An MMS bow shock database using machine learning

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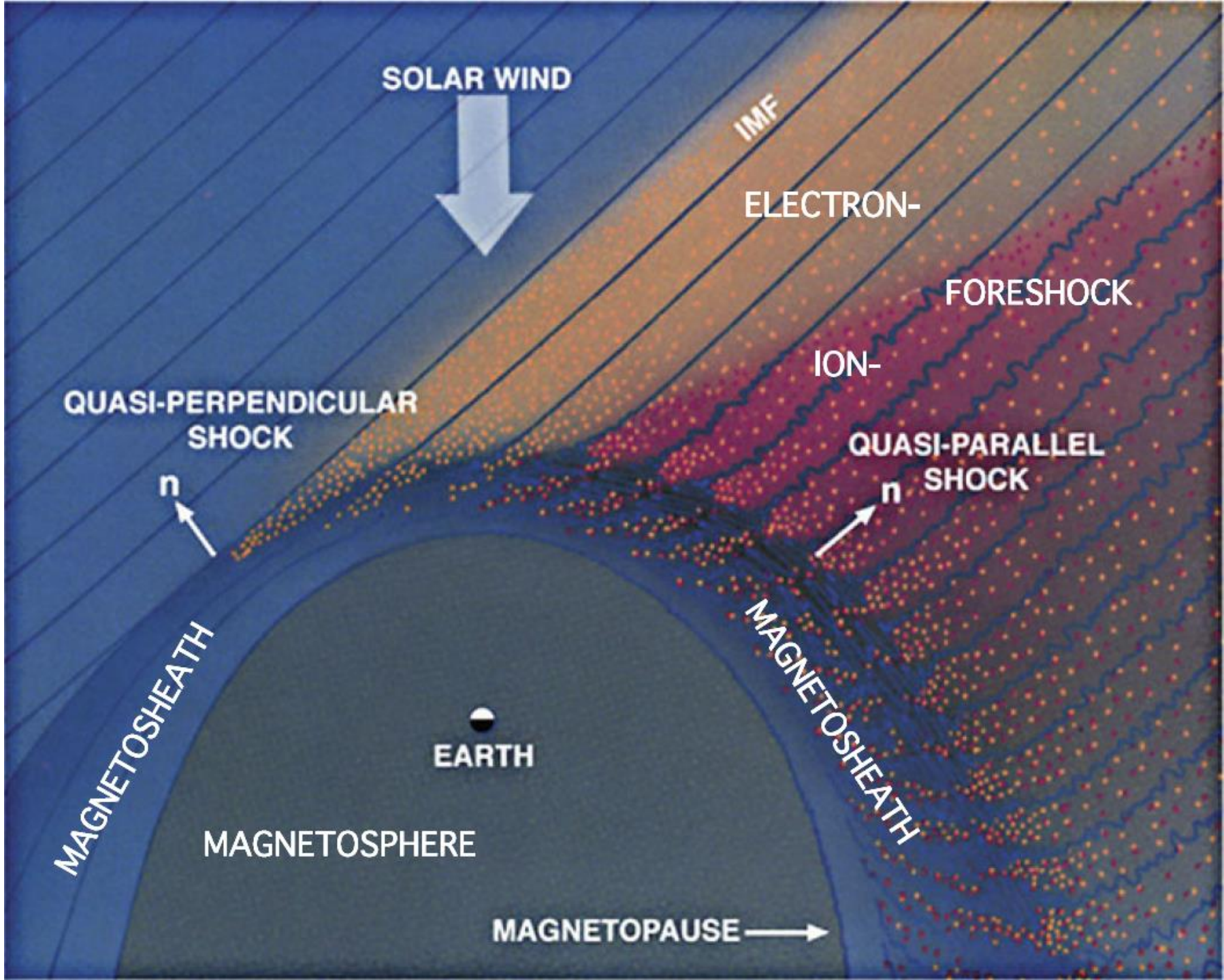
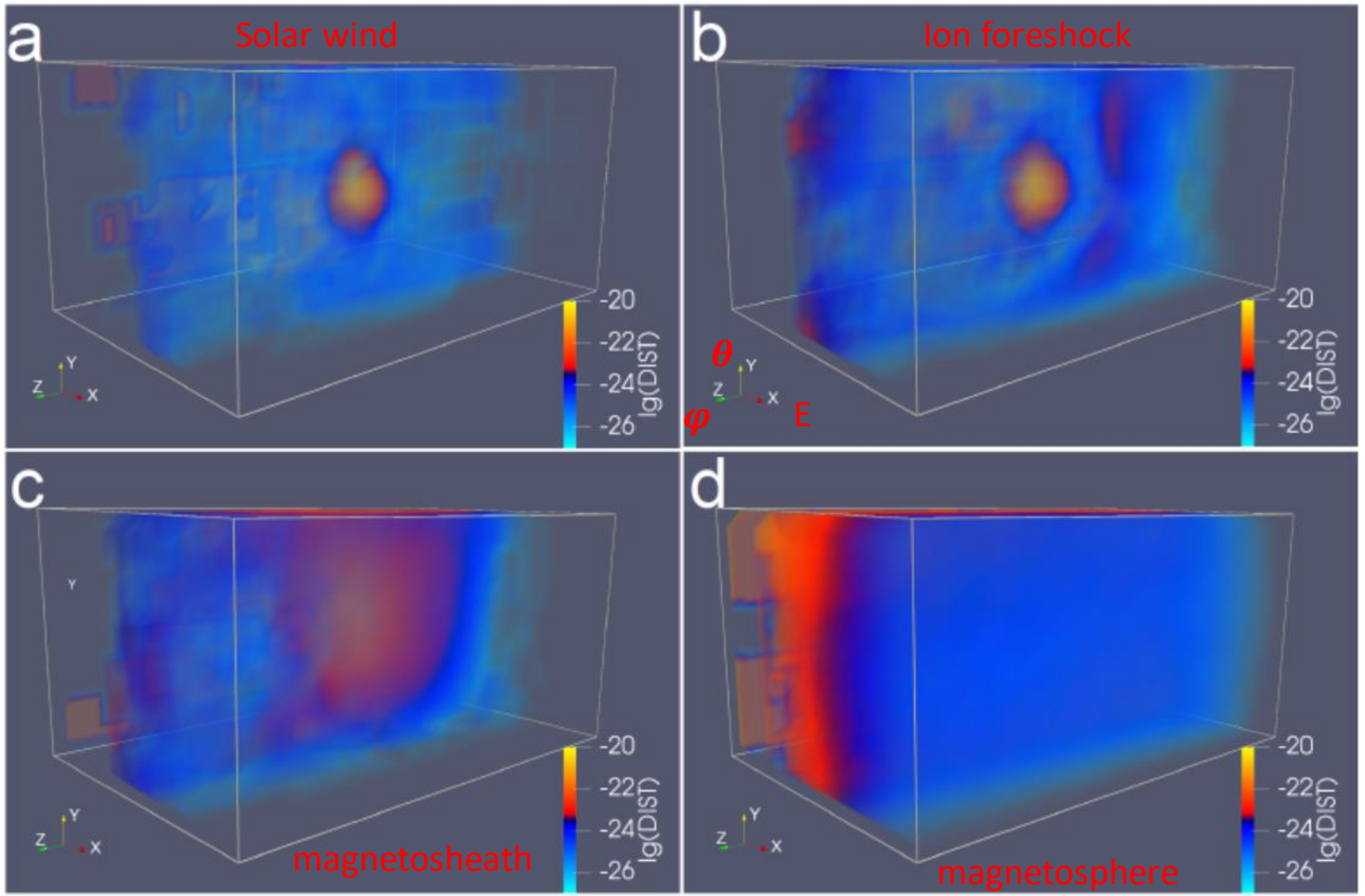
Collisionless shocks are ubiquitous in space and are not yet fully understood.
Some of the still standing problem ranges from solar wind thermalization to particle acceleration.

Scientists go through huge amount of data looking for spacecraft shock crossings in order to advance our knowledge about shocks.

A shocks database would make shock physicists lives easier!



Training convolutional neural networks to detect different regions in space from FPI data:



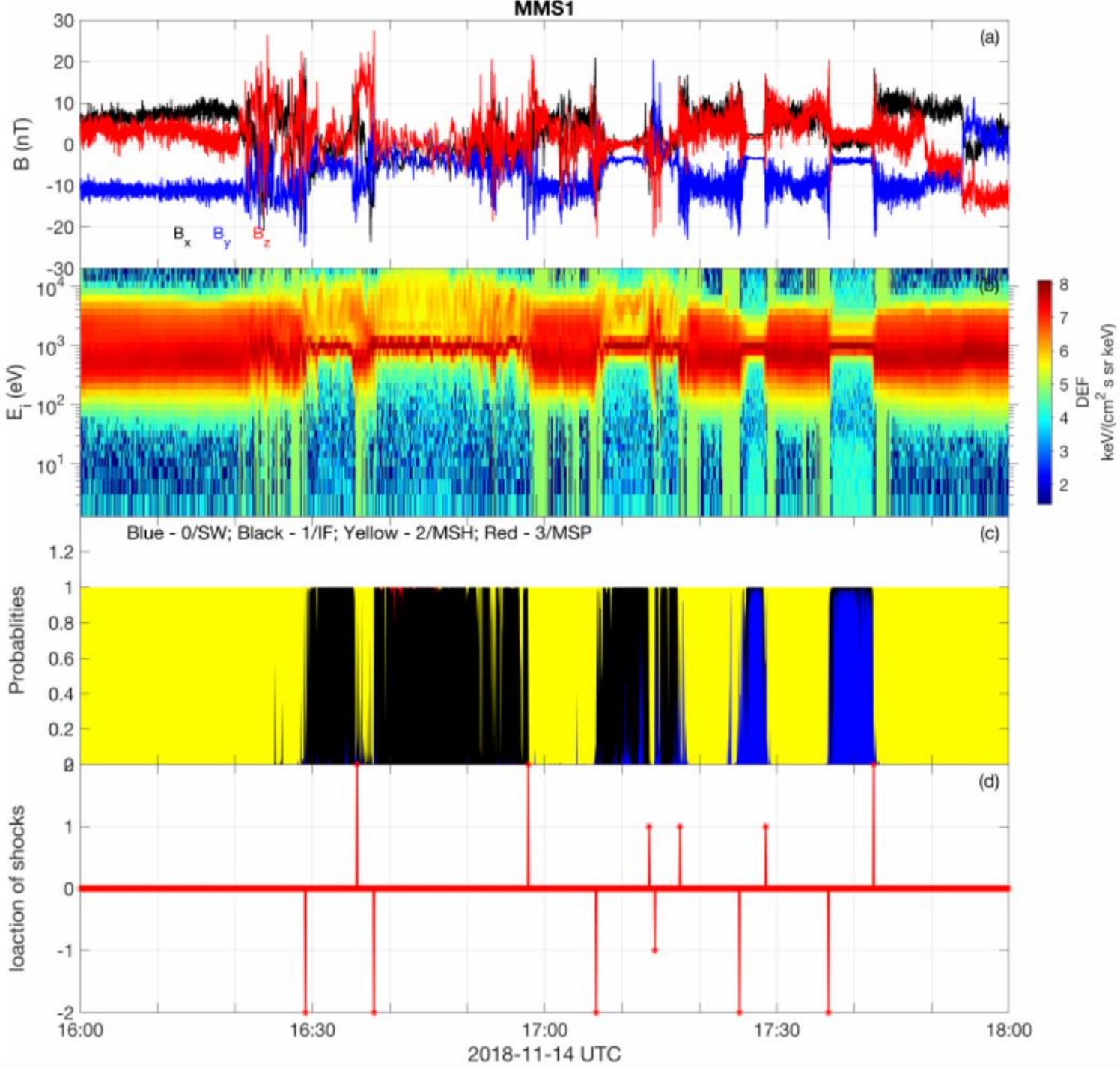
3D rendering of ion velocity distribution functions measured by the dual ion spectrometer of FPI at 4 different region in space

More details at:
Olshevsky et al 2021
https://doi.org/10.1029/2021JA029620

The CNN returns probabilities for each region as shown in panel (c)

Using this classification to detect shock crossings:

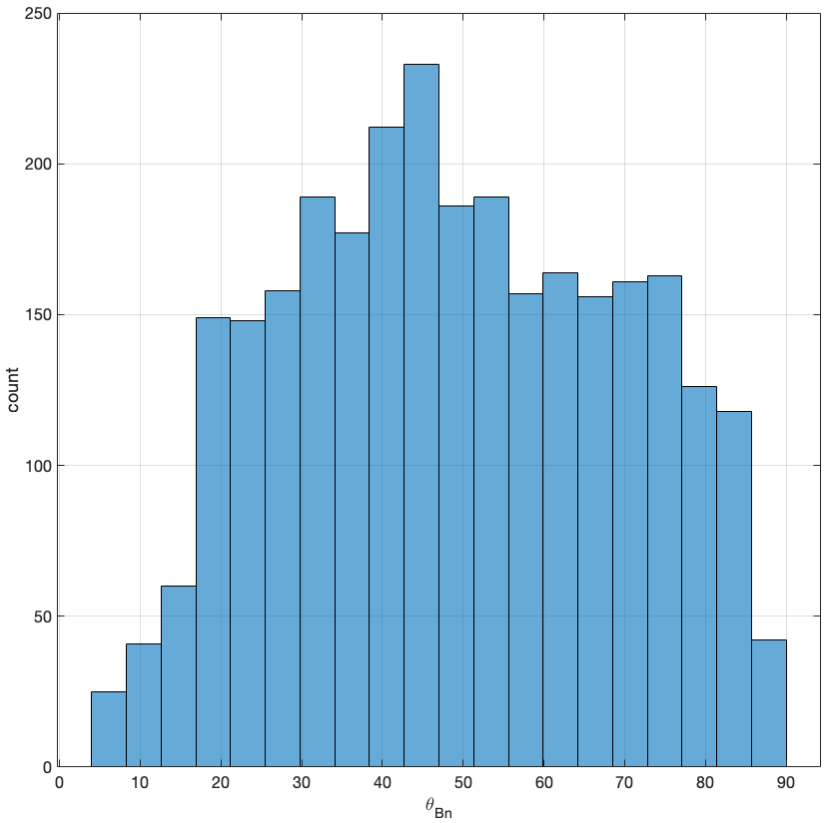
~3000 shock crossings were identified in the period from 2015 to end of 2020

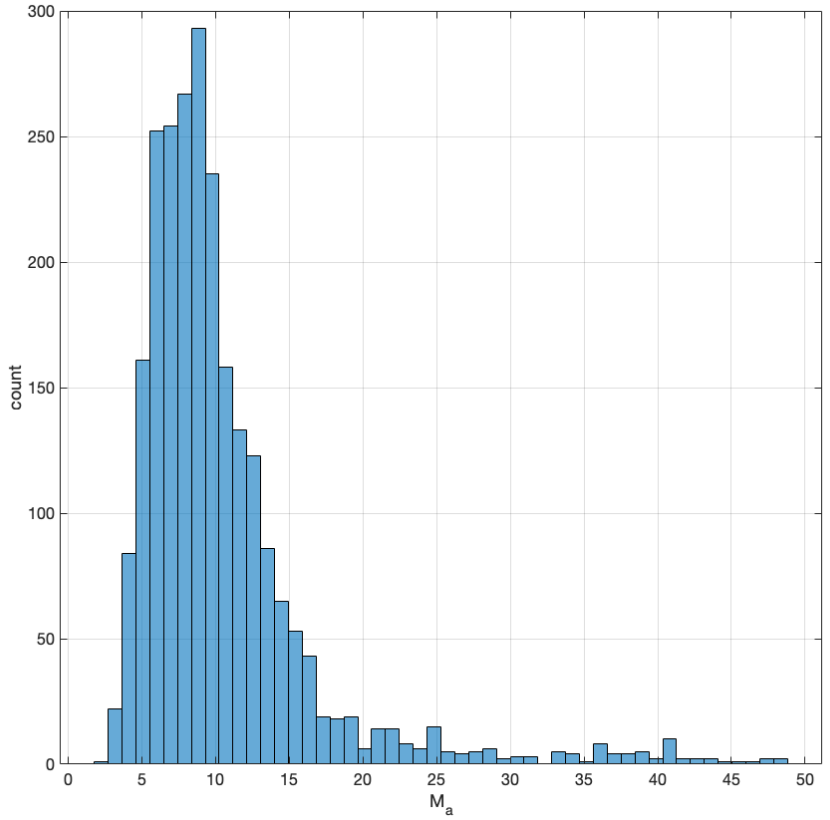


For each shock crossing the following is determined:

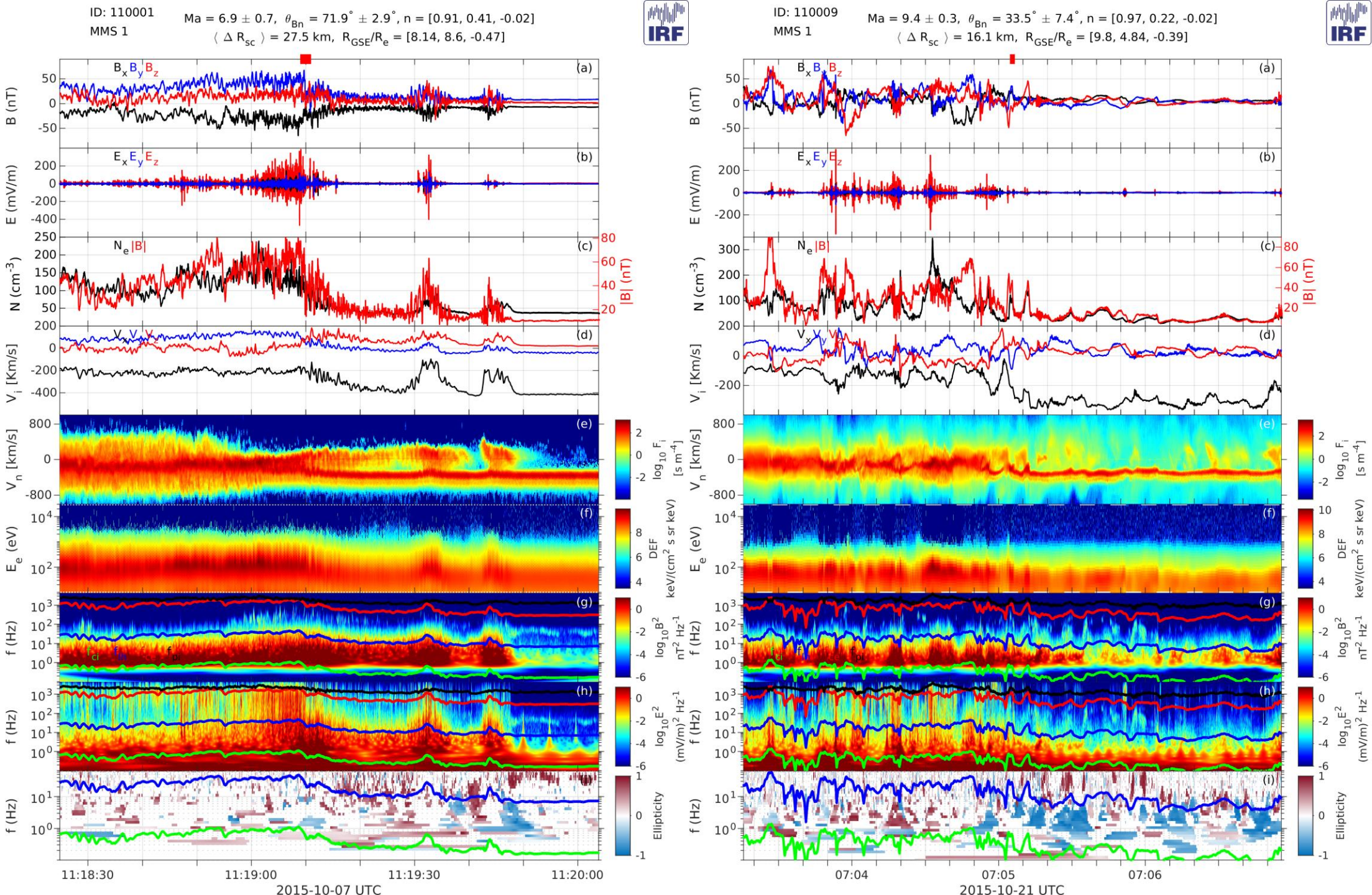
- Time of crossing
- Start and end time of Burst data if existent
- Upstream to downstream or vice versa
- Position of the spacecraft in GSE
- Spacecraft separation
- Tetrahedral quality factor
- Shock normal from a global model
- Upstream B from OMNI
- Alfvenic Mach number in the NIF (data from OMNI)
- θ_{Bn}
- β_i

So far the database has shock crossings at various Ma and θ_{Bn}





Overview plots:



Conclusions:

- We have compiled a database for shock crossings by MMS using machine learning
- Each crossing has different parameters characterizing the shock (θ_{Bn}, Ma, n, …)
- Overview plots are made for each crossing
- In the future the database will include IP shocks and shocks from different spacecrafts
- An interface will be developed by Finnish meteorological institute (FMI) where the database will be publicly available:
    - It will allow users to extract subsets of shocks filtered according the desired parameters
    - It will allow users to download quicklook plots for the chosen subset of shocks