BOREXINO AT GRAN SASSO

A STATUS REPORT

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NO-VE

VENEZIA JULY, 24, 2001

SUMMARY

- DESCRIPTION OF THE DETECTOR
- PHYSICS PROGRAM - IMPACT OF SNO RESULTS
- RADIOPURITY ISSUES
- STATUS OF THE INSTALLATION
- CONCLUSIONS

Borexino Collaboration

✓Belgium
I.R.M.M. European Joint Research Centre - Geel

✓France
College de France

✓Germany
Max-Planck-Institut Für Kernphysics Heidelberg
Technische Universität München

✓ Hungary
KFKI-RMKI Budapest

✓Italy
Dipartimento di Fisica e INFN Genova
Lab. Naz. INFN del Gran Sasso
Dipartimento di Fisica e INFN Milano
Dipartimento di Fisica e INFN Pavia
Dipartimento di Fisica e INFN Perugia

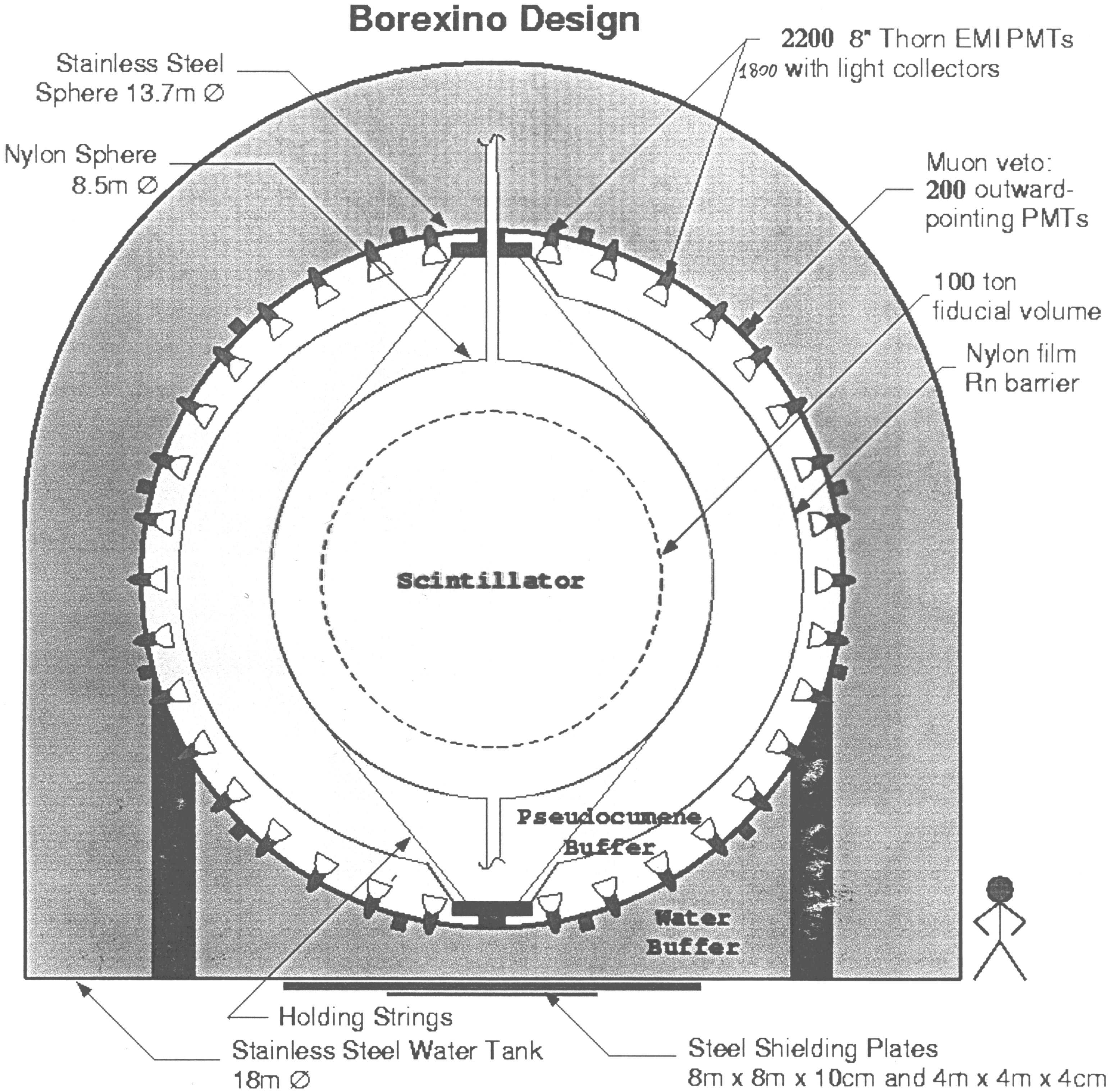
✓Poland:
Jagellonian University Krakow

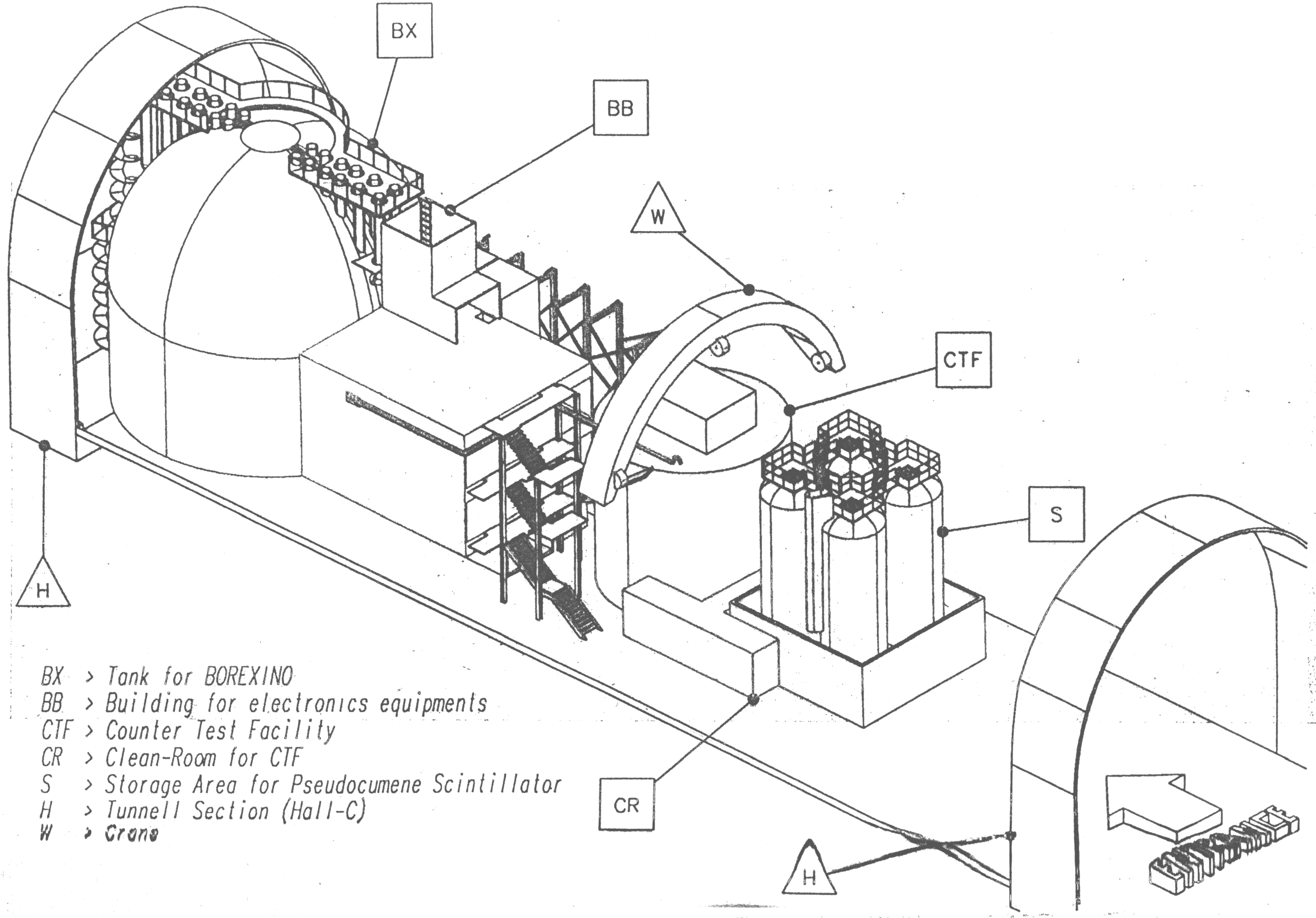
✓Russia
JINR Dubna
Kurchatov Intitue - Moscow

✓United States
Bell Laboratories, Lucent Technologies
Massachusetts Institute of Technology
Princeton University
Virginia Polytechnic Institute

Borexino

A real time, calorimetric, scintillation detector, for low energy solar neutrinos, under installation at the Gran Sasso underground Laboratory, aimed at the detection of the monoenergetic ^{7}Be neutrinos, through scattering off the electrons of the scintillator


Borexino Design
Stainless Steel
Sphere 13.7m Ø
2200 8" Thorn EMI PMTs
1800 with light collectors
Nylon Sphere
8.5m Ø
Muon veto:
200 outward-
pointing PMTs
100 ton
fiducial volume
Nylon film
Rn barrier
Scintillator
Pseudocumene
Buffer
Water
Buffer
Holding Strings
Stainless Steel Water Tank
18m Ø
Steel Shielding Plates
8m x 8m x 10cm and 4m x 4m x 4cm


BX
BB
W
CTF
S
H
CR
H
BX > Tank for BOREXINO
BB > Building for electronics equipments
CTF > Counter Test Facility
CR > Clean-Room for CTF
S > Storage Area for Pseudocumene Scintillator
H > Tunnell Section (Hall-C)
W > Crane

Main Components: Detector

Scintillator

Nylon (Inner and Outer) Vessels

Buffer Liquid

Stainless Steel Sphere

support of PMT's

containment of the buffer (zero buoyancy for the nylon vessels)

PMT's

Concentrators

Muon veto

Calibration equipments

Water Tank

Electronics and DAQ

Main components: Plants

Storage Vessels

Scintillator Purification systems

- Water extraction
- Distillation
- Column purification
- Nitrogen sparging

N_2 PLANT

Fluid Handling System

Water Purification System

Clean room

Scintillator

Solvent : Pseudocumene

Solute: PPO (1.5 g/l)

Light yield: 11000 ph/MeV

Att. Length (@420): 30 m

Scatt. length (@420 nm): 7 m

Decay Time (fast component) : 3.5 ns

Good α /β properties

Photomultipliers

8" Electron Tubes Limited 9351 type

P/V : 2.5

Transit Time Spread: 1 ns

Dark Count rate: 1kHz

Afterpulsing < 3%

Low radioactive glass and internal parts

Light Concentrators

Truncated string cone design

Optimized to collect the light from the inner vessel and 20 cm beyond it

Material: anodized aluminum

Mesured quantities

The electronics measures and provides for each triggered event :

- **the photomultipliers pulse height**

⇨ energy measurement

- **the photoelectrons arrival time (0.3 ns resolution)**

⇨ location identification

- **the absolute time of the event**

Expected detector performances

Effective Coverage: 30%

Photoelectron yield: 400 pe/MeV

Energy resolution (@1MeV): 5 %

Position resolution (@ 1 MeV): 10 cm

Calibrations

A variety of calibration and monitoring systems are planned:

✓Laser pulses distributed to all PMT's with a fiber optics splitting system

- timing calibration
- gain adjustment via detection of the single photoelectron peak

✓External sources (Th) located in the S.S.S close to the light cones

- check of the stability in time of the overall detector response

✓Internal sources inside the scintillator

- position calibration
- energy calibration
- α/β PSD determination

Calibrations

✓Laser beams with different wavelengths through the buffer and laser excitation of the scintillator

- stability monitoring of optical properties

✓Blue LEDs on the external tank for the outer muon veto detector

✓Active tags of trace impurities in the scintillator

- cross check of the absolute energy scale determination
- additional stability monitor

✓Calibration of the overall detector response via a sub-MeV ν-source (^{51}Cr)

Neutrino Detection in Borexino

Detection through the scattering reaction

$$\nu + e^- \rightarrow \nu + e^-$$

off the electrons of the scintillator

The high luminosity and high radiopurity

of the scintillator lead to a low detection threshold: 250 keV.

It is possible to detect the recoil electrons produced by the monoenergetic (0.861 MeV) 7Be ν.

Maximum recoil energy: 0.66 MeV

SSM prediction: 55 ev/d for 100 T F. V

The Borexino program

- First direct measurement of ^7Be flux

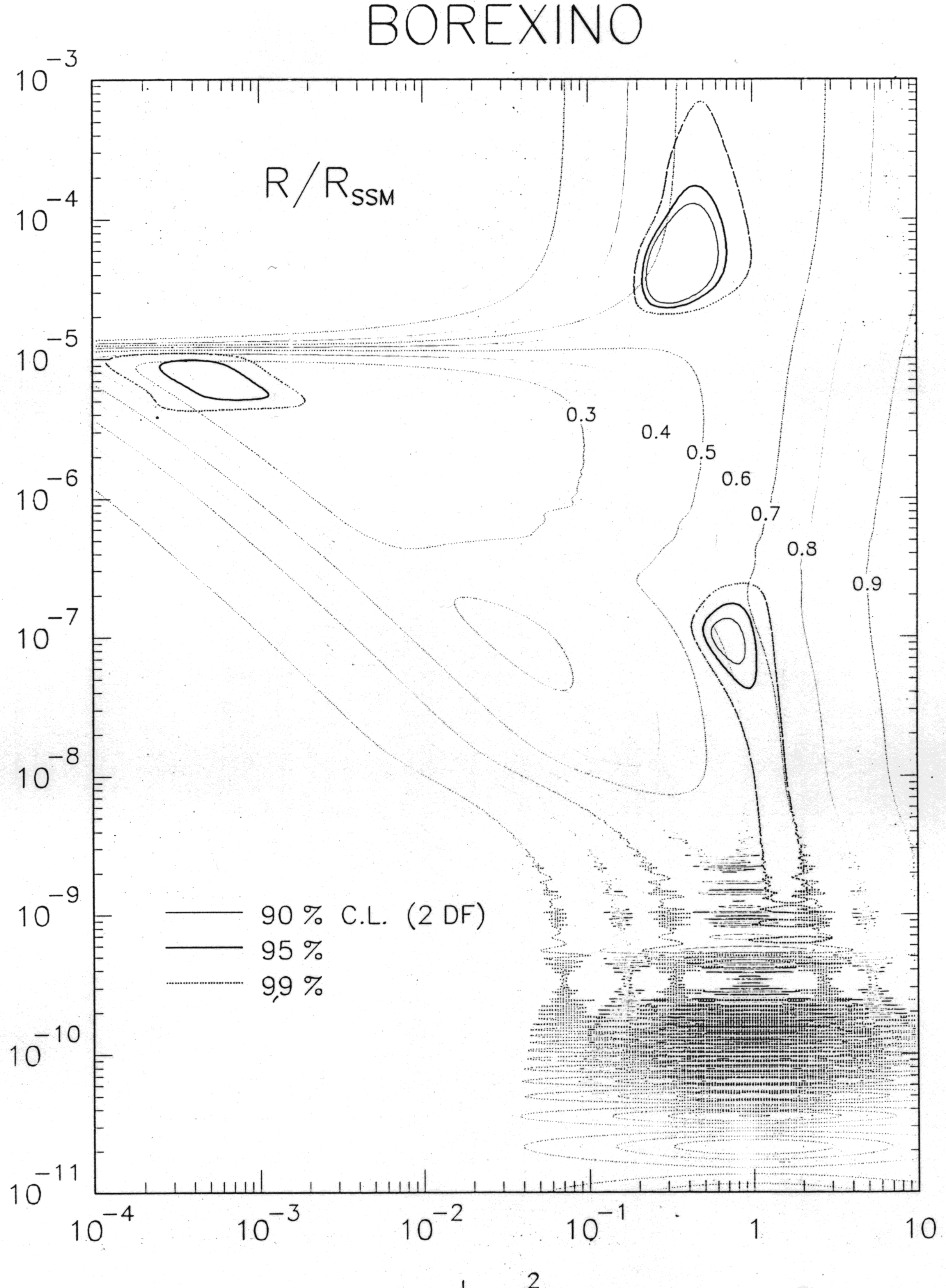
Expected rates (ev/d) in a F.V. of 100 T

Recoil Energy window MeV	SSM	LMA	SMA	LOW	VO
		$\Delta m^2=1.8 \times 10^{-5}$ eV^2 $\sin 2\theta=0.76$	$\Delta m^2=5.4 \times 10^{-6}$ eV^2 $\sin^2\theta=5.5 \times 10^{-3}$	$\Delta m^2=7.9 \times 10^{-8}$ eV^2 $\sin^2\theta=0.96$	
0.25 - 0.8	55.2	30.7	11.7	29.0	
				day/night effect	**seasonal variation**

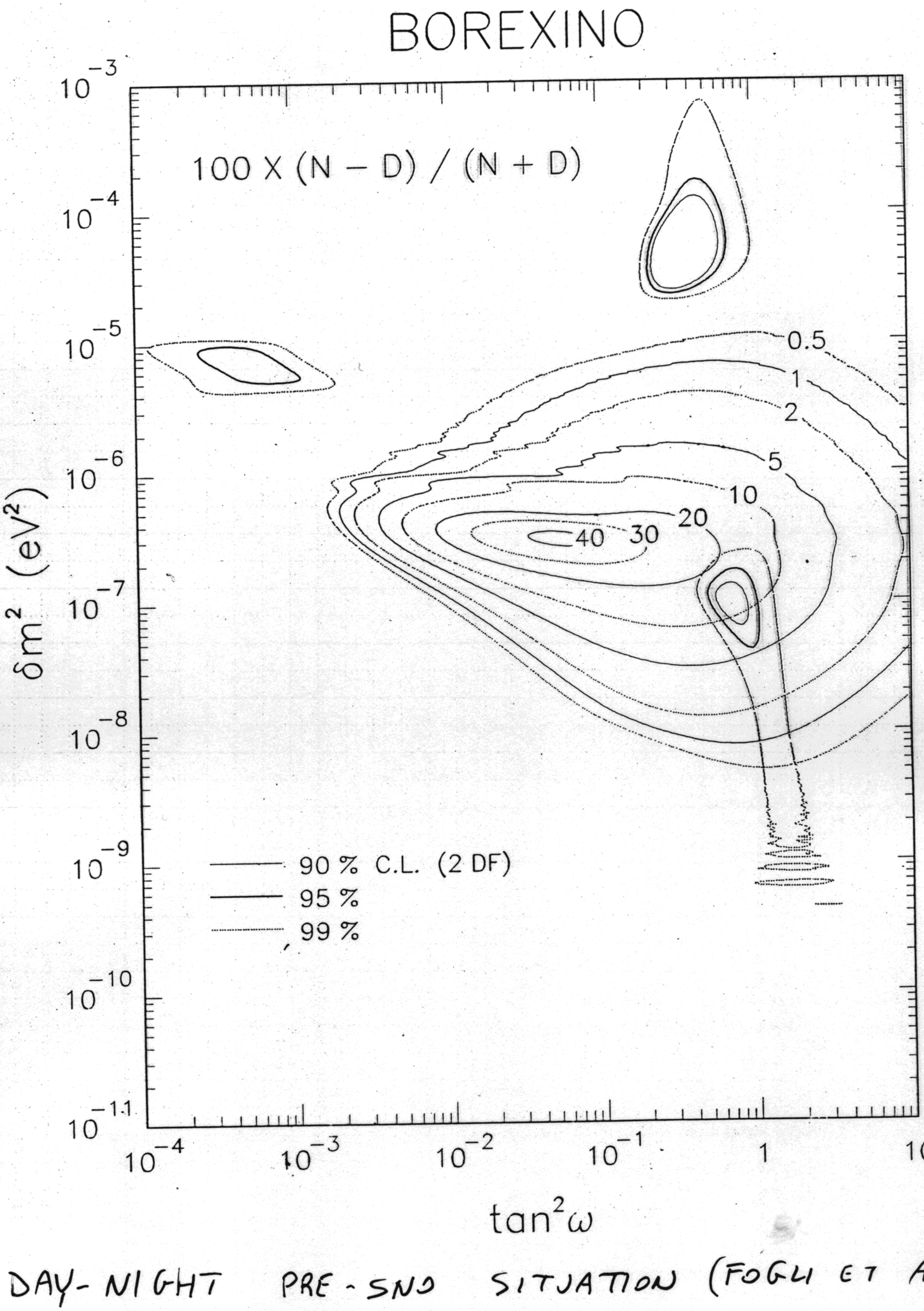
- Probing vacuum oscillations via seasonal variation of the flux

- In absence of other time variations, demonstration of the solar origin of the signal through the 7% variation due to the Earth-Sun distance variation during the year

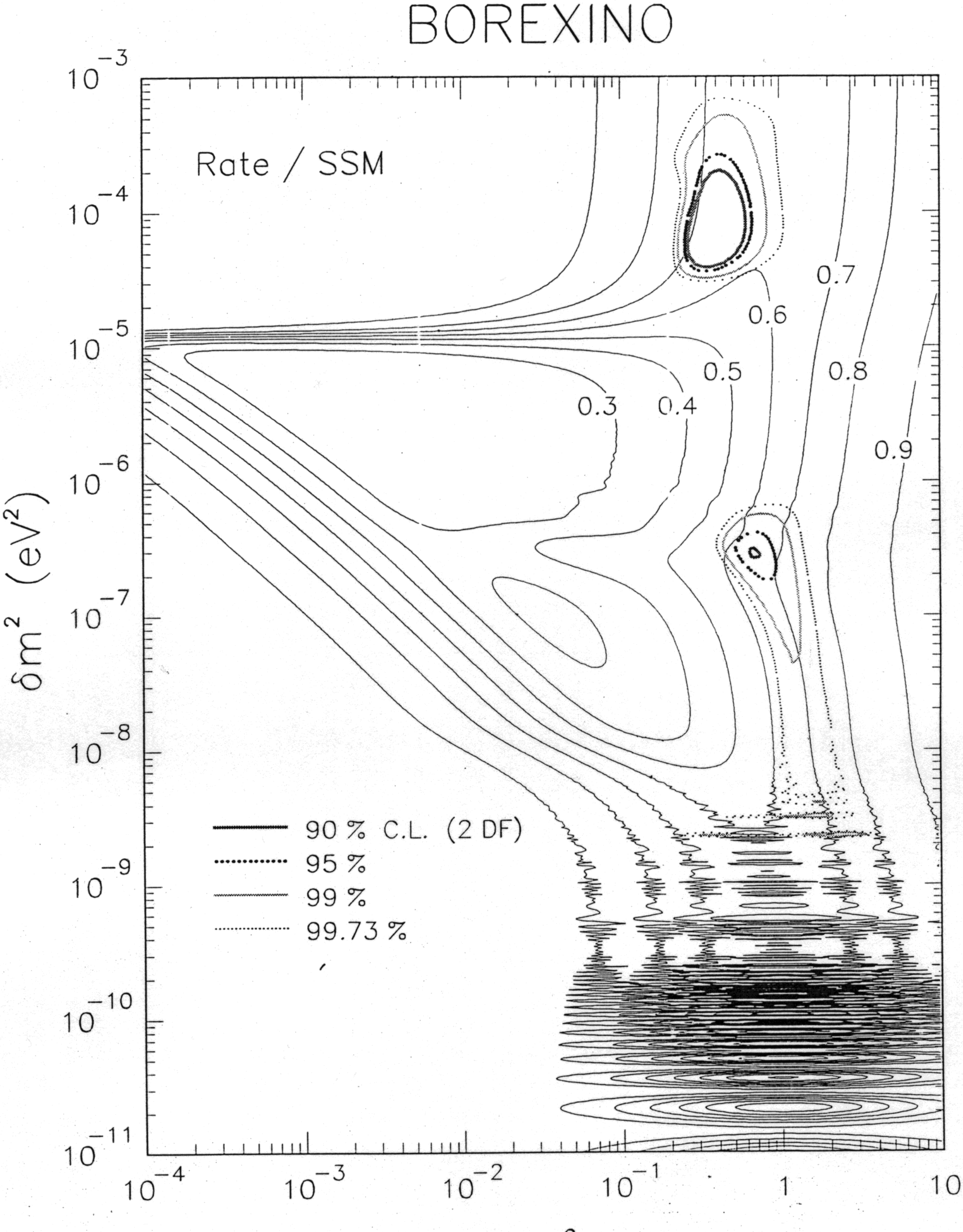
- Background ~ 15 ev/d



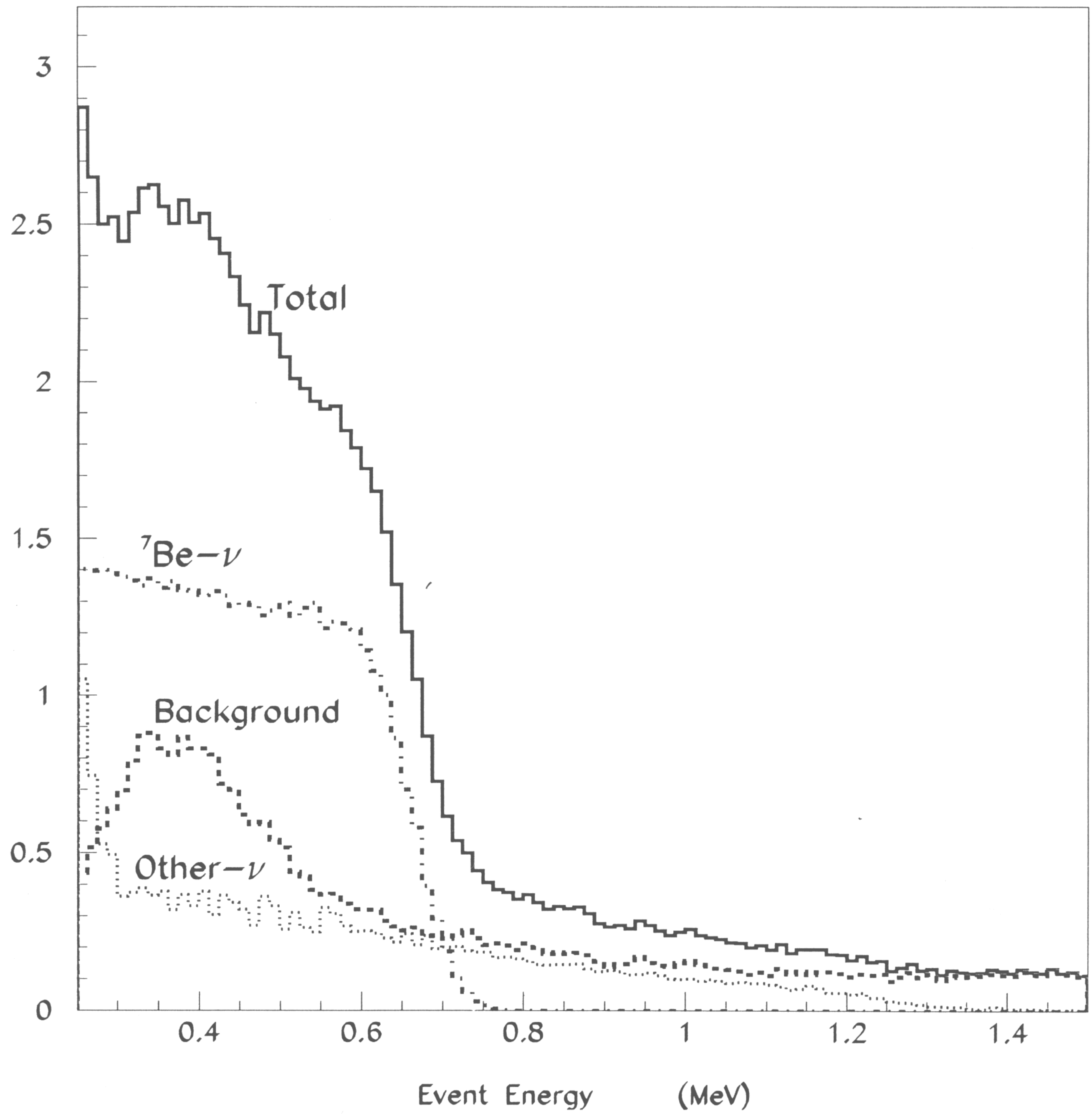
RATES - PRE SNO SITUATION (FOGLI ET AL.)



DAY-NIGHT PRE-SNO SITUATION (FOGLI ET AL.)



RATES - POST SNO SITUATION (FOGLI ET AL.)



3
2.5
2
1.5
1
0.5
0
Total
^{7}Be−ν
Background
Other−ν
0.4
0.6
0.8
1
1.2
1.4
Event Energy (MeV)

Other capabilities

- ^{8}B spectrum in the unique energy window 1.5-5 MeV

- Antineutrino Science

$$\bar{\nu} + p \rightarrow n + e^{+} \qquad \text{th=1.8 MeV}$$

$$\downarrow 200\ \mu s$$

$$n + p \rightarrow {}^{2}_{1}H + \gamma \qquad (2.2\ \text{MeV})$$

Search for solar $\bar{\nu}_e$
Geophysical $\bar{\nu}_e$ from the Earth
$\bar{\nu}_e$ from Type II Supernovae
Long-baseline $\bar{\nu}_e$ from European reactors

Radiopurity of the scintillator

Main issue for the feasibility of the experiment

Purity requirements for ^{238}U and ^{232}Th in the range of 10^{-16} g/g

Laboratory measurements on small samples: 2-3 x 10^{-15} g/g
manly limited by impurities leached from the wall of the vessels

Needed a direct measurement on some tons of scintillator with a sensitivity level at least 5 x 10^{-16} g/g $\rightarrow$ CTF

Further high sensitivity measurements performed with Neutron Activation Analysis

Achievements of CTF

1 - Demonstration of unprecedented purity levels

$^{14}C/^{12}C = (1.94+/-0.09) \times 10^{-18}$

$^{232}Th<(4.4 +/-1.5) \times 10^{-16}$

$^{238}U<(3.5 +/-1.3) \times 10^{-16}$

2 - Demonstration of the effectiveness of the planned purification methods for Borexino

Purity levels confirmed with Neutron Activation Analysis

$^{238}U < 2 \times 10^{-16}$

CTF has been recently reinstalled for quality control of the scintillator prior to detector filling

OTHER BACKGROUND ISSUES

- EXTERNAL BACKGROUND FROM DETECTOR COMPONENTS
  → PROPER SELECTION OF LOW RADIOACTIVE MATERIALS

- Rn EMANATION FROM PMT'S SYSTEM
  → EMANATION TESTS OF MATERIALS PLUS Rn BARRIER

- Rn AND ^{85}Kr IN THE SCINTILLATOR
  → SPARGING WITH ULTRAPURE N_2

$$Rn \sim 0.5\ \mu Bq/m^3$$

- COSMOGENIC ACTIVITIES → MUON VETO

- DUST → CONTRUCTIONS/INSTALLATIONS UNDER CLEAN ROOM CONDITIONS

- SURFACE CONTAMINATIONS
  → PASSIVATION/ELECTROPOLISHING OF ALL SURFACES EXPOSED TO SCINT. AND BUFFE

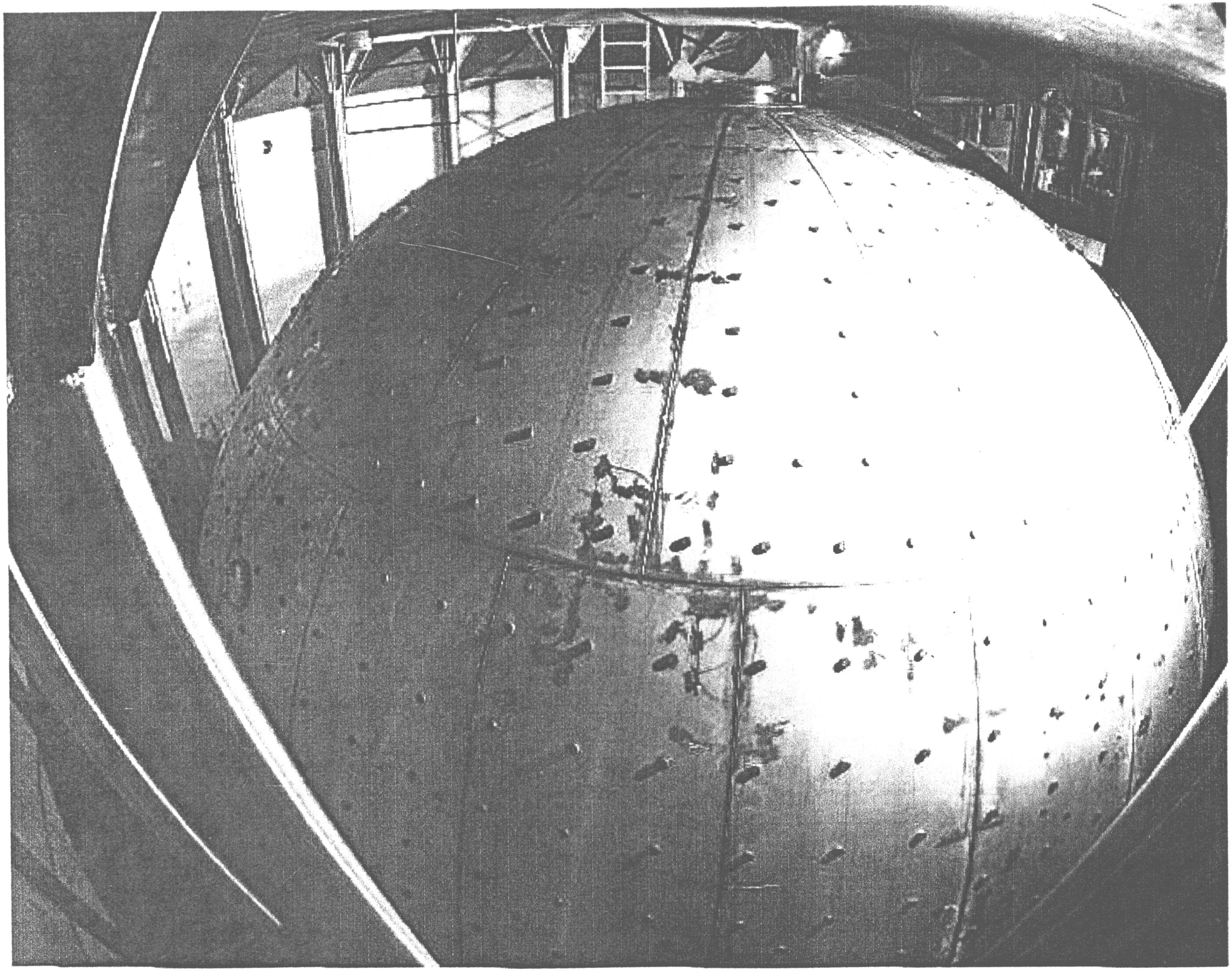
STATUS OF THE EXPERIMENT PREPARATION

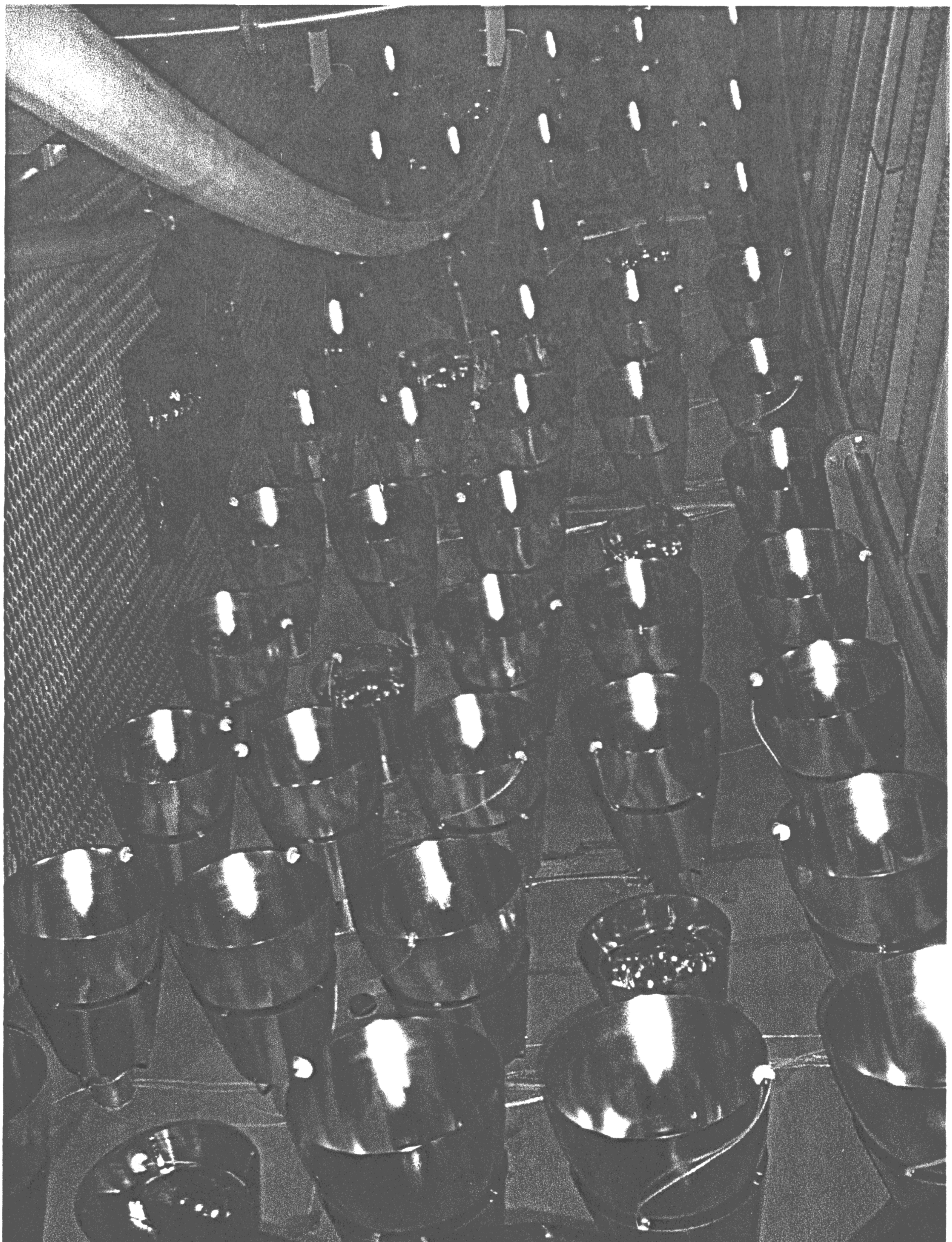
SCINTILLATOR COMPONENTS (PC AND PPO): MANUFACTURERS IDENTIFIED, CONTRACTS FINALIZED, ON PURPOSE LOADING STATION CONSTRUCTED AT THE COMPANY PLANT

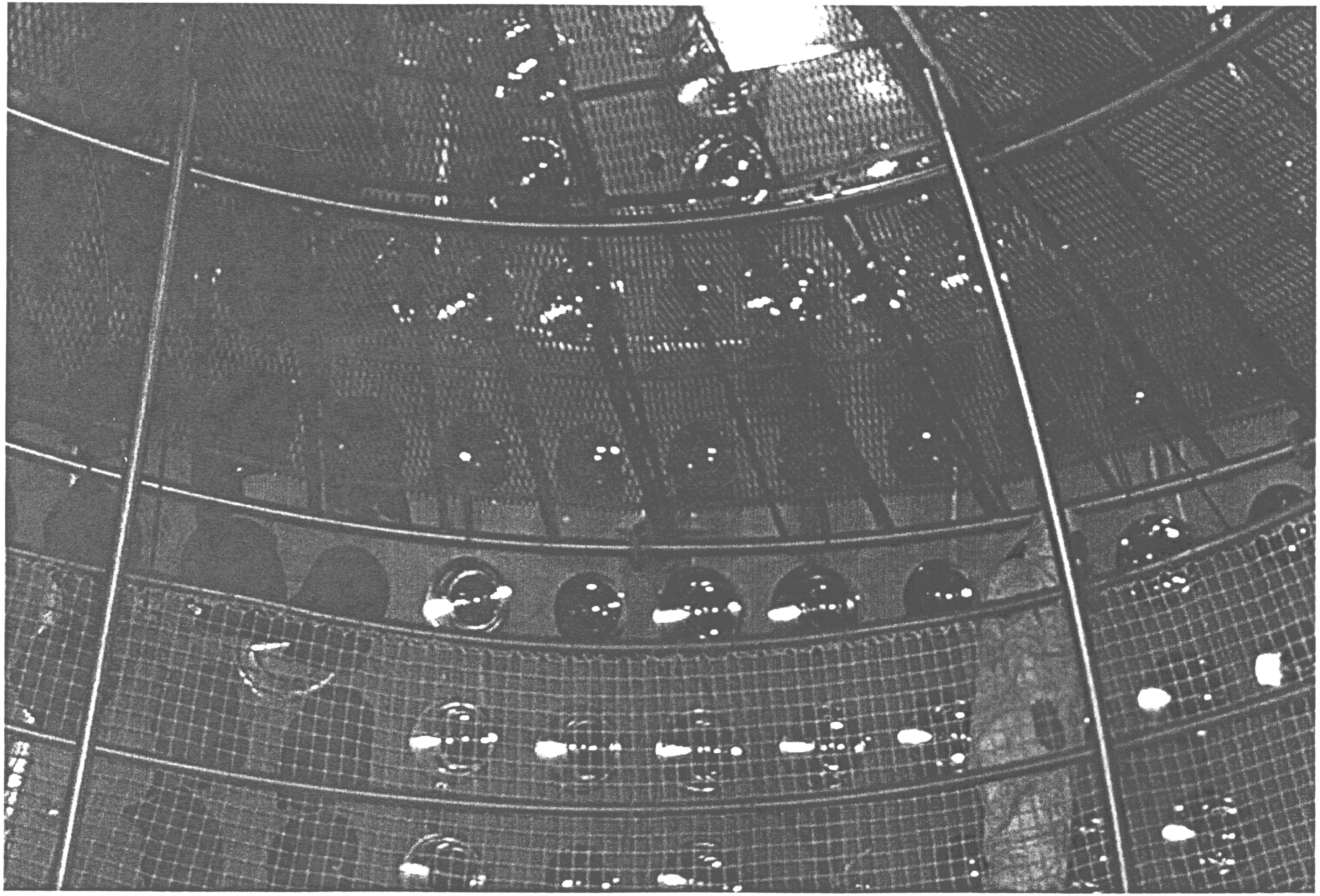
NYLON (INNER AND OUTER) VESSELS: TEST PROTOTYPES ALREADY PRODUCED, MATERIAL SELECTION COMPLETED, WHOLE AMOUNT OF NYLON EXTRUDED

STAINLESS STEEL SPHERE: CONSTRUCTION AND SURFACE TREATMENTS COMPLETED

PMT'S: ALL DEVICES PRODUCED
50% INSTALLED ON THE SPHERE
SUITABLE TO BE IMMERSED IN WATER AND PSEUDOCUMENE







STATUS OF THE EXPERIMENT PREPARATION

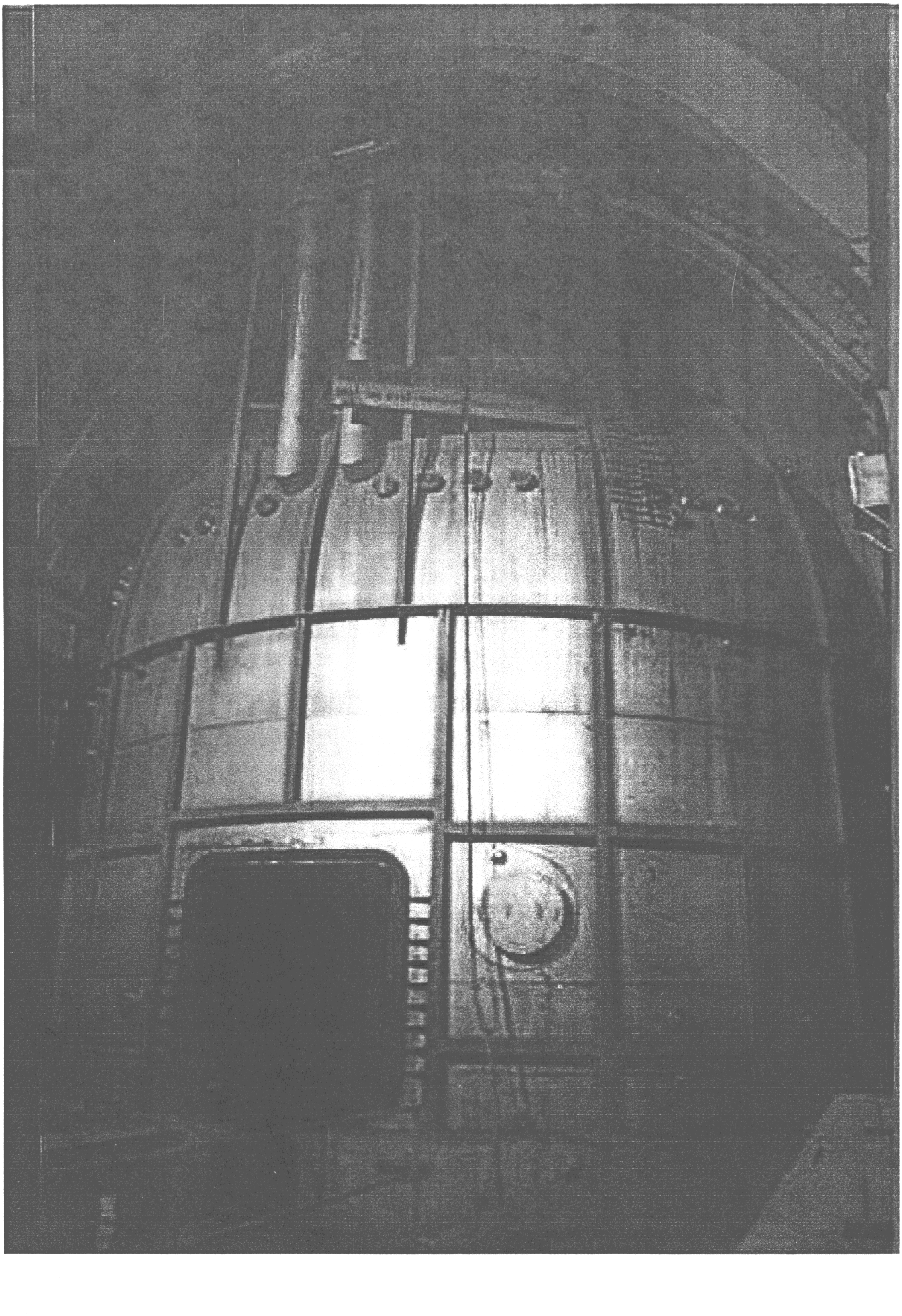
WATER TANK: COMPLETED

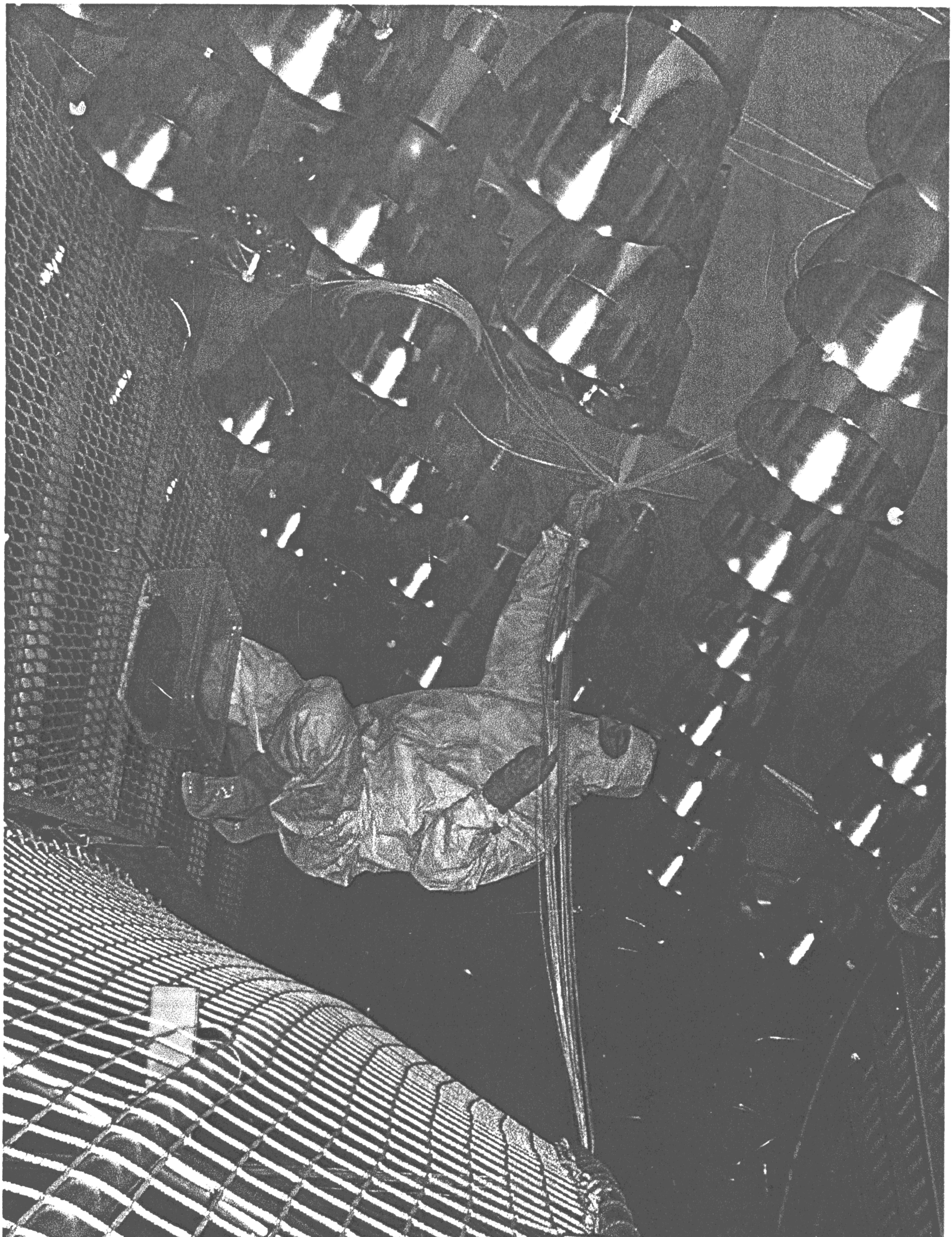
ELECTRONICS AND DAQ: HARDWARE AND SOFTWARE READY, FINAL INTEGRATION IN PROGRESS

MUON VETO: DEDICATED PMT'S READY, ELECTRONIC IN PREPARATION

CONCENTRATORS: 80% PRODUCED, 50% INSTALLED

CALIBRATION EQUIPMENTS: FIBERS, EXTERNAL SOURCES EQUIPMENT, BUFFER MONITORING EQUIPMEN INSTALLED ON THE TOP HEMISPHERE





STATUS OF THE EXPERIMENT CONSTRUCTION

STORAGE VESSELS : COMPLETED

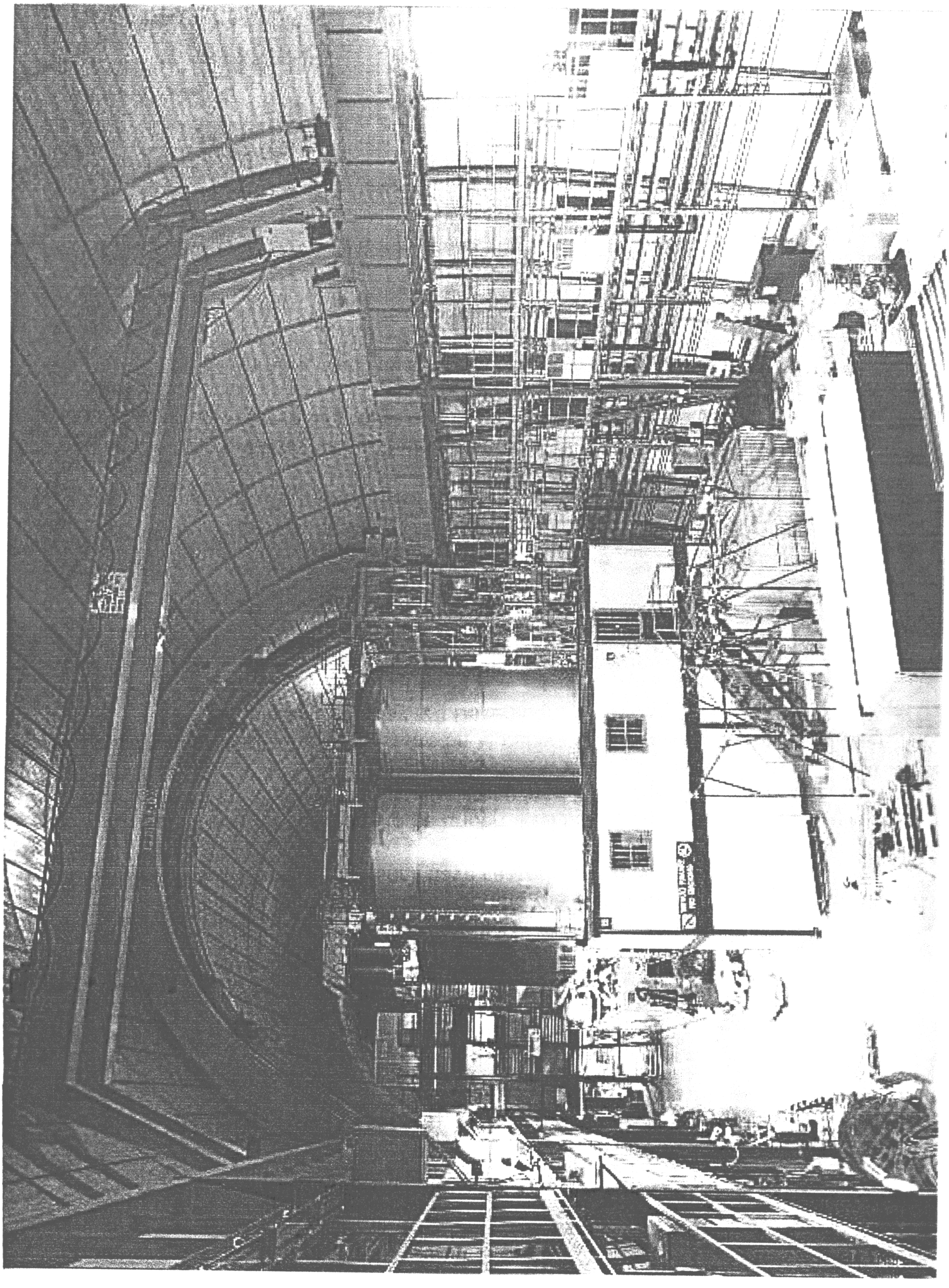
SCINTILLATOR PURIFICATION SYSTEMS : IN ADVANCED PHASE OF INSTALLATION, TEST FORESEEN FROM SEPTEMBER WITH CTF

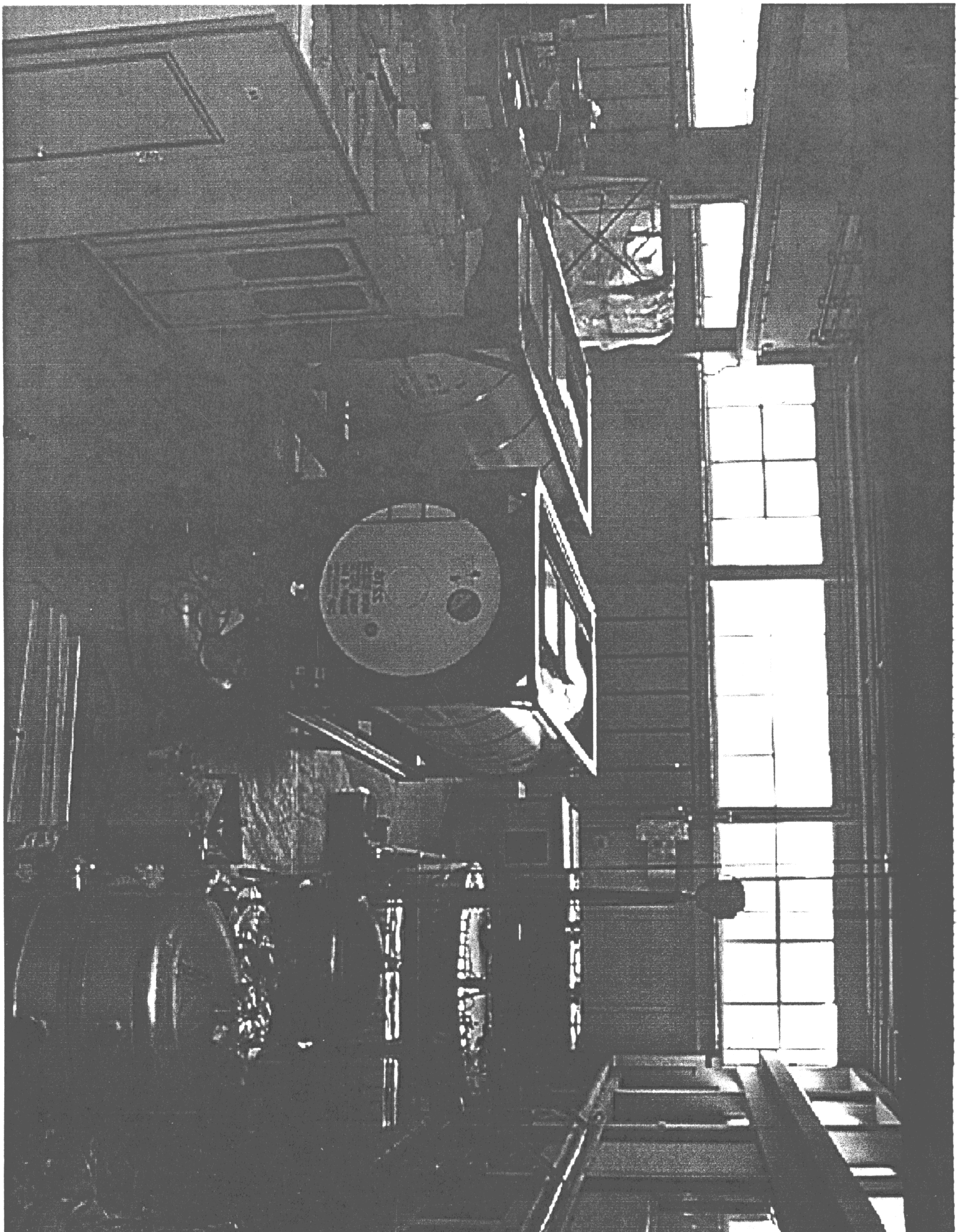
FLUID HANDLING SYSTEM : READY BY THE FALL

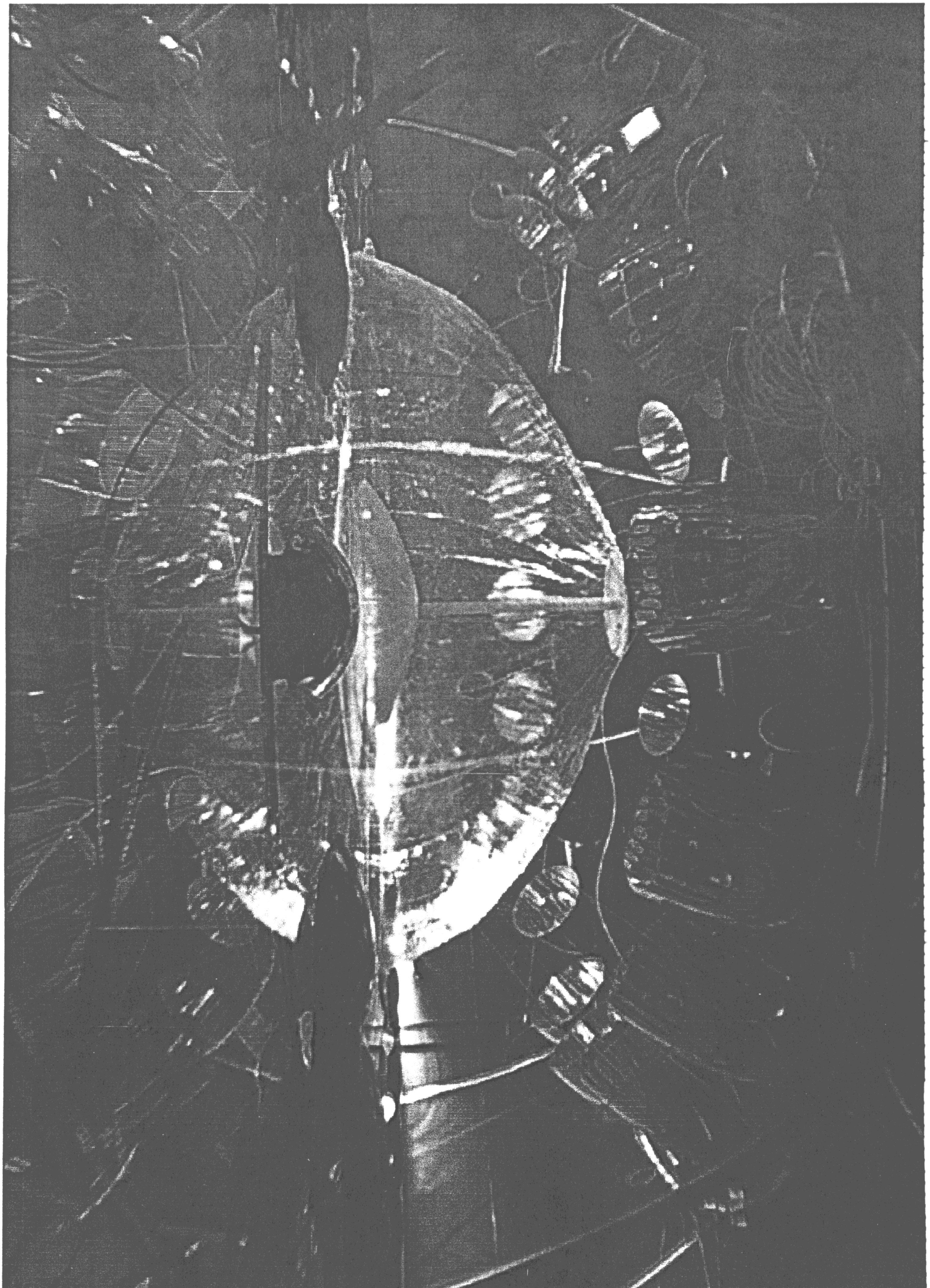
CLEAN ROOM : CONSTRUCTED AND IN USE

FIRST DELIVERY OF PSEUDOCUMENE : 18 TONS AT THE END OF AUGUST FOR TEST IN CTF

CTF (COUNTING TEST FACILITY) : RE-BUILT AND PRESENTLY FILLED WITH WATER







CONCLUSIONS

MOST OF THE BOREXINO INSTALLATIONS HAVE BEEN COMPLETED IN HALL C

ALL THE REMAINING EQUIPMENTS ARE RAPIDLY APPROACHING THE INSTALLATION PHASE

START-UP OF THE FILLING EXPECTED WITHIN THE NEXT SPRING

CTF REBUILT, READY FOR QUALIFICATION OF THE SCINTILLATOR AND FOR TEST OF THE PURIFICATION SYSTEMS

THE BOREXINO DATA WILL BE THE FIRST OUTCOME OF A REAL TIME INVESTIGATION OF THE SUB-MEV SOLAR NEUTRINO REGION. THEY WILL CONSTITUTE A POWERFUL DIAGNOSTIC TOOL FOR THE <u>LOW</u> REGION