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THE GRAN SASSO PROJECT

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1. INTRODUCTION

During two days of work, you have been discussing a series of very interesting topics. This afternoon I was told that the projection on the real axis of many of these dreams is the new project called "Gran Sasso".

The purpose of this lecture is to report on the basic features of this laboratory, its aims, and the present status.

There is a happy coincidence which will allow the community of physicists from all over the world to have such a facility available: it is the first time that an underground highway is built, but not finished, before the site for a large laboratory can be excavated. If a similar coincidence would have occurred, for example, with the Fréjus or the Mont-Blanc tunnels, we would already have had the laboratory.

2. THE BASIC FEATURES OF THE "GRAN SASSO" LABORATORY

The "Gran Sasso" is a mountain located near Rome. Its schematic profile is shown in Fig. 1: the underground laboratory is shown in black; the horizontal lines indicate the highways, already excavated. The

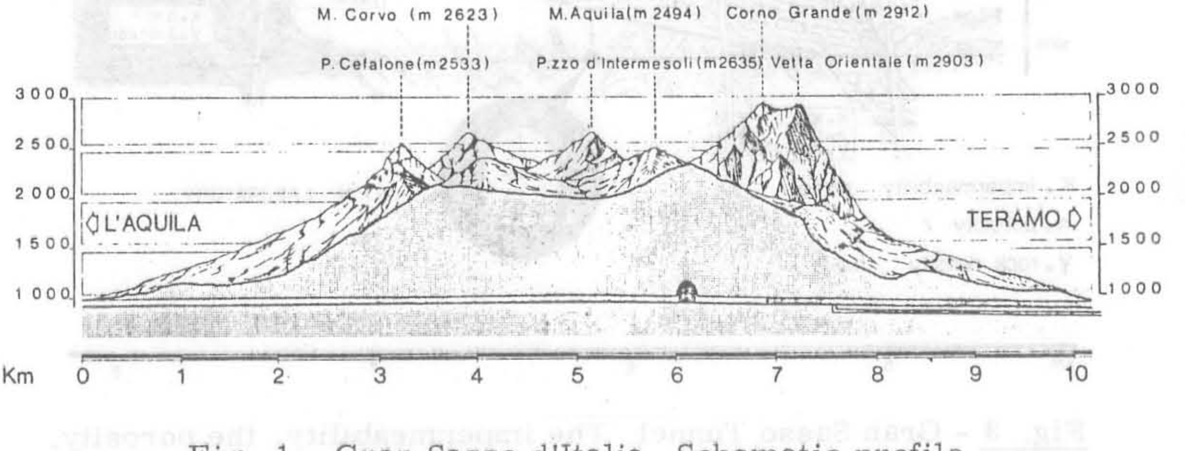


Fig. 1 - Gran Sasso d'Italia. Schematic profile.

structure of the mountain in terms of its main constituents -- detritus, limestone, dolomite -- is shown in Fig. 2, where again the INFN laboratory is indicated. The impermeability, the porosity, and the rock density of the various strata are illustrated in Fig. 3. There are at present two alternatives being considered.

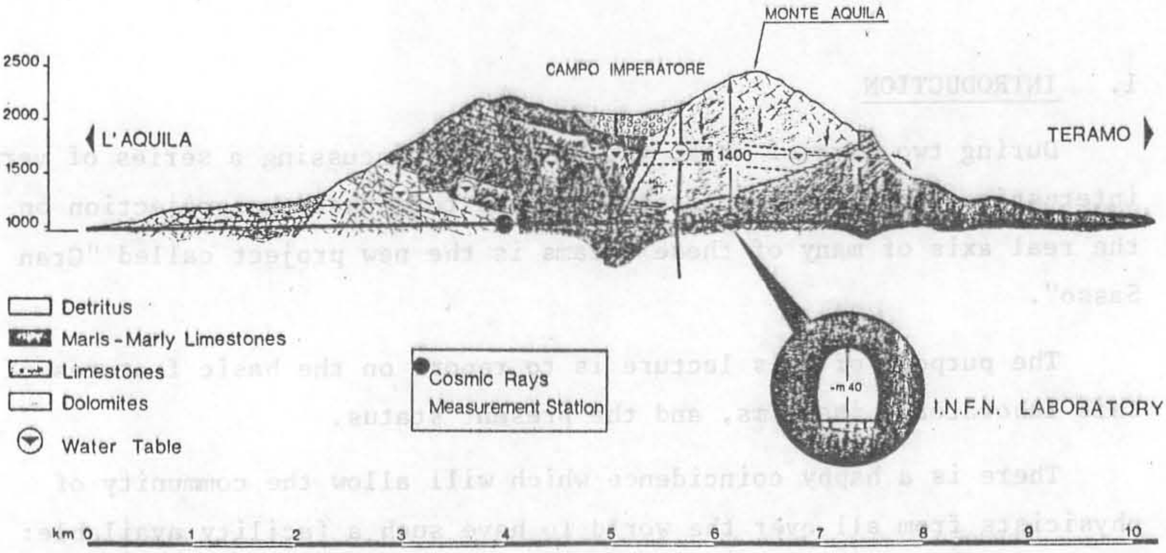


Fig. 2 - Gran Sasso Tunnel. Geological profile.

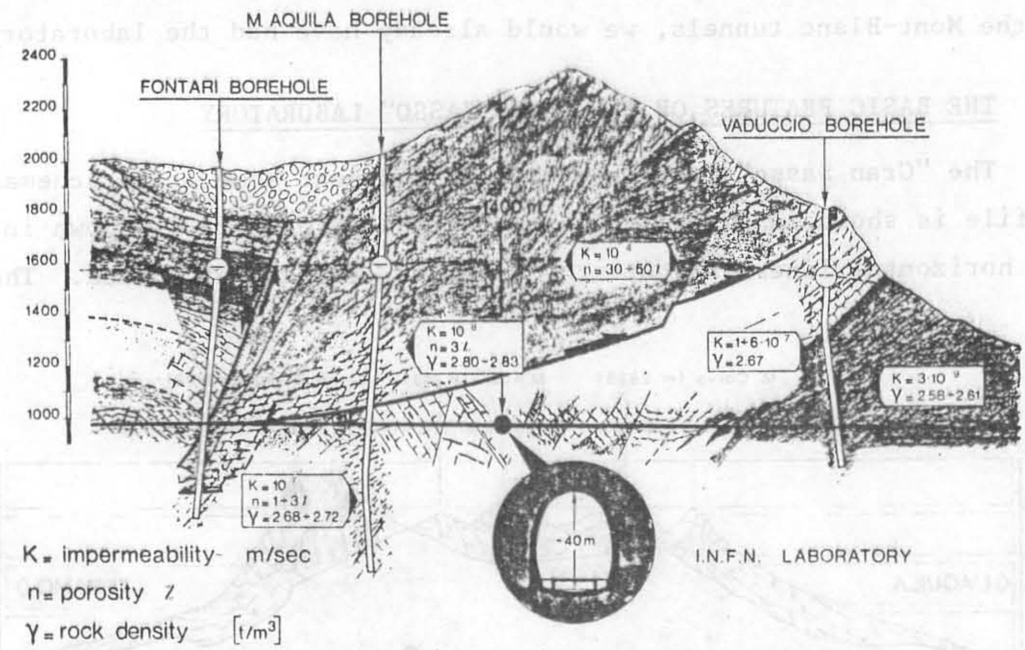


Fig. 3 - Gran Sasso Tunnel. The impermeability, the porosity, and the rock density of the various strata.

2.1 The first alternative

The laboratory dimensions are $(80 \times 20 \times 25)\ m^3 = 4 \times 10^4\ m^3$. How the laboratory is located in the general structure of the mountain is shown in Fig. 4, where the schematic plans and the profile of the mountain, the highways, and the laboratory are also given.

Notice that the underground laboratory is connected to the highways by means of two types of bypass. The location of the guest rooms and that of the offices (library, workshop, small lecture hall) are also indicated in the same figure.

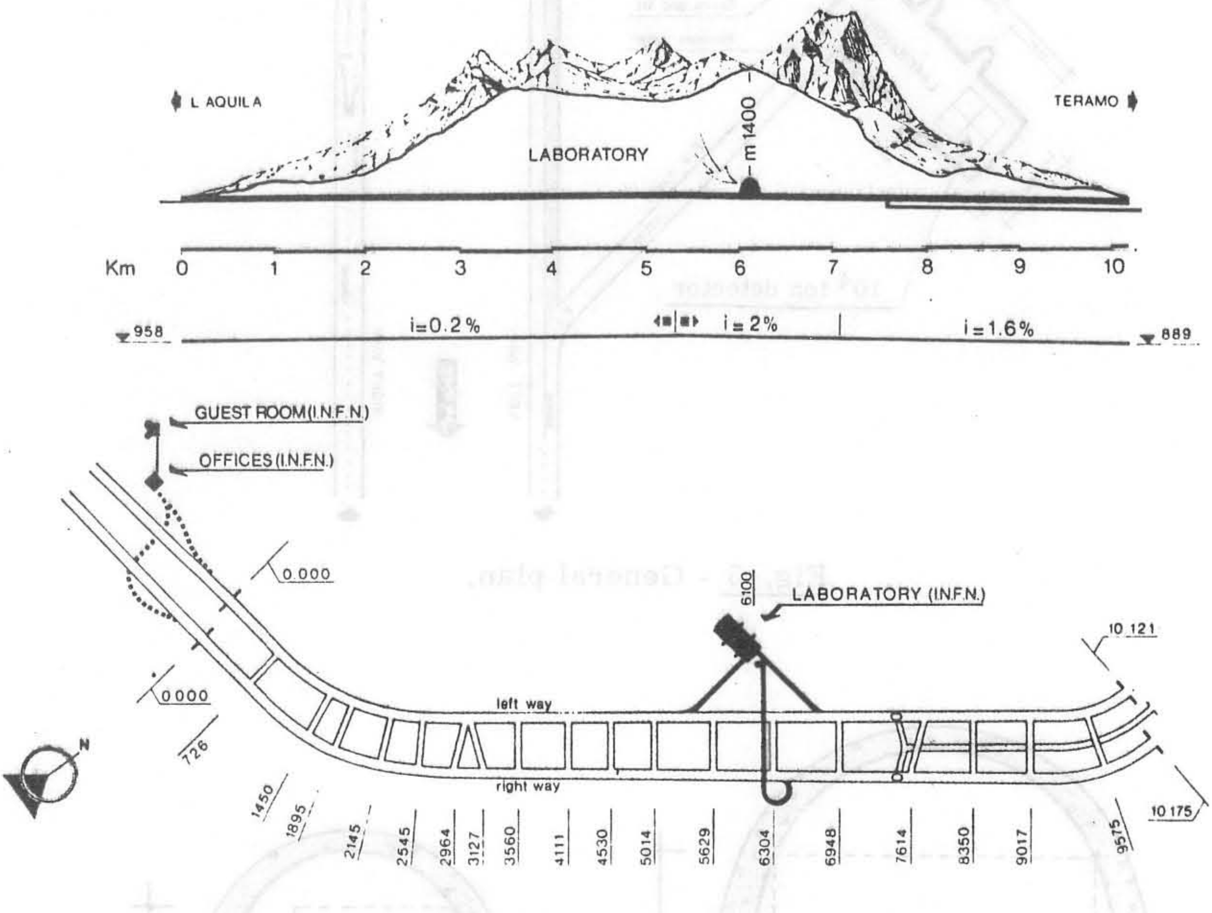


Fig. 4 - Schematic plan and profile.

A general plan of the laboratory and of its connection to the outside world is shown in Fig. 5. The "access" and "exit" tunnels are for heavy weights and large lorries; the "service" tunnel is for everyday use. The "access", "exit", and "service" tunnels are planned so as not to interfere with the main traffic. The main parameters of the "access" and "exit" tunnels are indicated in Fig. 6, where the cross-section is shown; the standard section of the "service" tunnel can be seen in Fig. 7. A more

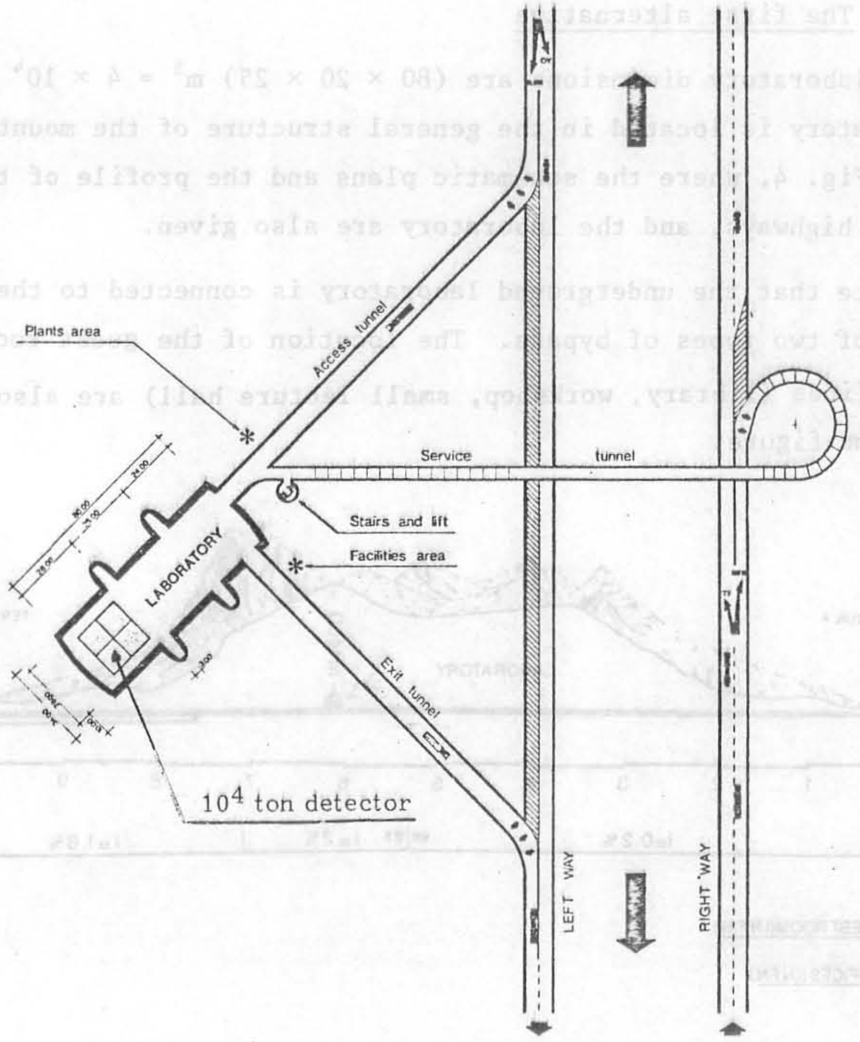
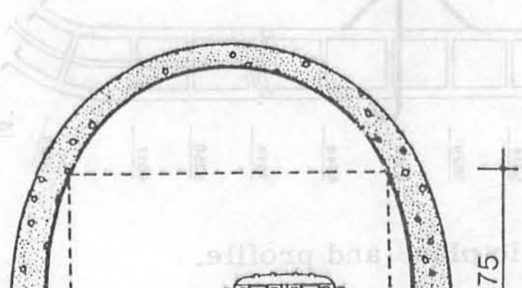


Fig. 5 - General plan.



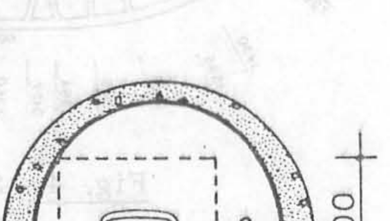


Fig. 6 - Access and exit tunnel. Standard section.

Fig. 7 - Service tunnel. Standard section.

detailed plan of the laboratory is given in Fig. 8, where the area occupied by a 10^4 ton detector is shown. Notice the large area that will remain available for other purposes, and also the four recesses. A longitudinal section of the laboratory (Fig. 9) shows the proposed location of the underground site, with respect to the highway tunnels. Also, compare the dimensions of the large lorry with those of the 10^4 ton detector. Details concerning the working plant and the connecting shaft to the service tunnel are shown in Fig. 10. A "standard" section of the laboratory is illustrated in Fig. 11, where, again, the 10^4 ton detector is schematically drawn. The laboratory cross-section through the recesses is shown in Fig. 12.

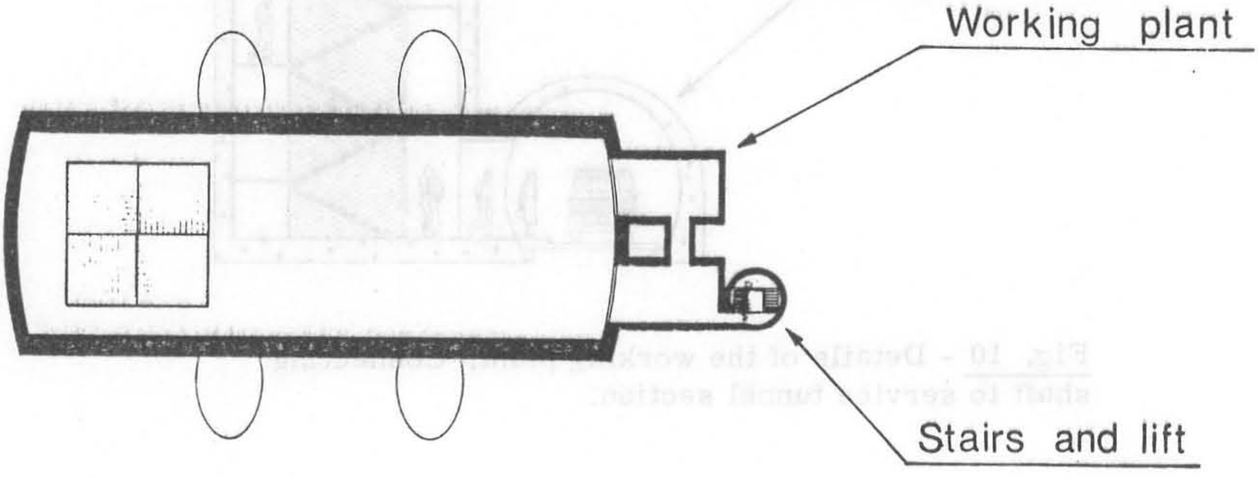


Fig. 8 - Working plant. Plan.

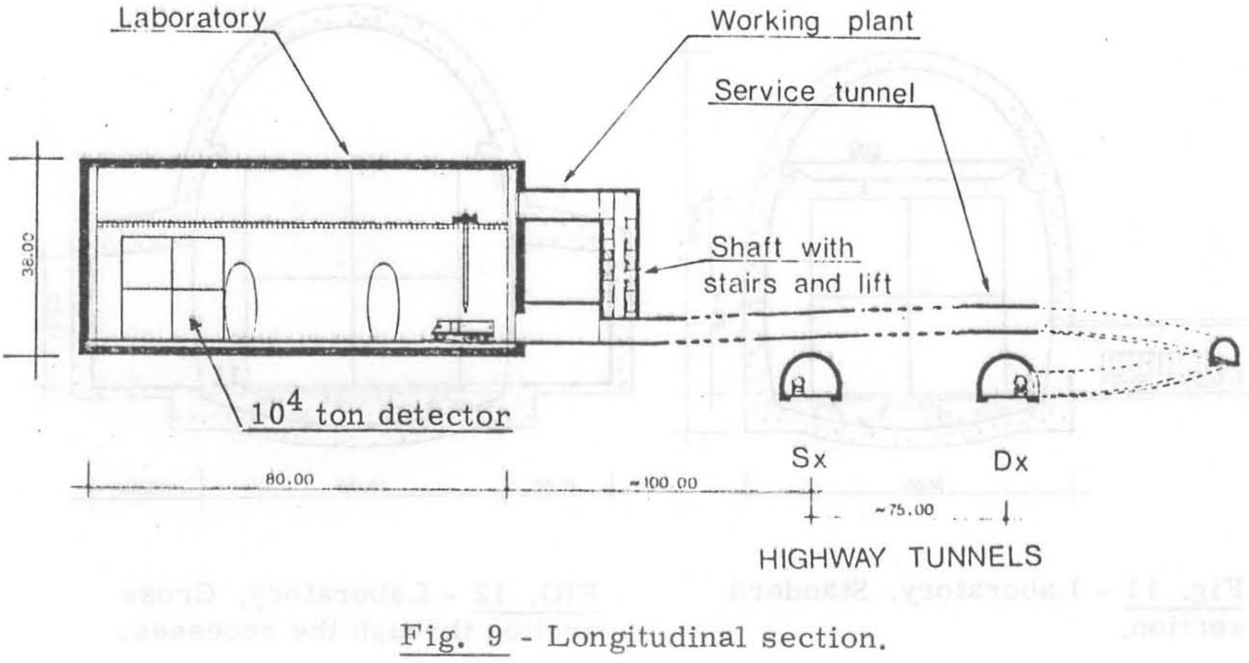


Fig. 9 - Longitudinal section.

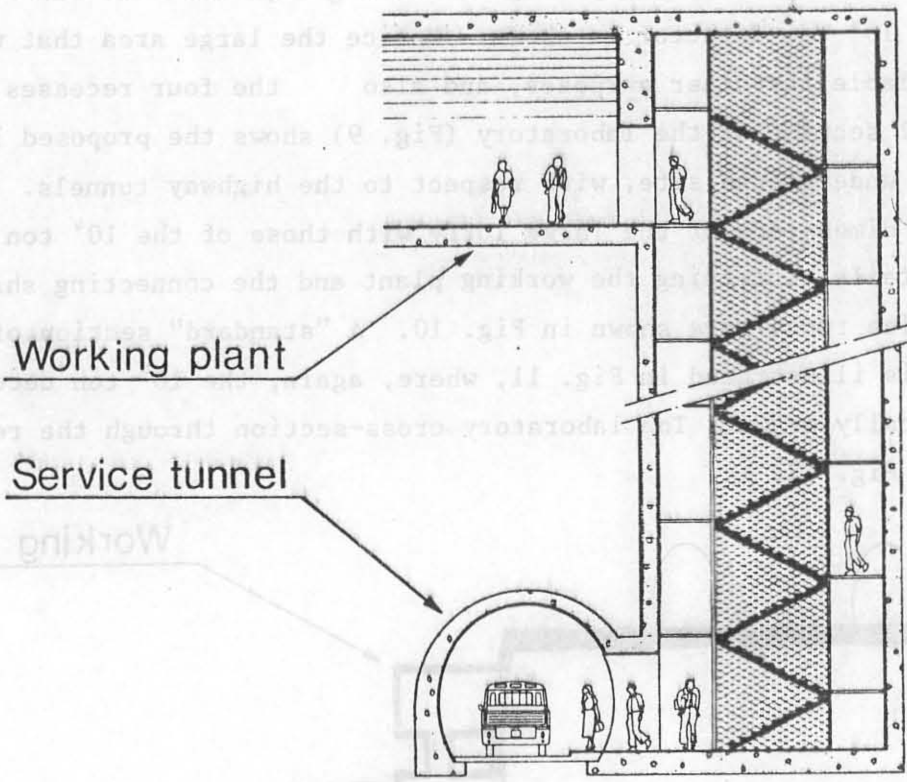


Fig. 10 - Details of the working plant. Connecting shaft to service tunnel section.

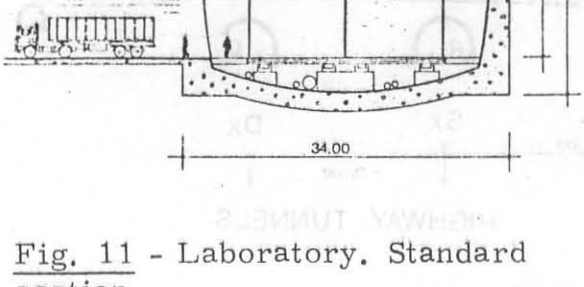


Fig. 11 - Laboratory. Standard section.

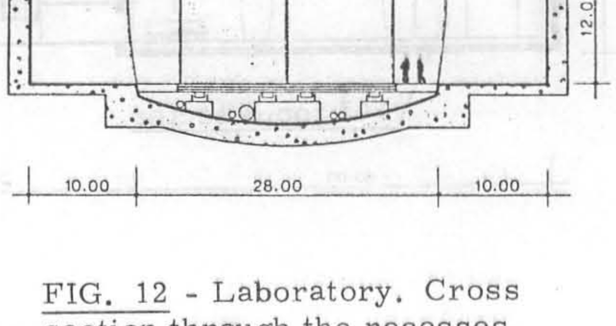


FIG. 12 - Laboratory. Cross section through the recesses.

2.2 The second alternative

This second alternative has in fact been studied at the very beginning of the project. The length of the laboratory would in this case be 100 m, instead of 80 m. The other dimensions would remain as in the "first alternative"; therefore the laboratory dimensions would be

$$(100 \times 20 \times 25)\ m^3 = 5 \times 10^4\ m^3 .$$

The details of this "alternative" are shown in Fig. 13. Notice that the "access" and "exit" connections would be more efficient in this case. There is no need for a "service" tunnel because the connection between the laboratory and the highways is as "rapid" as possible.

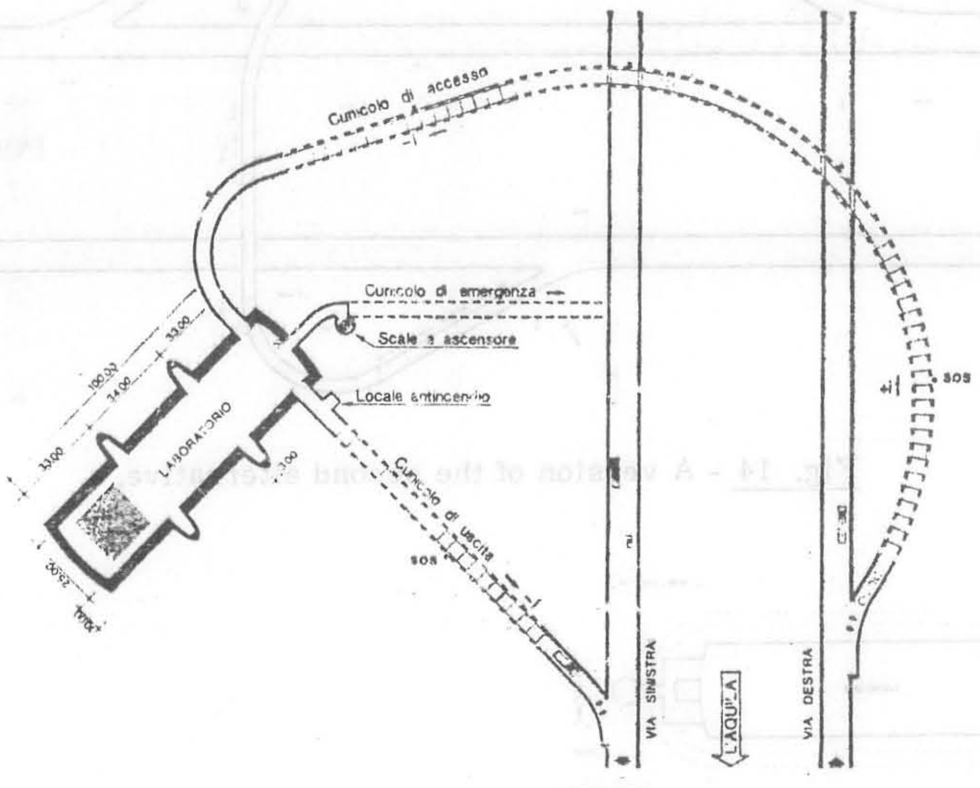


Fig. 13 - General plan of the second alternative.

Another version of this alternative, i.e. $(100 \times 20 \times 20)\ m^3$, with unique "access" and "exit" plus a "service" tunnel is shown in Fig. 14. Other details of the same project are shown in Figs. 15 and 16.

The key problem is the detailed estimate of the money needed for each version. Once this detailed estimate is known, it is the scientific community that has to decide whether the larger-volume laboratory ($5 \times 10^4\ m^3$) is preferable to the smaller one ($4 \times 10^4\ m^3$) and how crucial are the various solutions for the "access" and "exit" tunnels.

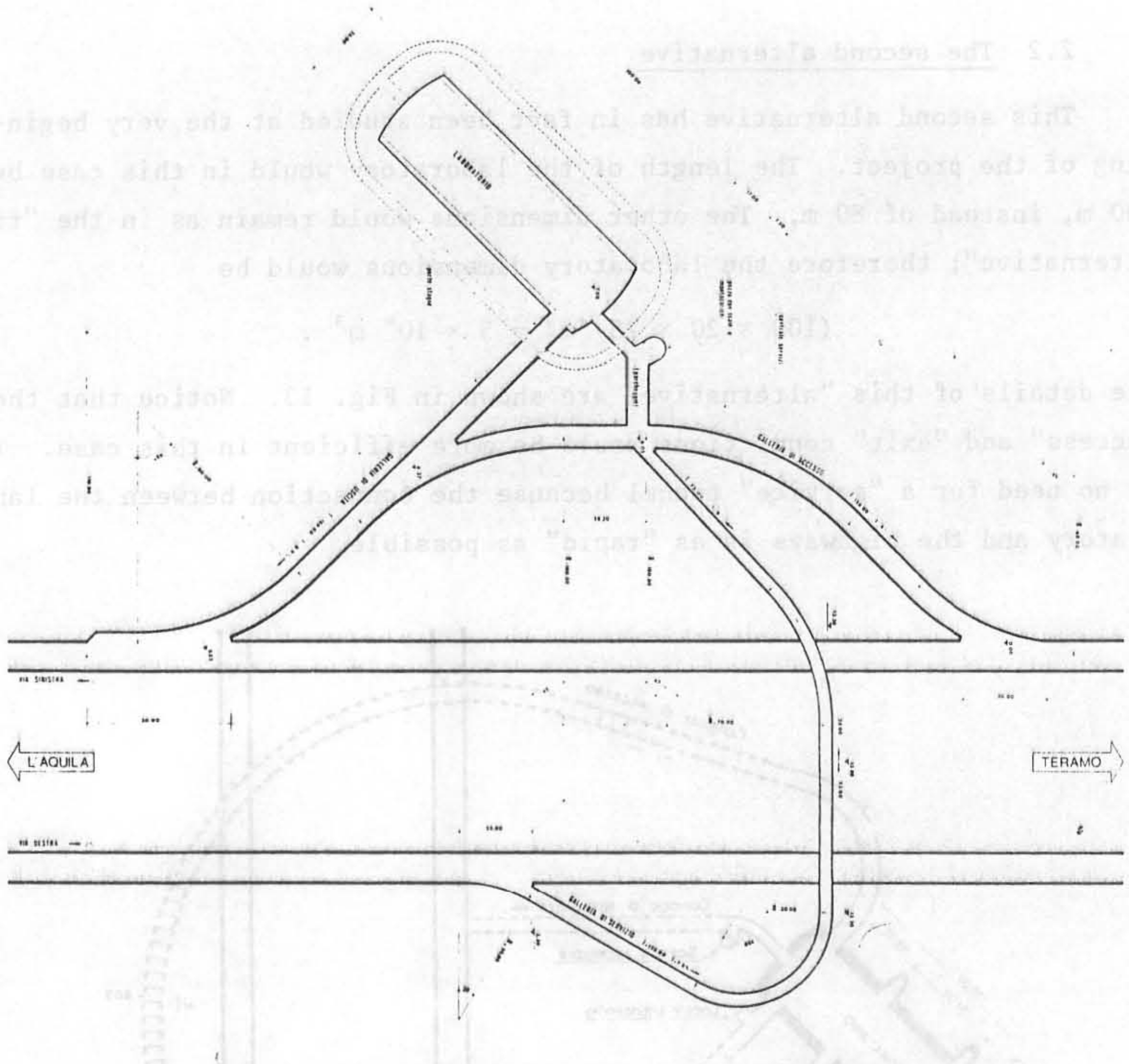


Fig. 14 - A version of the second alternative.

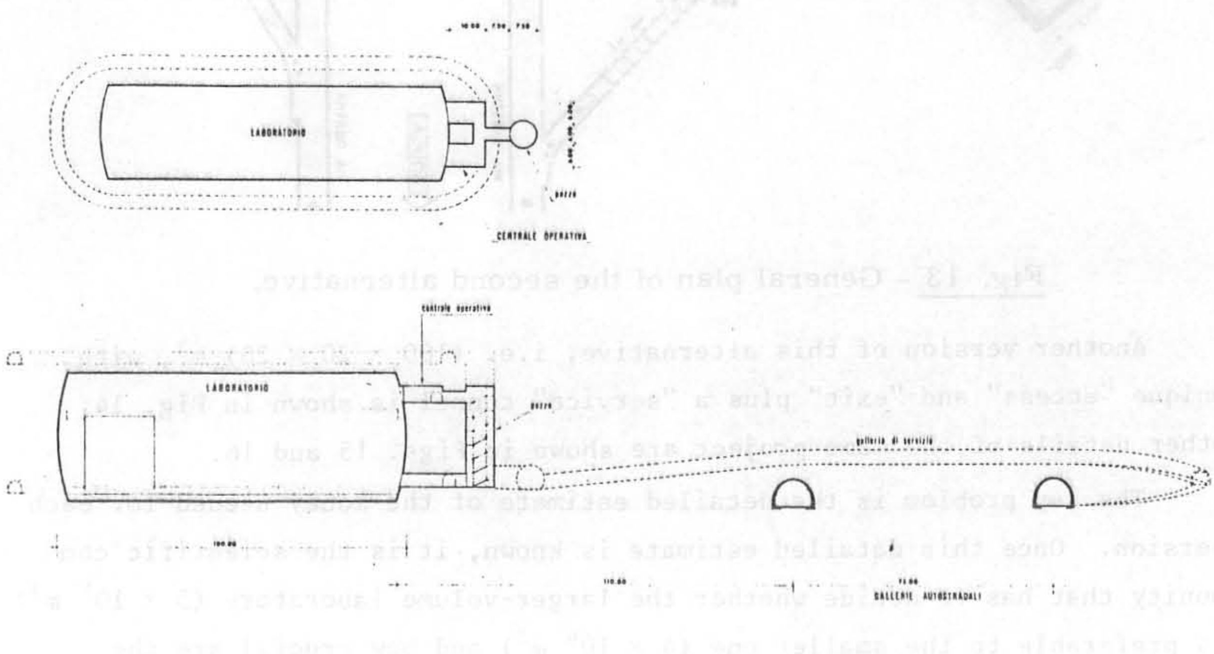


Fig. 15 - Details of Fig. 14.

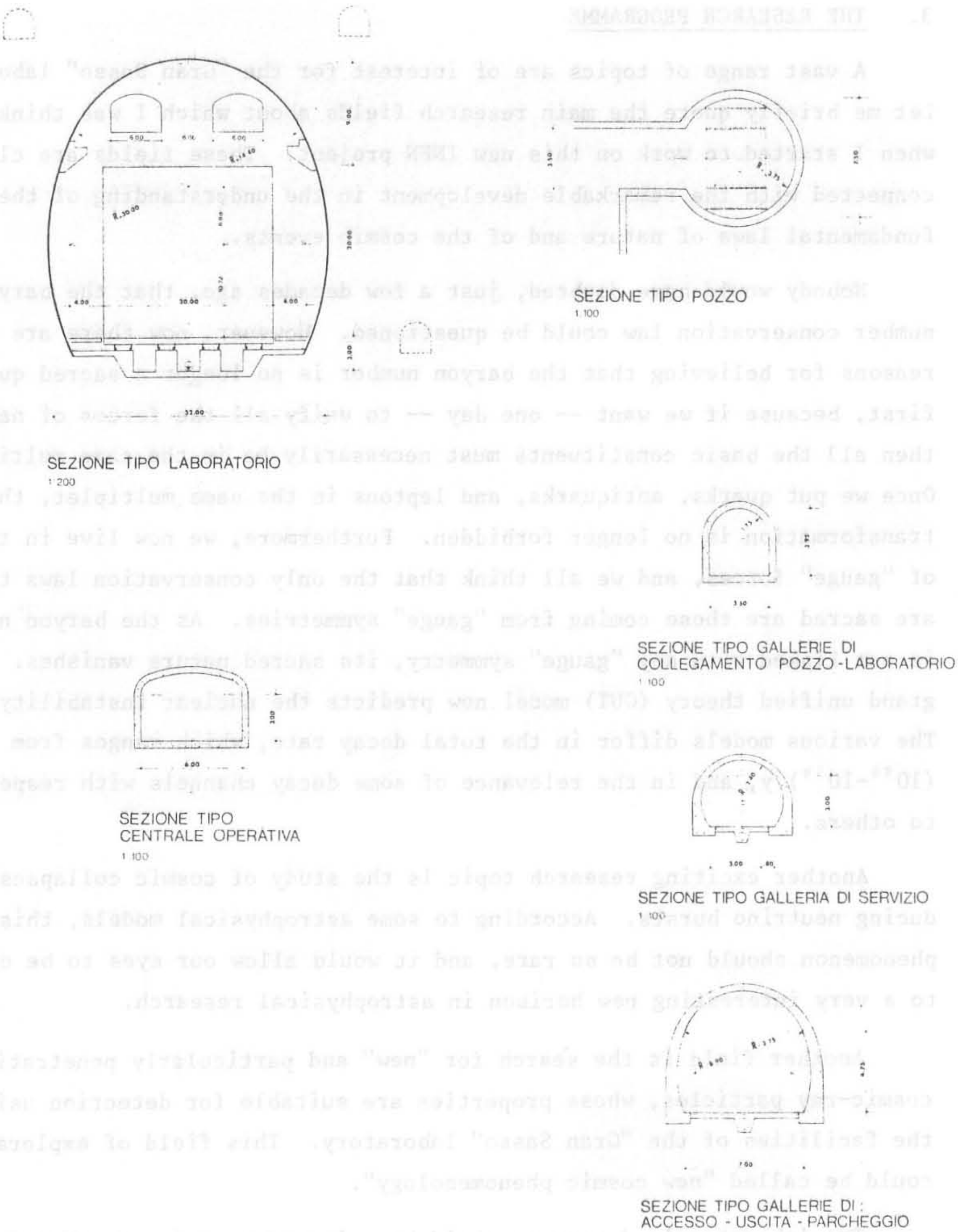


Fig. 16 - Details of Fig. 14.

As mentioned before, historically the alternative shown in Fig. 13 was the first to be studied, and it was used as the basis for estimating the amount of money needed for the project. This resulted in a sum of 20×10^9 Italian lire ($\sim 20 \times 10^6$ USA $).

3. THE RESEARCH PROGRAMME

A vast range of topics are of interest for the "Gran Sasso" laboratory. Let me briefly quote the main research fields about which I was thinking when I started to work on this new INFN project. These fields are closely connected with the remarkable development in the understanding of the fundamental laws of nature and of the cosmic events.

Nobody would have doubted, just a few decades ago, that the baryon number conservation law could be questioned. However, now there are several reasons for believing that the baryon number is no longer a sacred quantity: first, because if we want -- one day -- to unify all the forces of nature, then all the basic constituents must necessarily be in the same multiplet. Once we put quarks, antiquarks, and leptons in the same multiplet, their transformation is no longer forbidden. Furthermore, we now live in the age of "gauge" forces, and we all think that the only conservation laws that are sacred are those coming from "gauge" symmetries. As the baryon number is not linked with any "gauge" symmetry, its sacred nature vanishes. Any grand unified theory (GUT) model now predicts the nuclear instability. The various models differ in the total decay rate, which ranges from $(10^{30}-10^{34})$ y, and in the relevance of some decay channels with respect to others.

Another exciting research topic is the study of cosmic collapses producing neutrino bursts. According to some astrophysical models, this phenomenon should not be so rare, and it would allow our eyes to be opened to a very interesting new horizon in astrophysical research.

Another field is the search for "new" and particularly penetrating cosmic-ray particles, whose properties are suitable for detection using the facilities of the "Gran Sasso" laboratory. This field of exploration could be called "new cosmic phenomenology".

The laboratory's detectors could be oriented towards the CERN Super Proton Synchrotron (SPS) in order to study the hot problem of neutrino oscillations. The interest in this search is particularly relevant since the SPS is a source of all sorts of neutrinos (ν_e, ν_μ, ν_τ) and antineutrinos ($\bar{\nu}_e$, $\bar{\nu}_\mu$, $\bar{\nu}_\tau$).

Moreover, the study of biologically active "living" matter, in this very low cosmic-ray background, is open to a systematic series of investigations.

Finally, the problem of the ground stability is a topic which has generated a lot of interest amongst physicists at the University of L'Aquila.

To summarize, the scientific aims of the "Gran Sasso" laboratory are the study of:

1) nuclear stability;
2) neutrino astrophysics;
3) new cosmic phenomenology;
4) neutrino oscillations;
5) biologically active matter;
6) ground stability.

4. PRESENT STATUS AND TIMETABLE FORECAST

There is already a lot of work being done on both alternatives. The main points to be solved are:

i) how to connect the laboratory with the external world in the best, most efficient, and not too expensive way;

ii) how to find the best dimensions in order to make the total excavated volume the most suitable for the research programme to be done there. The final decision on this point will be taken after consultation with all the physicists who have shown an interest in our project.

Concerning the "ways and means", the Chamber of Deputies has already approved the bill granting 20×10^9 Italian lire ($\sim 20 \times 10^6$ USA \$) for the construction of the underground laboratory plus two buildings at the entrance to the highways, one for 20 guest rooms and another building for offices, a library, a workshop, and a small lecture hall (to hold about 80 people). The bill has now to go before the Senate for final approval. The pessimists say that this will take at least one year, as from now, because our Minister of Finance tries to slow down all public investments. The same pessimists were telling me last year that, in Italy, to obtain approval by Parliament takes three years. I myself hope that the Senate will give its definite approval in a record few months from now*).

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* Note: The bill has been passed by the Senate on 7 February 1982 and has already appeared in the "Gazzetta Ufficiale" of 12 February, signed by the President of the Italian Republic, Sandro Pertini.

The forecast is for having the laboratory completely ready in two years from the date of approval.

5. THE INTERNATIONAL CHARACTER OF THIS NEW INFN LABORATORY

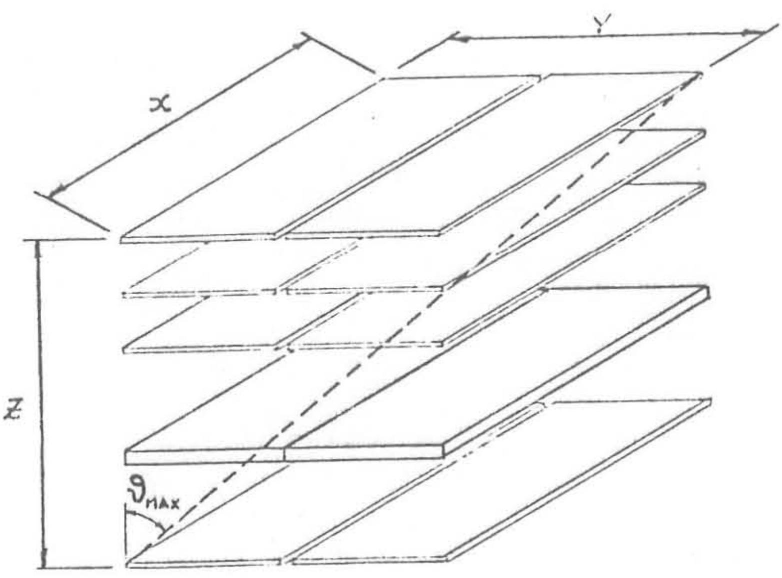
The research programme outlined in Section 3 has attracted the interest of many physicists; not only throughout Europe but all over the world: China, Japan, the USA, Canada, and the USSR.

The laboratory will be open to anyone who wants to exploit its unique properties. In the near future the Council of Directors of INFN will nominate a Scientific Committee where the international character of the laboratory will be confirmed. This Scientific Committee will study the proposals and then go on to make a series of very important decisions. For example, it would be highly desirable -- indeed, of vital importance -- to decide on the "best" detector for the study of the nuclear stability. Furthermore, this 10^4 ton detector should be constructed in a modular form in order to make possible a widespread international co-operation. For instance, even a small group in a small European university could contribute with its own small module, should they wish to do so.

Appendix: Measurements of the cosmic-ray background

The cosmic-ray background has been measured along the highway, and the best location for the laboratory has been determined. Details of the cosmic-ray telescope used and the results obtained are given in Fig. 17. The experimental results are the work of Dr. L. Federici and his team. The theoretical expectations have been calculated by Dr. B. D'Ettorre and agree very well with the experimental findings.

This investigation was carried out using a cosmic-ray telescope mounted on a big lorry. The results were obtained in three months of full-time work by Dr. Federici.



x(cm)	y(cm)	z(cm)	ϑ_{max}	N_{exp}(d)	N_{cal}(d)
140	140	140	55	14.4 $\pm$1	12.6
140	70	140	48	4.24 $\pm$0.5	3.7
140	140	45	77	38.6 $\pm$1.7	30

Fig. 17