Available online at www.sciencedirect.com

ScienceDirect

Physics Procedia 61 (2015) 586 – 590

Physics Procedia

# Towards the South African Underground Laboratory (SAUL)

S. M. Wyngaardt[a], R. T. Newman[a], R. Lindsay[b], A. Buffler[c], R. de Meijer[b], P. Maleka[d], J. Bezuidenhout[e], R. Nchodu[d], M. van Rooyen[a], Z. Ndlovu[a]

[a]*Department of Physics, Stellenbosch University, Private Bag X1, Matieland, Stellenbosch, 7602*
[b]*Department of Physics, University of the Western Cape, Modderdam Road, Private Bag X17, Bellville, 7530*
[c]*Department of Physics, University of Cape Town, Rondebosch, 7700, South Africa*
[d]*iThemba LABS, P.O. Box 722, Somerset West, 7129, South Africa*
[e]*Military Academy, Private Bag X2, Saldanha, 7395*

**Abstract**

Over the past two years there has been discussion among South African physicists about the possibility of establishing a deep underground physics laboratory to study, amongst others, double beta decay, geoneutrinos, reactor neutrinos and dark matter. As a step towards a full proposal for such a laboratory a number of smaller programmes are currently being performed to investigate feasibility of the Huguenot Tunnel in the Du Toitskloof Mountains near Paarl (Western Cape, South Africa) as a possible sight for the South African Underground Laboratory facility. The programme includes measurements of radon in air (using electret ion chambers and alpha spectroscopy), background gammaray measurements (inside/outside) the tunnel using scintillator (inorganic) detectors, cosmic ray measurements using organic scintillators and radiometric analyses of representative rock samples.


Selection and peer review is the responsibility of the Conference lead organizers, Frank Avignone, University of South Carolina, and Wick Haxton, University of California, Berkeley, and Lawrence Berkeley Laboratory

*Keywords:* , Underground laboratory, Neutrinos, Gammaray, Radon, Darkmatter

## 1. Introduction

Discussions about an underground research facility in SA started in 2011. As one of the worlds largest producers of gold, South Africa has a number of the worlds deepest gold mines (TauTona Gold Mine 3.9 km). The use of deep mines in the search for neutrino events is not new to the South African Research community. In 1965 the Nobel Prize laureate along with South African Physicist, Friedel Sellschop detected the first atmospheric neutrino events in the Eastrand mine near Johannesburg (South Africa) [1].

Initial focus by the South African nuclear physics community was on establishing an underground facility in one of South Africas deep gold mines.The alternative is to develop such an underground laboratory inside the Huguenot Tunnel which is located between the towns of Paarl and Worcerster in the Wester Cape Province of South Africa.

The development of the Huguenot tunnel as an underground low level radiation facility holds a number of strategic advantages in for the South African physics communities in the Western Cape. Such a facility located approximately 25 km for Stellenbosch University and 40 km for the iThemba Laboratory of Accelerator Based Sciences and therefore provides quick and easy access to the local research communities. Research programs done at such a facility will also also support postgraduate training programs in nuclear physics at Stellenbosch University, the University of the Western Cape and the University of Cape Town. Furthermore the research at the SAUL will support national and international research activities in astronomy, nuclear and particle physics, as well as atmospheric and space science linked to the iThemba LABS [2], Square Kilometre Array (SKA) [3], South African Astronomical Observatory


Selection and peer review is the responsibility of the Conference lead organizers, Frank Avignone, University of South Carolina, and Wick Haxton, University of California, Berkeley, and Lawrence Berkeley Laboratory
doi:10.1016/j.phpro.2014.12.056

(SAAO) [4], the Southern African Large Telescope (SALT) [5], South African National Space Agency [6], and High Energy Spectrospopic System (HESS) [7] in Namibia.

The SAUL facility at Huguenot tunnel will provide a plateform for training and the development of a research footprint for a dedicated facility in the TauTona mine. The preliminary geological and radiation background studies is currently underway.

## 2. Preliminary studies

In order to decide on the best course to take in order to develop sensible research programs around the huguenot tunnel facility a number of measurable parameters will have to be known. According to the geological survey which was done during the excavation period (1973 - 1984) the composition of the mountain range mainly composes of quarzitic sandstone (also refered to as Tablemountain sandstone). It is therefore expected that radon concentration levels within the tunnel should be insignificant,and should therefore not have any considerable contribution on the background radiation signature. Figure 1 shows the height profile of the du Toitskloof mountain range above the huguenot tunnel.

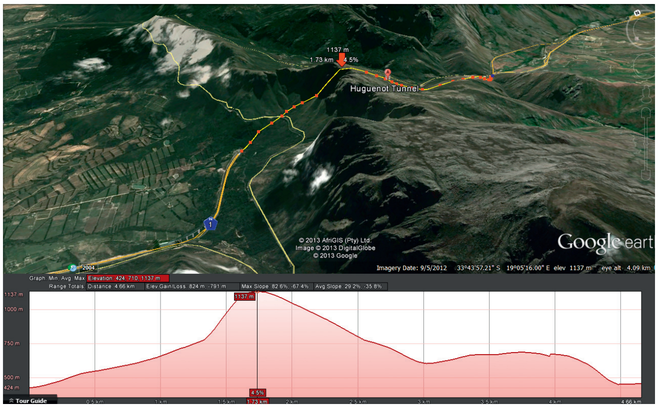


Figure 1. Height profile of du Toitskloof mountain range above the Huguenot tunnel.

In April 2013 the environmental radiation groups at Stellenbosch University and iThemba LABS performed a preliminary radon measurements by placing 3 electrets at the three vehicle cross-cut (VCC) areas to monitor the radon in the undeveloped Northern tunnel seen in figures 2 and 3.


Figure 2. Electrets mounted in groups of 3 on the walls of the tunnel close to the vehicle cross-cuts.


Figure 3. Vehicle cross-cut area

The radon concentrations at the three measured sites shown in the table in figure 4 confirms that the levels of radon is well below any conciderable levels. Comparison between the radon levels at the three sites also shows a slightly higher level at VCC2 as compared to VCC1 and VCC3.

| | Mean | Standard Deviation |
|---|---|---|
| location | Air Radon Concentration | Air Radon Concentration |
| | (Bq.m$^{-3}$) | (Bq.m$^{-3}$) |
| VCC1 | 45.4 | 0.1 |
| | | |
| **VCC2** | **52.7** | **7.1** |
| | | |
| VCC3 | 64.9 | 5.2 |
| | | |

Figure 4. Radon levels measured at vehicle cross-cuts

The radon background measurements have been followed up by an accumilated gamma ray measurement with the multi-element detector using a scintillator array (MEDUSA) detection system (see figure 5). The gammaray spectrum from the MEDUSA was then compared to the known gamma energy spectral of $^{40}K$, $^{238}U$, $^{232}Th$, and $^{137}Cs$ shown in figure 6. This measurement, however, lacks position information which will be included in the next series of measurements.

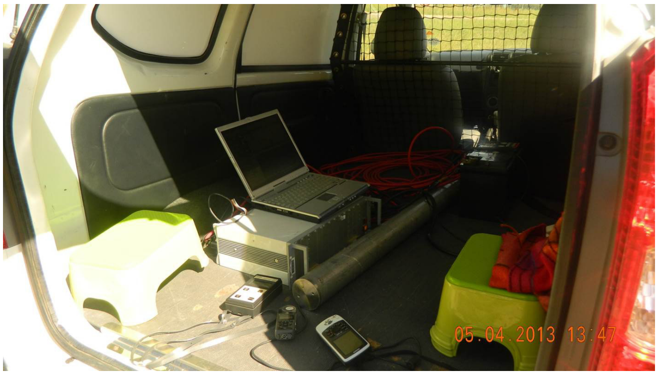


Figure 5. The MEDUSA gammaray detector system


Figure 6. Gammaray spectrum of tunnel obtained with the MEDUSA detector compared to the gammaray spectra of $^{40}K$, $^{238}U$, $^{232}Th$, and $^{137}Cs$

In addition to the gammaray spectra and radon background measurement the collaboration will soon be measuring the muon background within the tunnel. In addition to the background measurements biomonitors were placed at strategic locations witin the tunnel in order to measure the air pollution levels within the tunnel as shown in figure 7.

## 3. Current and Future projects

To improve on the available data Radon-in-Air measurements in the Northern bore using Electret Ion Chambers to monitor Radon continuously. Gamma-ray measurements along the length of the northern bore as well as outside the tunnel with the MEDUSA scintillator detector will be included into the next survey. Inaddition long term ( one month) gammaray measurement inside and outside the tunnel will also have to be performed. Measurement of Cosmic ray background both inside and outside the tunnel (muon measurement starting in the middle 2014).

Following the current feasibility study a small workshop will be held in conjuction with the South African Department of Science, South African Roads Agency Limited (SANREL), potential role players (SA Universities, iThemba LABS and International community) enter discussions to have a permanent facility in place within the tunnel. One of the first steps in setting up the SAUL facility would be to develop an established dedicated low level research laboratory and programs which will detect geoneutrinos, look for a possible seasonal signature of dark matter and search for opportunities which could uniquely be studied in the southern hemisphere. In partnership with the Earth Antineu-


Figure 7. Biomonitors placed at locations to monitor air pollution levels in the tunnel.

tRino TomomograpHy (EARTH) collaboration we intend utilizing the Koeberg nuclear power plant to investigate the posible neutrino oscilations which, was initially observed by Alburger et al [8], with the GIZA antineutrino detector system shown in figure 8.

In our quest to set up such an underground facility we envision an internation partnership which aims to expand on the exchanging of knowledge, skills and the training of young people.

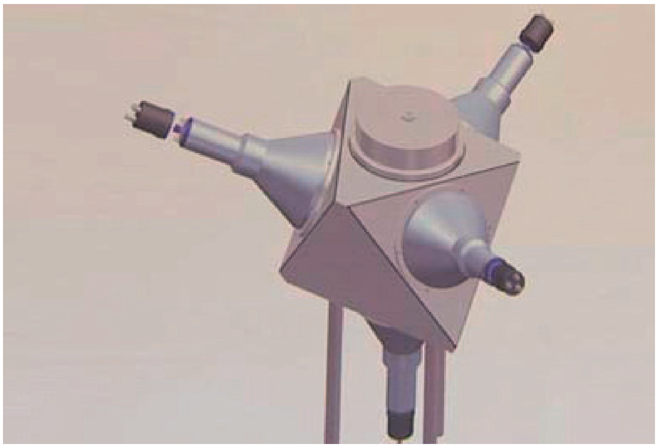

Figure 8. Schematic picture of the GIZA antineutrino detector system.

## 4. Acknowledgements

The collaboration would like to acknowledge the financial support from the National Research Foundation through the Knowledge, Interchange and Collaboration fund.

## References

[1] F. Reiner, et al, Phys. Rev. Lett. 15, 428 (1965)
[2] www.tlabs.ac.za
[3] www.ska.ac.za
[4] www.saao.ac.za
[5] www.salt.co.za
[6] http://www.space-sci.sansa.org.za/
[7] http://www.mpi-hd.mpg.de/hfm/HESS/
[8] Alburger et al,Earth and Planetary Science Letters, 78, p168-176 (1986)