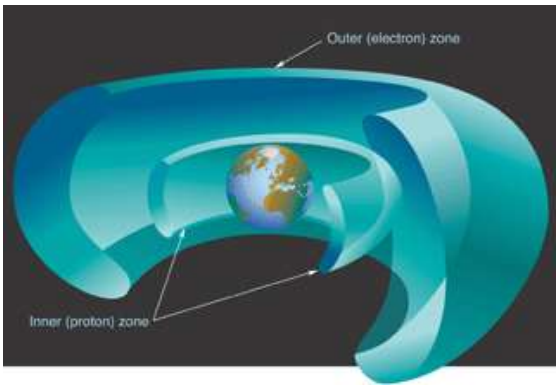
The Deadly Van Allen Belts?

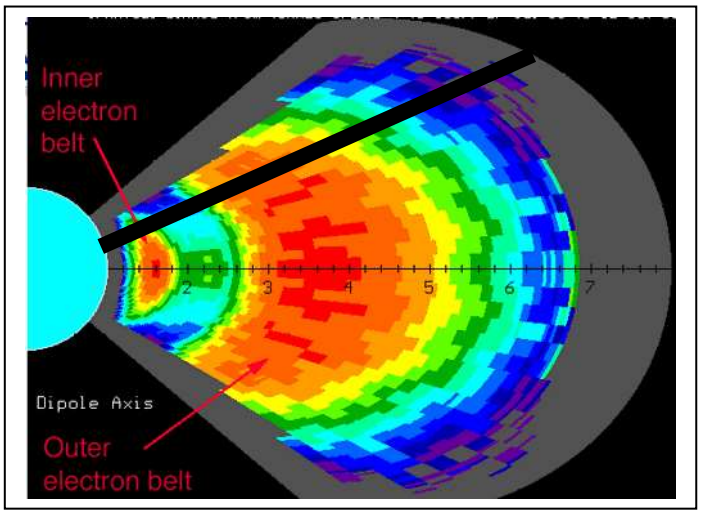


In 1958, Dr. James Van Allen discovered a collection of high-energy particle clouds within 40,000 km of Earth. Arranged like two nested donuts, the inner belt is mainly energetic protons, while the outer belts contain both protons and electrons. These belts have long been known as 'bad news' for satellites and astronauts, with potentially deadly consequences if you spend too much time within them. The figure below, produced by scientists from the NASA, CRRES satellite, shows the radiation dosages at various locations within the belts.

Blue = 0.0001 Rads/sec Green= 0.001 Rads/sec Yellow= 0.005 Rads/sec Orange= 0.01 Rads/sec and Red= 0.05 Rads/sec.

The numbers along the horizontal axis give the distance from Earth in multiples of the Earth radius (1 Re=6378 km). The Inner van Allen Belt is located at about 1.6 Re. The Outer van Allen Belt is located at about 4.0 Re. At a distance of 2.2 Re, there is a 'gap' region in between these belts. Satellites such as the Global Positioning System (GPS) orbit in this gap region where radiation effects are minimum.

The International Space Station and Space Shuttle, on this scale, orbit very near the edge of the blue 'Earth disk' in the figure, so are well below the Van Allen Belts.



Apollo astronauts, and astronauts in the upcoming visits to the Moon, will have to travel through some of these belt regions because the orbit of the Moon lies along the fastest line-of-travel from Earth. On the scale of the above figure, the distance to the Moon is 60 Re.

1. The speed of the spacecraft will be about 25,000 km/hour. If the spacecraft travels along the indicated path (black bar), how long, in minutes, will it spend in the Blue, Green, Yellow, Orange and Red regions?

2. Given the indicated radiation dosages in Rads/sec for each zone, what will be the dosages that the astronauts receive in each zone?

3. What will be the total radiation dosage in Rads for the transit through the belts?

4. Some people believe that the Apollo moon landings were a hoax because astronauts would have been instantly killed in the radiation belts. According to the US Occupation Safety and Health Agency (OSHA) a lethal radiation dosage is 300 Rads in one hour. What is your answer to the 'moon landing hoax' believers?

Note: According to radiation dosimeters carried by Apollo astronauts, their total dosage for the entire trip to the moon and return was not more than 2 Rads over 6 days.

Answer Key:

Apollo astronauts, and astronauts in the upcoming visits to the Moon, will have to travel through some of these belt regions because the orbit of the Moon lies along the fastest line-of-travel from Earth. On the scale of the above figure, the distance to the Moon is 60 Re.

1. The speed of the spacecraft will be about 25,000 km/hour. If the spacecraft travels along the indicated path, how long, in minutes, will it spend in the Blue, Green, Yellow, Orange and Red regions?
Note: transit estimates may vary depending on how accurately students measure figure.

Blue: 1.8 Re x (6378 km/Re) x (1 hour/25,000 km) x (60 minutes/1 hour) =	27.6 minutes
Yellow: (1.4 x 6378) /25,000 x 60 =	21.4 minutes
Orange: (1.0 x 6378) / 25,000 x 60 =	15.3 minutes
Green: (0.25 x 6378)/25,000 x 60 =	3.8 minutes
Red:	0 minutes
Total transit time……	68.1 minutes

2. Given the indicated radiation dosages in Rads/sec for each zone, what will be the dosages that the astronauts receive in each zone?

Blue: = 27.6 minutes x (60 sec/ 1 minute) x (0.0001 Rads/sec) =	0.17 Rads
Yellow = 21.4 minutes x 60 sec/minute x 0.005 rads/sec =	6.42 Rads
Orange = 15.3 minutes x (60 sec/minute) x 0.01 rads/sec =	9.18 Rads
Green = 3.8 minutes x (60 sec/minute) x 0.001 rads/sec =	0.23 Rads

3. What will be the total radiation dosage in Rads for the transit through the belts?
0.17 + 6.42 + 9.18 + 0.23 = 16.0 Rads

4. Some people believe that the Apollo moon landings were a hoax because astronauts would have been instantly killed in the radiation belts. According to the US Occupation Safety and Health Agency (OSHA) a lethal radiation dosage is 300 Rads in one hour. What is your answer to the 'moon landing hoax' believers?

Note: According to radiation dosimeters carried by Apollo astronauts, their total dosage for the entire trip to the moon and return was not more than 2 Rads over 6 days.

The total dosage for the trip is only 16 Rads in 68.1 minutes. Because 68.1 minutes is equal to 1.13 hours, his is equal to a dosage of 16 Rads / 1.13 hours = 14.0 Rads in one hour, which is well below the 300 Rads in one hour that is considered to be lethal. Also, this radiation exposure would be for an astronaut outside the spacecraft during the transit through the belts. The radiation shielding inside the spacecraft cuts down the 14 Rads/hour exposure so that it is completely harmless.