

High-Energy Neutrinos of Astrophysical Origin

High Energy Physics Course

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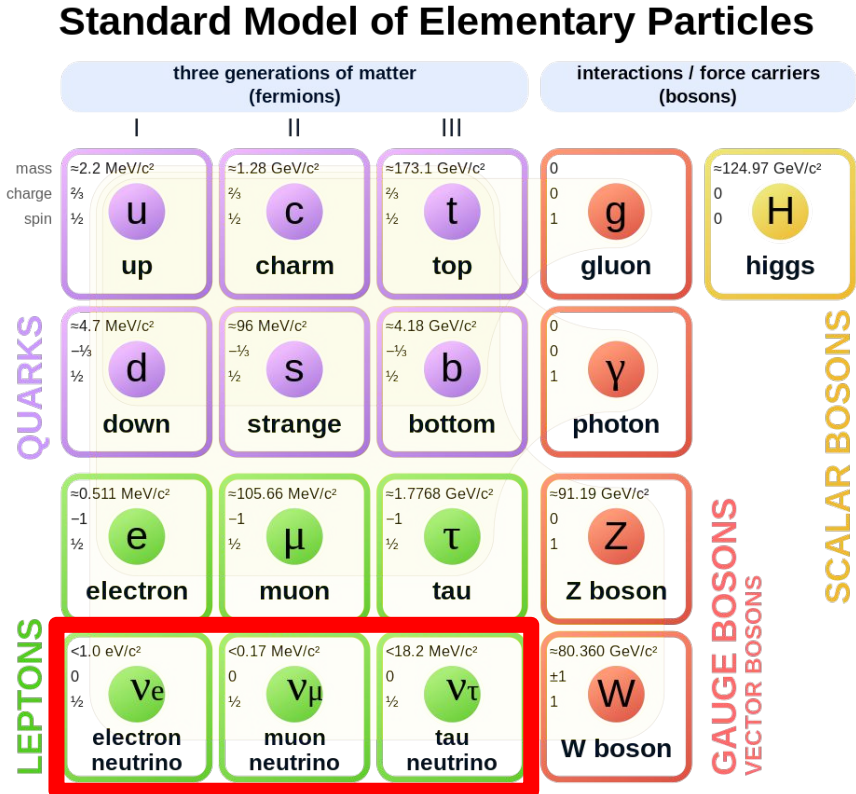
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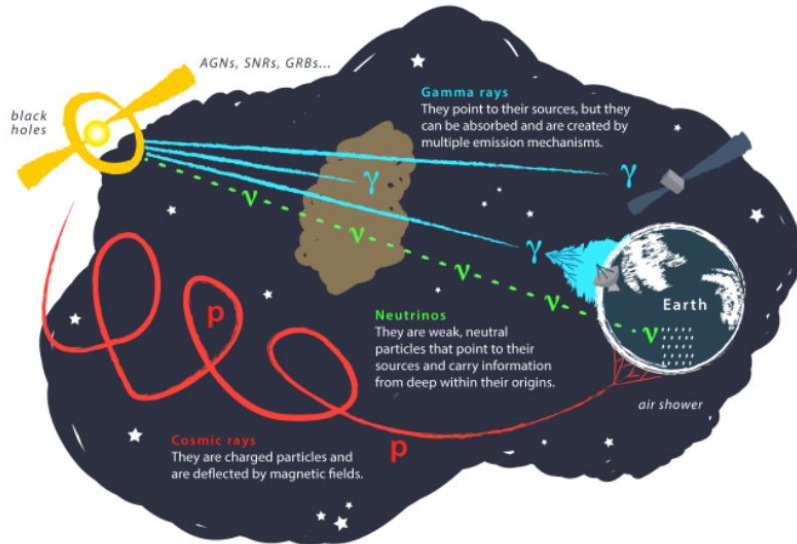
Neutrino and The Multi-Messenger Era

Neutrino

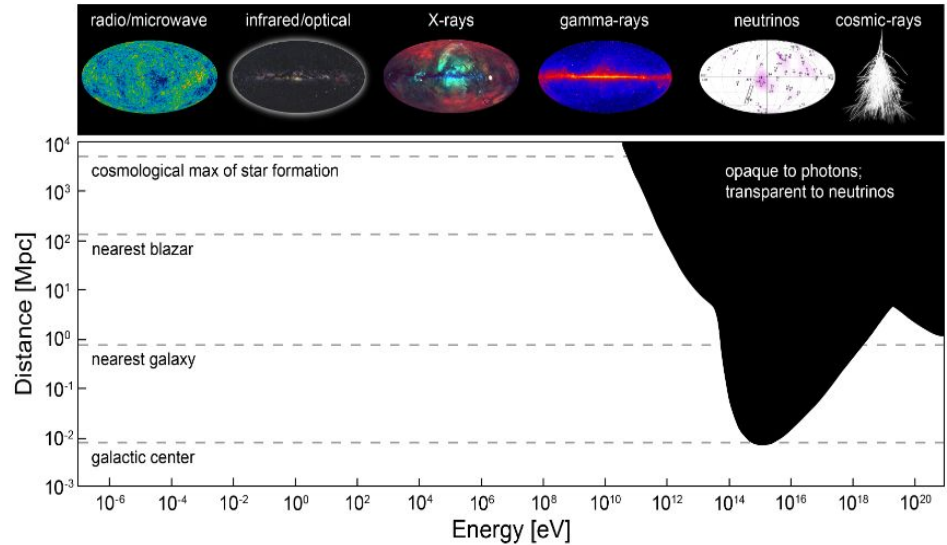
- Neutrino is a fermion, which interacts via weak force and gravity.
- Comes in three leptonic flavours: electron neutrino, muon neutrino and tau neutrino.



The Multi-Messenger Era

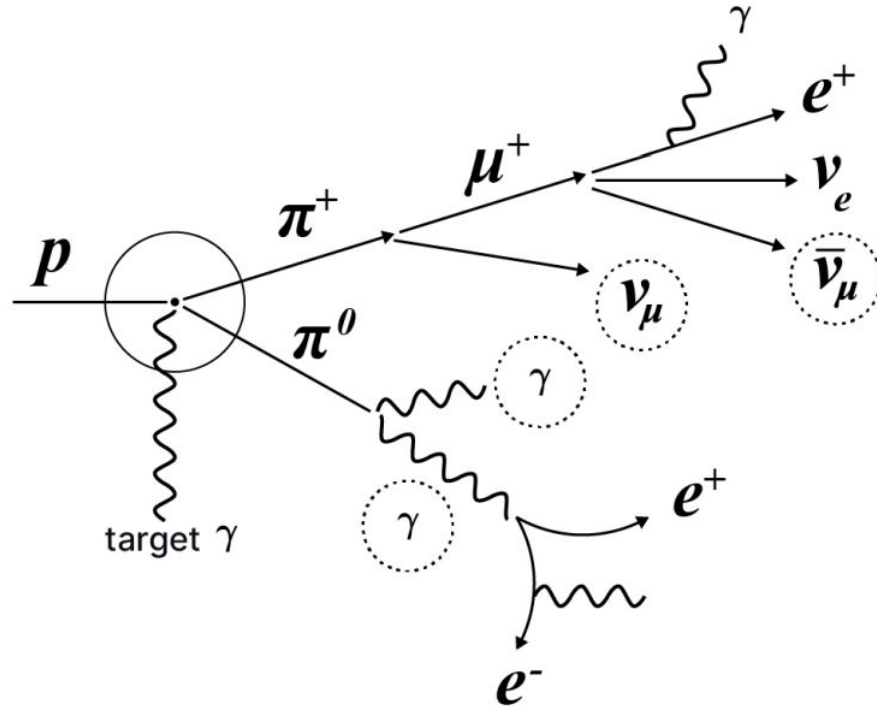


Propagation of cosmic rays from their source to the Earth.



Energy and Wavelength spectra vs distance of the visible universe.

Neutrino Production



Flow diagram showing the production of charged and neutral pions in $p\gamma$ interactions.

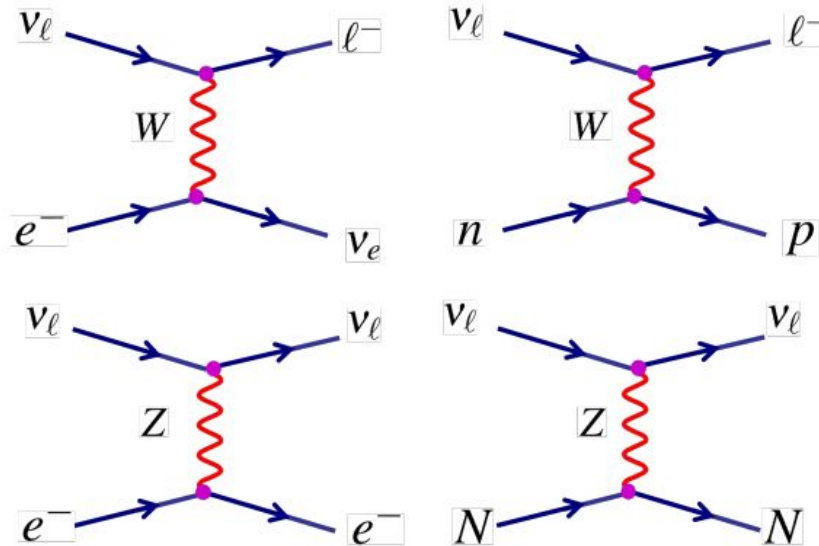
Neutrino Detection Principles

Detection Challenges

- No electric charge, meaning no direct ionization and generation of light
 - The detection must rely on the secondary particles of a neutrino interaction.
- Neutrinos have a small chance of interacting with particles of matter
 - Constrain in detector size.

Neutrino Interactions With Matter

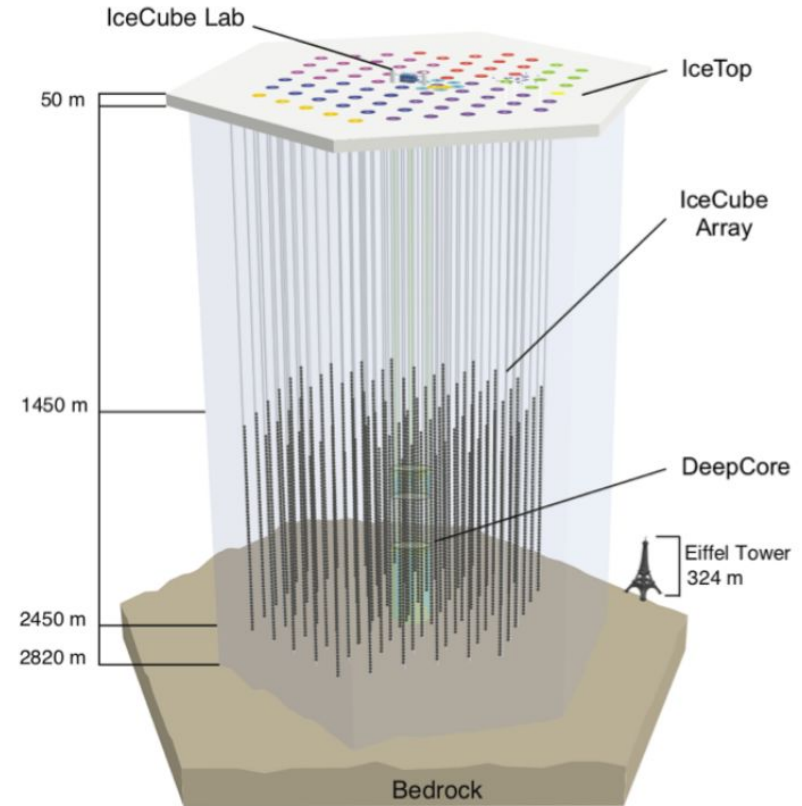
- Two Interaction processes:
 - Charged current interactions resulting in visible charged lepton;
 - Neutral current interactions.



Observation of HE Neutrinos

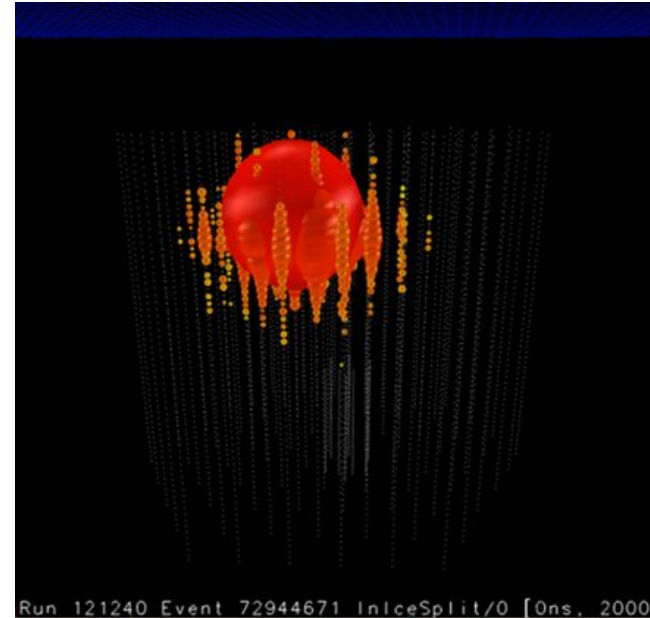
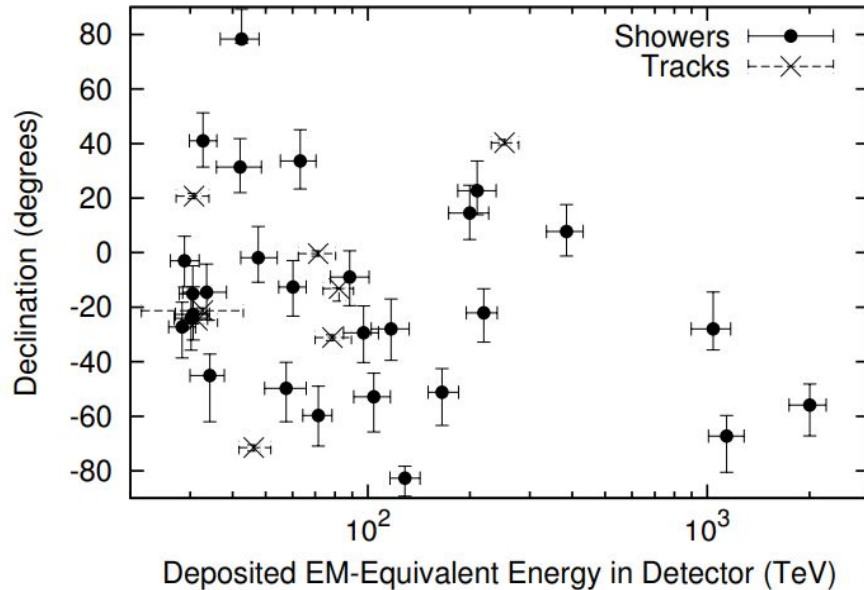
IceCube Neutrino Observatory

- IceCube is a natural Antarctic Ice transformed into a Cherenkov detector.
- The arrival direction of secondary particles are determined by the arrival time of the Cherenkov Photons.
- The number of photons is a proxy for the energy deposited by secondary particles in the detector.



Results from IceCube

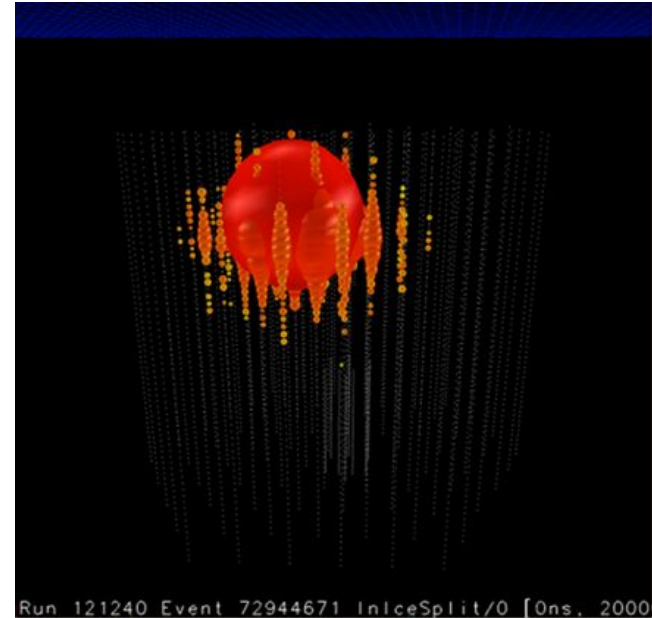
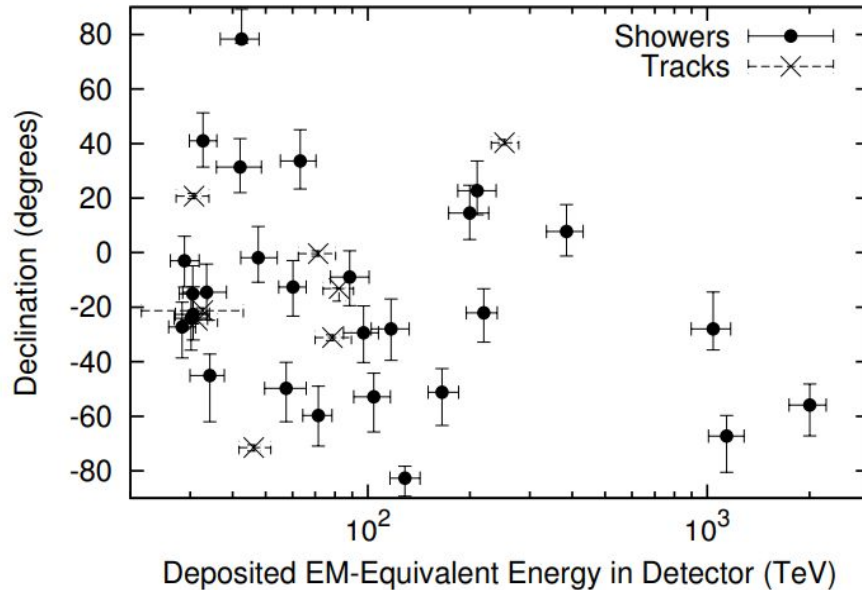
- Within three years of observation, IceCube was able to detect neutrinos of astrophysical origin with energies up to the PeV.



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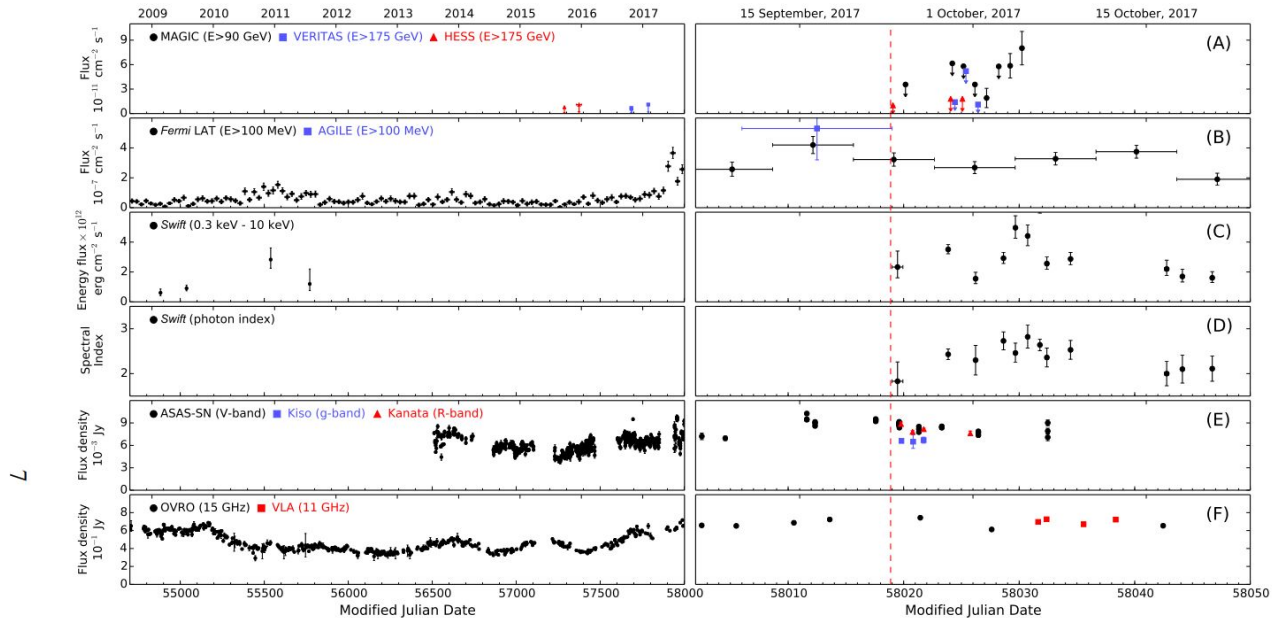


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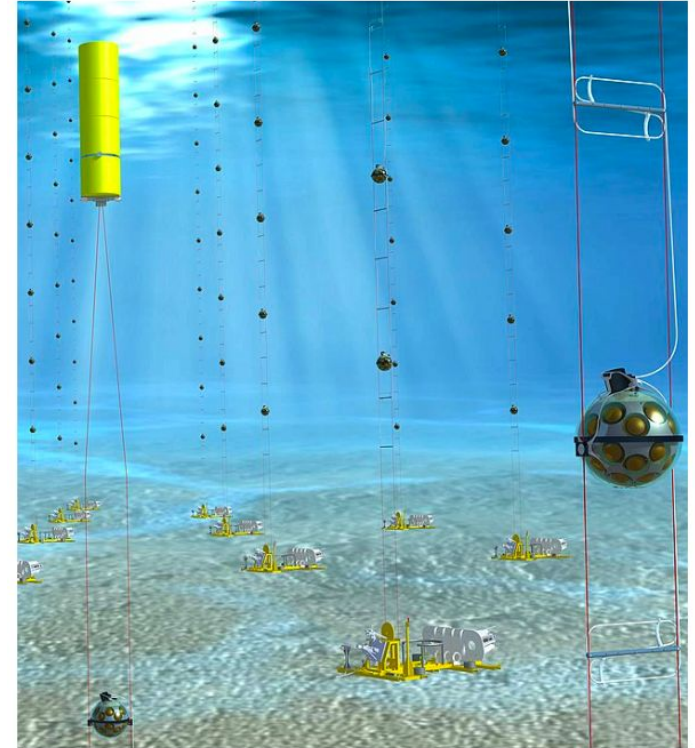
Results from IceCube

- In 2017, IceCube traced high-energy neutrinos back to its point of origin.



Future of Neutrino Detectors

- Another important project is being constructed in the mediterranean sea since 2015, the KM3NeT detector.
- General Concept similar to IceCube detector. It will provide complementary information, due to its location in the Northern Hemisphere.



Thank You!