Aircrew Exposure to Cosmic Radiation

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Plan

- Overview
- Applicability to Commercial Aviation
- Possible Effects on Health of Aircrews
- Legal considerations
- International Best Practices
- Recommendations

Air travel: Pleasure or Peril?

“Fasten your seat belts - it could be a sickly ride” .. Mail on Sunday July 2000

- “Long flights cost 2000 lives a year” ..Telegraph Jan 2001

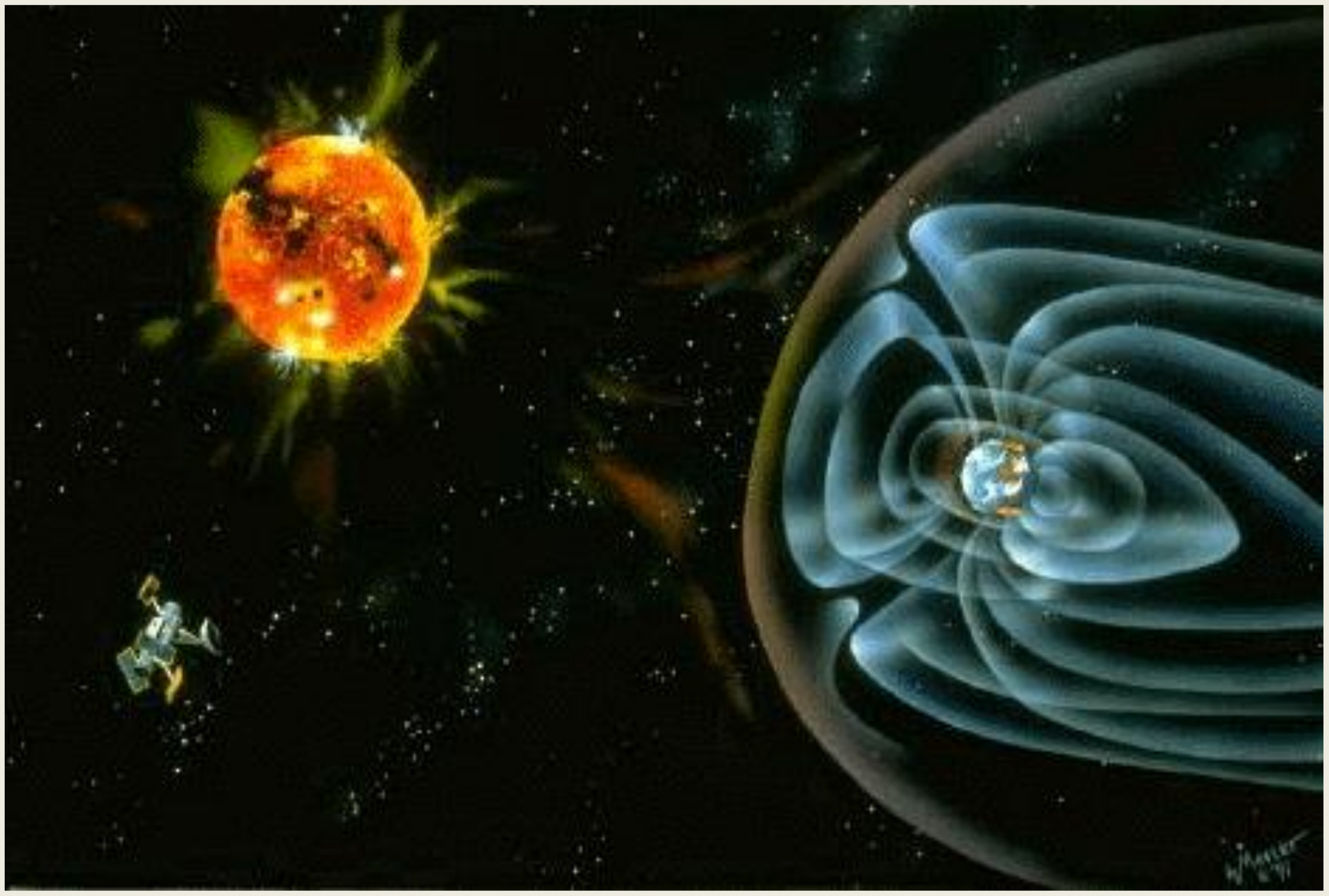
“Flying can prove fatal in economy class” ..Independent on Sunday May 2000

- “Long haul passengers pass out from oxygen shortage” ..Sunday Times 5/2000

- “Welcome aboard Toxic Airlines” ...Movie

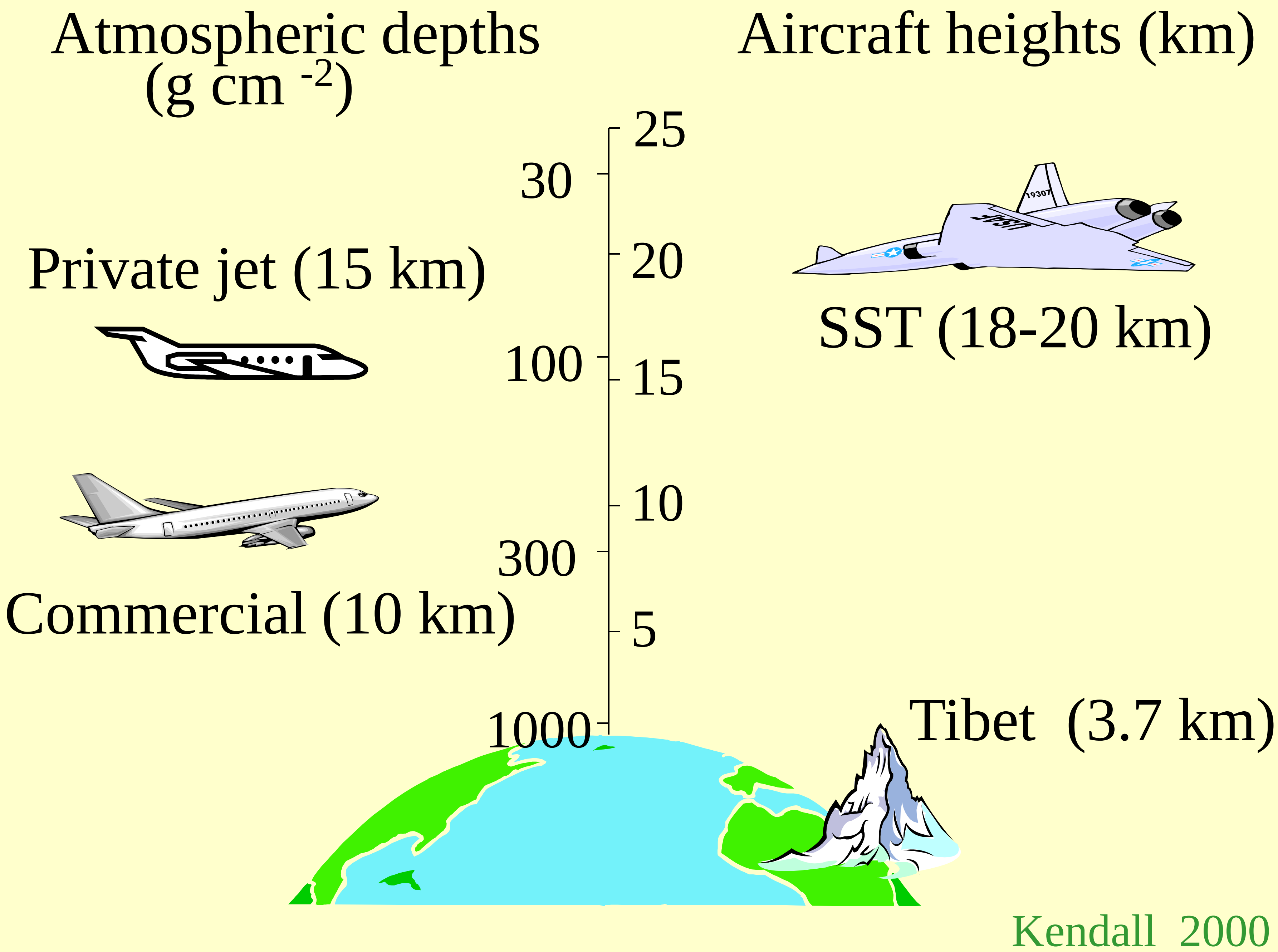
Interest

- The consideration that the relative biological effects of the neutron component is being underestimated;
- The trend towards higher cruising altitudes for subsonic commercial aircraft and business jet aircraft; and,
- Lack of regulatory compliance with regards to occupational hazards and diseases in the aviation industry

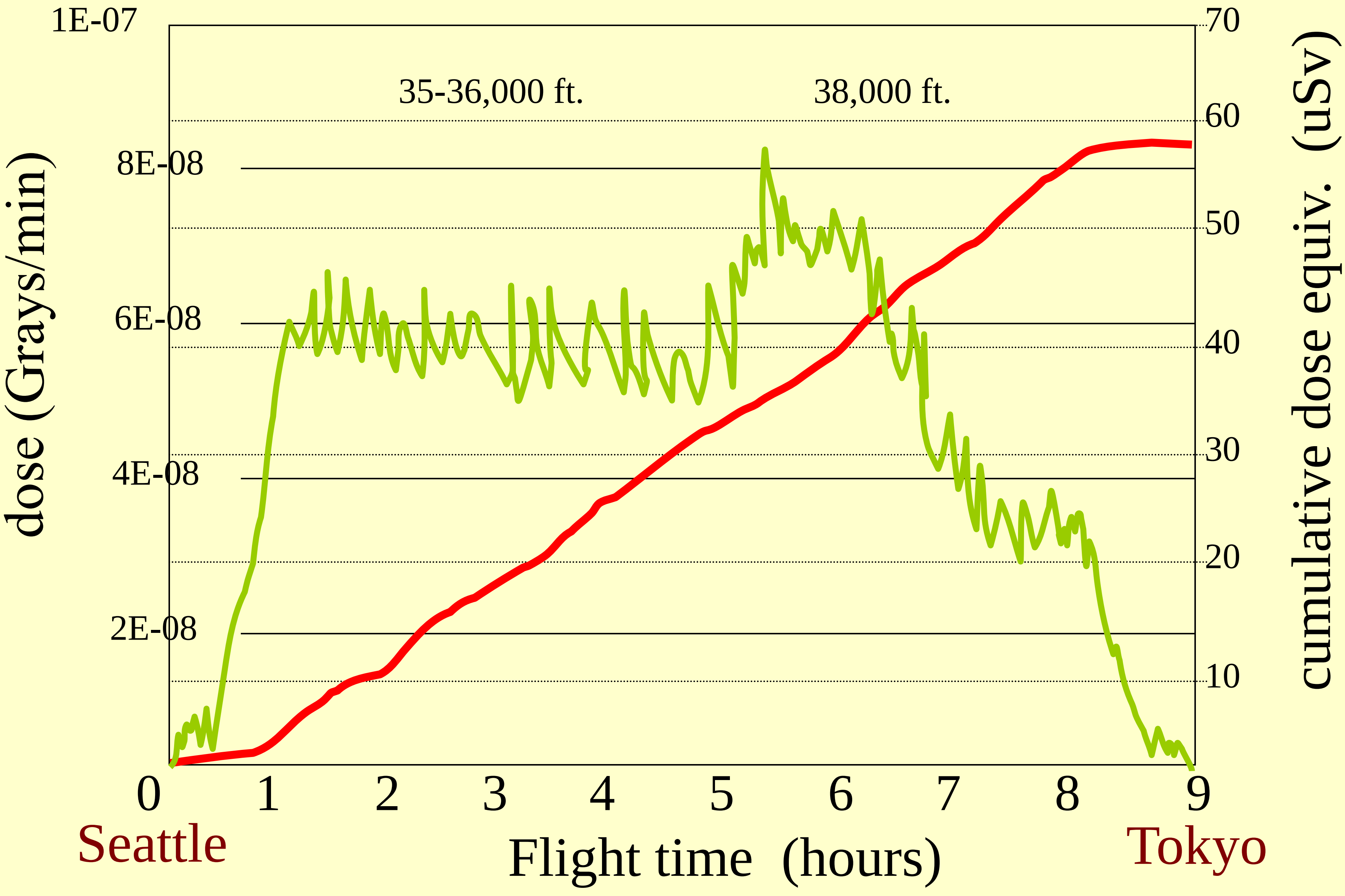


Cosmic Radiation Background

- There are three main factors that can affect the amount of exposure to cosmic radiation:
  - **Altitude:** the higher we go, the greater the dose
  - **Latitude:** the closer we get to the poles, the greater the dose
  - **Duration:** the longer we stay aloft, the greater the dose

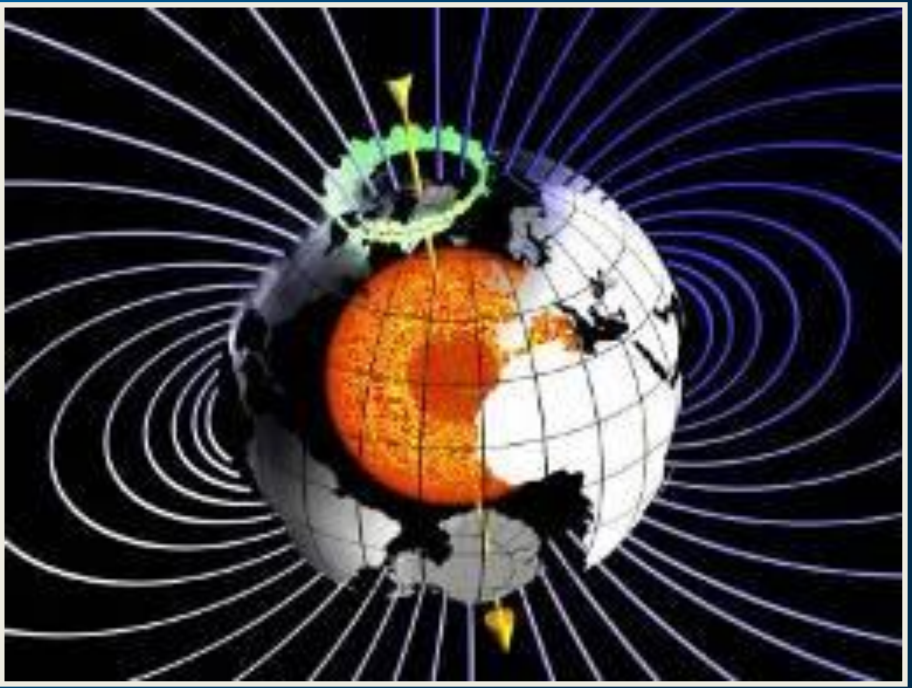

Atmospheric depths
(g cm -2)
Aircraft heights (km)
25
30
20
Private jet (15 km)
SST (18-20 km)
100
15
10
300
Commercial (10 km)
5
1000
Tibet (3.7 km)
Kendall 2000

Radiation Exposure in Flight



- Radiation dose will thus vary between different flights depending on:

  - **origin,**
  - **destination,**
  - **route,**
  - **flight level pattern and**
  - **solar activity at the time.**



- Aircrew and frequent flyers get the most additional exposure because of the extra time they spend at cruising altitudes

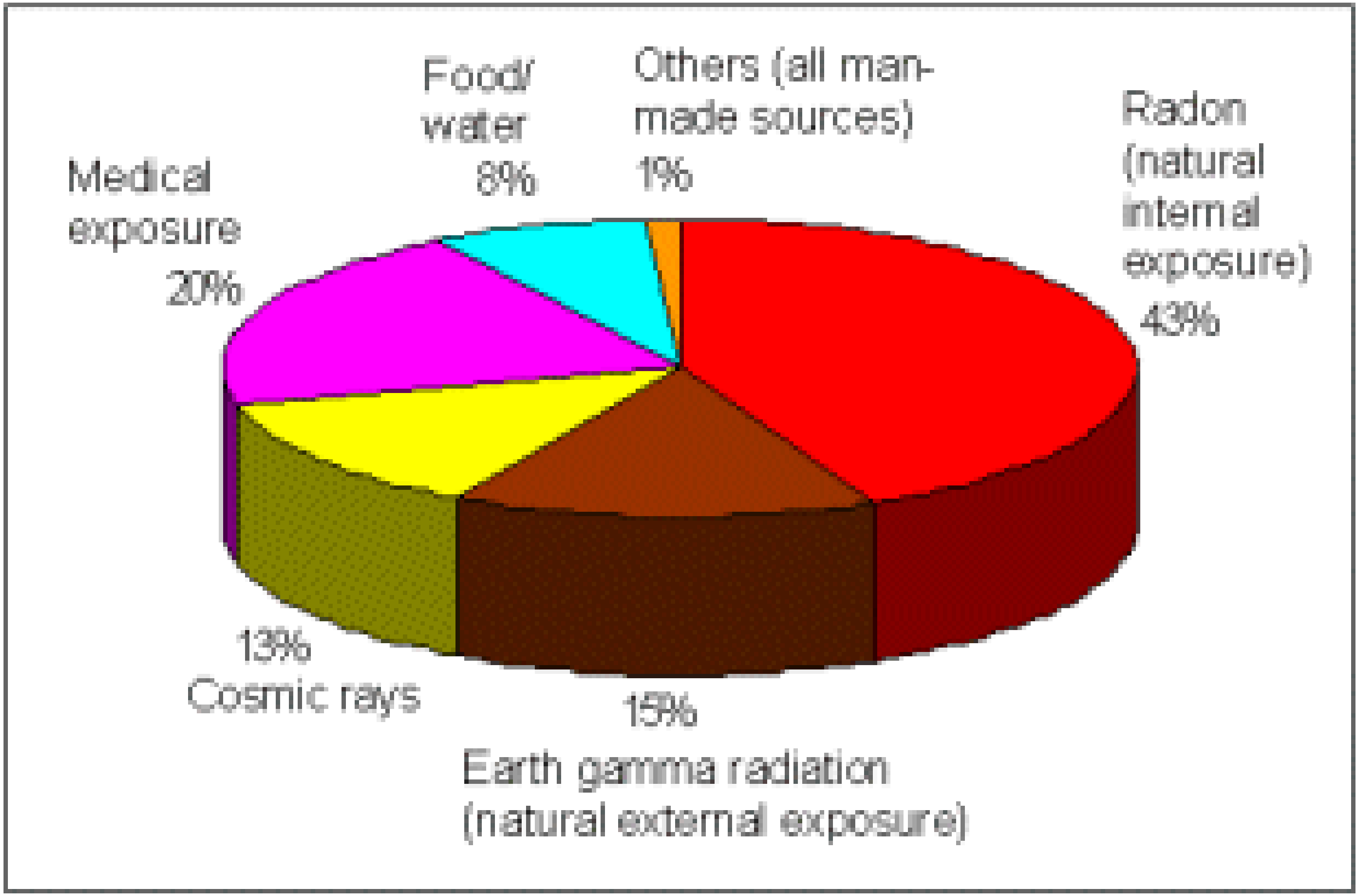
- In the United Kingdom (UK), the average background radiation dose is 2.2 milli-sieverts (mSv) per annum.

- CR effective dose (E_D) rates increase with altitude up to a maximum at about 20 km (66,000ft), and with increasing latitude reaching a constant level at about 50°.

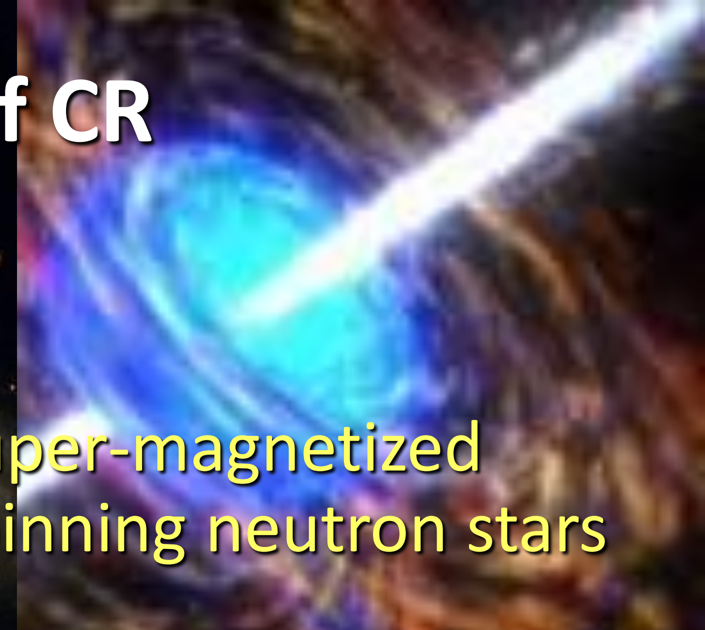
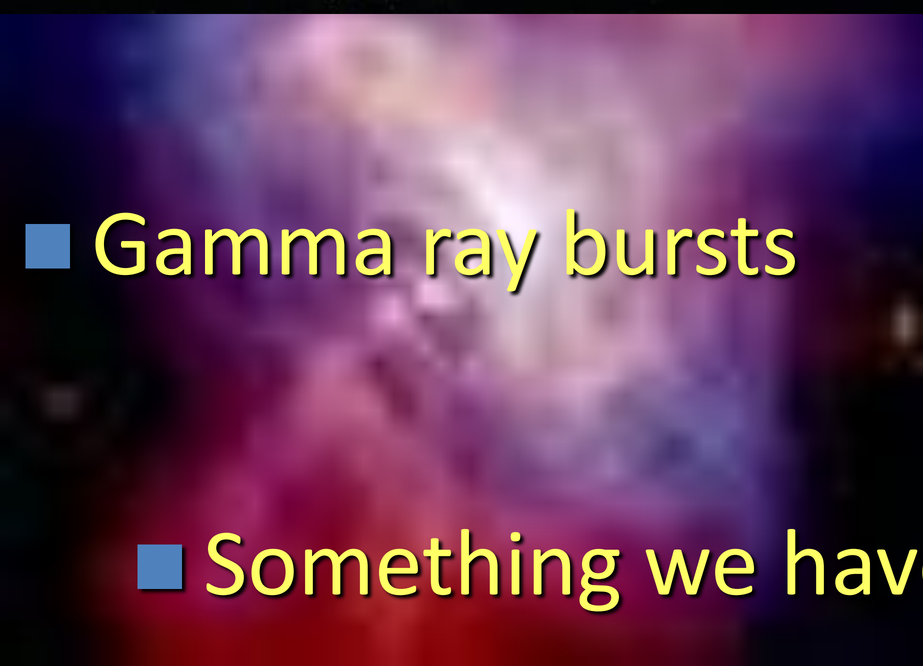
- The E_D rate at an altitude of 8 km (26,000ft) in temperate latitudes is typically up to about 3 microSv per hour (1000 microSv = 1 mSv), but near the equator only about 1 to 1.5 microSv per hour.

- At 12 km (39,000ft), the values are greater by about a factor of two.

Radiation dose	Source
0.01 millisievert (mSv)	Tooth X--ray
0.06 mSv (60µSv)	Flight(approx.9 hrs flight time)
0.1 mSv (100 µSv)	Chest X--ray
1 mSv	Annual dose limit for the public
2-5 mSv	Annual cosmic radiation dose for flying personnel
3.7 mSv	Average annual Finnish radiation dose (background radiation, indoor radon, medical radiation, etc.)
20 mSv	CT Scan, Limit on E_D for occupationally exposed workers averaged over defined periods of 5 years, with no single year exceeding 50 mSv
500-1000 mSv	Dose required for acute radiation illness
4000 mSv	Lethal dose when received at once



Sources and distribution of average radiation exposure to the world population


Potential sources of CR

- Colliding galaxies
- Super-magnetized spinning neutron stars
- Giant black holes spinning rapidly
- Gamma ray bursts
- Something we haven’t seen yet?

Aircrews and Radiation

- Cosmic radiation (CR) is naturally occurring ionising radiation arising from sources outside the Earth's atmosphere.

- It is one component of the natural radiation environment to which mankind is constantly exposed.

- CR increases with altitude and so flight crews and other frequent flyers are exposed to enhanced levels of this type of radiation.

Aircrews and Radiation

- ICRP, FAA, officially consider aircrews to be **occupationally exposed** to ionizing radiation.
- Passengers = Same radiation dose as the crew *on that flight*.
- But aircrews fly again and again and again, for years, = cumulative dose much greater than virtually any passenger, including "frequent fliers."

Aircrews and Radiation

- Pilots are exposed > doses than cabin crew, since the passenger cabin provides more shielding than the cockpit.

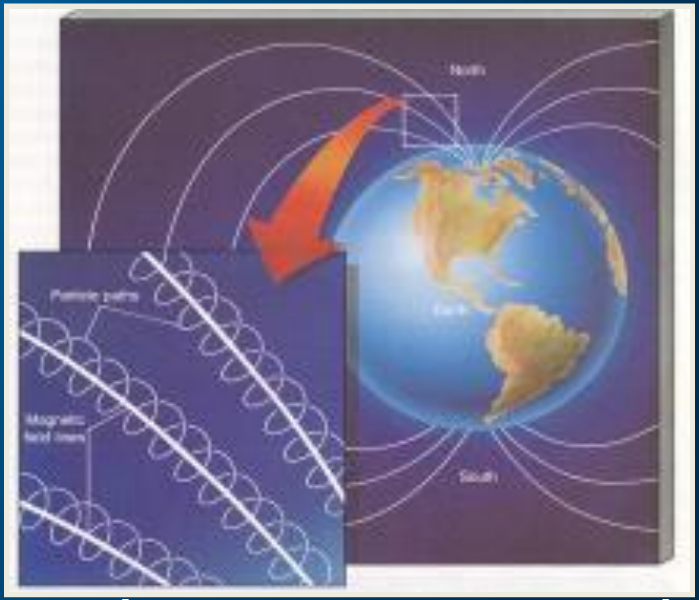
- Doses on board aircraft **are generally predictable**,

- Unforeseen exposures, such as may occur in other radiological workplaces, **cannot occur**

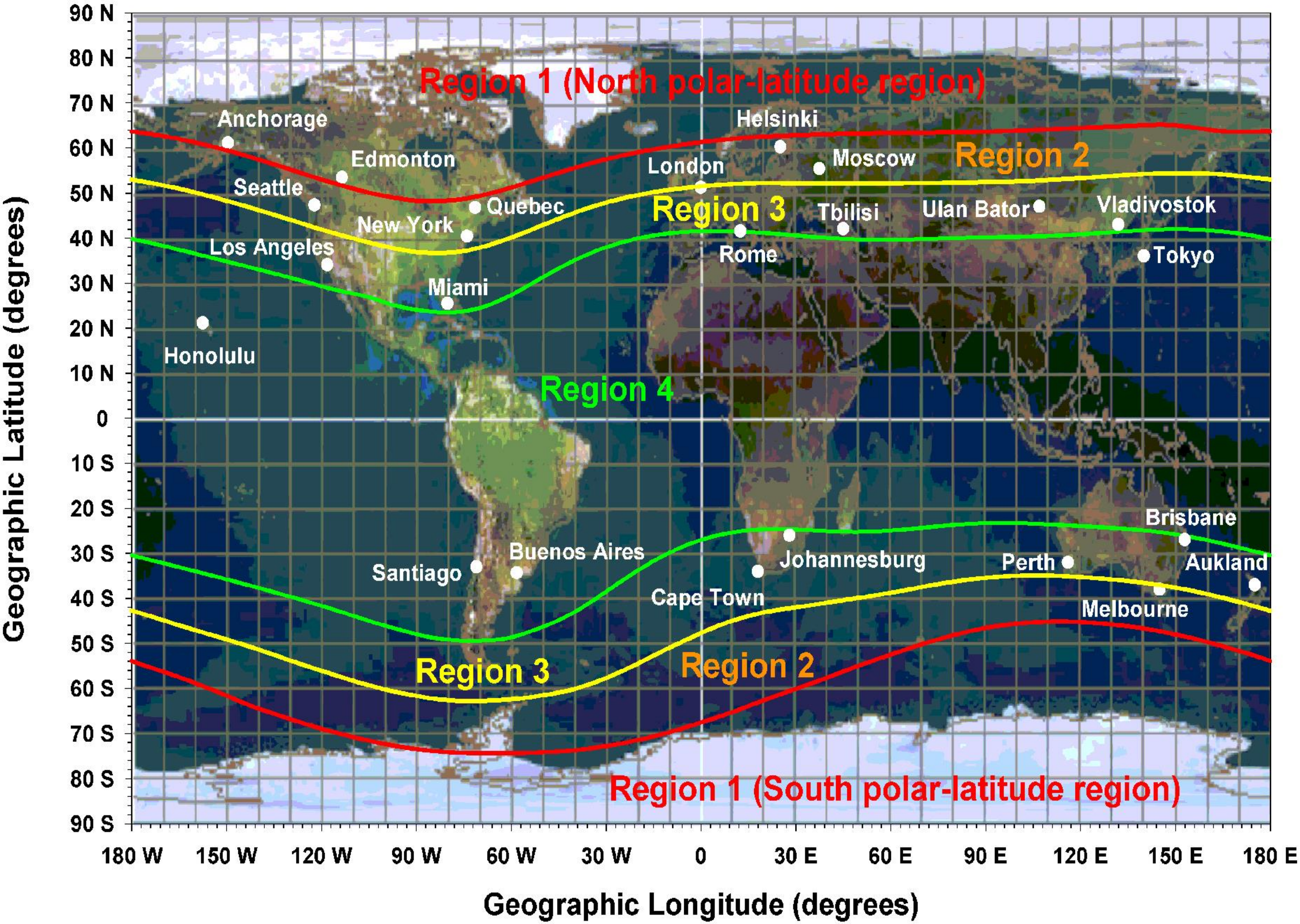
Rare Exceptions:

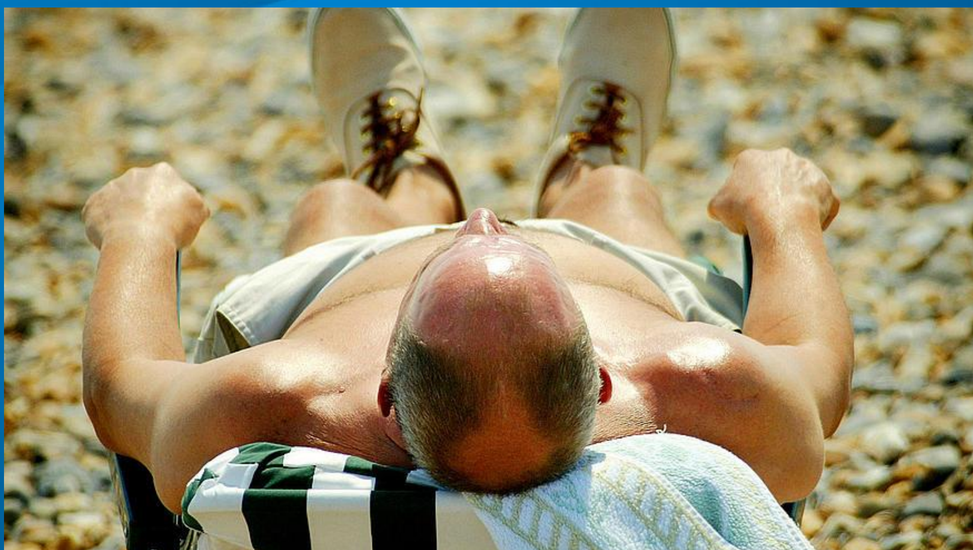
- The extremely intense and high energy solar particle events (SPEs): (ICRP Publication 97)

- Calculations can be made directly of the E_D per unit time as a function of:
  - **Geographic location,**
  - **Altitude, and**
  - **Solar cycle phase.**



- When folded with flight and staff roster information, estimates of the E_D for individuals are obtained


Region 1 (North polar-latitude region)
Region 2
Region 3
Region 4
Region 3
Region 2
Region 1 (South polar-latitude region)
Anchorage
Helsinki
Edmonton
London
Moscow
Seattle
Quebec
Tbilisi
Ulan Bator
Vladivostok
New York
Los Angeles
Rome
Tokyo
Miami
Honolulu
Brisbane
Buenos Aires
Santiago
Johannesburg
Perth
Aukland
Cape Town
Melbourne
90 N
80 N
70 N
60 N
50 N
40 N
30 N
20 N
10 N
0
10 S
20 S
30 S
40 S
50 S
60 S
70 S
80 S
90 S
180 W
150 W
120 W
90 W
60 W
30 W
0
30 E
60 E
90 E
120 E
150 E
180 E
Geographic Latitude (degrees)
Geographic Longitude (degrees)



CAUSES OF CANCER

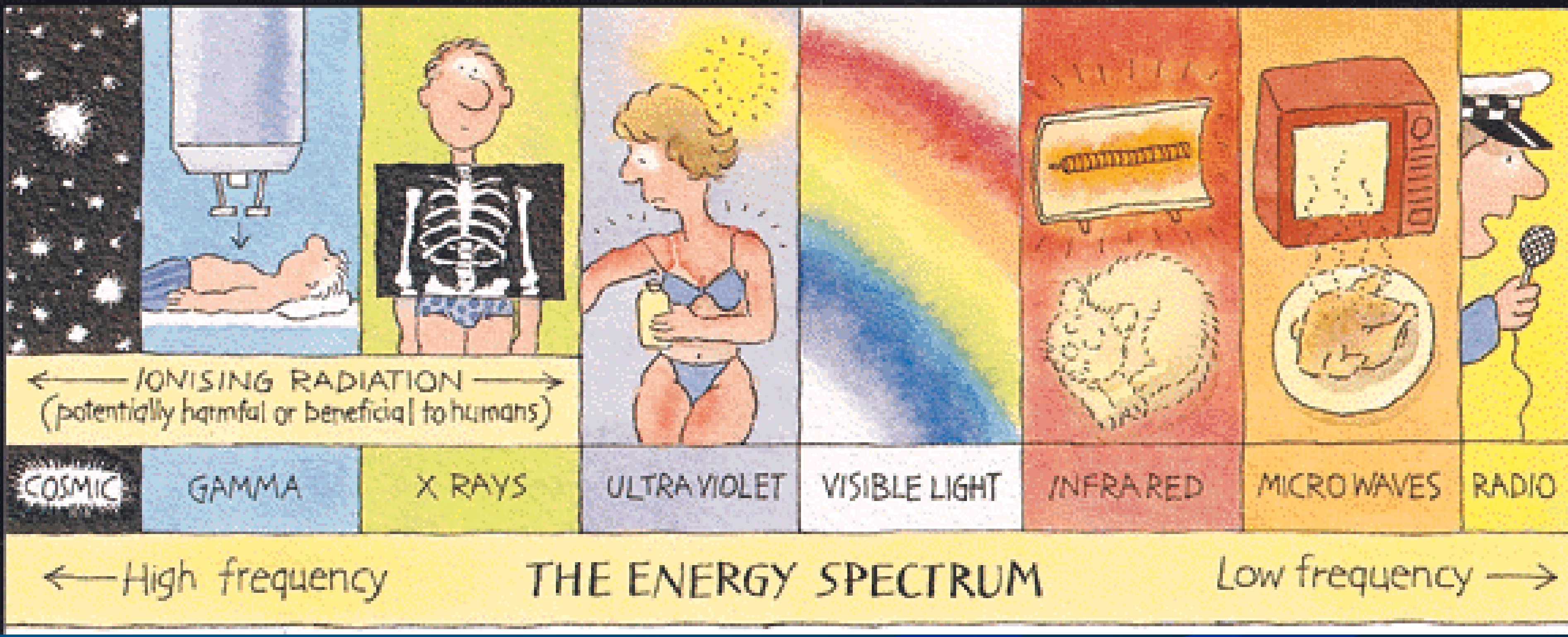
The main concern with CR exposure is:

- The possible long term risk of radiation induced **cancer**

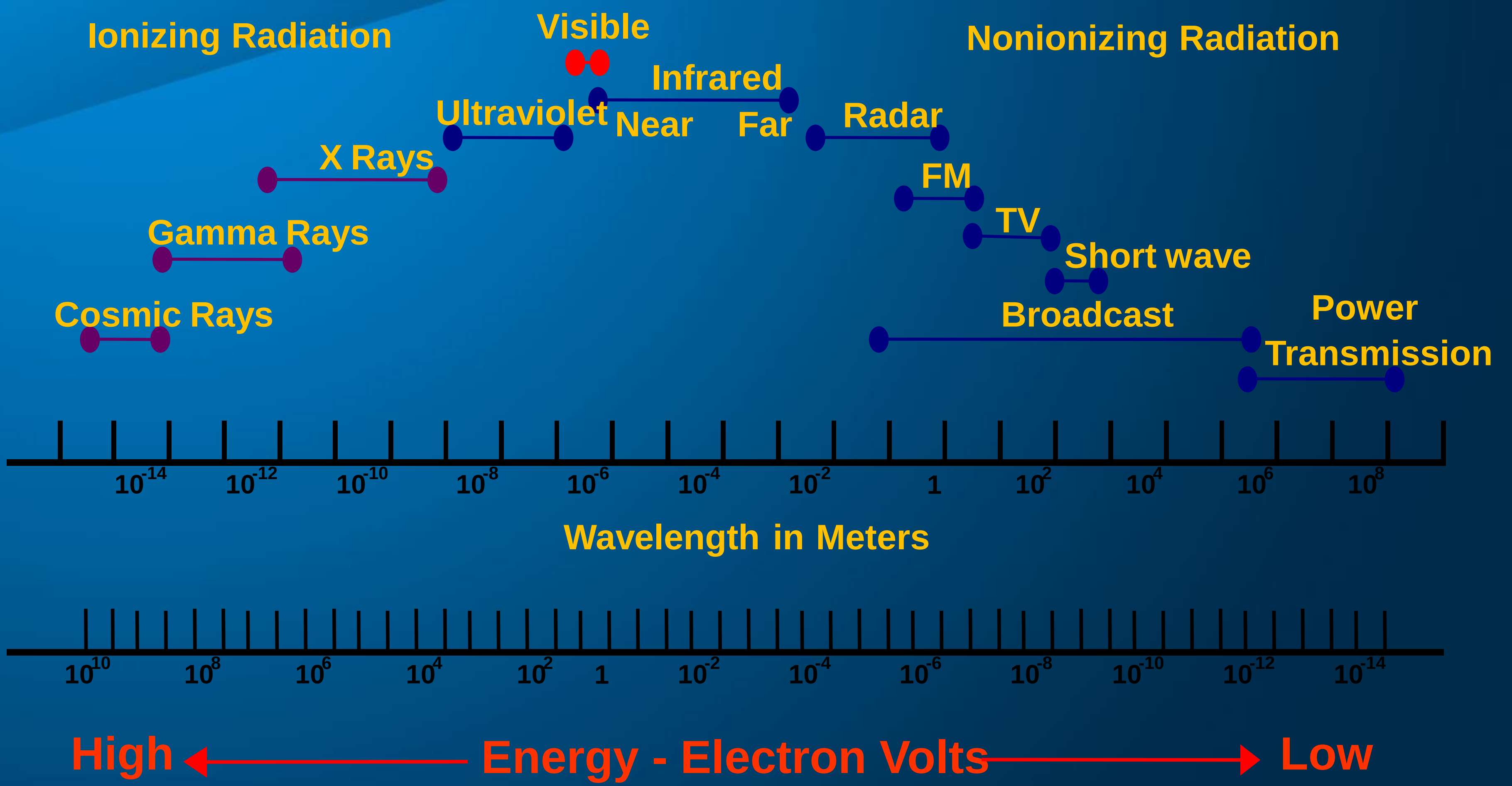
(Friedberg et al estimated that the increased risk of dying from cancer because of cosmic radiation received over 20 years of flying, ranges from 0.1 to 5 in 1000.) ***(General risk of dying from cancer in the US = 220 in 1000)***

- In the case of pregnant air crew, possible harm to the foetus – mainly ***stochastic*** effects later in life and to a lesser extent, **birth defects**

Radiation 101



Electromagnetic Spectrum



Establishing risk: Epidemiological approaches

- A meta-analysis of both published and unpublished cohort studies of air crew concluded that :

- Air crew seemed to be **at risk** of several types of cancer:
  - **melanoma,**
  - **brain,**
  - **prostate, and**
  - **breast.**

- **<u>But on closer examination</u>**, these studies share the common problems of:
- a) **small cohorts**, and
- b) **conspicuous confounders,** e.g.
  - **Reproductive factors such as nulliparity, in rates of Breast CA**
  - **Leisure time activities in rates of Melanoma**
  - **Lifestyle factors**
  - **Circadian disruption**

- Not possible, based on these studies, to **pinpoint** cosmic radiation as the culprit.
- The authors recommended that future studies must also compare risks within cohorts by:
  - **flight routes,**
  - **work history, and**
  - **Exposures to:**
    - **cosmic and ultraviolet radiation,**
    - **electromagnetic fields, and**
    - **chemical substance**

Legal considerations and International Best Practices

ICAO Annex 6

- 6 6.12 requires all airplanes intended to be operated above 15,000m (49,000ft) to carry equipment to measure and indicate continuously the dose rate of total cosmic radiation being received and the cumulative dose on each flight.

- 6 4.2.11.5 requires the operator to maintain records of flights above 15,000m (49,000ft) so that the total cosmic radiation dose received by each crew member over a period of 12 consecutive months can be determined.

- According to Section 8(1) of the Occupational Health and Safety Act (OHSA) (Act 85 of 1993), as amended by Occupational Health and Safety Amendments Act (Act 181 of 1993) in the ‘general duties of employers to their employees’:

Employers must ensure:

- *Provision and maintenance, as far as is reasonably practicable, of:*
  - *A safe environment, and*
  - *An environment that is without risk to the health of all employees (including pregnant females).*

- *These include, amongst other things:*

- *Taking such steps as may be reasonably practicable to:*

  - *Eliminate or mitigate any hazard or potential hazard to the safety or health of the employees, and*

  - *Make arrangements for ensuring the safety and absence of risk to health in connection with related work*

RECOMMENDATIONS

Control of occupational exposure: general considerations

- **Operators/Employers should make arrangements to :**
  - Give information and provide education regarding the risks of occupational exposure to radiation to their air crew.

    (air crew being defined as flight crew, cabin crew and any person employed by the aircraft operator to perform a function on board the aircraft while it is in flight.)

  - Make female air crew aware of the need to control doses during pregnancy and to notify their employer if they become pregnant so that any necessary dose control measures can be introduced.

When the crew is exposed to radiation which exceeds 1 millisievert a year:

Employers must:

- Estimate the crew's exposure to cosmic radiation,
- Consider the estimated radiation exposure of crew members when drawing up the working schedule in order to reduce the radiation dose of crew members who have already been exposed to high-level of radiation,
- Familiarize crew members, those to whom it applies, with health risks related to the pursuit of their professional activities

- Ensure that working schedule for female crew members, once they have been notified that they are pregnant, keep the foetus exposed to radiation as little as possible and ensure that the dose does not exceed 1 millisievert for the remainder of the pregnancy,

- Keep records on each individual and especially on crew members who are exposed to higher doses of radiation.

- Crew members have to be informed about the cosmic radiation doses **every year** and **upon retirement**.

For aircrew that are likely to receive exposures in excess of 1 msv per annum:

The employer must:

- Assess the exposure of the crew concerned;
- Take into account the assessed exposure when organising working schedules with a view to reducing the doses of highly exposed aircrew;
- Inform the workers concerned of the health risks their work involves;
- Apply special protection for female aircrew during declared pregnancy.

Control of occupational exposure in high flying aircraft

- Aircraft capable of operating at altitudes greater than **15 km** (49,000ft) should:
  - **Carry an active radiation monitor**, which monitors current levels of radiation, to detect any significant short-term variation in radiation levels during flight.
  - Such variations may arise as a result of **solar flares, or other solar events**, which can cause a sharp increase in the solar component of cosmic radiation, especially at altitudes above 15km.

(Potential exposure resulting from such an event can be greatly reduced by a controlled descent if active monitoring is used.)

- Air crew operating such high flying aircraft should be subjected to the same general monitoring regime as for those operating between **8 and 15 km** but account should be taken of the greater potential variability of dose.

- **<u>Active monitoring may be used to:</u>**

  – Assess the doses to which air crew are exposed (rather than using a computer program to predict dose) or

  – Simply to provide a warning of high dose rates.

Current IFALPA policy (2012) requires:

- ICAO lead task-force to evaluate the possible descent procedures for a large number of aircraft in the event of a solar storm

Control of occupational exposures of pregnant women

- Once the pregnancy is declared:

The employer must:

- Plan future occupational exposures such that the equivalent dose to the foetus is unlikely to be greater than 1 mSv during the remainder of the pregnancy.

(The CR exposure of the body is essentially uniform and the maternal abdomen provides no effective shielding to the foetus).

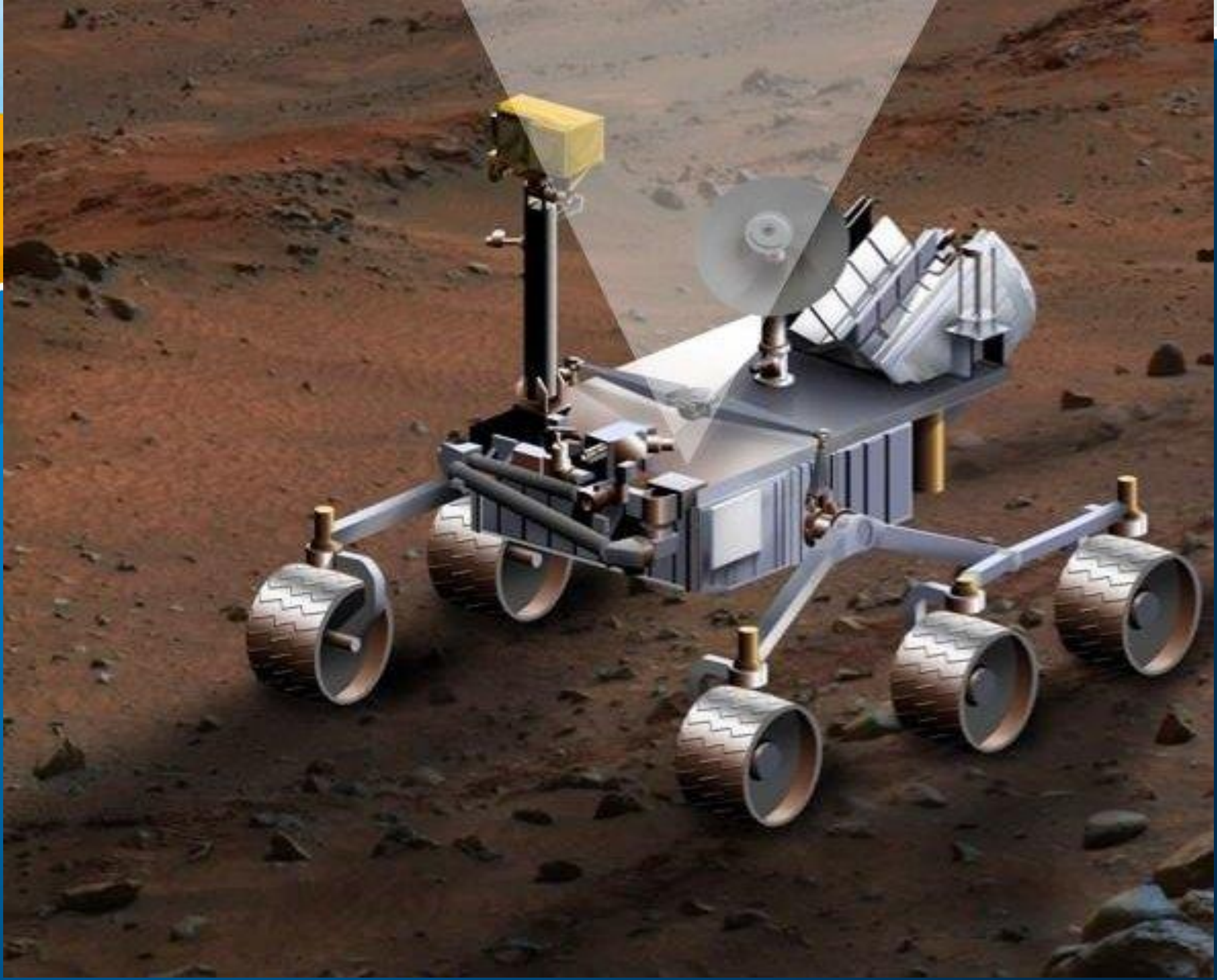
E_D same for mother and child

- Some operators have determined that pregnant aircraft crew **should cease flying duties** on declaration of pregnancy,
- **South African Airways** is one such operator
- This is with regard to the requirement of keeping doses **as low as reasonably achievable.**

- It should also be noted that the practice of grounding crew from the moment they declare pregnancy may be based on **<u>other aviation physiological risk factors</u>** to the mother and foetus, including:
  - circadian dysrhythmia,
  - hypoxia, dehydration,
  - noise,
  - vibration and turbulence,
  - mental fatigue and injury through manual handling and
  - exertion.

- Although further studies are necessary to clarify the exact role of occupational exposure,
- **All airlines should**, as some companies do,
  - **Estimate radiation dose,**
  - **Organize the schedules of crew members in order to reduce further exposure in highly exposed flight attendants,**
  - **Inform them about health risks, and**
  - **Give special protection to pregnant women.**

- Pregnant crewmembers can minimize occupational exposure to CR by working on:
  - **short,**
  - **low-altitude, and**
  - **low-latitude flights.**



CONCLUSION

- Aircrew have very unique working conditions.

- Their work is often **shift work**, working at **high altitude**, and **high latitude**, with a possibility of **flights over different time zones;**

- This exposes them to:

  - **Circadian disruption ,**
  - **Exposure to higher cosmic radiation**, and
  - **High risk of illnesses**

- Our public today still **seems insufficiently informed** when it comes to hazards brought about by natural sources of radiation.
- There need to be protection for aircrew from radiation as a means to comply with occupational health and safety laws and regulations.

TAKE HOME MESSAGE

- We all face risks in everyday life.
- It is impossible to eliminate them all
- **But it is possible to reduce them**
- Knowledge in radiation protection is an important tool in the battle for survival on our planet.
- **Seneca wrote: “***that no life is more secure than any other and that no one is safe for tomorrow.”*

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