Auroral electron energy and energy flux derivation using multi-spectral imaging

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Background

- Auroral electrons are stopped at different altitudes based on their energy [1] (Fig. I) : use simultaneous multi-spectral measurements to derive energy and energy flux
- Approach: fit modeled brightness/ brightness ratios using an electron transport model with measurement to derive energy and fluxes

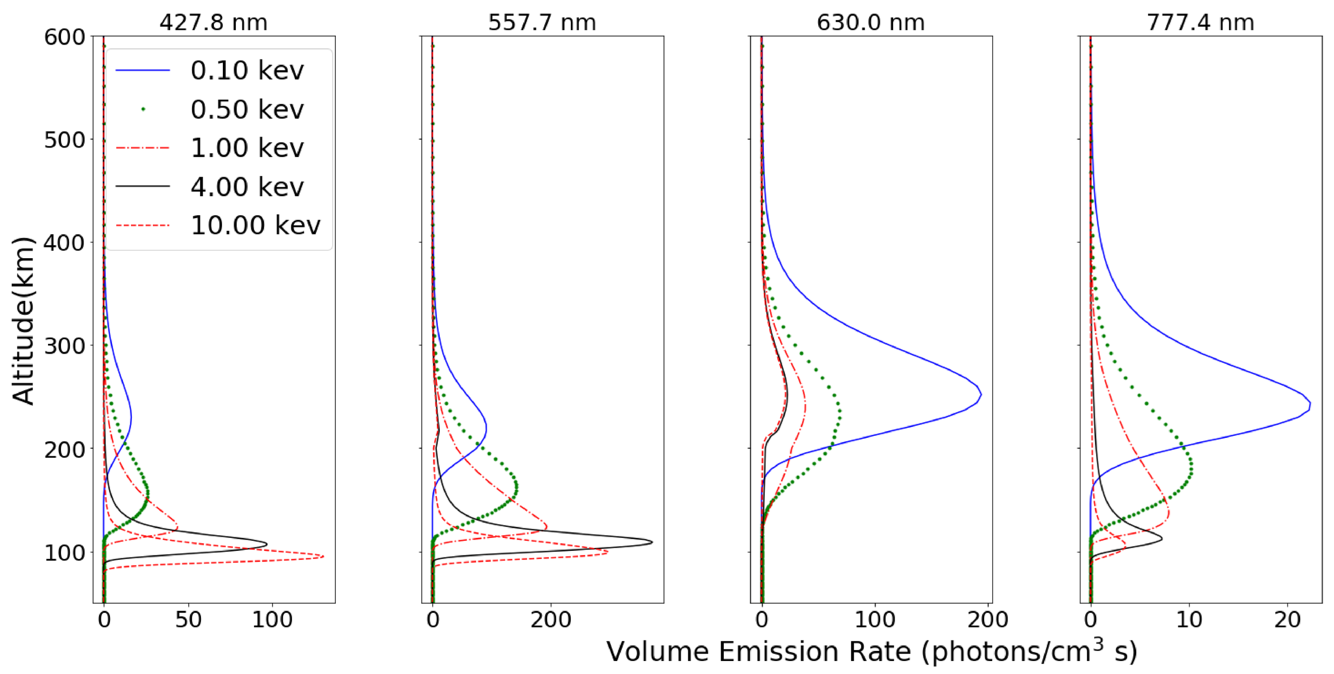


Fig I: Volume emission rates of various upper atmospheric emission features as a function of primary electron energy using GLobal airglOW (GLOW) model [2]. Note the peak height of emission shifts with energy.

Instrument and Data

- High Throughput and Multislit Imaging Spectrometer (HiT&MIS): ~ 0.01 nm resolution (at 630 nm) and FOV of 0.1 X 50° [3]
- We present June 22, 2015 G4 storm observed at Lowell, MA (42.6° N, 71.3° W) ~ 45° from zenith due northeast
- Simultaneous measurements OI: 630.0 nm (red), OI: 557.7 nm (green), OI: 777.4 nm and N^+_2: 427.8 nm (blue) and Ne I 630.5 nm (for cloud activity)

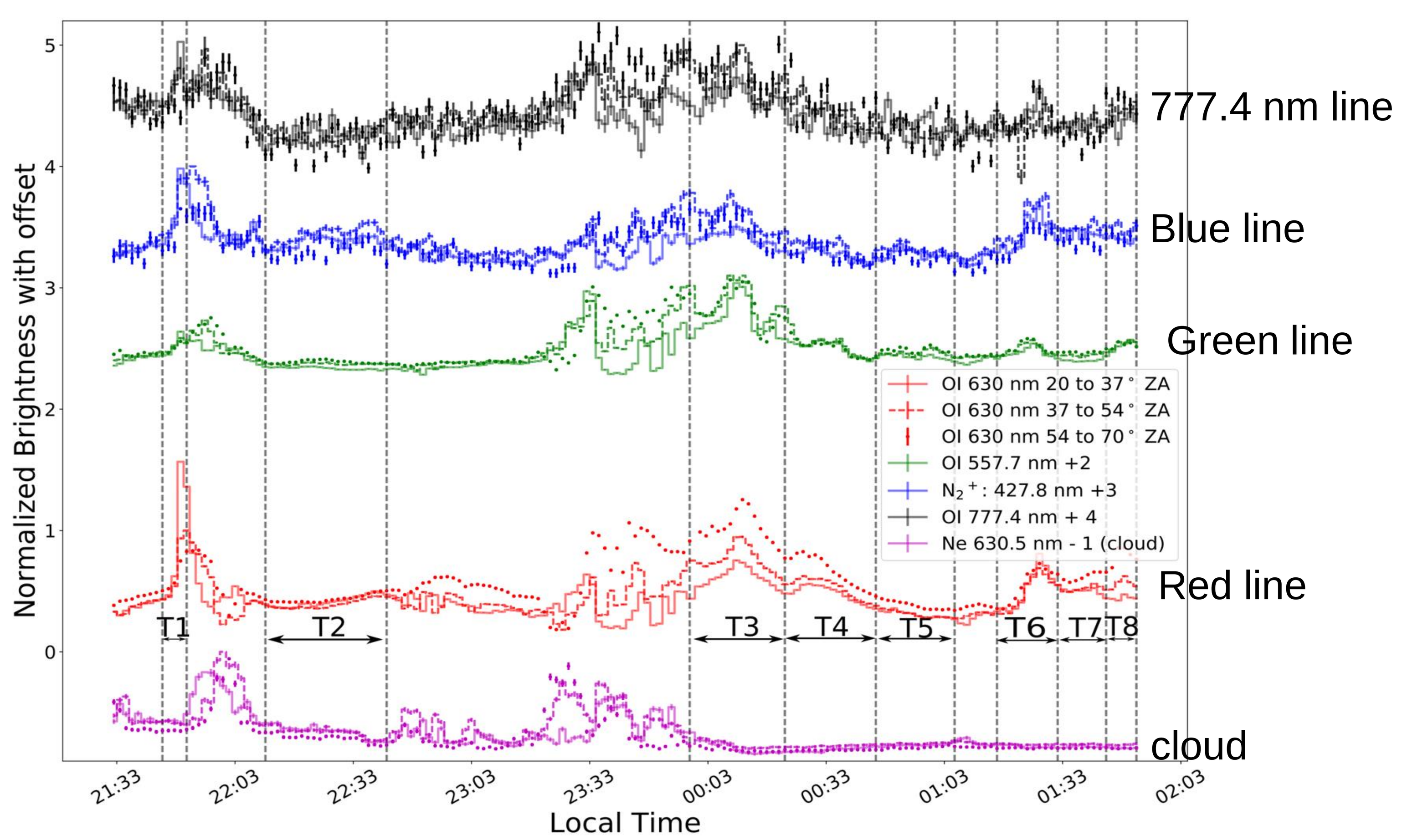
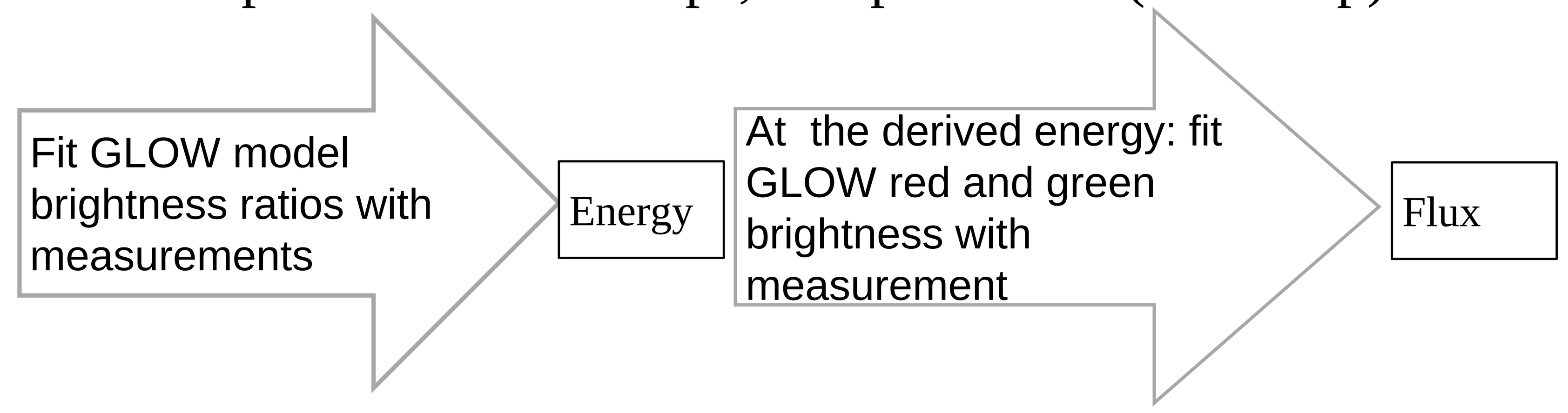


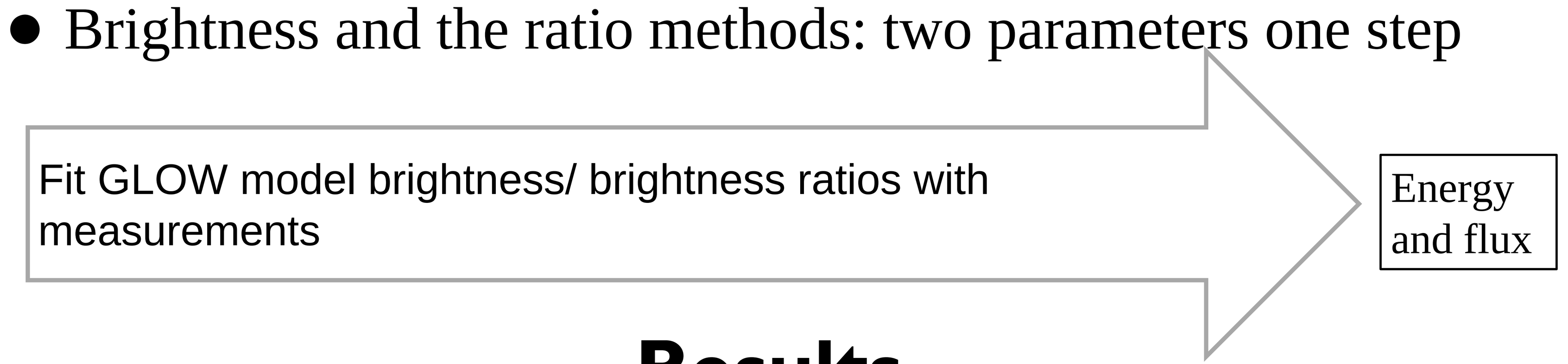
Fig II. Normalized average brightnesses as a function of local time (LT) for the four observed features at different Zenith Angle (ZA) bins. The Ne I: 630.5 nm feature (also present in HiT&MIS) is used as a tracer for cloud activity. The time periods T1 through T8 are picked for analysis based on the cloud activity.

Derivation of Energy and Flux

- Energies and fluxes for the time periods chosen (T1-T8) in Fig. II are derived using three methods based on non-linear least-squares minimization by utilizing the Levenberg–Marquardt algorithm
- Two step method: two steps, one parameter (each step)



- Brightness and the ratio methods: two parameters one step



Results

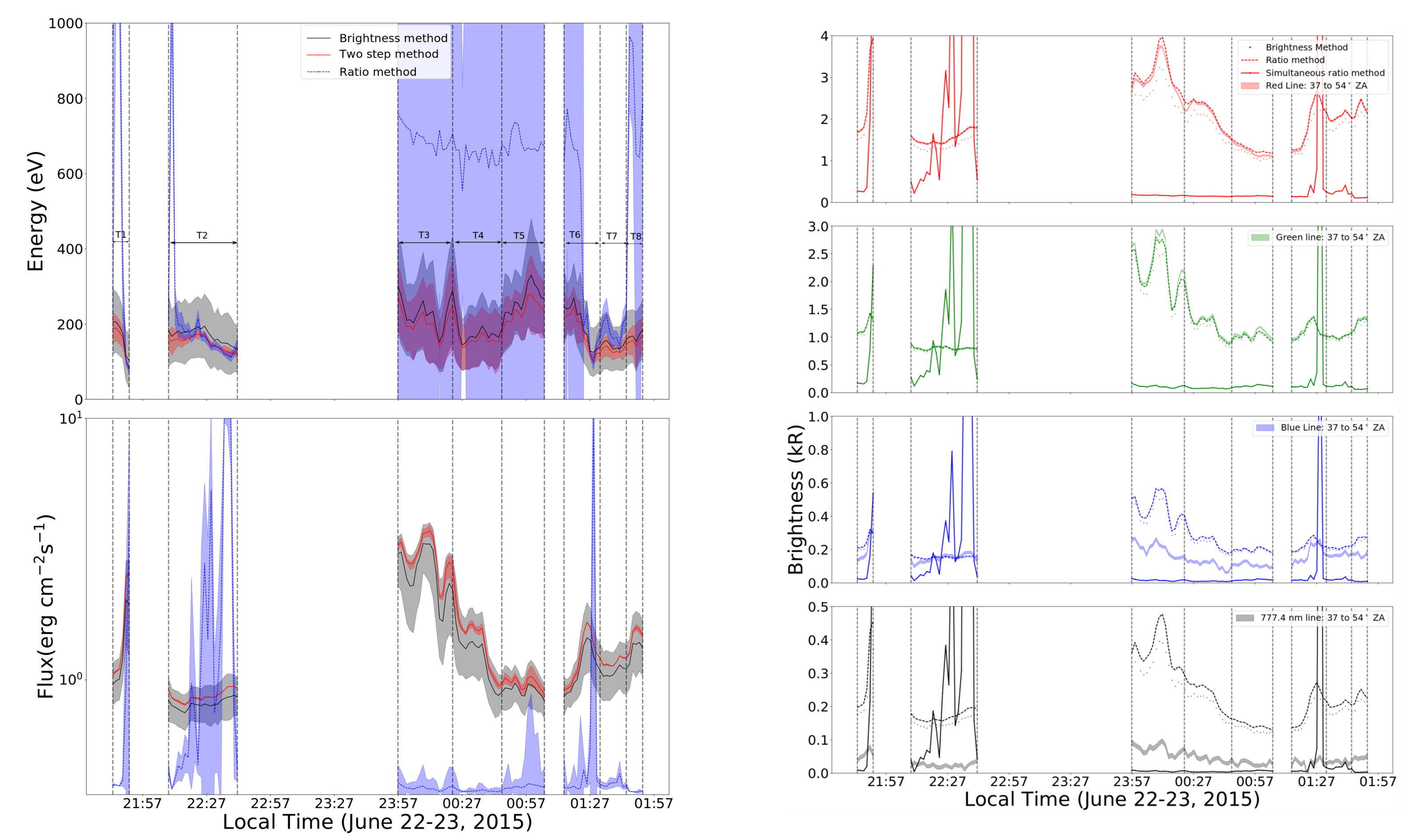


Fig III: Energies and fluxes derived using the three different methods at the 37-54 ZA (left) and comparison of measured brightnesses with brightnesses estimated using the derived energies and fluxes (right). Notice that the brightness and the two step method have similar results and produce better fits to the measurements

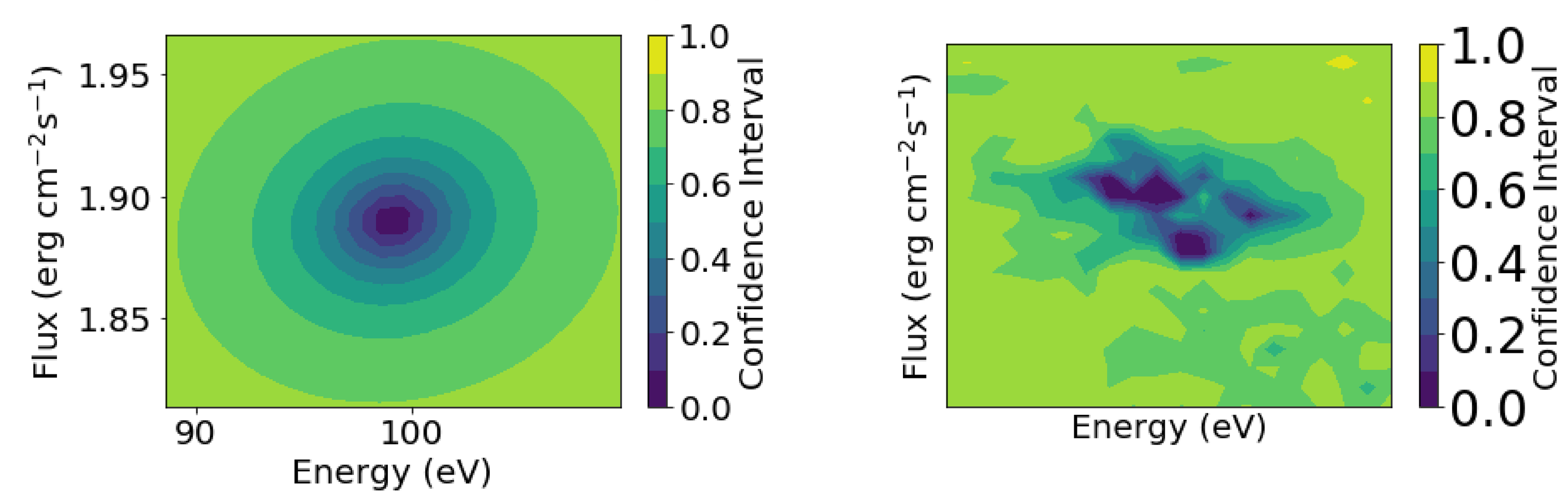


Fig IV. Confidence interval at 10:30 PM LT derived using the brightness method (left) and the ratio method (right). The location of the minimum least-squares is at the 0 confidence interval. Notice the confidence interval for the brightness method is symmetric.

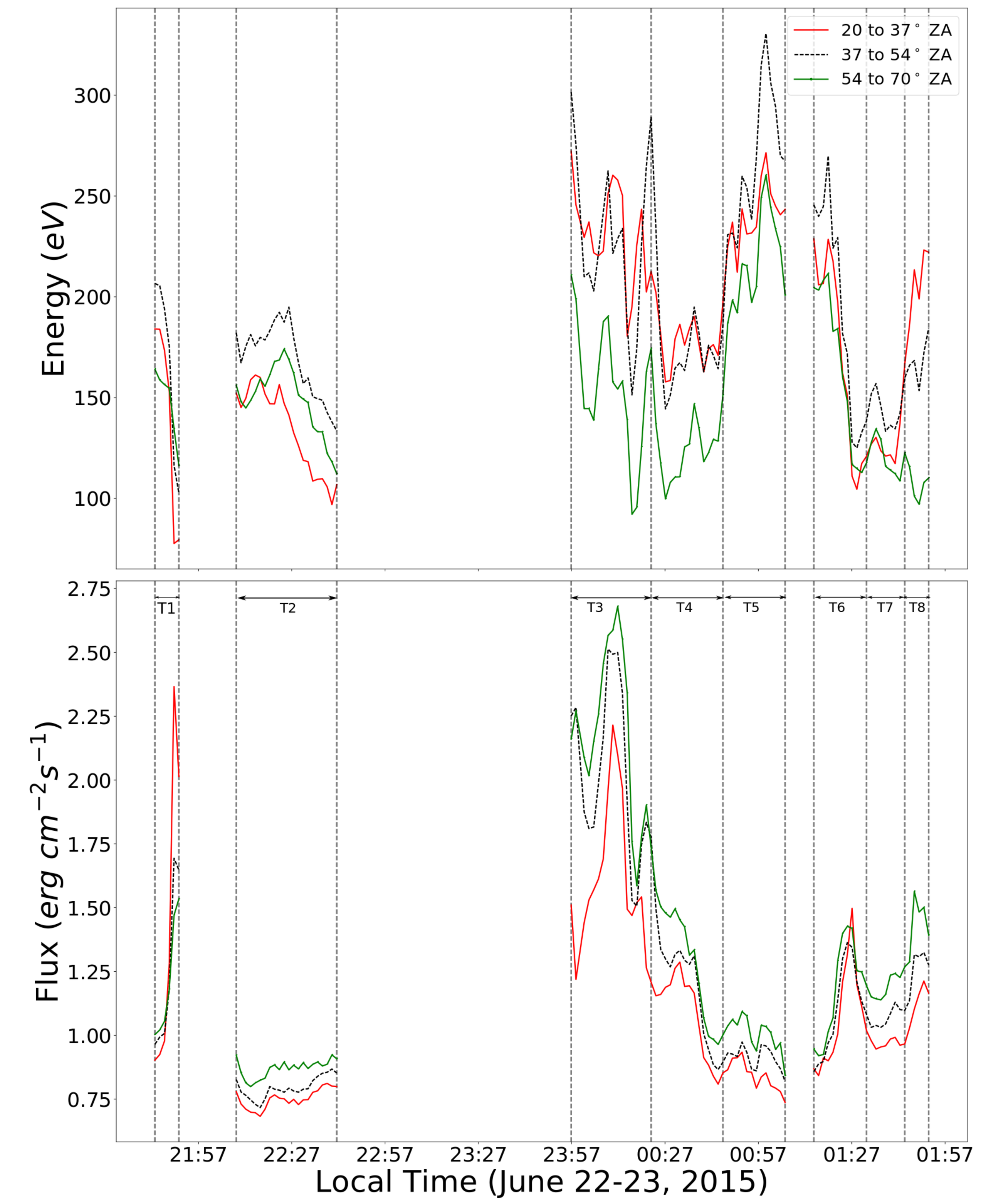


Fig V. Energies and fluxes derived for the time periods selected in Fig. II (T1-T8) using the brightness method at different look direction bins.

Summary

- We derived energy and energy flux of an auroral event at mid-latitude during a G4 storm by fitting the model brightness/brightness ratios with measurements by performing non-linear least-squares minimization using the Levenberg–Marquardt algorithm
- The energy is derived to be ~ 100-300 eV and flux ~ 0.8-3 ergs cm^{-2}s^{-1} and there are spatial and temporal variations.

Instrument/ Collaboration?

- HiT&MIS can observe six upper atmospheric emission feature simultaneously on a round the clock basis, portable
- Continuous observation at MIT Haystack facility previously
- Contact: saurav_aryal@student.uml.edu for more information

References:

[1] Rees, M. H., and D. Luckey. "Auroral electron energy derived from ratio of spectroscopic emissions 1. Model computations." *Journal of Geophysical Research* 79.34 (1974): 5181-5186.

[2] Solomon, S. C., Hays, P. B., & Abreu, V. J. "The auroral 6300 Å emission: Observations and modeling." *Journal of Geophysical Research: Space Physics* 93.A9 (1988): 9867-9882.

[3] Chakrabarti, Supriya, et al. "High-throughput and multislit imaging spectrograph for extended sources." *Optical Engineering* 51.1 (2012): 013003-1.

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