The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
Cultural Organization

IAEA
International Atomic Energy Agency

2246-2

Workshop on Cosmic Rays and Cosmic Neutrinos: Looking at the Neutrino Sky

20 - 24 June 2011

OPENING ADDRESS

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Trieste
Italy

Looking at the Neutrino Sky

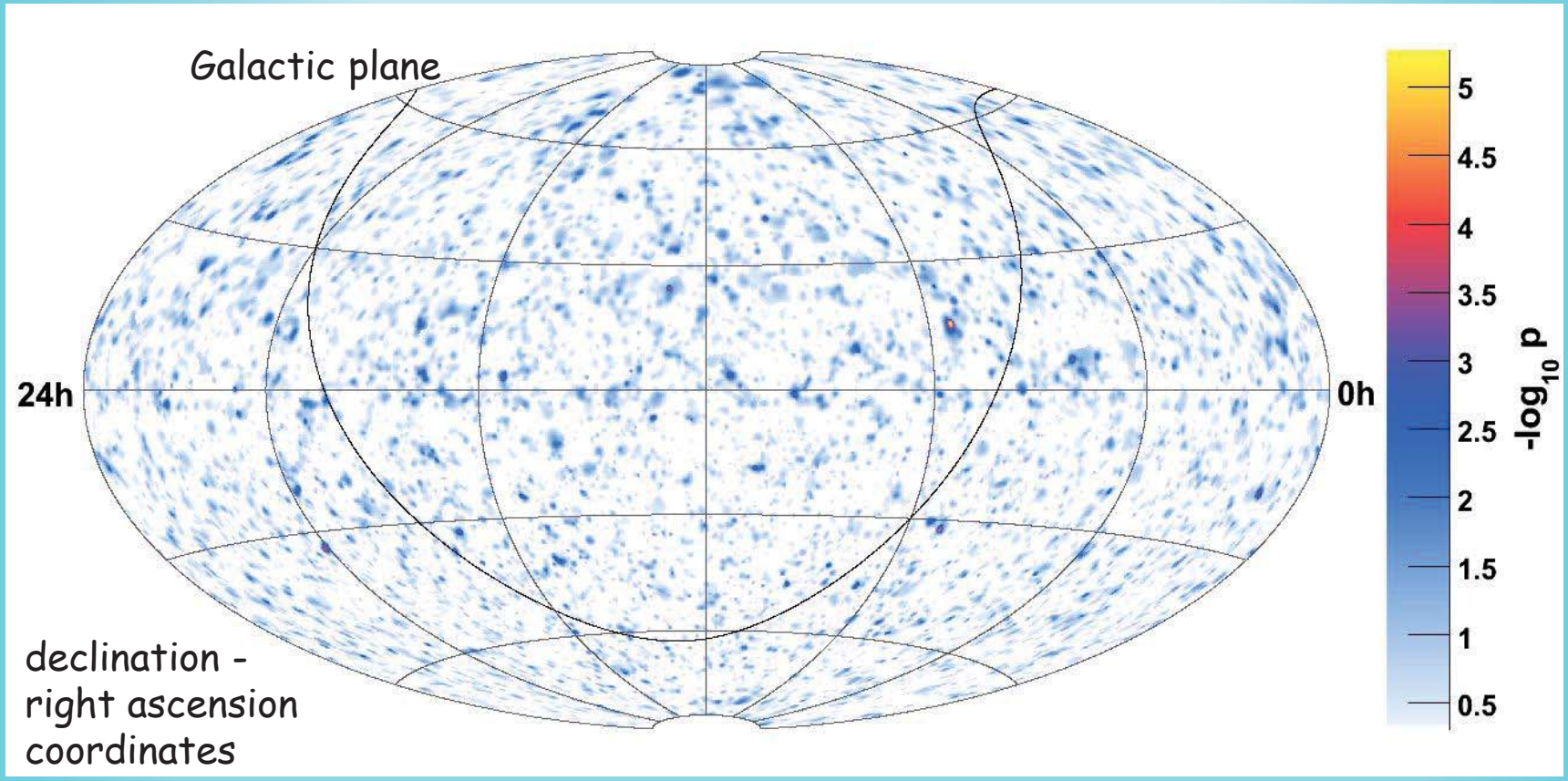
June 20 – 24, 2011

International Centre for Theoretical Physics,
Trieste, Italy

Map of the neutrino sky

E = 100 GeV – several 100 TeV

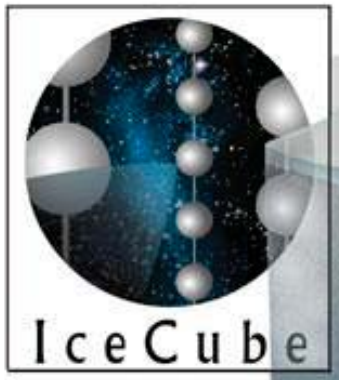
IceCube Collaboration
arXiv:1010.6263

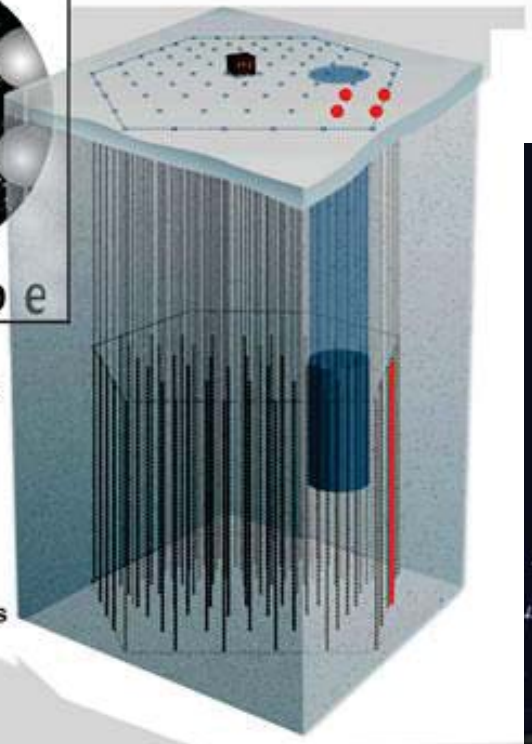


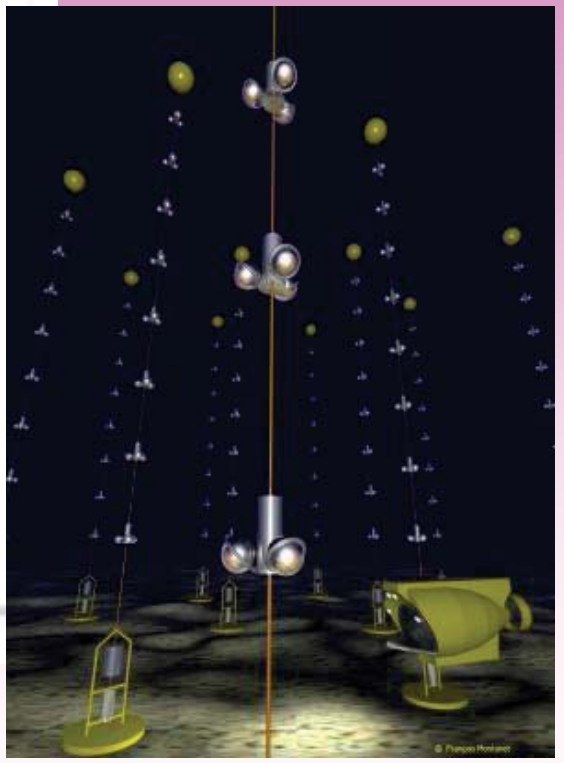
Probability (significance) for a point source not readily accommodated by the atmospheric neutrinos. p-value: probability of background fluctuation. The hottest spot: $p = 5\ 10^{-6}$ (4.5σ). Post-trial $p = 0.18$

Neutrino "eyes"

Auger







Antares

Share responcibility

Paolo Lipari
Subir Sarkar
Tom Weiler

Daniel Hernandez

Critical mass for serious discussion

Talks

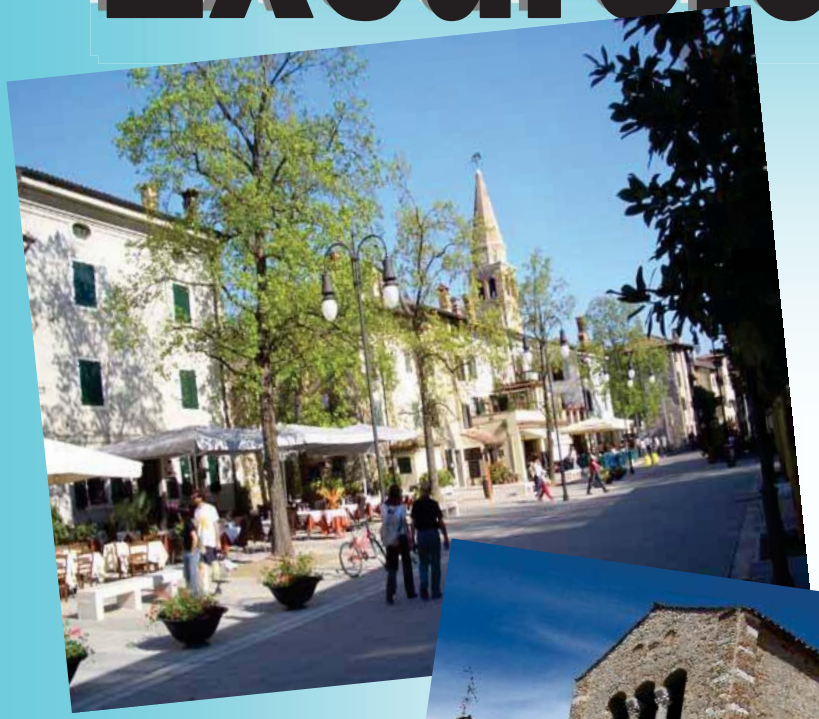
30 min + 15 min discussion

Discussion on Friday: contact John Learned

Slides on our website

- no proceedings,
- report on the workshop in CERN Courier ?

Excursion, dinner



Aquileia - Grado

Pope visit

Decide in advance about company?

Outside the Castler hall

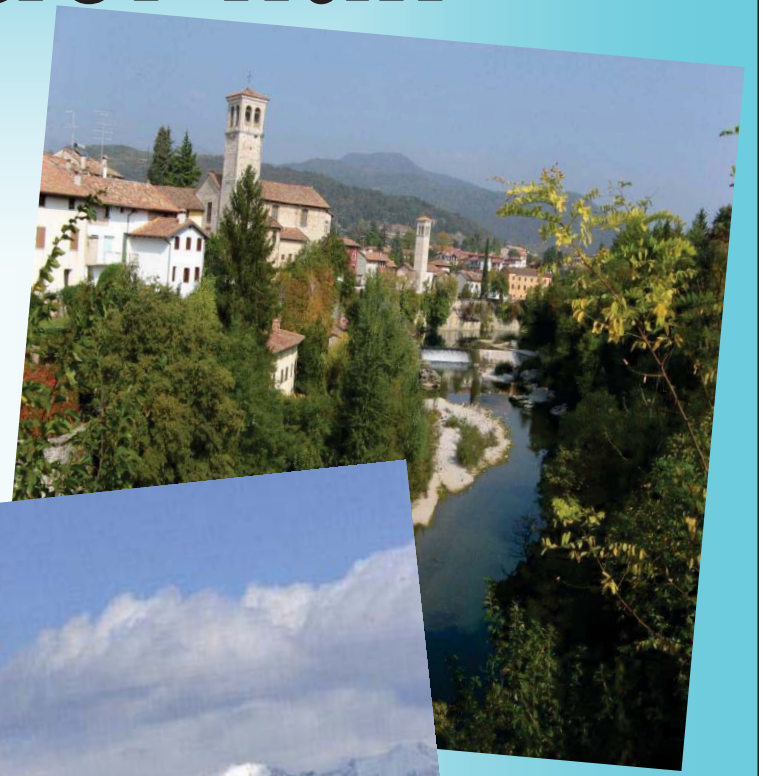
Duino castle: two castles, Rilke pass, …

Wine road: Cormons - Cividale

Festa in San Daniele June 24 - 27:

Proshiuto crudo (ham), wine, music…

Venice: Art biennale



Things to do

Weather:

Swimming:

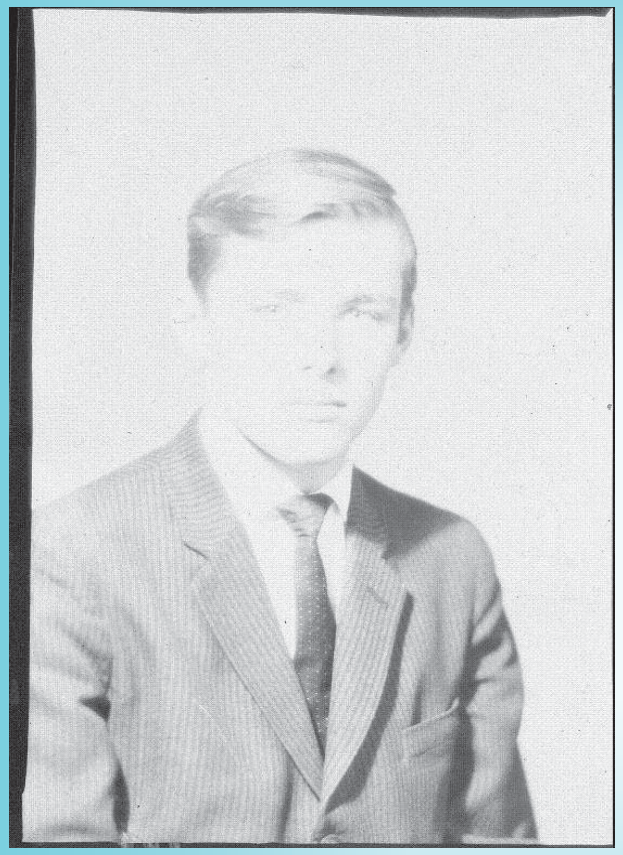
Boat Delfino Verde:
Trieste - Sistiana


In memory
of the one who was
looking at the neutrino sky

Stanislav Mikheyev
1940 - 2011

... outstanding experimentalist in the field of underground physics and neutrino astronomy

... one of the ``inventors'' of the MSW effect



- born in Moscow on October 11, 1940
  in family of known specialist of
  deep mining Paul Kail;
  early lost his father

- Decided to be physicist under influence
  of his uncle professor of Moscow state
  University Sergey Strelkov

- 1959 – physics department of Moscow
  state University

- Last year – in JINR, Dubna – met
  and was strongly inspired by B. Pontecorvo

- Since 1965 – PhD studies, Lebedev Physics
  Institute, laboratory of A Chudakov

- Since 1970 - Institute for Nuclear research

Constructing Baksan Telescope

Group created by A Chudakov:

Development of a prototype of neutrino scintillator detector

Mikheyev became a leader of the neutrino experiments

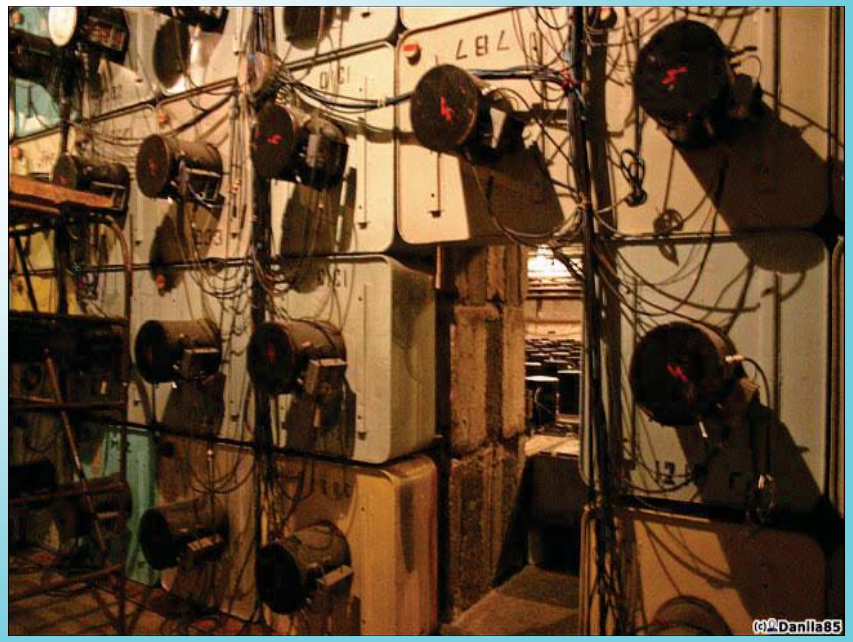
with V Bakatanov and A Voevodsky and others:
has developed a method of a time-of-flight detection of muons

→ direction of muons, neutrinos
→ basis of operation of Baksan telescope

Baksan Telescope

BUST

launched in 1978



Mikheyev made a great contribution to
- the design
- construction and
- research program

of the telescope

More than PhD...

1983 PhD ``Detection of muon flux from neutrinos of cosmic rays by the time-of-flight method"

1. Zenith angle distribution of the upward-going muons produced by atmospheric neutrinos

2. Search for neutrino oscillations of atmospheric neutrinos the first bound:

$\Delta m^2 < 6\ 10^{-3}\ eV^2$ for maximal mixing

3. The strongest upper bound on diffuse flux of cosmic neutrinos

B. Pontecorvo: deserves degree of doctor of physical and mathematical sciences

Main topics

Leader of experimental group

Atmospheric neutrinos searches for oscillations

Neutrinos from WIMPs

Neutralino searches

Cosmic neutrinos diffuse fluxes sources

Cosmic rays, muon and neutrino interaction

Neutrino bursts from SN

Searches for magnetic monopoles

with Chudakov and Muraki

MSW

Searches for oscillations of atmospheric neutrinos, analysis of the Baksan results

Beginning of 1984

Is the Wolfenstein's paper correct?
Should we take into account matter effect in analysis of atmospheric neutrinos?

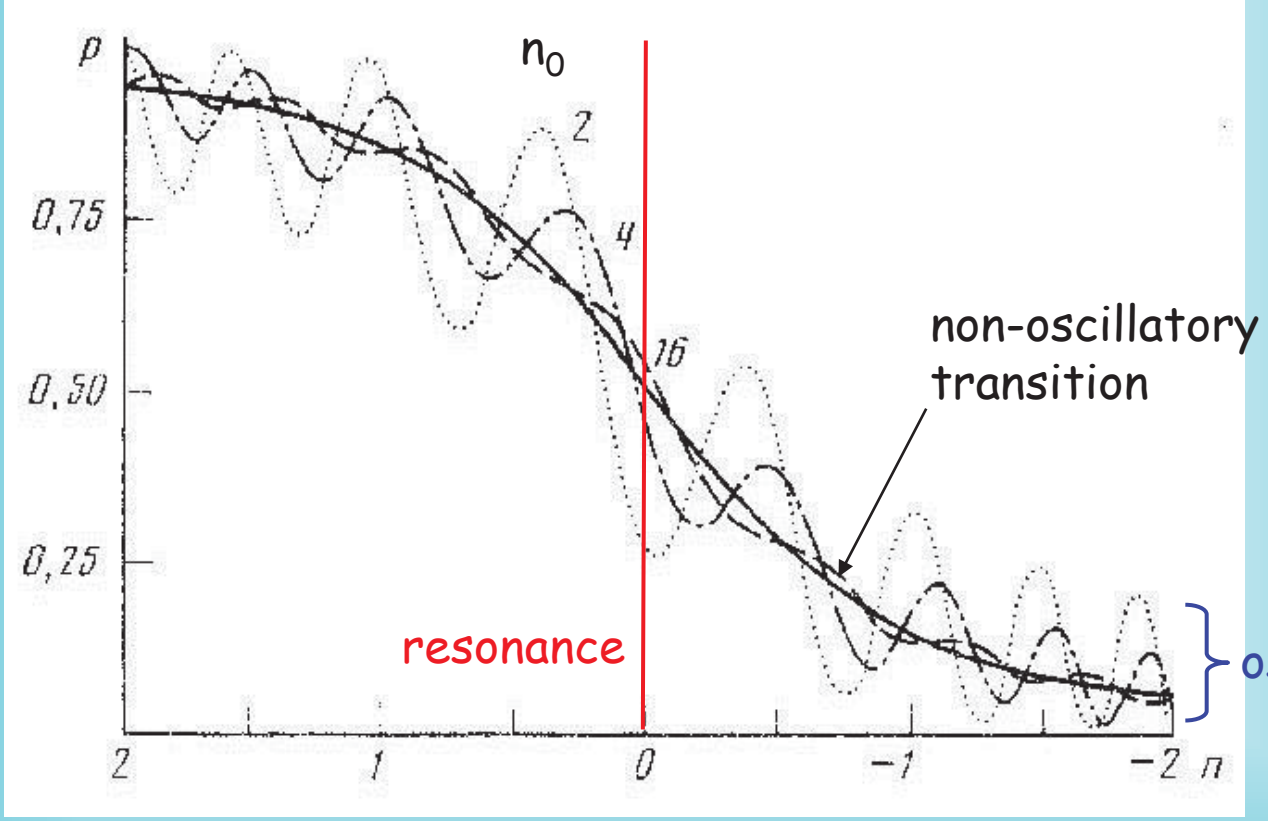
Resonance; resonance condition
Resonance enhancement of oscillations in uniform medium

Medium with varying density?
Resonance condition should be satisfied in wide range of energies inside the Sun and in supernovae
Oscillations?

MSW - adiabatic conversion

≠ oscillations

Sov. Phys. JETP 64, 1 (1986)



Survival probability for different initial densities n_0

$n = \frac{\rho - \rho_R}{\Delta\rho_R}$ - distance in units of width of the resonance layer

Tokyo, 2004

MACRO at Gran-Sasso

Mikheyev joined MACRO in 1991

1991 – 1999
worked in Gran-Sasso

Mikheyev & Mikheev

By MACRO Collaboration:

CR

- High energy cosmic ray physics with the MACRO detector

- Composition of the ultrahigh-energy primary cosmic rays as measured by MACRO detector

Experimental study of hadronic interaction model using coincident data from EAS-TOP and MACRO

Muons Neutrinos

- Vertical muon intensity measured with MACRO...

- A sky survey using muons in the MACRO detector

- Atmospheric neutrino flux measurements using upgoing muons

- Neutrino astronomy with MACRO detector

- Searches for cosmic point sources of muons and seasonal variations in the underground muon flux ...

WIMPS

- Limits on dark matter WIMPS using upward going muons

By MACRO Collaboration:

Oscillations

- Atmospheric neutrino flux measurements using upgoing muons

- Measurement of the atmospheric neutrino induced upgoing muon flux using MACRO

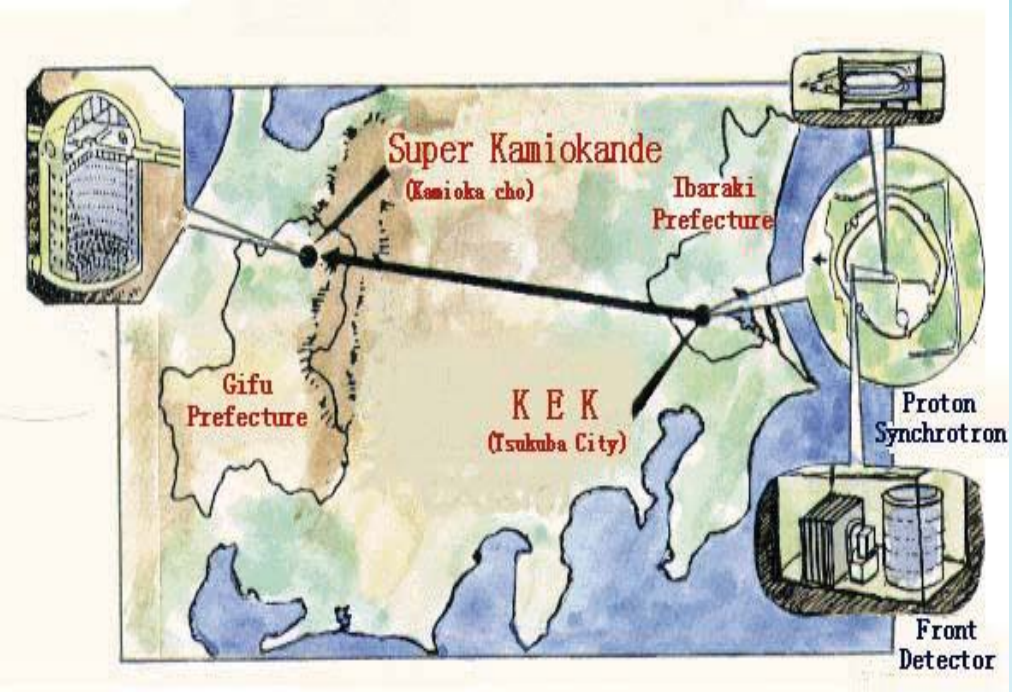
- Atmospheric neutrino oscillations from upward through going muon multiple scattering in MACRO

- Matter effects in upward going muons and sterile neutrino oscillations

- Low energy atmospheric muon neutrinos in MACRO

K2K

2001 - 2005



- Evidence for muon neutrino oscillation in an accelerator-based experiment

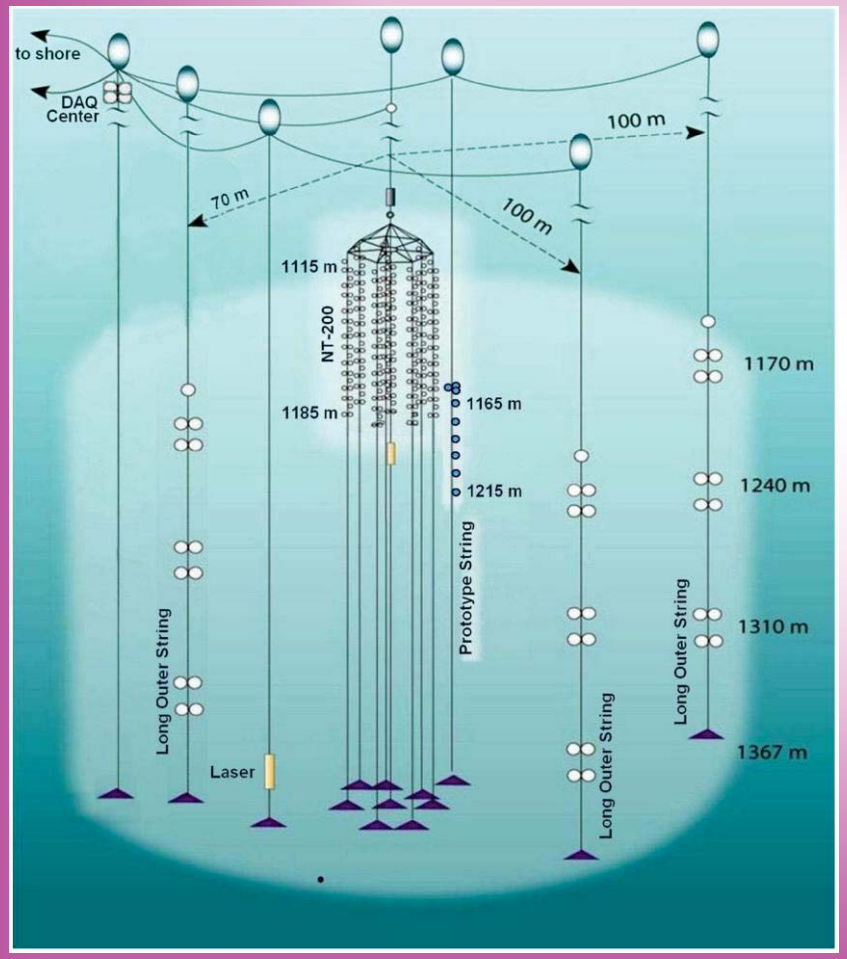
- Measurement of Neutrino Oscillation by the K2K Experiment

Some work for T2K (another front detector)

with Kamyshkov

Baikal neutrino telescope

NT200+ 10 Mton After 2000

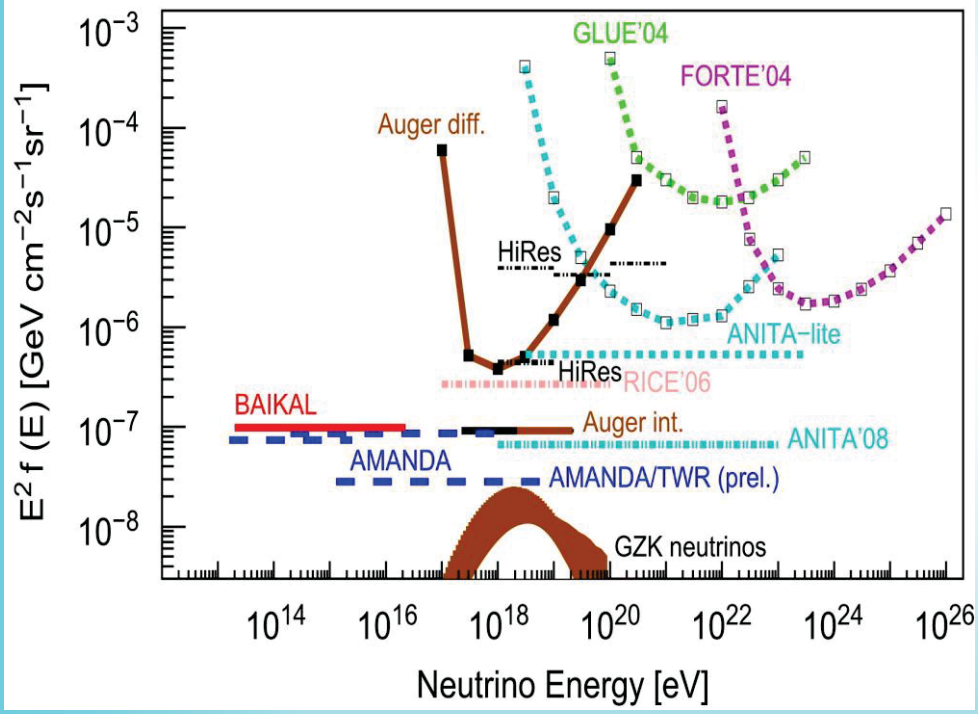


3 outer strings

New technology string for GVD

Baikal NT200+

A. Avronin et al, Nucl. Inst Meth. in Phys. Res. A 630 (2011) 115.



Limits (90% CL) on the diffuse extraterrestrial flux of HE neutrinos per flavor

Search for neutrinos from WIMP's in the Earth and the Sun

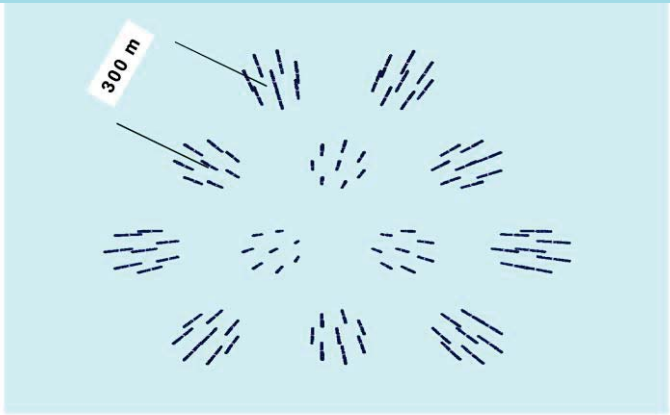
Nearly vertically going muons:

Observed: 48
Expected 56.6 with osc.
73.1 without osc.

Towards a km3 scale GVD

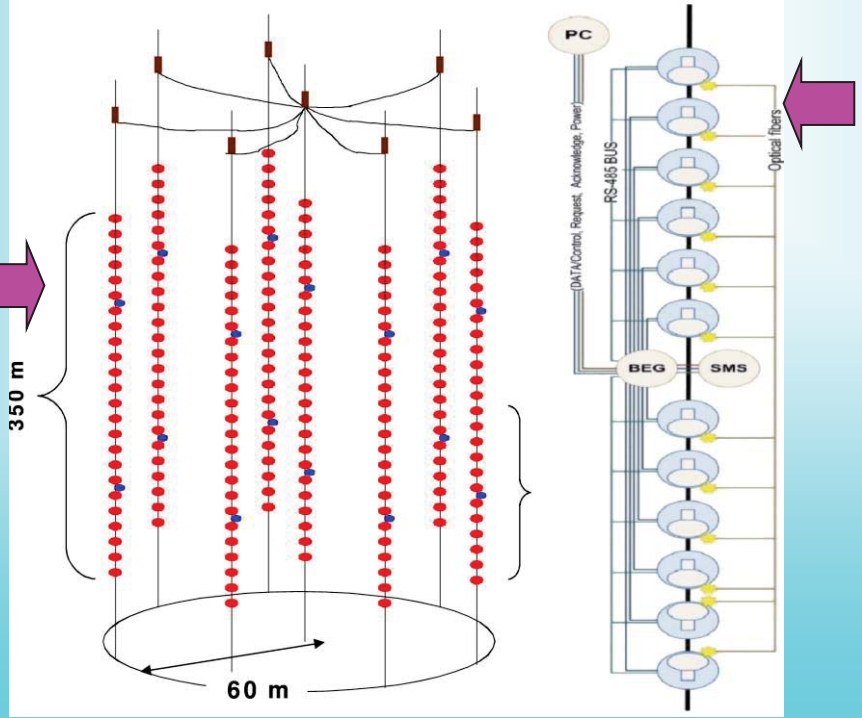
Gigaton
Volume
Detector

in Lake Baikal



top view
12 clusters
(2304 OMs)

96 strings with 24 OM



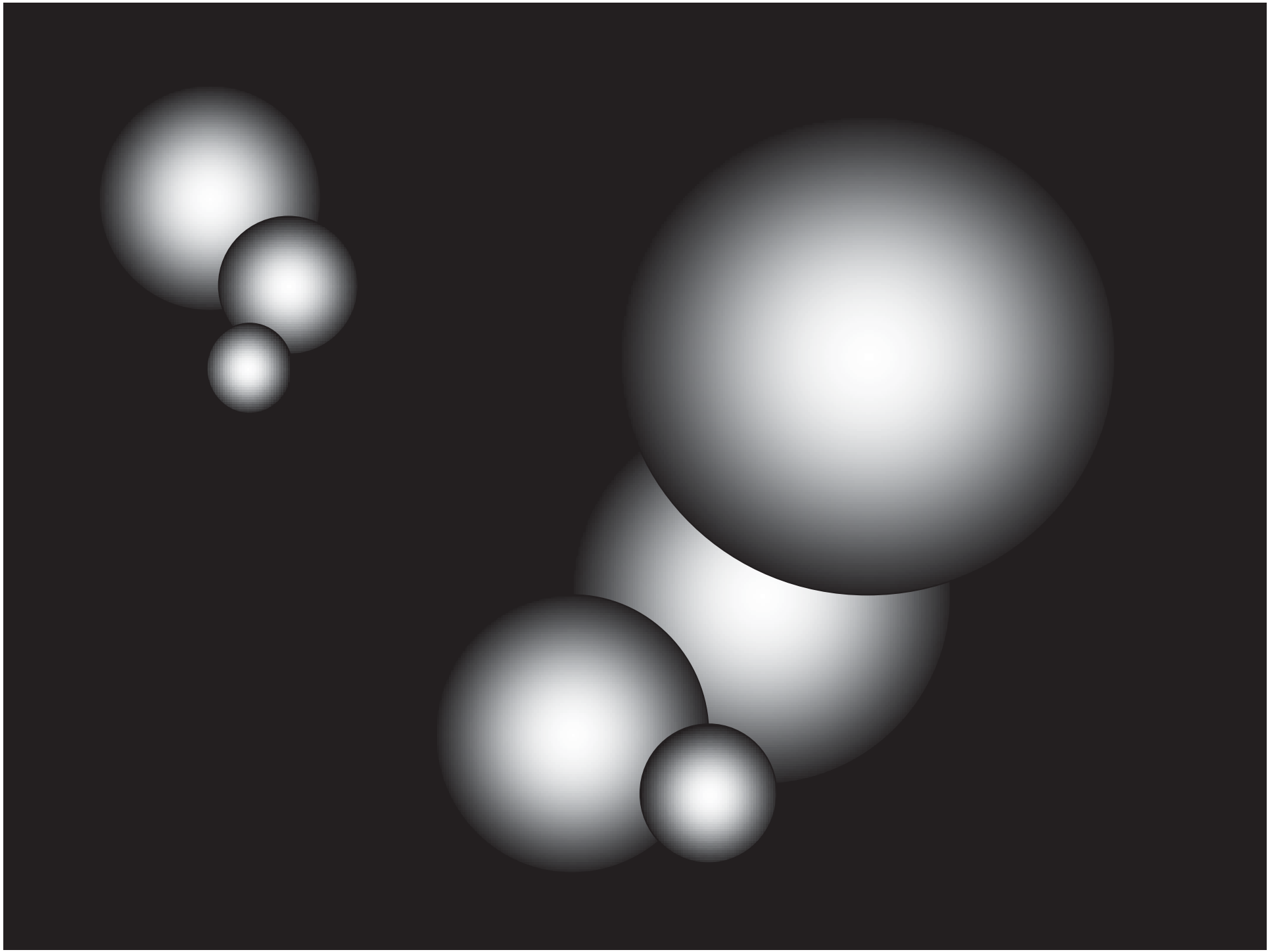
a cluster with
8 strings

half strings with

12/13 in. photomultipliers
XP1807 (Photonis)
R8055 (Hamamatsu)

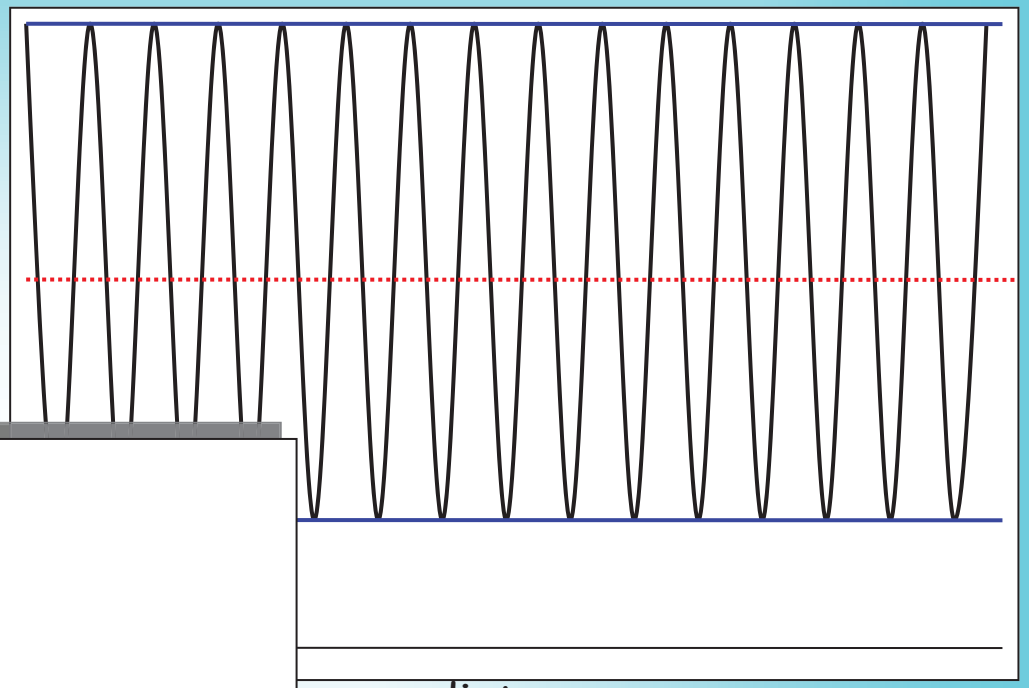
Technical design 2011


Let us start...

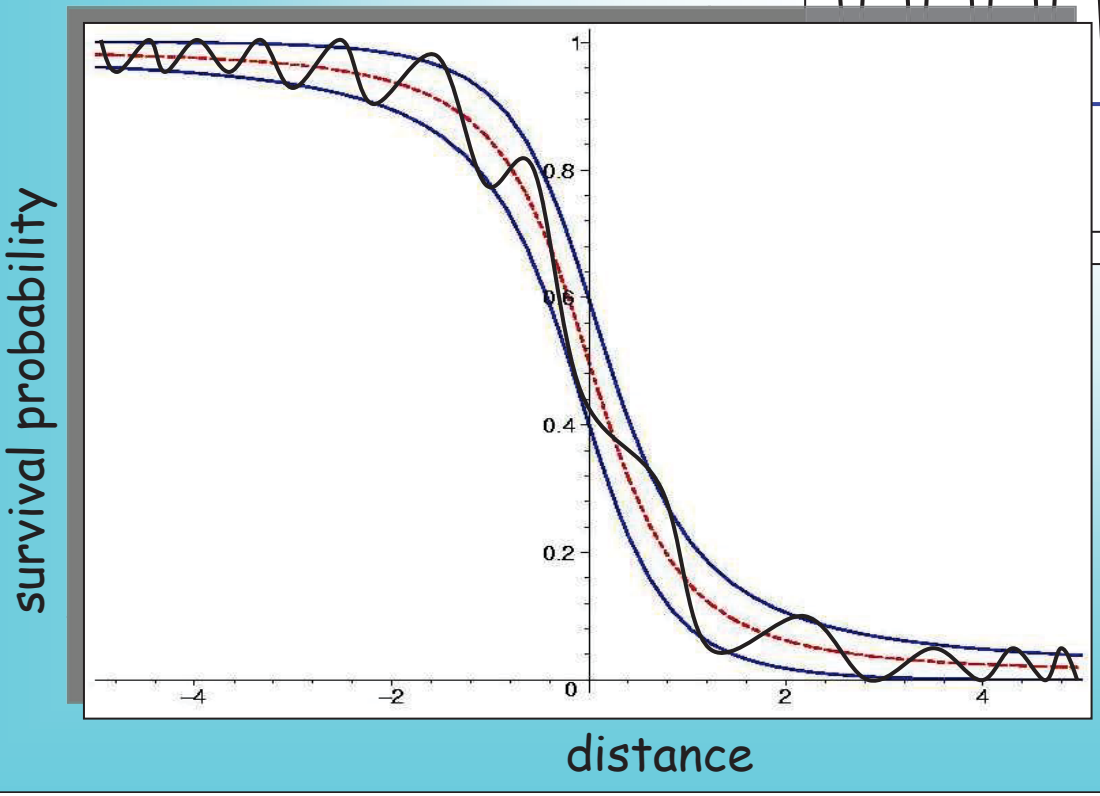


Spatial picture

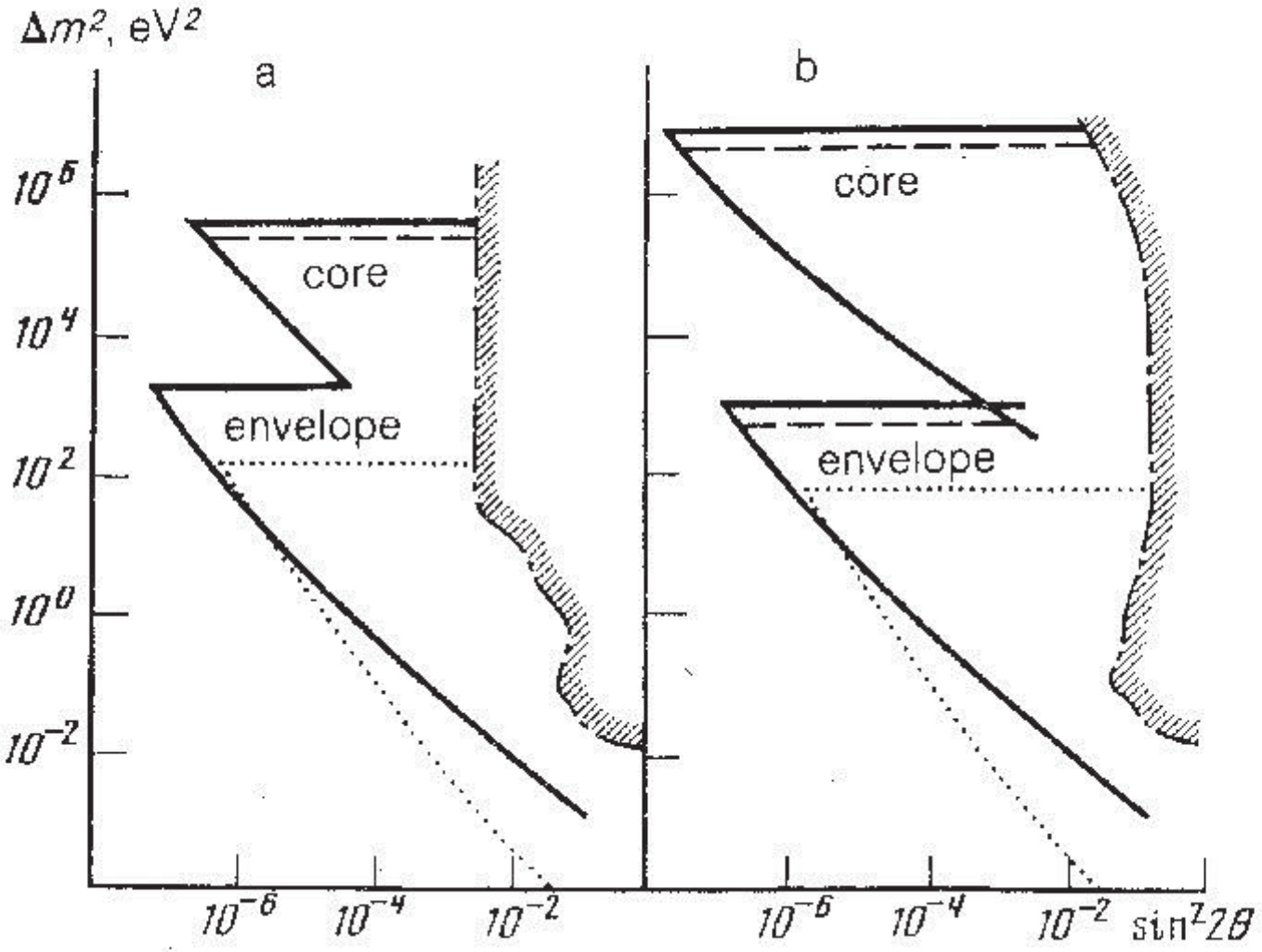
Oscillations



Adiabatic conversion



A Yu Smirnov


Δm², eV²
a
b
core
envelope
core
envelope
10⁶
10⁴
10²
10⁰
10⁻²
10⁻⁶
10⁻⁴
10⁻²
10⁻⁶
10⁻⁴
10⁻²
sin²2θ