LABORATOIRE SOUTERRAIN DE MODANE : STATUS AND PROJECTS AT FRÉJUS SITE

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The "Laboratoire Souterrain de modane", with a rock coverage of 4800 mwe, is one of the deepest underground laboratory in the world. It is currently sheltering experiments dedicated to fundamental research in physics and low radioactivity measurements applied to many fields. In this paper, the main characteristics, activities and performances of the lab are given together with a brief history. Short, medium and long term projects are sketched. More informations can be found on dedicated web sites.

1. Introduction

The "Laboratoire Souterrain de Modane"[1] has been running for more than 20 years. This underground laboratory is located in France in Savoie, almost exactly in the middle of the 12.6 km road tunnel between France (Modane) and Italy (Bardoneccia), at an altitude of 1263 m under the Fréjus peak culminating at 3000 m.

Excavated in 1981, it has been opened on december 1982 to host a single experiment, TAUP, a 900 T detector dedicated to the search of the decay of the proton. The size of the cavern was adjusted to the size of the planned experiment, namely a hall of about 30 m long by 10 m wide by 10 m high, plus additional smaller rooms. This German French experiment has been running for 5 years without detecting evidence for proton decay, but setting constraints on proton decay models.

Then the experiment was dismounted in 1988 and progressively, the lab hosted more and more activities requiring protection against cosmic rays and/or dedicated low radioactive environmental background.

The lab became a facility for many experimental programs. Since the beginning, it has been funded equally by IN2P3 (Institut National de Physique

Nucléaire et de Physique des Particules) of CNRS (Centre National de la Recherche Scientifique) and DSM (Direction des Sciences de la Matière) of CEA (Commissariat à l'Energie Atomique). Today, the lab is one of the 20 laboratories of IN2P3 in France. Three structures, the Steering Committee, the Scientific Council, the User group Committee constitute the bodies allowing proper running of the LSM.

The laboratory is currently hosting experiments in particle and astroparticle physics -dark matter and double beta decay searches, super heavy elements search- and low level gamma spectroscopy activities performed with 13 very low activity Germanium detectors.

As explained in the N. Ferrari talk in same proceedings, four european underground labs, Gran Sasso (Italy), Canfranc (Spain), Boulby (UK) and LSM laboratories are involved in a European Community program, ILIAS[4], dedicated to the coordinated development of underground infrastructures, low level measurements and background reduction techniques. This program has three main activities : networking, research and developmment and exchange of research teams. The LSM runs a dedicated program[5], centered on development of gamma ray Germanium detectors. This is in view of preparing next generations of dark matter and double beta decay experiments.

2. Main features and equipements of infrastructure

Main technical features are given in table 1.

Table 1. Main features of lab.

Depth	4800 mwe
Rock	Schistes lustrés
U content	about 1 ppm
Density	2.7 g/cm^3
Temperature of rock	32 deg
Total volume of lab	3300 m^3
Power consumption	60 kW
Air renewal rate	4800 m^3/h
Muon flux	4/m^2/day
Neutron flux	1.6 10^{-6} /cm^2/s (E $1MeV$)
Radon concentration	5 to 15 Bq/m^3

All the surfaces of the lab were covered with a low U/Th content concrete. This, together with the high renewal rate of the air allowed to obtain the very low rate of radon inside the lab. The air used to ventilate the lab comes from one of the 4 big road tunnel ventilation units drawing air through a 700 m high chimney from 2000 m altitude mountain.

A special radon reduction device has been installed recently in the laboratory. Though the radon content is quite low, it is still too high for the NEMO3 experiment, who is searching for double beta decay events. A tent has been built around the detector and de-radonised air is sent within the tent to reduce the migration of radon through the joints inside the detector volume. The 150 m^3/h flushed through NEMO3 are produced by compressing, drying, cooling and pushing air in two 500 kg active carbon towers. This system is similar to the one used by SuperKamiokande to produce the air above the water inside the 50kT tank.

Thanks to the optmised cooling unit, which temperature drives the performance of the radon trapping, radon concentration was brought from 5-10 Bq/m^3 down to about 10 mBq/m^3.

All parameters of the lab -temperature, pressure, input air flux, O_2 N_2 CO NO concentrations, radon level and various controls- are now continuously monitored and available on a dedicated web page.

The lab is equipped with an early fire detection system, allowing a prompt detection and triggering the intervention of the firemen within 6 mins.

Access to the lab is done with dedicated vehicules equipped with safety lights and external paintings. According to safety rules defined by the company running the tunnel, the SFTRF, only two cars can park in front of the lab and 17 people can be simultaneously present in the lab at any moment.

Outside facilities are situated in the town of Modane : offices, computer network, storage and mechanical workshop, liquid nitrogen tank, small housing unit run by the lab.

The operational staff is composed of a team of about 10 people, 1 director and deputy, 1 post doc, 1 technical and administrative manager, 1 administrative assistant and 4 technicians.

3. Scientific activities

The figure 1 shows the implantation of the experiments in the main hall and in the dedicated rooms for the Germanium detectors.

Current status of running experimental programs is described in the

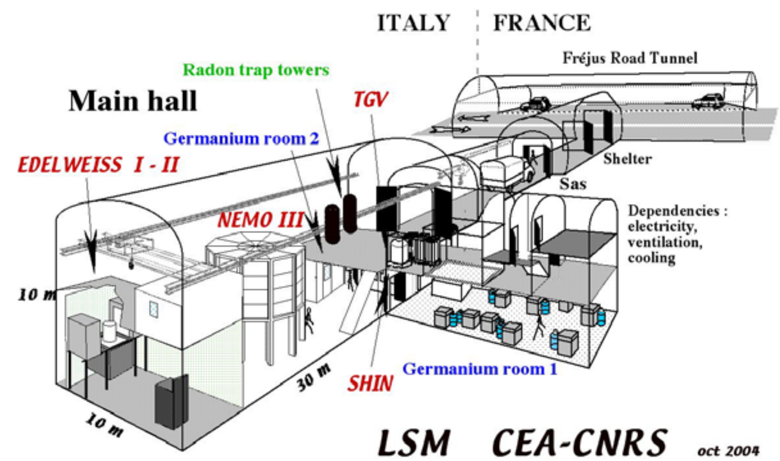

Figure 1. Implantation of experiments in laboratory.

following.

Dark Matter search under the form of WIMP particles is performed by the EDELWEISS[2] collaboration, gathering laboratories from France, Germany and Russia. The first phase of this experiment, EDELWEISS 1, used three Germanium heat-ionisation bolometers of masss 320 g each operated in a dilution refrigerator at 20 mK, made with low radioactivity materials inside shields of lead copper and parrafin. With such twin measurements, most of the residual electromagnetic background can be differentiated and rejected. This allowed to obtain the best world wide sensitivity in 2002 to spin independant coupling WIMP's. The set up has been dismounted these last months to allow for the installation of the second version, EDELWEISS II, which will involve in a first step, 28 detectors in a much larger volume cryostat. End of installation and start of tests are expected to take place in summer 2005. Ultimateley, this refrigeretor will be able to accomodate up to 30 kg of detectors, the largest capacity among the competitors in the 4 to 5 years to come.

NEMO3[3] is the third and largest avatar of a series of "traco-calo" detectors for the double beta decay search. The NEMO collaboration involves laboratories from France, Russia, Czek republik, UK, Finland, USA, Japan. The tracking detector, composed of drift wire chambers operated in Geiger mode allows to identify electron tracks while plastic scintillators measure their total energy. With about 7 kg of Molybden 100 and 0.9 kg of Selenium 82, and other isotope small masses samples, the detector is triggered by "allowed" 2 neutrino double beta decay events at a rate of 0.7 evt/min !

Sensitivity to double beta decays without neutrino was limited until recently radon induced background, from the air surrounding the detector. Now equipped with an air tight "tent" flushed with radon free air -see section 2-, NEMO3 is in the best position to take data and hope to set an upper limit of .2-.35 eV to the effective mass of the neutrino, in a five year run.

TGV (Telescope Germanium Vertical) is a detector designed and built by a collaboration involving Russian, French, Czech, Slovakia laboratories. Combining advantages of excellent energy resolution of semiconductors and identification power of tracking devices, this "telecope", composed of a stack of 32 Germanium detectors of 60 mm diameter can only accomodate 10 to 20 grams of materials in between the detectors. Very rare isotopes are thus the target of such a detector. After setting a limit on Calcium 48 with the TGV1 set up with a 1 g sample, the detector has been upgraded for low energy event detection with the goal of observing for the first time double electron capture process in Cadmium 106, with a 10g sample. The data taking should start in the coming months.

SHIN experiment is a new experiment recently installed in the lab to search for the presence of super heavy elements in nature. Designed and built by a Russian team from Dubna, this detector will search for multi neutron production from fission of superheavy element 108 in a 500 g sample of Osmium (chemically close to the searched element. The detector is composed of 60 ^{3}He counters in a 50 cm diameter, 1 m long cylinder filled with paraffin. With this set-up, a sensitivity to the presence of such element of 10^{-22} g/g in earth material can be achieved in one year, assuming that its half life is 10^{9} years.

In addition to these particle physics experiments, a 15 year long tradition in low level gamma spectroscopy has led the lab to shelter 13 ultra low level gamma ray measurement Germanium detectors. These detectors, belonging to 5 differents users, are used for the material selection for physics experiments (NEMO and EDELWEISS), for the environmental control (2 national institutions), and for various scientific and dating applications (Oceanography, climatology, geology, Bordeaux wine dating ...). Among them are 400 CC detectors with background of order of 1 count/day at most natural isotopes lines and two 1000 CC well type detectors.

4. Projects

The next version of the Edelweiss set-up will require a much larger electric consumption, 80 kW instead of 15 kW. This is essentially due to the fact that this innovative cryogenic device will generate its own cold by pulse tubes and ^{4}He liquefier, without, in principle requiring feeding with cryogenic liquids. The operation of the radon trapping device induces also a large increase in the power consumption of the lab. This has led us to redefine the actual cooling system, unable to handle such a dissipation of heat. The new cooling system will use as cold source the air of the tunnel and will have a 300 kW cooling power. This is going to be installed in 2005.

Another project for next years is the building of a new single infrastructure in Modane, which will shelter the offices, the storage hall, the mechanics and chemistry workshops, accomodations for a few guests and a sizeable hall for outreach and mediation, part of a local scientific tourist network.

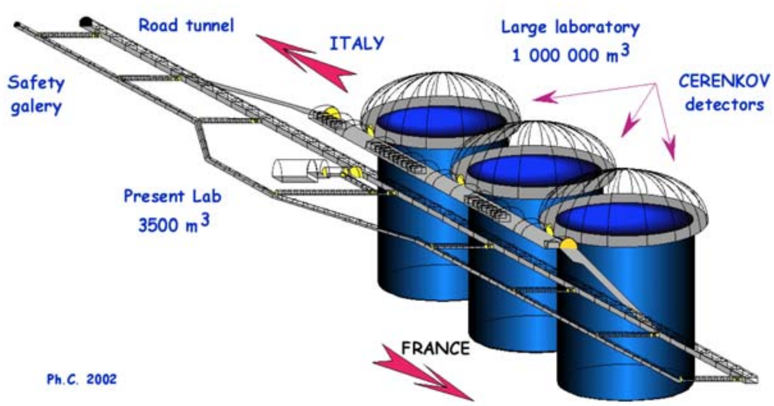

Figure 2. An artist view of what could a Megaton detector along the road tunnel.

A longer term project of a water megaton size detector installed under the Frejus mountain has received special attention these last years. Such a multipurpose detector for rare event search -proton decay, supernova watch- would have also the virtue of contributing to a very sensitive measurement of the mixing angle theta 13, by detecting neutrinos from with a few hundred MeV neutrino beam sent from CERN. Beside the scientific interest and ideal distance from CERN, the Frejus location offers specific advantages : known and good quality of rock, horizontal access by car through possibly shared security tunnel, central location in Europe, fast access by TGV train, highway, closeby airports, nice surroundings for snowboarding in winter and climbing in summer.

This very short introduction does not reflect the amount of work already done by the working groups[6] at CERN and in Europe. The coming NNN05 workshop[7], held in Aussois, 5 km away from Modane, on april 5th to 9th 2005 will be an occasion to gather the world wide community interested in nucleon decay and neutrino studies with large detectors.

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