Energetic ion fluxes during recent solar minima

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The Sun is now recovering from a deep and long minimum

Good chance for checking on accepted dogmas of SH physics.

Uncertain predictions about maximum of next solar cycle

Voyager and IBEX: new regions studied under quiet conditions.

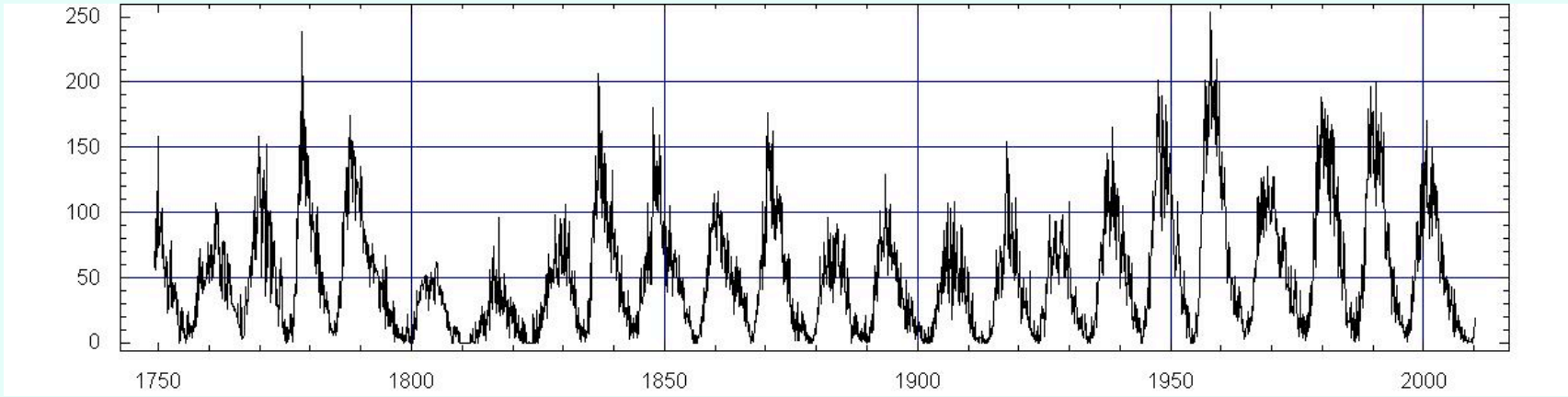
Complications: weak solar wind and magnetic dipole!

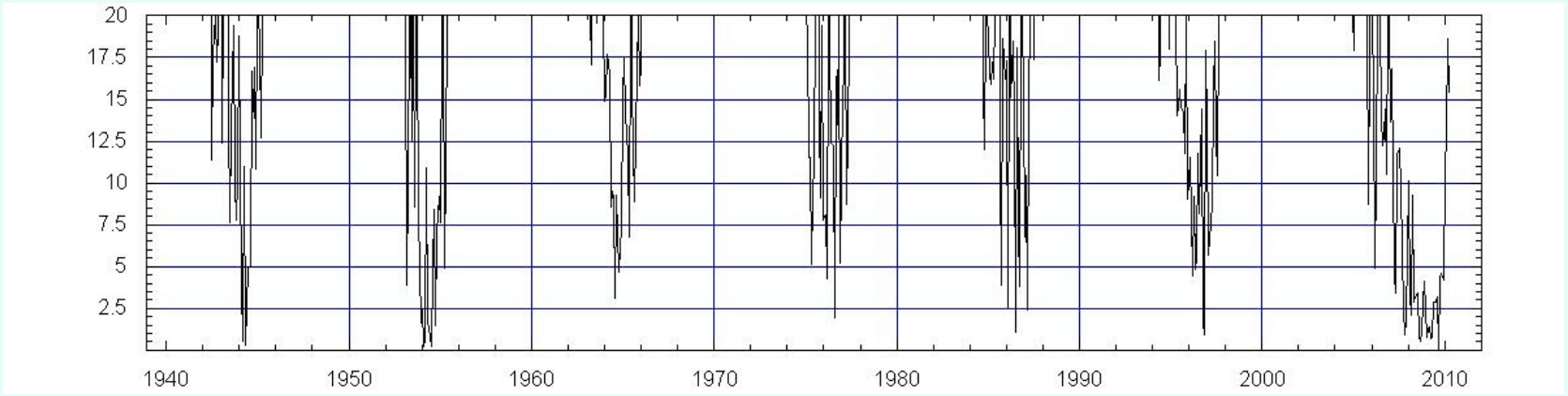
Galactic connections: more weight for external influences.

Unexpected roles of pick-up ions and perhaps of local galactic B.

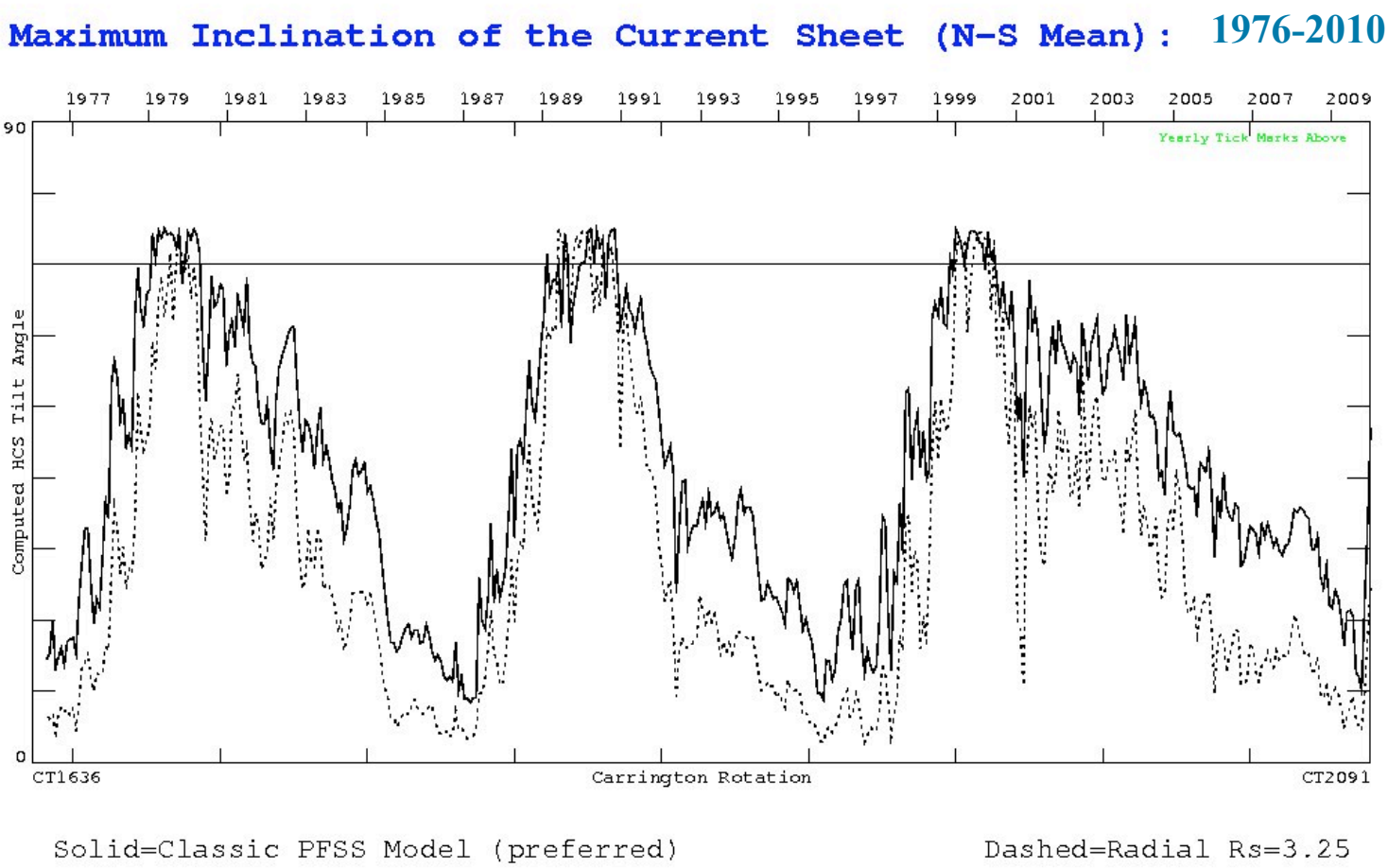
Any important consequences for astrophysical shocks?

Sunspot numbers since 1750 (top) and during recent low activity periods (bottom)

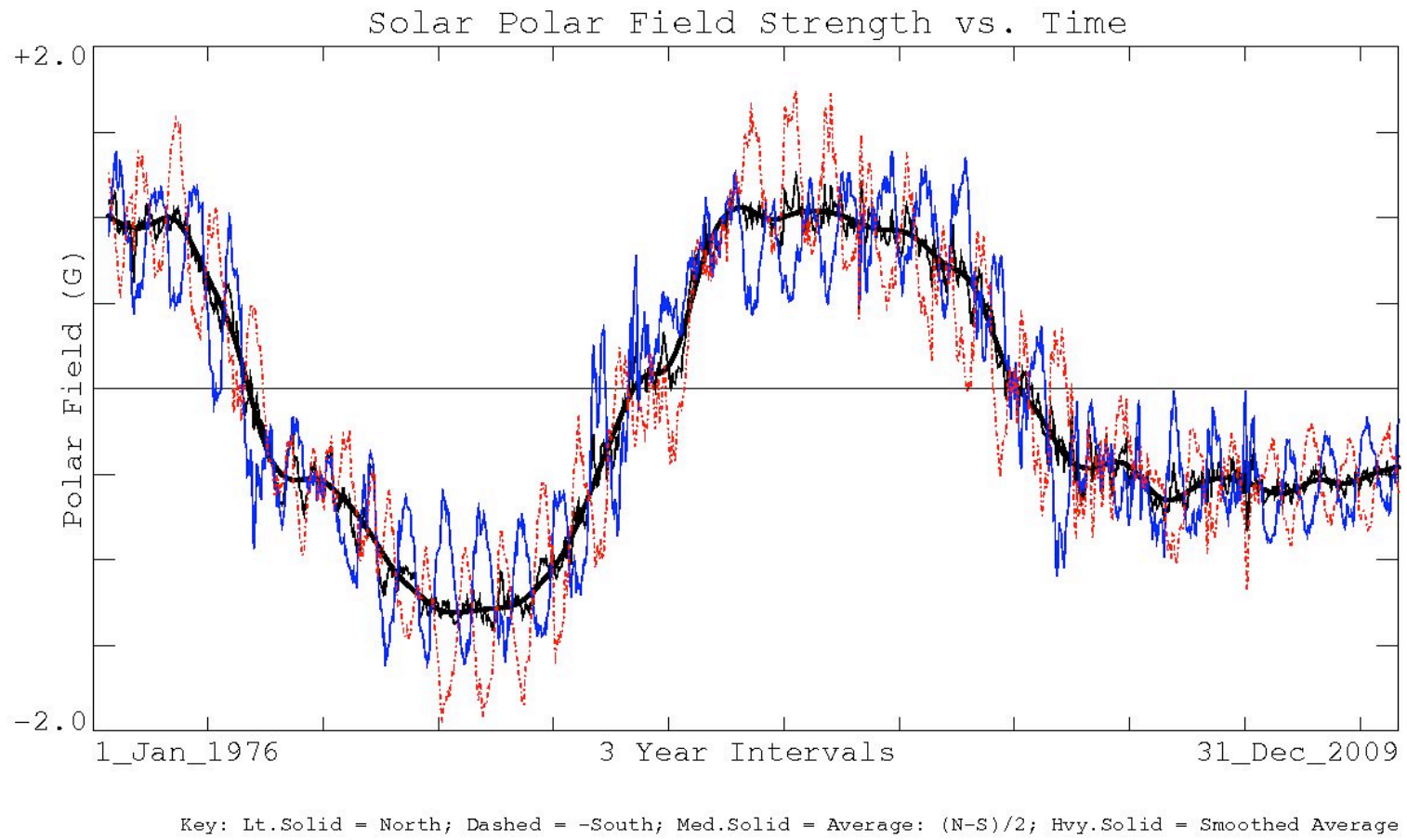




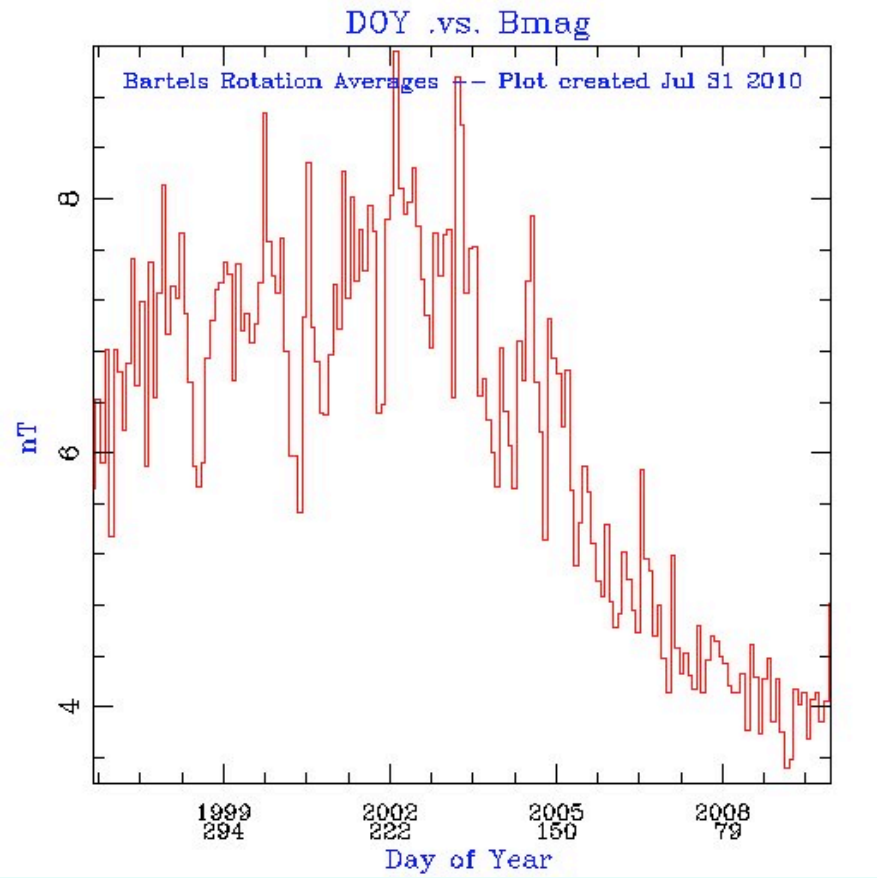
Unusual behaviour ot the solar magnetic dipole tilt angle

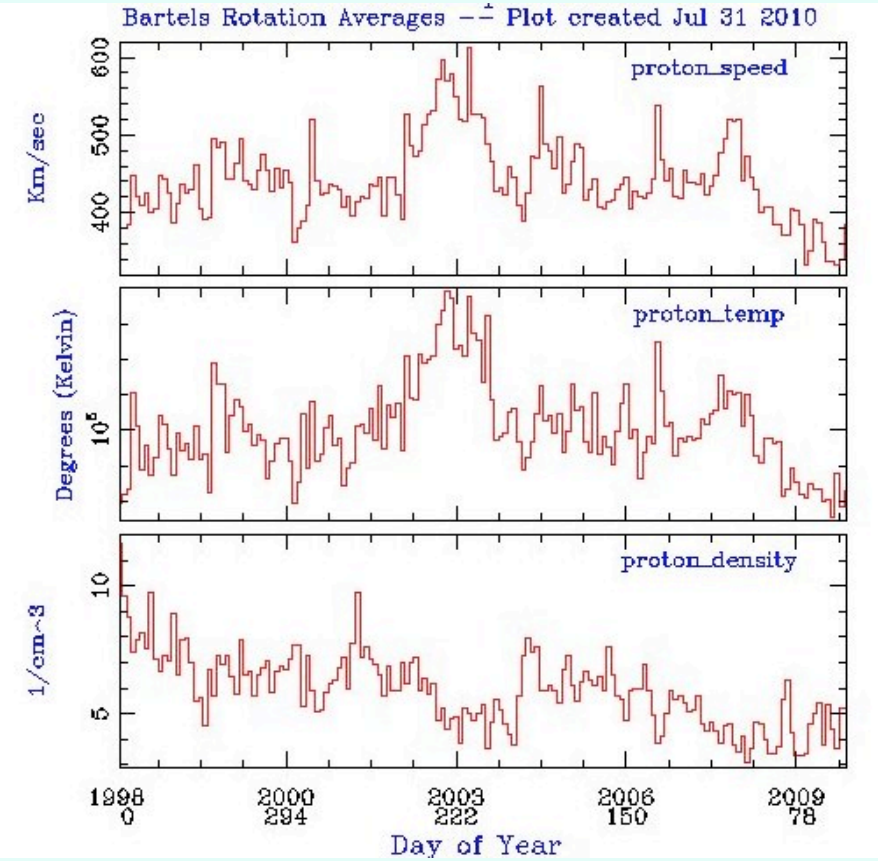


Solar Polar Field Strength (from Wilcox Observatory)



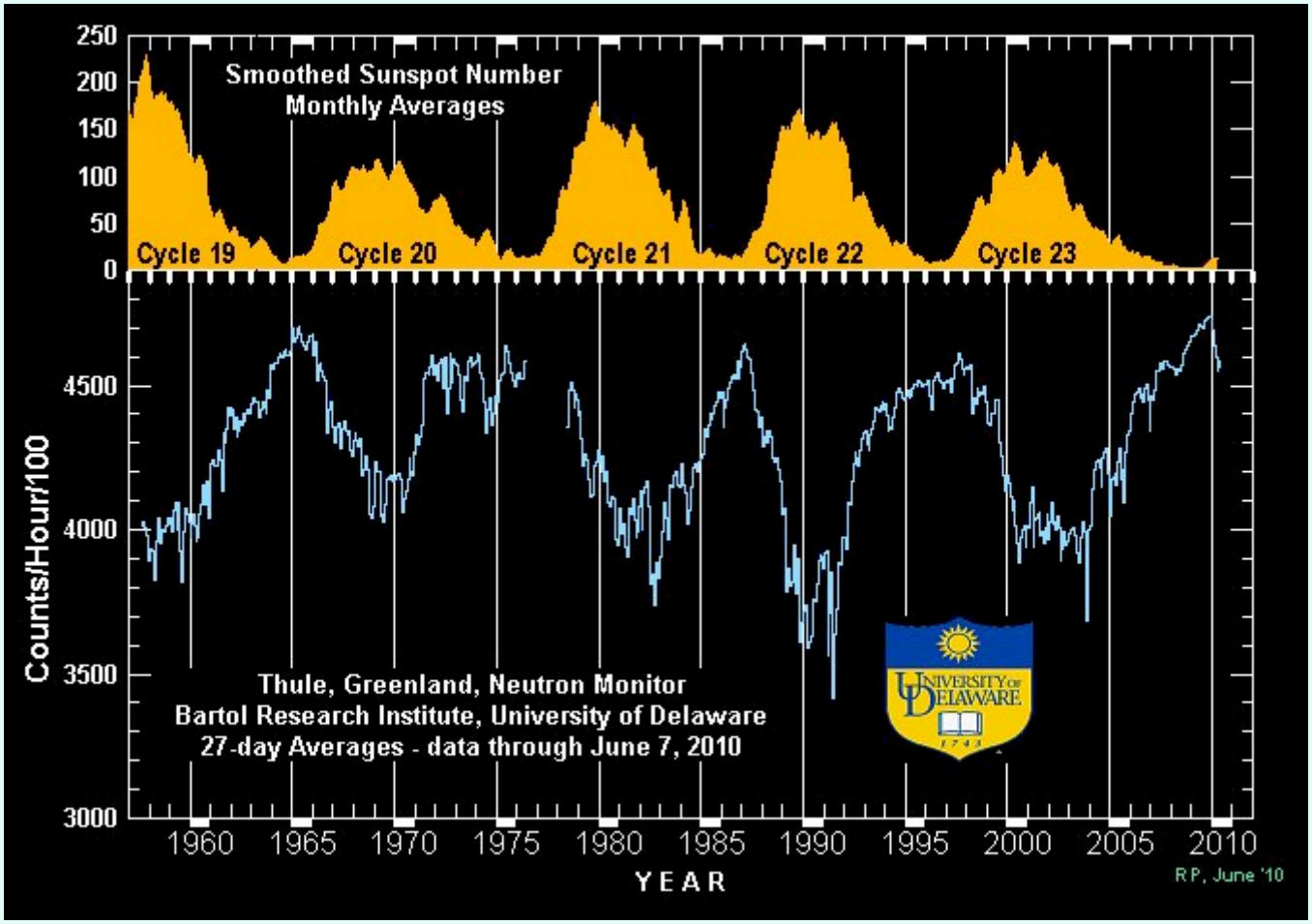
ACE MAG (left) and SWEPAM (right) plots for changes of the magnetic field and of other SW parameters from 1998 up to now

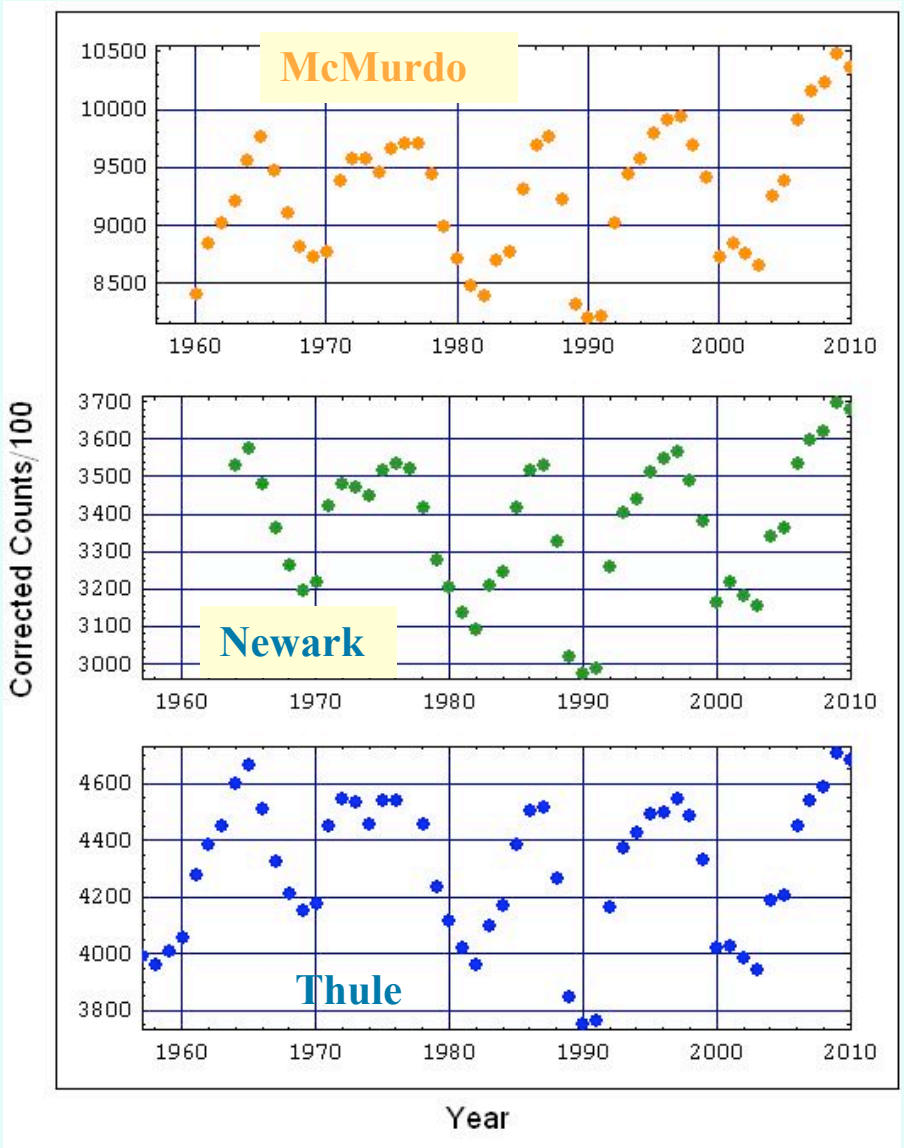




How are galactic cosmic rays affected?

Sunspot numbers and records of the Thule neutron monitor

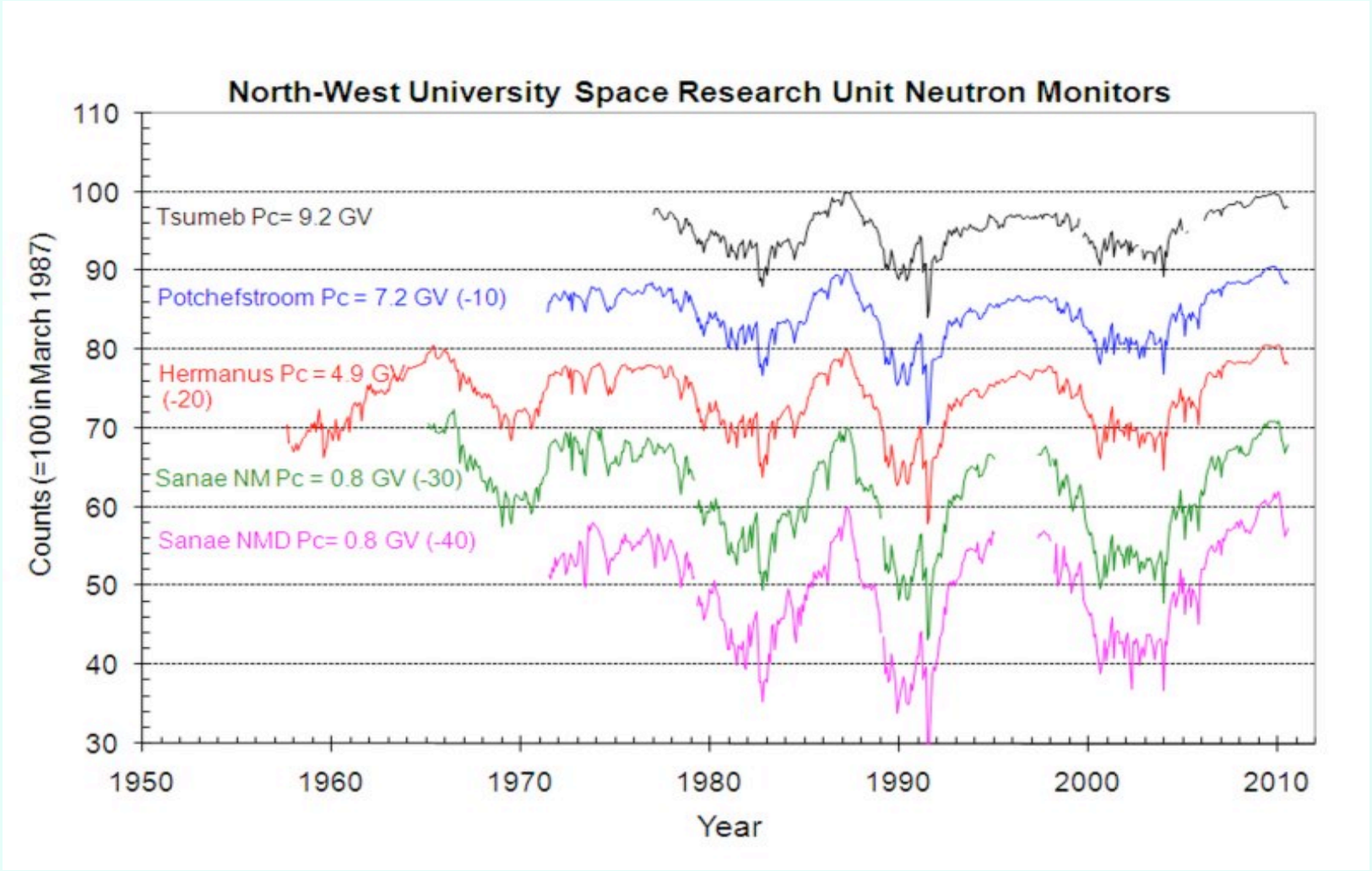




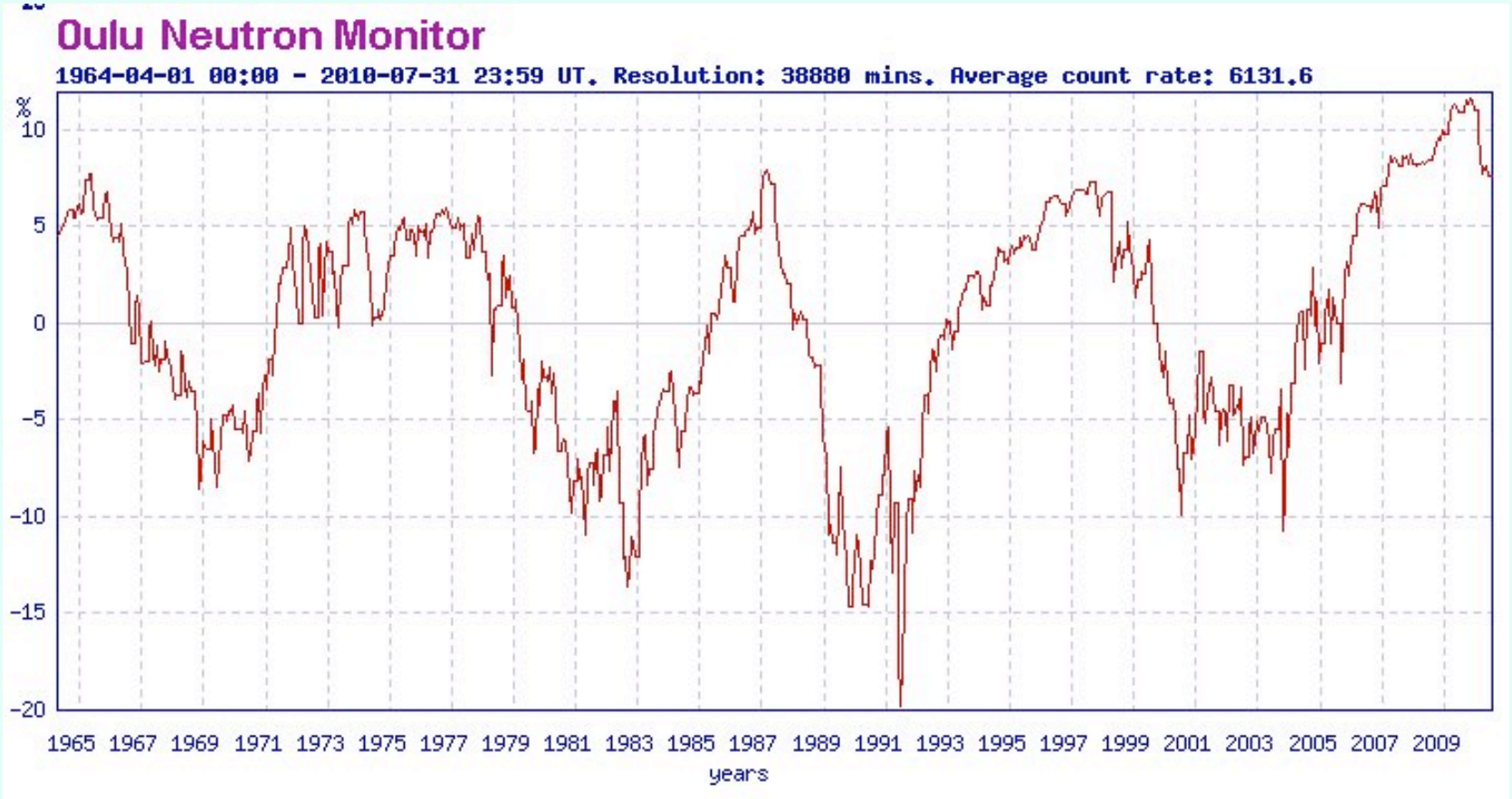
Cosmic ray fluxes in the GeV range were obviously less modulated (reduced) at Earth in 2009 than during earlier solar minima!

(Data taken from University of Delaware NMs)

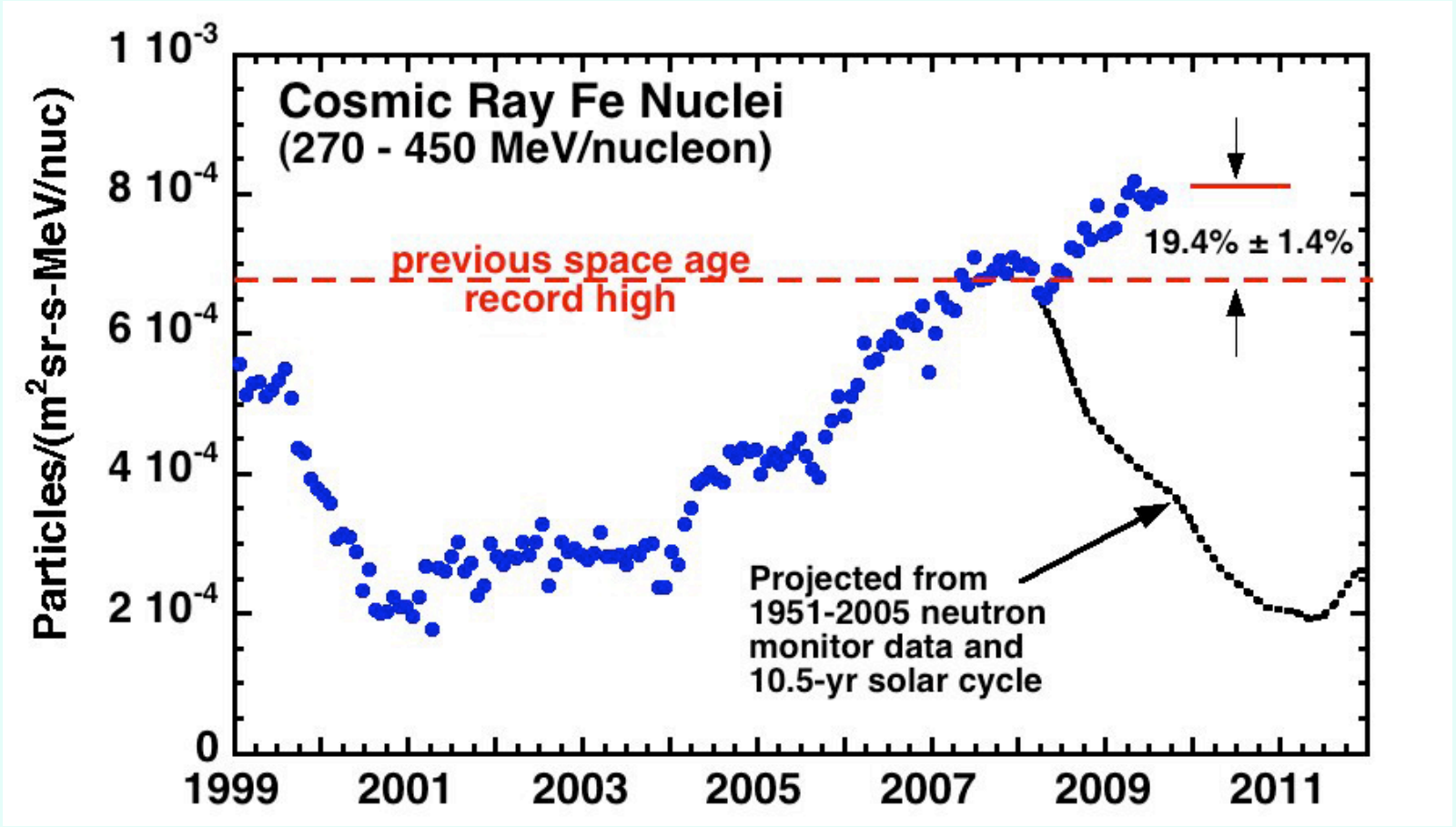
Neutron monitor results from the Southern hemisphere



Oulu neutron monitor data from Finland
(cutoff rigidity: 0.8 GV, effective energy: 5.6 GeV)

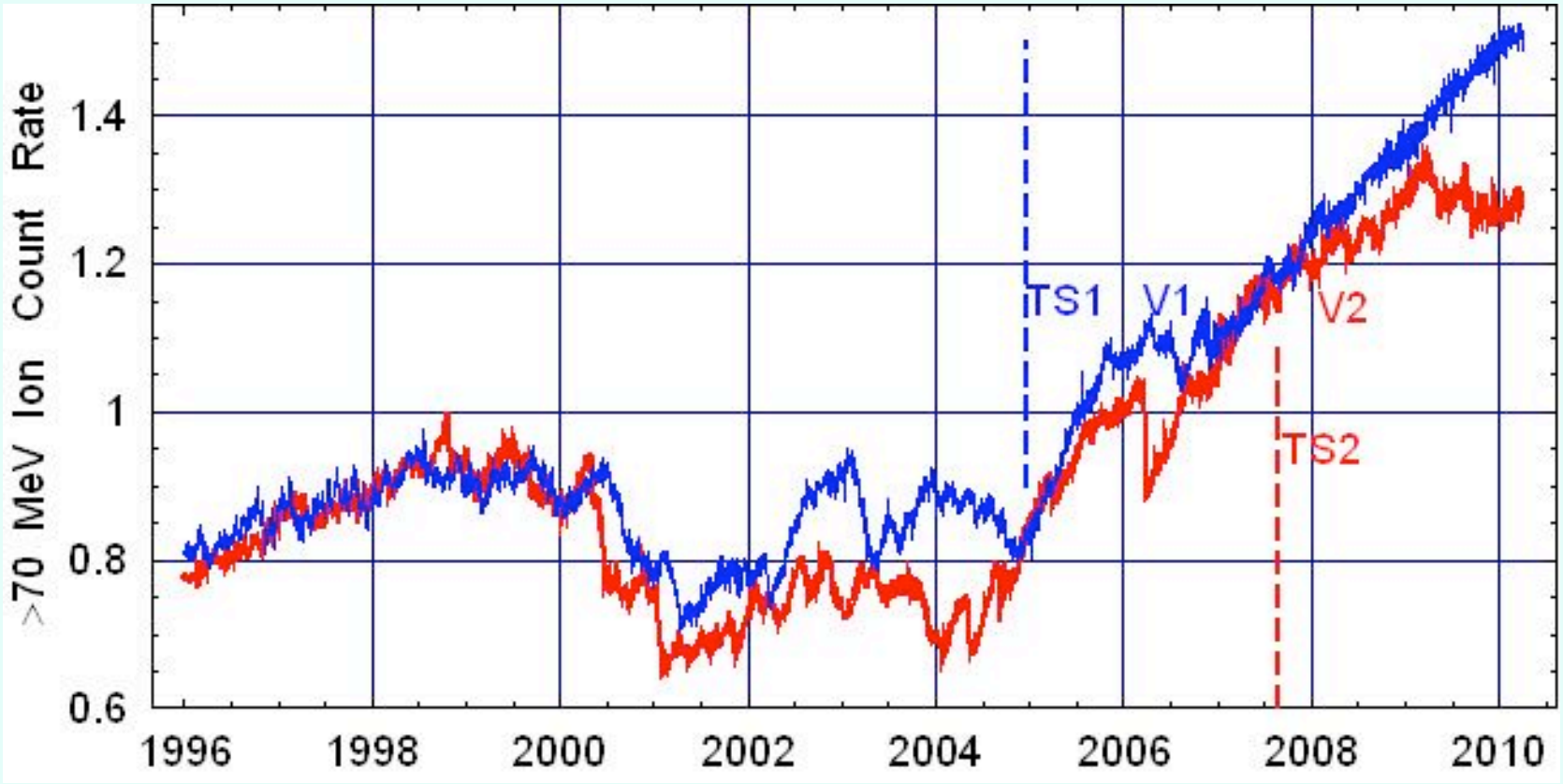


Superflux of iron nuclei in 2009 (ACE data, Mewaldt)

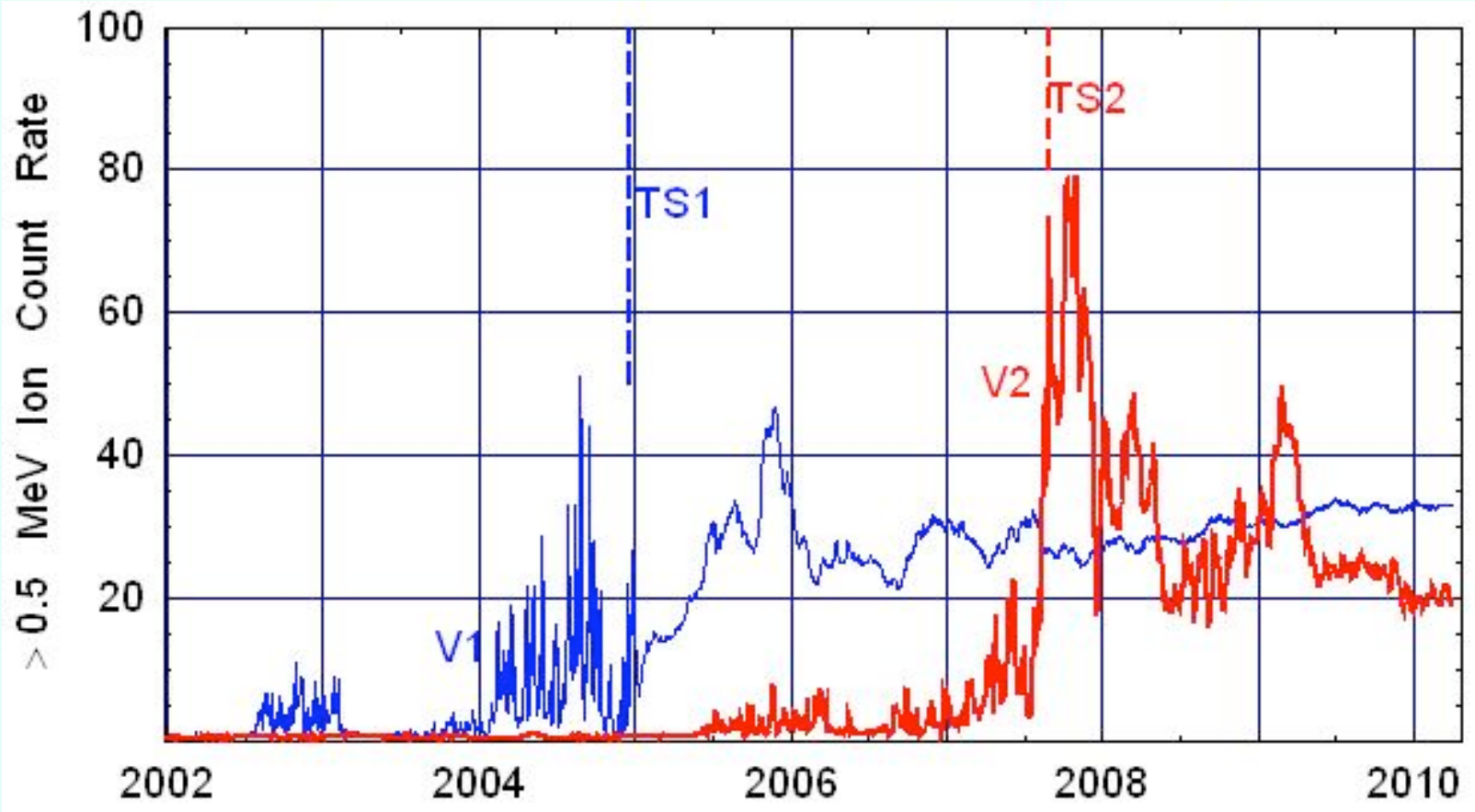


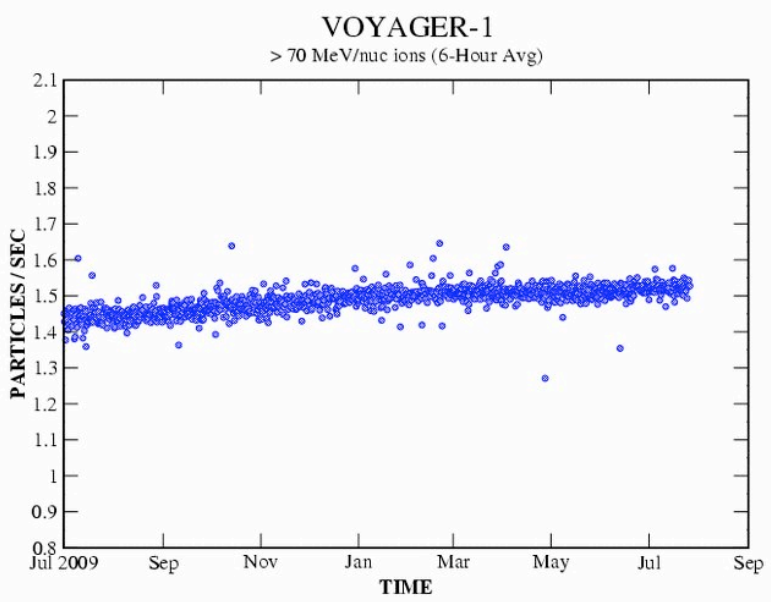
What happened in the distant heliosphere?

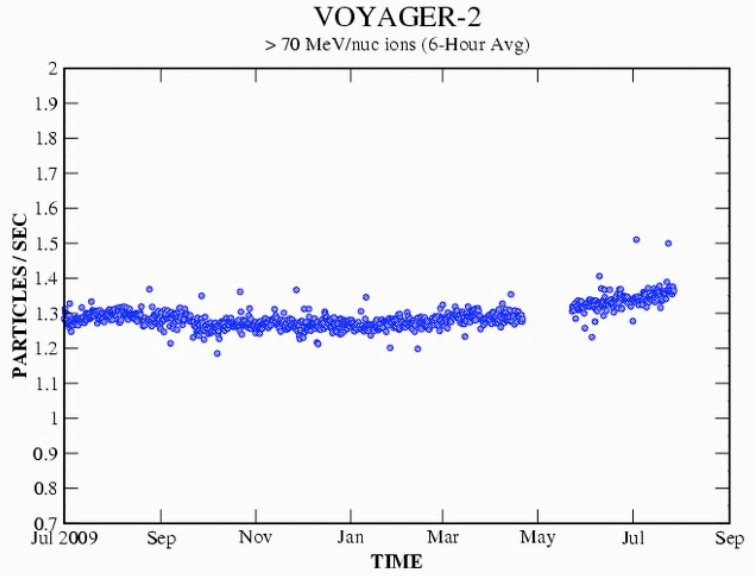
„Cosmic ray" data measured at Voyager 1 and 2 (V1, V2), at present heliocentric distances of 114 and 93 AU, respectively



Variation of count rates of mildly energetic (> 0.5 MeV) ions at both Voyagers before and after termination shock transit



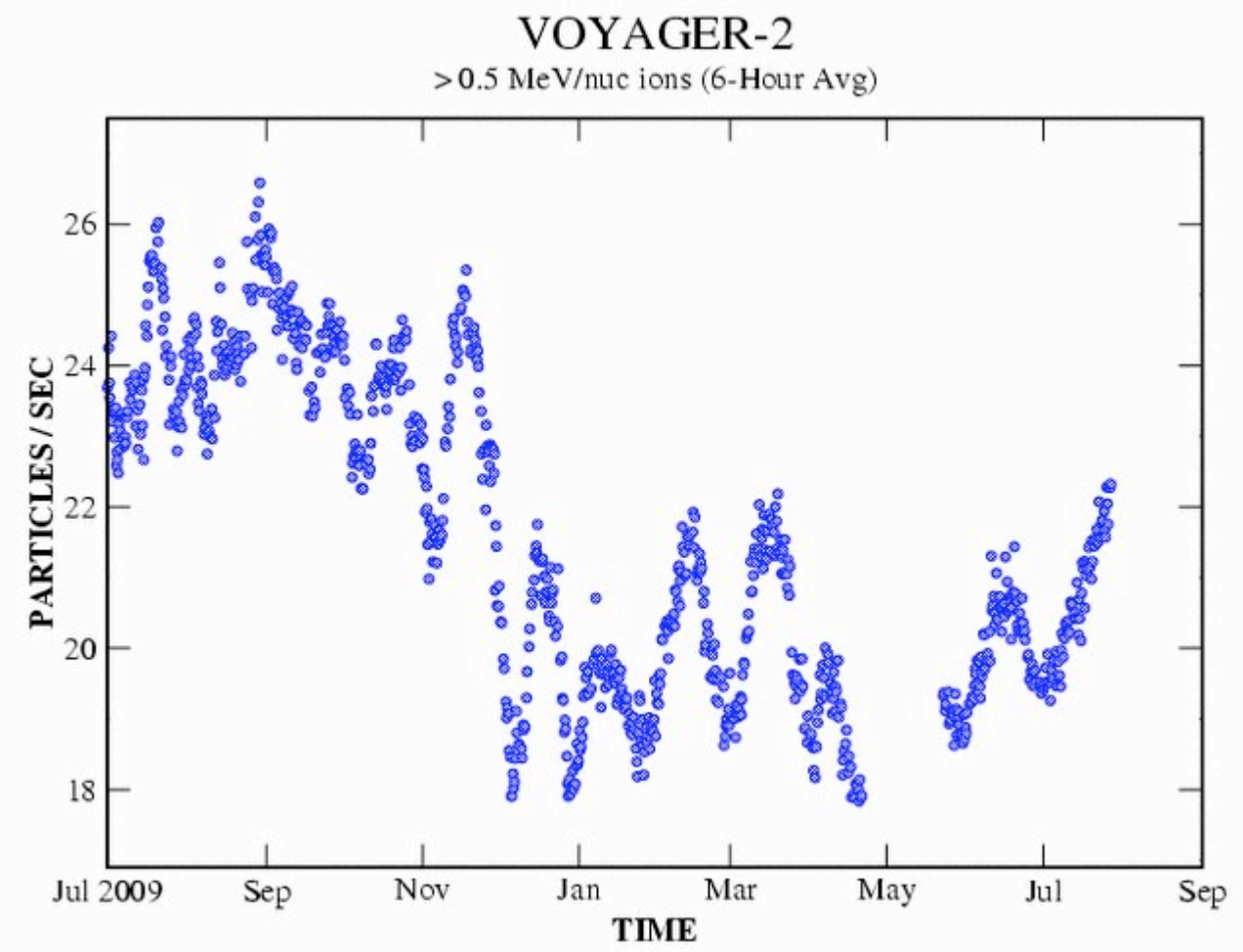




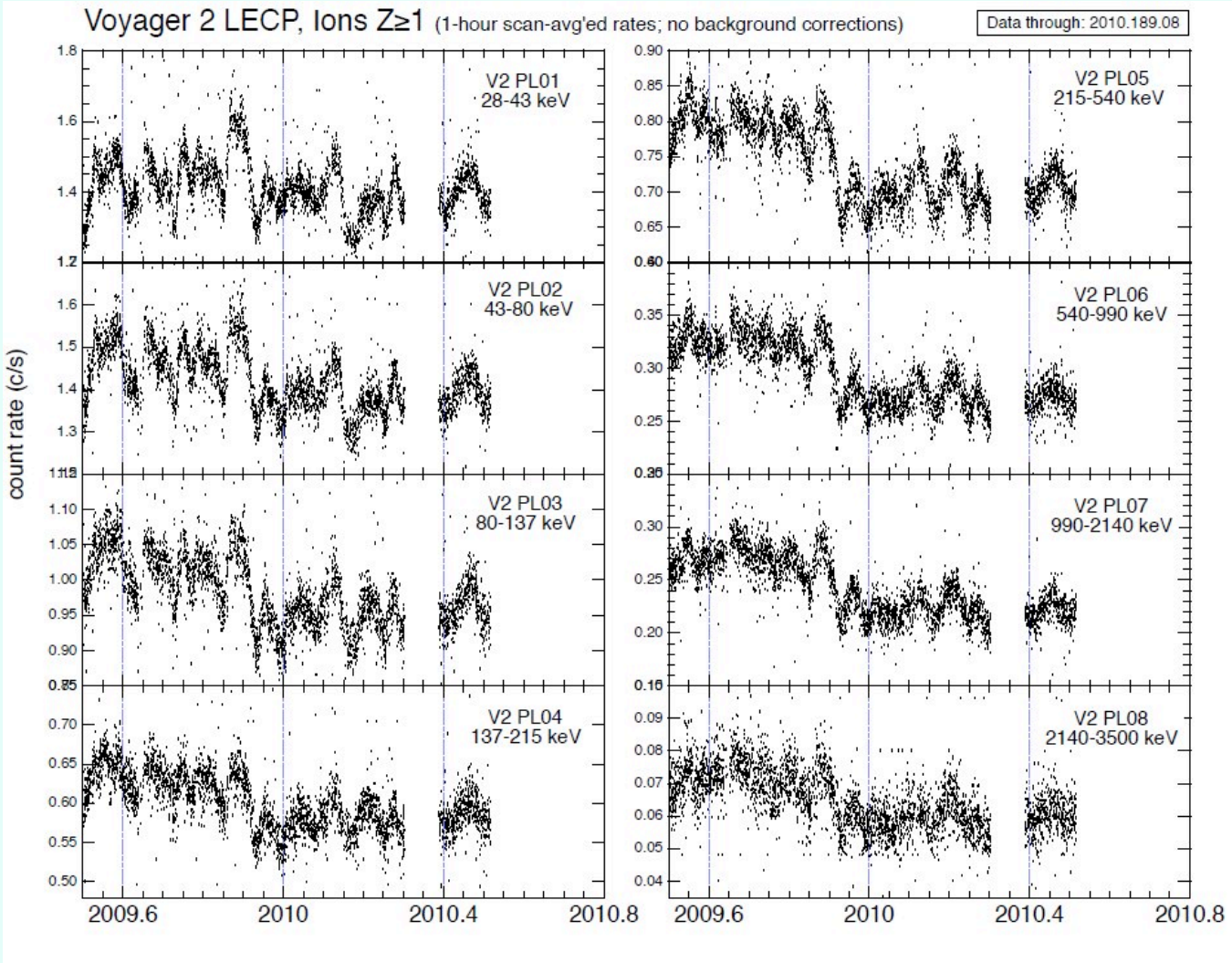
Above 70 MeV (mainly CRs):

Count rates are still increasing as V1 and V2 move outwards in the Heliosheath.

Strange 1month periodicity in the low-energy count rates at V2



Similar variations in past year between 28 keV and 3.5 MeV

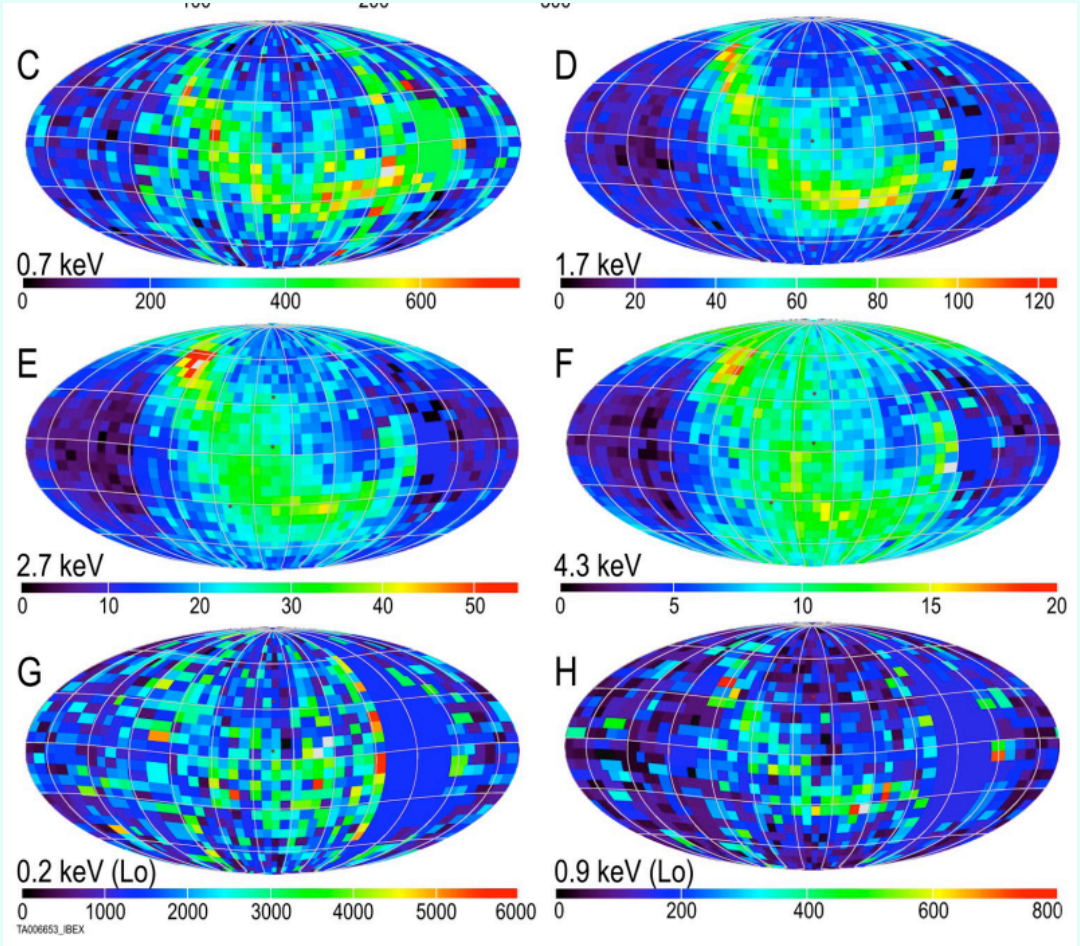


IBEX mission for remote sensing of the heliospheric boundary regions by neutral atoms (mountain goat: capra ibex)

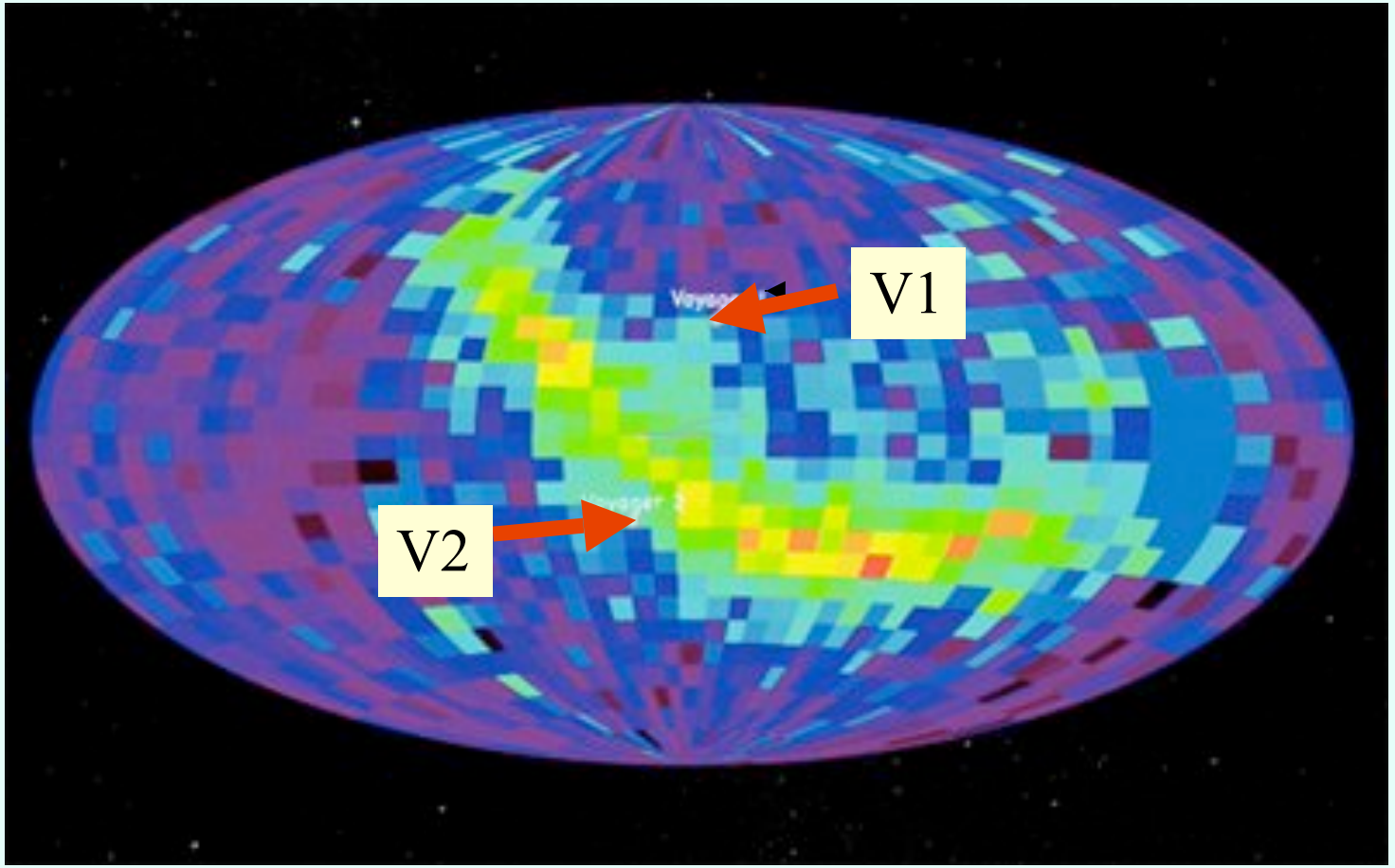
Interstellar Boundary Explorer

IBEX

IBIS neutral atom maps in 6 energy bands (McComas et al.)
A belt or ribbon with high contrast is seen. (Ecliptic coordinates)



The two Voyagers on both sides ob the ribbon (just missing it!)



Conclusions

The deep, extended solar minimum is now over.

New activity starts to disturb a relatively well studied structure, and the spatial and temporal sequence of changes will provide new information.

Voyager data in the distant heliosphere and changes of IBEX neutral atom data, in connection with changes in cosmic ray modulation at different energies, will enhance our understanding of heliospheric structure and of our galactic connections – and may also have important consequences for cosmic ray injection and acceleration.