LOCAL INTERSTELLAR SPECTRA OF ELECTRONS AND POSITRONS BY DEMODULATING FLUXES FROM THE PAMELA EXPERIMENT

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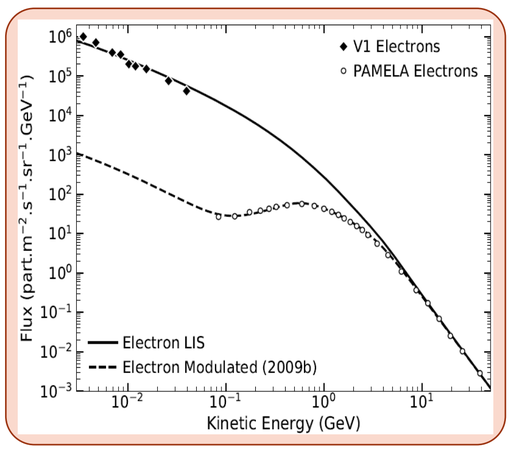
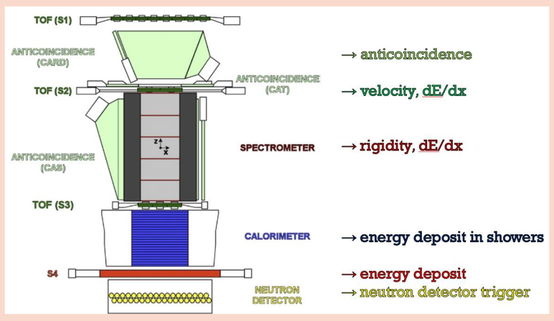
Goal: comprehensively researching modulation of cosmic-ray electron and positron fluxes
Current task: restoring local interstellar spectra (LIS) by demodulating observed fluxes near Earth

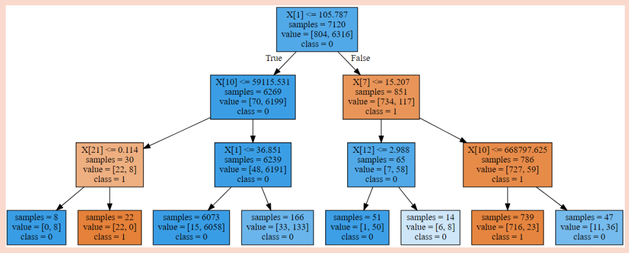
But why? This is an indirect way to obtain data on fluxes outside the Solar system that Voyager-1 [1] could observe *(see on the right)*. Analyzing PAMELA data may produce such results for particles of both signs of charge.

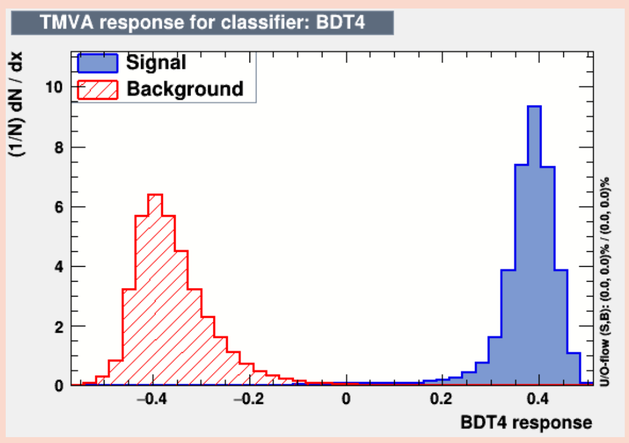


Step 1: PAMELA data → observed fluxes

To restore PAMELA data, a new method based on **machine learning** was applied. This method (Boosted Decision Tree, BDT) analyzes 20+ parameters of every single event detected, and it returns an effective separation of electron-like events from proton-like background.







Accounting for time and selection efficiencies, it is possible to obtain **$e^{\pm}$ fluxes** for **2006-2016**, especially with energies from **50 MeV and higher**.

Step 2: Demodulation → LIS

Analyzing proton and nuclei fluxes similarly, there is a way to transform observed fluxes using the formula [2] below:

$$J(E_A,t) = J_{LIS}(E_A + \Phi, t)\frac{E_A(E_A + 2M_A)}{\big(E_A + \Phi(t)\big)(E_A + \Phi(t) + 2M_A)}$$

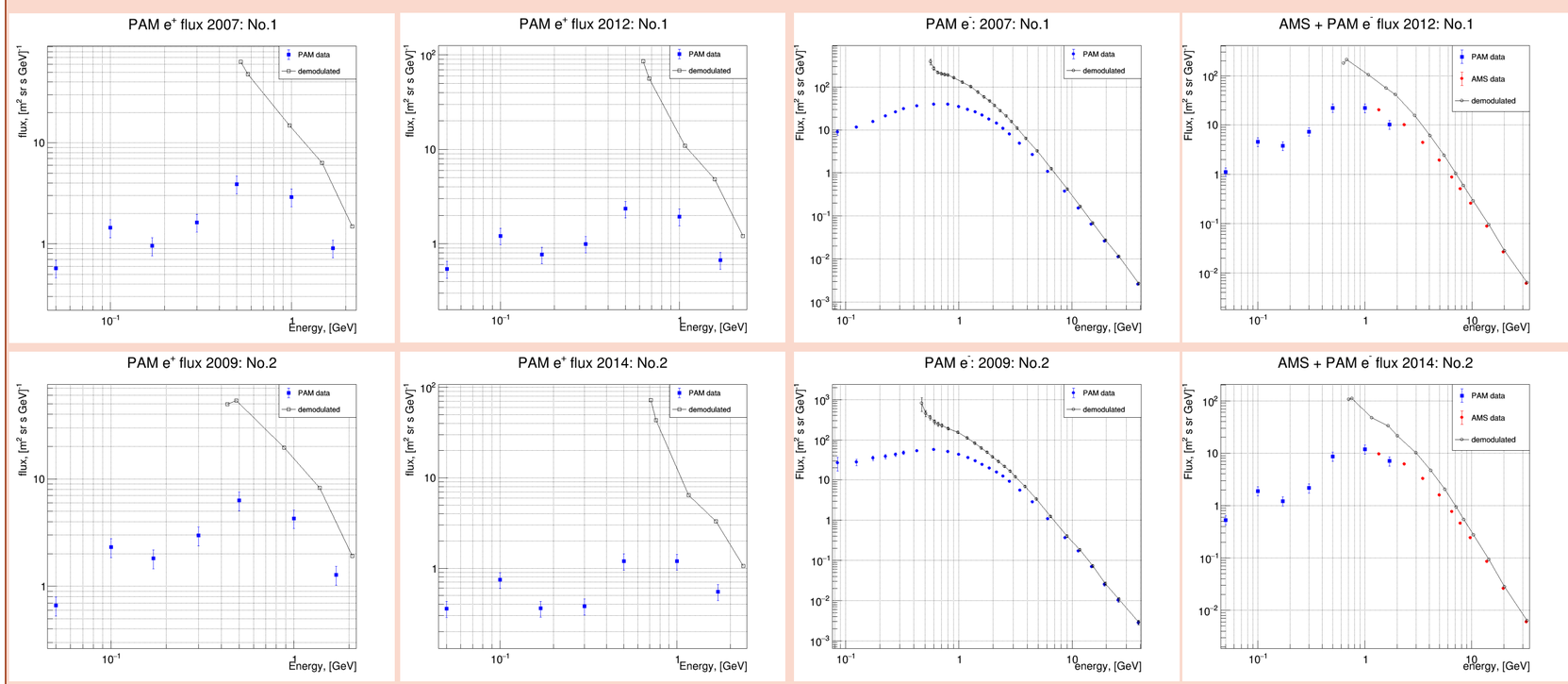
where $J(E_A,t)$ is the observed flux of the particle of M_A mass per nucleon with E_A energy per nucleon at the t time; $\Phi(t) = Ze/A \cdot \varphi(t)$ is the energy shift to obtain J_{LIS}, which accounts for the unsigned charge Z and atomic number A of the nucleon and so-called **modulation potential** φ which depends on the solar activity [2].

Therefore, supposing that $A \neq 0$ can take non-integer values and that $E \gg M$ for $e^{\pm}$, the applied flux transformation is:

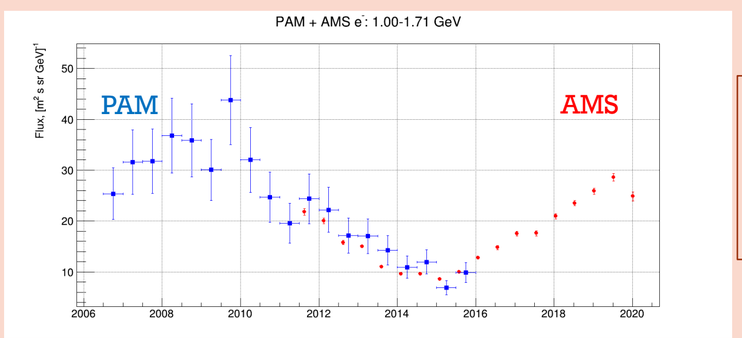
$$J_{LIS}(E + e\varphi, t) = J(E,t)\left(1 + \frac{e\varphi(t)}{E}\right)^2$$

Results: Fluxes and LIS

New e+ data *(smoothened)* | Old PAMELA data [3] | New data + AMS-02 [4]



New data errors: systematic
No LIS errors shown



e– flux timeline

No LIS

Analysis; conclusion

This data analysis enabled restoring the local interstellar fluxes of electrons and positrons based on observed fluxes with energies below 1 GeV.

Comparing the LIS derived from old and new PAMELA data, there is a slight discrepancy in shape observed, which could be explained by different approaches to data processing and their efficiencies of these methods.

Despite a lower limit for energies detected than AMS-02, PAMELA cannot reach energies observed by Voyager-1 unless an extrapolation is made similar to Potgieter's works [1].

1. DOI: 10.3847/1538-4357/ab1e4a
2. DOI: 10.1029/2023JA031352
3. DOI: 10.1088/0004-637X/810/2/142
4. DOI: 10.1103/PhysRevLett.121.051102