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Development of the safety policy for the Borexino experiment at the Gran Sasso National Laboratories in Italy

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Laboratori Nazionali del Gran Sasso

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- Overview of the National Laboratories of Gran Sasso;
- Overview of the Borexino Experiment;
- Description of the main safety devices;
- The Borexino Safety Management System.

Overview of the National Laboratories of Gran Sasso (1)

- The Gran Sasso National Laboratories (**LNGS**) is one of 4 INFN national laboratories. They are located close the town of L'Aquila about 120 km from Rome.
- They are the largest underground laboratory in the world for experiments in particle physics, particle astrophysics and nuclear astrophysics. It is used as a worldwide facility by scientists, presently 750 in number, from 22 different countries, working at about 15 experiments in their different phases.

A bit of History

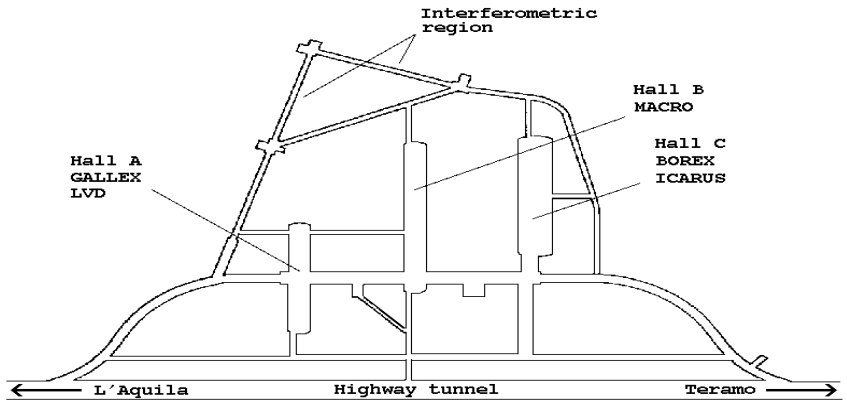
- In 1979 it wase proposed to the Italian Parliament the project of a large underground laboratory close to the Gran Sasso highway tunnel, then under construction
- In 1982 the Parliament approved the construction, finished in 1987
- In 1989 the first experiment, MACRO, started taking data

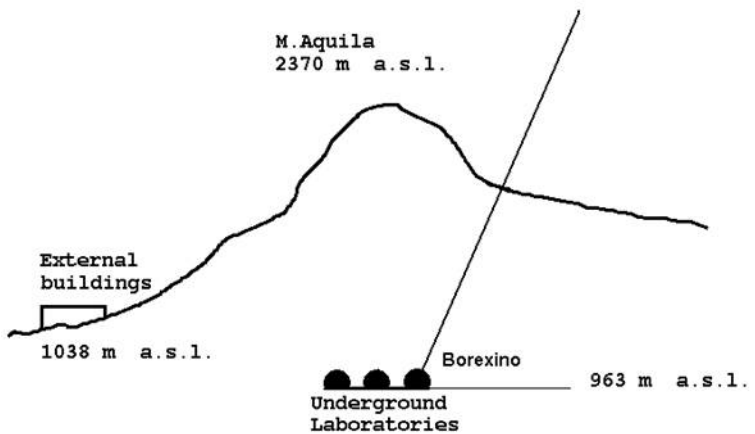
Overview of the National Laboratories of Gran Sasso (2)

- The underground facilities are located on a side of the 10 kilometers long freeway tunnel crossing the Gran Sasso Mountain. They consist of three large experimental halls, each about 100 m long, 20 m wide and 18 m high and service tunnels, for a total volume of about 180,000 cubic meters.

- The average 1400 m rock coverage gives a reduction factor of one million in the cosmic ray flux; moreover, the neutron flux is thousand times less than on the surface.

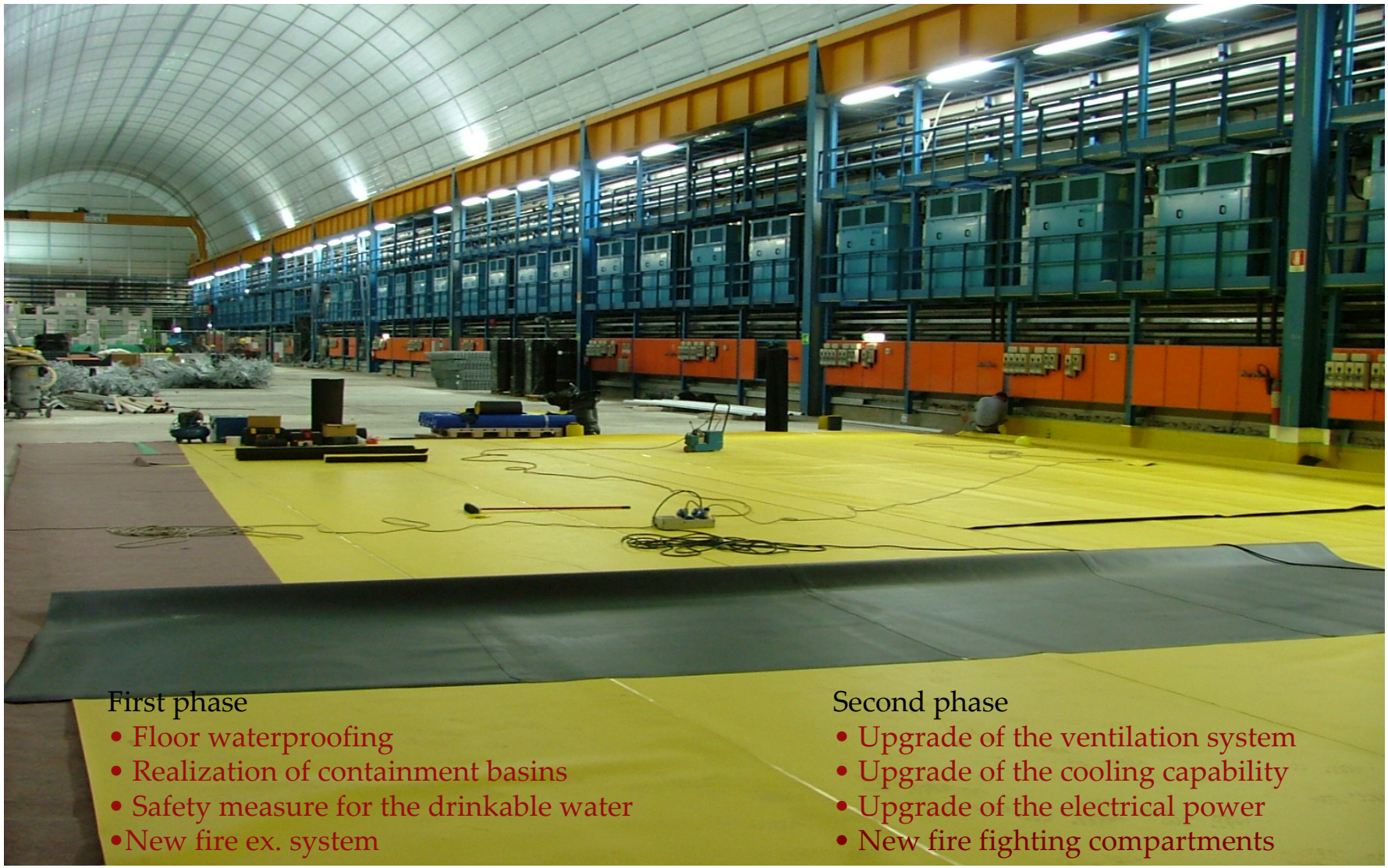
- The headquarters and the support facilities are located in the external building






External facilities
Administration
Public relationships support
Secretariats (visa, work permissions)
Outreach
Environmental issues
Prevention, safety, security
General, safety, electrical plants
Civil works
Chemistry
Cryogenics
Mechanical shop
Electronics
Computing and networks
Offices
Assembly halls
Lab & storage spaces
Library
Conference rooms
Canteen

2004 - 2005 – 2006 – 2007
Important safety and infrastructures upgrade of the Laboratories



First phase
- Floor waterproofing
- Realization of containment basins
- Safety measure for the drinkable water
- New fire ex. system

Second phase
- Upgrade of the ventilation system
- Upgrade of the cooling capability
- Upgrade of the electrical power
- New fire fighting compartments

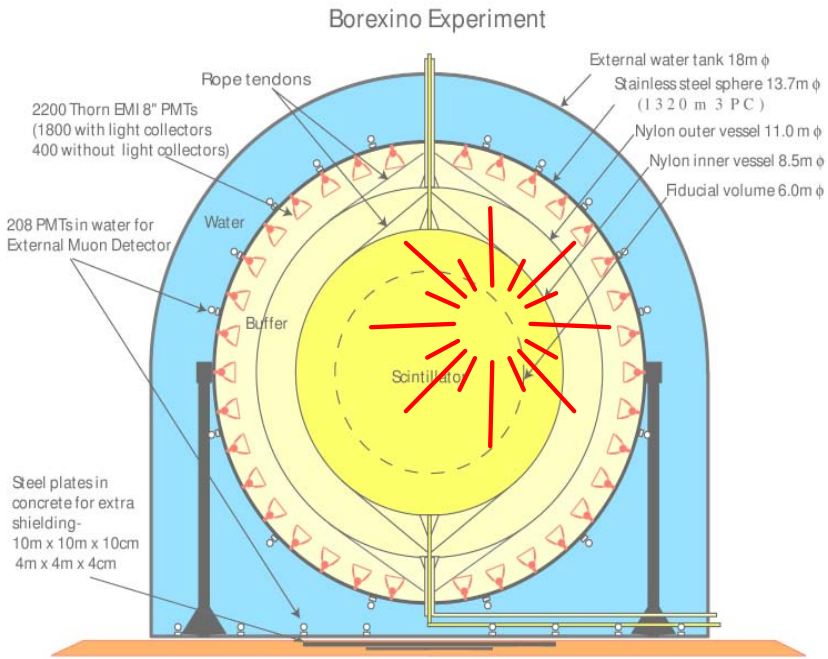
Borexino Detector

Borexino is a liquid scintillator detector installed in the hall C of the LNGS. Its main goal is to detect the ^{7}Be mono-energetic neutrinos (862 keV) from the sun, through the elastic scattering between the neutrinos and the electrons of the scintillator. 278 tons of pseudocumene (PC) added with 1.5 g/L of 2,5dipheniloxazole (PPO), contained in a 4.25 m radius nylon vessel at the center of the detector, act as scintillator.

890 tons of PC added with 5 g/L of dimethylphthalate , contained in a second 5.5 m radius nylon vessel (323 t) and in a 6.85 m radius Stainless Steel Sphere (567 t), act as first radioactive shielding.

2100 tons of ultrapure water in an external tank act as second radioactive shielding.

2200 photomultipliers inside the SSS detect the scintillation light from the internal events



200 photomultipliers outside the SSS detect the Cherenkov light from external muon events.

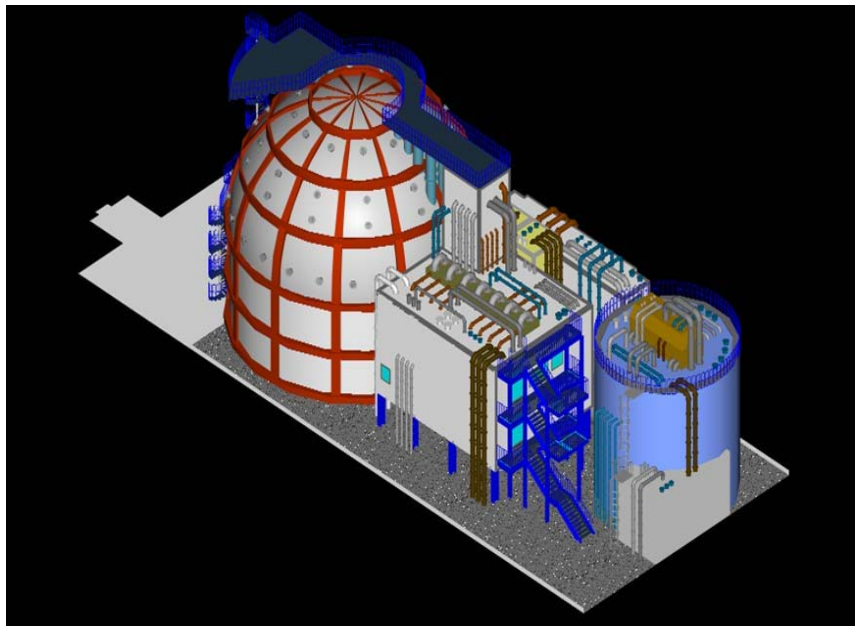
Borexino is taking data

Borexino occupies a portion of 60 x 20 m of the Hall C, it consists in the main detector plus a series of ancillaries plants and builing.

Borexino filling with scintillator was completed in May 2007

Since the 15th of May 2007 Borexino is taking data

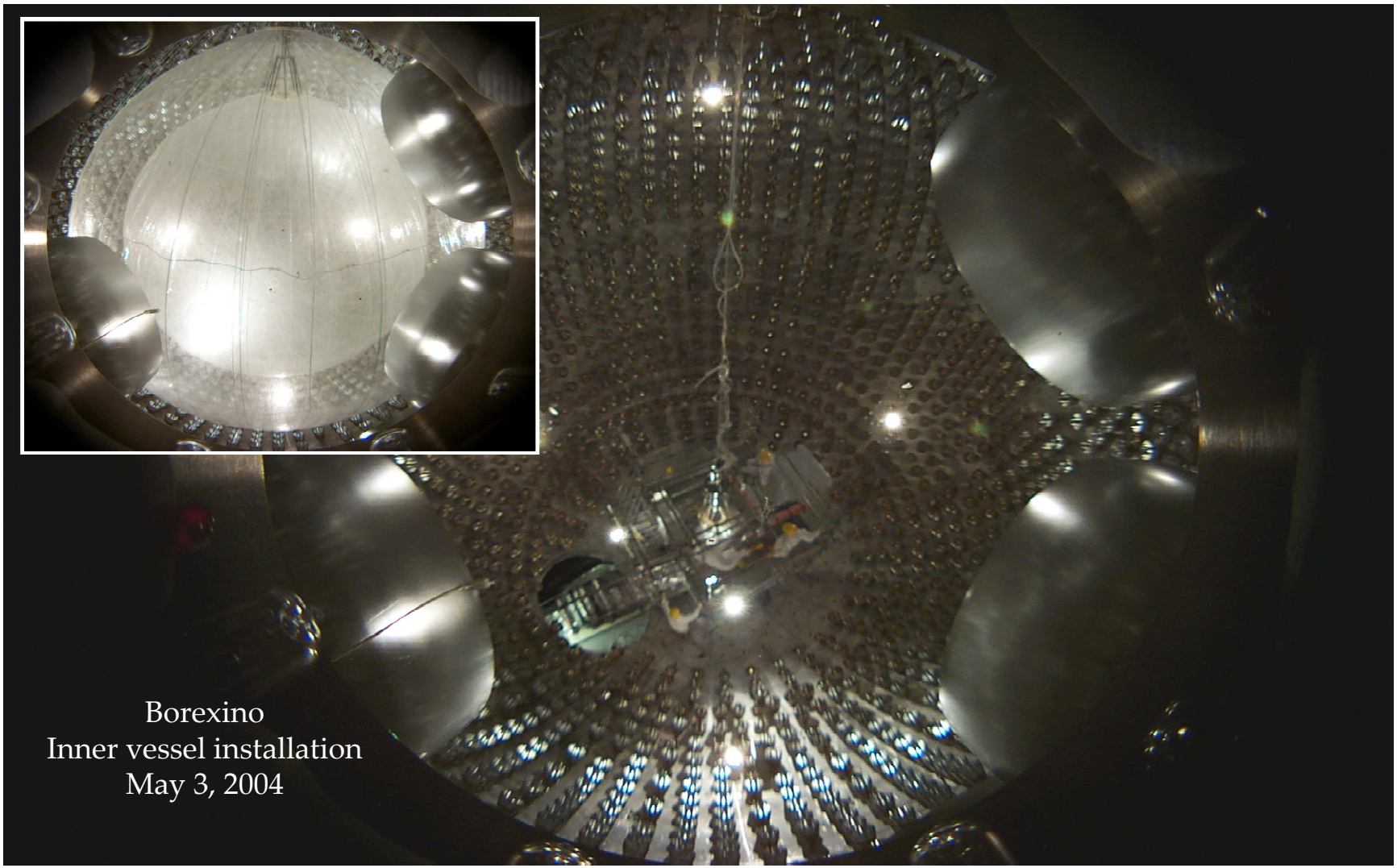
From the beginning, **the very low background**, allowed the real time detection of ^{7}Be solar neutrinos



for the first time in the world

First real time detection of ^{7}Be solar neutrinos by Borexino
Physics Letters B PLB-D-07-00772R2 (2007)

First operations: vessels installation and Water Filling



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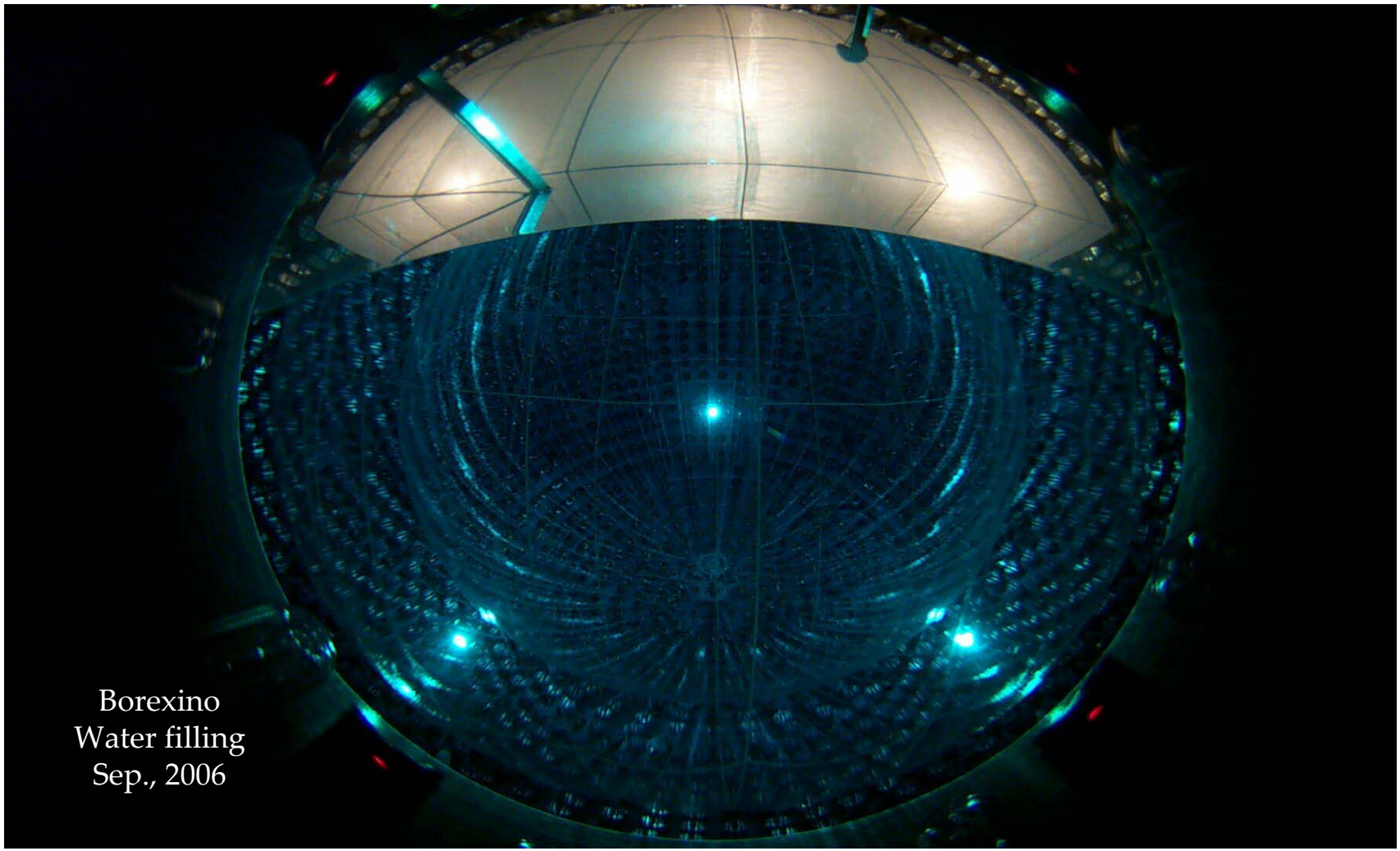
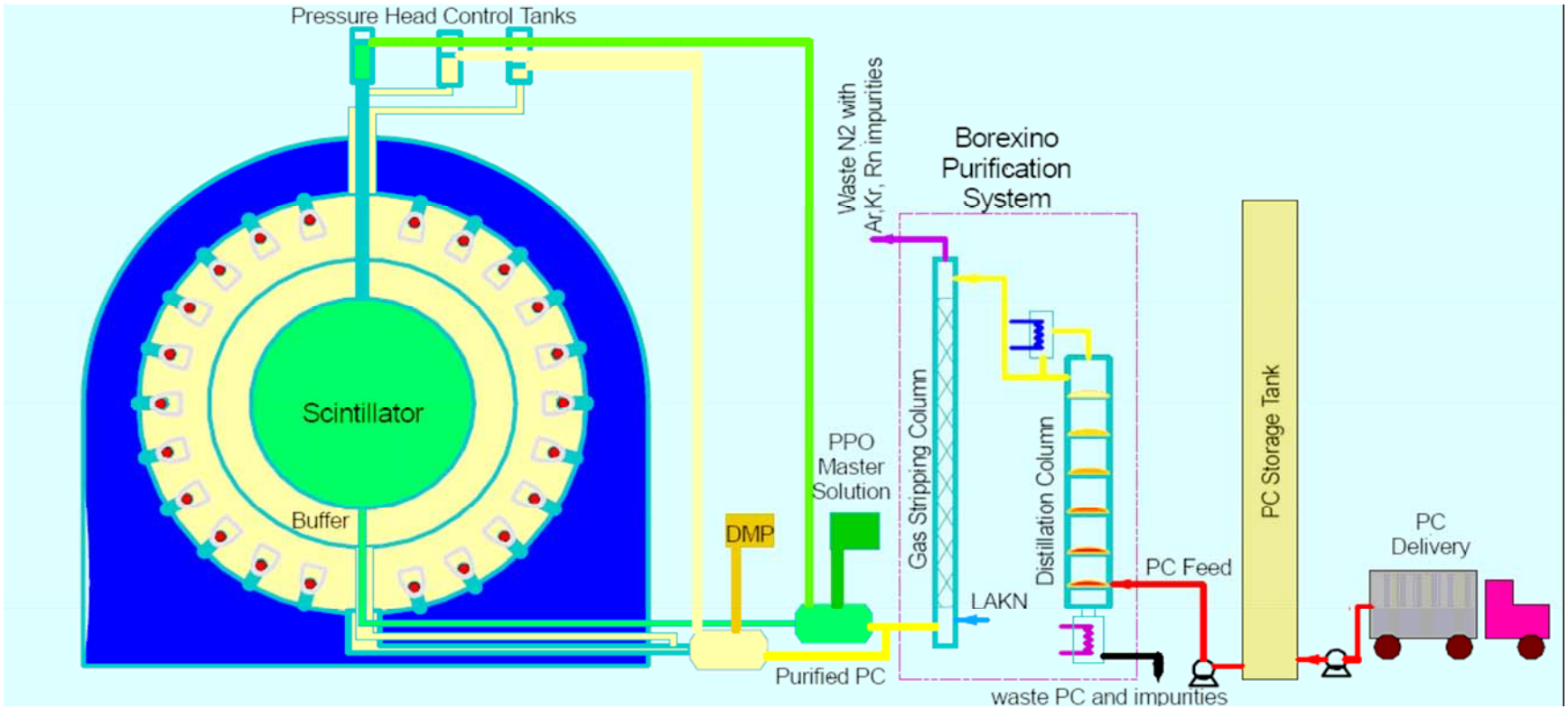


Water filling of the Detector

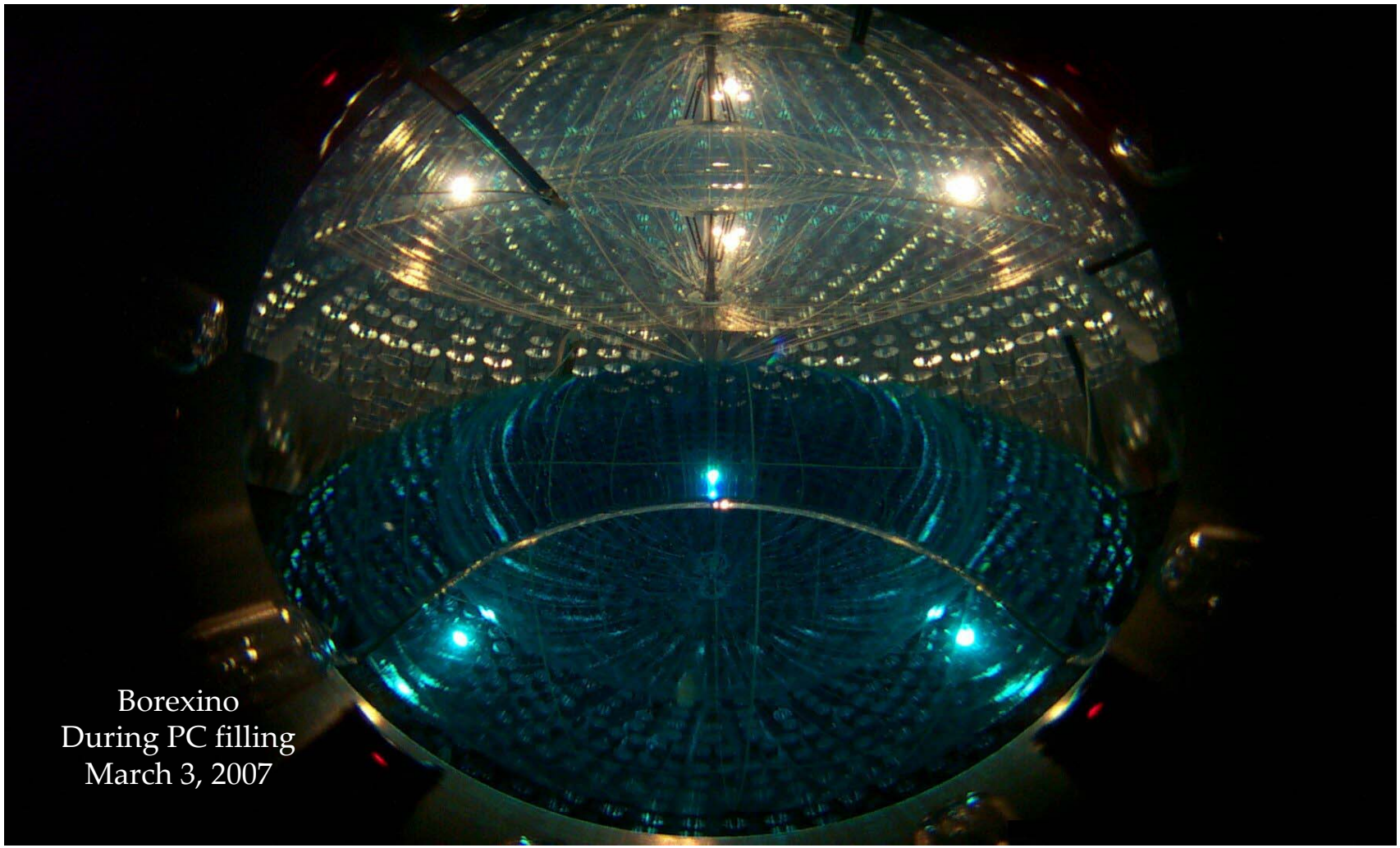
Purification and PC filling

All the 1168 ton of PC have been vacuum distilled and nitrogen stripped during the Detector filling



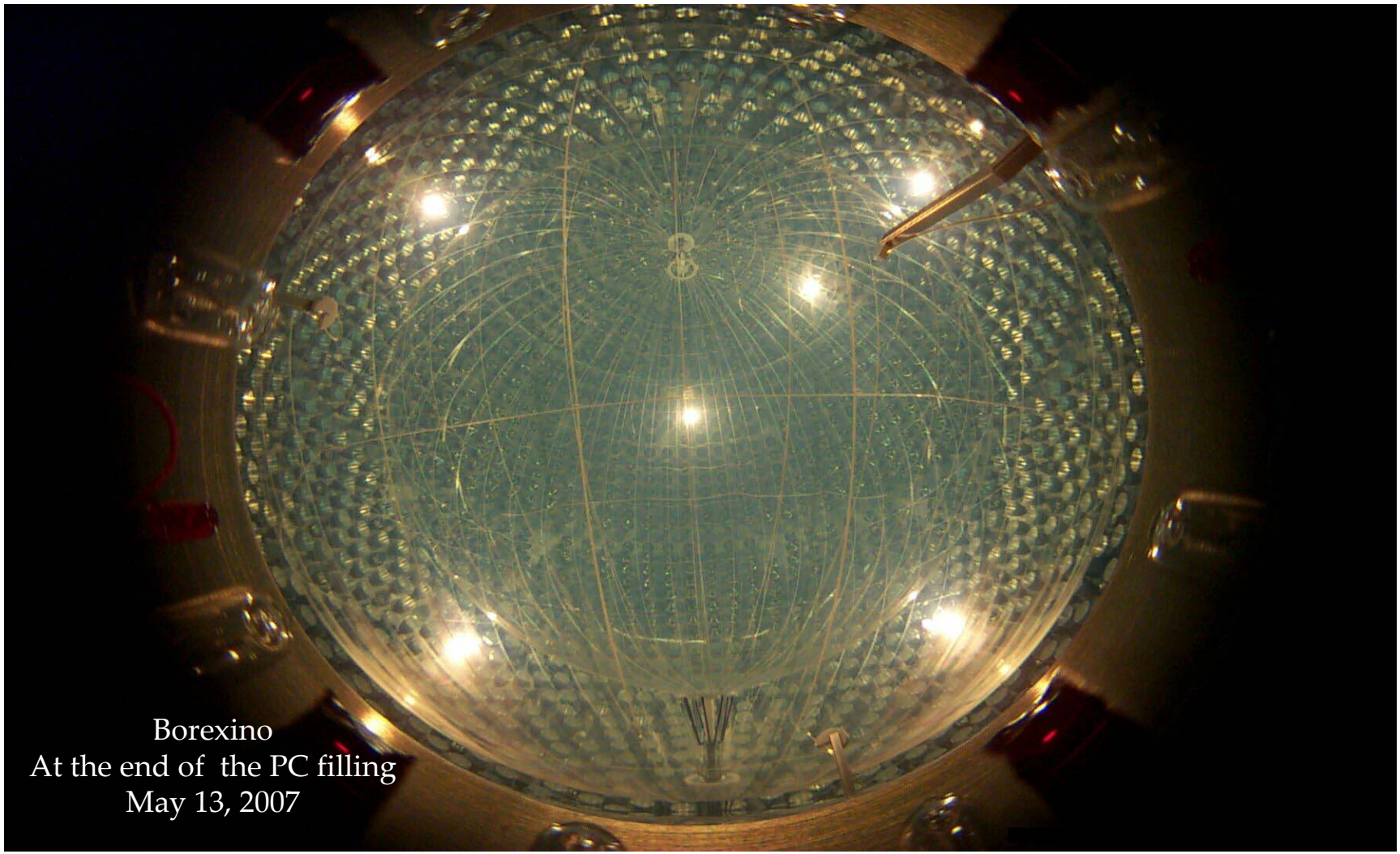
Borexino filling scheme

PC filling



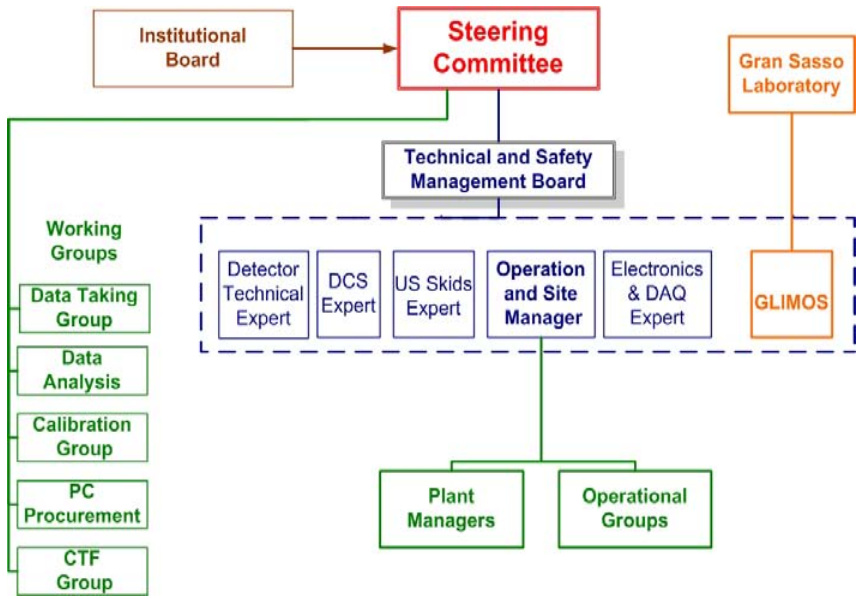
PC filling of the Detector

PC filling



The Borexino Collaboration

- The Borexino collaboration is an international group of ca. 100 scientist and engineers coming from universities and institutes worldwide
- Most of them are professors, postdocs, graduate students, engineers and technical staff of the universities and institutions, which represent a big diversity in the safety culture of the collaboration members.



Borexino Collaboration

France
- APC_ Paris

Germany
- Max-Planck Institute fuer Kernphysik _ Heidelberg
- Technische Universitaet _ Muenchen

Italy
- INFN Laboratori del Gran Sasso-Assergi
- INFN e Dipartimento di Fisica dell'Universita'_ Genova
- INFN e Dipartimento di Fisica dell'Universita'_ Milano
- INFN e Dipartimento di Chimica dell'Universita' _ Perugia

Poland
- Institute of Physics, Jagellonian University _ Cracow

Russia
- JINR _Dubna
- Institute for Nuclear Research_Gatchina
- Kurchatov Institute _Moscow
- University of Moscow_Moscow

USA
- Princeton University _ Princeton
- Virginia Tech,_Blacksburg

The Borexino Risks and the Safety Plants

- LNGS are immerged in one of the biggest water reserve of Italy, they are close to a public aqueduct which serve more of 1 million people;
- LNGS are inside the Gran Sasso – Monti della Laga National Park.
- For scientific reasons Borexino uses as liquid scintillator Pseudocumene; its Main Risk phrases are: R10, R20, R51/53, it is flammable, and most important:

it is toxic to aquatic organisms and it may cause long-term damage to the environment.

Borexino has many safety plants:

-) Fire extinguish systems (foam systems, Inergen, "passive" system);
-) sensors (oxygen, PC vapors, etc, etc..)
-) full monitor of the physical parameters (control system for more then 500 signals):
-) double containment of all the pipes and/or tanks where PC is stored;

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The Borexino Safety Management plan

Why To Have a Plan?

- Designed to Protect:
  - Personnel
  - Environment
  - Public
  - Operation and Equipment

- To accomplish the Laws!

Safety Program Development

- Assignment of responsibility (see Organization Chart)
- Hazard identification and control (Hazop of all the plants..)
- Training and communication
- Documentation and enforcement of safety rules

Safety Program

- Maintenance of safe working conditions
- Setting performance goals;
- Rewarding safety performance
- Reviewing circumstances involved in incidents
  - Taking appropriate correction actions
- Establishing Safety performance objectives for all levels of management (GLIMOS as member of the Technical board)
- Including safety as part of management performance reviews
- Roles and Responsibilities

-Supervisors/Management

- Establish safe work practices
- Enforce safety rules and regulations
- Train employees how to avoid hazards
- Enforce reporting work-related injuries, illnesses, and near misses
  - » Investigate causes of incidents or near misses
  - » Take the appropriate action to prevent recurrence

-

- Borexino Collaboration is divided into 2 main group: “normal users” and the Operation Group.
  - Basic Safety Orientation Training (in collaboration with LNGS Safety staff):
    - Personal Protective Equipments;
    - Hearing Conservation;
    - Lockout Tag out;
    - Hazard Communication;
    - Fire / Fire Extinguishers;
    - Heat/Cold Stress;
    - Good Safety Practices;
    - Environmental issues.
  - Advanced Training for the Operation Group (handled by Borexino Glimos):
    - Breathing apparatus;
    - Confined Space
    - Cryogenic liquid training;
    - Work permits (also for Contractors);
    - Emergency Response.

Example of Work Permit for Contractors

Work permits:

- Welding;
- Heavy equipment;
- Electric works;
- Confined-space entry;

INFN
BOREXINO experiment

CONFINED SPACES WORK PERMIT

N.....

THE ORIGINAL OF THIS WORK PERMIT MUST BE KEPT AT THE PLACE OF WORK

A *REQUEST TO EXECUTE A JOB/WORK*

Work area ..... DATE .....

Equipment involved .....

Work/job description .....

Particular work with an attached operating procedure: ☐ NO ☐ YES [☐ predetermined ☐ specific]

Execution of the job in care of: ☐ INFN ☐ CONTRACTOR.....

People involved: #N..... suitable work tools to be used:..... Use of truck/vehicle: ☐ NO ☐ YES

Work begins: DATE..... TIME..... work presumed to finish: DATE..... TIME.....

Maximum daily duration: (start) TIME..... (finish) TIME.....

APPLICANT ..... SIGNATURE .....

B 1 *INFORMATION ABOUT SUBSTANCES THAT INTERFERE WITH THE JOB AND THE SPECIFIC AMBIENT RISKS*

equipment ☐ contained [☐ PC ☐ other:.....] ☐ contains [☐ PC ☐ other:.....]

Noxious substances which could concern the work area: .....

B 2 *PROCESS AND OPERATIVE PRECAUTIONS TO ADOPT*

☐ locked out equipment ☐ emptied equipment ☐ apparatus sealed ☐ neutralized equipment

☐ emptied equipment ☐ elect. equip. isolated ☐ air samples taken ☐ Request for continuous operator presence

B 3 *FURTHER PROTECTIVE OPERATING PRECAUTIONS – FIRE EXTINGUISHING EQUIPMENT AND PRECAUTIONS*

☐ neoprene gloves ☐ anti-dust mask ☐ other: .....

☐ helmet with visor ☐ breathing apparatus ☐ other: .....

☐ fireproof tarpaulin ☐ CO_2/powder/foam fire extinguisher ☐ other: .....

☐ explosion risk analysis before the start/renewal of work ☐ coordination .....

B 4 *AUTHORIZATION TO BEGIN WORK*

Having checked the conditions cited in Section B2, the work is authorized to begin provided that the precautions in Section B3 are respected.

DATE ..... TIME ..... ISSUANT ..... SIGNATURE .....

C *ACCEPTANCE OF THE WORK EXECUTION METHOD*

I declare that I am aware of the specific risks mentioned in Section B1 and to have informed the people performing the work. I take it upon myself not to alter what is foreseen in Section B2 and to respect, and to be made respected, at least which is foreseen in Section B3. I have taken the view of what is described on the back of this permit for the instructions to follow in case of emergency. I am aware of the safety procedures in effect at these laboratories.

☐ INFN ☐ CONTRACTOR .....

TASK MANAGER ..... SIGNATURE .....

D *RENEWALS*

Accepted that the conditions on the above remain, the present permit is renewed:

	Date	Time	Applicant	Issuant	Task Manager
1					
2					
3					
4					
5					

E *WORK CONSIGNMENT*

I certify that the work on the equipment/area is completed and the equipment/area is consigned in a perfect state of safety and cleanliness.

DATE..... TIME..... TASK MANAGER ..... SIGNATURE .....

For acceptance APPLICANT ..... SIGNATURE .....

To put in operation ISSUANT ..... SIGNATURE .....

FORM WW (yellow colour)

7

- *B 1- INFORMATION ABOUT SUBSTANCES THAT INTERFERE WITH THE JOB AND THE SPECIFIC AMBIENT RISKS*
- B 2 - *PROCESS AND OPERATIVE PRECAUTIONS TO ADOPT*
- B 3 *FURTHER PROTECTIVE OPERATING PRECAUTIONS – FIRE EXTINGUISHING EQUIPMENT AND PRECAUTIONS*

Contractor Prequalification

- Must complete prequalification
  - Incident rates
  - General company information
  - Safety programs
  - Medical surveillance programs

Determine Contractor Relationship

- General LNGS Safety training: MANDATORY!
- Identify who supervises contractor's employees
- Must have on-site project supervisor/manager
- Must share responsibility/liability

Organization of the operations

Due to very high complexity of the Experiment all the operations have been carried out by the Operation Group.

The main goal of the Safety Management System were:

- Eliminate hazards;
- Reduce risks when hazards cannot be eliminated;
- Develop and implement procedures and training;
- Full automation of all controls;
- Accountability must be present;
- Management commitment must be visible;
- Teamwork is a requisite for success.

Example of Procedure

Istituto Nazionale di Fisica Nucleare

Laboratori Nazionali del Gran Sasso

Borexino Project

Process Procedure

Borexino PC Filling

Process Procedure Number: OPER-BX-03-2006 REV. 0

Last Revision Date: 12 October 2006

Procedure Authors: Augusto Goretti

Last Revised by: Augusto Goretti

Reviewed by: Jay Benziger _____
Andrea Ianni _____
Cristian Galbiati _____

Stefano Gazzana (GLIMOS) _____

Approved by: Augusto Goretti _____Date____

Procedure validity: from 01-11-2006 to 31-10-2007

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Conclusion

Due to adopted safety policy, in the last ten years the collaboration has carried out the design, preparation, and commissioning of all the plants. The operations for the detector filling, i.e. purging of the SSS with nitrogen, filling of the SSS with water, filling of the SSS with PC, and the WT filling were all carried out under the best achievable safety conditions. All those operations were successfully covered 24h/day for 5-7 days for week. In addition to the plant operations within Borexino, in the past three years the underground Laboratories as a whole have undergone a general upgrade including a lot of heavy works.

The described safety and global organization guaranteed also to keep the schedule and to maintain the extreme cleanliness mandatory for making the experiment work. As a result of this ten-year effort, in the summer of 2007 Borexino succeeded in being the first experiment world-wide having performed a real time measurement of low energy ^{7}Be solar neutrinos.