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# BHARATIYA ANTARIKSH HACKATHON 2025

**Team Name : Notion**

**Team Leader Name : Mujeeb Nouman**

**Problem Statement : PS-10  Identifying Halo CME Events from SWIS-ASPEX Data**

**GitHub Repo :  https://github.com/AREEB-08/HALO_cme-10**


**Team of 4 Student Developers from**

- Delhi
- Uttar Pradesh
- Telengana
- & Bihar

# Team Members

**Team Leader: Mujeeb Nouman**
**College:** Jamia Hamdard University
**Batch:** CSEAI-27(IV Sem)
**Role:** Visualization & UI Developer

- Designs graphs, time-series plots, mock visualizations

**Team Member-1: Mohammad Areeb Uddin**
College: Jamia Hamdard University
Batch: CSEAI-27(IV Sem)
Role: Data Acquisition & Preprocessing

- Downloading, parsing, and cleaning SWIS Level-2 and CACTUS data.

**Team Member-2: Mobashshir Asad**
**College:** Jamia Hamdard University
**Batch:** CSE-27(IV Sem)
**Role:** Data Research and Clarification

- Handles core logic for CME detection, threshold modeling data exploration.

**Team Member-3: Aabid Rizwan Ansari**
**College:** Jamia Hamdard University
**Batch:** CSEAI-27(IV Sem)
**Role:** Model Validator & Documentation

- Tests accuracy of derived thresholds, validates results

# Brief about the Idea

- We aim to build an **AI system** to detect **Halo CME (Coronal Mass Ejection)** events using real solar wind data. The system analyzes over one year of **SWIS Level-2** data (**flux, density, temperature, velocity**) from **Aditya-L1**.

- We match this data with known **CME** events from the **CACTUS** database to identify patterns and correlations.

- Using signal processing and feature engineering, we extract key indicators that **consistently** appear during **CME** events.

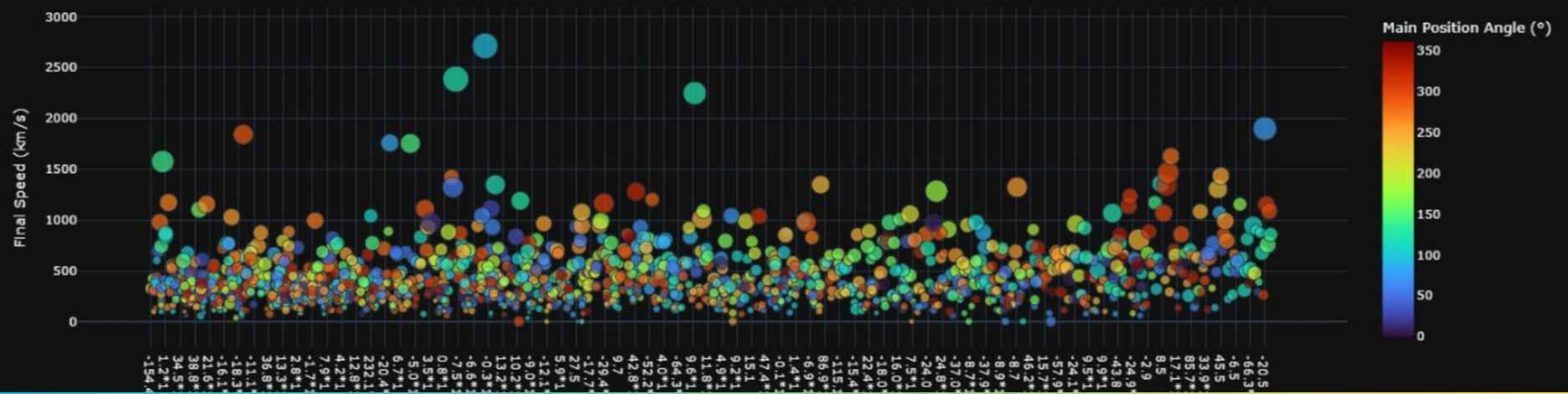
- After multiple tests, tuning, and **validation**, we've created a model capable of **high accuracy detection** of transient events.

- The ultimate goal is to provide a reliable **early-warning system** to protect space assets from solar disruptions.

- Our approach is a perfect blend of space science and **AI** turning raw data into actionable insights.

# How Its Different and USP

- Most current **CME detection** methods rely on post event analysis or indirect solar imaging. These approaches often face delays and depend on multiple data sources. Our idea focuses on **real time analysi**s using particle data from the **SWIS instrument** on **Aditya L1**, enabling earlier detection of CME activity.
- By comparing solar wind data such as flux, speed, density, and temperature with confirmed events from the **CACTUS database**, we can identify early signs of a Halo CME. This gives a faster and more direct way to recognize **critical solar activity** before it impacts Earth.
- The **unique strength** of our solution is its blend of space science and AI. It uses real data, is easy to interpret, and does not need large external inputs. This makes it suitable for **real time alert systems** and future integration into onboard space weather monitors.
- Our approach stands out by being simple, accurate, and fast. It offers a practical path to improve **space weather forecasting** and **protect critical systems** in orbit and on Earth.



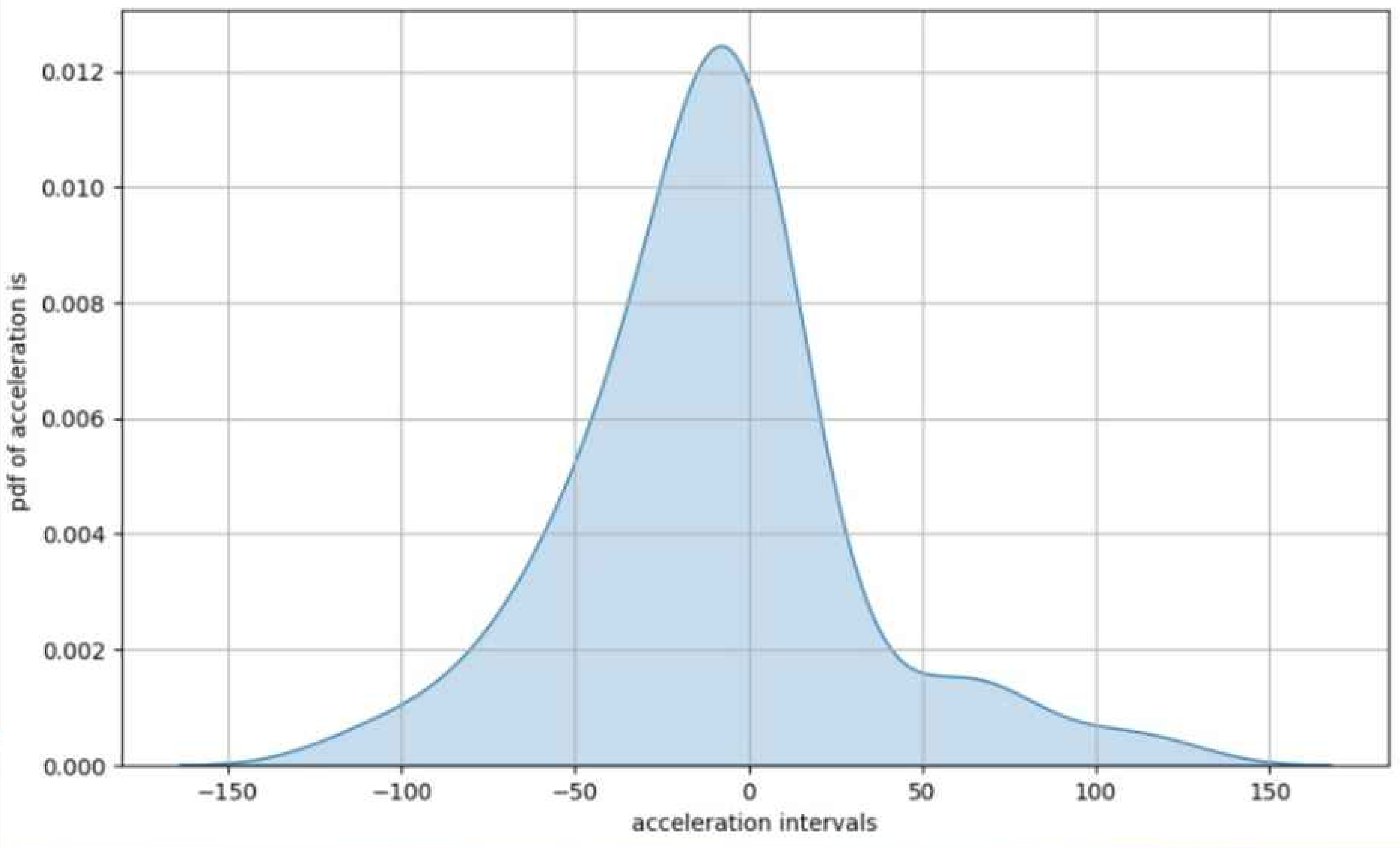

This image shows a scatter plot of Halo CME events, with acceleration on the **x axis** and final speed on the **y axis**. Each bubble represents one event, where the color shows the **main position angle** and the **size** indicates the **linear speed** of the CME. Most events are grouped at lower speeds and accelerations, while a few outliers show very **high values**, which may represent more intense and potentially dangerous events.

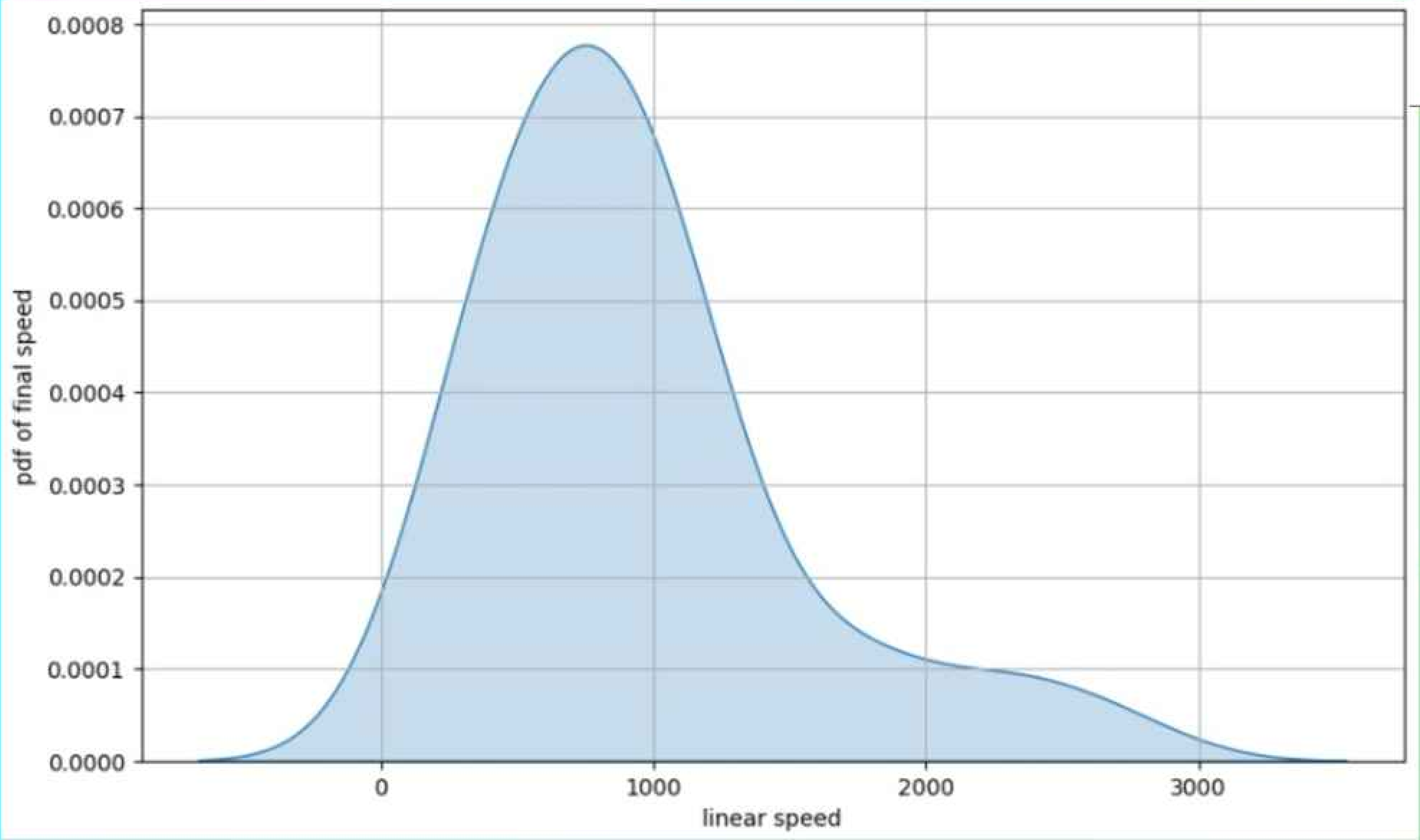
This visualization helps us recognize patterns in CME behavior, spot unusual activity, and better understand how direction and intensity are related. It also supports the development of precise detection thresholds and helps guide the AI model toward the **regions of highest risk**. This is a good example of how **space science data** can be turned into meaningful insights for early warning systems.

# Features

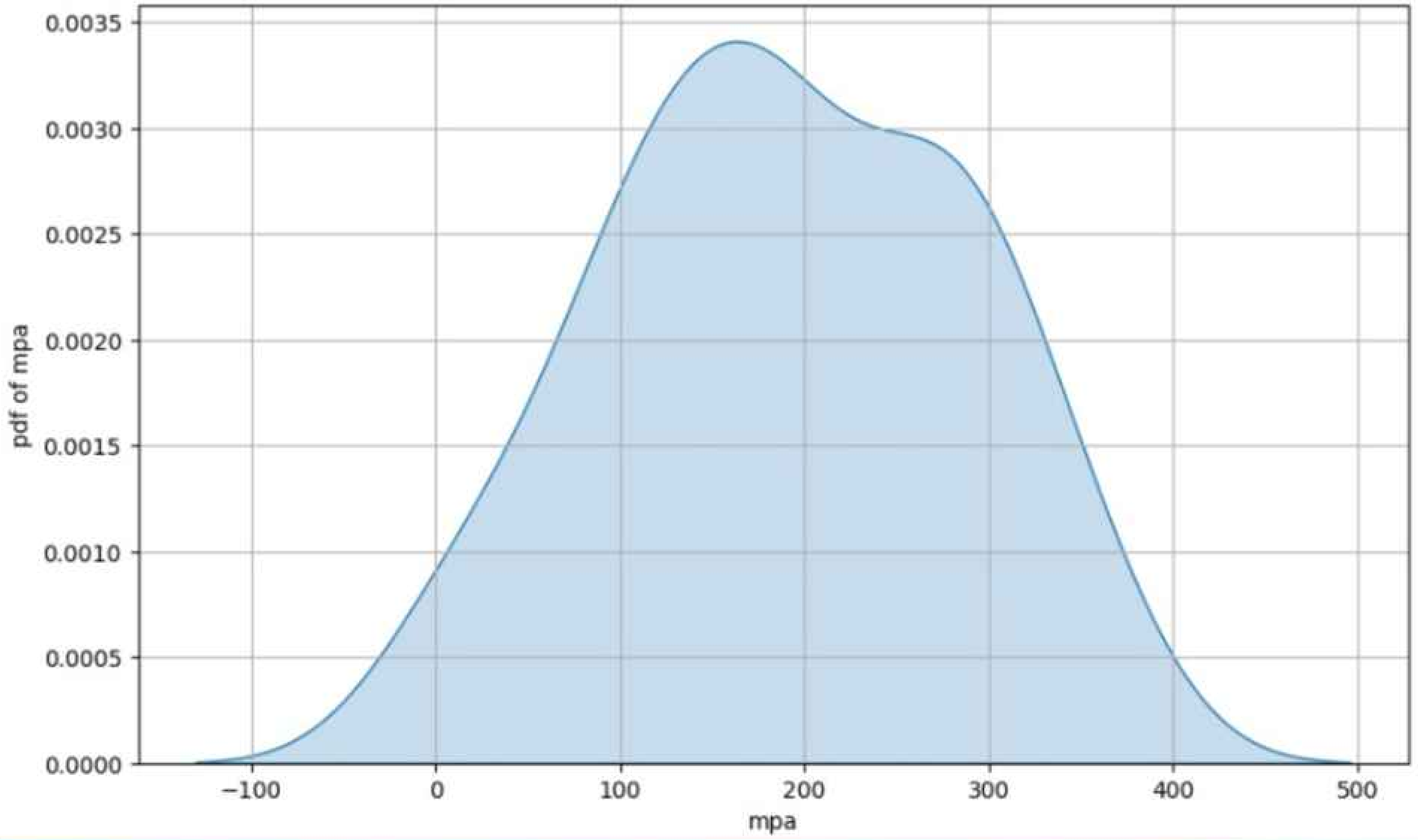
- Automatic **detection of Halo CME** events using solar wind data from the **SWIS** instrument onboard **Aditya L1**
- Analysis of key physical parameters such as particle **flux**, **number density**, **temperature**, and **velocity**
- Real time pattern recognition based on known **CME characteristics** from the CACTUS database
- Custom **threshold modeling** based on statistical behavior of past CME events
- Visual spike detection system with graphs and plots highlighting CME windows
- Lightweight and explainable **AI integration** for **future prediction** enhancement
- Modular design allowing smooth integration with real time space weather monitoring platforms
- Scientifically validated results with multiple **test windows** and **comparison** against known events
- **Potential to scale** into a full warning system for space agencies and research centers

The probability distribution of acceleration intervals. Most acceleration values cluster around 0, indicating low or moderate changes in speed are most frequent.



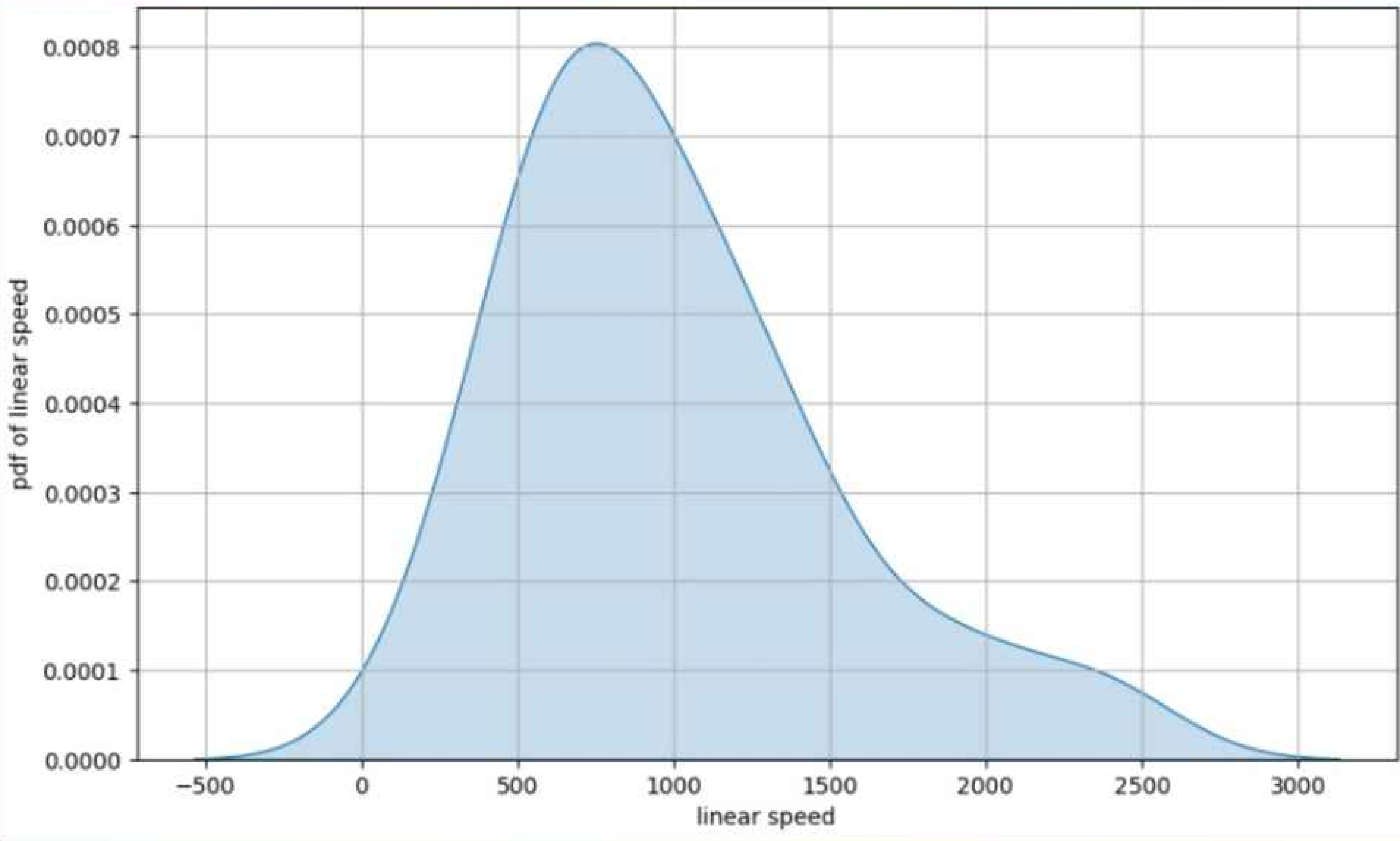




The probability distribution of final linear speeds. The peak is near 800–1000 units, suggesting most objects attain moderate final speeds, with fewer reaching very high speeds.




The probability distribution of mpa values peaks around 200, showing most data points lie in the 100–300 range

Linear speed is concentrated around 800, with a positively skewed distribution indicating fewer instances of very high speeds.




The polar plot illustrates the distribution of **Main Position Angles (MPA)** for observed Halo CME events, measured in **degrees** from the **solar north pole (0°)** in a counterclockwise direction. The **MPA** is a crucial parameter that tells us the direction from which a CME is propagating, relative to the Sun's disk. In this plot, we observe that a significant concentration of CME events occurs between **0° to 90°** and **180° to 270°**, which correspond to the solar **eastern and western hemispheres**. These regions align closely with the solar equatorial plane, where active regions and sunspots are more common, making CMEs in these zones more frequent and more likely to be Earth directed.

# Tech Stack

- **Python** – Core language for data analysis and processing
- **Pandas & NumPy** – Handling structured data and numerical computations
- **SciPy** – Signal processing and scientific computations
- **Scikit-learn** – Basic machine learning and anomaly detection
- **cdflib** – Reading SWIS Level-2 CDF data files
- **Matplotlib & Seaborn** – Creating static visualizations
- **Plotly** – Building interactive graphs and polar plots
- **Streamlit** – Rapid prototyping and dashboard generation
- **Node.js & Express.j**s – Backend for alert handling and future APIs
- **MongoDB** – Flexible storage for logs, thresholds, and event metadata
- **Regex & Datetim**e – Parsing, cleaning, and timestamp alignment
- **React, HTML, CSS, and JavaScript** – For building clean, responsive interfaces to visualize CME detections and interact with system outputs

# Past Hackathon Experience

- Our team has taken part in over **12 major hackathons across India**, working on projects that combine innovation, real world impact, and cutting edge technology.
- We were proud finalists and winners at the NeoX Grind Hackathon organized by RiseIn and Innov8 Gurugram, where we built a working **NFT marketplace** using a Layer 2 **blockchain**. At the **BNB Chain AI** Hackathon held at **IIT Delhi**, we created a decentralized insurance platform that used AI to predict and manage risk. We also showcased a DeFi powered NFT project at the Monad Blitz Hackathon, which was appreciated for its originality and clean architecture.
- In events like **Flipkart GRiD 6.0**, **Smart India Hackathon 2024**, and the **Google Solution Challenge 2025**, we focused on solving large scale challenges, including e commerce optimization and AI for public services.
- Apart from that, we have worked on AI and data driven projects at **Hack24 hosted by IIIT Delh**i, **Code4Cause at NSUT**, **Hackers Playground at MIET**, and **TechXcelerate at BITS Hyderabad**. These events helped us explore a wide range of problem statements and sharpen our skills across both software and hardware domains.
- All of this hands on experience has prepared us to take on complex challenges like the one presented in the **Bharatiya Antariksh Hackathon**. We are confident in our ability to design, build, and pitch solutions that are both technically sound and practically useful.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