

JOURNEY TO MARS: HOW TO PROTECT ASTRONAUTS FROM SPACE RADIATION



VERONICA BINDI - UNIVERSITY OF HAWAII

THE HUMAN DESIRE FOR EXPLORATION
LEADS TO DISCOVERY

THE HUMAN DESIRE FOR EXPLORATION LEADS TO DISCOVERY

- C. Columbus, an Italian explorer, wanted to reach India by sea going west instead of east. Portugal, Italy, England thought it was a crazy idea and did not supported him. Spain and its Queen Isabella D'Aragona gave him 3 caravels with food and water to accomplish the travel. In 1492 Columbus arrived in the costs of America.



THE HUMAN DESIRE FOR EXPLORATION LEADS TO DISCOVERY

- It is believed that the Hawaiian Islands were uninhabited until around 400 – 500 A.D., when the Polynesians arrived. Skilled mariners, Polynesians had a long history of exploration and settlement of other lands.

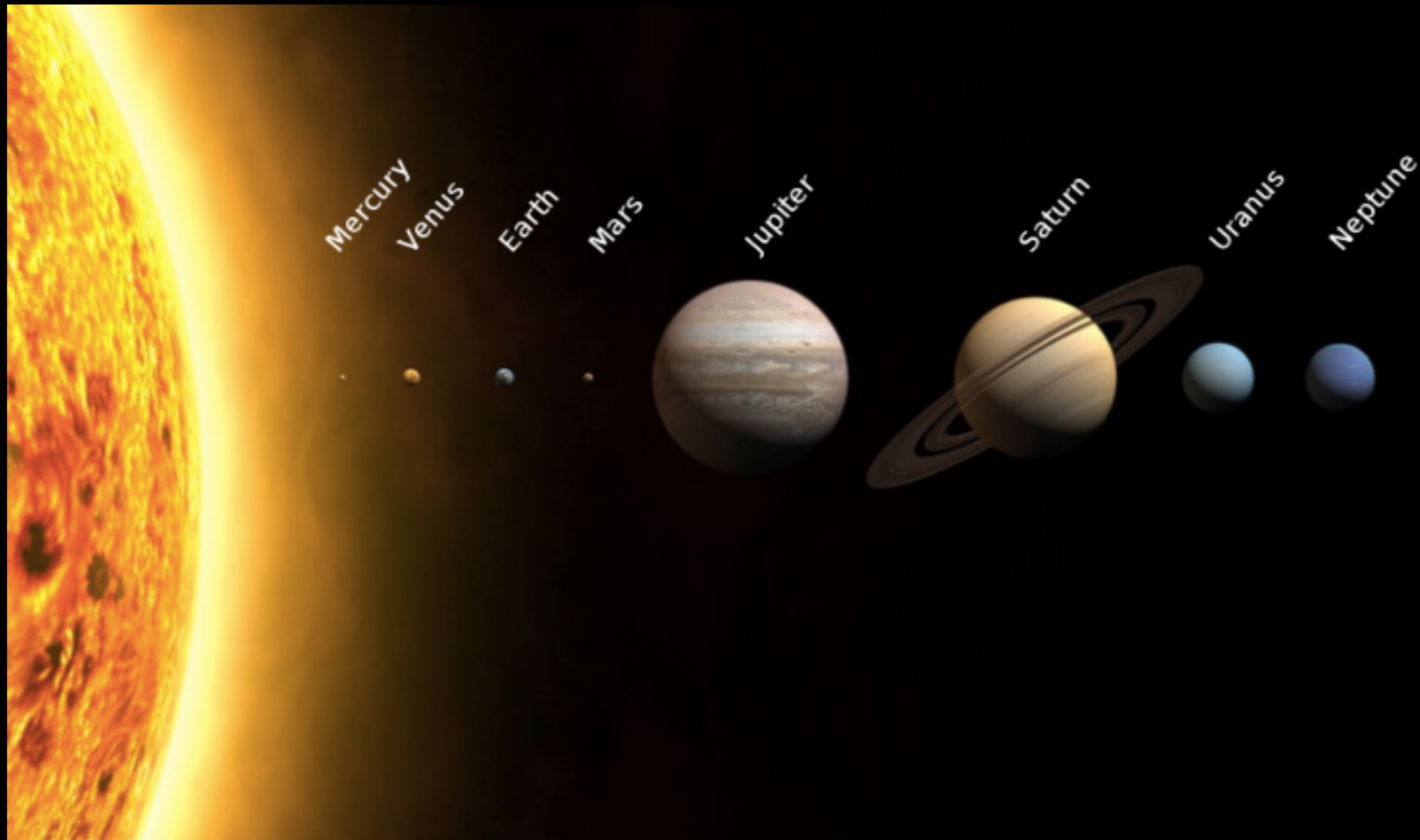


ANCIENT POLYNESIAN, COLUMBUS AND
OTHER EXPLORERS WERE CONSIDERED
LIKE TODAY WE CONSIDER ASTRONAUTS.

ASTRONAUTS ARE TRUE EXPLORERS

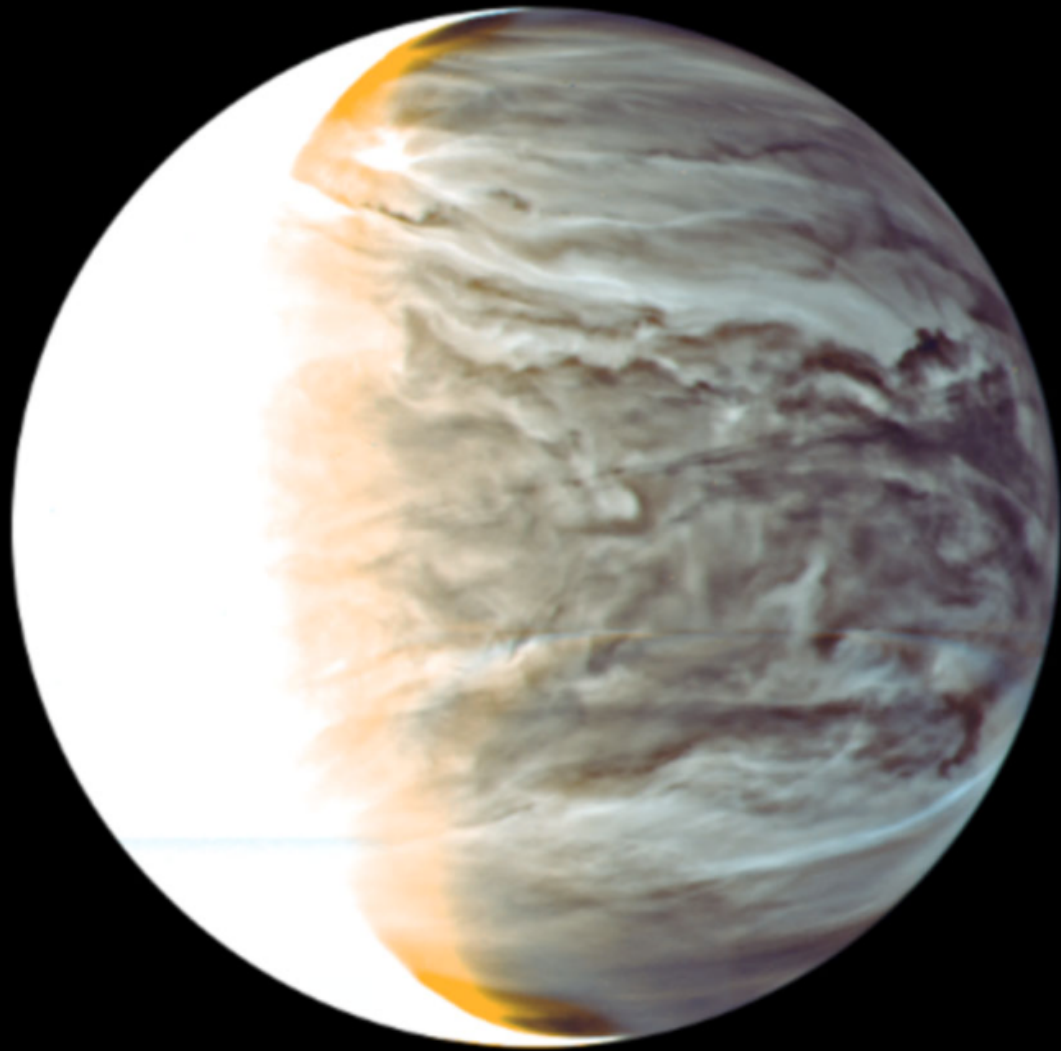
WHY DO WE WANT TO GO TO MARS
AND NOT TO AN OTHER PLANET?

WHY TO DO WE WANT TO GO TO MARS AND NOT TO AN OTHER PLANET?



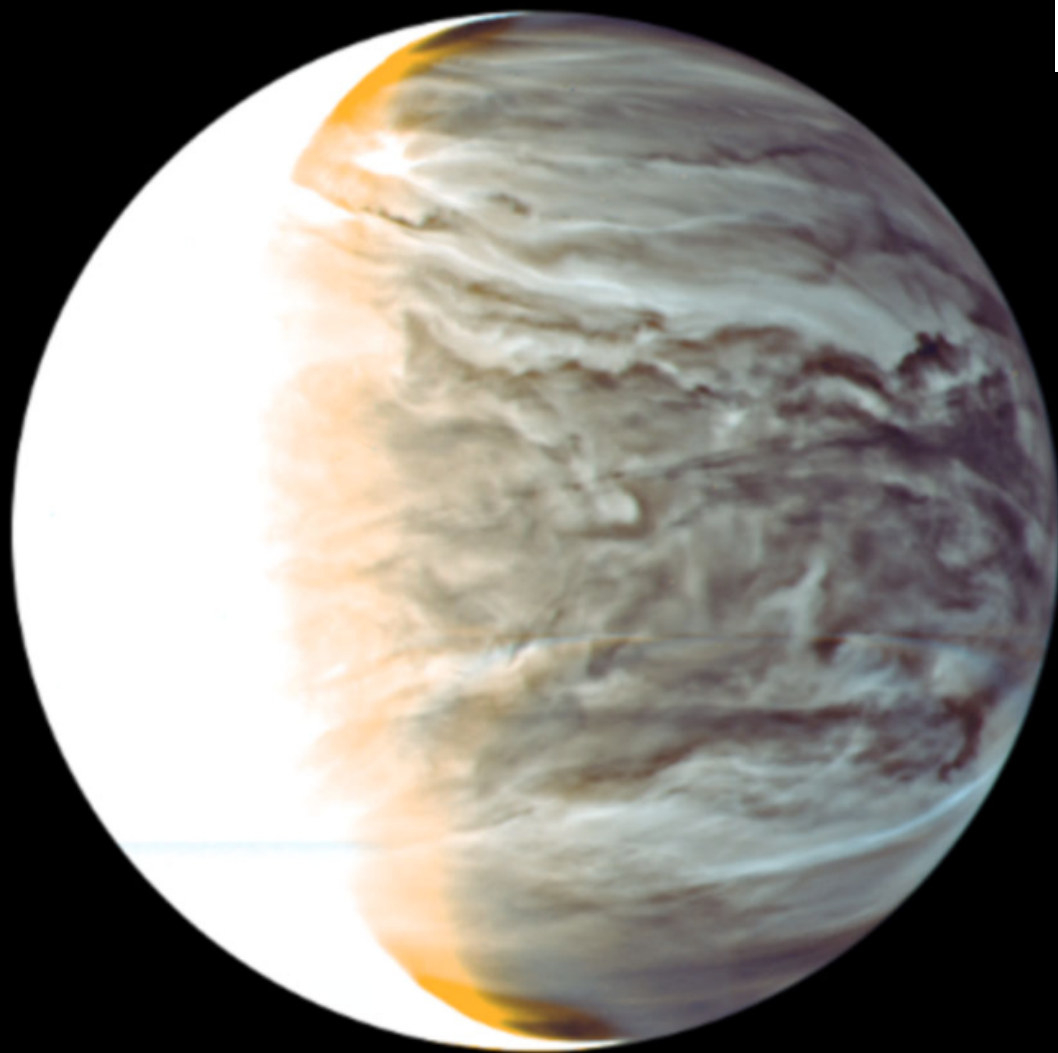
<https://solarsystem.nasa.gov>

Venus



© ISAS/JAXA

Venus



Surface Gravity

Metric: 8.87 m/s^2

English: 29.1 ft/s^2

By Comparison: If you weigh 100 pounds on Earth, you would weigh 91 pounds on Venus.

© ISAS/JAXA

Atmospheric Constituents

Carbon Dioxide, Nitrogen

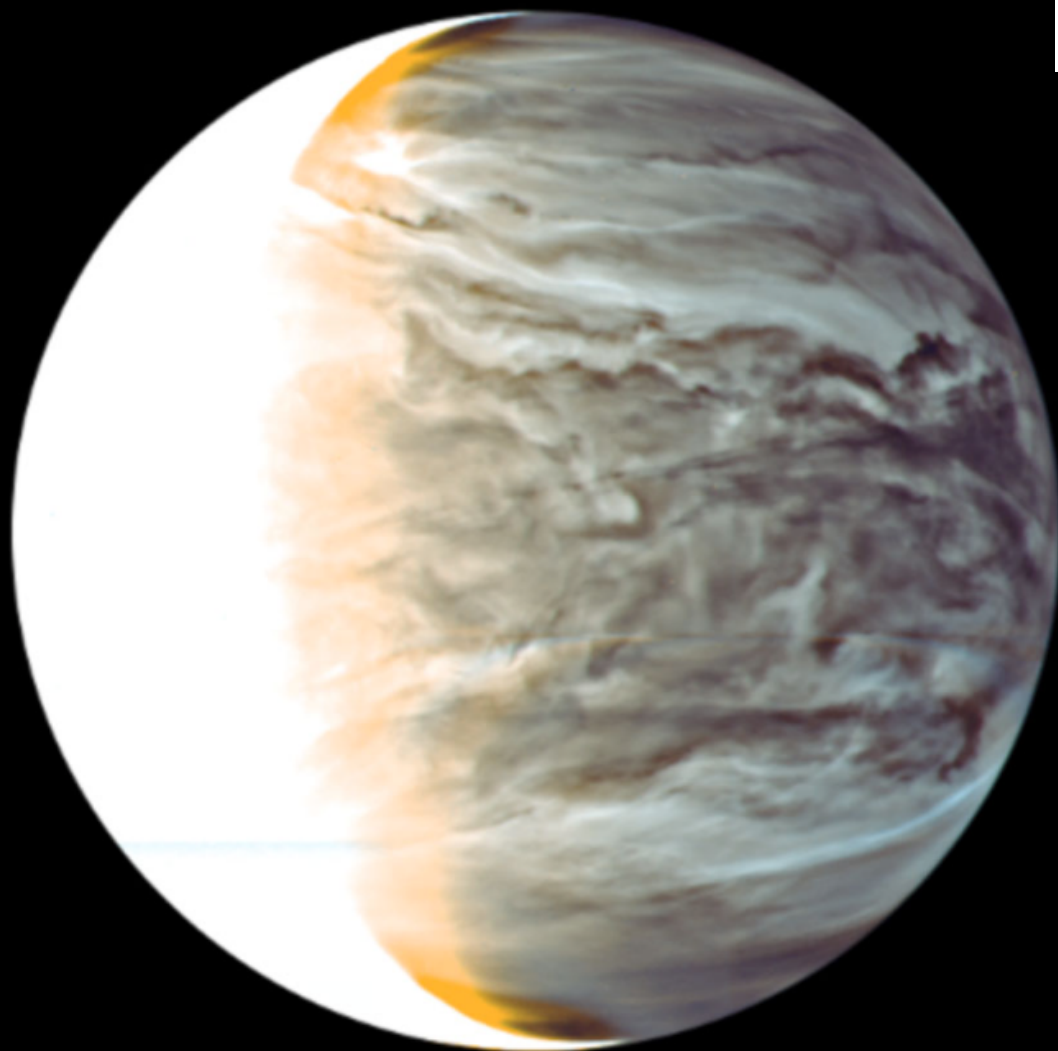
Scientific Notation: CO_2 , N_2

By Comparison: Earth's atmosphere consists mostly of N_2 and O_2 .

CO_2 is largely responsible for the Greenhouse Effect and is used for carbonation in beverages.

N_2 is 80% of Earth's air and is a crucial element in DNA.

Venus



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Quick Facts

- **Day:** 243 Earth days
- **Year:** 225 Earth days
- **Radius:** 3,760 miles | 6,052 kilometers
- **Planet Type:** Terrestrial
- **Moons:** None

Surface Temperature

Metric: $462 \text{ }^\circ\text{C}$

English: $864 \text{ }^\circ\text{F}$

Scientific Notation: 735 K

© ISAS/JAXA

Atmospheric Constituents

Carbon Dioxide, Nitrogen

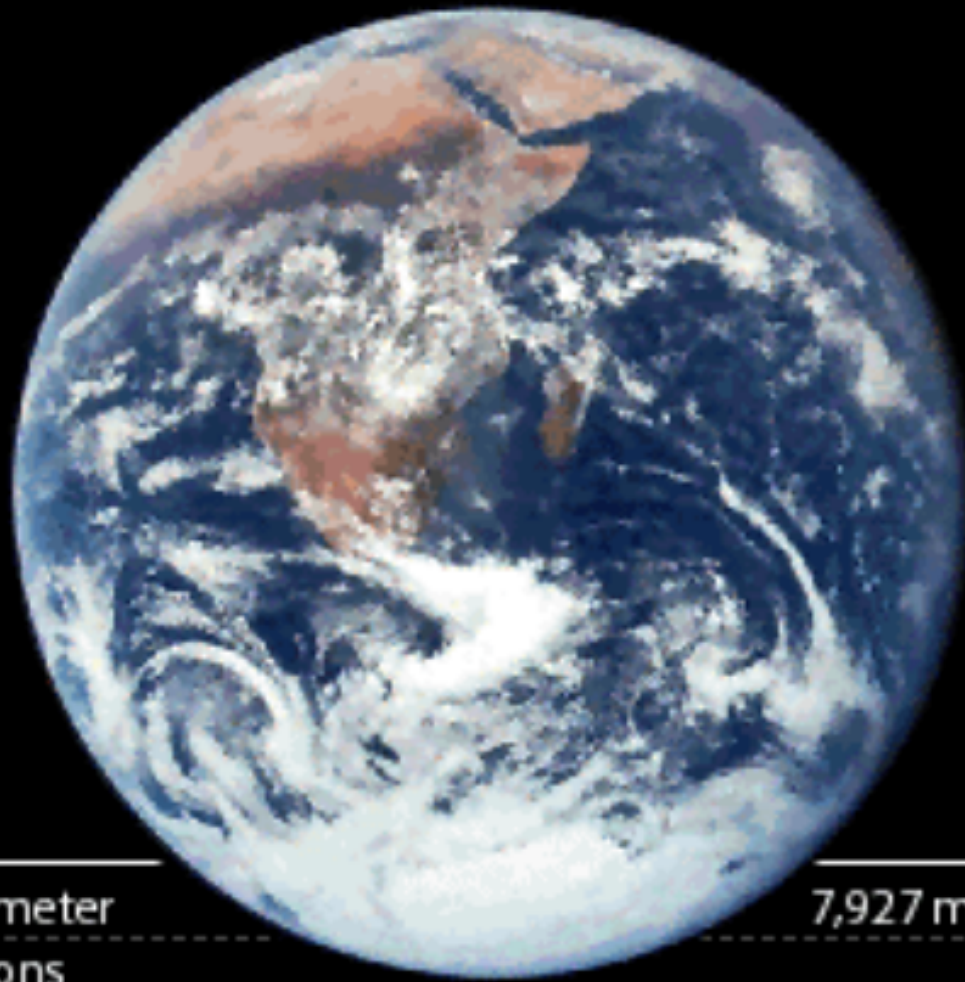
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<http://mars.jpl.nasa.gov>



	EARTH	MARS
Diameter	7,927 miles (12,756 km)	4,222 miles (6,794 km)
Moons	One	Two (Phobos/Deimos)
Gravity	1.000	0.379
Average temperature	56.93° F (13.85° C)	-67.27° F (-55.15° C) ^o
Average distance from the sun	92.6 million miles (149.6 million km)	141.6 million miles (227.9 million km)

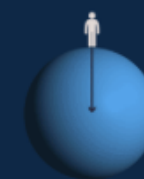
SOURCE: NASA

GRAVITY

On Mars, you'd experience
62.5% less gravity
than you're used to on Earth

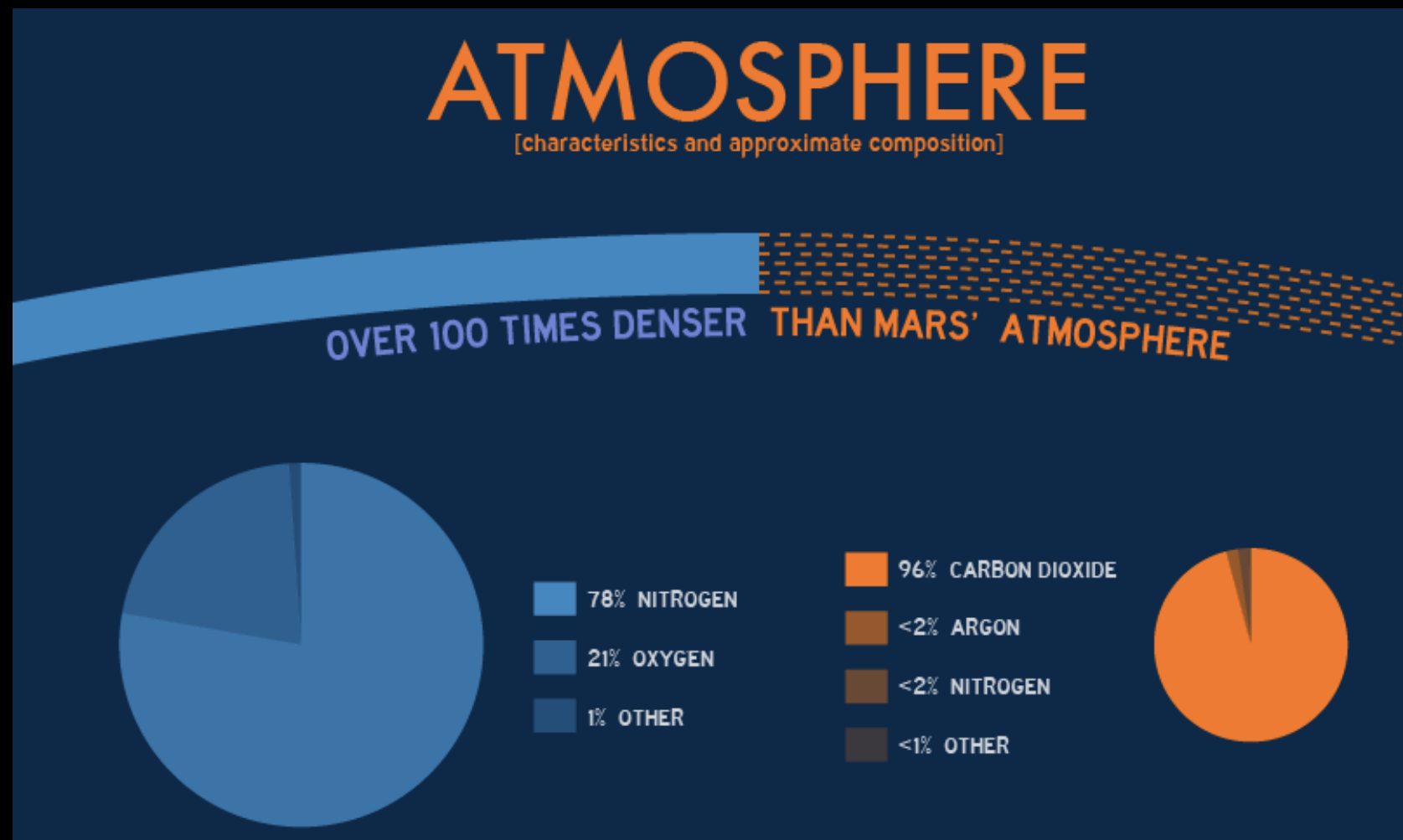


MARS FACTS / WEIGHT



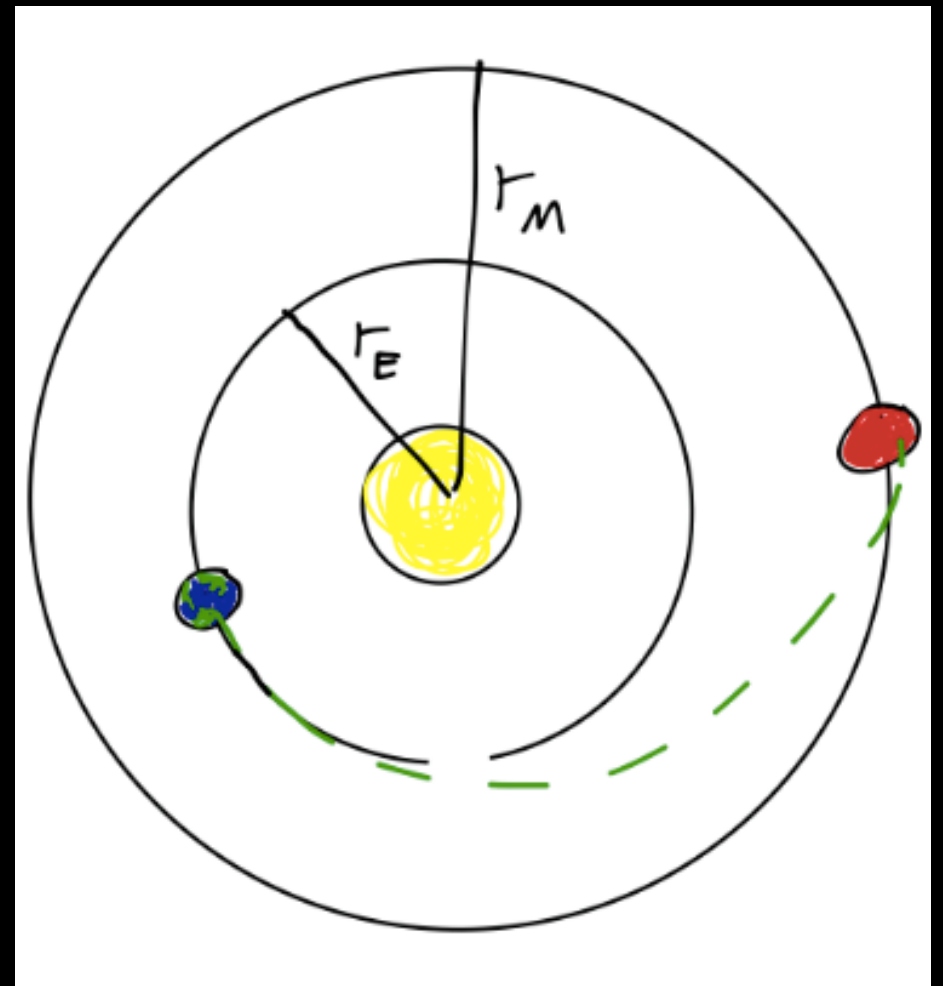
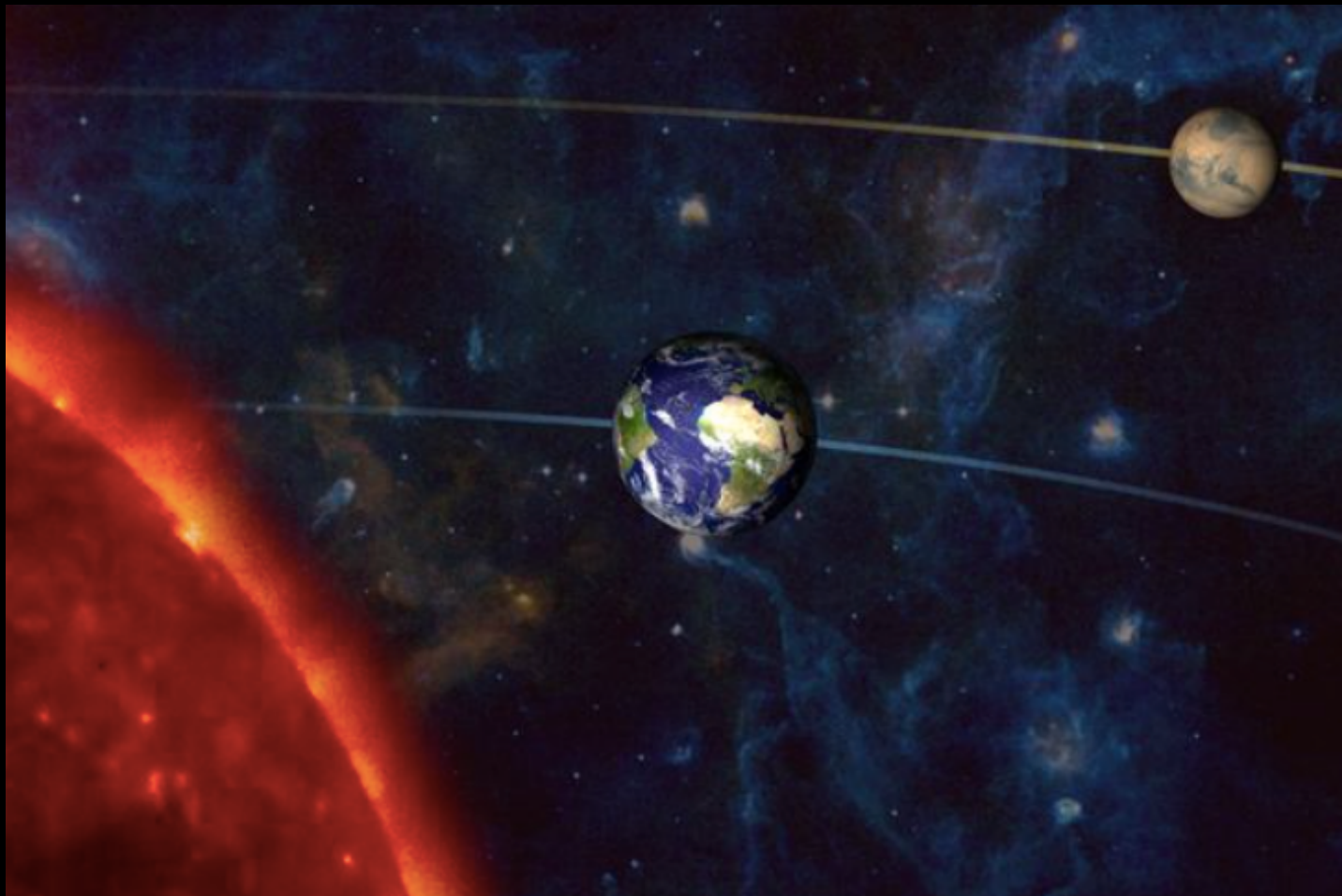
If you weighed 100 lbs on Earth,
you would weigh only 38 lbs on Mars!

#JOURNEYTOMARS
mars.nasa.gov

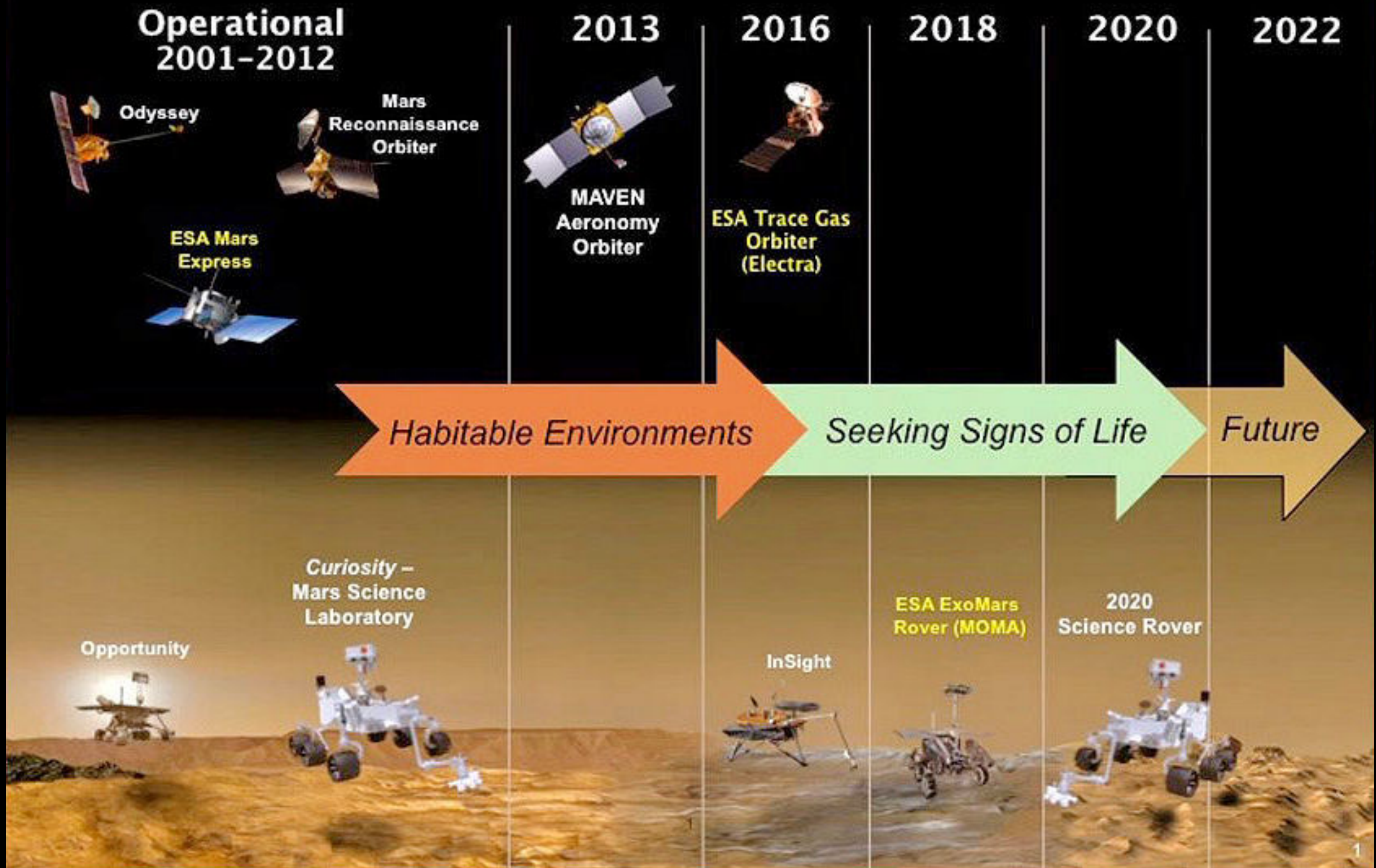


HOHMANN TRANSFER ORBIT

- The most efficient route to take from Earth's orbit to that of Mars
- Mars oppositions happen about every 26 months (May 2016)



Mars Missions in This Decade



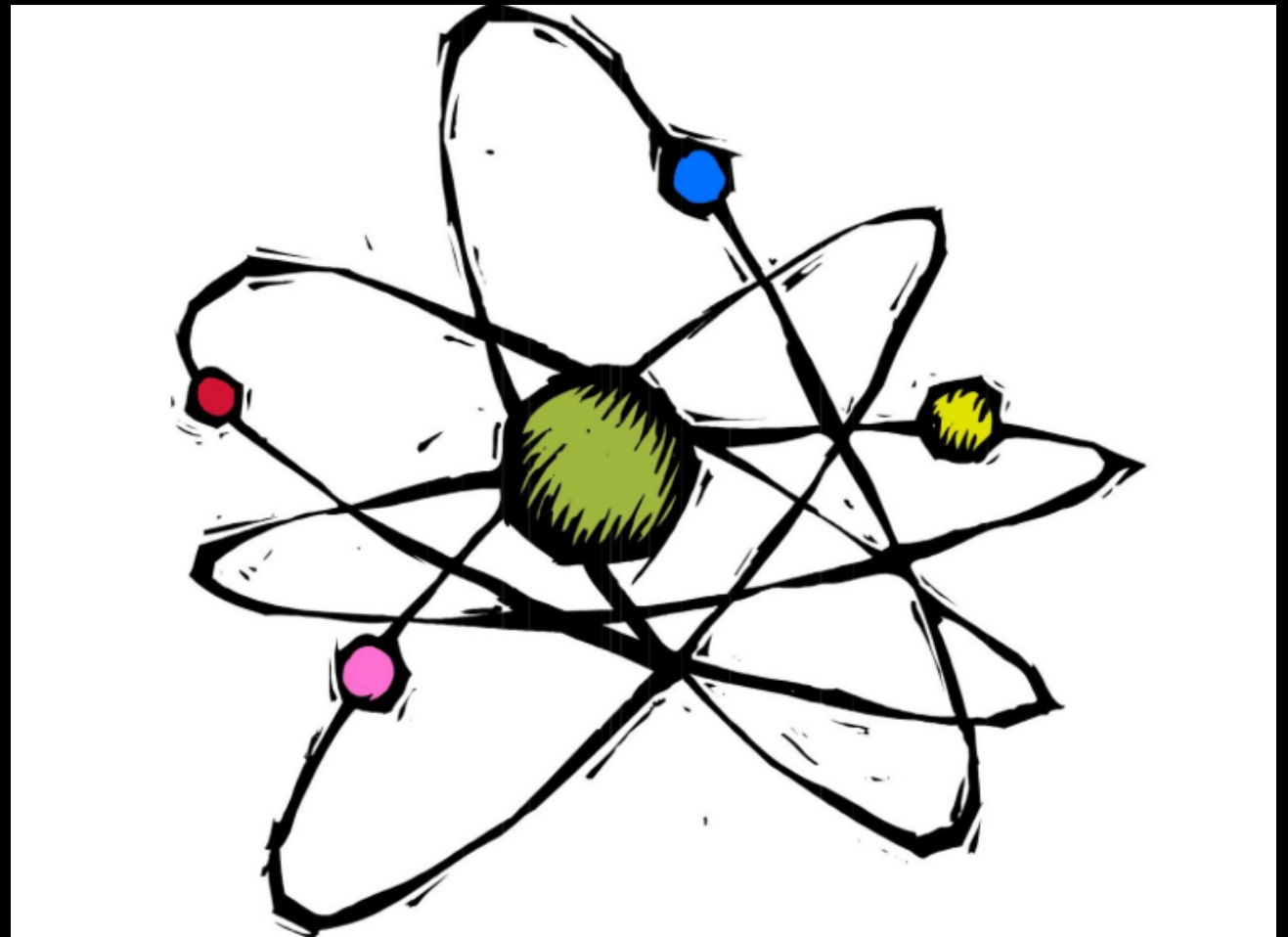
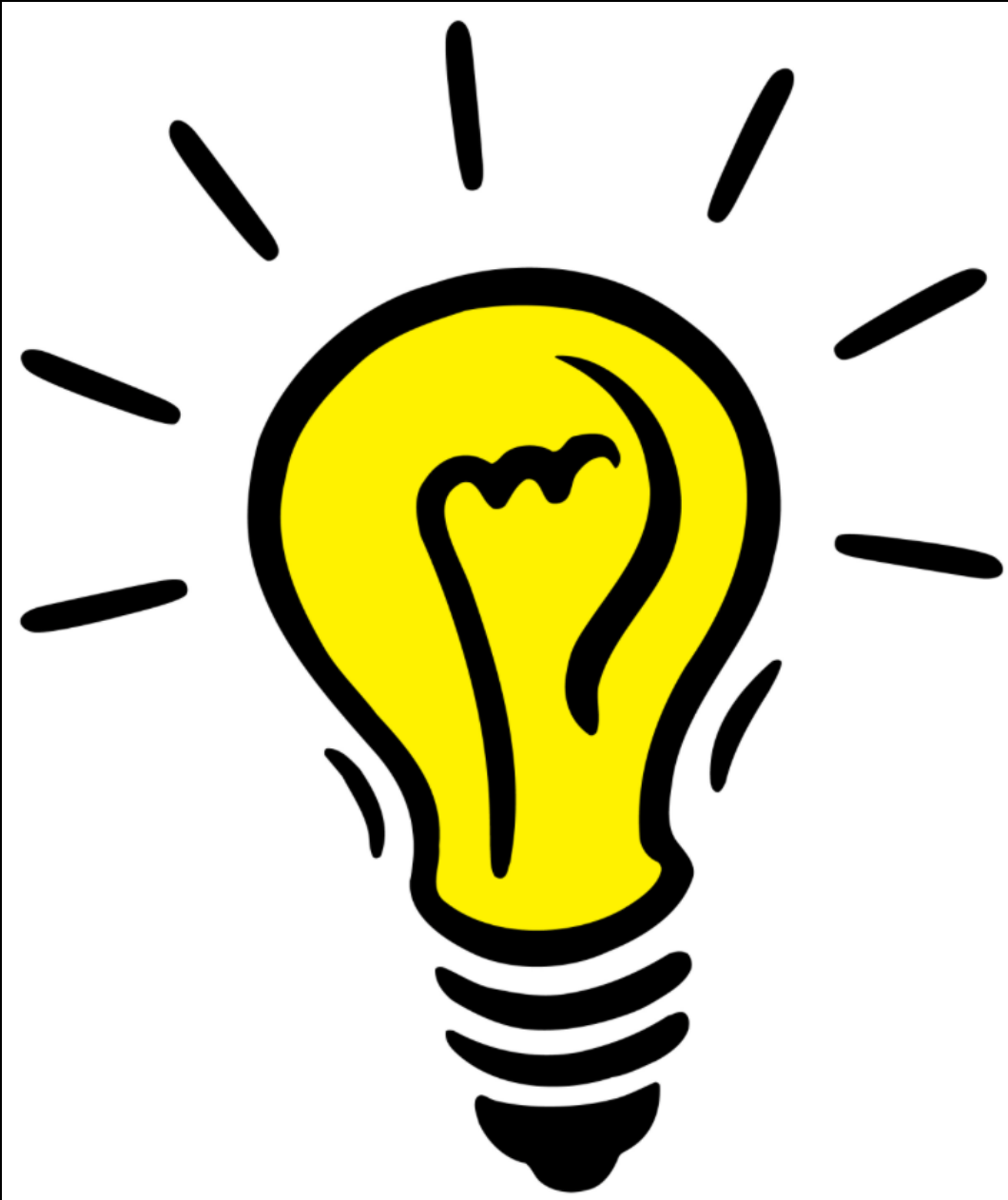
WE ARE ABLE TO SEND ROBOTS TO MARS
SO WHY DON'T WE SEND HUMANS?

IS IT SAFE TO GO TO MARS?

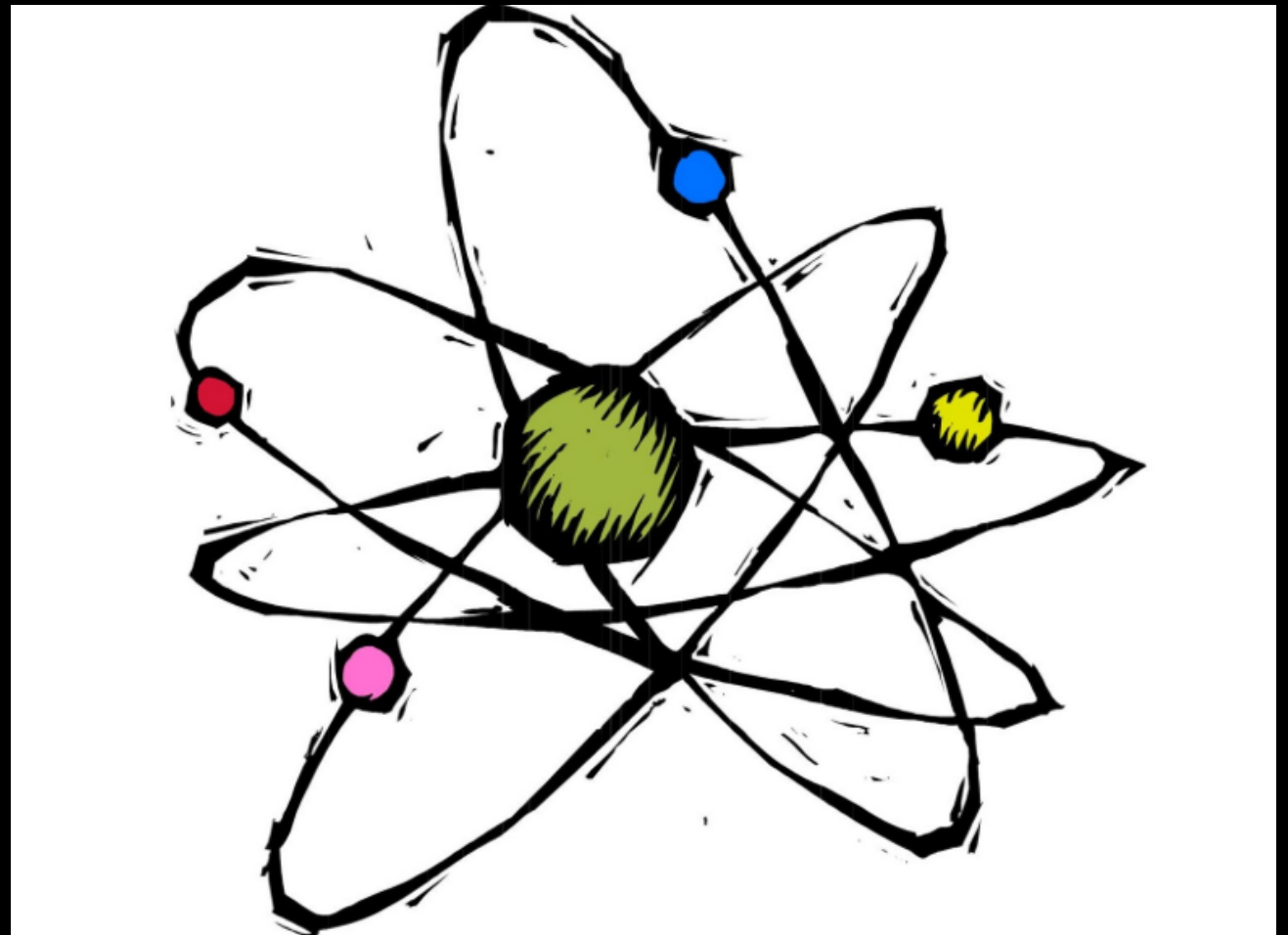
IS THE SPACE EMPTY?

INTERSTELLAR MEDIUM IS FILLED
WITH SPACE RADIATION

WHAT ARE COSMIC RAYS?

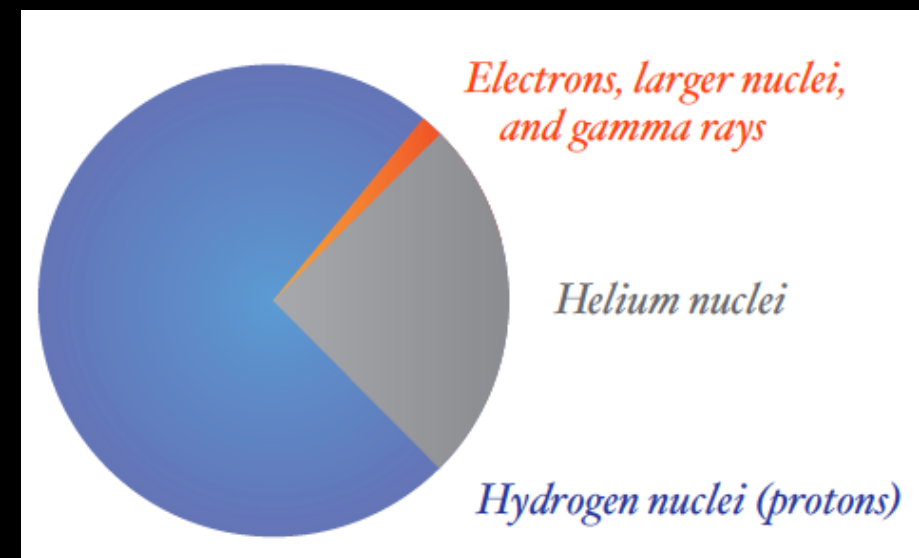
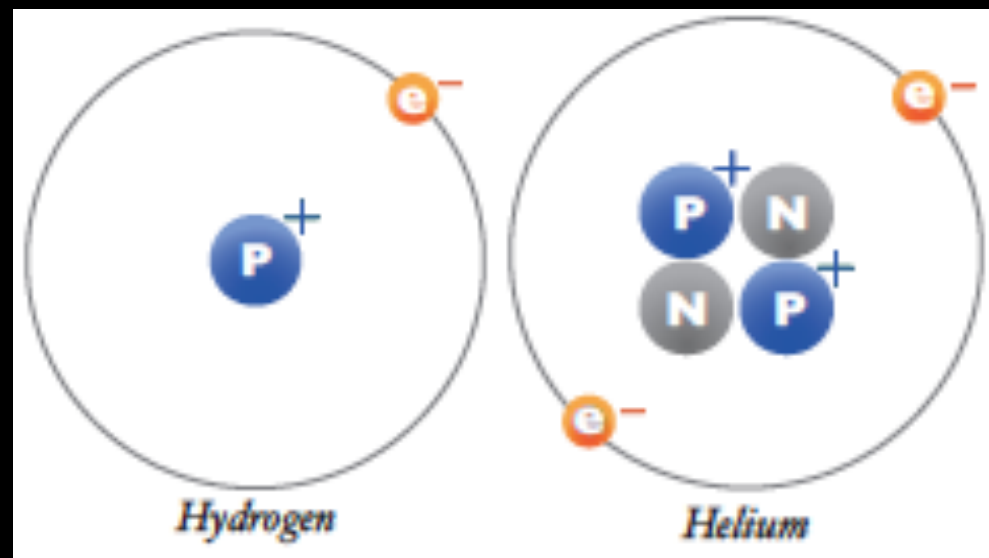


WHAT ARE COSMIC RAYS?

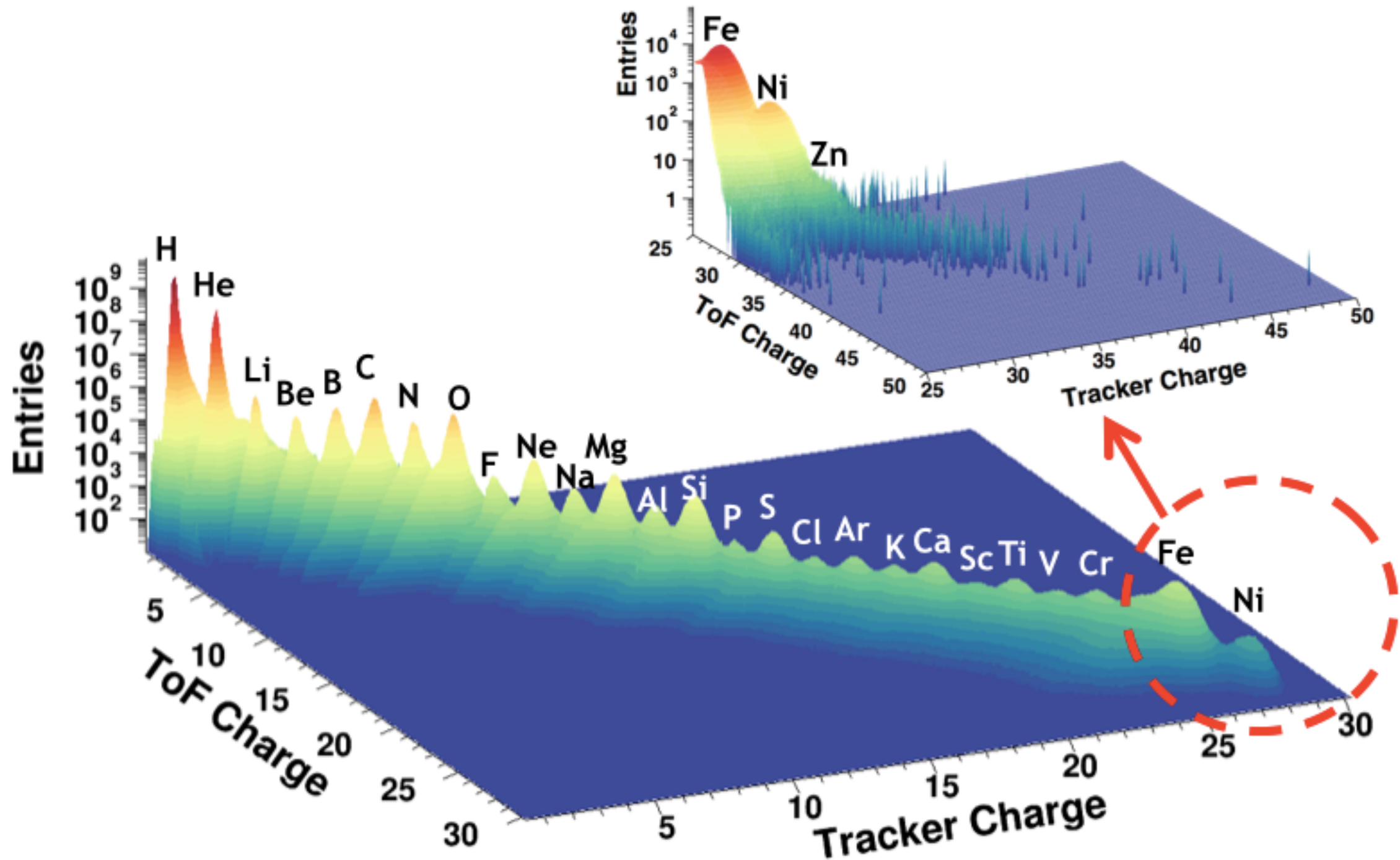


WHAT ARE COSMIC RAYS?

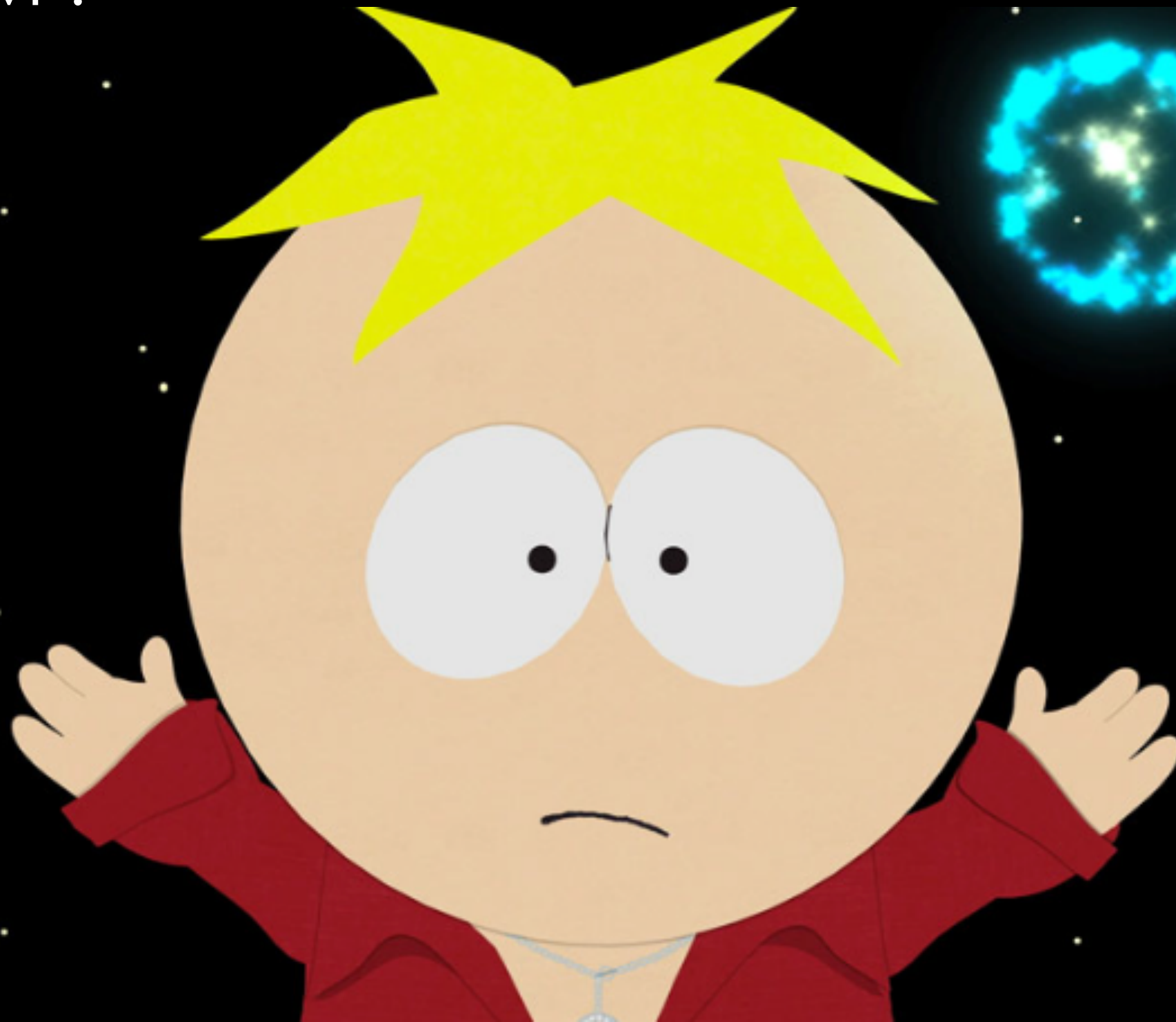
- CR are charged particles composed of the same subatomic particles that make up all matter on Earth (H, He, ions).
- About 79% of all CRs are nuclei of hydrogen atoms (protons), almost 14% are nuclei of Helium and 7% are heavier nuclei. The rest consist of electrons and extremely energetic light rays known as gamma rays.



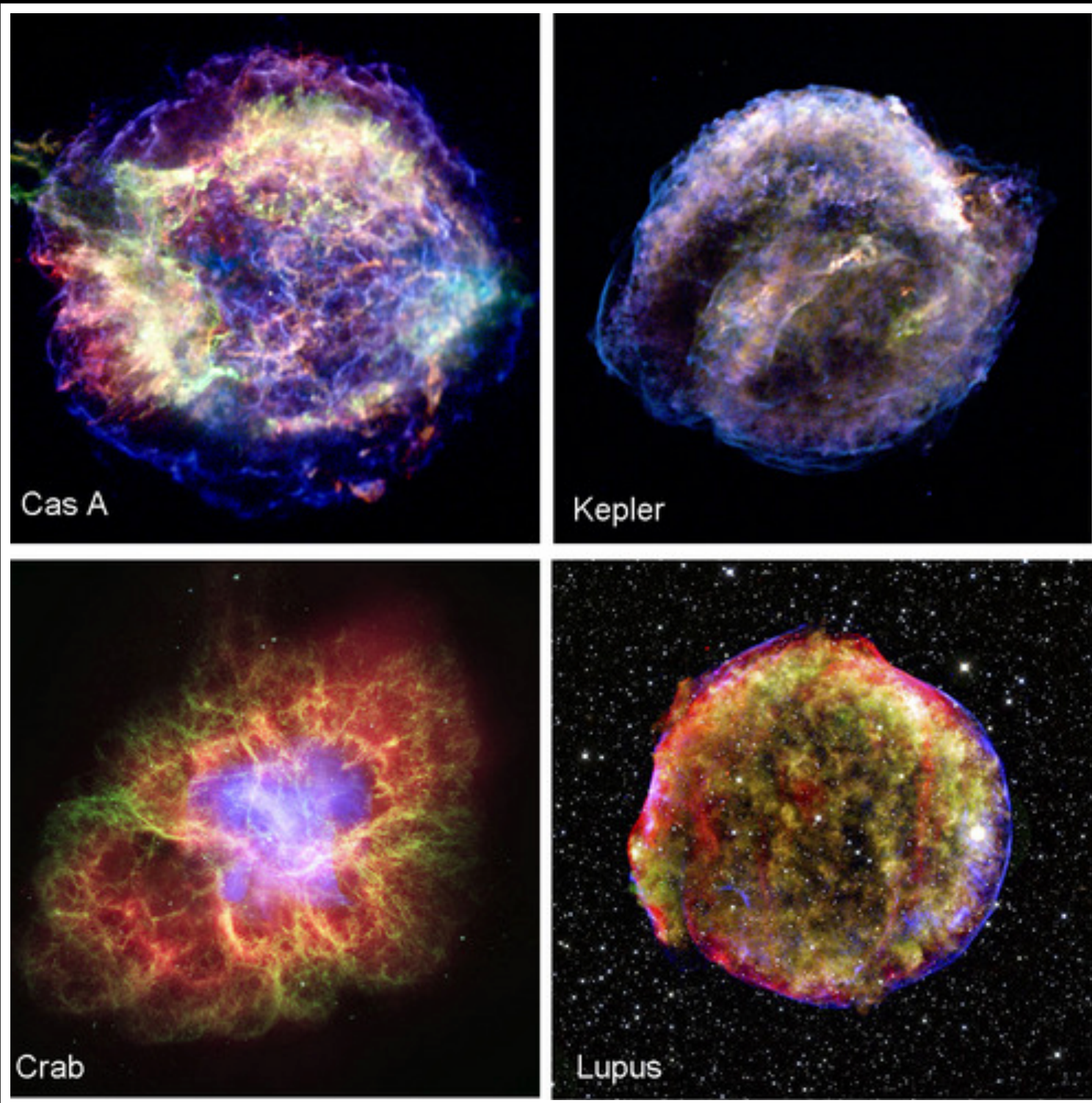
WHAT ARE COSMIC RAYS?



WHERE DO COSMIC RAYS COME
FROM?



WHERE DO GALACTIC COSMIC RAYS COME FROM?



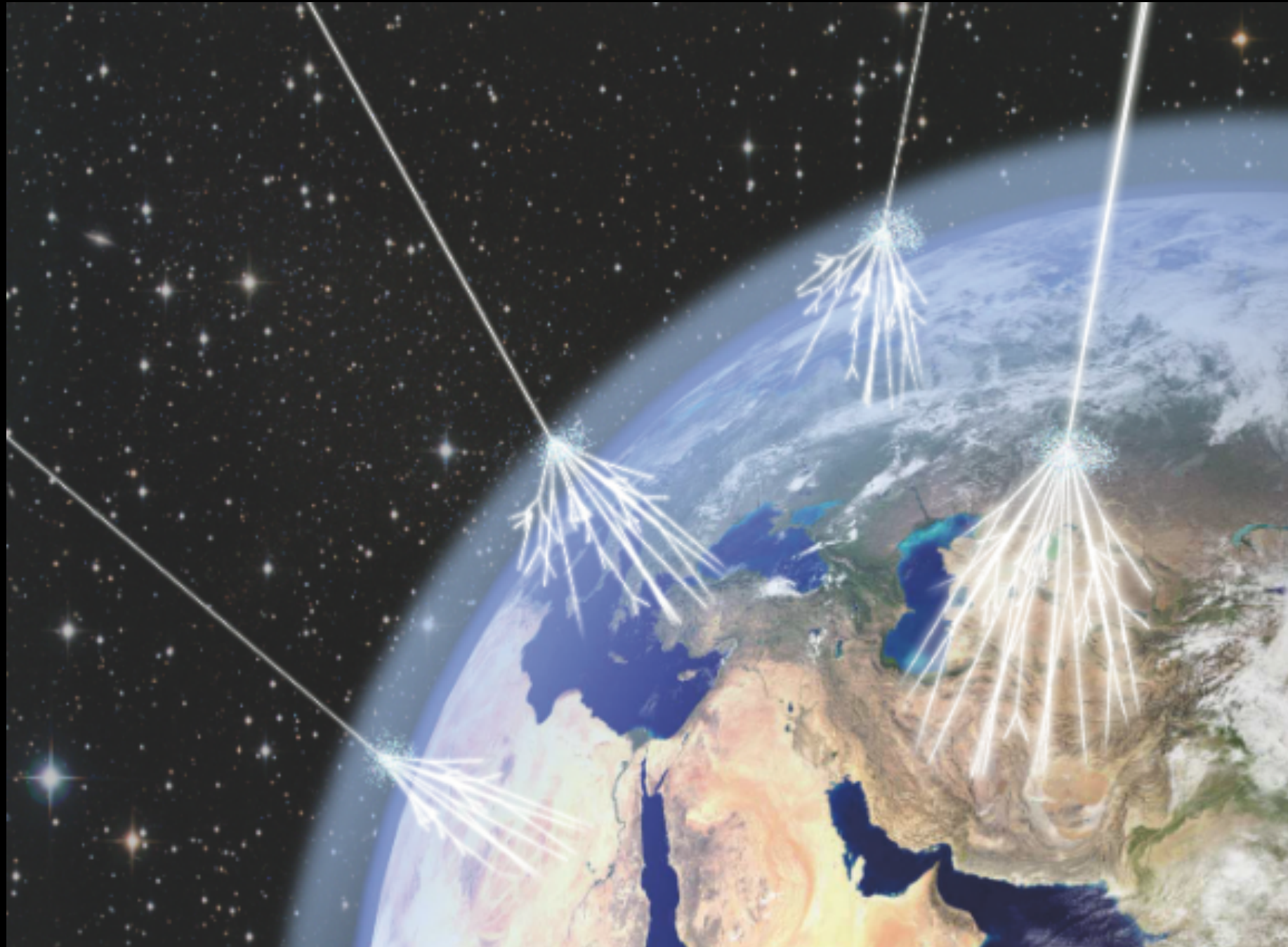
COSMIC RAYS FROM THE SUN: SOLAR ENERGETIC PARTICLES



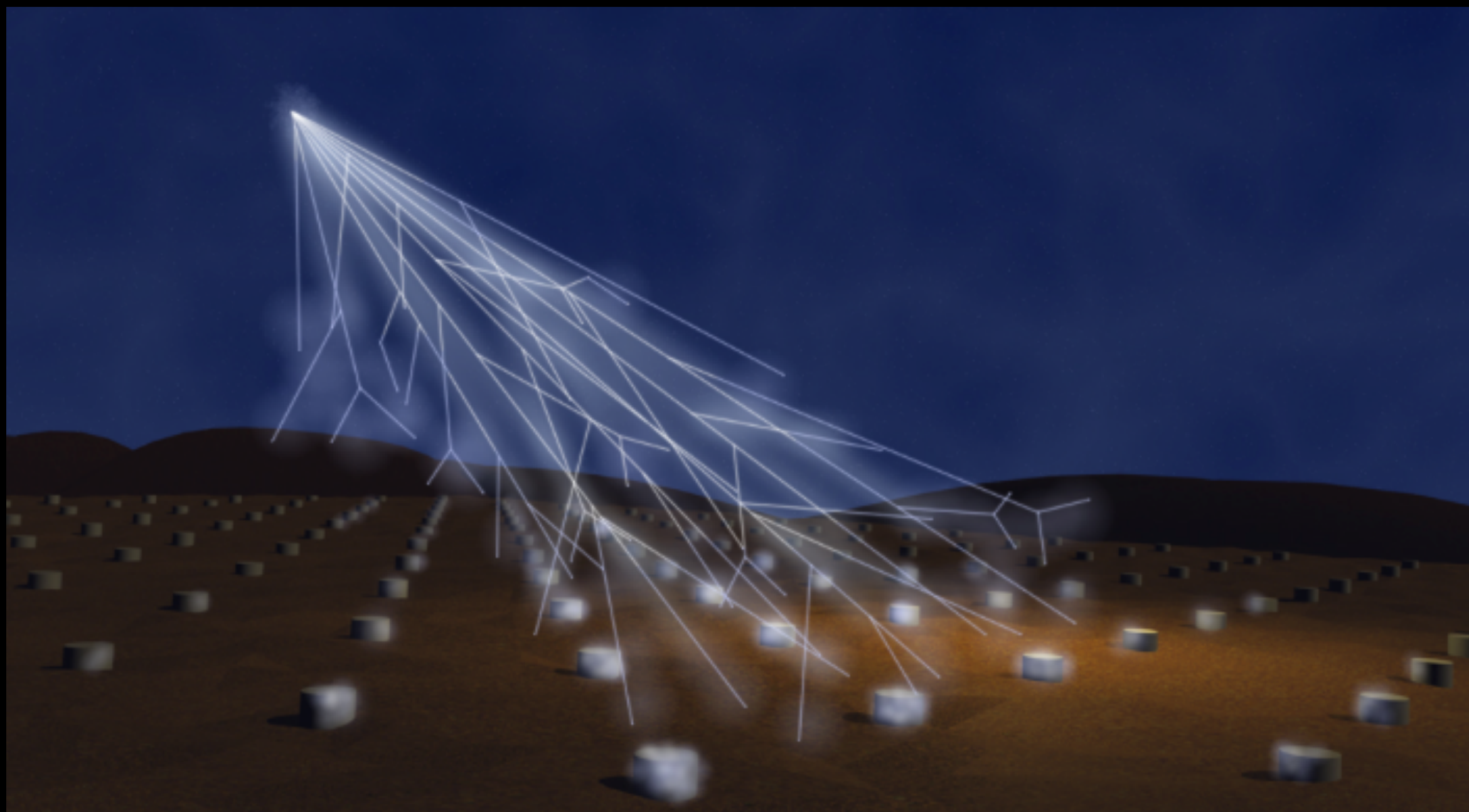
SOLAR FLARES AND CORONAL MASS EJECTIONS

- The Sun at its maximum of its activity, can experience many explosive events, such as flares and coronal mass ejections (CMEs).
- The largest and most energetic of these explosive events can accelerate charged particles that can reach Earth from a few minutes till a few days.

EARTH IS CONSTANTLY BOMBARDED BY COSMIC RAYS

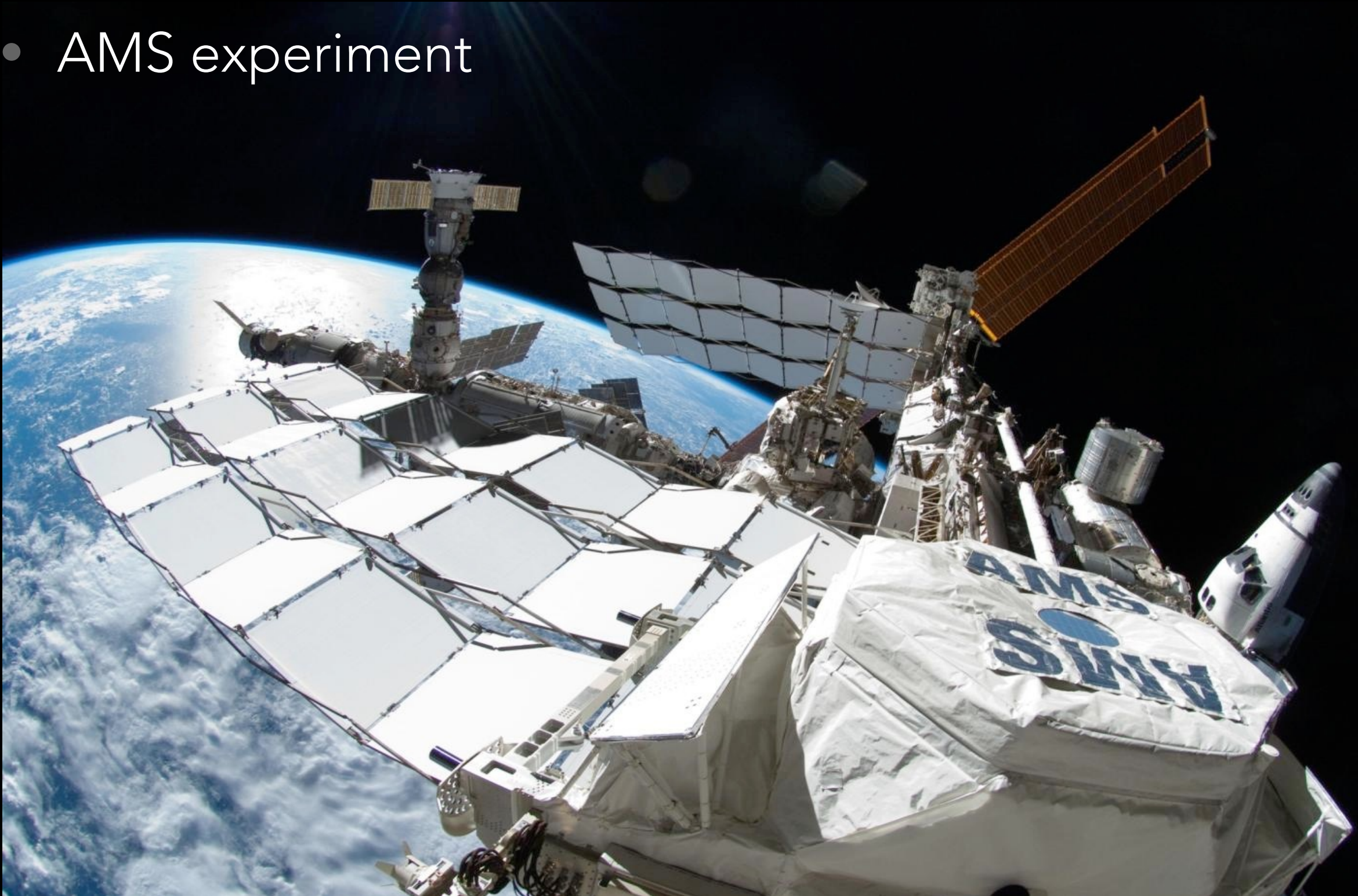


COSMIC RAY AIR SHOWERS



DIRECT MEASUREMENT OF CR

- AMS experiment



AMS-02

Size: 5m x 4m x 3m (16ft x 13ft x 10ft)

Weight: 7 ton (15000 lbs)

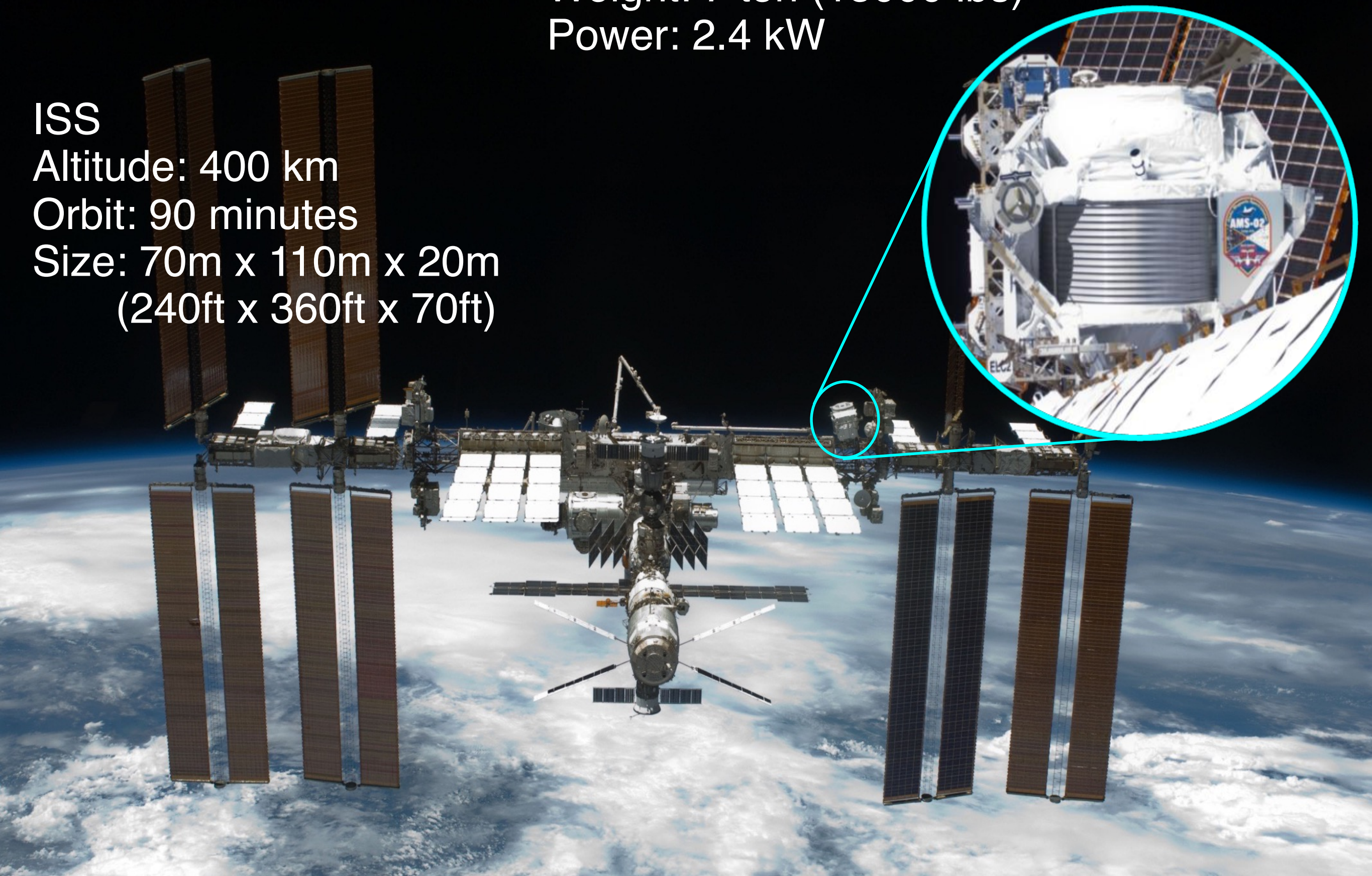
Power: 2.4 kW

ISS

Altitude: 400 km

Orbit: 90 minutes

Size: 70m x 110m x 20m
(240ft x 360ft x 70ft)





AMS-02 Journey



May 16, 2011: AMS Flight, Space Shuttle Endeavor

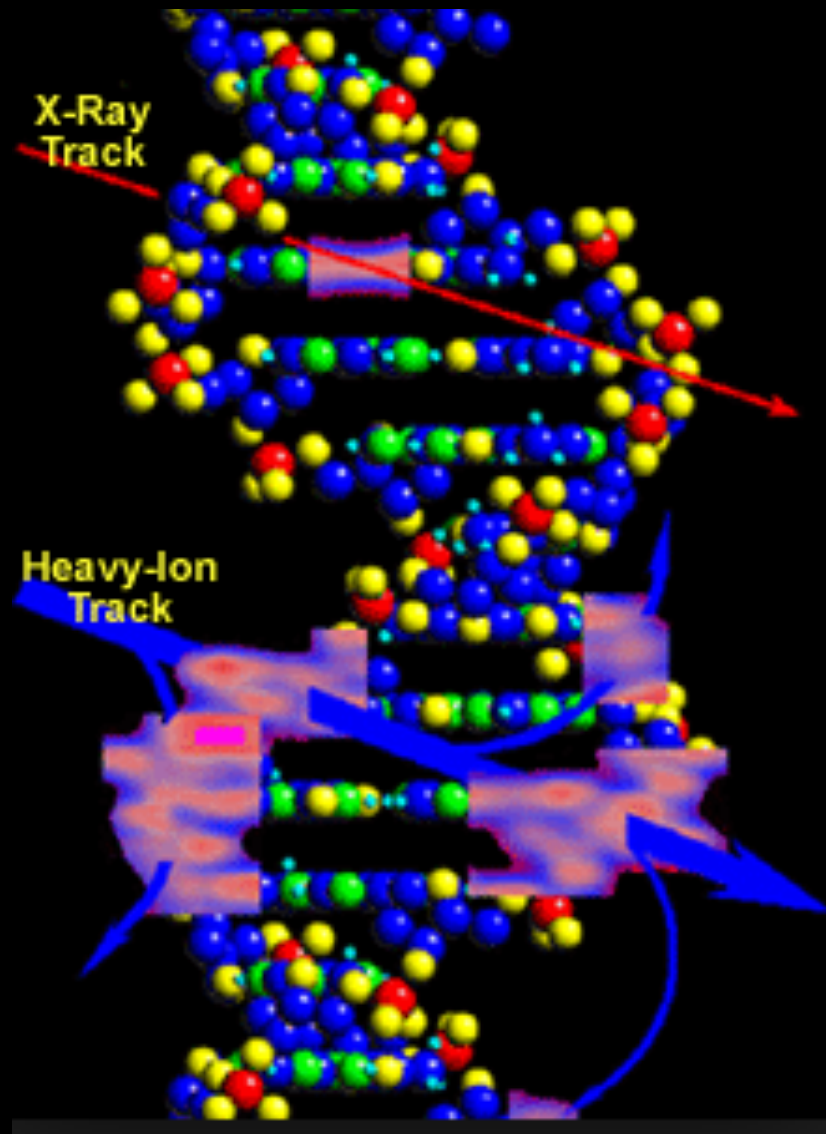
AMS-02 ON THE ISS TILL 2024



**May 19, 2011: AMS installation
completed at 5:15 AM.
Data taking started at 9:35 AM**

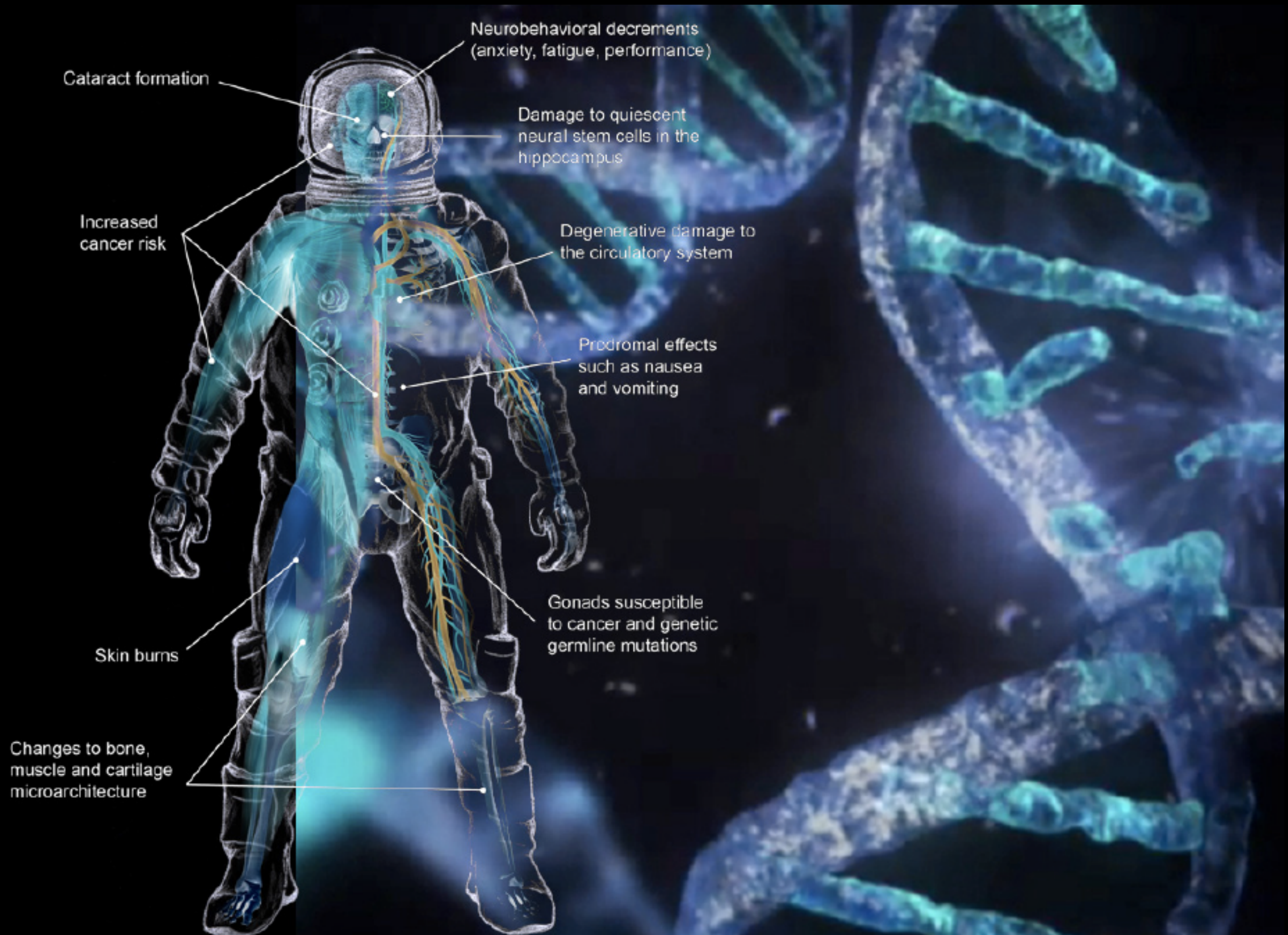
CR are not harmful at EARTH but... what about in space?

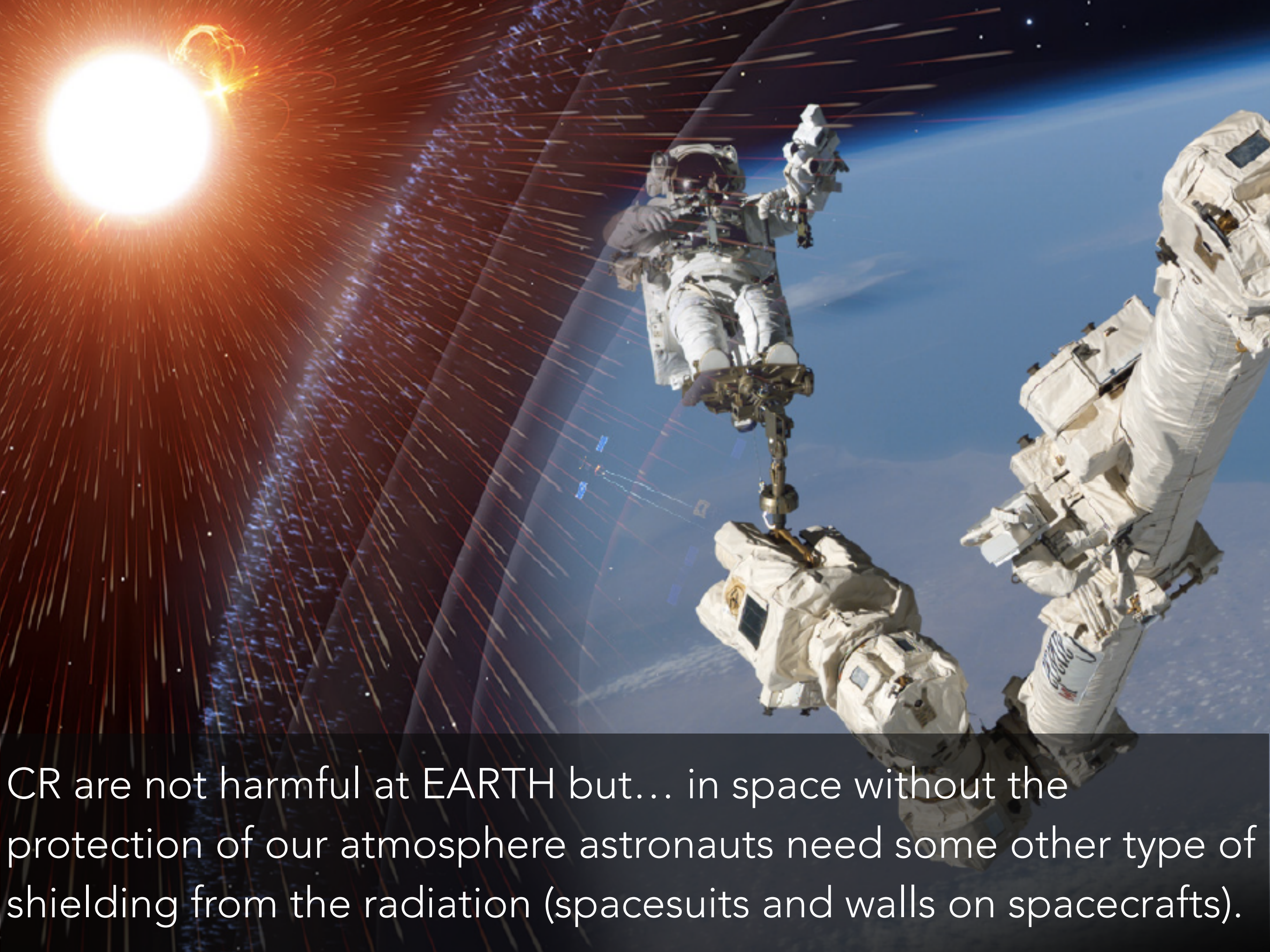
SPACE RADIATION



Cosmic rays and solar energetic particles represent a real problem for the safe leaving of astronauts in space. These particles easily penetrate shuttle and space station walls and astronauts suits, as well as human skin, cells, and DNA.

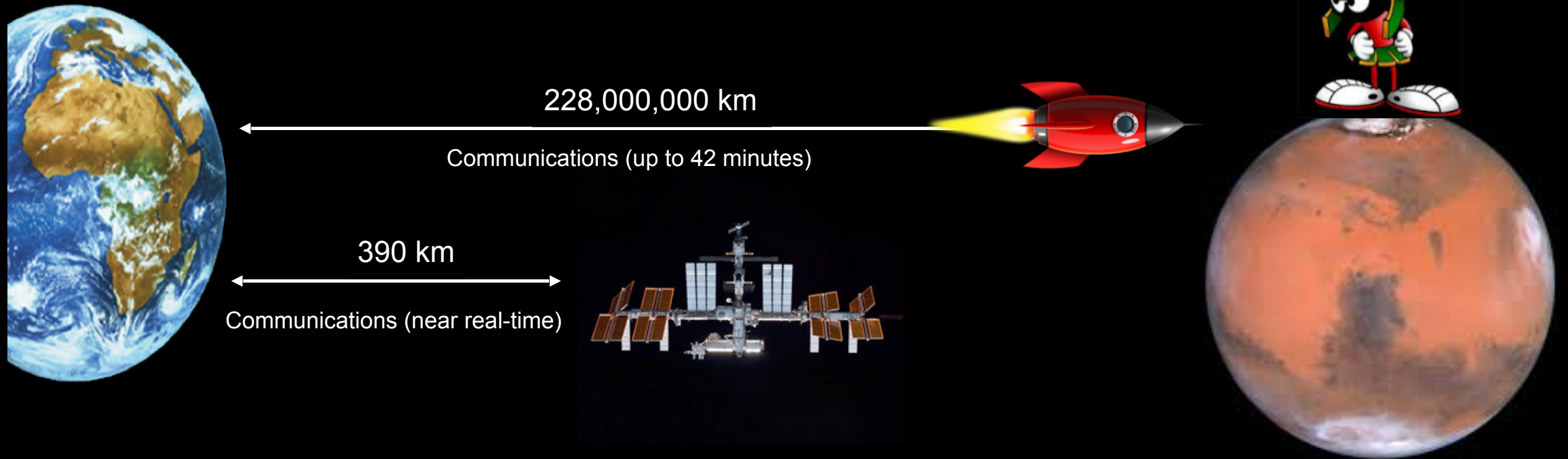
EFFECTS OF RADIATION





CR are not harmful at EARTH but... in space without the protection of our atmosphere astronauts need some other type of shielding from the radiation (spacesuits and walls on spacecrafts).

JOURNEY TO MARS



- The AMS group at UH works with NASA to improve radiation shielding for astronauts for the coming human mission to Mars.



WHAT WE HAVE LEARNED SO FAR

- We want to send astronauts to Mars. We have sent many robots and learn lots of things about Mars.
- Every two years is when Mars is closer to Earth.
- Space is not empty and is filled by Cosmic Rays. Most of cosmic rays are generated by Super Novae remnants, some others by the Sun and are called solar energetic particles.
- Atmosphere protects us from cosmic rays but astronauts in Space are not shielded and their body is exposed to this space radiation which is one of the main concerns for human exploration.
- NASA and UH are working together to study this radiation and find possible solutions to make Mars human exploration possible.

- Let's have a break!

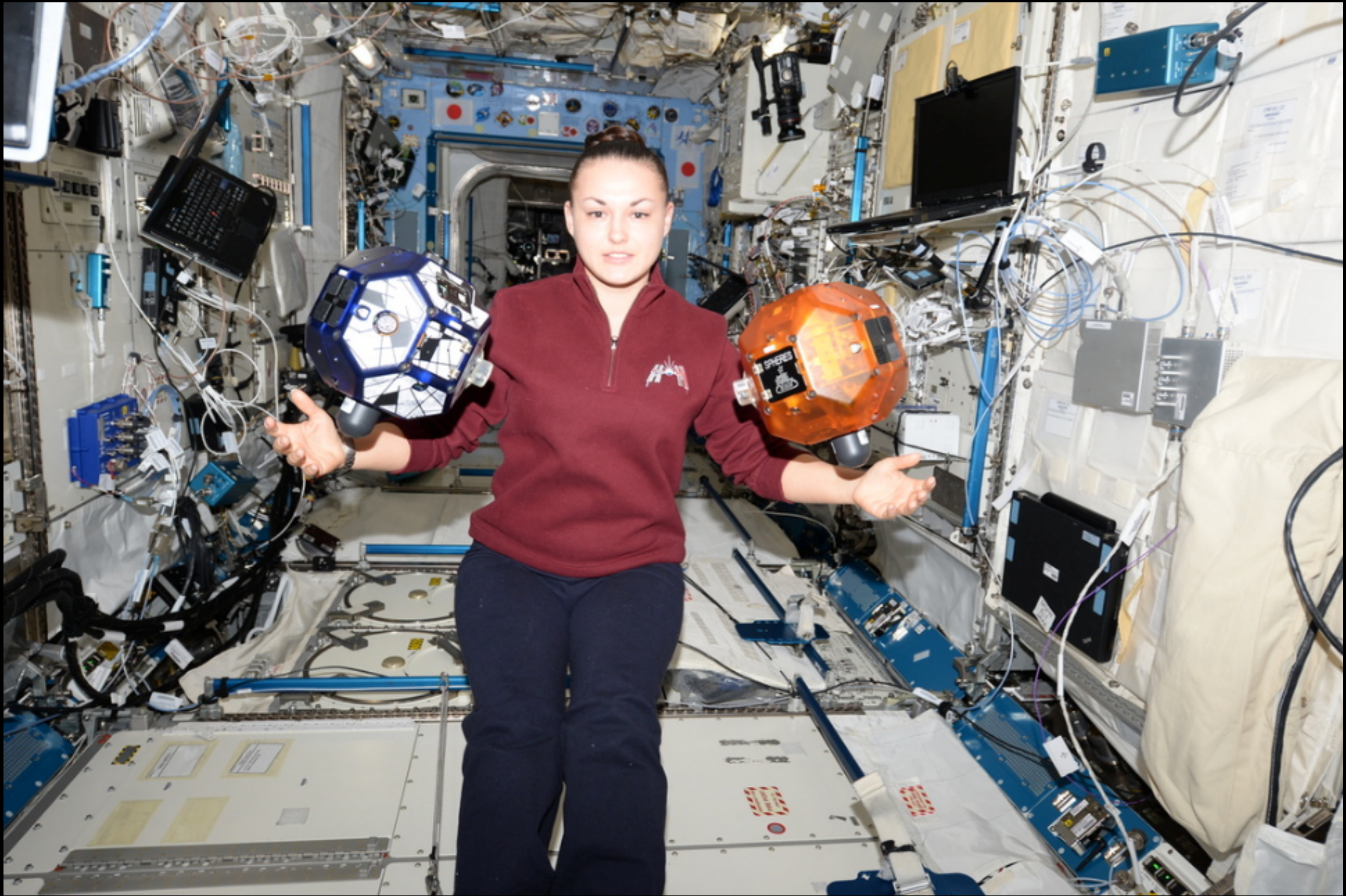


A large, spherical space station with a circular hatch, floating in space above the Earth's blue horizon. The station has a complex internal structure visible through the transparent sections. The Earth's horizon is a bright blue curve at the bottom of the frame, with white clouds visible. The background is the black void of space.

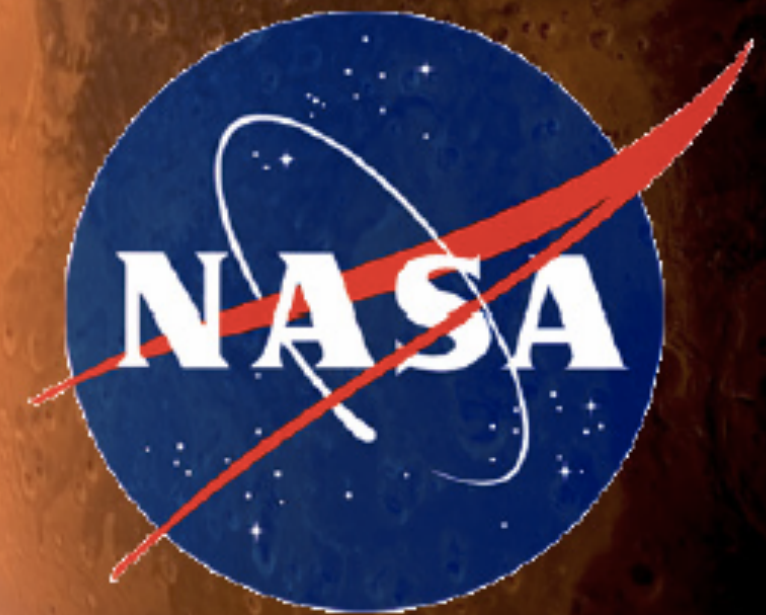
IS AN EXTRA-TERRESTRIAL
SETTLEMENT FEASIBLE FOR
HUMANKIND?

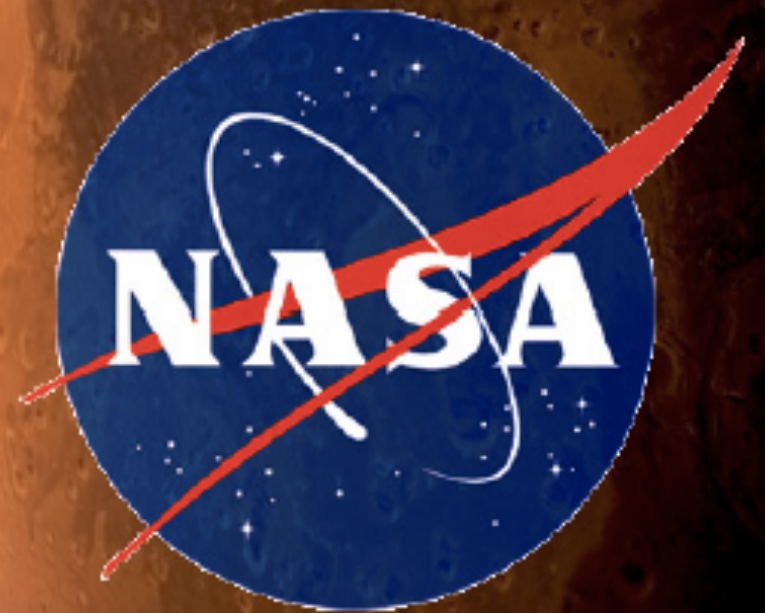
ISS - EXTRATERRESTRIAL COLONY





Humans can live on the ISS for more than a year, monitored from Earth.



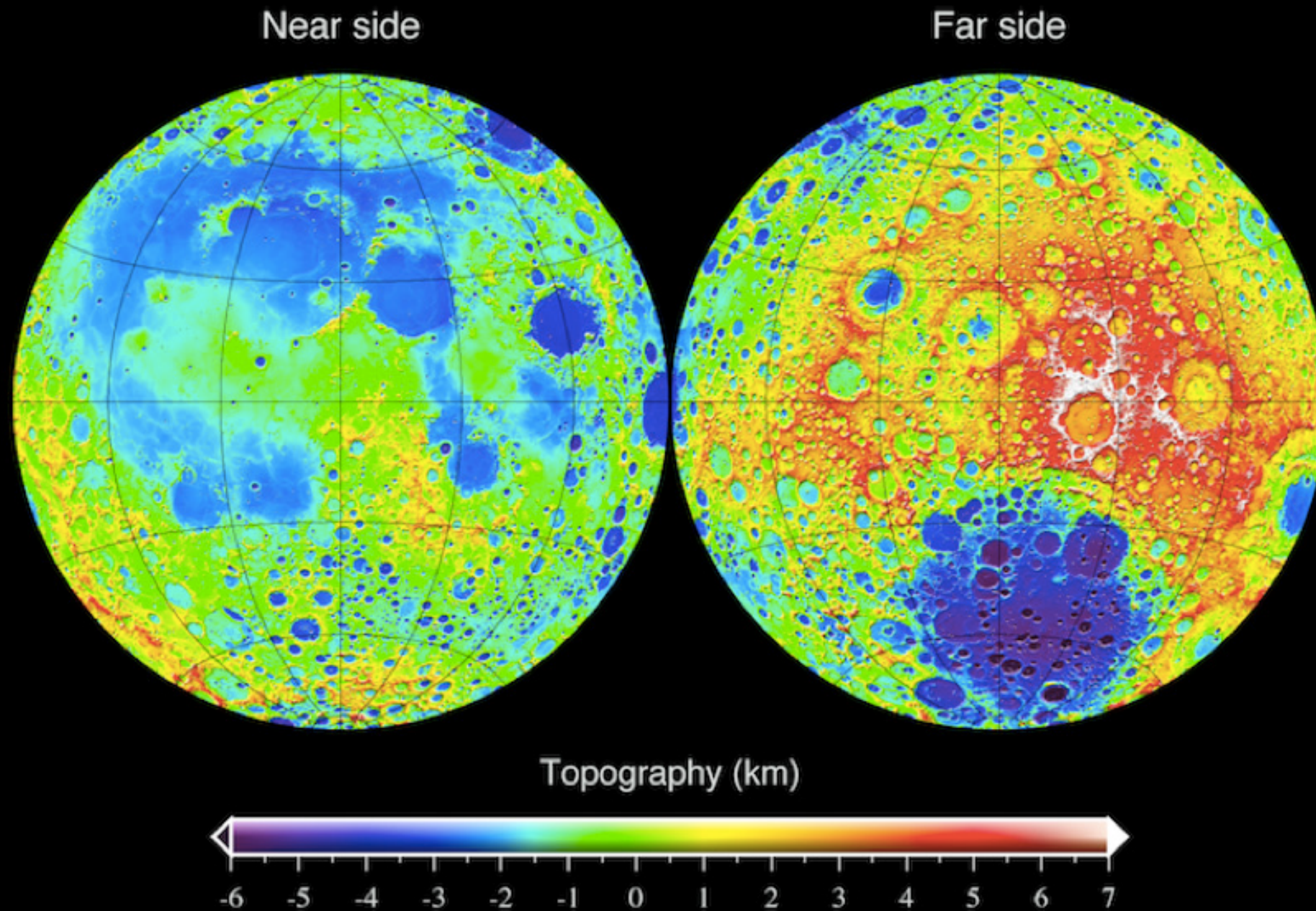


**If it would be up to you to decide,
where would you go? and why?**



Apollo 11, 1969

Moon Village ESA



Working on the project



Sir Norman Foster (Foster and Partner)



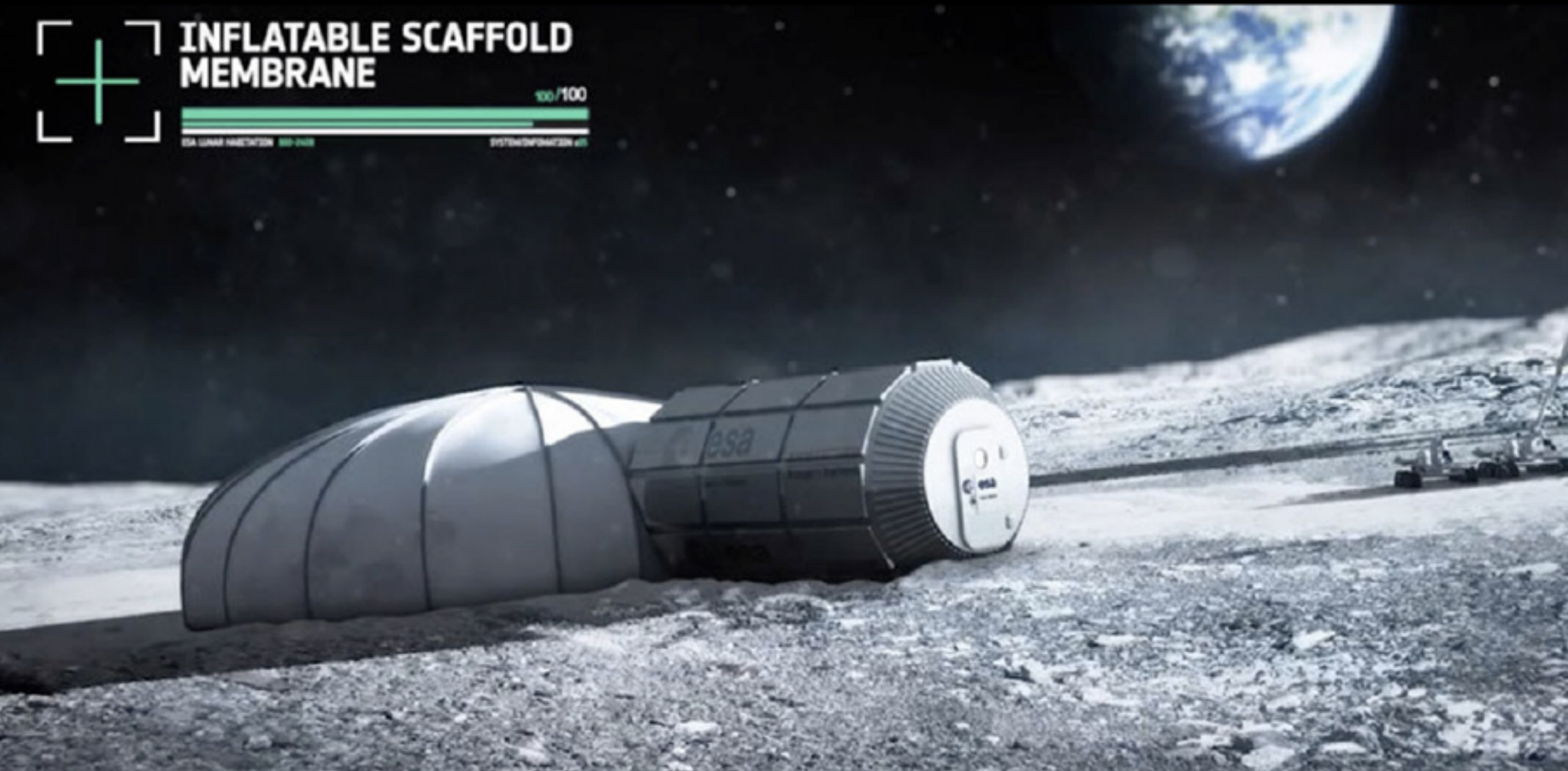
Enrico Dini (Monolite)

MOON VILLAGE



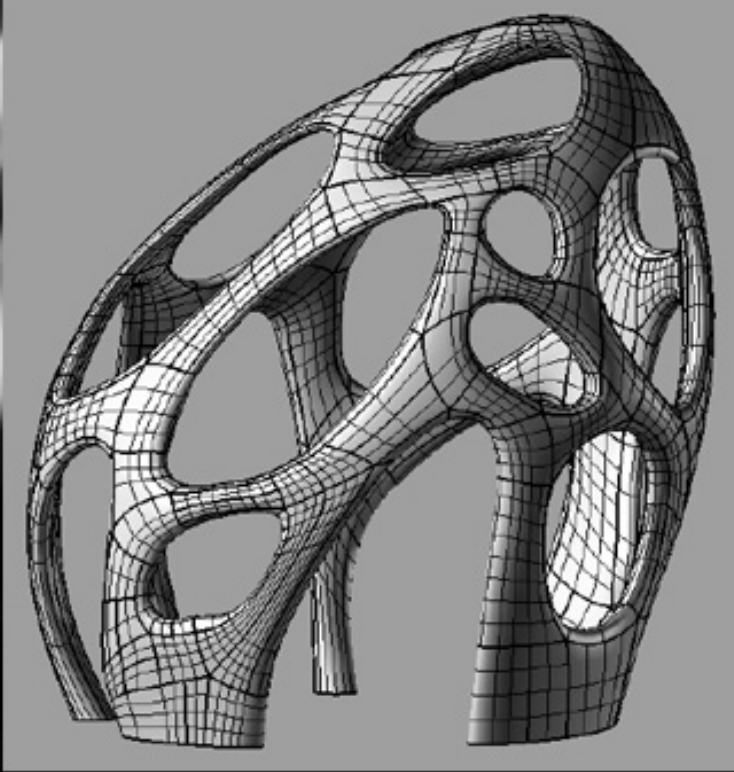
INFLATABLE SCAFFOLD MEMBRANE

100/100

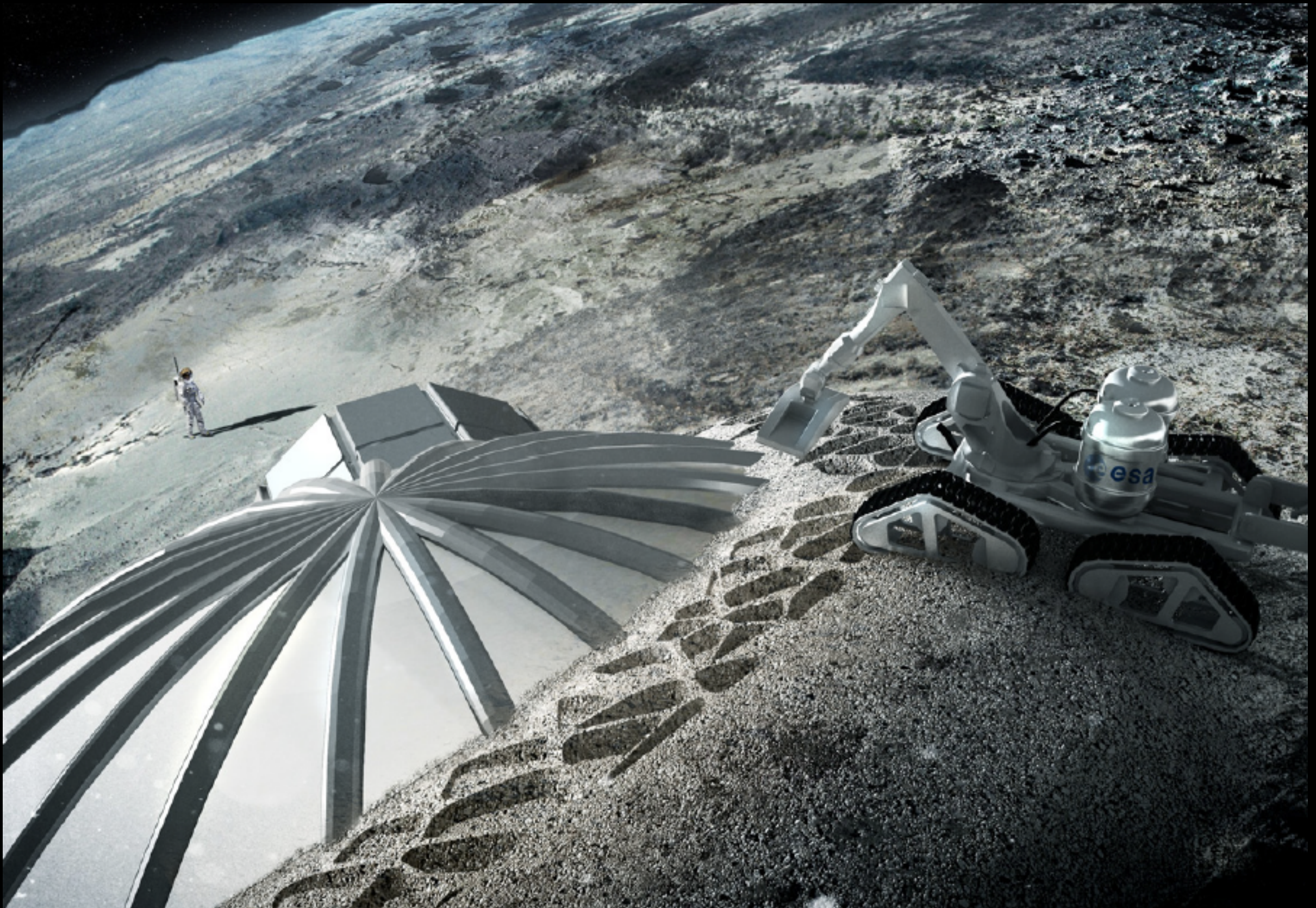


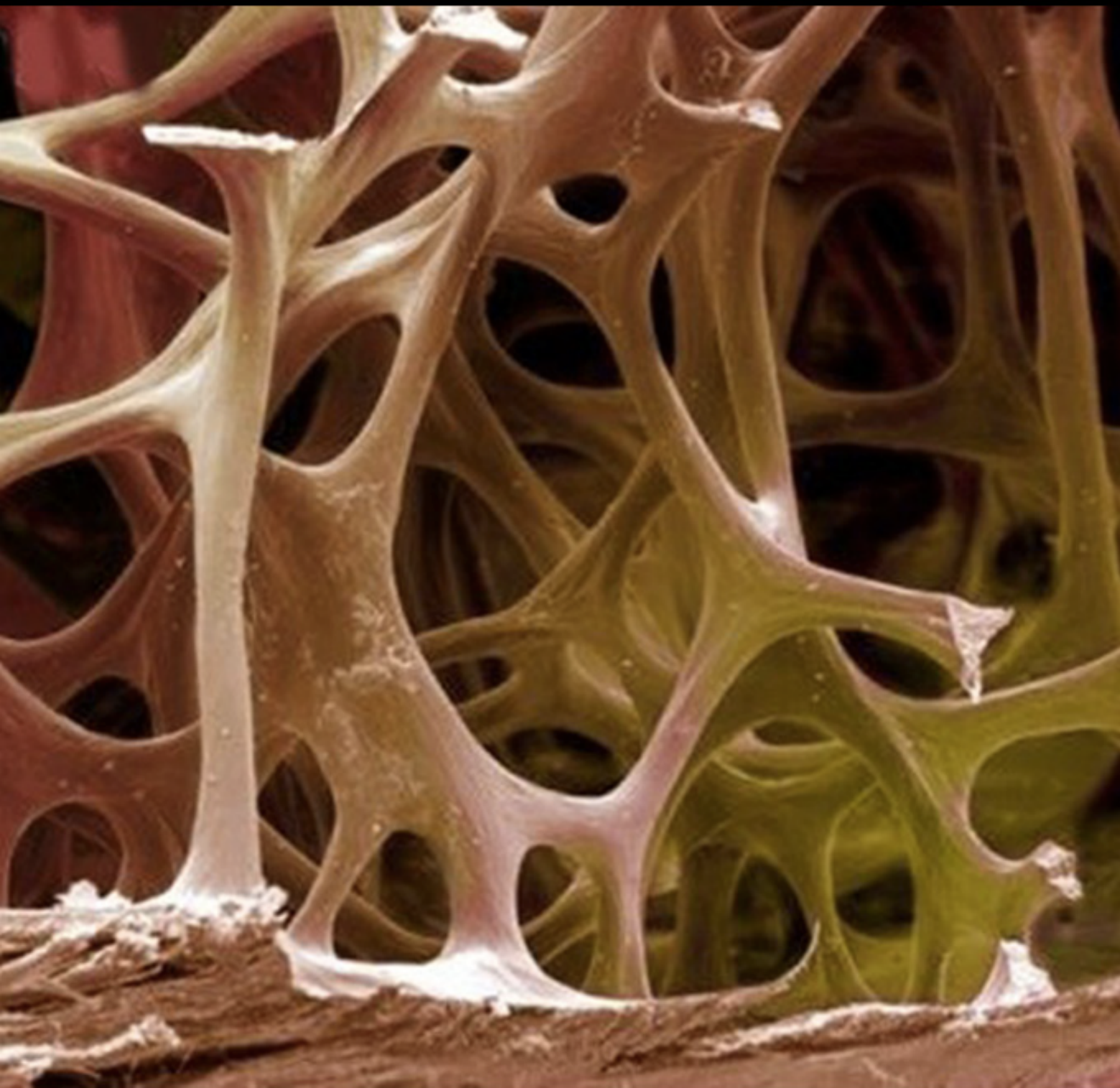
Biomimicry seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies.



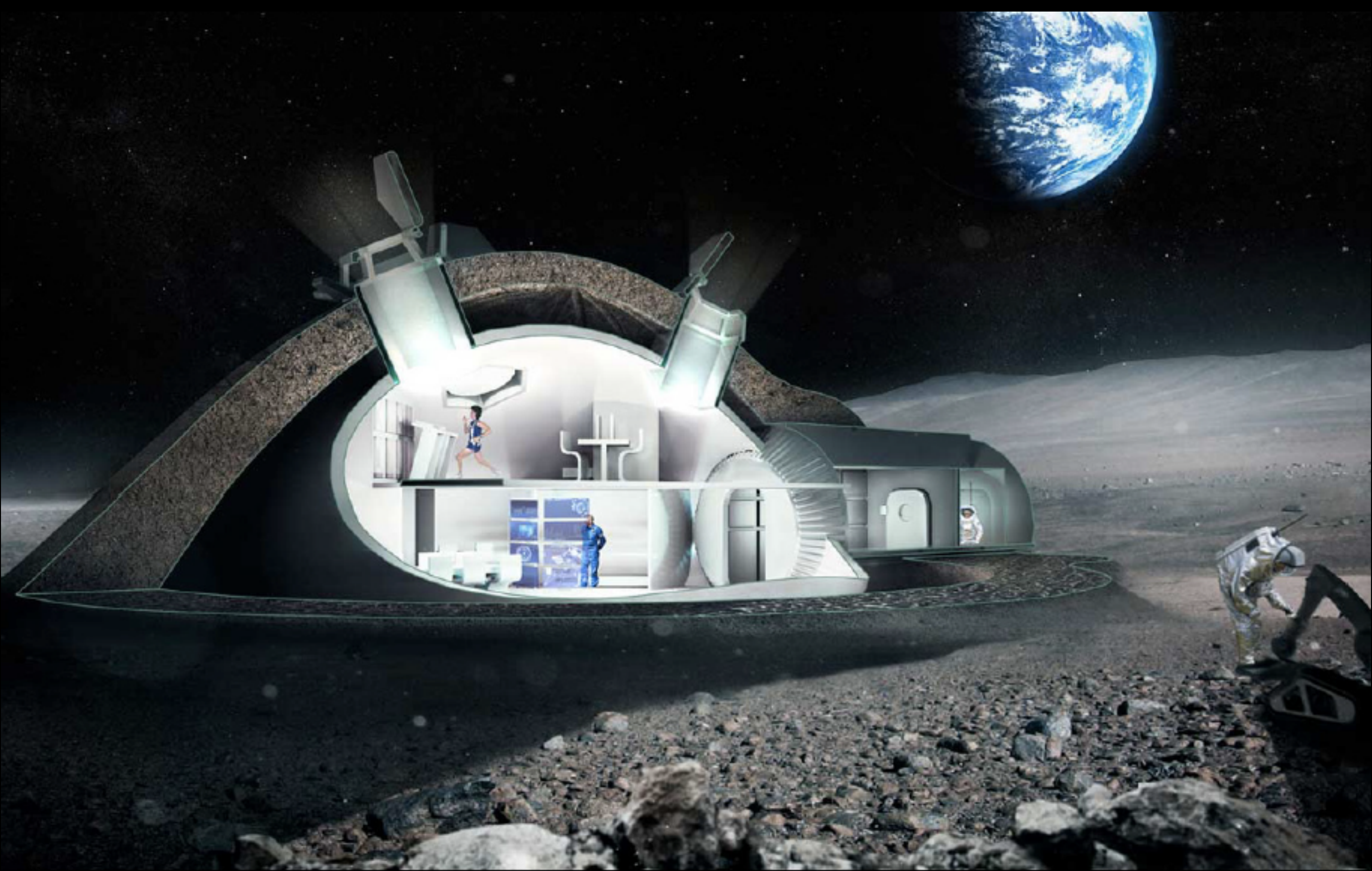


honeycomb structure built by 3-D printing robots





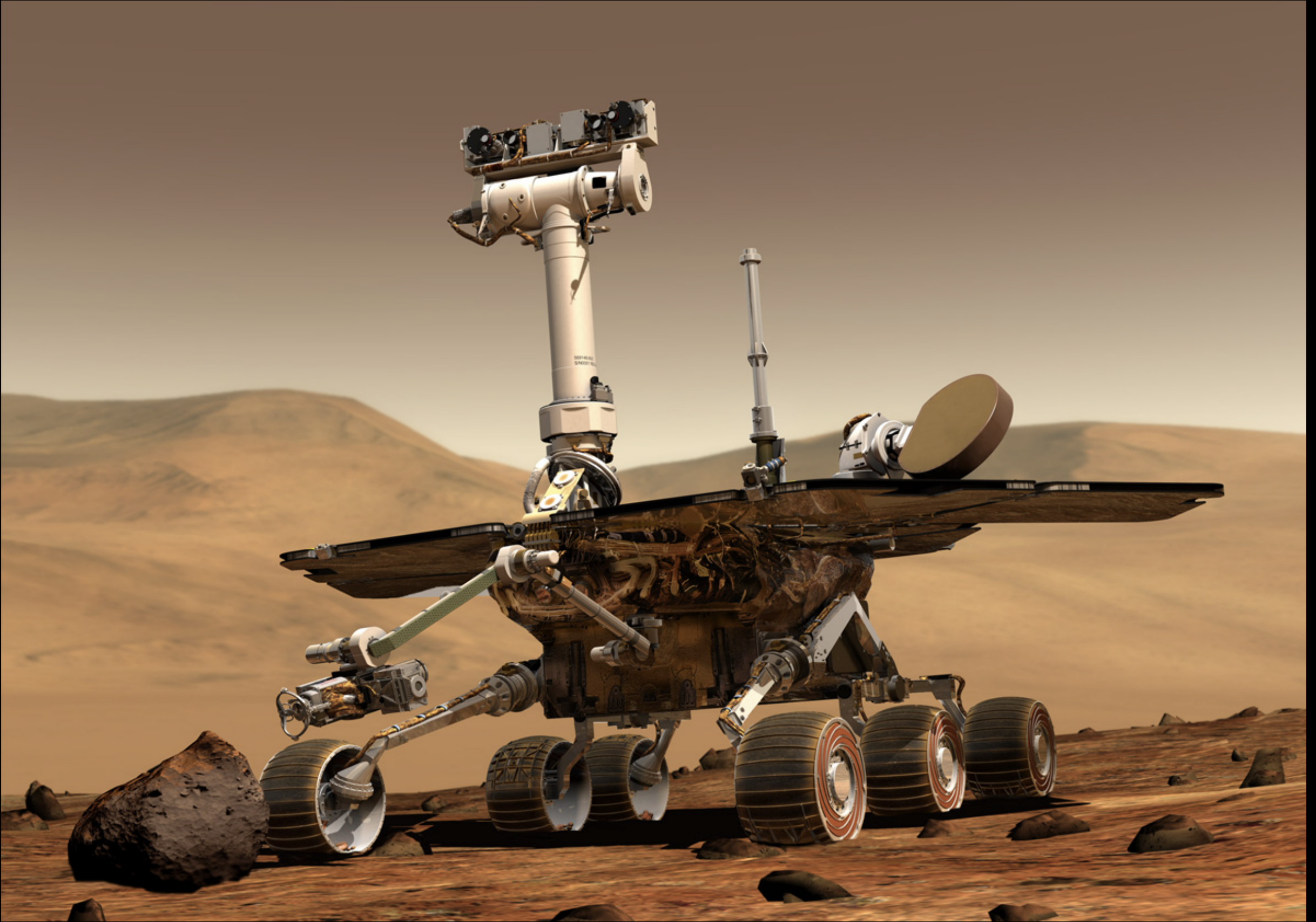






2037

Mars rovers: Spirit and Opportunity



Curiosity taking a Selfie on Mars!

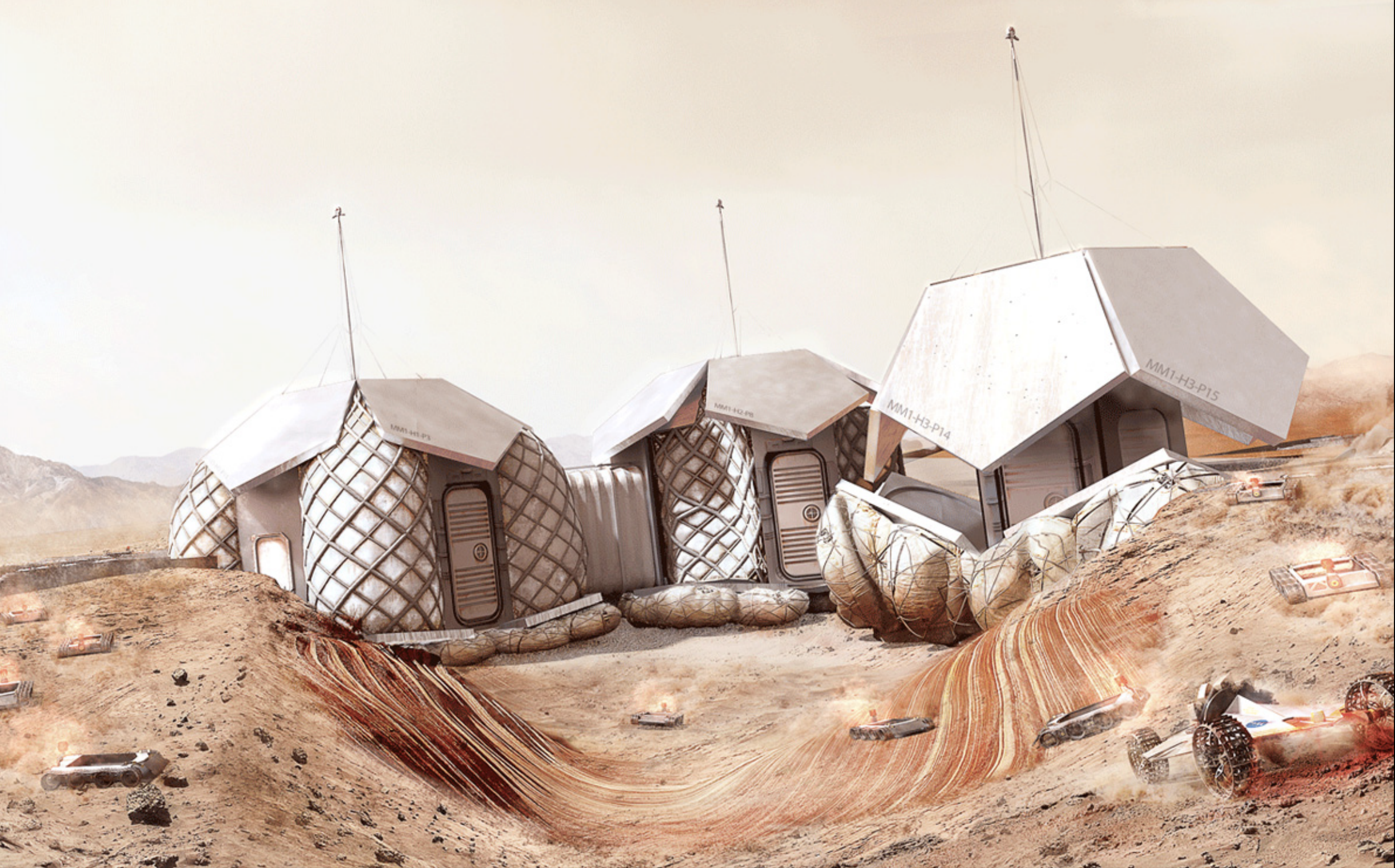




MARS Valles Marineris
grafik.deviantart.com



Foster & Partners



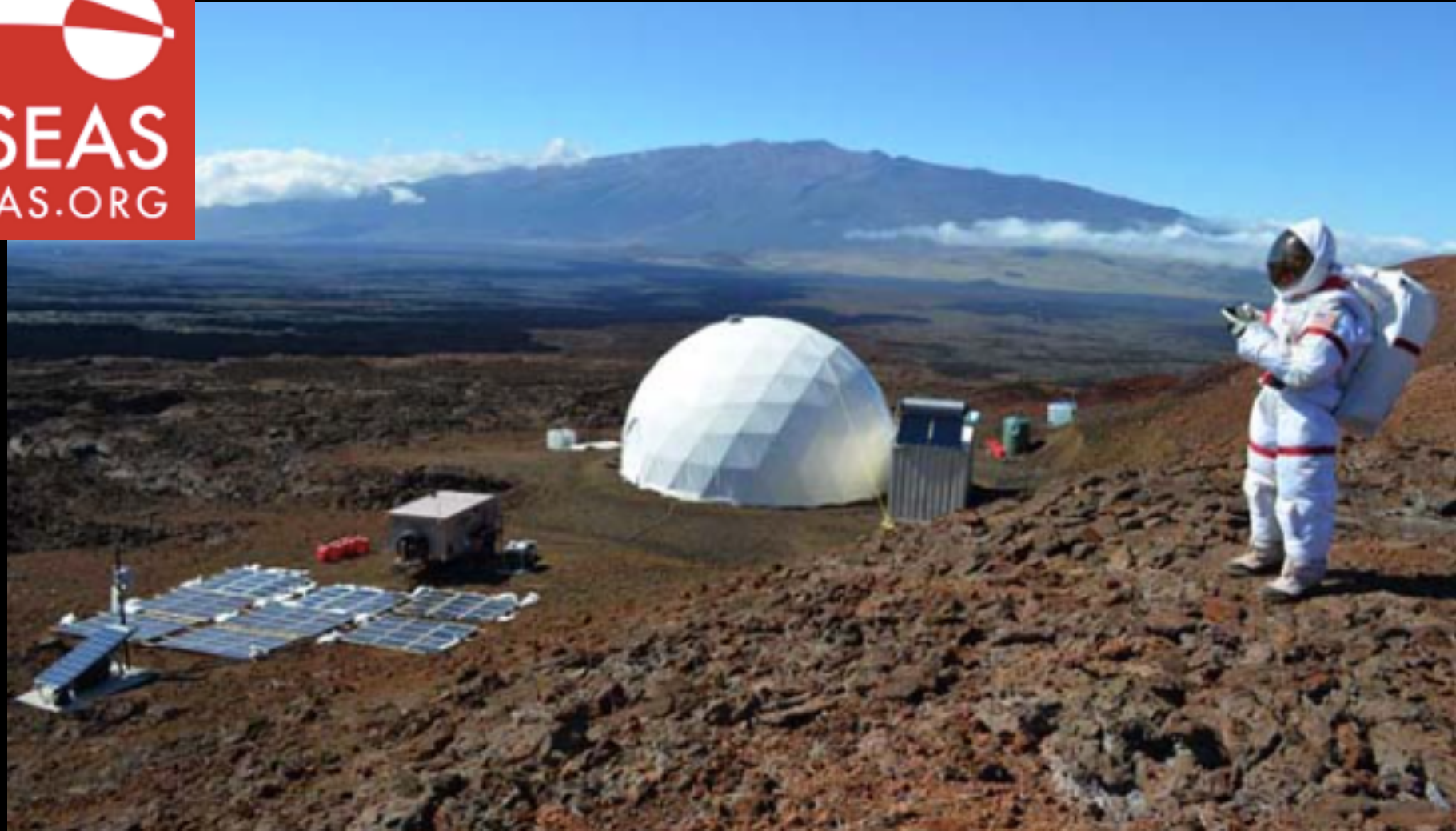
Foster & Partners



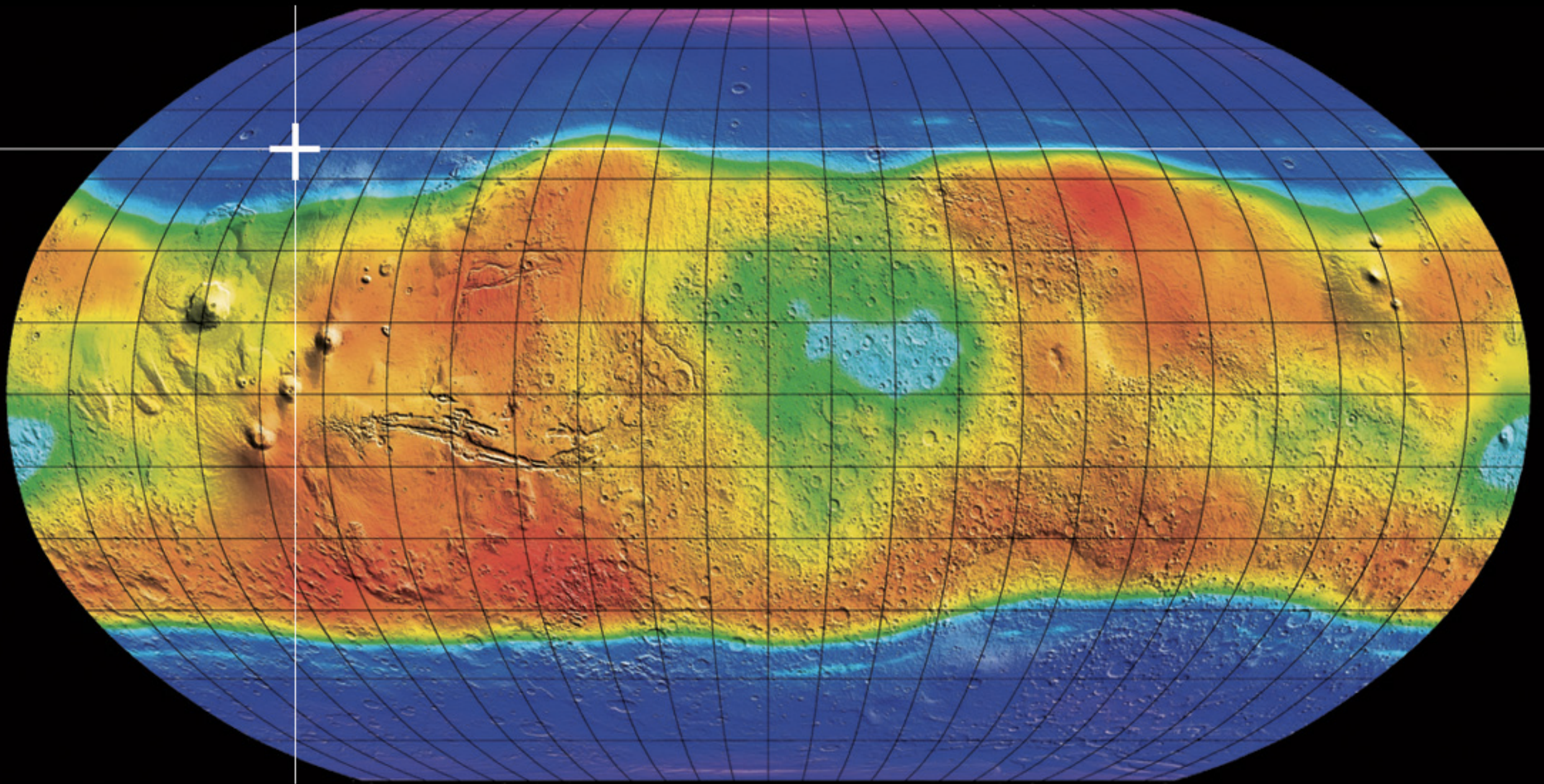
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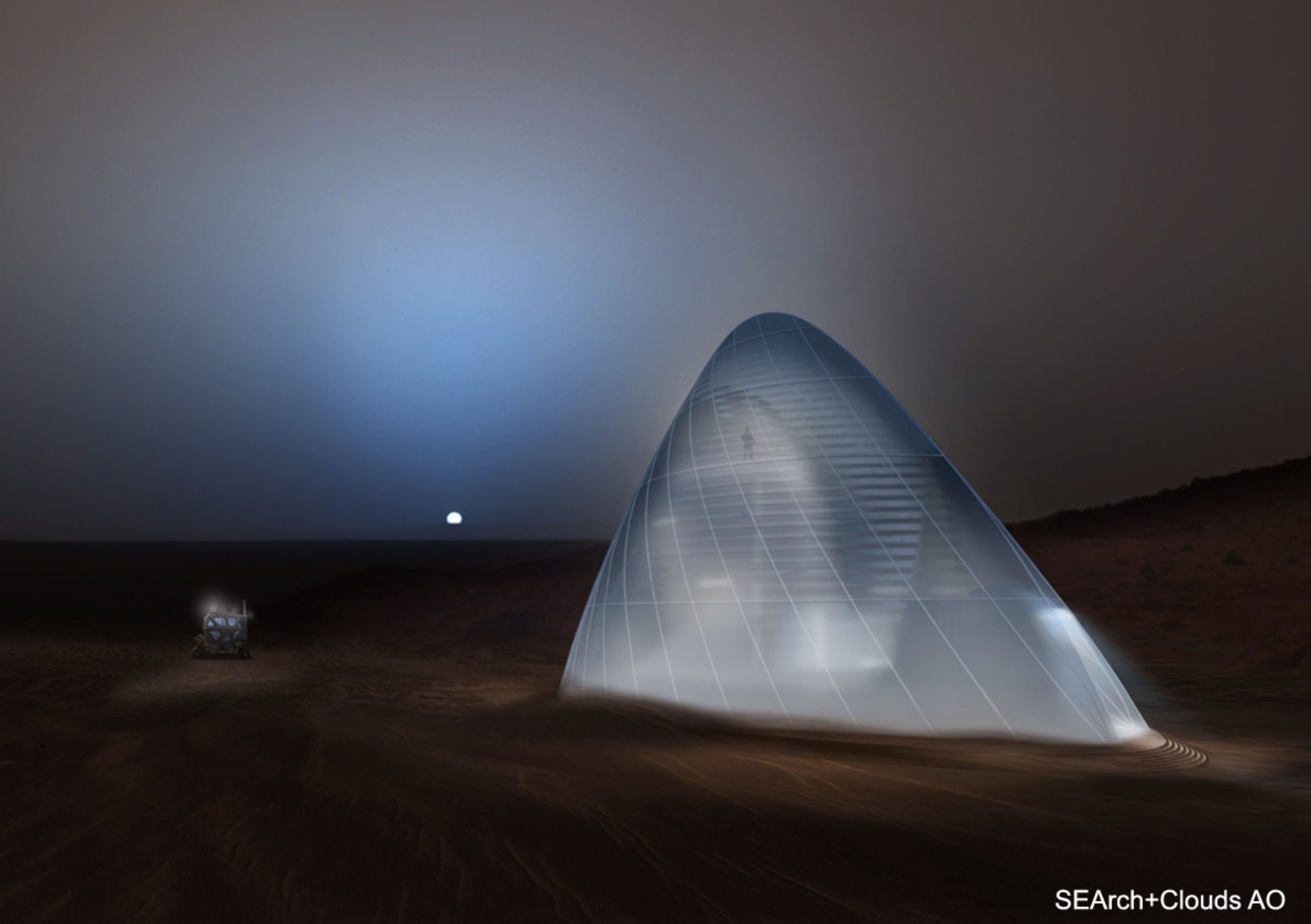
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Hawai'i Space Exploration Analog and Simulation is a Habitat on an isolated Mars-like site on the Mauna Loa on the Big Island of Hawaii at approximately 8200 feet above sea level.

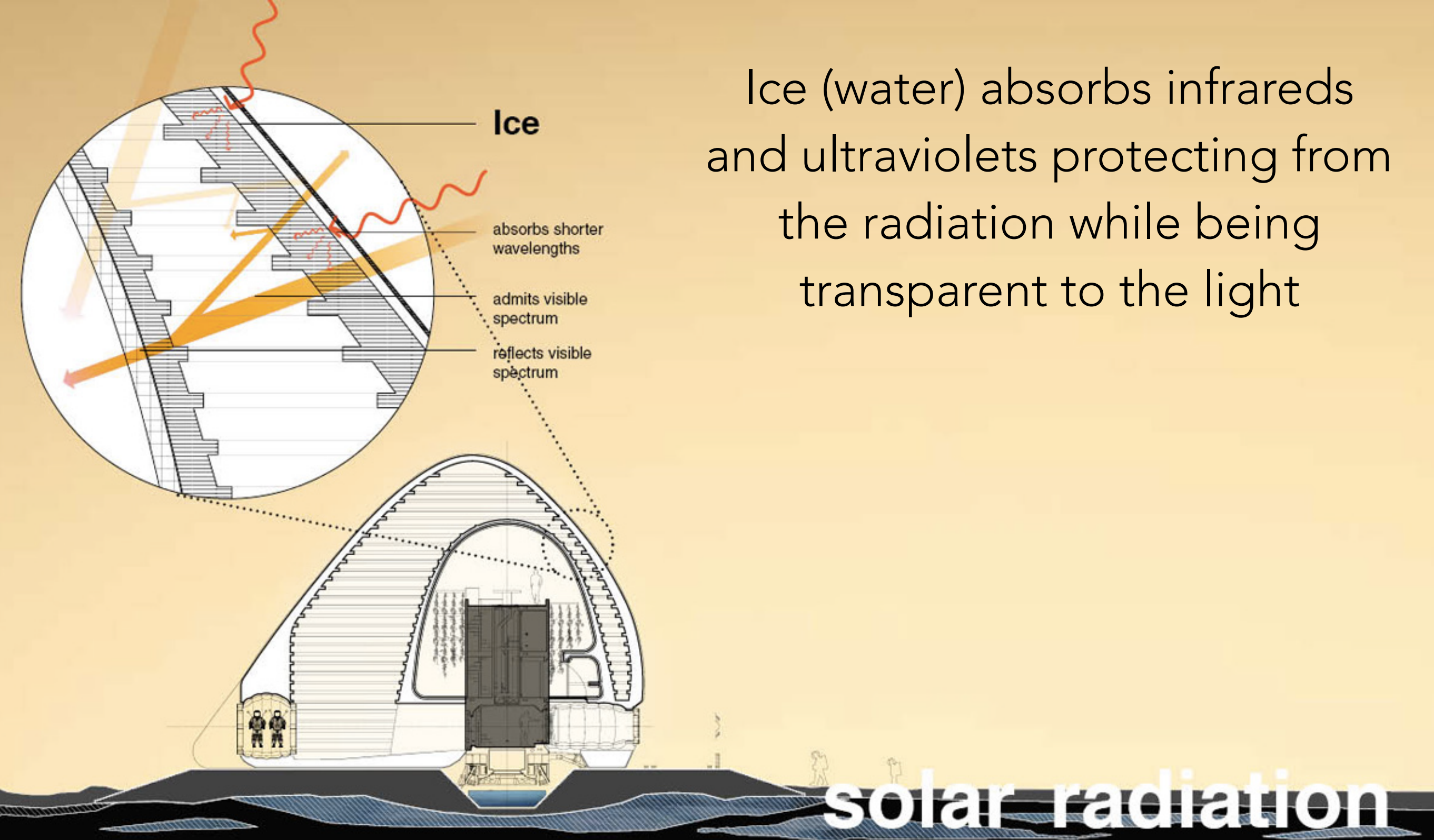


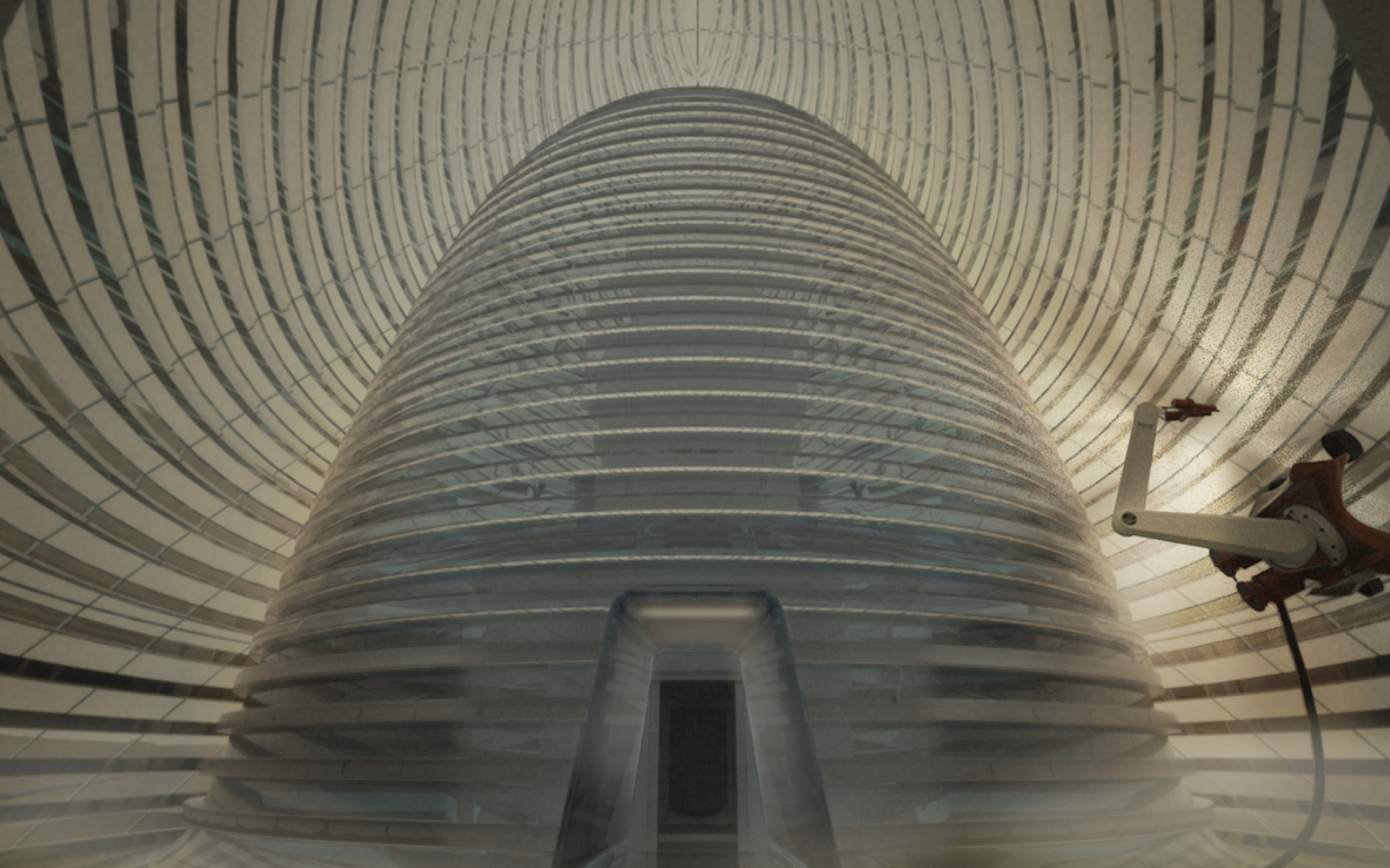
SEArch+Clouds AO

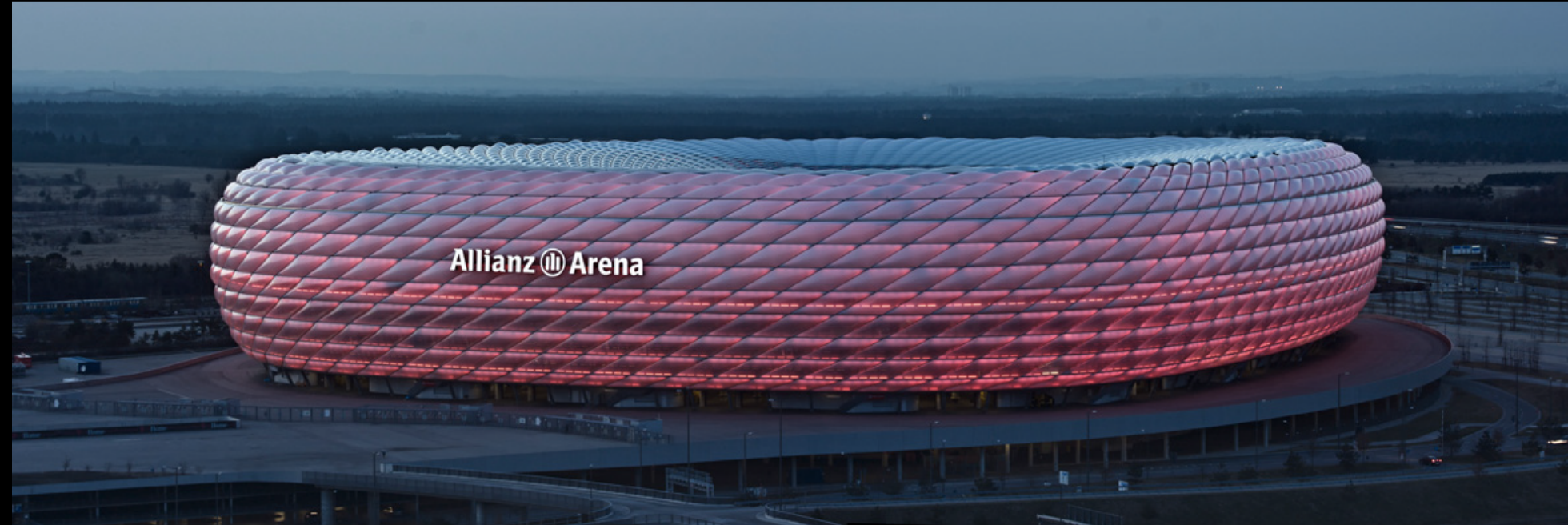


SEArch+Clouds AO

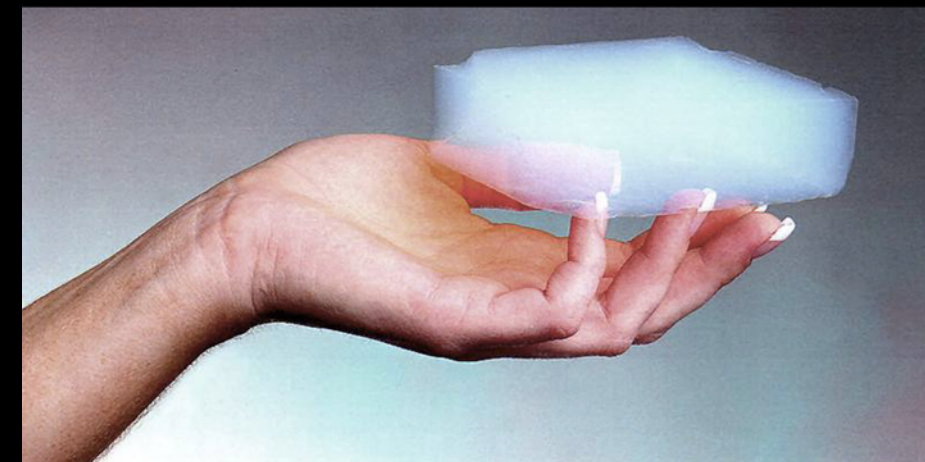
Ice (water) absorbs infrareds and ultraviolets protecting from the radiation while being transparent to the light







Allianz Arena, 2008, Herzog & de Meuron



Water Cube, 2008, PTW Architects



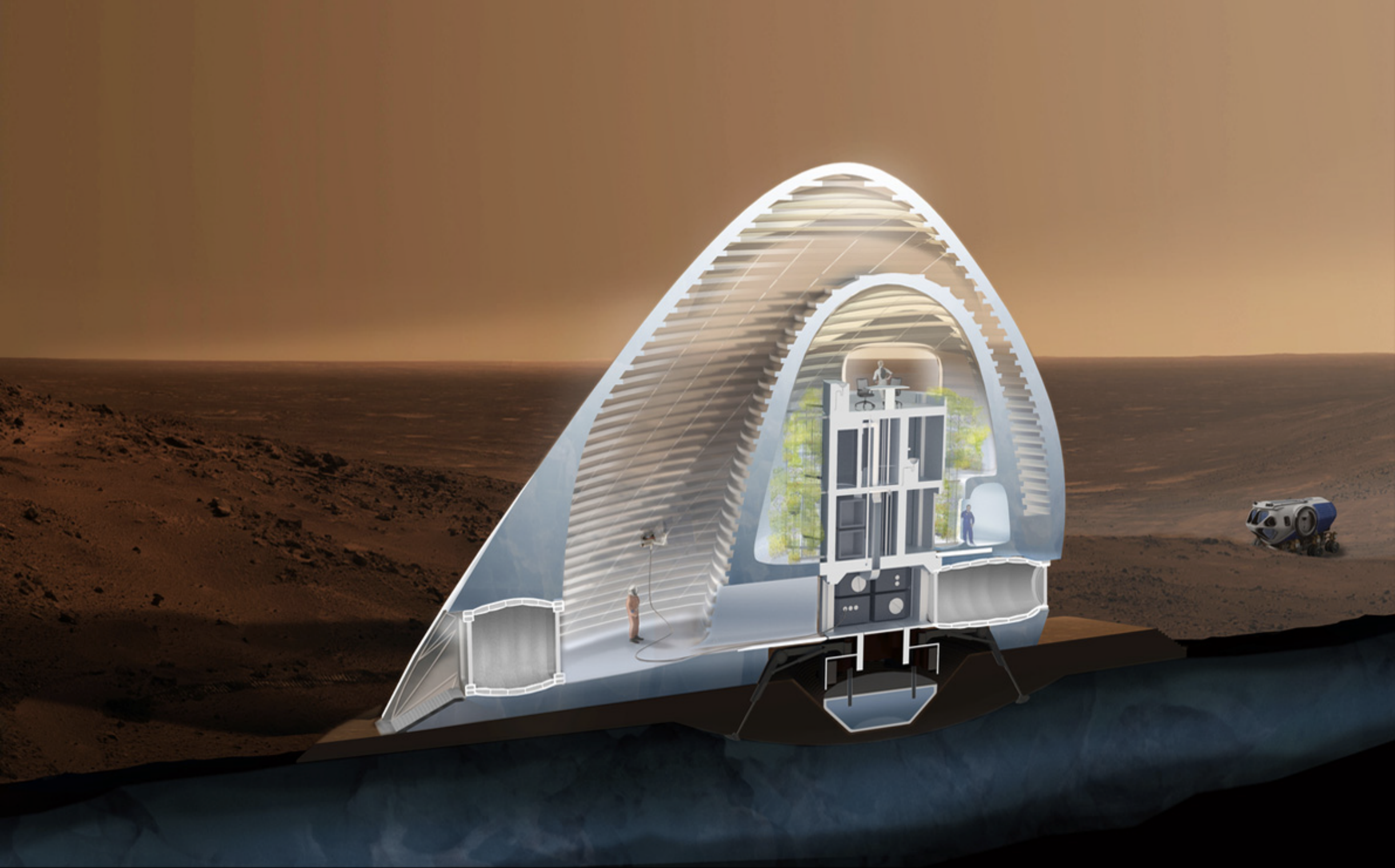
Igloo is sustainable and
uses local material



Physalia physalis made up of
different minute individual for
mutual benefit in symbiosis

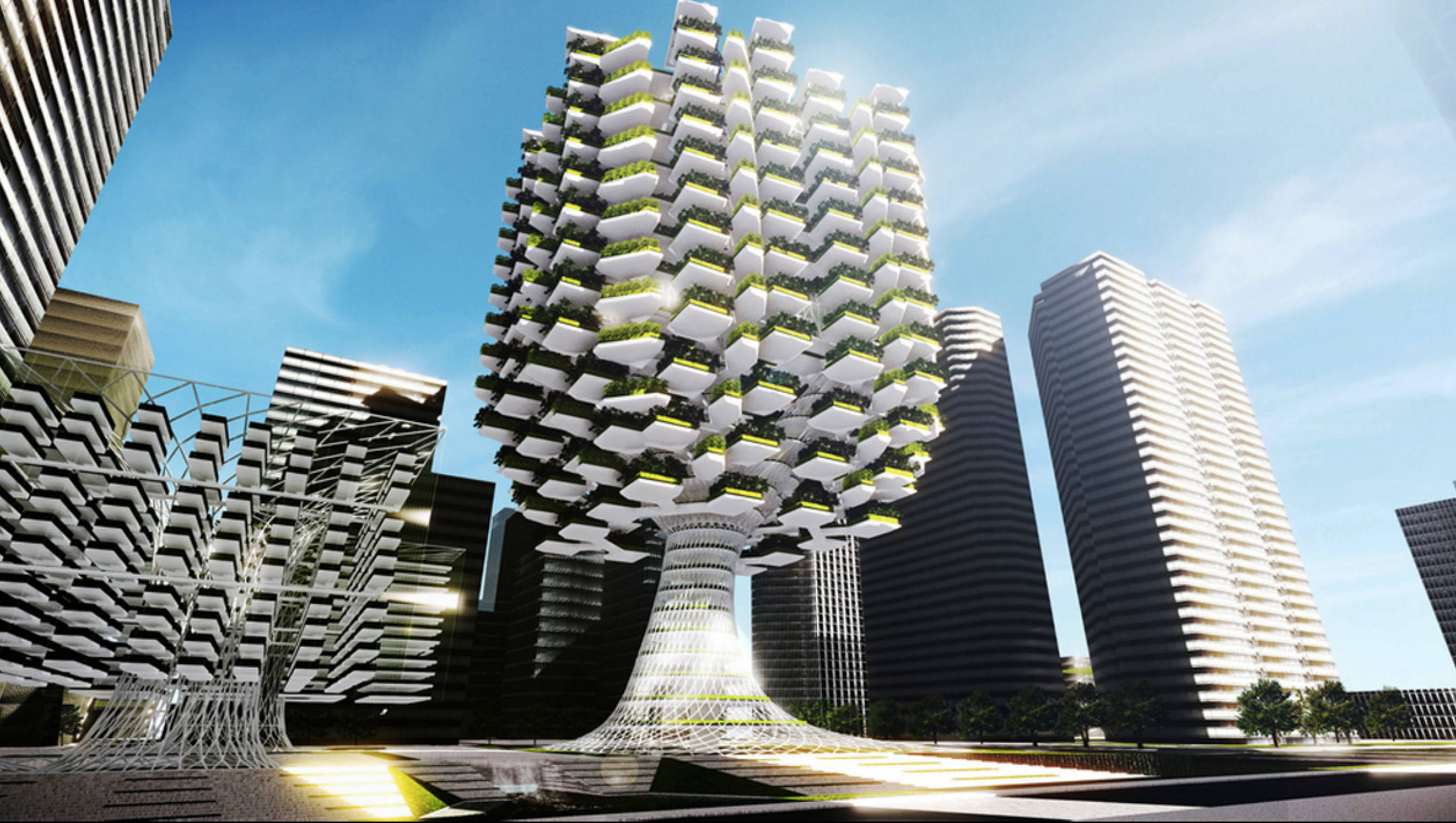


Hydroponic to grow plants using mineral nutrient solutions, in water, without soil.



Hydroponic plants consume CO_2 and produce Oxygen.

SEArch+Clouds AO



Urban Skyfarm, Seoul, Korea




Termites using a complex ventilation system keep nest temperature and humidity always constant to garden mushrooms in a symbiotic way.

Multiple subsystems cooperating to survive in a sustainable way.



CONCLUSIONS

- The Human Desire for Exploration Leads to Discovery.
- Discovery requires technical solutions that do not yet exist, embracing multidisciplinary aspects (engineering, architecture, agriculture, medicine) in a cooperative way.
- Nature has solved many problems and we can learn from those solutions.
- Science is nourished by creativity that is particularly necessary to overcome challenges. Often, solutions find application different from the original purpose resulting in human advancement.
- Today we have studied that cosmic radiation is still a barrier to go to Mars. People all over the world are working together and facing these challenges to make human manned mission to Mars possible. **You might be the next explorers to Mars!**



Pale Blue Dot is a photograph of planet Earth taken on February 14, 1990, by the Voyager 1 space probe from a record distance of about 6 billion kilometers.

"Consider again that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives."

Carl Sagan, 1997

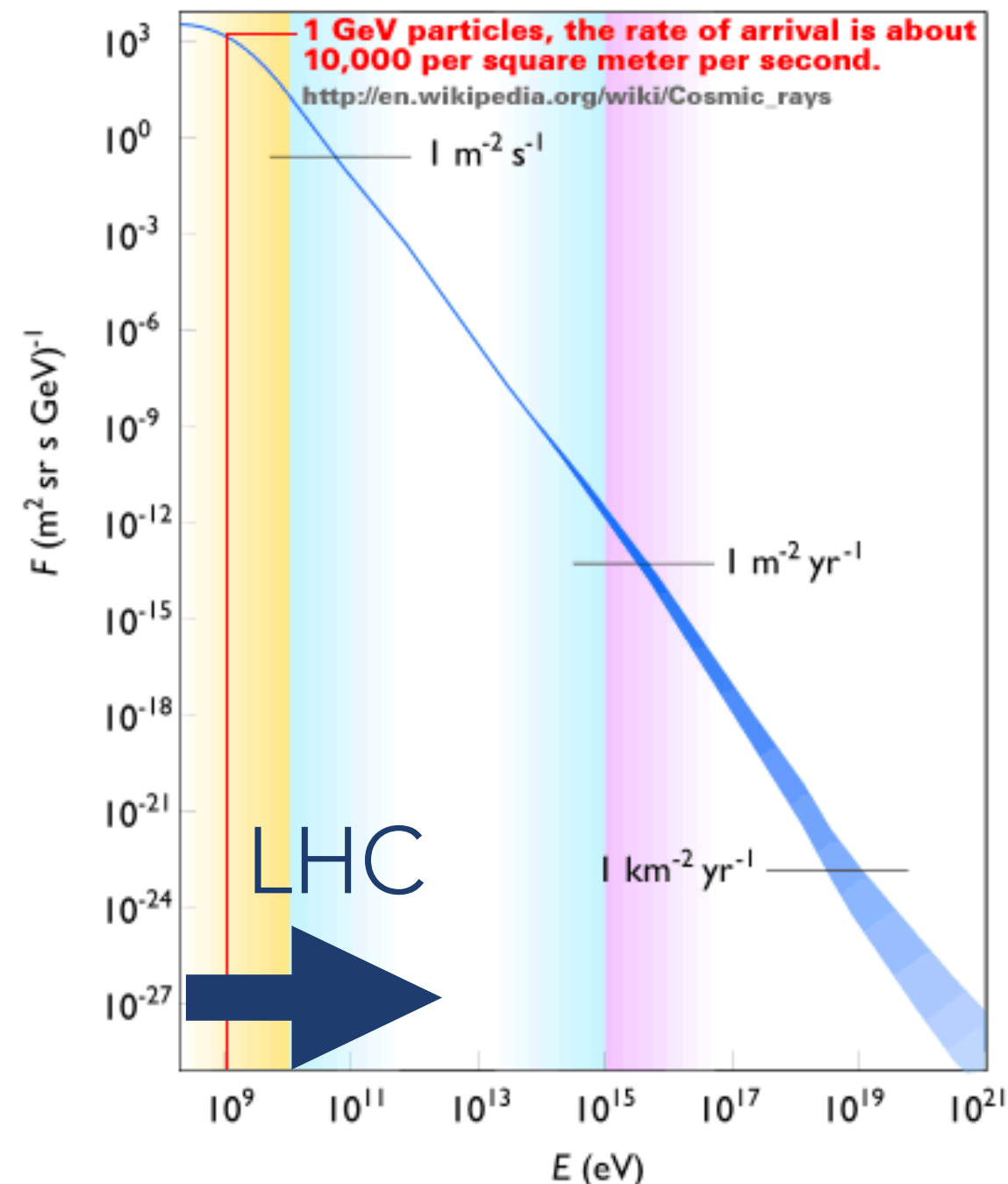
THANK YOU

Images Credit: NASA, ESA, AMS, Architect Sorito

THE UNIVERSE IS THE MOST POWERFUL ACCELERATOR

- Cosmic Ray flux is divided in three main regions.

Cosmic Ray Flux versus Particle Energy



Yellow Zone
Mainly attributed to
Solar cosmic rays

Blue Zone
Mainly attributed to
Galactic cosmic rays

Purple Zone
Mainly attributed to
Extragalactic cosmic rays

Flux – number of arriving particles per (unit area x unit time)
eV – (very small) unit of energy

- one volt times the charge of a single electron
- $1 \text{ eV} = 1.609 \times 10^{-19} \text{ joules}$

THE UNIVERSE IS THE MOST POWERFUL ACCELERATOR

