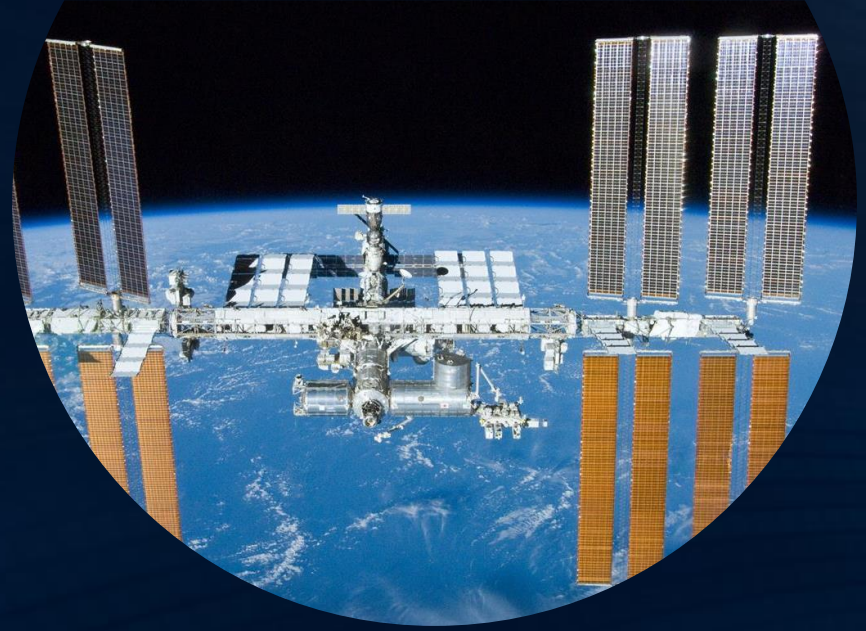

AMS ROMA-1 ACTIVITIES 2022-2023

CDS “PREVENTIVI”

ROME JULY 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) (preliminary)

Persone	FTE
11	5.4

Missioni	Consumi	Servizi	Inventariabile	Totale
30	3	1	3	**34**

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

frontiers in Public Health | Radiation and Health

INFN Istituto Nazionale di Fisica Nucleare

POLICLINICO DI SANT'ORSOLA

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]

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[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, [redacted]

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Materials and Methods
Results
Discussion
Conclusion
Author Contributions
Conflict of Interest
Publisher's Note
Acknowledgments
References

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 [redacted] 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.

Model	Study type	Dose range/threshold or LET	Reference	Reliability	Priority
Eye flashes	Spaceflight	LET > 5–10 keV/μm	(7–10)	*	*
Cataract	Spaceflight	8 mSv	(11–15)	**	**
CNS	Ground/Simulation	100–200 mGy	(16–27)	**	****
CVD	Spaceflight	1000 mGy	(28–31)	*	***
	Ground/Simulation	(0.1–4,500) mSv	(32–36)		
Cancer	Spaceflight	< 100 mGy	(40, 41)	***	****
	Ground/Simulation	< 100 mGy	(42–50)		
Biomarkers or Chromosomal aberrations	Spaceflight	5–150 mGy	(51–61)	***	****
	Ground/Simulation	< 10,000 mGy	(62–65)		
Other Risks	Ground/Simulation	~2,000 mGy	(66, 67)	*	***

* = Very Low; ** = Low; *** = Medium; **** = High; ***** = Very High.

39% Views rank
This article has more views than 39% of all Frontiers articles.

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This article has more downloads than 42% of all Frontiers articles.

Article Statistics (June 26, 2022)

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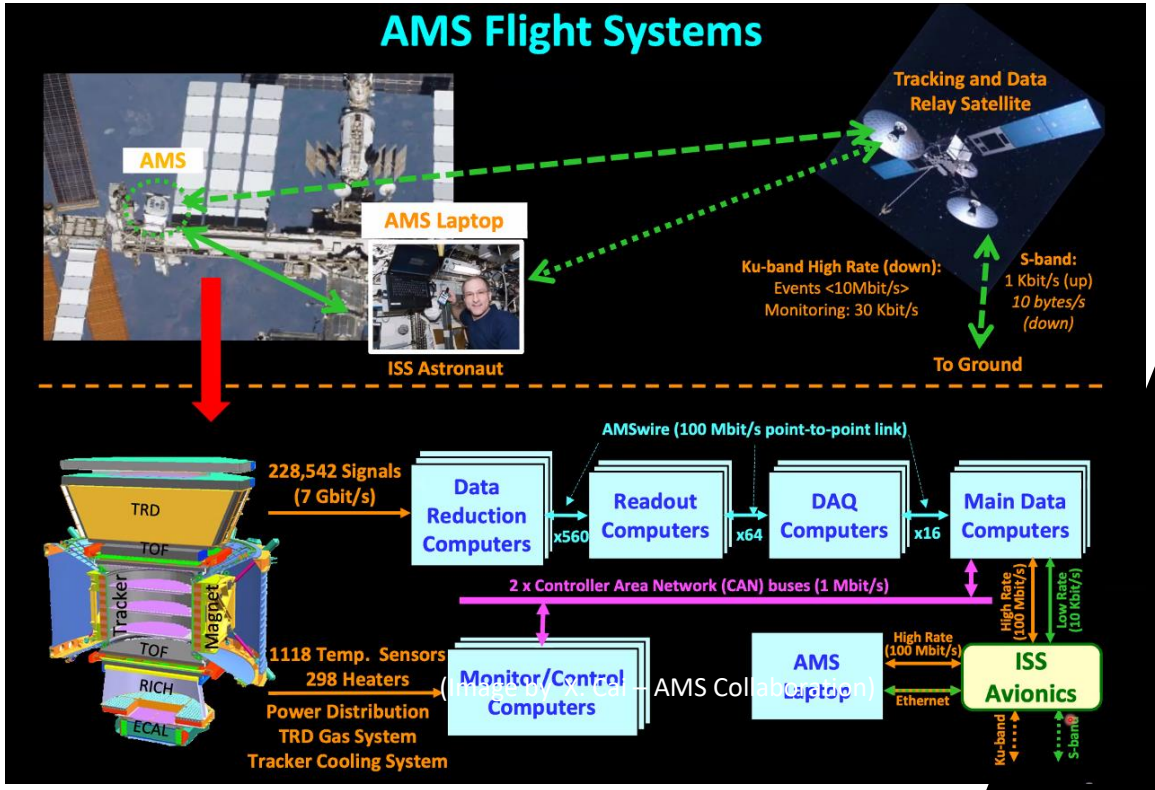
Russian Federation 80

2,325 TOTAL VIEWS

08 November 2021 | https://doi.org/10.3389/fpubh.2021.733337

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 Xu Gao – 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.
…

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.

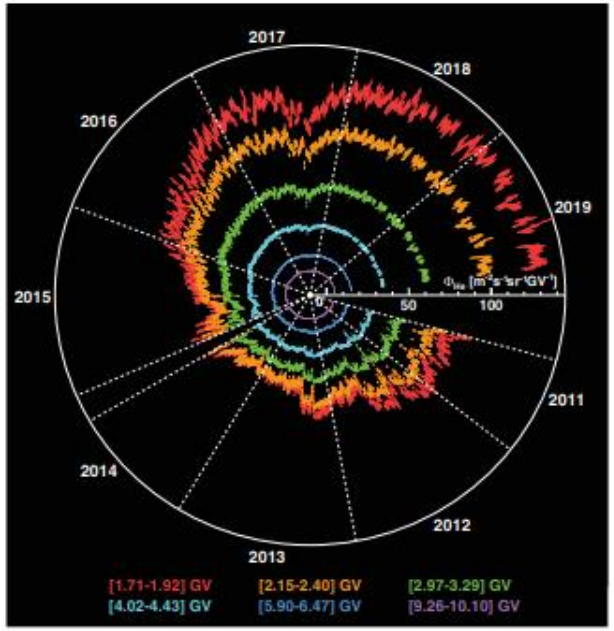


FIG. 1. The daily AMS helium fluxes Φ_{He} for six rigidity bins from 1.71 to 10.10 GV measured from May 20, 2011 to October 29, 2019 which includes a major portion of solar cycle 24 (from December 2008 to December 2019). The scale of daily helium fluxes Φ_{He} is shown on the radius. The AMS data cover 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.

AMS/SPRB

Some highlights from AMS Roma wiki logbook

21-06-2022

• Participation at the **Frontiers of Neurology 2022** Conference - "Dose-Effects Models for Space Radiobiology: An Overview on Central Nervous System Dose-Effect Relationship« by L. Strigari, A.N. Guracho, S. Strolin, A.G. Morganti and A.Bartoloni (Presenter)

16-06

• Participation at the **RAD 10 Conference Spring Edition – Oral Talk**
Slide AstroParticle Experiments 4 Space Radiobiology : The Research Topic Initiative PDF file

23-05

• Participation at the **15th Pisa Meeting on Advanced Detectors** - Poster

09-05

• The AMS Roma INFN group activities will be part of a special lecture (6 June 2022) for the 4th year Physics students of the Sapienza University in the "Particle Physics" course. AMS Roma for the 4th year student slides

08-05

• 1 abstract was accepted at the **ICHEP2022 - XLI International Conference on High Energy Physics** , July 2022, Bologna Italy Conference WebSite

20-04

• 3 abstracts were accepted at the **73th IAC2022 International Astronautical Congress** , September 2022, Paris France Conference WebSite1) Dose-Effects Models 2) TE vs NTE Effects 3) AstroparticleExperiments4SpaceRadiobiology

13-04

• 2 abstracts were accepted at the **44th COSPAR Scientific Assembly**, 16 July – 24 July 2022, Athens Greece Conference WebSite Astroparticle Experiments to Improve the Biological Risk Assessment of Exposure to Ionizing Radiation in the Exploratory Space Missions: A Research Topic Initiative.

10-02

• A new paper was accepted for publication **"High Energy Physics Astroparticle Experiments to Improve the Radiation Health Risk Assessment in Space Missions«** https://pos.sissa.it/398/106 by A. Bartoloni, G. Della Gala, A.N. Guracho, G. Paolani, M. Santoro, L. Strigari, S. Strolin pdf format

28-10

• **IAC-2021 International Astronautical Conference** Conference Web Site ***IAF/IAA SPACE LIFE SCIENCES SYMPOSIUM (A1)*** *Track 5 : Radiation Fields, Effects and Risks in Human Space Missions* **"Space Radiation Field Characterization Using the Astroparticle Operating Detectors«** by A. Bartoloni, G. Della Gala, A.N. Guracho, G. Paolani, M. Santoro, L. Strigari, S. Strolin IAC-A1.5.1 (ID:63116) slides in pdf format

28-07-2021

• **EPS-HEP 2021 European Physical Society High Energy Particle Conference** Conference Web Site Track 1 : *Astroparticle and Gravitational Waves* **"High Energy Physics Astroparticle Experiments to Improve the Radiation Health Risk Assessment in Space Missions«** by A. Bartoloni, G. Della Gala, A.N. Guracho, G. Paolani, M. Santoro, L. Strigari, S. Strolin EPS-HEP T01 slides in pdf format

INFN Istituto Nazionale di Fisica Nucleare Sezione di Roma

POLICLINICO 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[1], S. Strolin[1], A.G. Morganti[1] and A.Bartoloni[2]

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[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.**

Ionizing Radiation risk for CNS

Origin of Space Radiation and Consequent Risk

Space Radiation effects on CNS

Dose-effects Relationship for CNS

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

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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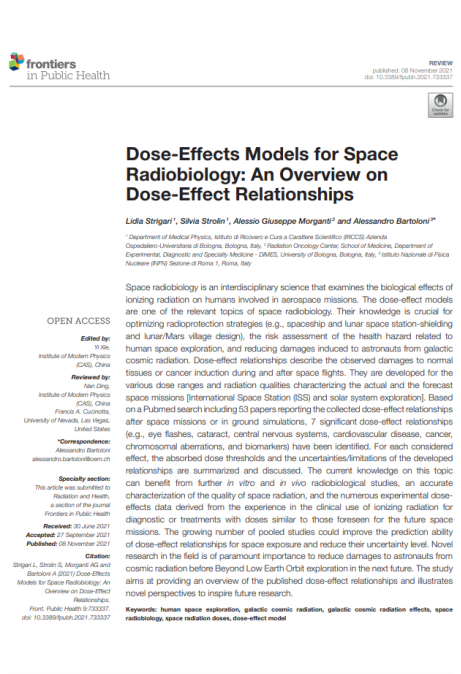
In the near future, all the space agencies are working to restart the human exploration of space outside the Low Earth Orbit (LEO). Crewed space missions in this and the next decade will see the presence of humans on the Moon and Mars surface. One of the main showstoppers to be investigated for safe 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



frontiers in Public Health

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

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November 2021 | Volume 9 | Article 733337

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

Participating Journals

SCAN the QR CODE to participate!

Contributors from different research areas

The research topic initiative was launched in November 2021

- 1500 views (topic & articles)
- 20 expected contributions
- 5 abstracts received
- 1 published manuscript

Open for articles submissions !

Worldwide interest for the topic