NEUTRINO TELESCOPES

The telscopes are instruments for looking at distant objects - parti-cularly at extra-terrestrial ones.

Galileo was the first man to use a telescope to study the sky (1610) he collected evidence that proved the earth revolves around the sun, and is not the center of the Universe as it was believed

The Observation and to "see"

Thomas Harriot:

The importance of the quality

resolution

From thousend of years the Universe has been studied by looking at the night sky guided by the visible light emitted from myriads of stars

During the last century new pictures of the night sky have been discovered using different wavelenghts of light such as radio waves - infrared light - x-rays and gamma-rays

Each time new windows in the sky are opened, new unespected phenomena have been discovered

NEUTRINO TELESCOPES

The field of ν astrophysics begun with the study of ν from the sun, which, as Pontecorvo said, "from the point of view of ν detection possibilities is an ideal object.

Neutrinos have a number of favorable proprierties that make them attractive as a means to study astrophysical objects, so that ν telescopes have a significant value for astrophysics

ν indeed can give information on otherwise inaccessible astrophysical regions or distant astrophysical sources.

NEUTRINOS

Pauli, Fermi (1930-1933)

Bethe and Peierls: m.f.p. for a low energy ν interaction : $\sim 10^{20}$ cm in H_2O

Pontecorvo (1946) suggests the N.T.!

$10^{20}\,\nu \rightarrow$ give an interaction in 1cm H_2O!

The sun: $4p \rightarrow He^4 + 2e^- + 2\nu$

shine $\downarrow$ $\sim 10^{11}\,\nu\ cm^{-2} s^{-1}$

Detect solar ν through reaction

$\nu + n \rightarrow p + e^-$

with $\nu + Cl^{37} \rightarrow A^{37} + e^-$

the final state is a radioactive nucleus

The induced radioactivity will measure the ν flux:

Davis: ~ 600 ton of C_2Cl_4 [$2 \cdot 10^{30}$ Cl atoms]

1 ev/day expected

Neutrino oscillations!

ν will take ~~to~~ the earth ~~ground~~ information about their production process in the center of sun
They reach the sun surface in 2 s and the earth in 8 m without interactions
The light ~~ing~~ takes 1 milion years to reach the sun surface!

Davis started his famous exp in the Homestake Gold Mine in 1966 about 10 years later the ν discovery in 1956 (Reines and Cowan).

The next detection of solar ν was made from 1988 with KamioKande, a large water tank (3 Kton) surrounded by phototubes, where particles were detected via their Cerenkov light

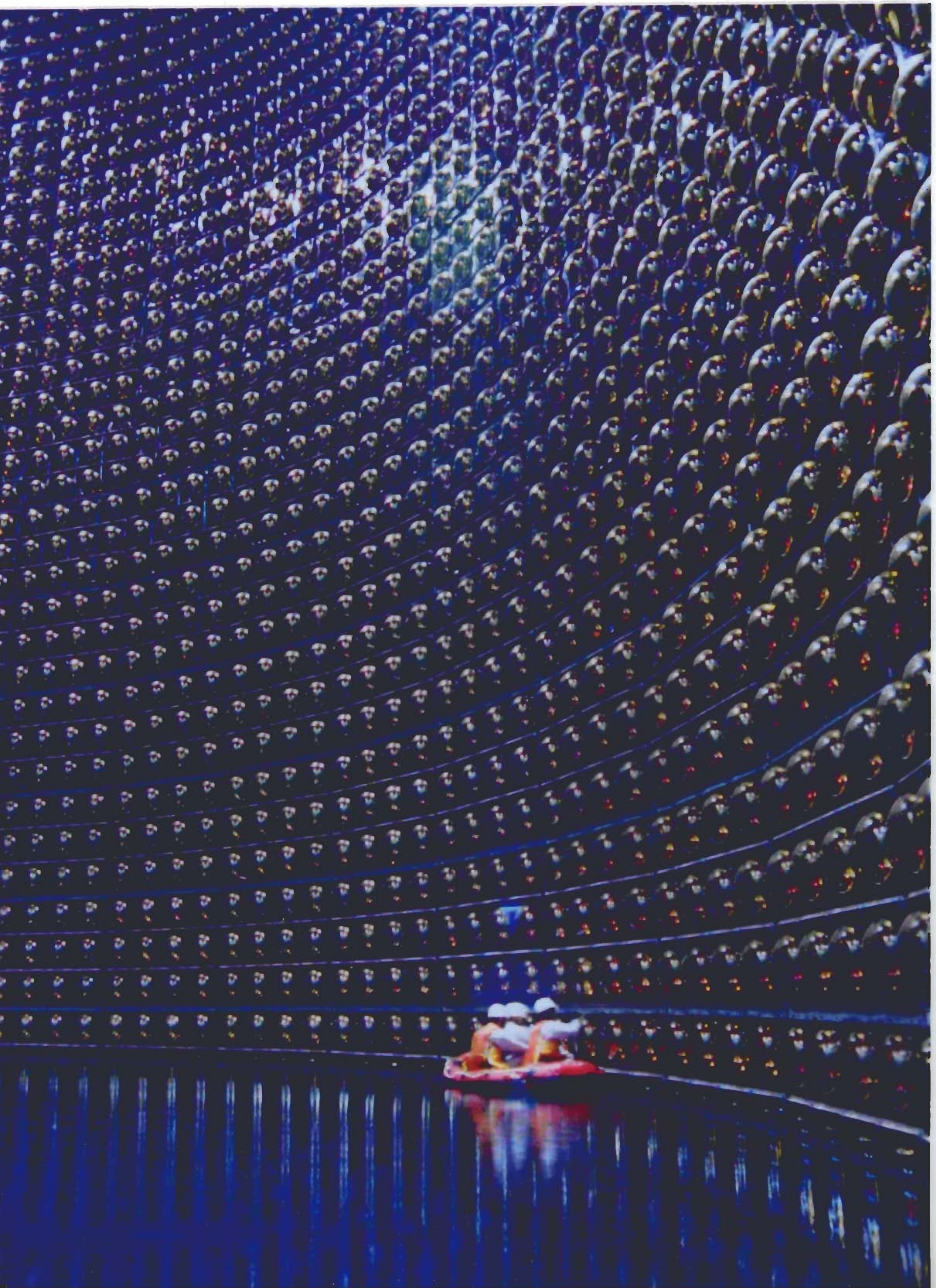
KamioKande detected solar ν in real time through the e-ν elastic scattering, showing that ν were coming from the sun, and starting a new generation of ~~a new generation of~~ astronomical instruments that contribute to the developing field of particle astrophysics

The Sudbury Neutrino Observatory located in a deep mine in Canada, a water detector like KamioKande but using heavy water in order to detect also the reaction

$$\nu + d \to e^- + p + p$$

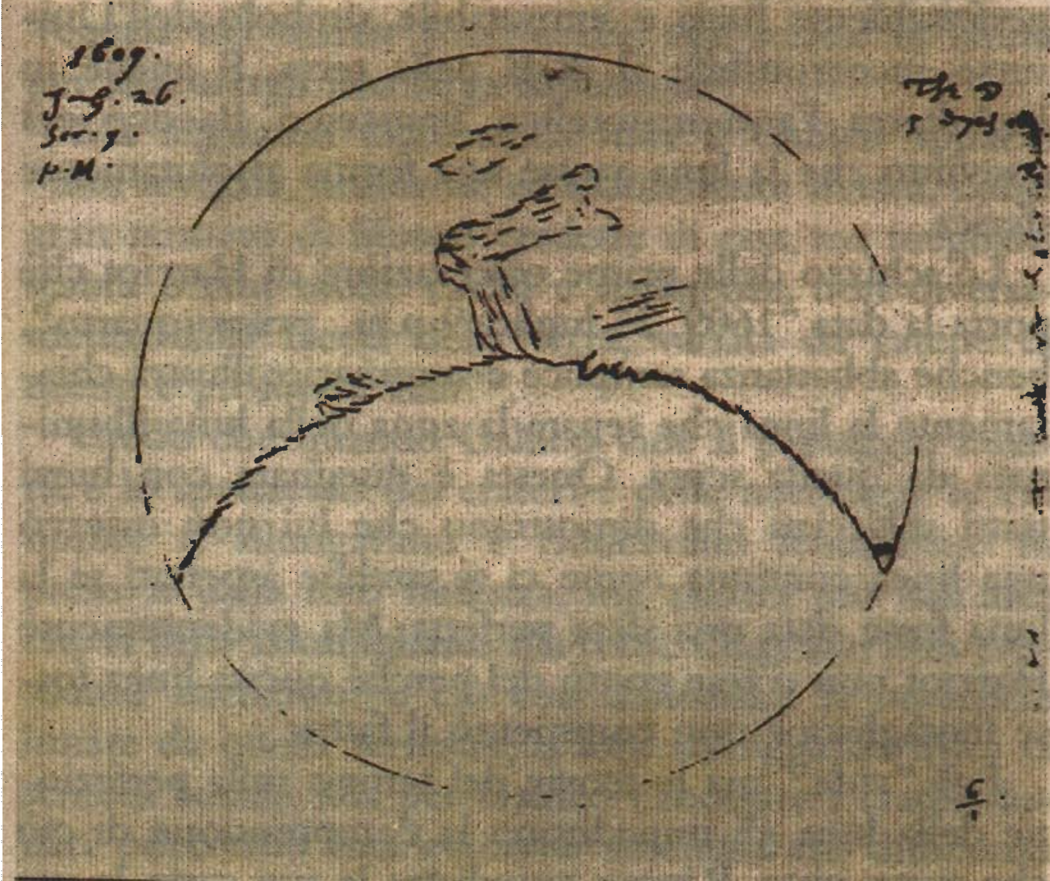
which has a much larger cross-section than ν-e scattering, gave the demonstration that solar ~~ν~~ $\nu(e)$ oscillate in ν_μ, ν_τ

The solar ν story represents one of the great success of modern science: we have learned about the sun and about ν



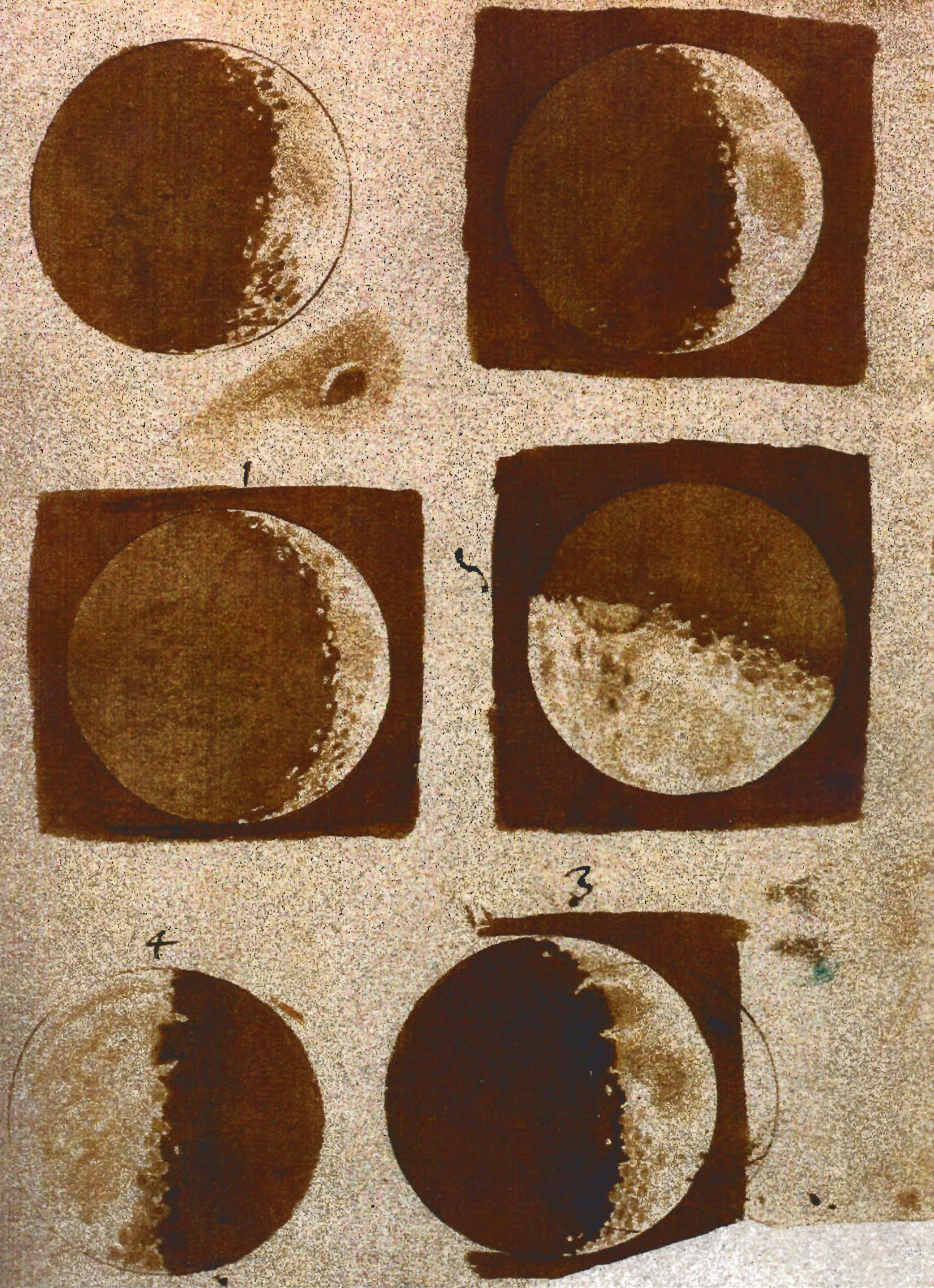
denza come entrambi, Galileo e Harriot, osservaro-no, lo stesso fenomeno.

Qui va ricordato che all'epoca la cultura filosofica europea era [illegible] accettata la Aristotelizzazione della filosofia [illegible], e per la cattolicizzazione di Aristotele [illegible] la luna come una sfera



[illegible] osservazioni, nelle quali non aveva trovato nulla di ec-citante, e non pubblicò mai i suoi disegni [illegible]

[illegible] Galileo, [illegible] la luna col [illegible] cannocchiale [illegible] ne di novembre, e quindi ne seguì le fasi con [illegible]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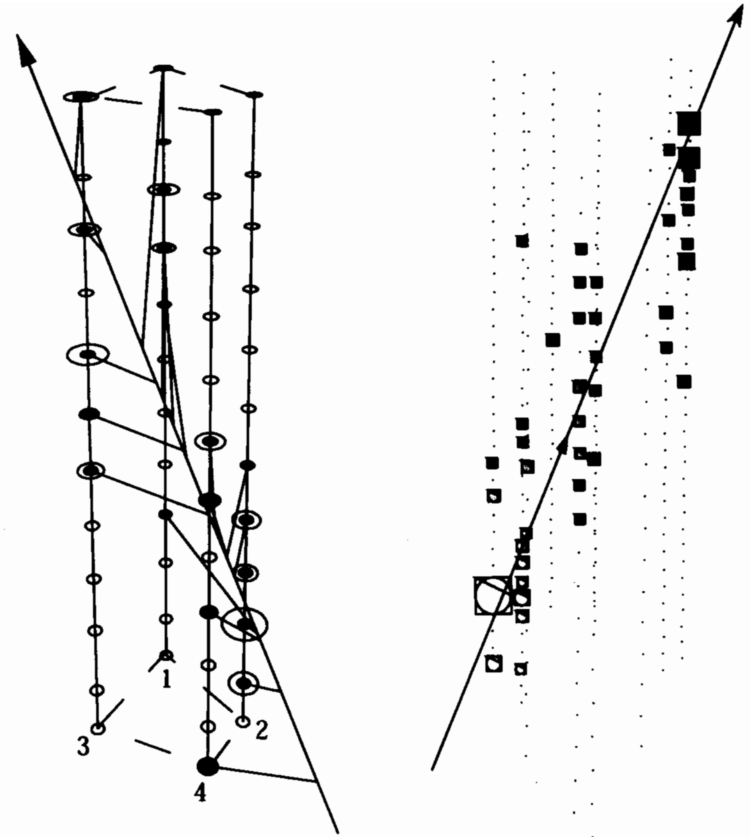

FIG. 28: Left: one of the rst clearly upward moving muons recorded with the 1996 four-string-stage of the Baikal detector. Small ellipses denote PMTs. Hit PMTs are black, with the size of the disc proportional to the recorded amplitude. The arrow line represents the reconstructed muon track, the thin lines the photon paths. Right: Upward muon recorded by the 1997 version of AMANDA. Small dots denote the PMTs arranged on ten strings. Hit PMTs are highlighted by boxes, with the degree of shadowing indicating the time (dark being late), and the size of the symbols the measured amplitude. Note the di erent scales: the height of the Baikal array is 72 meters, that of AMANDA nearly 500 meters.

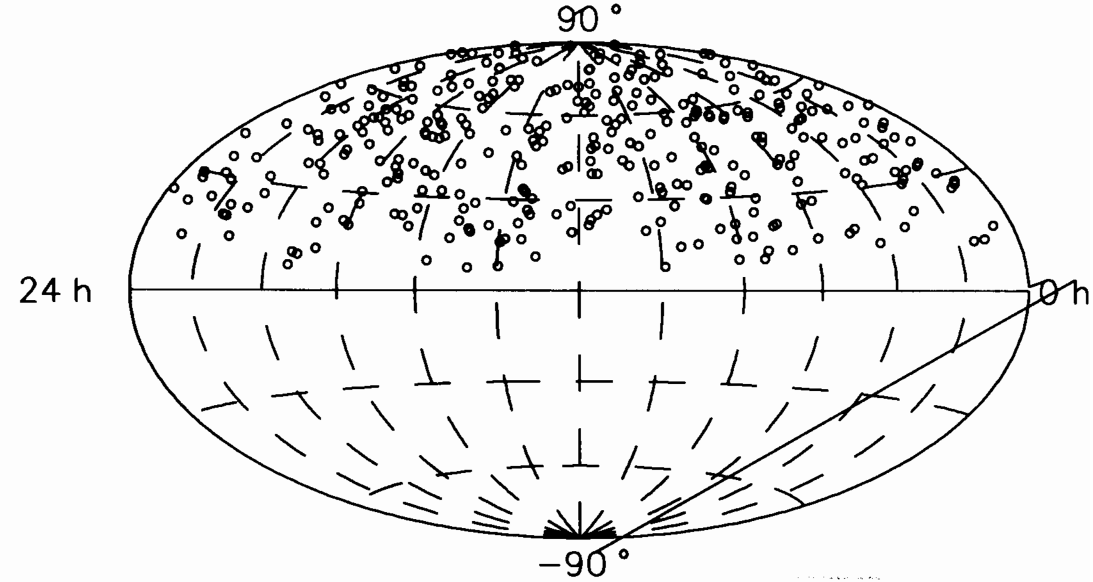

FIG. 29: Sky map of 300 neutrino candidates taken with AMANDA B10 in 1997. No indication of extraterrestrial point sources on top of atmospheric neutrinos are found.