NESTOR

NEUTRINO EXTENDED SUBMARINE TELESCOPE WITH OCEANOGRAPHIC RESEARCH

The NESTOR Collaboration

GERMANY	UNIVERSITY OF KIEL UNIVERSITY OF HAMBURG
GREECE	UNIVERSITY OF ATHENS UNIVERSITY OF CRETE DEMOKRITOS NATIONAL RESEARCH CENTER NESTOR INSTITUTE FOR : DEEP SEA RESEARCH TECHNOLOGY AND NEUTRINO ASTROPARTICLE PHYSICS
ITALY	UNIVERSITY OF FLORENCE UNIVERSITY OF ROME * FRASCATI *
RUSSIA	RUSSIAN ACADEMY OF SCIENCES : INSTITUTE FOR NUCLEAR RESEARCH, INSTITUTE OF OCEANOGRAPHY, EXPERIMENTAL DESIGN BUREAU OF OCEANOLOGICAL ENGINEERING
SWITZERLAND	BERN UNIVERSITY CERN*
USA	SCRIPPS INSTITUTE OF OCEANOGRAPHY UNIVERSITY OF HAWAII UNIVERSITY OF WISCONSIN

* NOT PARTICIPATING AFTER 1/1/99

* LONG BASE LINE

PHYSICS SCOPE OF NEUTRINO TELESCOPES

1. NEUTRINO ASTRONOMY (galactic and extragalactic) and the search for cosmic accelerators.

2. PHYSICS BEYOND THE STANDARD MODEL (a few examples follow):

(a) SEARCH FOR DARK MATTER PARTICLES. Their annihilation or decay will eventually give neutrinos e.g. neutralinos trapped in the Sun or the Earth.

(b) ULTRA HIGH ENERGY NEUTRINOS have energies beyond 10^7 GeV in the Laboratory. No terrestrial accelerator can produce these energies. If the neutrino telescope is large enough the limitation of low flux can be, in part, overcome and this might be the only way for High Energy Physics to reach these Ultra High Energies. In any case we can start right away, the experimental problems of neutrino telescopes are well understood.

Multiple W/Z production. Search for possible substructure of the elementary particles i.e. compositeness of quarks and leptons.

3. NEUTRINO OSCILLATIONS using neutrinos produced in the atmosphere. The large range of the available oscillation length (15 km to 13000 km) gives an extremely good sensitivity down to $\Delta m^2 \sim 10^{-4}$ eV^2

4. LONG BASELINE NEUTRINO OSCILLATIONS using one of the high energy physics accelerators.

5. PROTON DECAY (in the sense that the ultimate background to proton decay experiment is atmospheric neutrino interactions and therefore a low threshold neutrino telescope can also be a proton decay detector).

6. SUPERNOVAE DETECTION.

7. MAGNETIC MONOPOLES.

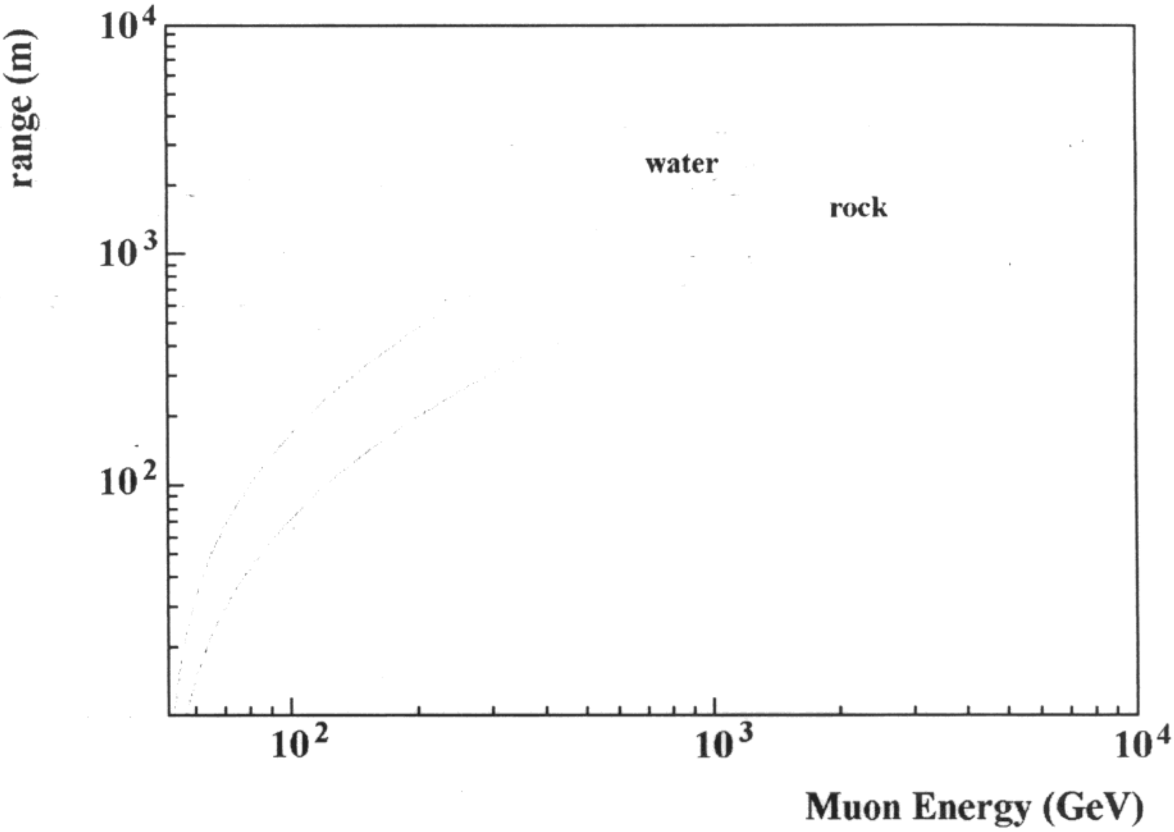
8. THE UNEXPECTED. A new observational window will open up with these neutrino telescopes. No one has ever viewed sites in the Universe shielded by more than a few hundreds grams of matter. One should keep in mind that every time a new brand of astronomy opened up, a new class of phenomena was discovered.

The experimental requirements for the study of the above physics topics look incompatible at first glance

e.g. low vs high energy threshold, good angular accuracy vs coarse,high fractional coverage with sensitive photocathode area vs maximising the detector's sensitive area, etc.

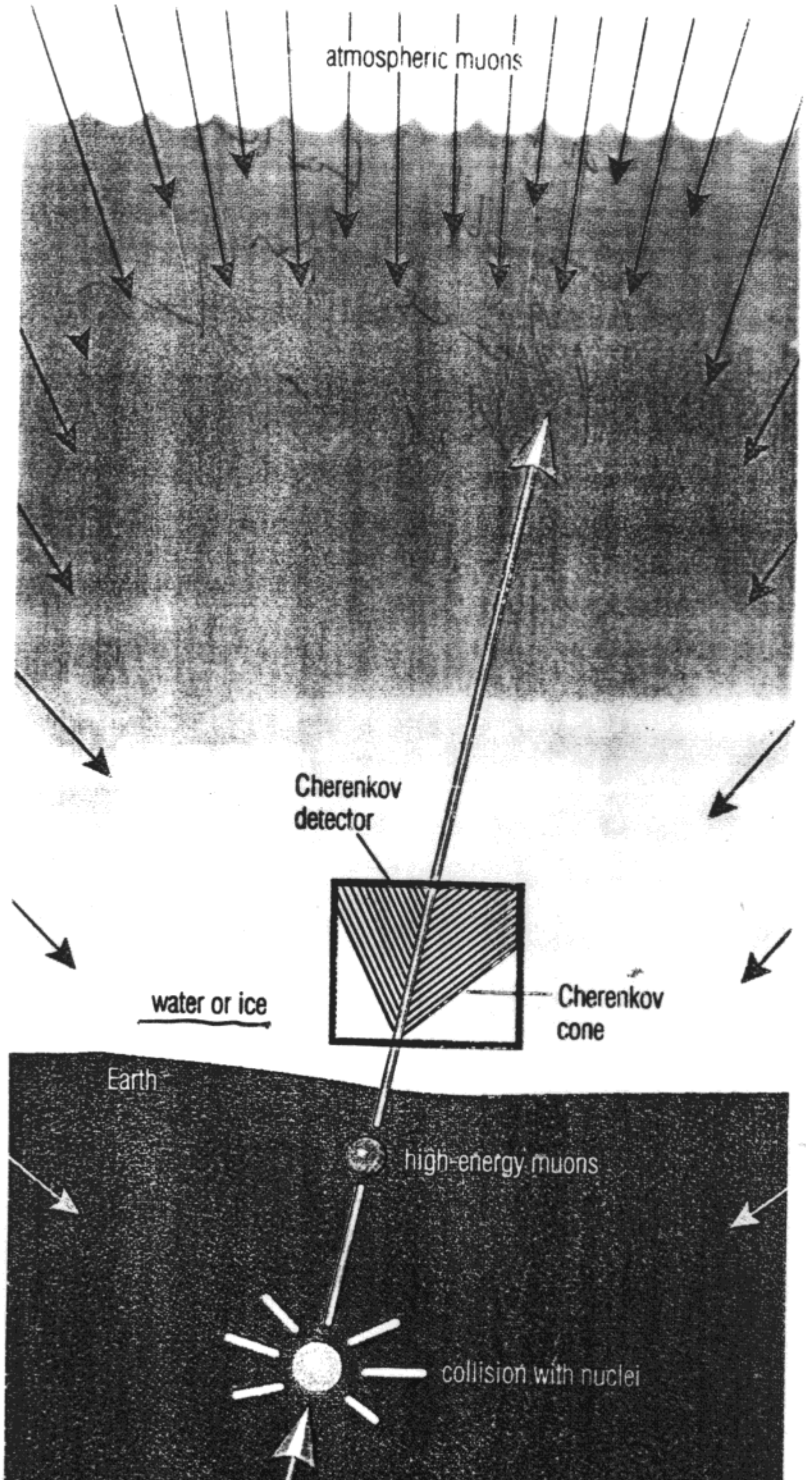
After a couple of decades of operating small prototypes and R+D the H.E.P. community seems to have the right tools to build a detector to study all the above.

The approach must be stepwise and modular. The detector of today's measurements is the prototype for tomorrow's experiments. The signal of today's measurement will probably be the background of tomorrow's experiments.



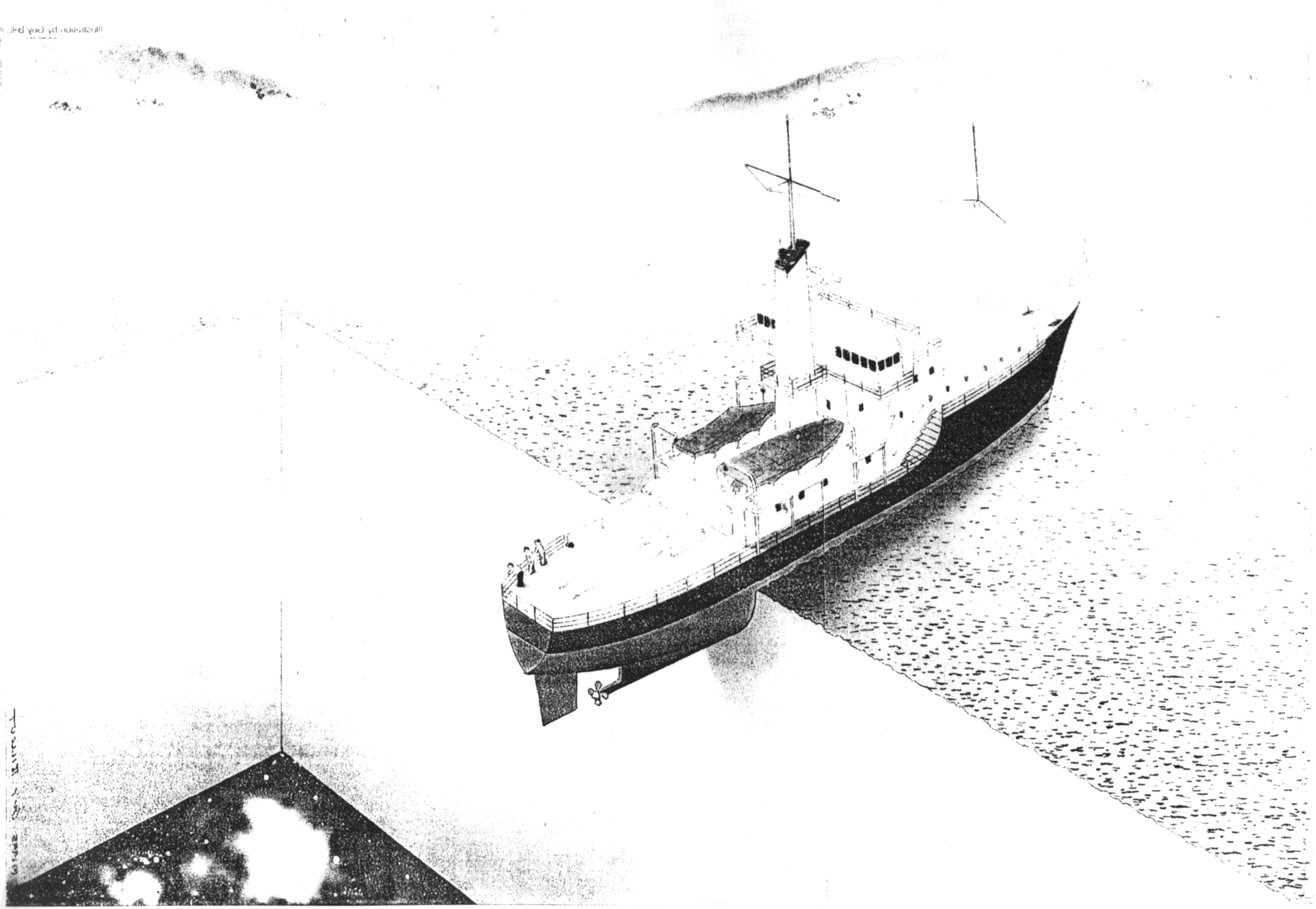
Η εμβέλεια του μιονίου παρουσιάζεται συναρτήσει της αρχικής ενέργειας του μιονίου για ενέργειες από 50GeV μέχρι 10TeV με βάση τον υπολογισμό των Lohmann, Kopp και Voss [251].

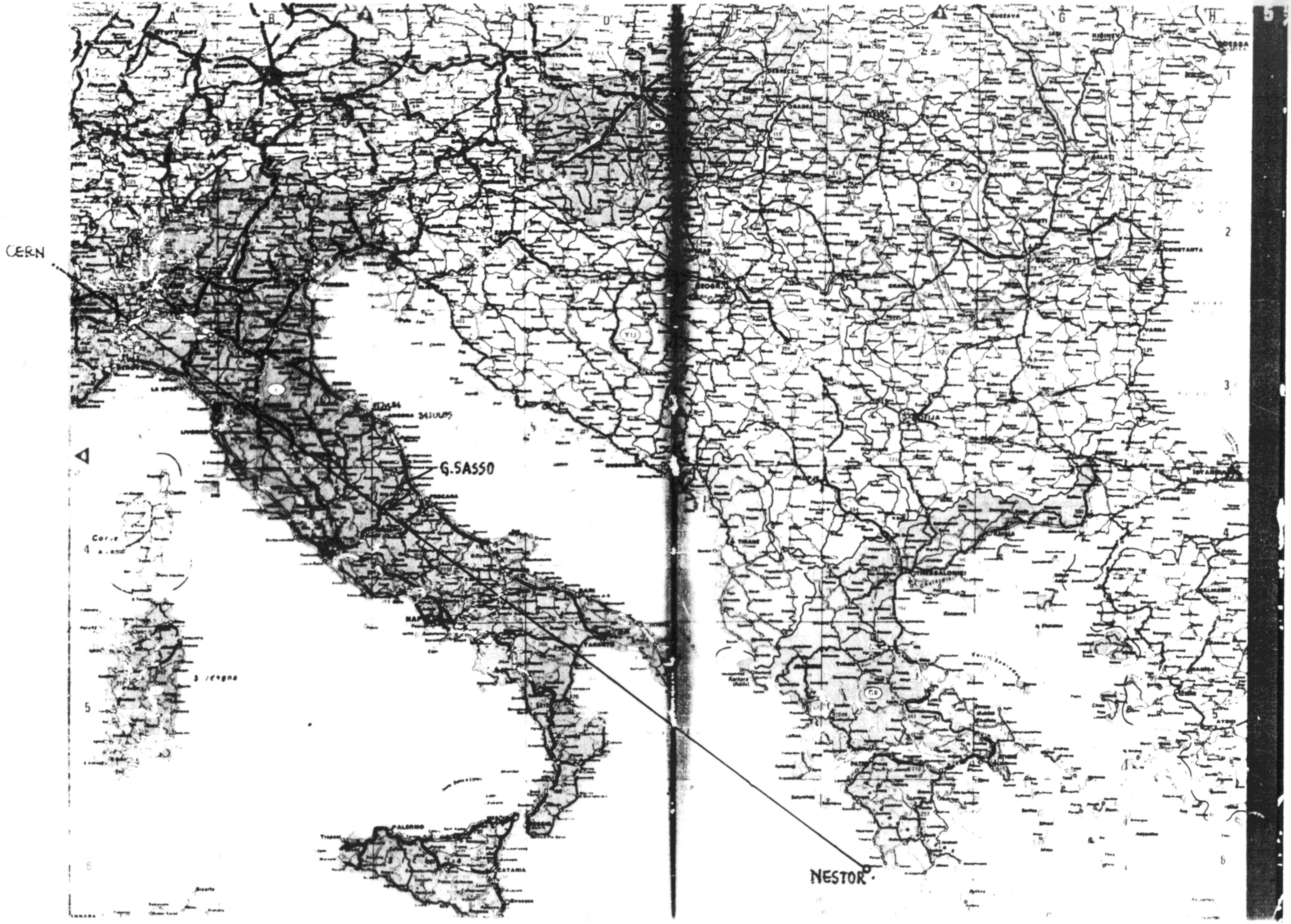
e.g. 1 TeV muon goes ~ 2.5 km in water.



In a neutrino telescope high-energy neutrinos collide with nuclei of matter and spawn high-energy muons. As the muons pass through a Cherenkov detector, they radiate photons in the form of a "Cherenkov cone" of light, which indicates the presence and direction of the high-energy neutrinos.

Illustration by Guy Billout





CERN
G.SASSO
NESTOR

—-	λ/in deg	ϕ/in deg
CERN	6.0732	46.2442
GRAND-SASSO	13.5744	42.4525
NESTOR	21.3500	36.3500

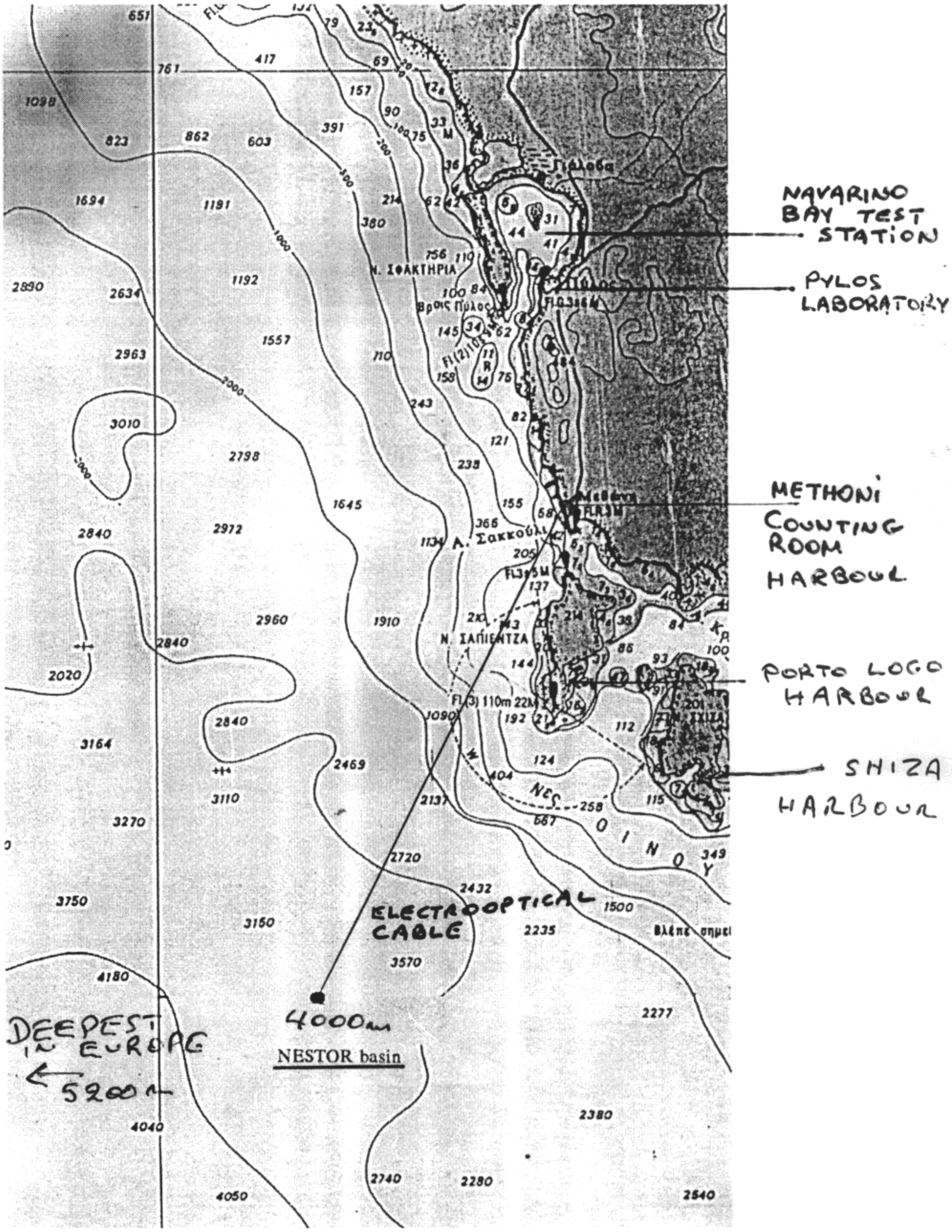
Table 1: Coordinates of CERN ,GRAND-SASSO,NESTOR

	A_z /in deg	α/in deg	Distance
GRAN -SASSO	122.502	3.283 (5.73%)	731 Km
NESTOR	124.1775	8.526 (13.5%)	1676 Km

Table 2: Angular pointing and distance from CERN

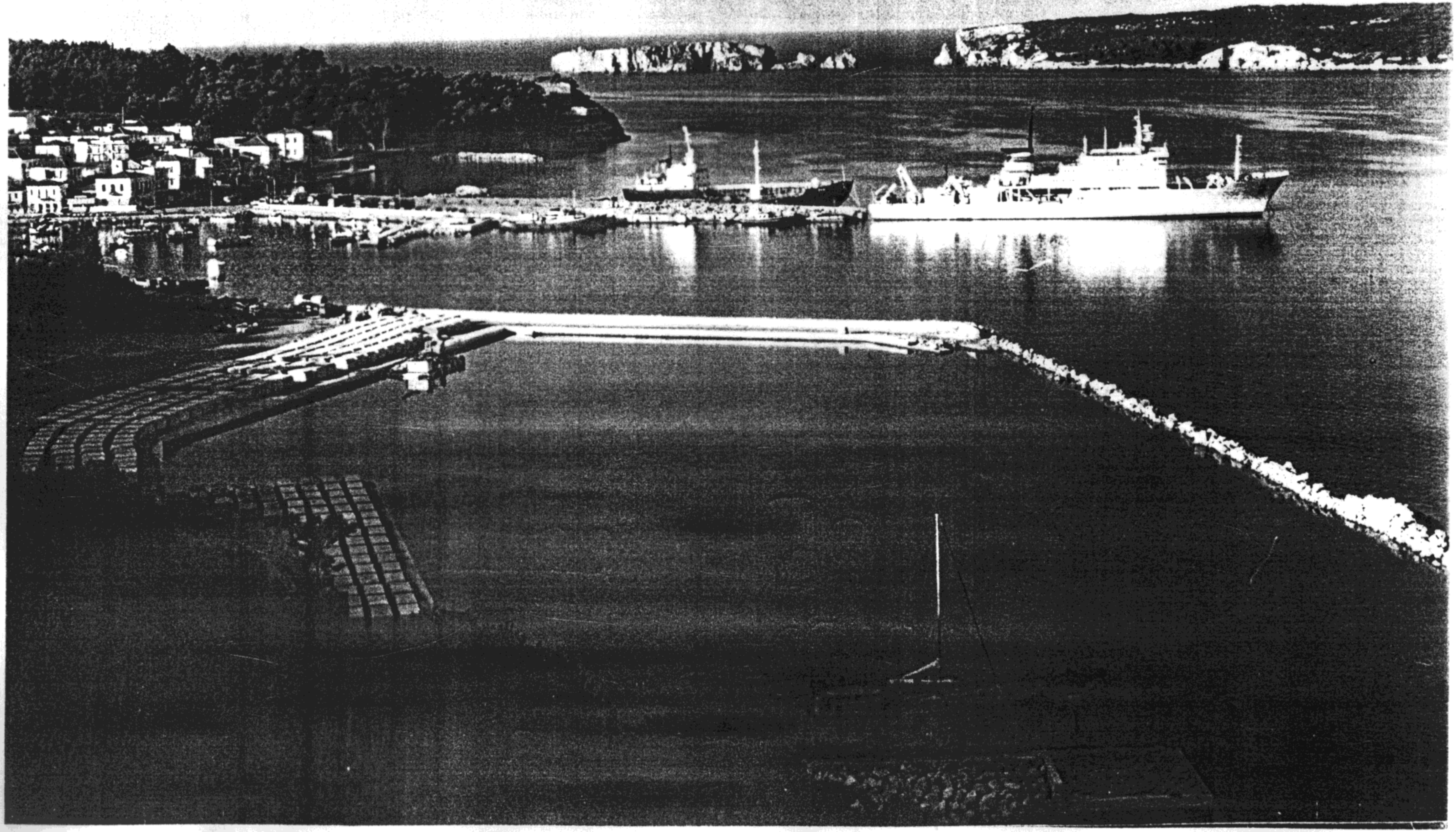
PROJECT GRAND-SASSO/NESTOR

Calculations by M.Mayoud 15/8/92



NOTE
4 HARBOURS
DISTANCE 8 - 15 miles

KELDYSH 92



ISOBATHS

CONTOURS OF EQUAL DEPTH

The lighthouse of Sapientza
will be the counting room.
Then the data will be transmitted
to PYLOS by cable or microwave link.

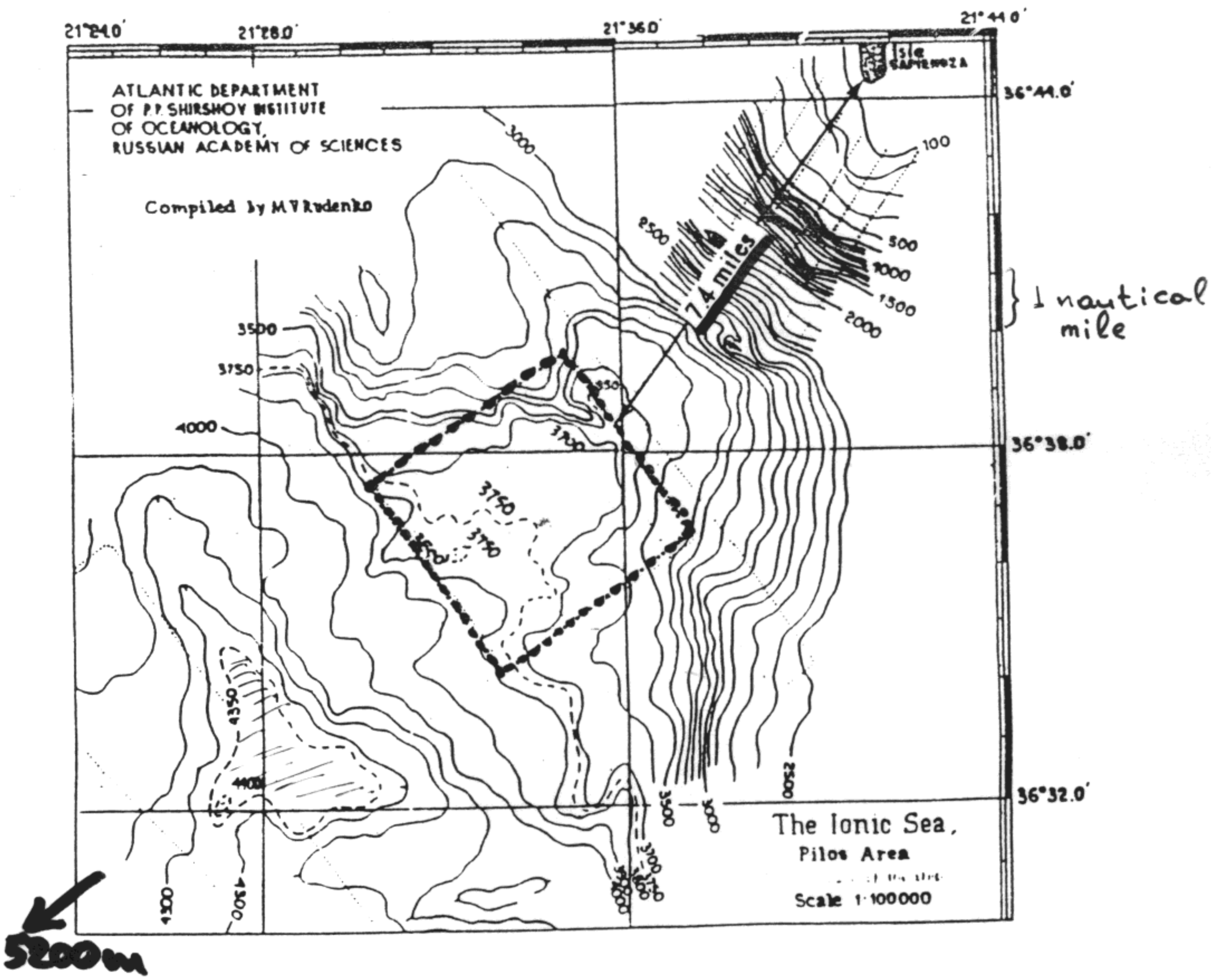


Figure 2

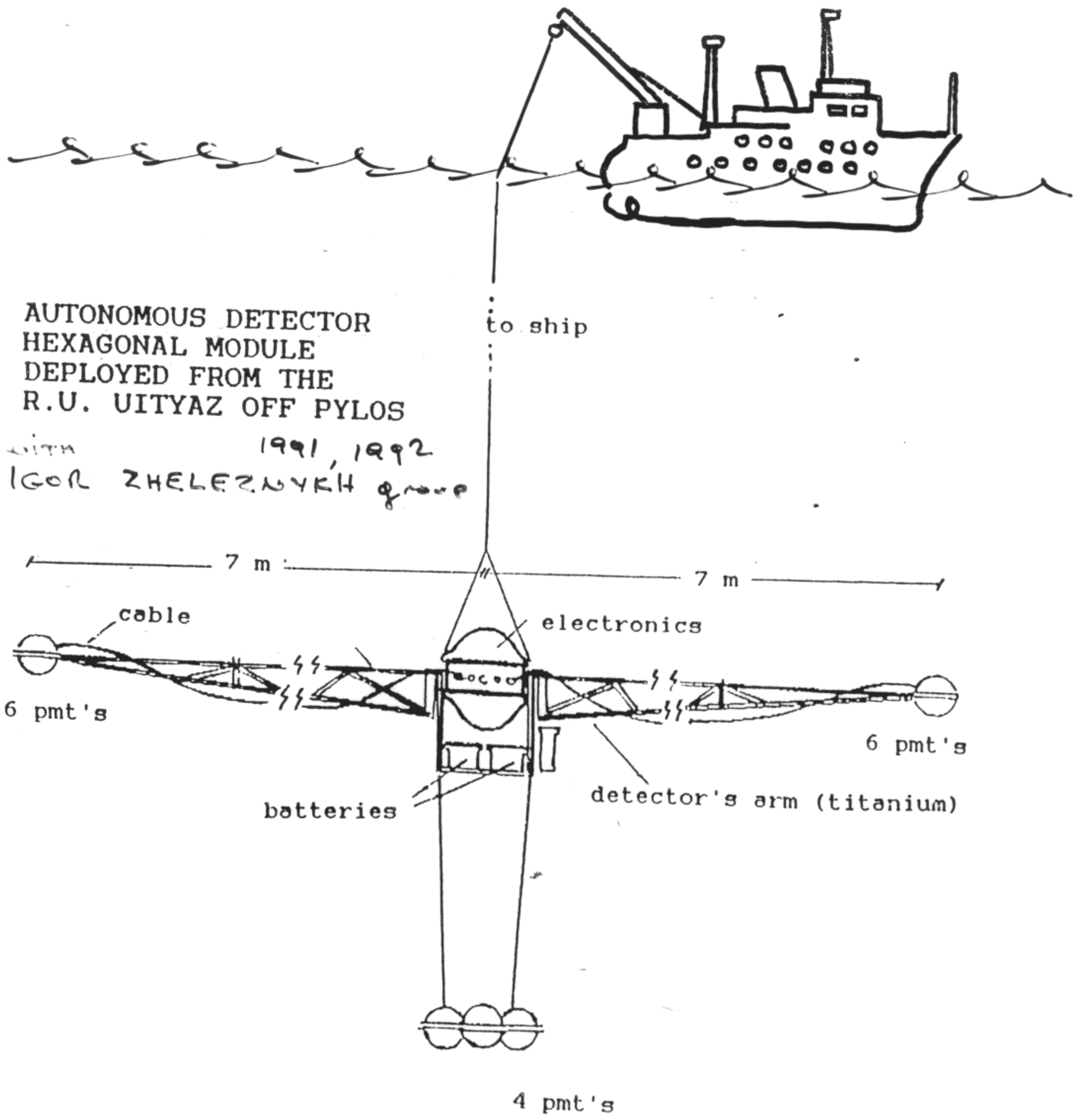
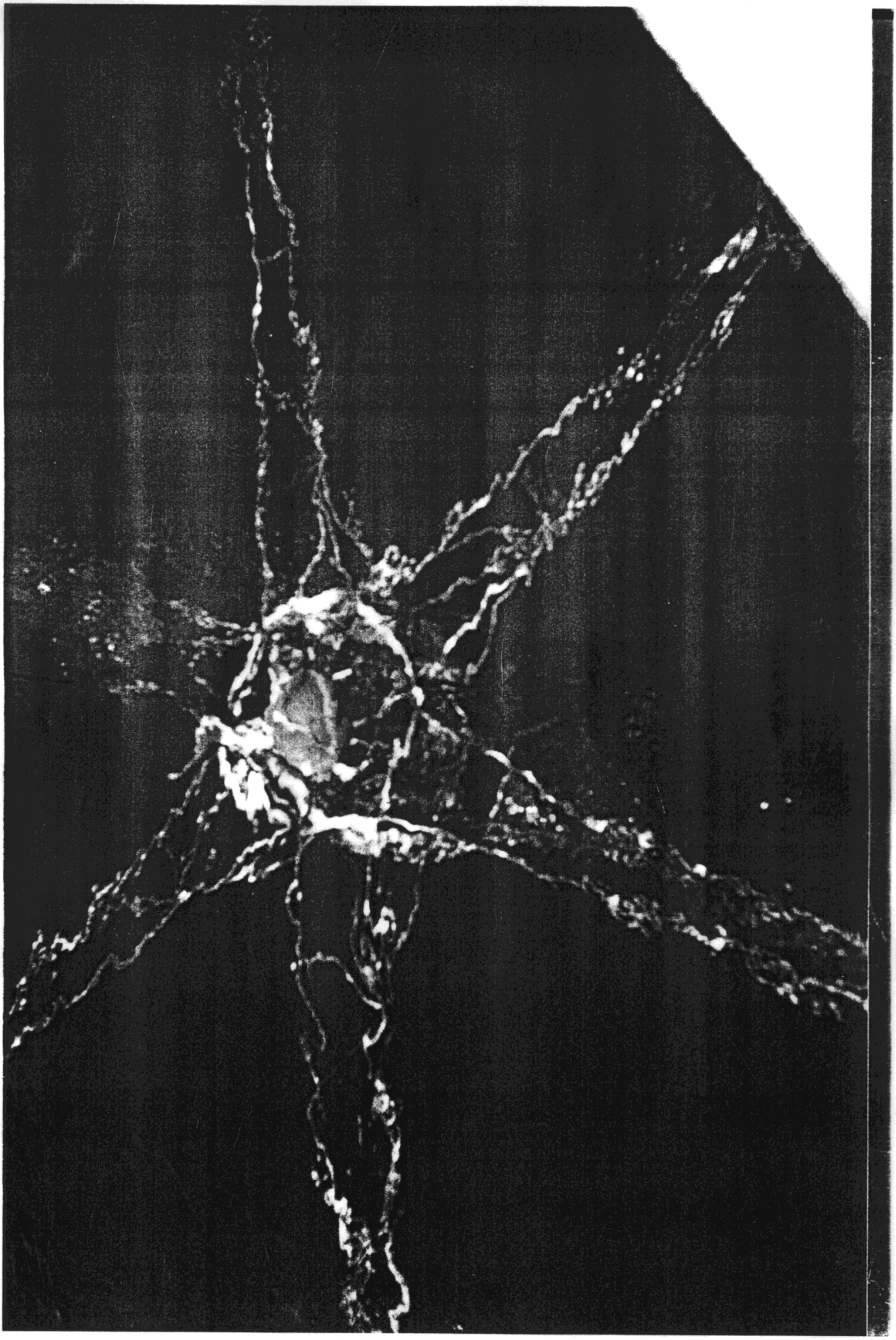

AUTONOMOUS DETECTOR
HEXAGONAL MODULE
DEPLOYED FROM THE
R.U. UITYAZ OFF PYLOS
with 1991, 1992
IGOR ZHELEZNYKH group
to ship
7 m
7 m
cable
electronics
6 pmt's
6 pmt's
batteries
detector's arm (titanium)
4 pmt's

Fig. 3



Comparison of underwater muon measurements.

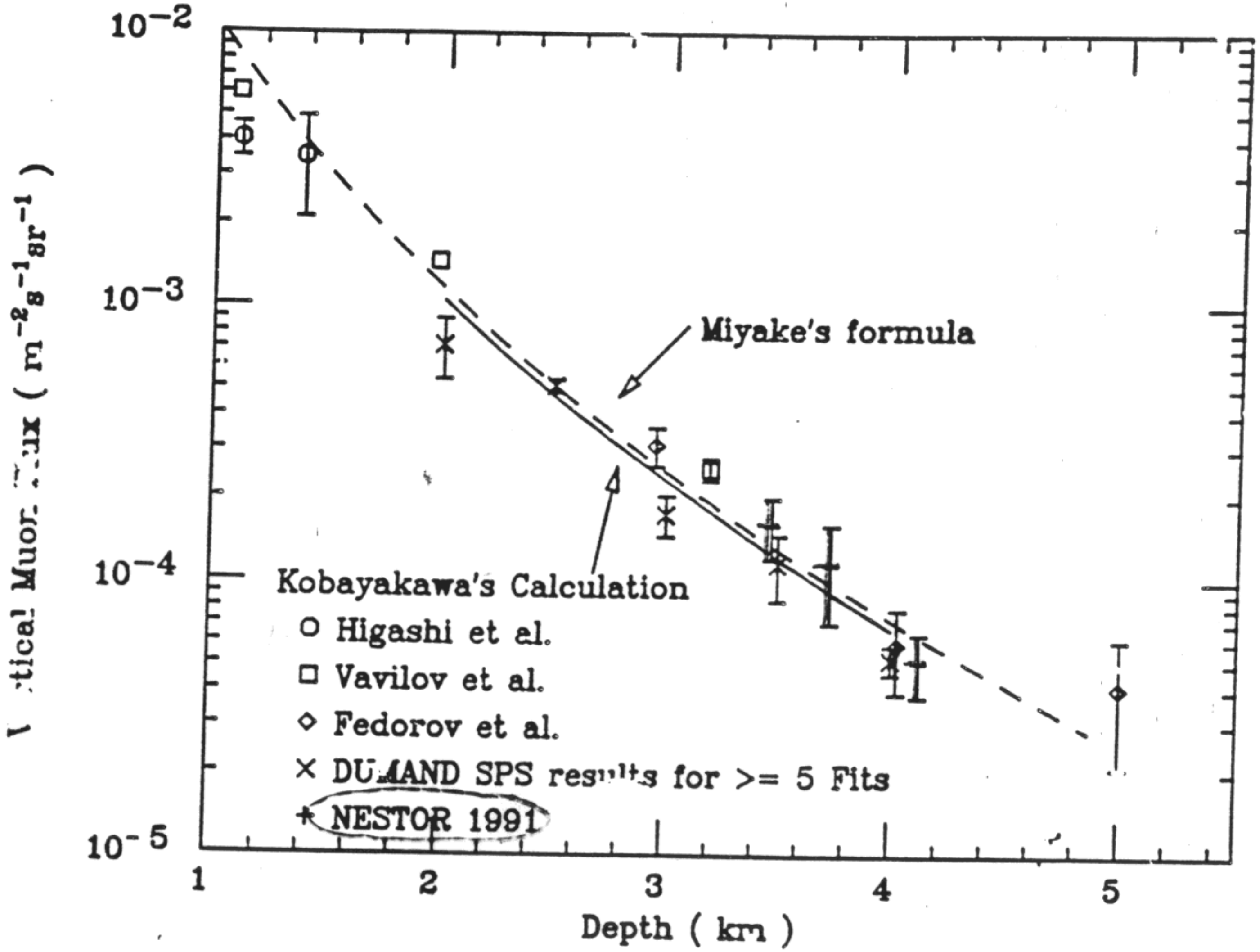


Fig. 13

The NESTOR Site

Water transmissivity

Attenuation length:55±10m. at λ=460nm, measured in situ by various methods in 1991 and 1992.
(Published: NIM A 349 (1994) 242)

Underwater Currents negligibly low

<10cm/sec, measured over the last 7 years (insignificant drag on the structure)

Sea Bottom Morphology

Detailed maps of site (1991 and 1992). The cable route was surveyed using side scan sonar and pressurized airgun (1995).

Sedimentology tests

Flat clay surface on sea floor, good anchoring ground.
(many core samples as deep as 2m, in 1992)

DESIGN CONSIDERATIONS

NO BATHYSCAPHS - NO ROVs

NO HIGHLY SPECIALIZED SURFACE VESSELS

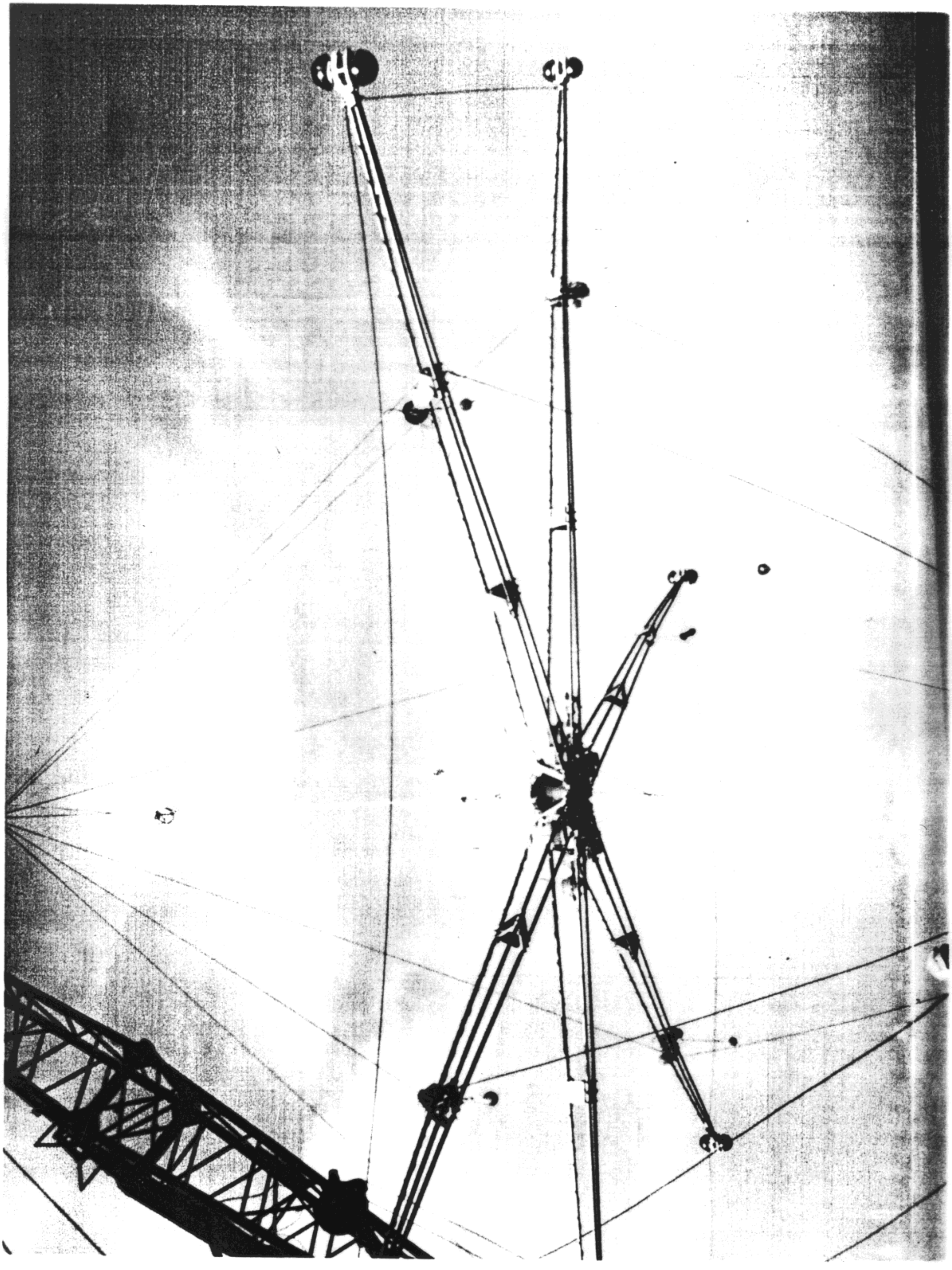
ALL CONNECTIONS TO BE MADE IN THE AIR

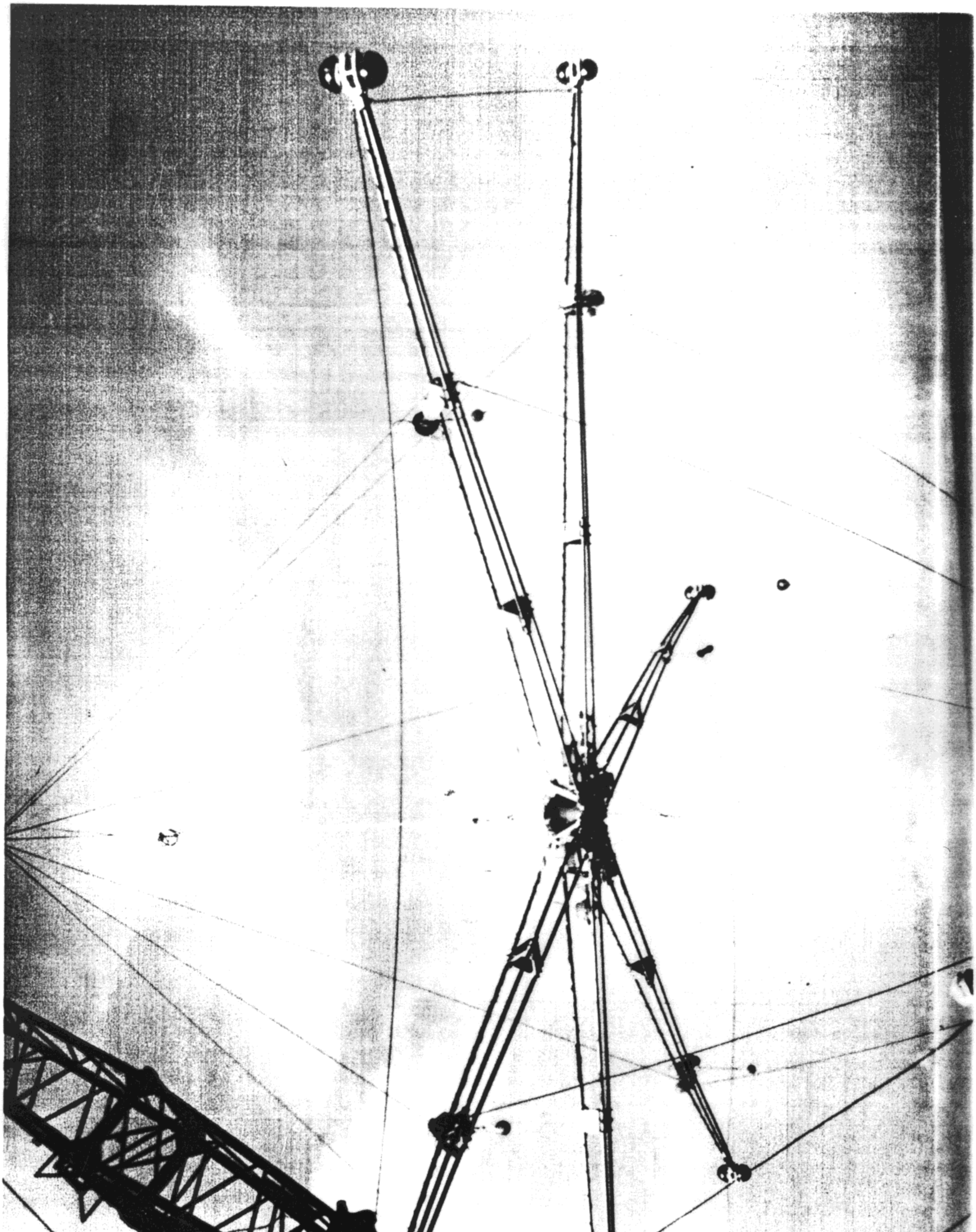
MINIMUM NUMBER OF CONNECTORS

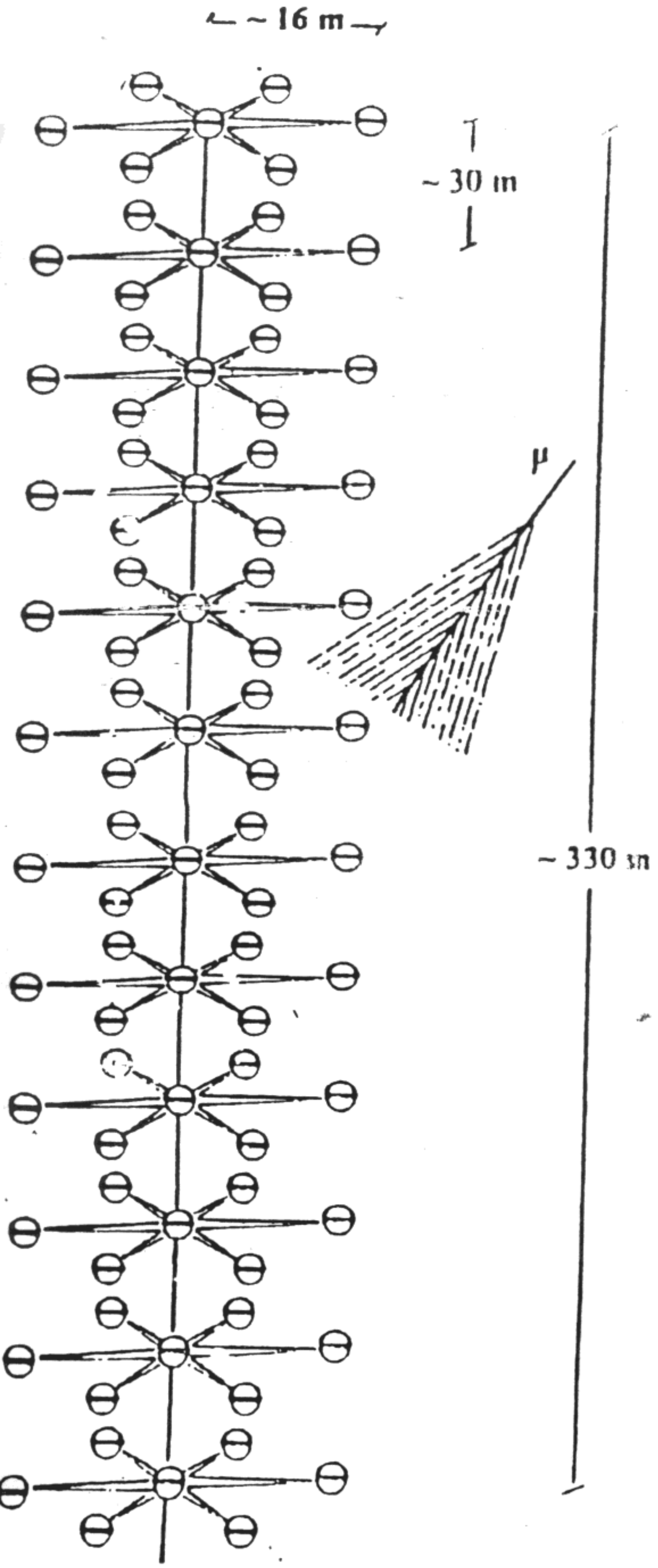
AS PASSIVE A SYSTEM AS POSSIBLE
(Triggering on the shore)

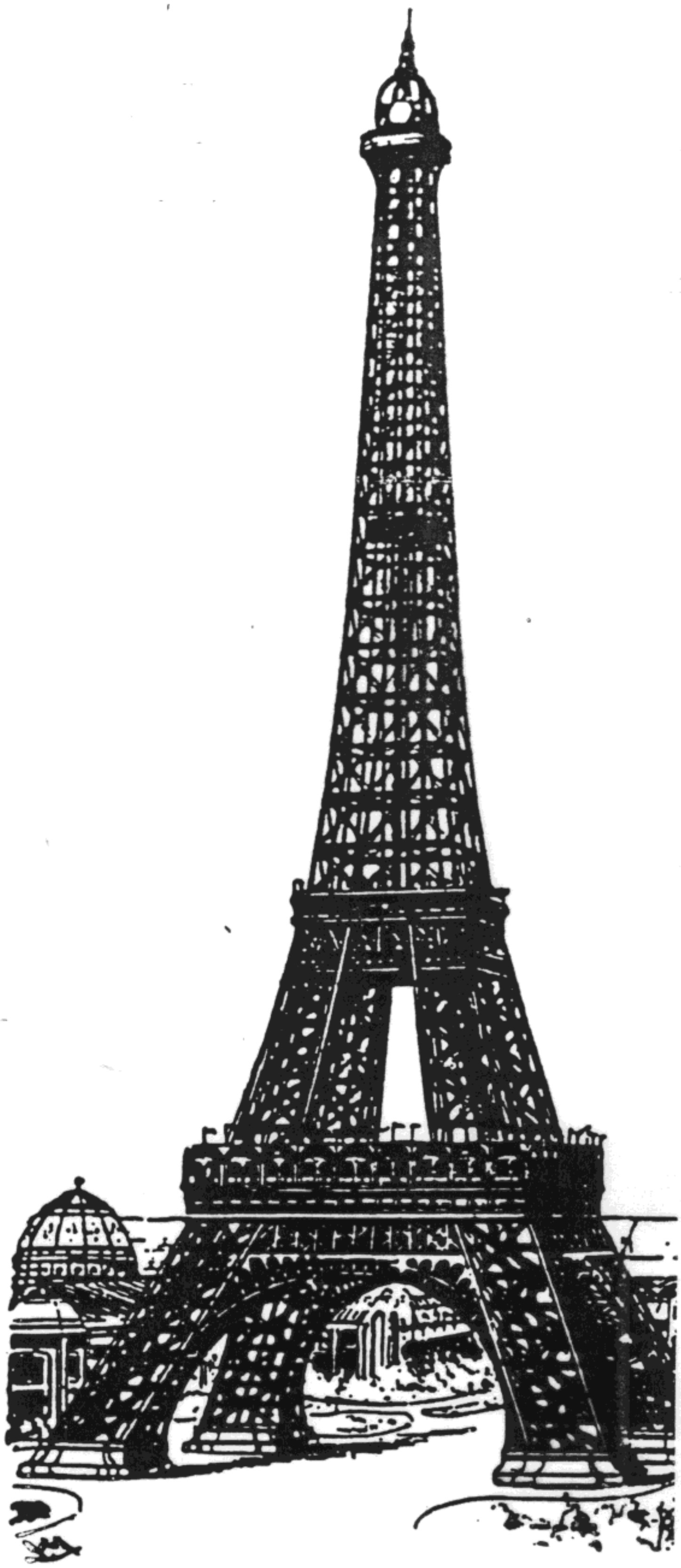
MODULAR SYSTEM WITH BUILT IN REDUNDANCY

RETRIEVABLE AND EXPANDABLE

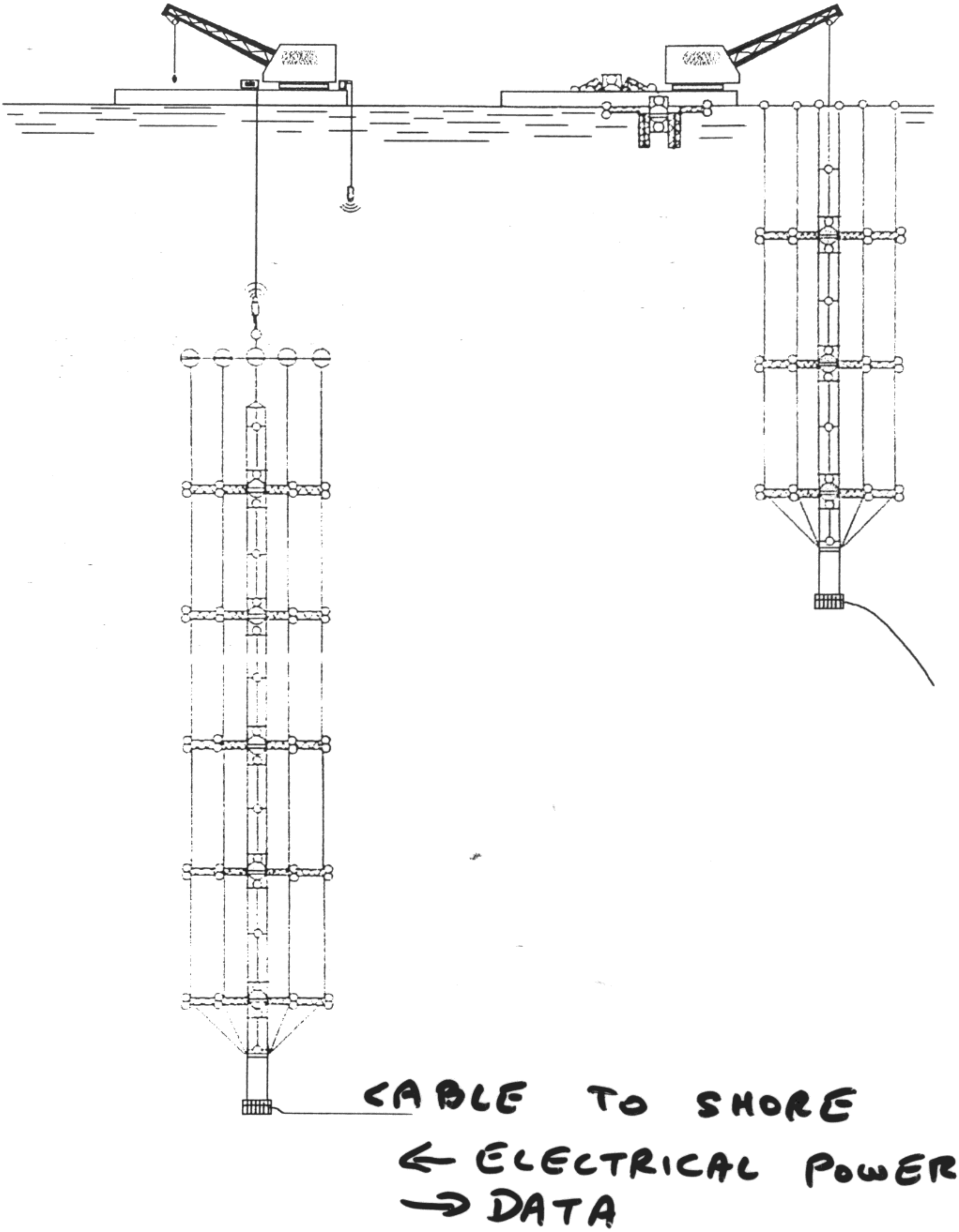


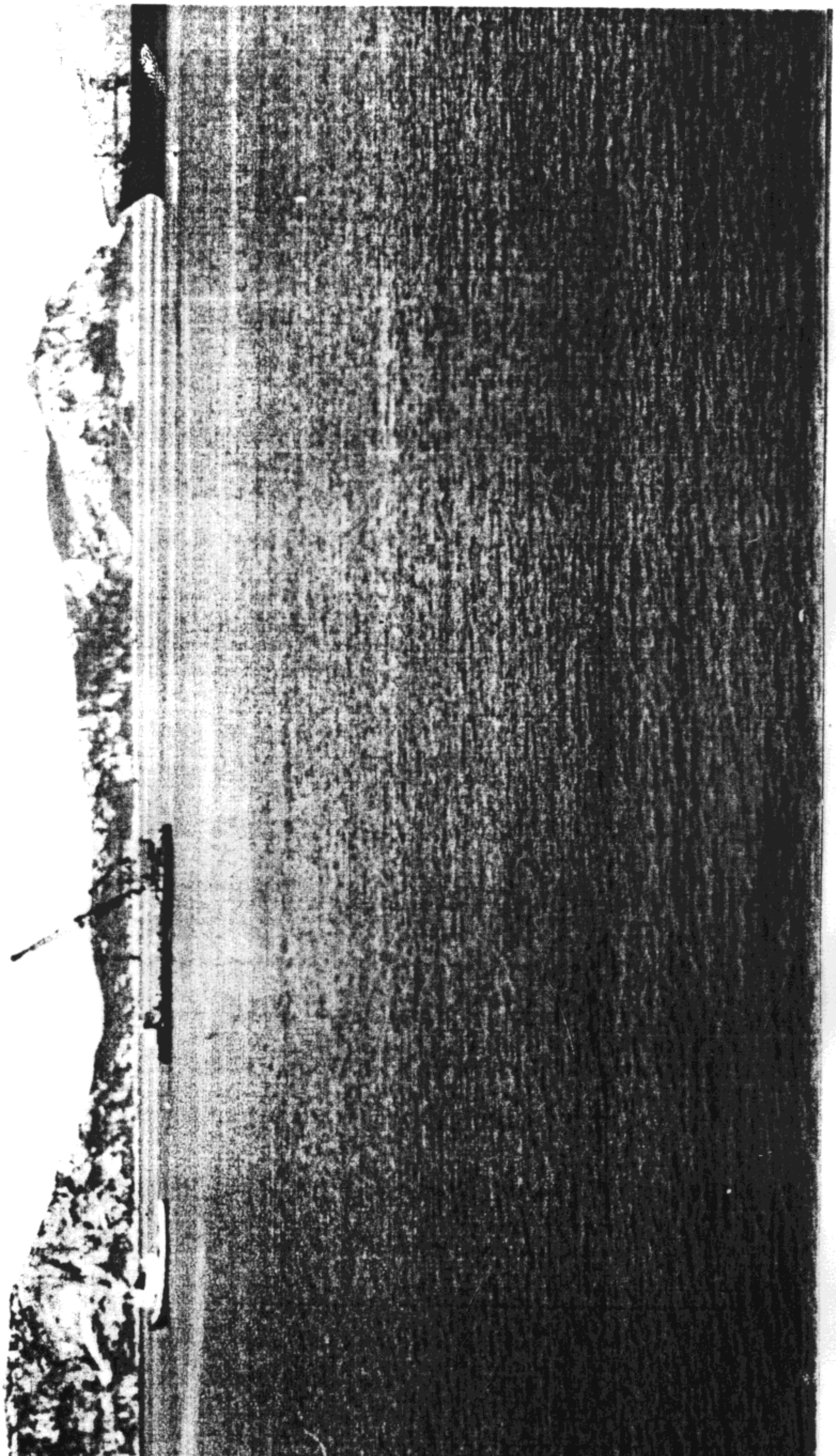


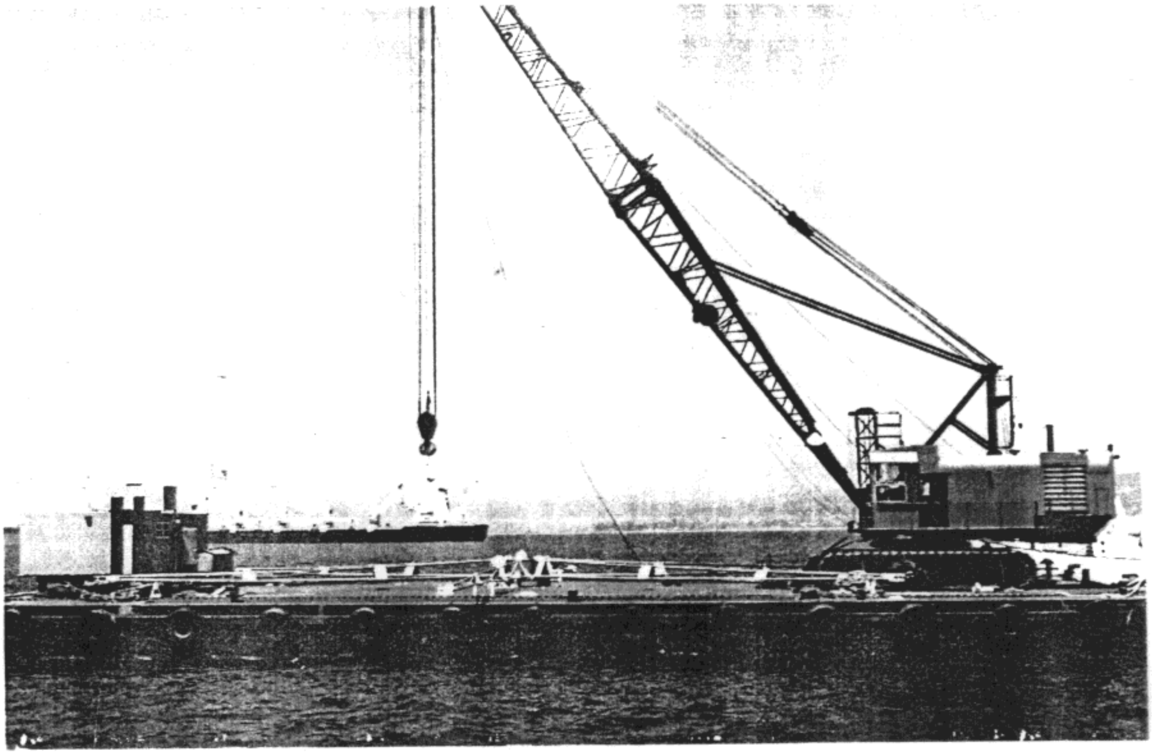


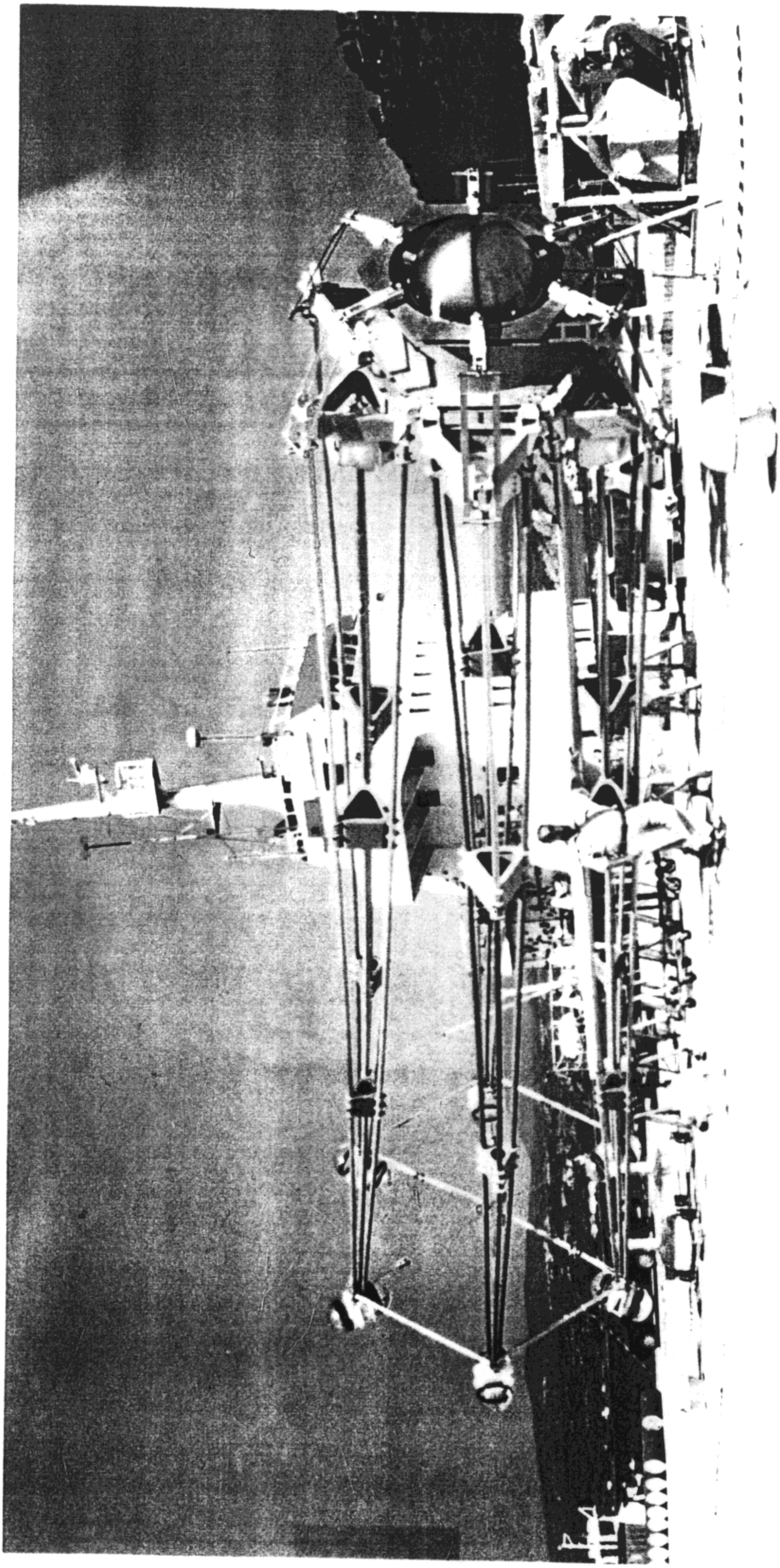


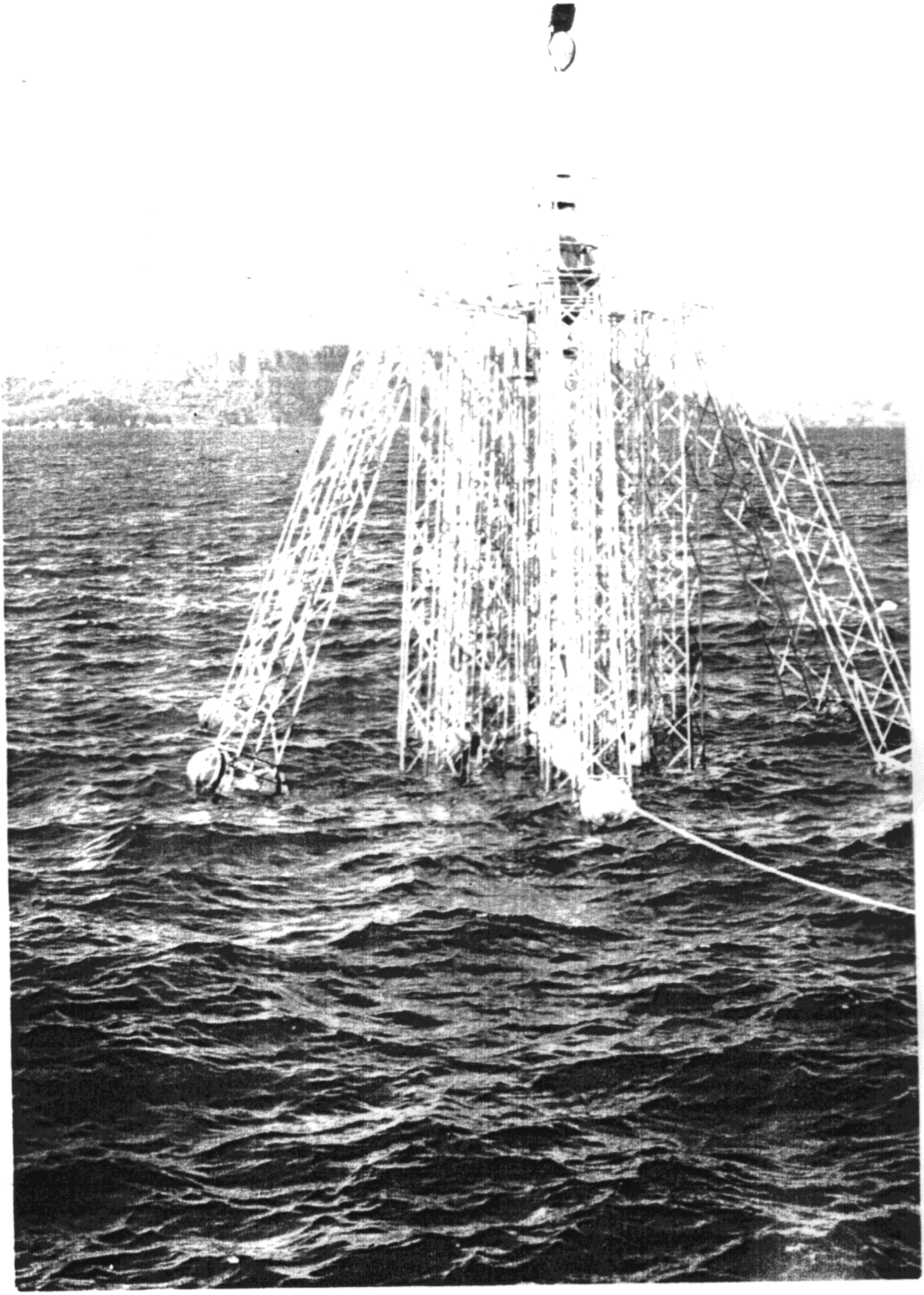
Πύργος Ἄϊφελ

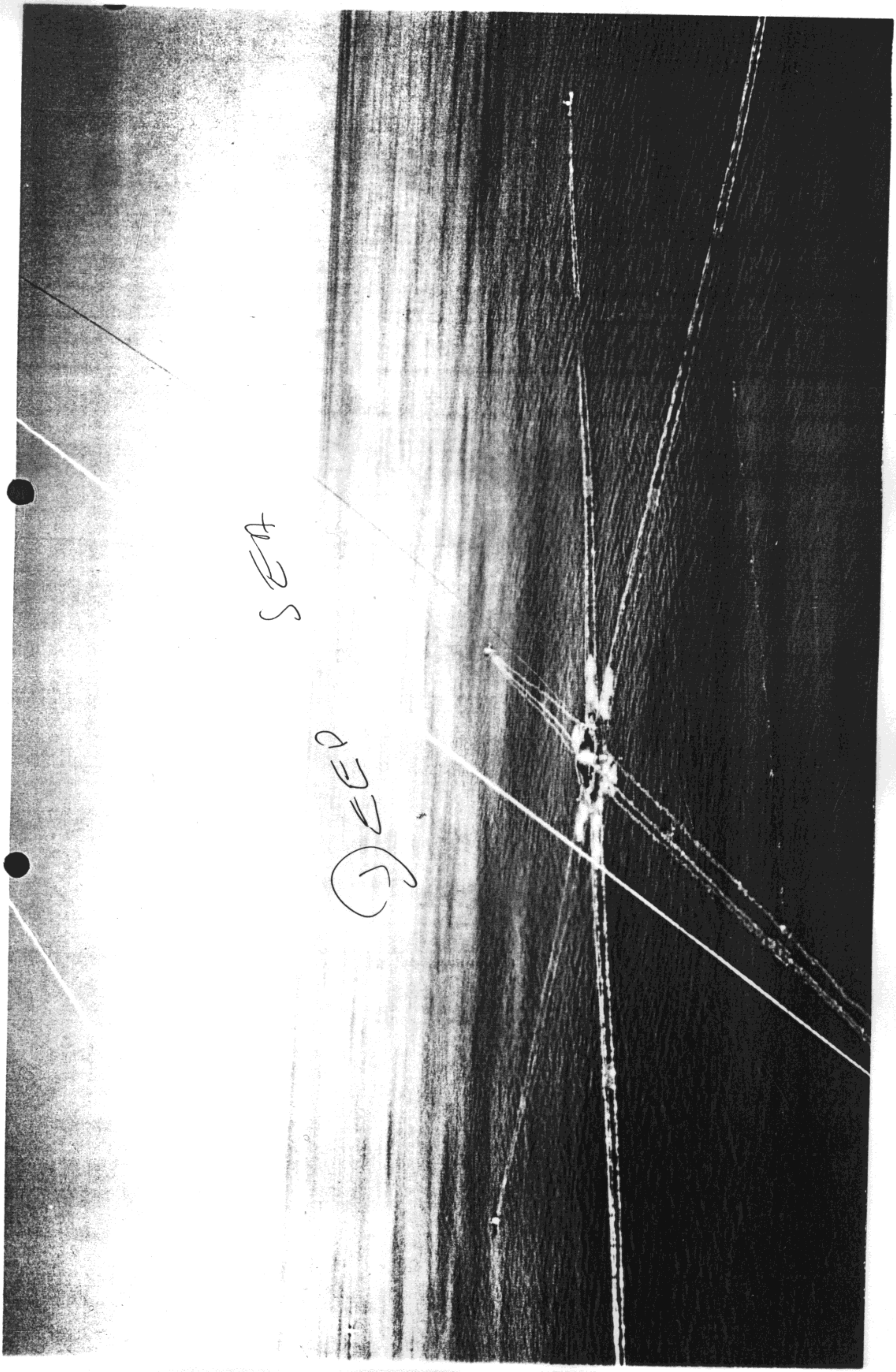

CABLE TO SHORE
← ELECTRICAL POWER
→ DATA











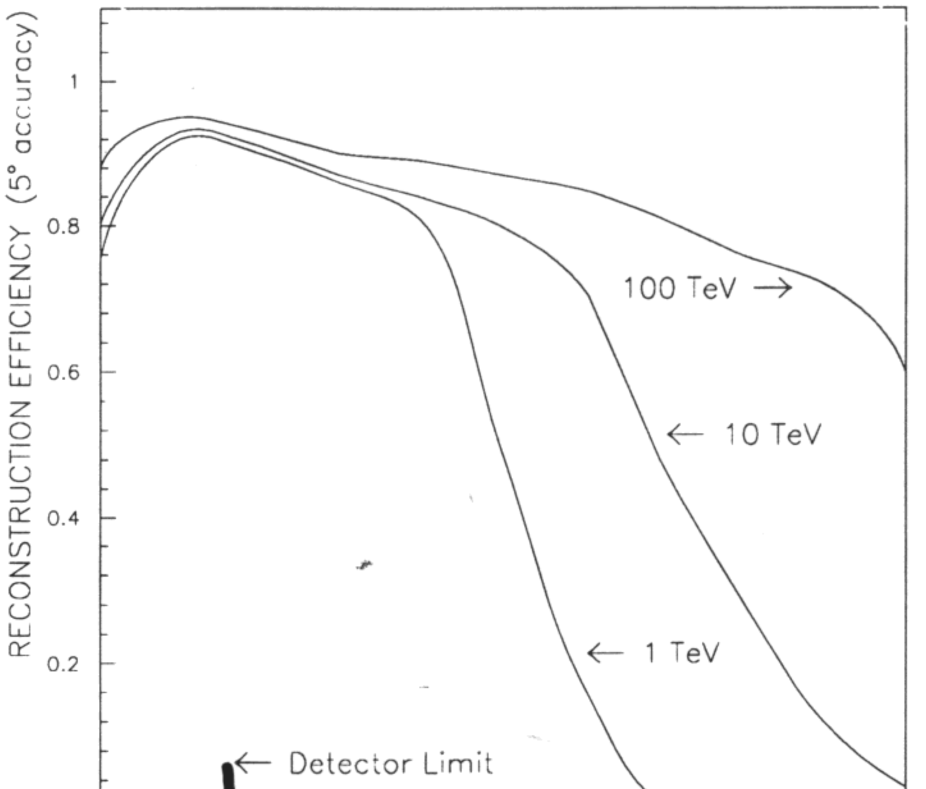


Figure 4 Reconstruction efficiency versus distance from the axis of tower (vertical incidence of muons) for one NESTOR tower (5° accuracy).

RECONSTRUCTIONS OF MUONS WHICH DO NOT CROSS THE DETECTOR

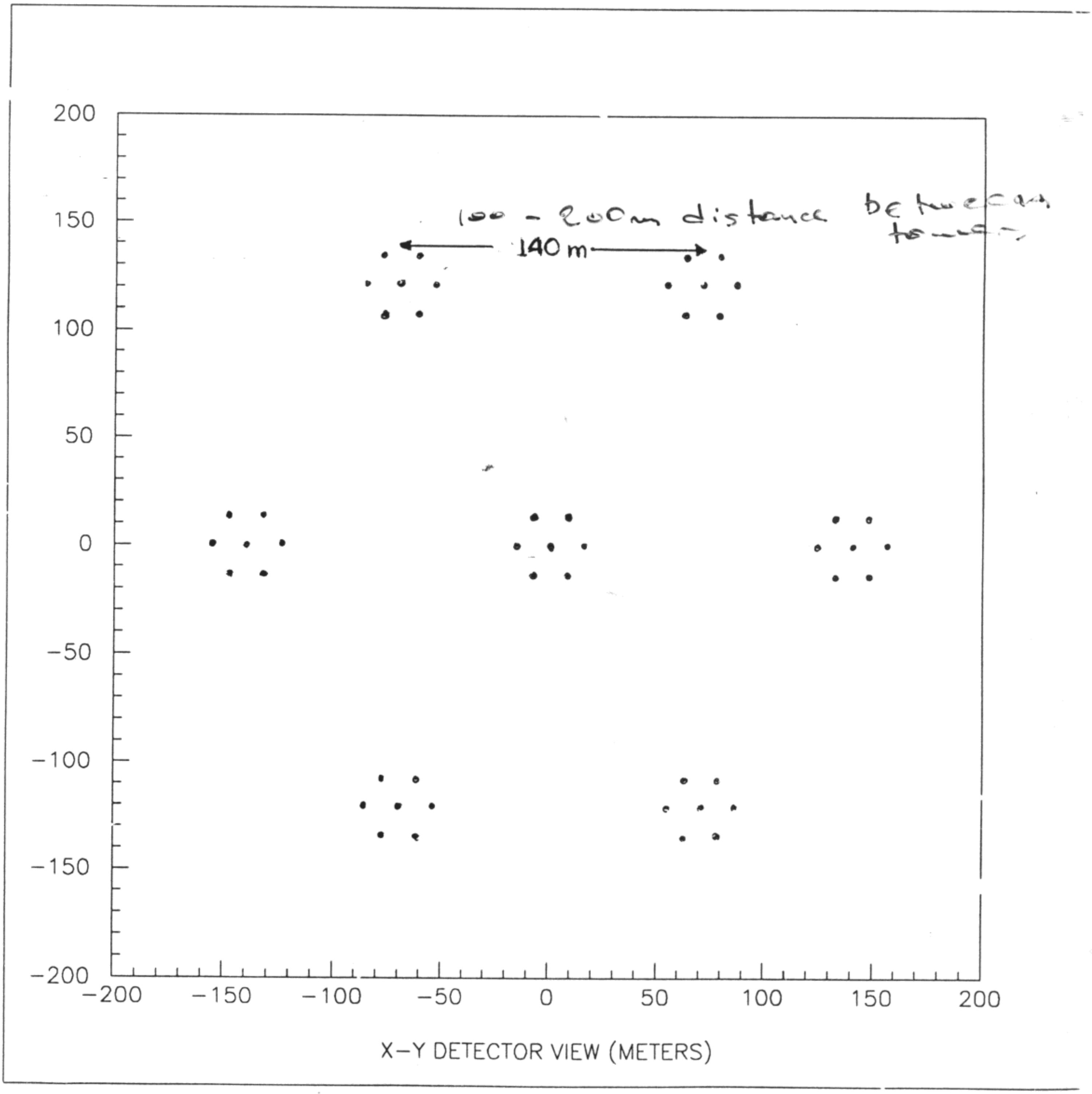
30, 140

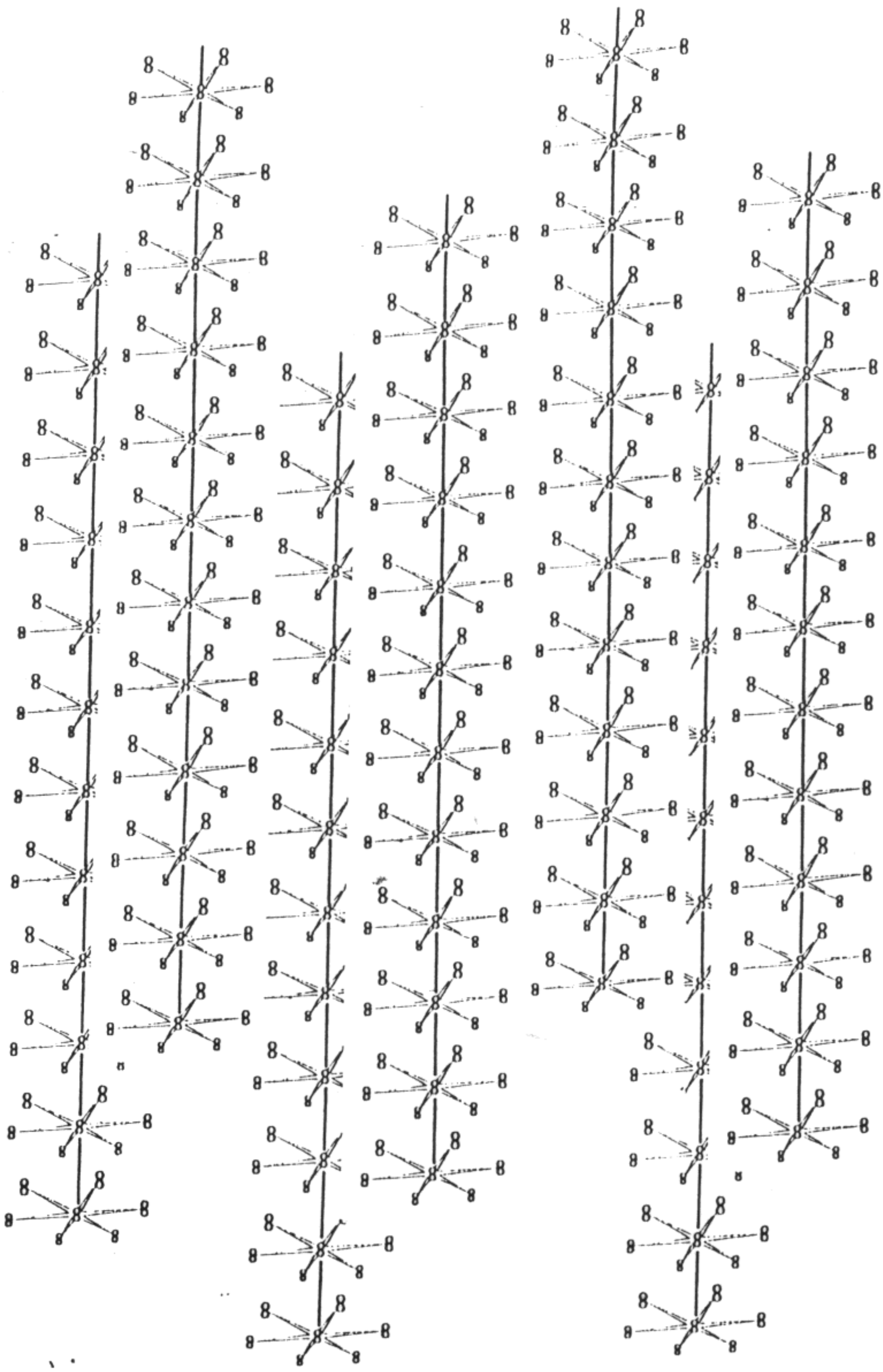
NESTOR

7 TOWERS, 1176 PHOTOMULTIPLIERS

1.8 MEGATONS OF DENSELY INSTRUMENTED MASS WITHIN THE 7 TOWERS i.e. FEW GeV THRESHOLD

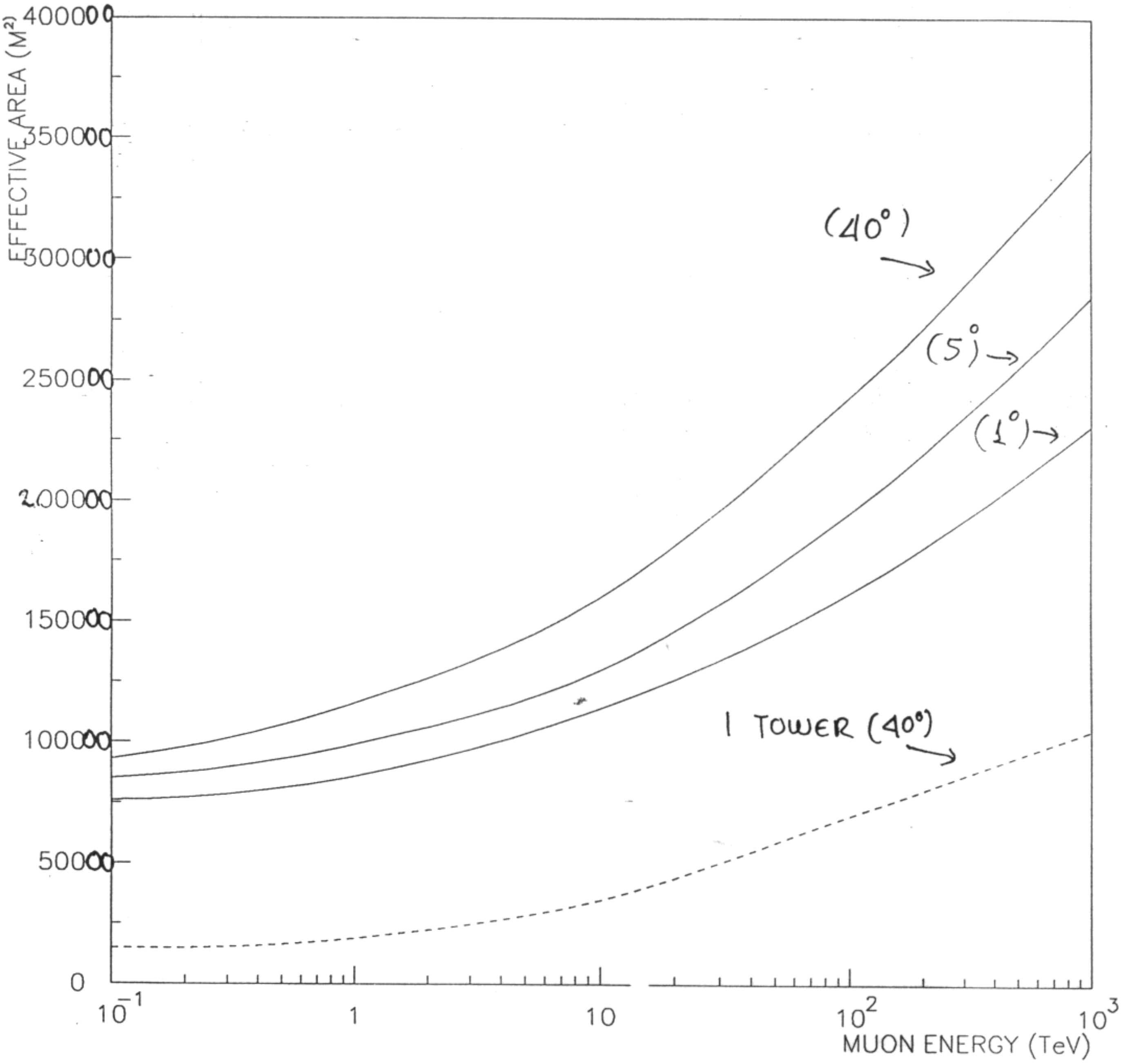
25. MEGATONS OF ENCLOSED MASS





150m

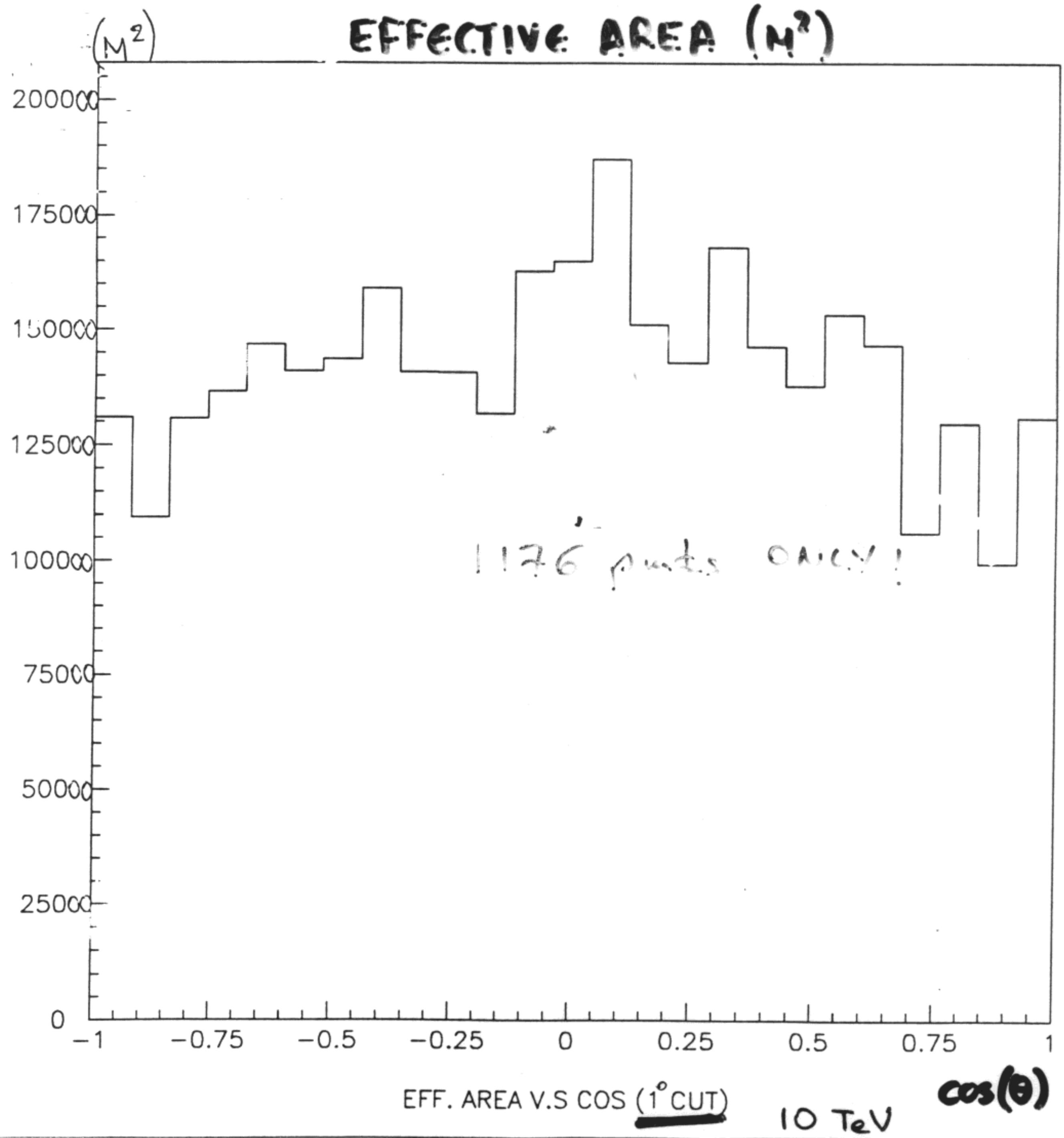
EFFECTIVE AREA OF SEVEN NESTOR TOWERS

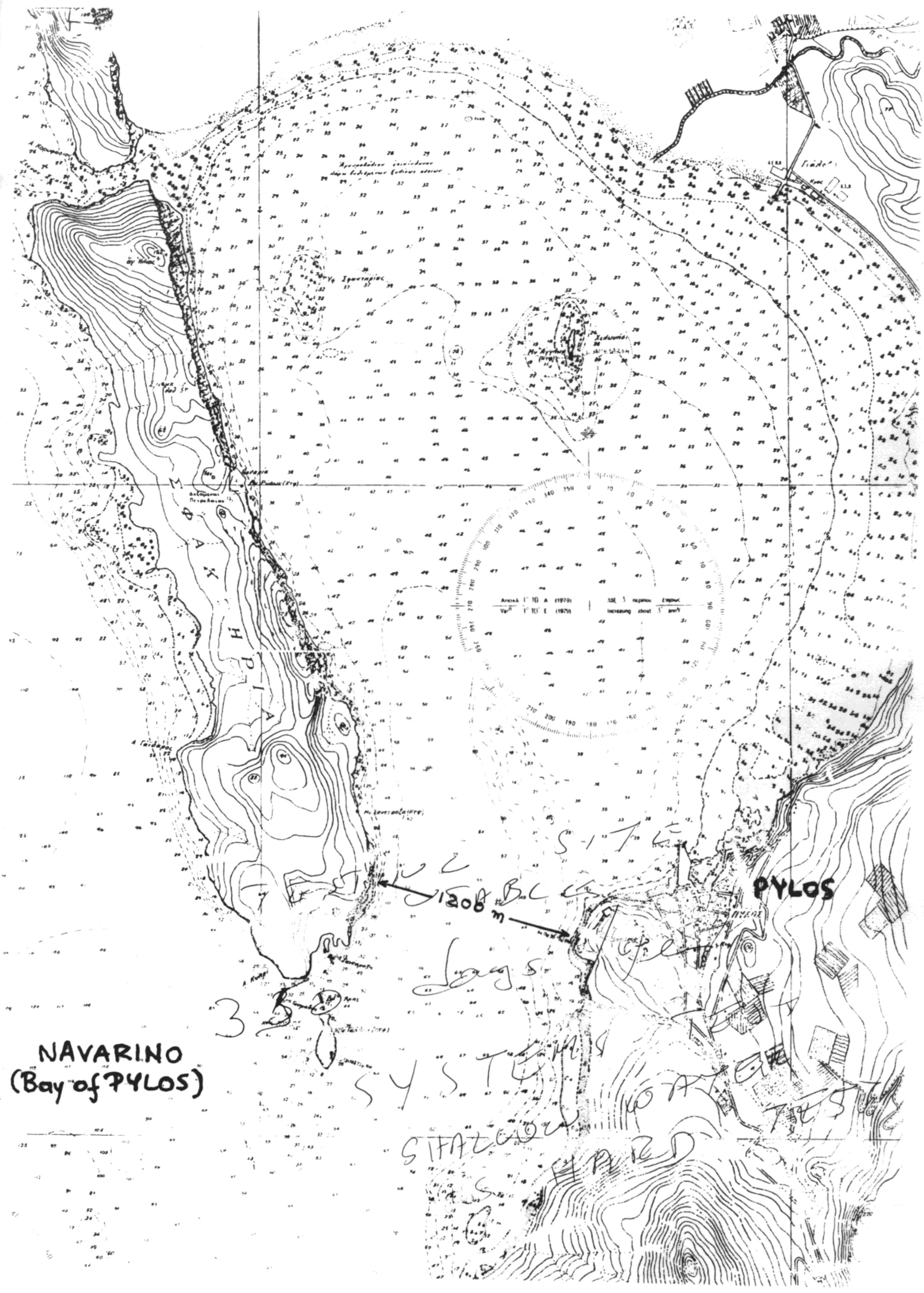


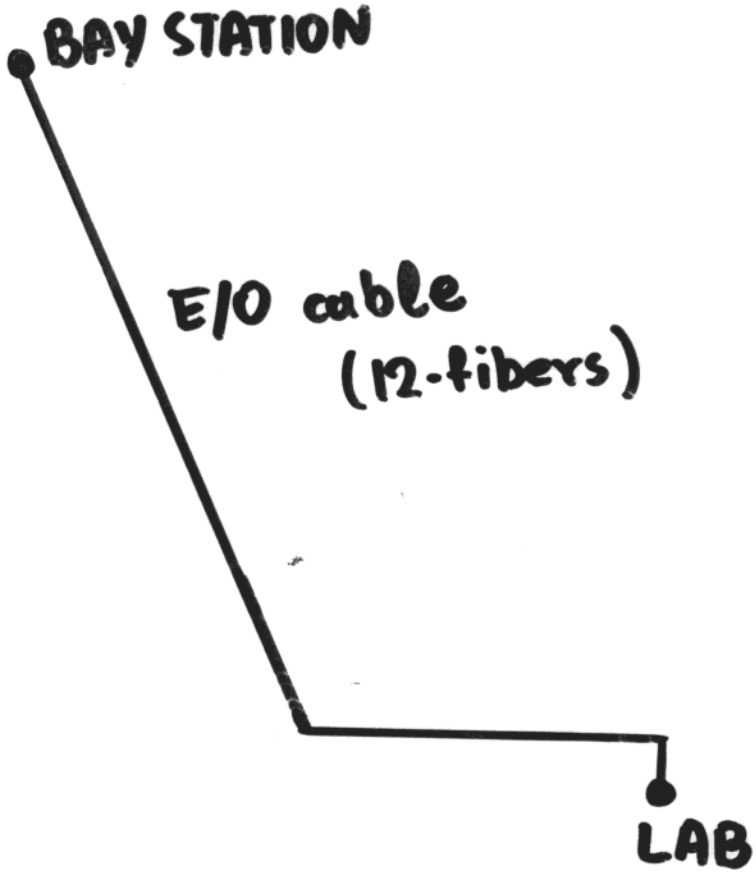
$E_\nu = 10$ TeV

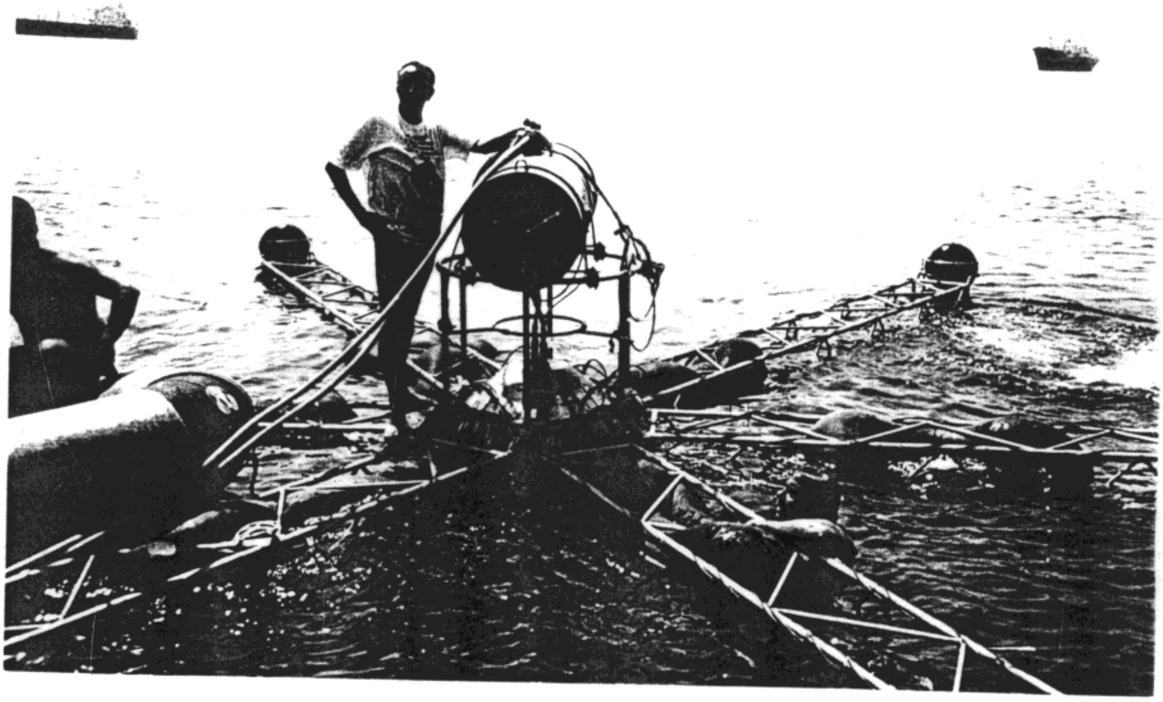
7 NESTOR TOWERS

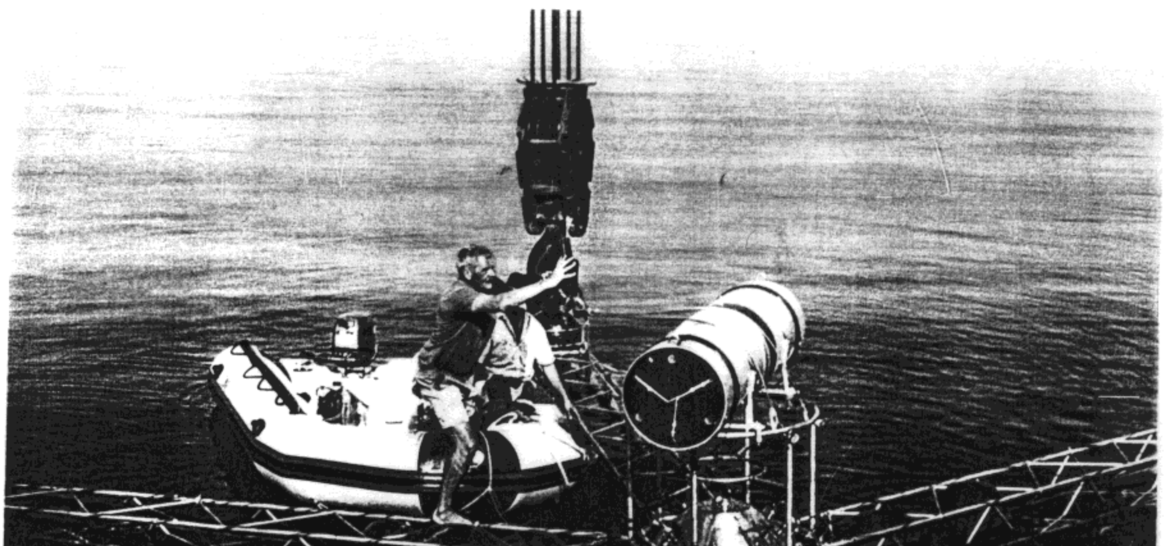
(30m between floors, 150m between towers)



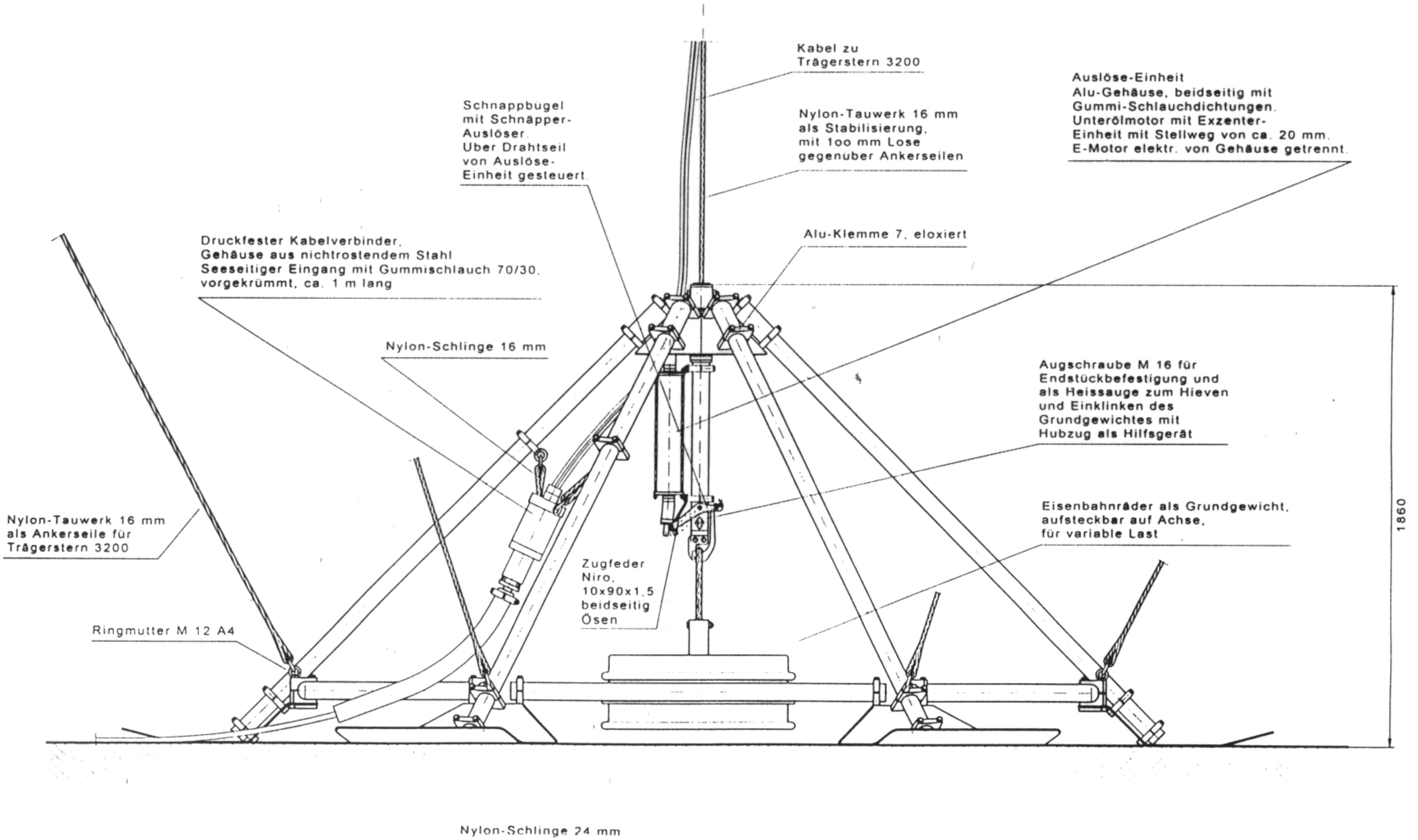

NAVARINO
(Bay of PYLOS)
PYLOS
1206 m

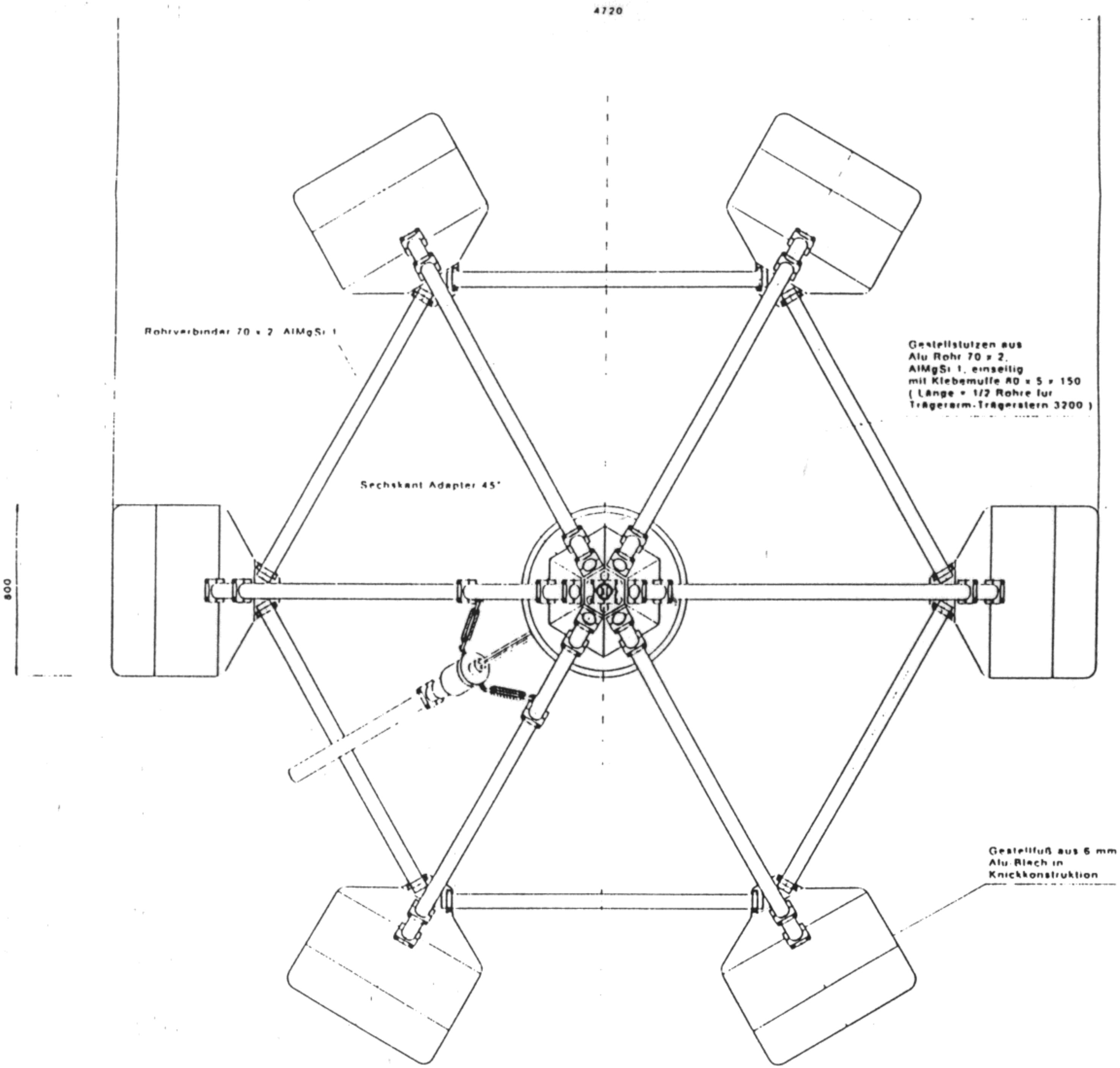

BAY STATION
E/O cable
(12-fibers)
LAB



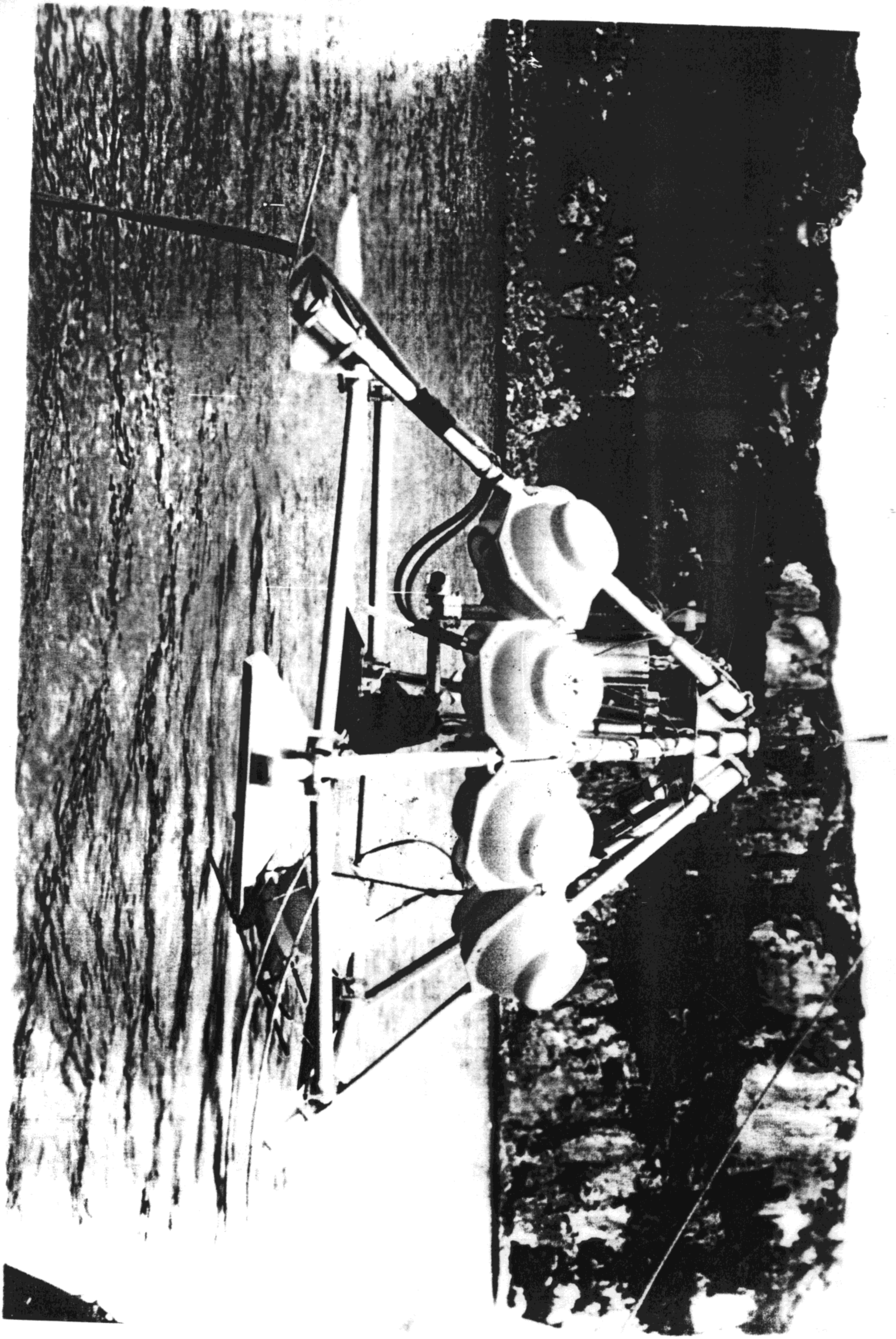


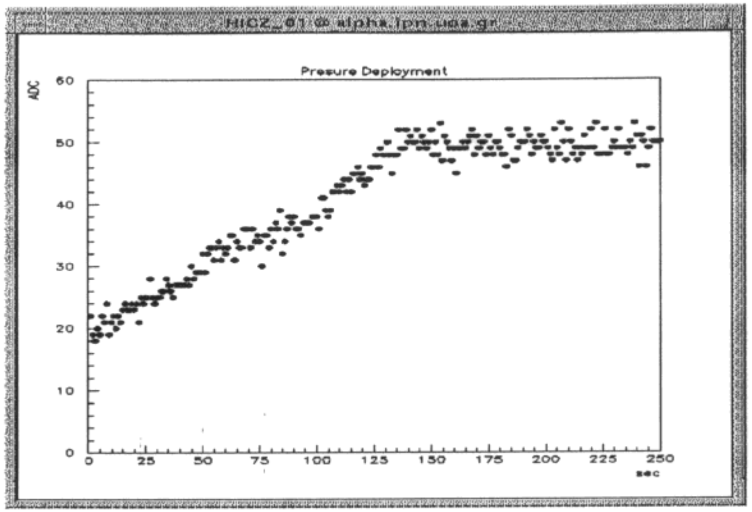
807161.(

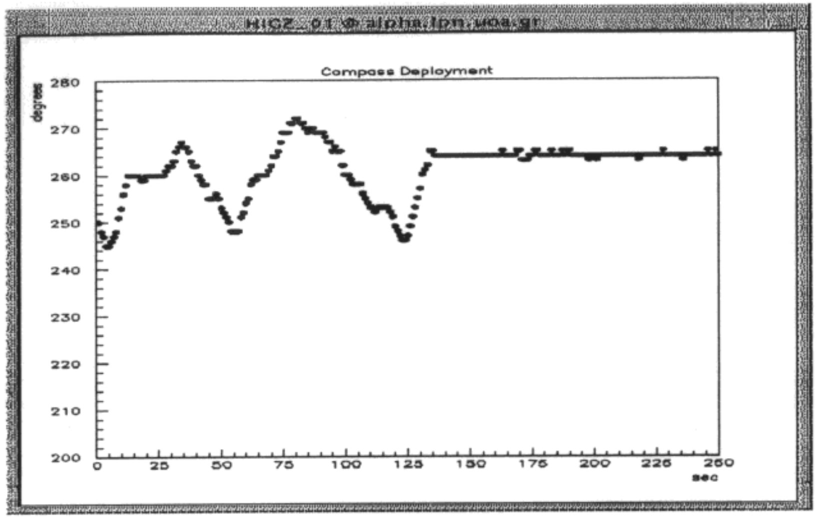

Kabel zu Trägerstern 3200
Auslöse-Einheit
Alu-Gehäuse, beidseitig mit Gummi-Schlauchdichtungen.
Unterölmotor mit Exzenter-Einheit mit Stellweg von ca. 20 mm.
E-Motor elektr. von Gehäuse getrennt.
Schnappbügel mit Schnäpper-Auslöser.
Über Drahtseil von Auslöse-Einheit gesteuert.
Nylon-Tauwerk 16 mm als Stabilisierung, mit 100 mm Lose gegenüber Ankerseilen
Druckfester Kabelverbinder,
Gehäuse aus nichtrostendem Stahl
Seeseitiger Eingang mit Gummischlauch 70/30,
vorgekrümmt, ca. 1 m lang
Alu-Klemme 7, eloxiert
Nylon-Schlinge 16 mm
Augschraube M 16 für Endstückbefestigung und als Heissauge zum Hieven und Einklinken des Grundgewichtes mit Hubzug als Hilfsgerät
Eisenbahnräder als Grundgewicht, aufsteckbar auf Achse, für variable Last
Nylon-Tauwerk 16 mm als Ankerseile für Trägerstern 3200
Zugfeder Niro, 10x90x1,5 beidseitig Ösen
1860
Ringmutter M 12 A4
Nylon-Schlinge 24 mm

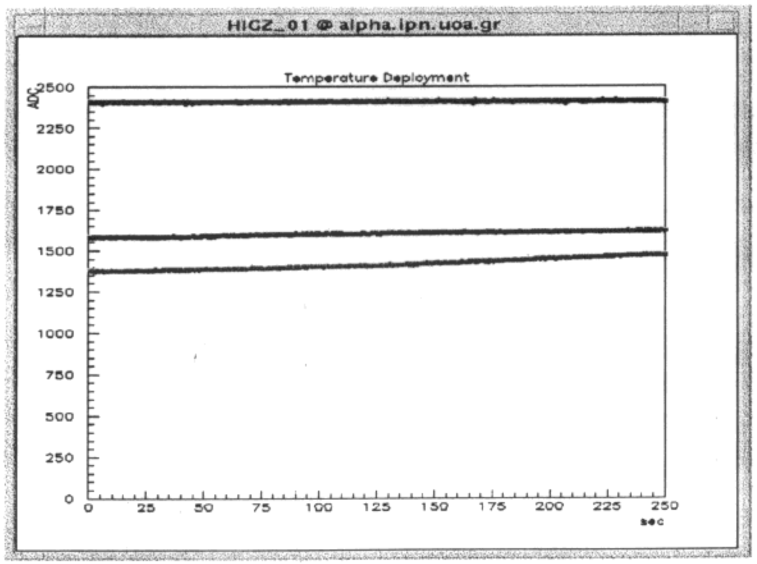

4720
800
Rohrverbinder 70 x 2 AlMgSi 1
Sechskant Adapter 45°
Gestellstutzen aus
Alu Rohr 70 x 2,
AlMgSi 1, einseitig
mit Klebemuffe 80 x 5 x 150
(Länge = 1/2 Rohre für
Trägerarm-Trägerstern 3200)
Gestellfuß aus 6 mm
Alu-Blech in
Knickkonstruktion

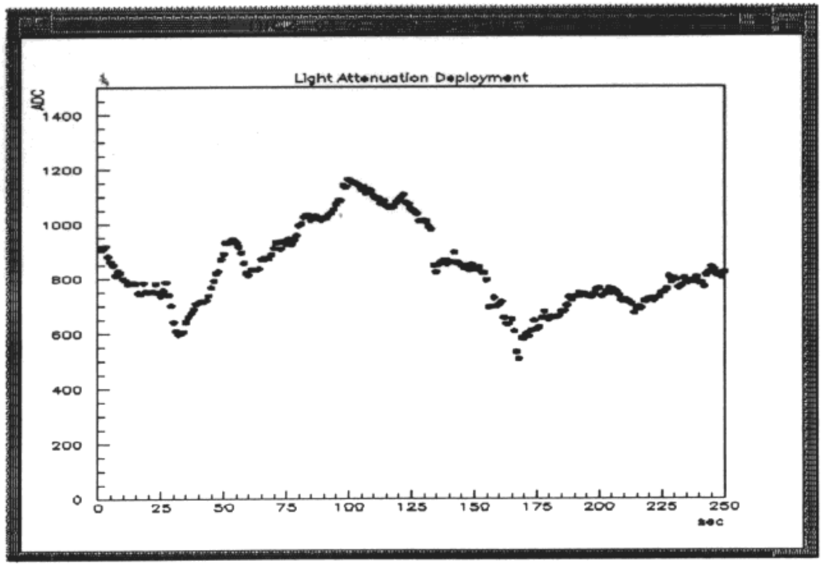
Maßstab 1 : 25




HIGZ_01 @ alpha.ipn.uoa.gr
Presure Deployment
ADC
sec


HIGZ_01 @ alpha.ipn.uoa.gr
Compass Deployment
degrees
sec

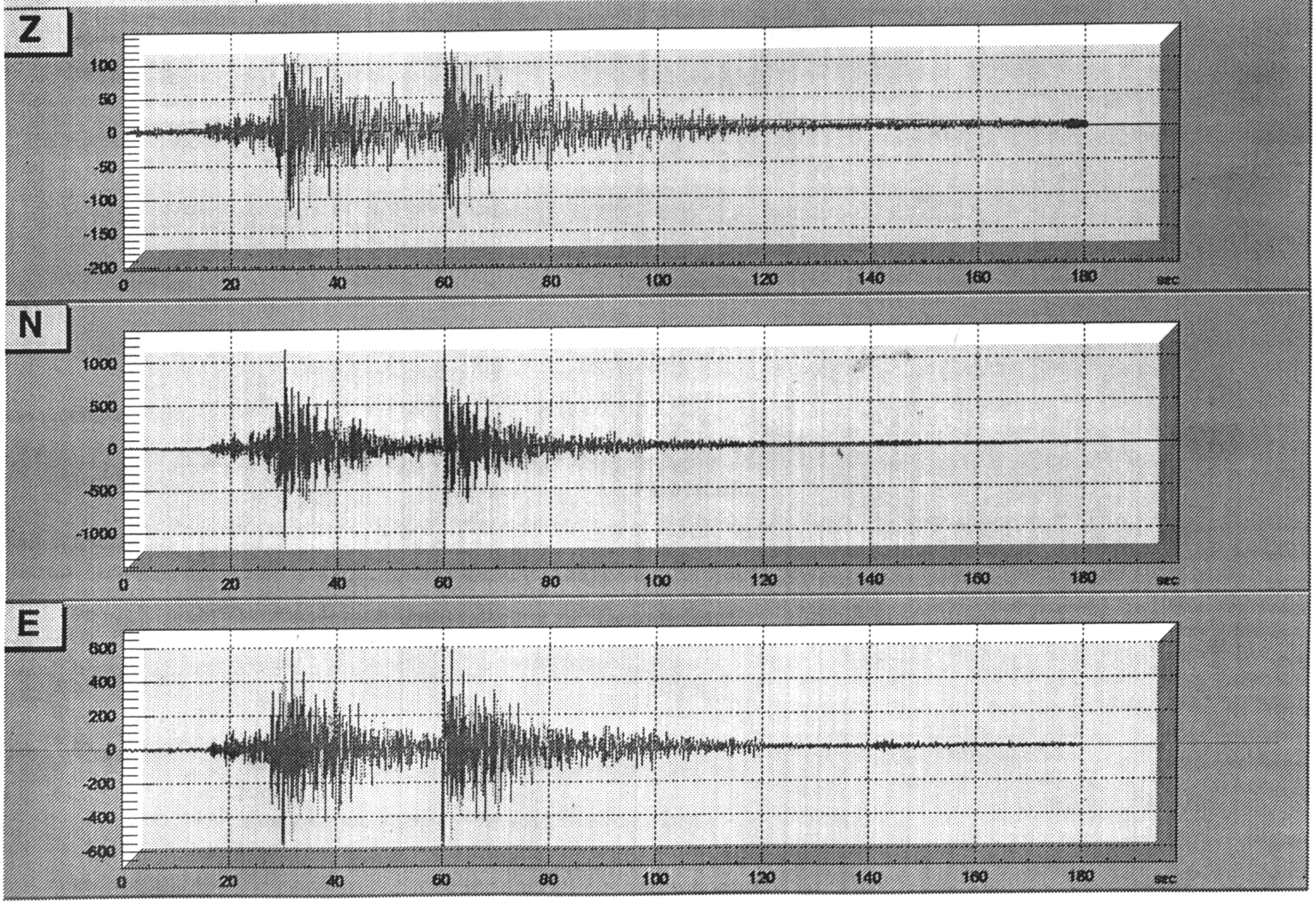

HIGZ_01 @ alpha.ipn.uoa.gr
Temperature Deployment
ADC
sec


Light Attenuation Deployment
ADC
sec

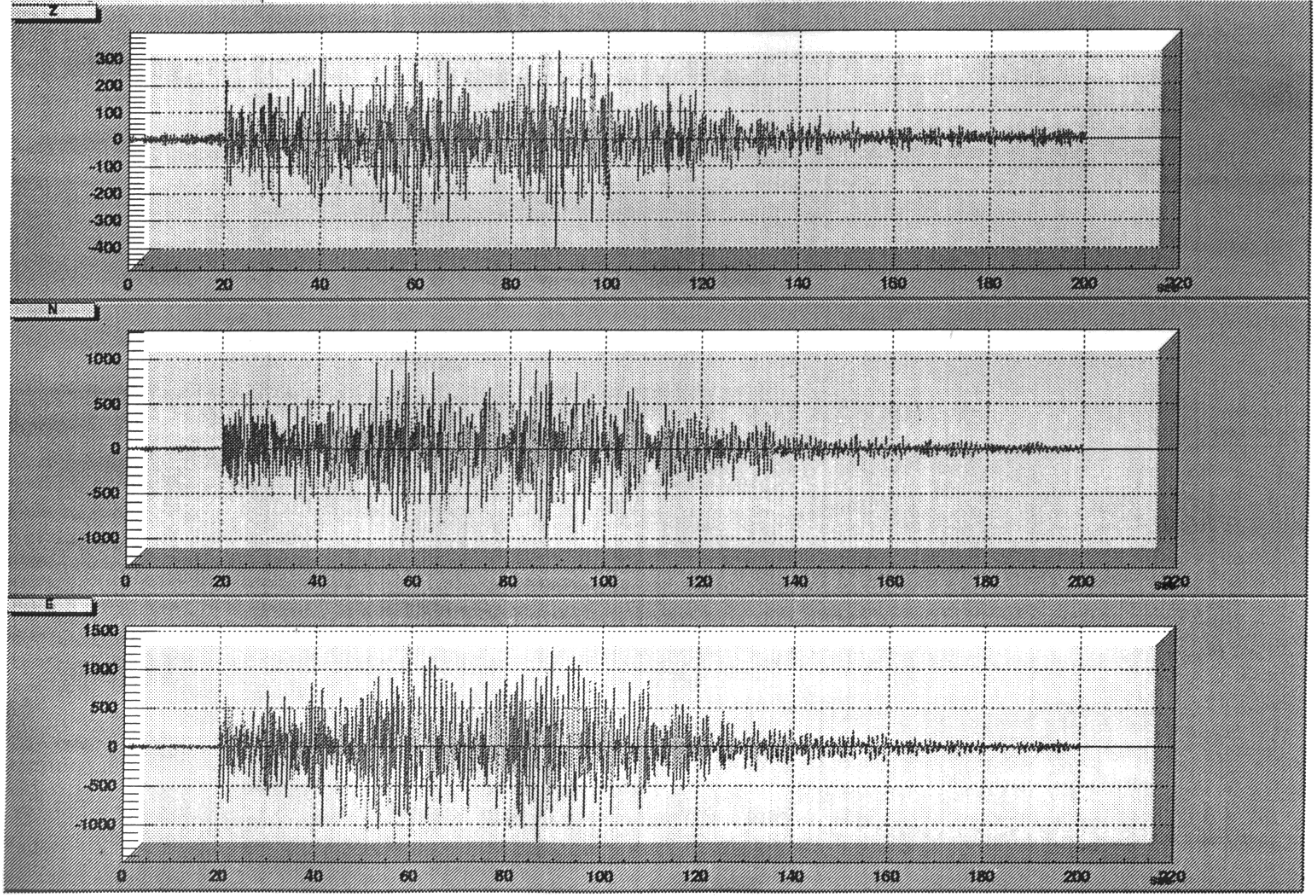
ON LINE

O.B.S. BAY STATION : NATIONAL SEISMIC NETWORK

PYLOS-LAERTIS STATION 27/01/99 20:07 GMT



PYLOS-LAERTIS STATION 07/02/99 22:30 GMT



STATUS

	NEED	HAVE
15" PMTs		164 ATHENS 4 KIEL 10 TOHOKU 70 DUMAND
	(168)	**248**
BENTHOS SPHERES	**(268)**	**350**
Ti SPHERES	**(12)**	**11**
MECHANICS (FLOORS)	**(12)**	**5** (3 Al, 2Ti)
ELECTRONICS (MOTHER BOARDS WITH14 CHANNELS OF 200MHz FADCs)	**(12)**	**2** (1 tested, almost O another is being tested now)
DATA AQUISITION	**(12 ALPHAS)**	**2**
E/O CABLE	18 monomode fiber E/O cable has been orderd to SIEMENS	
BAY STATION	5km long E/O cable, 12 monomode fibers, is already deployed in the bay. Bay Station is operational **since July 1998.**	

PLUS...

NESTOR is also a testbed for the Berkeley km^3 electronics development program.

Dave Nygren et al. are preparing electronics for the two NESTOR floor deployment (at the end of this summer) 300MHz-2GHz sampling rate, readout and transmission to shore will be initiated by a 3-fold coincidence in any floor.

PLAN

1. The Anchor Unit with Environmental Instruments will be deployed in 3800 m. deep water at the end of the 30 km long Electrooptical cable (18 fibers) in May/June 99.

2. Test deployment and operation of a two floor array in the Bay of Navarino Testing Station in the summer 1999.

3. Recovery of the end of the long cable, deployment and operation of the two floor array at the NESTOR site (3800m). (October 1999)

Effective area (10 TeV): 6 000m^2 (40^o angular resolution)
Effective area (1000 TeV): 15 000m^2 (40^o angular resolution)

4. Assuming that the electronics for another 10 floors will be ready a year later, we will recover the two floor array and redeploy the full 12-floor tower.

Effective area (10TeV): 40 000m^2 (40^o angular resolution)
15 000m^2 (5^o angular resolution)
Effective area (1000TeV): 100 000m^2 (40^o angular resolution)
50 000m^2 (5^o angular resolution)

5. Hexagon of Hexagonal towers.

Effective area (10TeV): 90 000m^2 (1^o angular resolution)
Effective area (1000TeV): 180 000m^2 (1^o angular resolution)
(time ???)

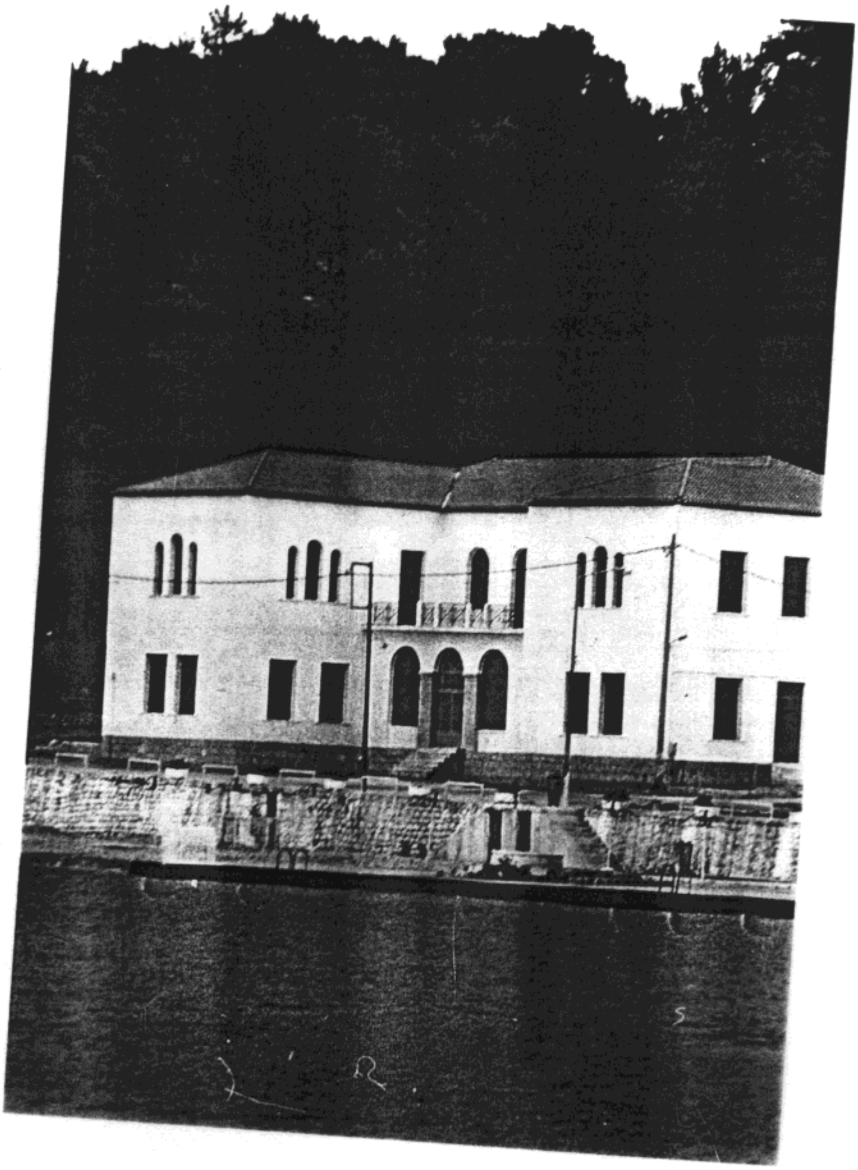
THE GREEK GOVERNMENT
CREATED A NEW NATIONAL
LABORATORY IN AUGUST 98

" THE NESTOR INDEPENDENT INSTITUTE FOR:
DEEP SEA RESEARCH TECHNOLOGY AND
NEUTRINO ASTROPARTICLE PHYSICS "

We are in the process of hiring staff.

WE INVITE YOU TO COME AND USE ITS FACILITIES

(even if your ideas and preconceptions are orthogonal to ours)



MARBLE AMPHITHEATER

NESTOR Institute's Home Page

http://solon.cc.uoa.gr/~nestor/