USING A NEURAL NETWORK APPROACH TO IDENTIFY ELECTRON BUTTERFLY PITCH ANGLE DISTRIBUTION SHAPES

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Acknowledgments
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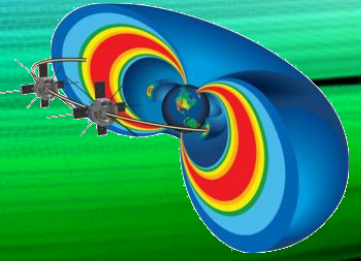


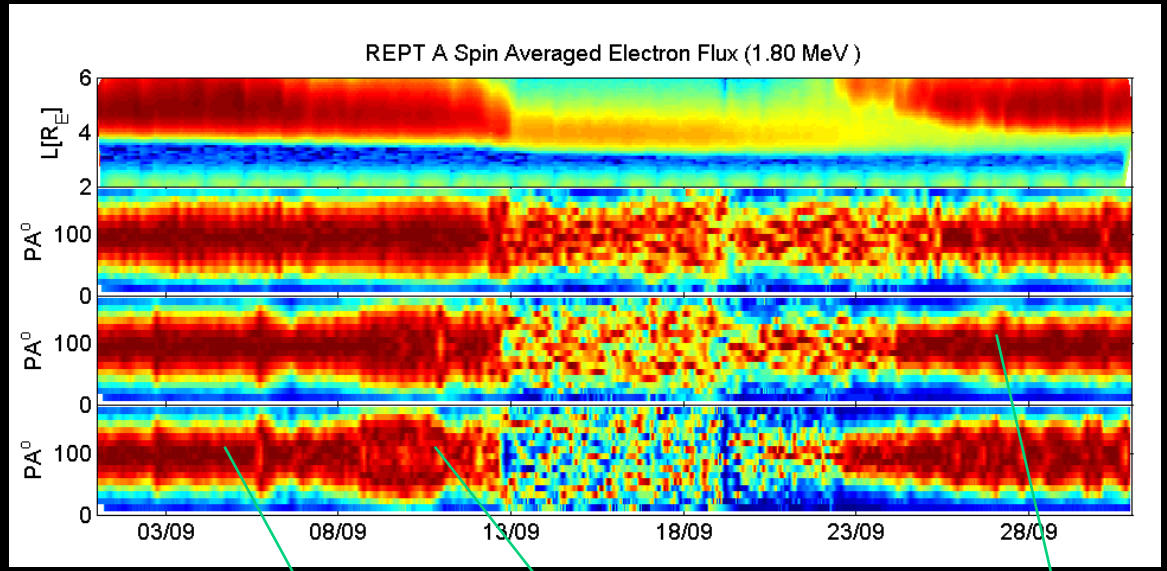
OUTLINE

- PREVIOUS WORK
- DROPOUT ON SEPTEMBER 12, 2014
- NEURAL NETWORK METHODOLOGY : Classification via Self-Organizing Map (SOM)
- PRELIMINARY CASE STUDY
- PRELIMINARY EXPANDED RESULTS
- CONCLUDING REMARKS

PREVIOUS WORK

Pitch Angle Distribution(PAD)

- Magnetopause Shadowing and/or Drift Shell Spliting
- Gain and Loss
- Wave-particle interaction - **EMIC**
- Injections



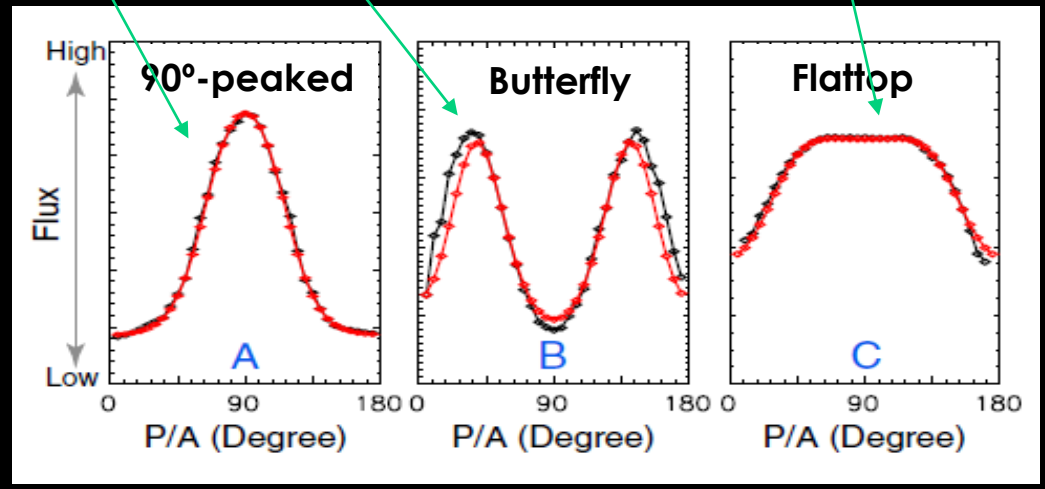
L = 4.5

L = 5.0

L = 5.5

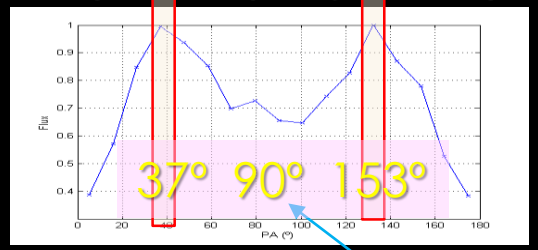
Gannon, J. L., X. Li, and D. Heynderickx (2007)

$$r = \frac{J^{\alpha=90^\circ}}{(J^{\alpha=45^\circ} + J^{\alpha=135^\circ})/2}, \begin{cases} r < 0.9 & \rightarrow \text{butterfly}, \\ r > 1.1 & \rightarrow 90^\circ\text{-peaked}, \\ 0.9 \leq r \leq 1.1 & \rightarrow \text{flattop}, \end{cases}$$

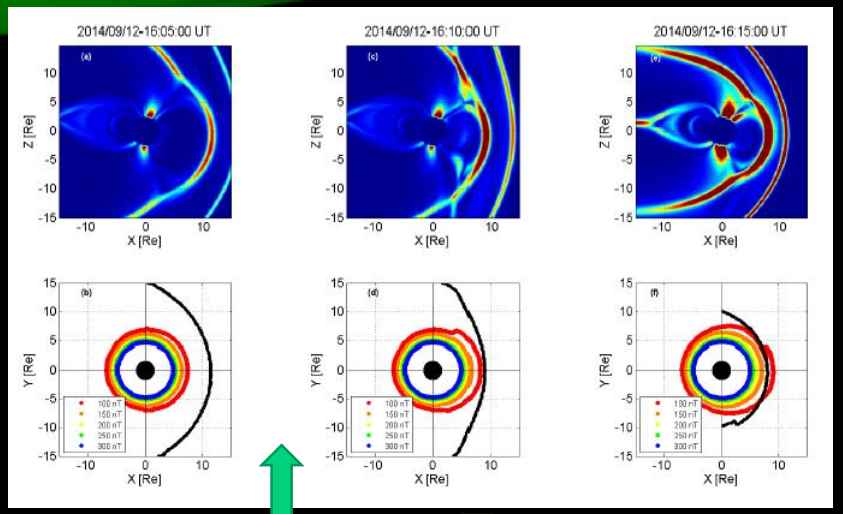


Adapted from Chen, Y et al. [2014]

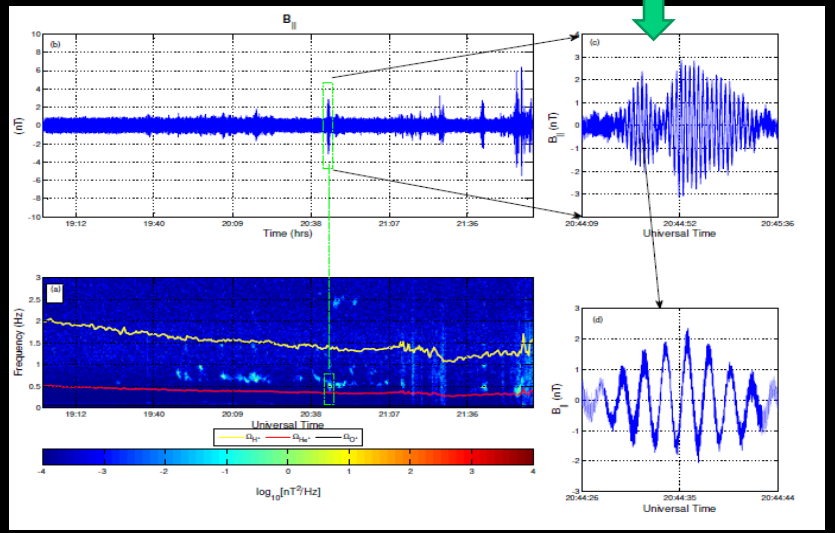
DROPOUT ON SEPTEMBER 12,2014

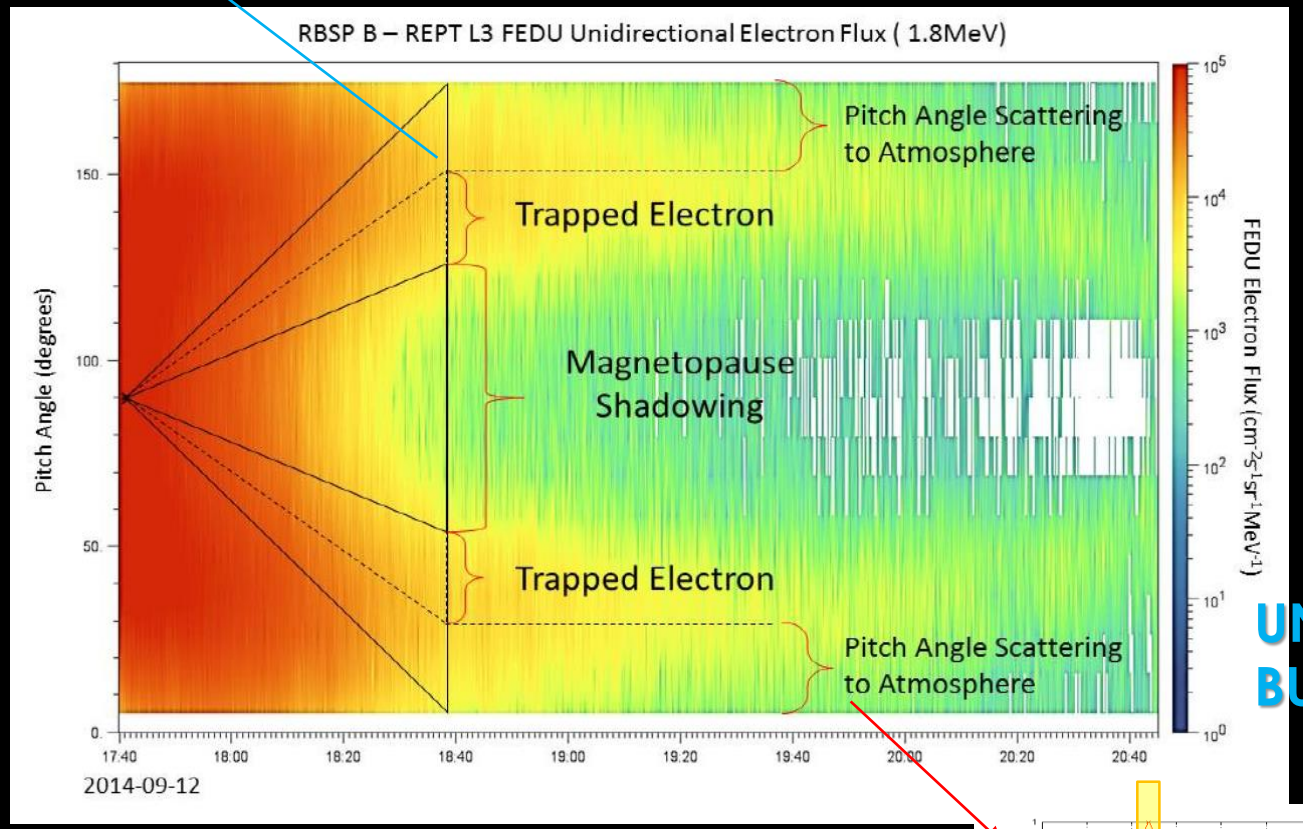


BUTTERFLY

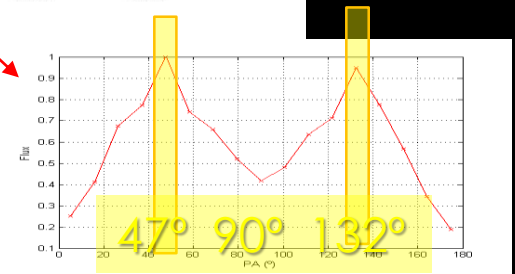


Magnetopause Shadowing + EMIC WAVES =





UNUSUAL BUTTERFLY

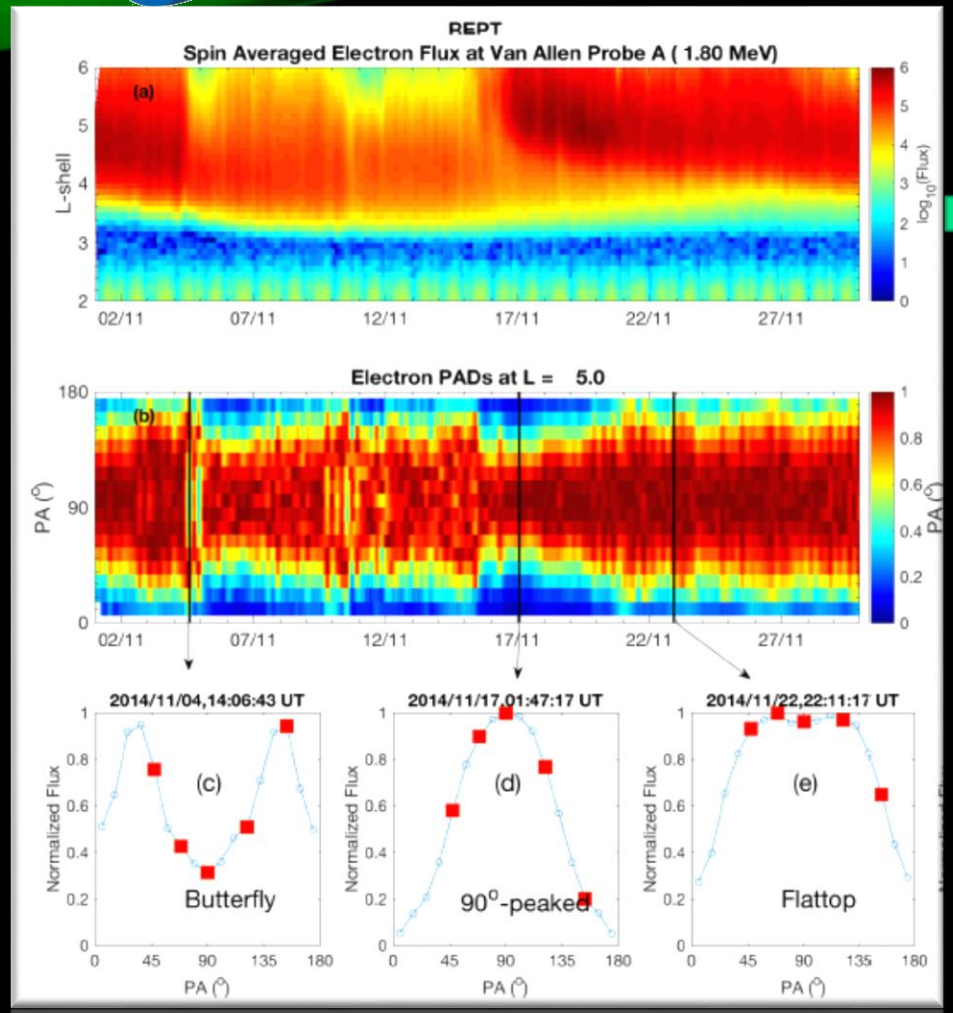


Submitted to JGR: C. Medeiros et al, Investigating an unusual pitch angle distribution during the electron flux dropout on September 12, 2014

MAGNETOPAUSE SHADOWING

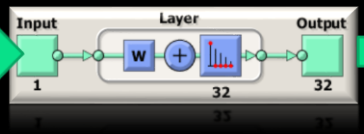
PREVIOUS WORK

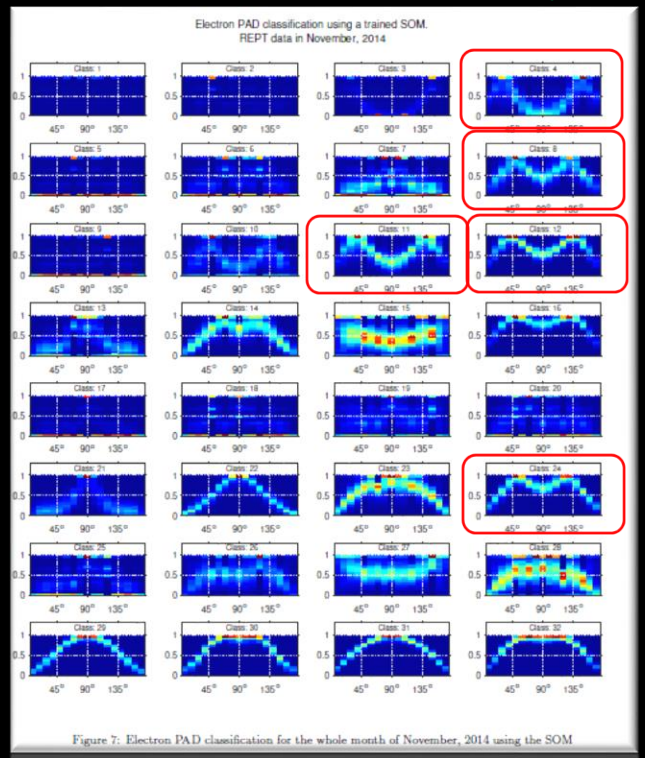
INPUTS



V. M. Souza et al, (2016)

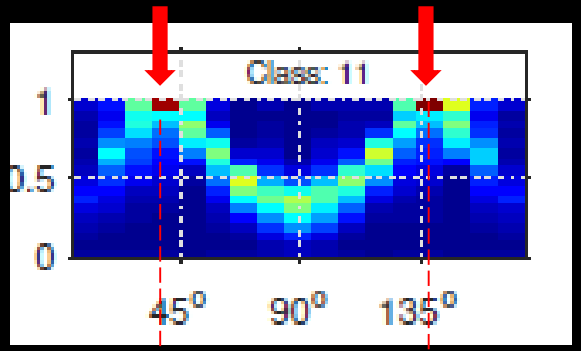
NEURAL NETWORK TRAINNING





OUTPUTS

Butterfly



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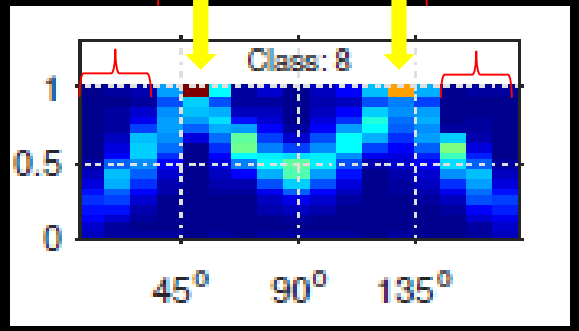


Unusual-Butterfly

SOM CLASSIFICATION

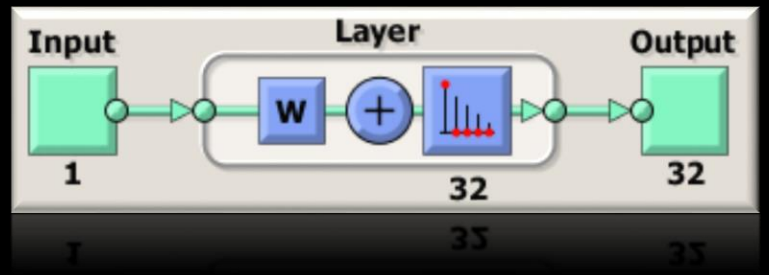
BUTTERFLY or **UNUSUAL BUTTERFLY**

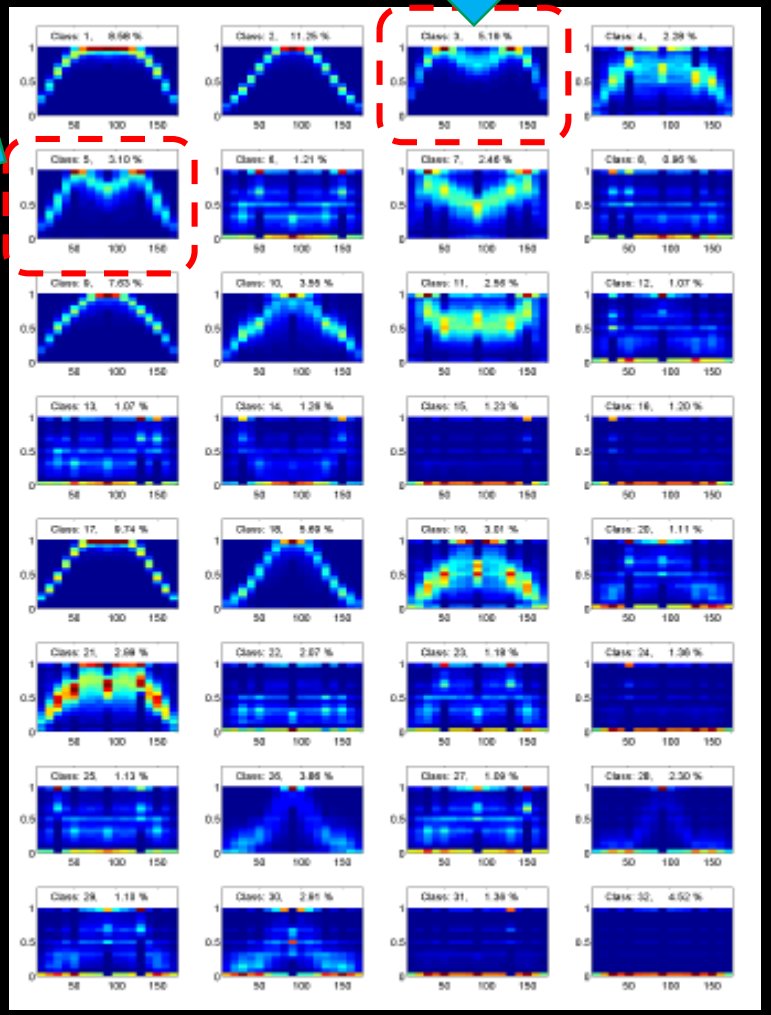
Sep 2014 REPT data (L3 level) – 1.8 MeV

Net (SOM) input data = Norm Electron Flux

PAD: 26° 47° 90° 132° 153°

Network with 32 neurons = 32 classes, Epoch=400)

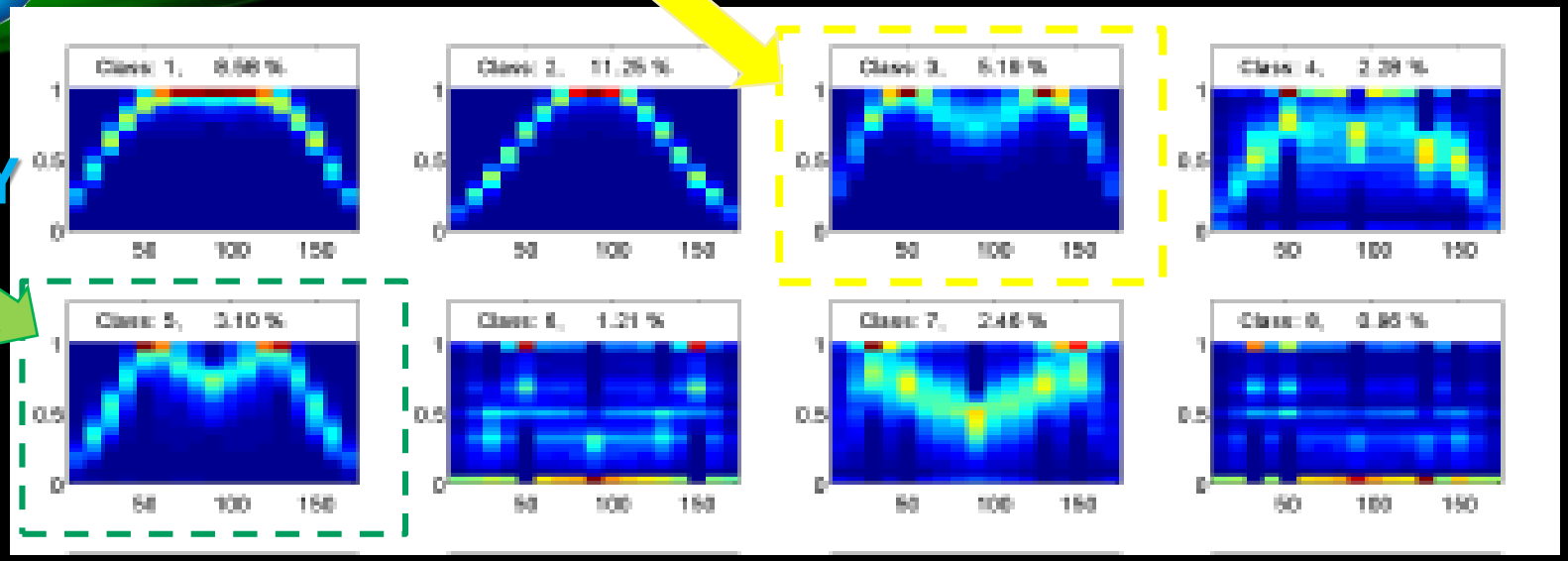


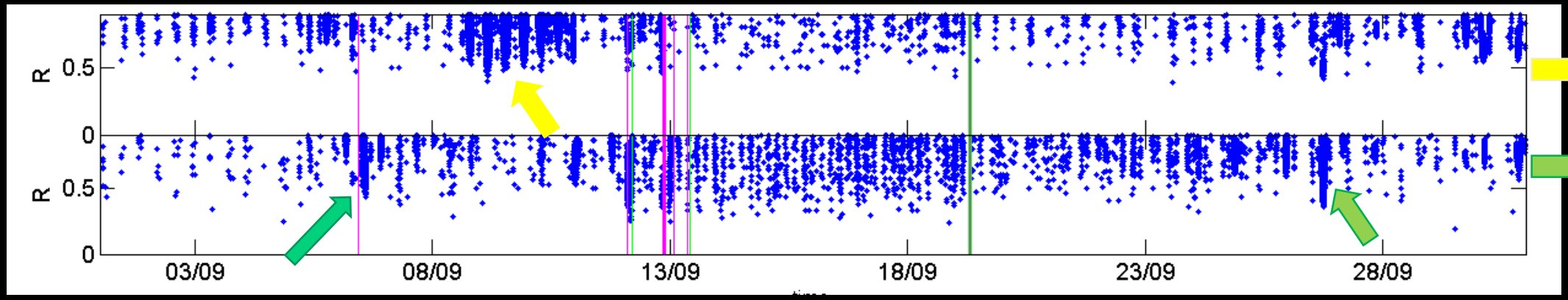


PRELIMINARY CASE STUDY

BUTTERFLY

UNUSUAL BUTTERFLY

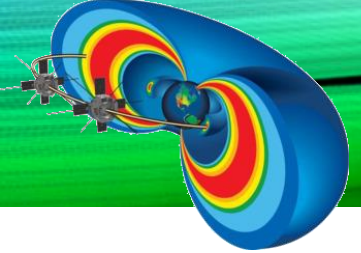


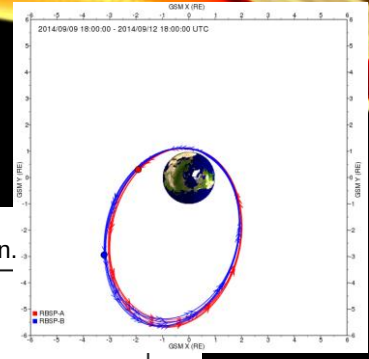


BUTTERFLY

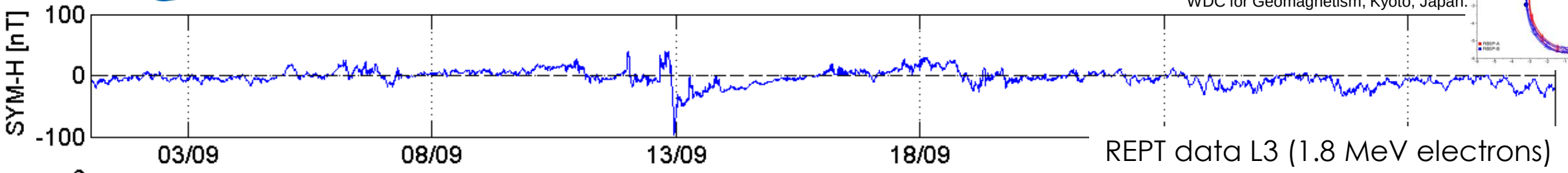
UNUSUAL BUTTERFLY

PRELIMINARY CASE STUDY

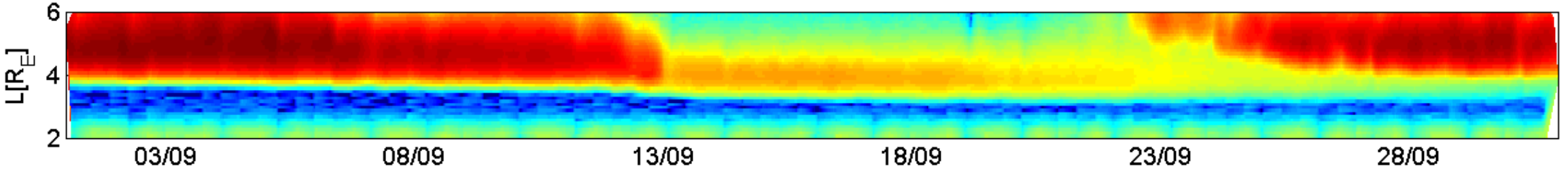


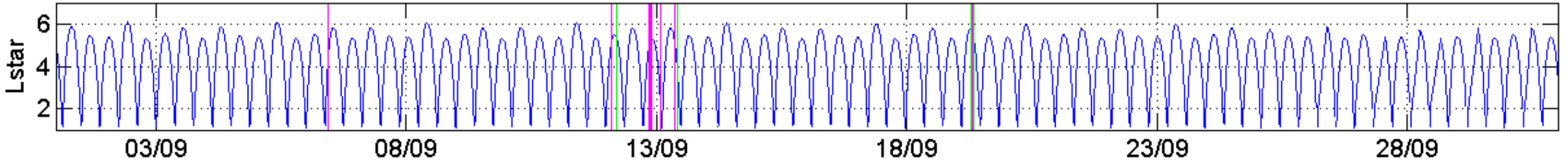


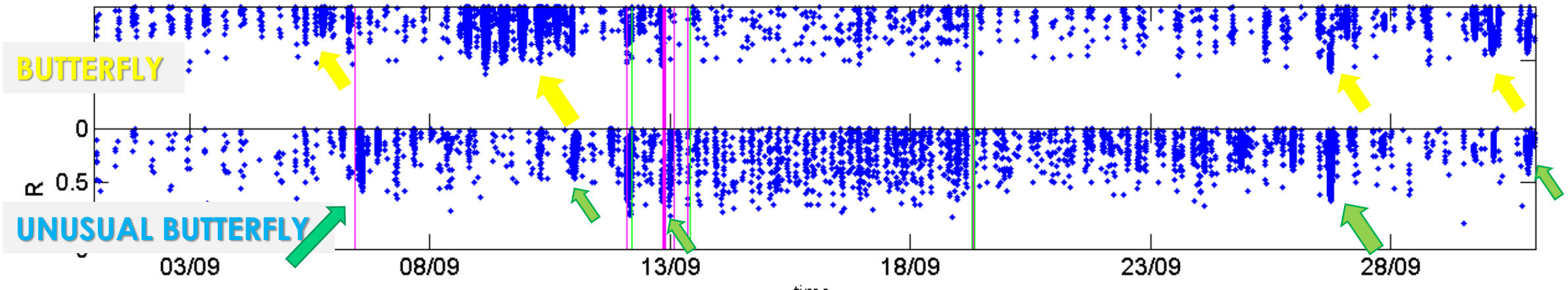
WDC for Geomagnetism, Kyoto, Japan.



REPT data L3 (1.8 MeV electrons)

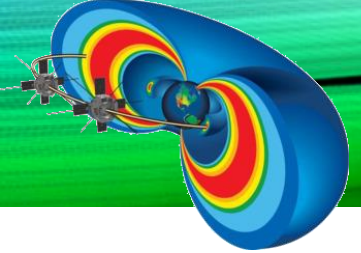


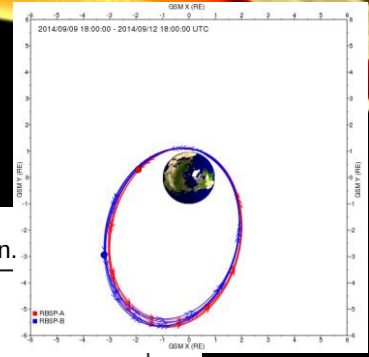




PRELIMINARY CASE STUDY

Dropout on September 12,2014





WDC for Geomagnetism, Kyoto, Japan.

SYM-H [nT]

REPT data L3 (1.8 MeV electrons)

L[R_E]

Lstar

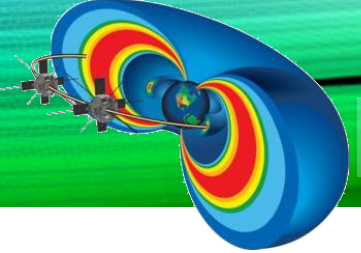
R

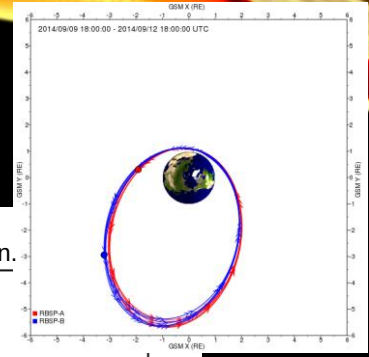
BUTTERFLY

UNUSUAL BUTTERFLY

PRELIMINARY CASE STUDY

Dropout on September 12,2014





EMIC + Shadowing

WDC for Geomagnetism, Kyoto, Japan.

SYM-H [nT]

REPT data L3 (1.8 MeV electrons)

$L[R_E]$

EMIC + Shadowing + Others...

Lstar

BUTTERFLY

Forget it!

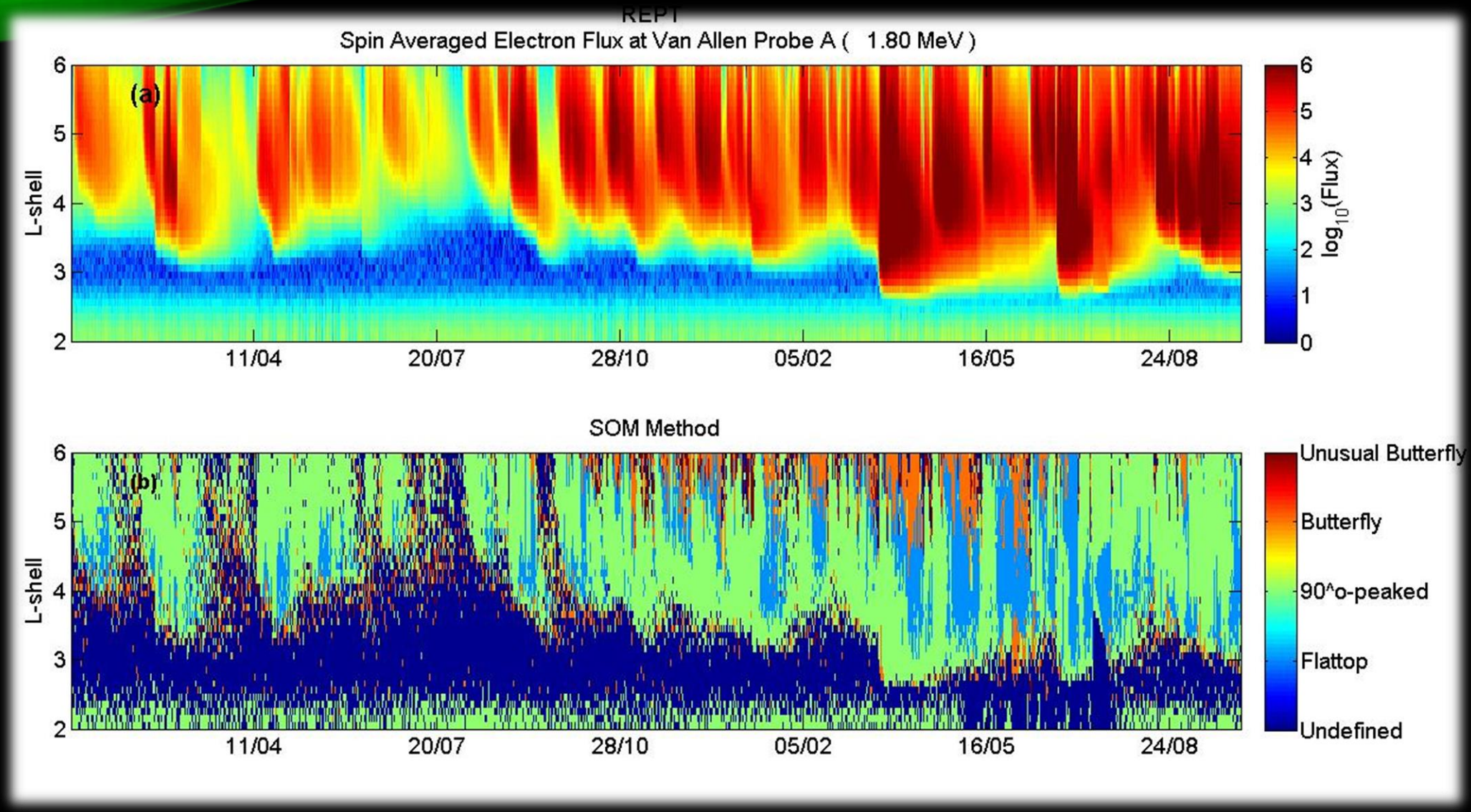
UNUSUAL BUTTERFLY

R

03/09 08/09 13/09 18/09 23/09 28/09

PRELIMINARY EXPANDED RESULTS

January 2014 to October 2015



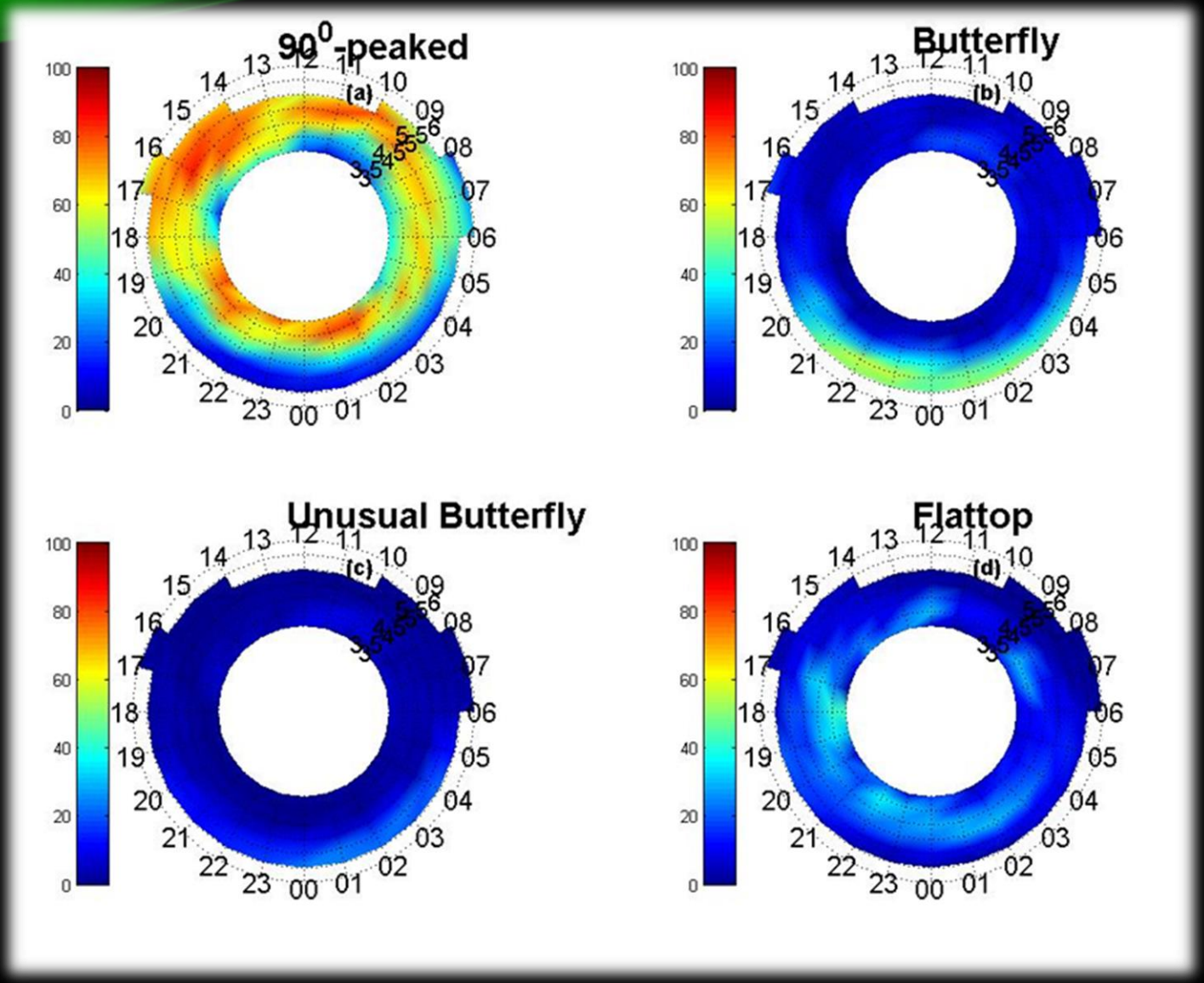
Electron Flux

PAD location

PRELIMINARY EXPANDED RESULTS

January 2014 to October 2015

REPT data L3 - 1.8 MeV

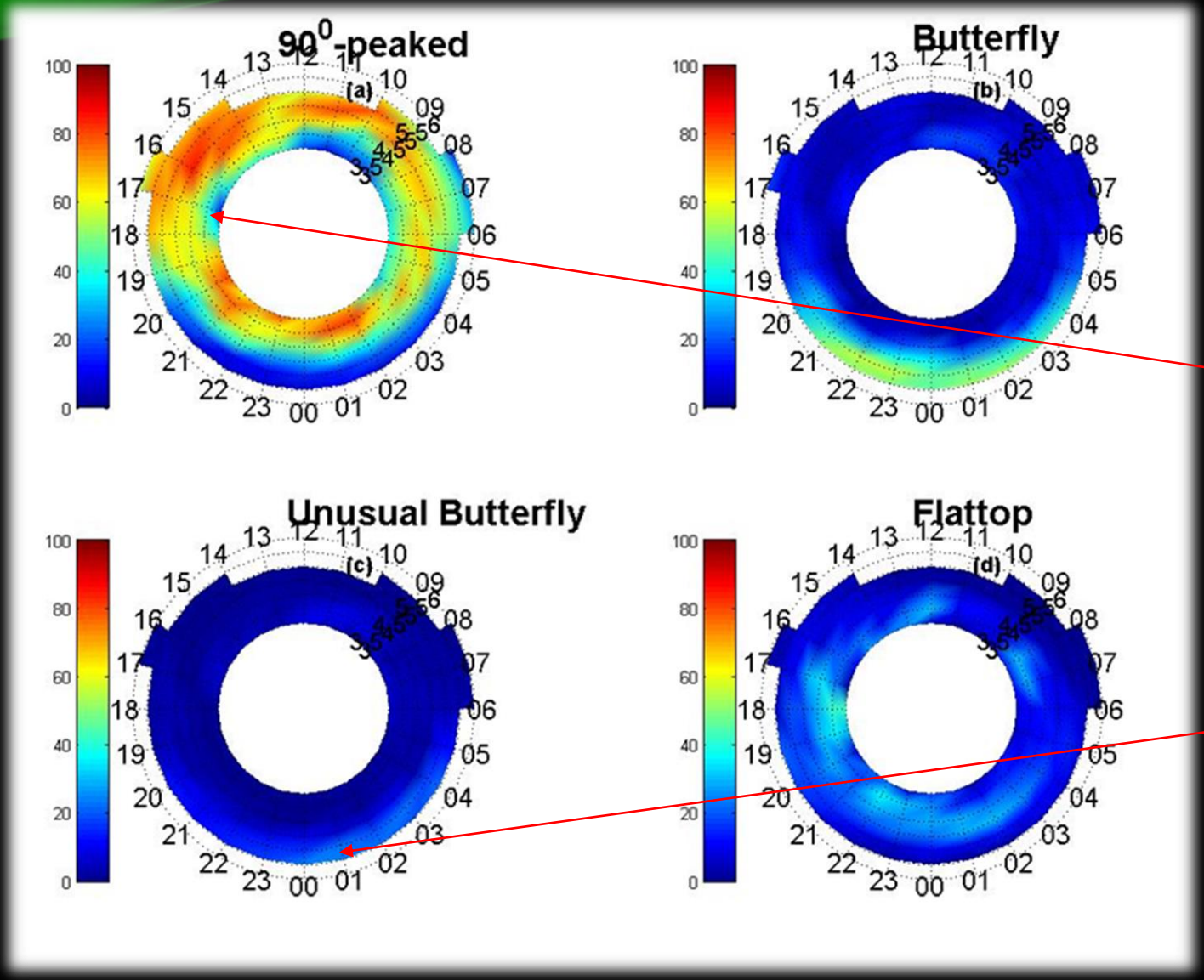


- Magnetopause Shadowing and/or Drift Shell Spliting
- Wave-particle interaction
- Other mechanism: gain and loss of particle

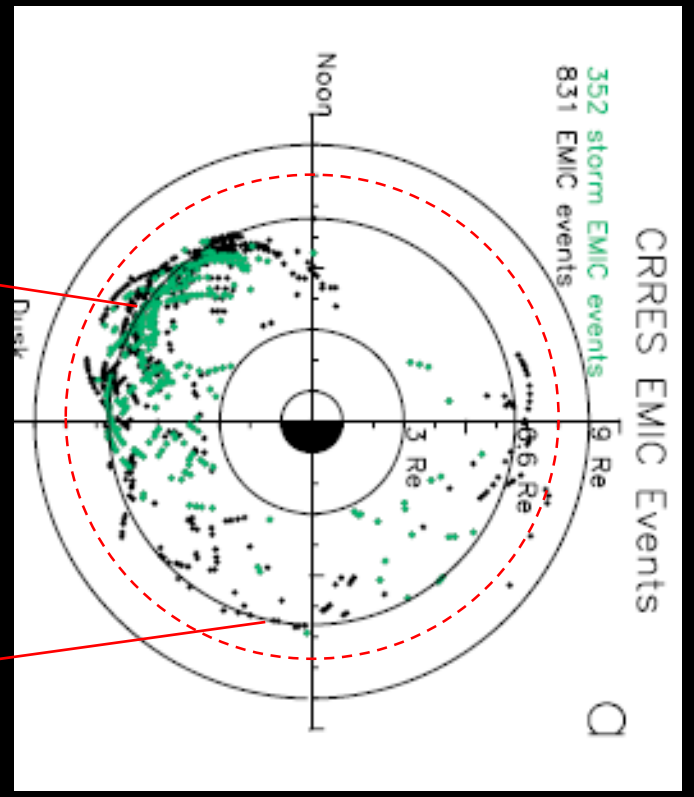
PRELIMINARY EXPANDED RESULTS

January 2014 to October 2015

REPT data L3 - 1.8 MeV



EMIC WAVES

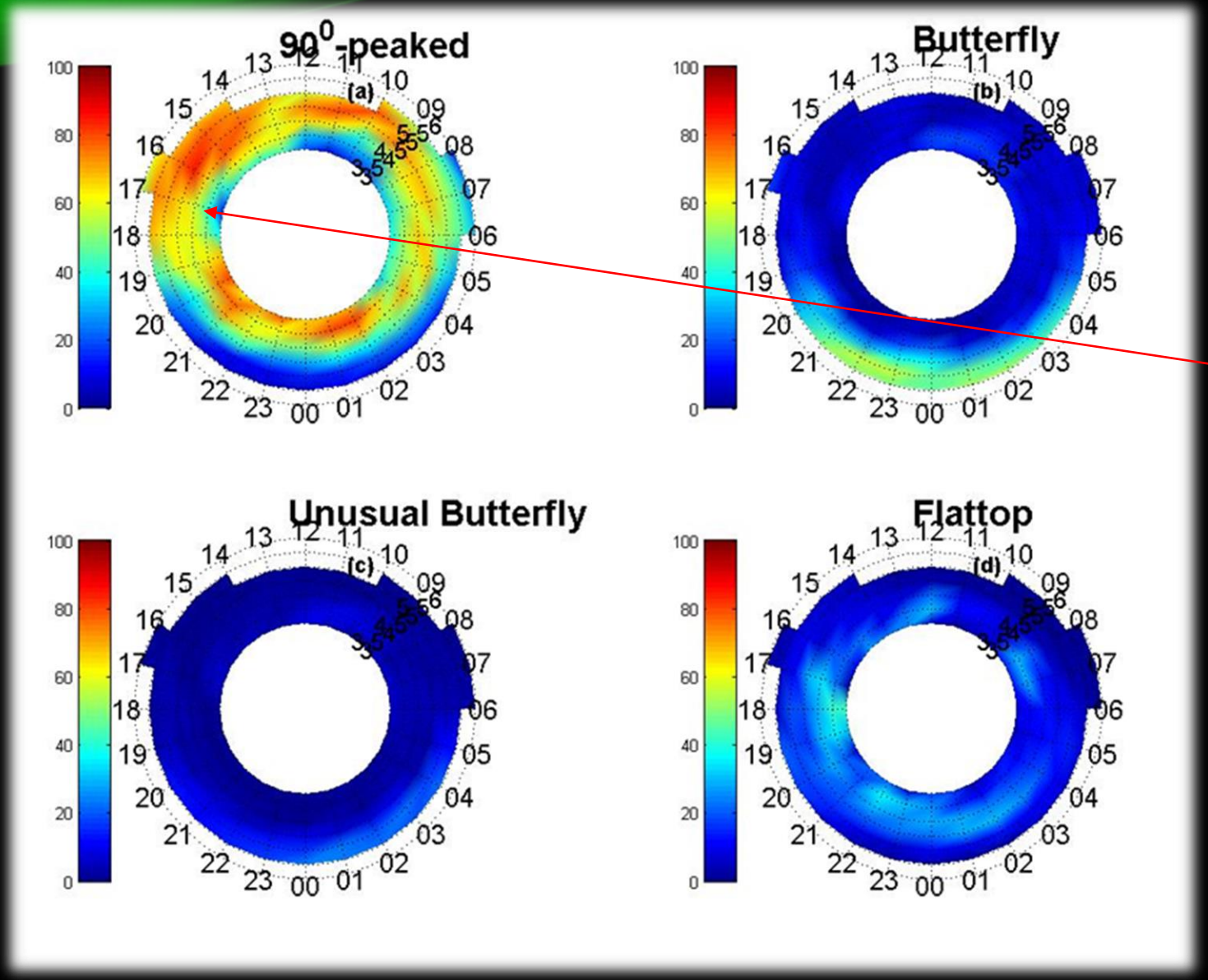


Halford, A. J., B. J. Fraser, and S. K. Morley (2010)

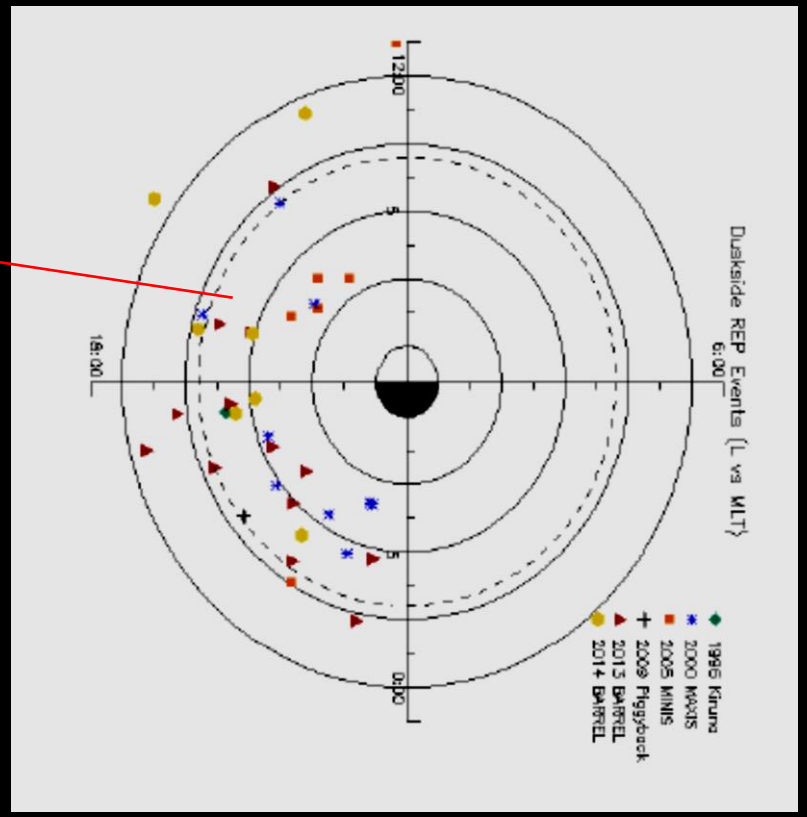
PRELIMINARY EXPANDED RESULTS

January 2014 to October 2015

REPT data L3 - 1.8 MeV



Balloon Observed Relativistic Electron Precipitation

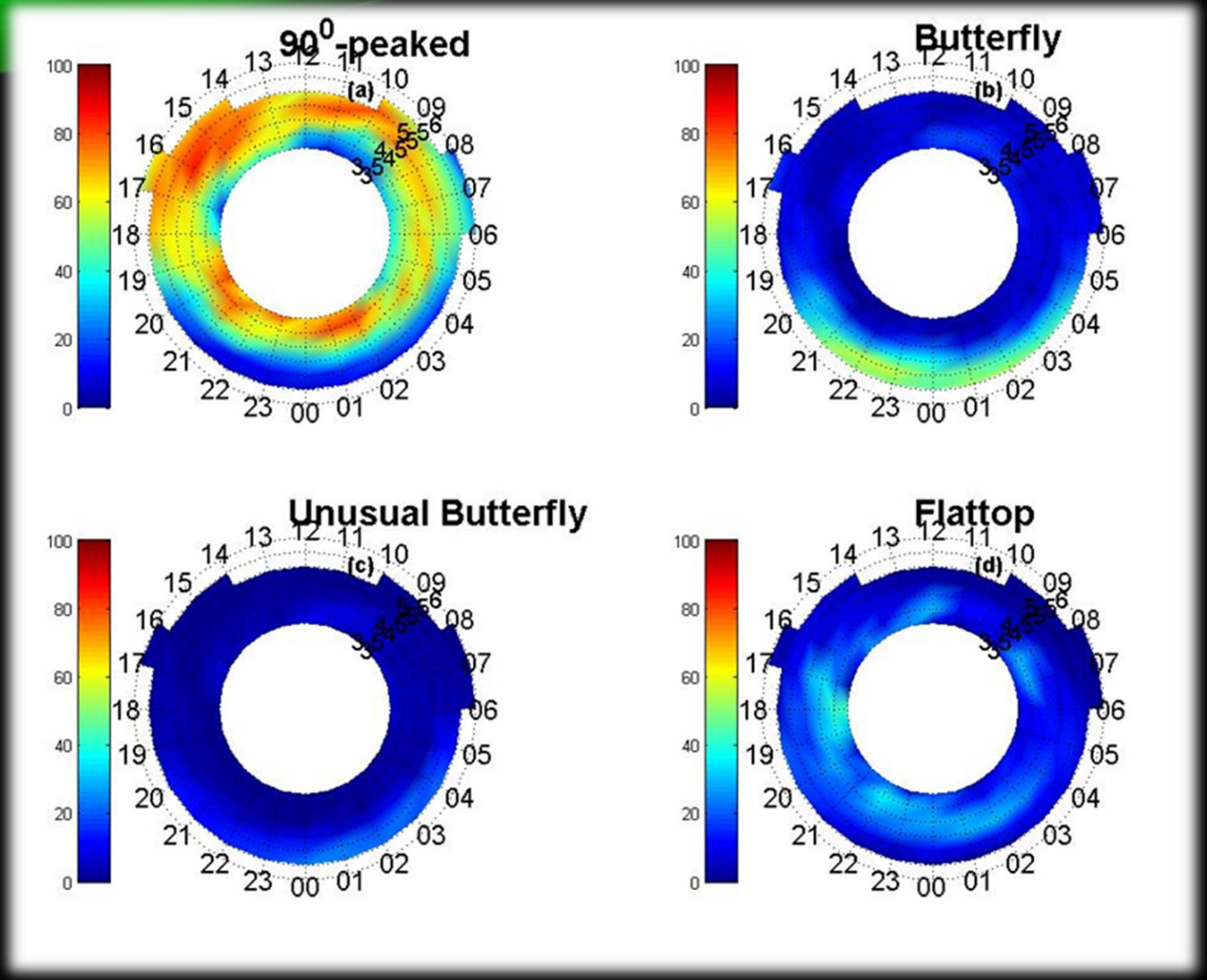


Leslie Woodger, Dartmouth College

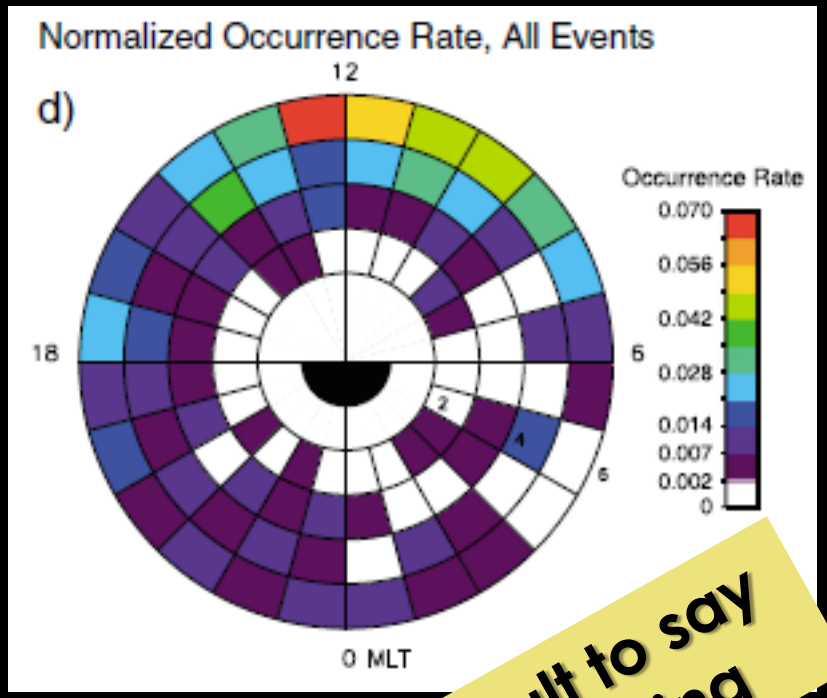
PRELIMINARY EXPANDED RESULTS

January 2014 to October 2015

REPT data L3 - 1.8 MeV



Magnetosonic Waves



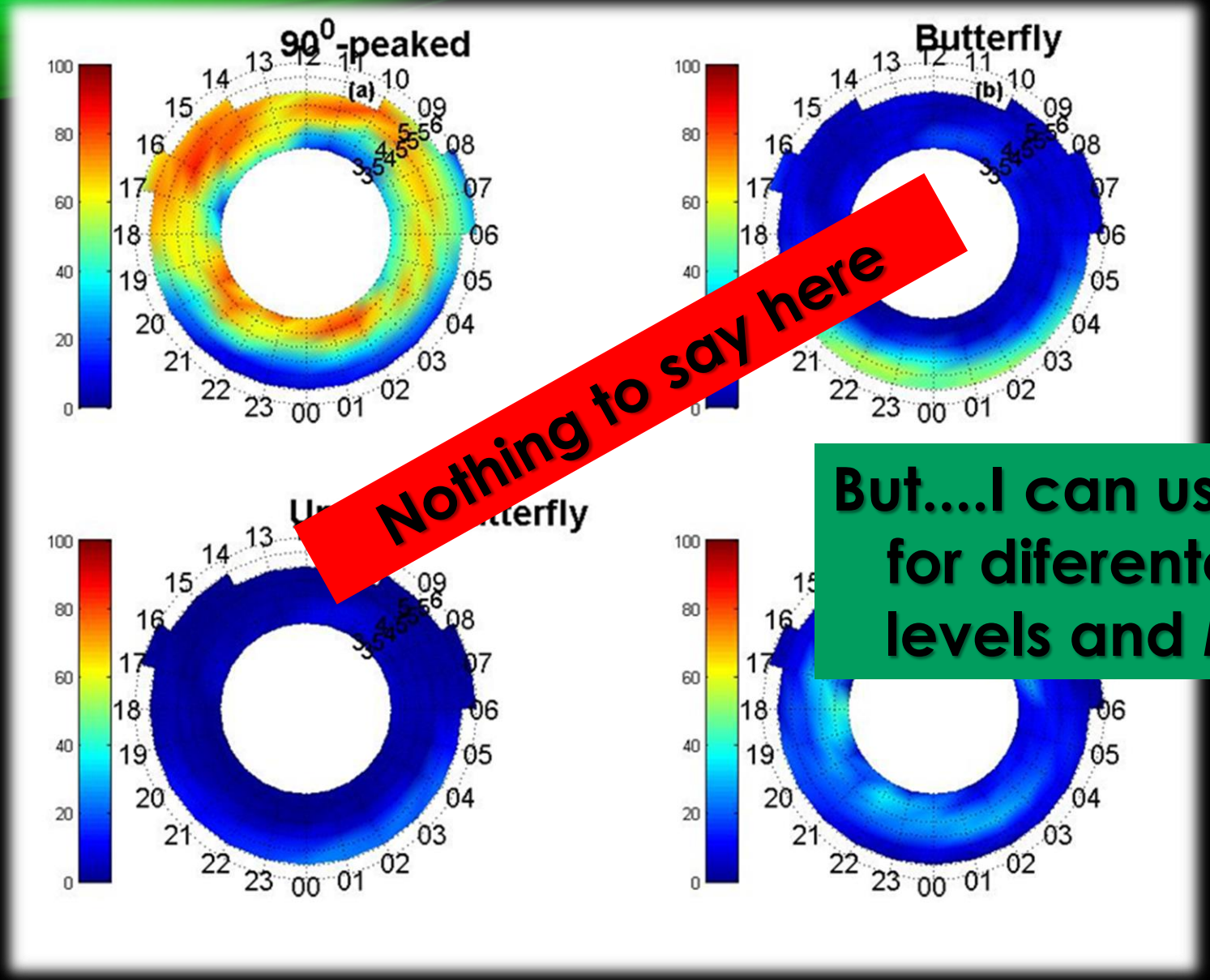
Posch, J. L.,M. et al.(2015)

Difficult to say something

PRELIMINARY EXPANDED RESULTS

January 2014 to October 2015

REPT data L3 - 1.8 MeV

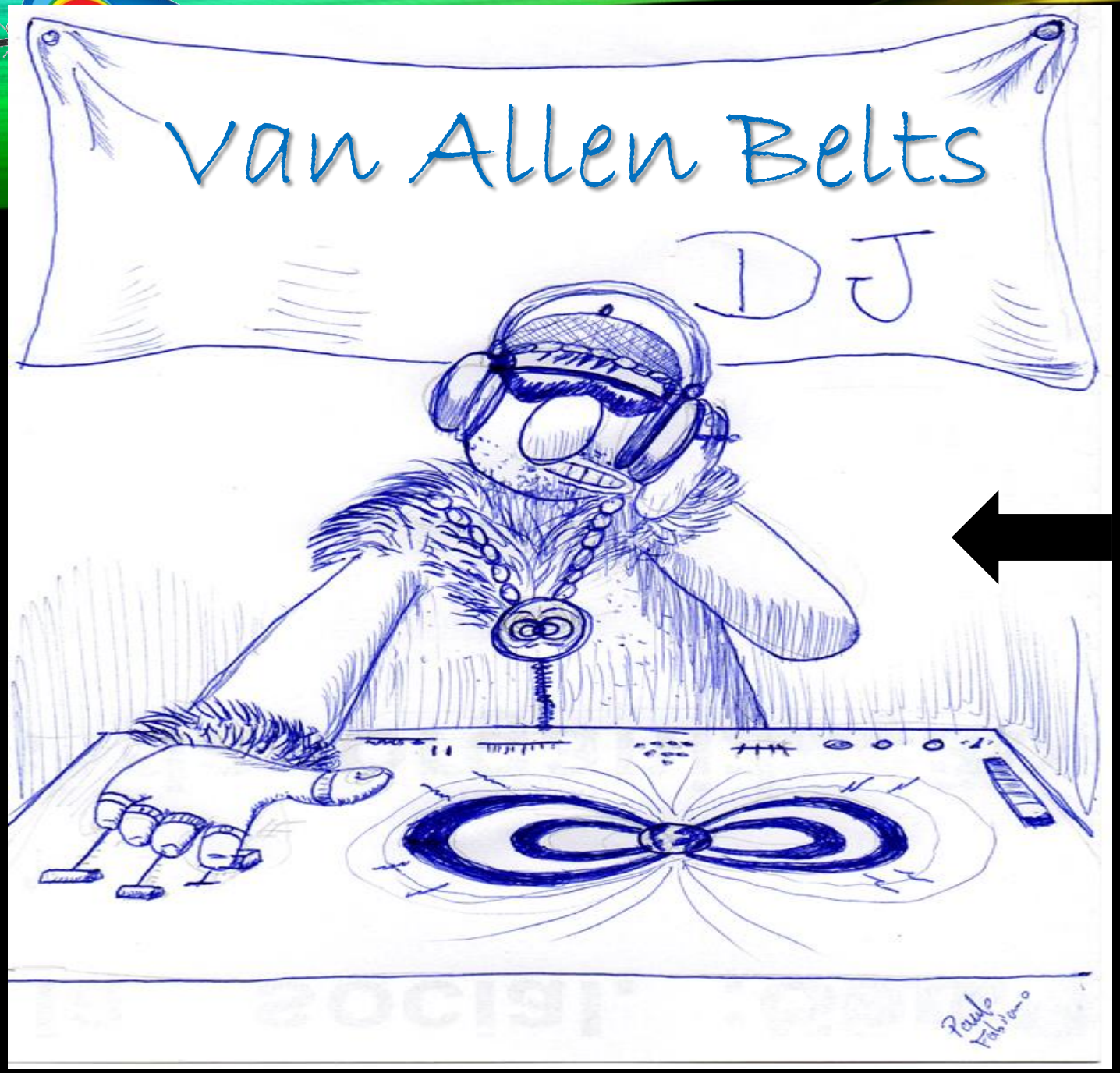


But....I can use the SOM for diferente energy levels and MagEIS!!!

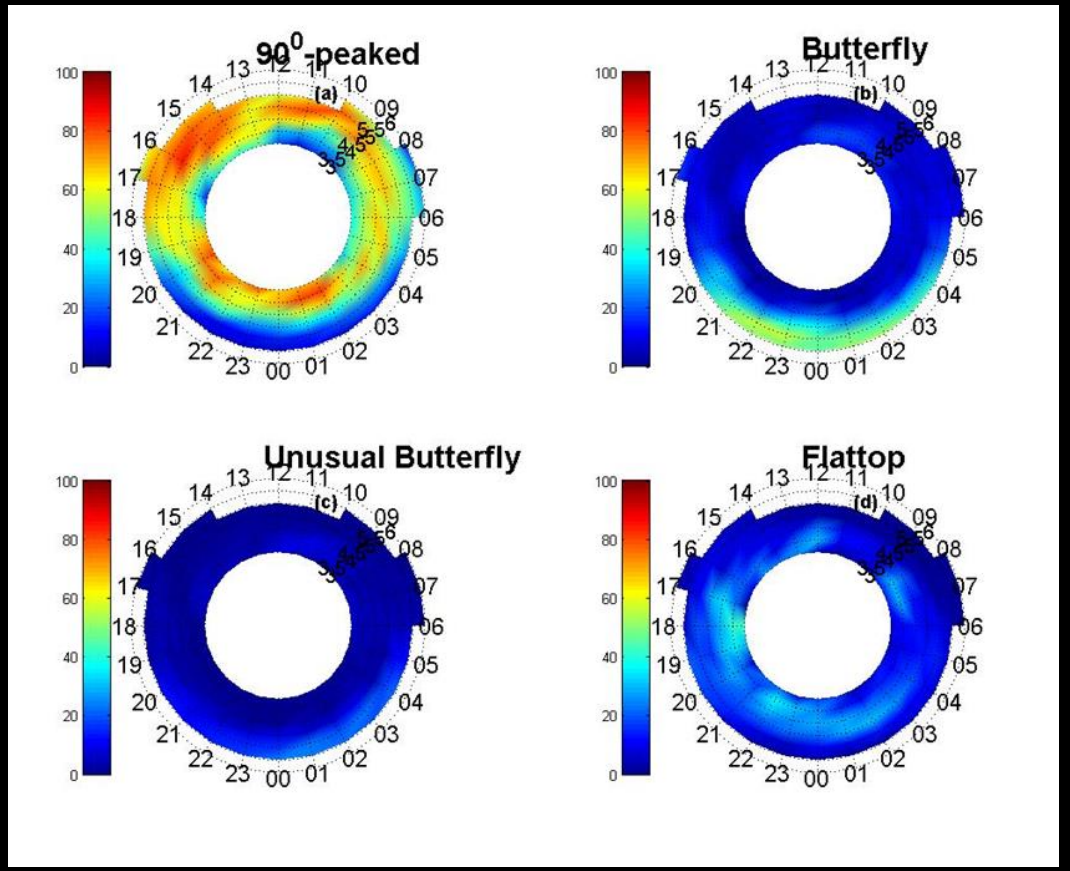
Li, W., et al. (2016)

CONCLUDING REMARKS

- ✓ SOM METHODOLOGY IS A POWERFUL TOOL TO CLASSIFY HUGE AMOUNTS OF PAD SHAPES
- ✓ THE INPUTS CAN BE SELECTED IN SUCH A WAY TO HELP US TO DISTINCT DIFFERENT ASPECTS OF THE ANALYZED PADs
- ✓ USING THIS APPROACH WE CAN INFER THE ACTIVE PROCCESS INTERACTING WITH THE RADIATION BELT PARTICLES (FUTURE WORKS)
- ✓ WE CAN ALSO INFER DIFFERENT OUTPUTS USING DIFFERENT INPUTS [ie, EMIC waves signature(working on it!)].
- ✓ THIS APPROACH CAN BE ALSO APPLIED TO FIND ANOTHER PATTERNS IN THE VAN ALLEN PROBE DATA AND/OR ANOTHER INSTRUMENTS (see Souza et al 2016, Souza et al., Book Chapter, Elsevier, 2017, in press).


Van Allen Belts
DJ

THANK YOU!!!


90^0-peaked
Butterfly
Unusual Butterfly
Flattop