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Identifying the cause of outer radiation belt flux enhancements: The importance of accounting for uncertainties in and the K-dependence of the electron phase space density.

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Acknowledge CARISMA, EMFISIS & ECT teams for data

AGU Chapman meeting, Cascais Portugal , 4 - 9 March 2018

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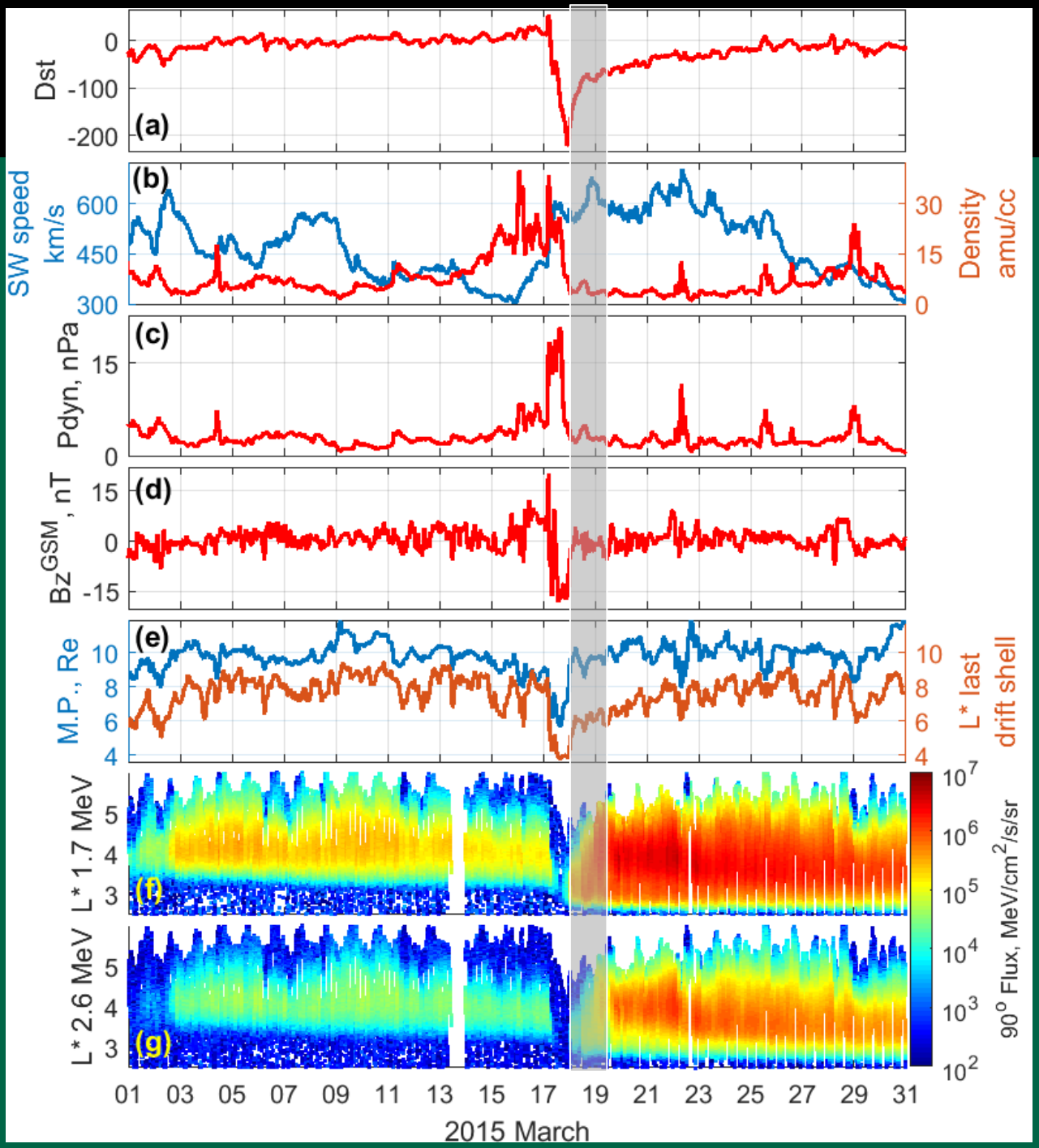
March 17th 2015 Storm

- Dst drops < -220 nT
- Pdyn spikes
- Bz < -15 nT
- MP inward <6 Re (Shue et al., 1998)
- Flux drop off *Olifer et. al.*, 2018
- Flux enhanced



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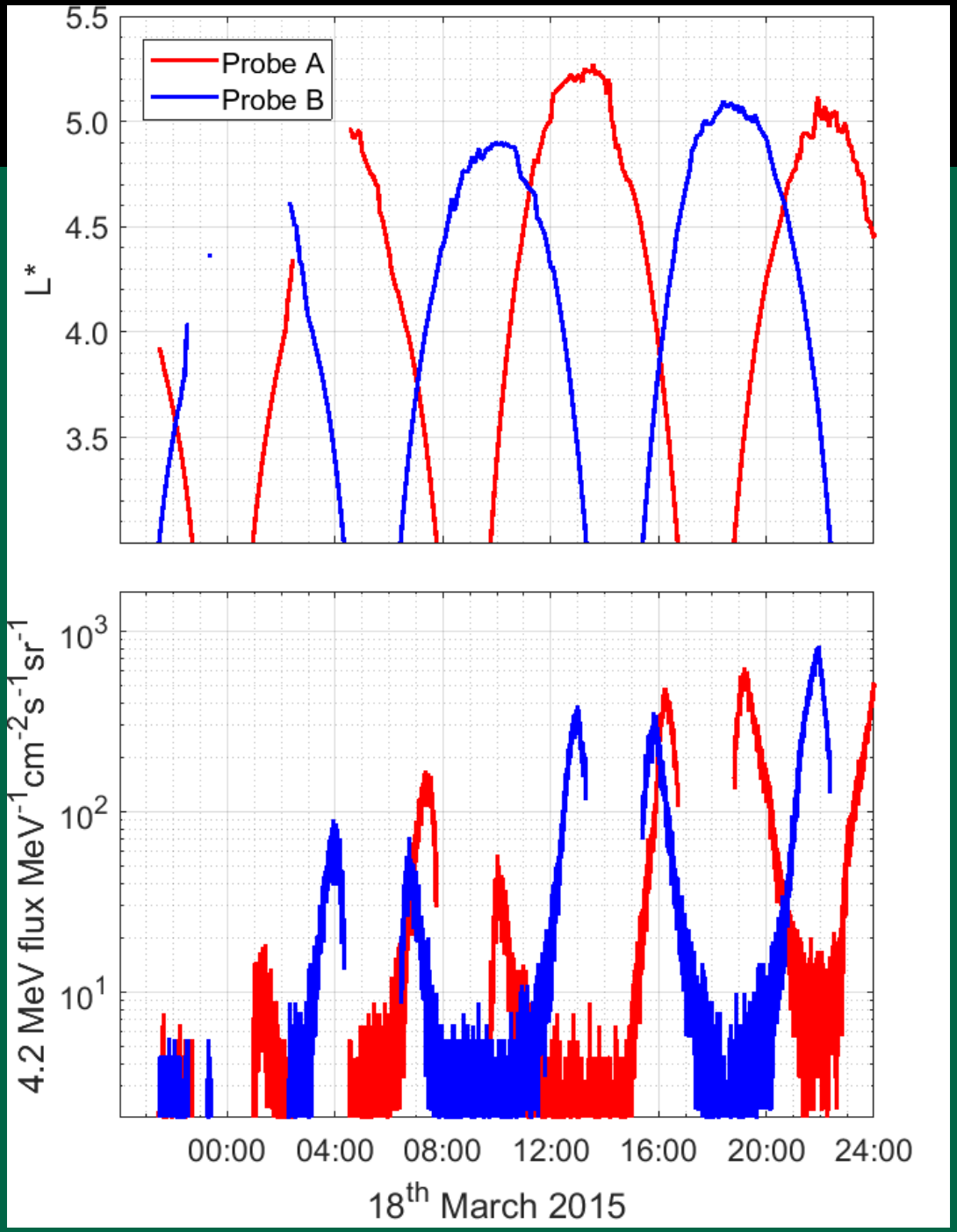
Flux Recovery on March 18th

- VAP apogee L*~5
- Flux enhanced 2 orders of mag.
- Flux increase is rapid, takes ~24 hours.



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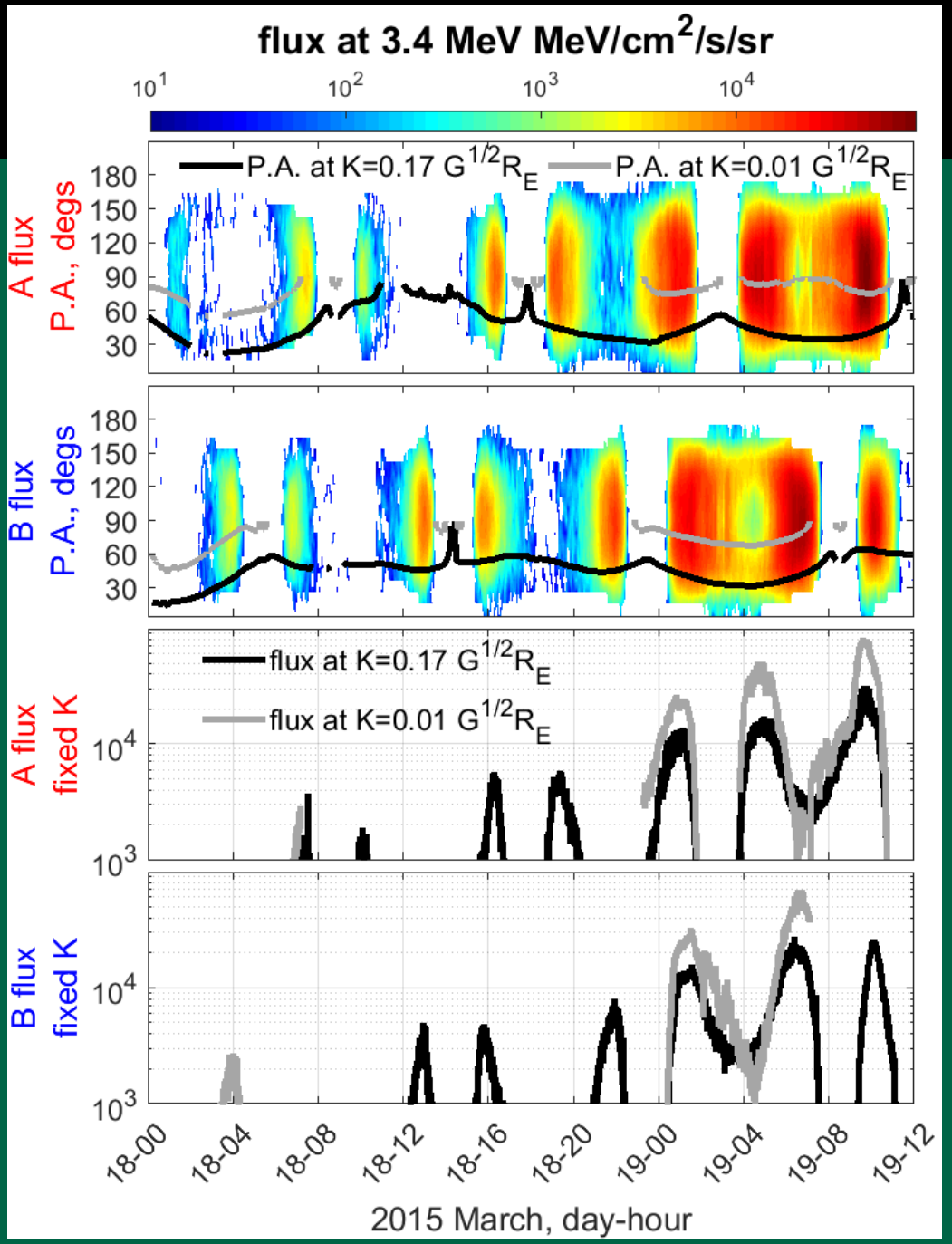
Pitch-Angle Distribution

- Flux is greater closer to 90˚ P.A.
- K=0.01→ ~ 90˚
  K=0.17→ ~ 45˚
- Flux greater at K=0.01 (grey) than K=0.17 (black)

Ozeke et al., 2018 in prep.



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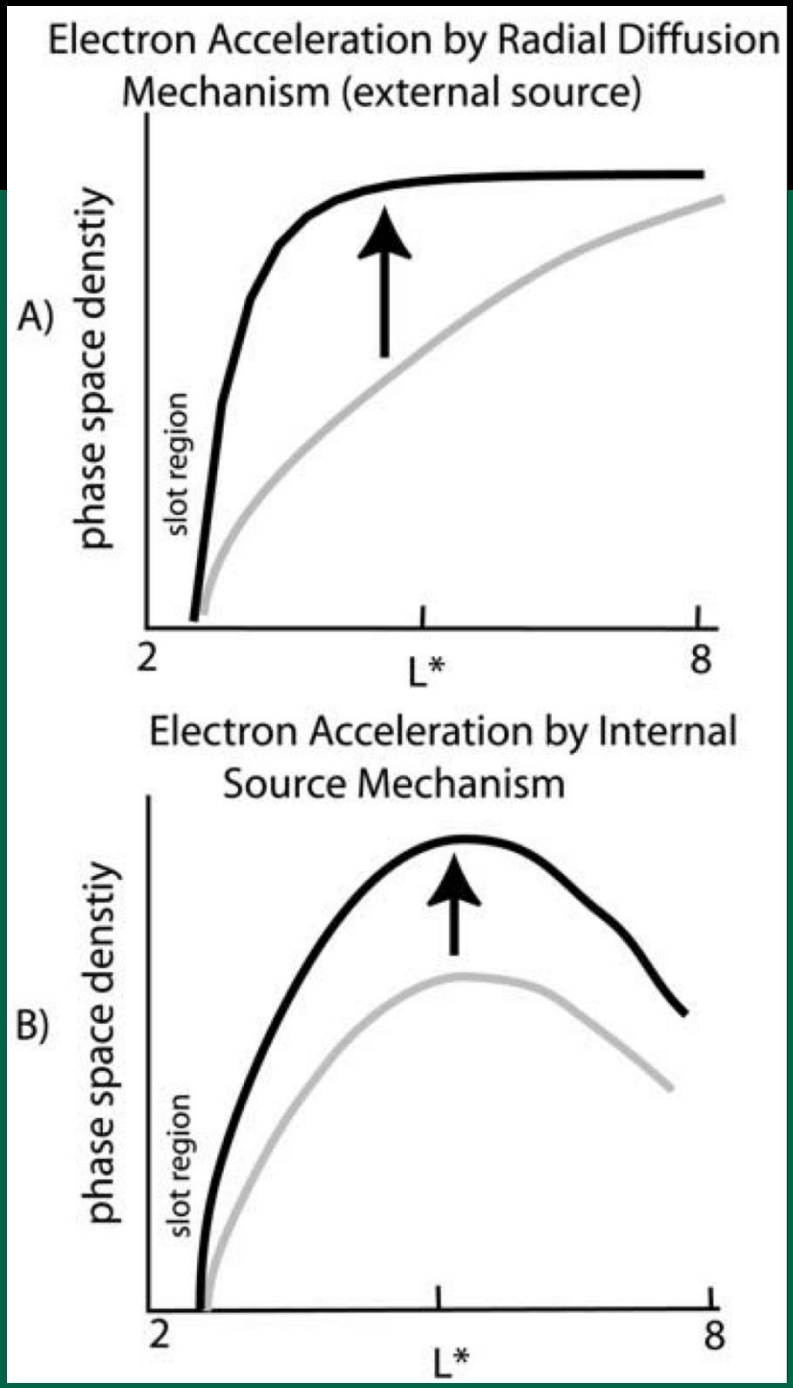
Differentiating between Acceleration Mechanisms

- Determine electron PSD at fixed M and K-values
- Inward radial diffusion from high to low L-shells due to ULF waves
  - +ve PSD gradient to flat PSD
- Local acceleration due to VLF chorus wave interaction
  - Growing peaks in the electron PSD

Schematic taken from *Green & Kivelson* 2004



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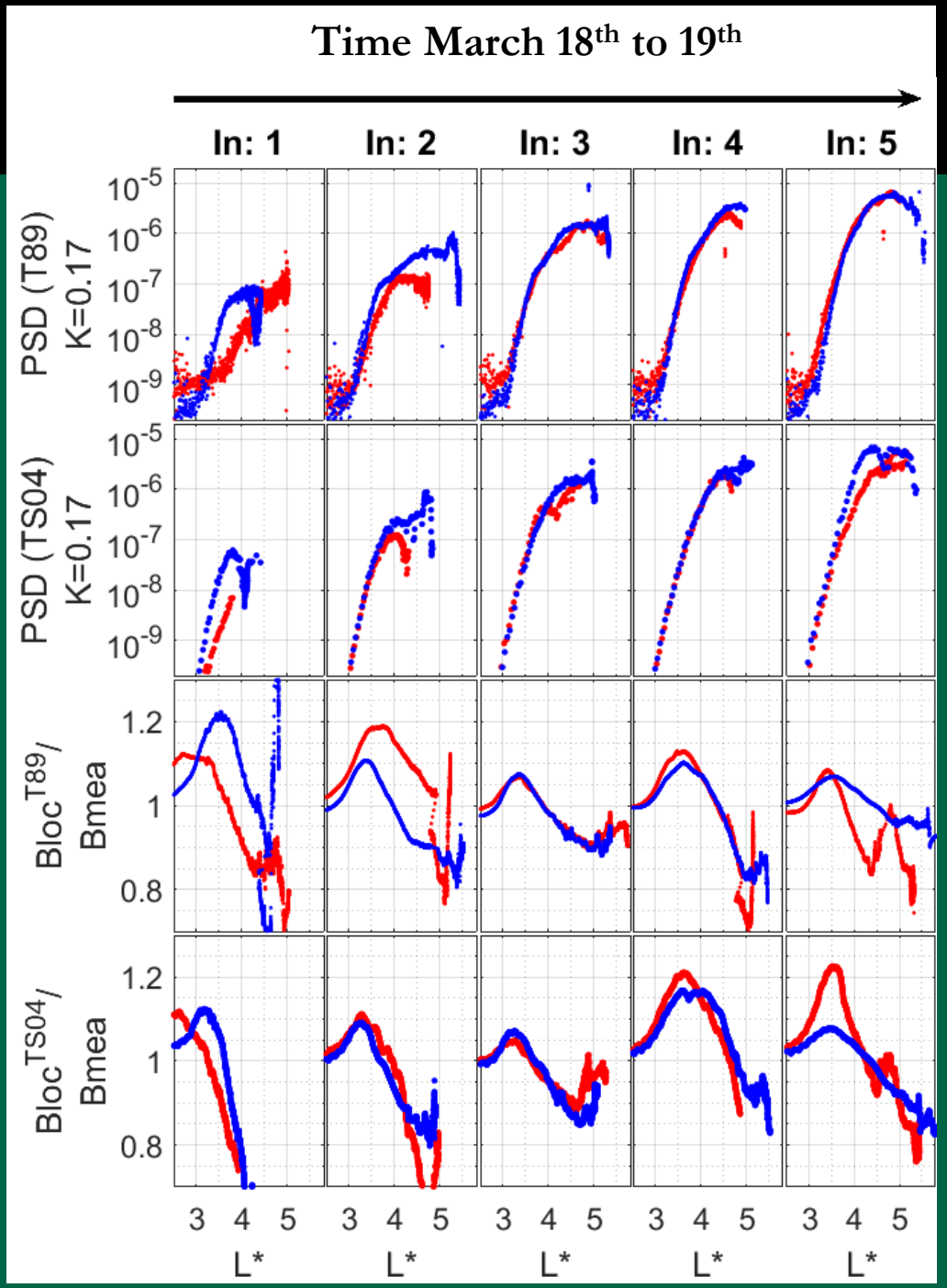
PSD profiles at 1000 MeV/G & K=0.17 $G^{1/2}R_E$

- In bound passes during March 18 th flux recovery
- PSD with T89D *Li et al., 2016*
- PSD TS04D
- Meas. & modelled magnetic fields are ~20% different
- What about lower K?



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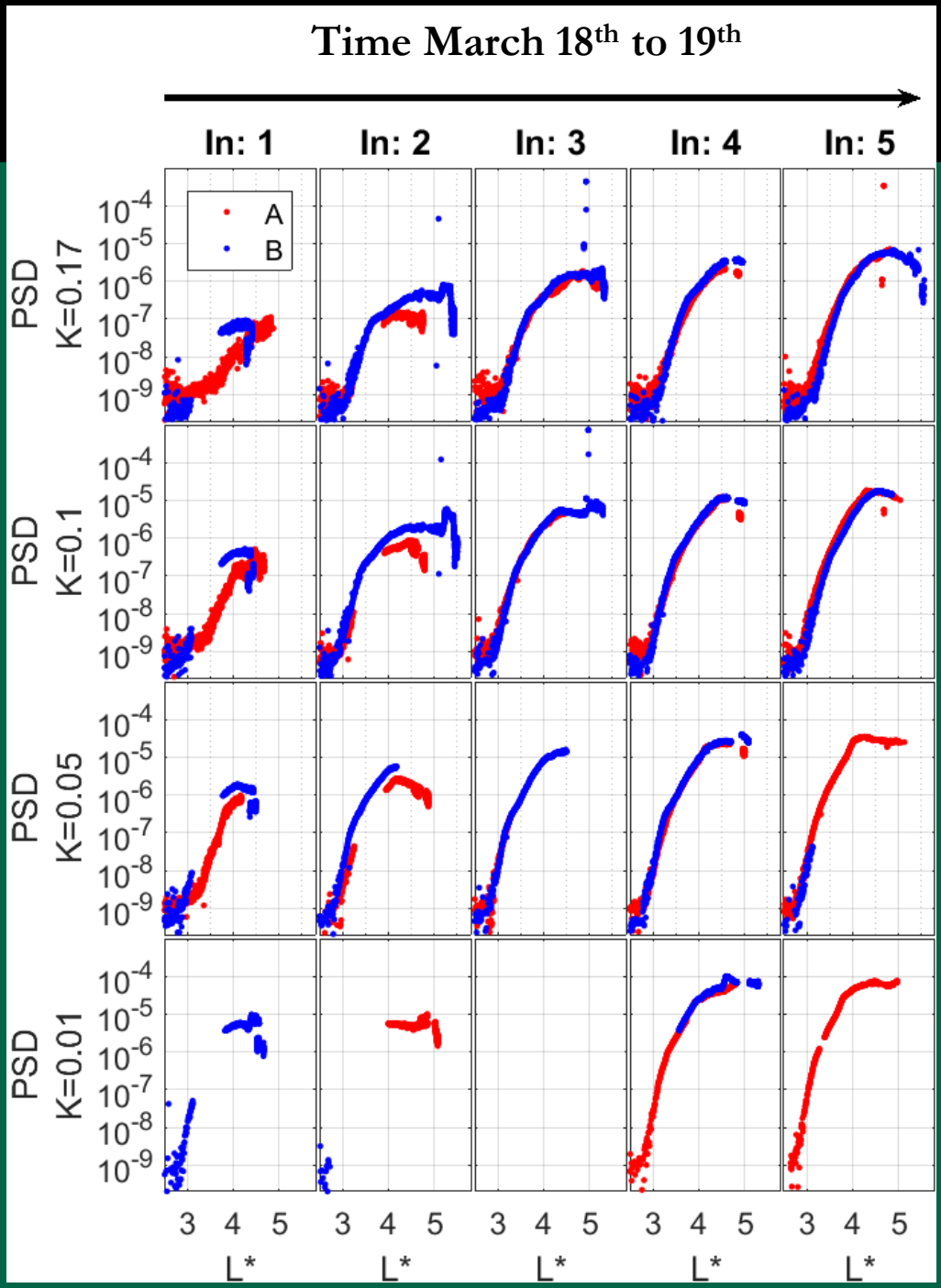
T89D 1000 MeV/G

- At high-K some evidence of PSD peaks
- At low-K no evidence of PSD peaks
- 1000 MeV/G ~ 1 MeV at apogee.
- What about the ultra-relativistic (> 2 MeV) energy population?

Ozeke et al., 2018 in prep.



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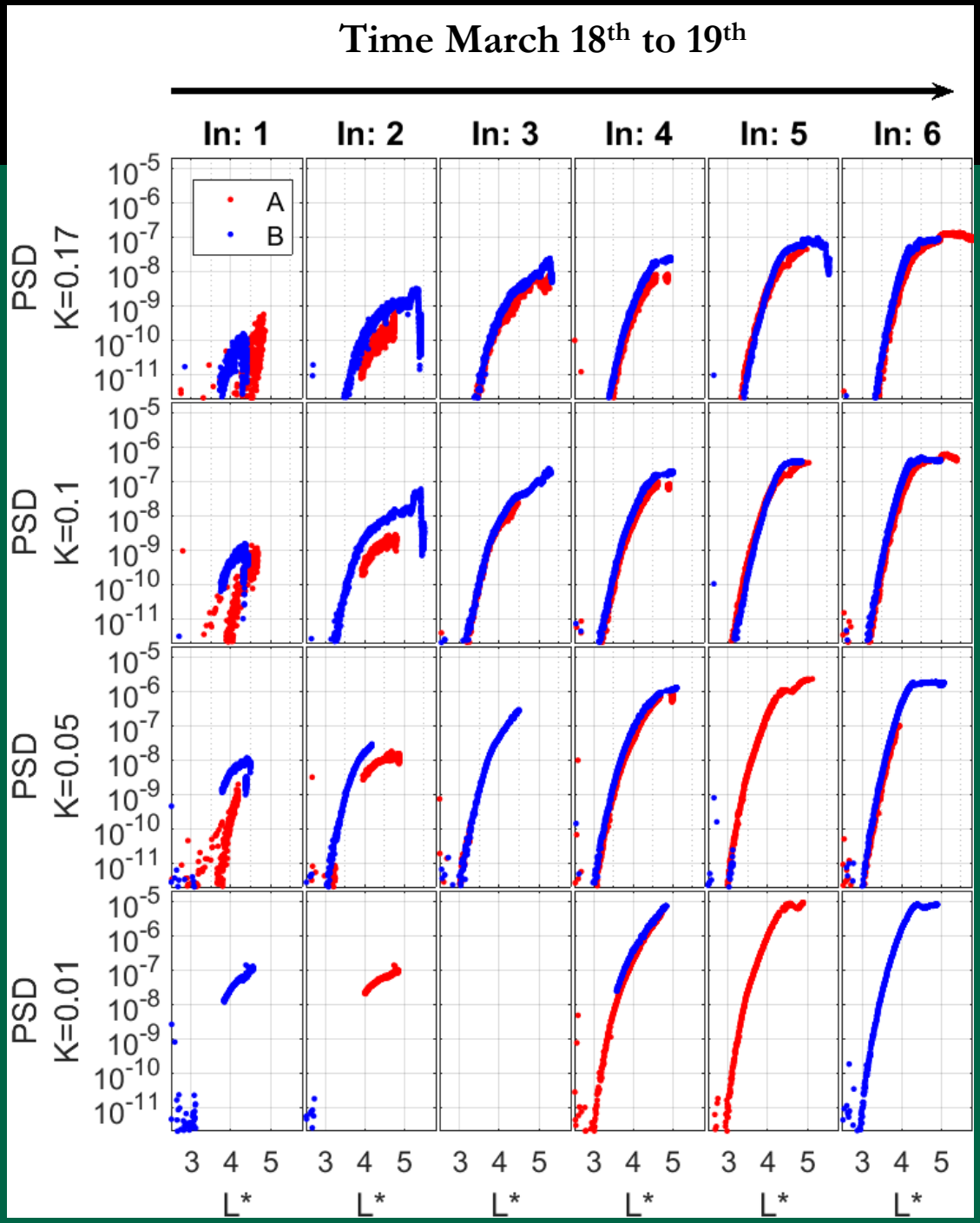
M=3310 MeV/G ultra-relativistic electrons > 2 MeV

- At high M no evidence of growing PSD peaks L*< 5
- True at both low or high K-values
- Are the PSD profiles consistent with RD?

Ozeke et al., 2018 in prep



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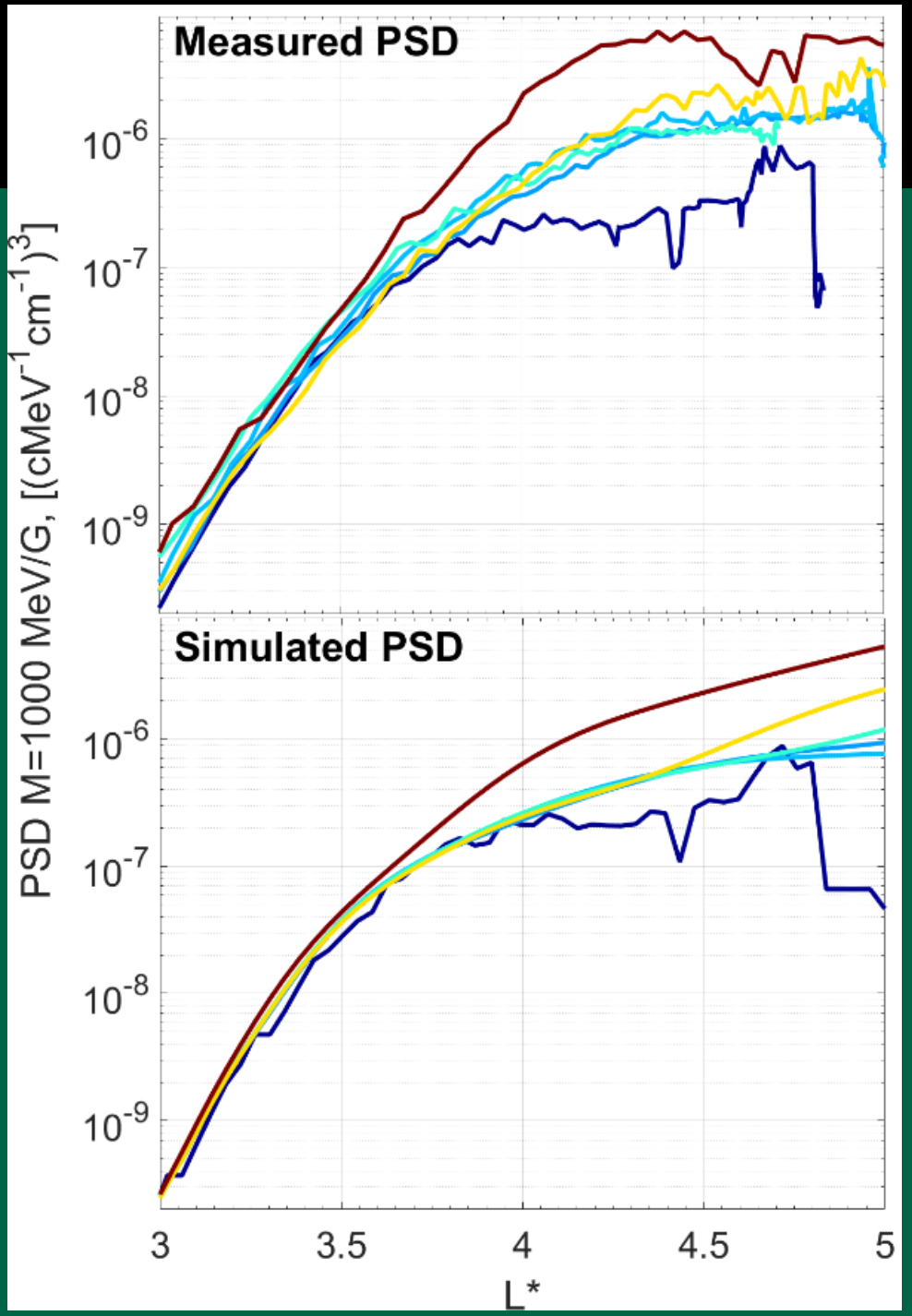
1000 MeV/G PSD profiles

- March 18th (blue) to 19th (red) PSD profiles
- Flux recovery interval
- Simulation is purely radial diffusion.



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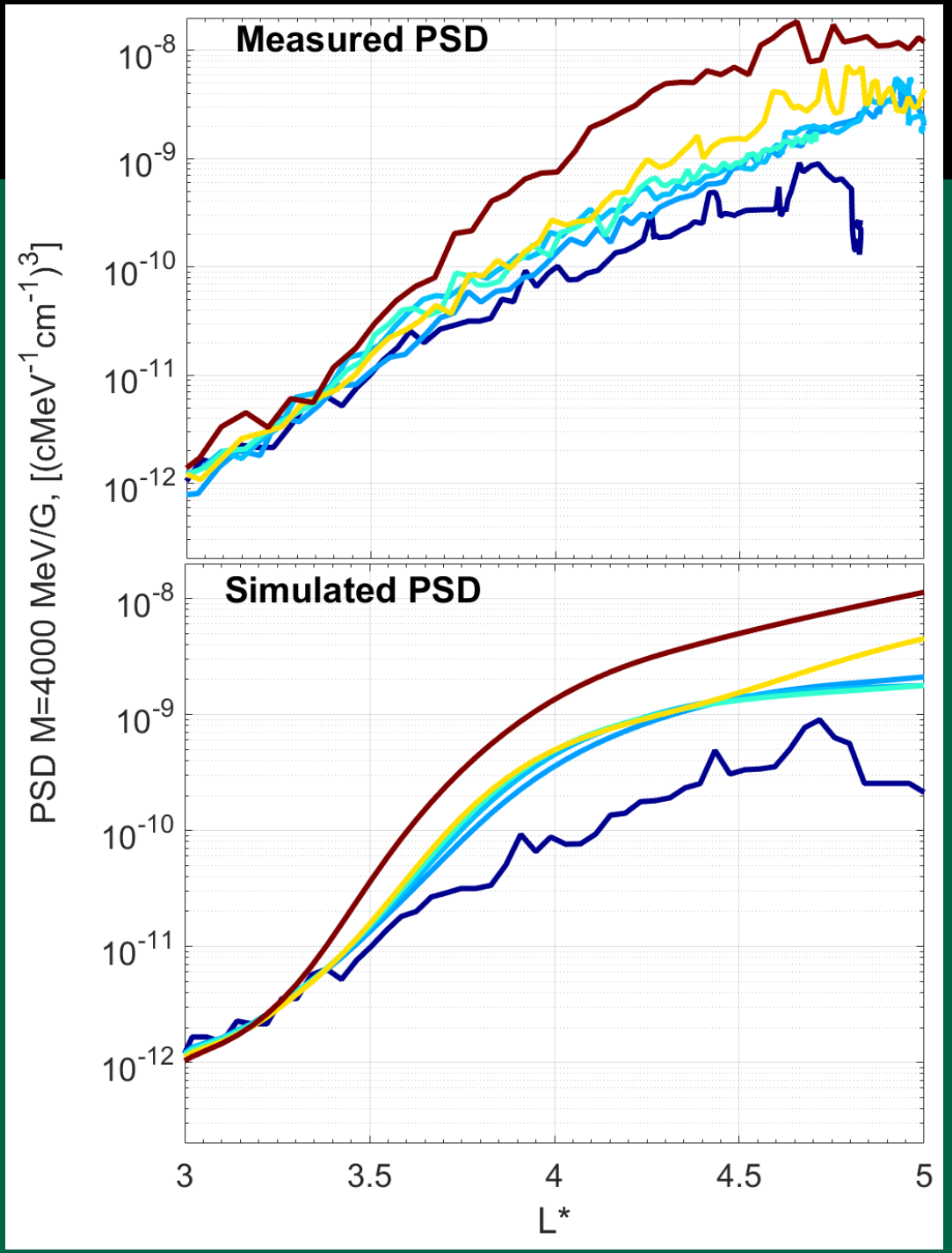
4000 MeV/G PSD profiles

- Agreement at higher energies too.
- What about over longer timescales?



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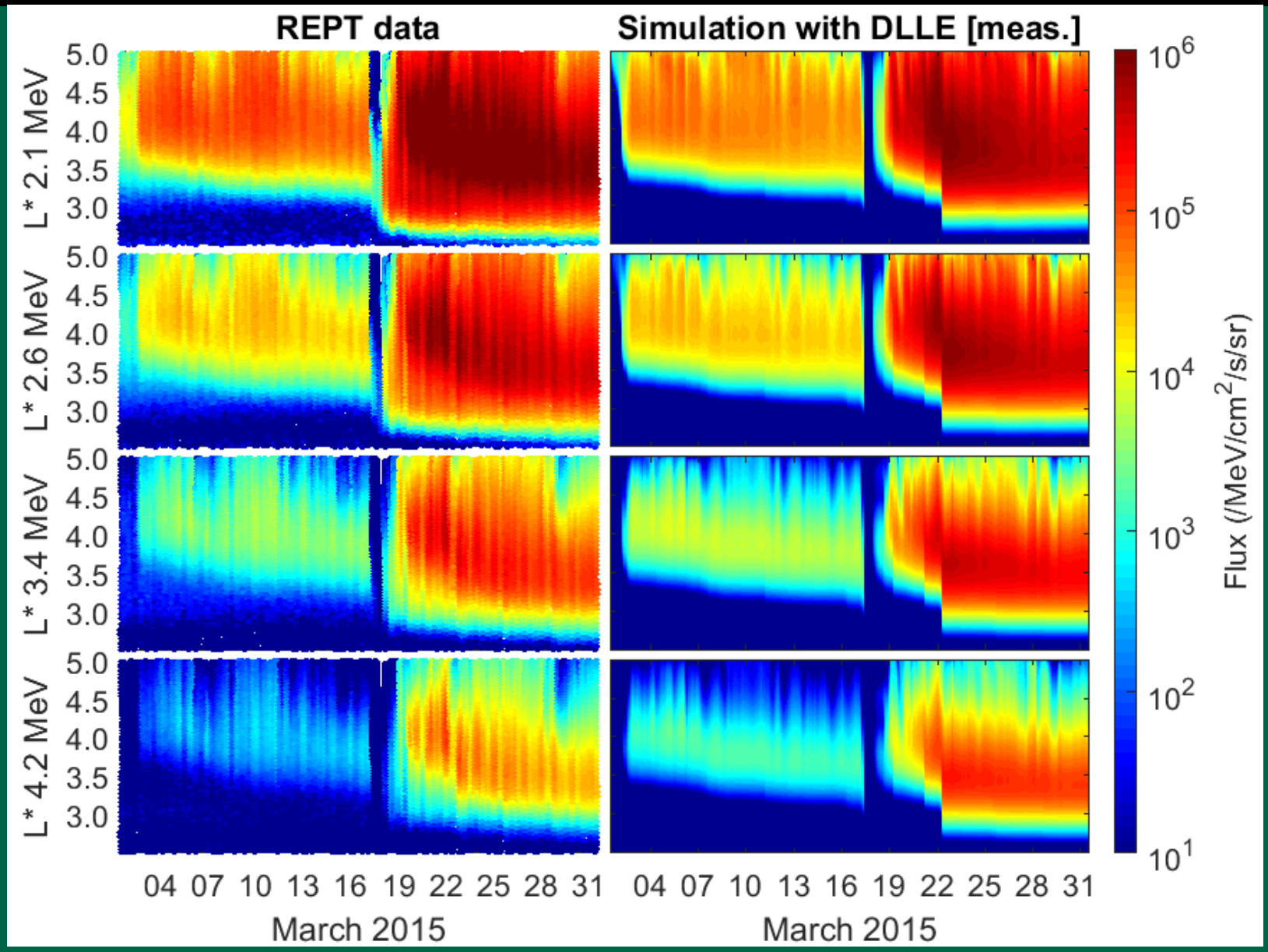
Flux Comparison



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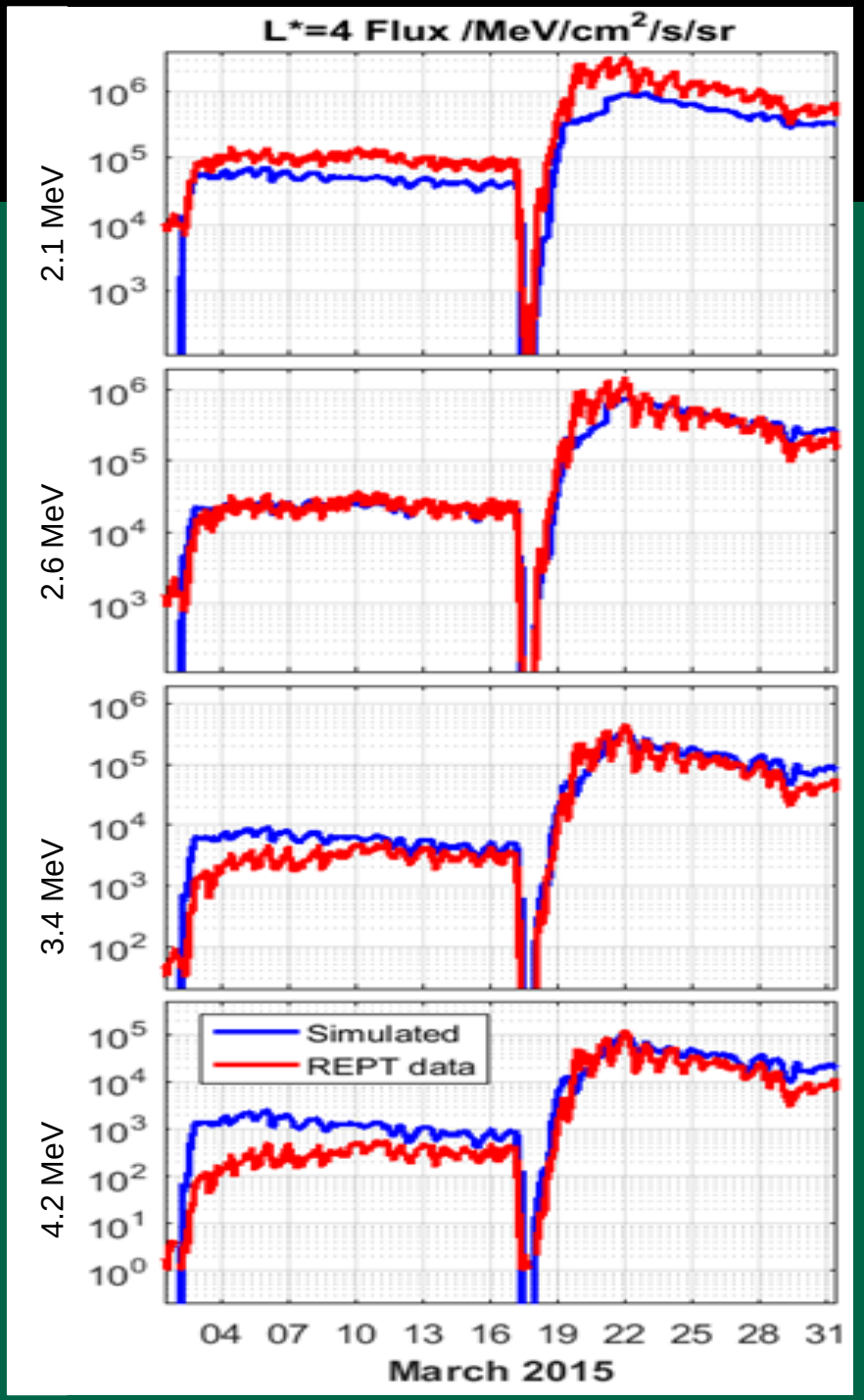
Flux Comparison at L*=4

- Measured (red) and simulated (blue) flux in agreement.
- Need a metric to better quantify these agreements.



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Summary & Conclusion

- Need to compare model B with meas. B when determining PSD
- Inside L*=5 the obs. PSD profiles at K<0.17 are consistent with that expected from radial diffusion.
- Once you specify the outer boundary PSD and DLL you can reproduce flux dynamics in the outer belt during this intense storm.

This program is undertaken with the financial support of the Canadian Space Agency

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Extra Slides

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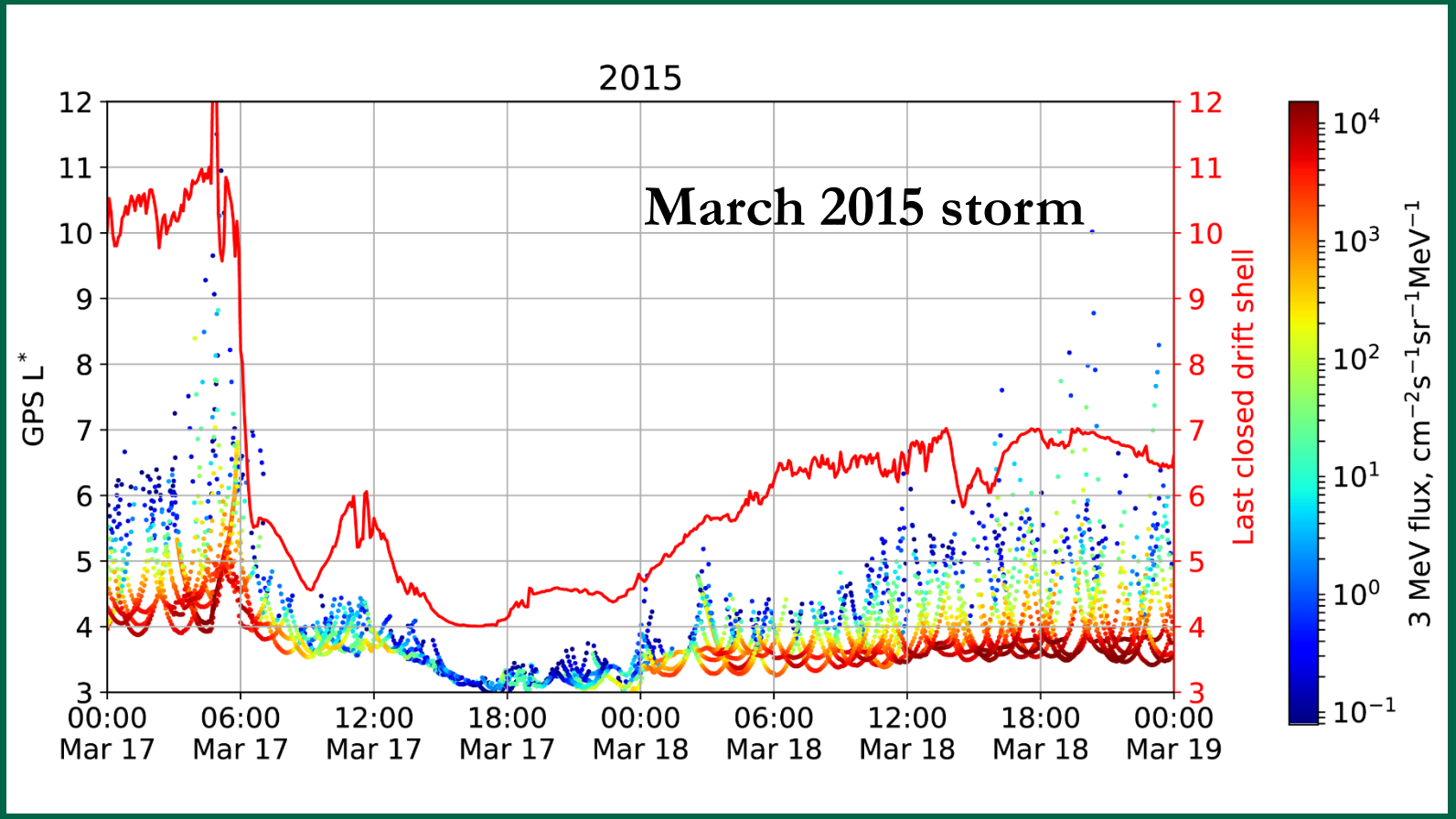
Radiation Belt Extinction



Hour timescale GPS loss; follows LCDS morphology!

Olifer et al., JGR, 2018 Under Review.

Olifer et al. Talk on Thursday.

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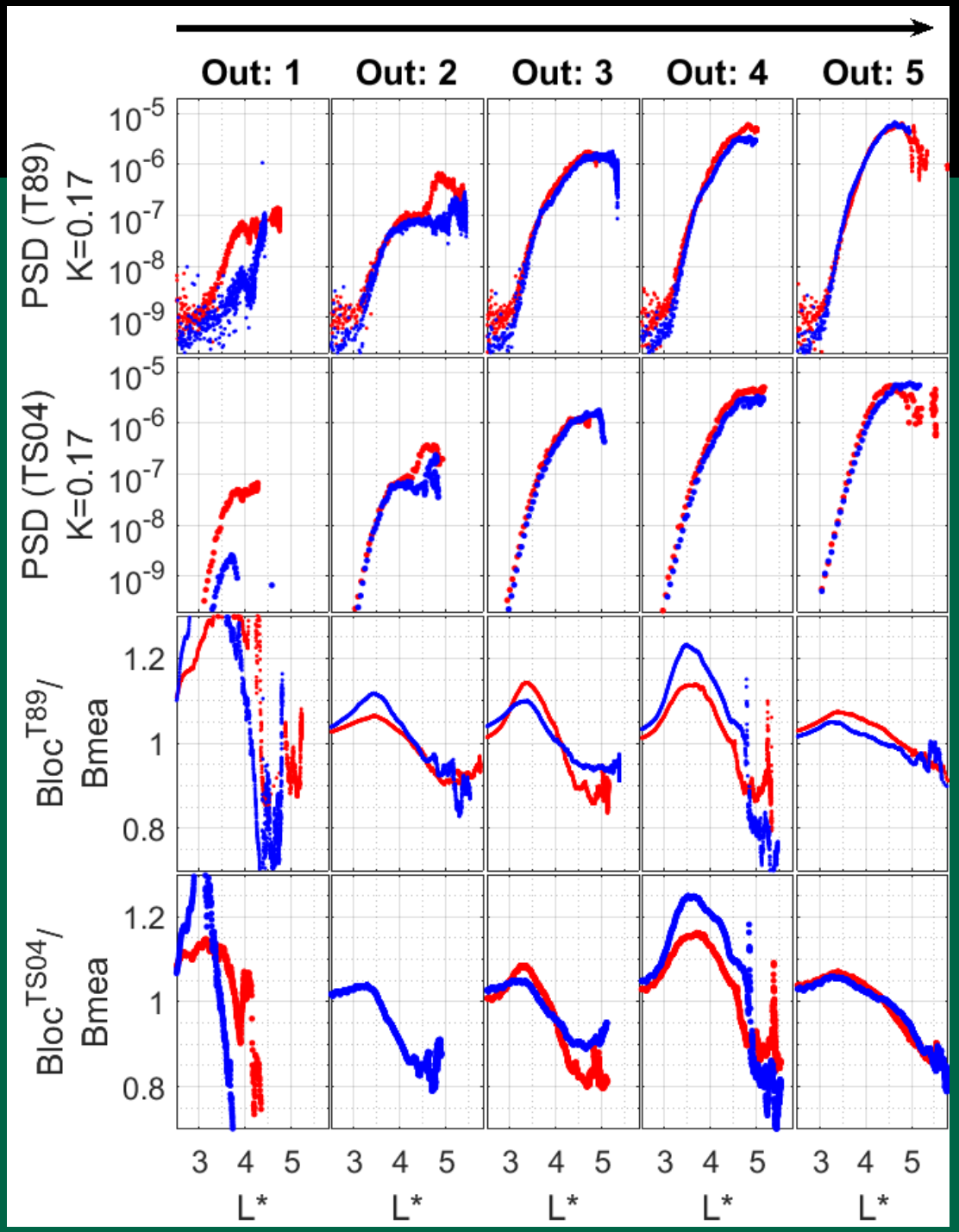
T89D 1000 MeV/G



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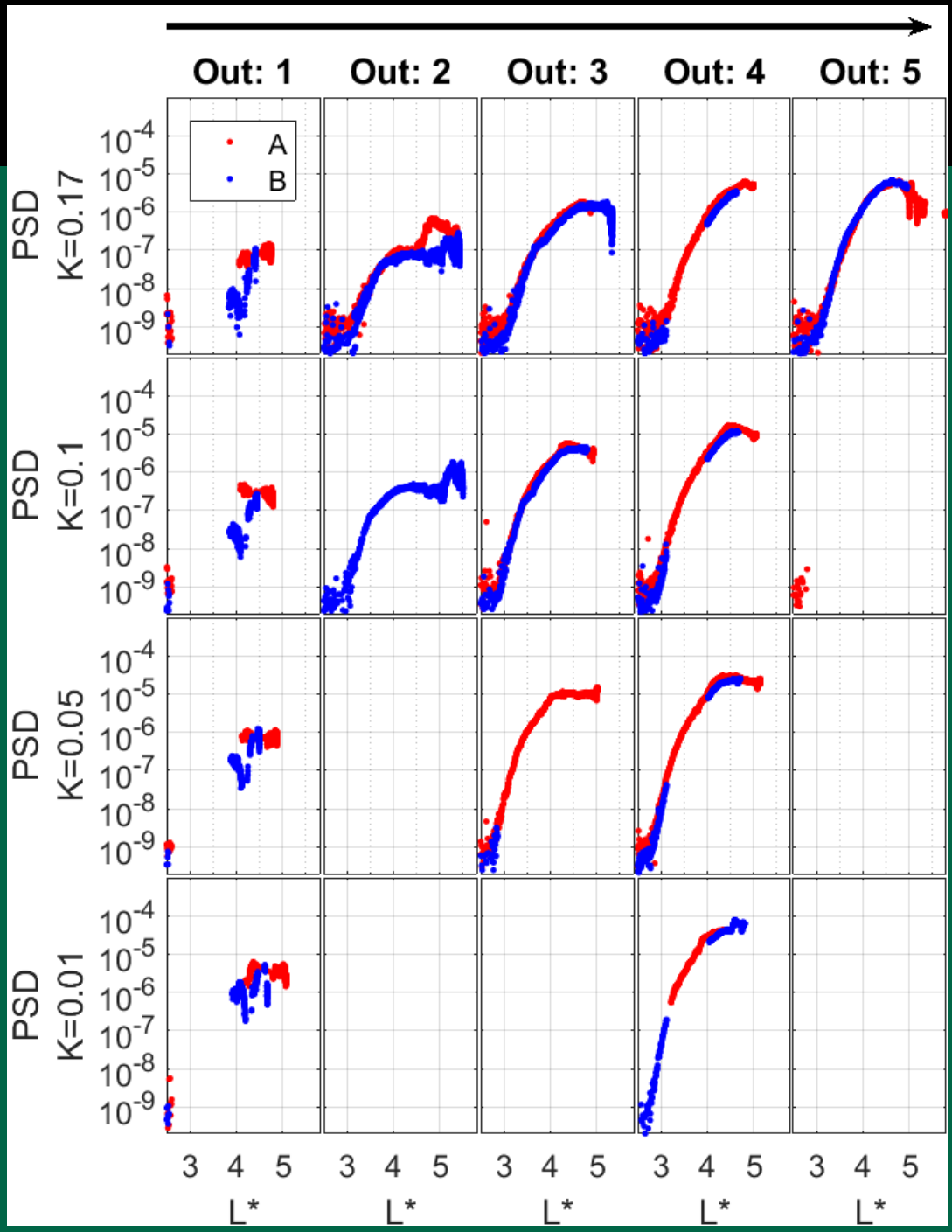
T89D 1000 MeV/G



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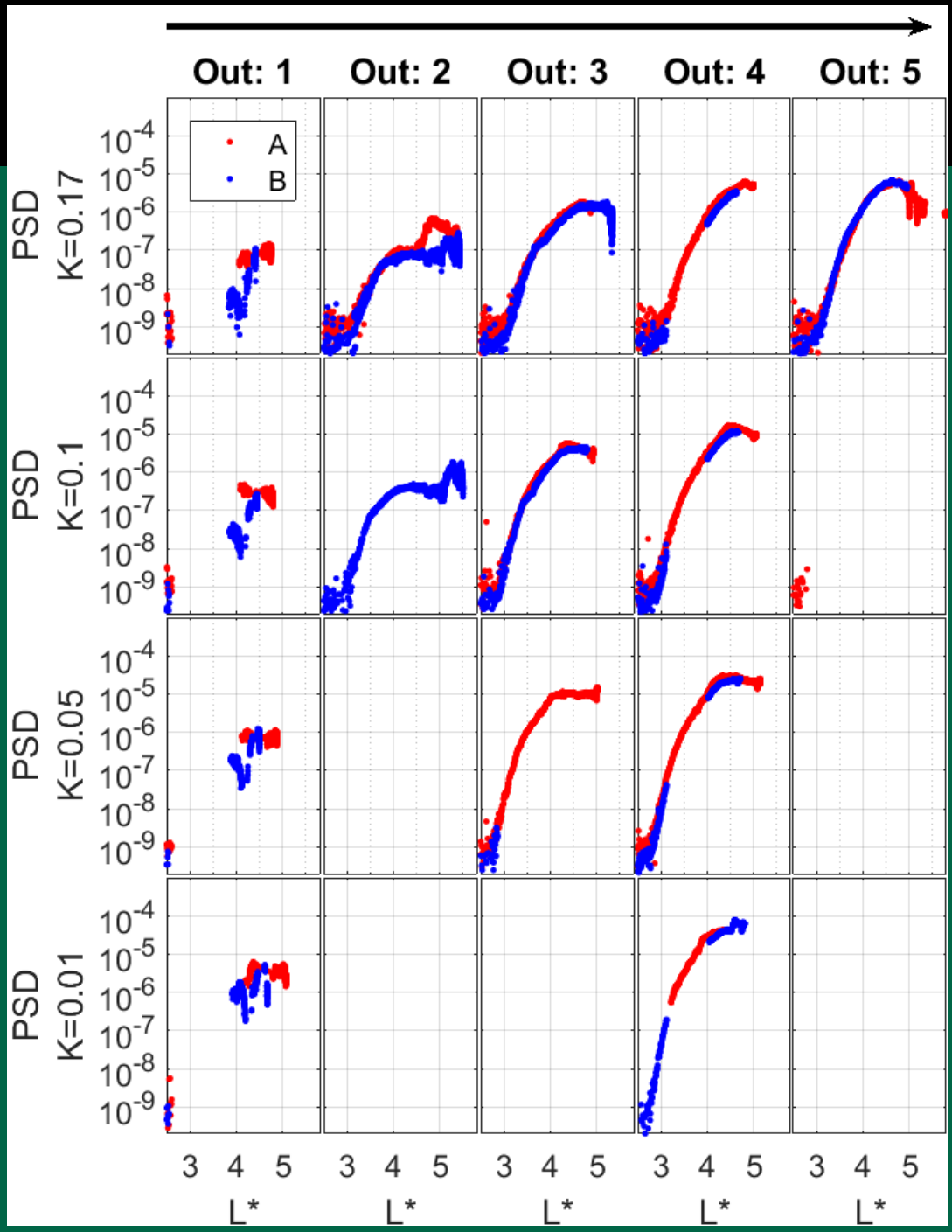
TS04D 1000 MeV/G



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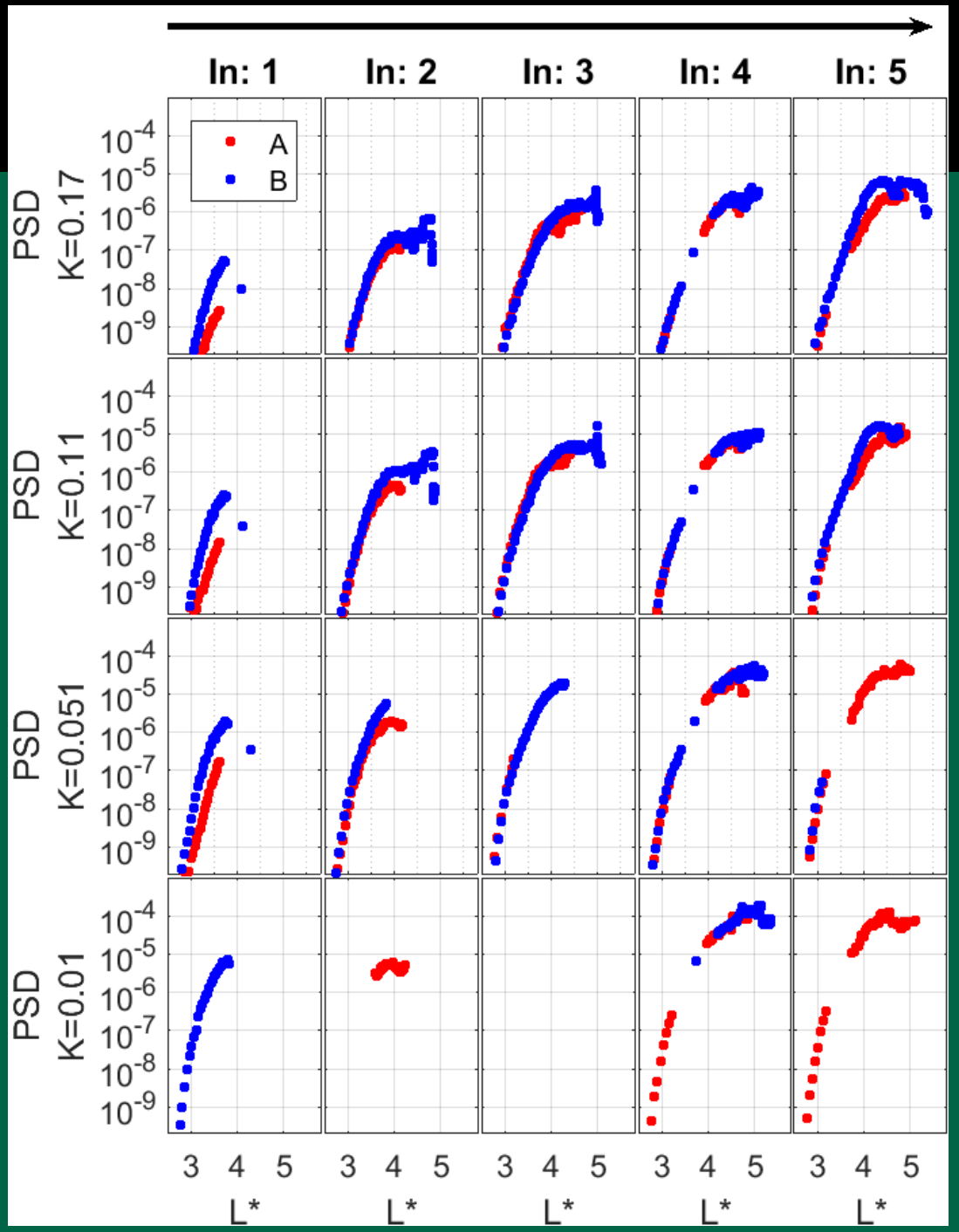
1000 TS04



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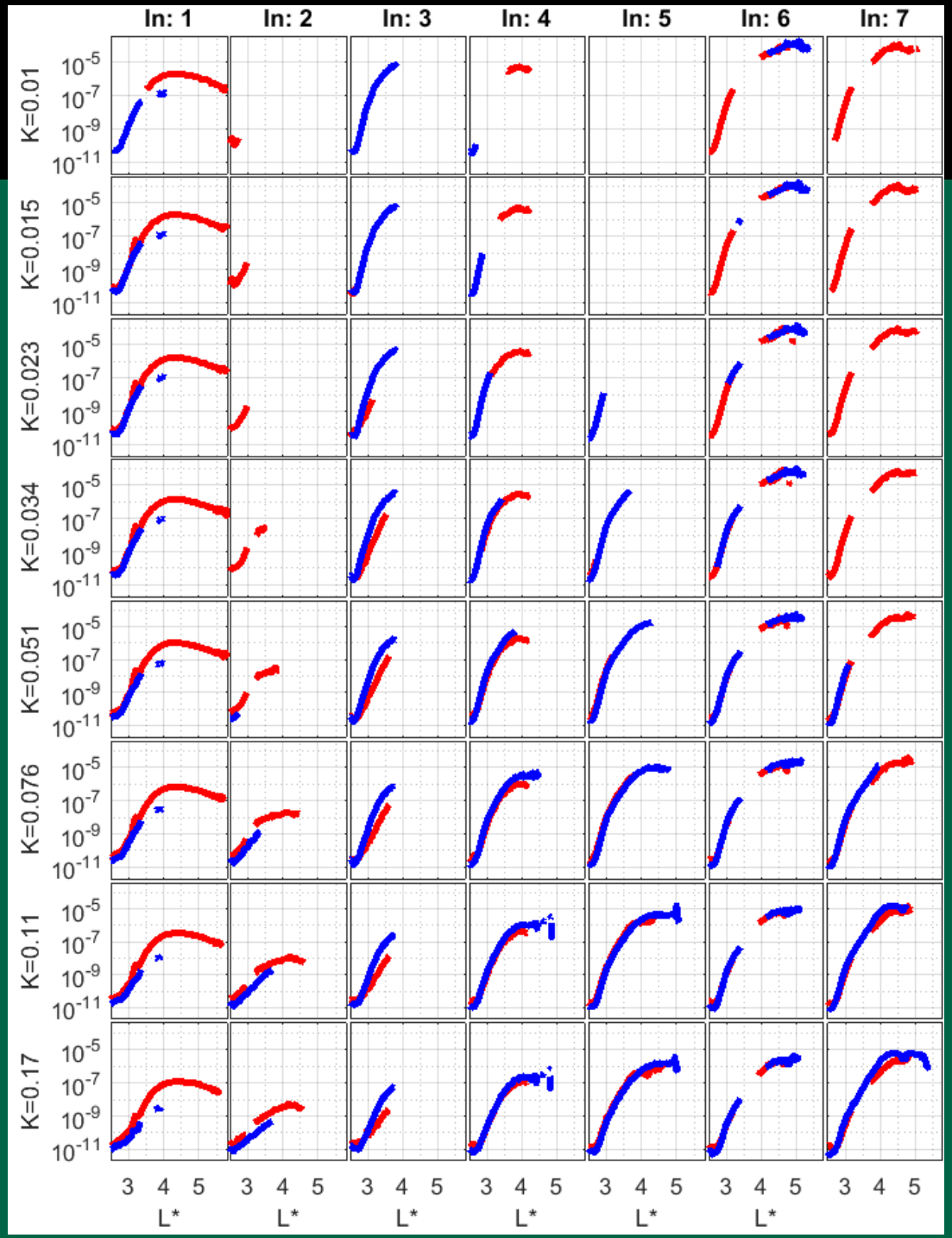
PSD at all K's in bound passes M=1100 MeV/G



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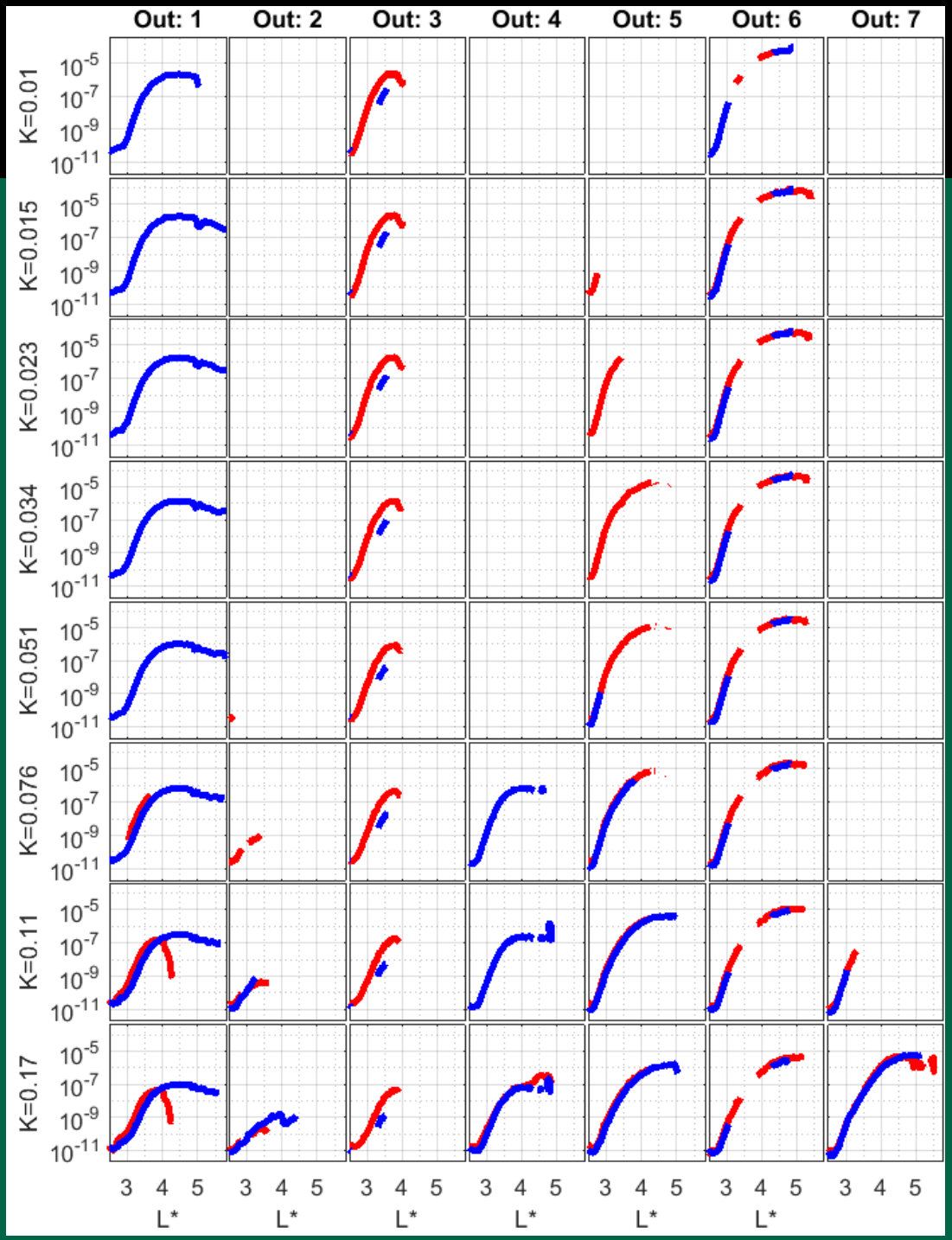
PSD at all K's out bound passes M=1100 MeV/G



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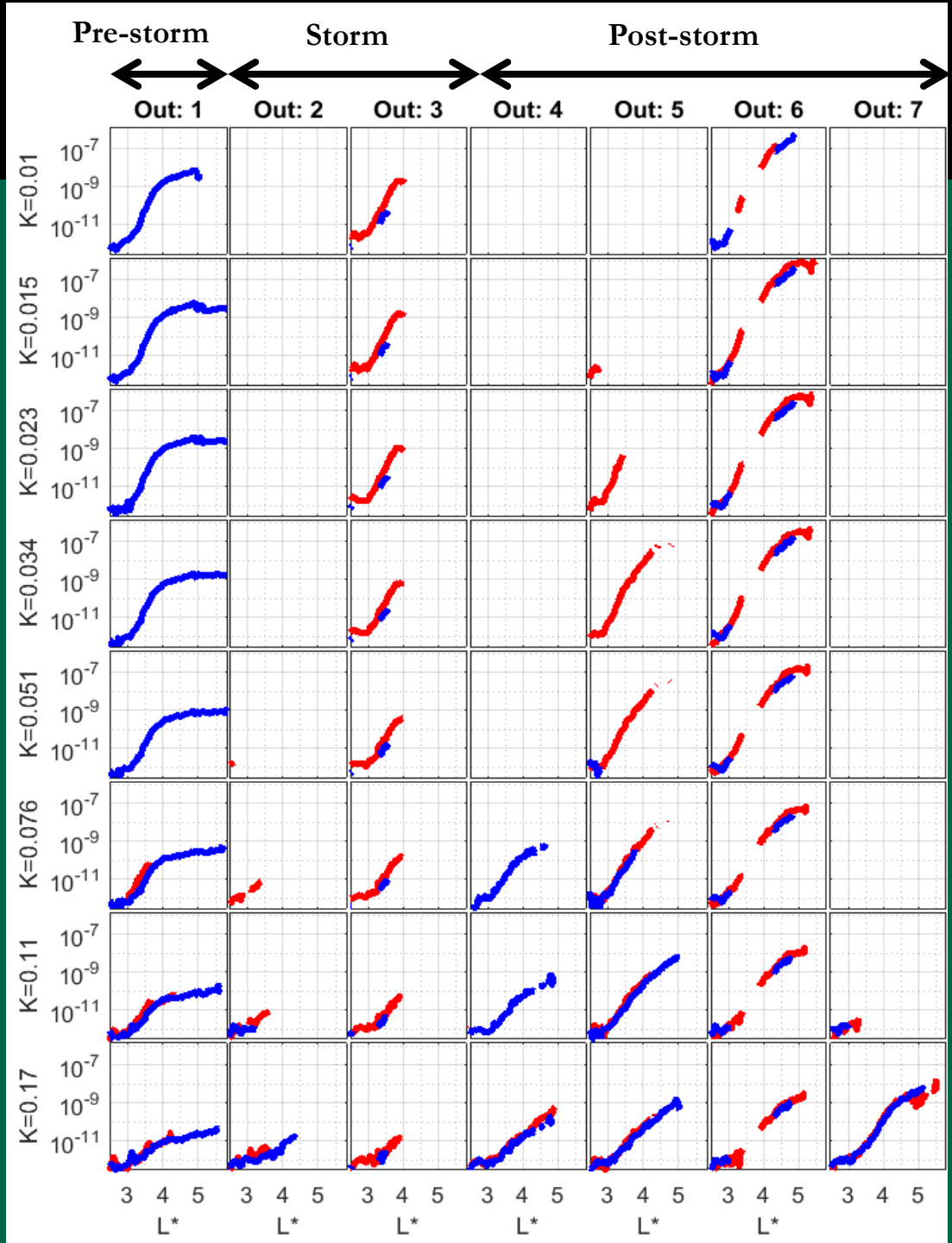
PSD at all K's out bound passes 4800 MeV/G



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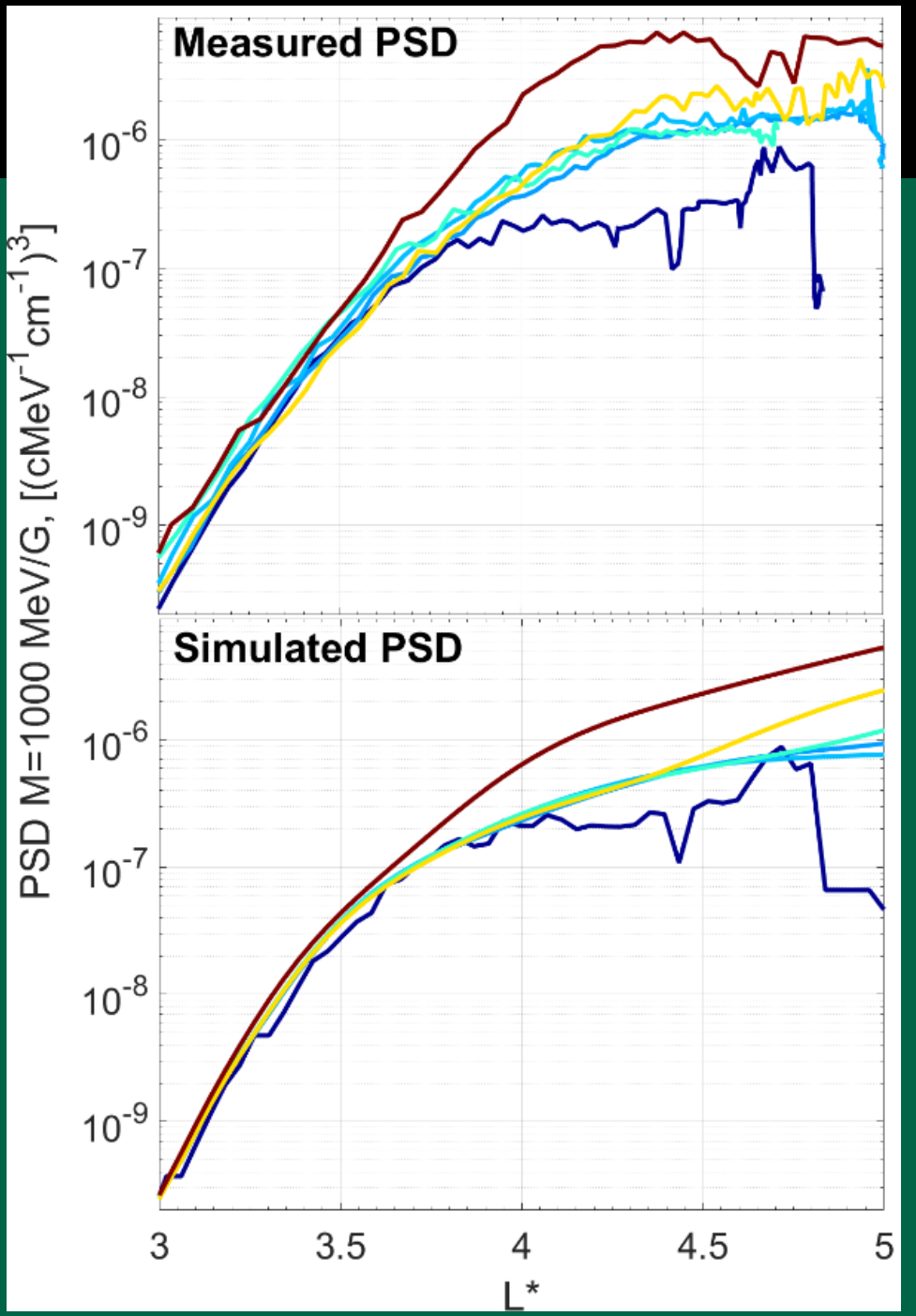

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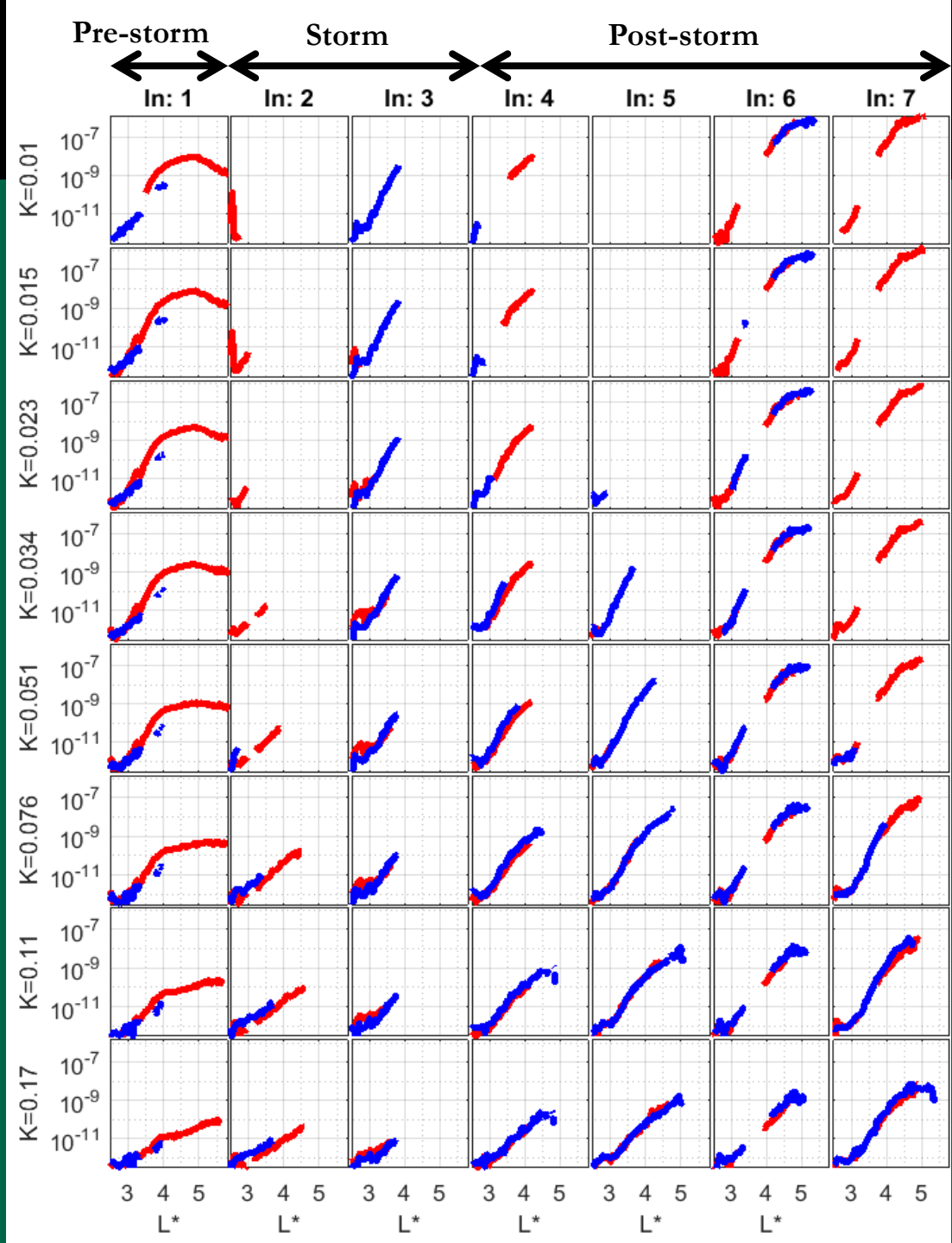
PSD at all K's in bound passes 4800 MeV/G



Radial Diffusion Model

$$\frac{df}{dt} = L^2 \frac{\partial}{\partial L}\left(\frac{1}{L^2} D_{LL} \frac{\partial f}{\partial L}\right) - \frac{f}{\tau}$$

Transport
Acceleration term

Loss term

Results from scattering of the electrons by ULF waves from high to low phase space density, f

$D_{LL} \propto$ ULF wave power in space

Results from pitch - angle scattering of electrons into the loss cone. *Orlova et al.*, 2015 (Hiss) & *Gu et. al.*, 2012 (Chorus) electron lifetimes are used here.

The initial condition $f(t=0)$ *and* f *at the outer boundary are both derived from in-situ flux measurements.*

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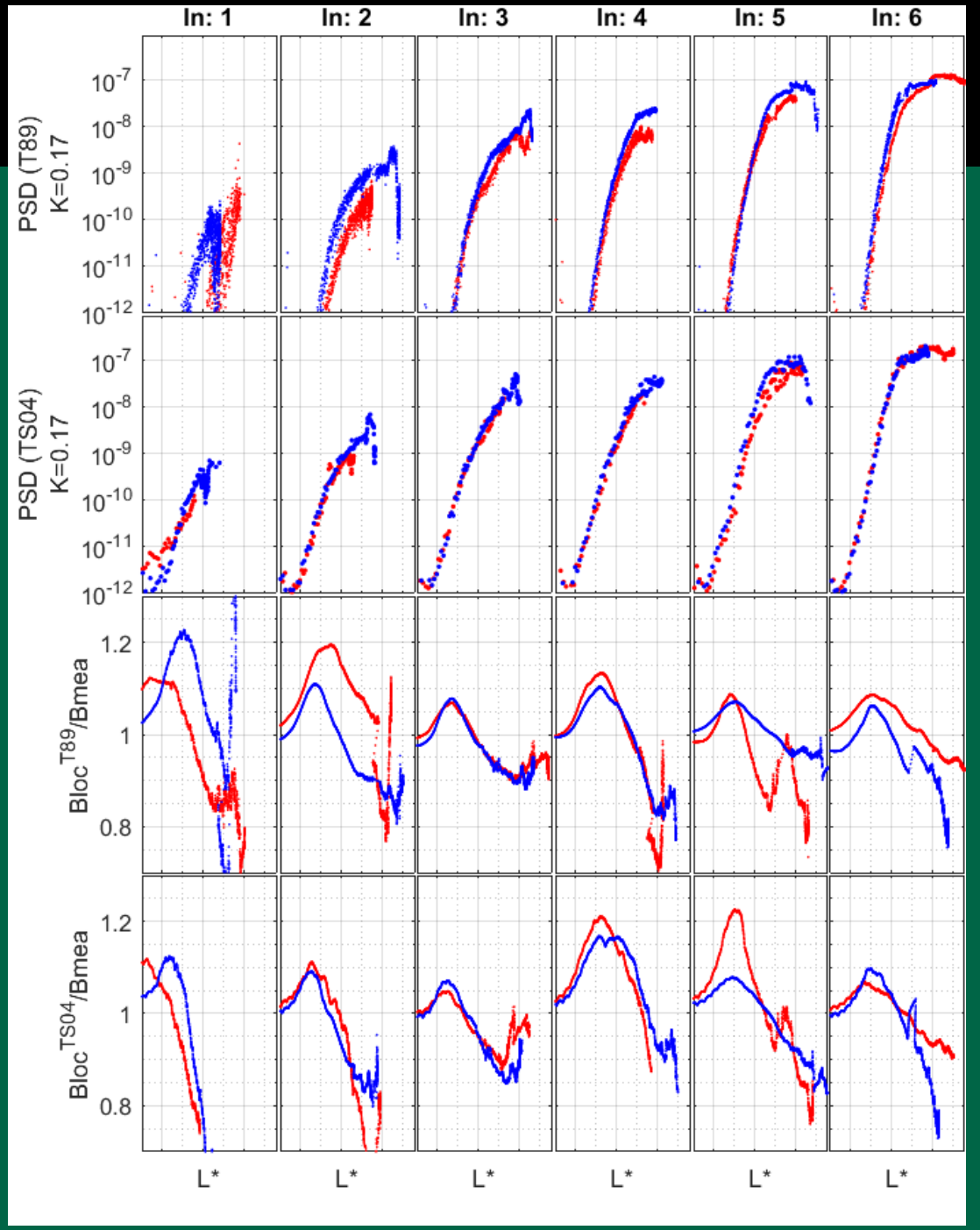
3310



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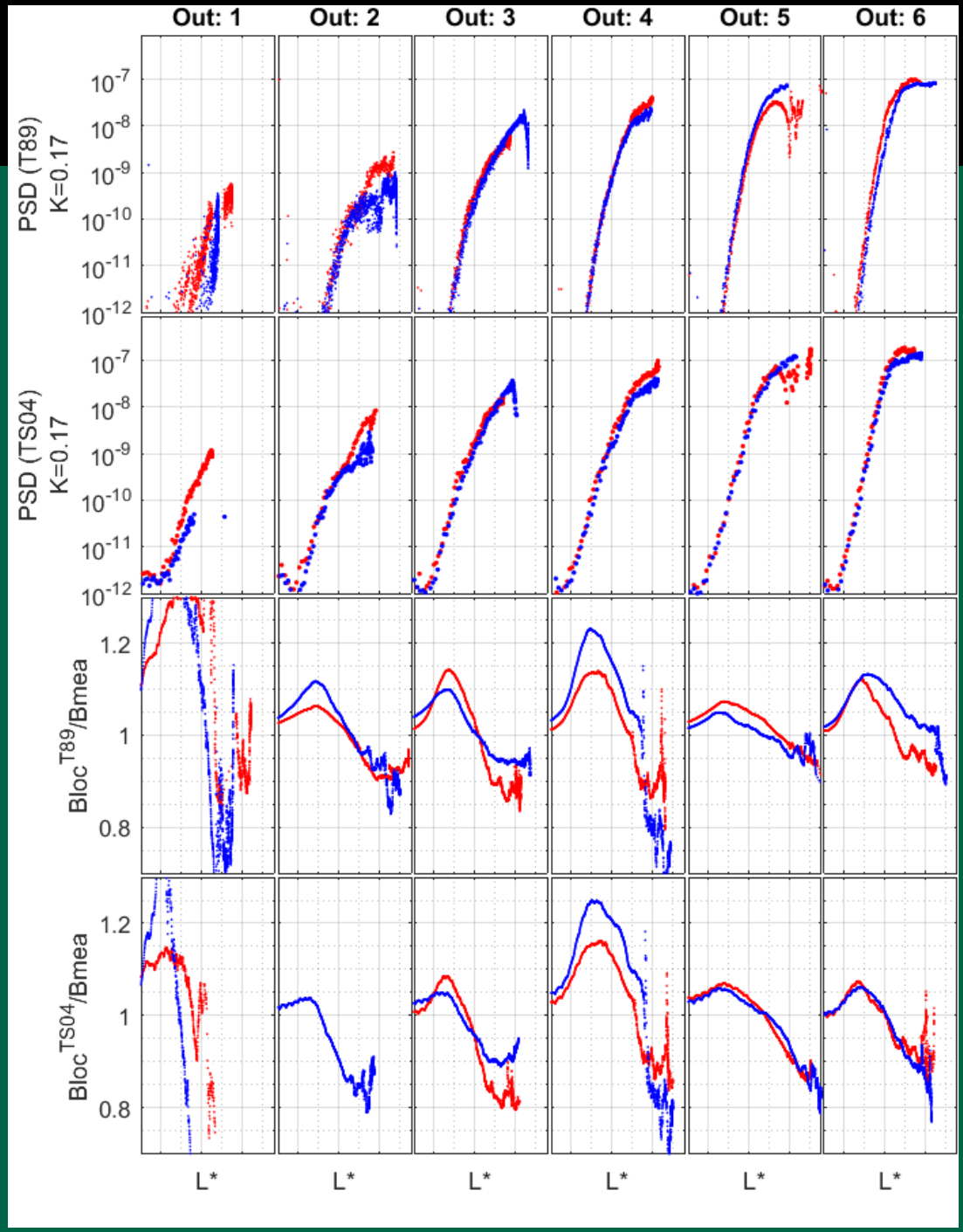
3310



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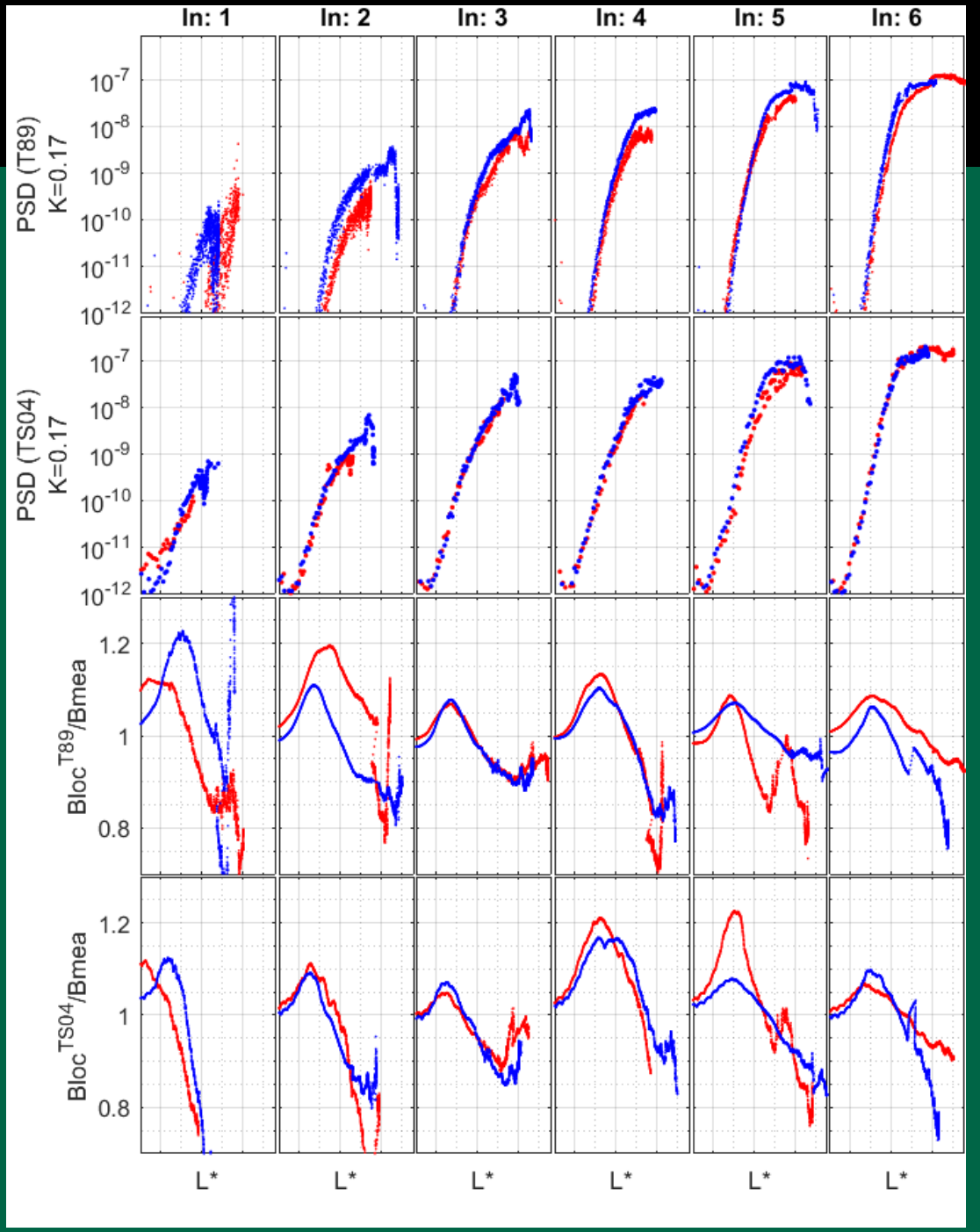
3310 MeV/G



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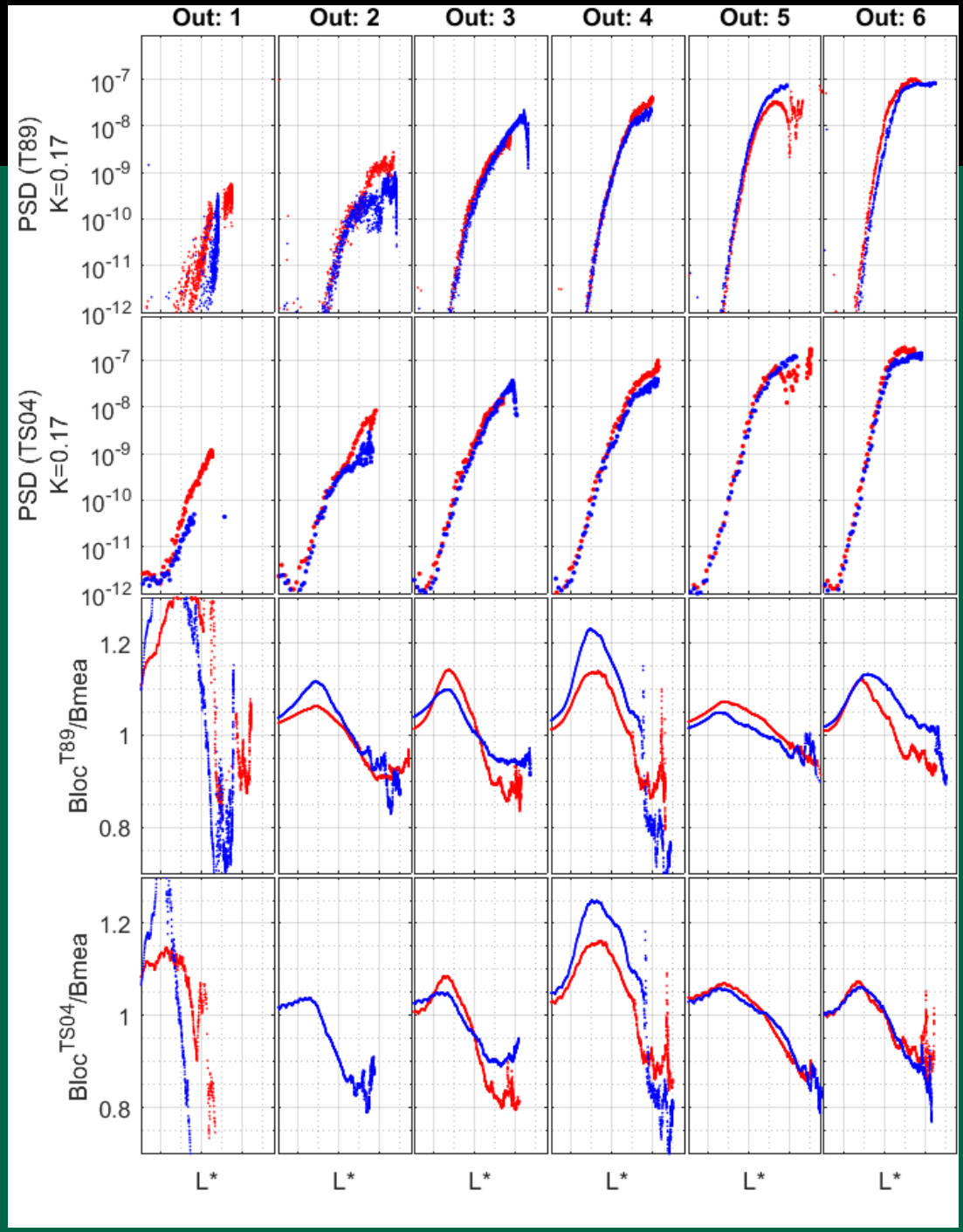
3310 MeV/G



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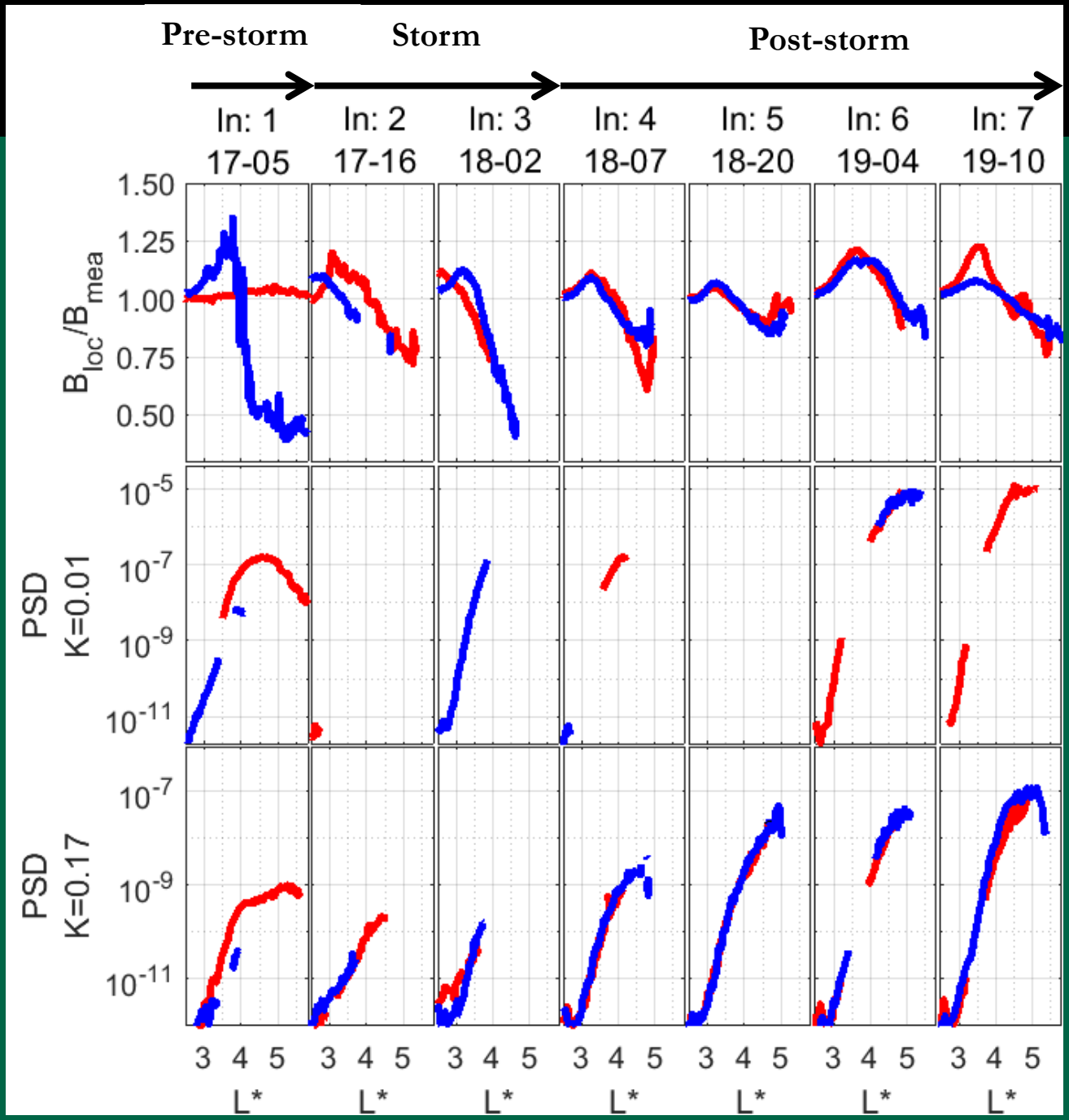
PSD's In Bound Passes 2750 MeV/G

- Pre-storm early 17th
- Storm late 17th to 18th low PSD
- Post-storm after 18th PSD enhanced
- PSD data gapes where electrons don't reach VAP's.
- TS04D B-field model > 0.20% different from the measured B-field



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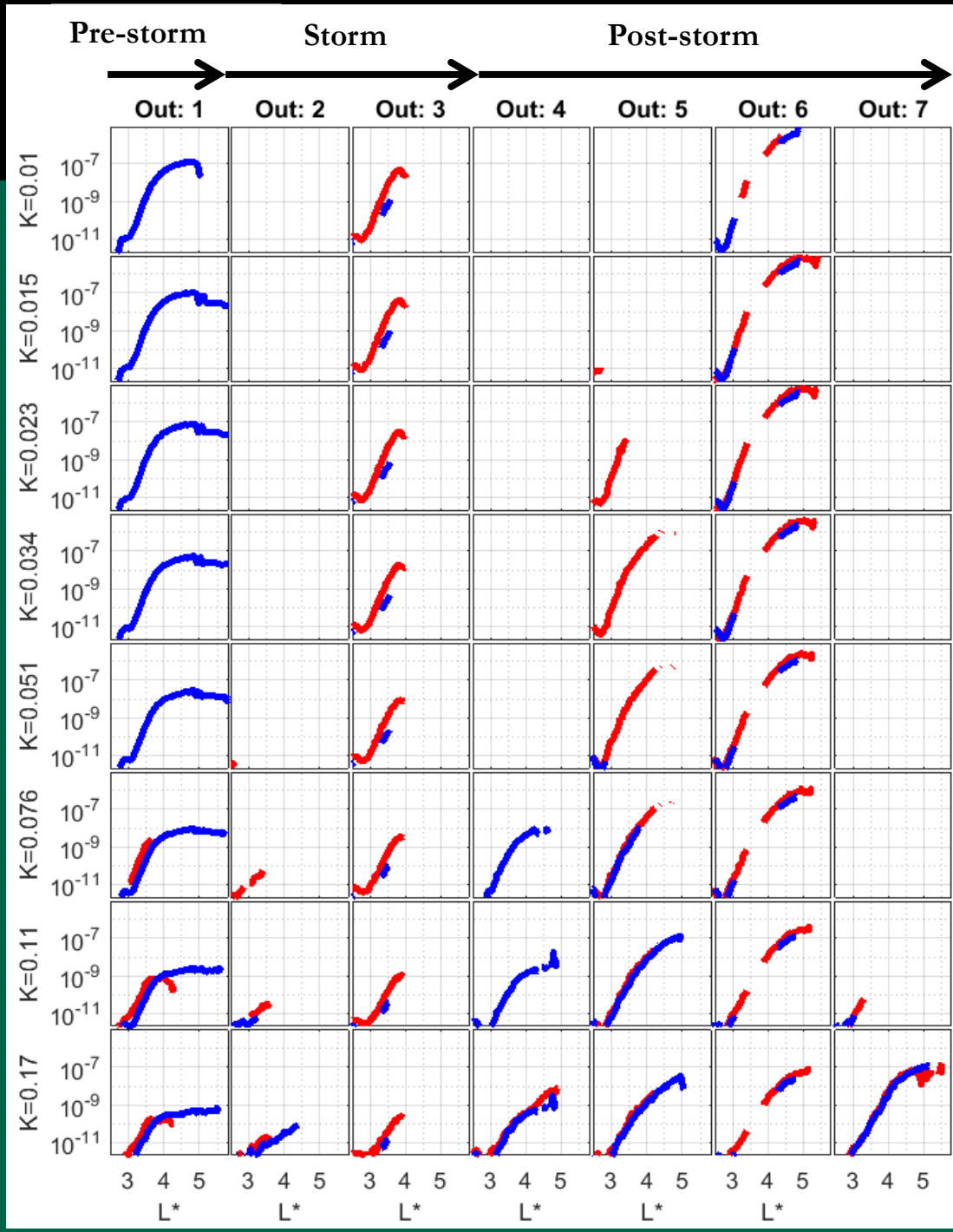
PSD at all K's out bound passes 2750 MeV/G

- Similar results for the out-bound passes
- No evidence of growing peaks during the PSD enhancement
- Results look consistent with that expected by inward RD from an increasing outer BC.



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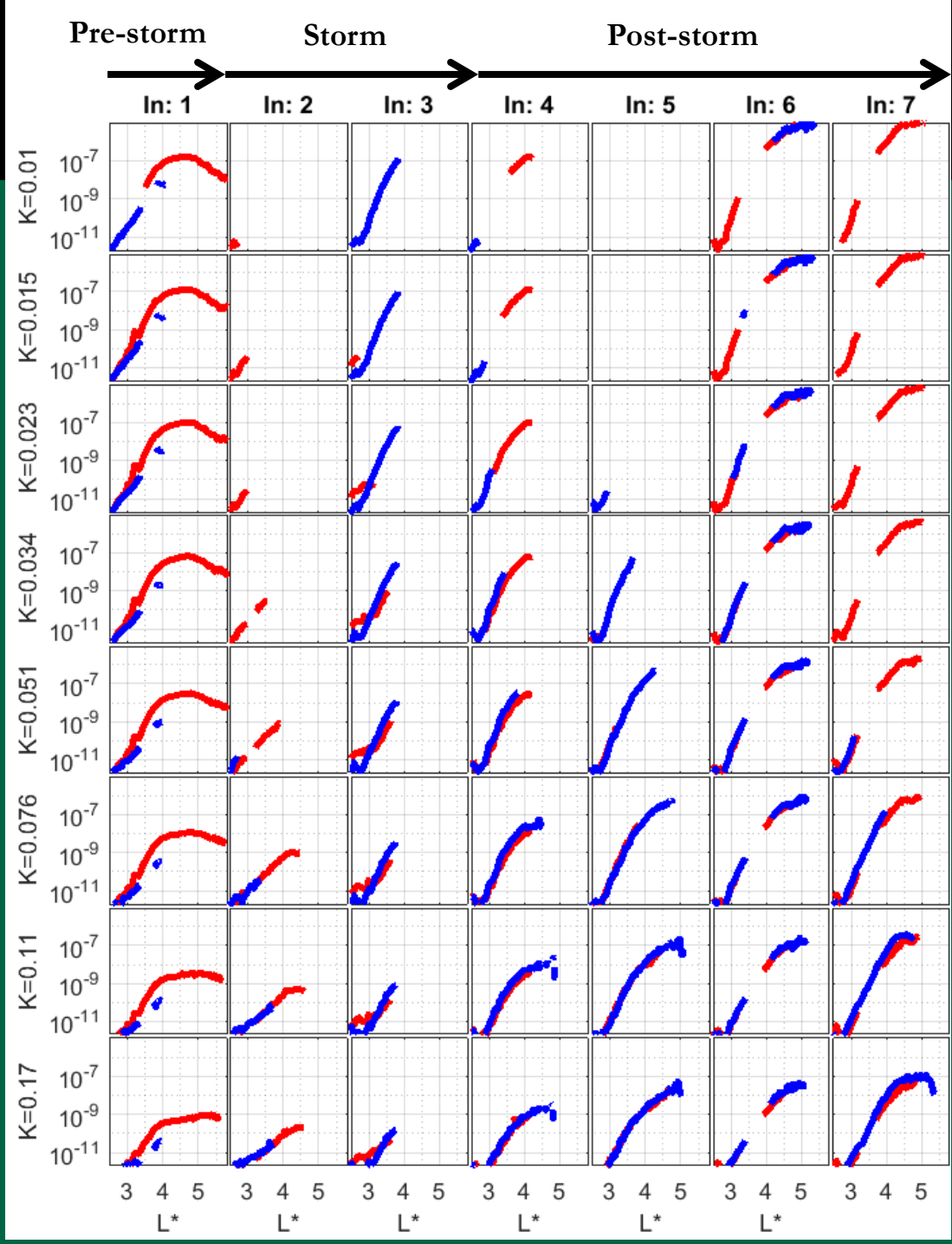
PSD at all K's in bound passes 2750 MeV/G

- All K-values from K=0.01 to K=0.17, no clear evidence of growing PSD peaks.



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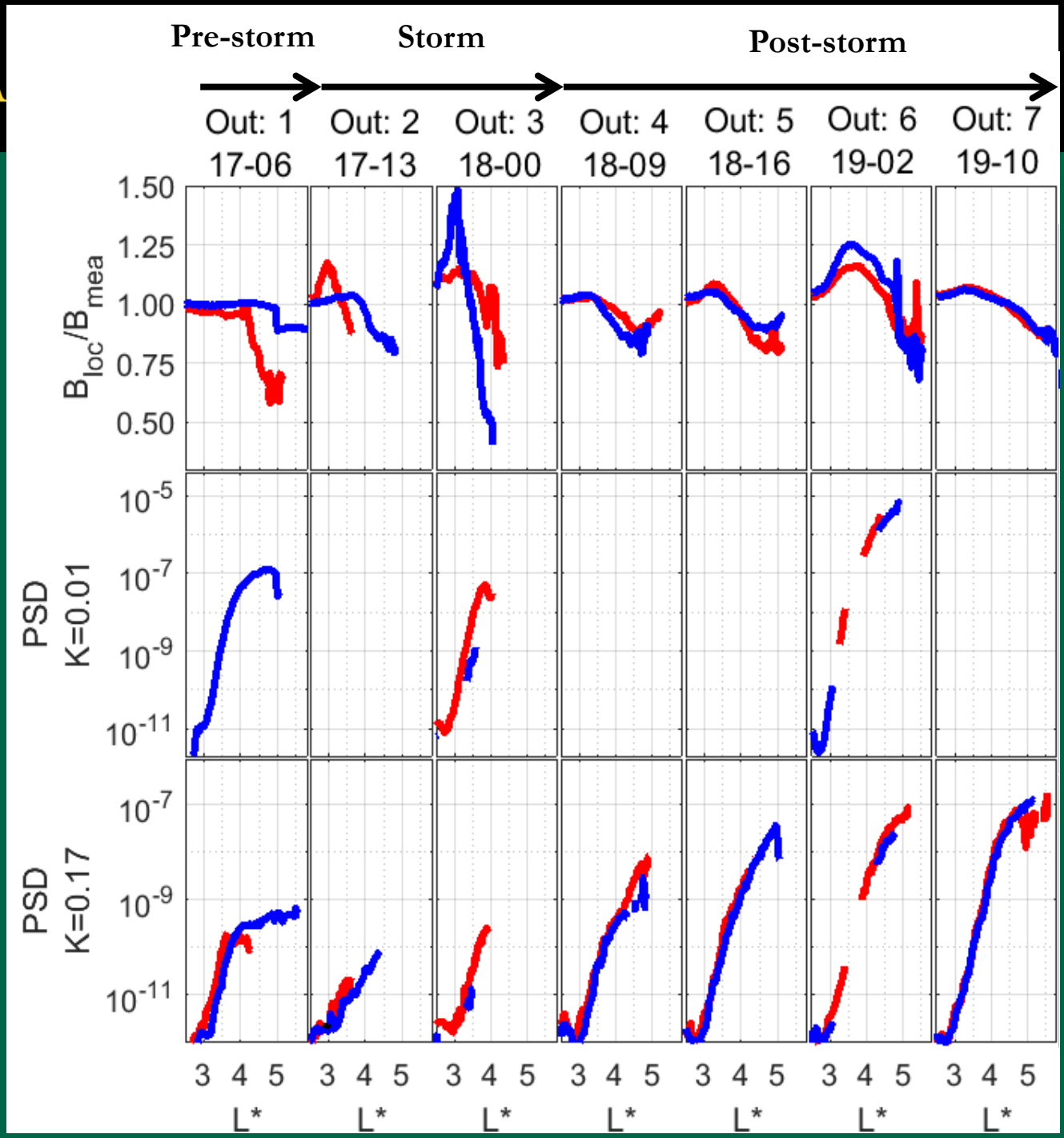
PSD's Out Bound Passes 2750 MeV/G

- Similar results for the out bound passes.
- No clear evidence of growing PSD peaks
- Large data gapes at lowest K-value



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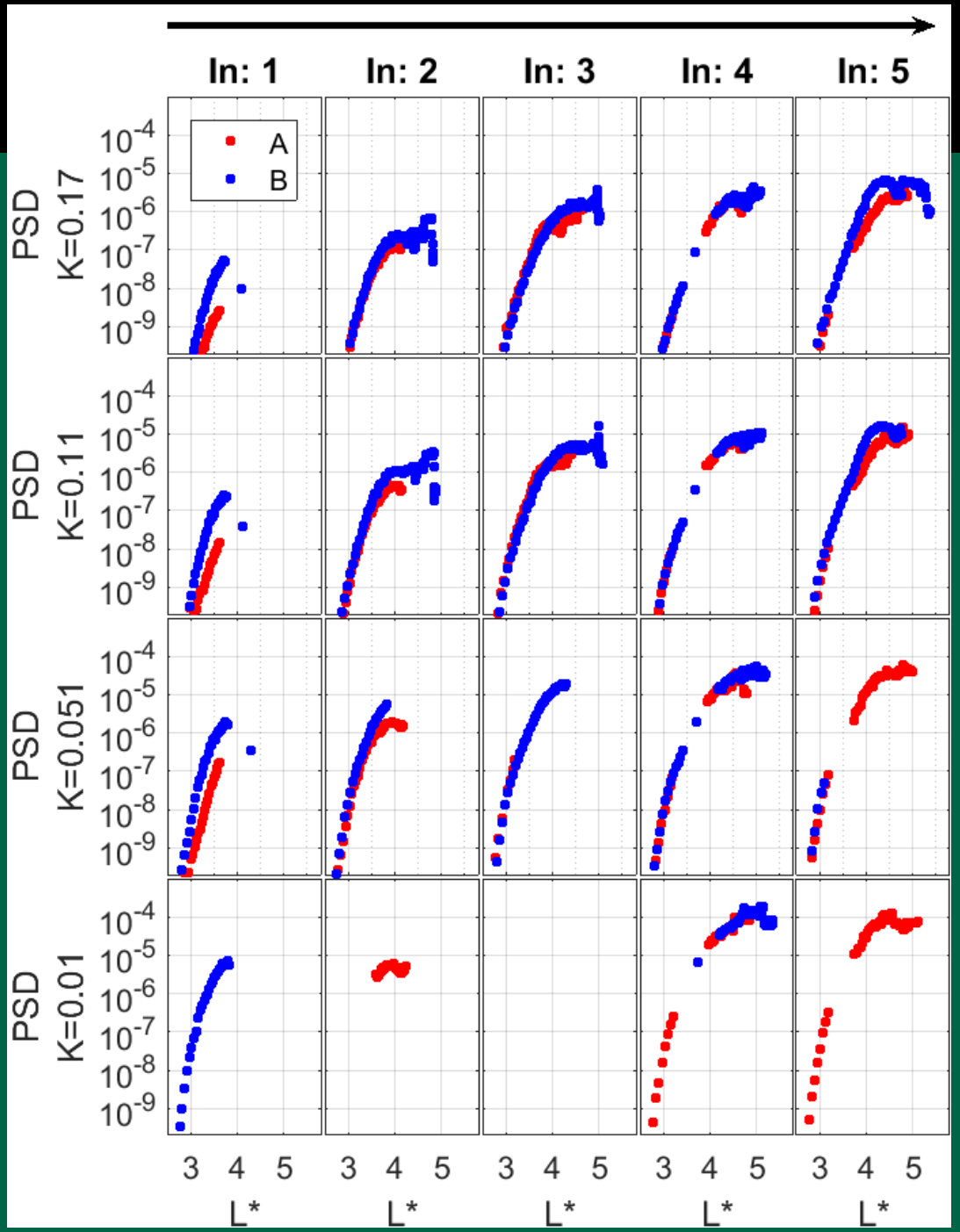
TS04D 1000 MeV/G



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3310 MeV/G