Muon Radiation in Seawater due to Nearby Supernovae

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Abstract

The chance that a supernova has caused extinctions in Earth's past is high (~99%). Cosmic ray primaries emitted by a supernova hit the atmosphere and produce particle showers. From these, particles called muons reach the earth's surface. Depending on how deep muons travel in seawater and the energy lost to the environment, aquatic life may be subject to large doses of irradiation.

Research Questions

- How far do muons travel in seawater?
- What is the radiation dose from muons at varying initial energies?

What is a Supernova (SN)?

- Exploding Star
- Emits high amount of energy in a short time

What is a Cosmic Ray (CR)?

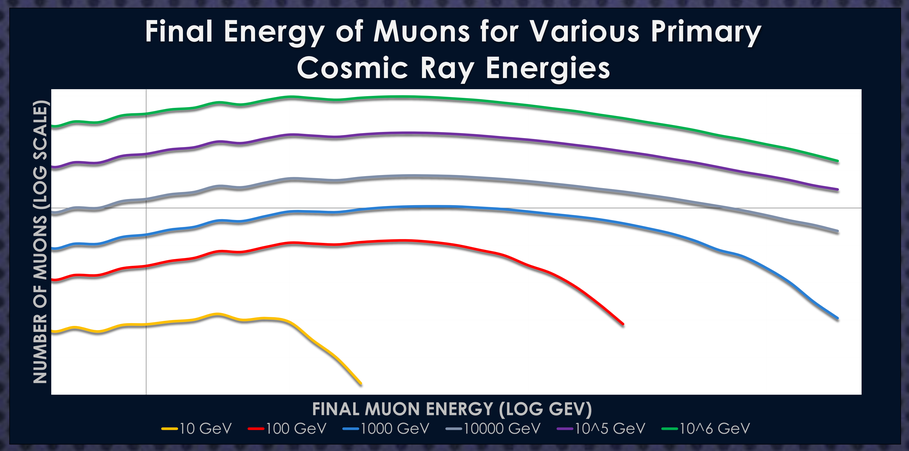
- Fast-moving particles (near speed of light)
- Originate beyond atmosphere

What is a Muon?

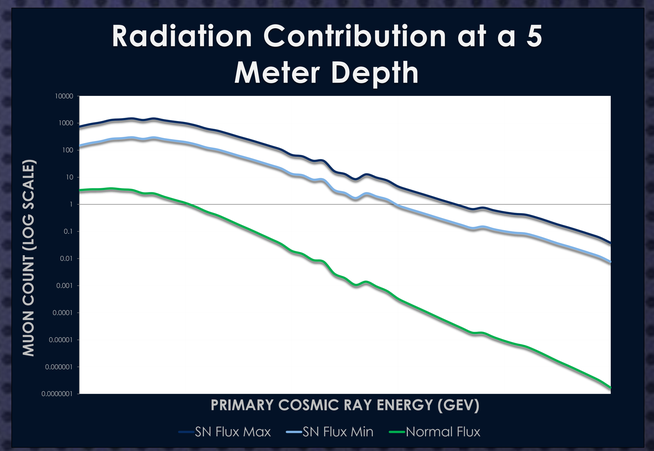
- Elementary particle
- Degradation of pion
- High-mass "electron"

Methods

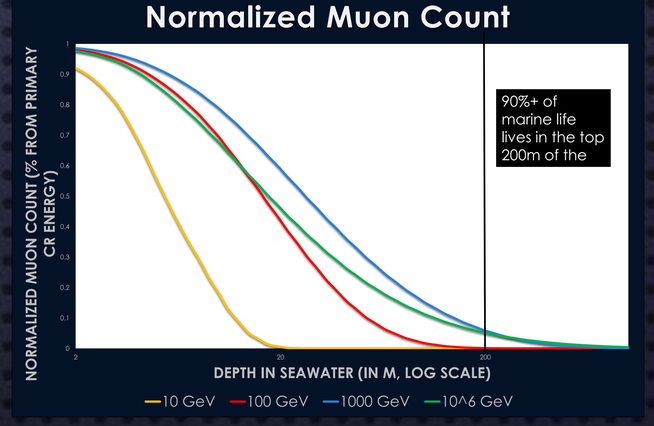
The depth that muon particles reach in seawater at various initial energies was modeled with computer simulations. The data obtained was combined with data concerning the primary energy of CR to create the graphs shown. They depict intermediate steps for determining the radiation dose by depth, which will be completed after simulating additional higher energies.



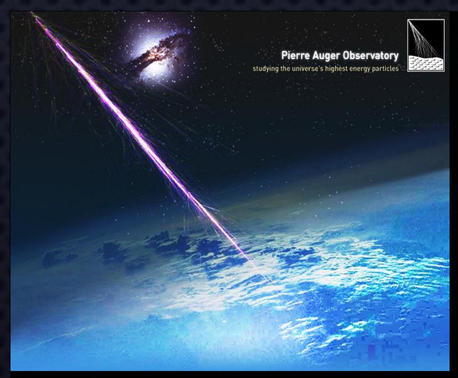
Higher energy cosmic rays (CR) produce more muons with greater energy (Legend indicates primary CR energy)



At a depth of 5 meters, the muon count is ~100-1000 times higher from CR emitted from supernovae (SN) than from a normal CR flux



A higher percentage of muons travel to a greater depth in seawater as the CR energy increases (Legend indicates primary CR energy)



Cosmic Ray - Courtesy of NASA

Supernova - Courtesy of NASA

Future Goals

- Create Lookup Tables for Primary CR Spectra
- Determine the Radiation Dose by Depth
- Implications for Biota

1. Klimushin, S., E. Bugaev, and I. Sokalski. "Precise Parameterizations of Muon Energy Losses in Water." ICRC 1 June 2001: 1-4. Print. **2.** Overholt, Andrew C., and Adrian L. Melott. "Cosmogenic Nuclide Enhancement via Deposition from Long-period Comets as a Test of the Younger Dryas Impact Hypothesis." Earth and Planetary Science Letters (2013): 55-61. Print. **3.** Overholt, Andrew C., Adrian L. Melott, and Dimitra Atri. "Modeling Cosmic Ray Proton Induced Terrestrial Neutron Flux: A Look-up Table." Journal of Geophysical Research: Space Physics 118.6 (2013): 2765-770. Print. **4.** Sliskonen, T. "Dose from Slow Negative Muons." Radiation Protection Dosimetry 128.2 (2007): 234-38. Print. 377-378