



## Introduction to IceCube

### Chasing the Ghost Particle post-movie discussion

#### Learning goals

- Describe IceCube and its main scientific goals.
- Explain how IceCube uses neutrinos to explore the universe.
- Understand how creating new tools enables new discoveries.
- Learn about the diversity of STEM related careers.

#### What's needed

A white board or a discussion question worksheet

#### Resources provided

*Chasing the Ghost Particle* [download](#).  
Example of discussion questions.

#### Activity proposal: guided discussion or individual reflection

What is the “ghost particle”?

Neutrinos are extremely small particles that very rarely interact with matter. They are difficult to detect, and that’s why they have been dubbed the ghost particle. Neutrinos are plentiful, tiny, extremely fast, neutral, and rarely interact.

What makes neutrinos good cosmic messengers?

Neutrinos are invisible, nearly massless subatomic particles that are electrically neutral. They can travel at nearly the speed of light from the edge of the universe without being deflected by magnetic fields or absorbed by matter. They travel in straight lines from their source. This makes them excellent messengers of information about the objects or events in which they originate. They are everywhere, but only the very high energy ones that began their journey from far off in the universe provide the opportunity to explore the cosmos as never before.

Why we are looking for very high energy neutrinos, i.e., that we want to find the sources of cosmic rays. What are some potential sources? Gamma-ray bursts, hypernova, super massive black holes or active galactic nuclei.

What is the purpose of IceCube?

IceCube is designed for exploration. IceCube gives us new ways to study the mysteries of our universe; it is likely to uncover or lead to the discovery of things we couldn’t have anticipated. Advances in technology have led to telescopes that allow



# ICECUBE

SOUTH POLE NEUTRINO OBSERVATORY

us to see a once hidden universe. Like X-rays and MRIs, which give doctors different views of our bodies, images from radio waves to gamma rays give new insights into the cosmos, showcasing the importance of creating new tools to enable new information.

How big is IceCube?

IceCube is a gigaton detector covering a cubic kilometer of Antarctic ice and located near the Amundsen-Scott South Pole Station. It is buried beneath the surface, extending to a depth of about 2,500 meters. The detector is so massive, you can fit a football field between each of the strings of sensors.

Why is IceCube at the South Pole?

Although neutrinos are abundant, they make contact so infrequently that catching even a few has become a matter of considerable design and experience, and patience. Detecting neutrinos requires a large volume of naturally occurring ice or water. The South Pole is the one place on Earth that holds large quantities of clear, pure, and stable ice and has the infrastructure to support scientific research.

How does IceCube detect neutrinos?

IceCube observes neutrinos only indirectly. Very high energy neutrinos that have traveled through the universe and accidentally crashed into an atomic nucleus in the ice will be observed thanks to the interaction of secondary particles with the ice. The nuclear reaction made by a single neutrino produces a stream of particles that create a burst of blue light, known as Cherenkov light. This shimmering light is detected by an array of optical light sensors frozen within the ice.

How was IceCube constructed?

A special hot water drilling system, not a mechanical drill, was designed for IceCube's construction. Hot water at high temperatures melted holes 2,500 meters deep. Because it's only possible to work at the South Pole during their summer, it took seven years to construct IceCube: 2004-2011.

Who makes a project like IceCube possible?

Physicists perform science and operate the detector. Engineers and technicians design, build, and manage the detector. IT specialists manage data taking and storage. Outreach and public relations specialists discuss the detector and science with broad audiences. Staff at the South Pole station keeps the station safe and comfortable for researchers handle: cooking, communications, travel and logistics, and electricity and water access. Business services and politicians make sure the project has the correct resources.