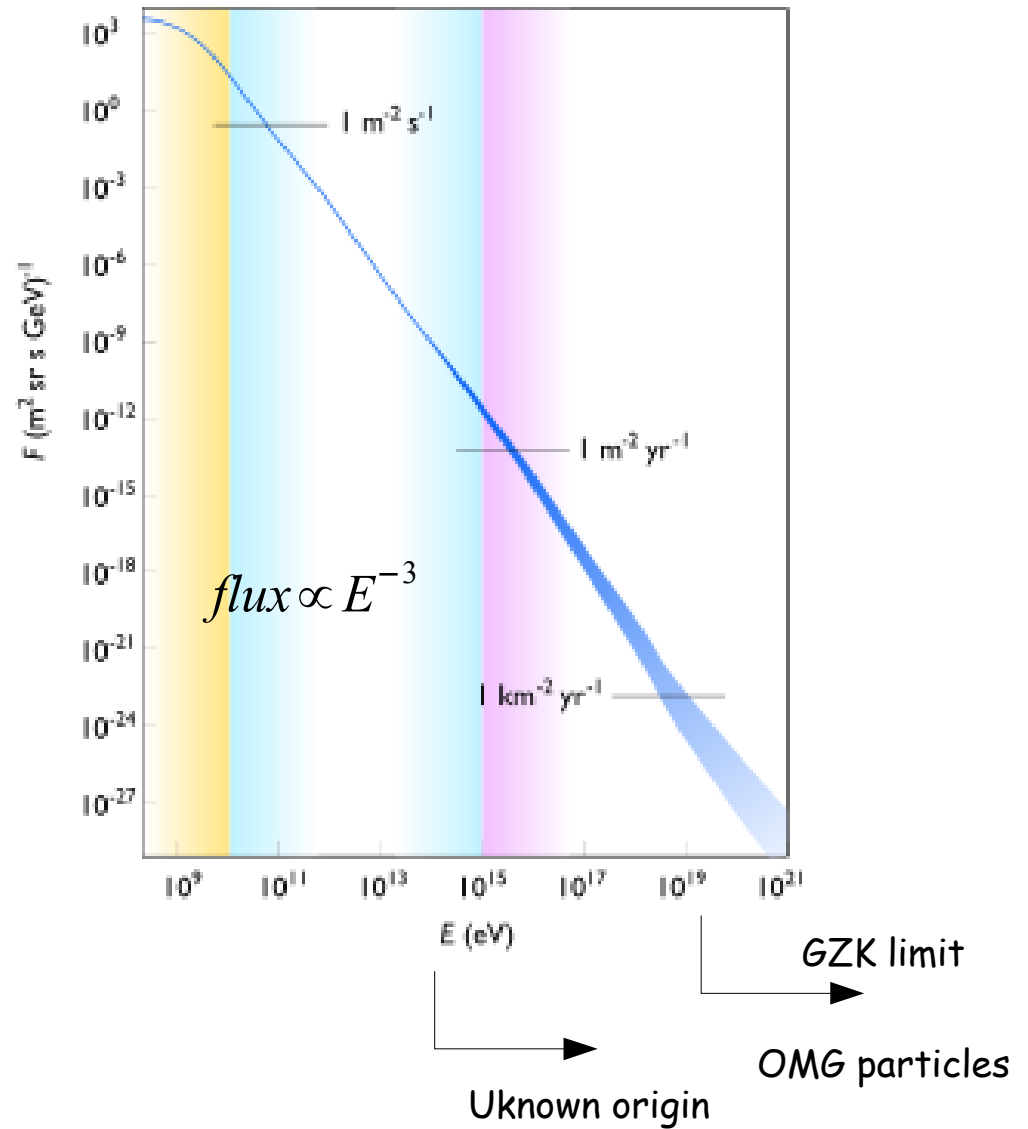


Cosmic Rays

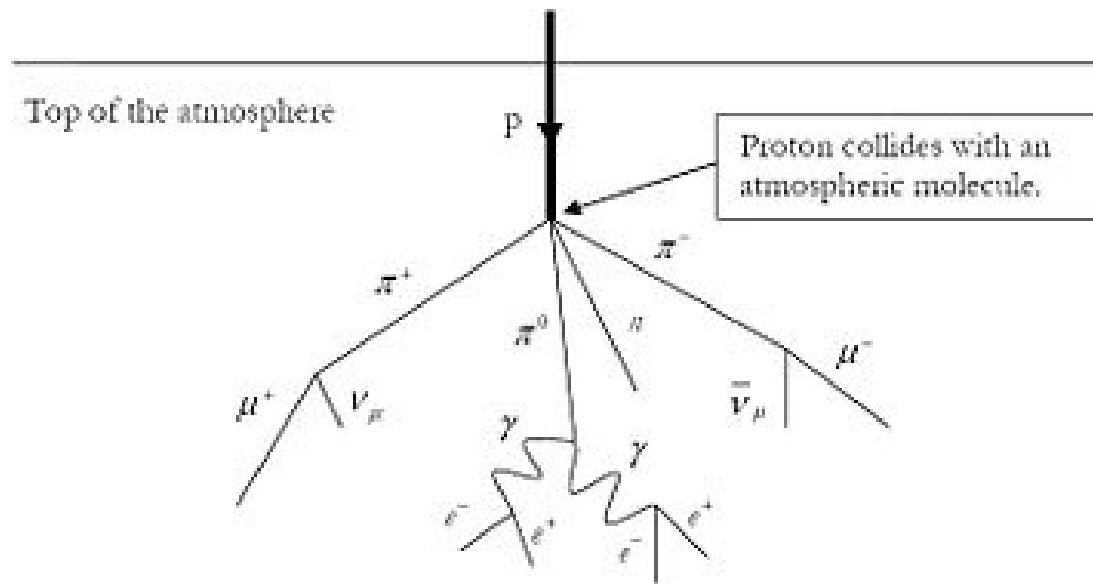
Protons 90%
Helium nuclei 9%
electrons 1%



Origin:

- Sun
- our Galaxy (neutron stars, supernovae, and black holes)
- extra-galactic (radio galaxies and quasars)

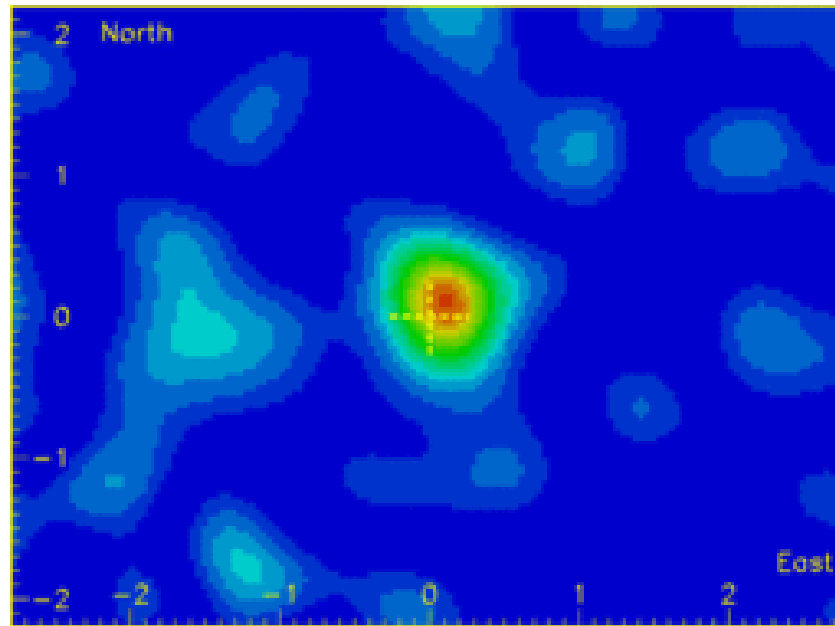
Interaction with the Earth's Atmosphere



- an air shower



Cosmic rays have kept the level of carbon-14 in the atmosphere constant (70 tons) for at least the past 100,000 years. This is an important fact used in radiocarbon dating which is used in archaeology.



The Moon's cosmic ray shadow, as seen in secondary muons detected 700m below ground, at the Soudan 2 detector

Greisen-Zatsepin-Kuzmin (GZK) limit

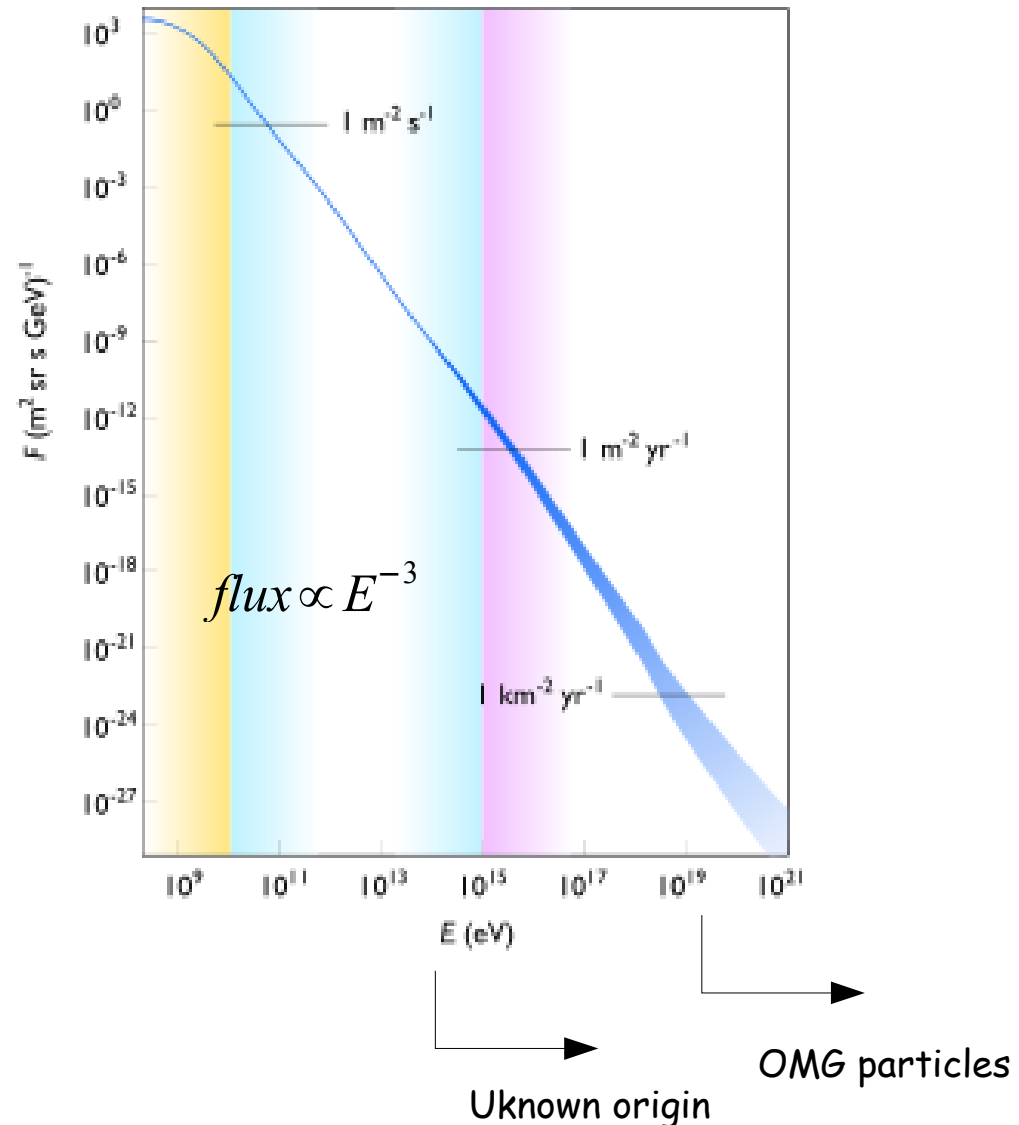
- a **theoretical upper limit** on the energy of cosmic rays from distant sources
- cosmic rays with energies over the threshold energy of 6×10^{19} eV would interact with **cosmic microwave background** photons to produce **pions**
- extragalactic cosmic rays with distances more than **50 Mpc** from the Earth with energies greater than this threshold energy **should never be observed** on Earth
- **no known sources** within this distance
- one of the **top eleven** unsolved mysteries in physics today

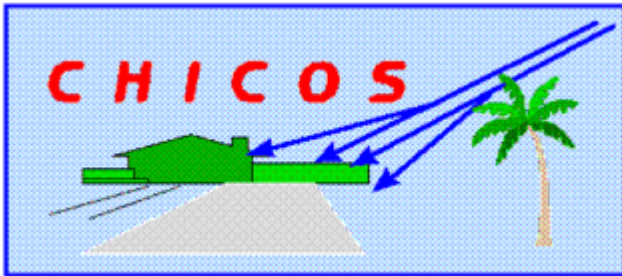
Oh-My God particles

October 15, 1991:

$$E = 3 \times 10^{20} \text{ eV} = 50 \text{ J}$$

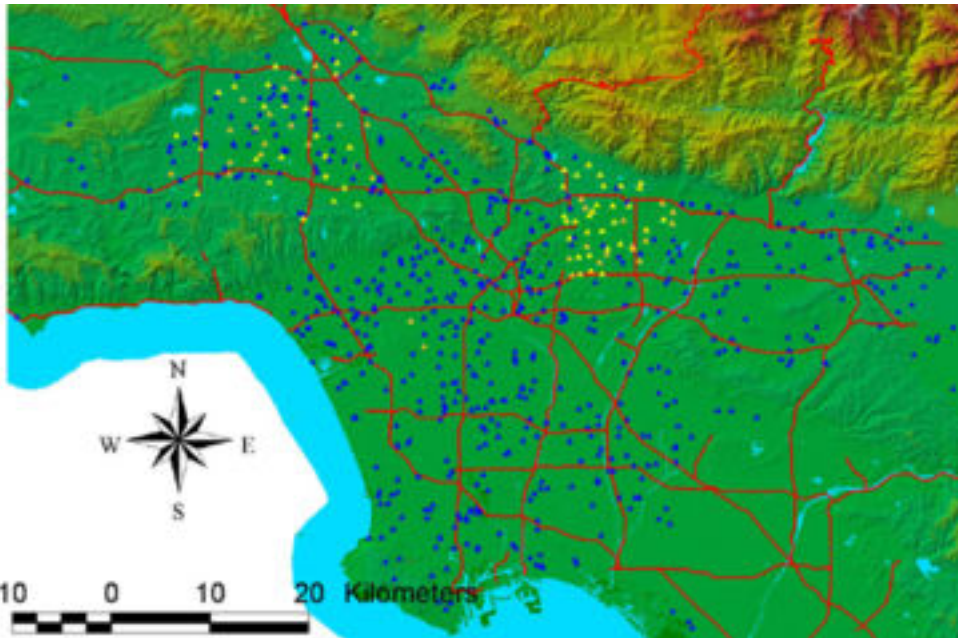
- kinetic energy of a baseball (140 g) which is moving at about 27 m/s
- most likely proton
- 15 more events up to now
- puzzle: the GZK limit
- no sources in the estimated directions of their origin





= The **C**alifornia **H**igh School **C**osmic
Ray **O**bservatory

Shmoos (The Cosmic Ray Detectors Unit)



Yellow and orange triangles are in operation. Blue triangles indicate the potential for future expansion.

Shmoos are generally setup at the Kellogg Radiation Laboratory and sent to schools. High school students have the chance to participate in the assembly process. Once the Shmoos are installed, the on-site teachers and students assist with their repair and maintenance.

