CHARACTERISING BERMS'S RESPONSE TO COSMIC RAY IONS

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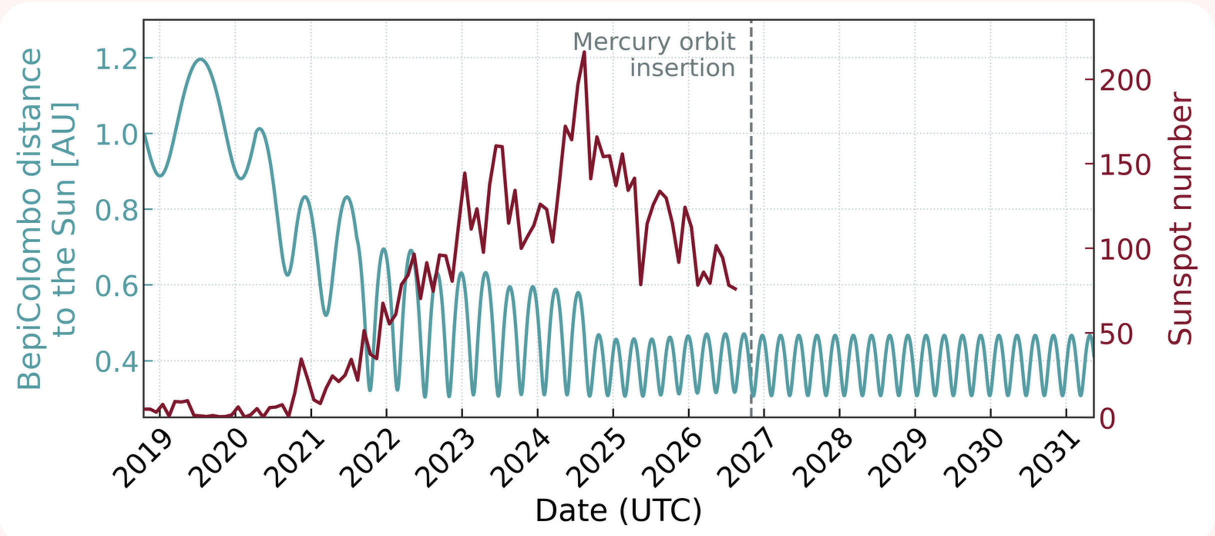
INTRODUCTION

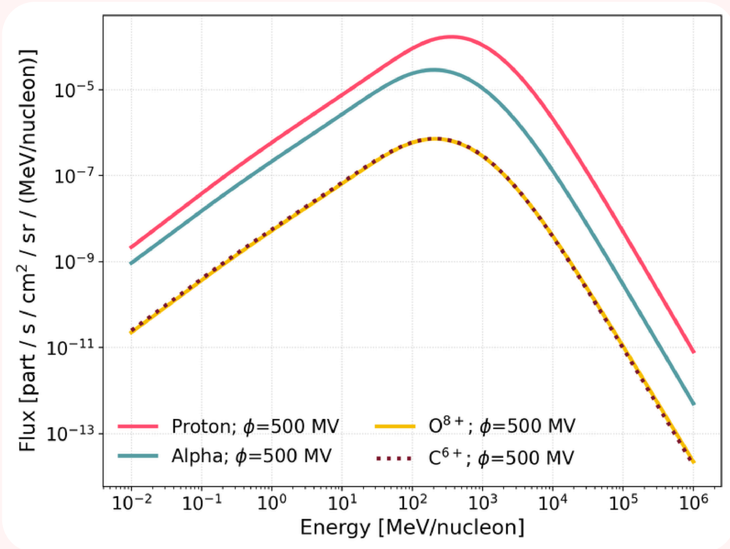
The BepiColombo mission

- BepiColombo is a joint mission from ESA/JAXA and it is the first european mission to visit Mercury.
- It was lauched in October 2018, with orbit insertion in November 2026.



Galactic Cosmic Rays

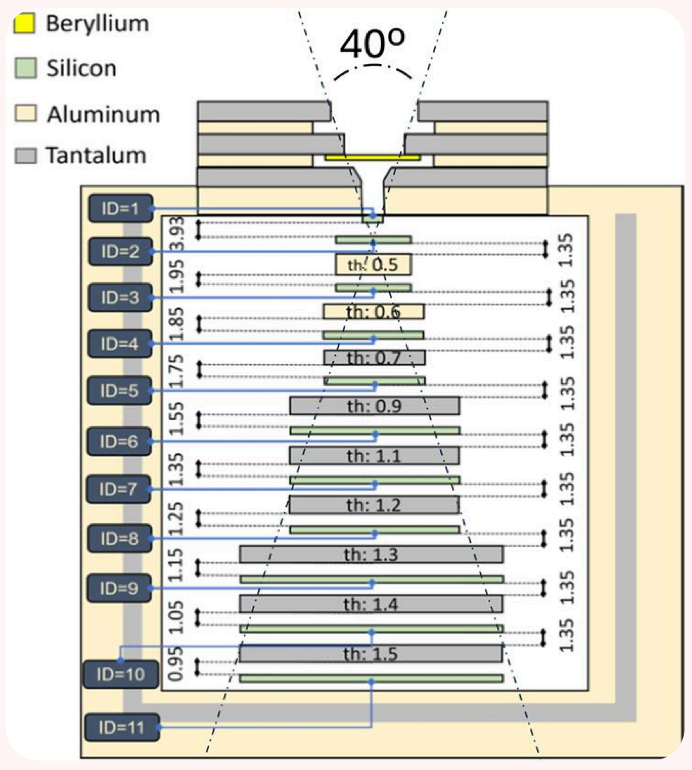
- Galactic cosmic rays (GCRs) originate outside the Solar System, reaching 10^{21} eV, and form an isotropic background.
- The GCR flux is modulated by the solar cycle and is inversely correlated with solar activity.
- GCRs are poorly studied in the inner Solar System, one of the things BepiColombo is well placed to address.



Differential flux of the most abundant species in the galactic cosmic ray spectrum, from the Badhwar–O'Neill 2020 [1] model at a modulation potential of 500 MV.

BERM

- The BepiColombo Environment Radiation Monitor (BERM) [2] is a facility instrument onboard the BepiColombo spacecraft responsible for monitoring radiation levels throughout all mission phases.
- BERM is a charged particle detector consisting of a telescope stack of 11 silicon detectors. Particles lose energy by ionisation, the energy loss scales with z^2/β^2. Therefore, a heavy ion will deposit more energy than a proton of the same velocity. This principle allows BERM to distinguish between particle species.
- BERM's algorithm sorts every detected particle into one of 18 channels: five for electrons, eight for protons, five for heavy ions.
- The goal of this work is characterising BERM's response to heavy ions.



Energy ranges	
Electrons	150 keV - 10 MeV
Protons	1.5 - 100 MeV
Heavy Ions (LET)	1 - 50 MeV/mg/cm²

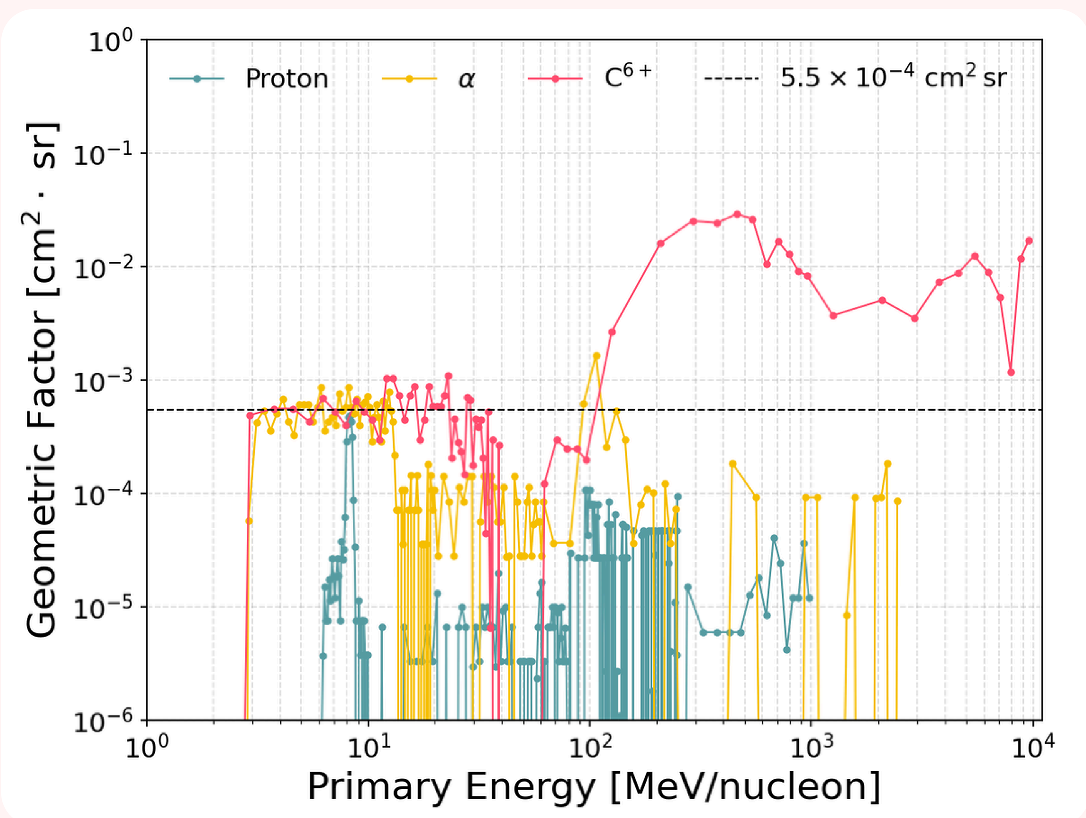
RESULTS

1 Respose Functions for HI1

In this work Geant4 [3] simulations were performed with a parallelepipedal carbon ion source surrounding BERM. Particles were simulated up to 10^4 MeV/nucleon.

Each channel's sensitivity is described by a **response function:**

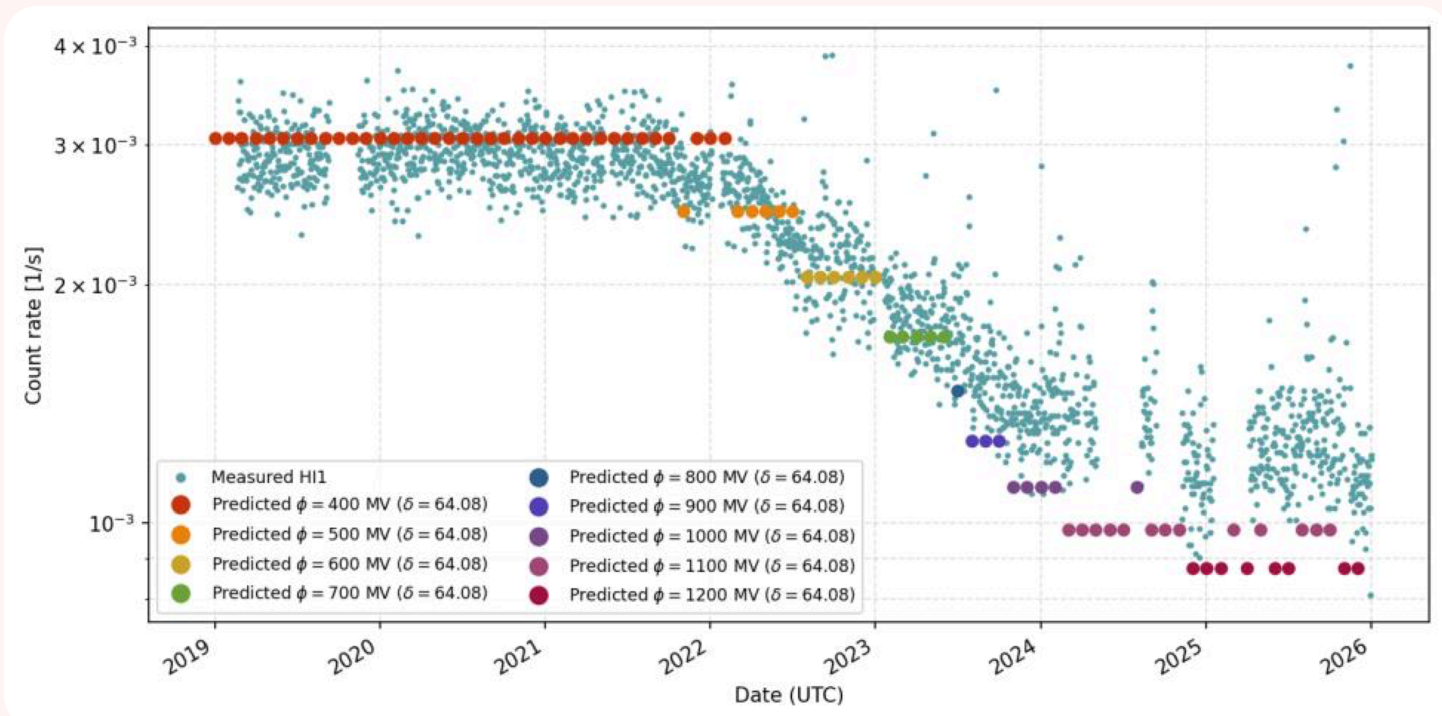
$$R(E) = A\pi \, \frac{N_{\text{channel}}(E)}{N_{\text{Inc}}(E)}$$



2 Count rate prediction Vs flight data for HI1

Once the response functions are known, they can be folded with the GCR flux to predict the count rates measured by each channel

$$C = \sum_s \int R_s(E)\, \Phi_s(E)\, \mathrm{d}E$$



- Scaled by an empirical factor δ, the predicted count rates reproduce the measured behaviour throughout 2019–2025. From the solar-minimum plateau of 2019–2021 and the decline into solar maximum.
- The contributions from other heavy ion species were calculated using carbon's response functions.

CONCLUSIONS

This work's achievements

- Response functions of all 18 channels computed from C^{6+} simulations.
- Temporal variation of count rates (2019–2025) reproduced; absolute normalisation requires the empirical factor δ.

Main limitations

- All heavier ions approximated by the carbon response function.
- Limited simulation statistics at high energies.

Future work

- Increase simulation statistics at high energies.
- Dedicated response functions per ion species, starting with oxygen (~25% of the heavy -ion count rate).
- Characterise the untested heavy ion electronics gain.

Enabling heavy ion flux reconstruction from BERM's flight data

References:
[1] T. C. Slaba and K. Whitman, "The badhwaro'neill 2020 model," NASA Technical Publication NASA/TP–2019–220419, NASA Langley Research Center, Hampton, Virginia, Nov. 2019.
[2] M. Pinto et al., "The BepiColombo environment radiation monitor, BERM," Space Science Reviews, vol. 218, p. 54, 2022.
[3] S. Agostinelli et al., "GEANT4: A simulation toolkit," Nucl. Instrum. Meth., vol. A506, pp. 250–303, 2003.