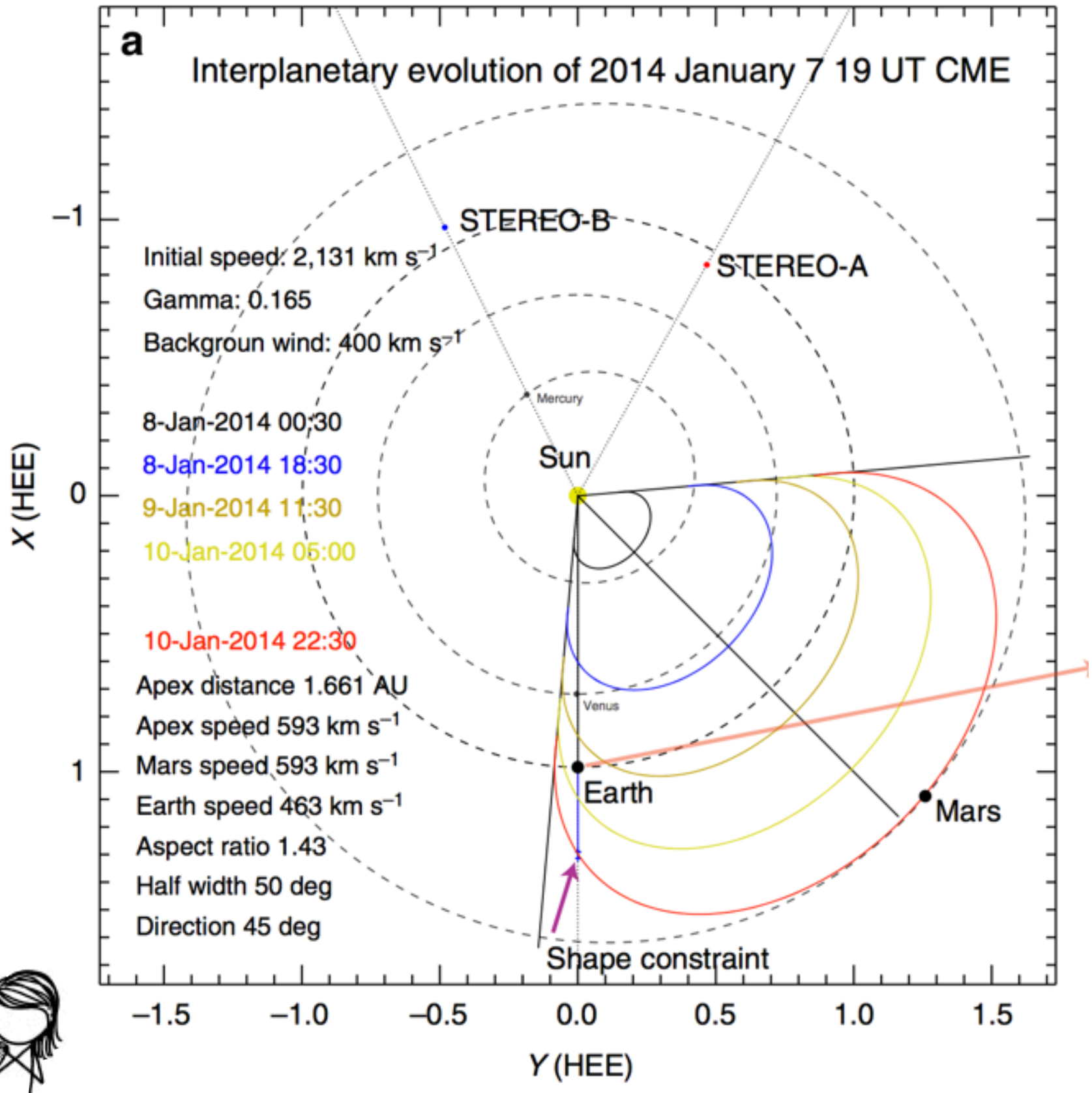
SM31B-2485

GENERATION OF COINCIDENT EMIC AND WHISTLER MODE WAVES BY AN ICME-SHOCK

A.J. HALFORD GSFC/DARTMOUTH COLLEGE , I.R. MANN UNIVERSITY OF ALBERTA EDMONTON, DREW TURNER AEROSPACE CORP. *

*SPECIAL THANKS TO RANDALL MUNROE AND THE XKCD FONT/COMIC STRIP AND XKCD.COM

ON JAN 7TH 2014 A LARGE CME LAUNCHED FROM THE SUN TOWARDS MARS... AND EARTH WAS IN THE VERY EDGE OF THE PATH RECEIVING A GLANCING BLOW ON JAN 9TH.



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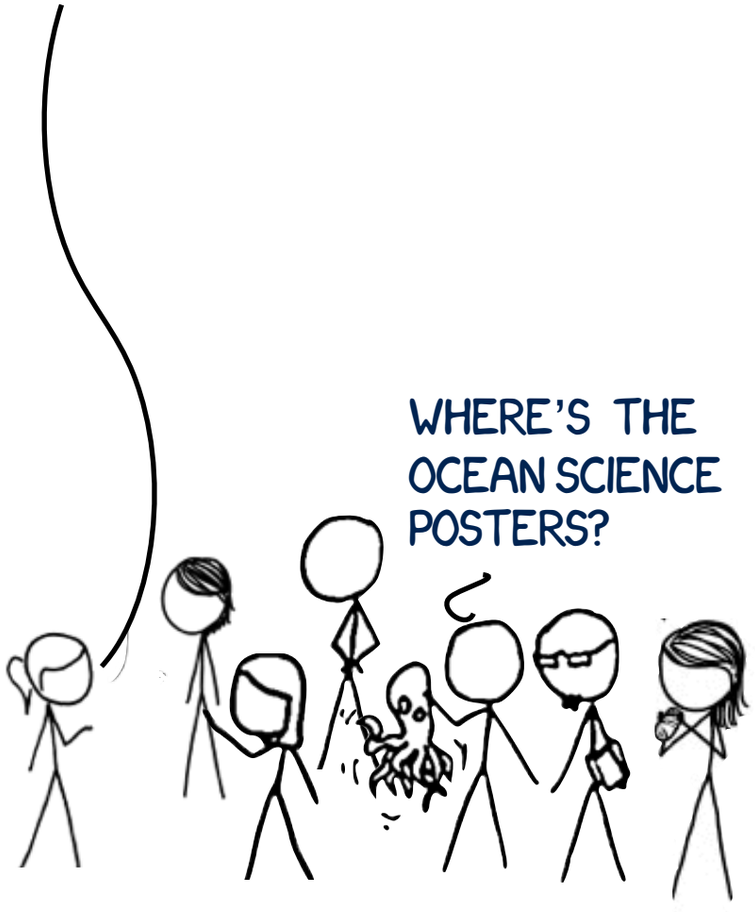
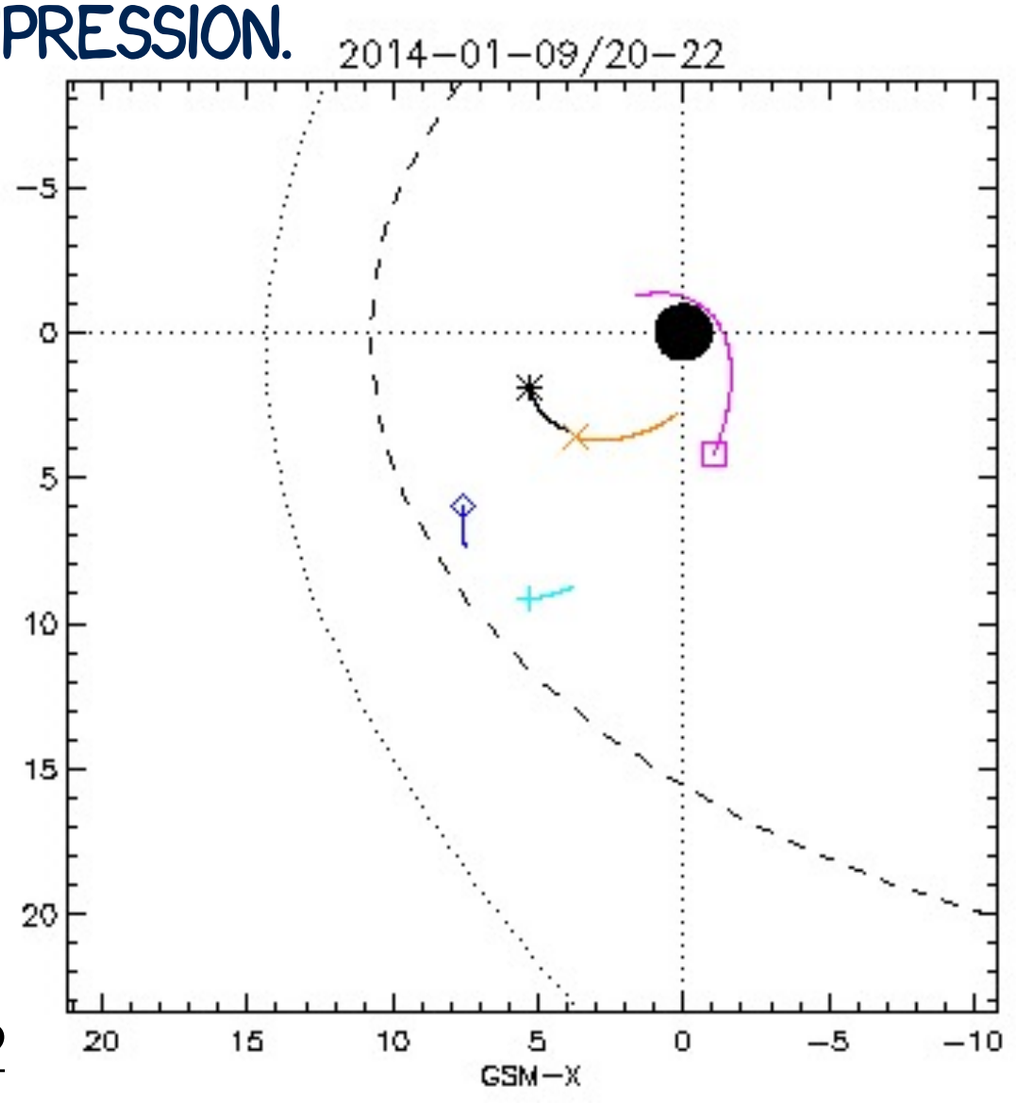
THEMIS HAPPENED TO BE NEAR THE MAGNETOPAUSE ALLOWING FOR US TO DETERMINE THE EXACT TIME THAT THE ICME-SHOCK HIT THE MAGNETOSPHERE.

DURING THIS TIME THE VAN ALLEN PROBES A AND B AS WELL AS GOES 13 AND 15 WERE ALL ON THE DAY SIDE OF THE MAGNETOSPHERE IN THE ECLIPTIC PLANE. FLOATING IN THE STRATOSPHERE, THREE BARREL BALLOONS, 2K, 2L, AND 2X MAPPED TO THIS SAME REGION.

THIS GIVES A VERY NICE ARRAY OF OBSERVATIONS TO STUDY THIS EVENT. ANOTHER BONUS IS THAT THERE WAS NO GEOMAGNETIC STORM OR SUBSTORM AT THIS TIME SO ALL ACTIVITY WE OBSERVE IS DUE TO THE MAGNETOSPHERIC COMPRESSION.

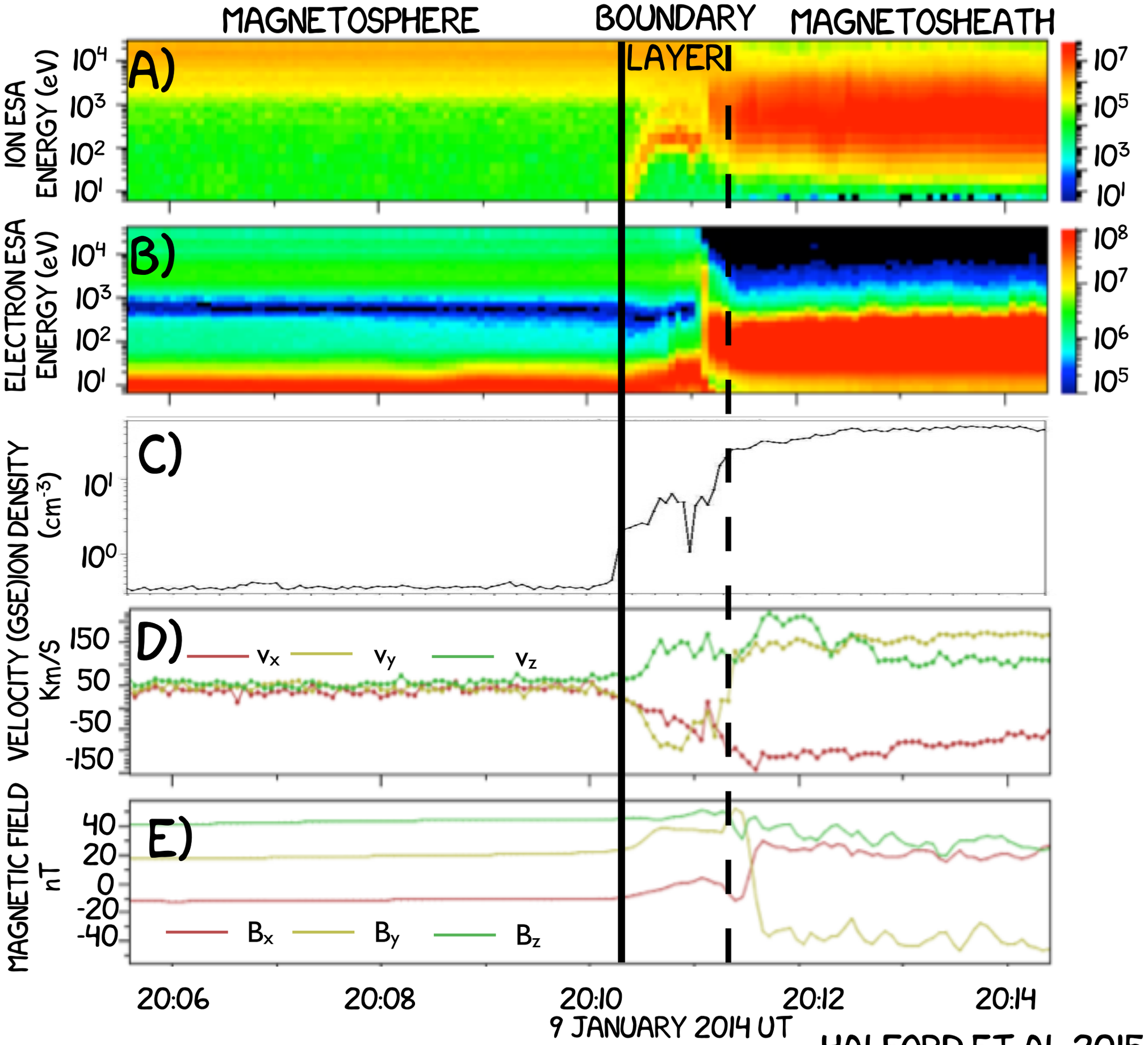


THEMIS-P1 (B)
THEMIS-P2 (C)
THEMIS-P3 (D)
THEMIS-P4 (E)
THEMIS-P5 (A)
RBSP-A
RBSP-B



HTTP://THEMIS.SSL.BERKELEY.EDU/SUMMARY.PHP

AS YOU CAN SEE, THEMIS SAW THE MAGNETO-PAUSE SWEEP BY AT ABOUT 20:10:30 UT.



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JANUARY 9TH - THE CME ARRIVAL

CME

ICME SHOCK

REGION OF CHORUS AND EMIC WAVE ENHANCEMENT AND OBSERVABLE ELECTRON PRECIPITATION

G15

12:00

7

B

5

3

2K

2X

A

ELECTRIC FIELD IMPULSE

2I

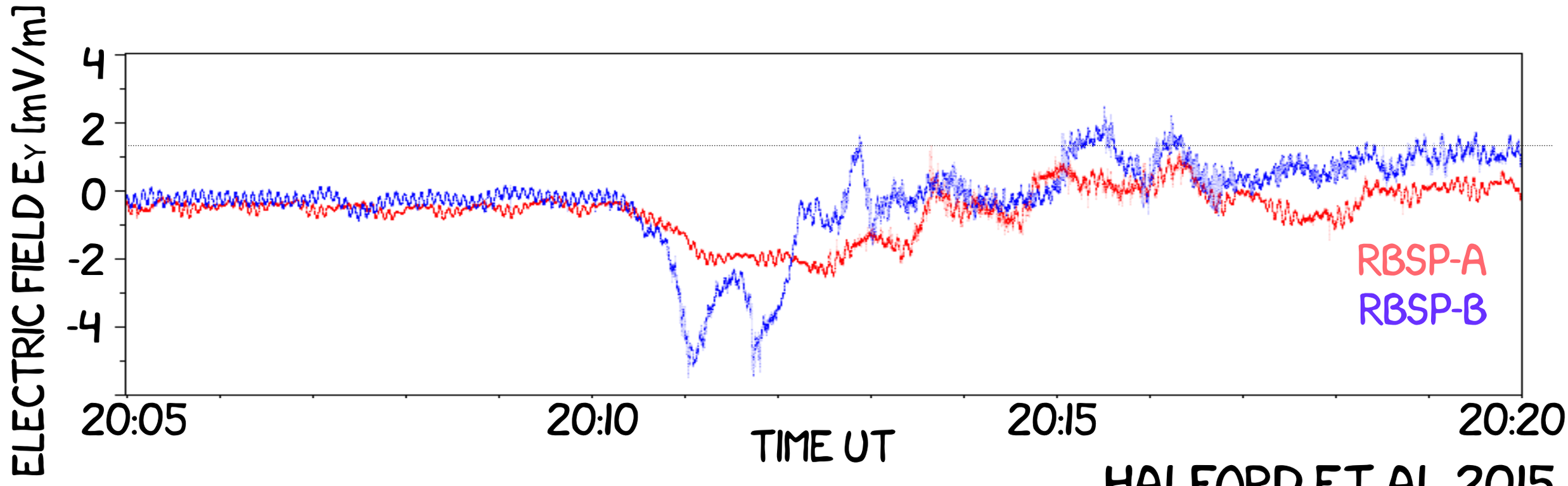
G13

PLASMASPHERE REGION OF PLASMASPHERIC HISS

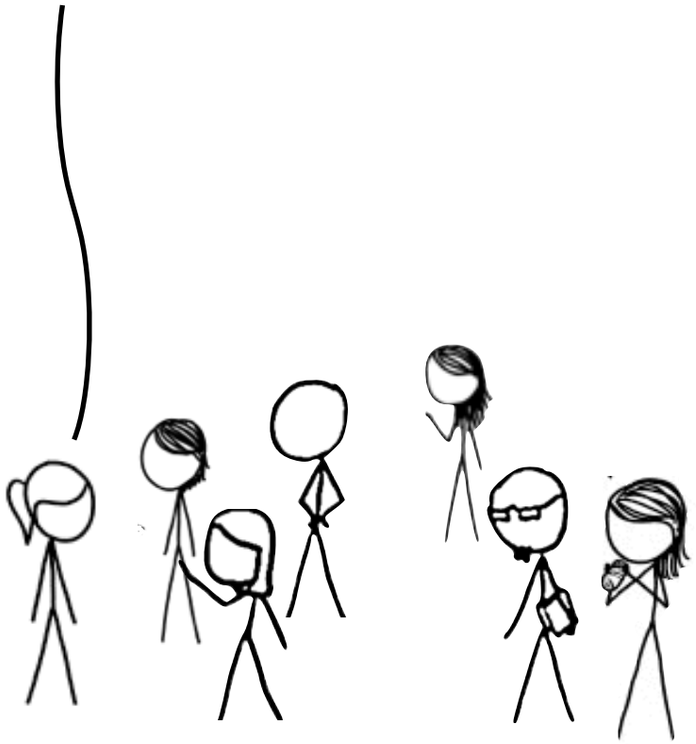
I THINK I MAY HAVE TAKEN A WRONG TURN AT THE VOLCANOLOGY AISLE

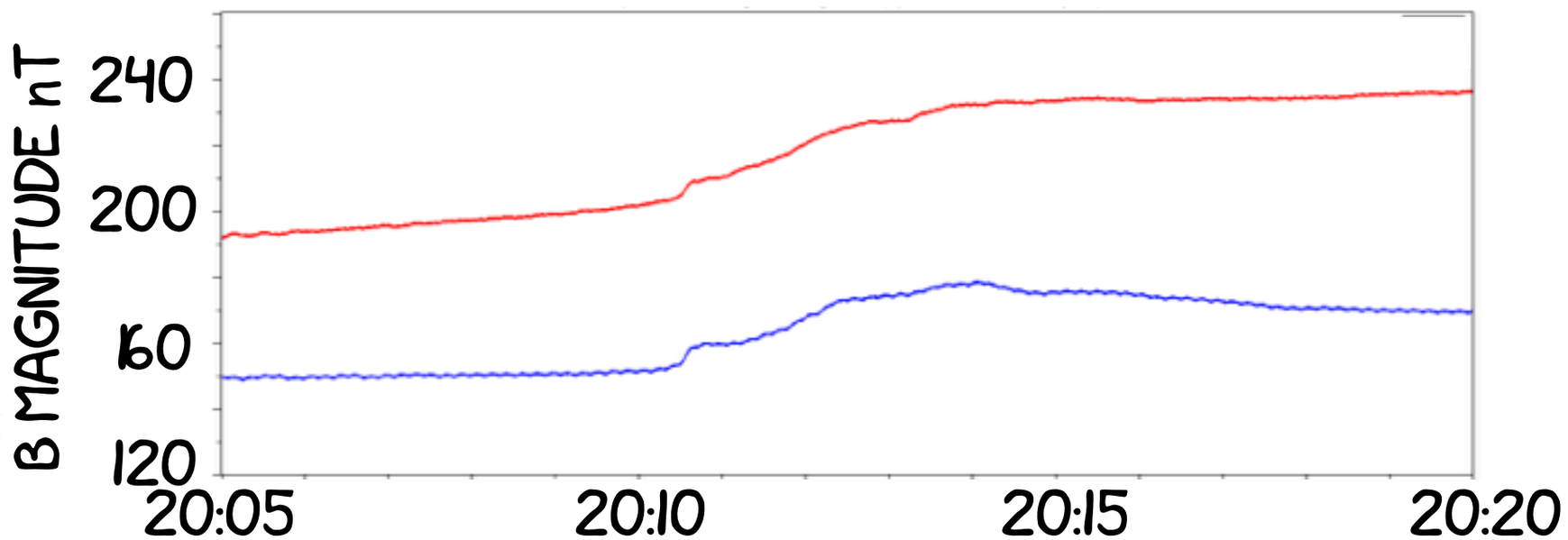
MODIFIED FROM MIKIĆ, Z., AND M. A. LEE (2006)

NOT TO SCALE



AFTER THE SHOCK HIT, BOTH VAN ALLEN PROBES SAW AN ELECTRIC FIELD IMPULSE AS WELL AS A RESPONSE IN THE MAGNETIC FIELD.





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

E.G. WYGANT ET AL 1994

L_F = 5.8, δT = 240S, E= -3.5 mV/m

=> L_0 = 6.8 AND THE FINAL LOSS CONE WILL BE LARGER

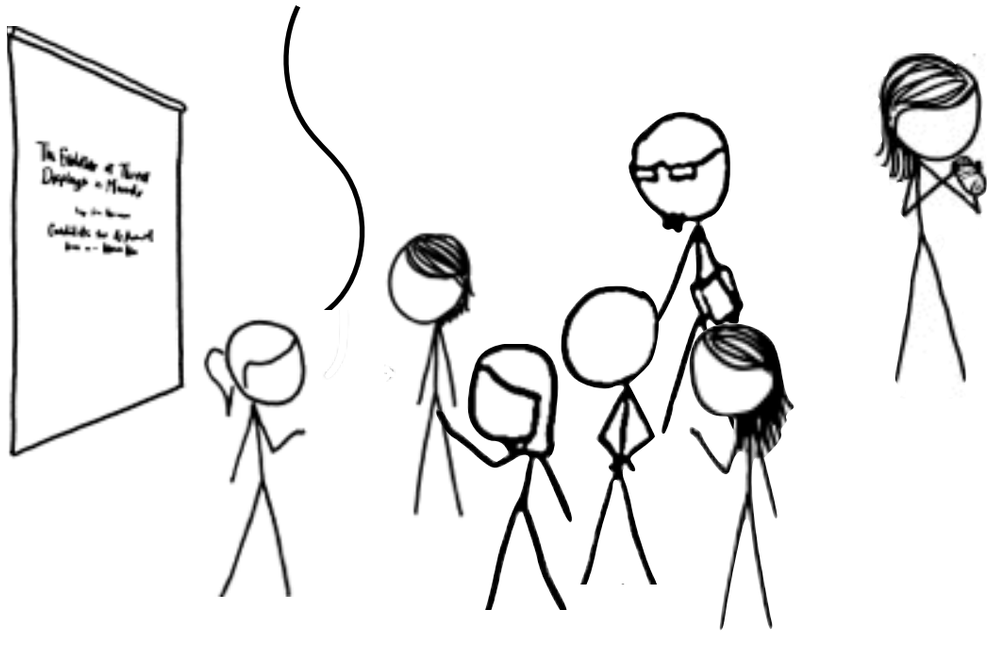
$$sin(\alpha_{eq_f}) = \frac{-L_f^{1/2} cos^2(\alpha_{eq_o})}{2L_o^{1/2} sin^2(\alpha_{eq_o})} + \frac{1}{2}\left(\frac{L_f cos^4(\alpha_{eq_o})}{L_o sin^2(\alpha_{eq_o})} + 4\right)^{1/2}$$

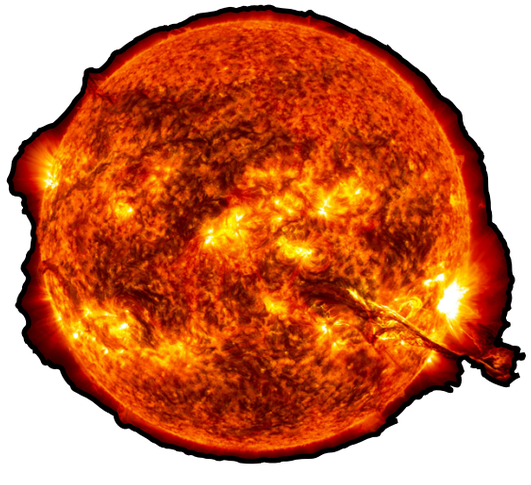
E.G. SHULTZ AND LANZEROTTI 1974

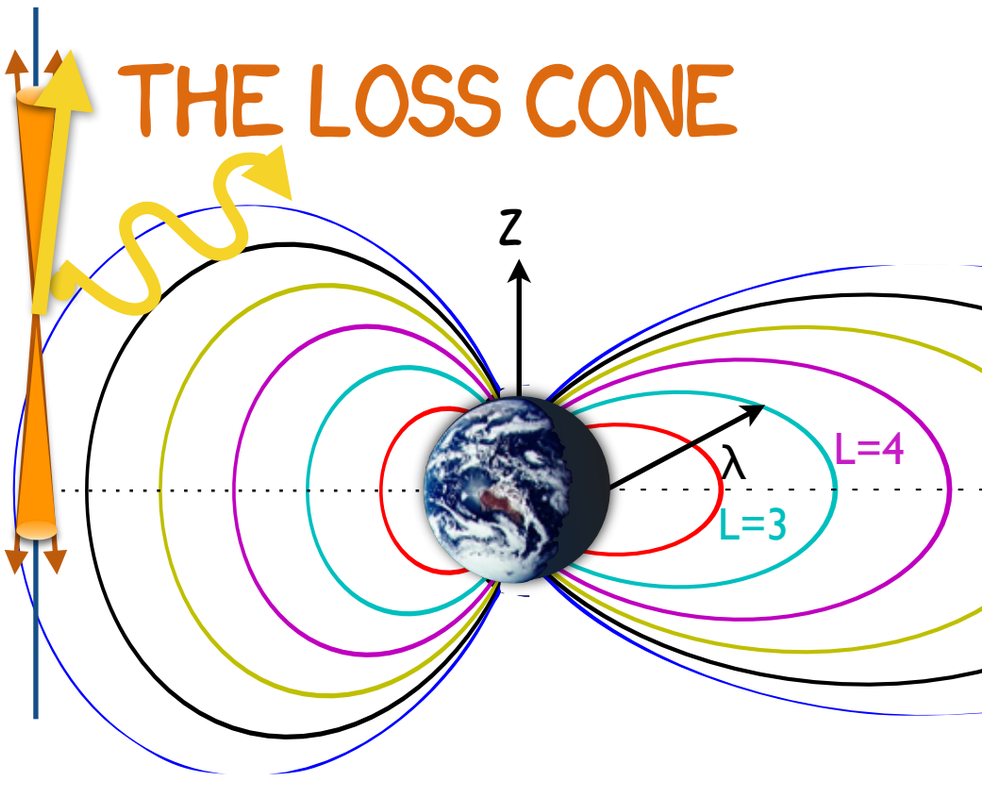
FOR $L_F = 5.8$, $L_O = 6.8$ => $\alpha_{eq_f} > \alpha_{eq_o}$

WE CAN ALSO DETERMINE HOW THE LOSS CONE AND PITCH ANGLE WILL CHANGE AS THE PARTICLE MOVED EARTHWARD.

AS A PARTICLE MOVES EARTHWARD, THE RATE THE PITCH ANGLE INCREASES IS SLOWER THAN THE RATE THE LOSS CONE INCREASES.







AS WE CAN SEE HERE, PARTICLES WITH PITCH ANGLES INITIALLY WITHIN ~0.5 DEG OF THE INITIAL LOSS CONE WILL BE LOST AS THEY MOVE IN I RE DUE TO THE ELECTRIC FIELD IMPULSE

FINAL EQUATORIAL PITCH ANGLE

INITIAL EQUATORIAL PITCH ANGLE

0
1
2
3
4
5

5.8
6.0
6.2
6.4
6.6
6.8

PARTICLE MOVED FROM L ~ 6.8 TO L ~ 5.8

LOSS CONE

L-VALUE

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CHANGE IN PRESSURE

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

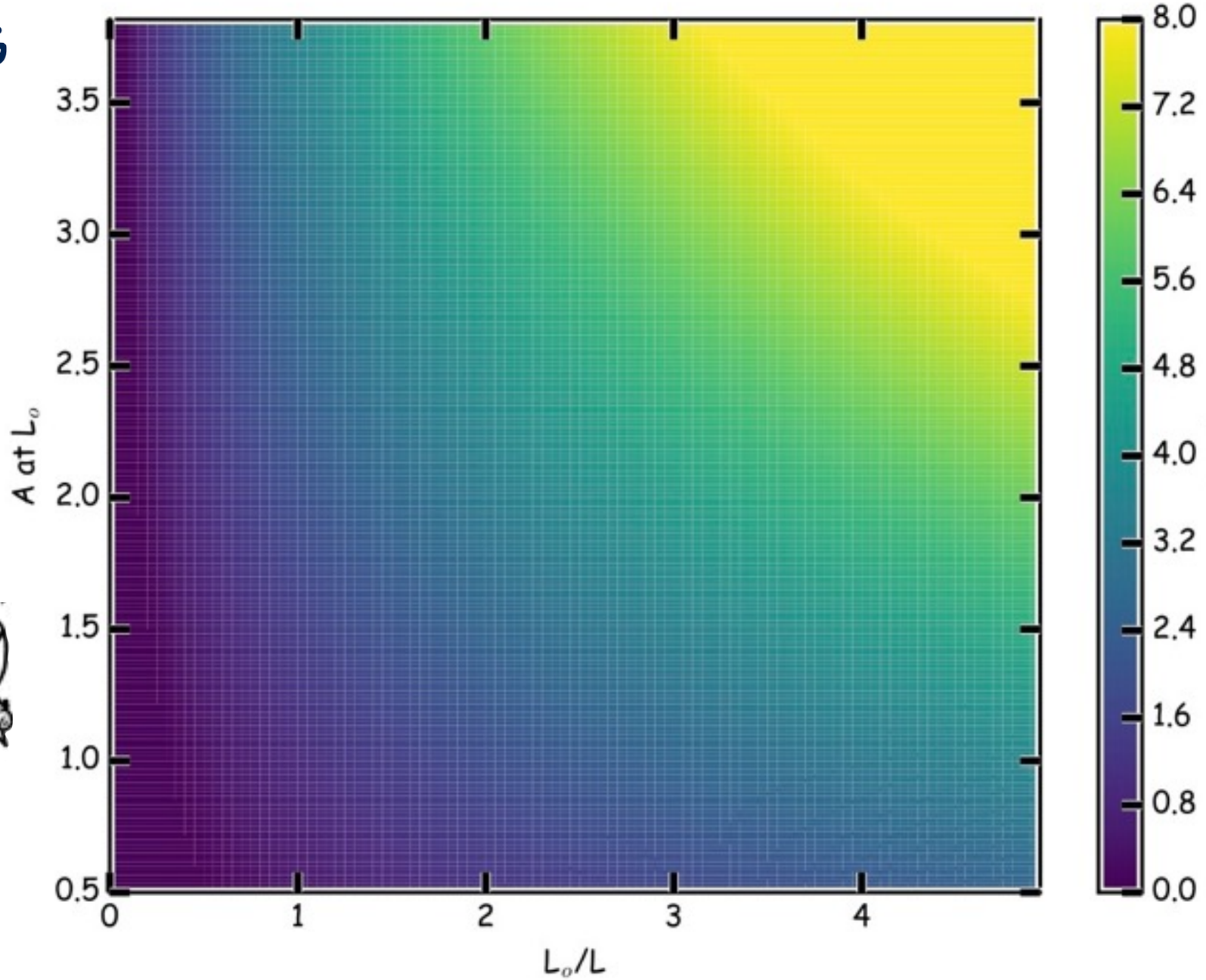
TEMPERATURE ANISOTROPY

$$A = T_\perp / T_\parallel - 1$$

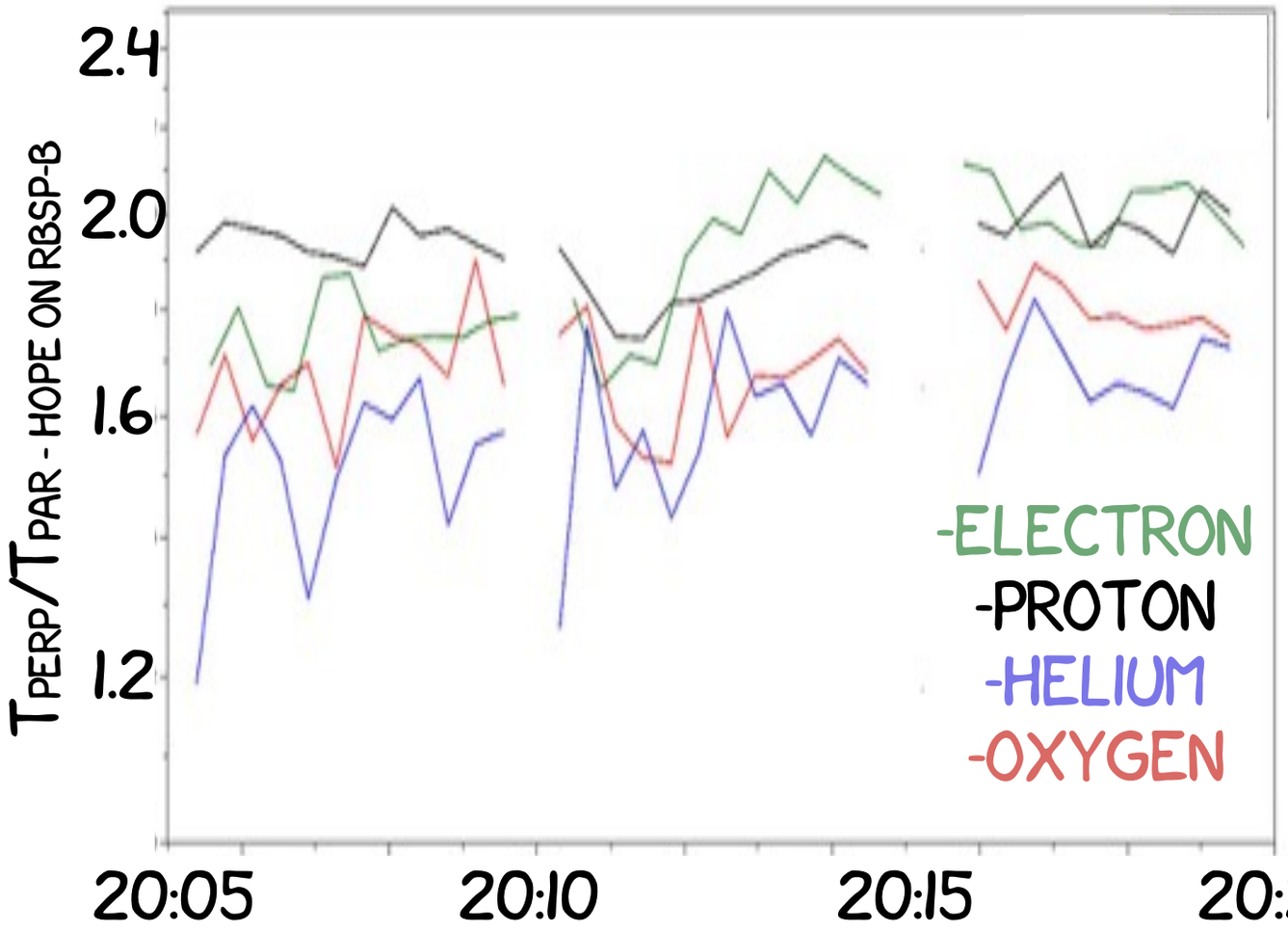
CHANGE IN A

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

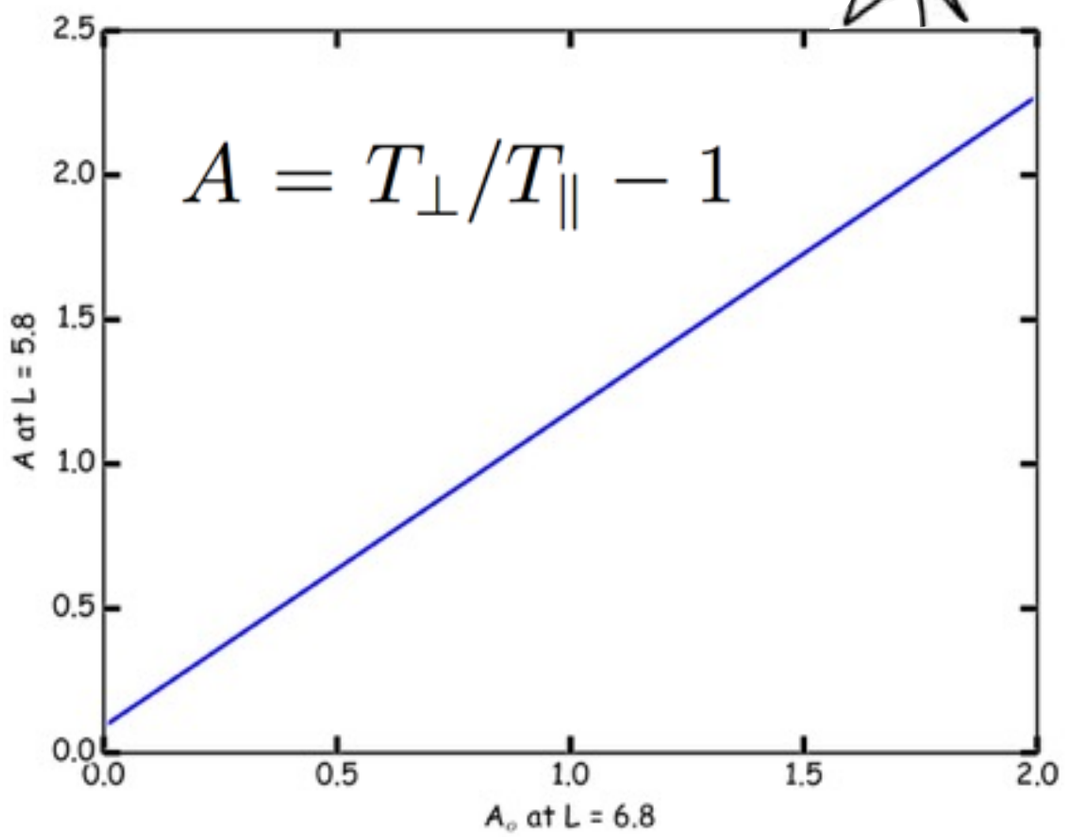
BY PUSHING THE PARTICLES EARTHWARD AND CHANGING THEIR PITCH ANGLE, WE ALSO CHANGE THE TEMPERATURE ANISOTROPY LIKE SOUTHWOOD AND KIVELSON DID IN 1975 FOR EMIC OBSERVATIONS FROM AMPTE DURING A COMPRESSION EVENT

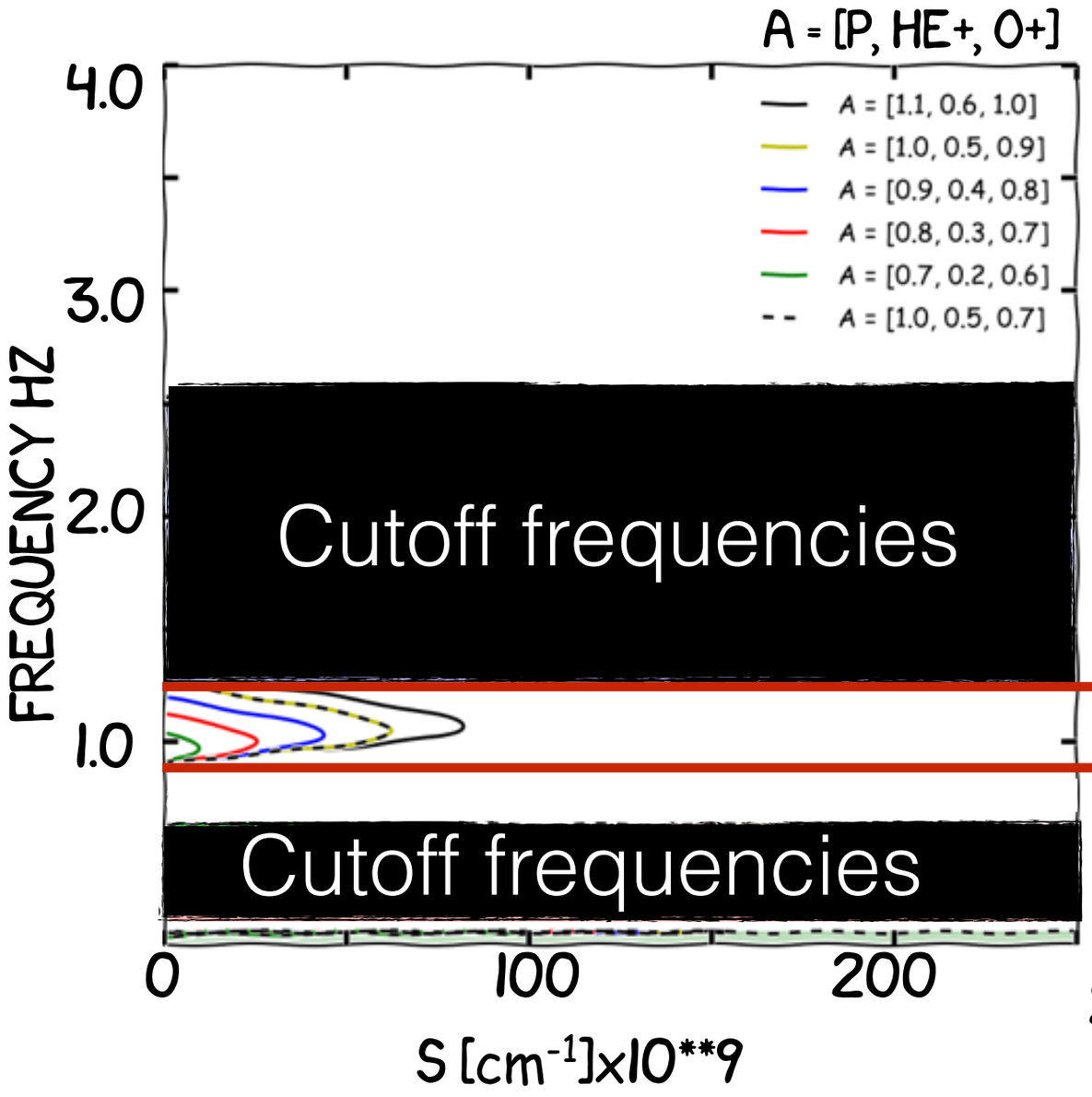


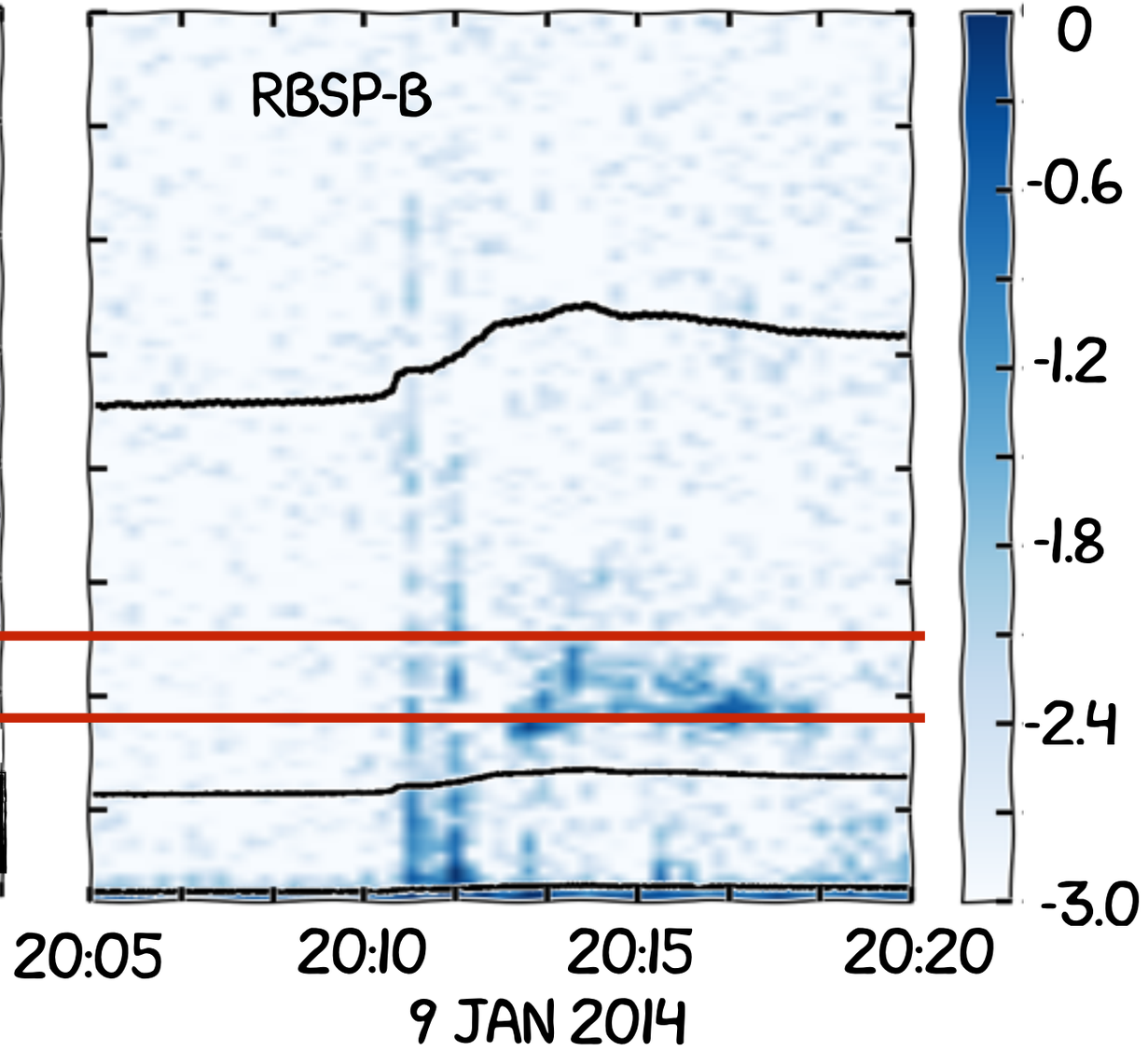
WE CAN SEE HOW THE TEMPERATURE ANISOTROPY IS CHANGING AT THE LOCATION OF THE SPACECRAFT - WHICH IS DIFFERENT FROM THE CHANGE IN THE PLASMA ELEMENT WE'VE BEEN CONSIDERING.



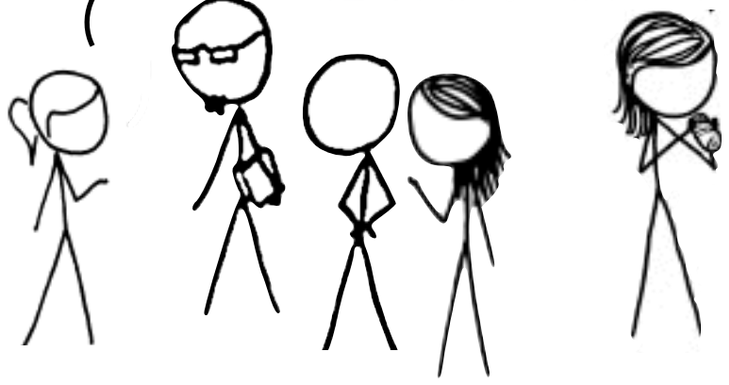
HERE'S THE EXPECTED CHANGING TEMPERATURE ANISOTROPY FOR OUR SPECIFIC EVENT/PLASMA ELEMENT





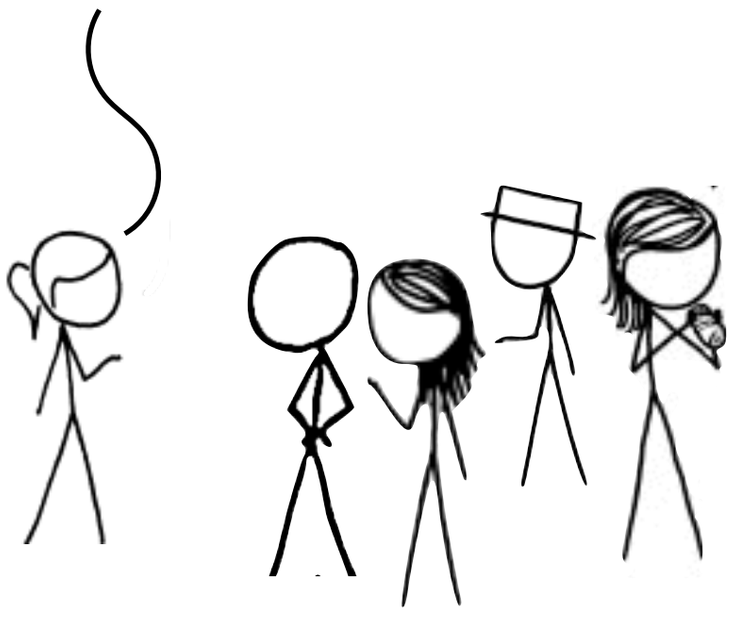


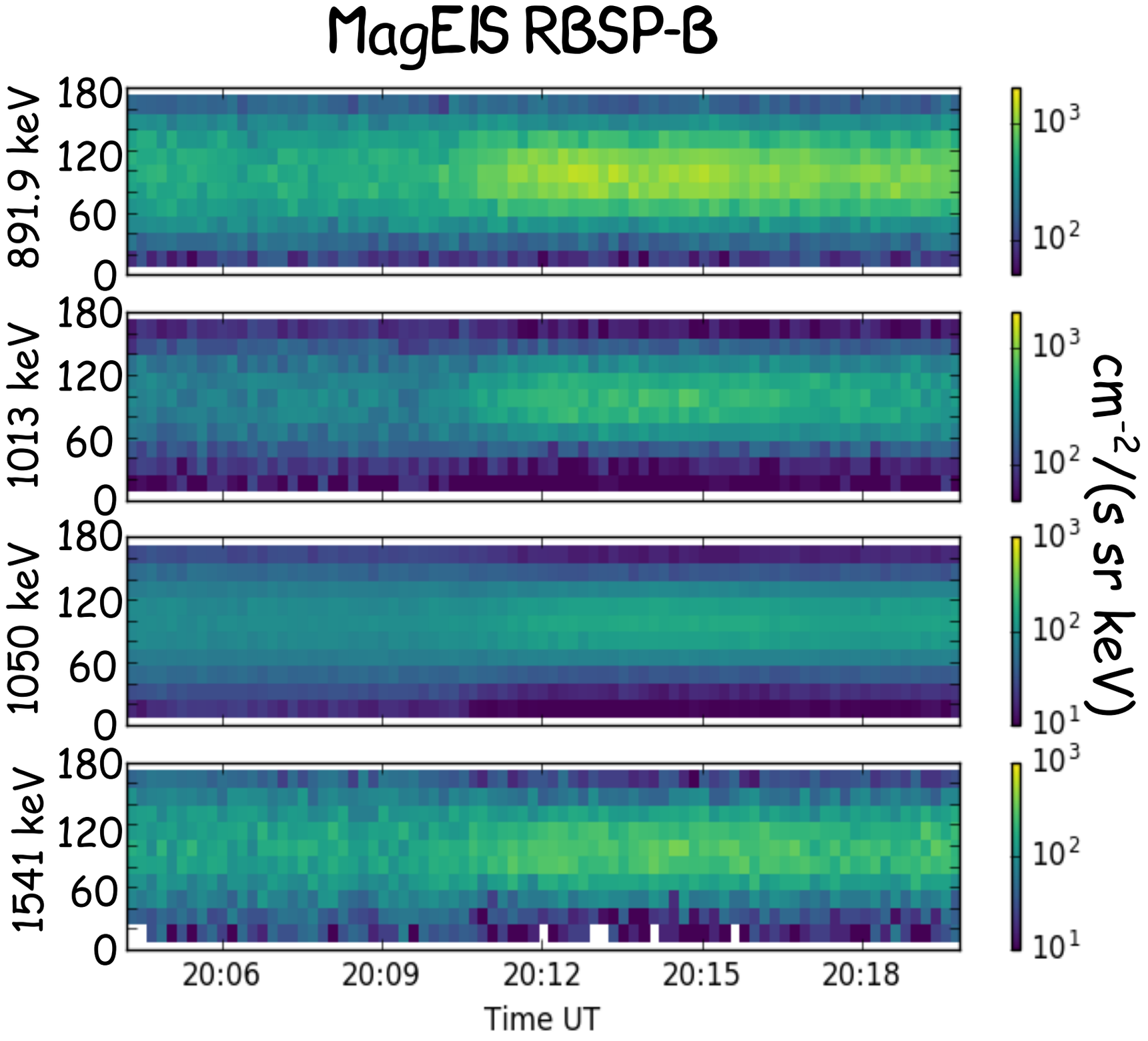
WE CAN SEE HOW THIS POTENTIALLY AFFECTS GROWTH RATES OF EMIC WAVES USING KOZYRA ET AL 1984 AND THE OBSERVED PLASMA CONDITIONS



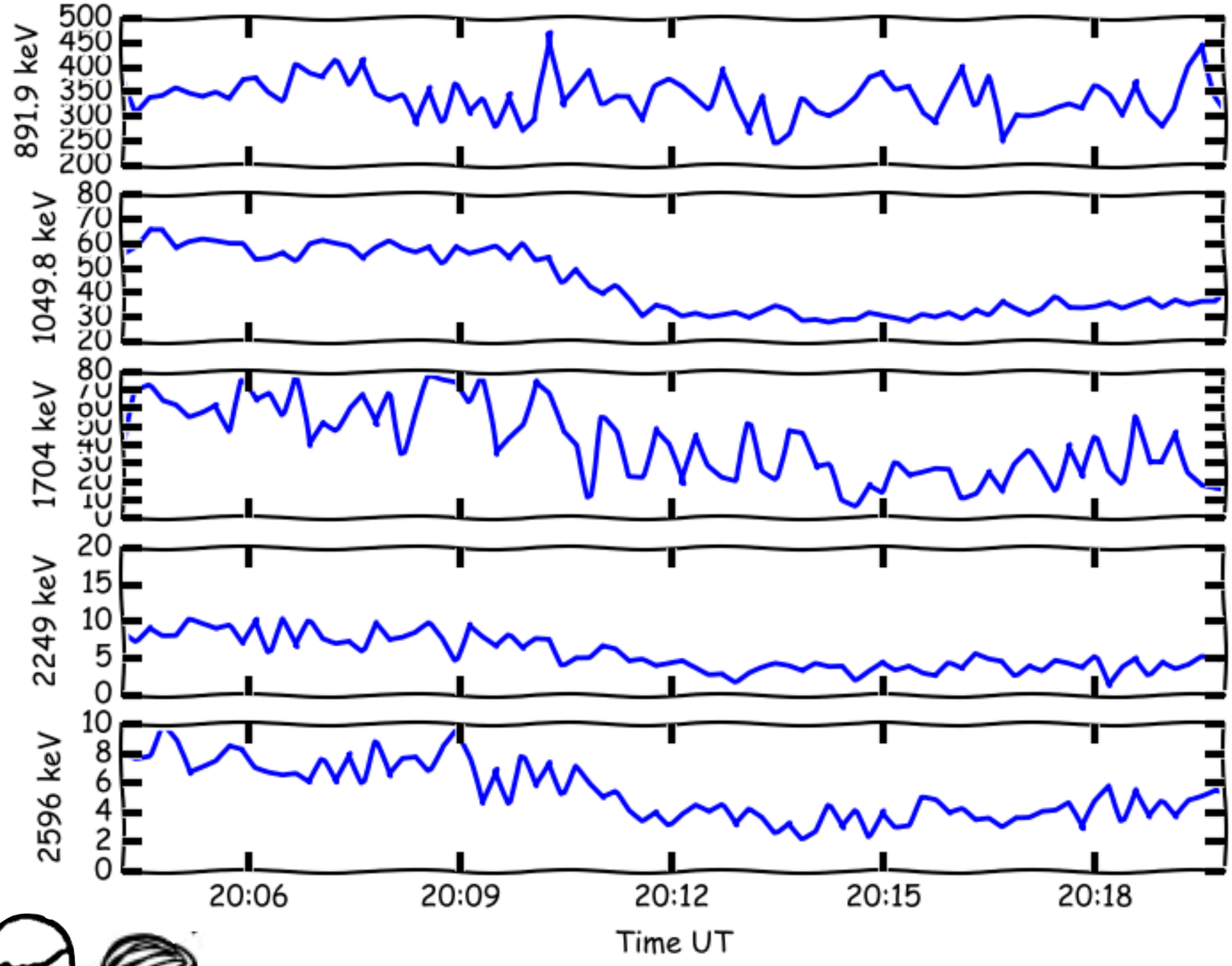
HERE'S AN EMIC WAVE THAT SHOWS UP AT RBSP-B, JUST AS ONE WOULD EXPECT.

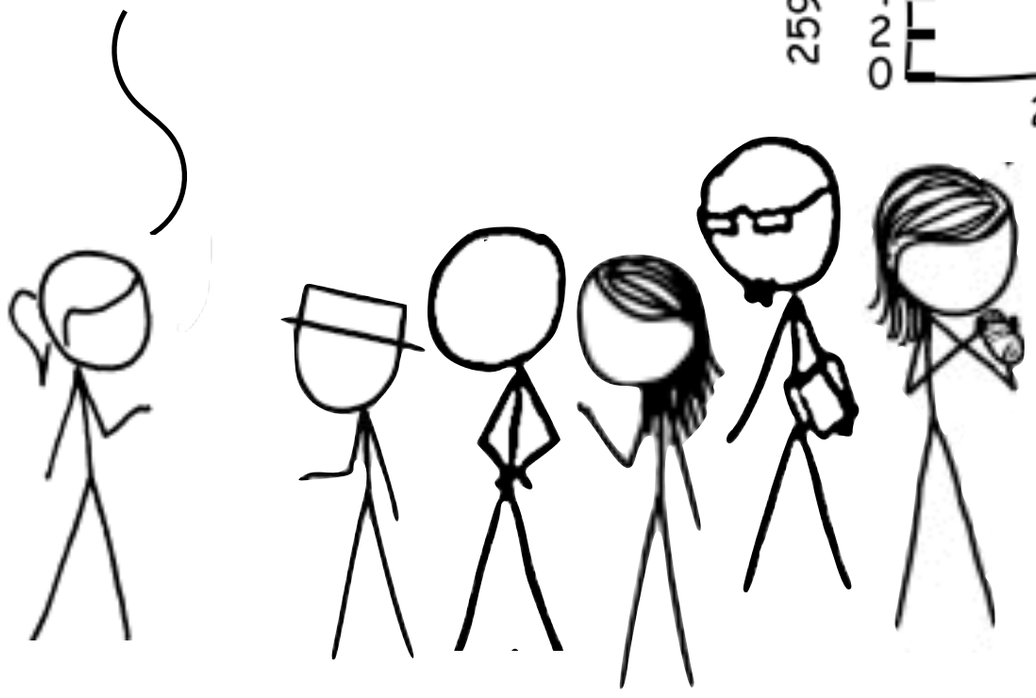
EMIC WAVES ARE ABLE TO CHANGE THE LOCAL PARTICLE POPULATION THOUGH PITCH ANGLE SCATTERING. WE KNOW THAT IT'S ENERGY SELECTIVE AND WILL ONLY RESONATE WITH GREATER THAN ~1 MeV ELECTRONS





PLOTTING ONLY THE PITCH ANGLES CLOSEST TO THE LOSS CONE SHOWS VERY CLEARLY THAT THERE IS A LOWER ENERGY CUT OFF AT AROUND 1 MeV.





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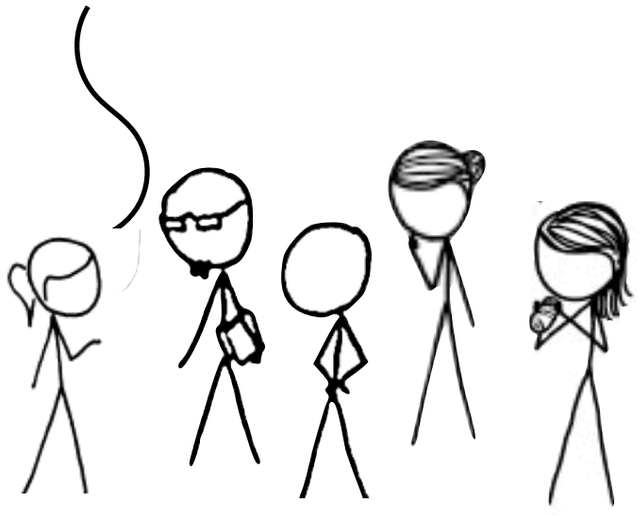
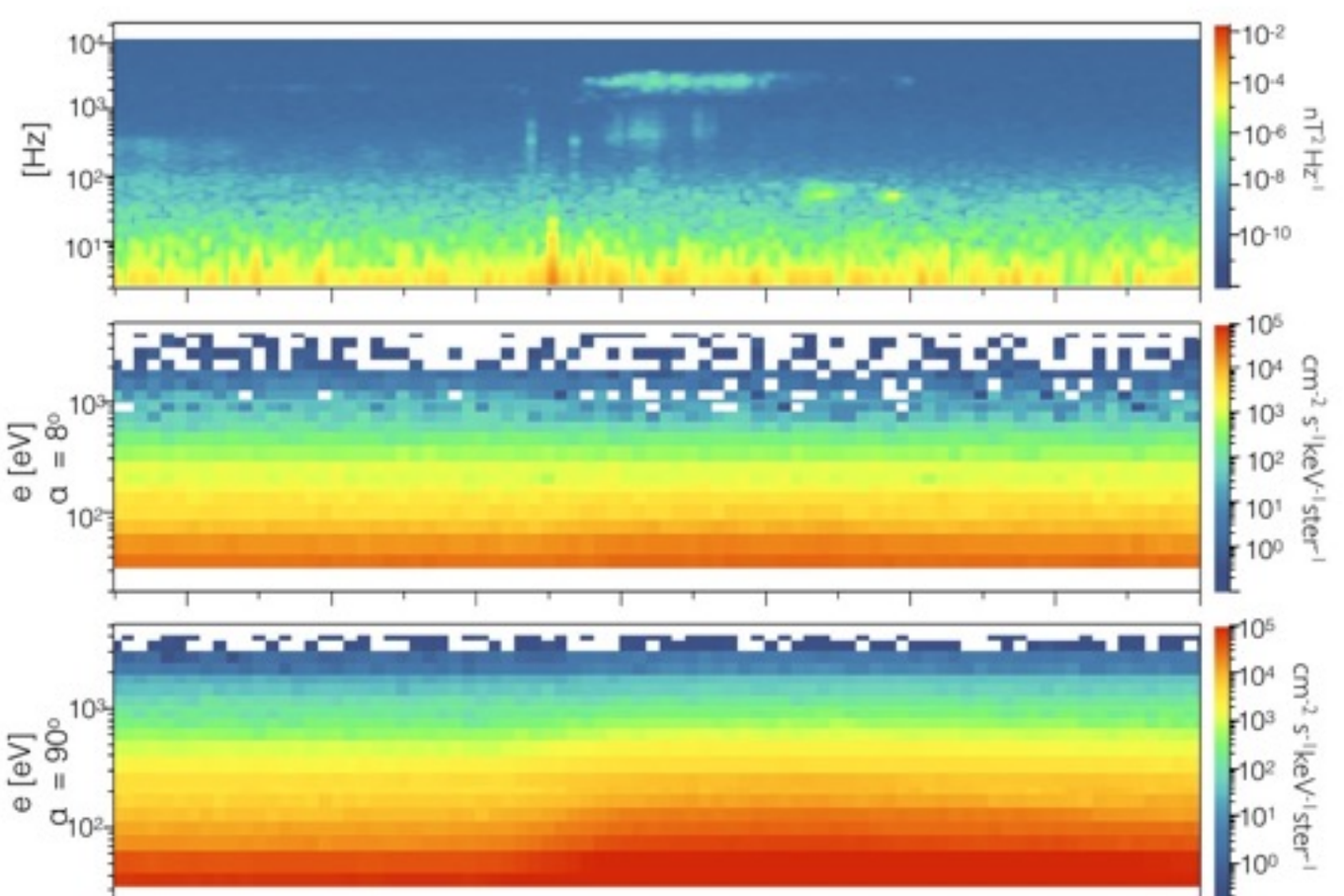
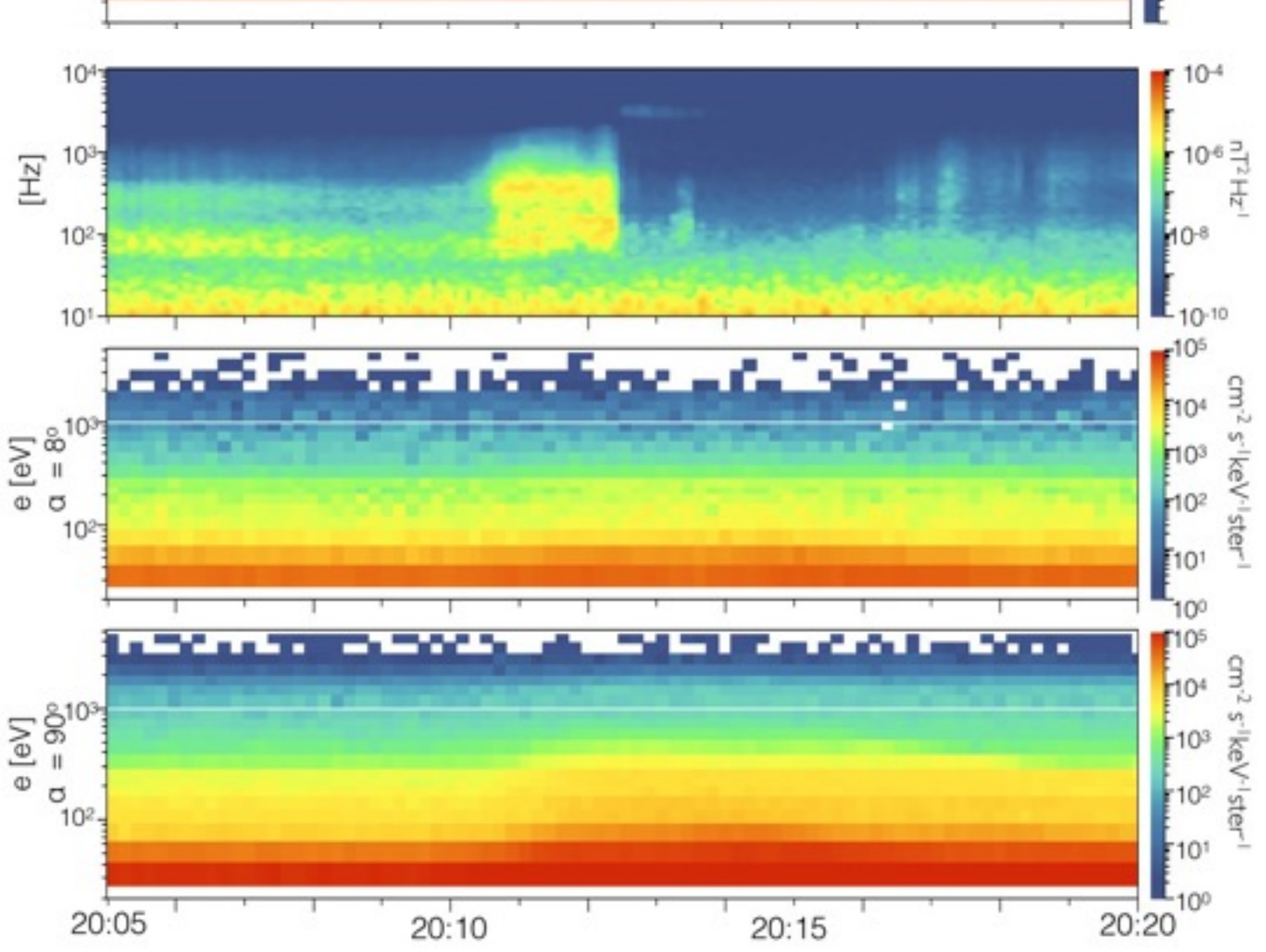
WE SEE THE SAME THING HAPPENING WITH THE ELECTRONS AND THE GENERATION OF WHISTLER MODE CHORUS OUTSIDE OF THE PLASMASPHERE AND HISS INSIDE THE PLASMASPHERE.



RBSP-B
OUTSIDE PLASMASPHERE
CHORUS



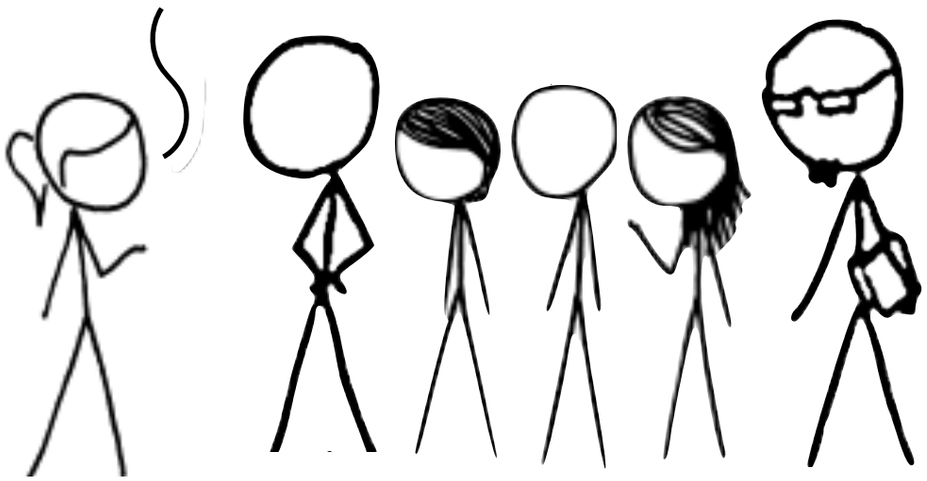
RBSP-A
INSIDE PLASMASPHERE
HISS



WE CAN LOOK FOR THE LOSS AT THE LOCATION OF THE SATELLITE AS WE DID WITH THE EMIC WAVE, BUT WE CAN ALSO AT IT FROM THE STRATOSPHERE. BARREL WAS A BALLOON ARRAY DESIGNED TO STUDY THE LOSS OF RADIATION BELT ELECTRONS FROM THE EARTH'S VAN ALLEN BELTS.

AS THE ELECTRONS ENTER THE ATMOSPHERE, THEY INTERACT WITH ATMOSPHERIC NEUTRALS CREATING A BREMSSTRAHLUNG CASCADE OF X-RAYS WITH ENERGIES UP TO THE ENERGY OF THE PRECIPITATING ELECTRON.

THE BALLOONS CARRIED A SODIUM IODIDE SCINTILLATOR WHICH MEASURES THESE X-RAYS. FROM THIS WE CAN INFER BACK THE ENERGY SPECTRUM AND FLUX OF THE PRECIPITATING POPULATION.



BARREL:
BALLOON ARRAY FOR RADIATION BELT RELATIVISTIC ELECTRON LOSSES

PRECIPITATING ELECTRON

IONOSPHERIC/ ATMOSPHERIC PARTICLES

BREMSSTRAHLUNG X-RAY

B-FIELD

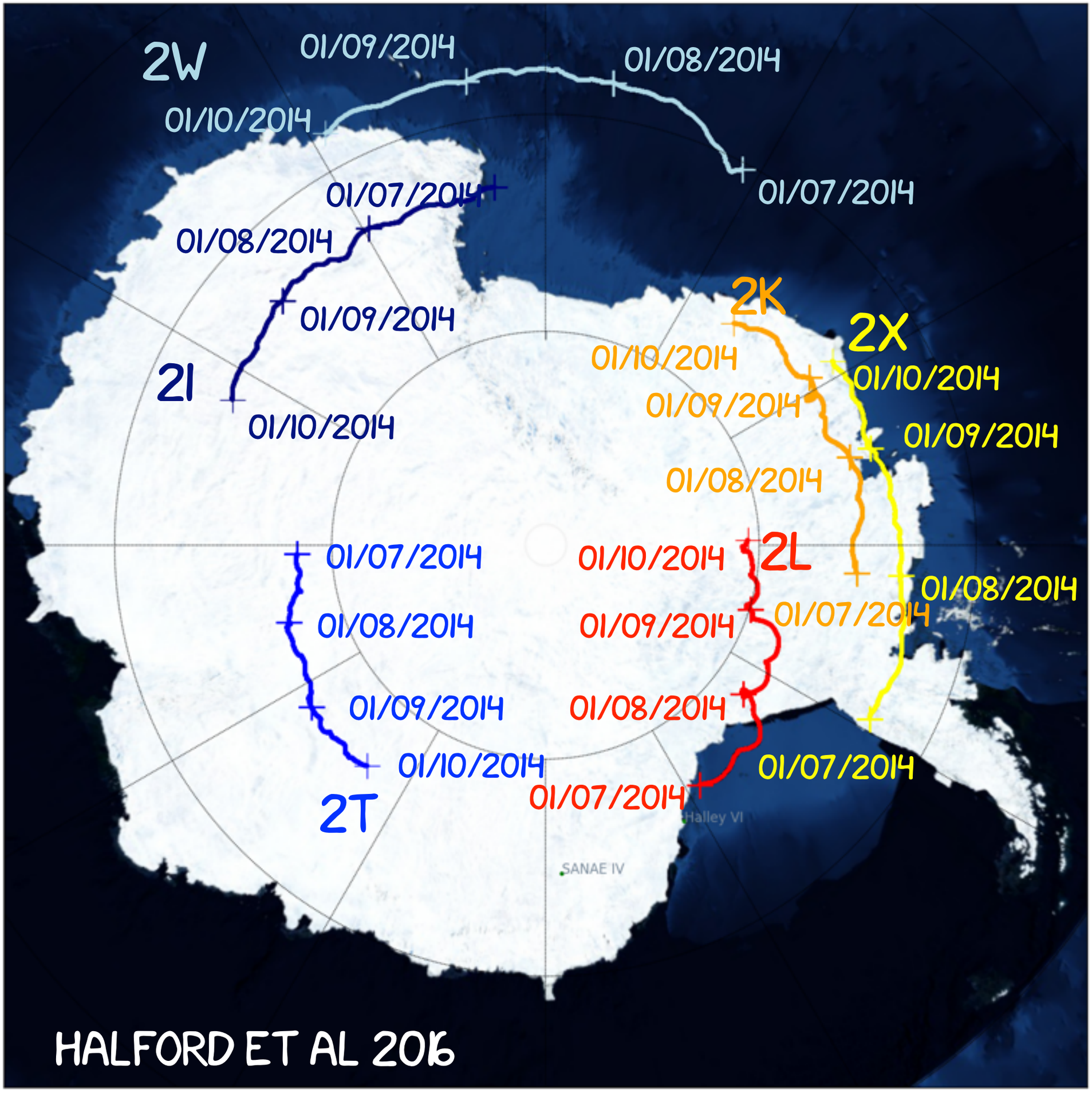
FLOAT ALTITUDE OF BARREL BALLOON ~22 - 40 KM

~27 KM

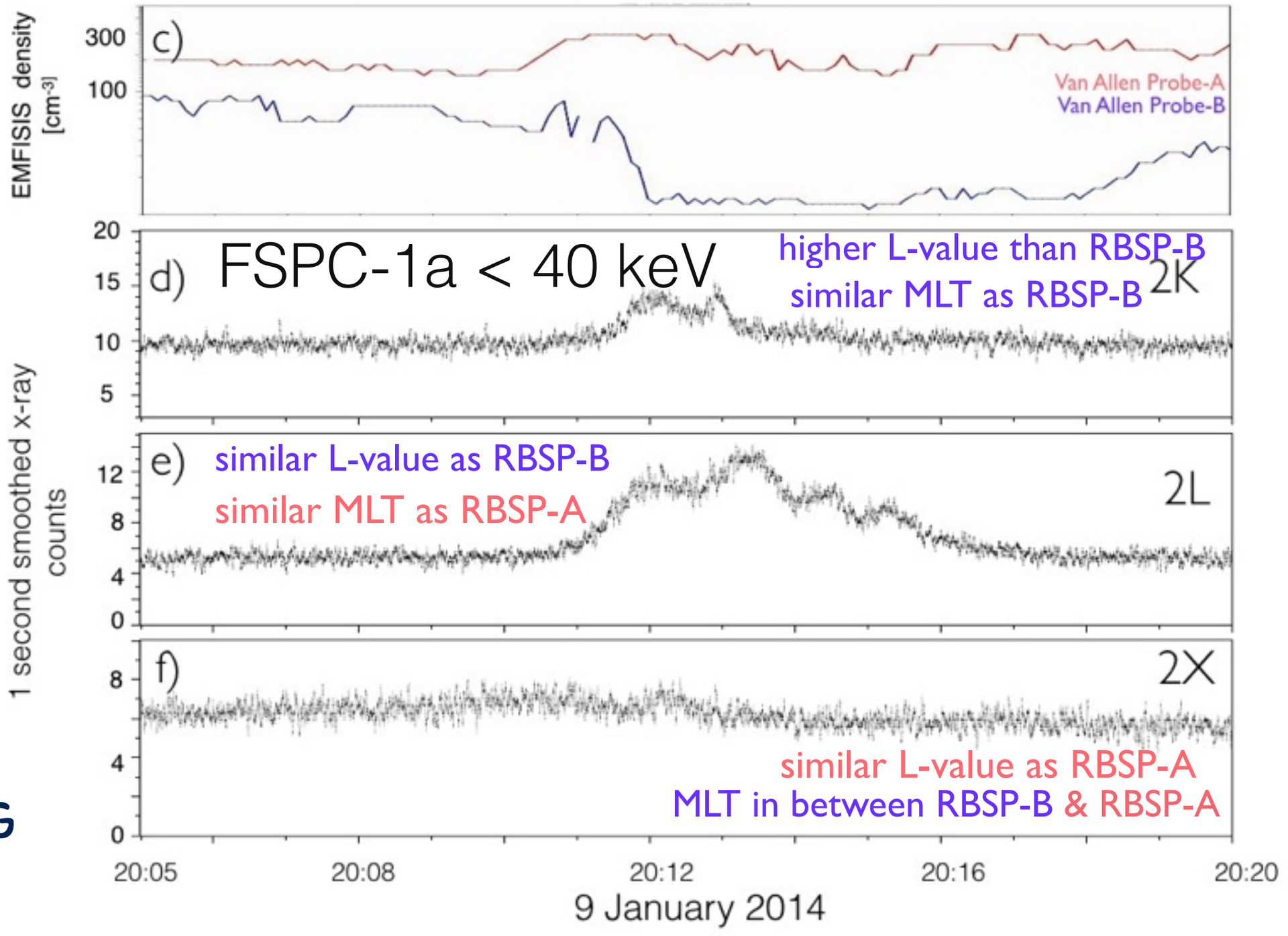
ATMOSPHERIC ABSORPTION OF X-RAYS

TERMINATED GROUND BASED BARREL MAGNETOMETER

DURING THE ICME-SHOCK 6 PAYLOADS FLOATING AROUND THE ANTARCTIC CONTINENT. THREE PAYLOADS, 2K, 2X, AND 2L HAPPENED TO BE ON THE DAY SIDE AND MAPPED CLOSE TO THE VAN ALLEN PROBES.



USING BARREL WE CAN INFER THAT THERE WAS ELECTRON PRECIPITATION OUTSIDE OF THE PLASMASPHERE DURING THIS COMPRESSION EVENT. SOME OF THESE PARTICLES WERE LIKELY LOST DUE TO THE POPULATION MOVING EARTHWARD



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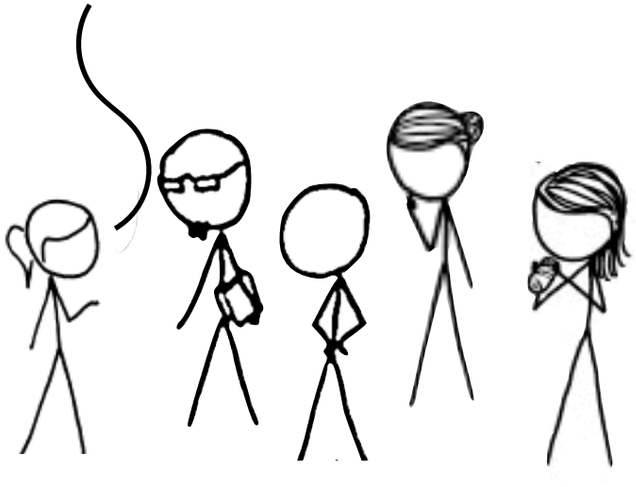
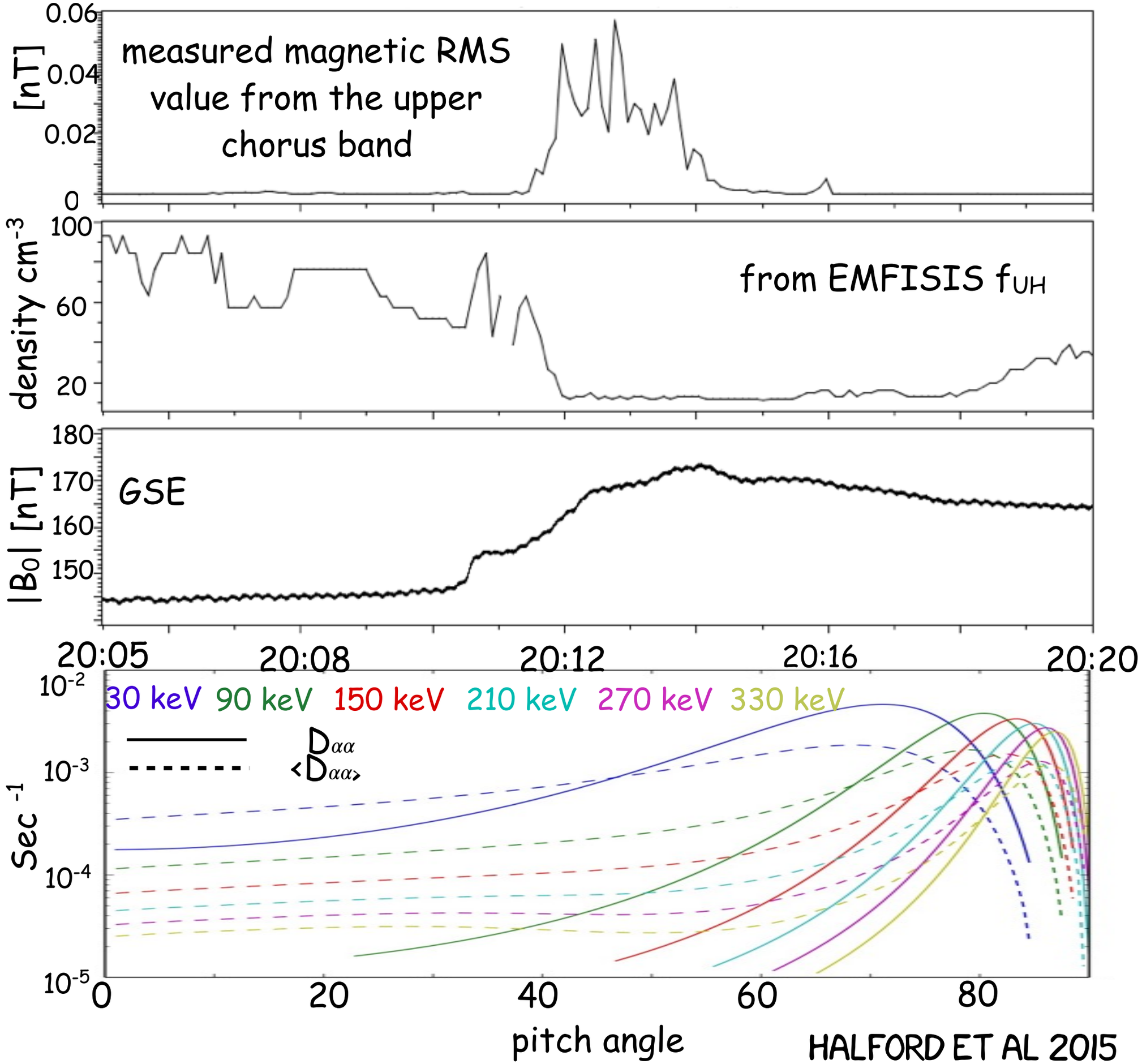


USING THE OBSERVED PLASMA AND WAVE DATA, WE CAN DETERMINE THE PITCH ANGLE SCATTERING OF THE PARTICLE POPULATION FROM CHORUS WAVES



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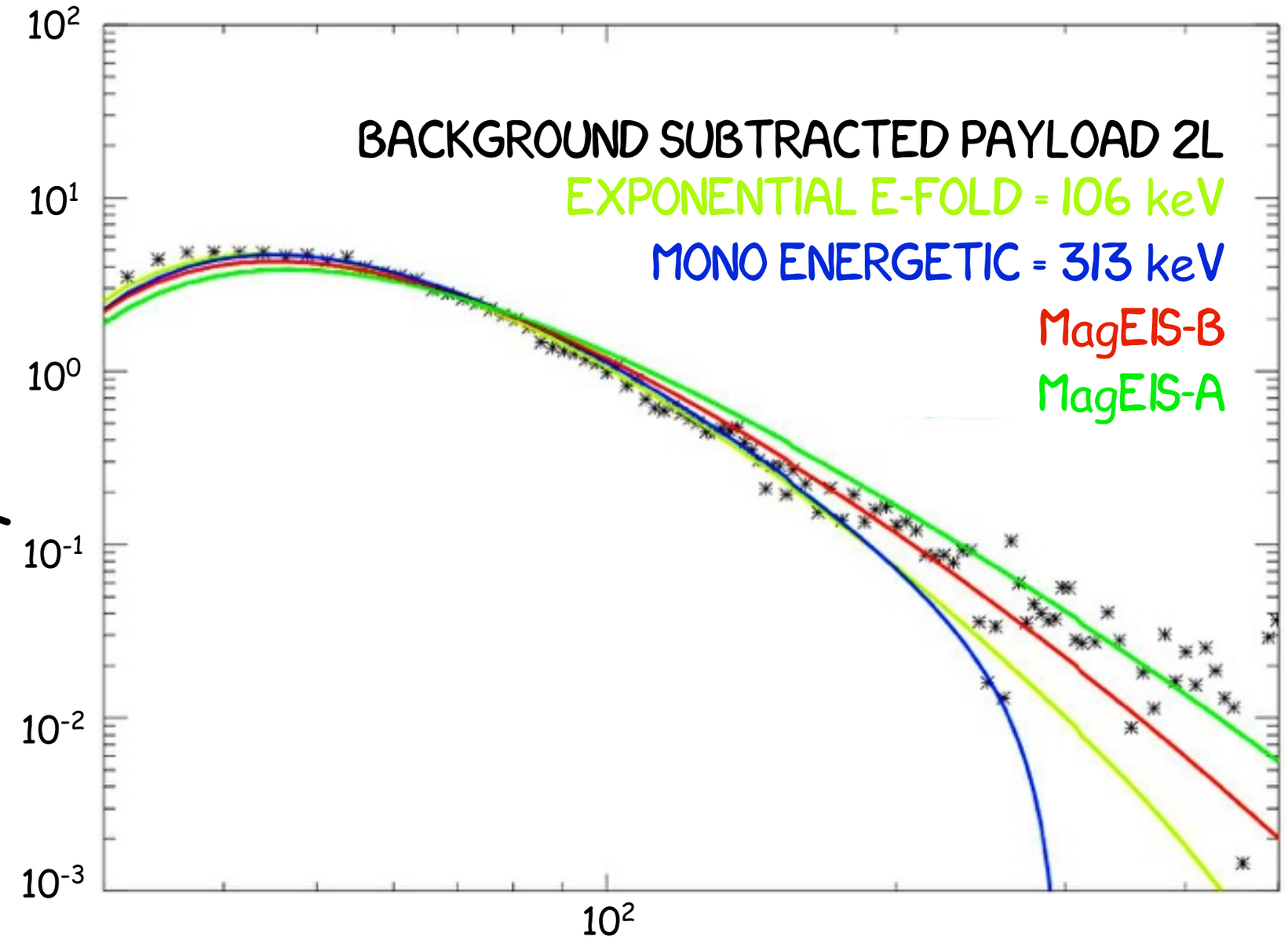
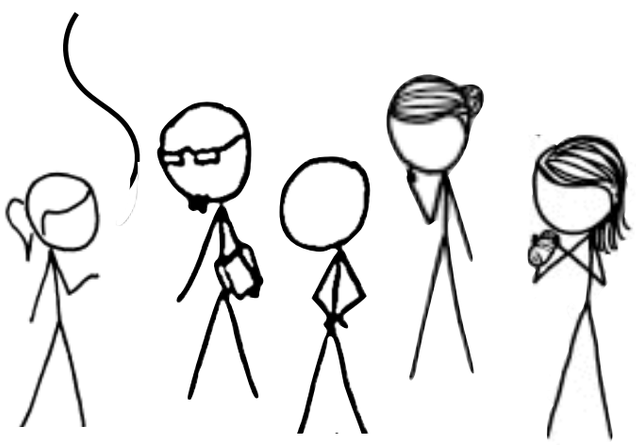
WE CAN ALSO INFER THE PRECIPITATING POPULATION ENERGY SPECTRUM FROM THE BALLOON X-RAY DATA. ASSUMING AN EXPONENTIAL ENERGY SPECTRA GIVES AN E-FOLDING ENERGY OF 106 keV, BUT THIS IS NOT HARD ENOUGH TO EXPLAIN THE OBSERVATIONS.



HALFORD ET AL 2015



THE BEST FIT MONO ENERGETIC POPULATION OF 313 keV ALSO DOES NOT PREFORM AS WELL AS THE SPECTRA OBSERVED BY MagEIS.

SO TO CONCLUDE -

DURING THE ICME-SHOCK ARRIVAL ON 9 JANUARY 2014 THE MAGNETOPAUSE WAS COMPRESSED BY 1 RE.

THIS COMPRESSION LED TO PARTICLES MOVING EARTHWARD AND THOSE WITHIN 0.5 DEGREES OF THE INITIAL LOSS CONE WOULD HAVE BEEN LOST IMMEDIATELY.

THE COMPRESSION ALSO LEADS TO A CHANGE IN THE TEMPERATURE ANISOTROPY WHICH IN TURN LEADS TO THE GENERATION OF EMIC AND WHISTLER MODE CHORUS AND HISS WAVES.

THESE WAVES IN TURN GENERATE ADDITIONAL PRECIPITATION AT SPECIFIC ENERGIES.

FUTURE WORK WILL CONTINUE EFFORTS TO MODEL THE TOTAL PRECIPITATION DUE TO THE WAVES IN ORDER TO COMPARE TO THE OBSERVED PRECIPITATION AT BARREL.

OTHER EFFORTS WILL ALSO CONSIDER EFFECTS FROM ULF WAVES ON 1) THE HIGHER FREQUENCY WAVE-PARTICLE DYNAMICS, AND 2) THEIR ABILITY TO AFFECT PARTICLE LOSS.

THIS WILL ALSO ALLOW US TO DETERMINE THE RELATIVE CONTRIBUTION FROM THE INDIVIDUAL LOSS MECHANISMS TO THE ATMOSPHERE WHICH MAY IN TURN HELP BETTER UNDERSTAND THE RELATIVE CONTRIBUTION OF THESE PROCESSES DURING MUCH MORE COMPLICATED EVENT TIMES SUCH AS DURING GEOMAGNETIC STORMS.

THANK YOU FOR COMING TO MY POSTER. IF YOU WOULD LIKE REPRINTS OR WOULD LIKE TO LEAVE A COMMENT PLEASE USE THE SPACE BELOW.