

The background features a grid of semi-transparent blue circles of varying sizes, overlaid on a light blue background with a subtle grid of thin white lines. The overall color palette is shades of blue, with a bright white light source on the left side creating a gradient effect.

Neutrino Telescopes in Water and Ice

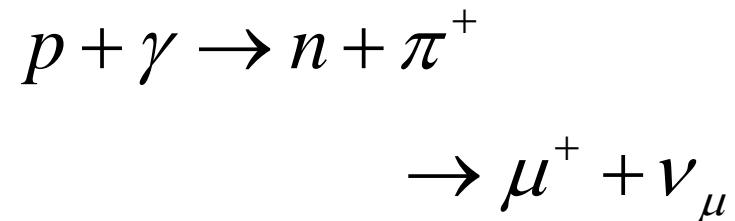
Christian Spiering, DESY

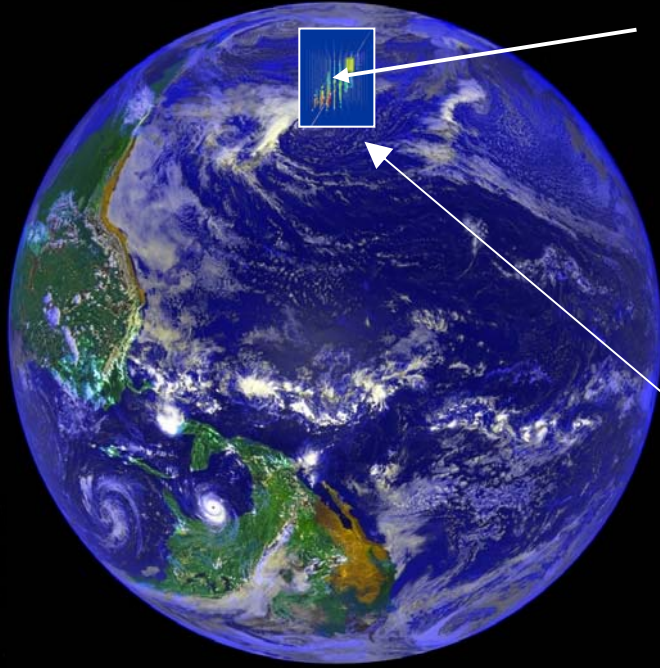


Another Approach to **Search** for the Origin of Cosmic Rays

Why Neutrinos ?

- ▶ **Travel straight**
(different to protons)
- ▶ **Are not absorbed**
(different to gamma rays and protons)
- ▶ **Can be generated only by protons, neutrons and nuclei**
(different to gammas which may be due to accelerated electrons)





**Neutrino
Telescope**
deep in water or ice

Only neutrinos can cross Earth.

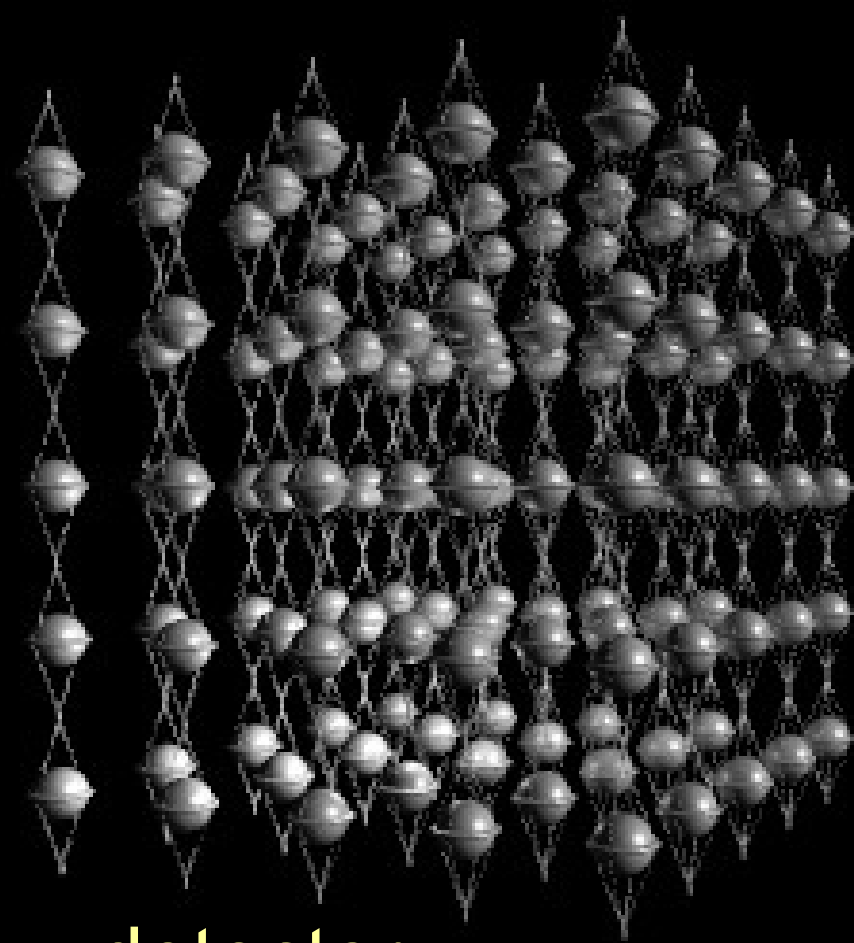
→ for unambiguous signature:

Look down !
(take Earth as a filter)

ν

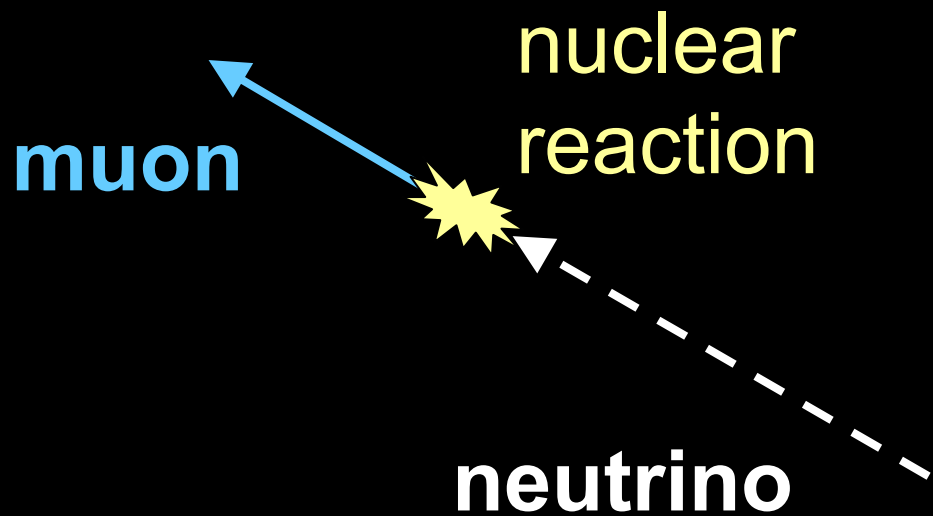
Active Galaxy
hundred million light years away





detector

infrequently, a cosmic neutrino
crashes into a nucleus in the ice
and produces a muon



muon can travel kilometers in water or ice ...

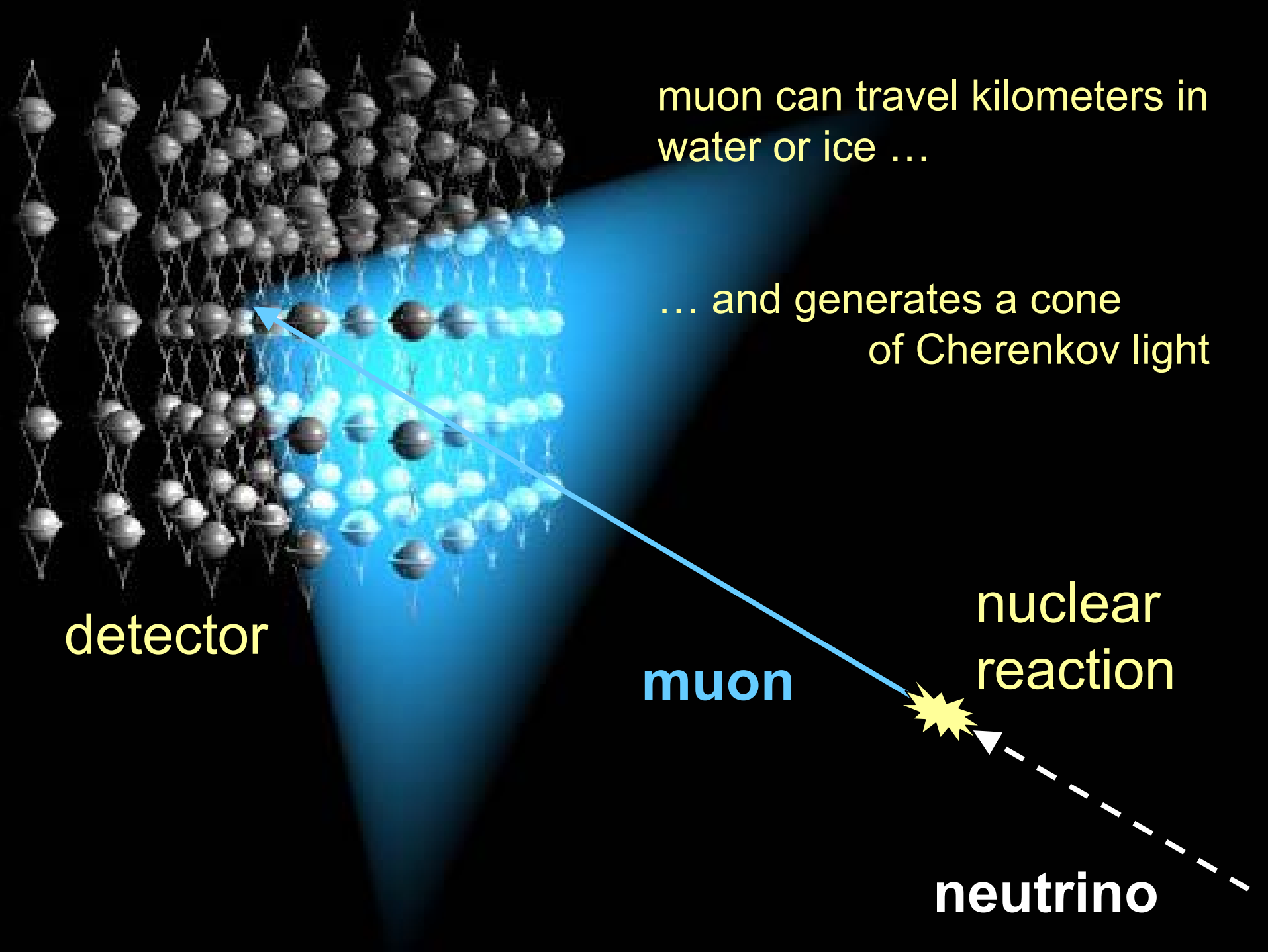
... and generates a cone of Cherenkov light

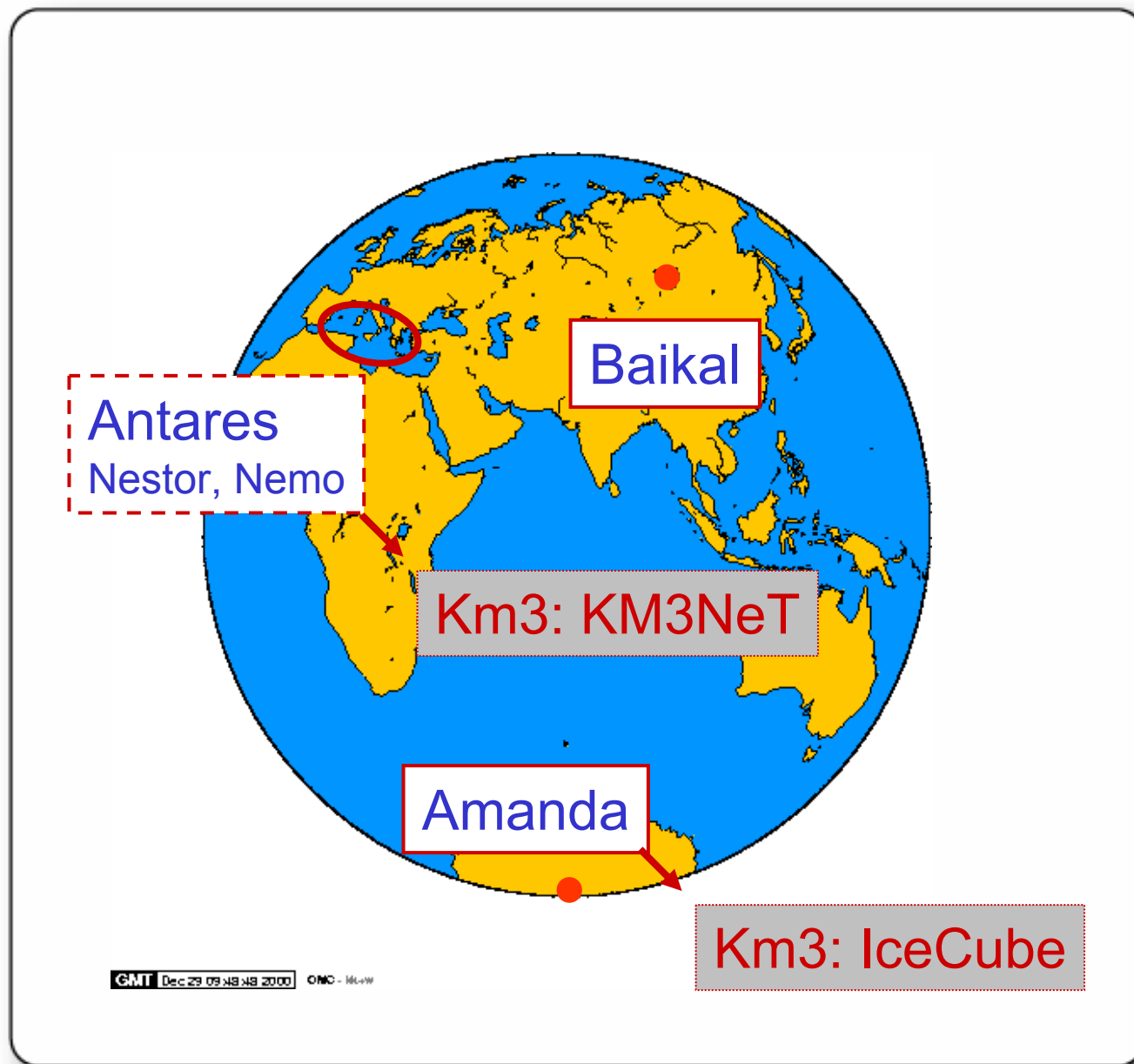
detector

muon

nuclear reaction

neutrino



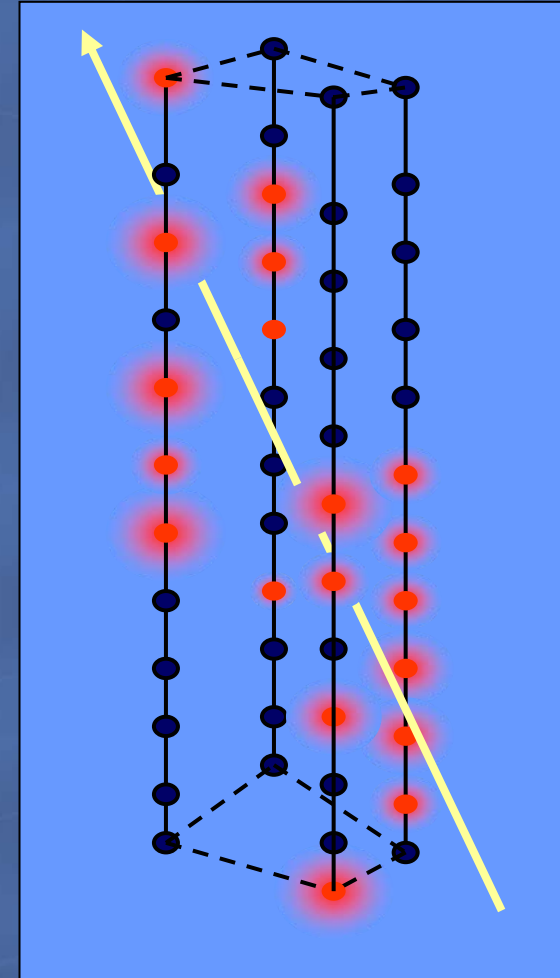


NT-200

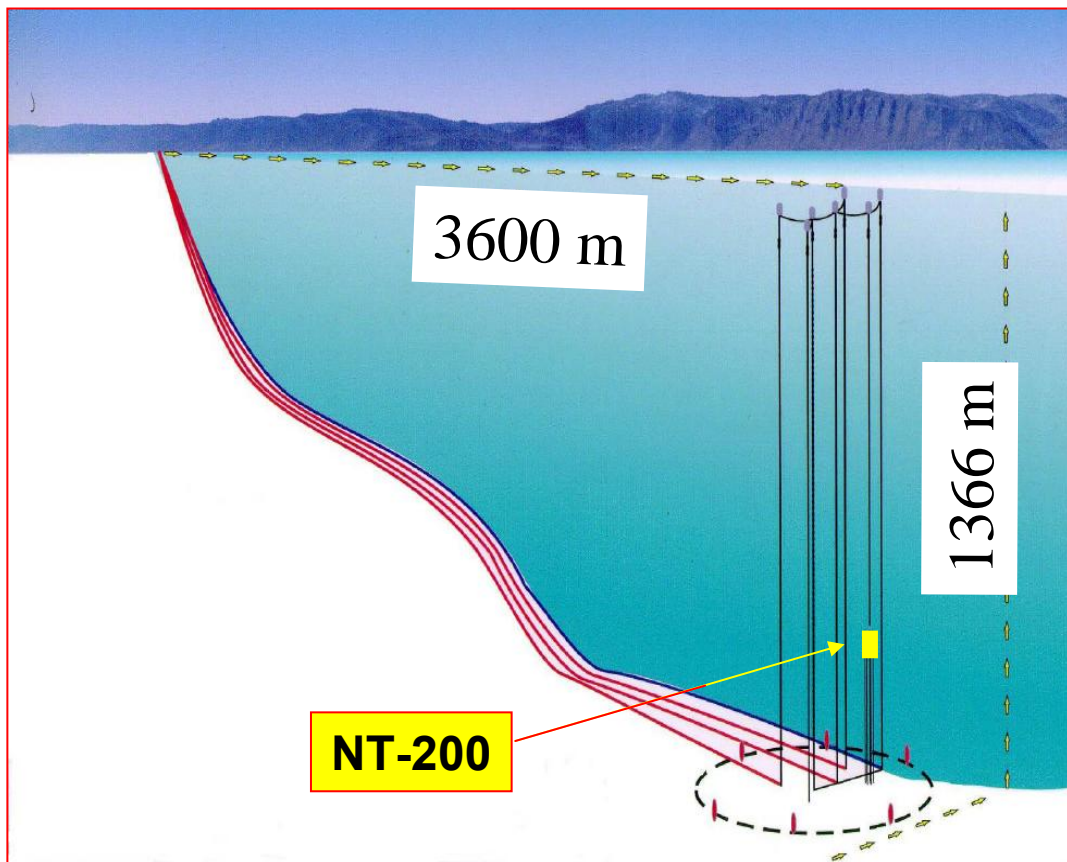
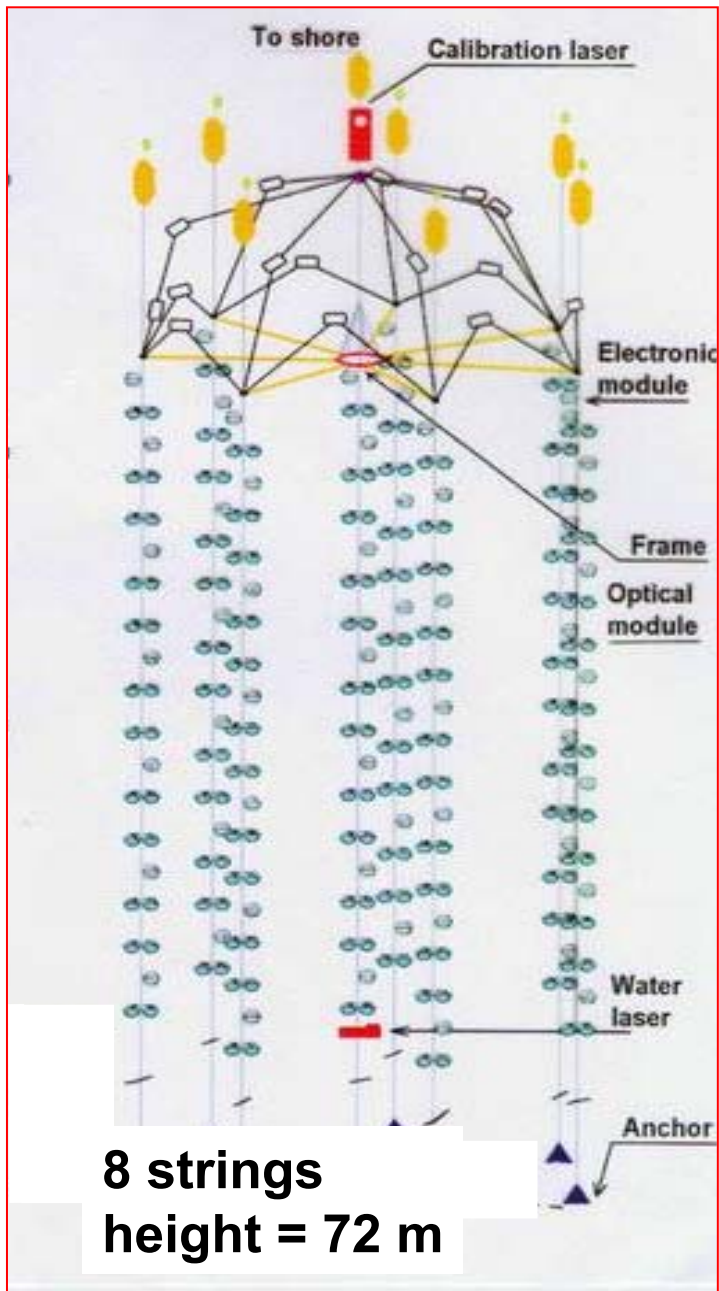
Lake Baikal



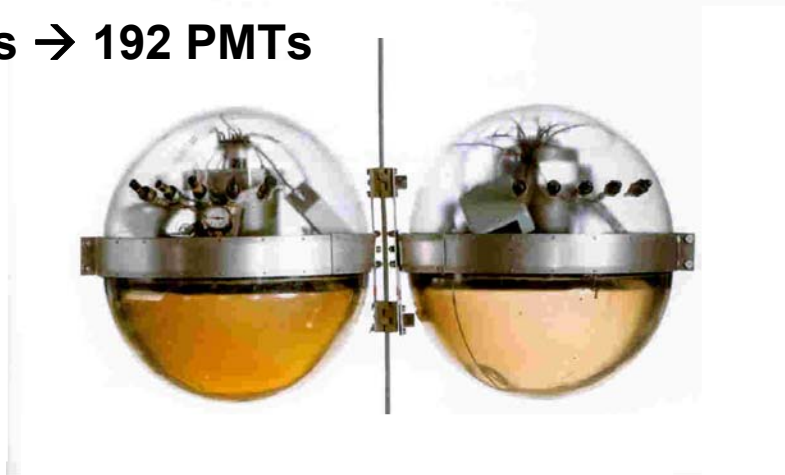
**Built
1993-1998**



Gold-plated neutrino event from 4-string stage (1996)



96 pairs → 192 PMTs



Ice – a perfect natural deployment platform

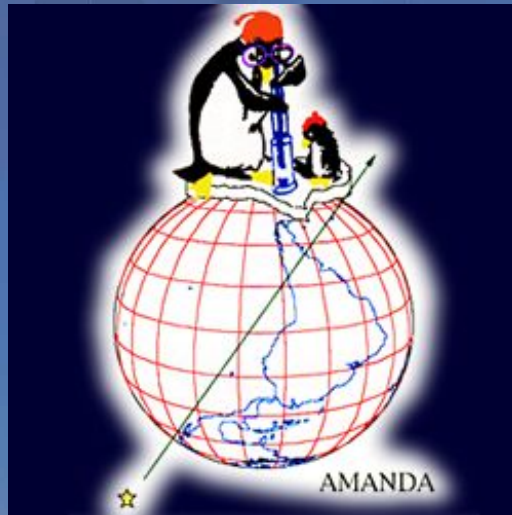


C. Spiering
ESOF
Munich
July 17, 2006



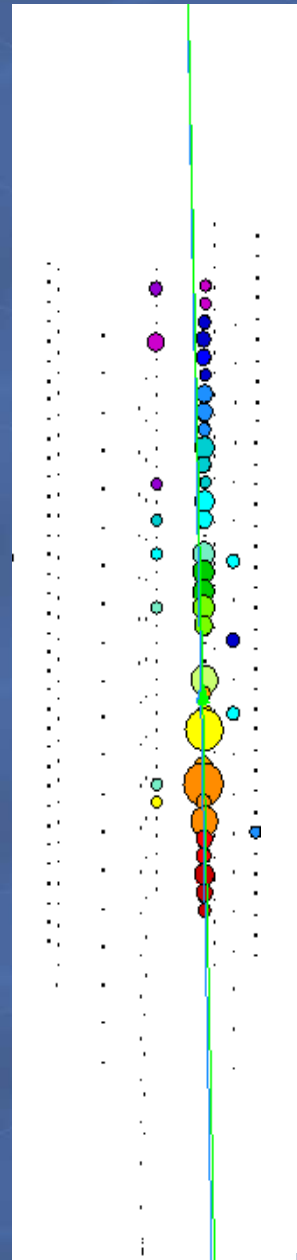
AMANDA

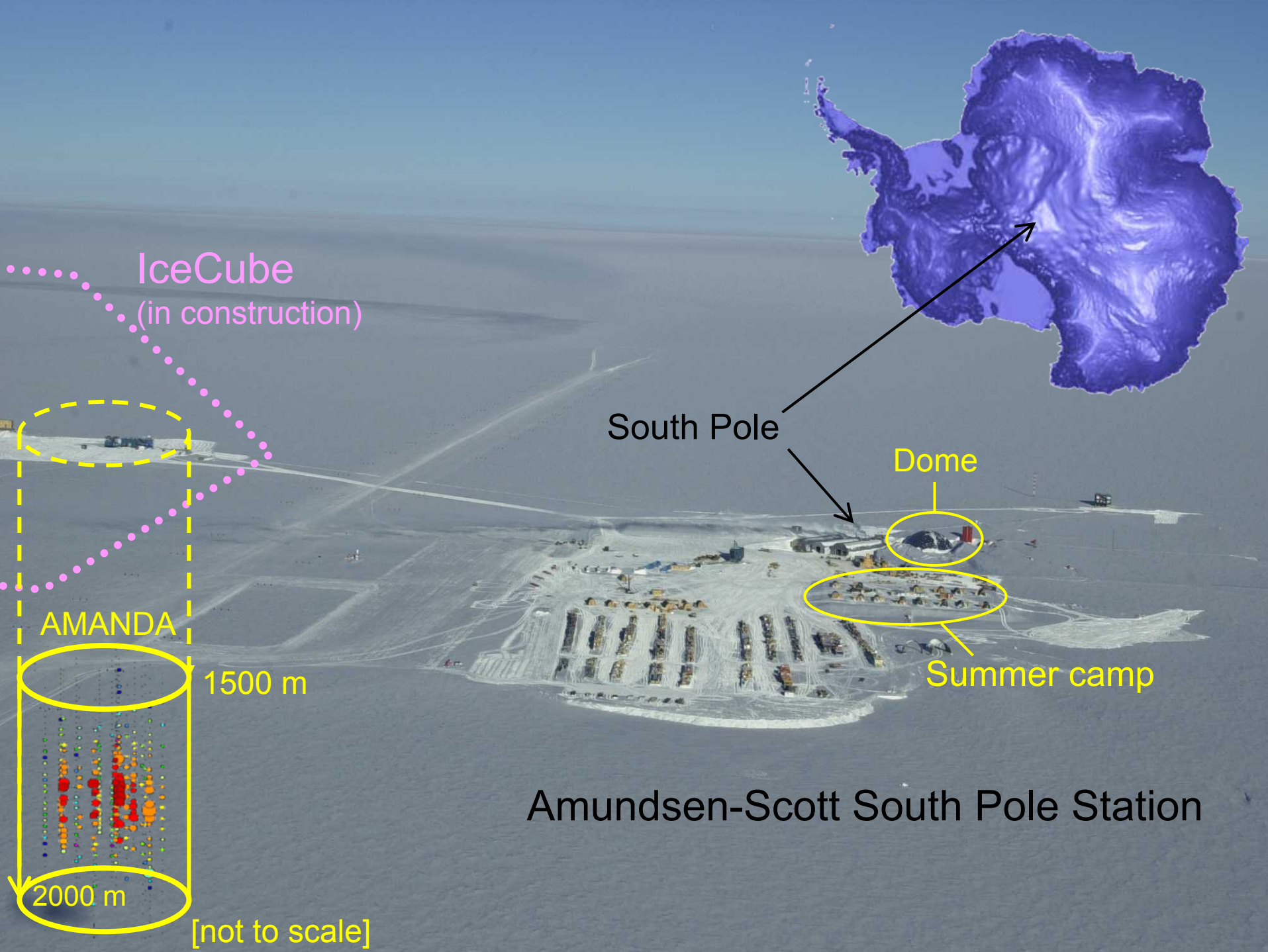
South Pole



Built
1996-2000

First gold-plated neutrino event
Amanda-B10





IceCube
(in construction)

South Pole

Dome

AMANDA

1500 m

Summer camp

2000 m

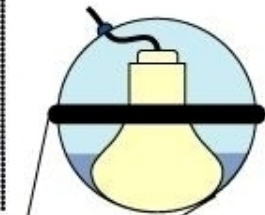
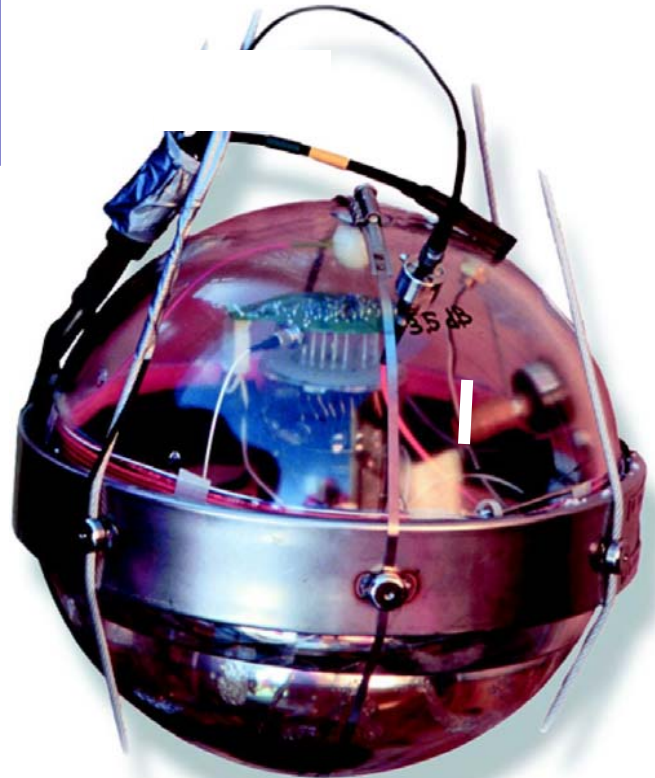
Amundsen-Scott South Pole Station

[not to scale]



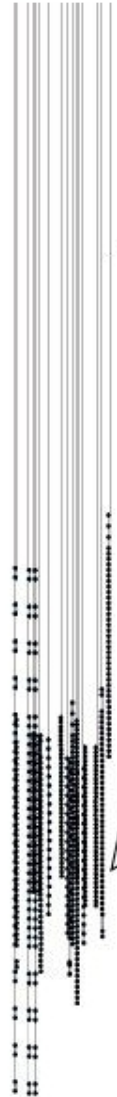
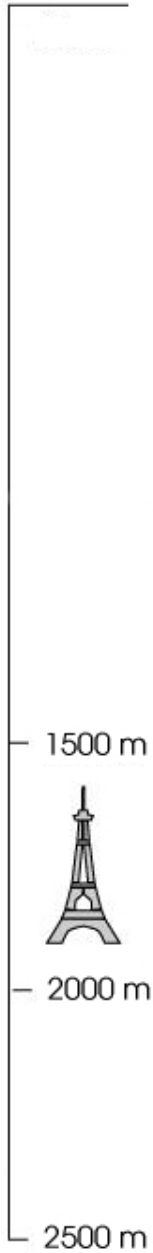
AMANDA-II

677 optical modules
at 19 strings



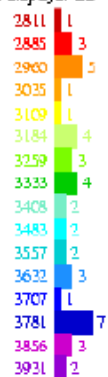
Installation
1996-2000

Depth



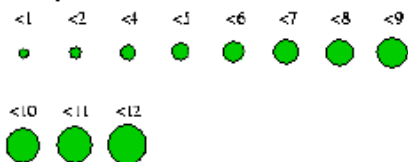
C. Sp
ESOI
Mun
July

Color displays: LE



Primary Channels

Size displays: ADC



Size scaling: Lin

No external geometry file is opened.

Detector: amanda-b-10, 10strings, 302 modules

Data file: /home/itsboada/ana_events/strick19.fzk

File contains 19 events.

Displaying data event 1197960 from run 0

Recorded y/yd: 1997/285

18132.0091381 seconds past midnight.

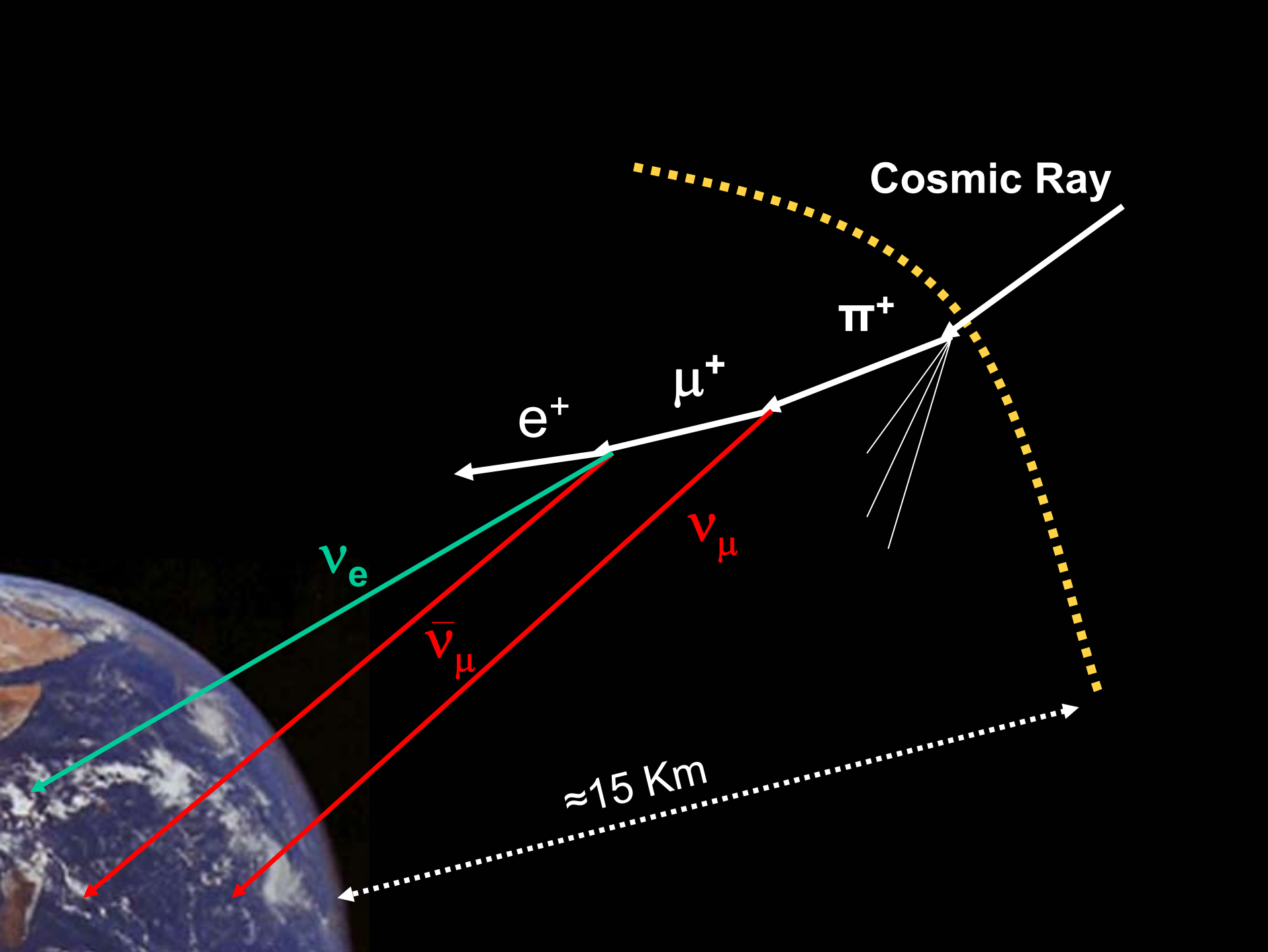
Before cuts: 44 hits, 44 OMs

After cuts: 44 hits, 44 OMs

Antineutrino

	x	y	z
Vertex pos :	12.4	-16.1	6.8 m
Direction :	0.03970	0.41614	0.90844
Length :	Inf m		
Energy :	? GeV		
Time :	3205.100000 ns		
Zenith :	155.3°		
Azimuth :	264.6°		





Cosmic Ray

π^+

e^+

μ^+

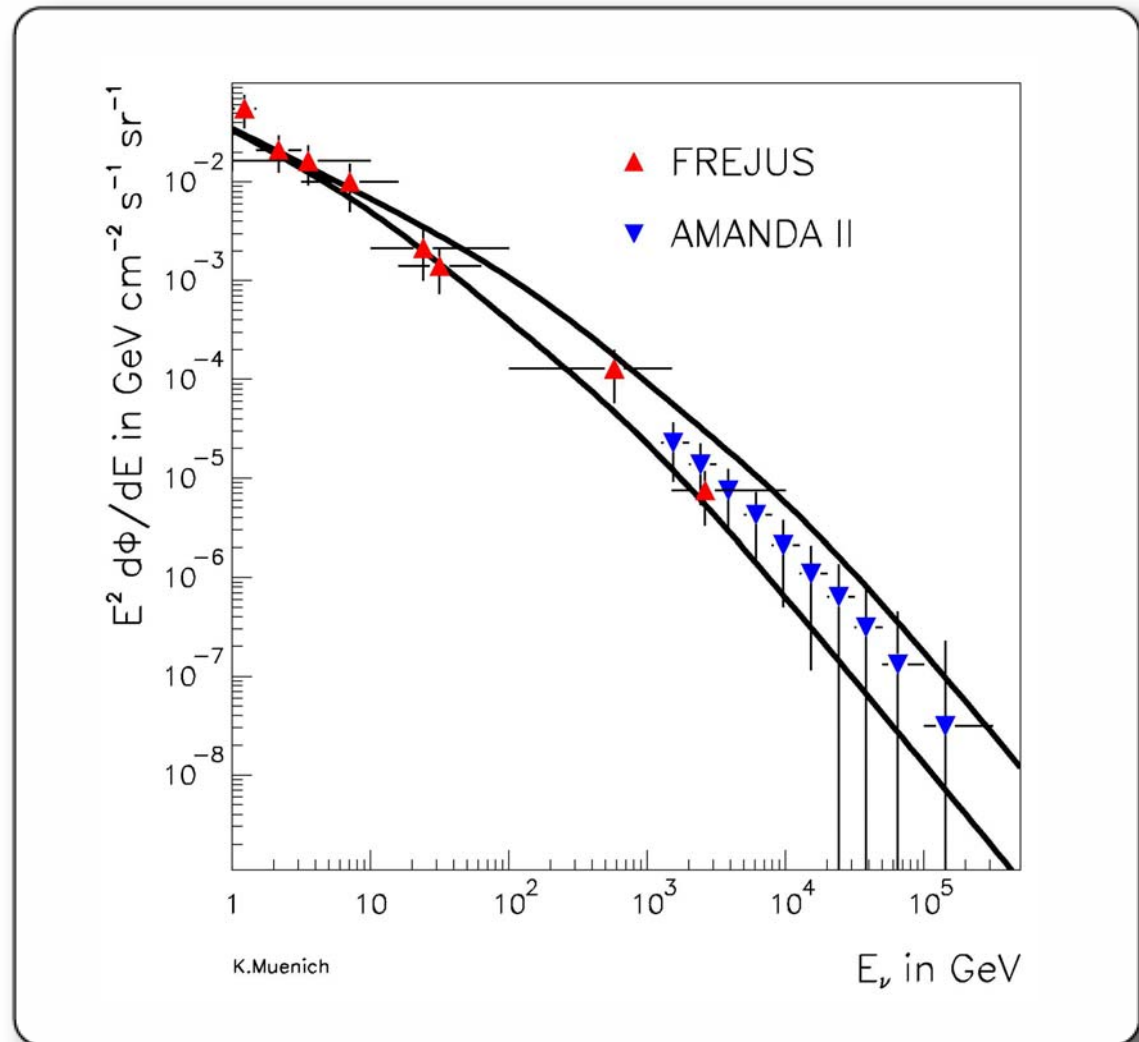
ν_e

ν_μ

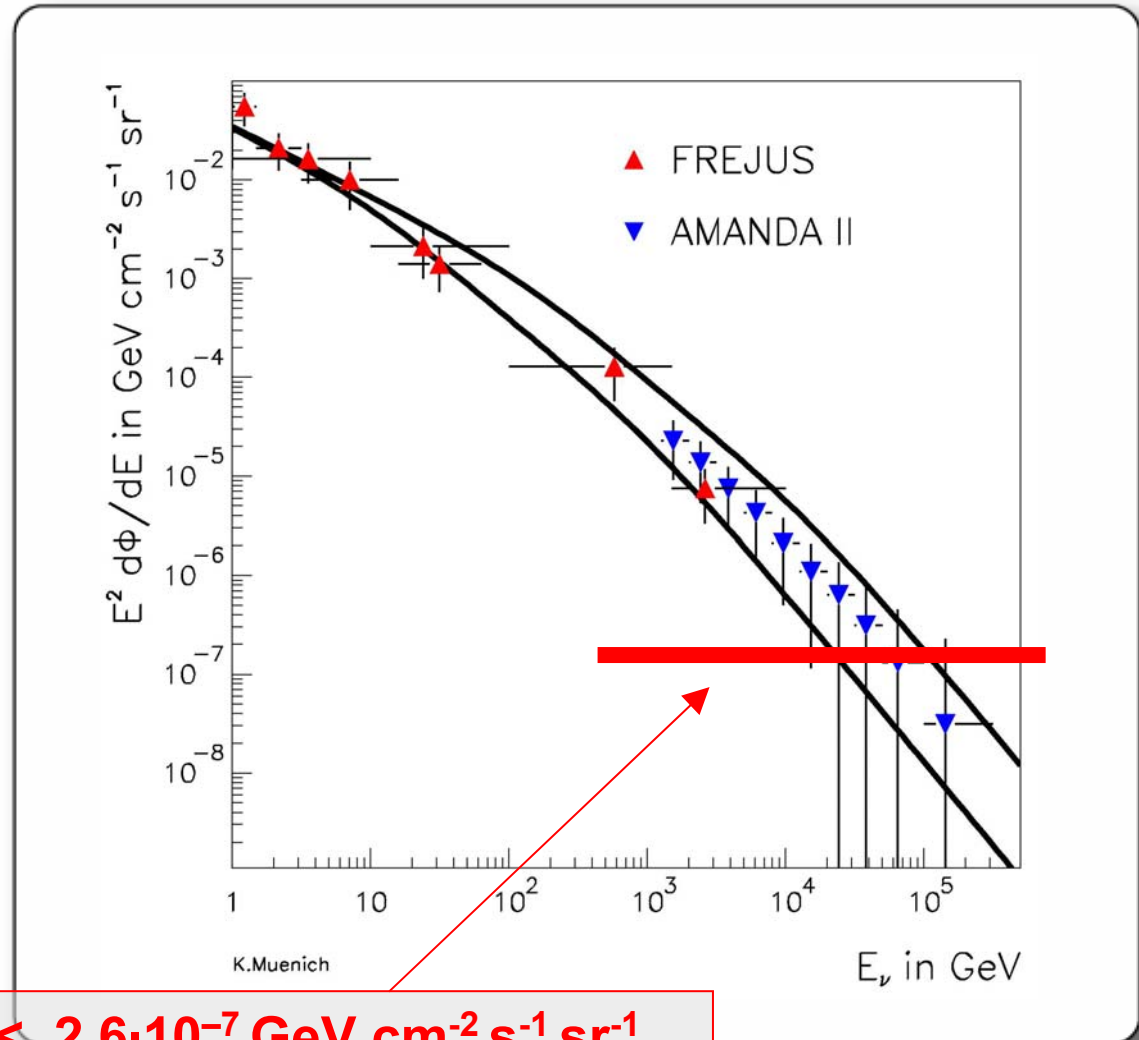
$\bar{\nu}_\mu$

≈ 15 Km

Energy spectrum of first 700 neutrinos detected by AMANDA

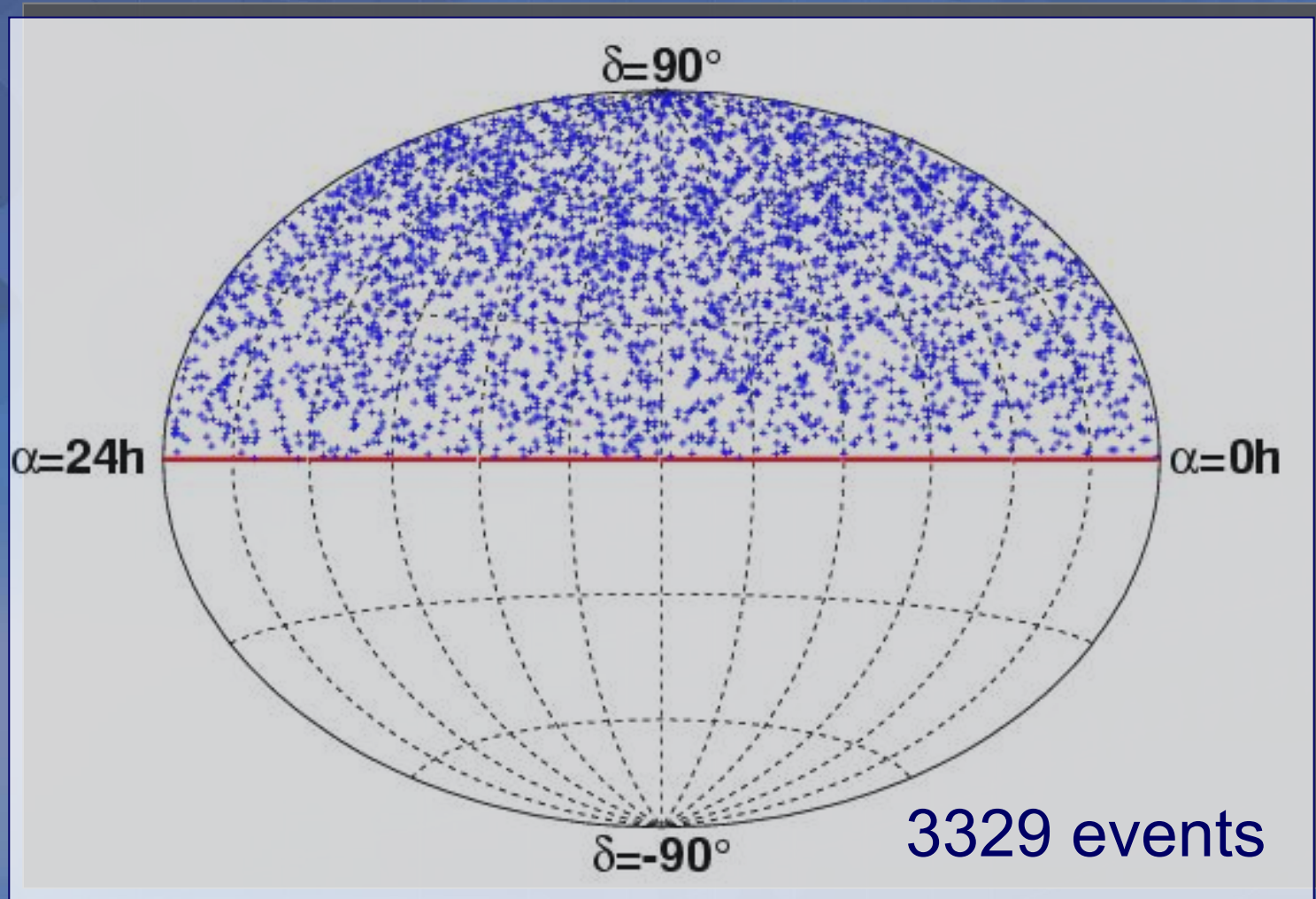


A Limit on the Extraterrestrial Flux (assuming E^{-2} shape)



AMANDA Sky 2000-03

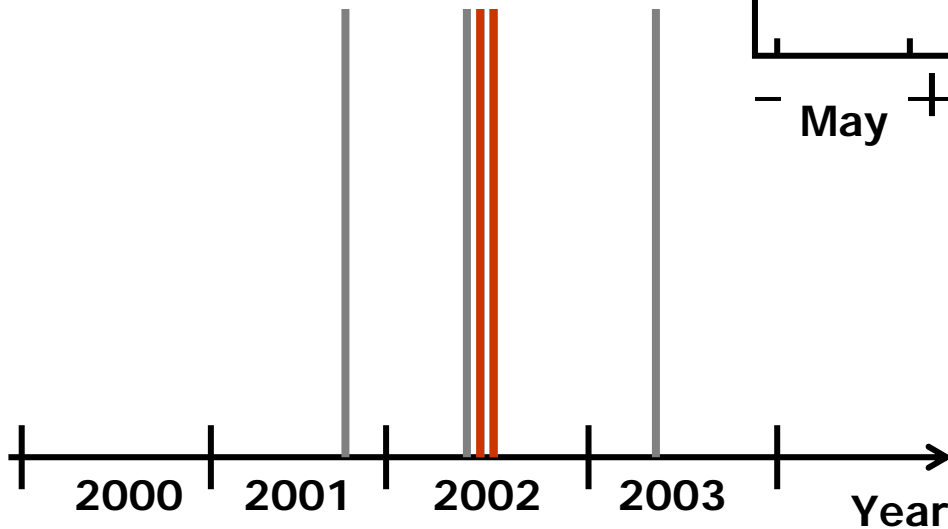
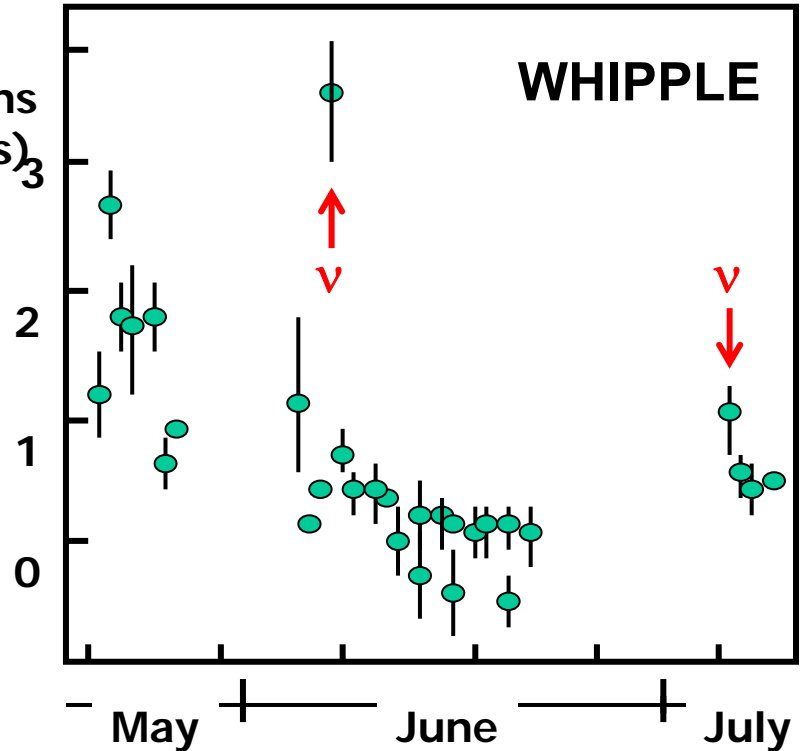
equatorial coordinates

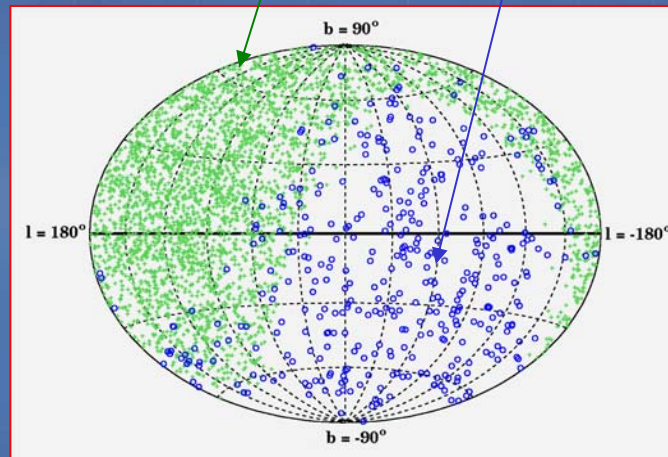
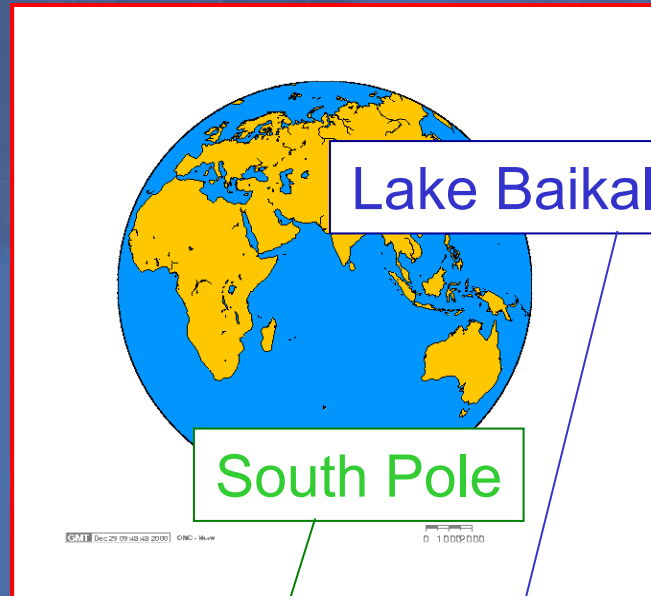


A Curious Coincidence

Arrival time of
neutrinos from the
direction of the
AGN ES1959+650

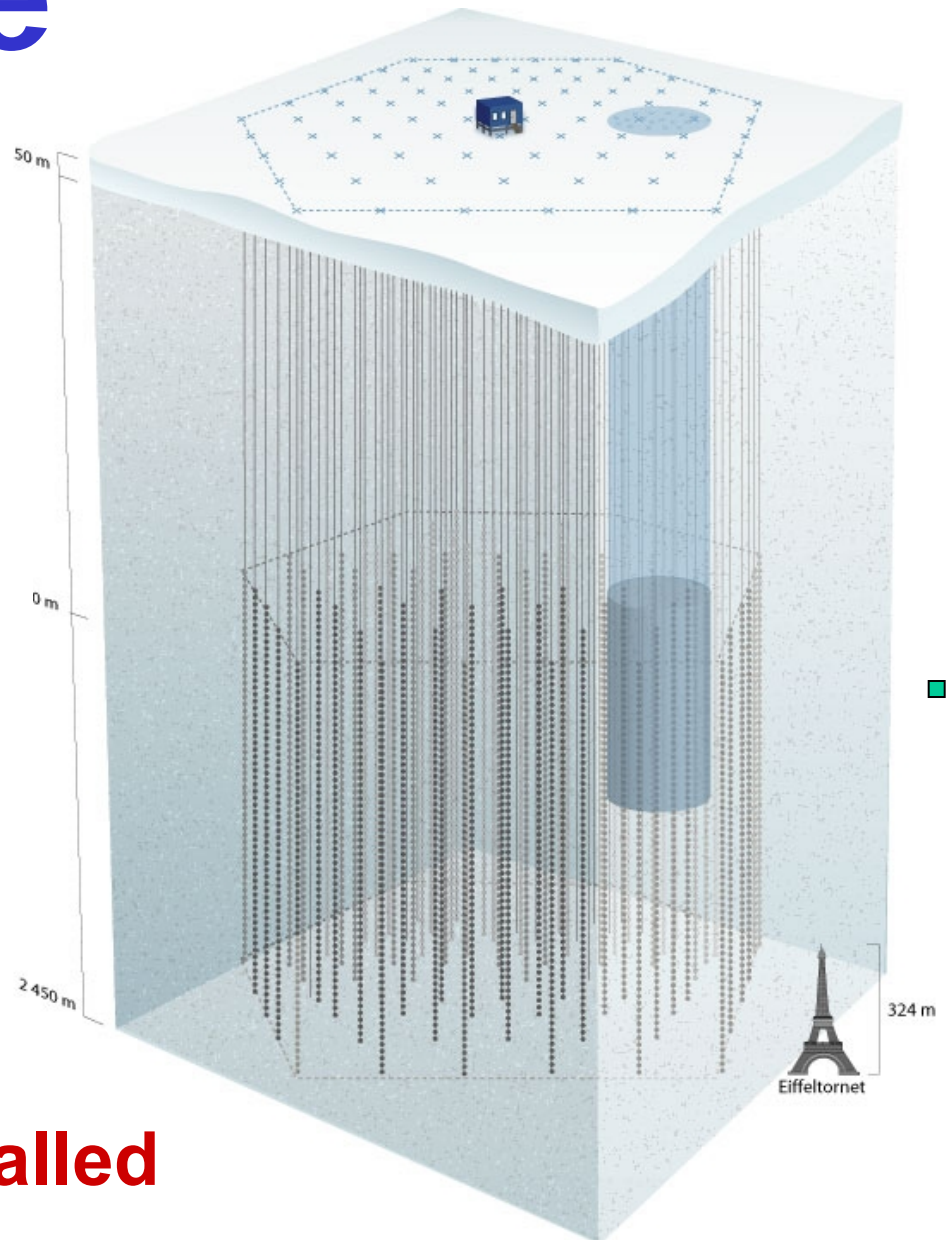
Flux of
TeV photons
(arb. units)





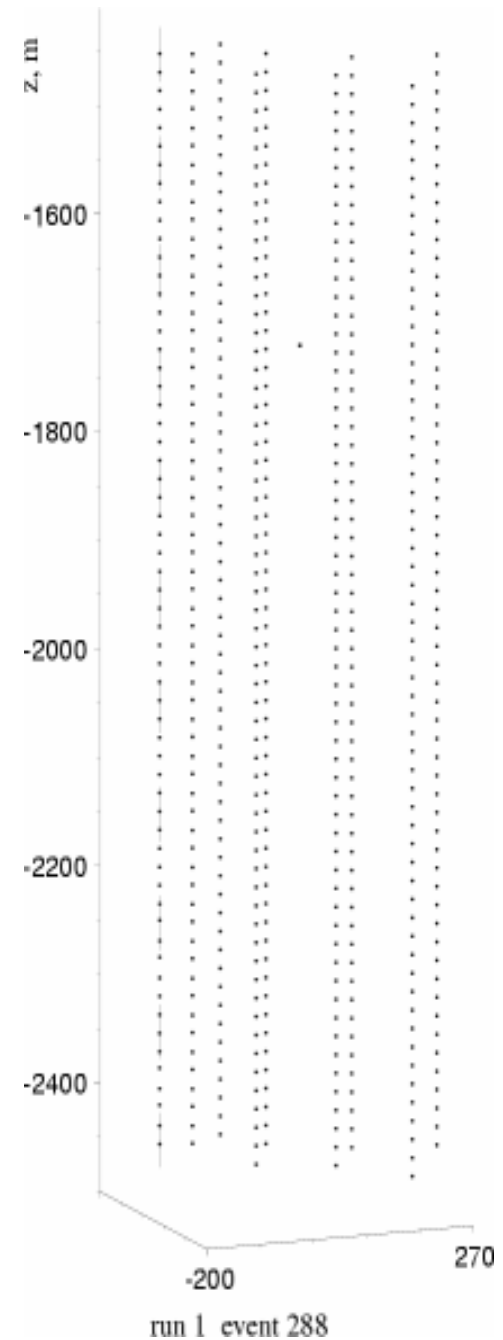
IceCube

- 80 Strings
- 4800 PMTs
- Instrumented
Volume: 1 km^3
- Installation:
2005-2011

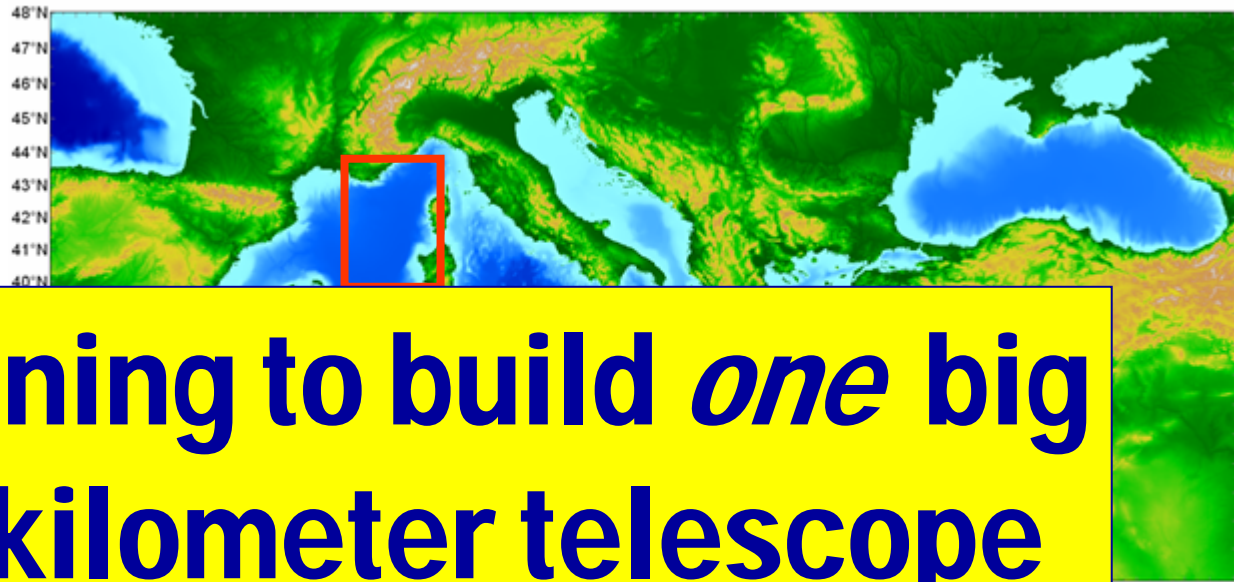


9 strings installed

One of the first Neutrino candidates seen with the nine deployed IceCube strings

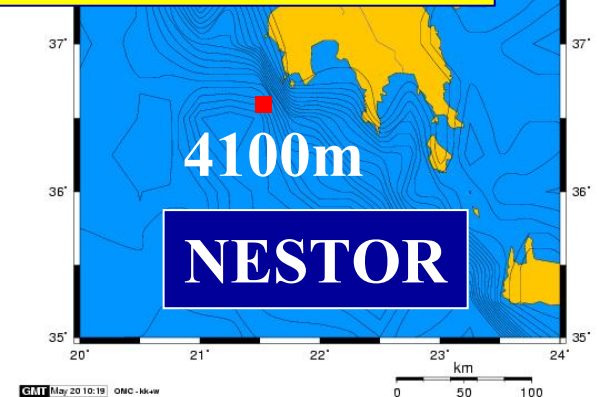
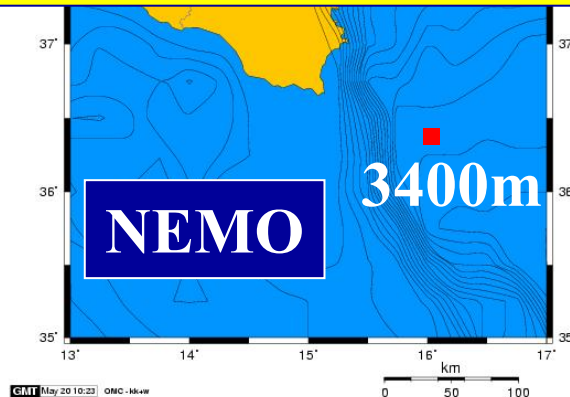
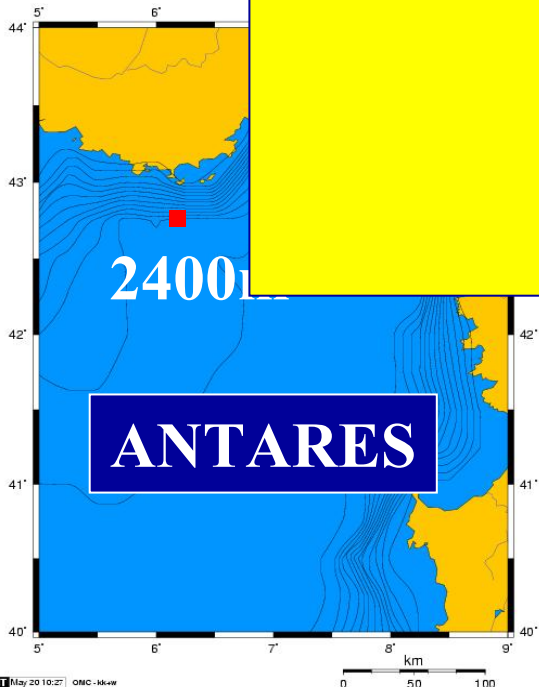


Under construction:
Telescope
Mediterranean



Are joining to build *one* big
cubic kilometer telescope

KM3NeT (2010-2014)



38°E 40°E 42°E

3900 m

24°

38°

37°

36°

35°

20°

21°

22°

23°

24°

37°

36°

35°

km

0 50 100

GMT May 20 10:27 OMC-kkww

GMT May 20 10:23 OMC-kkww

GMT May 20 10:19 OMC-kkww

GMT May 20 10:27 OMC-kkww

Charged Particles

at $> 10^{19}$ eV

around knee

γ

ν

Origin of Cosmic Rays

**Will the puzzle of
Cosmic Rays last for 100
years ?**

My guess:

NO

**We will solve it
before 2012!**