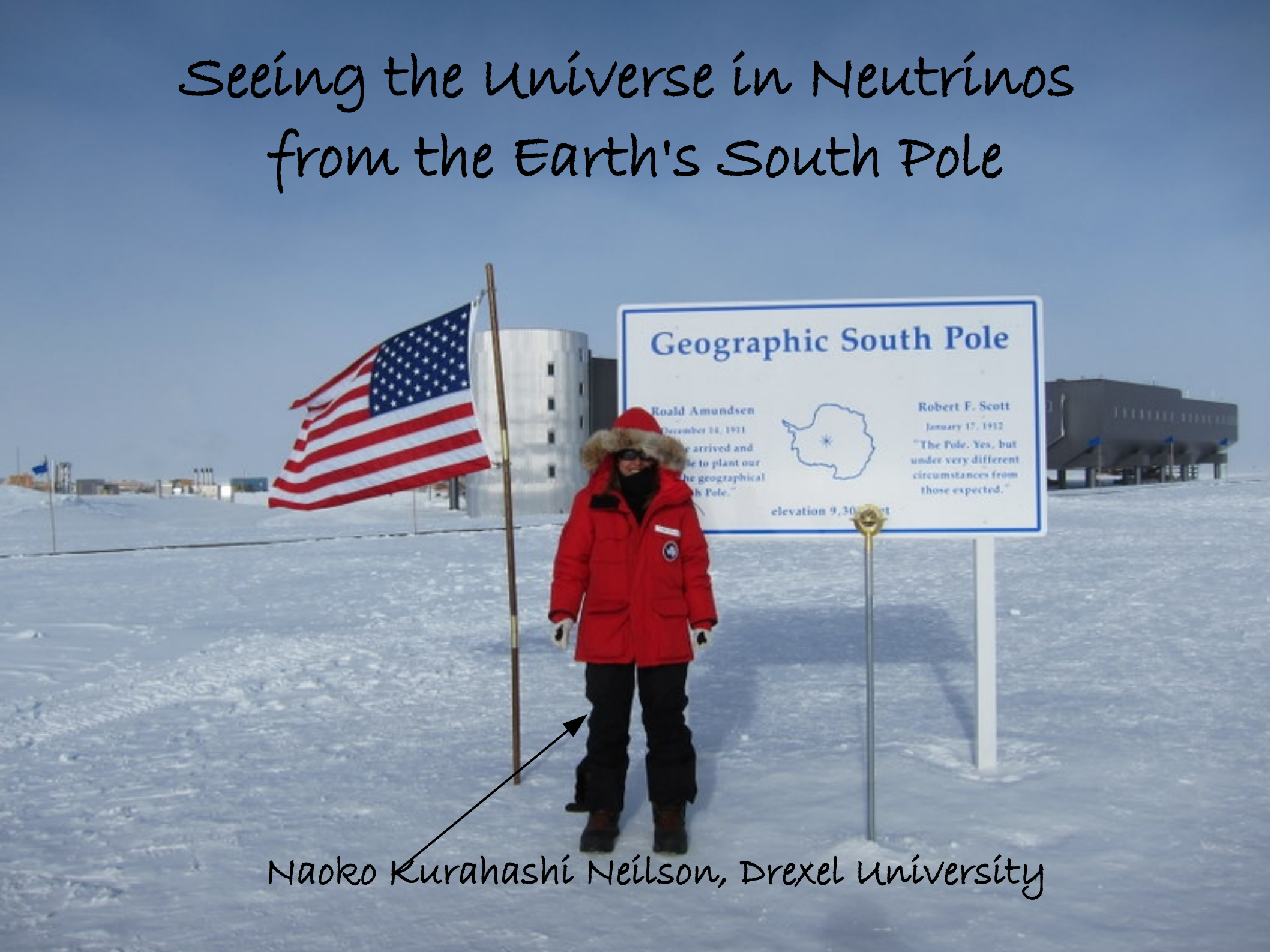
Seeing the Universe in Neutrinos from the Earth's South Pole



Naoko Kurahashi Neilson, Drexel University

If you don't know what a hand is....

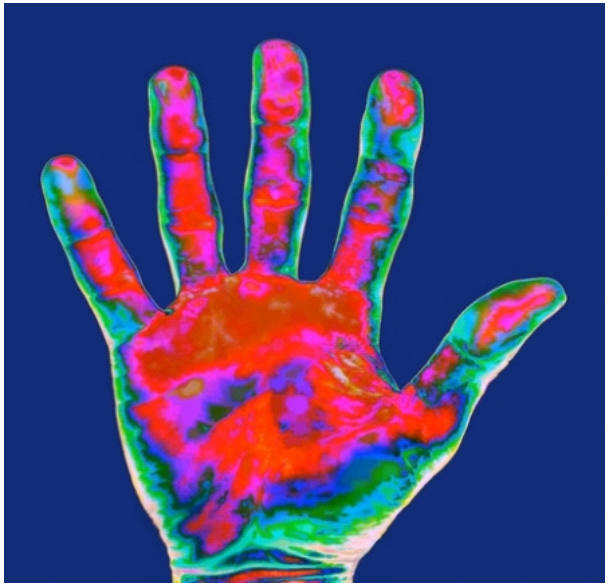
What can you tell me about a hand just by looking at it
(you can't touch it, dissect it, make any contact with it)

Optical image

If you don't know what a hand is....

MRI image

X-ray image

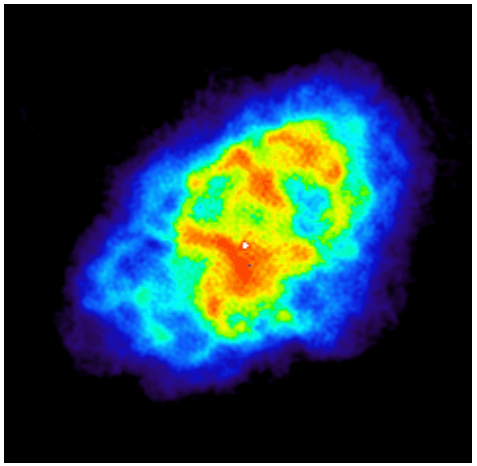


Infrared image

Optical image

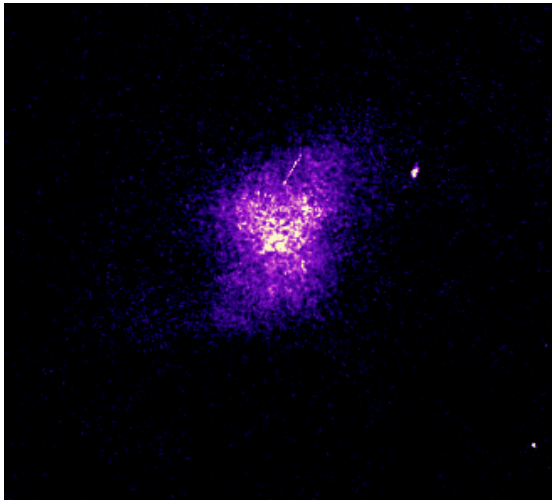
The Crab Nebula

Star with gas cloud around it

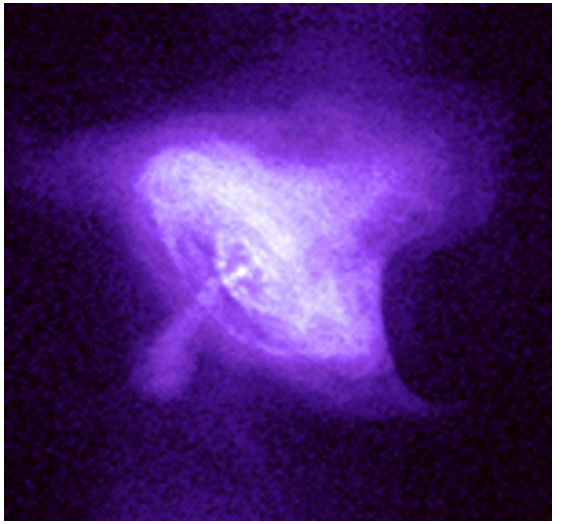


Radio image

Ultraviolet image

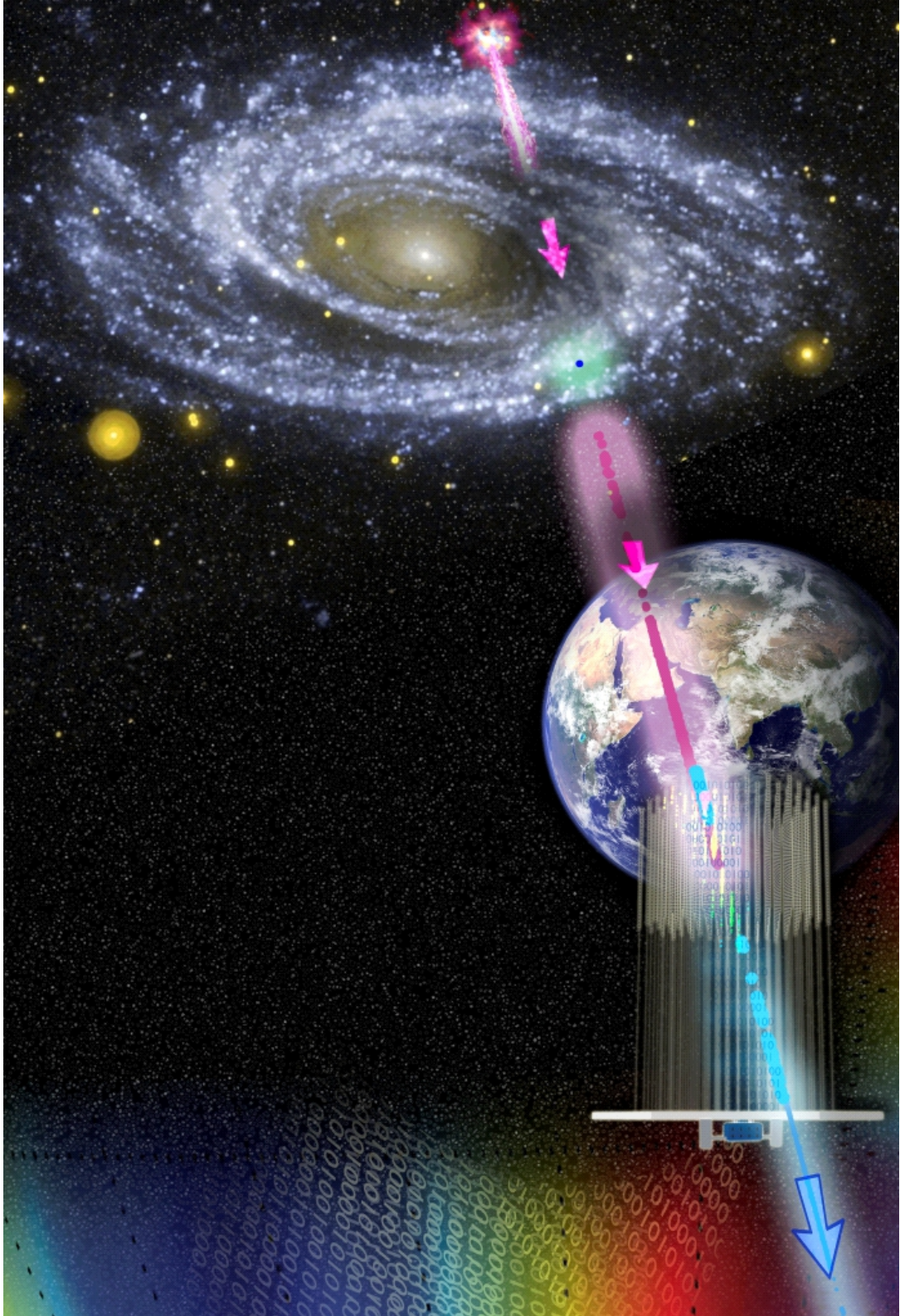


Optical image



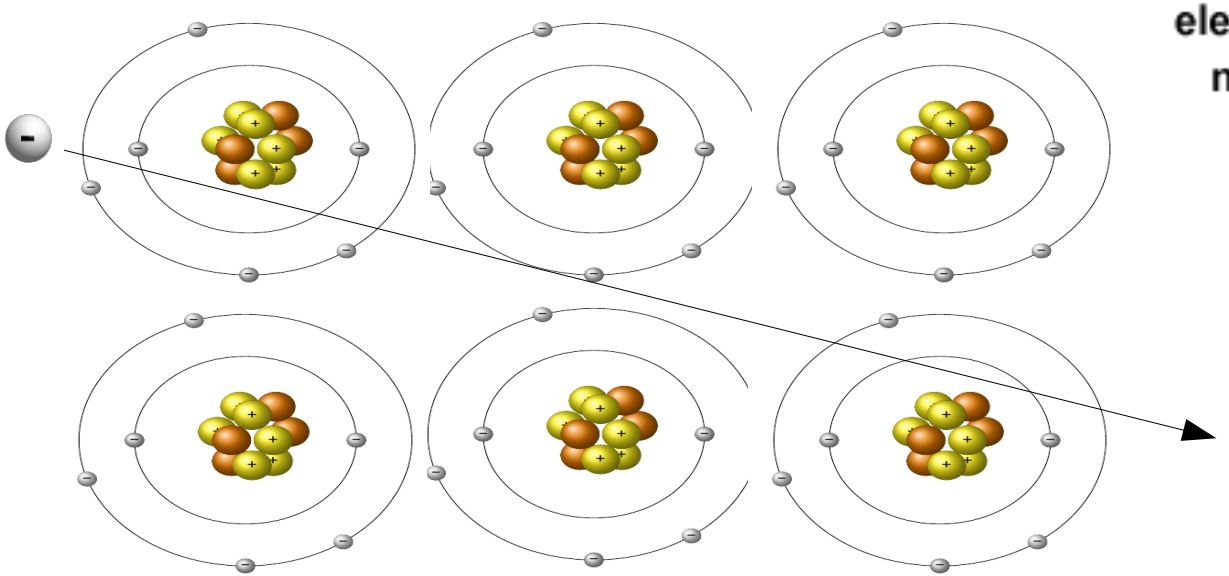
X-ray image

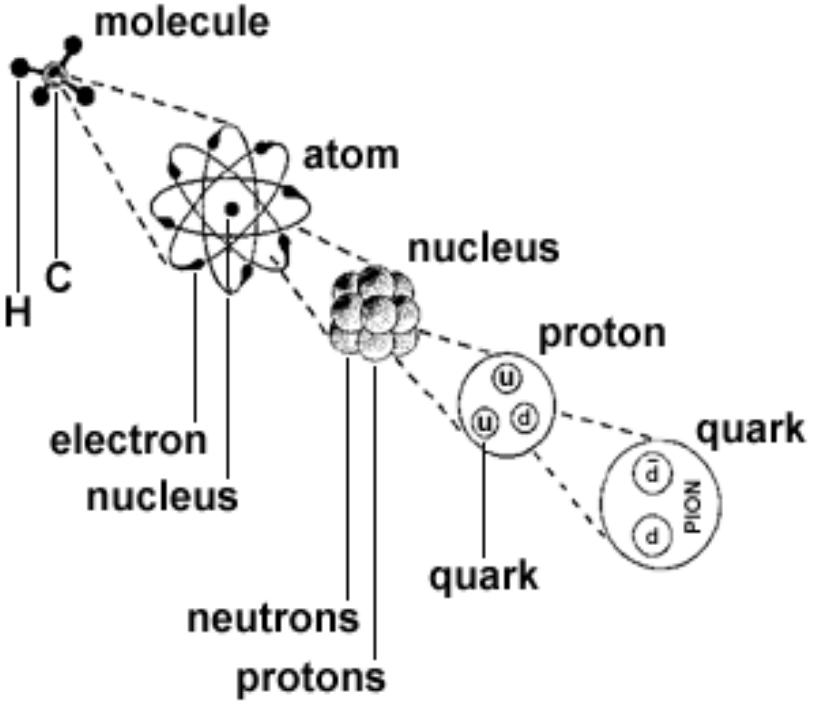
Seeing the universe in Neutrinos!



What are neutrinos?

- Elementary particle
- “Invisible” or “ghost” particle
  - No Electromagnetic Charge
  - Rarely Interact

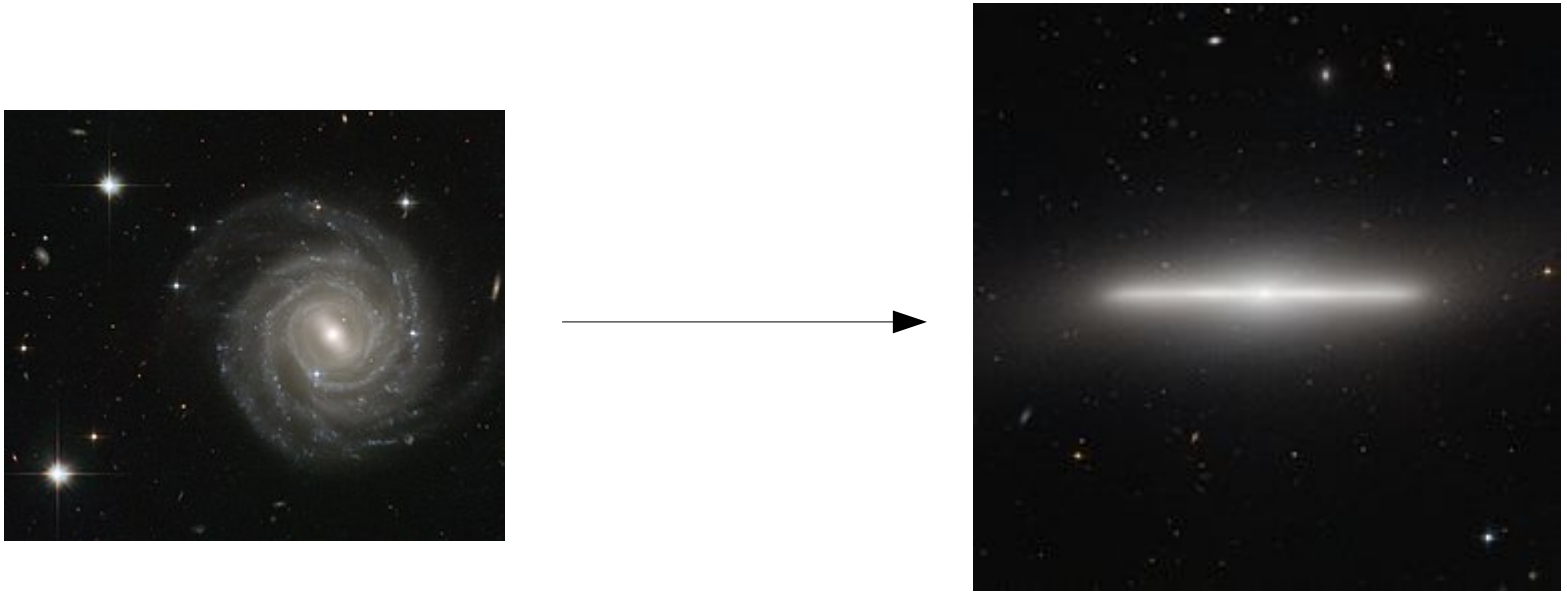




img credit: http://neutrino.aquaphoenix.com

Once in a while, interacts with stuff to create charged particles (like electrons, muons). These charged particles make light.

Why use neutrinos instead of light?

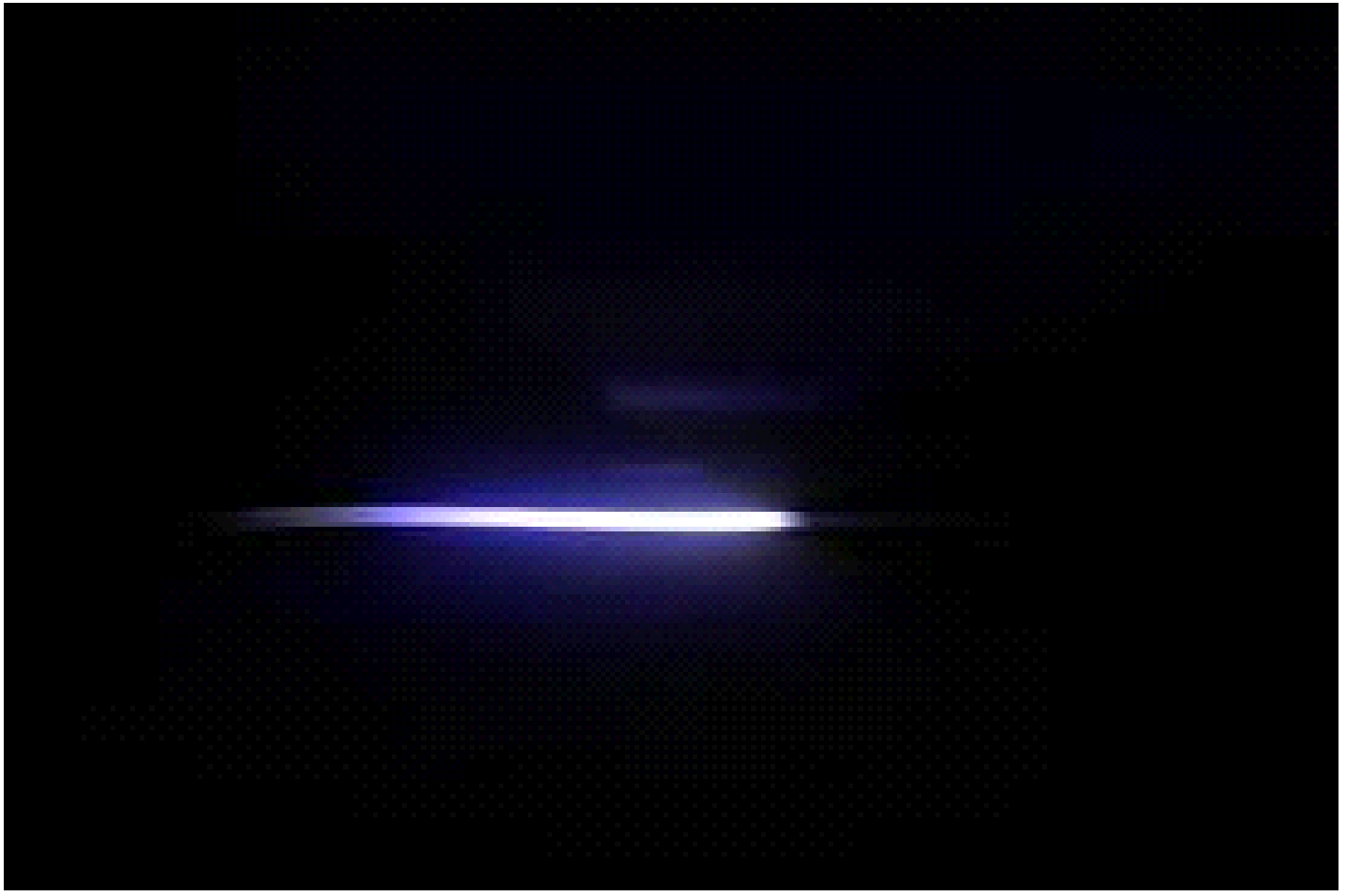


Have you ever been buried in snow?

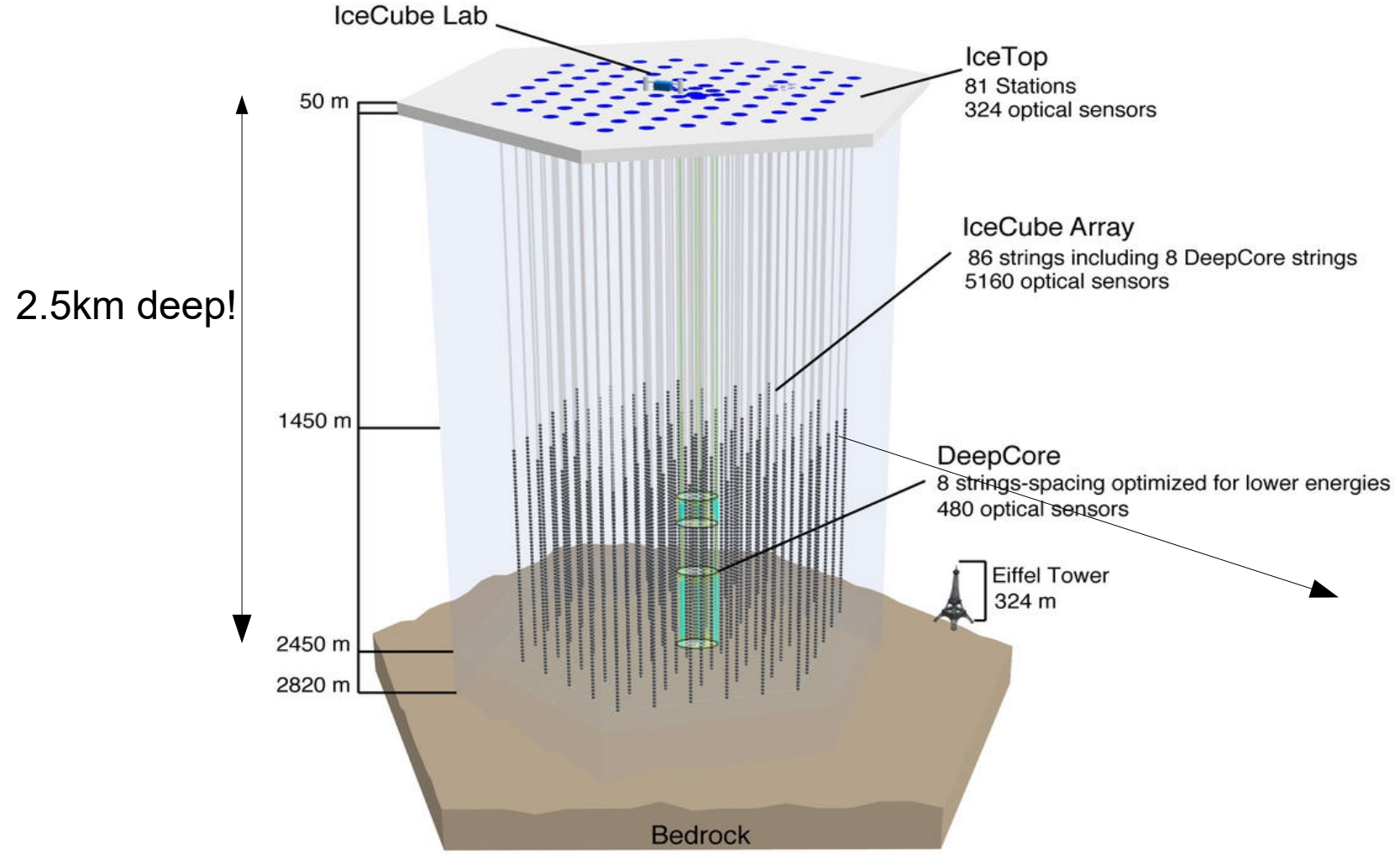
What if you're buried 1 mile deep?

Should you see light?

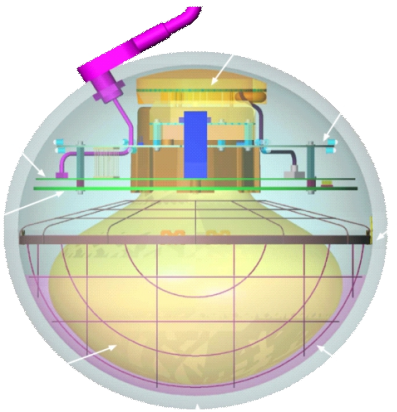
Only when small particles go through very fast (Cherenkov Radiation)

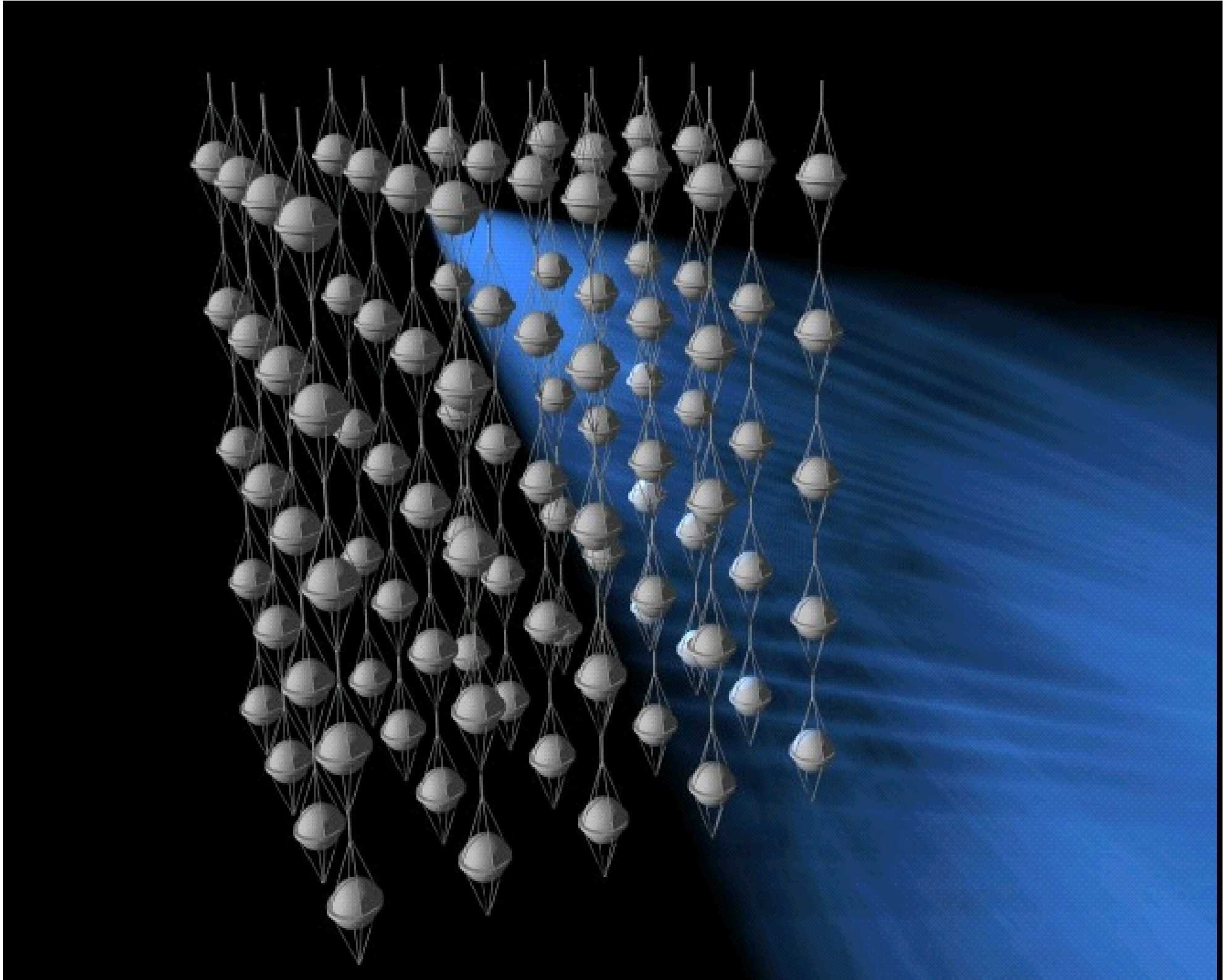


Glacier at the South Pole



Light Sensor



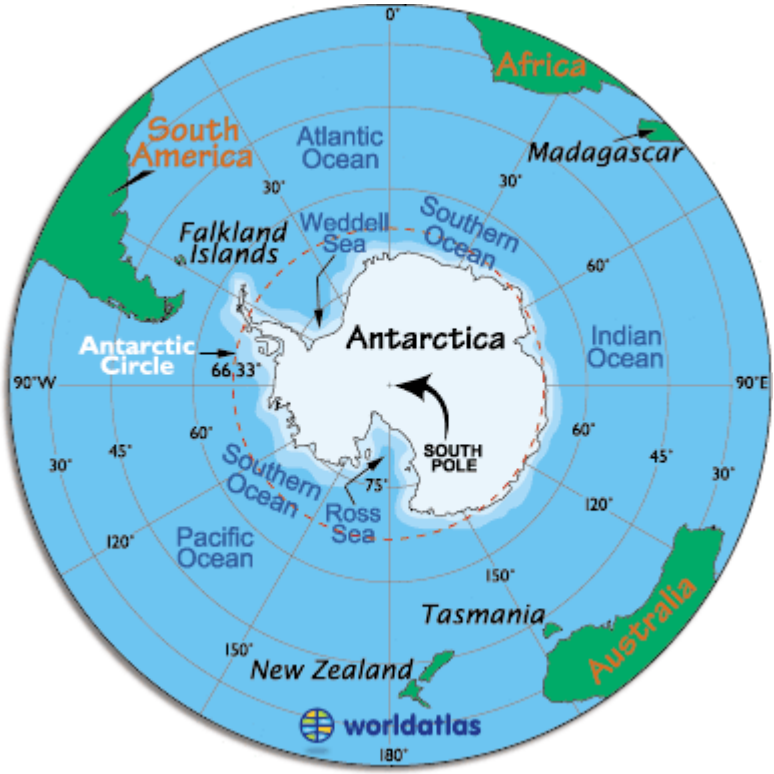


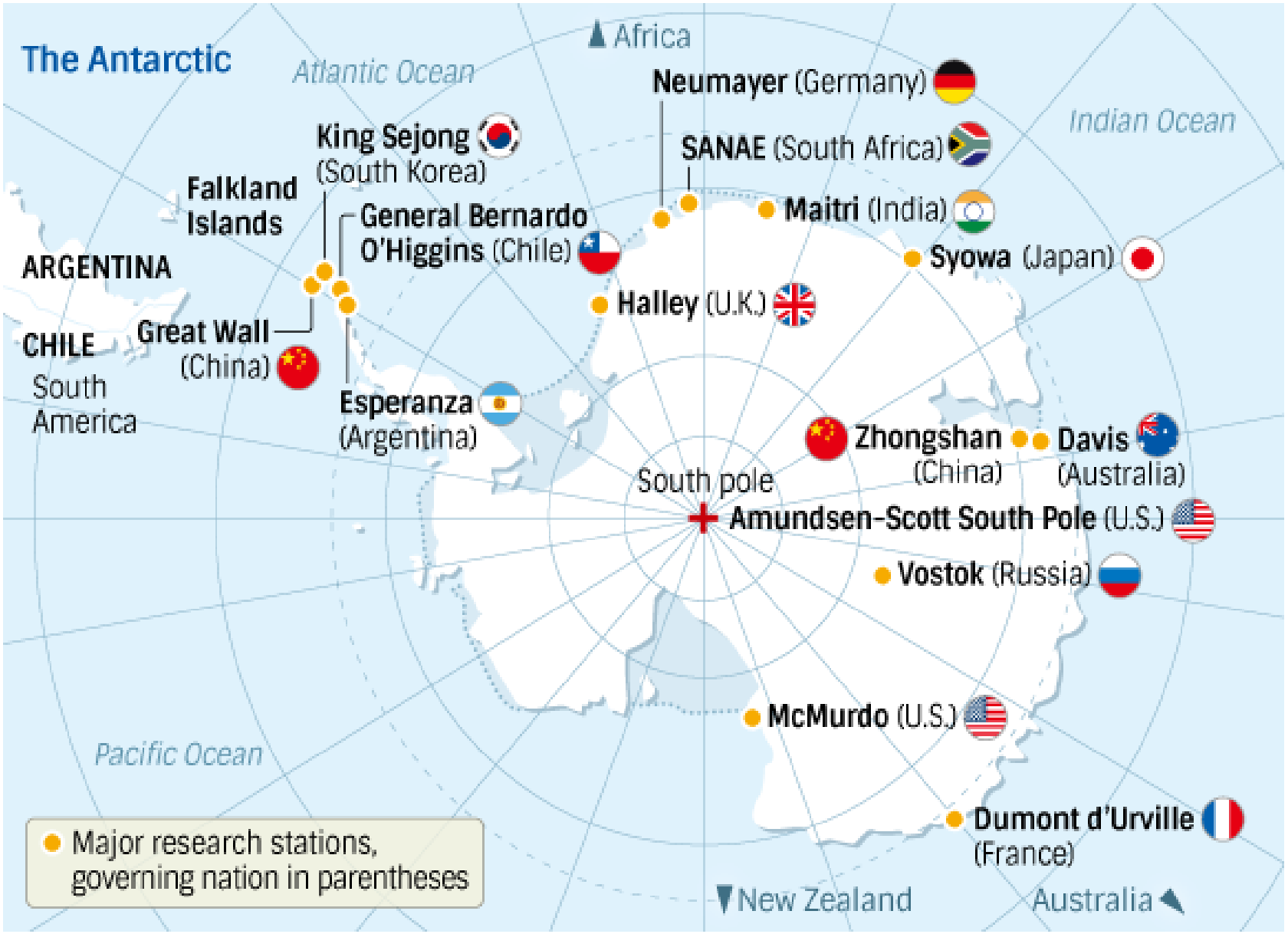
“Event View” video

Journey to the South Pole

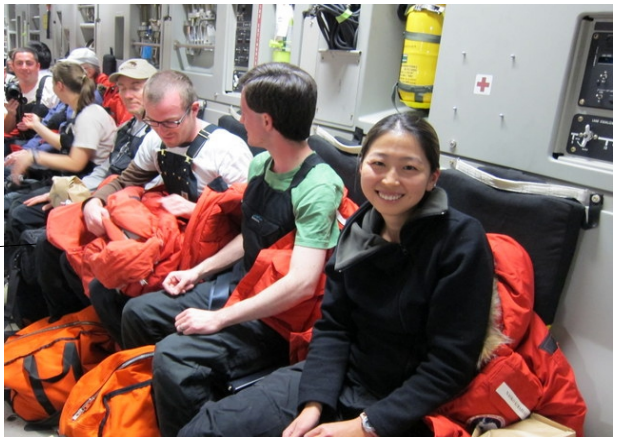
New Zealand (Christchurch)

Gateway to Antarctica!
Gear issue



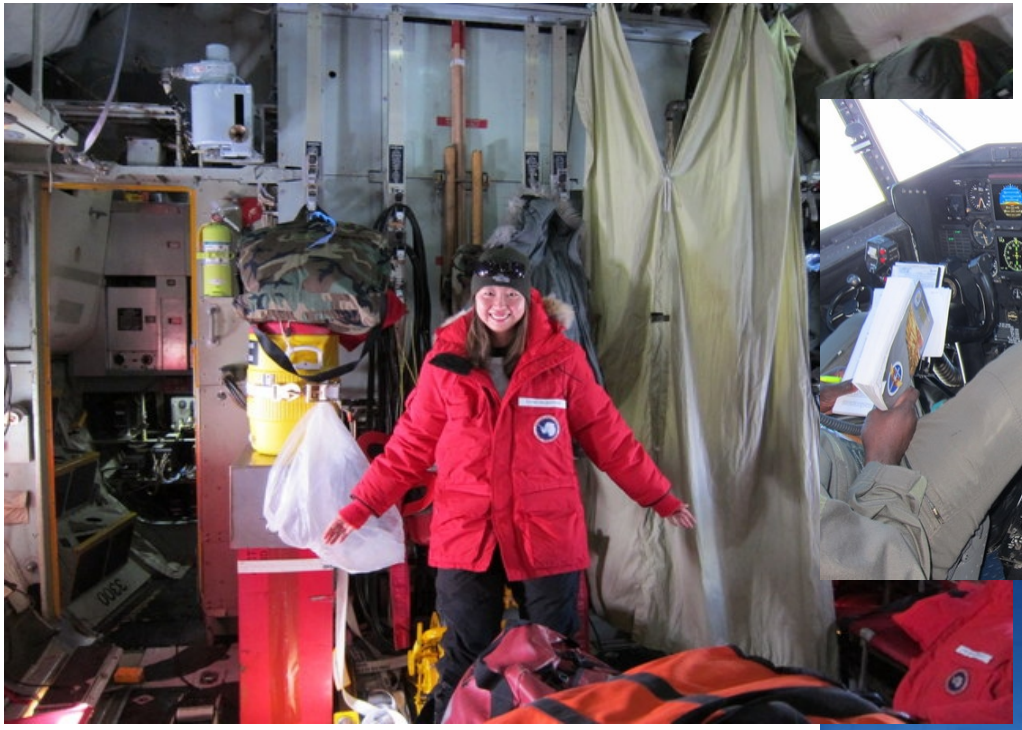

The Antarctic
Atlantic Ocean
Africa
Indian Ocean
Neumayer (Germany)
SANAE (South Africa)
Maitri (India)
Syowa (Japan)
King Sejong (South Korea)
Falkland Islands
General Bernardo O'Higgins (Chile)
ARGENTINA
CHILE
South America
Great Wall (China)
Esperanza (Argentina)
Halley (U.K.)
Zhongshan (China)
Davis (Australia)
South pole
Amundsen-Scott South Pole (U.S.)
Vostok (Russia)
McMurdo (U.S.)
Pacific Ocean
Dumont d'Urville (France)
New Zealand
Australia
Major research stations, governing nation in parentheses

Arriving at McMurdo



McMurdo Station

C130 to South Pole Station



South Pole Station

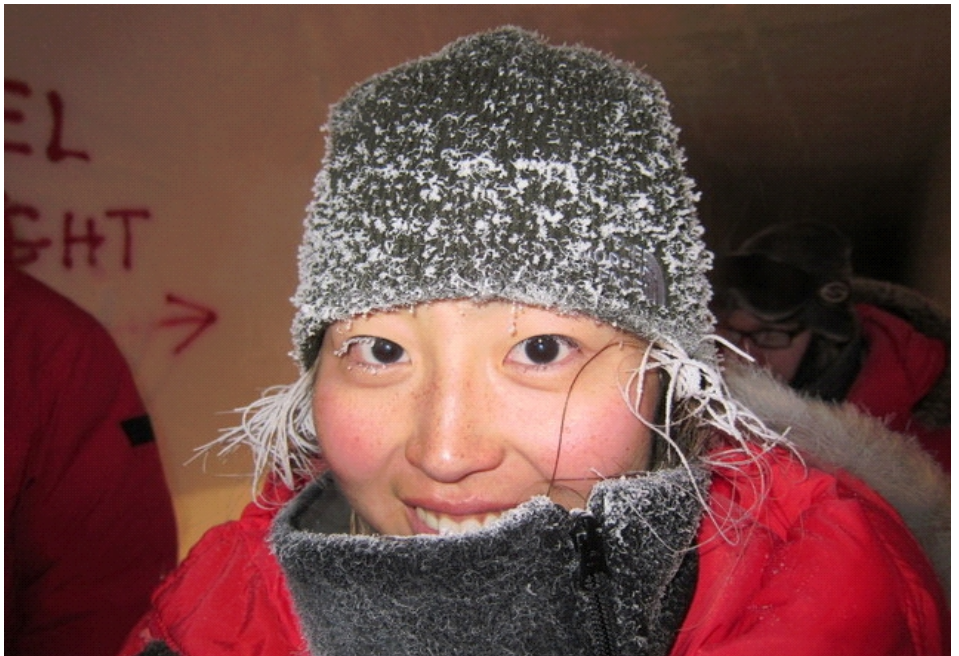
“Around the World” video

Life at the station

commute

work

sleep



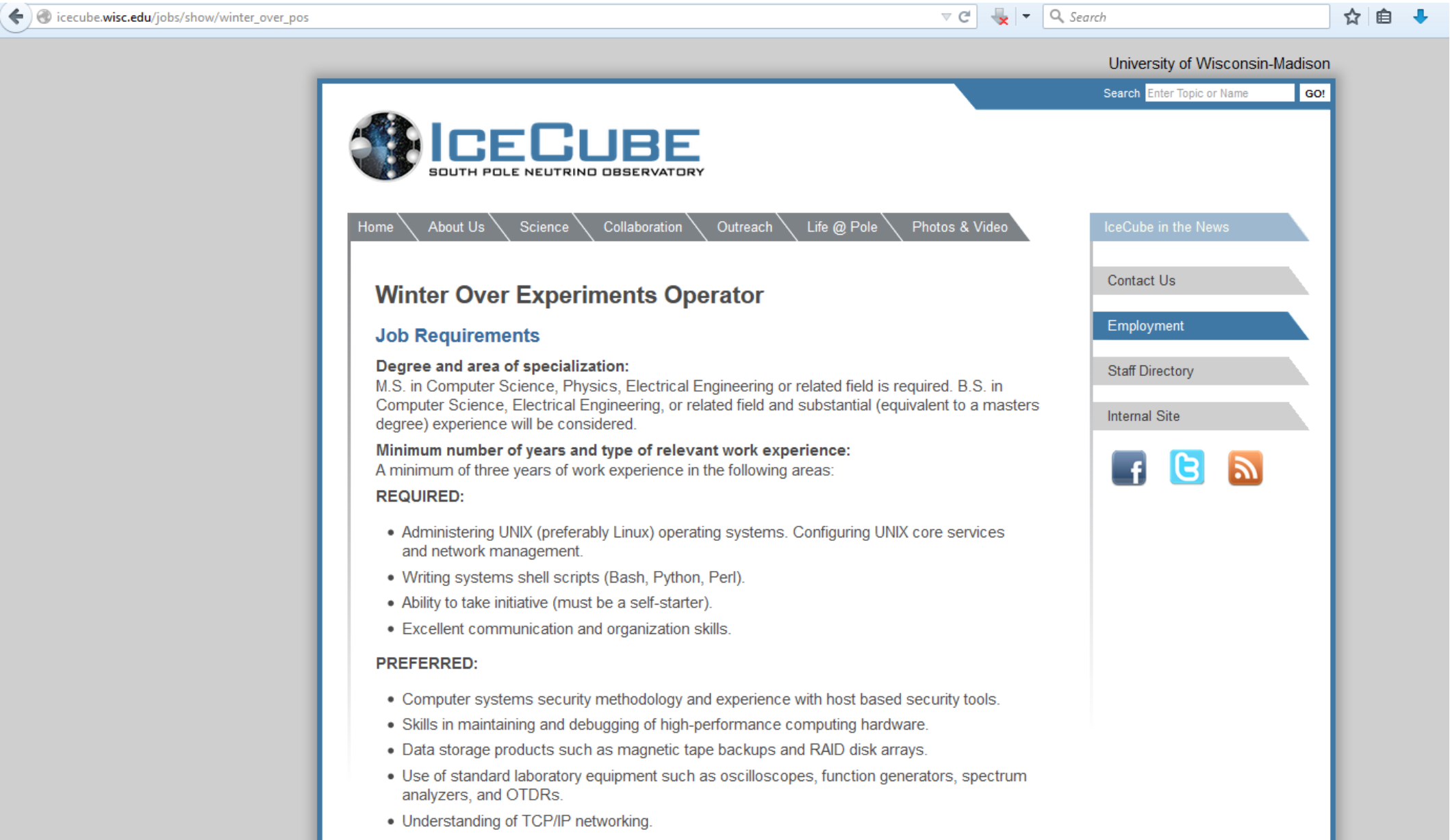
The screen to live by at South Pole Station

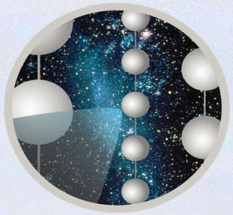
Note: Satellite coverage times are subject to change without notice.
Satellite times are presented in the same timezone as the clock on your computer.

DATE	EVENTS	SATELLITE
Fri 12/06/2013	2:02 PM - 2:52 PM	TDRS-5
	3:41 PM - 4:52 PM	TDRS-5
	5:17 PM - 6:06 PM	TDRS-5
	11:35 PM - 4:05 AM	SKYNET
Sat 12/07/2013	4:19 AM - 10:19 AM	GOES
	1:16 PM - 2:04 PM	TDRS-5
	2:59 PM - 3:41 PM	TDRS-5
	4:32 PM - 5:34 PM	TDRS-5
	5:36 PM - 5:56 PM	TDRS-5

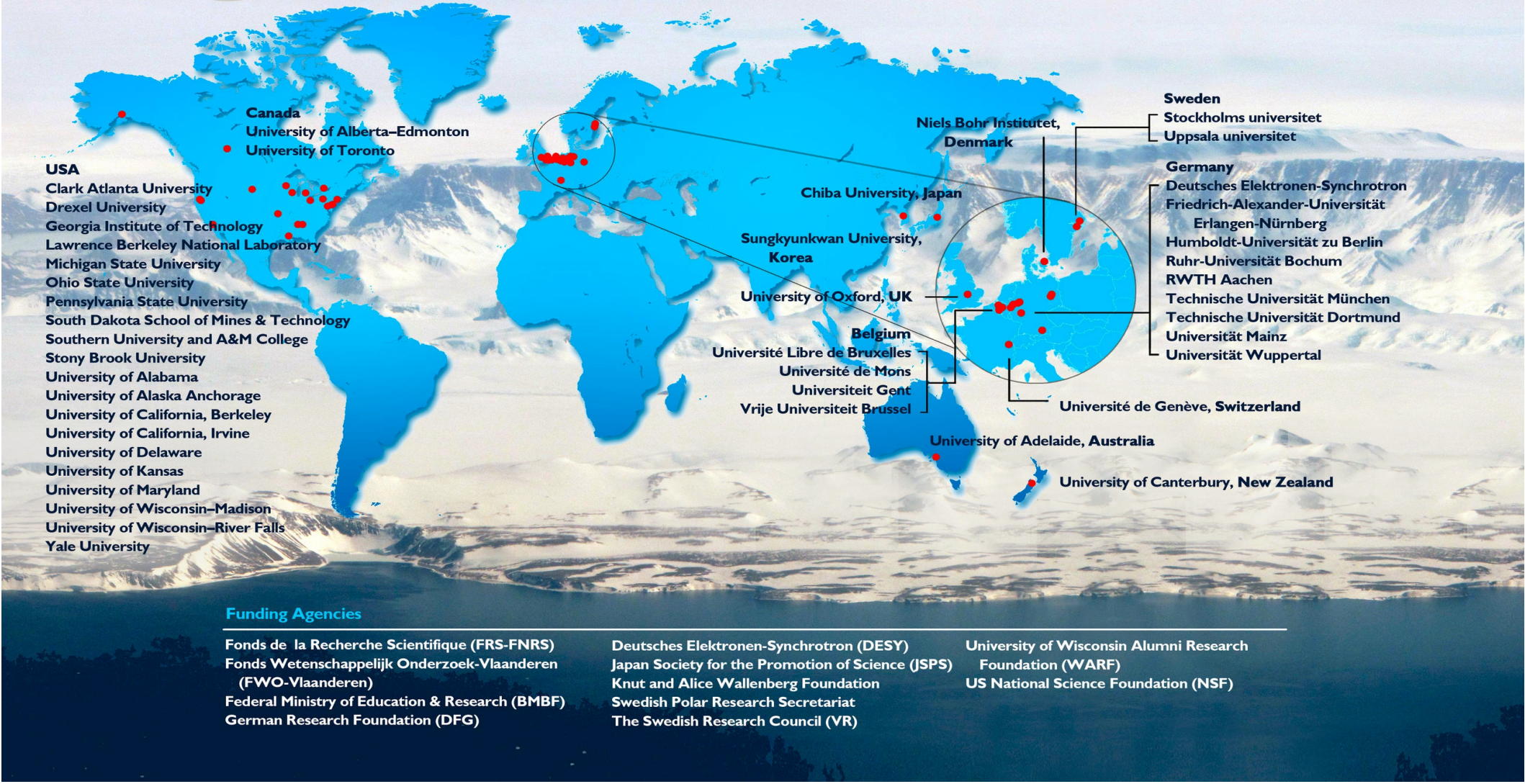
Winter Over!

You can apply to winter over too!
http://icecube.wisc.edu/jobs/show/winter_over_pos





The IceCube Collaboration



Funding Agencies

Fonds de la Recherche Scientifique (FRS-FNRS)
Fonds Wetenschappelijk Onderzoek-Vlaanderen (FWO-Vlaanderen)
Federal Ministry of Education & Research (BMBF)
German Research Foundation (DFG)
Deutsches Elektronen-Synchrotron (DESY)
Japan Society for the Promotion of Science (JSPS)
Knut and Alice Wallenberg Foundation
Swedish Polar Research Secretariat
The Swedish Research Council (VR)
University of Wisconsin Alumni Research Foundation (WARF)
US National Science Foundation (NSF)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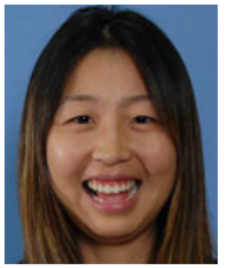
- Overview
- Research News
- Faculty Directory
  - Kurahashi Neilson Naoko
- Undergraduate Research
- Research Fellowships
- Seminars & Colloquia
- Faculty & Staff Resources



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Phone: 215.895.2725

Additional Sites: Personal Website, Particle Physics Group

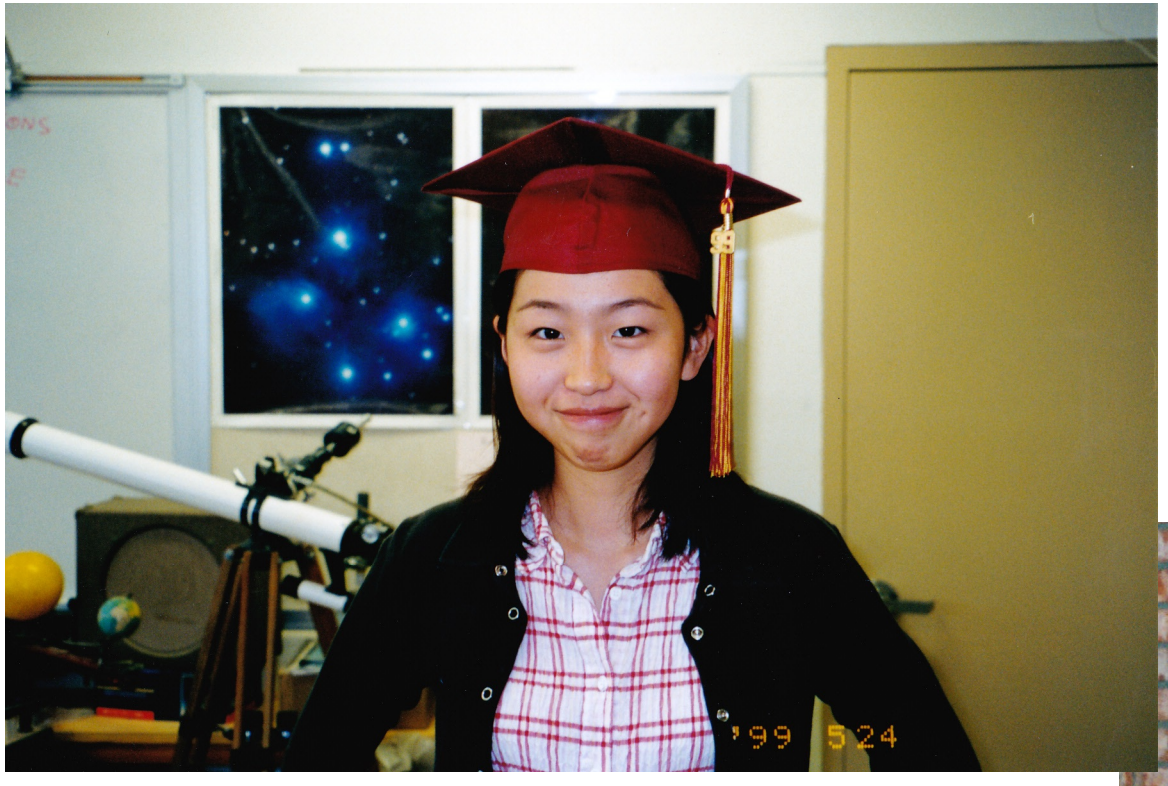
Education:

- BA physics University of California, Berkeley 2002
- PhD Physics/Applied Physics Stanford University 2010

Bio:

Naoko Kurahashi Neilson's background is in very high energy neutrino astro-particle physics. She completed graduate work listening to extremely high energy neutrinos acoustically in the Bahamian ocean. Kurahashi Neilson is a member of the IceCube collaboration, a high-energy neutrino telescope operating at the geographic South Pole. She studies neutrinos as high-energy messengers from the universe. She is interested in outreach

How did I get here?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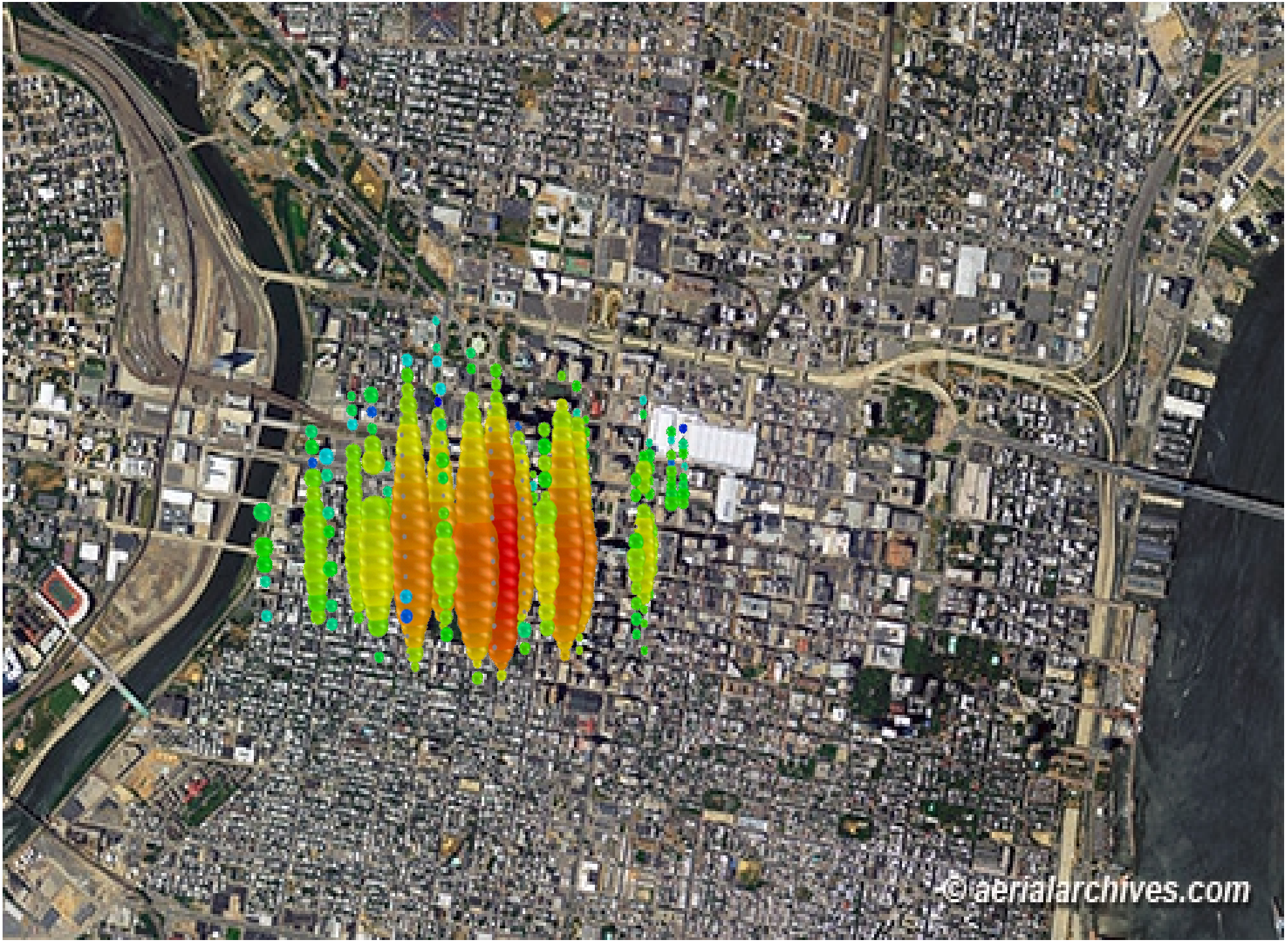
'99


AUTEC


U.S. AIR FORCE
3300


Journey to the South Pole
New Zealand (Christchurch)
Gateway to Antarctica!
Gear issue

Doing astronomy using neutrinos was just a dream until 2013....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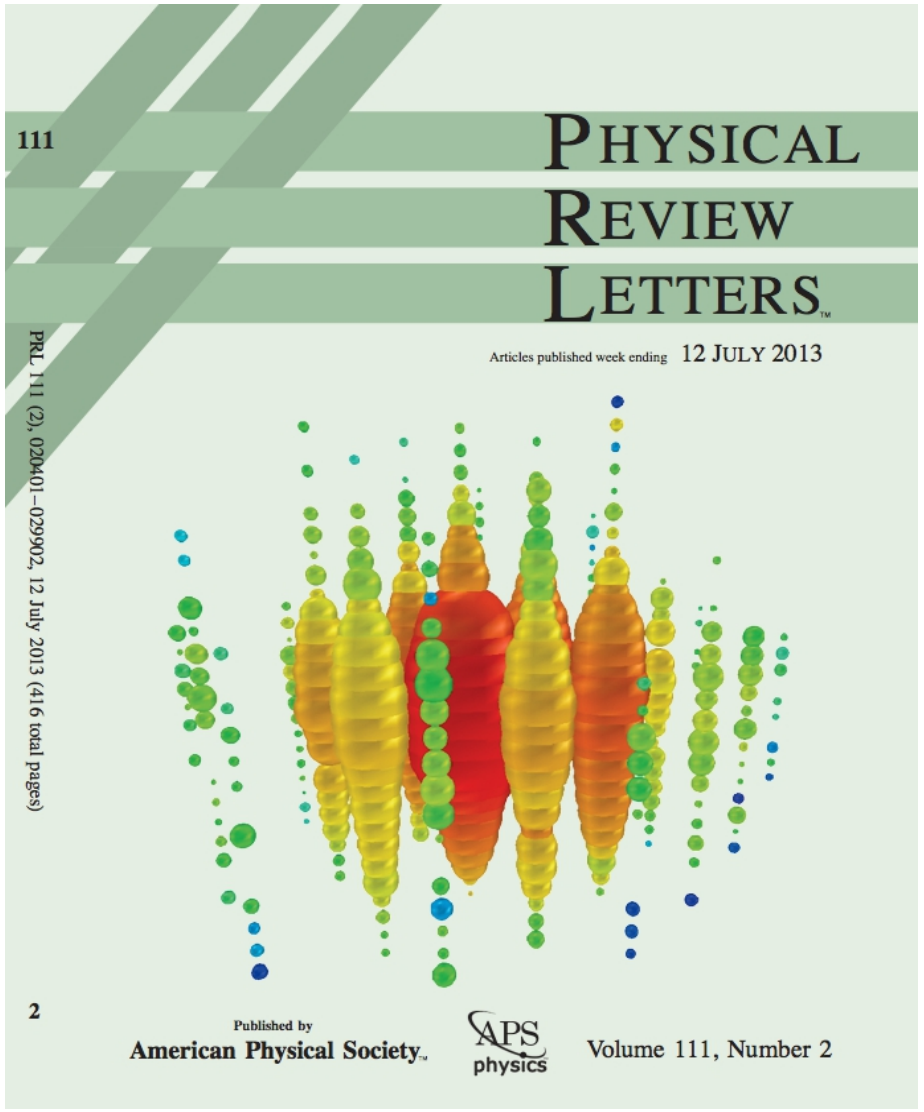
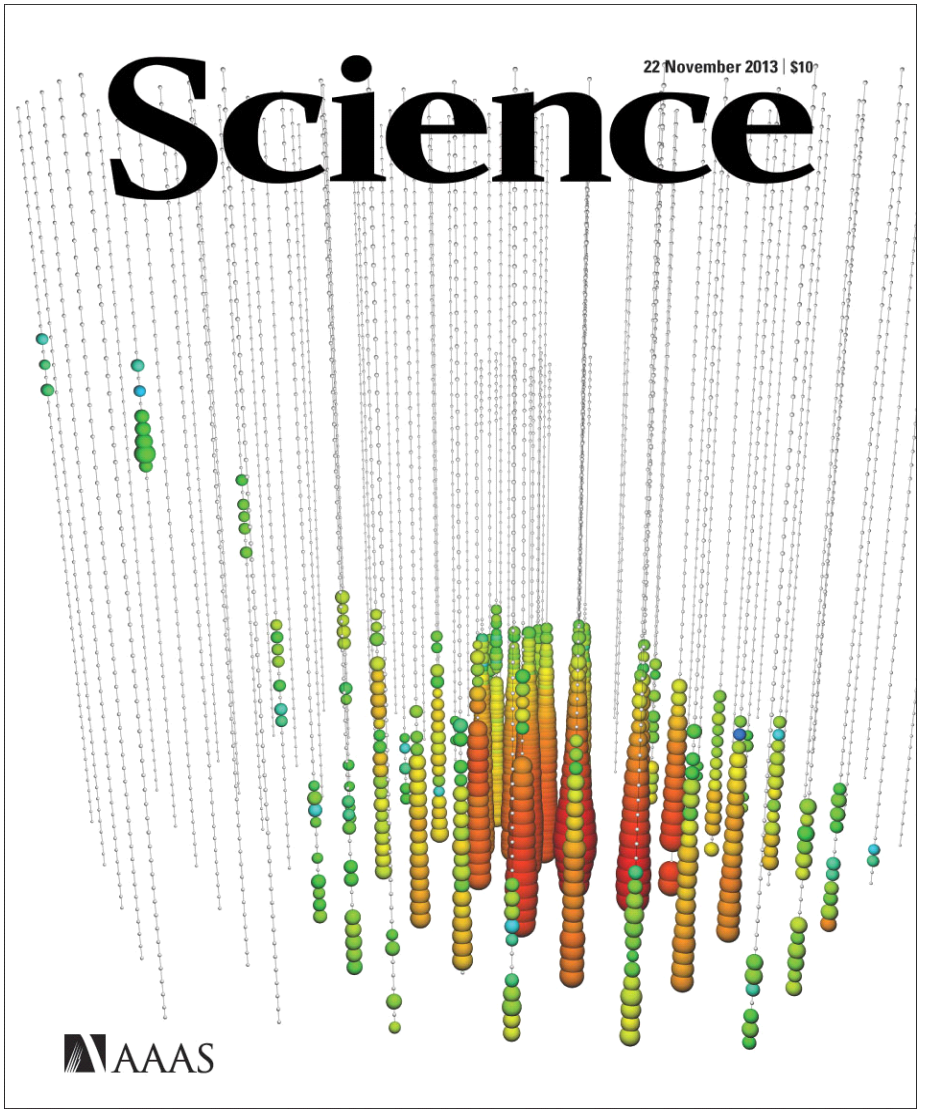
This was the first time neutrinos from outside our Galaxy was seen. This created buzz in scientific papers.





But where do these super-high-energy neutrinos come from?

How do you look for a star/galaxy?

Two *Science* publications 2018

RESEARCH ARTICLE

NEUTRINO ASTROPHYSICS

Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A

The IceCube, *Fermi*-LAT, MAGIC, *AGILE*, ASAS-SN, HAWC, H.E.S.S, *INTEGRAL*, Kanata, Kiso, Kapteyn, Liverpool telescope, Subaru, *Swift/NuSTAR*, VERITAS, and VLA/17B-403 teams*†

Previous detections of individual astrophysical sources of neutrinos are limited to the Sun and the supernova 1987A, whereas the origins of the diffuse flux of high-energy

evaluated below, associating neutrino and γ-ray production.

The neutrino alert

IceCube is a neutrino observatory with more than 5000 optical sensors embedded in 1 km^3 of the Antarctic ice-sheet close to the Amundsen-Scott South Pole Station. The detector consists of 86 vertical strings frozen into the ice 125 m apart, each equipped with 60 digital optical modules (DOMs) at depths between 1450 and 2450 m. When a high-energy muon-neutrino interacts with an atomic nucleus in or close to the detec-

RESEARCH ARTICLES

NEUTRINO ASTROPHYSICS

Neutrino emission from the direction of the blazar TXS 0506+056 prior to the IceCube-170922A alert

IceCube Collaboration*†

A high-energy neutrino event detected by IceCube on 22 September 2017 was coincident in direction and time with a gamma-ray flare from the blazar TXS 0506+056. Prompted by this association, we investigated 9.5 years of IceCube neutrino observations to search for excess emission at the position of the blazar. We found an excess of high-energy neutrino events, with respect to atmospheric backgrounds, at that position between September 2014 and March 2015. Allowing for time-variable flux, this constitutes 3.5σ evidence for neutrino emission from the direction of TXS 0506+056, independent of and prior to the 2017 flaring episode. This suggests that blazars are identifiable sources of the high-energy astrophysical neutrino flux.

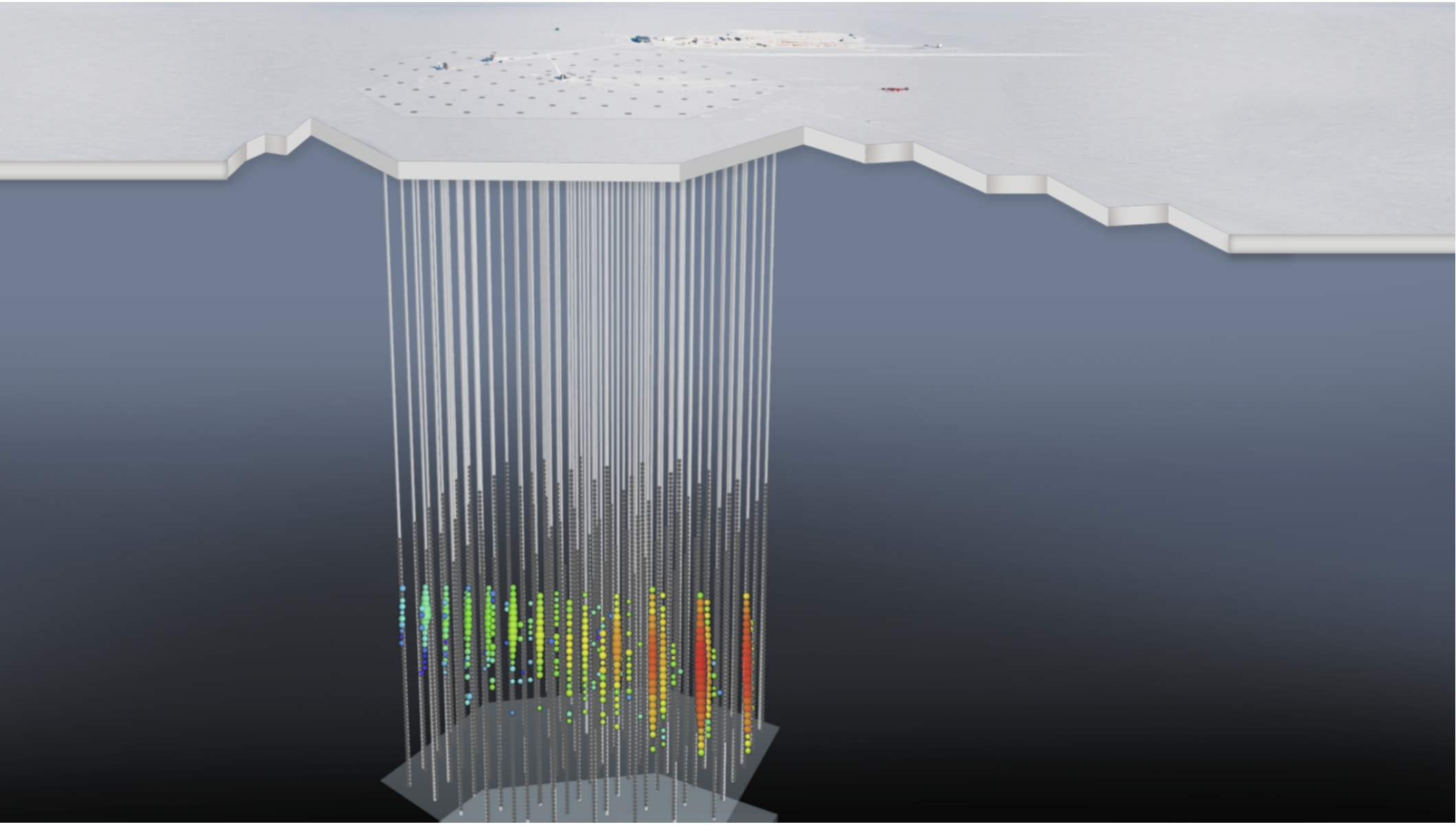
tion of TXS 0506+056 and coincident with a state of enhanced gamma-ray activity observed since April 2017 (*23*) by the Large Area Telescope (LAT) on the Fermi Gamma-ray Space Telescope (*24*). Follow-up observations of the blazar led to the detection of gamma rays with energies up to 400 GeV by the Major Atmospheric Gamma Imaging Cherenkov (MAGIC) Telescopes (*25*, *26*). IceCube-170922A and the electromagnetic observations are described in detail in (*20*). The significance of the spatial and temporal coincidence of the high-energy neutrino and the blazar flare is estimated to be at the 3σ level (*20*). On the basis of this result, we consider the hypothesis that the blazar TXS 0506+056 has been a source of high-energy neutrinos beyond that single event.

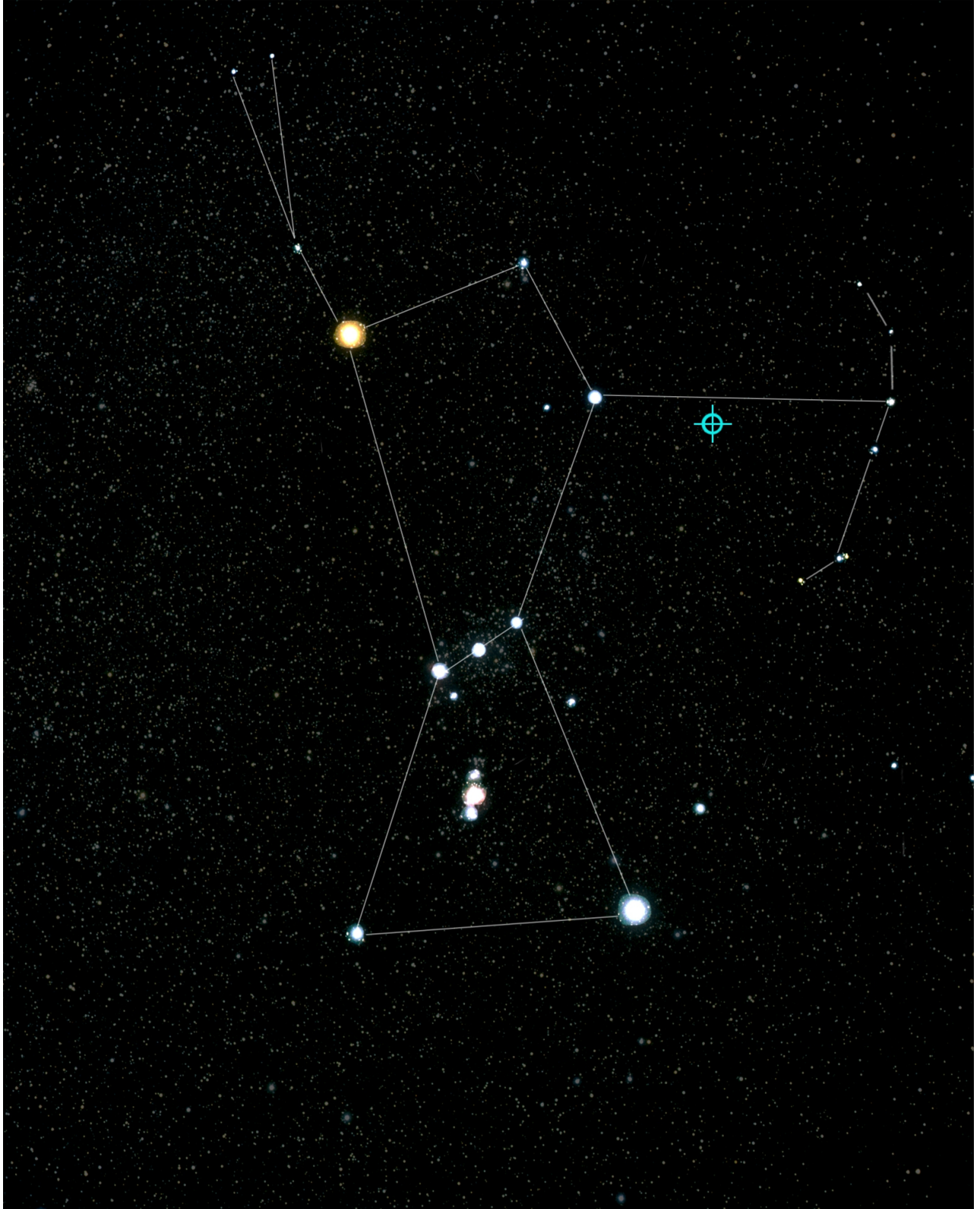
Searching for neutrino emission

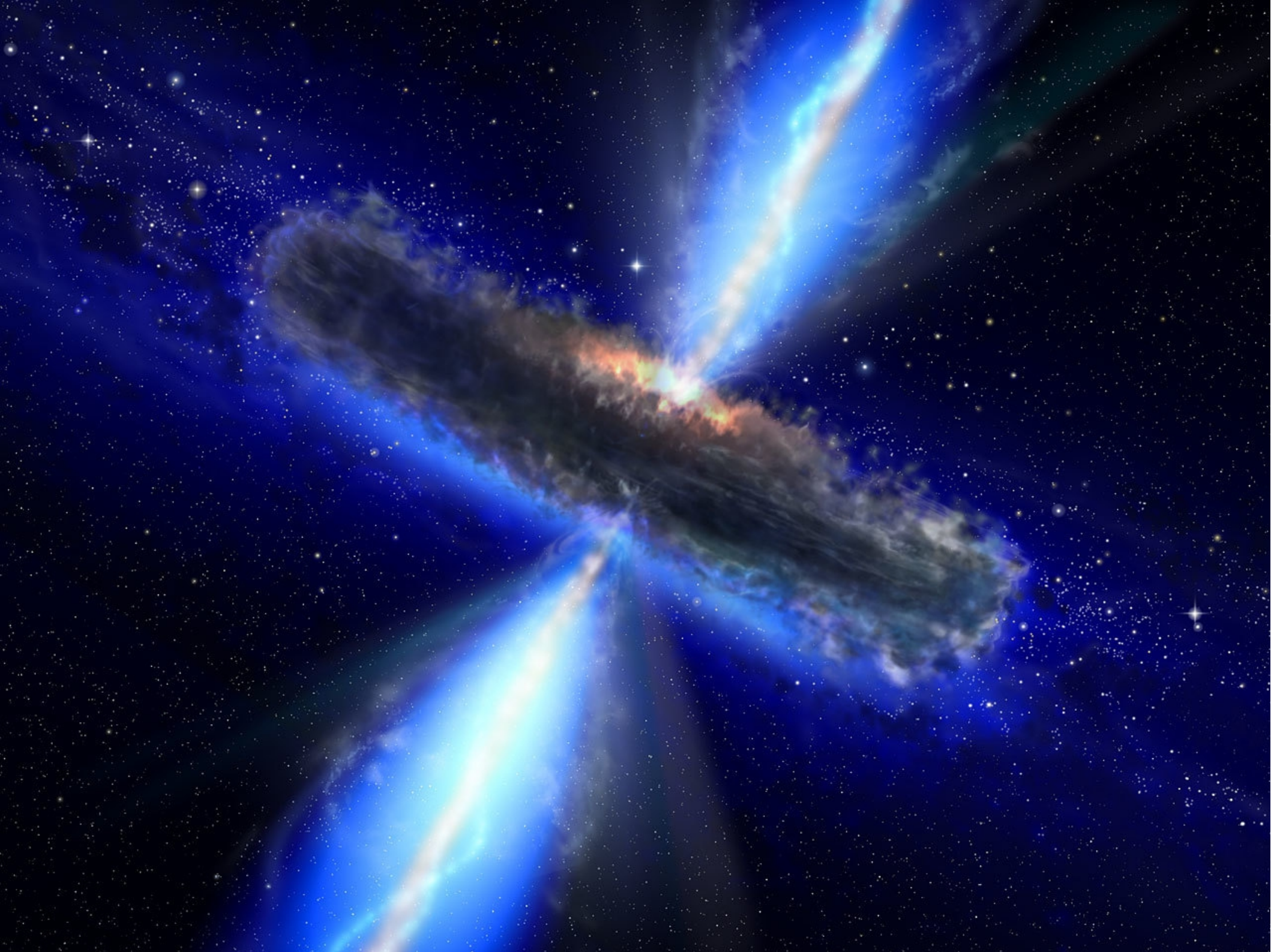
IceCube monitors the whole sky and has maintained essentially continuous observations since 5 April 2008. Searches for neutrino point sources using two model-independent methods, a time-integrated and a time-dependent unbinned maximum likelihood analysis, have previously been

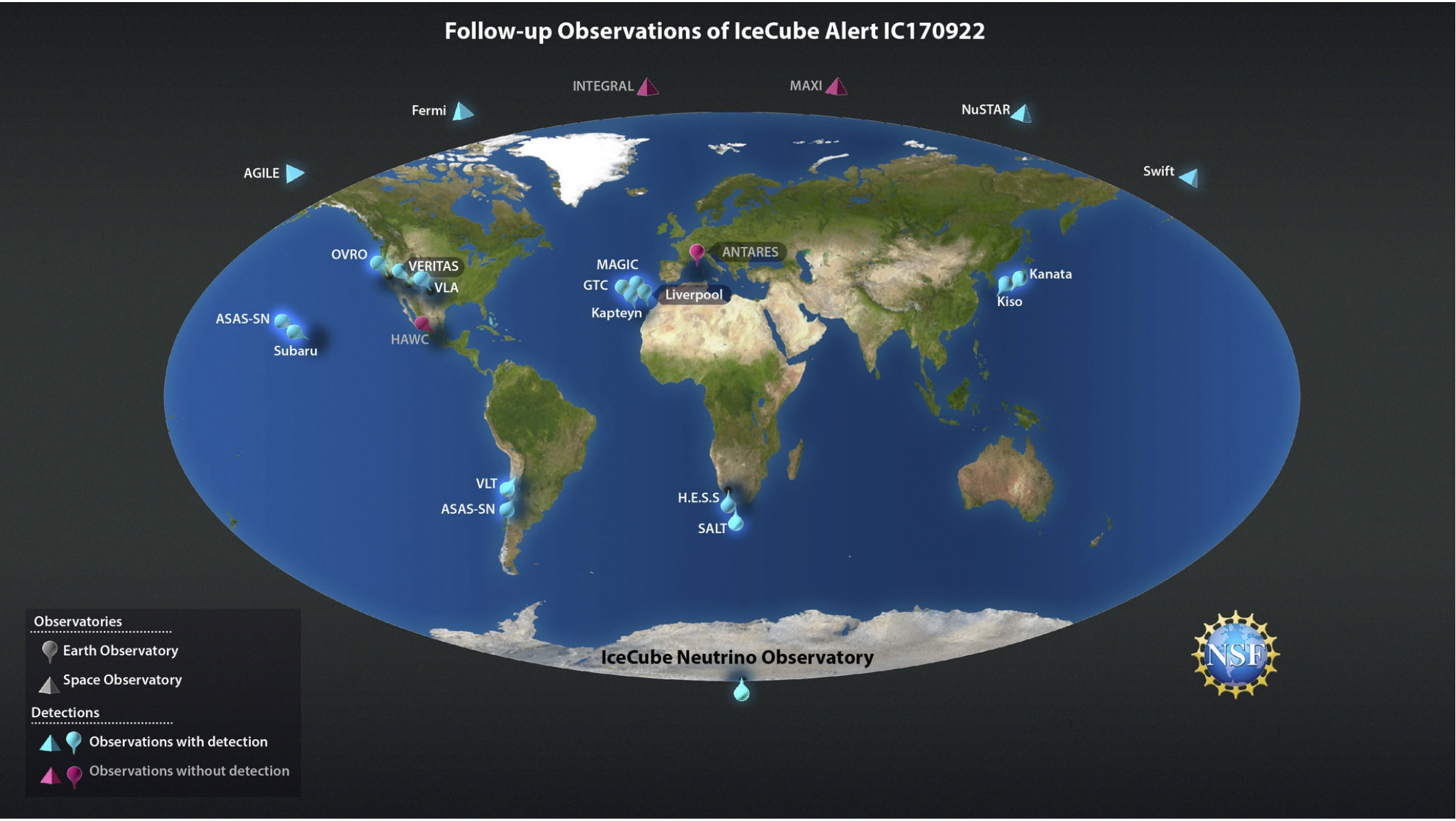
We even had a press conference

On Sept 22, 2017 a high energy neutrino left a spectacular trail of light








Follow-up Observations of IceCube Alert IC170922
INTEGRAL
MAXI
Fermi
NuSTAR
AGILE
Swift
OVRO
VERITAS
VLA
ASAS-SN
Subaru
HAWC
MAGIC
GTC
Kapteyn
ANTARES
Liverpool
Kanata
Kiso
VLT
ASAS-SN
H.E.S.S
SALT
IceCube Neutrino Observatory
Observatories
Earth Observatory
Space Observatory
Detections
Observations with detection
Observations without detection
NSF

First time a possible source was located!

Newsweek

HIGH ENERGY NEUTRINO SOURCE DISCOVERED, RESEARCH HERALDS 'NEW ERA' FOR PARTICLE PHYSICS

BY KATHERINE HIGNETT ON 7/12/18 AT 11:00 AM

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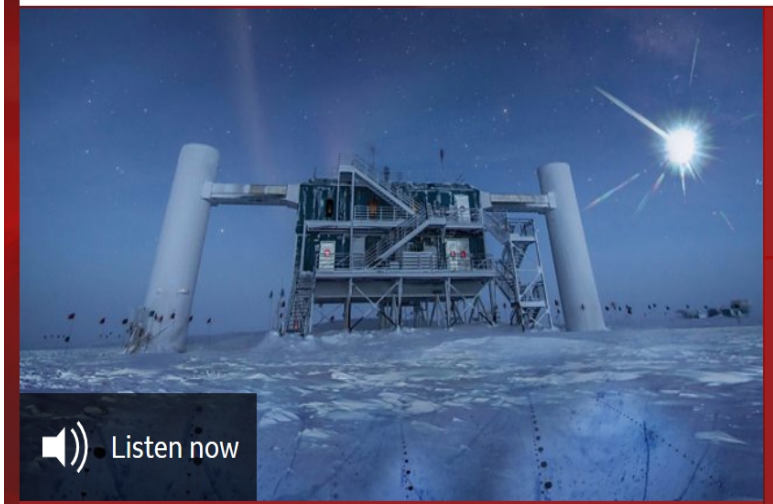

New Neutrino Source Found

Universe mapping with neutrinos, as new source found in far off galaxy. Also, early humans arrived in Asia sooner than thought,

Available now 26 minutes

Last on

BBC WORLD SERVICE Sun 15 Jul 2018 20:32 Local time

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PREVIOUS Bringing Back the Northern White Rhino

NEXT Heatwaves and Droughts

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SPECIAL SERIES joe's big idea

A 4 Billion Light-Year Journey Ends At The South Pole

3:44 + QUEUE DOWNLOAD EMBED TRANSCRIPT

July 12, 2018 · 11:01 AM ET

Heard on All Things Considered

JOE PALCA

Where do we stand?

- We've seen extremely high energy neutrinos from outside our galaxy
- Astronomy has become truly “multi-messenger”
- What does the “night” sky look like in neutrinos? Stay tuned...