



BHARATIYA ANTARIKSH HACKATHON 2025

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Team Name :ASNR

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Identifying Halo CME Events Based on Particle Data from SWIS-ASPEX Payload onboard Aditya-L1

Team Members

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A Hybrid Approach for CME Event's Identification

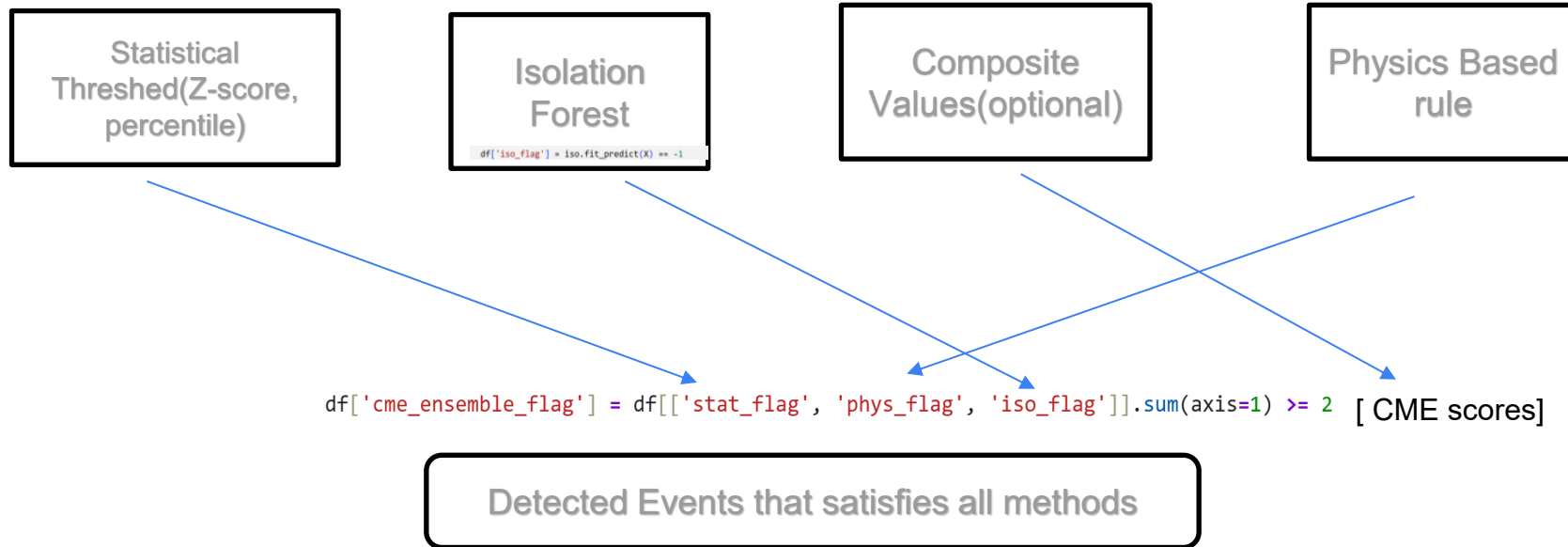
Integrating Statistical Thresholds, Physics-Based Rules, and Machine Learning (Isolation Forest)

We aim to detect halo CME events by combining results from multiple methods example statistical thresholds, physics-based rules, and machine learning. Relying on just one method can miss events or give false alarms. By combining outputs, we can make detection more accurate and reliable. This approach works even without any labeled examples.

Derived Parameters' after preprocessing

Feature Name	Description
flux_spike_score	Relative increase in solar particle flux over moving average
speed_jump_score	Gradient of proton bulk speed normalized by std dev
density_spike_score	Deviation of proton density from moving average
thermal_shock_score	Rate of change in proton thermal speed over average
alpha_proton_ratio	Alpha particle to proton density ratio
B_total_grad (not added in present experiment)	Gradient in total magnetic field magnitude indicating shock
Bx_jump_score (not added in present experiment)	Normalized spike in Bx magnetic component (IMF turning)

Physics values reference from : <https://www.sciencedirect.com/science/article/abs/pii/S0273117705010884> and https://www.researchgate.net/publication/251430386_Solar_energetic_particle_flux_enhancement_as_an_indicator



Method	Description	Formula
Composite Score	Weighted combination of derived parameters indicating abnormal activity.	$\text{CME_Score} = 0.3 \times \text{Flux Spike} + 0.25 \times \text{Speed Jump} + 0.25 \times \text{Density Spike} + 0.2 \times \text{Thermal Shock}$
Statistical Thresholding	Z-score and percentile-based thresholds on key features to detect spikes.	$\text{Z-Score} = (\text{Score} - \mu) / \sigma$, Flag if $Z > \text{threshold}$; also uses percentile $> P$
Isolation Forest (ML)	Machine Learning model that isolates rare or abnormal behavior in feature space.	$\text{IsolationForest}(\text{features}) \rightarrow \text{Flag if prediction} = -1$
Physics-based Rules	Simple rules based on solar physics (e.g., speed > 500 , flux $> 1e7$).	Flag if: speed > 500 , density > 5 , avg_flux_th1 $> 1e7$

```
df['cme_ensemble_flag'] = df[['stat_flag', 'phys_flag', 'iso_flag']].sum(axis=1) >= 2
```

Conclusion:

Our main idea is to integrated different methods to accurately identify CME event timestamp.
The reason behind choosing hybrid solution is we are unable to conclude the detected cme as proper or not

In our Ensemble method we integrated results from including statistical scores, ML approah and hard code physics thresholds

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THANK YOU

