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Magnetic Local Time (MLT) and geomagnetic activity variations in signatures of the Open-Closed magnetic field-line Boundary (OCB)

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The nightside SWB/OCB problem:

- **Here we investigate whether the HF radar spectral width boundary (SWB) is a reasonable proxy for the OCB in the evening, midnight, and morning sectors during quiet and disturbed geomagnetic conditions, including small to moderate substorms.**

- **The nightside SWB was observed using the Tasman International Geospace Environment Radar (TIGER) located on Bruny Island, Tasmania (43.4°S, 147.2°E; –54.5°Λ).**

- **The OCB was taken as the most poleward edge of the ion or electron auroral oval measured using SSJ/4 particle detectors on board DMSP satellites orbiting at an altitude of 830 km.**

- **Whilst allowing for experimental errors, the location of the satellite-based OCB was compared with the location of the HF radar SWB on three different evenings: 1 April, 5 September, and 31 October, 2000.**

Experimental errors involved in comparing the DMSP OCB and radar SWB include:

(1) Estimating of the OCB from the DMSP dynamic spectra, probably <1° in latitude.

(2) Mapping the DMSP measurements to AACGM latitude, probably <0.5°.

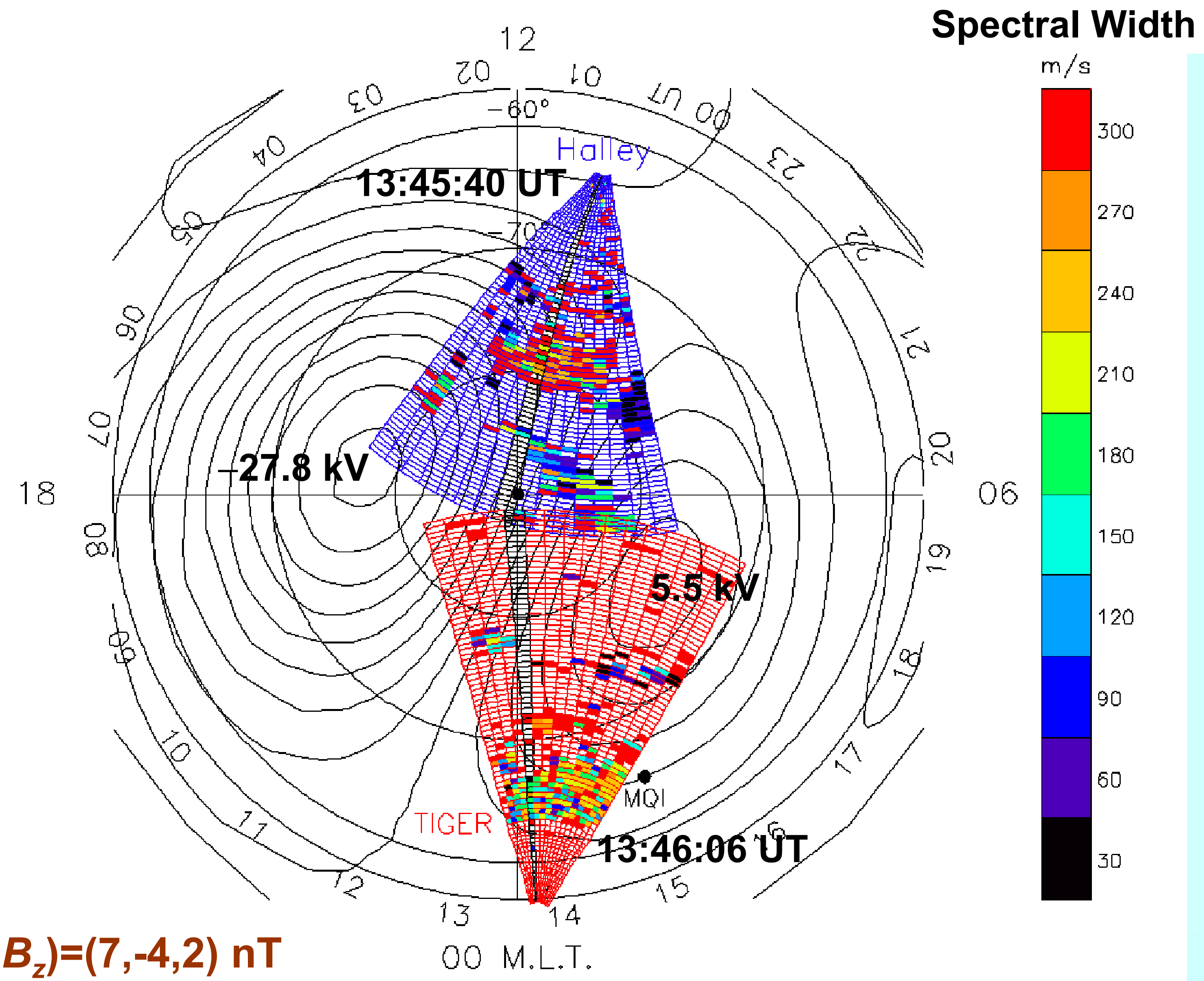
(3) Mapping the radar scatter from group range to magnetic latitude, probably <1°.

(4) Defining the latitude the radar SWB, probably <1°.

(5) Geophysical fluctuations in either boundary that are too rapid in space and time to resolve, probably <1°.

Adding these errors in quadrature provides an estimate of the maximum error: $\sqrt{4.25} \approx 2°$

Experimental configuration:



(B_x, B_y, B_z)=(7,-4,2) nT

Solar-wind and geomagnetic conditions, 1 April 2000

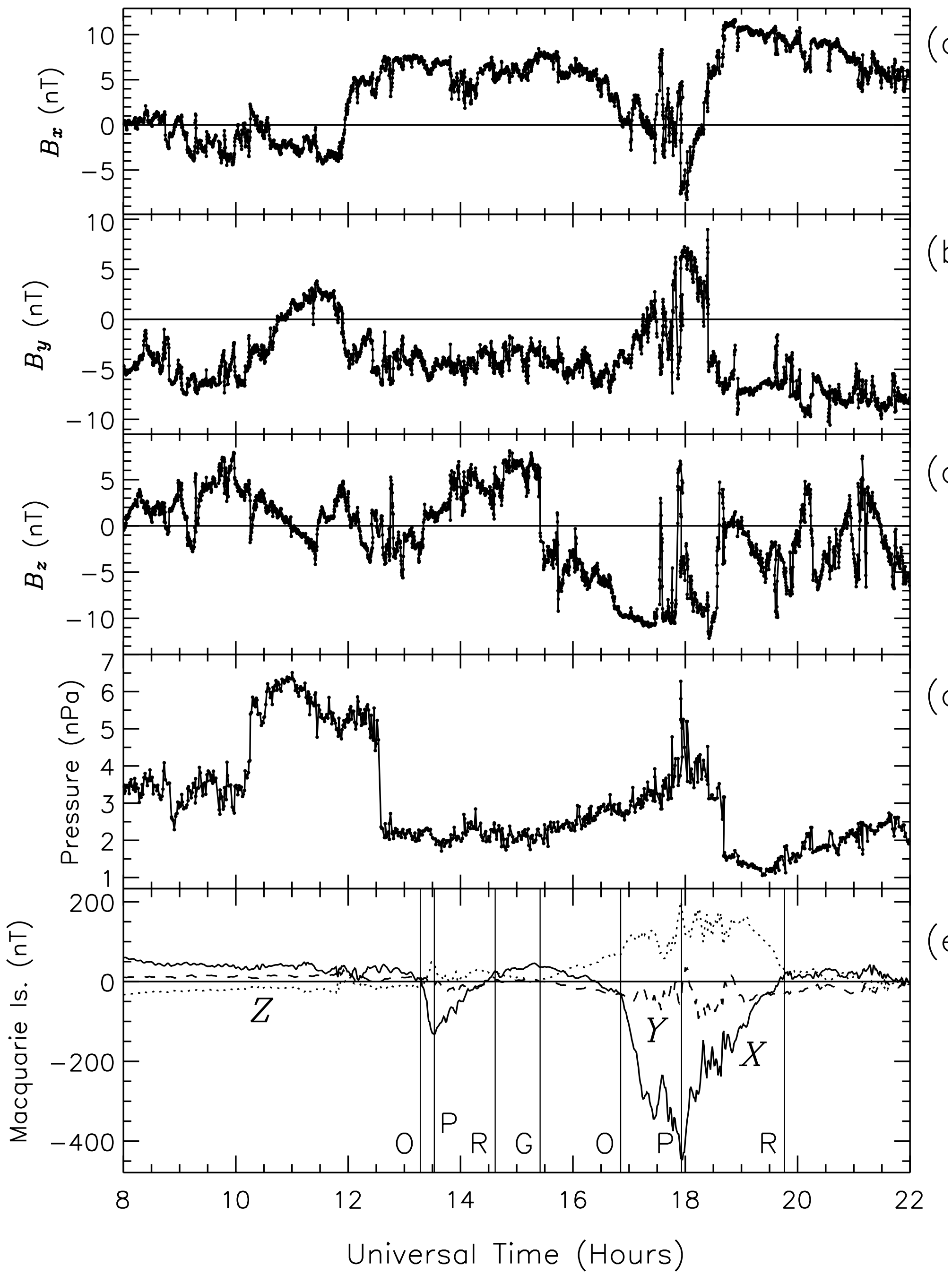
(a) *ACE* IMF B_x

(b) *ACE* IMF B_y

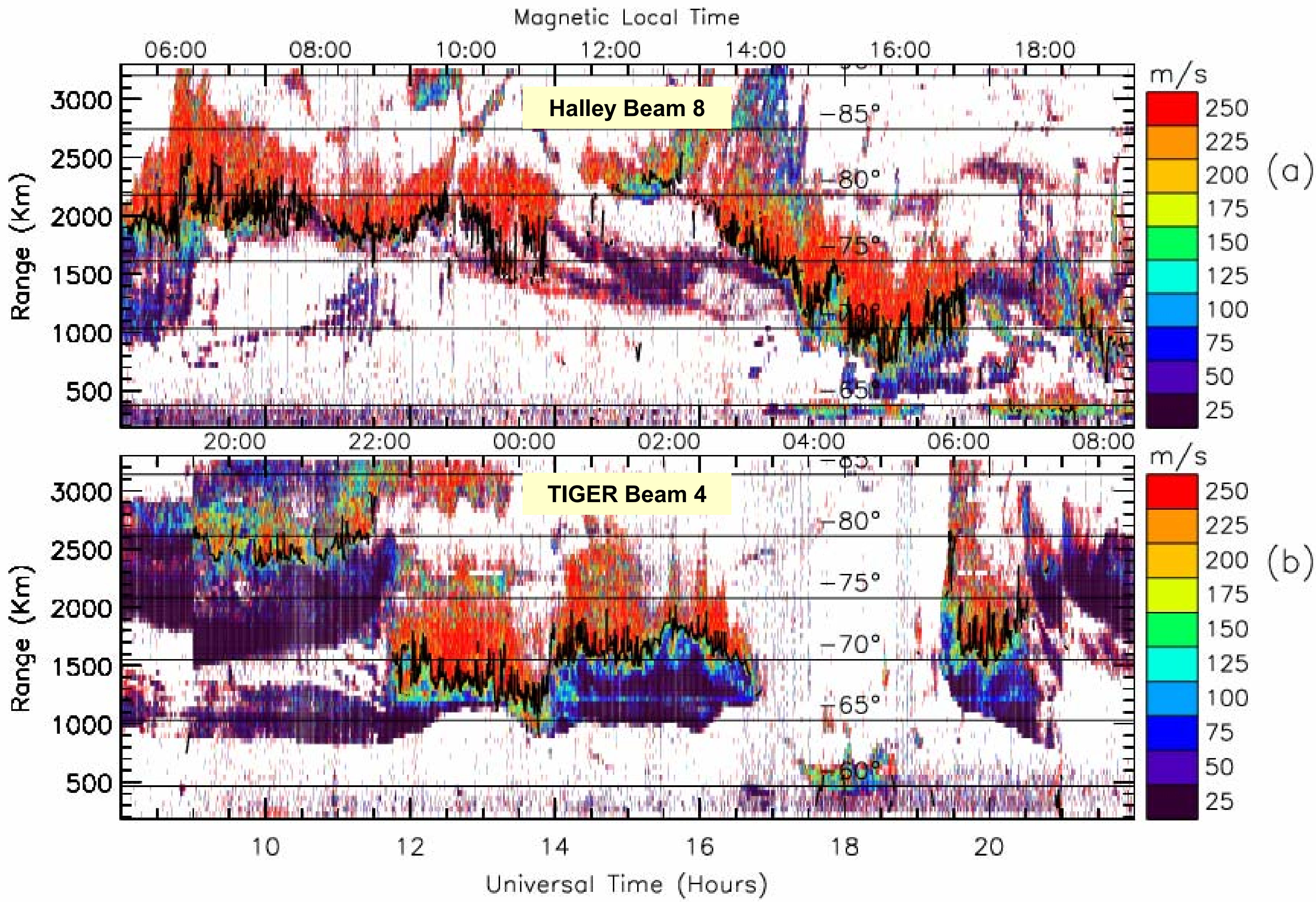
(c) *ACE* IMF B_z

(d) *ACE* dynamic pressure

(e) Macquarie Is. fluxgate magnetometer



Spectral width vs. group range and time, 1 April 2000



Spectral Width Boundary (SWB) width, 1 April 2000

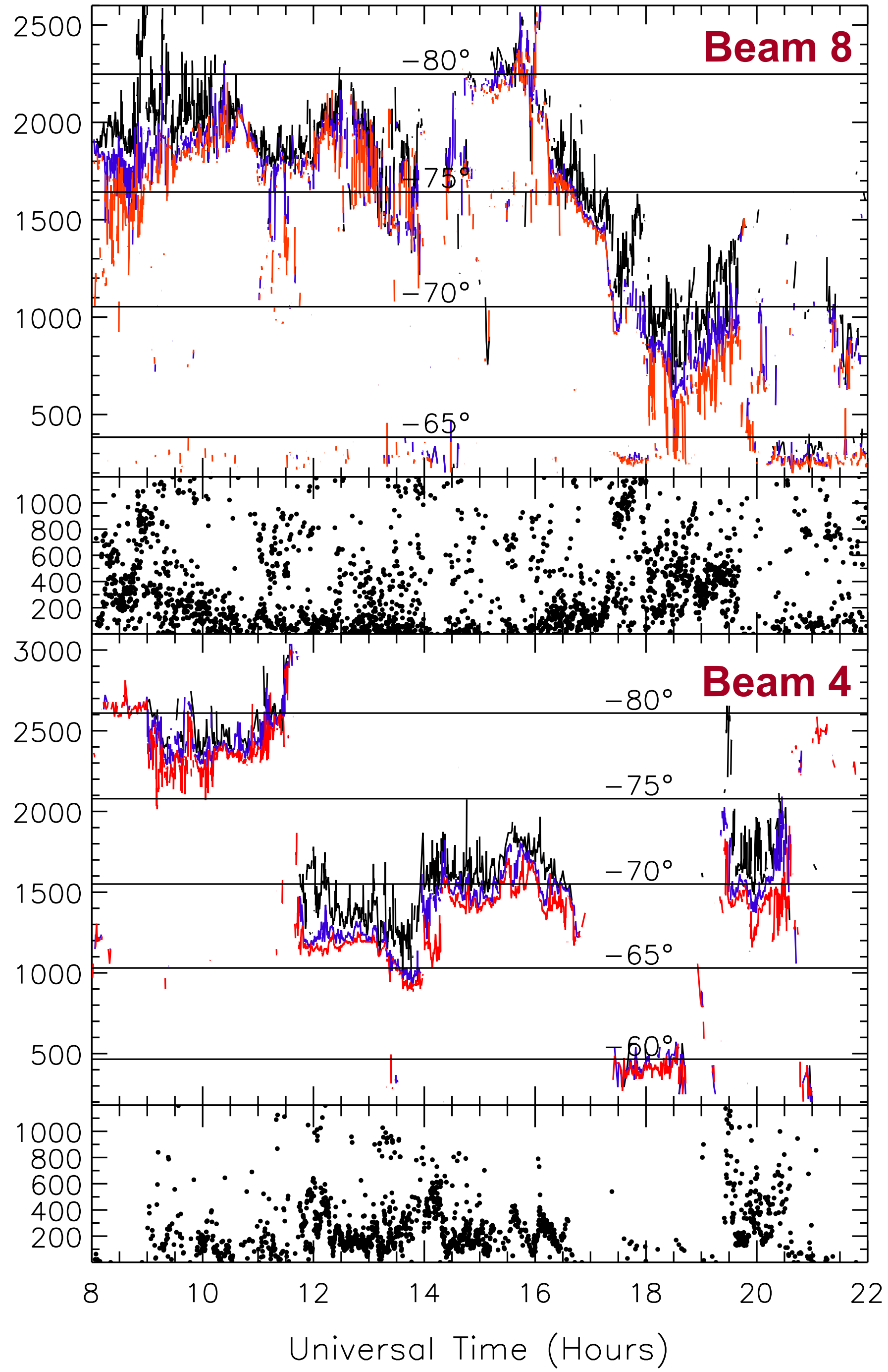
SWB **threshold 200 m s^{-1}**
SWB **threshold 100 m s^{-1}**
SWB **threshold 50 m s^{-1}**

(a) ***SWB*** **s, Halley beam 8**

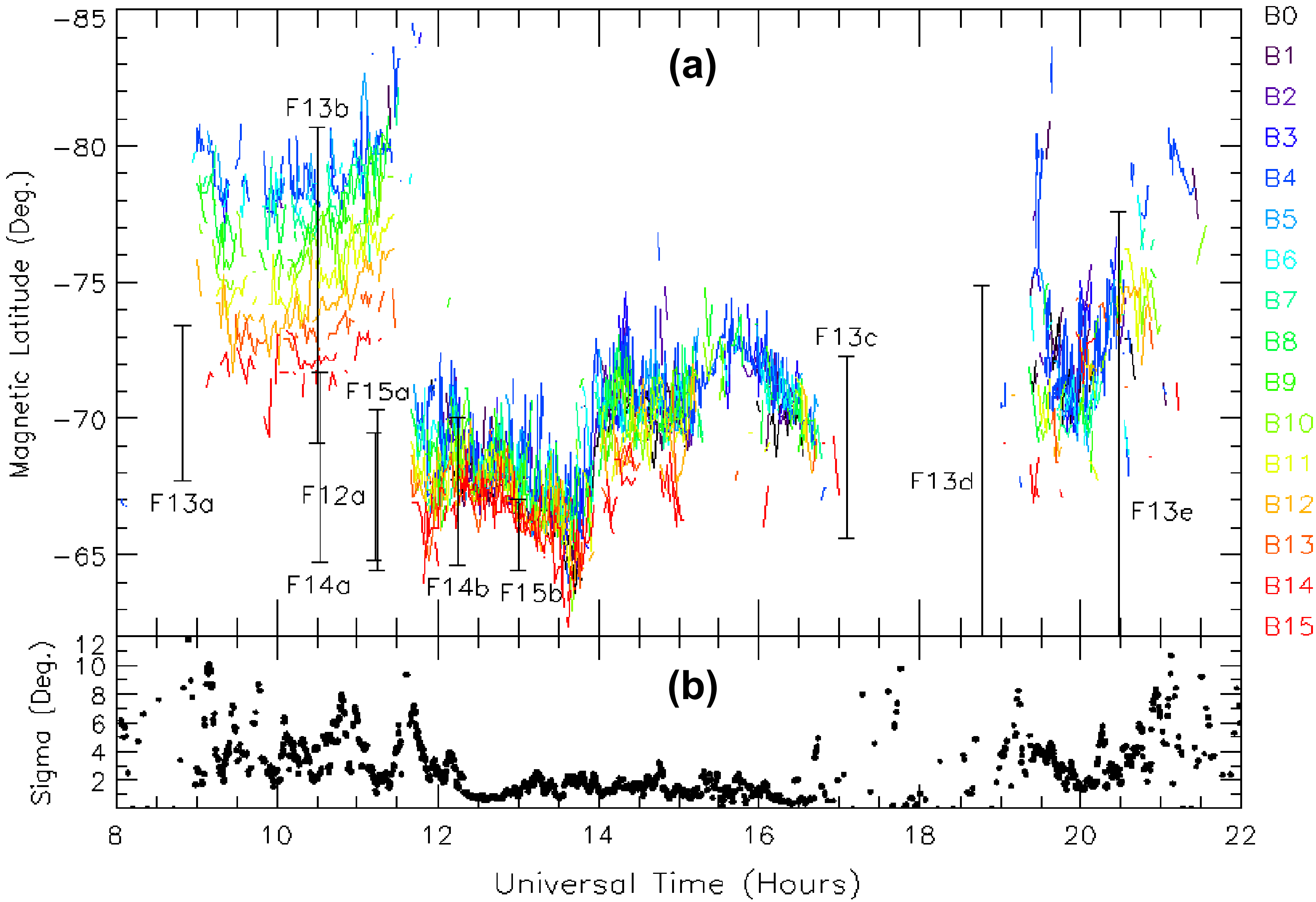
(b) ***SWB*** $_{200\ m/s}$ – ***SWB*** $_{50\ m/s}$

(c) ***SWB*** **s, TIGER beam 4**

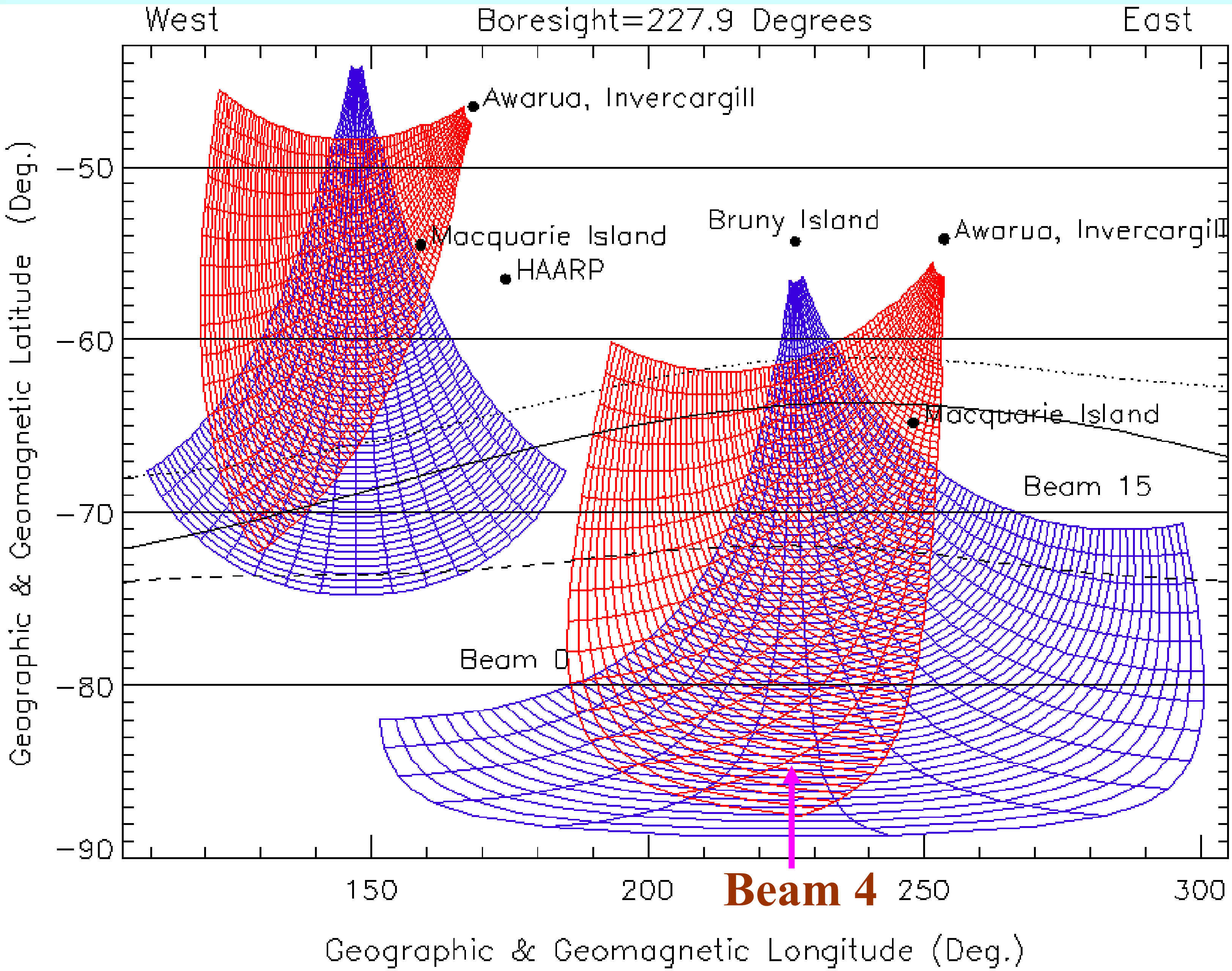
(d) ***SWB*** $_{200\ m/s}$ – ***SWB*** $_{50\ m/s}$



Spectral Width Boundary (SWB) vs. MLAT and time

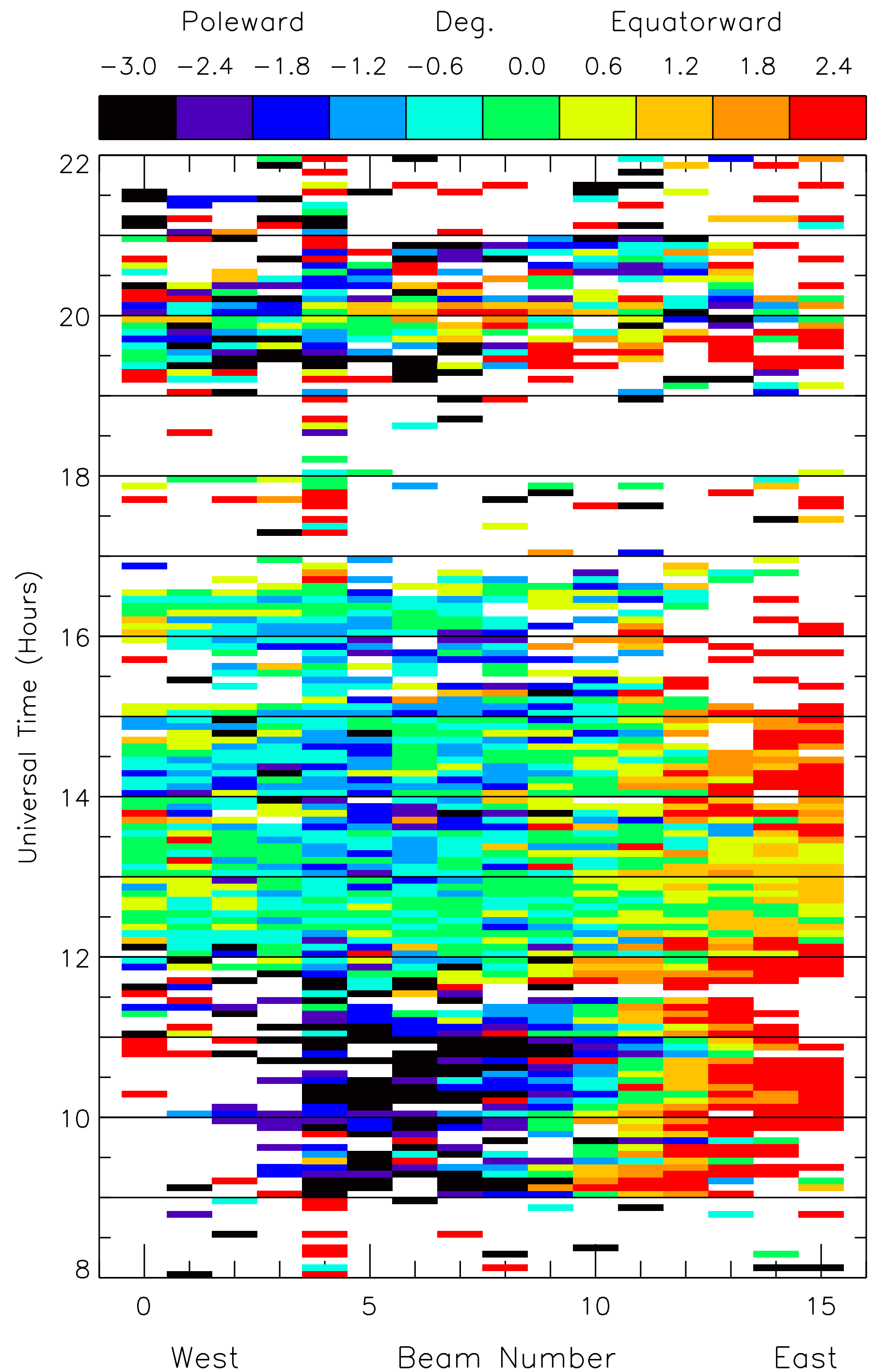


TIGER I & II Field Of Views (FOVs):



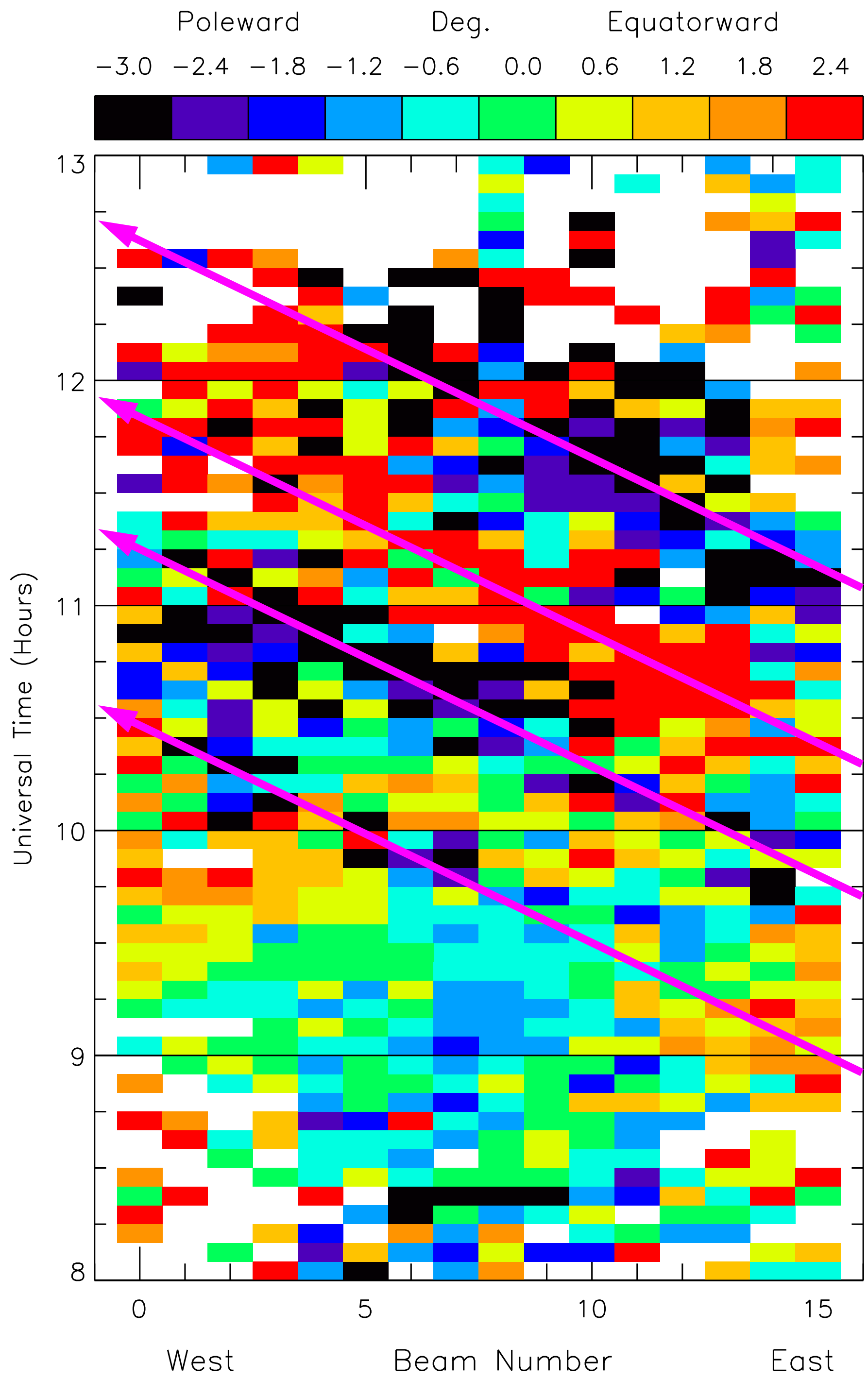
Variations in Spectral Width Boundary (SWB) shape, 1 April 2000

TIGER Full Scans, 5-minute intervals



Variations in Spectral Width Boundary (SWB) shape, 3 April 2000

Halley Full Scans, 5-minute intervals



TIGER Spectral Width Boundary, 5 September 2000

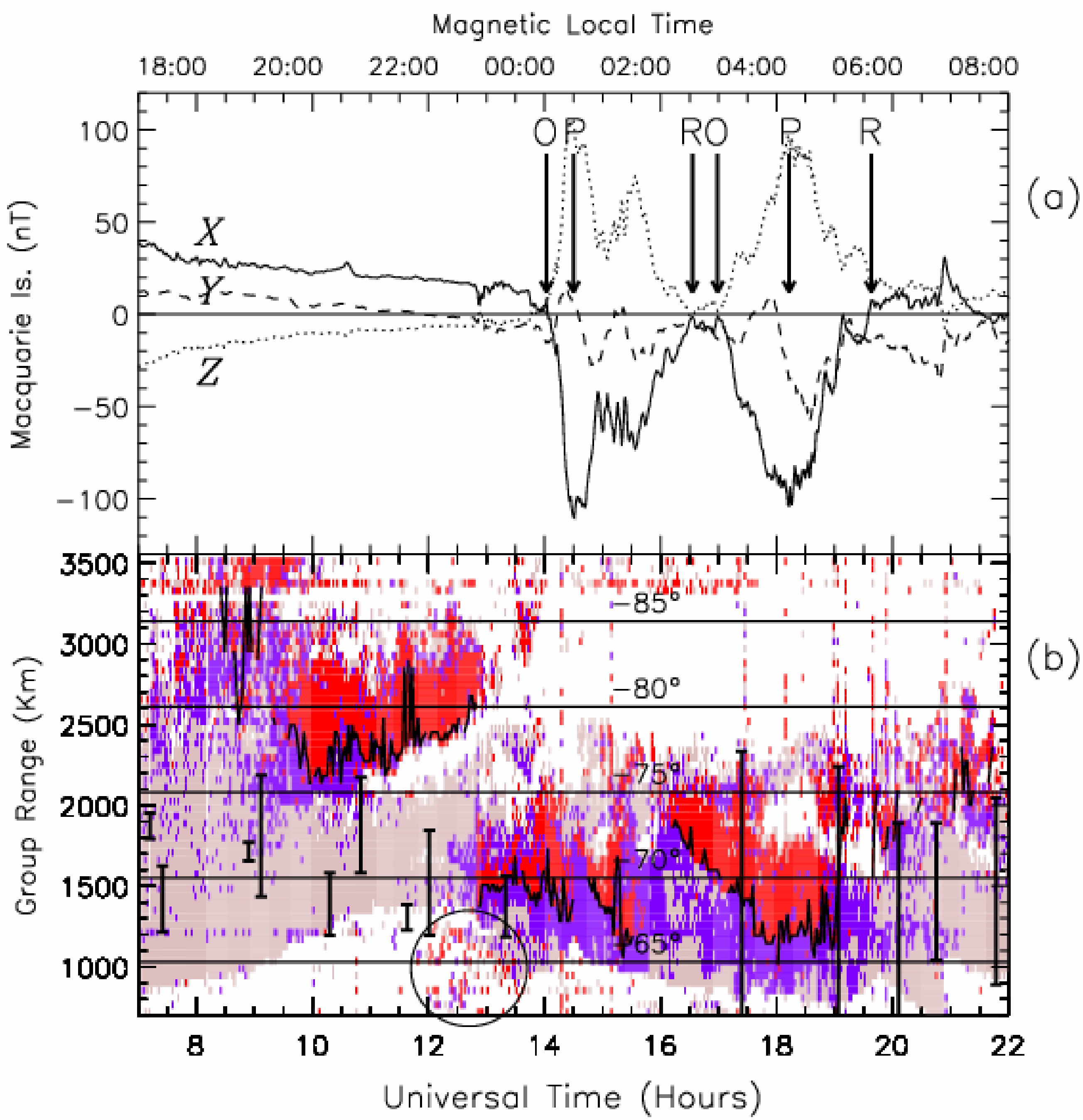
(a) Macquarie Is. fluxgate magnetometer

(b) Spectral widths vs. group range and time, beam 4

Ionospheric echoes, spectral width ≥200 m s^{-1}

Ionospheric echoes, spectral width <200 m s^{-1}

Sea echoes, spectral width <50 m s^{-1}



TIGER Spectral Width Boundary, 31 October 2000

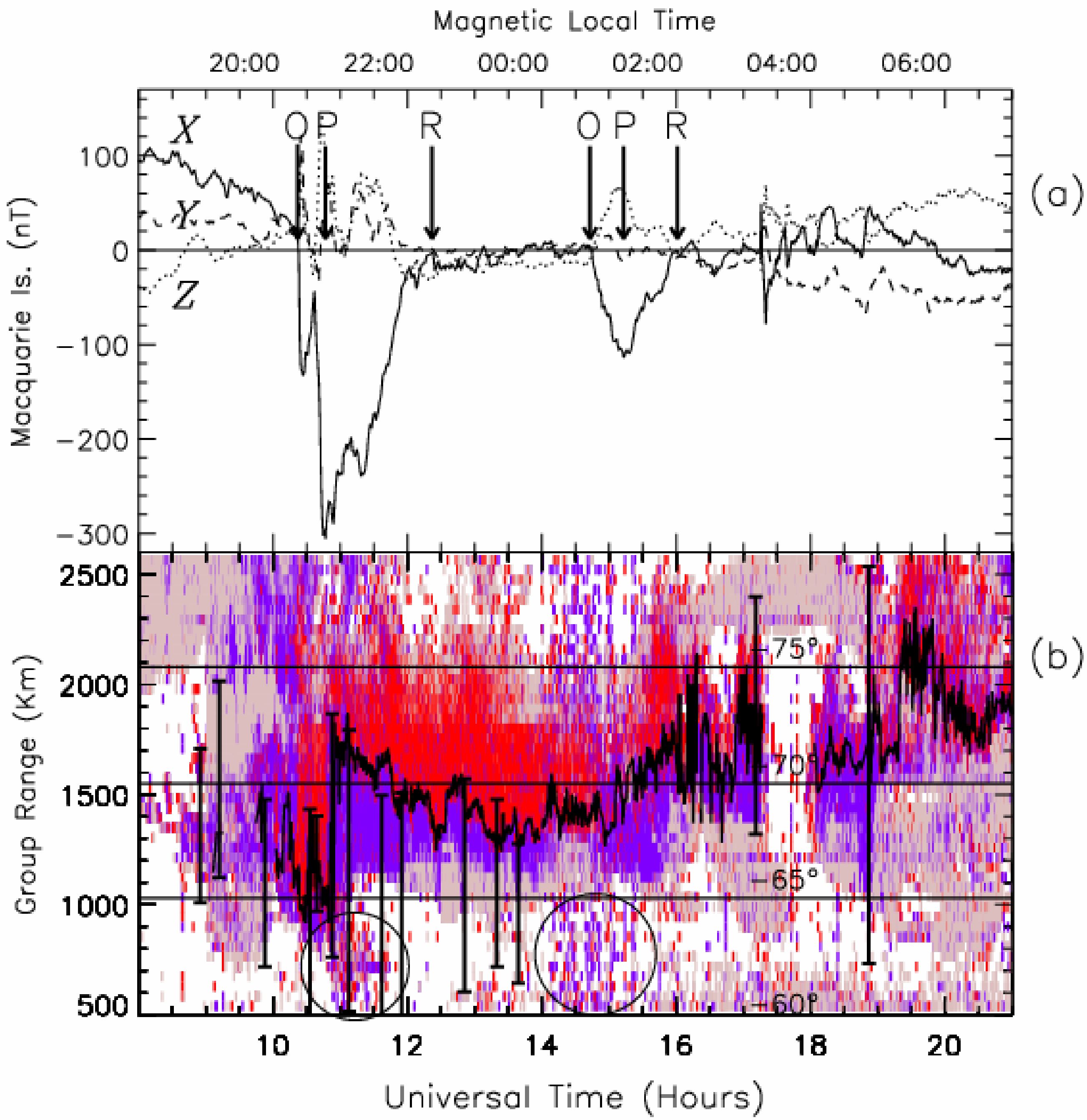
(a) Macquarie Is. fluxgate mag-netometer

(b) Spectral widths vs. group range and time, beam 4

Ionospheric echoes, spectral width ≥200 m s^{-1}

Ionospheric echoes, spectral width <200 m s^{-1}

Sea echoes, spectral width <50 m s^{-1}



Summary:

- The day- and night-side HF radar SWBs are highly structured entities, constantly fluctuating in MLT and UT (i.e. in space and time).
- The SuperDARN network can potentially discriminate between longitudinal and temporal variations in SWB shape simultaneously over many hours of MLT.
- Fluctuations in the SWB can be understood in terms of the expanding/contracting polar cap model of high-latitude convection change. The behaviour of the nightside SWB can also be organised according to substorm phase.
- When allowing for rapid variations in the nightside SWB shape, it is usually found to be a reasonable proxy for the DMSP-inferred OCB from dusk to just past midnight.
- Similarly, the HF radar SWB may be a reasonable proxy for the OCB from dusk to just past midnight during the growth, onset, and recovery phase of substorms.

Summary:

- However, the HF radar SWB tends to be a better proxy for the BPS/CPS boundary in the post-midnight to dawn sector, but again becomes a better proxy for the OCB past dawn.
- By "usually a reasonable proxy," we mean the estimated locations of the SWB and OCB can nearly always (>90%) be reconciled within experimental error (~2°Λ).
- The HF radar SWB is more reliably identified as a transition between ionospheric scatter with low and high spectral widths. N.B. Propagation effects and scatter boundaries!
- TIGER Tasmania can reliably identify the SWB shape from dusk to just past midnight, but it may struggle to do likewise in the morning sector. The converse should apply to TIGER New Zealand presently under construction.

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See http://www.tiger.latrobe.edu.au/