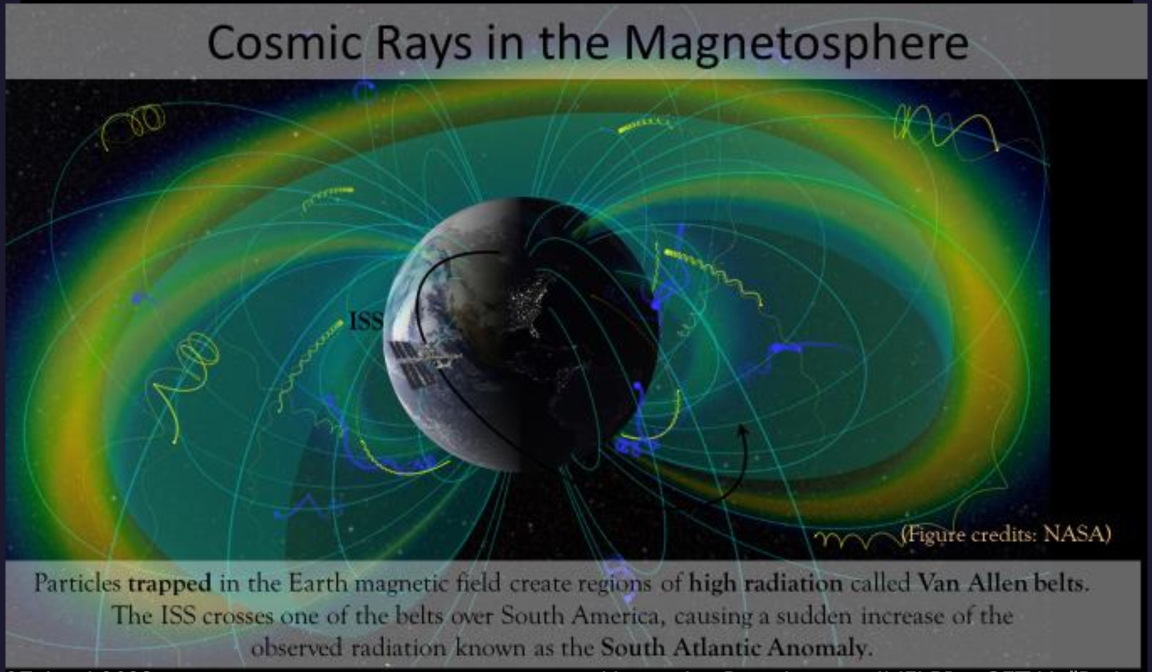
AMS – Measurements

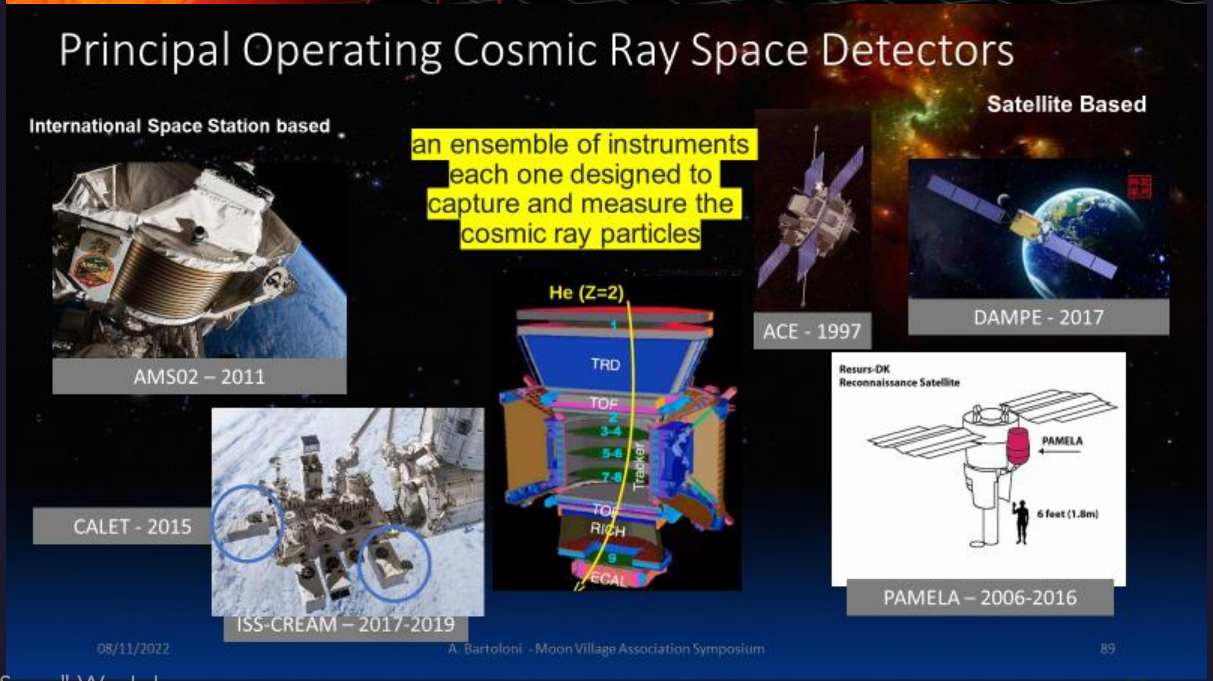





Cosmic Rays
(Primary & Secondary)
p
He
C
O
Interstellar Medium
Li
Be
B


Cosmic rays & the earth-sun connection
Deep understanding of solar effects is needed
to unveil the properties of the local interstellar spectrum
of galactic cosmic rays
&
… is a complex physics where AMS can
contribute with new and precise measurements
pointing to unexpected phenomena


Cosmic Rays in the Magnetosphere
ISS
(Figure credits: NASA)
Particles trapped in the Earth magnetic field create regions of high radiation called Van Allen belts.
The ISS crosses one of the belts over South America, causing a sudden increase of the
observed radiation known as the South Atlantic Anomaly.


Principal Operating Cosmic Ray Space Detectors
International Space Station based
an ensemble of instruments
each one designed to
capture and measure the
cosmic ray particles
Satellite Based
AMS02 – 2011
He (Z=2)
TRD
TOF
Tracker
RICH
ECAL
ACE - 1997
DAMPE - 2017
CALET - 2015
ISS-CREAM – 2017-2019
Resurs-DK
Reconnaissance Satellite
PAMELA
6 feet (1.8m)
PAMELA – 2006-2016
08/11/2022
A. Bartoloni - Moon Village Association Symposium
89

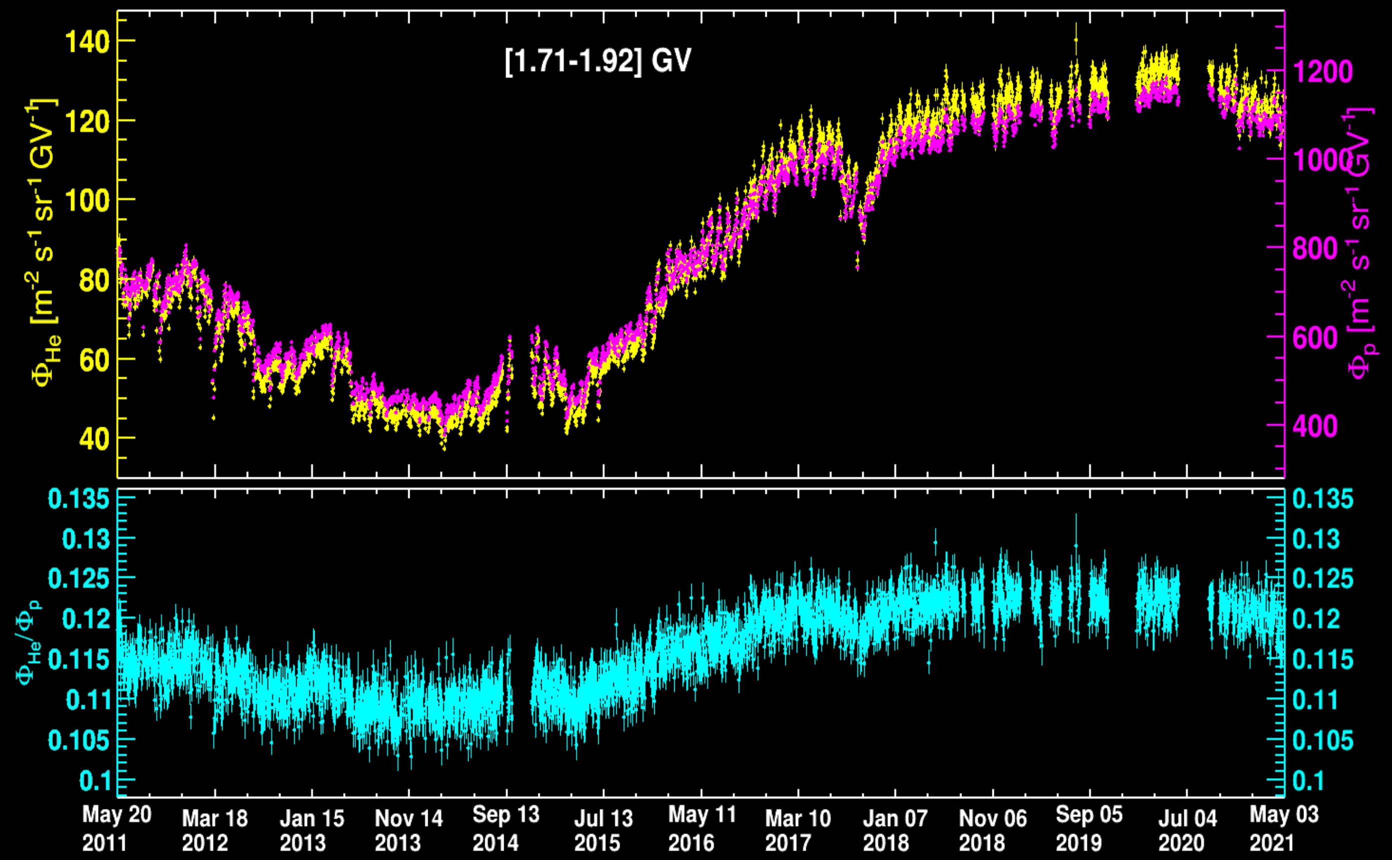
Properties of Daily Helium Fluxes

AMS Collaboration • M. Aguilar (Madrid, CIEMAT) et al. (Jun 10, 2022)

Published in: *Phys.Rev.Lett.* 128 (2022) 23, 231102

Periodicities in the Daily Proton Fluxes from 2011 to 2019 Measured by the Alpha Magnetic Spectrometer on the International Space Station from 1 to 100 GV

AMS Collaboration • M. Aguilar (Madrid, CIEMAT) et al. (Dec 27, 2021)



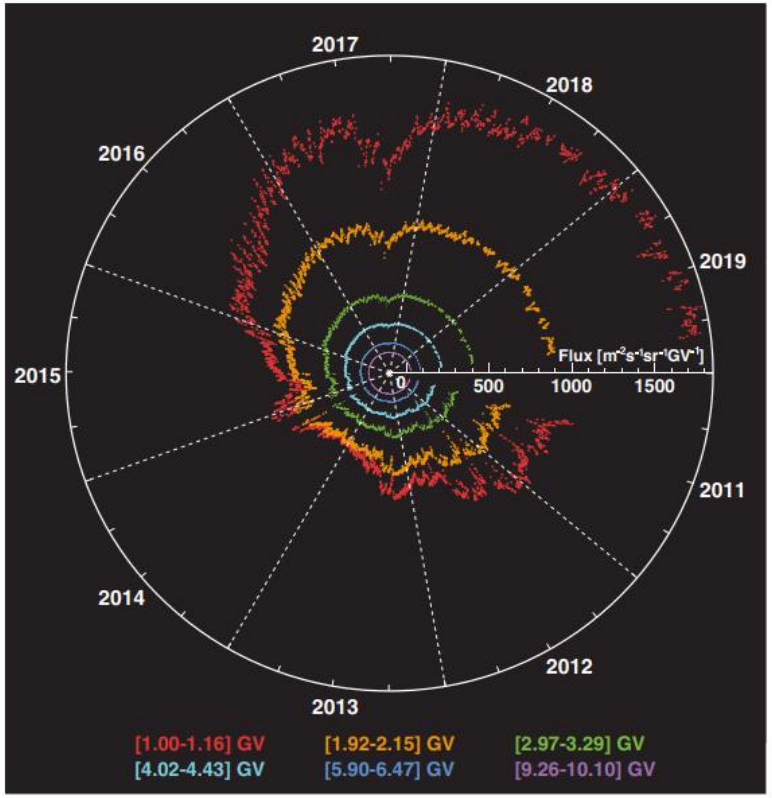


FIG. 1. The daily AMS proton fluxes for six typical rigidity bins from 1.00 to 10.10 GV measured from May 20, 2011 to October 29, 2019 which includes a major portion of solar cycle 24 (from December 2008 to December 2019). The AMS data

Short term Solar Modulation of GCR

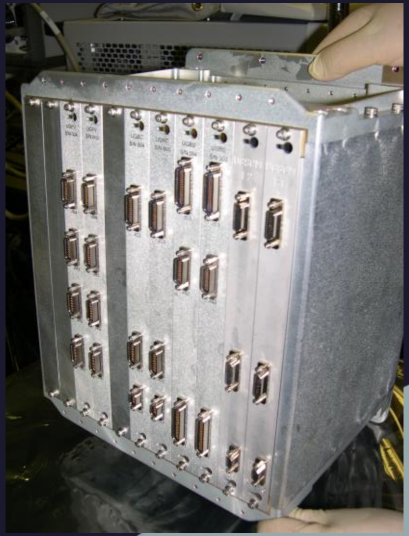
Daily Proton and Helium Fluxes and Helium to Proton flux ratio

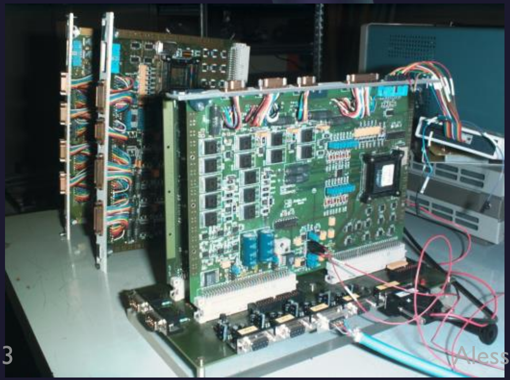
Part of the AMS02 experiment was built at Rome (INFN & Sapienza)

The INFN Roma and the Sapienza university joined the AMS collaboration in 2001.

The group has taken part to the construction of the Transition Radiation Detector (TRD), having as main task the responsibility to develop the slow control electronics of the GAS System of the TRD (UG-Crate).

The UG-CRATE was part of a safety-critical system and the group took care of all the phases of the development (Design–Test-Integrate-Fly) following the NASA requirements.





Design

2001-2003
- Engineering Modules

Test

2004-2005
- Qualification Modules (EMC-Thermo/Vacuum-Vibration Test)

Integrate

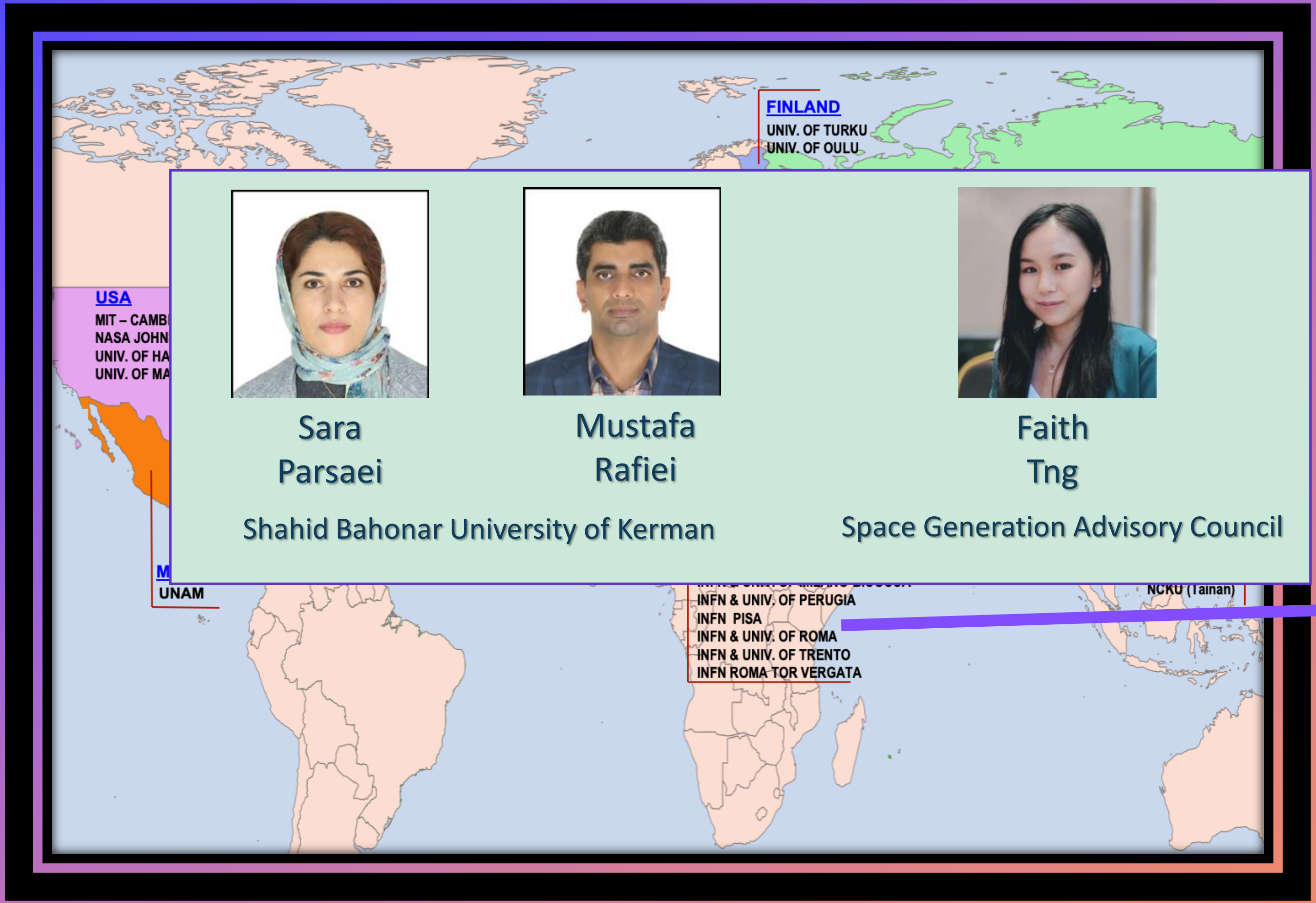
2006-2008
- Flight & Spare Modules production (now on ISS)

Fly

2009-2011
- UGPD-Crate Assembly in AMS02 and Space Qualification at ESA-ESTEC
- Launch ops at NASA-MSFC

The AMS SPRB collaboration was created in 2017 by the synergy of the AMS INFN Roma Sapienza (Italy) group leaded by Alessandro Bartoloni with the medical physics research group leaded by Lidia Strigari currently at IRCCS university Hospital of Bologna (Italy)

AMS INFN
ROMA SAPIENZA GROUP



Aboma Negasa Guracho

Alessandro Bartoloni

- Giuseppe Della Gala

Silvia Strolin

Miriam Santoro

Lidia Strigari

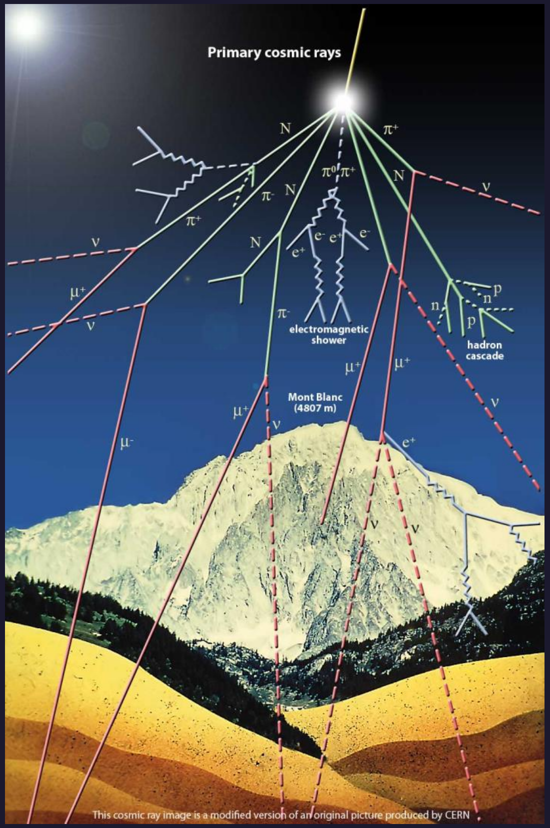
Giulia Paolani

Cosmic rays (CR) approaching our planet interact with the Earth's magnetic field and atmosphere, and such interaction protects humans living on the Earth's surface.

The Magnetosphere rejects most particles (99%) while the rest loose most energy going through the atmosphere before reaching the Earth's surface.

Completely different is the situation in space where the CR interacting with the human body release some energy and can be dangerous for the human health.

In this regard, this is one of the main concerns for safe space exploration as planned for the coming years by all the national space Agencies.



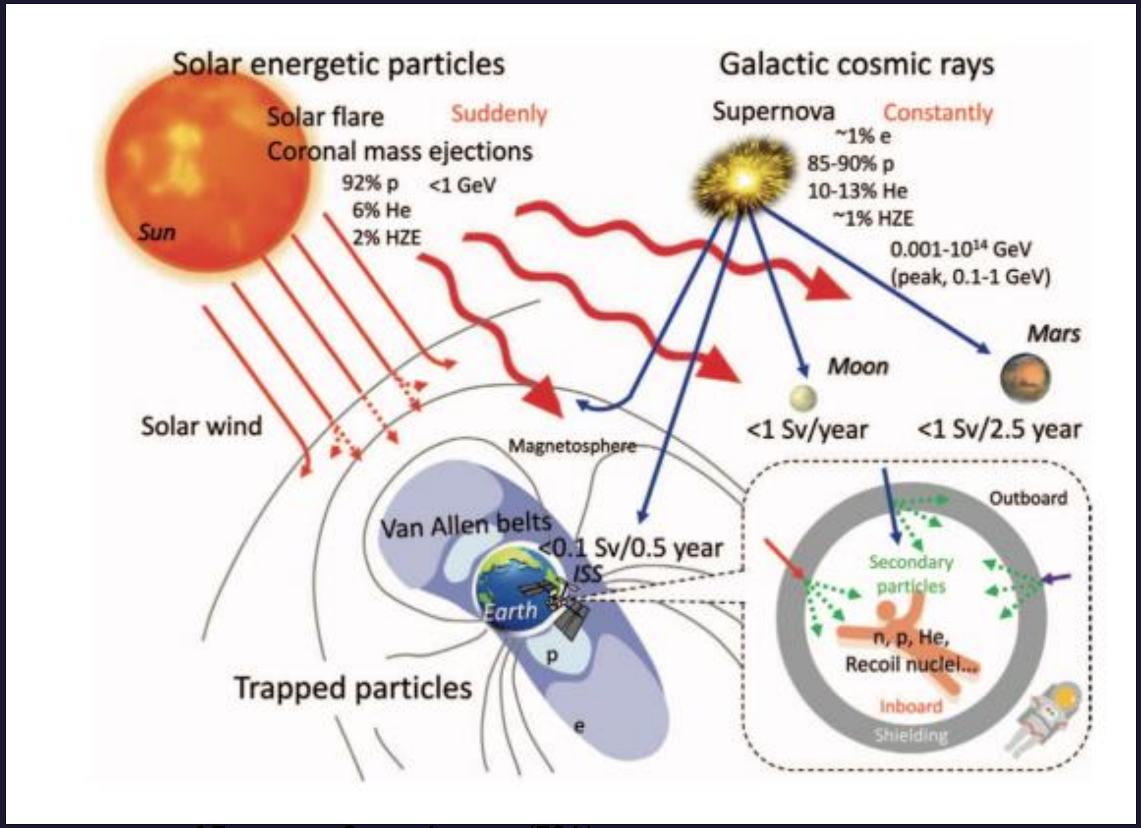


Image courtesy of European Space Agency (ESA)

Since 2018, the INFN Roma Sapienza AMS group has collaborate with researchers and scientists to investigate the possibilities of using the CRD to improve the radiation health risk assessment for humans in space missions.

In 2019 we organize at INFN Roma Sapienza a thematic meeting with participants from ESA and Thales Alenia Space

Collaborations were mainly focused on creating synergy within different scientific communities

(radiobiology, medical physics, radiotherapy, and nuclear medicine)

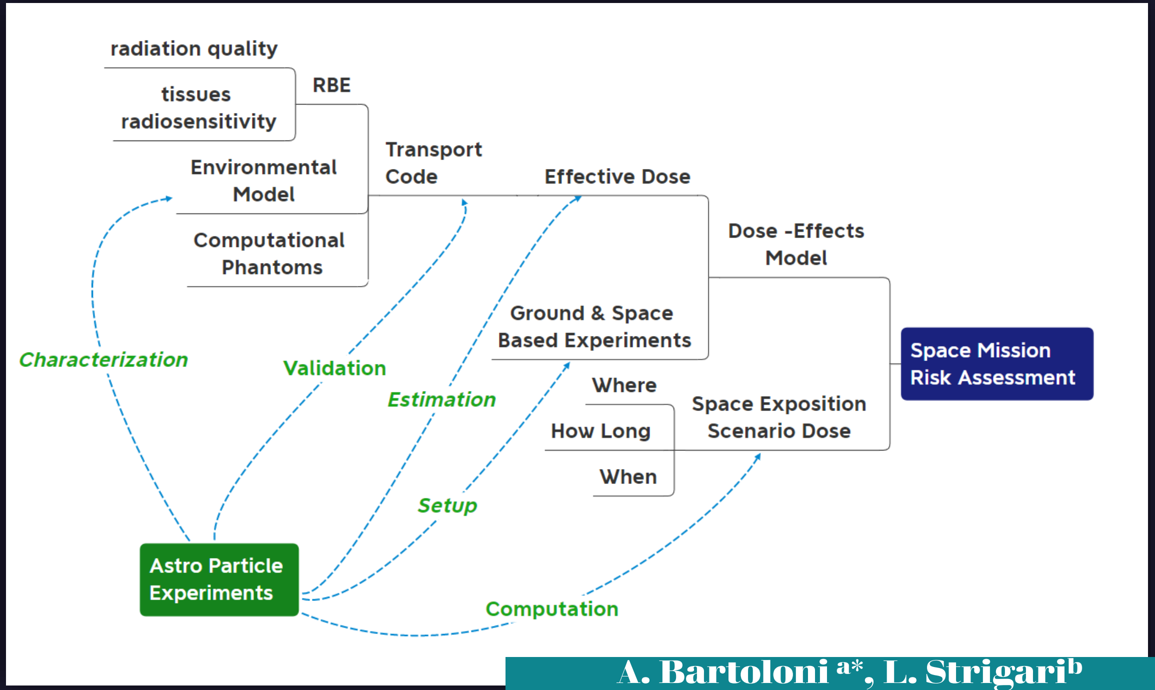
and Institutions playing a crucial role in the human space exploration

(Research, Universities, and National Space Agencies).

We have many studies on the capabilities and possibilities in that direction, especially regarding the AMS02 and also we identify many opportunities for improvement.

AMS02 GCR sensitivity analysis

A. Bartoloni [a]*, L. Strigari[b]
SIF2019



A. Bartoloni [a]*, L. Strigari[b]
GLEX-21-8.2.5 (ID:62186)

SPACE RADIATION
&
ASTRONAUT SAFETY

«To fully understand the relationship between ionizing radiation and biology, and to solve problems in this field, researchers incorporate fundamentals of **biology, physics, astrophysics, planetary science, and engineering»** *(credit : NASA)*

The manned spaceflight especially Beyond the Low Earth Orbit (BLEO) could represent a concern for the health of astronauts.

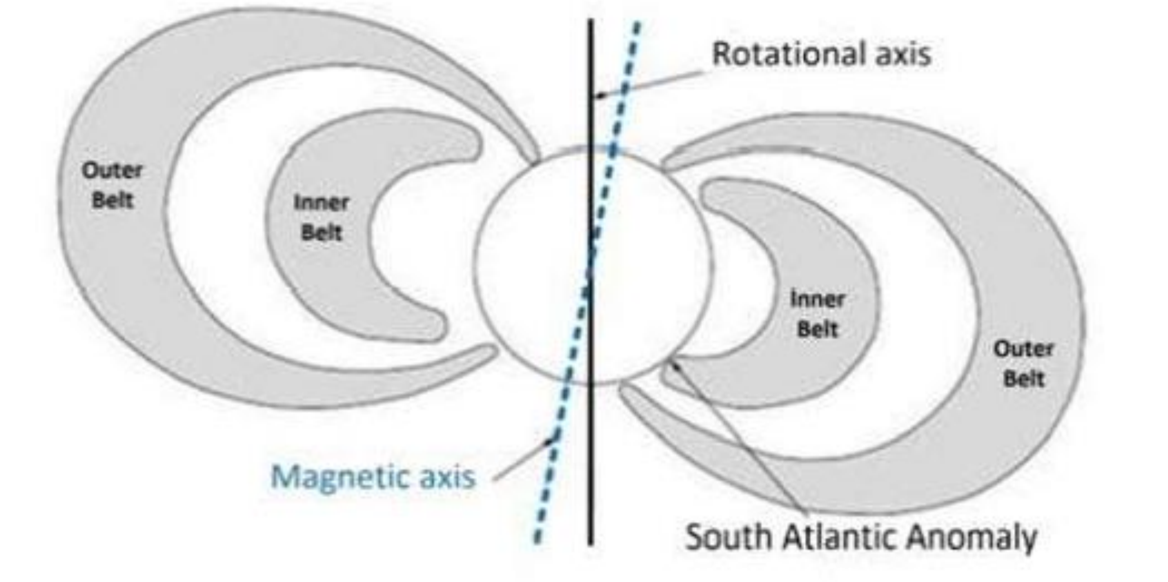
Images Courtesy of NASA

Travelling to the Moon to Stay

Apollo 11 data reports from dosimetry 1.8 mGy that the are optimistically equal to 1.8 mSv (Sievert indicates the biological effects).

Less that the annual dose expected on the Earth (2.-4.5 mSv)

Flight Path



Radiation Quality

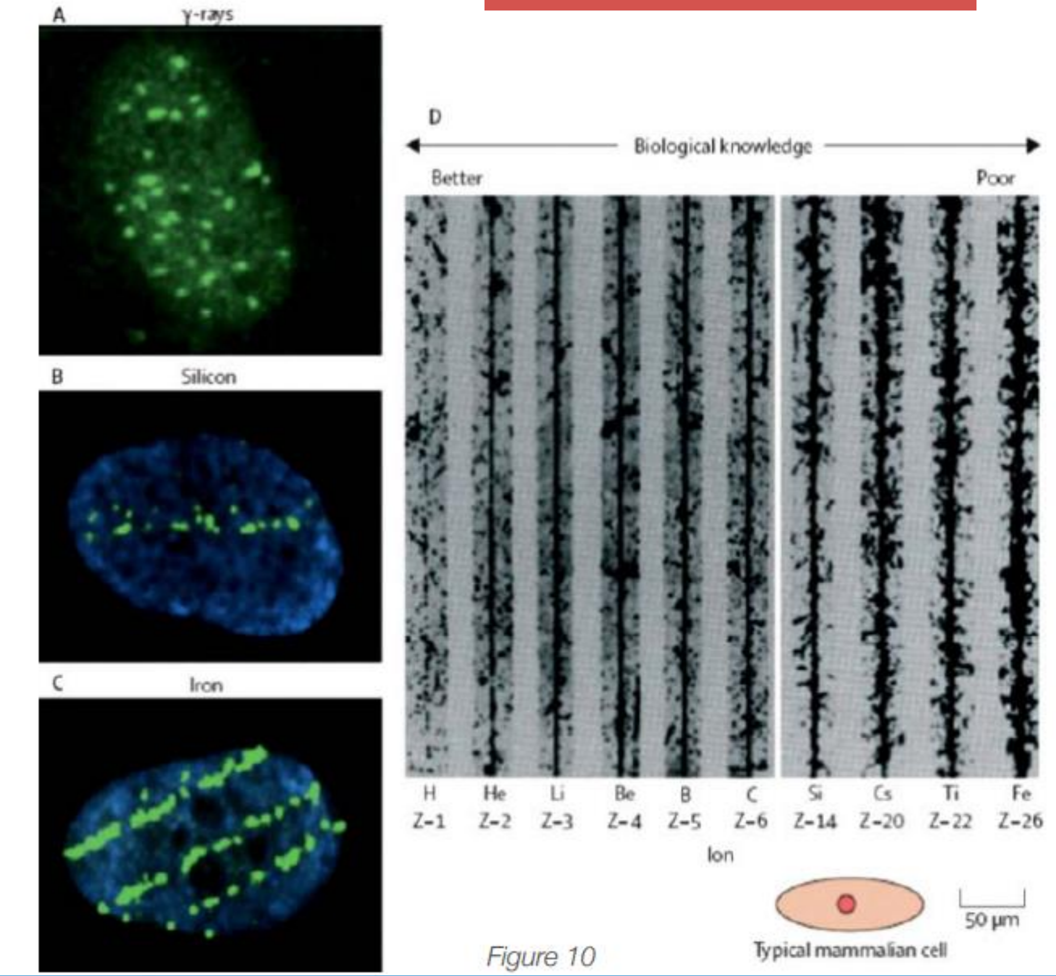


Figure 10

Travelling through the VAB (Worst Case Flight Path)

Radiation Analysis for Moon and Mars Missions

Andreas Märki

Märki Analytics for Space, Erlenbach ZH, Switzerland

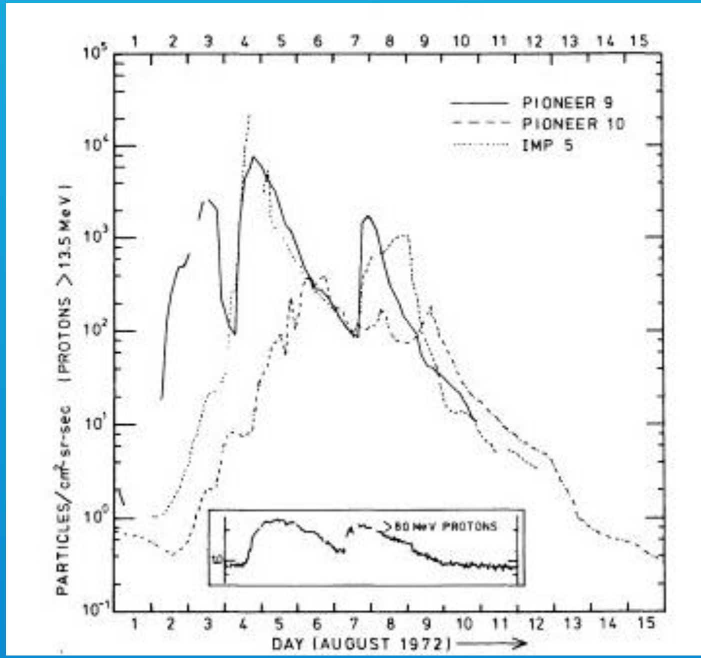
Table 2. *Determination of the Radiation Dose for 4mm Al Shielding through the VAB.*

	Zone	Time in Zone	Dose Calculation	Dose
Path to the Moon	1E3 … 1E4 p^+	400s ≈ 7min	400s * (1/300)*465mSv/h	>0.2 mSv
	1E4 … 1E5 e^-	≈0s	≈0 mSv	≈0 mSv
	1E5 … 1E6 e^-	800s ≈ 13min	800s * (1/30)*355mSv/h	>2.6 mSv
	>(≈) 1E6 e^-	700s ≈ 12min	700s * (1/3)*355mSv/h	>(≈) 23.0 mSv
	1E6 … 1E5 e^-	2700s=45min	2700s * (1/30)*355mSv/h	>8.9 mSv
	1E5 … 1E4 e^-	1383s ≈ 23min	1383s * (1/300)*355mSv/h	>0.5 mSv
Total Outward				>35.2 mSv
Return Path	1E4 … 1E5 e^-	1500s=25min	1500s * (1/300)*355mSv/h	>0.5 mSv
	1E5 … 1E6 e^-	1200s=20min	1200s * (1/30)*355mSv/h	>3.9 mSv
	1E5 … 1E4 e^-	≈0s	≈0 mSv	≈0 mSv
Total Return				>4.4 mSv
Total Resulting Dose				>39.6 mSv >39.6 mGy
Apollo 11 Mission Dose				1.8 mGy

This analysis reports more than 70 mSv from VAB Protons and Electrons using a 4mm Aluminum shields

The 4 August 1972 Solar Flare

April 1972



August 1972

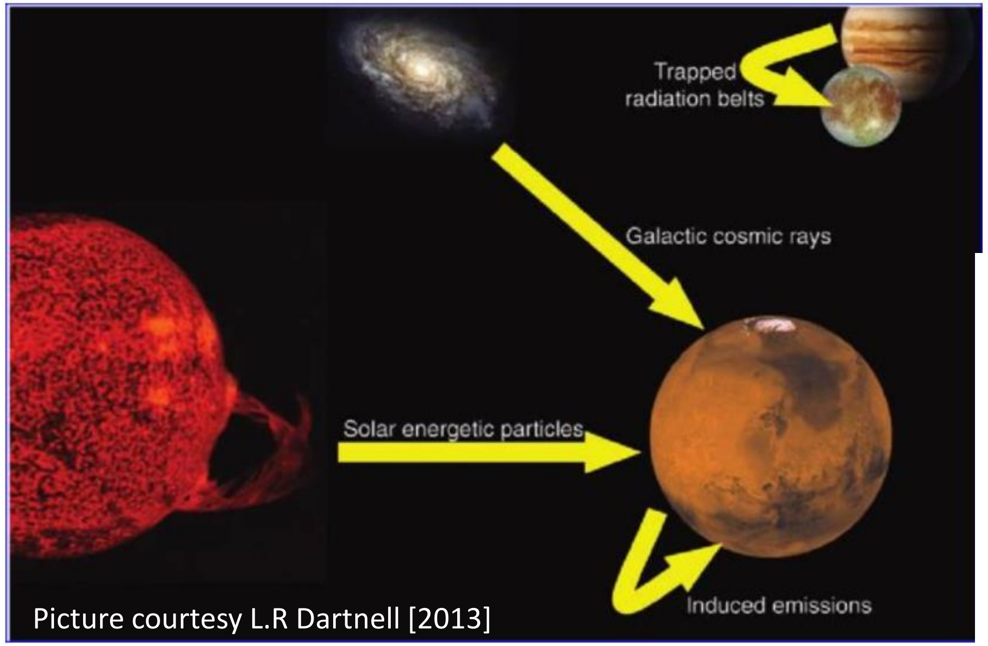
December 1972

Sun Activities

Alessandro Bartoloni - INF LPR - CETAL

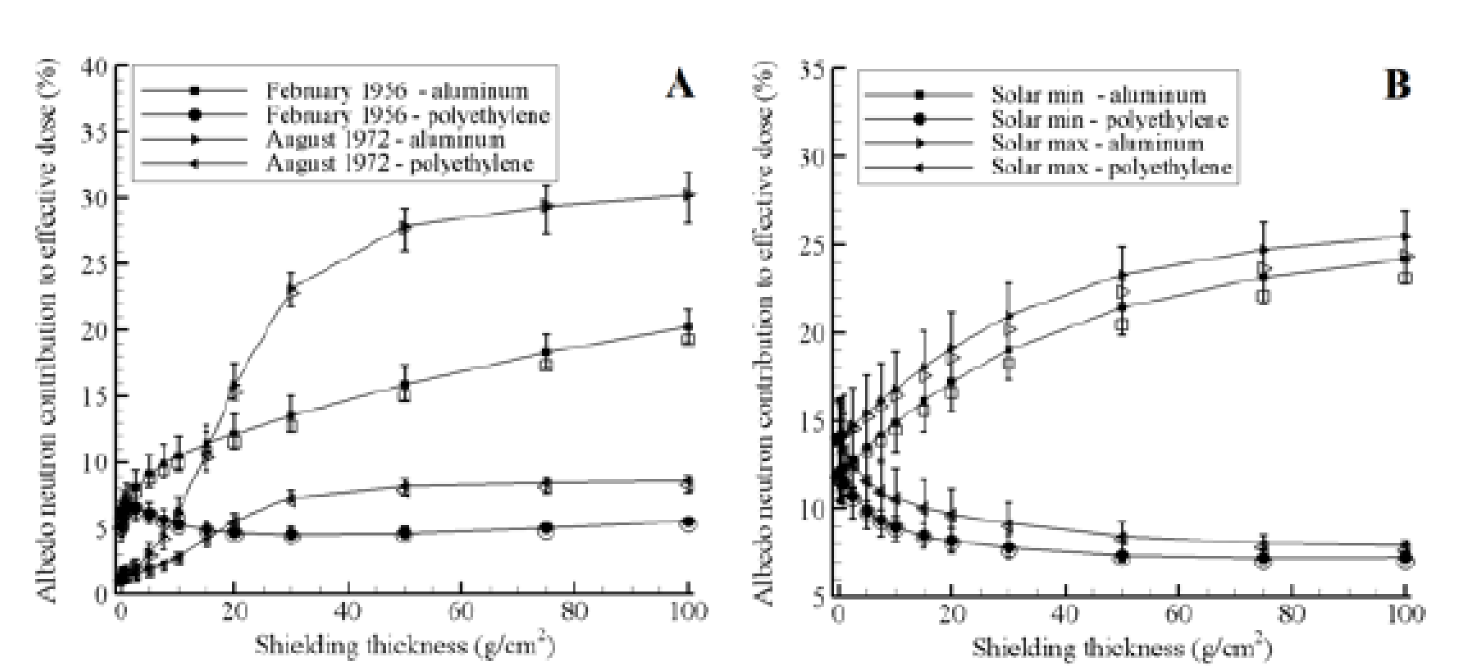
Images Courtesy of NAS

GCR and SEP interaction with the lunar surface



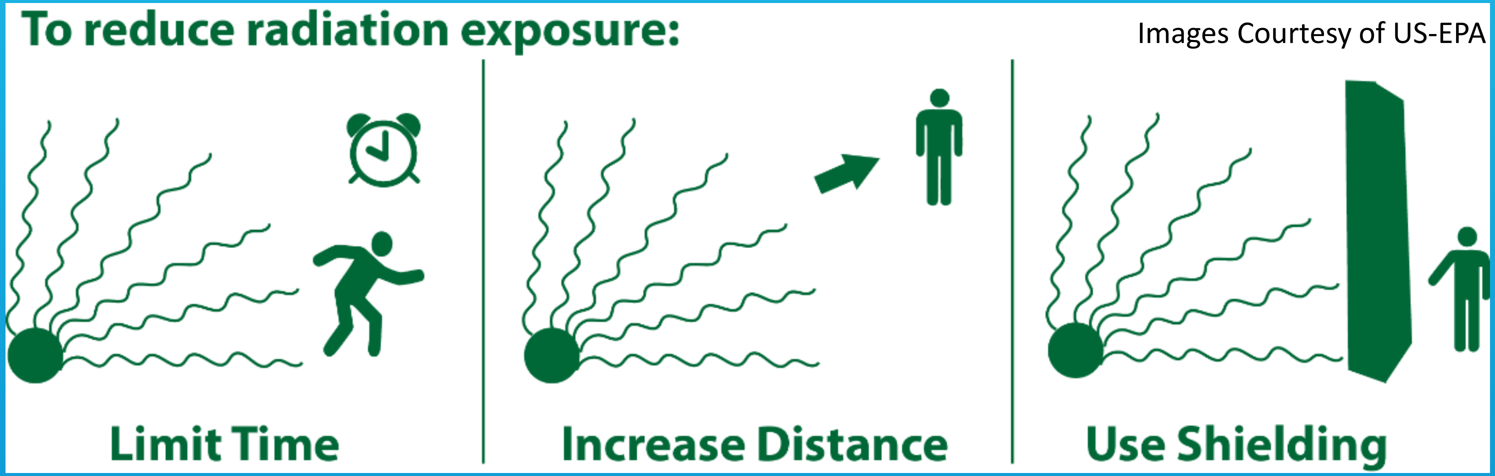
Albedo Ionizing Radiation

On the surface of the Moon the free space GCR or SPE environments interact with the planetary surface, yielding a back-scattered radiation field.



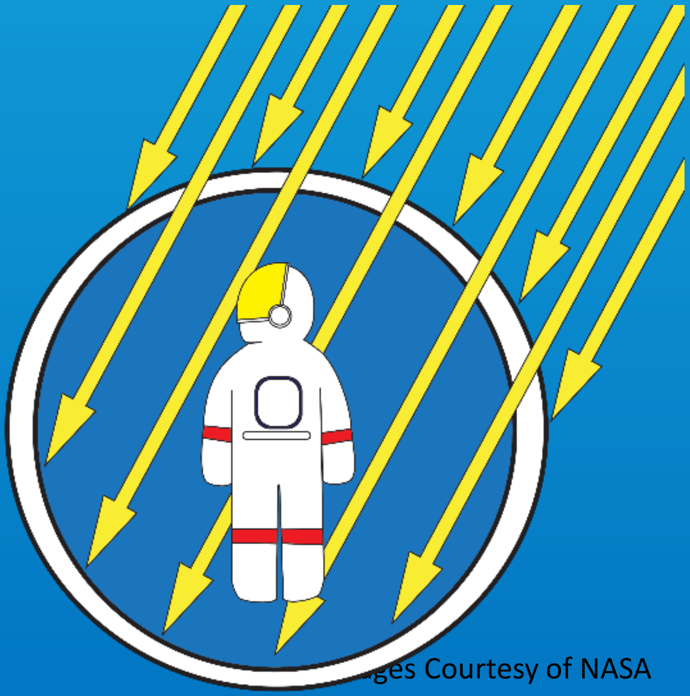
Percent Contribution to Effective Dose from Albedo Neutrons on Lunar Surface behind different types of shield From Slaba et Al [2011]

Radioprotection criteria used on Earth....



Images Courtesy of US-EPA

...do not work in space !


ges Courtesy of NASA

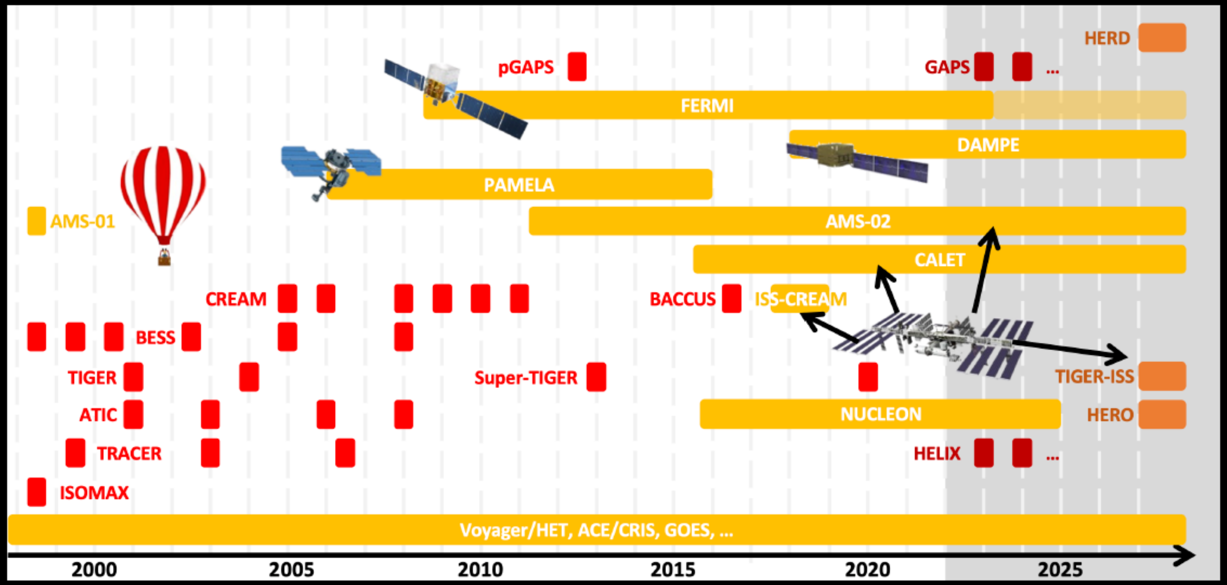
Cosmic Ray Detectors in Space

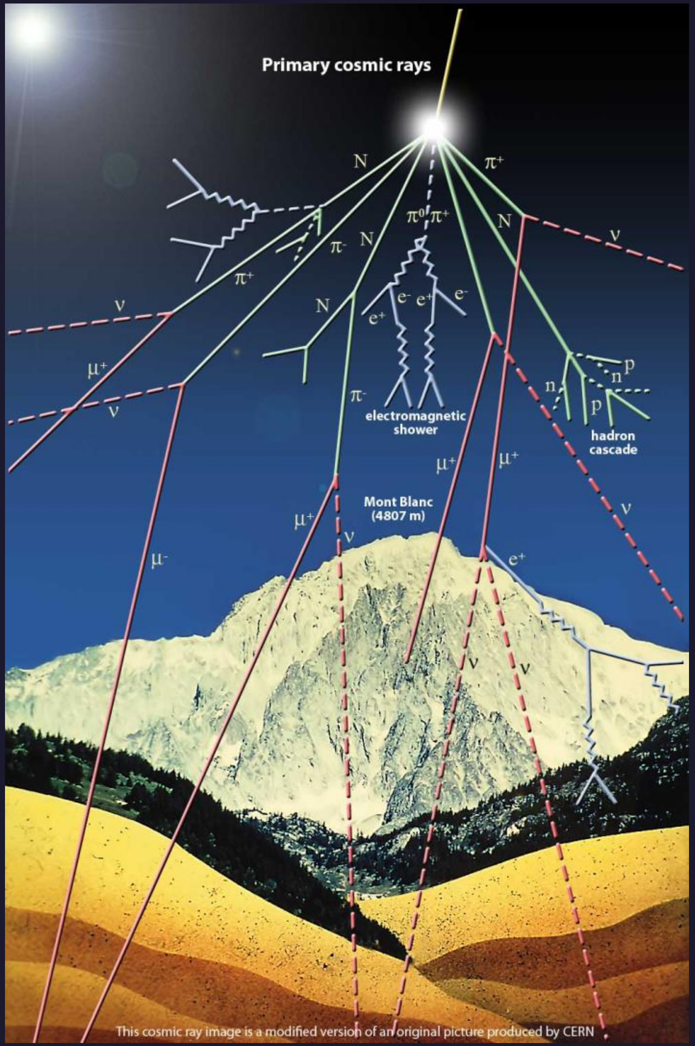
Astroparticle Experiments in Space

In the last two decades, many astroparticle experiments have been built and deployed in space to investigate many open questions in fundamental physics and cosmology, for example, the dark matter and dark energy existence and composition or the existence of primordial antimatter.

A particular class of experiments, the CR Detectors (CRD), are designed to produce a complete inventory of charged particles and nuclei in CR since the knowledge of this information is crucial to solving the above physics open problems.

Timeline of Direct Measurement of CRs from 2000





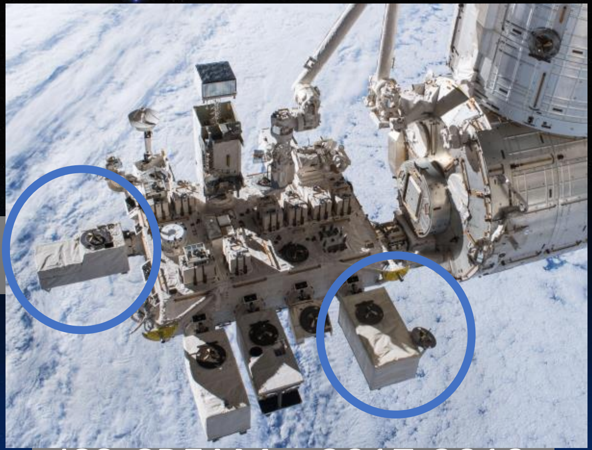
Principal Operating Cosmic Ray Space Detectors

International Space Station based

Satellite Based

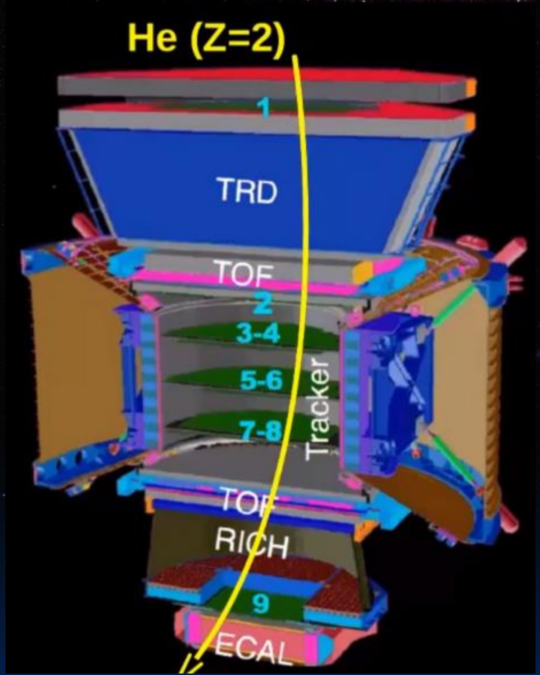
an ensemble of instruments each one designed to capture and measure the cosmic ray particles

AMS02 – 2011



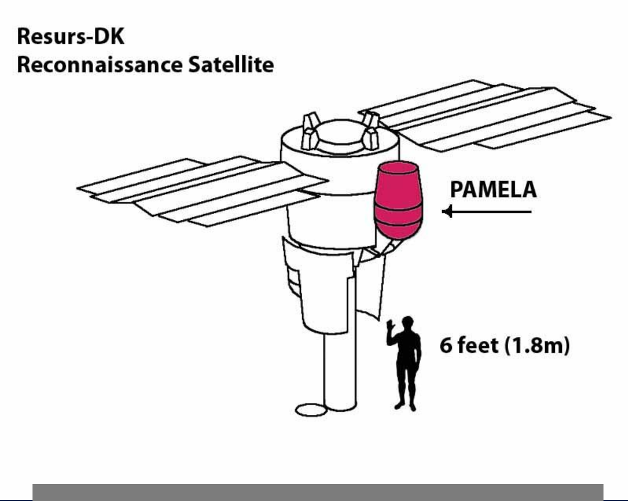
CALET - 2015

ISS-CREAM – 2017-2019



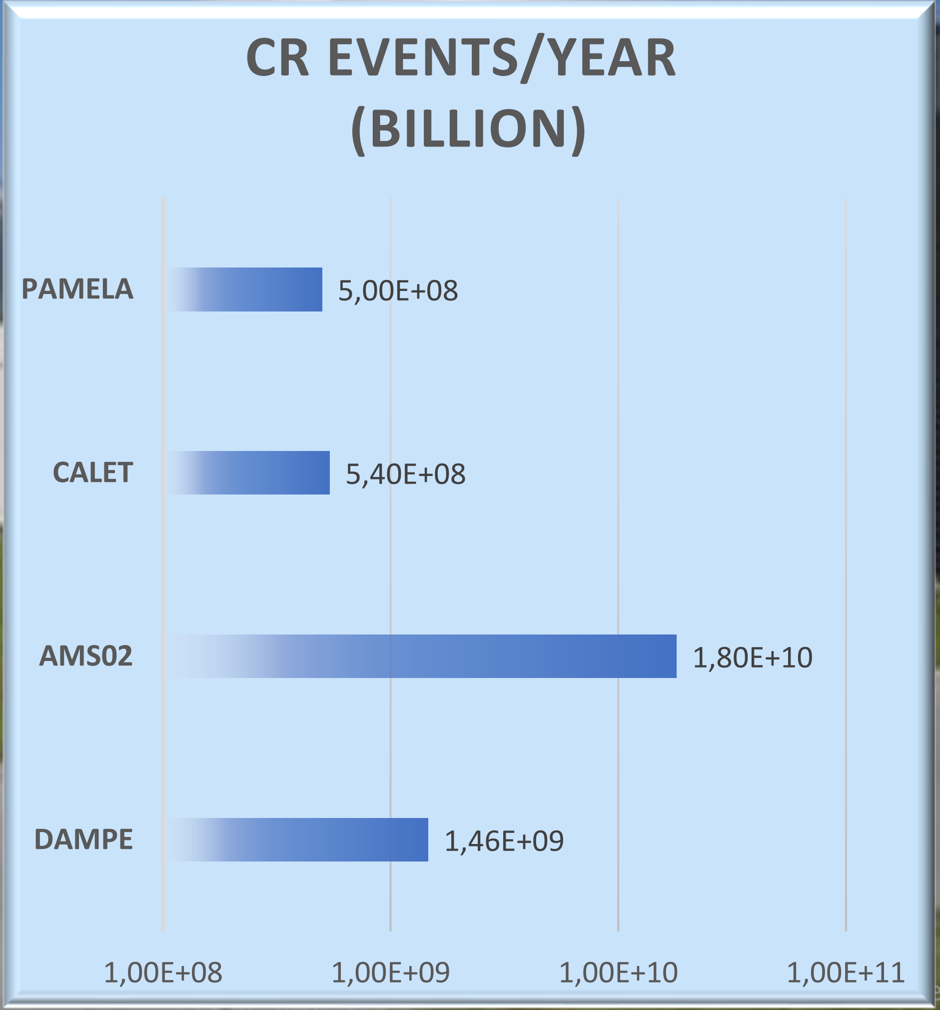
ACE - 1997

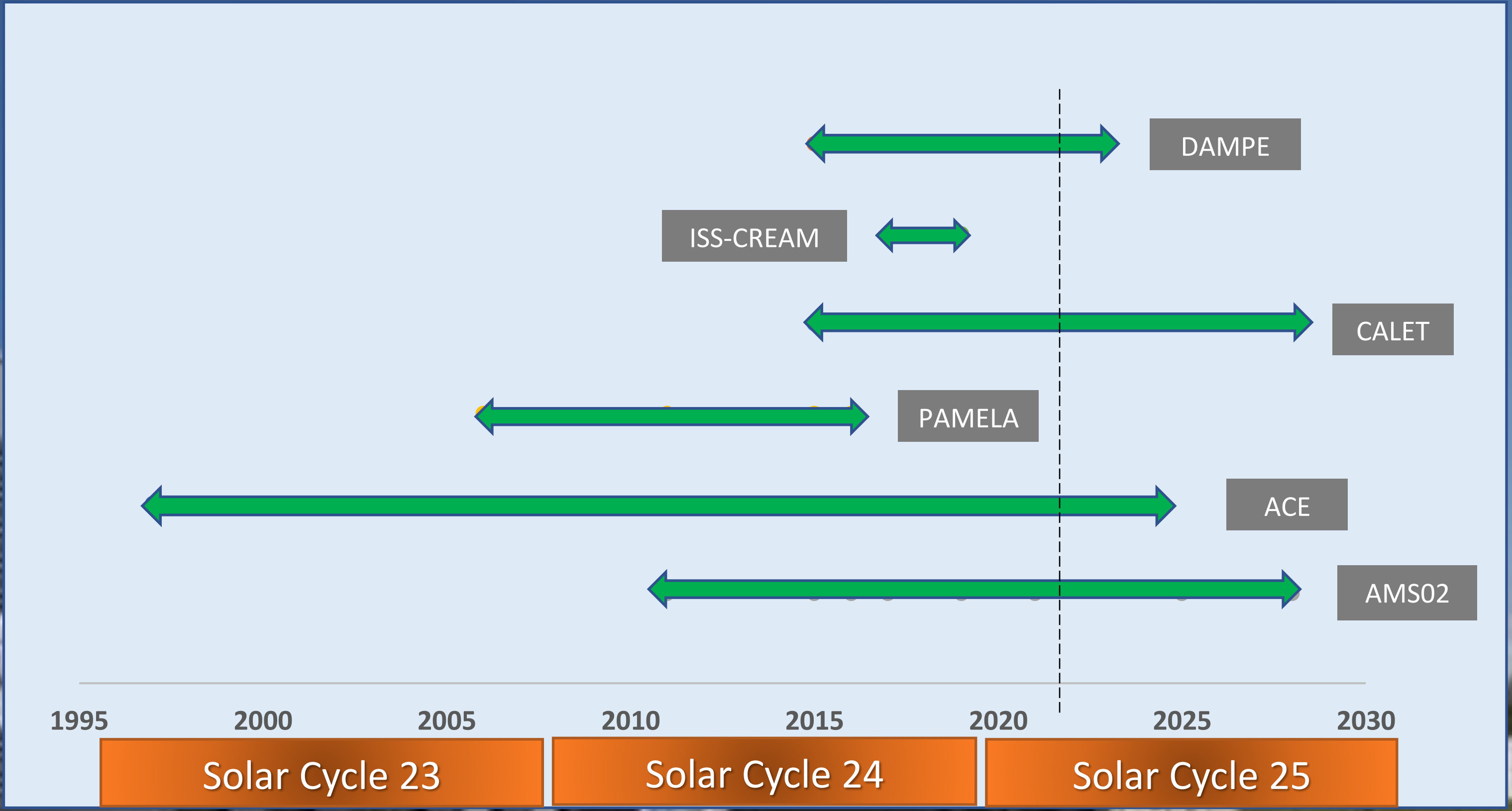
DAMPE - 2017



PAMELA – 2006-2016

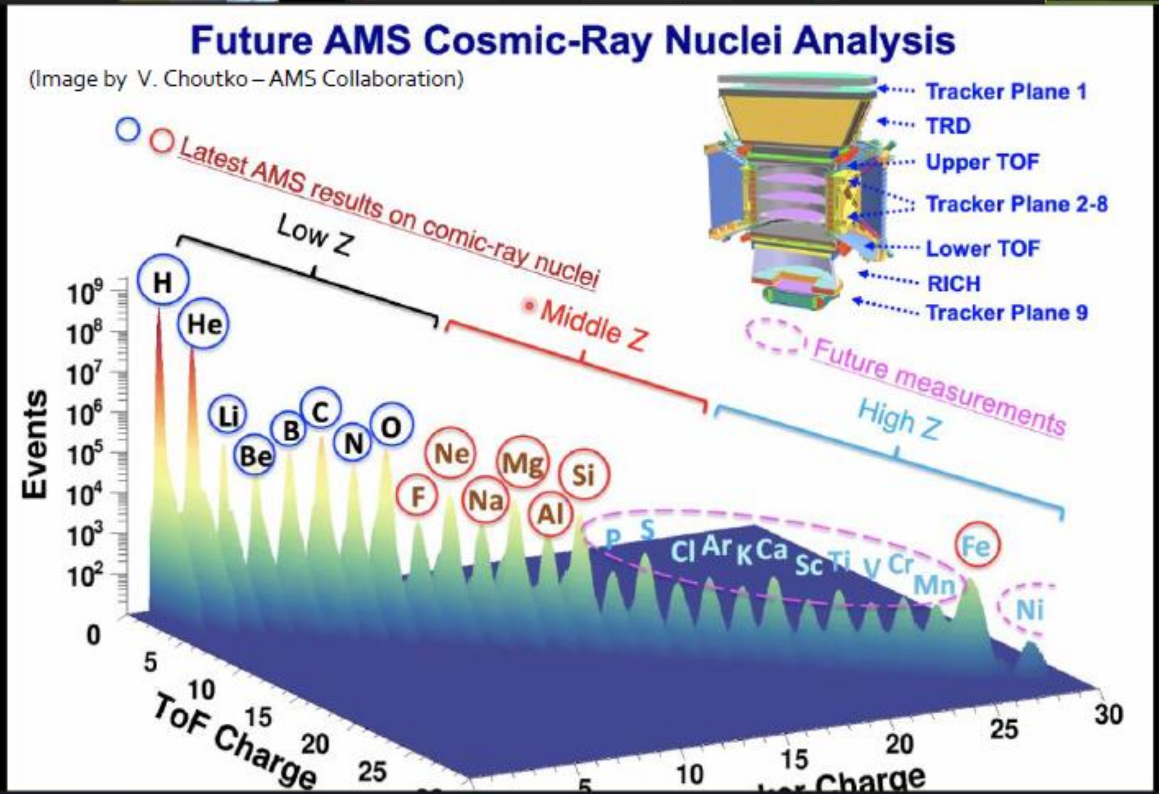
Missions Operations





Cosmic Ray Components Identification

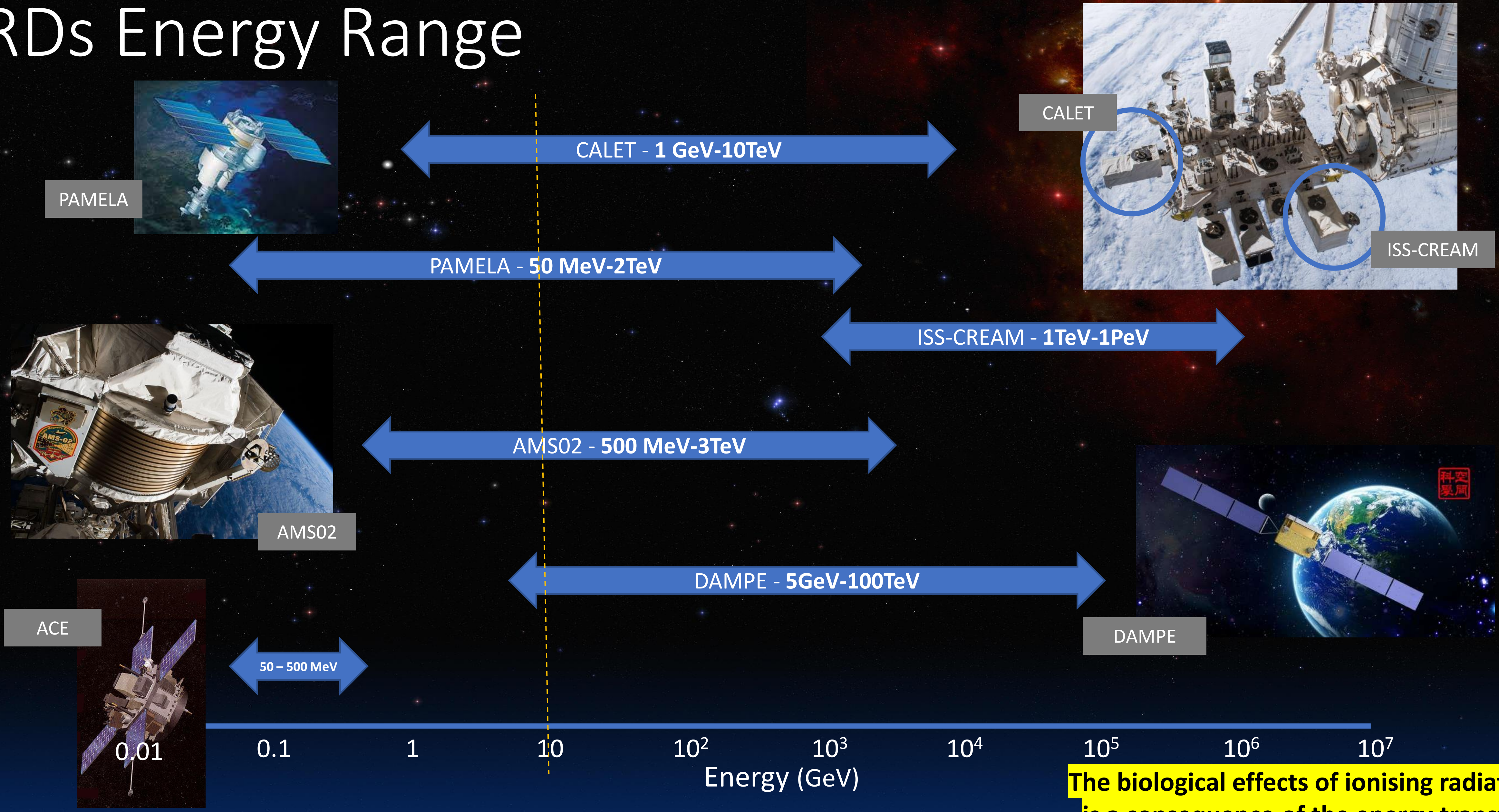
e+,e-	✅ ALL
p+,p-	✅ ALL
D,He	✅ ALL
Low-Z (<=8)	✅ ALL (PAMELA up to Z=6)
Middle-Z	✅ AMS02, CALET, ISS-CREAM, ACE, DAMPE
High-Z (>14)	✅ AMS02, CALET, ISS-CREAM, ACE, DAMPE



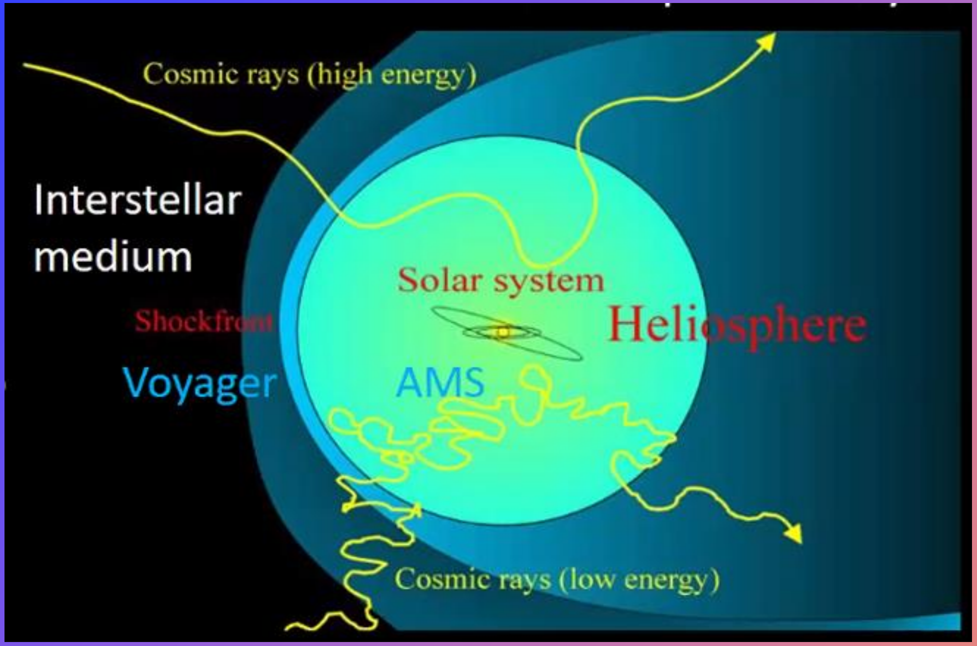
Properties of Iron Primary Cosmic Rays: Results from the Alpha Magnetic Spectrometer
AMS Collaboration • M. Aguilar (Madrid, CIEMAT) et al. (Jan 29, 2021)
Published in: *Phys.Rev.Lett.* 126 (2021) 4, 041104

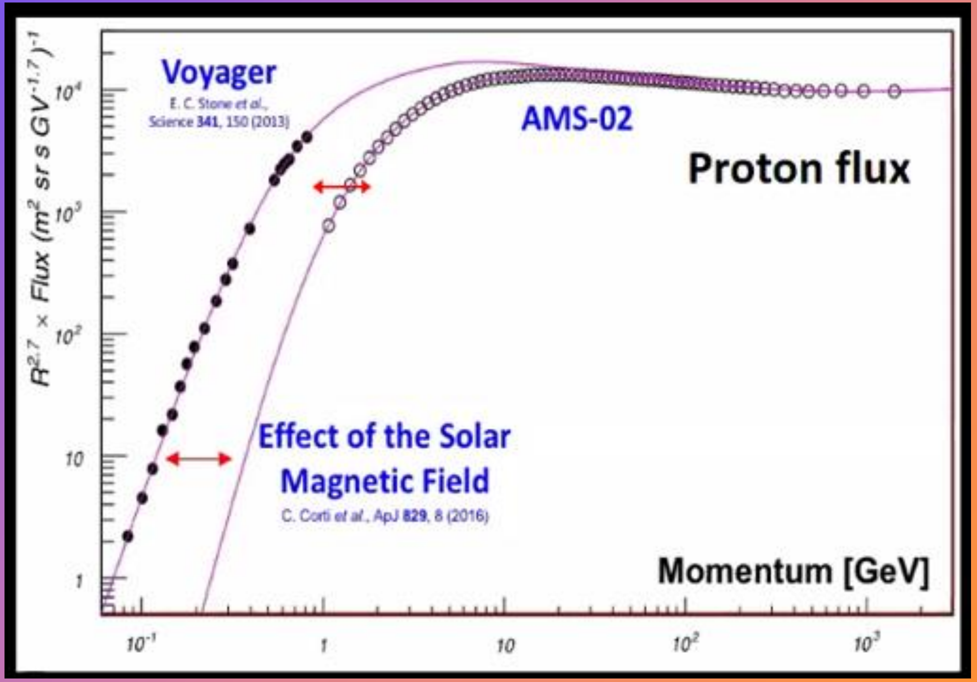
Properties of Heavy Secondary Fluorine Cosmic Rays: Results from the Alpha Magnetic Spectrometer
AMS Collaboration • M. Aguilar (Madrid, CIEMAT) et al. (Feb 25, 2021)
Published in: *Phys.Rev.Lett.* 126 (2021) 8, 081102

CRDs Energy Range



The biological effects of ionising radiation is a consequence of the energy transfer by ionization and excitation to body cells





Credit S.Ting & AMS Collaboration

Cosmic Rays Solar modulation

Cosmic rays from interstellar mediaum are «screened» by the Heliosphere.

This effect is particulary visibile at low energies

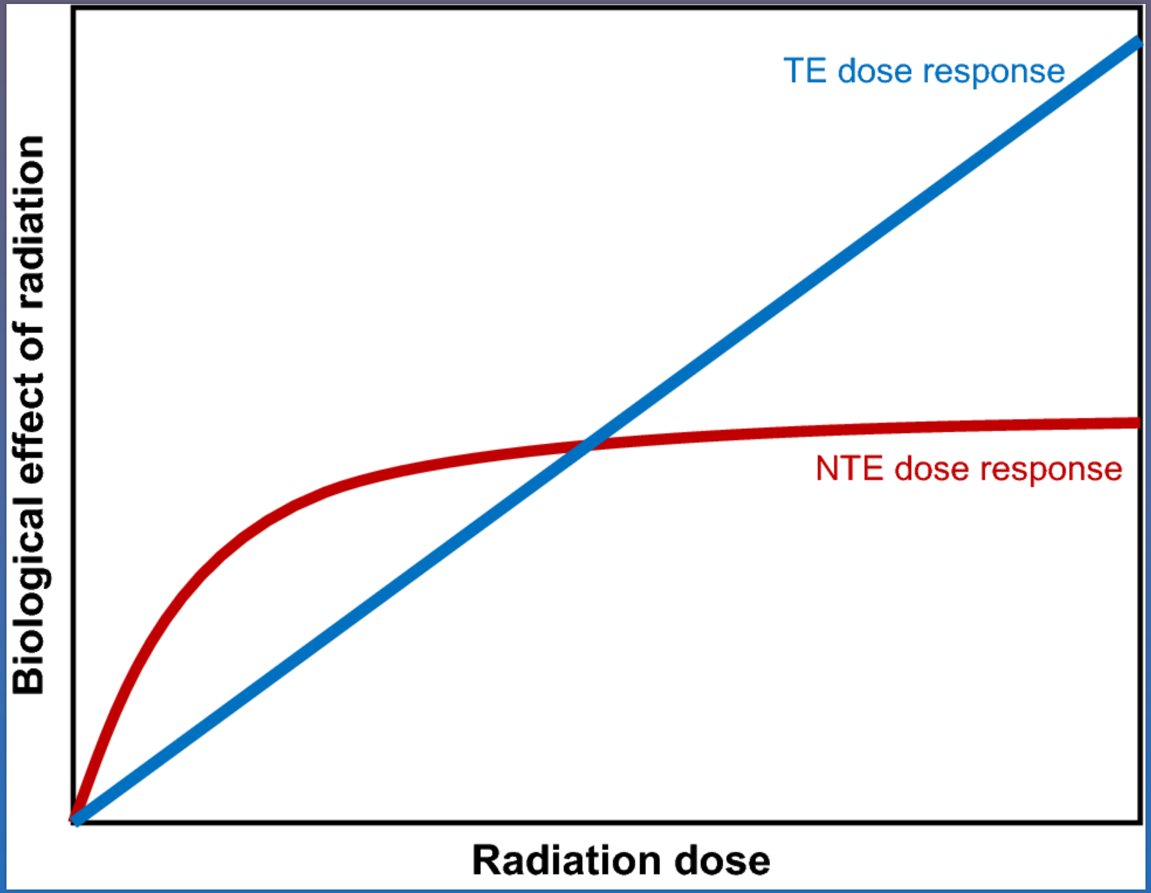
Measurements of time evolution of cosmic ray fluxes of different particles over an extende period of time is very valuable

Enabling Research @ AMS Roma Group

Dose-Effects Models

Dose-Effect Relationship (DER)

A crucial point to predict the toxicity of the space radiation expected for the astronauts/space workers is the creation of reliable mathematical models that describe the correlation between the exposition to IR and the possible damage to the organ at risk.



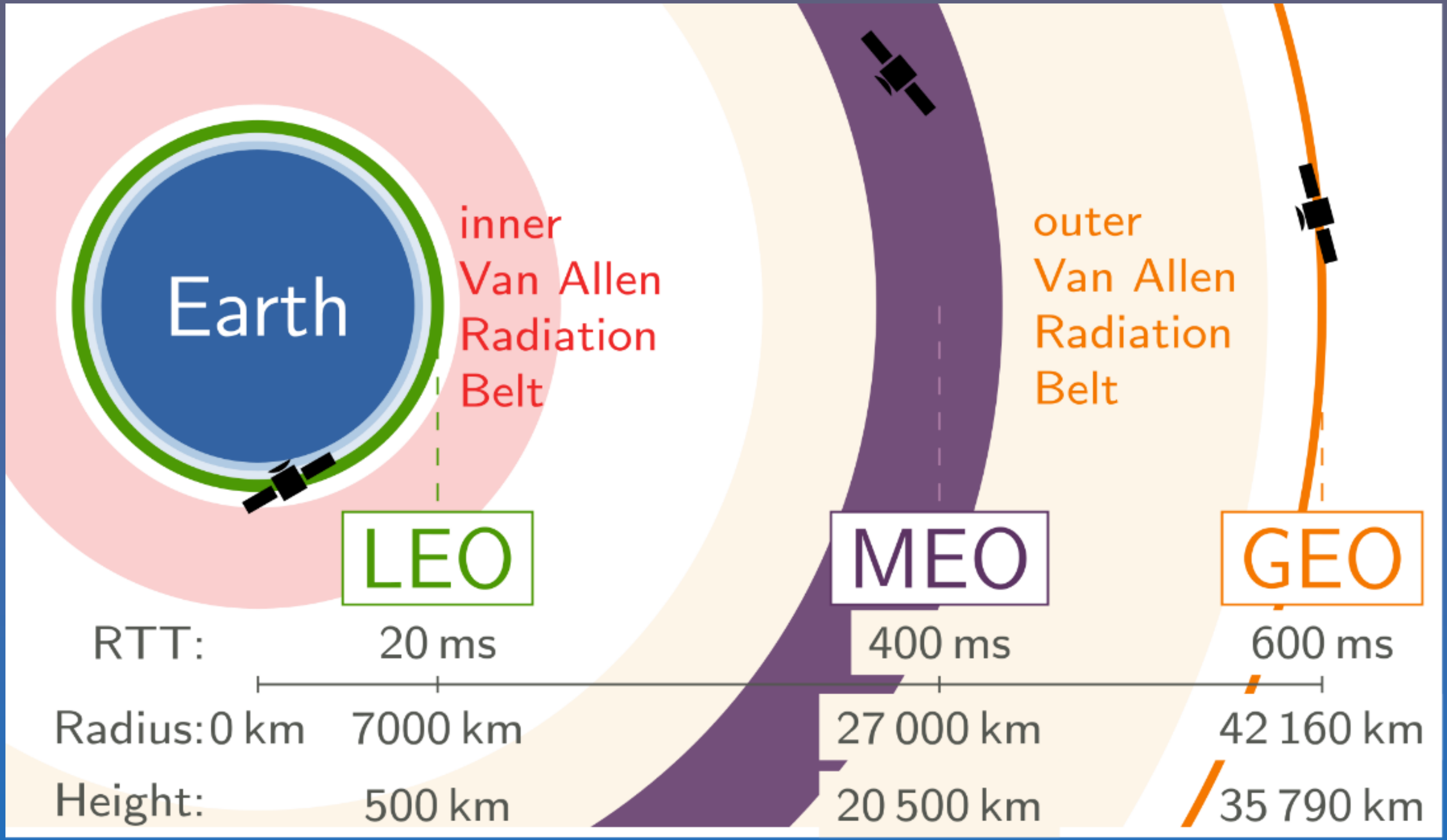
3 only reached a sub-orbital flight, 567 people reached the LEO

24 traveled in BLEO + 12 walked on the Moon

The known dose-effect relationships are based on a limited number of astronauts

574 people have gone into space according to the FAI criterion (as 20 July 2021)

Space travelers have spent a cumulative total of over 77 years



We made and publish in 2021 an extensive review of the existent literature to use as starting point for improvements this research areas

REVIEW article

Front. Public Health, 08 November 2021
Sec.Radiation and Health
https://doi.org/10.3389/fpubh.2021.733337

This article is part of the Research Topic

Medical Application and Radiobiology Research of Particle Radiation

View all 16 Articles >

Dose-Effects Models for Space Radiobiology: An Overview on Dose-Effect Relationships

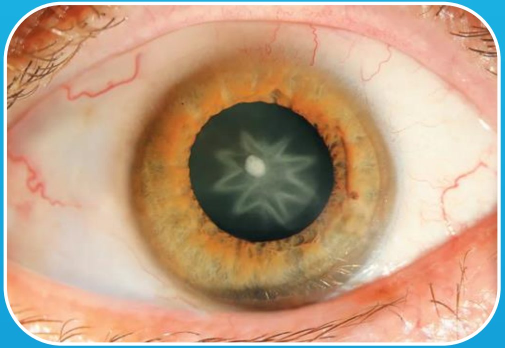
Lidia Strigari[1], Silvia Strolin[1], Alessio Giuseppe Morganti[2] and Alessandro Bartoloni[3*]

https://doi.org/10.3389/fpubh.2021.733337

Articles dose-effect models exploration and identification

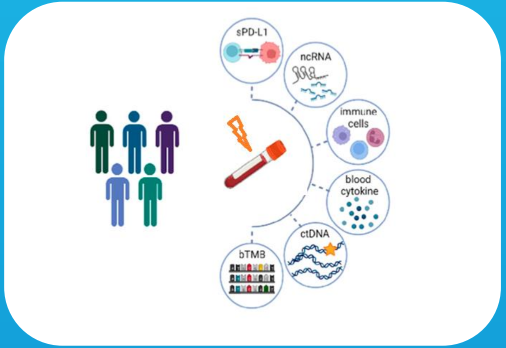
- **Identification of**
  - Types of irradiation
  - Data
  - Models
- **Experimental Type**
  - In Vitro
  - Pre-clinical
  - Clinical
- **Study Type**
  - Ground
  - Simulation
  - Spaceflight

«Eye-Flashes»

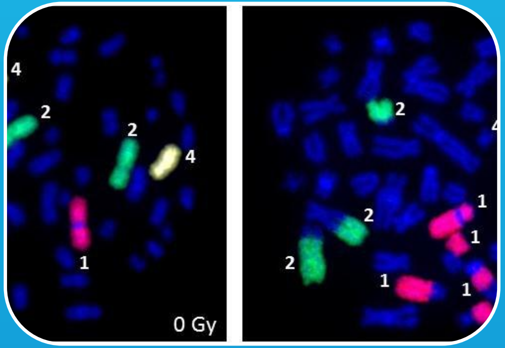


Cataract or

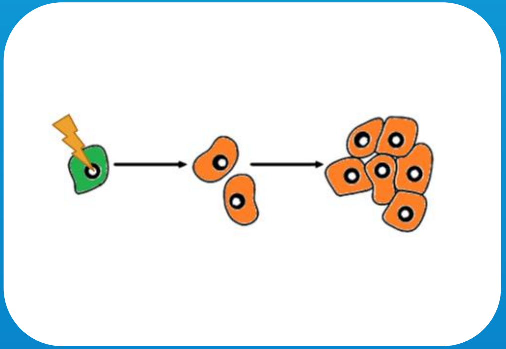
Visual impairments



Biomarkers

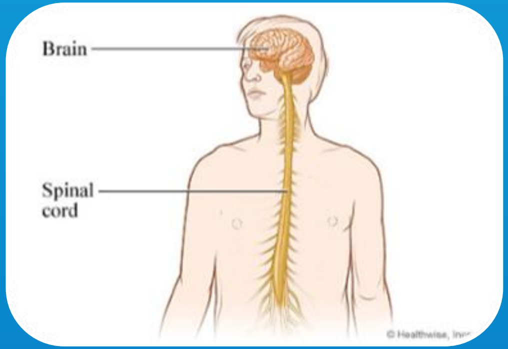


Chromosomal Aberrations

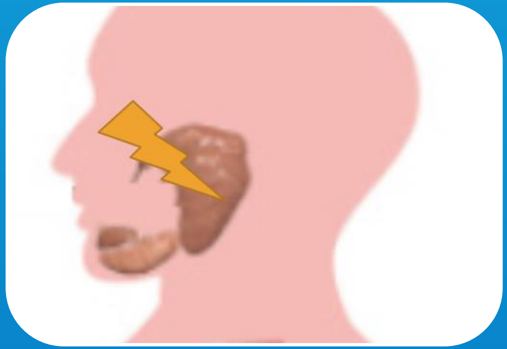


Carcinogenesis

Cardiovascular Disease (CVD)



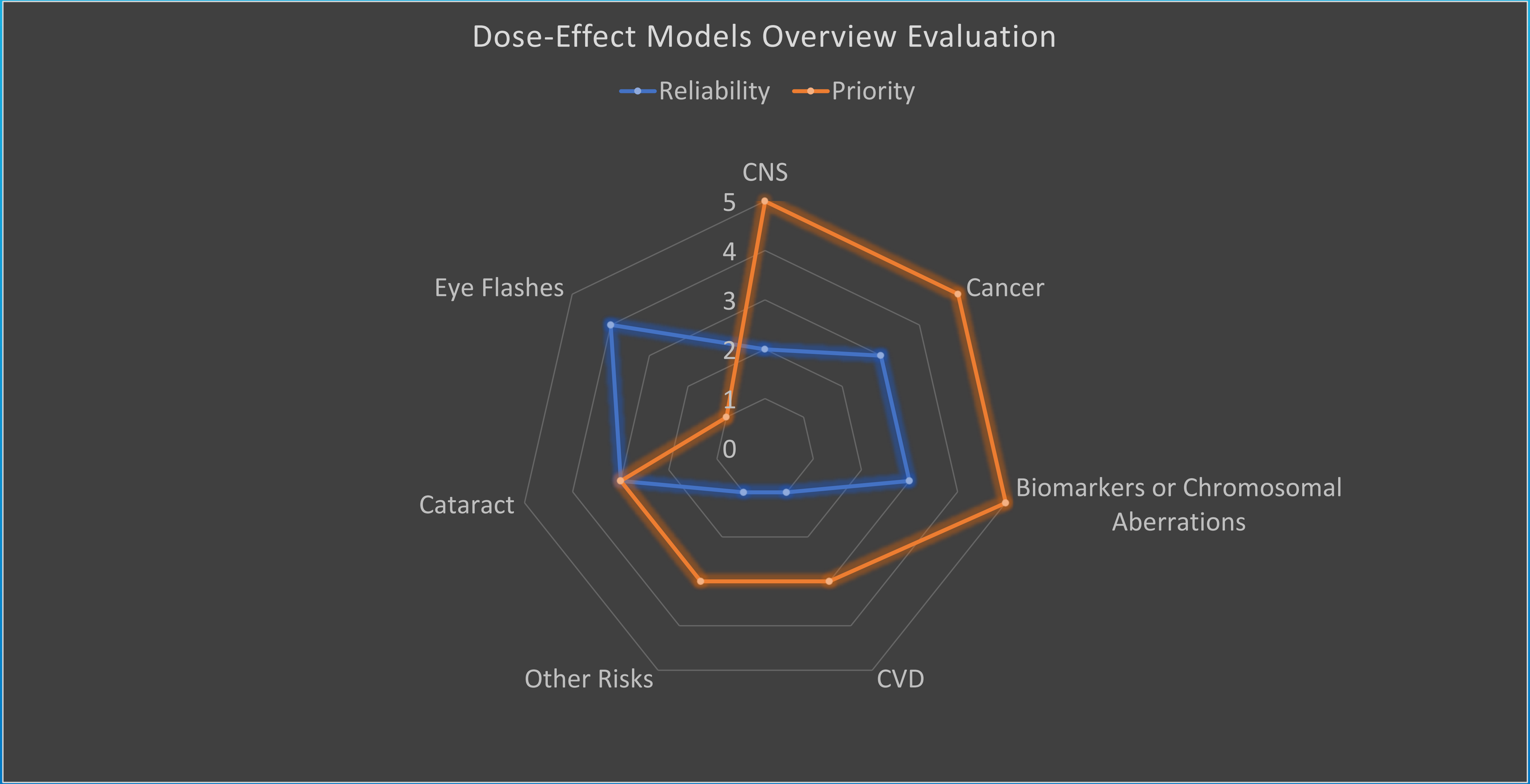
Central Nervous System (CNS)



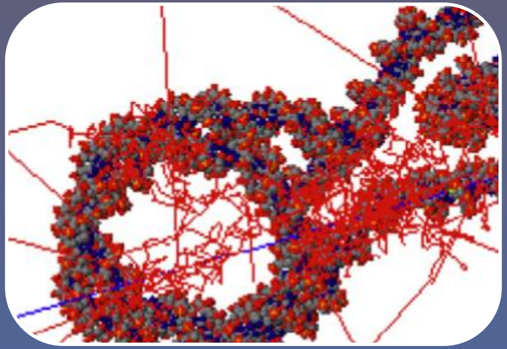
Other Risks

Analysed IR related health hazard

Model	Study Type	Dose Range/Threshold or LET	#Papers	Reliability	Priority
Eye Flashes	Spaceflight	LET>5-10 KeV/μm	4	****	*
Cataract	Spaceflight	8 mSv	5	***	***
CNS	Ground/Simulations	100-200 mGy	11	**	*****
CVD	Spaceflight	1000 mGy	4	*	***
	Ground/Simulations	0.1-4,500 mSv	8		
Cancer	Spaceflight	< 100 mGy	2	***	*****
	Ground/Simulations	< 100 mGy	9		
Biomarkers or Chromosomal Aberrations	Spaceflight	<5-150 mGy	11	***	*****
	Ground /Simulations	< 10,000 mGy	4		
Other Risks	Ground/Simulations	2,000 mGy	2	*	***
= Very Low, **=Low,*=Medium,**** = High, ***** = Very High.*					

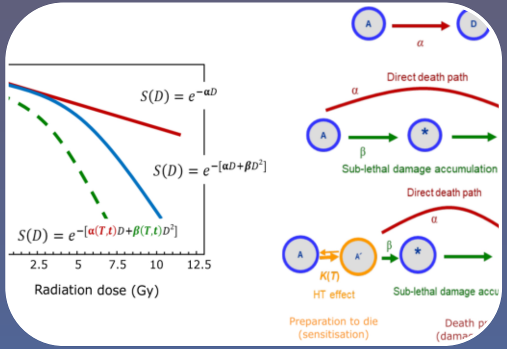

Dose-Effect Models Overview Evaluation
Reliability
Priority
CNS
Cancer
Biomarkers or Chromosomal Aberrations
CVD
Other Risks
Cataract
Eye Flashes
5
4
3
2
1
0

Further investigation are required to produce dose-effects models that will allows to predict the risk due to radiation during the space exploration

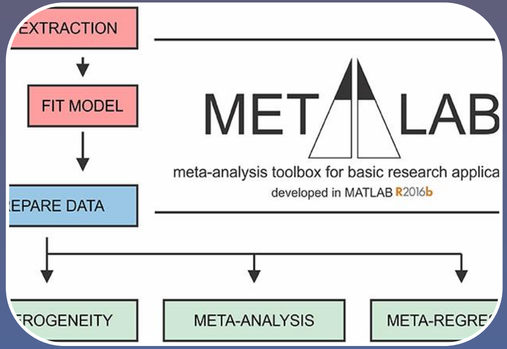


Computer Simulation of interactions of IR with biological matter
»

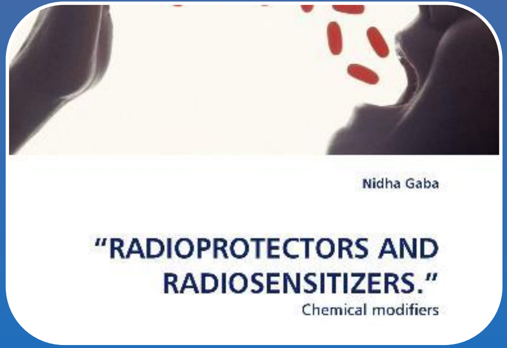
Synergy with the Clinical Field



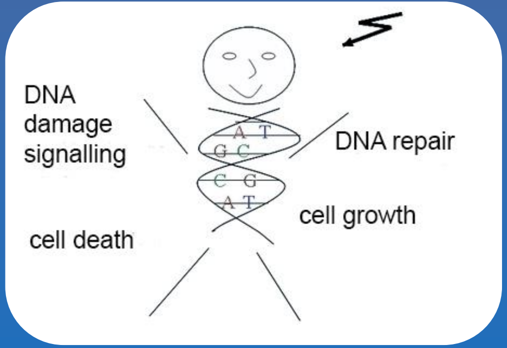
Mathematical Modelling



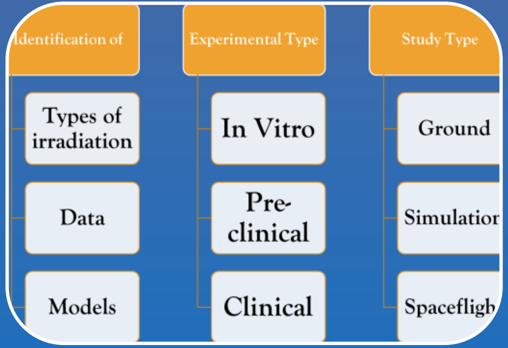
Quantitative Meta Analysis



Radioprotectors inclusion in DER



Individual Radio Susceptibility



Dose-Effects Model Integration Platform

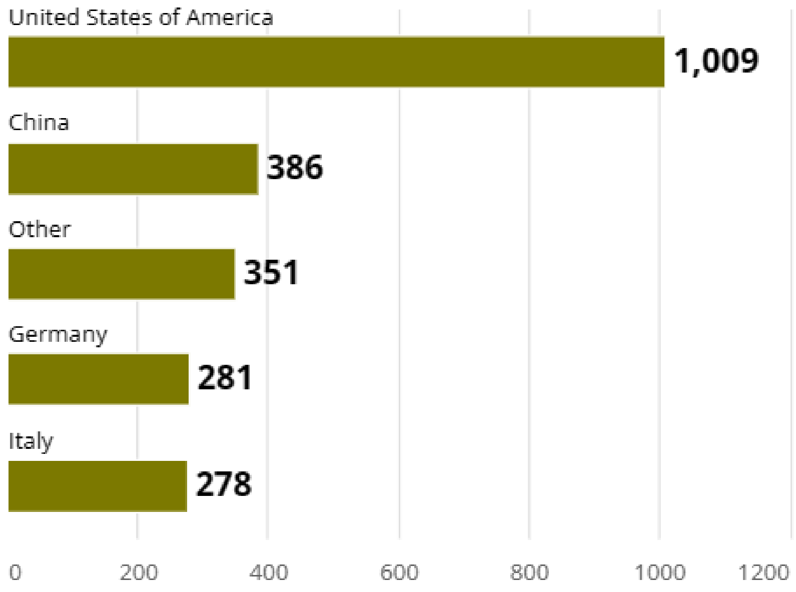
Synergy with Astroparticle Experiments

Dose-Effects Models for Space Radiobiology: An Overview on Dose-Effect Relationships

Publication Impact (March 2023)

Frontiers in Public Health
Published on 08 Nov 2021

[Loop | Publication Impact | Dose-Effects Models for Space Radiobiology: An Overview on Dose-Effect Relationships (frontiersin.org)]



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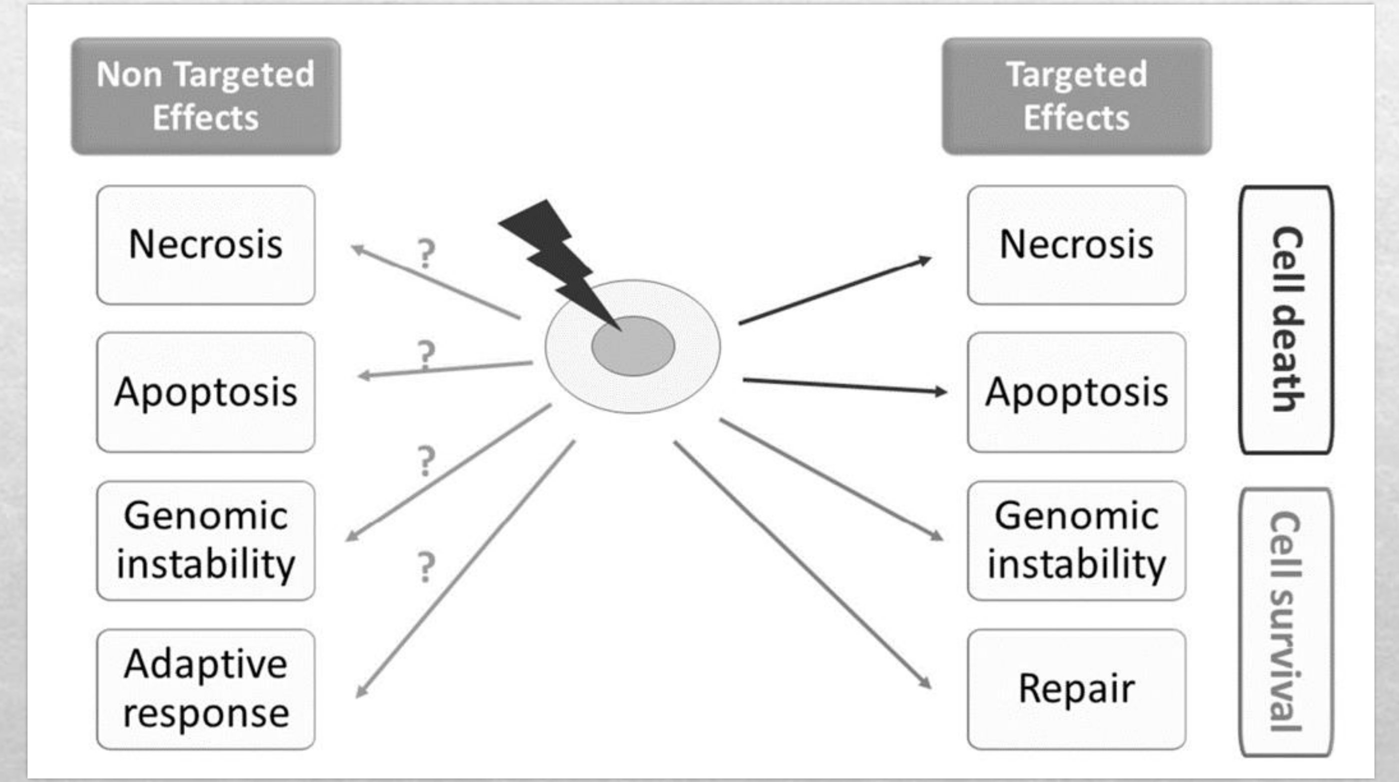
Target Effects vs Non Target Effects

Following this analysis, we started to investigate one of the promising and not yet understood effects of ionization radiation, usually referred to as the non-targeted effect (NTE) of great relevance for space radiation.

- In-vitro and in-vivo pre-clinical studies as well as many mechanistic studies support the NTEs, with evidence of a a supra-linear effects at low doses of NTE compared to the linear one of TE
- NTEs include bystander effects where cells traversed by heavy ions transmit oncogenic signals to nearby cells and genomic instability in the cell's progeny.
- The NTE are expected also at the fluences and space radiation species that occur in space



An example on Research activities on DEM in progress at AMS INFN Roma-Sapienza Group

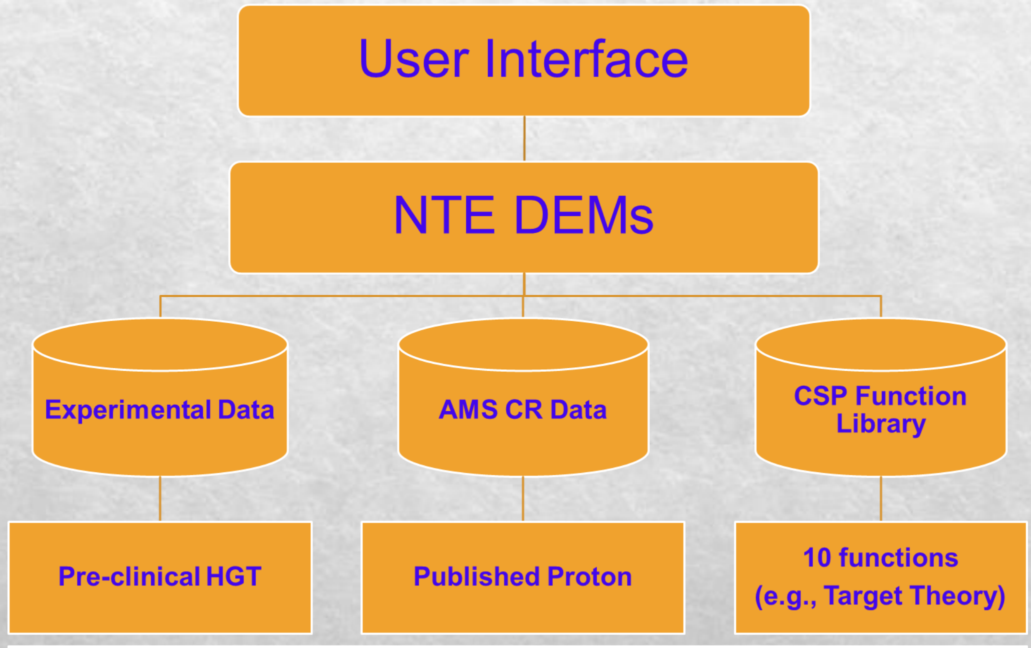


Fig.1 The NTE-DEM v1.0 architecture.

Following this analysis, we started the development of an ad hoc software tool to investigate the NTEs

The NTE-DEM aims to combine the existing experimental data (clinical, pre-clinical and in vitro), the cosmic ray fluences, as measured by the AMS detector and the cell survival probability function existing in the literature to produce reliable DEMs.

We use the R-Studio integrated development environment to code it. The first NTE-DEM release (Fig. 1) comprises a main program and several libraries for>10K lines of code.

Journal of Mechanics in Medicine and Biology
"SPACE RADIATION INDUCED BYSTANDER EFFECT IN ESTIMATING THE CARCINOGENIC RISK DUE TO GALACTIC COSMIC RAYS" A. Guracho et al (published in Jan 2023)

Tumor Prevalence Dose Effects Model

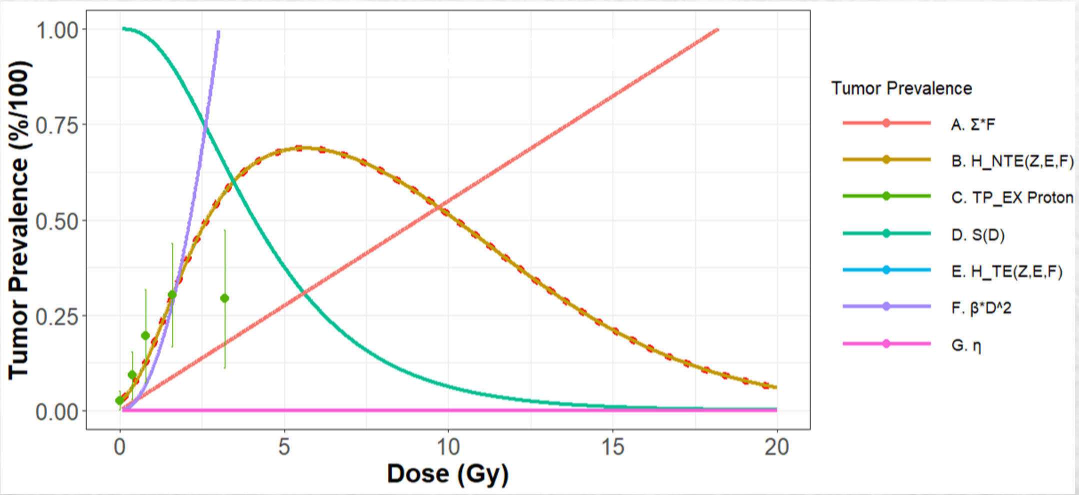
$$TP = 1 - e^{(-H(Z,E,F))}$$

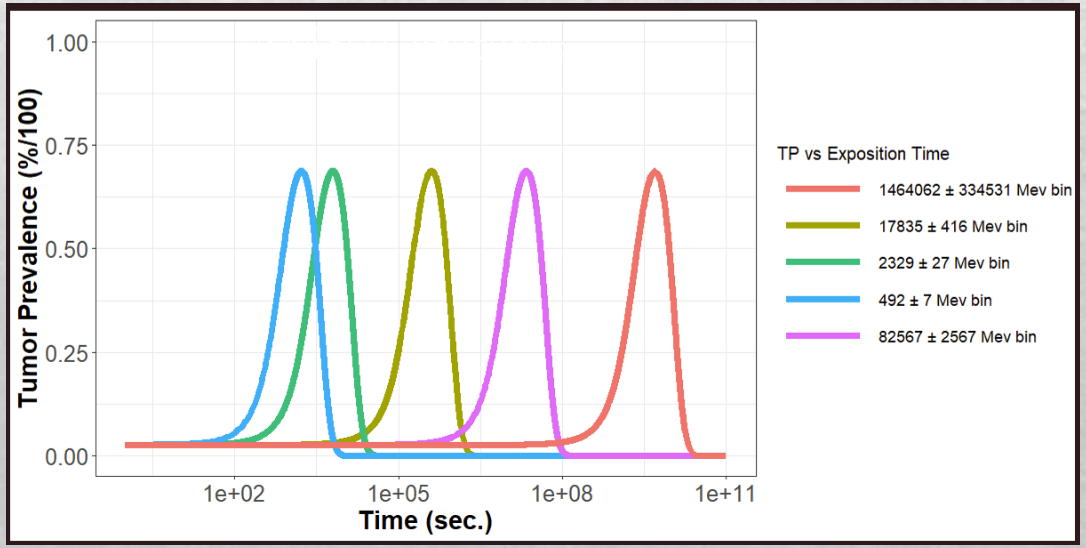
Hazard Function for Target effects

$$H_{TE}(Z,E,F) = H_0 + [\Sigma F + \beta_{CP} D^2] S(Z,E,F) \, .$$

Hazard Function for Target + Non Target Effects

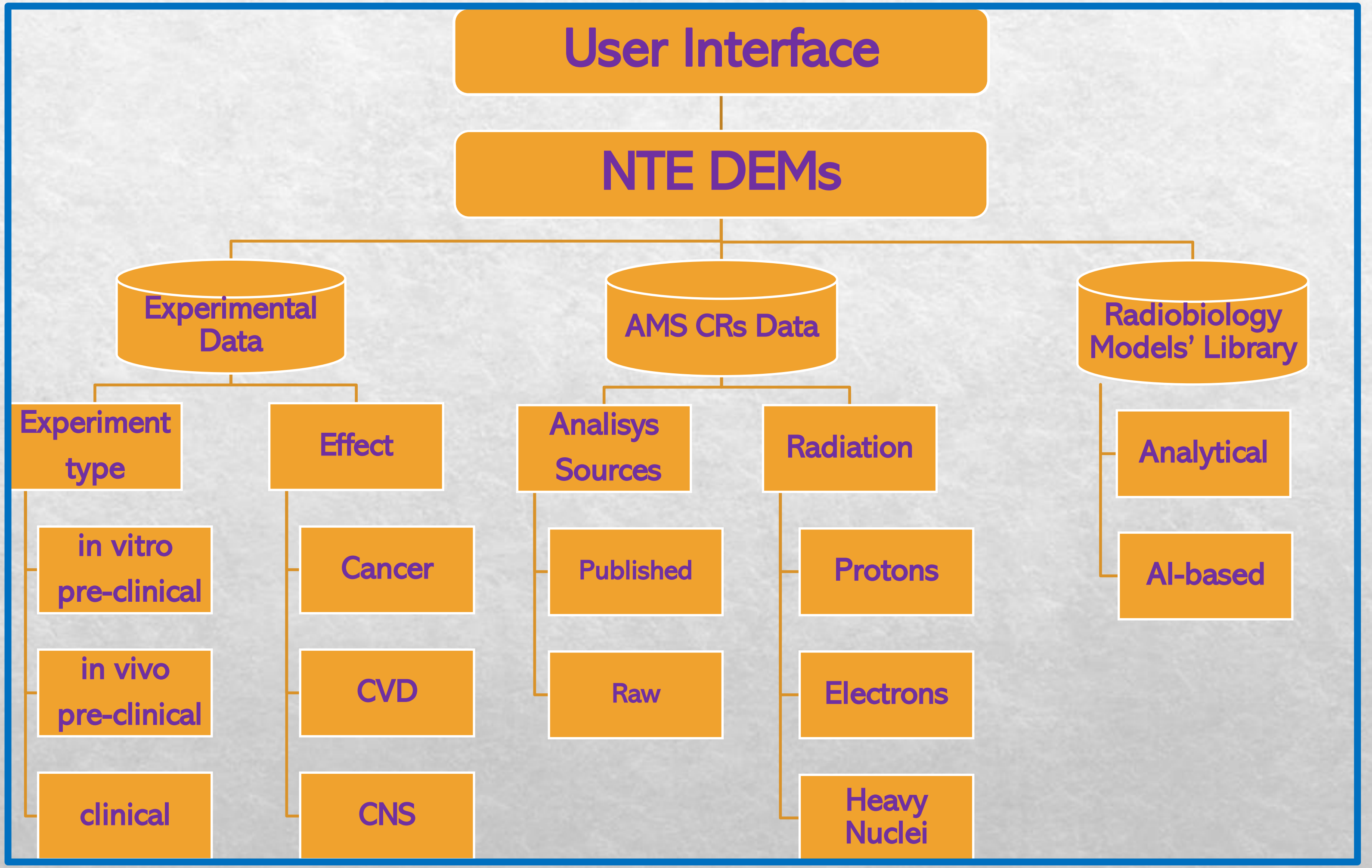
$$H_{NTE}(Z,E,F) = H_0 + [\Sigma F + \beta_{CP} D^2 + \eta] S(Z,E,F)$$





The NTE-DEM software architecture «evolution» V2.0

- The experimental data includes the other diseases expected from space radiation exposure.
- The AMS-02 detector measures the CRs components (electrons, heavy nuclei).
- The Radiobiology Mathematical models' library addresses specific NTE biologic mechanisms and AI-based data analysis technique.



Enabling Research @ AMS Roma Group

Laser Plasma Accelerators

The research Topic and Context

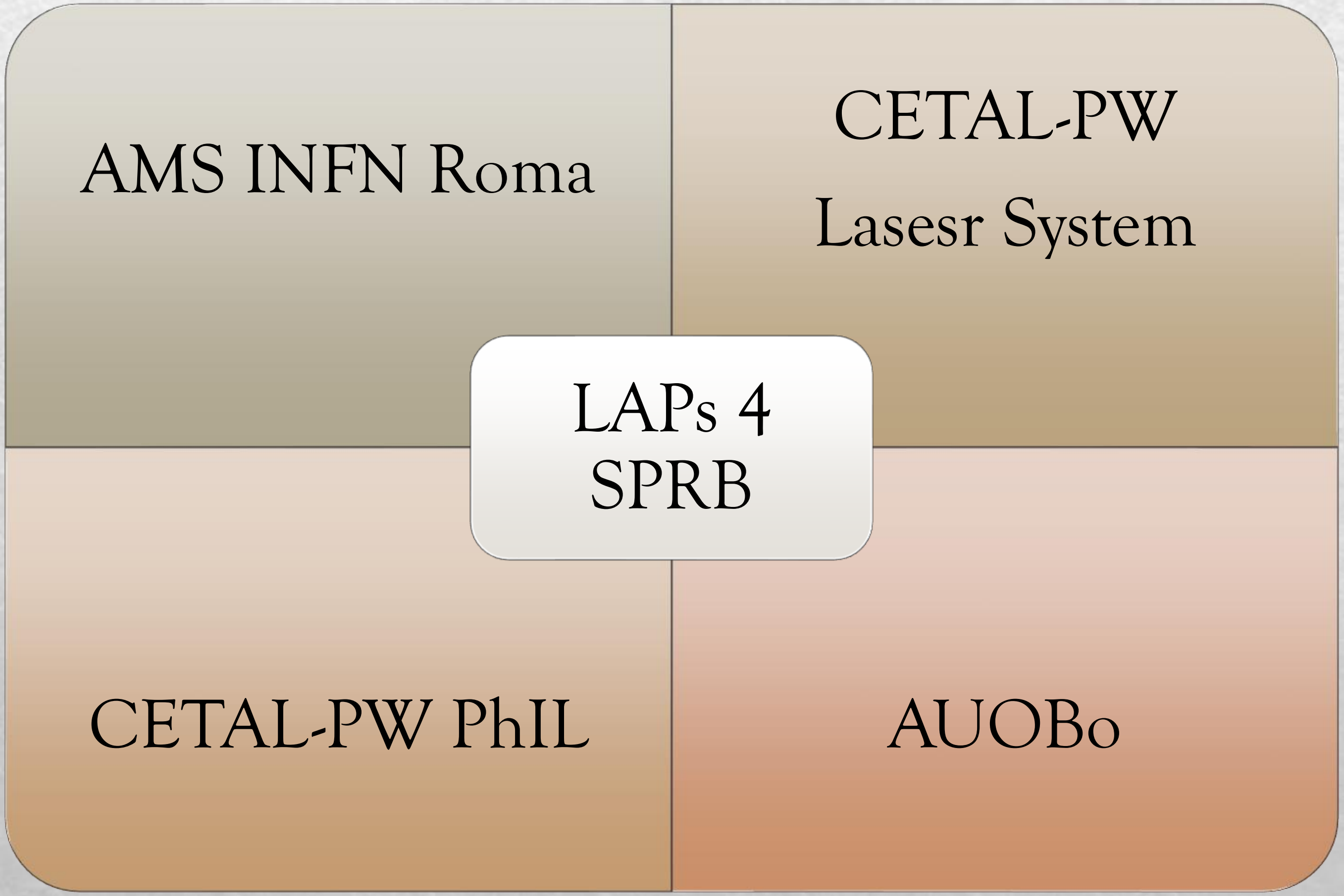
One of the Space Radiobiology crucial points in advancing the knowledge in this field is **enhancing the possibility of generating experimental data**; to that, space radiation reproduction is mandatory.

Using the **analogue approach** that in many other areas of space research is of great success, it could be possible to use Laser Plasma Accelerators (LPA) to reproduce the space radiation condition in ground experiments and design radiobiology investigations in the space environment.

LPA is capable of robust generation of particle beams such as electrons, protons, neutrons and ions, as well as photons, having a wide range of accessible parameters.

Several facilities exist in the world equipped with LPAs, however to full understand the radiobiology mechanism and models ad **hoc tuning of all the LPAs parameters to reproduce the exposure conditions** are mandatory.

The (Topical?) Team



INFN Roma are in the expertise of CRs physics and Space Radiation as well as in the ICT necessary to develop radiobiology models.Also are present all the data collected by the AMS experiments since 2011

IRCCS AUOBo medical physicists will contributes due their experience in dosimetry, radiology and radiobiology applied at the nuclear medicine and radiotherapy.

INFLPR-CETAL equipment consists of ultrashort pulsed laser systems and the necessary expertise for microfluidic lab-on-a-chip device fabrication, as well as cell culture facility, PW-laser class system, controlled gas valve target system, experimental chamber system and beam characterization tools, as well as the expertise for generation of accelerated particles and associated ionizing and non-ionizing radiations within space radiation spectra.

Scope

Scope: Identification exposure protocols and methodologies for improving Space Radiation testing analogues using LPAs using the Alpha Magnetic Spectrometer (AMS02) detector Cosmic Rays fluxes and spectra measurements.

Development : Foster collaboration from different scientific communities (Space Radiation , Medical Physics, LPAs Experts), Characterization and definition of protocols suited for space radiobiology testing

Technological Gap : Coupling of the existing LPAs technologies with a platform including all the relevant dose effects information and exposure conditions necessary for better characterize and investigate target and non-target effects in SPRB.

Innovations Areas : Combining LPAs low cost space radiation analogue methodologies with a proven platform with experimental information , now in development at INFN Roma Sapienza AMS group.

The final result will enable greater usability of these new technologies for the SPRB and hence for a safe space exploration.

Scope

Scope: Identification of exposure protocols and methodologies for improving Space Radiation testing analogues using LPAs using the Alpha Magnetic Spectrometer (AMS02) detector Cosmic Rays fluxes and spectra measurements.

What next ?

- A pleasure to be here to be here
- Talks/papers accepted/to be submitted on different conferences potentially interested to the topics (hopefully to write in collaboration with CETAL people)
- Propose an ESA topical team ?
- ……

IAC 2023 BAKU — 74th INTERNATIONAL ASTRONAUTICAL CONGRESS — 2-6 OCTOBER 2023 BAKU, AZERBAIJAN — Global Challenges and Opportunities: Give Space a Chance — WWW.IAC2023.ORG

24 April 2023

Alessandro Bartoloni
National Insitute of Nuclear Physics - INFN
Italy

74th International Astronautical Congress
Baku, Azerbaijan
2-6 October 2023

Subject: IAC 2023 — Notification to Authors

Dear Dr. Bartoloni,

As Co-Chairs of the International Programme Committee for the 74th International Astronautical Congress, we are pleased to inform you that your abstract "**Towards an Analogue Environment for Space Radiation and Radiobiology Investigations: the Laser Plasma Accelerators Case**" has been accepted for a **10-minute interactive presentation** (including Q&A and group discussion).

Please find the details hereunder.

Symposium	A1 - IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM
Presentation ID Nr.	IAC-23,A1,IP,24,x79003

Conclusions

Technological advancements might realize the dream of human space exploration, and crewed spaceflights to explore the Moon and Mars are on the agenda of space agencies.

In the latest years, significant improvements have been made in the absorbed dose-effect estimation for predicting risks for human health on space exploration.

Unfortunately, the number of events helpful in modeling the radiobiological effects is still limited. On Earth experiments may reinforce knowledge on cancer and non-cancer space-radiation induced effects.

The AMS Roma Sapienza group is part of the scientific community investigating this crucial research topic for safe human exploration of space.

Actual research on DEM are on the evaluation in Non-Target Effects in Carcinogenesis Risk

Thanks for yours attention !

Alessandro Bartoloni

alessandro.bartoloni@cern.ch

AMS02 INFN ROMA and Sapienza University Web Site

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Multidsciplinary and TT

The proposed research activity is highly interdisciplinary and involves three scientific communities (space radiation, medical physics, and laser-plasma accelerators) in defining and harmonizing exposure protocols and methodologies for SPRB investigations.

Further, the first steps of protocol definitions imply a comparison in a multidisciplinary contest to set up the appropriate exposure scenarios for facilitating the investigation of mechanistic models predicting the radiation-induced effects in deep Space. This process and the consequent exchange of knowledge and information may improve the researcher's scientific skills and thinking, opening new perspectives and methodologies of work.

The defined LPAs protocols for space radiobiology investigations could be transferred to many other fields of applications, particularly the reliability of electronic components onboard deep space starships. Laser plasma accelerators might become an indispensable tool for future advanced testing and certification of electronic components for use in Space, for high-altitude flights and in other harsh radiation environments. Consequently, their use could decrease the lag of performance of electronic components used in Space today compared to standard microelectronics used on Earth.

Scientific and technological impact in space, national and / or international

The proposal's impact is to reproduce or mimic certain kinds of space radiation with a much higher realism than state-of-the-art techniques, thanks to the use of LPAs technology in multidisciplinary frameworks.

This combination holds for Van-Allen Belt electron and proton radiation but might also be valid for the heavy nuclei components in the Galactic Cosmic Rays.

Testing radiobiological samples in space missions are among the most expensive and time-consuming processes in life space science study.

LPAs could substantially decrease the costs and time consumption of these tests to benefit all the national space agencies and international collaborations involved in space mission design.

Consequently, their use could reduce the mission's design times and improve overall safety thanks to the deep comprehension of mechanistic radiobiological models.

Thus, testing by LAPs could enhance the knowledge of the health risk of future space missions beyond the current progress. Furthermore, using LPA instead of radioactive radiation sources or poly-energetic accelerators is also desirable under proliferation and management aspects.

17th International Conference on Space Operations, Dubai, United Arab Emirates, 6 - 10 March 2023.
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Space Radiation Characterization for a Safe Human Space Exploration and Colonization

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Abstract

All the space agencies are working to restart the human exploration of space outside the Low Earth Orbit (LEO). Crewed space missions in this and the next decade will see the presence of humans on the Moon and Mars surfaces. One of the main showstoppers to be investigated for a safe exploration and colonization is the ionizing radiation biological effects that can compromise the health of astronauts/space workers. The characterization of the space radiation fields on the Moon and Mars surface, as well as in the Beyond Low Earth Orbit space, will be the first step toward an accurate description of the radiobiological effects, and continuous monitoring of the radiation level will allow a safe permanence of the humans in the Moon and Mars habitat. In this vital task, the astroparticle experiments presently operating in space could play a principal role. Such experiments are a source of information crucial to improving the knowledge of radiobiology effects in space. This paper will review some of the most successful astroparticle space missions (AMS-02, Pamela, …) and their results, the planned ones for the next decades as well as the critical technologies derived from these instrumentations that will be crucial for on-surface and on-orbit radiations levels monitoring and surveillance systems design. Further the current activities and the future perspectives of the AMS INFN Roma Sapienza research group in this topic are described.

Keywords: Space Radiation, Human Space Exploration, Space Radiobiology, Cosmic Rays, AstroParticle Experiments, Cosmic Rays Detectors

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Space Radiation Characterization for Safe Human Space Exploration and Settlements

(manuscript accepted 6/4/2023)

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