Scientific topics and research interests

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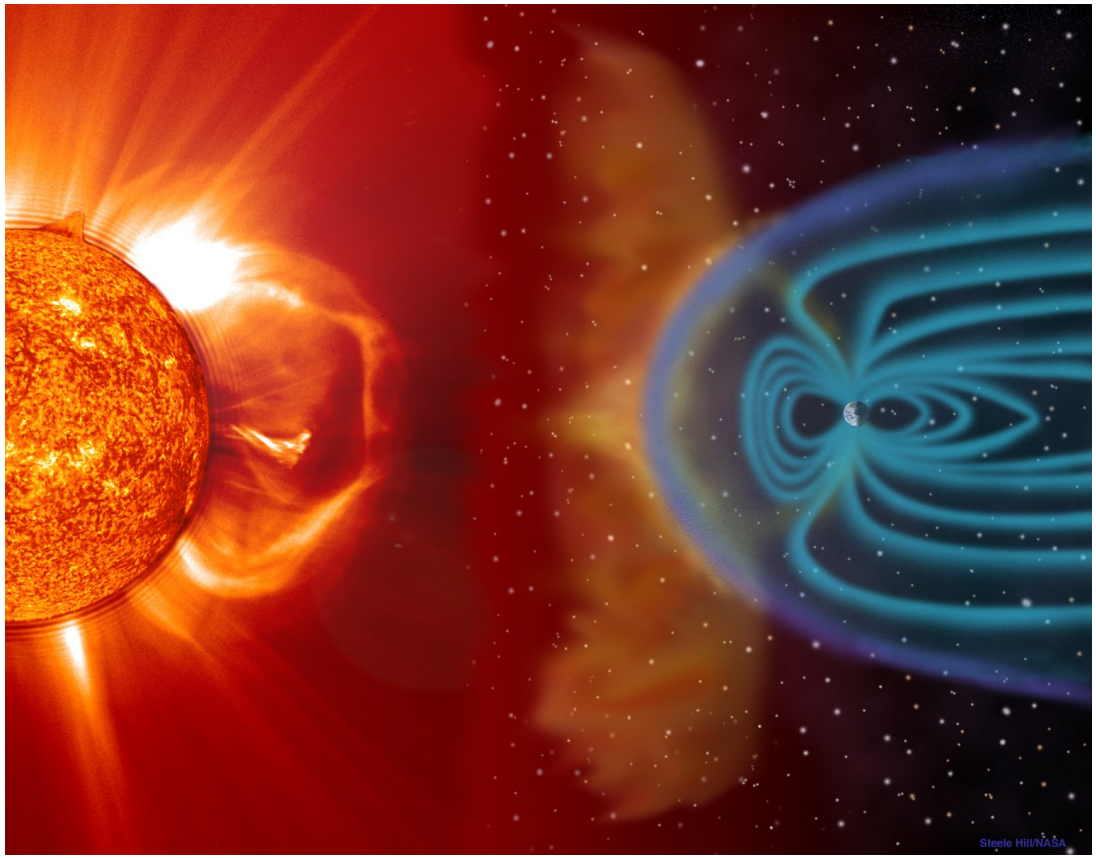
5th August 2019

Vysoké Tatry [High Tatras], Slovakia

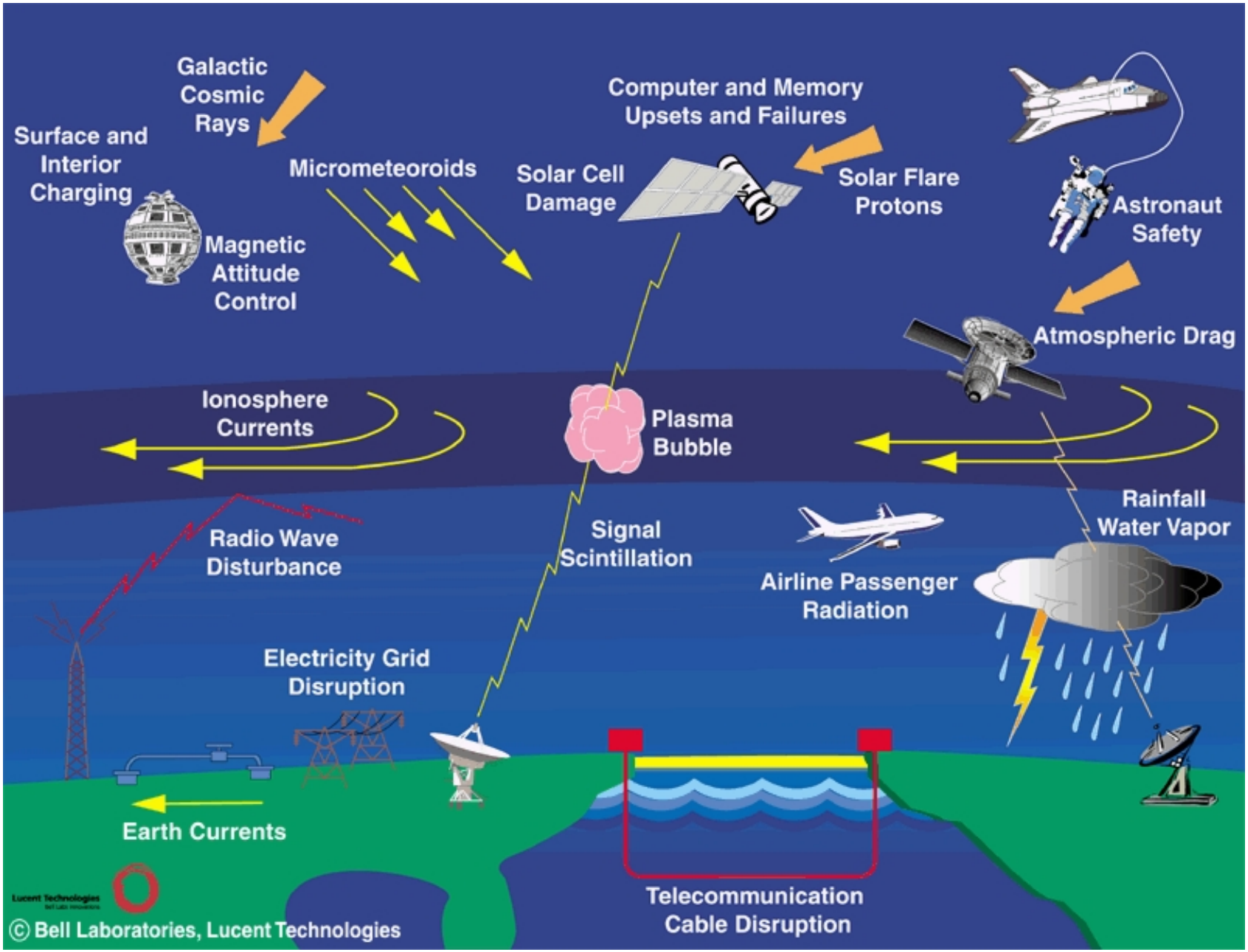
1. Skalnaté Pleso Observatory [lake] (Elevation: 1 754 m)
2. Lomnický Štít Observatory [peak] (Elevation: 2 634 m)
3. Stará Lesná (Elevation: 780 m)

Sun – Earth connection

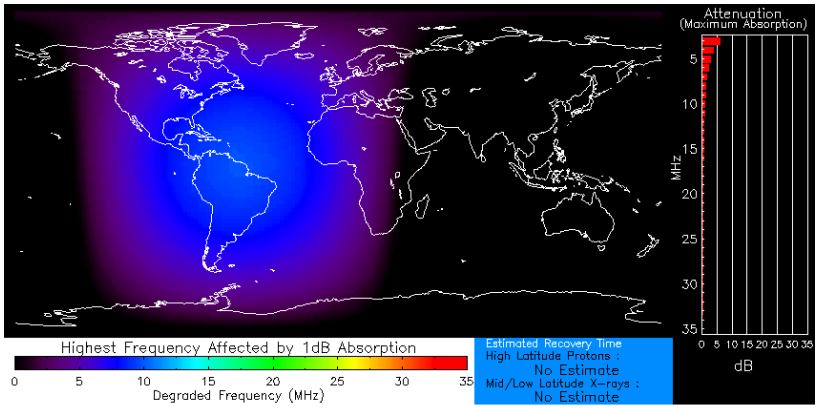


- 11–year solar cycle
- photons (broadband) (8.5 minutes)
- coronal mass ejections (magnetised plasma) (1–3 days)
- **energetic particles** (protons: $1\,\mathrm{MeV} - 1\,\mathrm{GeV}$) (≈30 minutes)

Space Weather

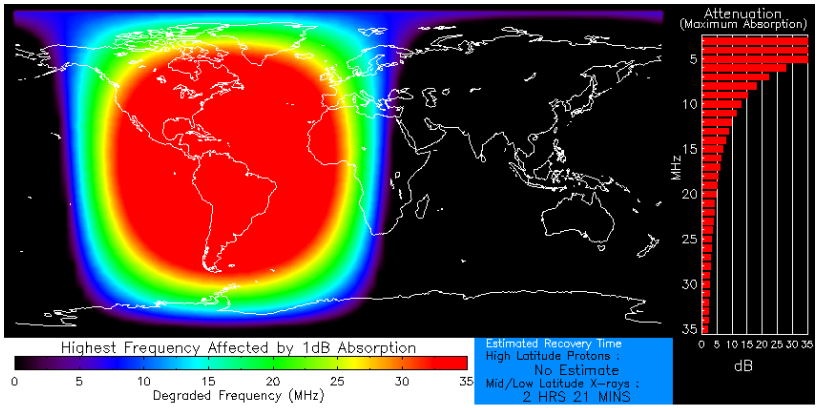


Effects of X–rays and SEPs on the ionosphere



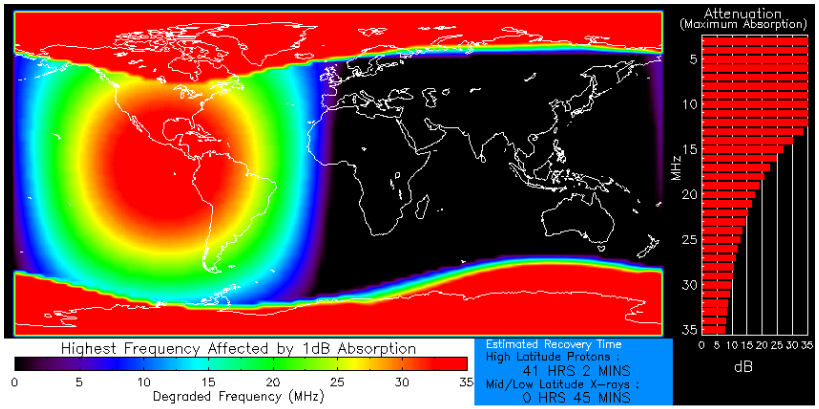
Normal X–ray Background
Product Valid At : 2017–09–10 15:40 UTC

Normal Proton Background
NOAA/SWPC Boulder, CO USA



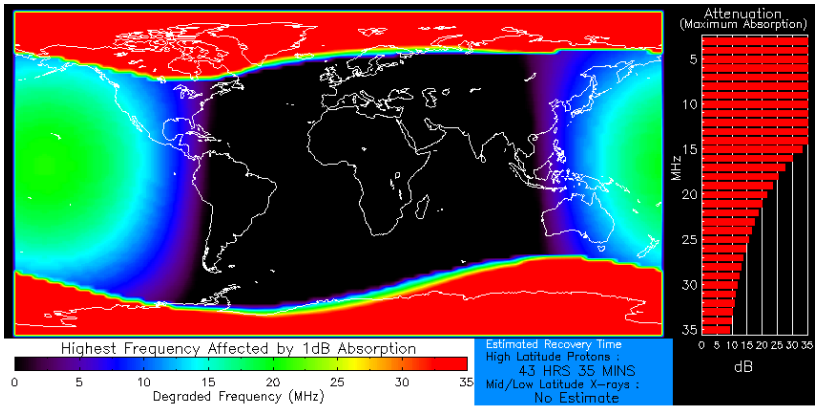
Strong X–ray flux
Product Valid At : 2017–09–10 16:06 UTC

Normal Proton Background
NOAA/SWPC Boulder, CO USA



Moderate X–ray flux
Product Valid At : 2017–09–10 18:16 UTC

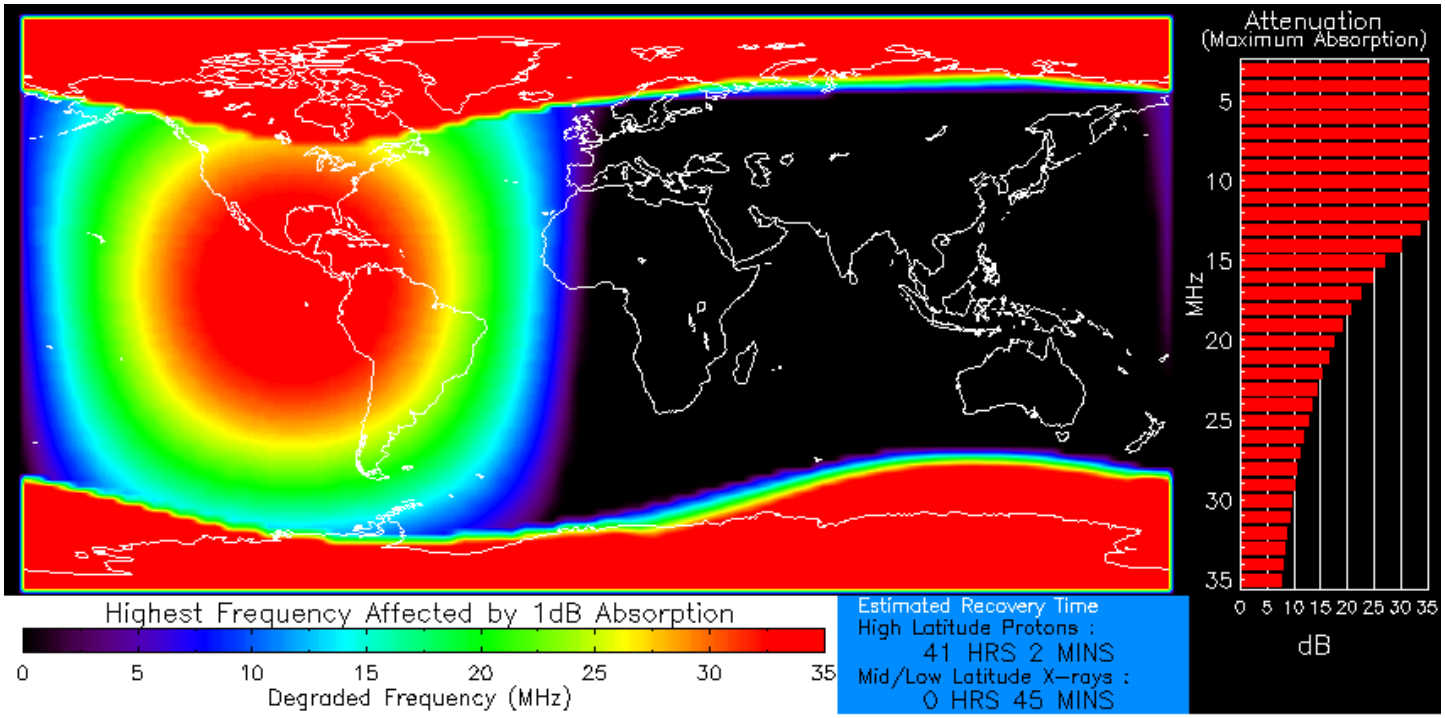
Moderate Proton Flux
NOAA/SWPC Boulder, CO USA



Elevated X–ray flux
Product Valid At : 2017–09–10 22:46 UTC

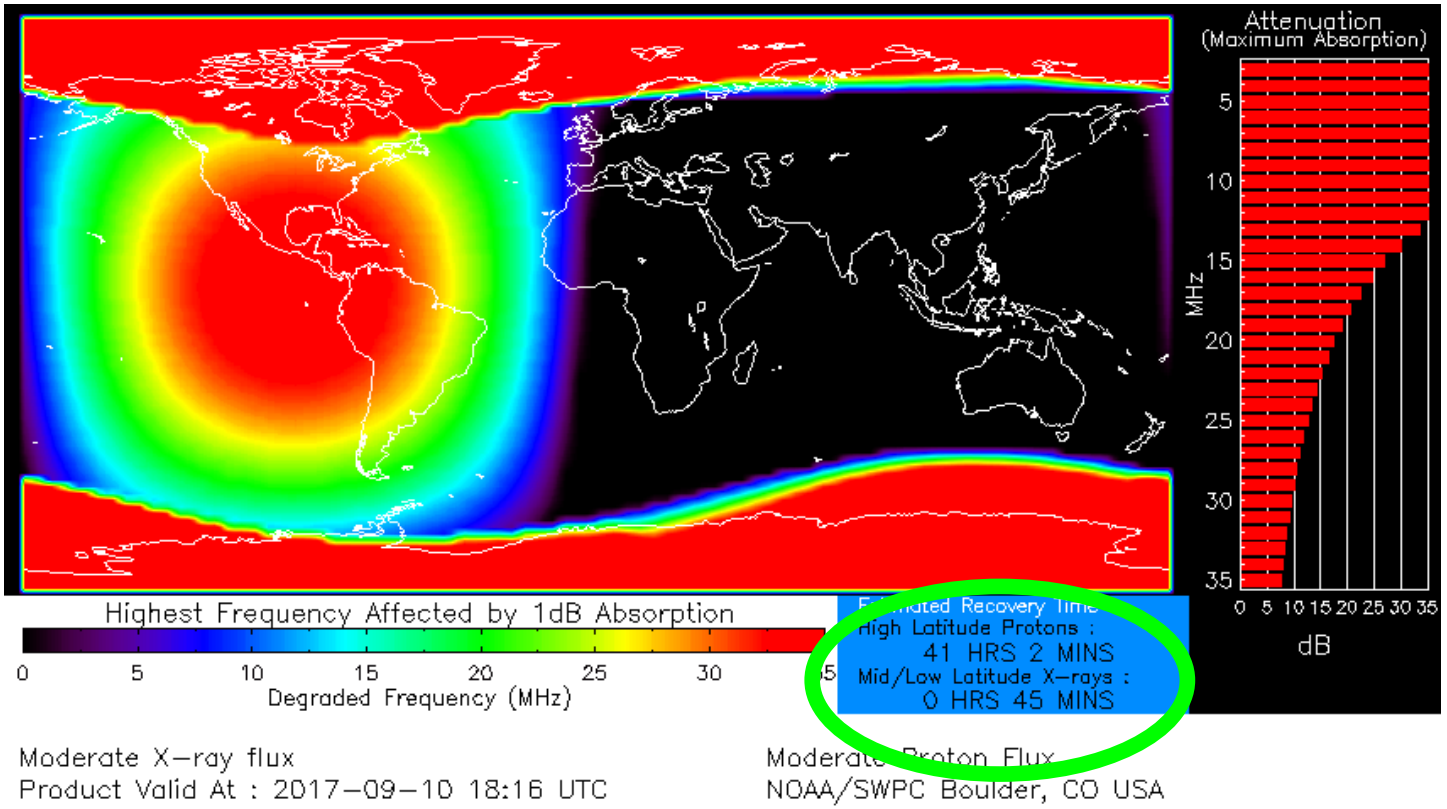
Moderate Proton Flux
NOAA/SWPC Boulder, CO USA

Effects of X–rays and SEPs on the ionosphere



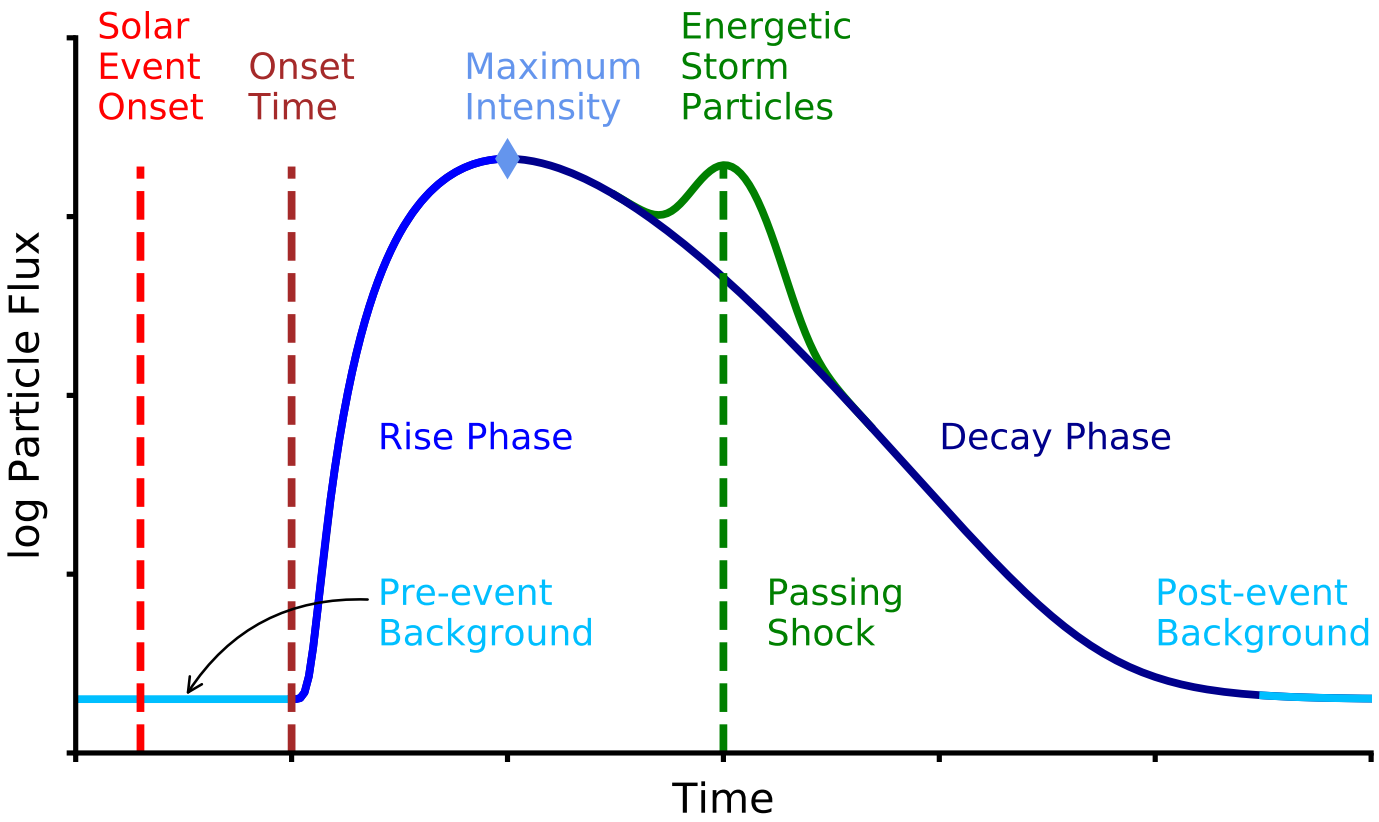
- particles $> 30\,\mathrm{MeV}$: astronauts in anti-radiation shield
- particles $> 100\,\mathrm{MeV}$: radiation dose for high-altitude passengers

Effects of X–rays and SEPs on the ionosphere

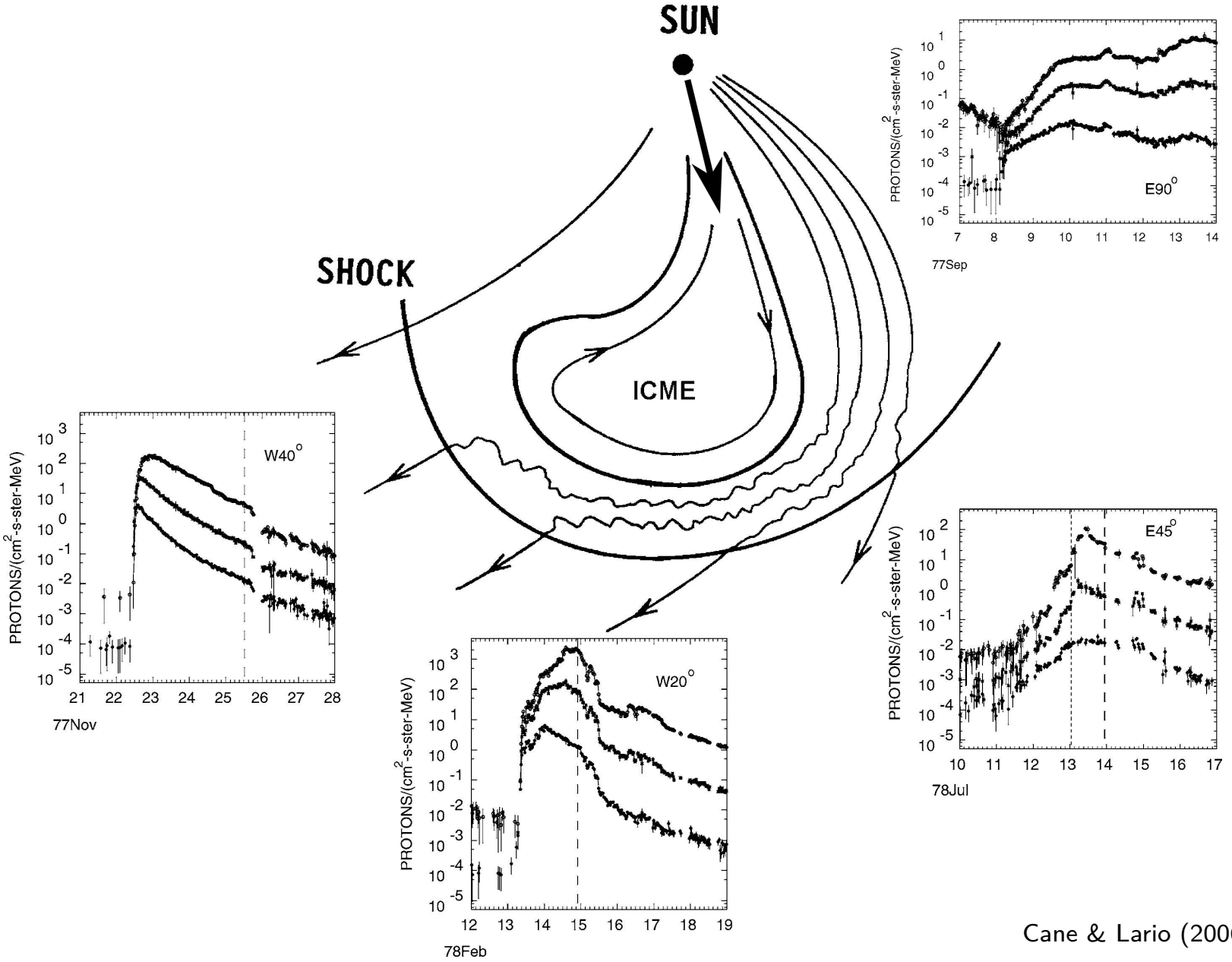


- particles $> 30\,\mathrm{MeV}$: astronauts in anti-radiation shield
- particles $> 100\,\mathrm{MeV}$: radiation dose for high-altitude passengers
- return to normal:
  - X–ray: 2–3 hours
  - energetic particles: up to 48 hours

SEP event


Solar
Event
Onset
Onset
Time
Maximum
Intensity
Energetic
Storm
Particles
log Particle Flux
Rise Phase
Decay Phase
Pre-event
Background
Passing
Shock
Post-event
Background
Time

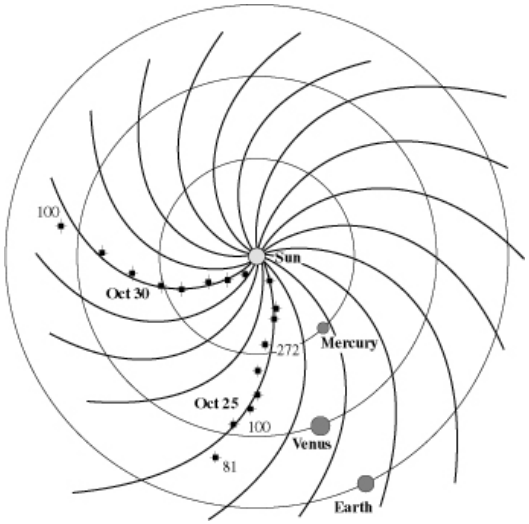
East–West particle flux dependence



Cane & Lario (2006)

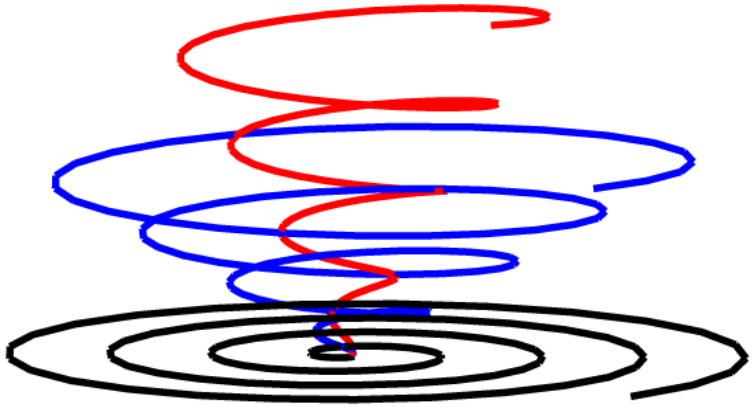
Parker spiral (1958)

Projection in the ecliptic plane (at 1 AU):



Credit: J. Reiner

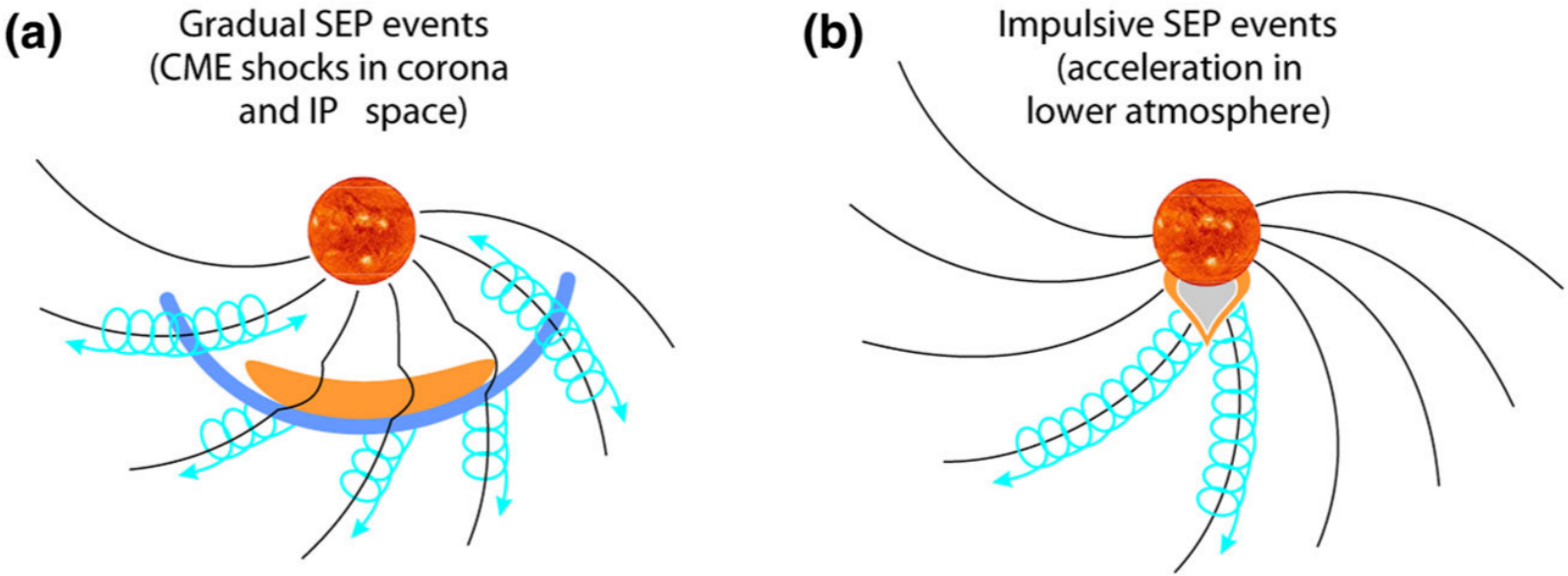
Parker spiral at 0 °, 30 °, 60 ° (at 25 AU):



Owens & Forsyth (2013)

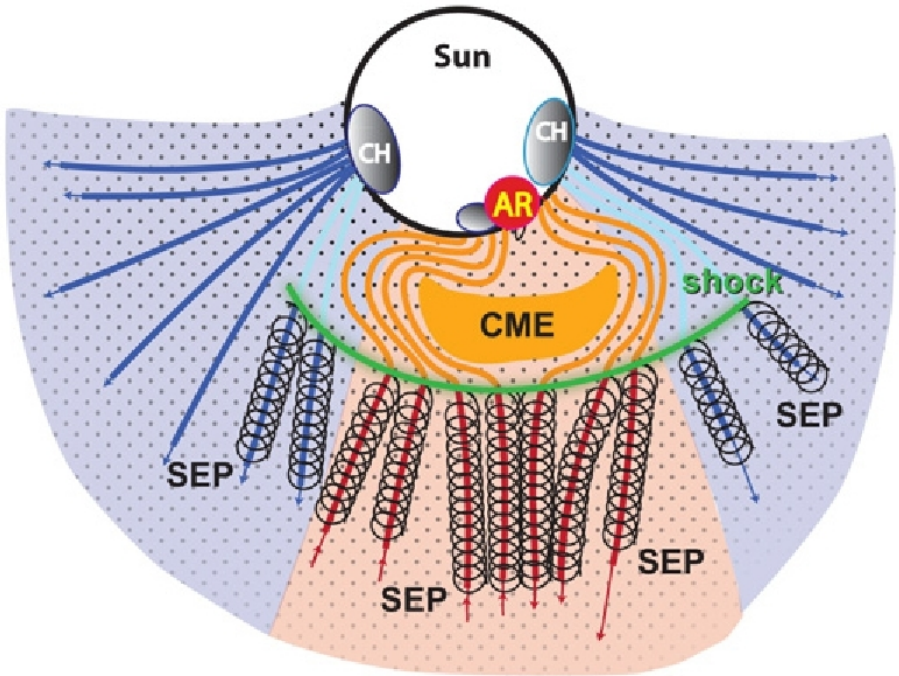
- a model of average interplanetary magnetic field
- describes magnetic connection of Earth/spacecraft to the Sun
- footpoint of the Earth: 50 °– 60 ° West on solar disk

Current paradigm for SEPs



- gradual events: poor in Fe (Fe/O $\lesssim 0.134$), wide in longitude, long duration
- impulsive events: rich in Fe (Fe/O > 0.134) and ^{3}He, narrow in longitude, short–lasted

SEP propagation in heliosphere (current view)



Ko et al. (2013)

- charged particles propagate mainly along magnetic field lines
- very little perpendicular transport (allowed by current theories)
- longitudinal spread is explained by the presence of a shock

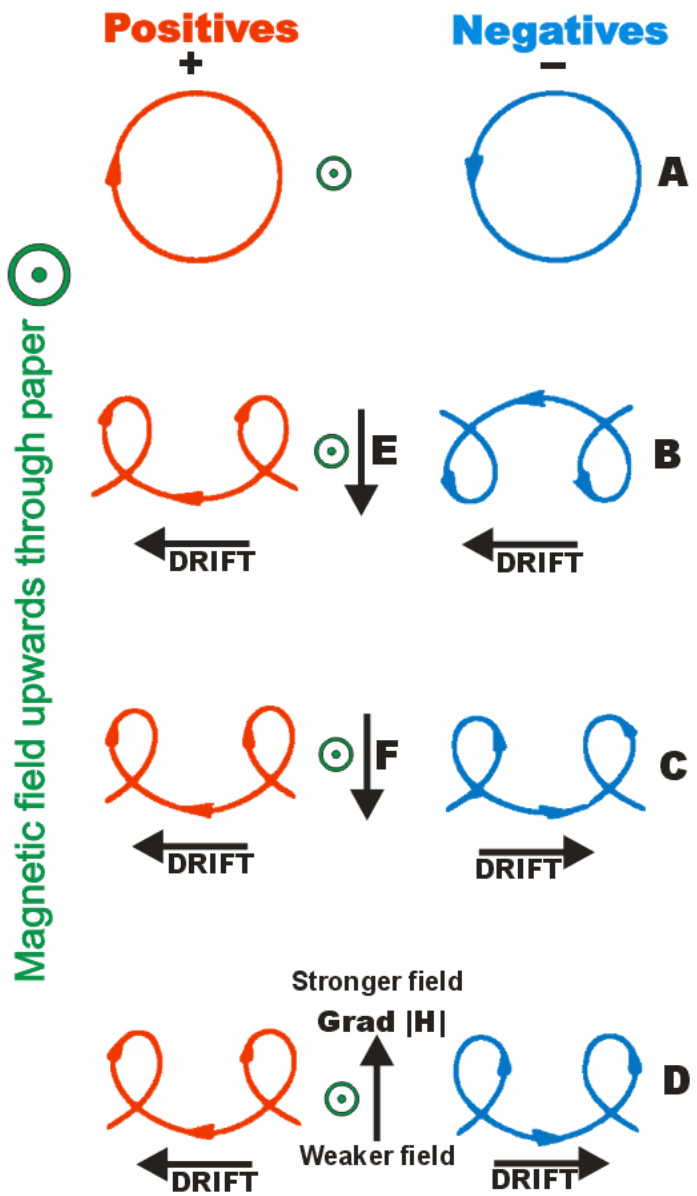
Single particle motion. Drifts.

Gyration and
guiding center motion:

- Uniform magnetic field (A)
- **E**–cross–**B** drift (B)
- general force **F** drift (C)
- non–uniform **B** drifts (D)

Drifts depend on:

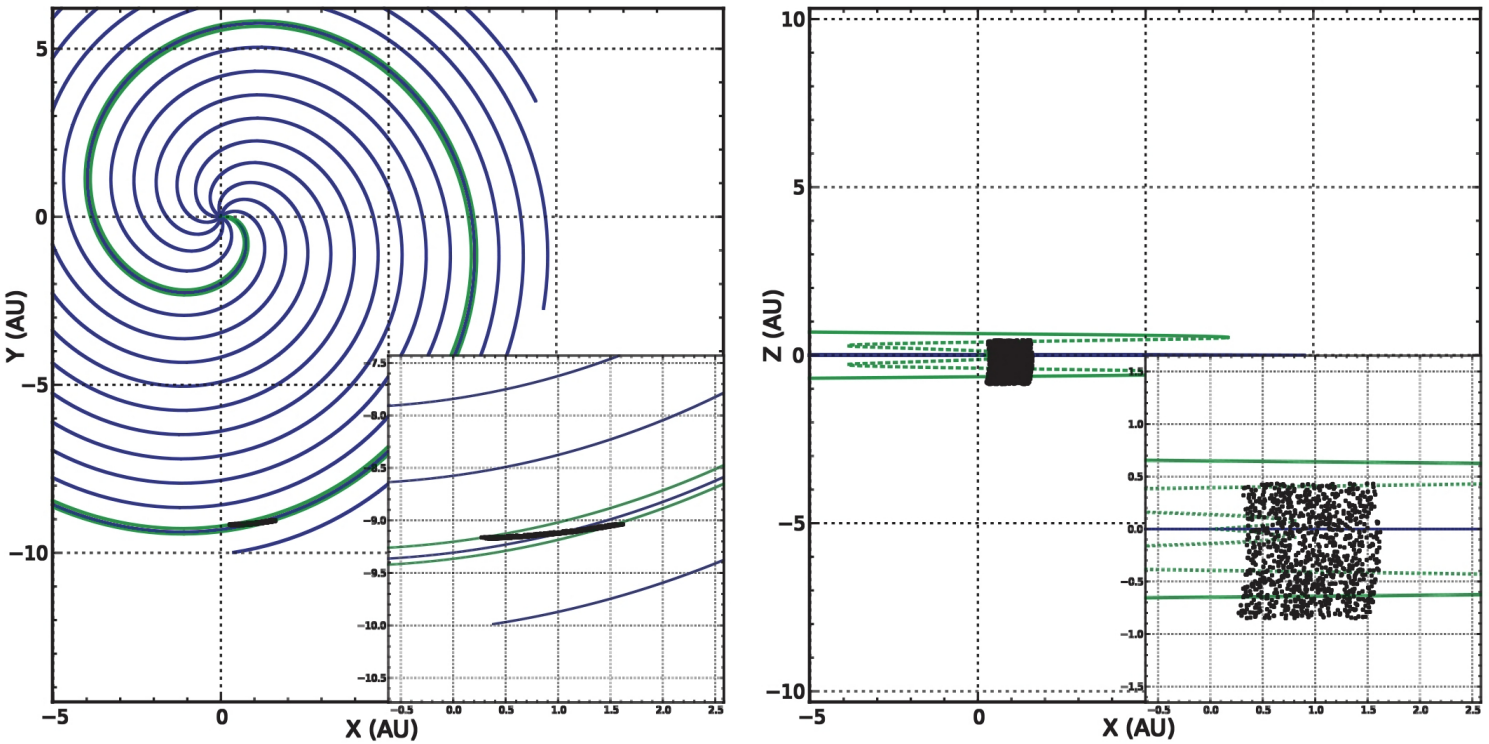
- particle velocity (kinetic energy)
- charge Q
- mass M



Credit: `http://www.plasma-universe.com/`

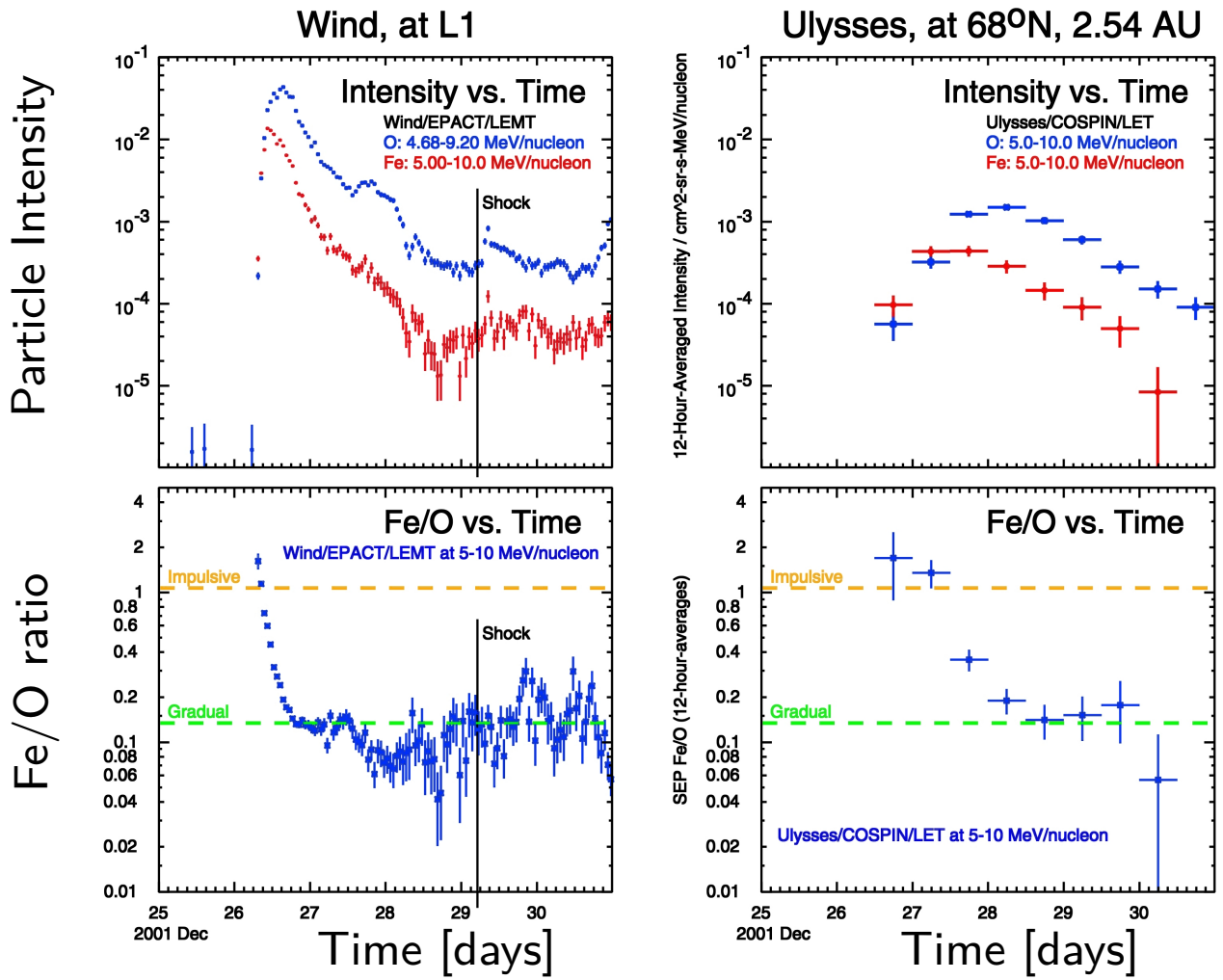
Drifts as a cross–field transport mechanism

- Dalla et al. (2013) and Marsh et al. (2013) showed that drifts are an important effect in perpendicular SEP transport
- M/Q ratio dependent



Marsh et al. (2013)

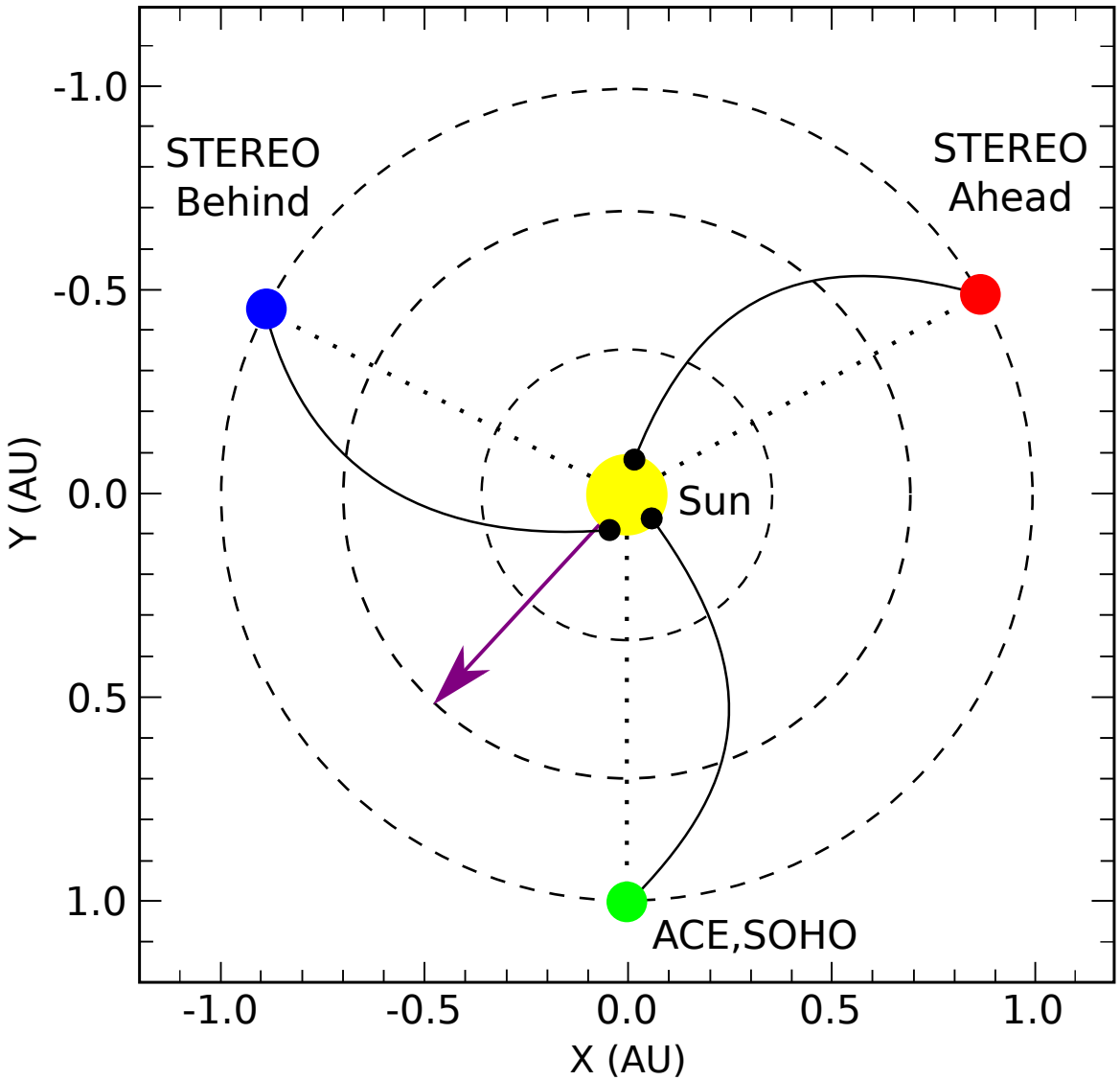
Fe/O decreases by Wind and Ulysses



(Tylka+2013)

- Tylka+2013 observed Fe/O decreases at 2 spacecraft
- similar observations by Scholer+1978, Mason+2006,2012
- Tylka+1999 analysed Fe/O and 6 other ratios

SEP event #1: 2012 Aug. 31, S16E42



SEP event #1: 2012 Aug. 31, S16E42