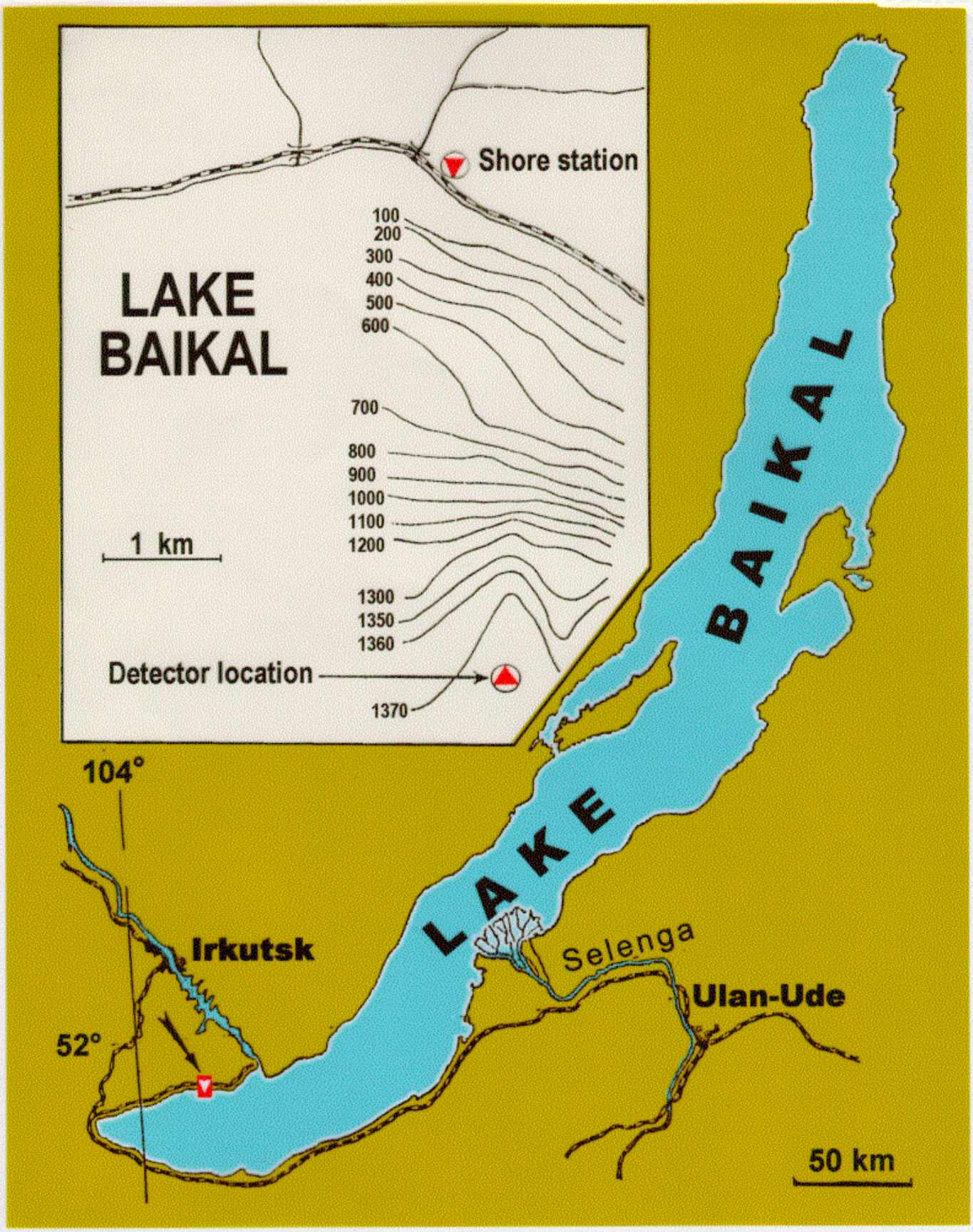
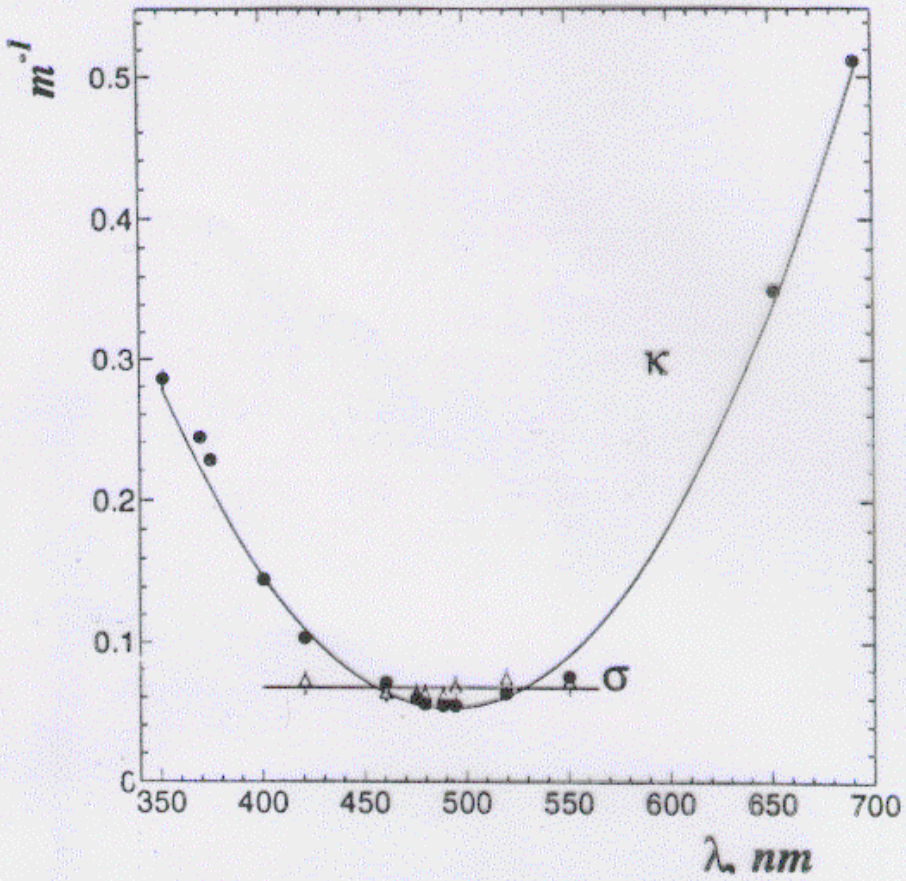
THE BAIKAL NEUTRINO PROJECT: STATUS REPORT

BAIKAL COLLABORATION

- Institute for Nuclear Research (Moscow, Russia)
- Irkutsk State University (Irkutsk, Russia)
- DESY Institute for High Energy Physics (Zeuthen, Germany)
- Moscow State University (Moscow, Russia)
- N.Novgorod State Technical University (N.Novgorod, Russia)
- State Marine Technical University (St.Petersburg, Russia)
- Kurchatov Institute (Moscow, Russia)
- Joint Institute for Nuclear Research (Dubna, Russia)
- KFKI (Budapest, Hungary)


LAKE BAIKAL
Shore station
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1350
1360
1370
1 km
Detector location
104°
52°
Irkutsk
Selenga
Ulan-Ude
LAKE BAIKAL
50 km

THE OPTICAL PARAMETERS OF THE BAIKAL WATER



COEFFICIENTS FOR LIGHT ABSORBTION (DOTS) AND SCATTERING (TRIANGLES) AT THE SITE OF BAIKAL EXPERIMENT AT THE DEPTH 1000 m VS. WAVELENGTH (IN SITU MEASUREMENTS, AUTUMN 1993)

$L_{abs} \sim 20$ meters ⇒ 22 ± 2 m

$L_{scatt} \sim 15$ meters ⇒ (23 - 30) m

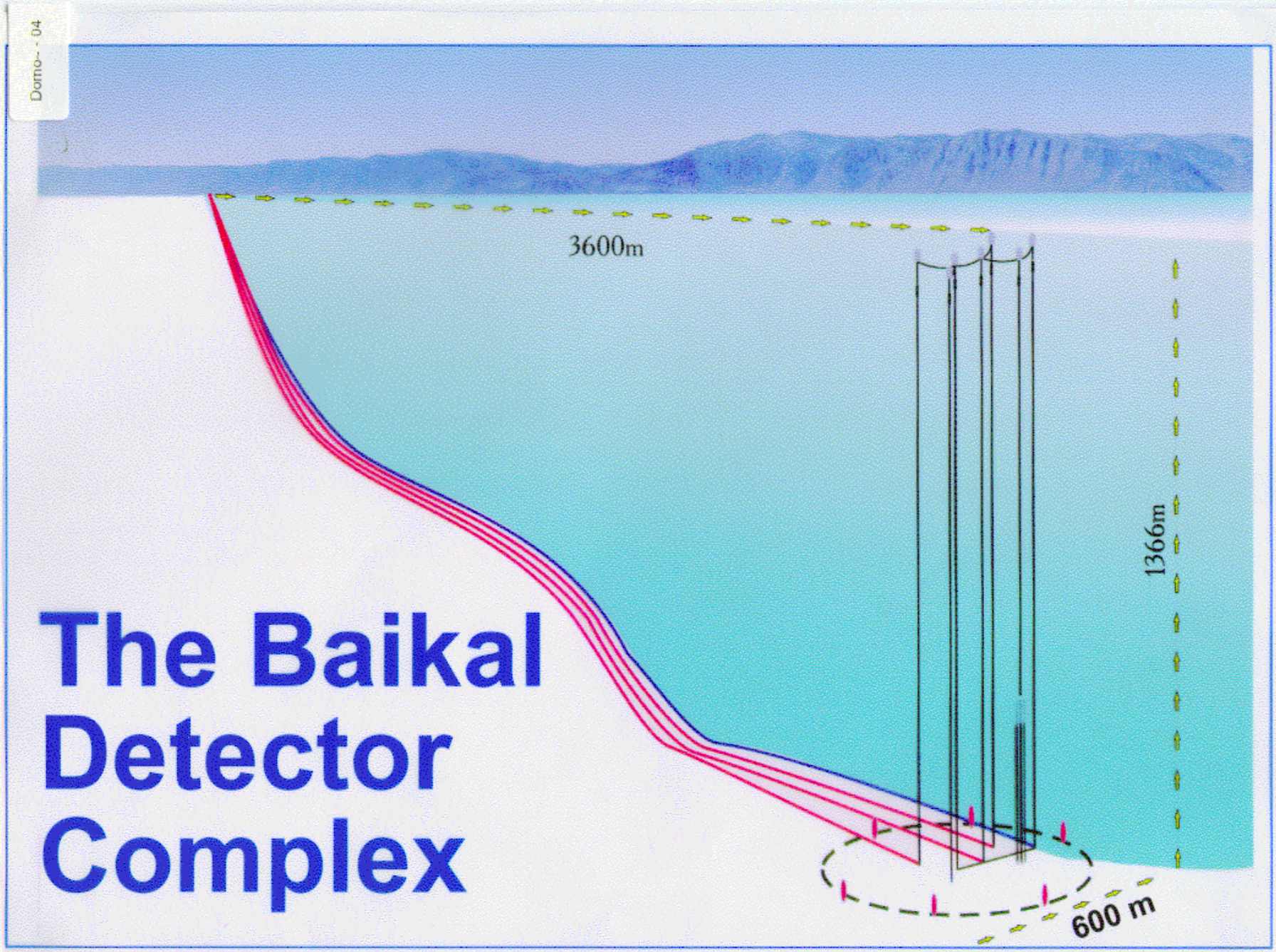
1996-1998 years

$\langle \cos\Theta \rangle \sim 0.95$ ⇒ 0.85 - 0.96

$L_{scatt}^{eff} = L_{scatt}/(1-\langle\cos\theta\rangle) = 300$ m

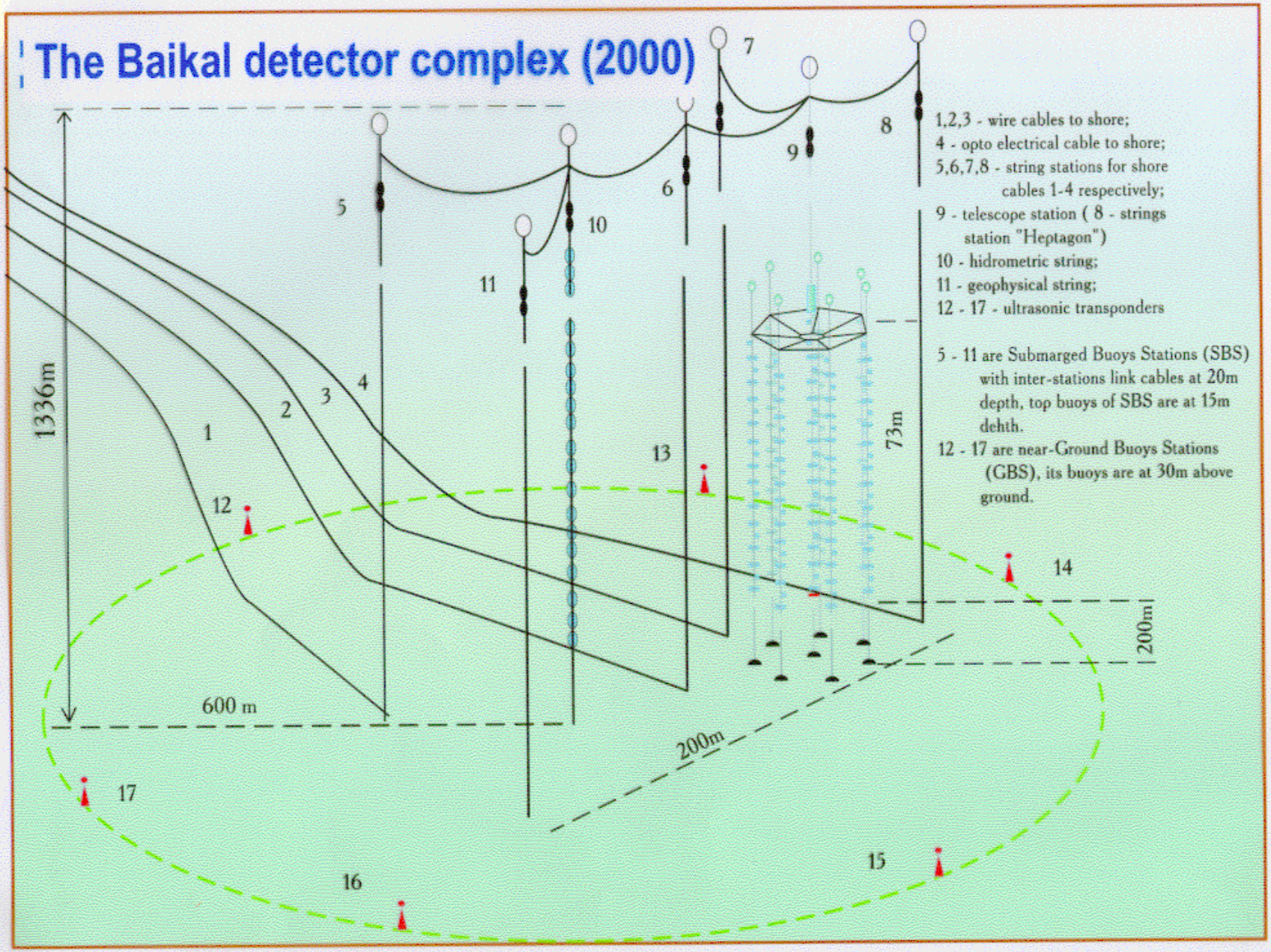
⇓

(100 - 400) m



The Baikal Detector Complex

The Baikal detector complex (2000)

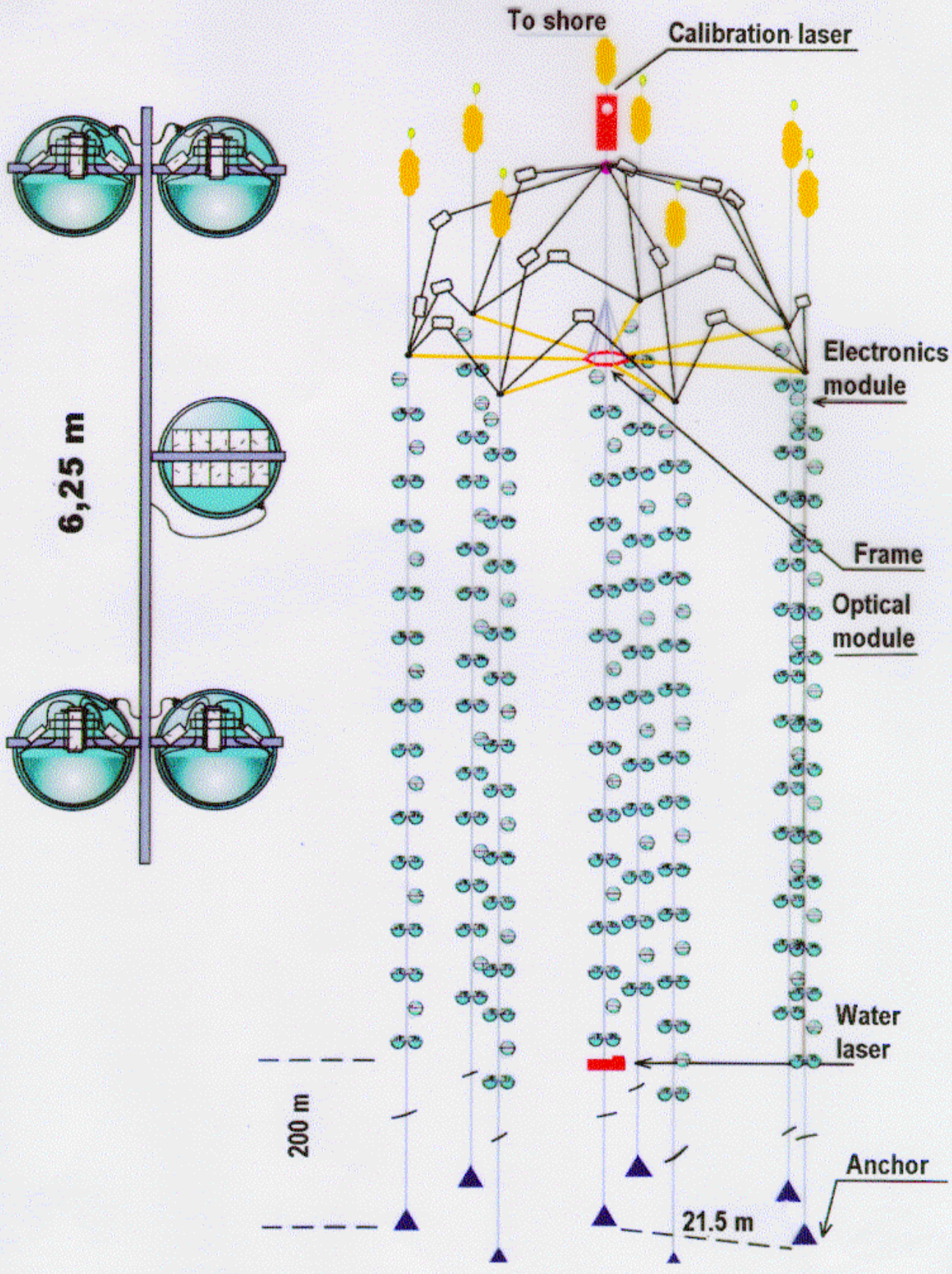


1,2,3 - wire cables to shore;
4 - opto electrical cable to shore;
5,6,7,8 - string stations for shore cables 1-4 respectively;
9 - telescope station (8 - strings station "Heptagon")
10 - hidrometric string;
11 - geophysical string;
12 - 17 - ultrasonic transponders

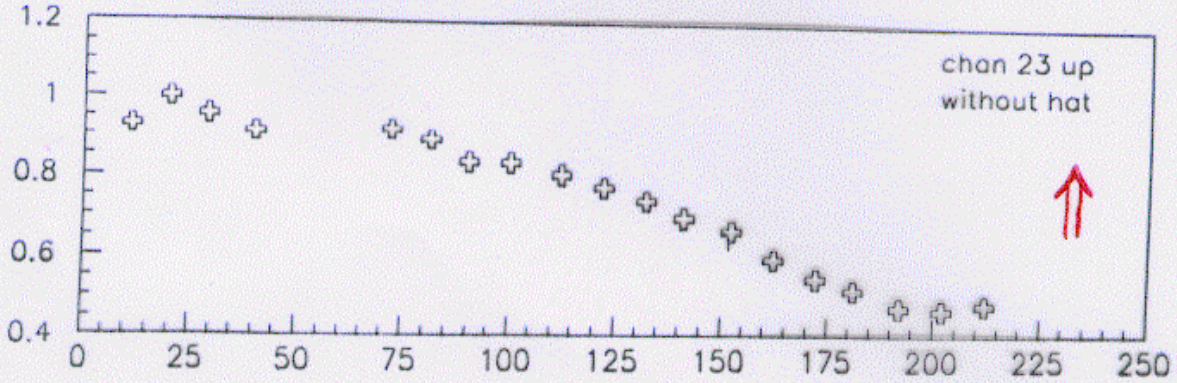
5 - 11 are Submarged Buoys Stations (SBS) with inter-stations link cables at 20m depth, top buoys of SBS are at 15m dehth.

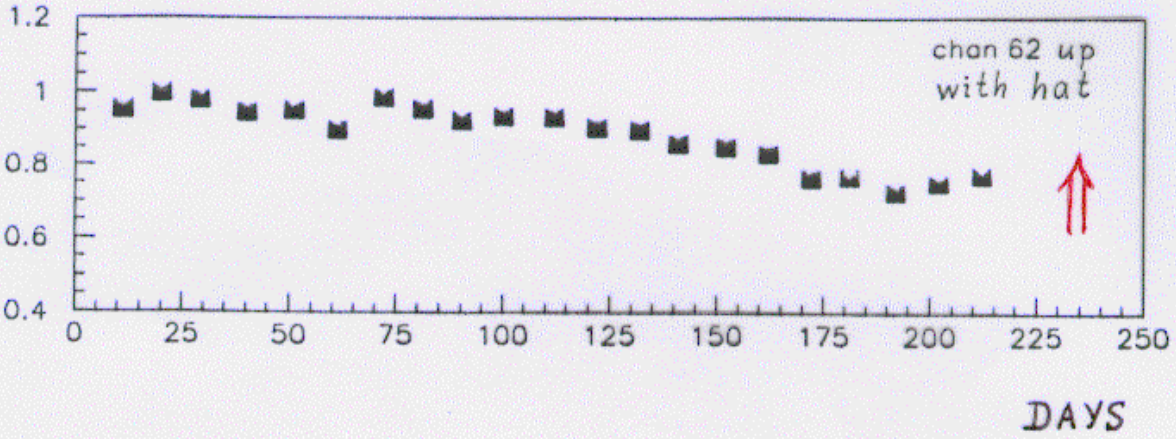
12 - 17 are near-Ground Buoys Stations (GBS), its buoys are at 30m above ground.

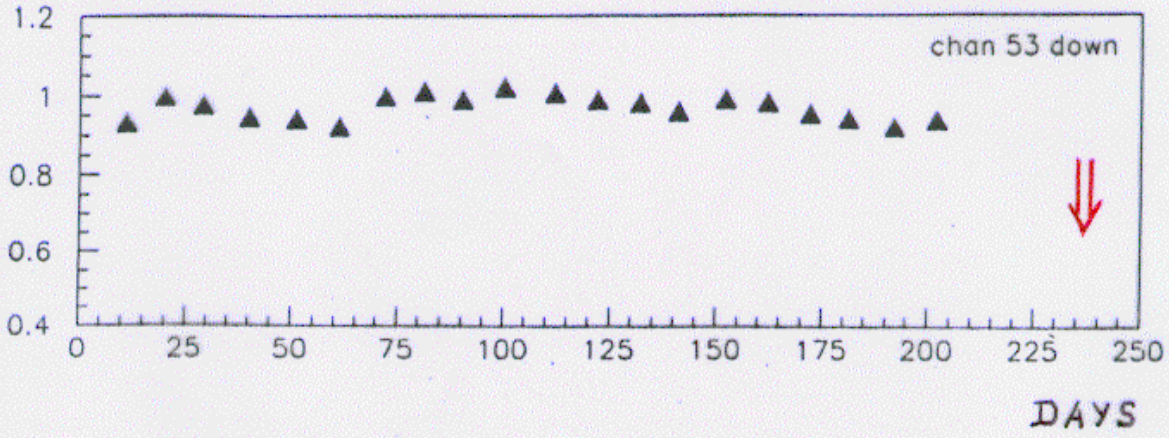
NEUTRINO TELESCOPE NT-200



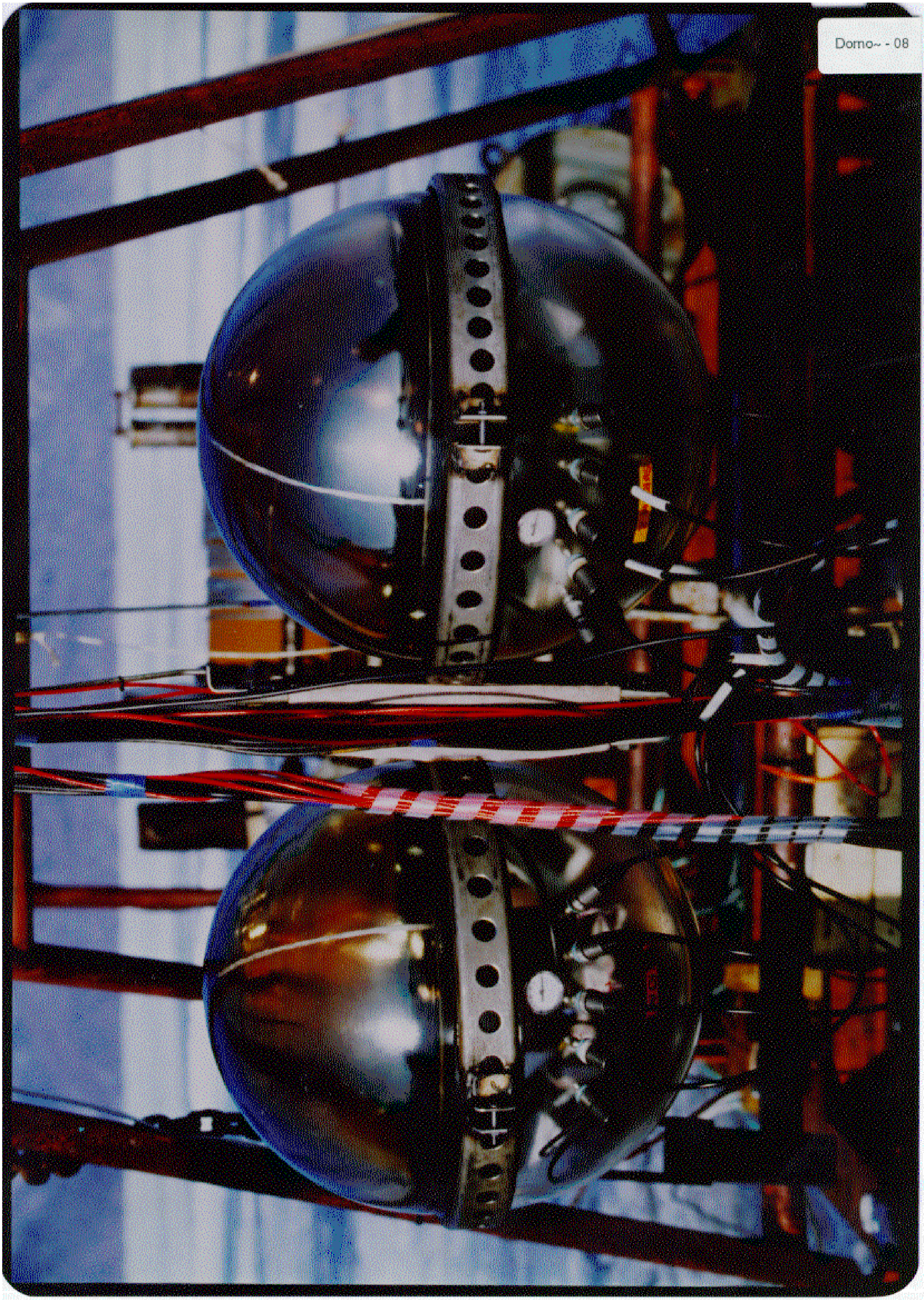
FOULING

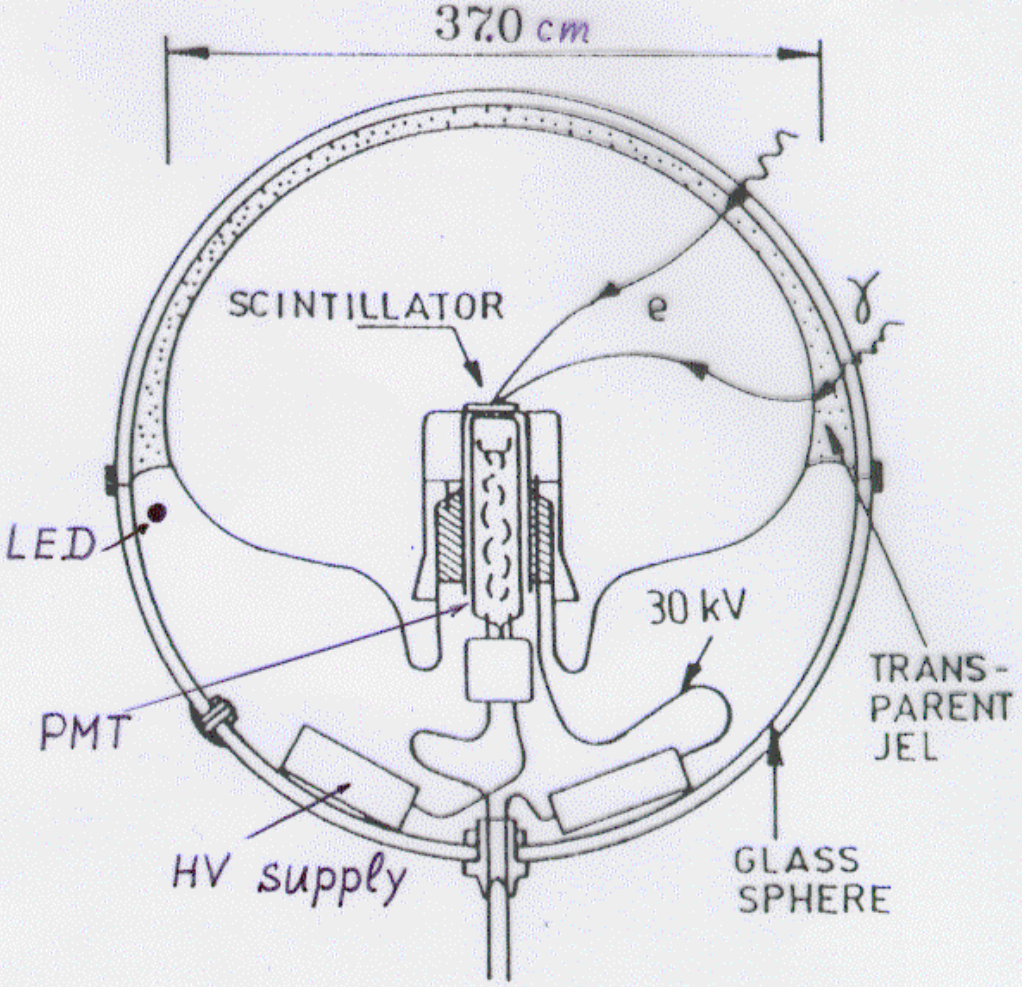

1.2
1
0.8
0.6
0.4
0
25
50
75
100
125
150
175
200
225
250
chan 23 up
without hat
DAYS


1.2
1
0.8
0.6
0.4
0
25
50
75
100
125
150
175
200
225
250
chan 62 up
with hat
DAYS


1.2
1
0.8
0.6
0.4
0
25
50
75
100
125
150
175
200
225
250
chan 53 down
DAYS

Domo~ - 08





BAIKAL OPTICAL MODULE

Phototube 'QUASAR'

The transit time differences due to geometrical path length < 1 ns.

Signal transit time distribution < 2 ns.

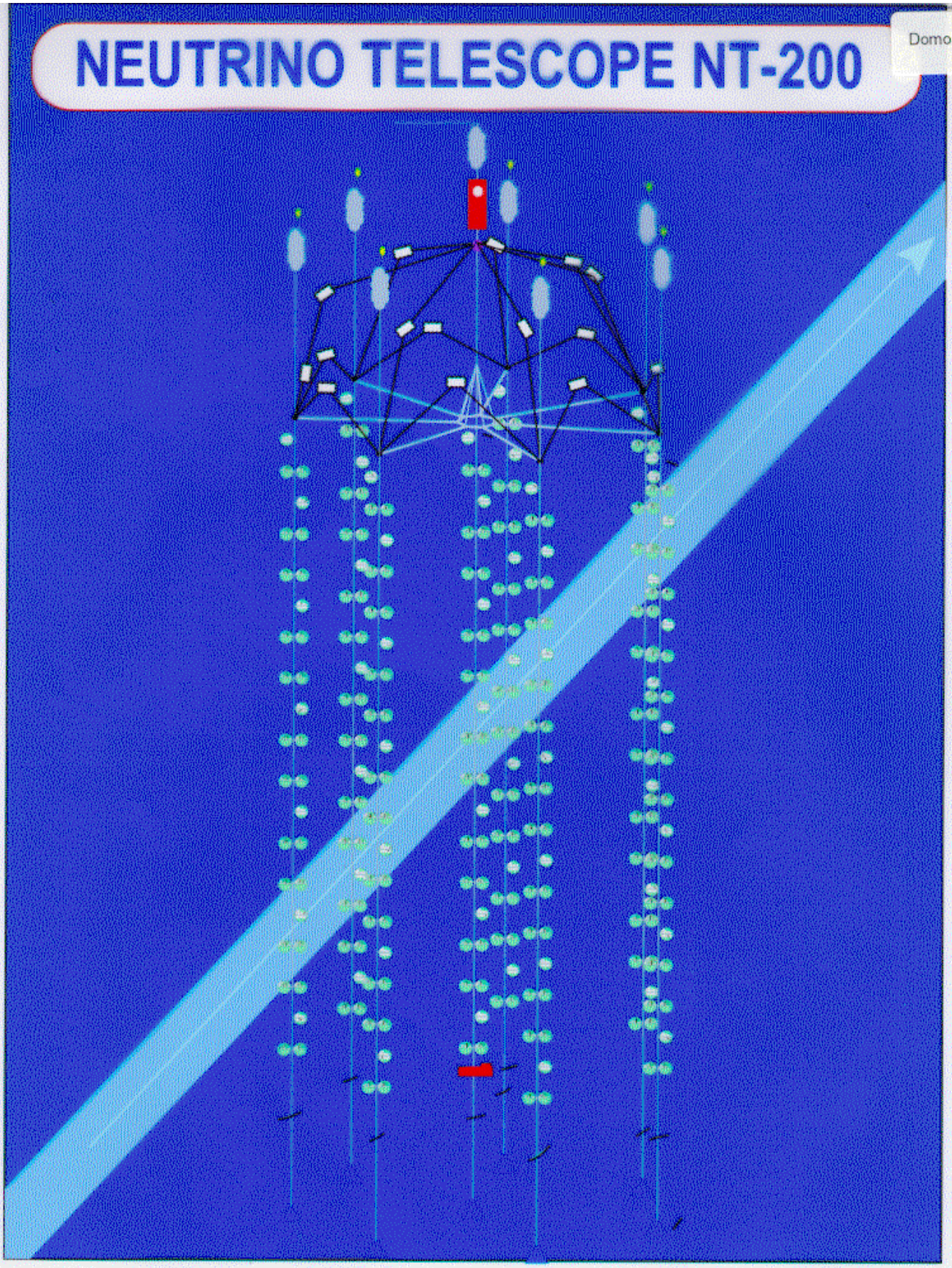
Single electron resolution < 70 %

Time jitter for 1 p.e. illumination is typically ~ 3 ns (FWHM)

Gain > 10^8

Peak / Valley ~ 2.5

NEUTRINO TELESCOPE NT-200



Domo-- 11

NT-200 STAGES

ν_{atm} $S_{eff}(\mu_\nu)$

		PMT		
APRIL	1993	36	3 short strings	150 m^2 ONLY NEARLY VERTICAL
	1994	36	— " — " —	
	1995	72	4 short + 1 long	
	1996	96	4 long strings	~400 m^2
	1997	144	6 long strings	~800 m^2
	1998	192	8 long strings	~1300 m^2
up to now				

LIVE TIME (1998) - 240 d = 6 d (8 str) + 101 d (~7str) + 133 d (~6str)

NT-200 (2000) - 9 ch (total-96) dead now

NEUTRINO INDUCED EVENTS (1998 y)

(WORK IN PROGRESS)

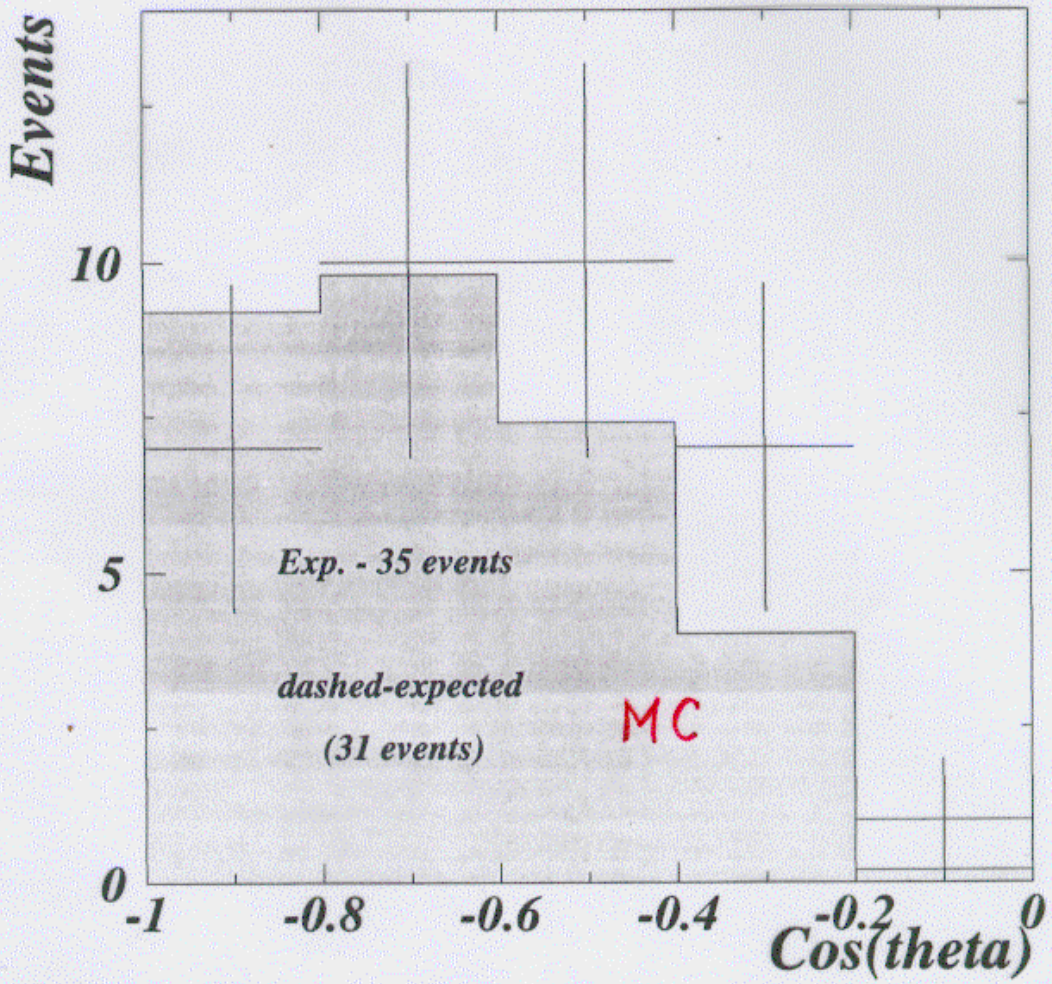
LIVE TIME - 240 days

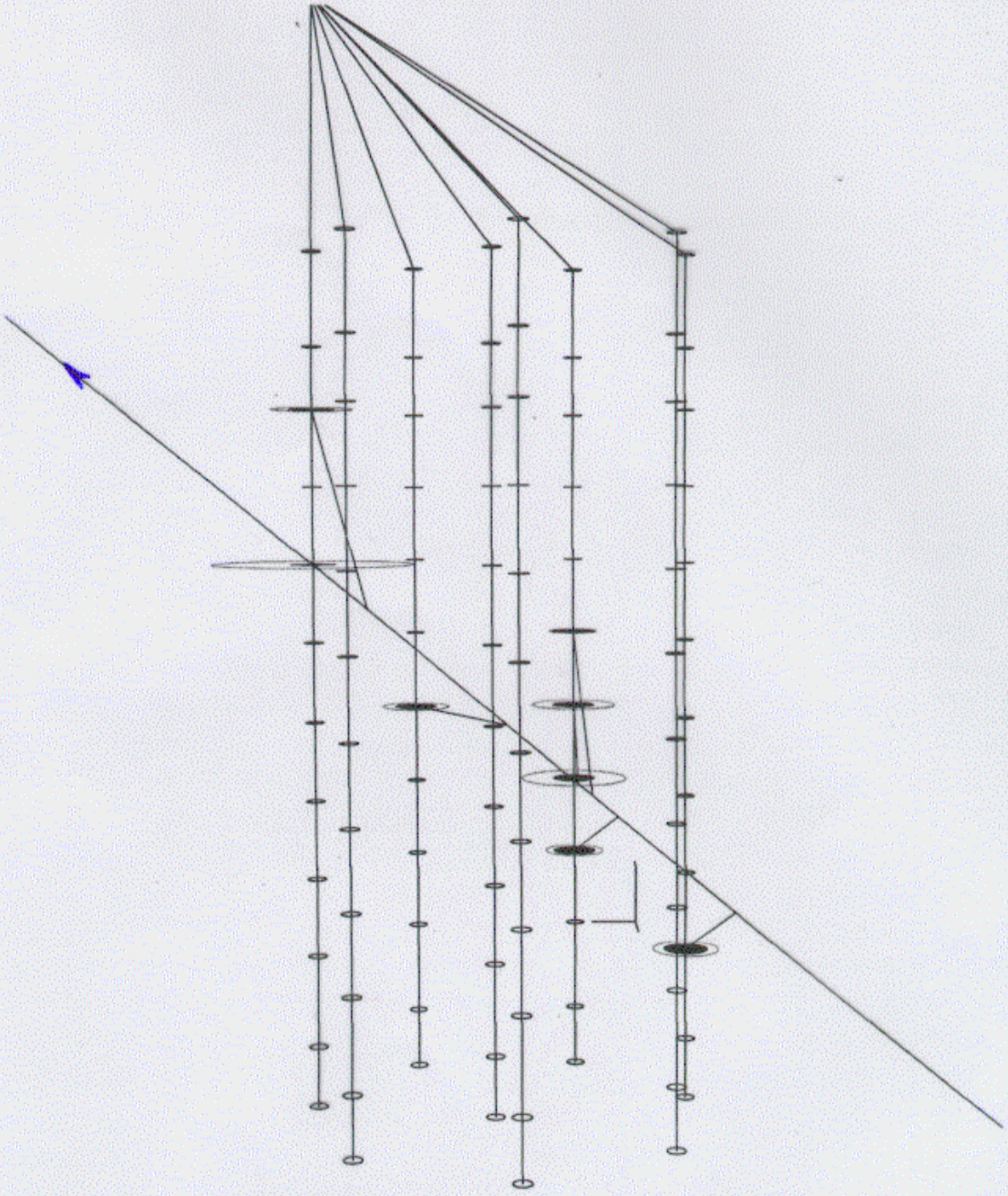
	Data	ν_{atm} (MC)
. NUMBER OF OFF-LINE TRIGGERS 6/3	$5.3 \cdot 10^7$	140
. RECONSTRUCTED AS TRACK WITH $\cos\theta < 0$	$2.5 \cdot 10^6$	140
. CUTS 1 - 11	35	31

BACKGROUND

. DETAILED MC FOR BACKGROUND INDUCED BY ATMOSPHERIC MUONS	$2.8 \cdot 10^6$
. RECONSTRUCTED AS TRACK WITH $\cos\theta < 0$	$1.35 \cdot 10^5$
. CUTS 1 - 11	0

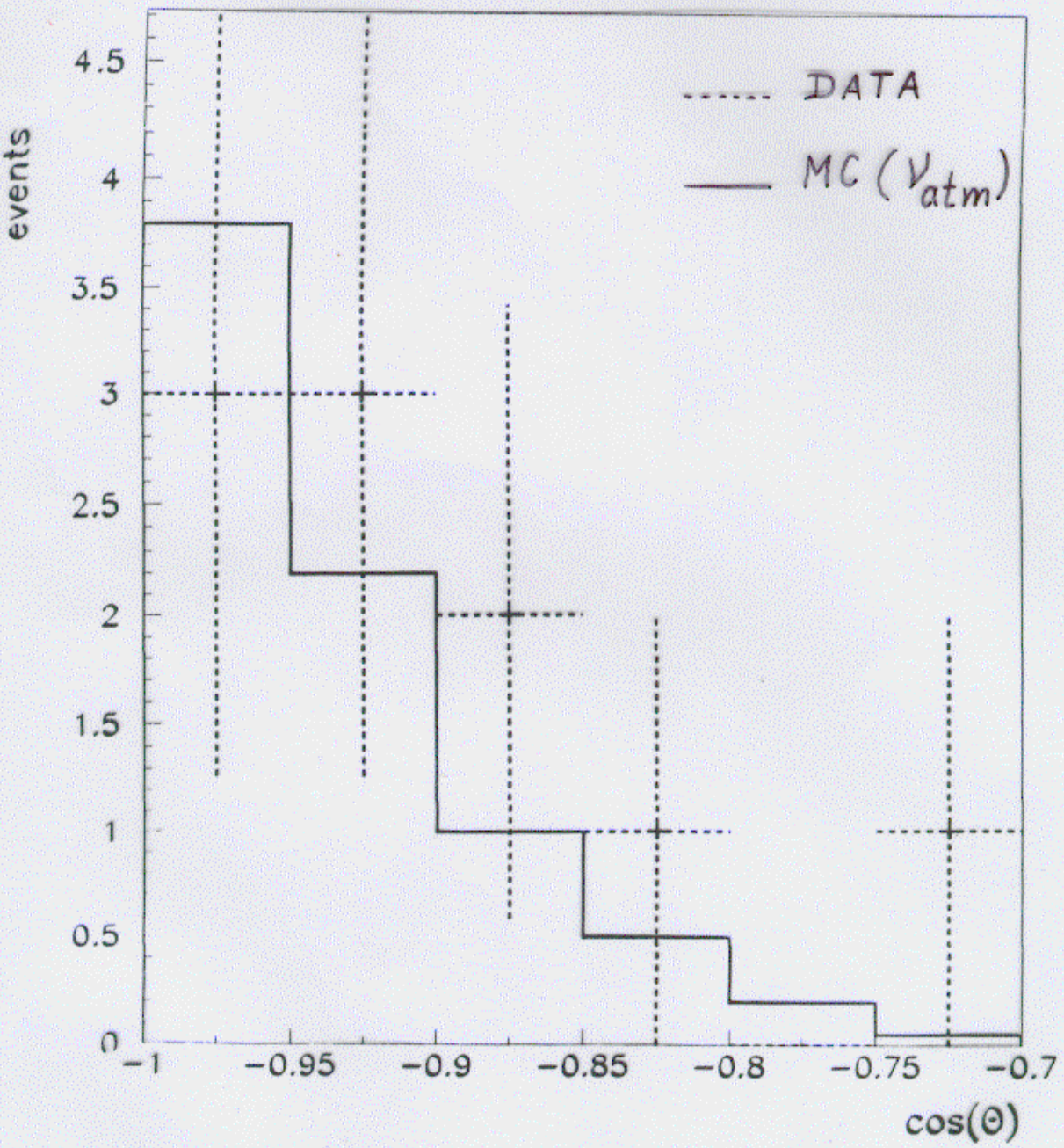
35 NEUTRINO CANDIDATES





NEUTRINO CANDIDATE, $\theta = 117^{\circ}$

NEAR VERTICAL UPGOING MUONS (1998y)



NEAR VERTICAL MUON TRACK, $\theta = 167^\circ$

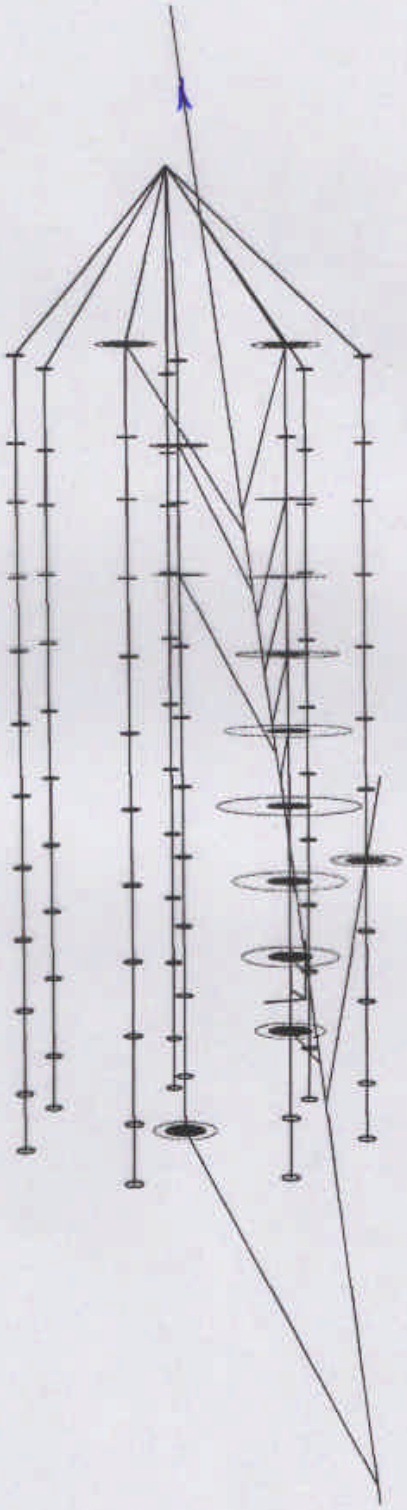
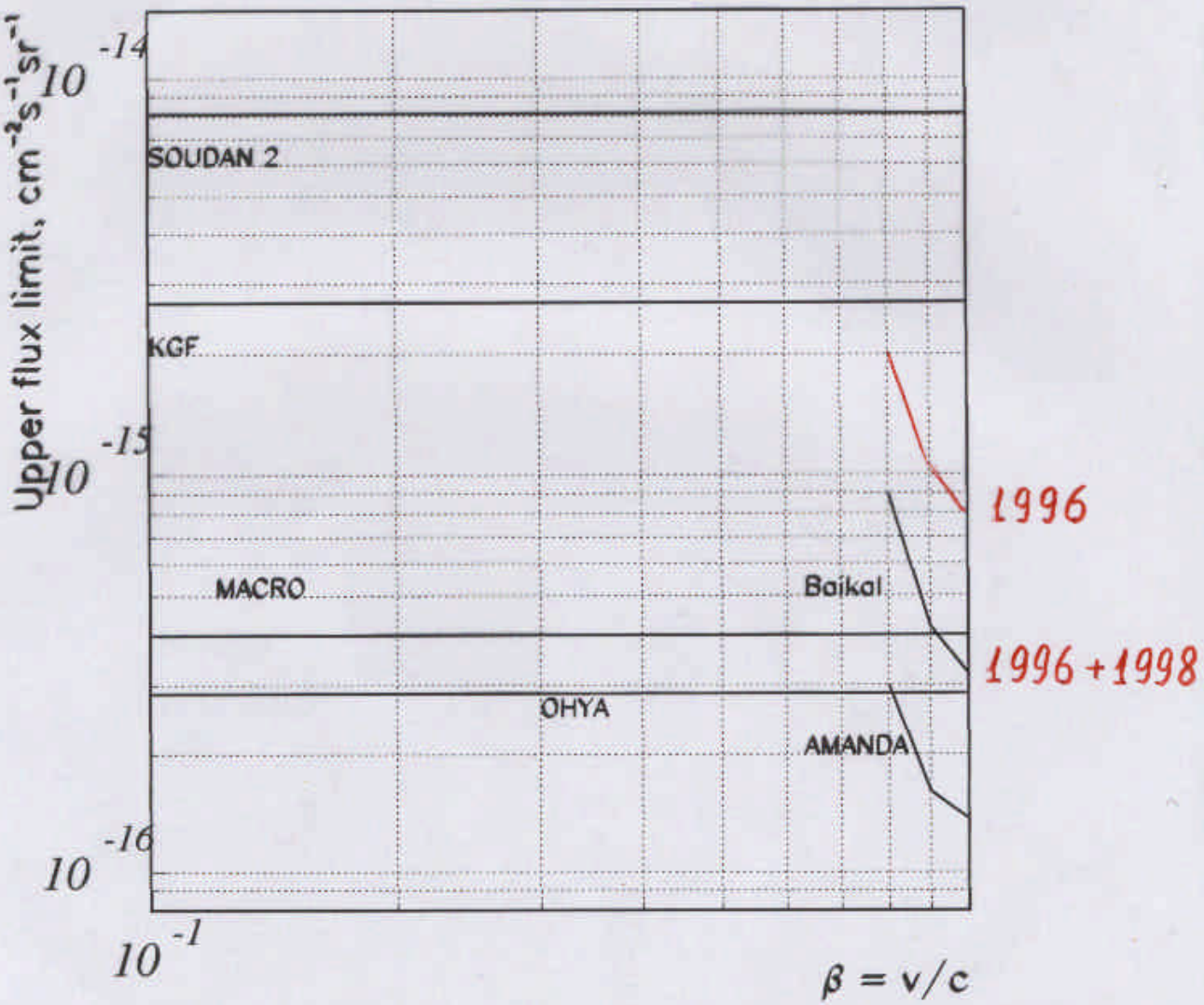


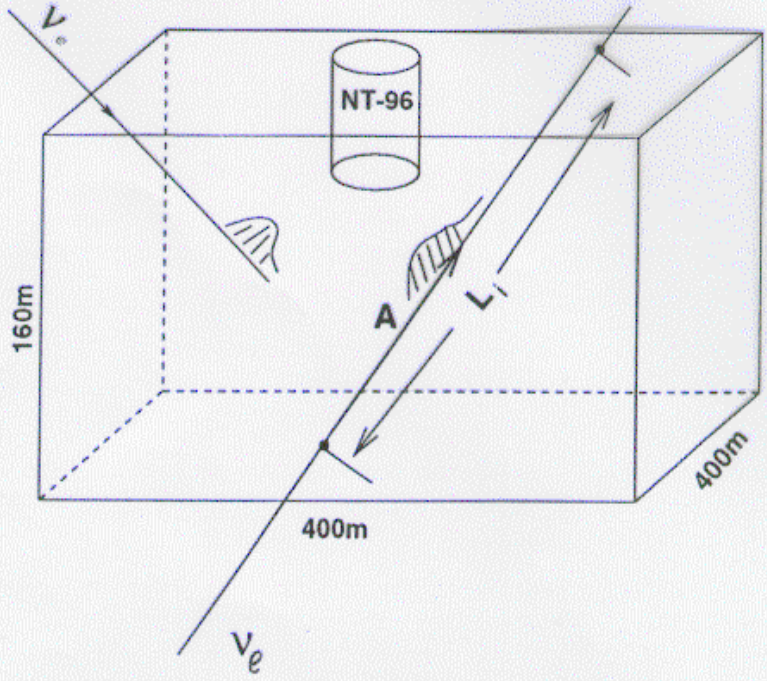
Table 1: 90% C.L. upper limits on the muon flux from the center of the Earth for six regions of zenith angles obtained in different experiments

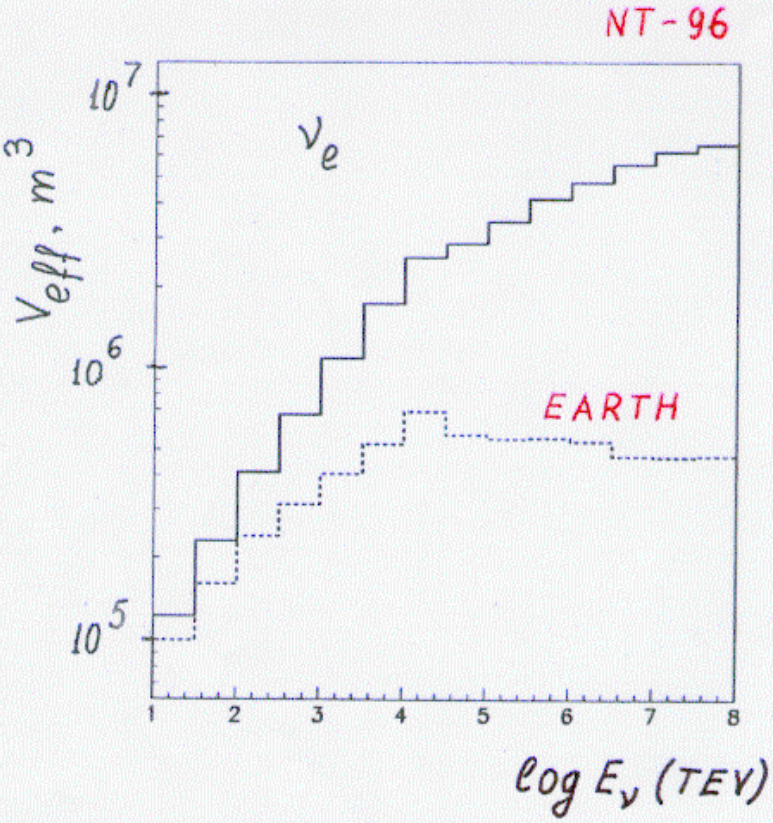
Half-cone	*Baikal*		Flux limit $(10^{-14} \cdot (cm^2\ sec)^{-1})$		
	Data	Back-ground	*Baikal* $> 10GeV$	*Baksan* $> 1GeV$	*MACRO* $> 1.5GeV$
30°	8	6.6	4.7	2.1	2.01
25°	6	5.6	3.4	3.2	1.56
20°	3	4.3	1.9	2.1	1.28
15°	2	2.7	1.5	–	1.03
10°	1	1.3	1.8	0.93	0.66
5°	0	0.4	1.2	0.54	0.51

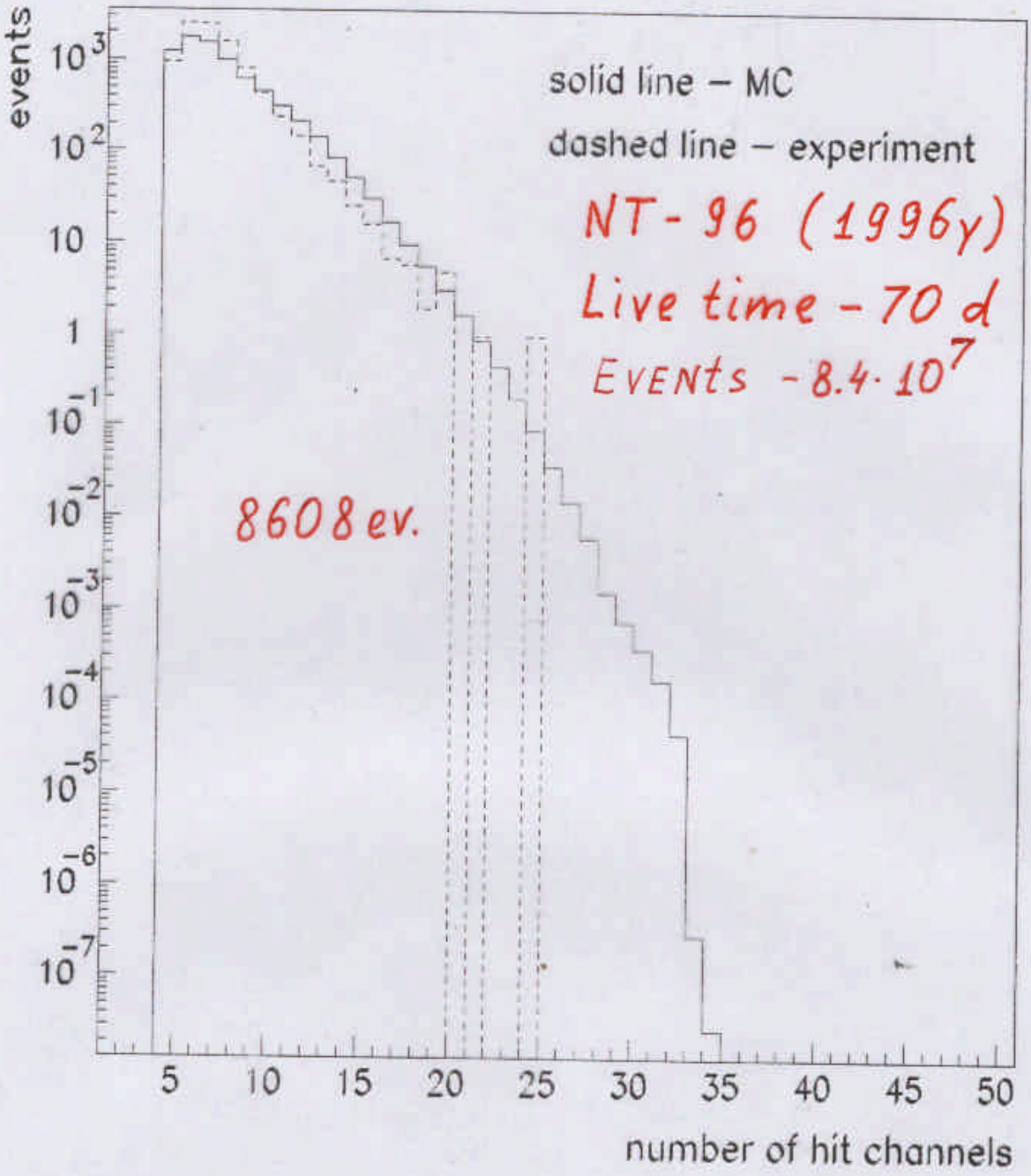
304 d

MAGNETIC MONOPOLE



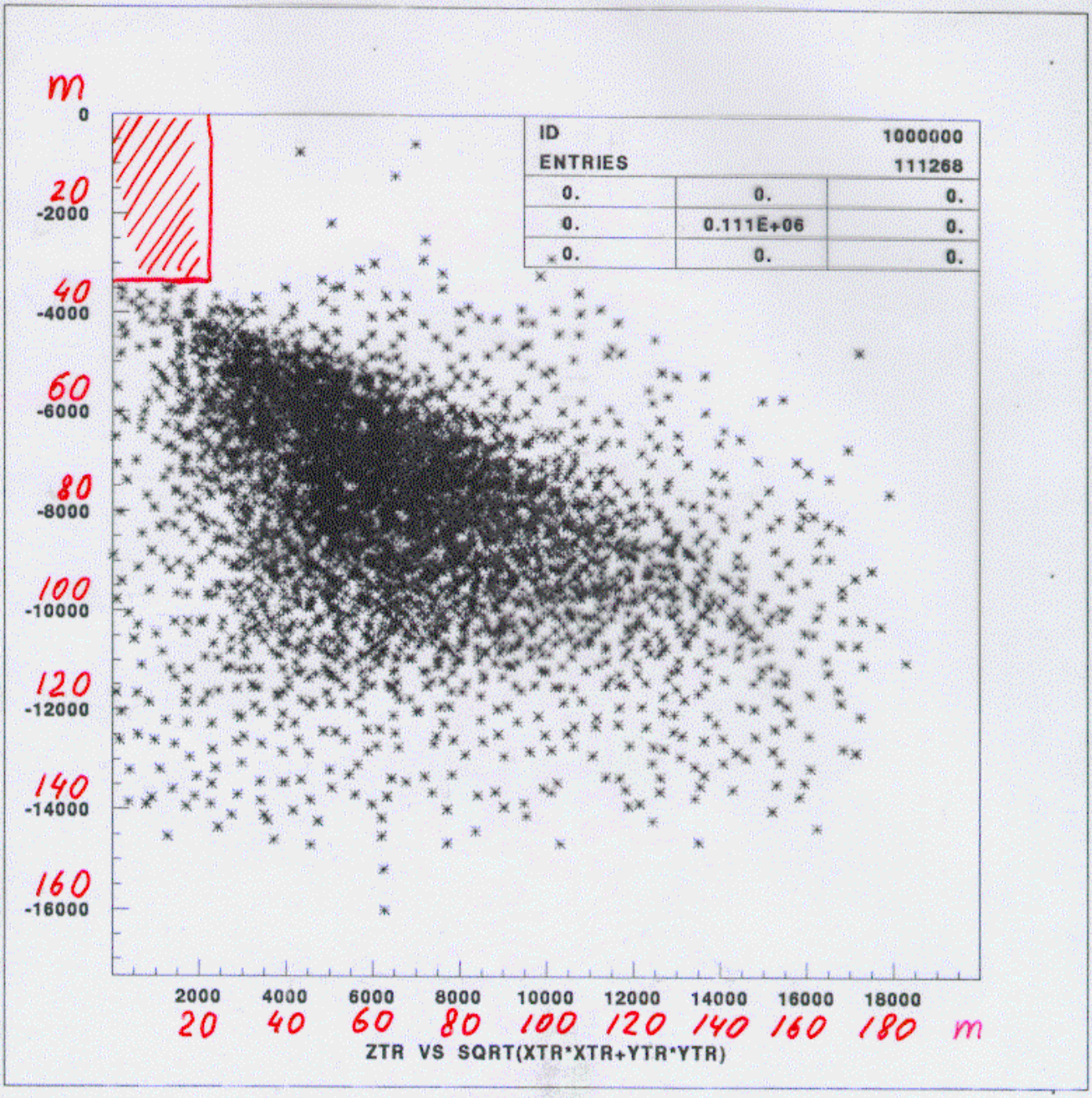

ν_e
NT-96
160m
A
L_i
400m
400m
ν_e


NT-96
10^7
10^6
10^5
ν_e
V_{eff}, m^3
EARTH
1
2
3
4
5
6
7
8
log E_ν (TEV)



MULTIPLICITY

- $|(t_i - t_j) - z_{ij}/c| < a \cdot z_{ij} + \delta_{ij}$ ($\delta = 5$ ns) ($a = 0$; $= 1$ ns/m)
- $N_{hit} > 25$ (27, 29)



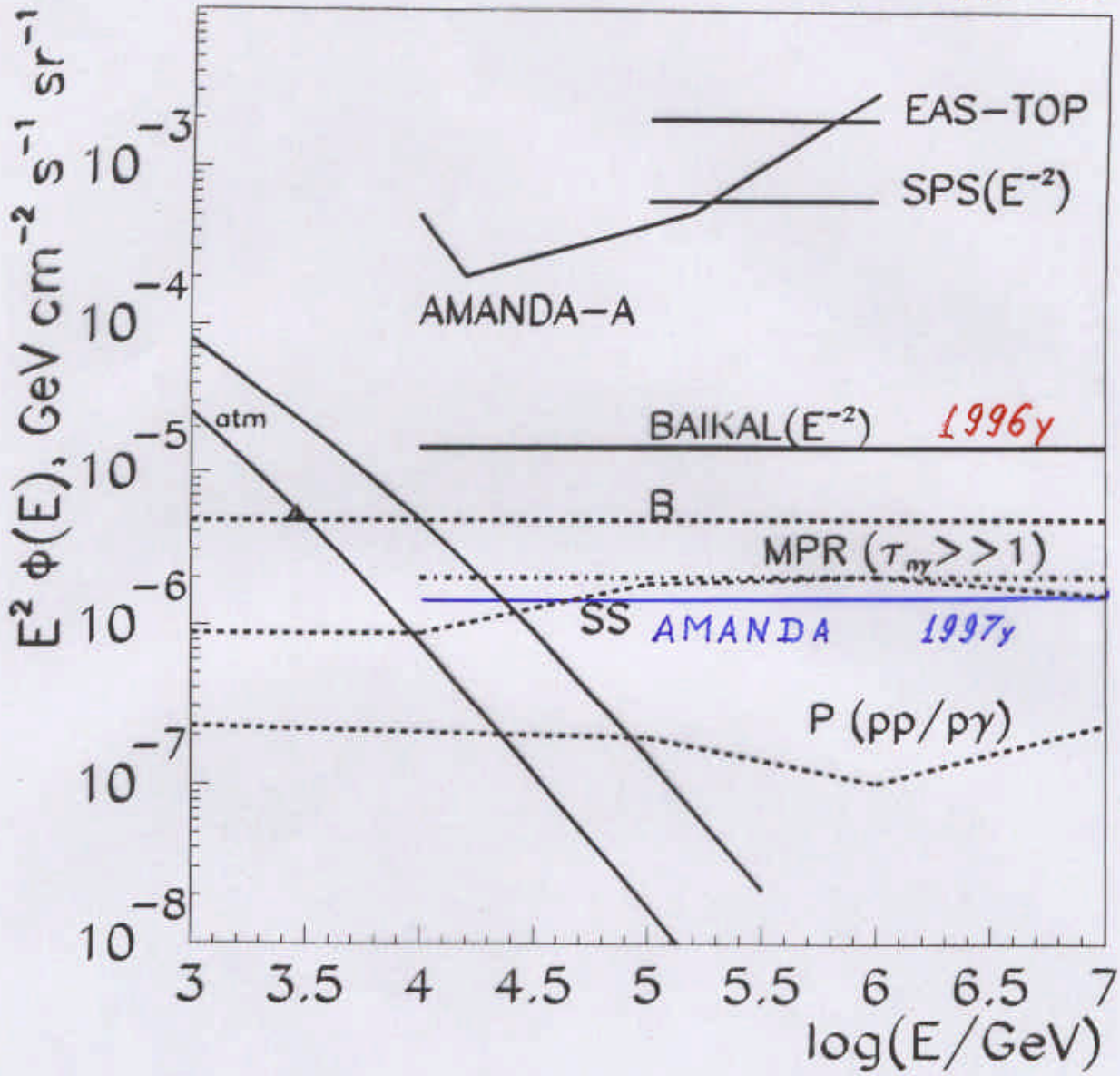
$6 \cdot 10^{16}$ eV

$\tilde{\nu}_e + e^- \Rightarrow W^-$

VERY HIGH ENERGY NEUTRINOS

[redacted]

NT-96

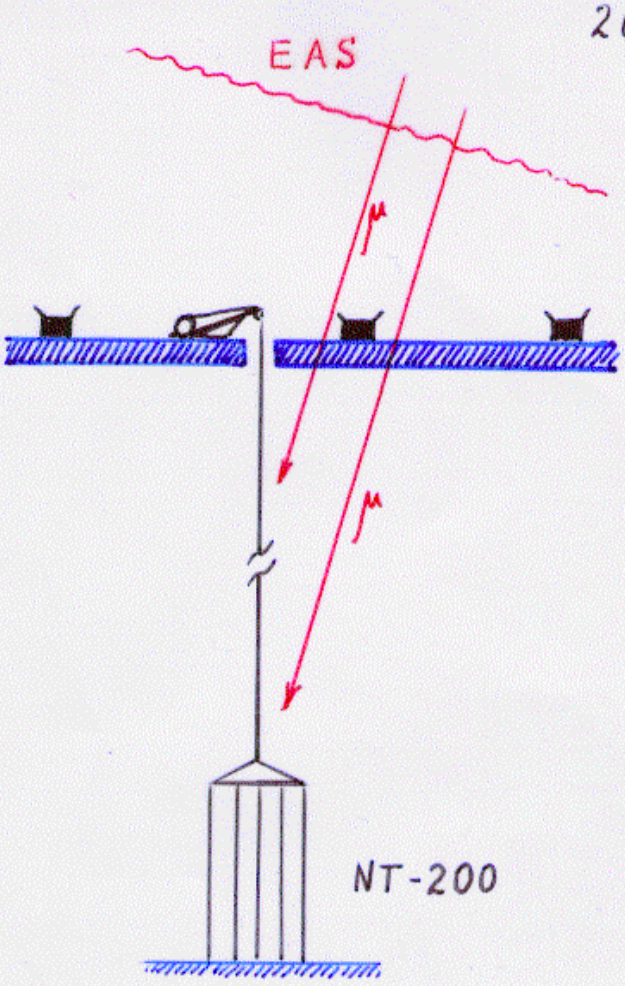


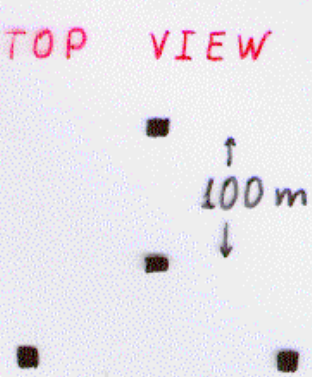
$\tilde{\nu}_e + e^- \Rightarrow W^- \Rightarrow$ anything $\quad E_0 = 6.3 \cdot 10^6$ GeV

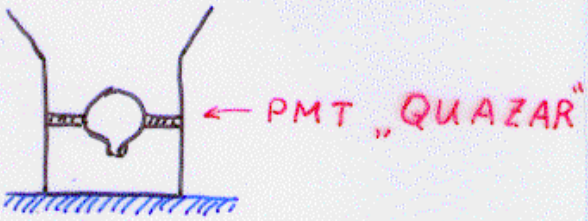
$$\begin{cases} \nu_e(\tilde{\nu}_e) + N \overset{CC}{\Rightarrow} l^-(l^+) + \text{hadrons} \\ \nu_e(\tilde{\nu}_e) + N \overset{NC}{\Rightarrow} \nu_e(\tilde{\nu}_e) + \text{hadrons} \end{cases}$$

CHERENKOV EAS ARRAY ON THE ICE

2000 year



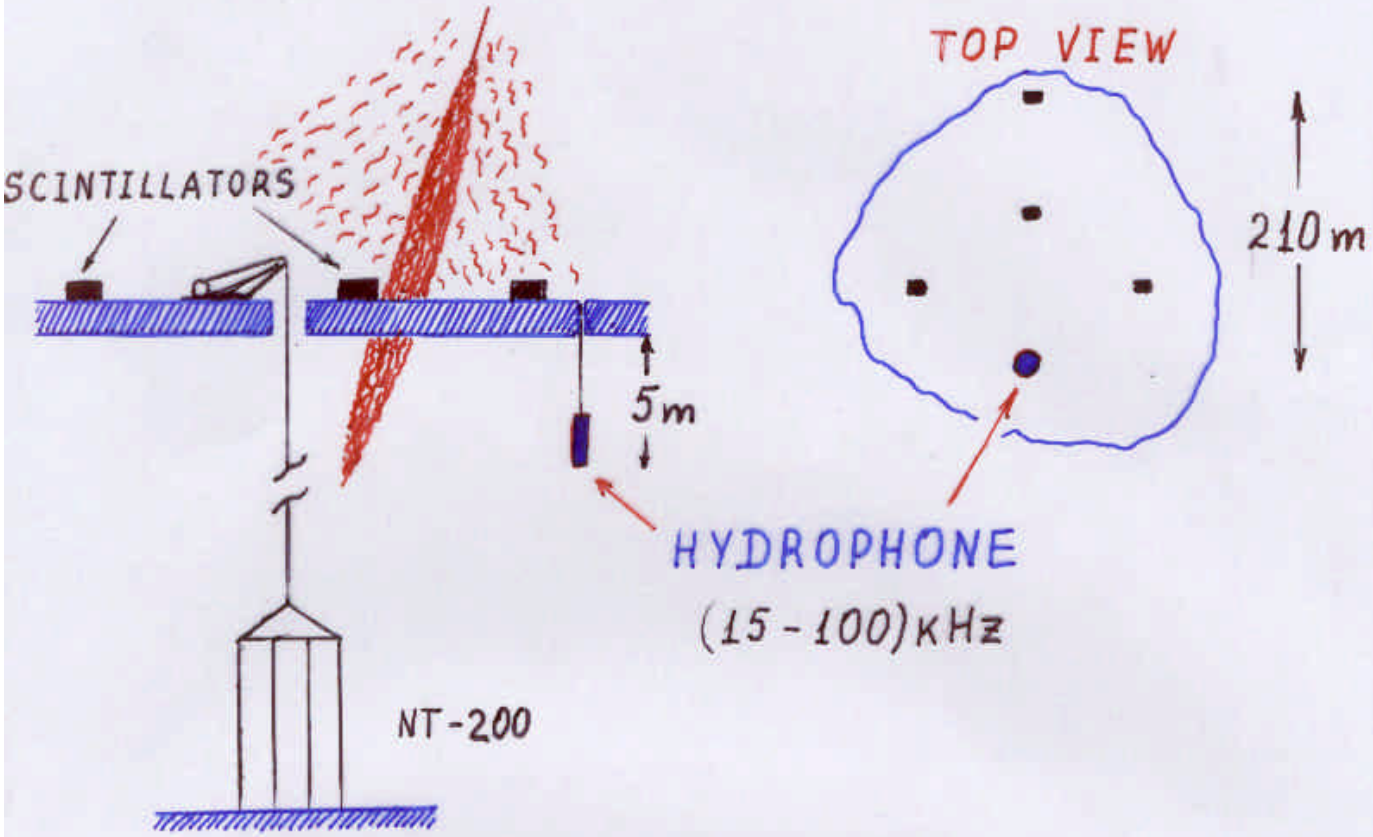




ANGULAR RESOLUTION	~ 0.5°
ENERGY THRESHOLD	~ 100 TeV
WORKING TIME	- 21 h
EVENTS (coincidence)	- 580

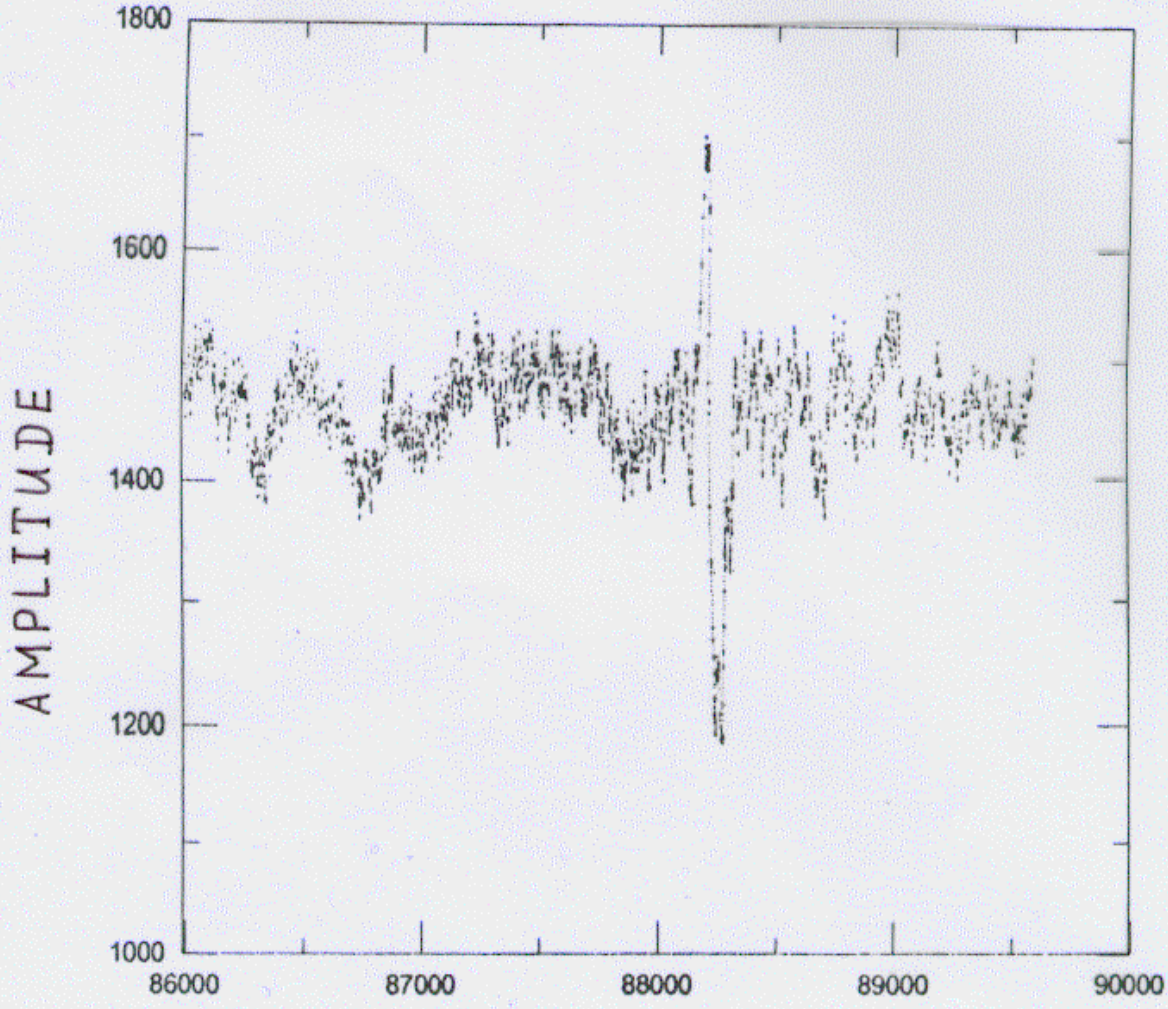
FIRST OBSERVATION
2000 y

EAS ARRAY + HYDROPHONE



EAS TRIGGER - 4-FOLD COINCEDENCE

RATE OF EAS TRIGGER	3 hour^{-1}
ENERGY THRESHOLD	~ 10^{16} eV
RATE OF EAS TRIGGER + HYDROPHONE	1 hour^{-1}



SAMPLE OF REGISTRATED SIGNAL

SUMMARY

CURRENT ACTIVITY

- DATA TAKING, KEEPING FULL DETECTOR ON
- DATA ANALYSIS - ν_{atm}, WIMP, MONOPOLE, VERY HIGH ENERGY NEUTRINOS
- ENVIRONMENT STUDIES

R & D

- DETECTION ACOUSTIC SIGNAL FROM VERY HIGH ENERGY NEUTRINO INTERACTIONS
- NEW VERSIONS OF OPTICAL MODULES, UNDERWATER ELECTRONICS, DATA TAKING SYSTEM (FIBER OPTIC)
- MORE LARGE-SCALE NEUTRINO DETECTOR