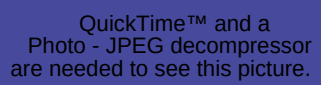
The INFN Gran Sasso Laboratory

Eugenio Coccia
coccia@lngs.infn.it

INFN Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali del Gran Sasso

CERN Council Strategy Group
Zeuthen May 2, 2006

Underground Laboratories



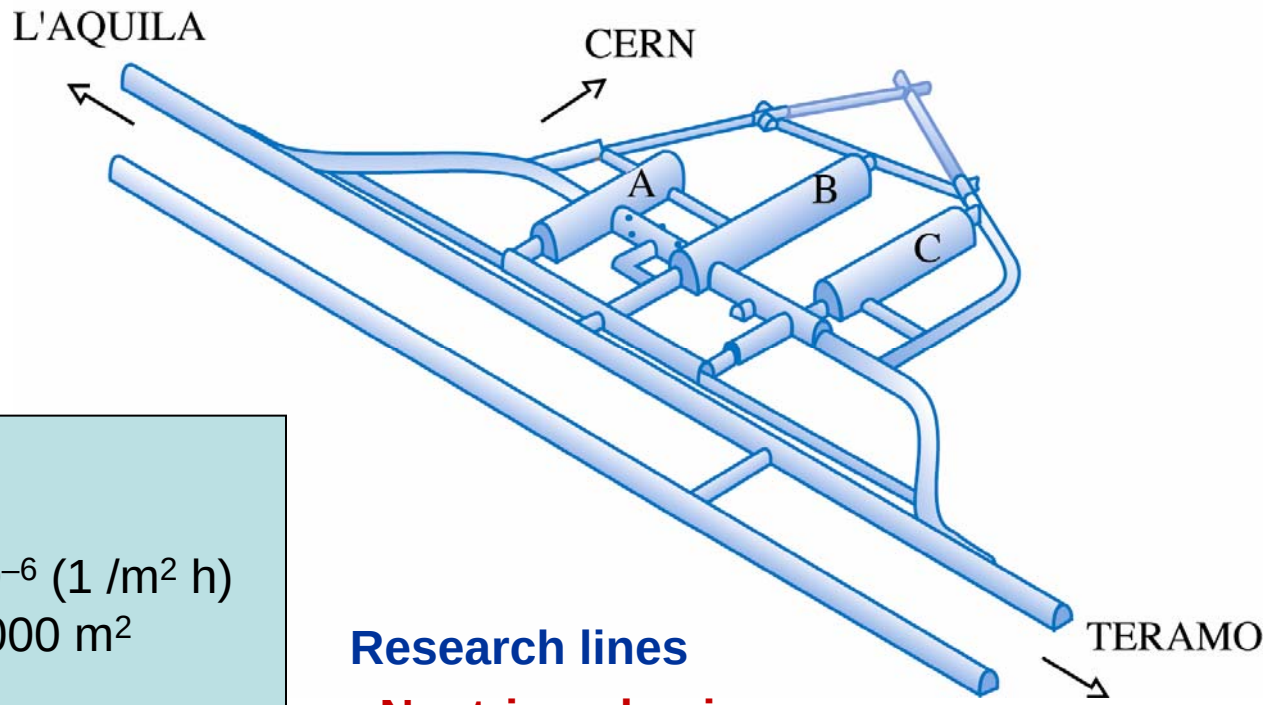
Very high energy phenomena, such as proton decay and neutrinoless double beta decay, happen spontaneously, but at extremely low rates. The study of neutrino properties from natural and artificial sources and the detection of dark matter candidates requires capability of detecting extremely weak effects.

Thanks to the rock coverage and the corresponding reduction in the cosmic ray flux, underground laboratories provide the necessary low background environment to investigate these processes.

These laboratories appear complementary to those with accelerators in the basic research of the elementary constituents of matter, of their interactions and symmetries.

LABORATORI NAZIONALI DEL GRAN SASSO - INFN

Largest underground laboratory for astroparticle physics

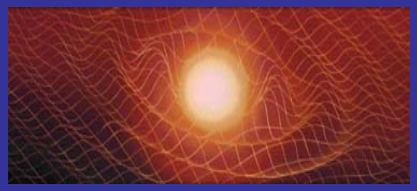


1400 m rock coverage
cosmic μ reduction= 10^{-6} (1 /m^2 h)
underground area: 18 000 m^2
external facilities
easy access
756 scientists from 24 countries
Permanent staff = 70 positions

Research lines

- **Neutrino physics**
  (mass, oscillations, stellar physics)
- **Dark matter**
- **Nuclear reactions of astrophysics interest**
- **Gravitational waves**
- **Geophysics**
- **Biology**


LNGS most significant results with past experiments
Evidence of neutrino oscillation
GALLEX / GNO - solar ν
MACRO - atmospheric ν
Unique cosmic ray studies
EAS-TOP with LVD



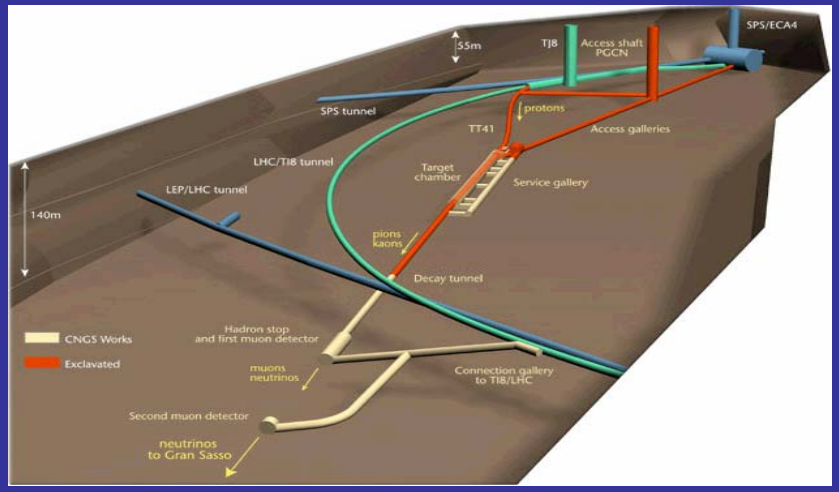
Gravitational Waves

Lisa test

ν beam from CERN:

OPERA

ICARUS



Fundamental physics

VIP

PRESENT EXPERIMENTS

ββ decay and rare events

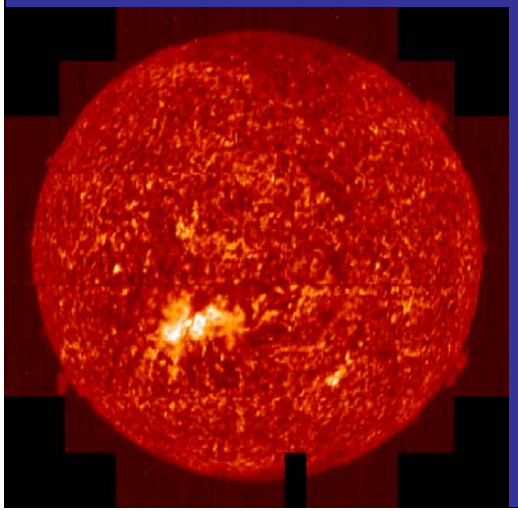
Cuoricino

CUORE; GERDA

Dark Matter

DAMA/LIBRA; CRESST

WARP; Xenon test



Solar ν

Luna

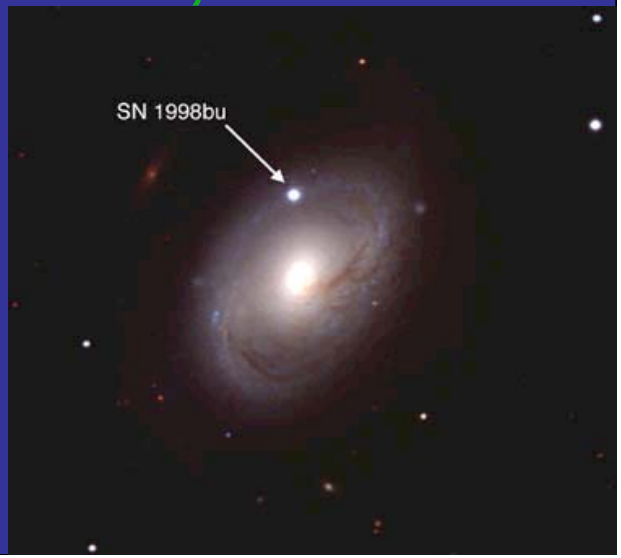
Borexino

ν from Supernovae

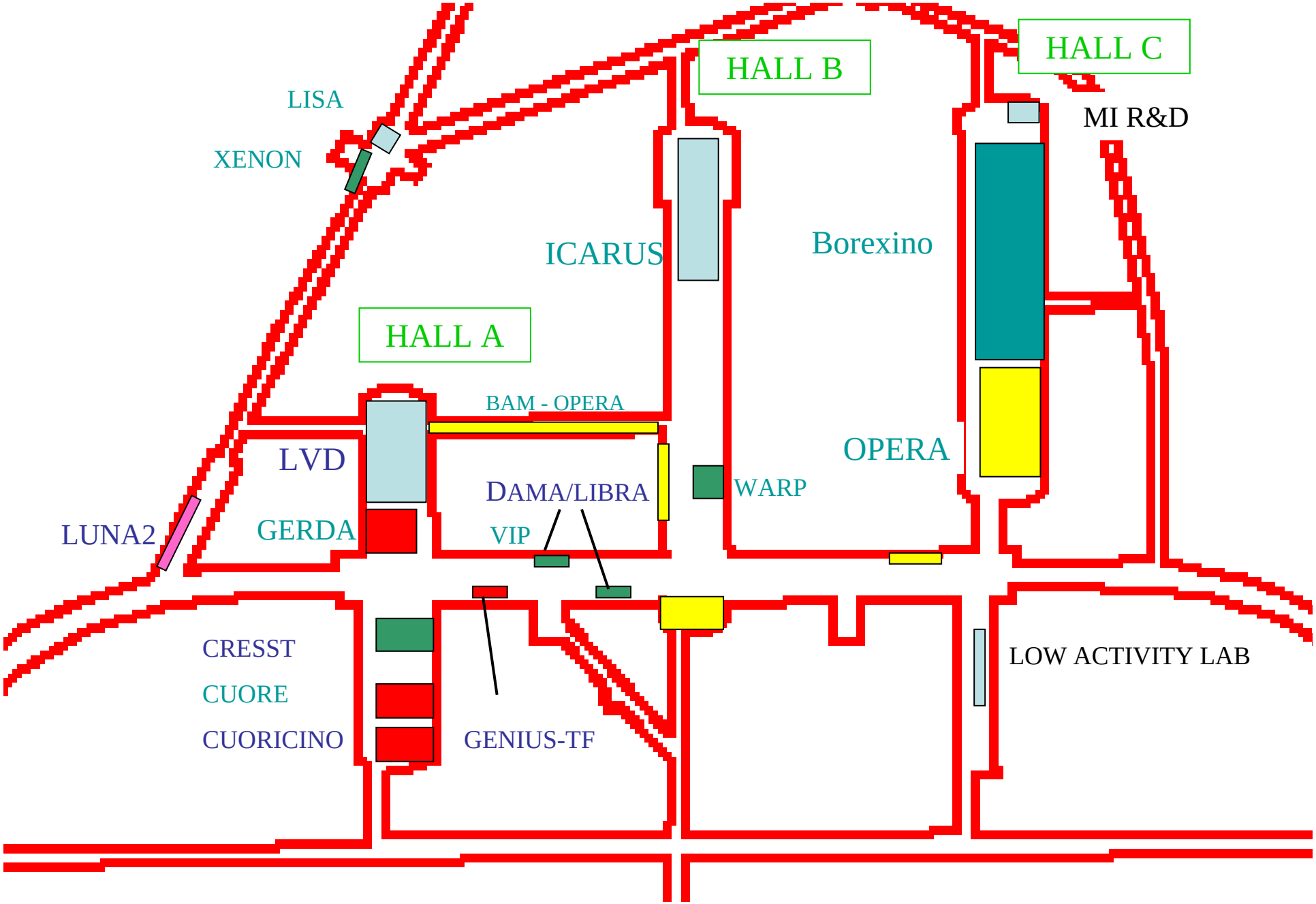
LVD

Borexino

ICARUS



Occupancy

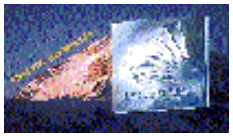

HALL C
HALL B
LISA
MI R&D
XENON
ICARUS
Borexino
HALL A
BAM - OPERA
LVD
OPERA
DAMA/LIBRA
WARP
LUNA2
GERDA
VIP
CRESST
CUORE
CUORICINO
GENIUS-TF
LOW ACTIVITY LAB

BOREXINO

A solar neutrino real time experiment using the neutrino-electron scattering reaction. One is mainly interested in the observation of the higher energy 7Be neutrinos, a monochromatic line at 863 keV. Recent issue: geoneutrinos.

LVD studies high energy cosmic rays and low energy neutrino bursts from SN explosions. It has a liquid scintillator sensitive mass of 1 kiloton.

OPERA will search for ν_μ-ν_τ oscillations with a long baseline τ appearance experiment in the approved CNGS neutrino beam from CERN to the Gran Sasso Laboratory. The ν_τ appearance is detected through its CC interactions and subsequent τ decay in emulsion films.

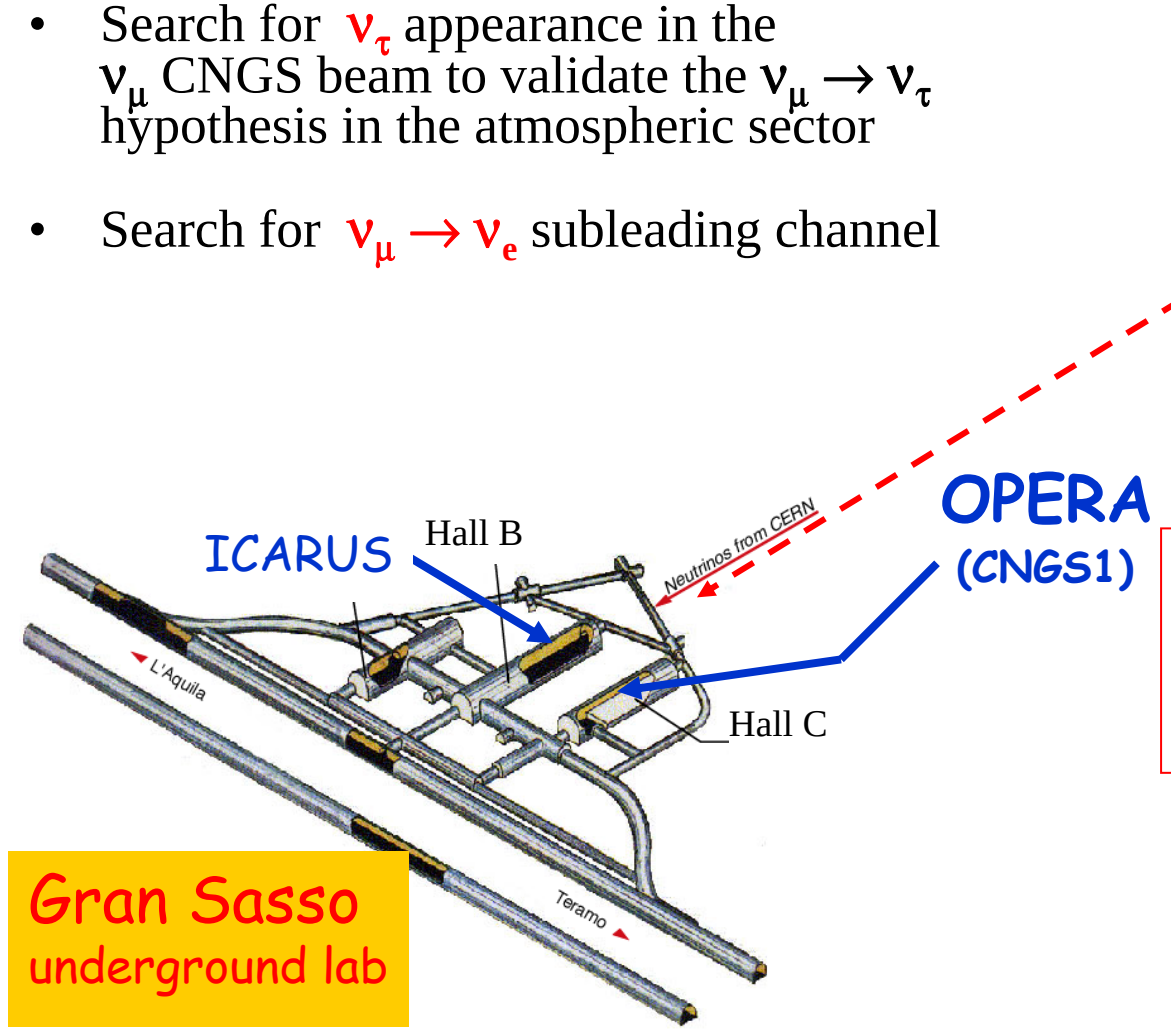


A self-triggering, high resolution, liquid argon calorimeter and tracker for studying neutrino interactions and proton decay.

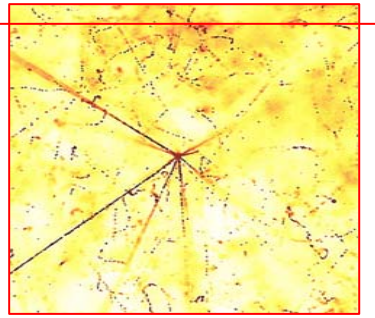
ICARUS

OPERA

- Search for ν_τ appearance in the ν_μ CNGS beam to validate the $\nu_\mu \rightarrow \nu_\tau$ hypothesis in the atmospheric sector
- Search for $\nu_\mu \rightarrow \nu_e$ subleading channel



Topological signature of the τ decay by using nuclear emulsions

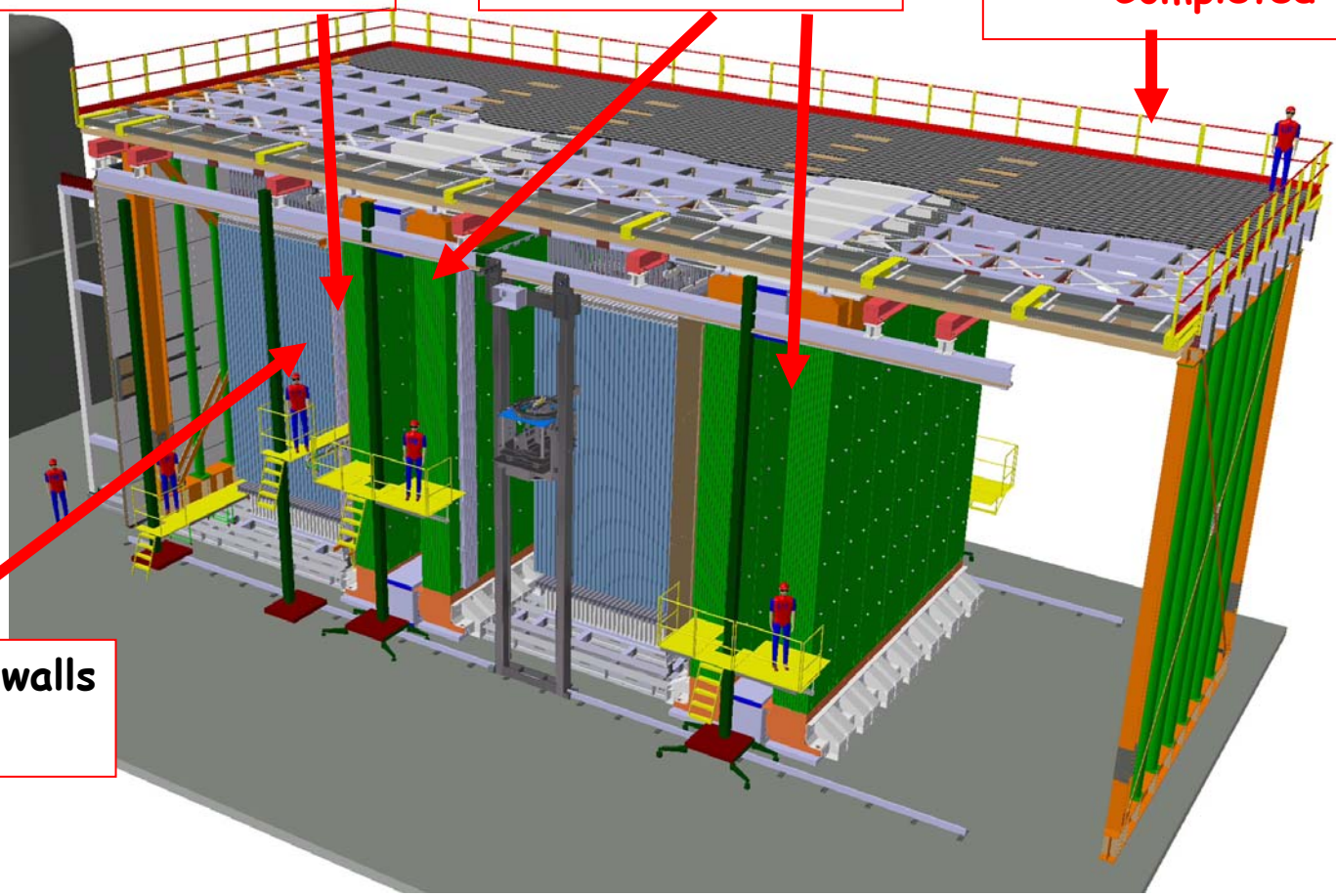


Status of the installation

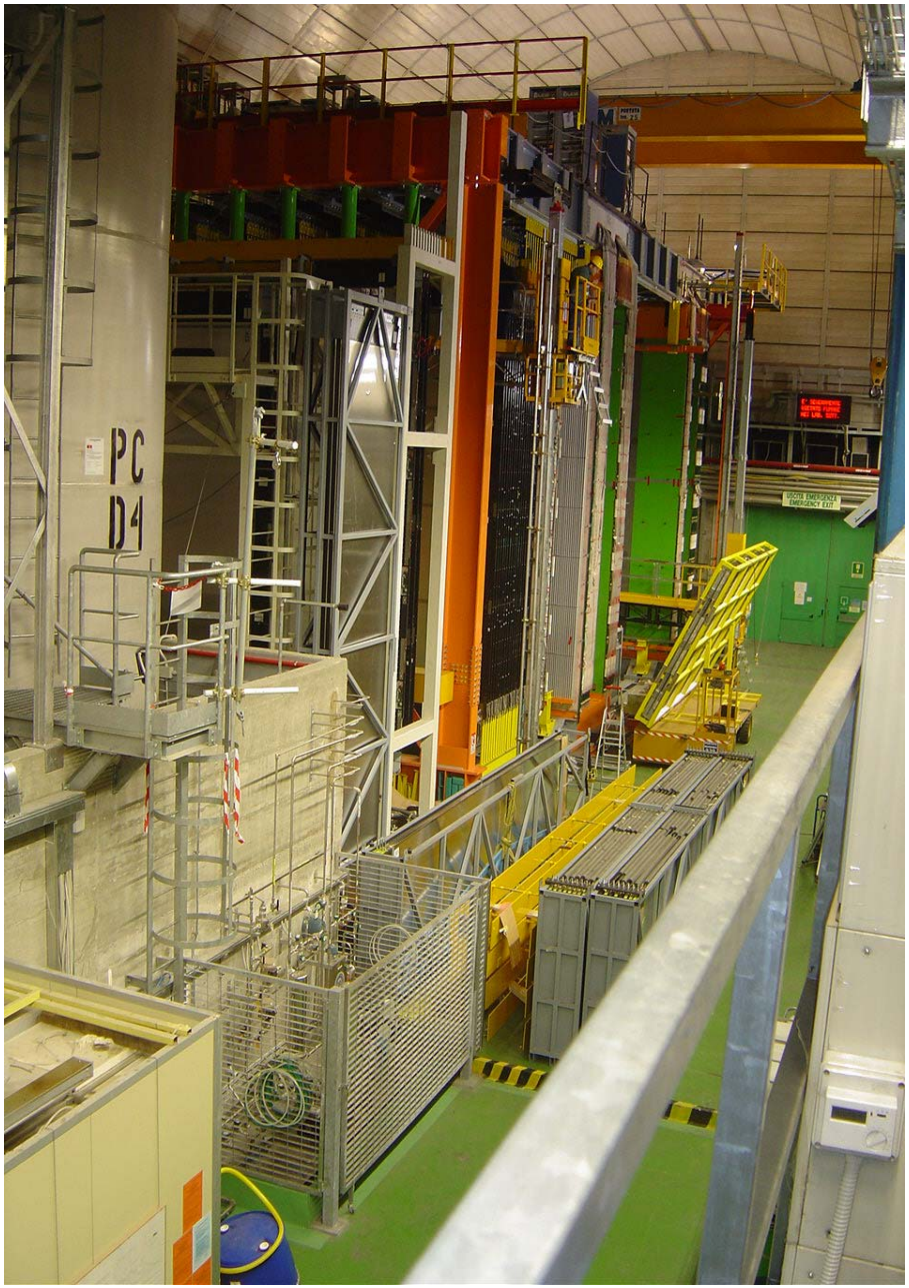
XPC 1&2 , HPT 1&2
Completed, Cabled

Magnet 1&2
Completed, cabled

Mechanical structure
Completed



26 TT & Bricks walls
Installed


PC
D4

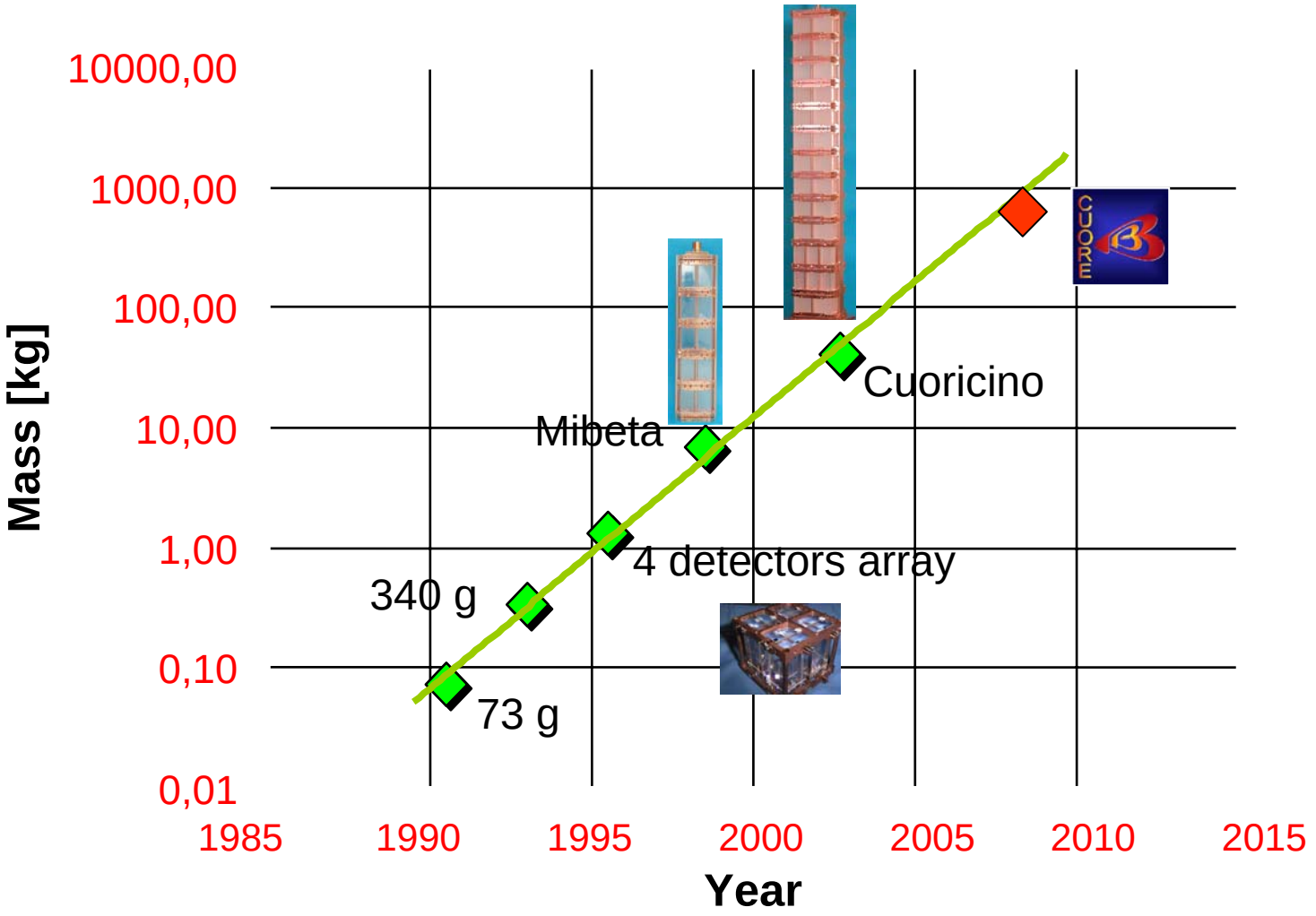
CUORE 400 kg cryogenic detector (now **Cuoricino** 42Kg) to search for double beta neutrino less events. ***Approved in 2004***

QuickTime™ e un
decompressore TIFF (LZW)
sono necessari per visualizzare quest'immagine.

The setup will probe the neutrinoless double beta decay of ^{76}Ge with a sensitivity of T1/2 > 10^{24} y at 90% confidence level, corresponding to a range of effective neutrino mass < 0.09 - 0.20 eV within 3 years.

Approved ***in 2005***

②


10000,00
1000,00
100,00
10,00
1,00
0,10
0,01
Mass [kg]
1985
1990
1995
2000
2005
2010
2015
Year
Cuoricino
Mibeta
4 detectors array
340 g
73 g

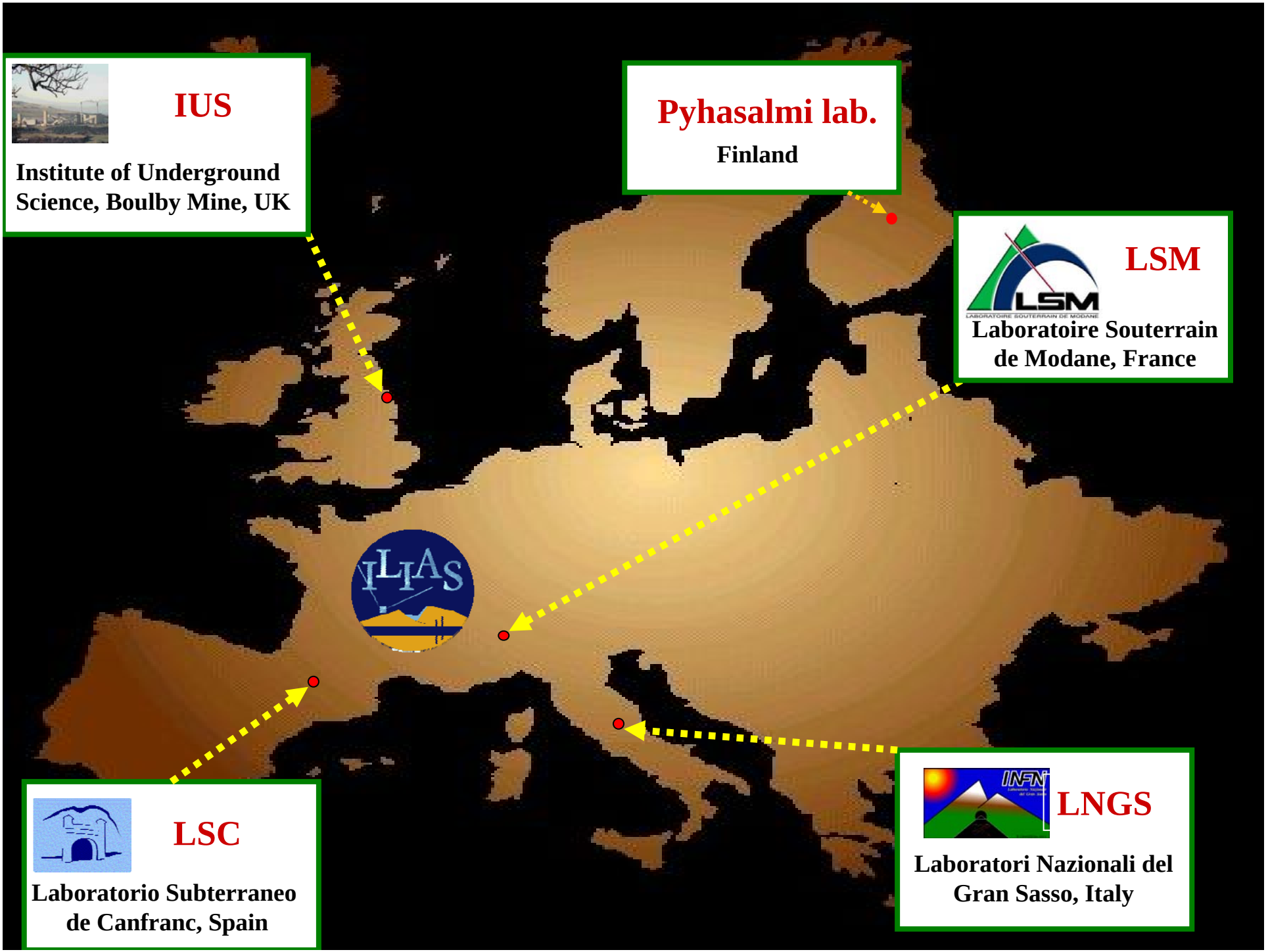
2004 - 2005 - 2006
Important safety and infrastructure upgrade of the Laboratory

- Floor waterproofing
- Realization of containment basins
- Safety measure for the drinkable water
- Upgrade of the ventilation system
- Upgrade of the cooling capability
- Upgrade of the electrical power

SAFETY

OUTREACH

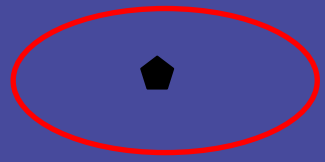
17000 visitors/year


IUS
Institute of Underground Science, Boulby Mine, UK
Pyhasalmi lab.
Finland
LSM
Laboratoire Souterrain de Modane, France
ILIAS
LSC
Laboratorio Subterraneo de Canfranc, Spain
LNGS
Laboratori Nazionali del Gran Sasso, Italy

Experimental activities in the ILIAS Deep Underground Labs

	LNGS	LSM	LSC	Boulby
Dark matter	DAMA/LIBRA CRESST HDMS/Genius-TF Cuore Warp, Xenon	Edelweiss I Edelweiss II	ANAIS ROSEBUD IGEX-DM	NAIAD ZEPLIN DRIFT
ββ decay	HD-Moscow MiBeta Gerda Cuoricino/Cuore	NEMO I-II NEMO-III TGV	IGEX-ββ	
ν astrophysics	MACRO GALLEX/GNO LVD Borexino			
ν long baseline	OPERA ICARUS			
Nuclear astrophysics	LUNA			
Proton decay		Frejus		
Other	Tellus, Ermes	SHIN		

QuickTime™ and a
Photo - JPEG decompressor
are needed to see this picture.



A new large European infrastructure for a detector 10^5-10^6 ton scale ?

Improved studies on proton decay, on low-energy neutrinos from astrophysical origin and possible detection of future accelerator neutrino beams

Three detection techniques being studied: water-Cherenkov, liquid scintillator and liquid argon

Worldwide efforts