Daily Proton and Helium Fluxes Temporal Evolution with AMS-02

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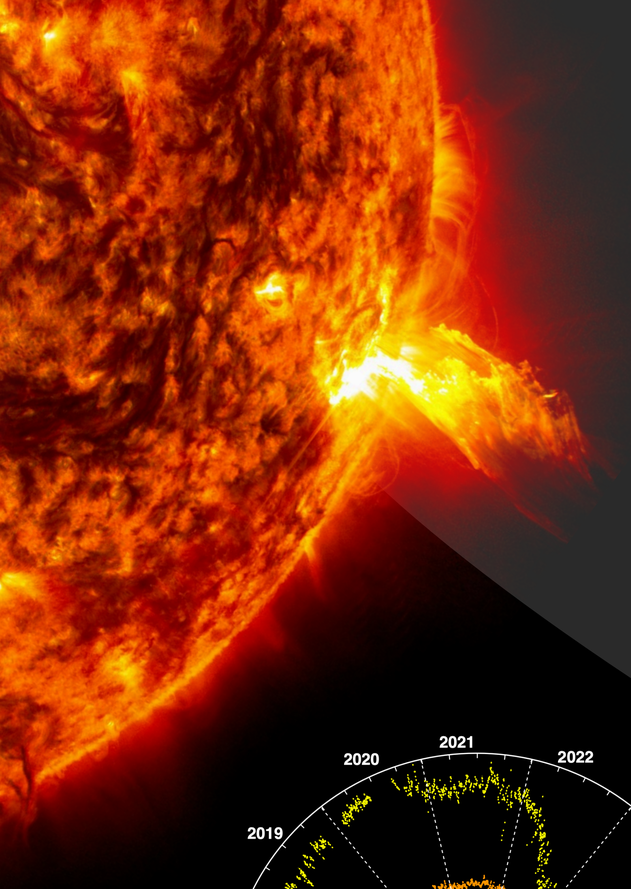
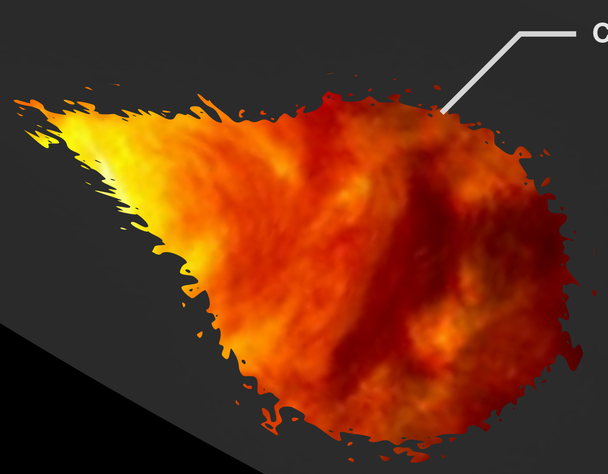
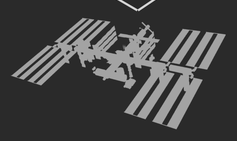
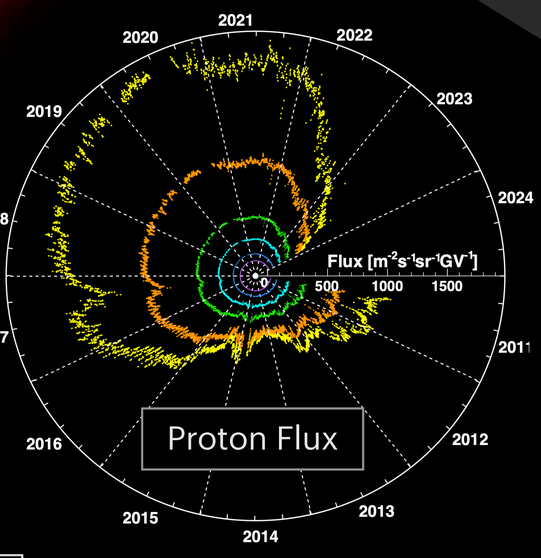




AMS-02 is a precision magnetic spectrometer devoted to the study of cosmic rays.
The experiment is operative on the International Space Station since May 2011 and it has collected over 218 billion cosmic ray events.
The rigidity interval studied by the experiment is comprised between the GV and the TV.

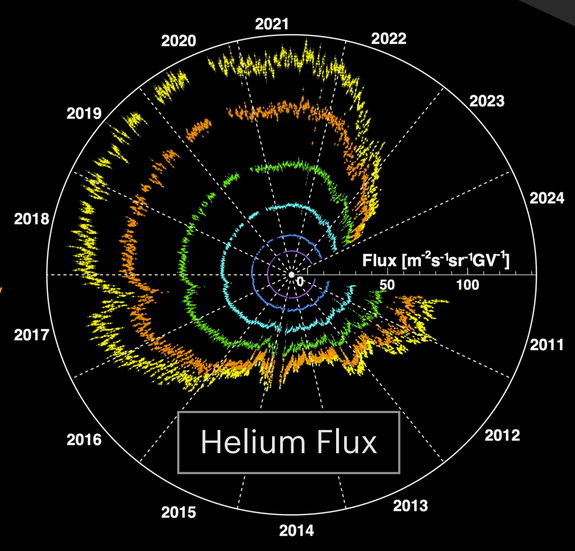




[1.00-1.16] GV
[1.92-2.15] GV

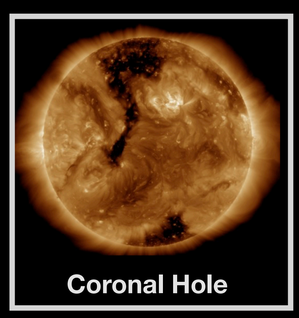
[2.97-3.29] GV
[4.02-4.43] GV
[5.90-6.47] GV
[9.26-10.10] GV

Rigidity = p/Z (GV)



[1.71-1.92] GV
[2.15-2.40] GV

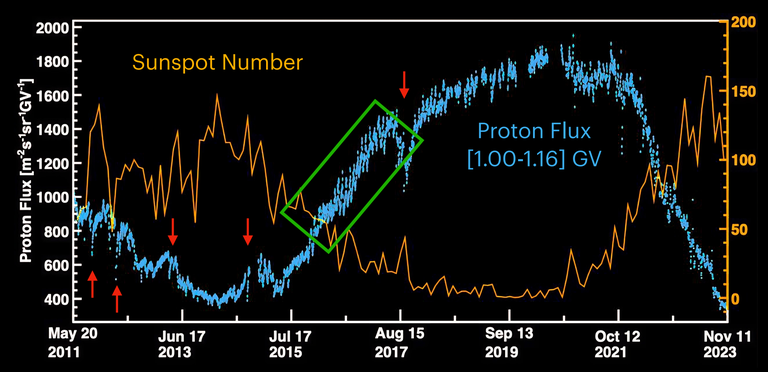
The cosmic ray flux is influenced by interplanetary environmental conditions and, in particular at rigidities below 100 GV, by the effects of **solar activity**.



The **daily proton** and **helium fluxes** show different **temporal variations.**

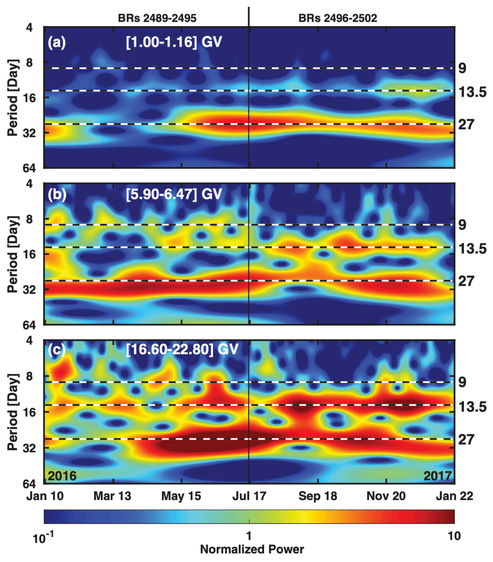
- **Long-term variations: 11-year solar cycle.** the proton flux is anti-correlated to the sunspot number.
- **Non-recurrent short-term variations** (indicated by arrows): **transient solar events**, like solar flares and CMEs.
- **Recurrent short-term variations** (sinusoidal shape): **cosmic rays and coronal holes correlation**.

Recurrent variations are related to the period of rotation of the Sun (27 days).



Results

Periodicities

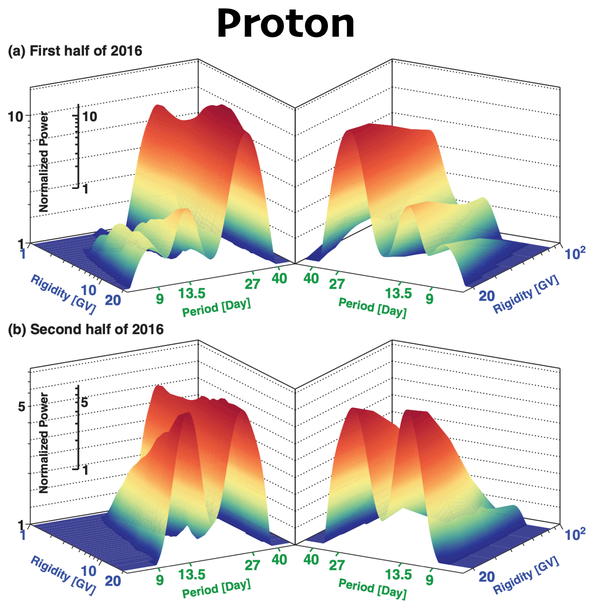


Wavelet Analysys

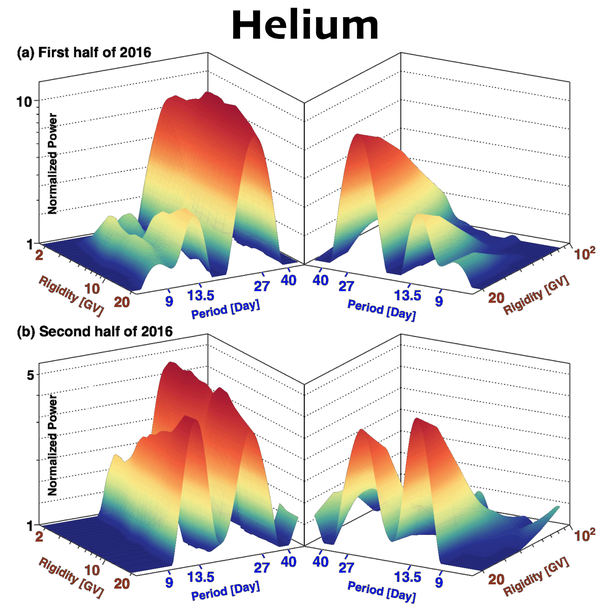
Sinusoids extend to infinity, not localized in time. Instead we use wavelets, localized both in time and frequency

Recurrent variations result in the observation of **periodicities** in the daily fluxes.
The wavelet transform shows the **intensity of the variations** with respect to the **period** (y axis) and **time** (x axis) in 2016, in three rigidity bins (proton flux).
The 27, 13.5 and 9 day periodicities (Sun's rotation period and submultiples) are significant.
The **shorter periods** of 9 and 13.5 days are particularly visible at **20 GV**.

Proton

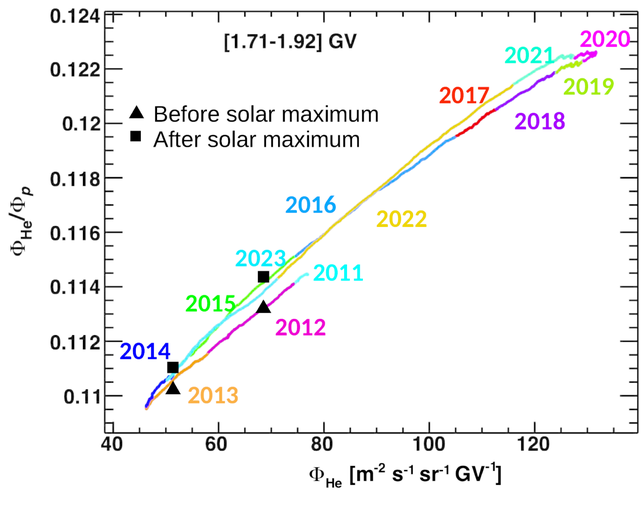


Helium



The above figures show the **rigidity dependence** of the intensity of periodicities for proton and helium fluxes.
The **intensity** of 13.5 and 9 days periodicities, in both cases, reaches a **maximum** respectively at 10 GV and 20 GV.
The AMS-02 result **is not compatible** with models that predict the **intensity of periodicities** to be constantly **decreasing** with increasing **rigidity**.

Hysteresis in Helium/Proton Ratio



Correlation plot between helium and proton fluxes. Data points are the moving average of 14 Bartels' Rotations (BR), with a step of 1 day.
The **ratio** of **Helium** and **proton fluxes ratio** is plotted with respect to **helium flux**.
In the rigidity bins **below 2.4 GV** we observe an **hysteresis** between **proton** and **helium fluxes**, before and after the **solar maximum** of **2014**.
The hysteresis in the flux ratio indicates a **different solar modulation** of the two species.
The significance of the structure around solar minimum (2020) is still under study and not significant with current systematic errors.

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[1] M. Aguilar et al., Properties of Dail Helium Fluxes, Phys. Rev. Lett. 128, 231102 (2022).
[2] M. Aguilar et al., Periodicities in the Daily Proton Fluxes…, Phys. Rev. Lett. 127, 271102 (2021).