Fishing for Neutrinos

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Ellinogermaniki Agogi

The Nobel Prize in Physics 2015
Takaaki Kajita, Arthur B. McDonald

The Nobel Prize in Physics 2015

Photo © Takaaki Kajita

Takaaki Kajita

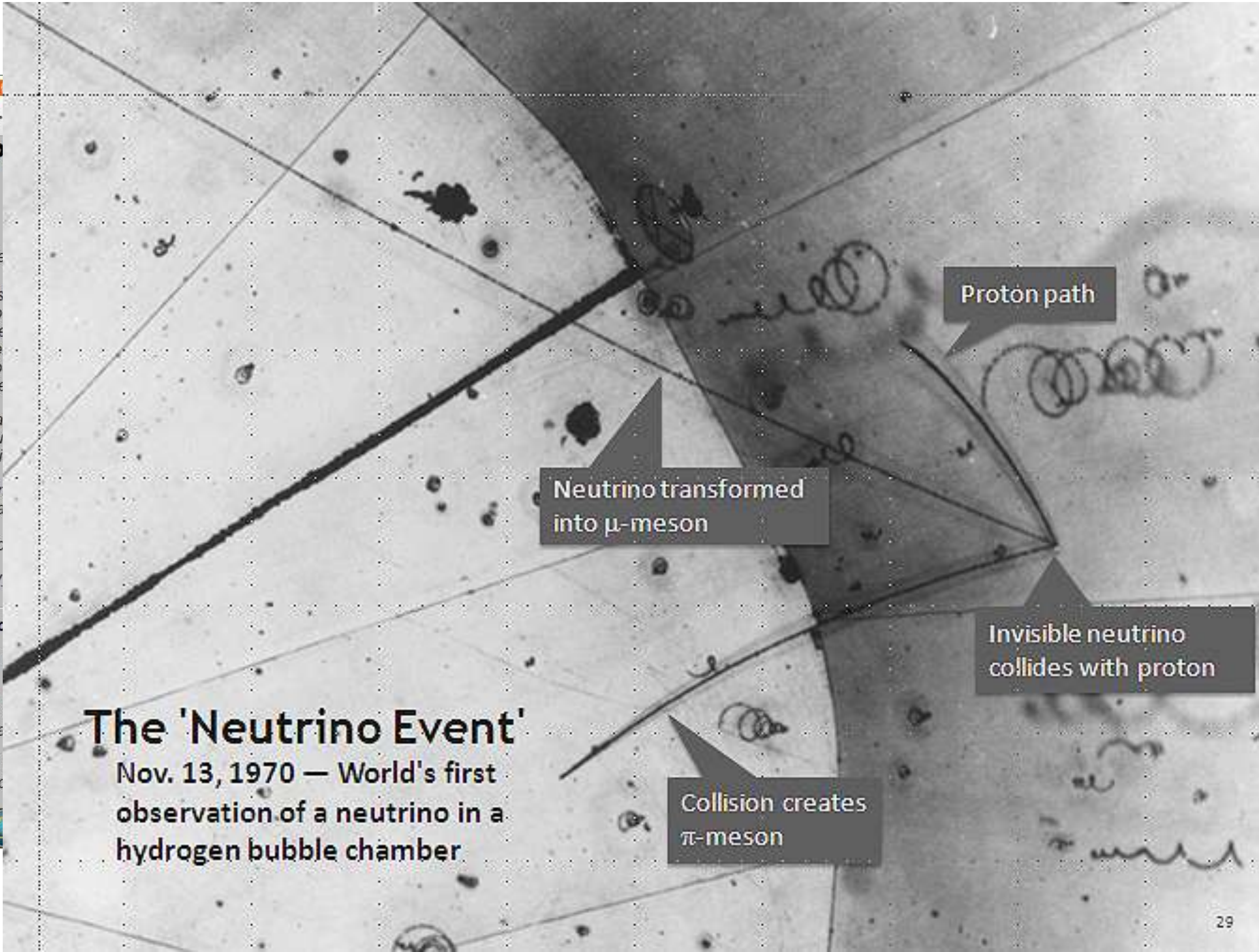
Prize share: 1/2

Photo: K. MacFarlane. Queen's University /SNOLAB

Arthur B. McDonald

Prize share: 1/2

The Nobel Prize in Physics 2015 was awarded jointly to Takaaki Kajita and Arthur B. McDonald *"for the discovery of neutrino oscillations, which shows that neutrinos have mass"*

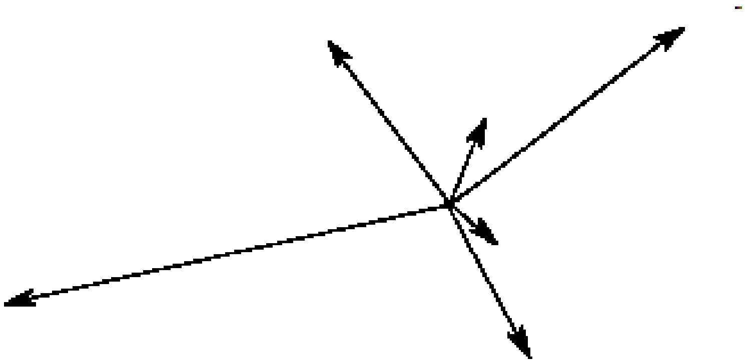


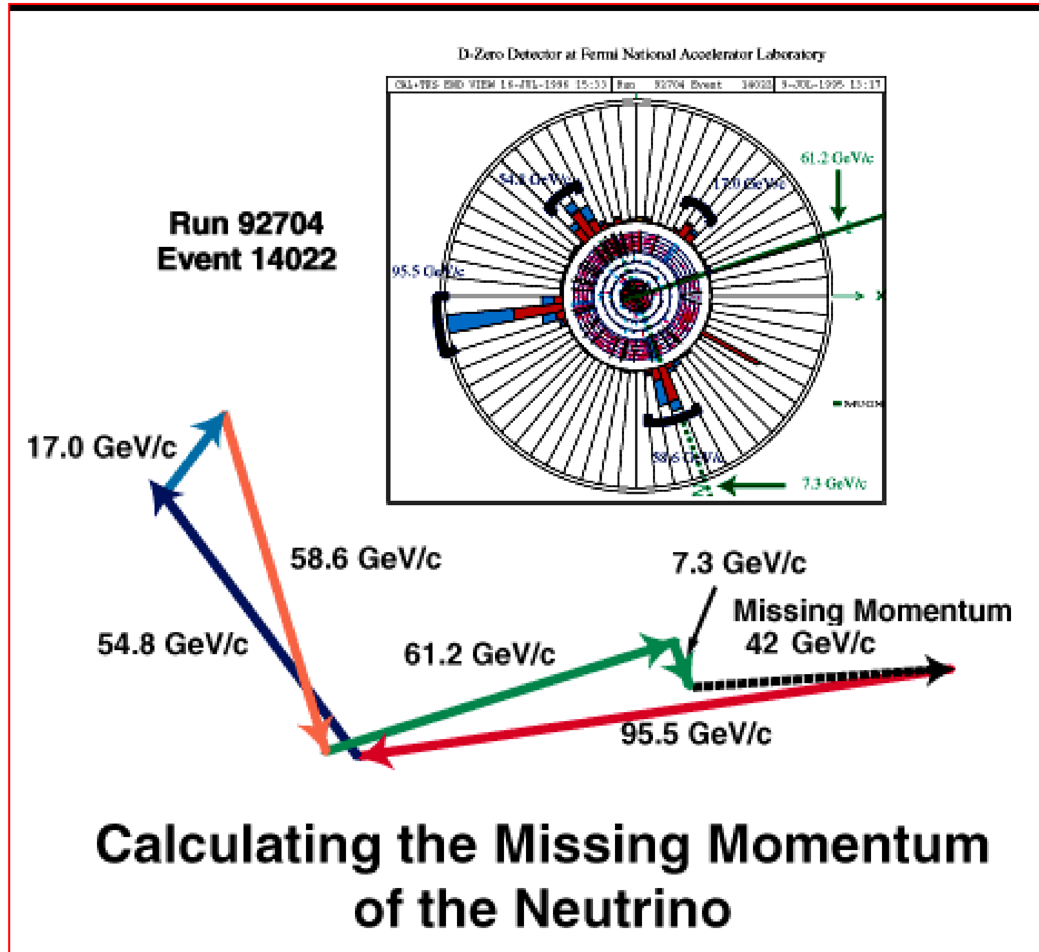
The 'Neutrino Event'

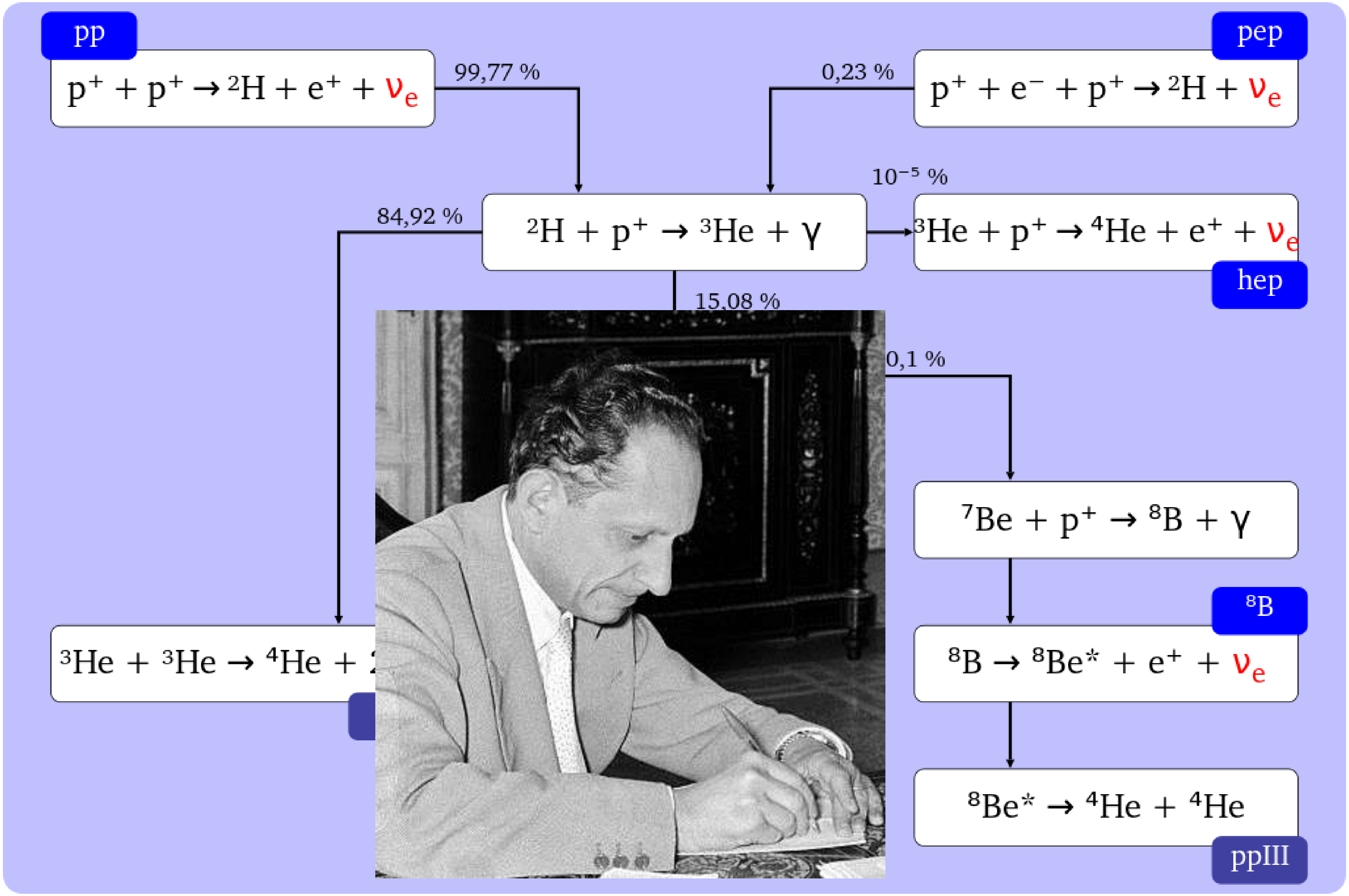
Nov. 13, 1970 — World's first observation of a neutrino in a hydrogen bubble chamber

An educational scenario for the appearance of neutrinos at CERN collisions

Momentum Vectors





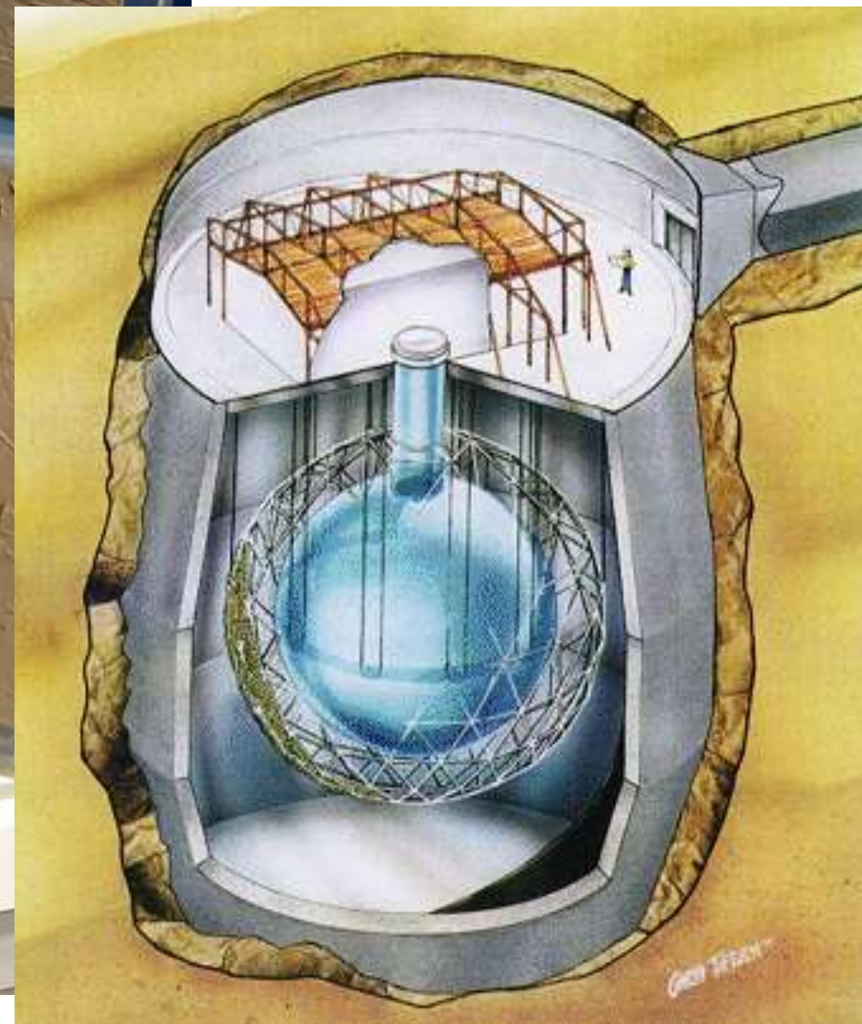

pp
$p^+ + p^+ \rightarrow {}^2H + e^+ + \nu_e$
99,77 %
0,23 %
pep
$p^+ + e^- + p^+ \rightarrow {}^2H + \nu_e$
10^{-5} %
84,92 %
${}^2H + p^+ \rightarrow {}^3He + \gamma$
${}^3He + p^+ \rightarrow {}^4He + e^+ + \nu_e$
hep
15,08 %
0,1 %
${}^7Be + p^+ \rightarrow {}^8B + \gamma$
${}^8B$
${}^8B \rightarrow {}^8Be^* + e^+ + \nu_e$
${}^8Be^* \rightarrow {}^4He + {}^4He$
ppIII
${}^3He + {}^3He \rightarrow {}^4He +$

$$|\nu_e >= U_{e1}|\nu_1 > +U_{e2}|\nu_2 > +U_{e3}|\nu_3 >$$

$$P(\nu_x \to \nu_y) = sin^2(2\theta) sin^2(1.27\Delta m^2 \frac{L(km)}{E(GeV)})$$

Neutrino-image of the Sun
Nobel Prize in Physics 2002
(Ravis and Koshiba)


東京大学宇宙線研究所

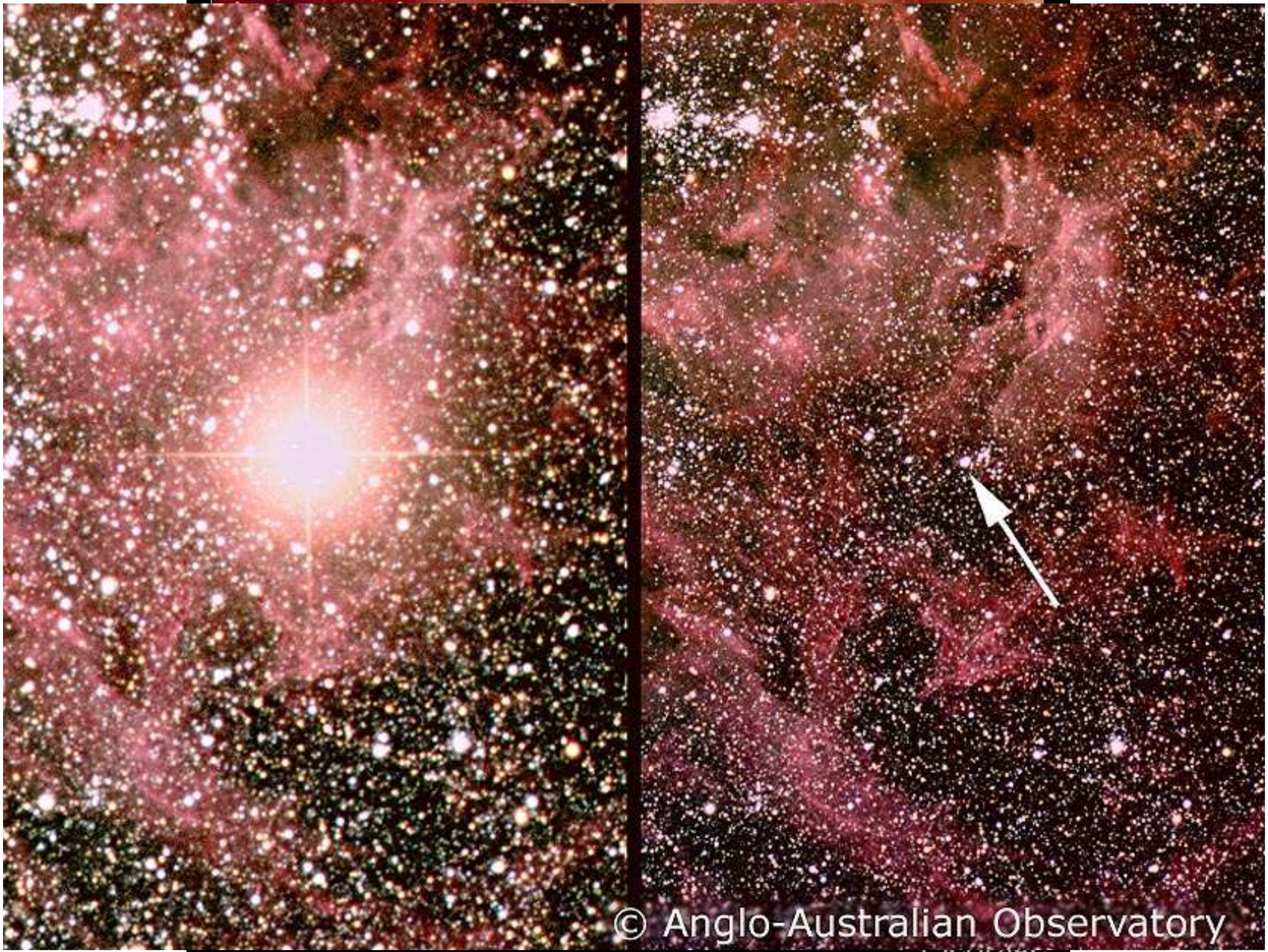


The birth of Neutrino Astronomy

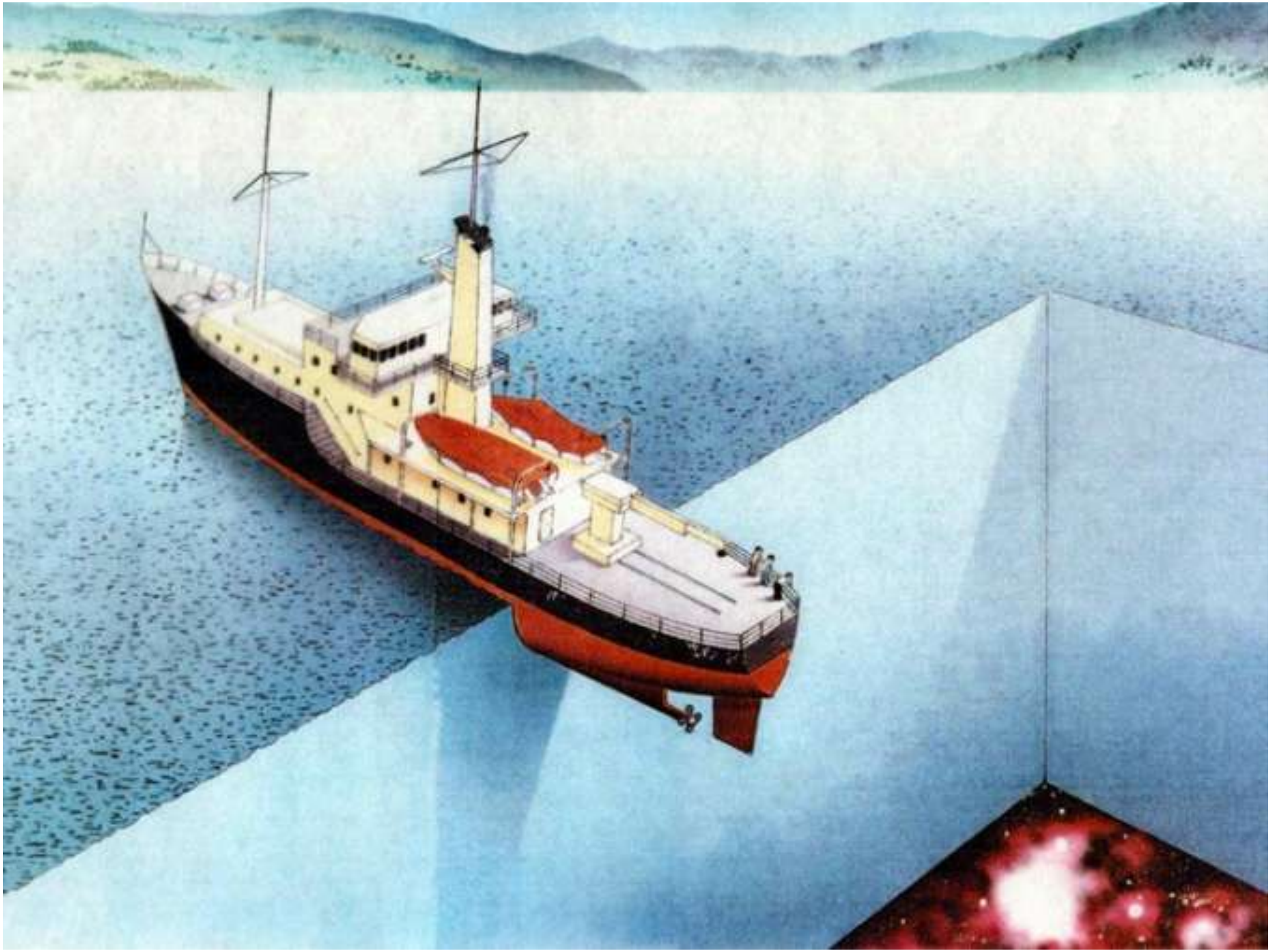
SN 1987A was a type II supernova in the Large Magellanic Cloud, a dwarf galaxy satellite of the Milky Way. It occurred approximately 51.4 kiloparsecs (168,000 light-years) from Earth and was the closest observed supernova since Kepler's Supernova. 1987A's light reached Earth on February 23, 1987, and as the earliest supernova discovered that year, was labeled "1987A". Its brightness peaked in May, with an apparent magnitude of about 3. Approximately two hours before the visible light from SN 1987A reached Earth, a burst of neutrinos was observed. This was likely due to neutrino emission, which occurs simultaneously with core collapse, but before visible light was emitted. Visible light is transmitted only after the shock wave reaches the stellar surface. At 07:35 UT, Kamiokande II detected 12 antineutrinos; IMB, 8 antineutrinos; and Baksan, 5 antineutrinos; in a burst lasting less than 13 seconds

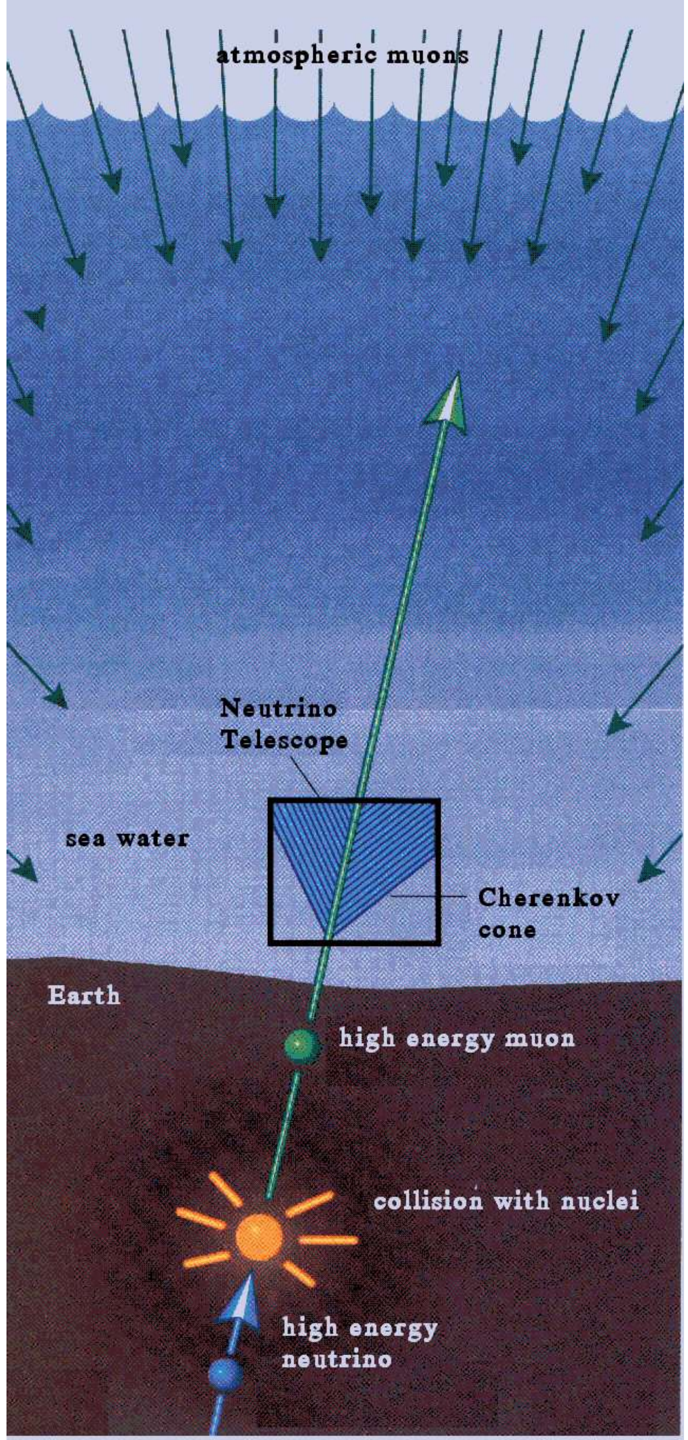
10^{58} neutrinos were produced with average energy of 10-15MeV.

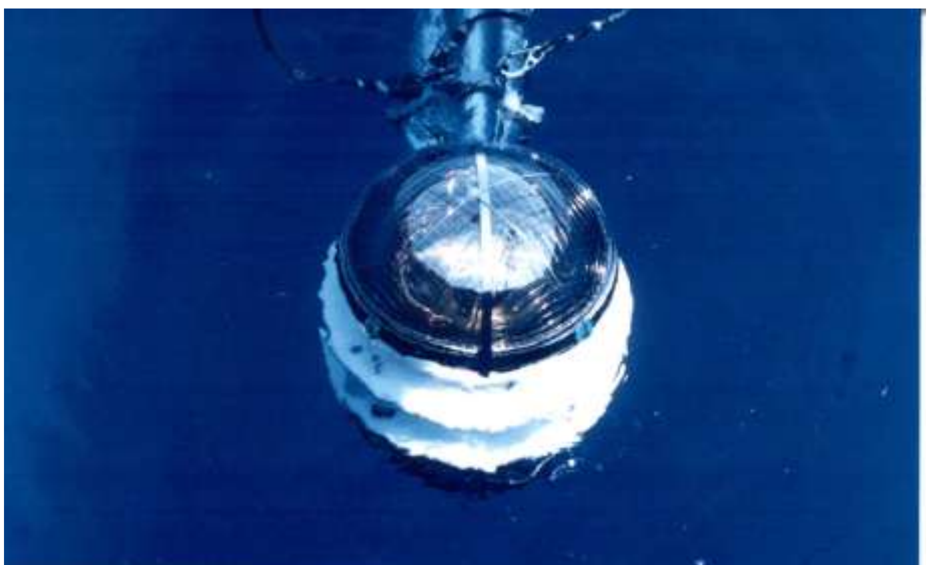
Supernova 1987A

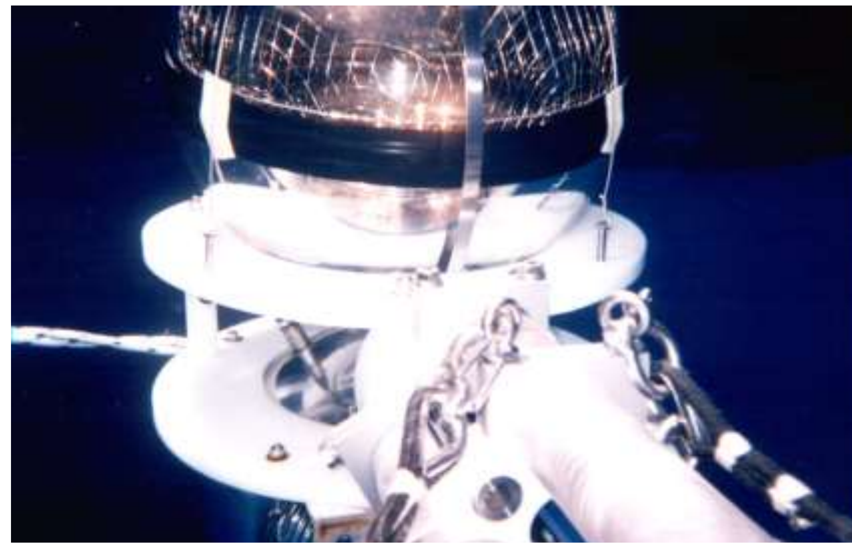


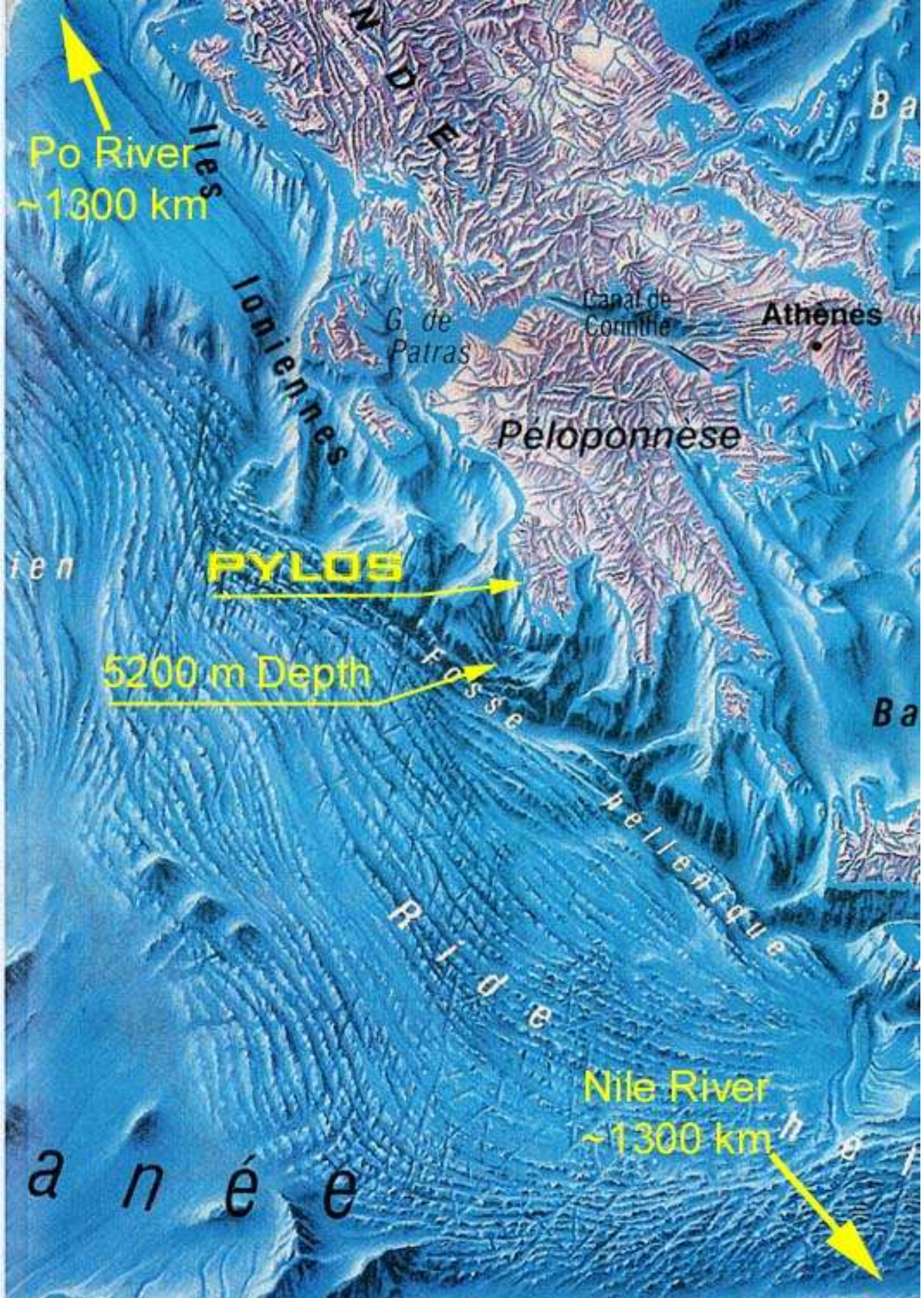
PRC99-04 • Space Telescope Science Institute • Hubble Heritage Team (AURA/STScI/NASA)



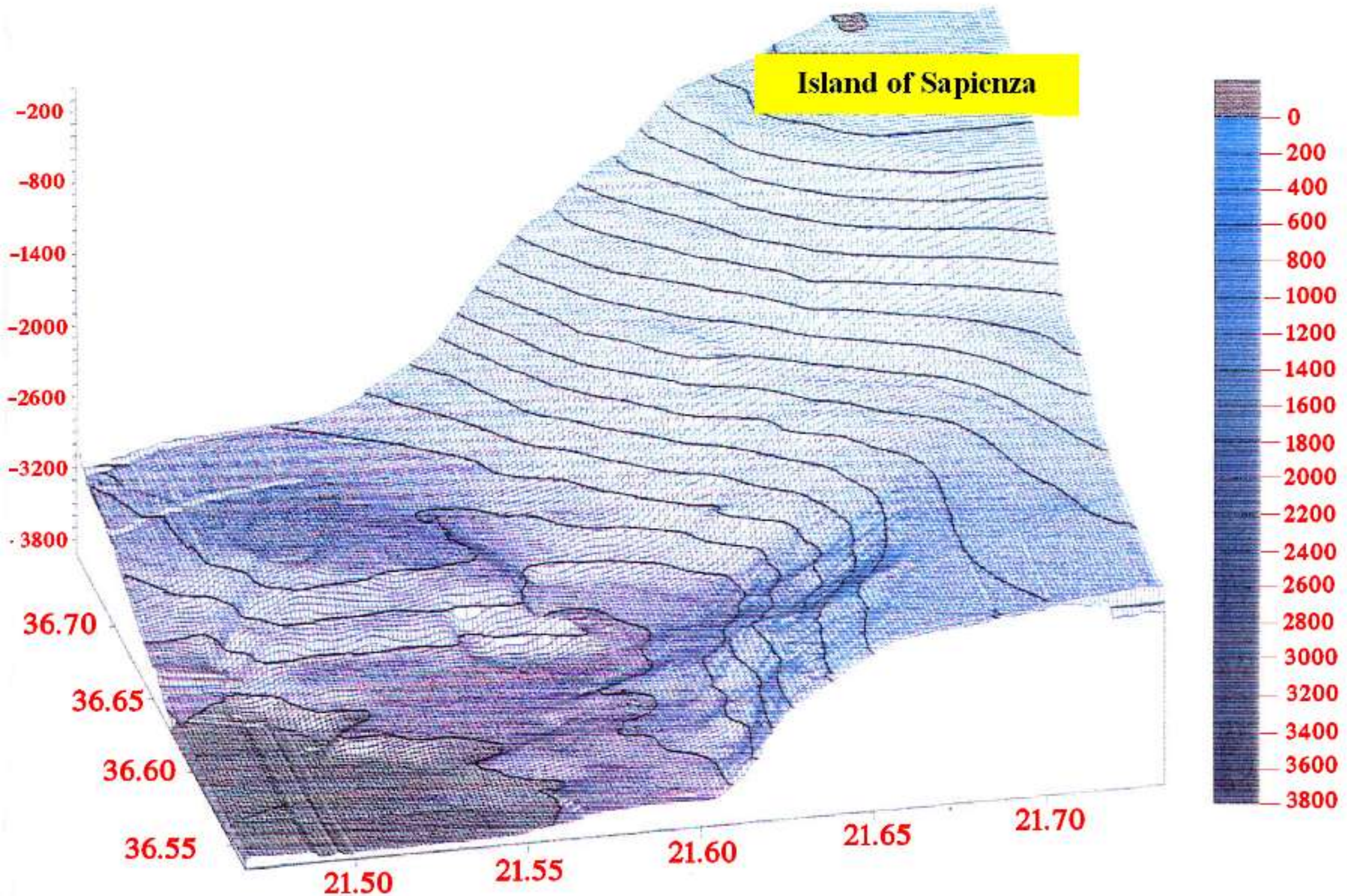

atmospheric muons
Neutrino
Telescope
sea water
Cherenkov
cone
Earth
high energy muon
collision with nuclei
high energy
neutrino

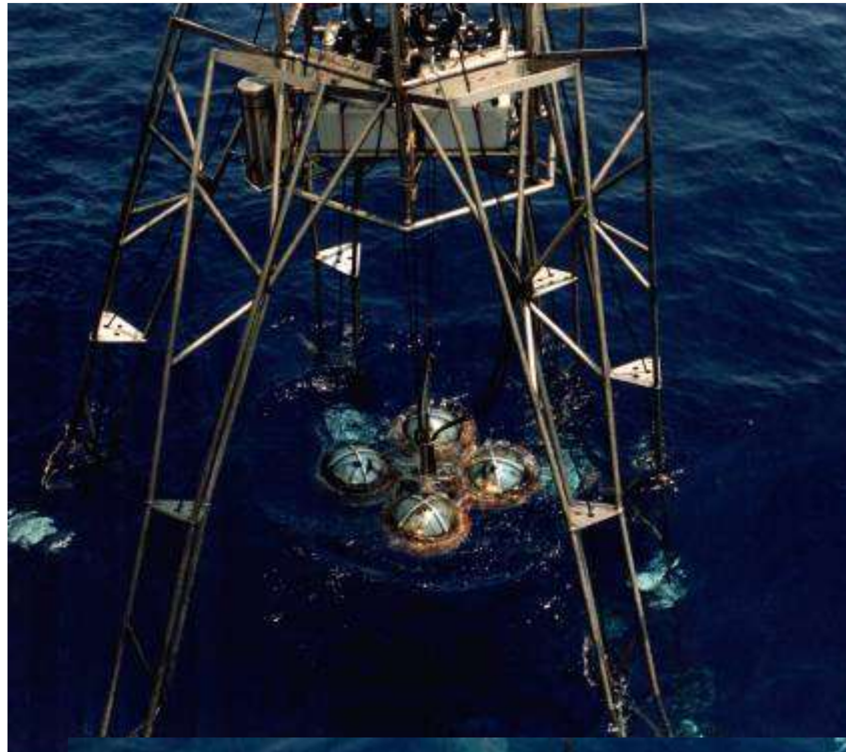
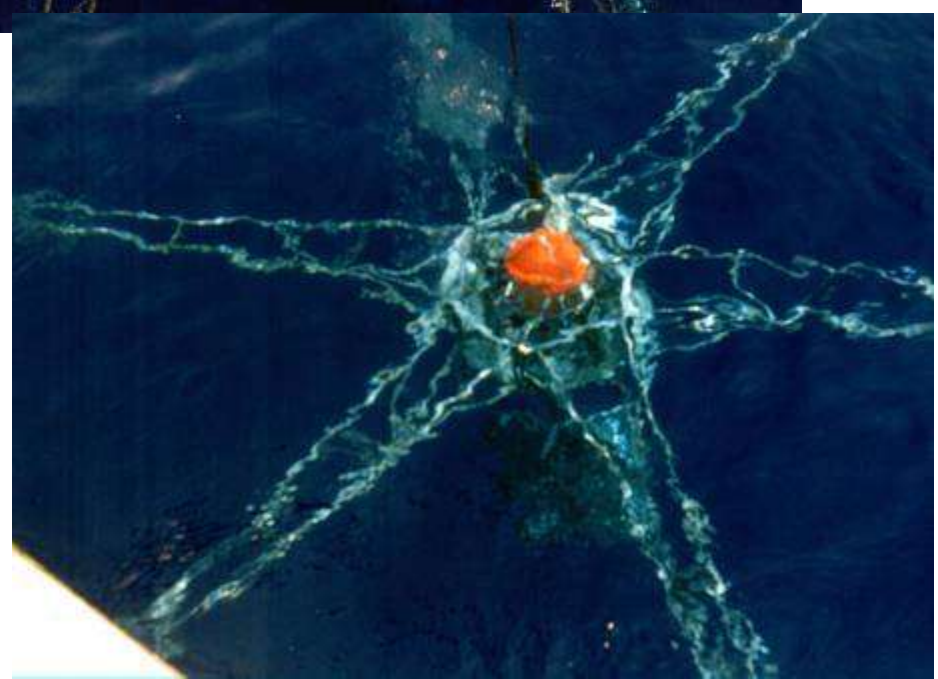


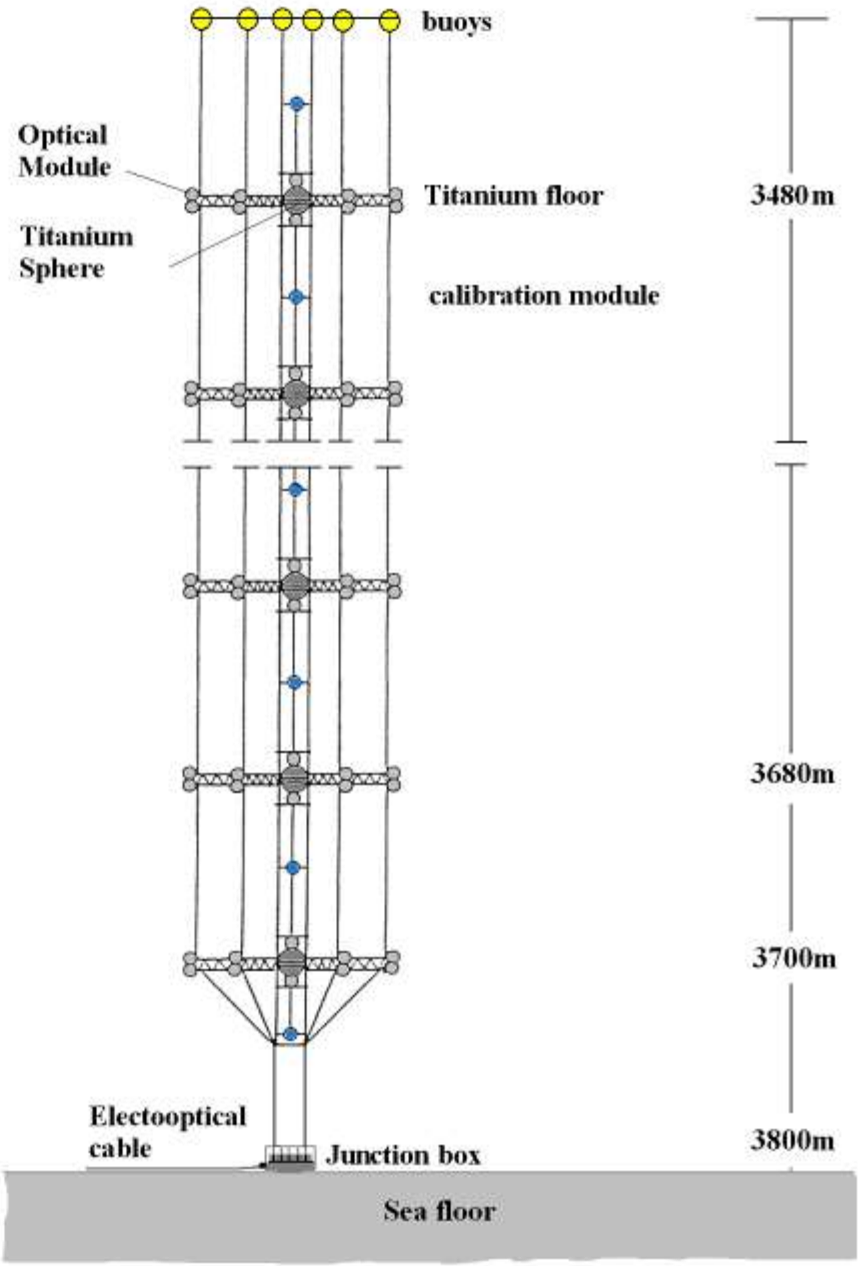


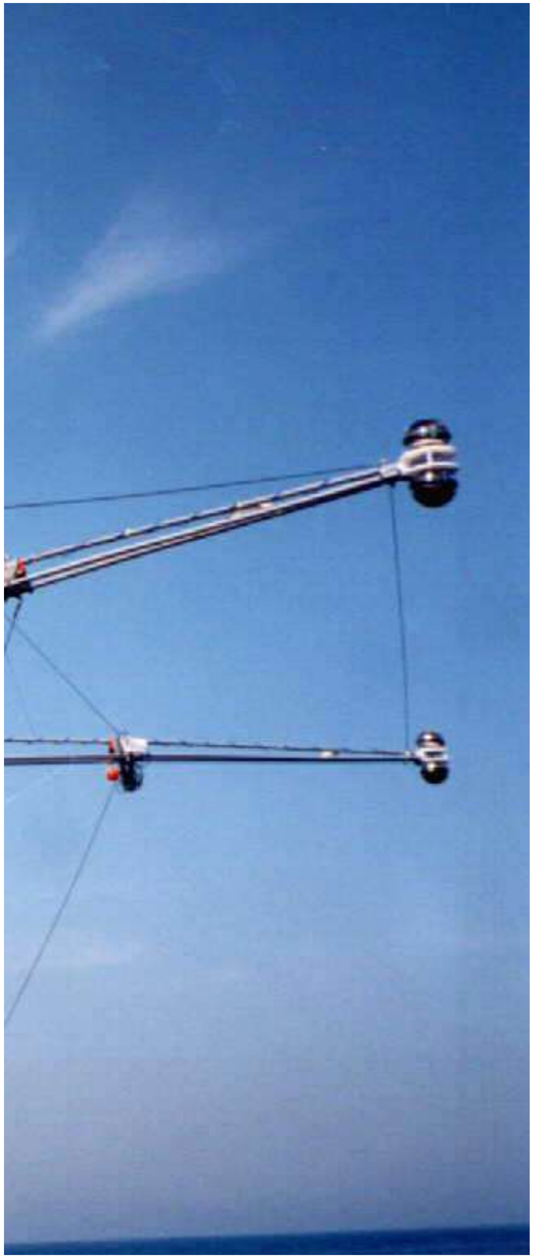


Po River
~1300 km
Iles
Ioniennes
G. de
Patras
Canal de
Corinthe
Athènes
Péloponnèse
PYLOS
5200 m Depth
Fosse hellénique
Ride
Nile River
~1300 km
anée


Island of Sapienza
-200
-800
-1400
-2000
-2600
-3200
3800
36.70
36.65
36.60
36.55
21.50
21.55
21.60
21.65
21.70
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800

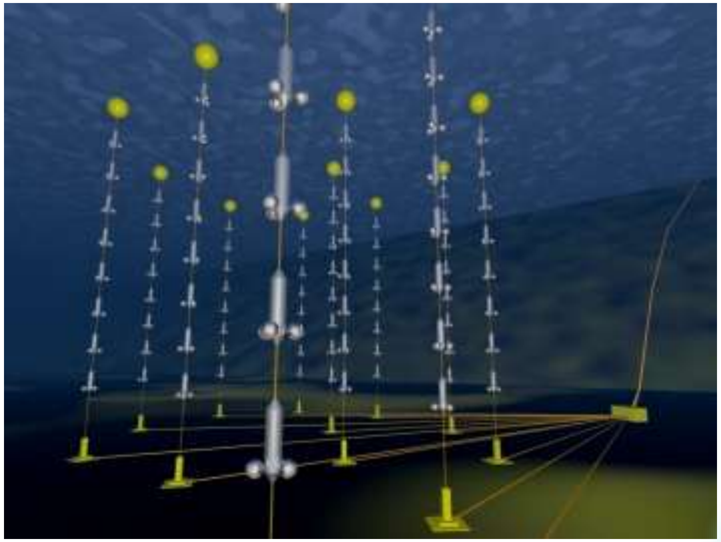

buoys
Optical
Module
Titanium floor
3480m
Titanium
Sphere
calibration module
3680m
3700m
Electooptical
cable
Junction box
3800m
Sea floor

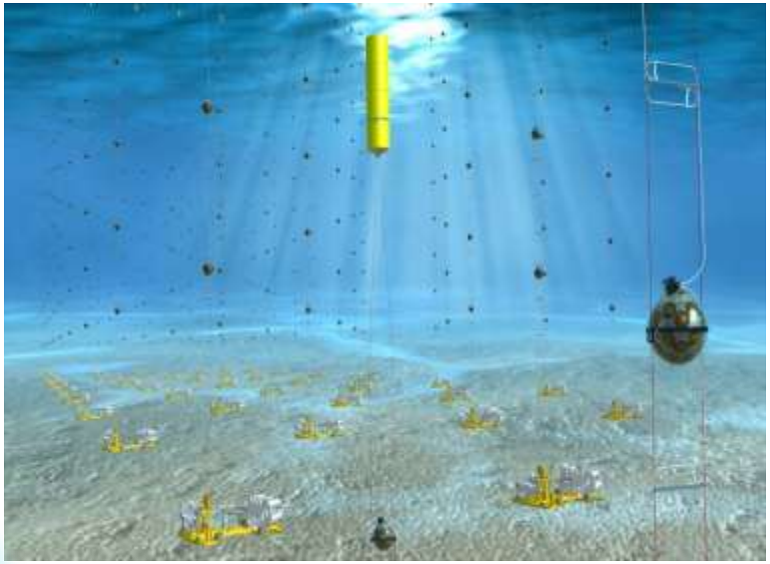


ANTARES->KM3NeT

12 lines, 900 OMs

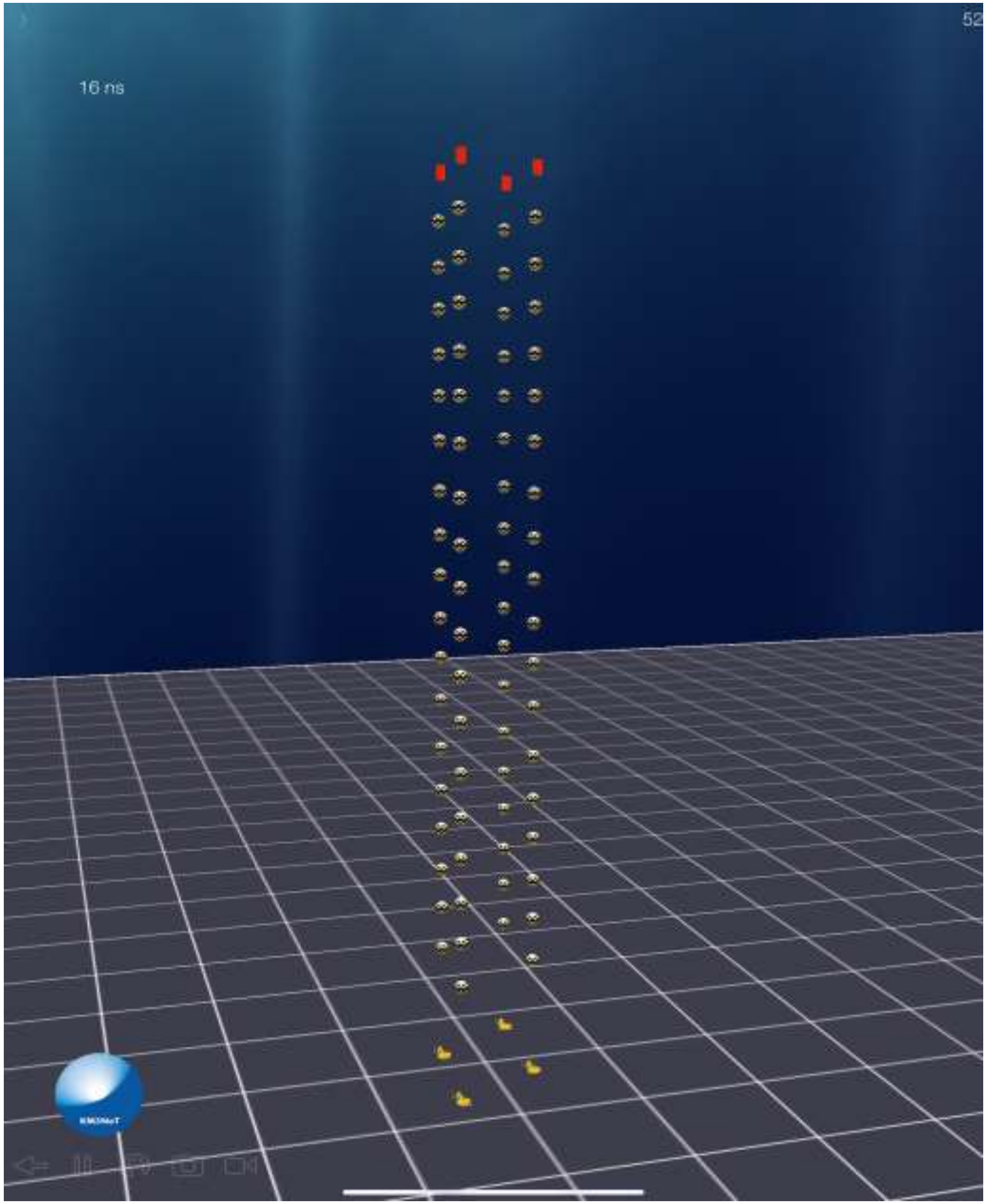
3 Building Blocks (3*115 lines, ~3*2000 OMs)



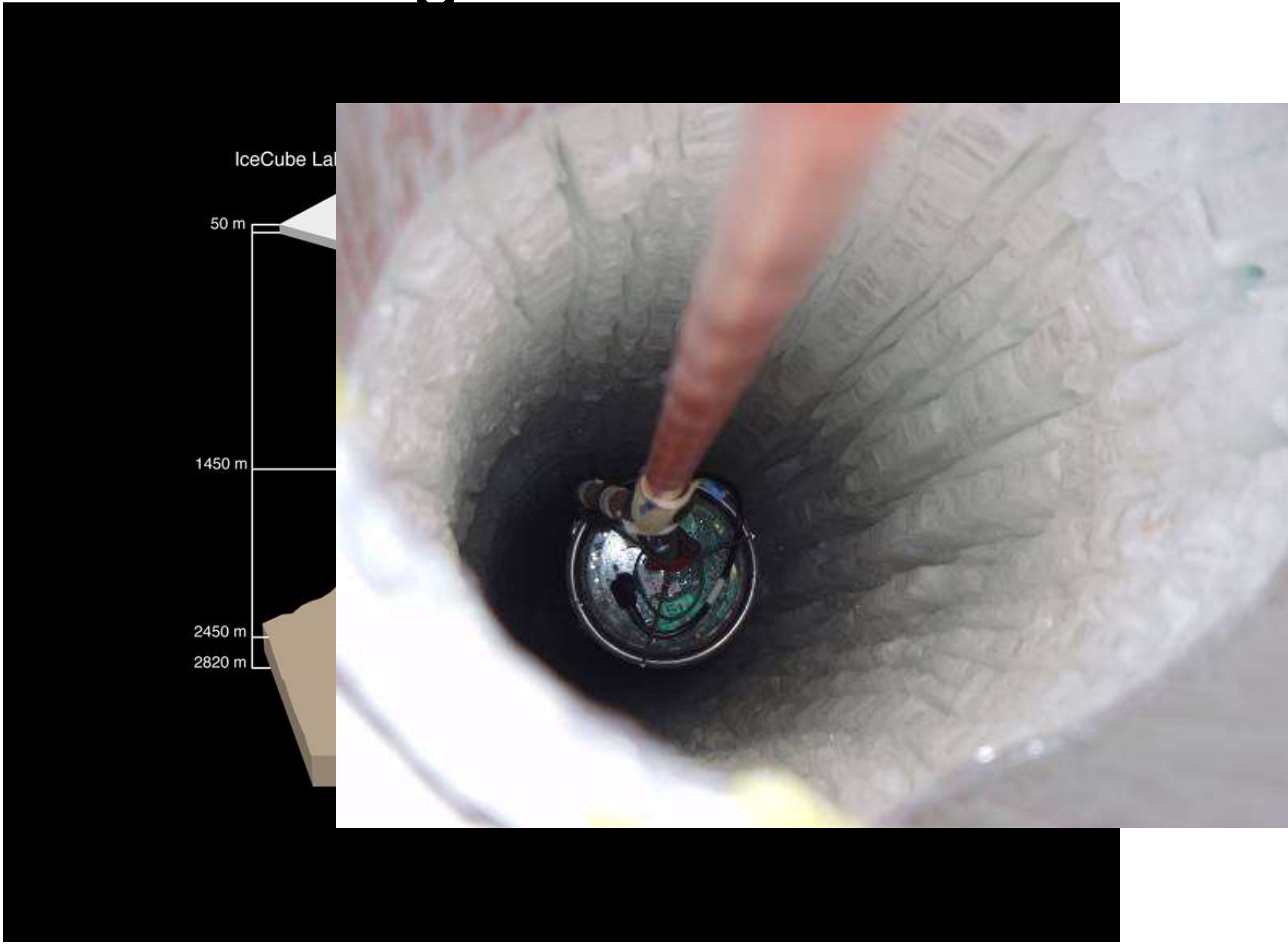


- 31 x 3" PMTs
- Uniform angular coverage
- Directional information
- Digital photon counting
- Reduced ageing
- All data to shore

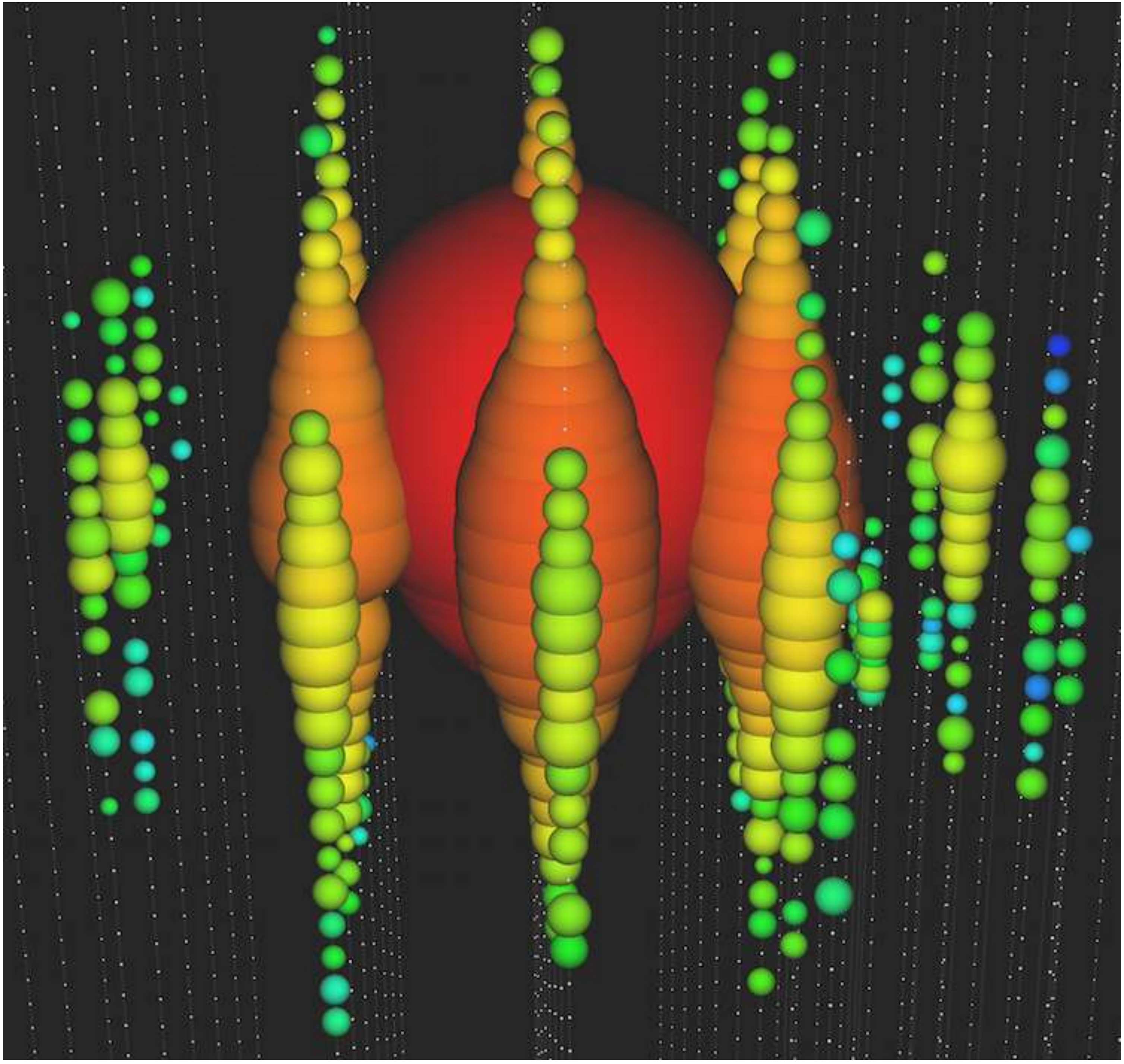
ORCA4 first events

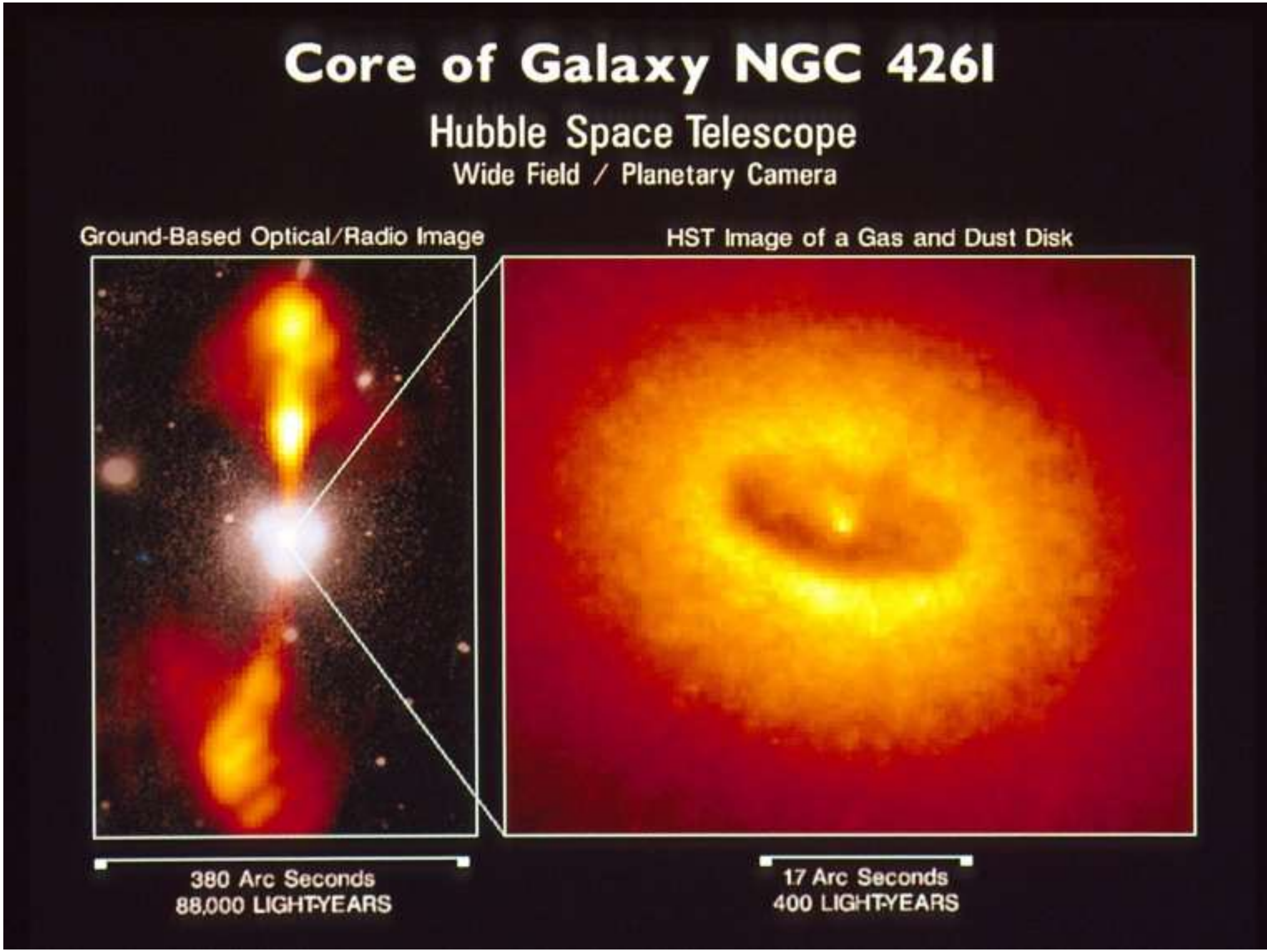


Ice-Fishing for Neutrinos




South Pole




Core of Galaxy NGC 4261
Hubble Space Telescope
Wide Field / Planetary Camera
Ground-Based Optical/Radio Image
HST Image of a Gas and Dust Disk
380 Arc Seconds
88,000 LIGHT-YEARS
17 Arc Seconds
400 LIGHT-YEARS

e-EPS
Facts and info from the European Physical Society

Editorial — Bringing Nobel Prize physics to high schools

By Sofoklis Sotiriou, Published on 27 February 2014 in:
Editorial, February 2014, Education, European Science Education Academy, Nobel Prize, Open Discovery Space

Today much of the ethical and political decision-making involves some understanding of the nature of science, its strengths and limits. There is perhaps no better or more recent example of this need, than the debate that arose around the discovery of the Higgs Boson and the operation of LHC at CERN, which has sparked the imagination of authors of works of fiction, occasionally causing concern among the general public. To understand the role of science in deliberations about the projected outcomes of the experiments taking place in the LHC, their safety and value – given the immense investment in human and other resources involved – all students, including future scientists need to be educated to be critical consumers of scientific knowledge.

We need to enrich our school curricula with activities that improved both students and teachers ability to engage with such debates, since they not only impart a knowledge of the content, but also a knowledge of 'how science works', "an element which should be an essential component of any school science curriculum"[1]. We need to design activities that heavily encourage critical and creative ways of thinking and enhance young people's critical attitudes to science and its experiments. When students get involved in such activities they appreciate the challenges and limitations of an experiment or observation and as a result develop a better understanding of the nature of scientific knowledge.

There are a series of initiatives that are trying to bring Nobel Prize winning Physics to school students. These initiatives promote science teaching and learning as a process of inquiry as well as technological thinking as a process of problem solving. They act as the window onto live scientific experiments and phenomena, on-going scientific research, and the personalities and stories of working scientists across Europe and beyond. For example, through advanced technical interfaces numerous students and teachers have the opportunity to access and use remotely robotic telescopes in real time, to discuss with researchers at South Pole, to perform experiments and to make observations, to analyse data from CERN detectors to discover Higgs boson and finally to develop and suggest solutions and provide answers to selected scientific topics. In doing so the we are promoting a reversal of school science teaching pedagogy from mainly deductive to inquiry-based methods, which is more likely to increase students' interest and attainment in science.

The European Physical Society aims to coordinate these unique initiatives and to develop a framework, through the European Science Education Academy, that will offer such opportunities to numerous schools in Europe.

On 23 January 2014 the Open Discovery Space project consortium that is working to introduce innovative practices in schools has organized a hangout between European and US schools and the control rooms of the IceCube Neutrino Observatory at the South Pole and of the CMS large CERN detector in Geneva. The aim of this event was to present to high school students the basic ideas between the efforts that are taking place in order the scientists to discover the origins of the universe, either looking for high energy neutrinos in the ice or by colliding high energy particles and study their interactions. The CERN education team, the IceCube outreach group and the Ellinogermaniki Agogi research group, are working together to bring Nobel Prize Winning Physics to schools all around the world.

Thank you!

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FRONTIERS