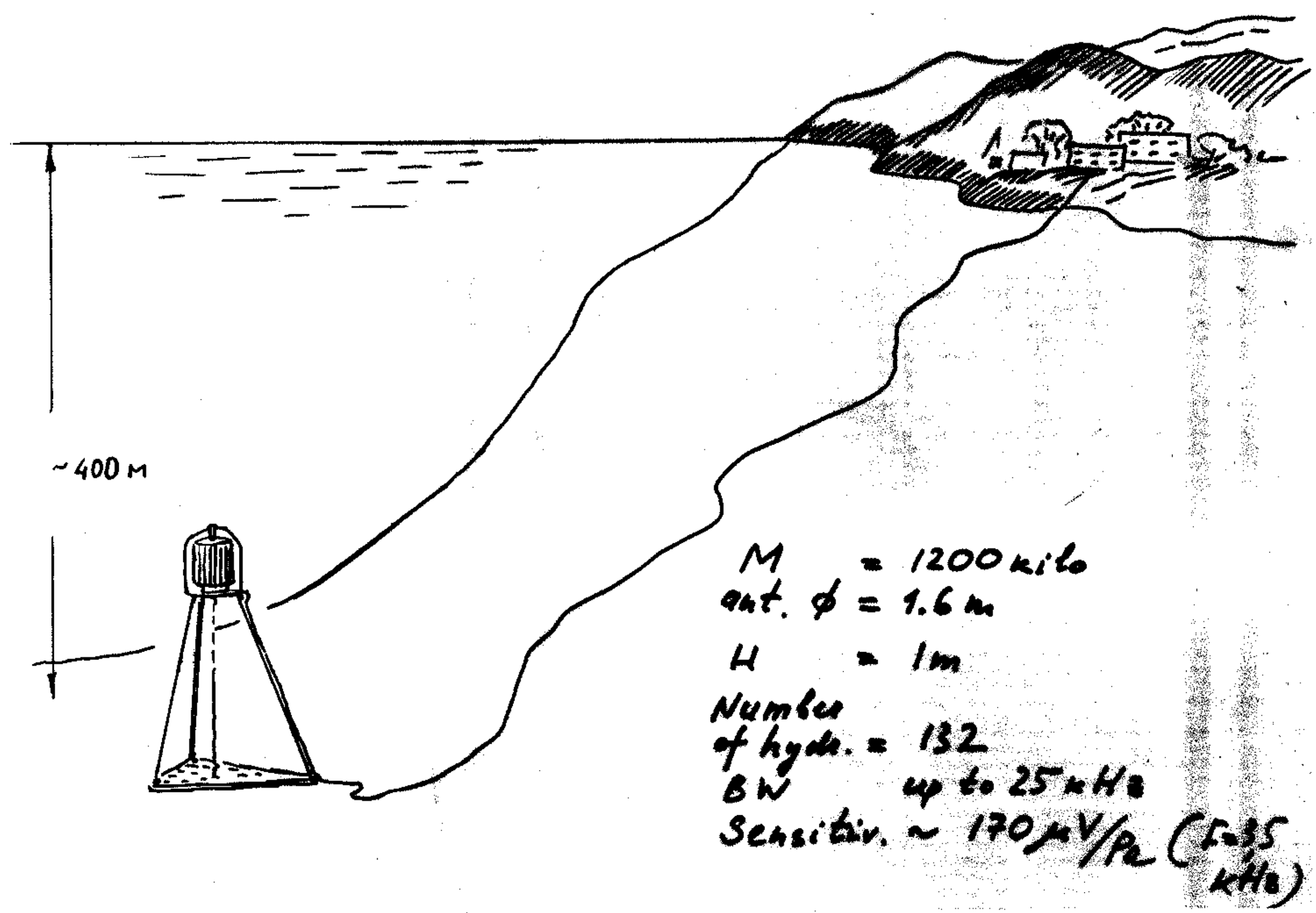
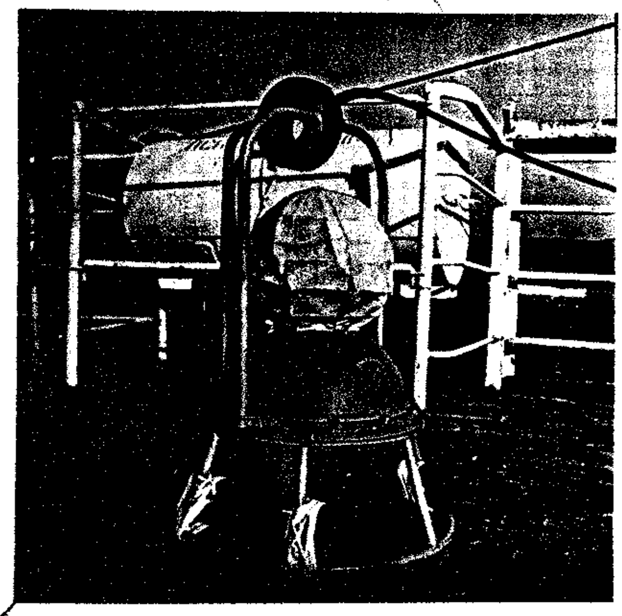
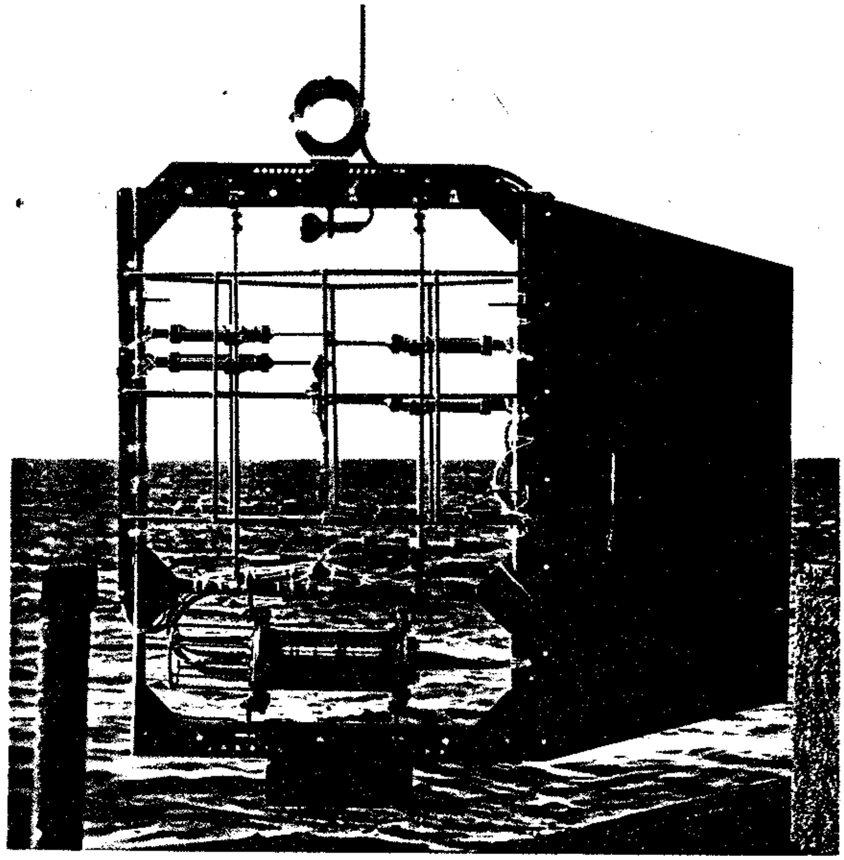
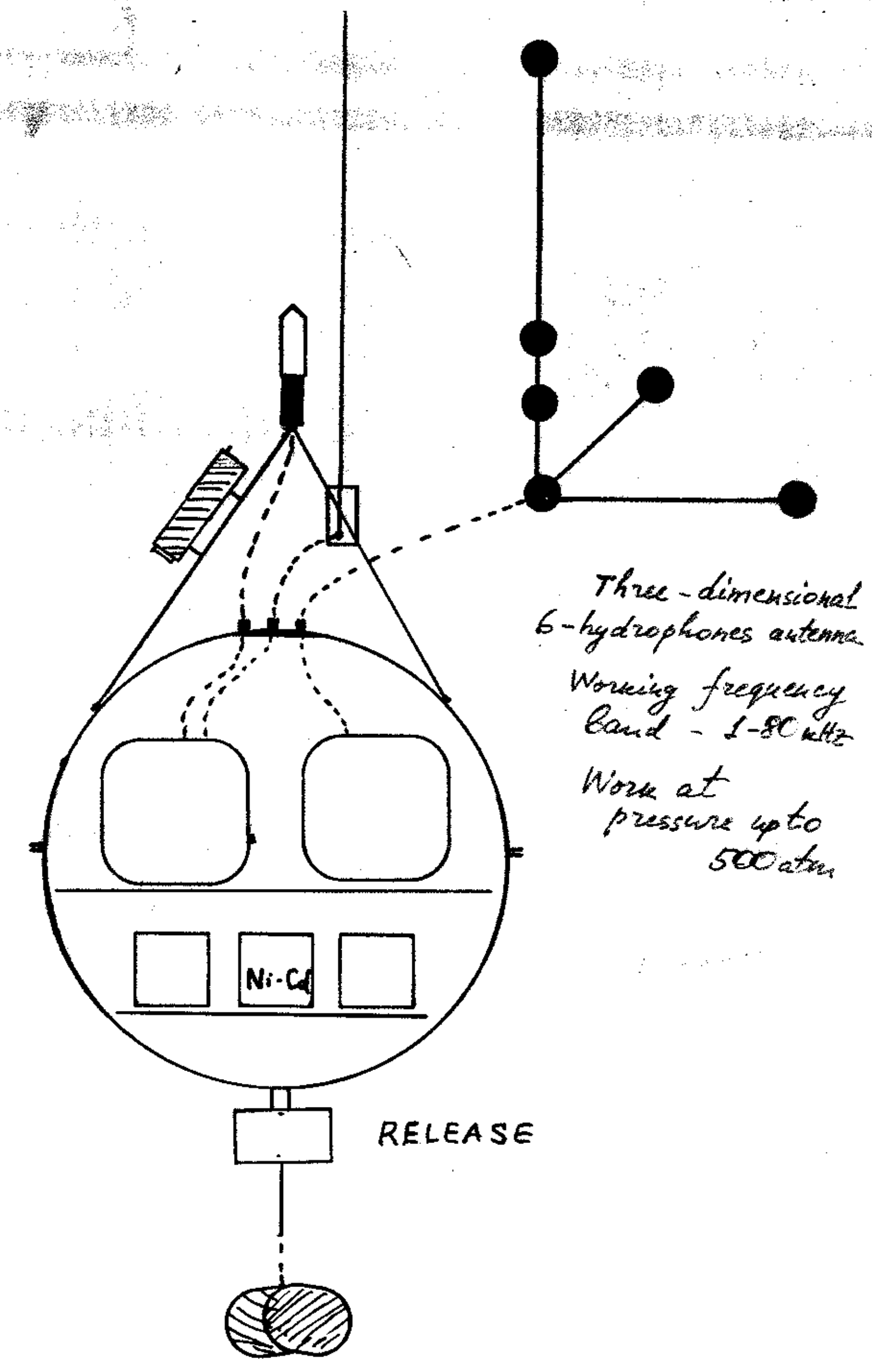
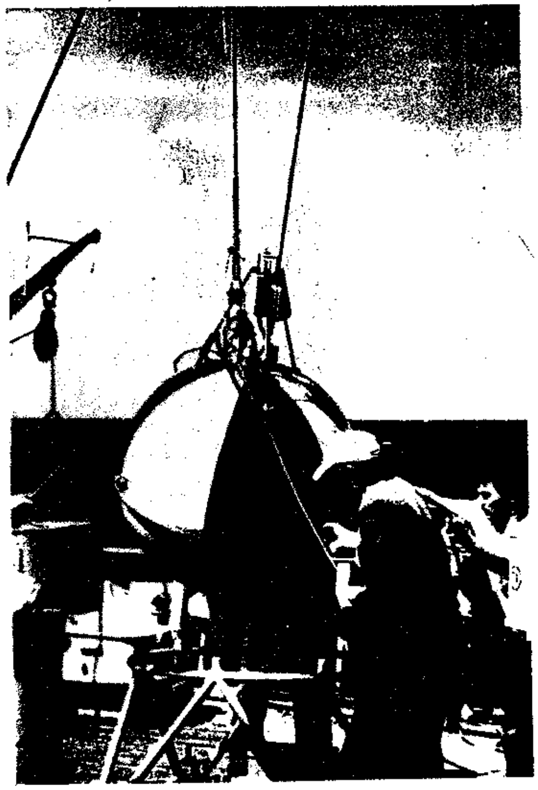

~400 m
M = 1200 kilo
ant. ϕ = 1.6 m
H = 1m
Number of hydr. = 132
BW up to 25 kHz
Sensitiv. ~ 170 μV/Pa (f=35 kHz)







Three-dimensional 6-hydrophones antenna
Working frequency band - 1-80 кHz
Work at pressure up to 500 atm
Ni-Cd
RELEASE



Bottom station:
To use for the long term variation of the acoustic noise at large depths

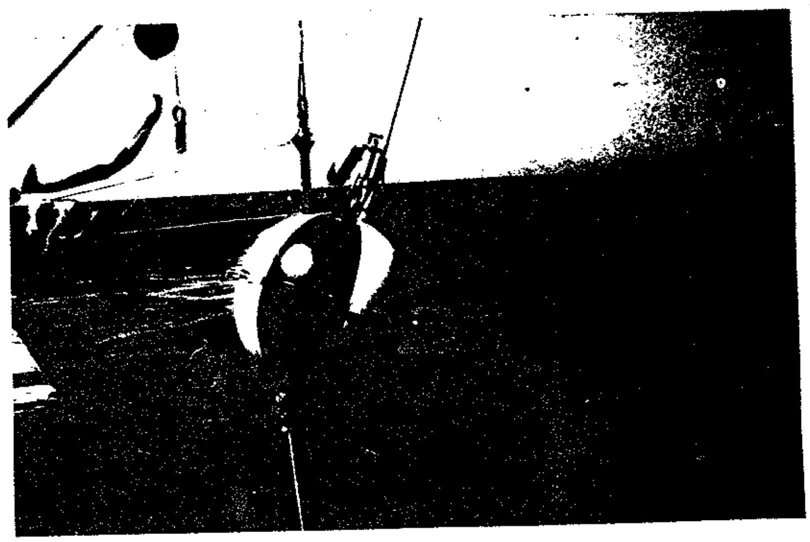
Глубоководный модуль
акустического нейтрин-
ного телескопа

BOTTOM STATION:

max depth . . . 7000 m
+floatability . . . 150 kg
weight . . . . 250 kg
residence . . . . >100 day
search distance . . . 40-80 km
hydroacoustic remote
distance - - - - 15-20 km

Рис. 3

Рис. 4



THE MAIN PROBLEMS WHICH HAS TO BE SOLVED ON KAMCHATKA ARRAY

1. OPTIMAL DETECTION ALGORITHMS
2. RECOGNITION AND CLASSIFICATION

APPROACHES:

- THEORETICAL INVESTIGATIONS
- DESIGN OF SPECIAL TRANSDUCER WITH ACOUSTIC PARAMETERS SIMILAR TO NEUTRINO SOUND EXITATION
- EXPERIMENTAL RESEARCHES OF IMPULSE NOISES
- FULL-SCALE OCEAN EXPERIMENTS WITH ARTIFICIAL SOUND SOURCE
- DESIGN OF METHODOLOGY OF NEUTRINO ACOUSTIC DETECTION, DEVELOPMENT OF REQUIREMENTS TO PERSPECTIVE ACOUSTIC DETECTION STATIONS

RESULTS:

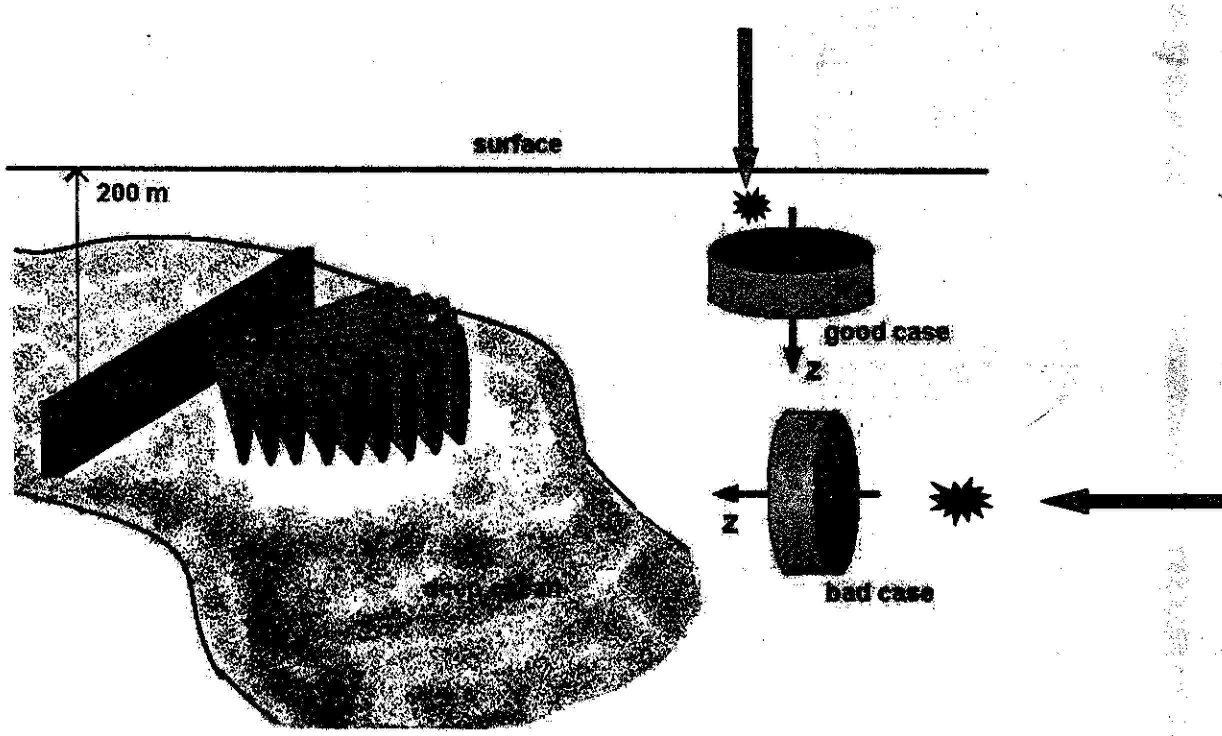
V_{eff} (in KM^3) for $E_{cascade} = 10^{20} (10^{21})$ eV

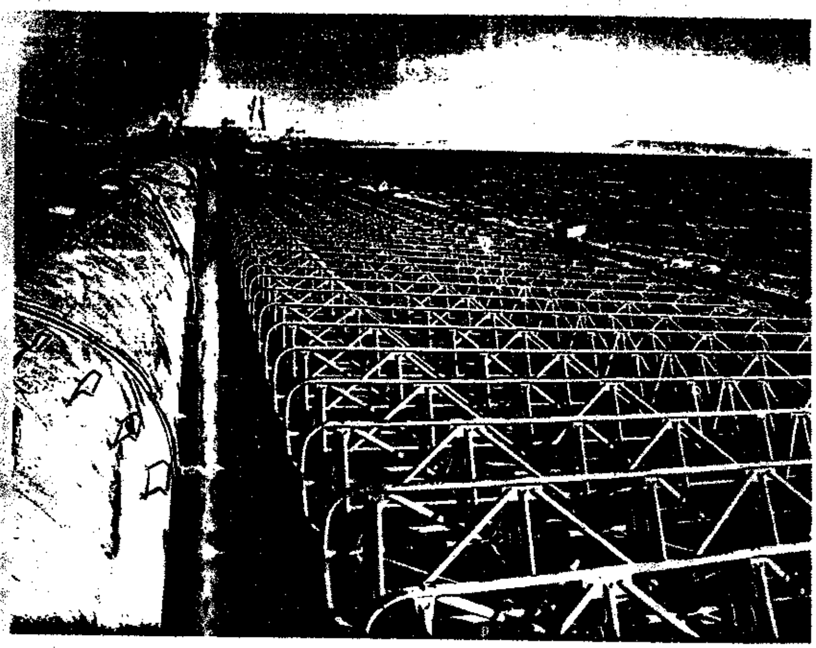
	SUMMER		WINTER	
v_{wind}	Bg (1/day	1/month	1/day	1/month)
2 M/sec	11	6,6	2,95	1,38
5.5 M/sec	3,9 (81)	2,2	0,43	0,15
10.2 M/sec	0,98 (24)	0,73		

Optimal upper frequency:

Distance, km	10	100	300	1000
f_{upper}, kHz	4	1,85	1,25	0,86

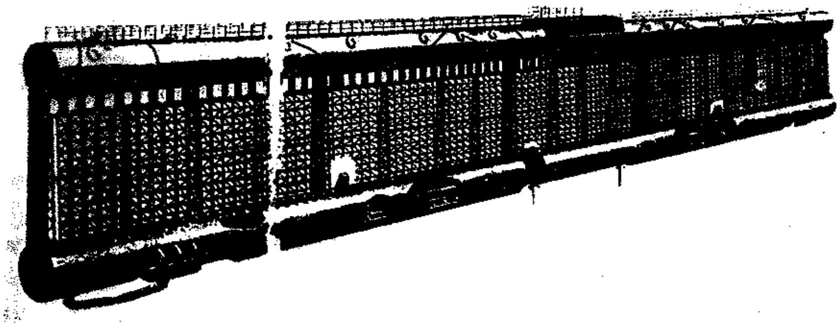
$$E_{cascade} = 10^{21} eV \rightarrow V_{eff.} \approx 80 \, KM^3 \, !$$


surface
200 m
good case
z
z
bad case



120 ant. (7,5 m each)
2×10 hydr
sensitivity in bandwidth 0,2–1,5 kHz
380 μV/Pa

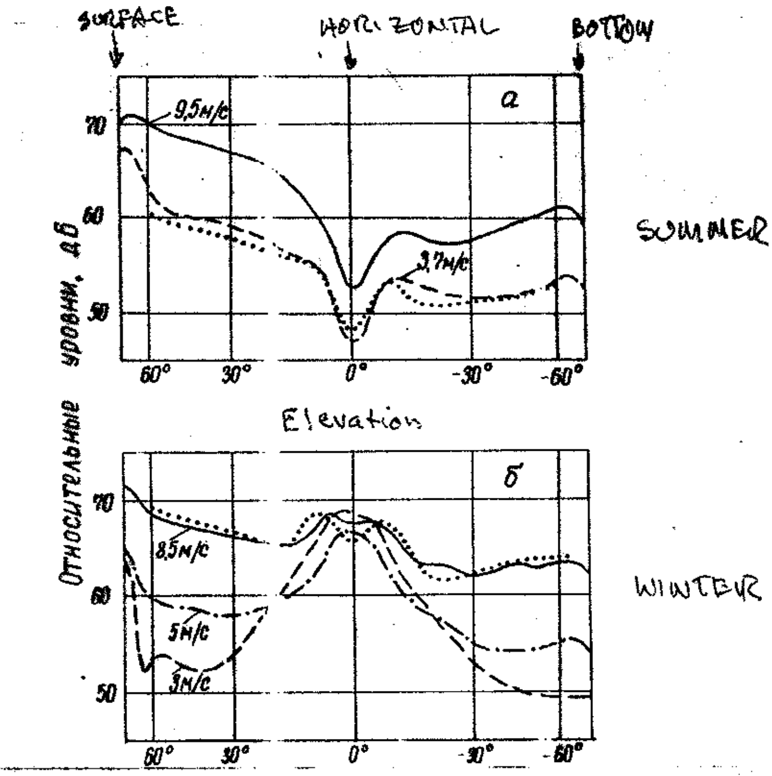
102 m ⊗ 17,3 m ⊗ 4,5 m
M = 840 tons



Kamchatka hydroacoustic array as a test base for the neutrino astrophysics in the Ocean.

<u>Objective</u>: to develop a special measurement system for search for cascades induced by SHE (TD) νs

Acoustic noise (f ~ 1kHz)



Characteristics of background anisotropy (antenna at 200 m depth) for summer conditions (a), for winter conditions (б).

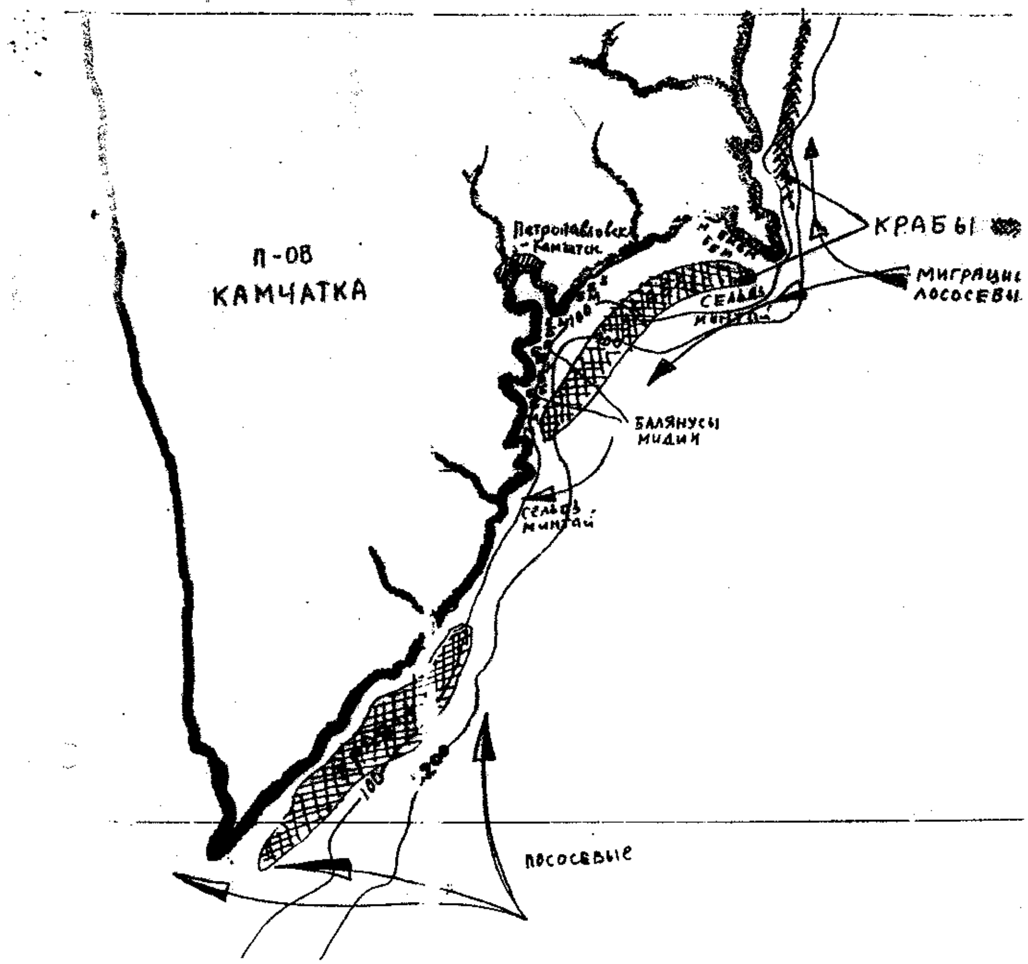


Рис. 4. Карта распространения отдельных видов звучащих в диапазоне частот 0.2 - 2 кГц гидробионтов в прикамчатской зоне Тихого океана.

DEEP UNDERWATER ACOUSTIC DETECTION

- alternative (complimentary) method to deep underwater optical detection.

SADCO proposal:
(SADCO = Sea Acoustic Detection of Cosmic Objects)
use existing hydrophysical array

Site:
Pacific Ocean near Kamchatka Peninsula

Existing Hardware:
- 2400 hydrophones in operation
- titanium frame of 100m X 20m
- 20 km from shore
- 300m depth (on slope)
- 120 vertical strings with electronics

Method:
- detection of acoustic signals produced by cascades in water
- frequency band (≤ 1,5 kHz) of the Kamchatka array is not optimal for detection of acoustic signals from cascades (> f preferable)
- Great antenna gain coefficient (~2500)
- Detection of cascades at large distances is possible - large volume
- Very high energy threshold ($\sim 10^{19}$ eV)

Goal:
Search for extremely high energy neutrinos $E \sim 10^{20} - 10^{22}$ eV

Effective volume:
$V \geq 10\ km^3 - 10^4\ km^3$

SADCO - 97 collaboration:
- Inst. for Nucl. Res. (INR), Moscow
- Acoustic Inst. (Moscow)
- "Morfizpribor" (St. Petersburg)
- Univ. of Hawaii
- OTHERS ? Since 99: Rome Univ., Kiel Univ.

"Plans" for 1997-1998: 1999 - 2000.
1. Background measurements
2. Development of detection algorithms
3. Technical Project Description
4. Development and construction of special measurement system
5. Construction of acoustic calibrator for neutrino induced signal.
6. Installation of the measurement system
7. Acoustic transducer tests

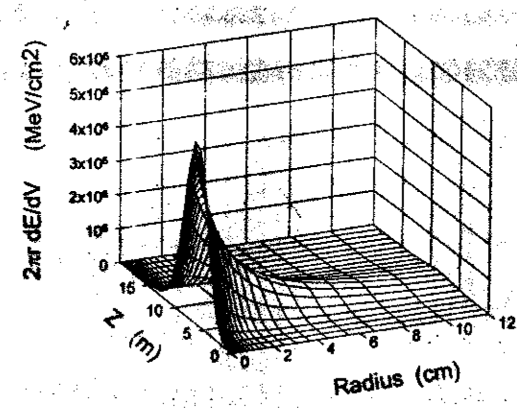


Figure 2. **Energy distribution multiplied by factor $2\pi r$ in electron-photon cascade ($E_0 = 6.4 \cdot 10^6$ GeV) in water.**

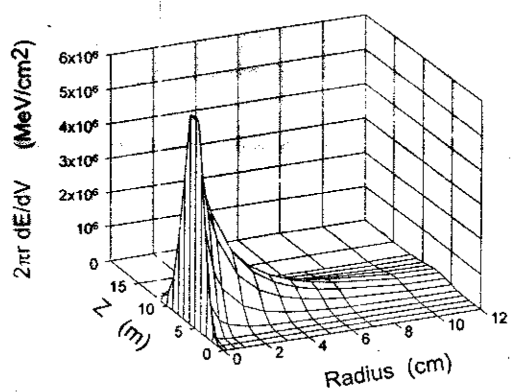


Figure 3. Energy distribution multiplied by factor $2\pi r$ in hadron cascade ($E_0 = 6.4 \cdot 10^6$ GeV) in water.

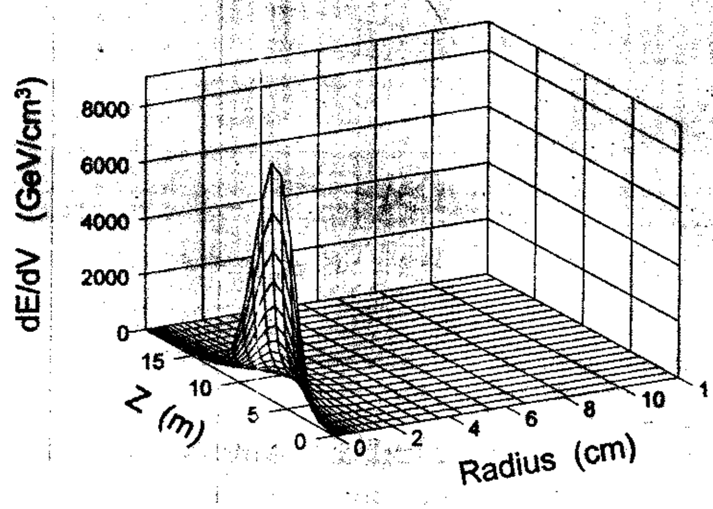


Figure 1. Energy distribution in electron-photon cascade ($E_0 = 6.4 \cdot 10^6$ GeV) in water.

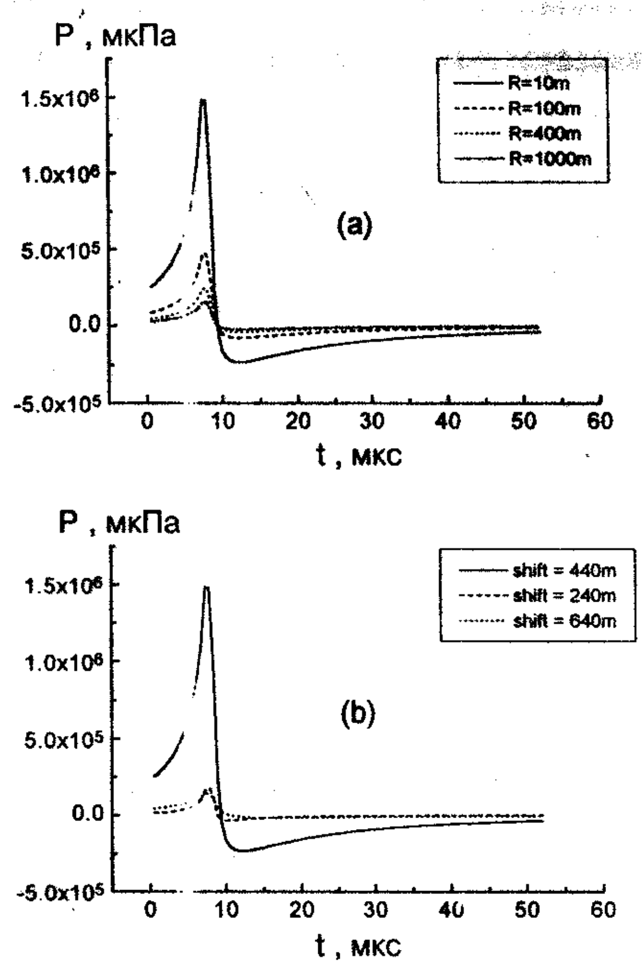
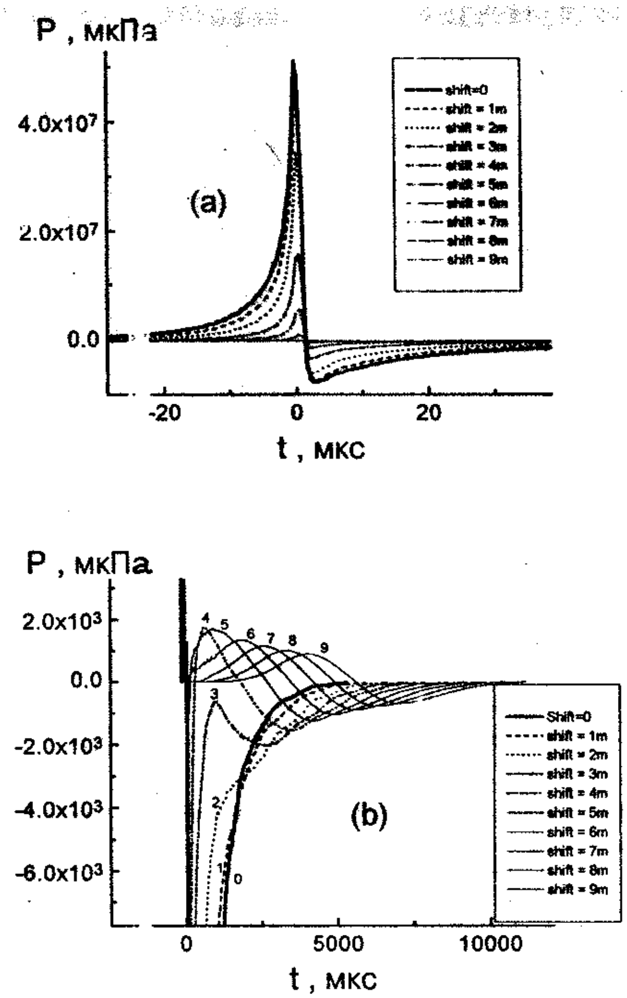


Рисунок 2

Acoustic pulses
E.m. cascade of 10^{21} eV
Distances R = 10, 100, 400, 1000 m
Shift = 440 m – max. cascade

LPM-effect taking into account



Acoustic pulse at distance 1 m from cascade (hadron), $E = 10^{20}$ eV
Shift = 0 – maximum of cascade

Рисунок 1

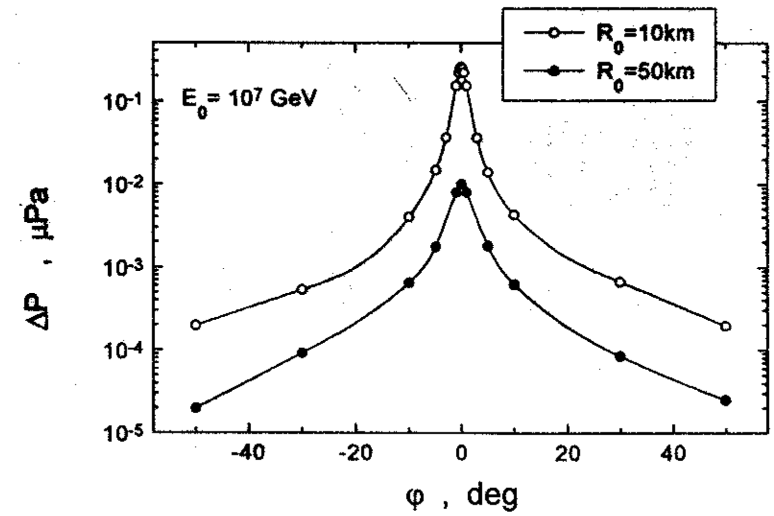


Figure 3. Maximal pressure value angular dependencies of acoustical pulse from high energ neutrino shower.

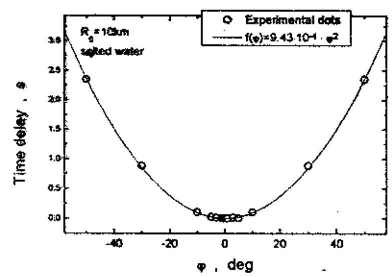


Figure 4. Angular dependencies of acoustical pulse time delay for high energy neutrino shower: $R_0 = 10$ km.

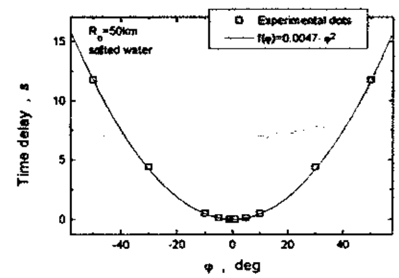


Figure 5. Angular dependencies (acoustical pulse time delay for high energ neutrino shower: $R_0 = 50$ km.

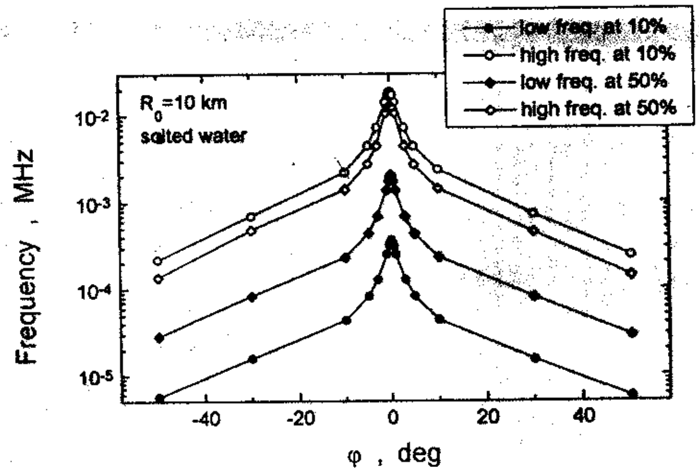


Figure 1. Angular dependencies of acoustical pulse boundary frequencies from high energy neutrino shower: $R_0 = 10$ km.

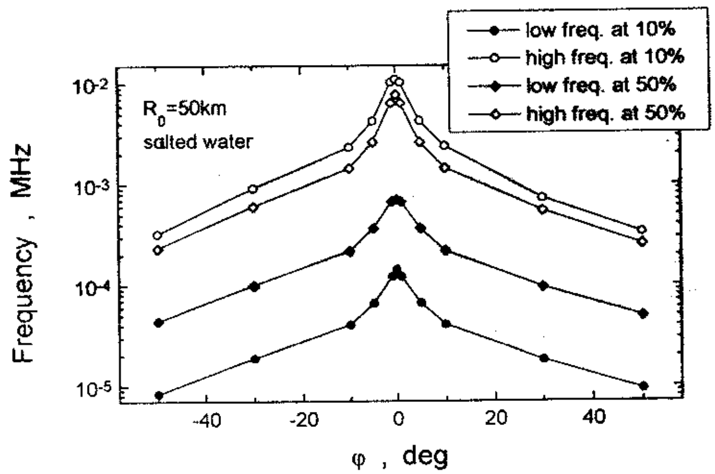


Figure 2. Angular dependencies of acoustical pulse boundary frequencies from high energy neutrino shower: $R_0 = 50$ km.

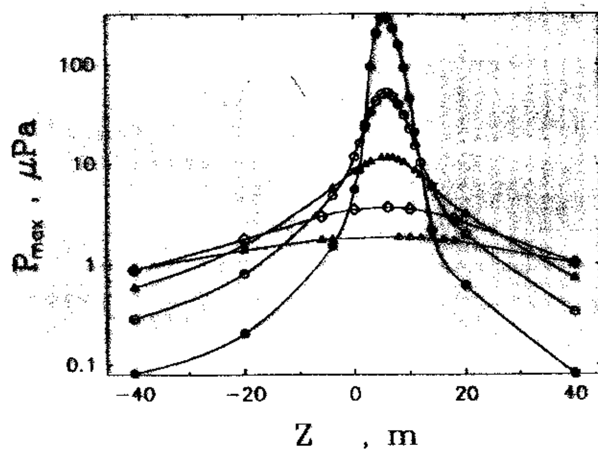


FIG. 5. The dependence of an acoustic signal amplitude on a displacement Z along the cascade axis. Symbols ●: R=100m; ○: R=400m; ▲: R=1000m; ◇: R=2000m; △: R=3000m. E_0=10 PeV.

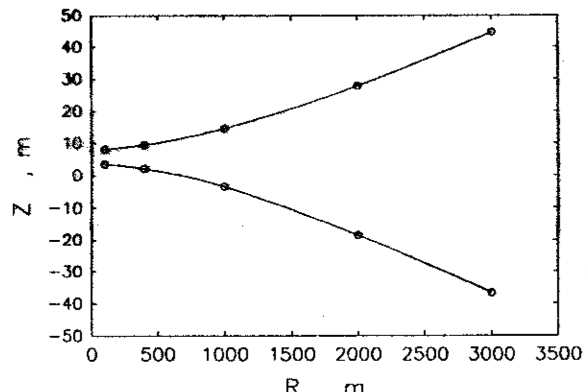


FIG. 6. Cross-section of divergent disk of acoustic radiation at -6 dB level for 10^{16} eV cascade. R - perpendicular distance from cascade axis.

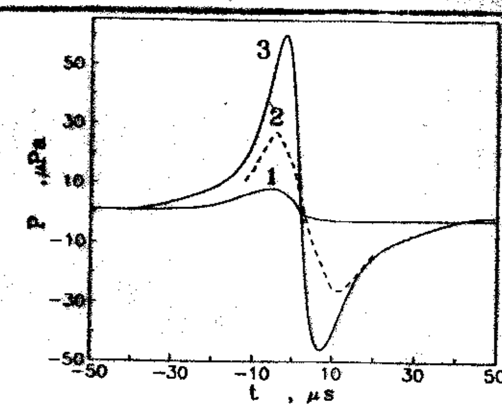


FIG. 3. The acoustic pulse in sea water at the distance of 400 m from a cascade with energy of 10 PeV. (1) Learned J. [5]; (2)Askaryan A. et al. [22], (3) Dedenko L. et al. [23].

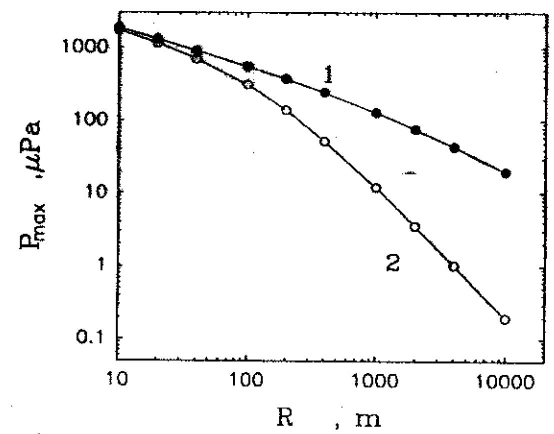


FIG. 4. The dependence of an acoustic signal maximal amplitude on a distance from the cascade shower without absorption (1) and with absorption taken into account (2).

USE EXISTING HYDROPHYSICAL ARRAY
1997

SADCO PROPOSAL – ACOUSTIC DETECTION of SHE neutrinos.

SHORT HISTORY:

1956	Askaryan G.	Acoustic method for particle detection
1976–1979	Askaryan, Dolgoshein, Bowen, Learned	Applications for UHE neutrinos

High threshold

Since 1991 diffuse AGN ν's Stecker, Birman, Mannheim, Protheroe et al

New interest to acoustic detection:

SADCO proposal – 1991 – for the Mediterranean Sea:

- to measure acoustic BG
- to calculate acoustic signals of SHE (EHE) cascades in water
- to suggest an acoustic array

SADCO collaboration

INR, Moscow: L.G. Dedenko, I.V. Denisov, S.Kh. Karaevsky, V.A. Matveev, A.A. Mironovich, I.M. Zheleznykh

MORFIZPRIBOR
St. Petersburg: Ya. S. Karlik

ACOUSTIC INST.,
Moscow: A.V. Furduev, V.D. Svet, V.P. Tebyakin

KAMCHATKA
HYDROPHYSICS INST.: G.E. Smirnov

HAWAII UNIV.,
Honolulu: J.G. Learned

+ (in 1999):

Rome Univ.: A. Capone

Kiel Univ.: P. Koske

16-18 Nov.
Igor Zheleznykh
INR, Moscow

SADCO status
(Sea Acoustic Detection of Cosmic Objects)

Gurgen Ashotovich ASKARYAN an

ALTERNATIVE KM3

NEUTRINO TELESCOPES

for UHE (>10^{15}eV) and SHE (>10^{18}eV) NEUTRINO ASTRONOMY.

I. ◉ RADIO-WAVE ν DETECTION in ANTARCTICA (Ant. ice as a ν target)

◉ RADIO-ASTRONOMY ν and HADRON DETECTION (the MOON as a target)

II. ◉ HYDROACOUSTICAL DETECTION of SHE νs

$E_{th} \sim 10^{19}$eV • Hydroacoustical array near Kamchatka as a cubic km-scale neutrino telescope.
(the Great Ocean as a ν target)

$E_{th} \sim 10^{15}$eV • New suggestion: to use submarine antennas as modules for SADCO