SA51B-1142 Frontiers in Aeronomy II

# Calculating Martian Auroral Emission including Strong Field Gradients and Accelerated Electron Spectra

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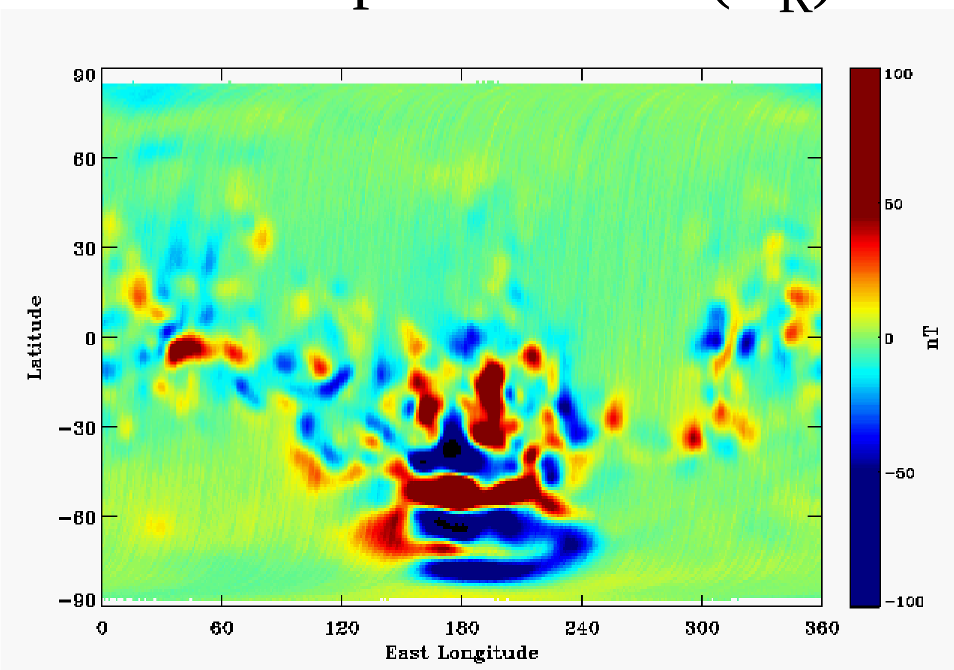
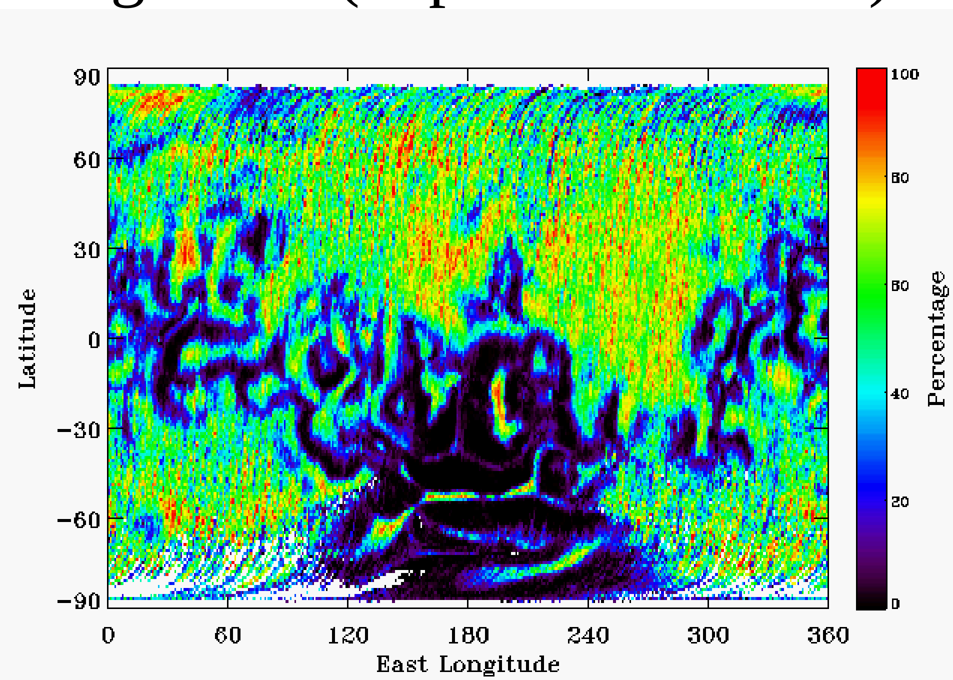
# Martian Magnetic Field

- Mars has no global dipole magnetic field
- But does have strong localized crustal fields
- “Cusps” form in strong field regions where the solar wind has access to the atmosphere

Map of the magnitude of the radial component of B ($B_R$)



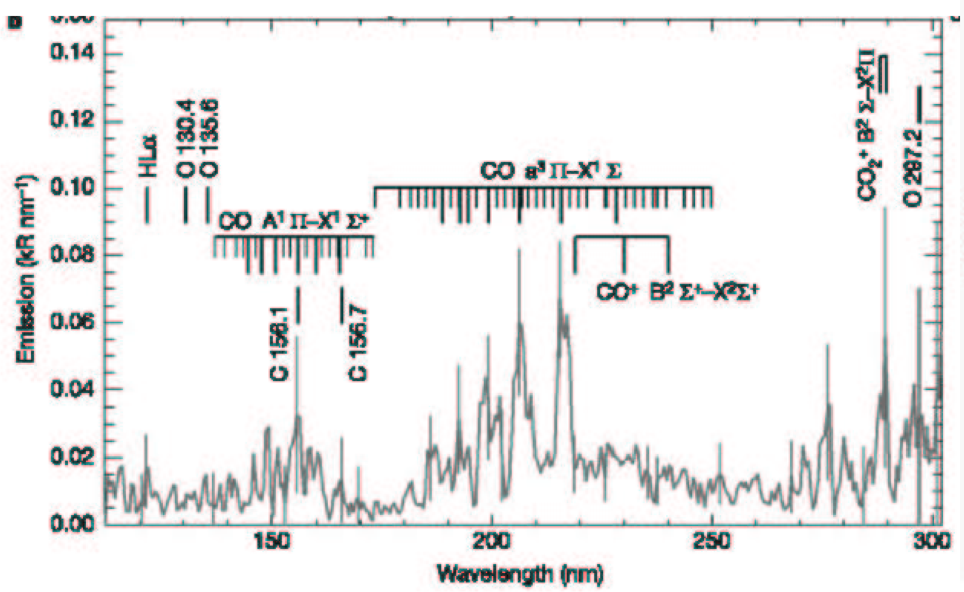

Probability of observing upward loss cones on the nightside (“open” field lines)



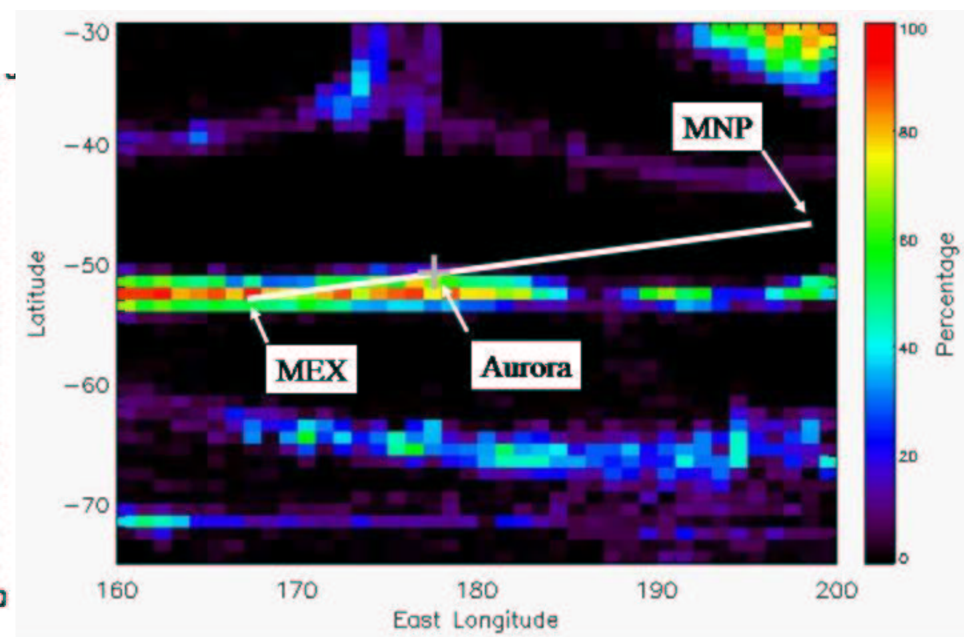
# Martian Aurora

- Aurora recently discovered at Mars [*Bertaux et al.*, 2005] using SPICAM UV spectrometer on Mars Express
- Emissions observed from CO, $CO_2^+$, and O
- Associated with magnetic cusps(?)

Auroral emission spectrum from *Bertaux et al.* [2005]



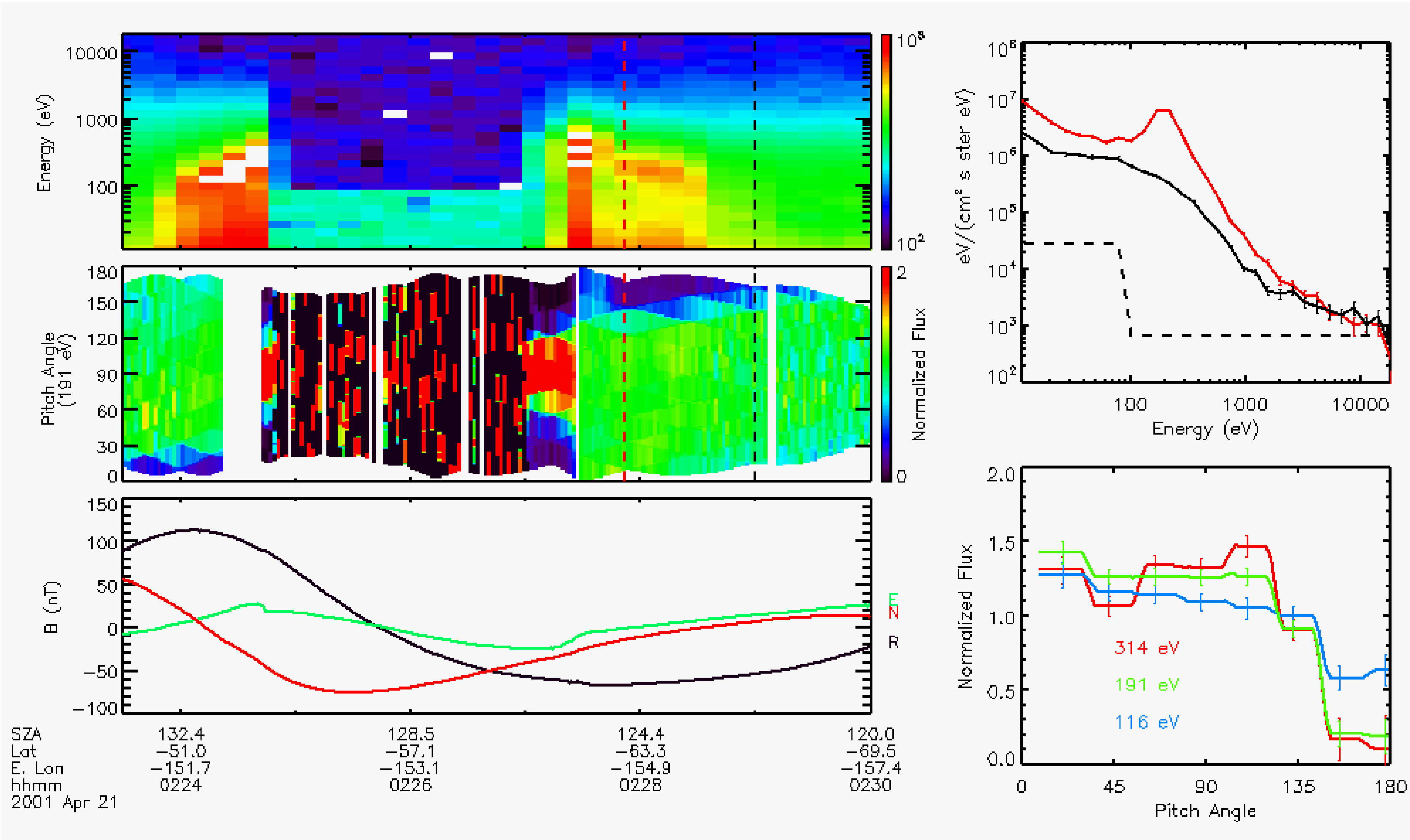

Position of observed emission with respect to magnetic cusp



# Accelerated (Auroral) Electron Spectra

(see Brain et al., SA53B-1166 this afternoon)

- MGS observes accelerated electrons near magnetic cusps



# Purpose

- Model Martian auroral emission using observed accelerated electron spectra as input
- Most auroral transport codes developed for Earth do not incorporate strong magnetic field gradients
- Such strong magnetic field gradients may be important at Mars
- Perform two model calculations:
  one run with no magnetic field gradient
  one run with strong (realistic) magnetic field gradient
- What is the effect of strong field gradients on the emission?

# Models

Mars Primary Electron Transport (MPET) Code:

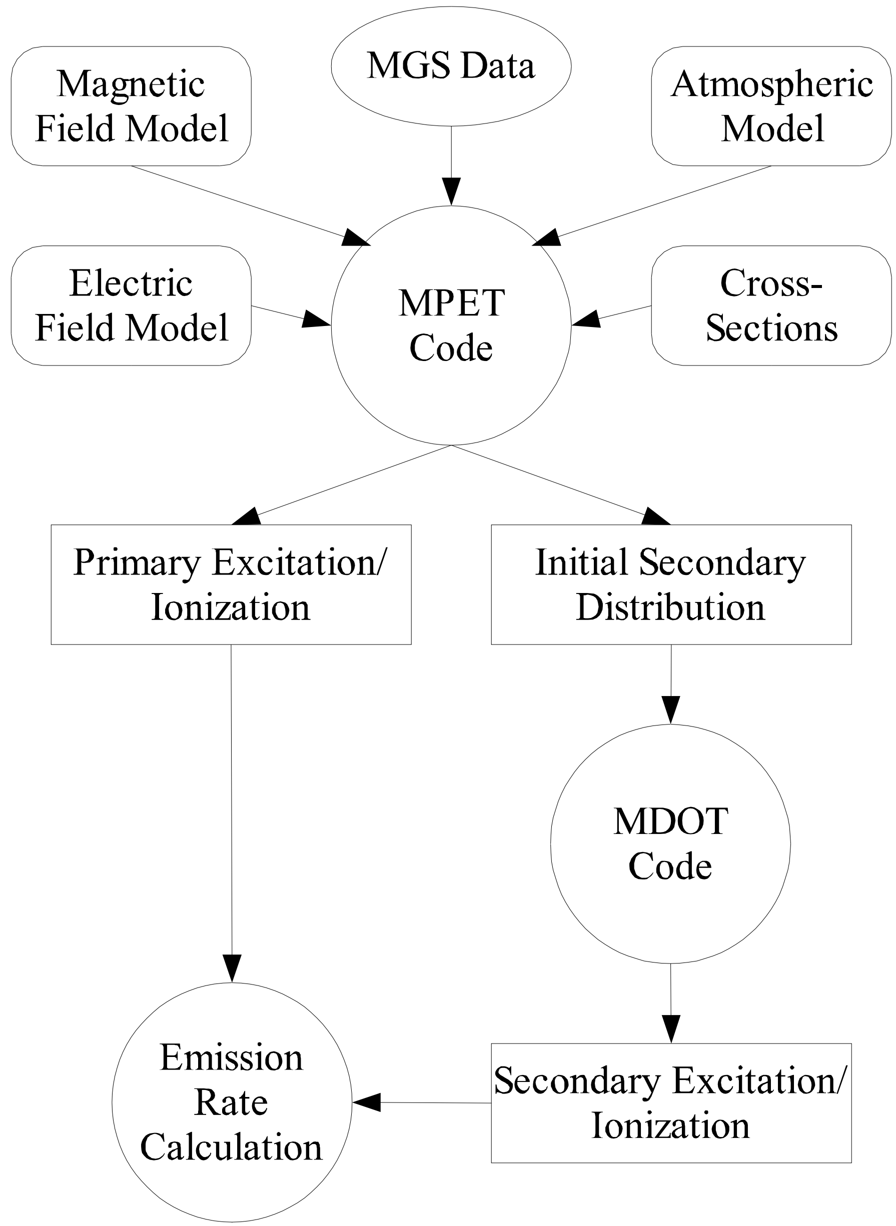
- described by *Lillis et al.* [2004]
- single particle Monte-Carlo model
- follows primary electrons in an arbitrary field configuration (i.e., strong or weak gradient)
- keeps track of primary collisions and production of secondaries

Mars Discrete-Ordinate Transport (MDOT) Code:

- modification of *Lummerzheim and Lilensten* [1994]
- uses discrete-ordinate method to solve multi-stream electron transport problem
- uses secondaries from MPET as input (similar to approach by *Peticolas and Lummerzheim* [2000] for Earth)
- ignores strong magnetic field gradients – OK since most secondaries are produced in narrow altitude range

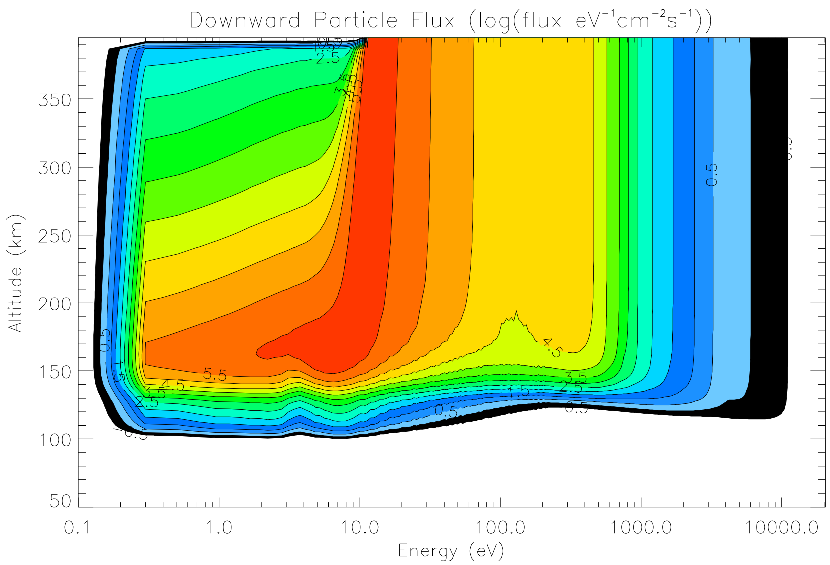
Flowchart illustrating the various inputs and the coupling between the MPET and MDOT codes:

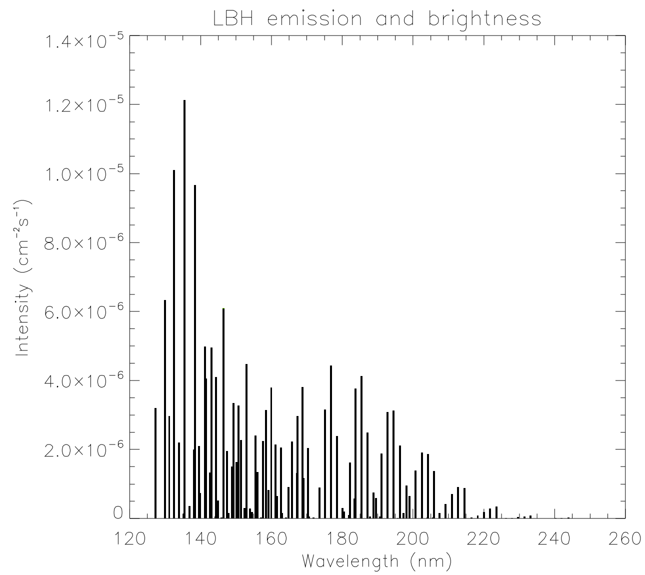
- Primary electrons given by observed accelerated electron spectra from MGS
- Atmospheric density profile given by MTGCM [e.g., *Bougher et al.*, 2000]
- Magnetic field is modeled as a straight line geometry with a specified exponential falloff
- Electric field is zero

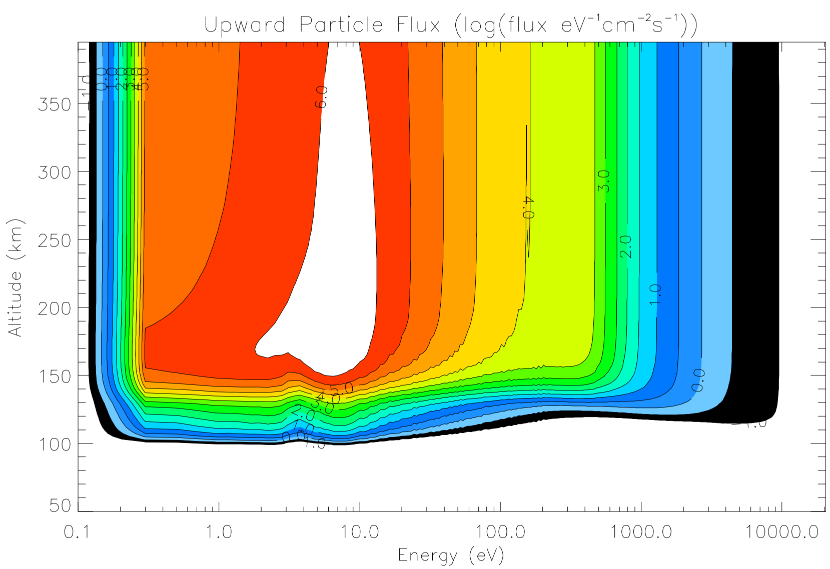


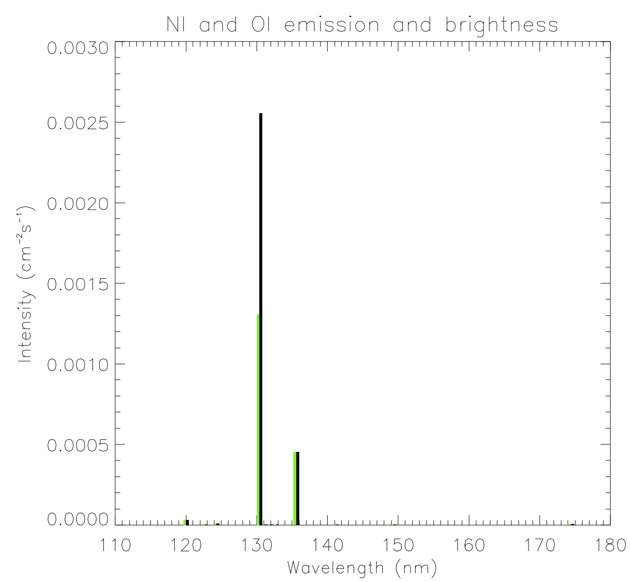
# No Magnetic Gradient

- MDOT used to model primary and secondary electron transport



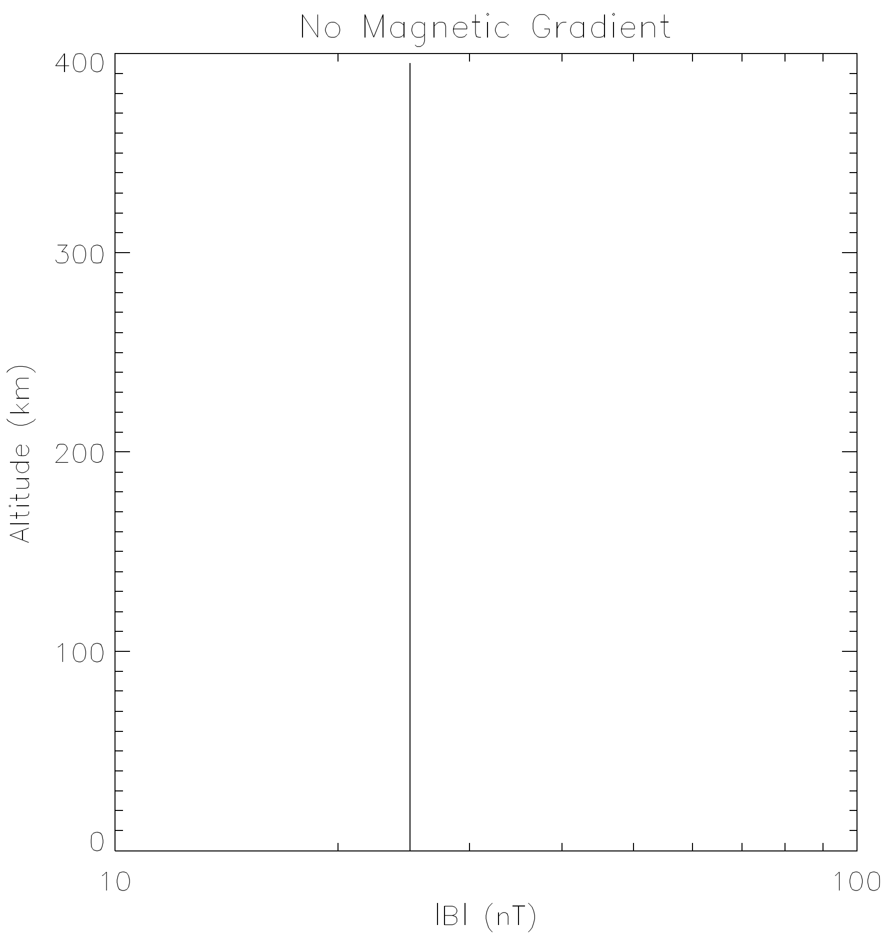



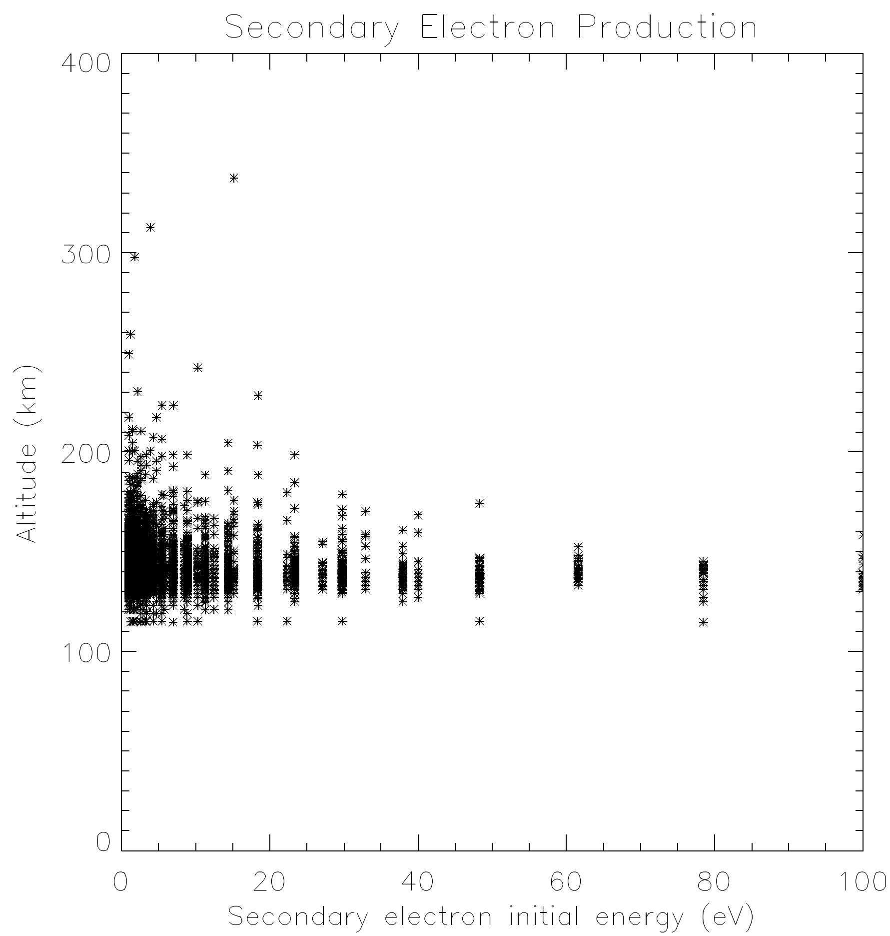



# No Magnetic Gradient

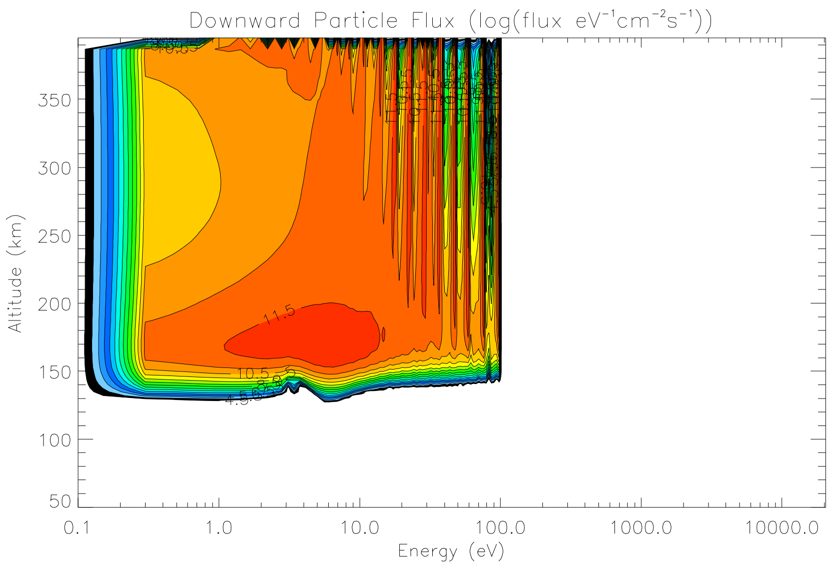
- MPET follows primaries and records secondary production
- 9000 primary electrons => ~ 200,000 secondaries

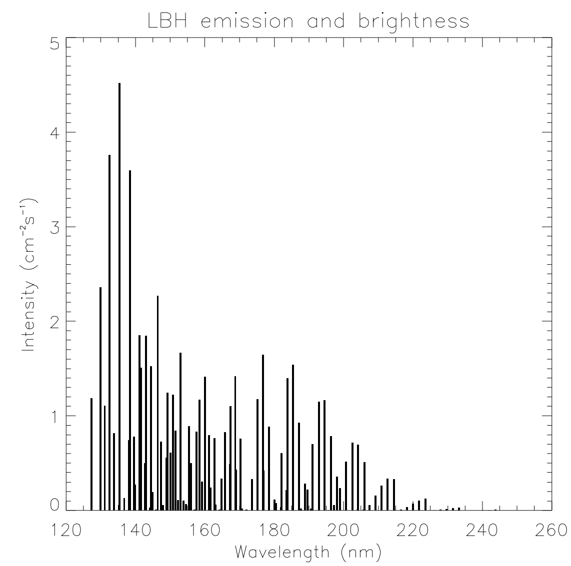


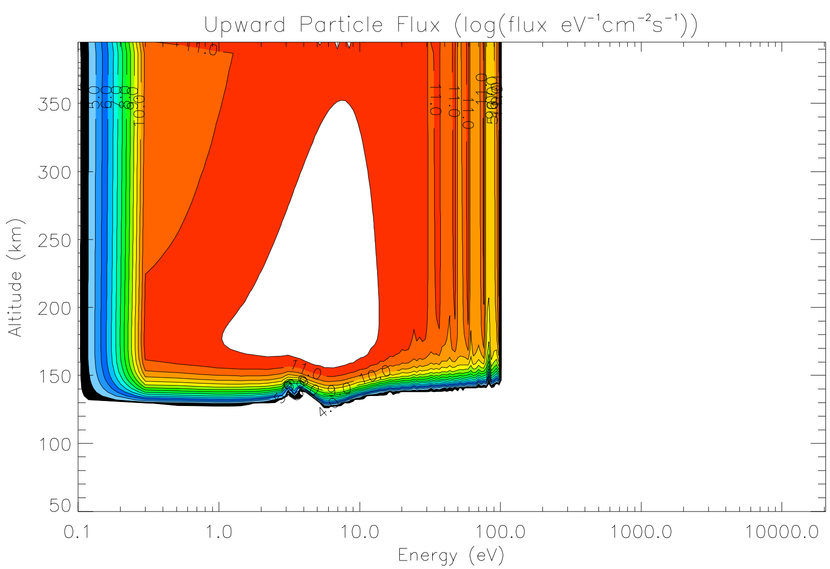



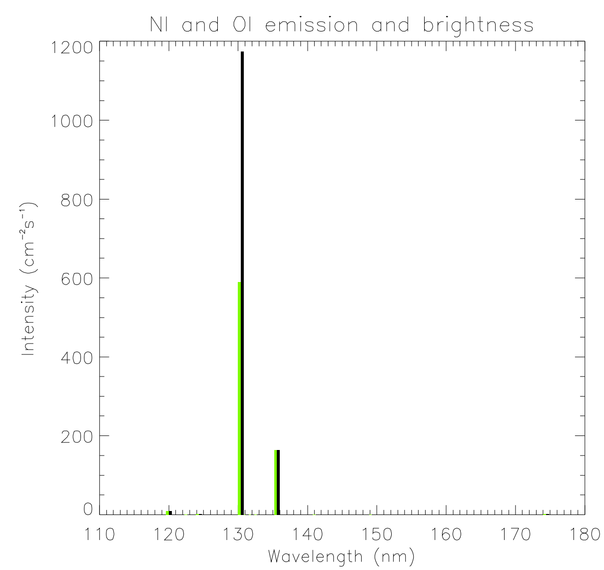
# No Magnetic Gradient

- MDOT models secondary electron transport



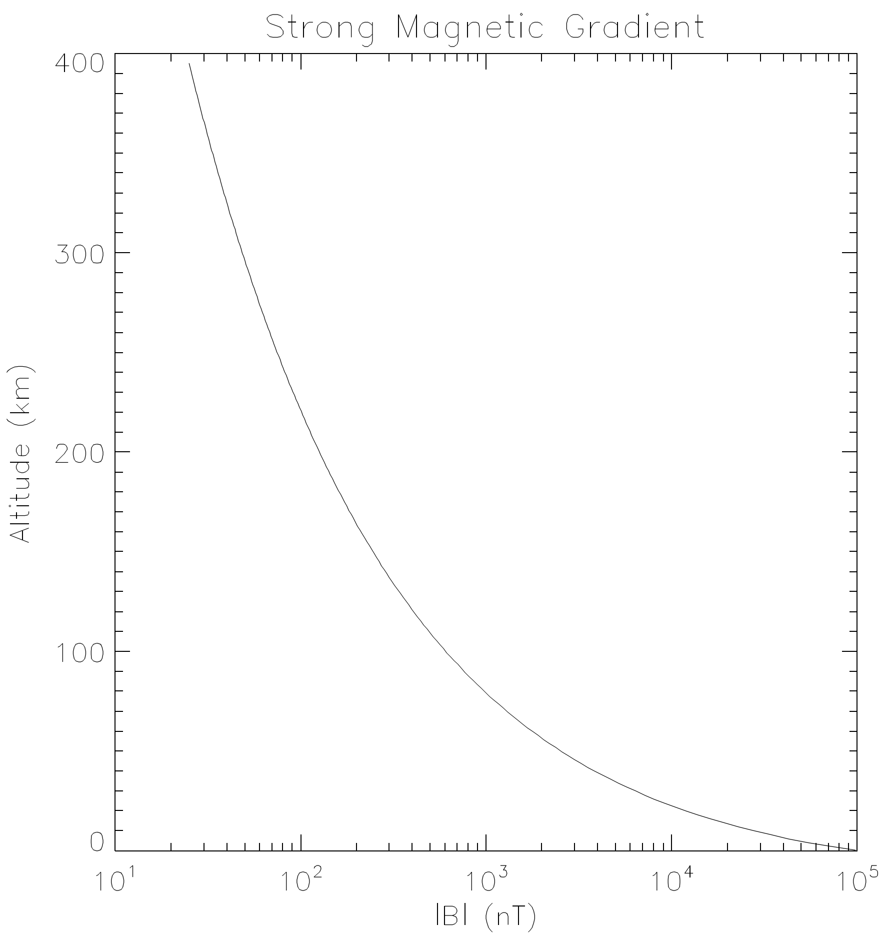



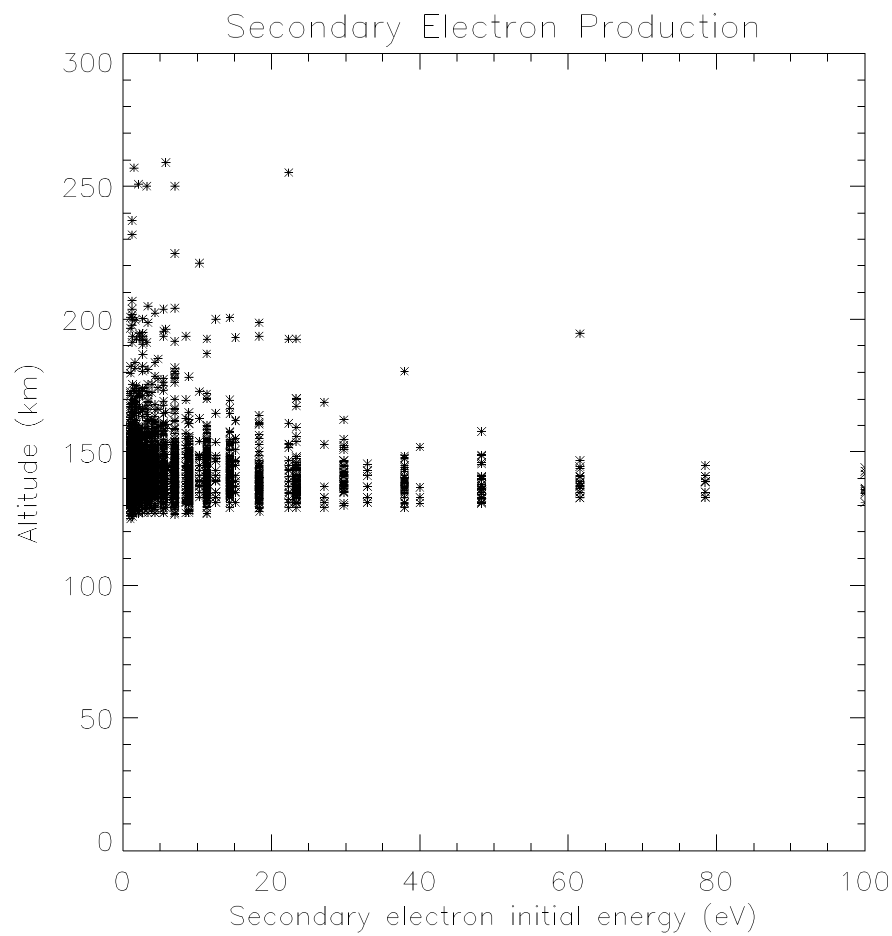



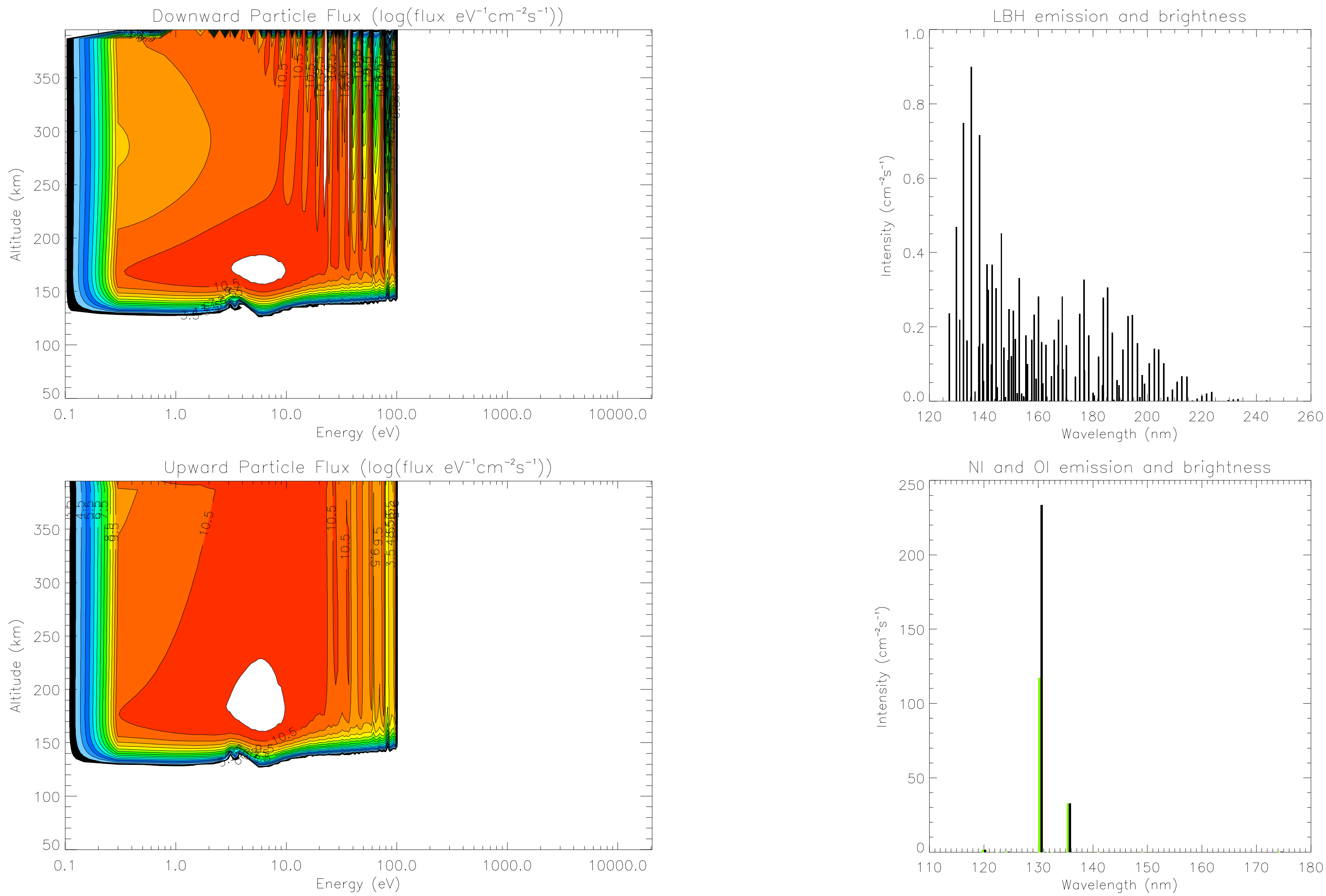
# Strong Magnetic Gradient

- 9000 primary electrons => ~ 35,000 secondaries
- Significant magnetic reflection



# Strong Magnetic Gradient



# Summary

- Significant reduction in secondary production in strong gradient case compared to no gradient (~ 80% decrease in secondaries)
- Mainly due to magnetic reflection of primary electrons
- Secondaries produced at higher altitude for strong gradient case
- Lower intensity emission (~ 5 X weaker) for strong gradient case

# Future Work

- Work-in-progress – still in testing phase
- Refine emission calculation
  - include CO, $CO_2$ lines to compare with observations
- 2-D model for converging field
  - larger collection area versus magnetic reflection of primaries
  - which dominates?