Using Photometer Data to Map the Magnetosphere

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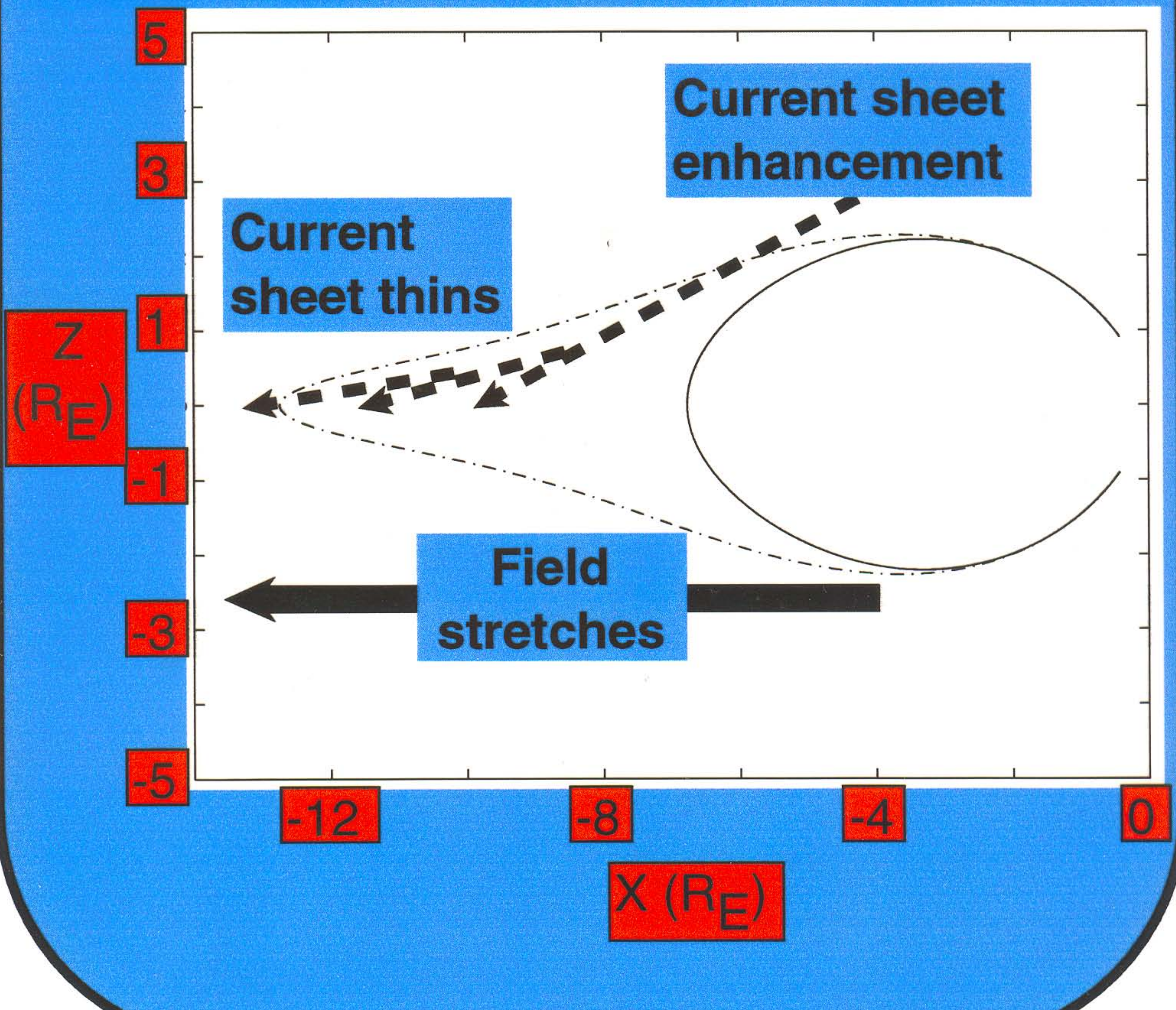
Introduction

* Our thesis is that growth phase proton aurora can be largely explained by proton precipitation out of the thin tail current sheet.

* **How will we test this thesis?**

1. Find the thickness of the current sheet during the substorm growth phase.
2. Determine the inner edge of the PS during the growth phase.
3. Determine the location of the region in the ionosphere where proton precipitation occurs

Magnetic topography during Growth phase



Magnetic Field Model

$$\vec{B}(\vec{r}) = \vec{B}_{Dipole}(\vec{r}) + \vec{B}_{Tail}(\vec{r}) + \vec{B}_{WFR}(\vec{r})$$

Tail Field

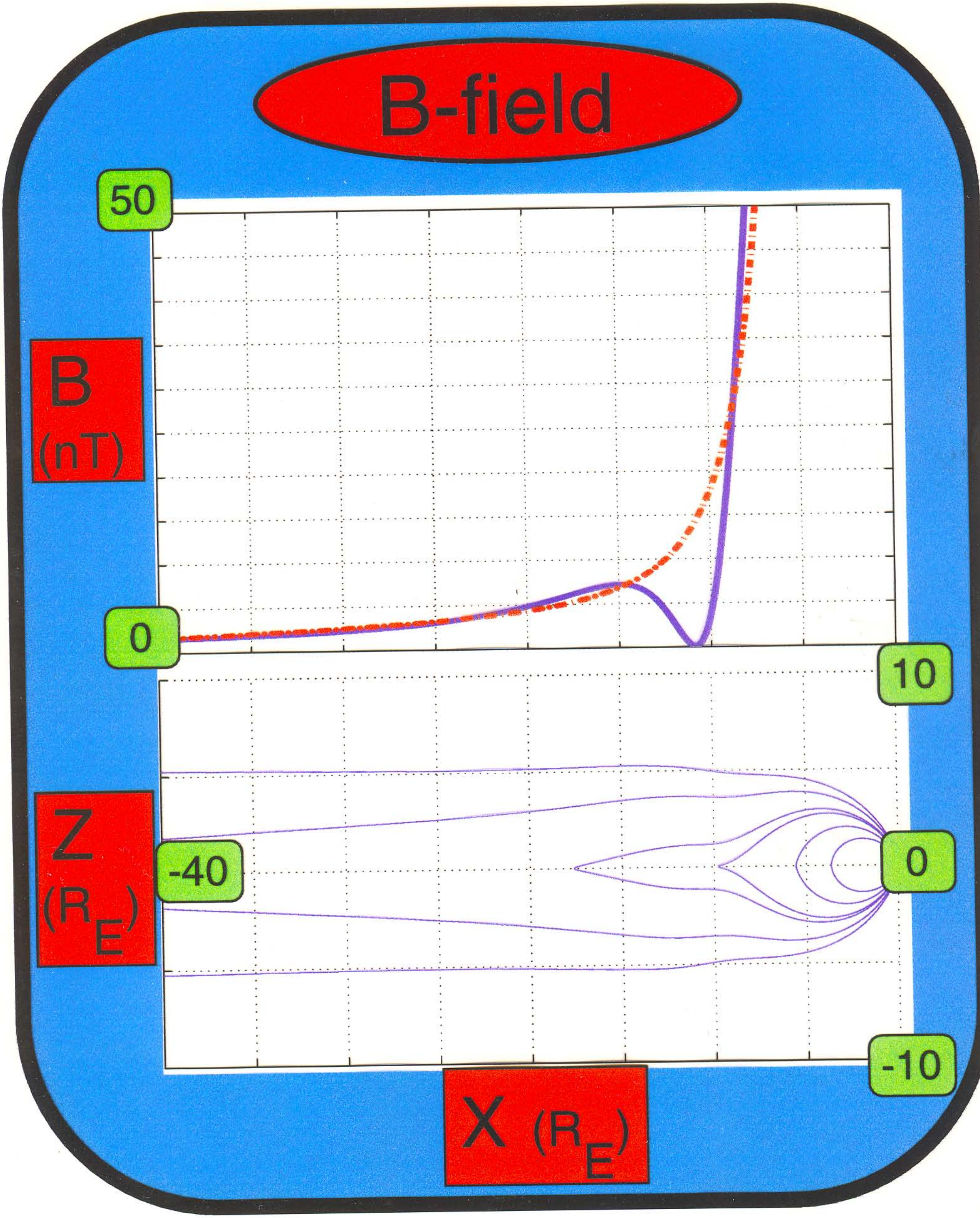
$$B_X = B_0 F(x) tanh(F(x)\frac{z}{L_z})$$

$$B_Z = (B_0 L_z \frac{\partial_x F(x)}{F(x)}[1 + F(x)\frac{z}{L_z} tanh(F(x)\frac{z}{L_z})])$$

Weak field region

$$B_y = B_p L_y sech(\frac{\overline{x}}{L_y}) tanh(\frac{y}{L_y}) \partial_z G(z)$$

$$B_z = B_n - B_p sech(\frac{\overline{x}}{L_y}) sech^2(\frac{y}{L_y}) G(z)$$



B-field
50
B
(nT)
0
10
Z
(R_E)
-40
0
-10
X (R_E)

Procedure

* We begin by fitting a Gaussian function to the borders of auroral luminosity that are measured by CANOPUS meridian scanning photometers (MSP).

* Figure 1 shows an example of such a fit for the 486.1 nm emissions measured on March 9, 1995 by the Rankin Inlet and Gillam MSP stations. Typically emissions are from precipitating protons with 20 keV average energy [*Samson et al.*, 1992].

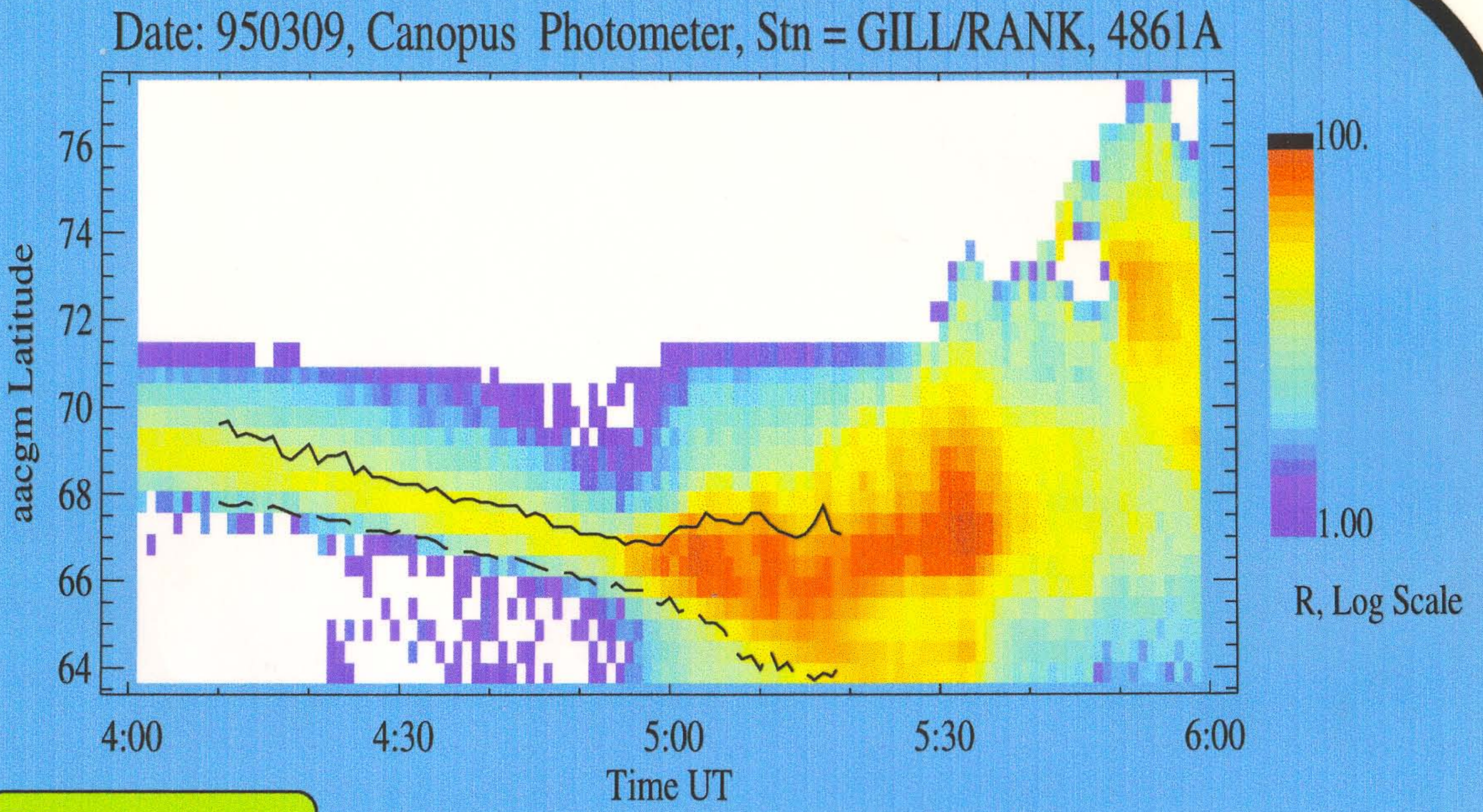


Figure 1.

March 9, 1995 photometer data in the 486.1 nm wavelength. The equatorward and poleward borders of luminosity are fitted with a Gaussian function.

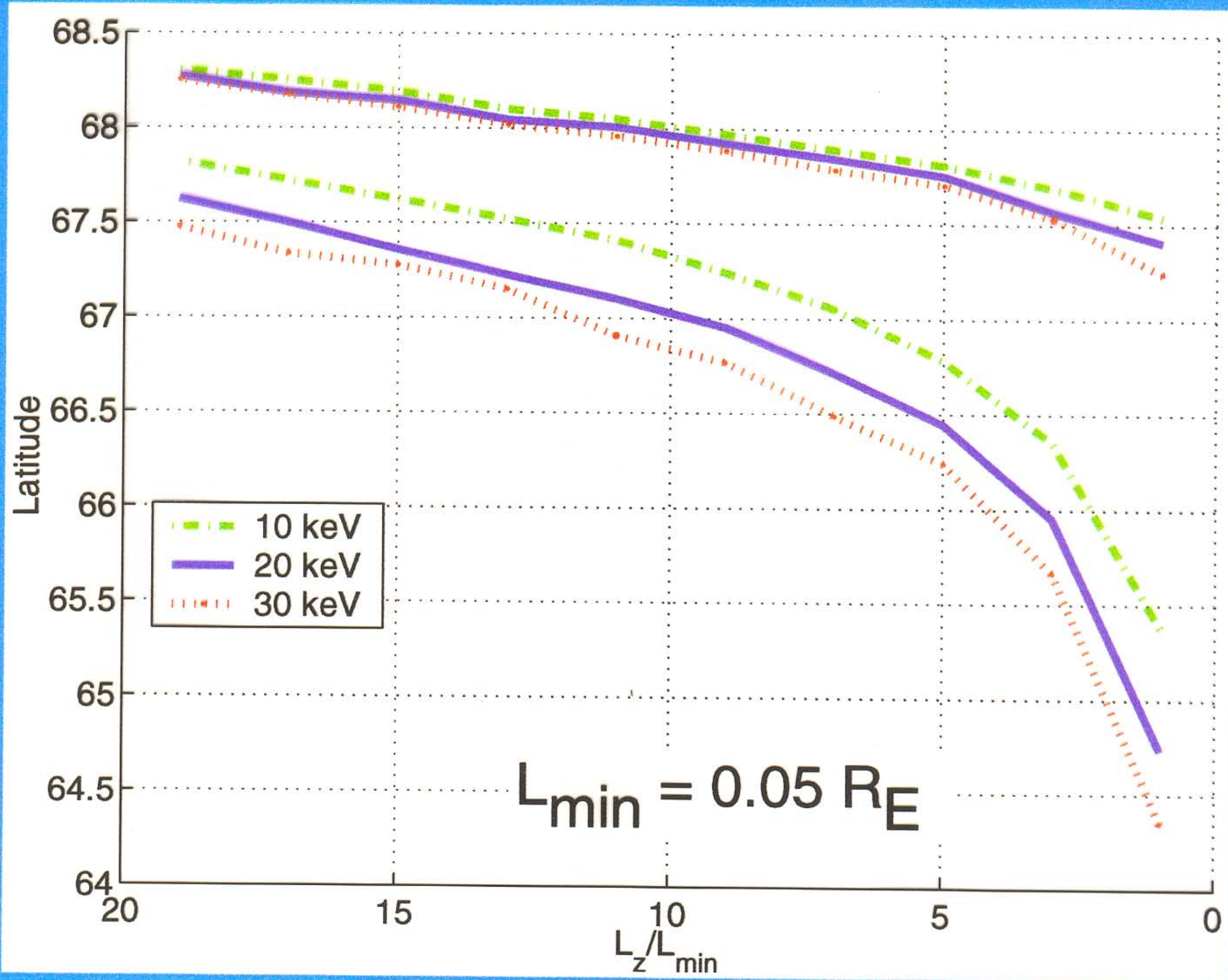


Figure 2.

Model predictions of ionospheric proton precipitation for 10, 20, 30 keV. The abscissa is the normalised model current sheet half-thickness.

Synopsis of March 9, 1995 substorm

* **Growth phase commences between 0325-0335 UT.**
  - Equatorward motion of the auroral emissions
  - Enhancement of the eastward electrojet, as observed by CANOPUS magnetometers

* **Expansive phase onset begins at 0459 UT.**
  - Poleward expansion of auroral luminosity
  - Negative magnetic X-component perturbation
  - Onset of Pi2 pulsations

March 9, 1995 substorm

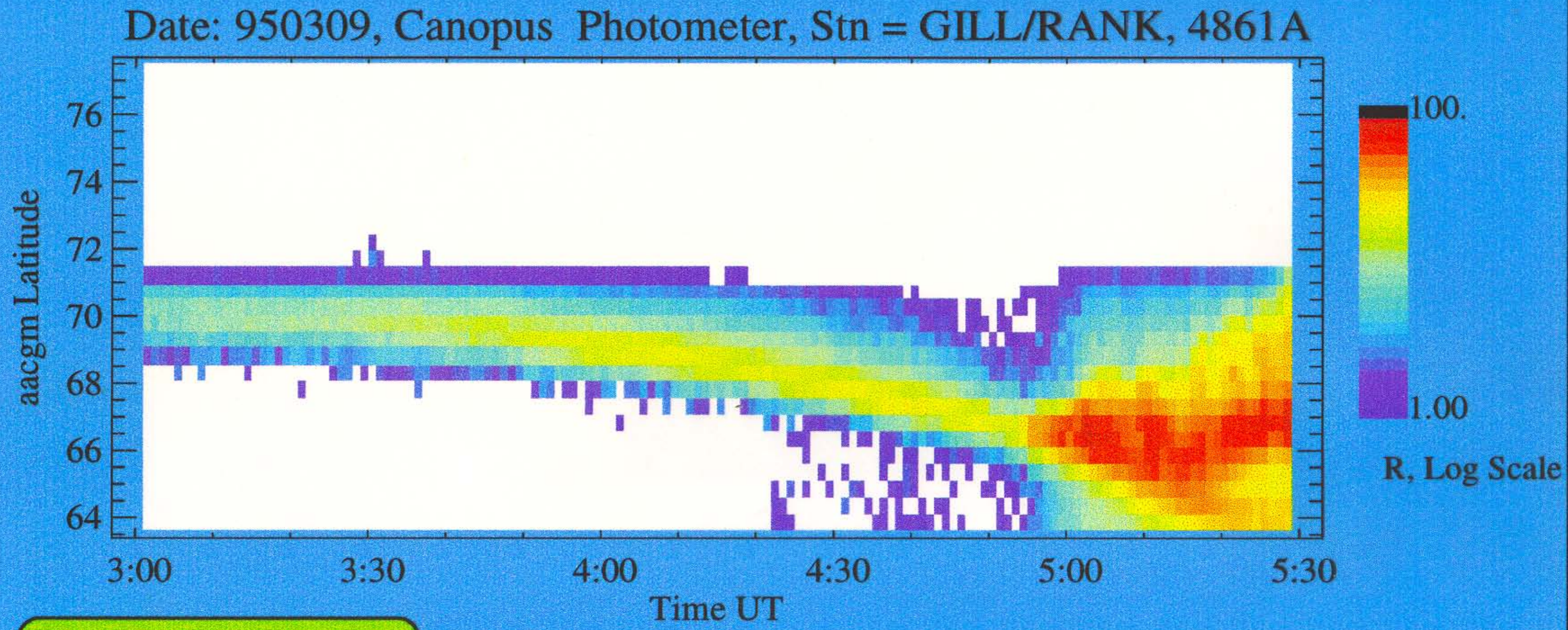


Figure 3a.

March 9, 1995 photometer data in the 486.1 nm wavelength, showing the growth phase and intensification at expansive phase onset. Local time is UT minus 6 hours.

* The model fit in Figure 3b (circled markers) is obtained by varying the current sheet half-thickness parameter, L_Z , and doing a least squares fit to the MSP data.

* The predicted precipitation region of 5-30 keV protons follows the MSP emissions extremely well.

* The current sheet thickness decreases exponentially during the course of the growth phase (Figure 3c). The decay constant between 270-310 UT minutes is $t = 9.6$ min.

* Note the good correlation between the thinning current sheet, corresponding to magnetic field line stretching, and the equatorward motion of the aurora (Figures 3b,c).

* *Samson et al.* [1992] showed that the equatorward border of auroral luminosity maps to the inner edge of the plasma sheet. In Figure 3c the solid curve shows the model position of the plasma sheet inner edge. The plasma sheet moves earthwards during the growth phase and is at X = -5.7 Re at expansive phase onset.

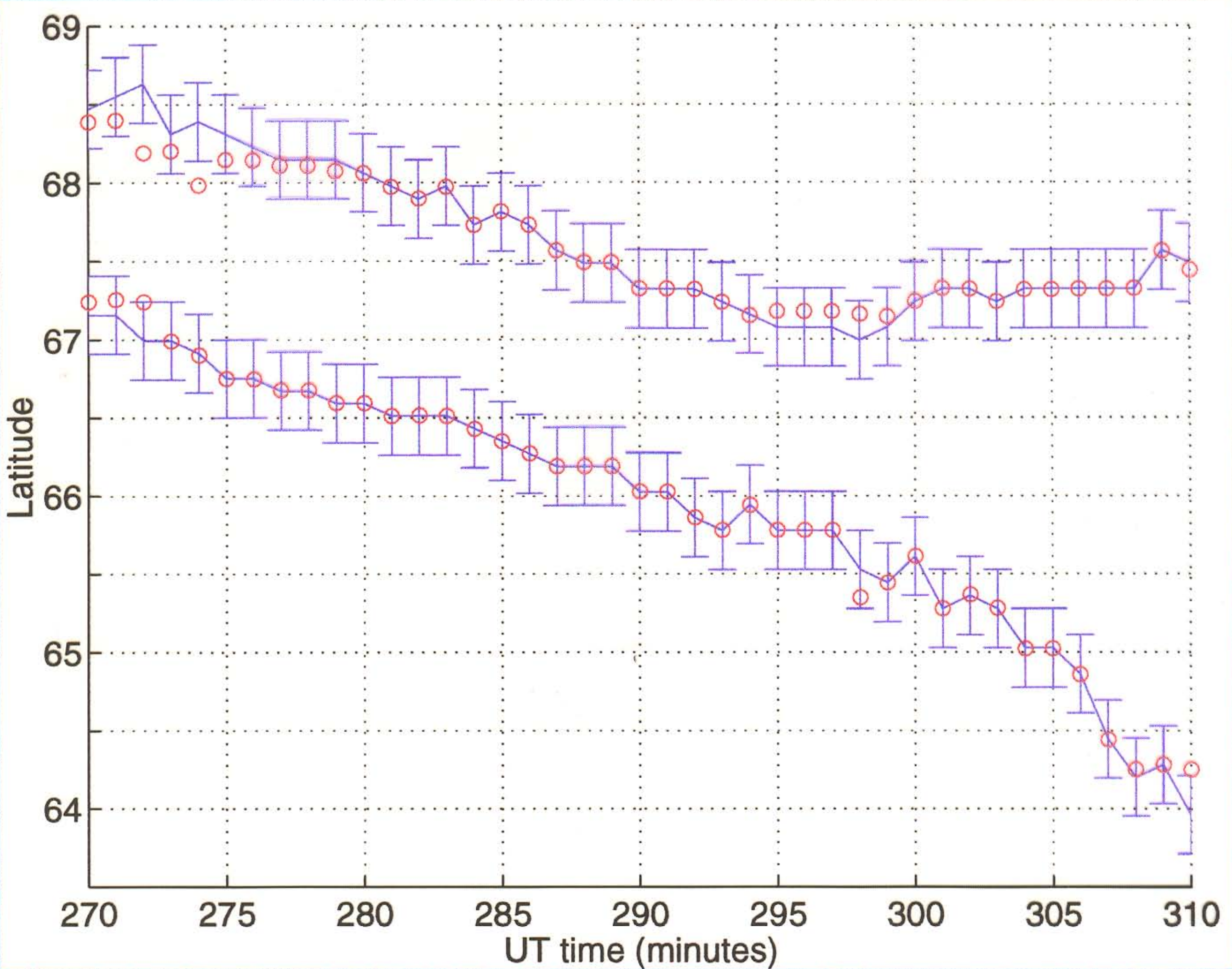


Figure 3b.

March 9, 1995 emission boundaries are shown as solid lines with error bars. Best fit values, calculated from the model precipitation regions, are shown as circles.

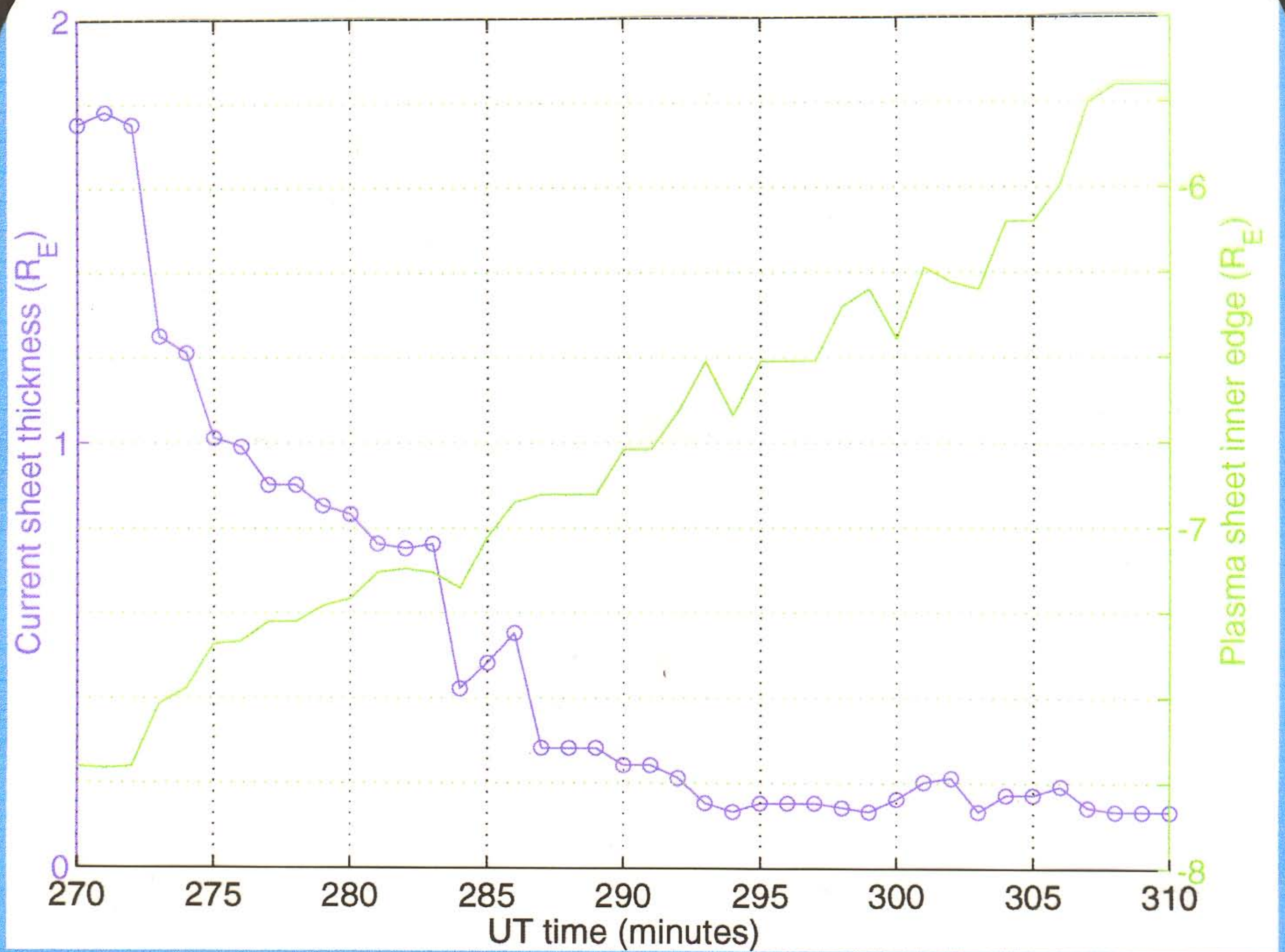


Figure 3c.

March 9, 1995 model predictions for current sheet thickness at 8 Re (circles), and plasma sheet inner edge position (right ordinate)

Conclusions

* Growth phase 486.1 nm auroral emissions are largely explained by proton precipitation out of the thinning tail current sheet.

* Magnetic field line stretching is correlated with equatorward motion of the proton aurora.

* Tail current sheet can thin to less than 0.2 Re during growth phase.

* Inner edge of plasma sheet moves earthwards during growth phase; can be inside 6 Re at expansive phase onset.