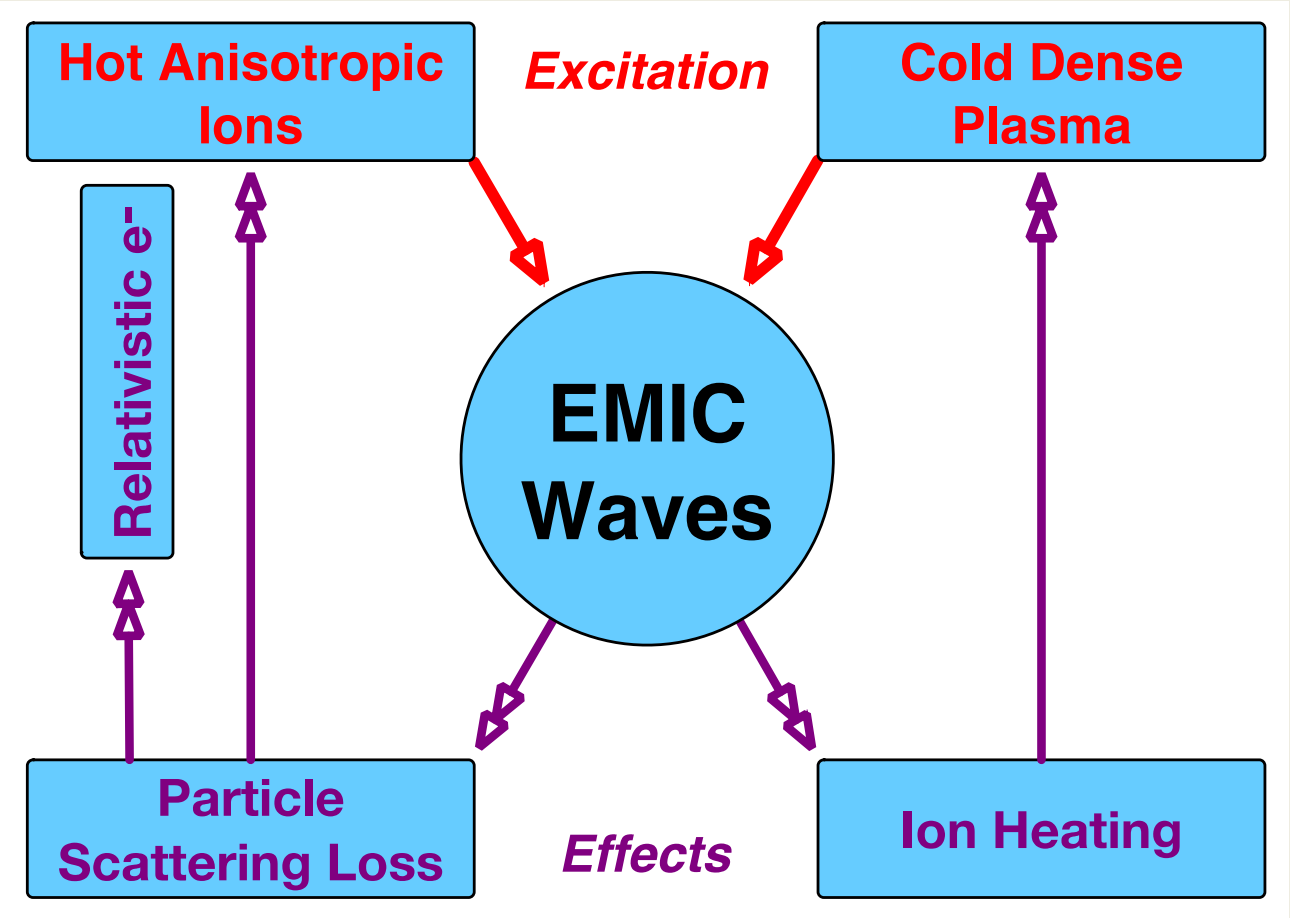
# EMIC waves in the geospace

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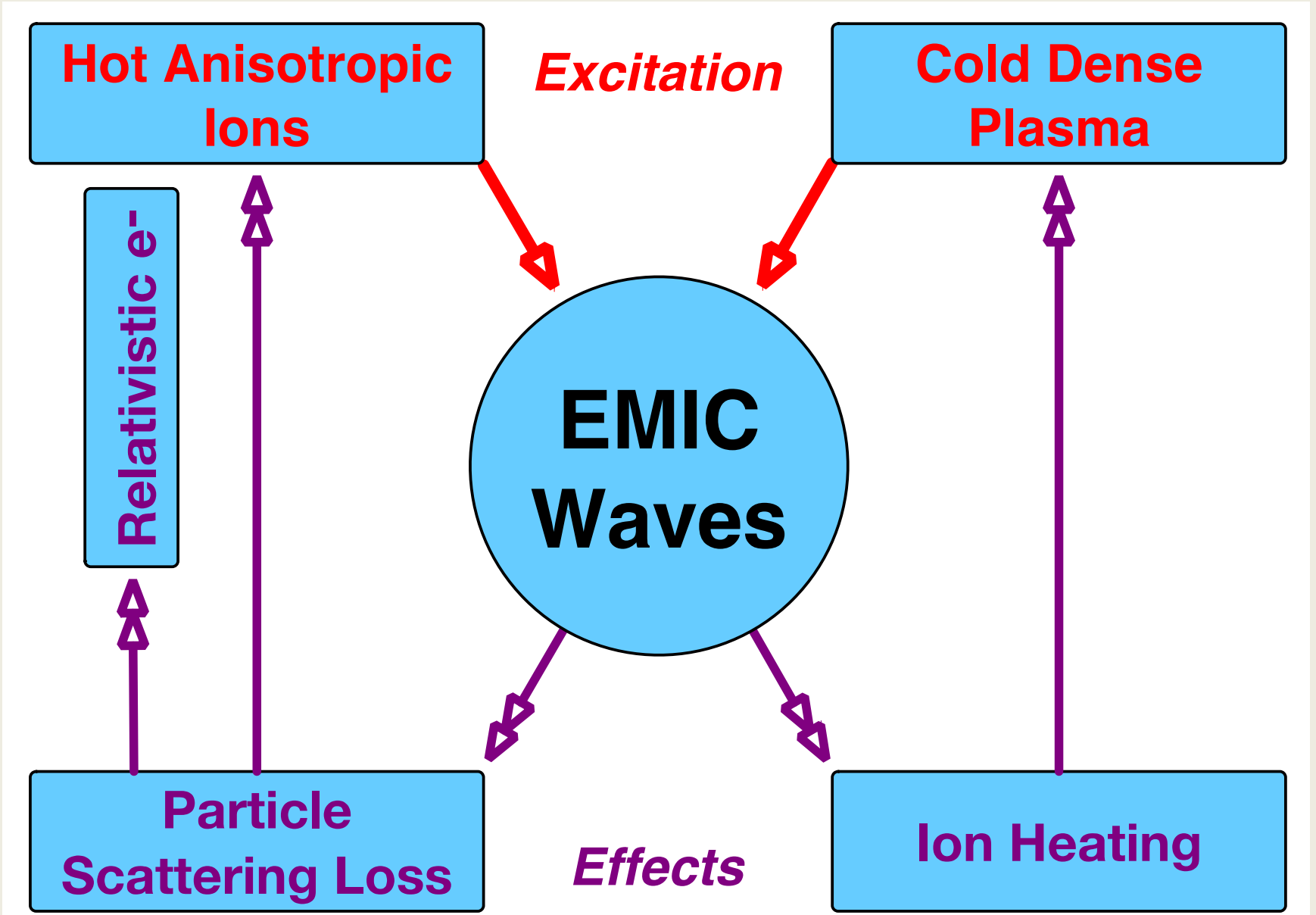
# Outline

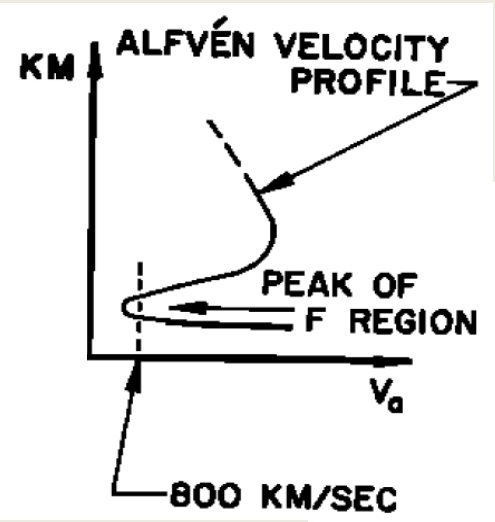
- [J.-C. Zhang] Introduction to EMIC waves
- [A. A. Saikin] EMIC waves from the Van Allen Probes
- Summary

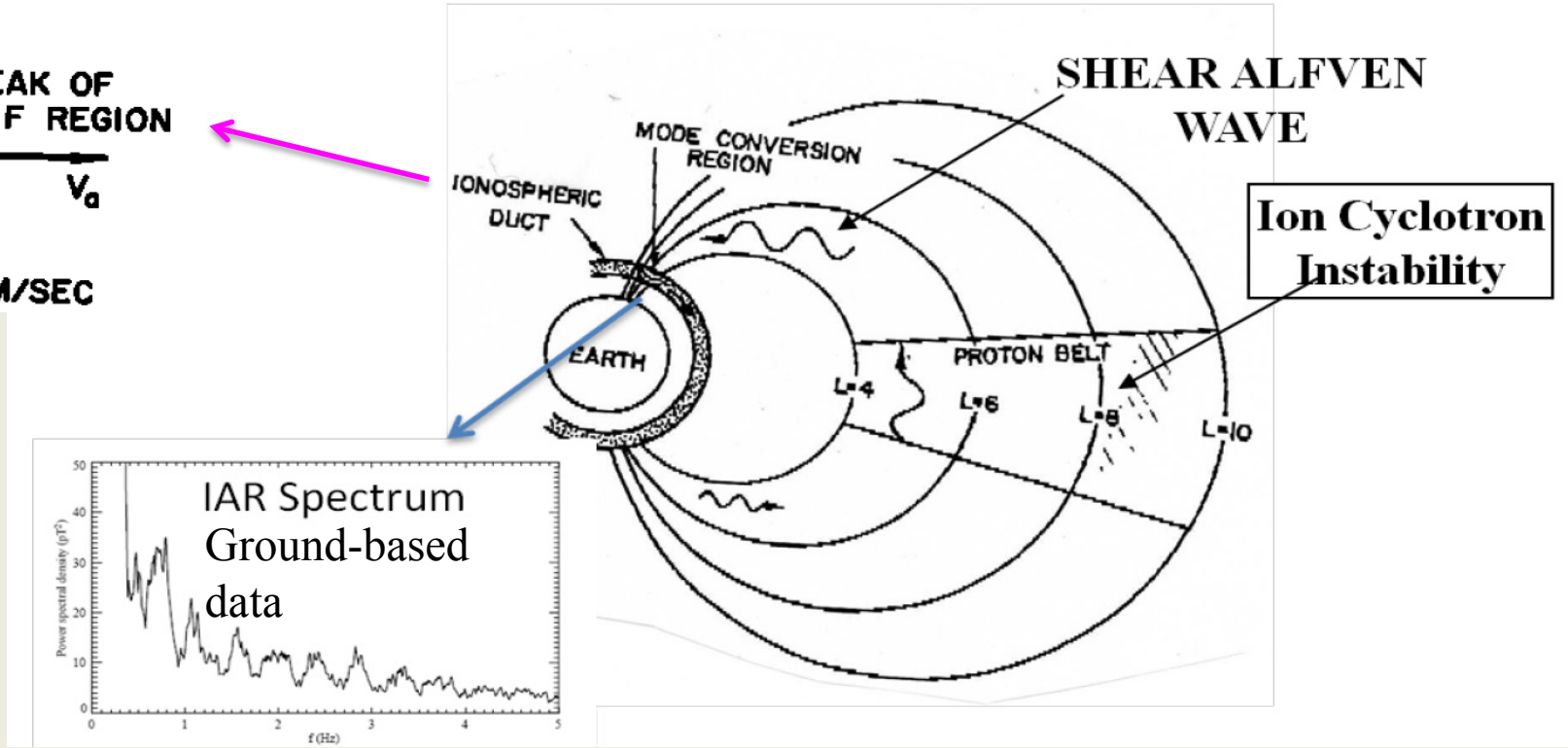
# Electromagnetic Ion Cyclotron (EMIC) Waves in ONE Diagram




*Zhang et al.* [2016]

# EMIC Wave Propagation in the Ionosphere: Ducting

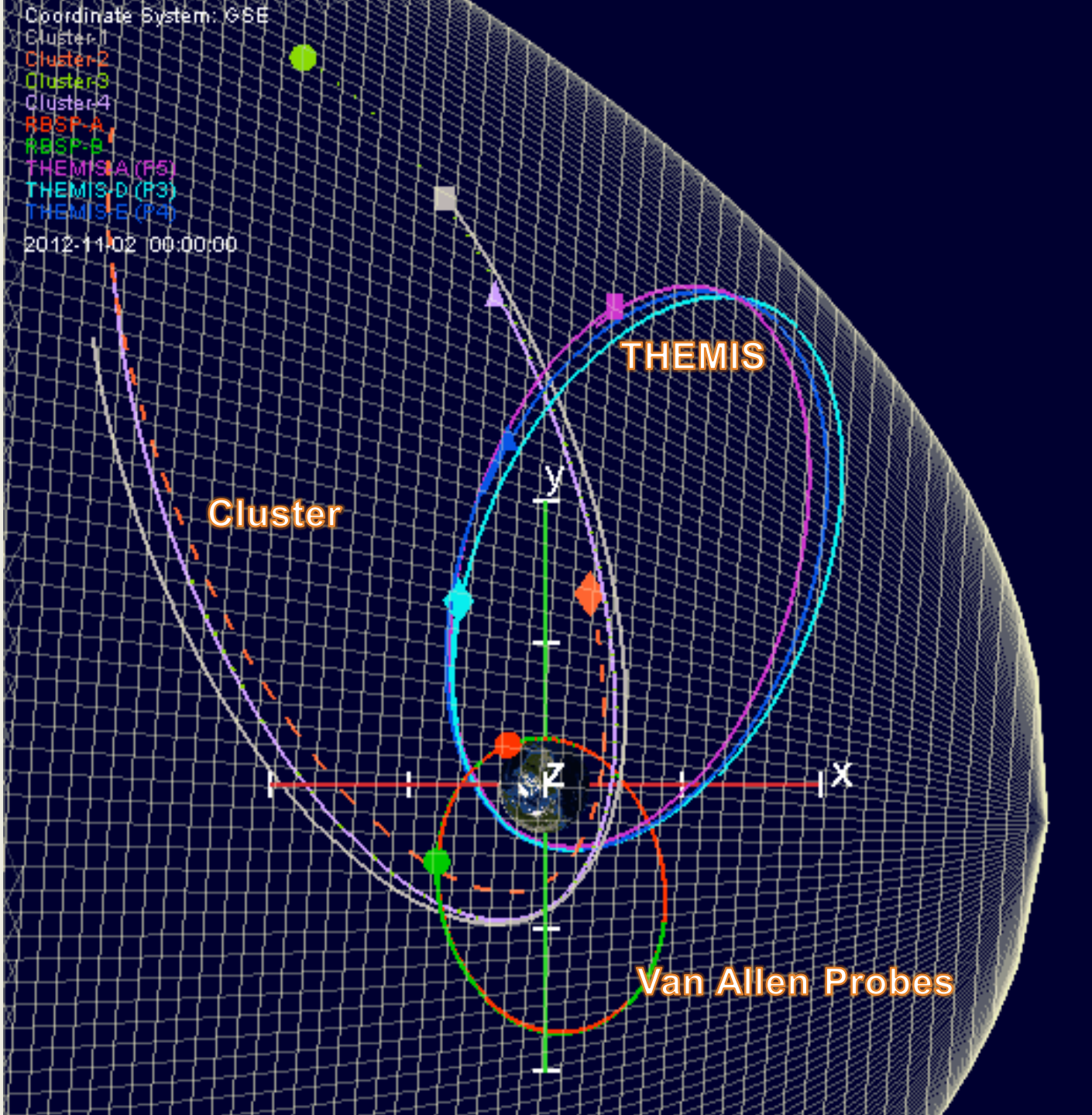



Energy flow starting as shear Alfvén wave (EMIC wave), filtered through the ionospheric Alfvén resonator (IAR) and propagating laterally as magnetosonic in the duct. Courtesy of K. Papadopoulos.

# Multi-point Observations

◆ Ongoing EMIC wave investigation: Combine observations from Van Allen Probes, Cluster, and THEMIS (as well as MMS and SWARM*) to investigate the spatial distribution & temporal evolution of EMIC waves in the magnetosphere

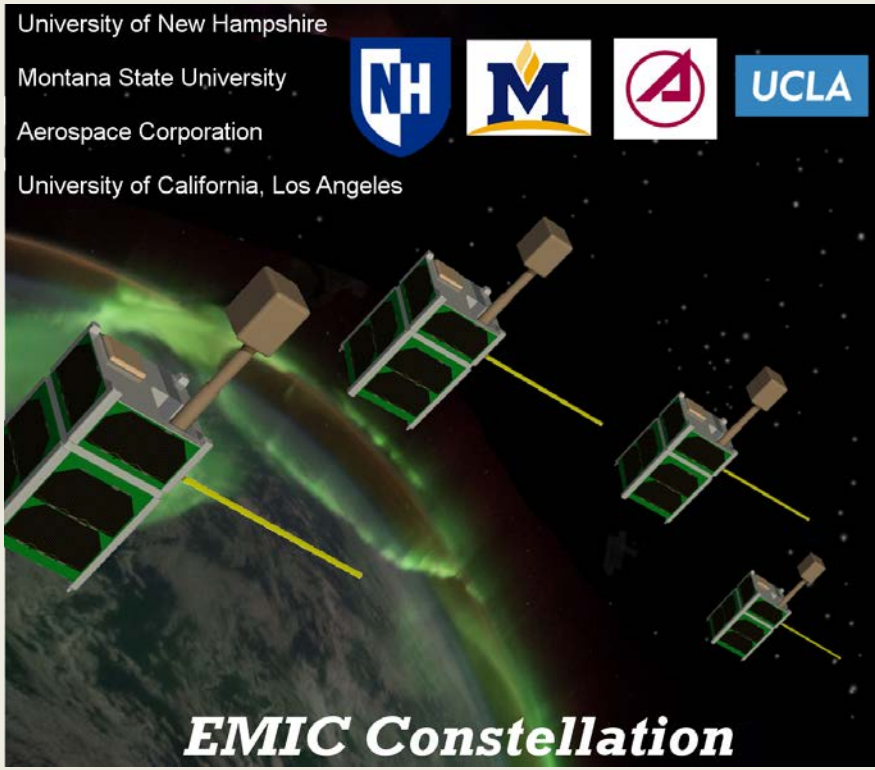



* Prof Hui Wang has worked on EMIC waves observed by SWARM.

# EMIC Multipoint Ionospheric CubeSat Constellation or EMIC Constellation

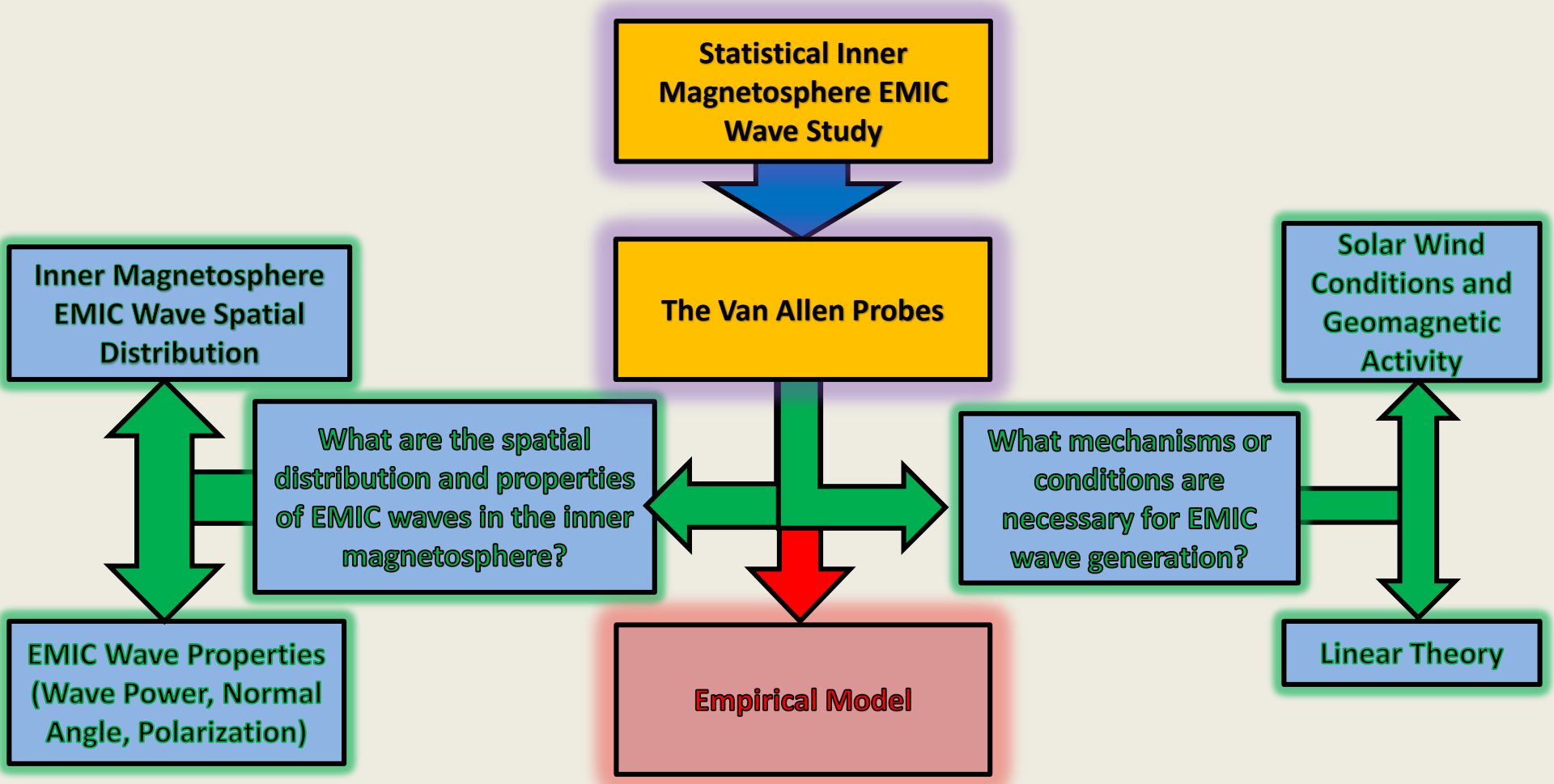
- Objective: To determine the role of electromagnetic ion cyclotron (EMIC) waves in causing relativistic electron precipitation (REP)

- Team: Jichun Zhang (PI) and a group of scientists/engineers at UNH, Montana State University, Aerospace Corporation, and UCLA

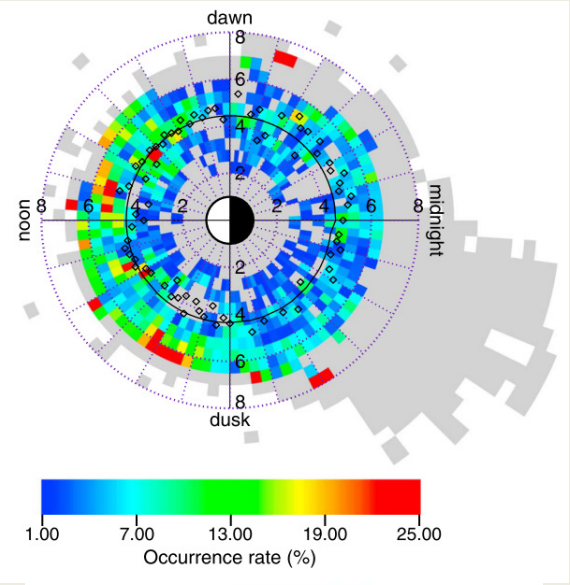



"CubeSats have historically been used as teaching tools and technology demonstrations, and now may offer newly developed capabilities for the conduct of NASA scientific research and technology advancement." [NASA ROSES-2016]

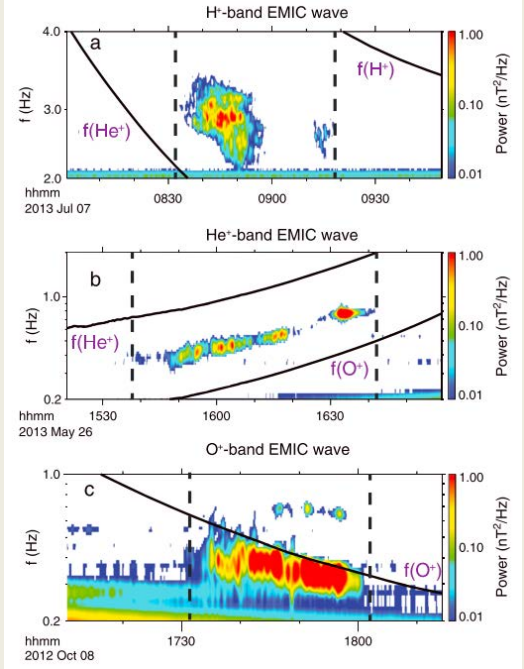
# Thesis Summary

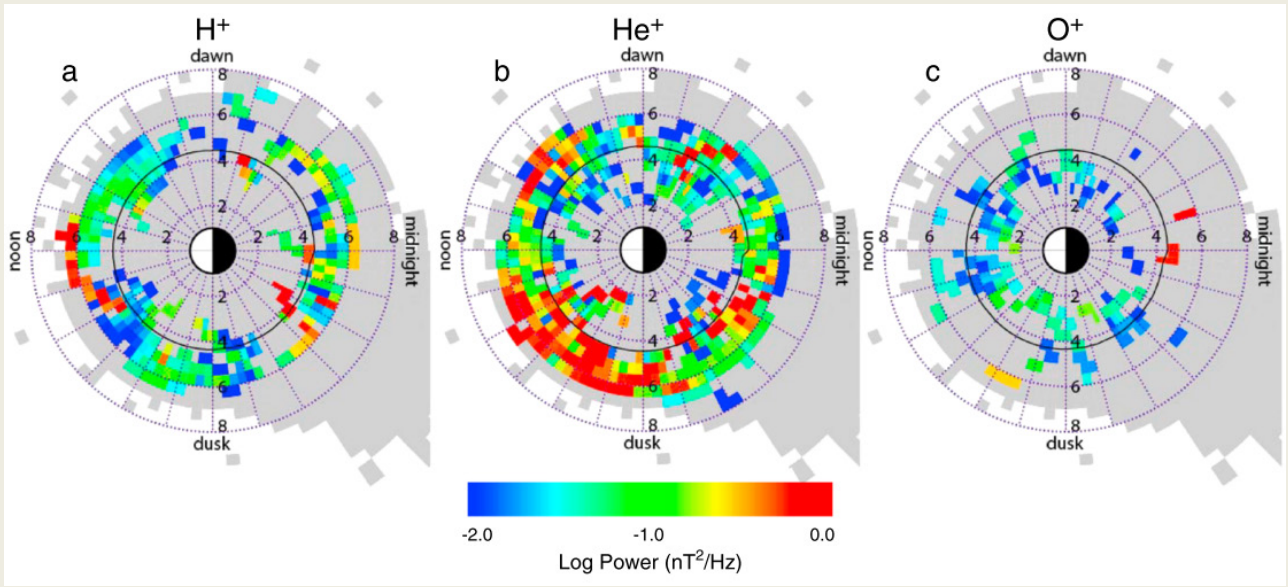


# Occurrence and wave power [*Saikin et al.*, 2015]



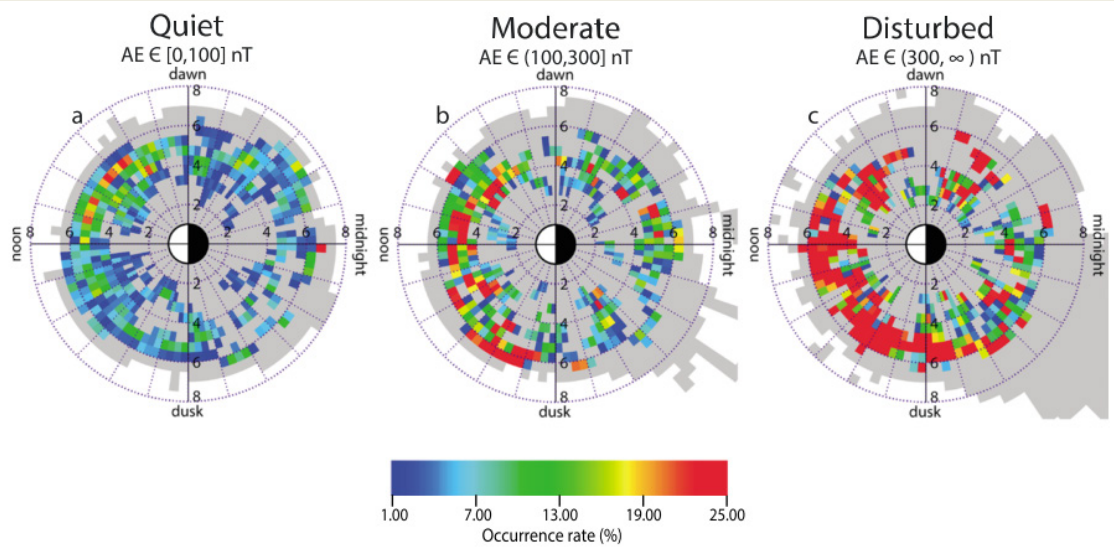

- Overall, EMIC waves are preferably observed on the dayside (left).
- EMIC waves occur in 3 distinct wave bands ($H^+$-, $He^+$-, and $O^+$-band) (bottom left).
- Wave properties (e.g., wave power (shown below), normal angle, polarization) are not consistent between wave bands.

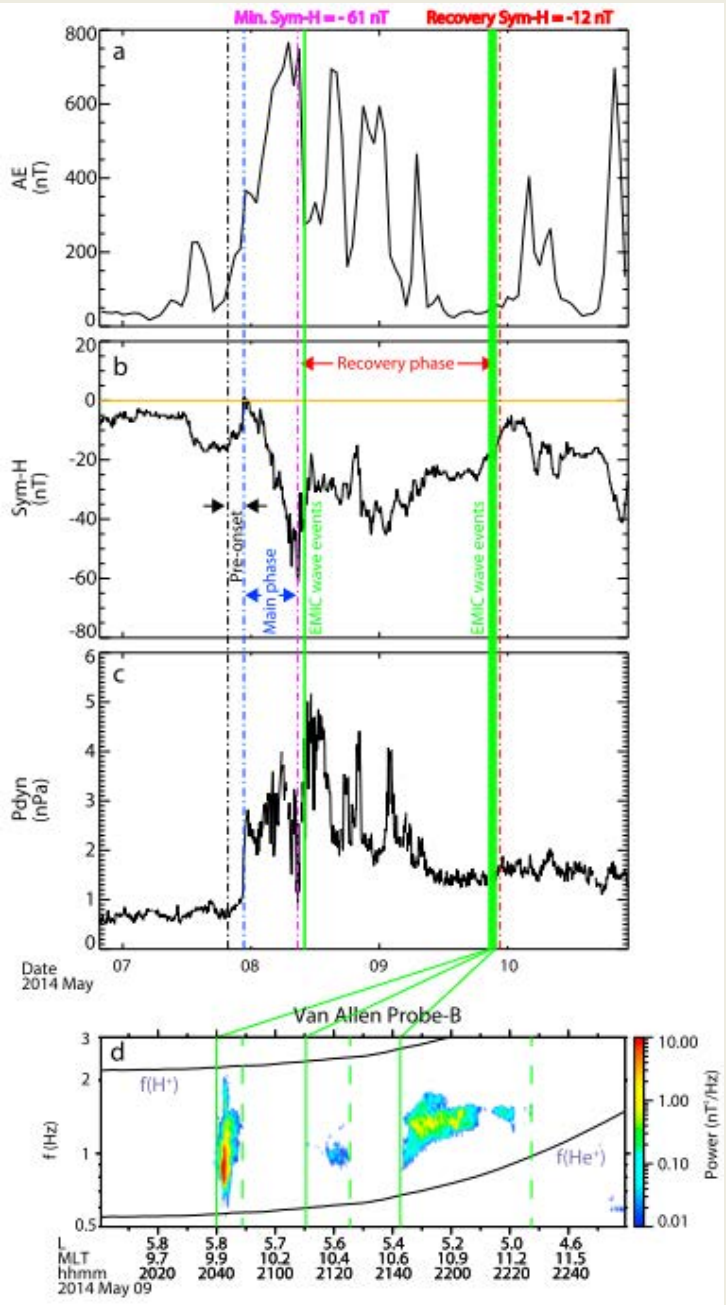


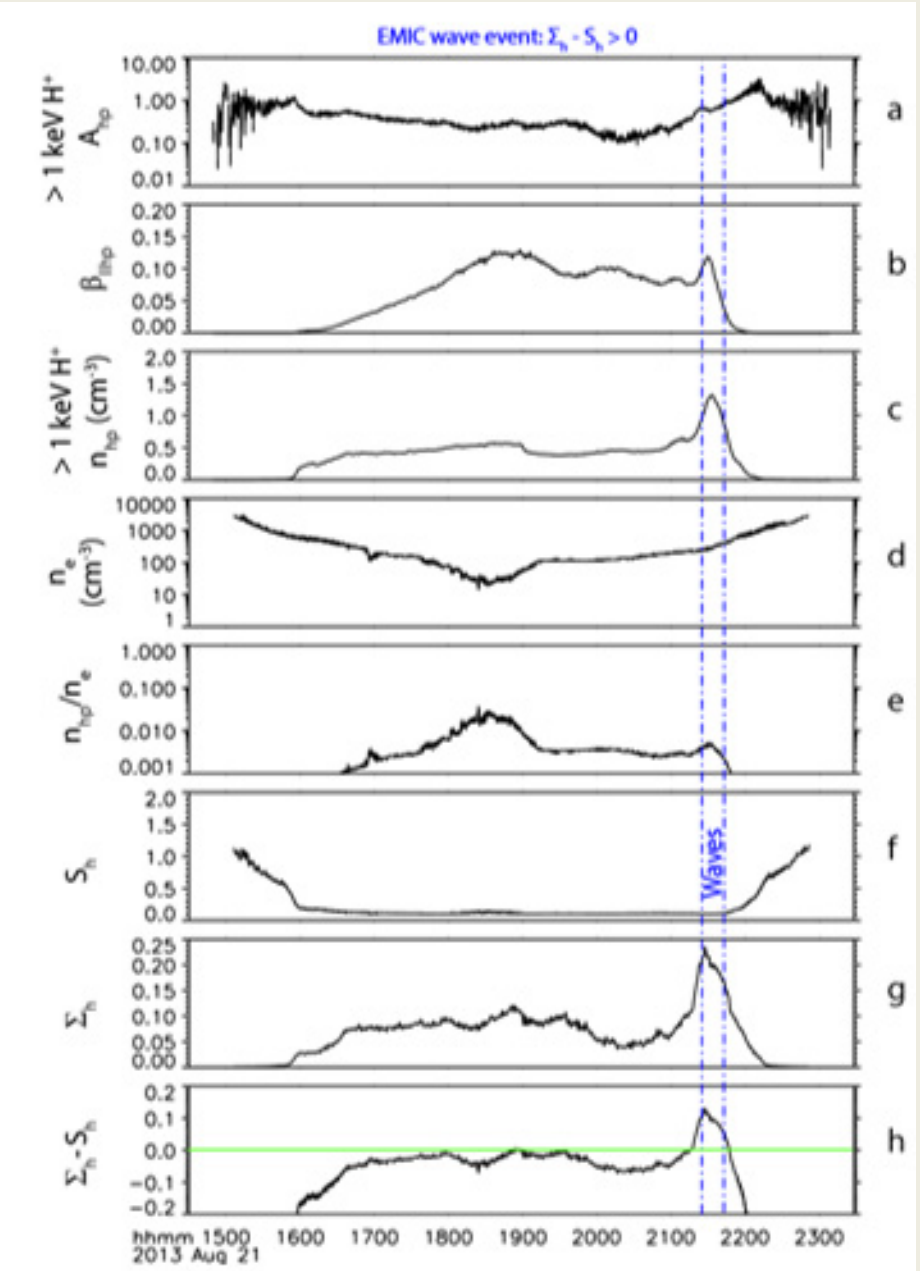
# Geomagnetic storms and EMIC waves [*Saikin et al.*, 2016]

- Geomagnetic activity can produce the conditions necessary for EMIC wave generation (right).
- The stronger the geomagnetic activity, the more likely EMIC waves will generate (below).

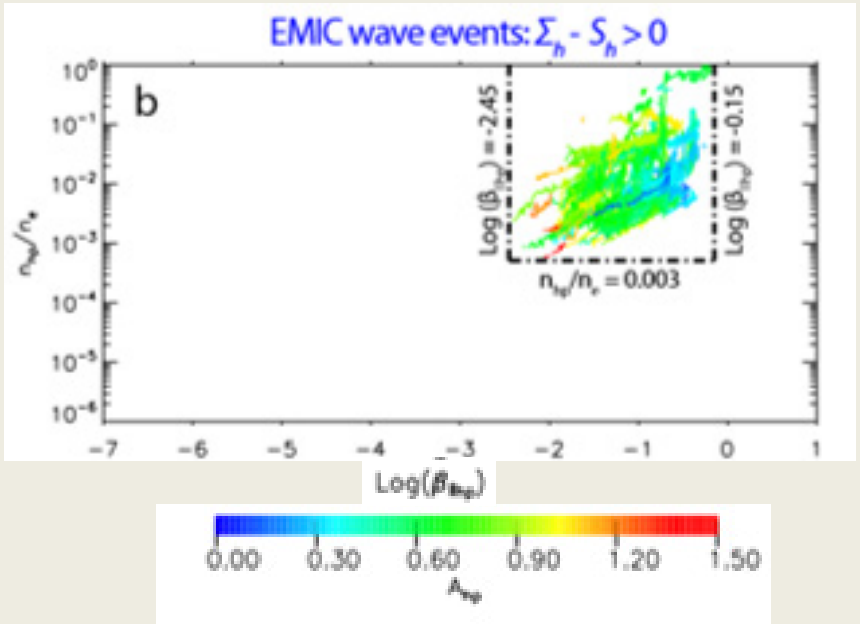


# Wave generation [*Saikin et al*., under review]




- Favorable plasma conditions for EMIC wave generation produce sufficient wave growth over the instability threshold.



# Summary

1. EMIC waves are induced by anisotropic distributions of energetic ions, overlapping with cold dense plasma, in the local min. *B* regions.

2. Predicting the occurrence regions of EMIC waves poses a challenge to our current magnetospheric modeling and theory.

3. So far, we have not reached a consensus on some key properties of EMIC waves., e.g., propagation & reflection.

4. Combining multi-point observations from space missions and a CubeSat constellation provides an unprecedented opportunity to better understand EMIC waves in the magnetosphere and ionosphere.