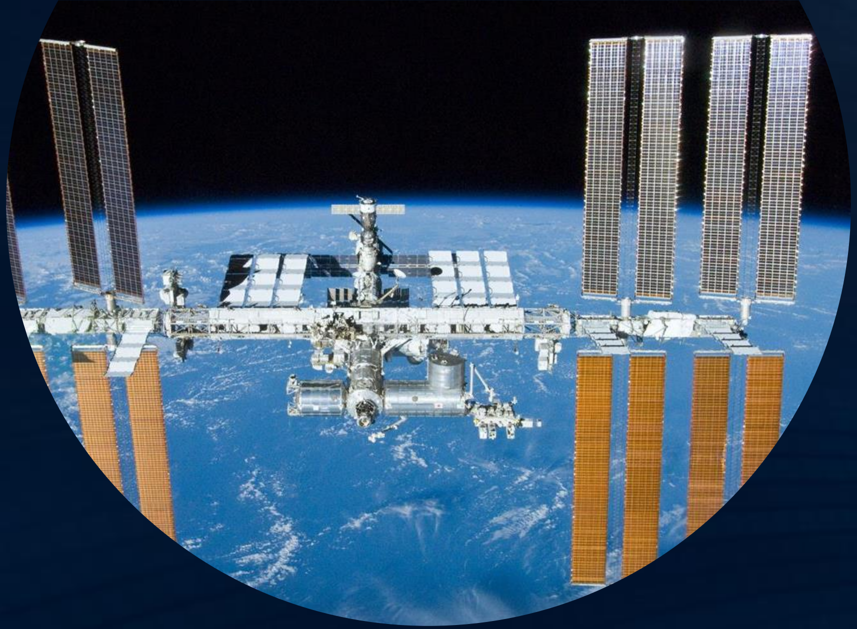


AMS ROMA-1 ACTIVITIES 2022-2023

REFEREE MEETING

8 SEPTEMBER 2022

AMS Roma-I group activities in 2022/23

- Support of AMS operations at POCC
- Research in Space Radiobiology in collaboration with **IRCCS University Hospital of Bologna** (IRCCS-UHB)
- Research in Space Radiation (GCRs,…) also in collaboration with **Shahid Bahonar University of Kerman (SBUK)**
- Editorial and Outreach activities

AMS Roma-I People 2022/23

- Alessandro Bartoloni – INFN (0.9 FTE)
- Bruno Borgia – INFN & Sapienza (-)
- Aboma Negasa Guracho – INFN Roma (1) NEW AdR since October 2021
- Giuseppe Della Gala – IRCCS UHB (0.3)
- Giulia Paolani - IRCCS UHB (0.3)
- Sara Parsaei – SBUK (0.3) NEW
- Mustafa Mohammad Rafiei – SBUK (1) – Winner of an INFN AdR in April 2022 will start in September
- Miriam Santoro – IRCCS UHB (0.3)
- Lidia Strigari – IRCCS UHB (1)
- Silvia Strolin – IRCCS UHB(0.3)
- Vincenzo Valente – GARR Associate & INFN (-)

2023 FTE & Funding Requests (Keuro)

Persone	FTE
11	5.4

Missioni	Consumi	Servizi	Inventariabile	Totale
29.5	4.5	1	3	38

At INFN Roma AMS group, led by **Alessandro Bartoloni,** the primary activity is the use of the AMS measurements of cosmic rays to improve the space radiobiology knowledge with a primary emphasis on

***the space radiation relevance and risk for human space exploration*.**

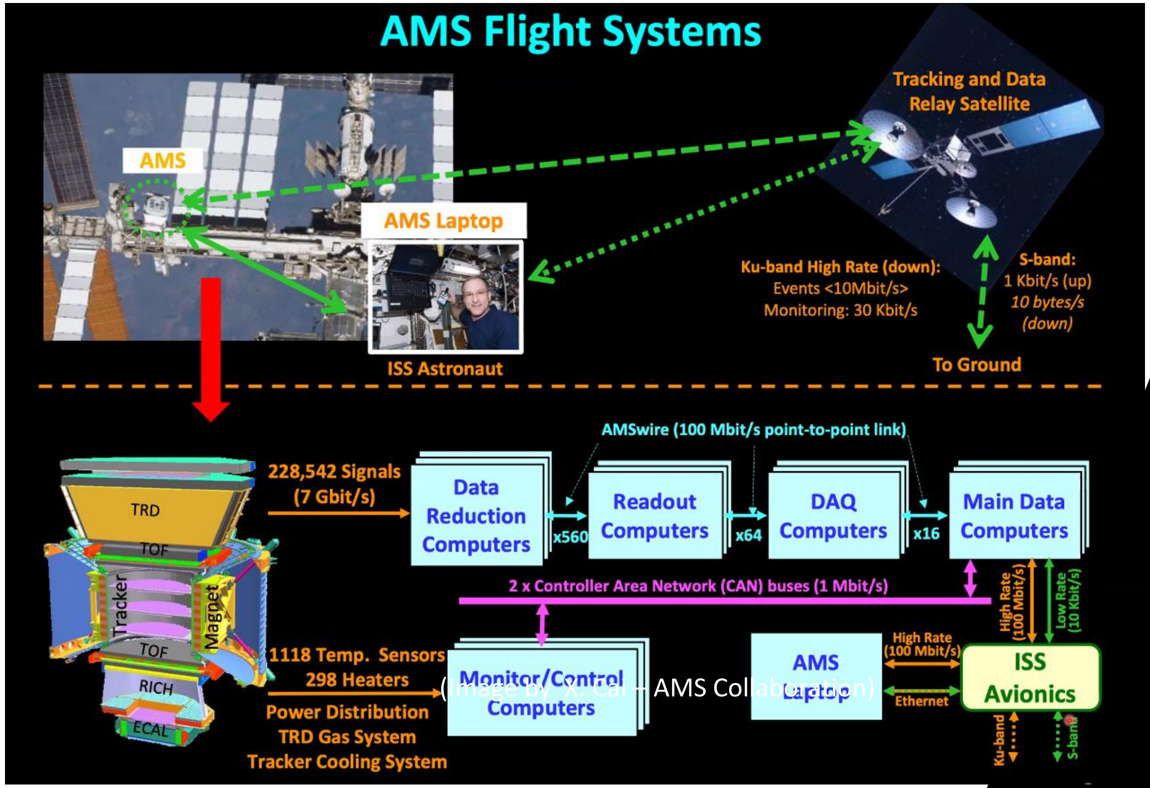
In this topic, there is a strong collaboration and participation to the Roma group of the Medical Physics department of the IRCCS University Hospital of Bologna, led by **Lidia Strigari.**

INFN Roma AMS-02 wiki:
https://wiki.infn.it/strutture/roma1/experiments/ams2/home

11/2021 Highlight:
We made and publish an extensive review of the existent literature to use as starting point for improvements in the fields dose-Effects model in space Radiobiology

Roma-I group supports AMS operations and hardware upgrade activities since 2011

06/2021-06/2022
3 persons did
8 blocks x 6 days of POCC shifts



(Image by X. Cai – AMS Collaboration)

In October 2021-
The AMS experiments successfully passed a DOE review

DoE AMS Review – Chair's Report
Barry C Barish
October 20, 2021

…

In this report, I summarize the main conclusions of the committee members from the review of the proposals for continued funding of the MIT AMS Operations and Research proposals, as well as more broadly regarding the international collaboration and envisioned future program. … We especially appreciate the efforts of the international partners to participate in the review, mostly in-person.

…

The precision AMS results themselves, on a wide range of cosmic ray channels, have unveiled a new set of exciting and some puzzling effects. The published results are truly impressive in their precision and breath. They provide a very good basis for the committee to evaluate both the performance of the detector, the collaboration, and to assess the future physics potential of AMS.

…

AMS is by far the most sophisticated and powerful particle detector ever put into space. It contains a large spectrometer magnet, the only such magnet in space.

…

AMS Operations Proposal

…

The working relationship between AMS operations and NASA remains strong in carrying out the AMS operations effectively on the ISS.

…

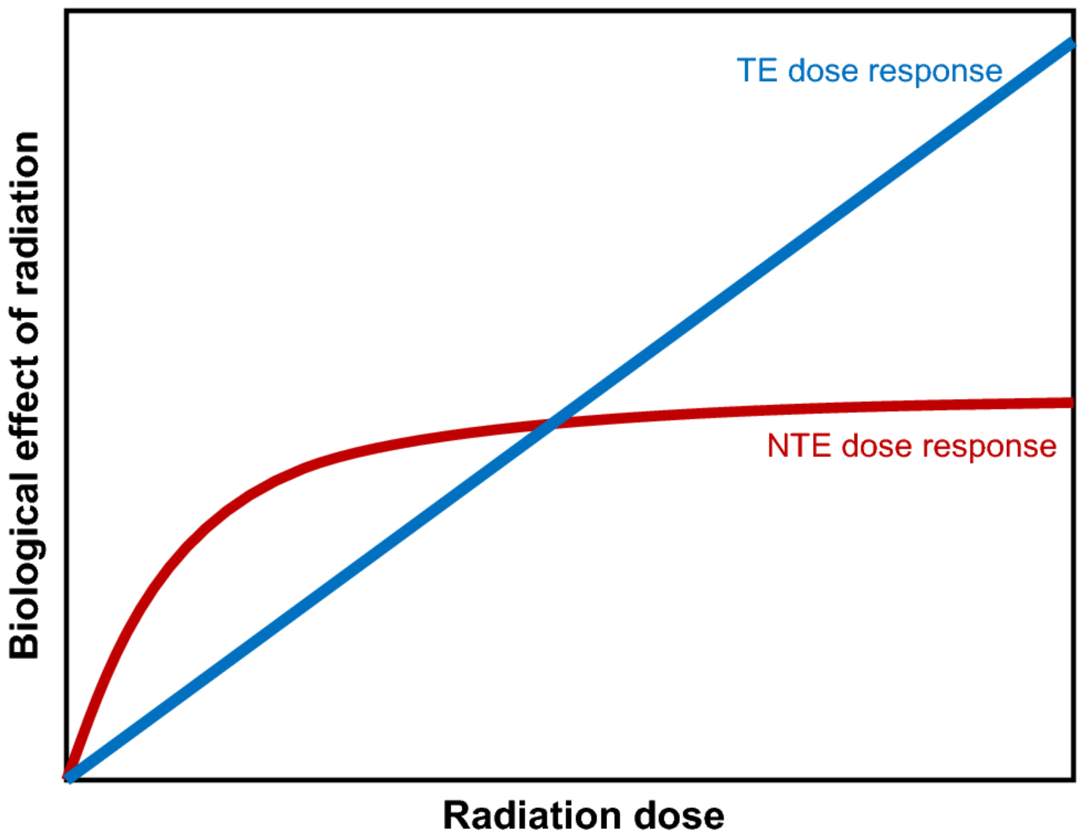
In summary, … The overall operations of AMS are very impressive.

…

Dose-Effect Relationship – Work in progress at Roma (Bartoloni, Guracho AdR, Strigari)

Crucial point is to predict the toxicity of the space radiation expected for the astronauts/space workers and the creation of reliable ***mathematical models*** that describe the correlation between the exposition to IR and the possible damages to the organs at risk

Aim: to implement a platform including the more reliable dose-effect models for space radiation, we developed an ad hoc software in R-script language



Target Effects (TE) vs Non Target Effects (NTE)

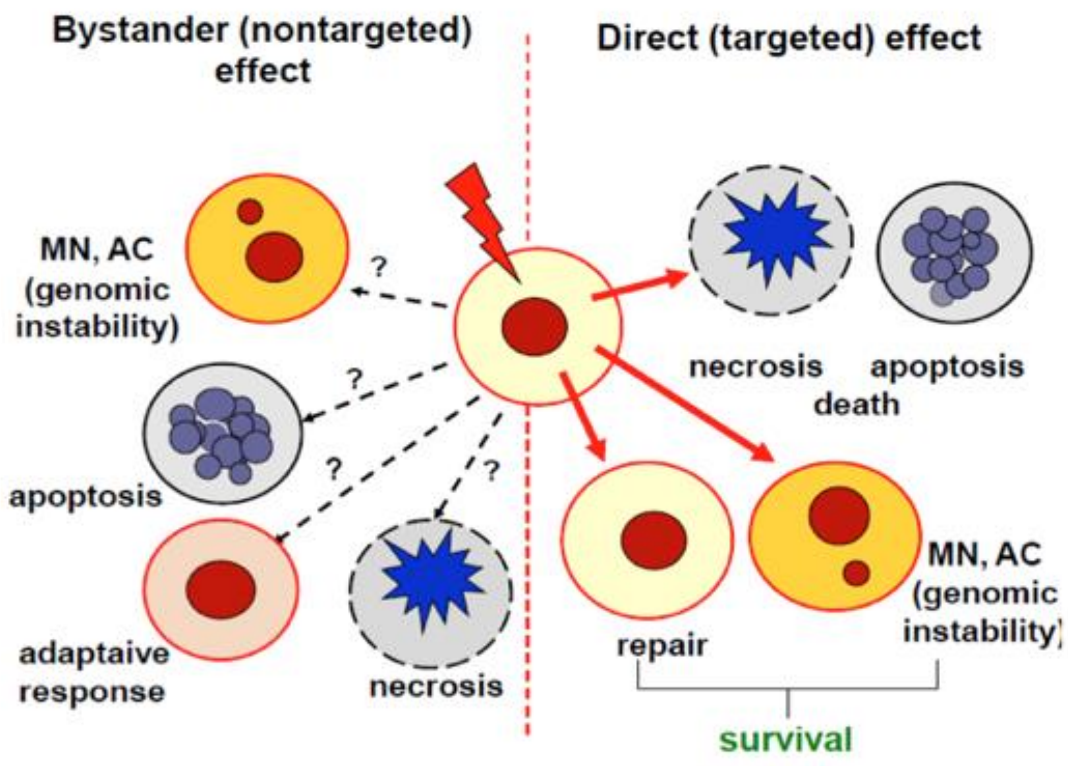
- Non-targeted effects (NTEs) include bystander effects where cells traversed by heavy ions transmit oncogenic signals to nearby cells, and genomic instability in the cells progeny.

- Studies on the Harderian gland, chromosomal aberrations at low dose and many mechanistic studies support the NTE model, with evidence of a **supra-linear effect at low doses** of NTE compared to a linear effects for TE

- This NTE are expected also at the **dose-rates that occur in space.**

Non-Targeted Effects Models Predict Significantly Higher Mars Mission Cancer Risk than Targeted Effects Models

F. Cucinotta, Eliedonna E. Cacao • Published 12 May 2017 • Biology, Physics • Scientific Reports



Status of the Project (11/2021-present)

Project status presented in differents conferences and workshops :
25° WRMISS (6/9/2022)
IAC 2022 (21/9/2022)
XXII ICMMB 2022 (19/9/2022)

We developed an ad hoc software in R-script language for Tumor Prevalence risk calculation including the more reliable dose-effect models for space radiation

An r-script library with different Cell Survival Probability models was developed to be used in the calculation of hazard functions of Tumor Prevalence.

Using the software and the experimental data set of Harderian Gland Tumor we tune all the parameter for the Tumor Prevalence Model for protons and we show that there are no substantial differences between the Target and Non-Target Effect as expected.

In the future, we extend the analysis to heavy ions, and we will use the data collected from the AMS02 detector to increase the modelling accuracy and risk prediction.

Asked the renewal for one year (Oct 2022-Sept. 2023) of the AdR for A.N. Guracho

AMS/SPRB

Some highlights from AMS Roma wiki logbook

November 2021

11/2021 Highlight:
We made and publish an extensive review of the existent literature to use as starting point for improvements in the fields dose-Effects model in space Radiobiology

frontiers in Public Health

REVIEW
published: 08 November 2021
doi: 10.3389/fpubh.2021.733337

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*]

[1] Department of Medical Physics, Istituto di Ricovero e Cura a Carattere Scientifico (IRCCS) Azienda Ospedaliero-Universitaria di Bologna, Bologna, Italy, [2] Radiation Oncology Center, School of Medicine, Department of Experimental, Diagnostic and Specialty Medicine - DIMES, University of Bologna, Bologna, Italy, [3] Istituto Nazionale di Fisica Nucleare (INFN) Sezione di Roma 1, Roma, Italy

OPEN ACCESS

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Space radiobiology is an interdisciplinary science that examines the biological effects of ionizing radiation on humans involved in aerospace missions. The dose-effect models are one of the relevant topics of space radiobiology. Their knowledge is crucial for optimizing radioprotection strategies (e.g., spaceship and lunar space station-shielding and lunar/Mars village design), the risk assessment of the health hazard related to human space exploration, and reducing damages induced to astronauts from galactic cosmic radiation. Dose-effect relationships describe the observed damages to normal tissues or cancer induction during and after space flights. They are developed for the various dose ranges and radiation qualities characterizing the actual and the forecast space missions [International Space Station (ISS) and solar system exploration]. Based on a Pubmed search including 53 papers reporting the collected dose-effect relationships after space missions or in ground simulations, 7 significant dose-effect relationships (e.g., eye flashes, cataract, central nervous systems, cardiovascular disease, cancer, chromosomal aberrations, and biomarkers) have been identified. For each considered effect, the absorbed dose thresholds and the uncertainties/limitations of the developed relationships are summarized and discussed. The current knowledge on this topic can benefit from further *in vitro* and *in vivo* radiobiological studies, an accurate characterization of the quality of space radiation, and the numerous experimental dose-effects data derived from the experience in the clinical use of ionizing radiation for diagnostic or treatments with doses similar to those foreseen for the future space missions. The growing number of pooled studies could improve the prediction ability of dose-effect relationships for space exposure and reduce their uncertainty level. Novel research in the field is of paramount importance to reduce damages to astronauts from cosmic radiation before Beyond Low Earth Orbit exploration in the next future. The study aims at providing an overview of the published dose-effect relationships and illustrates novel perspectives to inspire future research.

Keywords: human space exploration, galactic cosmic radiation, galactic cosmic radiation effects, space radiobiology, space radiation doses, dose-effect model

Front. Public Health 9:733337.
doi: 10.3389/fpubh.2021.733337

Work presented in differents conferences and workshops :
IAC 2022 (September)
RAD 10 (July)
COSPAR 2022 (July)

2021/22

Initiative presented in differents conferences :
PISA «Biodola» meeting
RAD 10
HICHEP 2022
COSPAR 2022

We launched a Research Topic Collection on the Frontiers supported by the Frontiers Editorial team

AMS/SPRB

Some highlights from AMS Roma wiki logbook

PROCEEDINGS OF SCIENCE

High Energy Physics Astro Particle Experiments to Improve the Radiation Health Risk Assessment for Humans in Space Missions

A. Bartoloni[a,*], G. Della Gala[a,b], A.N. Guracho[a], G. Paolani[a,b], M. Santoro[a,b] L. Strigari[a,b], S. Strolin[a,b]

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In the near future, 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 surface. One of the main showstoppers to be investigated for safe exploration and colonisation is the biological effects of ionising radiation that can compromise the health of astronauts/space workers. In this vital task, a principal role could be done by the astroparticle experiments presently operating in space. Such experiments are a source of information crucial to improving the knowledge of radiobiology effects in space. In this talk, a review of the past and present astroparticle experiments will be presented and will highlight some of the possible contributions and improvements in the space radiobiology research field.

The European Physical Society Conference on High Energy Physics (EPS_HEP2021)
26-30 July 2021
Online conference, jointly organized by Universität Hamburg and the research center DESY

*Speaker

https://pos.sissa.it/

February 2022

Work presented in differents conferences and workshops :
IAC 2022 (September)
25° WRMISS (September)

June 2022

INFN Istituto Nazionale di Fisica Nucleare Sezione di Roma

POLICLINICO DI SANT'ORSOLA

SERVIZIO SANITARIO REGIONALE EMILIA-ROMAGNA Azienda Ospedaliero - Universitaria di Bologna

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

FUTURE NEUROLOGY 2022 3RD GLOBAL CONGRESS

Dose-Effects Models for Space Radiobiology:
An Overview on Central Nervous System Dose-Effect Relationship

L.Strigari[1], A.N. Guracho[2], S. Strolin[1], A.G. Morganti[1] and A.Bartoloni[2*]

[1]Department of Medical Physics, Istituto di Ricovero e Cura a Carattere Scientifico (IRCCS) Azienda Ospedaliero-Universitaria di Bologna, Bologna, Italy
[2]Radiation Oncology Center, School of Medicine, Department of Experimental, Diagnostic and Specialty Medicine - DIMES, University of Bologna, Bologna, Italy
[3]Istituto Nazionale di Fisica Nucleare (INFN) Sezione di Roma 1, Roma, Italy

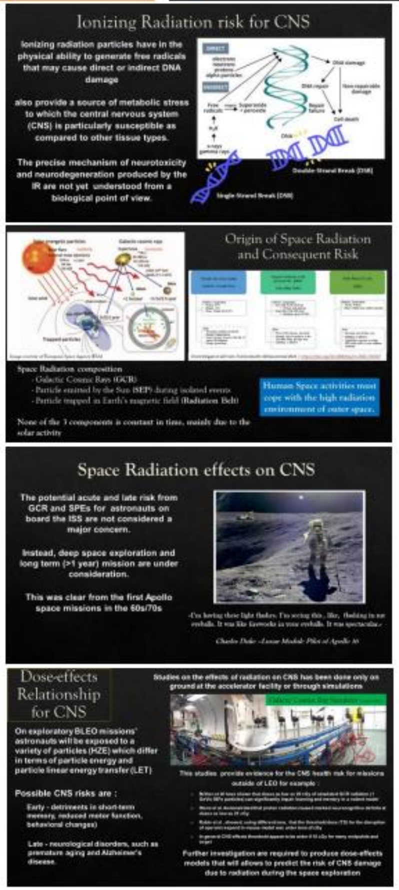
Space radiobiology is an interdisciplinary science that examines the biological effects of ionizing radiation on humans involved in aerospace missions. The dose-effect models are one of the relevant topics of space radiobiology. Their knowledge is crucial for optimizing radioprotection strategies, the risk assessment of the health hazard related to human space exploration, and reducing damages induced to astronauts from galactic cosmic radiation. Dose-effect relationships describe the observed damages to normal tissues or cancer induction during and after space flights. They are developed for the various dose ranges and radiation qualities characterizing the actual and the forecast space missions.

Based on a Pubmed search including 53 papers reporting the collected dose-effect relationships after space missions or in ground simulations, 7 significant dose-effect relationships (e.g., eye flashes, cataract, ***central nervous systems***, cardiovascular disease, cancer, chromosomal aberrations, and biomarkers) have been identified.

For each considered effect, the absorbed dose thresholds and the uncertainties/limitations of the developed relationships are summarized and discussed. The current knowledge on this topic can benefit from further in vitro and in vivo radiobiological studies, an accurate characterization of the quality of space radiation, and the numerous experimental dose-effects data derived from the experience in the clinical use of ionizing radiation for diagnostic or treatments with doses like those foreseen for the future space missions.

The growing number of pooled studies could improve the prediction ability of dose-effect relationships for space exposure and reduce their uncertainty level. Novel research in the field is of paramount importance to reduce damages to astronauts from cosmic radiation before Beyond Low Earth Orbit exploration in the next future.

In that sense **an innovative approach could come from state of the art instrumentation and detectors operating in space**, built for astroparticle measurements, allows for the estimation of GCR properties and absorbed dose with a greater accuracy, **thanks to the recent availability of the Alpha Magnetic Spectrometer (AMS) detector, installed on the International Space Station, that measures charged components of cosmic rays since 2011 and is approved to be operative for all the life cycle of the ISS.**



For further info visit the following web page
AMS02 INFN ROMA and Sapienza University [INFN wiki]
or email to Alessandro.Bartoloni@cern.ch

AMS PRL published HEP spires statistics (06/2021 vs 06/2022)

Citation summary results	*2021*	*2022*
Total number of papers analyzed:	20	24
Total number of citations:	4924	5806
Average citations per paper:	248	242
Breakdown of papers by citations		
Renowned papers (500+)	4	4 (3%)
Famous papers (250-499)	4	4 (2%)
Very well-known papers (100-249)	3	4 (0.5%)
Well-known papers (50-99)	4	4
Known papers (10-49)	3	4
Less known papers (1-9)	2	3
Unknown papers (0)	0	1

in parenthesis the
AMS papers / INFN RM papers*100 ratio
Period is 2012-2022

In the past hundred years, measurements of charged cosmic rays by balloons and satellites have typically had 30% to 50% accuracy.

AMS is providing cosmic ray information with ~1% accuracy.
The improvement in accuracy is providing new insights about the cosmos.

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

We present the precision measurement of 2824 daily helium fluxes in cosmic rays from May 20, 2011 to October 29, 2019 in the rigidity interval from 1.71 to 100 GV based on 7.6×108 helium nuclei collected with the Alpha Magnetic Spectrometer (AMS) aboard the International Space Station.

The helium flux and the helium to proton flux ratio exhibit variations on multiple timescales. In nearly all the time intervals from 2014 to 2018, we observed recurrent helium flux variations with a period of 27 days. Shorter periods of 9 days and 13.5 days are observed in 2016. The strength of all three periodicities changes with time and rigidity.

In the entire time period, we found that below ~7 GV the helium flux exhibits larger time variations than the proton flux, and above ~7 GV the helium to proton flux ratio is time independent. Remarkably, below 2.4 GV a hysteresis between the helium to proton flux ratio and the helium flux was observed at greater than the 7σ level. This shows that at low rigidity the modulation of the helium to proton flux ratio is different before and after the solar maximum in 2014.

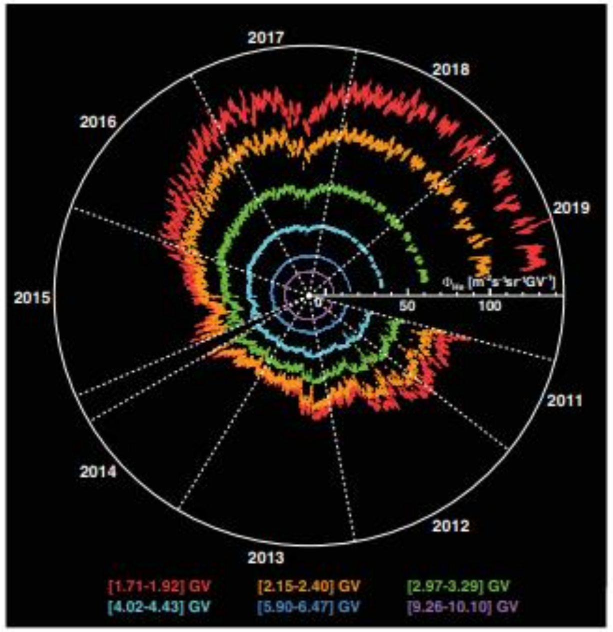


FIG. 1. The daily AMS helium fluxes Φ_{He} for six rigidity bins from 1.71 to 10.10 GV measured from May 20, 2011 to October 29, 2019 which includes a major portion of solar cycle 24 (from December 2008 to December 2019). The scale of daily helium fluxes Φ_{He} is shown on the radius. The AMS data cover the ascending phase, the maximum, and descending phase to the minimum of solar cycle 24. Days with SEPs are removed for the two lowest rigidity bins shown. The gaps in the fluxes are due to detector studies and upgrades. As seen, Φ_{He} exhibit large variations with time, and the relative magnitude of these variations decreases with increasing rigidity.