Electron acceleration: Shock vs. Magnetosheath

Elin Eriksson[1,2],
A. Vaivads[1], D. B. Graham[1], Yu. V. Khotyaintsev[1], E. Yordanova[1], H. Hietala[3], M. André[1], MMS instrument teams

[1]Swedish Institute of Space Physics, Uppsala, Sweden. [2]Uppsala University, Department of Physics and Astronomy, Uppsala, Sweden. [3]Department of Earth and Space Sciences, University of California, Los Angeles, California, USA

UPPSALA UNIVERSITET

IRF

elin.eriksson@irfu.se

PhD Topic

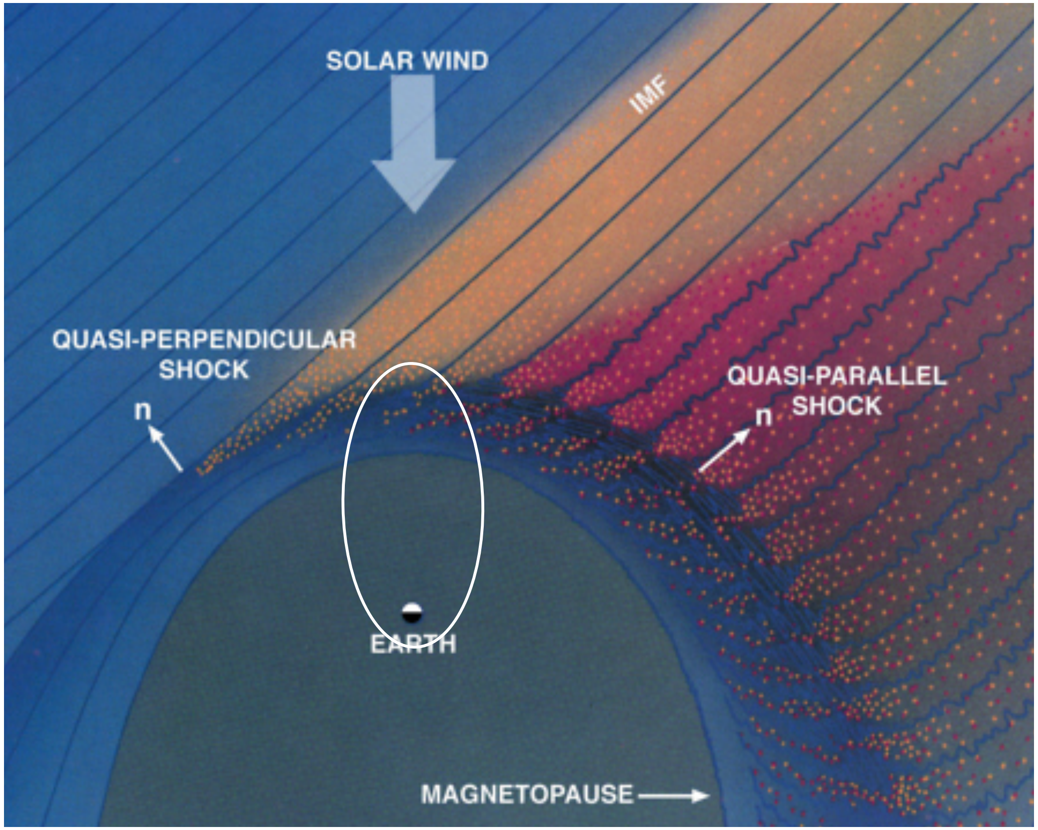
3D effects in relation to reconnection – electron acceleration.

Cluster and MMS.

Reconnection current sheets has been observed in the turbulent MSH.

Efficient thermalization and particle acceleration processes.

The main processes not well understood.



Adapted from *Tsurutani and Rodriguez 1981 JGR*

elin.eriksson@irfu.se

Outline

- Electron acceleration theory at the bow shock
- Observations in MSH
- Conclusions

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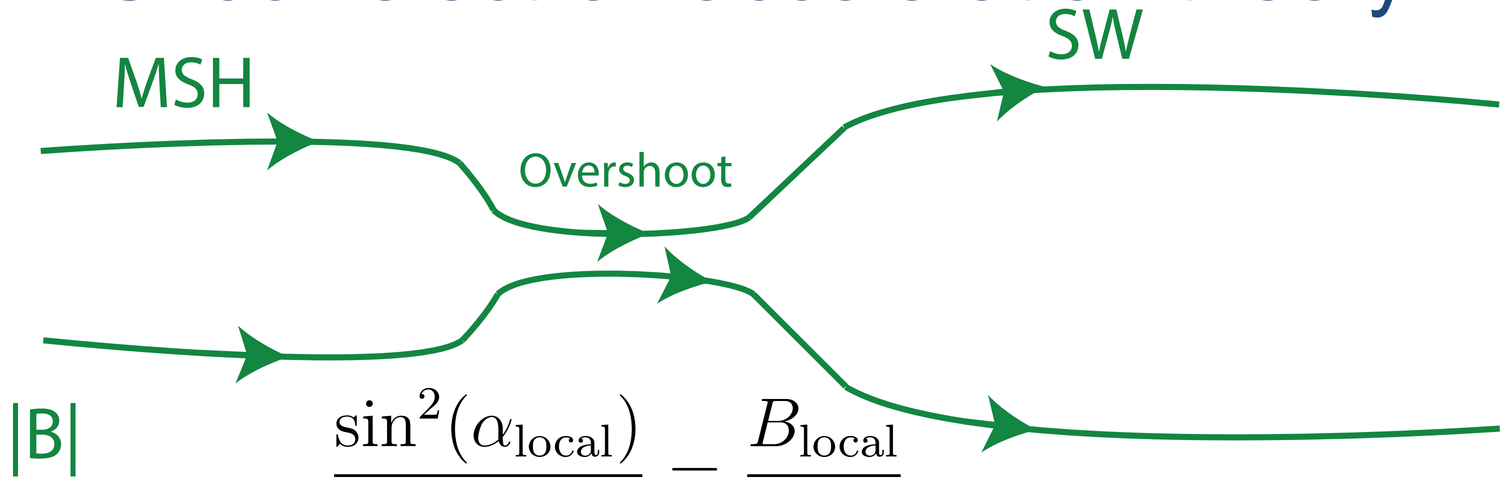
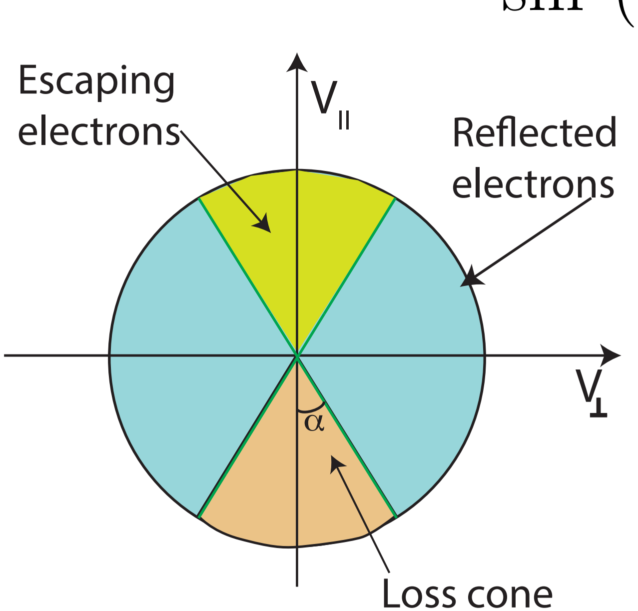
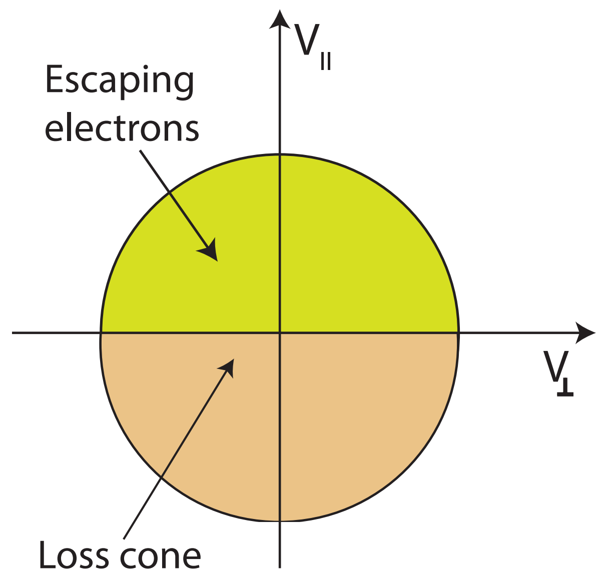
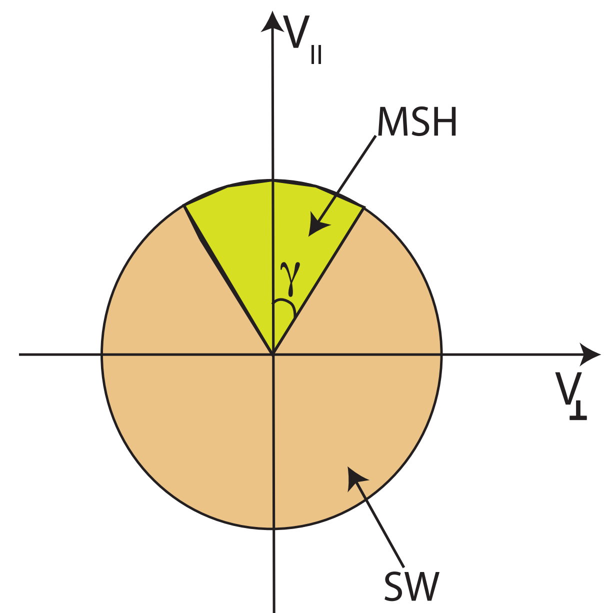
Shock electron acceleration theory



$$\frac{\sin^2(\alpha_{\mathrm{local}})}{\sin^2(\alpha_{\mathrm{max}})} = \frac{B_{\mathrm{local}}}{B_{\mathrm{max}}}$$





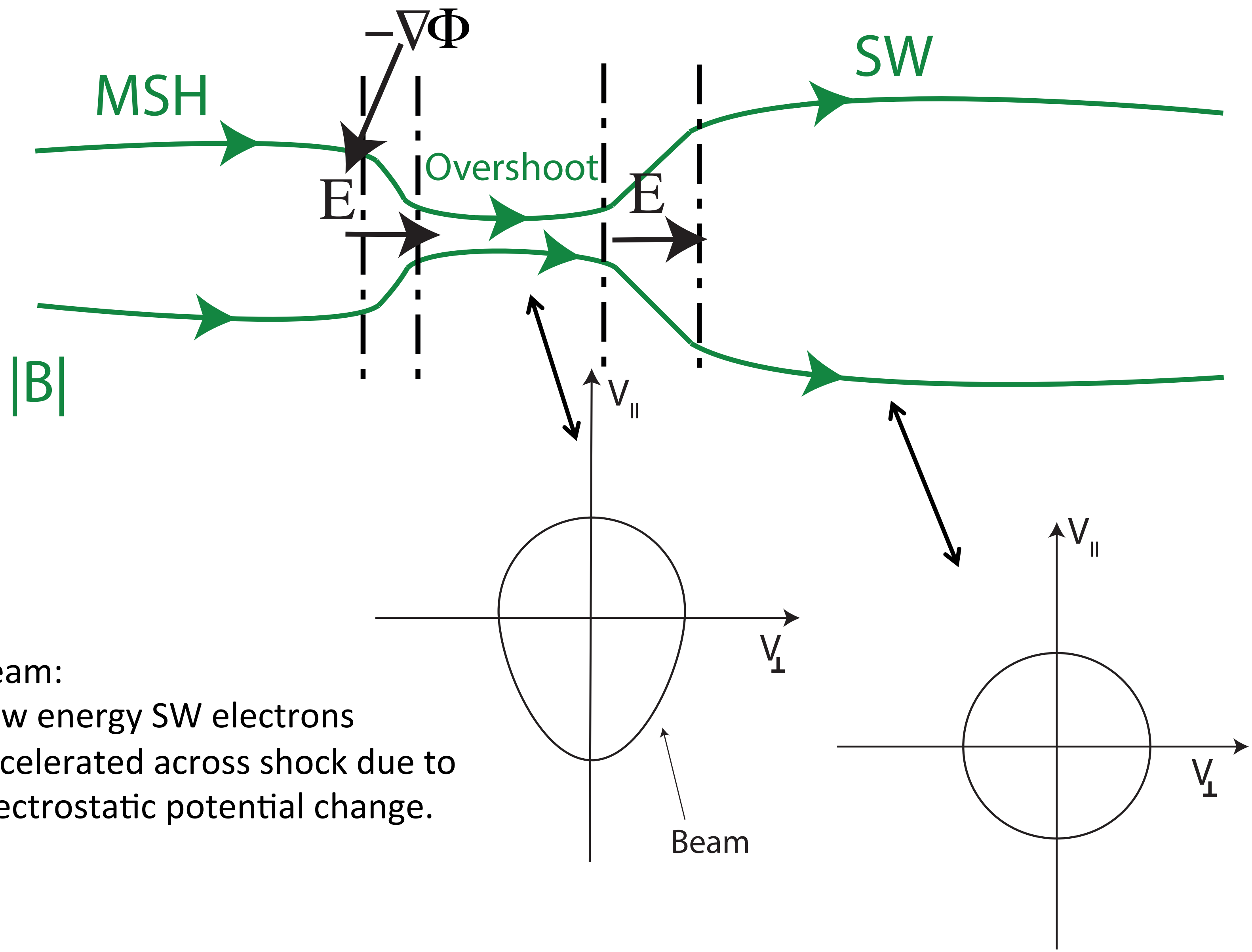


$$\sin^2(\alpha) = \frac{\mathrm{B_{MSH}}}{\mathrm{B_{Overshoot}}}$$

$$\sin^2(\gamma) = \frac{\mathrm{B_{SW}}}{\mathrm{B_{Overshoot}}}$$

Feldman et al. 1983 JGR

Shock electron acceleration theory

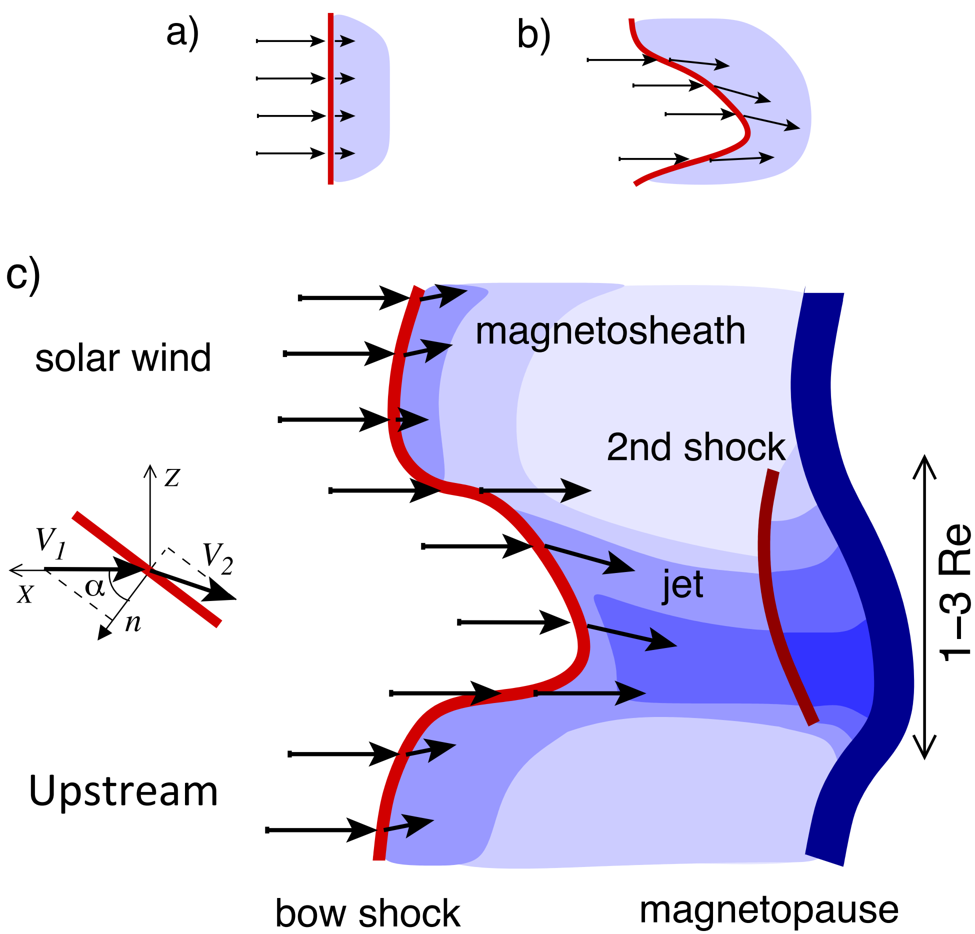


Beam:
Low energy SW electrons accelerated across shock due to electrostatic potential change.

Feldman et al. 1983 JGR

elin.eriksson@irfu.se

MSH jets



Downstream

Hietala et al., 2012 AG.

- Jets not related to reconnection
- Possible mechanism – shock geometry
- decelerates upstream velocity normal to the shock, while tangential velocity is the same. Whole vel. deflected.
- Deflected flow causing local density enhancement.

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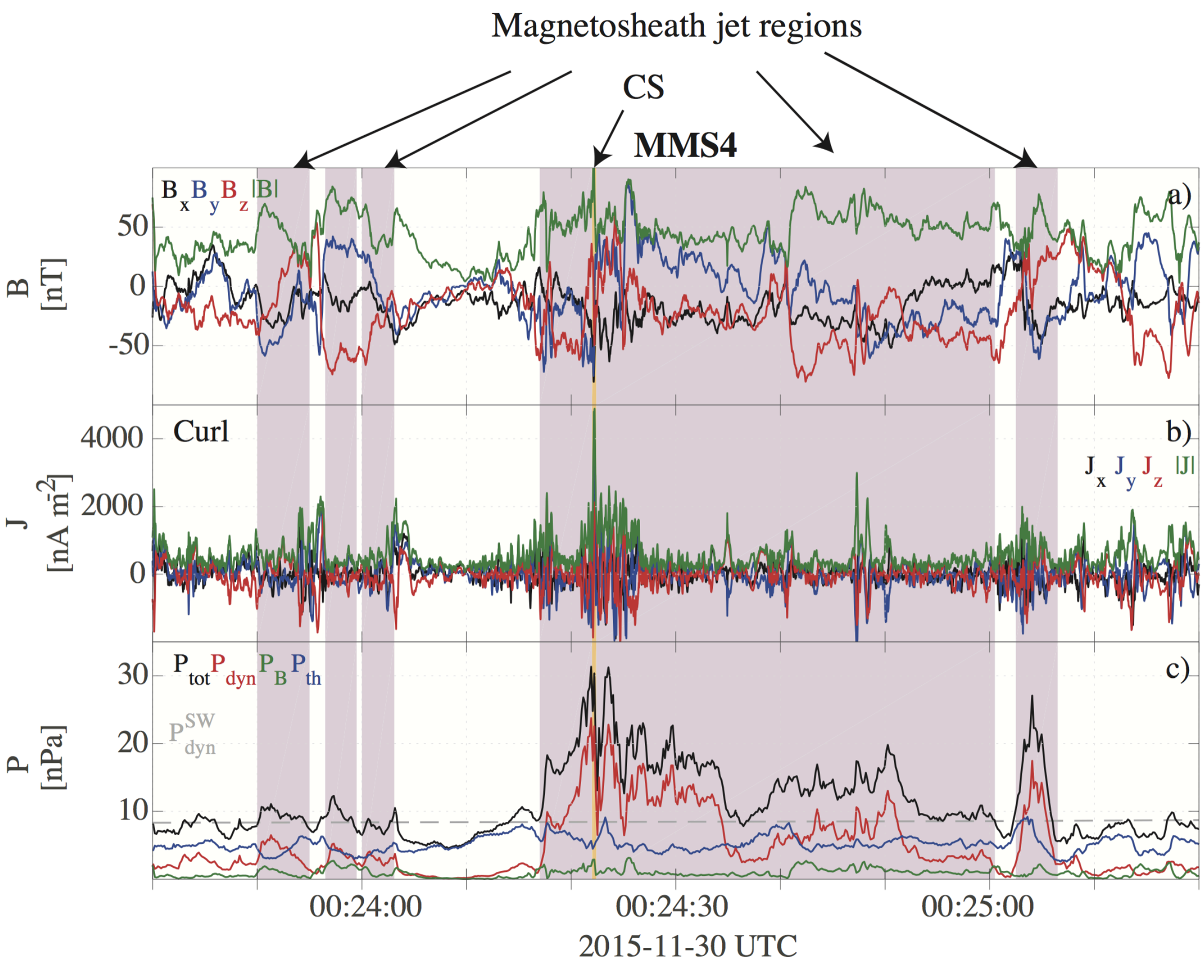
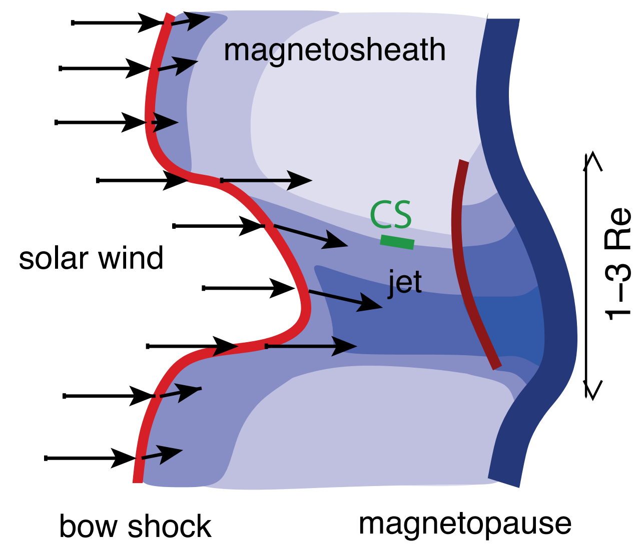
CS Overview – MSH jets



Adapted from *Eriksson et al. 2016 JGR*

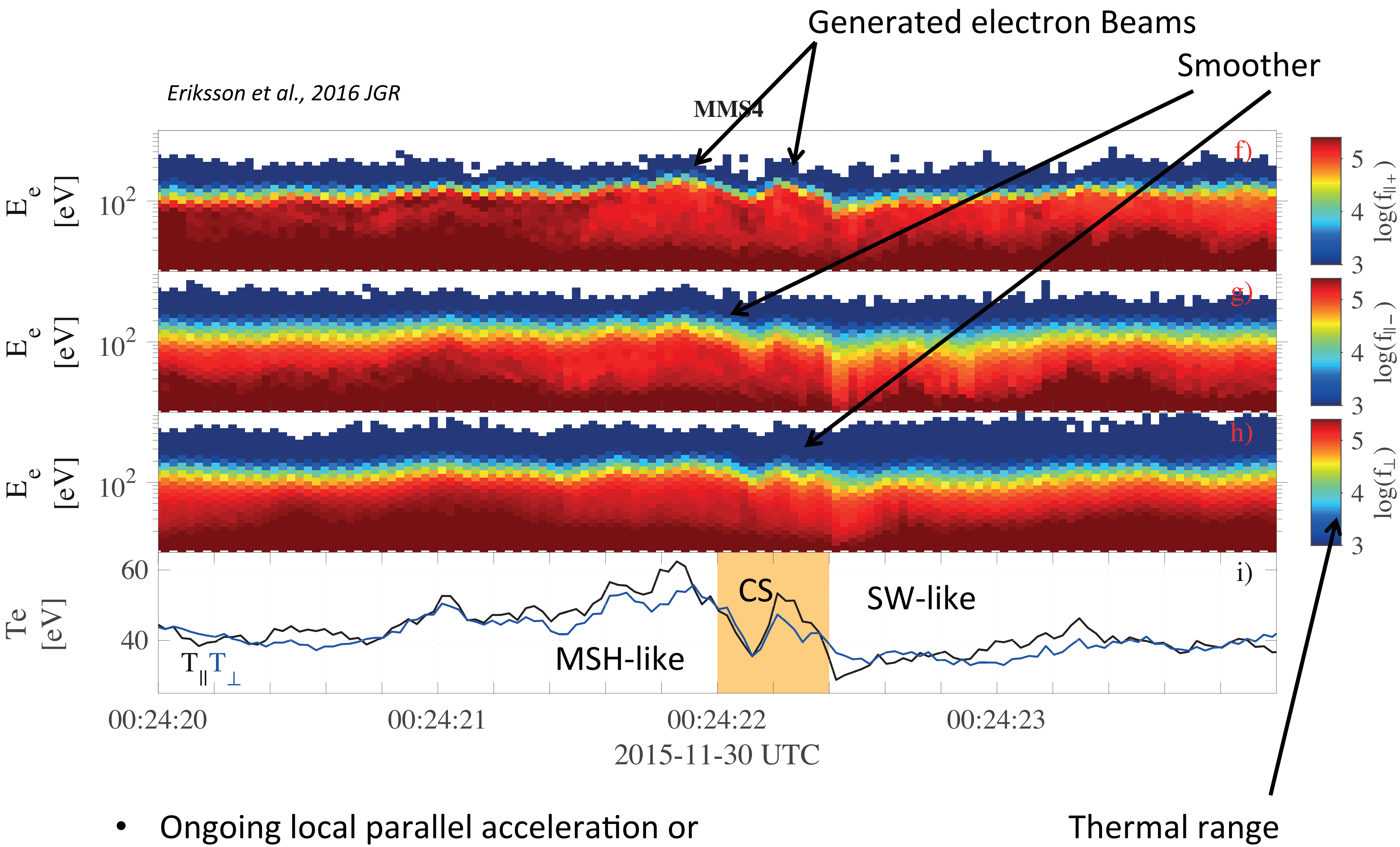


Adapted from *Hietala et al. 2012 AG.*

- Plaschke et al 2013 AG criteria => MSH jets.
- v_sw=466 km/s, n=19 cm^{-3} => highly compressed MSH.

elin.eriksson@irfu.se

MSH CS Acceleration



- Ongoing local parallel acceleration or forming elsewhere and propagating in.

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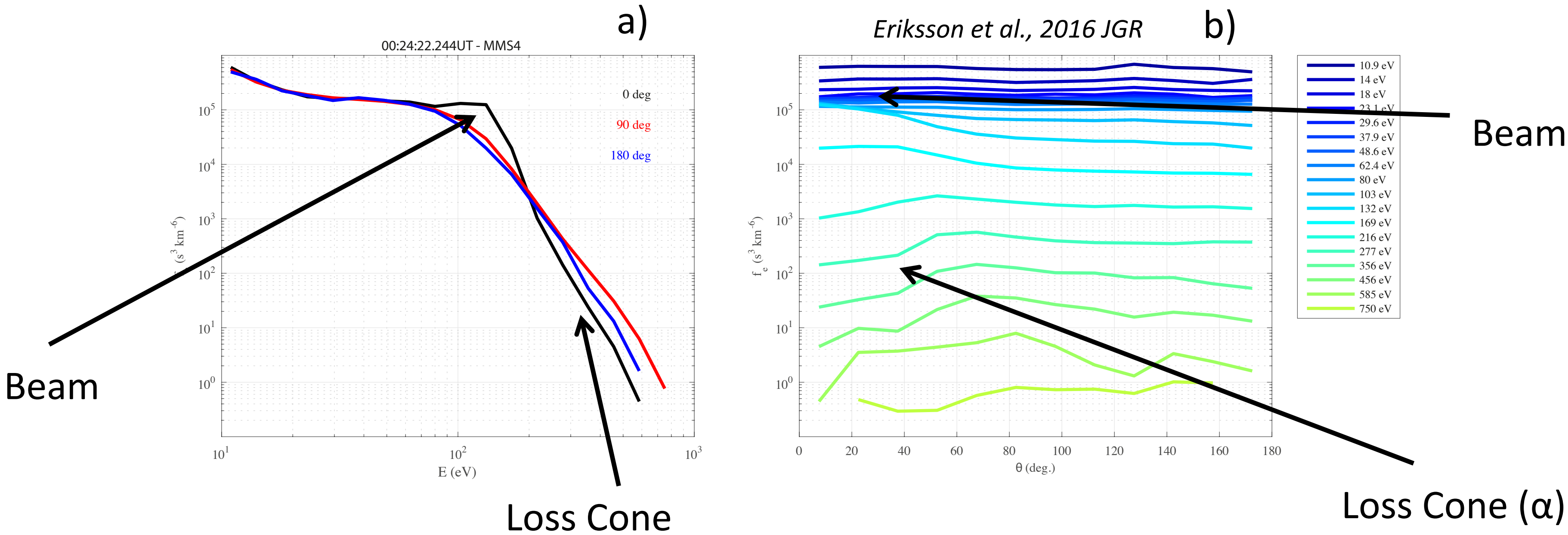
Local parallel acceleration - Electron beam



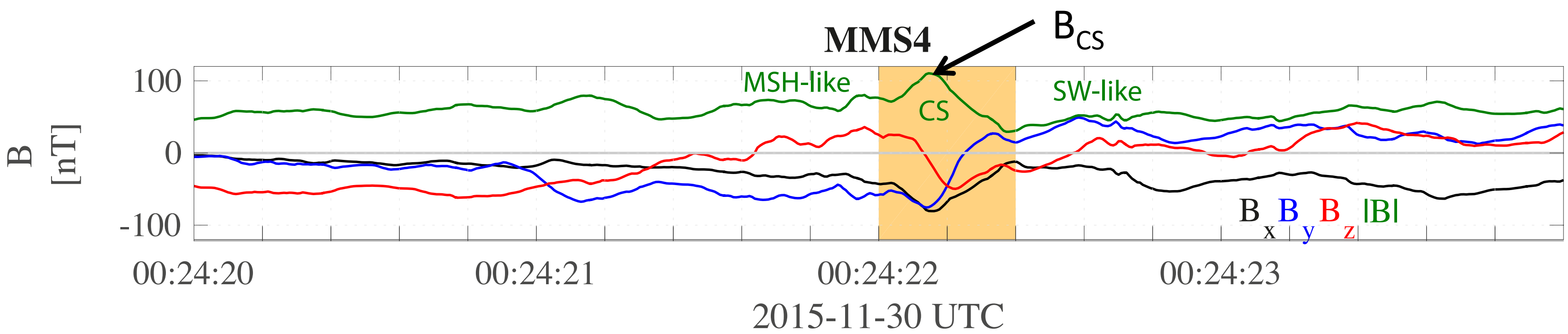
Study electron distribution function in detail.

Beam in the middle of the current sheet.

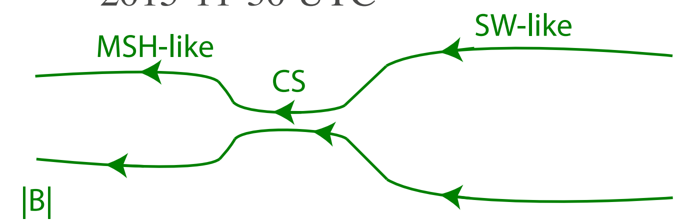
Beam at 80-200 eV angular direction of PA less than about 45 degrees.
Decrease in the electron distribution in parallel direction compared to other direction at higher energies => loss cone.

elin.eriksson@irfu.se

Local parallel acceleration - Electron beam



$$\sin^2(\alpha) = \frac{B_{\mathrm{MSH-like}}}{B_{\mathrm{CS}}}$$



Ratio of local magnetic field magnitude and the peak magnitude (CS) along the electron path.

Loss cone with PA close to 90° at the largest magnetic field magnitude (CS).

All observed high energy (MSH) electrons from MSH-like region escape into SW-like region.

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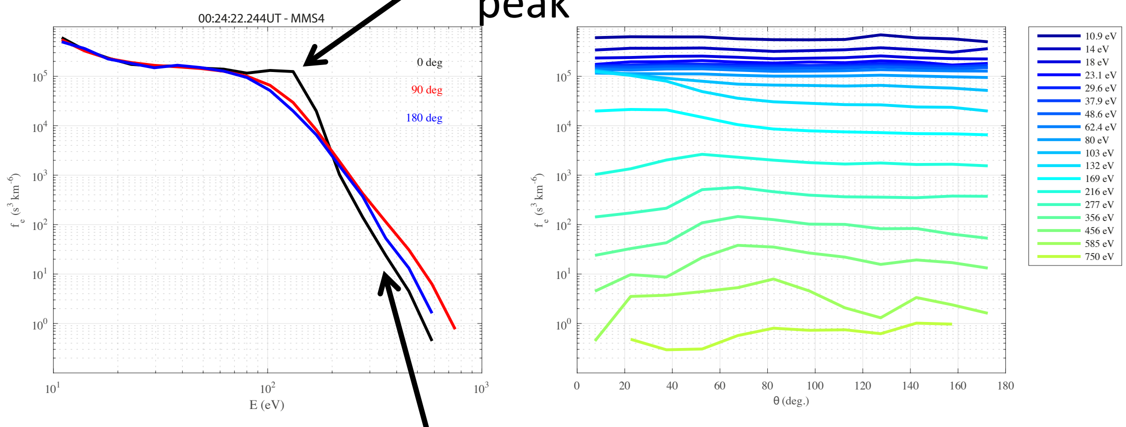
Local parallel acceleration – acceleration mechanism

High energy peak



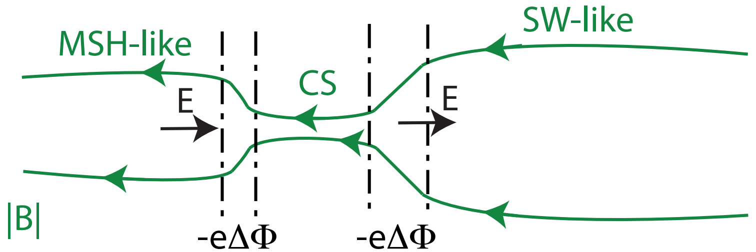
Eriksson et al., 2016 JGR

Sharp Slope

Two reasons.

1) Local parallel electric field.
2) More diffused beams at other places in the interval.

Observed beam and loss cone features fits well with Feldman et al. 1983 JGR theory of electron acceleration across a shock due to change in electrostatic potential.



Beams are locally generated in the MSH as well.

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Conclusions

Beams can be locally accelerated in the MSH not just at the bow shock.

This study can be important when interpreting interplanetary shocks with Solar Orbiter. Larger region for brst interval.

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