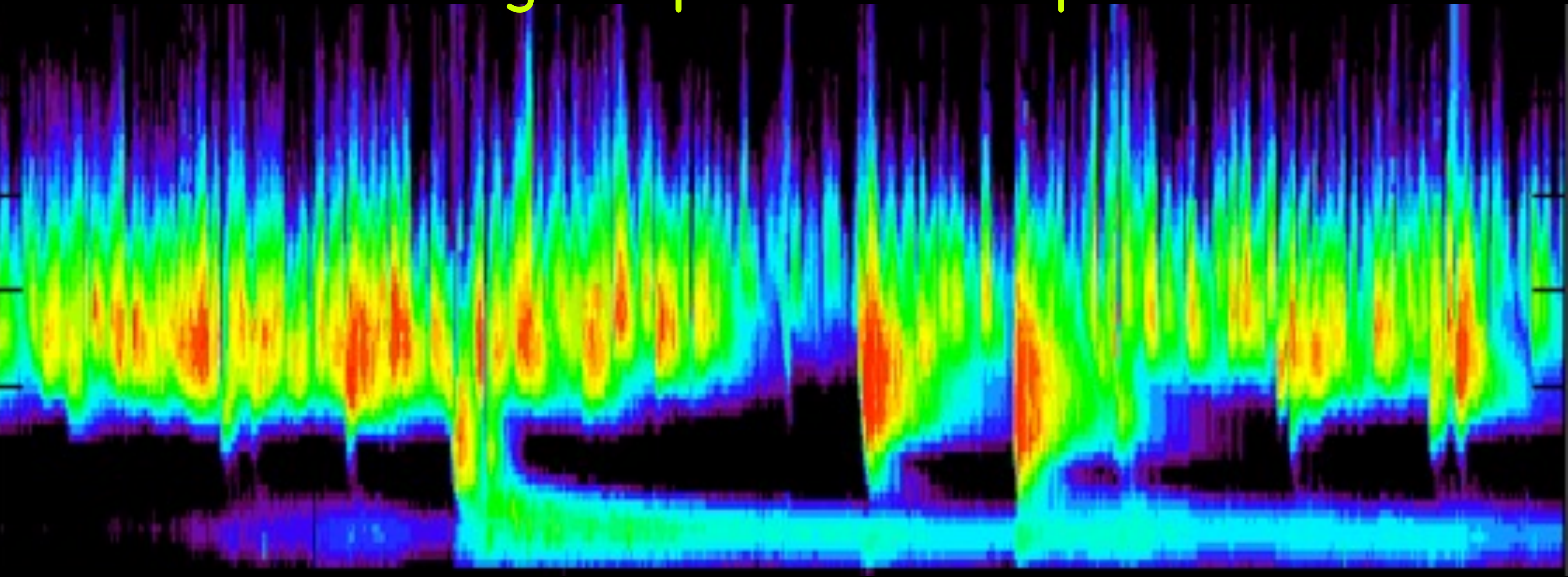
Μέρος Β′

Μετρήσεις σωματιδίων

Χωροχρονικές μεταβολές ενεργητικών ηλεκτρονίων

Energetic particles in space



<u>what do we measure in space ?</u>

omnidirectional flux

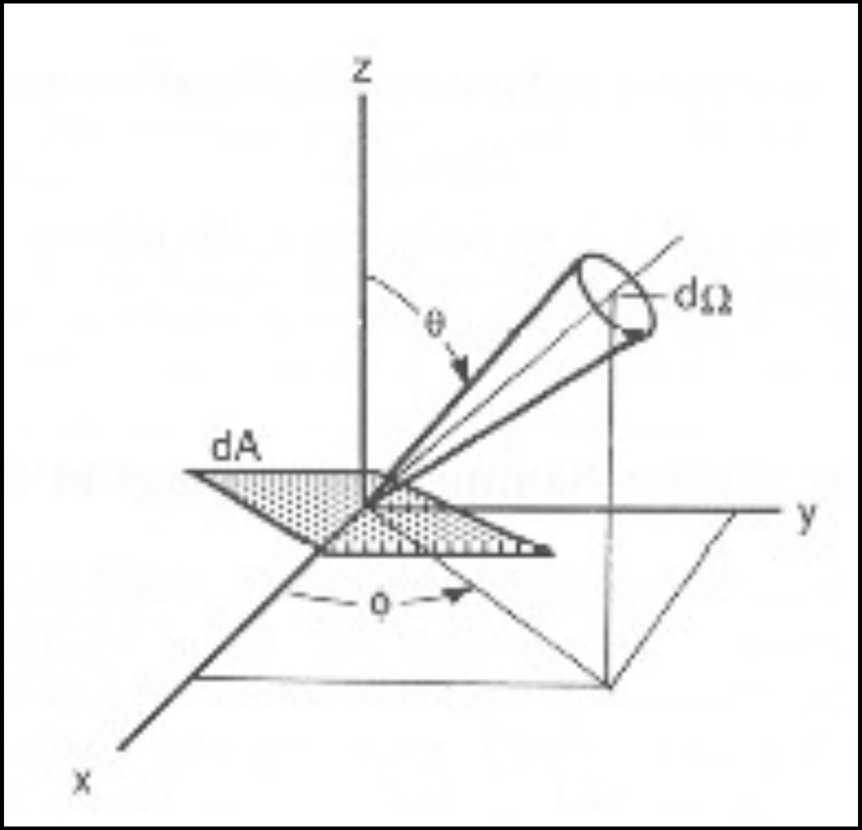
differential flux

pitch angle distribution

<u>time evolution</u> of particle fluxes,

& pitch angle distributions

Integral, Differential, Omnidirectional … flux

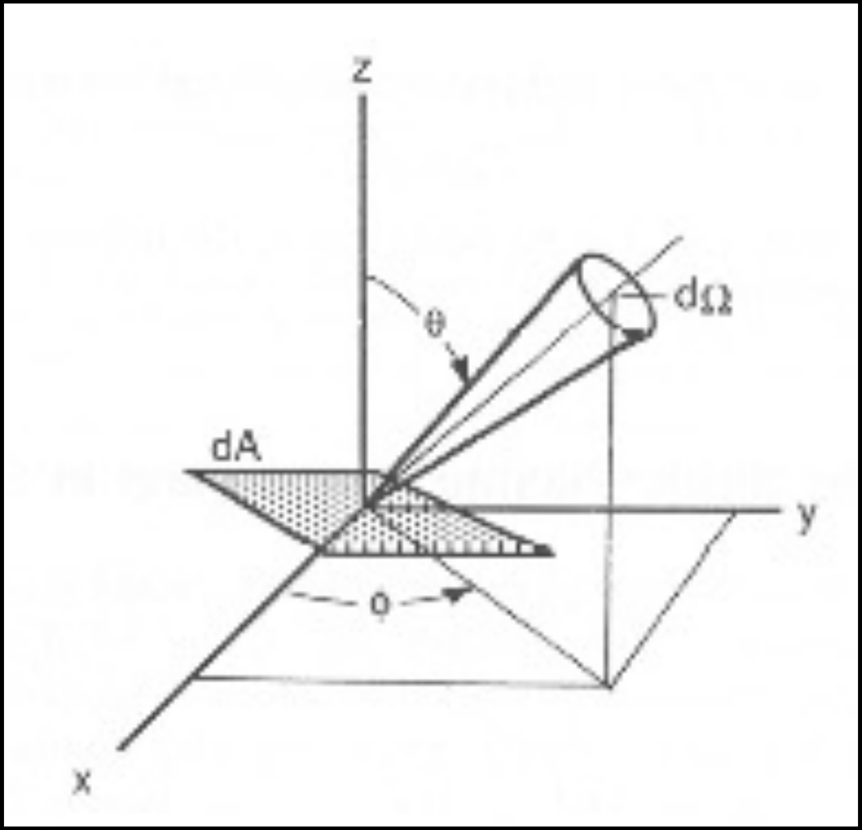


Integral directional flux

particle counts = N / t

(particles with E > E')

Integral, Differential, Omnidirectional … flux



Integral directional flux

particle counts = N / t

(particles with E > E')

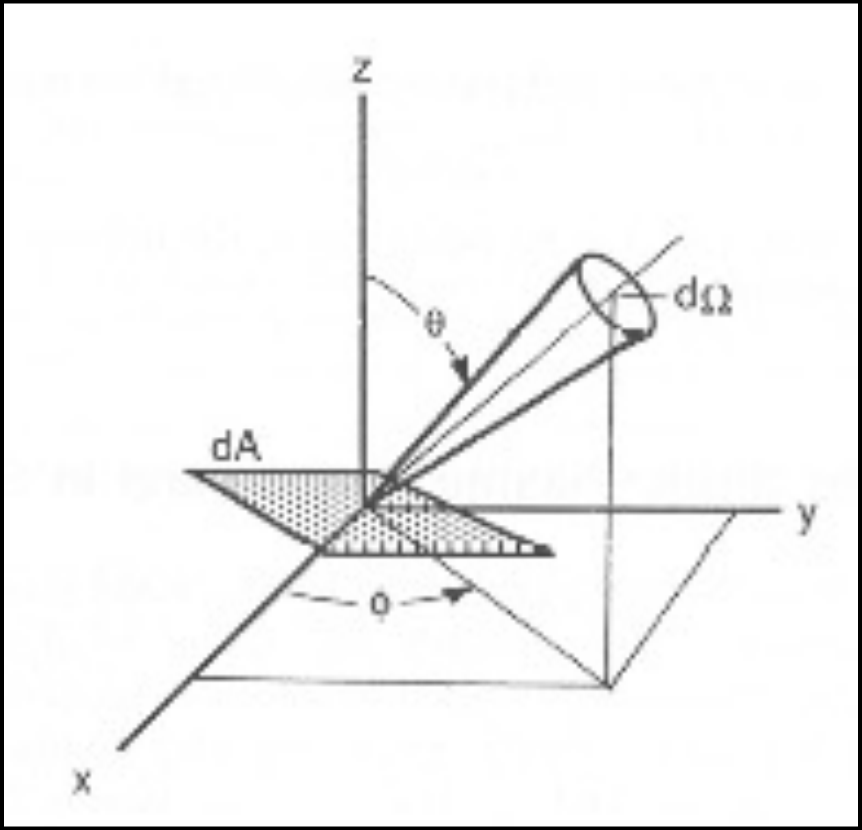
detector area = A cm^2

field of view = Ω sr (solid angle)

flux = N / [A Ω t]

units = cm^{-2} Sr^{-1} sec^{-1}

Integral, Differential, Omnidirectional … flux



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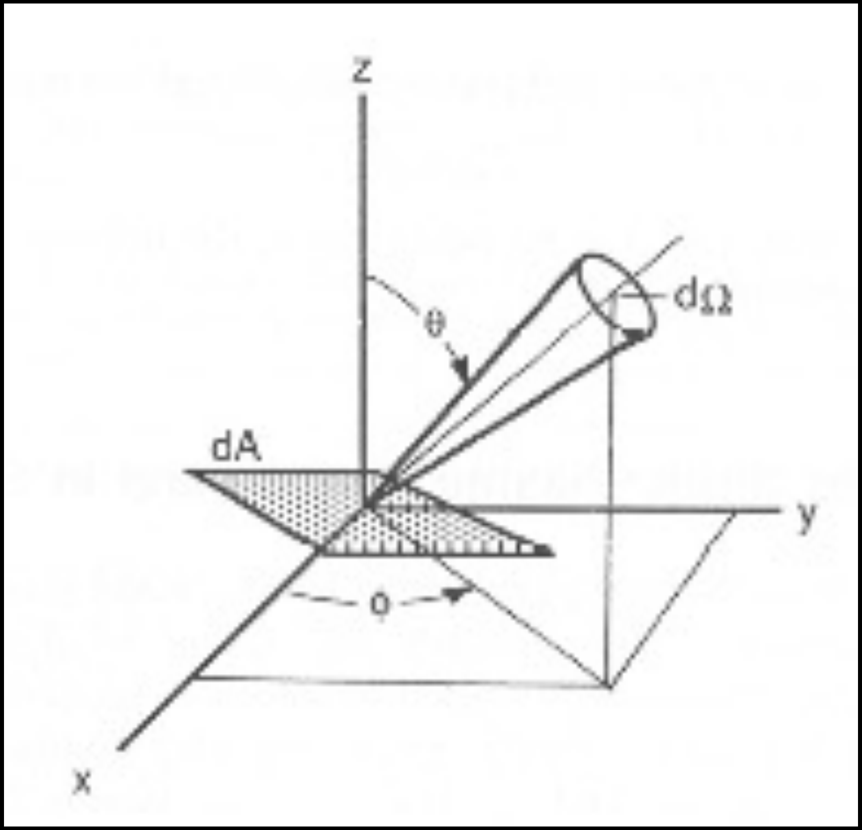
units = cm^{-2} Sr^{-1} sec^{-1}

differential directional flux

flux = N / [A Ω ΔE t]   units = cm^{-2} Sr^{-1} sec^{-1} MeV^{-1}

detector counts particles with E1 < E < E2 = ΔE

Integral, Differential, Omnidirectional … flux



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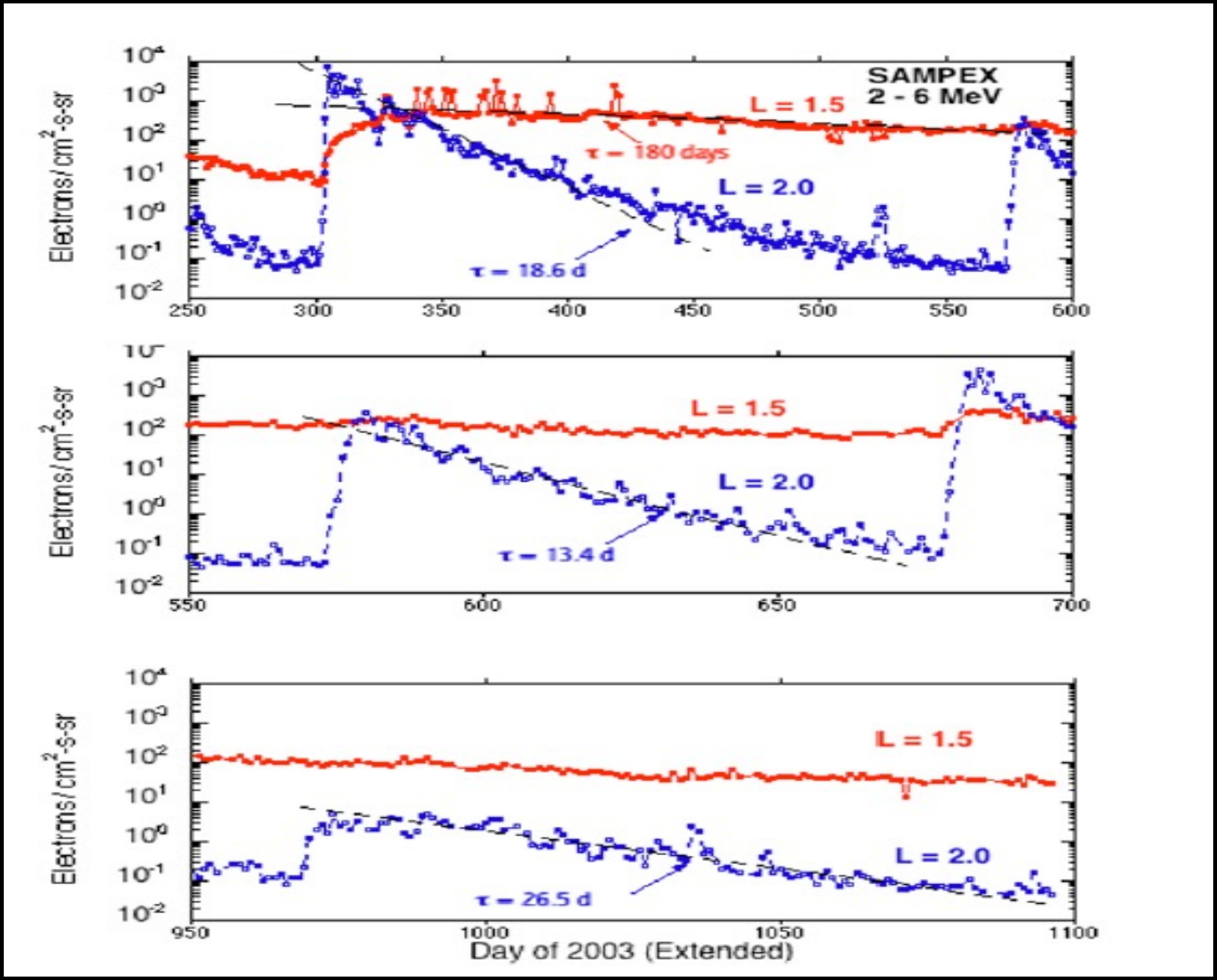
differential directional flux

flux = N / [A Ω ΔE t] units = cm^{-2} Sr^{-1} sec^{-1} MeV^{-1}

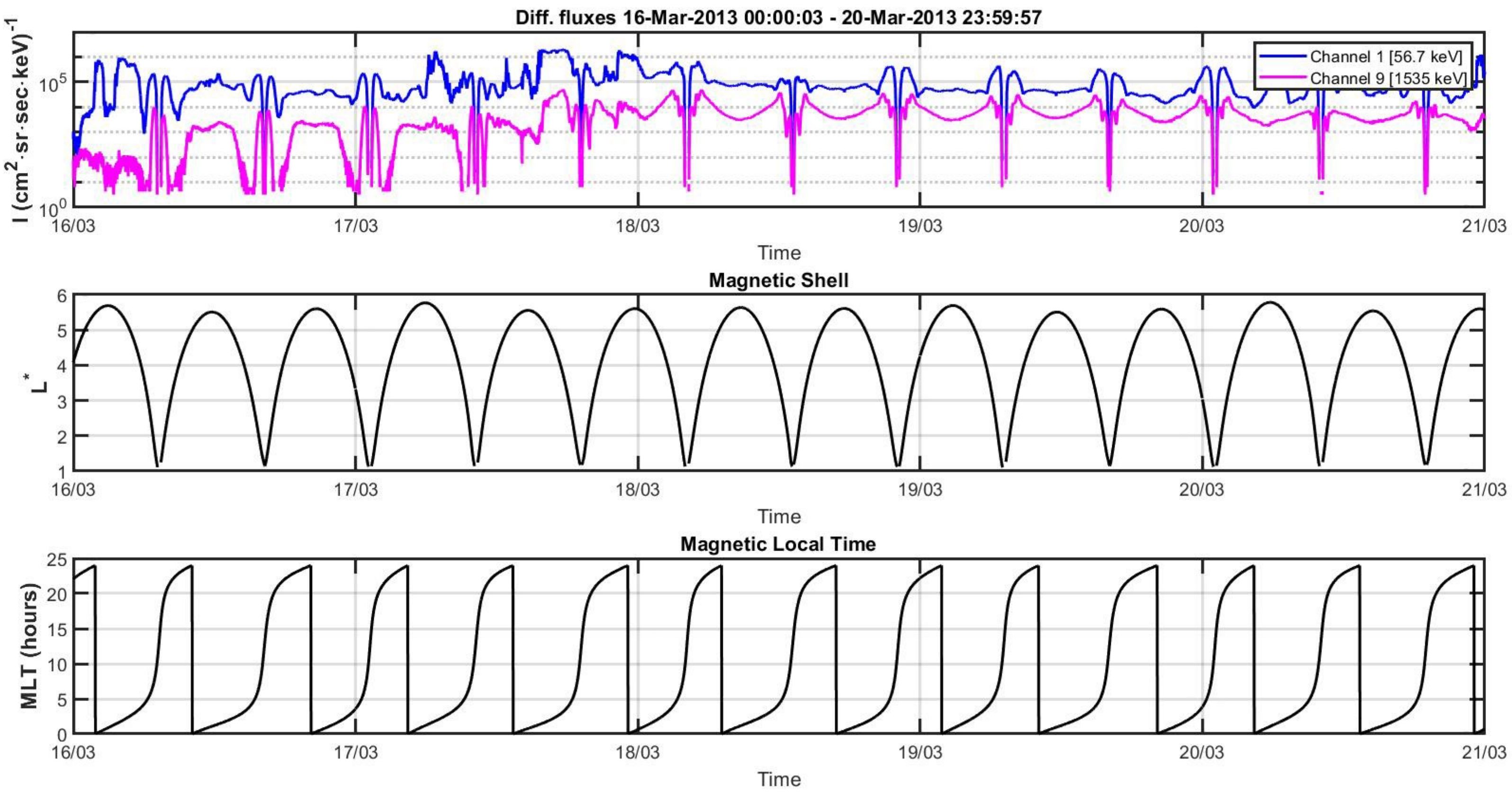
detector counts particles with E1 < E < E2 = ΔE

Omnidirectional flux => over full 4π sr

Electron fluxes in geospace



Electron fluxes in geospace



Interaction of charged particles with matter

When charged particles pass through matter ($M > m_e$)

a) <u>they lose energy</u>

- ➢ inelastic collisions mainly with atomic electrons

  cause ionization or excitation of the atoms

  many many many collisions !!

  statistical average

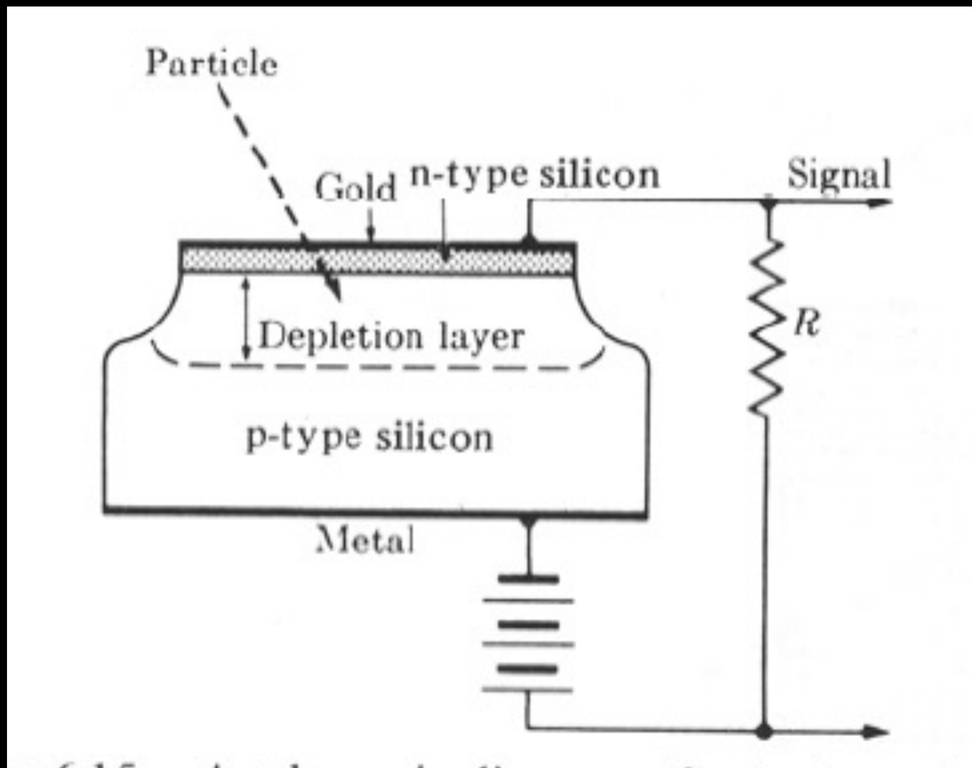
  energy loss/unit length "dE/dx"

Stopping power (ισχύς πέδησης): $S = -\frac{dE}{dx}$

b) <u>they change direction</u>

- ➢ elastic scattering from atomic nuclei

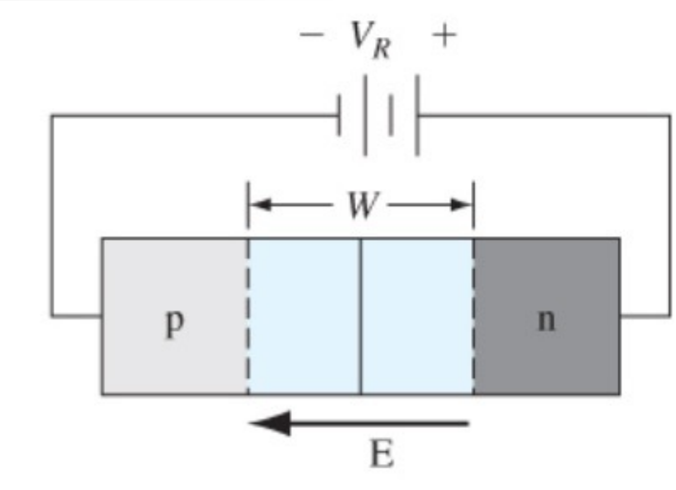
Principle of operation: simple solid-state detector

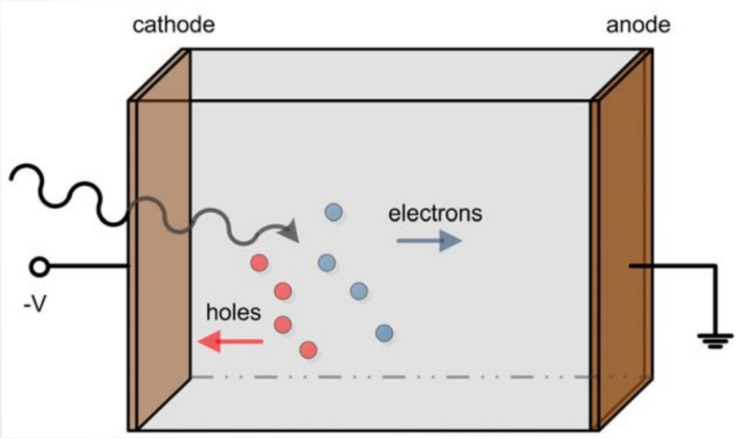


$$Q \propto \Delta E$$

Charged particle passing through silicon creates electron-hole pairs. The total charge collected is proportional to the energy lost by the charged particle

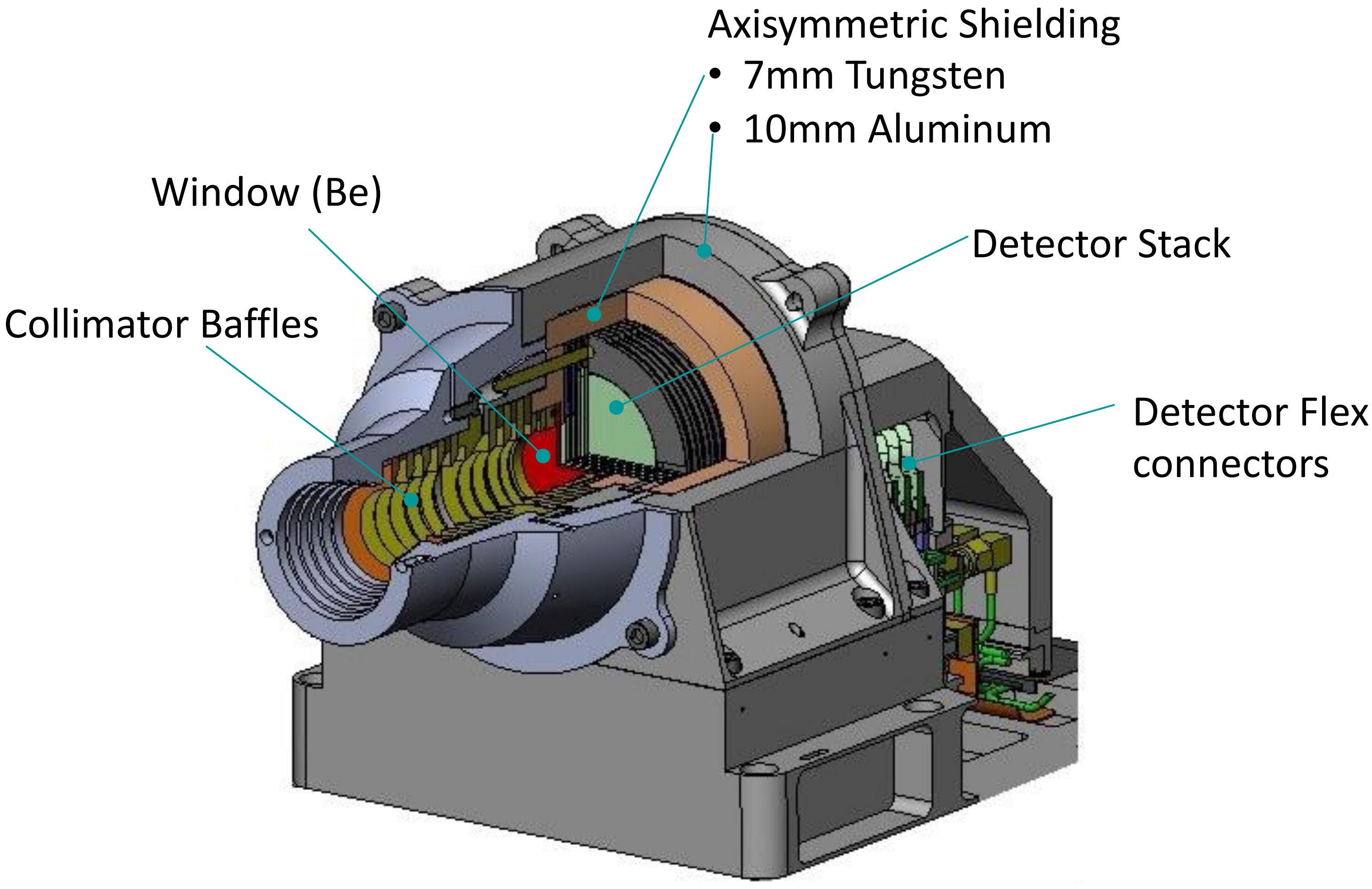
Ανιχνευτές Στερεάς Κατάστασης





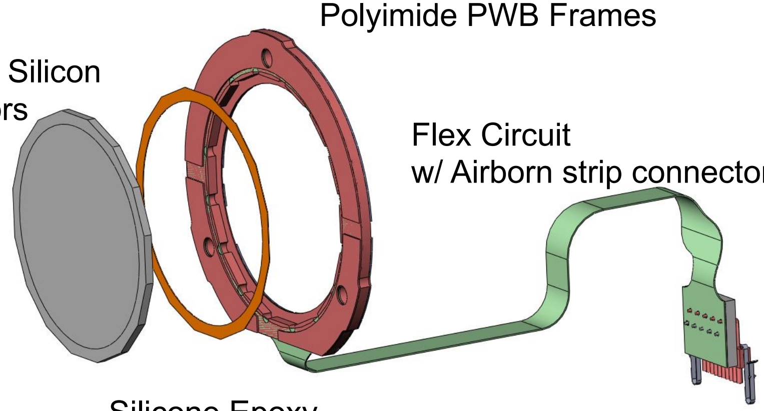
Οι φορείς οδηγούνται λόγω του ηλεκτρικού πεδίου στην άνοδο (ηλεκτρόνια) και την κάθοδο (οπές)

Relativistic Electron-Proton Telescope Instrument Detail

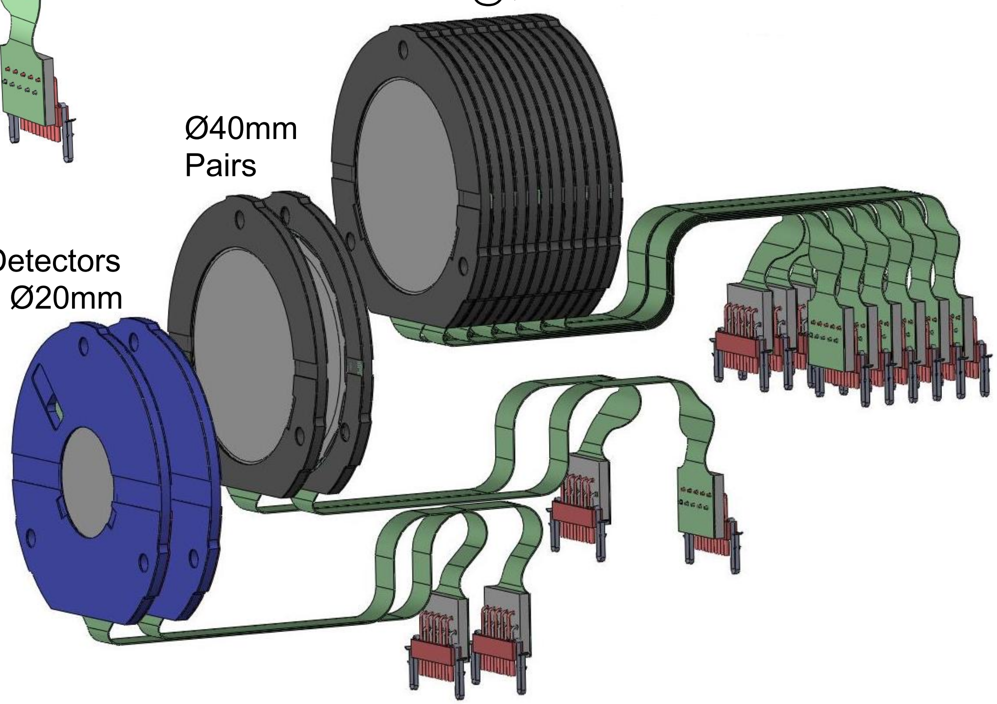


REPT Detector Stack

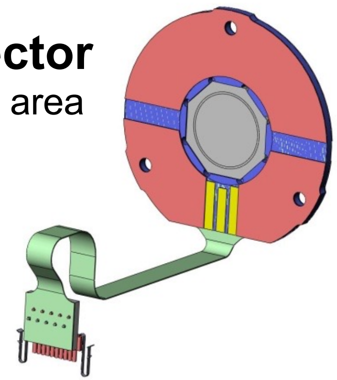
MS40 Detector - Ø40mm active area



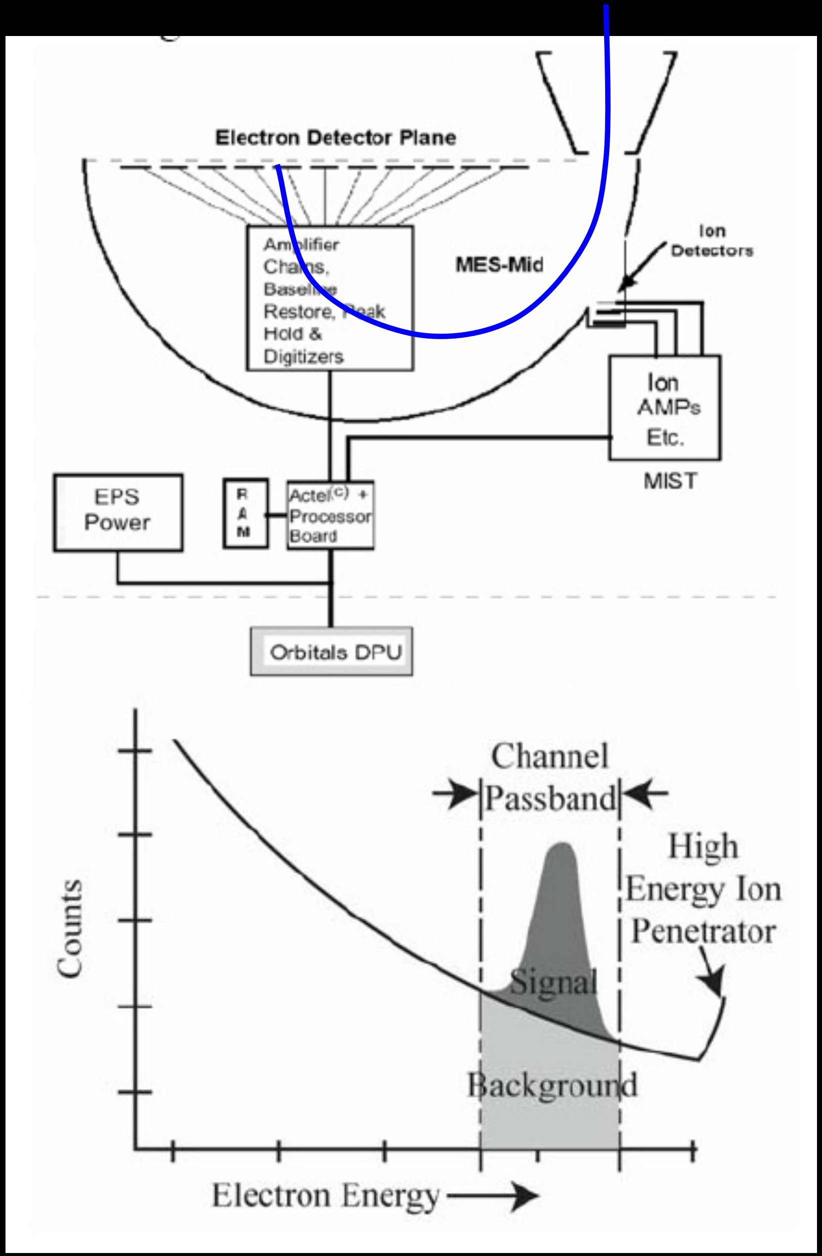
Detector Stack
- 24mm of silicon
- 2.5 mm pitch



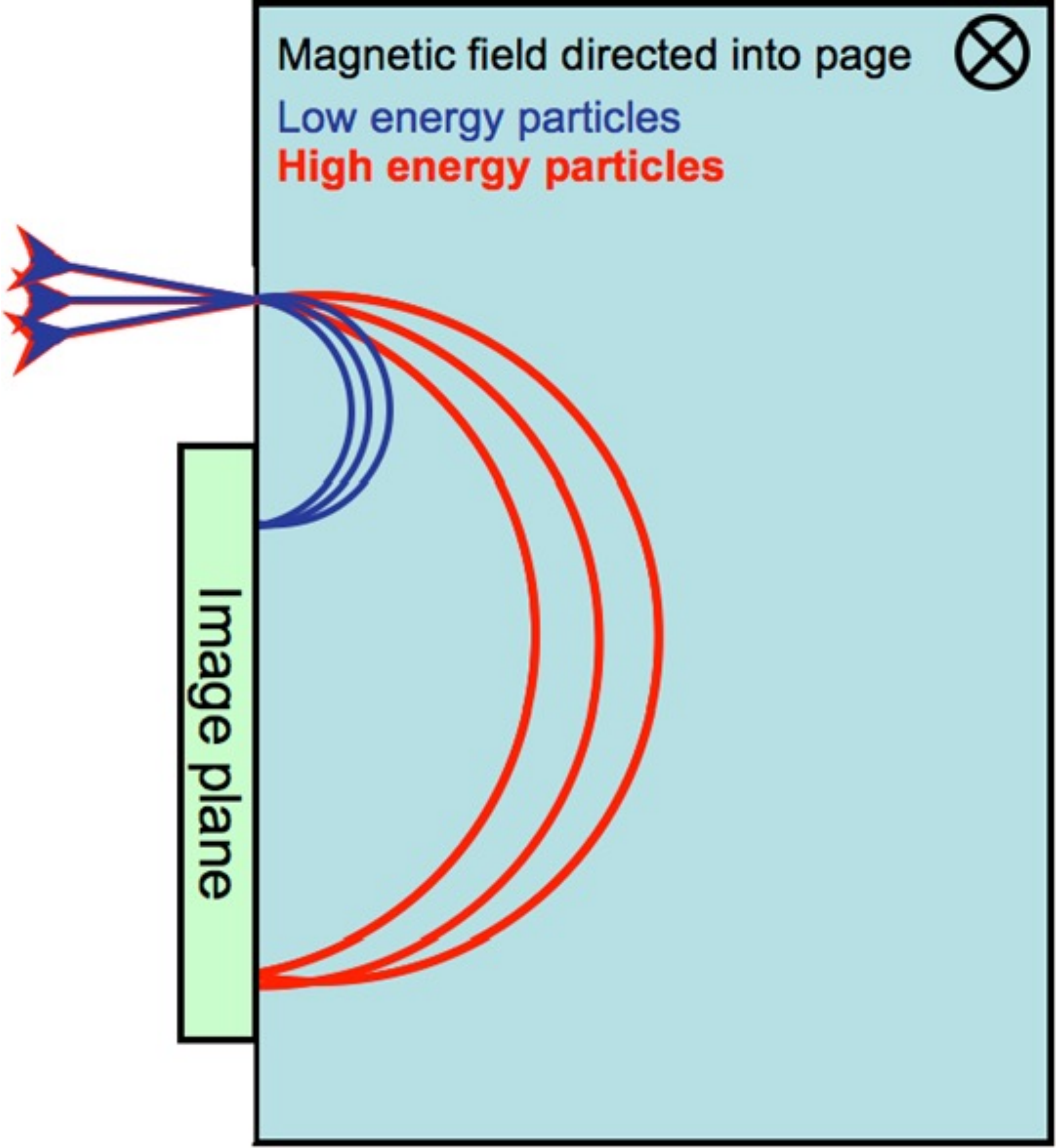
MS20 Detector
Ø20mm active area
two regions



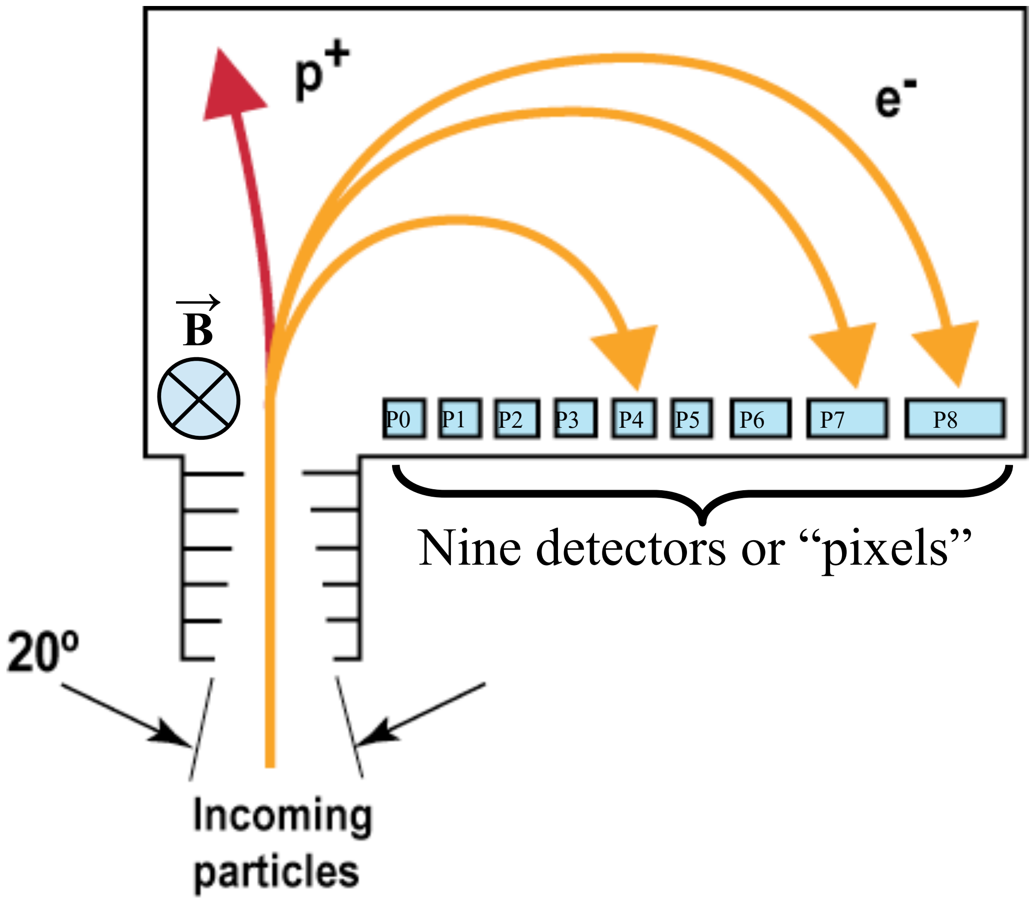
An electron spectrometer type instrument



Electrons bend in a magnetic field and reach the detection plane at different distances proportional to their energies and are detected by dE/dx loss in individual solid state detectors


Magnetic field directed into page
Low energy particles
High energy particles
Image plane

MagEIS:
Magnetic Electron Ion Spectrometer of Van Allen Probes

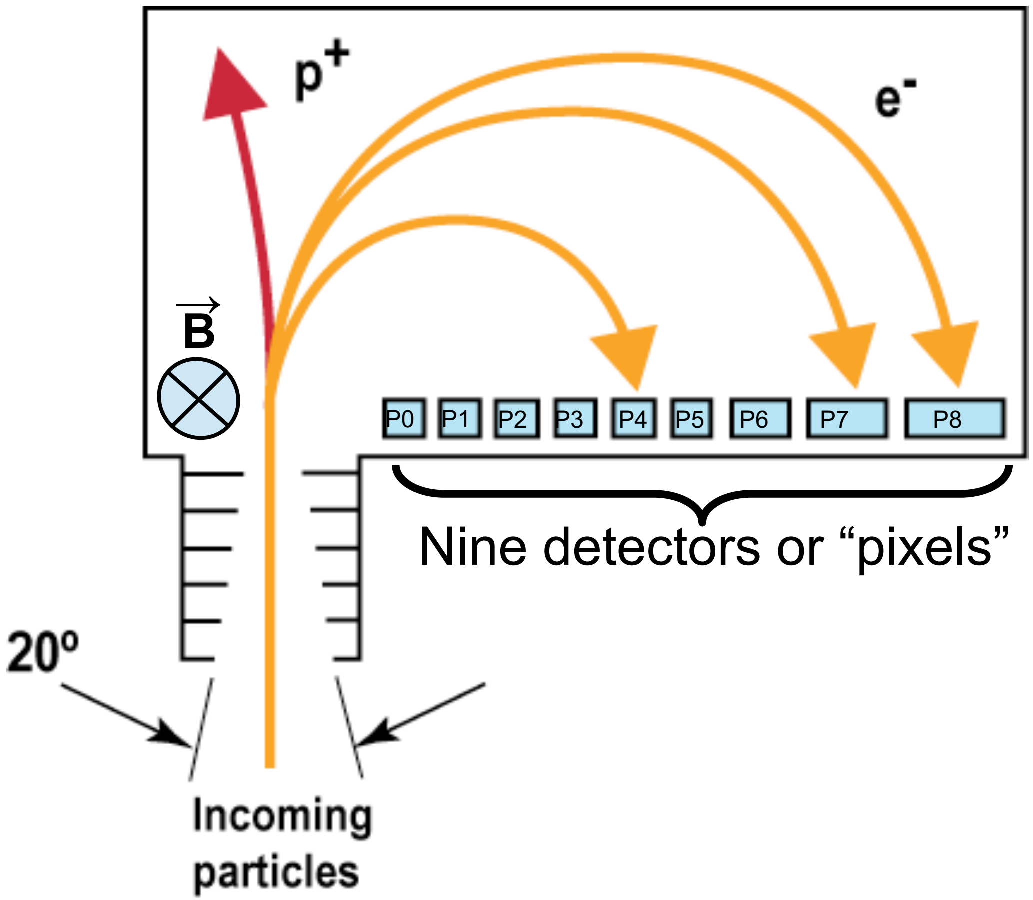


$$r_c = \frac{mv_\perp}{qB}$$

Exploring the Extremes of Space Weather

Van Allen Probes

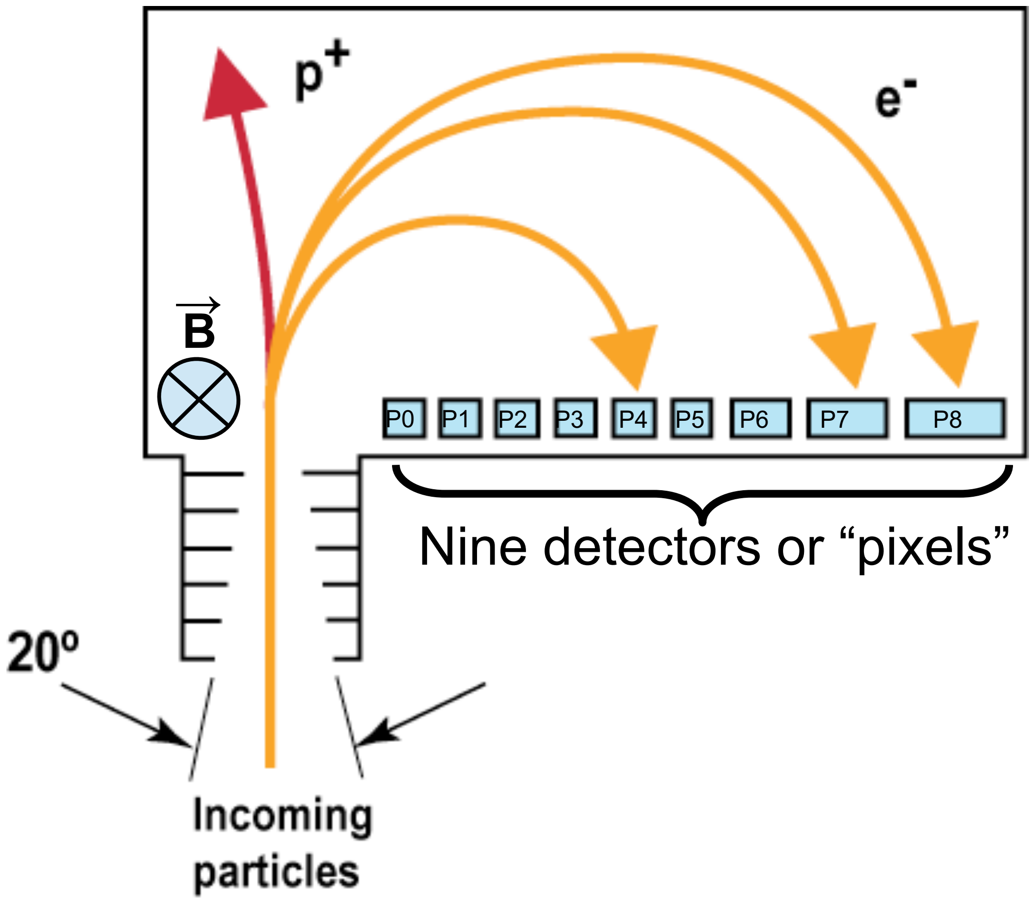
MagEIS:
Magnetic Electron Ion Spectrometer



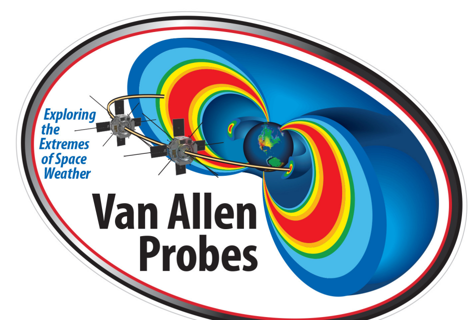
$$r_c = \frac{mv_\perp}{qB}$$

MagEIS

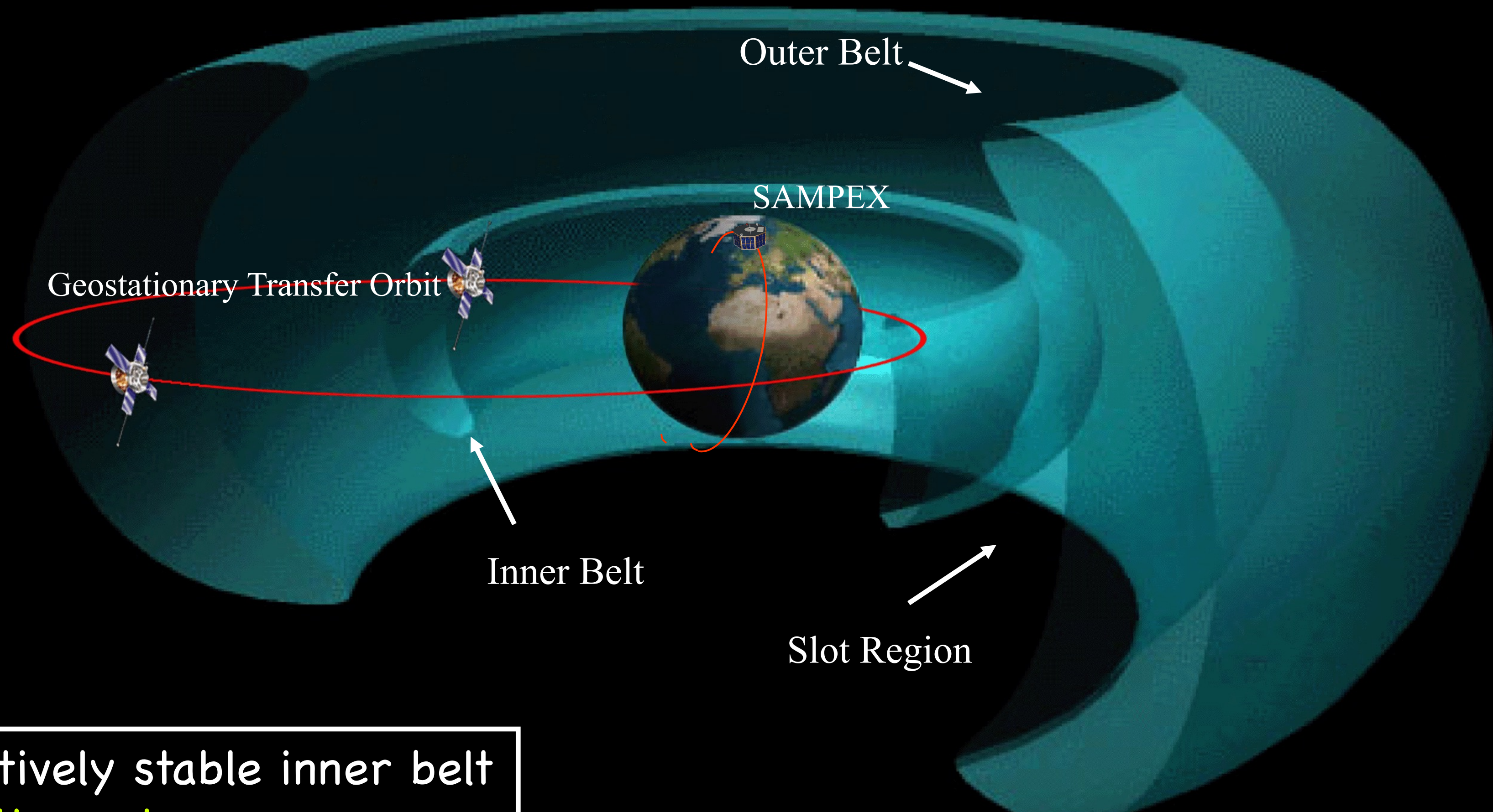
$$I = \frac{Counts}{\Delta E * G * \Delta t}$$



$$r_c = \frac{mv_\perp}{qB}$$



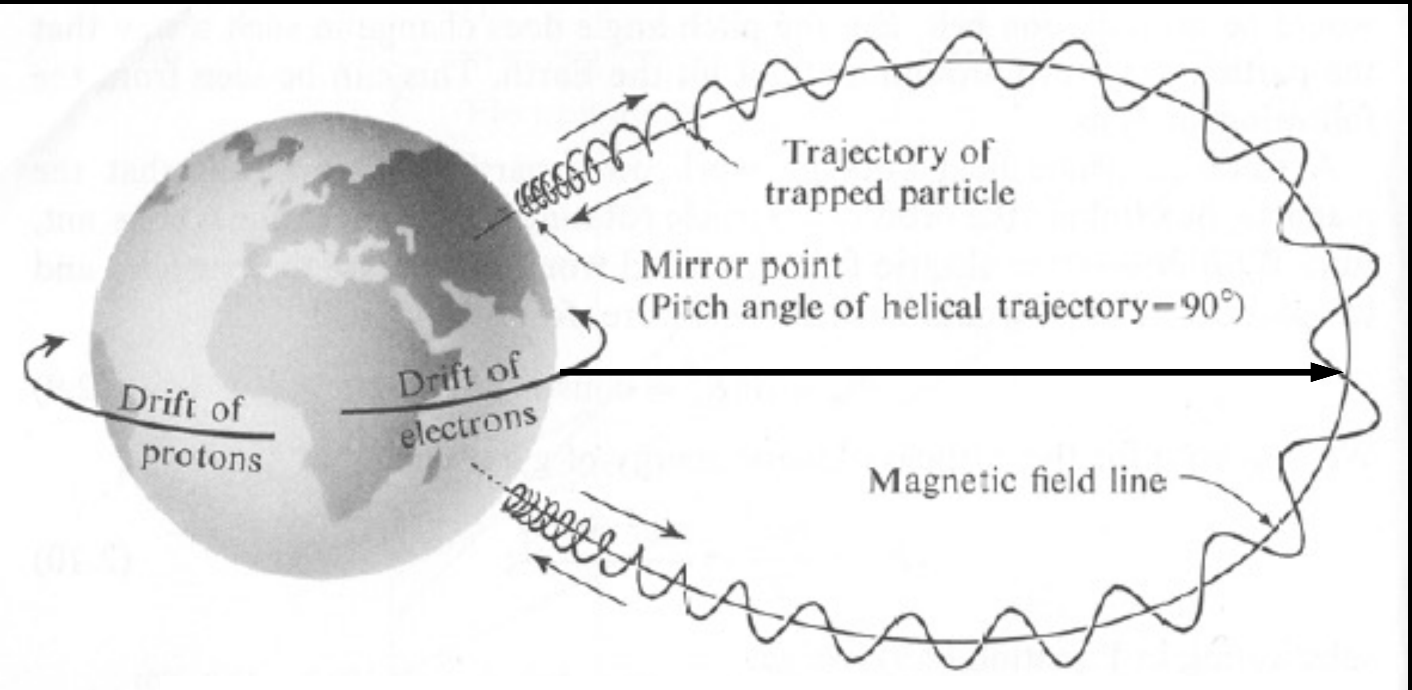
Van Allen radiation belts



Relatively stable inner belt
Mostly protons
Sources : CRAND protons
SEP events

Dynamic Outer belt
Mostly electrons
Sources : Magnetotail electrons

Particle motions in a magnetic dipole

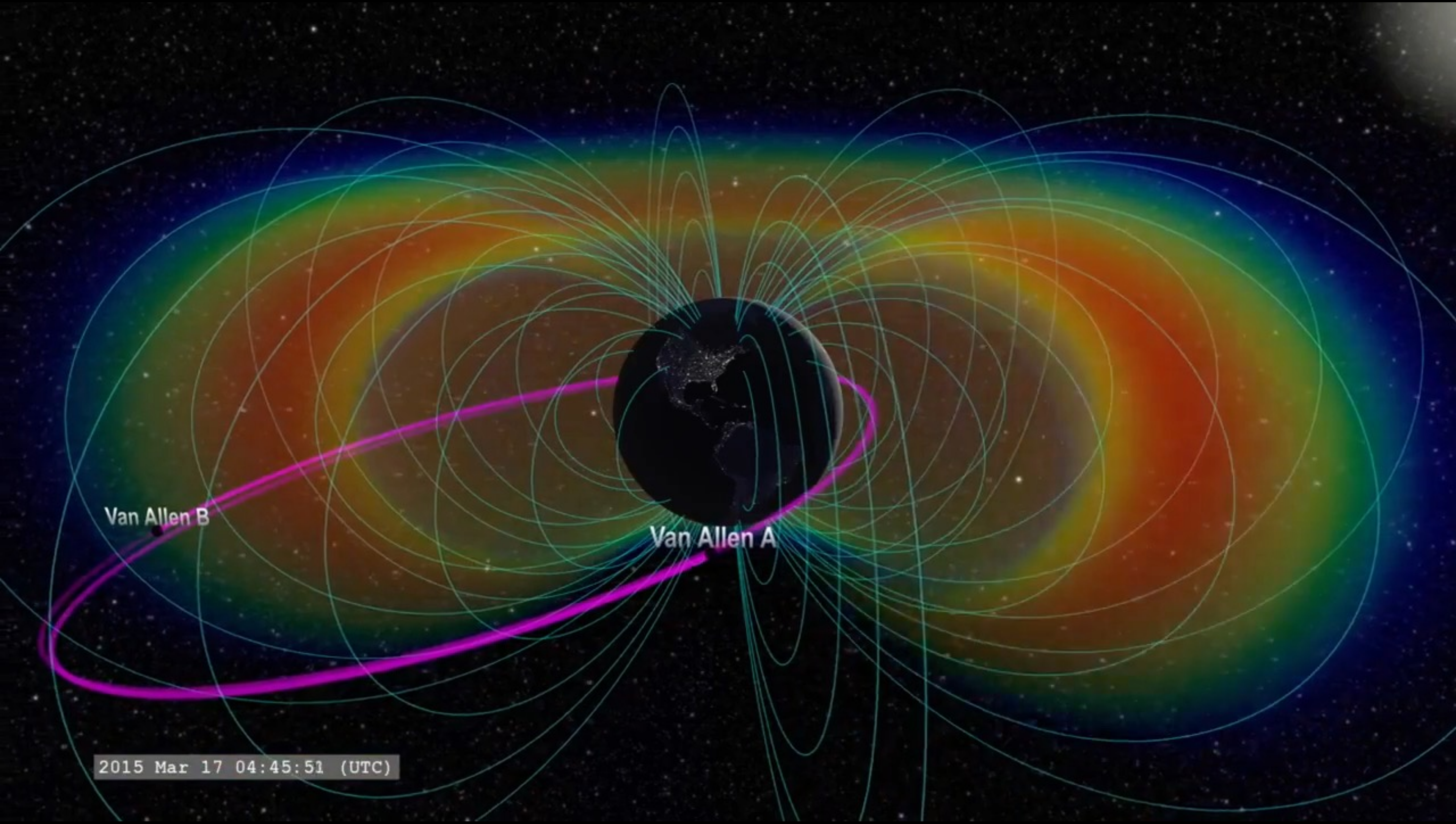


L = equatorial distance of a field line in a dipole field

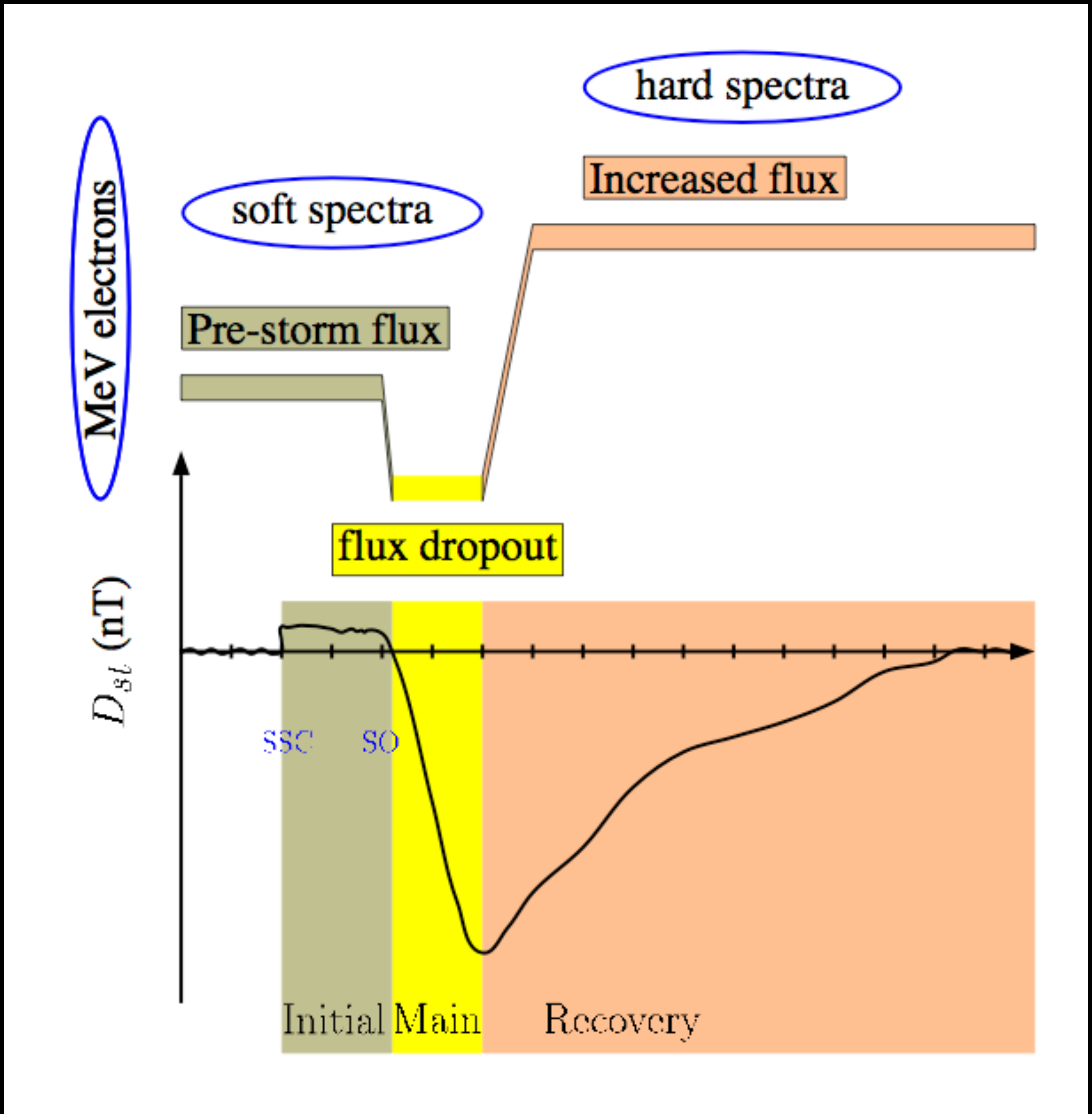
Magnetic moment	Longitudinal Invariant	Flux Invariant
$\mu = \frac{E_\perp}{B}$	$J = 2\int m v_\parallel dl$	$\Phi_m = 2\int B.dS$
$\tau_1 \approx 10^{-3}$ secs	$\tau_2 \approx 10^0$ secs	$\tau_3 \approx 10^3$ secs

(1 MeV electron 6 Re 60° pitch angle)

geomagnetic perturbations $\tau_{1,2,3}$ $\Rightarrow$ violation of adiabatic invariants


Van Allen B
Van Allen A
2015 Mar 17 04:45:51 (UTC)

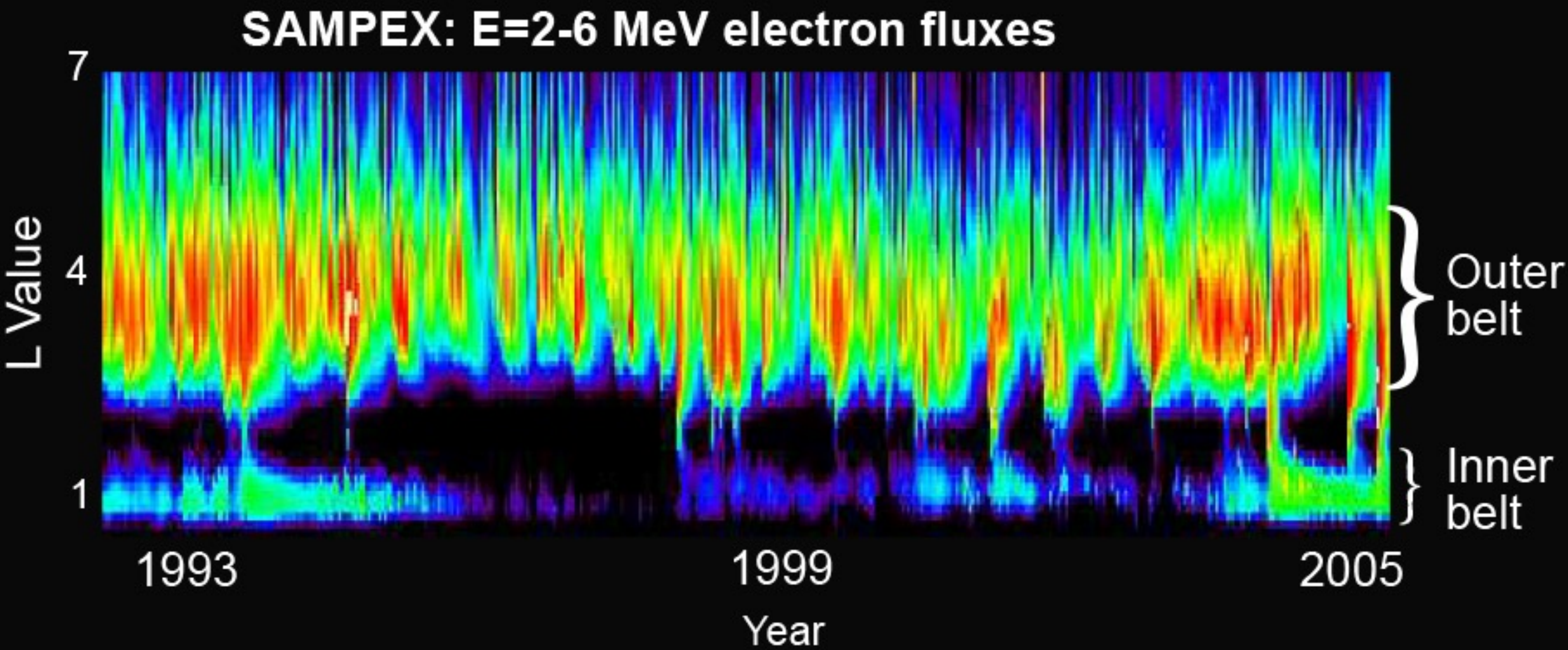
Relativistic Electrons & Geomagnetic Storms



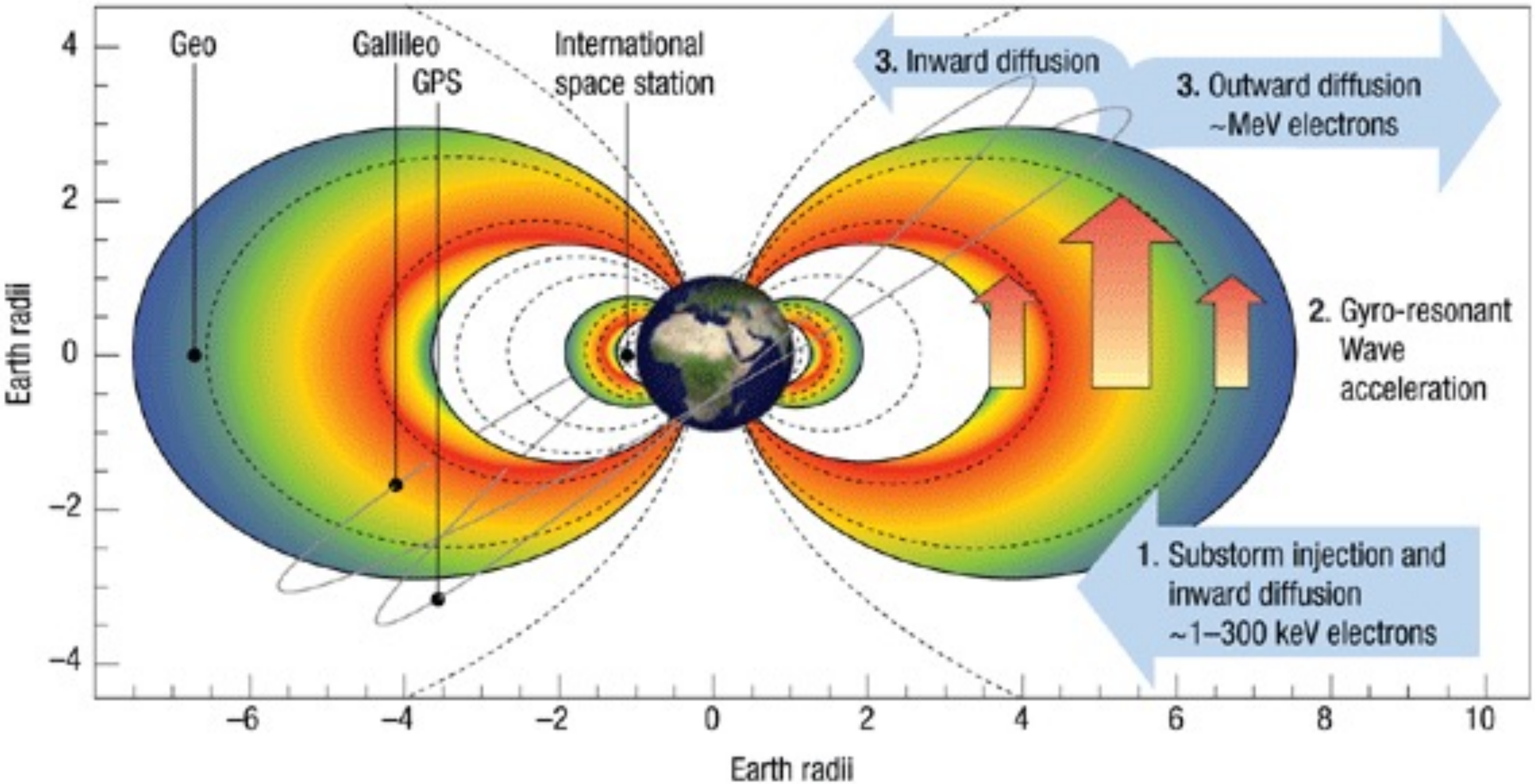
- Recovery phase
  - Increased fluxes
  - Energization
- Main phase
  - Flux dropout
  - Adiabatic field change & particle loss
- Flux changes
  - Decrease or no change in about 50% of storms - GEO data

SAMPEX Shows Traditional Two Belt Structure

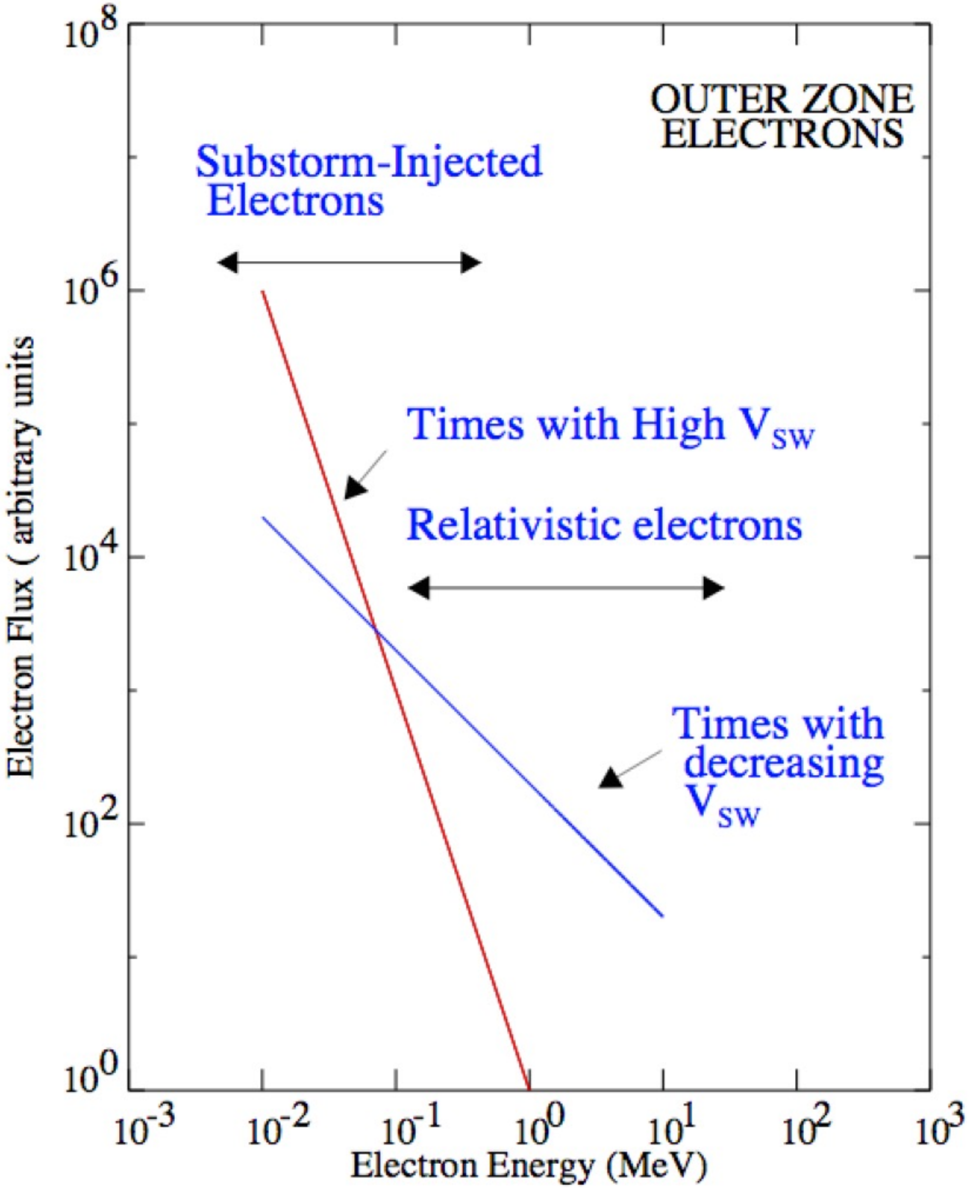
Long term (~12 year) plot from SAMPEX shows the established two belt structure



Electron acceleration in the outer radiation belt



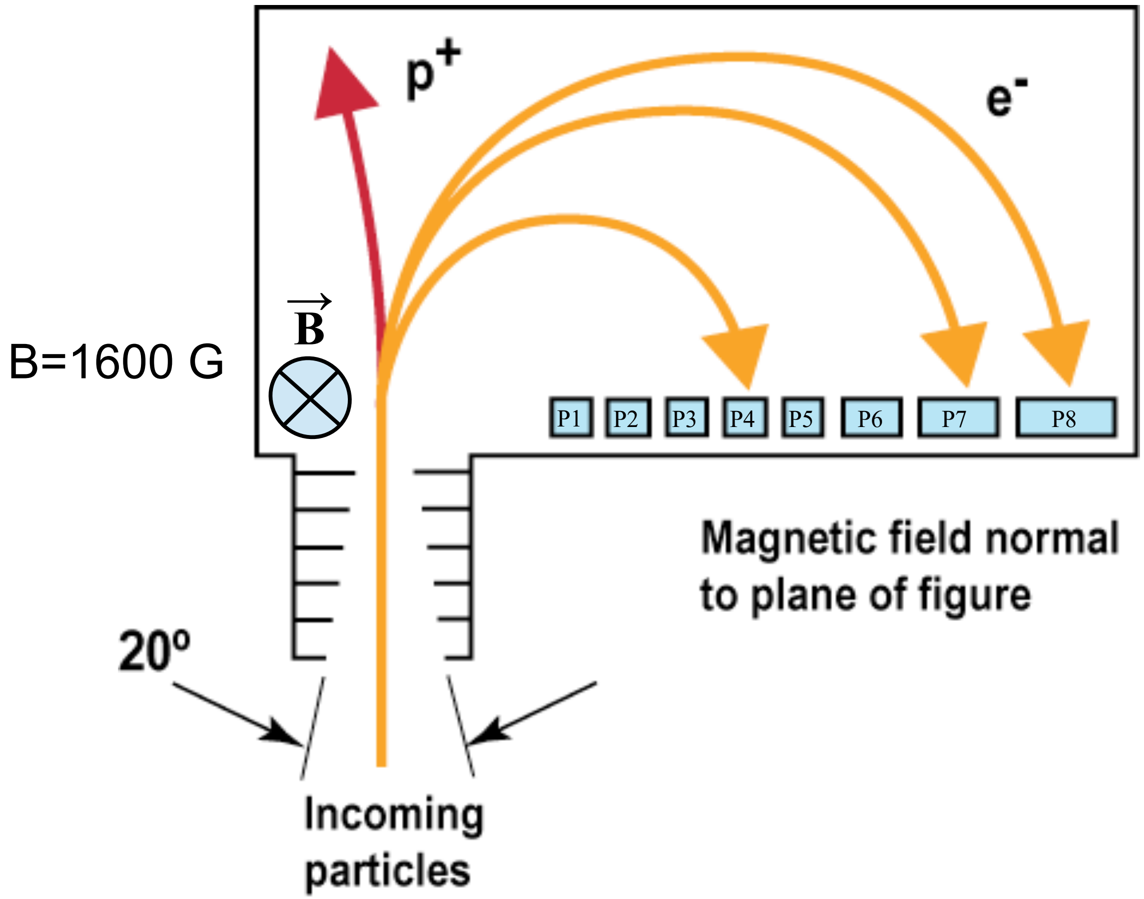
Relativistic Electrons: Energization



- High solar wind speeds (> 500 km/s) and southward B_z
- Substorm-generated seed population (extending to hundreds of keV)
- Physical processes
  - radial transport
  - in-situ acceleration

MagEIS Medium Unit
(Calculation of nominal energy)

Pixel	P1	P2	P3	P4	P5	P6	P7	P8
r (mm)	8.1	10.2	12.2	14.1	16.1	17.9	19.7	21.5



MagEIS Medium Unit
(Calculation of differential flux)

$$J = \frac{Counts}{\Delta \mathrm{E} \cdot \Delta t \cdot \mathrm{G}}$$

Pixel	P1	P2	P3	P4	P5	P6	P7	P8
CR (#/sec)	5607	2461	1932	1347	906	721	523	398
ΔE (keV)	72	90	106	120	132	144	150	162
G (cm^2 sr keV)	0.281	0.328	0.342	0.343	0.332	0.316	0.303	0.287