1

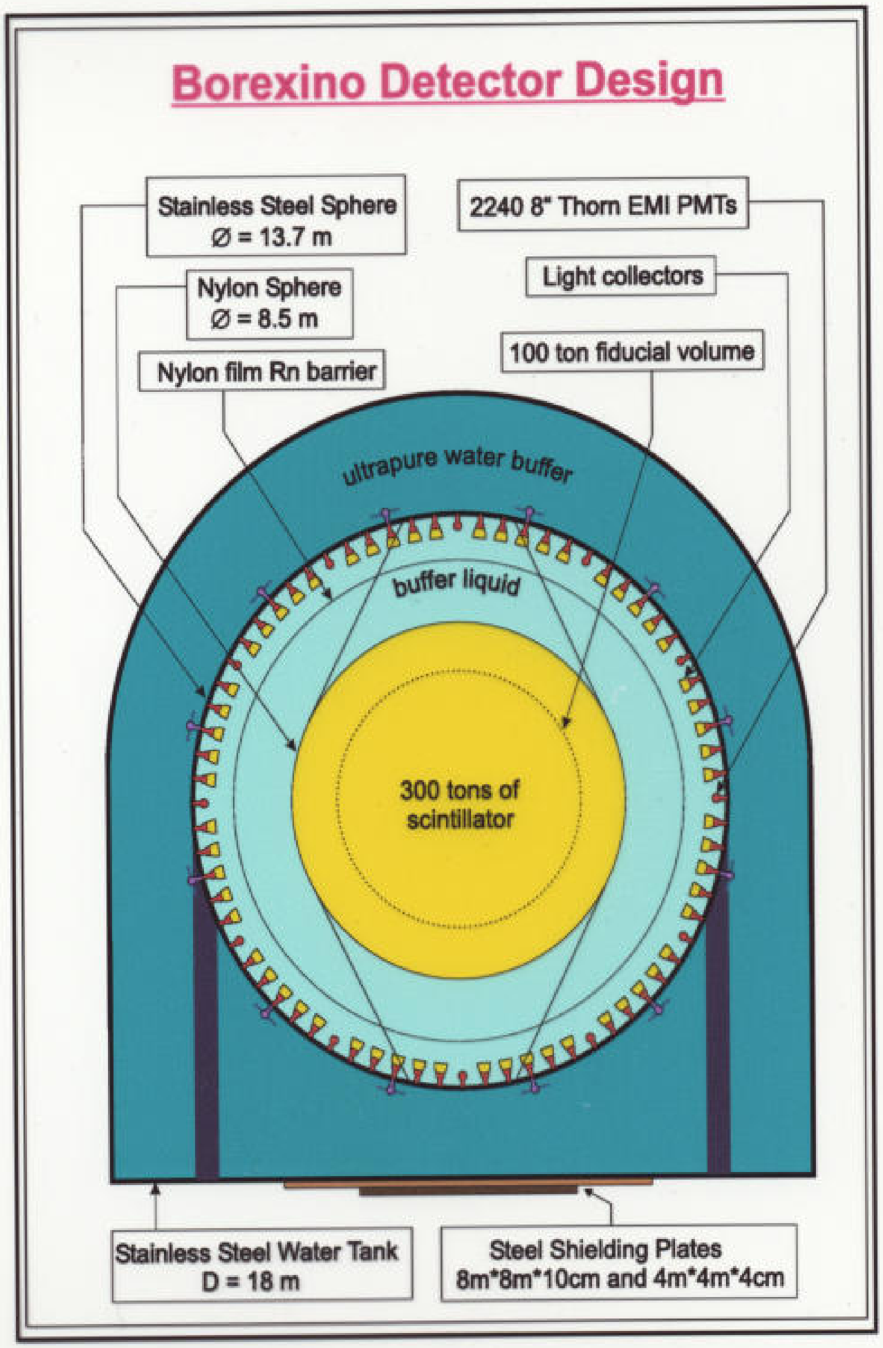
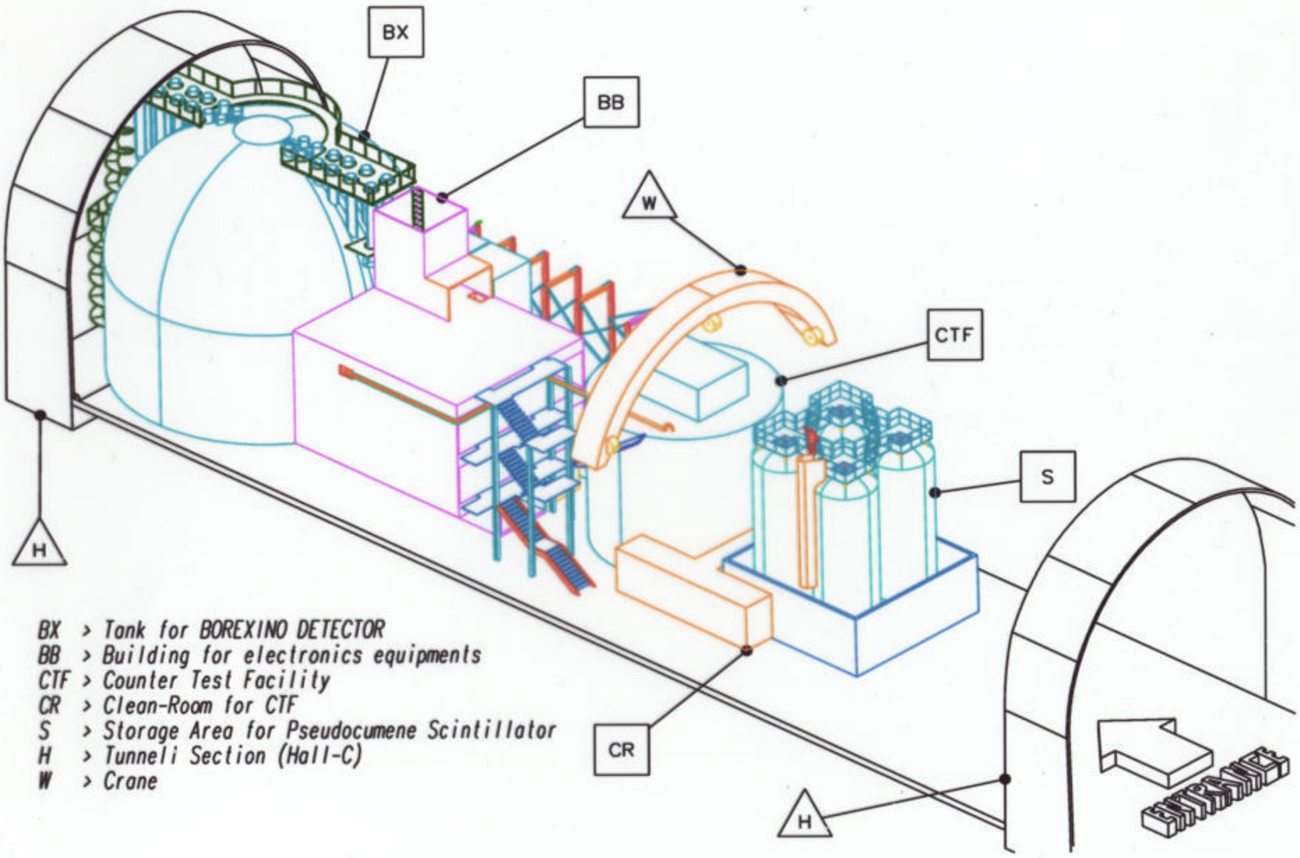


Figure 1. Schematic view of BOREXINO. The ultrapure scintillator (300t) inside a nylon vessel is shielded differentially by means of a liquid buffer (1040t), a steel sphere on which the tubes are mounted, and the outer water buffer which is contained in an external steel tank with dimensions of about 18m. A transparent nylon shroud hinders radon convection in the liquid buffer region. Additional tubes mounted on the outer surface of the steel sphere allow detection of penetrating muons via the Cherenkov effect.


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

Radiopurity

Scintillator:

- ^{14}C in the range: 10^{-18} $^{12}C/^{14}C$
- U, Th at ~10^{-16} g/g
- K at ~ 10^{-12} g/g
- Rn μBq range

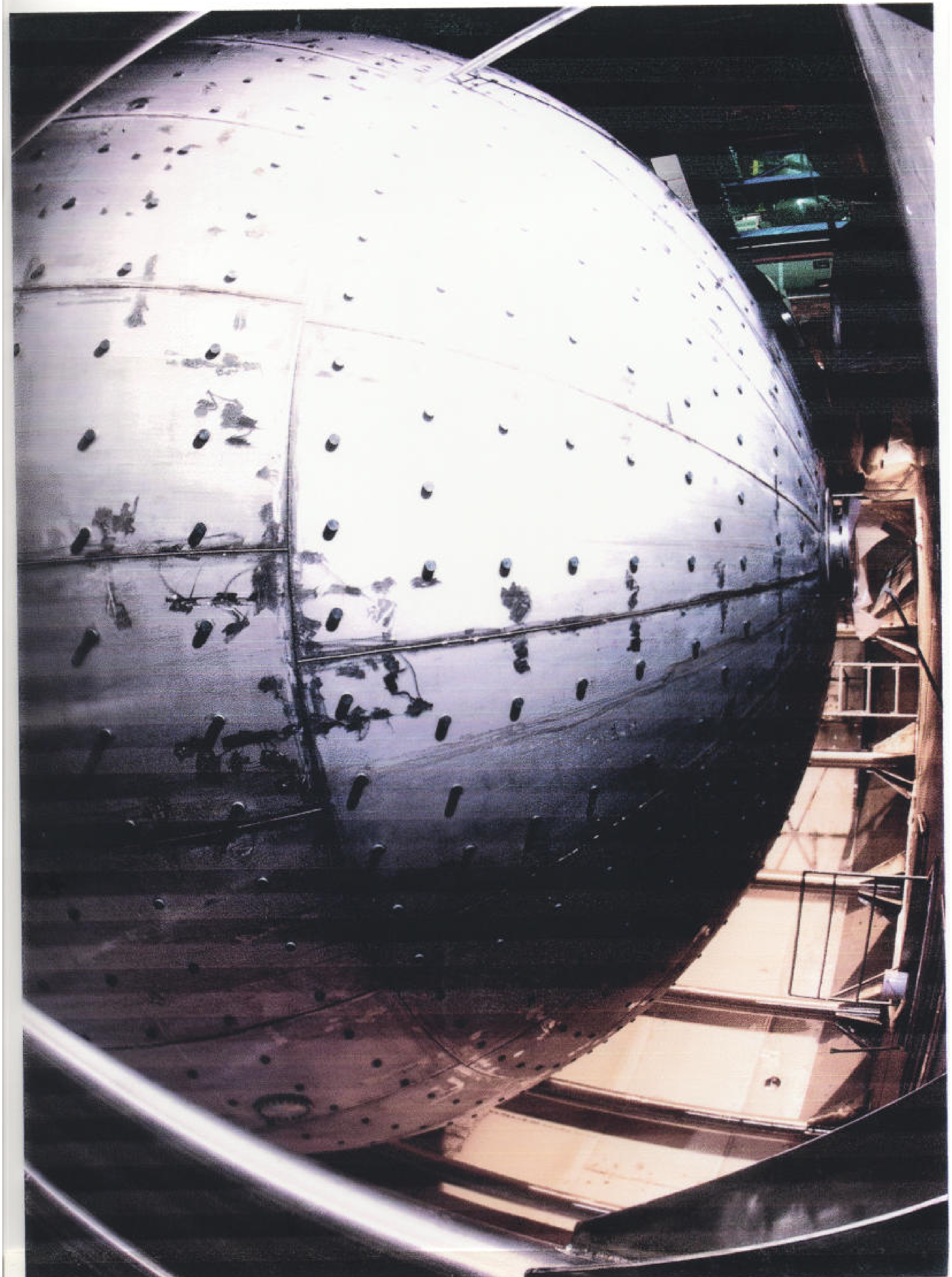
Buffer liquid:

- U, Th ~ 10^{-15} – 10^{-14} g/g

- electropolished, roughness → r_a ~ 0.4 μm
- tightness single component ~ 10^{-8} st cm^3/s

  (underground Rn: 40-80 mBq in air)
- cleanliness < class 10-50 Mil. St. for the surfaces
- 4Cr class 10-1000

  SSS class 5000



PMT's and electronics

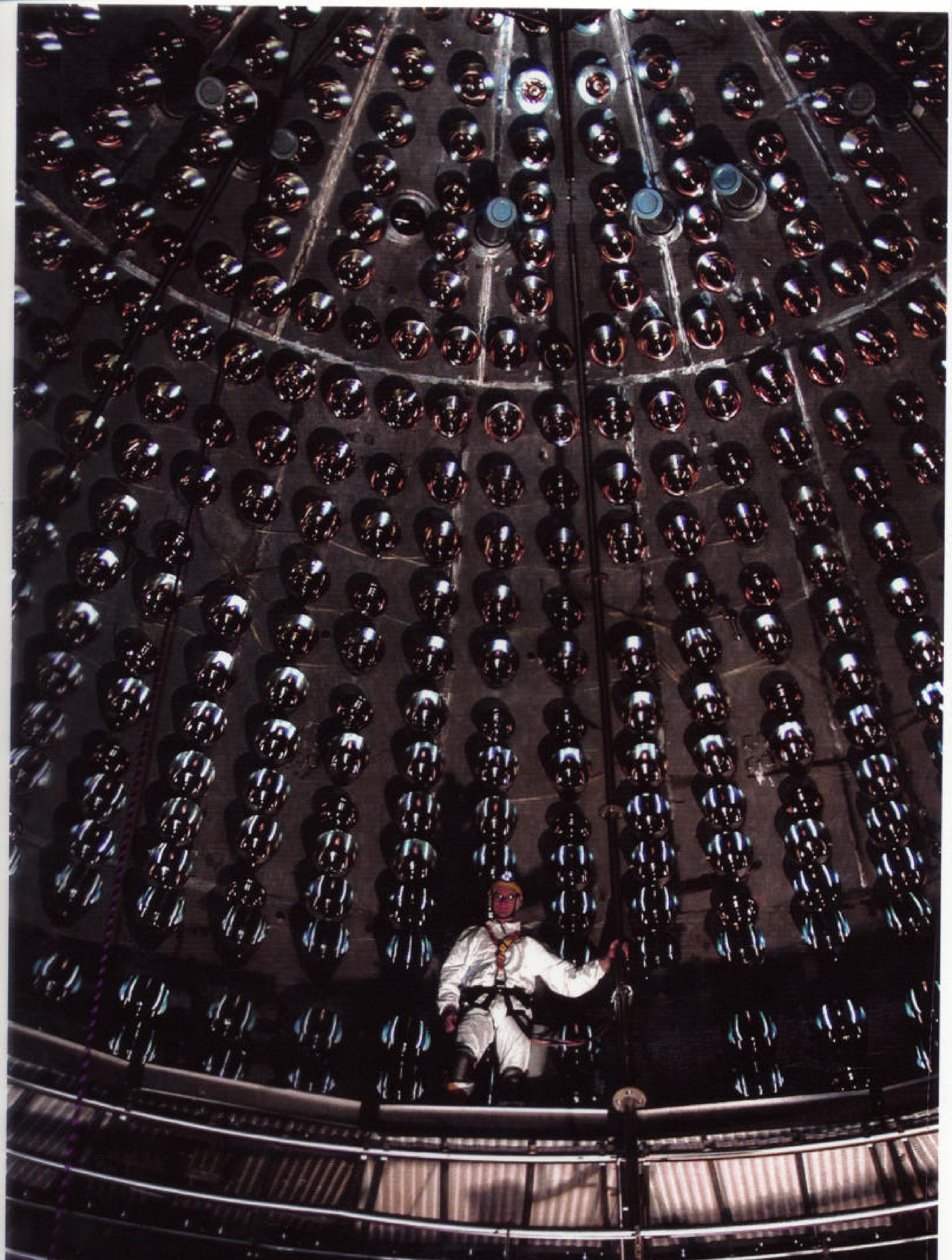
- The 2414 PMT's almost installed (160 left in the inner detector and 140 left in the outern muon veto: waiting for the I.V. installation) – infant mortality < 1%
- Leak checks of all flanges successfull

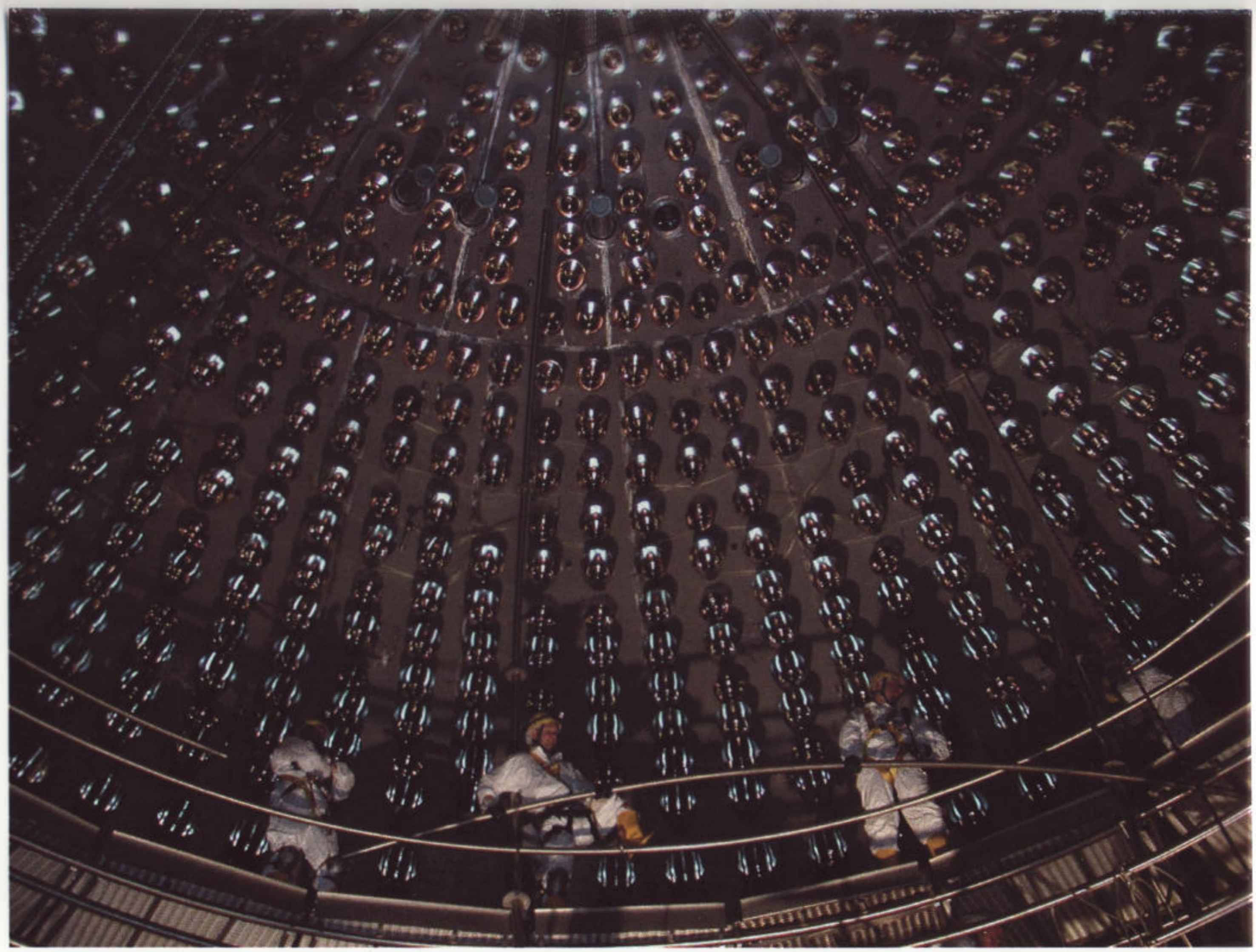
- Arrival time and collected charge from PMT

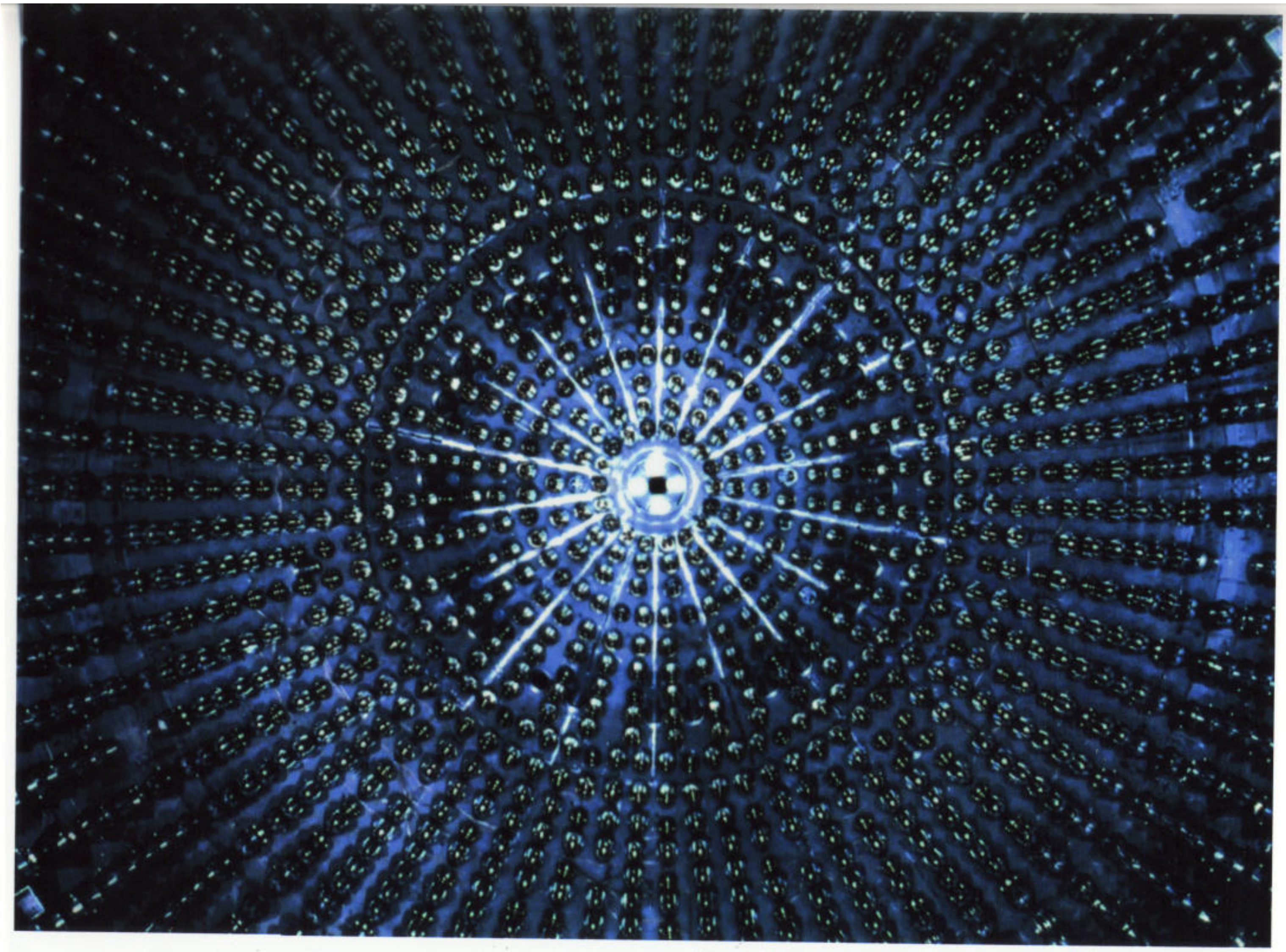
  Front-end electronics, 8 bit ADC (range → 3 MeV)
  Trigger → coincidence in a time< 50 ns

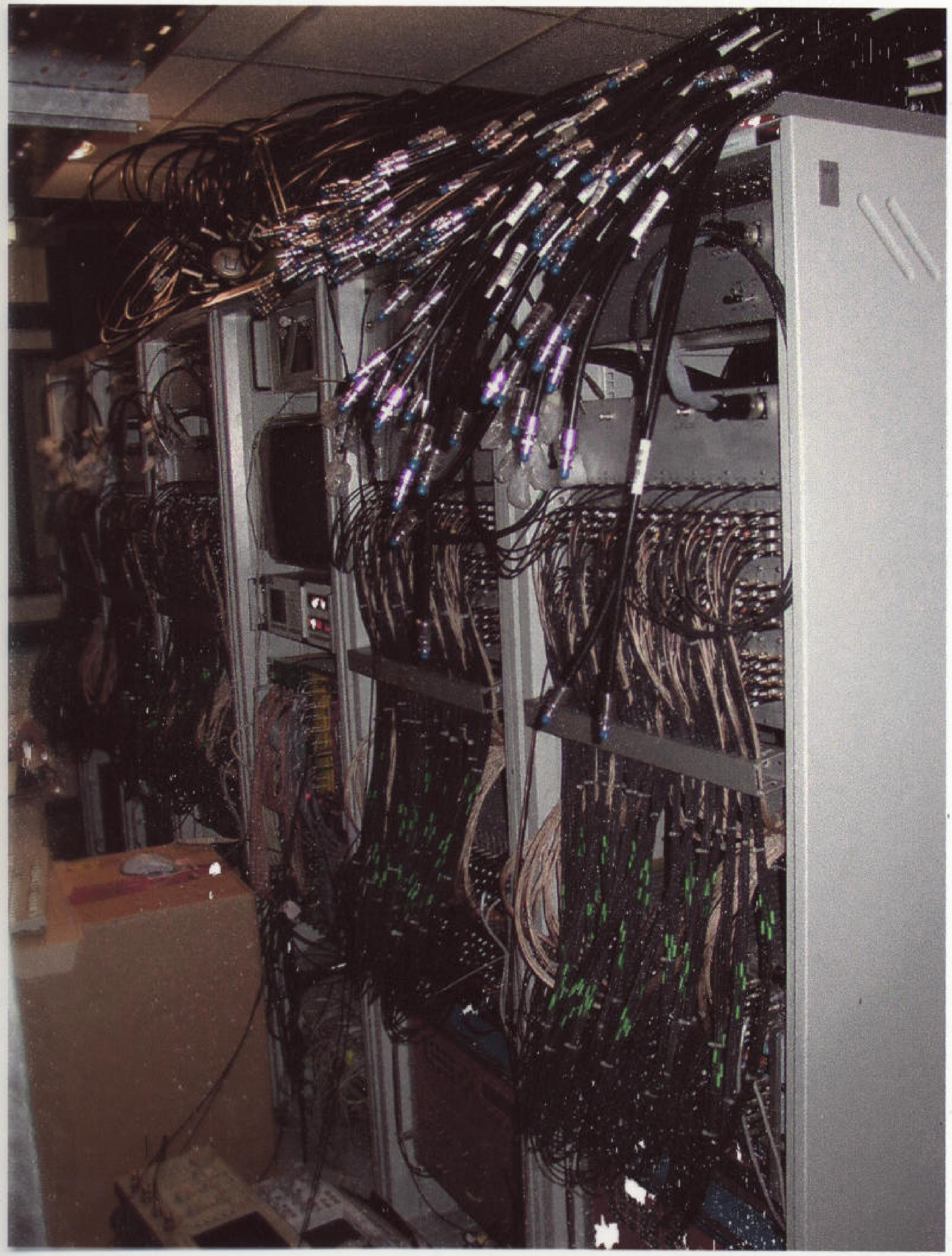
  tested and tuned during 2 "air runs" (one week each) successful
  DAQ tested successfully

- Analog sum of 50 PMT's: FADC (range → 20 MeV)
  - FADC will be installed in June
- Outer muon electronics: ready in July









Calibration

1. timing calibration

   394 nm laser 35 fibers (6 spares) → 90 fibers each

   test: > 99% of the fibers run properly

2. transparency monitor system (TMS)

   - 2 lasers (394 and 355 nm) via 31 optical fibers convey the light on 31 SSS points crossing the scintillator and the buffer liquid.

   installed and tested

3. Monitor of the scintillator response
   1 laser (266 nm) via 1 optical fiber within the Inner Vessel

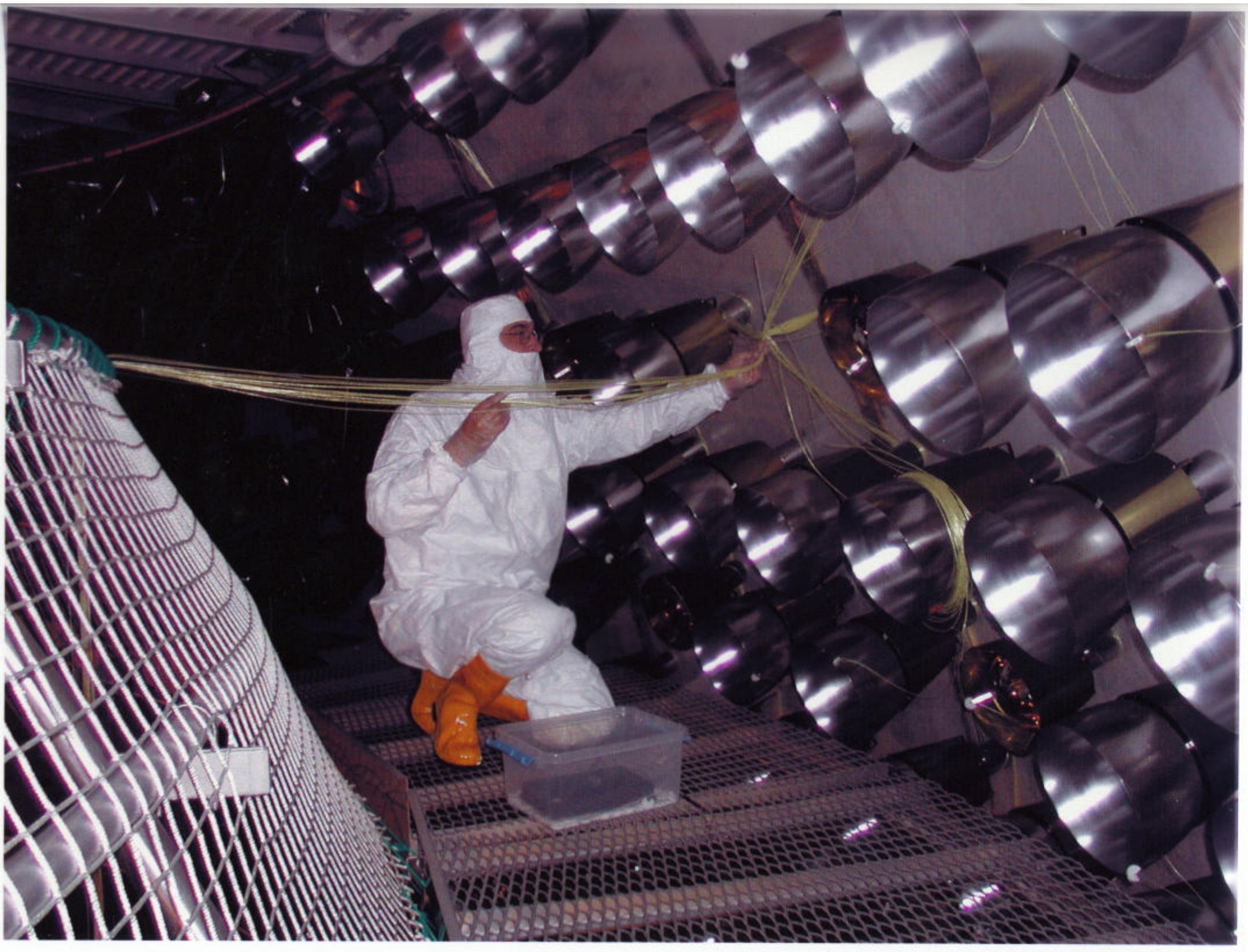
   (installed), tested

4. Positioning System (6 CCD cameras)

   installed

5. Internal Source Insertion System (SIS)
   Installation during the water filling

   in construction phase



Scintillator properties

Pseudocumene + PPO (1.5 g/l)

Light yields: 380 photoelectrons/MeV

^{14}C	1.8 ± 0.09	x 10^{-18}	$^{14}C/^{12}C$
	1.34 ± 0.01	"	"
	2.6 ± 0.2	"	"
	4.7 ± 0.2	"	"

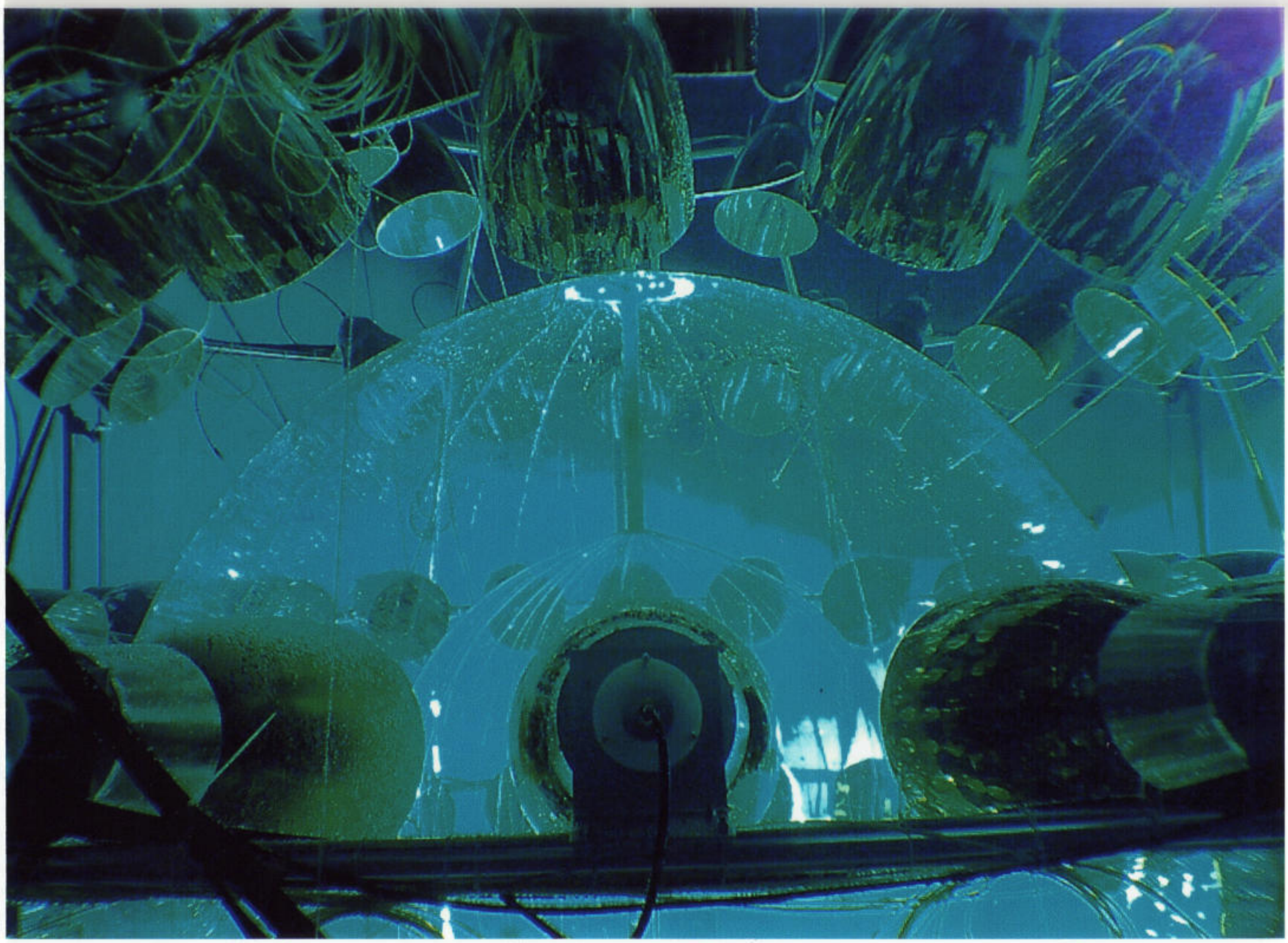
Absorption length	> 8 m
Brom index	< 5
O_2 content	< 10^{-5} g/g

PC

- 300 mc (for the scintillator) procured within end of June;
- stored in 3 of the 4 silos of the storage area (100 mc each)
- 4th silo used for the PC (or scintillator) movements during the purification (s)

PPO

- procured (1.5 g/l)
- master solution prepared and prepurified in the PPO plant (water extraction + stripping)
- master solution purified through a water extraction + stripping system
- also sigel column can be used for the purification
- added to PC either in the storage area or during the Borexino filling



Purification systems

- Water   tested in CTF   Rn: 25 mBq/mc

  Ra: < 2 mBq/mc

  Within the shroud: 2. ± 0.5 mBq/mc

- Scintillator
  - water extraction

    in testing phase
  - silicagel column

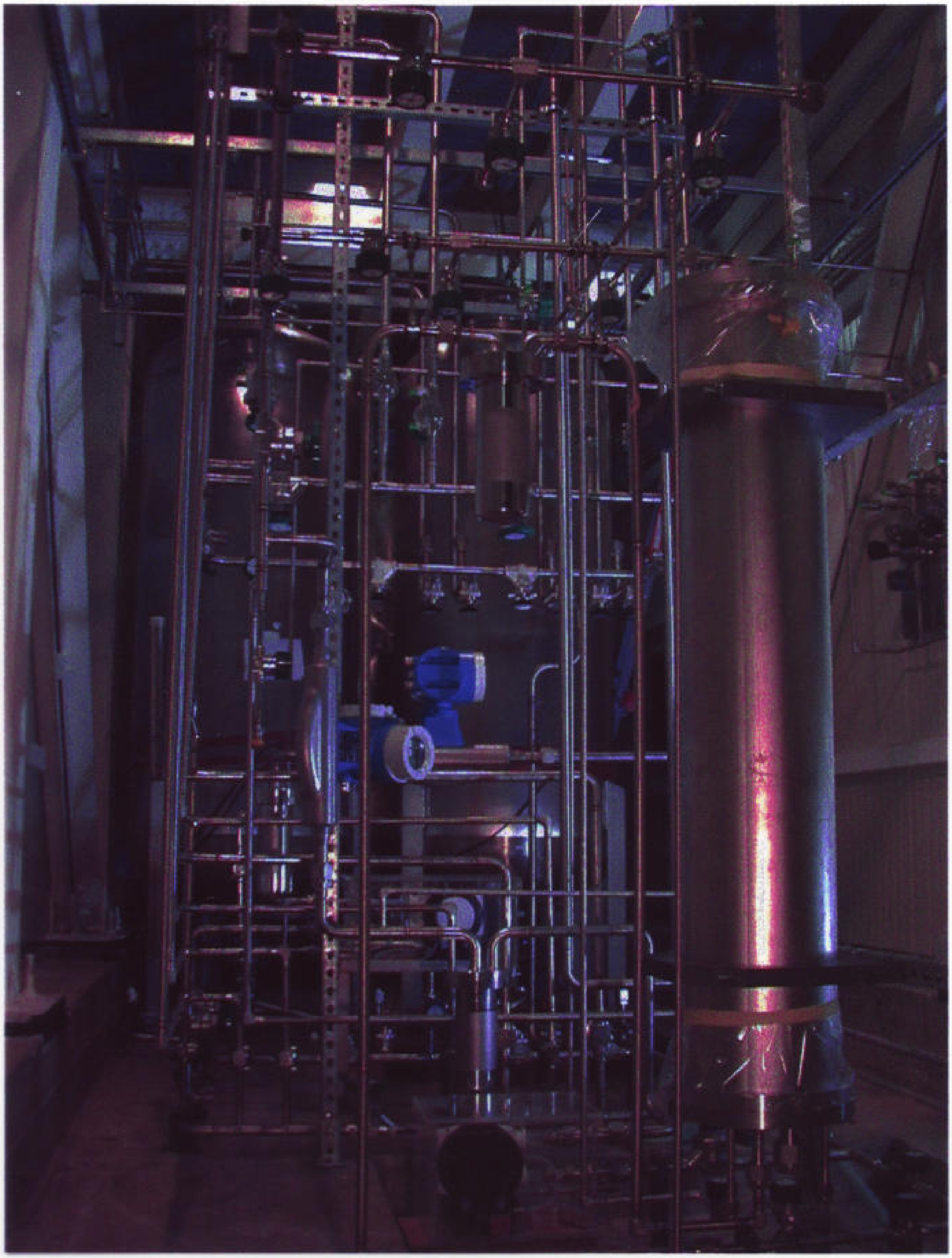
    tested in continuous mode

    next test in batch

- PC
  - distillation

    to be tested

- N_2
  - regular   Rn: 80-100 μBq/mc
  - ultrapure   Rn: 0.3 ± 0.1 μBq/mc



Nylon Vessels

Inner vessel:	nylon 6 co-polymer (Sniamid)
	diam. 8.5 m
	thickness 125 μm
	U, Th: ~ 1 ppt
Shroud:	nylon 6 (Capron)
	diam. 11 m
	thickness 125 μm
	U, Th: ~ 15 ppt

Light trasmittance: > 90%
Haze < 2%

Nylon becomes brittle if dry:

humidity:
- 50% during the construction
- > 60% during the installation
- 20-30% in operation

Rn diffusion: diff. length: 10 μm at 20-30% of humidity
100 μm at 90% of "

Buoyancy: 0.4% of density difference
5 ^{0}C of difference in temperature

Filling

- Purify the scintillator before the filling and test it with CTF
- Two possibilities: → PPO added to PC during the filling
  → PPO added in the storage area
- Possible final purification during the filling (emanation of the vessels and pipes)

- First filling with water (easiest recovery in case of problems – maximum stress of the I.V. during the first filling)
- Replace water with PC: → PC from the top
  → water from the bottom

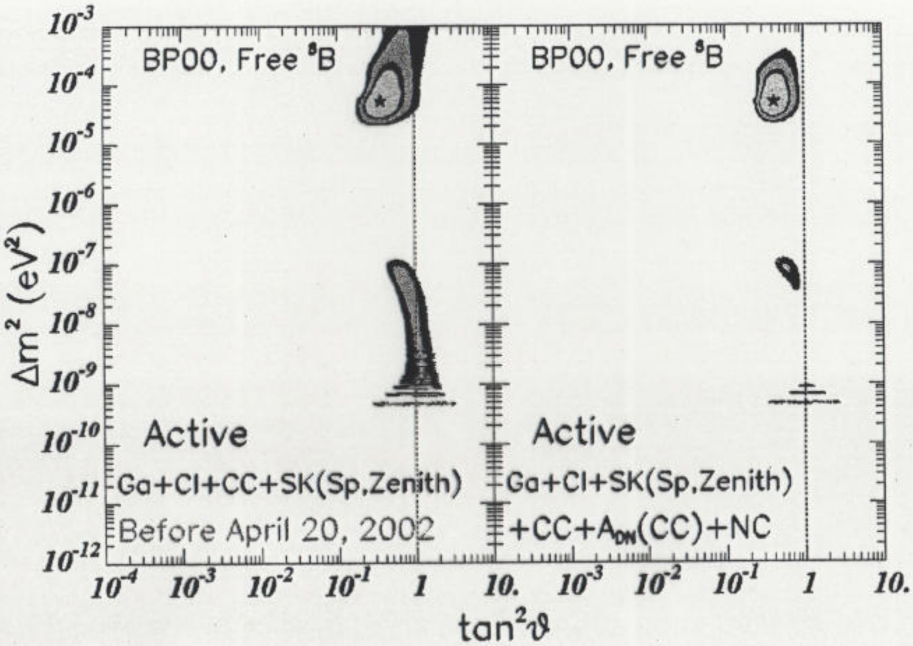
- Contemporary filling of the buffer PC after a stripping (~ 1000 mc)
- Mixing with DMP during the buffer filling (~5 g/l).

Safety

- Strong effort on the safety systems and on the procedures
- 5 fire systems, each of them redondant
- Double containing for all systems handling PC also temporarily → $<10^{-6}$ probability of leakage everywhere.
- All vapors purified through charcoal with final check via analyzer
- Bleeding and waste systems
- Possible heavy earthquake (0.3 g) taken into account in the design

Operation sequence

- Nylon vessels installation: July and August (first half)
- Filling with water: August, September
- Scintillator preparation and purification: since October
- PC filling: start November 2002 – and April-May 2003
- Study of the background during the filling



BP00, Free ^{8}B
BP00, Free ^{8}B
Active
Active
Ga+Cl+CC+SK(Sp,Zenith)
Before April 20, 2002
Ga+Cl+SK(Sp,Zenith)
+CC+A_{DN}(CC)+NC
Δm^2 (eV^2)
$\tan^2\vartheta$
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10. 10^{-3} 10^{-2} 10^{-1} 1 10.

The "Borexino" program

Main interaction:

$\nu_x + e \rightarrow \nu_x + e$

Measurement of the ν from ^7Be

250-800 KeV

- Rates expected (ev/day):

	S.S.M. (B.P.)	MSW-SMA	MSW-LMA ±3 σ	MSW-LOW ±3 σ	VO ±3 σ
With SK total rates	55	$12^{+16}_{-0.5}$	32^{+7}_{-8}	26	38^{+15}_{-10}
Before SNO			36^{+5}_{-4}	32^{+7}_{-3}	32^{+9}_{-4}
After SNO			35^{+5}_{-3}	32±3	32^{+5}_{-4}

Expected background: ~15 ev/day

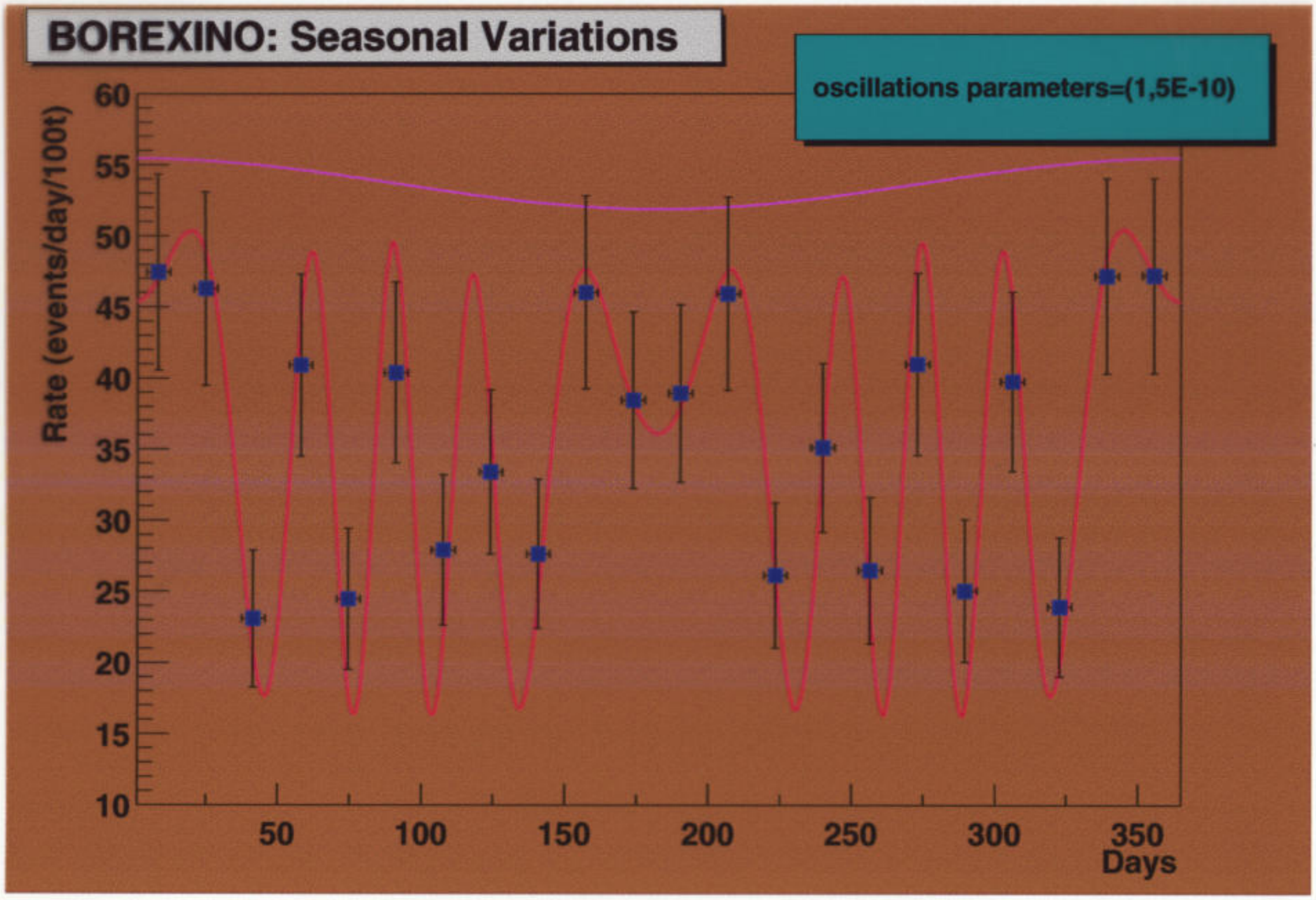
- Day/night (%)

	LMA	LOW
Before SNO	$0.0^{+0.1}_{-0.0}$	15^{+17}_{-15}
After SNO	$0.0^{+0.1}_{-0.0}$	23^{+10}_{-13}

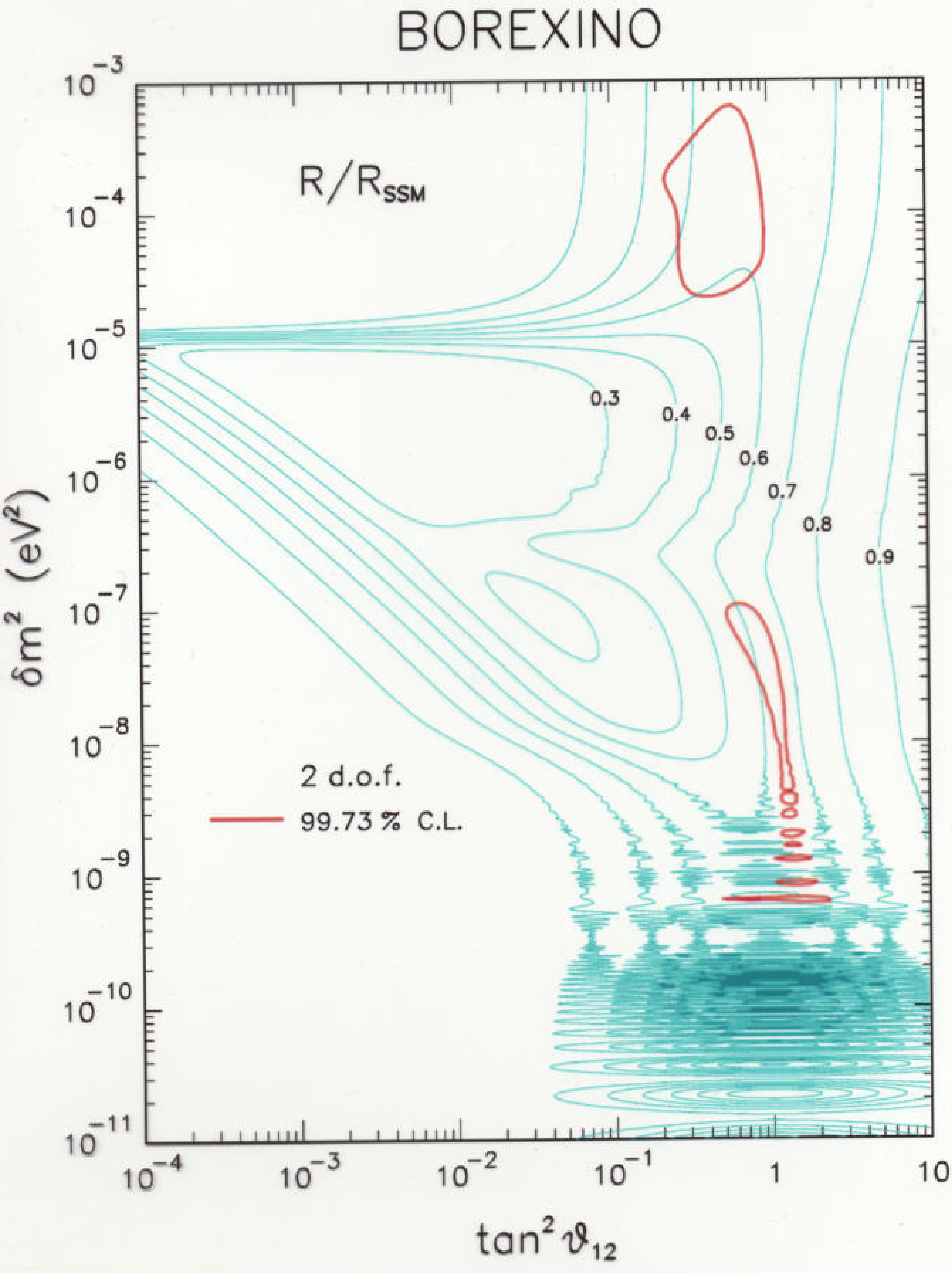
- Seasonal variation (VO)

Measurement of the ν from ^8B:threshold at 3.5 MeV – expected rate: ~60-125 ev/year.

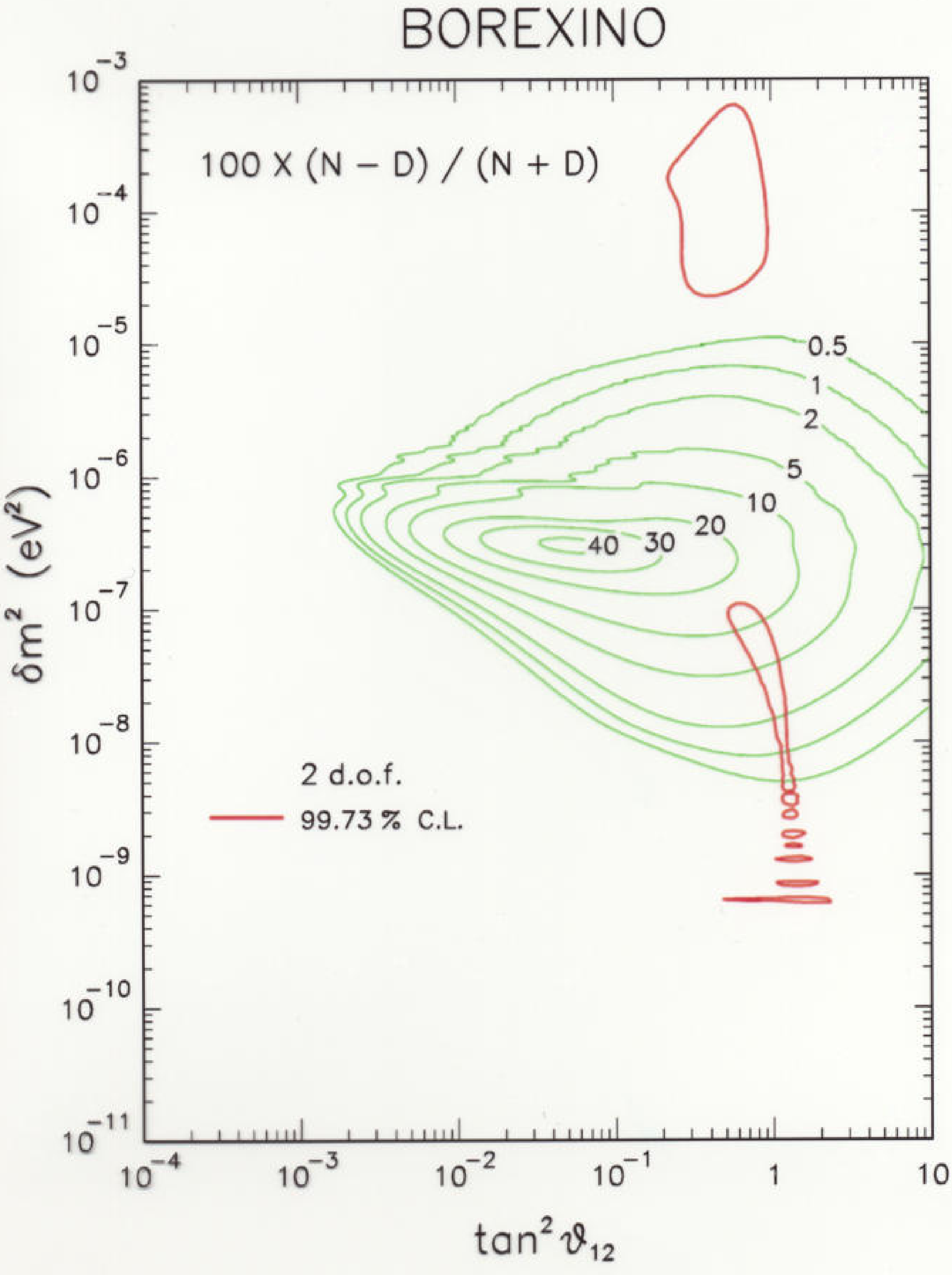
G. Bellini - INFN and Milano University



BOREXINO: Seasonal Variations
oscillations parameters=(1,5E-10)
Rate (events/day/100t)
60
55
50
45
40
35
30
25
20
15
10
50
100
150
200
250
300
350
Days



BOREXINO
R/R_SSM
0.3
0.4
0.5
0.6
0.7
0.8
0.9
2 d.o.f.
99.73 % C.L.
δm² (eV²)
tan² ϑ12
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
10^-4
10^-3
10^-2
10^-1
1
10



BOREXINO
100 X (N − D) / (N + D)
0.5
1
2
5
10
20
30
40
2 d.o.f.
99.73 % C.L.
δm² (eV²)
tan² ϑ₁₂
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
10⁻¹⁰
10⁻¹¹
10⁻⁴
10⁻³
10⁻²
10⁻¹
1
10