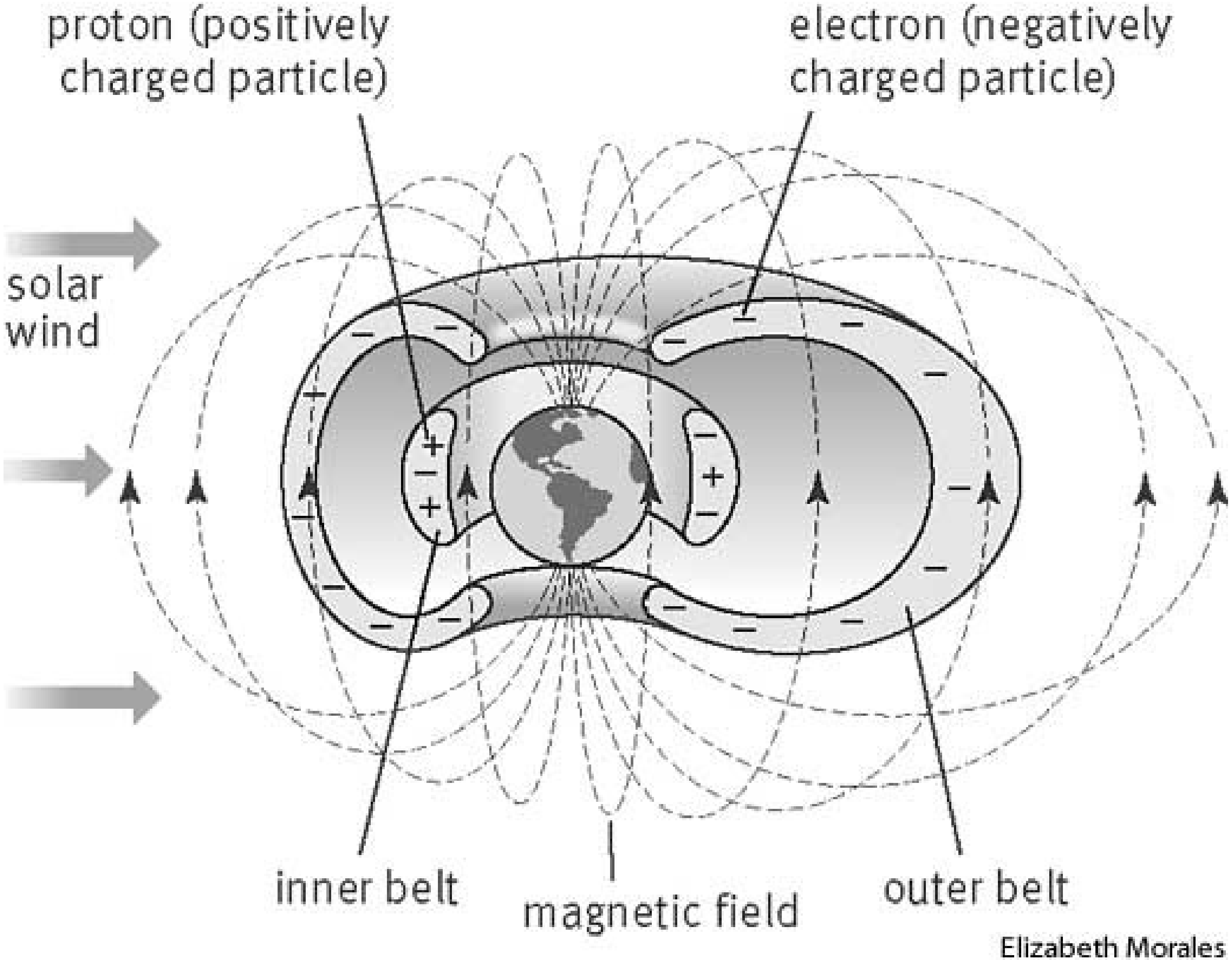
Van Allen Radiation Belt

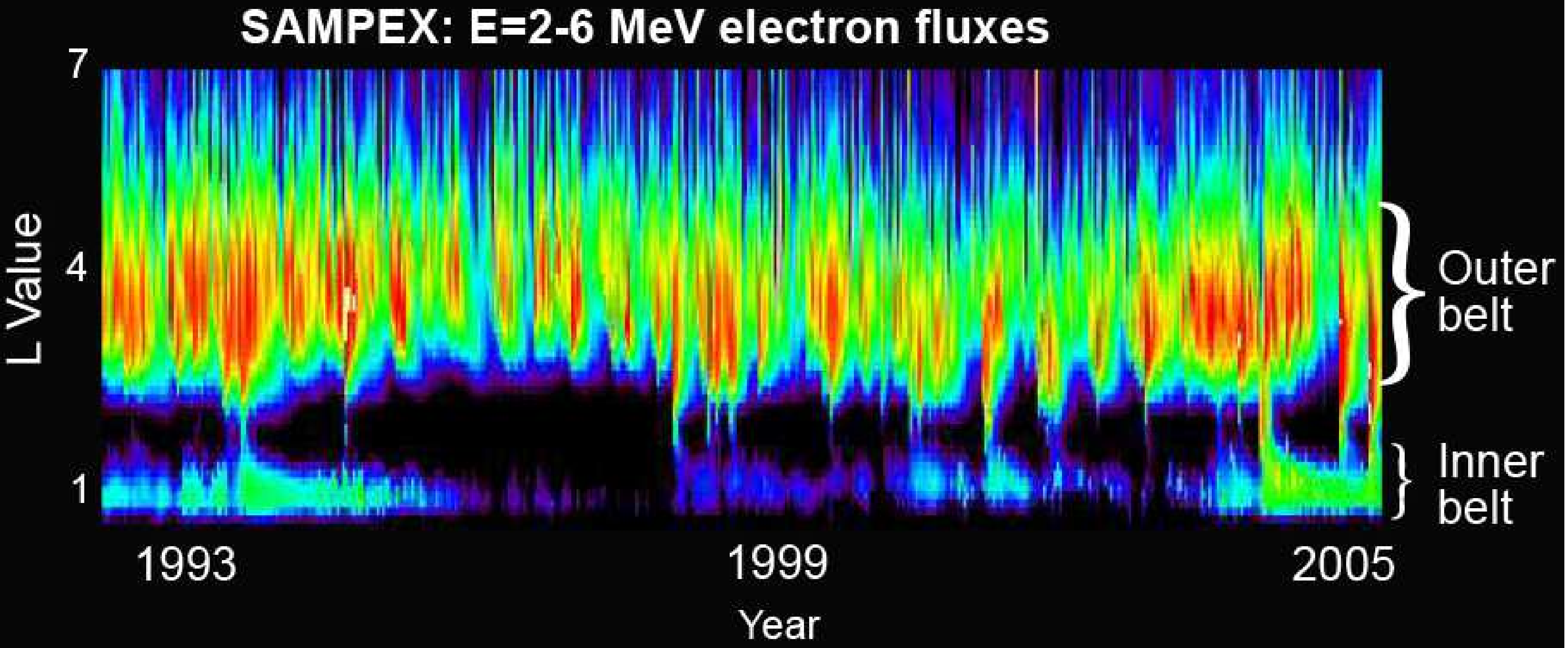


The inner radiation belt mainly comprises the energetic protons and appears to be relatively stable. In contrast, the outer radiation belt primarily consists of energetic electrons and often exhibits the complex and dramatic dynamics.

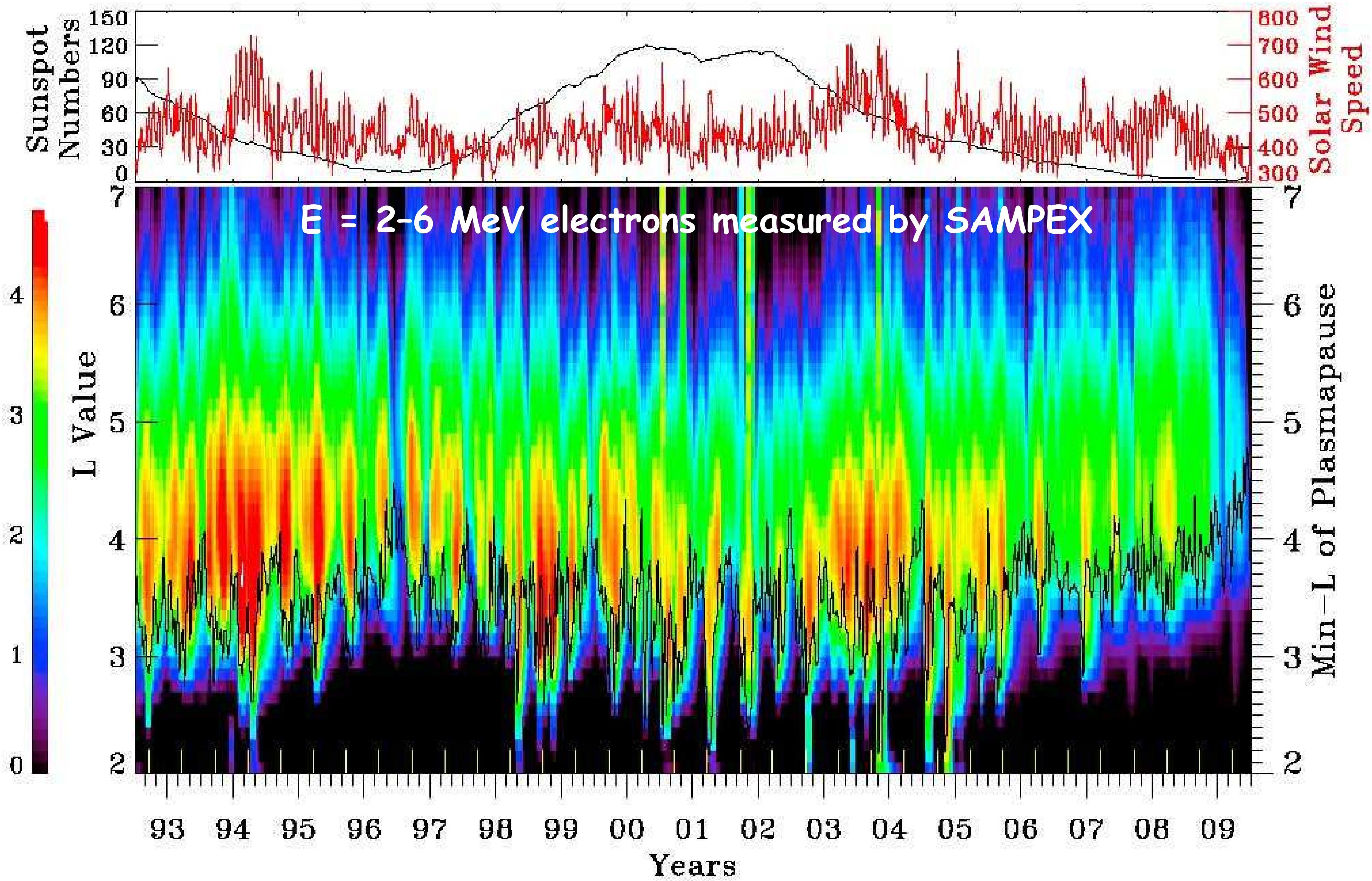
http://static.sfdict.com/dictstatic/dictionary/graphics/ahsd/jpg/ASvanall.jpg

SAMPEX Shows Traditional Two Belt Structure

Long term (~12 year) plot from SAMPEX shows the established two belt structure



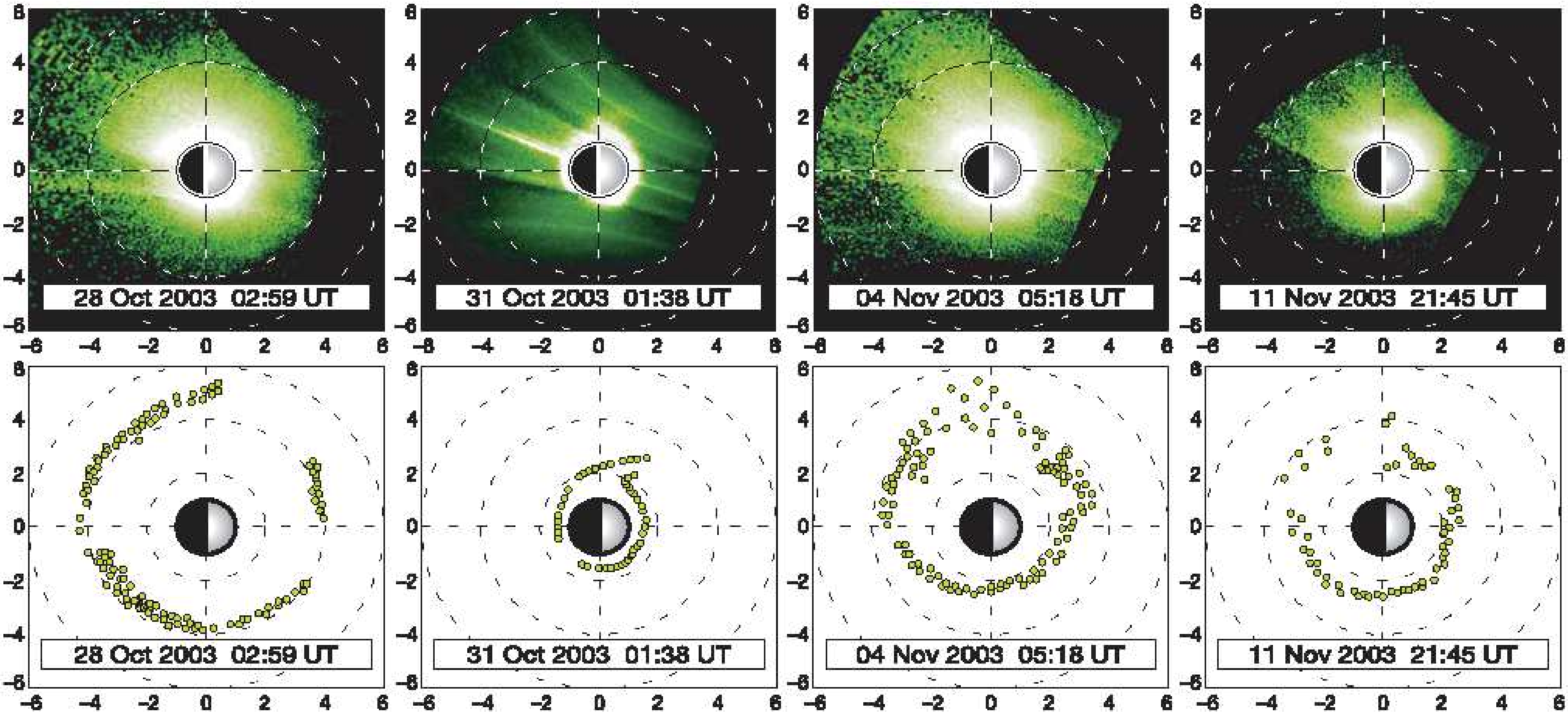
http://svs.gsfc.nasa.gov/vis/a010000/a011200/a011212/Dan3.jpg

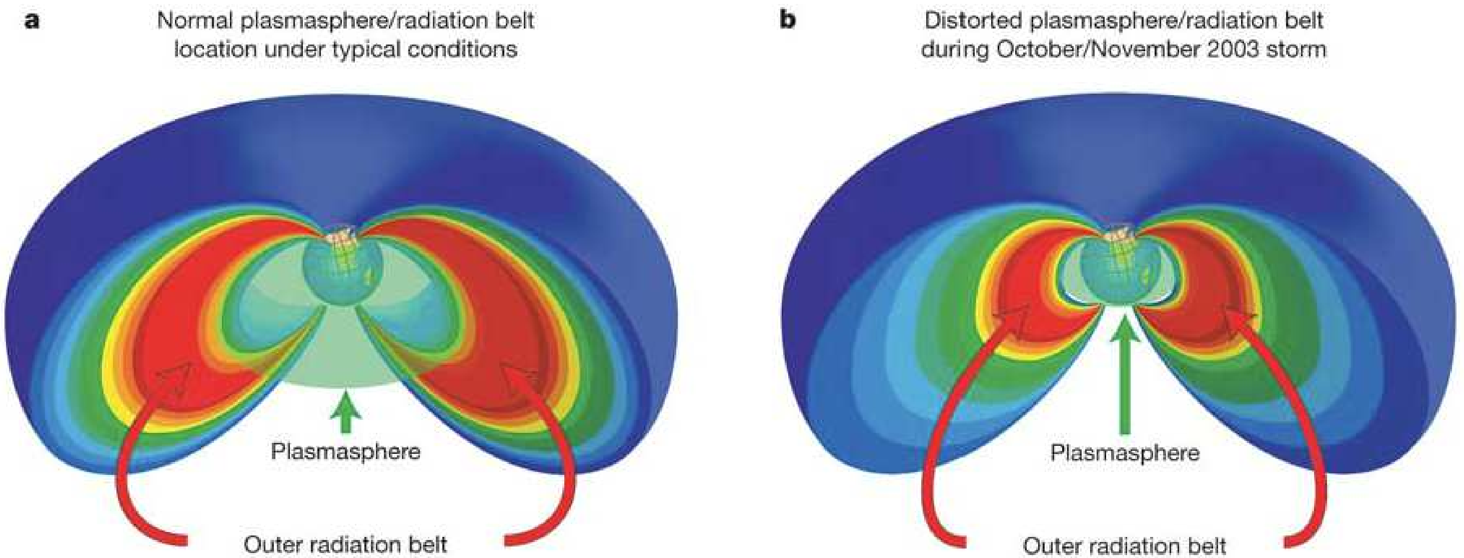


Intensity of outer belt electrons is very well correlated with the solar wind speed. → IMF B?

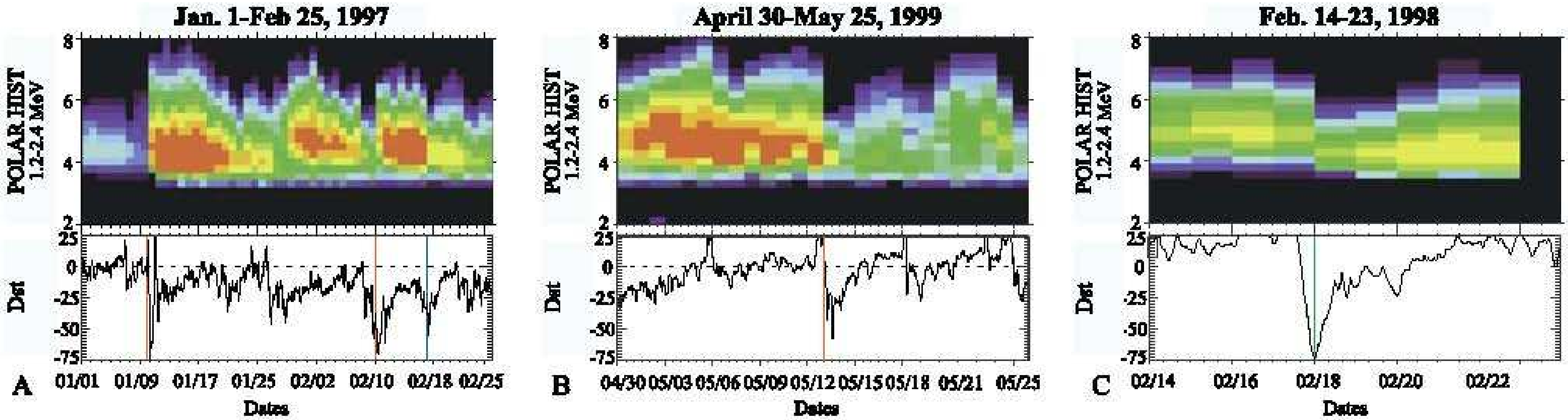
A remarkable correlation is evident between the inner edge of the outer radiation belt and the innermost position of the plasmapause over a long term period.

Li et al. (2011)

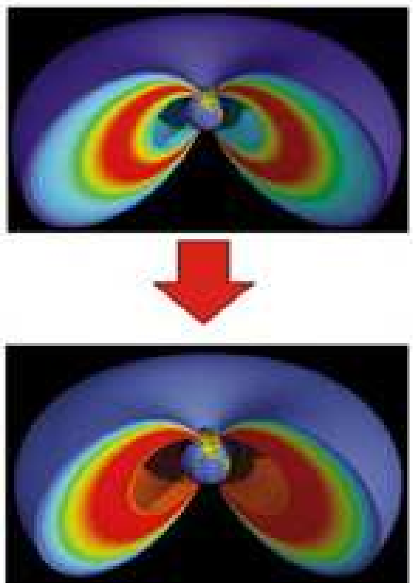




http://www.nature.com/nature/journal/v432/n7019/full/nature03116.html

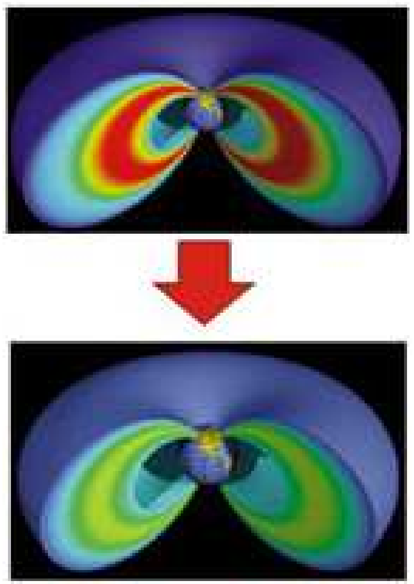


enhanced



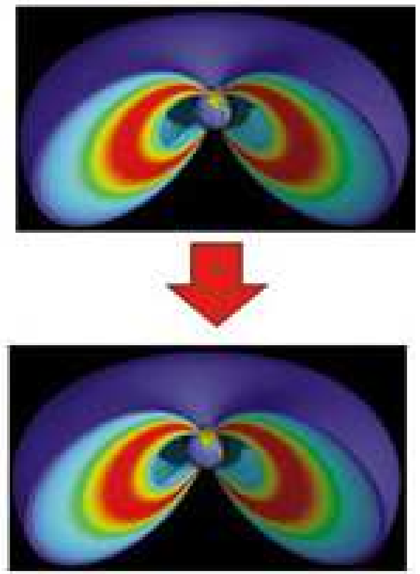
145/276 ~ 53%

depressed



53/276 ~ 19%

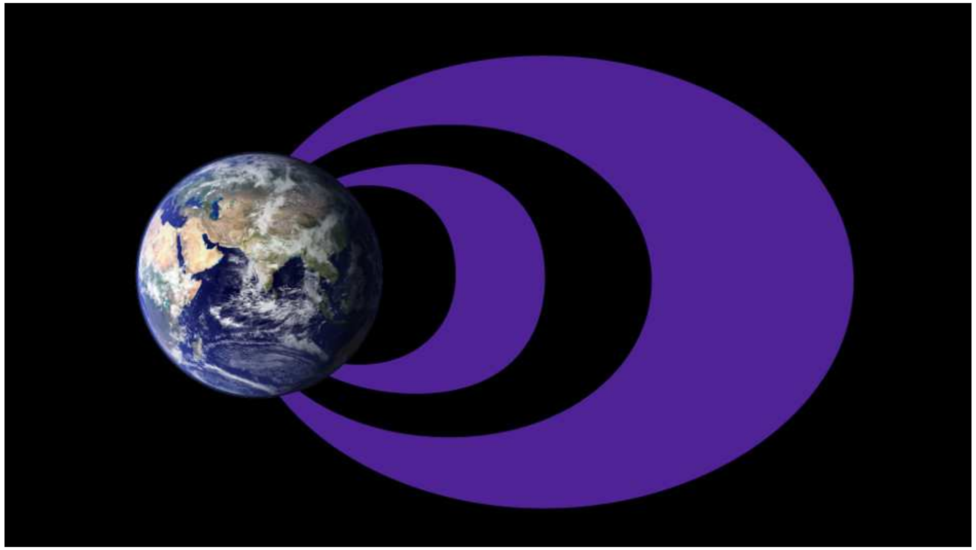
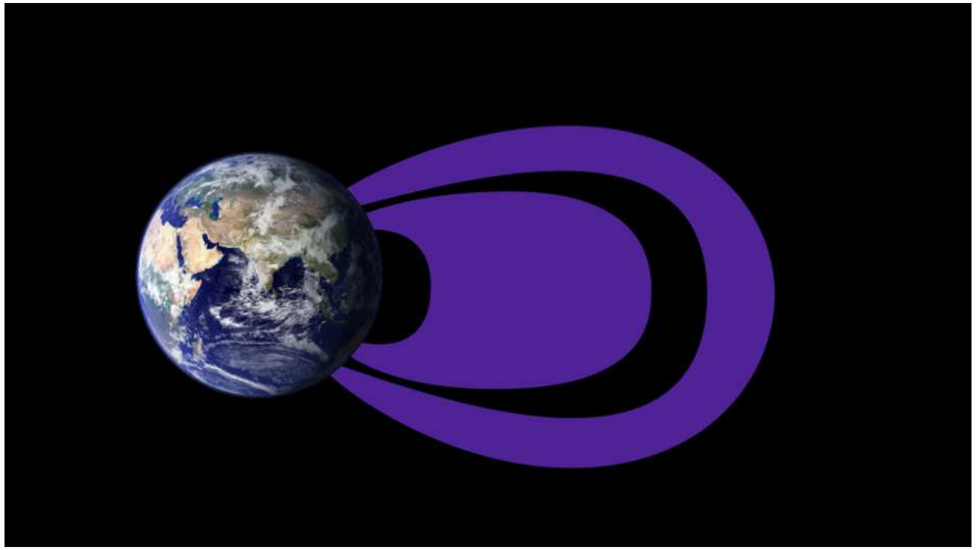
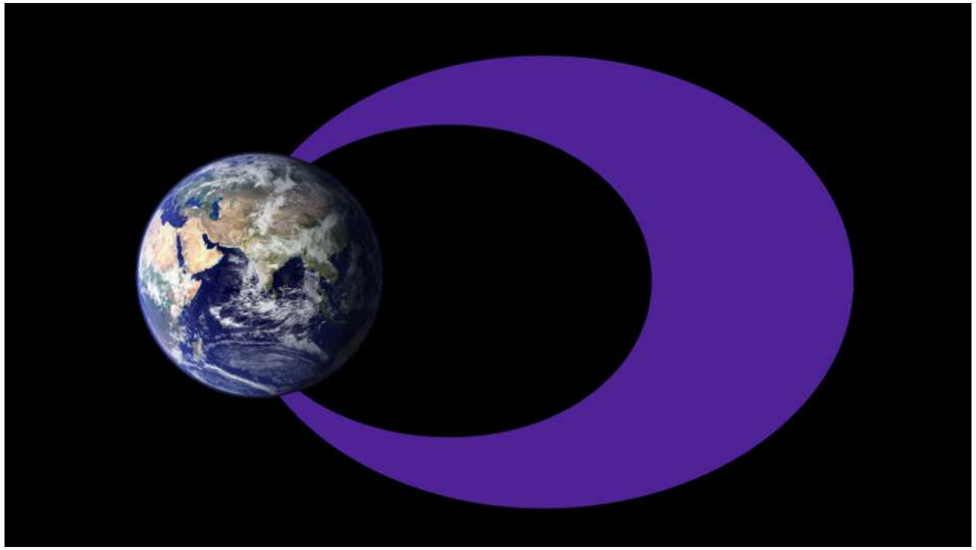
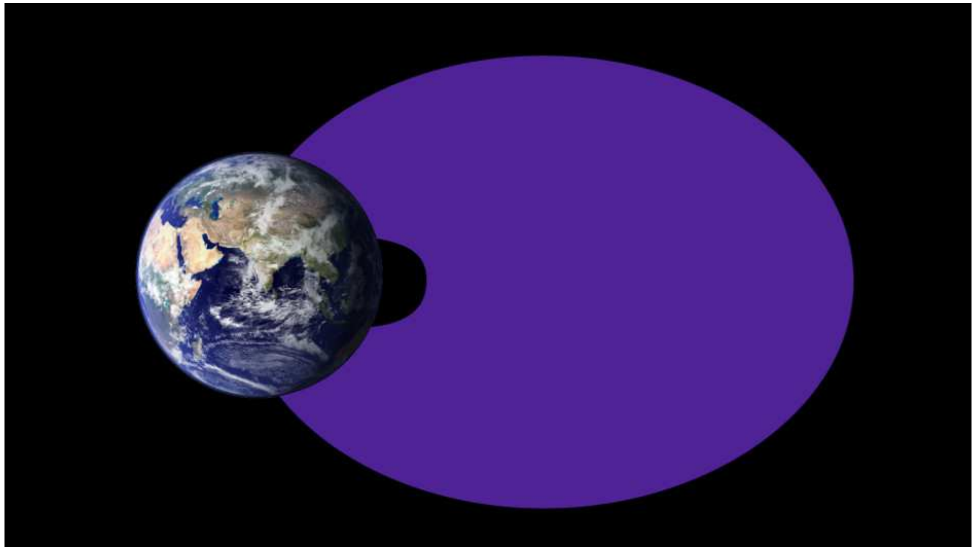
essentially unchanged



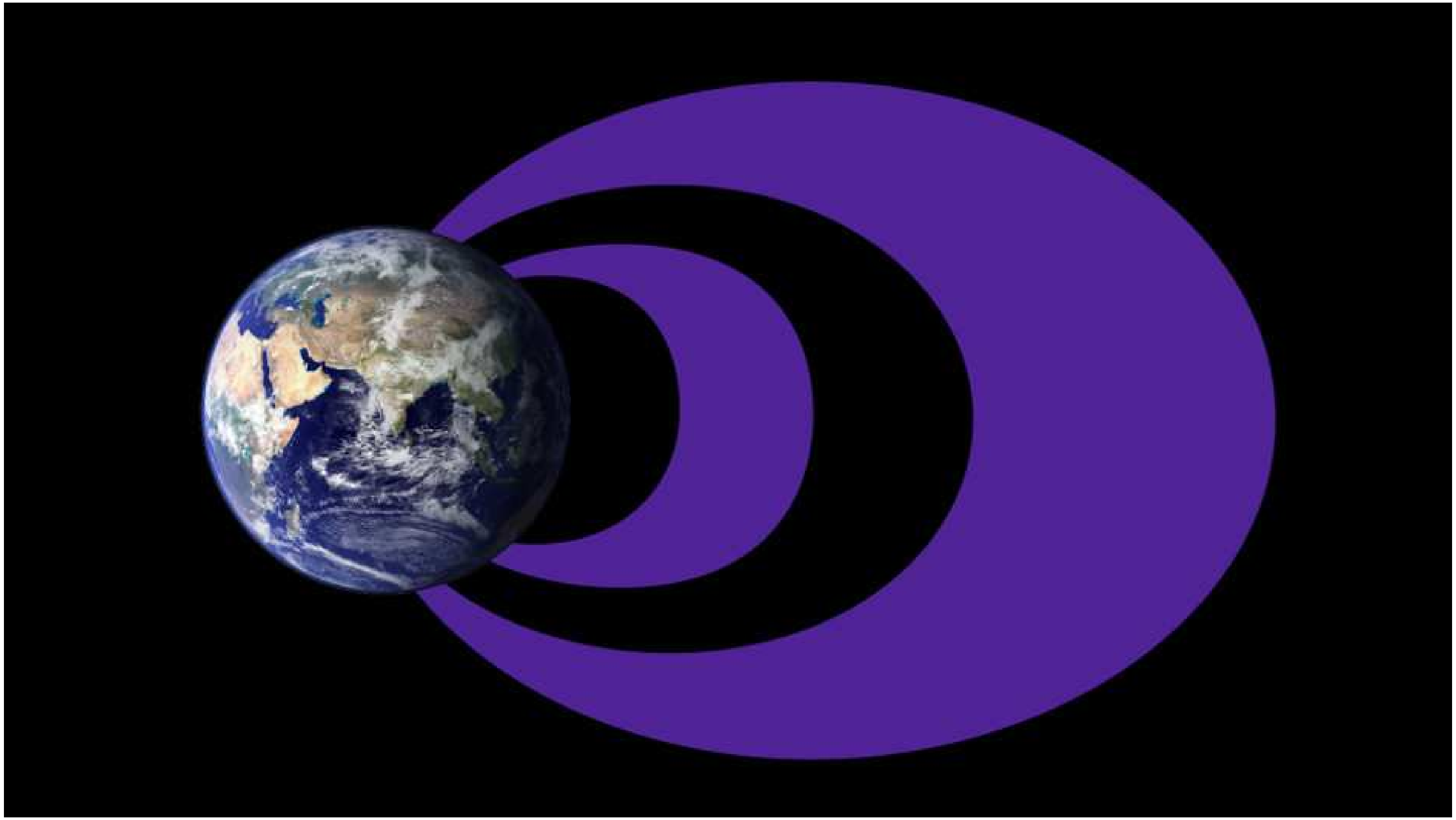
78/276 ~ 28%

These statistical results suggest that, there simultaneously exist various acceleration and loss mechanisms, and the competition of these mechanisms determines the final variation in energetic electron fluxes.

Reeves et al. (2003), Yihua Zheng (2013)

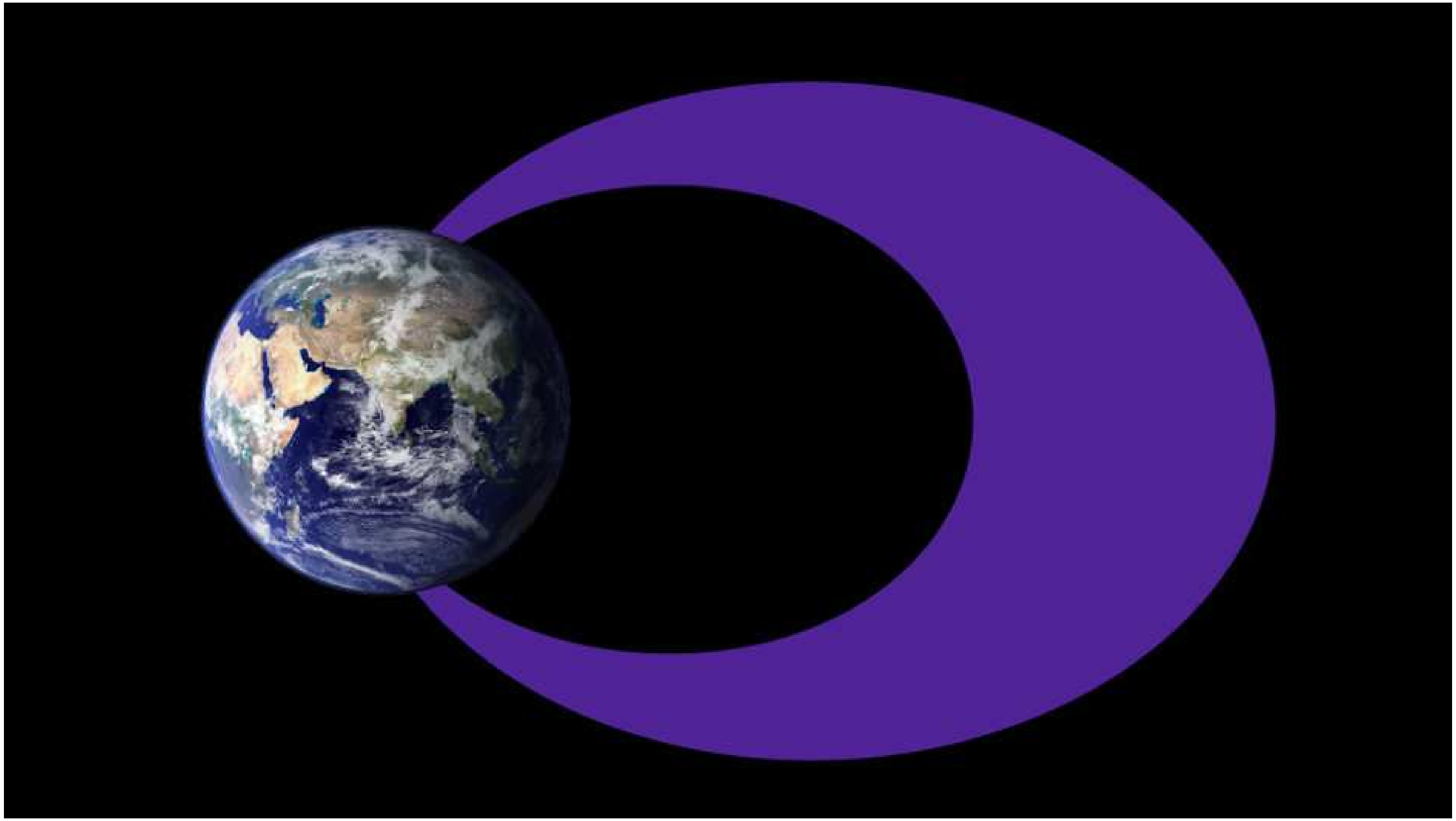





https://www.nasa.gov/feature/goddard/2016/nasa-s-van-allen-probes-revolutionize-view-of-radiation-belts



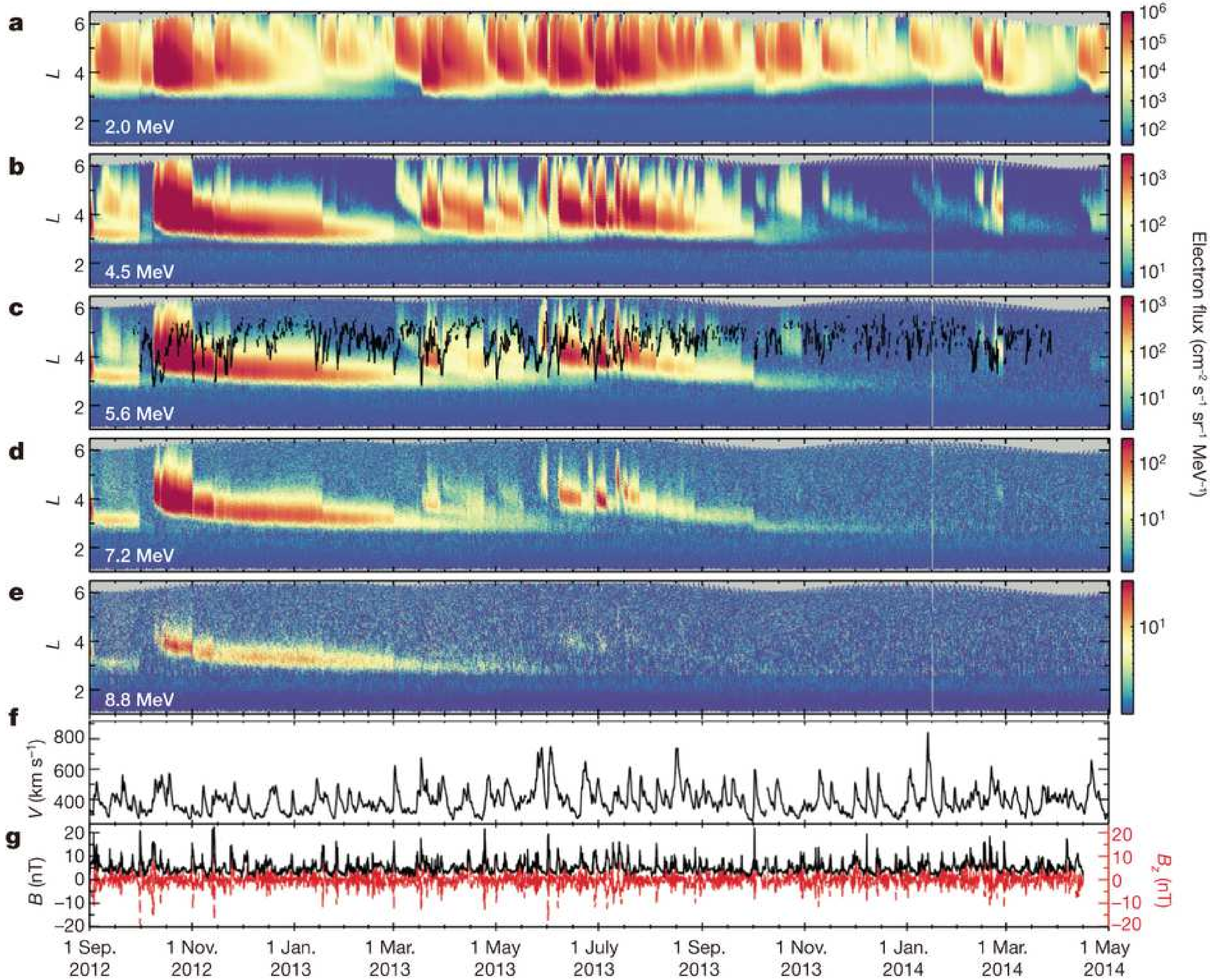
The traditional idea of the radiation belts includes a larger, more dynamic outer belt and a smaller, more stable inner belt with an empty slot region separating the two. However, a new study based on data from NASA's Van Allen Probes shows that all three regions — the inner belt, slot region and outer belt — can appear different depending on the energy of electrons considered and general conditions in the magnetosphere.

https://www.nasa.gov/feature/goddard/2016/nasa-s-van-allen-probes-revolutionize-view-of-radiation-belts

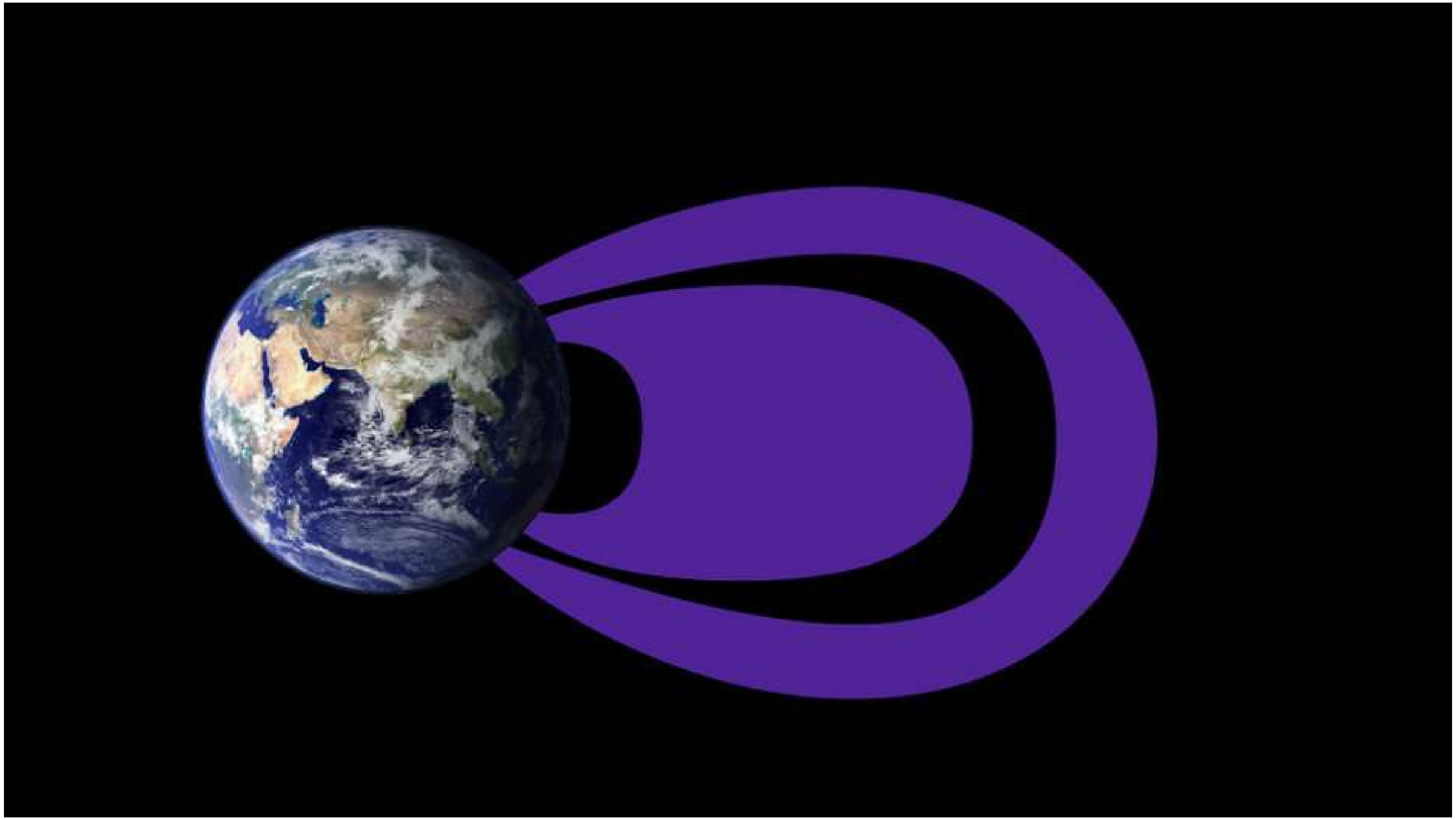


At the highest electron energies measured — above 1 MeV — researchers saw electrons in the outer belt only.

https://www.nasa.gov/feature/goddard/2016/nasa-s-van-allen-probes-revolutionize-view-of-radiation-belts

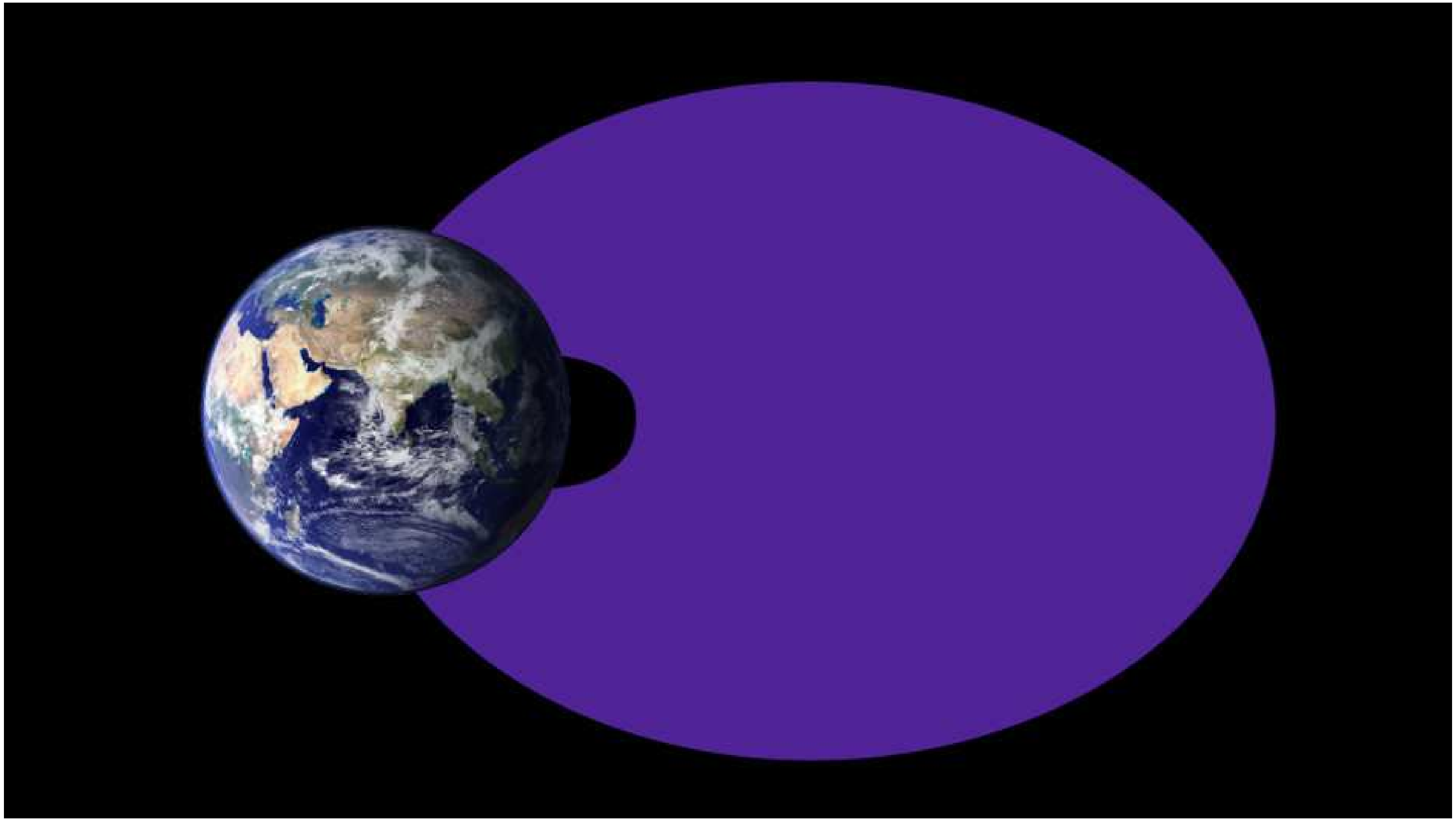


http://www.nature.com/nature/journal/v515/n7528/fig_tab/nature13956_F1.html



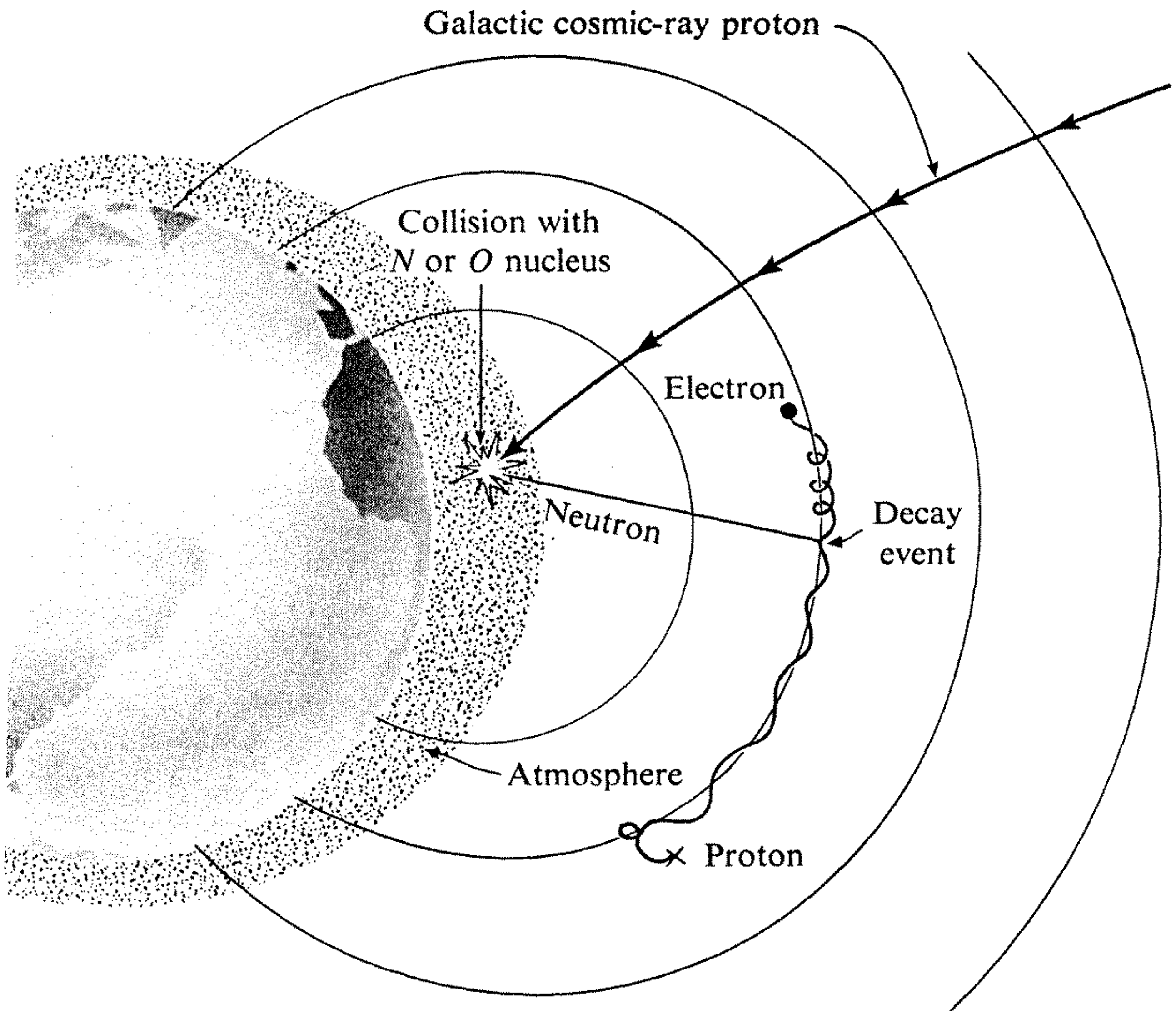
The radiation belts look much different at the lowest electron energy levels measured, about 0.1 MeV. Here, the inner belt is much larger than in the traditional picture, expanding into the region that has long been considered part of the empty slot region. The outer belt is diminished and doesn't expand as far in these lower electron energies.

https://www.nasa.gov/feature/goddard/2016/nasa-s-van-allen-probes-revolutionize-view-of-radiation-belts



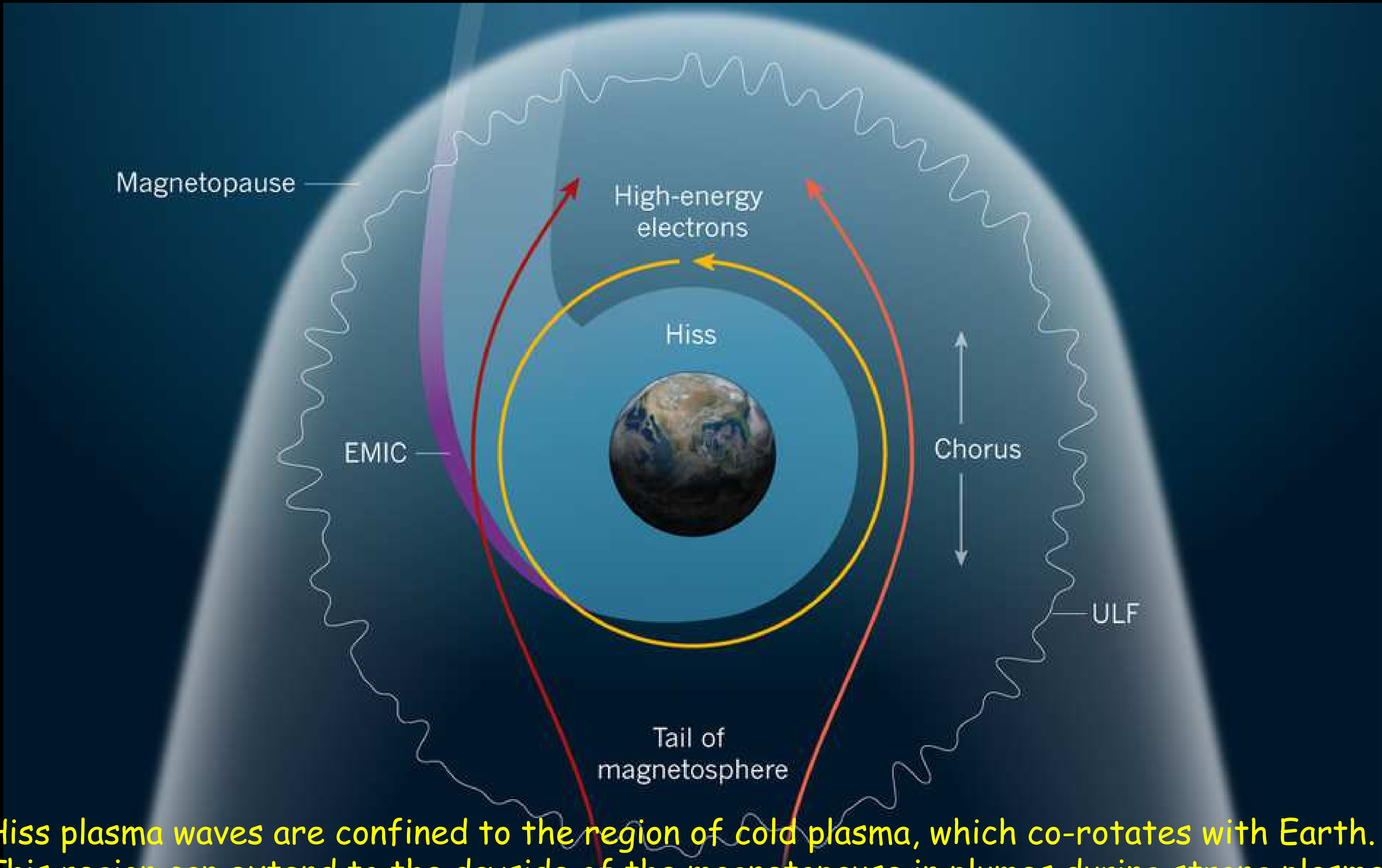
During geomagnetic storms, the empty region between the two belts can fill in completely with lower-energy electrons. Traditionally, scientists thought this slot region filled in only during the most extreme geomagnetic storms happening about once every 10 years. However, new data shows it's not uncommon for lower-energy electrons — up to 0.8 MeV — to fill this space during almost all geomagnetic storms.

https://www.nasa.gov/feature/goddard/2016/nasa-s-van-allen-probes-revolutionize-view-of-radiation-belts



- CRAND (cosmic ray albedo neutron decay) is used to describe the mechanism that populates the inner belt
- A galactic cosmic ray hits the atmosphere and produces a neutron
- The neutron decays in a short time producing a proton and electron that become trapped

Kazue Takahashi (2011)



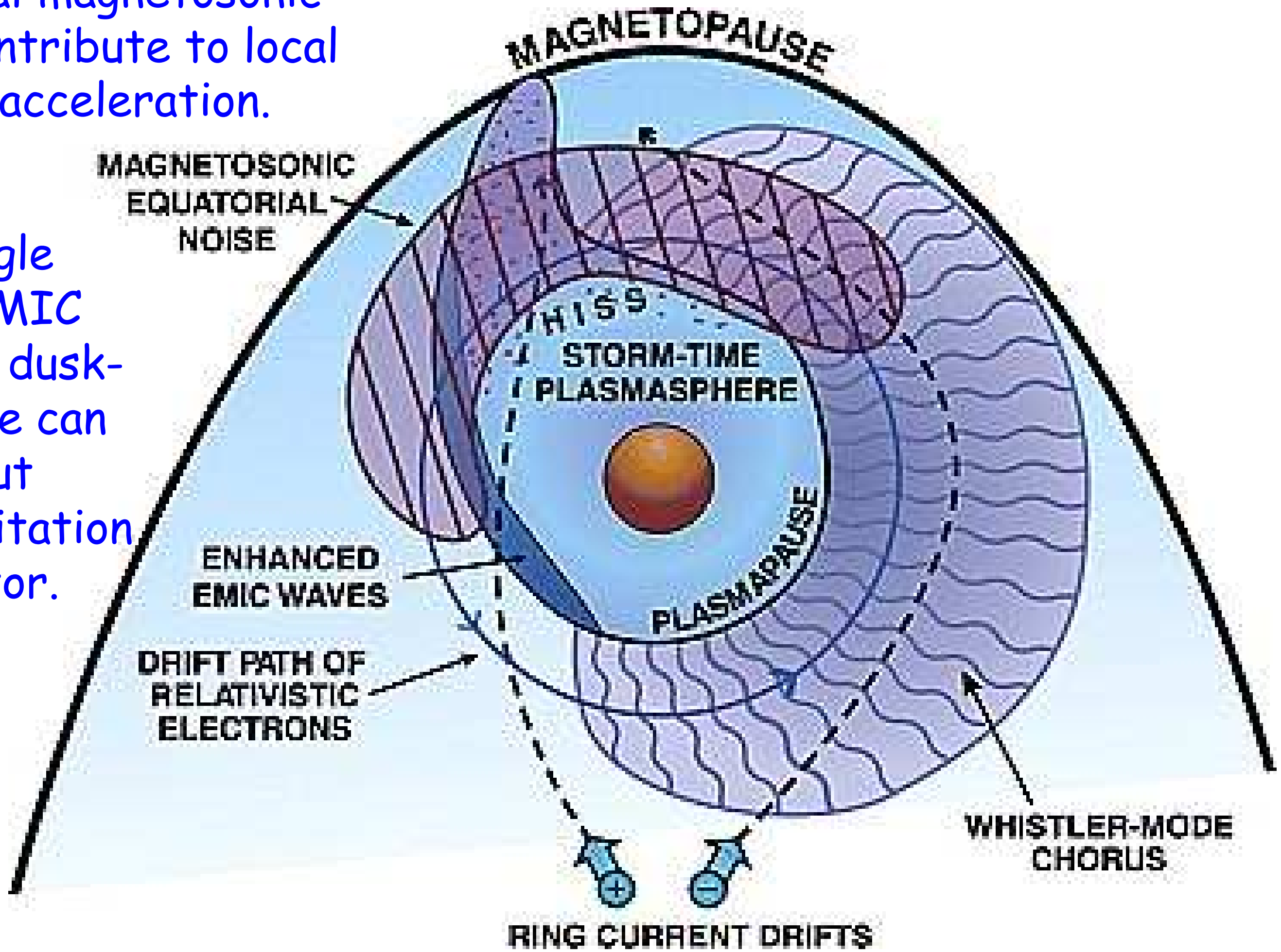
Hiss plasma waves are confined to the region of cold plasma, which co-rotates with Earth. This region can extend to the dayside of the magnetopause in plumes during strong plasma convection from the tail of the magnetosphere. Electrons and ions transported from the tail excite electromagnetic ion cyclotron (EMIC) waves around the dusk side and chorus waves around the dawn side. The yellow circular arrow shows the direction of high-energy electron drift around Earth. Ultra-low-frequency (ULF) waves are also shown.

http://www.nature.com/nature/journal/v504/n7480/images/504383a-f1.jpg

Electrons are also subject to weak diffusion scattering on the dayside during resonance with plasmaspheric hiss.

Equatorial magnetosonic waves contribute to local electron acceleration.

Strong pitch angle scattering by EMIC waves along the dusk-side plasmapause can cause intense but localized precipitation in the dusk sector.



Whistler-mode chorus can induce microburst precipitation and local stochastic acceleration along a broad portion of the electron drift path between midnight and noon.

Relativistic electron drift times are typically less than 10 minutes and the average rate of precipitation loss or stochastic acceleration must be averaged over both the bounce and drift motions in this highly variable environment.

http://link.springer.com/article/10.1007/s11214-013-9993-6