# Magnetosheath Jets Close to the Bow Shock | Generation Scenarios using MMS

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Collisionless Shocks | mini-GEM 2021
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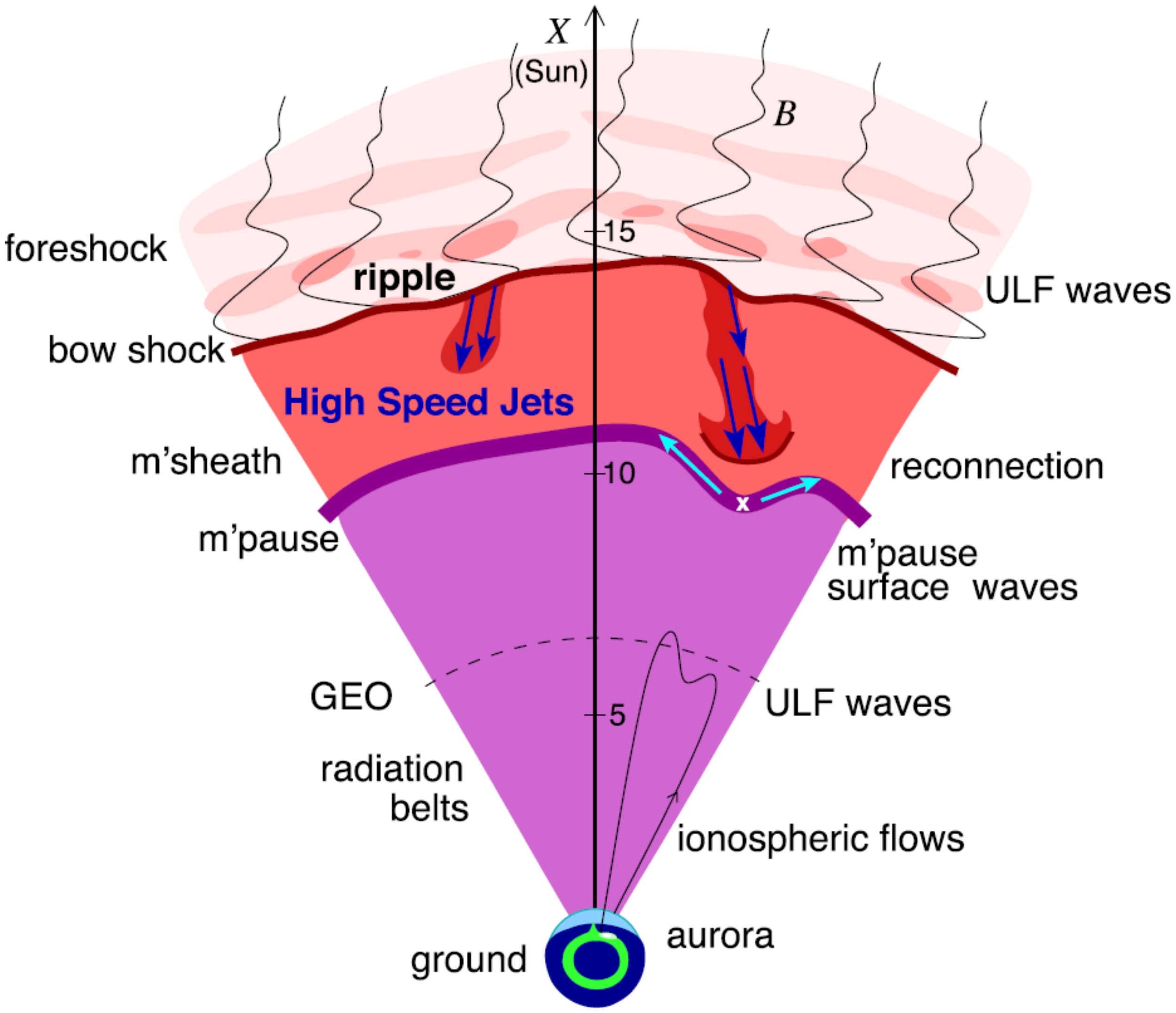
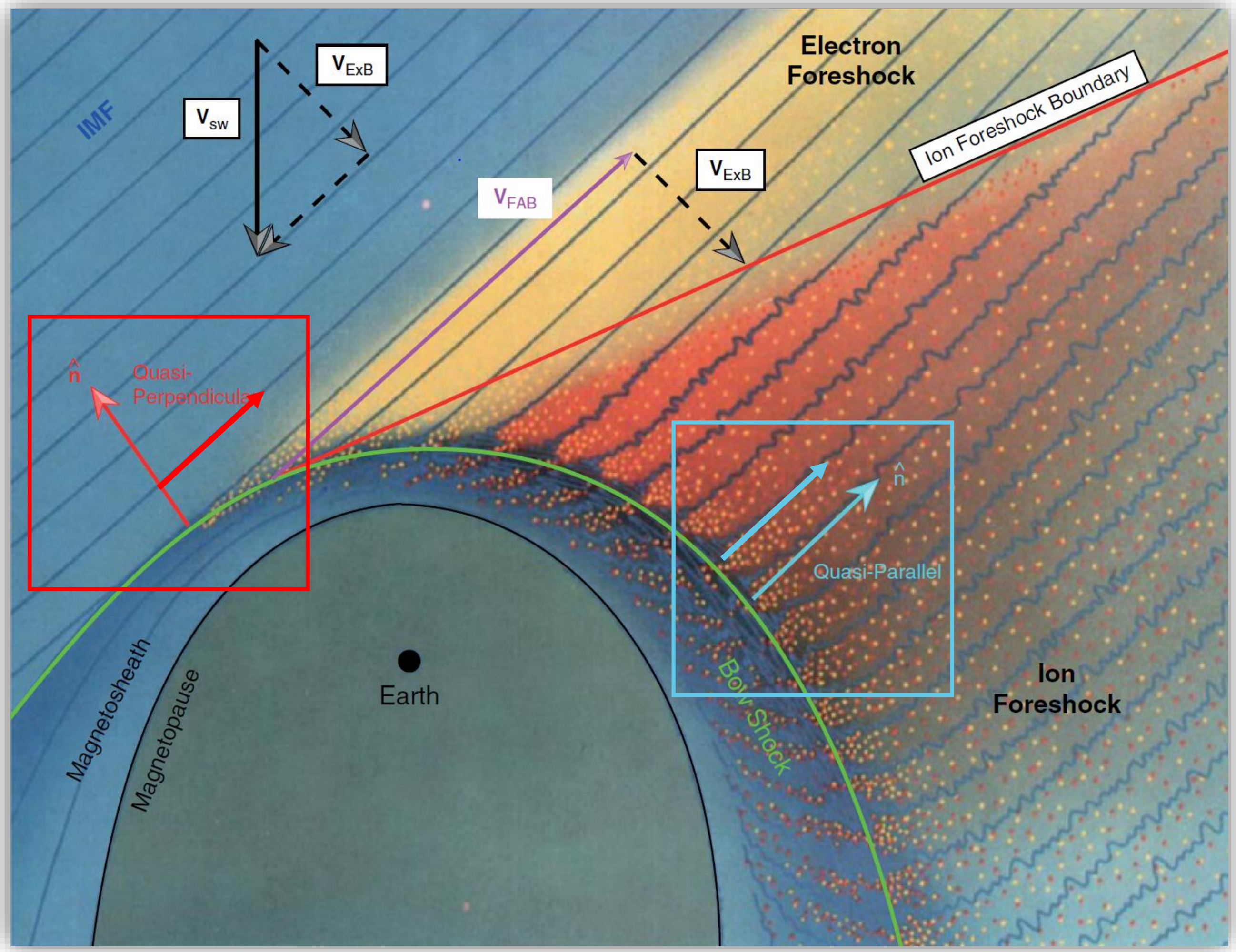
# Introduction – Magnetosheath Jets




Plaschke F. et al. (2018); sketch by H. Hietala | Space Sci. Rev

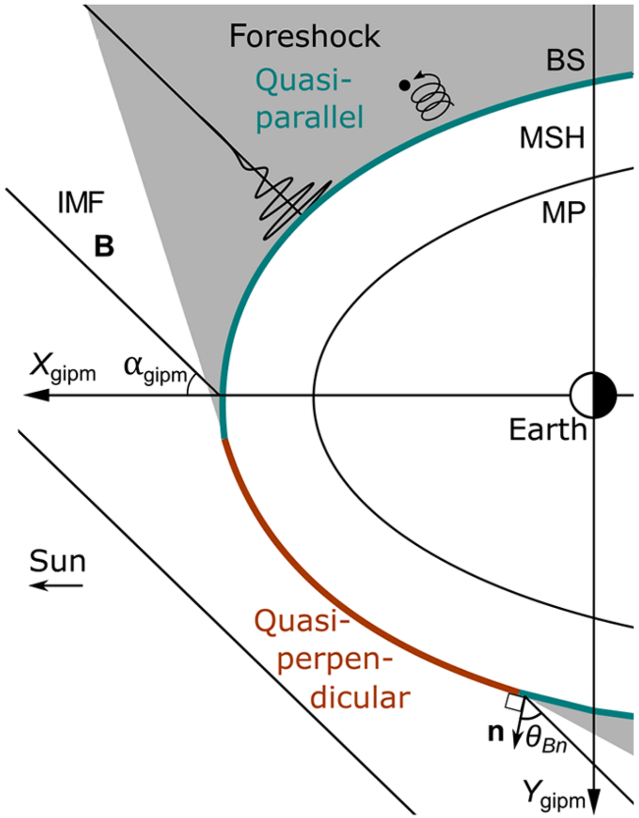
# Motivation – Main Subcategories




L. B. Wilson (2016) | Geophysical Monograph Series

"Found ~9 times more often behind the Qpar bow shock"

| $Q_{par}$ | $Q_{per}$ |
| --- | --- |




Vuorinen, et al. (2019) | Annales

# Classification Procedure in progress

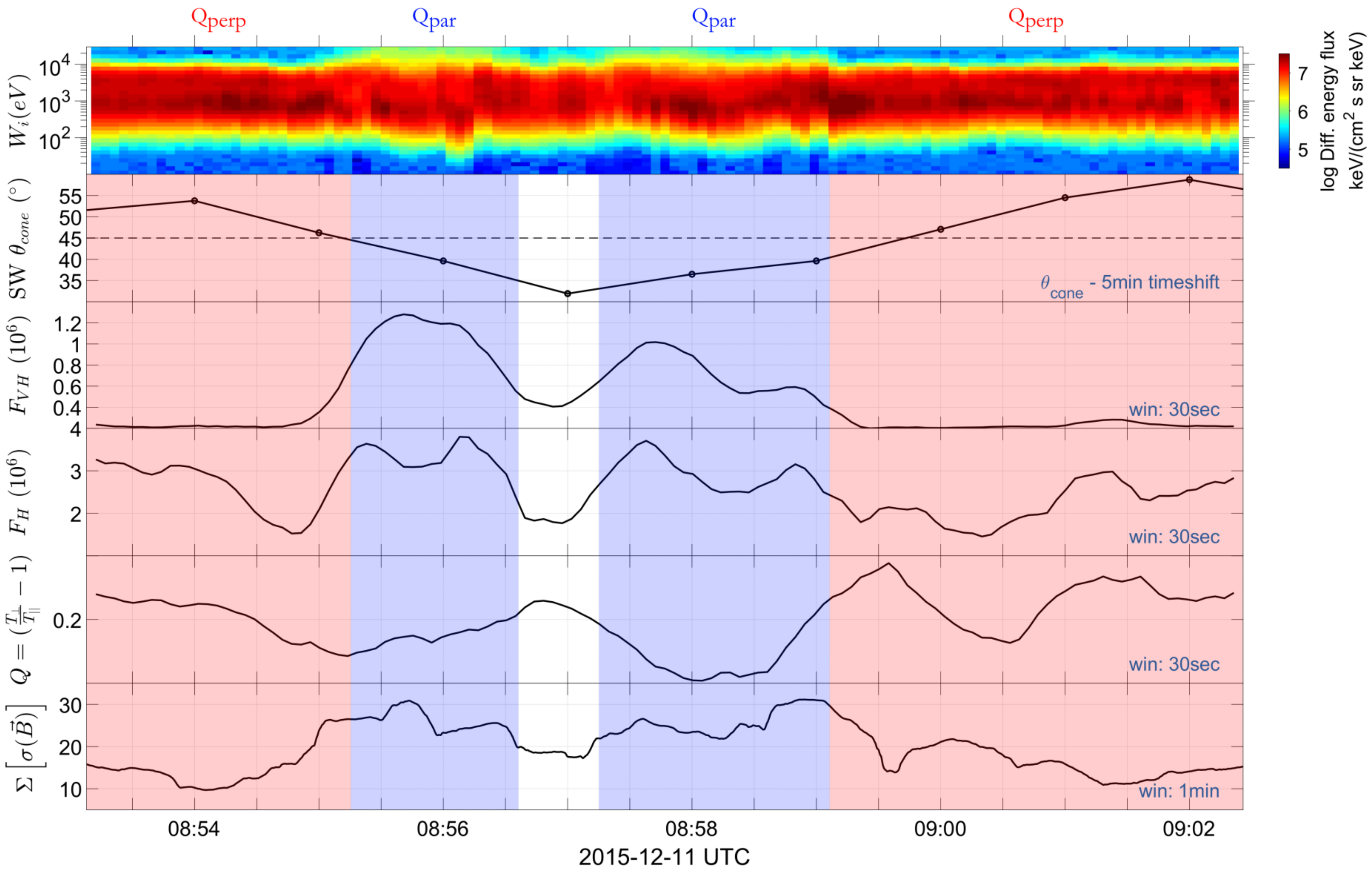
Cone Angle

Very High Energy Flux

High Energy Flux

Anisotropy

Magnetic Field stdev




**Raptis**, Karlsson, et al. (2020) | JGR
Karlsson, **Raptis**, et al. (2020) | Ongoing

# Multispacecraft Classification using Cluster

Energy Spectrum Magnetosheath (eV)

Energy Spectrum Solar Wind (eV)

Magnetic Field (nT)

Magnetic Field (nT)

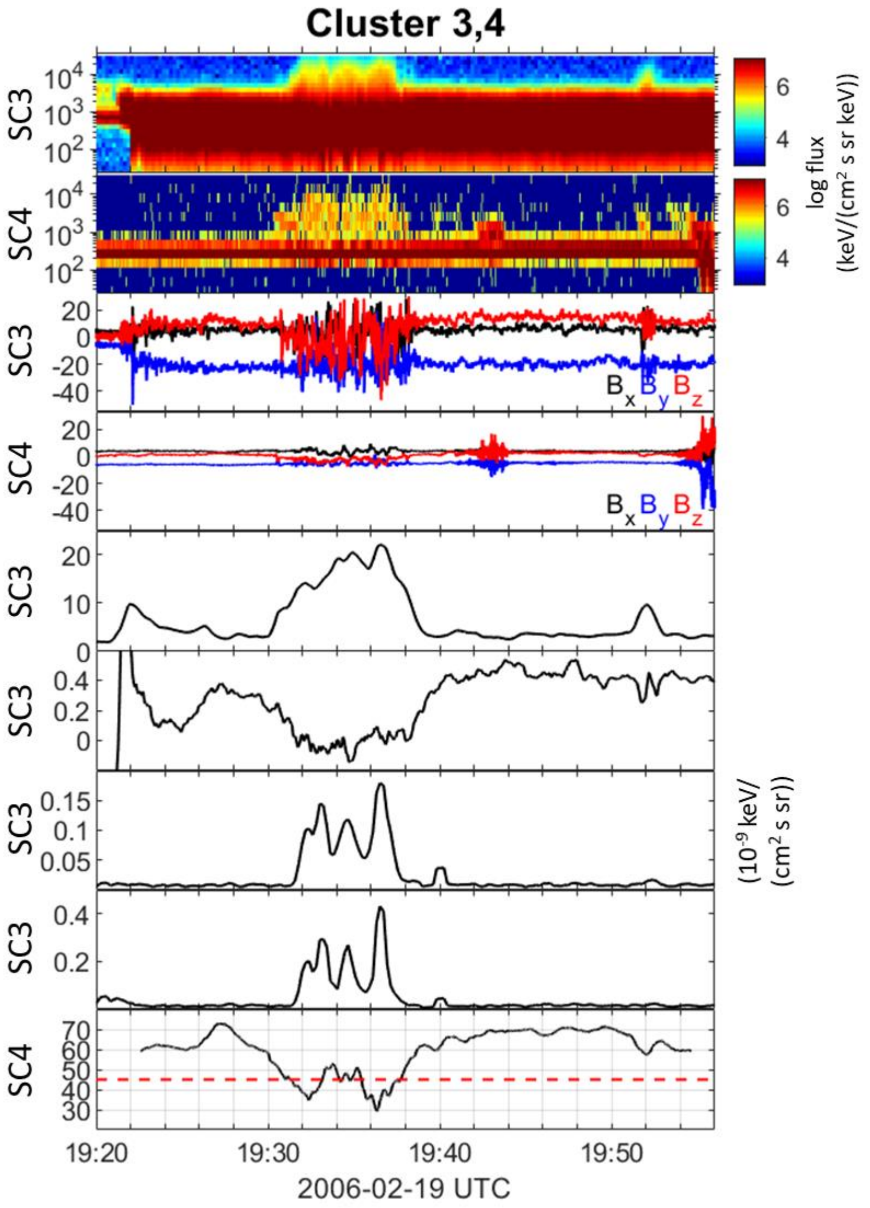
Magnetic Field Stdev (nT)

Anisotropy(Q)

High Energy Flux

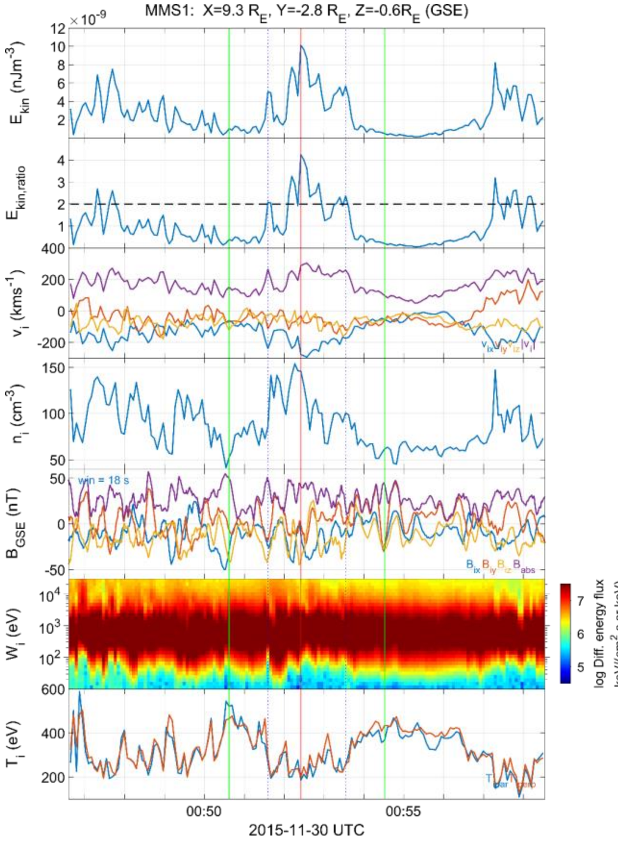
Energy Flux Ratio

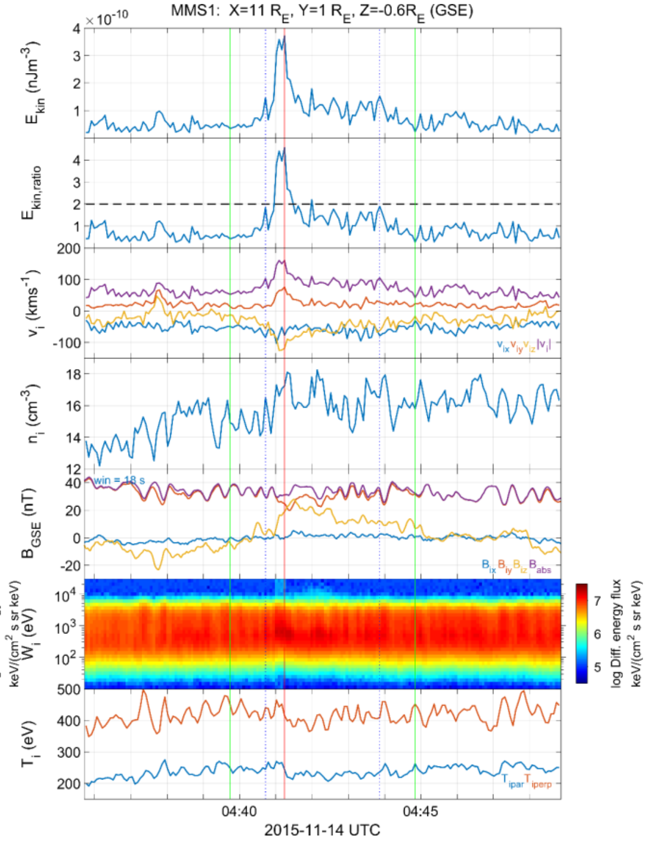
Theta Bn

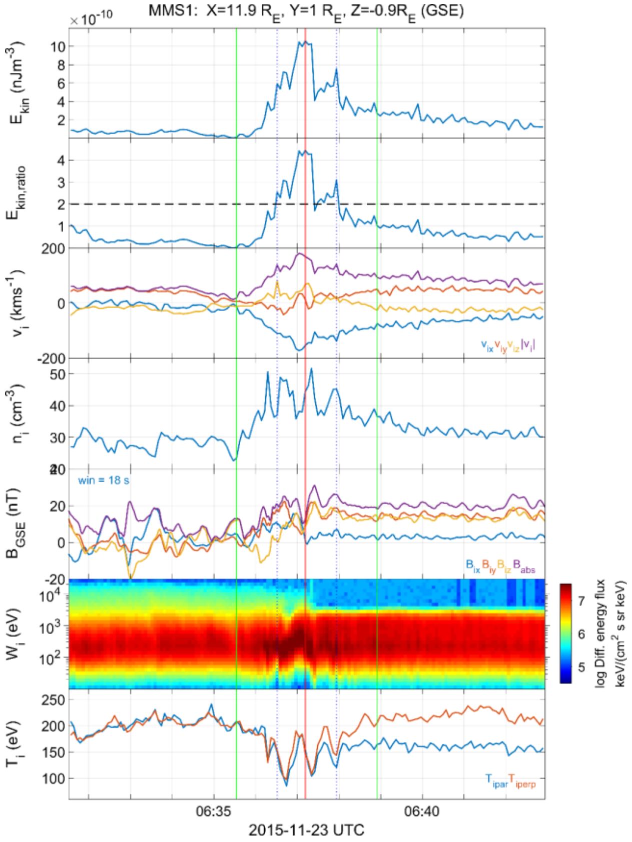


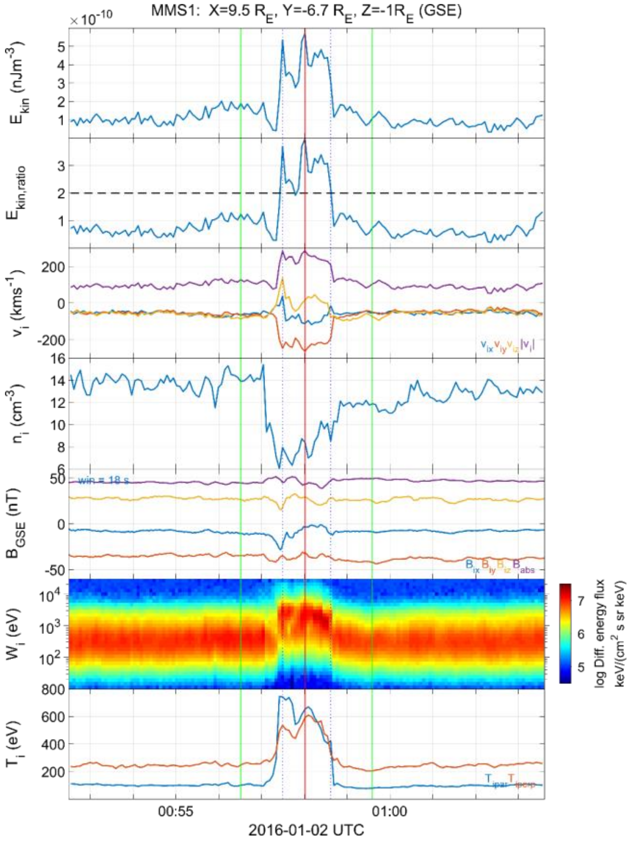

Karlsson, **Raptis**, et al. (2020) | Ongoing

# Main Categories of Jets




Qpar Jet

Jets found in $Q_{\parallel}$ MSH

Qperp Jet

Jets found in $Q_{\parallel}$ MSH

Boundary Jet

Jets found in the boundary between $Q_{\parallel}$ and $Q_{\perp}$ MSH

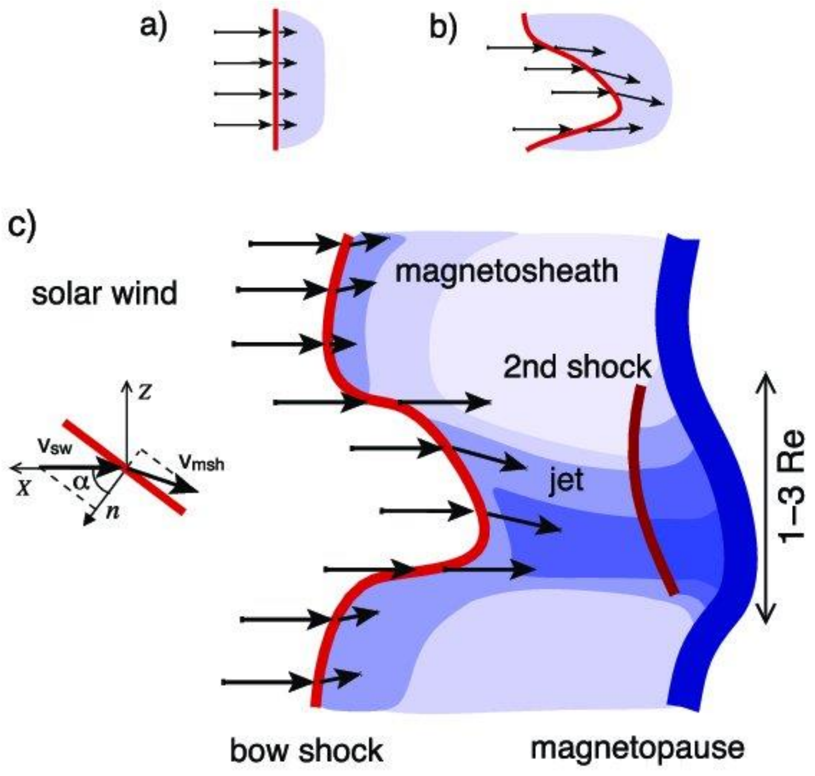
Encapsulated Jet

Jets corresponding to $Q_{\parallel}$-like MSH plasma enclosed in $Q_{\perp}$ MSH

**Raptis S.**, Karlsson T., et al. (2020) | JGR
**Raptis S.**, Aminalragia-Giamini S., et al. (2020) | Frontiers

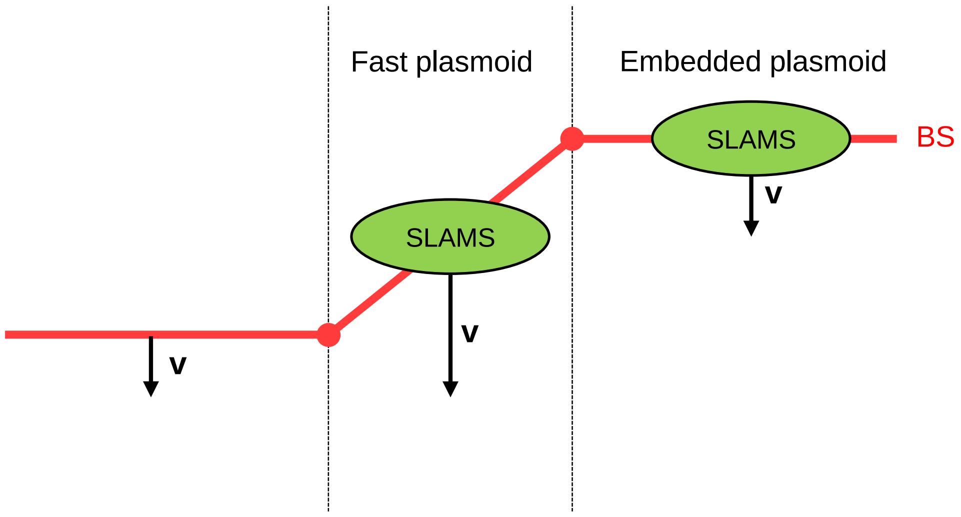
# Connecting to existent mechanisms

## Bow shock ripples




Faster flow ($\Delta V$) → Less heated ($\Delta T$)

## SLAMS penetration

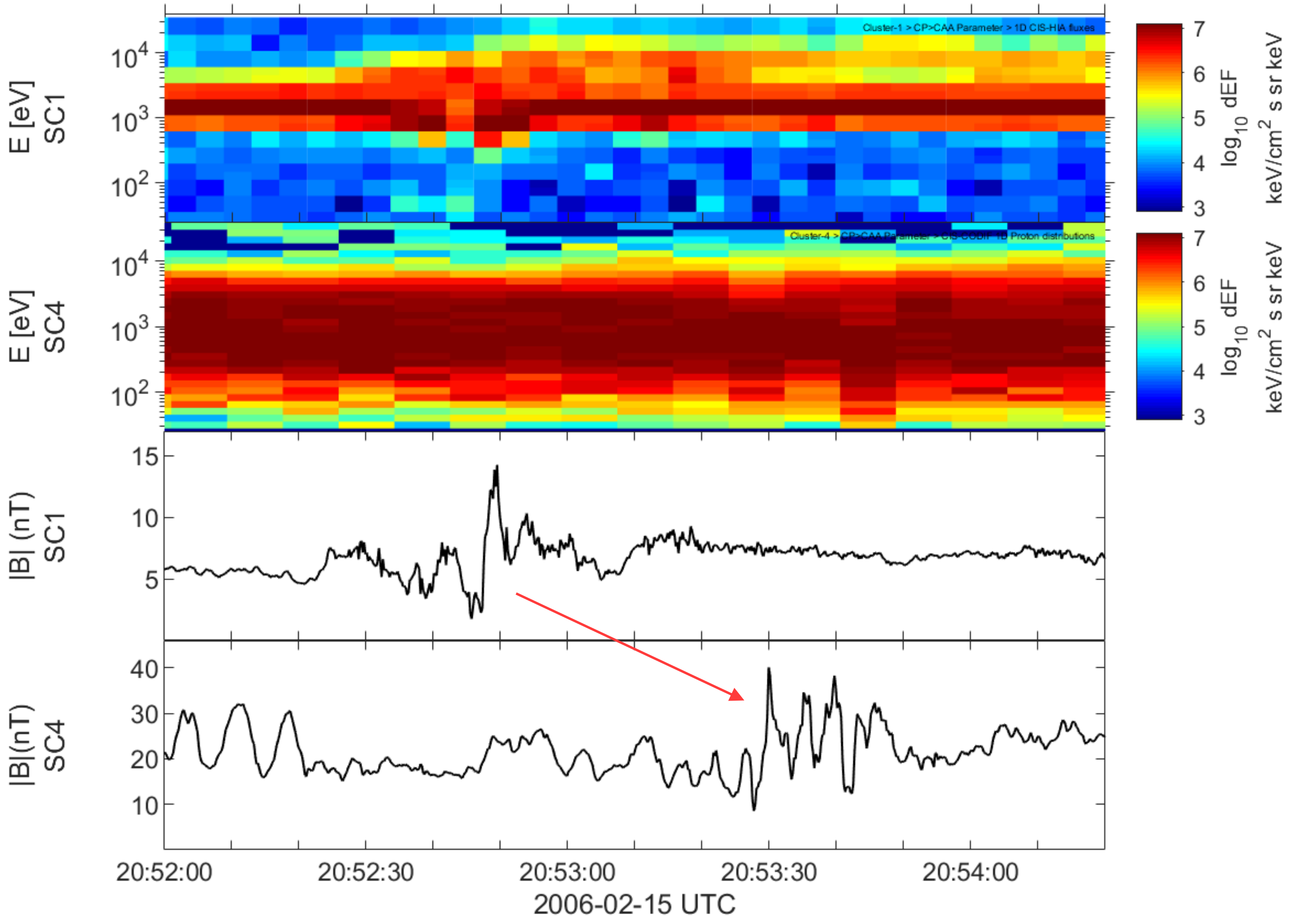


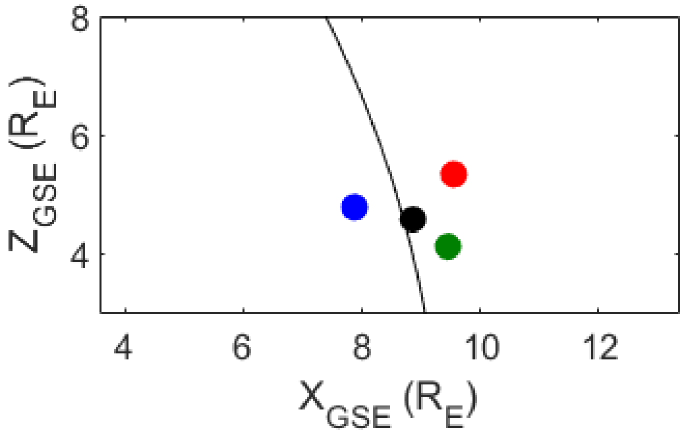

Steepened wave ($\Delta$B) → Density enhancement ($\Delta n$)

Qpar : Hietala et al., (2009,2012) | Qperp : Johlander et al. (2016)

Hietala et al., (2009,2012), Karlsson et al. (2015)

# Can SLAMS go through the Shock ?



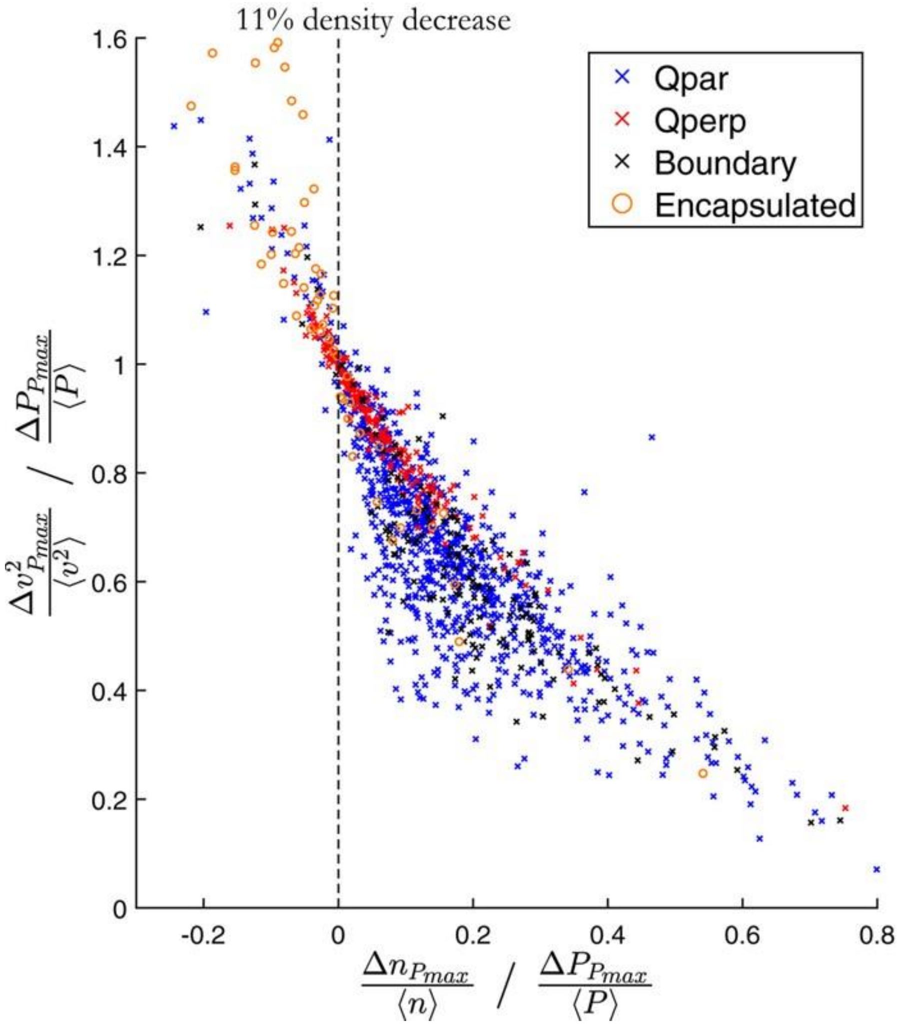




Karlsson, et al. | Ongoing

# Recent Results

**Raptis S.**, Karlsson T., et al. (2020) | JGR
**Raptis S**., Aminalragia-Giamini S., et al. (2020) | Frontiers
Palmroth M., **Raptis S**., et al. (2020) | Annales (under review)

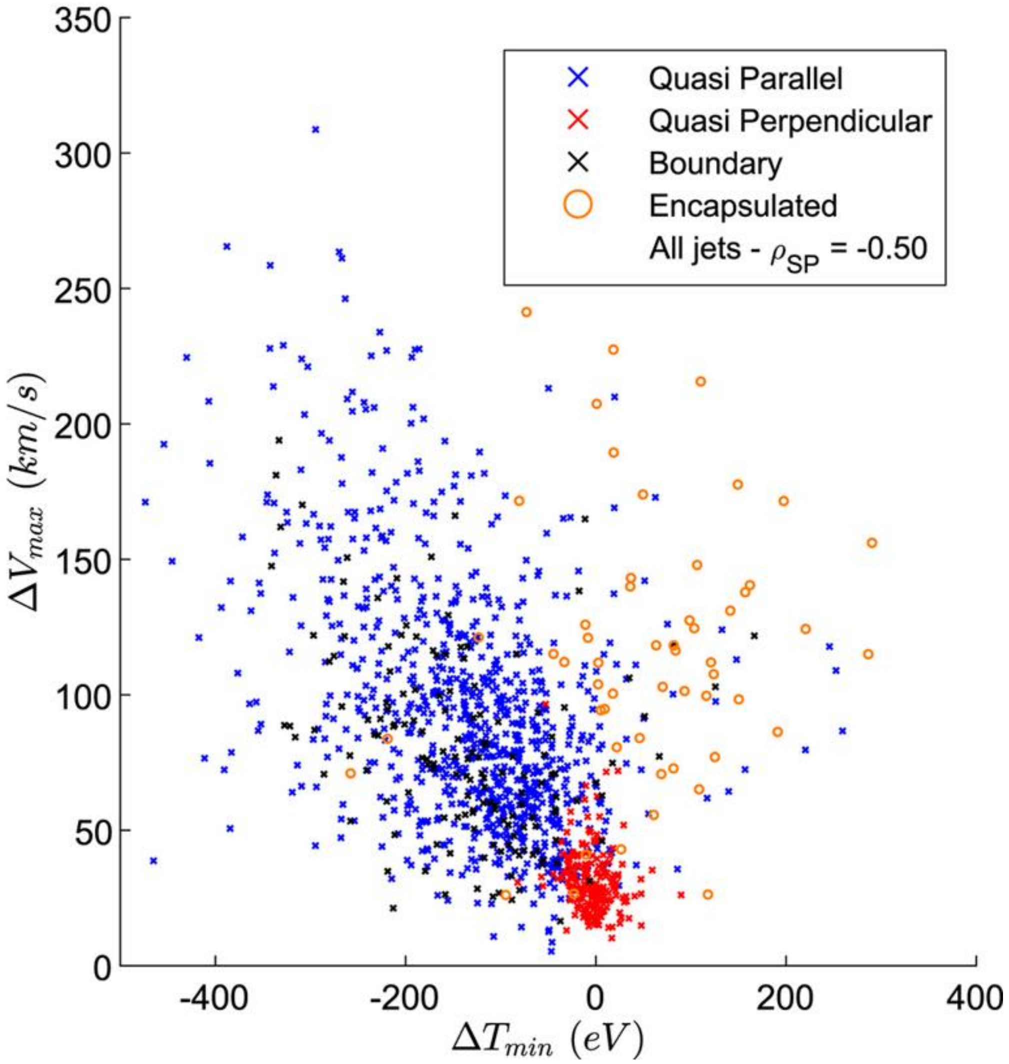
# Current main results (1)

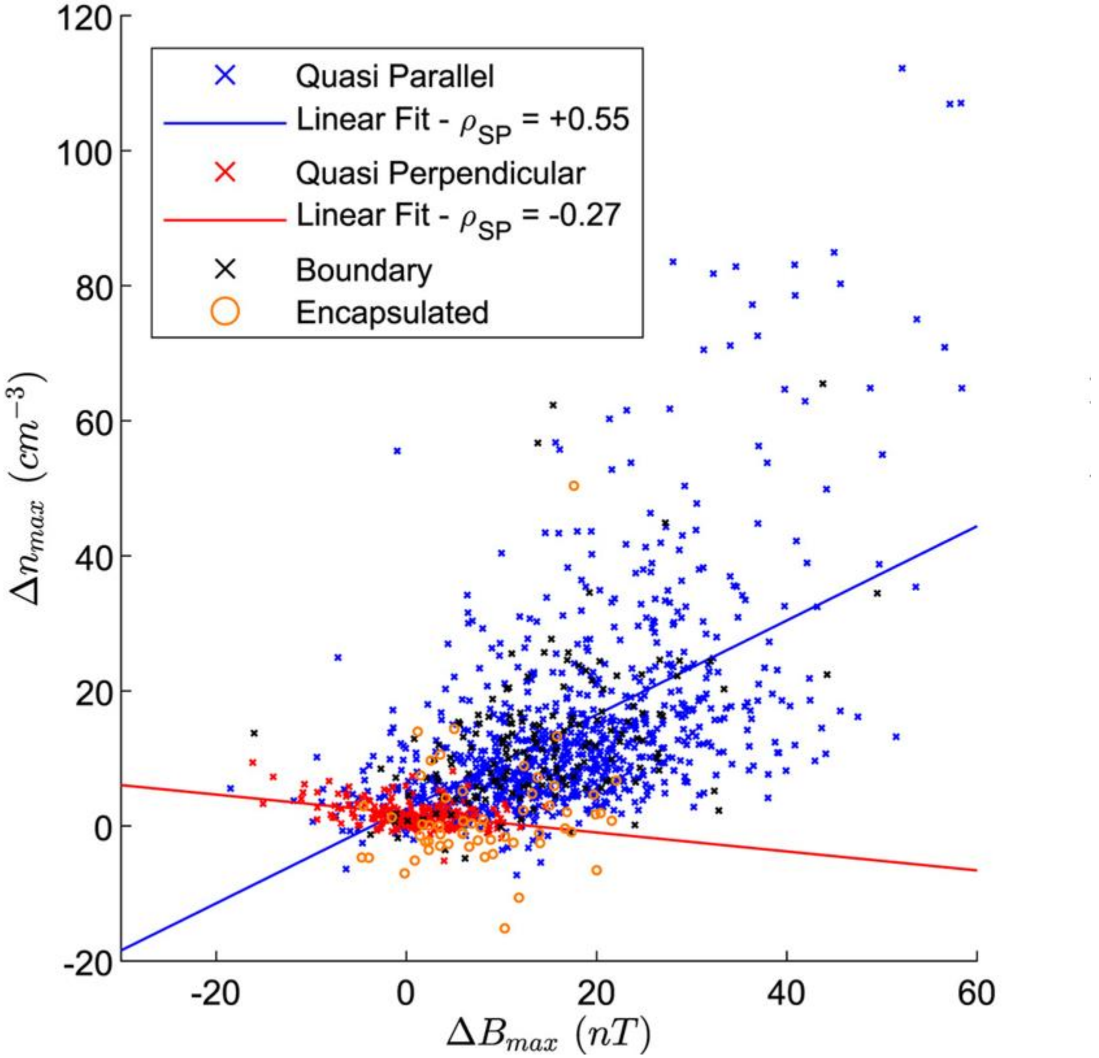



**Raptis S.**, Karlsson T., et al. (2020) | JGR
**Raptis S**., Aminalragia-Giamini S., et al. (2020) | Frontiers

# Current main results (2)

"Ripples" $\Delta X = X_{jet} - \langle X_{BG} \rangle_{5min}$ "SLAMS"



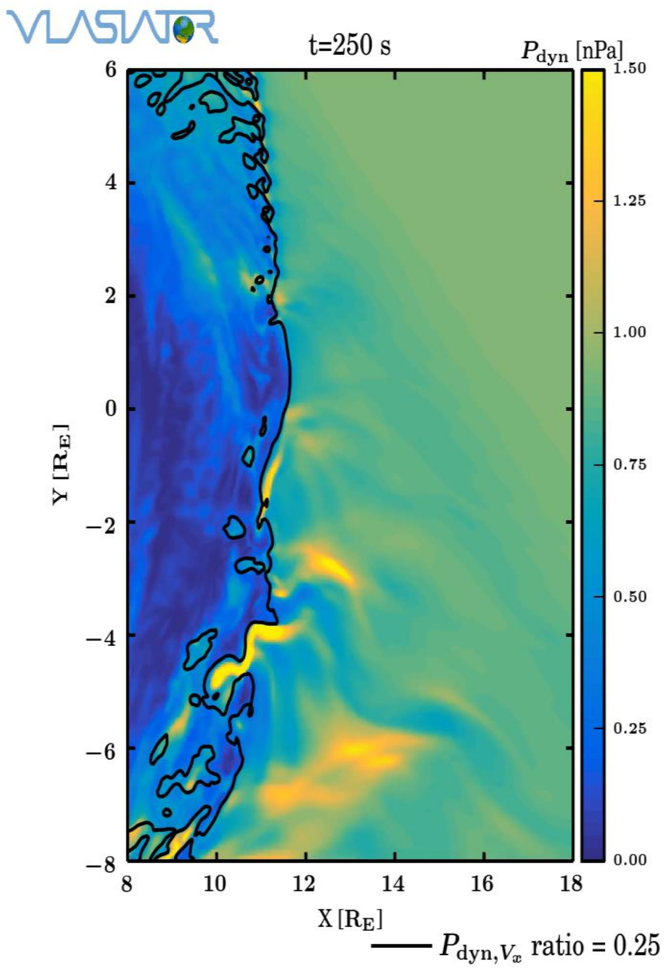



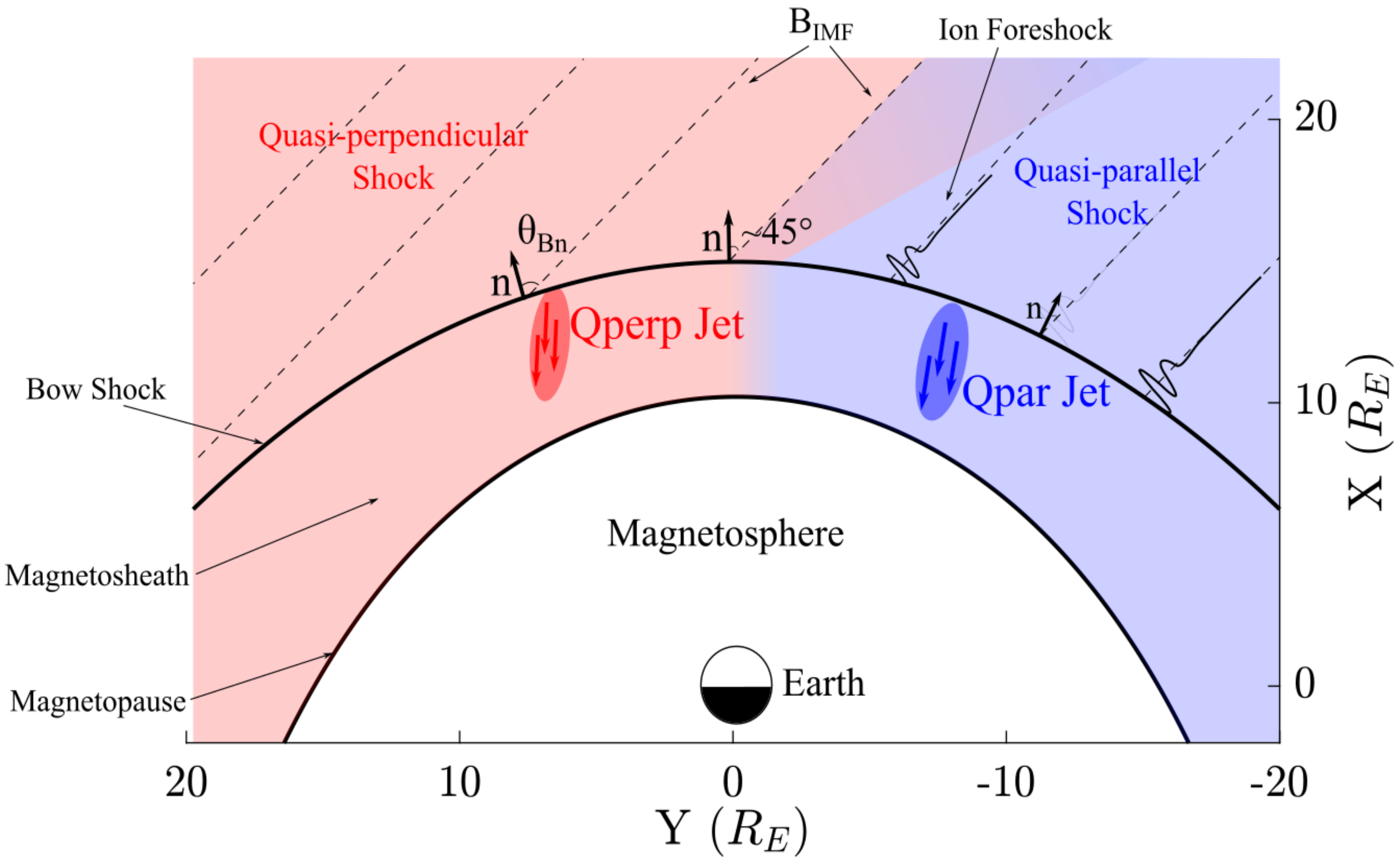

**Raptis S.**, Karlsson T., et al. (2020) | JGR

# Ongoing Work

**Raptis**, Karlsson, et al. | Ongoing

# Ongoing work – Approaching the shock




Palmroth M., **Raptis S.**, et al. (2020) | Annales (under review)
Palmroth M., et al. (2018) | Annales

**Raptis S.**, Aminalragia-Giamini S., et al. (2020) | Frontiers

# Updated database of jets

## Initial: N = 8499

| Subset | Number | Percentage (%) |
|---|---|---|
| Quasi-parallel | 2284 | 26.9 |
| Final cases | **860** | 10.1 |
| Quasi-perpendicular | 504 | 5.9 |
| Final cases | **211** | 2.5 |
| Boundary | 744 | 8.8 |
| Final cases | **154** | 1.8 |
| Encapsulated | 77 | 0.9 |
| Final cases | **57** | 0.7 |
| Other | 4890 | 57.5 |
| Unclassified/Uncertain | 3499 | 41.2 |
| Border | 1346 | 15.8 |
| Data Gap | 45 | 0.5 |

09/2015 - 04/2019

**Raptis S.**, Karlsson T., et al. (2020) | JGR
**Raptis S.**, Aminalragia-Giamini S., et al. (2020) | Frontiers
Palmroth M., **Raptis S.**, et al. (2020) | Annales (under review)

## Updated: N = 9196

| Subset | Number | Percentage (%) |
|---|---|---|
| Quasi-parallel | 2458 | 26.7 |
| Final cases | **901** | 10.1 |
| Quasi-perpendicular | 542 | 5.9 |
| Final cases | **214** | 2.3 |
| Boundary | 781 | 8.5 |
| Final cases | **191** | 2.1 |
| Encapsulated | 80 | 0.9 |
| Final cases | **60** | 0.7 |
| Other | 5335 | 58.0 |
| Unclassified/Uncertain | 3789 | 41.2 |
| Border | 1500 | 16.3 |
| Data Gap | 46 | 0.5 |

9/2015 - 9/2020

~**300** close to the bow shock

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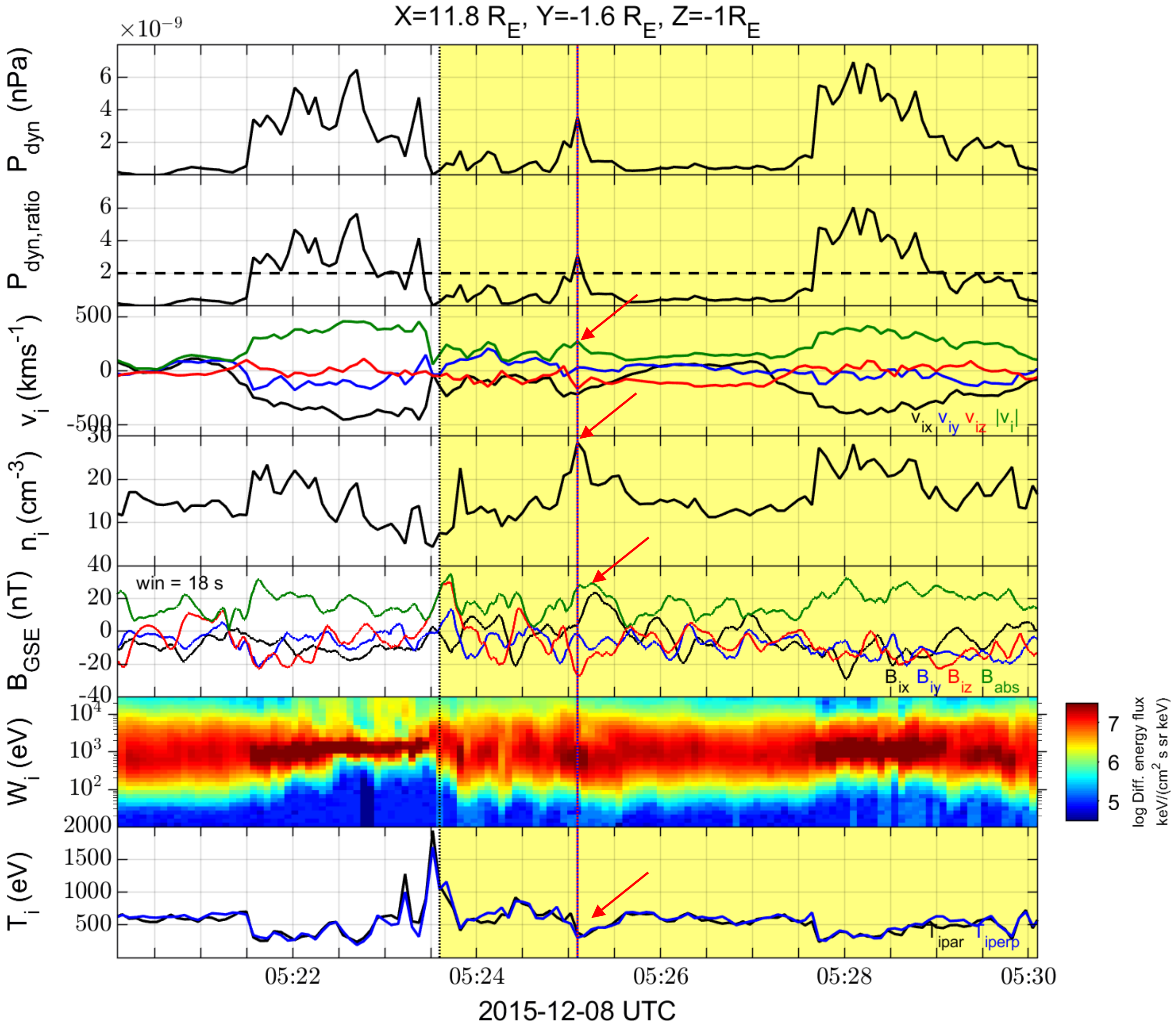
# Example: close to the bow shock jet

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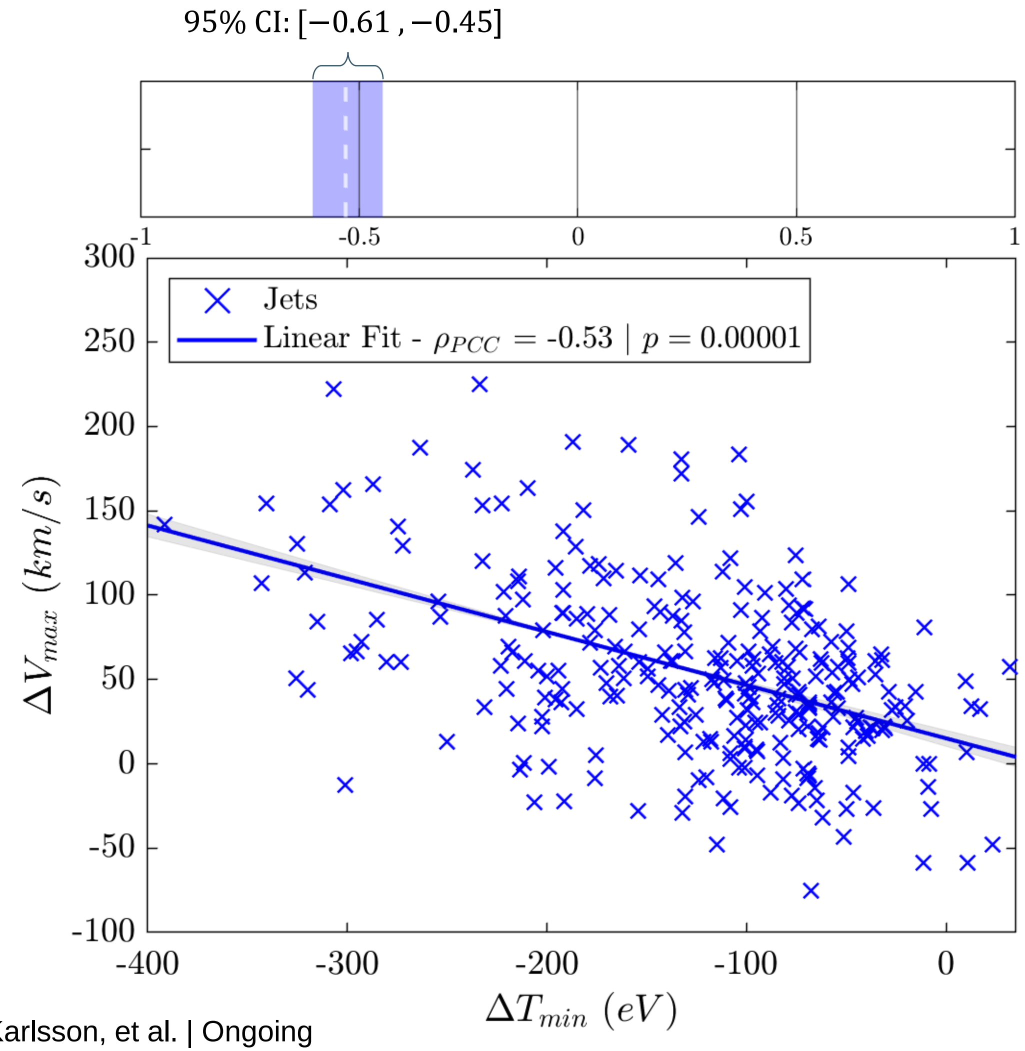
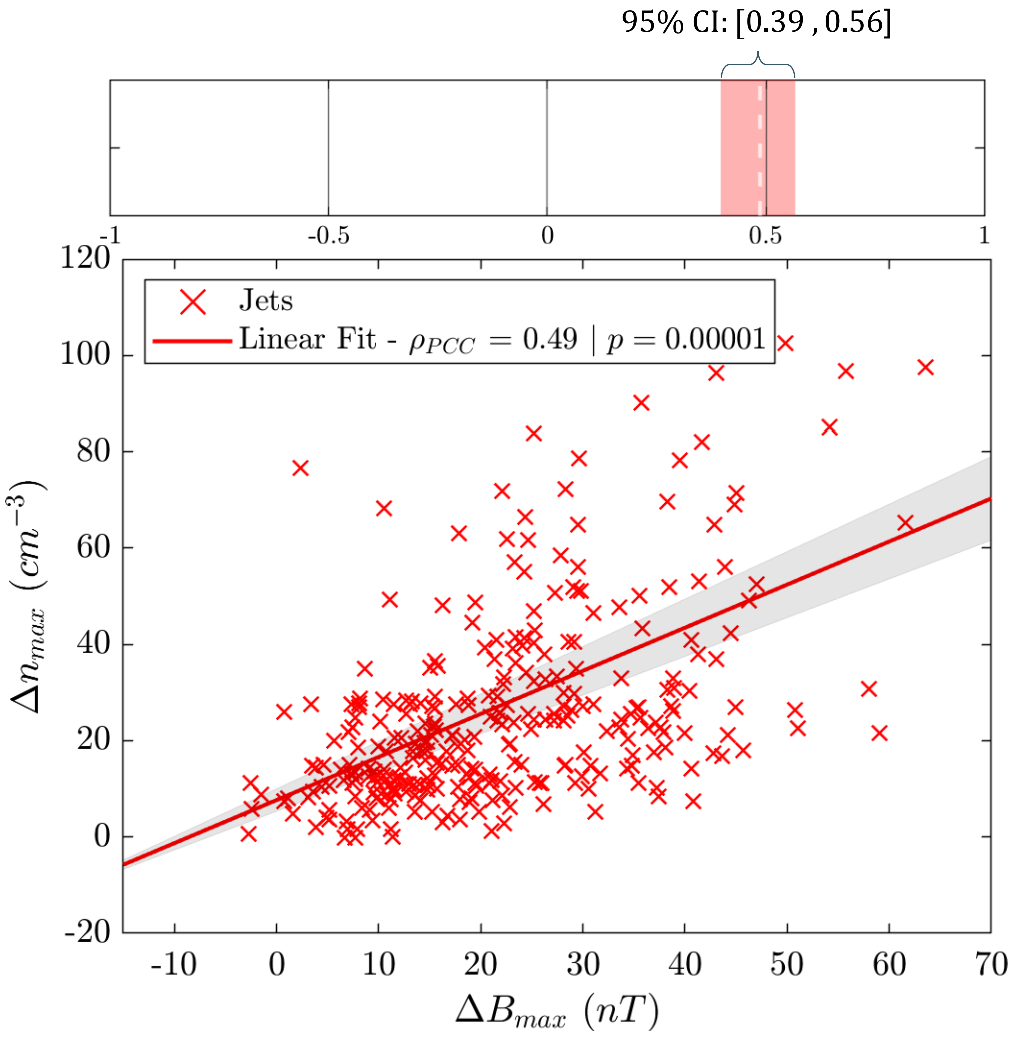
# Ongoing Correlation Results

"Ripples" $n = 310$ "SLAMS"

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# Summary & Conclusion

Good indication that existent mechanism are at least partially responsible for what we see.

Quite a few things to be done:

- See class specific correlations close to the bow shock.
- Check burst data availability and see if this provides new insight.
- Check other tools of connecting mechanisms (time series analysis, mutual information (MI), prediction power scores (PPS), machine learning (ML), analytical prediction etc.)
- Quantification of other possible mechanisms (e.g. reconnection “plasmoids”, Preisser et. al. 2020 | ApJL).
- Inspect for statistical artifacts (e.g. partial shock crossings, foreshock, other irregularities etc.)

Other ongoing projects with jets : Interaction of jets with ambient plasma in the magnetosheath.

# Extra

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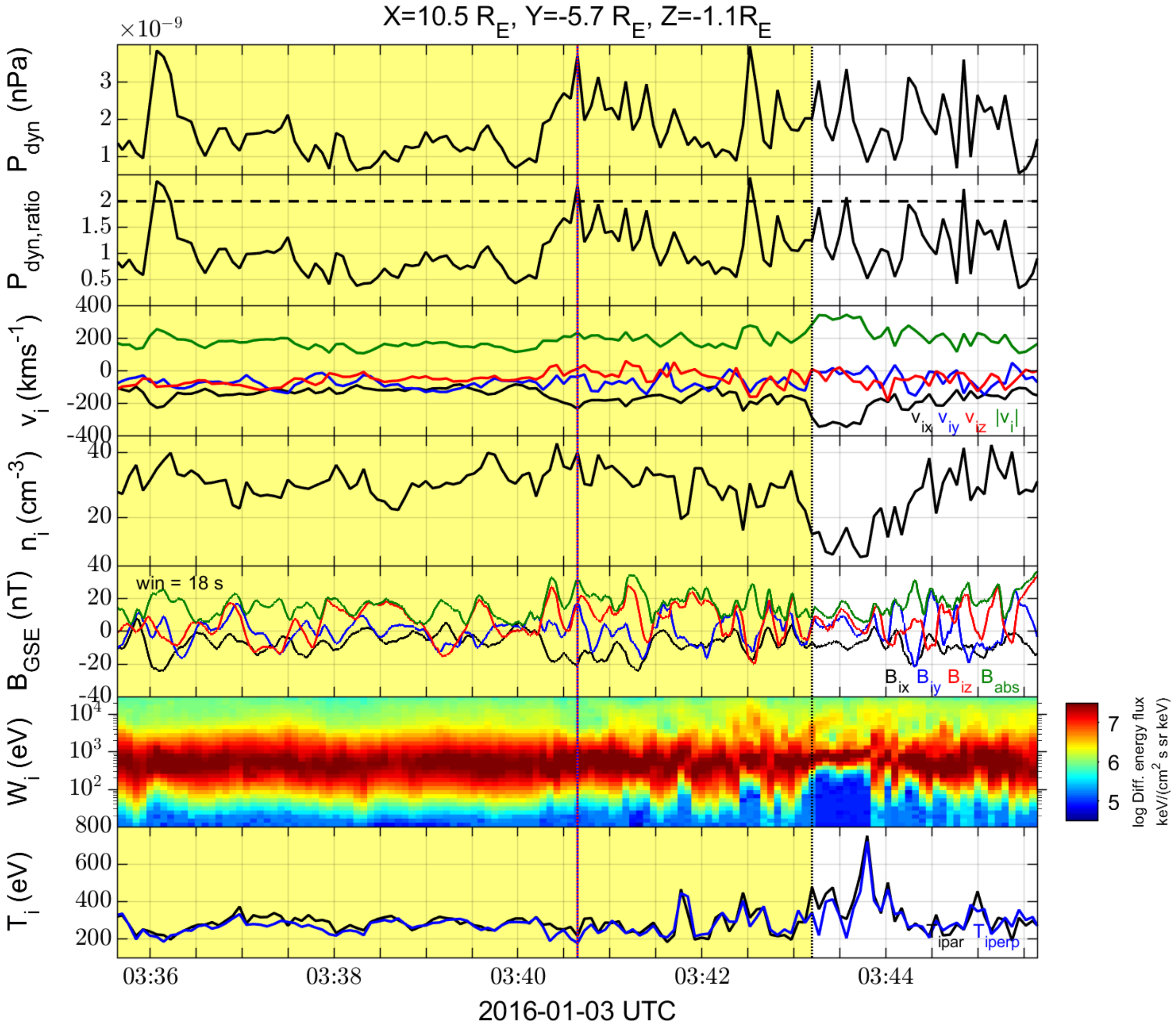
# Background – Fully automated

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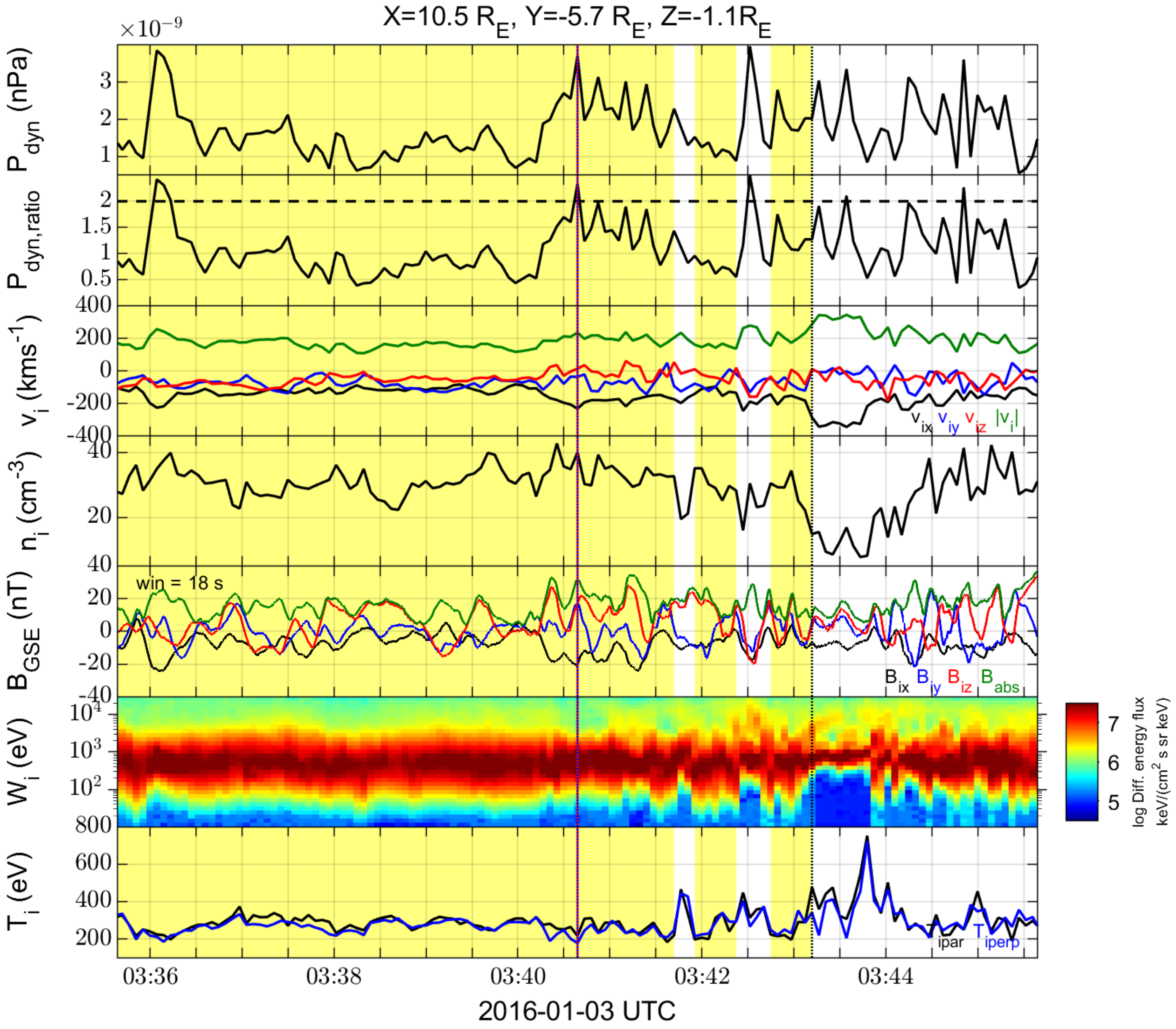
# Background – Manual Addition

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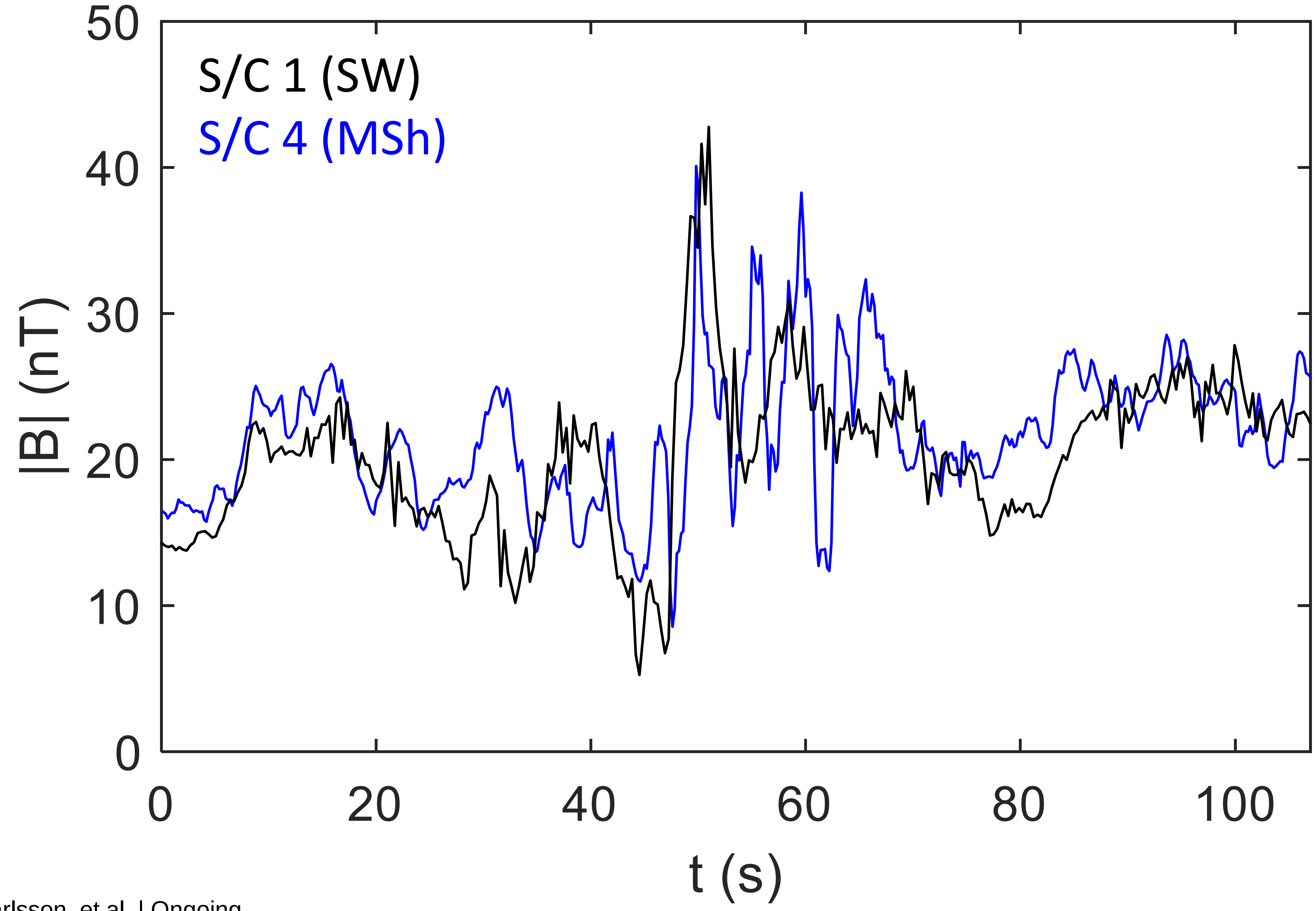
# SLAMS Penetration example




plot($B_4(t)$)

plot($\alpha B_1(\beta t - \gamma)$)
$\alpha = 3.0$
$\beta = 1.7$
$\gamma = 7$ s

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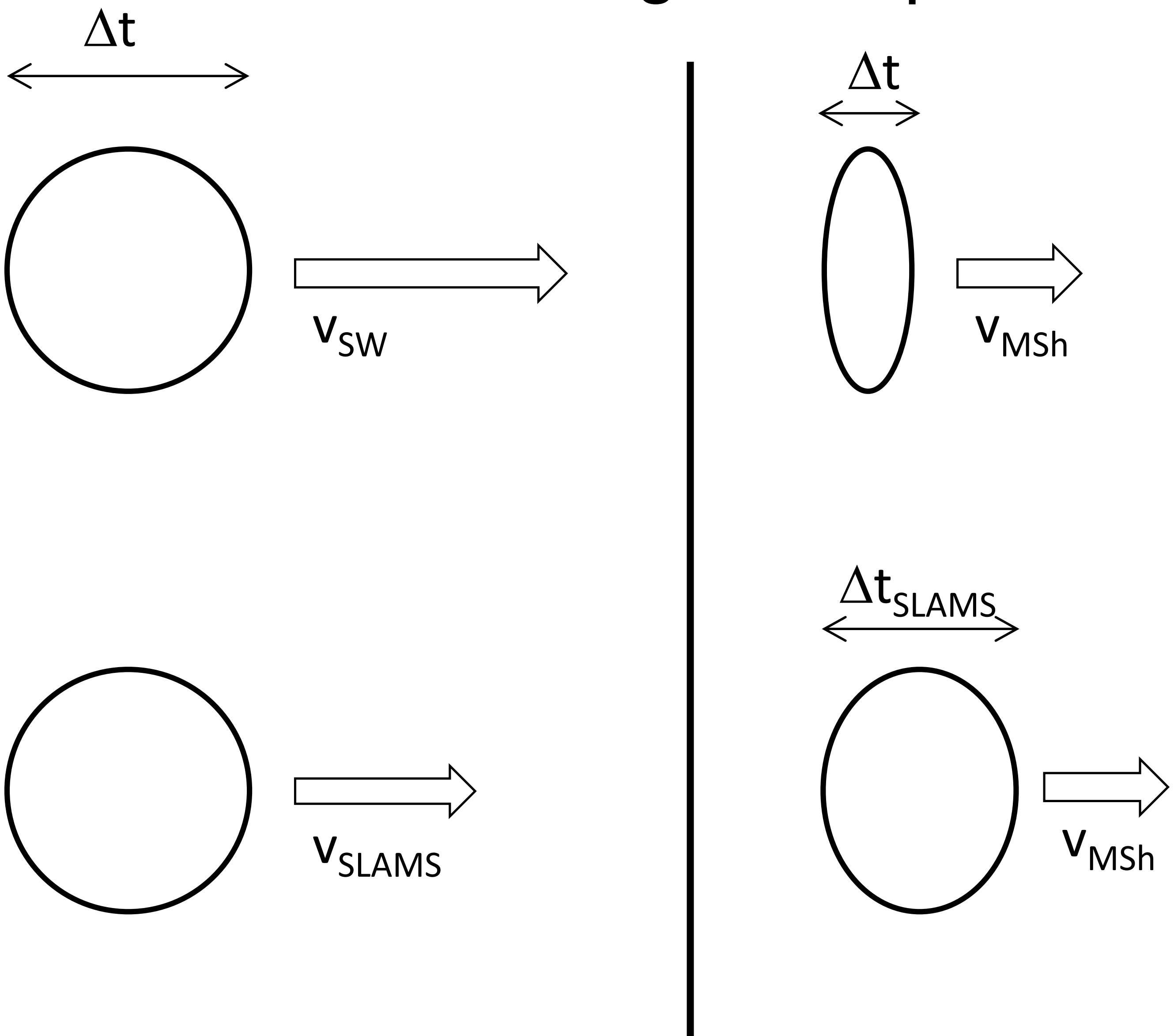
# How SLAMS get compressed ?




$$vn = const \Rightarrow$$

$$\frac{v}{\Delta l} = const \Rightarrow$$

$$\Delta t = const$$

$v_{SLAMS} = v_{SW}/1.7 = 0.6v_{SW}$

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