I gratefully acknowledge the strong support from the AMS collaboration, from the INFN Scientific Committee 180 2 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

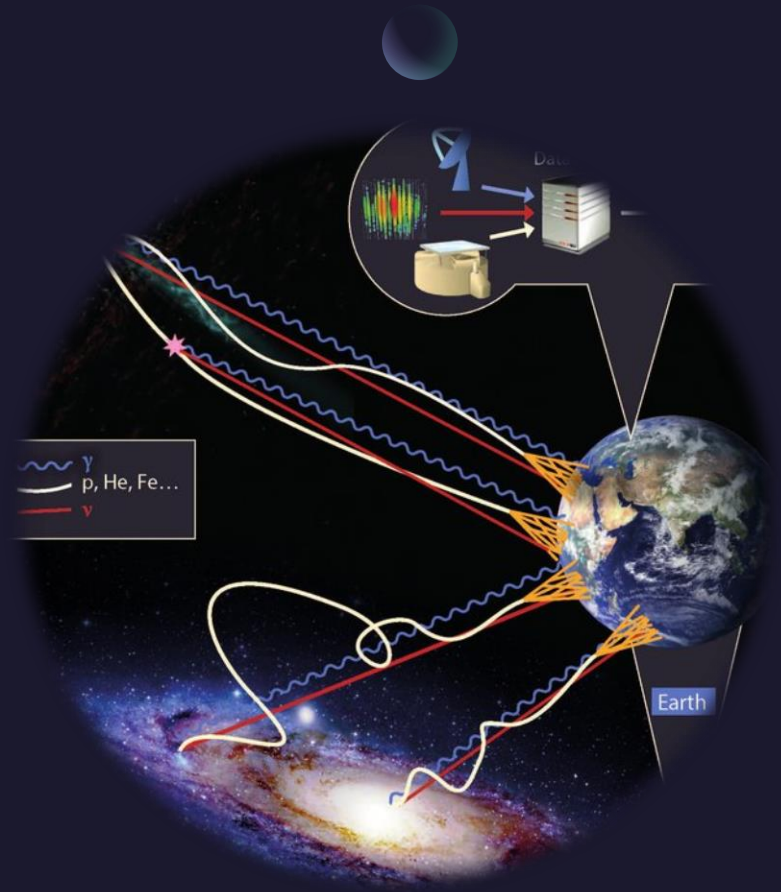
Alessandro Bartoloni

On behalf of the AMS Roma Sapienza group

Italian Institute for Nuclear Physics (INFN)

Outline

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



The AMS Roma Sapienza Research Group

POLICLINICO DI
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Azienda Ospedaliero - Universitaria di Bologna

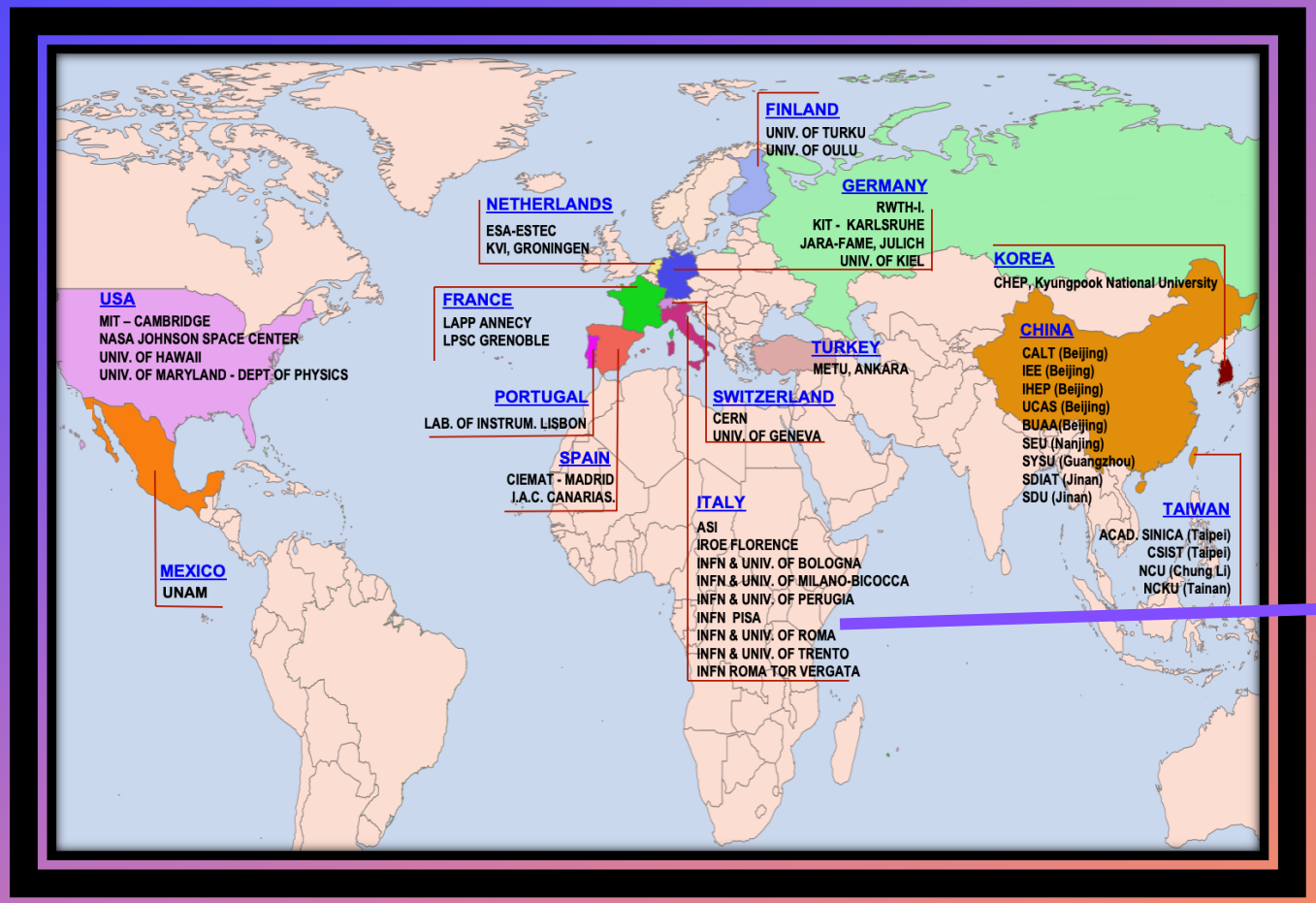
ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

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

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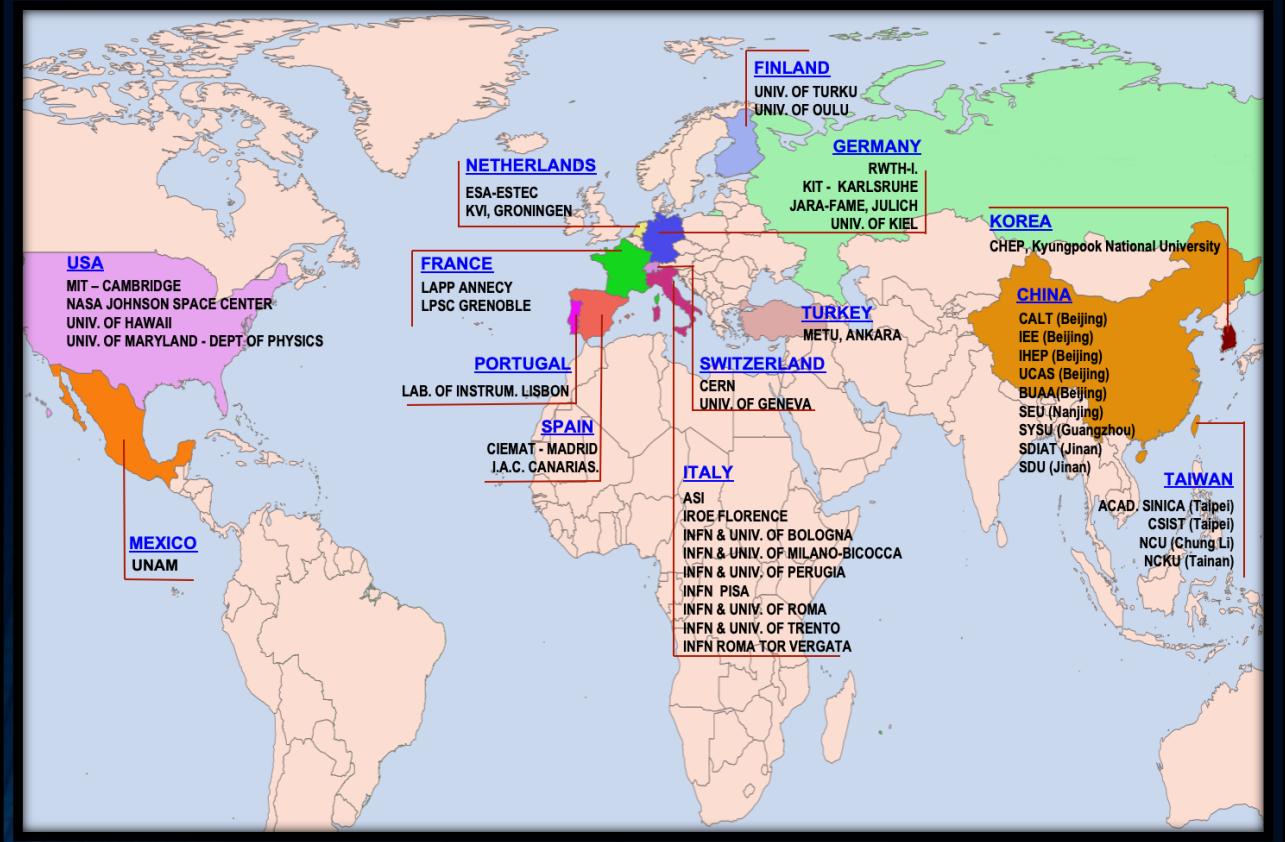
• Giuseppe Della Gala

Silvia Strolin

Giulia Paolani

Miriam Santoro

Lidia Strigari



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,PI,PG,RM1,RM2,TN)

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

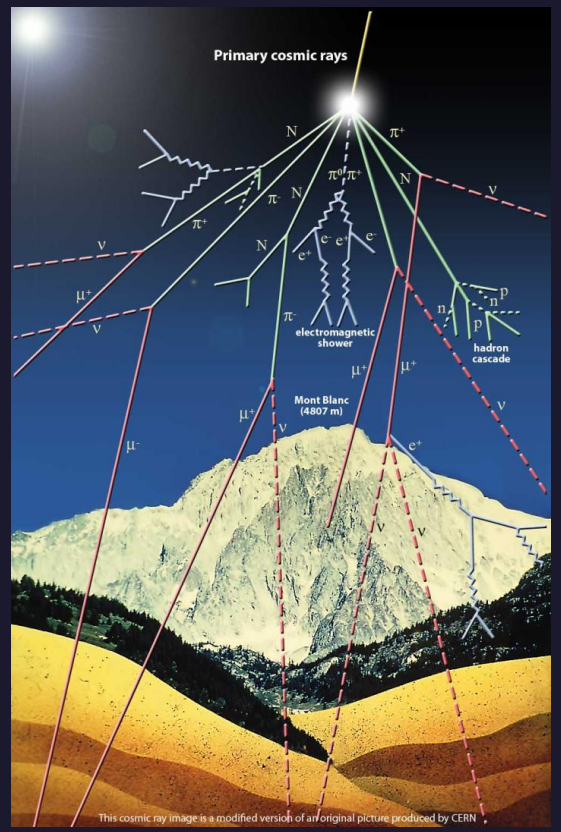
The AMS02 detector has collected so far more than **200 billion** Cosmic Rays events.

More Info in the AMS-02 webpage:

https://ams02.space

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.

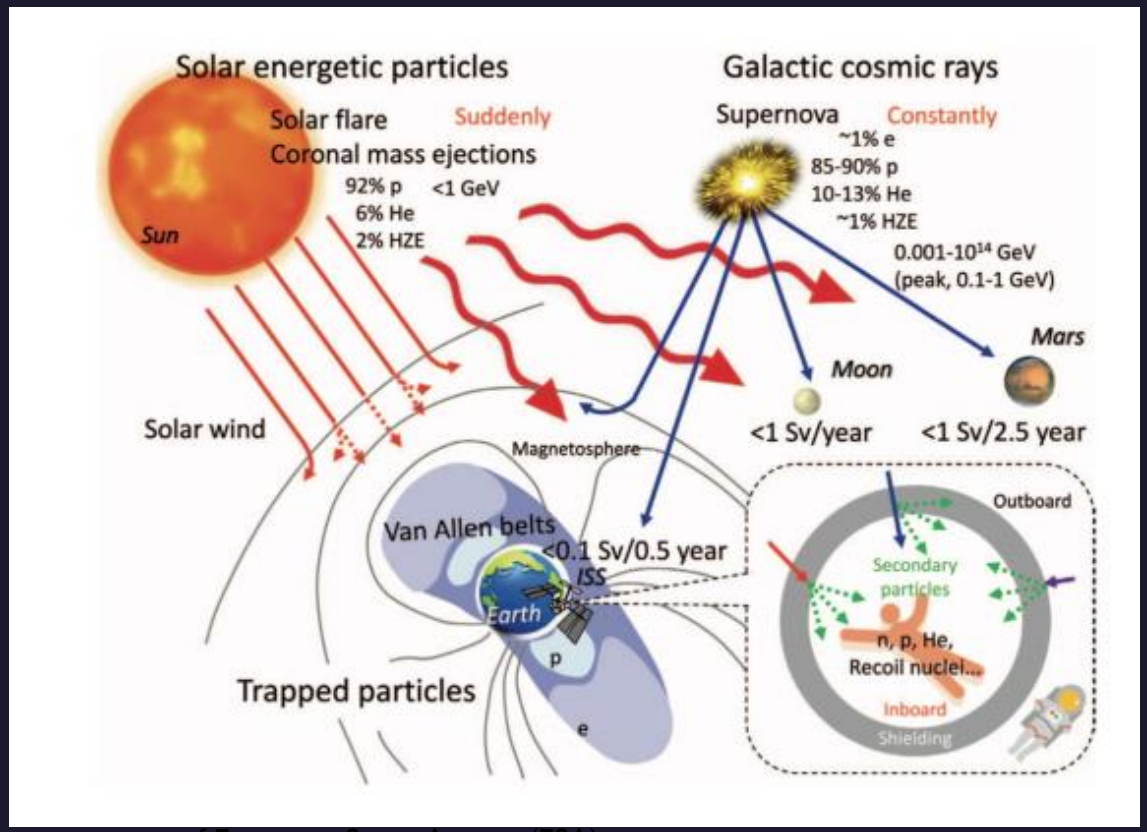


Image courtesy of European Space Agency (ESA)

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

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

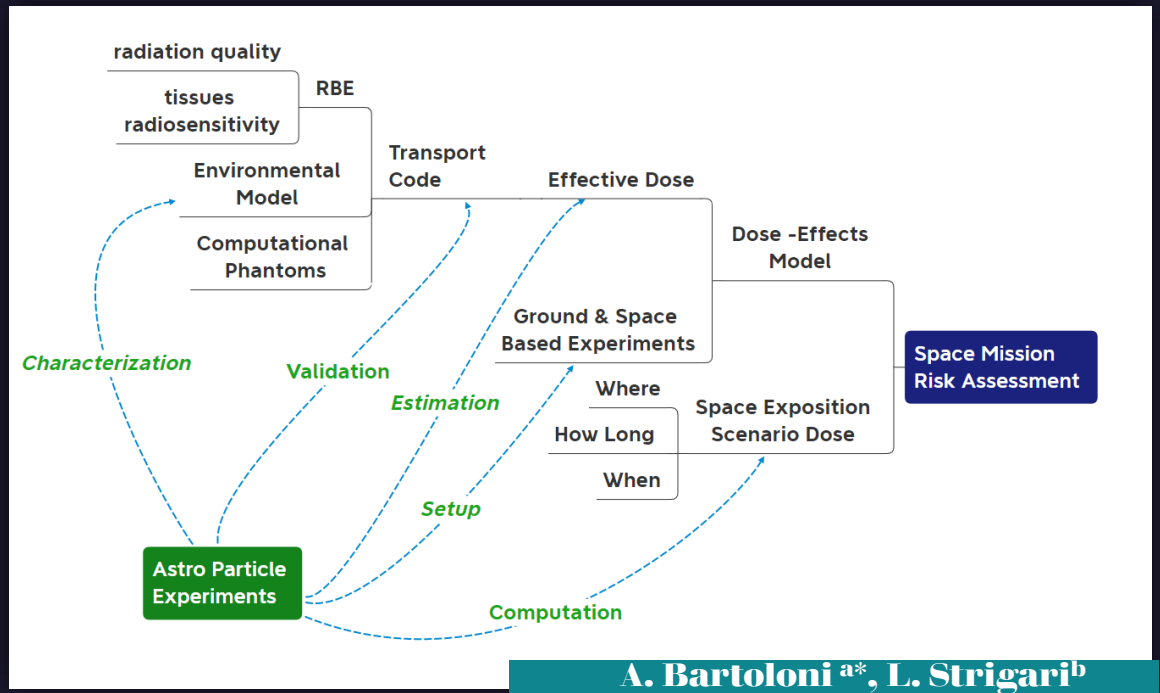
(Research, Universities, and National Space Agencies).

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



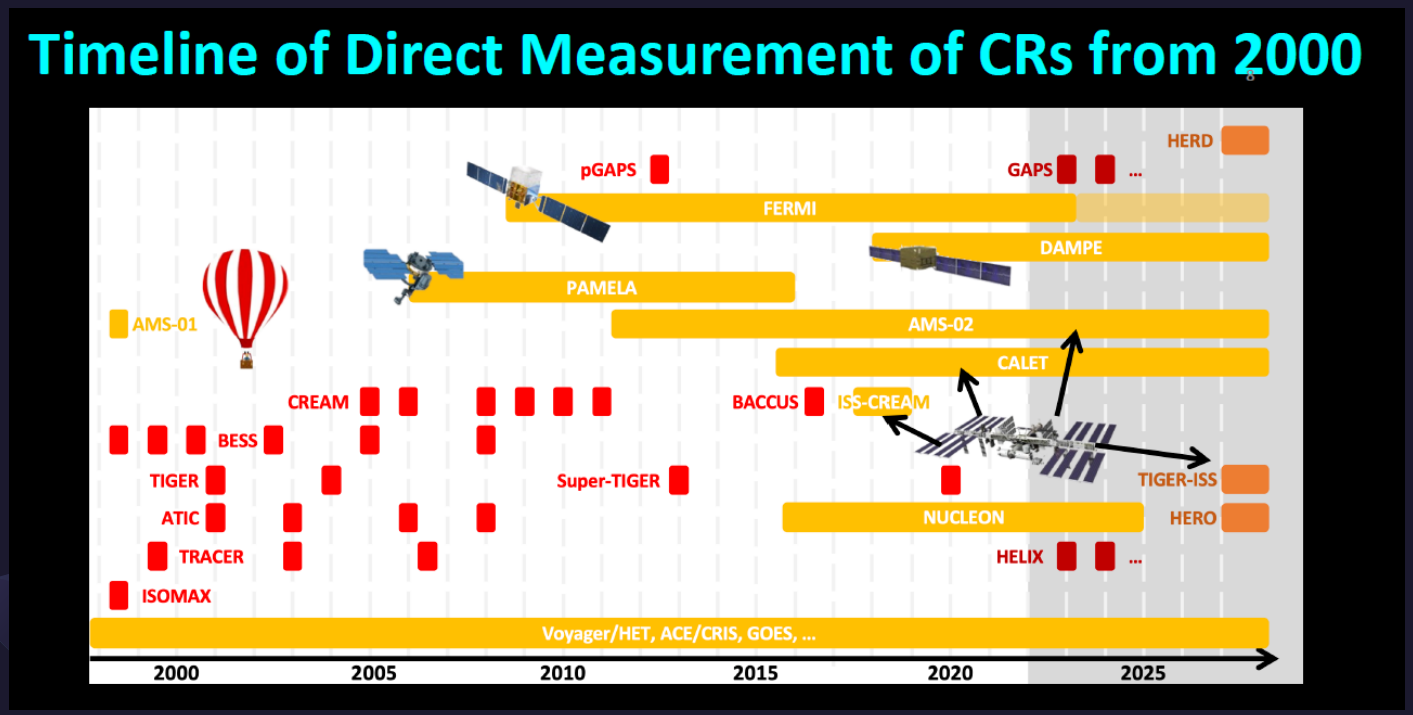
A. Bartoloni [a*], L. Strigari[b]

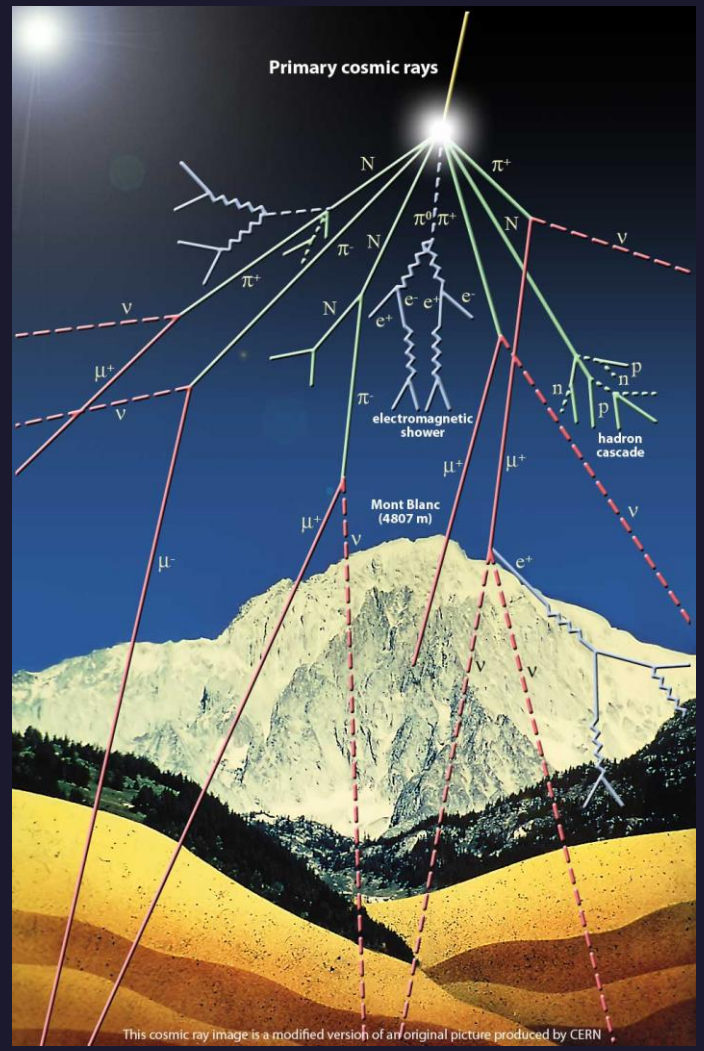
GLEX-21-8.2.5 (ID:62186)

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.



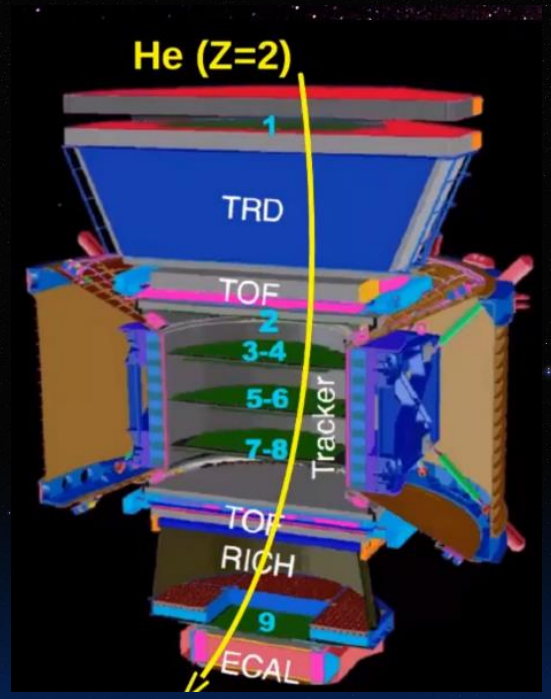


Principal Operating Cosmic Ray Space Detectors

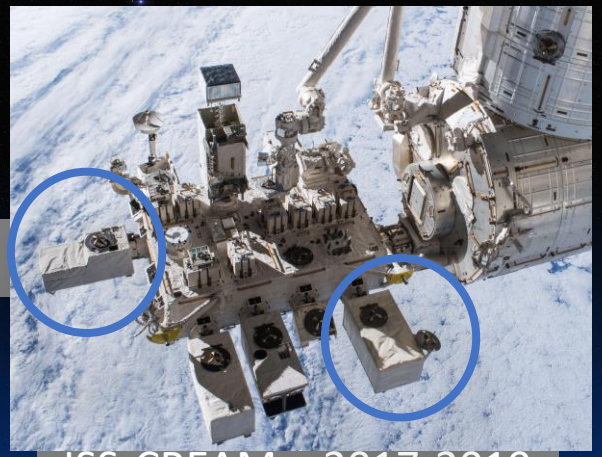
International Space Station based

AMS02 – 2011

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



CALET - 2015

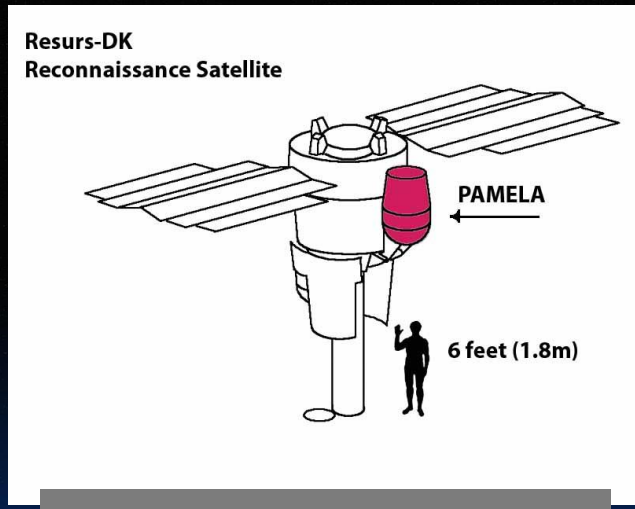


ISS-CREAM – 2017-2019

Satellite Based

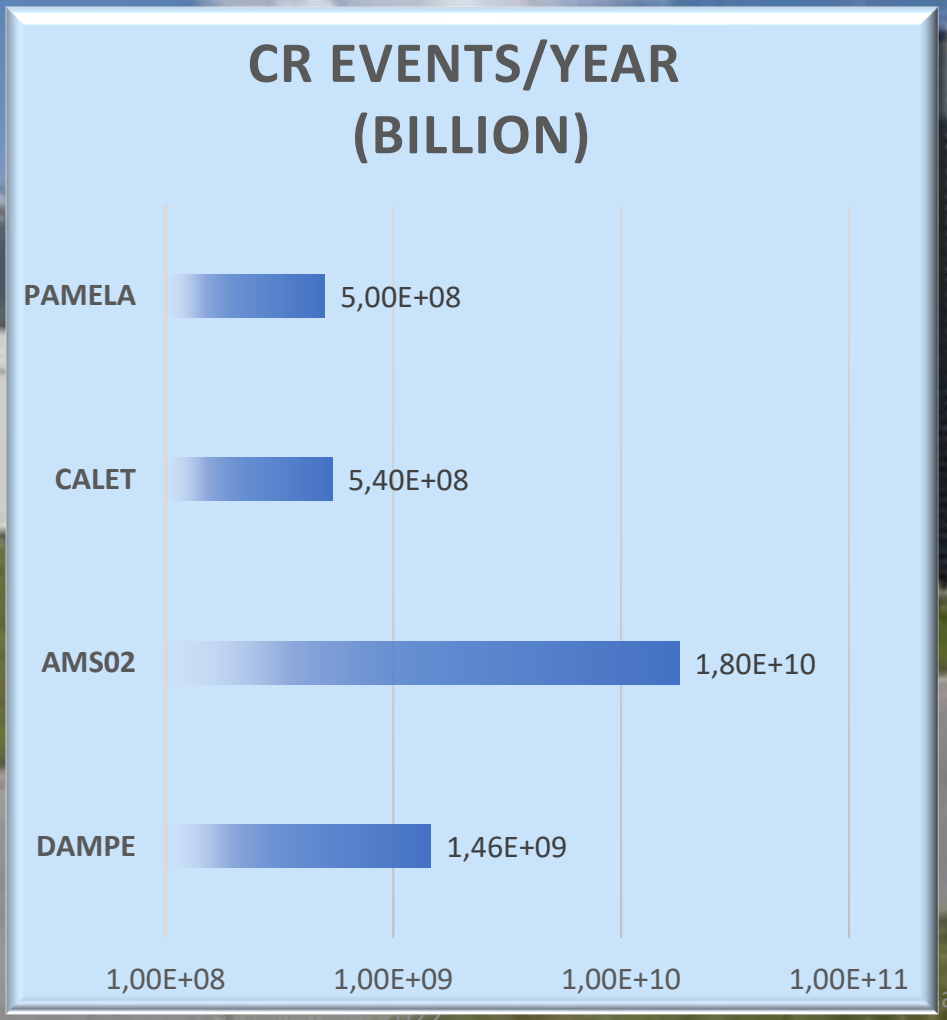
ACE - 1997

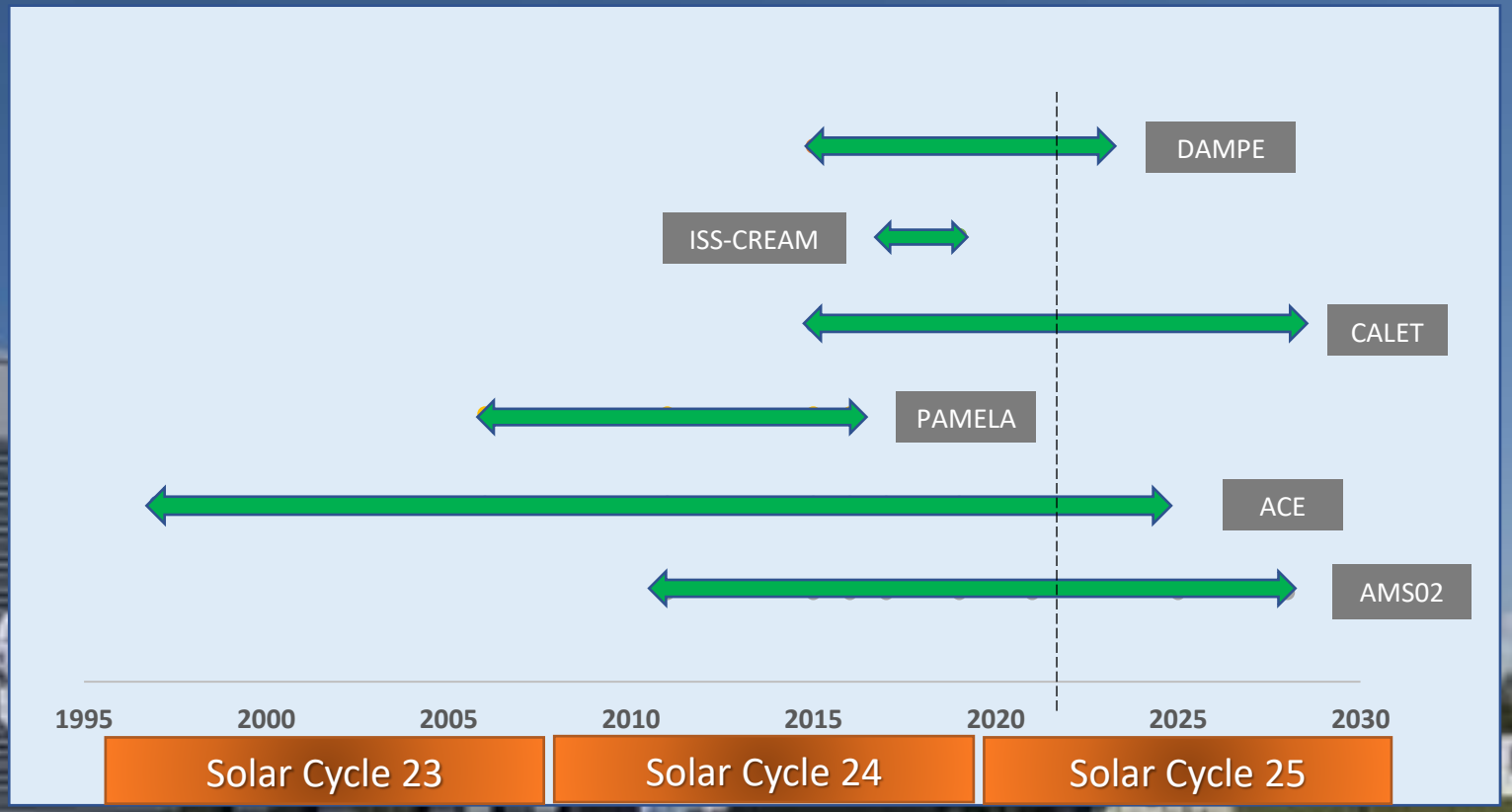
DAMPE - 2017



PAMELA – 2006-2016

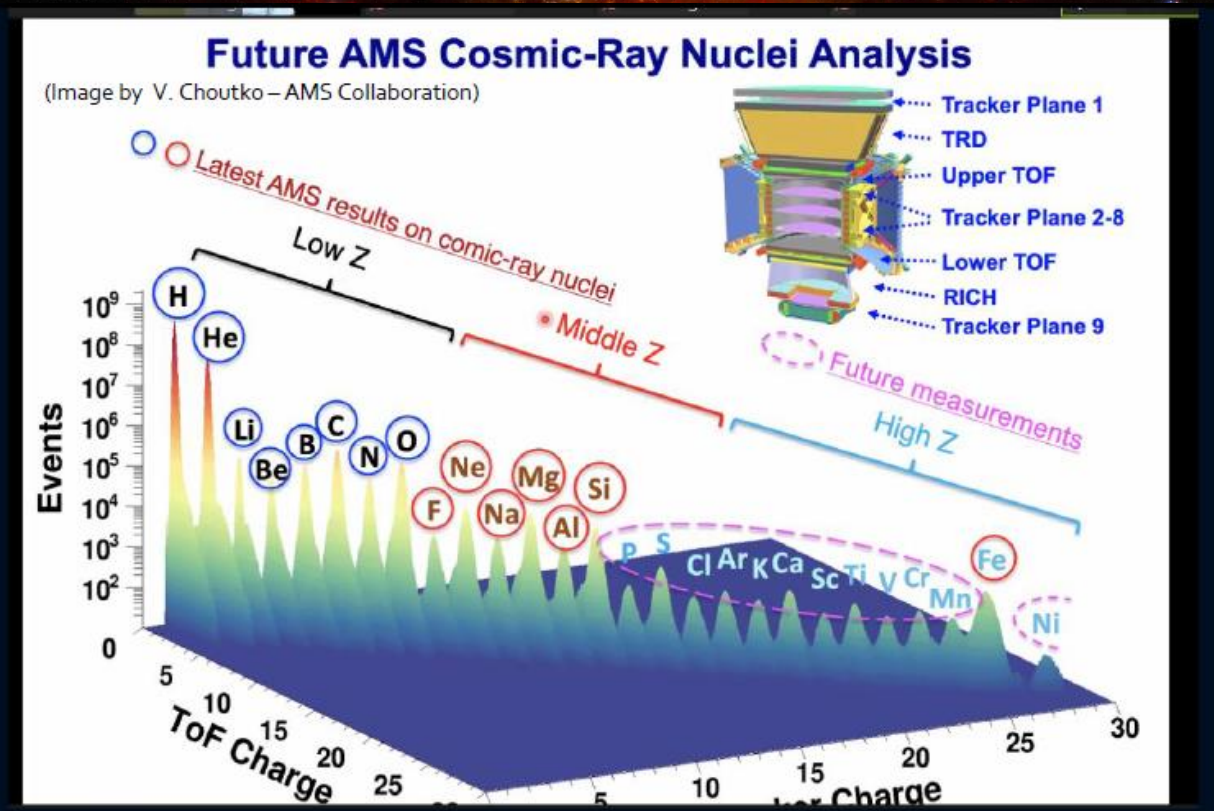
Missions Operations





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

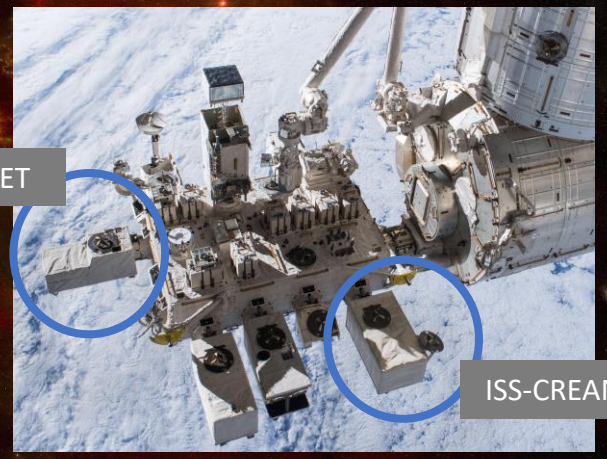
AMS Collaboration • M. Aguilar (Madrid, CIEMAT) et al. (Feb 25, 2021)

Published in: *Phys.Rev.Lett.* 126 (2021) 8, 081102

CRDs Energy Range

PAMELA

CALET - **1 GeV-10TeV**



CALET

ISS-CREAM

PAMELA - **50 MeV-2TeV**

ISS-CREAM - **1TeV-1PeV**

AMS02

AMS02 - **500 MeV-3TeV**

DAMPE - **5GeV-100TeV**

DAMPE

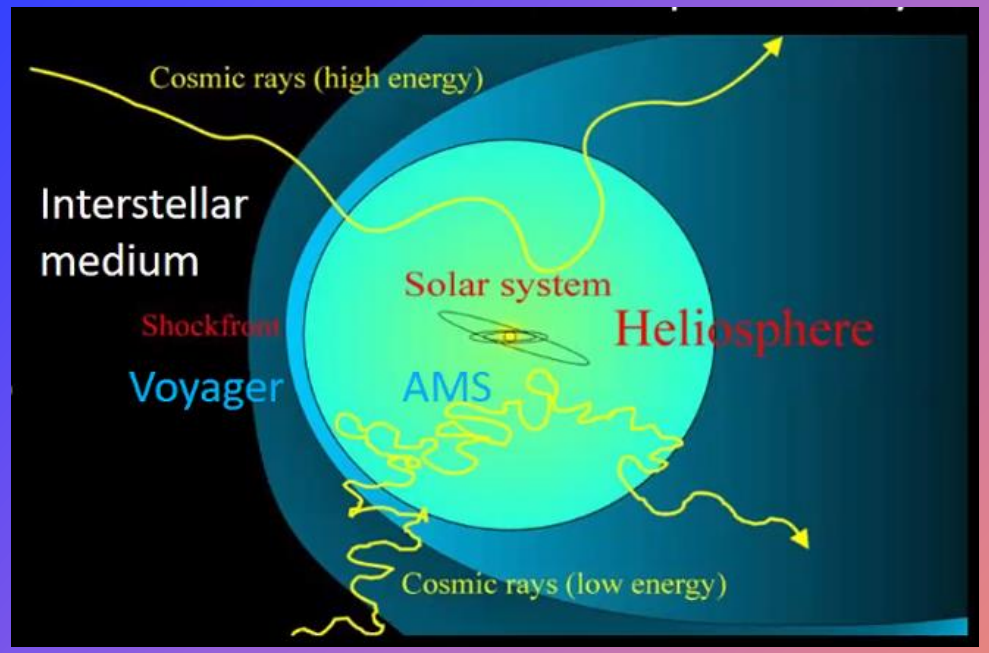
ACE

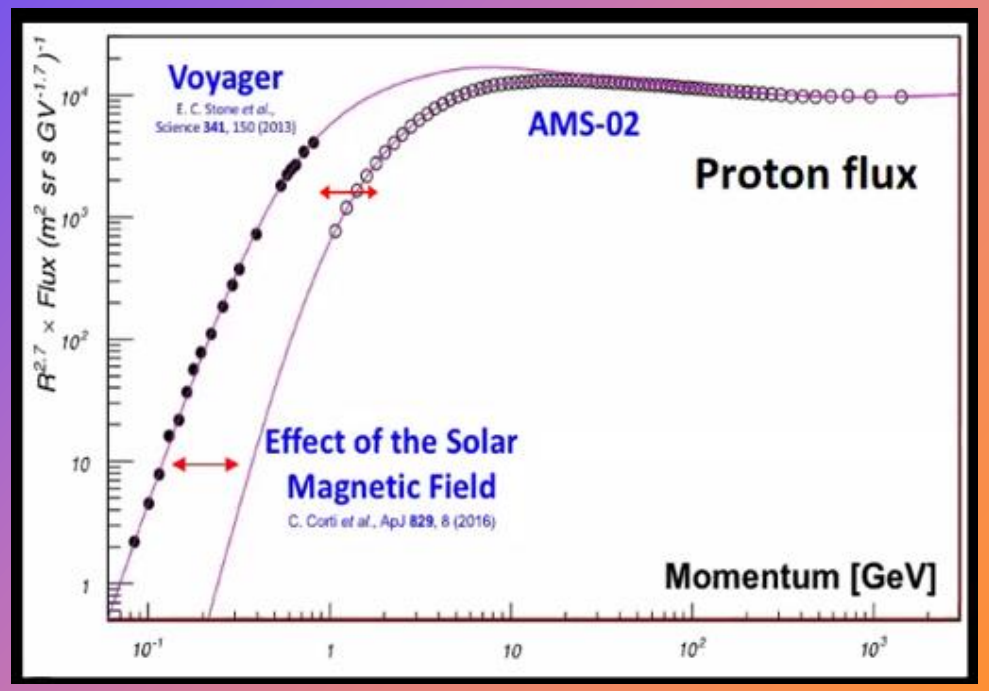
50 – 500 MeV

0.01 0.1 1 10 10^2 10^3 10^4 10^5 10^6 10^7

Energy (GeV)

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

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

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

Topic Editors

Alessandro Bartoloni
National Institute of Nuclear Physics of Rome
Rome, Italy

Nan Ding
Institute of Modern Physics, Chinese Academy of Sciences (CAS)
Lanzhou, China

Gianluca Cavoto
Sapienza University of Rome
Rome, Italy

Cristina Consolandi
University of Hawaii at Manoa
Honolulu, United States

Lidia Strigari
Dipartimento di Fisica Medica, IRCCS Azienda Universitaria di Bologna
Bologna, Italy

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

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**".

-

EDITORS

Alessandro Bartoloni

INFN Istituto Nazionale di Fisica Nucleare
Sezione di Roma

Cristina Consolandi

UNIVERSITY OF HAWAI'I
MĀLAMALAMA
UA MAU KE EA O KA ʻĀINA I KA PONO
1907

Lidia Strigari

POLICLINICO DI SANT'ORSOLA
SERVIZIO SANITARIO REGIONALE
EMILIA-ROMAGNA
Azienda Ospedaliero - Universitaria di Bologna
ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Nan Ding

IMP

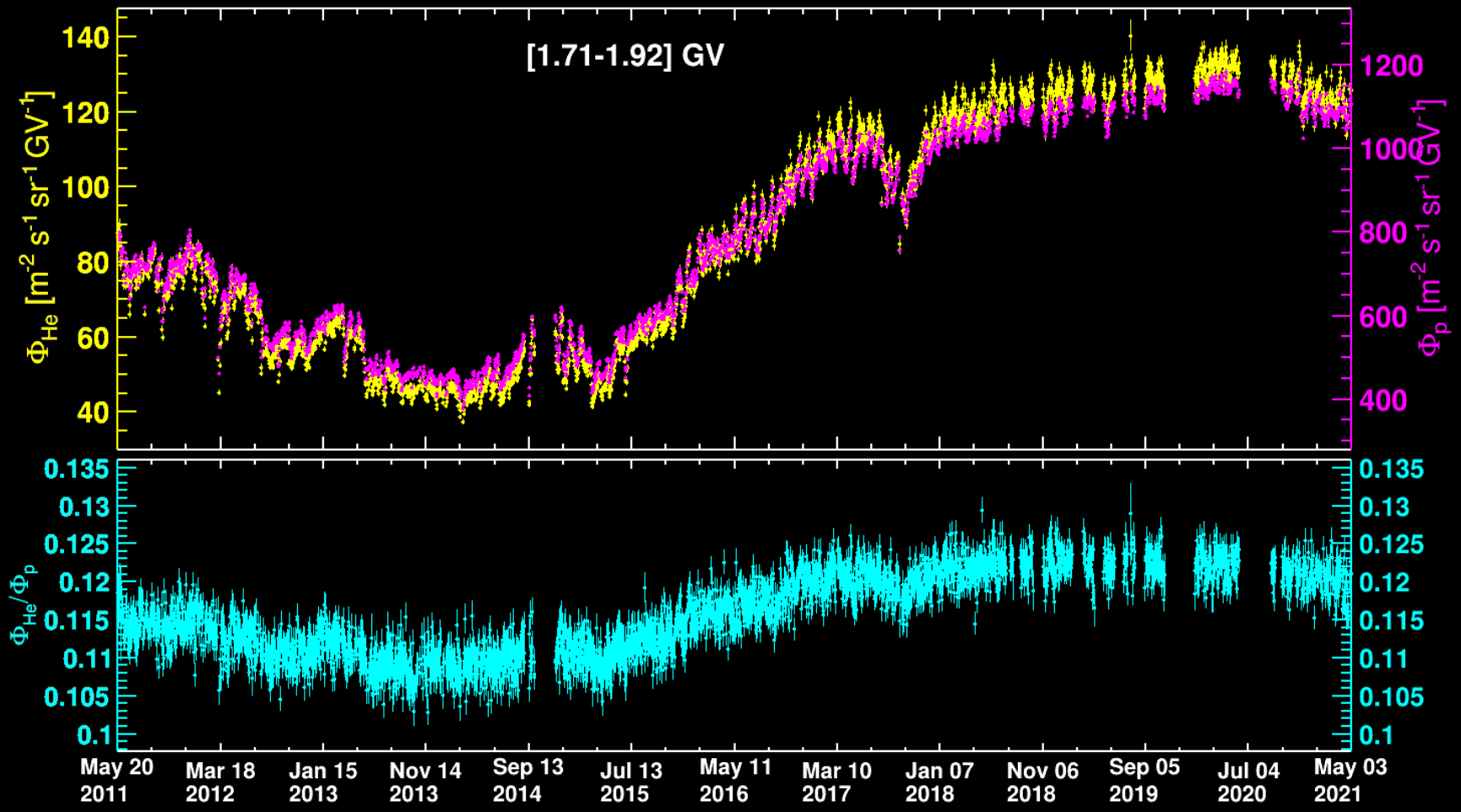
Gianluca Cavoto

SAPIENZA
UNIVERSITÀ DI ROMA

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



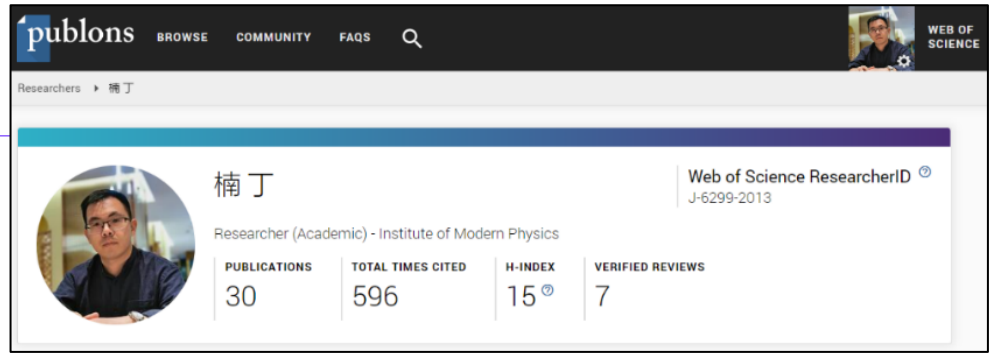
PHYSICAL REVIEW LETTERS 127, 271102 (2021)
PHYSICAL REVIEW LETTERS 128, 231102 (2022)

Dr. Cristina Consolandi
University of Hawaii, United States

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

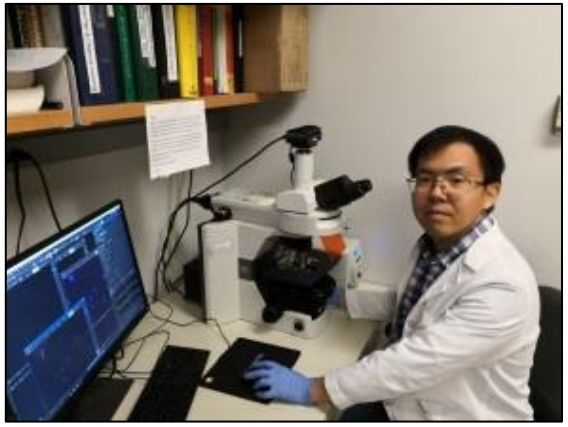
Nan Ding dn@impcas.ac.cn

Associate professor, Bio-Medica centra,
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

Interdisciplinary Topic

Participating Journals

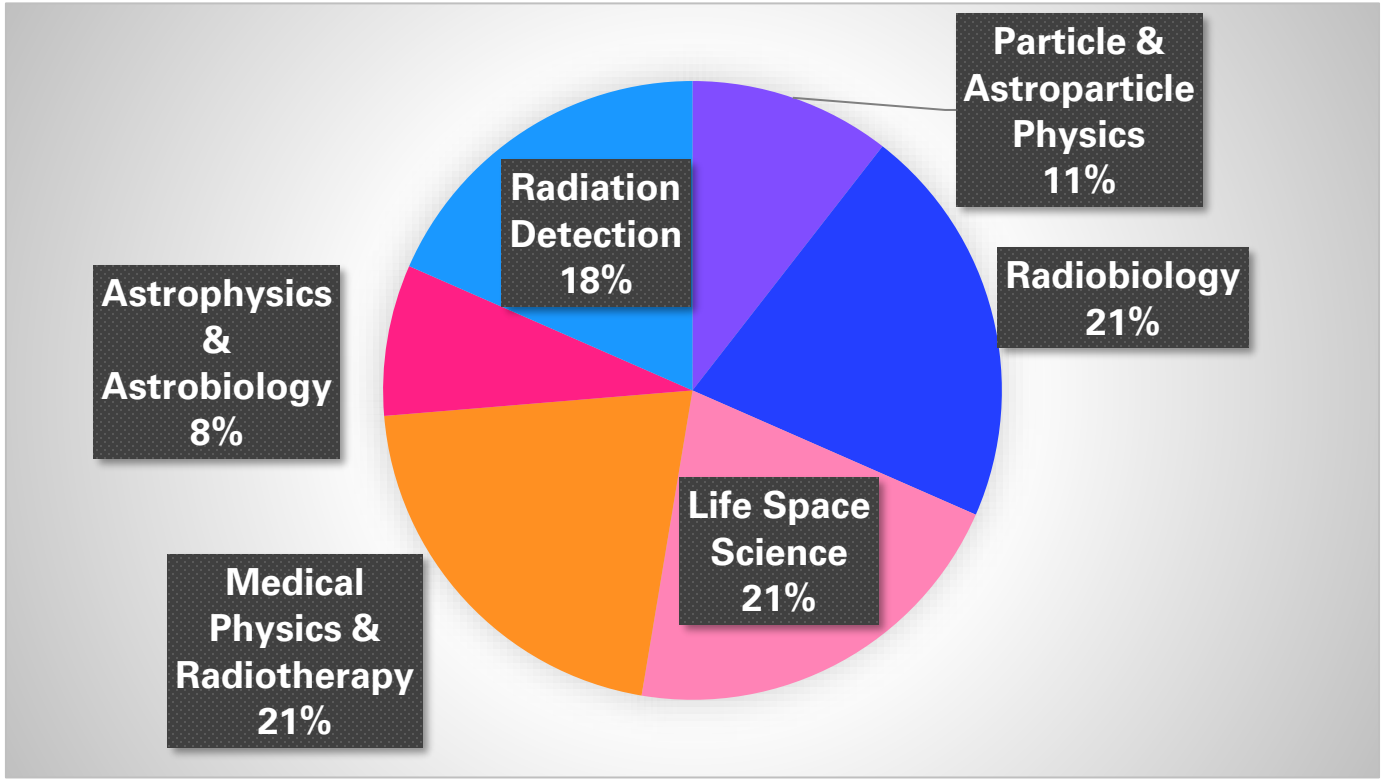
Manuscripts can be submitted to this Research Topic via the following journals:

Frontiers in
Astronomy and Space Sciences
Astrobiology

Frontiers in
Physics
Radiation Detectors and Imaging

Frontiers in
Public Health
Radiation and Health

Contributors from different research areas



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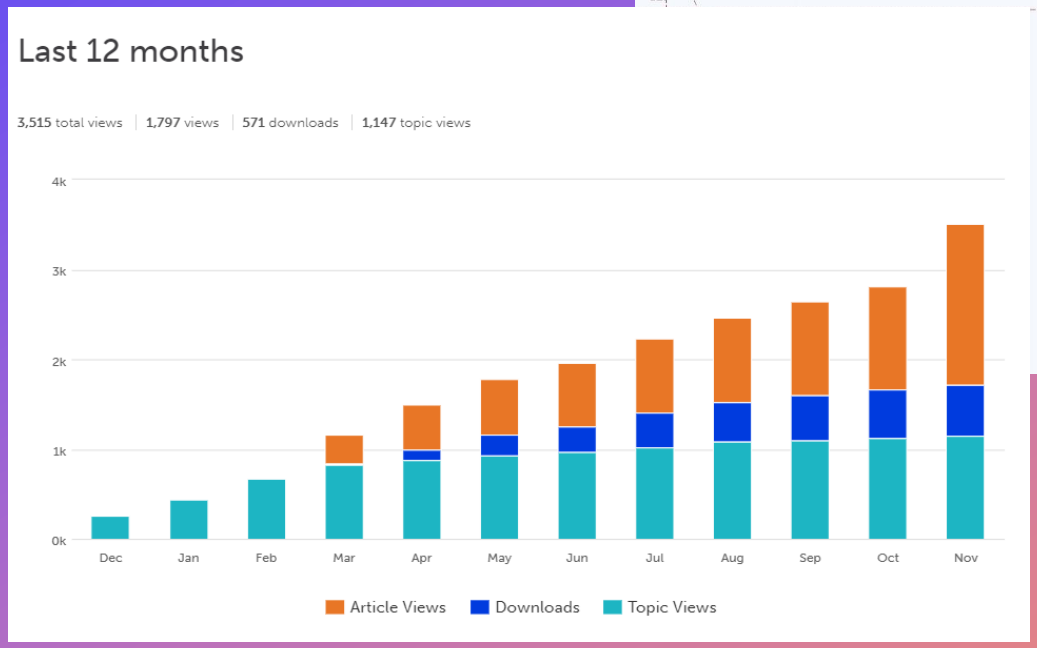
RT Impact after 1 year

> 3500 views (topic & articles)

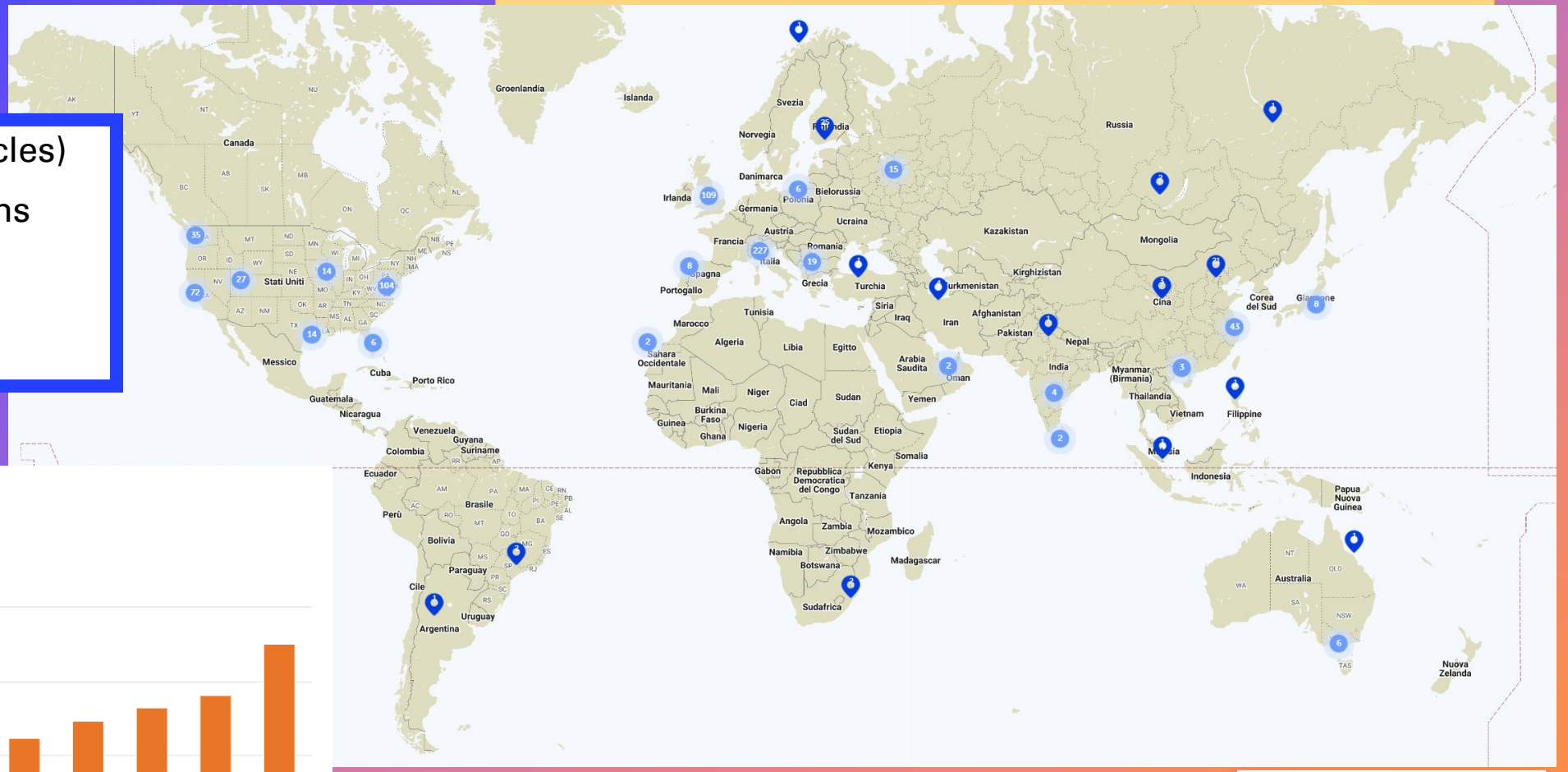
> 20 expected contributions

> 5 abstracts received

2 published manuscript



Worldwide interest for the topic



Open for articles submissions !

SCAN the QR CODE to participate !

Thanks for yours attention !

Alessandro Bartoloni

alessandro.bartoloni@cern.ch

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