



Quasi-parallel & Quasi-perpendicular Magnetosheath Jets Using MMS

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Swedish Space Plasma Meeting 2019
2019/02/07, Uppsala

Magnetosheath Jets

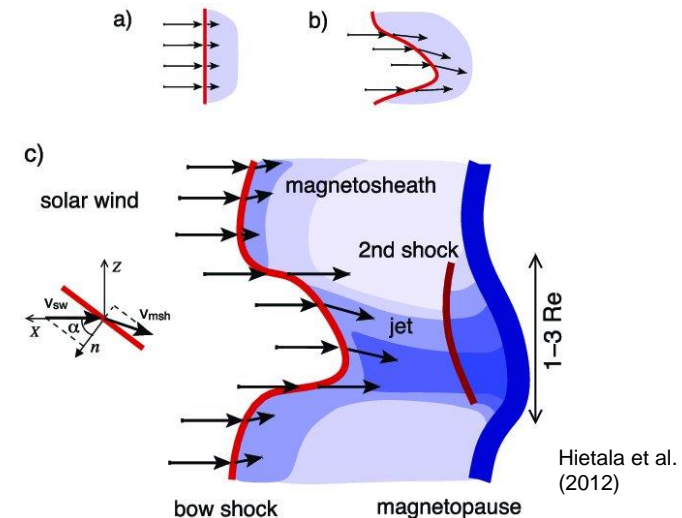
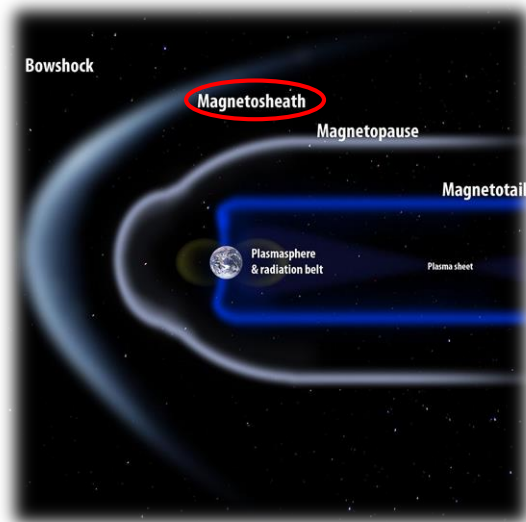
What: Enhancements of dynamic pressure above the general fluctuations level.

Where: Magnetosheath

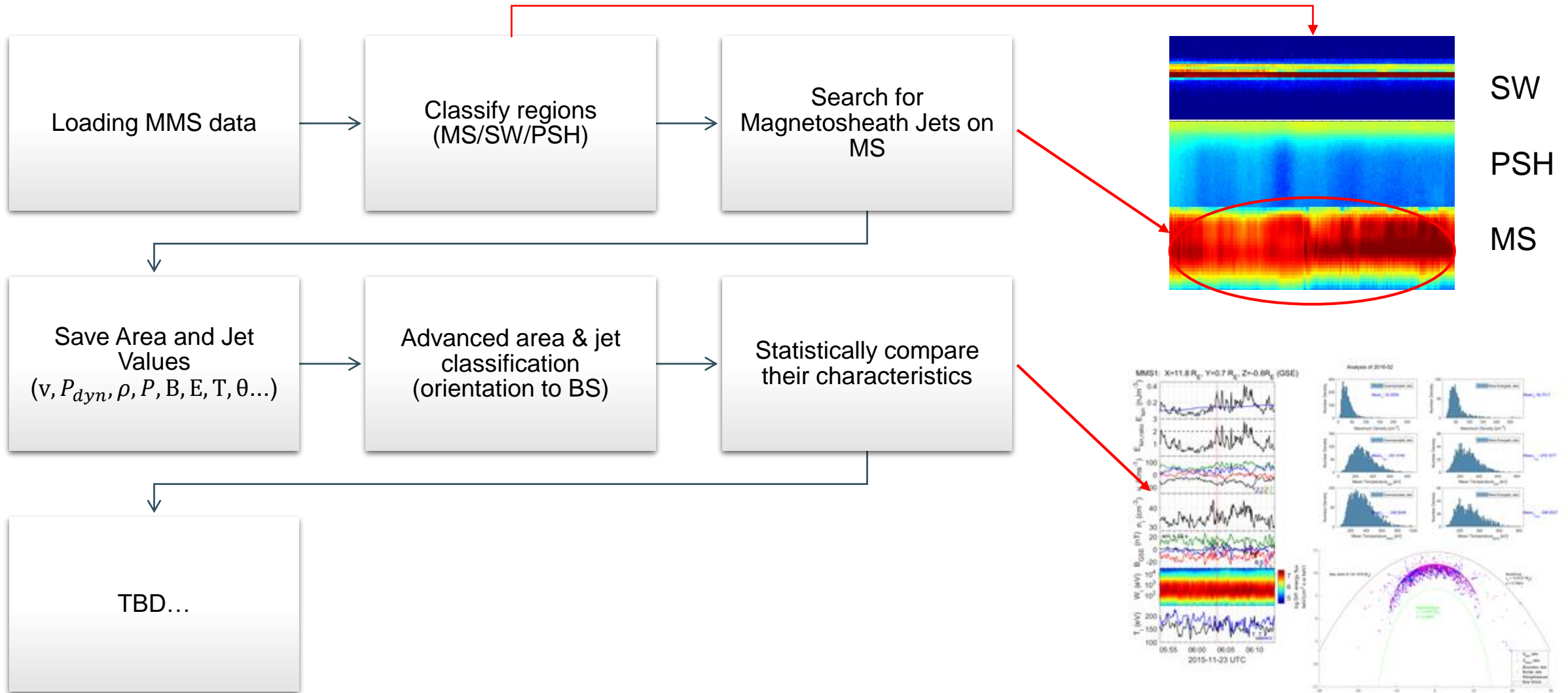
Data: MMS

How: Many possible mechanisms (Foreshock waves, SW Discontinuities, Magnetic reconnection etc.)

Why: Interaction of SW & Magnetosphere, magnetopause reconnection, radiation belts, auroral features...



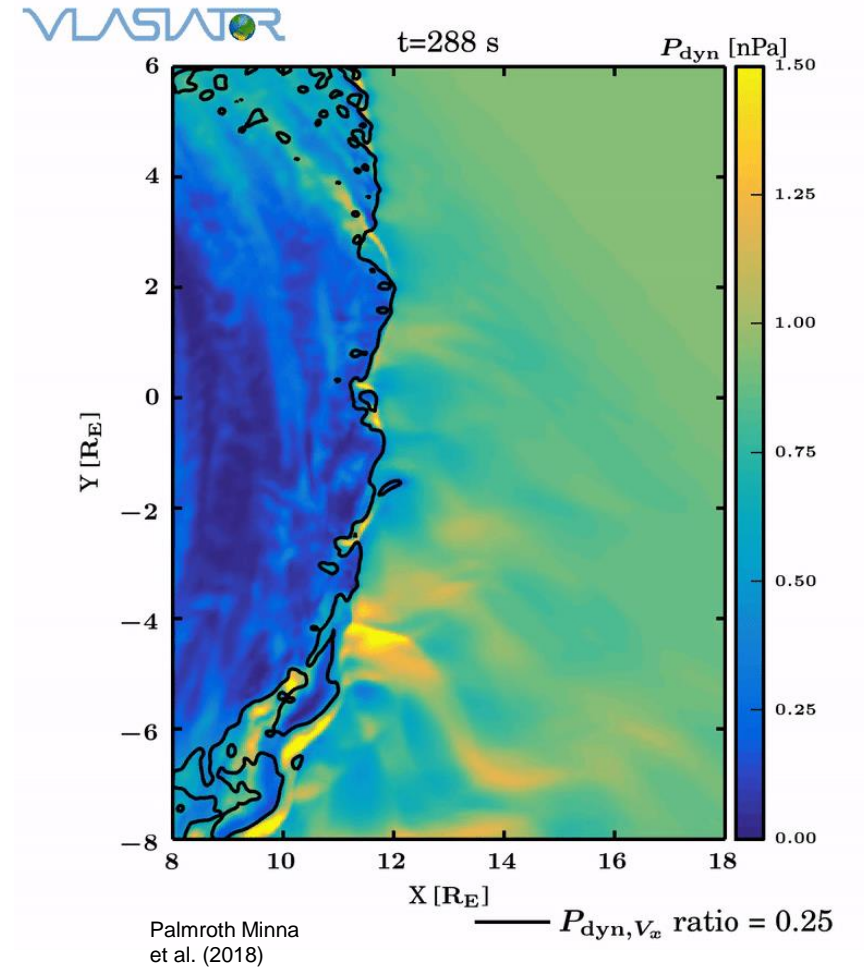
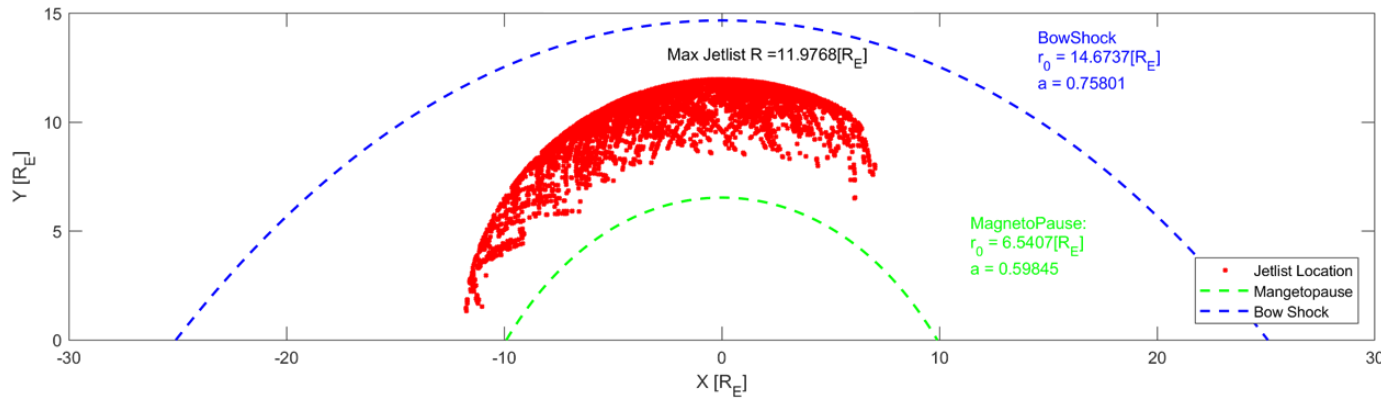
Searching for Jets



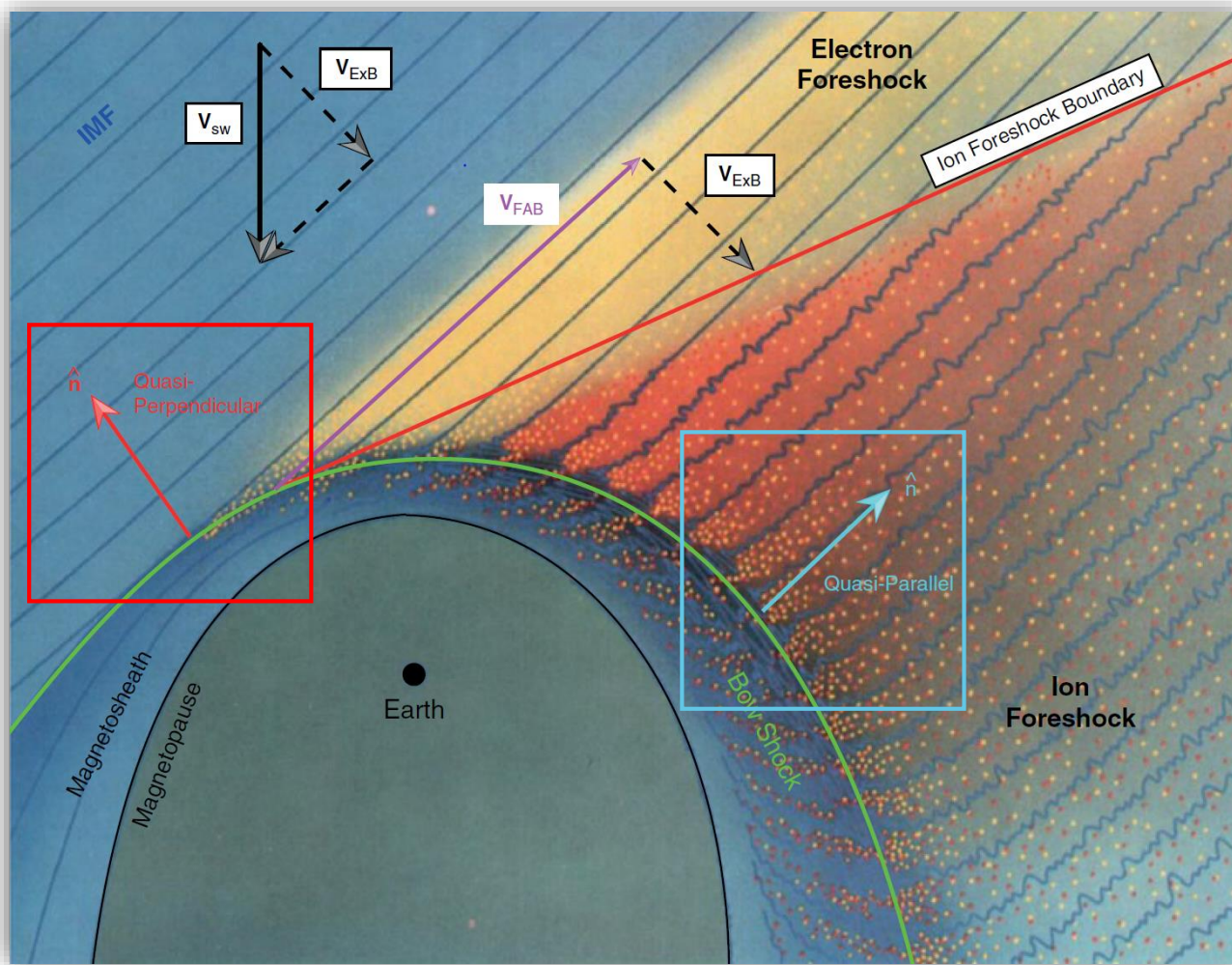
Derived database for Jets

Time Period
1/9/2015 – 1/12/2018

Total	Downsampled $dt < 60$ s	High Energy $E_{kin} > 3 \text{ nJ m}^{-3}$
13050	7020	817



Motivation – Subcategories



L. B. Wilson (2016)

Fact: **Fluctuations** are found **mainly** in **Quasi-parallel shock** ($\theta_n < 45^\circ$).

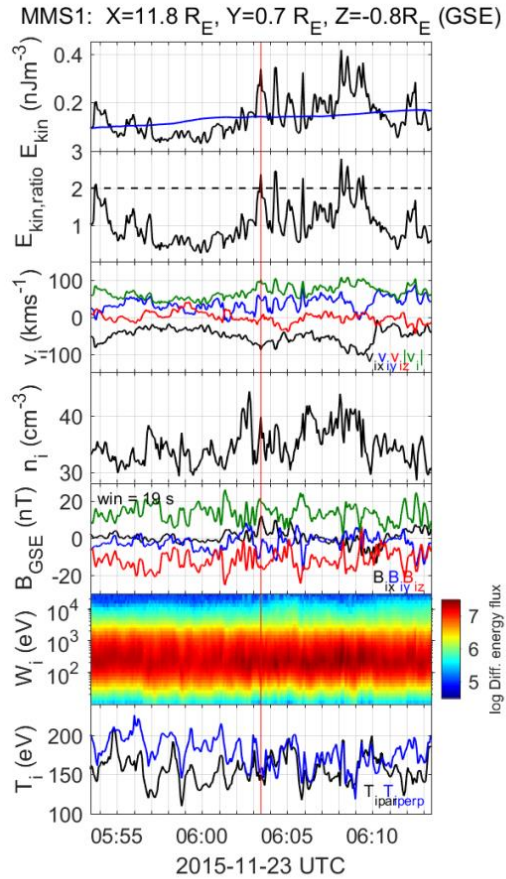
However, fluctuations **also** found in **Quasi Perpendicular** regions.

Hypothesis of different type of jets, origin, generation mechanism & characteristics.

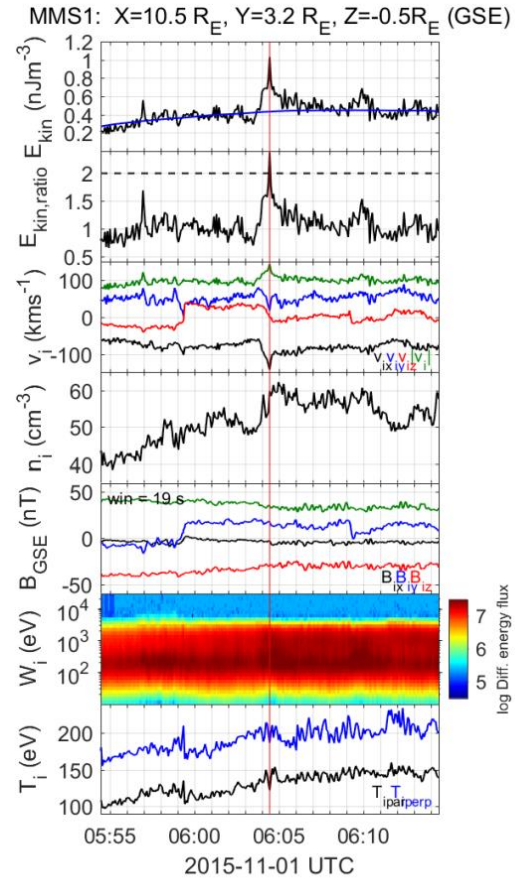
Q_{par}	Q_{per}	<i>Boundary</i>
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Preliminary Results

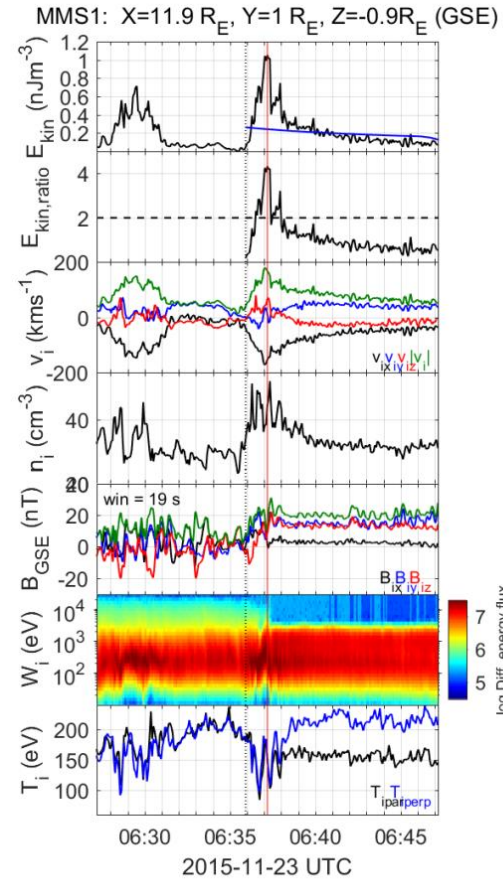
Main Categories



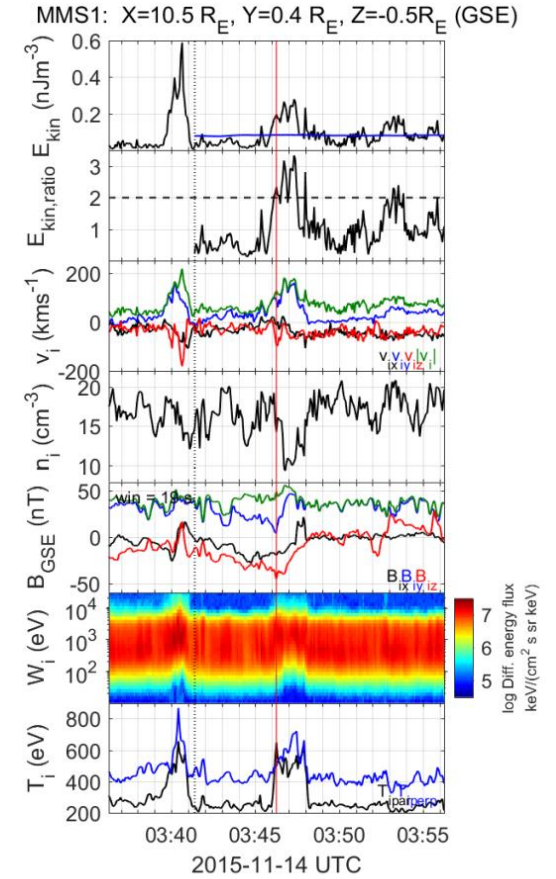
Qpar Jet



Qperp Jet

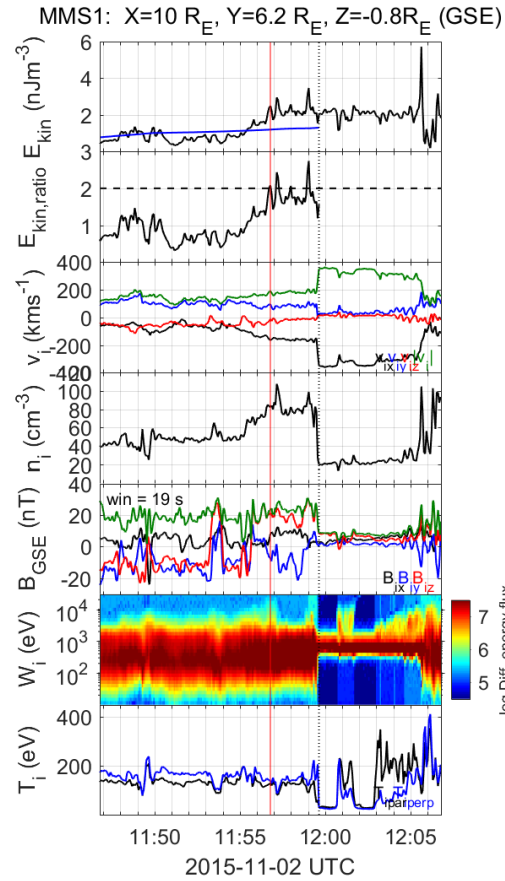


Boundary Jet

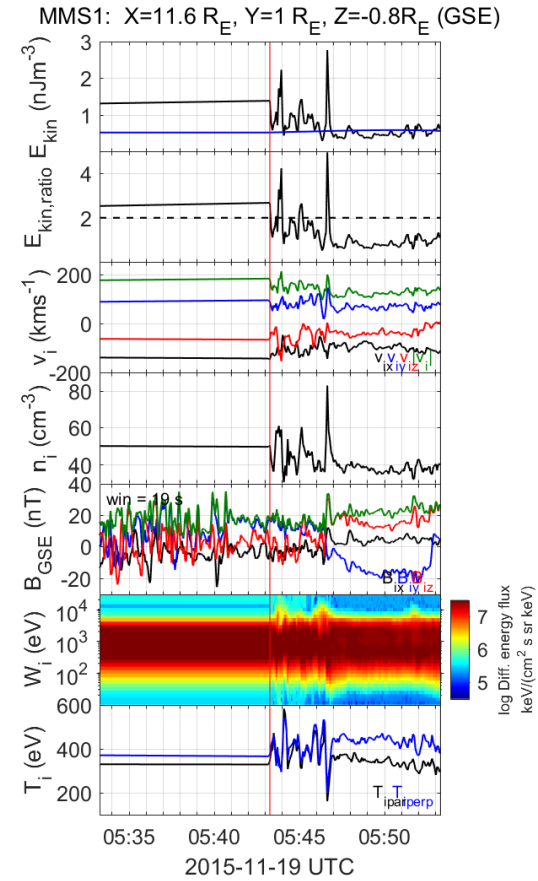


Encapsulated Jet

“Necessary Evil” Categories

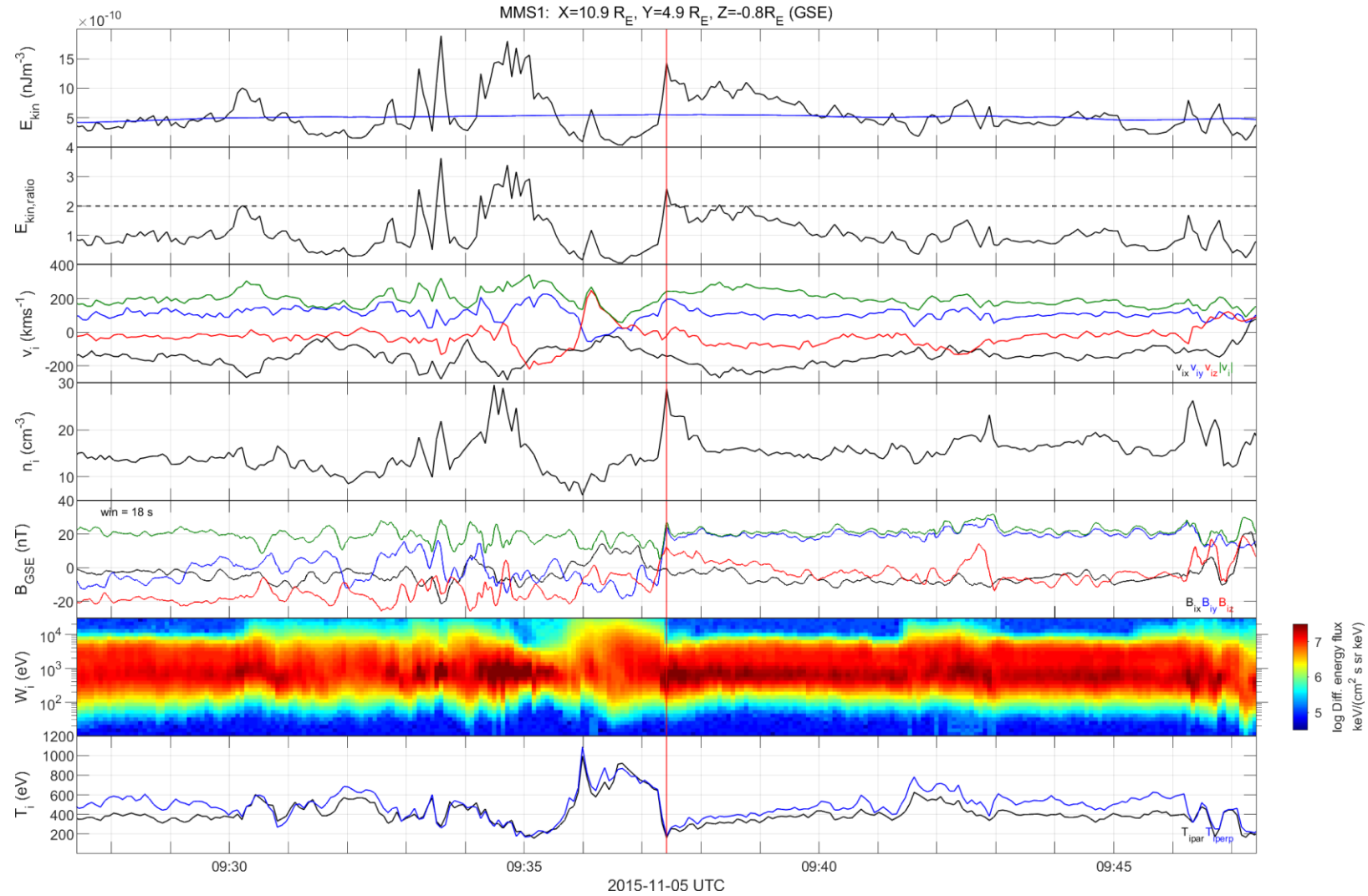


Border Jets

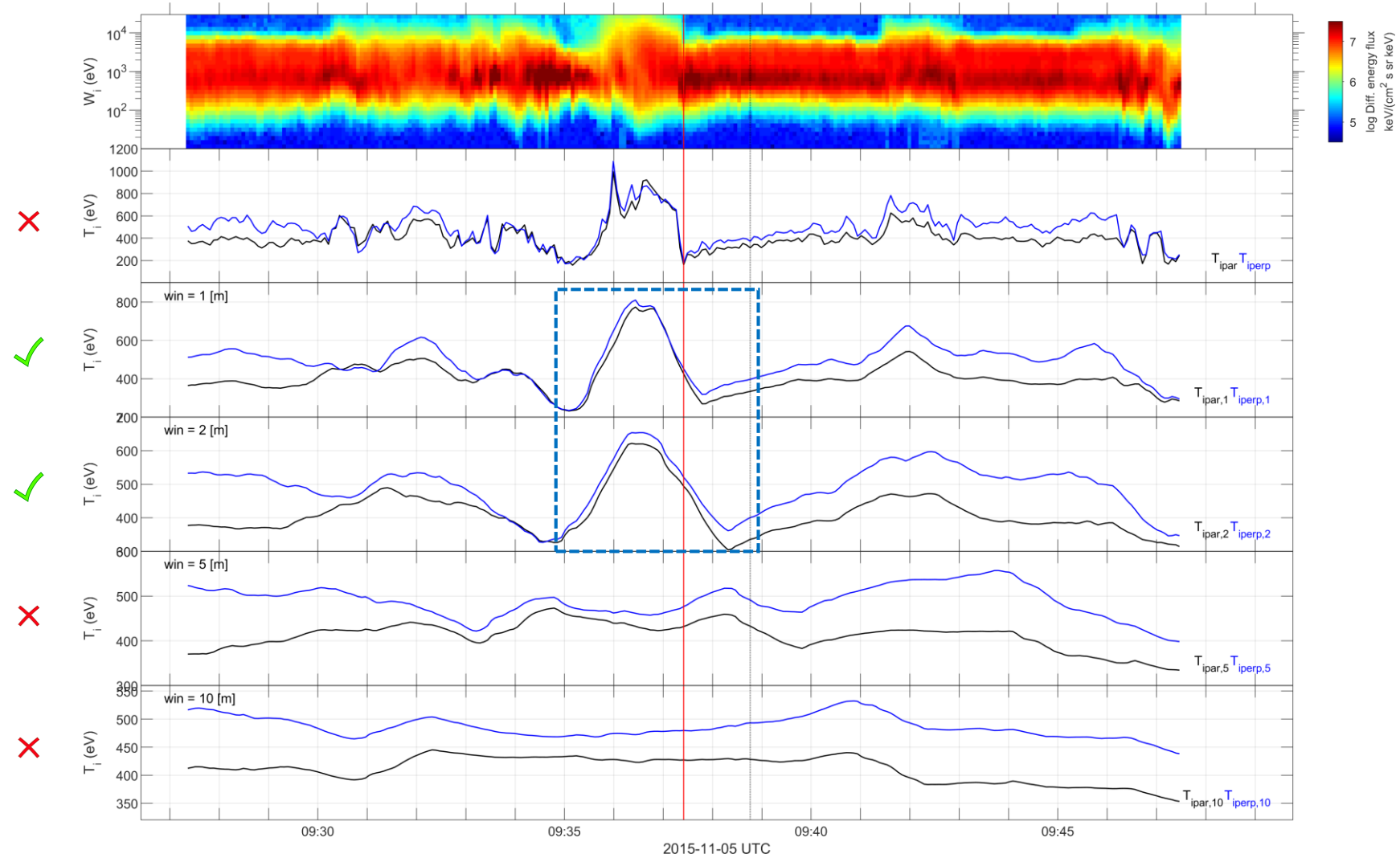


Unclassified Jets

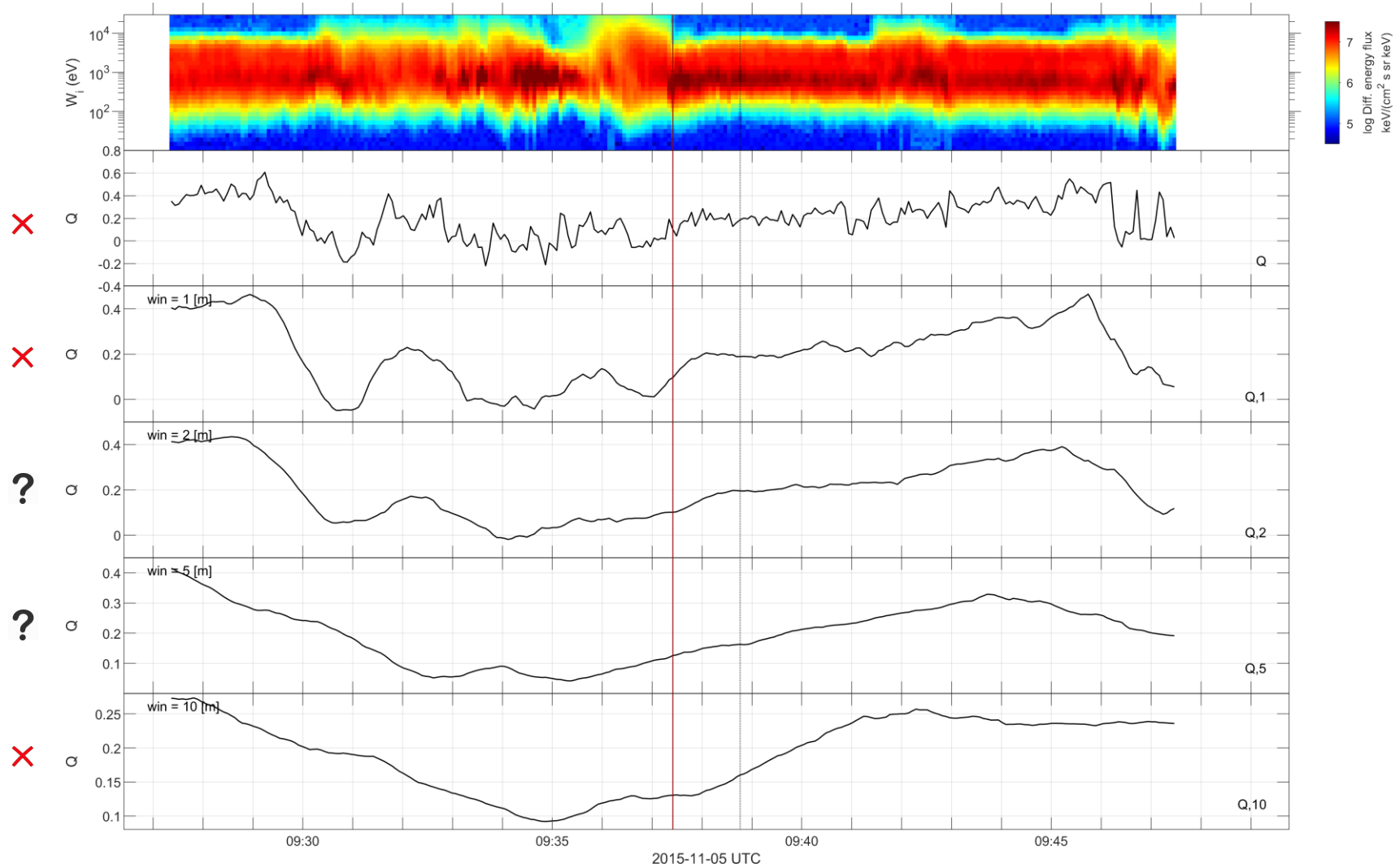
Boundary Example



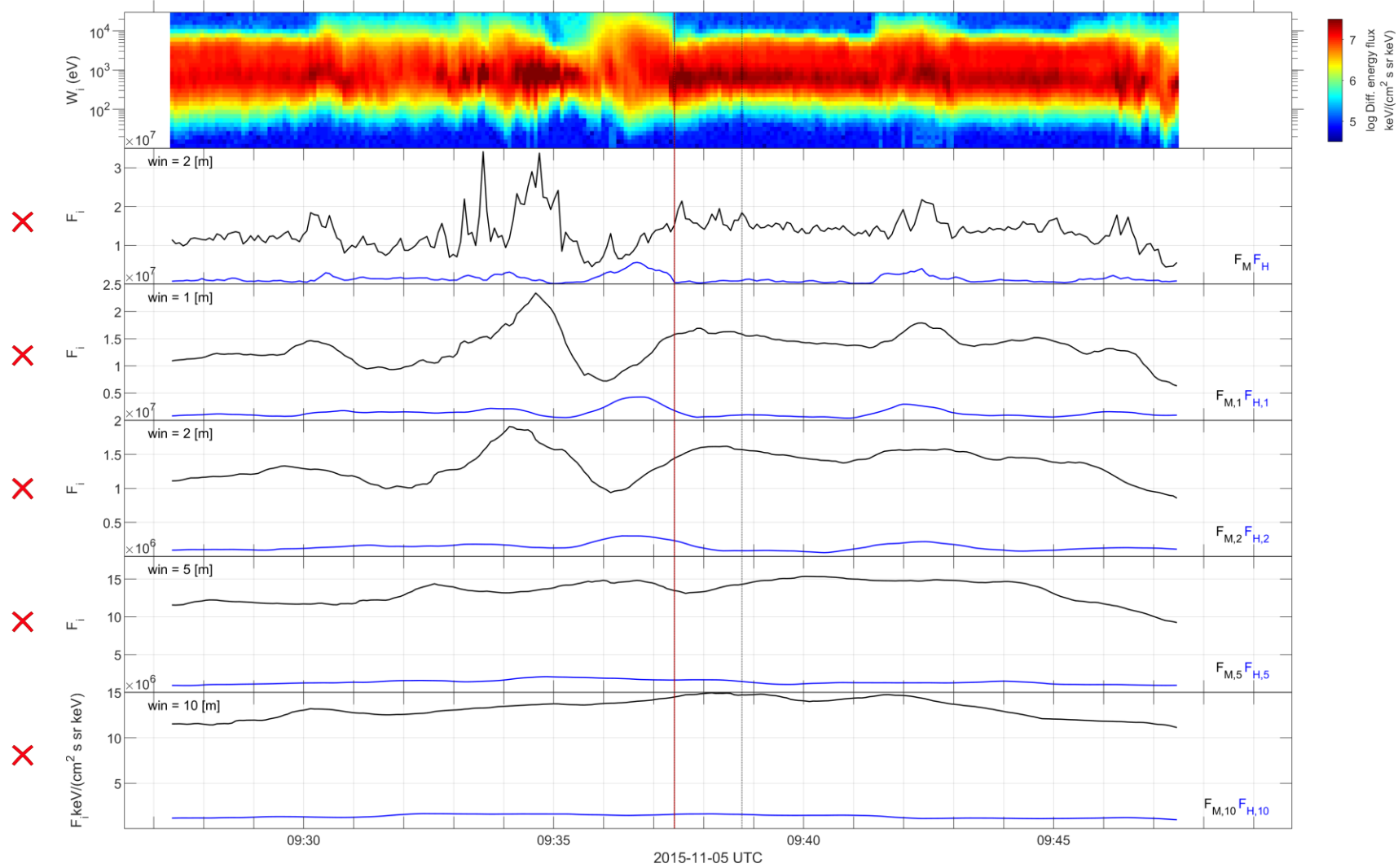
Classifying Jets – Boundary Example – Temperature



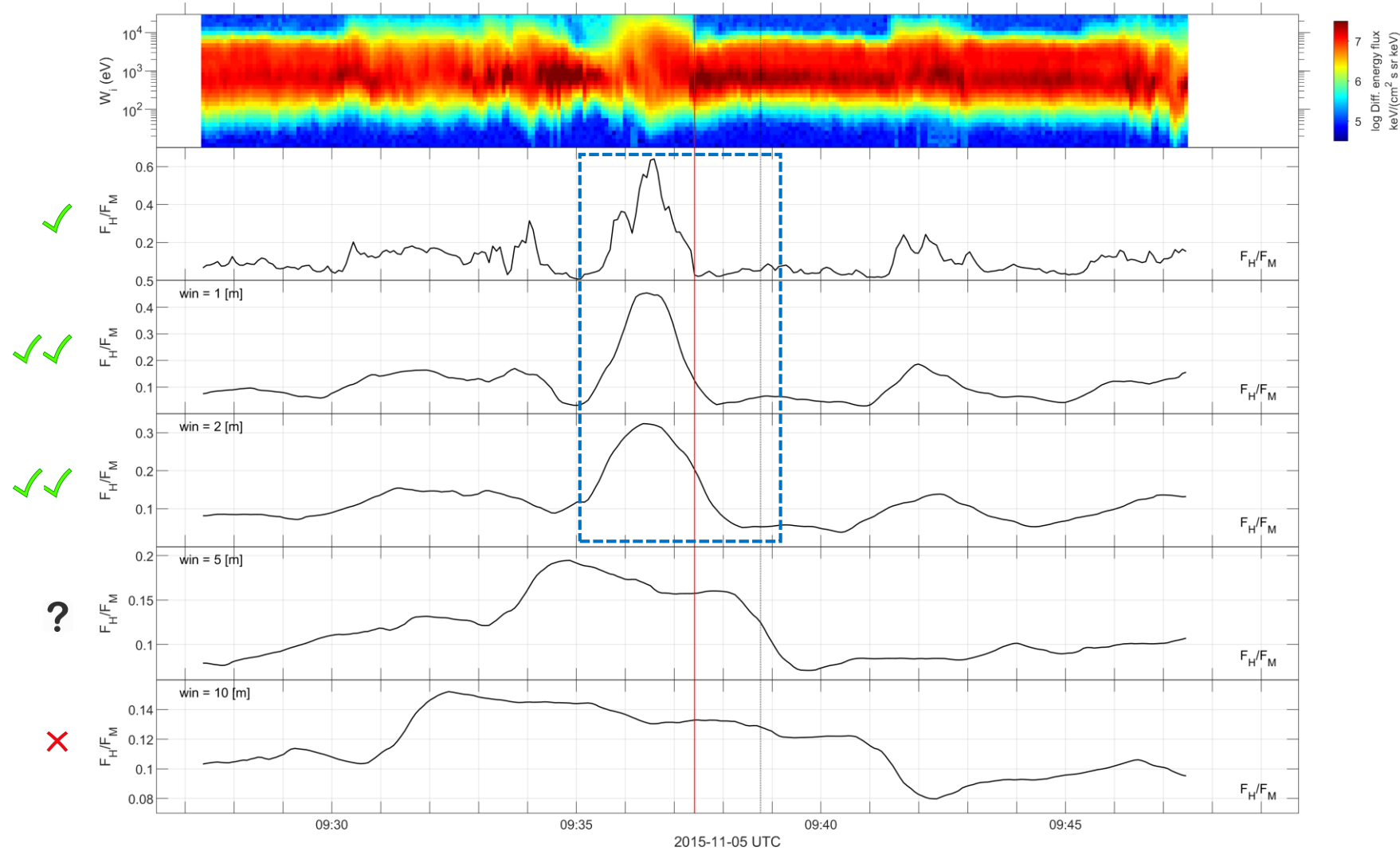
Classifying Jets – Boundary Example – Anisotropy



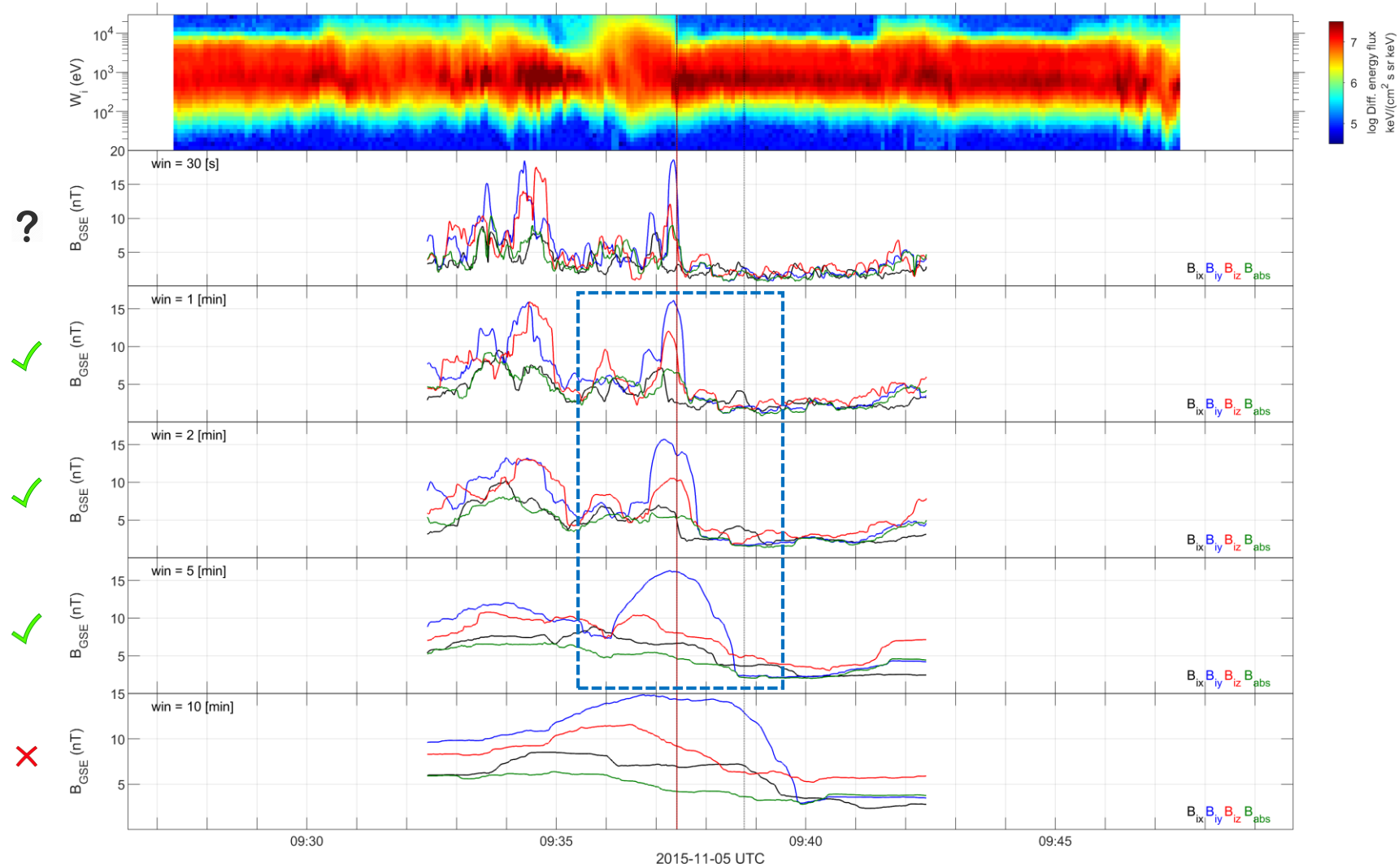
Classifying Jets – Boundary Example – Flux



Classifying Jets – Boundary Example – Flux Ratios



Classifying Jets – Boundary Example – $STD(\vec{B})$



Updated database for Jets (Example)

Time Period
1/9/2015 – 1/12/2018

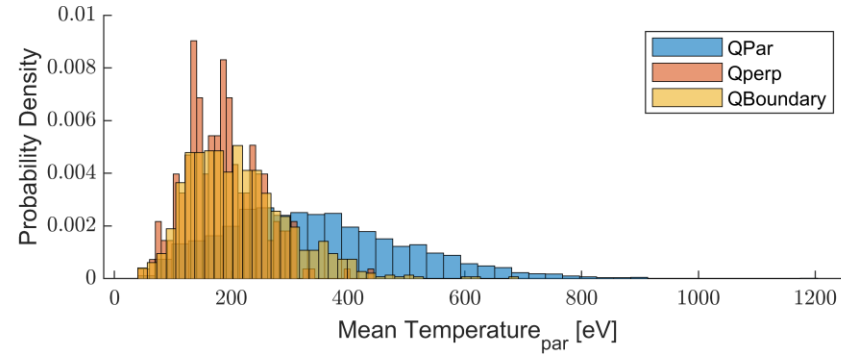
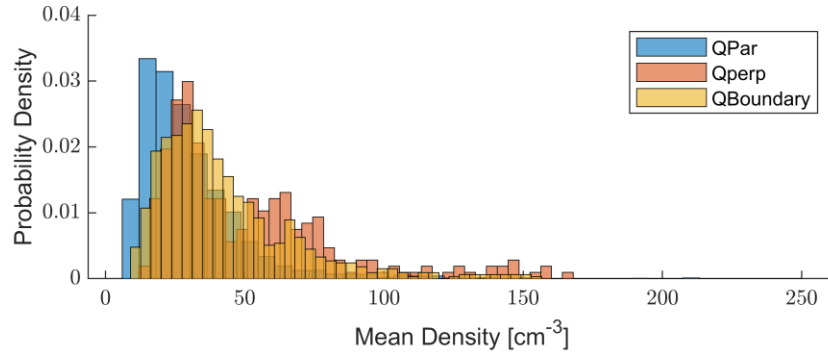
Downsampled $dt < 60$ [s]	Quasi – Parallel jets	Quasi – Perpendicular jets	Boundary Jets	Border Jets	Unclassified/ Unknown
7020	4174	274	910*	690	962

$$Q_{\text{par}} > 0.05 \left(\frac{F_H}{F_m} \right)_5$$

$$Q_{\text{perp}} < 0.02 \left(\frac{F_H}{F_M} \right)_5$$

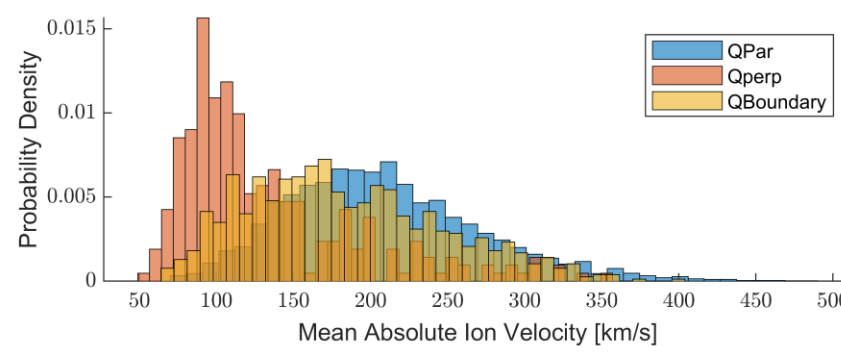
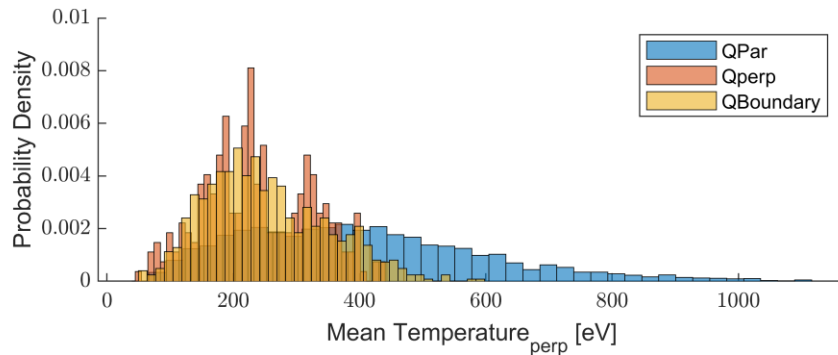
Characteristics of each category

Mean_Q : 30.23
 Med_Q : 25.49
 Mean_Q^{//} : 51.11
 Med_Q^{//} : 40.47
 Mean_Q[⊥] : 42.47
 Med_Q[⊥] : 35.89



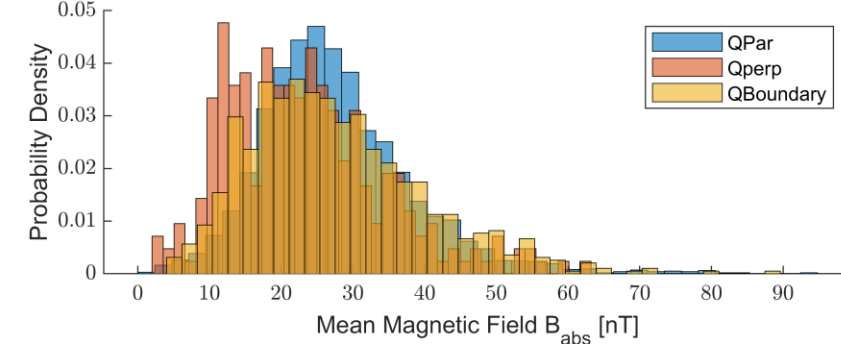
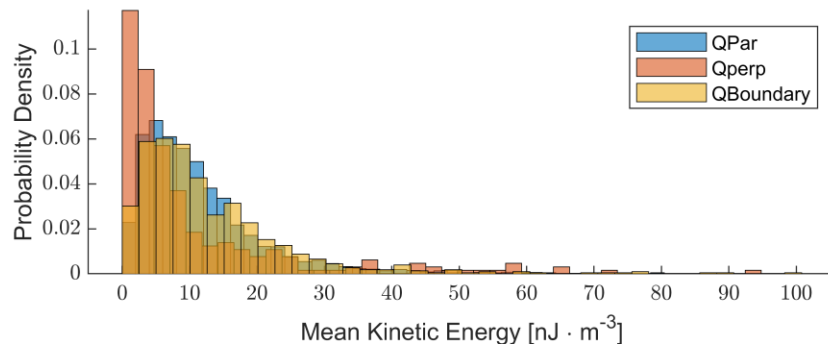
Mean_Q : 344.84
 Med_Q : 328.56
 Mean_Q^{//} : 184.99
 Med_Q^{//} : 182.53
 Mean_Q[⊥] : 213.13
 Med_Q[⊥] : 202.10

Mean_Q : 405.12
 Med_Q : 381.44
 Mean_Q^{//} : 239.78
 Med_Q^{//} : 227.01
 Mean_Q[⊥] : 251.79
 Med_Q[⊥] : 237.90



Mean_Q : 208.82
 Med_Q : 202.17
 Mean_Q^{//} : 132.76
 Med_Q^{//} : 112.53
 Mean_Q[⊥] : 183.67
 Med_Q[⊥] : 174.08

Mean_Q : 11.70
 Med_Q : 9.27
 Mean_Q^{//} : 10.31
 Med_Q^{//} : 4.88
 Mean_Q[⊥] : 12.89
 Med_Q[⊥] : 9.63

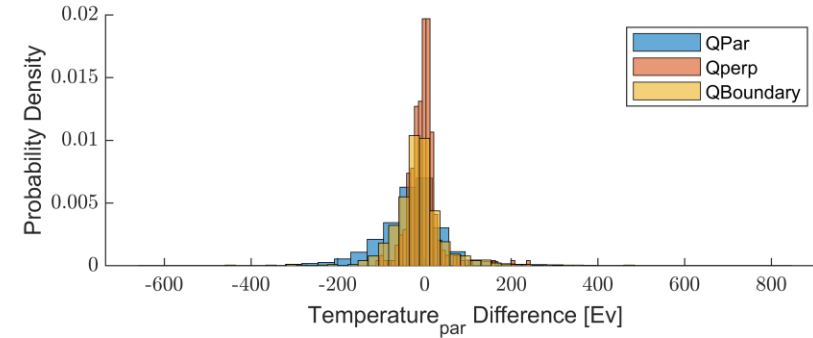
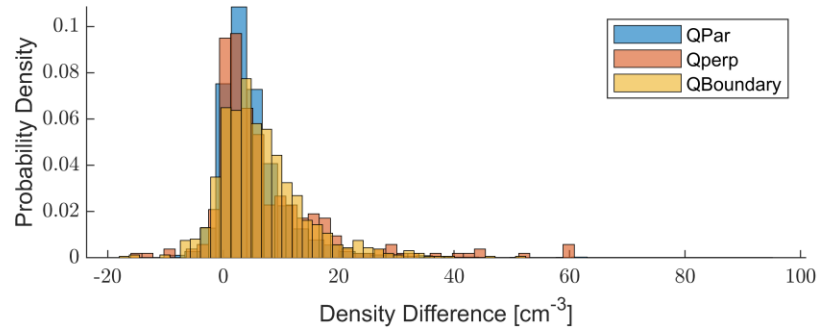


Mean_Q : 27.72
 Med_Q : 26.21
 Mean_Q^{//} : 23.28
 Med_Q^{//} : 21.98
 Mean_Q[⊥] : 27.63
 Med_Q[⊥] : 25.70

“Background Difference” Statistics

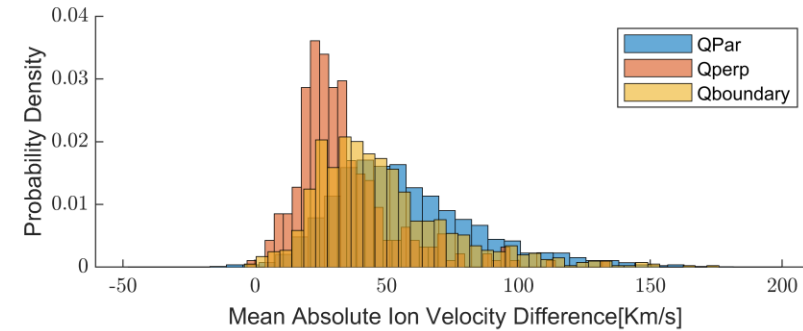
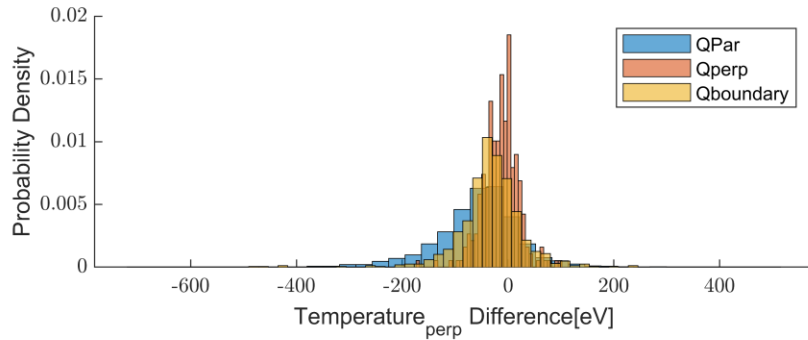
Quantity Analyzed: $X_{\text{mean}} - X_{\text{movemean,10min}}$

Mean_Q^{||}: 5.22
 Med_Q^{||}: 3.69
 Mean_Q[⊥]: 7.31
 Med_Q[⊥]: 3.87
 Mean_{Q_B}[⊥]: 6.65
 Med_{Q_B}[⊥]: 5.18



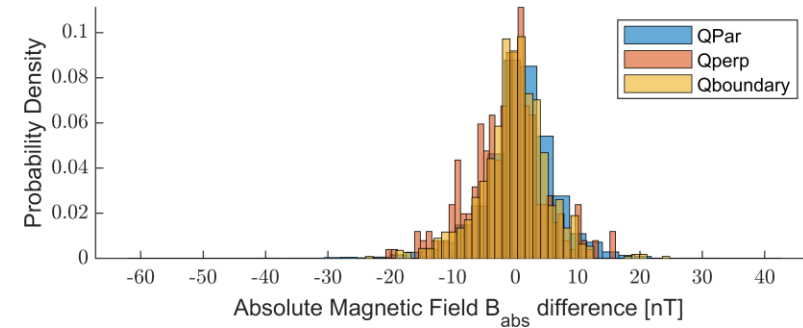
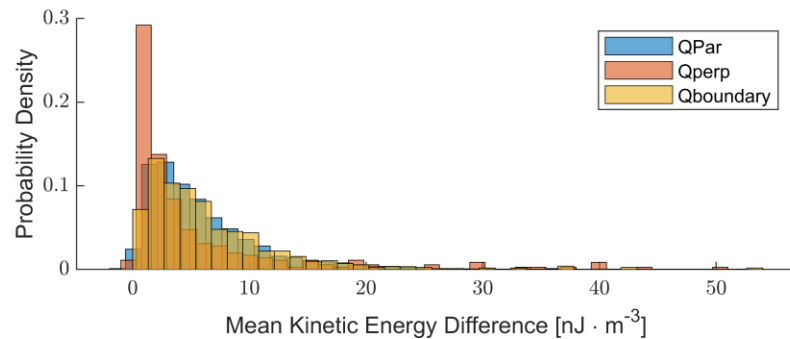
Mean_Q^{||}: -26.88
 Med_Q^{||}: -23.28
 Mean_Q[⊥]: -3.57
 Med_Q[⊥]: -2.64
 Mean_{Q_B}[⊥]: -12.72
 Med_{Q_B}[⊥]: -14.75

Mean_Q^{||}: -56.88
 Med_Q^{||}: -49.47
 Mean_Q[⊥]: -13.84
 Med_Q[⊥]: -11.54
 Mean_{Q_B}[⊥]: -32.61
 Med_{Q_B}[⊥]: -31.69



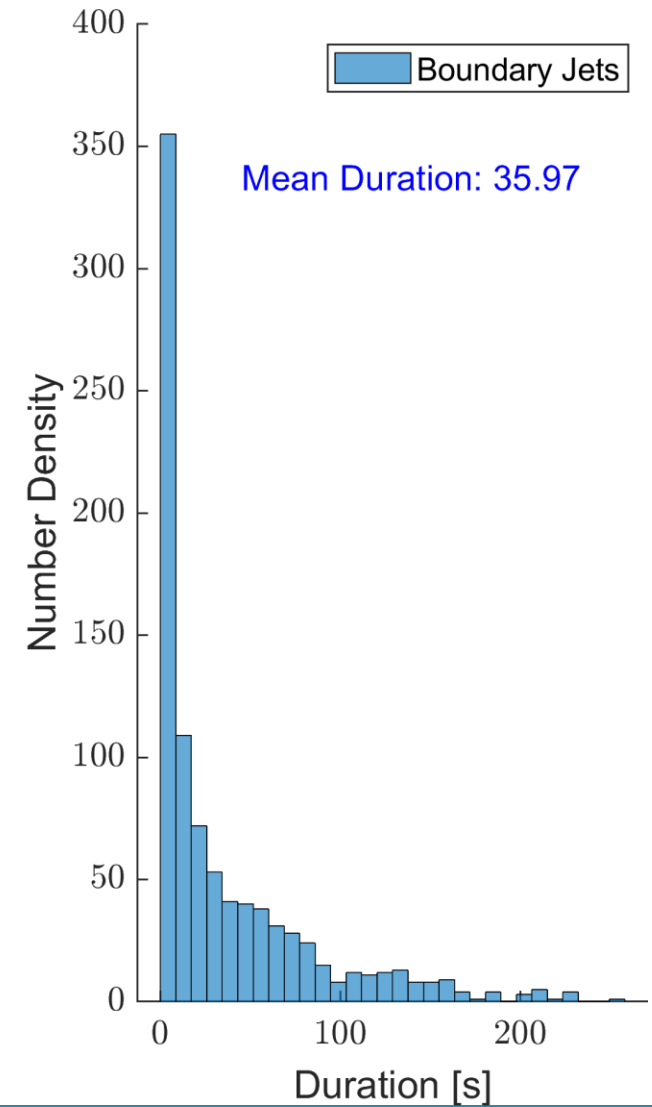
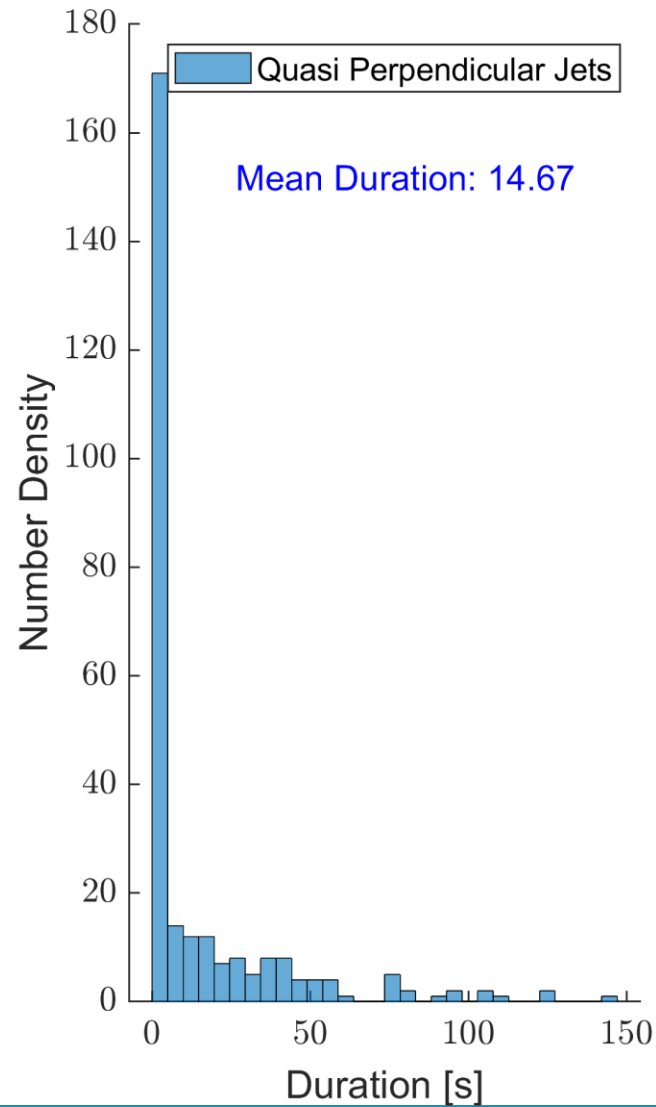
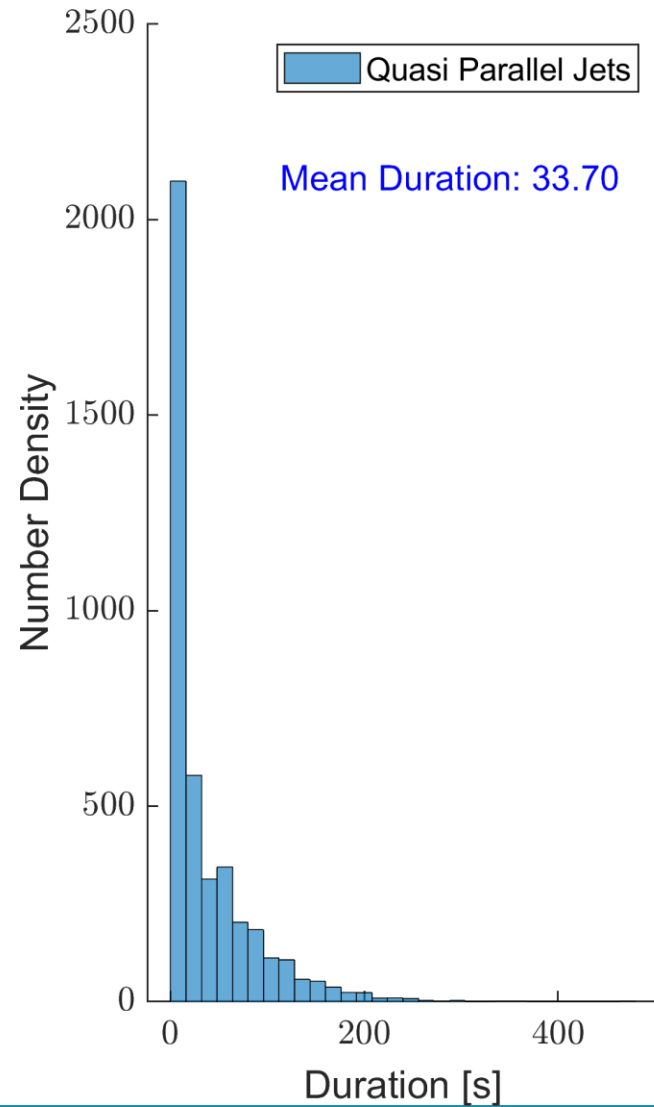
Mean_Q^{||}: 57.35
 Med_Q^{||}: 52.63
 Mean_Q[⊥]: 33.91
 Med_Q[⊥]: 30.10
 Mean_{Q_B}[⊥]: 48.53
 Med_{Q_B}[⊥]: 42.57

Mean_Q^{||}: 6.18
 Med_Q^{||}: 4.60
 Mean_Q[⊥]: 5.38
 Med_Q[⊥]: 2.35
 Mean_{Q_B}[⊥]: 6.59
 Med_{Q_B}[⊥]: 4.78



Mean_Q^{||}: 0.66
 Med_Q^{||}: 0.89
 Mean_Q[⊥]: -1.29
 Med_Q[⊥]: -0.75
 Mean_{Q_B}[⊥]: -0.13
 Med_{Q_B}[⊥]: -0.15

Duration of Jets



Conclusion

Summary

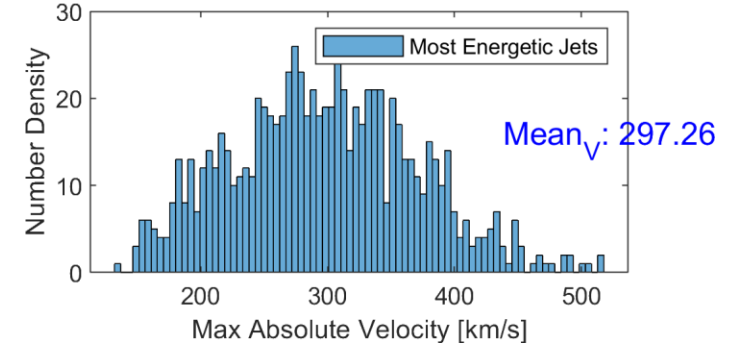
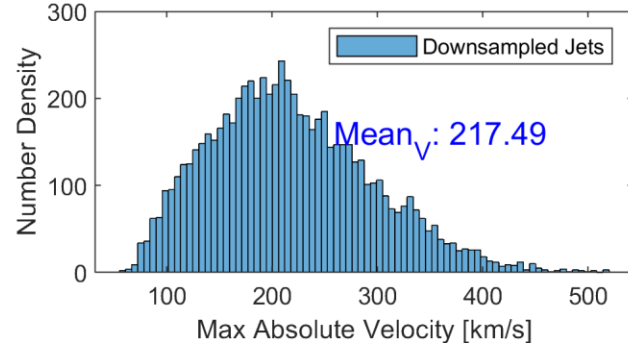
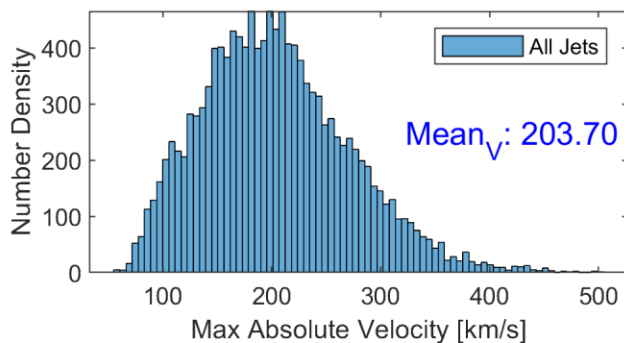
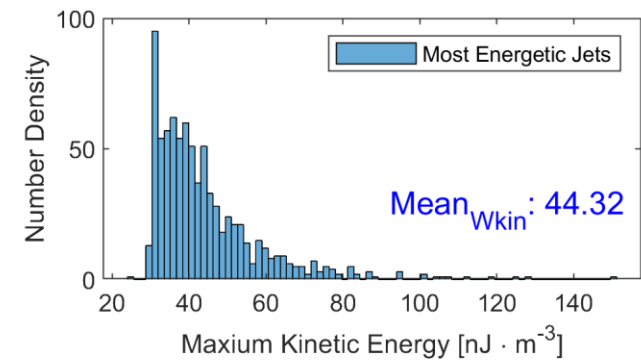
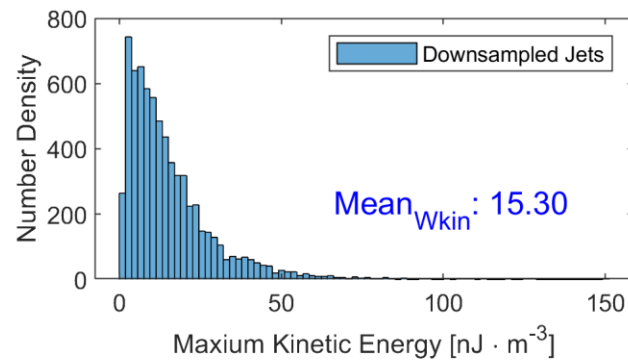
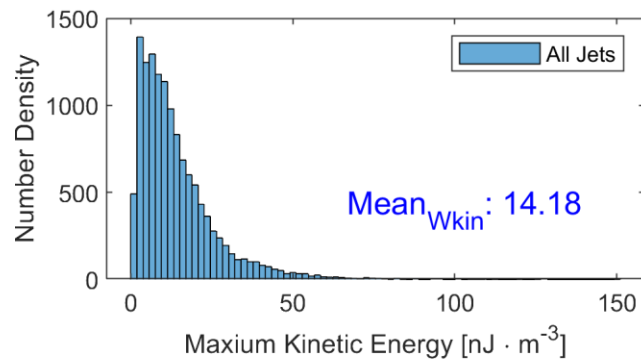
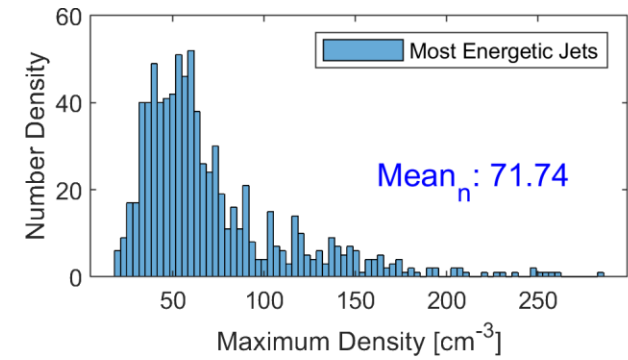
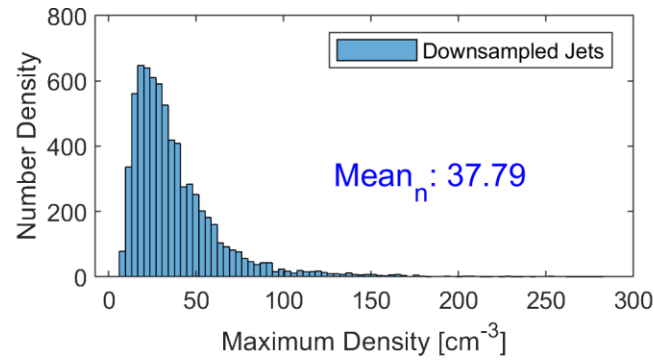
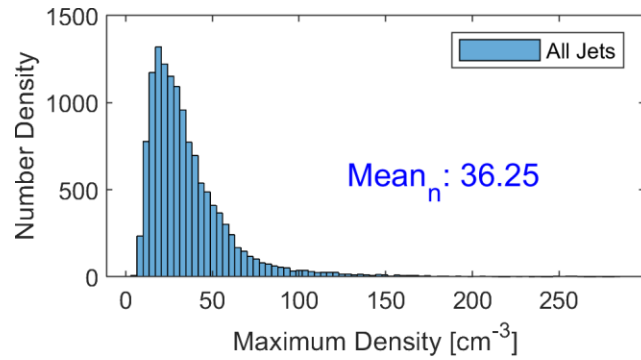
- Obtained a large **database of Magnetosheath Jets** using all available MMS data.
- Analyzed their **statistical characteristics** and found **interesting similarities and differences** compared with earlier results.
- Successfully **classified them into different categories** showing different characteristics.

Future Work

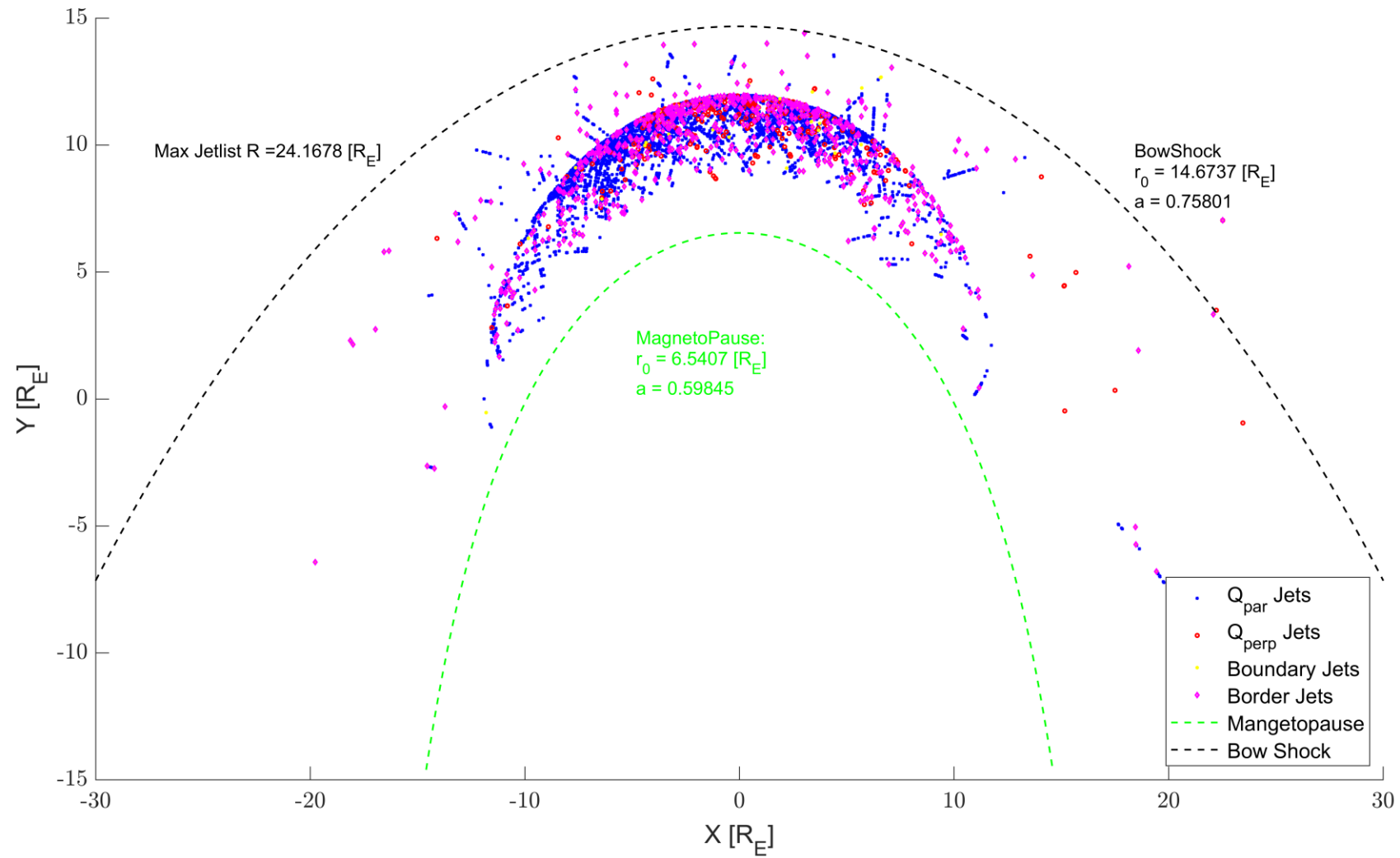
- Quantify **true negative** and **false positive** situations from classification.
- Verify **classification algorithms** via **Machine Learning** (Hierarchical, k-means, SOM etc.)
- Investigate **pre-jet** and **post-jet plasma properties** in comparison to each category.
- Connect each category to **a generation mechanism and origin candidate**.

Extras

Some General Properties of Jets

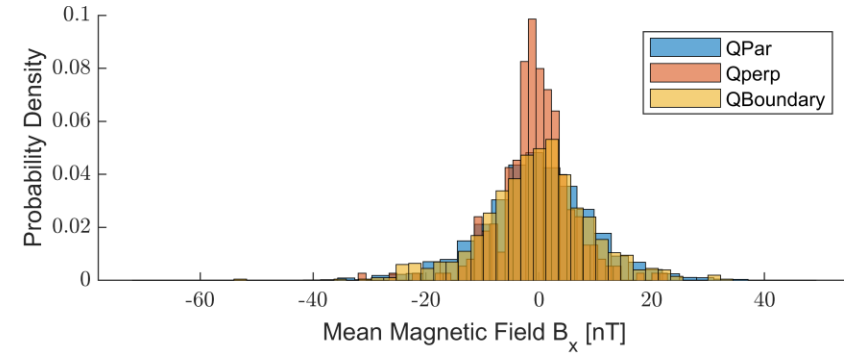
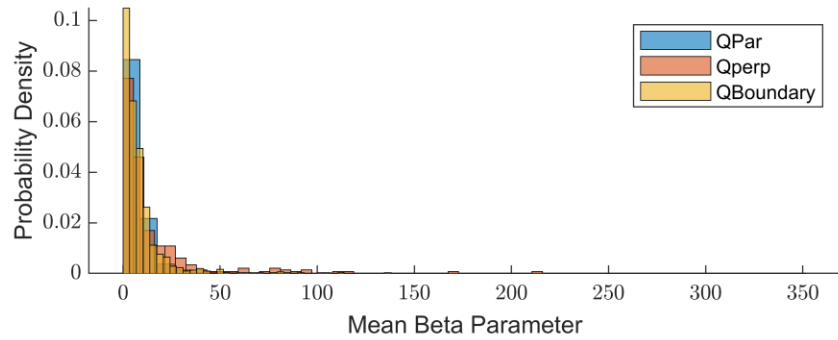


Where are they?



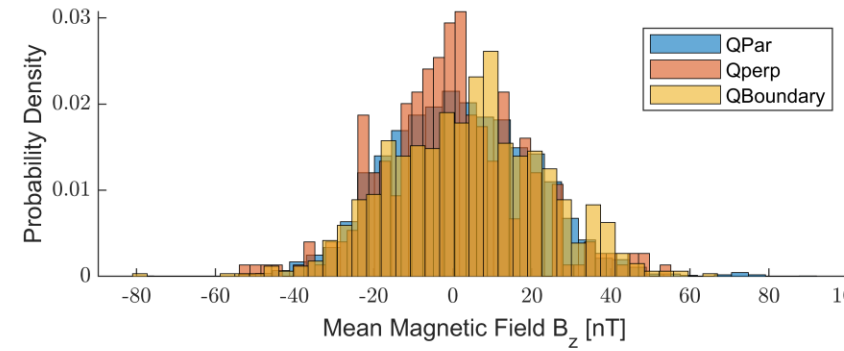
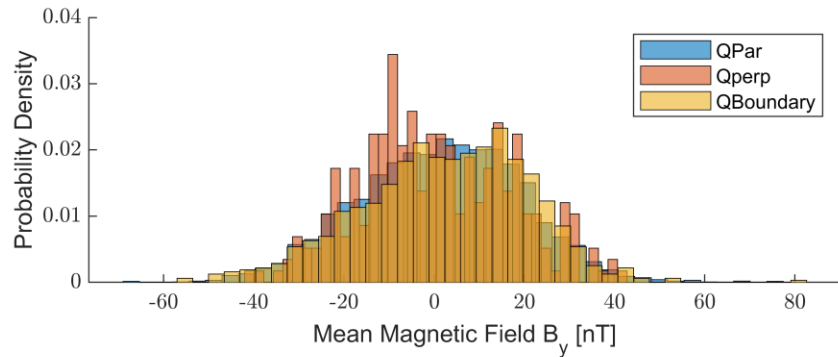
Characteristics of each category

$\text{Mean}_{Q_{\parallel}} : 8.26$
 $\text{Med}_{Q_{\parallel}} : 5.52$
 $\text{Mean}_{Q_{\perp}} : 14.89$
 $\text{Med}_{Q_{\perp}} : 6.61$
 $\text{Mean}_{Q_{\perp}^B} : 8.72$
 $\text{Med}_{Q_{\perp}^B} : 5.47$



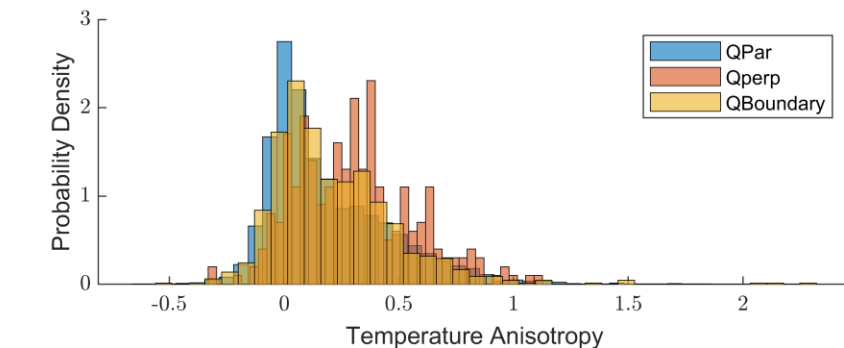
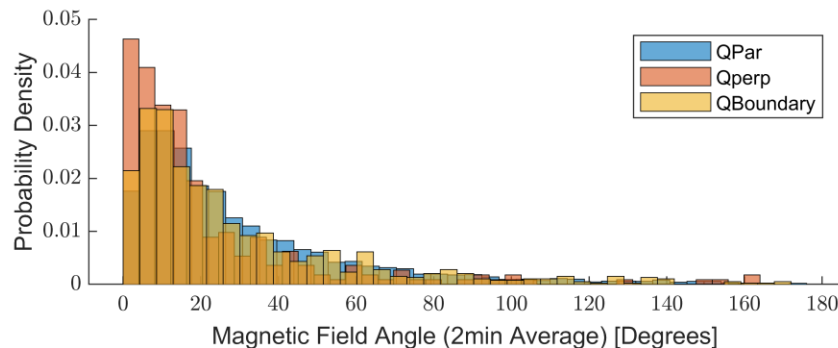
$\text{Mean}_{Q_{\parallel}} : -0.38$
 $\text{Med}_{Q_{\parallel}} : -0.31$
 $\text{Mean}_{Q_{\perp}} : -0.58$
 $\text{Med}_{Q_{\perp}} : -0.50$
 $\text{Mean}_{Q_{\perp}^B} : -0.44$
 $\text{Med}_{Q_{\perp}^B} : -0.09$

$\text{Mean}_{Q_{\parallel}} : 1.29$
 $\text{Med}_{Q_{\parallel}} : 1.78$
 $\text{Mean}_{Q_{\perp}} : 0.40$
 $\text{Med}_{Q_{\perp}} : -0.84$
 $\text{Mean}_{Q_{\perp}^B} : 2.56$
 $\text{Med}_{Q_{\perp}^B} : 3.91$



$\text{Mean}_{Q_{\parallel}} : 1.91$
 $\text{Med}_{Q_{\parallel}} : 1.47$
 $\text{Mean}_{Q_{\perp}} : -0.45$
 $\text{Med}_{Q_{\perp}} : -0.78$
 $\text{Mean}_{Q_{\perp}^B} : 3.95$
 $\text{Med}_{Q_{\perp}^B} : 4.86$

$\text{Mean}_{Q_{\parallel}} : 30.22$
 $\text{Med}_{Q_{\parallel}} : 20.36$
 $\text{Mean}_{Q_{\perp}} : 21.20$
 $\text{Med}_{Q_{\perp}} : 12.41$
 $\text{Mean}_{Q_{\perp}^B} : 29.11$
 $\text{Med}_{Q_{\perp}^B} : 18.46$



$\text{Mean}_{Q_{\parallel}} : 0.19$
 $\text{Med}_{Q_{\parallel}} : 0.11$
 $\text{Mean}_{Q_{\perp}} : 0.31$
 $\text{Med}_{Q_{\perp}} : 0.30$
 $\text{Mean}_{Q_{\perp}^B} : 0.22$
 $\text{Med}_{Q_{\perp}^B} : 0.15$

How Jets look like from MMS?

Can see many different characteristics (Density/Energy/Velocity/Magnetic Field etc.)

