Muon flux estimation at the ANDES deep underground laboratory

Xavier Bertou
Centro Atómico Bariloche, Argentina

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Abstract

Two positions of interest are proposed in the "Nuevo Estudio Conceptual" (NEC) of ANDES [1]. In this short note a study of the impact of the exact location on the background muon flux is presented. Any location in between the two considered positions of interest seems acceptable.

1 Introduction

One of the most relevant parameters for a deep underground laboratory is the rock overburden. The Agua Negra tunnel seems able to provide a depth of about 1700 m, very competitive with other underground laboratories and compatible with the scientific programme thought for the laboratory. While the vertical depth is usually the number quoted, other parameters are relevant. One can consider the minimum overburden, but in fact the important parameter is the muon flux. In this short note a simple estimation of the muon flux is computed for locations around the deepest points of the Agua Negra tunnel in order to estimate an ideal location.

2 Depth estimation

Data from the Shuttle Radar Topography Mission of NASA [2] was used to get 3 arc-second resolution elevation data of the area of the Agua Negra tunnel. Better accuracy maps have also been studied, but no significant differences were found. The tunnel coordinates, including the slope, were extracted from Agua Negra documents [3].

The vertical depth and minimum omnidirectional depth were computed in an area encompassing the two locations "Variante 1" and "Variante 3" proposed in the NEC. A map of these depths can be seen in figure 1. A significant difference of about 100 m is found between the two locations.

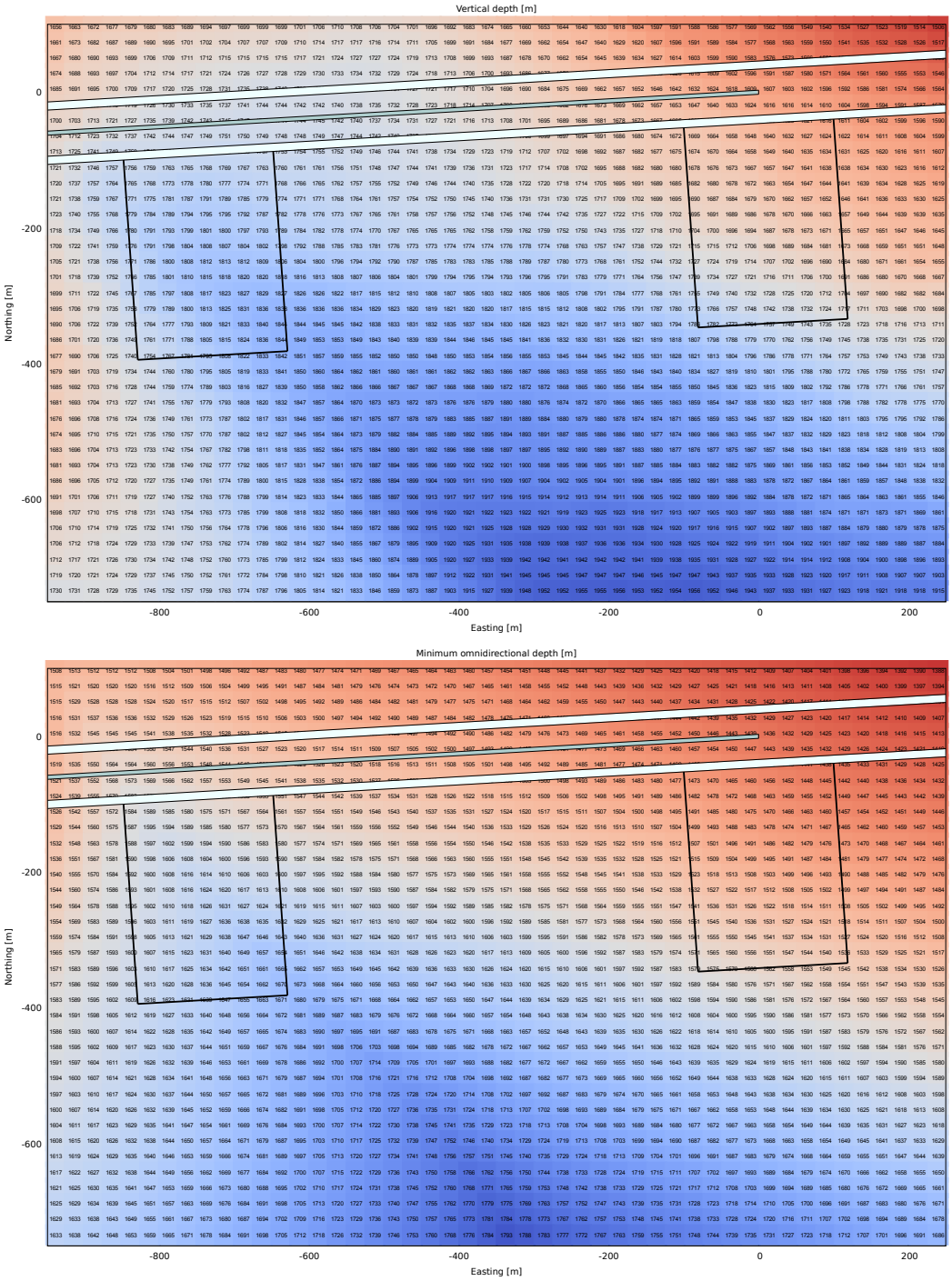

Figure 1: Vertical and minimum omnidirection overburden for possible locations of ANDES. The two proposed "Variante 1" and "Variante 3" locations are indicated, together with the two road tunnels and the extra ventilation tunnel. The (0,0) coordinates are located at the ventilation cavern. A difference of above 100 m is found between the two variants.

However, the relevant parameter is not the depth but the total muon flux. For example, the left position, "Variante 3", on the border, may seem to have more overburden, but gets significant muon flux from both sides, while the right one, "Variante 1", has a lot of overburden on the west side and gets most of its flux from the east. To take this into account, a uniform muon flux was integrated moving the point of interest over the whole area (taking into account the tunnel slope), providing normalised muon maps as seen in figure 2.

Once the integration over the full solid angle is done, the difference between the two sites is much less. While a 100+ m difference can translate into a difference of up to 60% in muon flux, the full integration gives a difference of only 5-10%. The two positions, "Variante 3" and "Variante 1", delimit an area where the flux is minimal, and any position in between is satisfactory from the scientific point of view. This analysis also confirms the southern side of the tunnel is favoured, with fluxes on average 30% lower than on the northern side at close distance from the tunnel.

3 Conclusions

After integration of the muon flux, there is no strong restriction from the science side on which option is chosen for ANDES. Any location to the south of tunnel between the border and the ventilation cavern is roughly equivalent within 10% of the muon flux. An independent crosscheck of the study was made and confirmed its results [4]. If "Variante 1" is chosen, it would be better to have the exit tunnel of the laboratory coincide with the access to the ventilation cavern.

References

[1] Informe Técnico 6198.0-R-01, Lombardi

[2] Farr, T. G., et al. (2007), The Shuttle Radar Topography Mission, Rev. Geophys., 45, RG2004, doi:10.1029/2005RG000183

[3] trazado del Túnel de Agua Negra (versión 31.03.2014), Lombardi

[4] H. Asorey, private communication

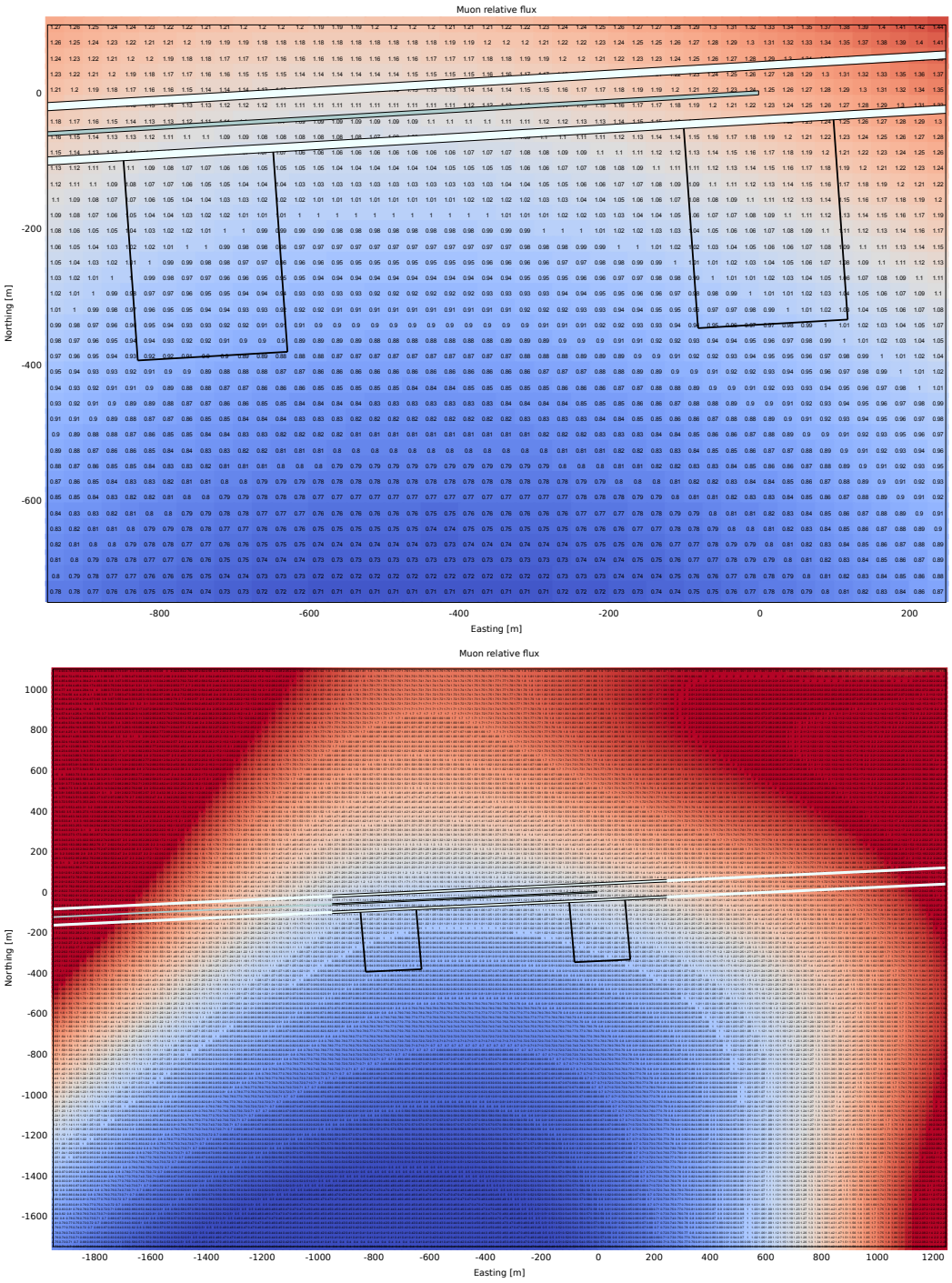

Figure 2: Muon flux normalised to the one at the centre of the laboratory in "Variante 3", on the border. Any location between the two proposed variants receives a similar muon flux within 10%.