



Aurora: Looking up at The Ionosphere

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Outline

General Properties of Optical Aurora

Auroral emissions, altitudes and characteristic energies

Looking up at an auroral substorm

Some types of auroral forms



Typical Properties of Optical Aurora



Emission/Intensity/Particles	Day		Night	
	Intensity (kR)	Height (km)	Intensity (kR)	Height (km)
Emission:				
Red aurora [O, 630 nm]	1–10	300	0.1–1	200
Green auroras [O, 557.7 nm]	0.1–1	< 200	1–30	120
Blue auroras [N ₂ ⁺ , 427.8 nm]	0.1–0.5	≪ 200	0.5–5	100
Relative Intensity:				
Red/green auroras [630 nm/557.7 nm]	10		0.1	
Red/blue auroras [630 nm/427.8 nm]	50		0.5	
Particles:				
Position [mag. lat.]	≈ 77°		≈ 67°	
Particle stream density (flux) [number/m ² s]	≈ 10 ¹⁴		2 · 10 ¹³	
Average energy [keV]	≈ 0.1		≈ 5	
Power density (energy flux) [Watt/m ²]	≈ 10 ⁻³		≈ 10 ⁻²	

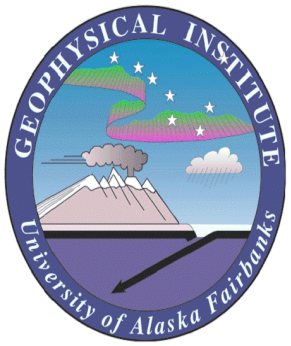
[Sandholt et.al., 2002]



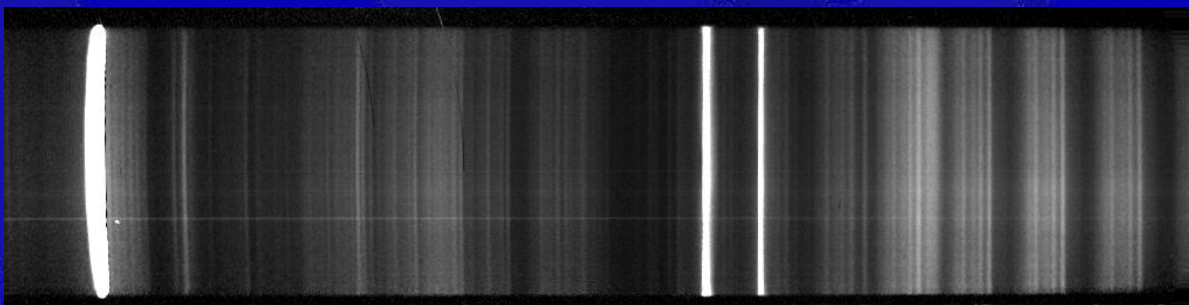
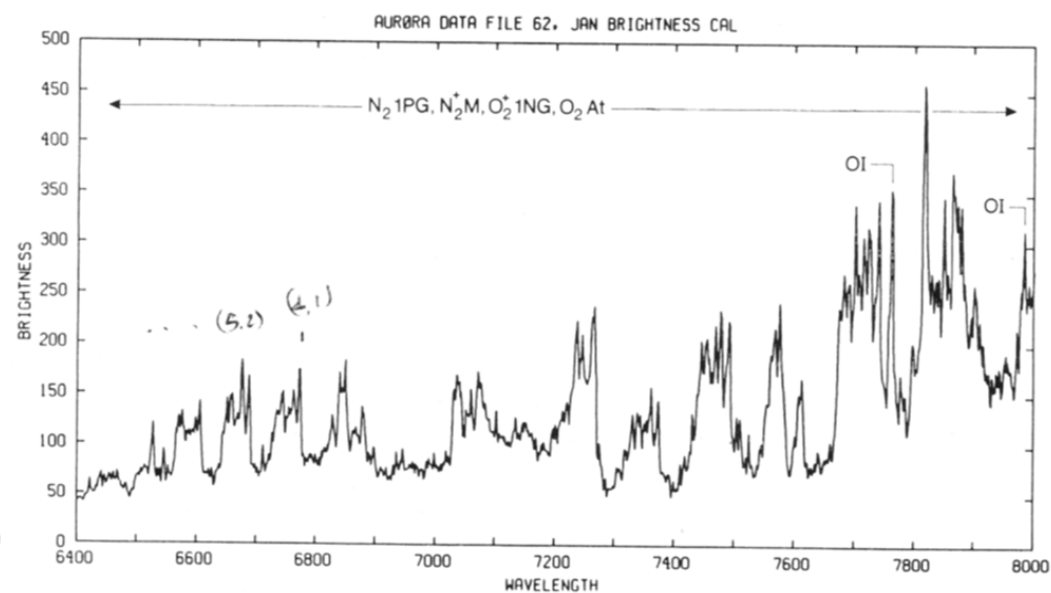
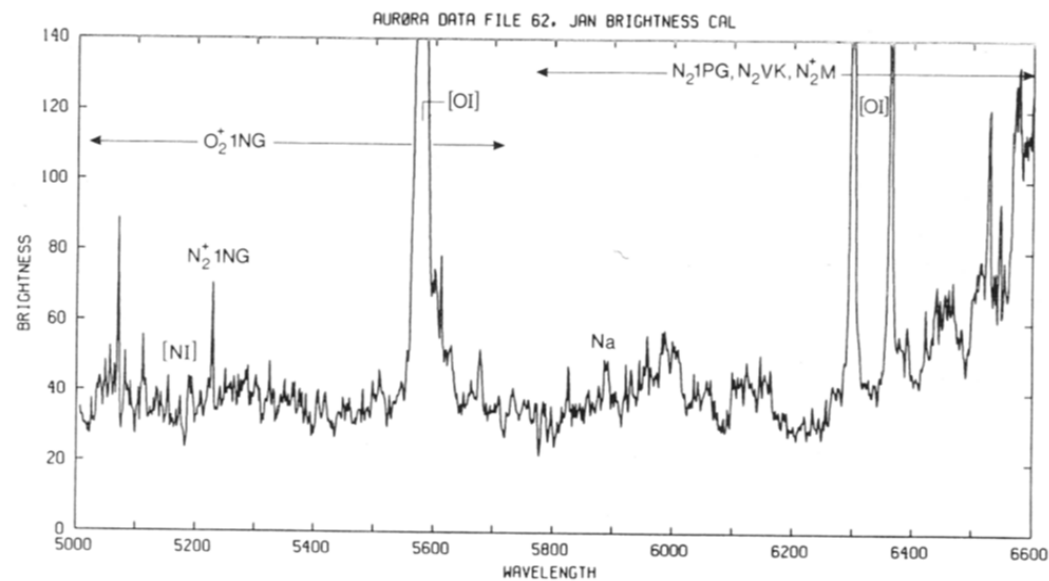
Visual Observing Standards



International Brightness Coefficient	Visual Impression	Brightness in kilorayleighs of 5577 Å [OI] ₃₂ emission.
I	Milky Way (Grey)	1
II	Moonlit, thin cirrus clouds (Green)	10
III	Moonlit cumulus clouds (Green)	100
IV	Total illumination of the ground equivalent to full moonlight (Green)	1000



Spectrum of the Aurora



Oxygen Emission Lines

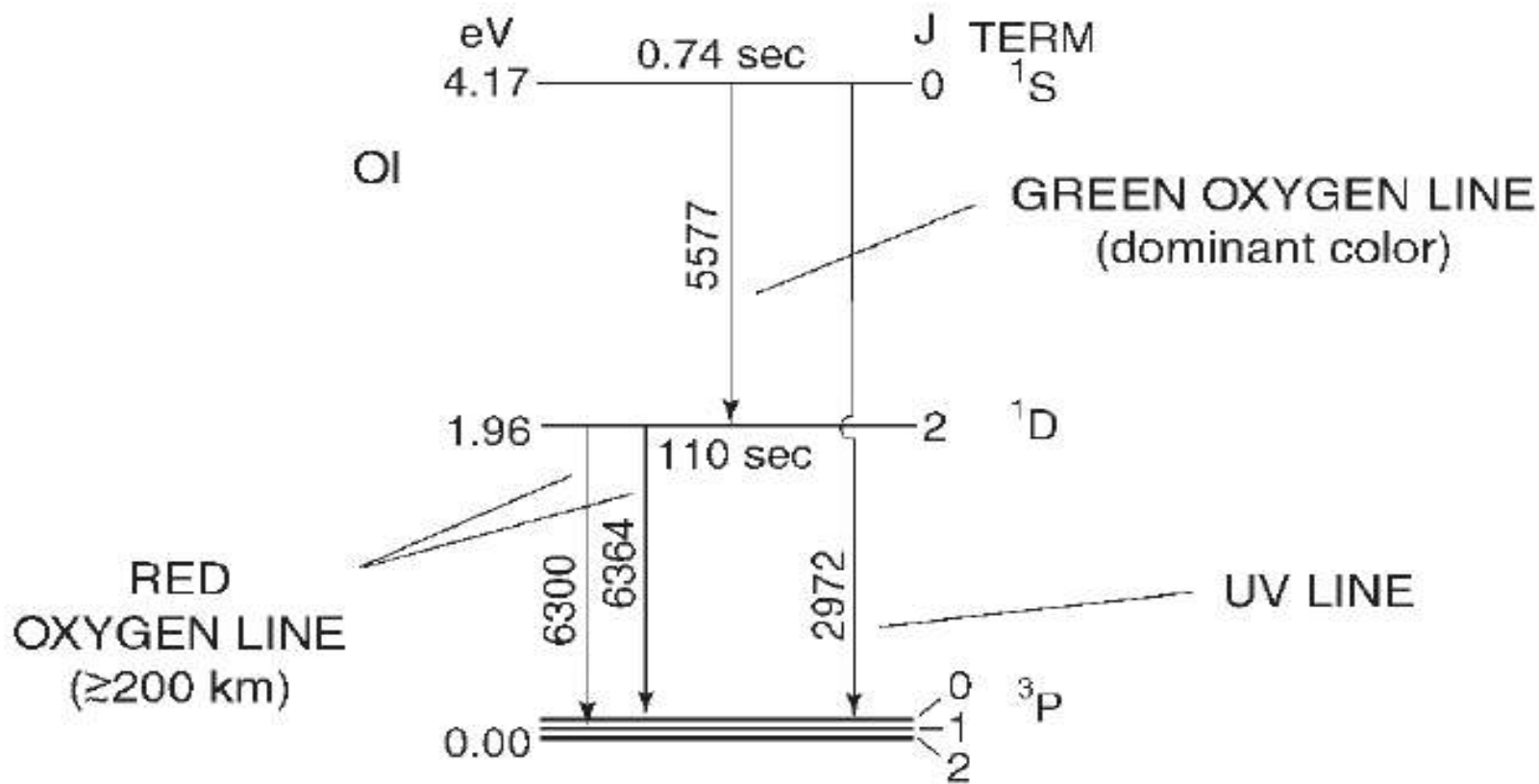
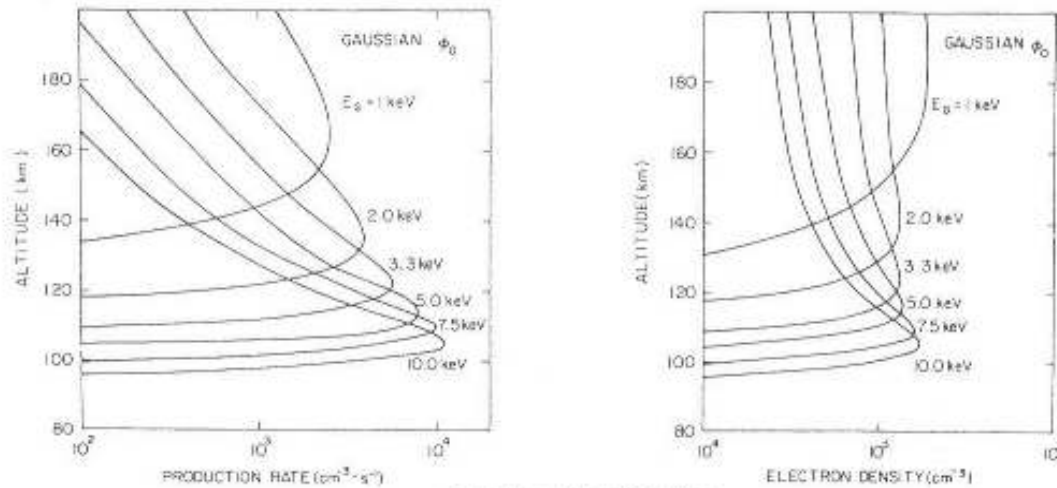


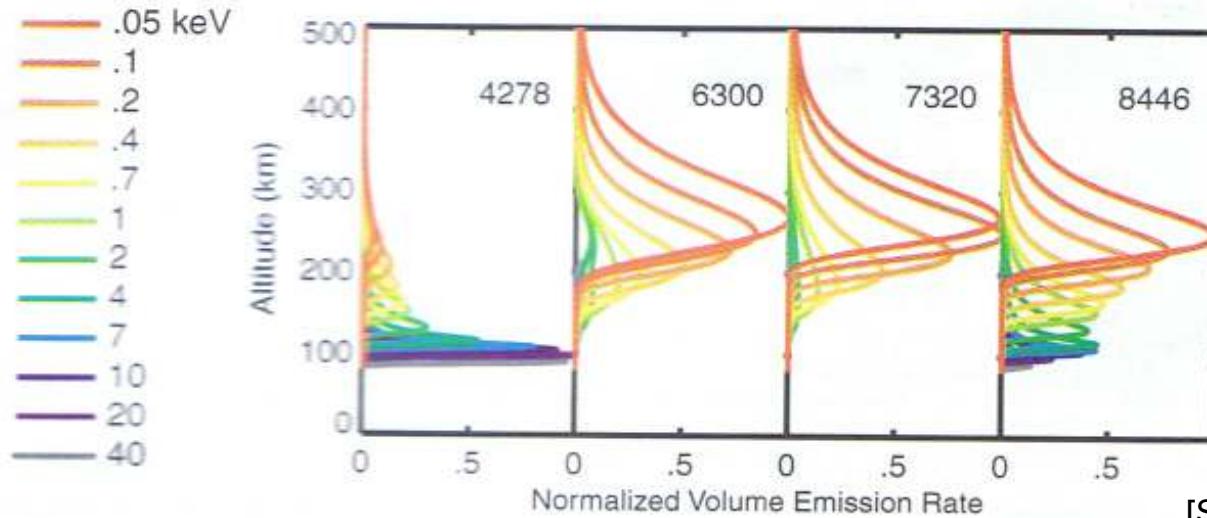
Figure 1.3. Excited states of the oxygen atom that give rise to forbidden transitions prominent in auroral emissions, and their lifetimes (after Roach and Smith, 1967). [Paschmann et. al., 2002]



Energy, Altitude, Color



Electron Precipitation
Gaussian Spectra (Discrete Aurora) [Sandholt et. al., 2002]

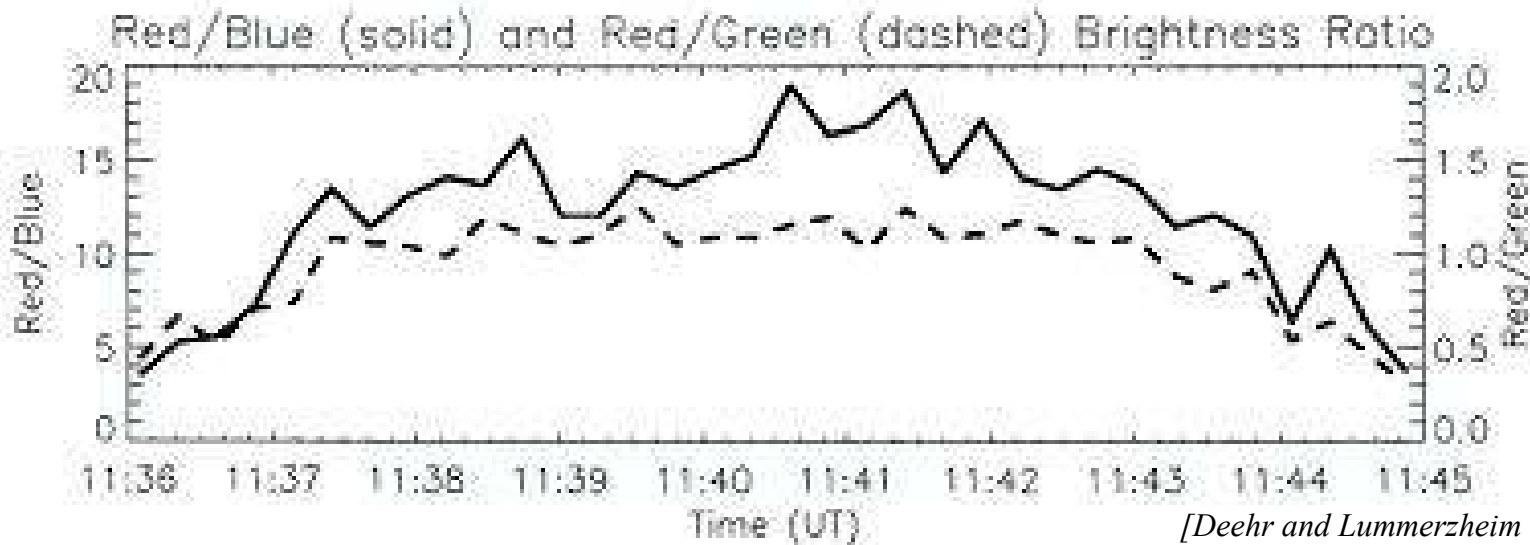
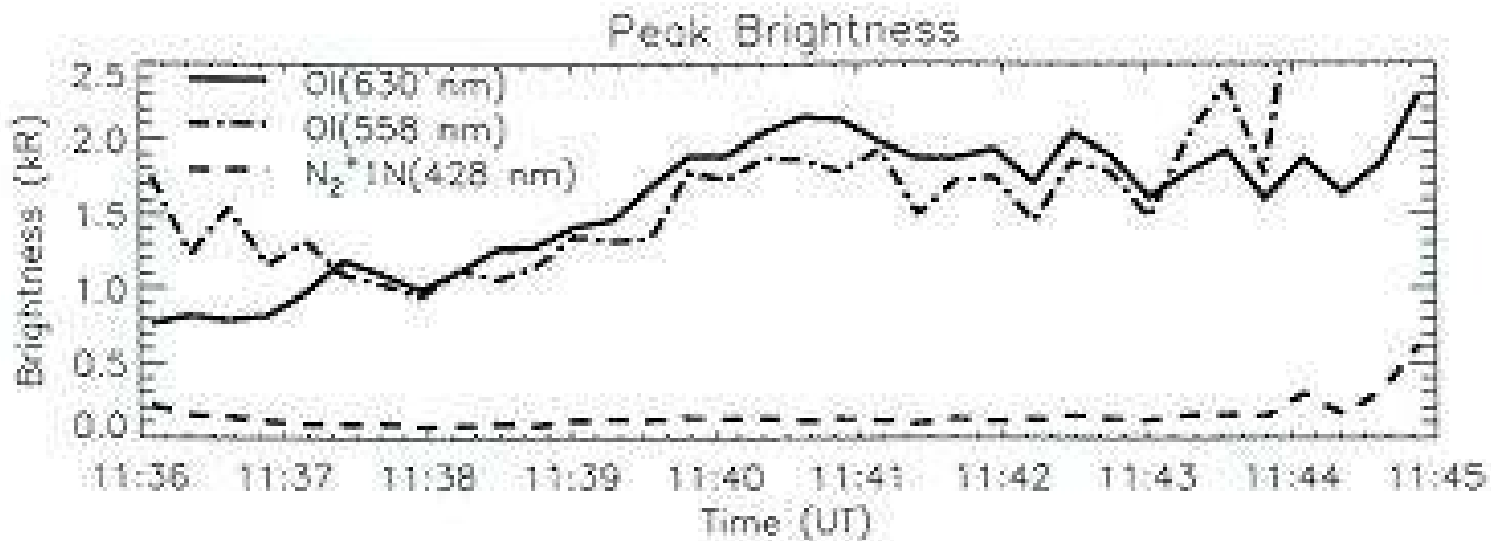


[Semeter et al, 2001]

Fig. 2. Modeled volume production profiles due to monoenergetic incident electron beams for four prominent auroral emissions.



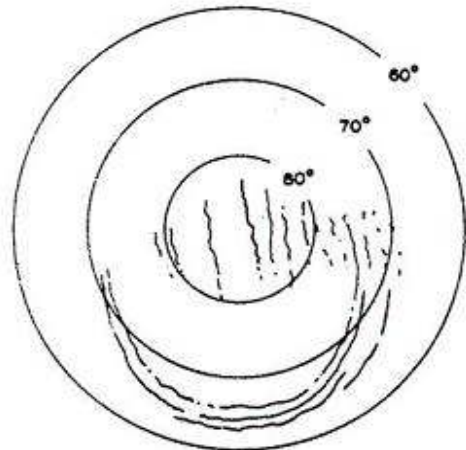
Characteristic Energy and Color Ratio



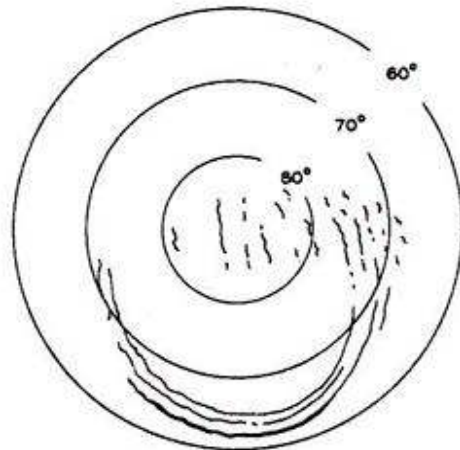
[Deehr and Lummerzheim 2001]



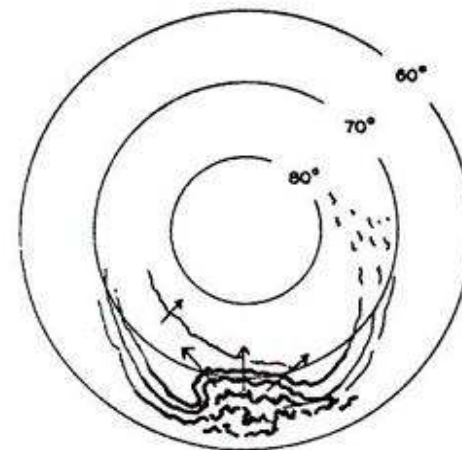
Looking up at a Substorm - All Sky Imager



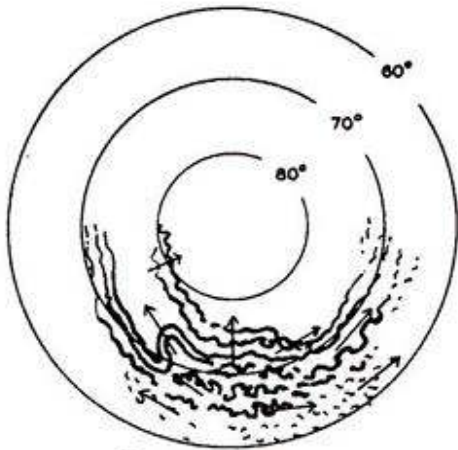
A. T=0



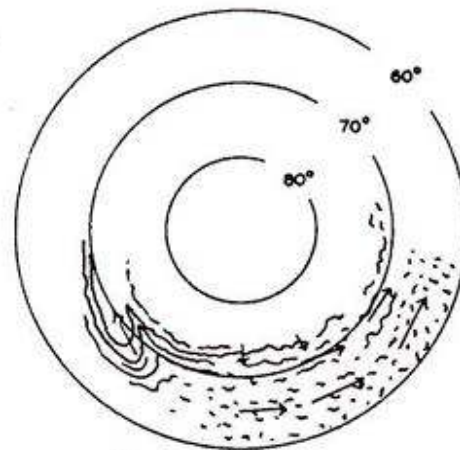
B. T=0-5 MIN



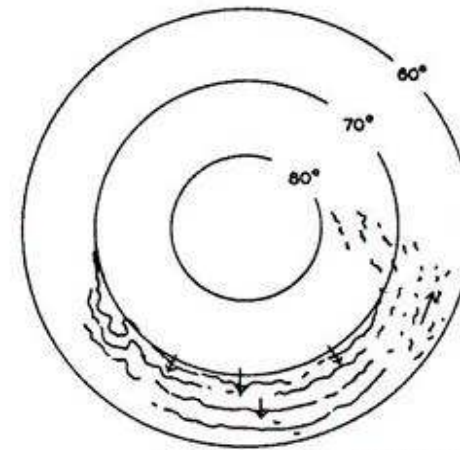
C. T=5-10 MIN



D. T=10-30 MIN



E. T=30 MIN-1 HR



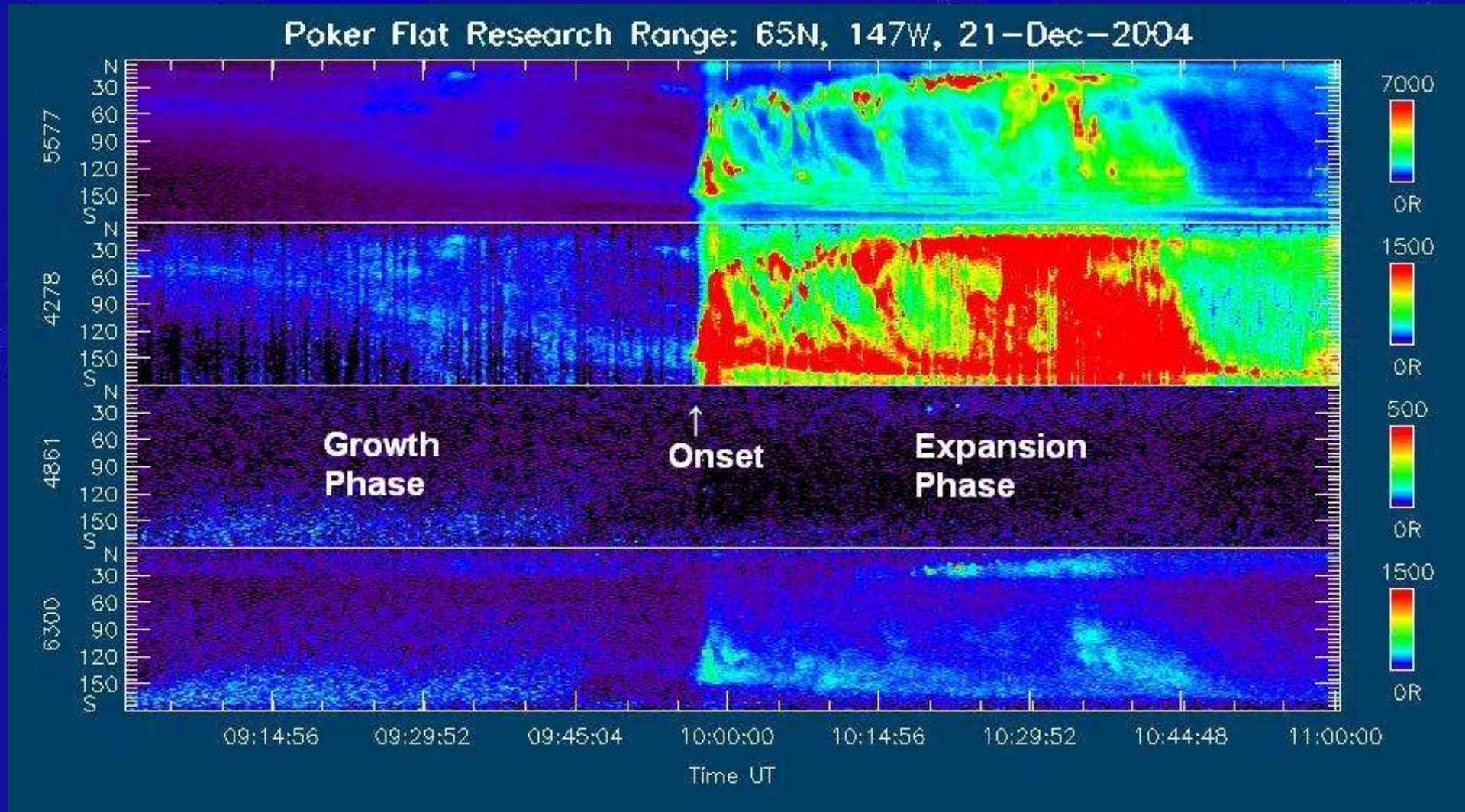
F. T=1-2 HR

T=2-3 HR
F → A

[Akasofu, 1963]

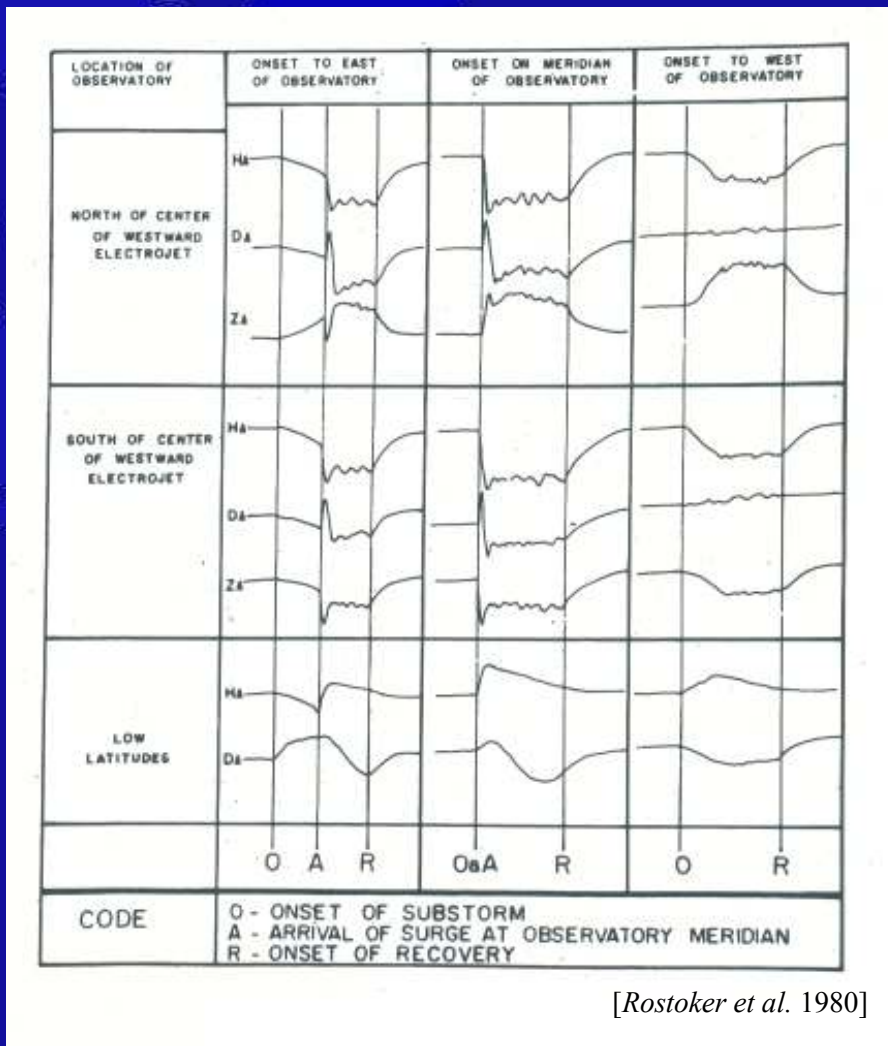


Looking up at a Substorm - Meridian Scanning Photometer





Substorm from the Ground - Magnetometer

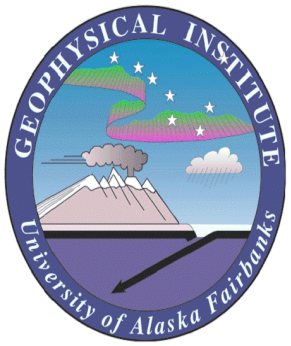


H component points along ground to magnetic pole

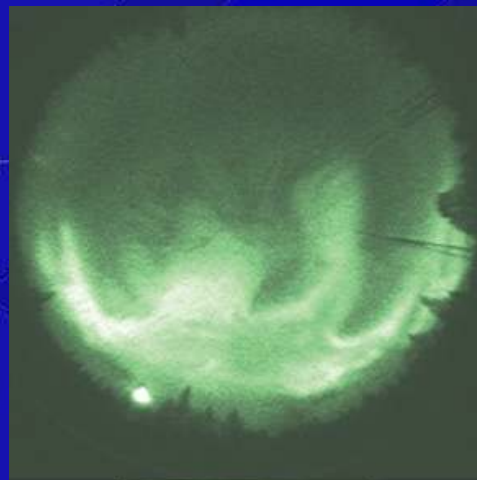
D component perpendicular to H component and along ground

Z component is pointing up, normal to ground

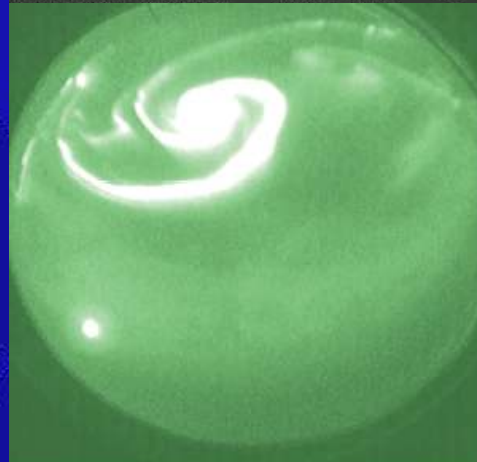
[Rostoker et al. 1980]



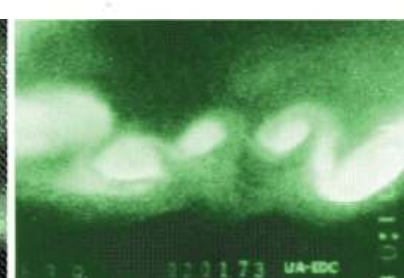
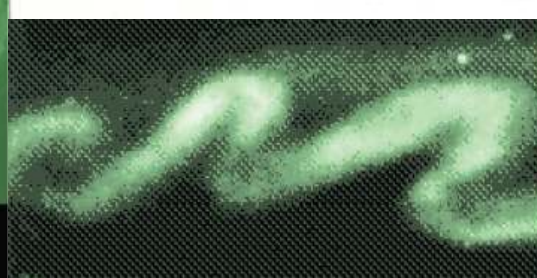
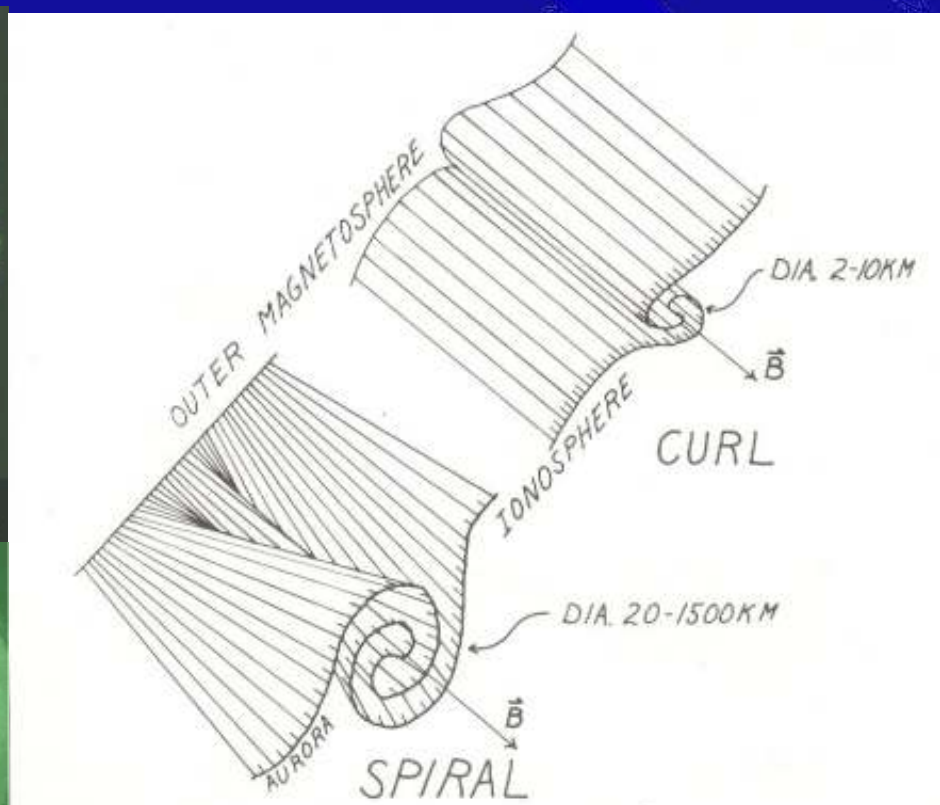
Auroral Forms

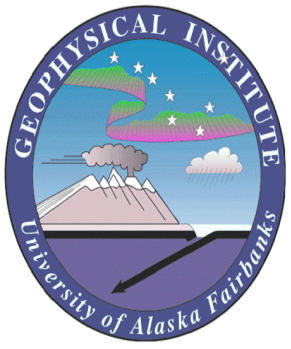


21:44:40 UTC 20 Sep 2001 N
600707 R11 Sky Camera Image Filter: 607 nm H + E



UTC 00:41:40 22 Mar 1997 N
FHI/920 R11 Sky Camera Image Filter: 607 nm H + E
Station KILPISJARVI, N69.02 E20.89 Exposure: 0520 ms S

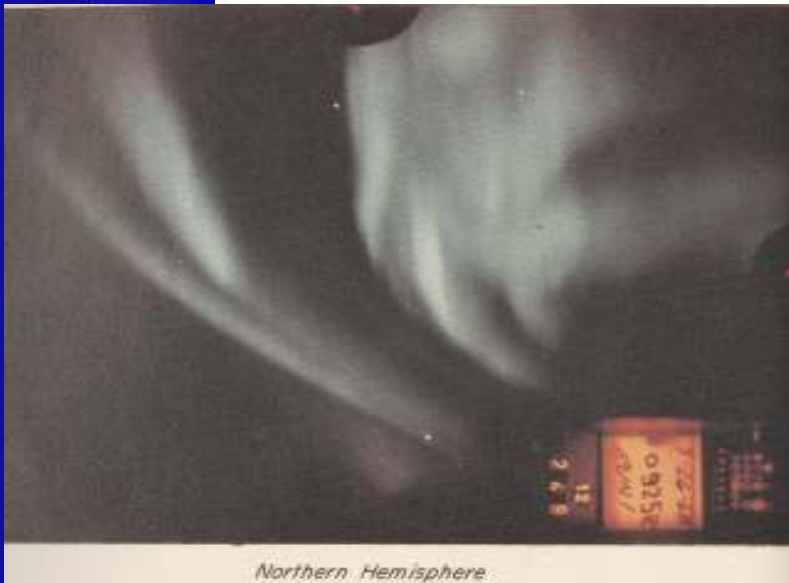
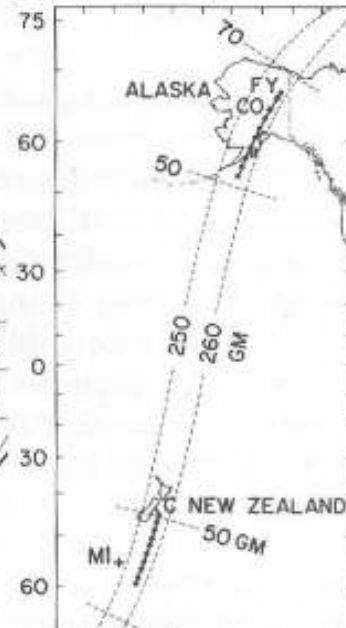
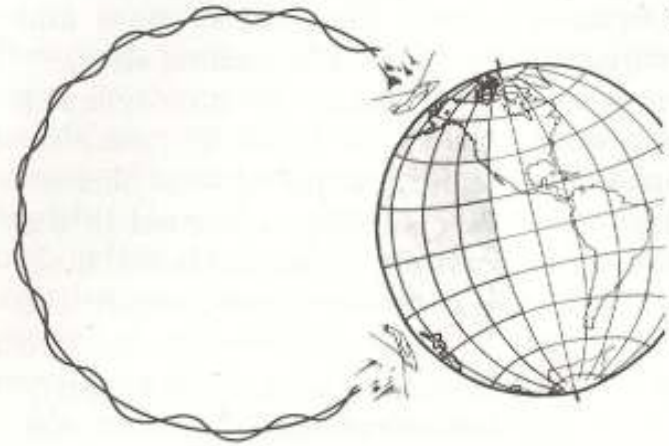




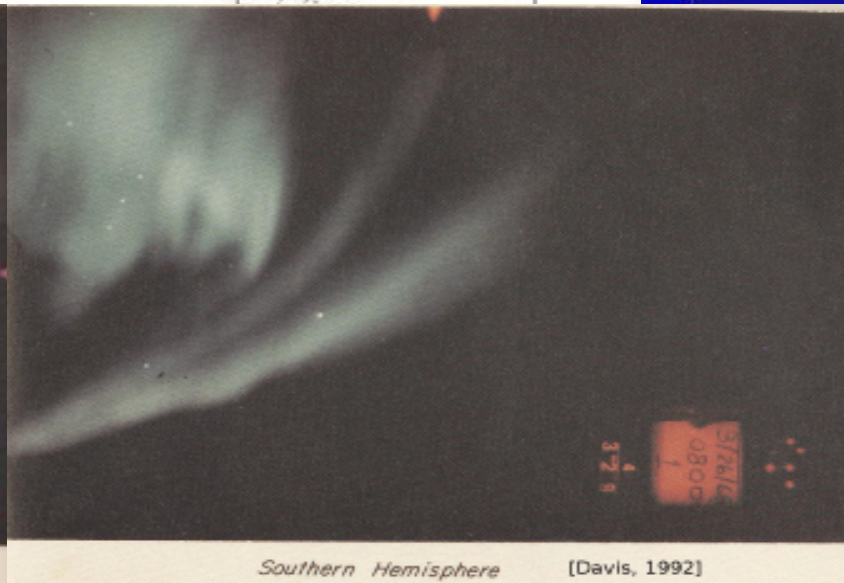
Conjugate Aurora



[Davis, 1992]

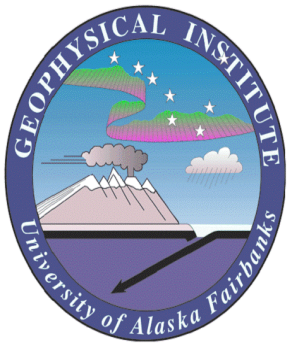


Northern Hemisphere

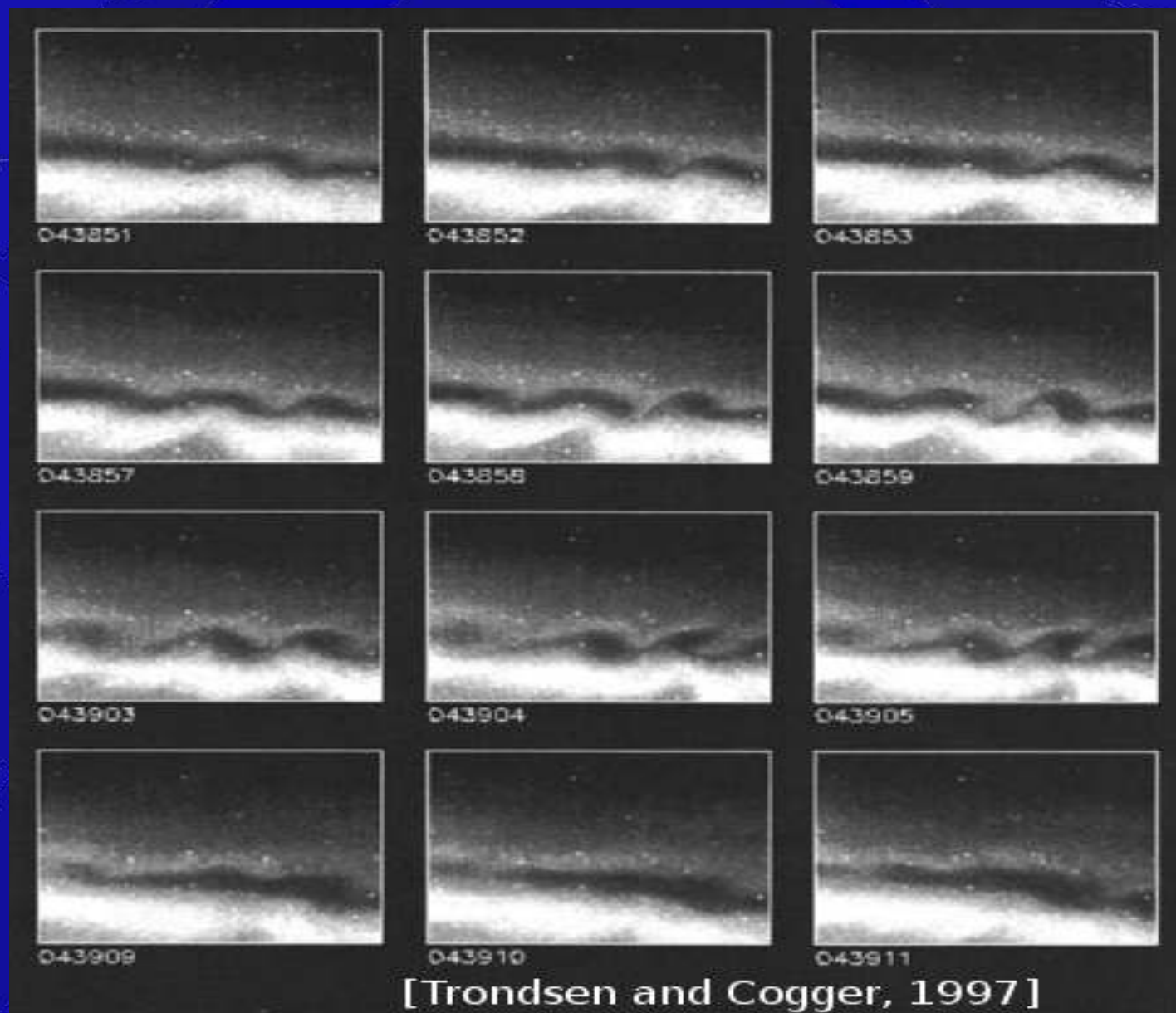


Southern Hemisphere

[Davis, 1992]



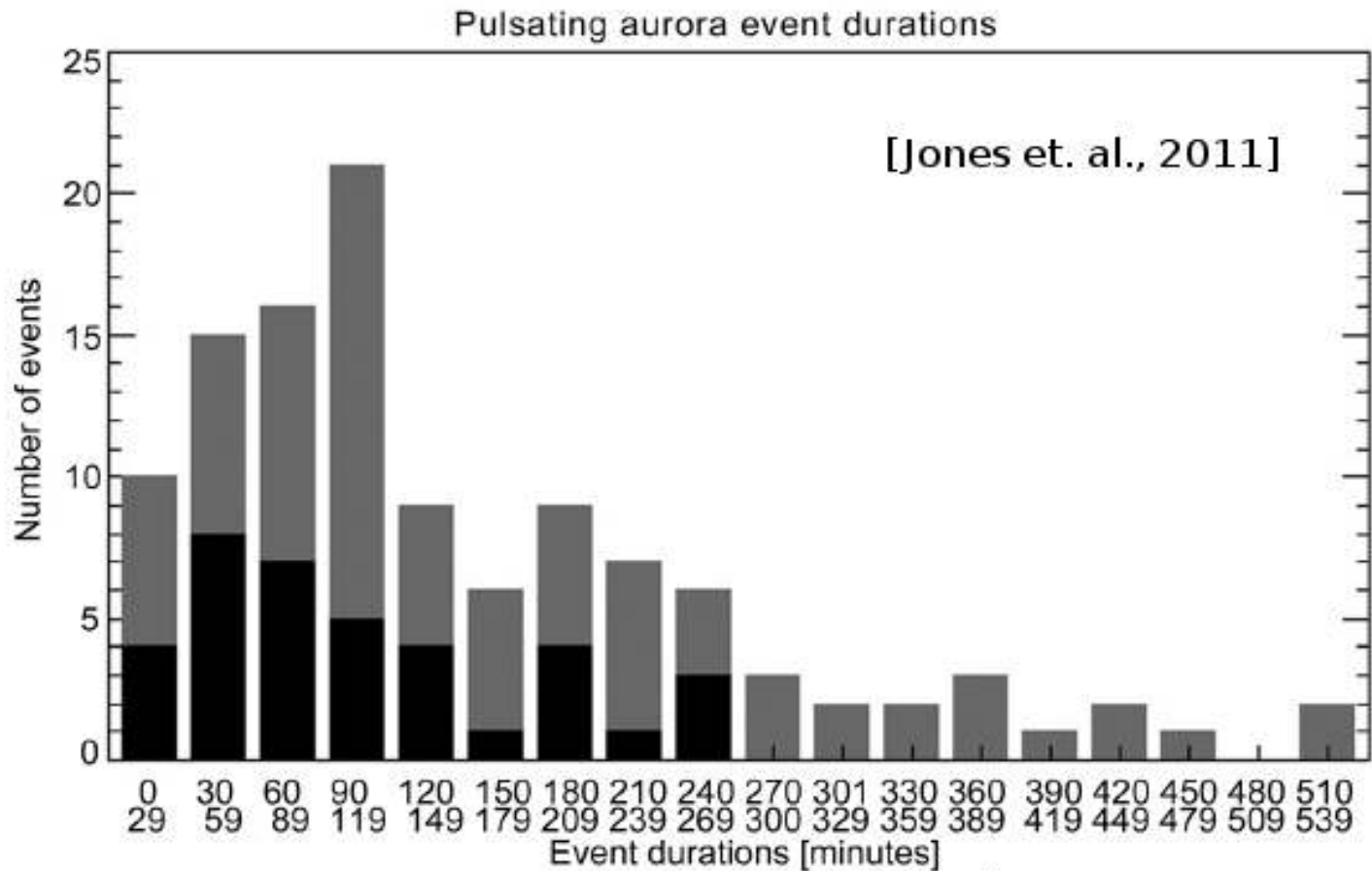
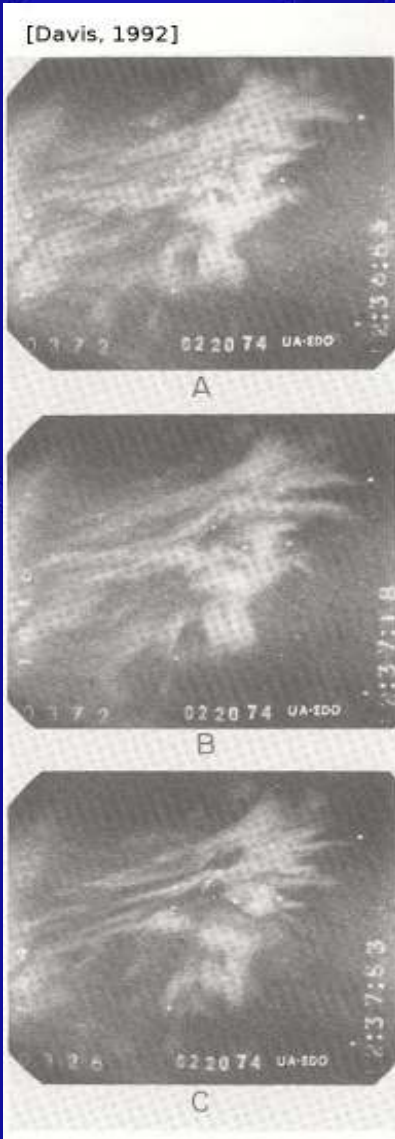
Black Aurora



[Trondsen and Cogger, 1997]



Pulsating Aurora



[1]

Coordinated Radar and Optical Observations

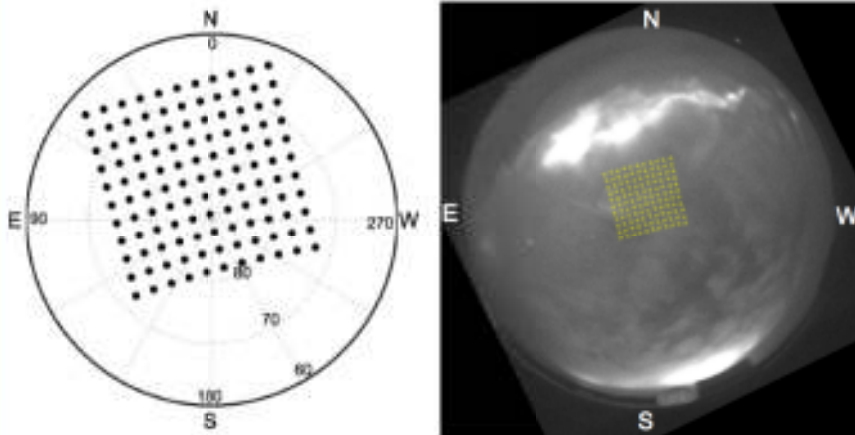


Fig. 1. a) PFISR beam positions used in this experiment, depicted in horizontal polar coordinates. b) beam positions superimposed on an image recorded with the collocated all-sky camera.

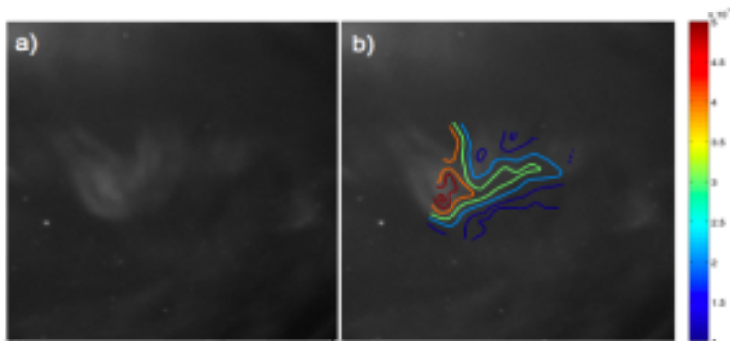
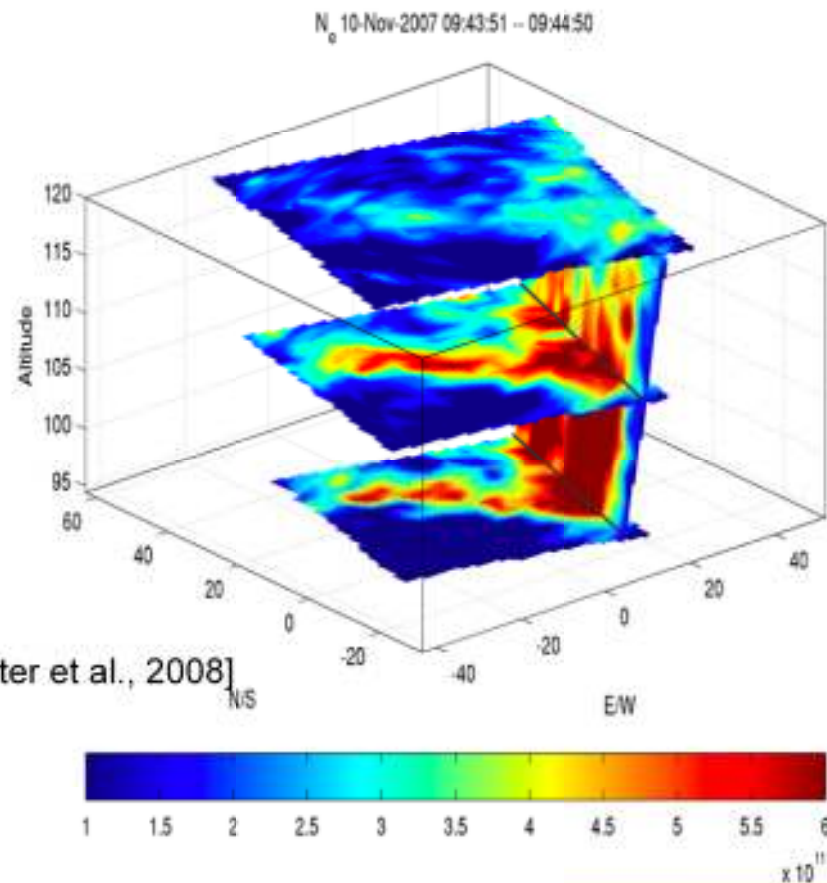


Fig. 3. a) An average auroral image corresponding to the period shown in Figure 2. The image is a cropped version of Figure 1. b) Same image overlain contours of $\int \alpha N_r^2 dr$ computed from PFISR measurements.





Acknowledgements & References



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Akasofu, S.-I., *The Development of the Auroral Substorm*, Planet. Space Sci., 12, 273

Davis, N., *The Auroral Watcher's Handbook*, University of Alaska Press, 1992

Jones, S. L., et. al., J. Geophys. Res., 116, A03214, 2011

Paschmann, G., S. Haalan, R. Treumann, *Auroral Plasma Physics*, Space Science Reviews, Vol. 103, Nos. 1-4, 2002

Sandholt, P.E., H. C. Carlson, Alv Egeland, *Dayside and Polar Cap Aurora* Kluwer Academic Publishers 2002

Semeter, J. et. al., *JASTP*, **71**, pp 738-743, 2008.

Semeter, J., et al. *JATP* **63**, pp 1981-1992, 2001

Trondsen, T.S., and L. L. Cogger, *High-resolution television observations of black aurora*, *JGR*, Vol. 102, NO. A1, 1997



Thank You!



Carl Stormer and Assistant Observing