

IRSN

INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

Rayonnement Cosmique et Radioprotection dans l'aviation civile et les activités spatiales



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INSTITUT DE RADIOPROTECTION
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EN DANGER

Découverte du Rayonnement cosmique

➤ Viktor Hess en 1911 et 1912

Le physicien autrichien V. Hess a effectué une série d'ascensions à bord d'un ballon à hydrogène afin de mesurer le rayonnement dans l'atmosphère. Il cherchait la source des rayonnements ionisants qui s'enregistraient sur un électroscope - la théorie dominante était que les rayonnements provenaient des roches de la Terre. Le rayonnement cosmique provient de l'espace et du soleil.



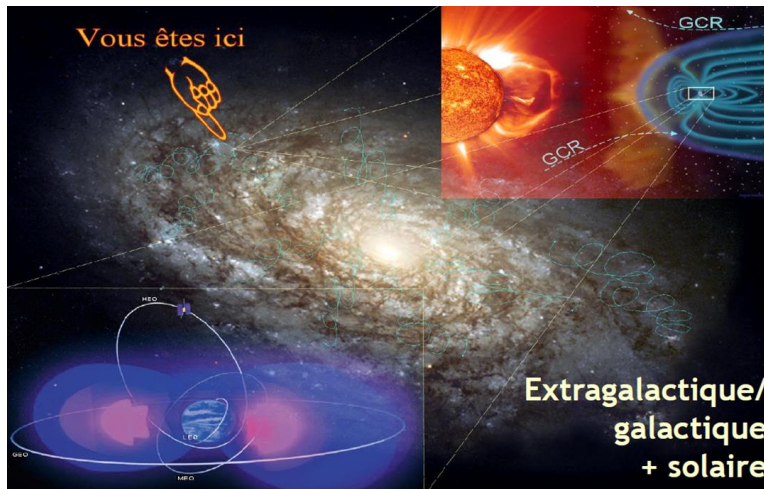
■ Prix Nobel en 1936

L'espace est radioactif!

Introduction

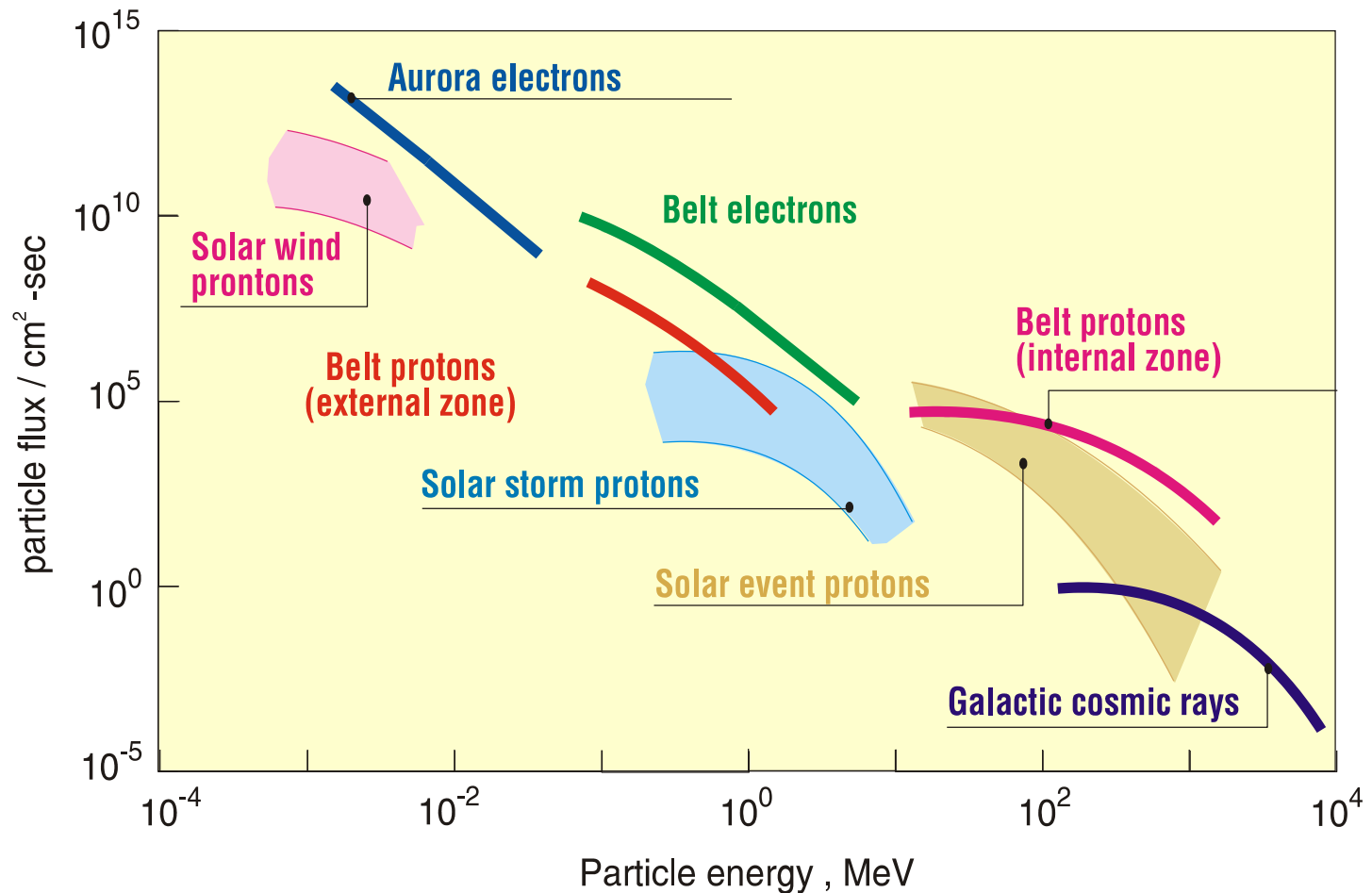
➤ Qu'est ce le rayonnement cosmique?

- Origine Galactique et extra Galactique et Solaire
- Nous sommes tous exposés au RC!
- RC représente 1/7 de notre exposition au rayonnement naturelle



Crédit: OMS

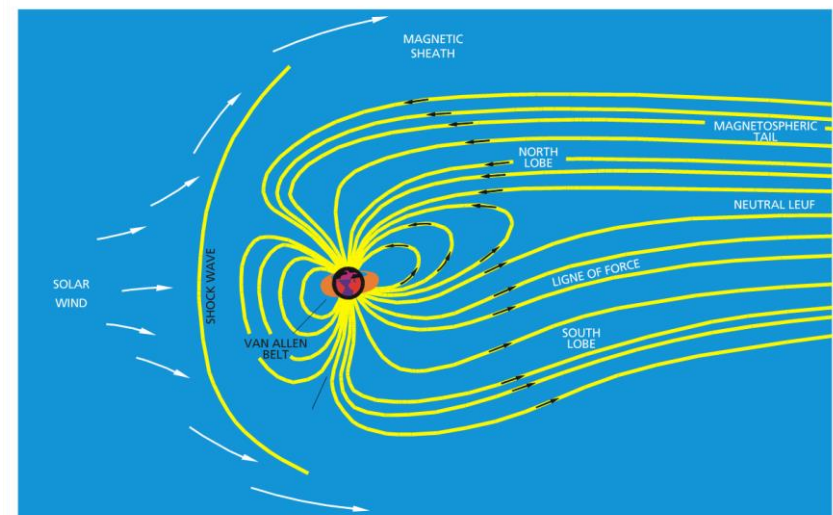
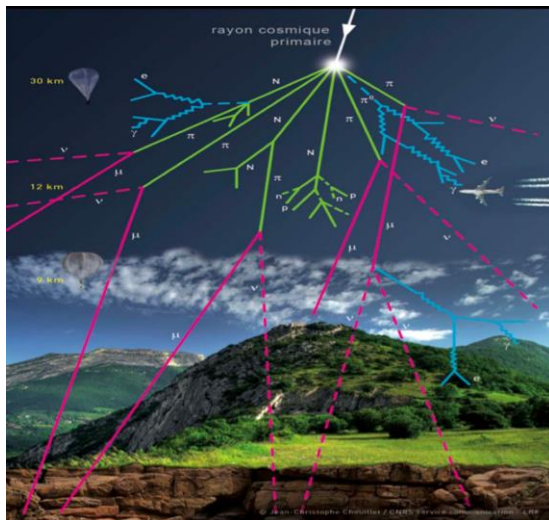
Energie du RC



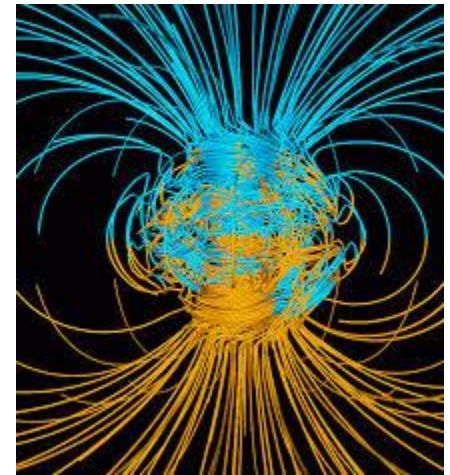
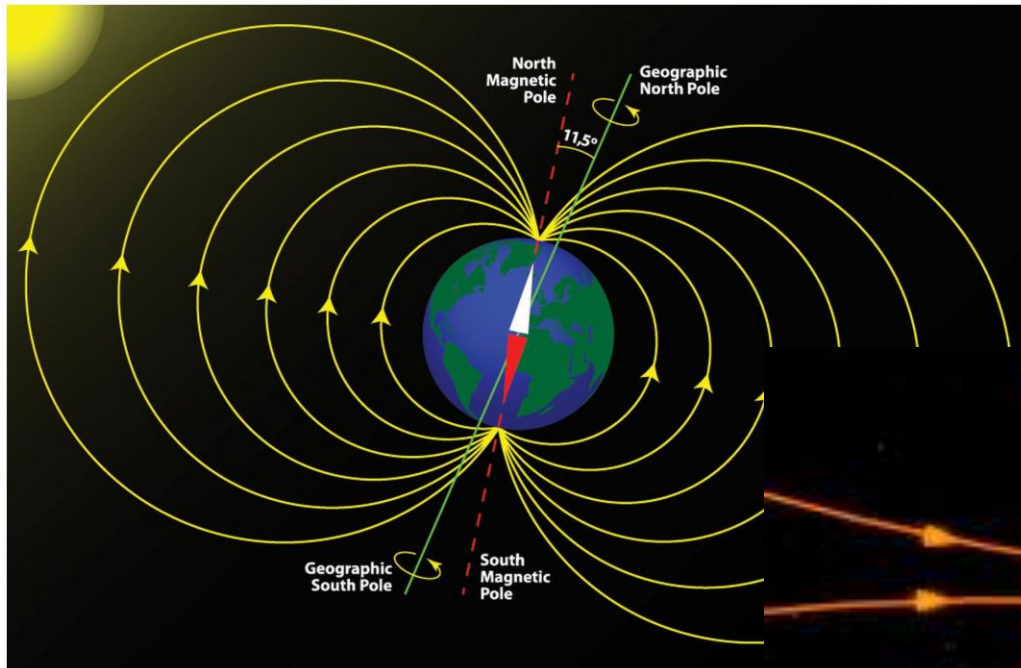
Protection contre le CR

➤ 3 barrières de protection

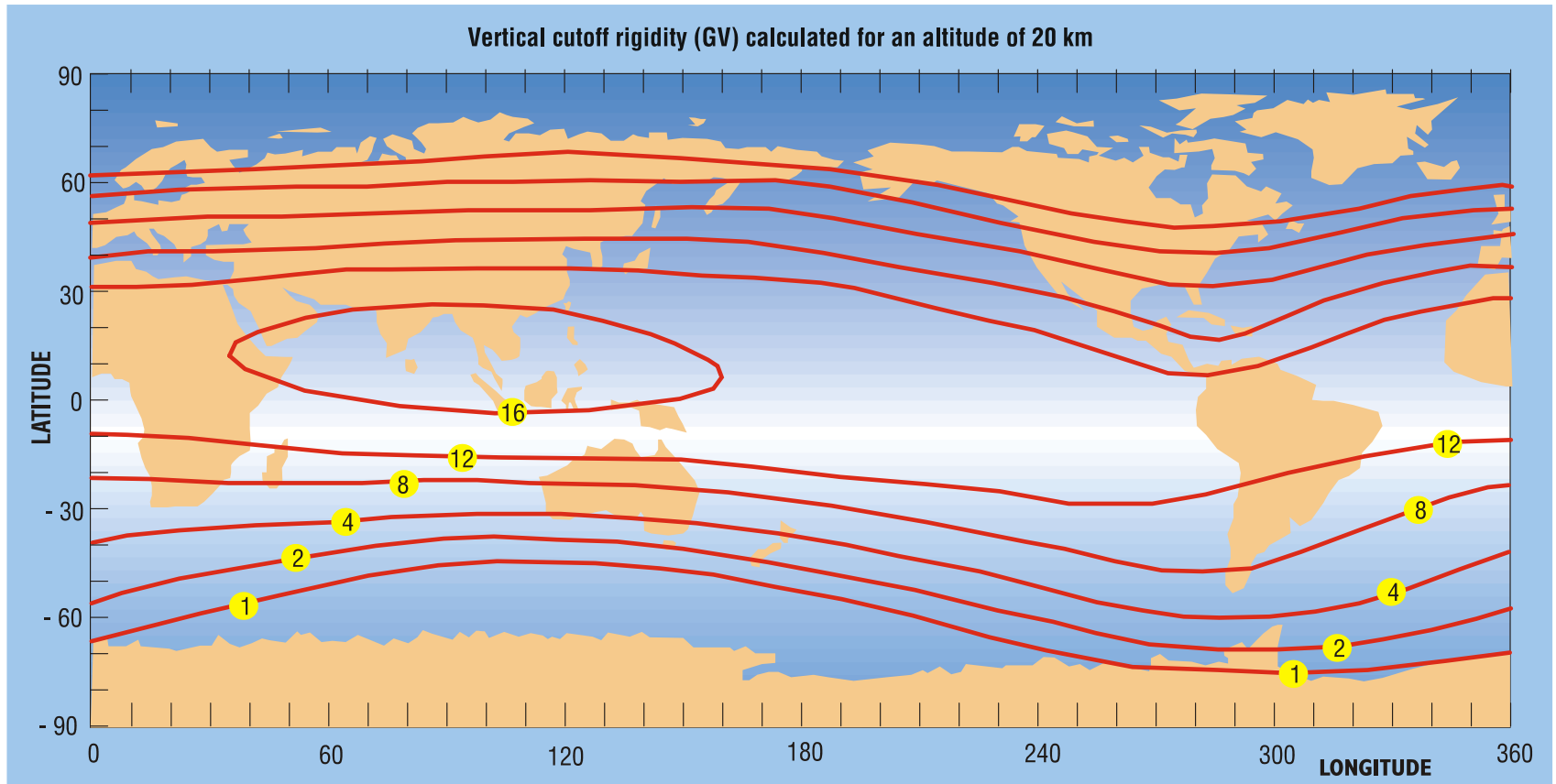
- Champ magnétique interplanétaire
- Magnétosphère terrestre
- Atmosphère



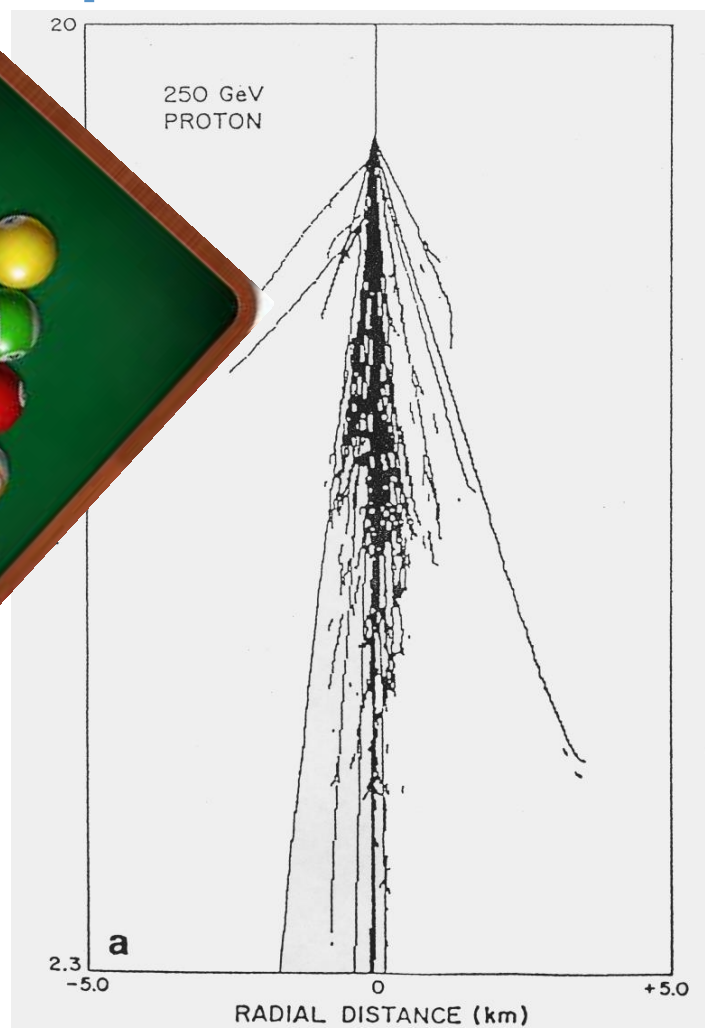
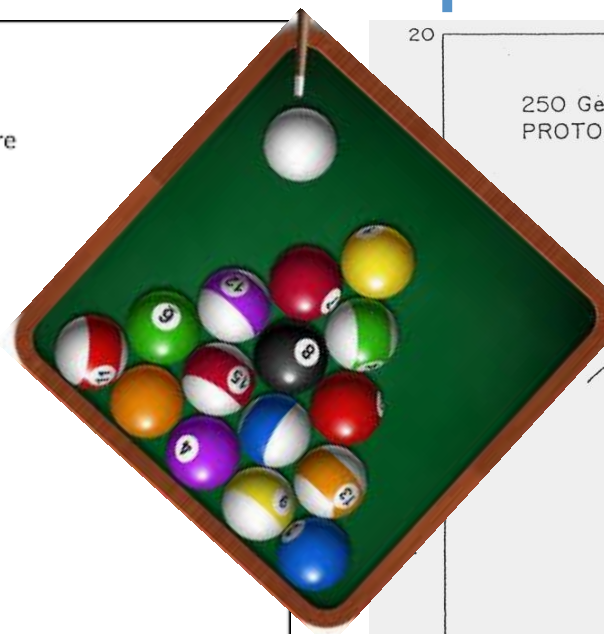
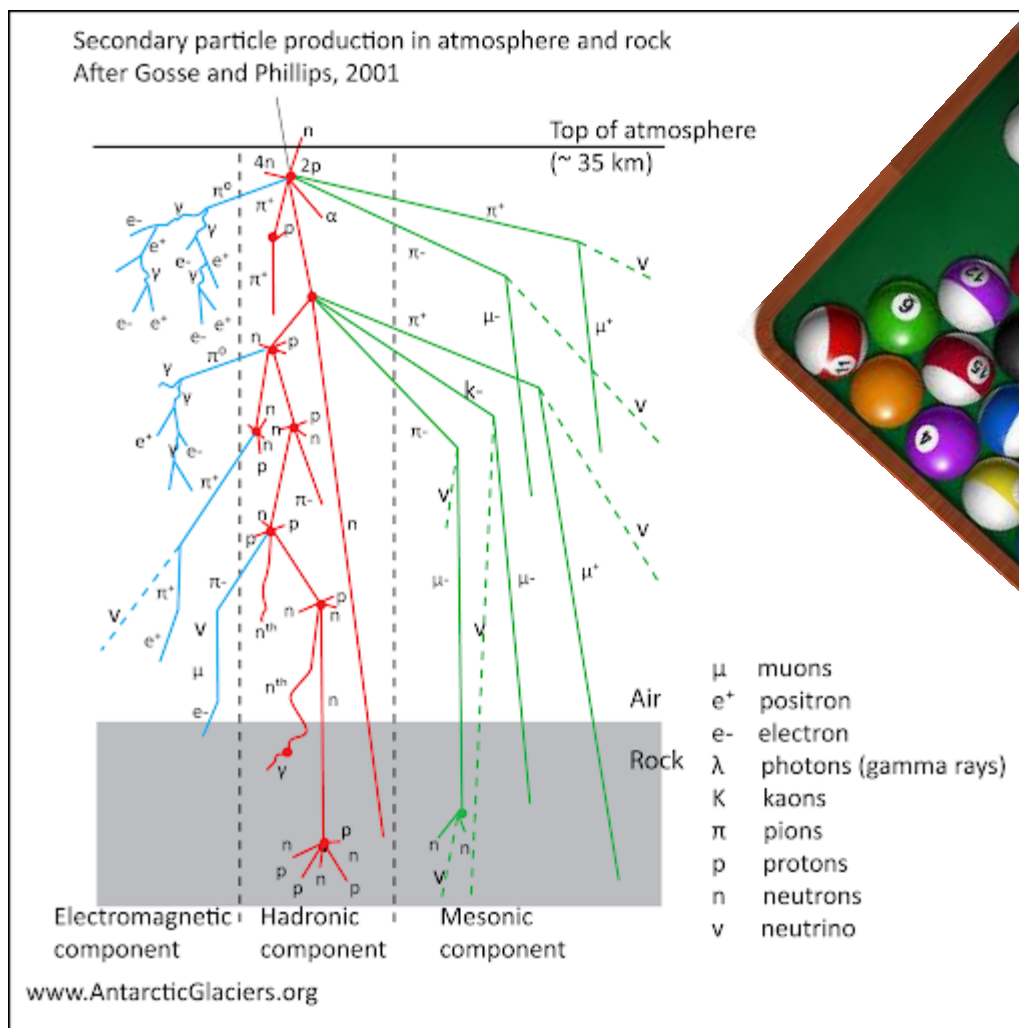
La magnétosphère



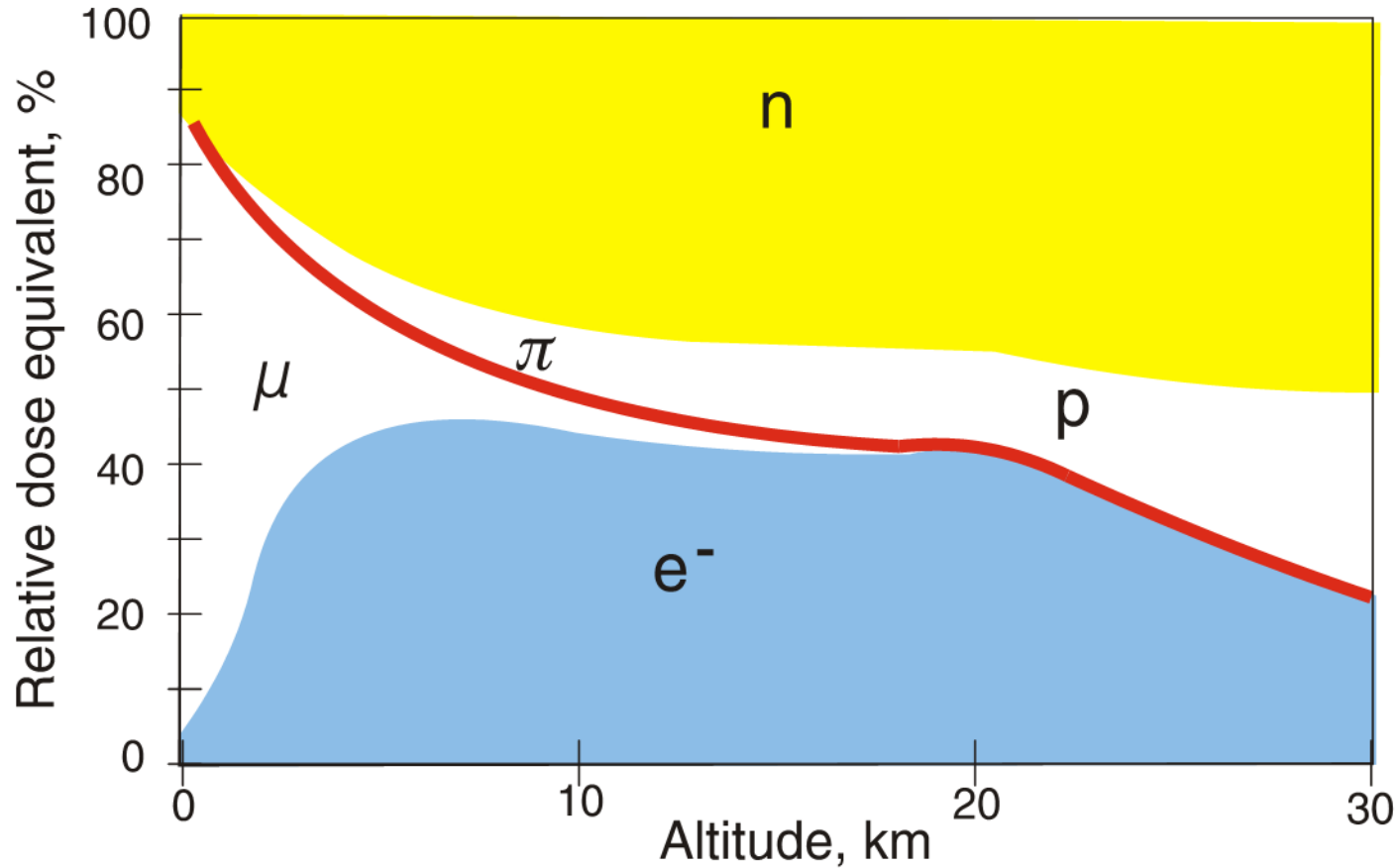
Rigidité magnétique



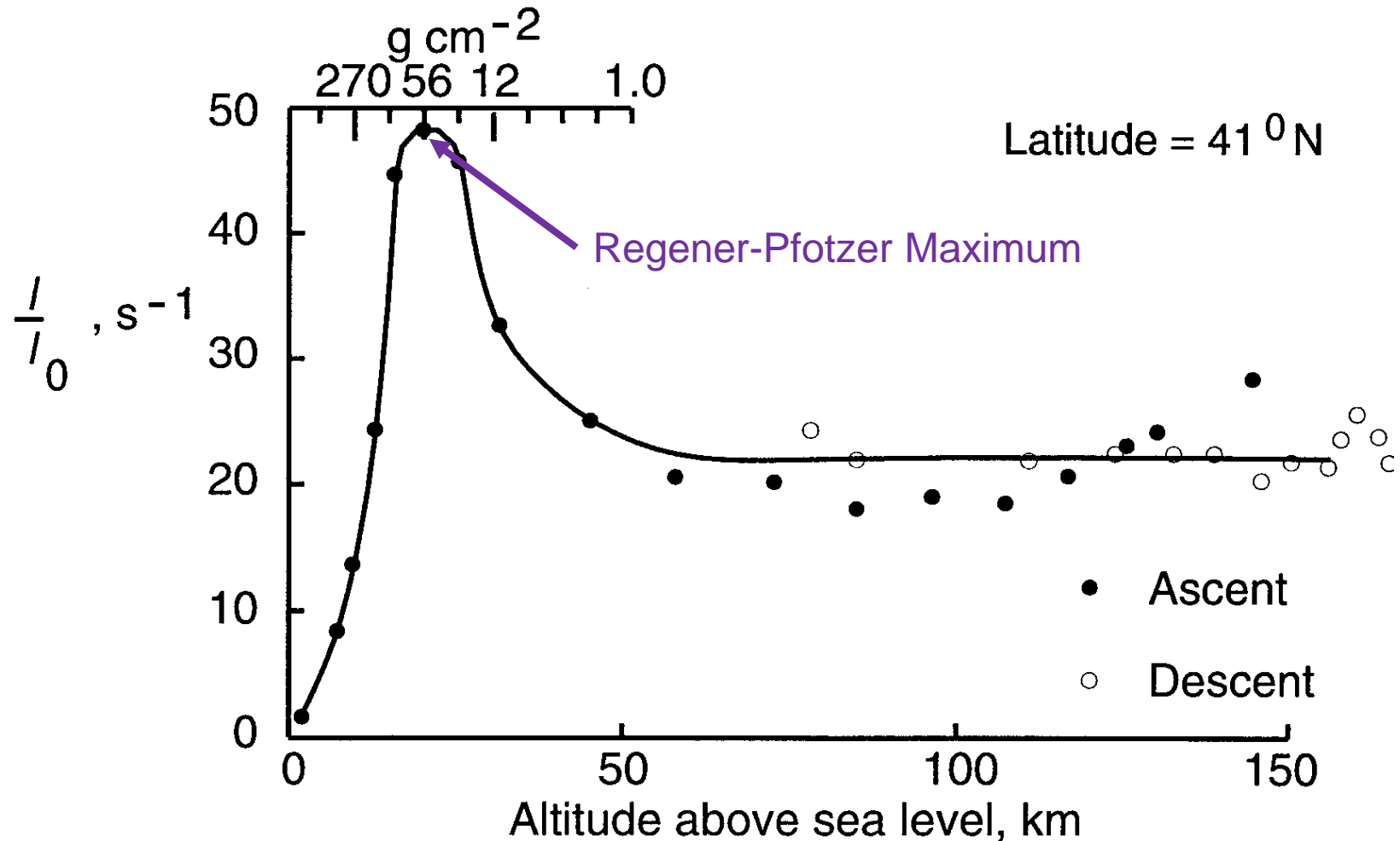
Interaction dans l'atmosphère



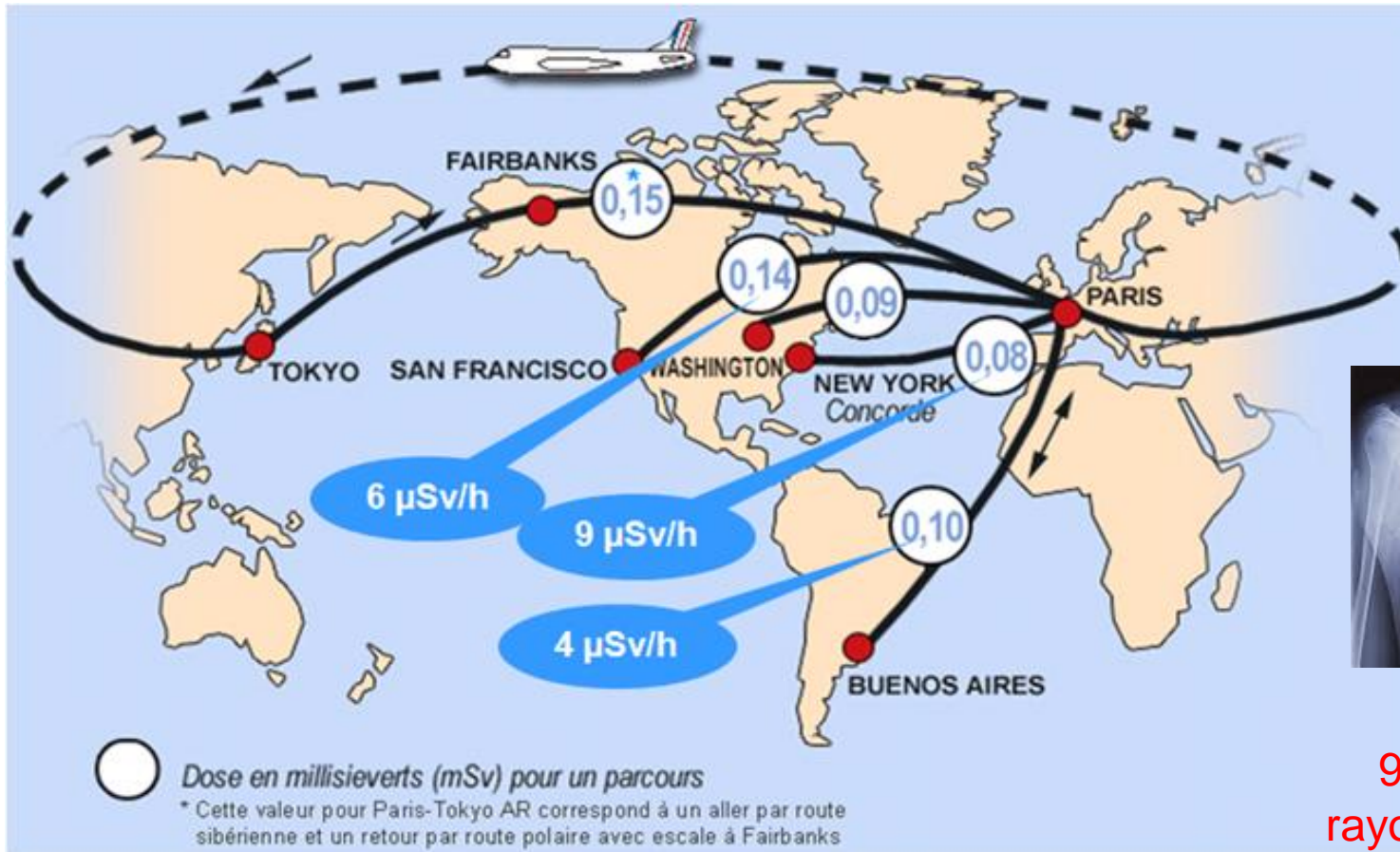
Interaction dans l'atmosphère



Interaction dans l'atmosphère

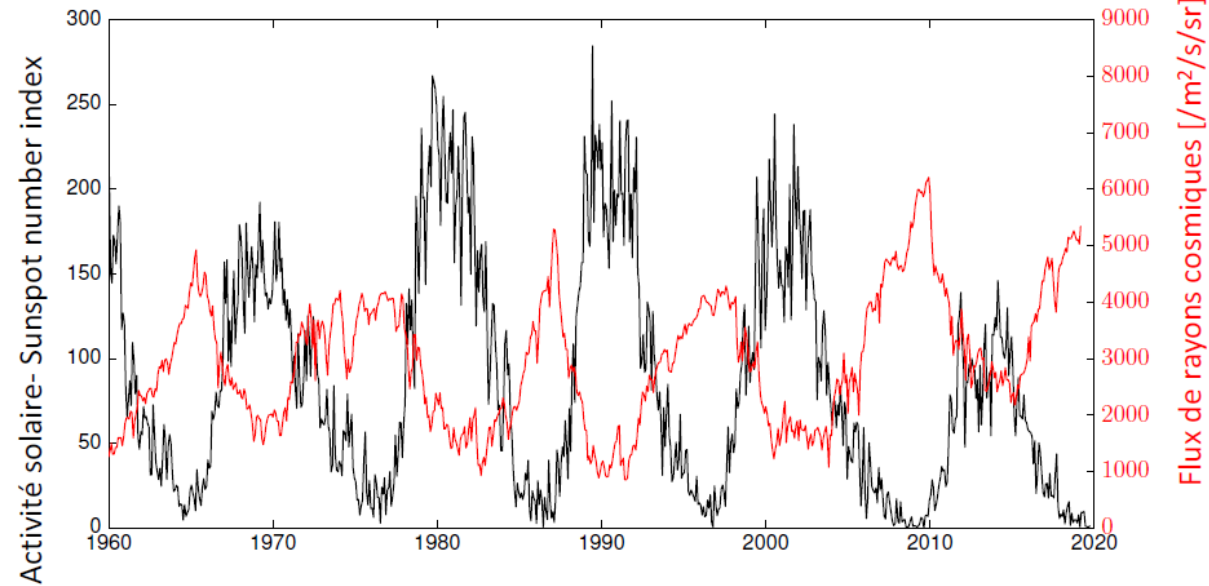
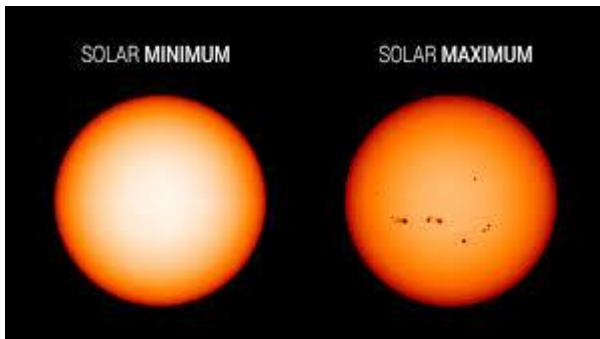
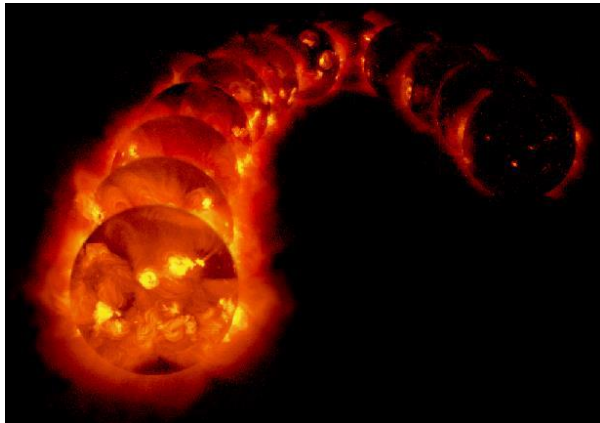


Exposition au RC en vol



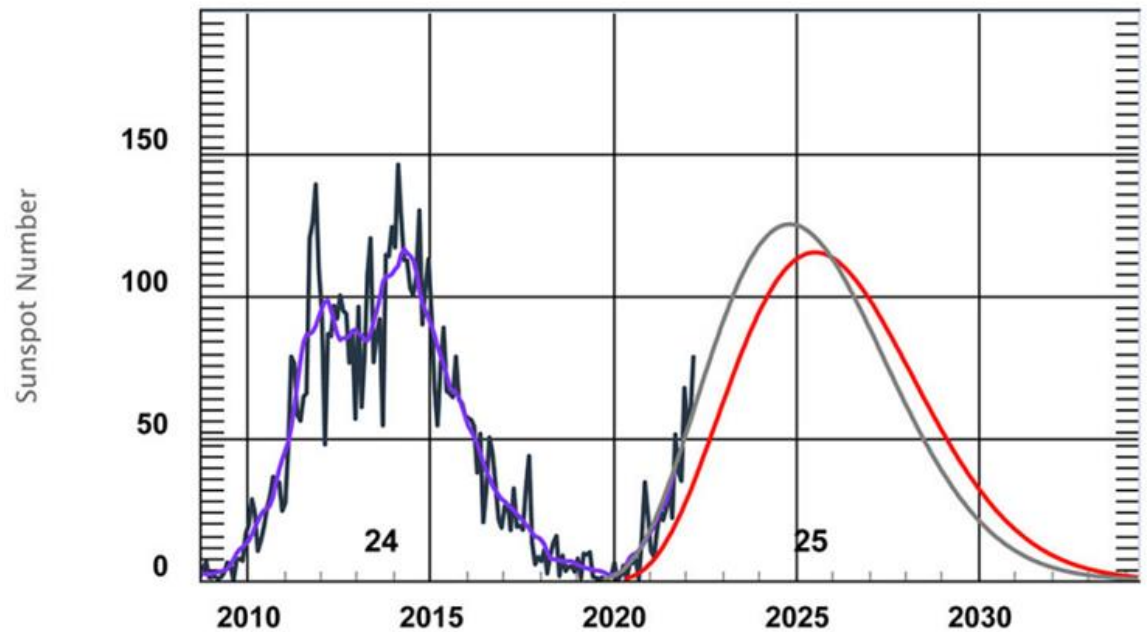
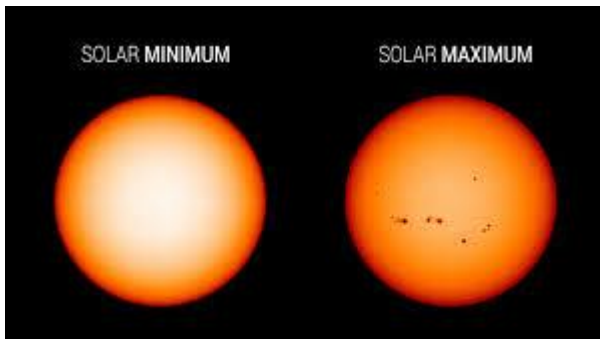
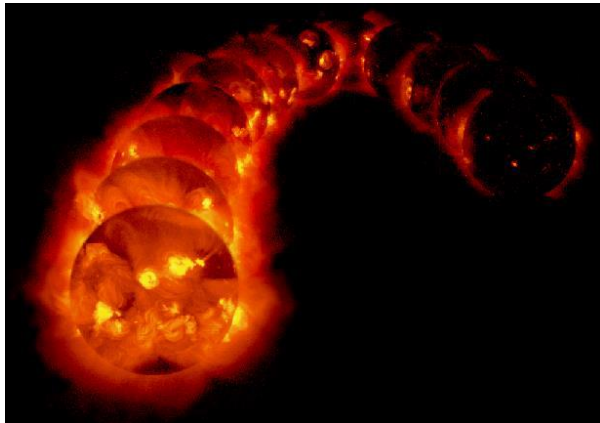
0,06 mSv
9 jours d'expo au
rayonnement naturelle

Modulation du RC galactique avec e cycle solaire

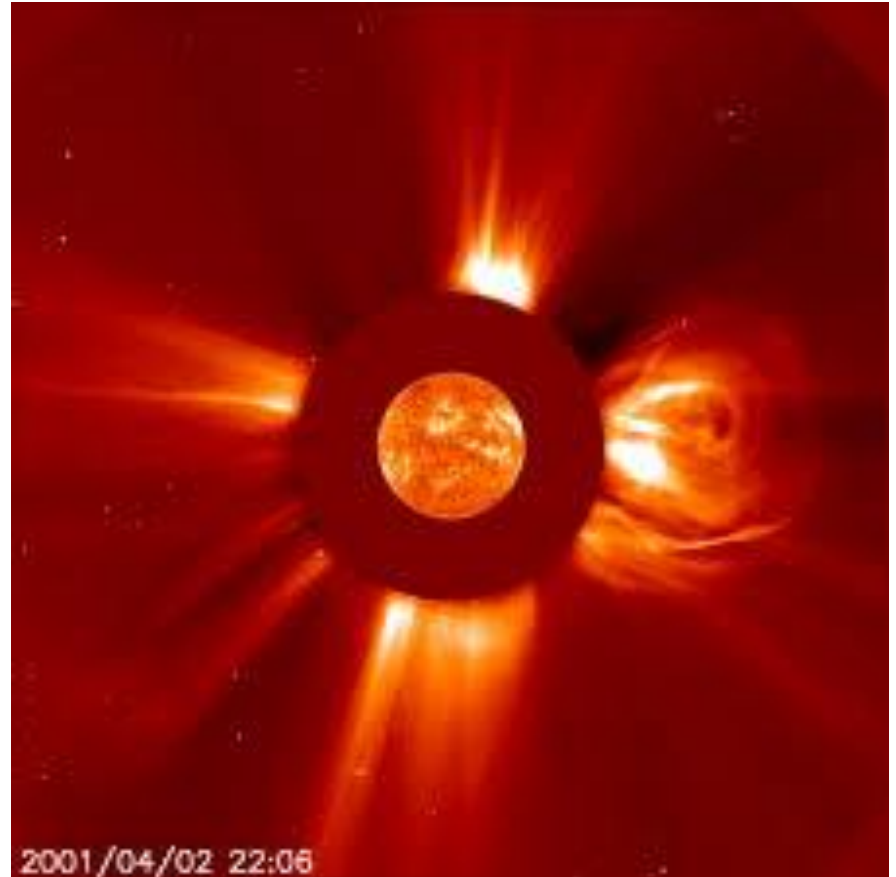


Modulation du flux de rayon cosmique dans l'espace proche de la terre calculé à partir de mesure de moniteur de neutron sur terre et des données satellite.

Modulation du RC galactique avec e cycle solaire

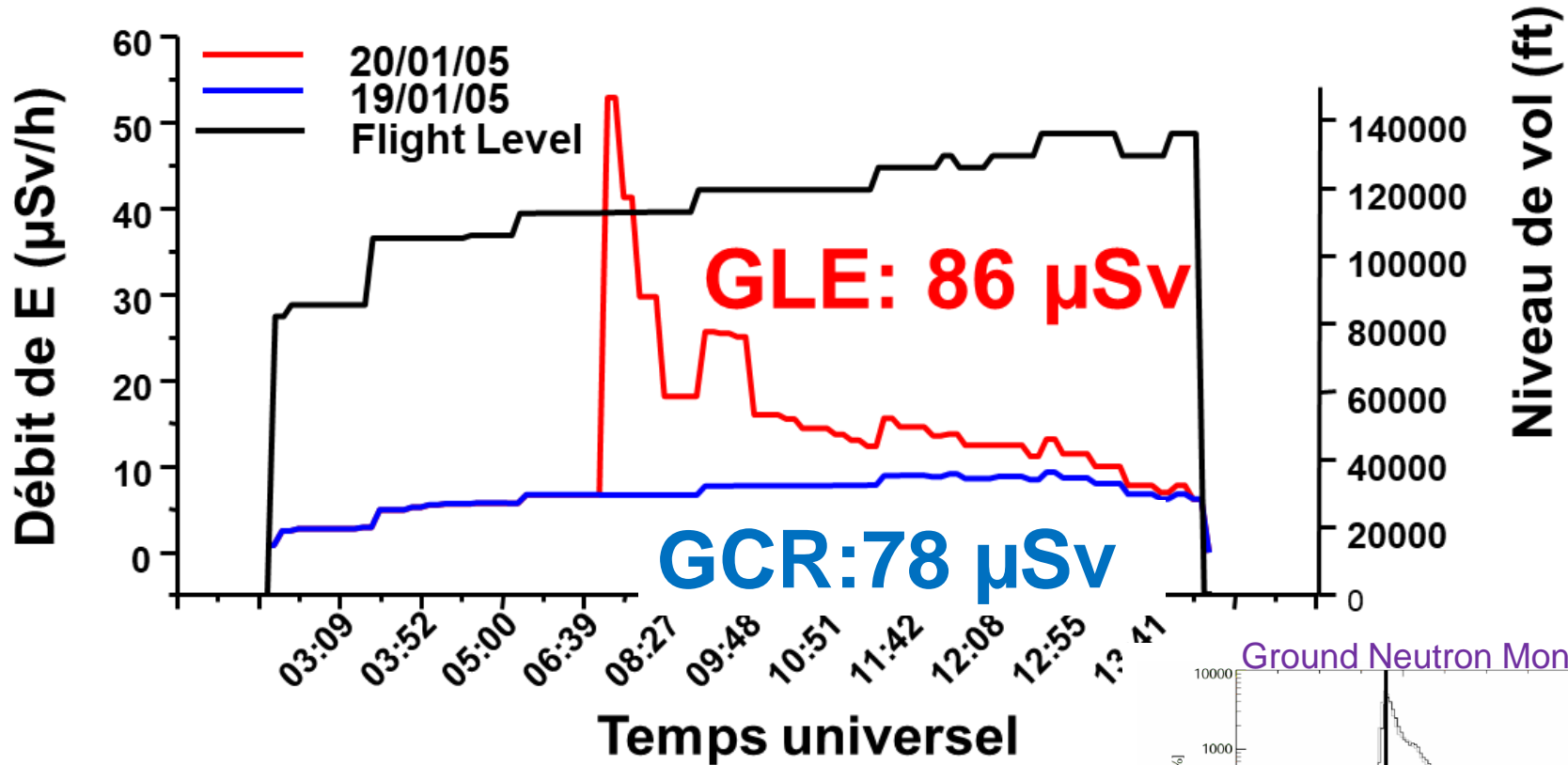


Eruptions solaires

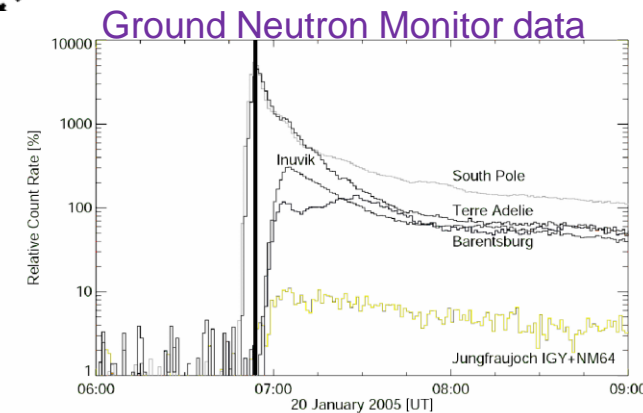


<https://www.youtube.com/watch?v=oHHSSJDJ4oo&list=RDCMUCsXVk37bltHxD1rDPwtNM8Q&index=1>

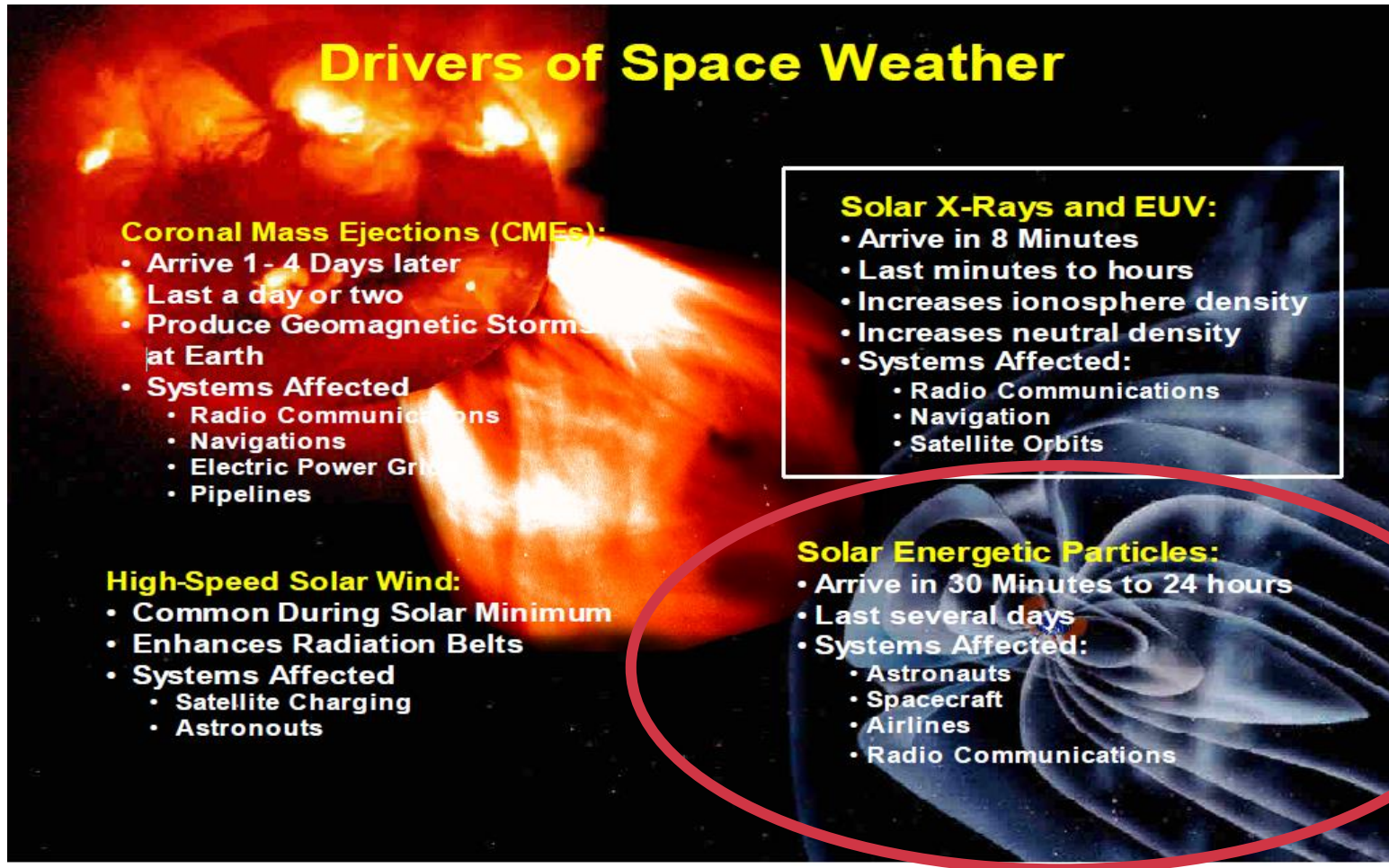
Impact aux altitude vol



GLE: Ground Level Event



« Space weather »

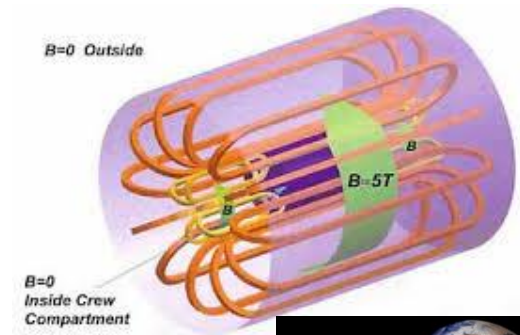
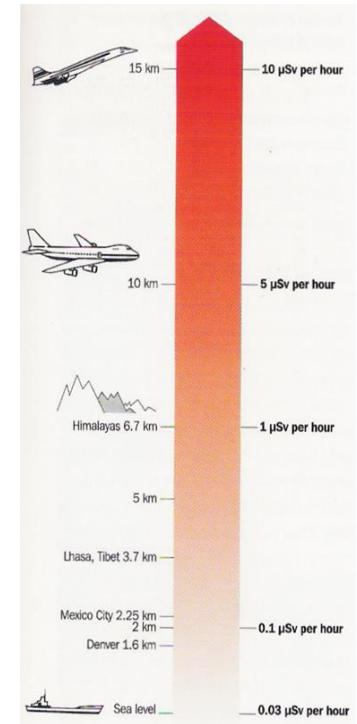


Drivers of Space Weather

- Coronal Mass Ejections (CMEs):**
 - Arrive 1- 4 Days later
 - Last a day or two
 - Produce Geomagnetic Storms at Earth
 - Systems Affected
 - Radio Communications
 - Navigations
 - Electric Power Grid
 - Pipelines
- High-Speed Solar Wind:**
 - Common During Solar Minimum
 - Enhances Radiation Belts
 - Systems Affected
 - Satellite Charging
 - Astronauts
- Solar X-Rays and EUV:**
 - Arrive in 8 Minutes
 - Last minutes to hours
 - Increases ionosphere density
 - Increases neutral density
 - Systems Affected:
 - Radio Communications
 - Navigation
 - Satellite Orbits
- Solar Energetic Particles:**
 - Arrive in 30 Minutes to 24 hours
 - Last several days
 - Systems Affected:
 - Astronauts
 - Spacecraft
 - Airlines
 - Radio Communications

Problématique santé

- Niveau du sol : contribution mineure
- Altitude de vol : en moyenne, le personnel navigant est la population de travailleurs la plus exposée (mais la dose maximale est d'environ 6 mSv/an).
- LEO : sous contrôle (0,2-0,7 mSv/j)
- Station lunaire (1,4 mSv/j)
- Mission spatiale (hors magnétosphère) : le RC est un problème critique pour la survie de l'équipage (SEP) et reste l'une des principales limitations des voyages spatiaux; les solutions sont encore à l'étude.



Réglementation pour l'exposition des PN

Council directive 96/29Euratom

Article 42, Protection of air crew

« *Each Member State shall make arrangements for undertakings operating aircraft to take account of exposure to cosmic radiation of air crew who are liable to be subject to exposure **more than 1 mSv per year**. The undertakings shall take appropriate measures, in particular:*

- ***to assess the exposure of the crew concerned,***
- ***to take into account the assessed exposure when organizing working schedules with a view to reducing the doses of highly exposed aicrew,***
- *to inform the workers concerned of the health risks their work involves,*
- *to apply Article 10 to female air crew. »*

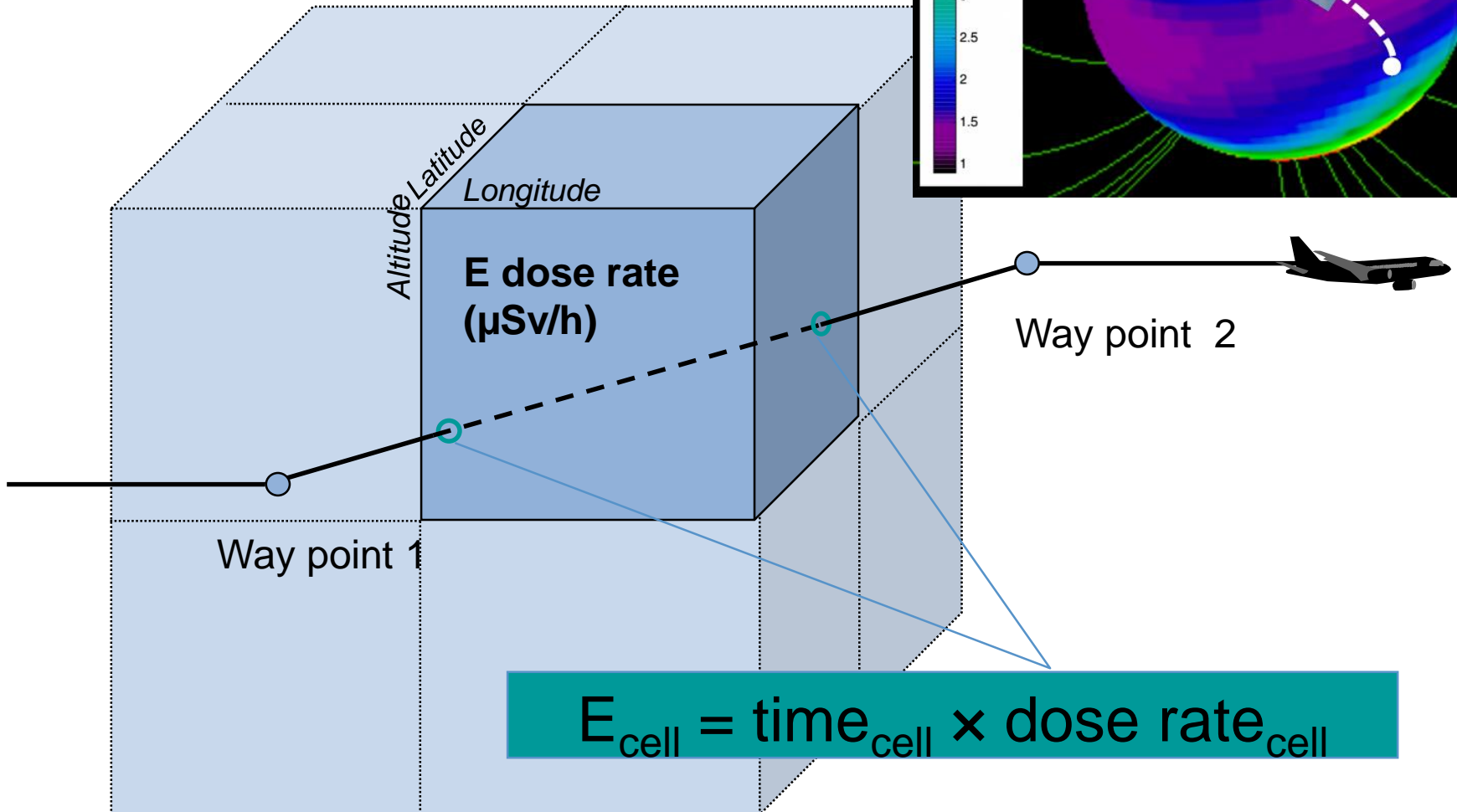
Estimation des expositions

- Pas de dosimètres, uniquement calcul
- Estimation mensuelle
- Galactique et éruptions (modèle SiGLE)
- Prédiction des doses sur 18 mois



The screenshot shows a web browser window with the URL <https://www.sievert-system.org/?locale=en#Calcul>. The page features the IRSN logo (Institut de Radioprotection et de Sécurité Nucléaire) and the SIEVERT PN logo. The main heading is "Calculate the dose received". The form is divided into two columns: DEPARTURE and ARRIVAL. Each column has fields for Country (dropdown), City (dropdown), Date (text input), and Time (time selector). Below these columns is a "Type of aircraft" dropdown menu set to "Subsonique". A "Calculate" button is located at the bottom of the form. A disclaimer at the bottom of the page reads: "Subject to local regulation modifications, the flight dates and times include time difference and, if necessary daylight saving time. Check the flight time."

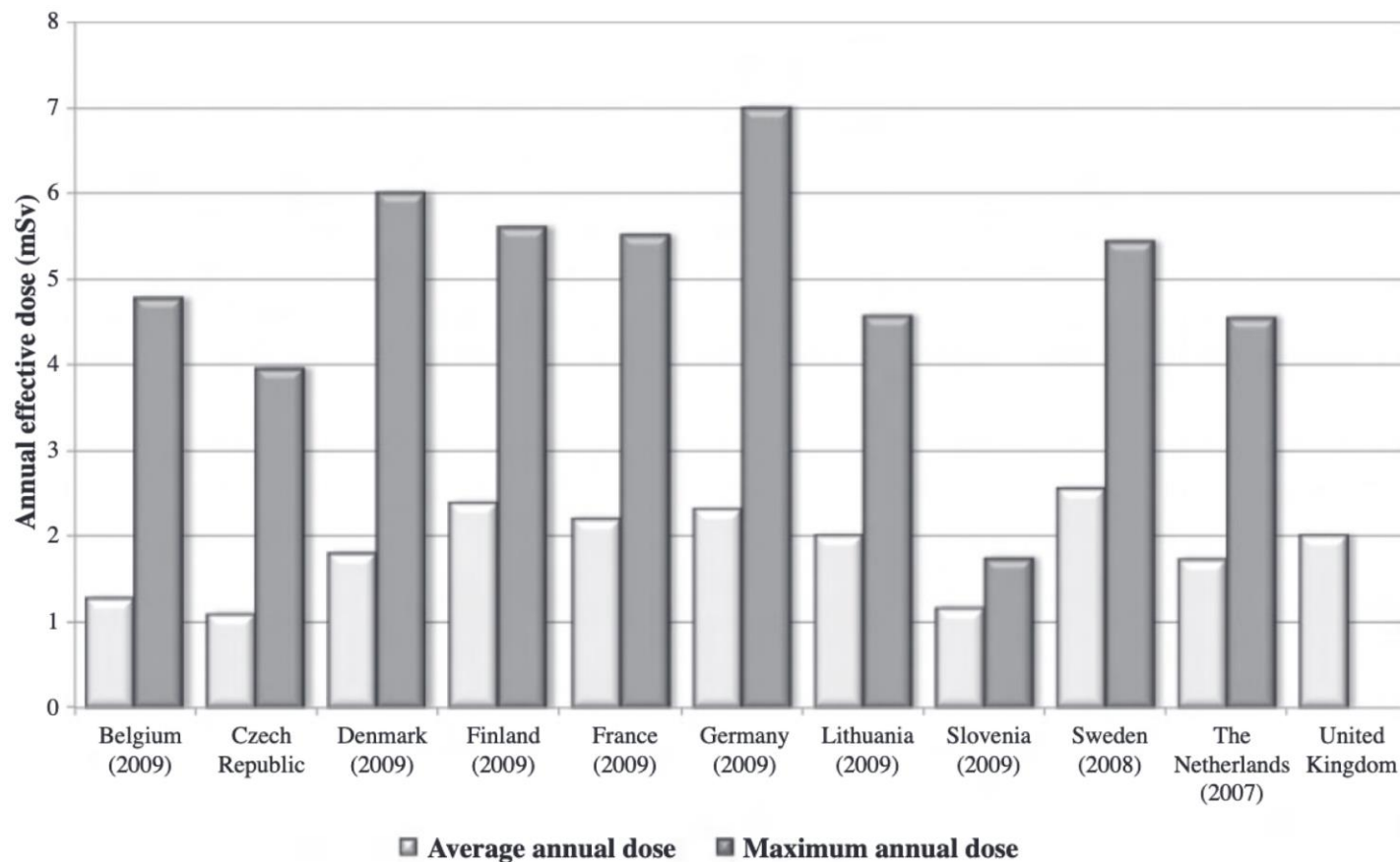
Evaluation par calcul



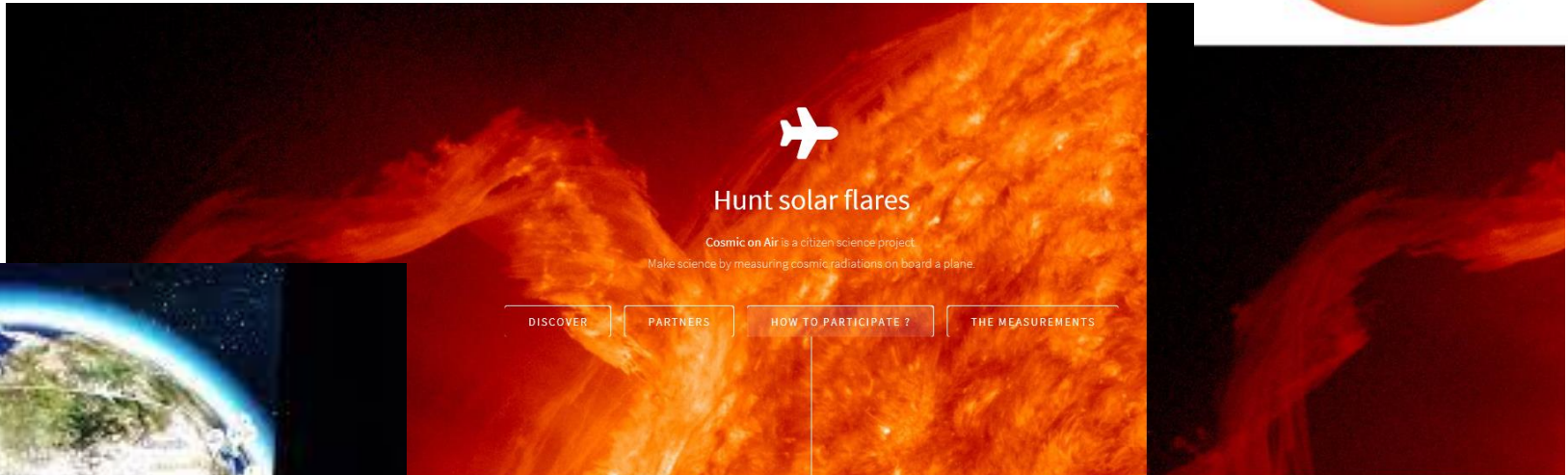
Validation des calculs



Exposition des PN en Europe



Projet de science citoyenne



The Cosmic on Air project

The Cosmic on Air project is a citizen science project which aims to collect measurements of dose rate carried out on board airplane by the public to organize and make them available to the scientific community, in particular those which could be carried out during solar flares. These phenomena can significantly increase dose rates at flight altitudes. Eruptions are sporadic phenomena and those with a significant effect are rare. Very few measurements made on board aircraft are available, which limits the understanding of these phenomena in the atmosphere.

[Understand more](#)



www.cosmic-on-air.com