AMS collaboration at LIP

LIP has been involved since beginning of the experiment (1998).

Since AMS' launch, 29 papers were published by the collaboration covering the following topics:

Primary & Secondary Nuclei Fluxes

Proton, Electron, Positron, Helium, Antiproton, Boron, Carbon, Oxygen, Lithium, Beryllium, Boron, Nitrogen, Sodium, Aluminium, Fluorine, Iron, Neon, Magnesium, Silicon

Time-resolved Particle Fluxes

Bartel: Proton, Helium, Electron, Positron, Lithium, Beryllium, Boron, Carbon, Nitrogen, Oxygen, Antiproton

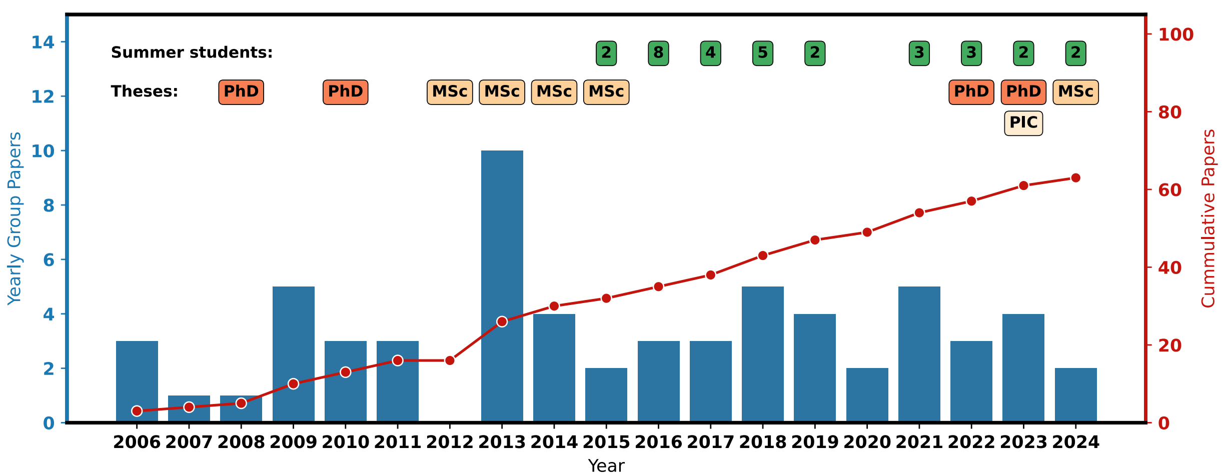
Daily: Proton, Helium, Electron, Positron

Isotopic Fluxes

^{3}He & ^{4}He, ^{2}H, ^{6}Li & ^{7}Li (Accepted)

AMS-LIP Physics Topics

- Time Variability of the Cosmic-ray Flux
- Isotopes (D, Li, B, C,…)
- RICH reconstruction monitoring and analysis




FERNANDO **BARÃO**


MIGUEL **ORCINHA**


JOÃO **ANTUNES**


LUISA **ARRUDA**


GUILHERME **GASPAR**


JOSÉ **MACHADO**


PAULA **BORDALO**


SÉRGIO **RAMOS**

Team: 5 Senior, 1 PhD, 1 MSc, 1 BSc

FCT CERN: 2024.00992.CERN
May 2024 – Oct 2025 (41k€)
Total FTE: **4.6**
Project end date to be extended to end of Jan 2026, (new FCT timeline)

Landmarks and Group Updates

From 2024 till now…

AMS collaboration papers: 3 (Deuterons, Nuclei and Antiprotons)

Few authors papers: 2

M. Borchelini, F. Barão, M. Vecchi, **L. Mano,** *Feature selection techniques for CR isotope identification with the AMS-02 experiment in space*, Particles 7 (2024) 2, 417-434

D. Pelosi, F. Barão, B. Bertucci, E. Fiandrini, M. Orcinha, A. Reina Conde, N. Tomassetti, *Cross-correlation analysis for cosmic ray flux forecasting*, EPJ Web Conf. 319 (2025) 13004

Additionally, two conference proceedings accepted, three new papers undergoing writing, several talks and posters at international conferences (ECRS, ESWW, EGU, …), and invited lectures and seminars.

Theses and students:

Bachelor student: **José Machado** (IST – University of Lisbon, ongoing)
Master student: **Guilherme Gaspar** (IST – University of Lisbon, ongoing)
Master student: **Margherita Fioroni** (University of Perugia, *defended*)
PhD student: **João Antunes** (IST – University of Lisbon & Shandong University, ongoing)

Internships:

Duarte Faustino, Pedro Ramos, *Analysis of temporal signals*

Ongoing research tasks:

RICH studies – F. Barão, G. Gaspar, J. Antunes, L. Arruda
Time Variability of Cosmic-ray flux – M. Orcinha, F. Barão, J. Antunes
Isotopic fluxes – F. Barão, G. Gaspar, J. Antunes, S. Ramos, P. Bordalo
Geomagnetic field and Space radiation studies – M. Orcinha, F. Barão

Main international research collaborations:

Perugia University / INFN – Solar Modulation: phenomenology and modelling; Space radiation: dose and magnetic environment in low orbit
Geneva University – Isotopic fluxes, RICH studies
Shandong University / SDIAT – Isotopic fluxes, RICH studies

AMS Lithium Isotopic Fluxes

Properties of cosmic lithium isotopes measured by the Alpha Magnetic Spectrometer, M. Aguilar et al. (Accepted), PRL

Preliminary work

Solar Modulation of Galactic CR's

1D equation with an effective advection

$$K\frac{\partial^2 f}{\partial r^2} + \left(\frac{2K}{r} - V_{\rm SW} - V_{\rm a}\right)\frac{\partial f}{\partial r} - \frac{2V_{\rm a}}{r}f + \frac{2V_{\rm SW}}{3r}\frac{\partial f}{\partial \ln p} = 0$$

Work presented in several conferences, article in last stages of preparation.

Diffusion coefficient

$$K = K_0\beta\left(\frac{P}{1\ \rm GV}\right)^{\delta}$$

Time-dependent parameters

$$K_0(t),\ \delta(t),\ \varepsilon(t)$$

Dynamic time delay of parameters

$$\tau(t) = \tau_{\rm M} + \tau_{\rm A}\cos\left(\frac{2\pi}{T_0}(t - t_p)\right)$$

Numerical approach (Crank-Nicolson scheme)

LIS - model by A. Reina Conde

$\mathbf{V_{SW}}$ - constant radial velocity of solar wind

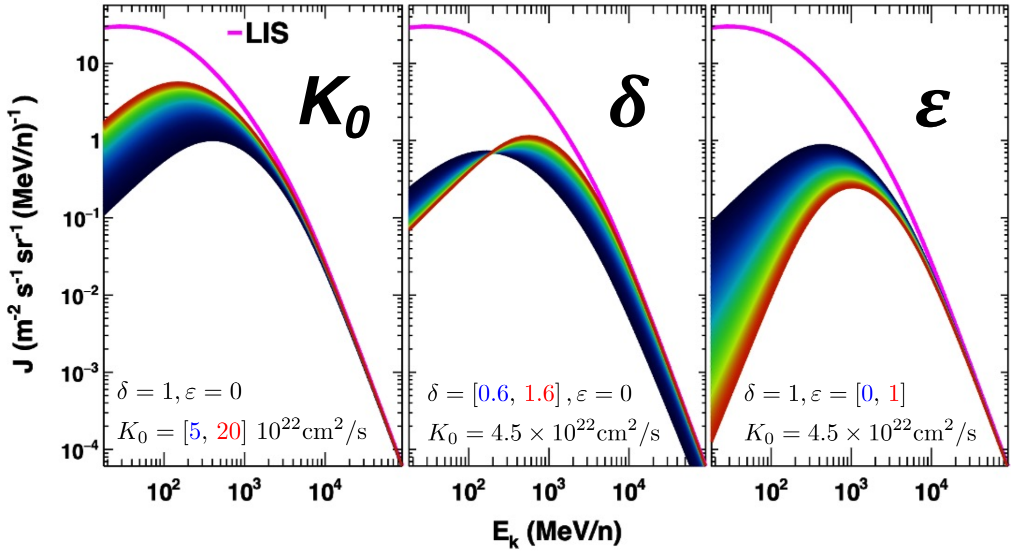
K - single power-law diffusion

$V_a = \varepsilon V_{SW}$ - effective advection parameter

K_0, δ, ε are the parameters used to describe the flux at any given moment.

In order to relate the CR flux to solar activity, the relationship between these parameters and the **delayed number of sunspots** was studied.

Propagation parameters impact spectral shape



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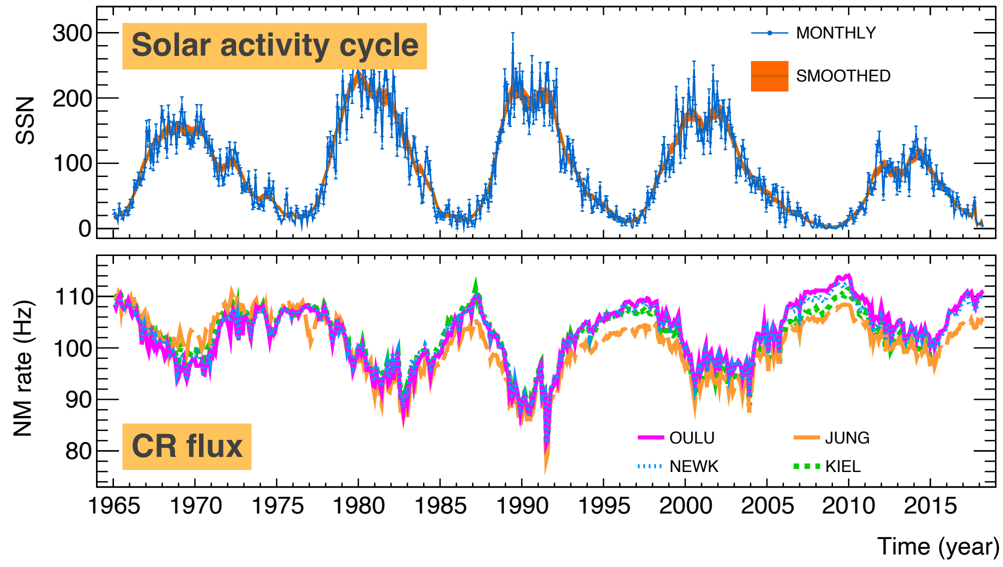
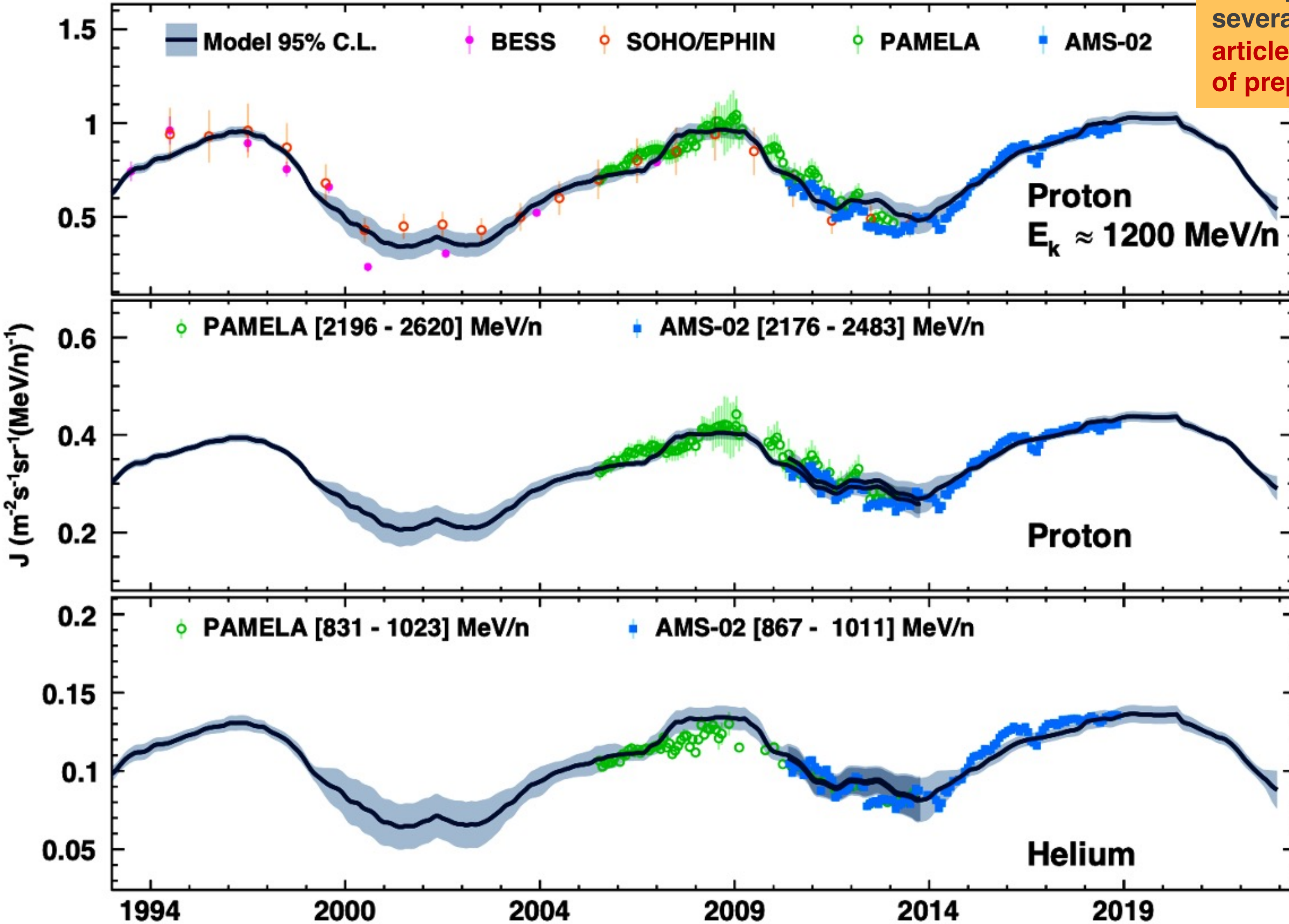
Propagation parameters relate to solar activity



Modelling and Forecasting CR Flux

Work presented in several conferences, **article in last stages of preparation.**

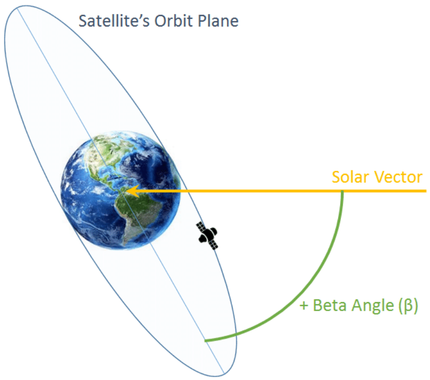


Parameters were estimated by fitting to **AMS** and **ACE/CRIS Carbon fluxes**, and **PAMELA proton flux**.

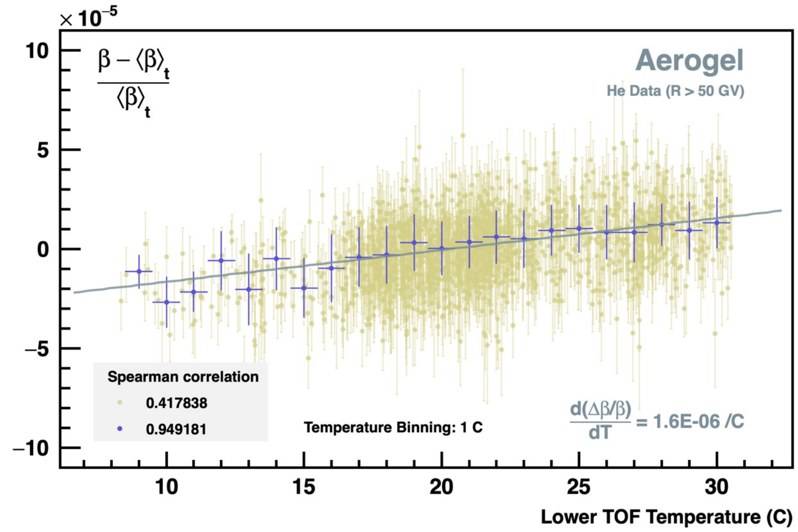
RICH Velocity: Time Variability

Velocity displays a slight variation with time, $v(t)$.

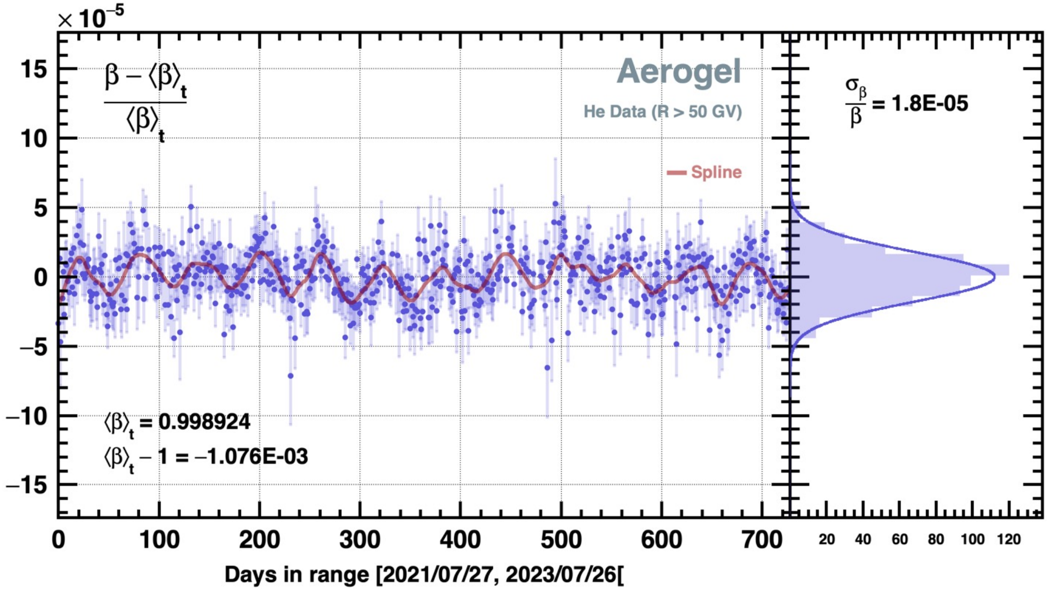
This variation can be related to temperature variations: orbital plane inclination with respect to solar radiation incidence.



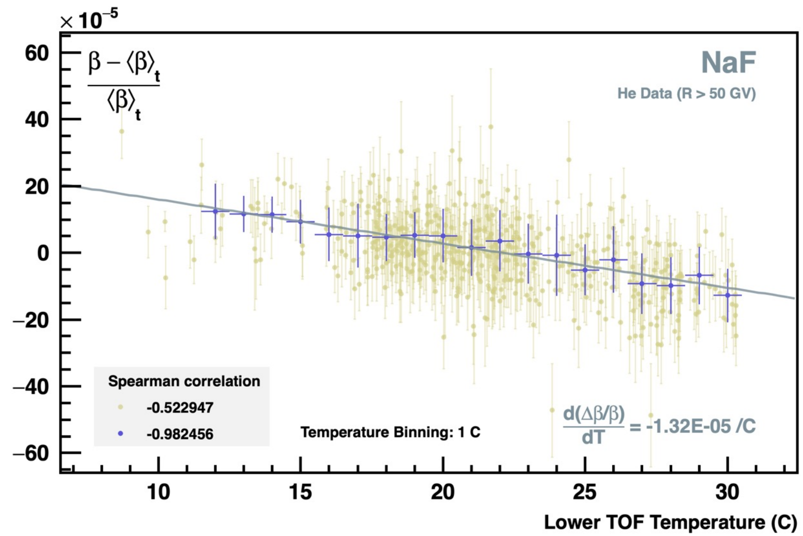
β resolution variation with temperature



Velocity variation with temperature



β resolution variation with temperature



Beryllium Isotopic Analysis: Backgrounds

Existing measurements of Be isotope flux are both at low energy and have low precision.

Potential background from nearby nuclei (in charge): B, C, N, O

- Fragmentation taking place before the first measurement of charge (Tracker Layer 1)

Different detector regions for the analysis: TOF, RICH (NaF and Aerogel).

$\frac{B}{B+S}$: background on Be selection is ~1.0-1.5%, coming from dominant channels, boron and carbon.

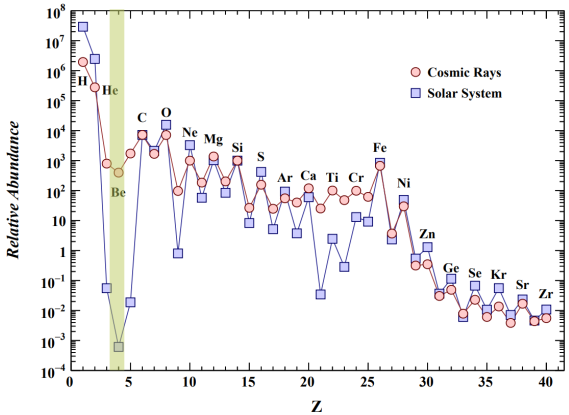
Background contribution is much higher in ^{10}Be: ~15% at low energy down to 4% around 10 GeV/n.

A further reduction of background is envisaged by using the TRD detector alongside machine learning techniques.

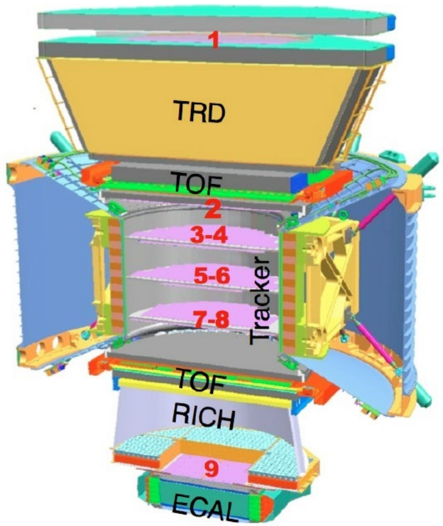
Preliminary work

Be isotopic abundance

^{7}Be	^{9}Be	^{10}Be
50-60%	30-40%	10-15%



Source: PDG



Radiation Risk at Low Earth Orbits

Dose due to cosmic radiation

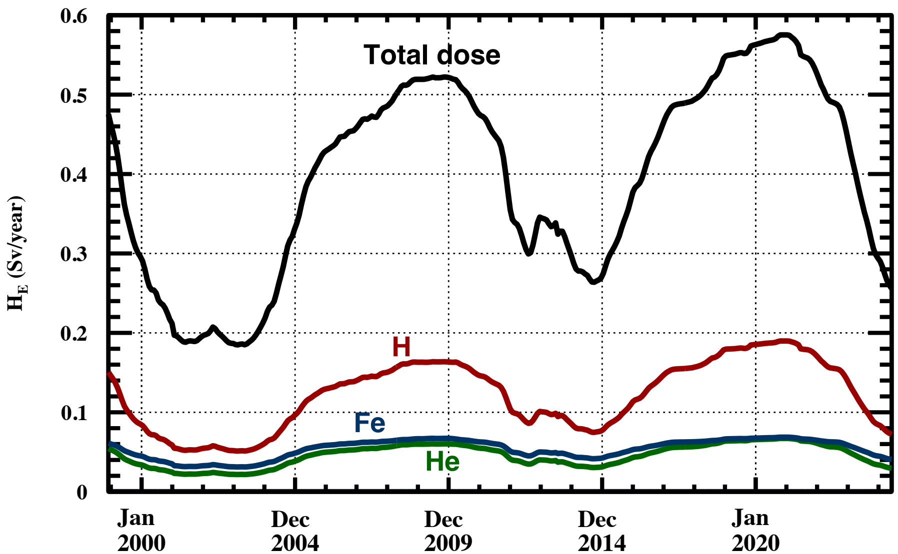
$$H_{\mathrm{T,p}} = 4\pi \int_{\mathrm{Time}} \int_0^{\infty} \mathcal{P}_{\mathrm{Cutoff}}(E|\vec{r},t)\, Q_{\mathrm{p}}(E)\, \frac{D_{\mathrm{T,p}}}{\Phi_p}(E)\, \varphi_{\mathrm{p}}(E,t)\, \mathrm{d}E\, \mathrm{d}t$$

p – particle

T – tissue

Work presented in several conferences, article being written.

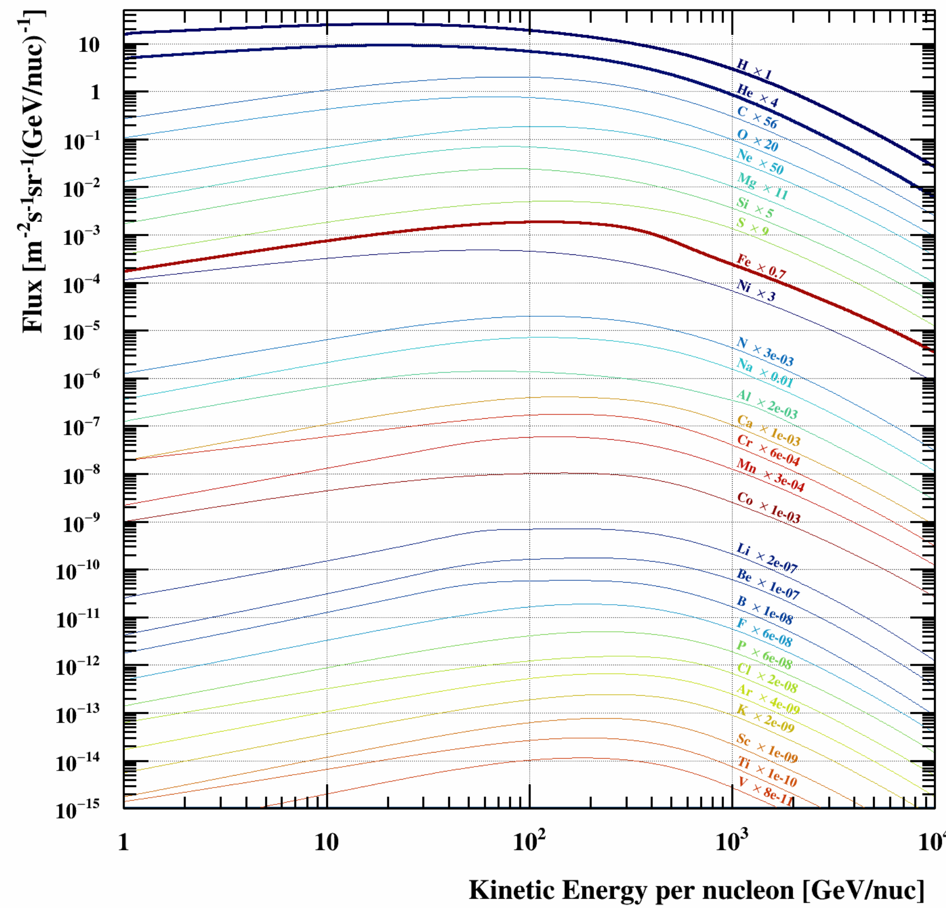
Deep space (1AU)



Average Dose: 0.395661 Sv/Year

Total dose includes all nuclei from Hydrogen (Z=1) to Nickel (Z=28).

Local Interstellar Spectra



Radiation Risk at Low Earth Orbits

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Work presented in several conferences, article being written.

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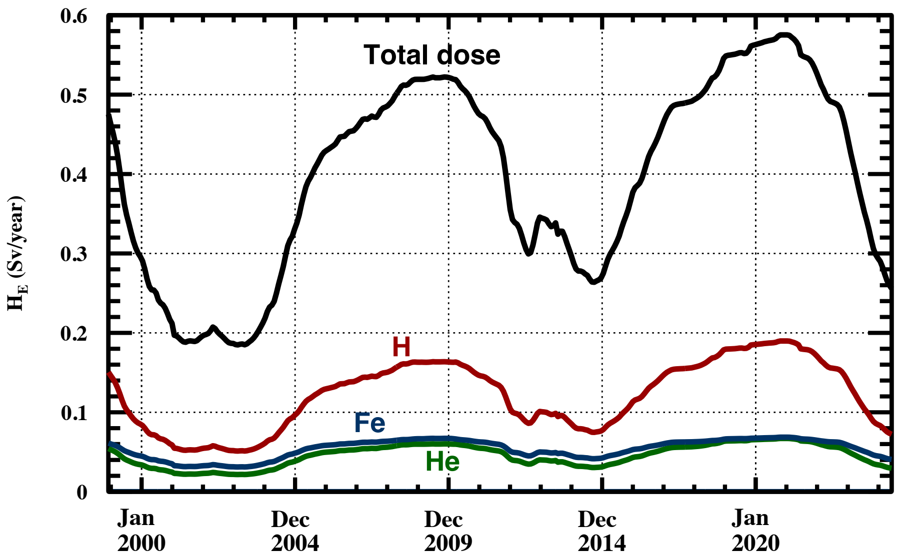

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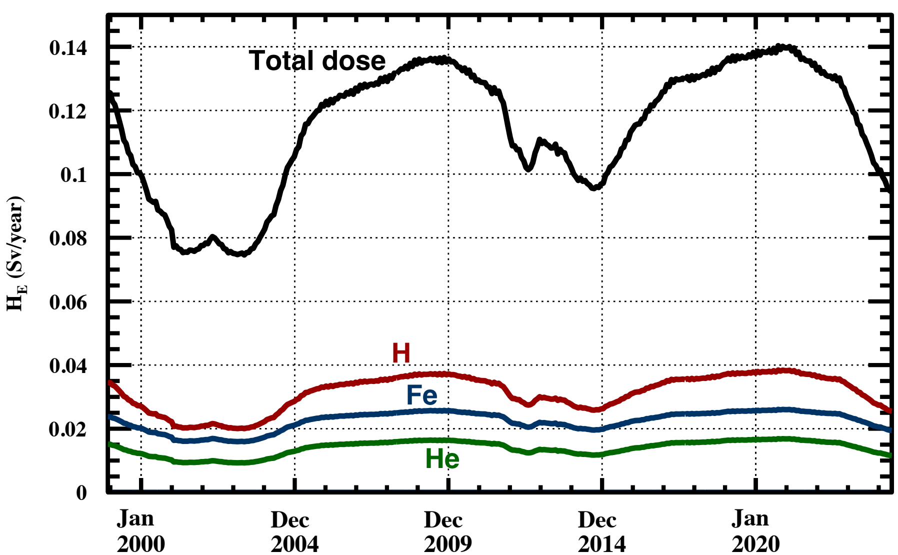
Total dose includes all nuclei from Hydrogen (Z=1) to Nickel (Z=28).

ISS orbit (with cutoff)



Average Dose: 0.114641 Sv/Year

(28.97% of deep space dose)

These studies are particularly relevant given the renewed interest in space travel.

STRENGTHS

- Experienced team in experimental, astroparticle and computational physics, with extensive computational and data science skills
- Long history of international relationships with other research groups
- Experience in developing extensive analysis frameworks

WEAKNESSES

The main weaknesses and threats are the relatively small size of the group and the lack of scientific overlap between the topics being researched by this group and other LIP research groups.

THREATS

OPPORTUNITIES

- AMS remains a unique observatory in space
- Increased interest by the scientific community in Dark Matter origin and cosmic antimatter
- Time-variability of CR fluxes is an emerging topic in the scientific community
- AMS' high exposure time gives access to low abundance nuclei and antimatter fluxes due to the sheer amount of data
- Involvement in isotopic analysis benefits greatly from the group’s RICH expertise

GROUP UPDATES

Ongoing theses:
José Machado (BSc, IST-UL, ongoing)
Guilherme Gaspar (MSc, IST-UL, ongoing)
João Antunes (PhD, IST-UL & Shandong University & SDIAT)

Defended theses:
Margherita Fioroni (University of Perugia)