Institute of Physics Publishing Journal of Physics: Conference Series **39** (2006) 157–159
doi:10.1088/1742-6596/39/1/037 TAUP 2005: Proc. Ninth Int. Conf. on Topics in Astroparticle and Underground Physics

The low noise underground laboratory of Rustrel-Pays d'Apt

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Abstract. The *Laboratoire Souterrain Bas Bruit (LSBB)* in Rustrel-Pays d'Apt, west of Avignon (France) presents a unique combination of environmental and technical characteristics in terms of anthropic activity, seismological noise, gravity, and electromagnetic shielding. Rustrel is the site of activity for small and medium experiments requiring ultra low-noise conditions in various scientific domains, astroparticle physics being one of them.

The creation of the "Laboratoire Souterrain Bas Bruit" (LSBB) is the product of a time coincidence between the search for an acoustically quiet surrounding for the SIMPLE experiment (Superheated Freon Droplet WIMP detectors) and… the decommissioning of the former underground launching control center n°1 of French nuclear missiles. The fact that there is no traffic two kilometers around the deepest zone of the laboratory as well as the absence of any industrial activity and no mechanical or mining activity in the site itself were of course the first justifications for calling Rustrel a low noise laboratory. This zone is at the center of a 3 km long gallery (figure 1) below 1500 m.w.e. It is an average value for shielding against cosmic muons (figure 2) but already at depth over some tens of meters, the dominant factor is the neutron flux from the rock (figure 3). The calcite rock radioactivity is dominated by traces of ^{226}Ra (0.64 Bq/kg) and ^{137}Cs (0.43 Bq/kg), whereas the radon rate in the gallery atmosphere is 28 Bq/m^3, a normal value for ventilated galleries [1].

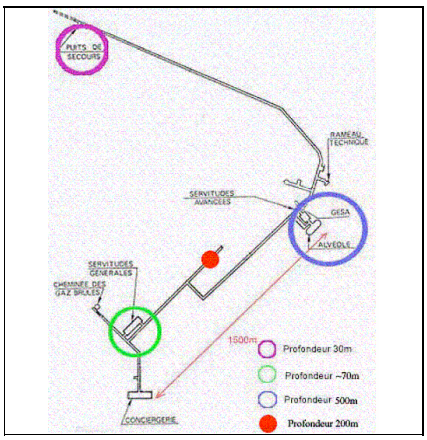

Figure 1. Overall view of the LSBB galleries. The deepest zone at the centre of the system, is a collection of rooms of various dimensions. The spin dependent dark matter detectors are installed in this zone, whereas the command control is at the entry of the laboratory. The total length of the galleries is more than 3 km and 3.6 m wide. The entry of the LSBB is at the bottom of the graph, whereas the upper branch is an emergency exit. The surface domain of the laboratory is an area of 54 hectares, 4 of them at the summit of the "Grande Montagne" at the vertical of the central zone, connected to the later by waveguide, coaxial cable and optical fibres.

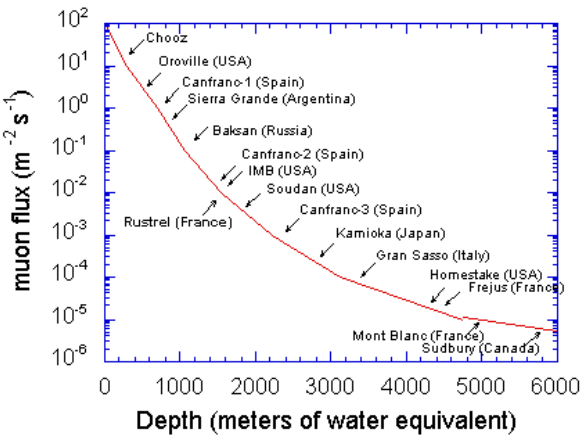

Figure 2. Muon flux in Rustrel.

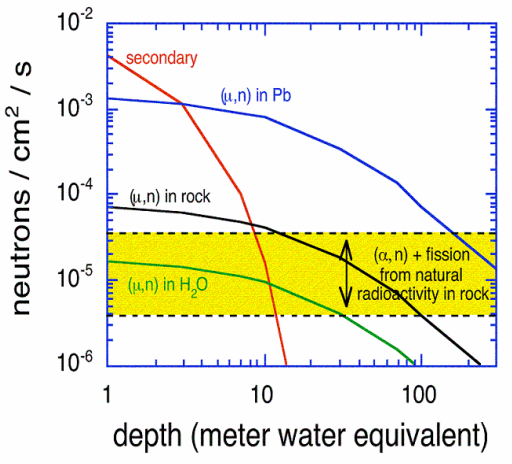

Figure 3. Neutron flux versus depth.

Geologically speaking, Rustrel is within the unsaturated layer of the Plateau de Vaucluse karstic system (fractured calcite), one of the largest in Europe and known for the Fontaine de Vaucluse resurgence. Although this area has an historical record of seismic activity, the first indication of the exceptional character of the environmental calm of this site was given by the observation of an ultra quiet seismic spectrum (figure 4) which is attracting for many seismologists and earth science specialists. The seismic station RUSF is a permanent observation point of international seismic networks.

This extreme calm is confirmed by the stability of the precision of the absolute measure of gravity g: better than 25 nanoGal over 80 hours [1]. This indicates that LSBB is far from any human noise source, but also that within the underground surrounding the laboratory there is no sudden variation of large water masses from one eventual reservoir to another, as it can happen in a karstic system.

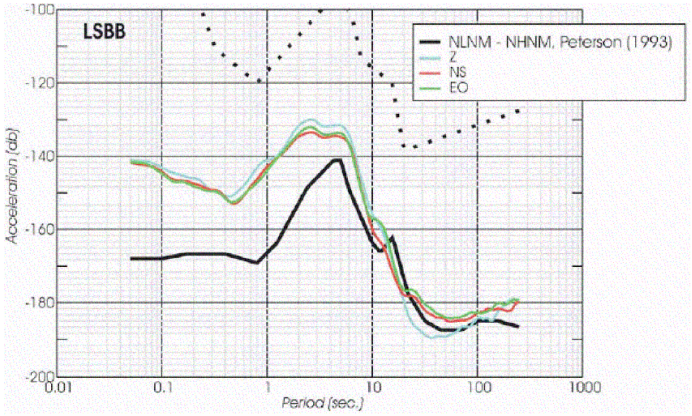

Figure 4. The LSBB seismic spectrum at 1500 below m.w.e. The three continuous traces are the spectrum for each component of a wideband seismometer. At periods longer than 8 seconds, these traces are almost superposed to the thick line representing the envelope of the minima recorded everywhere in the world according to Peterson. At higher frequencies the LSBB spectrum is always less than 30 dB from this envelope of worldwide minima.

These exceptional natural characteristics are combined with an unusual feature for an underground laboratory: the former command control centre itself. It has been designed in order to remain operational in case of near by high power explosions inducing strong shockwaves and even to the electromagnetic pulse associated with a nuclear explosion. The resulting structure in an horizontal

capsule 28 m long, 8 m in diameter with a 2 cm thick steel wall surrounded by a 2 m thick reinforced concrete coffin. At the center of this capsule a 100 m^2 cabin able to be carry 100 tons of equipment is suspended with pneumatic jacks and resting on shock absorbers (figure 5). The efficiency of this

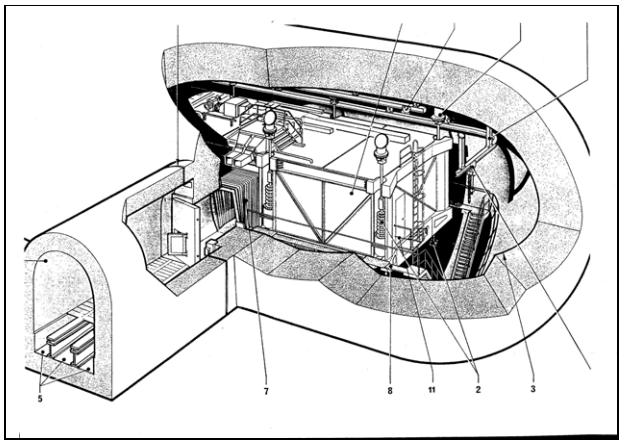

Figure 5. Blown up view of the capsule; the total volume is 1250 m^3.

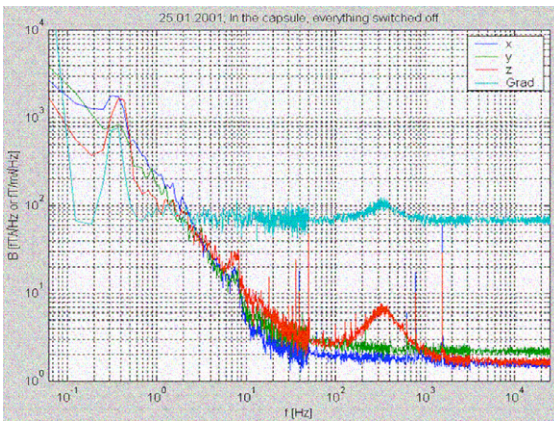

Figure 6. Electromagnetic noise in the capsule above 10Hz; the baseline is $2fT/\sqrt{Hz}$.

electromagnetic shielding was evaluated with a 3 axis SQUID magnetometer installed on the cabin floor [2]. The capsule is a low-pass filter with a 10 Hz cut-off frequency above which the electromagnetic noise is lower than $2fT/\sqrt{Hz}$, noise baseline of the SQUID, This competes with the new zero gauss chambers in PTB Berlin but in Rustrel we are not in zero field since there is no μ metal in the walls and the volume is 1250 m^3 against 27 m^3. Earth magnetic field fluctuations induced by the arrival of seismic waves have been recorded from an earthquake of magnitude 6.7 at more than 6200 km from Rustrel. As a result a permanent SQUID magnetometer is now operating, to analyse the these magneto-seismic signals and control the noise level in the capsule (figure 7).

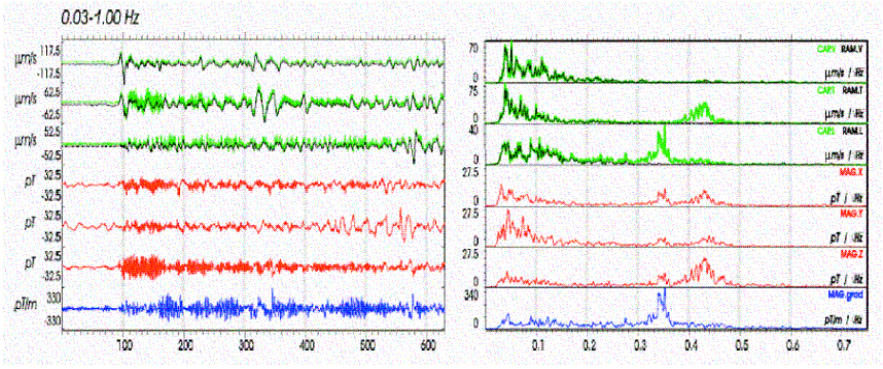

Figure 7. Seismic and magnetic raw signals in the LSBB capsule for the January 26, 2001 Indian earthquake. The full analysis is in [2]: (left) time variations, (right) deduced spectra.

References

[1] The raw radon data are available on the LSBB web site: http://lsbb.unice.fr/

[2] Gaffet S, Guglielmi Y, Virieux J, Waysand G, Chwala A, Stolz R, Emblanch C, Auguste M, Boyer D and Cavaillou A 2003 *Geophys. J. Int.* **155** 981