

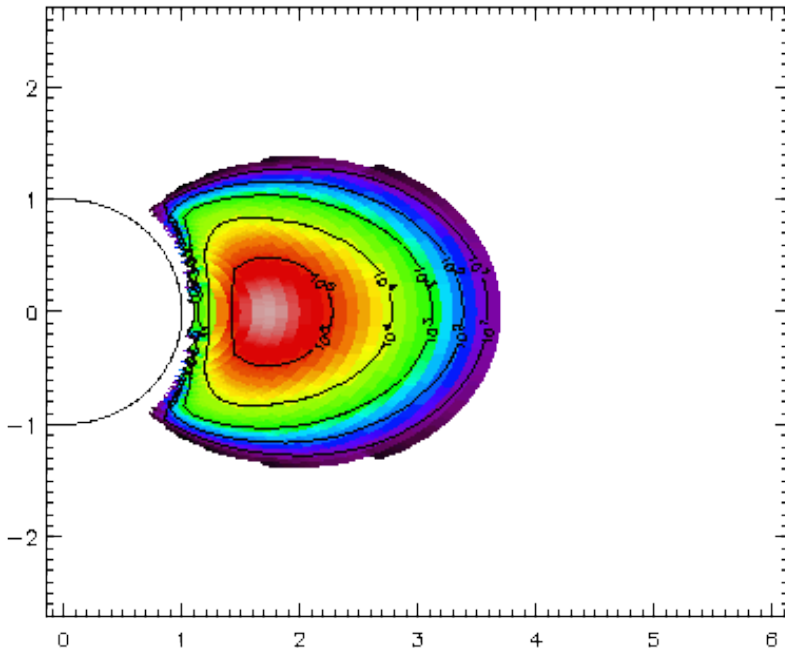


Analysis Methods for Electron Bursts

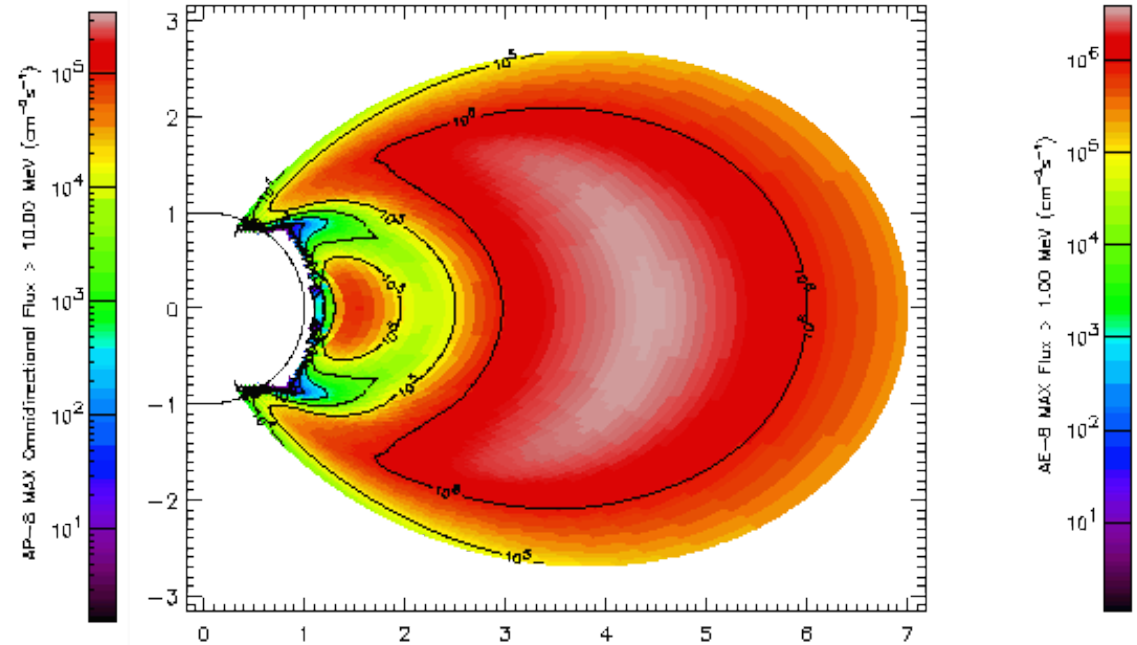
Vincenzo Vitale, ISSS 2017

Van Allen Belts

E>10MeV



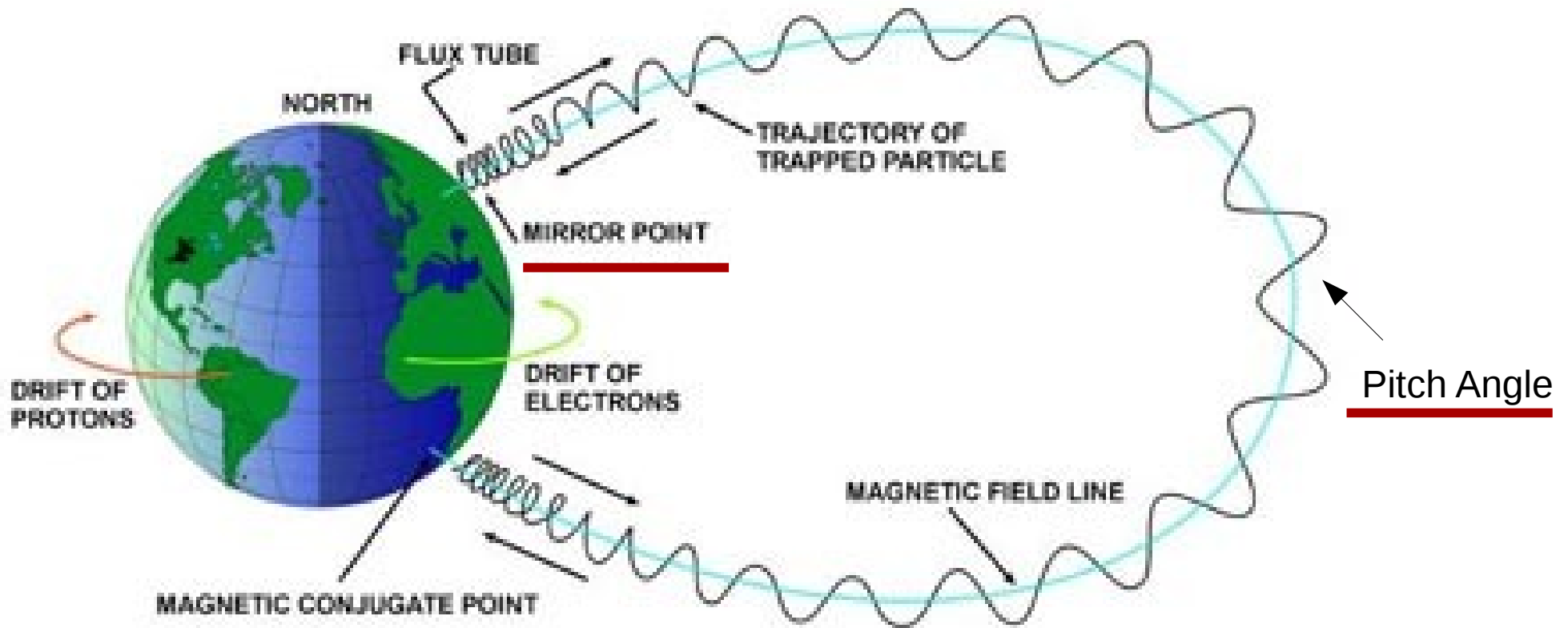
E>1MeV



McIlwain L shell

- Proton belt (100keV-50MeV)
- Electron belts, inner (1-10MeV), outer(40keV-5MeV)
- Occasionally a third belt can arise (StarFish exp., Sun activity)

Trapped Particles Dynamics

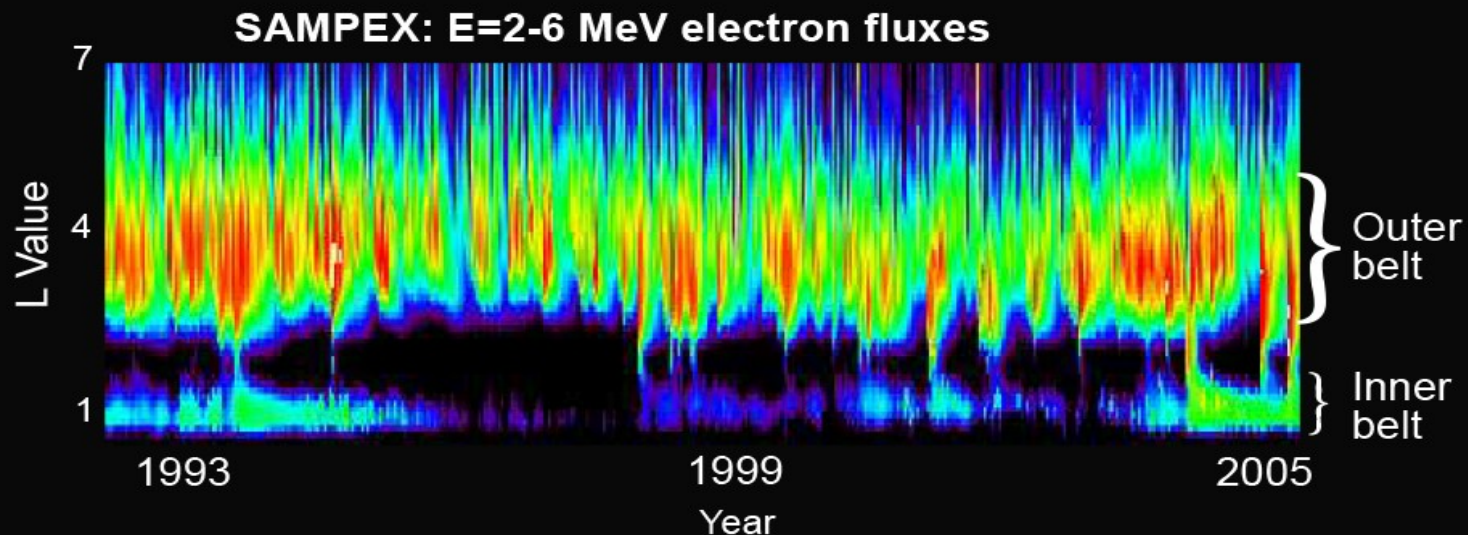


- Particle motion described with adiabatic invariants if the energy variation is slow
- **Gyration.** Rotation around the magnetic field line (magnetic moment).
- **Bouncing.** Reflection between the two mirror points (longitudinal invariant J)
- **Drift.** It is related to the magnetic field gradient (flux invariant)
- Important **Mirror Point and Pitch Angle**

Van Allen Belts Variability

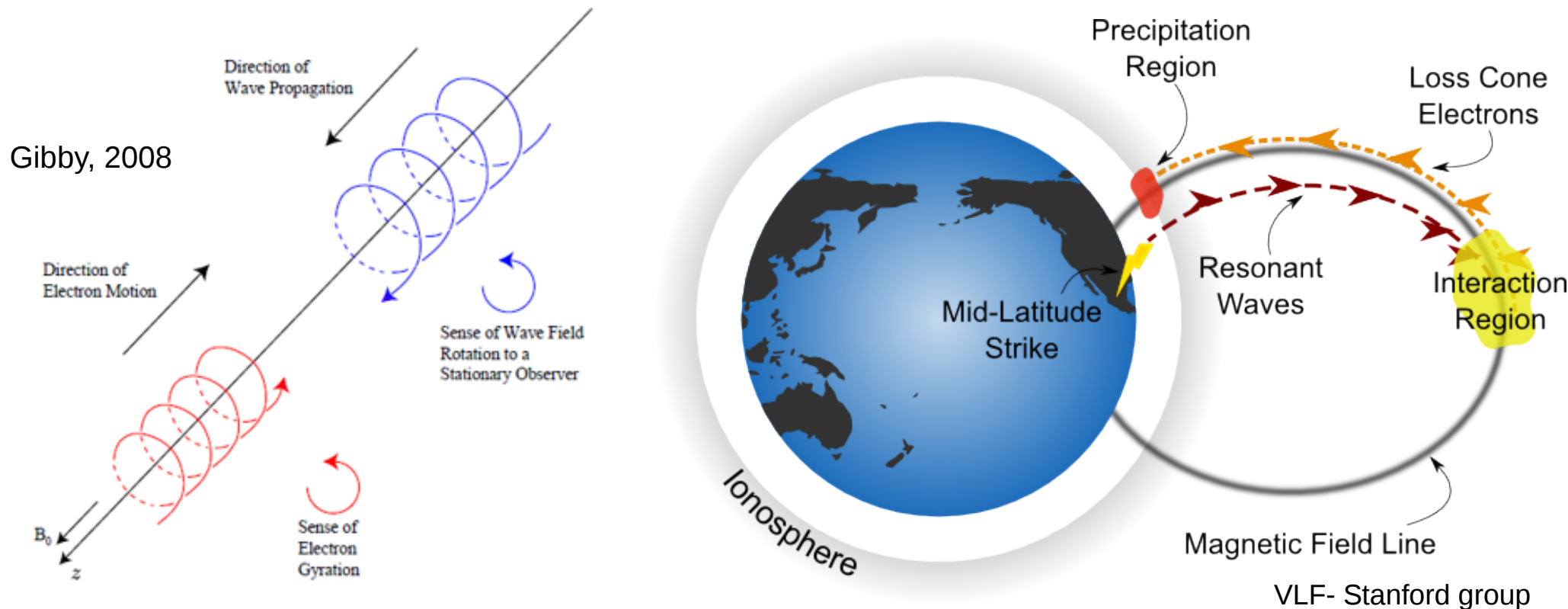
SAMPEX Shows Traditional Two Belt Structure

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



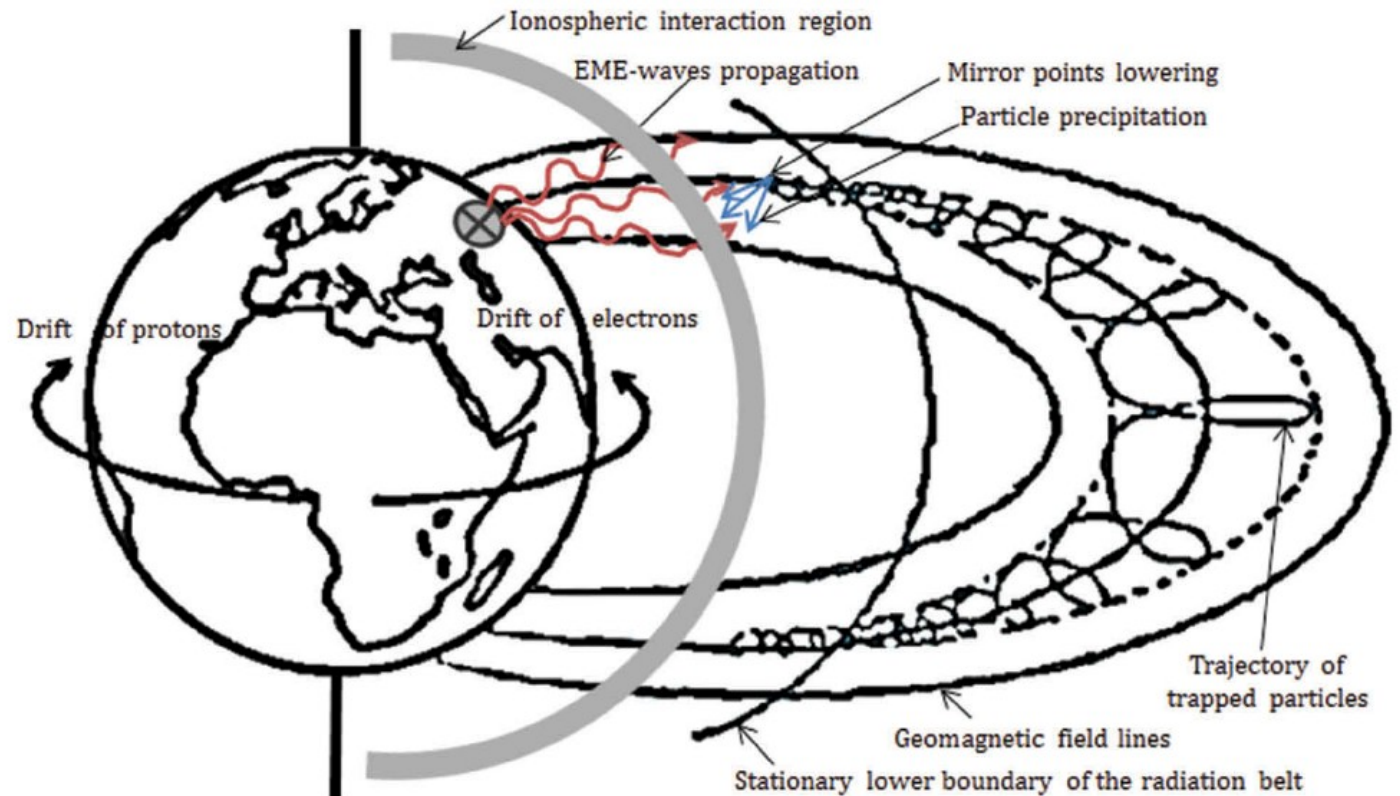
- Strong Flux variability for a quite large number of causes, both from the space and from Earth
- Disturbances of the magnetic system;
- Fast injection of energy and changes in the **Pitch Angle Distribution**

Wave-Particle Resonant Interaction



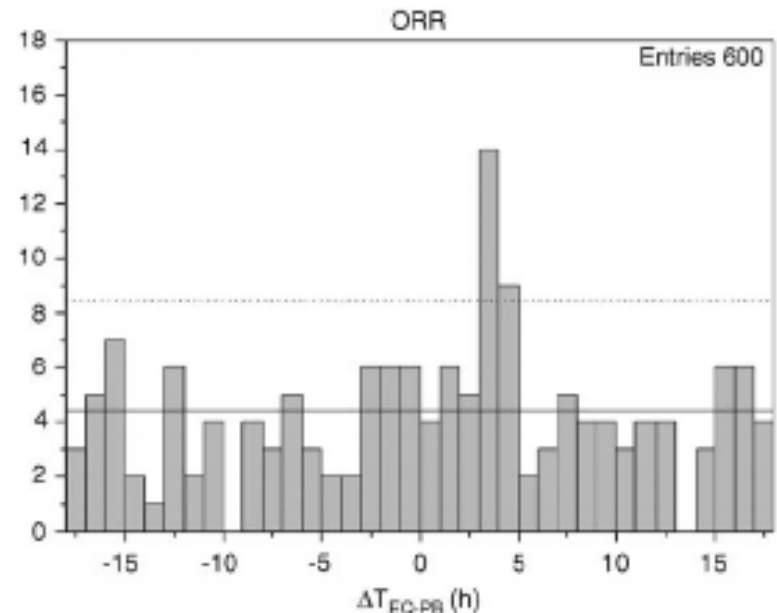
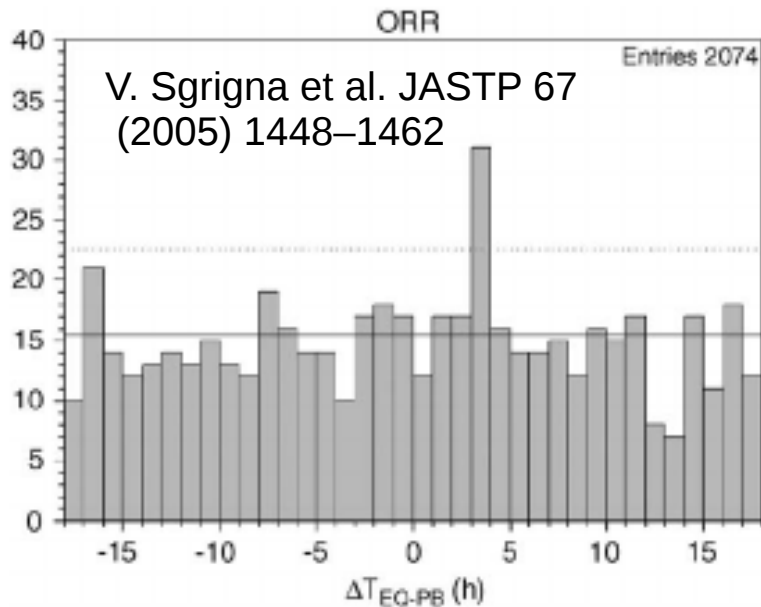
- VLF-ULF e.m. waves can lower the **mirror points** and cause **Electron Burst** for **LEO satellites**
- 1MeV electron at $L=4.5$ has 10kHz, 3Hz, 1mHz associated frequencies
- **A large number phenomena give e.m. emissions**

Litho-Magnetosphere Coupling



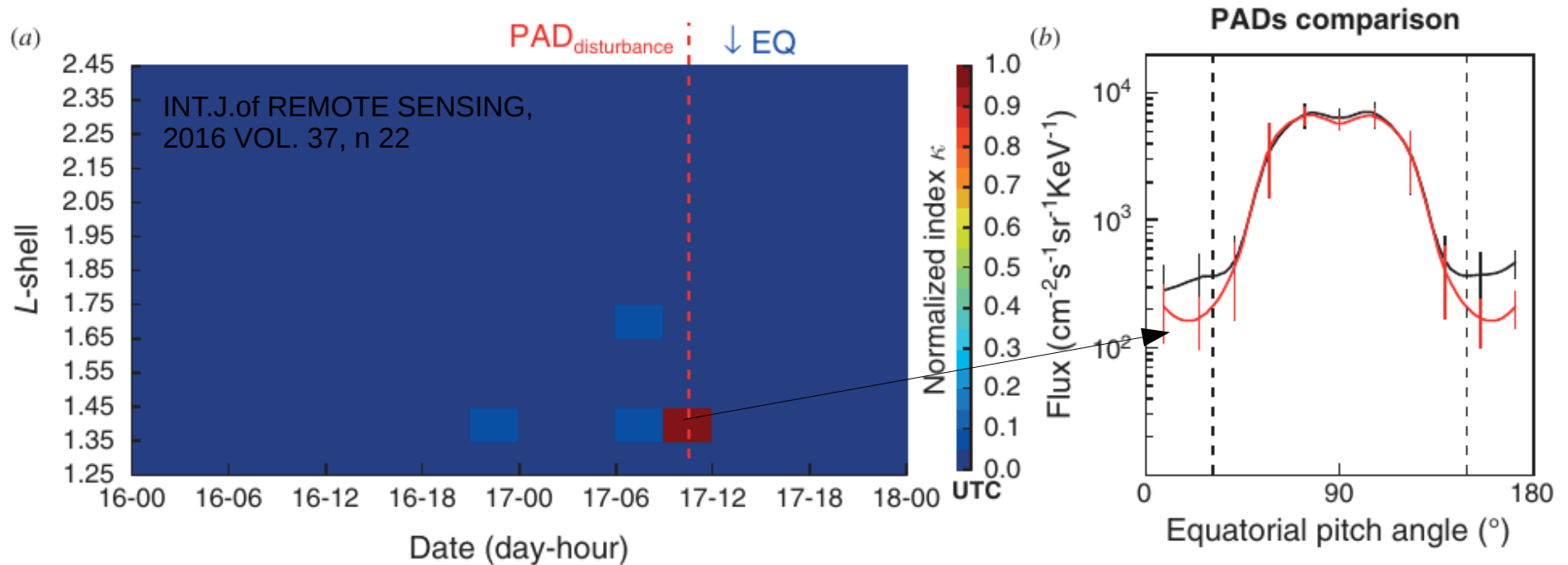
- **Hypothesis:** if earthquakes produce VLF-ULF e.m. waves (SEME) these can be the coupling agent between litho and magnetosphere
- **A large number of backgrounds**

SAMPEX/PET Electron Bursts



- **Observable:** count rate within 30s, energy 4-15MeV.
- **Cells Method.** Rates are a function of satellite location. A binned in the LshellxPitch angle two dim. Space needed for a proper comparison.
- **Background Suppression.** The main known sources of Belts disturbances are filter by avoiding time periods with geomagnetic activity (A_p , SID indices) or when crossing the SAA
- **Main Selection.** Particle Burst and Earthquake with comparable Lshell are selected. The Earthquake Lshell is related to the particle-e.m. wave coupling position. Its high is main parameter of this type of analysis
- **Correlation Method.** The time difference distribution is assumed as correlation test.
- Main stream analysis, applied to 100s of keV to 10s of MeV electrons

VAB Probes Pitch Angle Distributions



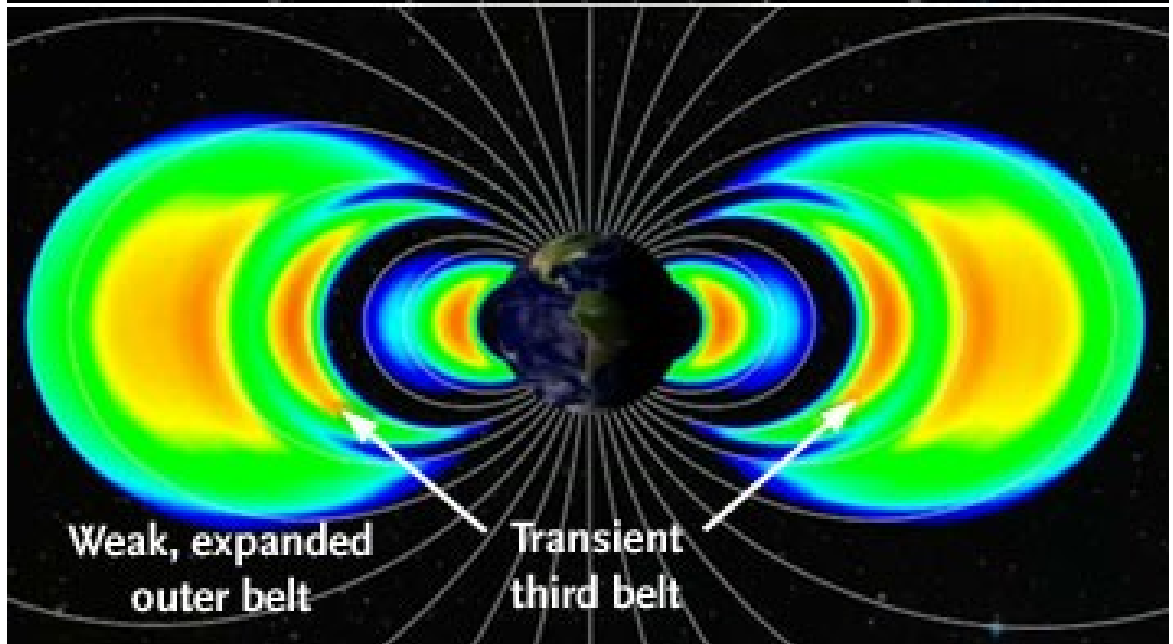
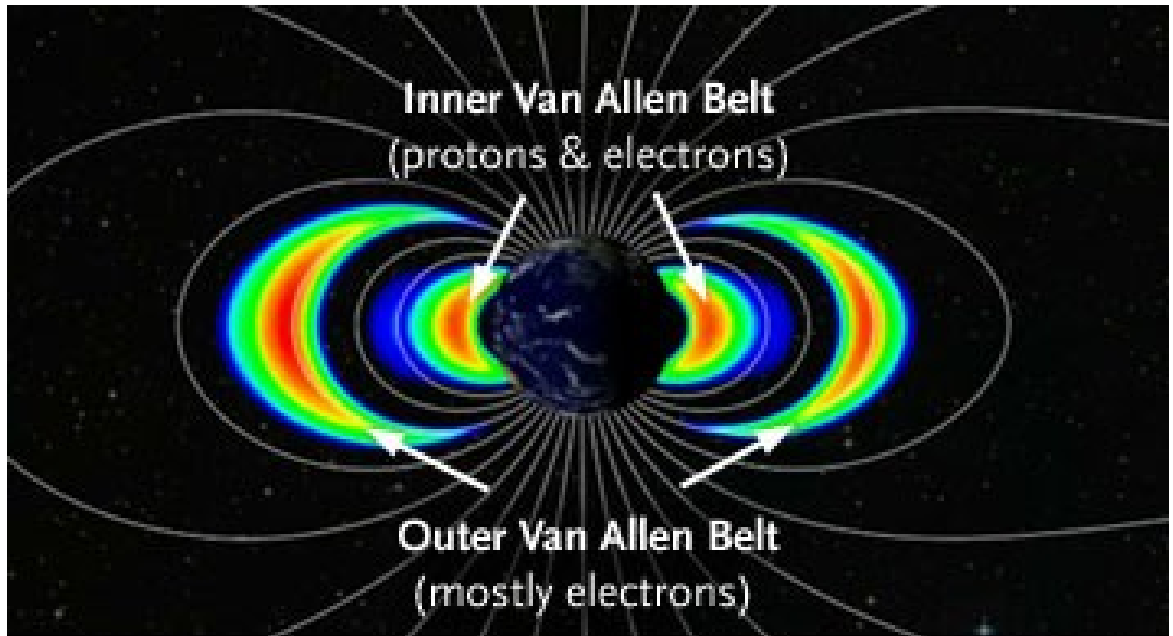
- New type of analysis we developed to exploit data from Highly Elliptical Orbits, as for the two Van Allen Belt Probes
- **Observable:** disturbances in the Pitch Angle Distribution (PAD). A PAD is built every 3h and compared to a set of reference PADs. An index κ is built to measure the disturbance significance. The correlation between PAD disturbances and Earthquake is then searched for. Used energy range 335-488keV.
- **Cell Method & Bck Suppression** are applied as for the burst analysis.
- **Correlation Method.** The time difference distribution is assumed as correlation test.



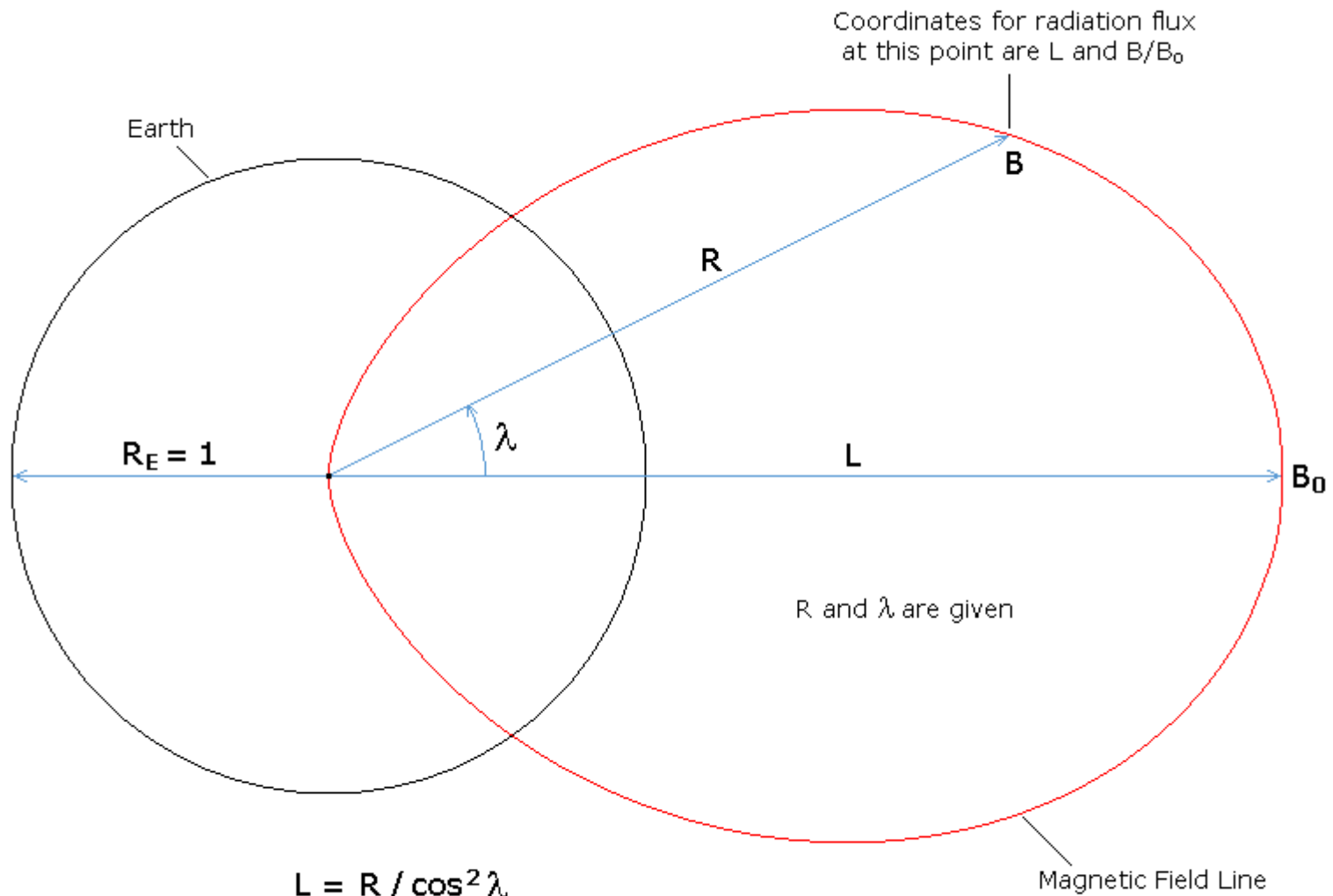
Backup Slides

Van Allen Belts

- Toroidal regions with energetic charged particles trapped by the geo-magnetic field
- Particle sources: (i) acceleration of low energy particles; (ii) trapping of neutrons decay products. These neutrons are produced by cosmic ray collisions with the atmosphere (CRAND); (iii) solar flares.
- Ionizing radiation belts reach lowest altitude at the South Atlantic Anomaly (SAA).



McIlwain L shell



$$L = R / \cos^2 \lambda$$

$$B/B_0 = (4 - 3 \cos^2 \lambda)^{1/2} / \cos^6 \lambda$$