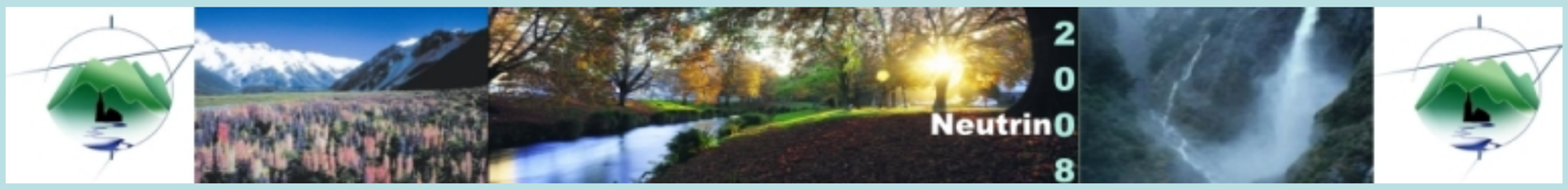


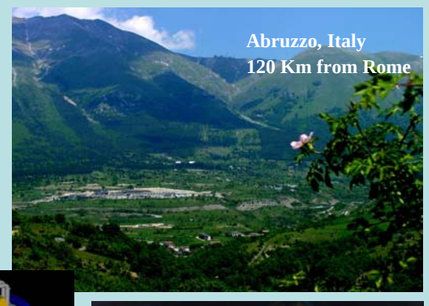
Neutrino 08 | May 25-31 | Christchurch | New Zealand

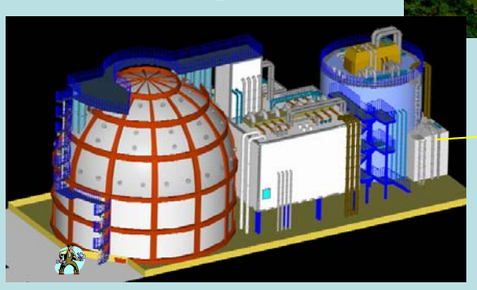
The Borexino Detector: photomultiplier system

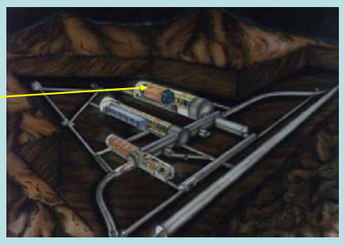
Paolo Lombardi
INFN – Sezione di Milano
on behalf of Borexino Collaboration

EXPERIMENTAL SITE

Borexino is located at Laboratori Nazionali of Gran Sasso near L'Aquila, shielded from cosmic muons by 1400 m of rocks. (3500 m water equivalent)

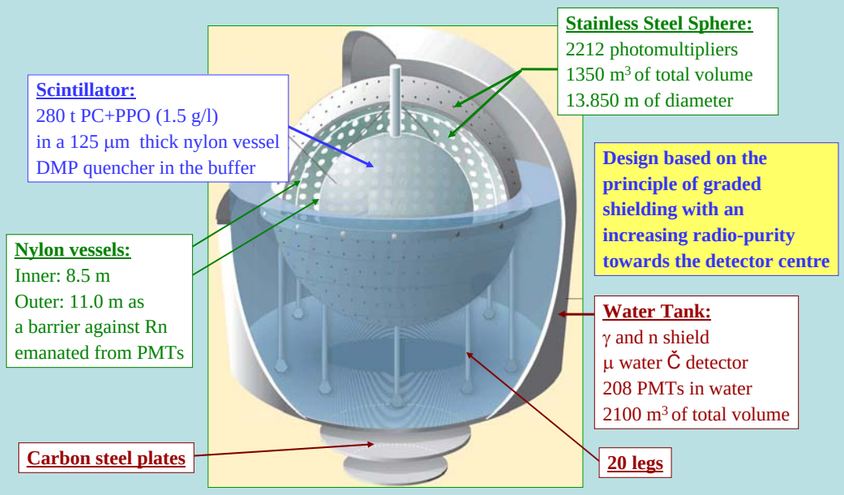






BOREXINO DETECTOR

Borexino aims to measure low energy solar neutrinos in **real time** by elastic neutrino-electron scattering in a volume of **highly purified liquid scintillator.** The experiment's goal is the direct measurement of **^{7}Be**, **pep**, **CNO** and possibly **pp** solar neutrinos . **Geoneutrinos** and **Supernova neutrinos** are measured as well. The experiment uses 280 t of ultra-pure liquid scintillator (fiducial volume 100 t) to detect the scattered electrons. The observed energy window has a threshold lower than 200 keV, at an expected rate of a few tens of events per day. Since these very rare events are practically indistinguishable from other ionizing events produced by natural radioactivity at the same energy, extremely high radio-purity standards must be met by all the materials used in the experiment. Muon induced background events are strongly suppressed by the overburden and by the aid of an additional muon veto shield. **Bibl. Ref. [1], [2], [3], [4], [5], [6]**



PHOTOMULTIPLIER TUBES: characteristics

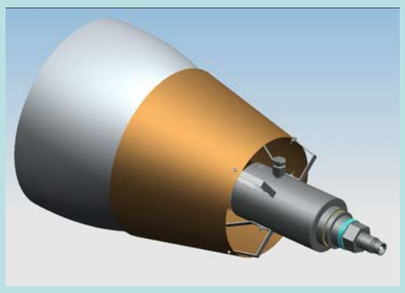
Photomultipliers have been produced by ETL (former Thorn-EMI) after a strict collaboration with Borexino by means of long and severe laboratory tests:

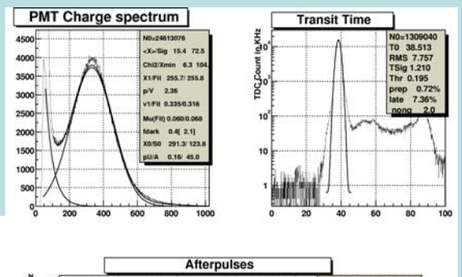
- selection of low radioactive materials with germanium detectors @ LNGS
- electrical performance measured in a custom dark room with earth magnetic field compensation (Merrit coils) and adjustable pico-second laser for uniform illumination
- data acquisition system with 128 channels (64 in D.R. and 64 for ageing in water)
- ageing tests of all the divider components

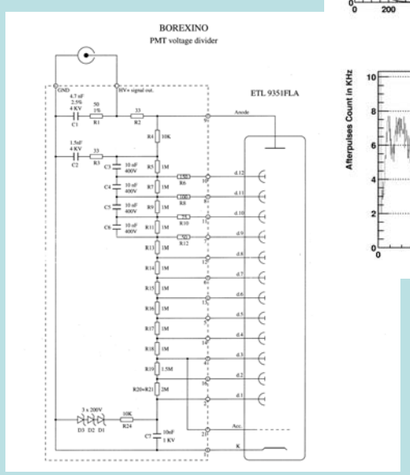
Main characteristics:

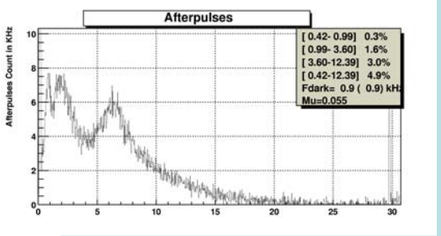
- 8" ETL 9351 with 12 linear focused dynods (BeCu)
- SbKCs hemispherical cathode (quantum efficiency ~ 26.5% @ 420 nm)
- Special low radioactive "Shott" glass
- 10^{7} voltage gain with low dark rate (< 1 kHz)
- After pulses < 5%
- Single p.e. transit time spread ~ 1.1 ns
- Peak to valley ratio > 1.5

Bibl. Ref. [7], [8], [9], [10], [11]









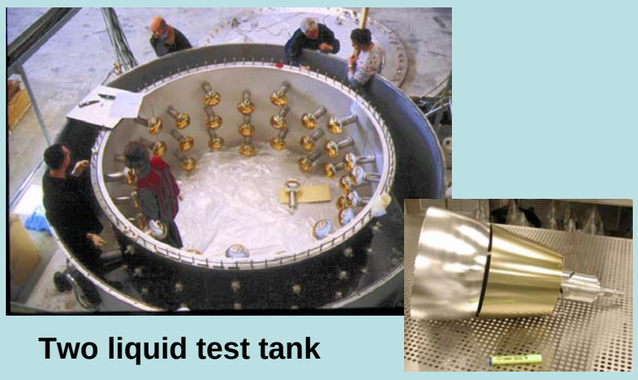
PHOTOMULTIPLIERS SEALING

Photomultipliers have been encapsulated to be operated both in high purity water and in pseudocumene scintillator at an operating pressure of 2 bars

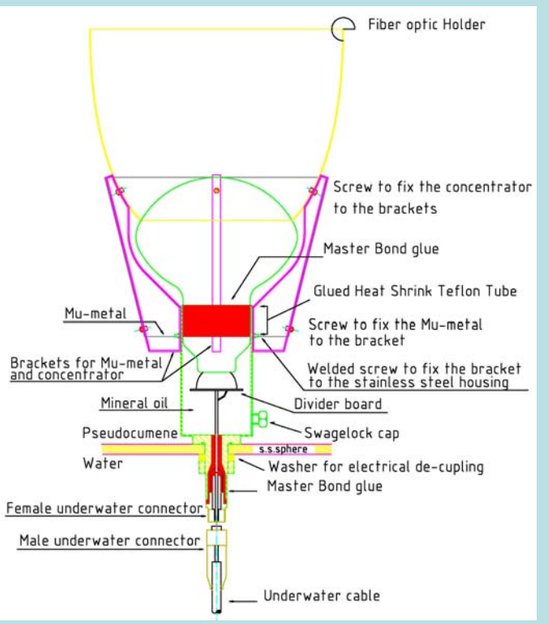
- all material selected with Germanium detector for low radioactivity
- thermal and mechanical ageing test (10y extrapolation)
- complete fine-elements mechanical simulation
- clean room assembly
- custom made epoxy resin (Master Bond EP45HT)
- patented "Gore" heat shrink Teflon tube etching
- special stainless steel can (AISI 470) to match glass thermal expansion coefficient
- underwater connectors (AISI 316L) with viton o-rings (Framatome-Jupiter) and special cables (Huber+Suhner)

INSIDE THE SEALING

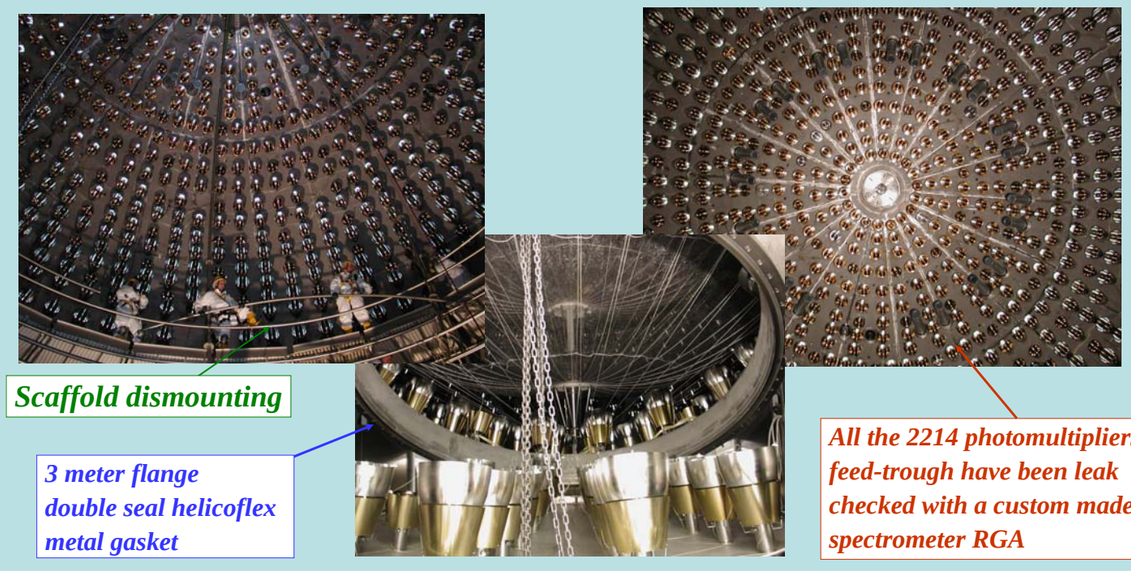
- all tubes have been tested for one week in high purity water @ 2 bars
- a long term test have been done on 54 PMTs in a Two Liquid Test Tank to simulate Borexino conditions (still working after more than 8 y)



Two liquid test tank

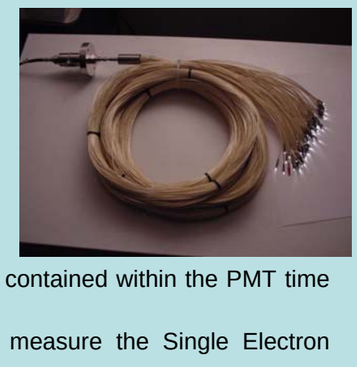


PHOTOMULTIPLIERS INSTALLATION

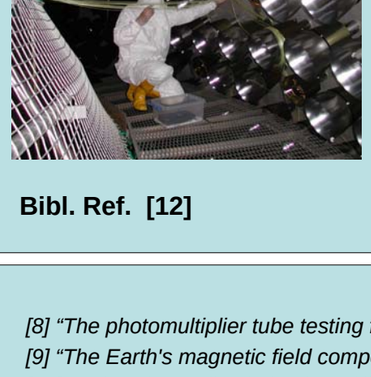


CALIBRATION SYSTEM

A multiplexed system of optical fibers has been designed for the photomultiplier calibration of the Borexino experiment at Gran Sasso. Both time and energy calibration are of paramount importance in Borexino for the measurement of the solar ^{7}Be neutrino flux.



System design:



- Inter-PMT equalization inaccuracy should be contained within the PMT time jitter, which is 1ns
- Accuracy in charge calibration in order to measure the Single Electron Response (SER) parameters of each PMT
- The system must allow for use of different illumination levels, in order to verify the linearity of the PMT response. The highest value is 8 p.e., limited by the dynamic range of the electronics
- The PMT calibration should be performed at the fastest rate allowed by the DAQ system, i.e., 20 kHz
- Long-term reliability (about 10 years of data taking)
- The system should allow a high level of automation for frequent use and must be operable from outside

Bibl. Ref. [12]

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