



UNITED NATIONS
Office for Outer Space Affairs



国家航天局
China National Space Administration

United Nations/China 2nd Global Partnership Workshop on Space Exploration and Innovation

November 2022

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

Astroparticle Experiments to
Improve the Biological Risk
Assessment of Exposure to Ionizing
Radiation in the Exploratory Space
Missions:

a Research Topic Initiative

Alessandro Bartoloni

On behalf of the AMS Roma Sapienza group

Italian Institute for Nuclear Physics (INFN)



United Nations/China 2nd Global Partnership Workshop on Space Exploration and Innovation

Session 4: Prospects and challenges in space science

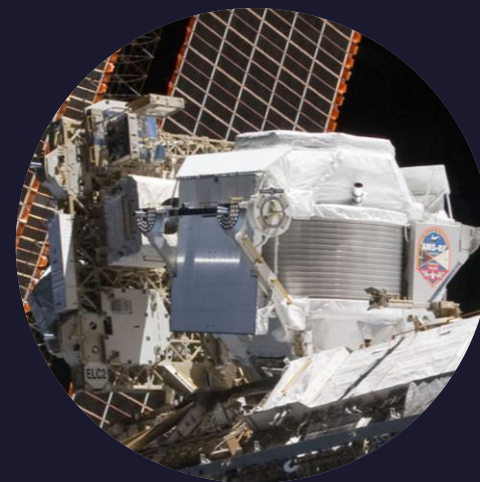
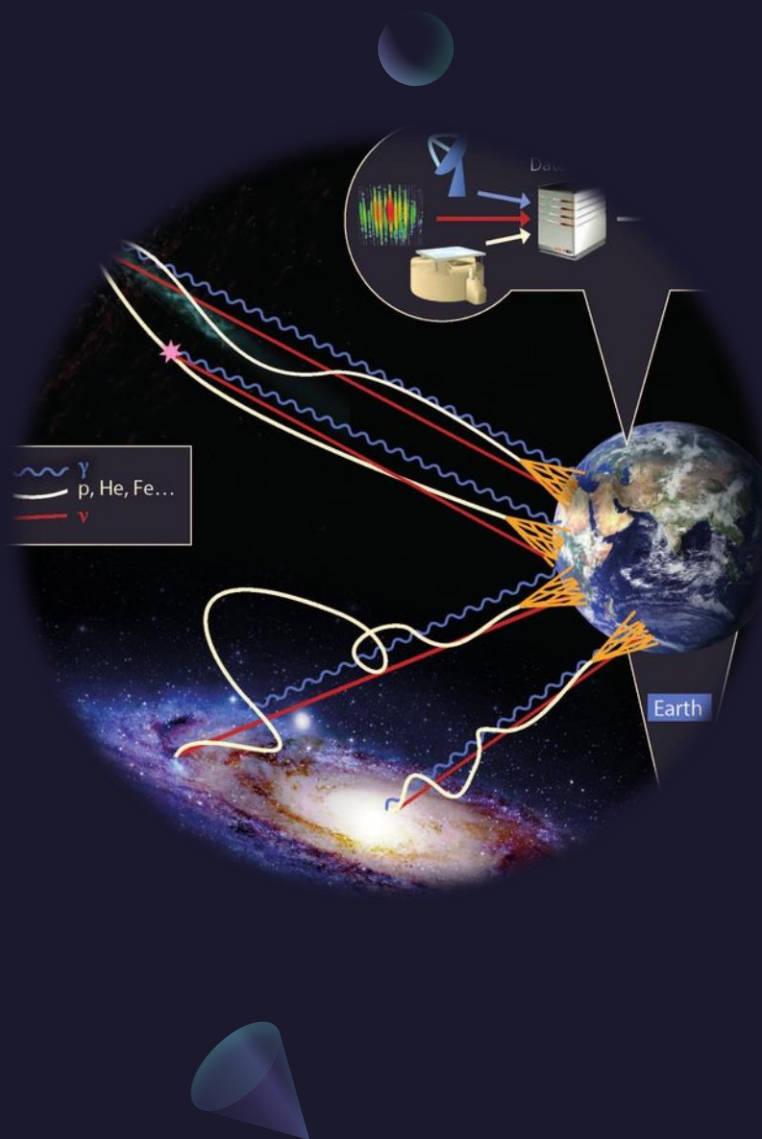
Organized by United Nations Office for Outer Space Affairs (UNOOSA)
and China National Space Administration (CNSA)
Hosted by National Space Science Center (NSSC), Chinese Academy of Sciences

23 Nov. 2022 Hainan, China



Outline

- The AMS Roma Sapienza Group
- The Research Topic Initiative
- Astroparticle Experiments in Space



The AMS Roma Sapienza Research Group



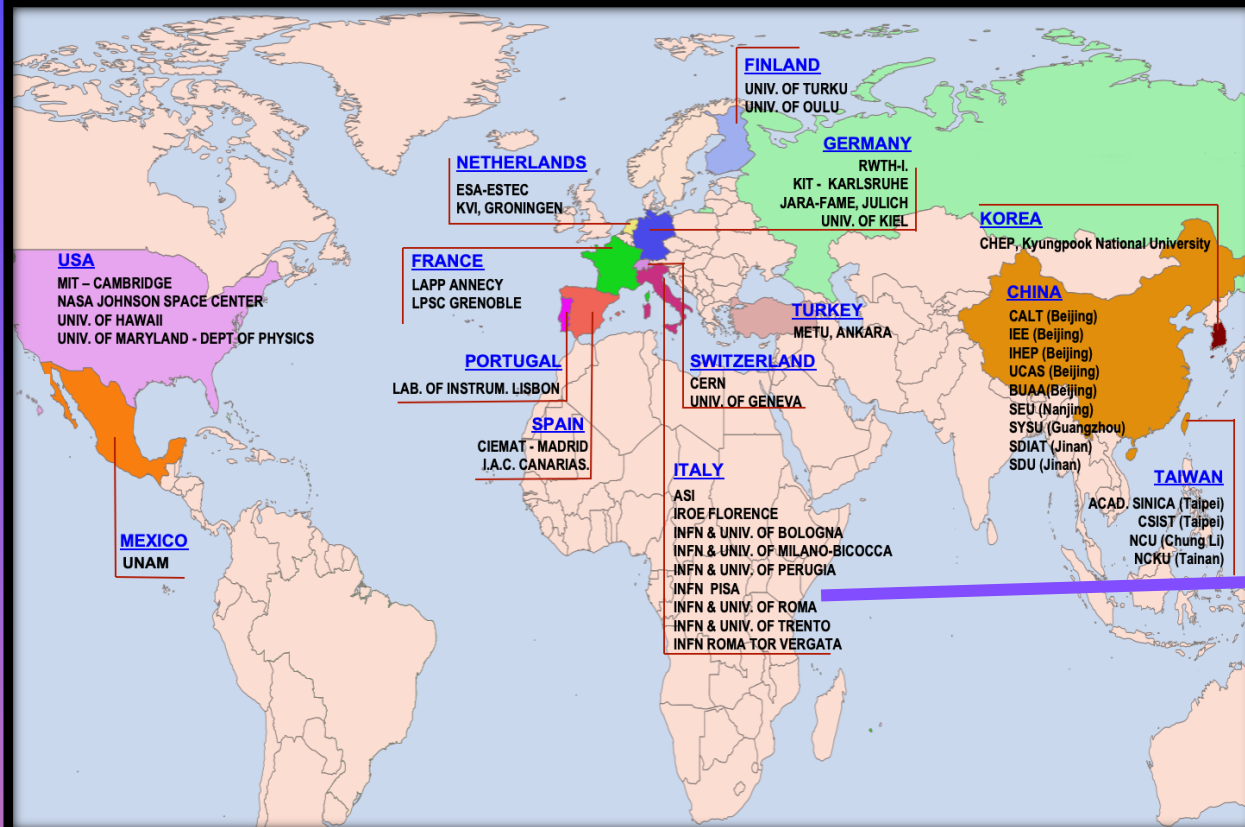
The AMS SPRB collaboration was created in 2017 by the synergy of the AMS INFN Roma Sapienza (Italy) group leaded by Alessandro Bartoloni with the medical physics research group leaded by Lidia Strigari currently at IRCCS university Hospital of Bologna (Italy)

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



AMS INFN ROMA SAPIENZA GROUP



Aboma Negasa
Guracho



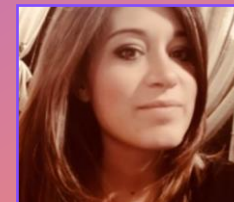
Alessandro
Bartoloni



+
○
● Giuseppe
Della Gala



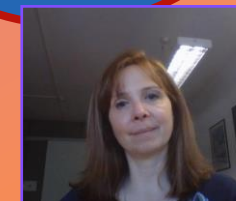
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Miriam
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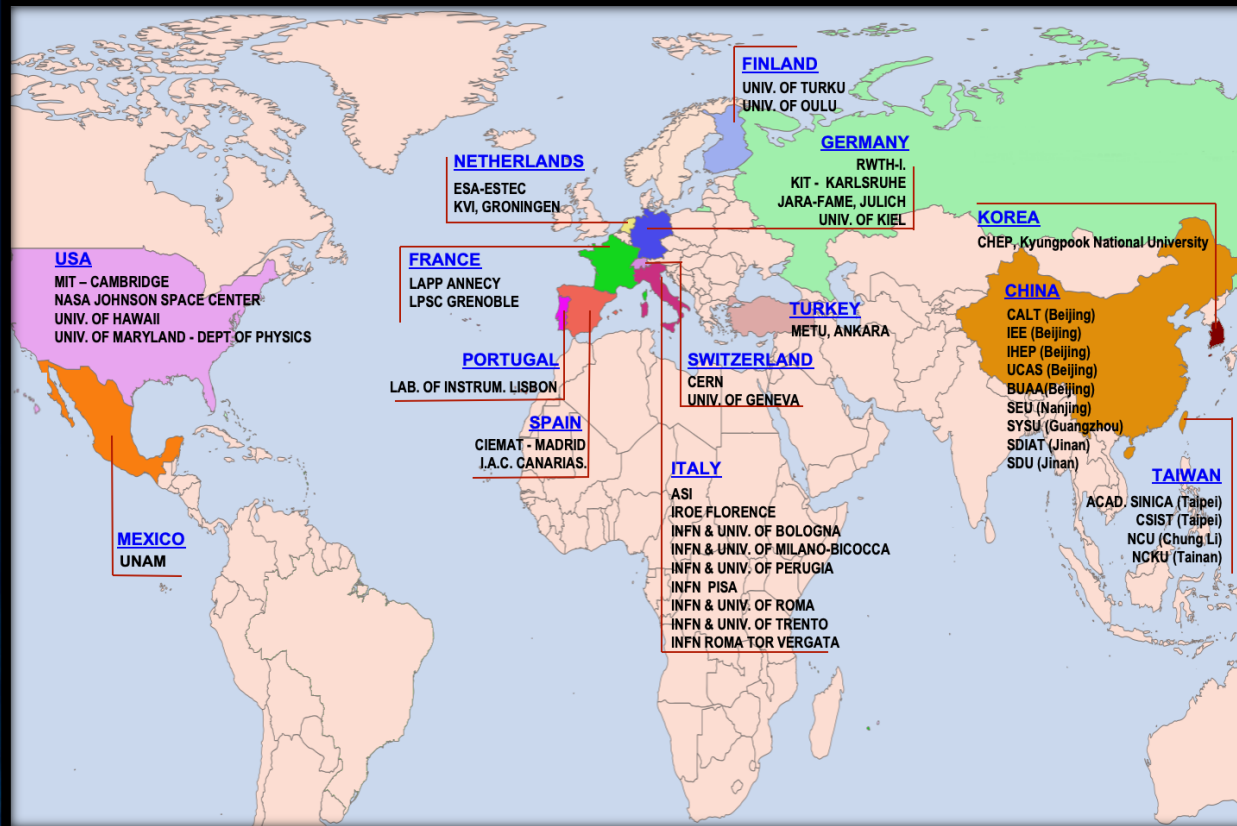


Lidia
Strigari



Giulia
Paolani





The AMS collaboration

(<http://ams02.space>)

An international collaboration made of 44 Institutes

from America, Asia and Europe

Presents in 7 INFN departments
(BO, MIB, PL, PG, RM1, RM2, TN)

Alessandro Bartoloni - UN-CNSA Workshop 21-23 November 2022



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

More Info in the AMS-02 webpage:

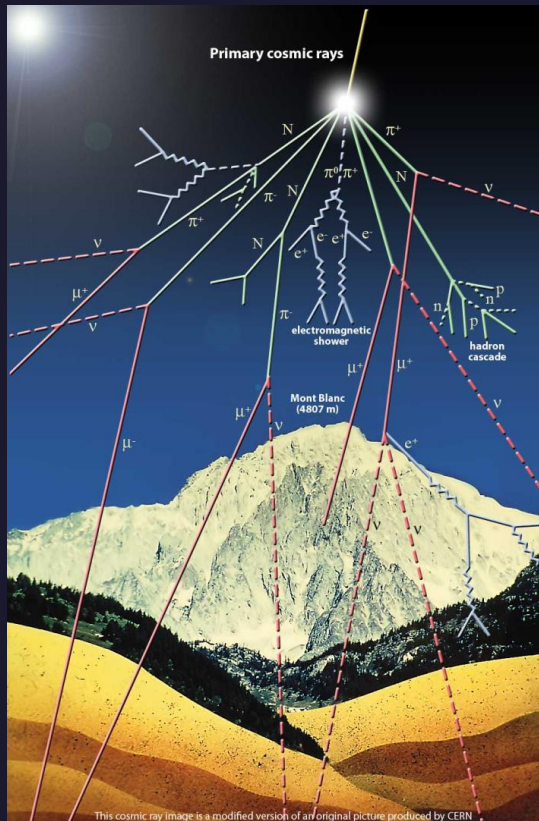
<https://ams02.space>

23 November 2022

8

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 lose 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.

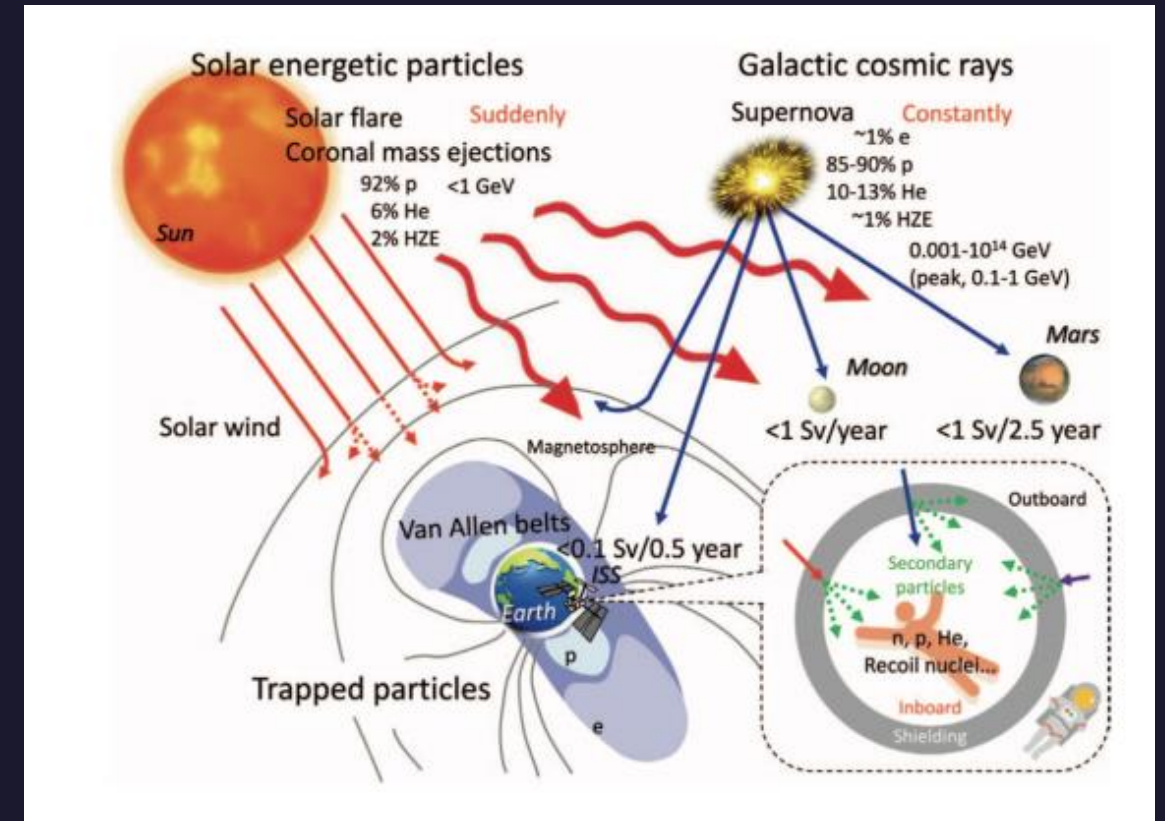


Image courtesy of European Space Agency (ESA)

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

**SPACE RADIOBIOLOGY
AND
PRECISION GALACTIC COSMIC RAY MEASUREMENTS**

**ON HOW THE AMS02 EXPERIMENT ON THE INTERNATIONAL SPACE STATION CAN HELP THE
RADIATION HEALTH HAZARD ASSESSMENT IN EXPLORATORY SPACE MISSIONS**

LUNEDÌ 4 NOVEMBRE 2019
DIPARTIMENTO DI FISICA – AULA CONVERSI

 **14:30-14:45**
Introduzione
A. Bartoloni – INFN Roma

 **14:45-15:35**
High precision measurements of charged cosmic rays in space with the Alpha Magnetic Spectrometer.
M. Paniccia, Università di Ginevra

 **15:35-16:20**
ESA Human Spaceflight Radiation Research Programme activities.
L. Surdo, European Space Agency

 **16:20-17:05**
Shielding design for long duration human exploratory space missions : issues and future perspective.
M. Giraudo, Thales Alenia Space



 **SAPIENZA**
UNIVERSITÀ DI ROMA

<https://agenda.infn.it/event/20462/>

Collaborations were mainly focused on creating synergy within different scientific communities (radiobiology, medical physics, radiotherapy, and nuclear medicine)

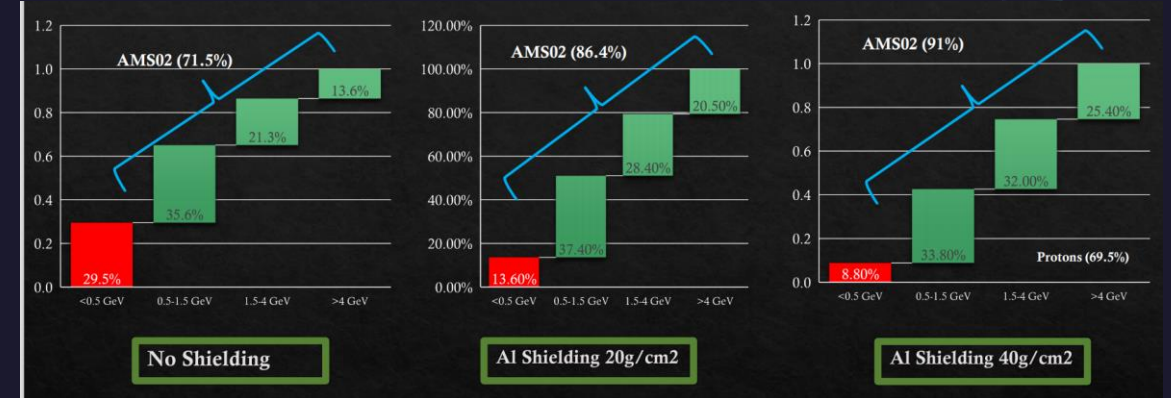
and Institutions playing a crucial role in the human space exploration

(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.

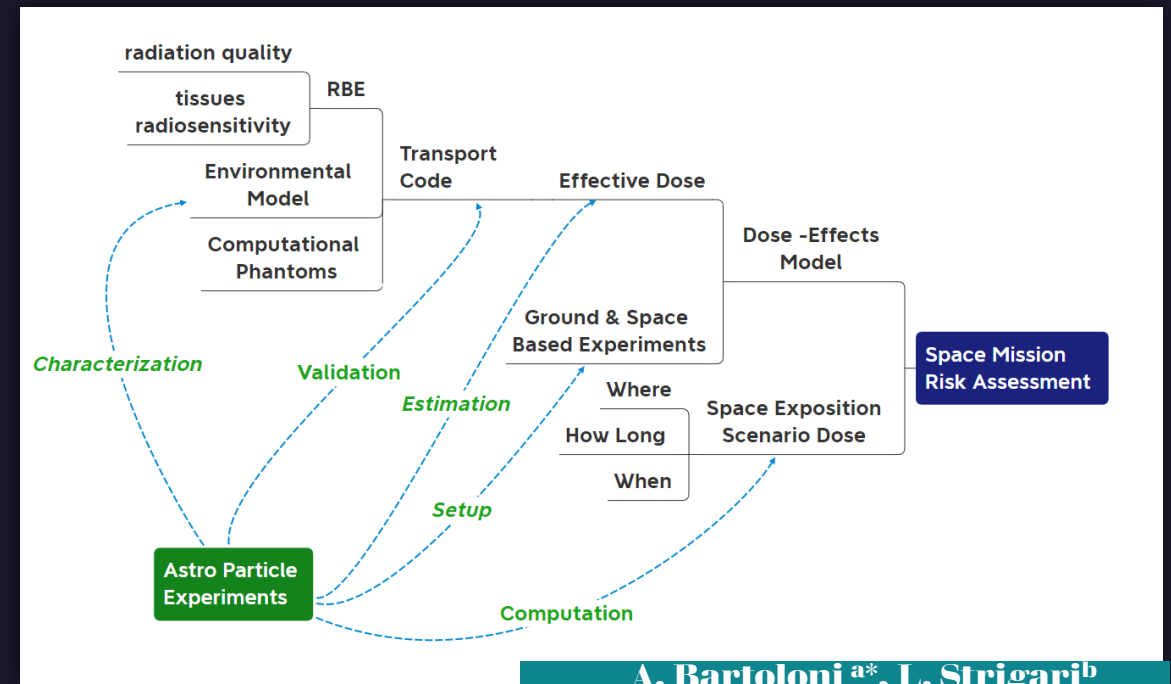


AMS02 GCR sensitivity analysis



A. Bartoloni ^{a*}, L. Strigari ^b

SIF2019



A. Bartoloni ^{a*}, L. Strigari ^b

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The Research Topic Initiative

Research Topics are Open Access themed article collections (similar in nature to classical special issues) with: a dedicated landing page, Continuous publication, Advanced impact metrics, Cross-disciplinarity, Multiple article types, e-book production



Research Topic

Astroparticle Experiments to Improve the Biological Risk Assessment of Exposure to Ionizing Radiation in the Exploratory Space Missions



frontiers
in Astronomy
and Space Sciences

Topic Editors



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The actual and next decade will be characterized by an exponential increase in the exploration of the Beyond Low Earth Orbit space (BLEO). Moreover, the firsts tentative to create structures that will enable a permanent human presence in the BLEO are forecast. In this context, a detailed space radiation field characterization will be crucial to optimize radioprotection strategies (e.g., spaceship and lunar space stations shielding, Moon / Mars village design, ...), to assess the risk of the health hazard related to human space exploration and to reduce the damages potentially induced to astronauts from galactic cosmic radiation. On the other side, since the beginning of the century, many astroparticle experiments aimed at investigating the unknown universe components (i.e., dark matter, antimatter, dark energy, ...) have been collecting enormous amounts of data regarding the cosmic rays (CR) components of the radiation in space.

Such experiments essentially are actual cosmic ray observatories, and the collected data (cosmic ray events) cover a significant period and permit to have integrated not only information of CR fluxes but also their variations on time daily. Further, the energy range is exciting since the detectors operate using instruments that allow measuring CR in a very high energy range, usually starting from the MeV scale up to the TeV, not usually covered by other space radiometric instruments. Last is the possibility of acquiring knowledge in the full range of the CR components and their radiation quality. The collected data contains valuable information that can enhance the space radiation field characterization and, consequently, improve the radiobiology issues concerning one of the most relevant topics of space radiobiology represented by the dose-effect models.

This articles collection accepts original research papers and review papers relating (but not limited to) the following topics:

- The analysis and proposal on how to use these astroparticle experiments data to enhance the space radiation field characterization and, consequently, improve the radiobiology issues in space concerning one of the most relevant topics of space radiobiology represented by the dose-effect models and relationship.
- The proposal of new methods or instruments to use the astroparticle experiments to improve the space radiobiology knowledge (i.e., real-time dosimetry, monitoring of solar activities, ...)

Keywords: Cosmic Ray, Space Radiation, Space Radiobiology, Astro-Particle Experiments, Human Space Exploration

Participating Journals

Manuscripts can be submitted to this Research Topic via the following journals:

Frontiers in
Astronomy and Space Sciences
Astrobiolology

Frontiers in
Physics
Radiation Detectors and Imaging

Frontiers in
Public Health
Radiation and Health



A new scientific language is needed to support the exploratory space missions because of the return of humans outside the Low Earth Orbit. The keywords are *Peacefully, Safely, Transparently*.

In that context, a priority is to keep the space exploration community secure and safe, and a crucial part is a detailed and accurate ionizing radiation health effects characterization.

Participate in creating part of this new language joining this interdisciplinary Frontiers Research Topic!

Research Topics are Open Access themed article collections (similar in nature to classical special issues) with: a dedicated landing page, Continuous publication, Advanced impact metrics, Cross-disciplinarity, Multiple article types, e-book production

The Research Topic Initiative

- While progressing in the research activity raised the awareness that to make progress in such a field it was required a new scientific language able to connect and create **synergy** between different scientific communities.
- Firstly, cause to **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.
- Further **space exploration and colonization** collects the worldwide hopes of a new era characterized by transparency and peacefully development. In that sense, these expectations coincide with the primary scientific interest, and science could play a breakthrough role in such direction.
- Among the many possibilities thus, we decided, supported and asked by the [Frontiers Editorial team](#), to launch this research topic named "**Astroparticle Experiments to Improve the Biological Risk Assessment of Exposure to Ionizing Radiation in the Exploratory Space Missions**".

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EDITORS

+

ALESSANDRO BARTOLONI - UN-ONSA
WORKSHOP 21-23 NOVEMBER 2022



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Bartoloni



Cristina
Consolandi



Lidia
Strigari



Nan
Ding



Gianluca
Cavoto

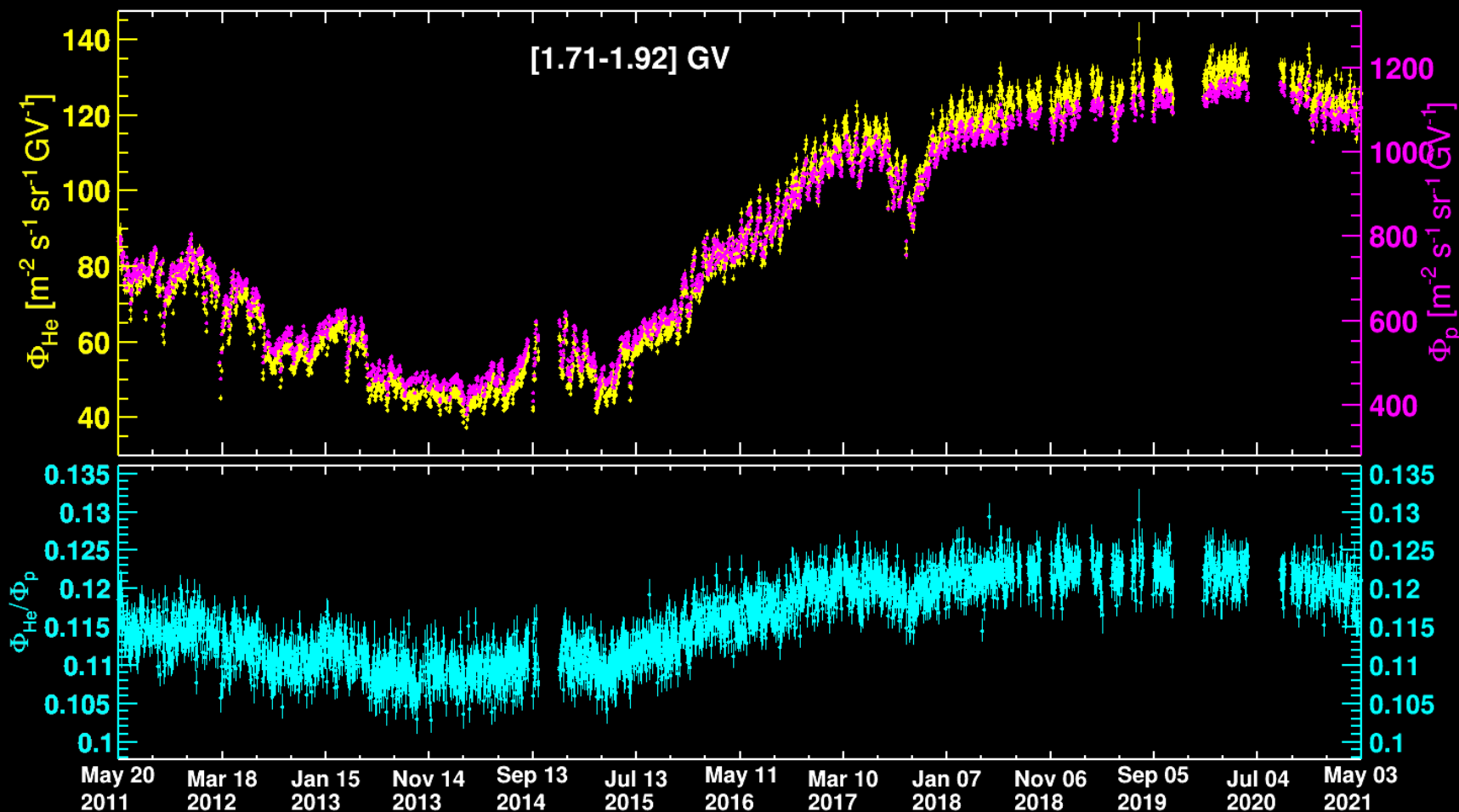


We created a research topic **editorial board** that was representative of **different scientific cultures** and **geographic areas** and invited many researchers and scientists from many different research areas due to the strong interdisciplinarity of the topic.



Short term Solar Modulation of GCR

Daily Proton and Helium Fluxes and Helium to Proton flux ratio



Dr. Cristina Consolandi
University of Hawaii,
United States

**member of the Alpha Magnetic
Spectrometer (AMS) collaboration
since 2010 (INFN MI Bicocca)**

PHYSICAL REVIEW LETTERS 127, 271102 (2021)
PHYSICAL REVIEW LETTERS 128, 231102 (2022)



Nan Ding dn@impcas.ac.cn

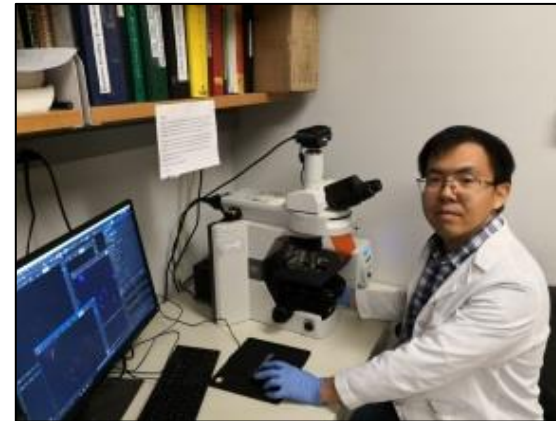
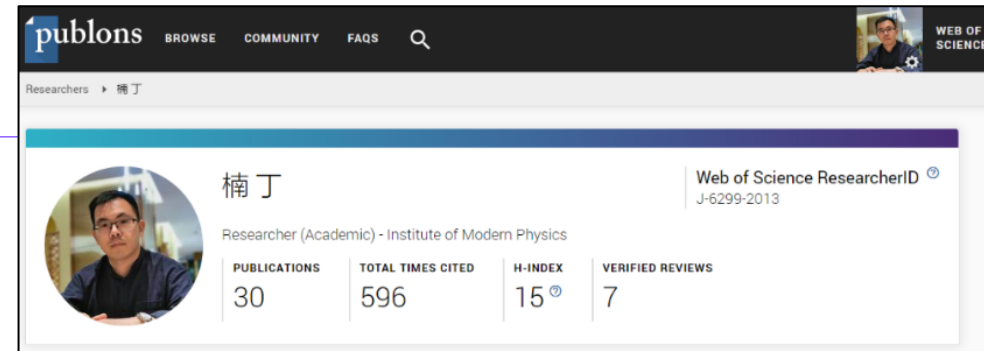
**Associate professor, Bio-Medical Center,
Institute of Modern Physics (IMP), CAS**

Research Interests

- ◆ Biological effects of heavy ion radiation
- ◆ Radiation induced bystander effects
- ◆ Radiation related ncRNAs

Work Experience

- ◆ 2007.7 to date IMP, Lanzhou, CHINA
- ◆ 2011.10-2012.4 NIRS, Chiba, Japan
- ◆ 2017.8-2018.10 OSU, Columbus, USA



Participating Journals

Manuscripts can be submitted to this Research Topic via the following journals:

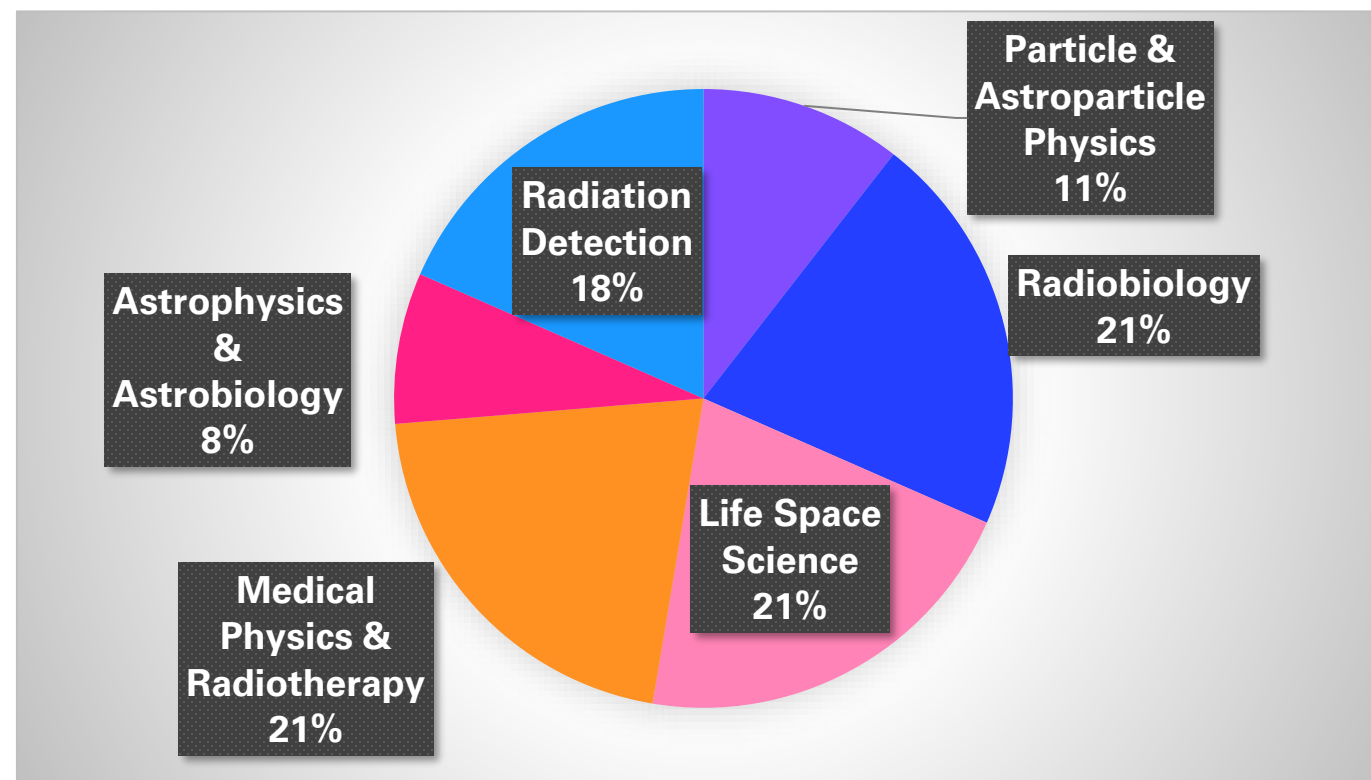
Frontiers in
Astronomy and Space Sciences
Astrobiology

Frontiers in
Physics
Radiation Detectors and Imaging

Frontiers in
Public Health
Radiation and Health

Interdisciplinary Topic

Contributors from different research areas



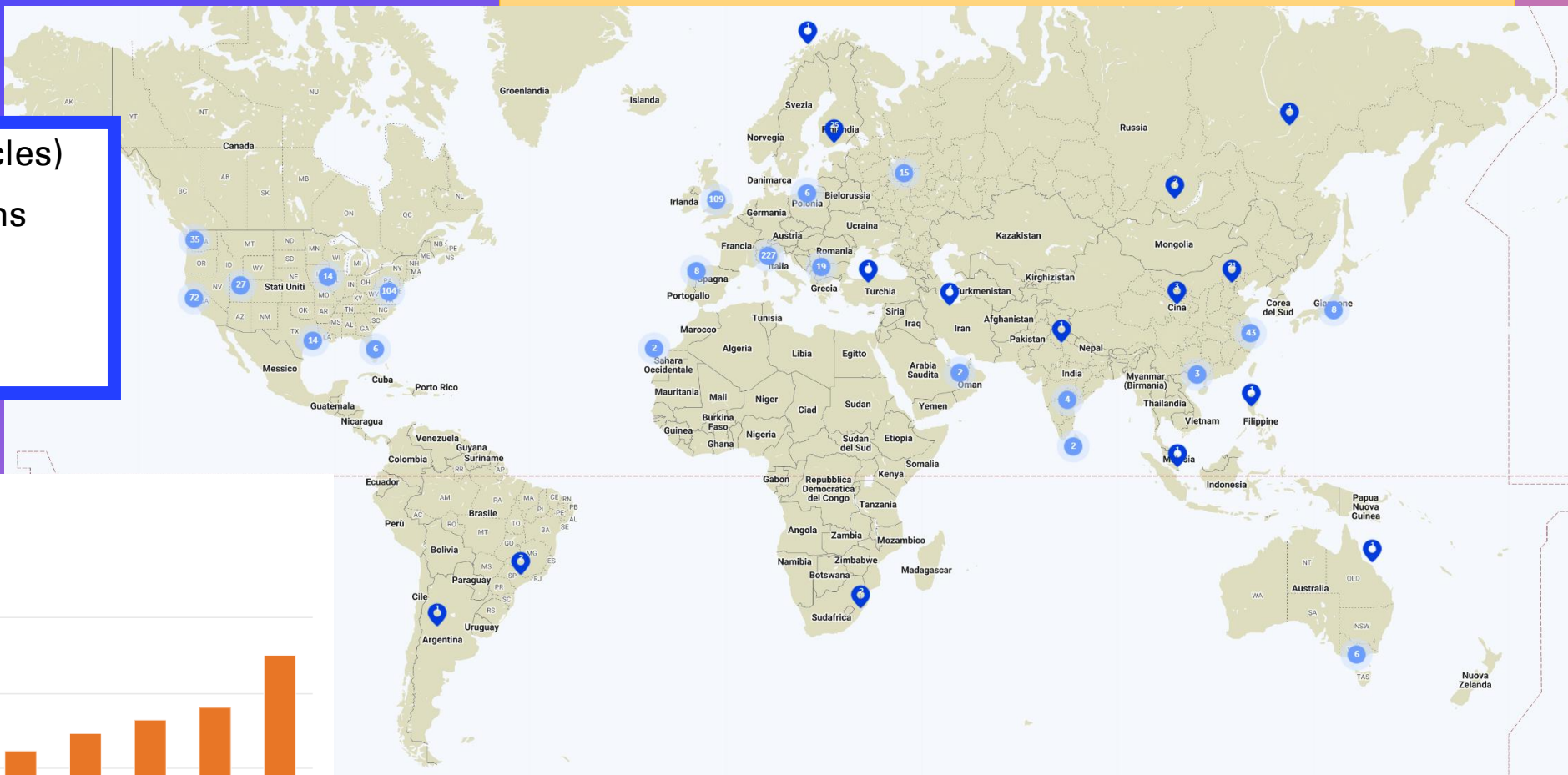
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- The proposal of new methods or instruments to use the **astroparticle experiments to improve the space radiobiology knowledge** (i.e., real-time dosimetry, monitoring of solar activities, ...)

RT Impact after 1 year

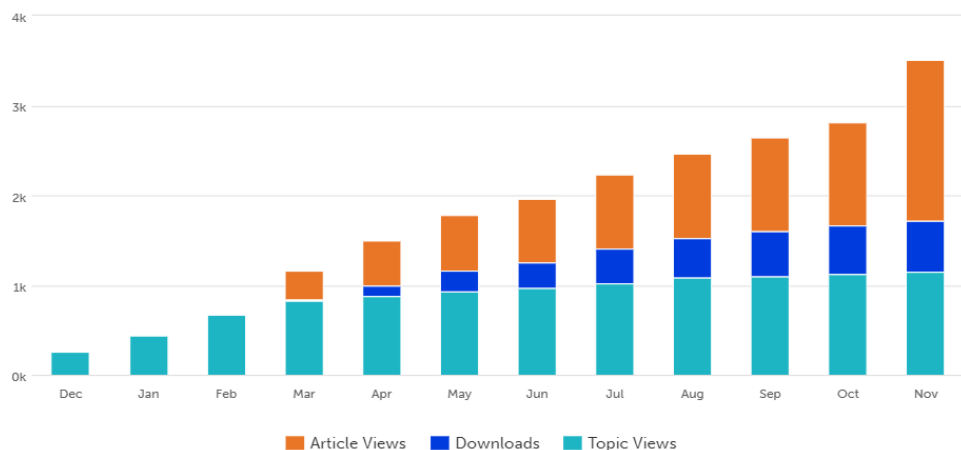
Worldwide interest for the topic

- > 3500 views (topic & articles)
- > 20 expected contributions
- > 5 abstracts received
- 2 published manuscript



Last 12 months

3,515 total views | 1,797 views | 571 downloads | 1,147 topic views



Open for articles submissions !

SCAN the QR CODE
to participate !

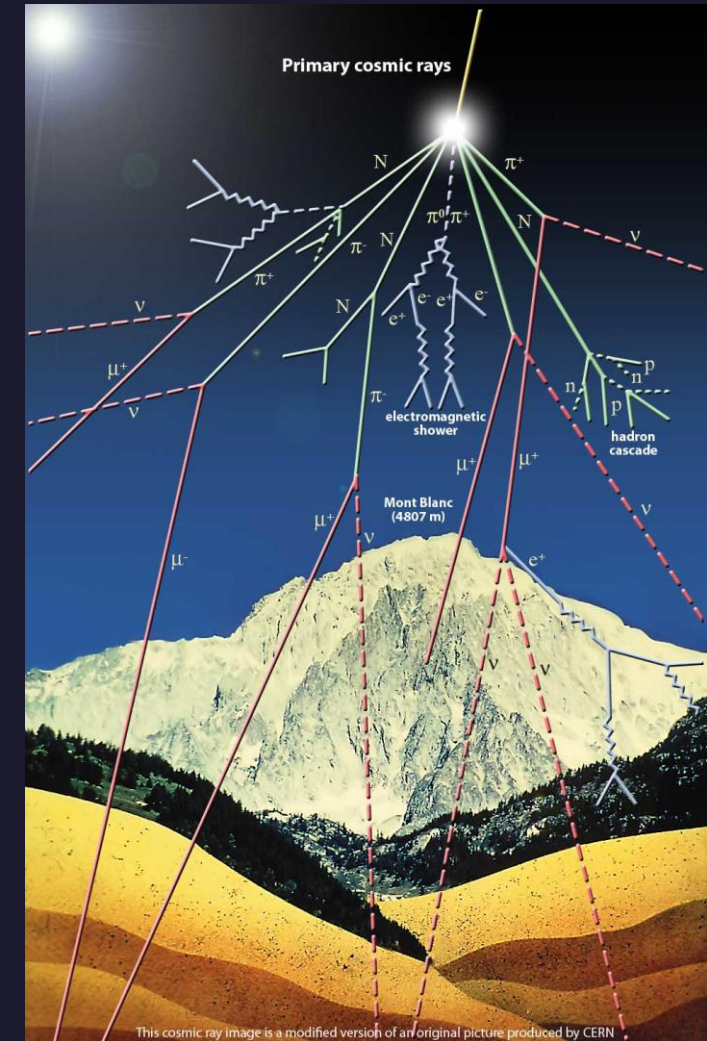
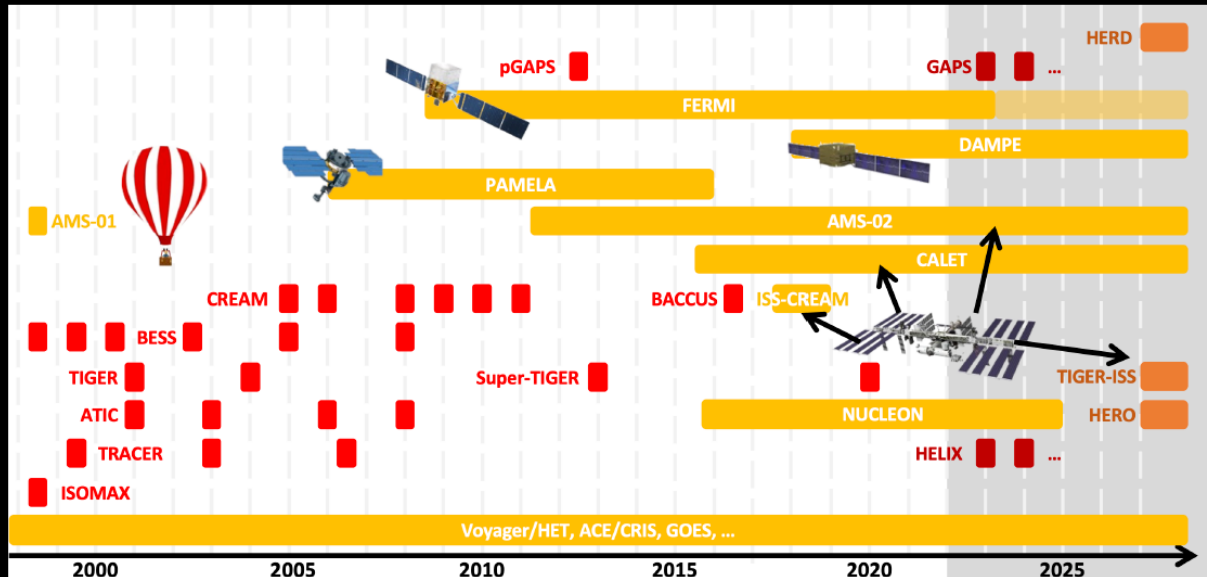


Astroparticle Experiments in Space

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



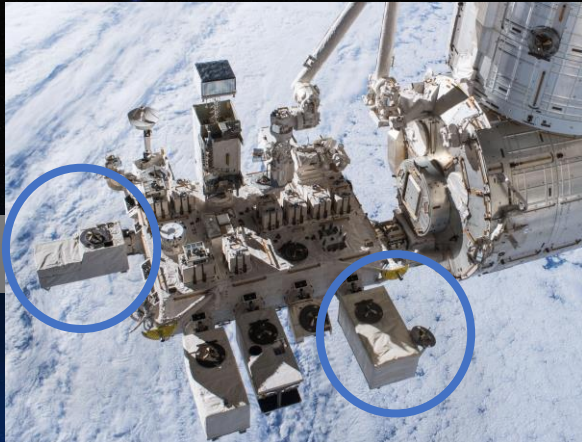
Principal Operating Cosmic Ray Space Detectors

International Space Station based



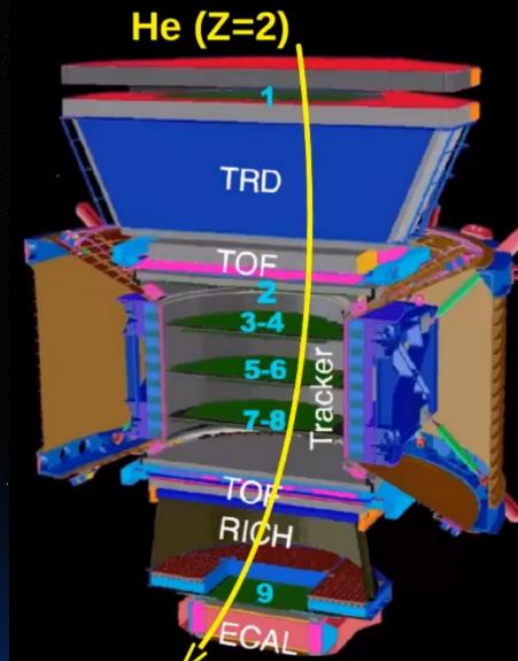
AMS02 – 2011

CALET - 2015



ISS-CREAM – 2017-2019

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



Satellite Based

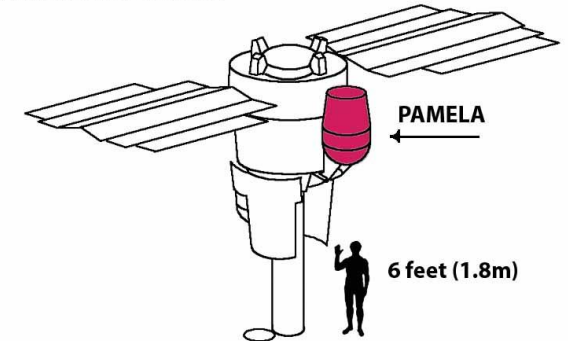


ACE - 1997



DAMPE - 2017

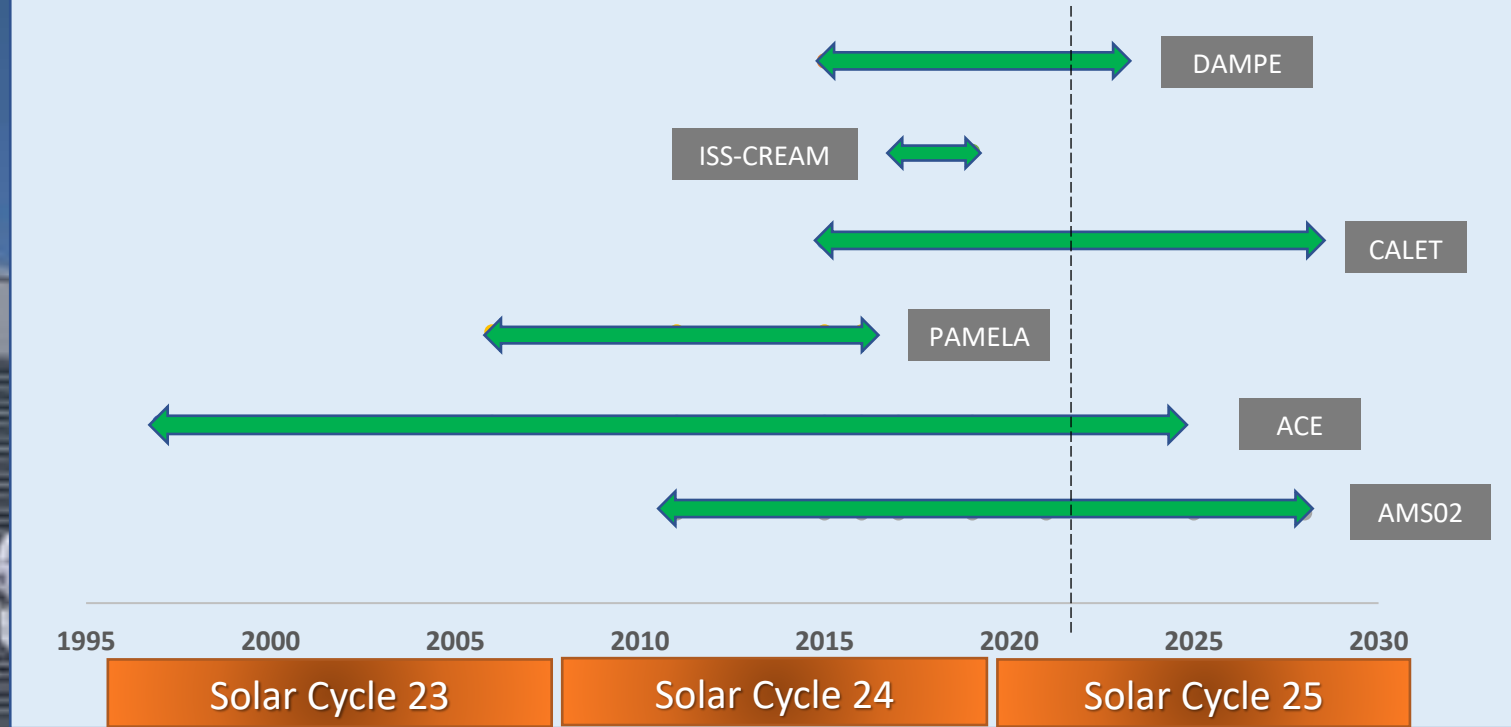
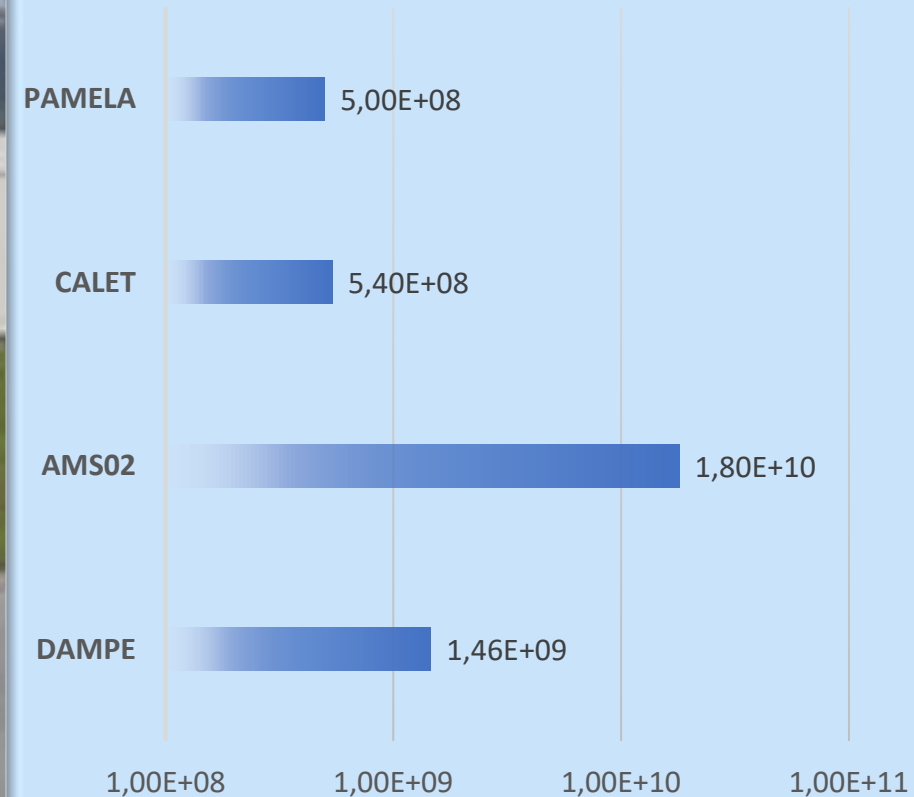
Resurs-DK
Reconnaissance Satellite



PAMELA – 2006-2016

Missions Operations

CR EVENTS/YEAR (BILLION)



Cosmic Ray Components Identification

e^+, e^- ✓ ALL

p^+, p^- ✓ ALL

D, He ✓ ALL

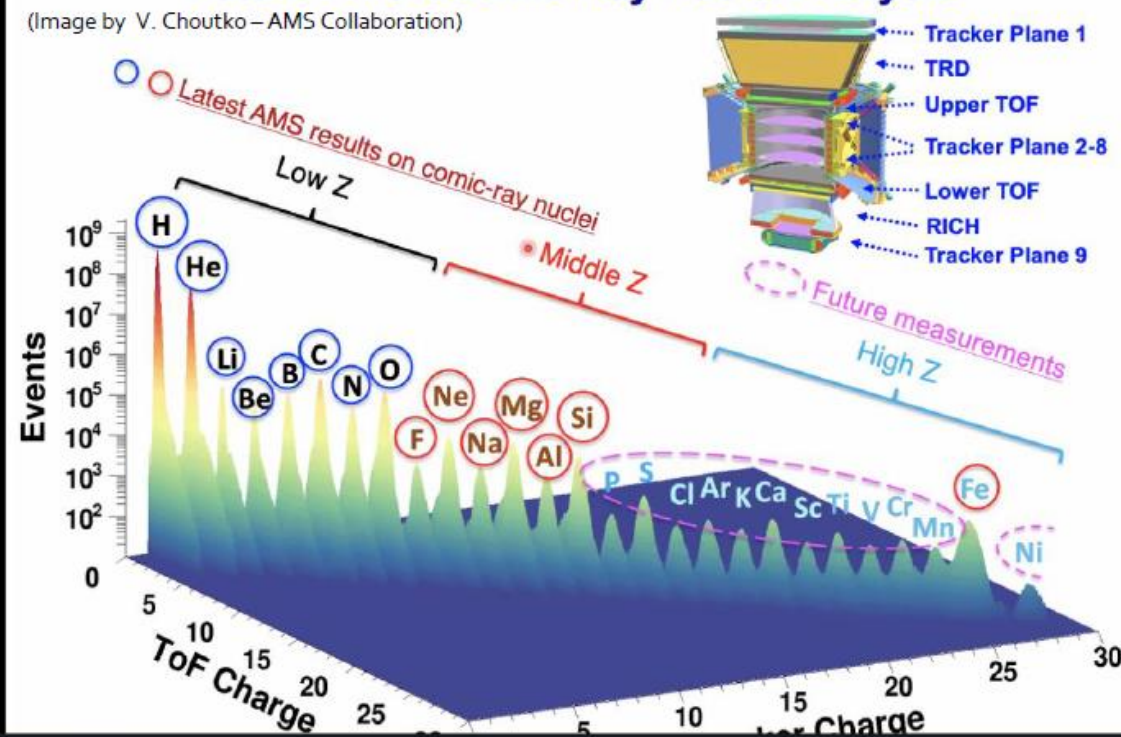
Low-Z (≤ 8) ✓ ALL (PAMELA up to $Z=6$)

Middle-Z ✓ AMS02, CALET, ISS-CREAM, ACE, DAMPE

High-Z (>14) ✓ AMS02, CALET, ISS-CREAM, ACE, DAMPE

Future AMS Cosmic-Ray Nuclei Analysis

(Image by V. Choutko – AMS Collaboration)



Properties of Iron Primary Cosmic Rays: Results from the Alpha Magnetic Spectrometer

AMS Collaboration • M. Aguilar (Madrid, CIEMAT) et al. (Jan 29, 2021)

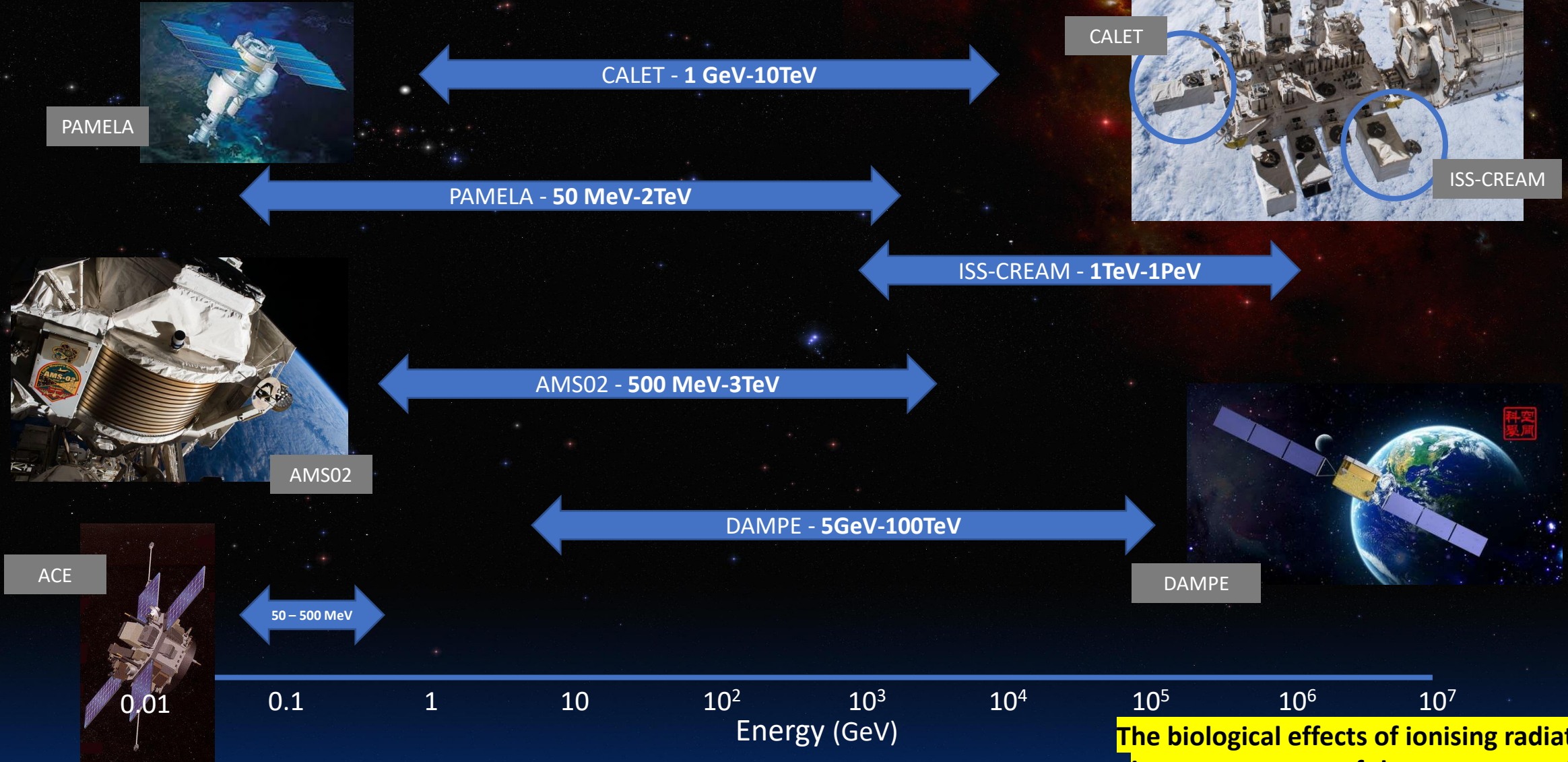
Published in: *Phys.Rev.Lett.* 126 (2021) 4, 041104

Properties of Heavy Secondary Fluorine Cosmic Rays: Results from the Alpha Magnetic Spectrometer

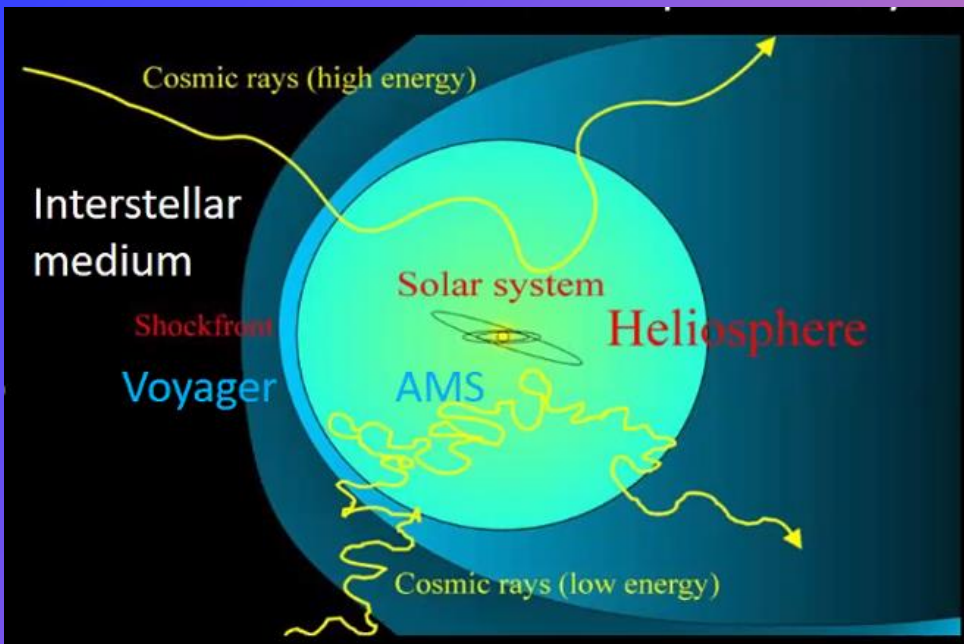
AMS Collaboration • M. Aguilar (Madrid, CIEMAT) et al. (Feb 25, 2021)

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

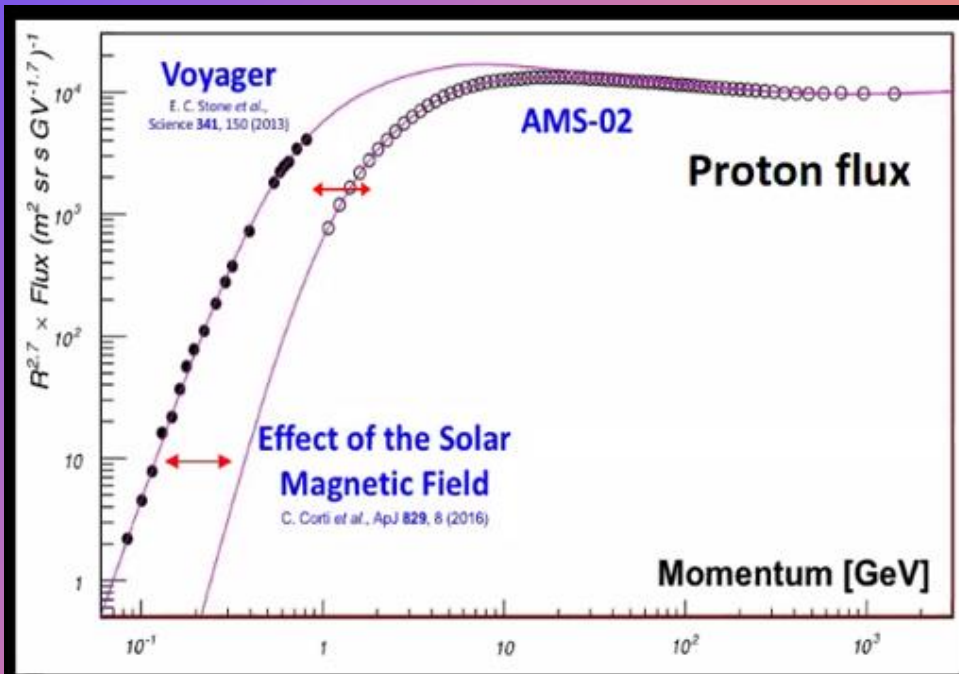


Cosmic Rays Solar modulation

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

This effect is particularly visible at low energies

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



Credit S.Ting & AMS Collaboration

Thanks for yours attention !

Alessandro Bartoloni

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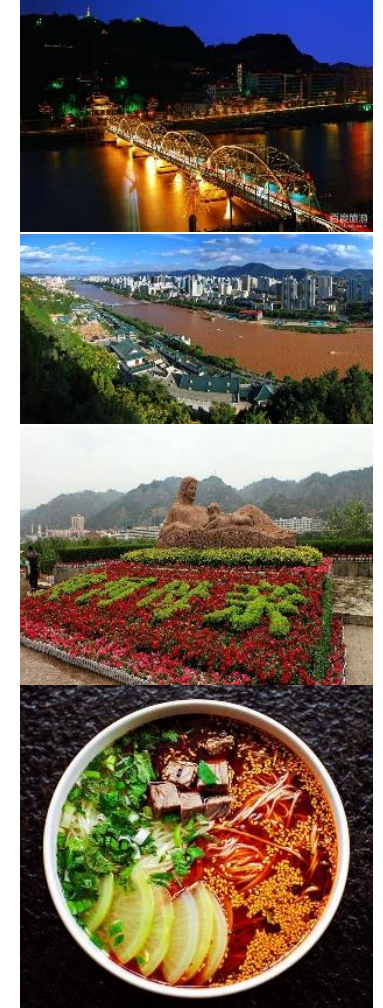


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Institute of modern physics, Chinese Academy of sciences



Institute of modern physics (IMP) was established in 1957 in Lanzhou, mainly works on basic and applied research in nuclear physics.



Institute of modern physics, Chinese Academy of sciences

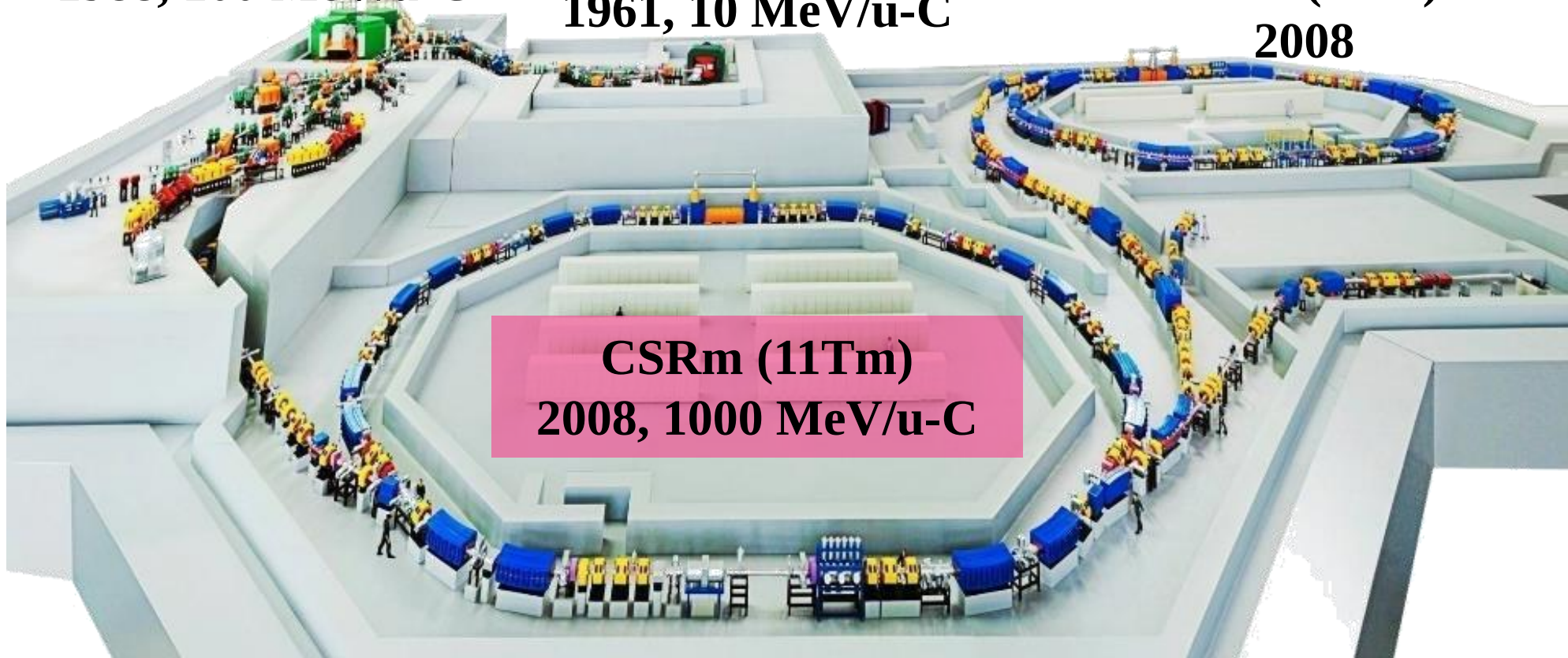
Heavy Ion Research Facility in Lanzhou (HIRFL)

The largest ion-accelerator complex in China

SSC (K=450)
1988, 100 MeV/u-C

SFC (K=69)
1961, 10 MeV/u-C

CSRe (9Tm)
2008



CSRm (11Tm)
2008, 1000 MeV/u-C