

The IceCube Experiment

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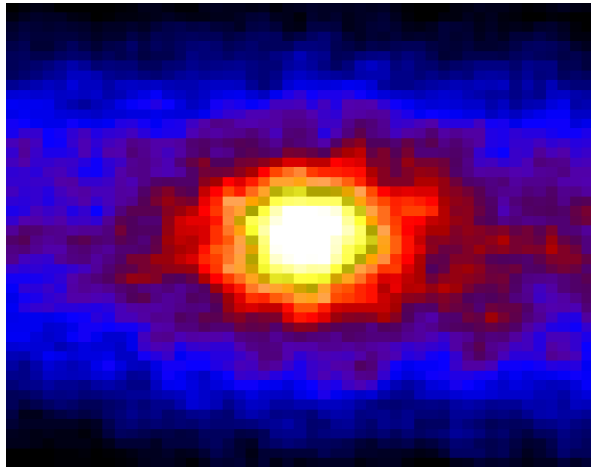


Neutrinos

Neutrinos are chargeless, almost massless leptons (cousins of electrons) which only interact through the weak nuclear force, meaning they generally pass through matter without interacting at all.

Billions of neutrinos are passing through us every second.

Neutrinos are produced in a number interactions on Earth, and also at very high energies in interesting objects in space



The sun as seen by Super Kamiokande in neutrinos

Neutrino Flavors:

ν_e : electron neutrino

ν_μ : muon neutrino

ν_τ : tau neutrino



Why Use Neutrinos for Astronomy?

Using neutrinos as an astrophysical messenger is promising for a number of reasons:

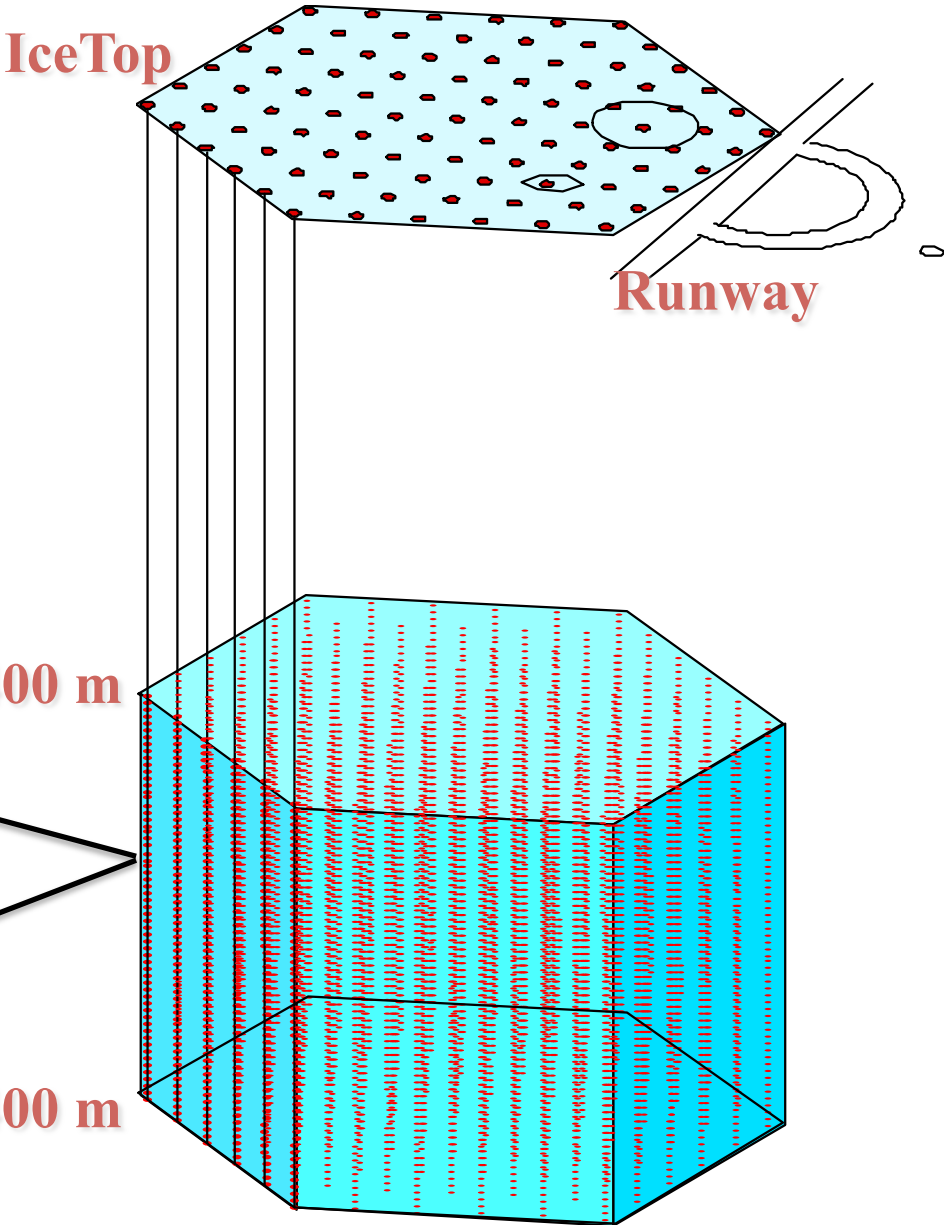
Unlike photons or cosmic rays, neutrinos (and gravitational waves) don't interact with anything between us and the source, providing one of the only direct probes of central engines of active galactic nuclei, gamma-ray bursts etc. which are otherwise hidden from us

Specifically, neutrino astronomy may help us determine the origin of the highest energy Cosmic rays – a longstanding question in astrophysics

Most generally, though, neutrinos let us see the universe in a completely different way – The universe looks different in x-rays or radio frequencies than in optical. Neutrinos are a way to extend astronomy beyond the electromagnetic spectrum.



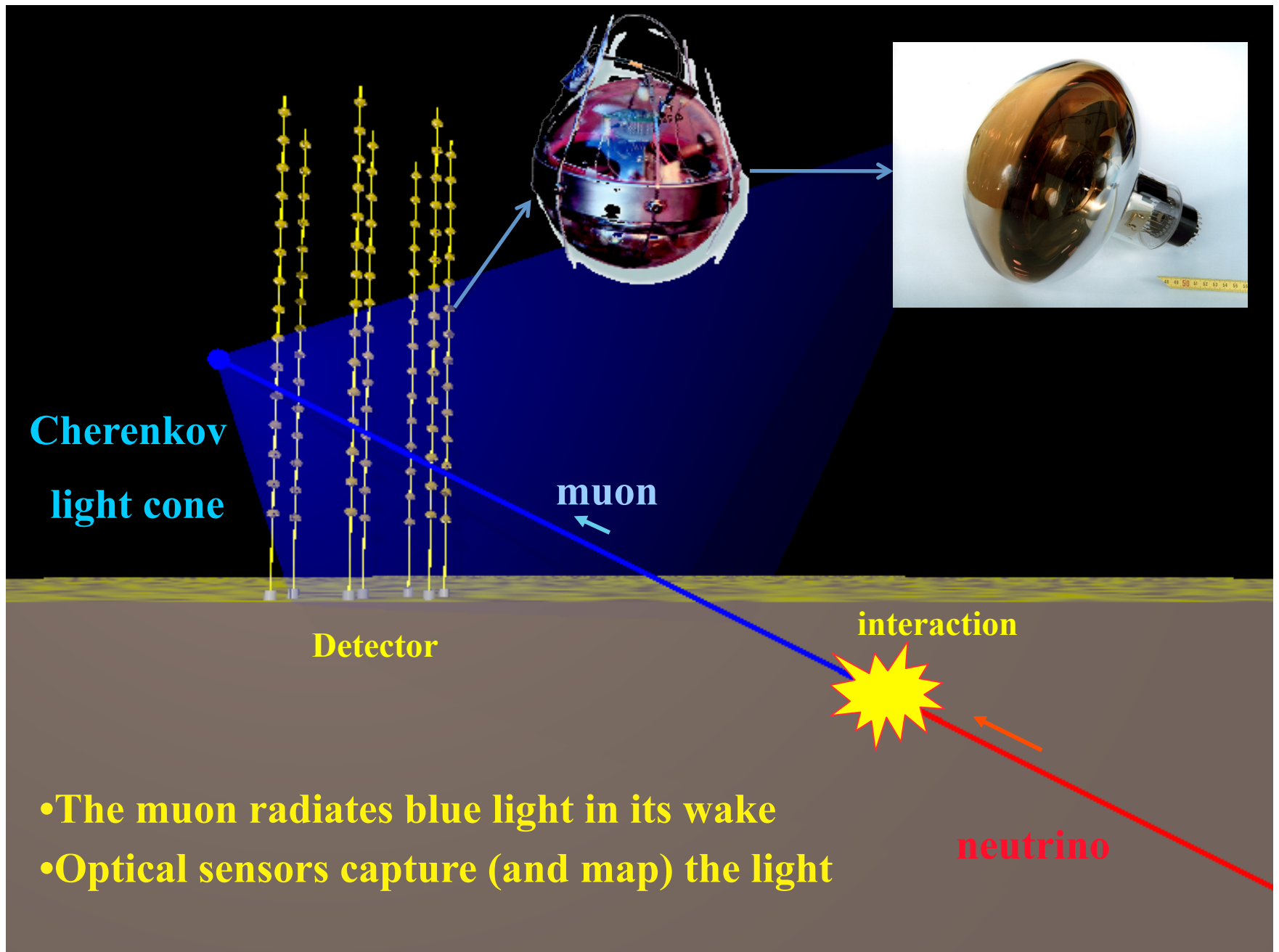
IceCube



IceCube is a neutrino detector situated a mile beneath the ice near the South Pole

It is composed of 4800 detectors on 79 strings deployed by melting a very deep hole in the ice and lowering them into the water (which will re-freeze after a few days)

A cubic kilometer instrumented volume

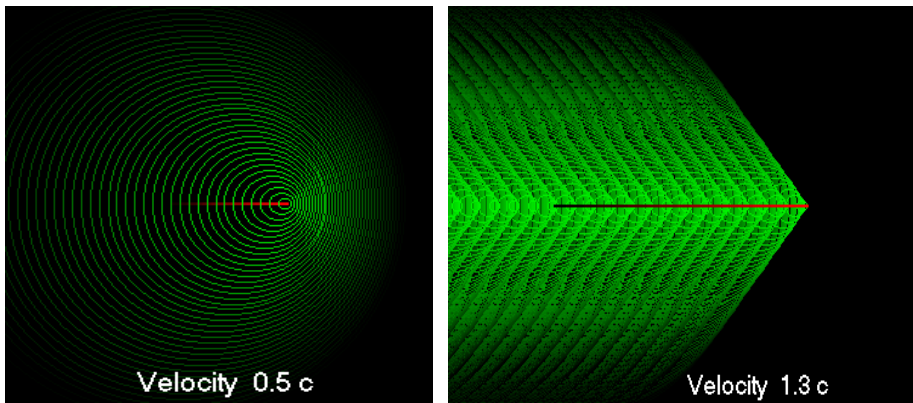


- The muon radiates blue light in its wake
- Optical sensors capture (and map) the light

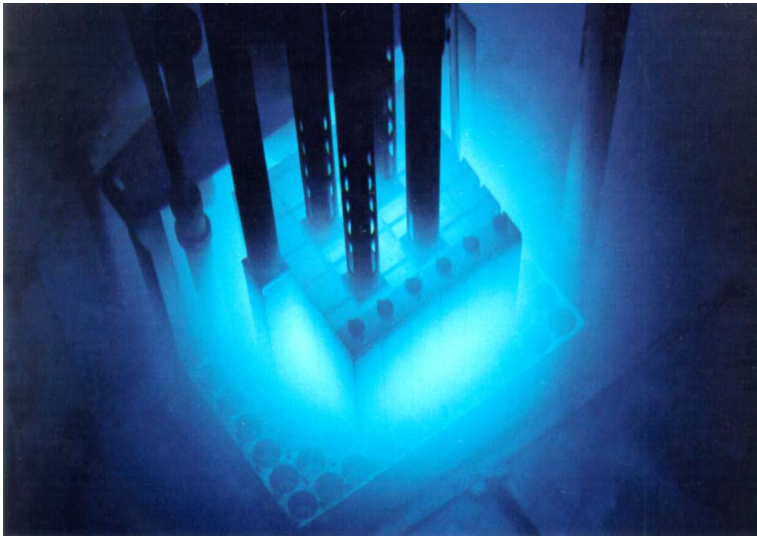
Cherenkov Radiation

The products of a neutrino-ice interaction emit a cone of blue Cherenkov radiation as they travel faster than the speed of light in ice*.

You can see the same thing as a wake in water (or hear it as a sonic boom for sound waves)



www.brantacan.co.uk/cherenkov.htm

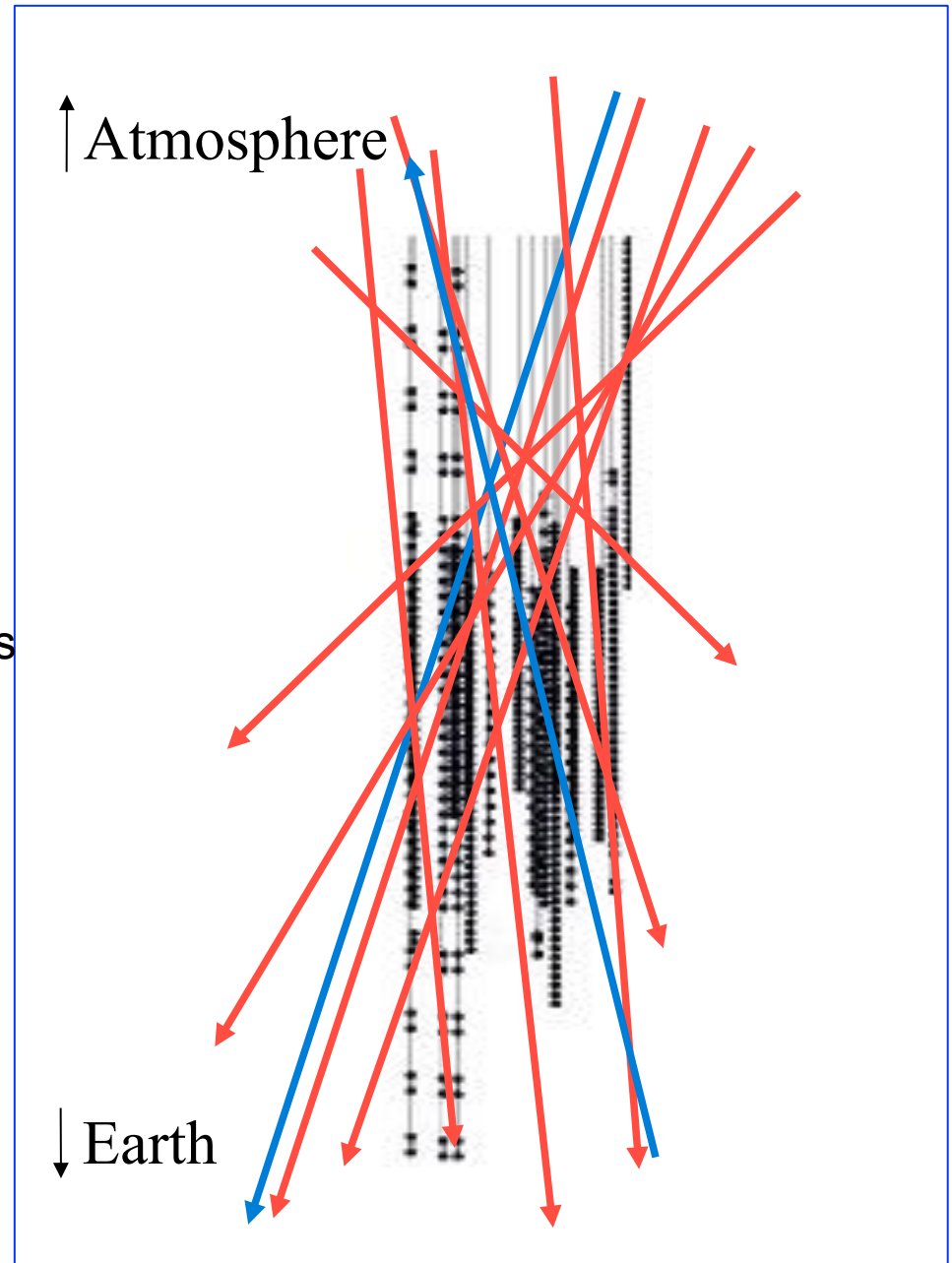
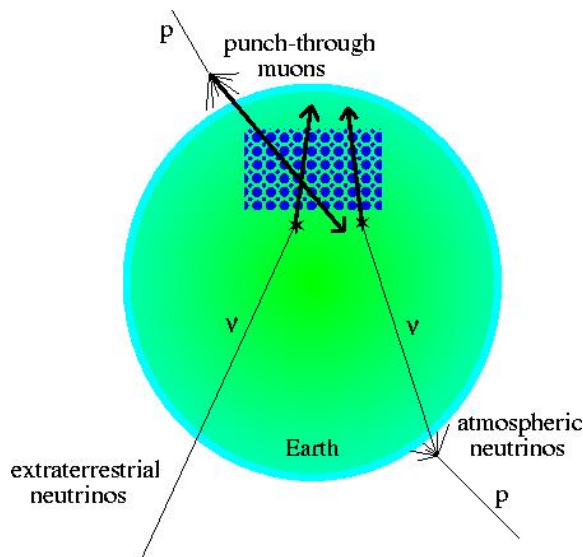


*Yes, Einstein would be okay with this. 6

Backgrounds

Downgoing muons – created by cosmic ray interactions with atmosphere
Outnumber neutrinos 1 million to 1
Cut out by direction – use entire Earth as shield

Atmospheric neutrinos –
Also created by cosmic rays hitting atmosphere
Distinguished from extraterrestrial neutrinos by energy

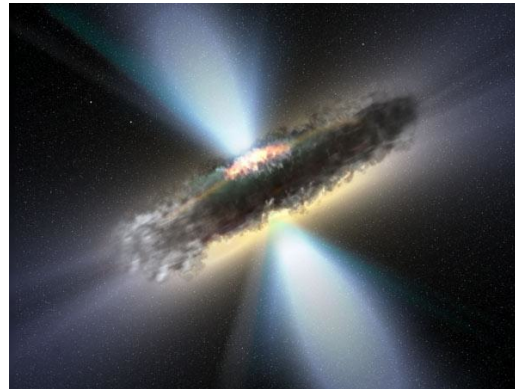


Many Different approaches to IceCube Science

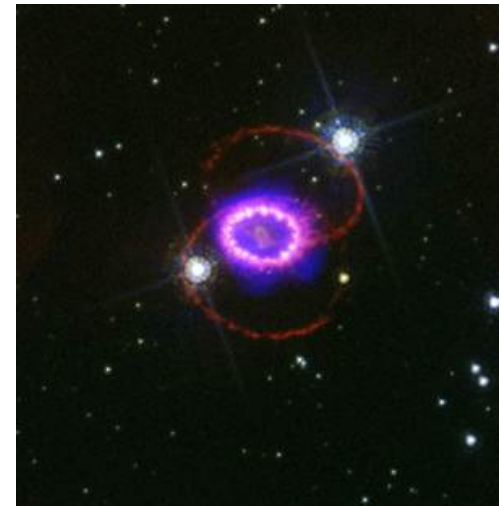
- ◆ Searches for neutrinos from point sources, diffuse sources, specific GRBs, cascades, etc.
- ◆ Dark matter candidate searches, magnetic monopole searches, supernovae
- ◆ Cosmic ray studies using IceCube with IceTop surface array



GRB

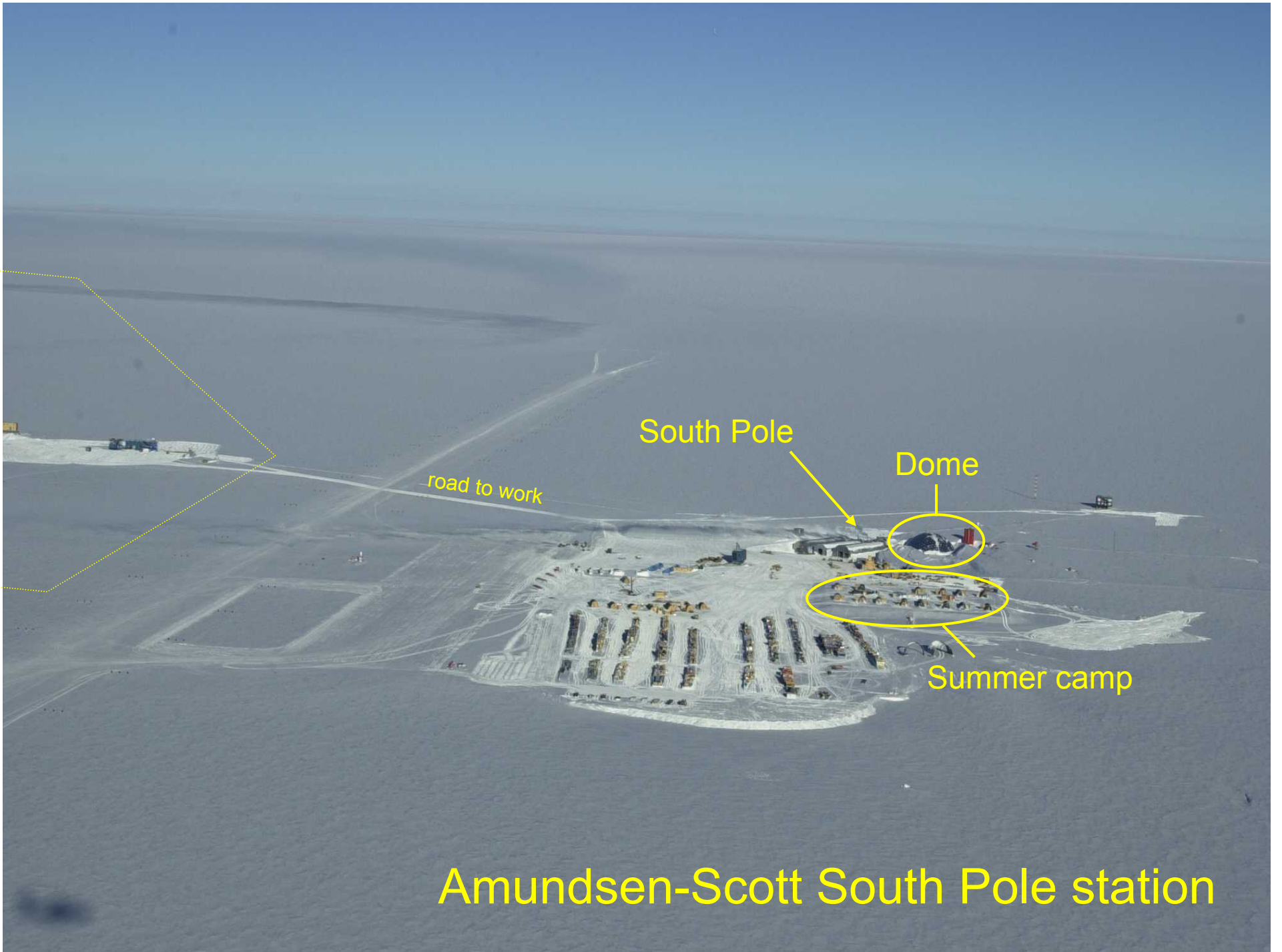


AGN (neutrino point source)



Supernova

(drawings & images NASA)



South Pole

Dome

road to work

Summer camp

Amundsen-Scott South Pole station



South Pole

Dome

road to West



Summer camp

South Pole station