The storm that wasn't:
A look at multiple loss processes occurring simultaneously and how they interact with each other

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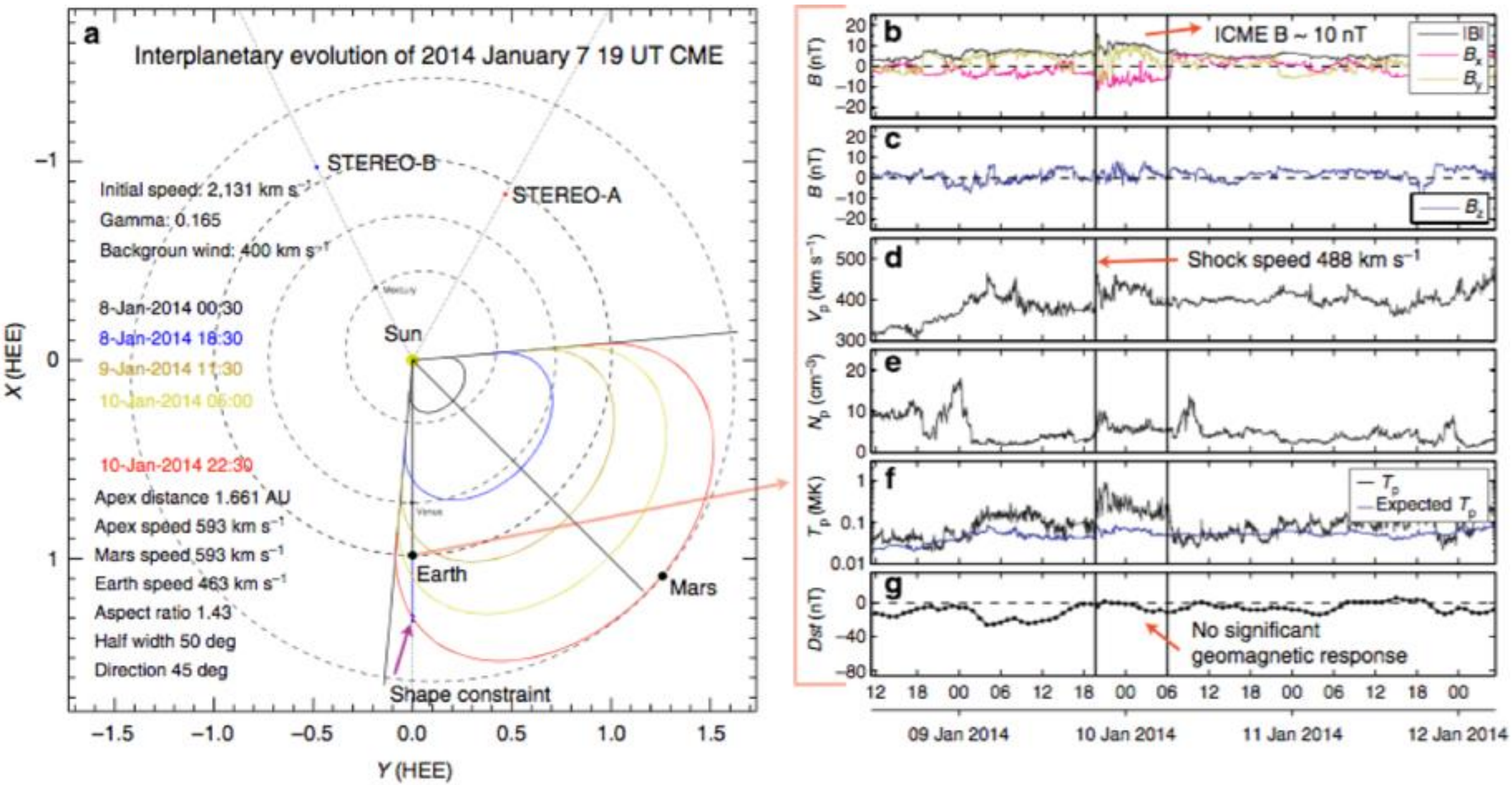
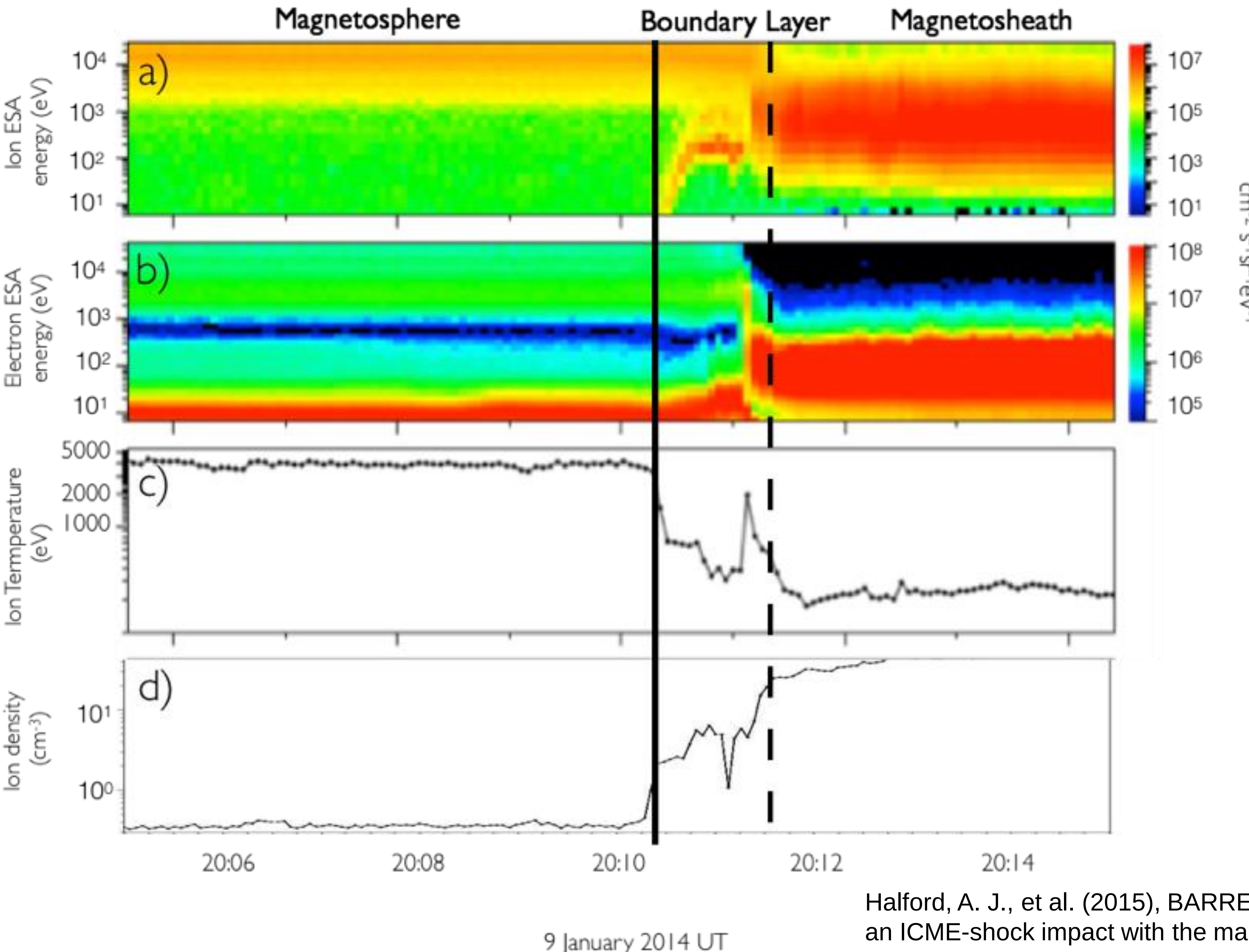
March 8th 2018
Chapman Conference:
Particle Dynamics in the Earth's Magnetosphere
Cascais Portugal

January 7th 2014 the CME and iCME-shock propagation



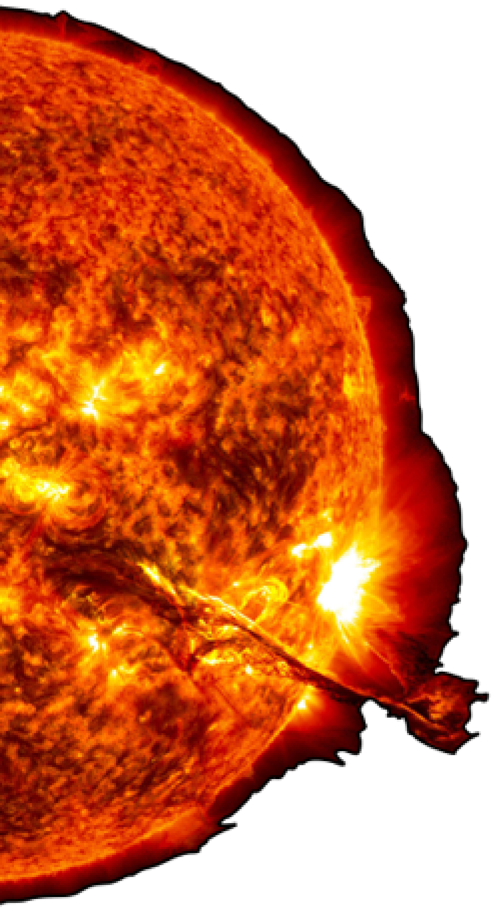
Möstl, C. et al. (2015), Strong coronal channeling and interplanetary evolution of a solar storm up to Earth and Mars, Nature Communications, doi: 10.1038/ncomms8135

January 9th 2014 Arrival of the ICME-Shock at Earth



Halford, A. J., et al. (2015), BARREL observations of an ICME-shock impact with the magnetosphere and the resultant radiation belt electron loss. J. Geophys. Res. Space Physics, doi: 10.1002/2014JA020873.

January 9th 2014 array of observations



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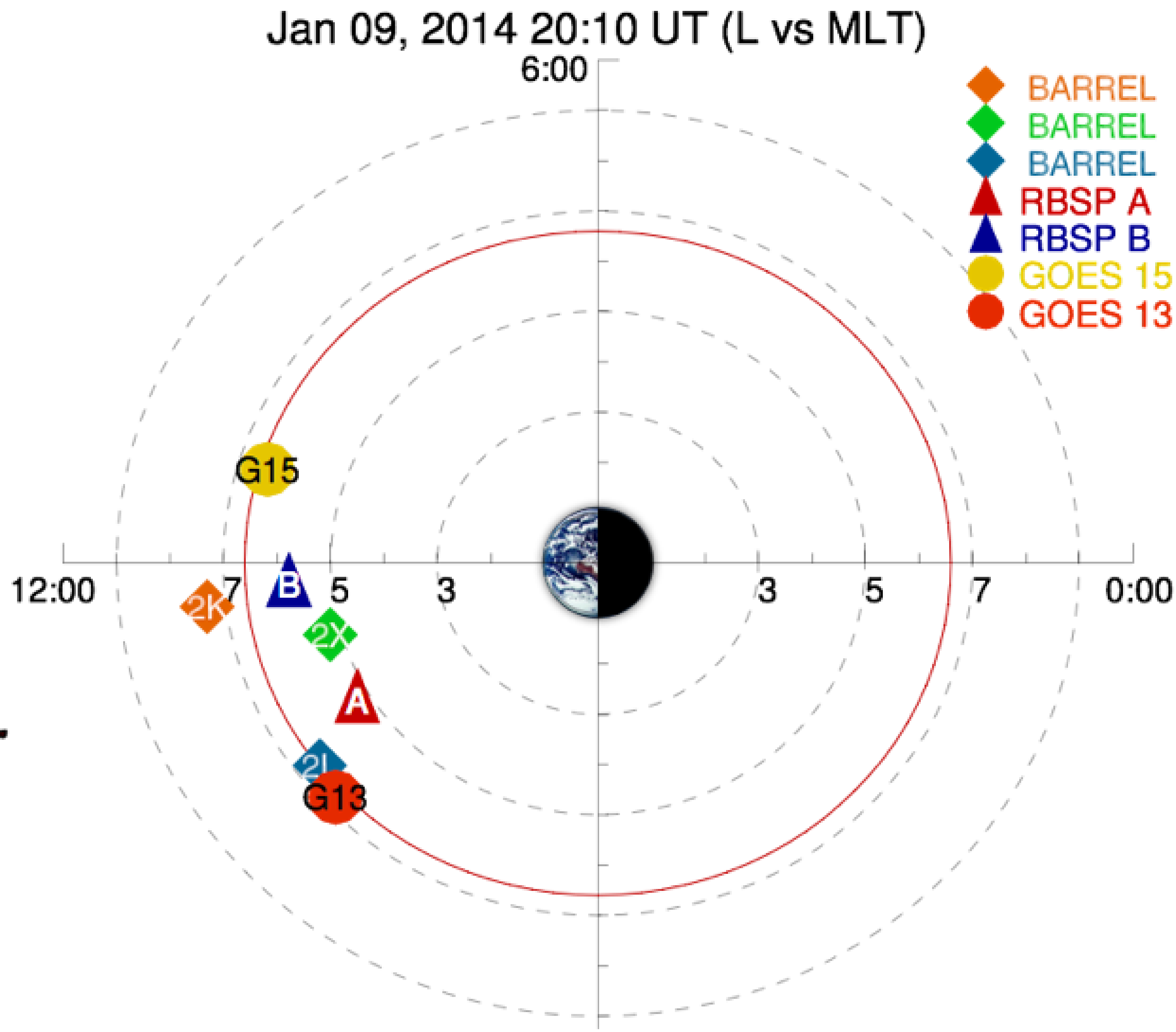

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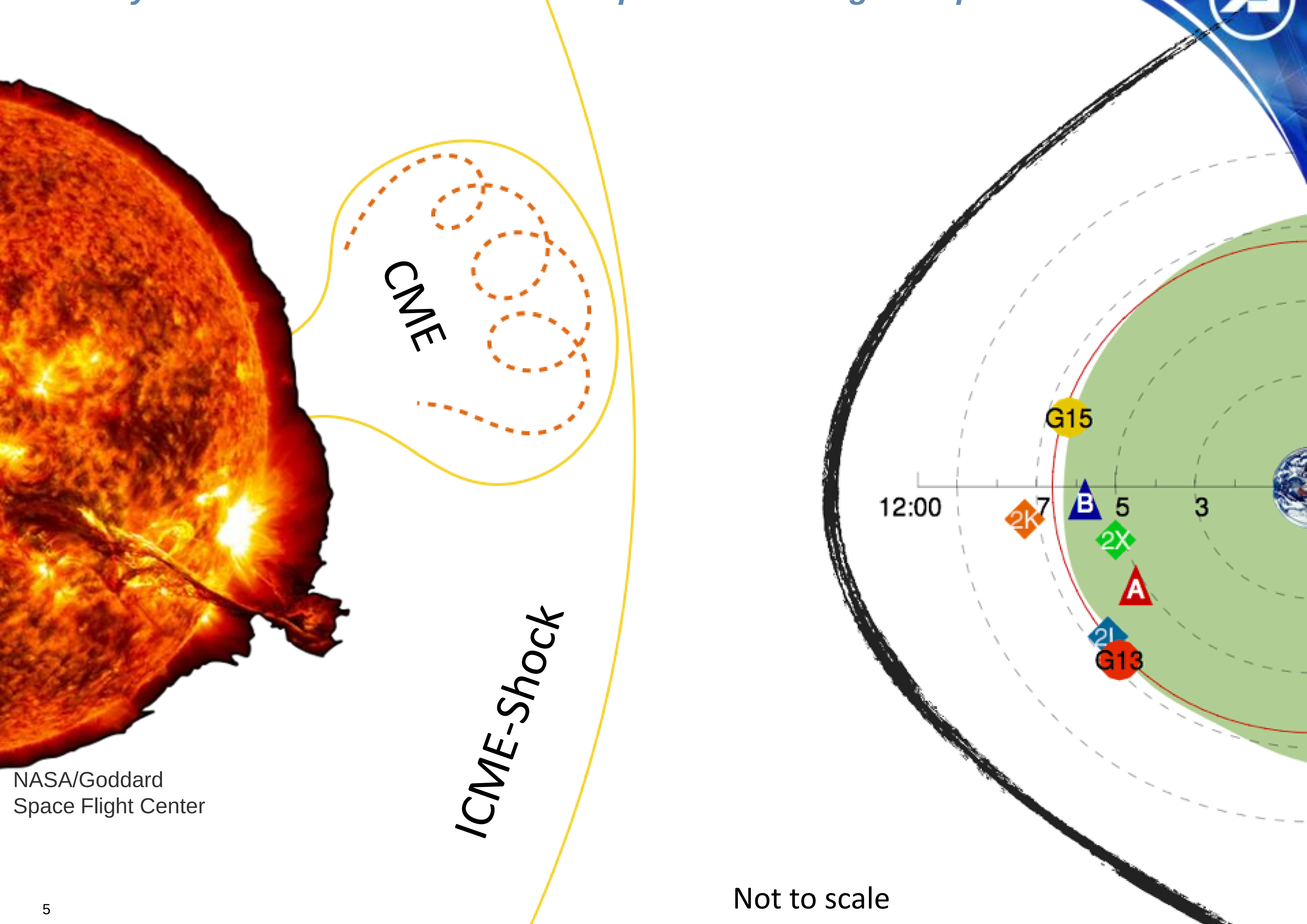
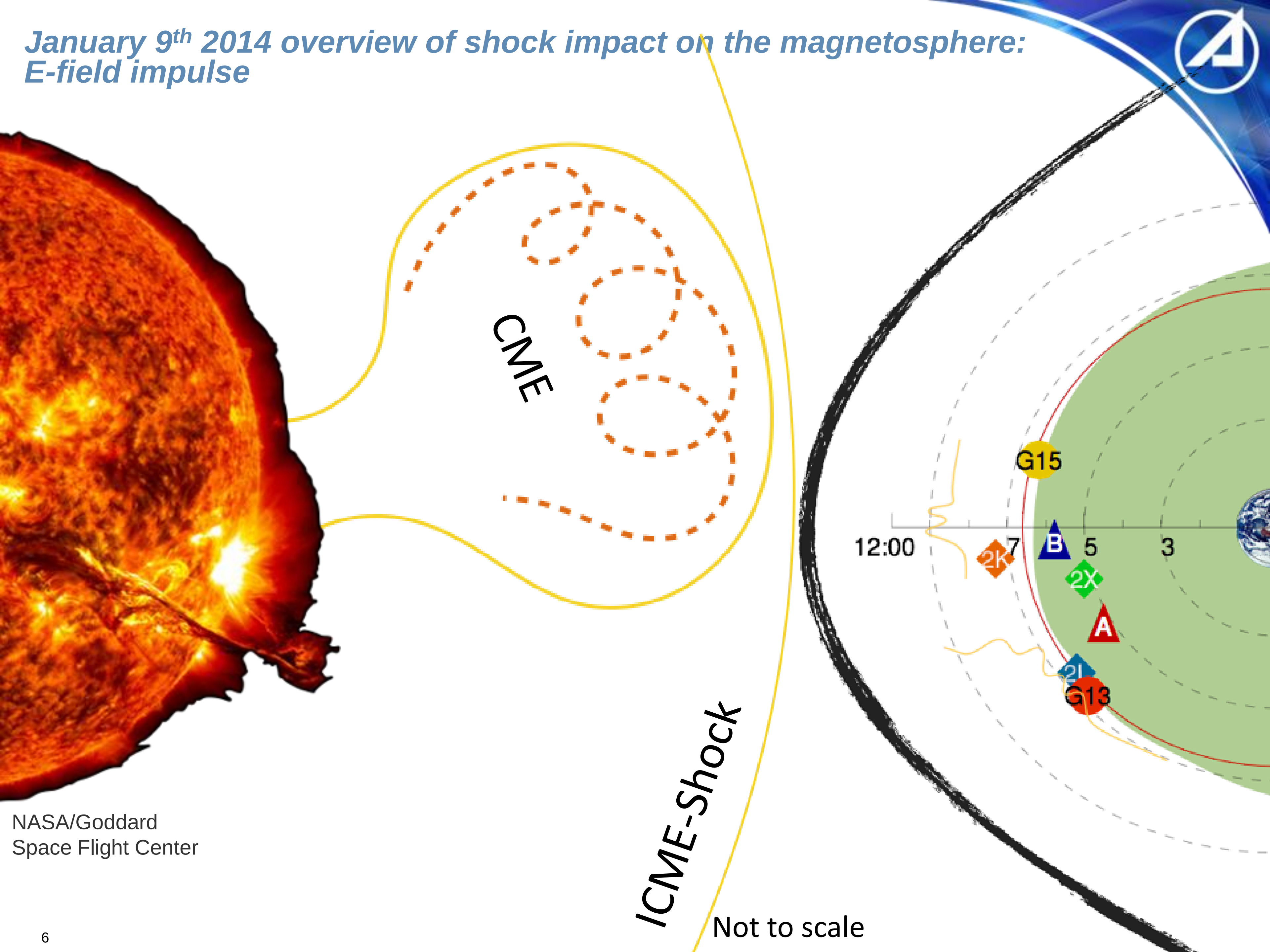
January 9th 2014 overview of shock impact on the magnetosphere:



January 9th 2014 overview of shock impact on the magnetosphere: E-field impulse



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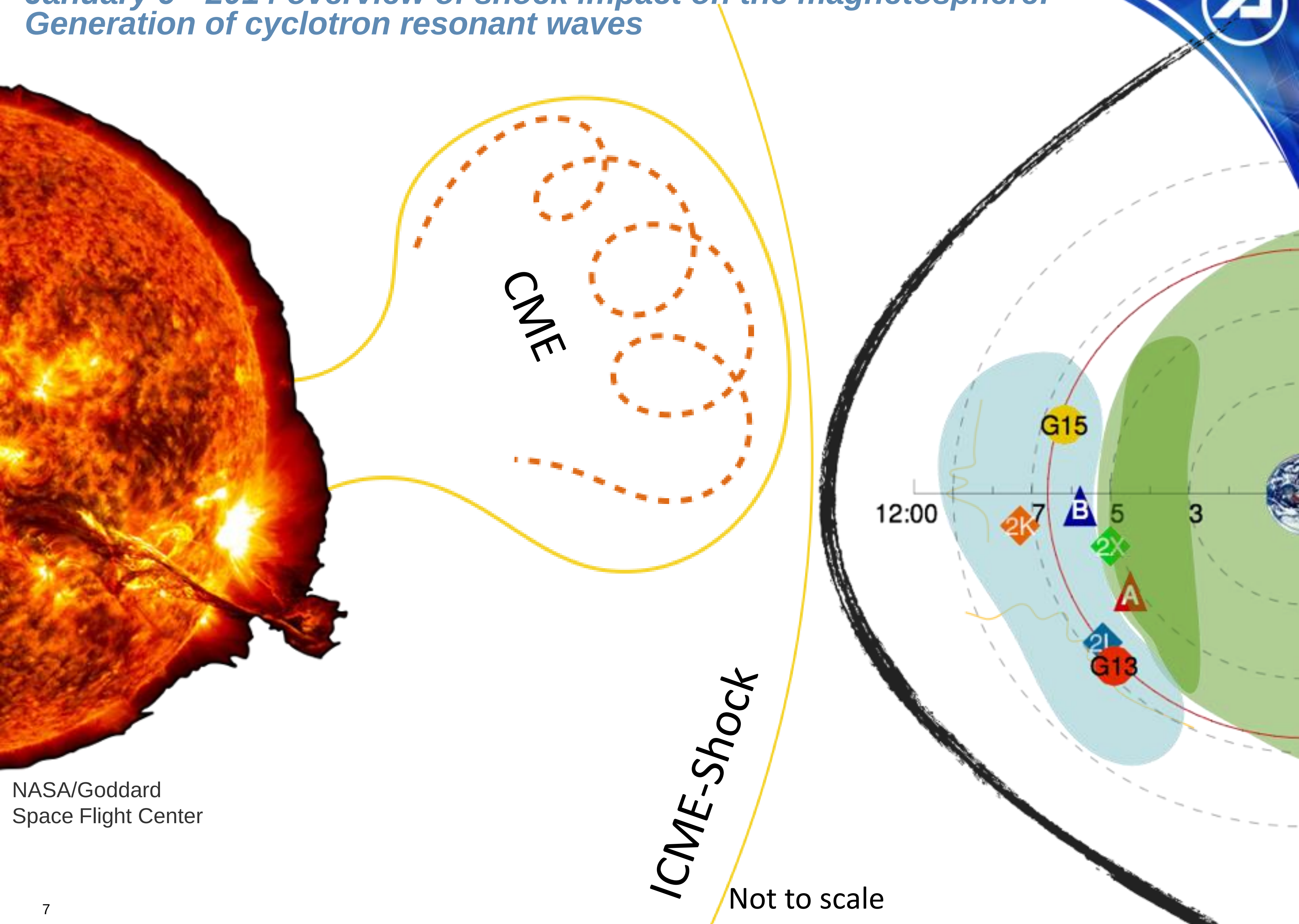
January 9th 2014 overview of shock impact on the magnetosphere: Generation of cyclotron resonant waves



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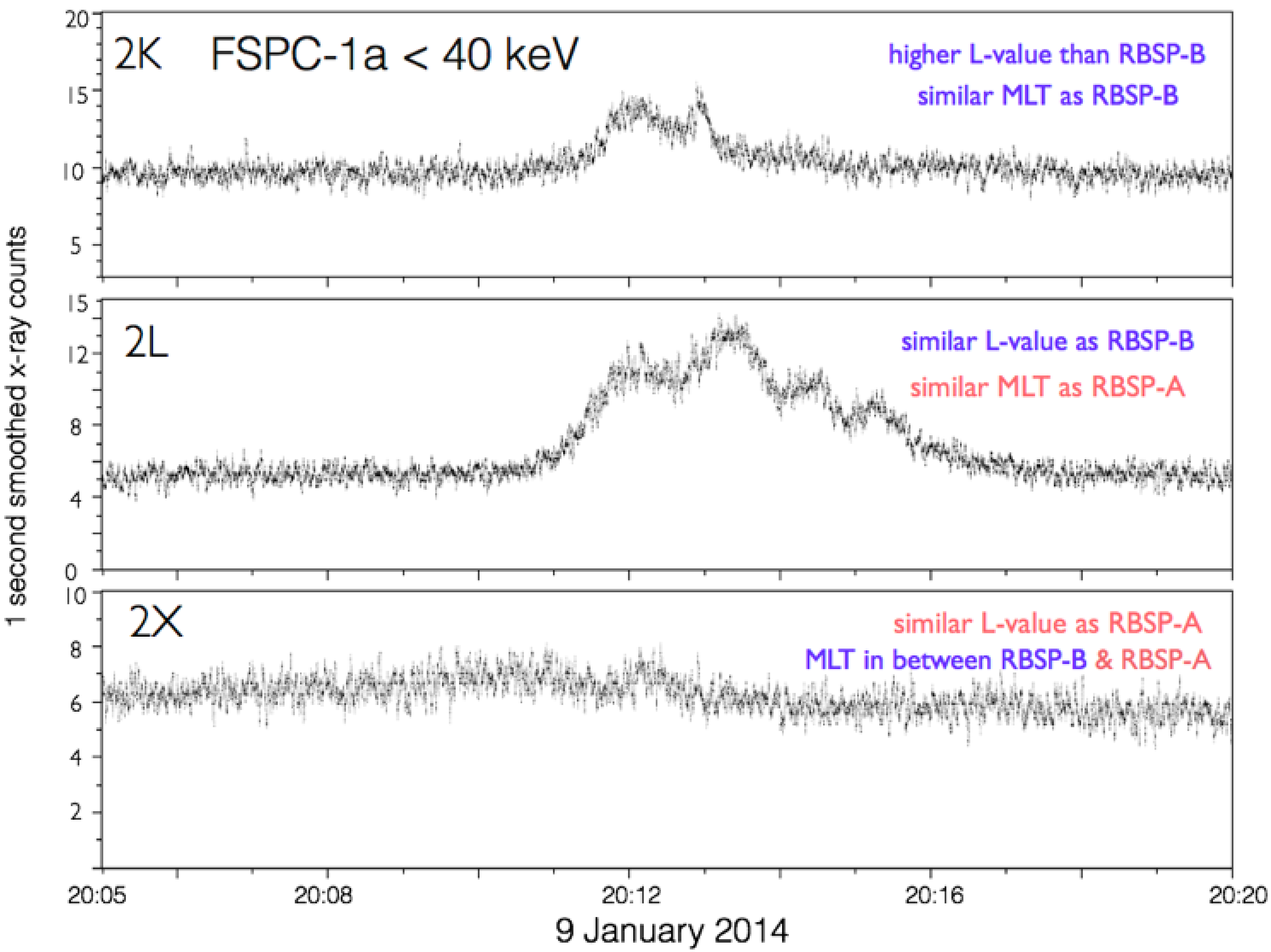
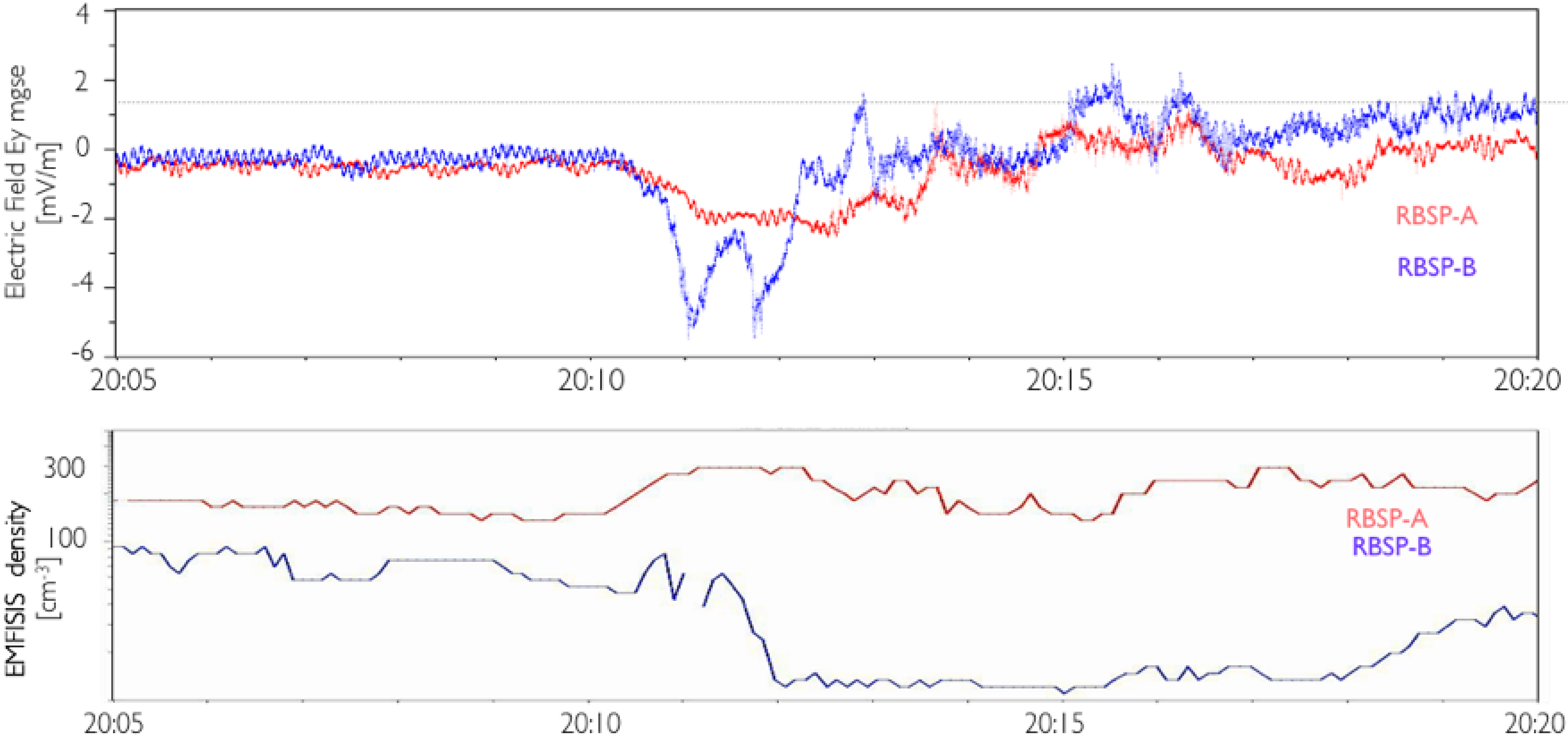
January 9th 2014 observations of inferred electron precipitation: BARREL observations



Halford, A. J., et al. (2015), BARREL observations of an ICME-shock impact with the magnetosphere and the resultant radiation belt electron loss. J. Geophys. Res. Space Physics, doi: 10.1002/2014JA020873.

January 9th 2014 observations of Electric field impulse: RBSP observations



Halford, A. J., et al. (2015), BARREL observations of an ICME-shock impact with the magnetosphere and the resultant radiation belt electron loss. J. Geophys. Res. Space Physics, doi: 10.1002/2014JA020873.

January 9th 2014 observations of Electric field impulse: Expected effect on the local particle population

Conservation of the first and second adiabatic invariants

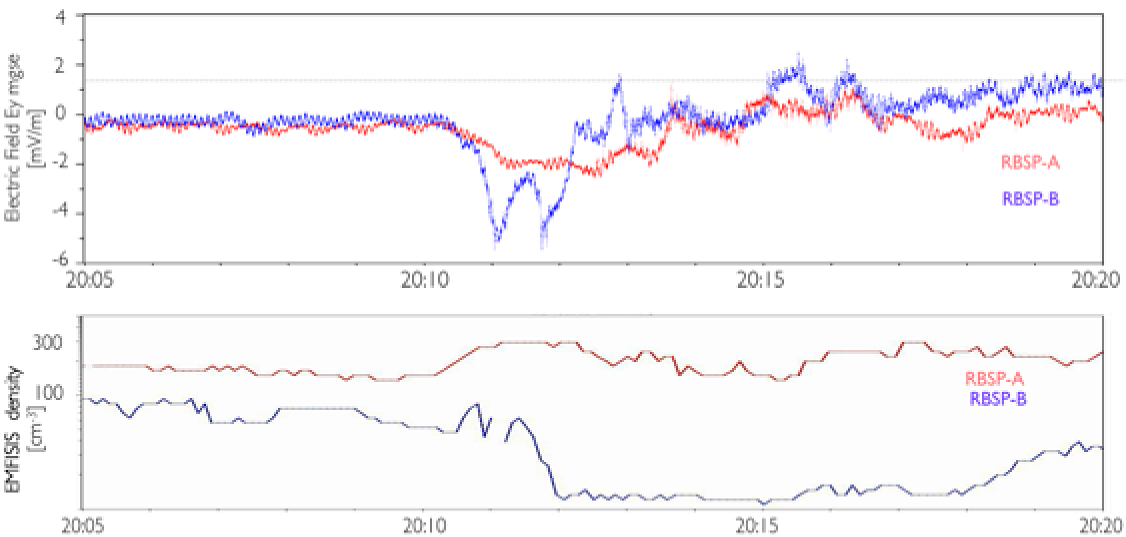
$$L_o = \left[\frac{R_E B_o L_f^2}{2E\delta t L_f^2 + R_E B_o}\right]^{1/2}$$

e.g. Wygant et al 1994

$$sin\alpha_{eq_f} = \left[\frac{-L_f^{1/2} cos^2\alpha_{eq_o}}{2L_o^{1/2} sin\alpha_{eq_o}}\right] + \frac{1}{2}\left[\frac{L_f cos^4\alpha_{eq_o}}{L_o sin^2\alpha_{eq_o}} + 4\right]^{1/2}$$

e.g. Shultz and Lanzerotti 1974

$$L_f = 5.8, L_o = 6.8 \Rightarrow \alpha_{eq_o} < \alpha_{eq_f}$$



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January 9th 2014 observations of Electric field impulse: Expected effect on the local particle population

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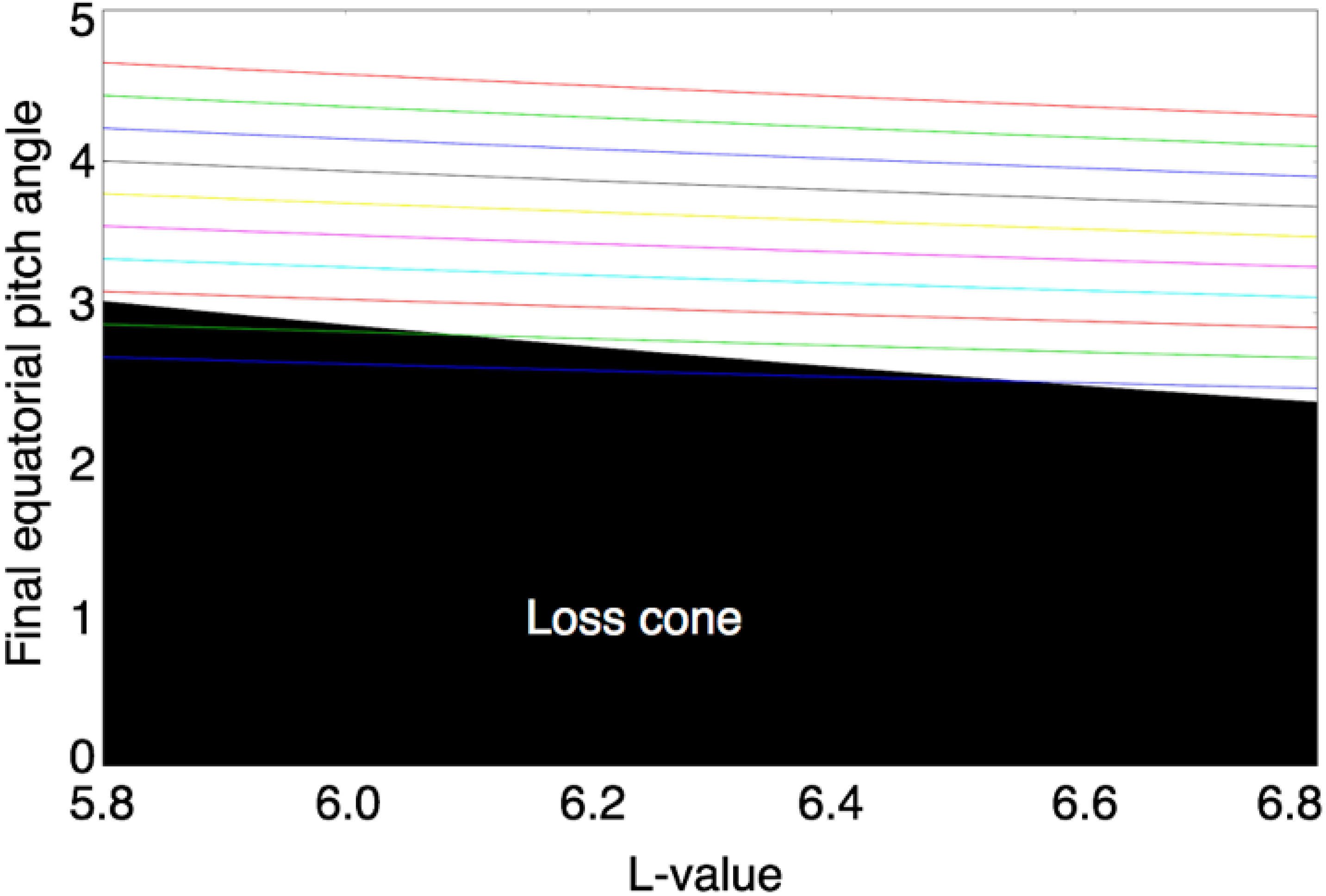

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January 9th 2014 observations of Electric field impulse: Expected effect on the local particle population

Conservation of the first and second adiabatic invariants

Change in pressure

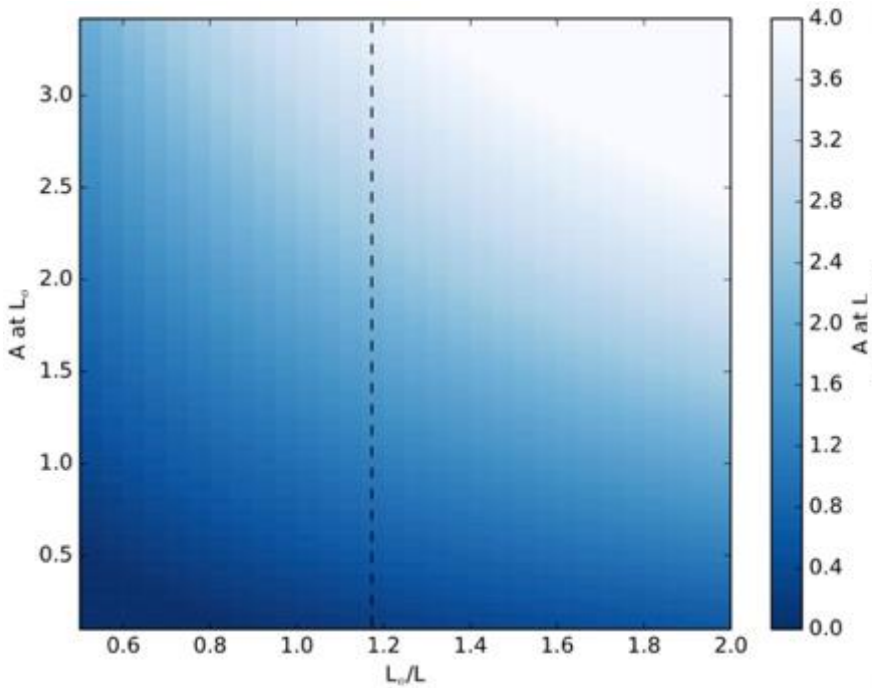
$$\frac{p_\perp}{p_{||}} \frac{p_{||o}}{p_{\perp o}} = \left(\frac{L_o}{L}\right)^{0.550}$$

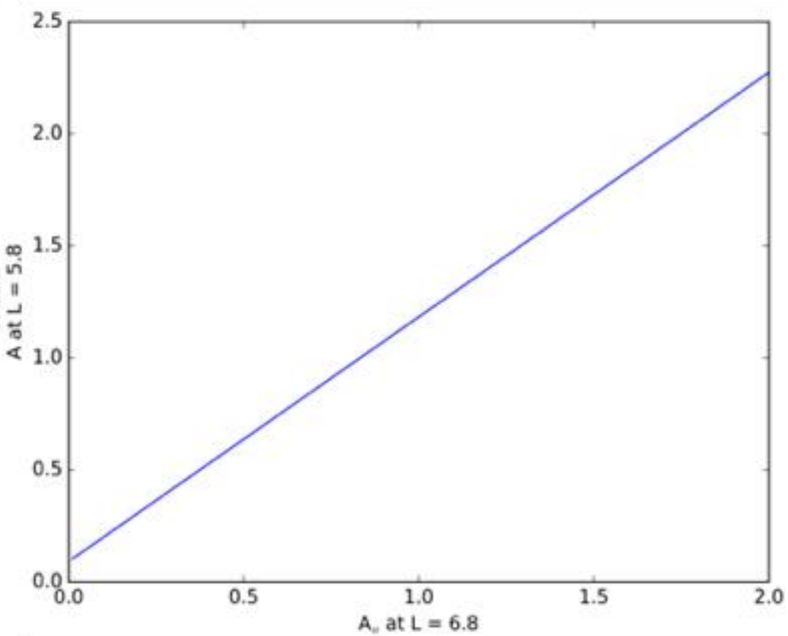
Temperature Anisotropy

$$A = T_\perp / T_{||} - 1$$

Change in A

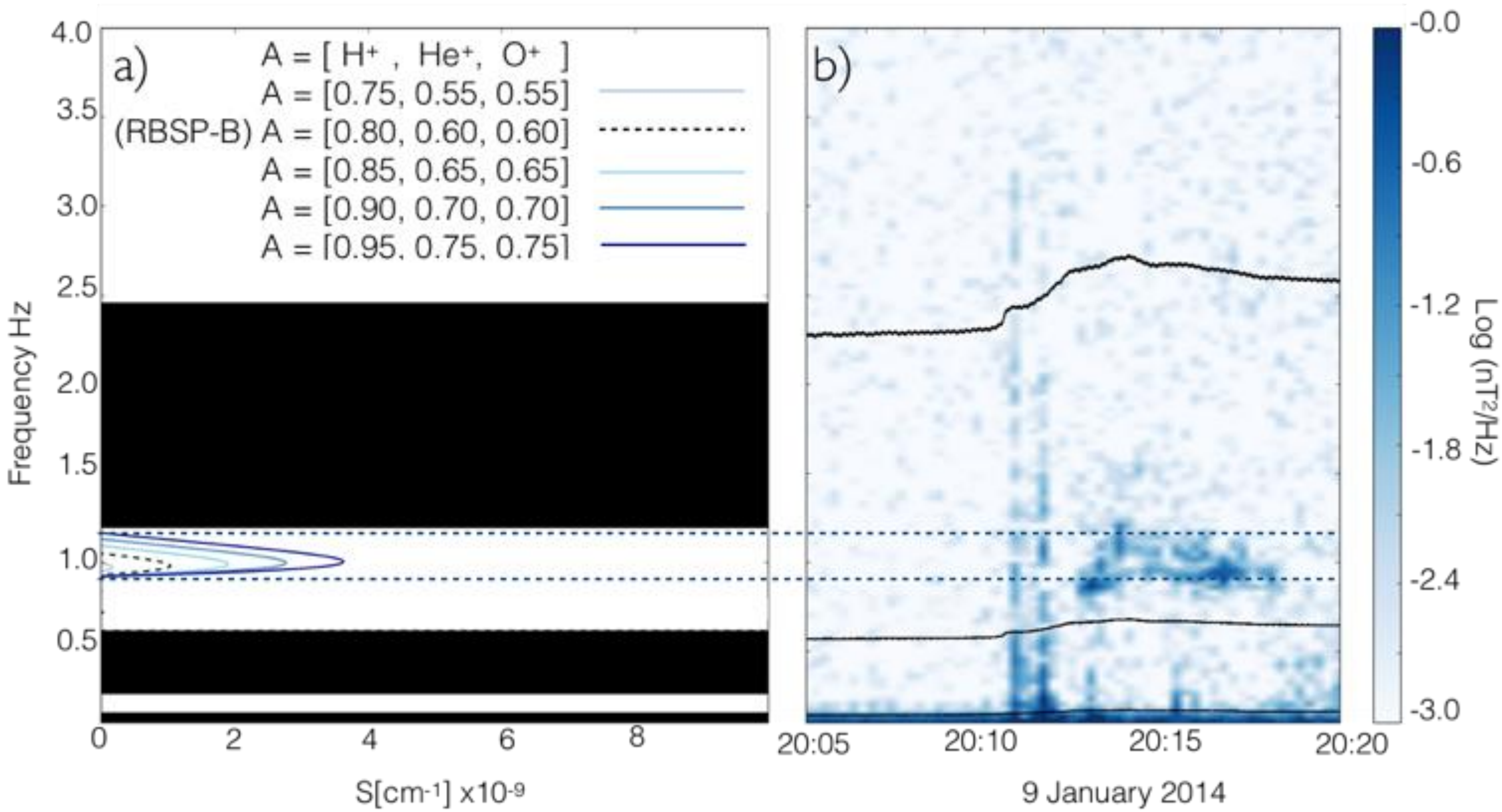
$$A = \left(\frac{L_o}{L}\right)^{0.550} \times (A_o + 1) - 1$$





Halford, A. J., et al. Submitted to JGR

January 9th 2014 observations of Electric field impulse: Expected generation of an EMIC wave



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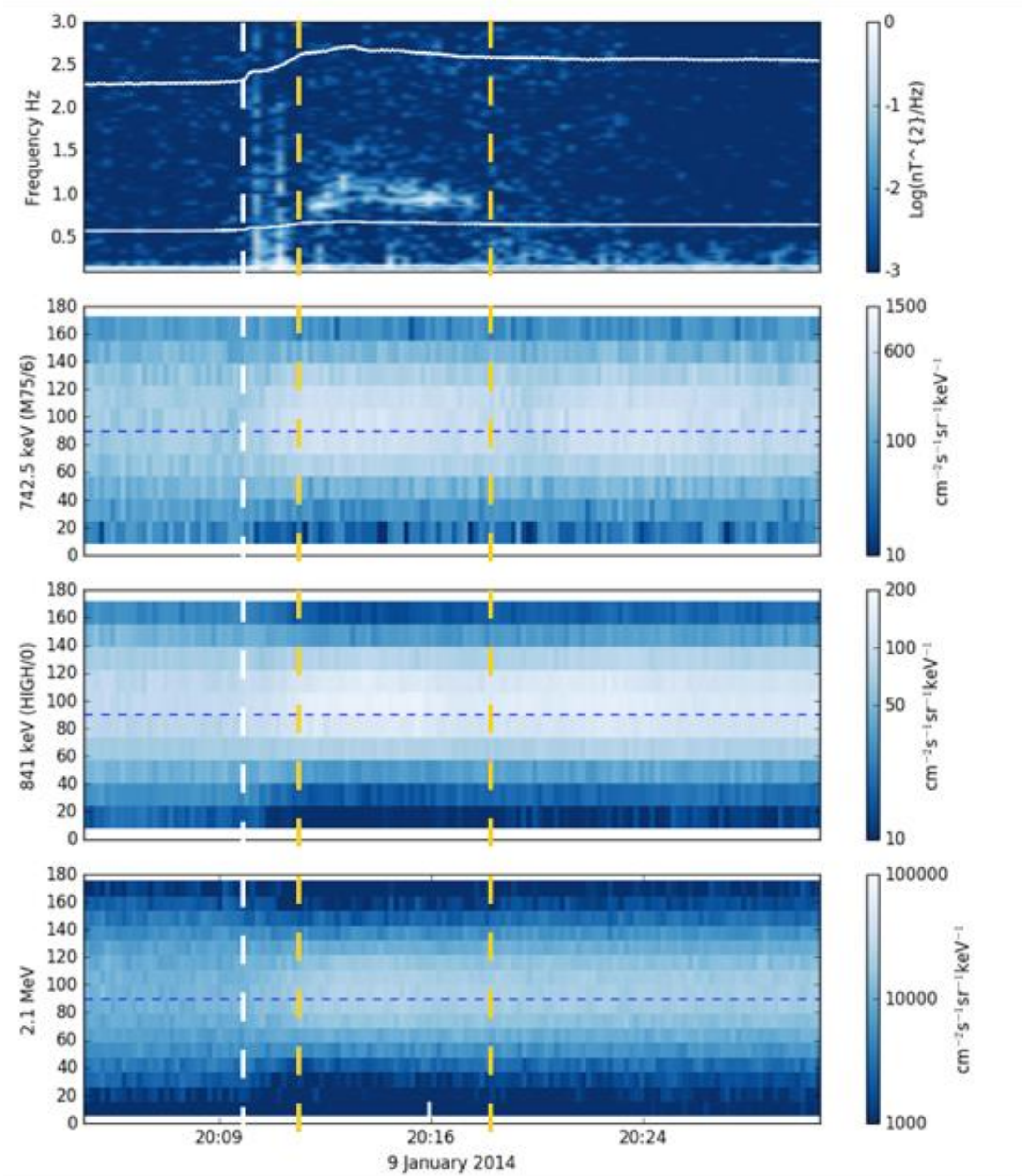
$$S = \frac{\mu}{V_g} = \frac{\Sigma_s \frac{\eta_{sw}\sqrt{\pi}}{M_s^2 \alpha_{||,s}}\left[(A_s+1)(1-M_sX)-1\right] \times exp\left[\frac{\frac{-\eta_{s,w}}{M_s}\frac{(M_sX-1)^2}{\beta_{sw}X^2}}{\frac{(1+\delta)}{(1-X)}+\Sigma_j\frac{(\eta_{jw}+\eta_{jc})M_j}{1-M_jX}}\right]}{2X^2\left[\frac{1+\delta}{1-X}+\Sigma_j\left(\eta_{jw}+\eta_{jc}\frac{M_j}{1-M_jX}\right)\right]}$$

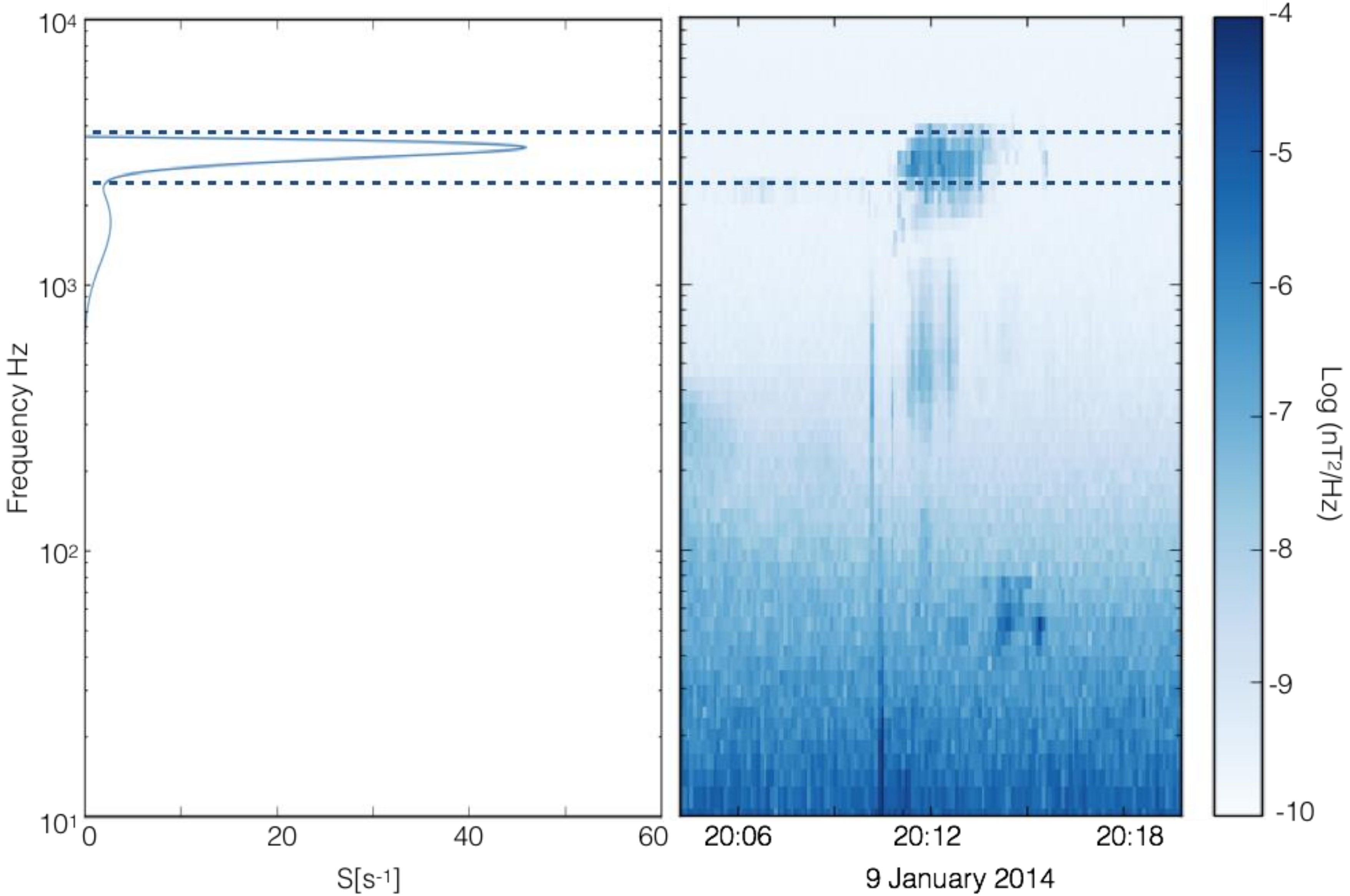
e.g. Halford 2012, Fraser et al 1989. Gomberoff and Neira 1983, and Kozyra et al 1984

January 9th 2014 observations of EMIC wave: Expected effect on the local particle population



Halford, A. J., et al. in prep

January 9th 2014 observations of Electric field impulse: Expected generation of an Chorus wave



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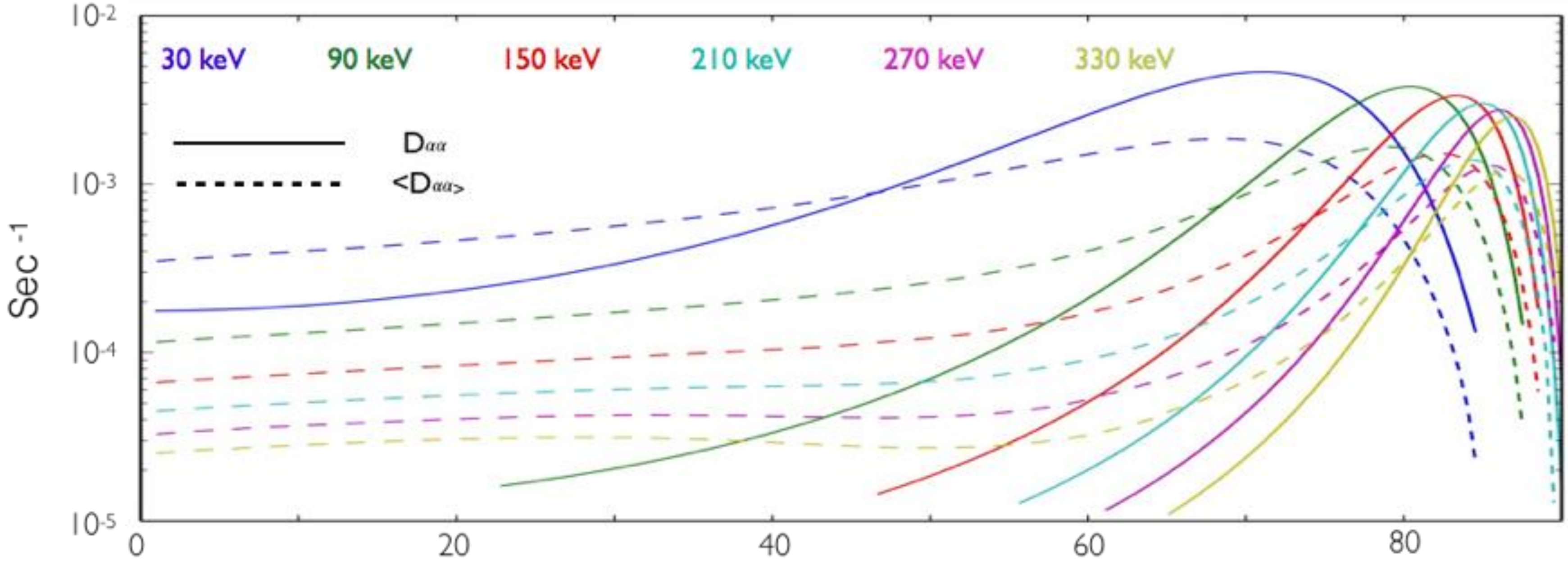
January 9th 2014 observations of Chorus wave: Expected effect on the local particle population

$$D_{\alpha,\alpha} = \frac{\pi\Omega_\sigma^2}{2v|\Omega_e|}\frac{1}{(E+1)^2}\sum_s\sum_j \frac{R\left(1-\frac{x\cos\alpha}{y\beta}\right)^2|F(x,y)|}{\delta x|(\beta\cos\alpha - F(x,y))|}e^{-\left(\frac{x-x_m}{\delta x}\right)^2}$$

Summers et al 2005, 2007



pitch angle

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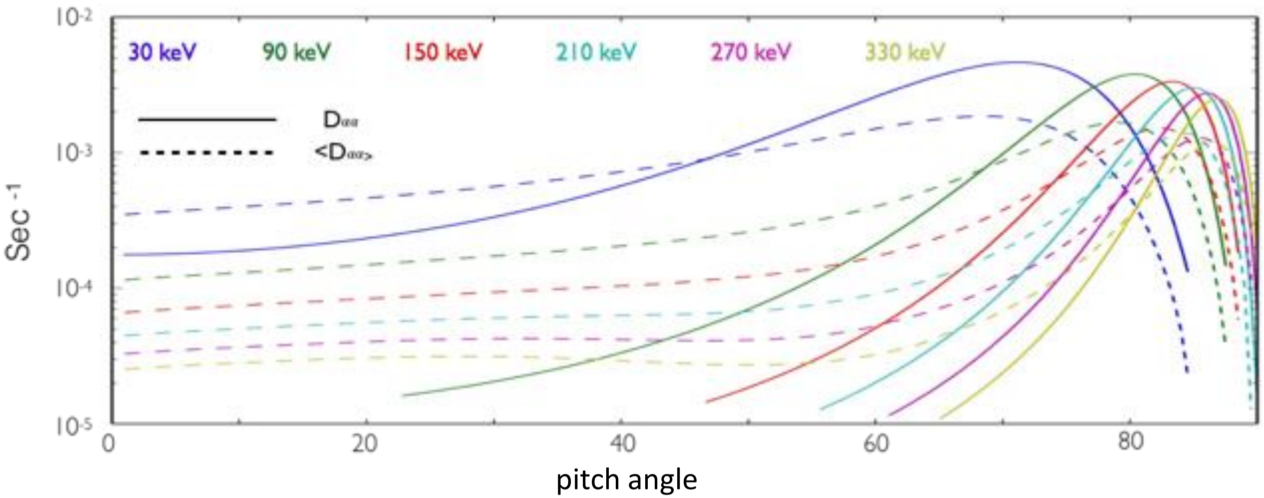
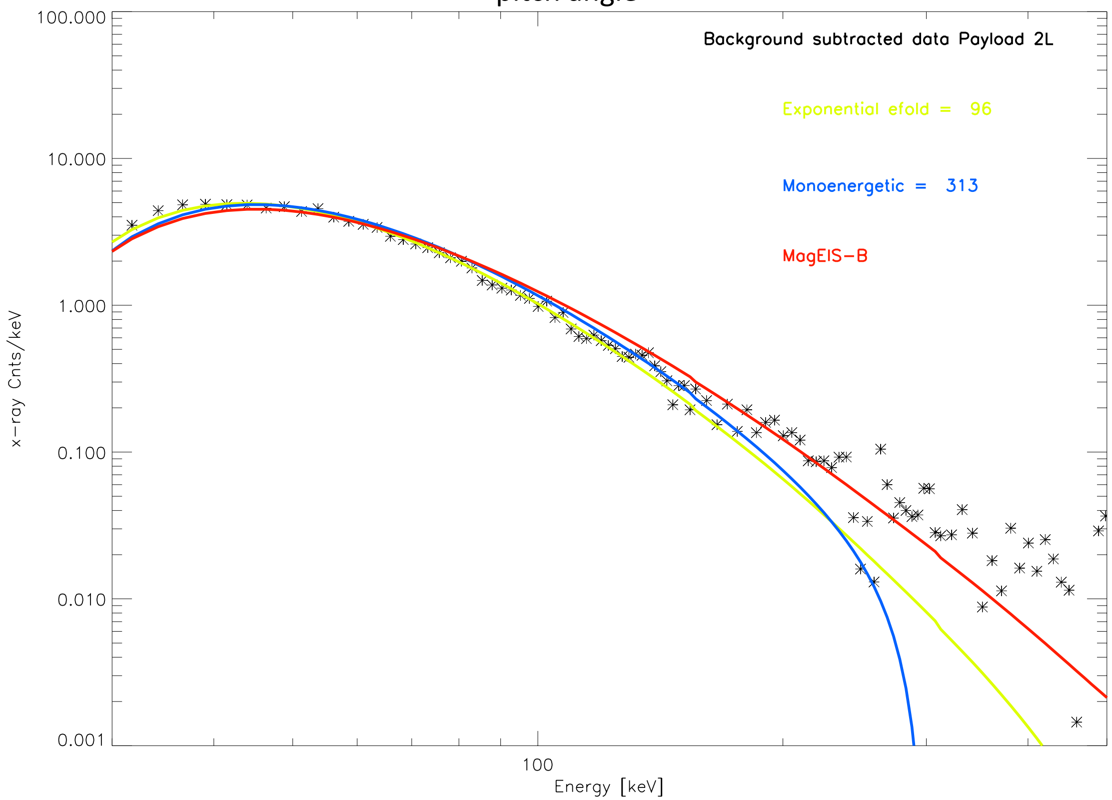
January 9th 2014 observations of Chorus wave: Expected effect on the local particle population





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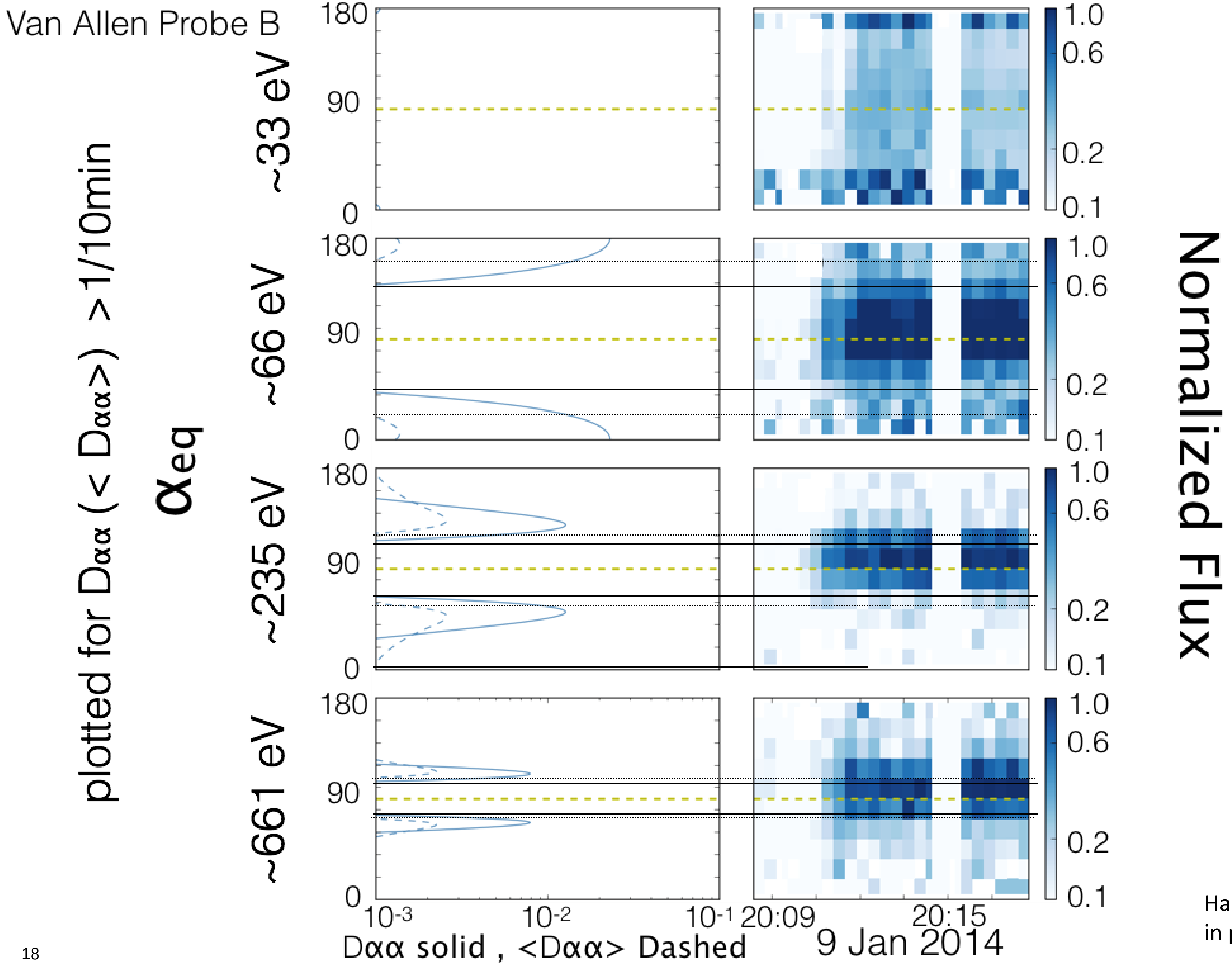
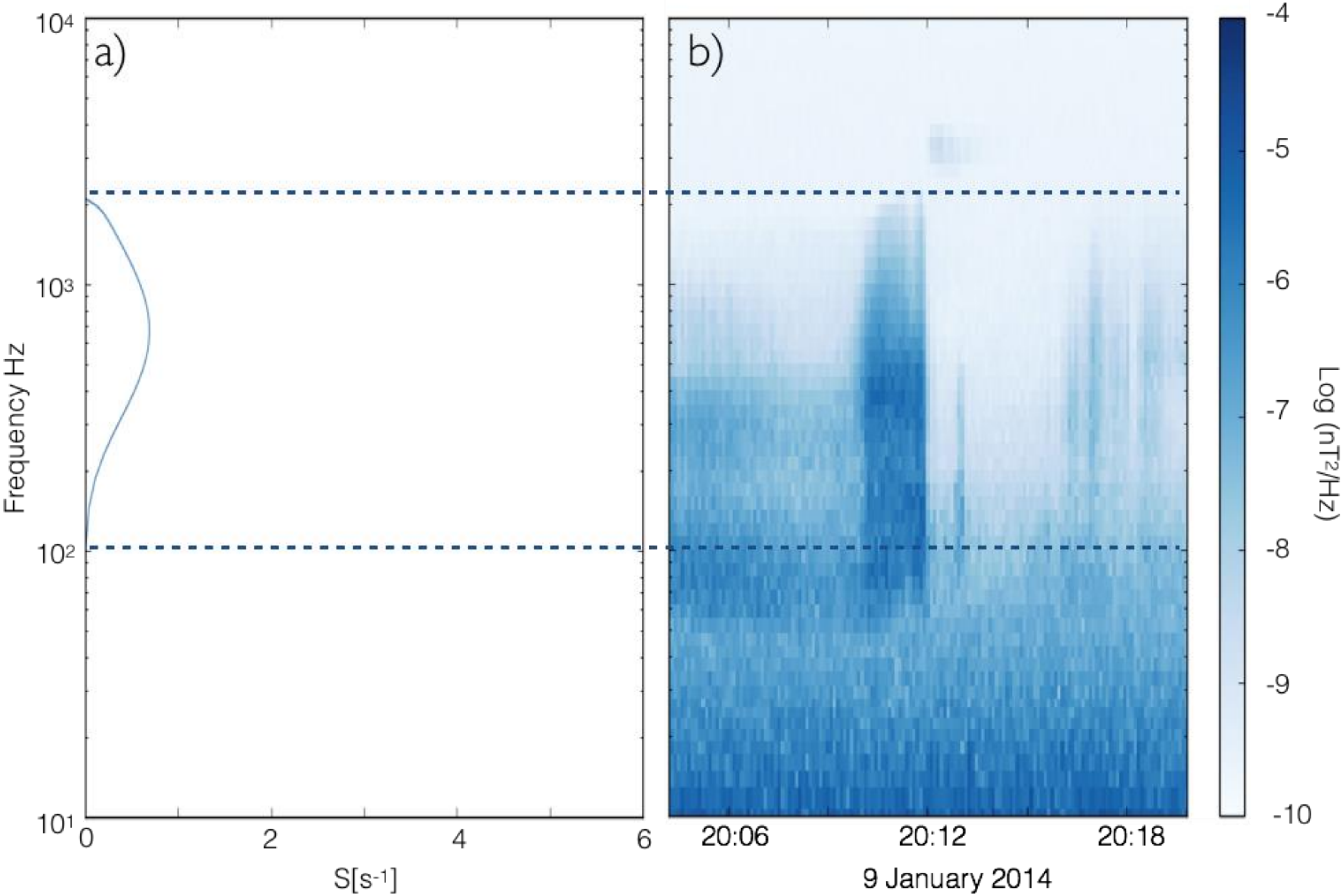
January 9th 2014 observations of Chorus wave: Expected effect on the local particle population



Halford, A. J., et al. in prep

January 9th 2014 observations of Electric field impulse: Expected generation of a Hiss wave



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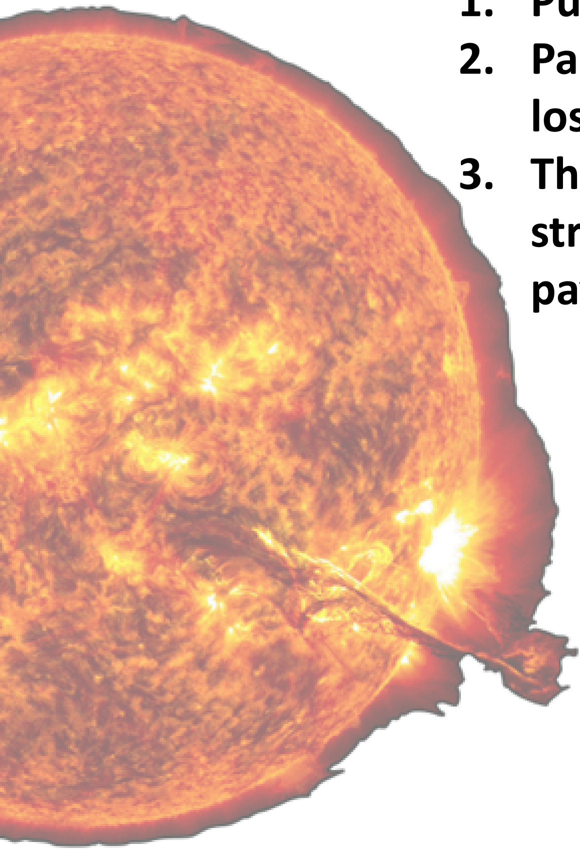
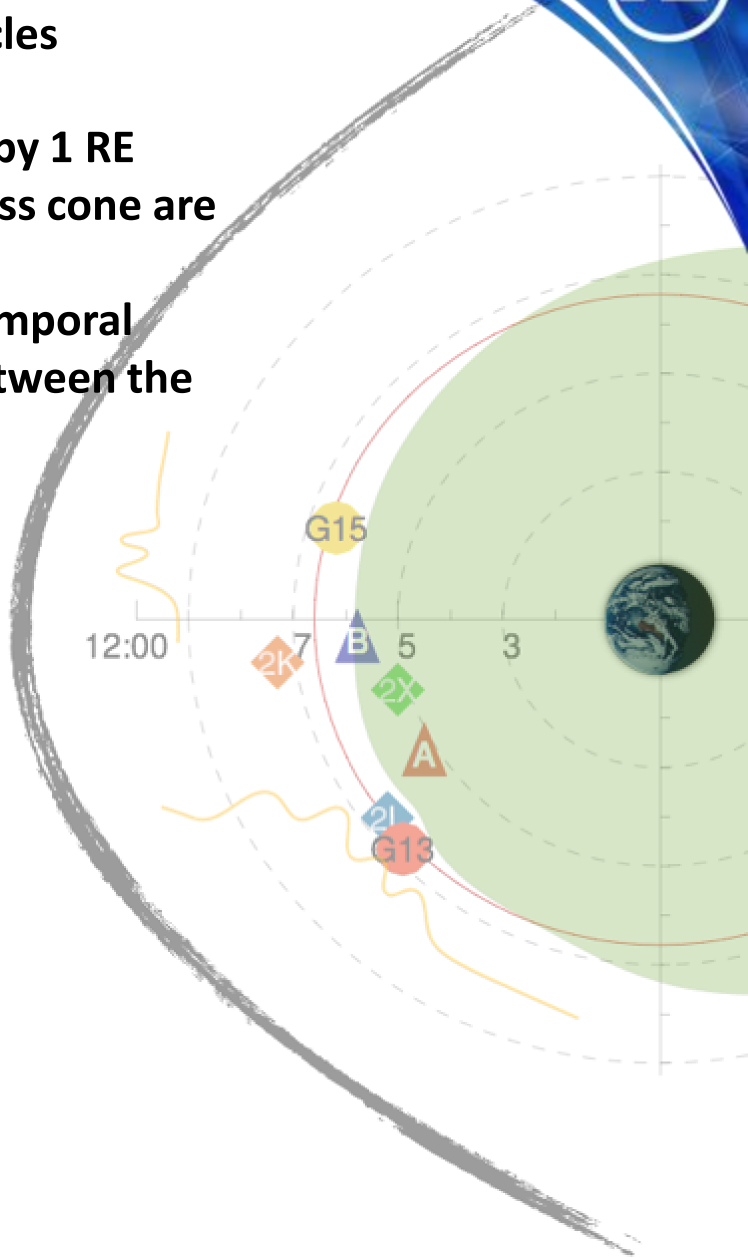
Conclusions



The Solar Wind Shock Impact: Particles

1. **Pushed the particles earthward by 1 RE**
2. **Particles within 0.5 deg of the loss cone are lost to the atmosphere**
3. **This may be the cause for the temporal structure and MLT difference between the payloads**



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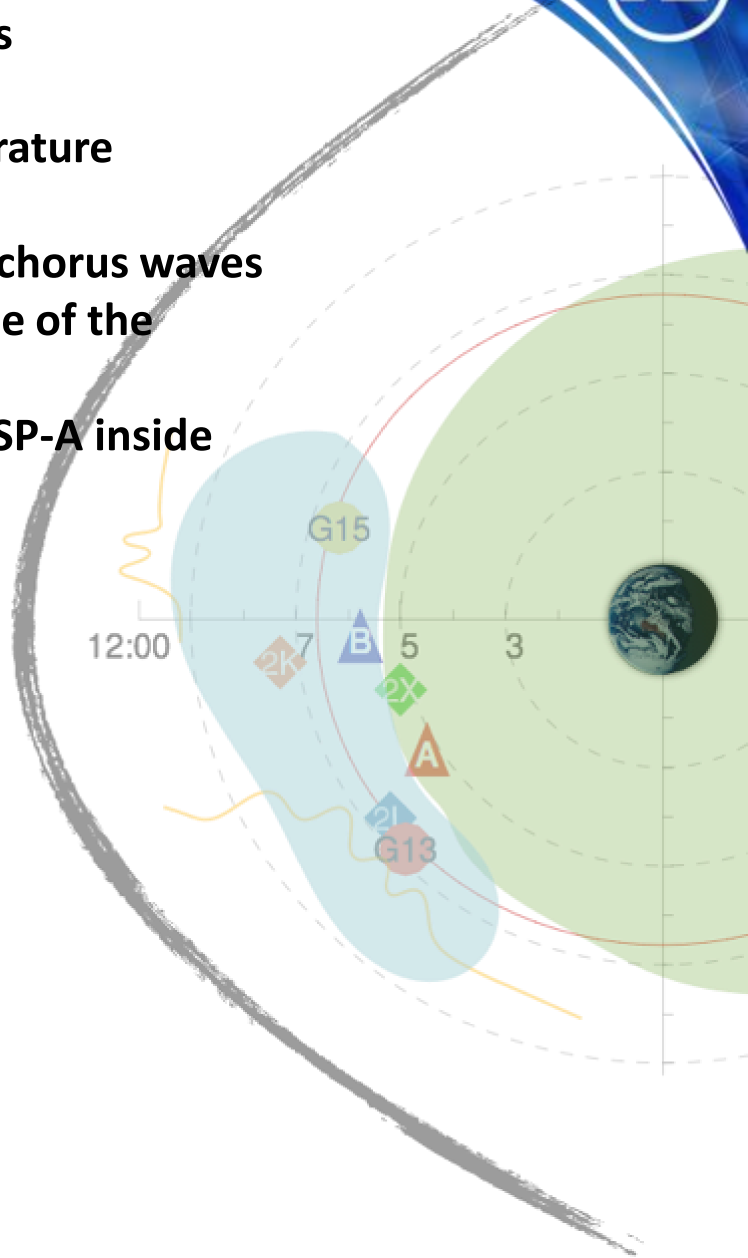
Conclusions

The Solar Wind Shock Impact: waves

1. Generated an increase in temperature anisotropy
2. Resulted in growth of EMIC and chorus waves simultaneously at RBSP-B outside of the plasmasphere
3. Resulted in growth of Hiss at RBSP-A inside the plasmasphere.



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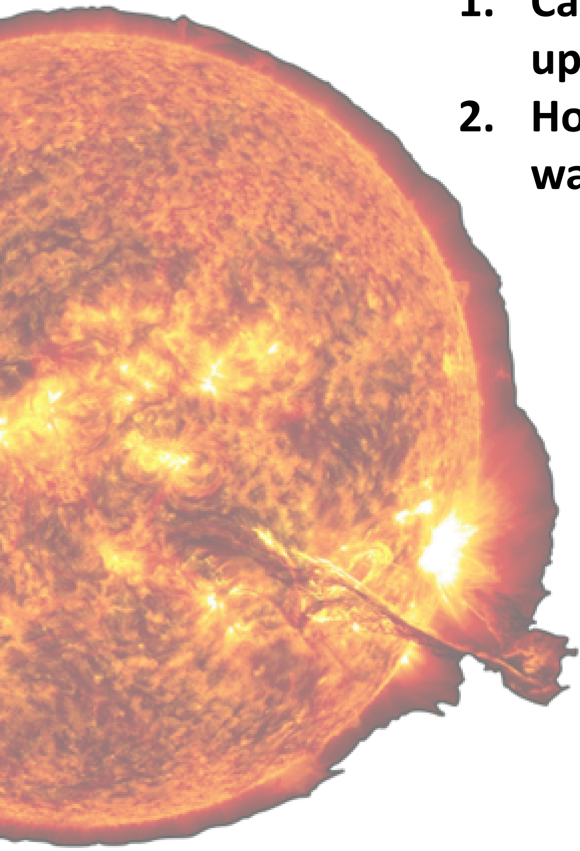
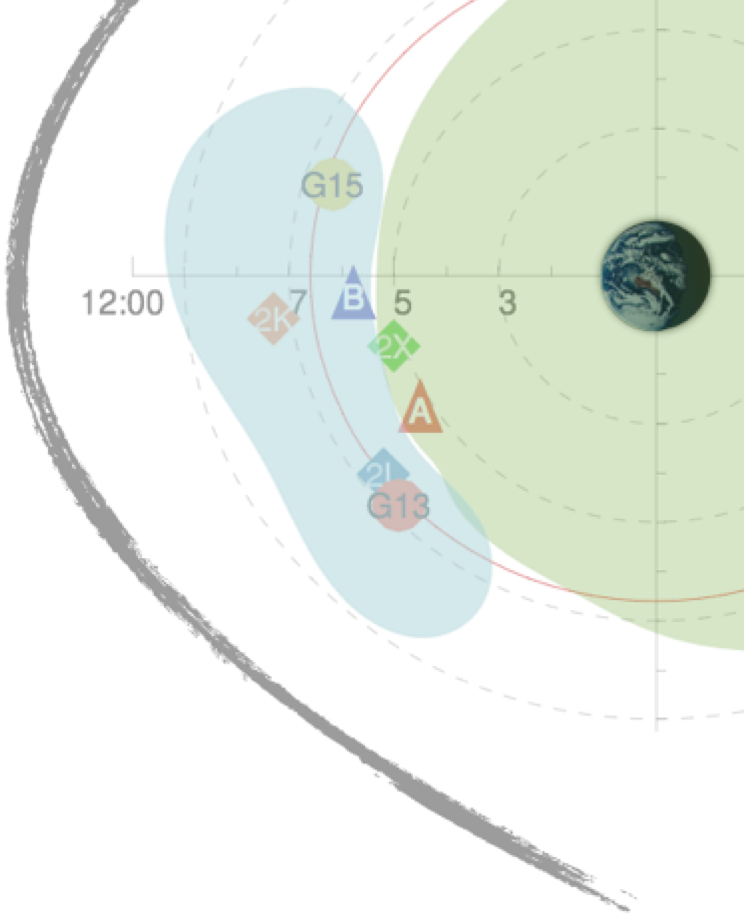
Conclusions

The EMIC wave Impact: Particles

1. **Caused the loss of MeV electrons into the upper atmosphere**
2. **However, very little loss at these energies was observed as inferred by the balloons**





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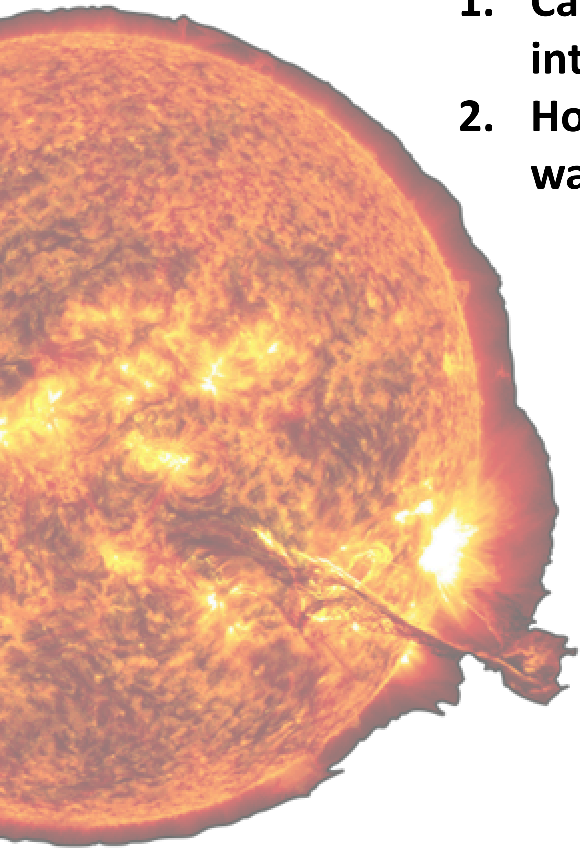
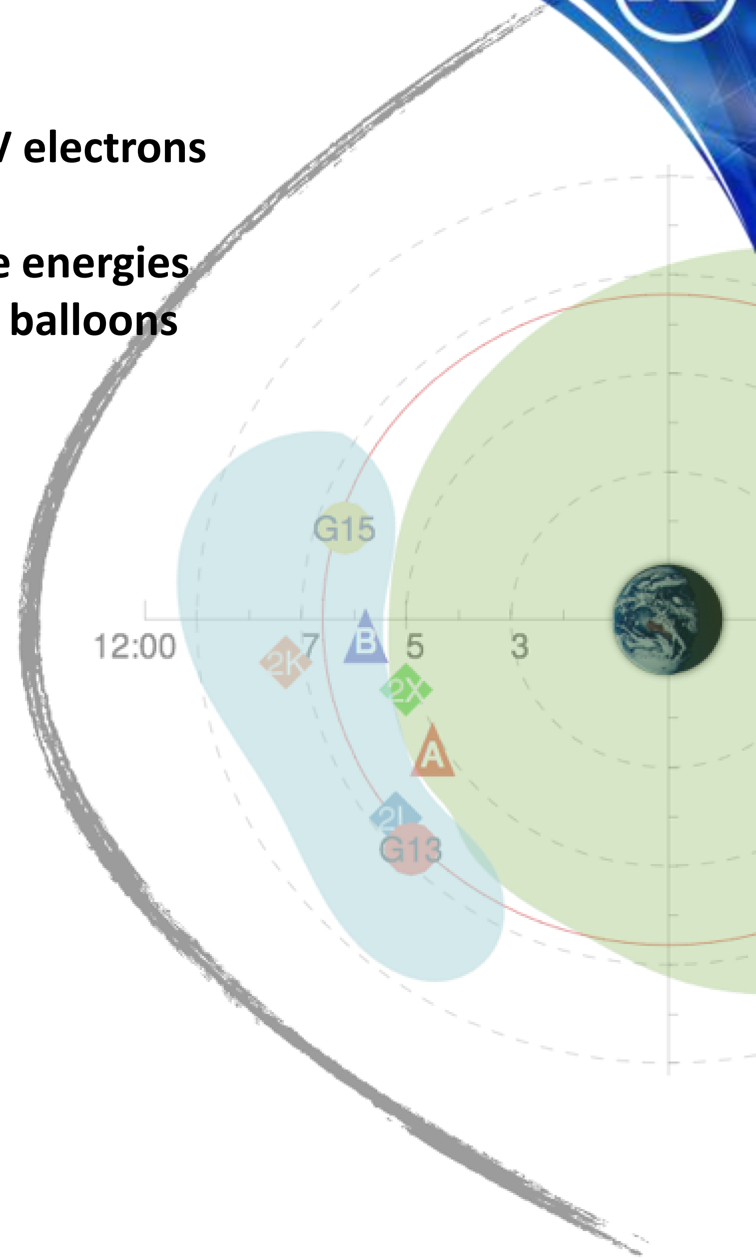
Conclusions

The Chorus wave Impact: Particles

1. Caused the loss of eV – 100s keV electrons into the upper atmosphere.
2. However, very little loss at these energies was observed as inferred by the balloons





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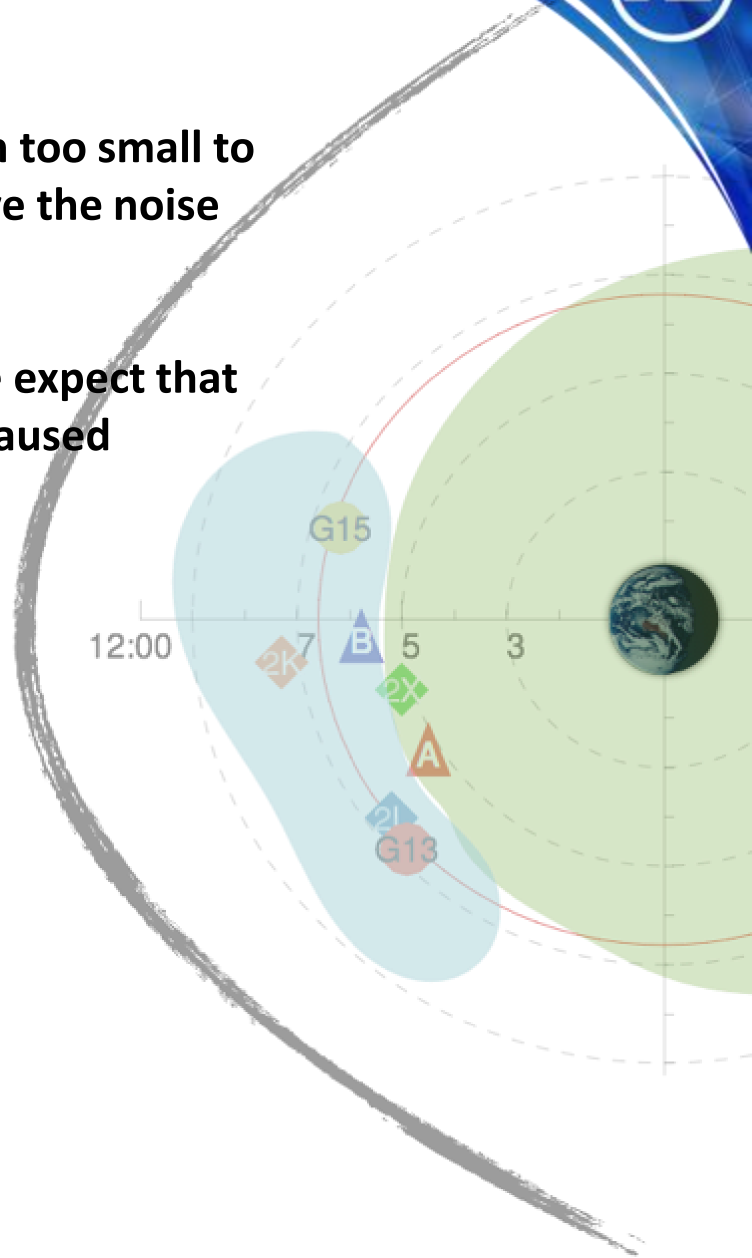
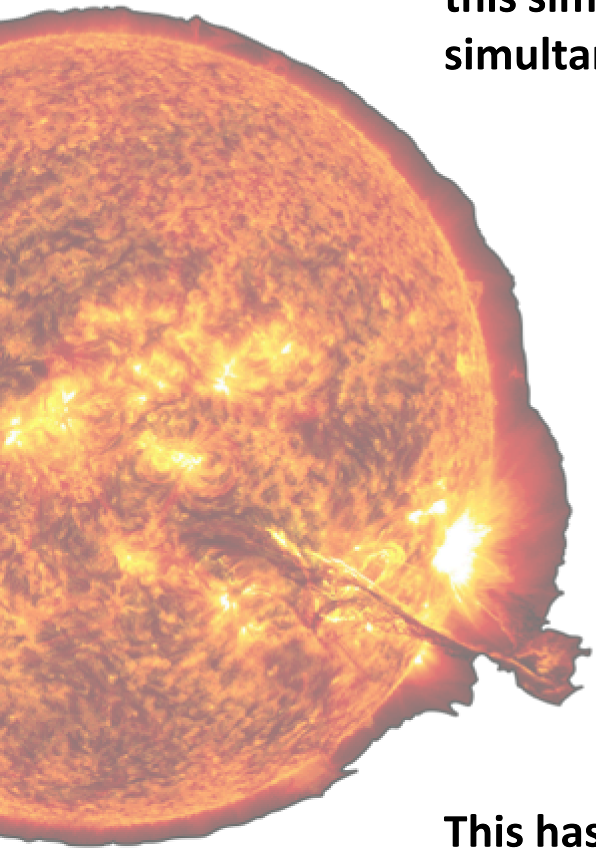
Conclusions

The Hiss wave Impact: Particles

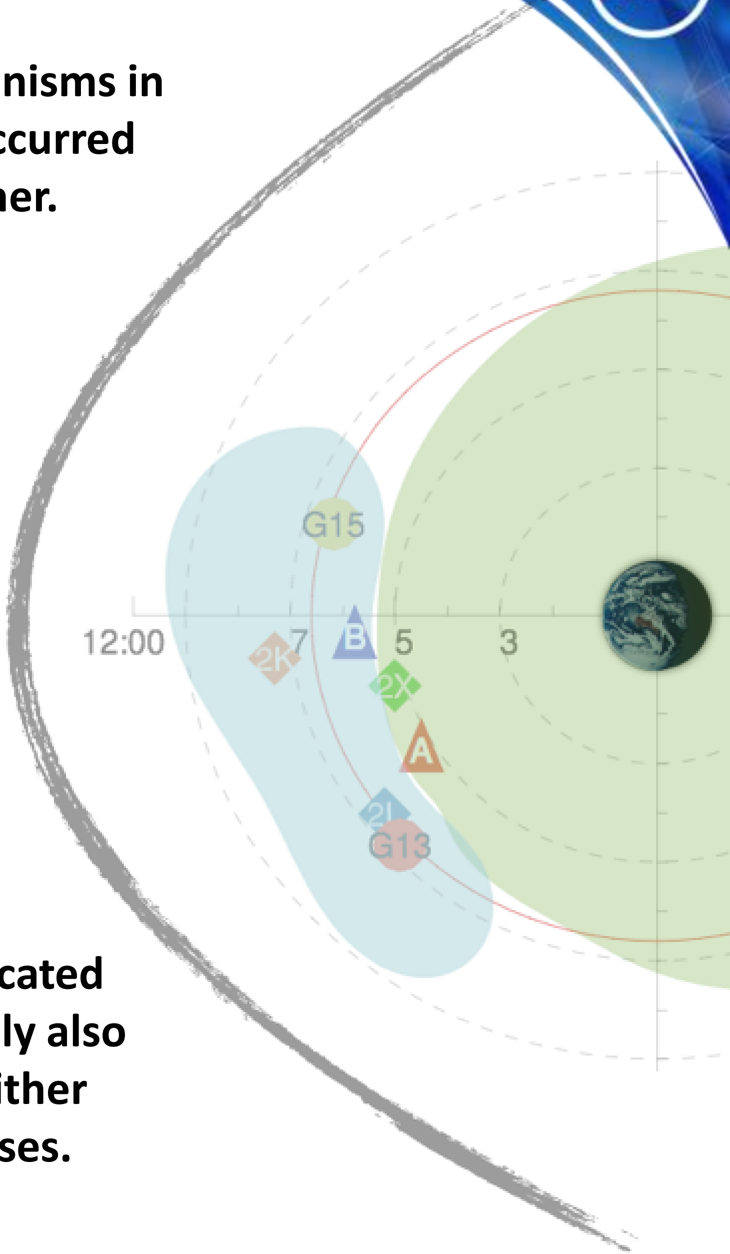
1. Time scales appear to have been too small to be able to infer significant (above the noise floor) precipitation inside of the plasmasphere.
2. If the event had been longer, we expect that the hiss wave would have also caused observed electron precipitation.



Conclusions



Thus we see how multiple loss mechanisms in this simply complicated event have occurred simultaneously, and affected each other.



This has implications for more complicated events where other processes are likely also active and may further interact and either help or impede additional loss processes.