Modeling the Magnetopause Shadowing Loss during the June 2015 Dropout Event

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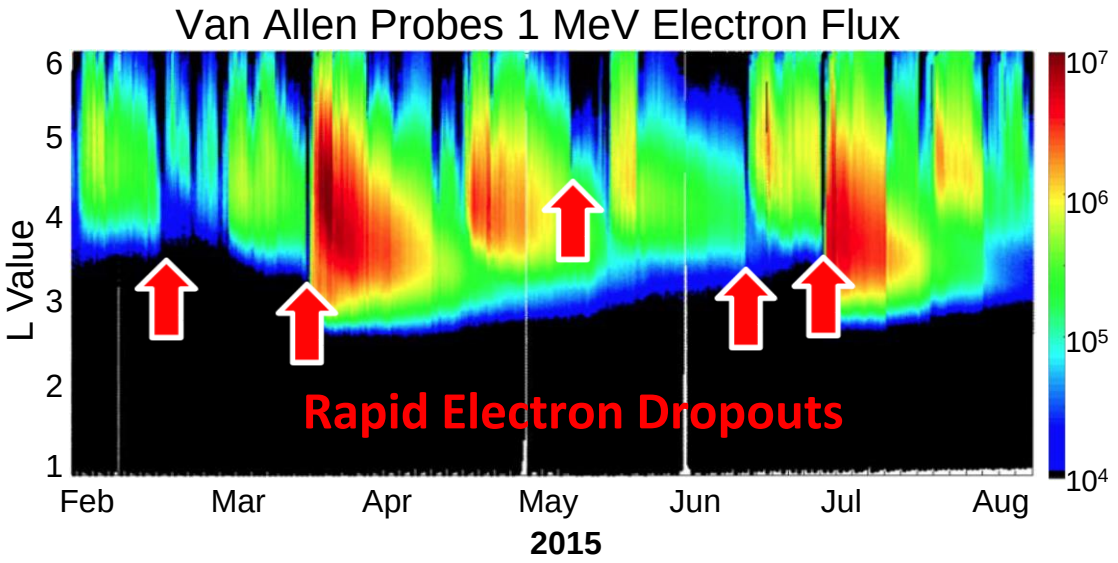
Radiation Belt Electron Dropouts

- Where do the electrons go during the dropouts?

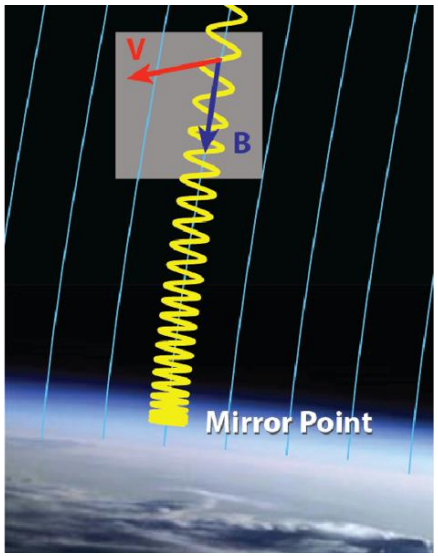
#1. Precipitation loss

#2. Magnetopause shadowing

– Combined with outward radial diffusion



#1.



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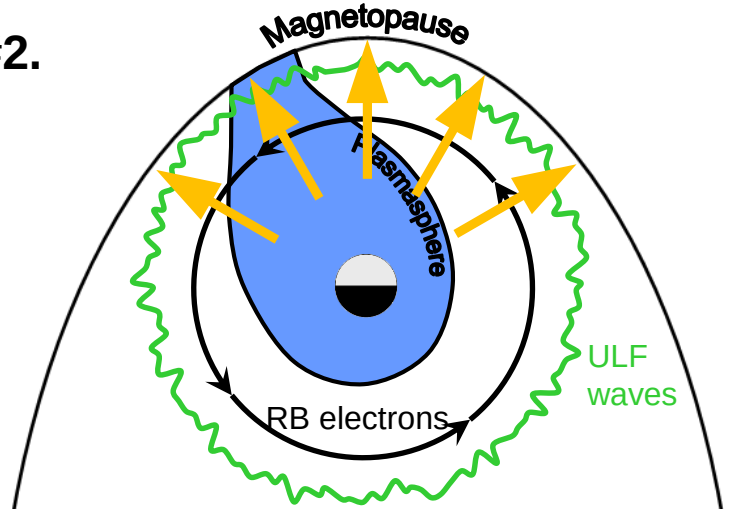
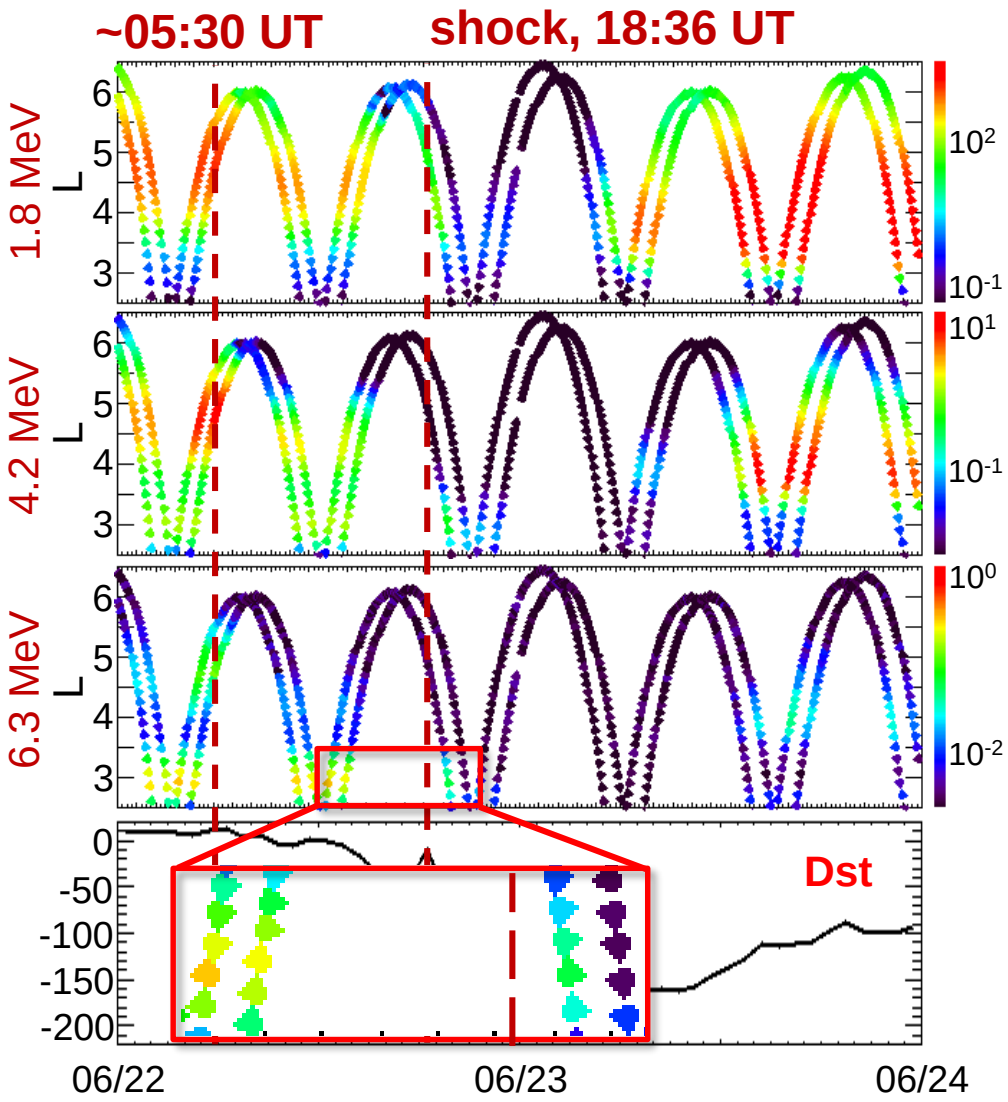
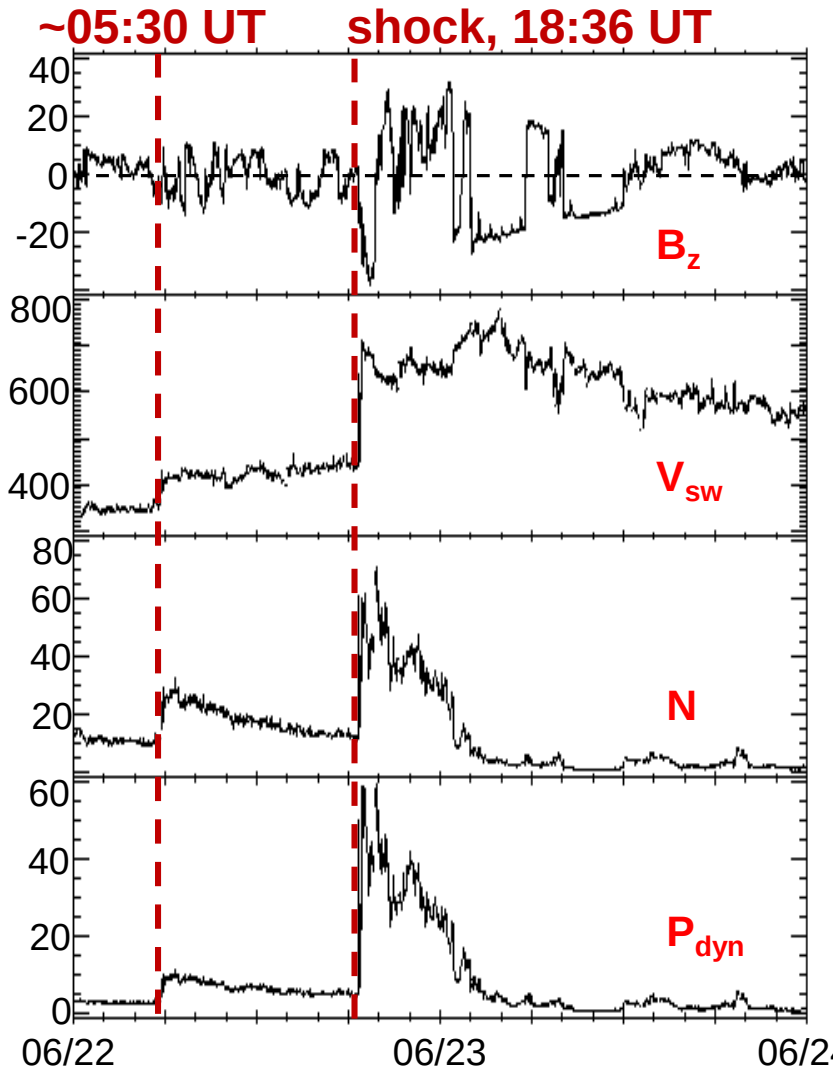


June 2015 Dropout Event: Flux and Solar Wind

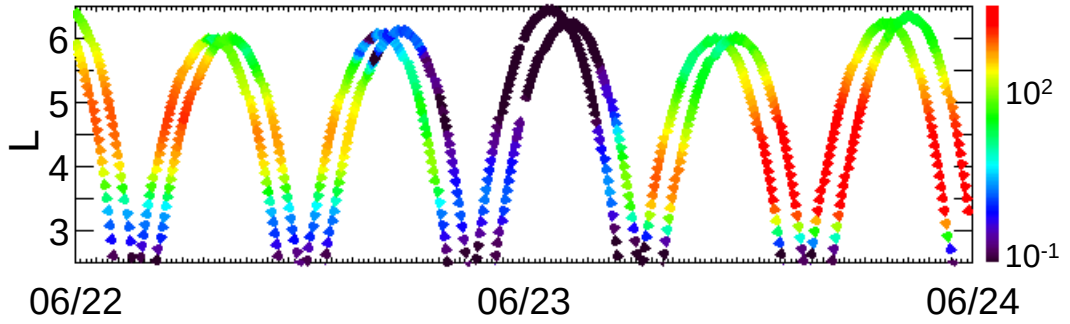




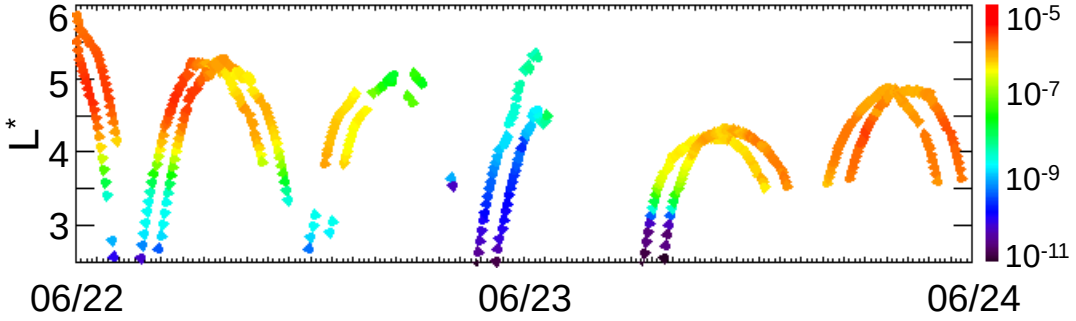
From Flux to Phase Space Density

- Large gaps in electron PSD at given μ and K, due to:

➢ Flux vs. L_m
(1.8 MeV, 90 deg)



➢ PSD vs. L* (TS04)
(μ=1318 MeV/G,
K=0.11 $G^{1/2}Re$)



From Flux to Phase Space Density

- Large gaps in electron PSD at given μ and K, due to:
  - Van Allen Probes on open drift shells

➢ Flux vs. L_m
(1.8 MeV, 90 deg)

➢ Flux vs. L* (TS04)
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➢ PSD vs. L* (TS04)
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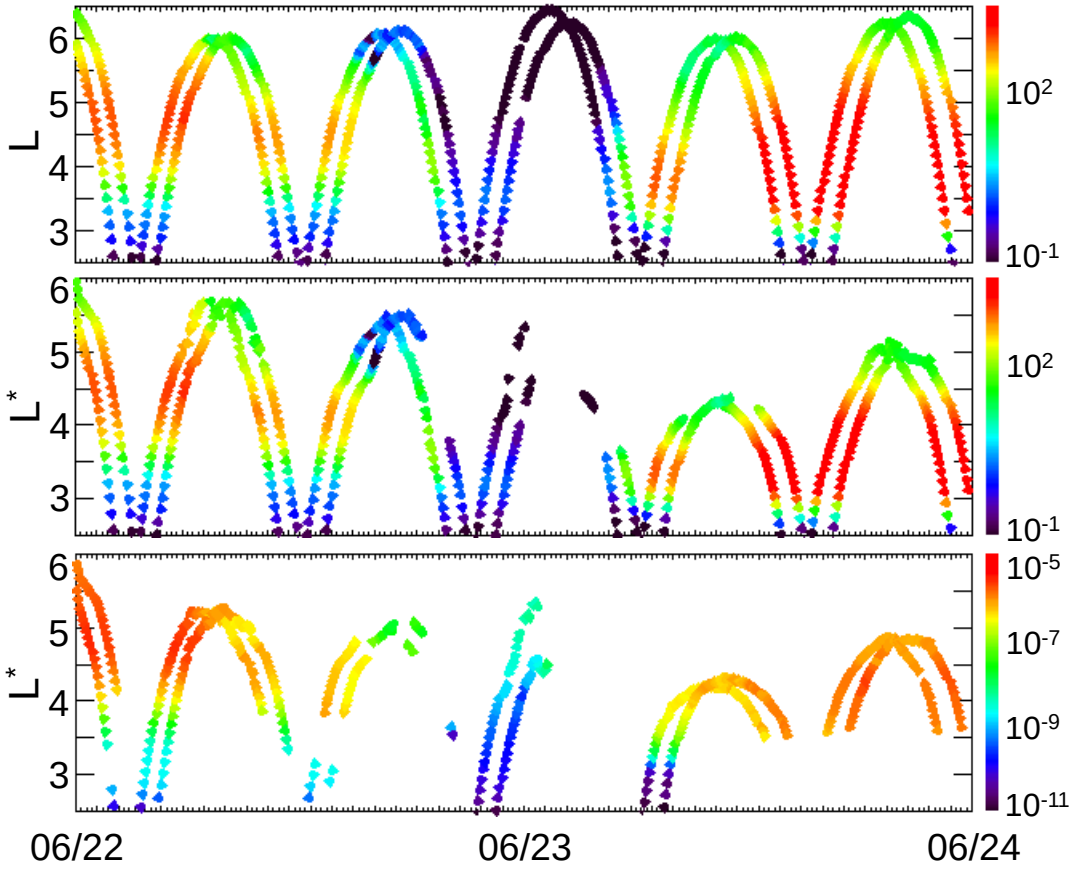


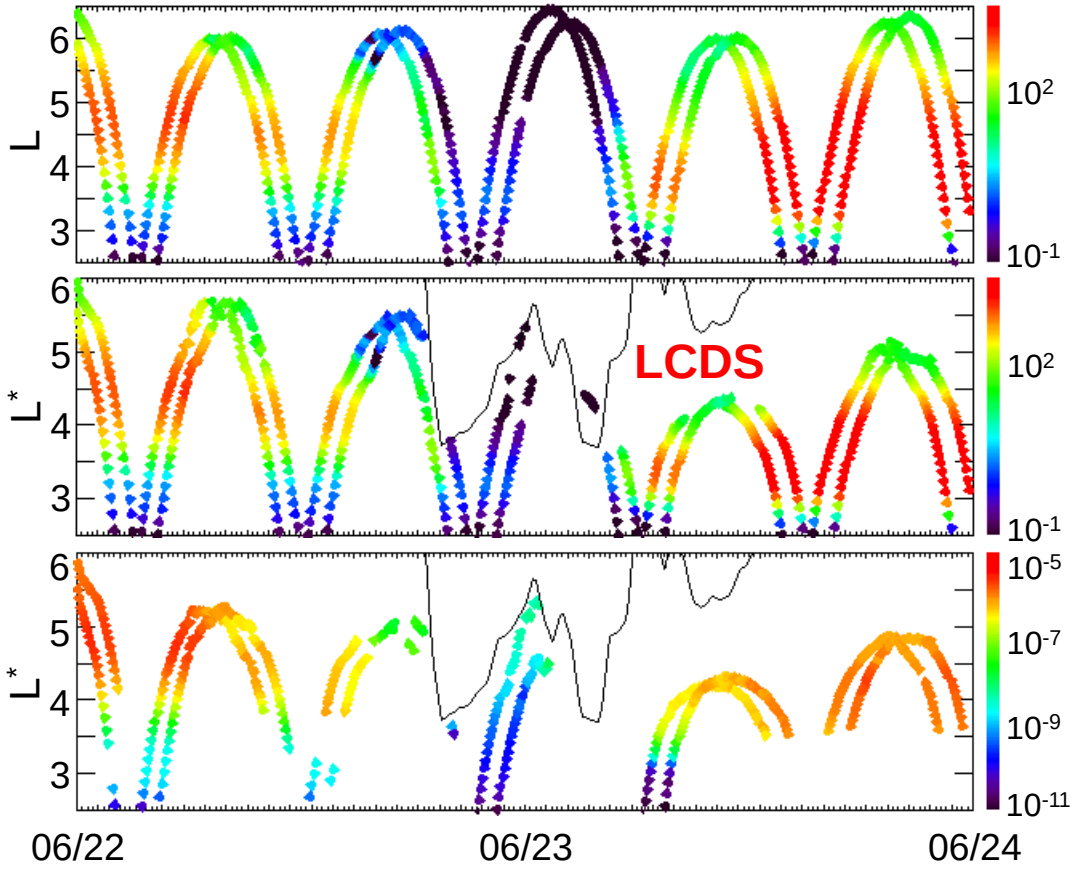
From Flux to Phase Space Density

- Large gaps in electron PSD at given μ and K, due to:
  - Van Allen Probes on open drift shells
  - Limited pitch angle coverage at certain parts of the orbit

➢ Flux vs. L_m
(1.8 MeV, 90 deg)

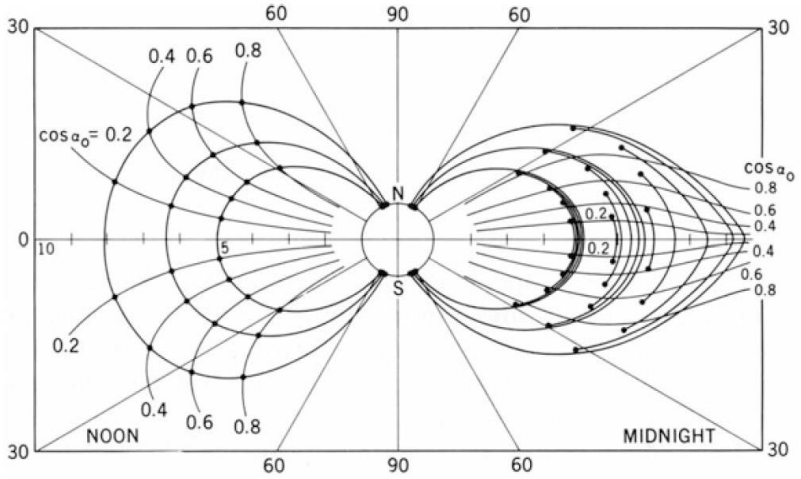
➢ Flux vs. L* (TS04)
(1.8 MeV, 90 deg)

➢ PSD vs. L* (TS04)
(μ=1318 MeV/G,
K=0.11 $G^{1/2}Re$)



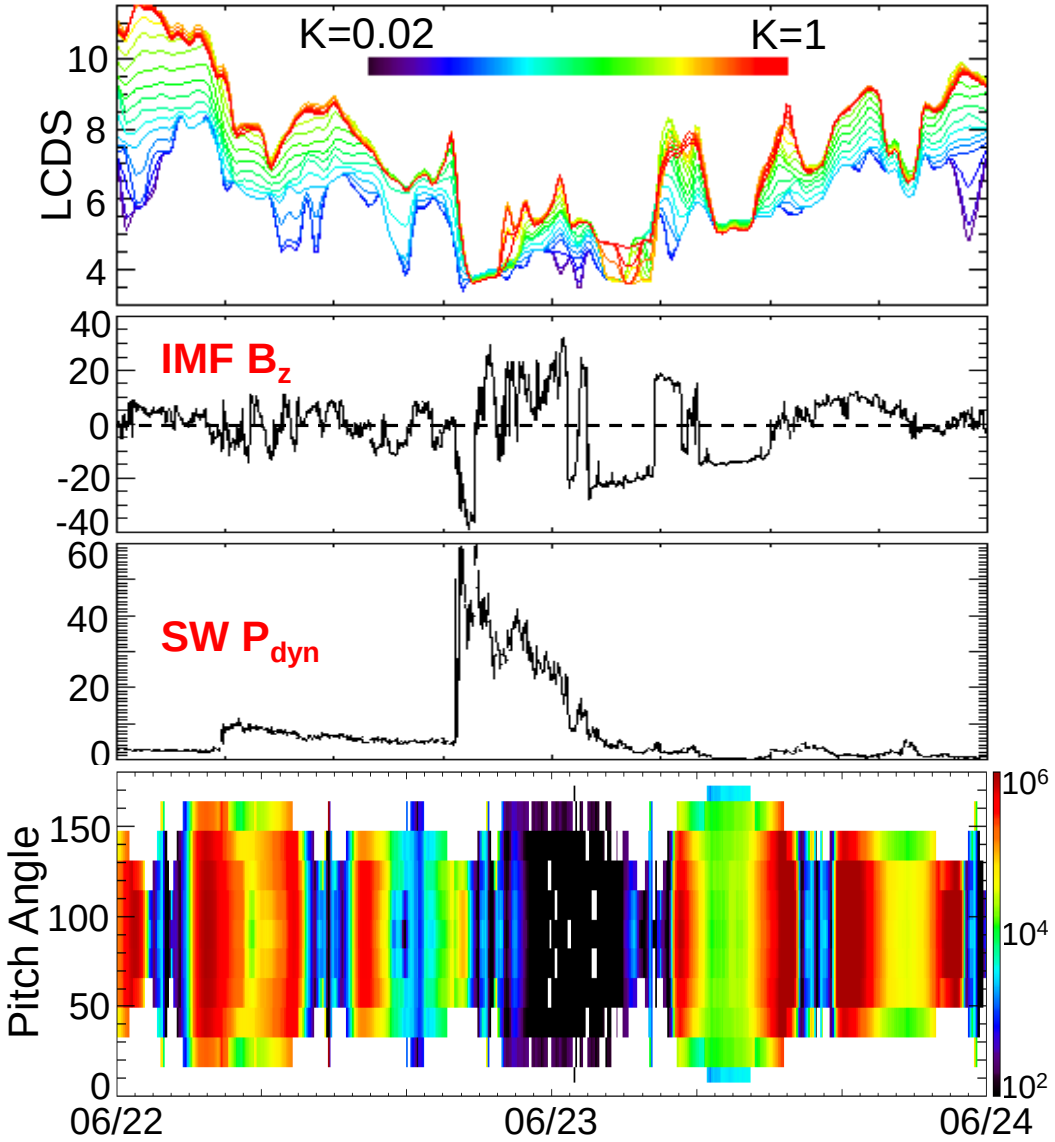
Last Closed Drift Shell (LCDS)

- LCDS traced in TS04 model
  - Strong K dependence



[Roederer and Zhang, 2014]

➢ Flux pitch angle distribution
(1.8 MeV, along RBSP-A orbit)

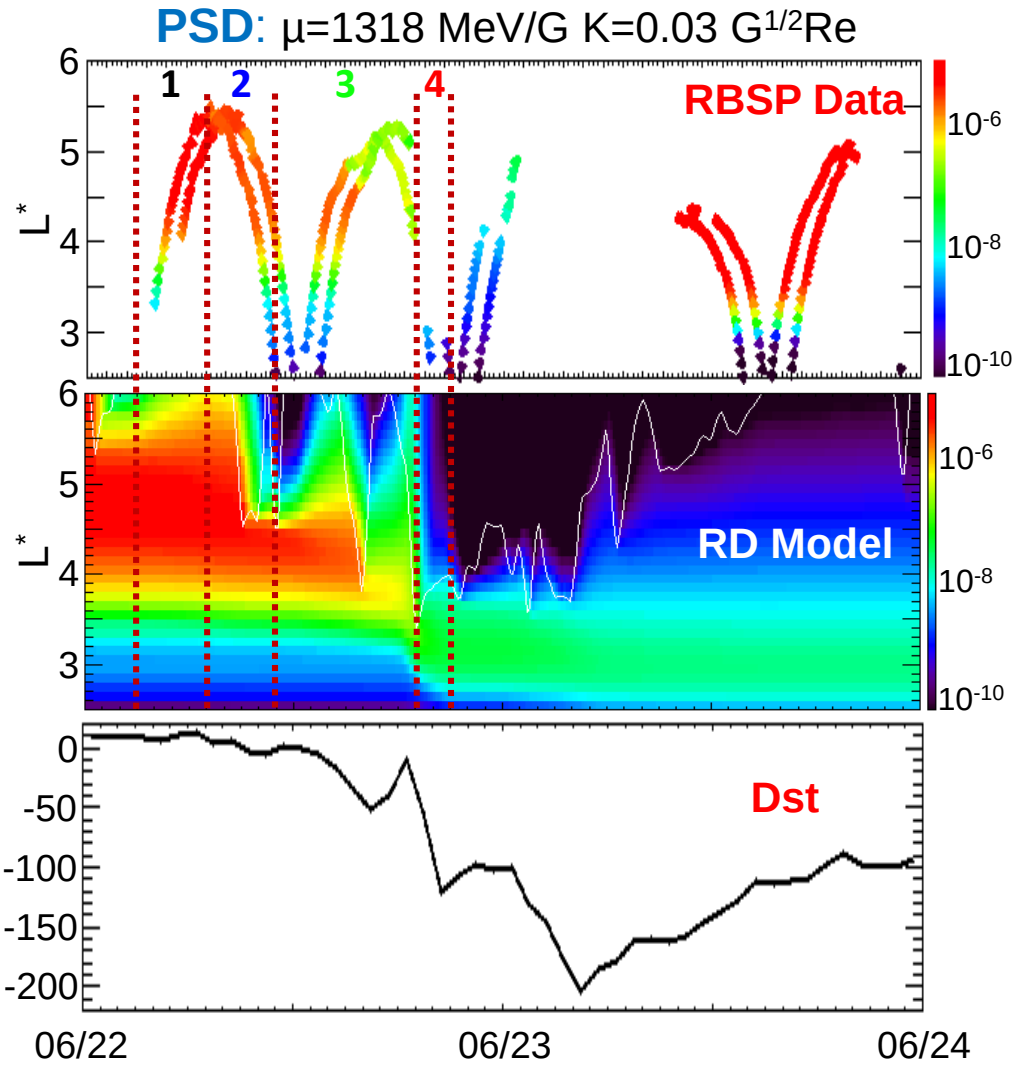


Modeling Magnetopause Shadowing Loss

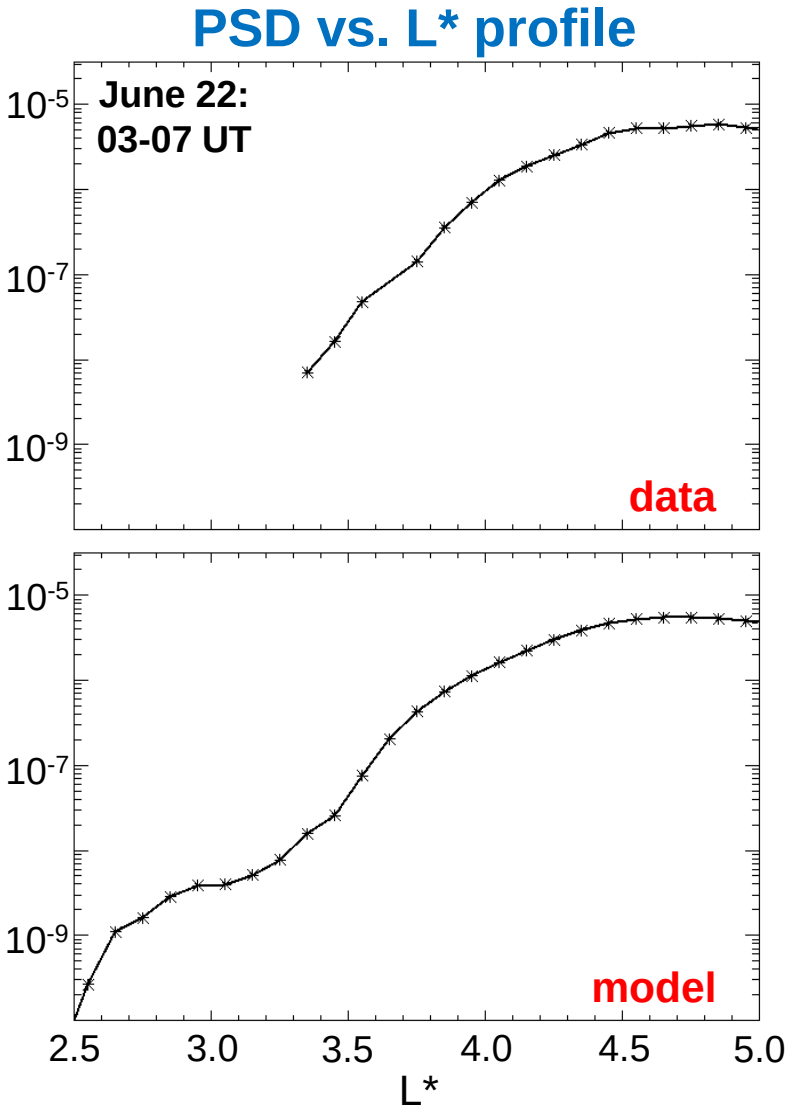
- Radial diffusion model:

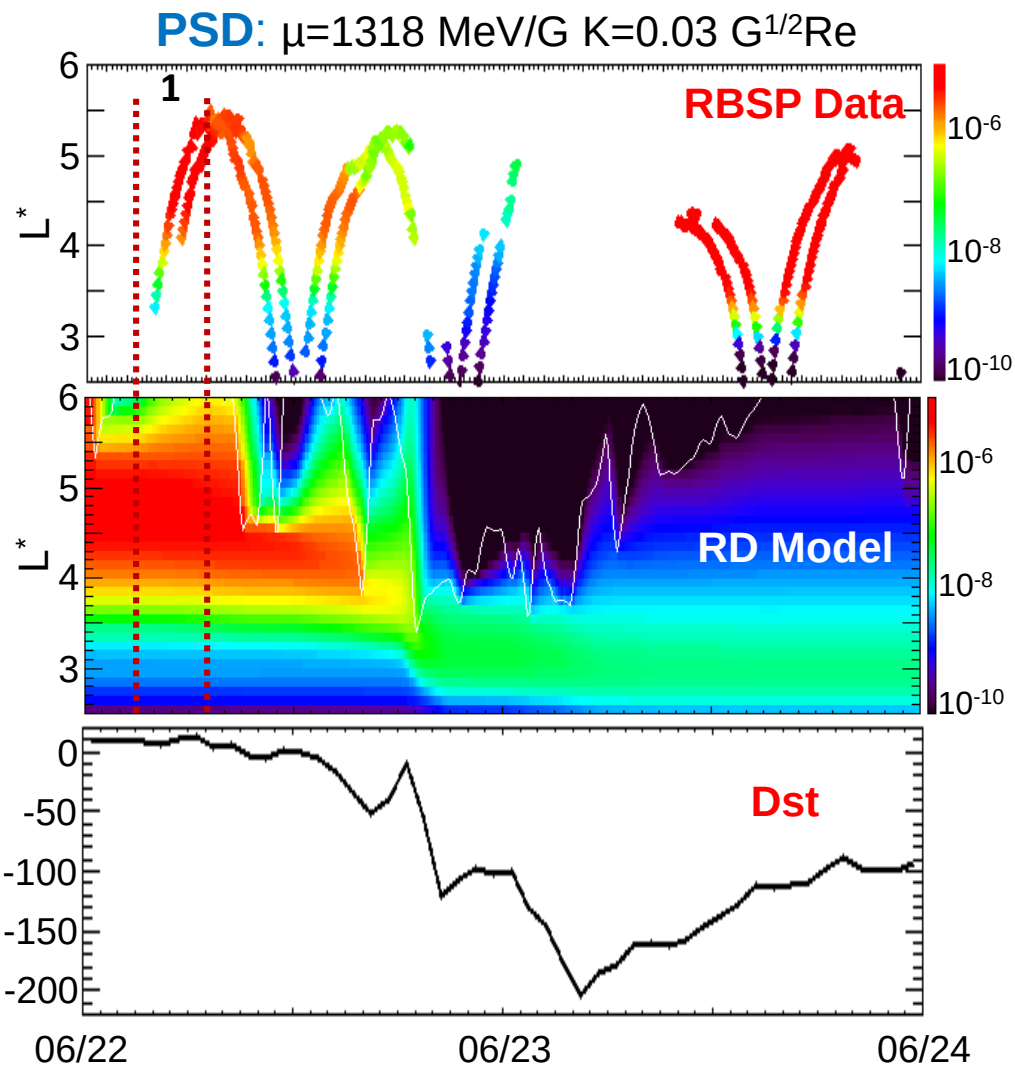
$$\frac{\partial f}{\partial t} = L^2 \frac{\partial}{\partial L}\left(\frac{D_{LL}}{L^2}\frac{\partial f}{\partial L}\right) - \frac{f}{\tau}$$

- Event-specific LCDS in TS04
- Electron lifetime τ = drift period outside LCDS
- Neumann boundary condition at L*=11
- Start with empirical $D_{LL}(Kp, L)$ [Brautigam and Albert, 2000]

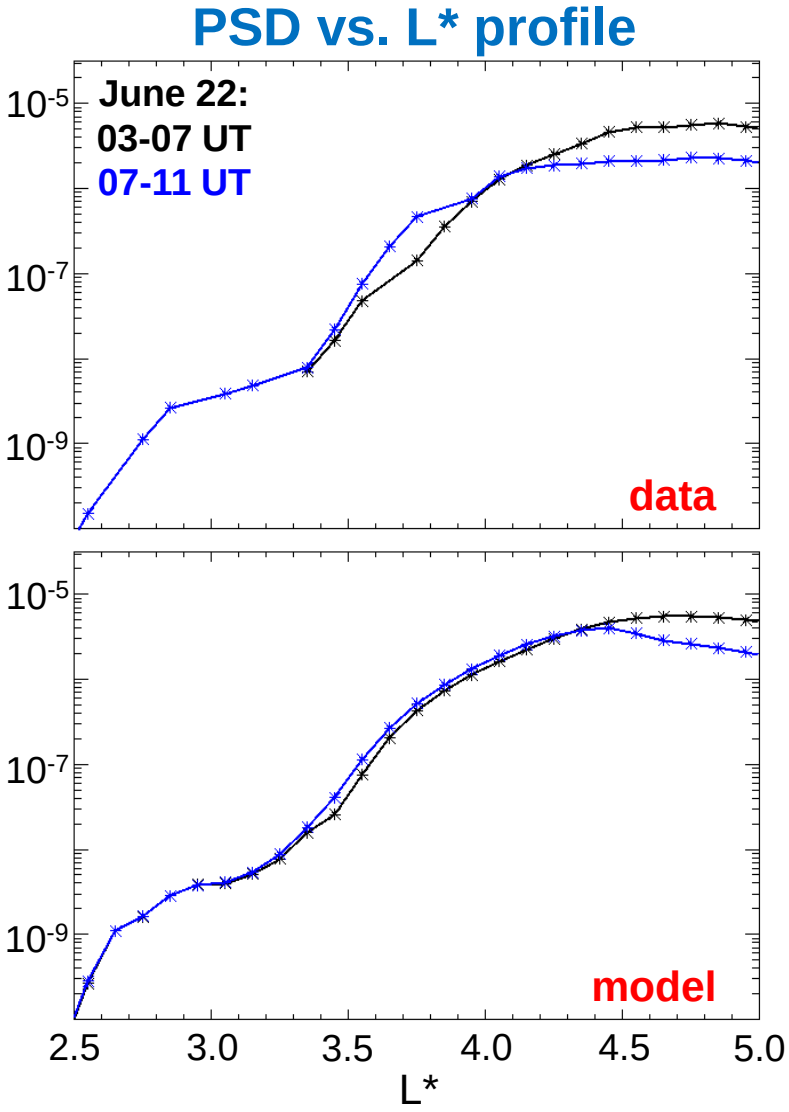


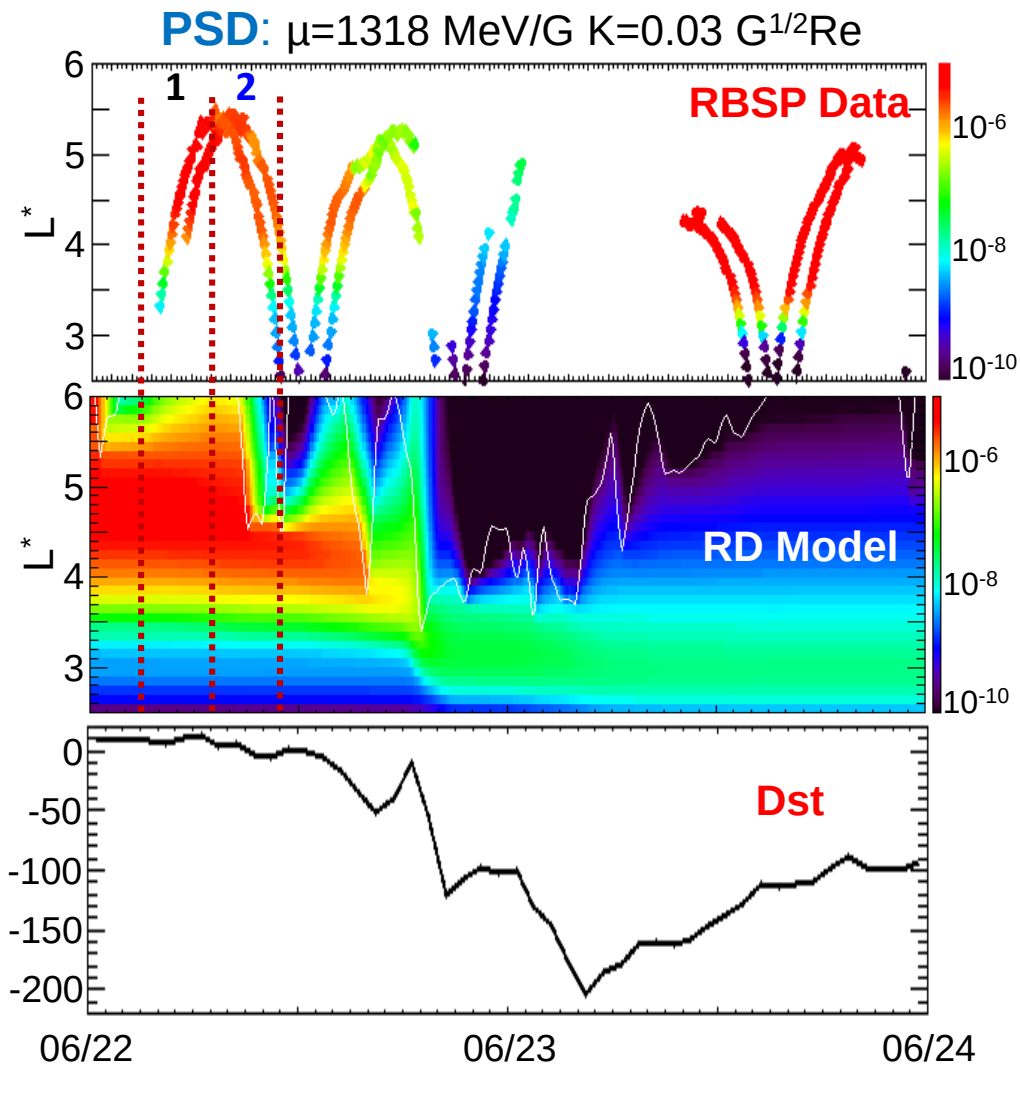
Model Results with D_{LL}(B&A)



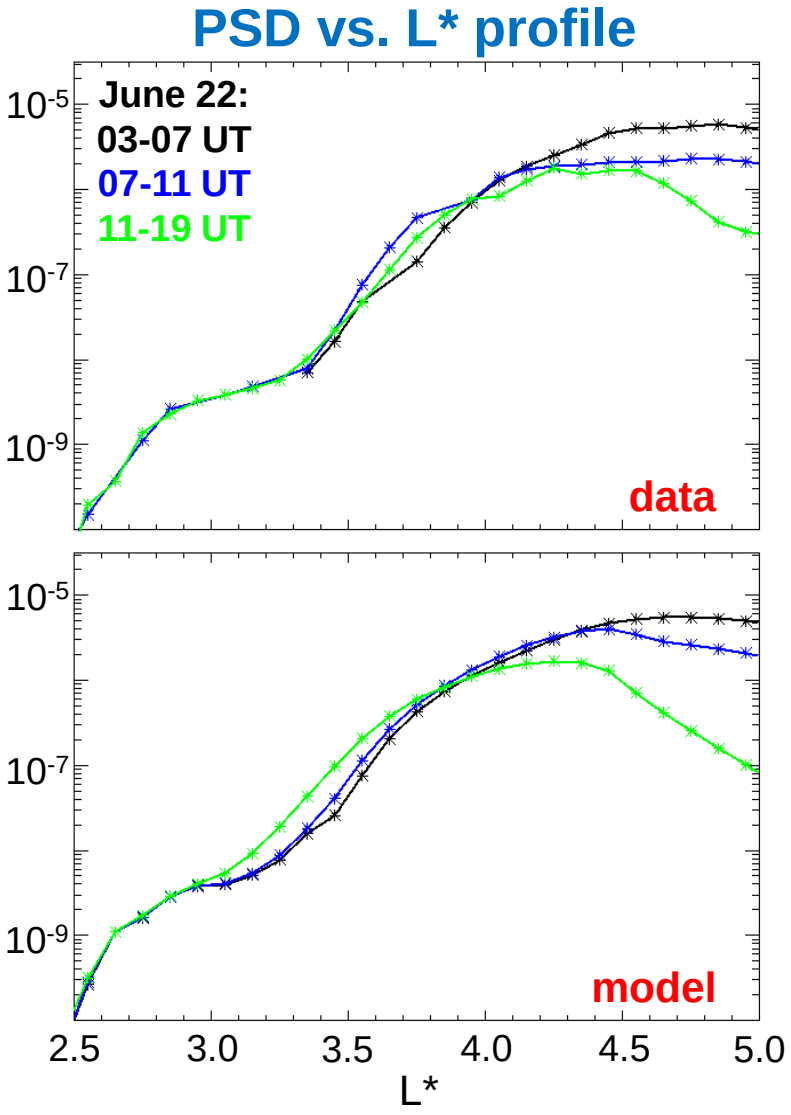


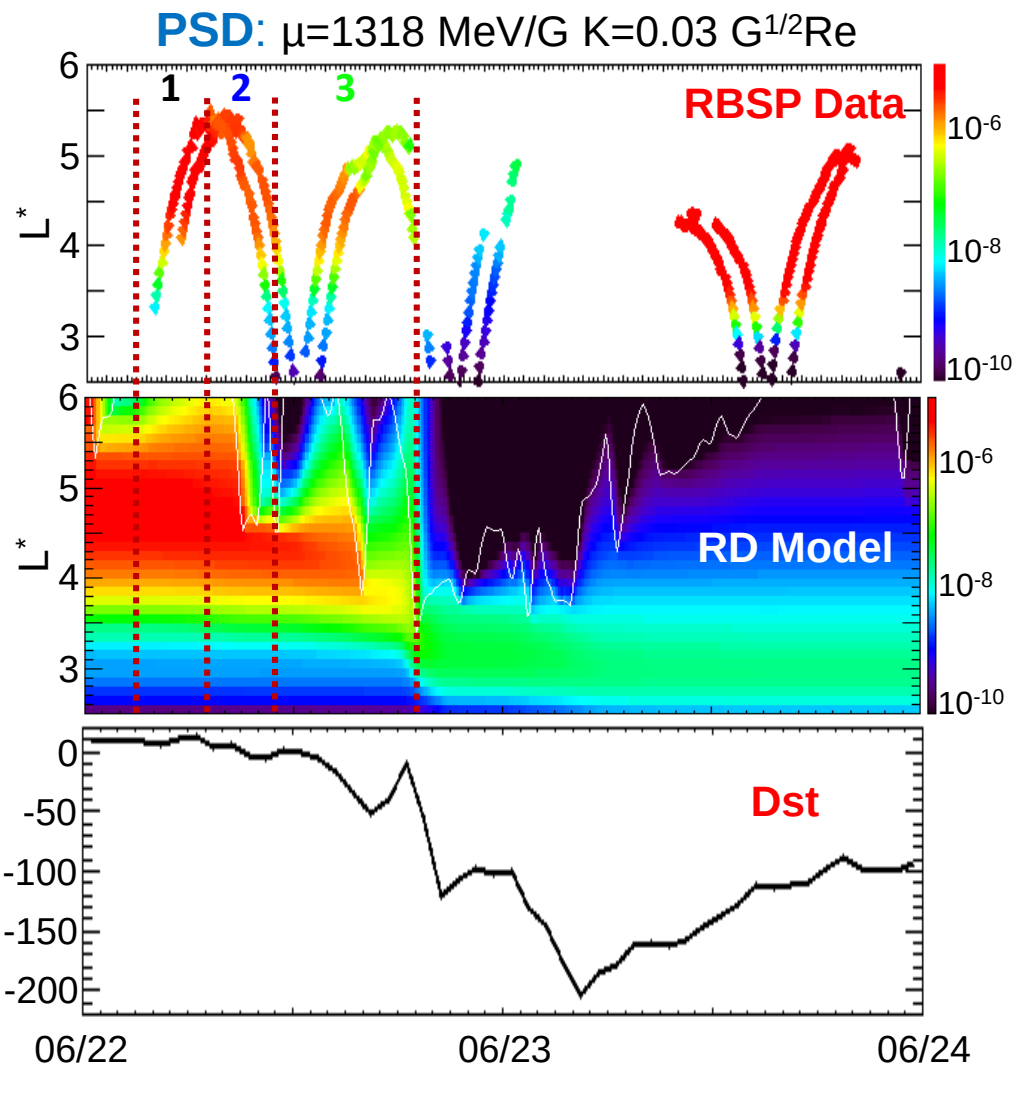
Model Results with D_{LL}(B&A)





Model Results with D_{LL}(B&A)





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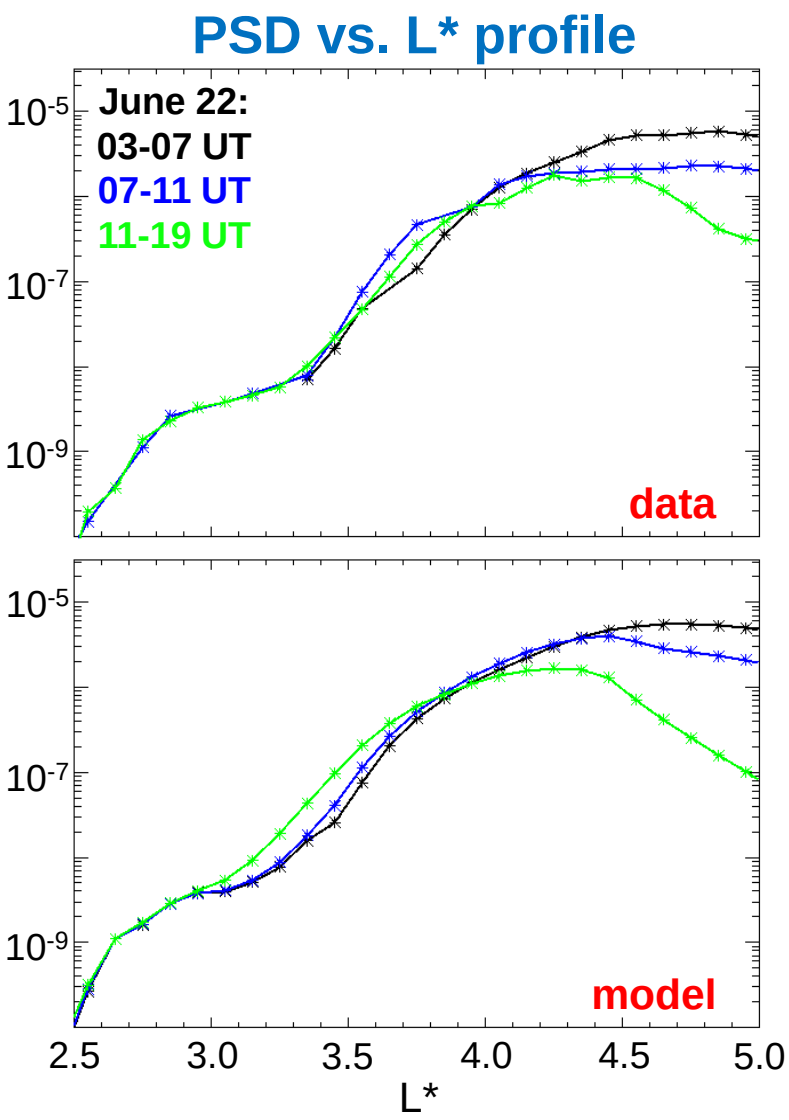

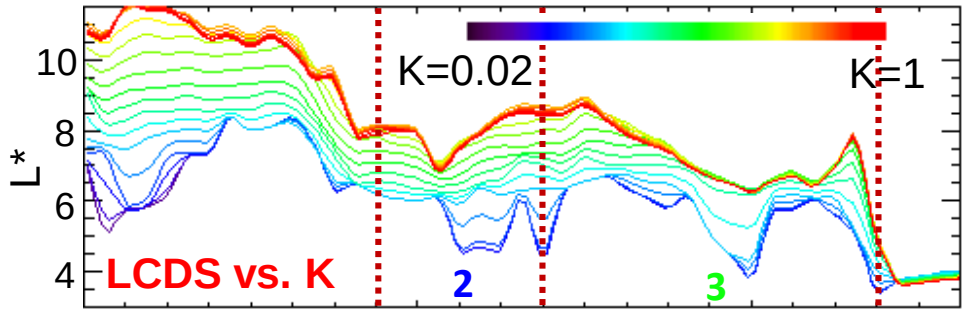

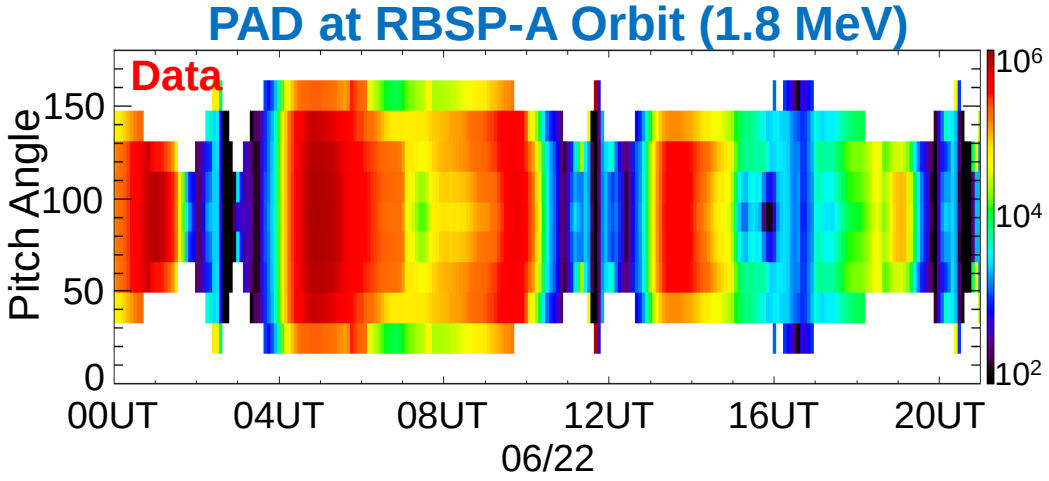

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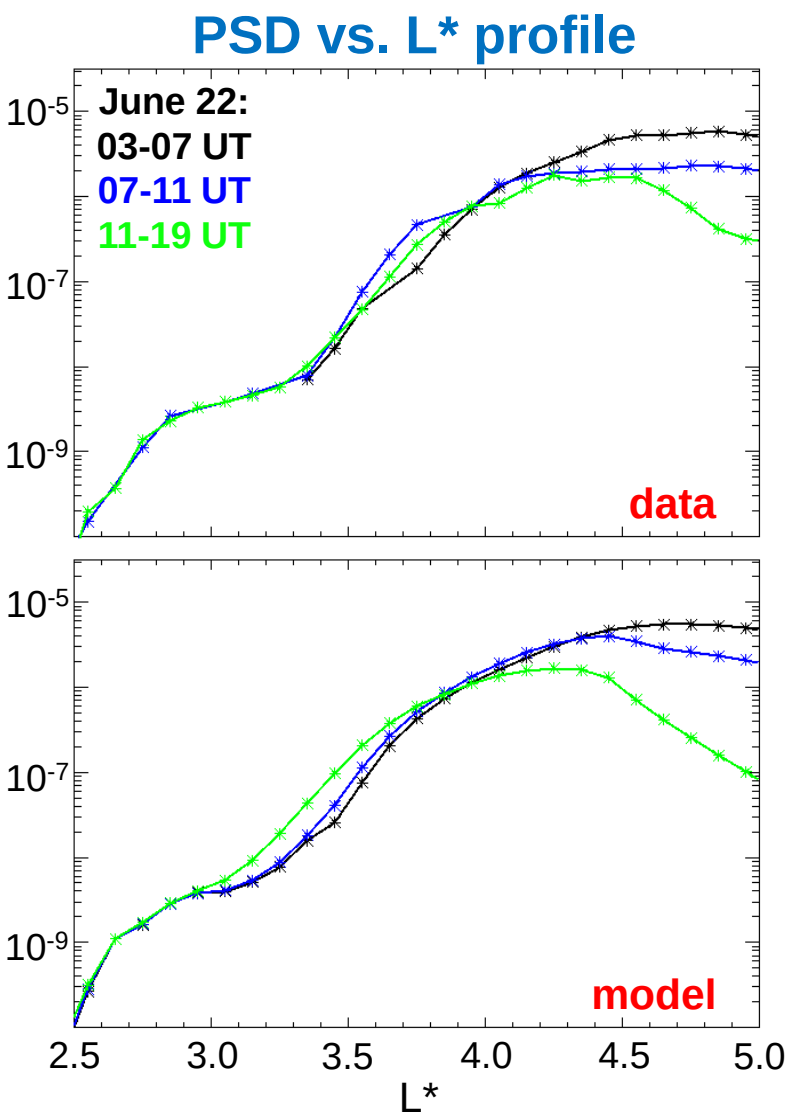
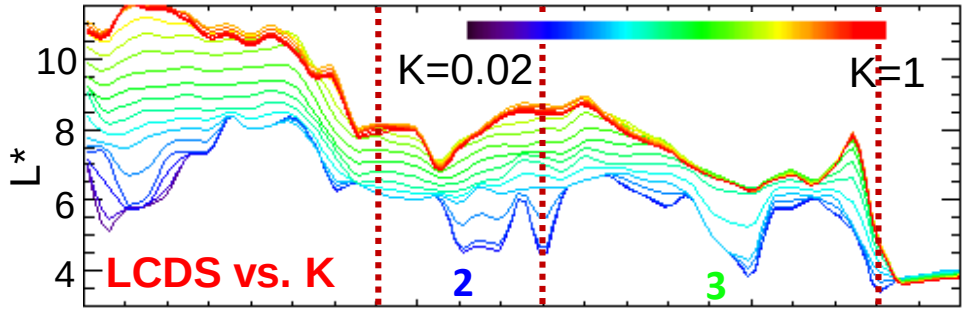
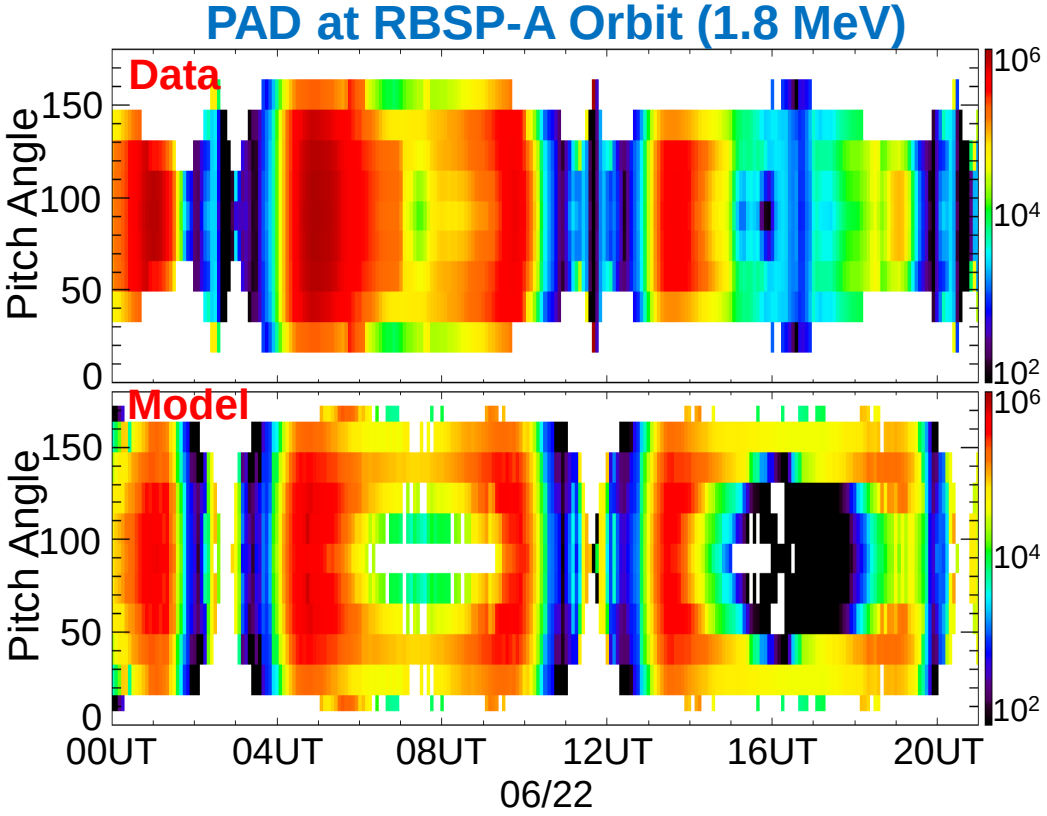
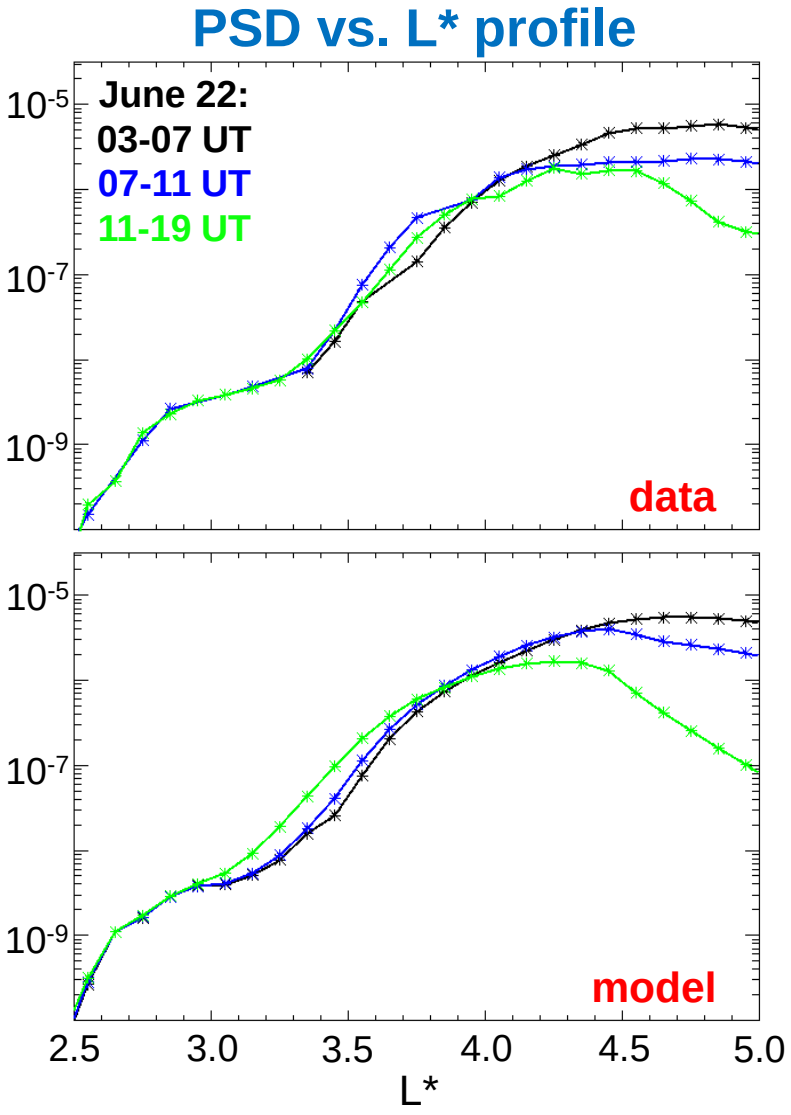
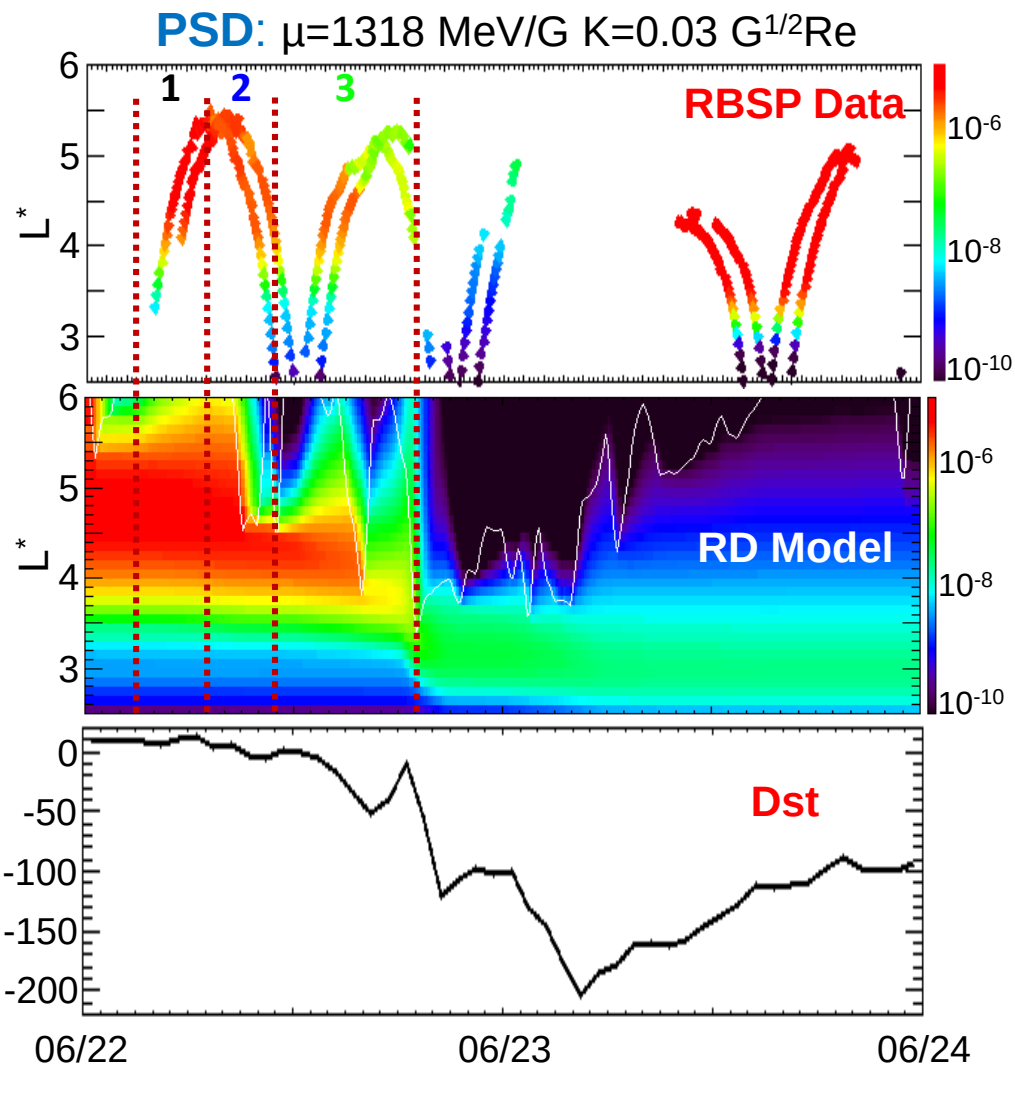






Model Results with D_{LL}(B&A)





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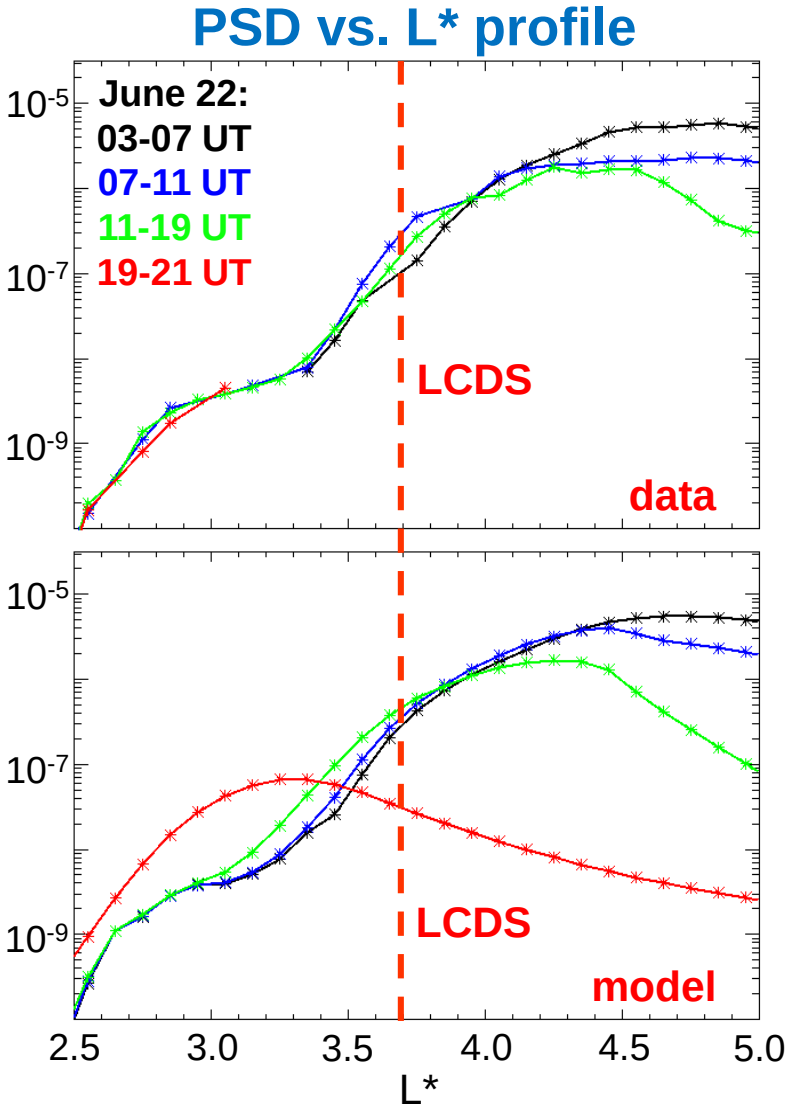

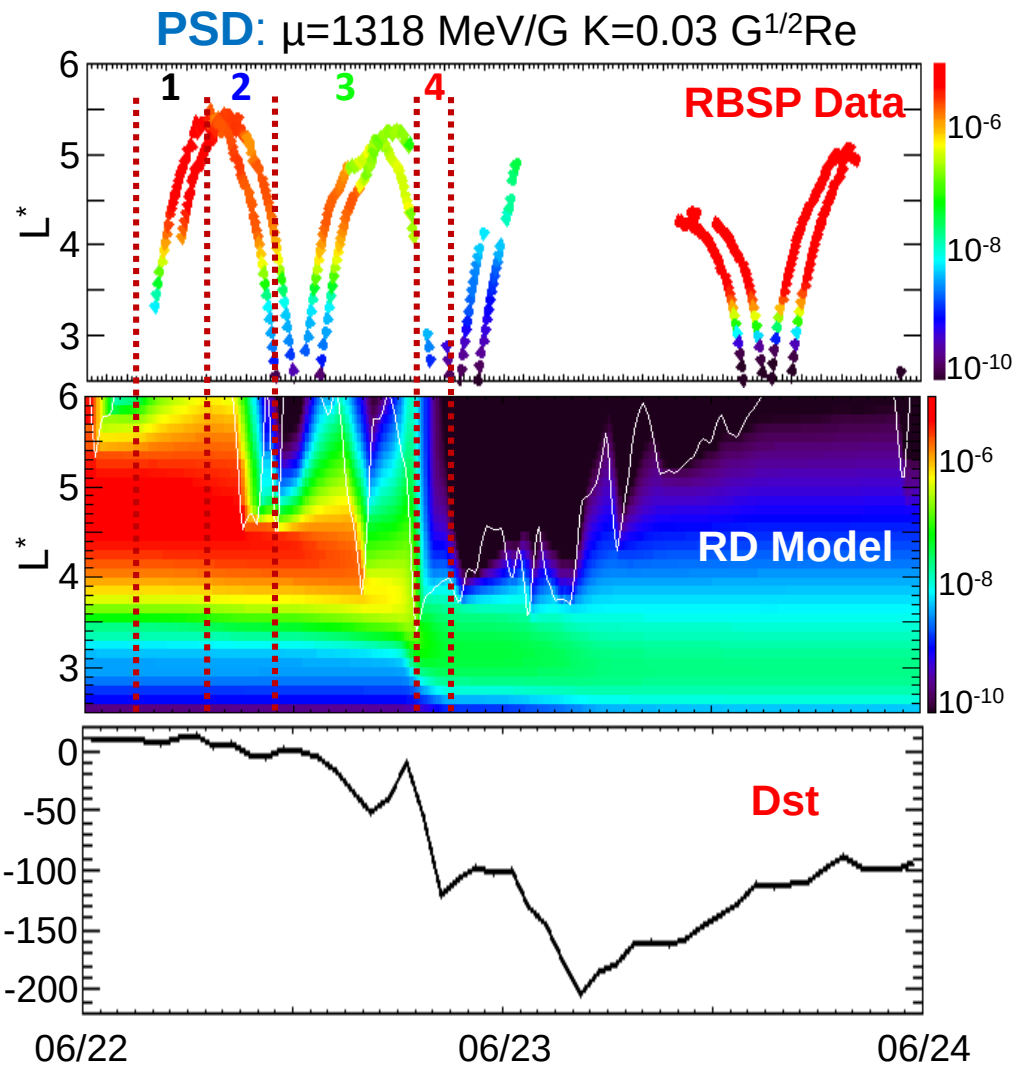

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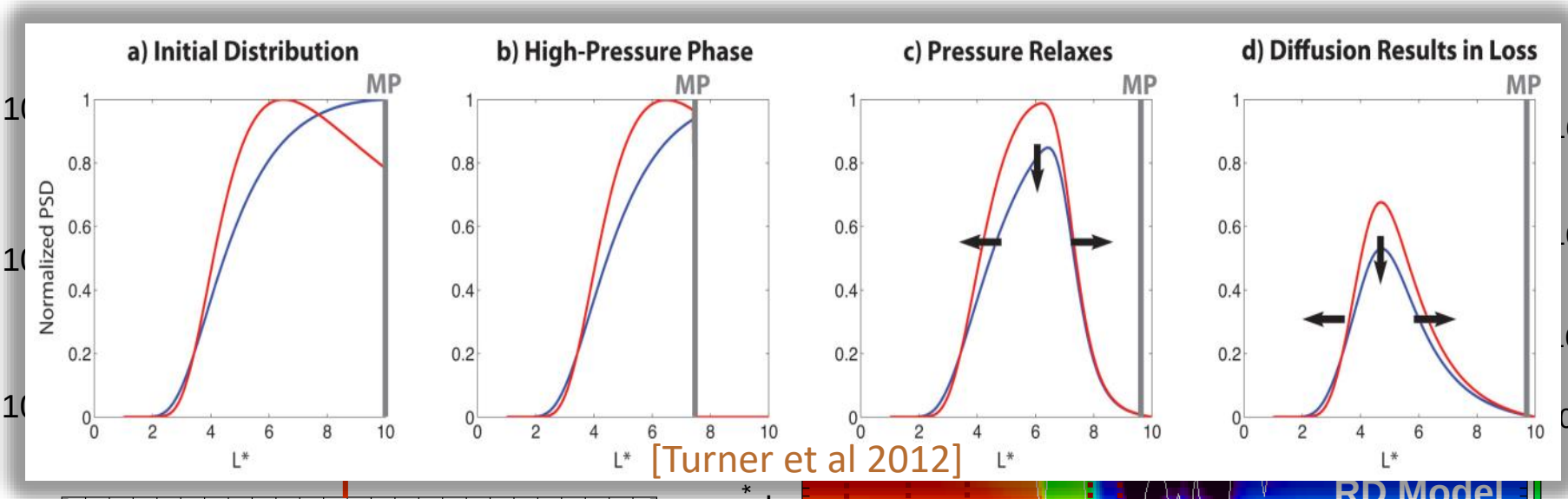
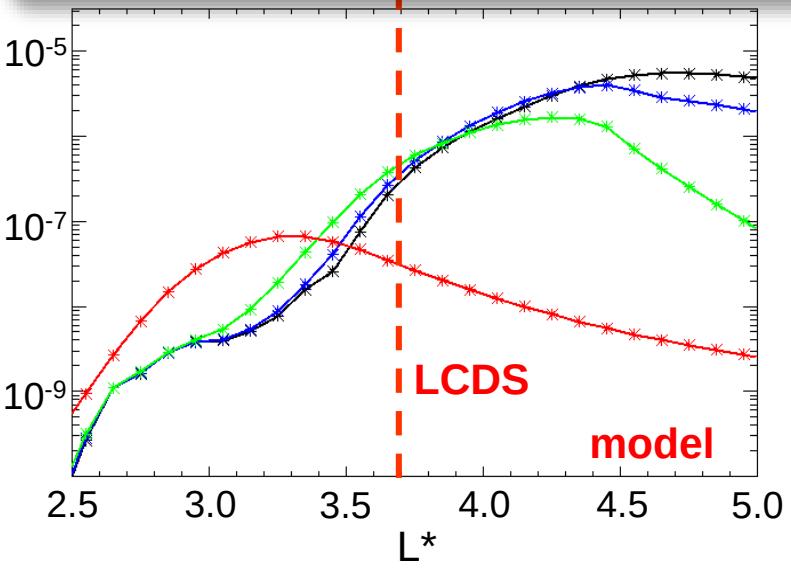
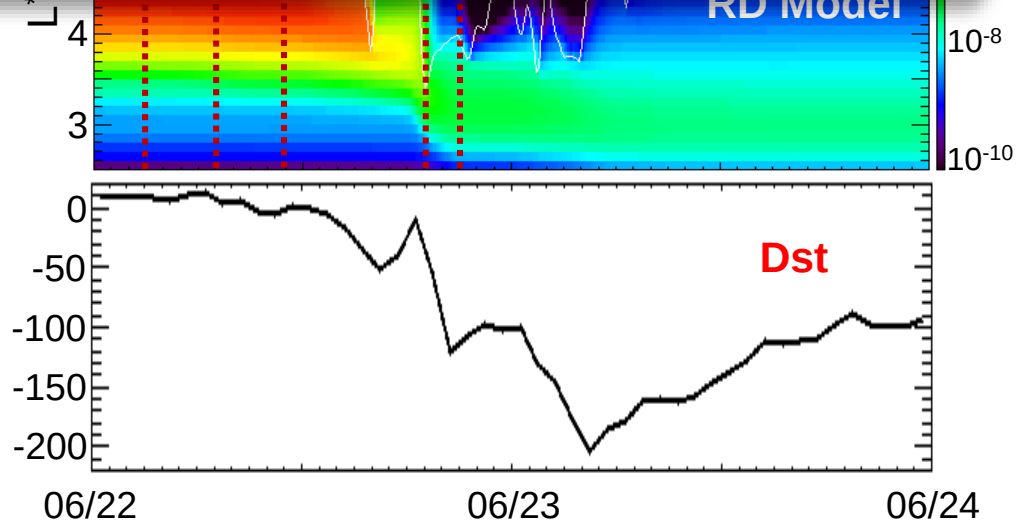
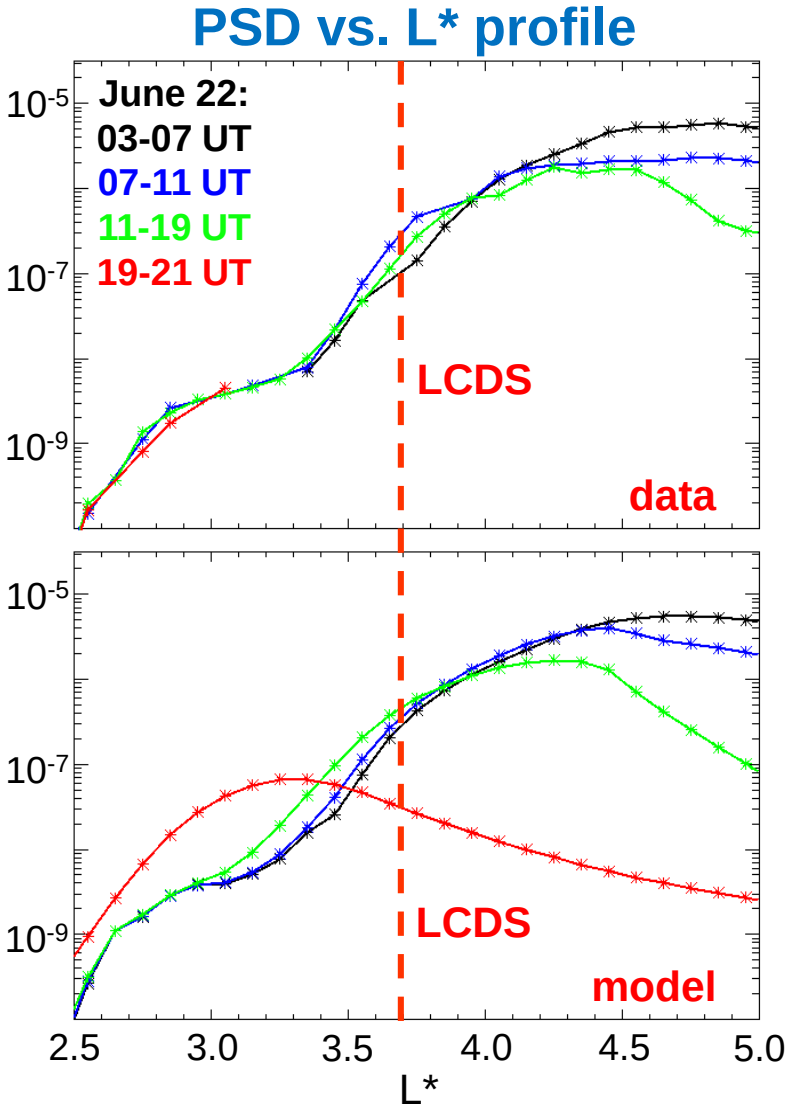


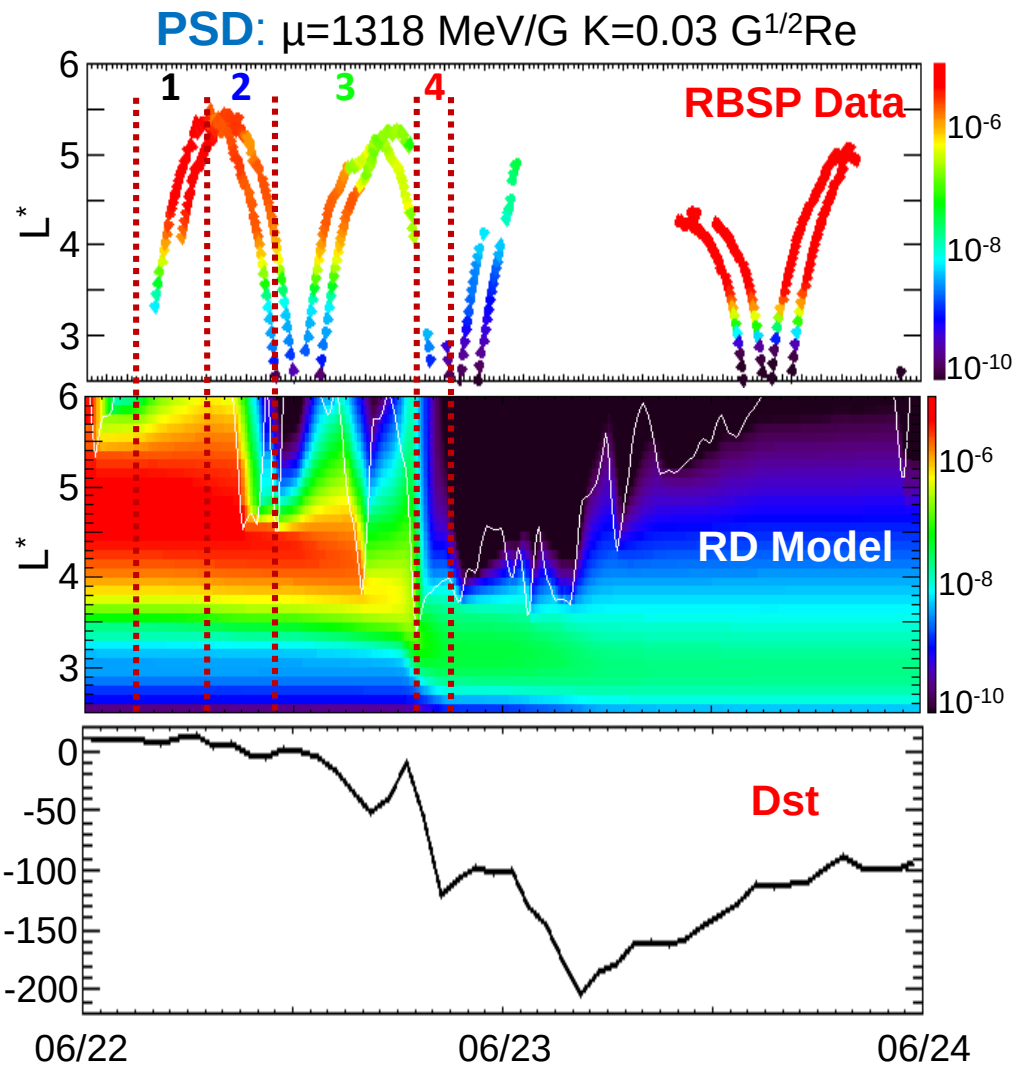
[Turner et al 2012]





Model Results with D_{LL}(B&A)





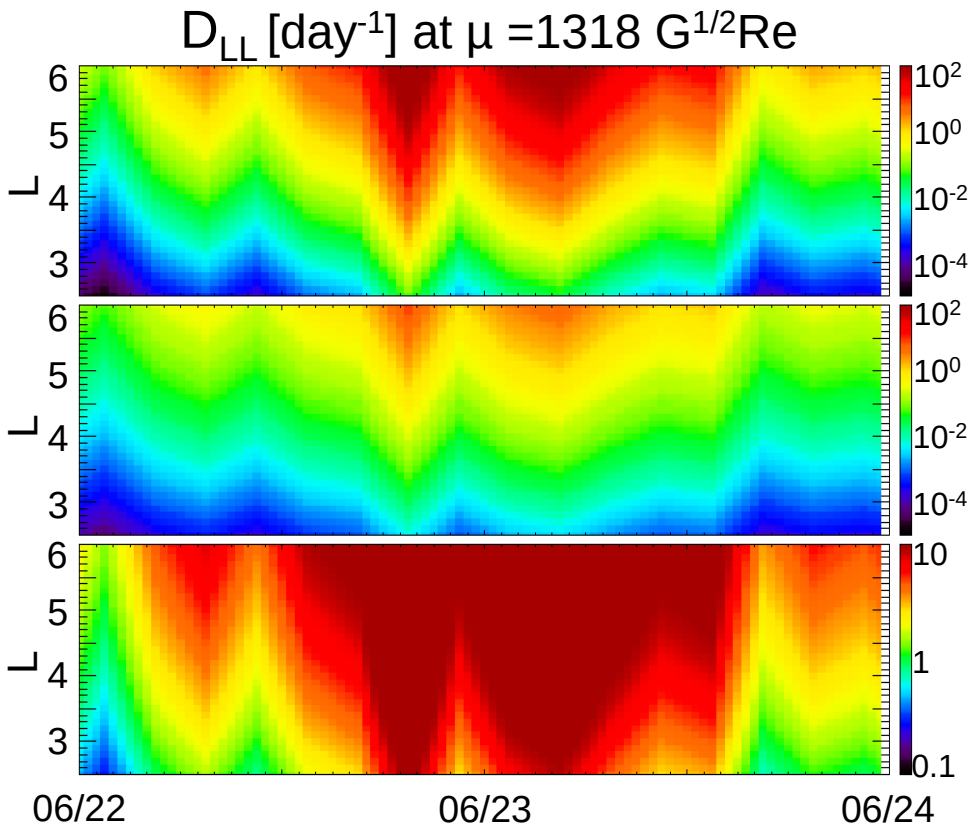
D_{LL}(B&A) vs. D_{LL}(Liu+Ali)

- New D_{LL}^{E} (μ, Kp, L) from [Liu et al., 2016] based on THEMIS data
- New D_{LL}^{B} (Kp, L) from [Ali et al., 2016] based on Van Allen Probes data
- More realistic D_{LL}^{Total} (μ, Kp, L) = D_{LL}^{E} (μ, Kp, L) + D_{LL}^{B} (Kp, L)

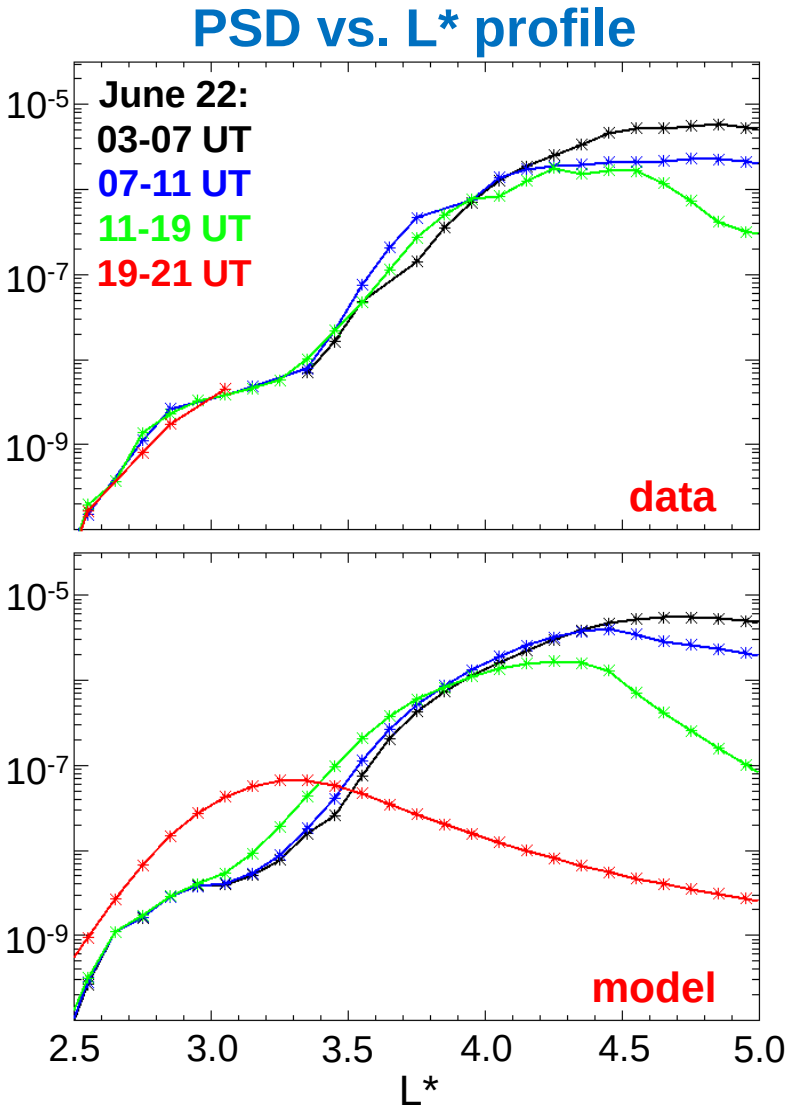
D_{LL}(B&A)

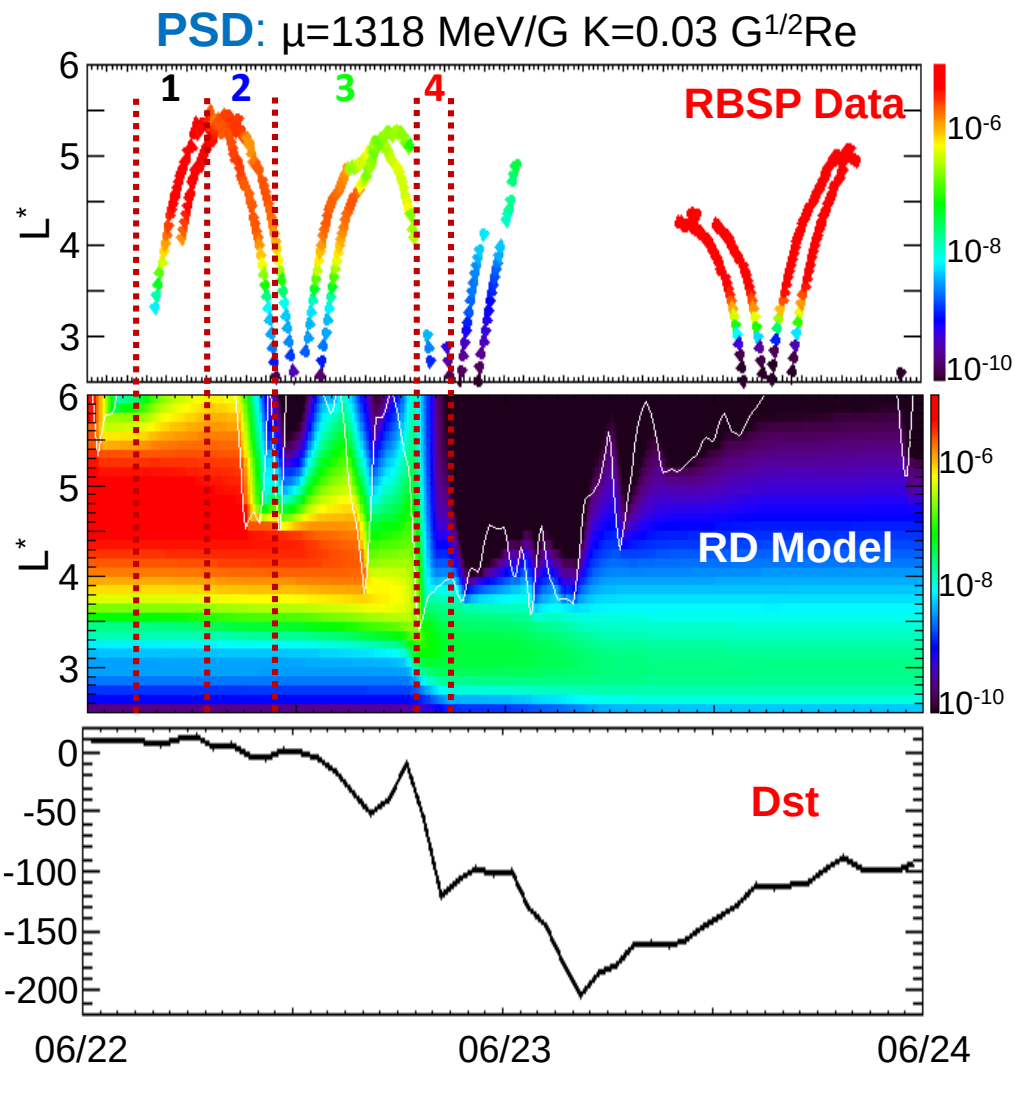
D_{LL}(Liu+Ali)

D_{LL} (B&A)/D_{LL}(Liu+Ali)

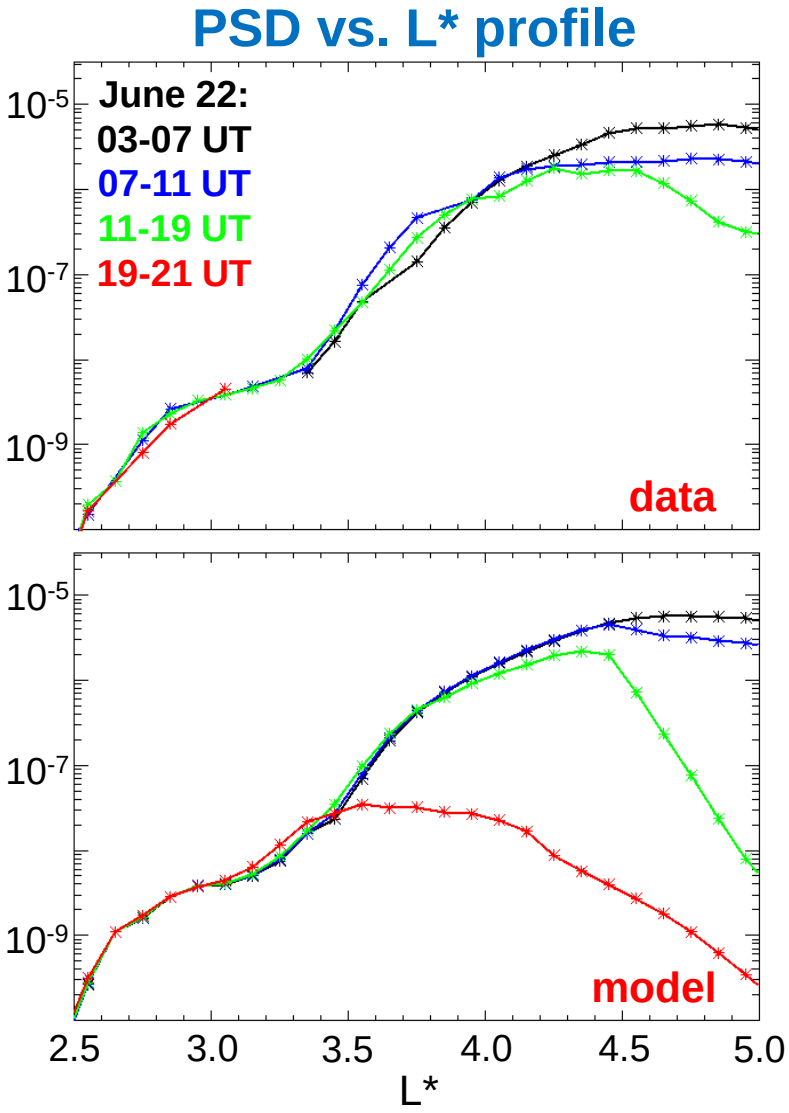


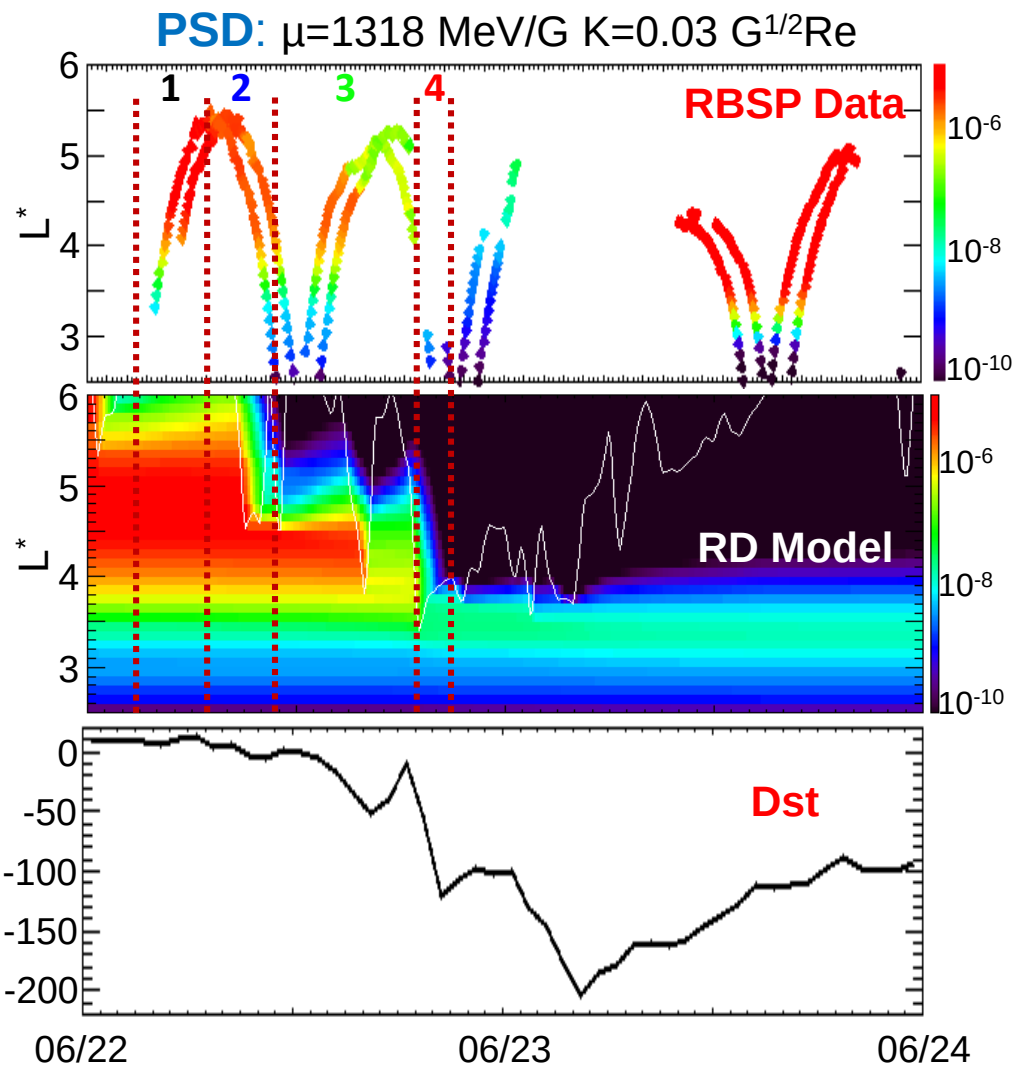
Model Results with D_{LL}(B&A)



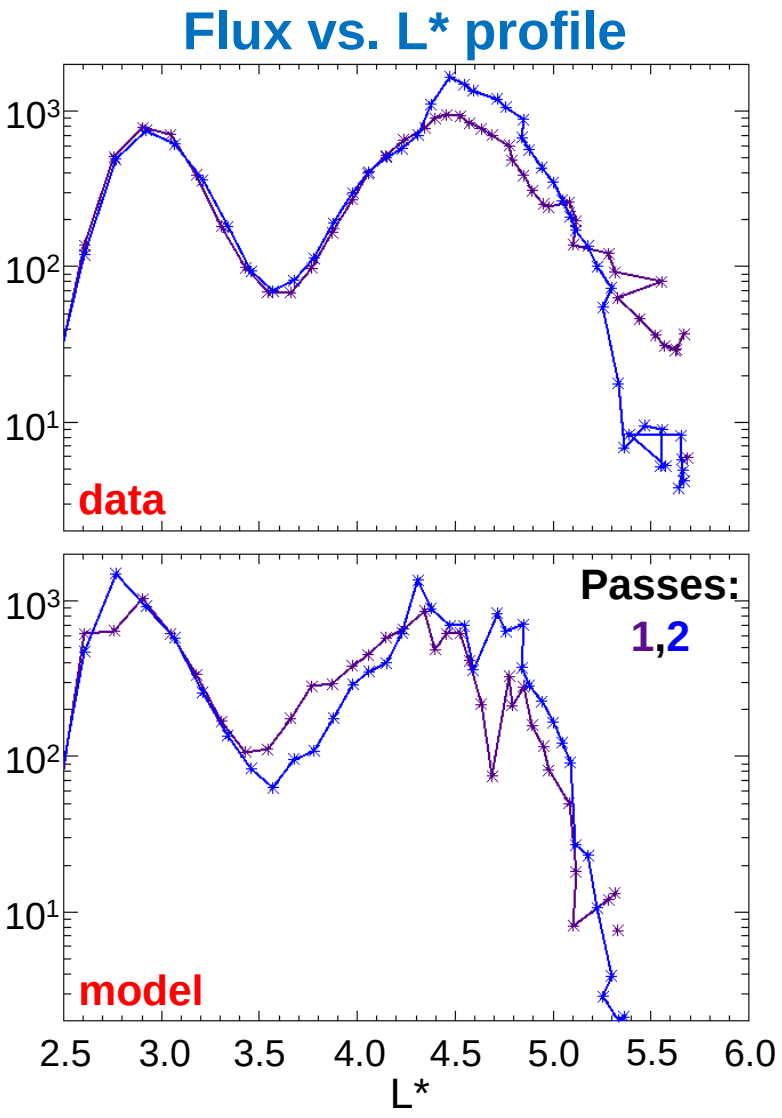


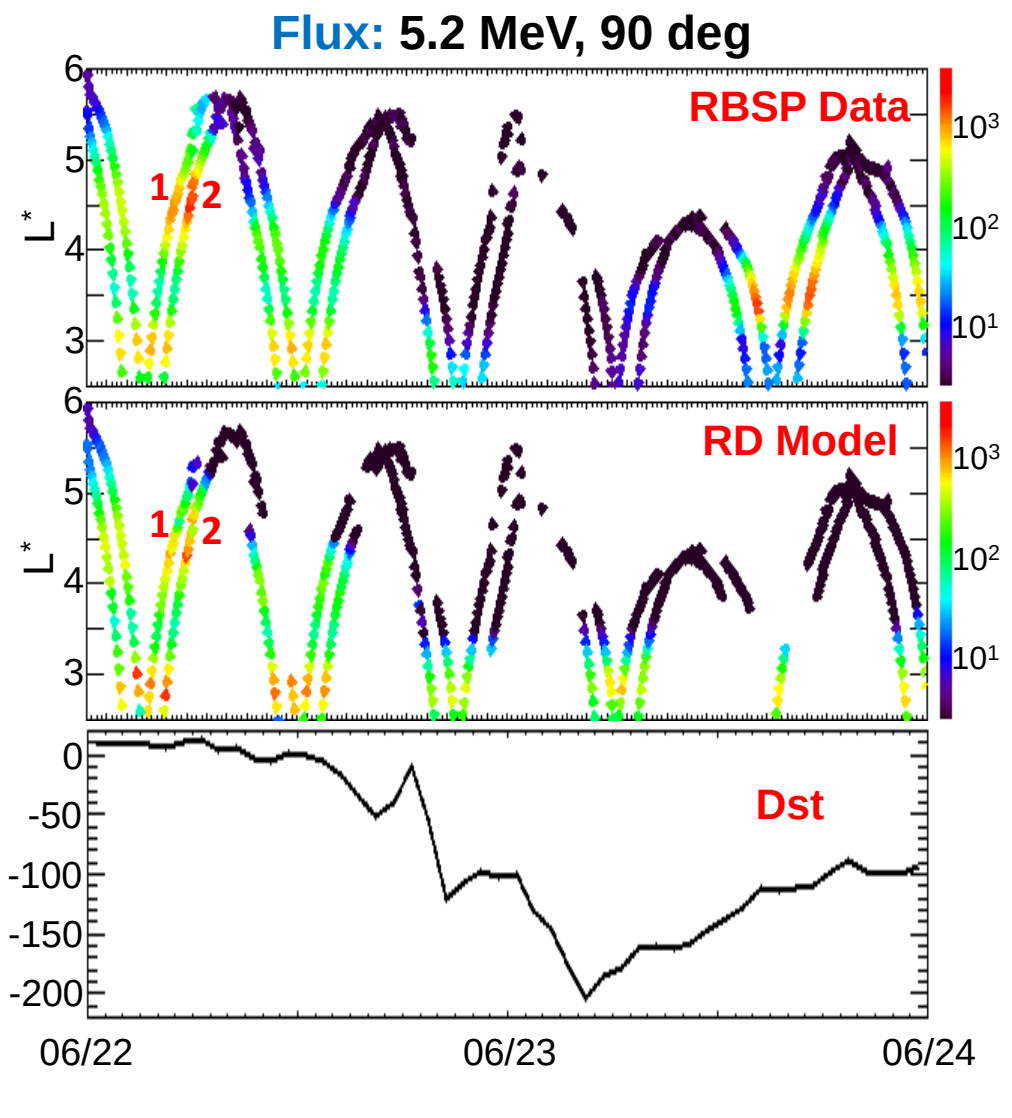
Model Results with D_{LL}(Liu+Ali)





Model Results in Flux





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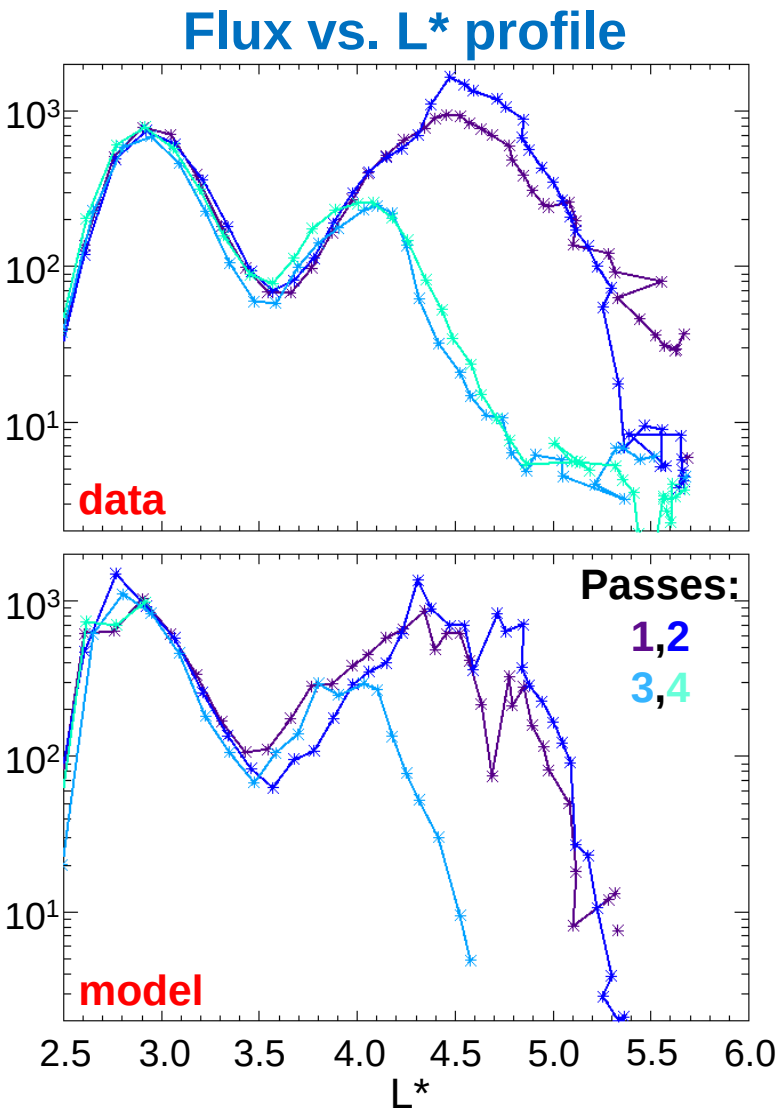
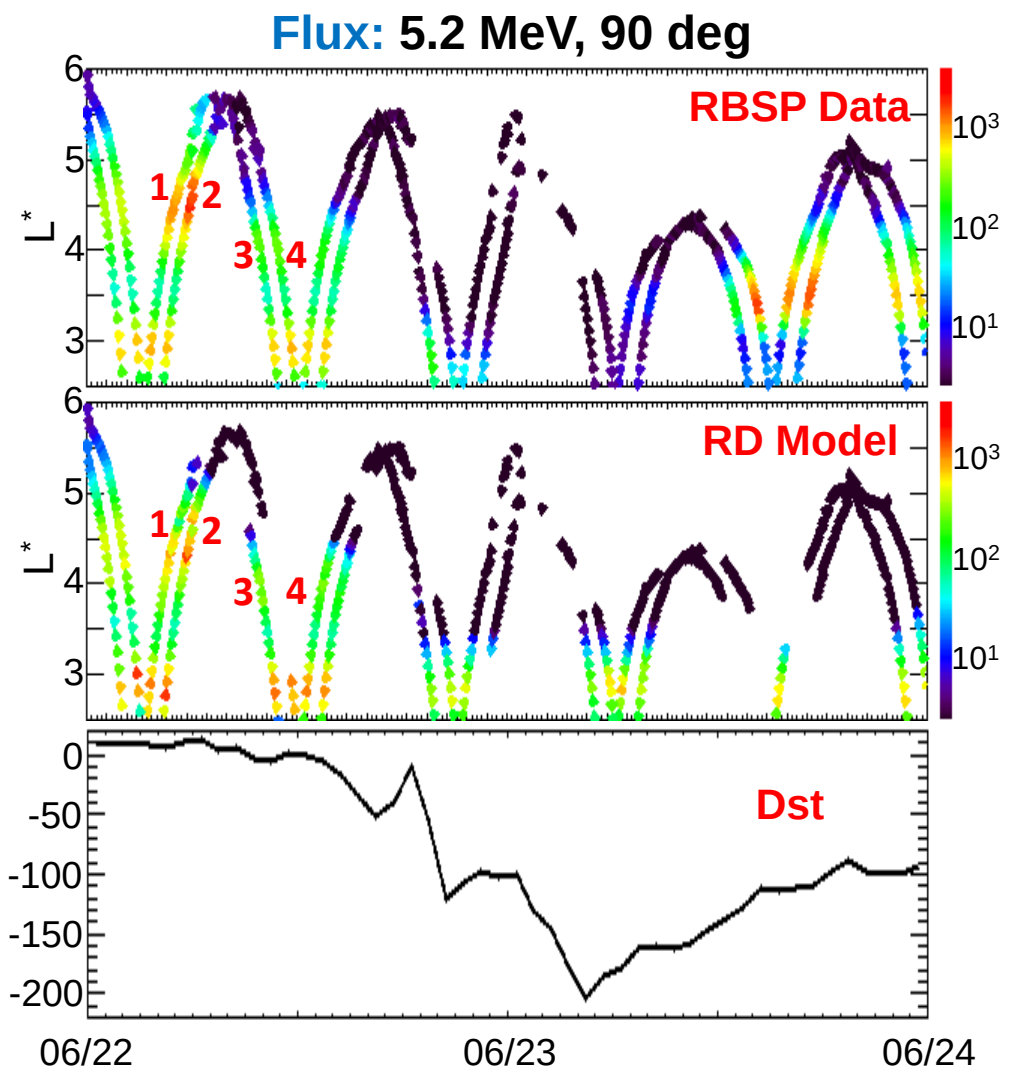
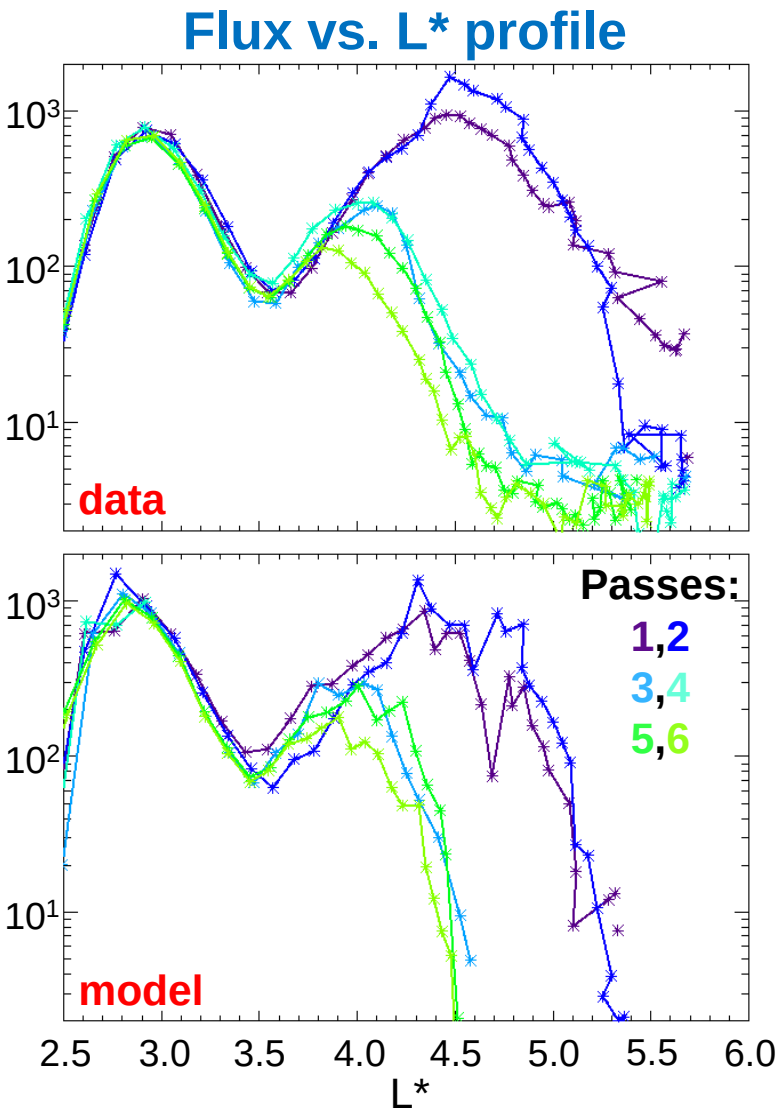
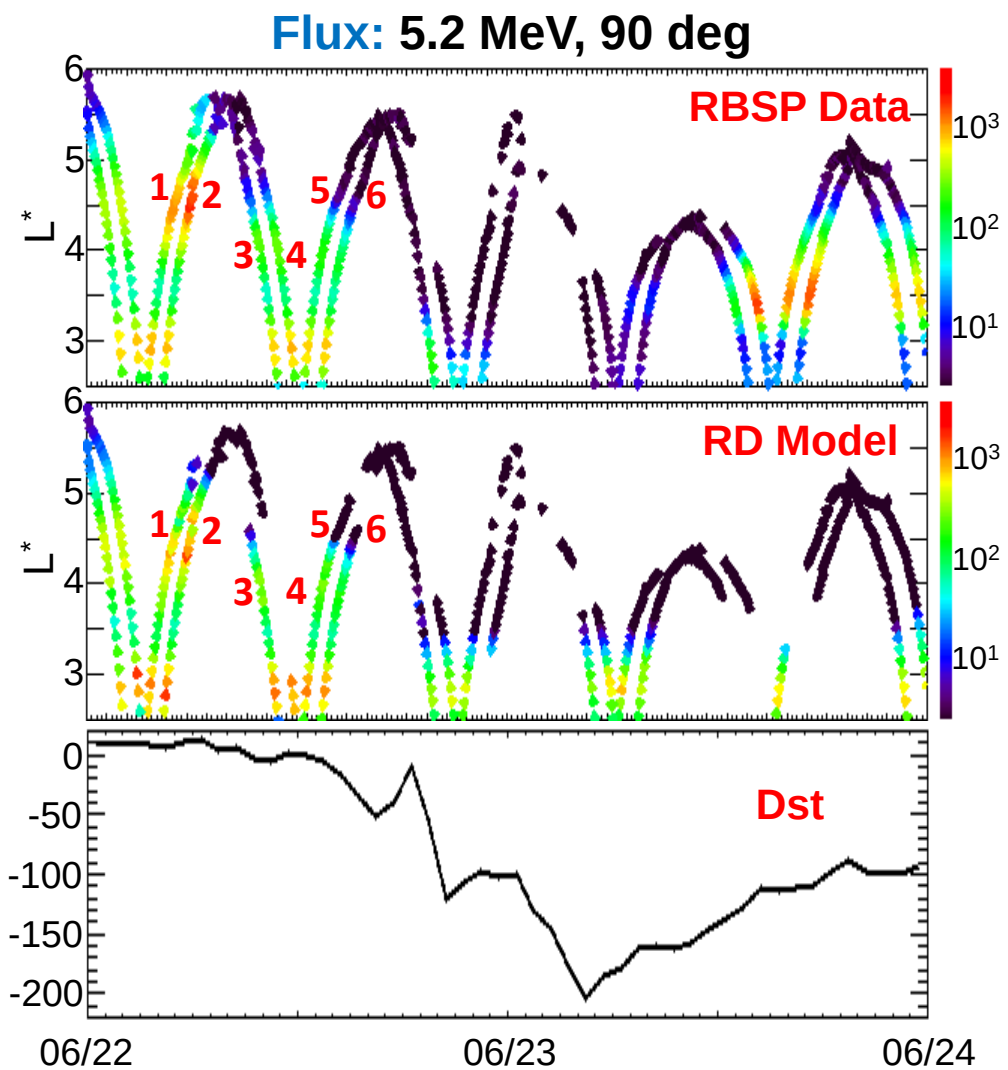




Model Results in Flux





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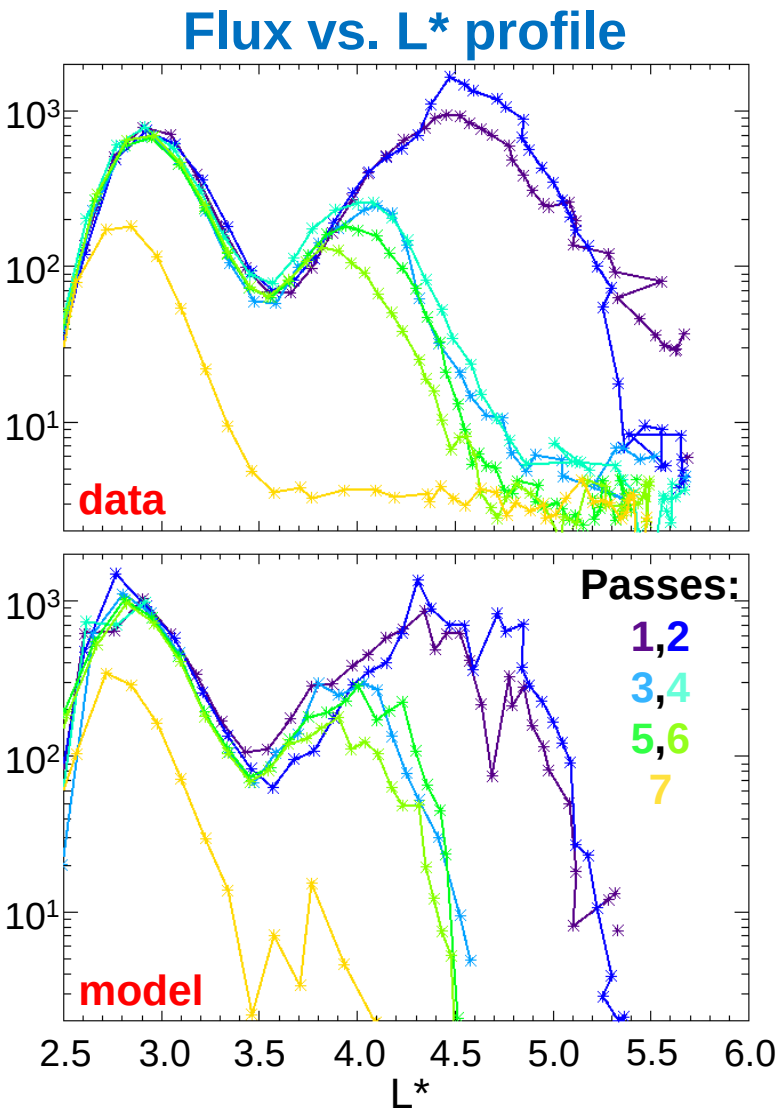
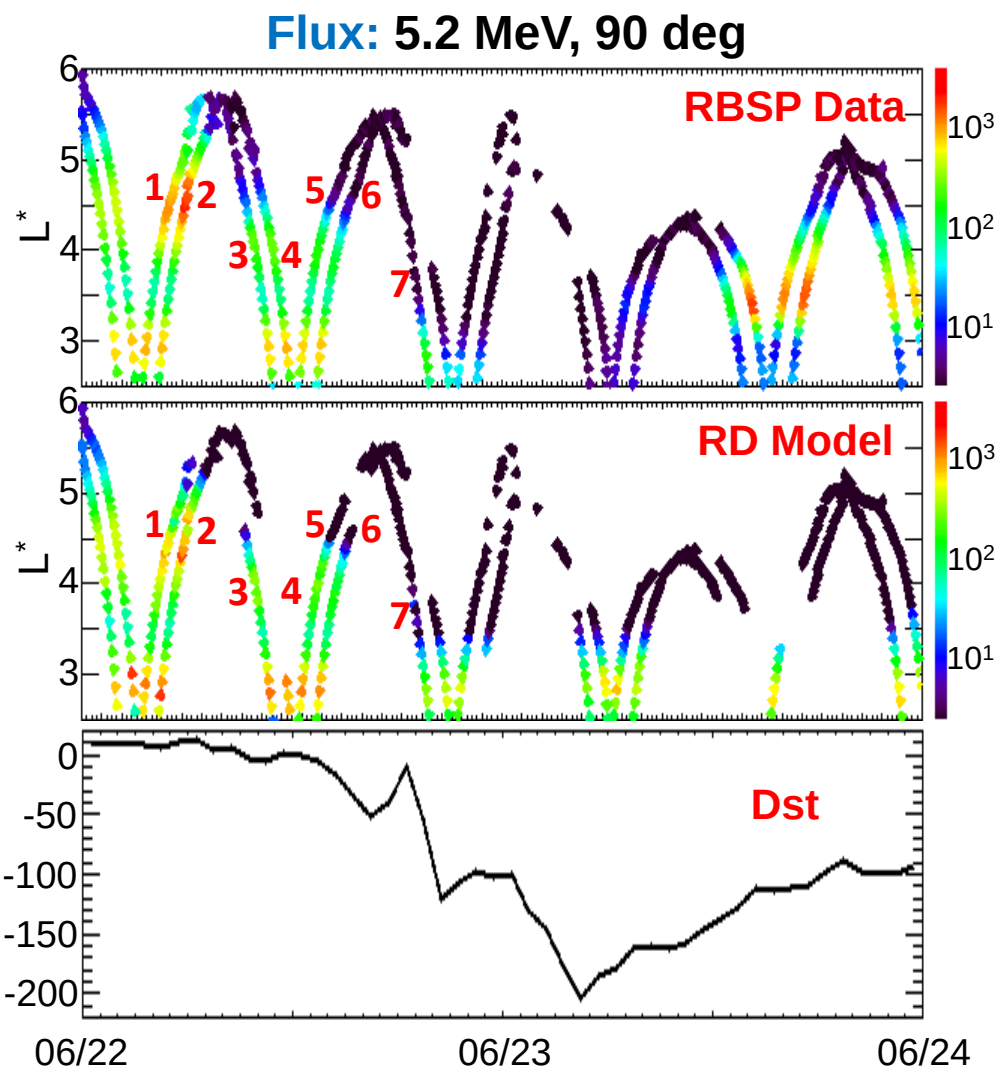
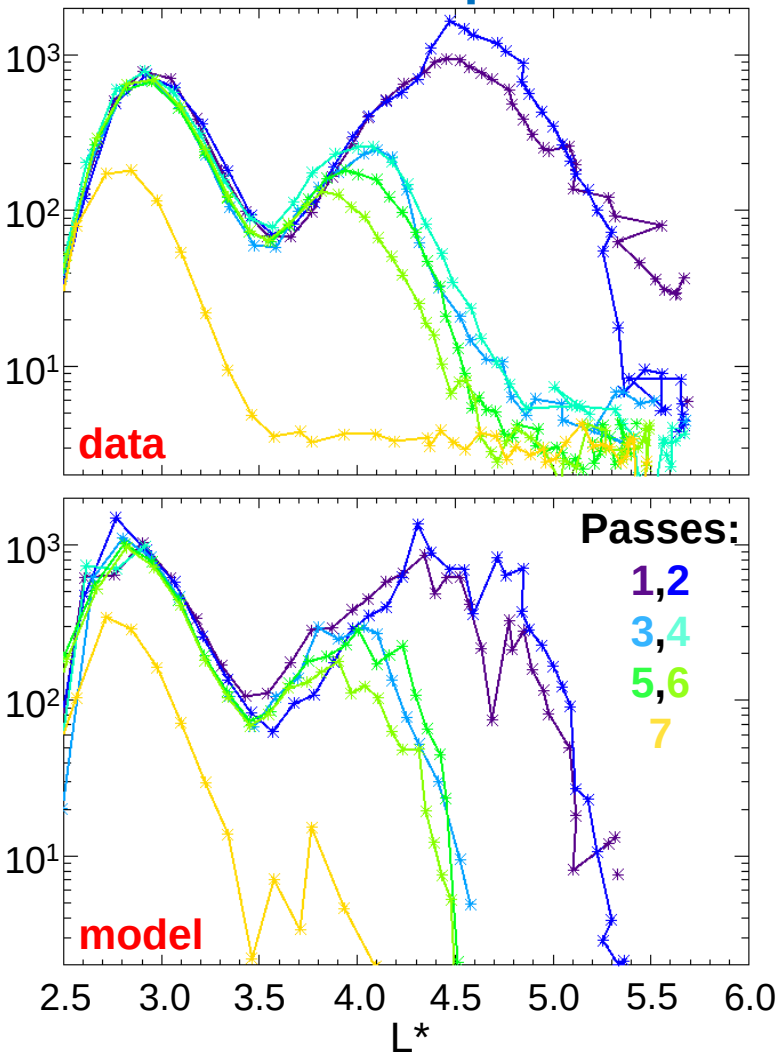


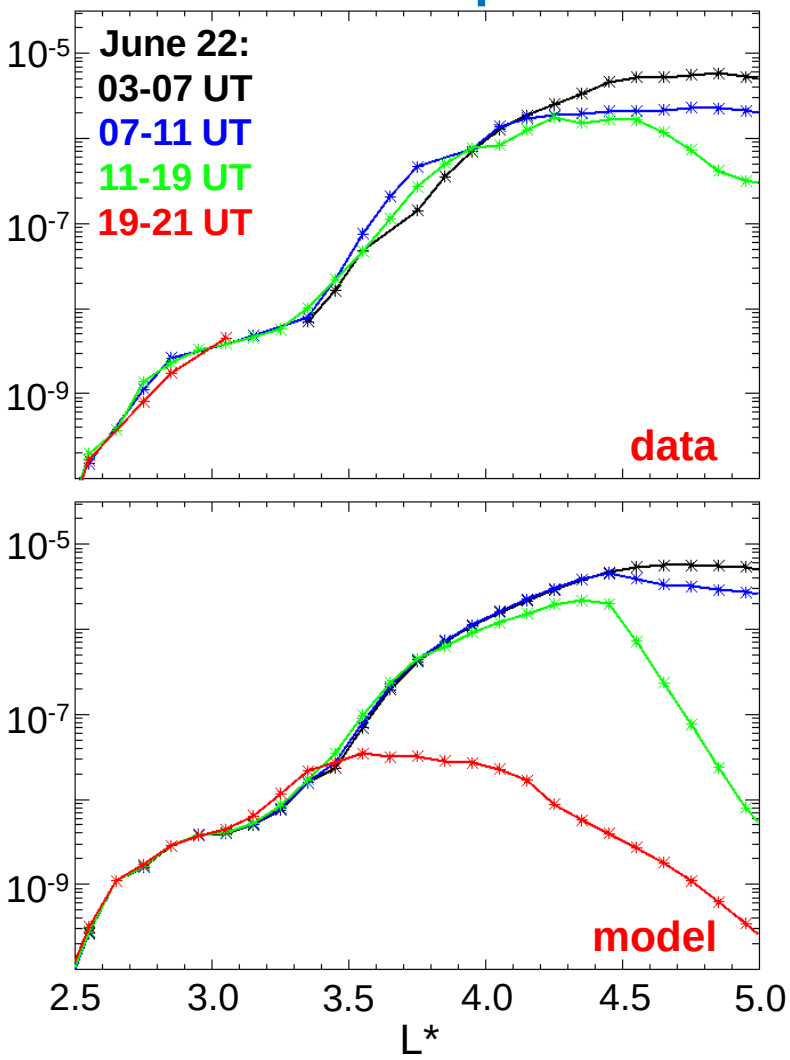


Model Results in Flux

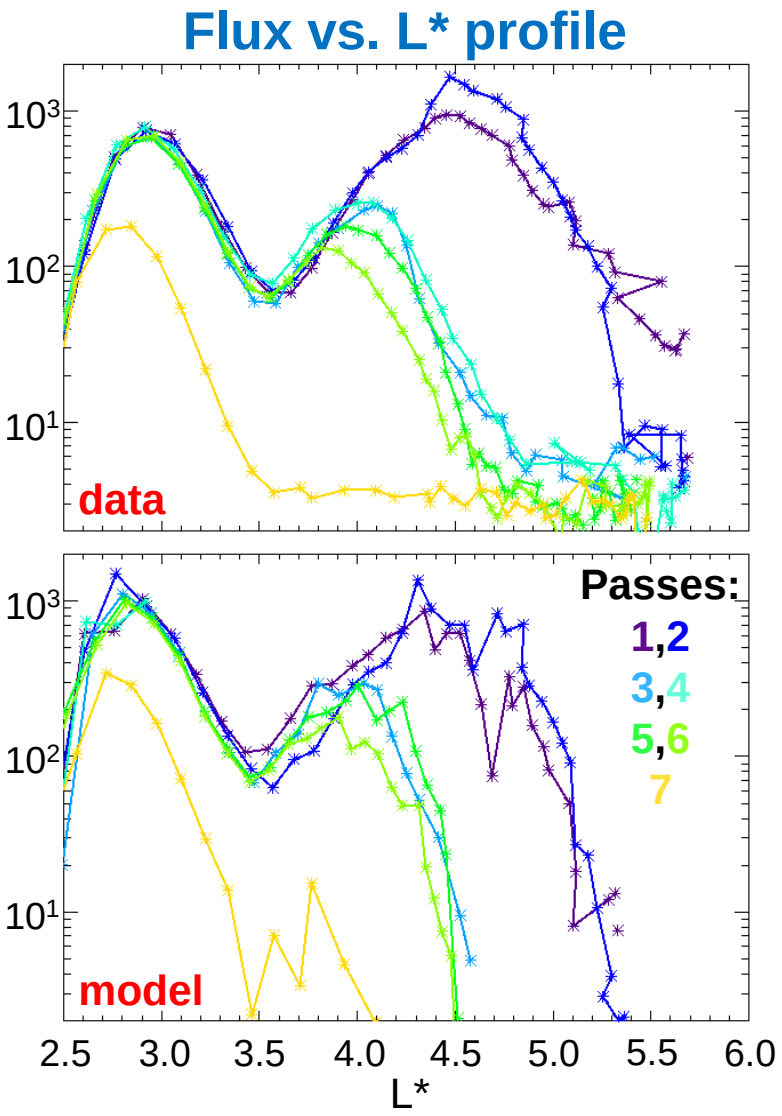
Flux vs. L* profile

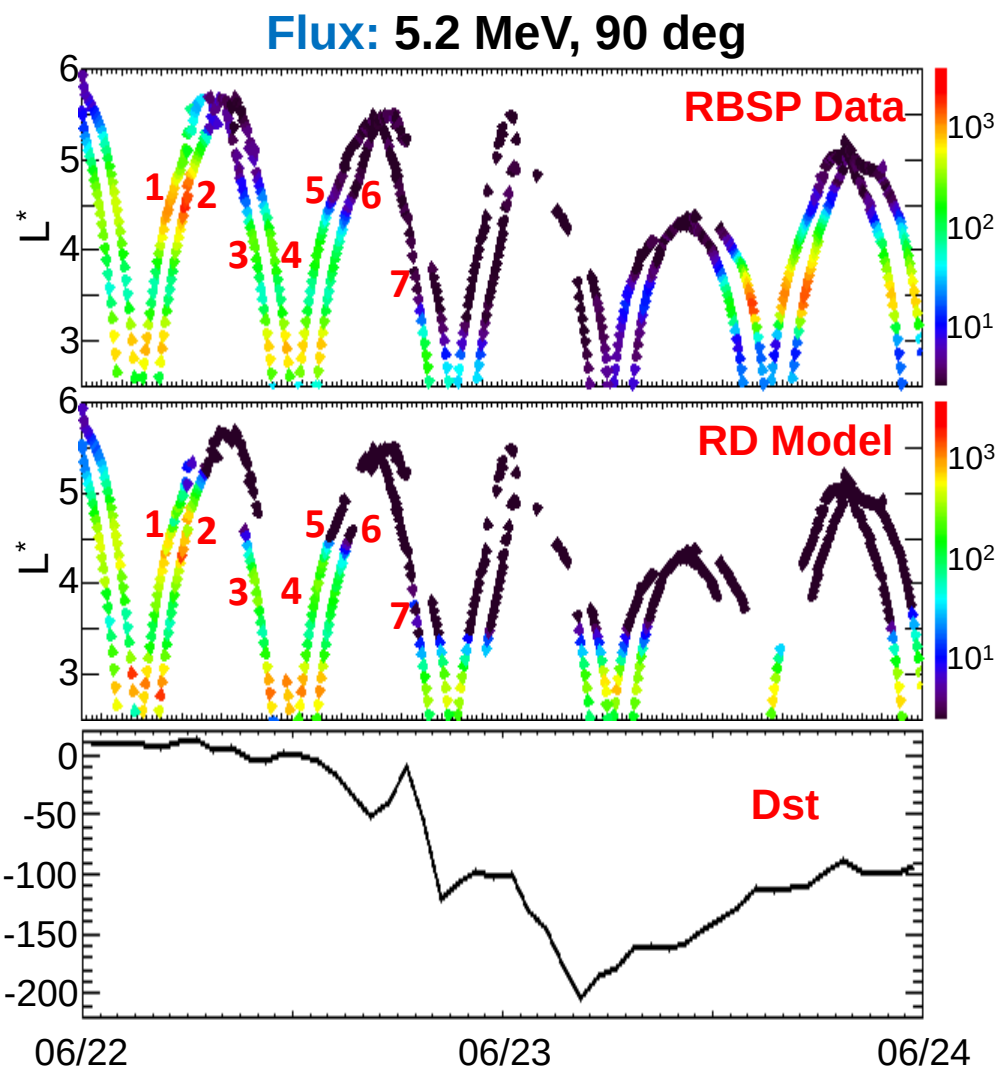


PSD vs. L* profile



Model Results in Flux





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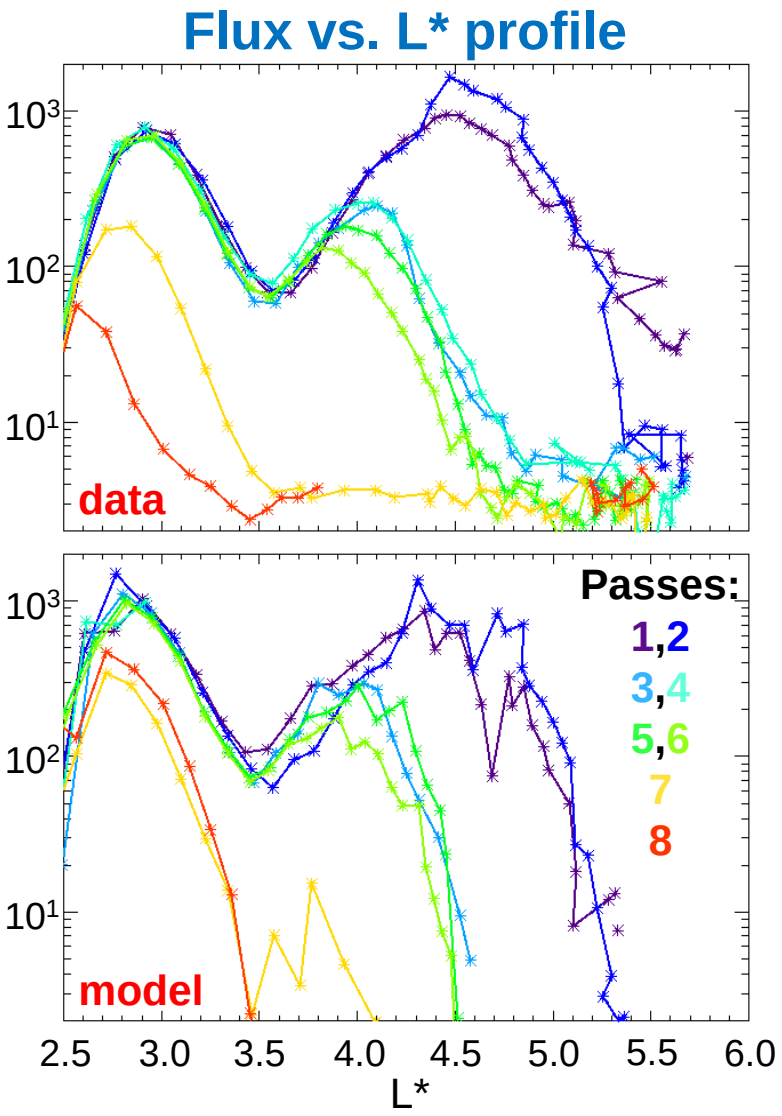
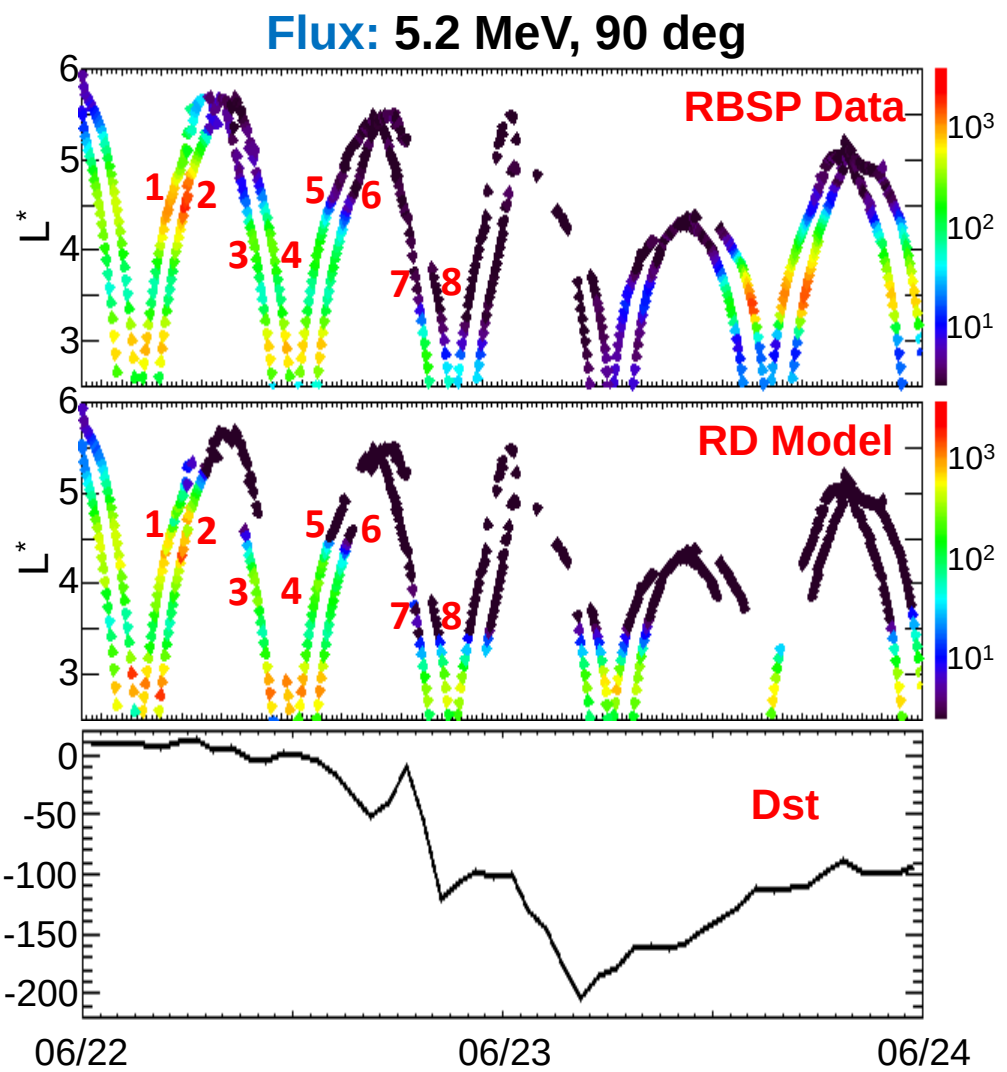
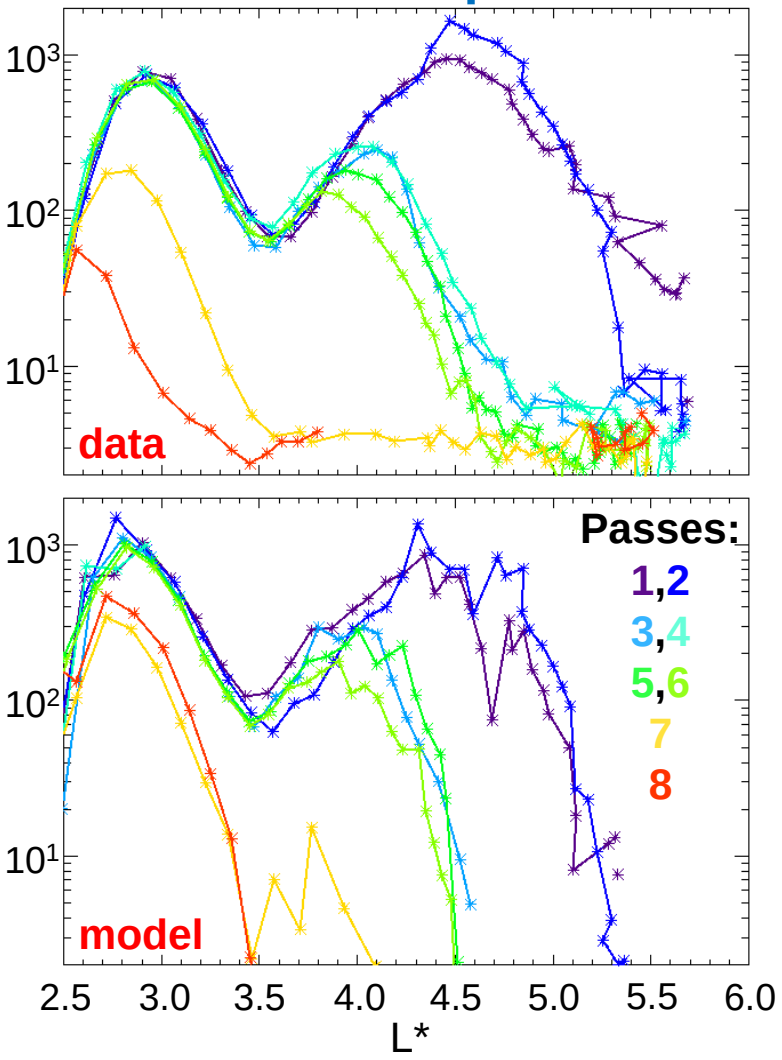


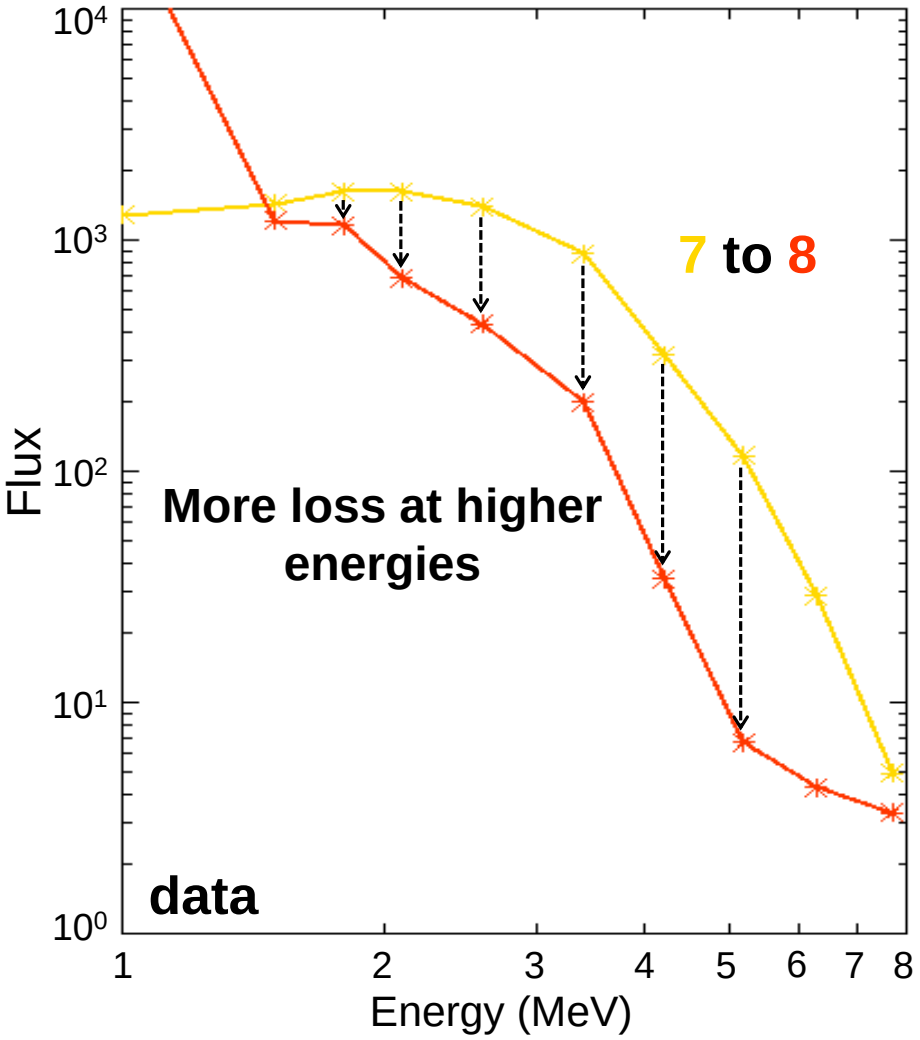


Model Results in Flux

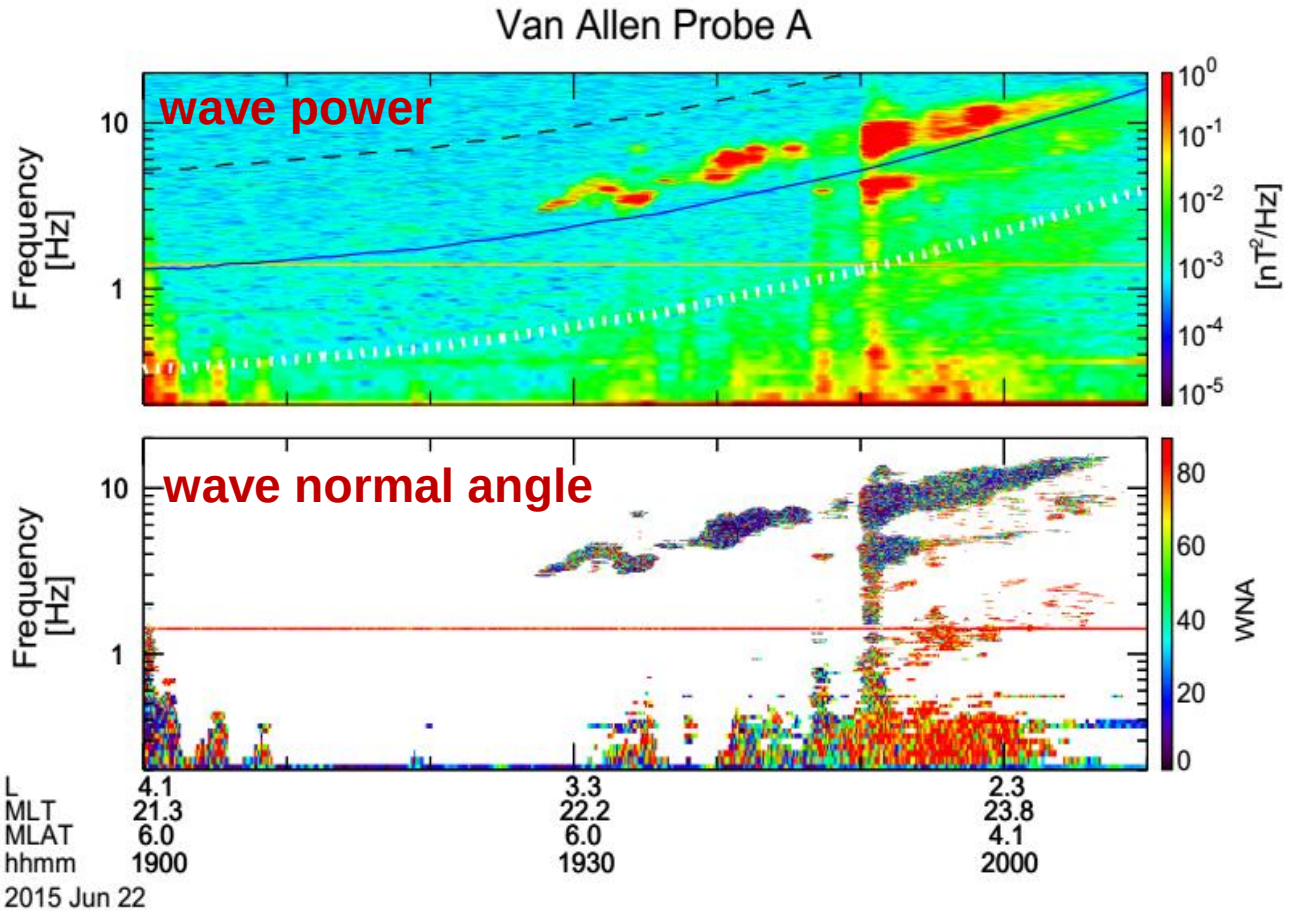
Flux vs. L* profile



Evolution of Energy Spectrum

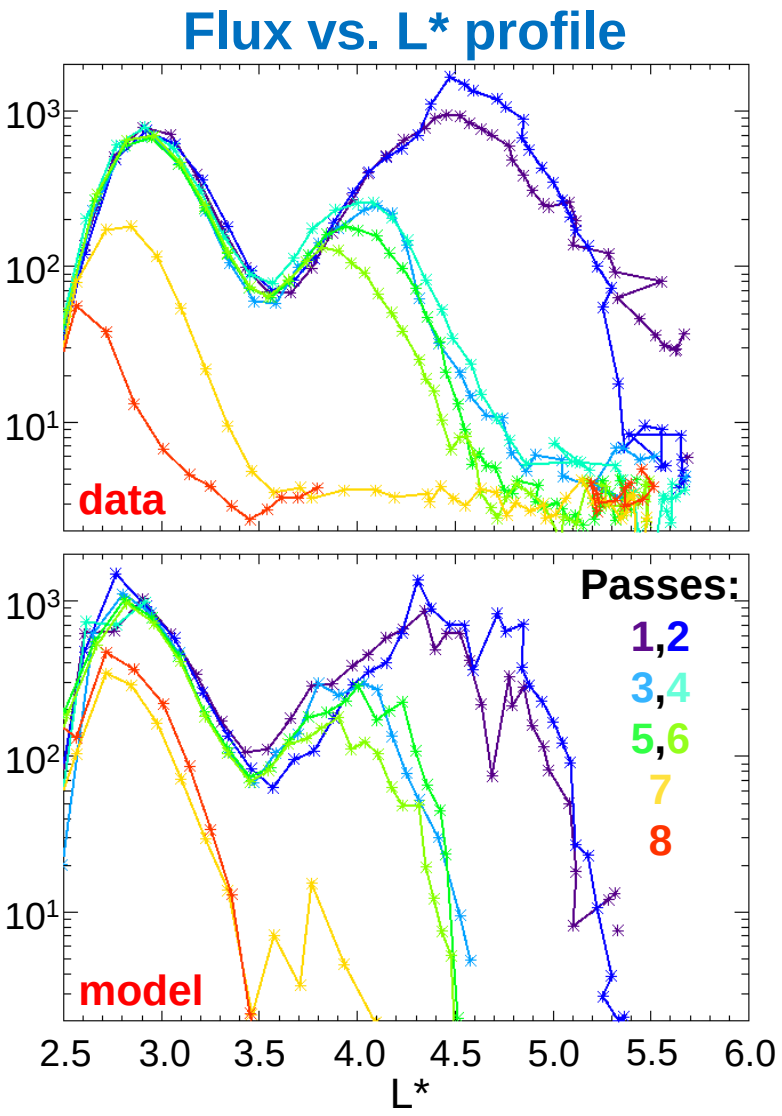


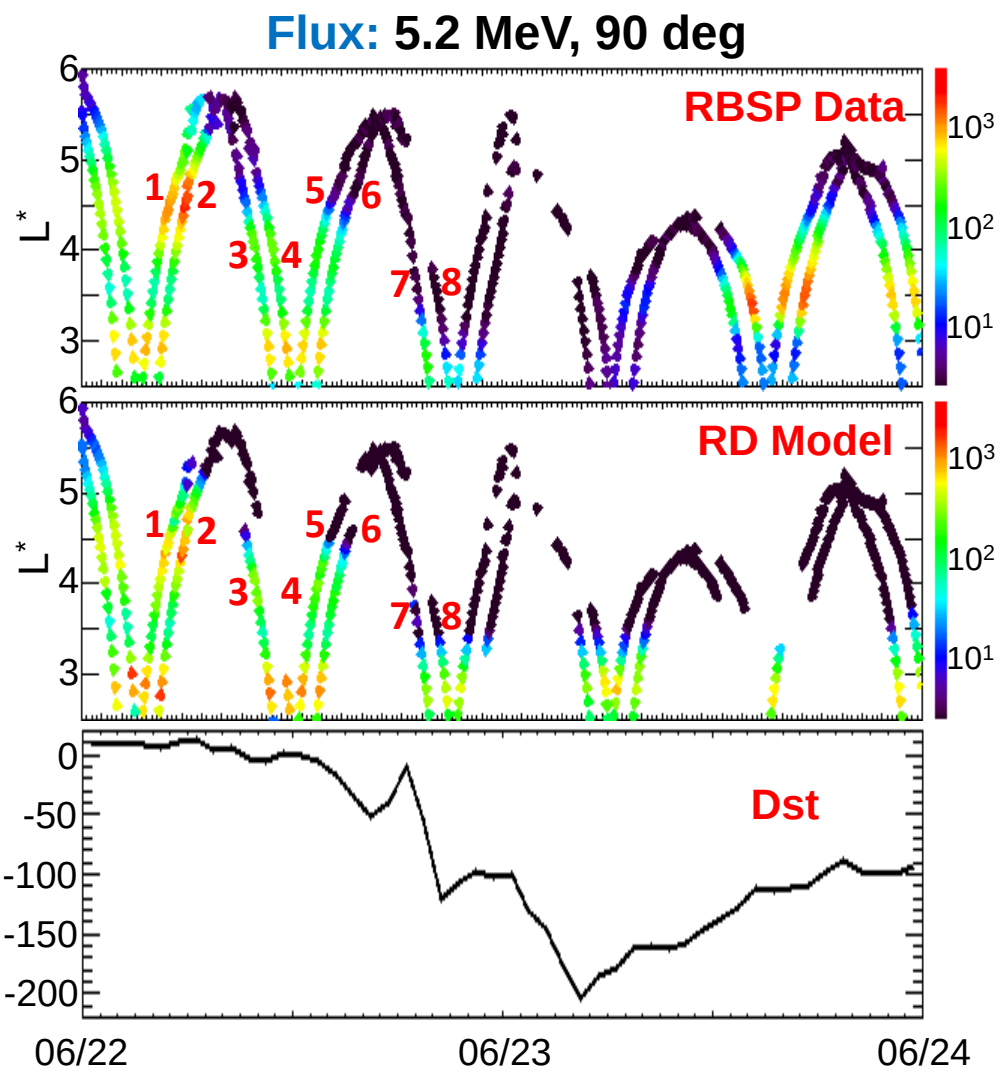
EMIC Wave Observations



- H+ band EMIC waves were detected at 2.5<L*<3.5 by RBSP-A during pass 7.

Model Results in Flux

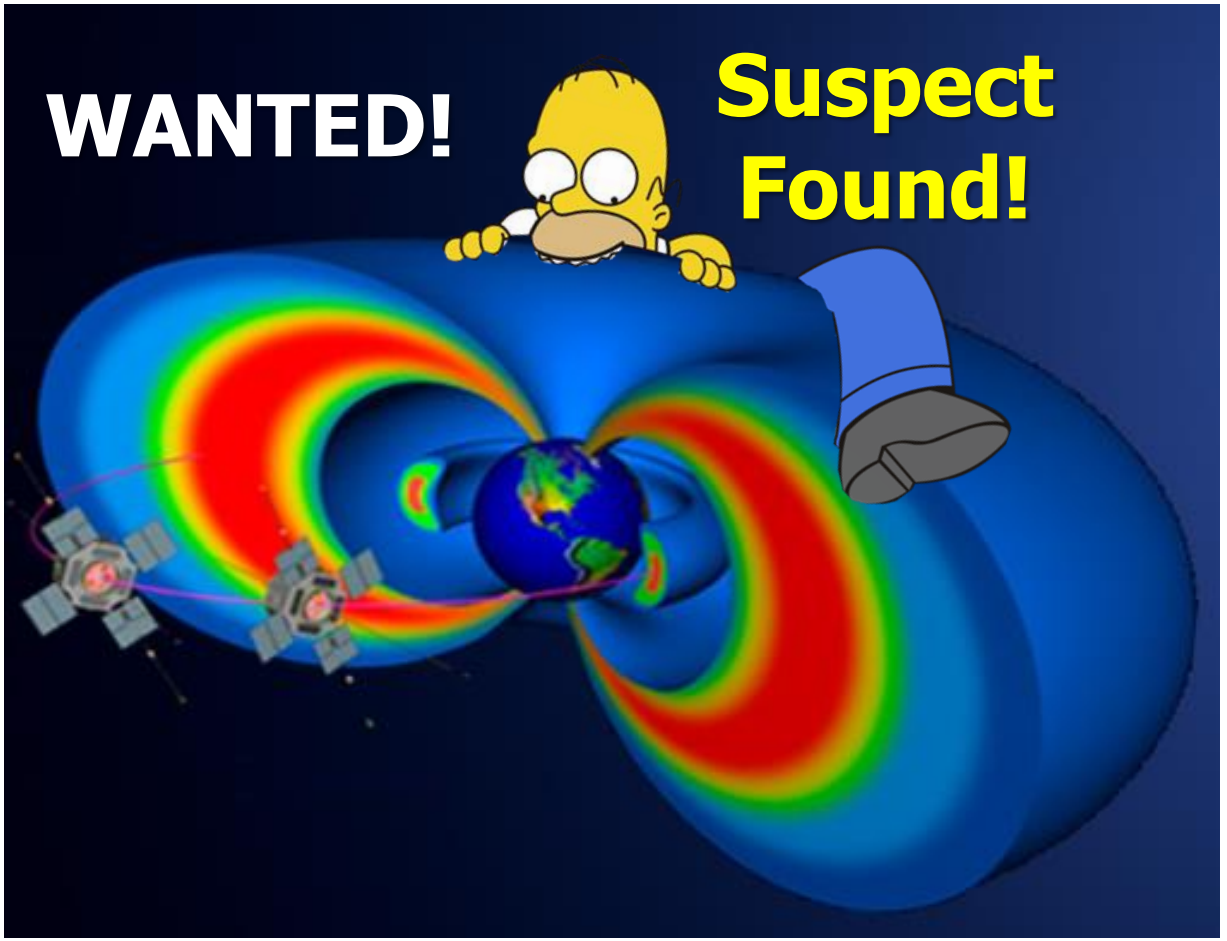




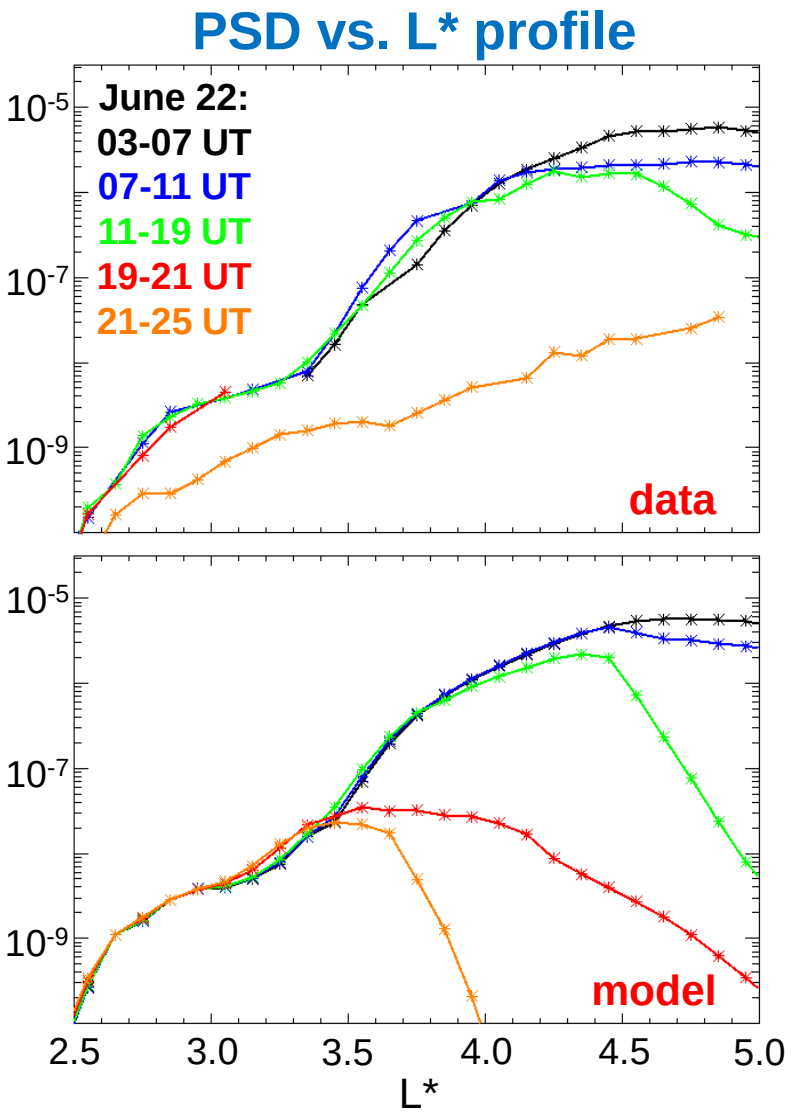
Conclusions

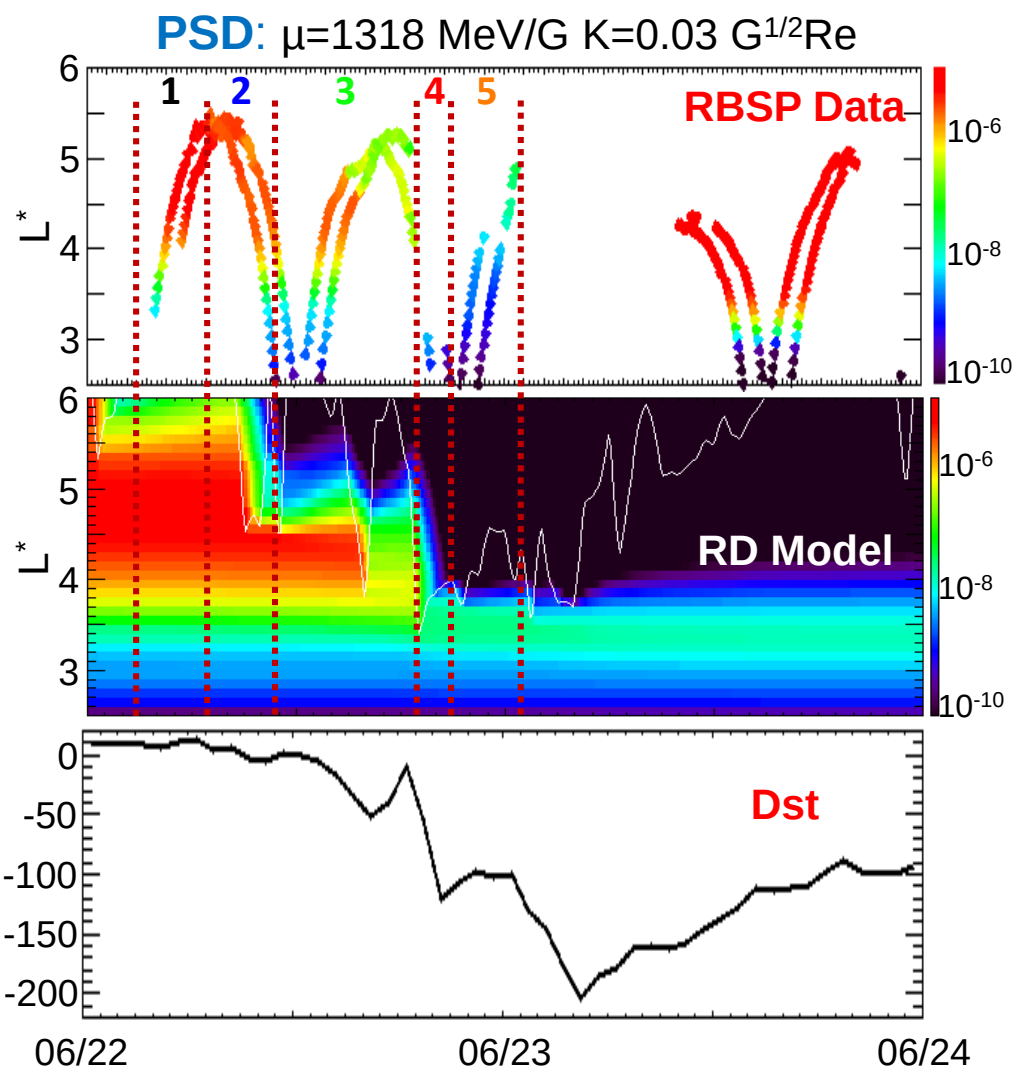
- A radial diffusion model with event-specific LCDS and new D_{LL} was developed to simulate the remarkable RB dropout during the intensely CME-shock driven June 2015 storm.
- The model well captured:
  - The fast magnetopause shadowing loss at high L* regions after both shocks;
  - The initial adiabatic loss of the storage ring at low L* regions after the second strong shock;
  - The event-specific and K-dependent LCDS and new D_{LL} are critical to reproduce the detailed dropout features (timing, location, PAD).
- Future work is needed to model the further loss of storage ring after the shock possibly by EMIC waves.

Who ate the RB donut?

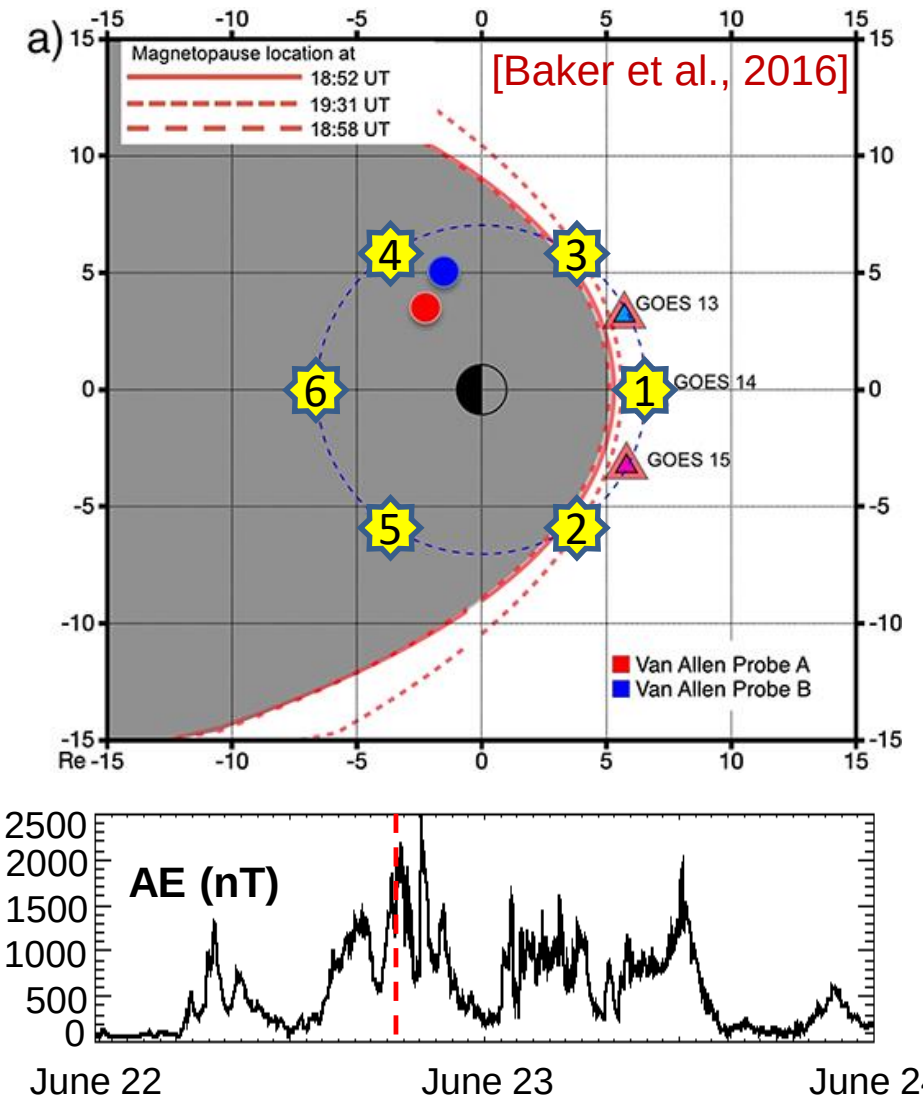


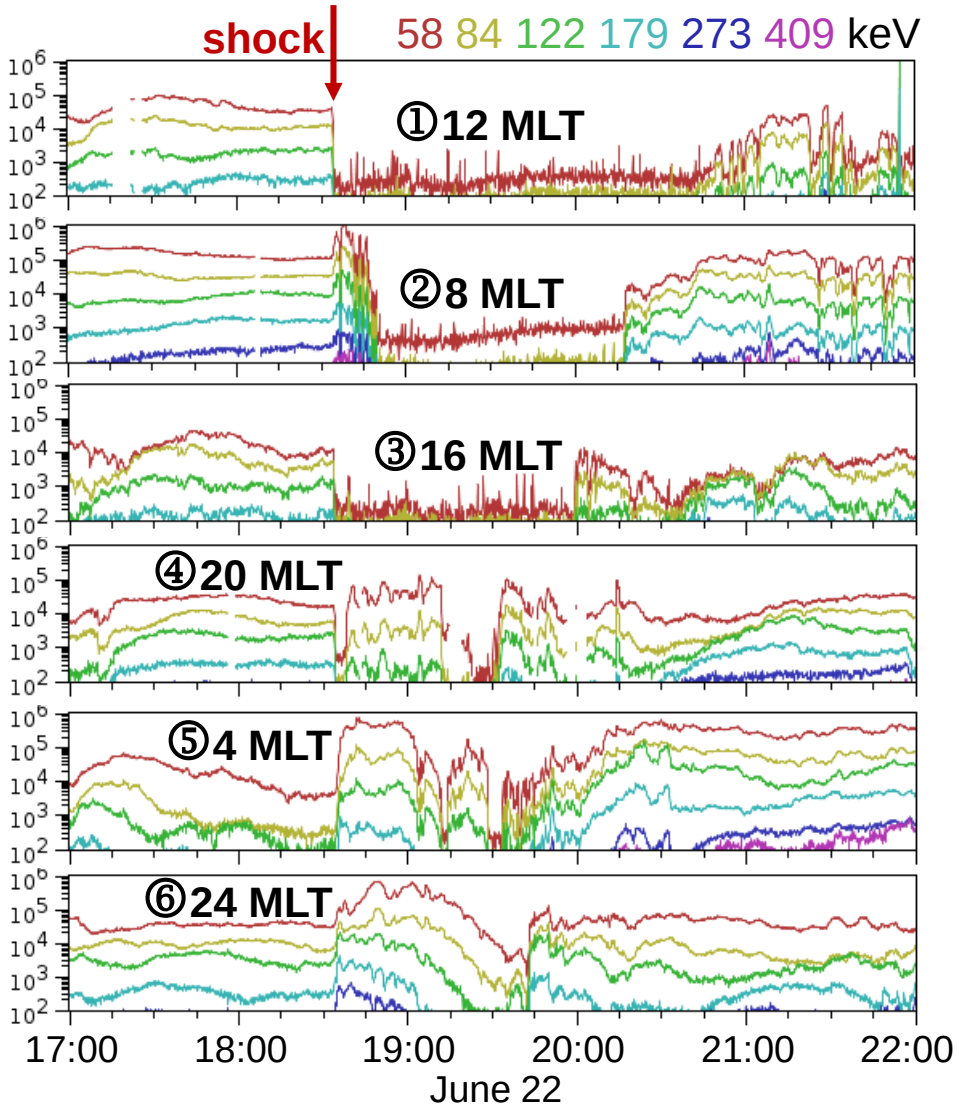
Model Results with D_{LL}(Liu+Ali)



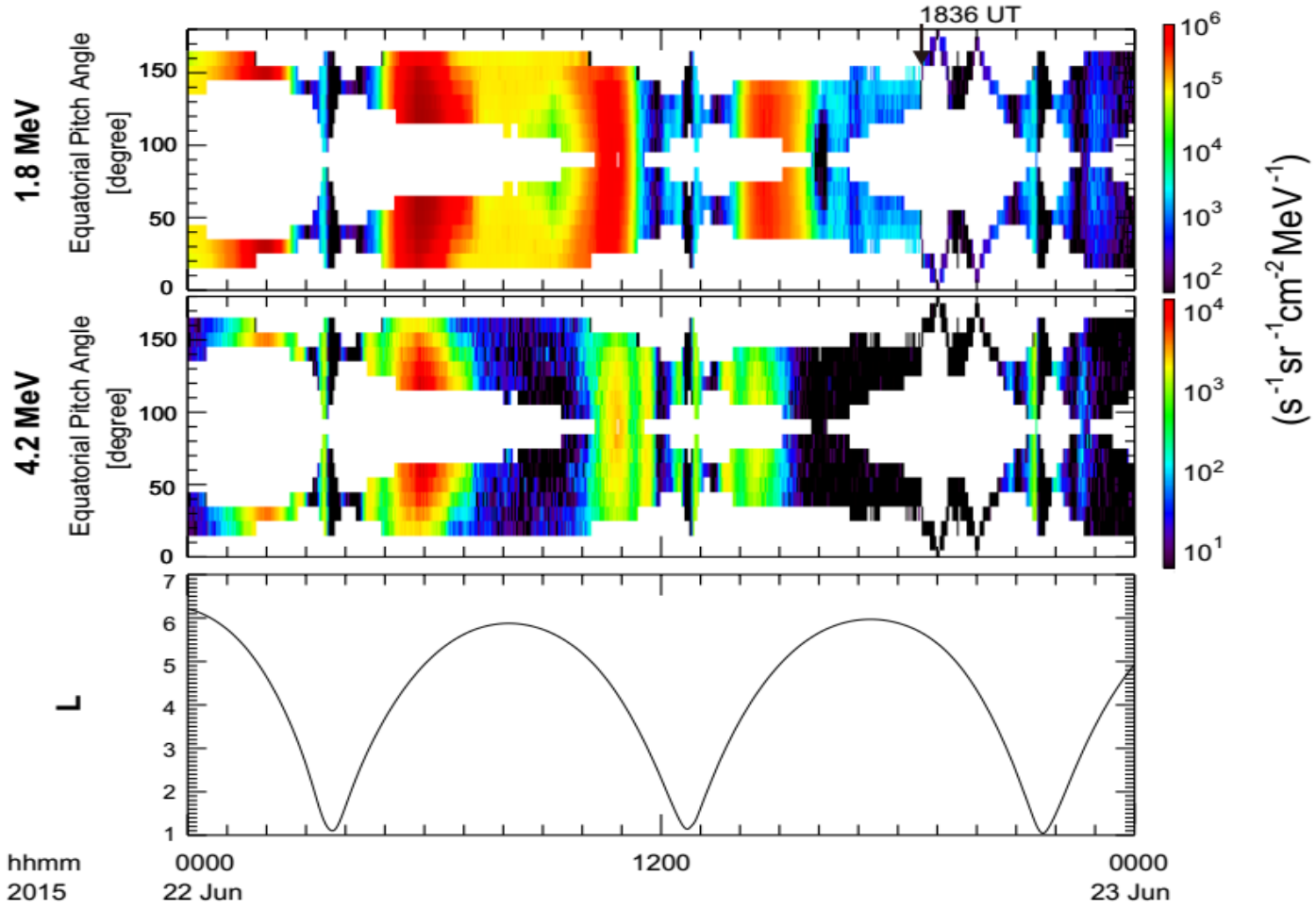


Flux Observed by 6 LANL-GEO Satellites



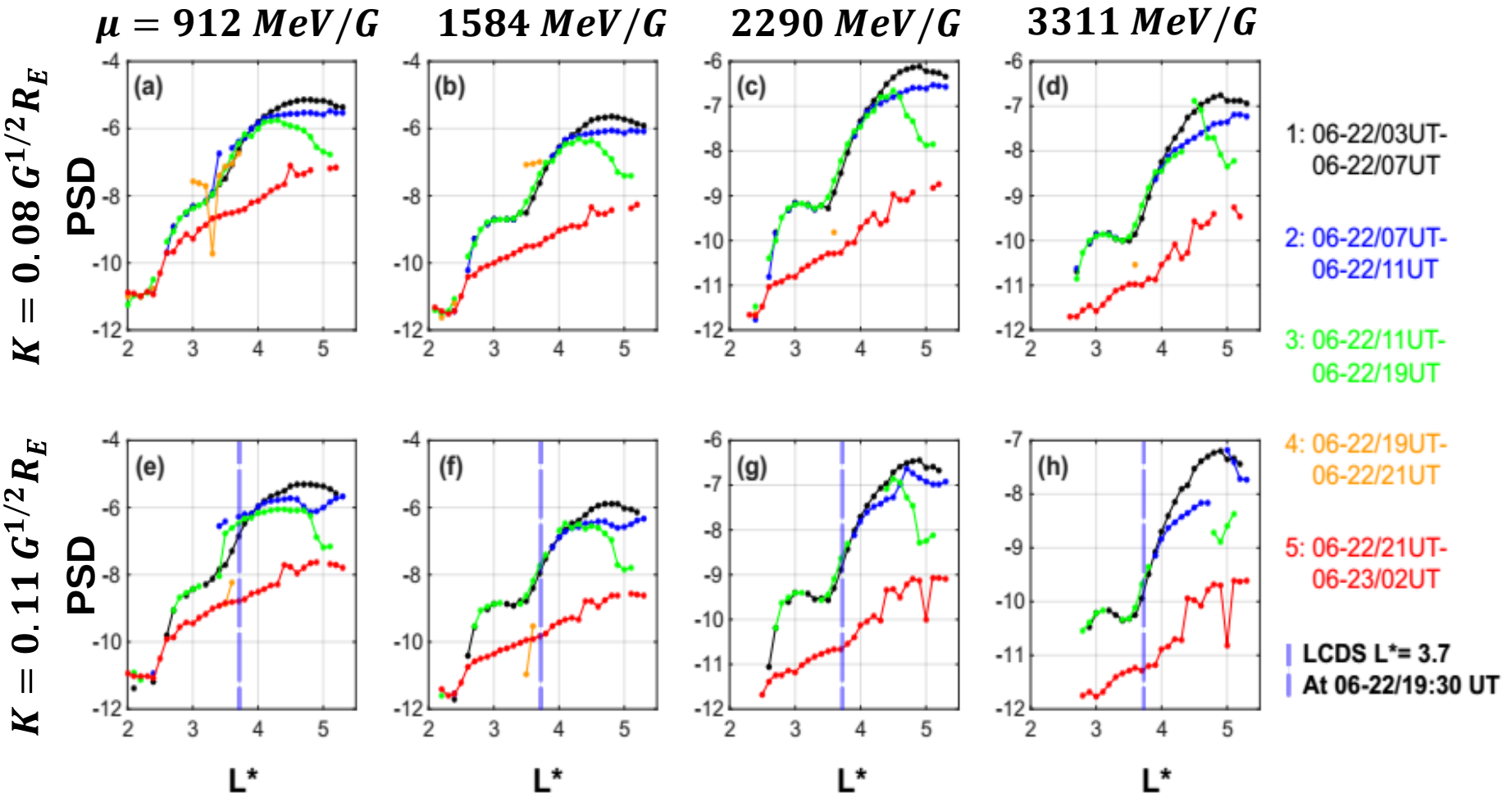


Event 1: PA Distribution



- Electron flux with 90° equatorial pitch angle were not observed.

Event 1: PSD vs. L* Profile



- Significant decrease in PSD over a broad range of μ and L* (L*>2.6): dominant mechanism is magnetopause shadowing.