

A visualization of the cosmic web, showing a complex network of filaments and clusters of galaxies. The filaments are colored in shades of orange, yellow, and green, while the clusters are more densely packed and appear in darker colors. The background is a deep blue/black space with scattered stars.

on the trail of the most energetic particles in the universe

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Oxford
28/Jan/2017

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historical overture



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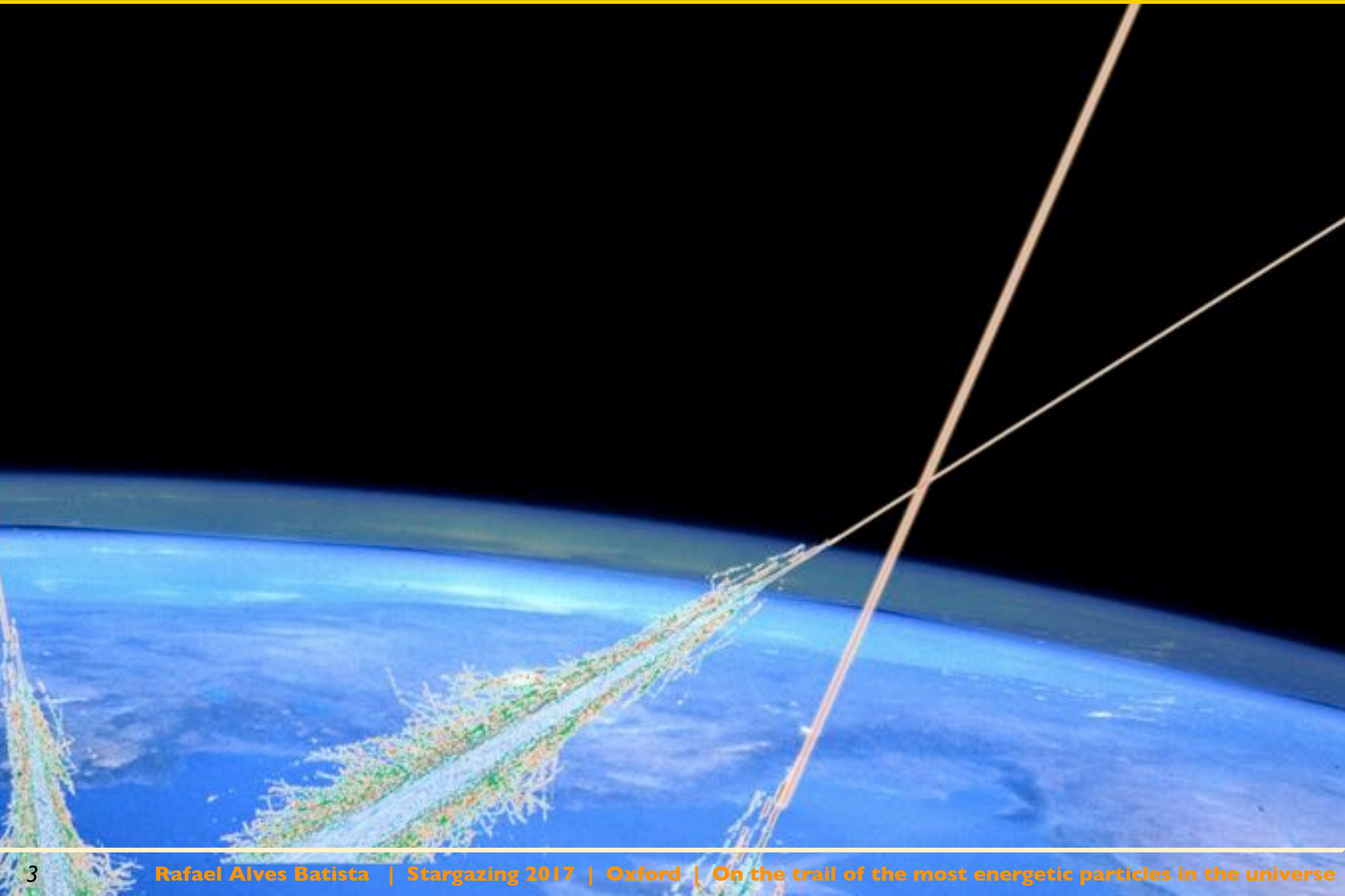
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- ▶ rest of the century: particle physics with cosmic rays

what are cosmic rays?



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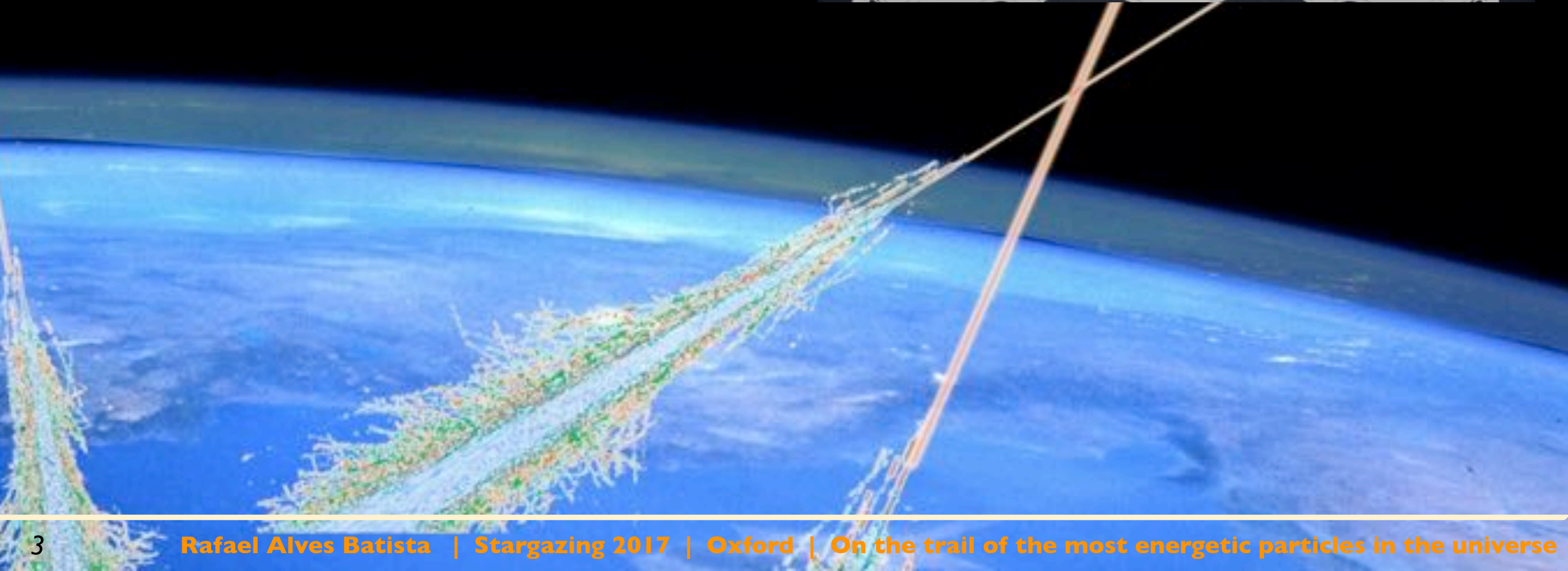
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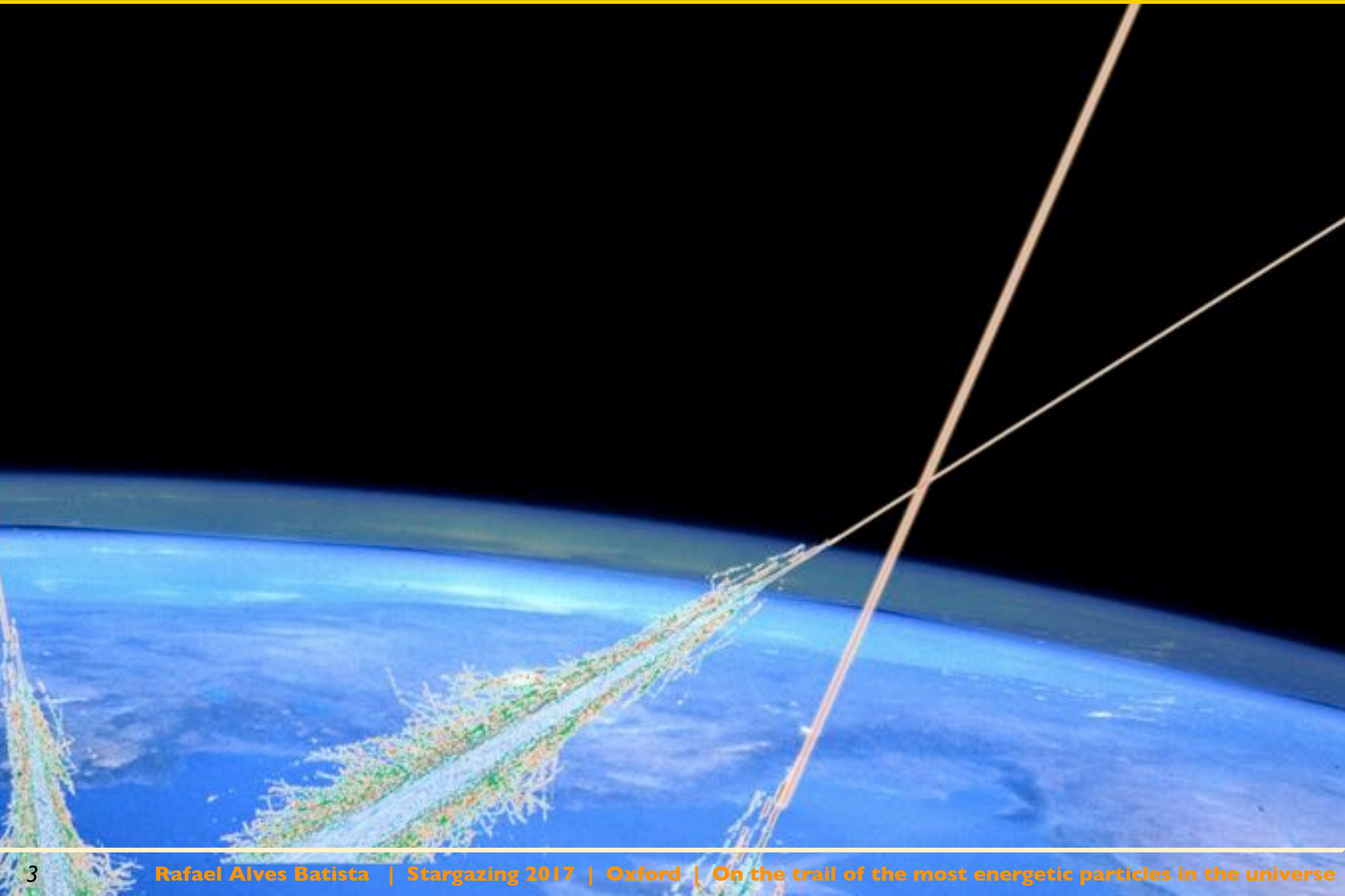
what are cosmic rays?



Four human beings--changed by space-born cosmic rays into something more than merely human.

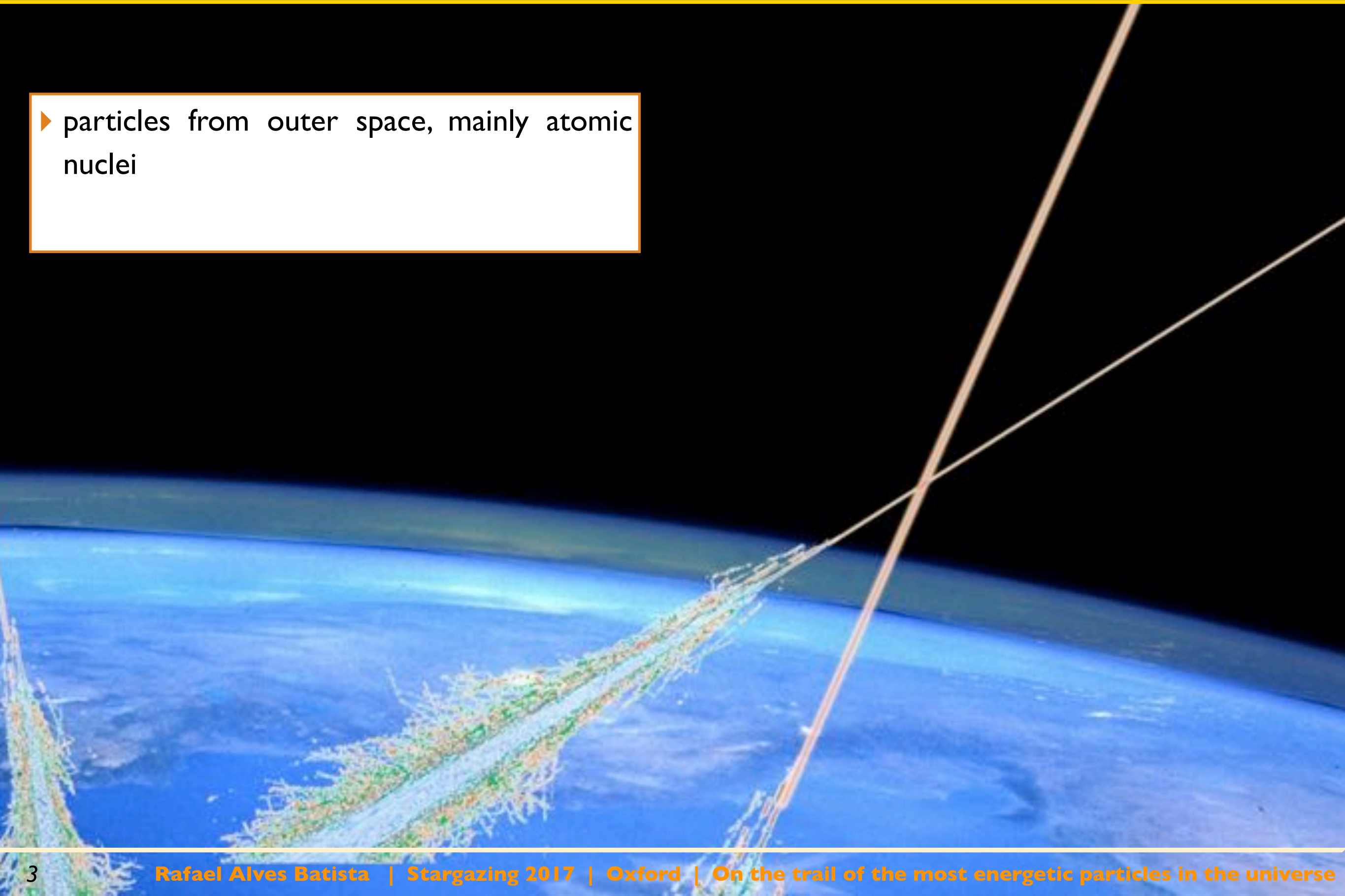
So was born The Fantastic Four--and from that moment on, the world would never again be the same.

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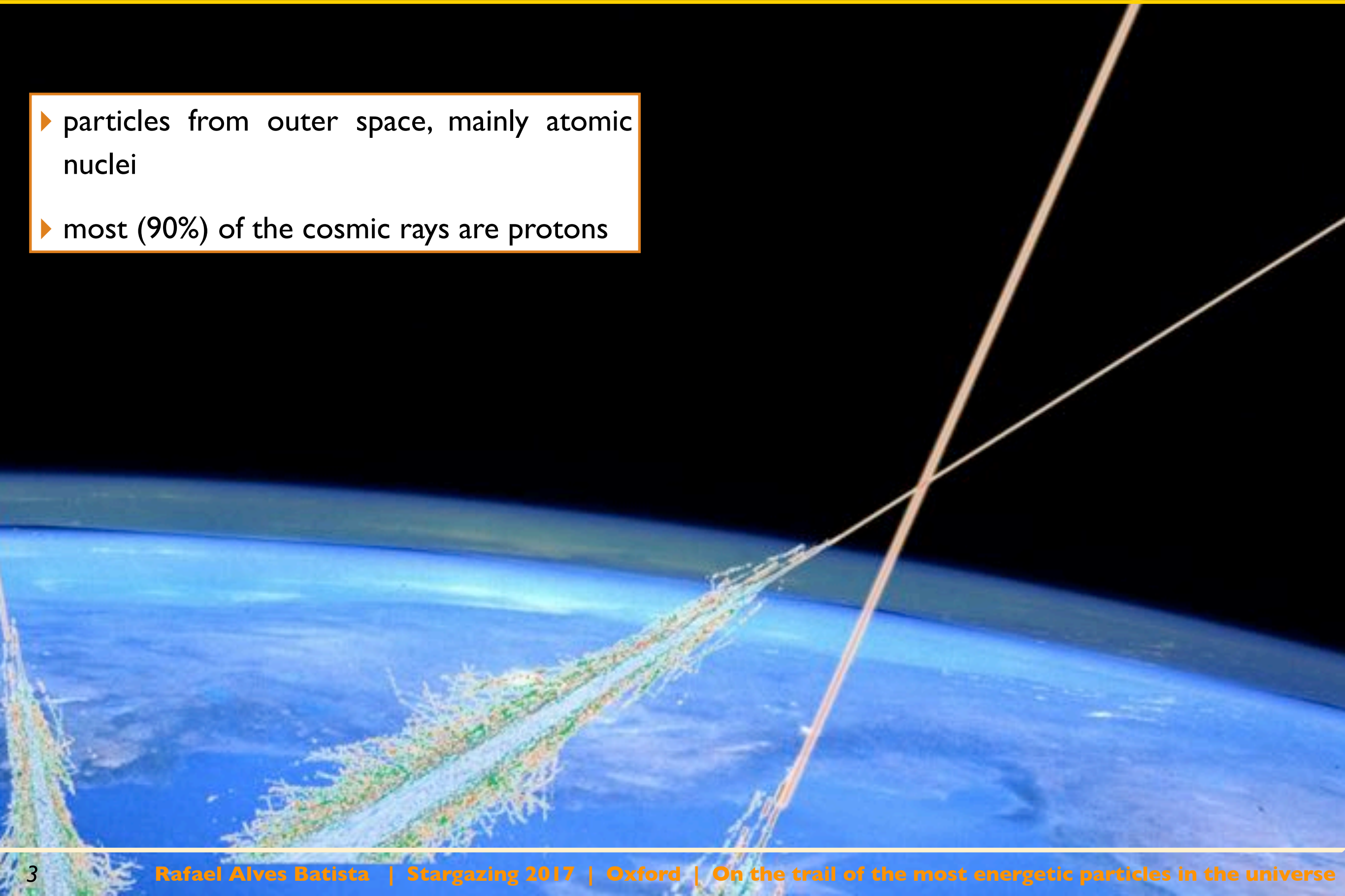
what are cosmic rays?

- ▶ particles from outer space, mainly atomic nuclei

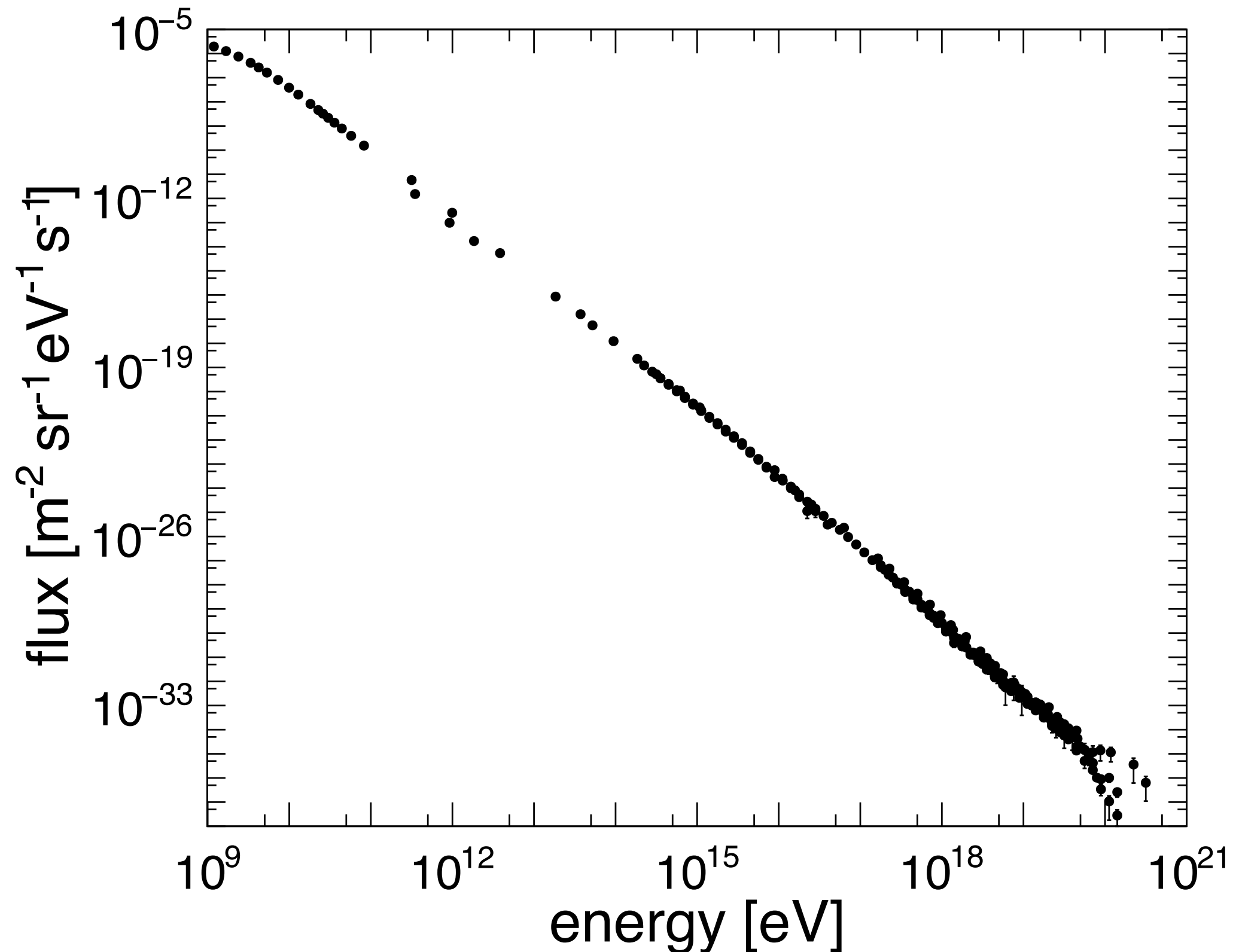


what are cosmic rays?

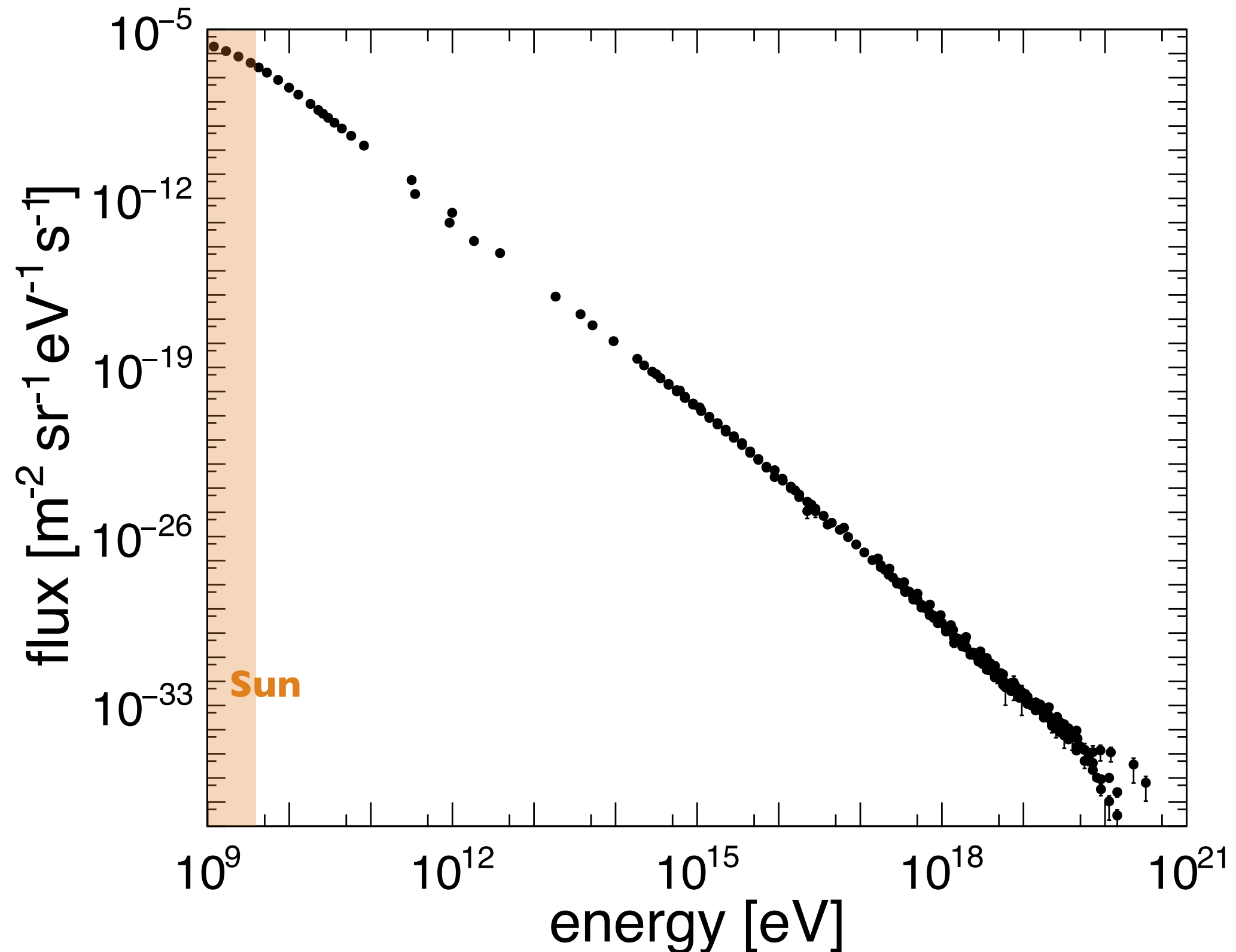
- ▶ particles from outer space, mainly atomic nuclei
- ▶ most (90%) of the cosmic rays are protons



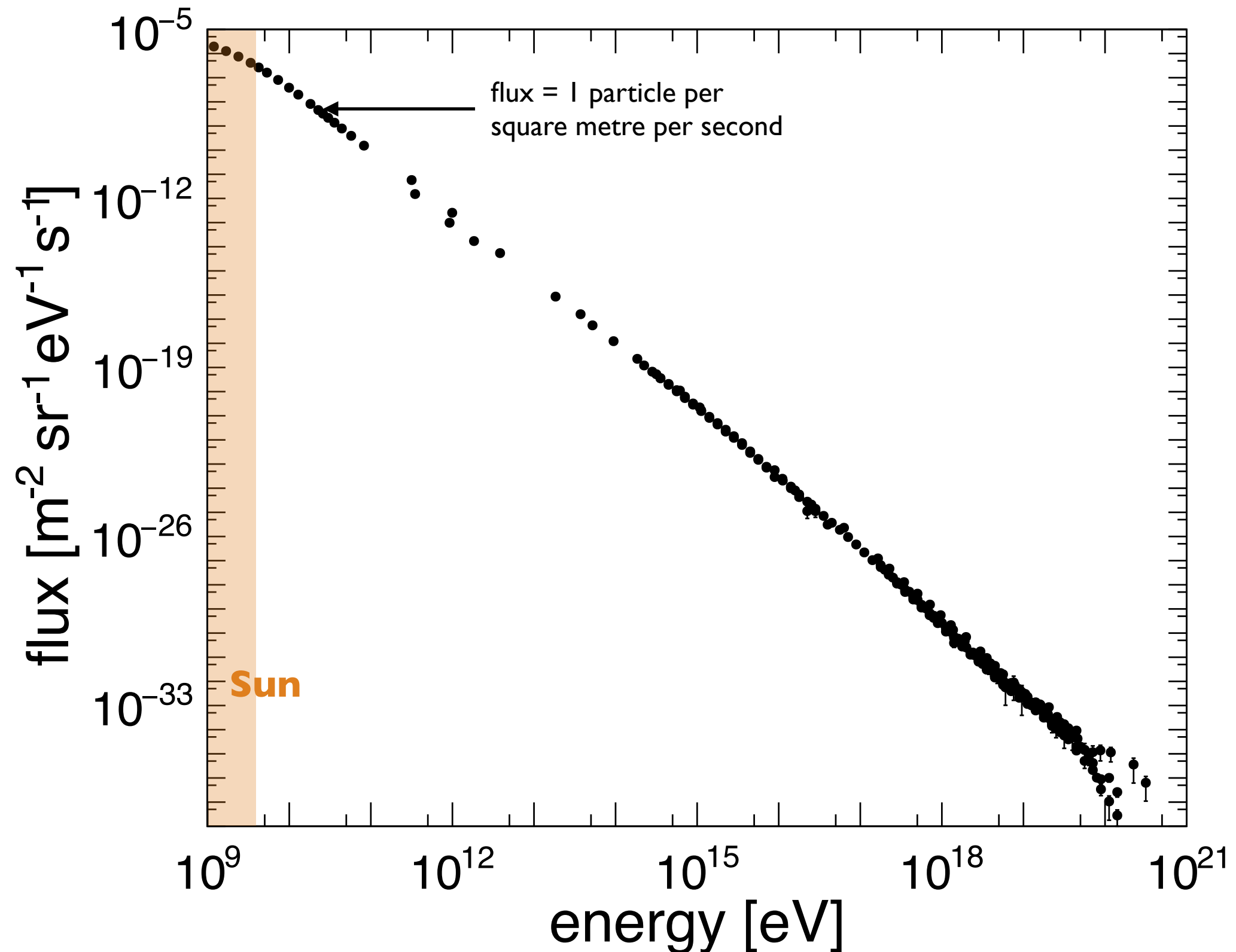
where do cosmic rays come from?



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northern/southern lights



image credits: Kristian Pikner

northern/southern lights

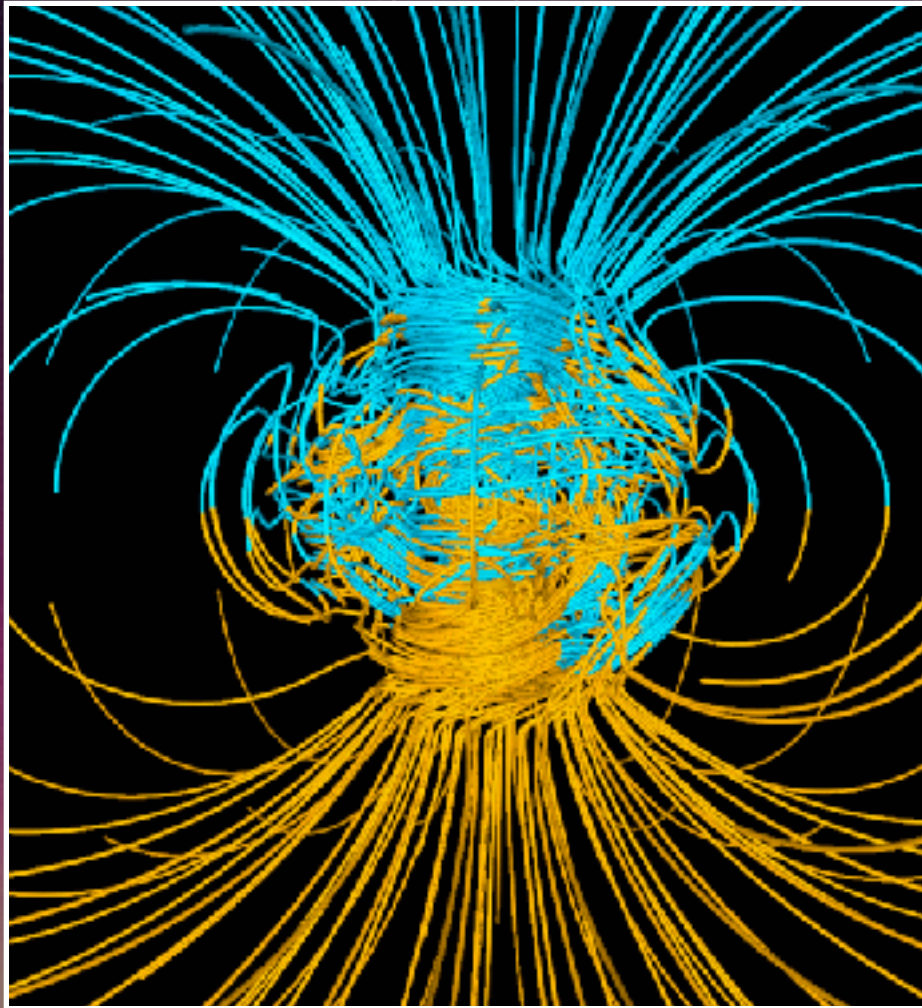


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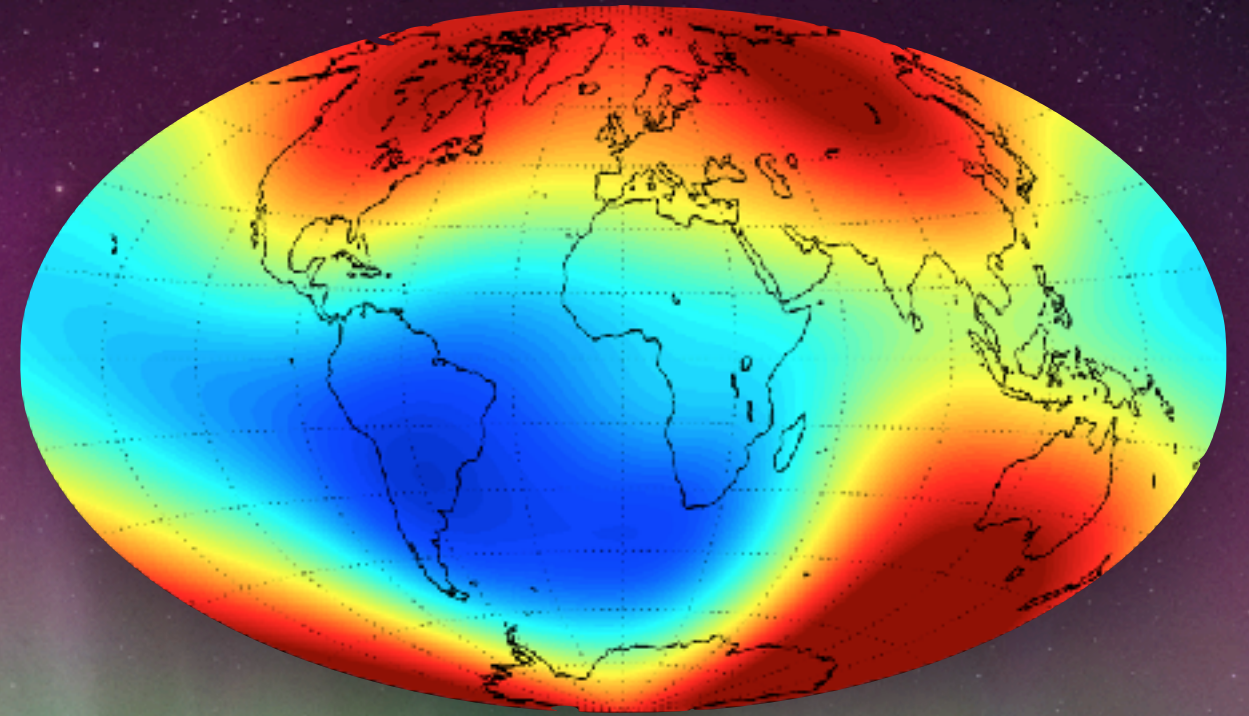
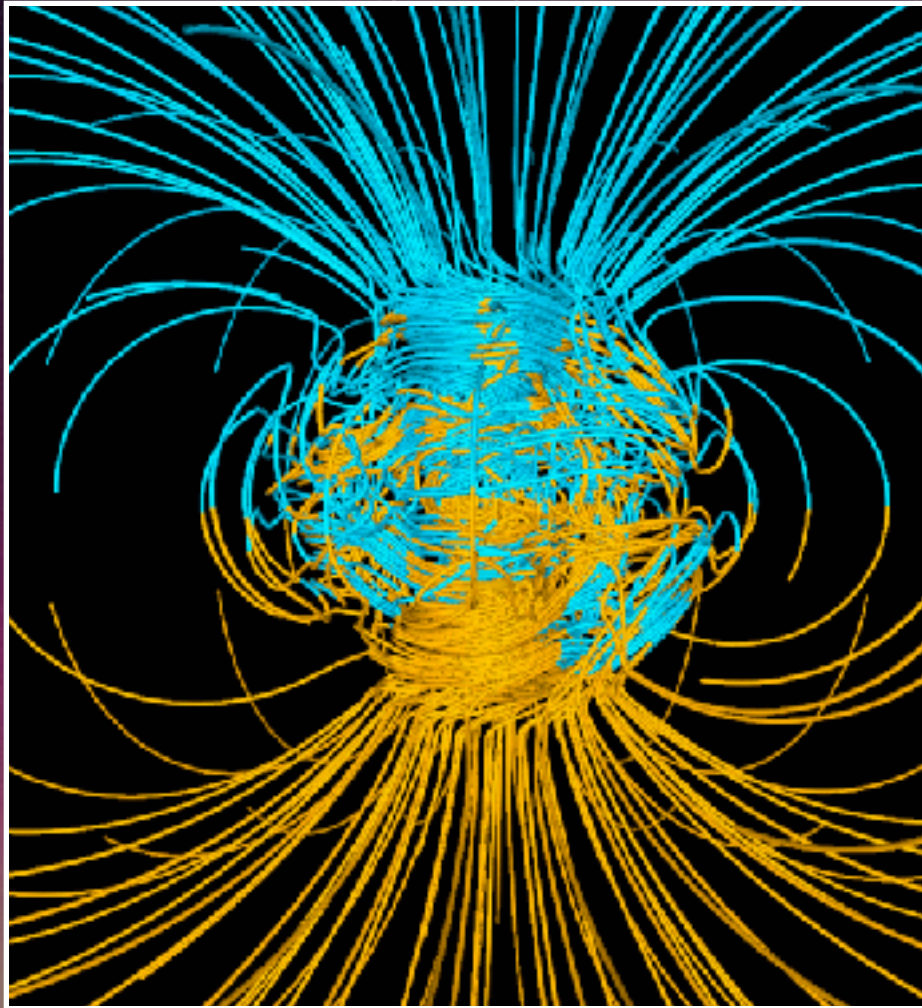
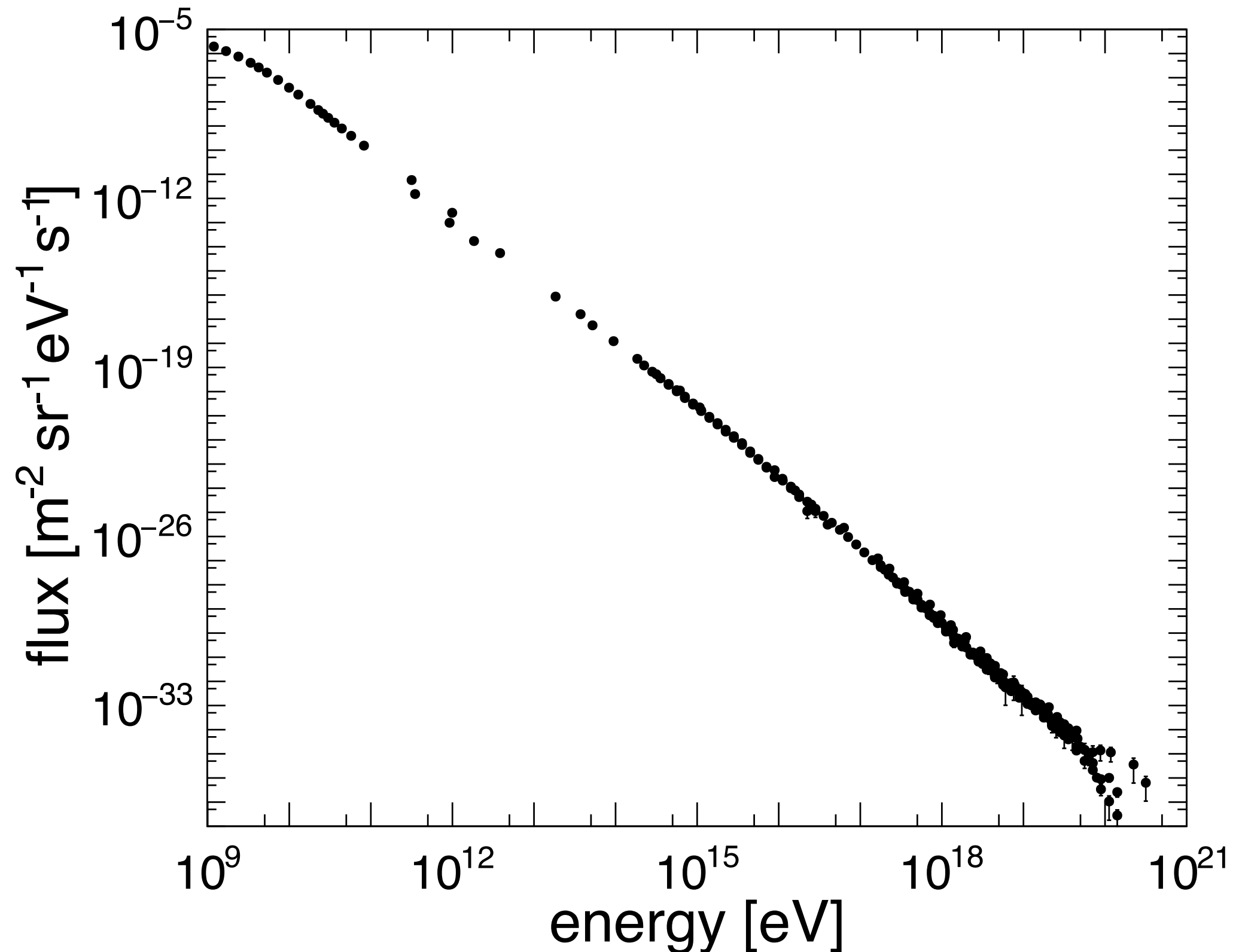
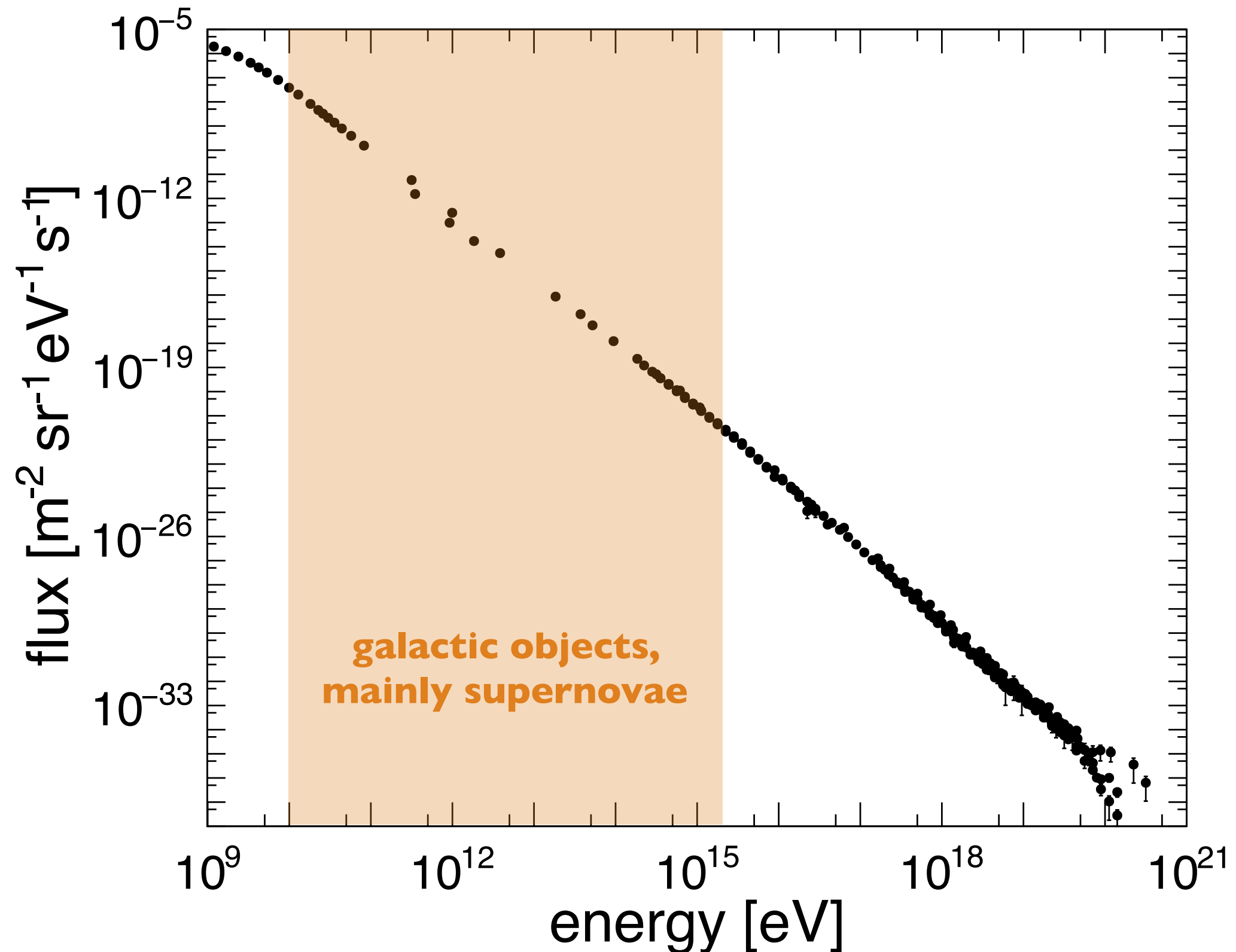


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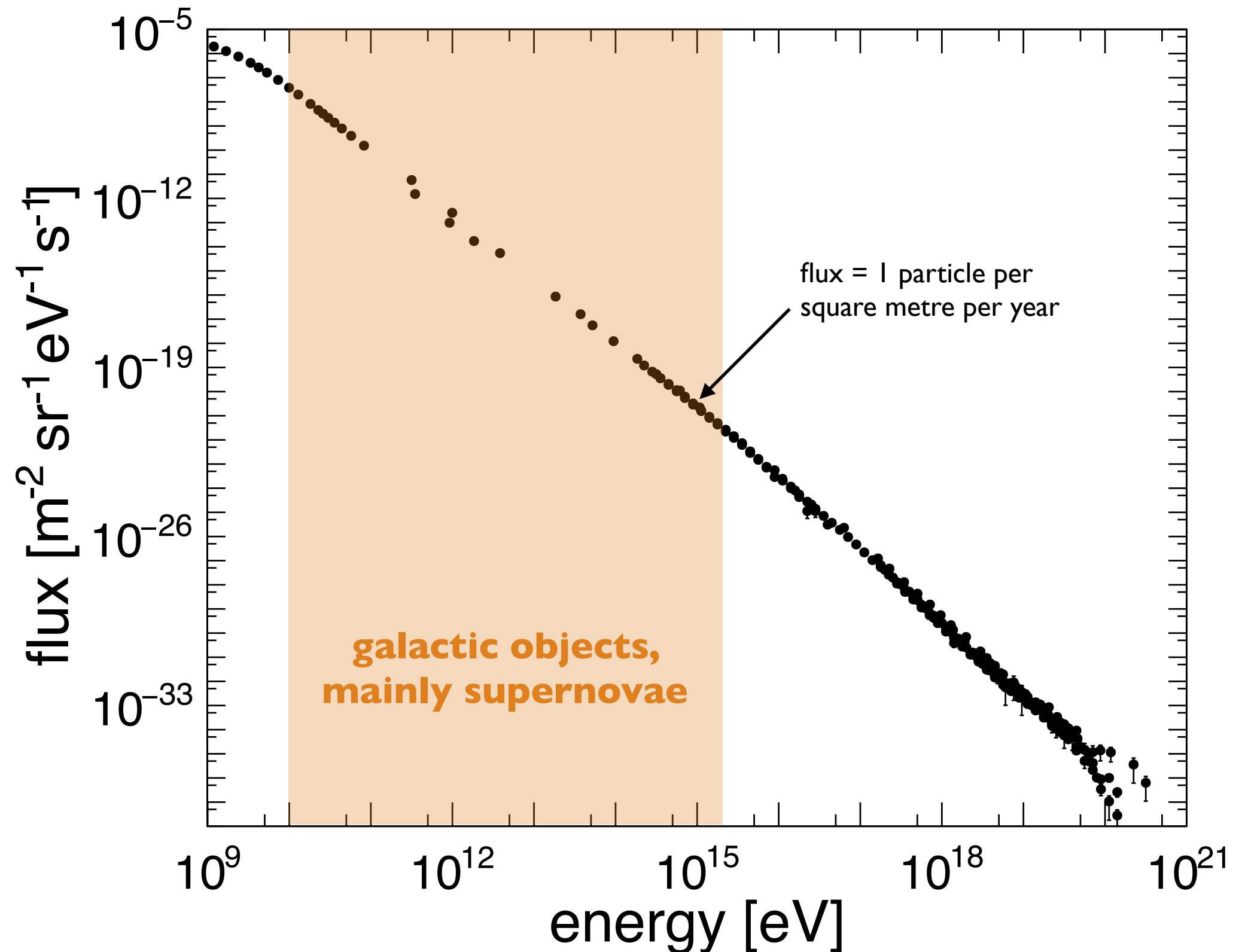
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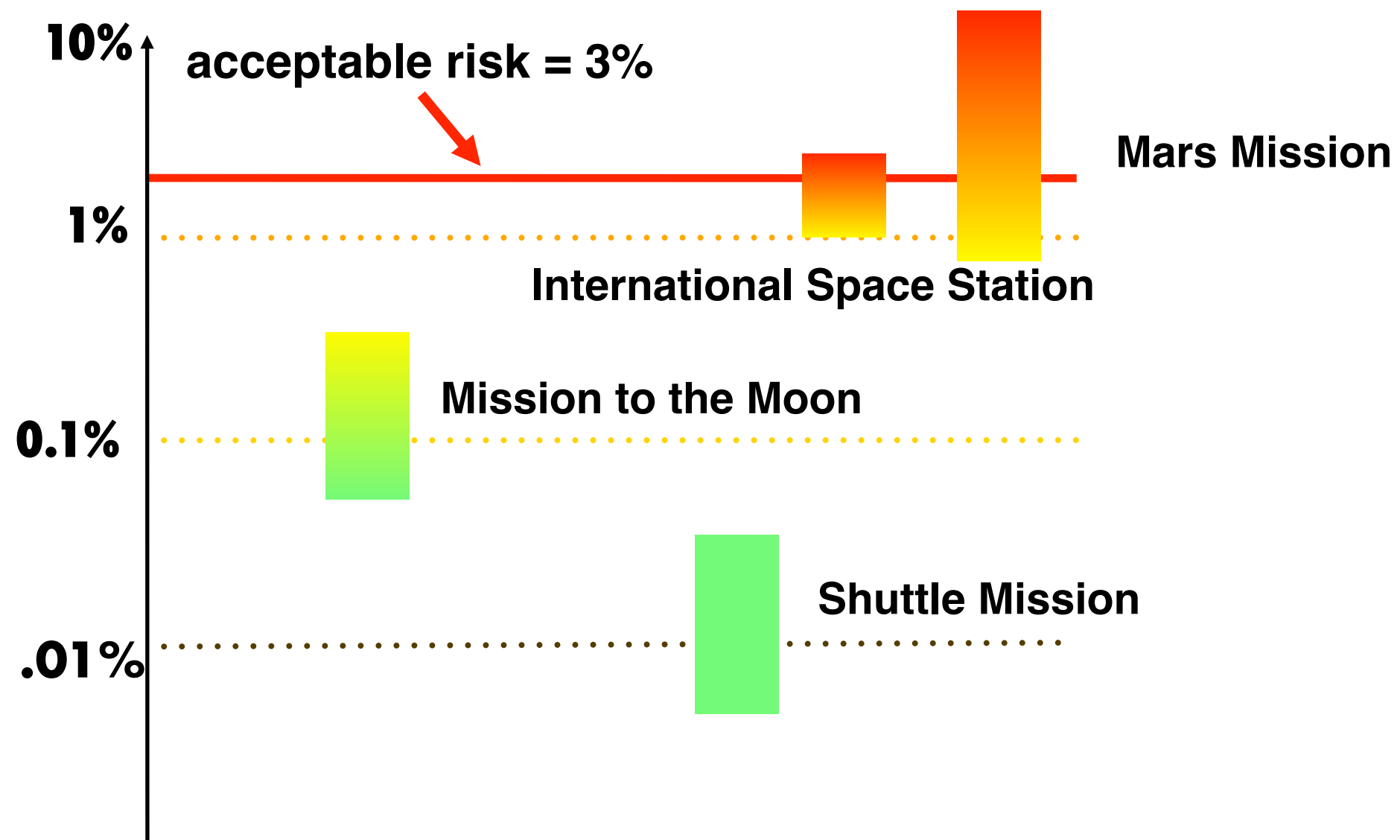
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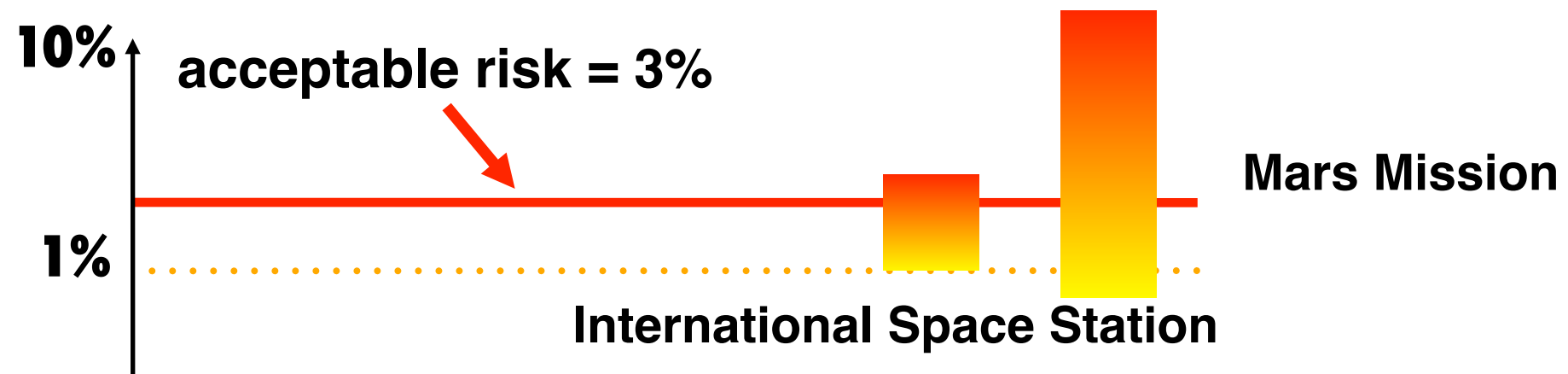
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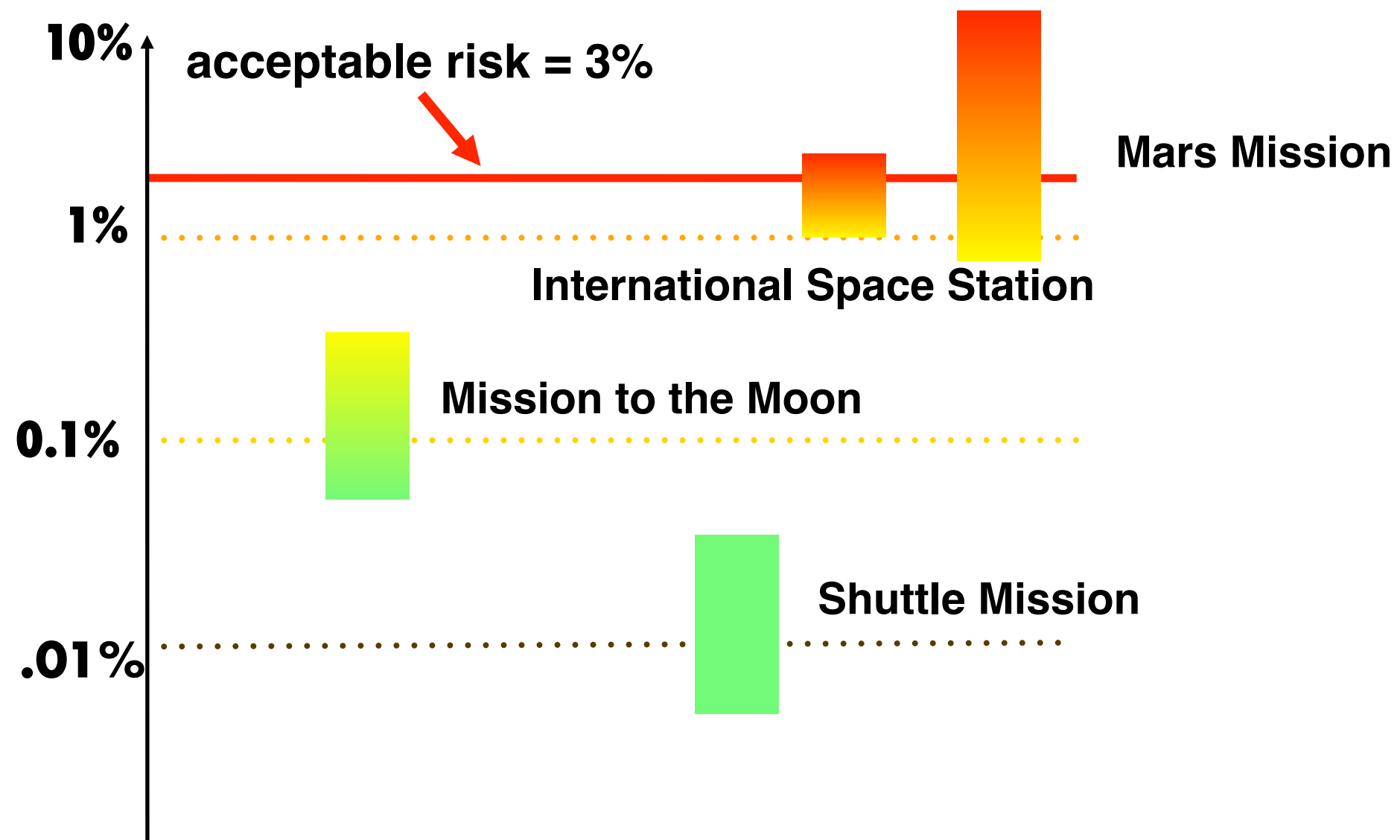
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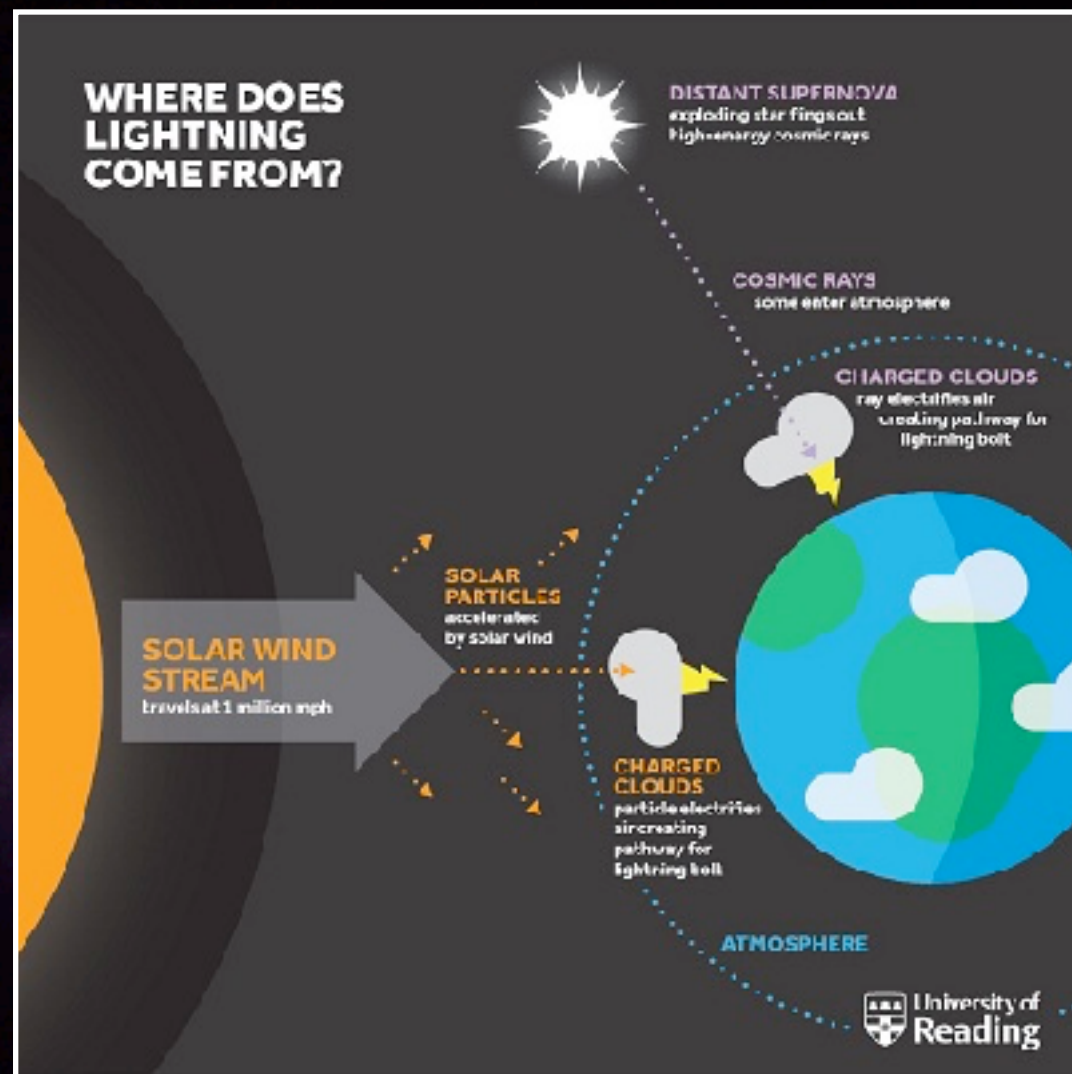


possible link between CRs and lightning

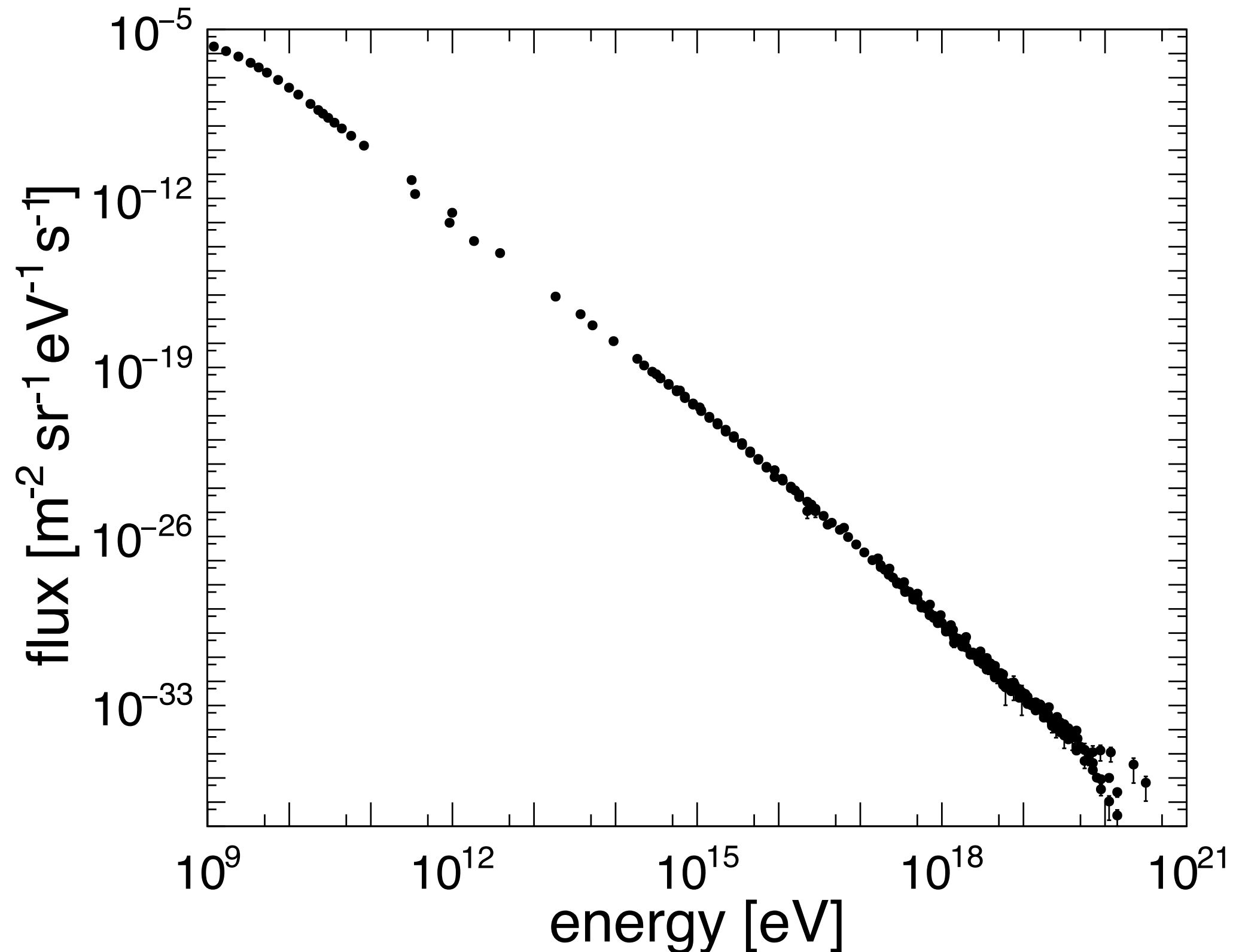
image credits: NOAA Photo Library, NOAA Central Library; OAR/ERL/National Severe Storms Laboratory (NSSL)



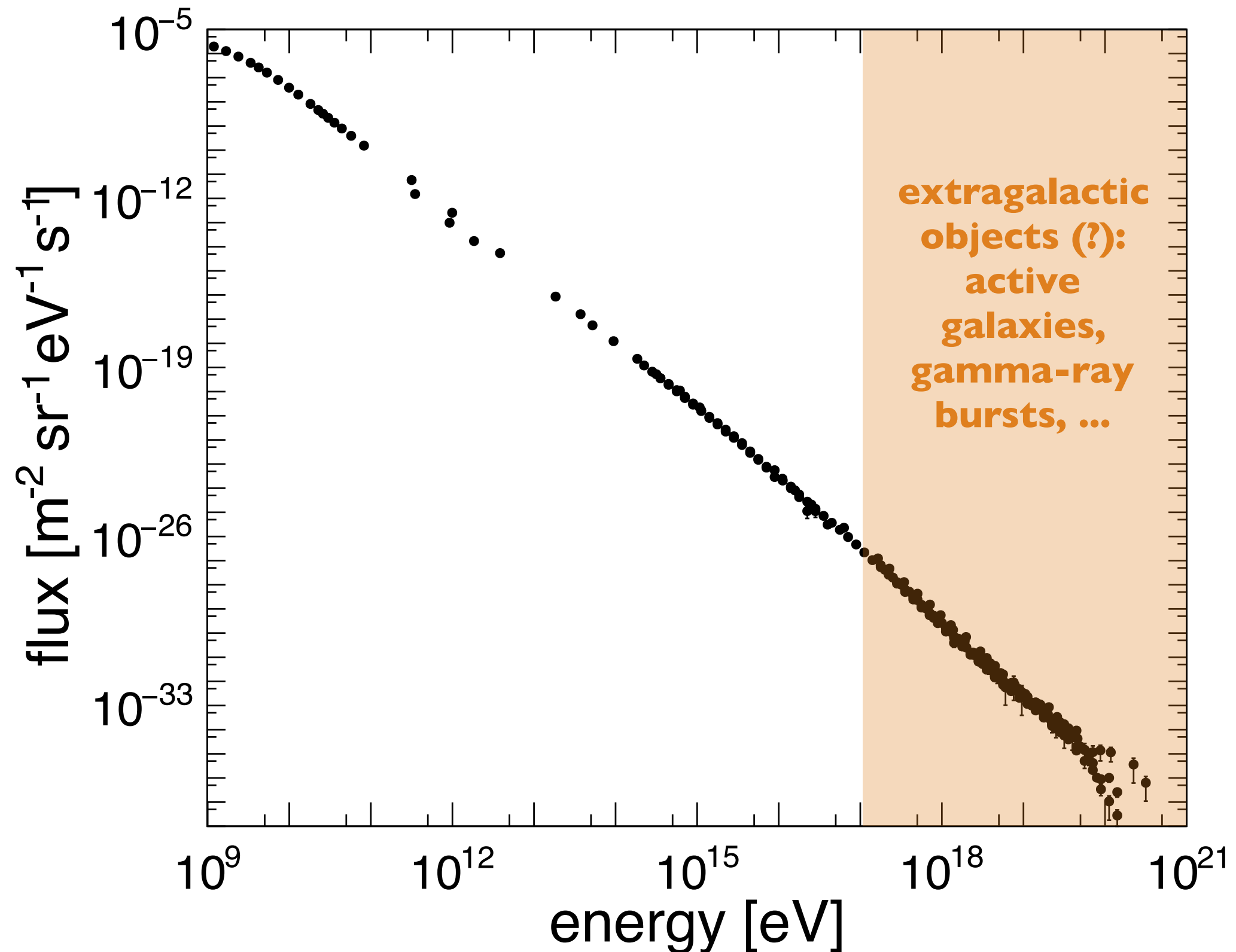
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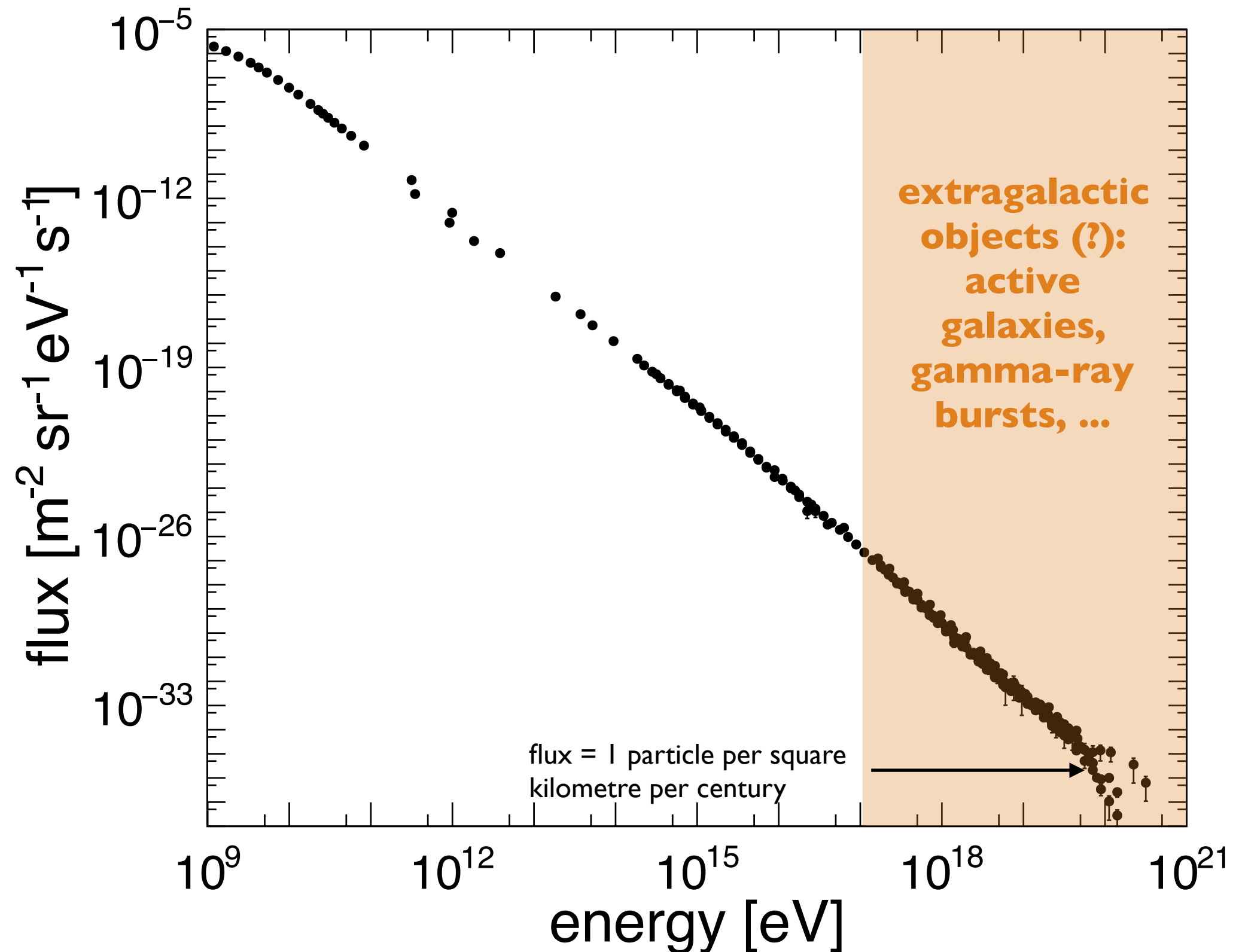
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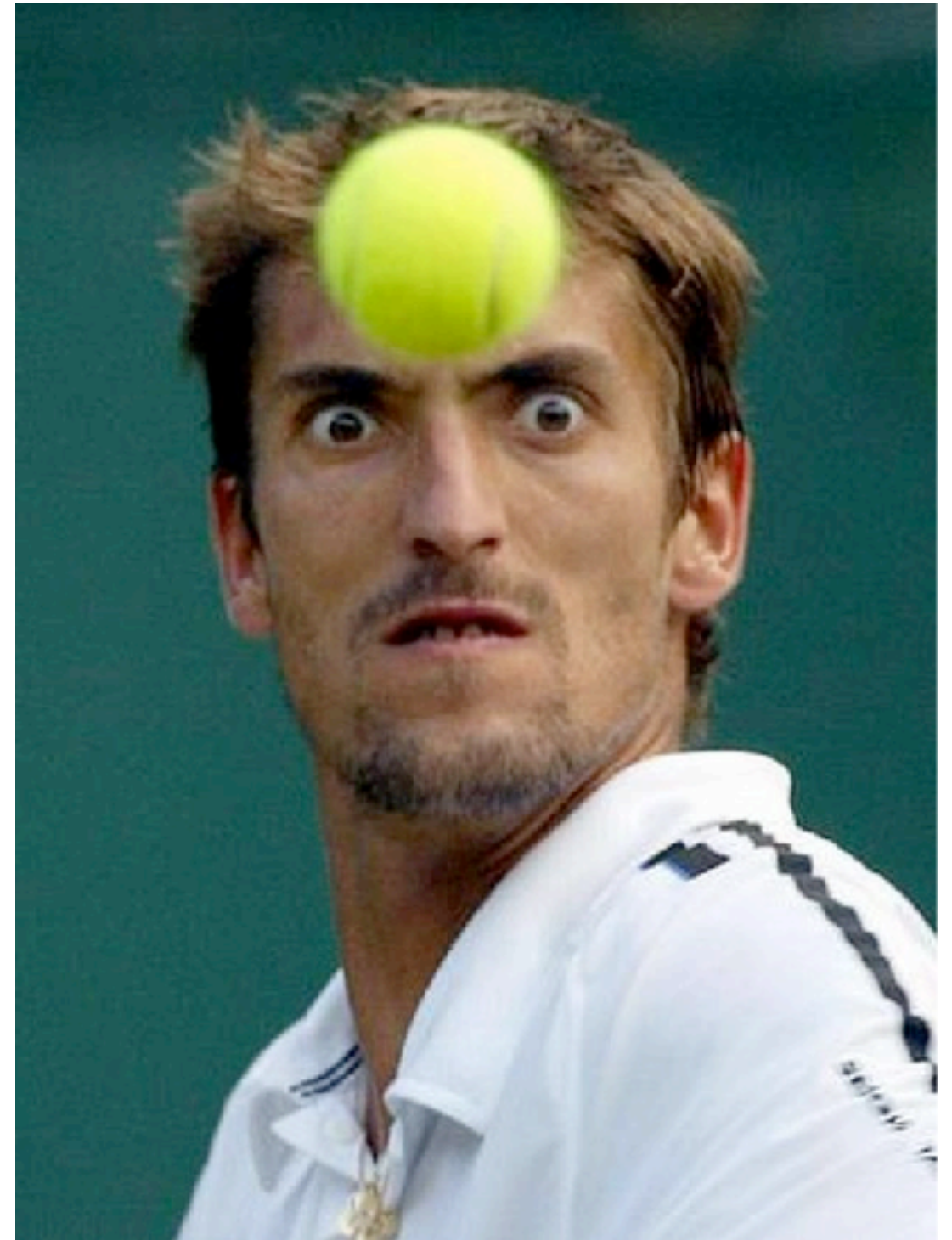
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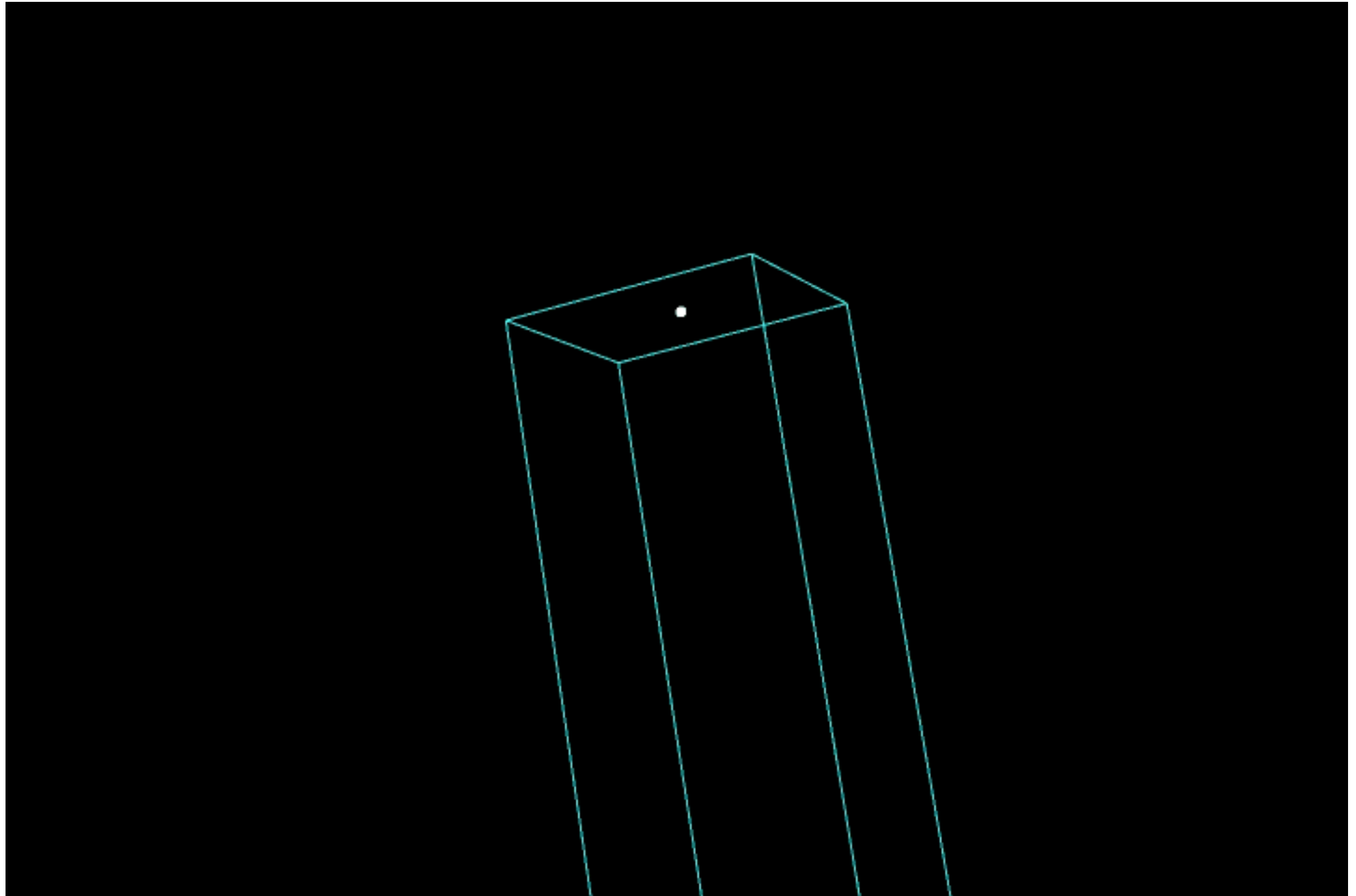
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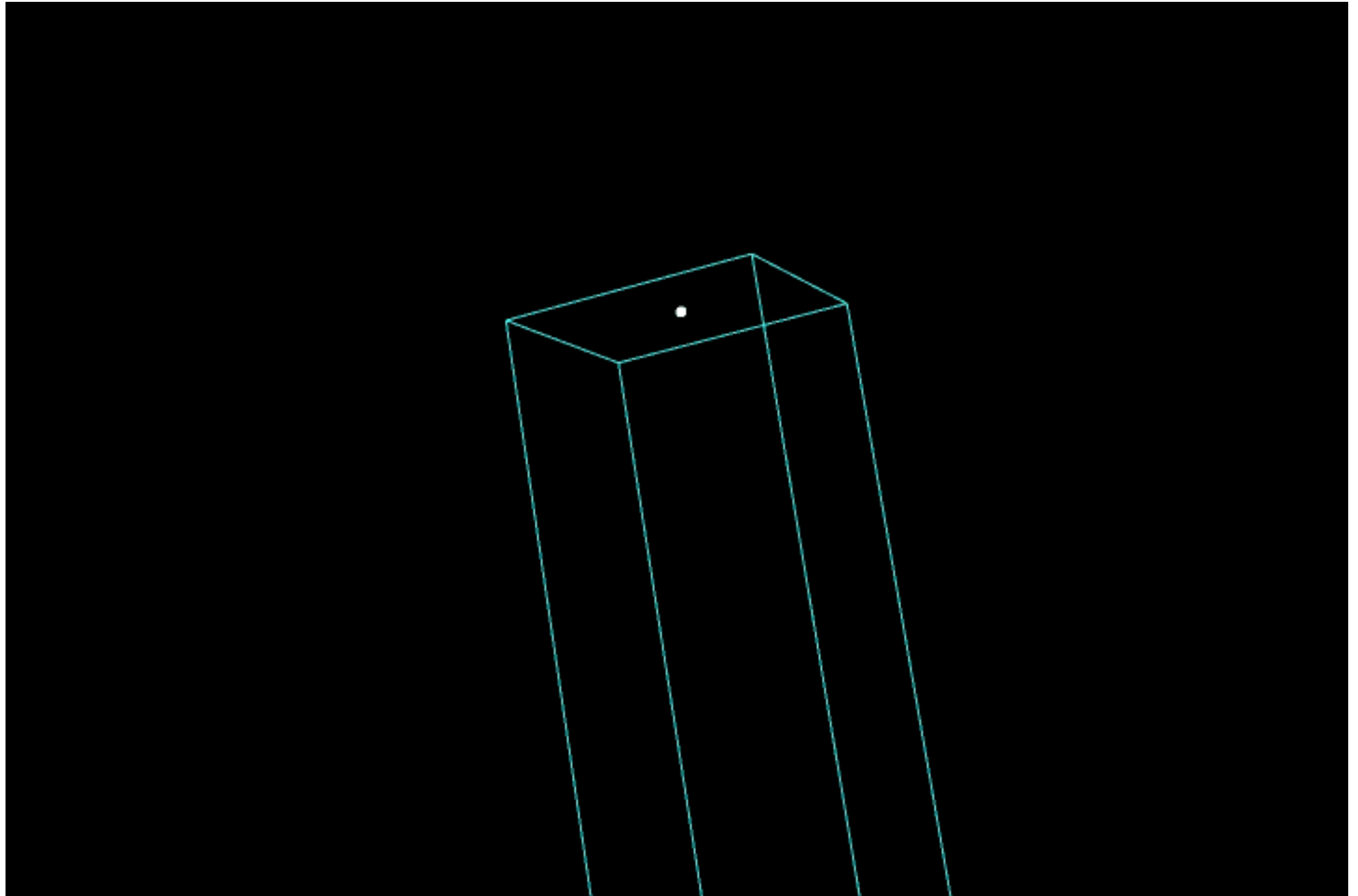
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- ▶ enough to raise 10 g of water by 1 °C
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- ▶ 60 grams of UHECR have the energy of 10,000,000,000 (10 billion) atomic bombs

cosmic-ray showers



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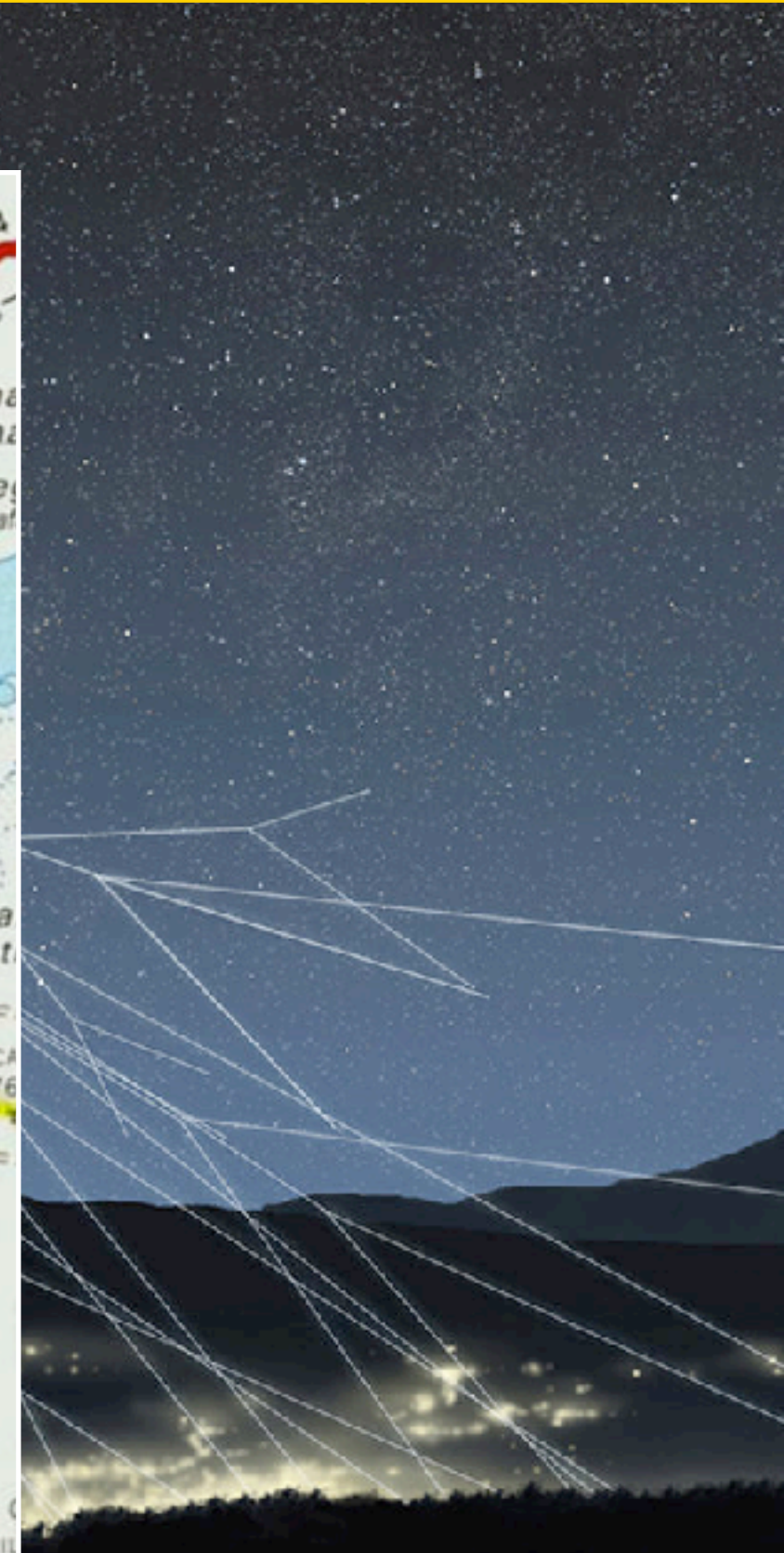
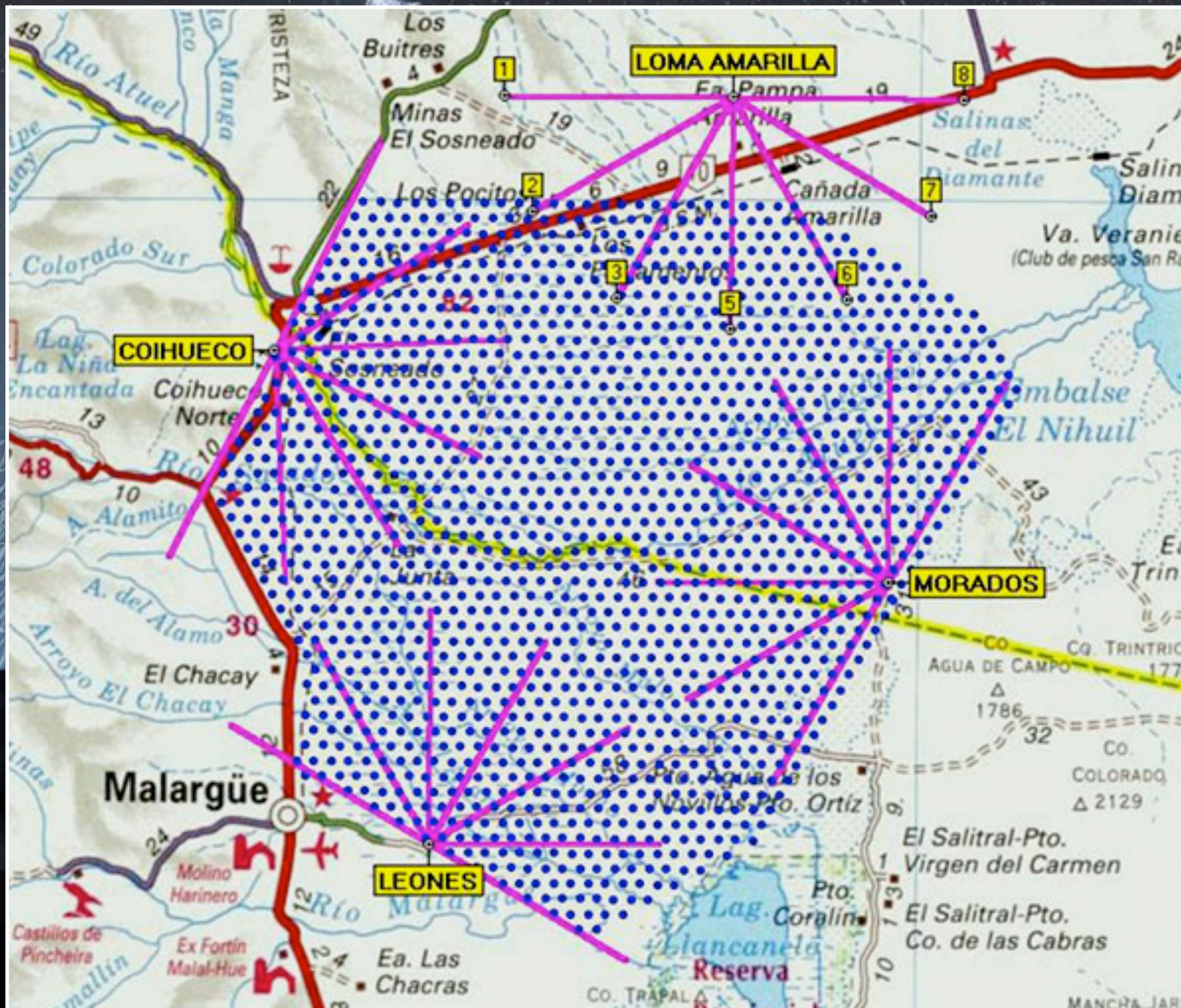
detecting ultra-high-energy cosmic rays



image credits: ASPERA/Novapix/L. Bret

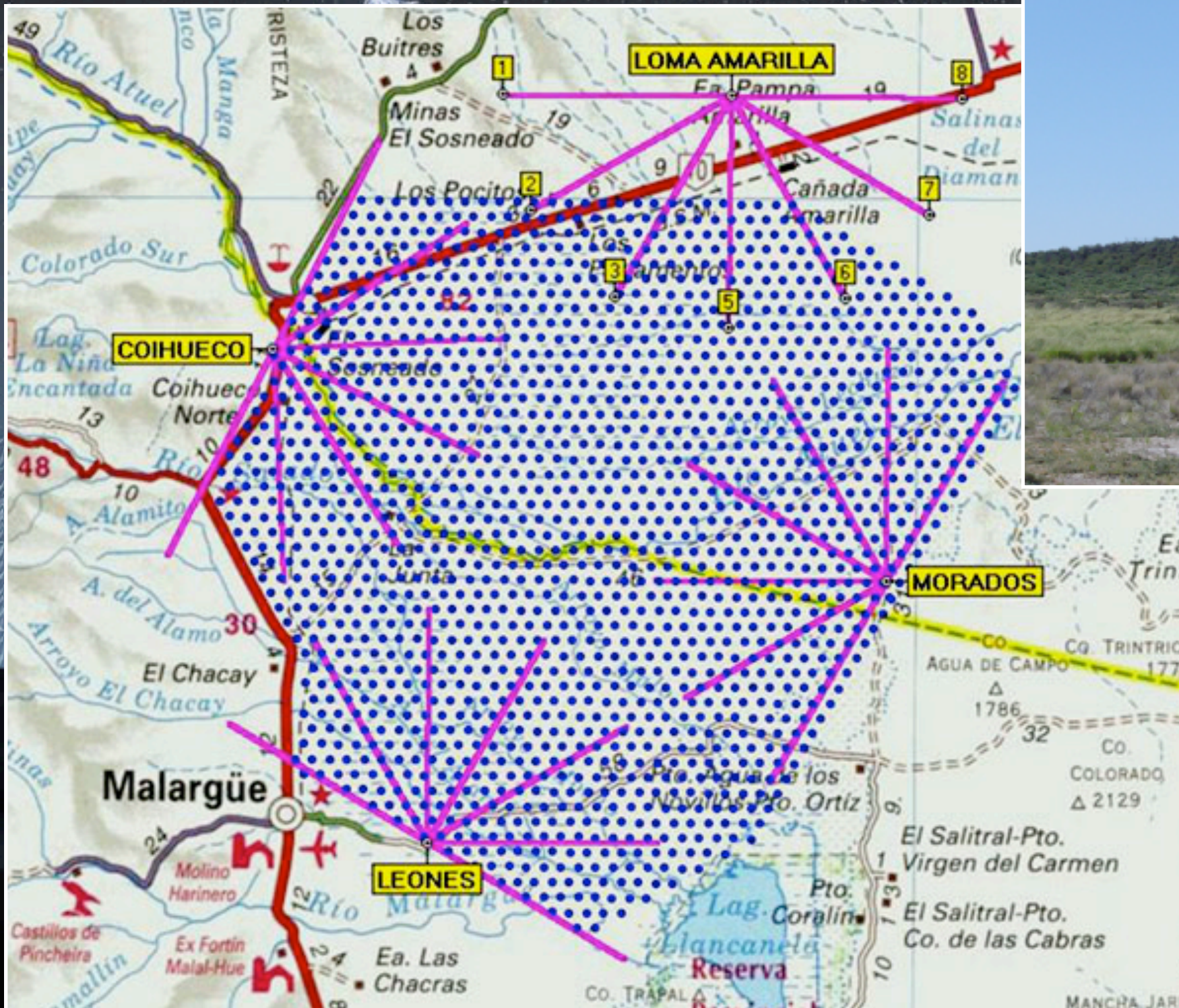
detecting ultra-high-energy cosmic rays

Pierre Auger Observatory, Argentina



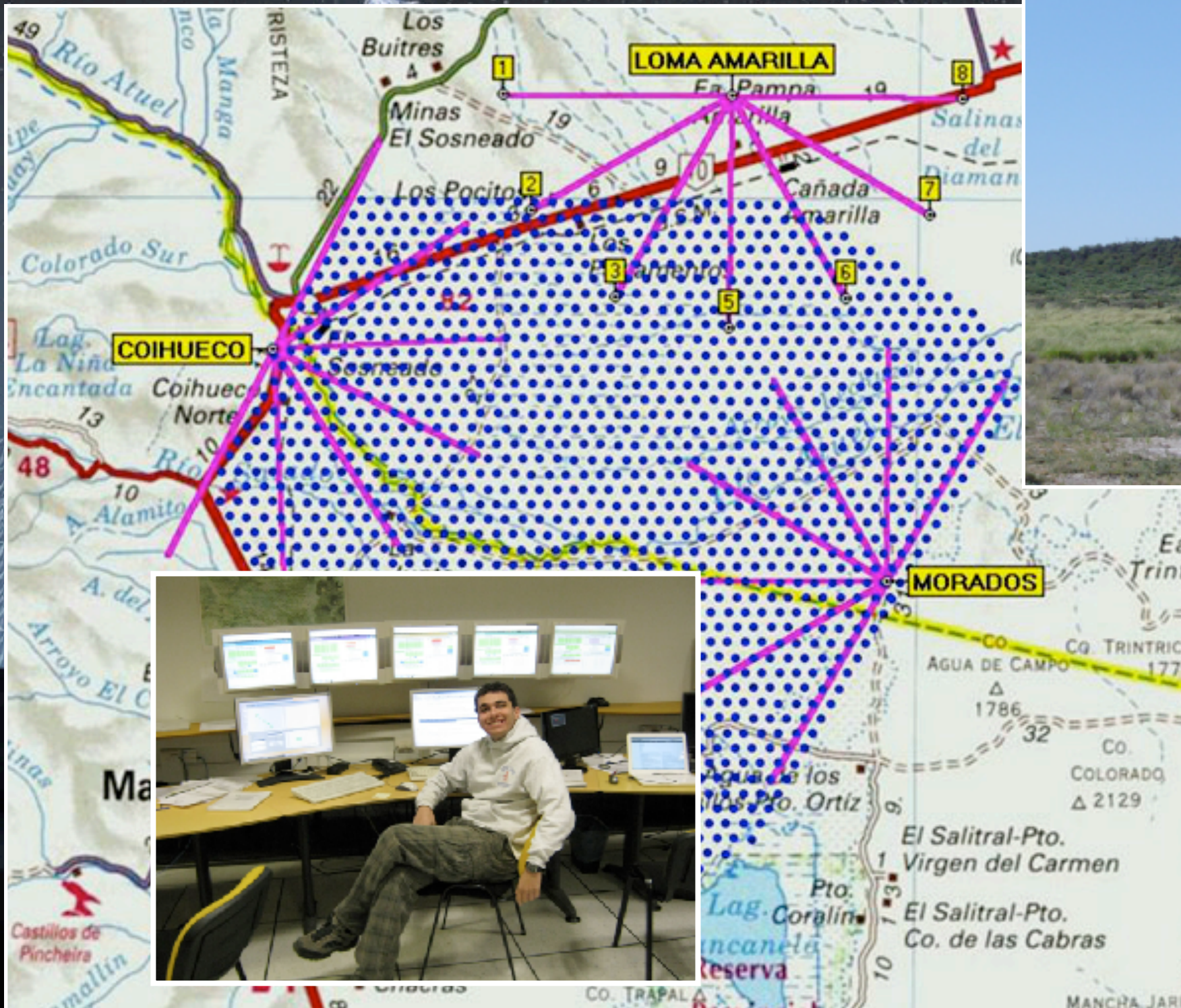
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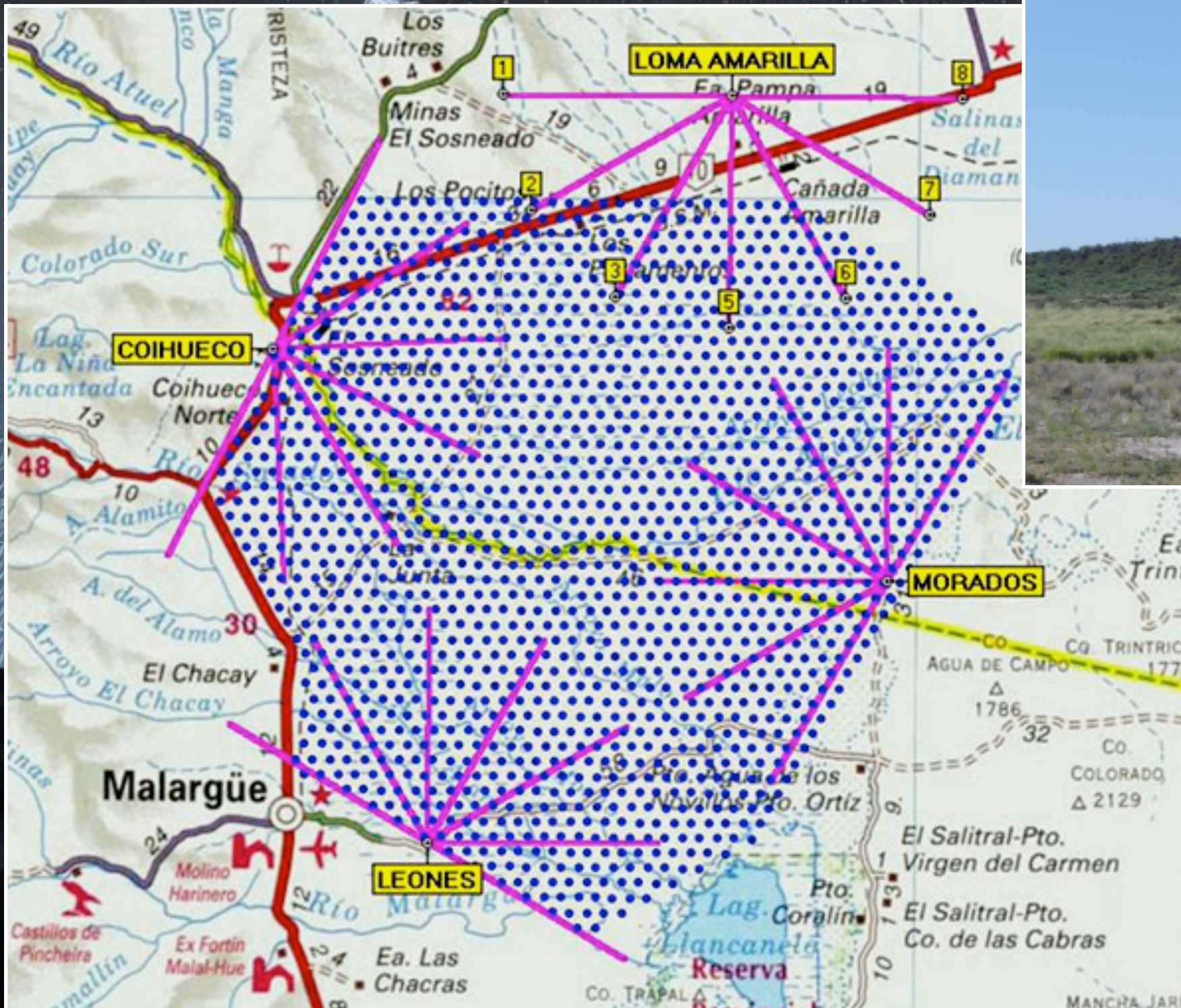
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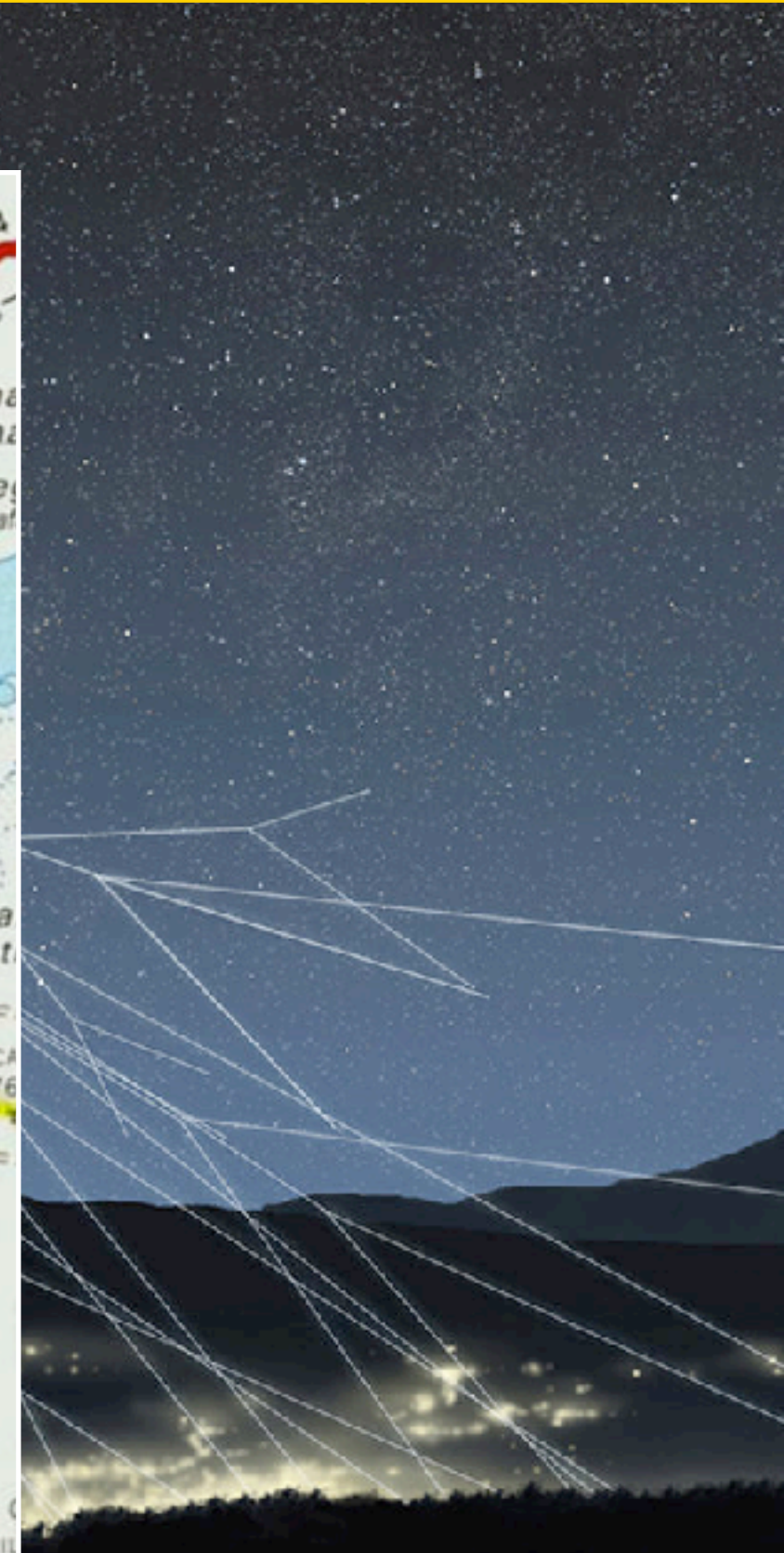
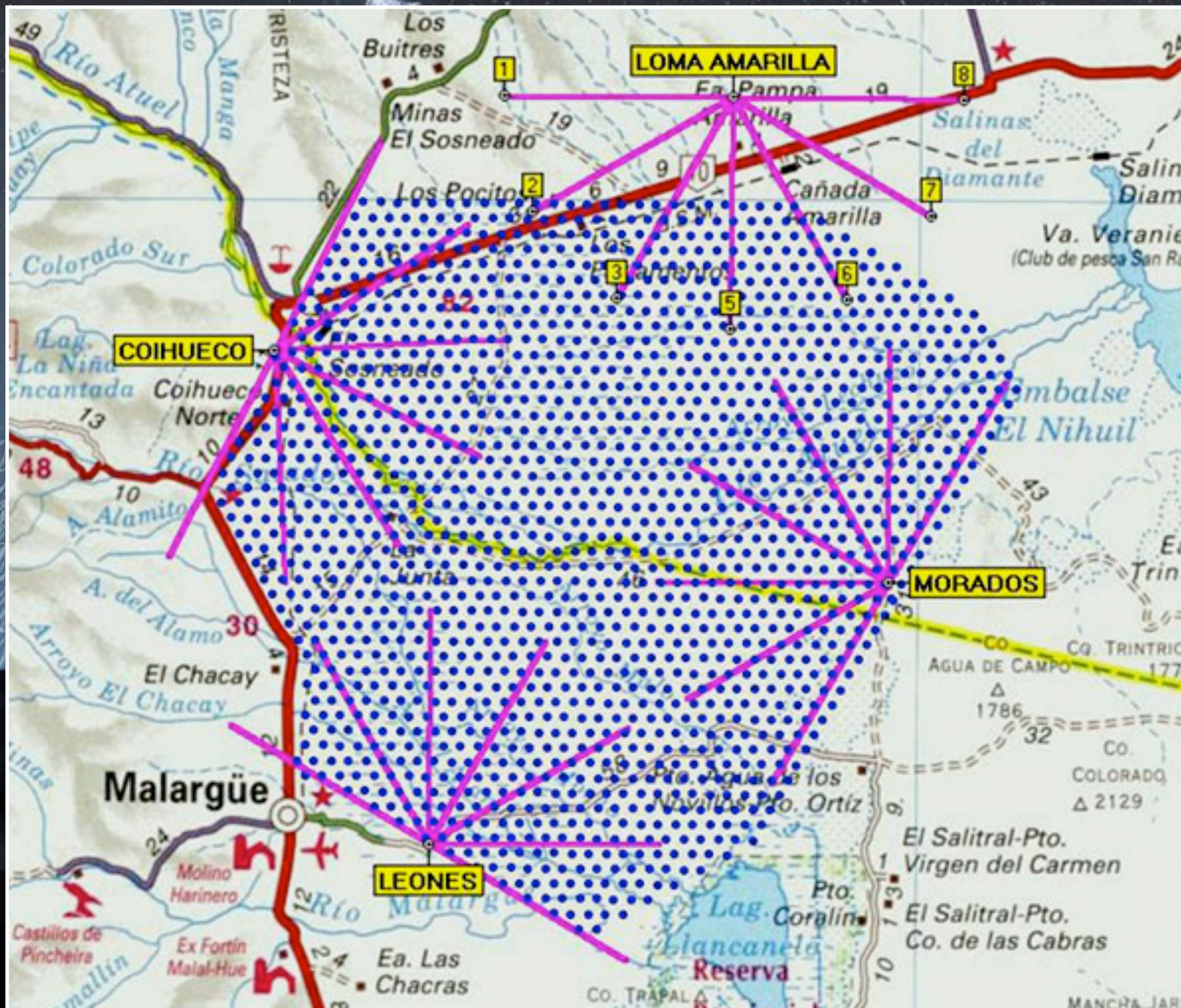
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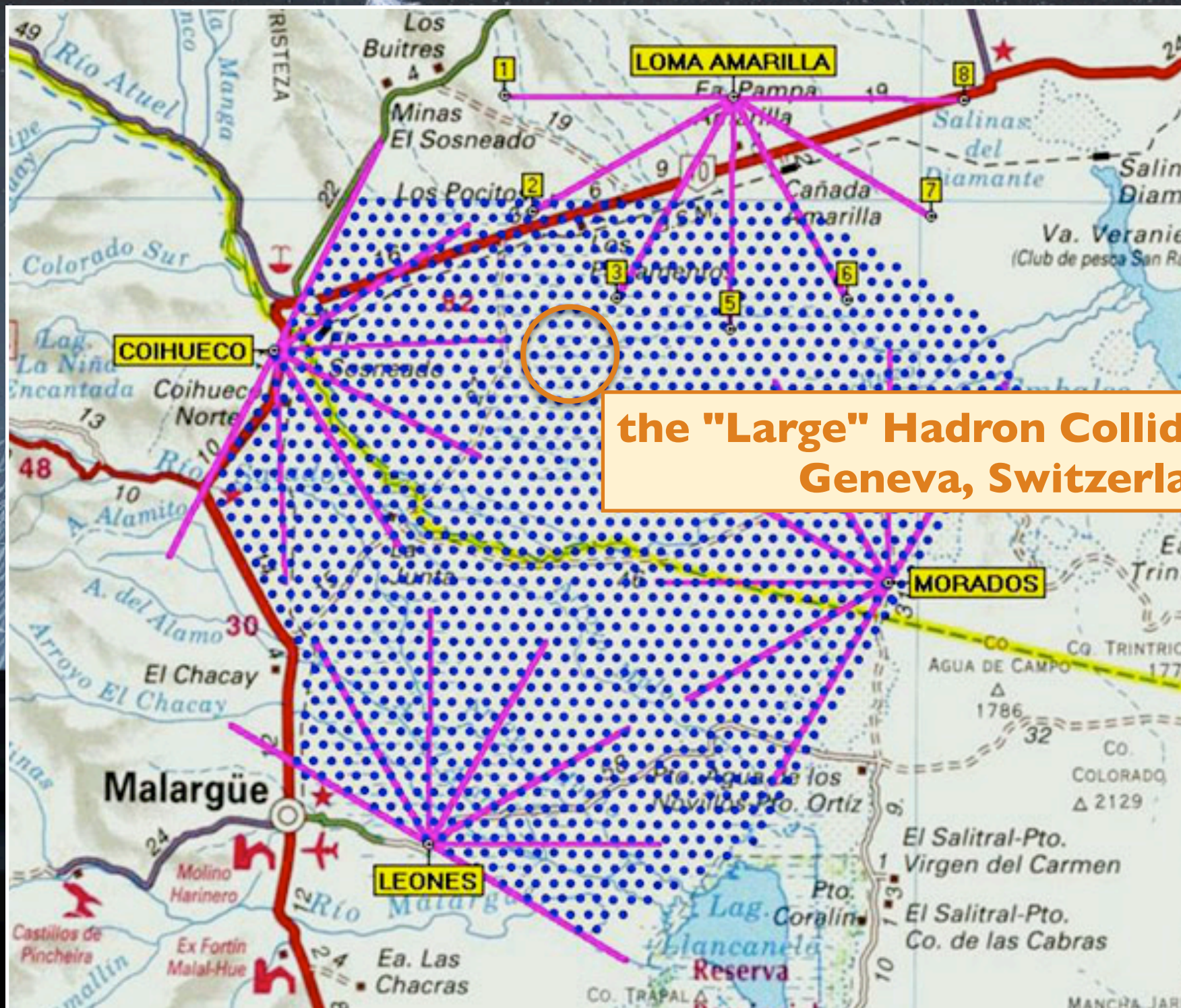
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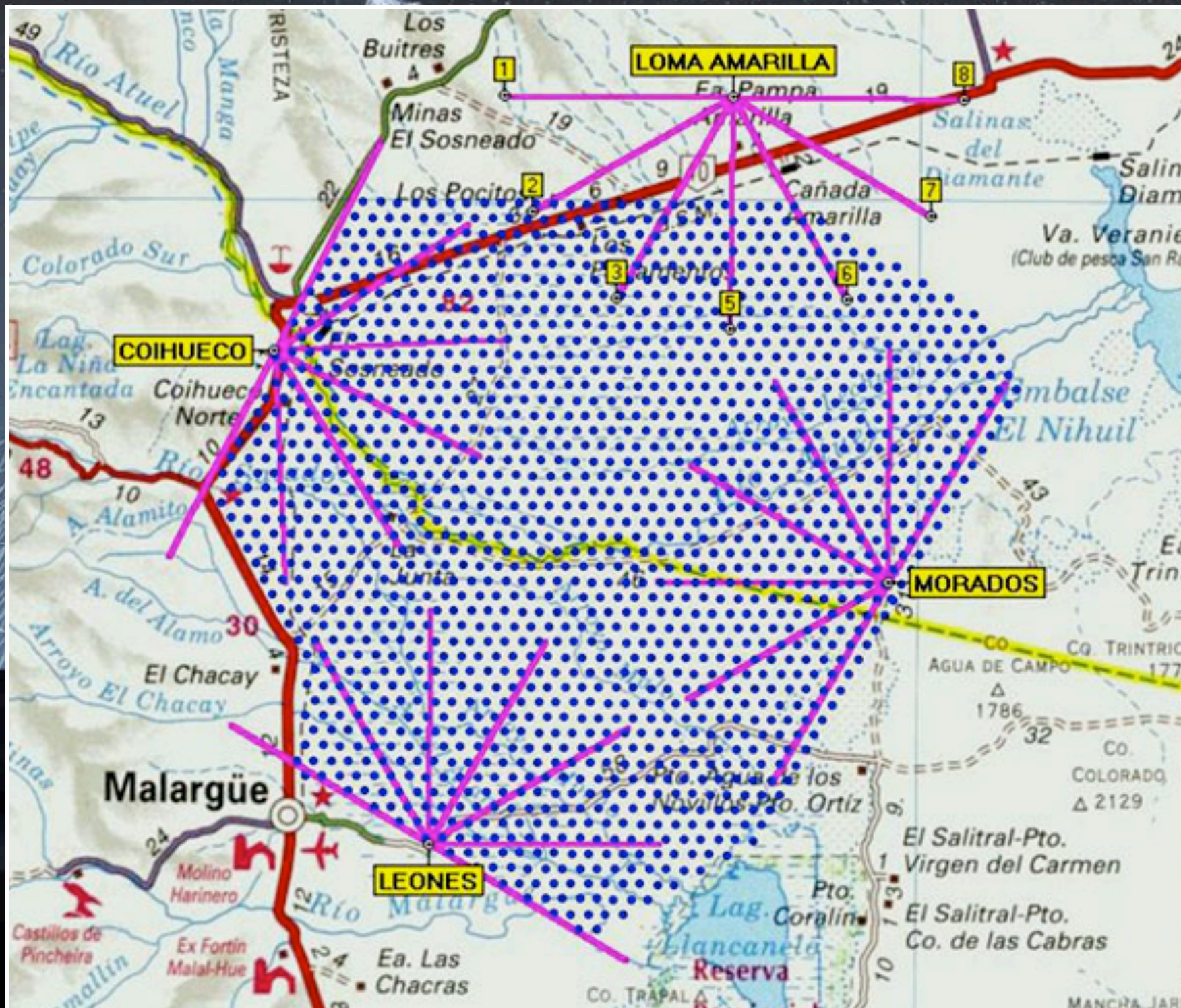
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the "Large" Hadron Collider (LHC) in Geneva, Switzerland

detecting ultra-high-energy cosmic rays

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detecting ultra-high-energy cosmic rays

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where do the most energetic cosmic rays come from?

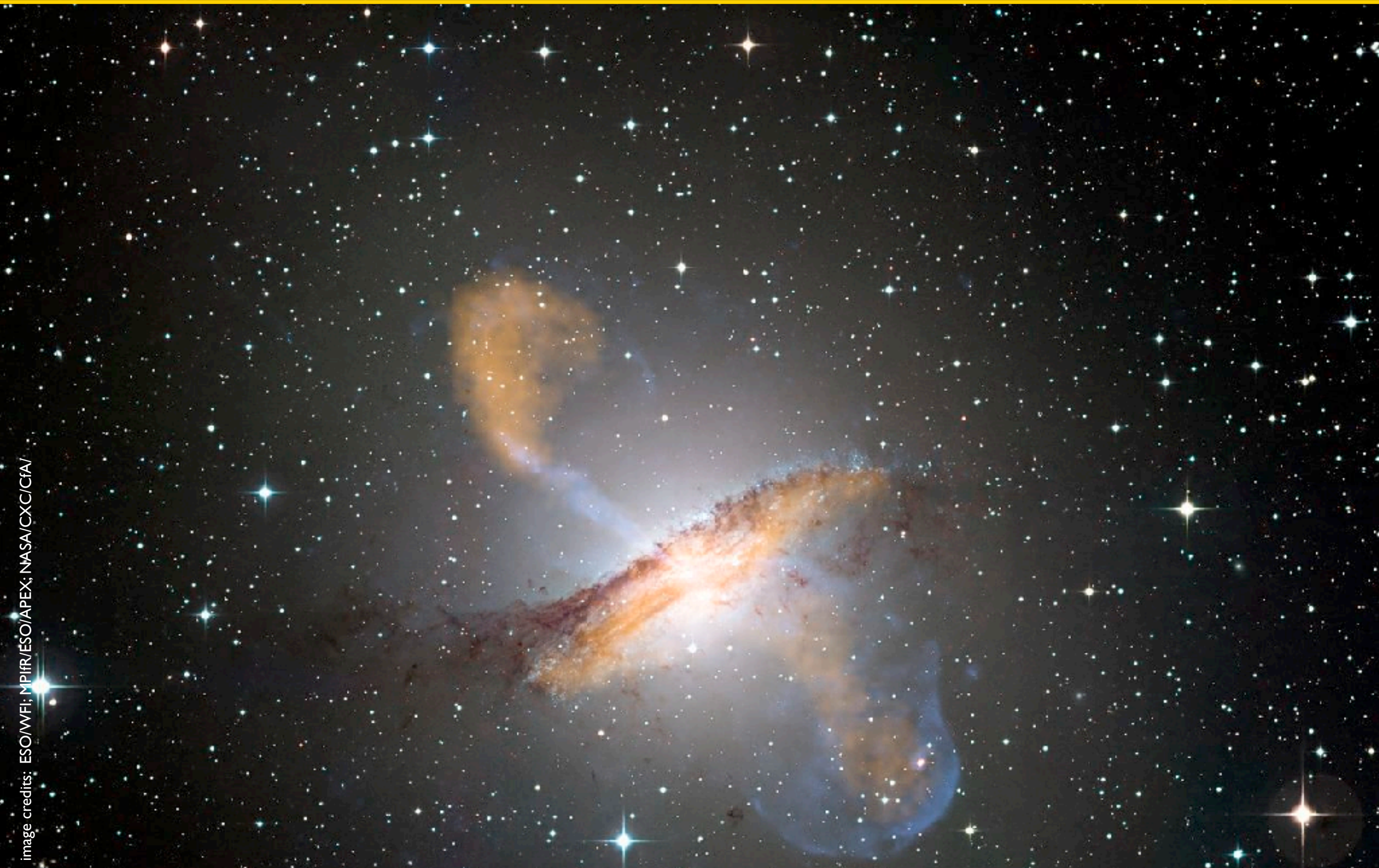


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where do the most energetic cosmic rays come from?

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...turned out to be a fluke 🙄

- ▶ cosmic rays affect our atmosphere, causing auroras, possibly lightning, etc
- ▶ they may be a hazard in space missions
- ▶ cosmic rays with high energies come from supernovae
- ▶ the origin of the most energetic particles in the universe remain a mystery

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thank you 😊

questions??

backup slides

supernovae

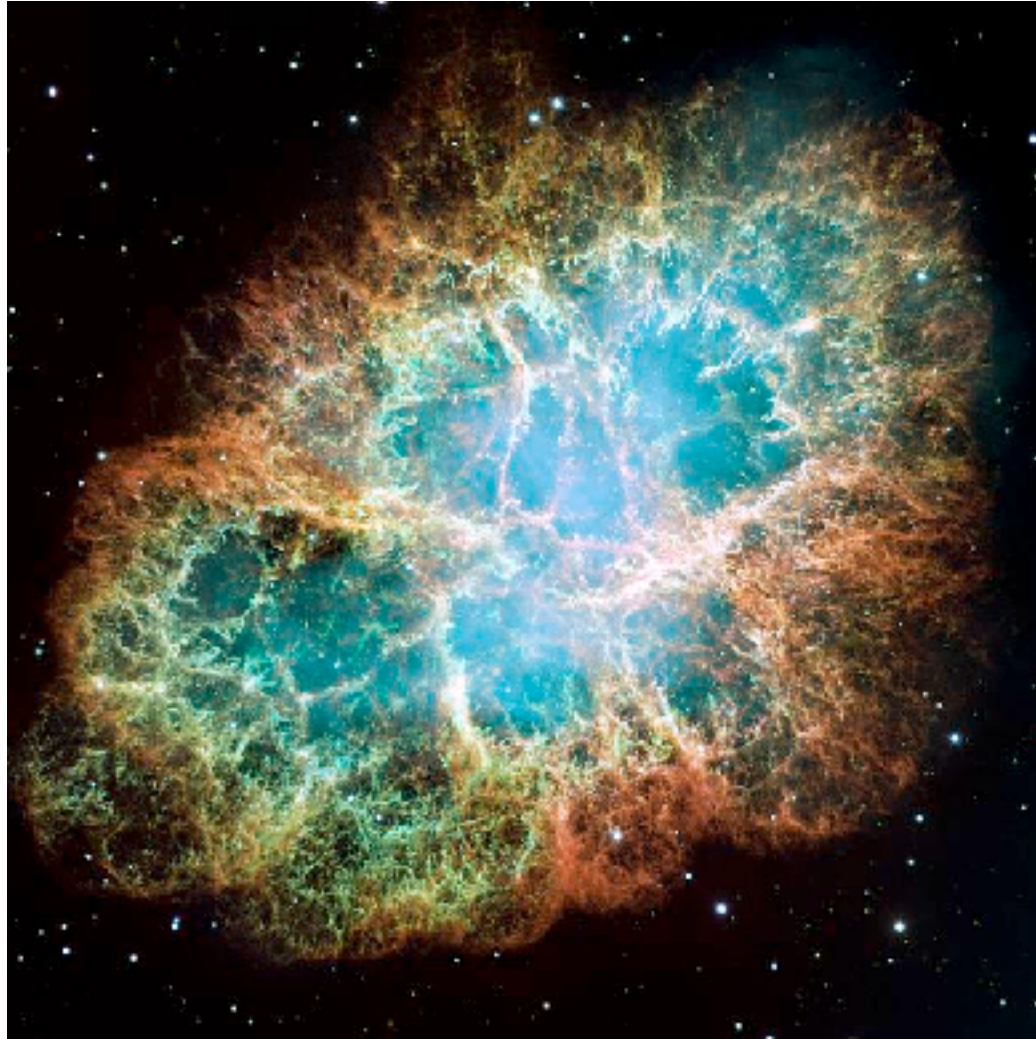
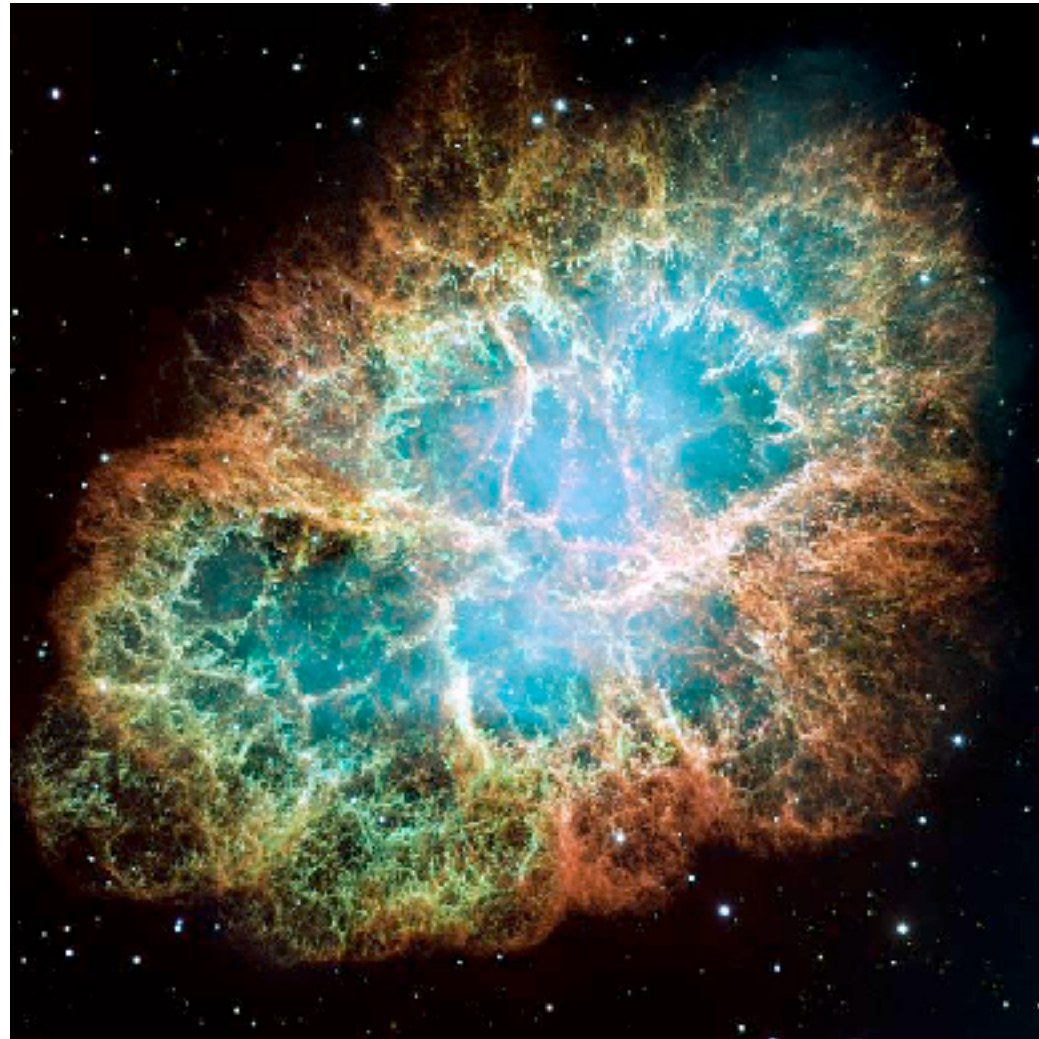


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supernovae



- ▶ come mostly from supernovae

galactic cosmic rays

supernovae



- ▶ come mostly from supernovae
- ▶ magnetic fields mess up their directions

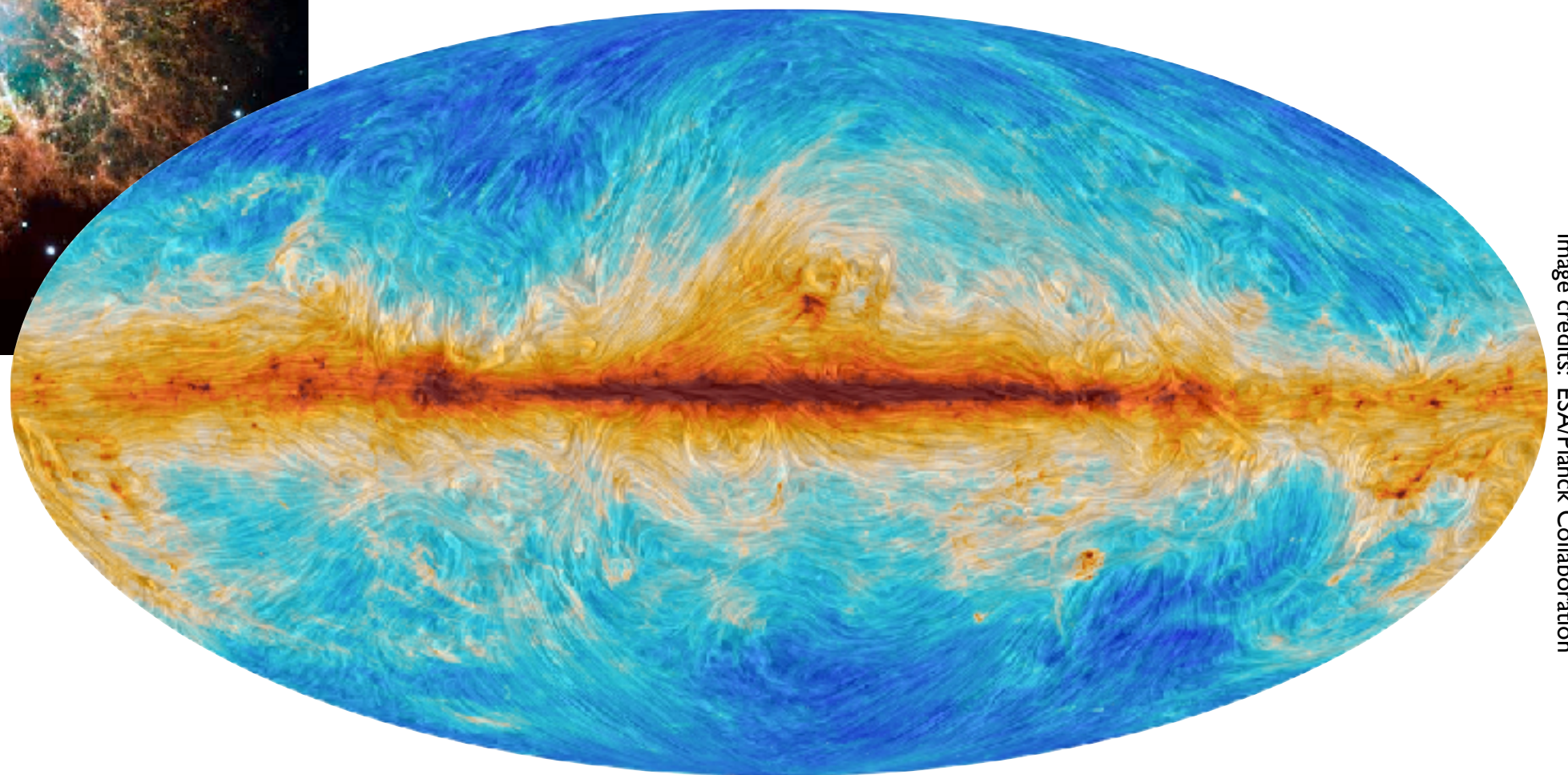


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galactic cosmic rays

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- ▶ we need indirect methods to locate their source

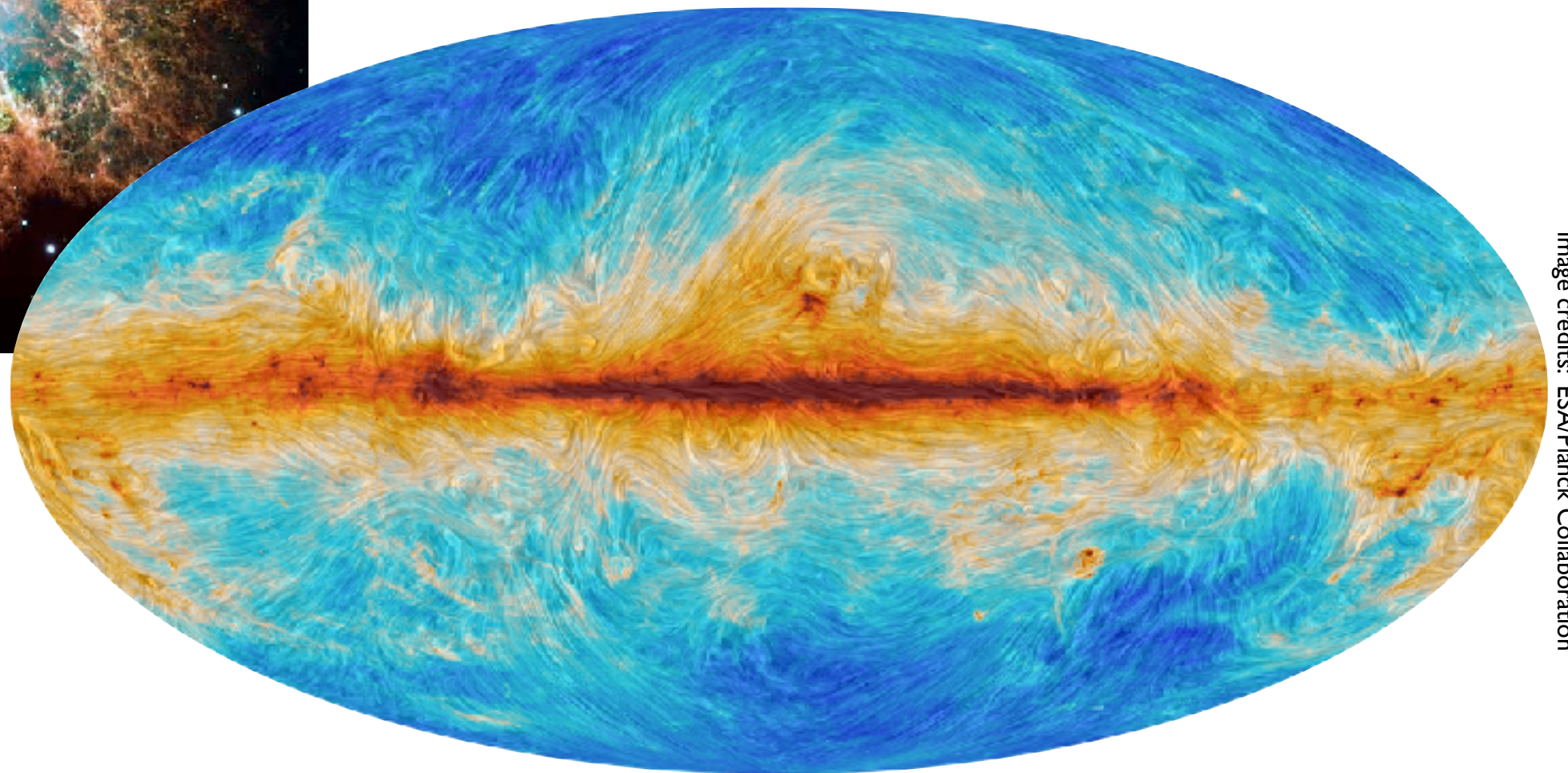


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galactic cosmic rays

supernovae



- ▶ come mostly from supernovae
- ▶ magnetic fields mess up their directions
- ▶ we need indirect methods to locate their source
- ▶ suitable method: look at the gamma rays (cosmic rays interact with stuff around their source, producing gamma rays)

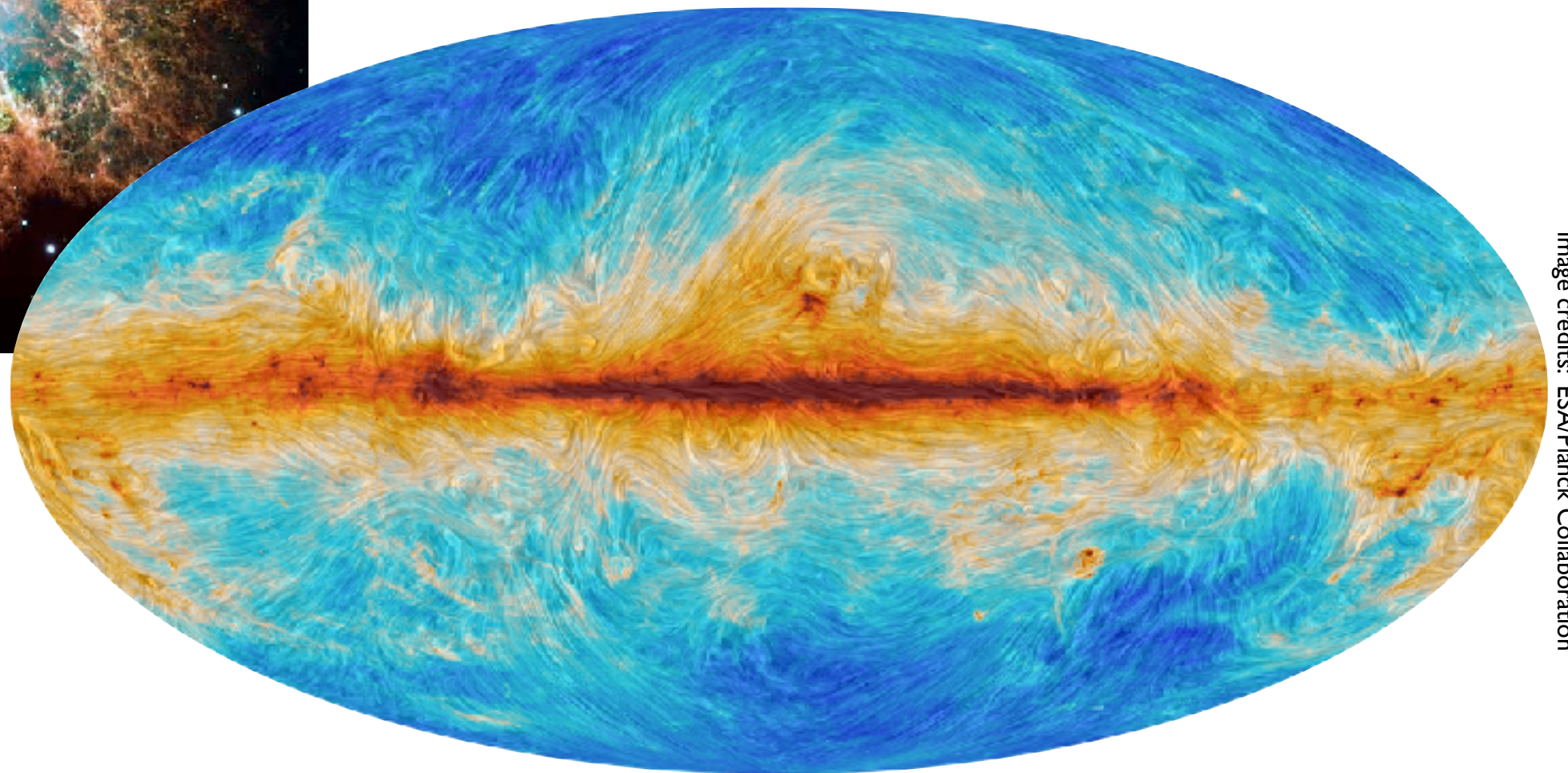


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