

Cosmic rays and dark matter

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Dark Matter:

We know it's there!

**Otherwise our whole Universe
would look different.**

**So far: no proof for what it is
exactly! :-)**

stuff we know

**stuff we don't know:
dark matter**

Now what?

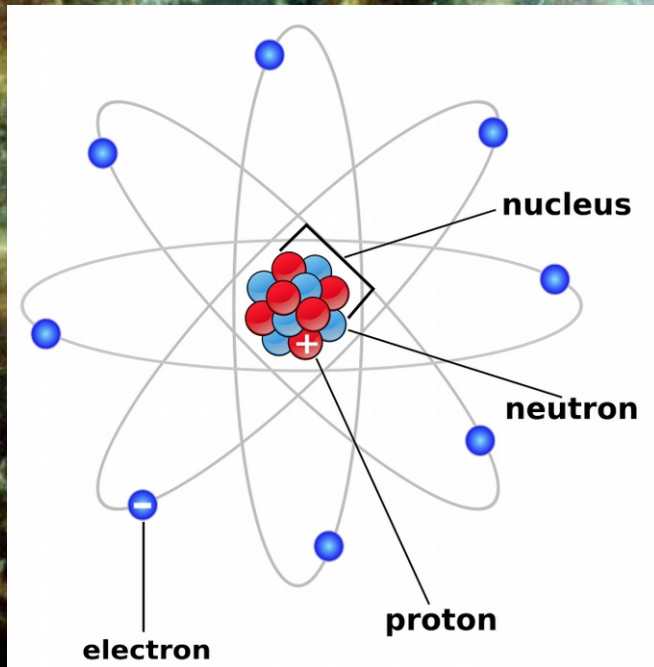
**Dark
Matter**



**Why not ask someone
who has been there and**

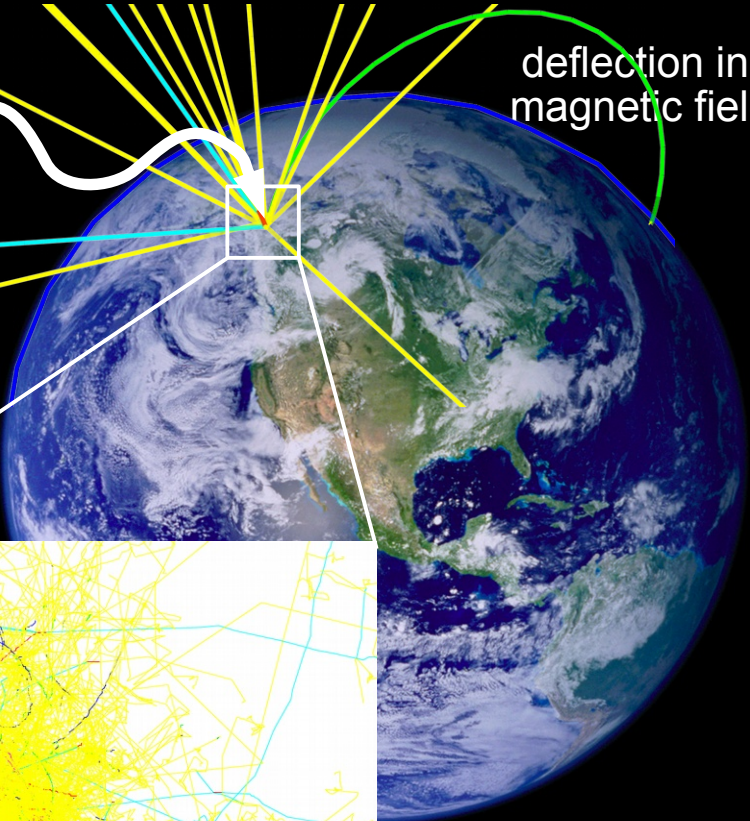
**These
guys could
be cosmic
rays**

Cosmic rays - What is that?

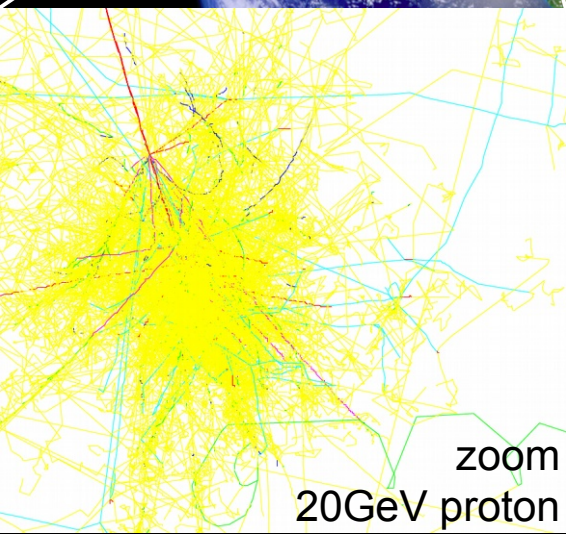


Products of star
explosions
→ mostly composed of
the same components
that we are made of

Cosmic rays on the journey to us



scattering in magnetic fields, interaction with interstellar medium



interactions with atmosphere

A visualization of the cosmic web, showing a complex network of filaments and nodes of matter. The filaments are colored in shades of purple and blue, while the nodes are bright yellow and orange. The overall structure is a dense, interconnected web of matter.

**Let's be honest: the details *do* require to study
Physics in more depth...however:**

125 Mpc/h

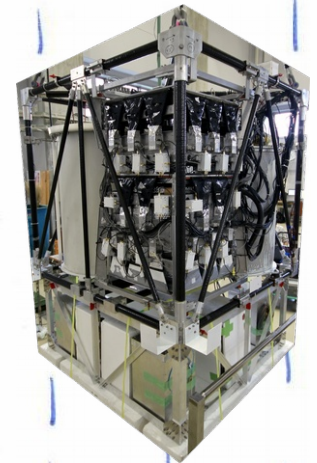
A horizontal scale bar with vertical end caps, indicating a distance of 125 Mpc/h.

**We can build machines that measure these
runners (cosmic rays) and tell us more**

**We are looking for special types of cosmic rays
that hopefully know more about dark matter.**

Where to install a cosmic-ray experiment?

Imagine you wanted to collect rain...



too dry

**The atmosphere acts as a
roof for cosmic rays**

atmosphere



***Which is good to stay
healthy, but bad to
measure cosmic rays***

**when you are hiking
at high altitudes**

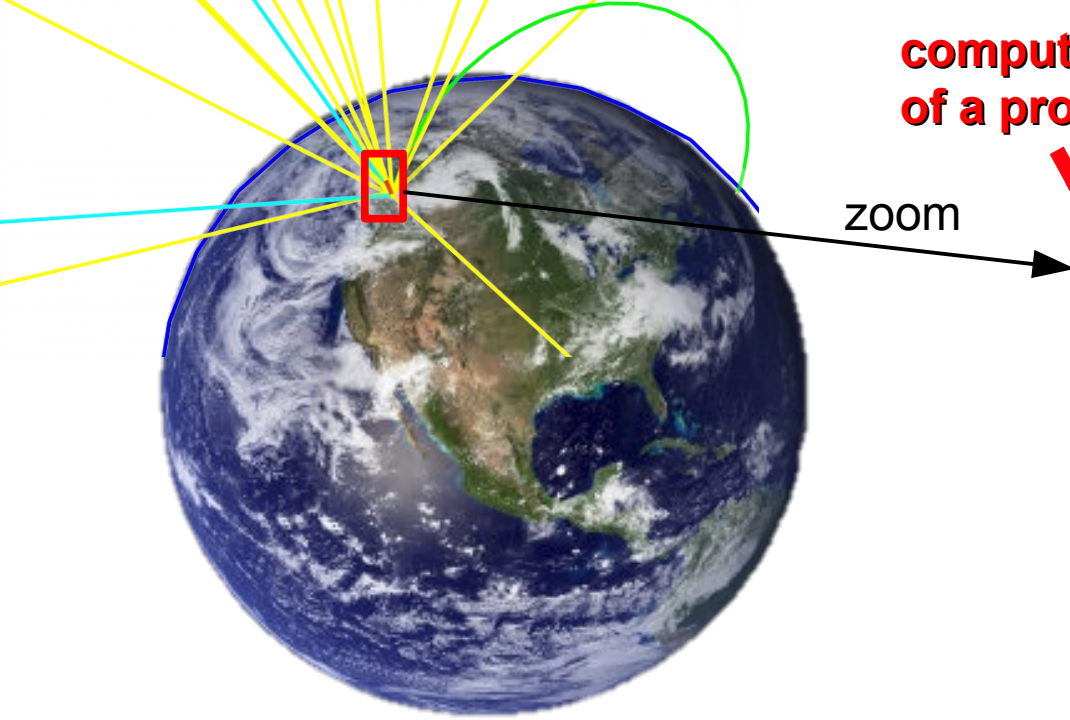
**→ you are exhausted
much faster**

**→ because there is
less air to breathe**

**→ roof for cosmic
rays is getting weaker**



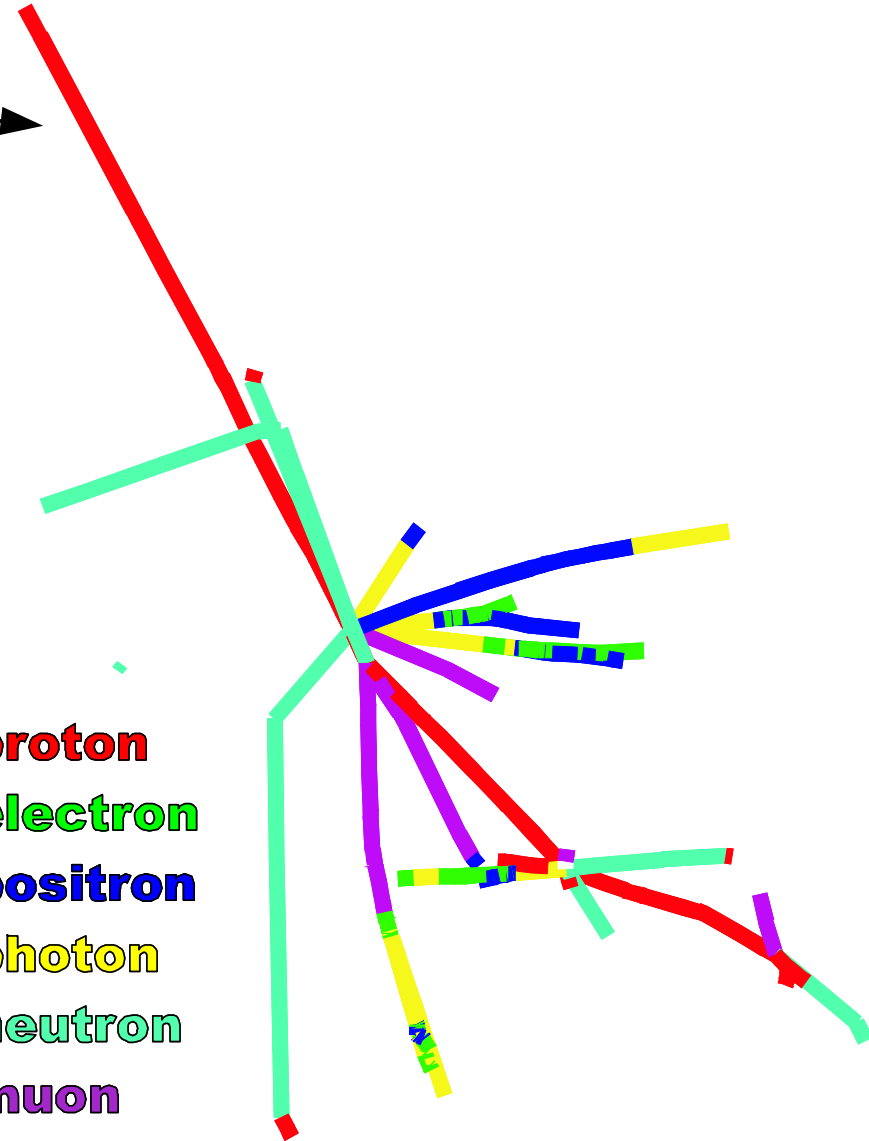
computer simulation of interaction of a proton with the atmosphere



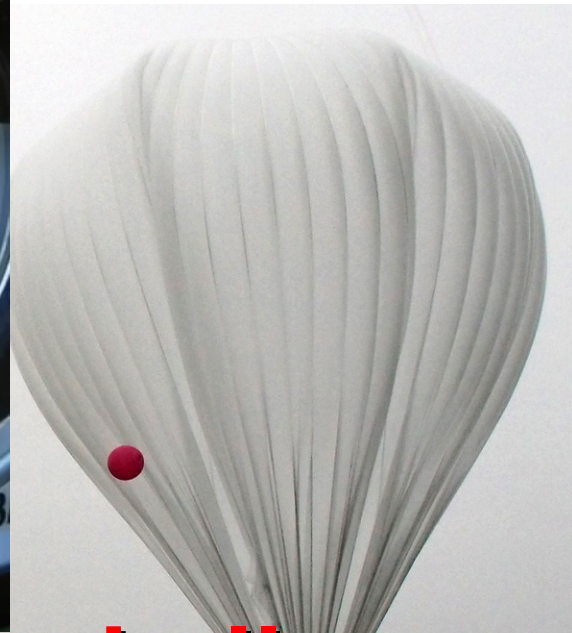
Cosmic ray interacts with atmosphere

- slows down
- composition changes a lot with altitude
- we are exposed to hundreds of cosmic rays this very moment

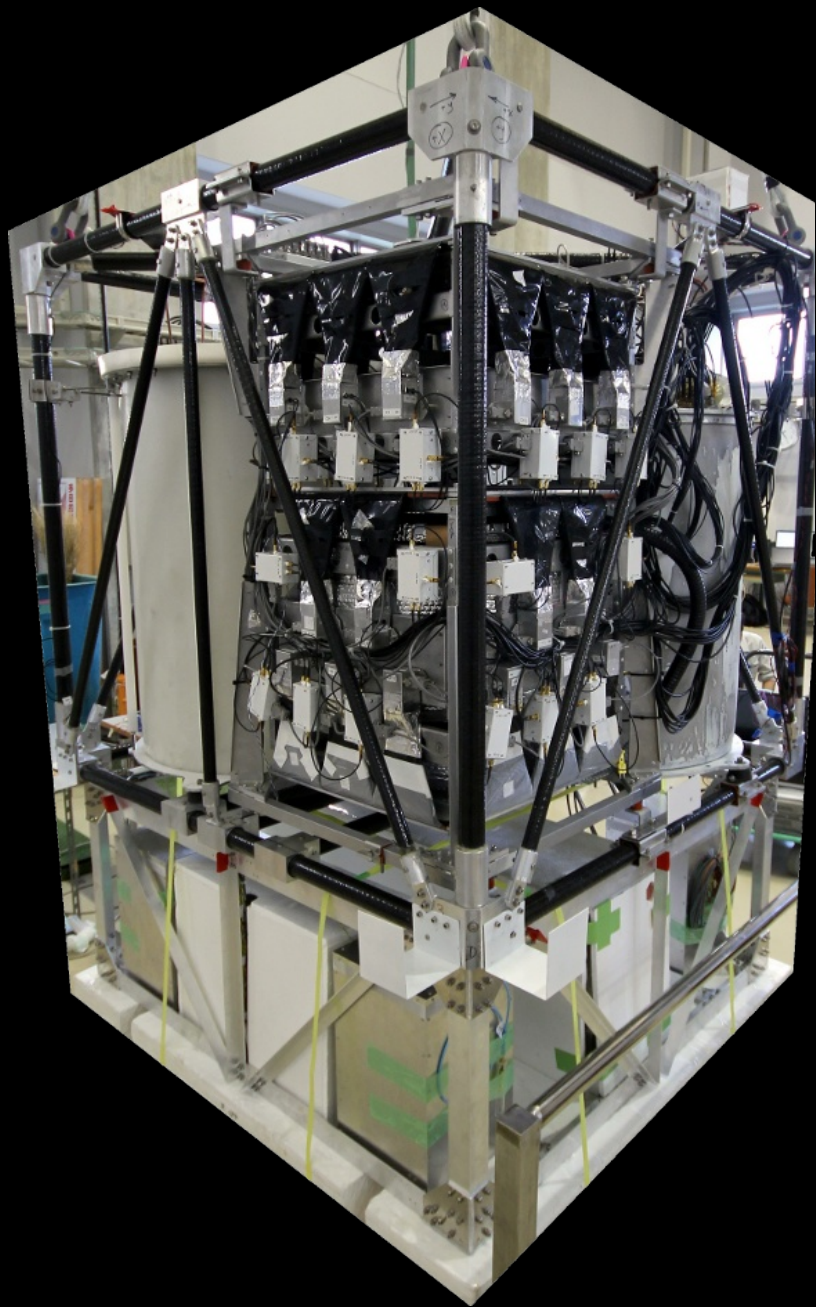
- proton
- electron
- positron
- photon
- neutron
- muon



Therefore put the experiment as high as possible!

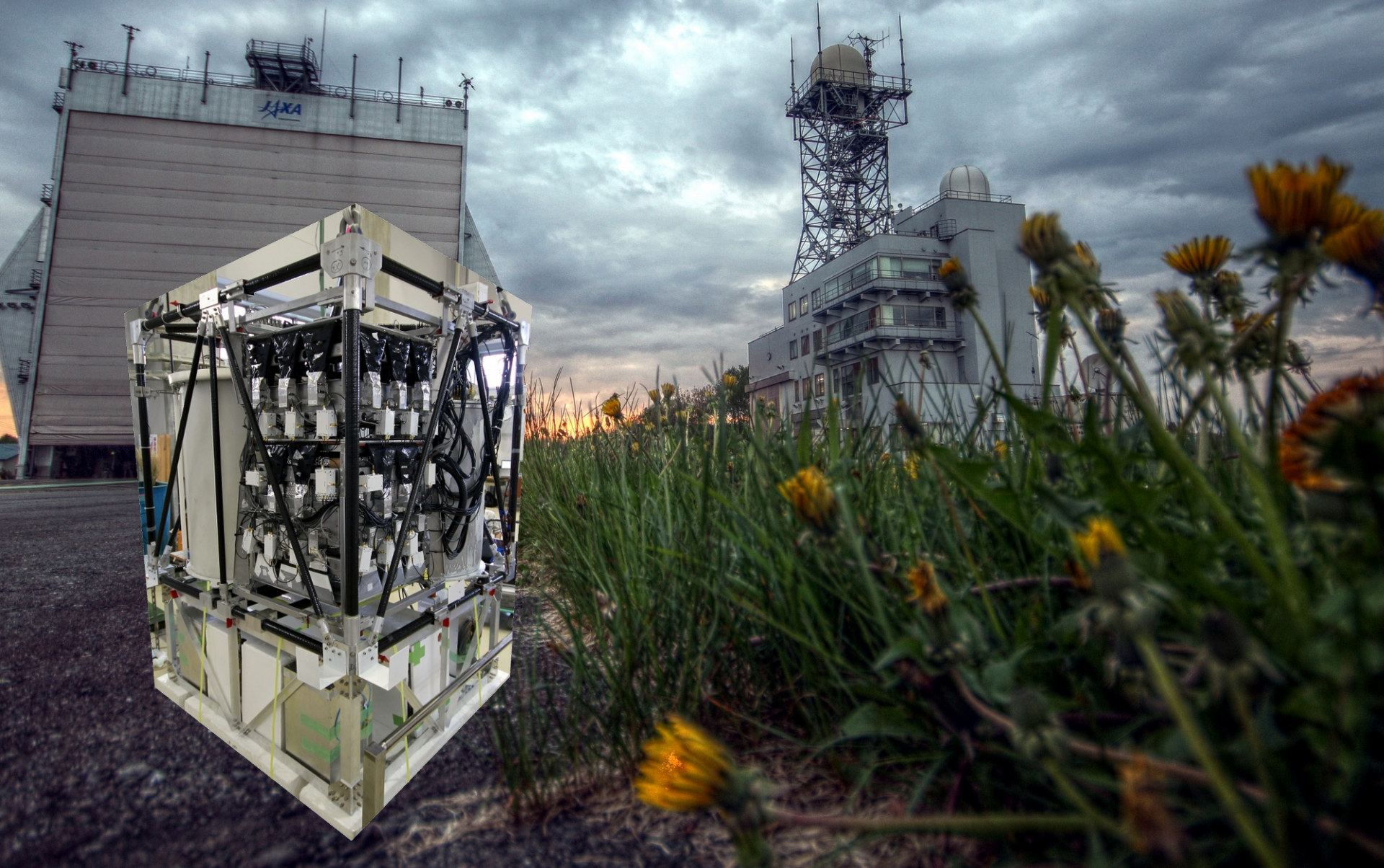


**use balloons
that go up very very high
→ 25 miles above ground**



***A lot of hands on
work with all sorts of
different tasks!
Playground for big kids***

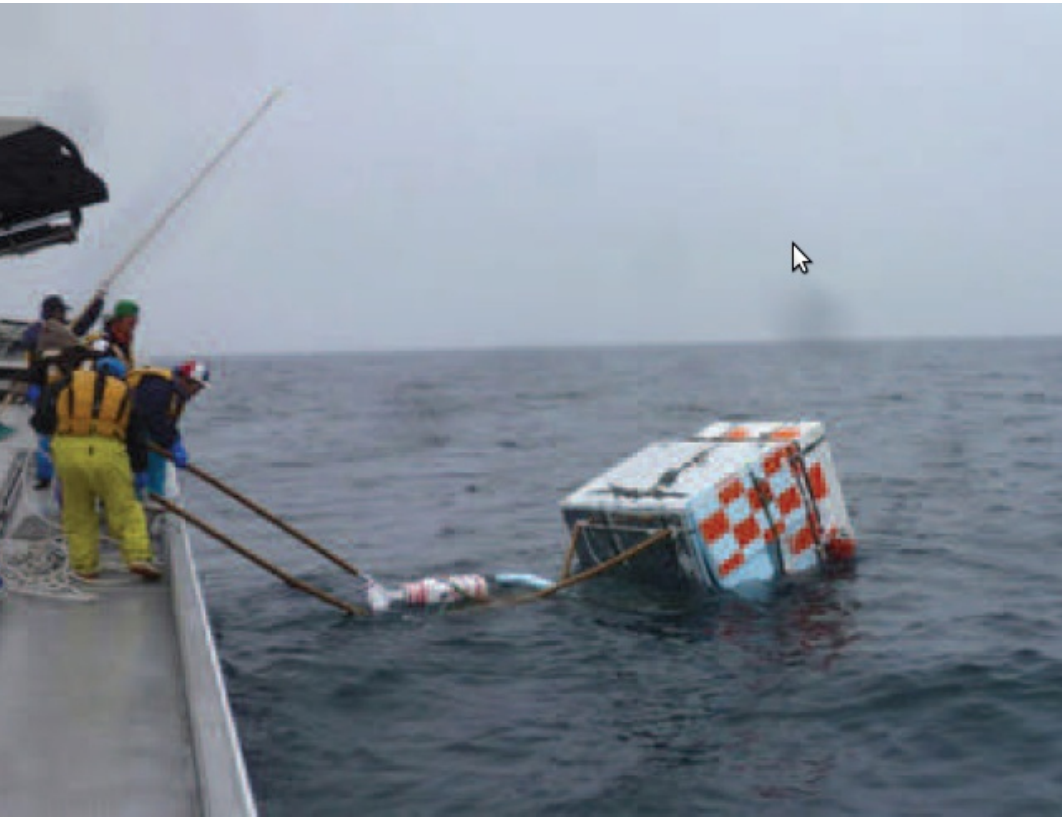
GAPS balloon experiment launched from Japan






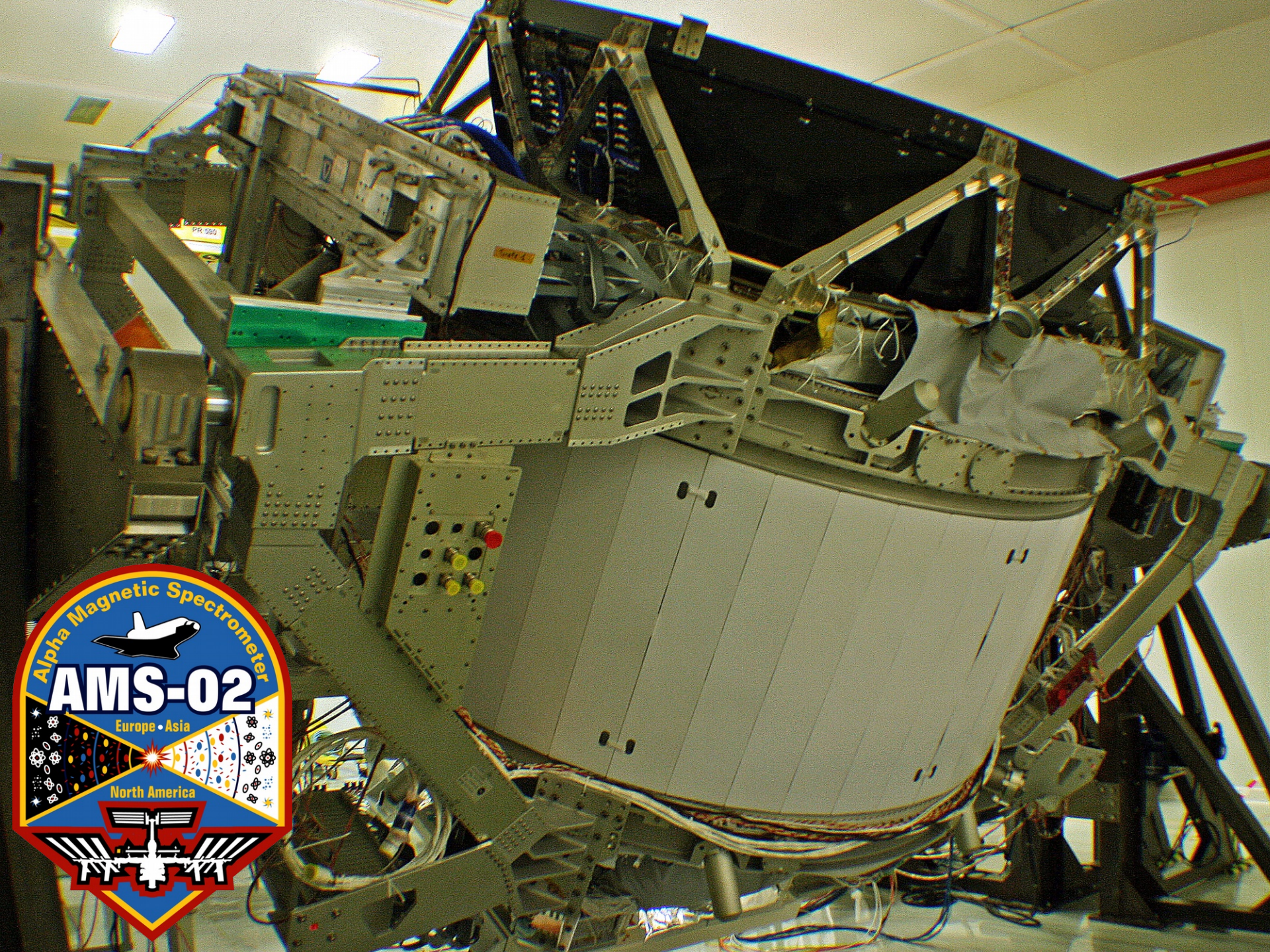
2012:06:03 02:29:14

Experiment landed in the Pacific ocean!



Want something better than high altitude balloon → go to space (expensive about \$1,000,000 for 2lbs)

- 
- AMS is a multi-purpose particle physics detector installed on the International Space Station
 - large international collaboration (~600 people from 60 countries involved)
 - AMS collected 10th of billions of events

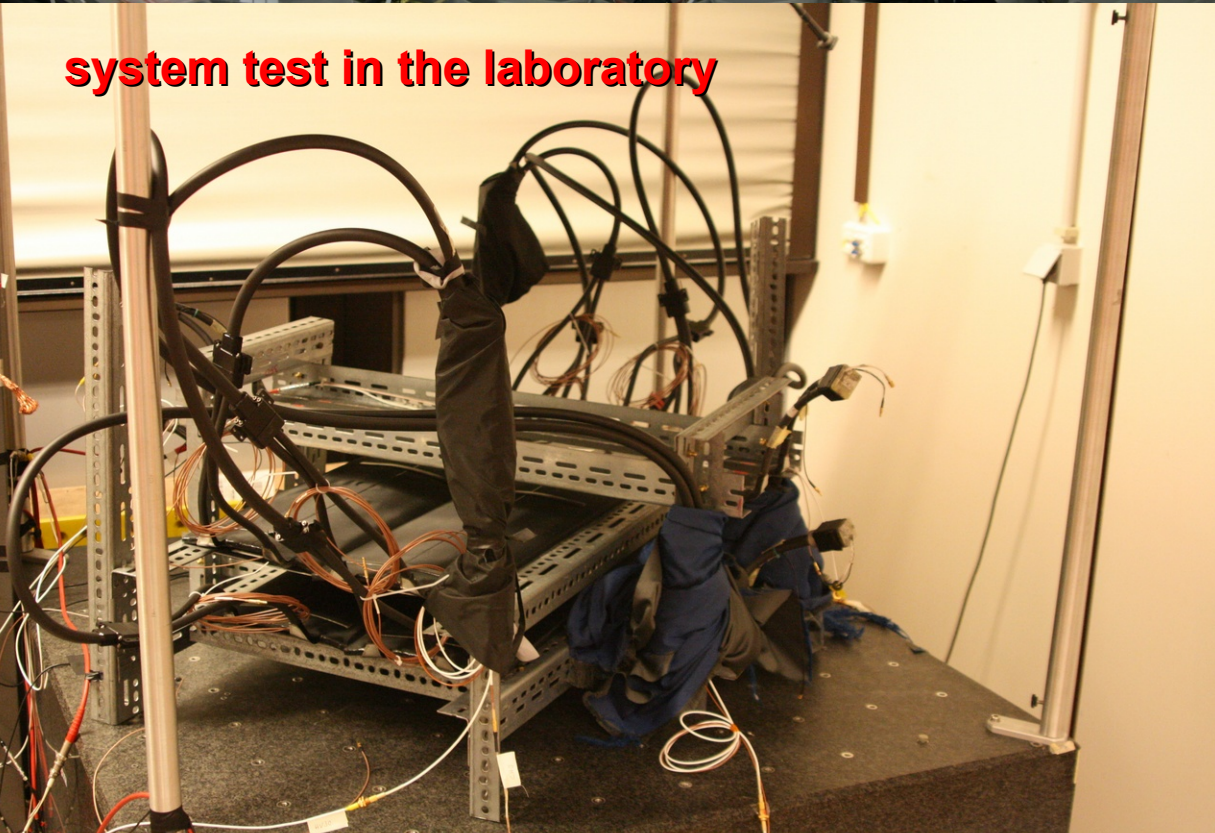




payload integration



vibration testing



system test in the laboratory



vacuum testing

Integration of AMS-02 at CERN with STS-134 astronauts



MW

PvD

AG

Mark E. Kelly

Gregory H. Johnson

Andrew J. Feustel

Gregory E. Chamitoff

Roberto Vittori

TK

Edward M. Fincke

Samuel C. C. Ting



Launch STS-134

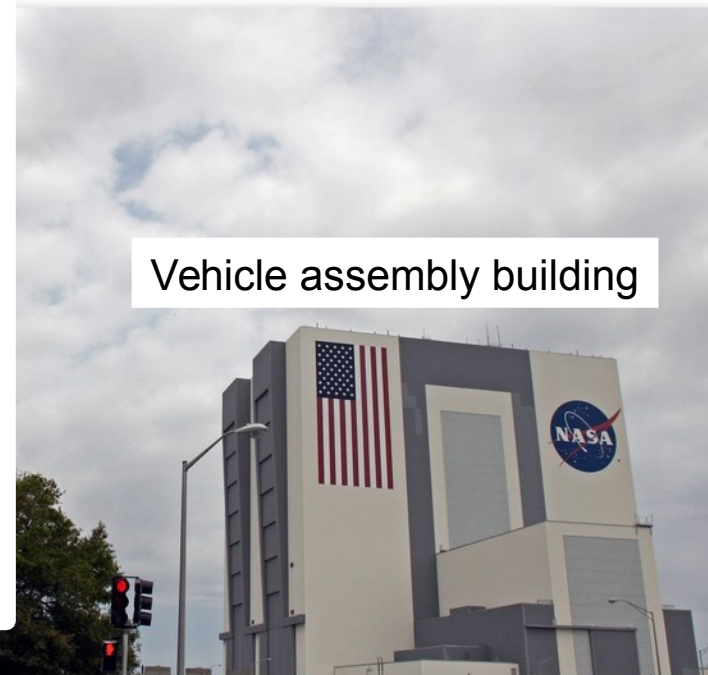
on the launch
4



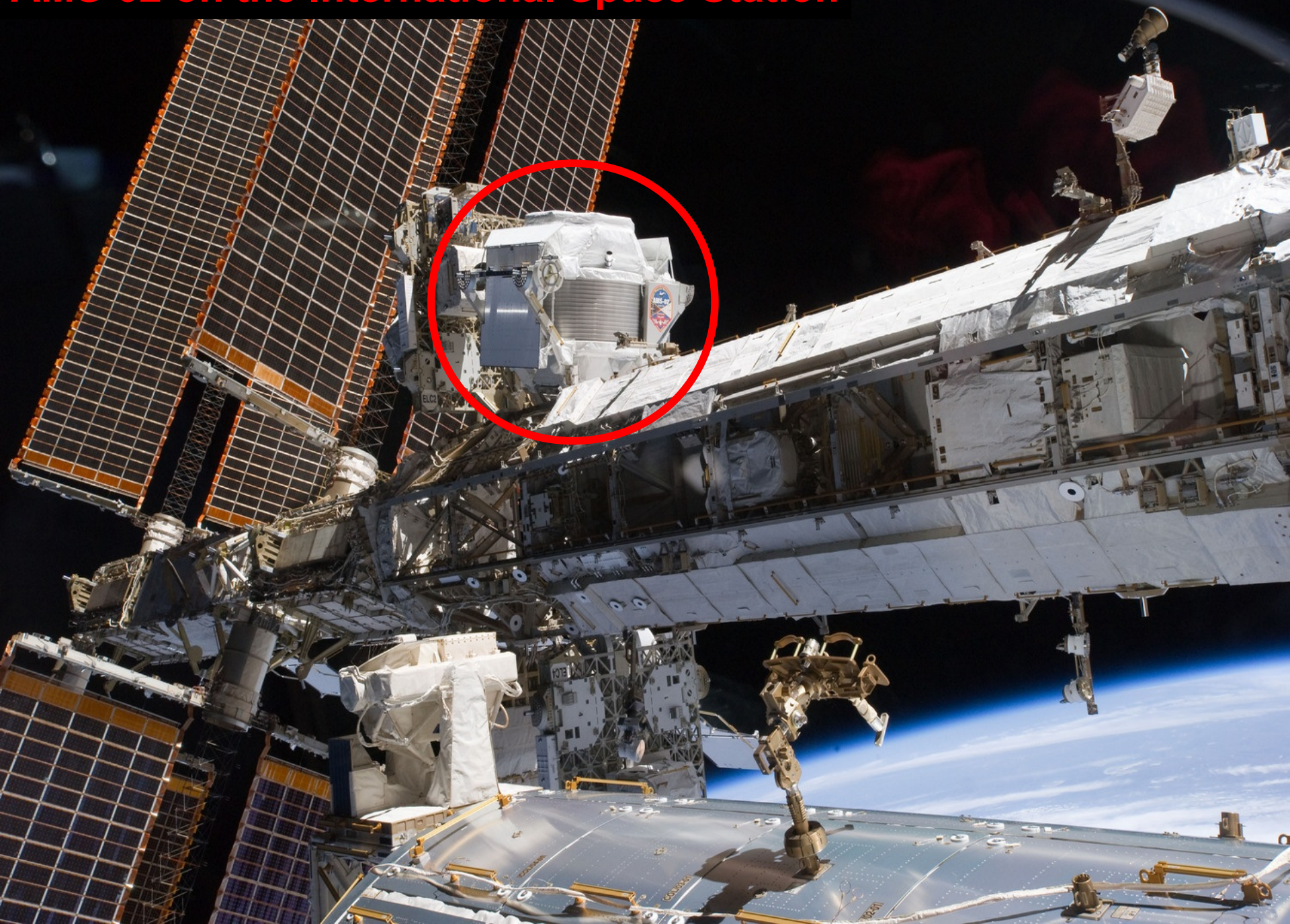
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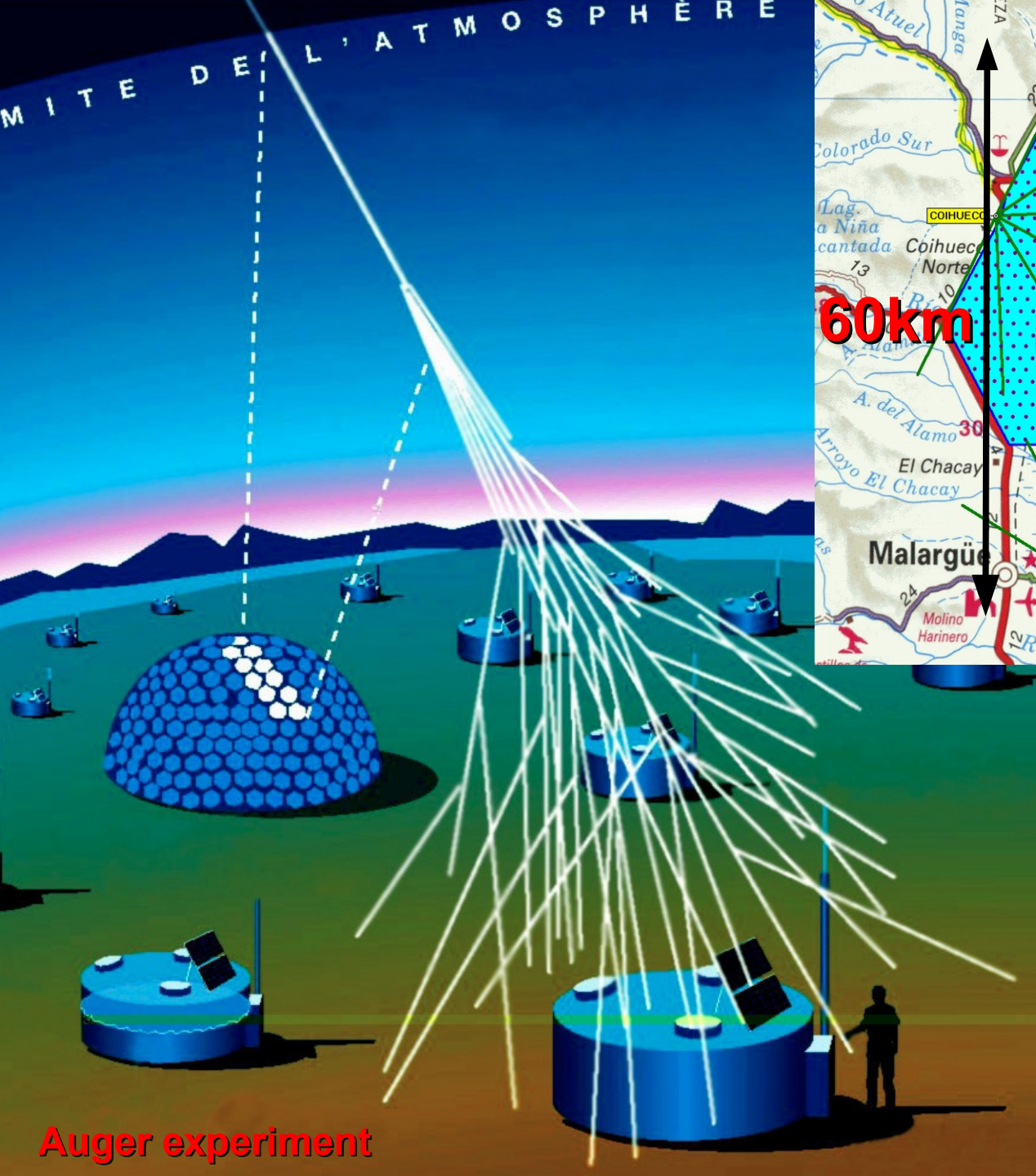
Vehicle assembly building



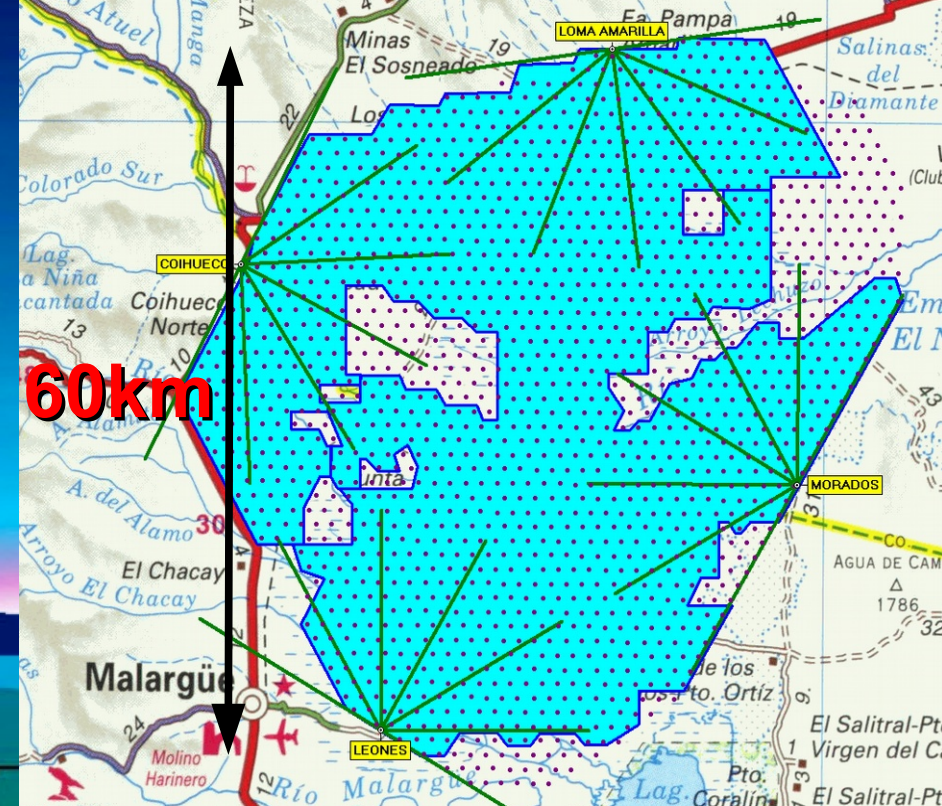
AMS-02 on the International Space Station



MITE DE L'ATMOSPHERE

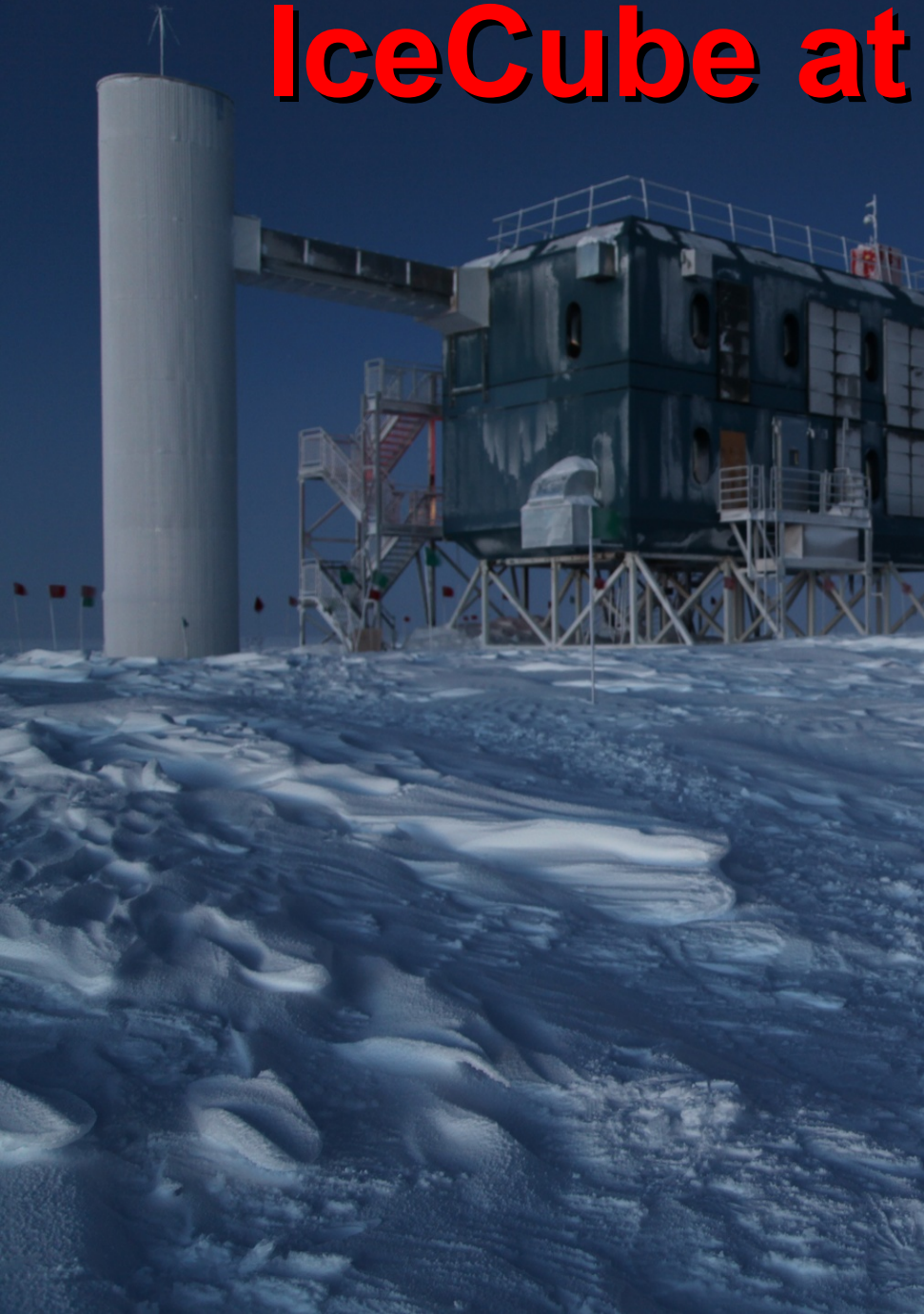


Auger experiment

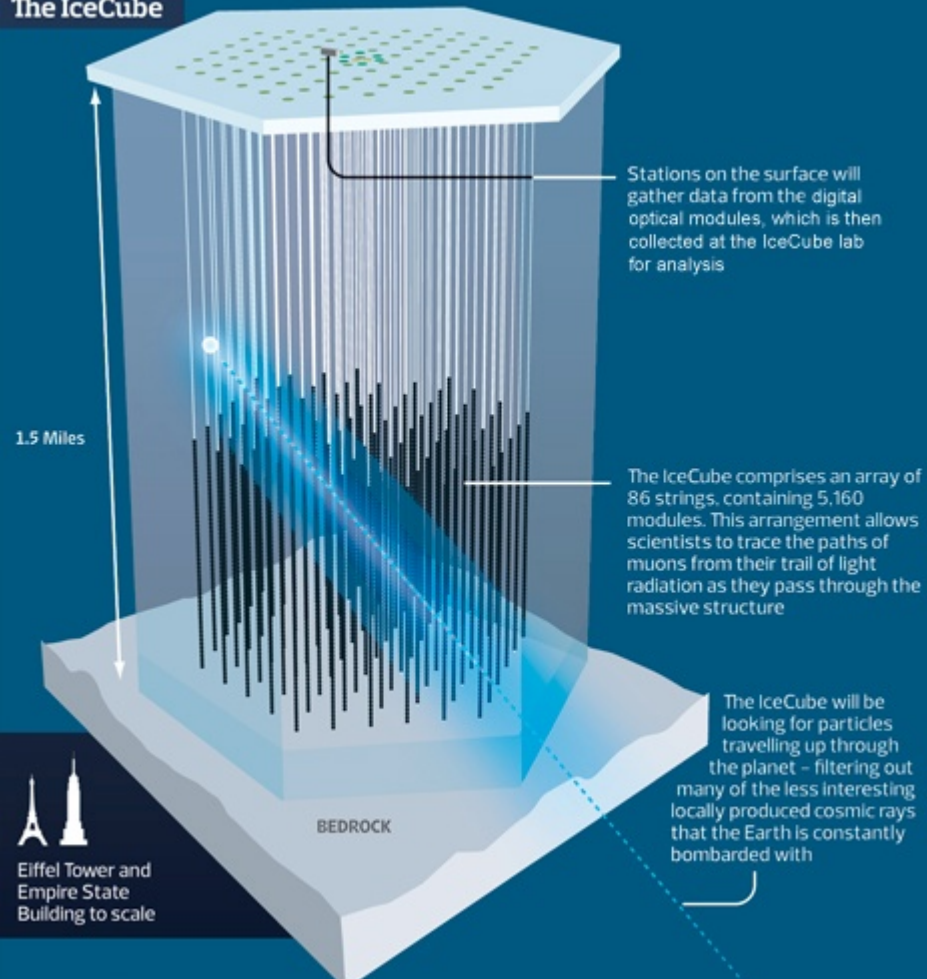


**You can also use
the atmosphere
to measure
cosmic rays
→ you can build
gigantic
detectors**

IceCube at the Southpole



The IceCube



Stations on the surface will gather data from the digital optical modules, which is then collected at the IceCube lab for analysis

1.5 Miles

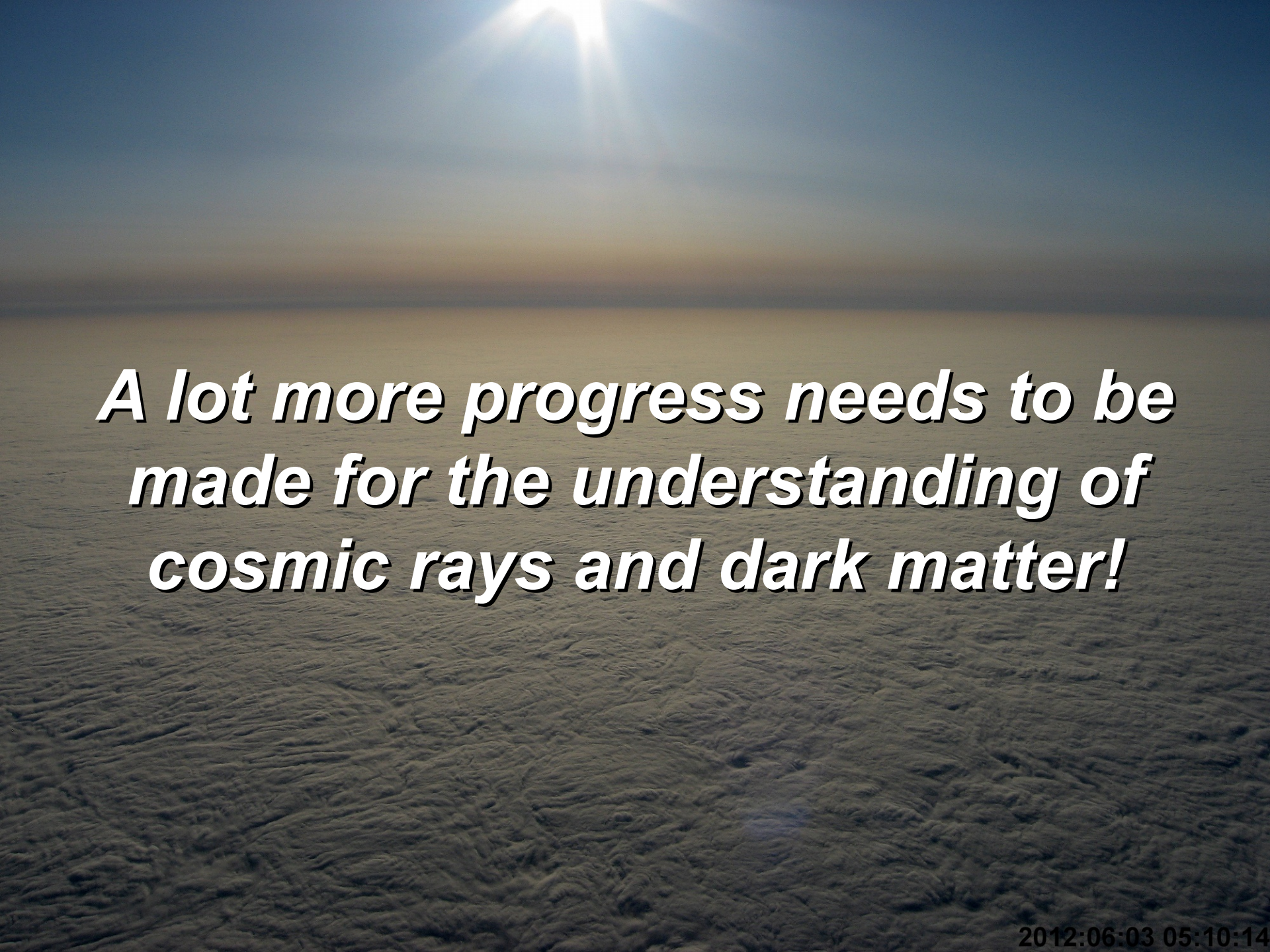
The IceCube comprises an array of 86 strings, containing 5,160 modules. This arrangement allows scientists to trace the paths of muons from their trail of light radiation as they pass through the massive structure

The IceCube will be looking for particles travelling up through the planet - filtering out many of the less interesting locally produced cosmic rays that the Earth is constantly bombarded with



Eiffel Tower and Empire State Building to scale

BEDROCK



A lot more progress needs to be made for the understanding of cosmic rays and dark matter!