In-situ measurement

In-situ: (origin) Latin

Importance of studying/expecting high energy particle behavior

Geospace

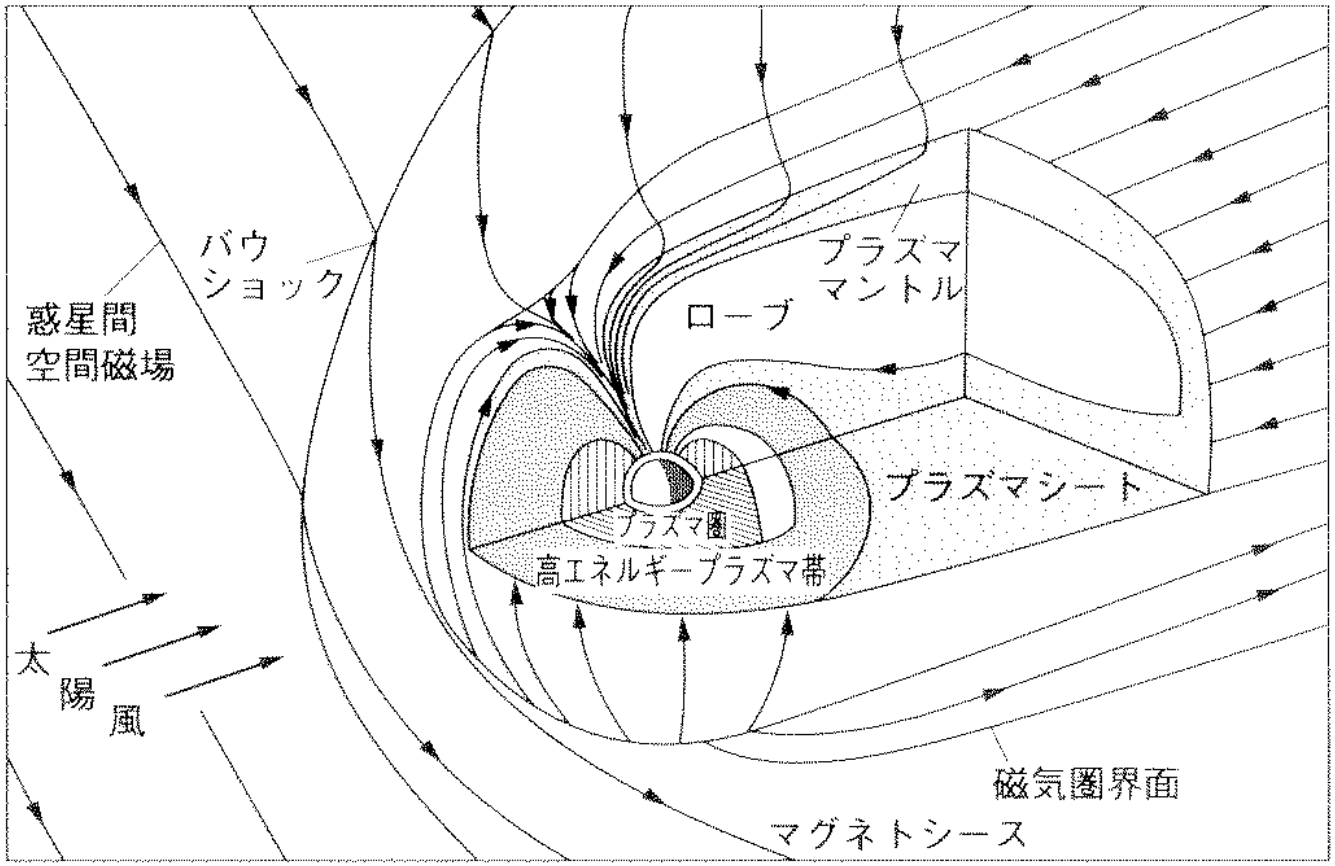


図 1・11　地球磁気圏の構造図

Magnetosphere model（Dungey, 1961)

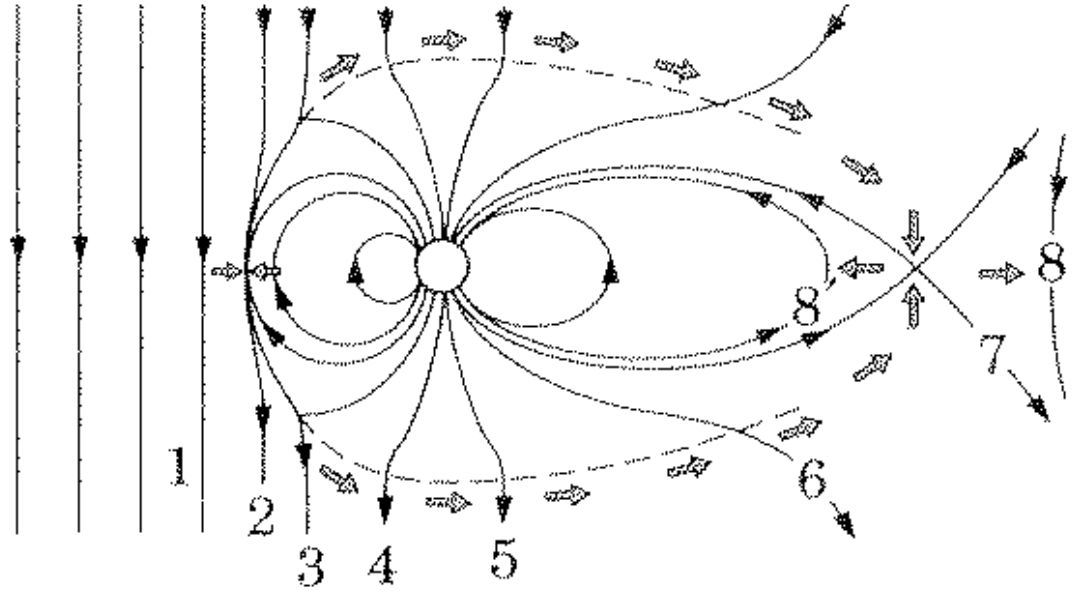
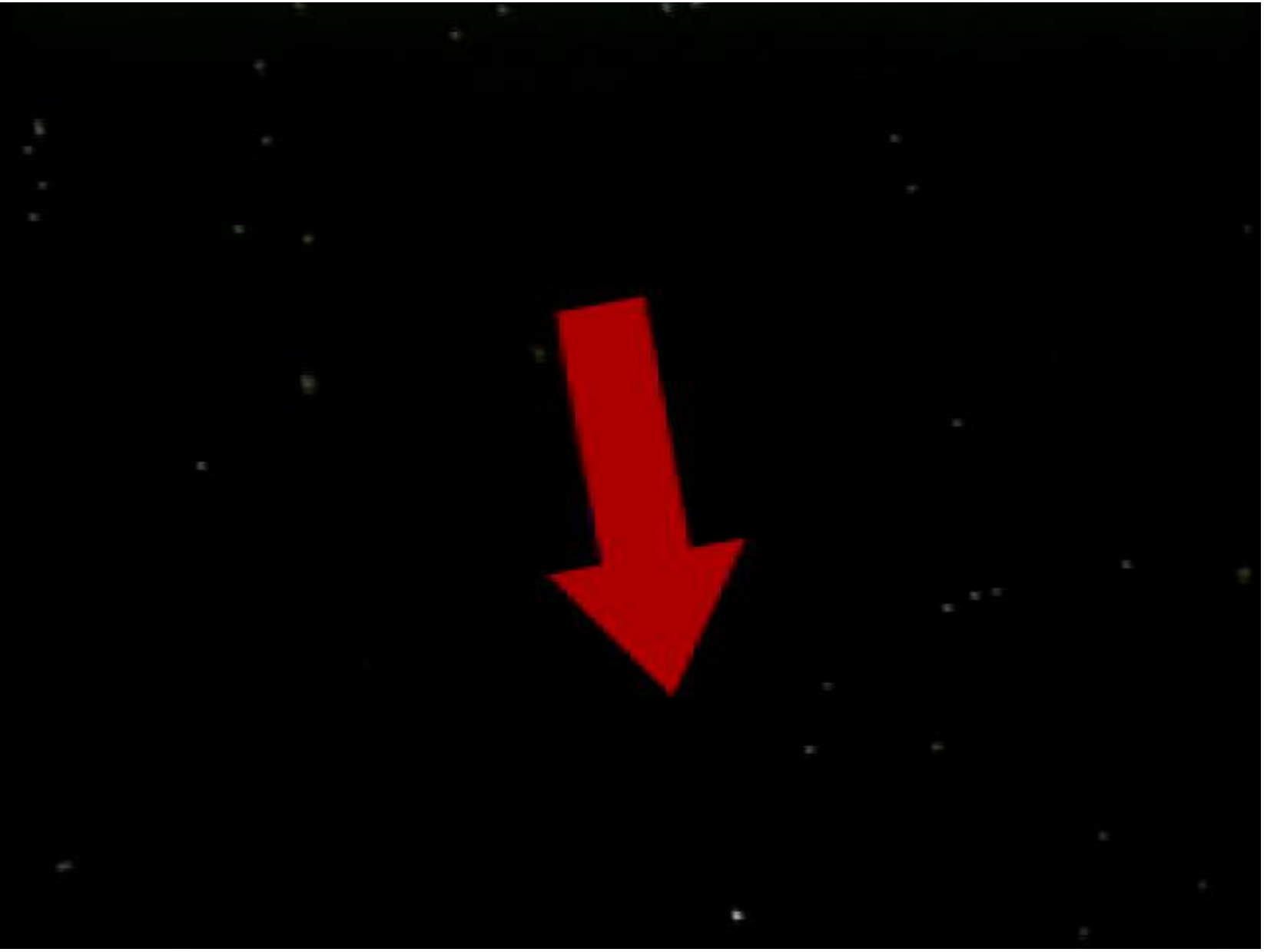


図 5・6　磁気圏の境界（太陽側）で磁力線は切断され，惑星間空間磁場とつながって磁気圏尾部が形成される．
下に示す数字（1〜8）に従って，磁力線が運動する

Key word:

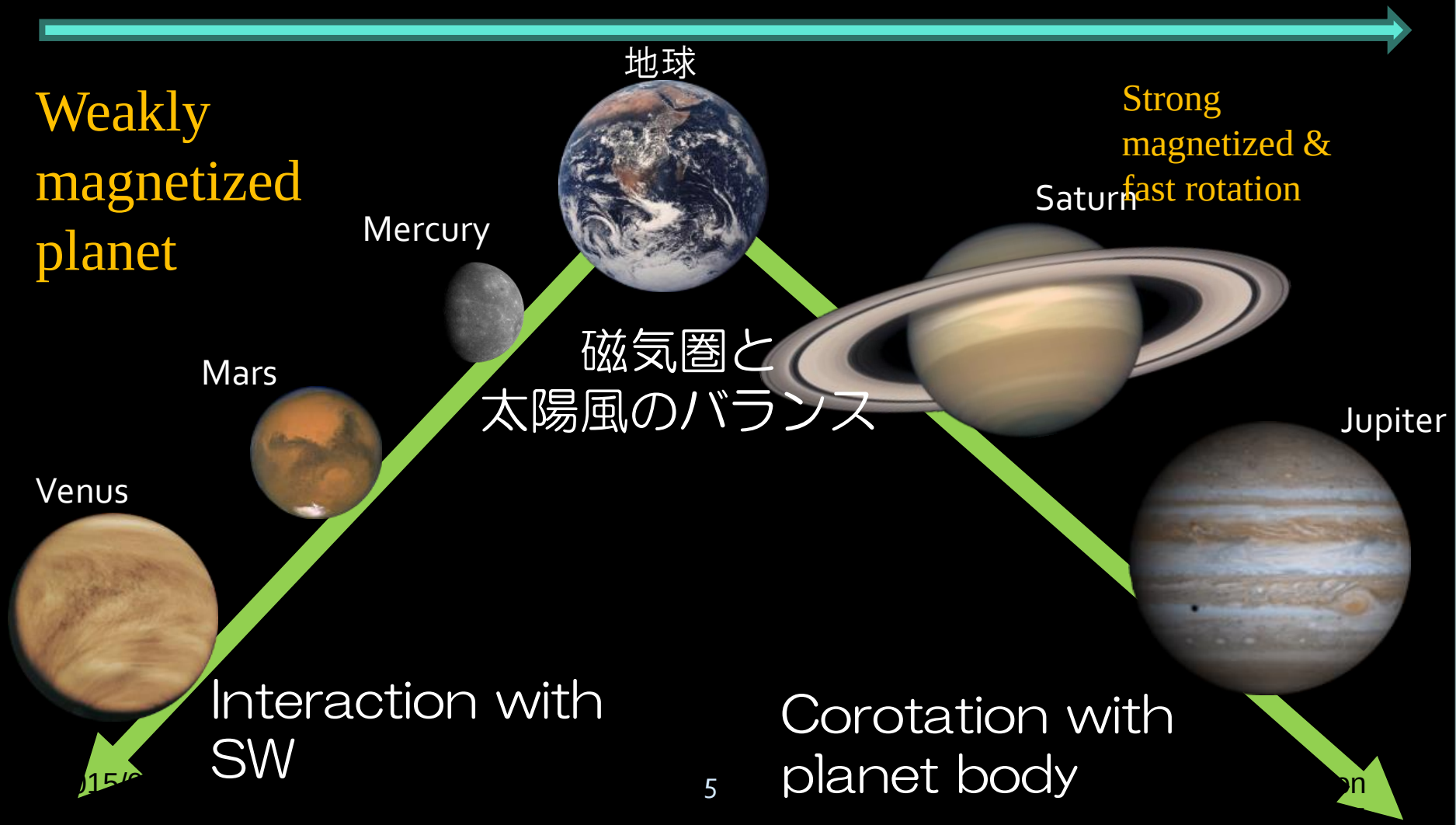
Reconnection

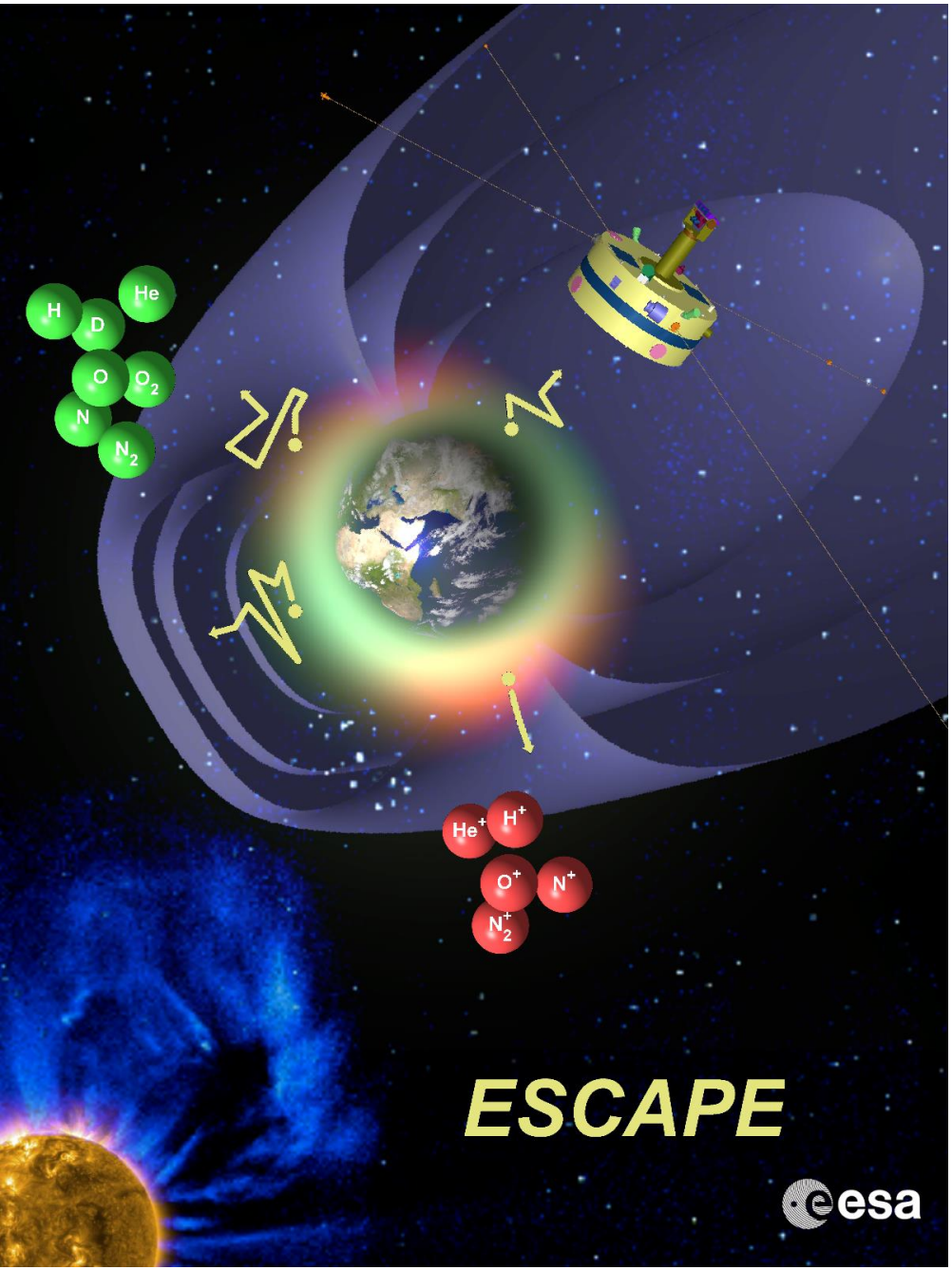
Magnetic reconnection



Solar planets

Rotation speed and strength of magnetic field





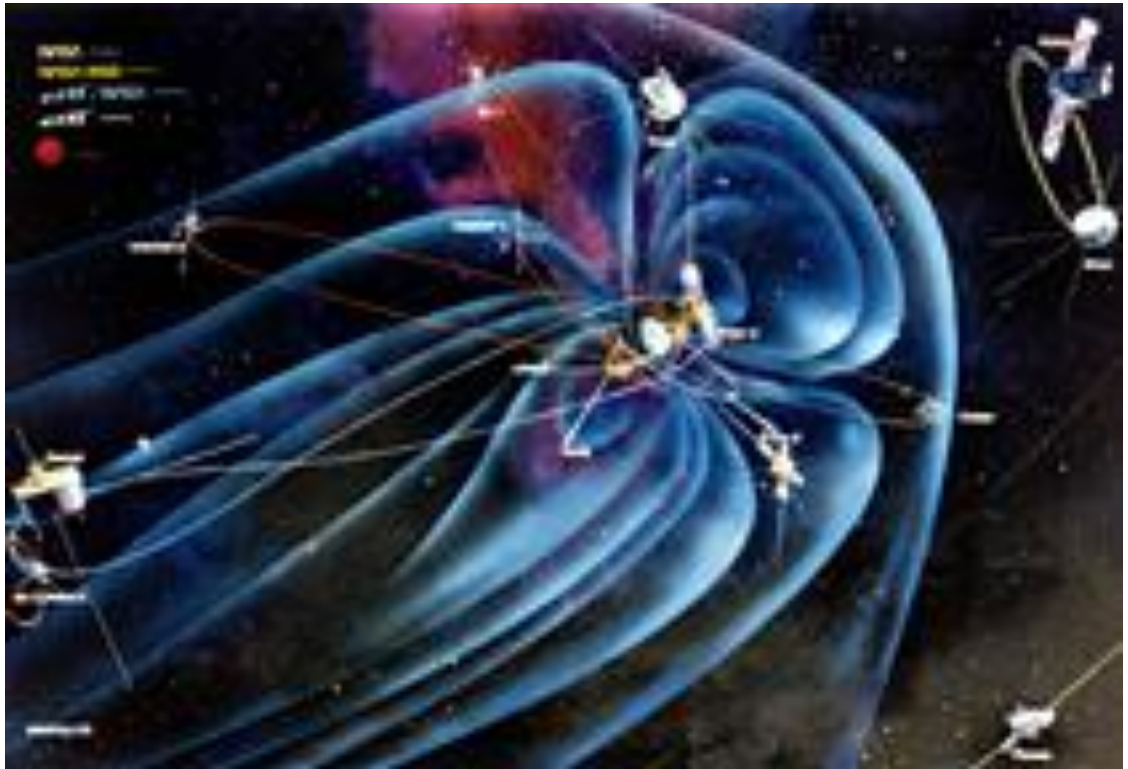
European SpaceCraft for the study of Atmospheric Particle Escape

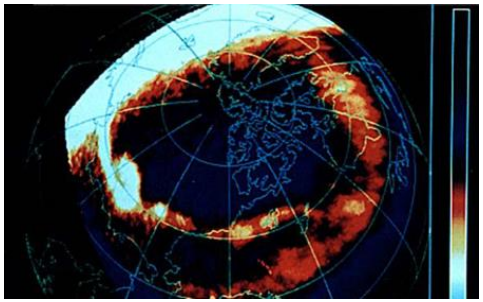
I. Dandouras, M. Yamauchi, and ESCAPE proposal team

A mission proposal to **ESA's M5 call** to understand the atmospheric escape from the Earth, a magnetized planet.

1990s Science Movements
- to understand the reaction of the Earth's magnetosphere to the fluctuation of solar wind-

International solar-terrestrial program(ISTP)





Upper region of the magnetosphere　　lower region of the magnetosphere

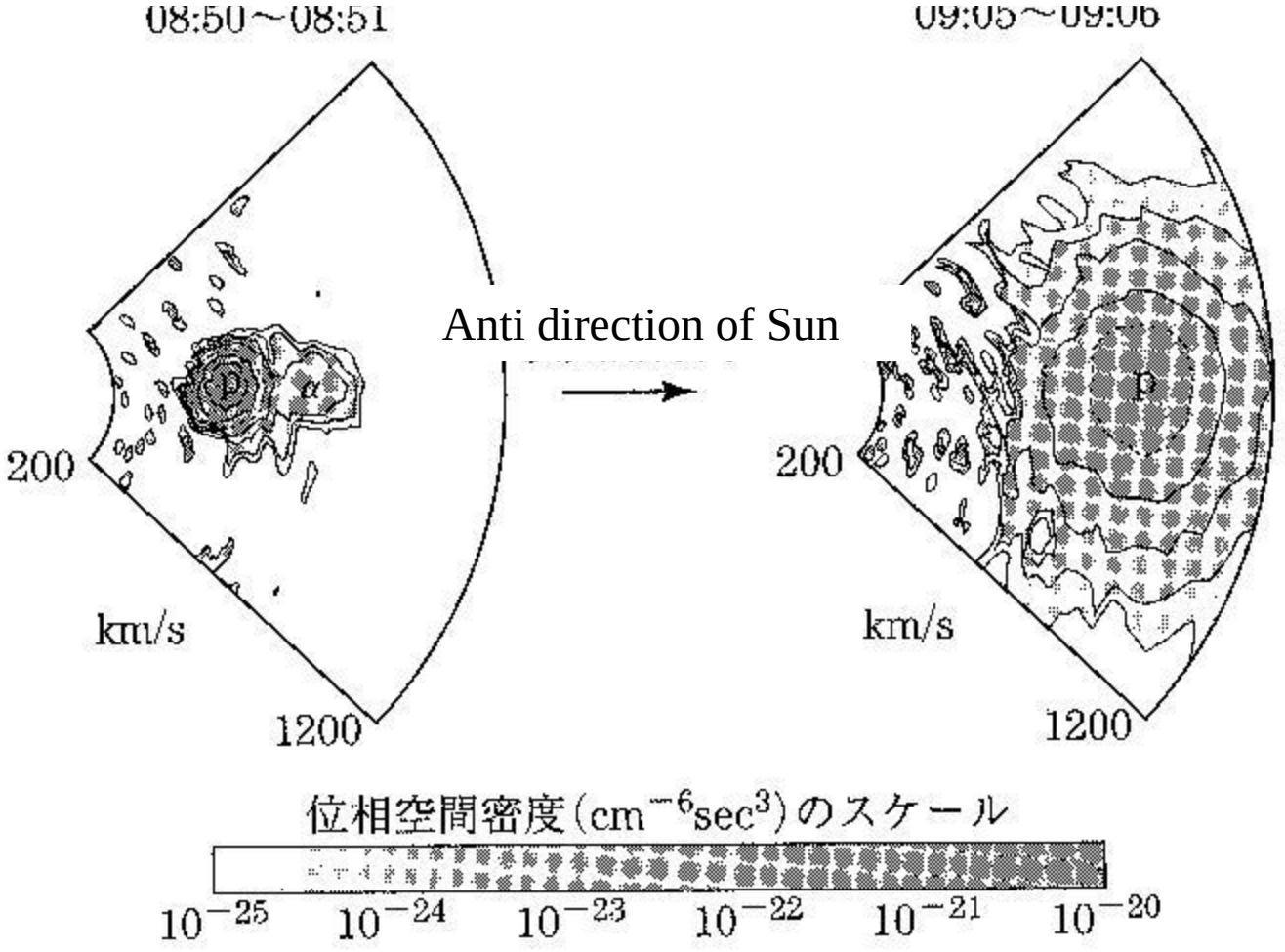


図 1.10　太陽風イオンの速度空間分布関数のスピン赤道面の断面図を衝撃波上流(左)と下流(右)について示す.

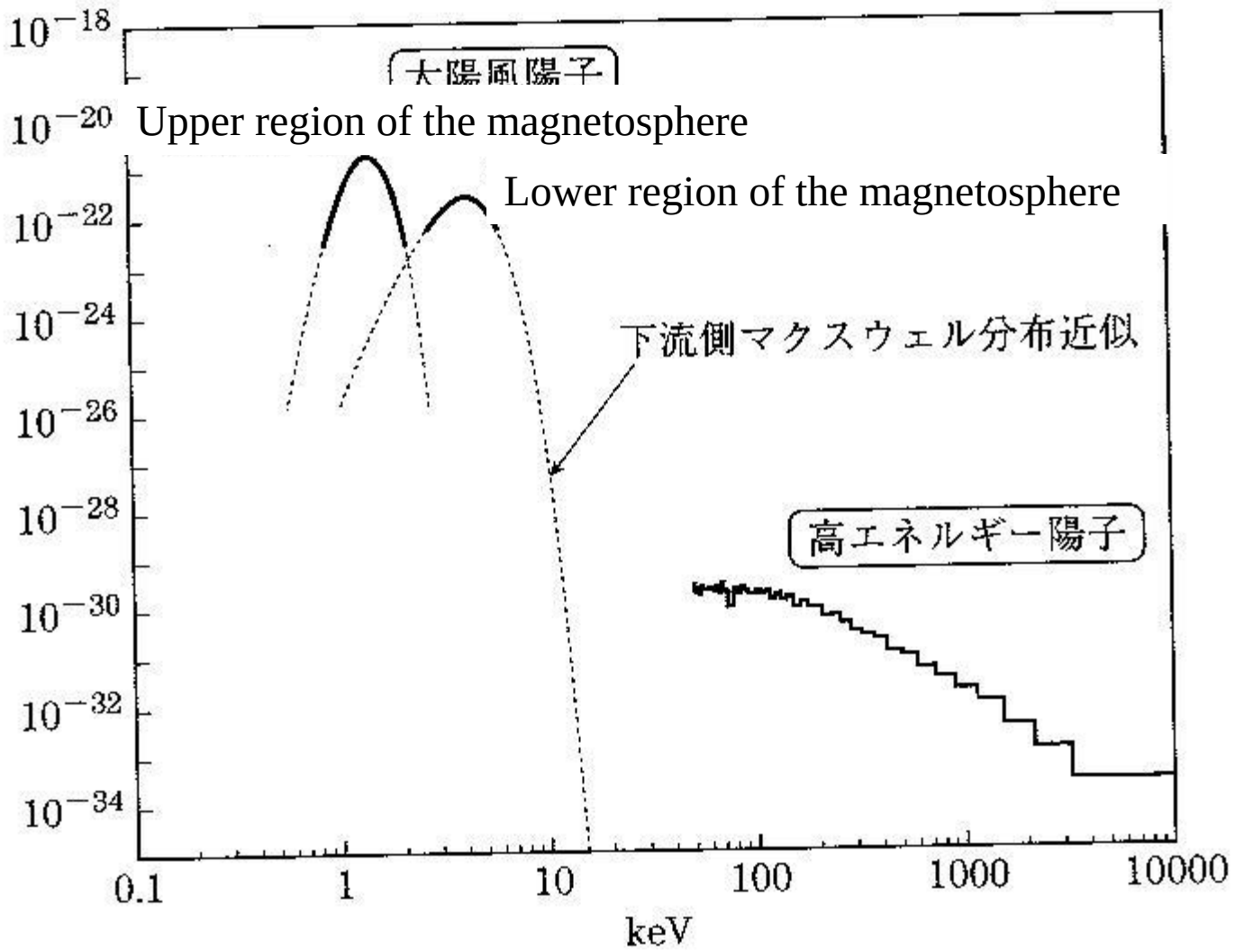


図 1.11　太陽風の熱的陽子(実線: 観測値，点線：マクスウェル-ボルツマン分布によるモデル)と，非熱的陽子(階段グラフ)の速度空間分布関数(縦軸は位相空間密度 $\mathrm{cm}^{-6}\mathrm{s}^{3}$).

First , we can obtain this function.

$$n_j \equiv \int f_j(\boldsymbol{V})\, \mathrm{d}^3\boldsymbol{V} \qquad (1.1)$$

として計算し，つぎに1次のモーメントより，平均速度 $\bar{\boldsymbol{V}}_j$ を

$$\bar{\boldsymbol{V}}_j \equiv \frac{1}{n_j} \int \boldsymbol{V} f_j(\boldsymbol{V})\, \mathrm{d}^3\boldsymbol{V} \qquad (1.2)$$

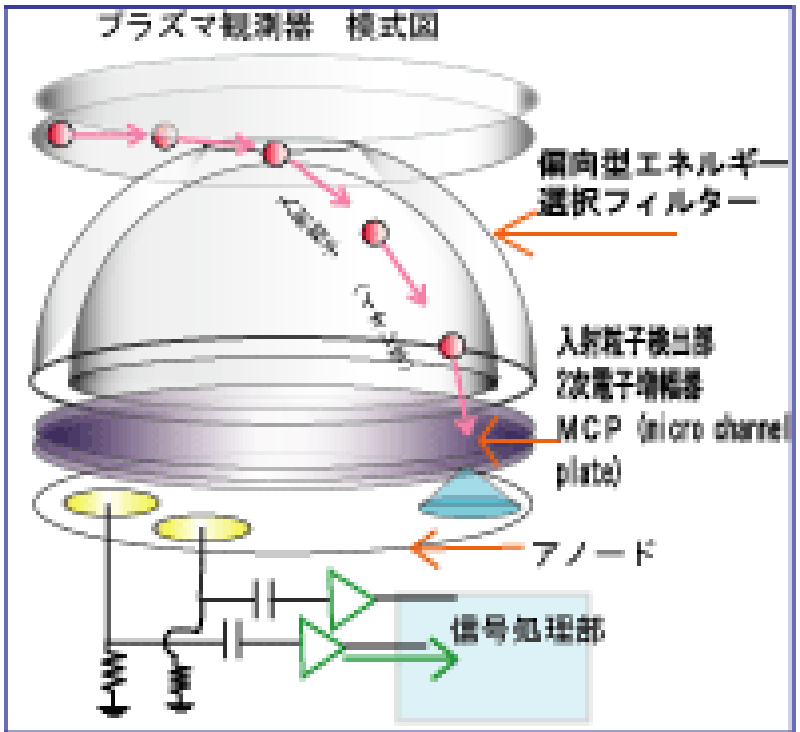
Second, we can obtain the physical values by the calculations, n, V, T..

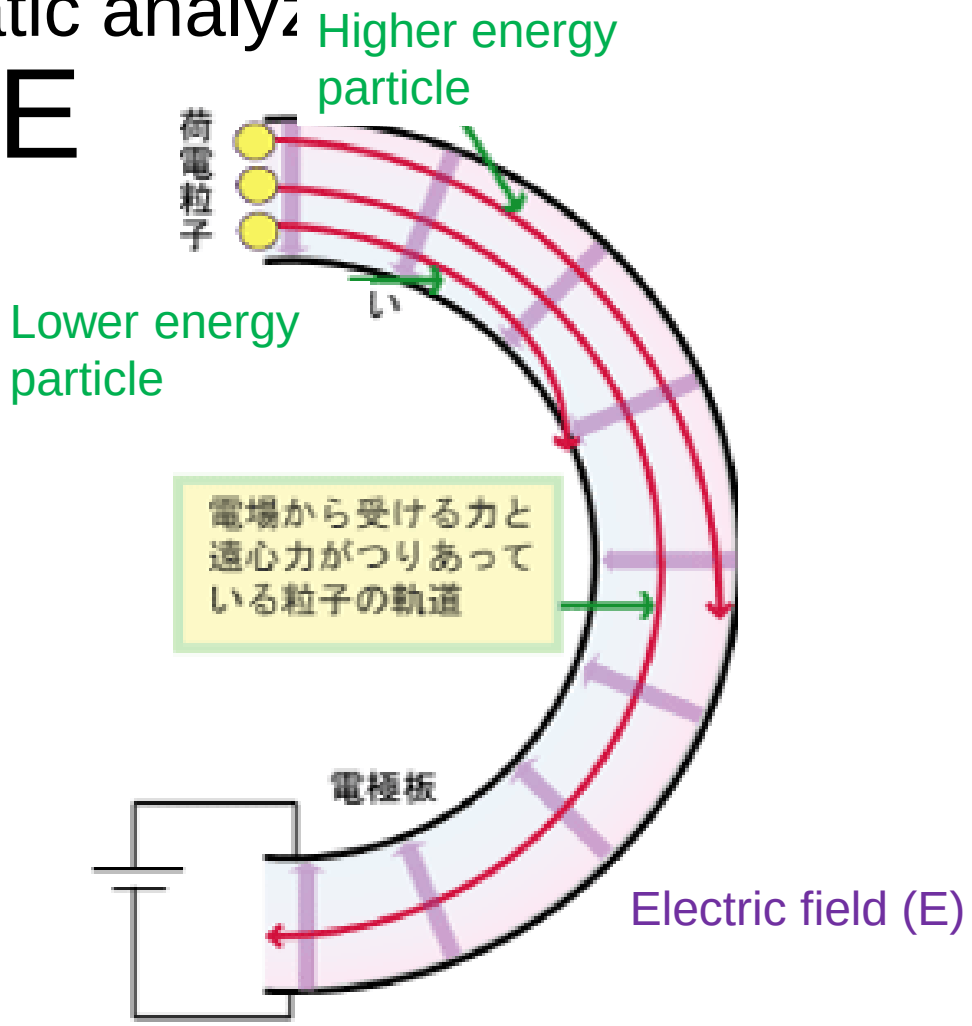
How to measure

How to measure the energy of particles (if m is known)

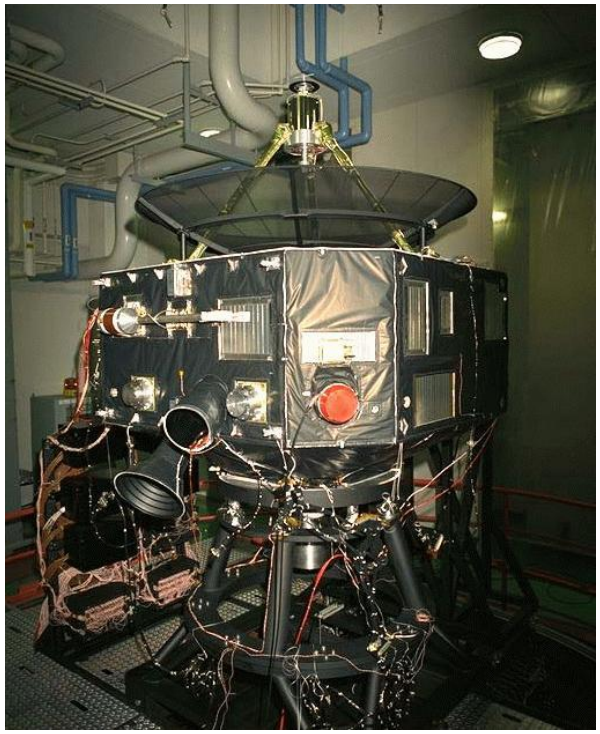
Electrostatic analyz

$$m v^2/R = qE$$

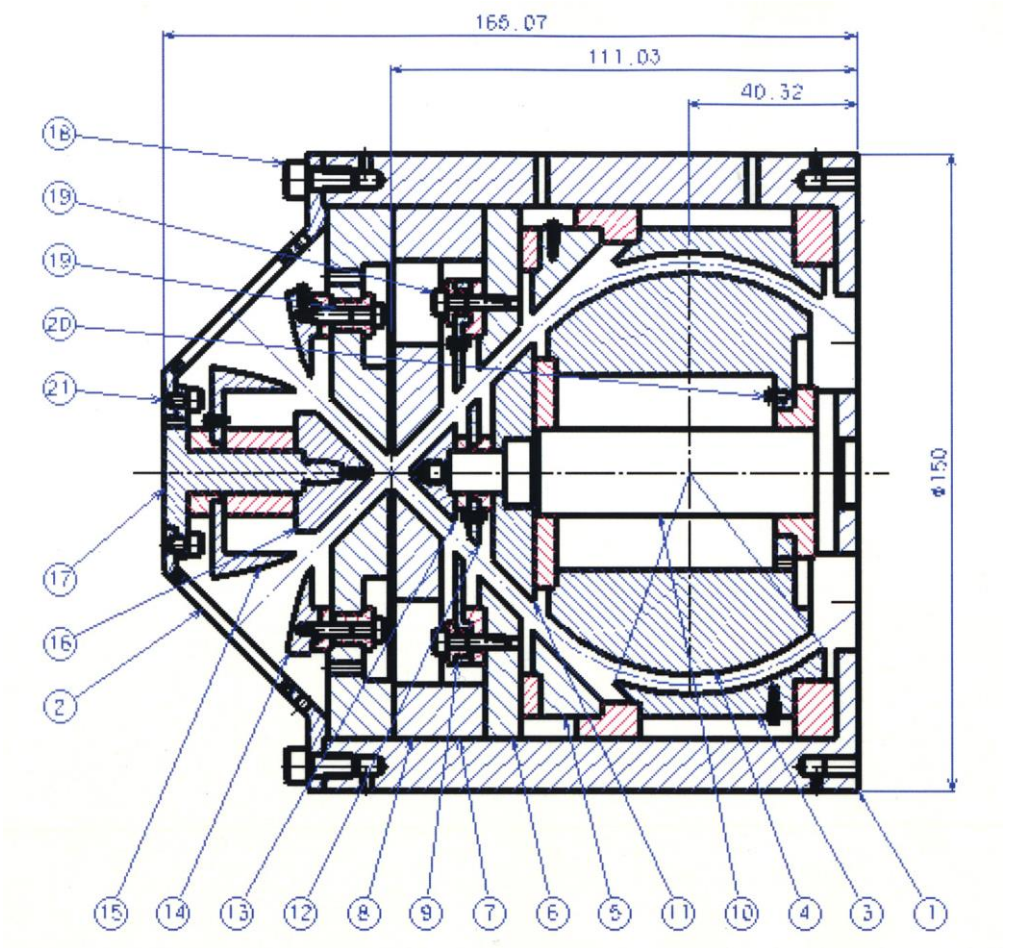




Top-hat type analyzer

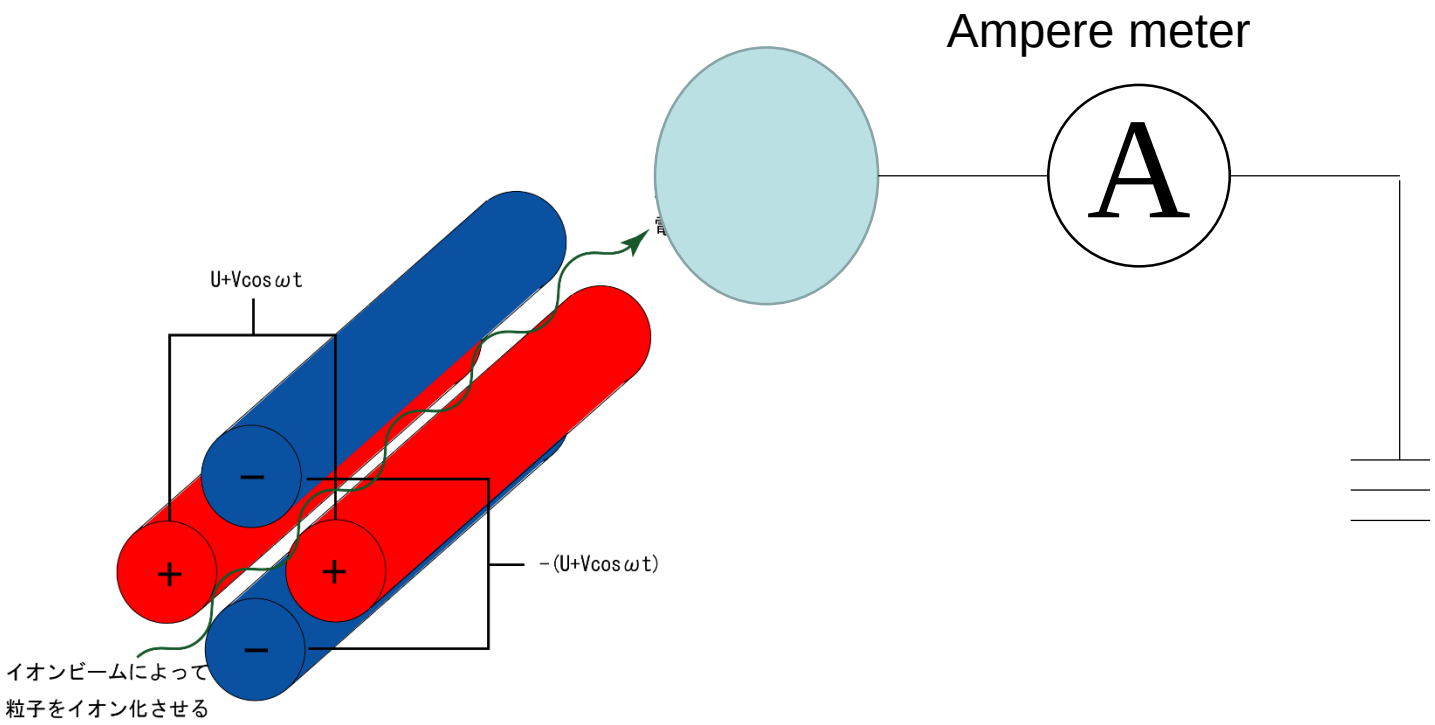


Japanese Mars Orbiter
(NOZOMI)

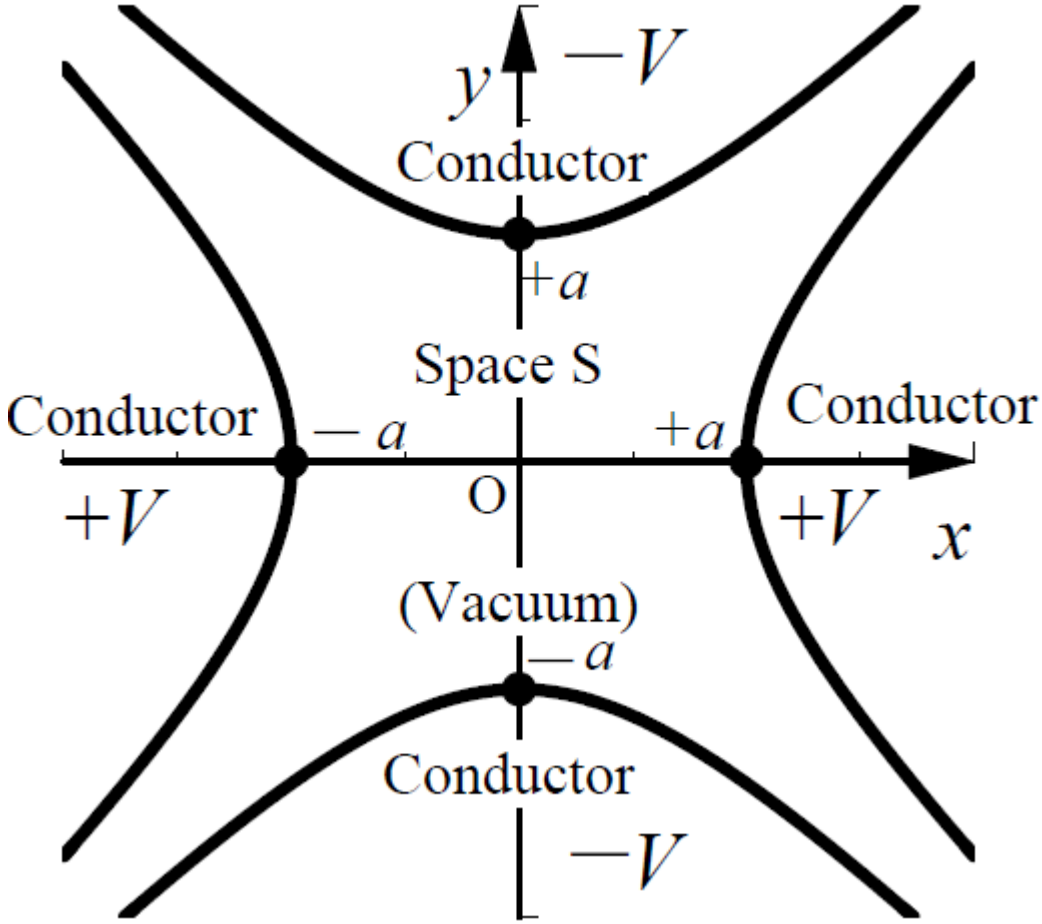


How to measure mass of particles

Quadrupole mass spectrometer



Questions (1).



Let us place four conductors, whose regions are expressed as

$$x^2 - y^2 \geq a^2 \qquad (-\infty < z < +\infty)$$

$$x^2 - y^2 \leq -a^2 \qquad (-\infty < z < +\infty)$$

Electric potentials $+V$ (>0) and $-V$ are applied to the conductors as shown in Figure.

(Q1) Prove that the electric potential at point (x, y, z) in Space S is given as

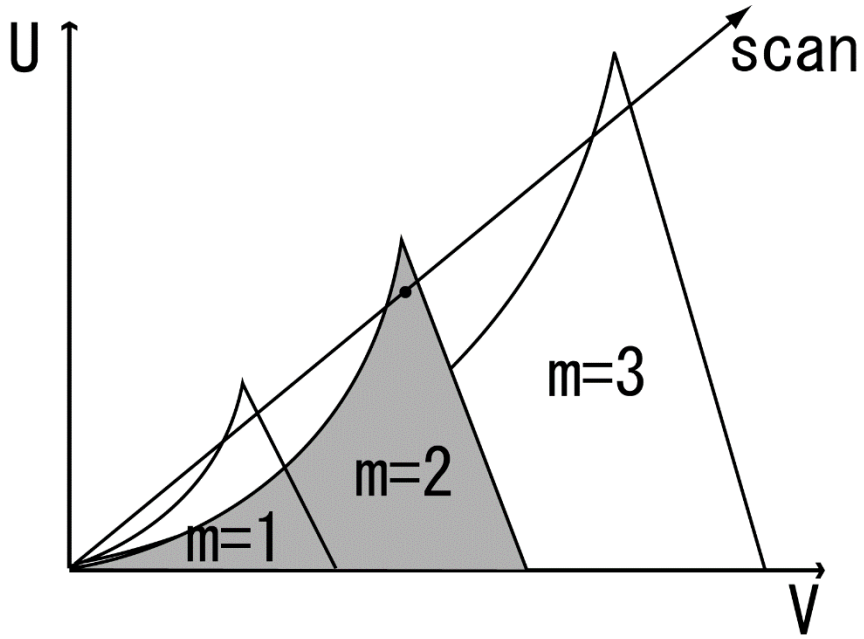
$$\Phi(x, y, z) = \frac{V}{a^2}(x^2 - y^2)$$

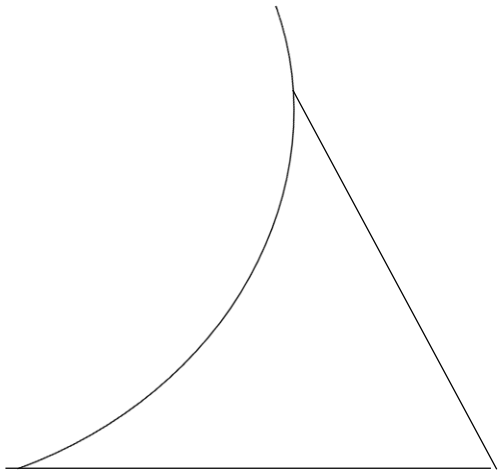
(Q2) Find the electric field (E_x, E_y, E_z) at point (x, y, z) in Space S.

If we apply V as a sinusoidal variation (V + U cos ωt), Newton equations can be converted into Mathieu's differential equation. (question(2): Prove this equation)

$$\frac{d^2y}{dx^2} + [a - 2q\cos(2x)]y = 0.$$ Mathieu's equation

(Question 3.) Explain where (how, what) this shape comes from qualitatively.





Your report should be posted on

- Report box located at EPS office

on 8F (hongo, Science building)

Otherwise

Envelop on the door of my office (4H4) (my office)

Due date is Jan. 31

Effect of the radiation on Health

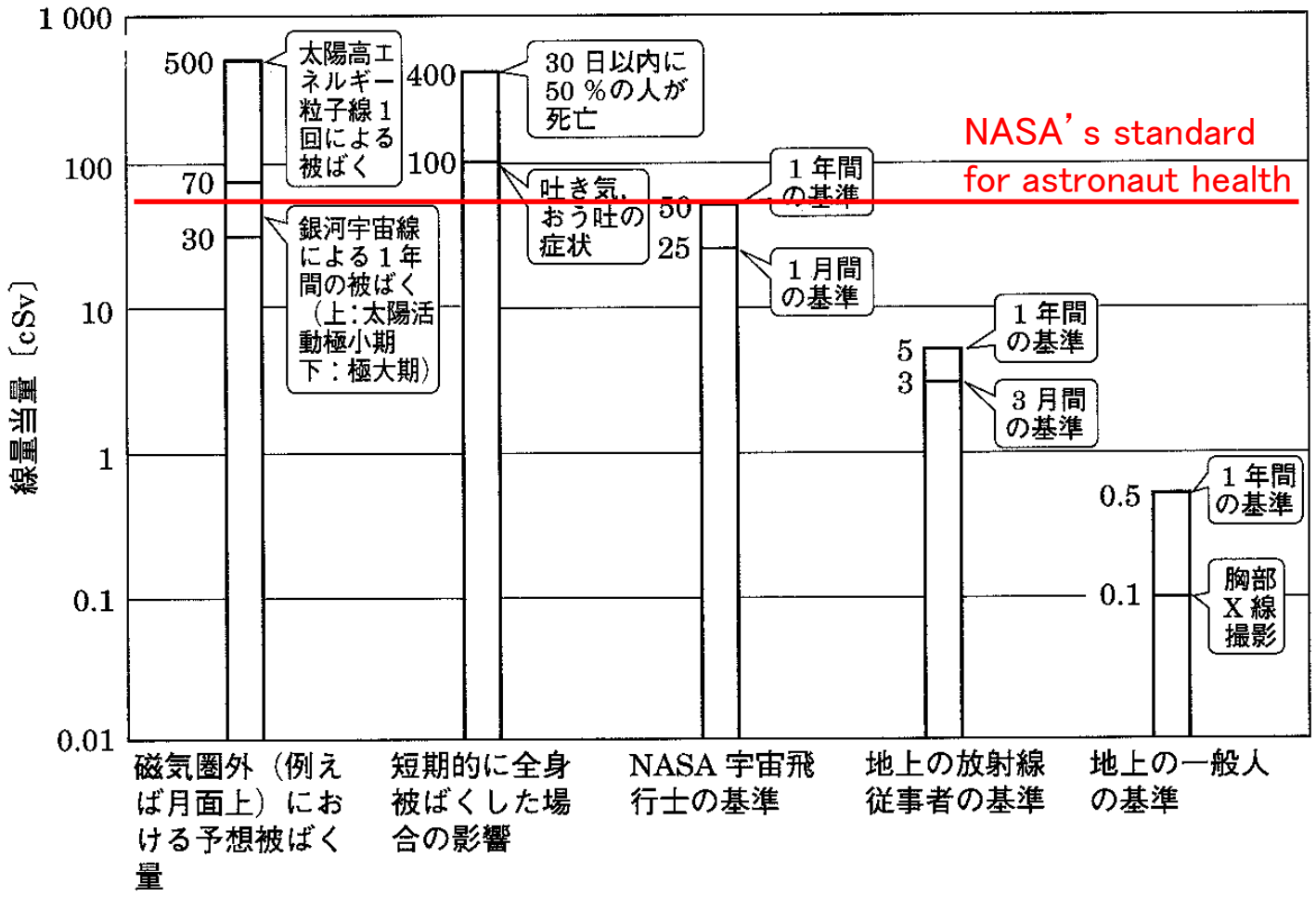


図 7・1　宇宙空間で被ばくすることが予想される放射線量と被ばく線量の基準との比較．縦軸は対数で表示した線量当量（単位：cSv）

現在のシャトル

Al 0.8mm壁

ー＞70　cSv/年

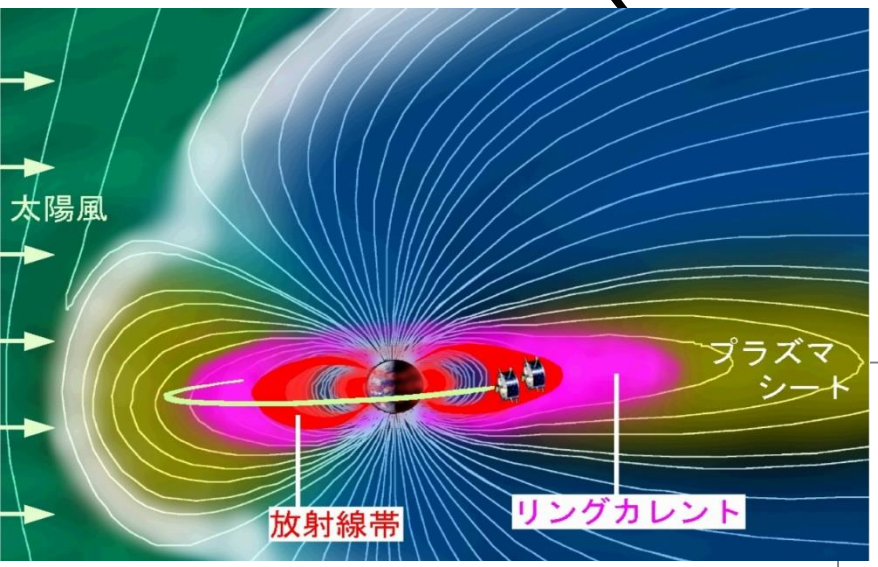
シャトル壁面

ー＞60cSv/年

→アルミに換算すると約10cm遮蔽が必要

重すぎる。。

Plasma (density, Temperature)



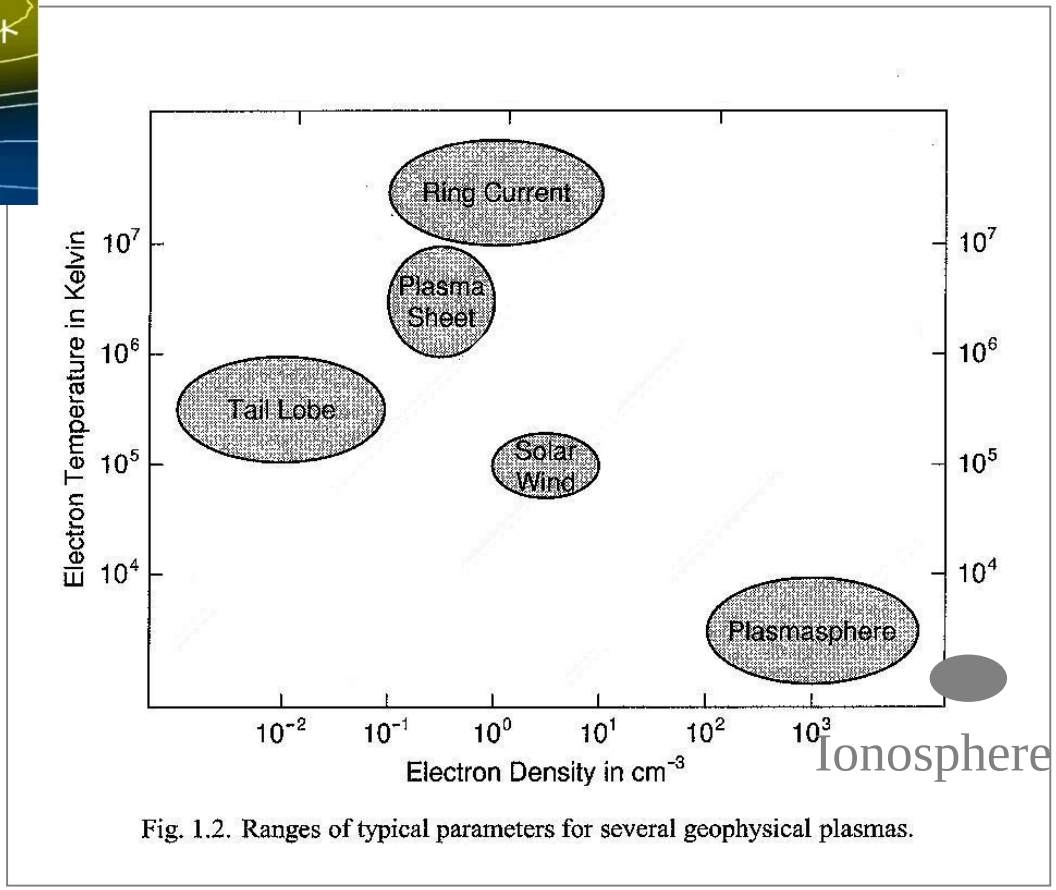
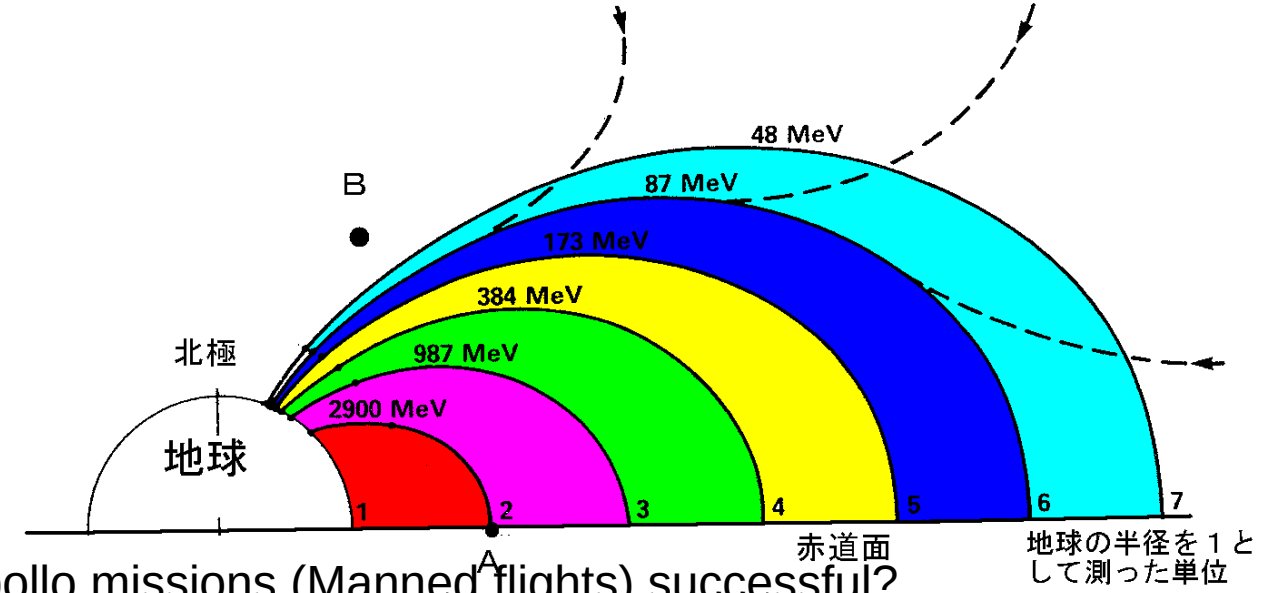


Fig. 1.2. Ranges of typical parameters for several geophysical plasmas.

Earth's Magneto prevents high energy particle incoming



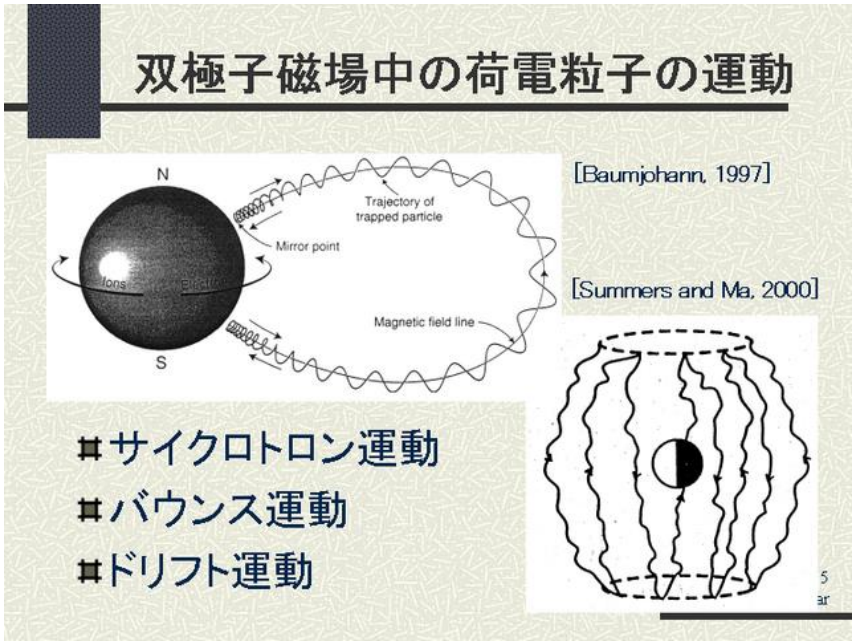
Why were Apollo missions (Manned flights) successful?

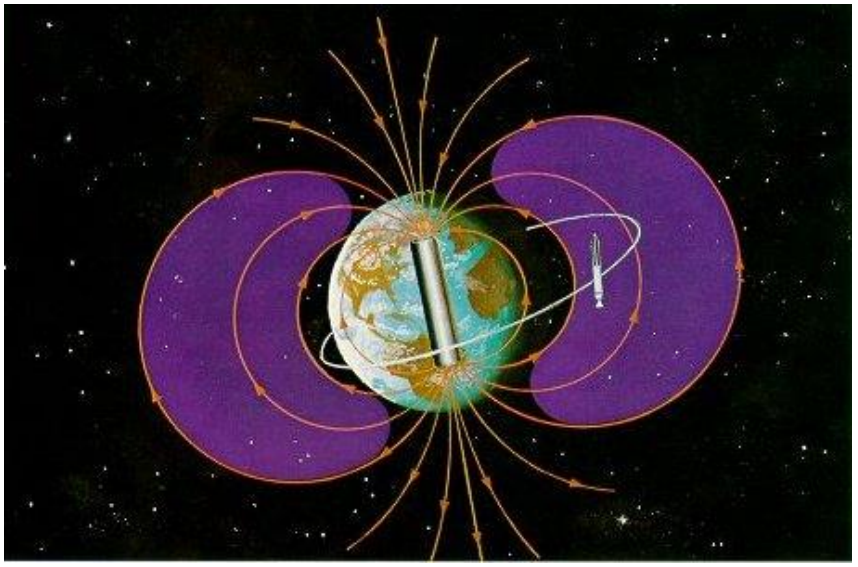
1. Relatively Short period
2. Careful examination for planning (orbit and date).

(e.g) At the altitude of 300-400km, MIR space-station with 50 deg orbital inclination encounters high-energy bomberments more severely than space-shuttle at 20deg orbital inclination.

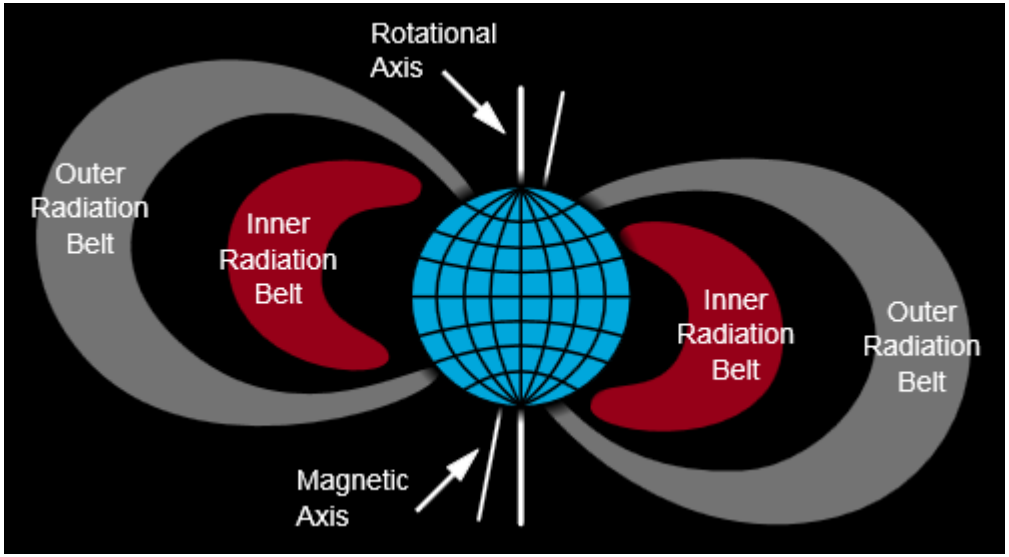
3. Good luck

Van Allen
Radiation belt around the Earth





A **radiation belt** is a layer of energetic charged particles that is held in place around a magnetized planet, such as the Earth, by the planet's magnetic field. The Earth has two such belts and sometimes others may be temporarily created. The discovery of the belts is credited to James Van Allen, and as a result the Earth's belts are known as the **Van Allen belts**. The main belts extend from an altitude of about 1,000 to 60,000 kilometers above the surface in which region radiation levels vary. Most of the particles that form the belts are thought to come from solar wind and other particles by cosmic

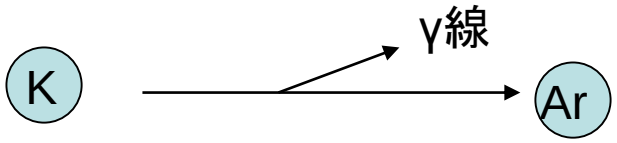


The belts are located in the inner region of the Earth's magnetosphere. The belts contain energetic electrons and protons. Other nuclei, such as alpha particles, are less prevalent. The belts endanger satellites, which must protect their sensitive components with adequate shielding if they spend significant time in the radiation belts. In 2013, NASA reported that the Van Allen Probes had discovered a transient, third radiation belt, which was observed for four weeks until it was destroyed by a powerful, interplanetary shock wave from the Sun.

“Radiation” (“放射線”) means what?

- Original meaning of “放射線” is somewhat strange.
  “放射線” means nuclear radiation in Japanese.

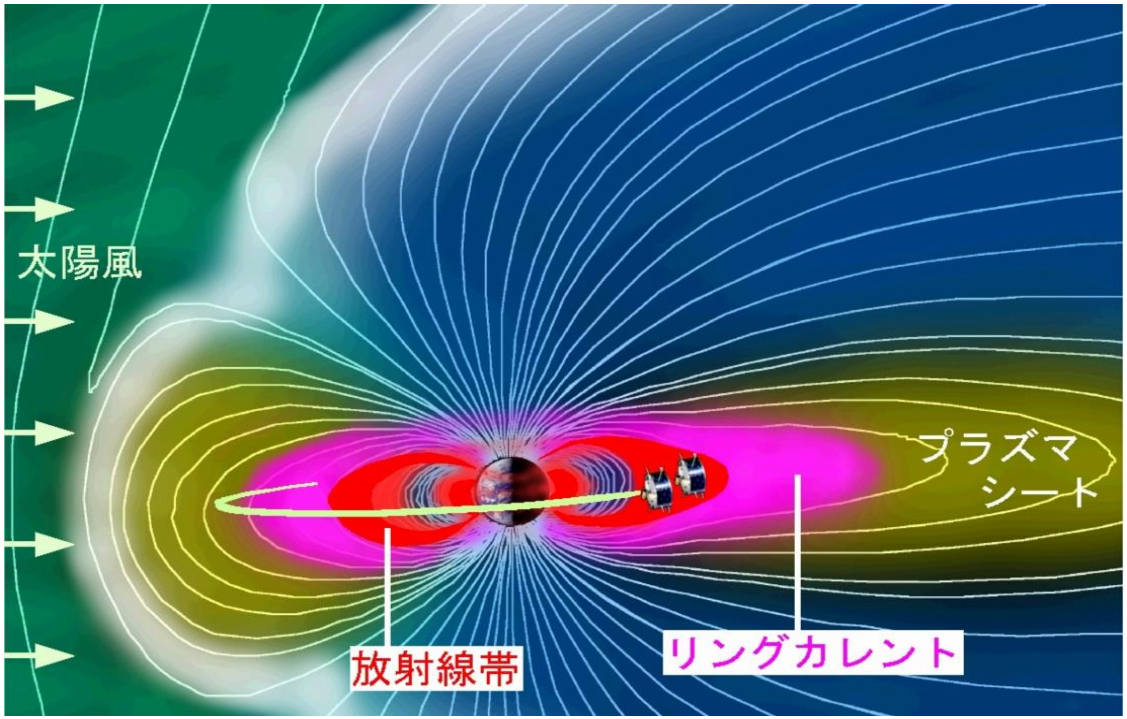
- In physics,
  “放射線” is General term meaning α-particle, β-particle, and γ-ray due to decay of radioactive nuclear species.



In general,
  It means X-ray, electromagnetic wave, and neutron due to the action of atomic nucleus.

In geophysics, “放射線” is a high energy particle, like ejecta due to the nuclear radiation.

Radiation belt is a part of the magnetosphere



- Wide Energy Range: 1-10 M eV
- co-existence of solar-wind and ionospheric origins
-

Shielding

- Terrestrial atmosphere is very thick from the view point of shielding against the radiation.

It is equivalent to

??? cm by lead or

??? cm by water. .

Shielding

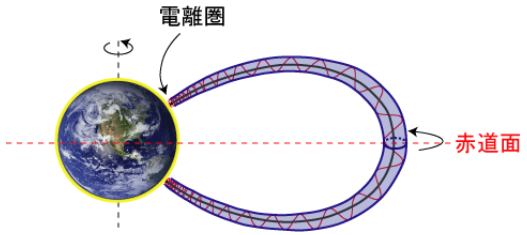
- Terrestrial atmosphere: 1-kg per cm2 (10 ton/m2), that is equivalent to 90cm (Lead) or 10m (water).

About Plasmasphere…

① Flow induced by the Earth's rotation (constant)

＋

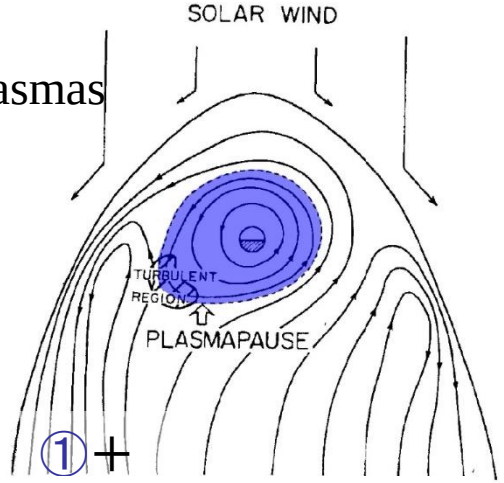
② Flow driven by solar wind (**depending on the activity of solar wind**)



Terrestrial magnetic field

Closed area : Filled with ionospheric plasmas (high density)

Open area : (within 24h, filled with plasmas but) go far away from the earth (low density)



Flow Pattern on the equator

IMAGE/NASA mission (15 years ago, 2000)

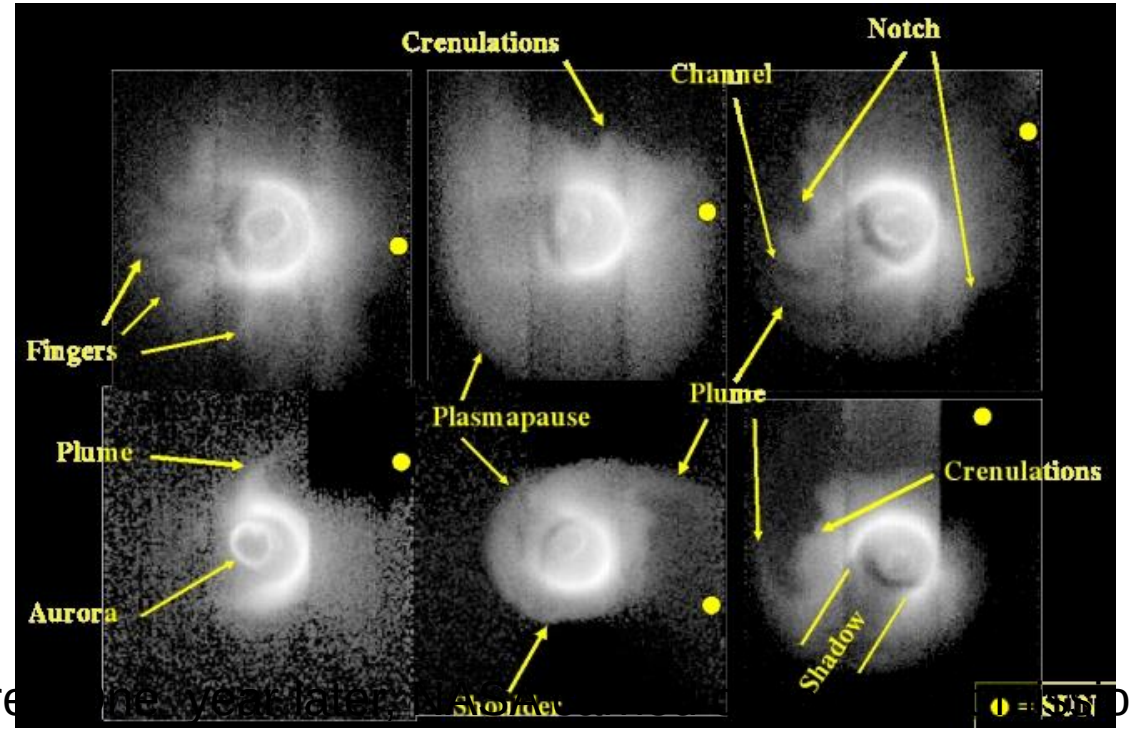


Figure [illegible] one year later [illegible] on to dedicate to plasmaspheric imaging in EUV. It took movie of the whole plasmasphere from the above. Unique features, such as finger, shoulder, and notch, were identified and named by IMAGE mission.

EXCEED-HST Jovian observation campaign

EXCEED has observed Io Plasma torus, while HST witnessed Jovian aurora.

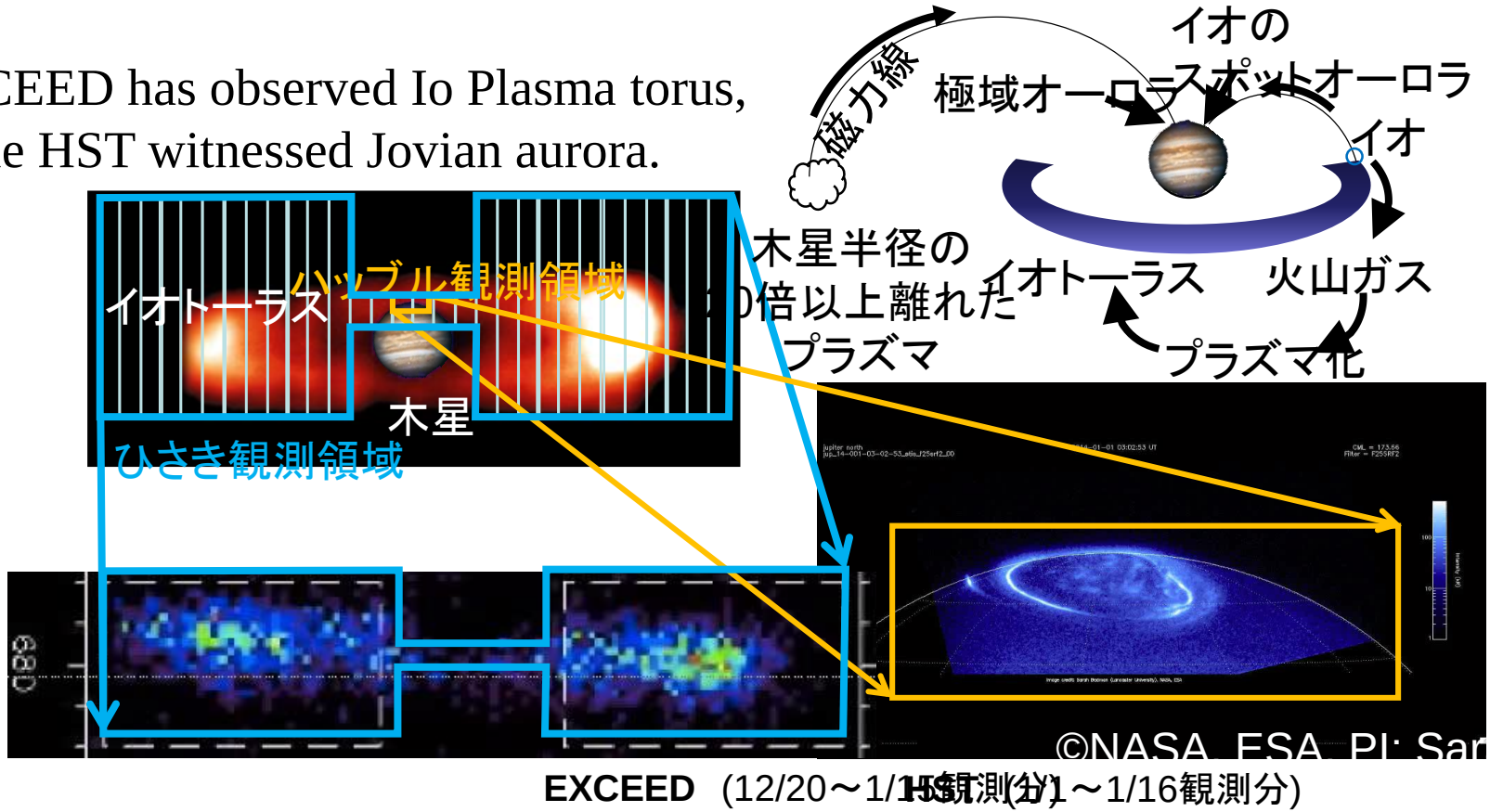


Figure 3. EXCEED has measured the variation of IPT in EUV, while HST has observed aurora with high spatial resolution.

What happens on Jupiter