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Dr. M.D .Grossi

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Raytheon
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1847 W. Main Road
Portsmouth RI 02871

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R & D STATUS REPORT AFOSR-TR- 89-1726

JUNE 1985

ANALYTICAL/EXPERIMENTAL INVESTIGATION
OF
CORPUSCULAR RADIATION DETECTORS

CONTRACT F49620-85-C-0030

DARPA ORDER 5271

PROGRAM CODE 5A10

Effective Contract Date: 1 May 1985

Contract Expiration Date: 30 September 1986

$490,725

PERFORMED BY RAYTHEON CO.

SUBMARINE SIGNAL DIVISION, P.O. BOX 360

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D. KRETZSCHMAR - PROGRAM MANAGER (401) 847-8000, x4164

Dr. M. D. GROSSI - PRINCIPAL INVESTIGATOR (401) 847-8000, x2863

SPONSORED BY DARPA

DEFENSE ADVANCED RESEARCH PROJECT AGENCY (DOD)

DARPA ORDER NO. 5271

MONITORED BY AFOSR UNDER CONTRACT F49620-85-C-0030

DARPA PROGRAM DIRECTOR: US ARMY MAJOR G. P. LASCHE, PhD

DARPA/DSO/GSD

Enclosure (1)

CONTRACT F49620-85-C-0030

2^{ND} MONTHLY R & D STATUS REPORT - JUNE 1985

1. Progress During Report Period

During the report period several efforts were initiated both at Submarine Signal Division, Portsmouth Lab, and at the subcontractors. Dr. D. Bramanti, visiting scientist at SAO from Florence, Italy, arrived in early June and started working on June 6, 1985 in Cambridge, MA. A draft of the SAO Subcontract was reviewed and is now under negotiation. Work at SAO has already started, on the basis of a written commitment sent to them by Raytheon, and under financial coverage by the Smithsonian Institution, Washington, DC, while waiting for the full execution of the contract. Also, Prof. R. R. Lewis, the second Raytheon Subcontractor, started his work for the project, based on a written commitment by Raytheon, while formal award of the subcontract is underway.

At Raytheon, work concentrated in program planning, and in the performance of such tasks as the definition of the signal processing approach to be used in connection with the field observations to be performed at the end of the contract, and the preliminary design of the instrumentation system. At SAO Dr. Bramanti started the analysis of the magnetic approach. Prof. Lewis initiated a theoretical effort on the magnetic effects of neutrino/electron interaction, to further extend Stodolsky's 1975 analysis.

On June 28, 1985, the status of the project was reviewed at Raytheon, Portsmouth, RI, by the DARPA Program Director, US Army Major George P. Lasche, PhD, DARPA/DSO/GSD. The list of the attendees is in Attachment #1, while copy of the handouts that were distributed at the meeting can be found in Attachment #2. The handout reproduces the viewgraphs used in the presentation by the various speakers.

2. Instrumentation

No equipment purchase was performed during the report period. Also, no developmental work was performed.

3. Project Personnel Status

No change, thus far, from the plan. Dr. A. K. Drukier is still expected to start working at SAO on the calorimetric SSC approach during July 1985. However, he might arrive a week or so later than initially expected. Dr. Fuligni is still scheduled to arrive at SAO in mid July and to stay there until mid August 1985. He will continue to work on his concept of the superconducting neutrino detector, based on the magnetic monitoring of Cooper pairs breakage.

4. Trips, Meetings, Briefings, Papers, etc.

A visit was paid by Mr. D. Grossi, on June 17 and 18, 1985 to the Physics Department of the University of British Columbia, Vancouver, B.C., Canada. This Institution had submitted a proposal to SAO on February 13, 1985 to perform experimental work, under a sub-subcontract from SAO, on the metal grain calorimeter. Dr. A. K. Drukier, had spent about three weeks during April 1985 at UBC, Vancouver, to work on this calorimeter. SAO is presently reviewing a formal proposal from UBC. The results of Dr. Grossi's visit to UBC were reported at the Program Review meeting of 6/28/85 held at Raytheon, Portsmouth, RI and are contained in Attachment #2 to this report.

5. Summary of Problem Areas

None thus far.

6. Effort's Deviation From Plan

None thus far.

7. Fiscal Status Report

(a) Funds currently available .... $ 490K

(b) Expenditures and commitments to-date (6/23/85)...... 2.8K

(c) Estimate of funds required to complete effort 487.2K

(d) Estimted date of program completion .... No Change From Contractual Date

Attachment #1

LIST OF ATTENDEES AT THE PROGRAM REVIEW MEETING, CONTRACT DARPA/AFOSR F49620-85-C-0039, HELD AT RAYTHEON, SUBMARINE SIGNAL DIVISION, PORTSMOUTH, RI ON JUNE 28, 1985.

Name	Organization	Telephone Number	
Dr. G. P. Lasche	DARPA	202-694-3145	
C. J. Dyer	Raytheon-SSD	401-847-8000	x2020
D. J. Kretzschmar	"	"	x4164
Dr. M. Grossi	"	"	x2863
Dr. C. Klein	Raytheon-Research Div.	617-860-3069	
Dr. A. E. Lilley	Harvard/SAO	617-495-3971	
J. Slowey	"		
Dr. D. Bramanti	" (Visiting Scientist)		
Dr. R. R. Lewis	University of Michigan		

Attachment #2

COPY OF HANDOUT DISTRIBUTED AT PROGRAM REVIEW MEETING OF JUNE 28, 1985, CONTRACT F49620-85-C-0039, CONTAINING PHOTOSTATS OF VIEWGRAPHS USED IN THE PRESENTATION.

Raytheon

ANALYTICAL/EXPERIMENTAL INVESTIGATION OF CORPUSCULAR RADIATION DETECTORS

CONTRACT F49620-85-C-0030

PROGRAM PLAN PRESENTATION

FOR

US ARMY MAJOR GEORGE P. LASCHÉ, PHD

DARPA/DSO/GSD

28 JUNE 1985

RAYTHEON COMPANY
SUBMARINE SIGNAL DIVISION
PORTSMOUTH, RI 02871

WORK STATEMENT

1. PERFORM AN ANALYSIS AND NUMERICAL CALCULATIONS OF THE EXPECTED INTENSITY AND SPECTRUM OF THE SIGNAL, OF THE NOISE BACKGROUND, AND OF THE DETECTOR'S SENSITIVITY, FOR TWO APPROACHES: THE CALORIMETRIC APPROACH AND THE MAGNETIC INTERACTION APPROACH.

2. DESIGN TWO INSTRUMENTS (ONE FOR EACH APPROACH) AND INITIATE THEIR DEVELOPMENT, USING WHEREVER POSSIBLE OFF-THE-SHELF SUBSYSTEMS.

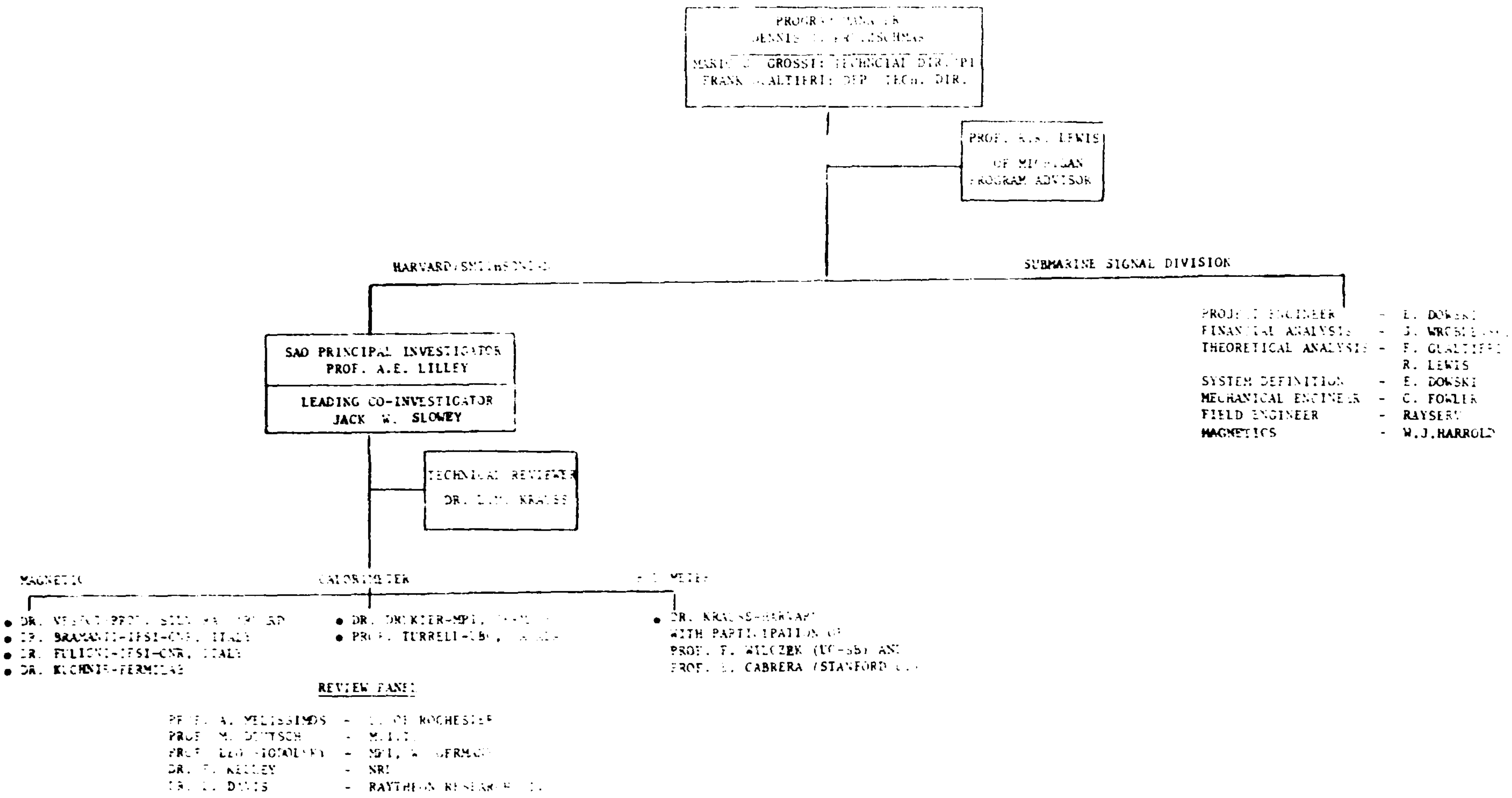
3. COMPLETE THE BREADBOARD DEVELOPMENT OF AT LEAST ONE SENSOR AND PERFORM LABORATORY FEASIBILITY TESTS.

4. DEPLOY SENSOR(S) IN THE FIELD, USING THE NECESSARY FIELD LABORATORY SPACE PROVIDED BY THE CONTRACTOR.

5. PERFORM MEASUREMENTS WITH SENSOR(S) ON THE OCCASION OF A DESIGNATED EVENT, UNDER DARPA INSTRUCTIONS.

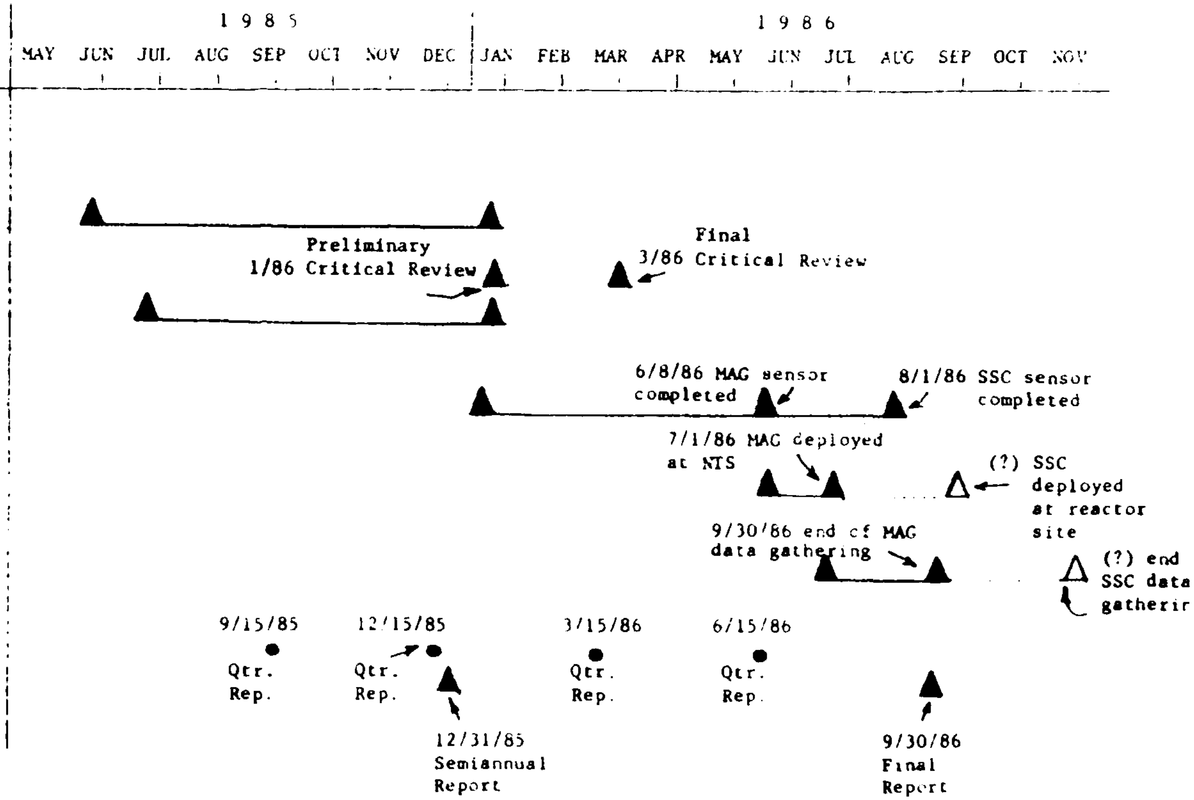
6. PREPARE AND SUBMIT MONTHLY, QUARTERLY, AND SEMI-ANNUAL PROGRAM STATUS REPORTS. A FINAL REPORT WILL DOCUMENT ALL THE FINDINGS DURING EXECUTION OF THE CONTRACT.

NEUTRINO DETECTION PROGRAM



<u>ANALYTICAL/EXPERIMENTAL INVESTIGATION OF CORPUSCULAR RADIATION DETECTORS</u>

1. Perform an analysis and numerical calculations of the expected intensity and spectrum of the signal, of the noise background, and of the detector sensitivity, for two approaches: the calorimetric approach and the magnetic interaction approach.
2. Design two instruments (one for each approach) and initiate their development, using wherever possible off-the-shelf subsystems.
3. Complete the breadboard development of at least one sensor and perform laboratory feasibility tests.
4. Deploy sensor(s) in the field, using the necessary field laboratory space provided by the Contractor.
5. Perform measurements with sensor(s) on the occasion of a designated event, under DARPA instructions.
6. Prepare semi-annual and final reports. Prepare monthly status letter reports.

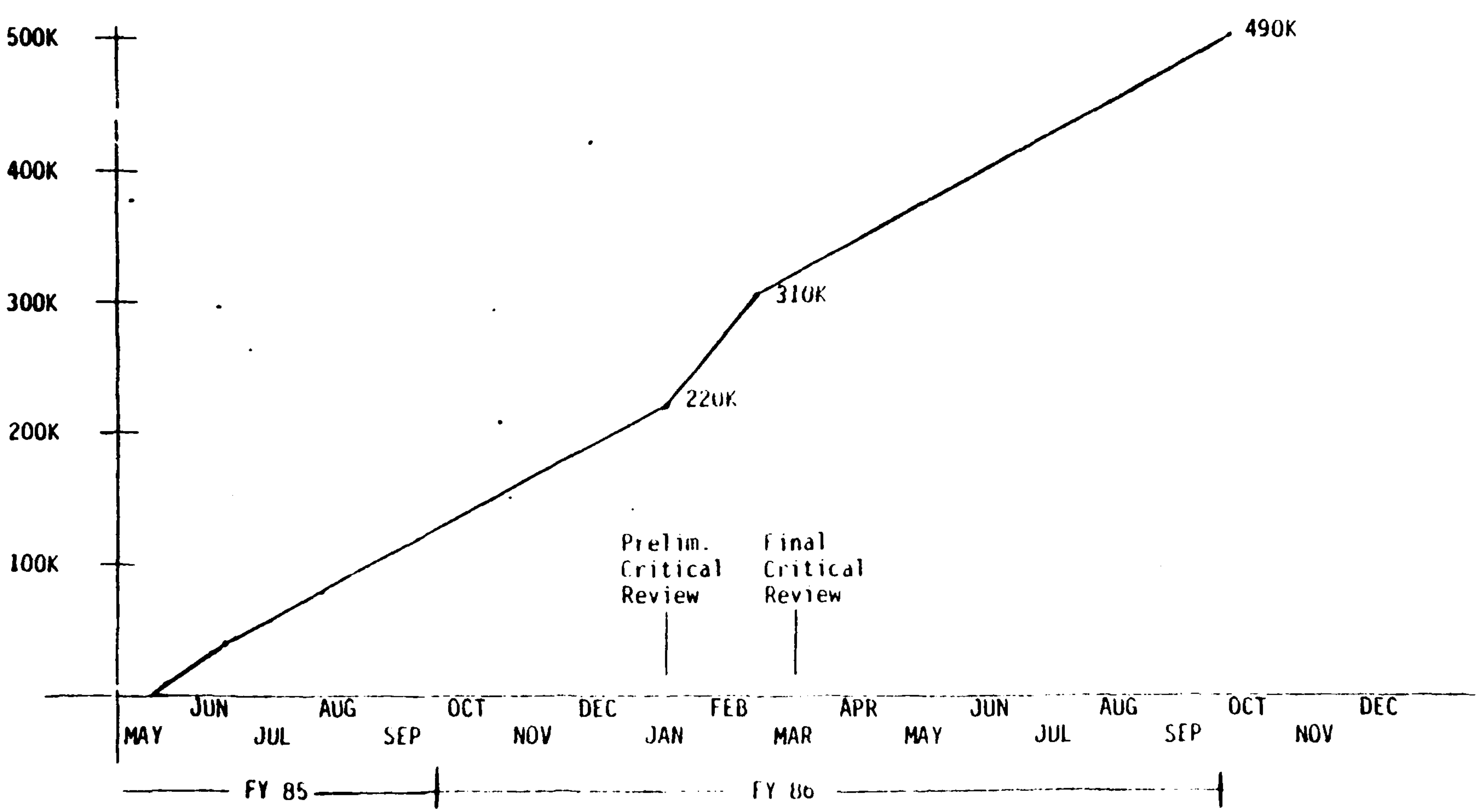


MAG = Magnetic Interaction Approach
SSC = Superheated Superconducting Colloid= Calorimetric Approach
NTS = Nevada Test Site

Raytheon

EXPENDITURE PLAN
FOR CORPUSCULAR RADIATION INVESTIGATION

6/28/85



TECHNICAL APPROACHES FOR DETECTION OF LOW-ENERGY NEUTRINOS RAYTHEON WILL INVESTIGATE

1. <u>MAGNETIC INTERACTION APPROACHES</u>

   A SQUID MAGNETOMETER DETECTS THE MAGNETIC SIGNAL THAT ARISES FROM THE TORQUE ON THE SPINNING ELECTRONS OF THE INTERACTION TARGET, WITH TORQUE DUE TO SCATTERING OF LOW-ENERGY NEUTRINOS BY TARGET BODY.

   AN ALTERNATIVE/ADDITION, SQUID MAGNETOMETER DETECTS MAGNETIC SIGNAL THAT ARISES FROM SUPERCONDUCTING TUNNEL JUNCTION, WHERE SMALL ENERGY PROVIDED BY NEUTRINOS BREAKS COOPER PAIR.

2. <u>SUPERHEATED SUPERCONDUCTING COLLOID (SSC)</u>

   CALORIMETRIC APPROACH, WHERE SUPERCONDUCTING GRAINS ARE "FLIPPED" INTO NORMAL STATUS BY ENGERGY DEPOSITION DUE TO NEUTRINO ELASTIC SCATTERING BY GRAIN NUCLEI. THE GRAIN FLIPPING IS DETECTED THROUGH DISAPPEARANCE OF MEISSNER EFFECT. THIS DISAPPEARANCE PRODUCES A MAGNETIC SIGNAL, DETECTABLE WITH A SQUID.

3. <u>SILICON BOLOMETER</u>

   NEUTRINO ELECTRON SCATTERING IN A SILICON BLOCK PRODUCES MEASUREABLE TEMPERATURE CHANGES IN BLOCK. TUNGSTEN SUPERCONDUCTING RING IS DEPOSITED ONTO SILICON BLOCK AND "FLIPS" TO NORMAL STATUS WHEN TEMPERATURE INCREASES. THIS CHANGE IS INDUCTIVELY DETECTED WITH A PILOT TONE, A TRANSFORMER, AND A SQUID.

Raytheon

SSD WORK ASSIGNMENTS (PHASE I)

TECHNICAL STAFF

M. GROSSI
- OVERALL PROGRAM TECHNICAL DIRECTION
  ESTABLISH SCIENTIFIC/ENGINEERING GUIDELINES AND DESIGN CRITERIA
  COORDINATE INPUTS FOR REPORTS AND PRESENTATIONS
  MONITOR SUBCONTRACTORS

W. HARROLD
- ANALYZE BOTH APPROACHES, FROM A MAGNETIC STANDPOINT
  CODE AND RUN SOFTWARE TO ANALYZE CRITICAL ASPECTS OF INSTRUMENTATION DESIGN

SYSTEMS

F. GUALTIERI
- CONTRIBUTE TO SCIENTIFIC/ENGINEERING ASPECTS OF EXPERIMENT APPROACH, DESIGN, AND INSTRUMENTATION.
  DIRECT AND PERFORM ANALYTICAL ACTIVITY FOR CRITICAL AREAS OF INVESTIGATION (MAGNITUDE OF NEUTRINO FLUX, BACKGROUND NOISE, ETC.)

E. DOWSKI
- PERFORM CONCEPTUAL DESIGN OF INSTRUMENTATION SYSTEM FOR BOTH APPROACHES
  DEFINE SUBSYSTEMS, LEASE VS. BUY

MECHANICAL

C. FOWLER
- MECHANICAL DESIGN OF SENSOR PACKAGES FOR BOTH APPROACHES
  LAYOUT SUBSYSTEMS IN EXPERIMENT CONTAINER
  IDENTIFY CONTAINER AND COST

RAYSERV
- PREPARE PLANS FOR SENSOR DEPLOYMENT AT EXPERIMENT SITE FOR BOTH APPROACHES
- PERFORM TWO FIELD SURVEYS - NTS AND SELECTED NUCLEAR RESEARCH REACTOR.

Raytheon

28 JUNE 1985

PROGRAM STATUS

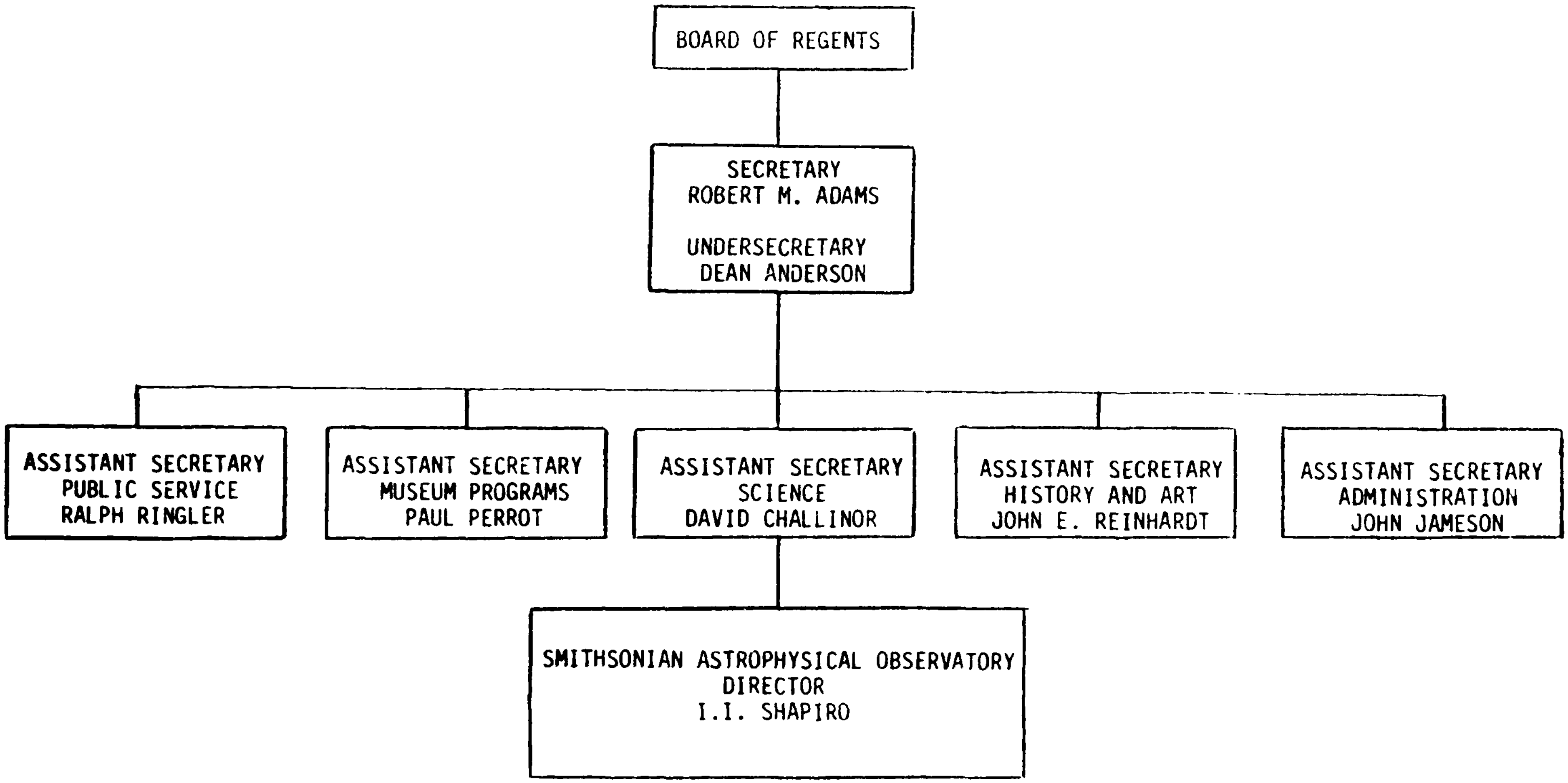
- CONTRACT SIGNED - MAY 15, 1985
- SSD KICKOFF MEETING - MAY 24, 1985
- SSD BUDGETS ALLOCATED AND TASKS ASSIGNED
- SUBCONTRACTS DRAFTED - SAO, PROF. LEWIS
- M. GROSSI VISIT TO UBC - PROF. TURRELL
- SAO VISITING SCIENTISTS

THE PARTICIPATION IN THE NEUTRINO INVESTIGATION OF THE SMITHSONIAN ASTROPHYSICAL OBSERVATORY

Smithsonian Institution
Astrophysical Observatory
Cambridge, Massachusetts 02138

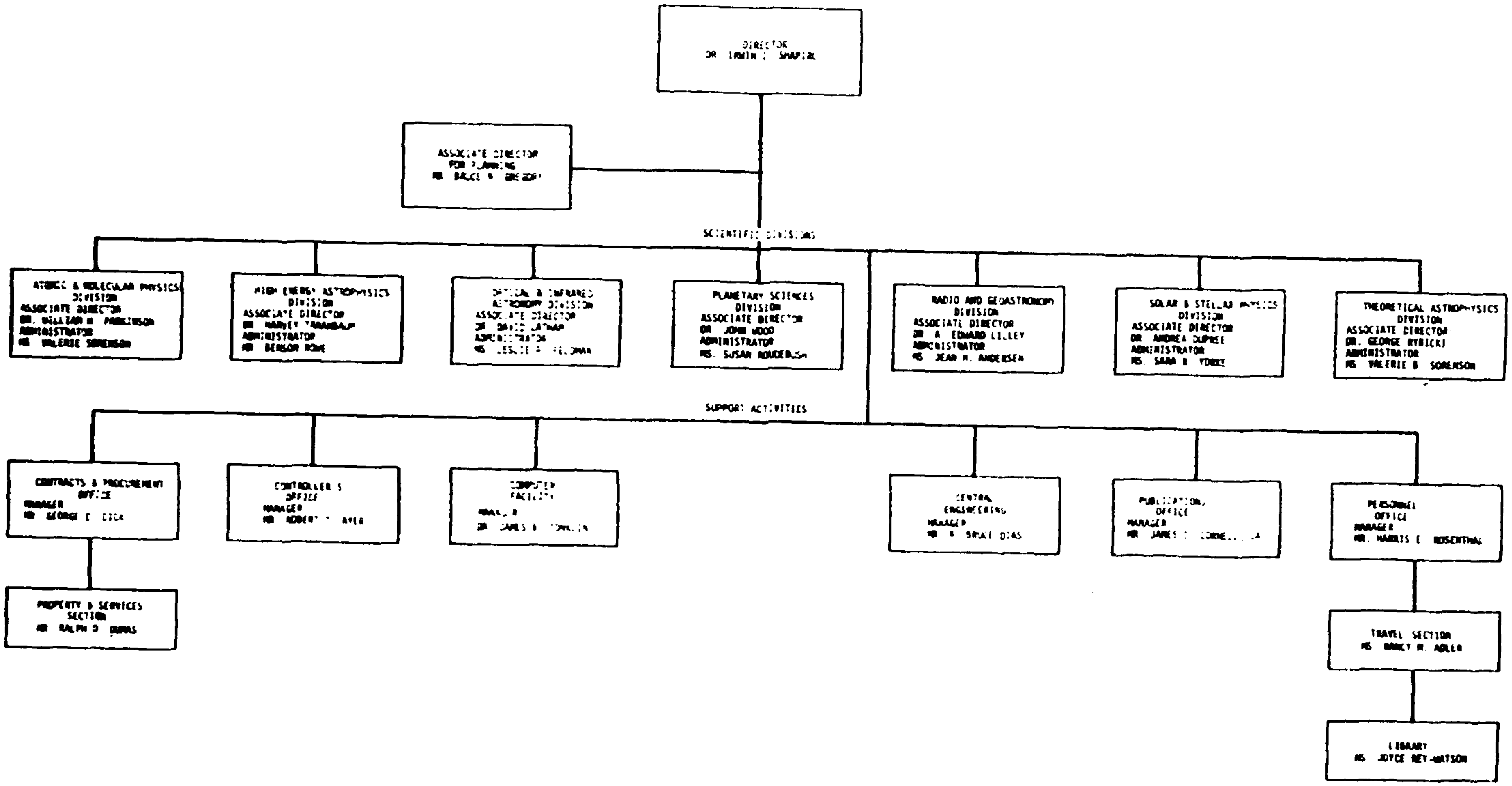
The Smithsonian Astrophysical Observatory
is a member of the
Harvard-Smithsonian Center for Astrophysics

SMITHSONIAN INSTITUTION ORGANIZATION CHART



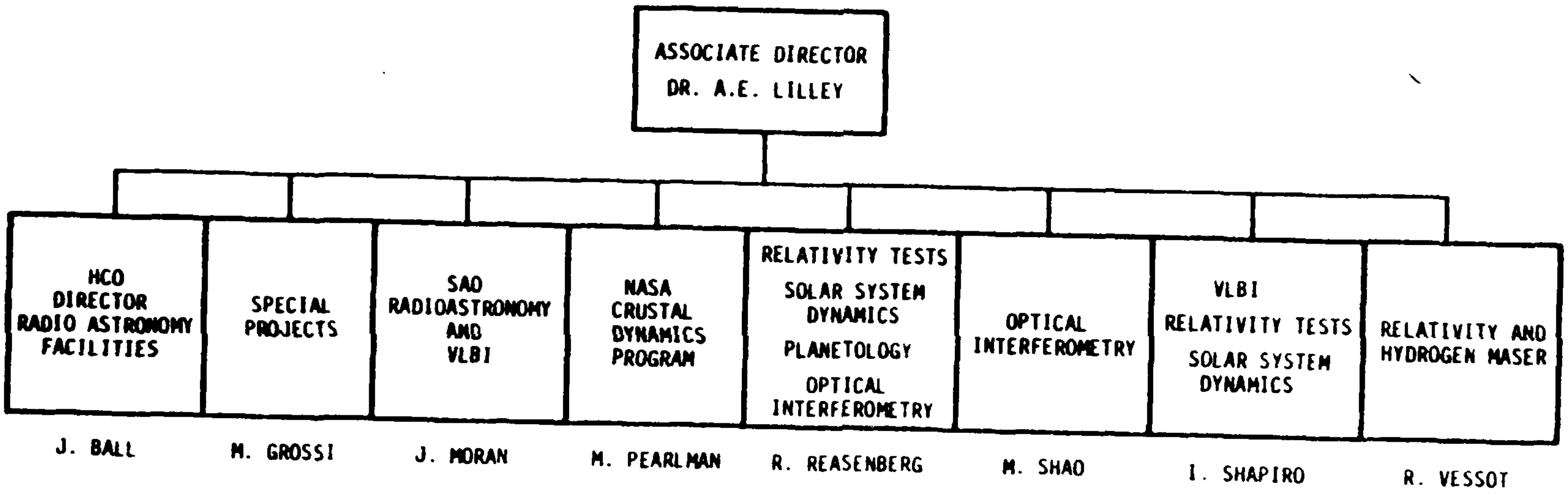
SMITHSONIAN ASTROPHYSICAL OBSERVATORY

ORGANIZATION CHART



OCTOBER 17, 1984

RADIO AND GEOASTRONOMY DIVISION ORGANIZATION CHART



FUNDAMENTAL GUIDELINES OF SAO PARTICIPATION IN PROJECT

- PRIMARILY, A THEORETICAL EFFORT, TO BE CONDUCTED WITH SCIENTIFIC RIGOR, WITH ANALYTICAL FINDINGS OF VARIOUS INVESTIGATORS SCRUTINIZED BY OTHER GROUP MEMBERS, AND FINALLY BY A BLUE-RIBBON REVIEW PANEL CHAIRED BY PROF. I.I. SHAPIRO, DIRECTOR OF HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS.

- LIMITED-SCOPE LABORATORY WORK STRICTLY DEVISED TO GATHER DATA THAT INVESTIGATORS CONSIDER ESSENTIAL FOR THE PERFORMANCE OF THEIR ANALYTICAL TASKS, AND TO VERIFY VITAL ANALYTICAL FINDINGS.

- ALL ACTIVITY AT SAO STRICTLY UNCLASSIFIED. THIS ACTIVITY IS RELATED TO INVESTIGATIONS OF FUNDAMENTAL PRINCIPLES OF NEUTRINO PHYSICS, AND SAO WELCOMES PUBLICATION POLICY SPECIFIED BY DARPA/AFOSR TO RAYTHEON, ESSENTIALLY AUTHORIZING UNRESTRICTED PUBLICATION OF THEORETICAL FINDINGS.

- EVERY SINGLE TASK TO BE PERFORMED AT SAO BY RECOGNIZED SPECIALISTS, INVITED TO JOIN SAO AS VISITING SCIENTISTS FROM THEIR INSTITUTIONS OF ORIGIN (MAX PLANCK, IFSI-CNR ETC.). OVERALL SAO EFFORT DIRECTED BY A PRINCIPAL INVESTIGATOR AT THE ASSOCIATE DIRECTOR LEVEL (PROF. A.E. LILLEY).

- PARTICIPATION OF OTHER INSTITUTIONS UNDER SAO COORDINATION : FERMILAB, HARVARD, STANFORD, MIT, YALE, ETC.

MAGNETIC INTERACTION TARGET

THEORETICAL

DEFINITION OF TARGET BODY/DETERMINATION OF THRESHOLD SENSITIVITY FOR AT LEAST TWO TARGET CONFIGURATIONS.

(BRAMANTI) HIGH PERMEABILITY TARGET STRUCTURE

(FULIGNI) COOPER PAIR BREAK-UP IN SUPERCONDUCTING RING

LABORATORY

FERMILAB (M. KUCHNIR)

MEASURE THERMAL NOISE OF LOADED SQUID
(LOAD IS MAGNETIC TARGET)

SAO AND HARVARD (PROF. SILVERA, DR. BRAMANTI, DR. MATTISON)

MEASUREMENT OF DIFFERENTIAL RELATIVE PERMABILITY OF TARGET AT AMBIENT AND $4^{o}K$ TEMPERATURES

SSC GRAIN CALORIMETER

THEORETICAL (DRUKIER)

'DETECTABILITY OF GRAIN "FLIPPING"

'ESTIMATION OF MINIMUM DETECTABLE NEUTRINO FLUX

'DEFINITION OF SQUID READ-OUT SYSTEM PARAMETERS

LABORATORY ,UBC VANCOUVER (PROF. TURRELL AND DR. DRUKIER)

VERIFICATION OF SSC CALORIMETER THRESHOLD SENSITIVITY BY X-RAY GRAIN ILLUMINATION AND MUON BEAM IRRADIATION

SILICON BOLOMETER

THEORETICAL - YALE (PROF. KRAUSS), UC-SB (PROF. WILCZEK)

- EFFECT OF BACKGROUND NOISE ON THRESHOLD SENSITIVITY
- PRELIMINARY DEFINITION OF 1 KG SI DETECTOR FOR TEST WITH NON AND KNOWN NEUTRINO SOURCES
- CONCEPTUAL DEFINITION OF 10 TO 100 KG NEUTRINO DETECTOR FOR USE IN REACTOR EXPERIMENTS

LABORATORY (NOT CURRENTLY INCLUDED)

RANK ORDER OF DETECTORS

1 CRITICAL REVIEW OF RANK ORDER OF DETECTOR JUDGED BEST FOR PROTOTYPE DEVELOPMENT AND TEST.

2 PROVIDE RAYTHEON WITH CONCLUSIONS OF REVIEW AND RANK AND ASSIST RAYTHEON IN PHASE II TASKS.

TECHNICAL DISCUSSION ON STUDY TASKS

THEORETICAL ESTIMATE OF NEUTRINO BURST PARAMETERS

P-14-79-U-287

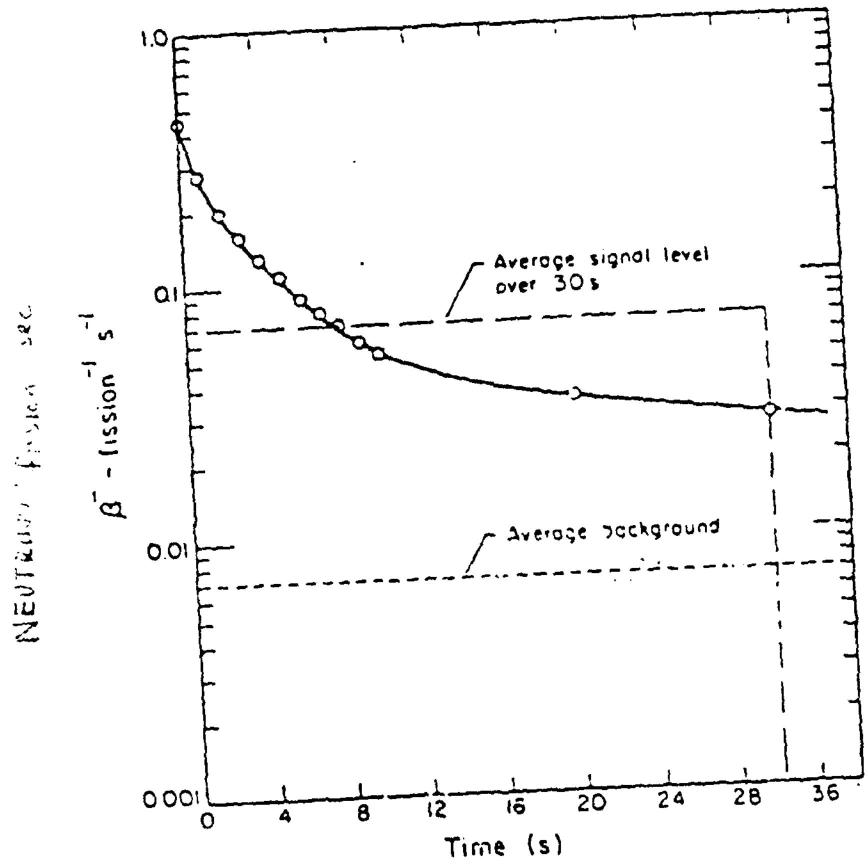


Fig. 1 Anticipated shape of counting rate vs time, in relation to desired background level.

copied from Harold Kruse and Rosalie Loncosk

Neutrino Proposal II

P-14-79-U-287

Oct 3 1979

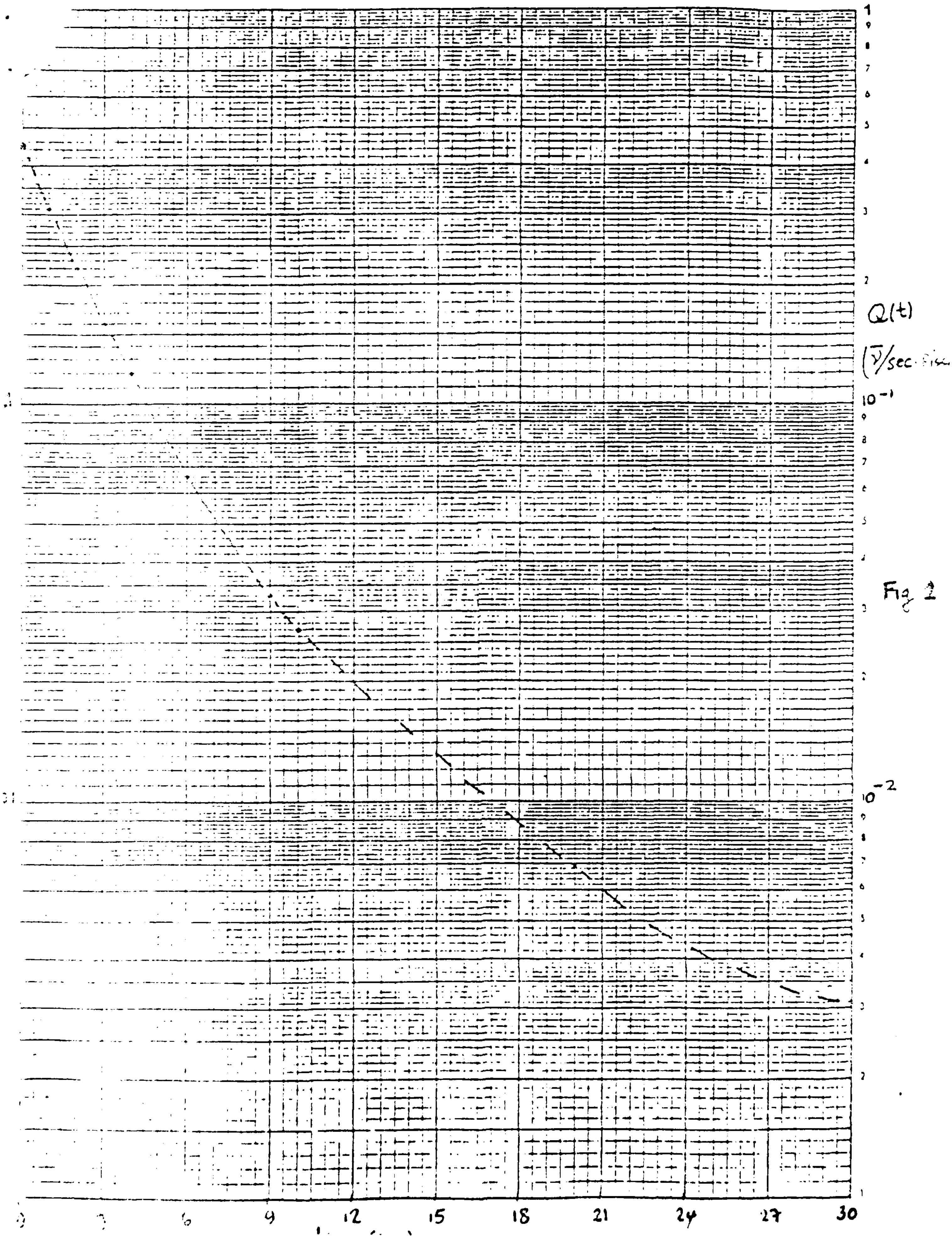
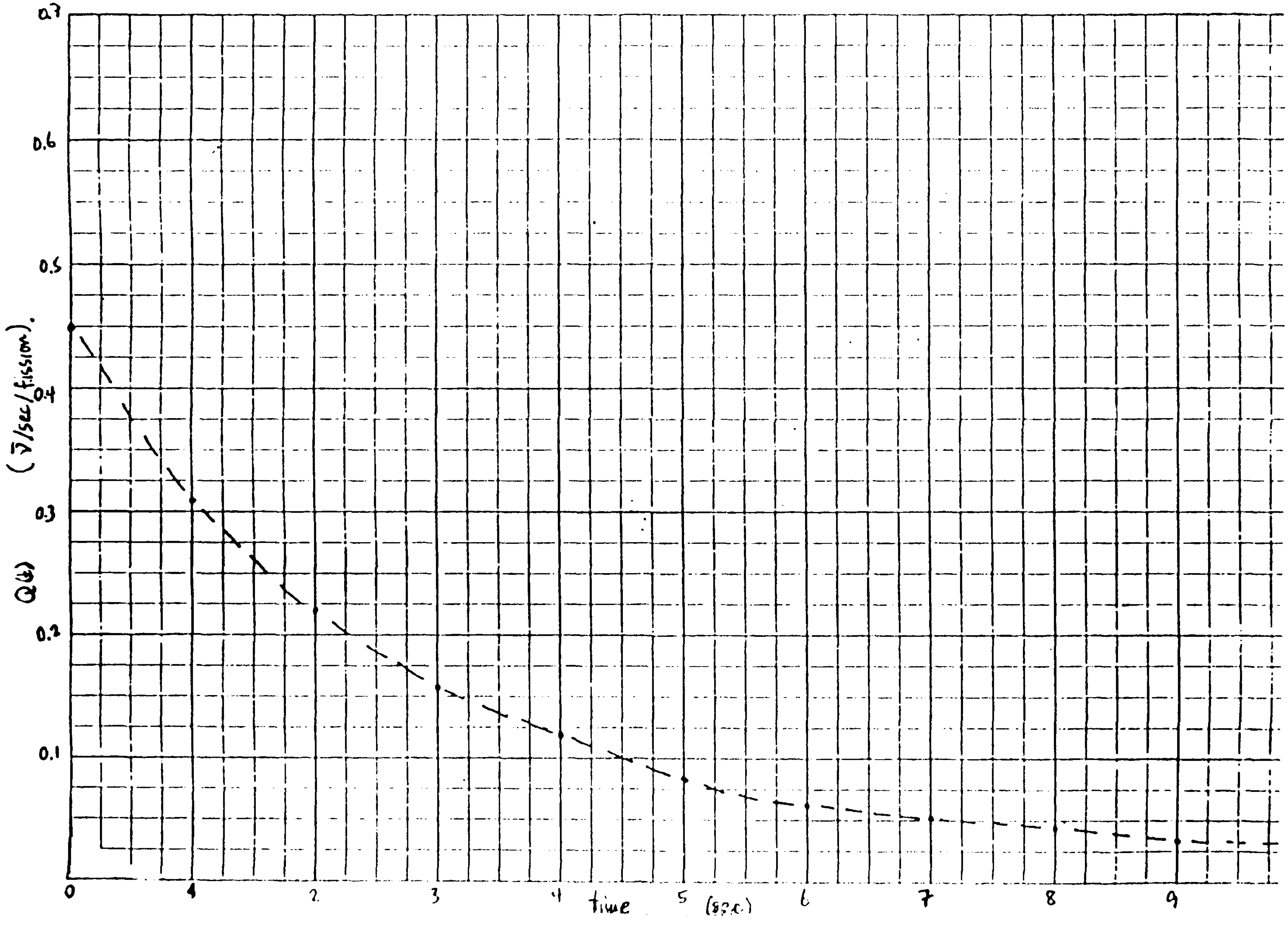
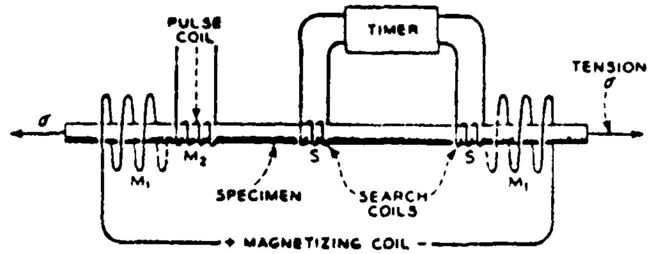


Fig 2

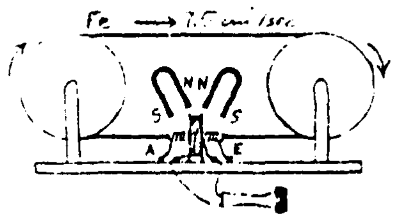
Figure 3 Approximate Line Shape of Neutrino Signal





MEASUREMENT OF AN AVALANCHE REVERSAL OF THE MAGNETIZATION IN A FERROMAGNETIC WIRE UNDER LONGITUDINAL STRESS. FROM BOZORTH, FERROMAGNETISM, PAGE 496, VAN NOSTRAND 1951.

FIGURE 2.



MARCONI's MAGNETIC DETECTOR (1902)

FROM: NOBEL LECTURES 1901-1921, page 218
ELSEVIER PUBLISHING COMPANY, 1967
AND FROM: G. MARCONI, PROC. ROY. SOC. LONDON, 70 (1902) 341.

FIGURE 3

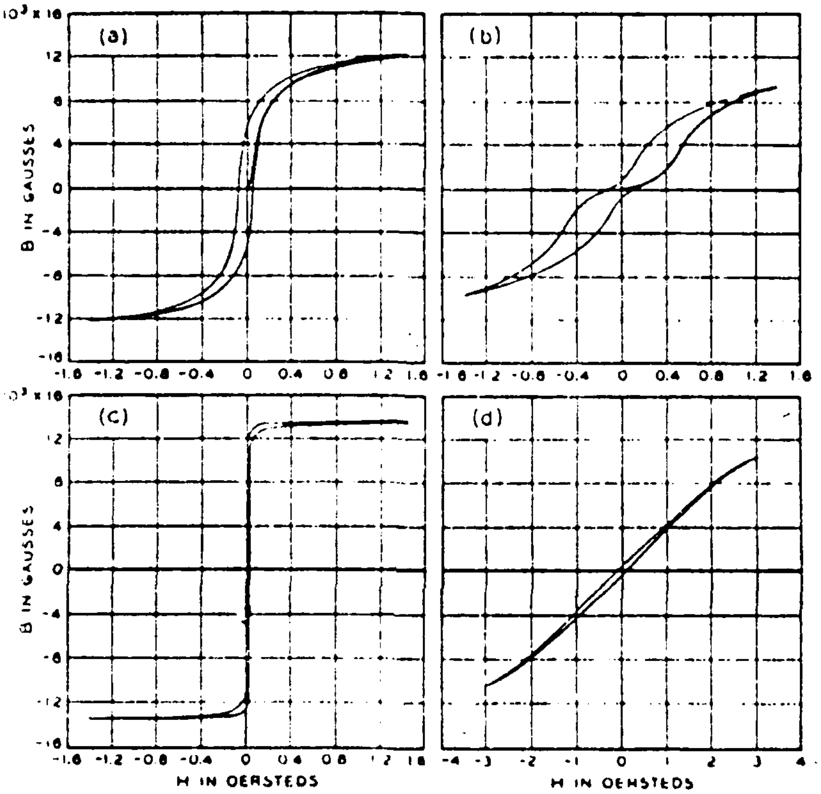


FIG. 11-19. Hysteresis loops of 65 Permalloy heat-treated in various ways: (a) annealed at 1000°C; (b) baked at 425°C for 24 hours, (c) heat-treated in a longitudinal field; (d) heat-treated in a transverse field.

FROM: BOZORTH, FERROMAGNETISM, VAN NOSTRAND (1951, p. 499).

FIGURE 1.

SENSITIVITY OF THE MAGNETIC DETECTOR

$$\Delta E = \frac{\sqrt{2}\, G_F}{c} \cdot J_\nu$$

with: $G_F = 1.01 \times 10^{-5} \frac{\hbar^3}{m_p^2 c} = 1.435$ erg cm^3 Fermi constant

$c = 3 \times 10^{10}$ cm sec^{-1}

$J_\nu = 10^{14}$ neutrinos (or antineutrinos) cm^{-2}sec^{-1}

we have: $\Delta E = 6.76 \times 10^{-46}$ ergs $= 4.22 \times 10^{-34}$ eV for one electron

If we take $(50\,\text{cm})^3 = 1.25 \times 10^5\,\text{cm}^3$ of Fe, ~ 1 ton, with $\sim 10^{27}$ magnetization electrons and if we can consider them independent one from the other:

$$\Delta E_{tot} = 4.22 \times 10^{-7}\,\text{eV}$$

$\Delta E_{tot} \geq kT$ for $T \lesssim 5\,\text{m}^\circ\text{K}$

Equivalent magnetic field $H_{eq} = \frac{\Delta E}{\mu_B} = 7.3 \times 10^{-26}$ gauss

with $\mu_B = \frac{e\hbar}{2m_e c} = 5.79 \times 10^{-9}$ eV gauss^{-1}

If $\mu = 10^{10}$ we have $B = 7.3 \times 10^{-16}$ gauss

With a superconducting transformer we can concentrate this field gaining a factor 10^5: $B' = 7.3 \times 10^{-11}$ gauss

SUPERCONDUCTING JOSEPHSON JUNCTION AS DETECTOR OF NEUTRINOS THROUGH MECHANISM OF COOPER PAIR BREAKING

- NEUTRINO FLUX INTERACTS WITH ELECTRON AT REST WITH ENERGY ΔE, GIVEN BY STODOLSKY, 1975.
- TWO SUPERCONDUCTING METALS, WITH VERY DIFFERENT ENERGY GAPS Δ_L AND Δ_R ARE CONNECTED BY JOSEPHSON JUNCTION
- IF $|\Delta_L| \ll |\Delta_R|$, NEUTRINOS WILL BREAK MORE COOPER PAIRS ON THE LEFT SUPERCONDUCTOR (L) THAN ON THE RIGHT SUPERCONDUCTOR (R). LET'S ASSUME THAT NO PAIRS ARE DESTROYED IN THE LATTER.
- CHANGING NUMBER OF PAIRS ON THE LEFT SUPERCONDUCTOR MAY BE DESCRIBED AS A VARIABLE IMPEDENCE IN PARALLEL WITH JUNCTION.
- WE MAY WRITE FOR DENSITY OF PAIRS IN THE LEFT SUPERCONDUCTOR $\rho_L = \bar{\rho}_L \left[1 + \varepsilon(t)\right]$

WHERE ε (T) IS A TERM THAT REPRESENTS NEUTRINO FLUX.

- THE PHENOMENON IS GOVERNED BY FOLLOWING EQUATIONS

$$\dot{\rho}_L = \frac{2}{\hbar} K \sqrt{\rho_L \rho_R} \sin\delta \ ; \ \dot{\rho}_R = -\frac{2}{\hbar} K \sqrt{\rho_L \rho_R} \sin\delta \ ; \ \dot{\delta} = \frac{K}{\hbar} \frac{\rho_L - \rho_R}{\sqrt{\rho_L \rho_R}}$$

- FROM THESE EQUATIONS WE OBTAIN THE EXPRESSION FOR THE CURRENT $I = I_0 \sin\delta$, WHOSE PHASE IS DEPENDENT UPON THE NEUTRINO FLUX.
- QUANTITATIVE ESTIMATE OF ACHIEVABLE SENSITIVITY IN NEUTRINO DETECTION IS EFFORT UNDER WAY.

STATUS OF EXPERIMENTAL PROGRAM ON THE SSC CALORIMETER AT UBC-VANCOUVER, CANADA

- UBC TEAM : PROF. BRIAN G. TURRELL, DR. ANDRZEJ KOTLICKI, MR. MARK LE GROSS (GRAD. STUDENT)

  (DR. A.K. DRUKIER, ON A VISTING-SCIENTIST BASE)

- LAST PROJECT STATUS REVIEW : HELD AT UBC ON JUNE 17, 1985, WITH PARTICIPATION OF M.D.GROSSI.

- REVIEW HIGHLIGHTS :

  A) CRYOSTAT, 1^{o} K, CONSTRUCTED AND OPERATIONAL. PRELIMINARY EXPERIMENTS ALREADY PERFORMED WITH AN INITIAL SSC MODEL, OBSERVING GRAIN FLIPPING WHEN VARIABLE TEMPERATURE GOES THROUGH TRANSITION POINT. READ-OUT BY RF SQUID.

  B) SSC SPECIMEN, IN 1^{o}K BATH , CONSISTS OF 20 GRAINS, MADE OF SN, KEPT BY A PARA-FILM ON A BRASS PLATE. GRAIN SIZE : 10 μm TO 15 μm.

  C) SUPERIMPOSED MAGNETIC FIELD PARALLEL TO ALIGNMENT. B IS KEPT STEADY AT ABOUT 50 TO 60 GAUSS.

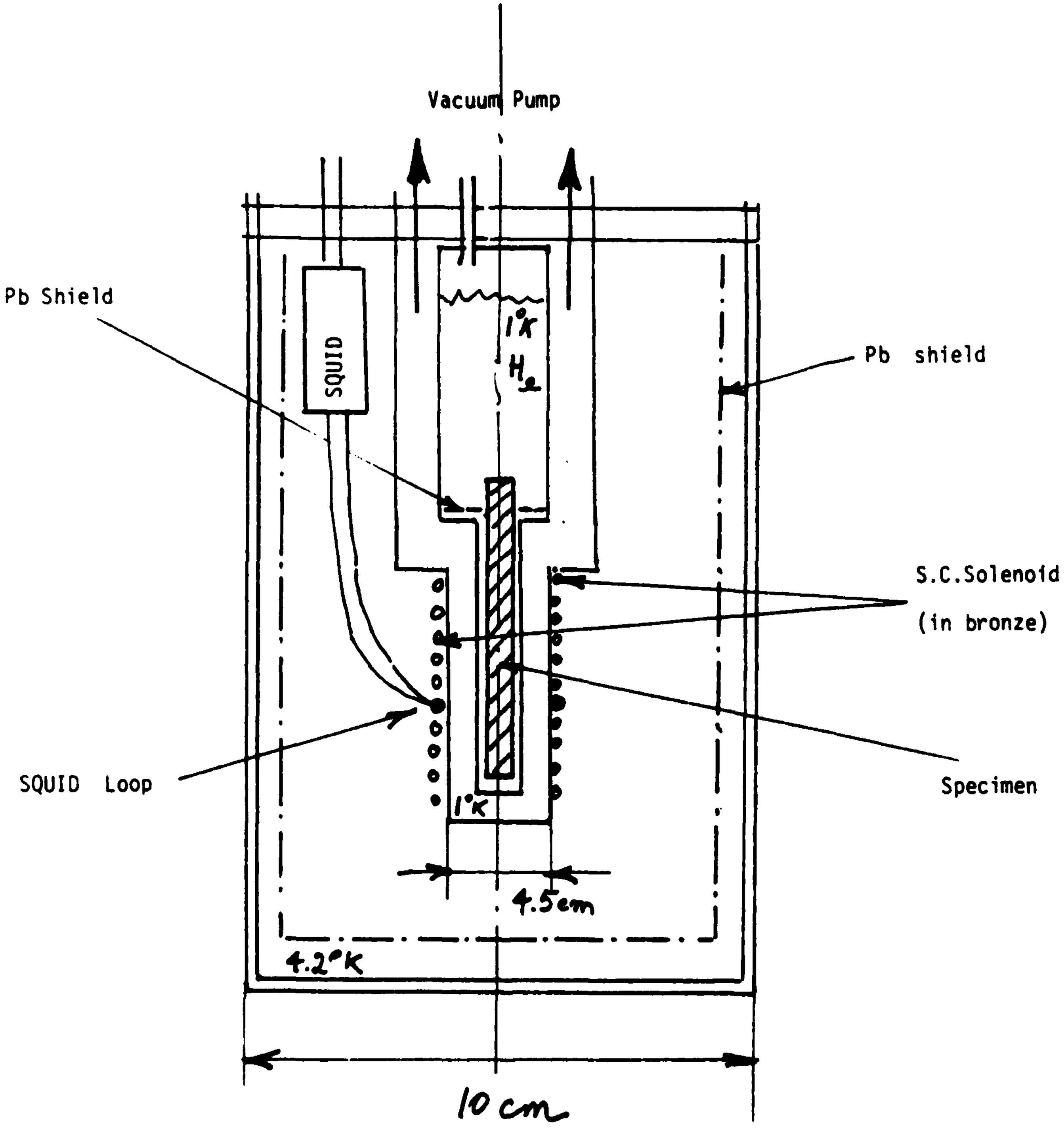
  D) VARIABLE-TEMPERATURE EXCURSION : FROM 4.2 ^{o}K TO 1.1 ^{o}K (3.5^{o} K TO 3.0 ^{o}K)

  E) EQUIPMENT ALREADY CONSTRUCTED : TEMPERATURE SWEEPER, FLUX COUNTER (FOR SQUID)

  F) OPTICAL TECHNIQUE (MEASUREMENT OF DIFFRACTION PATTERN) PRESENTLY UNDER DEVELOP-MENT, TO MEASURE ACCURATELY MEAN DIAMETER AND DIAMETER DISTRIBUTION OF EACH GRAIN-SAMPLE.

  G) CALCULATIONS OF SQUID RESPONSE TO GRAIN FLIPPING HAVE BEEN PERFORMED.

  H) PLANNING UNDERWAY OF A 200 MEV MUON BEAM EXPERIMENT USING UBC ACCELERATOR FACILITY CALLED TRIUMF. ALSO UNDER STUDY EXPERIMENT USING A GAMMA EMITTER WITH A FEW-DAY LIFETIME, SUITABLE FOR INSTALLATION INSIDE SSC CRYOSTAT.



SCHEME OF THE SSC CALORIMETER
UNDER STUDY AT U.B.C.

BOLOMETRIC DETECTOR OF LOW-ENERGY NEUTRINOS

- SILICON BLOCK WELL SUITED FOR THERMOMETRIC DETECTION OF RECOIL ELECTRONS AND LOWER-ENERGY RECOIL NUCLEI, DUE TO INTERACTIONS WITH NEUTRINOS.

- SILICON READLILY AVAILABLE WITH EXTREMELY HIGH PURITY AND IN LARGE QUANTITIES. NEARLY TOTAL ABSENCE OF RADIOACTIVE IMPURITIES. STRONG LIMITATION OF LEVEL OF INDUCED RADIATION.

- DETECTION SCHEME BASED ON OBSERVING TEMPERATURE RISE CAUSED BY THERMALIZATION OF RECOIL ENERGY THROUGHOUT MACROSCOPIC SILICON MASS. TYPICALLY, ENERGY TRANSFER OF 100 KEV WILL RAISE TEMPERATURE OF 1 KG SILICON BLOCK (INITIALLY AT 1 MILLI °K) OF ABOUT 4 MILLI °K.

- MEASUREMENT OF TEMPERATURE RISE IN SILICON BLOCK PERFORMED BY USING THIN-FILM RING MADE OF TUNGSTEN (WITH TRANSITION TEMPERATURE OF 15 MILLI °K), DEPOSITED ONTO SILICON BLOCK AND MONITORED INDUCTIVELY WITH A SQUID.

- FLIPPING OF TUNGSTEN RING INTO NORMAL STATUS INCREASES OF A FACTOR OF ABOUT 5 THE MUTUAL COUPLING BETWEEN A PRIMARY AND A SECONDARY OF A MEASUREMENT TRANSFORMER, WITH THE SQUID AT ITS OUTPUT.

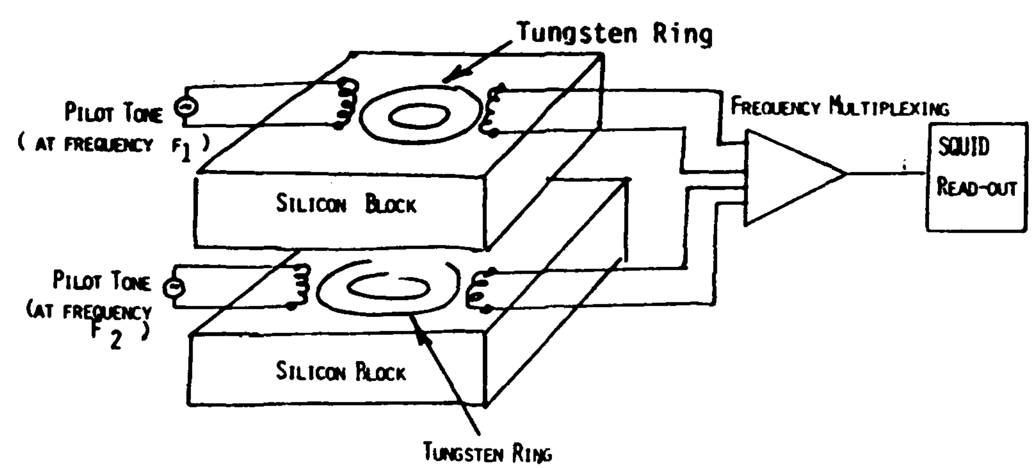
- STACK OF SEVERAL SILICON BLOCKS MAKE IT POSSIBLE TO DISTINGUISH BETWEEN NEUTRINO EVENTS AND COSMIC-RAY (MUONS) EVENTS. IN FACT, IN THE NEUTRINO SCATTERING CASE, RECOIL ELECTRONS AND NUCLEI LOSE THEIR ENERGY IN LESS THAN 1mm AND EXCITE ONLY ONE BLOCK. MUONS WILL EXCITE MANY BLOCKS.

- SINGLE SQUID READ-OUT CAN MONITOR SEVERAL INDIVIDUAL SILICON BLOCKS, BY MONITORING SEVERAL DIFFERENT PILOT-TONES (A TONE FREQUENCY FOR EACH BLOCK).

ACTIVITY PLAN FOR INVESTIGATION OF BOLOMETER DETECTOR

- CONTINUE ANALYSIS OF THRESHOLD SENSITIVITY
- PRELIMINARY DESIGN OF SINGLE SILICON BLOCK DETECTOR OF MASS 1 KG FOR DETECTION OF KNOWN NON-NEUTRINO SOURCES TO ALLOW MEASUREMENT OF THE THERMODYNAMIC PROPERTIES OF SILICON IN THE MILLI ^{o}K REGIME, AS WELL AS CALIBRATION OF THERMOMETRY, TIMING, THRESHOLDS, ETC.
- CONCEPTUAL DESIGN OF A REACTOR EXPERIMENT WITH 10-TO-100 KG ACTIVE DETECTOR, TO ALLOW TESTS OF SHIELDING APPROACHES AND DETECTION OF COHERENT SCATTERING OF NEUTRINOS

SCHEME OF PRINCIPLE OF BOLOMETER



FIELD INSTRUMENTATION AT THE NEVADA TEST SITE (NTS)

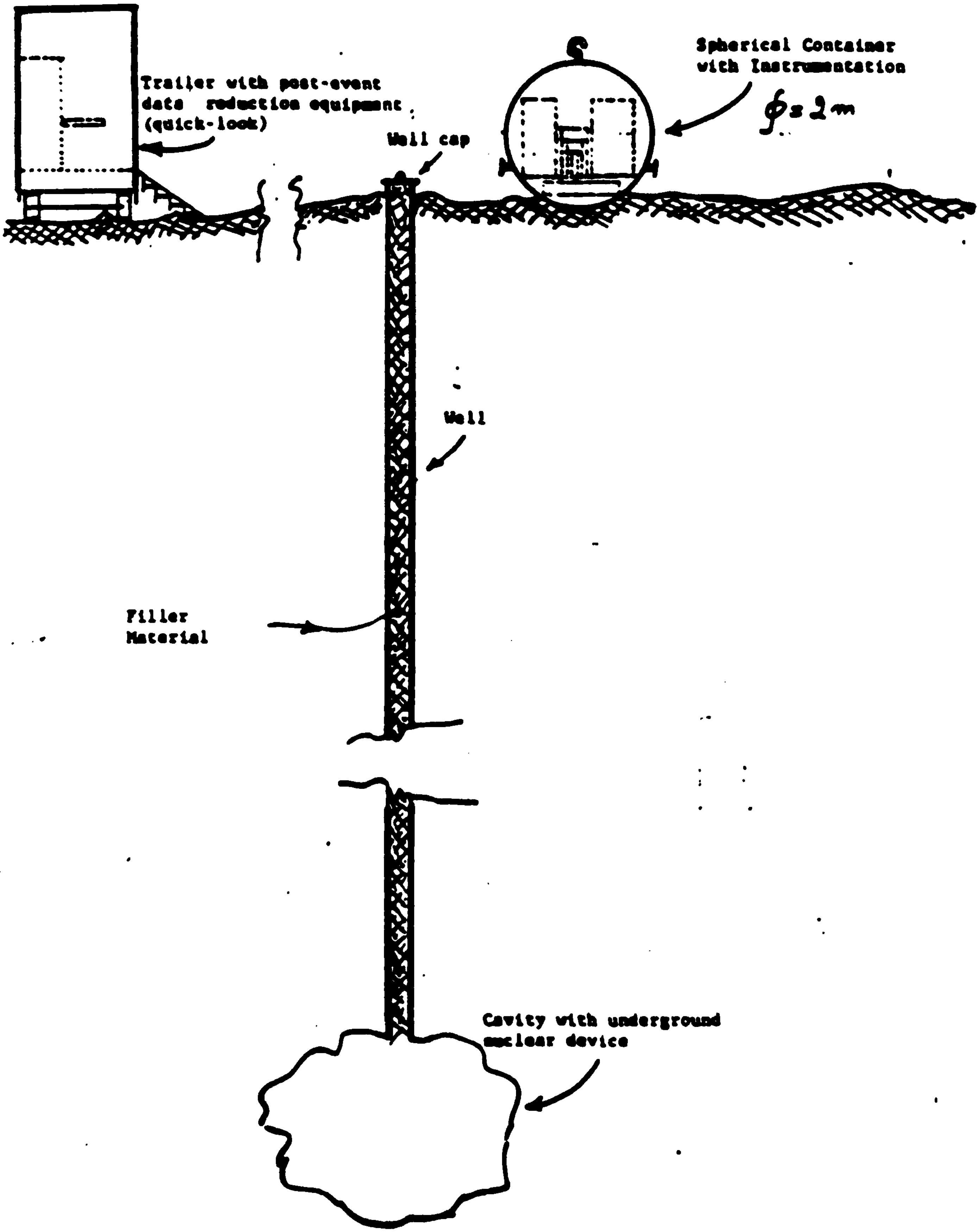
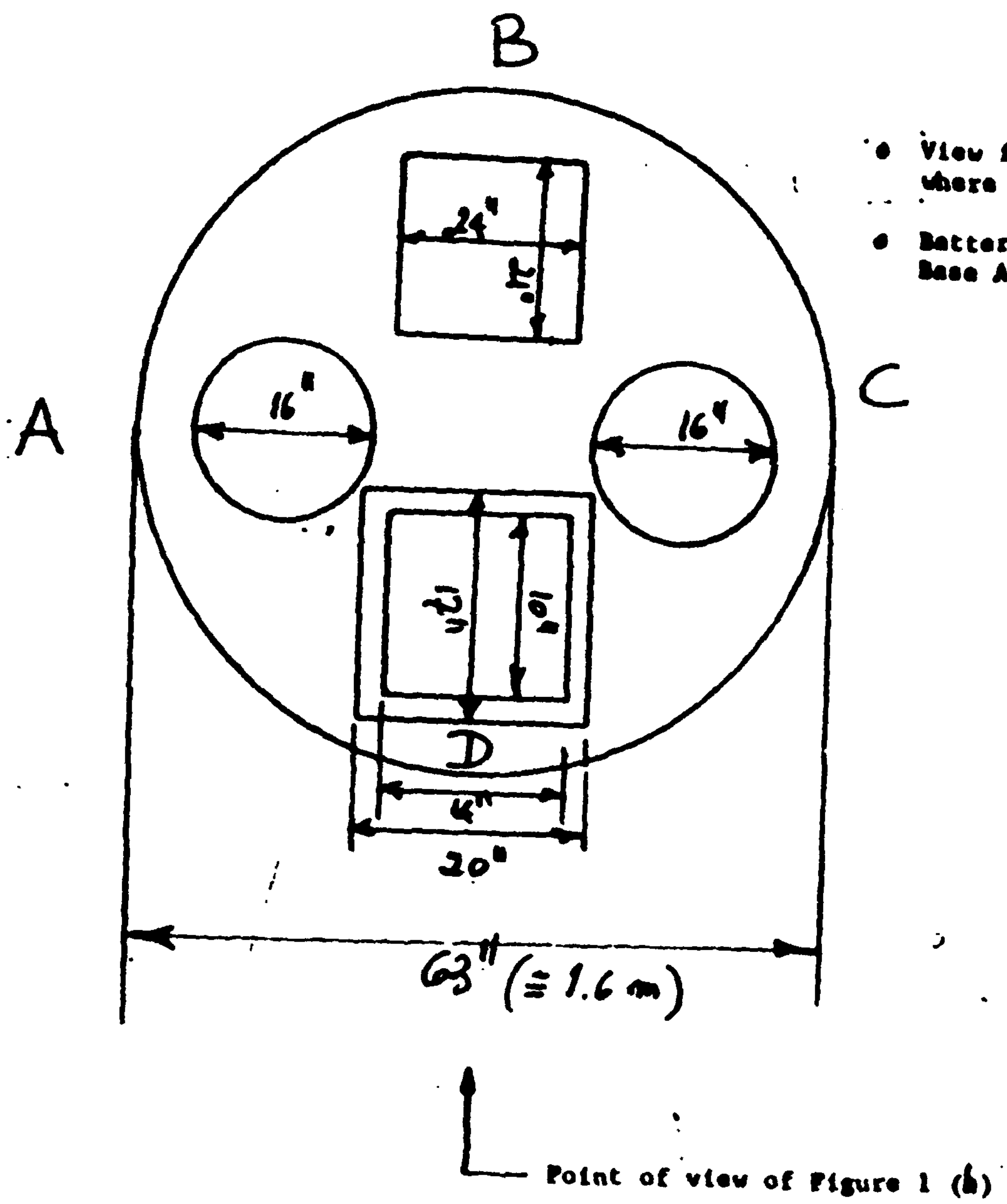


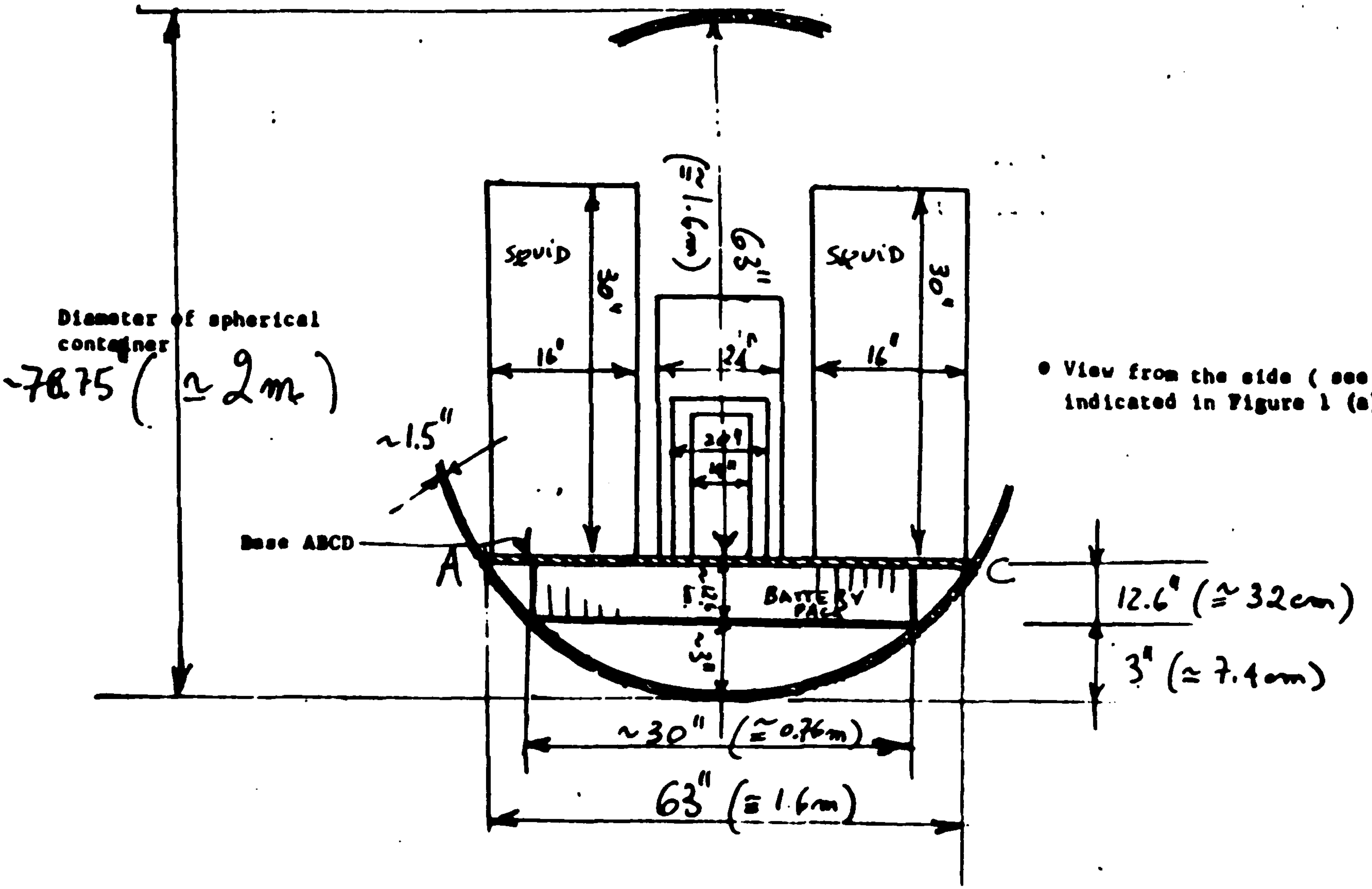
FIGURE 1 - Preliminary System Layout

(a)



- View from the top of Base ABCD, where instrumentation is mounted.
- Battery Pack is mounted underneath Base ABCD

Figure 1 (b) - Preliminary System Layout (cont.)



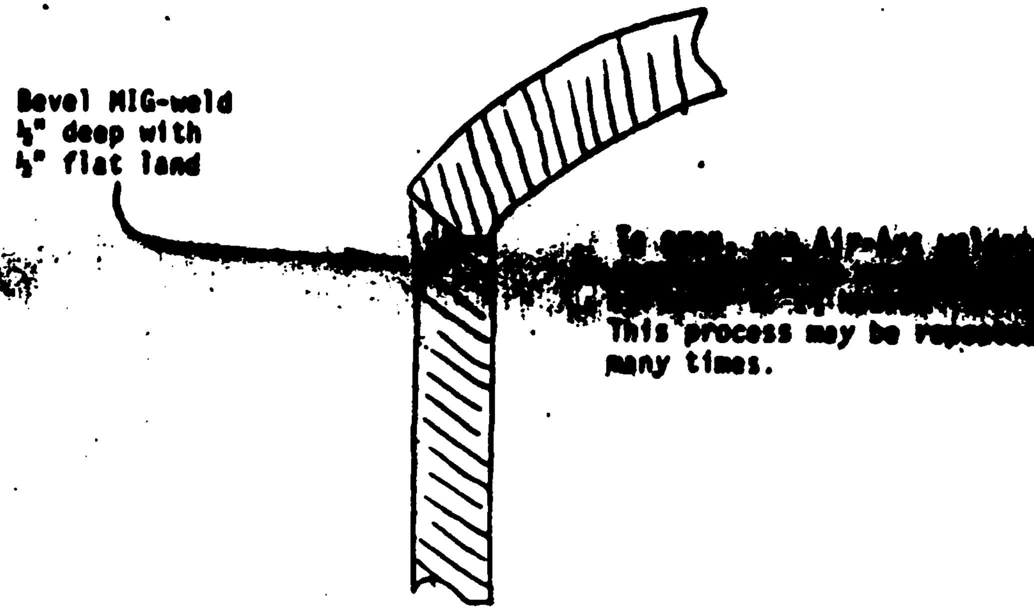
• View from the side (see point of view indicated in Figure 1 (a)).

Raytheon

INSTRUMENTATION CONTAINER

DESCRIPTION	APPROX. COST ($)
10 ft. Dia. Sphere 1 in. thick Welded Panels	20K
10 ft. Dia. Sphere 1 ½ in. thick Welded Panels	>30K
10 ft. Long Cylinder 6 ft. Dia. 1 in. thick Semi-elliptical Heads [illegible]	7K
[illegible] 6 ft. Dia. 1 in. thick Semi-elliptical Heads Welded Panels	15K - 20K
10 ft. Long Cylinder 6 ft. Dia. 1½ in. thick Semi-elliptical Heads Welded Panels	>20K

SEAM CONCEPT*



* Sphere or cylinder

Add approx. $1500 - $3000 for support stand, platform, etc. and $1000 shipping.

TABLE I (a)

MAGNETIC INTERACTION SENSOR-System Composition

- Spherical Container, $\phi \simeq 2$ m , iron wall, about 1.5" thick
- Battery Pack, 200 Ni-Cd cells, each 1.25 V, connected to provide 24 V , 40 A , 6 Hours discharge (5.5 KWH required), Weight 550 lb, Size 4,230 cu.in. (30"x12"x12").
- DC/AC Inverter, 1 KW, Weight 10 lb, Size 50 cu.in. (6"x2"x4").
  (We might be able to eliminate this unit ,by choosing the subsystems operating at 24V. For instance, SQUID magnetometers can be obtained from vendor suitable for dc line, 24 V.)
- SQUID Magnetometer, signal channel, Size: a cylinder 30" high, 16" diameter (cryostatic container), Power consumption : 20 VA at 110 V, ac.
- SQUID as above, for reference channel.
- Control Unit for SQUID, signal channel, Size 4"x10"x14", Weight 4 Kg.
- Control Unit for SQUID, reference channel, as above.
- Multichannel,Wide-band, Tape Recorder ,Honeywell 101-WB, 24"x21"x17", Weight 130 lb, Power consumption : 800 W.
  (This subsystem is by far the unit with most power consumption. We should look for an alternative storage approach: bubble memory ? etc.)
- Time Code generator, Datum 9310, Size 3"x20"x17", Weight 20 lb, power consumption: 20 W.
- Interaction target, laminated mumetal, Size 4"x4"x4", Weight 10 Kg.
- Audio-tone receiver, decoder and actuator, Size 10"x3"x2", Weight 3 Kg, Power consumption : 5 W.

All above units are mounted <u>inside</u> the spherical container, without requiring any wire coming-in from the outside, or going-out from the inside.

TABLE I (b)

SUBSYSTEMS OF THE SENSOR TO BE MOUNTED OUTSIDE THE SPHERIC CONTAINER

- Audio-tone Code Generator, complete with audio emitter, battery-operated, manually-controlled.
- Memoscope HP 181 (or Nicolet 2090) for Signal Channel.
- Memoscope as above, for Reference Channel.
- Battery Charger.
- Liquid Helium Reservoir.
- Accessories (cables, junction boxes, etc.).