BOREXINO: THE DETECTOR AND THE PHYSICS PROGRAM

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TOKYO, JUNE 12, 1998

NEW ERA IN NEUTRINO PHYSICS

- DESCRIPTION OF THE DETECTOR
- PHYSICS PROGRAM
- CTF RESULTS

BOREXINO COLLABORATION

GERMANY:
MAX-PLANCK-INSTITUT FÜR KERNPHYSIK HEIDELBERG
TECHNISCHE UNIVERSITÄT MÜNCHEN

HUNGARY:
KFKI-RMKI BUDAPEST

ITALY:
UNIVERSITA' DI GENOVA
LAB. NAZ. DEL GRAN SASSO
UNIVERSITA' DI MILANO
UNIVERSITA' DI PAVIA
UNIVERSITA' DI PERUGIA

POLAND:
JAGELLONIAN UNIVERSITY KRAKOW

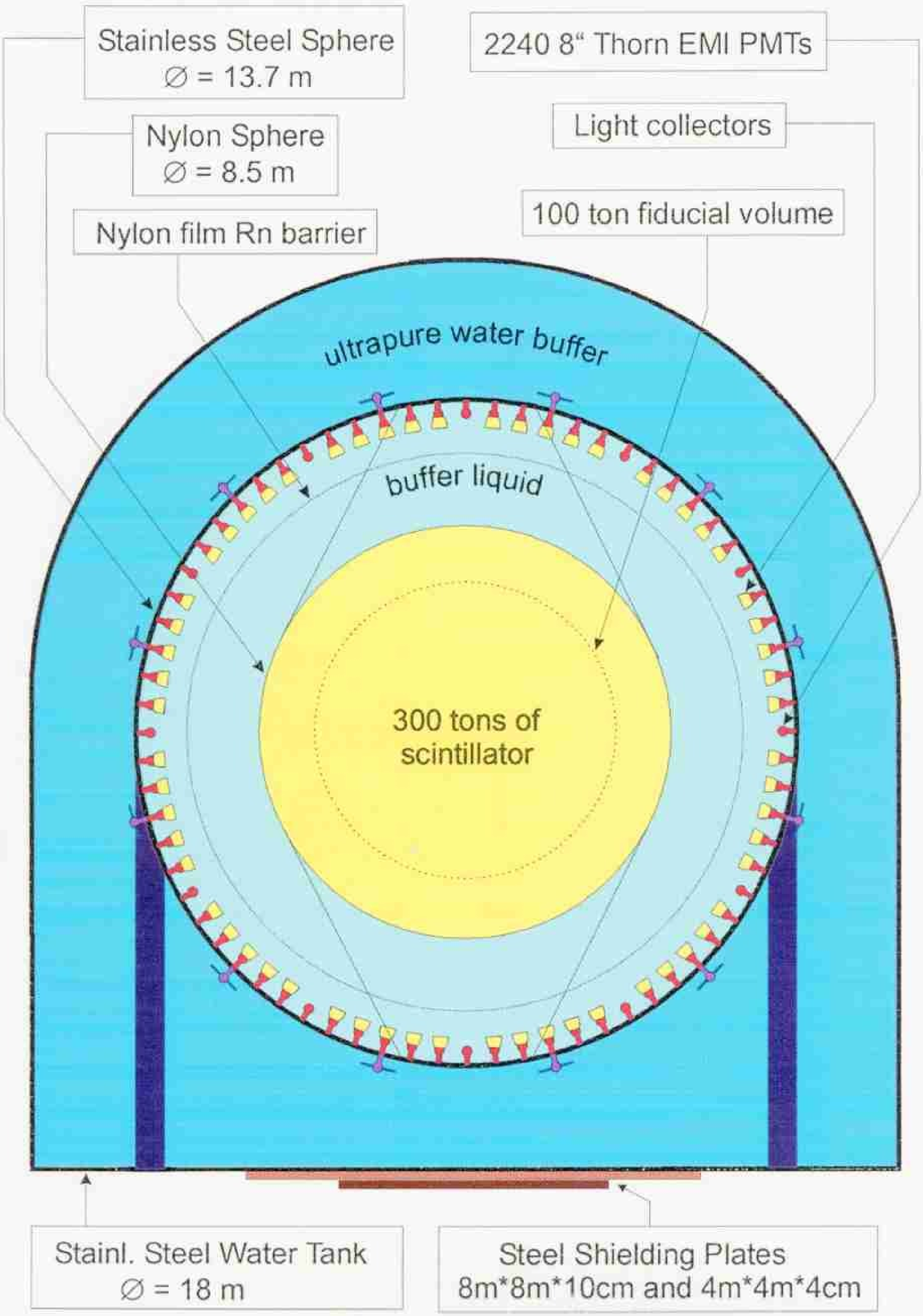
RUSSIA:
JINR DUBNA

USA:
AT&T BELL LABORATORIES
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
PRINCETON UNIVERSITY

BOREXINO

A REAL TIME, CALORIMETRIC SCINTILLATION DETECTOR FOR LOW ENERGY SOLAR NEUTRINOS, TO BE INSTALLED AT THE GRAN SASSO UNDERGROUND LABORATORY, AIMED AT THE DETECTION OF THE ^{7}Be NEUTRINO LINE.

Borexino Detector Design



SCINTILLATOR

SOLVENT: PSEUDOCUMENE

SOLUTE: PPO (1.5 g/l)

LIGHT YIELD: ~11,000 PH/MeV

ATT. LENGTH (@ 420 nm): 30 m

SCATT. LENGTH (@ 420 nm): 7 m

DECAY TIME (FAST COMPONENT): 3.5 ns

GOOD α/β DISCRIMINATION PROPERTIES

PHOTOMULTIPLIERS

8" THORN EMI 9351

P/V = 2.5

TRANSIT TIME SPREAD 1 ns

DARK COUNT RATE 1 KHz

AFTERPULSING < 3%

LOW RADIOACTIVITY GLASS AND INTERNAL PARTS

LIGHT CONCENTRATORS

TRUNCATED STRING CONE DESIGN

OPTIMIZED TO COLLECT THE LIGHT FROM THE INNER VESSEL AND 20 cm BEYOND IT

DETECTOR PERFORMANCES

COVERAGE: 34 %

PHOTOELECTRON YIELD: ~450 PE/MEV

ENERGY RESOLUTION (@1 MeV): ~8%

SPATIAL RESOLUTION (@1 MeV): 12 cm

CALIBRATIONS

A VARIETY OF CALIBRATION AND MONITORING SYSTEMS ARE ENVISAGED:

- LASER FEEDING FIBERS CONNECTED TO EACH TUBE
    - TIMING CALIBRATION
    - GAIN ADJUSTEMENT VIA DETECTION OF THE SINGLE PHOTOELECTRON PEAK
- EXTERNAL SOURCES (TH) LOCATED NEAR TO THE S.S.S.
    - CHECK OF THE STABILITY IN TIME OF THE OVERALL DETECTOR RESPONSE
    -
- INTERNAL SOURCES (RN) INSIDE THE SCINTILLATOR
    - TIME (AND SPACE) CALIBRATION

- INTERNAL SOURCES (RN) IN THE BUFFER
  - STUDY OF SCINTILLATION IN THE BUFFER

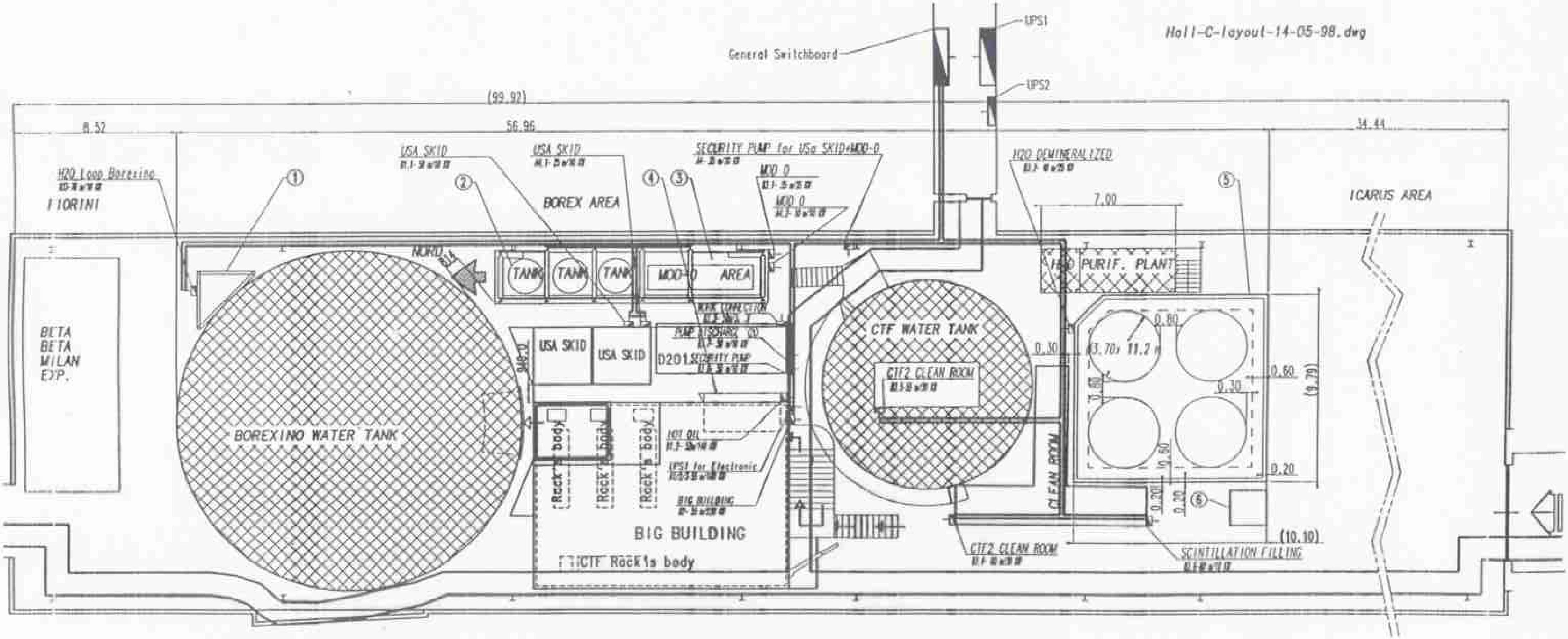
- LASER BEAM THROUGH THE BUFFER AND SCINTILLATOR
  - "ON SITE" VERIFICATION OF OPTICAL PROPERTIES OF BUFFER AND SCINTILLATOR VIA PHOTOEXCITATION

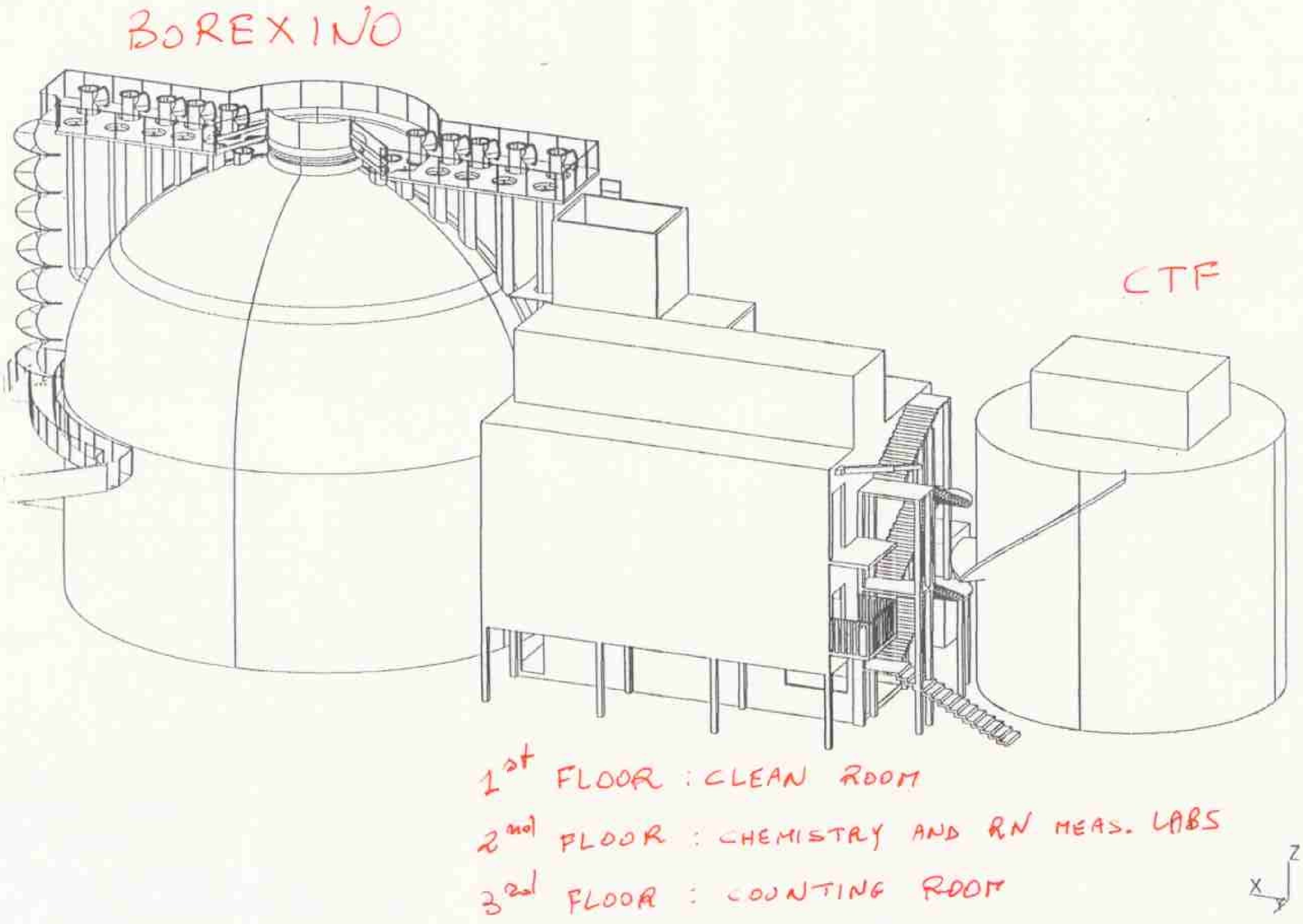
- DIFFUSING BALL IN THE CENTER OF THE DETECTOR
  - ALTERNATIVE MEAN OF PMT+ ELECTRONIC TIMING CALIBRATION

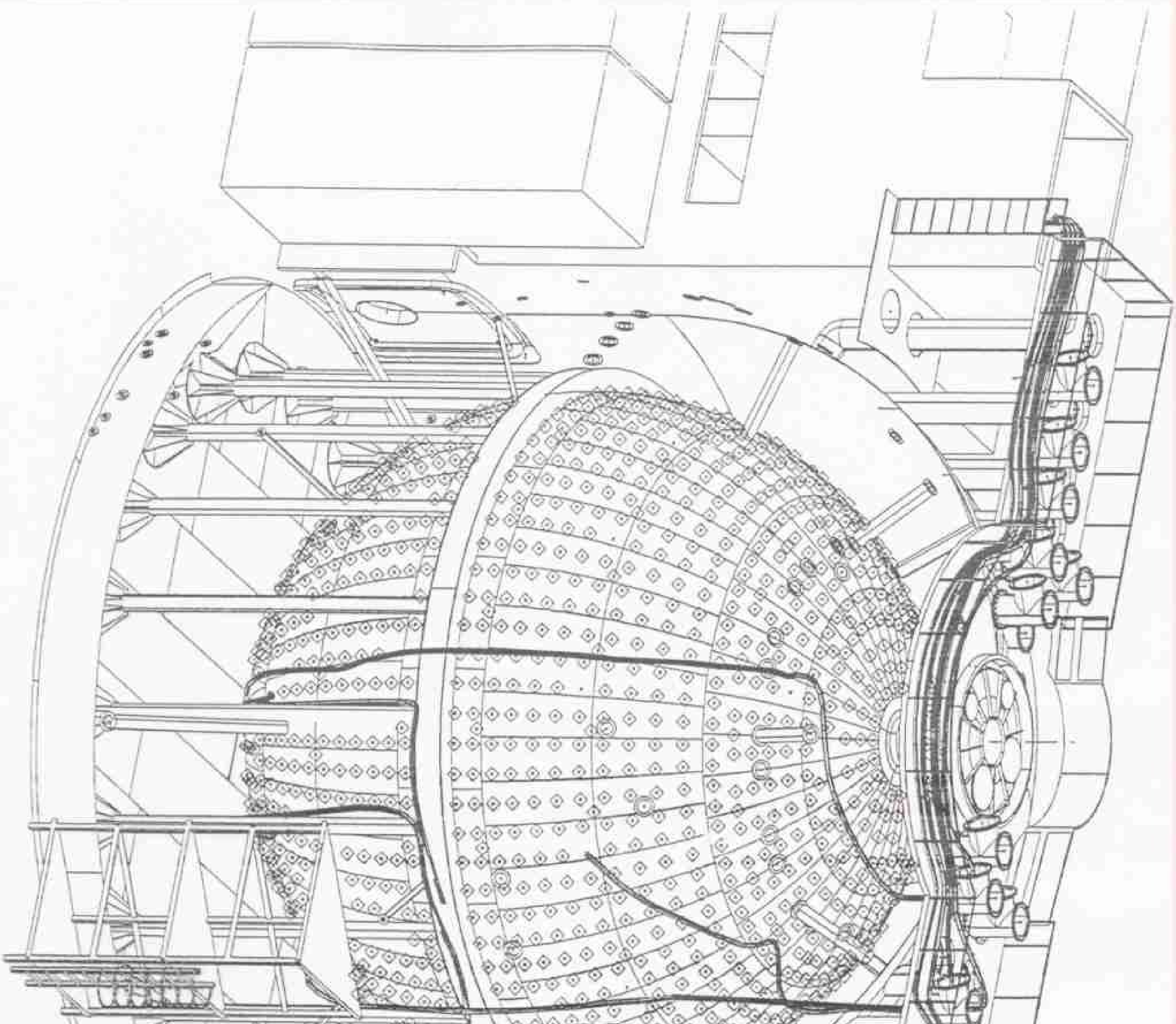
- TAGGING OF INTERNAL BACKGROUNDS VIA CORRELATED EVENTS
  - ABSOLUTE ENERGY SCALE DETERMINATION

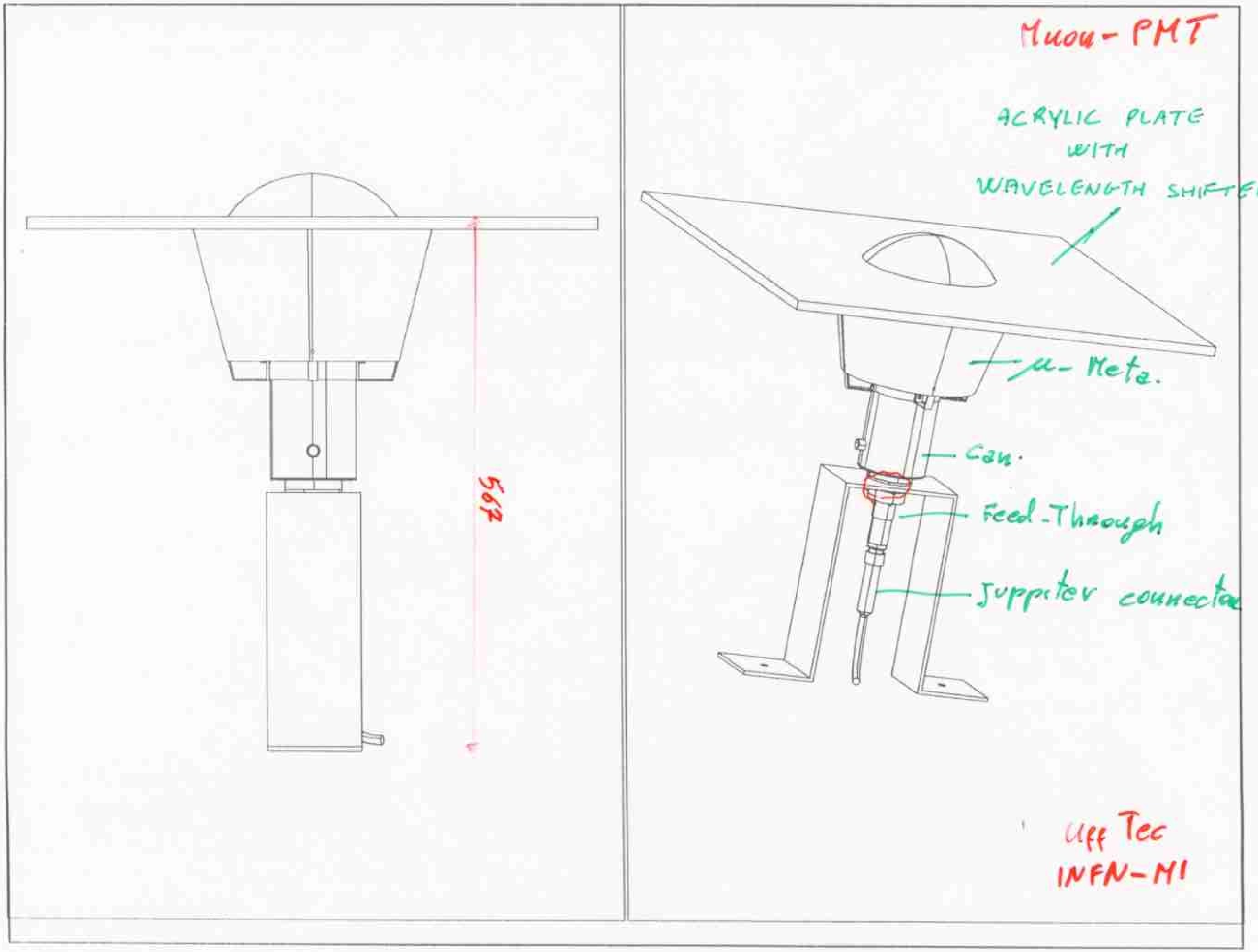
PLANTS

- PURIFICATION SYSTEM (SCINT.)
  - WATER EXTRACTION
  - DISTILLATION
  - NITROGEN FLUSHING
- WATER PURIFICATION SYSTEM
- LIQUID HANDLING
- STORAGE VESSELS


Hall-C-layout-14-05-98.dwg
General Switchboard
UPS1
UPS2
(99.92)
8.52
56.96
34.44
H2O Loop Borexino
FIORINI
BETA
BETA
MILAN
EXP.
BOREXINO WATER TANK
NORD
USA SKID
USA SKID
BOREX AREA
TANK
TANK
TANK
MOD-0
AREA
SECURITY PUMP for USa SKID+MOD-0
MOD 0
MOD 0
USA SKID
USA SKID
D201
PUMP DISCHARGE
SECURITY PUMP
Rack's body
Rack's body
Rack's body
HOT OIL
UPS1 for Electronic
BIG BUILDING
BIG BUILDING
CTF Rack's body
CTF WATER TANK
CTF2 CLEAN ROOM
CTF2 CLEAN ROOM
CLEAN ROOM
H2O DEMINERALIZED
7.00
H2O PURIF. PLANT
0.30
0.80
0.60
(9.79)
0.30
0.20
(10.10)
SCINTILLATION FILLING
ICARUS AREA


BOREXINO
CTF
1st FLOOR : CLEAN ROOM
2nd FLOOR : CHEMISTRY AND RN MEAS. LABS
3rd FLOOR : COUNTING ROOM
X
Y
Z





Muon-PMT
567
ACRYLIC PLATE
WITH
WAVELENGTH SHIFTER
μ-Meta.
Can.
Feed-Through
Juppiter connector
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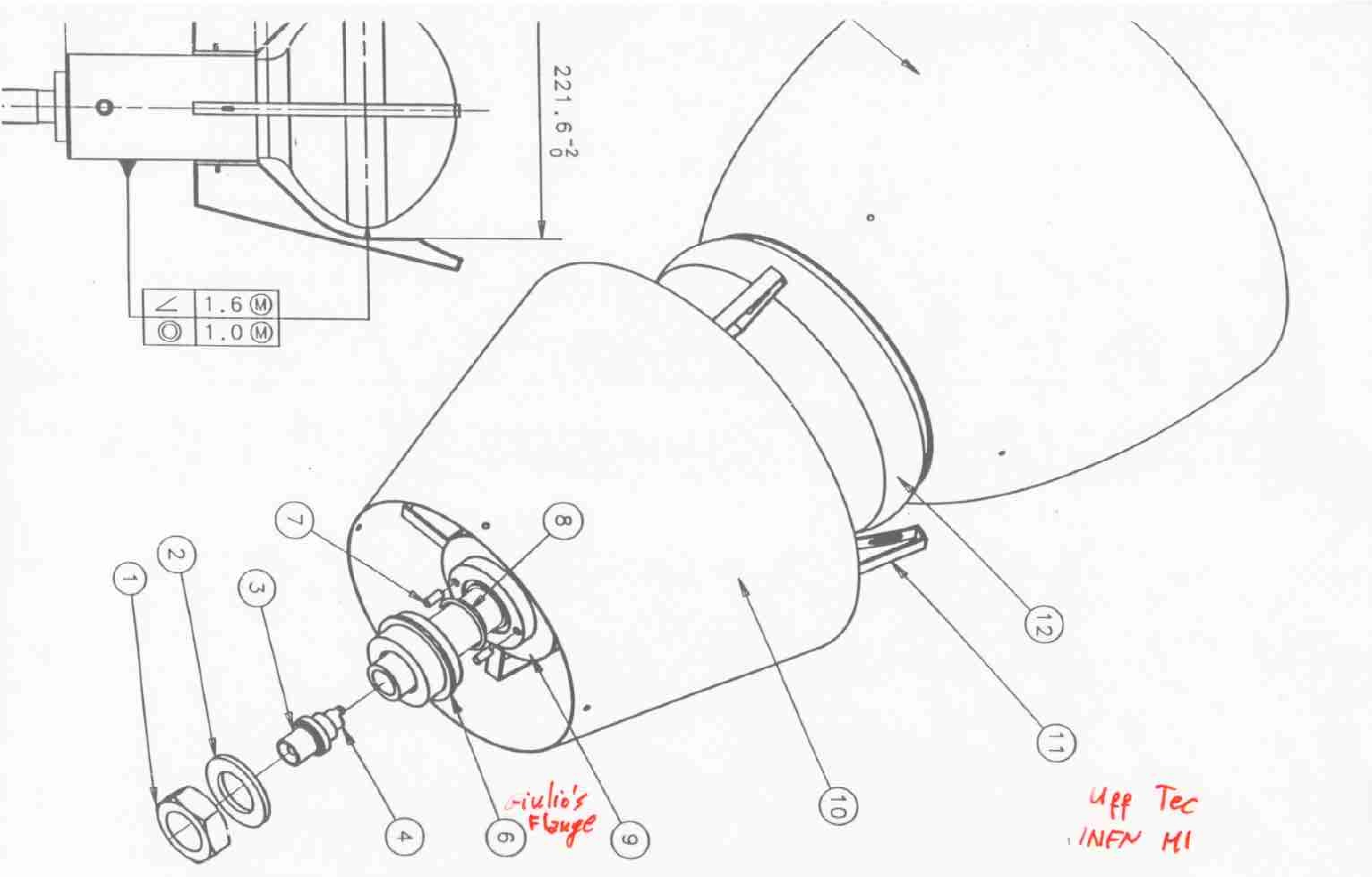
INFN-MI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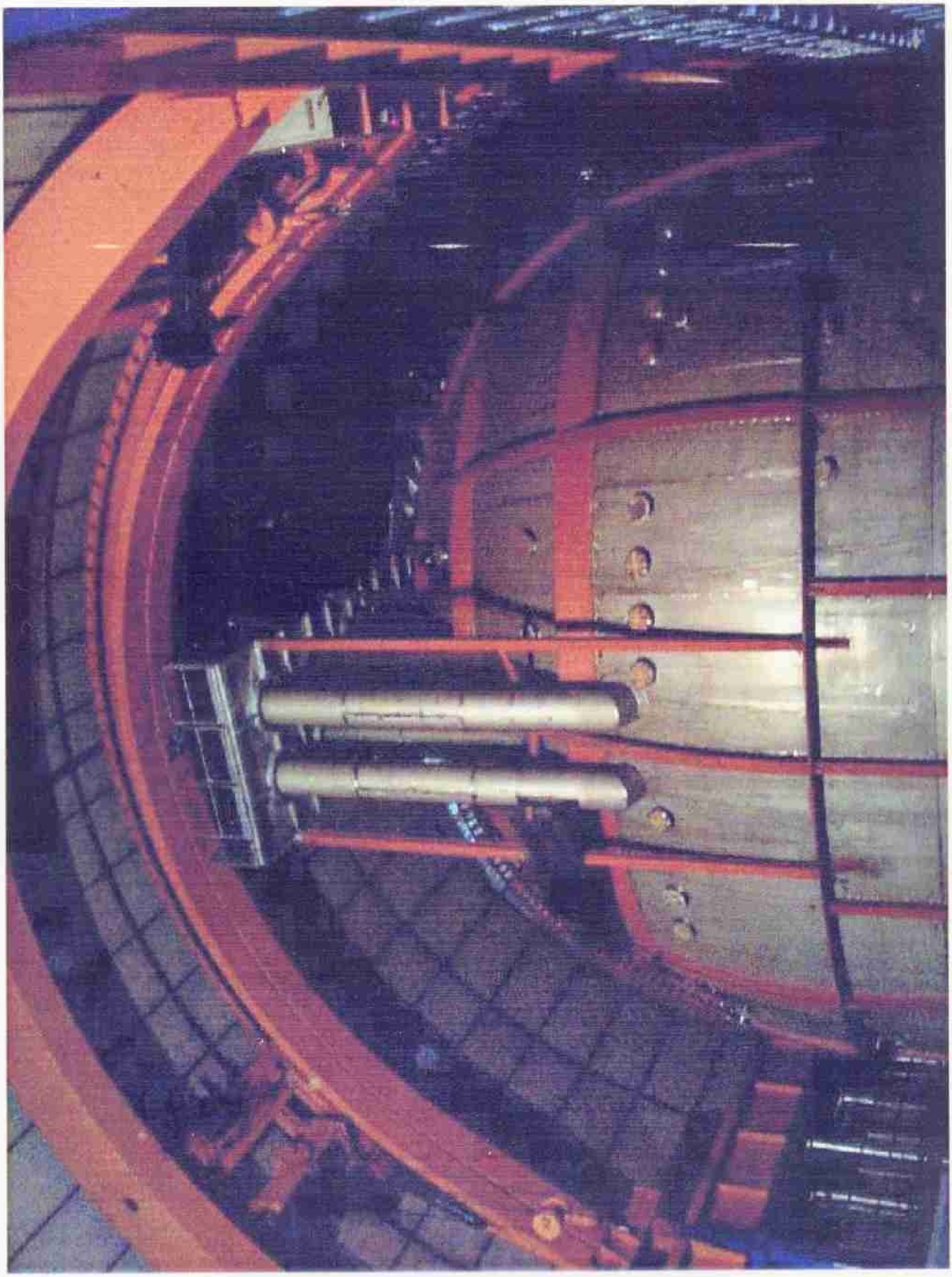
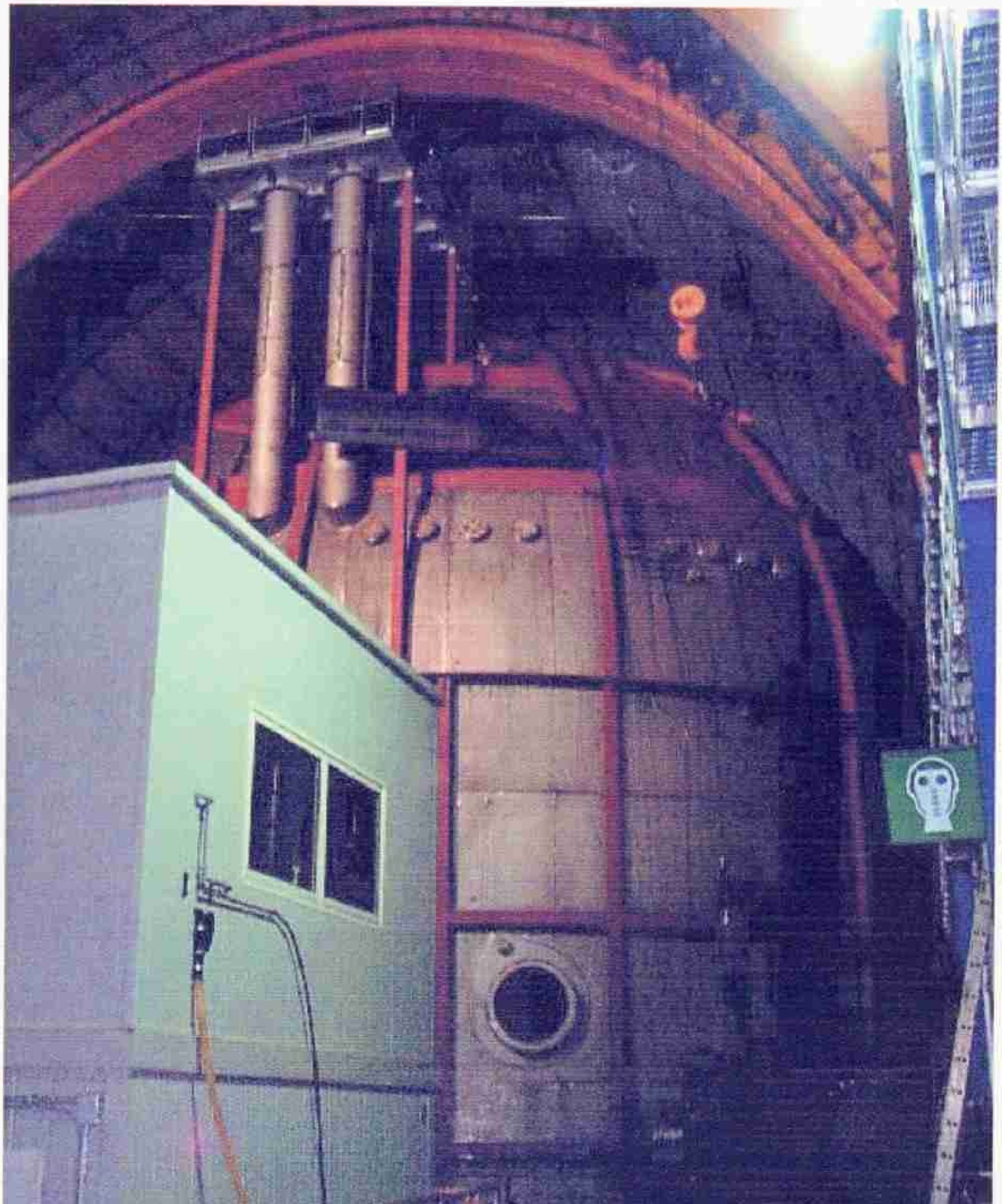
Giulio's Flange
Uff Tec INFN MI





NEUTRINO DETECTION IN BOREXINO

DETECTION THROUGH THE SCATTERING REACTION

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

OFF THE ELECTRONS OF THE SCINTILLATOR

- 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**

S.S.M. PREDICTION ~55 ev/d FOR 100 T F.M.

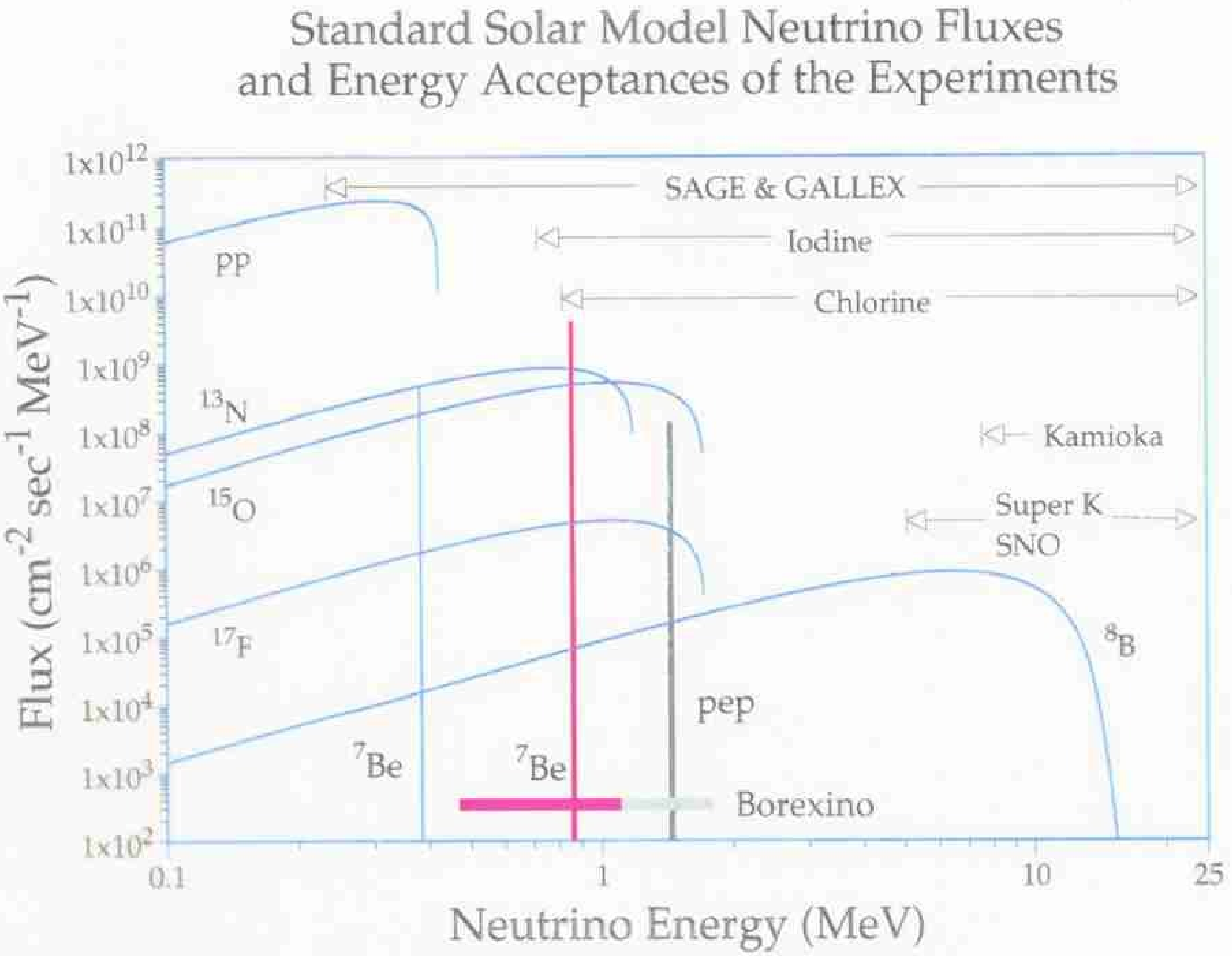
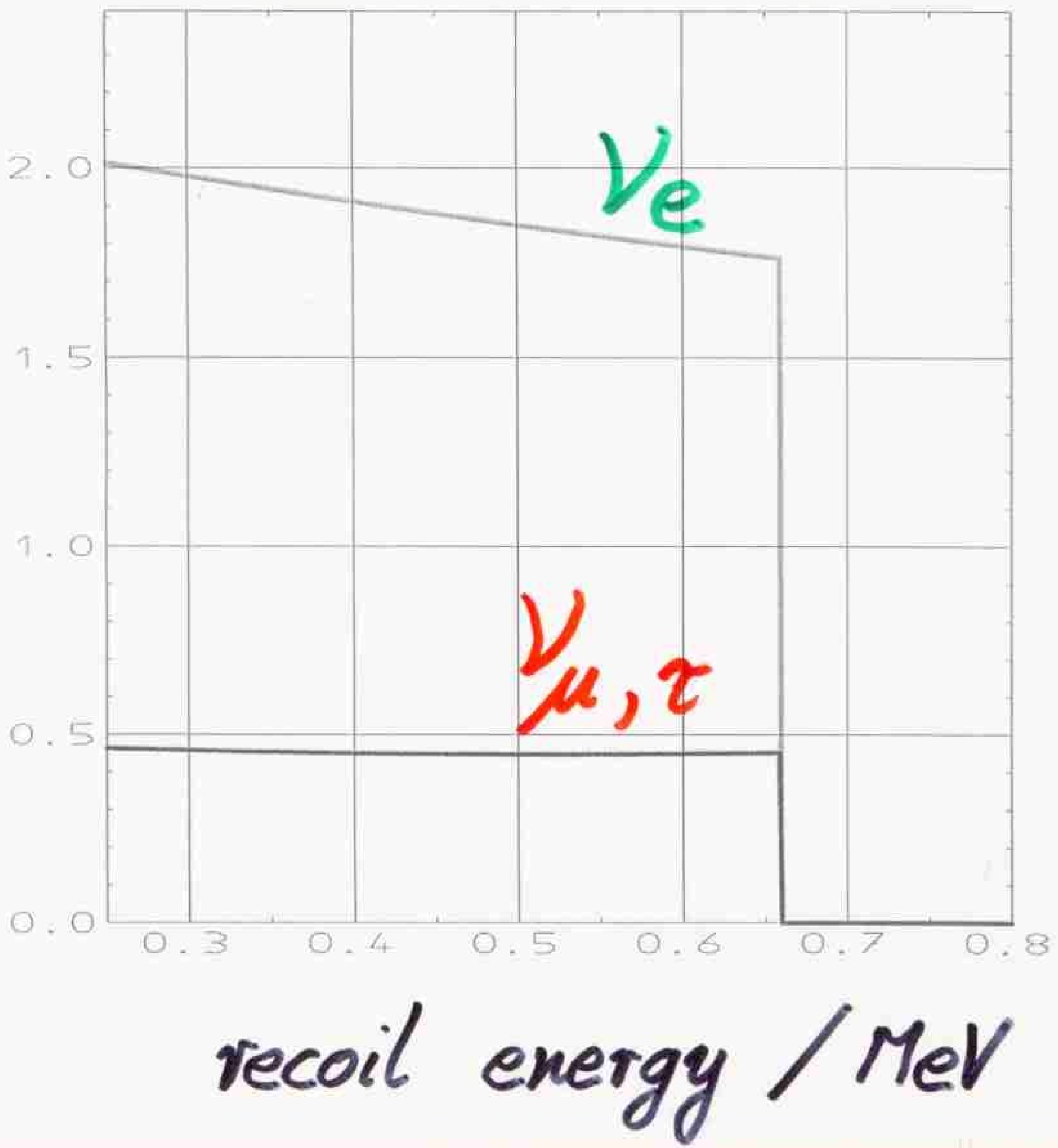


Figure 2: *The energy spectrum of solar neutrinos produced by the pp and CNO cycles in the Standard Solar Model [3]. The monoenergetic line fluxes have units* $cm^{-2}s^{-1}$.

Recoil energy spectrum ^7Be-$\nu_\odot$



$\nu_\odot = \nu_e$ (SSM)

~ 55 / day

$\nu_\odot = \nu_{\mu,\tau}$ (MSW)

~ 15 / day

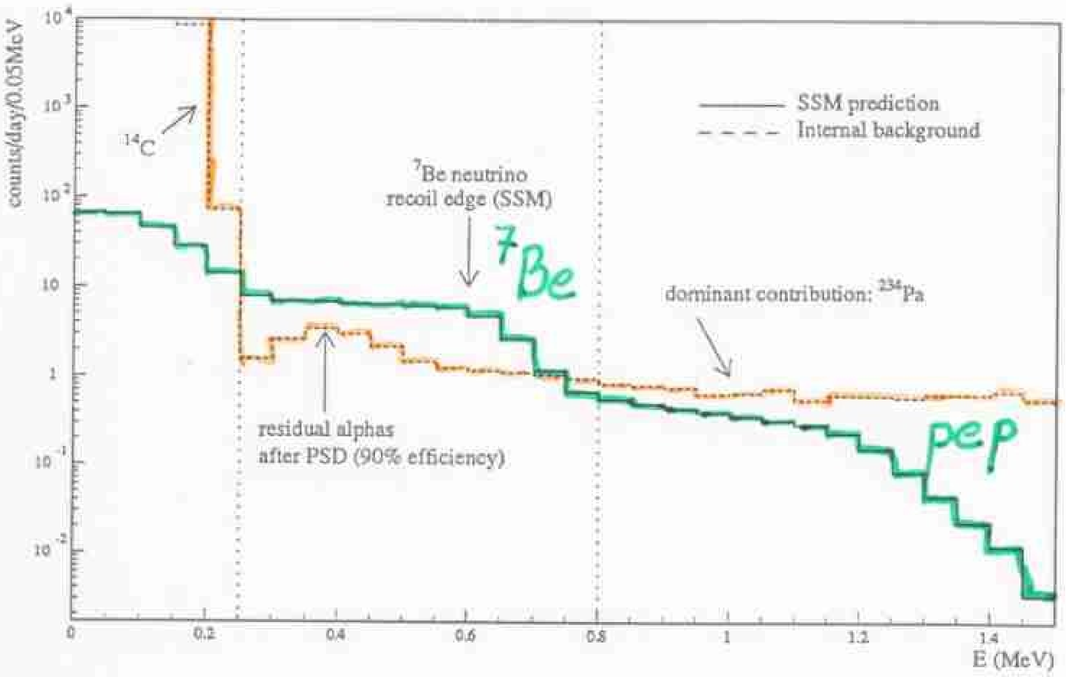


Figure 15: *Estimate of internal background spectrum and SSM neutrino signal in a 100-ton fiducial volume, assuming 300 photoelectrons/MeV and an energy resolution given by:* $\Delta E/E = 1/\sqrt{N_{pe}}$.

Energy spectrum ν - events

and internal bg.

Requirements :

^{238}U : 10^{-16} g/g

^{232}Th : 10^{-16} g/g

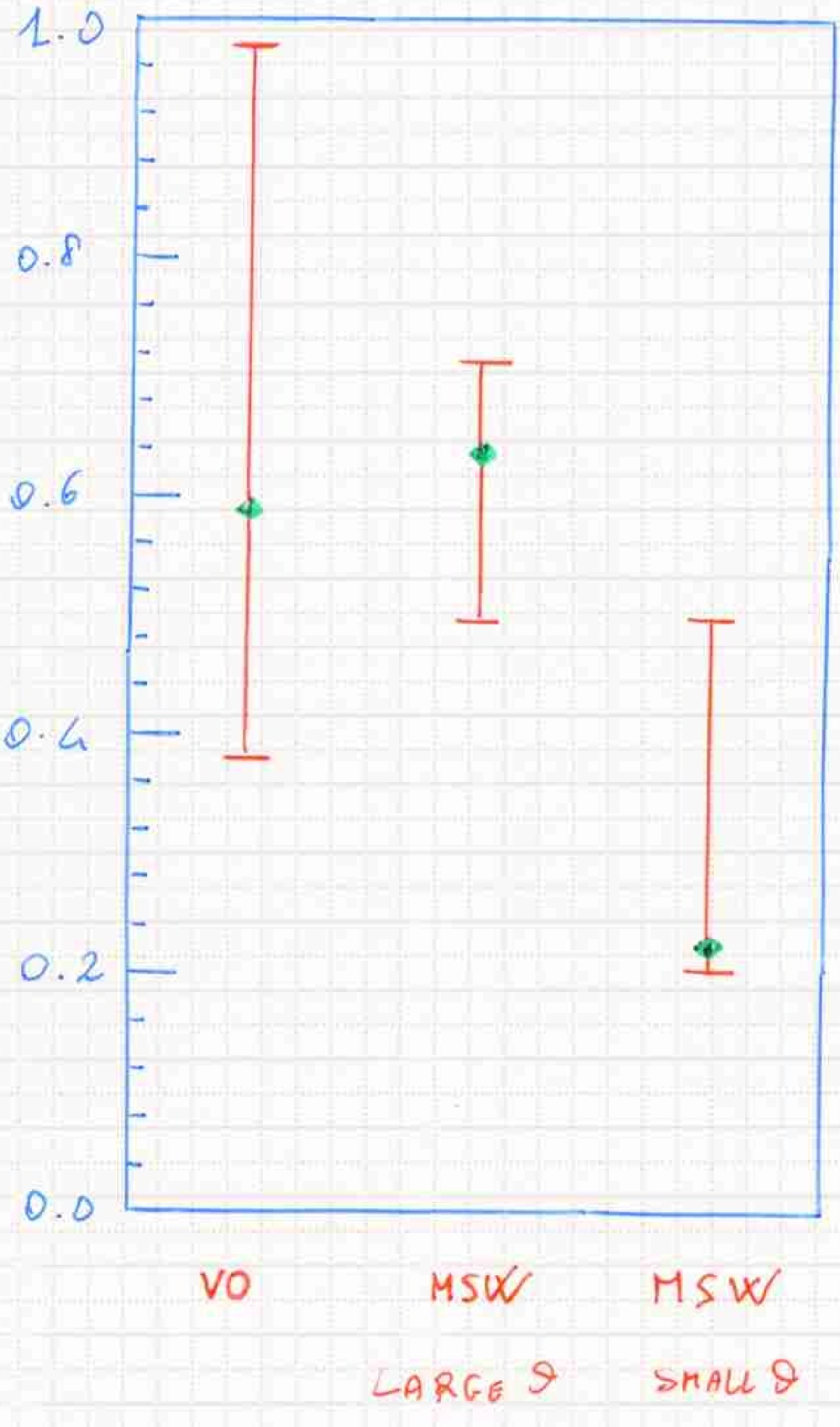
$^{14}C/^{12}C$: 10^{-18}

K_{nat} : 10^{-14} g/g

BOREXINO CAPABILITIES

- FIRST DIRECT MEASUREMENT OF ^{7}Be FLUX
- 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

PREDICTED FLUXES AT 90% CL IN THE THREE ALLOWED REGIONS



Vacuum Oscillations $^7Be-\nu_\odot$

RADIOPURITY OF THE SCINTILLATOR

- MAIN ISSUE FOR THE FEASIBILITY OF THE EXPERIMENT

- PURITY REQUIREMENT FOR ^{238}U AND ^{232}Th $\sim 10^{-16}$ g/g

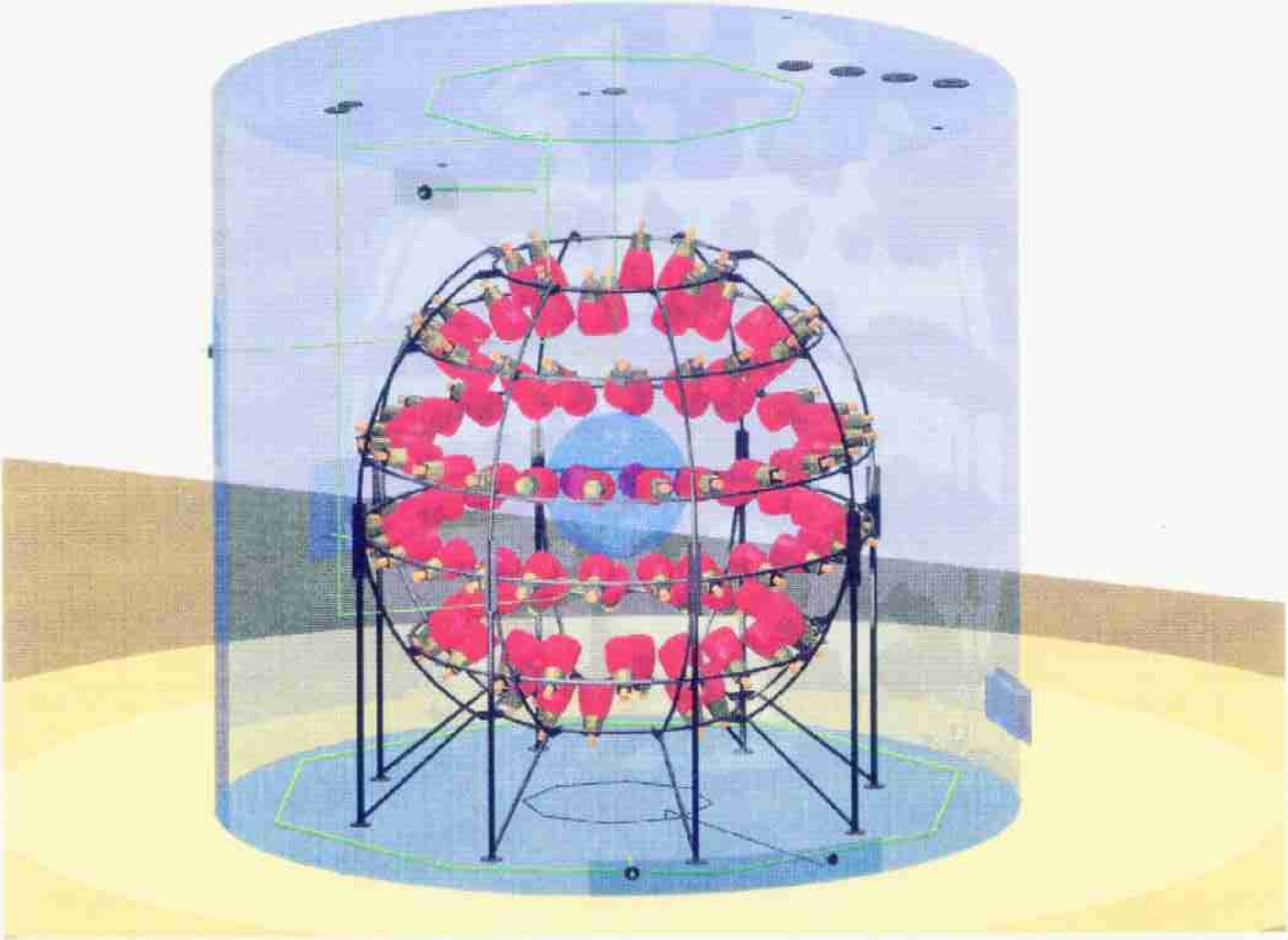
- LABORATORY MEASUREMENTS ON 1L SAMPLES $\sim 2 \div 3 \times 10^{-15}$ g/g

  MAINLY LIMITED BY IMPURITIES LEACHED IN FROM THE WALL OF THE VESSELS

- NEEDED A DIRECT MEASUREMENT ON SOME TONS OF SCINTILLATOR WITH A SENSITIVITY LEVEL OF AT LEAST 5×10^{-16} g/g

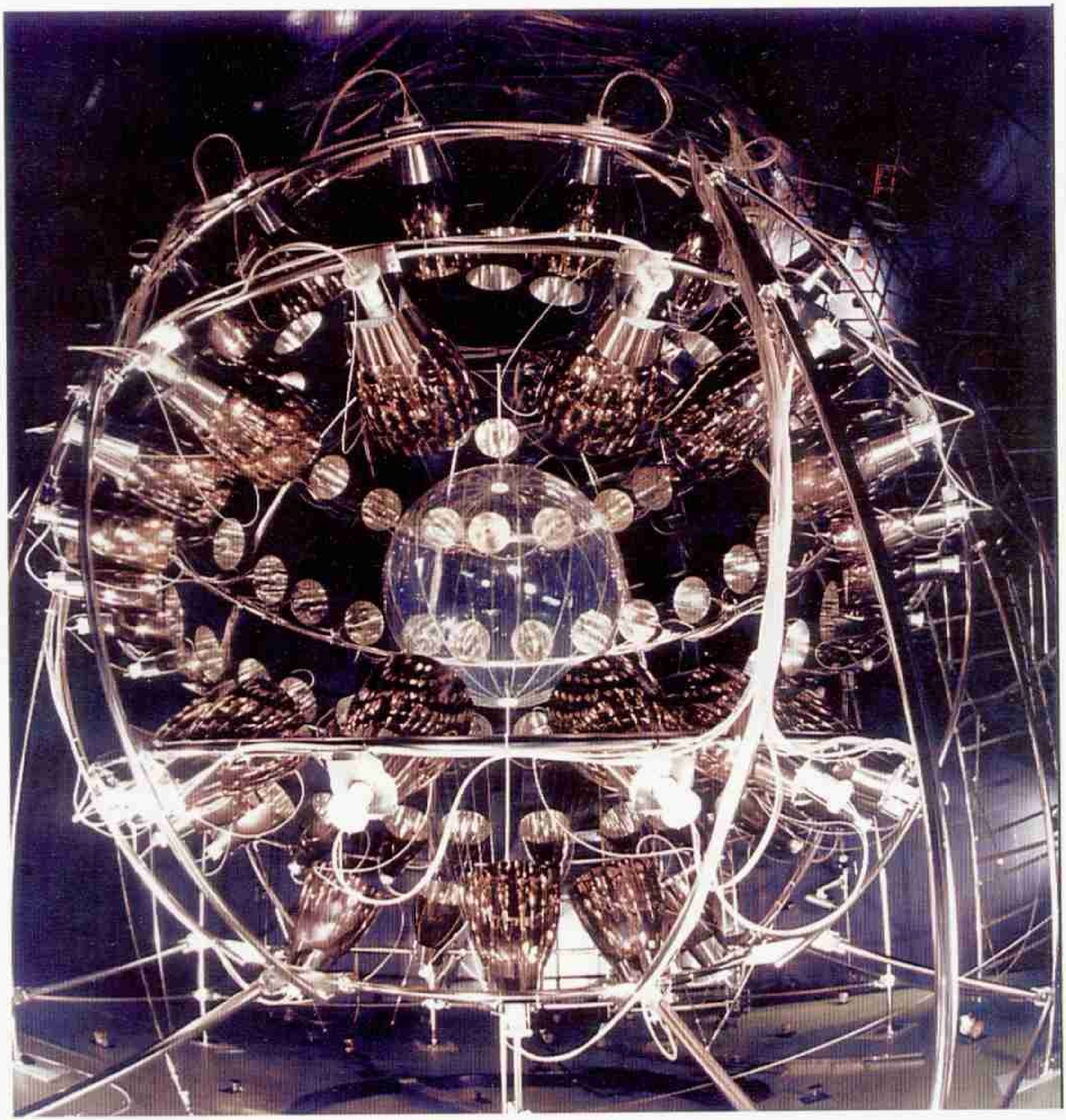
⇓

CTF



Uff. Tecnico INFN MI A. Gargiola

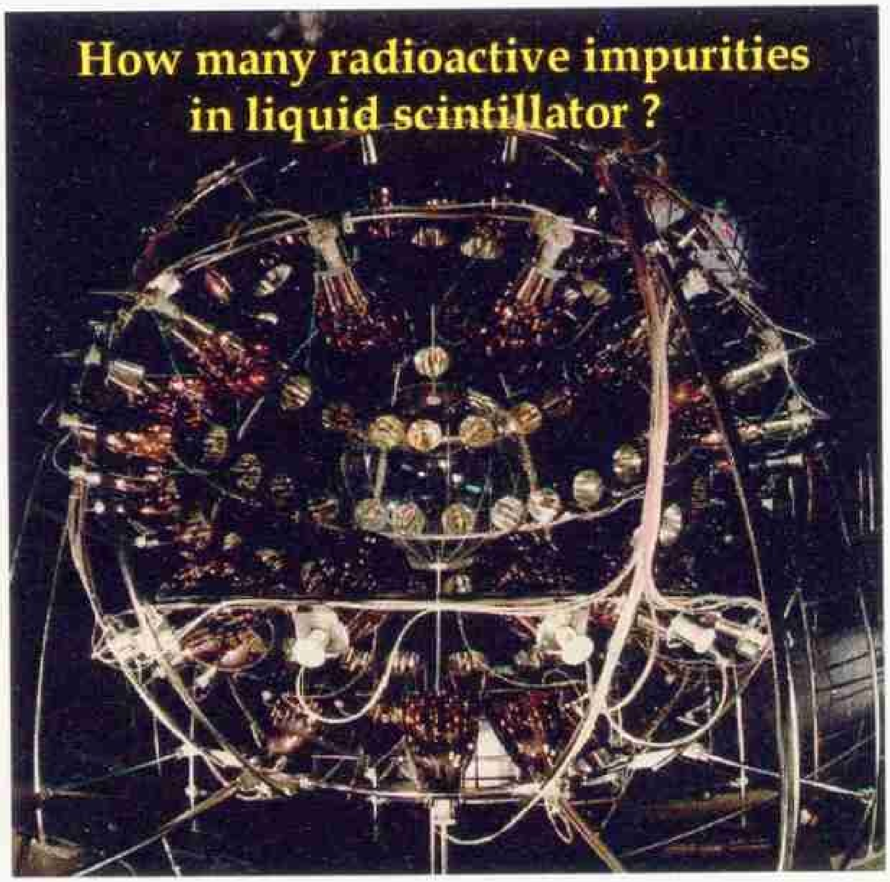
Counting Test Facility



of Borexino at Gran Sasso

Results of the CTF

(Countig Test Facility for Borexino)



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

$^{232}Th < (4.4 \pm 1.5) * 10^{-16}$

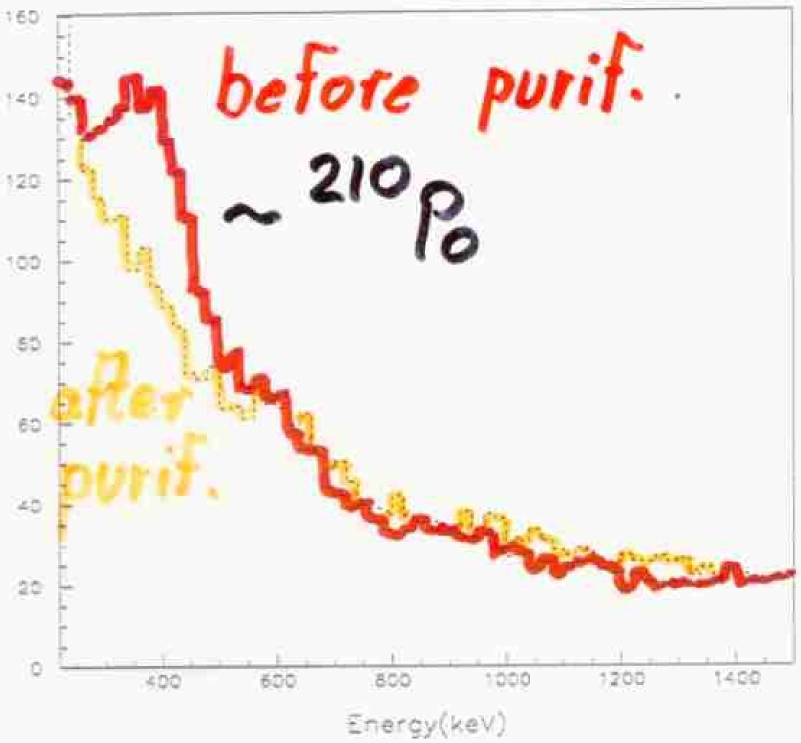
$^{238}U < (3.5 \pm 1.3) * 10^{-16}$

BOREXINO Collab., Astroparticle Physics 8 (1998) 141
BOREXINO Collab., Phys. Lett. B 422/1-4 (1998) 349

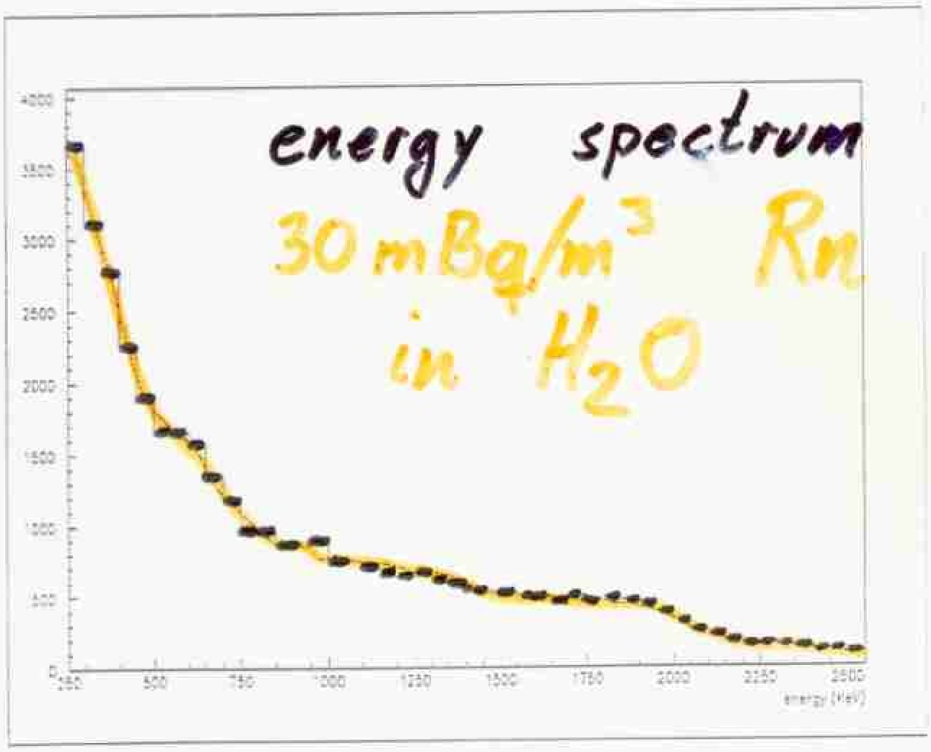
Neutron Activation Analysis:

$^{238}U < 2 * 10^{-16}$

Scintillator purification



- N_2 bubbling
- H_2O extraction
- distillation



single counting rate dominated by external background (Rn in H_2O)

CONCLUSIONS

- UNPRECETENTED PURITY LEVELS IN SCINTILLATOR HAVE BEEN DEMONSTRATED IN CTF

- ON THIS BASIS BOREXINO HAS BEEN APPROVED AND THE CONSTRUC= TION ALREADY STARTED

- THE DETECTOR ASSEMBLY IS EXPECTED TO BE COMPLETED IN THE YEAR 2000