



BOREXINO

Laura Perasso
INFN - Milano

for the Borexino Collaboration

Venezia, XII Neutrino Telescope, March 6, 2007



Content:

- I. *Borexino in brief*
- II. *Status of the filling of the detector*
- III. *The first detected CNGS events*

The Borexino Collaboration:

~70 physicists from 14 institutions:

Italy : INFN / Milano, Genova, Laboratori del Gran Sasso,
Perugia e Ferrara

France: APC/ College de France

Germany: Max-Planck-Institut fuer Kernphysik / Heidelberg
Technische Universitaet / München

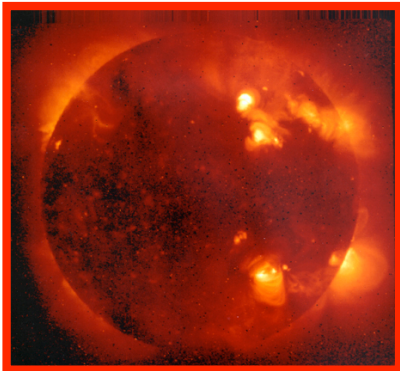
Poland: Jagellonian University / Krakow

Russia: J.I.N.R. / Dubna
Kurchatov Institute / Moscow

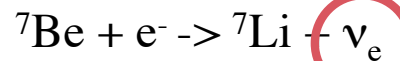
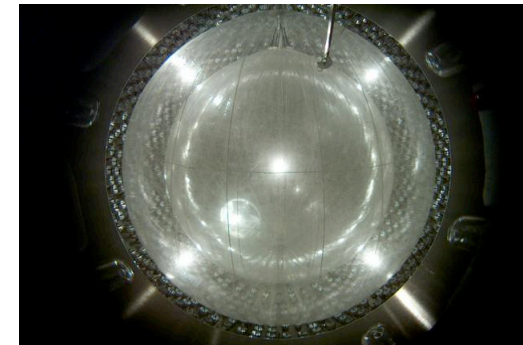
USA: Princeton University (Phys. and Chemical Eng. Dept.)
Virginia Polytechnical Institute

The Borexino physics:

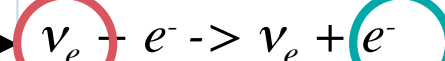
*To measure, for the first time in real-time,
the solar ${}^7\text{Be}$ ν_e flux
day/night, seasonal ($1/r^2 \sim \pm 3.5\%$), periodic variations
comparison with the theoretical predictions (model LMA-MSW)*



$$E_{thr} = 250 \text{ keV}$$



0.861 MeV (90%)
0.383 MeV (10%)



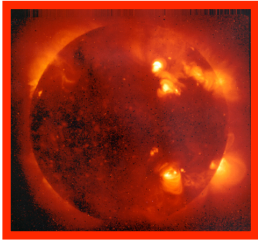
$E_{e,max} = 0.664 \text{ MeV}$
(Compton edge)

$\sim 7\%$ of the solar ν flux

$\exp \Delta\phi_{7\text{Be}}/\phi_{7\text{Be}} \sim 40\%$ (SSM gives it at 5%)

note: the ${}^8\text{B}$ ν are only 10^{-4} of the total solar ν flux !!

Other possible measurements:



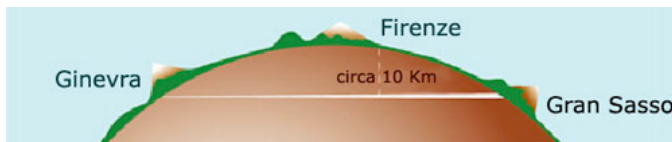
- solar 1.4 MeV *pep* [0.8 - 1.3 MeV] \rightarrow 2% stat. in 5 years
- CNO ν



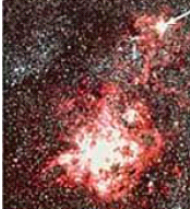
- $\bar{\nu}_e$ from the Earth (*geoneutrinos*) ($\sim 10 \div 60$ ev/year)



- ν and $\bar{\nu}$ from *supernovae* (~ 100 ev in 10 sec, at 10kpc)

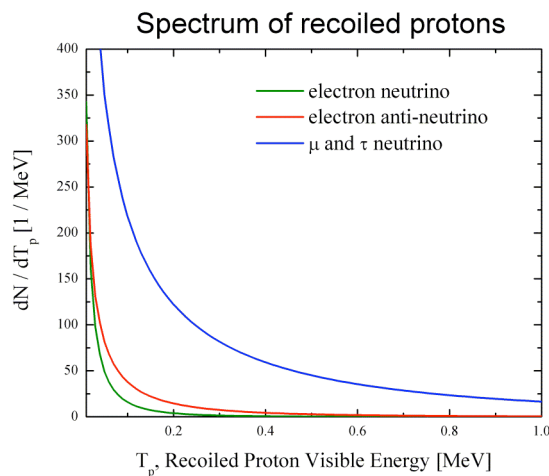
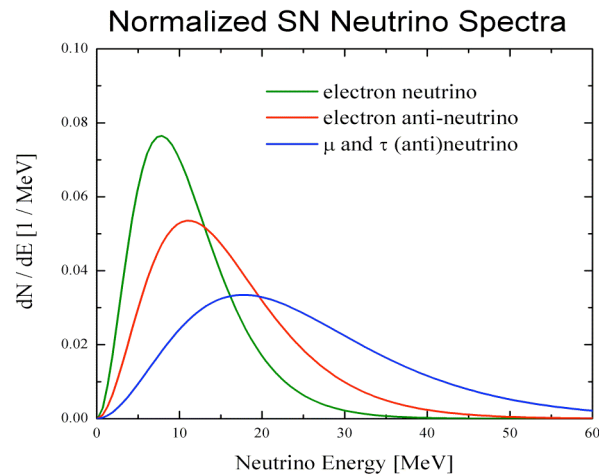


- the CNGS ν_μ flux via the ν induced muons detection



Signal from a Galactic Supernova

1. Standard SN @ 10kpc
2. 0.3kt target mass



The case of Borexino [$E_{\text{threshold}} = 250 \text{ keV}$]

Detection channel	Normal hierarchy ($\theta_{13} > 1^\circ$)	Inverted hierarchy ($\theta_{13} > 1^\circ$)
ES ($E_\nu > 0.25 \text{ MeV}$)	5	5
Electron anti-neutrinos ($E_\nu > 1.8 \text{ MeV}$)	79	100
ν-p ES ($E_\nu > 0.25 \text{ MeV}$)	55	55
$^{12}\text{C}(\nu, \nu)^{12}\text{C}^*$ ($E_\gamma = 15.1 \text{ MeV}$)	17	17
$^{12}\text{C}(\text{anti-}\nu, e)^{12}\text{B}$ ($E_{\text{anti-}\nu} > 14.3 \text{ MeV}$)	3	6
$^{12}\text{C}(\nu, e)^{12}\text{N}$ ($E_\nu > 17.3 \text{ MeV}$)	9	6

The Borexino detector

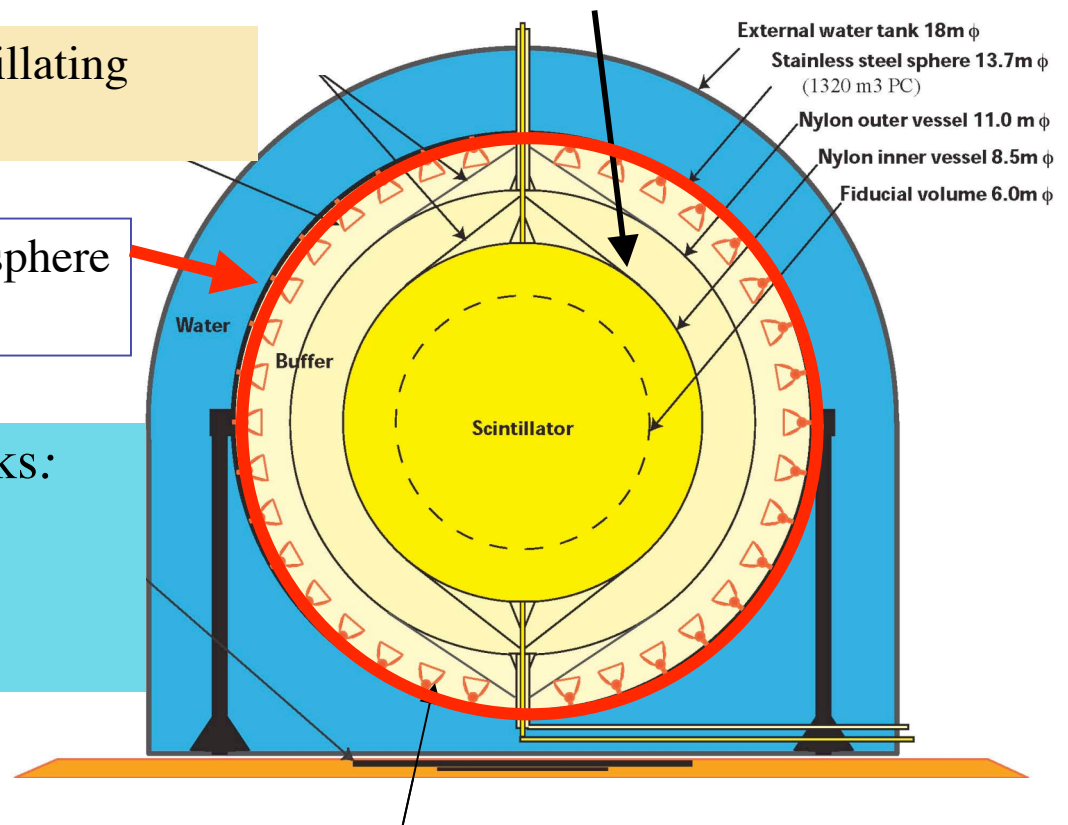
The Detector = 300 t (100 fid) of liquid scintillator : PC+PPO (1.5 g/l)

Suspended inside a nylon sphere $\varnothing=8.5\text{m}$

The buffer zone = 1040 t of non scintillating liquid: PC + DMP

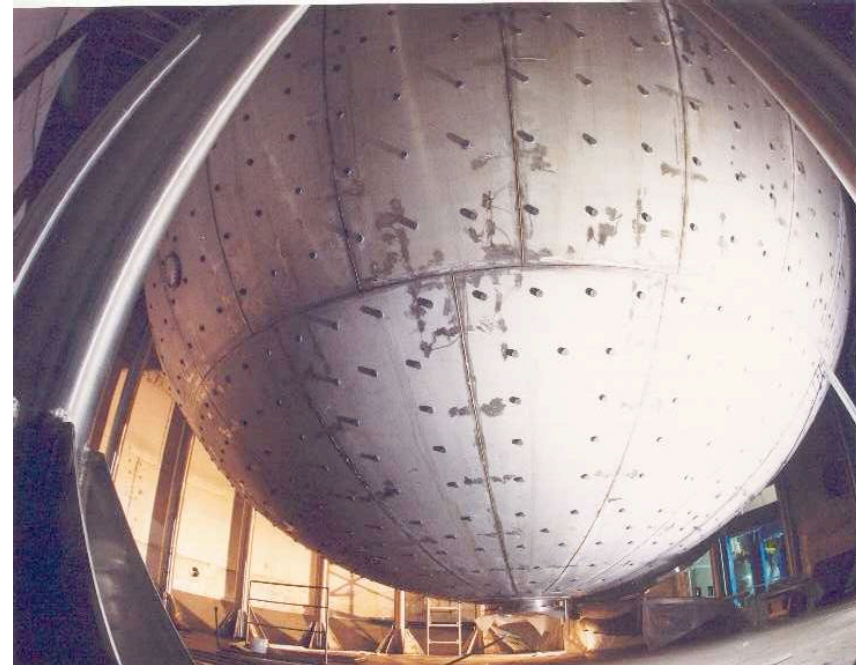
All inside a SS sphere $\varnothing=13.7\text{m}$

The shielding of the γ from the rocks:
2m of ultrapure water
In a SS Water Tank
 $\varnothing= 18\text{m}$



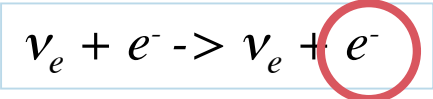


Water Tank (1999)



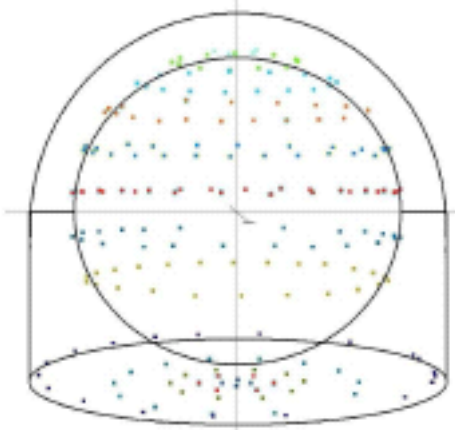
The outside of the SSS (2000) ...

The Borexino detector

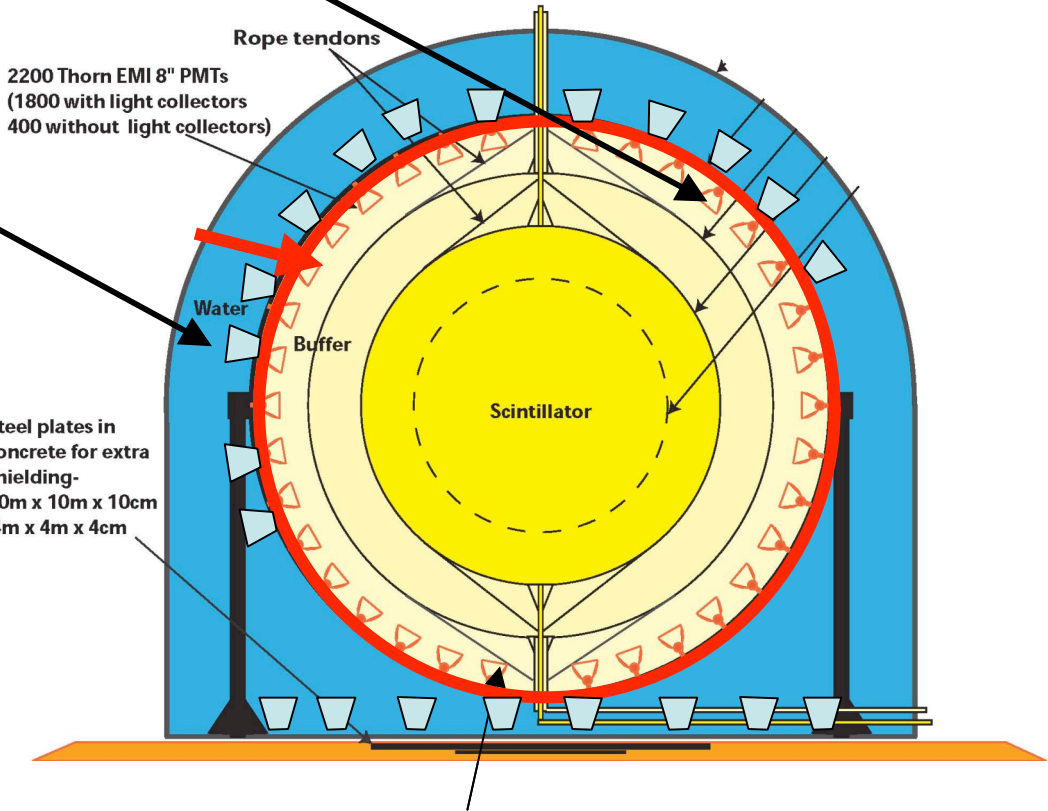


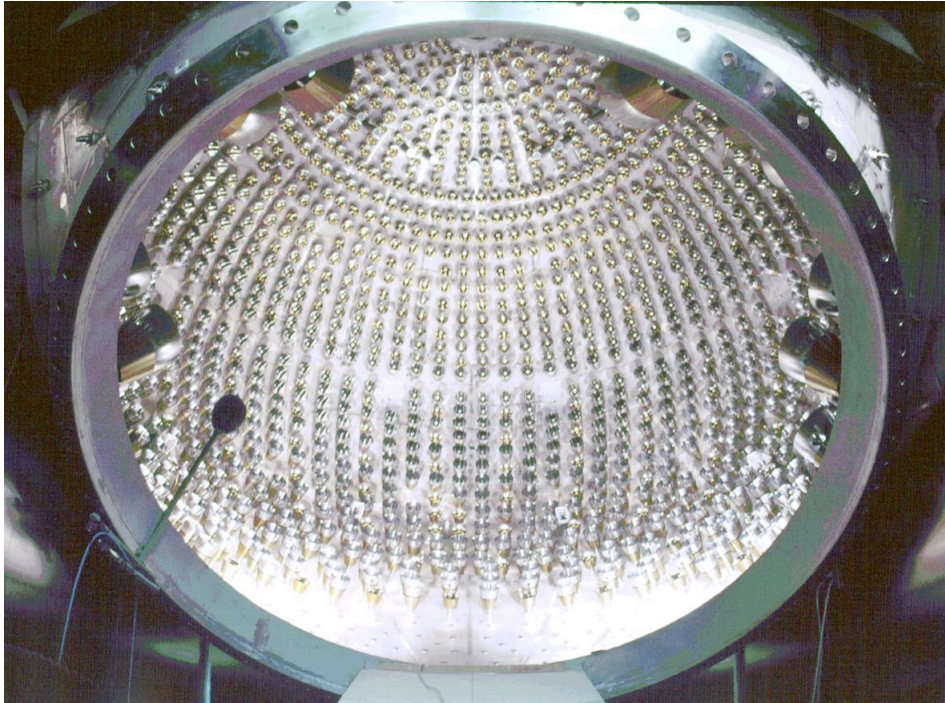
The recoiling e^- signal is seen by 2240 PMTs

Outer Muon system = 208 PMT's



Calibration systems
(lasers, pulsers, ..)





.. its inside with part of the 2240 PMT
(2001) ...

... and with the
nylon vessels
during their
inflation (2004) ...



The Outer Muon System PMTs



Water buffer



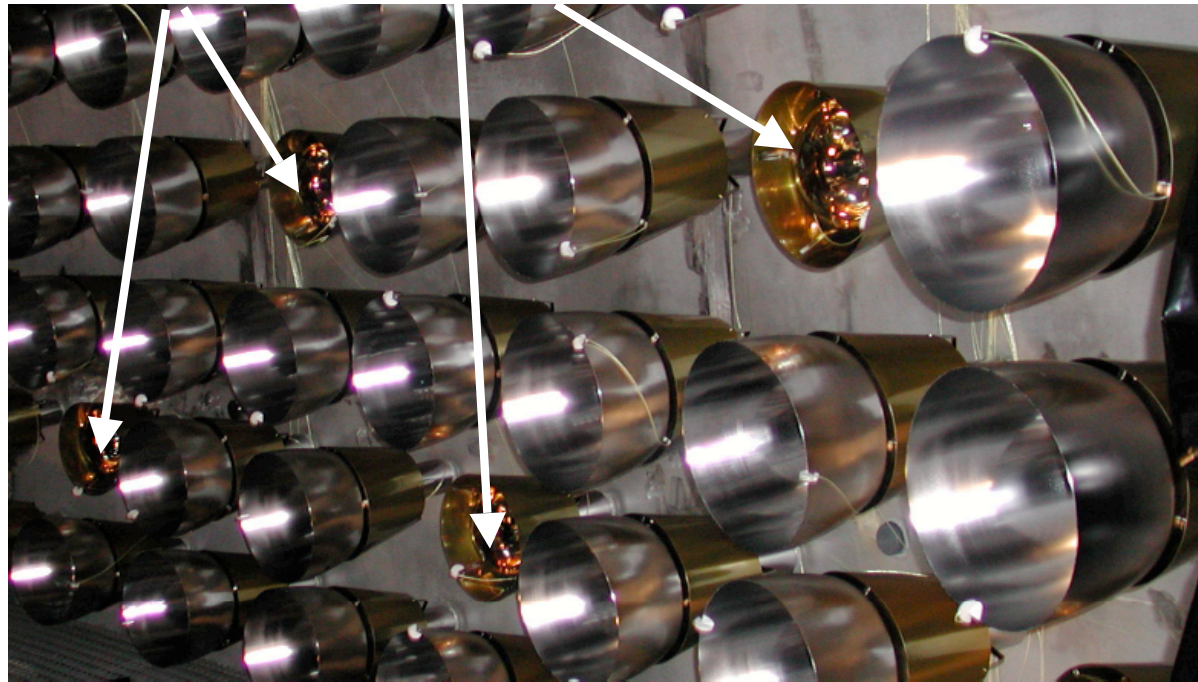
SS Surface is covered by Tyvek

The Inner Muon System:

374 (out of the 2212 total) 8" ETL-9351 PMs ***do not have*** the Al light concentrators ($\varnothing=20\text{cm}$)

=> their acceptance angle is wider than the other ones optimized to view the Inner Vessel.

These 374 ***no-cone PMs*** will more likely detect particle not crossing the IV



Main Borexino challenge:
!!! Radiopurity !!! Suppress radio background (U,Th,K) !!!

15 years of R&D on :
new purification techniques and detection methods
⇒ proved by the CTF successful results

Needed extreme care in the material-selection

Nylon vessel: U & Th chains $\sim 10^{-12}$ g/g

and in the construction methods

⇒ special purification plants

Purification plants

for PC : Water extraction, Distillation, Nitrogen stripping,
Silicagel column

Scintillator (*PC+PPO*): *U & Th* chains: $\sim 10^{-16}$ g/g

$^{14}\text{C}/^{12}\text{C} \sim 10^{-18}$

$^{40}\text{K} \sim 10^{-14}$ g/g

Buffer liquid (*PC+DMP*): *U & Th* chains: $\sim 10^{-14}$ g/g

for the Water buffer: $U \& Th$ chains: $\sim 10^{-14}$ g/g

Purification plants

for Nitrogen :

regular nitrogen (^{222}Rn 0.1-0.2 mBq/m³ -STP)

HPN (^{222}Rn < 1μBq/m³)

LAKN used to sparge scint.

≤ 0.14 ppt of Kr in N₂

(0.2 μBq ⁸⁵Kr/m³ N₂)

≤0.36 ppm of Ar in N₂ (0.5 μBq ³⁹Ar/m³ N₂)

Synthetic air line: HPN + O₂

^{222}Rn 0.1-0.2 mBq/m³

Ancillary plants :

- 1 PPO plant
- 1 DMP plant
- 4 PC storage vessels ($\sim 113\text{m}^3$)
- interconnection systems / pumps / filling stations (for water/PC)
- 4 ISOTANKS + loading (at Sarroch)/ unloading (at LNGS) stations
- exhaust systems (to reduce the PC content in the nitrogen)
- emergency systems

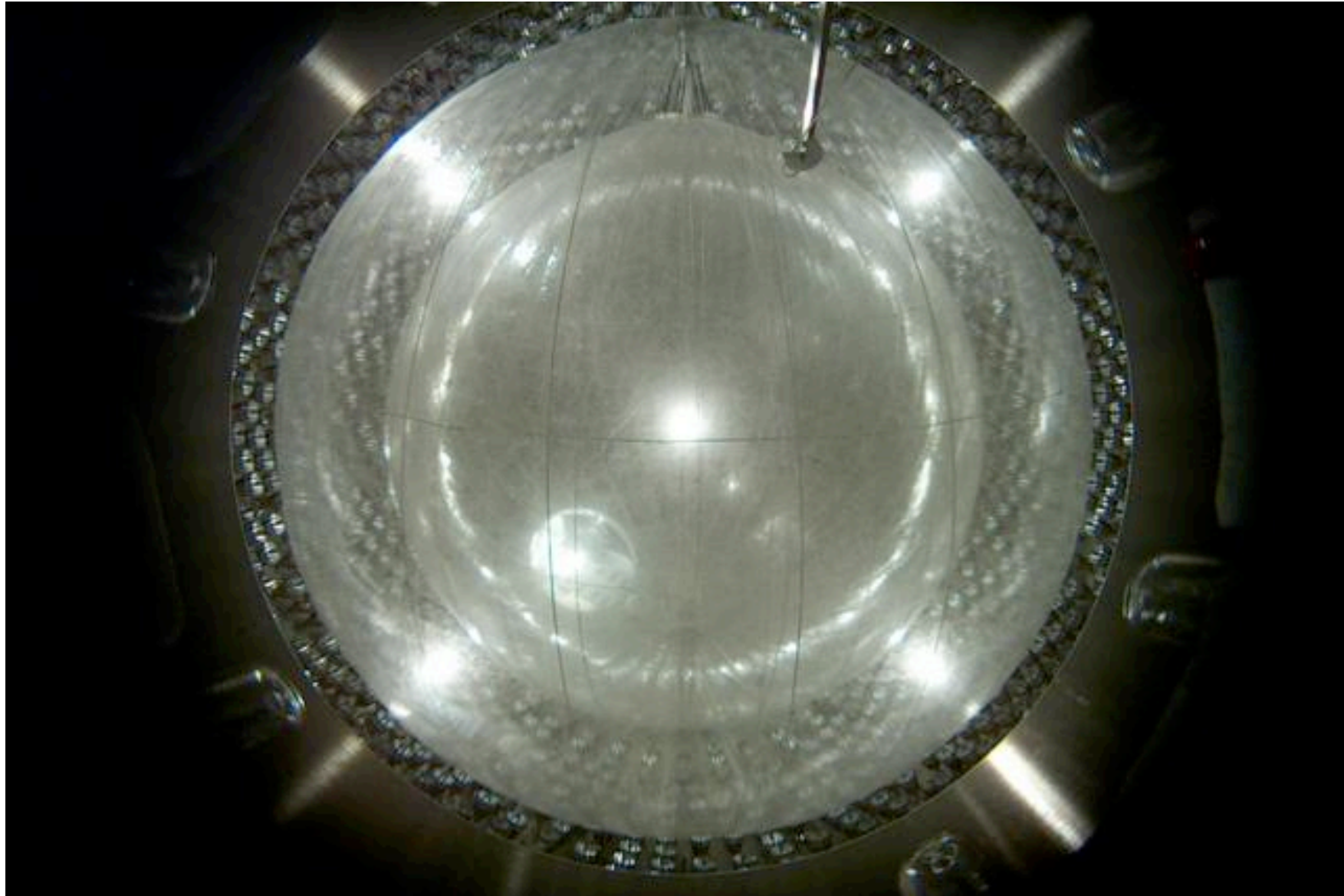
!! 4 Clean rooms !! (one stays for access to the det)

The Detector Status

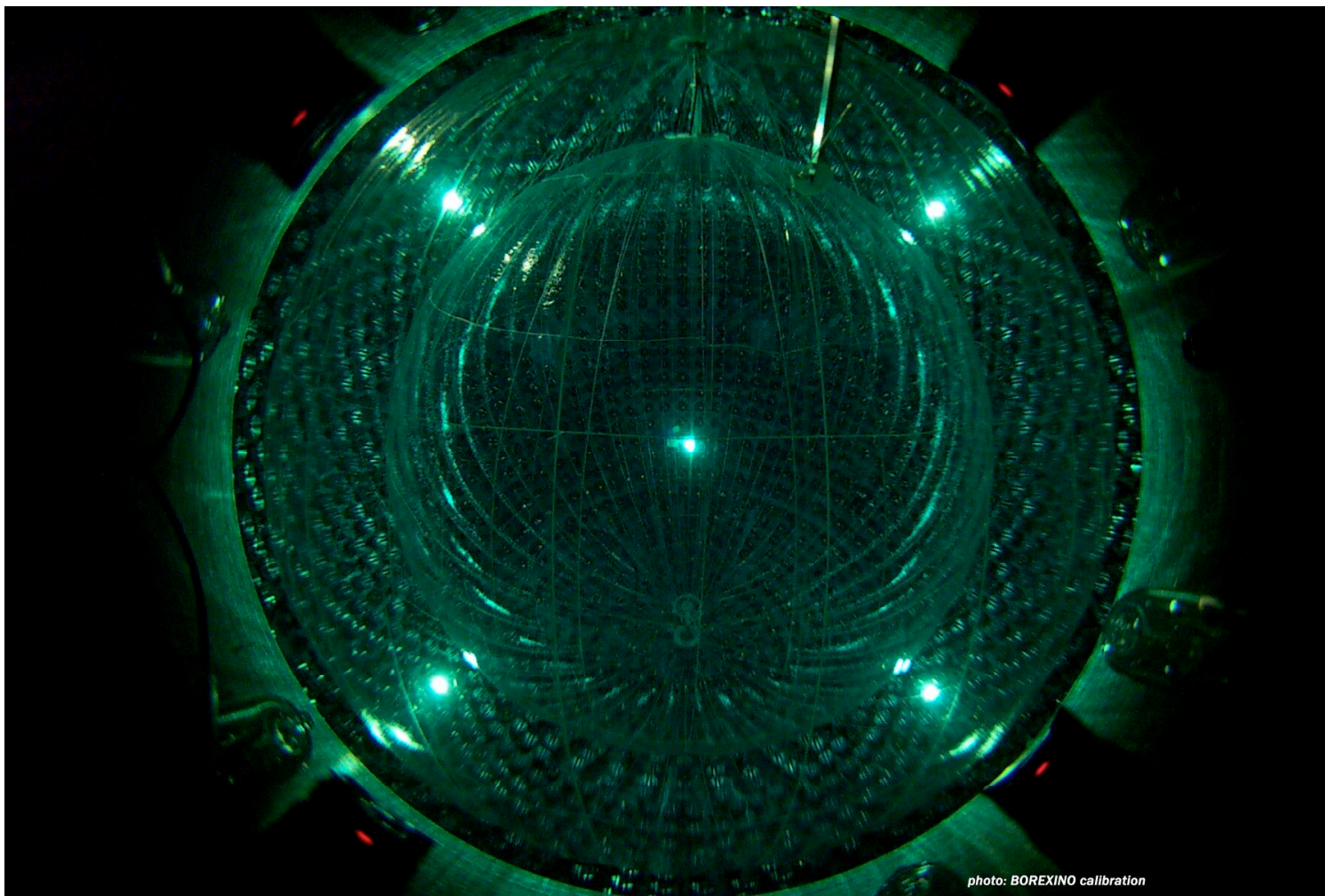
After a stop of 2 years:

- on August 1, 2006: we could start the SSS filling with HPwater
- Nov.10 : SSS filled with HPwater
- Dec. 20: first 11m³ of PC+PPO (water extracted, LAKN sparged and distilled) inside the Inner Vessel !!
- Jan 9, 2007: WT filling has begun

May 7, 2004: the nylon Vessels are full inflated

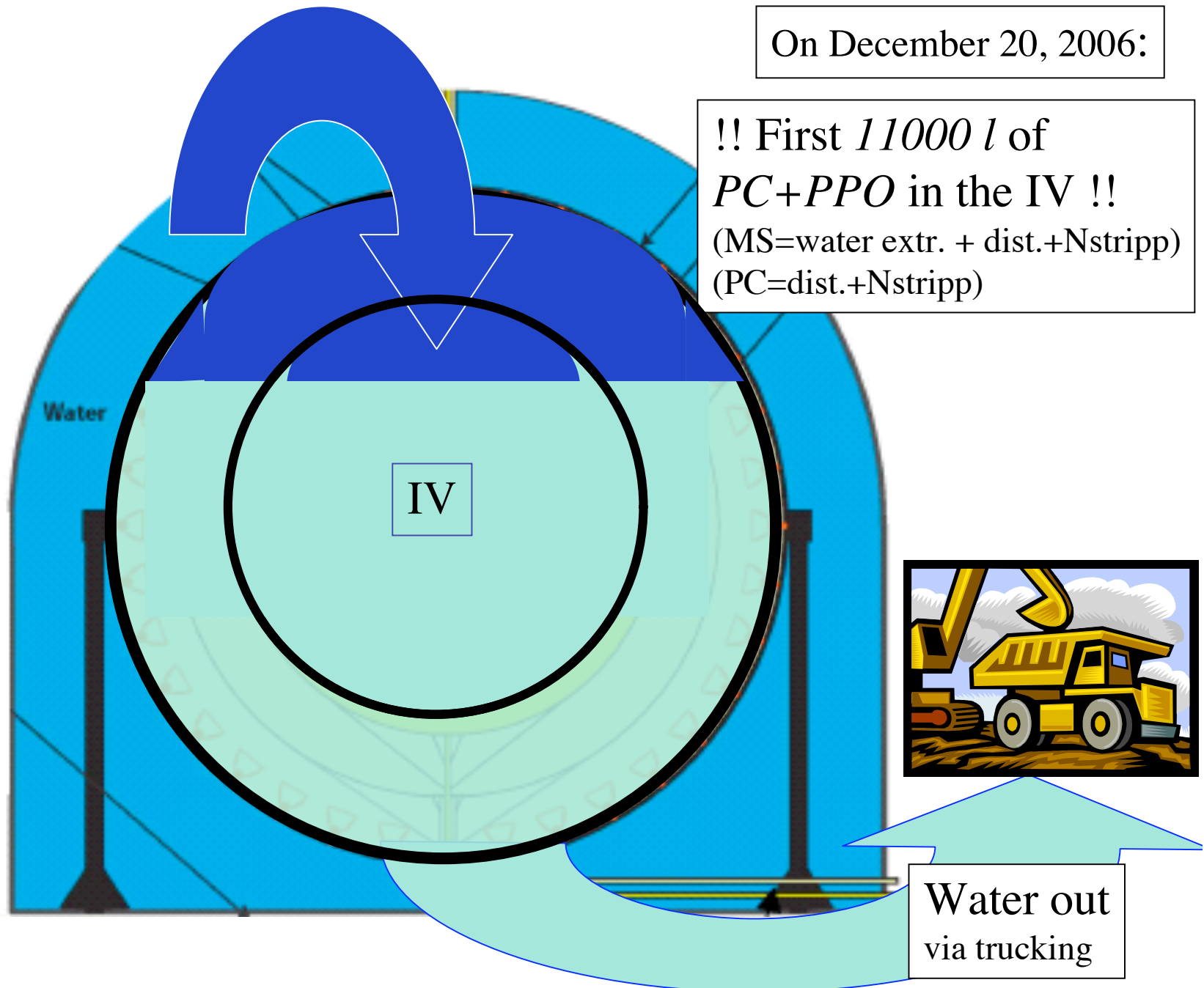


November 10, 2006: the SSS is FULL of HPwater



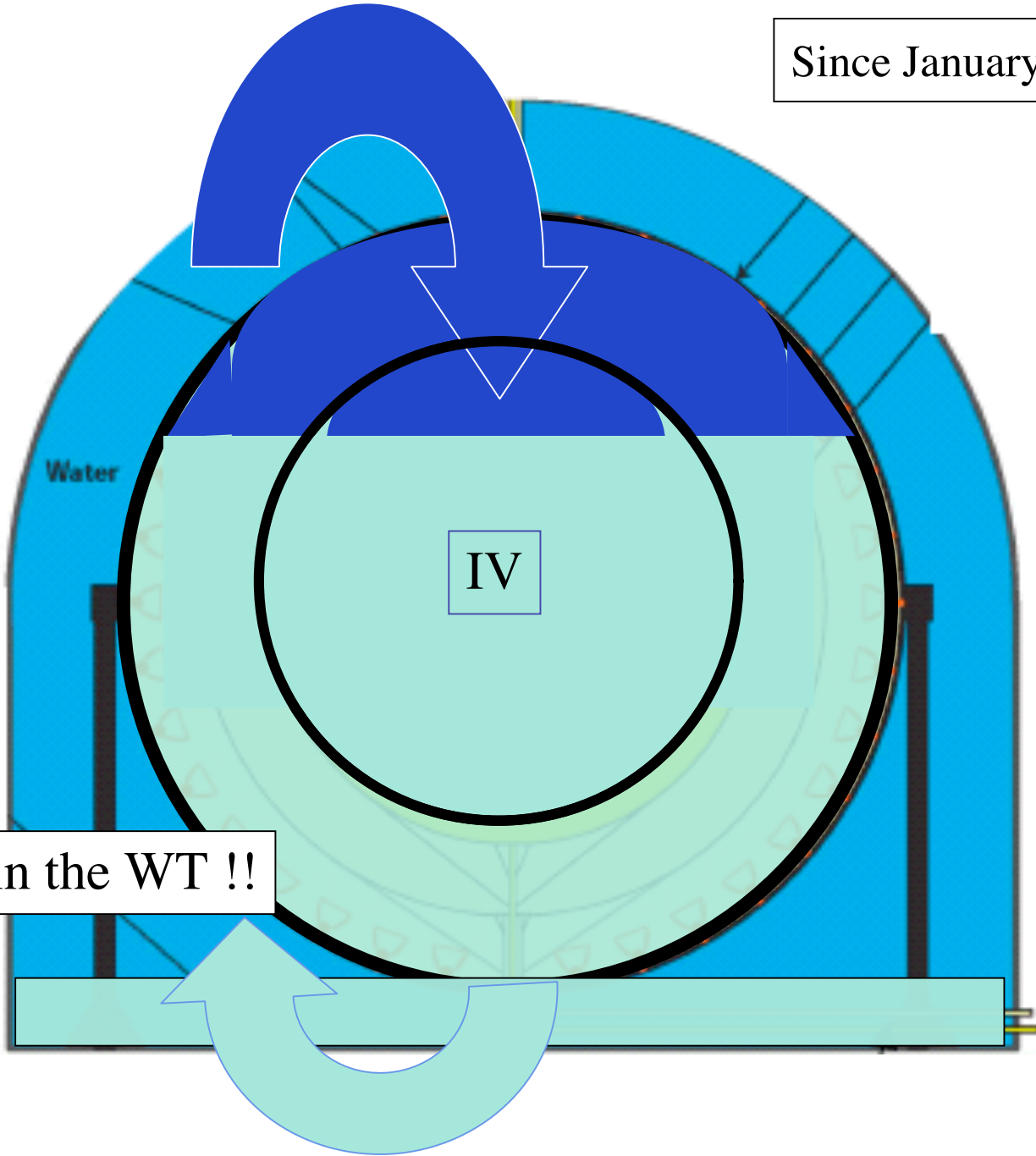
On December 20, 2006:

!! First *11000 l* of
PC+PPO in the IV !!
(MS=water extr. + dist.+Nstripp)
(PC=dist.+Nstripp)



Since January 9, 2007:

Water in the WT !!



since January 8, 2007:

--> fresh- PC trucking from Sarroch (Sardinia) to LNGS has begun

4 isotanks
24 m³ each
4 (3,5) trips/week

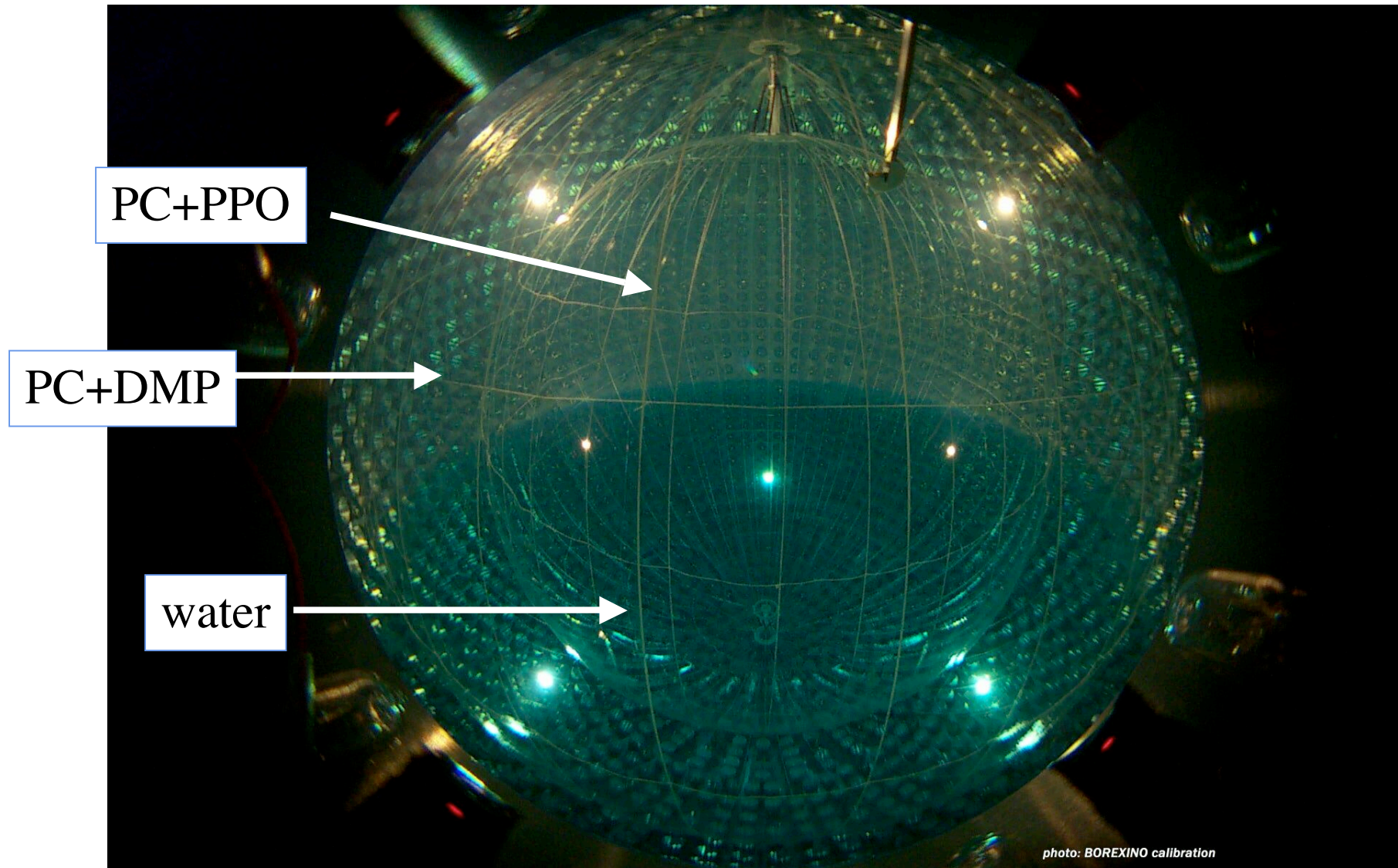


The “loading platform” at Sarroch:



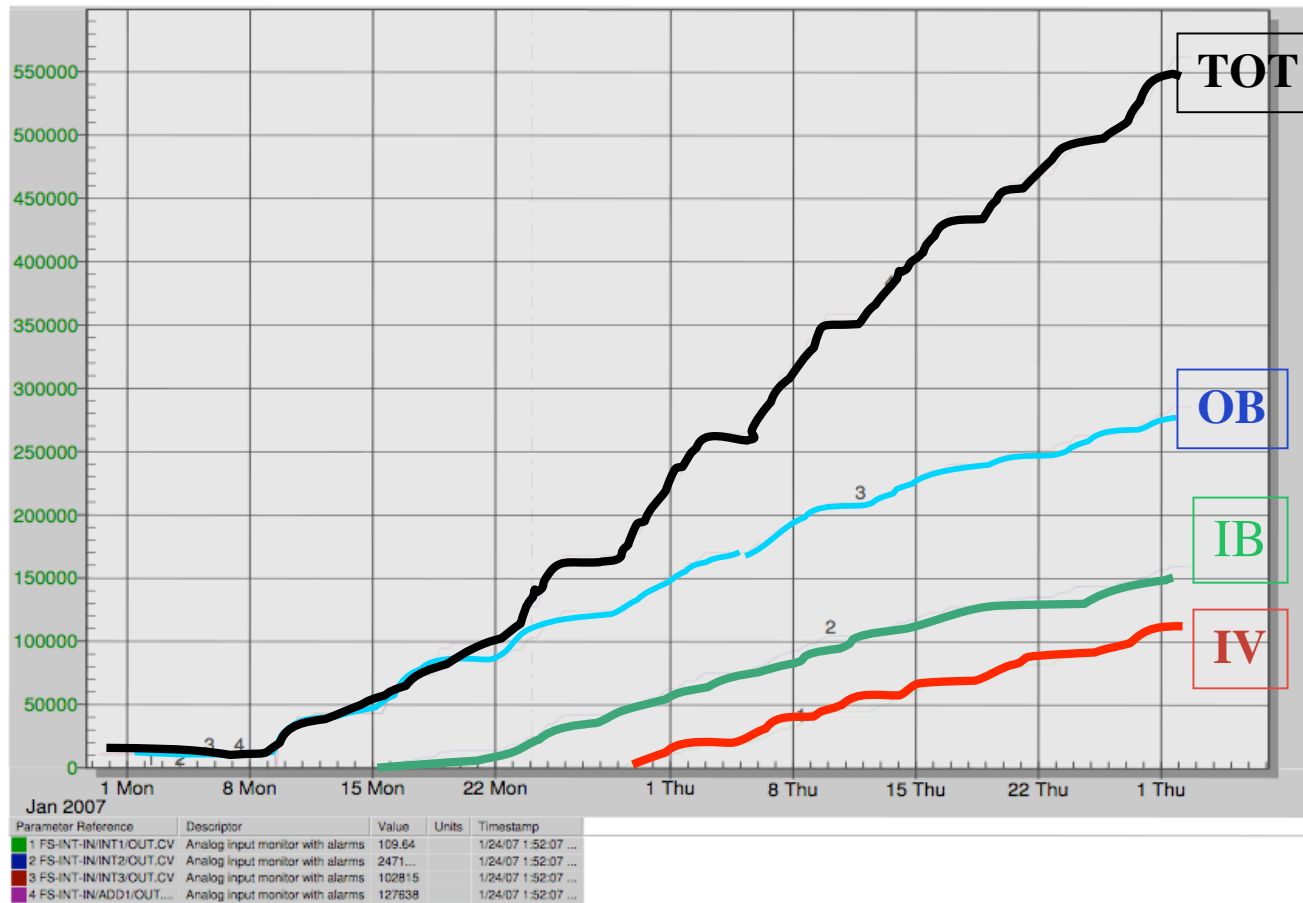
Top of the ISOTANK

March 2, 2007 10:12: inside of the SSS



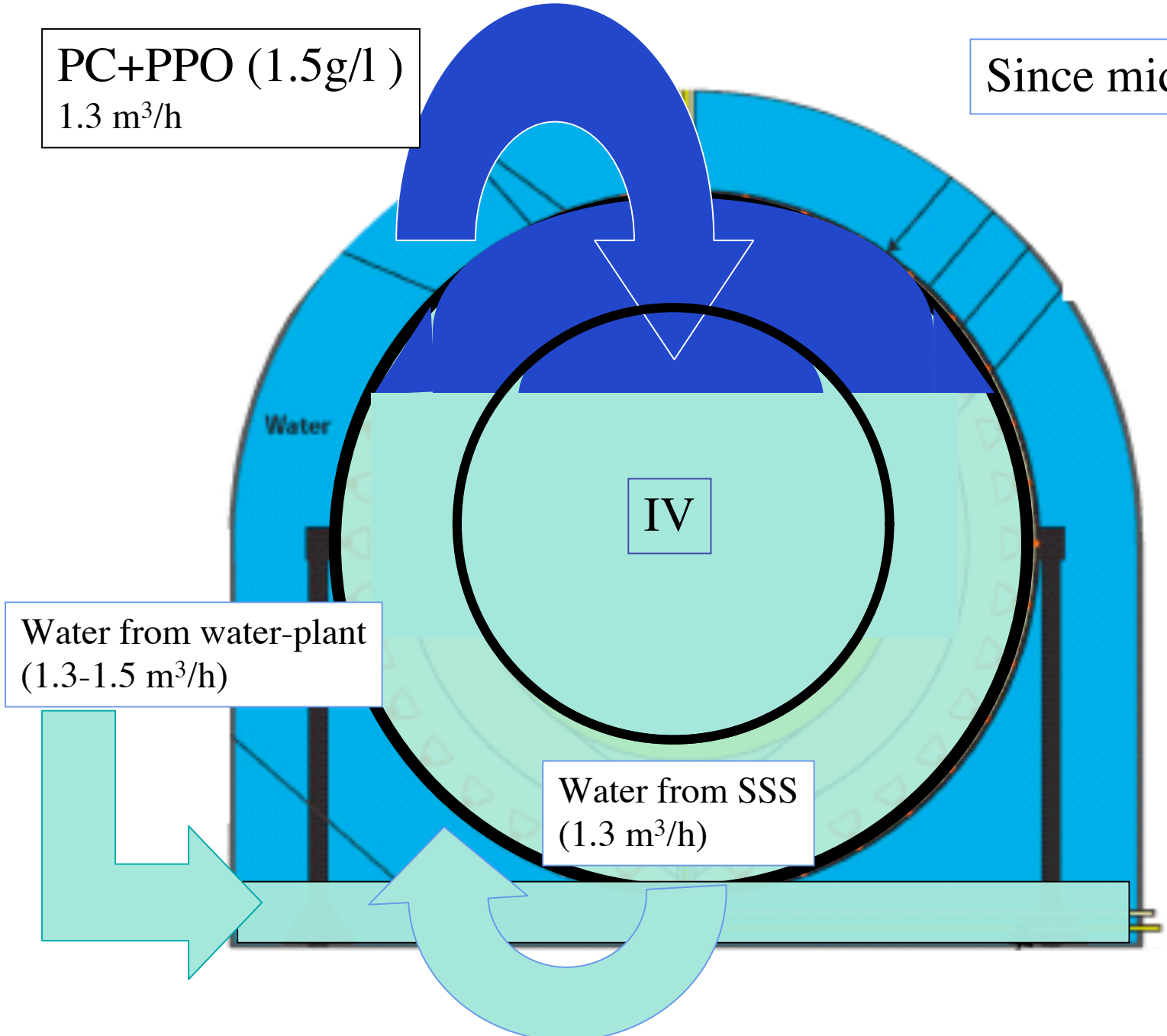
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PC level in IV + IB + OB as on March 2, 2007



PC+PPO (1.5g/l)
1.3 m³/h

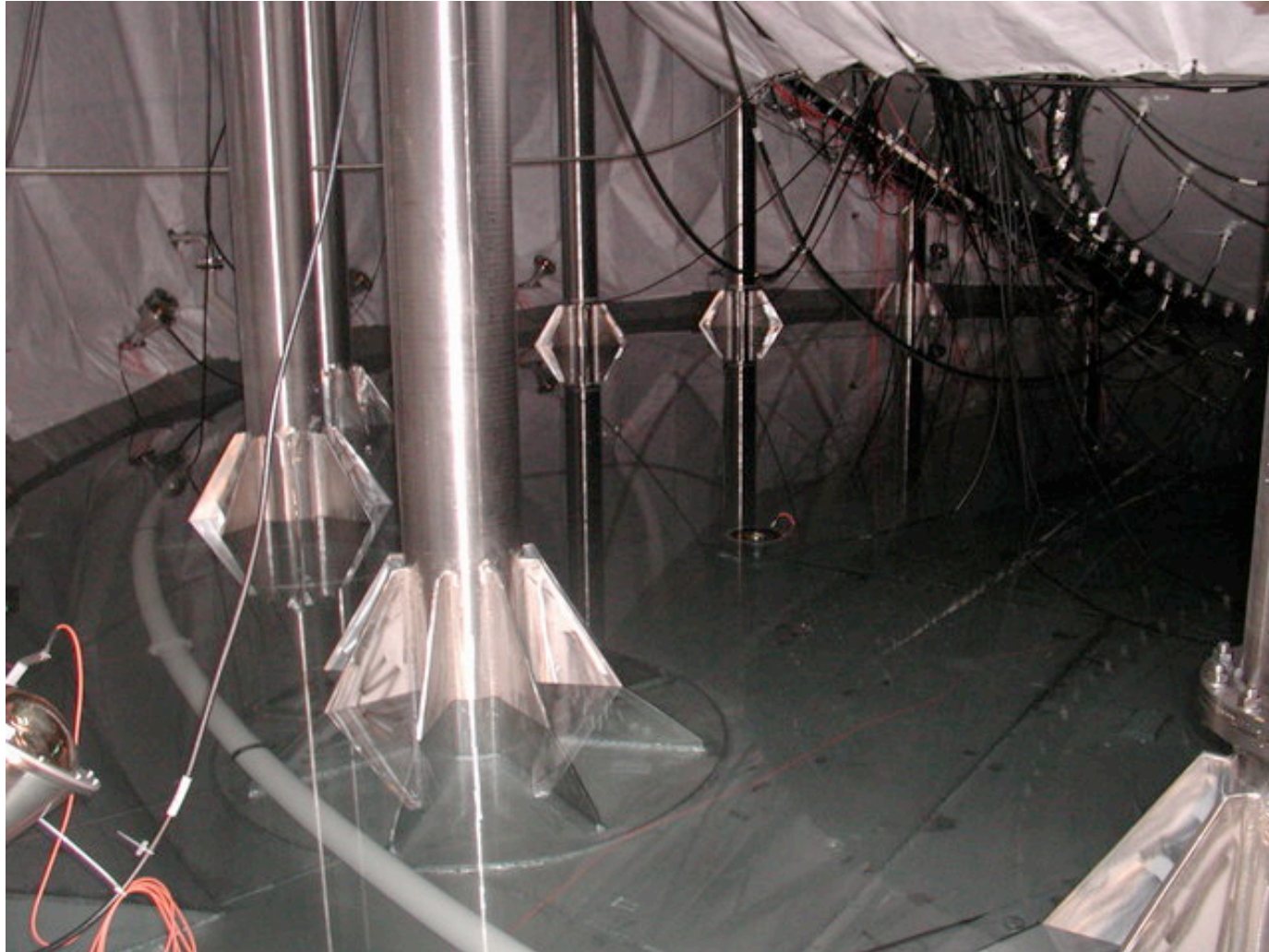
Since mid february



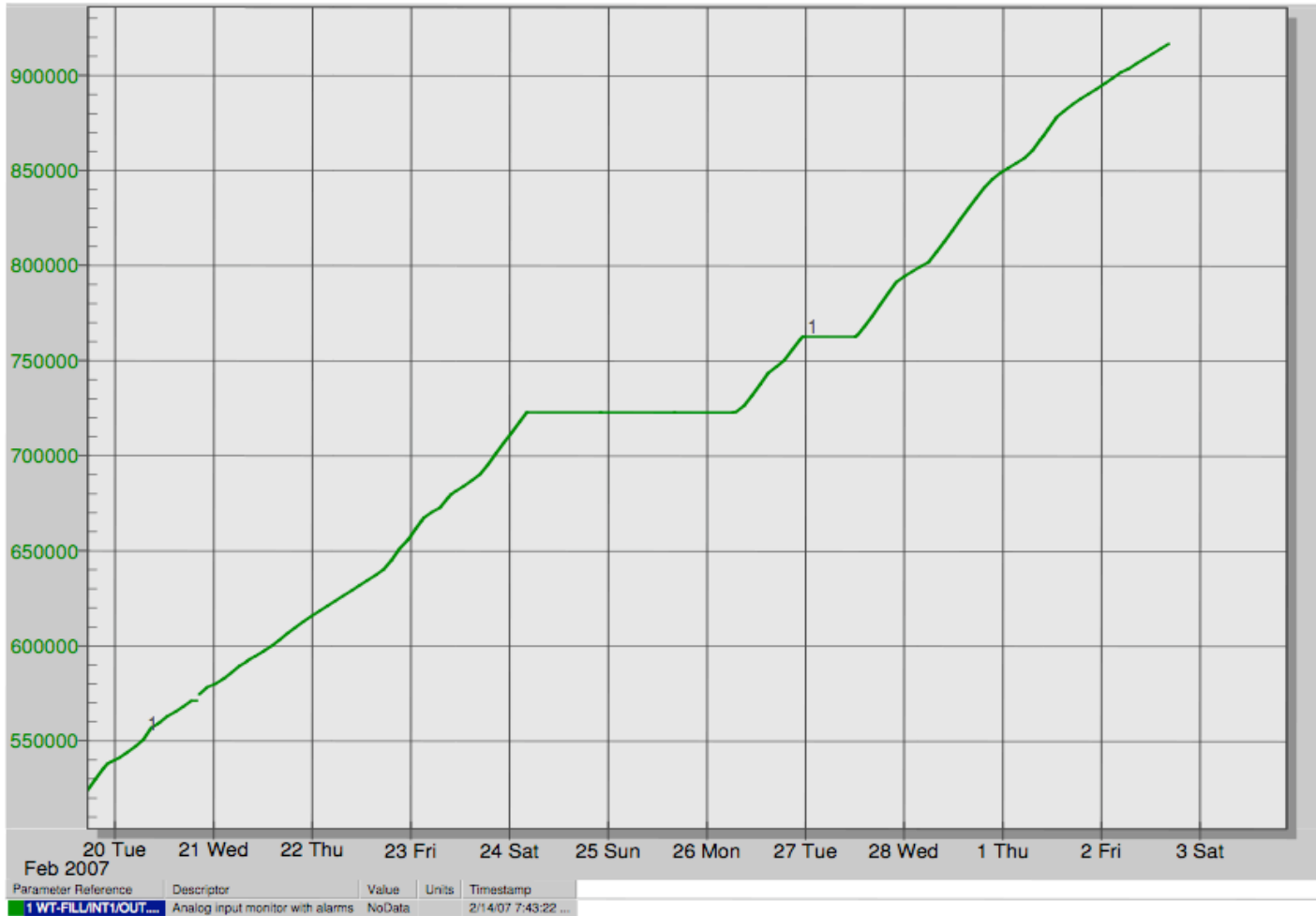
Water from water-plant
(1.3-1.5 m³/h)

Water from SSS
(1.3 m³/h)

The first Water in the Water Tank



Water volume in the WT as on March 2, 2007



On March 2nd 2007, there were :

561.7 m³ PC in SSS (1346 m³) => 42%

908.1 m³ water in WT (2142.41 m³) => 43%
-> h = 4.60 m (~ 28%)

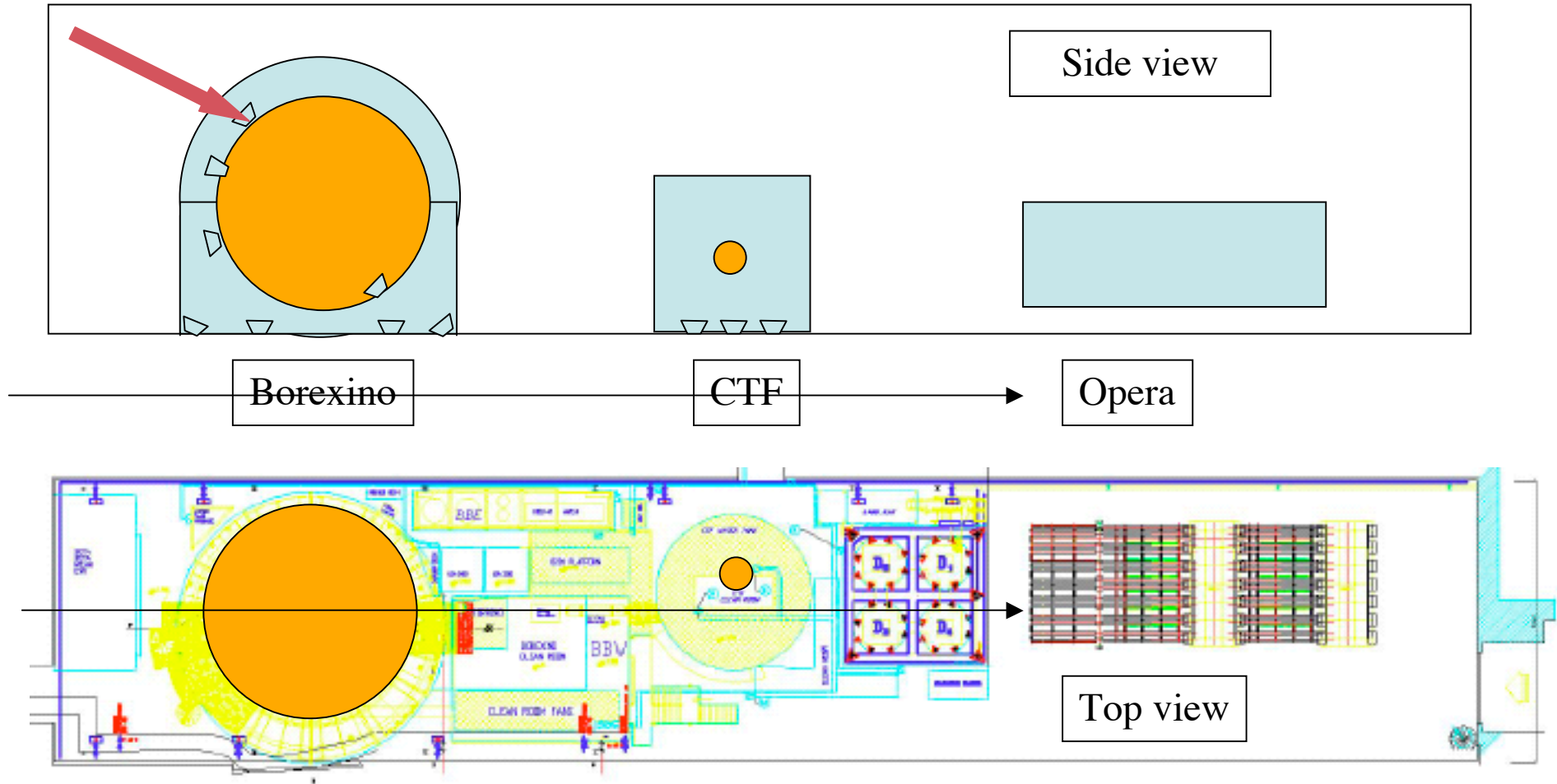
We plan to complete the Detector filling
~ by may 2007

The CNGS induced events detected in Borexino

Borexino:

- ***has two independent muon systems***
 - ***is huge (≈ 3.3 kt)***
- ***sits on the CNGS beam (it is just in front of OPERA) !!!***

Hall_C at LNGS:



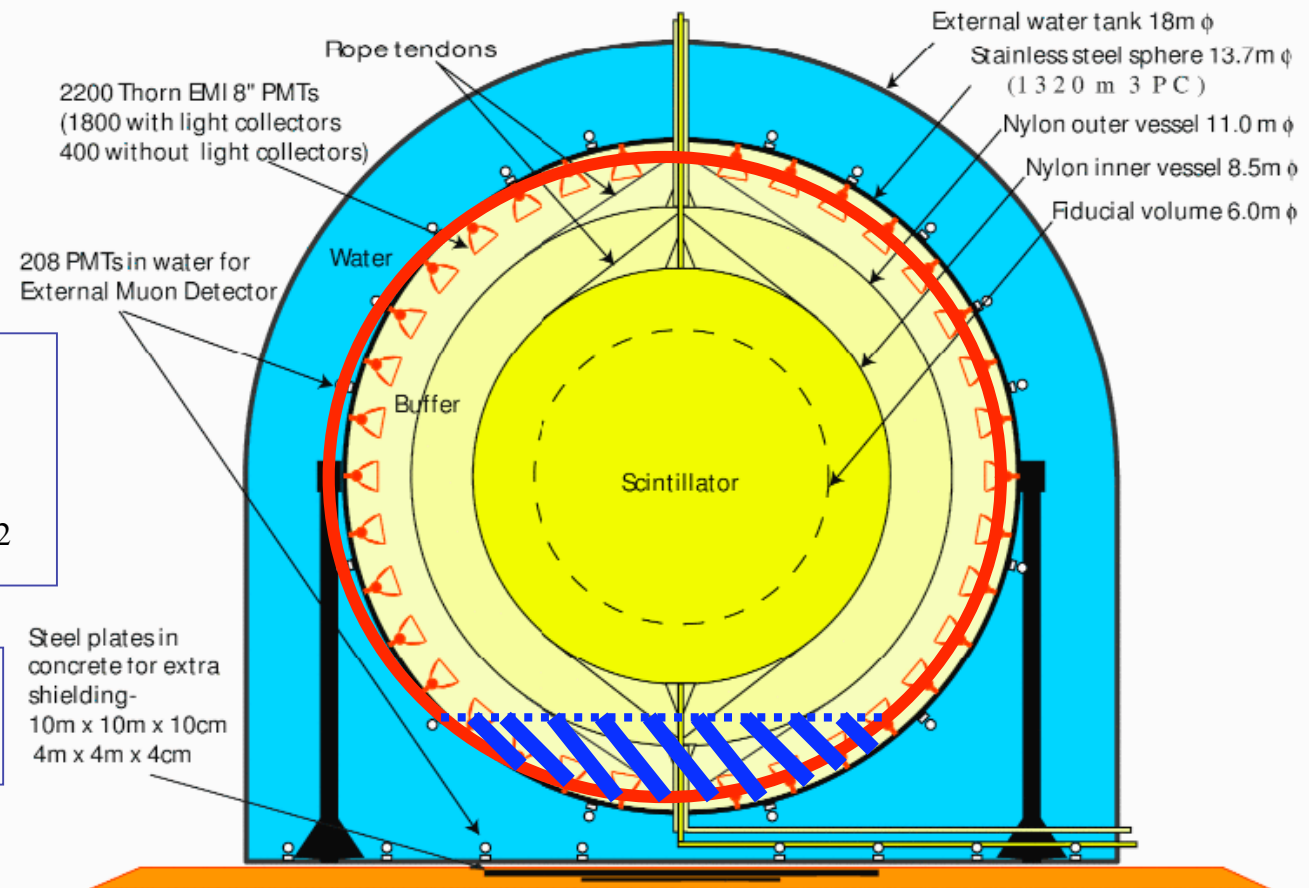
Expected rate values in Borexino (preliminary!!):

In Borexino :

muons generated		Det eff.	Final rate[ev/day]
inside the det. (CC+NC)	48	~98%*	47
in the rocks	271	~99%	268
Total rate	319		315 [ev/day]
Cosmic muon rate bk in the CNGS gate			2 ev/day

Borexino during the August runs:

Borexino Experiment



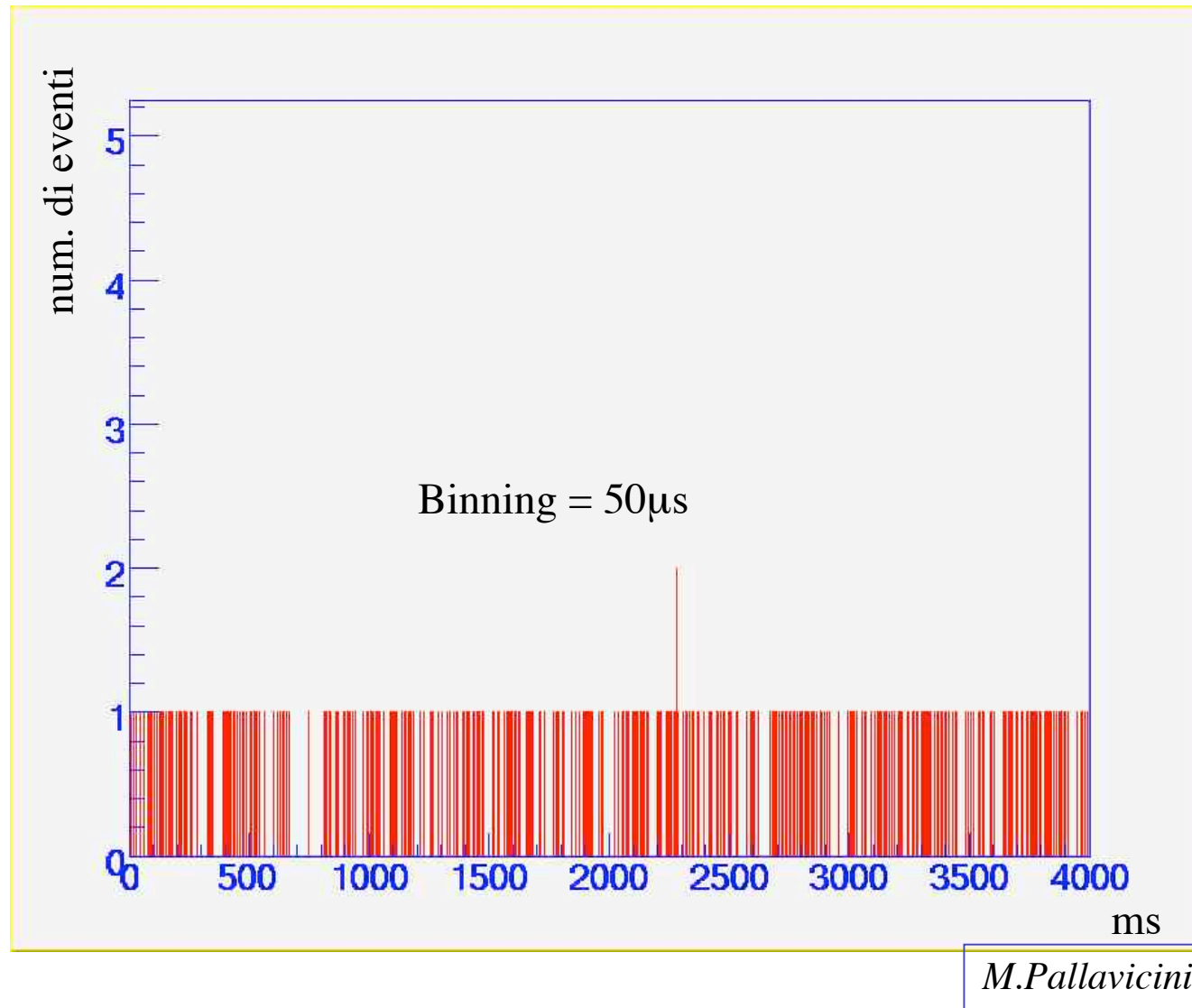
55 t of water
h~ 1.8 m

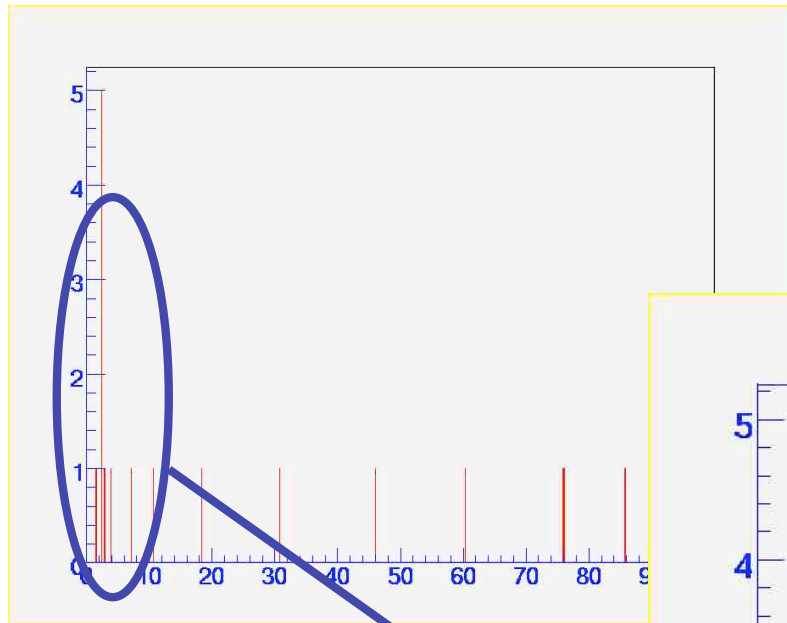
Surface \perp beam~ 10.5 m²

For 30 h of data taking:
Expected 5 CNGS μ

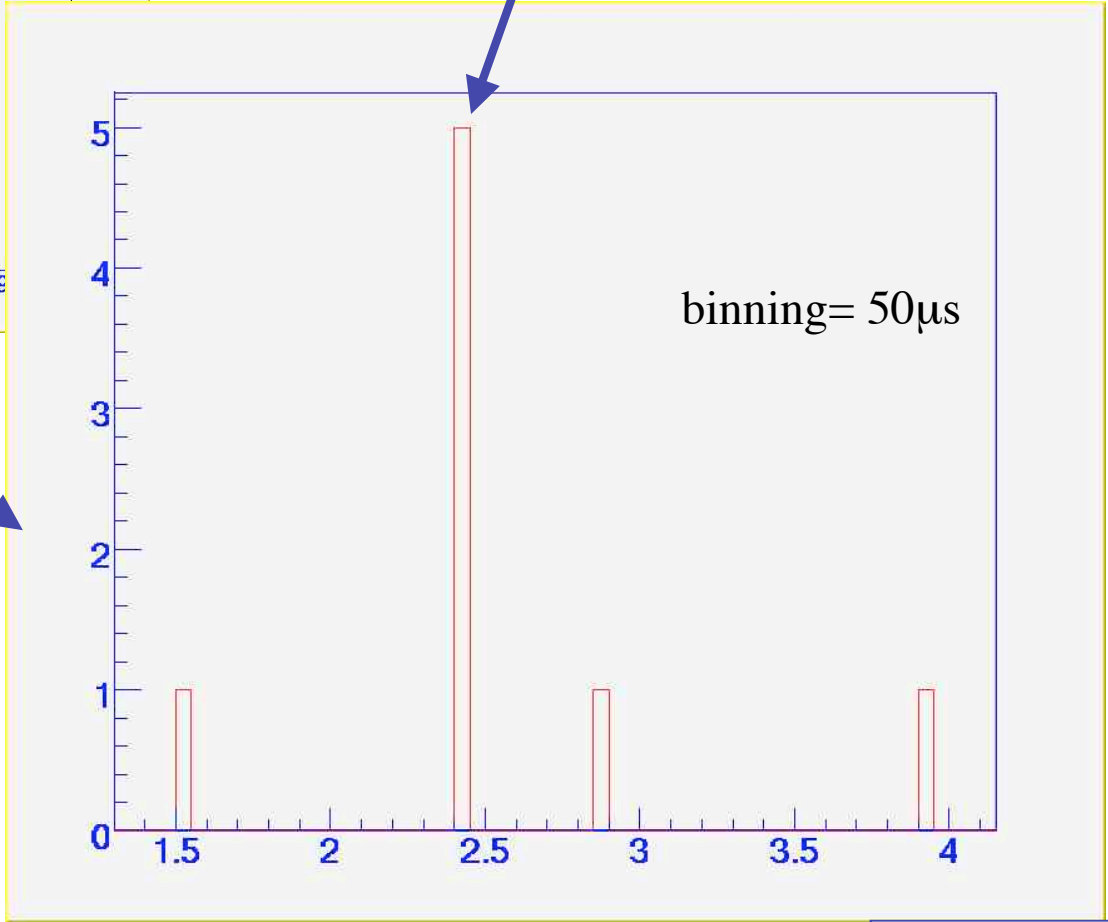
Steel plates in
concrete for extra
shielding-
10m x 10m x 10cm
4m x 4m x 4cm

August 2006 time difference between the BX trigger time and the preceding GPS signal



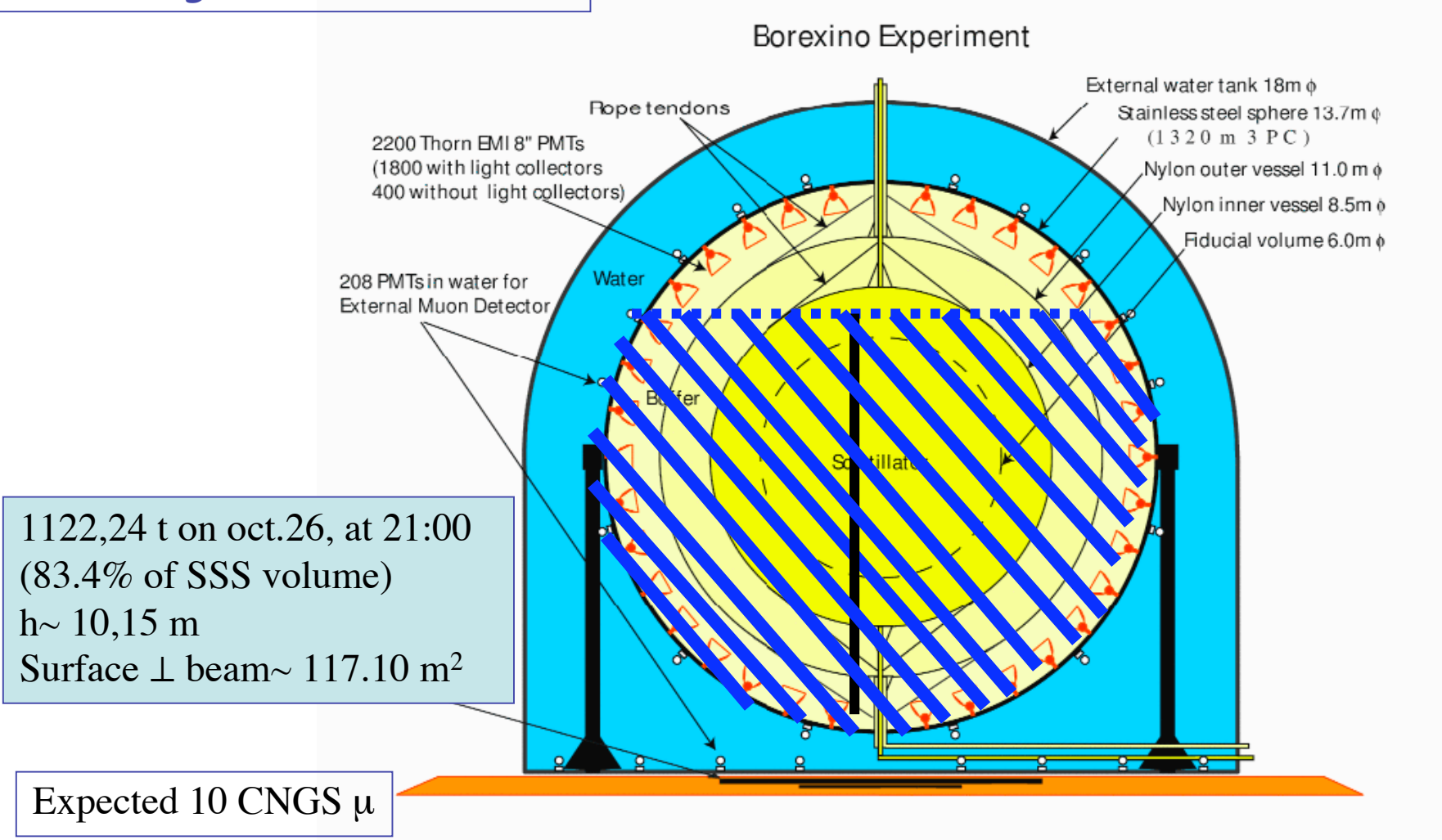


5 events at $\Delta t \sim 2.4$ ms

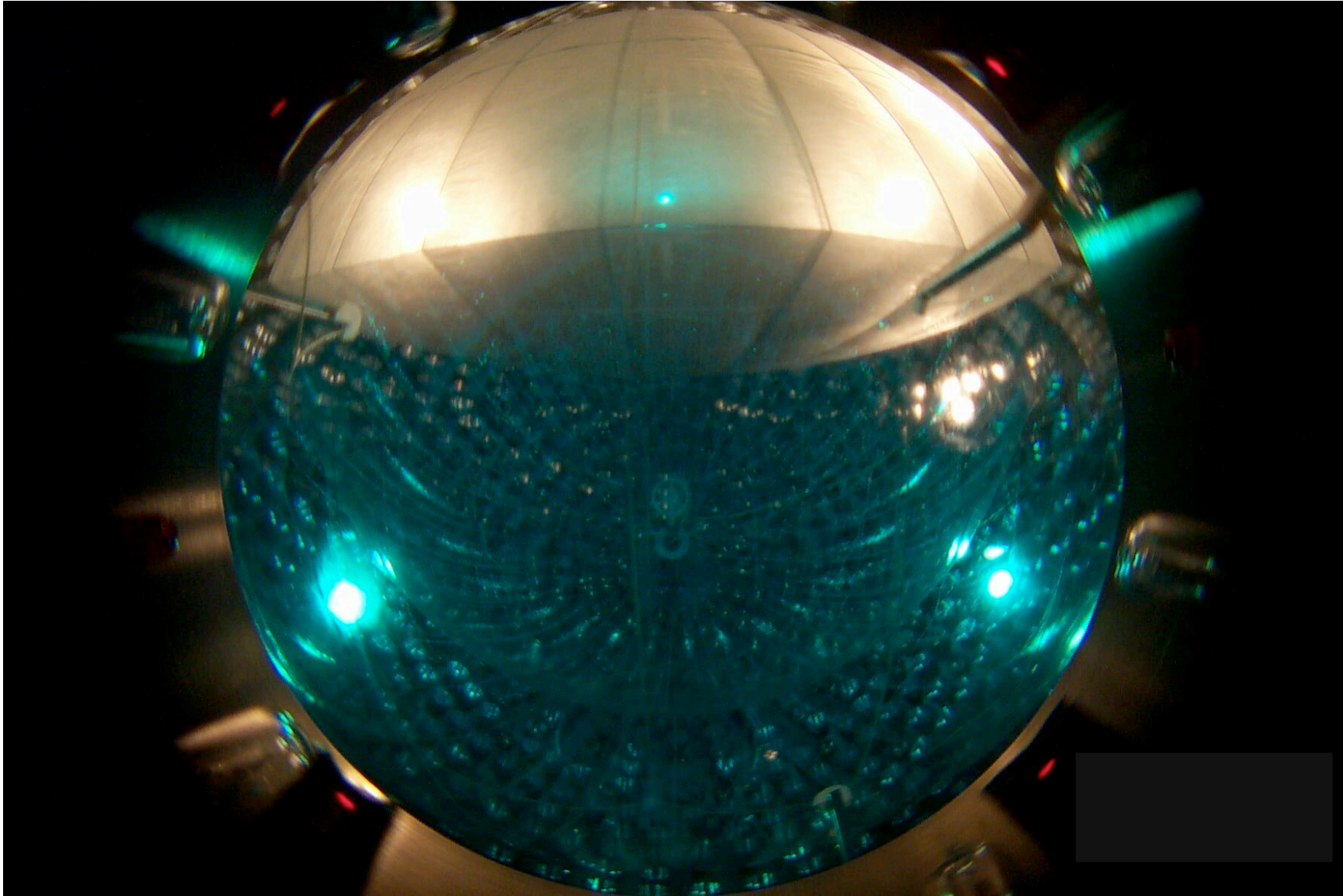


M.Pallavicini

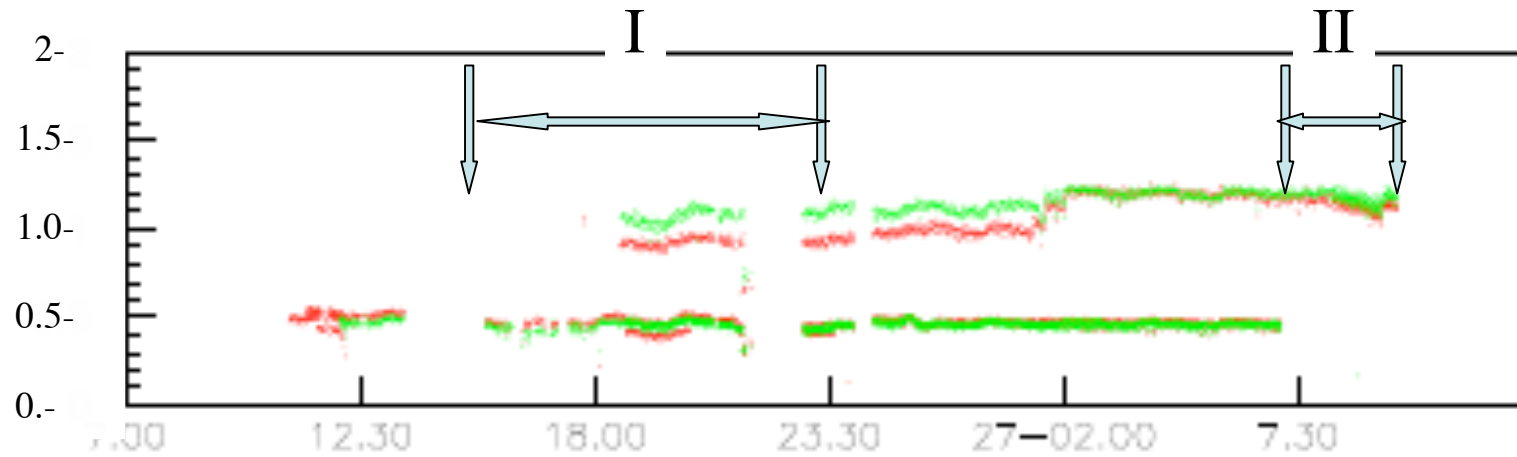
Borexino during the October runs:



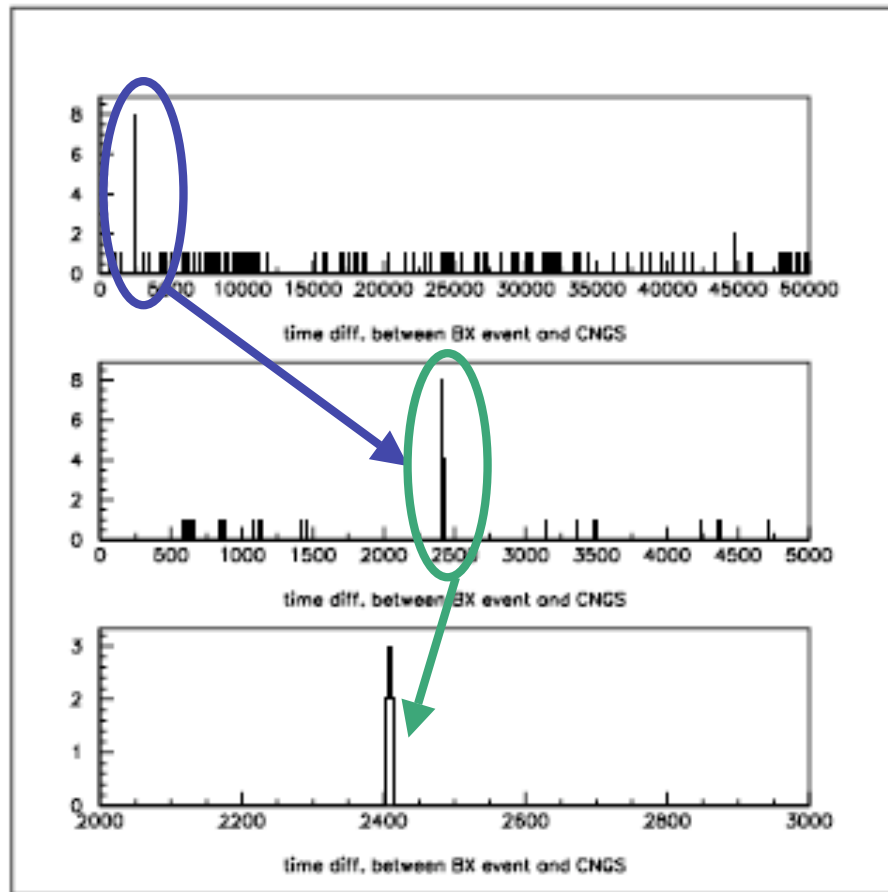
The inside of the Borexino SSS as on October 27th, at 7AM



In October 2006 we had two running periods,
compatible with the SSS water filling,
for a total of ~ 10 h, equivalent to $\sim 1.8 \cdot 10^{16}$ pot



October 2006 time difference between the BX trigger time and the preceding GPS signal



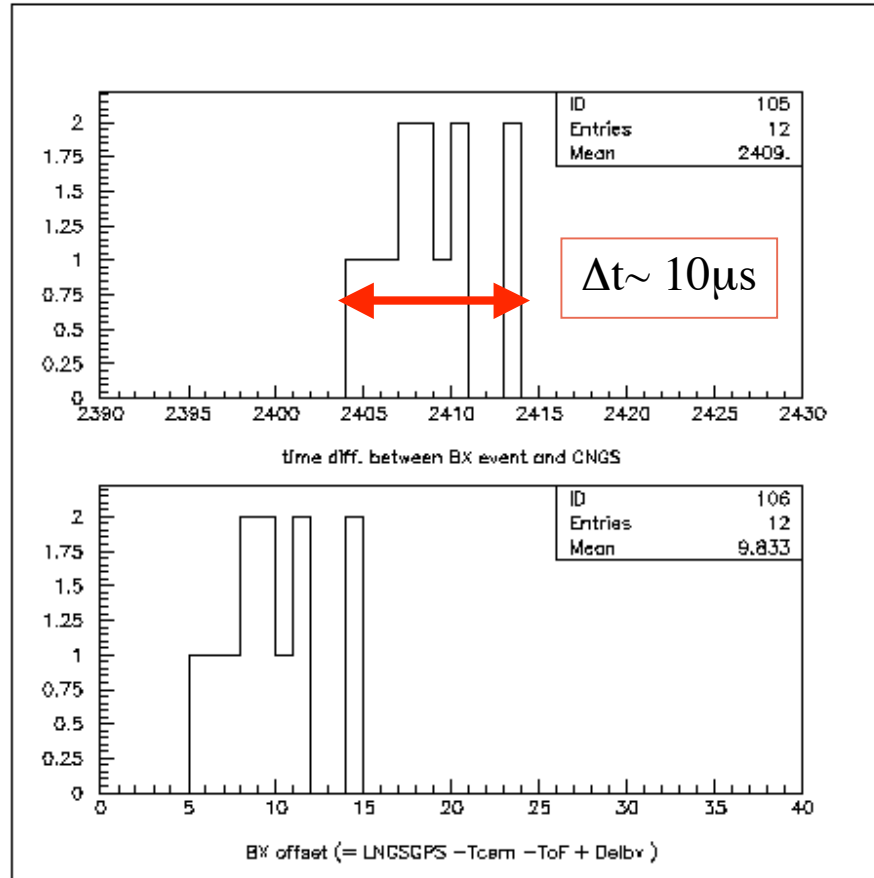
12 events at $\Delta t \sim 2.4$ ms

October 2006 time difference between the BX trigger time and the preceding GPS signal

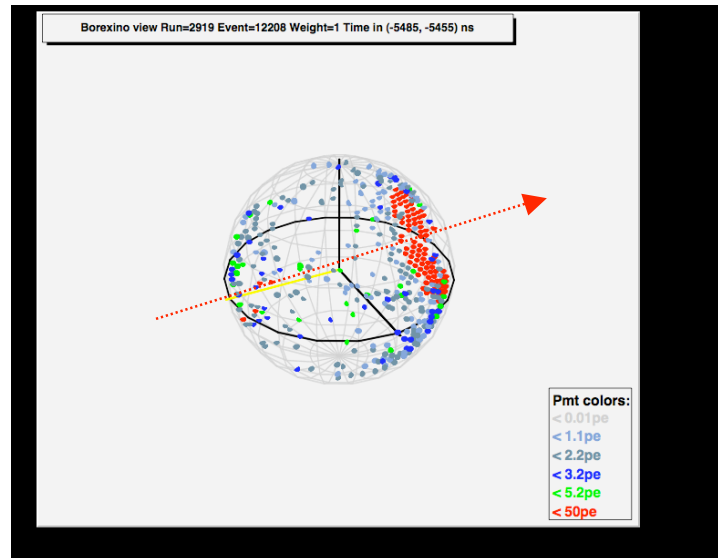
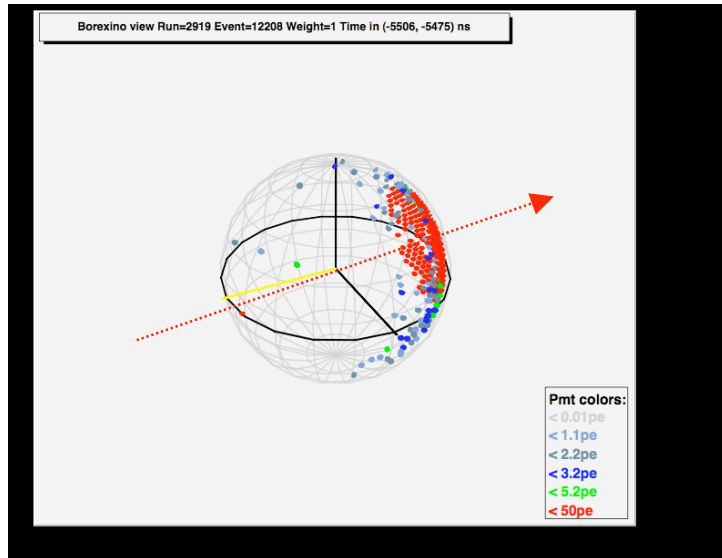
12 events at $\Delta t \sim 2.4$ ms
with the expected Δt

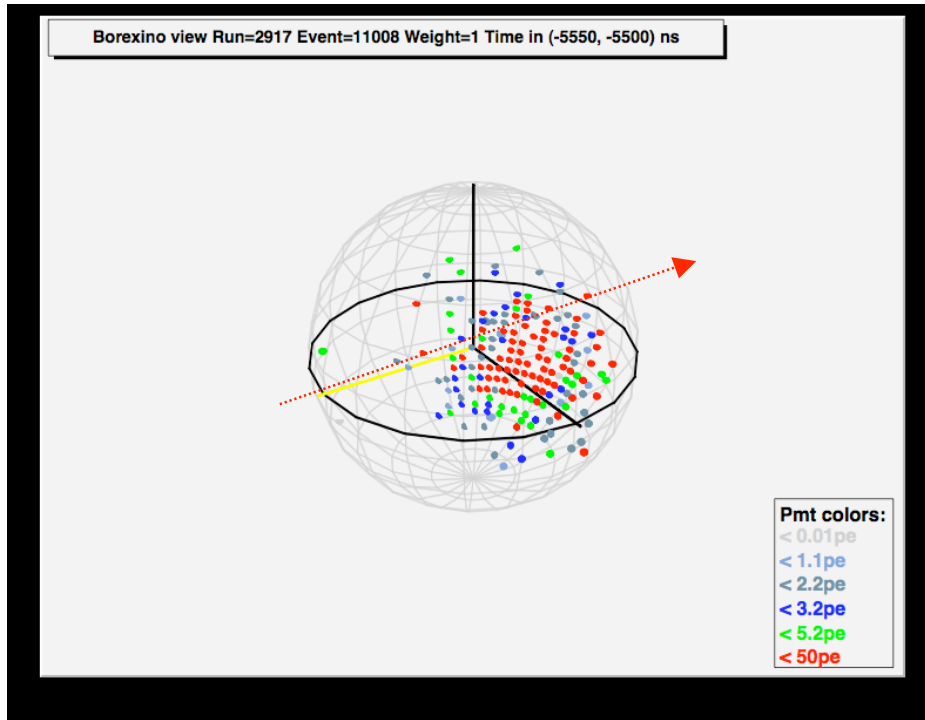
Expected CNGS events: 10

Bx offset (el.offset = $5\mu\text{s}$) =
 $\text{BXGP} - \text{CernUTC} - \text{ToF} - \text{LNGSdelay}$



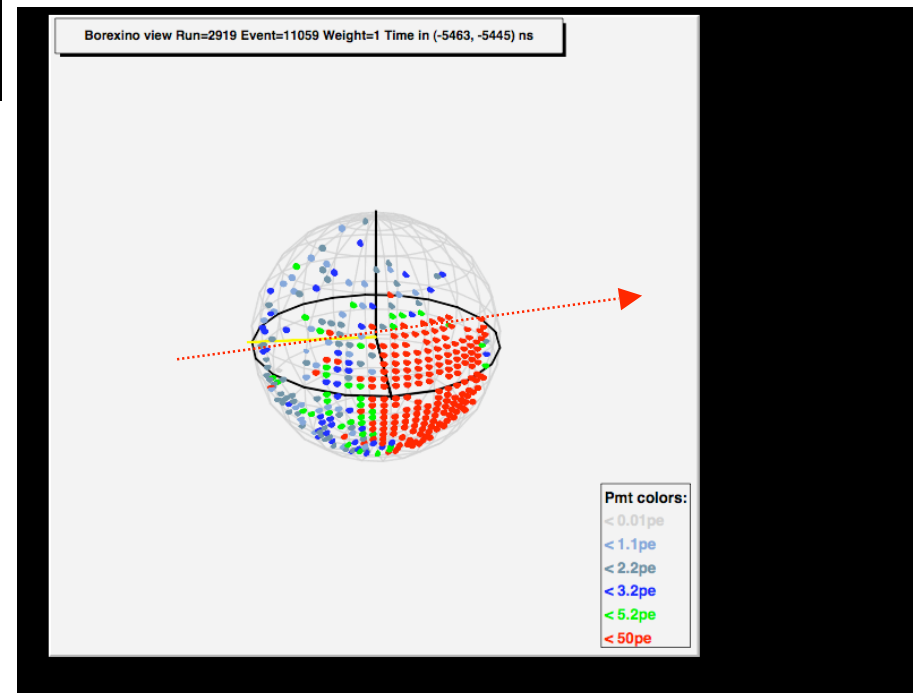
Run 2919, ev.12206





Run 2917, ev.11008

Run 2919, ev.11059



Conclusions:

Last October:

- Borexino SSS ~ full of water - acting as a Cherenkov detector- has detected the expected CNGS number of events (one, as expected, together with Opera!)
- The CNGS beam has been very useful to:
 - test all the BX DAQ machinery in a “beam” environment

Now:

- Borexino has > 40% of the volume of:
 - { (PC + PPO) in the IV
(PC + DMP) in the IB and OB } all inside the SSS
 - HPWater in the water tank
- Final detector and electronics calibrations are in progress

.... and we are waiting for Borexino to be in its final configuration (~may)
=> to start the background studies and data taking

.... to show you some
real data next year

Arrivederci !!

... and *grazie* !

