Mysteries at the Frontier: Deconvolving the Energetic Particle Rates of the Voyager Spacecraft

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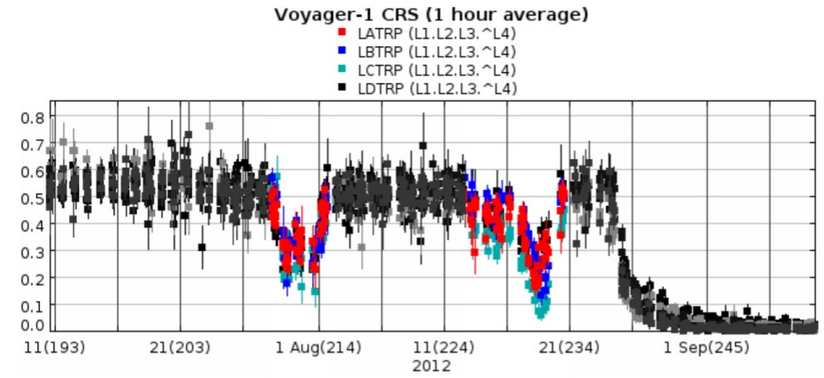
1. OBJECTIVE

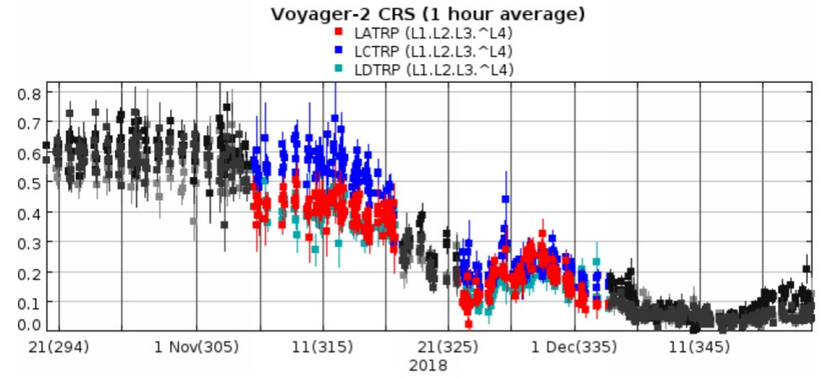
A) **What were the physical causes?**

Magnetic Flux Tube - VLISM to HS
Magnetic Flux Tube - HS to VLISM
Motion of Heliopause

B) **What can we learn from them?**

Width of Structure
Radial Velocity of Plasma



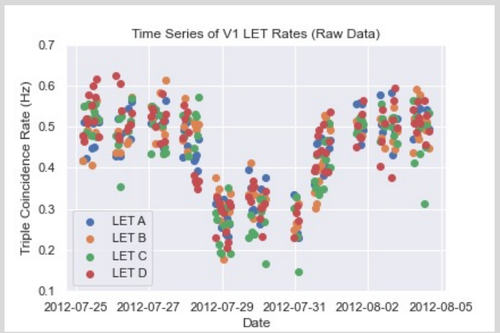


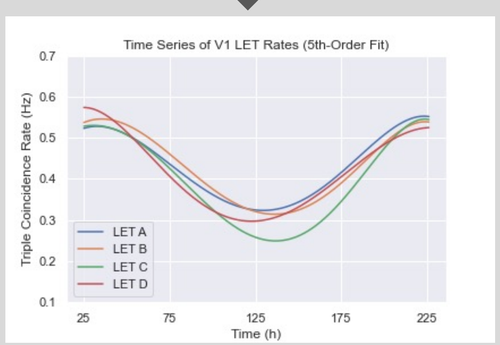
2. DATA

Source: Anomalous Cosmic Rays (ACRs)

Measure: LET Triple Coincidence Rates

Data Processing





3. ANALYSIS

Time Delay Estimation (TDE) by Deconvolution

Definition of Discrete Convolution

$$(f * g)[n] = \sum_{m=-\infty}^{\infty} f[n-m]g[m].$$

Discrete Deconvolution

Solve a Linear System of Equations

Techniques for Deconvolution

Solver-Level Techniques

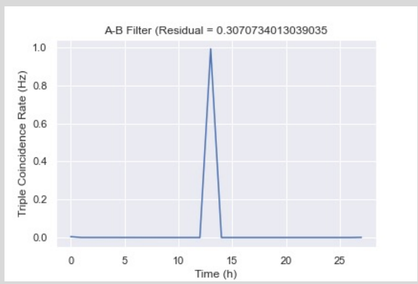
Total Variation Diminishing (TVD) Condition

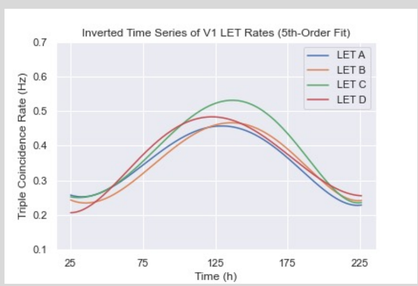
Nonnegative Least Squares (NNLS) Solver

Signal-Level Techniques

Polarity Inversion

Artificial Shift





4. RESULTS

Development of Techniques for Deconvolution

Development of Open-Source Software

Future Work

Continued Regularization

Cross-Correlation

References

Florinski, V., Stone, E. C., Cummings, A. C. & le Roux, J. A. Energetic particle anisotropies at the heliospheric boundary. II. Transient features and rigidity dependence. *Astrophys. J.* 803, 47–54 (2015).

Acknowledgements

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