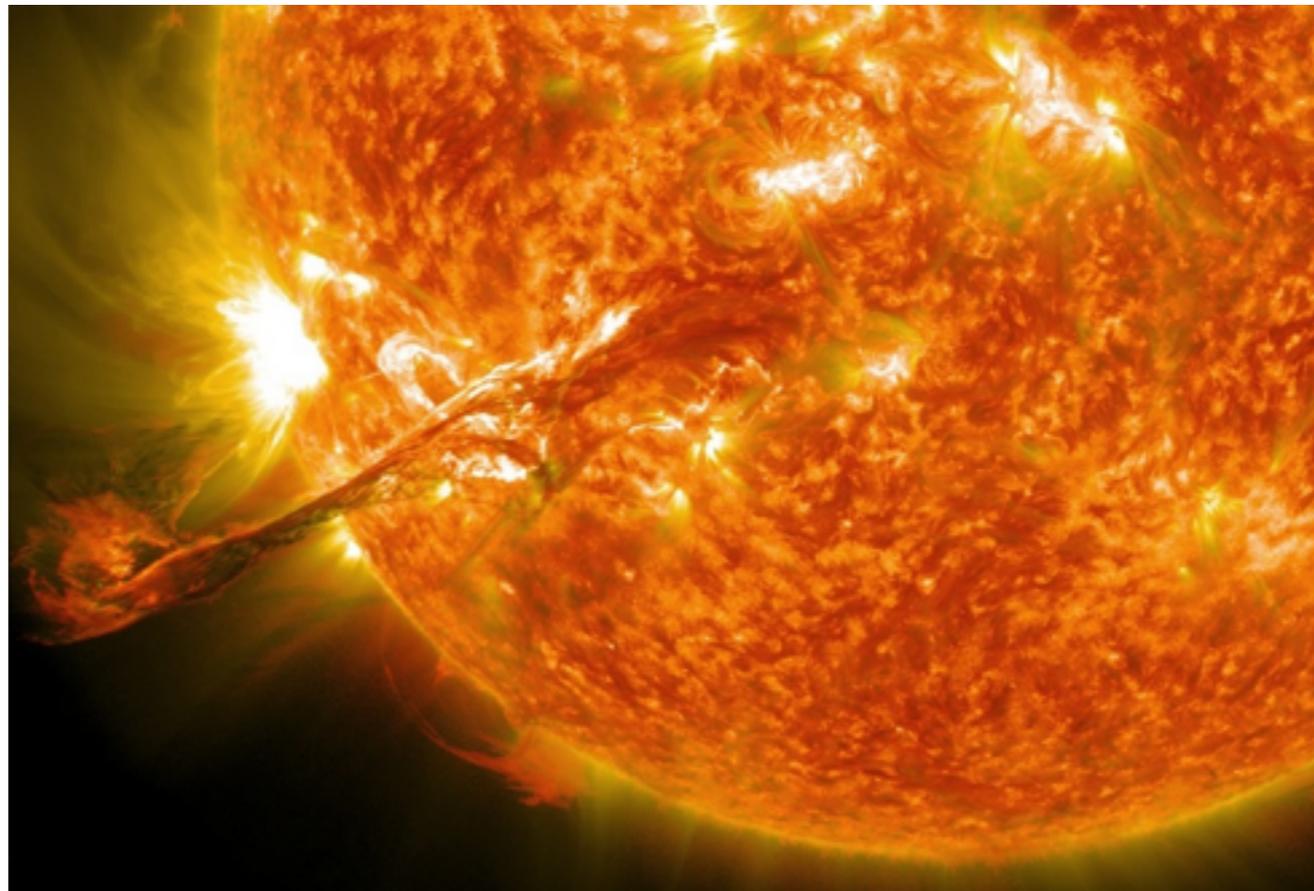


Can we remote sense coronal mass ejections using neutron monitors?



Simon R Thomas

Mathew Owens | Mike Lockwood | Chris Scott | Luke Barnard
University of Reading

1st Solar Orbiter Summer School - September 2014

Overview

Introduction:

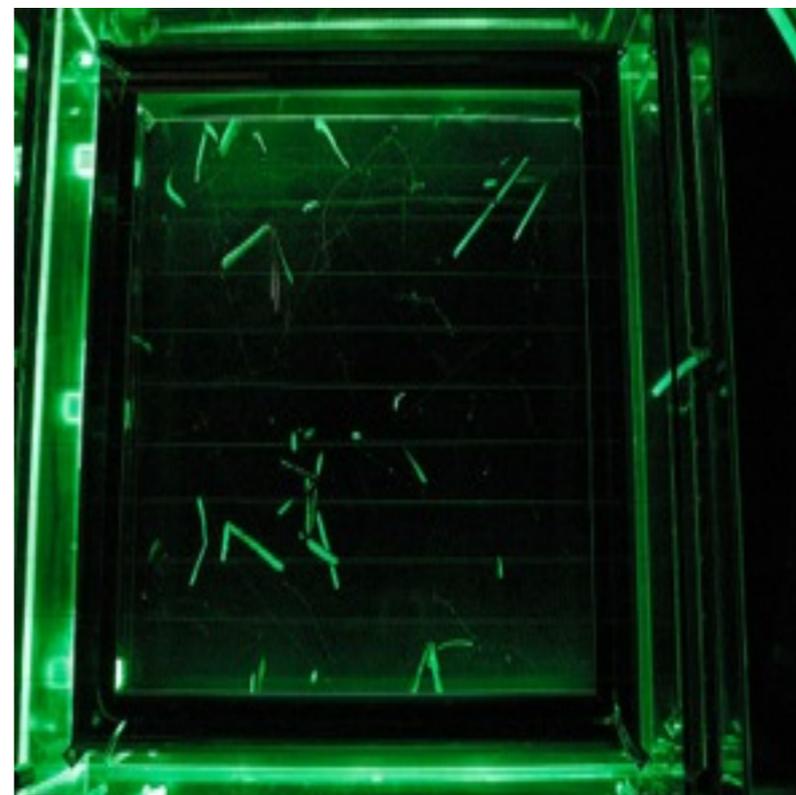
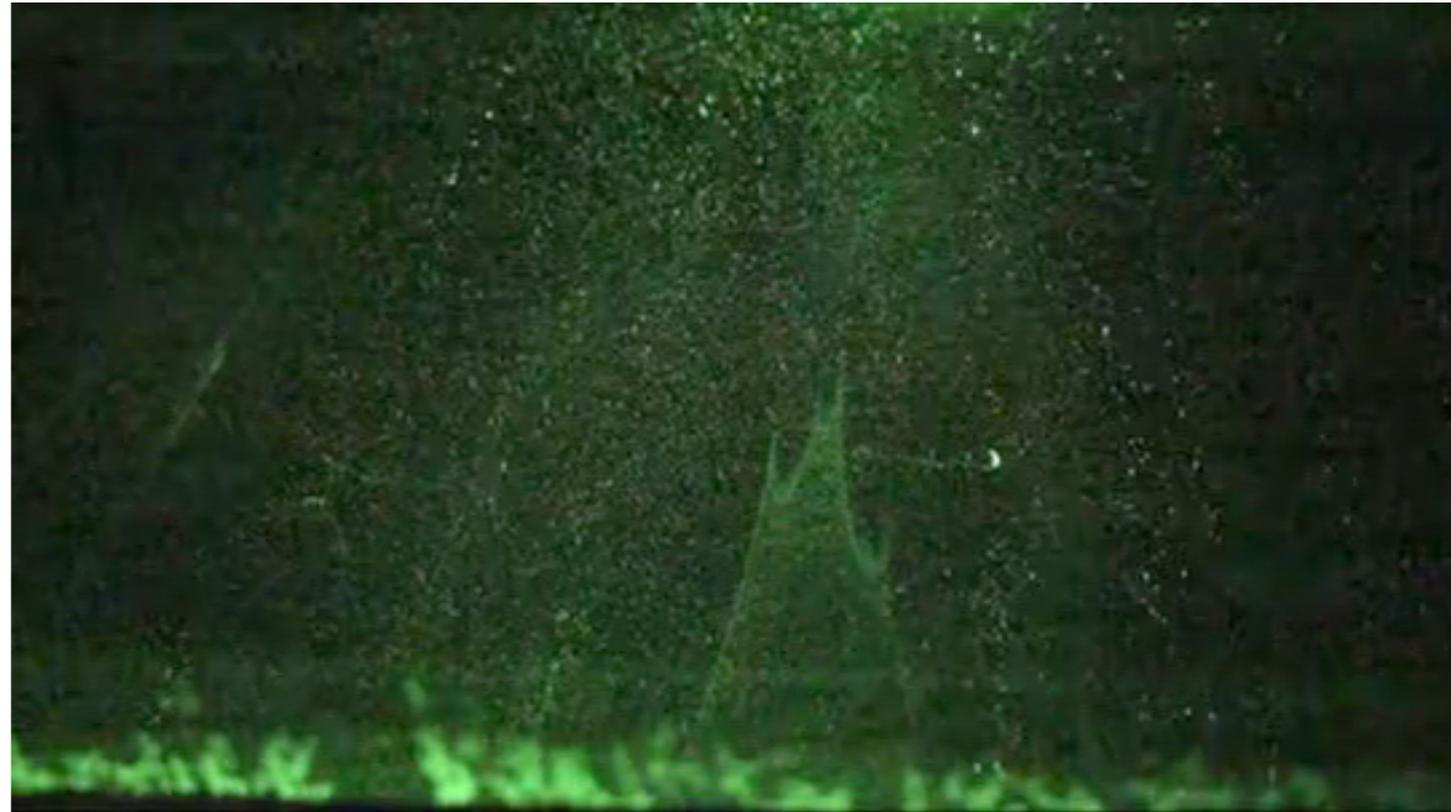
- Galactic cosmic rays and neutron monitors
- Modulation of cosmic rays
- Forbush decreases

Results:

- Observations of some unusual events
- Case study of May 2012 event
- How do these allow us to remote sensing coronal mass ejections?

What are Galactic Cosmic Rays?

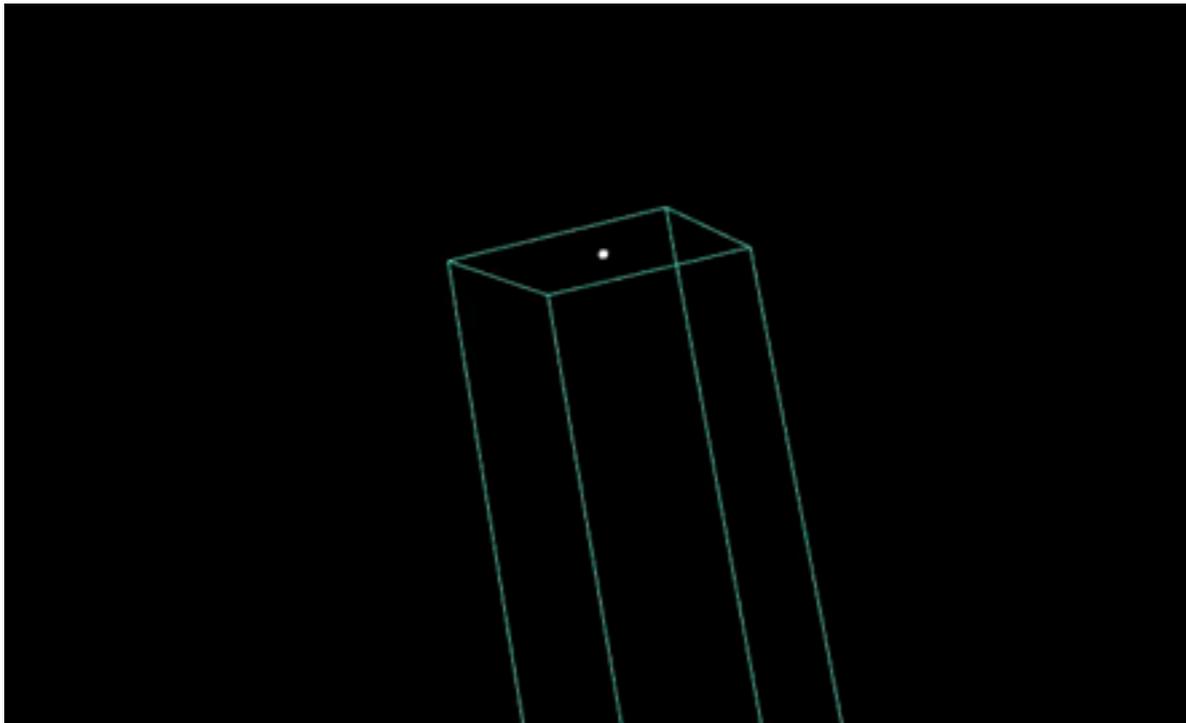
- Highly energetic, charged particles accelerated at sources such as supernovae, black holes and neutron stars.
- Energy is large enough so that they can be detected at Earth's surface $\sim 100\text{MeV} - 100\text{GeV}$.
- Consist mostly of protons, but we also observe electrons and heavier nuclei.
- They are almost always isotropic in their arrival directions at Earth.



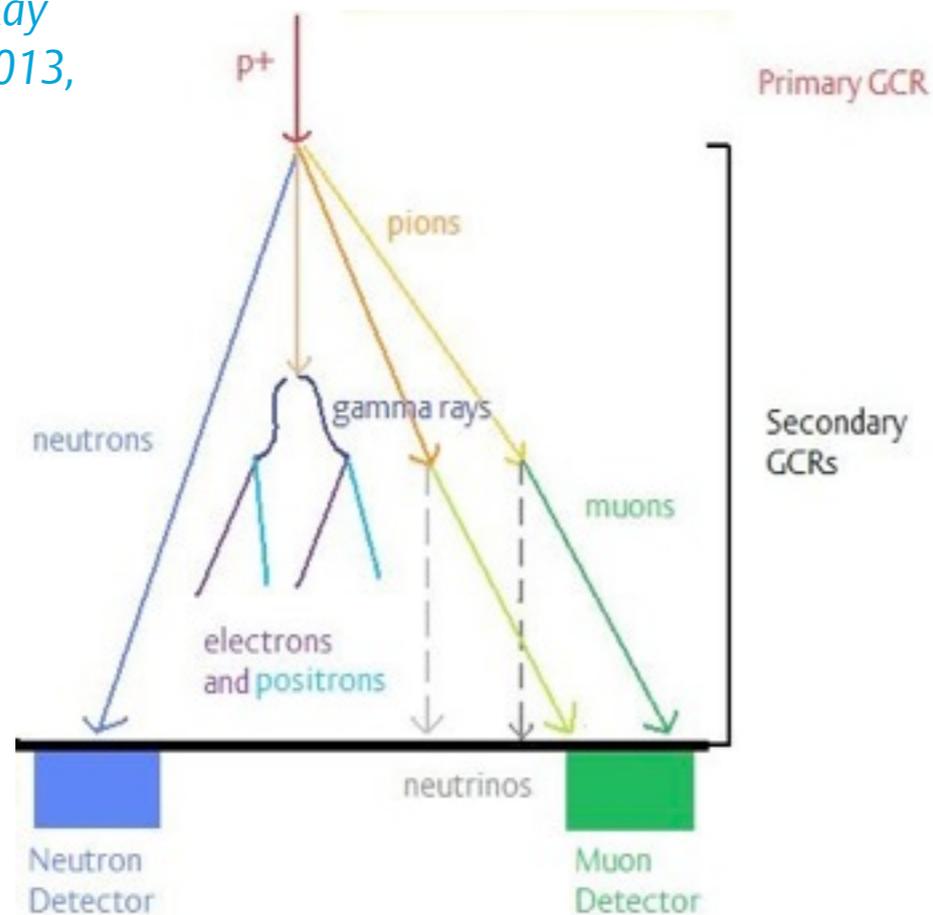
Cloud Chambers:

Charged particles cause super-cooled vapour to condense giving vapour trails

Galactic Cosmic Ray Detection



ILC Cosmic Ray
Workshop 2013,
Tokyo



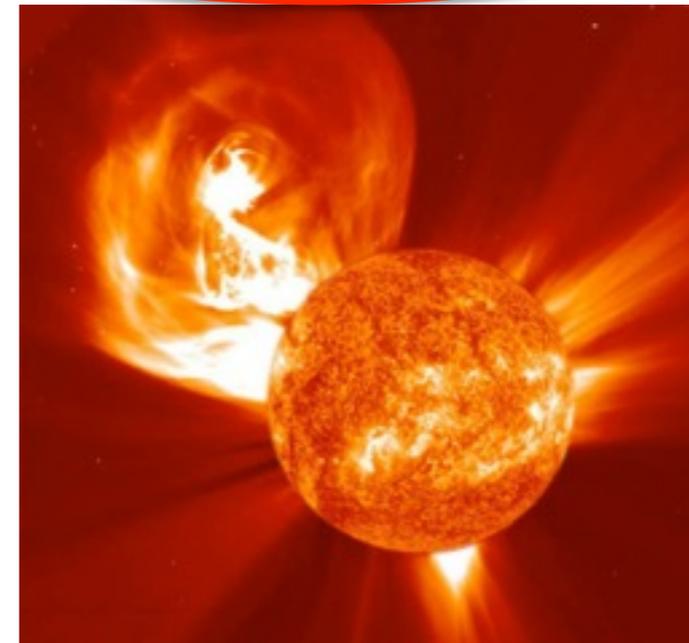
- When a cosmic ray enters the atmosphere it will collide with atmospheric particles.
- The cosmic ray thus decays into several different particles such as neutrons and muons.
- Ground-based neutron monitors and muon telescopes count these particles.
- For this work I have used data from neutron monitors at a number of longitudes and latitudes to give a good spatial coverage.

The Modulation of Galactic Cosmic Rays

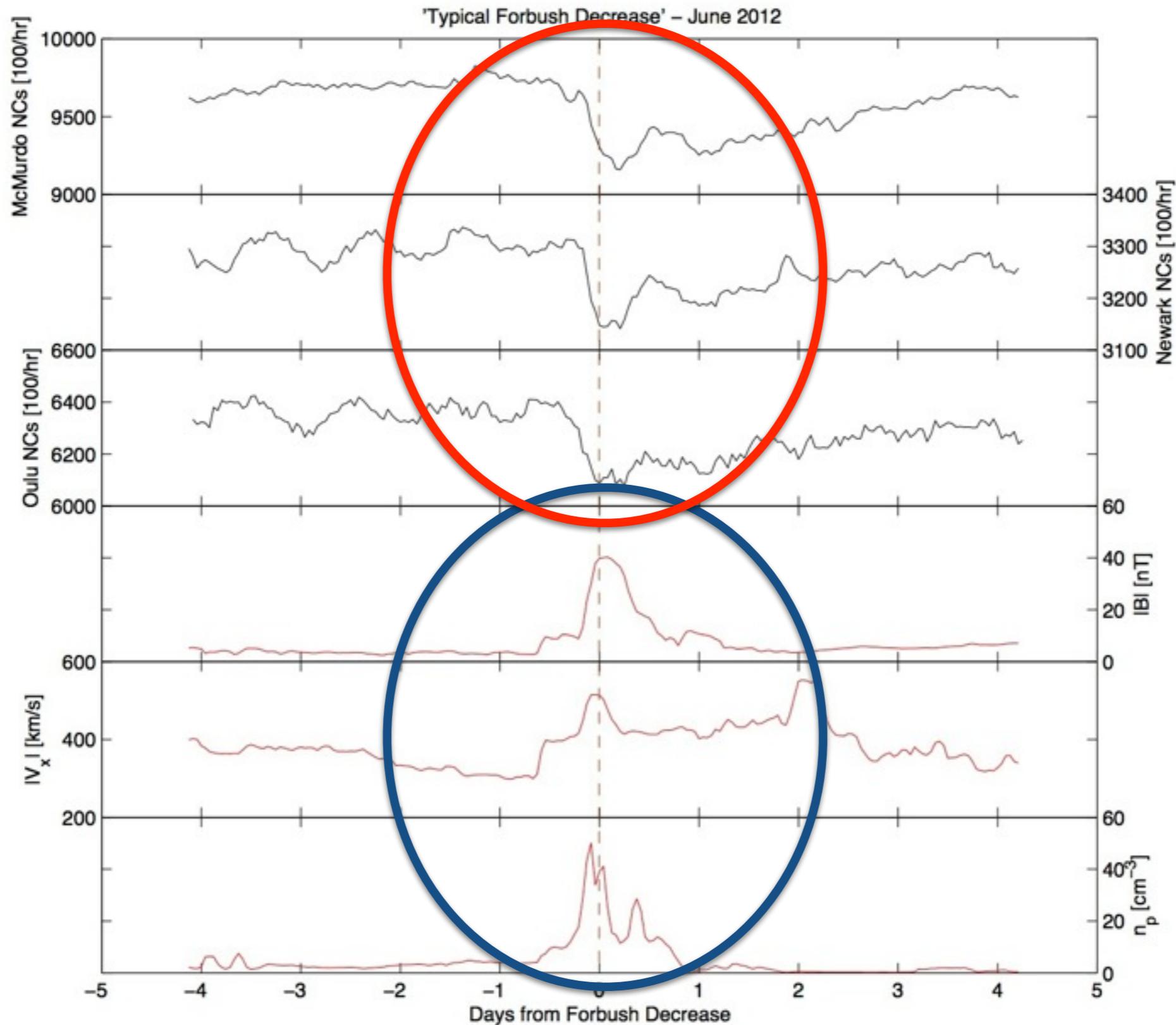
Galactic cosmic rays are charged particles - they are deflected by a magnetic field

Long term changes (\sim decades)
due to variability in solar
activity

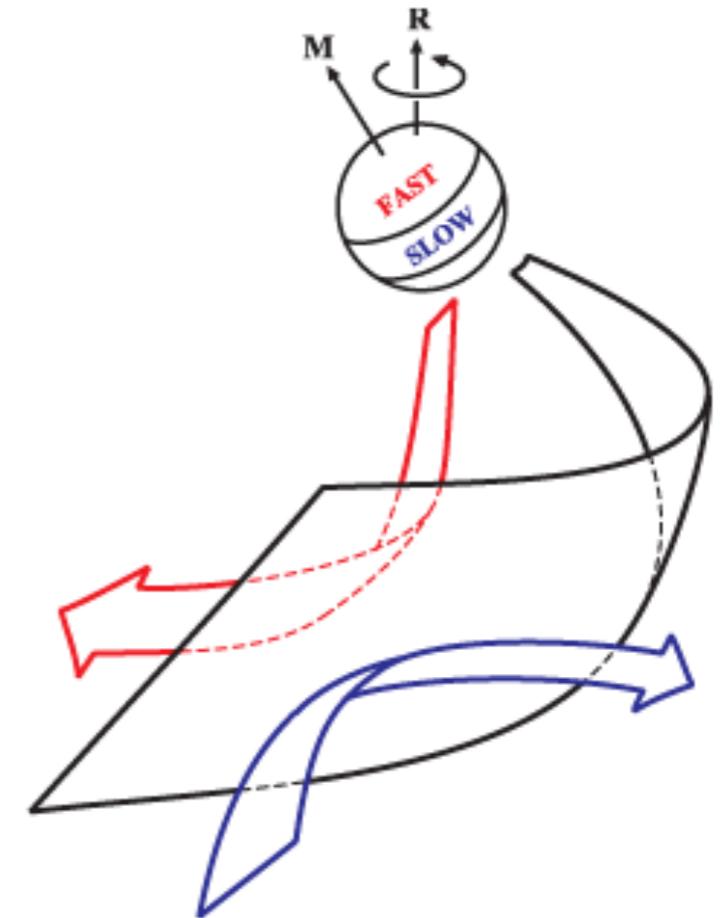
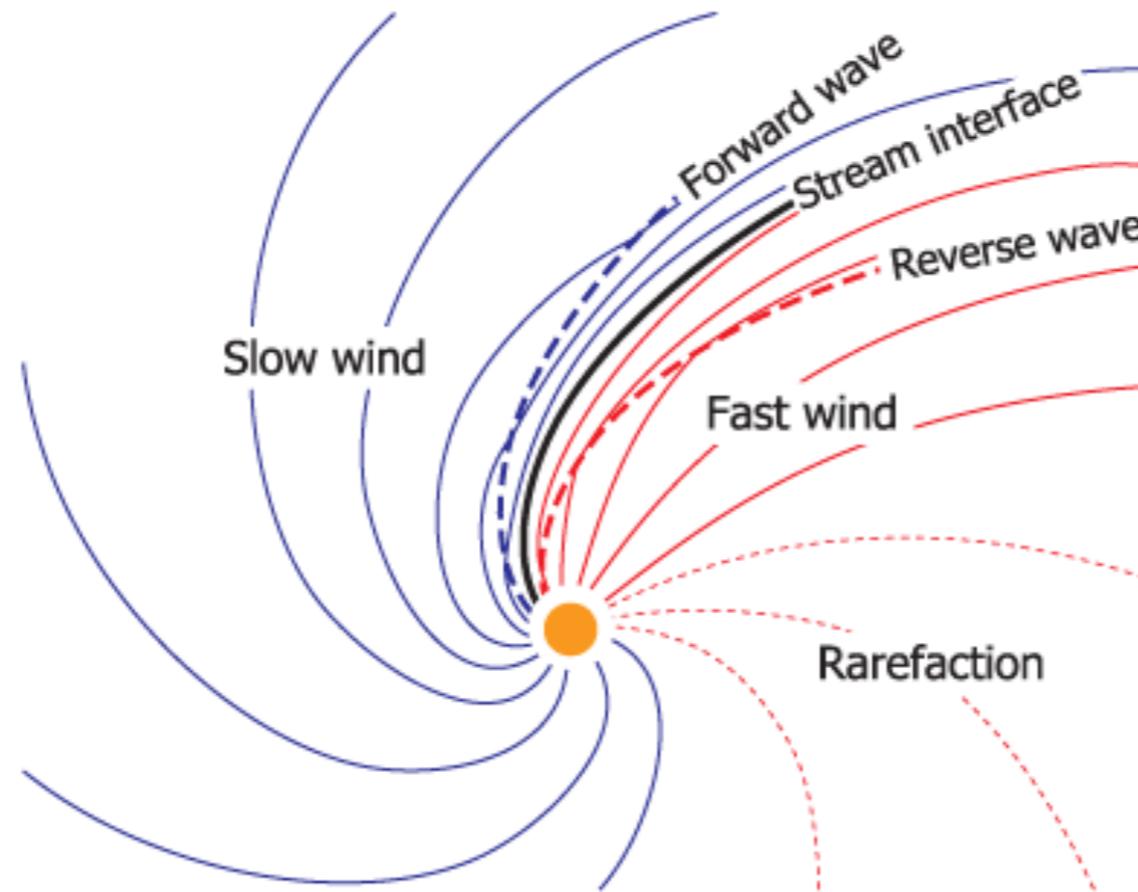
Sudden drops (\sim hours)
caused by shorter term
magnetic events



“Typical” Forbush Decrease seen in *in-situ* Data

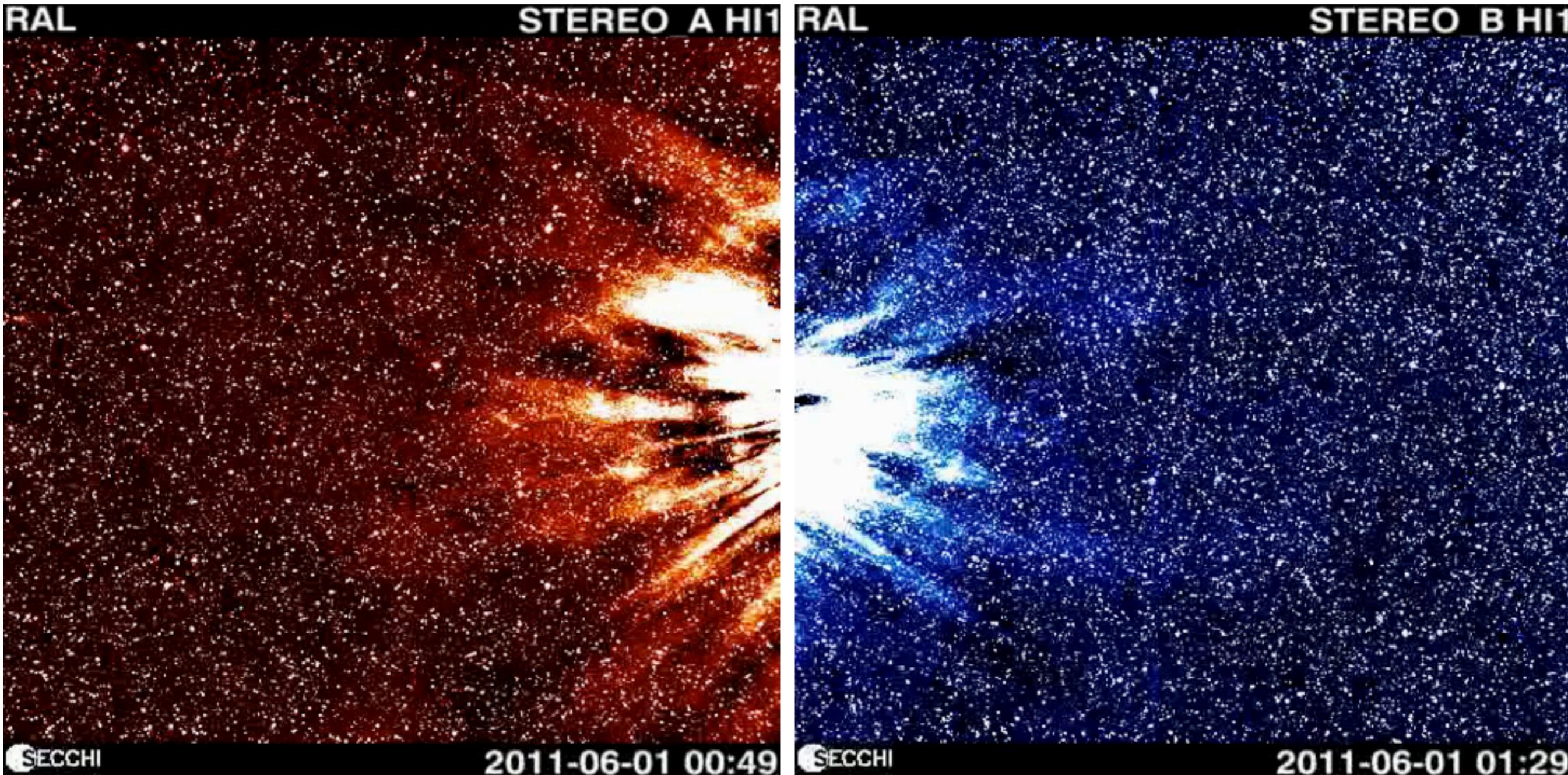


Corotating Interaction Regions

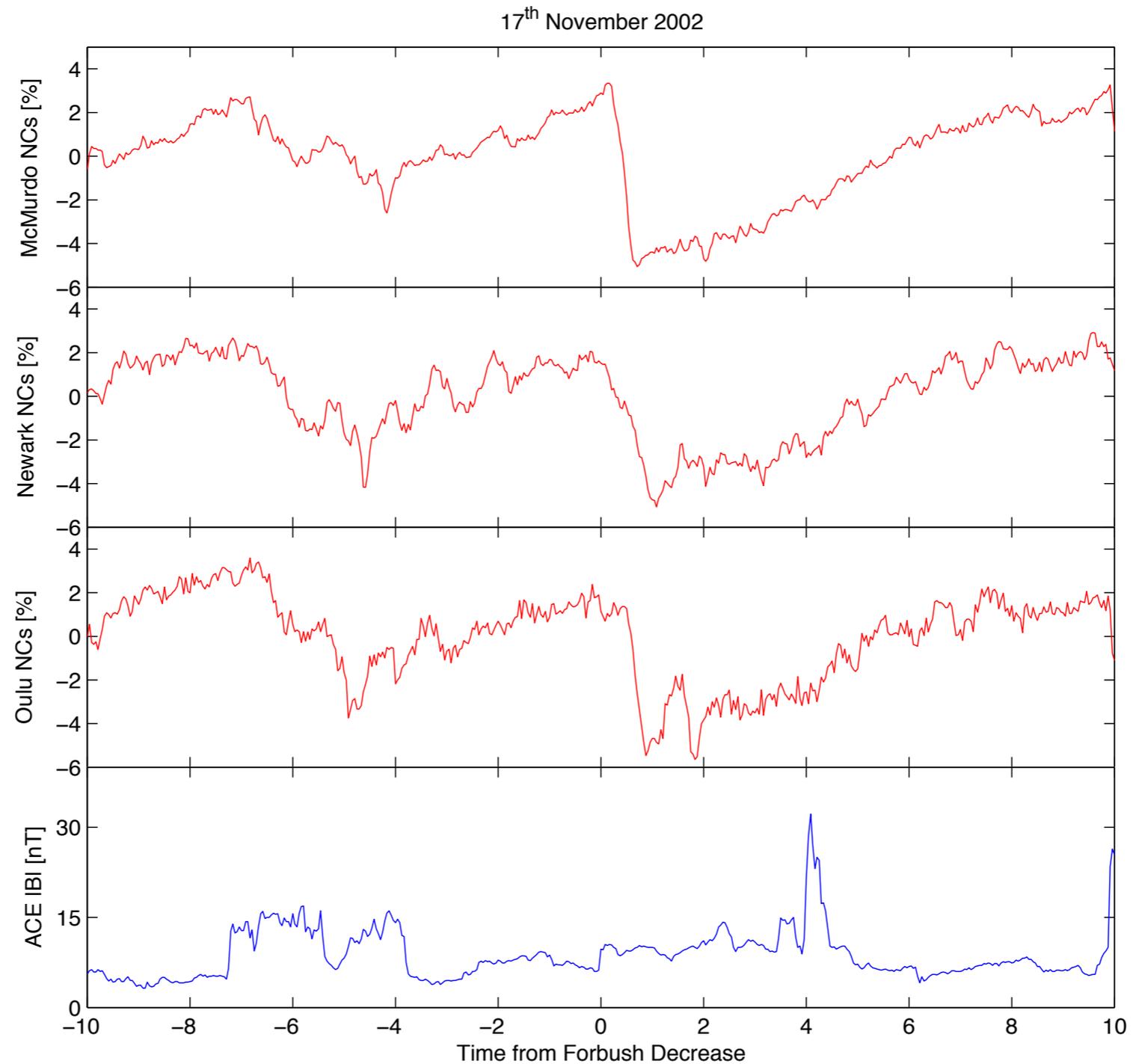


Owens and Forsyth [2013]

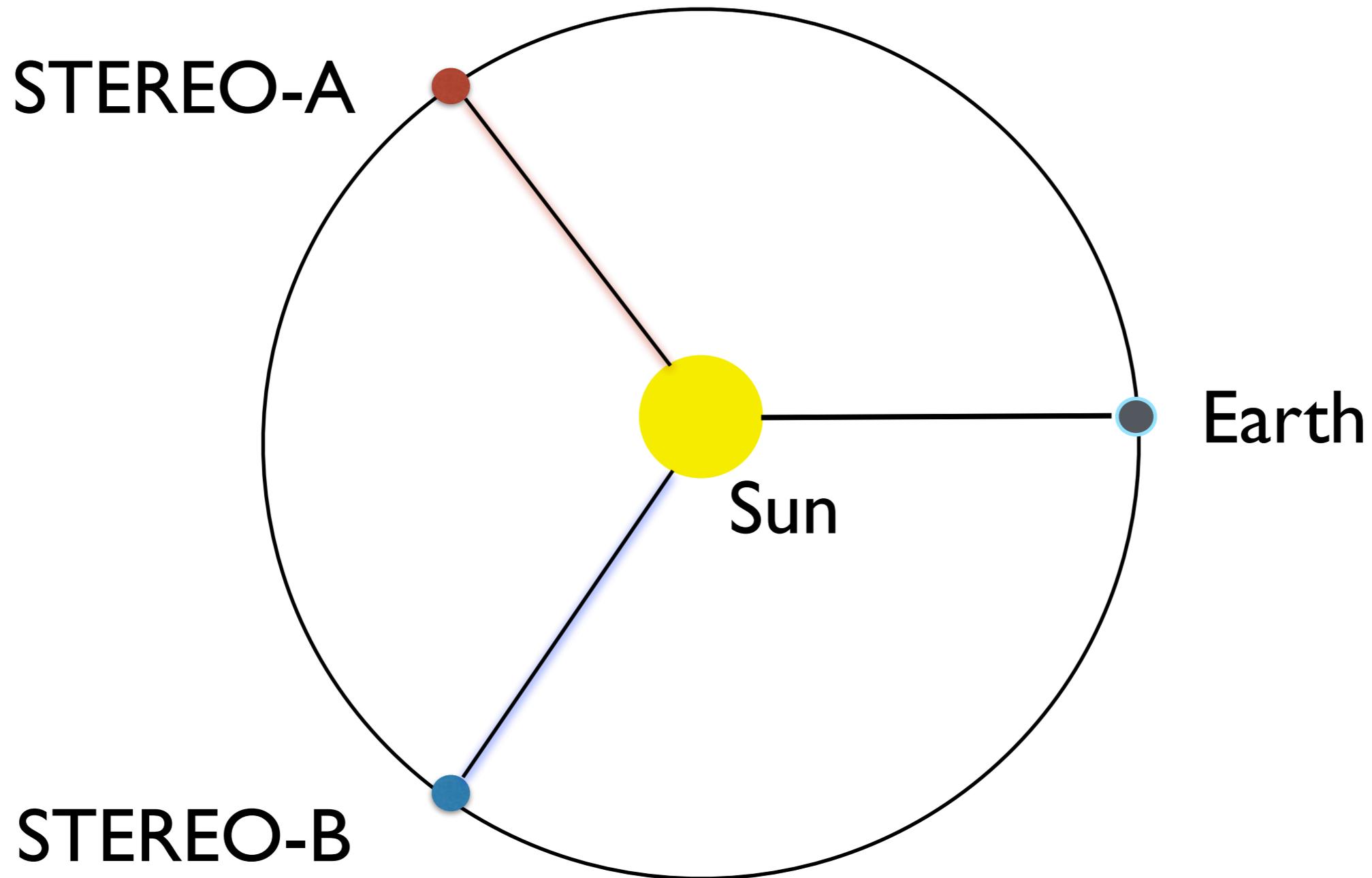
Coronal Mass Ejections



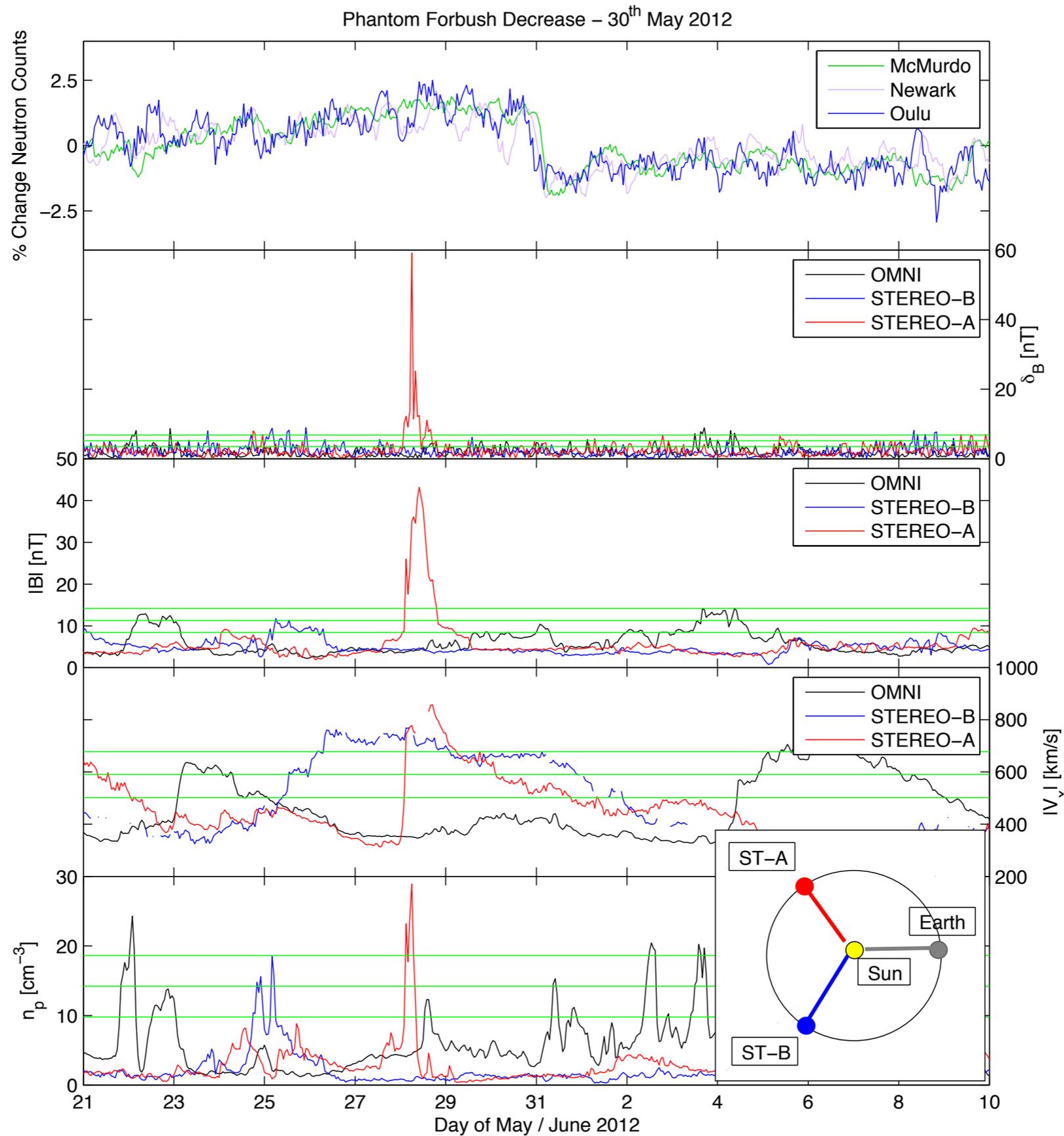
Phantom Forbush Decrease



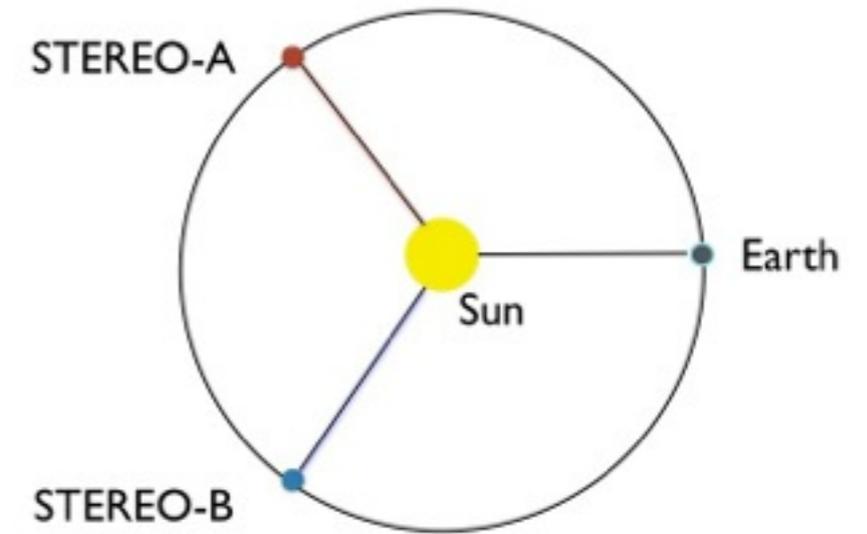
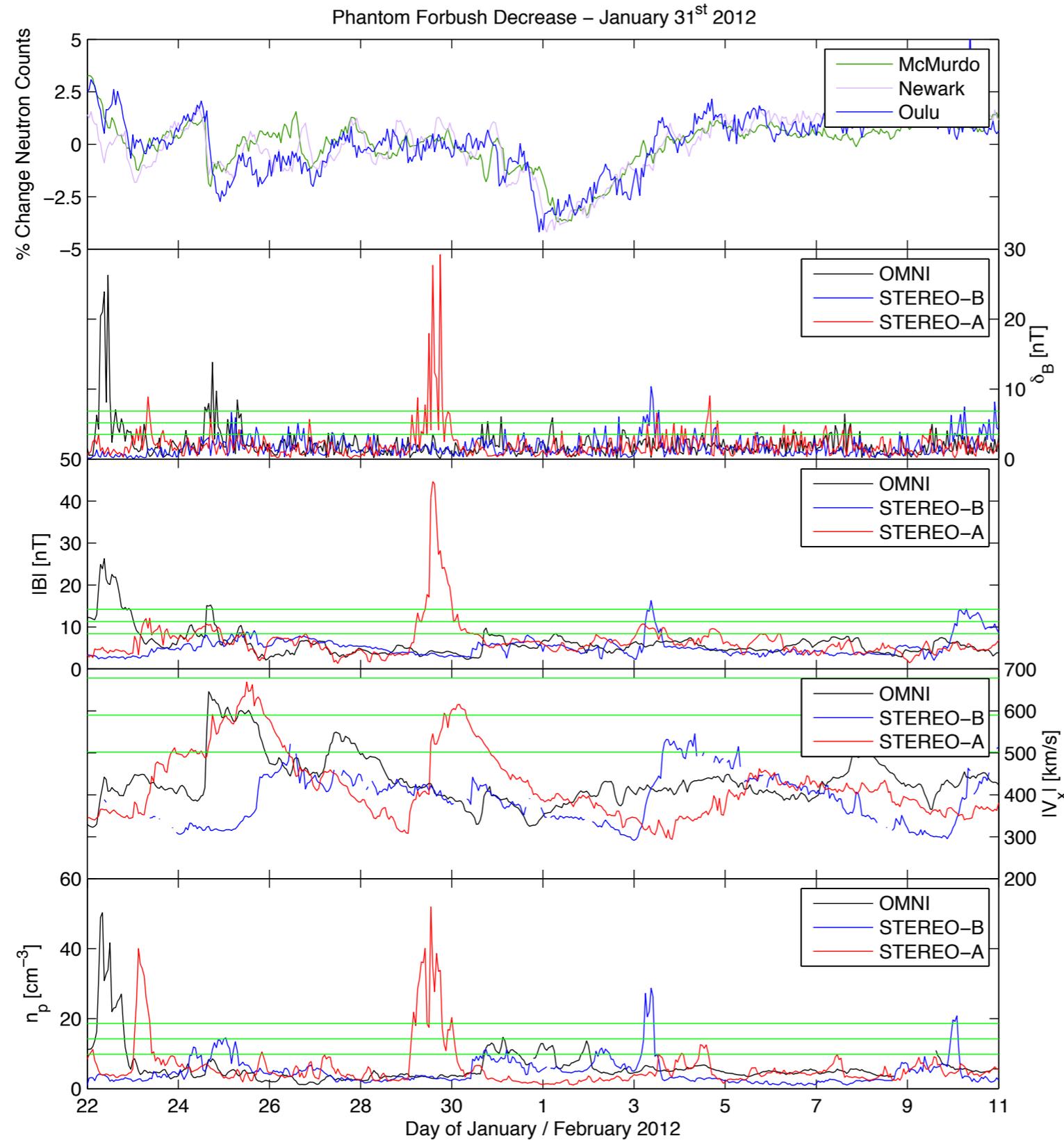
The STEREO Spacecraft



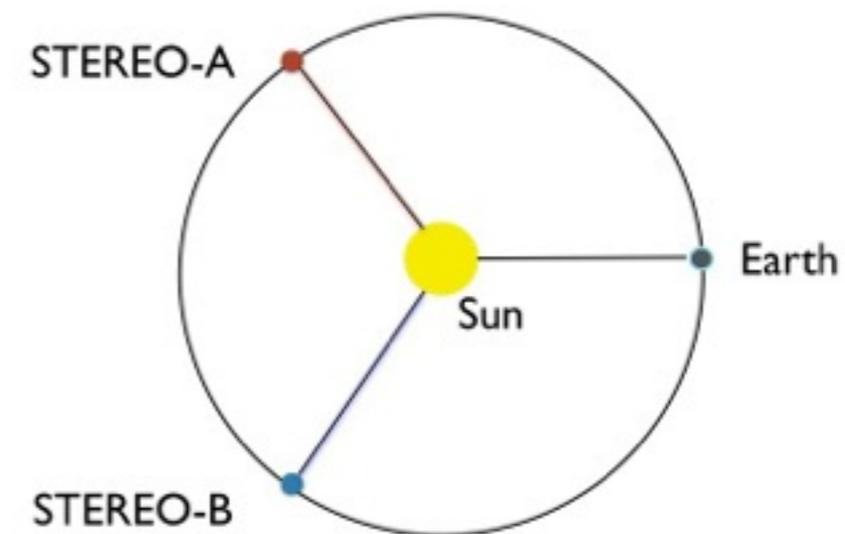
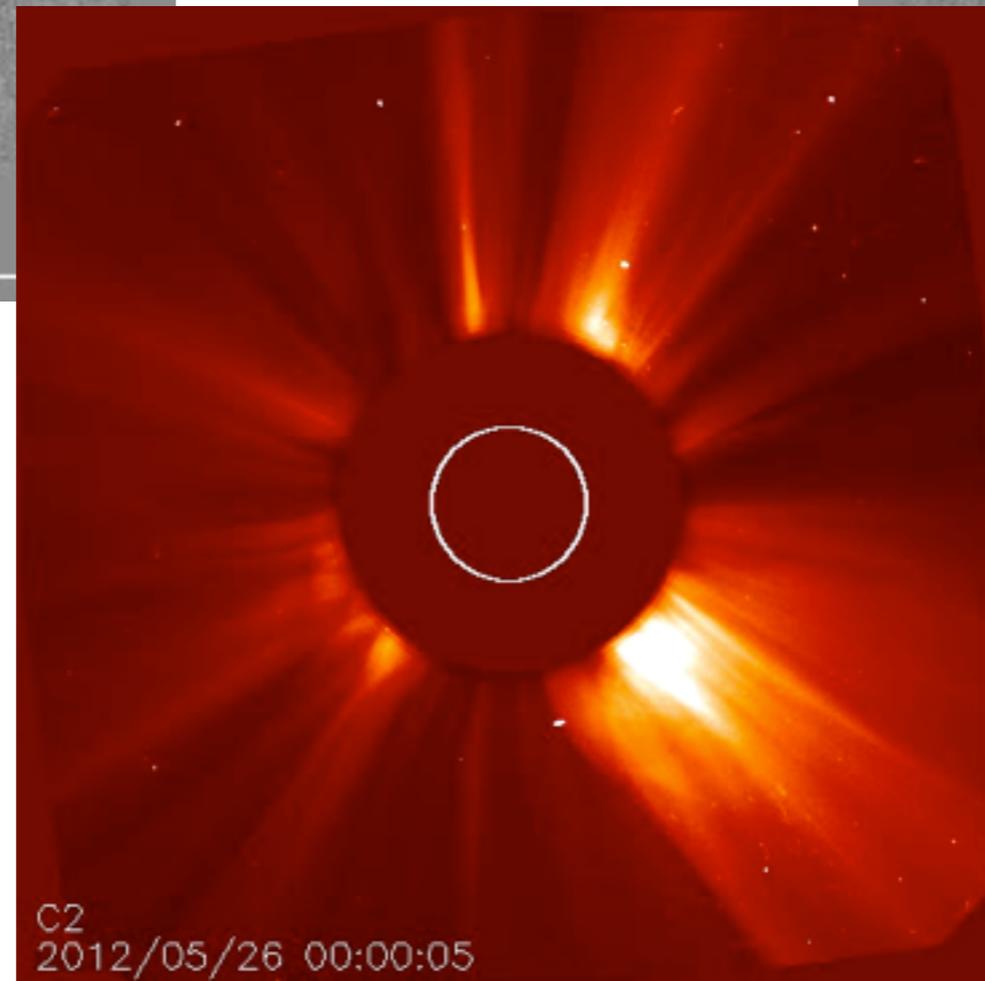
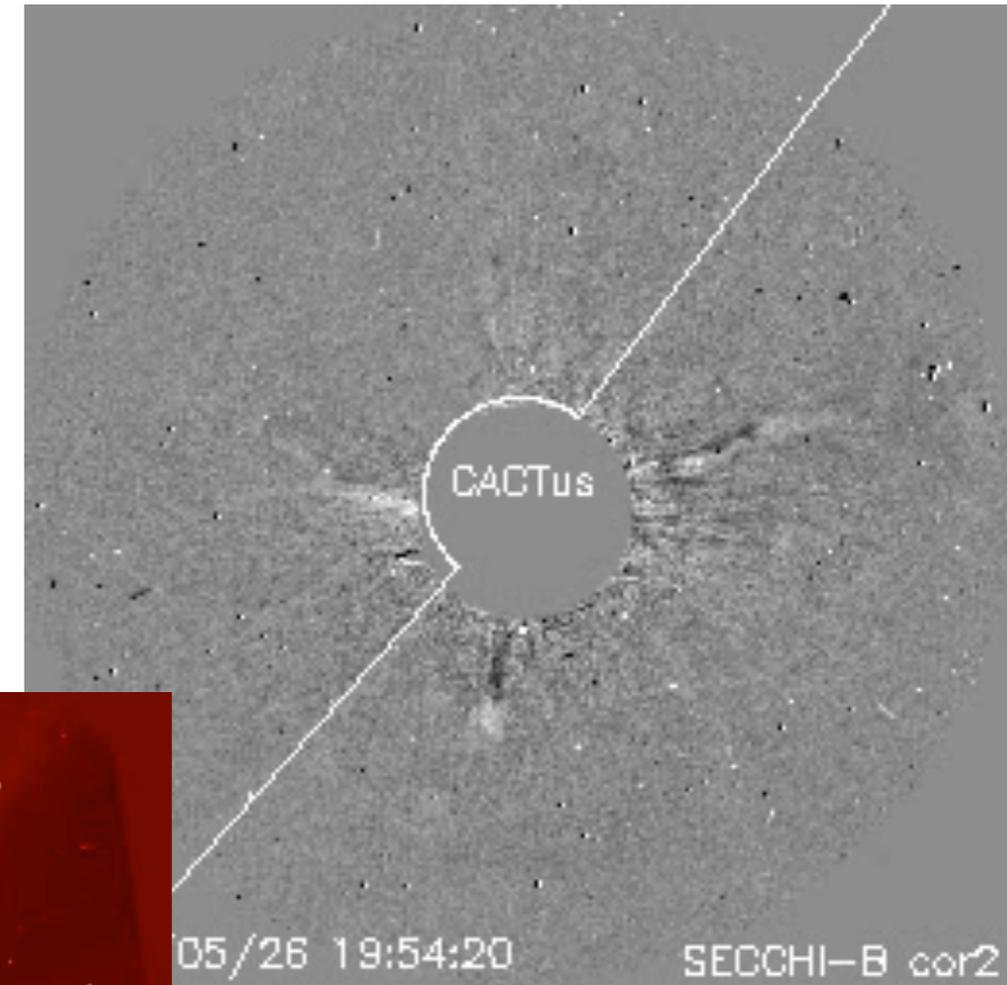
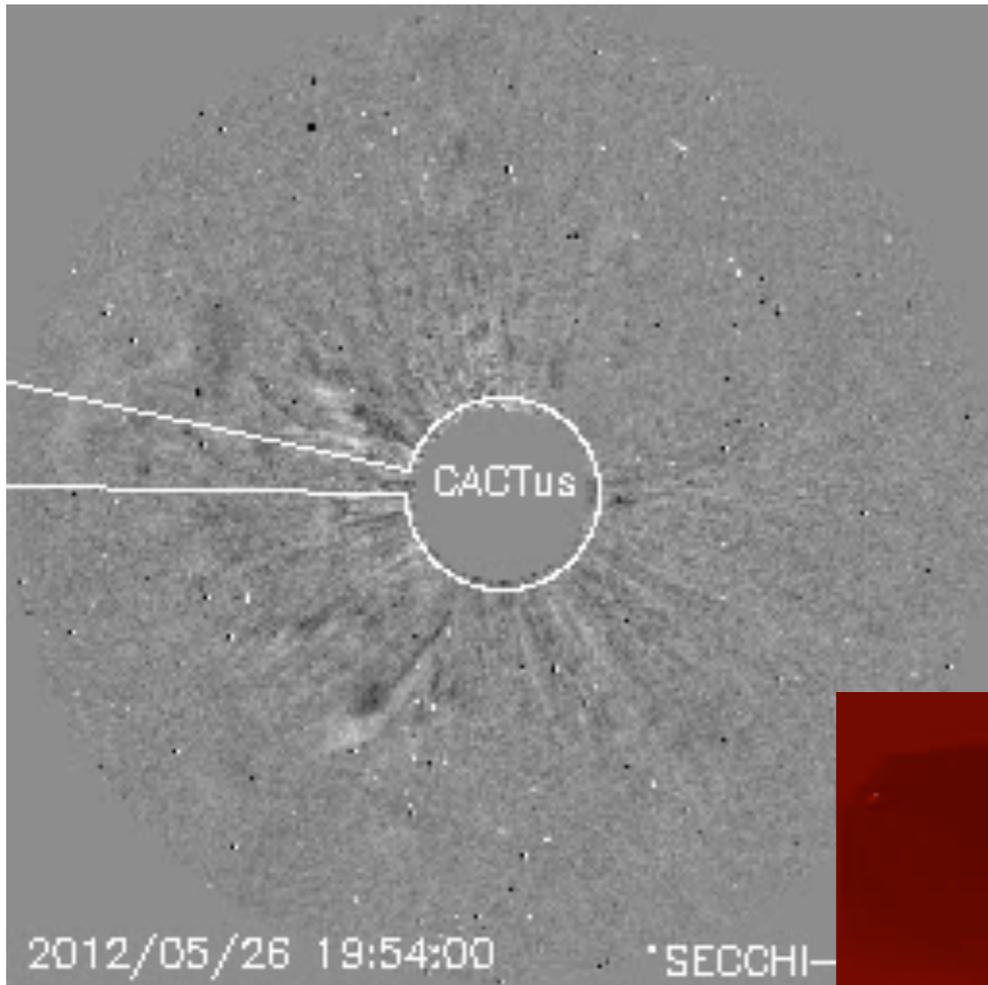
Phantom Forbush Decrease (2)



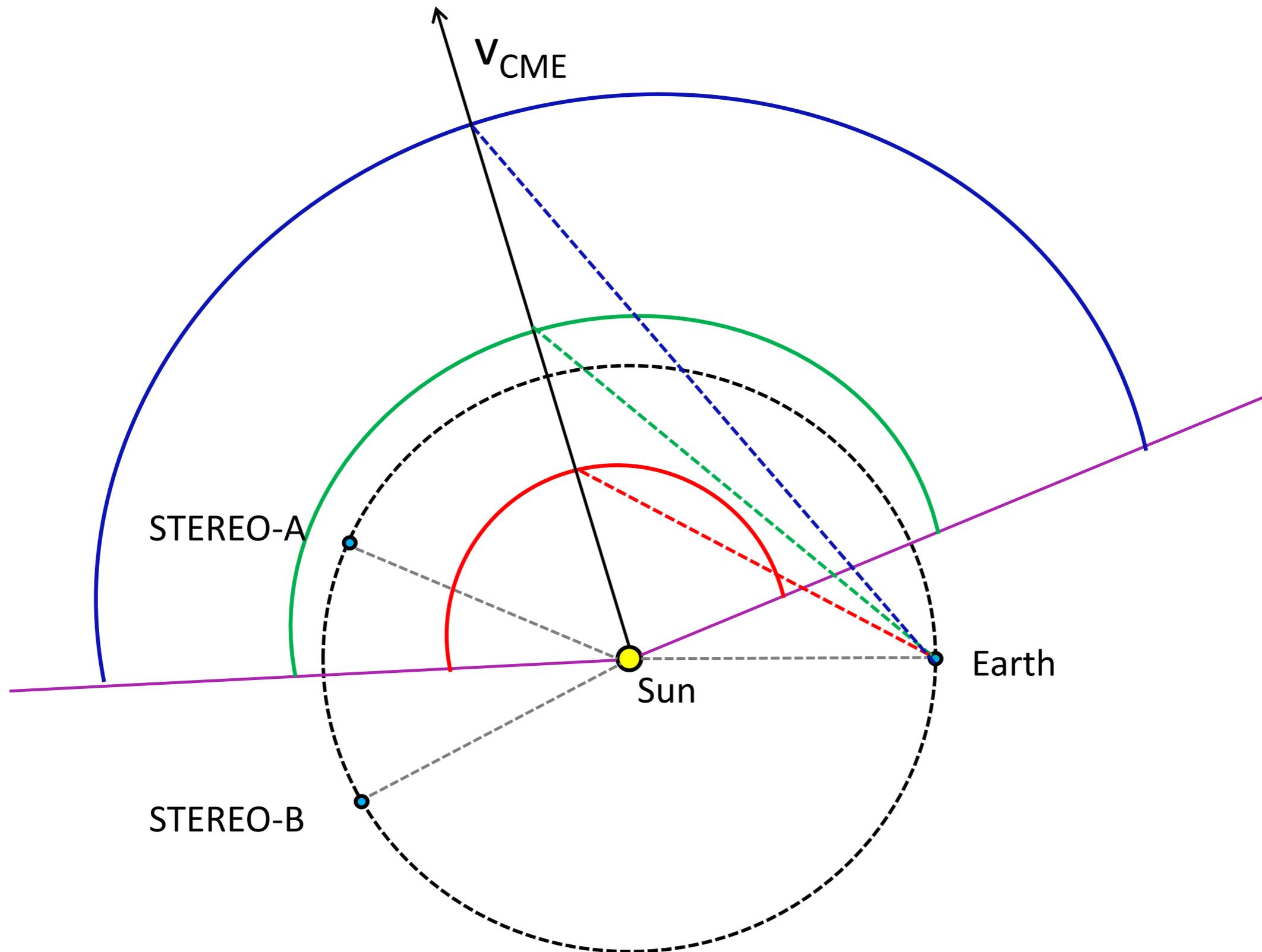
Phantom Forbush Decrease (3)



May 2012 Case Study from STEREO-A



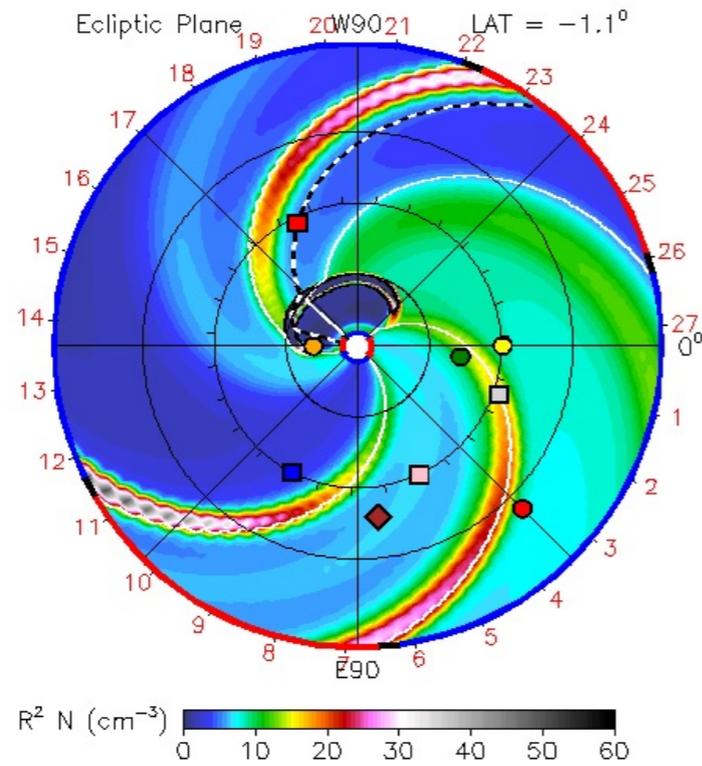
26th May 2012 Coronal Mass Ejection



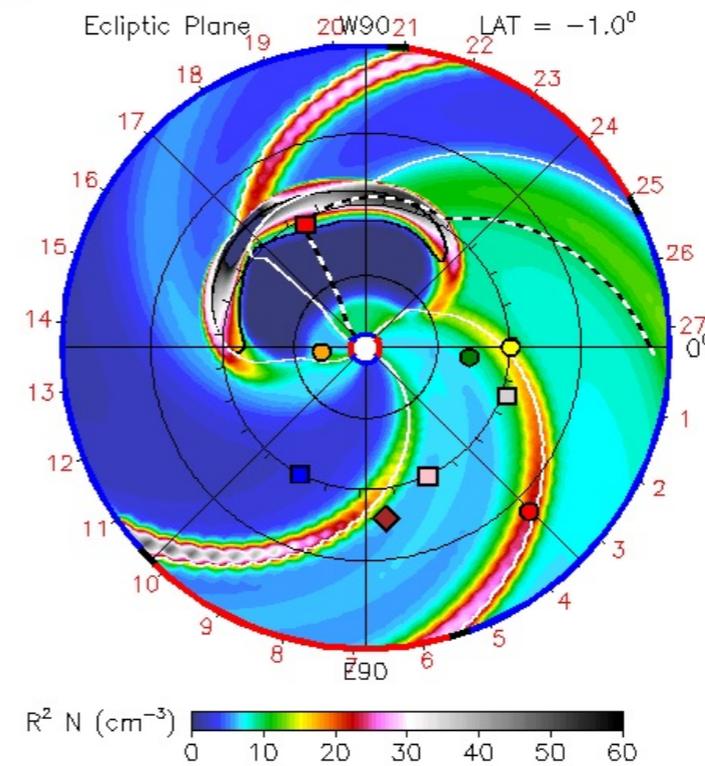
Enlil MHD Model Results

● Earth ● Mars ● Mercury ● Venus ◆ Epoxi □ Kepler □ Spitzer ■ Stereo_A
■ Stereo_B

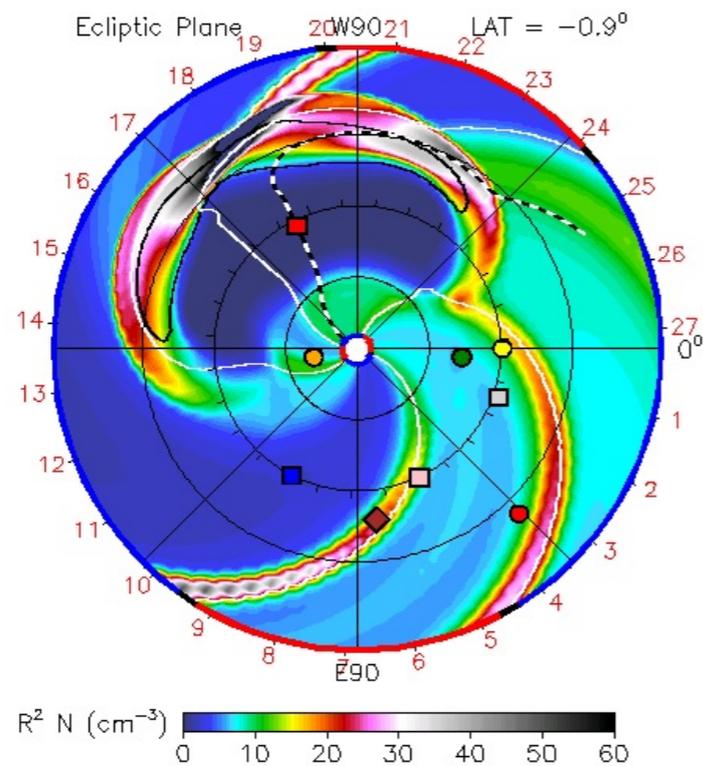
2012-05-27T12:00



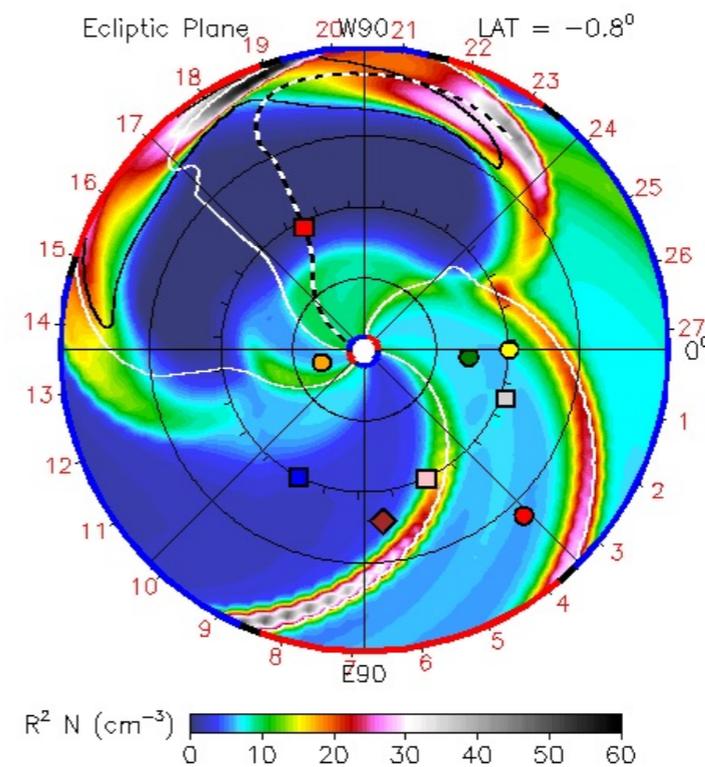
2012-05-28T12:00



2012-05-29T12:00



2012-05-30T12:00



Can we remote sense coronal mass ejections using neutron monitors?

Quick Answer: Probably

Long Answer:

- We have observed unusual Forbush Decreases, where a CME has missed Earth but we have noticed its presence in neutron monitors.
- Variations in the diurnal signal may also be consistent with the passages of the CME.
- However, further work is required to establish whether we can use this for remote sensing CMEs