Paarl Africa Underground Laboratory Introduction

General Meeting- June 26, 2023

The context: Previous publications

2015: Towards the South African Underground Laboratory :

Physics Procedia
Volume 61, 2015, Pages 586-590

Towards the South African Underground Laboratory (SAUL) ☆

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2019: Latest Updates on Developments of the Underground Neutrino Facility in South Africa

LABORATOIRE DE PHYSIQUE SUBATOMI

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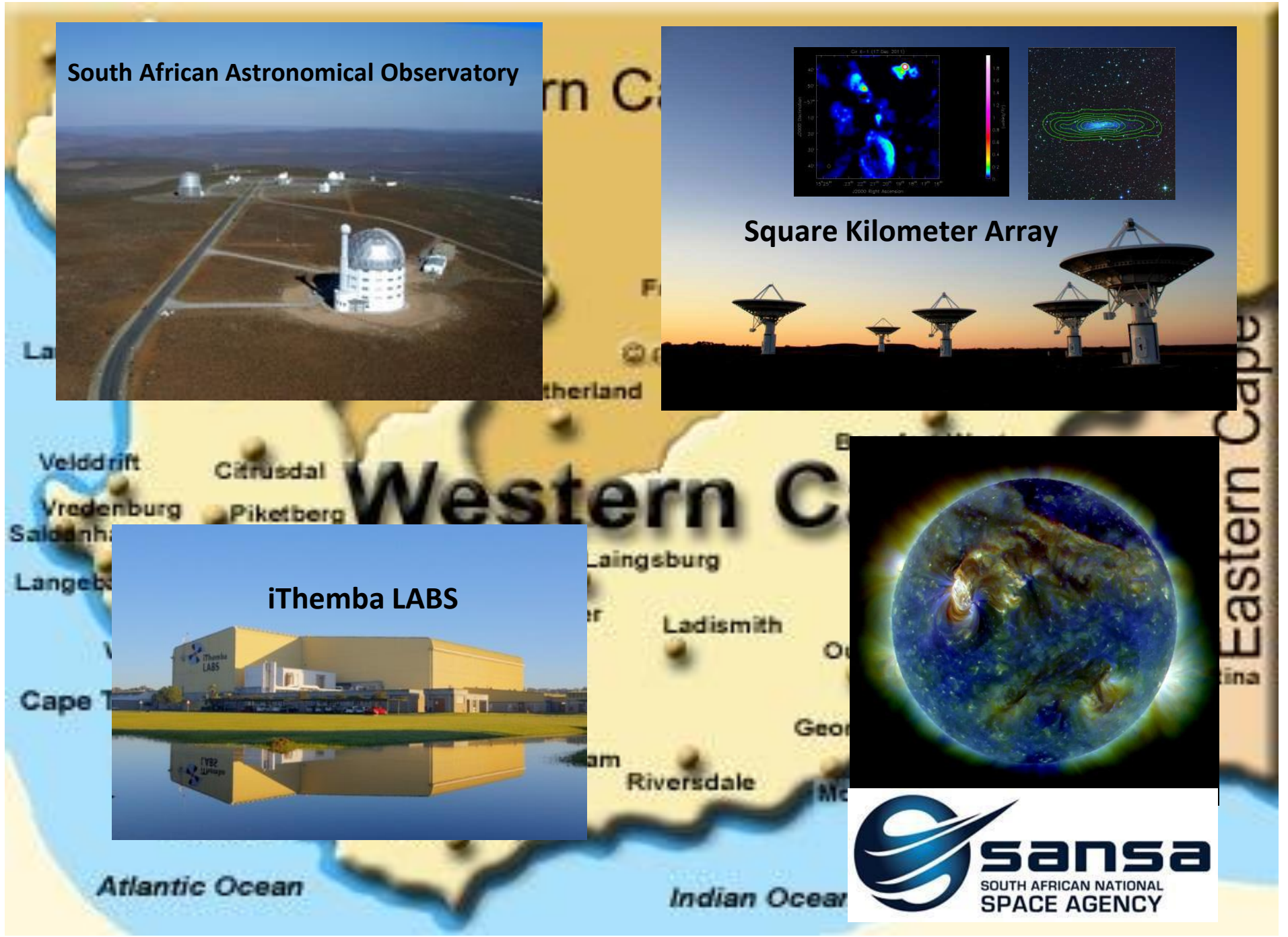

South African Astronomical Observatory
Square Kilometer Array
iThemba LABS
sansa
SOUTH AFRICAN NATIONAL
SPACE AGENCY
Western C
Eastern Cape
Velddrift
Citrusdal
Vredenburg
Piketberg
Laingsburg
Ladismith
Riversdale
Cape T
Atlantic Ocean
Indian Ocean

World Class Universities

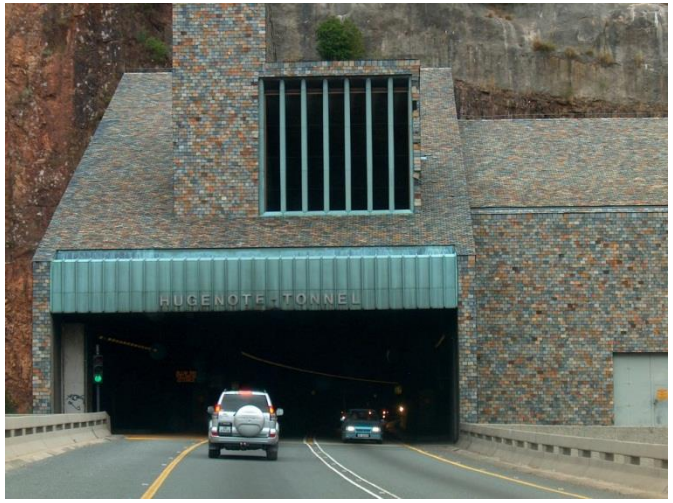
Stellenbosch University

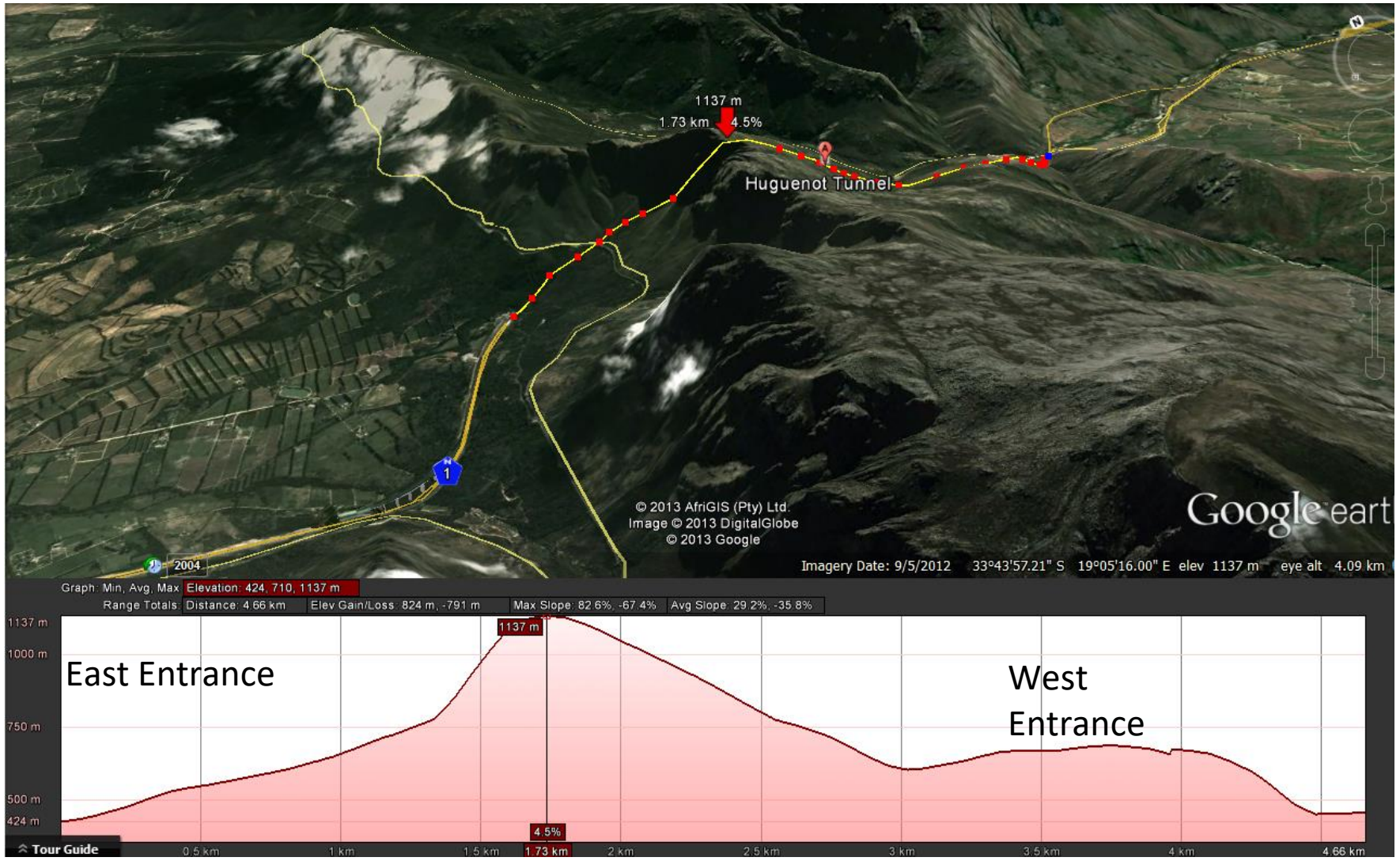
University of Cape Town

University of the Western Cape


Huguenot Tunnel
Paarl
Stellenbosch
iThemba LABS
Cape Town
Robben Island
Table Mountain National Park
False Bay
Bain`s Kloof Pass
Slanghoek
Wellington
Philadelphia
Windmeul
Worcester
Nuy
Aan de Doorns
Brandvlei
Alfalfa
Area
Winelands Lifestyle Estate
Klapmuts
Haweqwa Nature Reserve
Hou Moed
Wemmershoek
Franschhoek
Mount Eland Twp
Jonkershoek Nature Reserve
Villiersdorp
Riviersonderend Nature Reserve
Dennehof
Greyton
Vyeboom
Helderstroom
Klipkraal
Groenlandberg Nature Reserve
Sir Lowry's Pass
Grabouw
Hottentots Holland Mountain Catchment Area
Bot River
Caledon
Oudekraal
Rooi-Els
Oude Bosch
Arabella Country Estate
Kleinmond
Pringle Bay
Betty's Bay
Bovenplaats
Tesselaarsdal
Hawston
Onrus
Hermanus
R300

The Huguenot tunnel





1300m Du Toitskloof mountain with ~800 m of rock overburden for the Huguenot tunnel

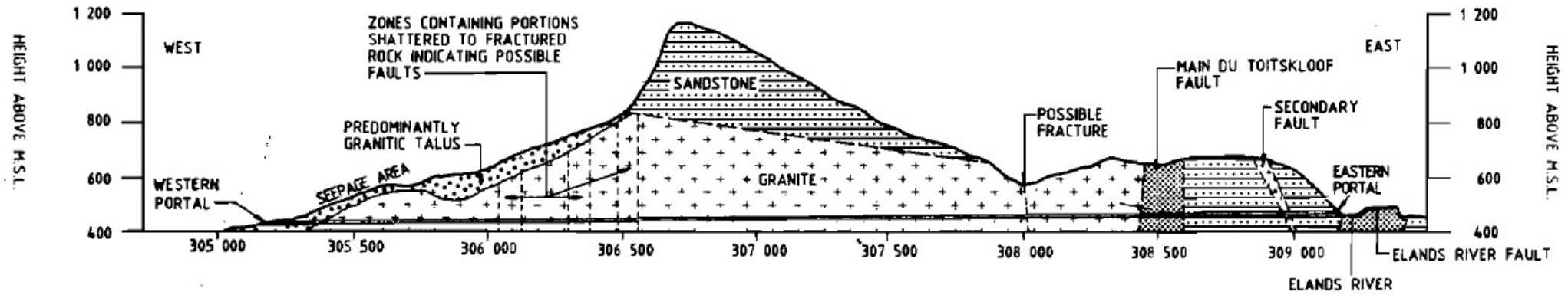
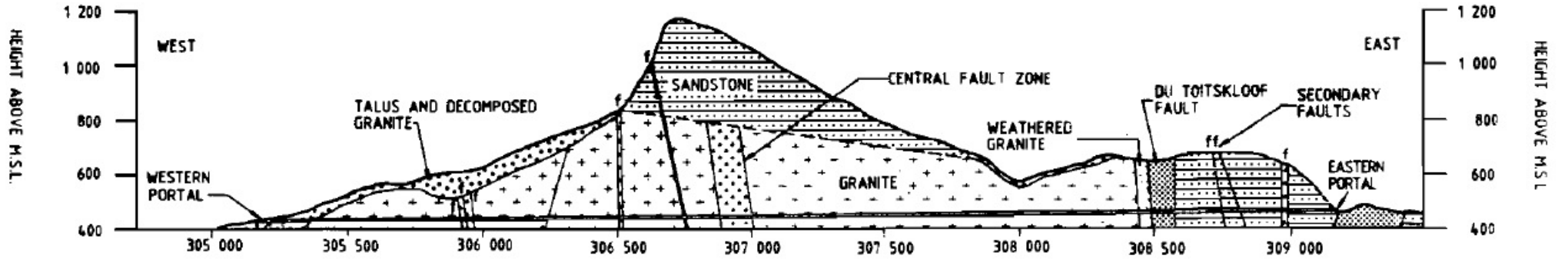


Fig 2: Pre-pilot bore geology

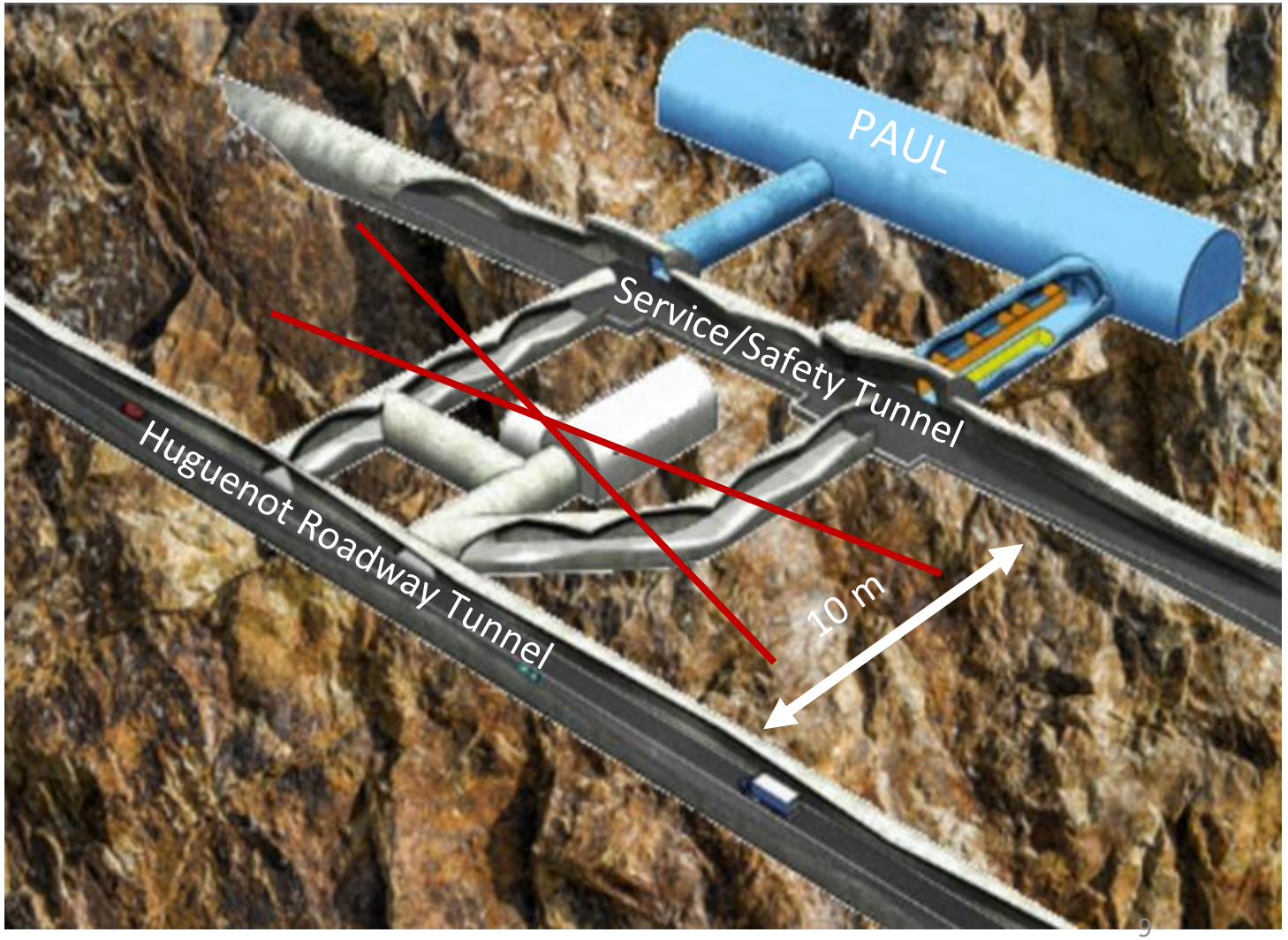


The range mostly consists of Table Mountain sandstone, an erosion-resistant quatzitic sandstone

PAUL in the Huguenot Tunnel

The design of LSM-Modane was used for the purpose of the illustration

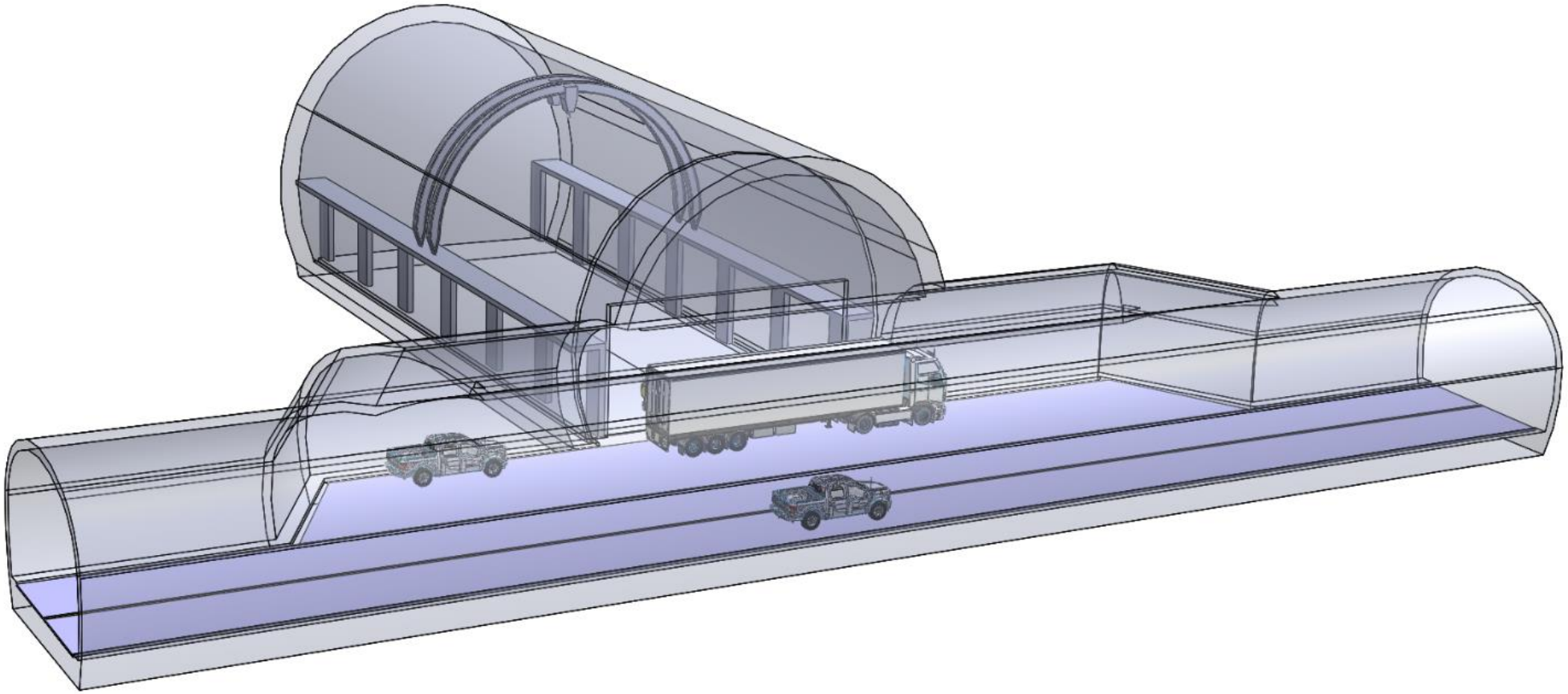
The future underground laboratory is currently being designed; It directly involves the company operating the Huguenot tunnel (SANRAL) since earthworks and infrastructure construction are planned over the next five to ten years.



Gamma-ray mapping in the Huguenot tunnel, 2013
Phys. Proc. 61 (2015) 586-590

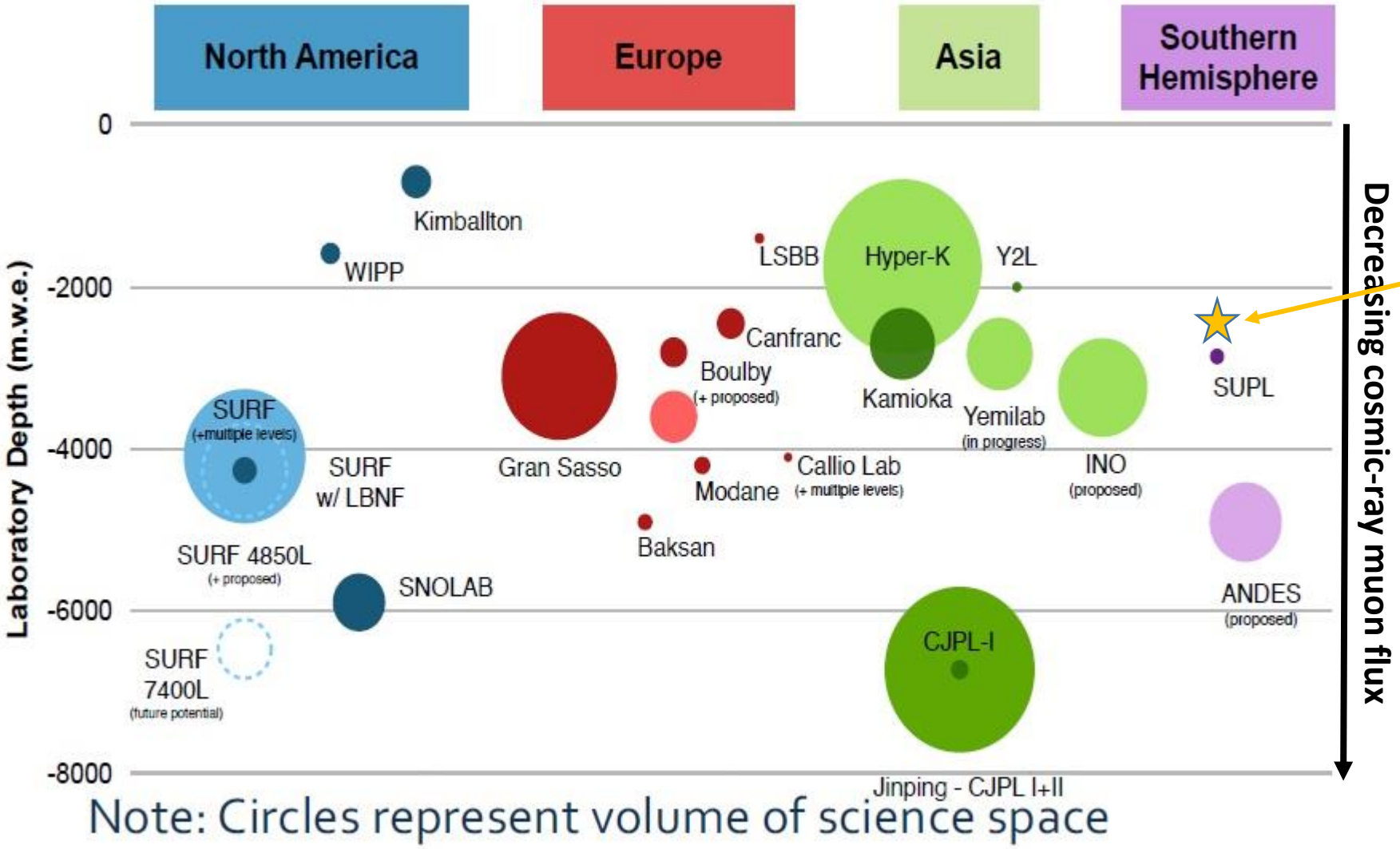
The concentrations measured at three sites confirm that the level of radon is well below any degree of consideration, with a mean level of radon no more than ~50 Bqm^{-3}

Mock up of PAUL facility



A possible 600m^2 laboratory (40x16x16 m^3) in the Huguenot tunnel.
Courtesy: Joaquin Venturino (CNEA), April 2023.

Lab Depth (mwe) vs Decreasing cosmic-ray muon flux



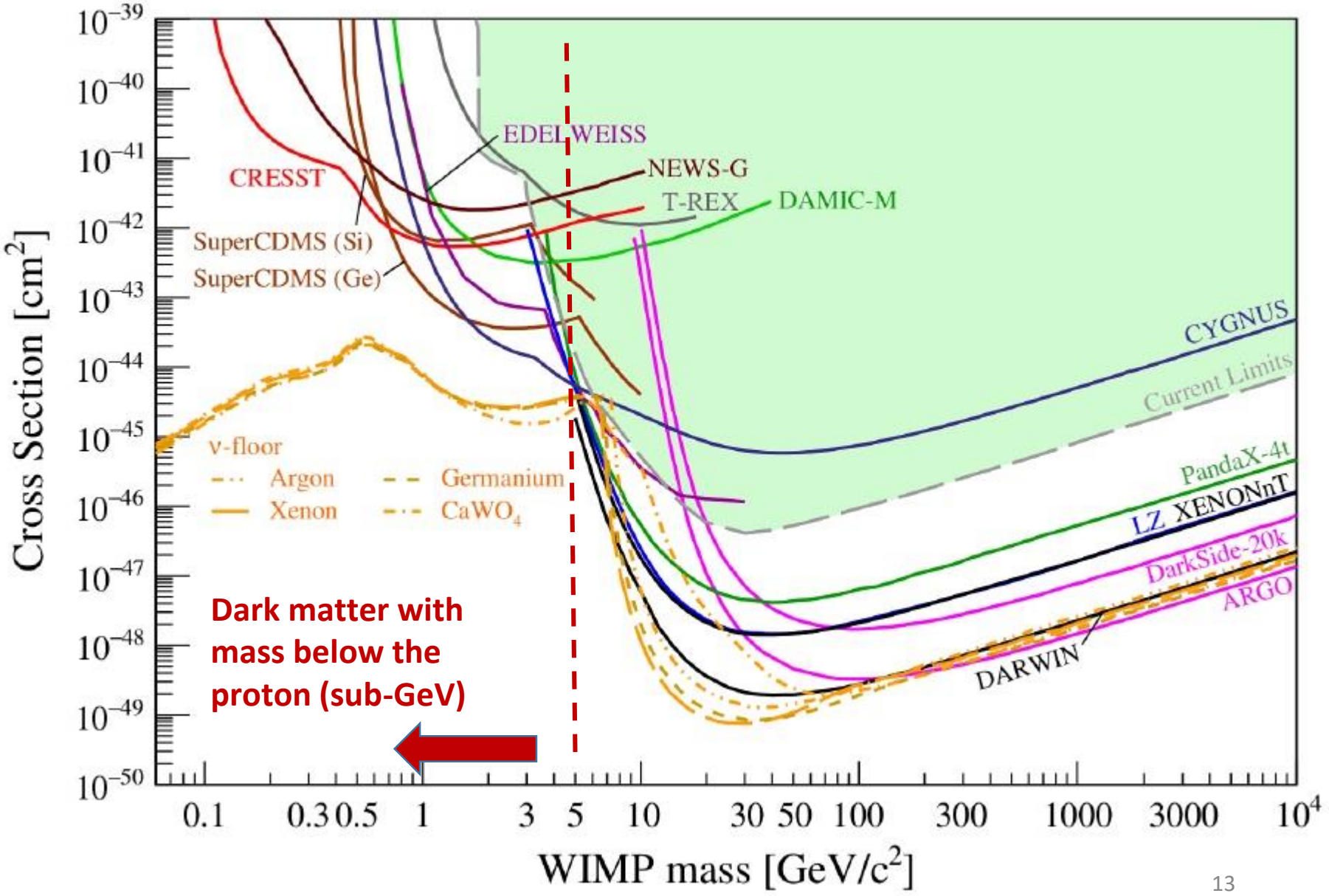
For PAUL, it is only an estimate as the cosmic-ray muon flux is not yet well measured, nor the real rock overburden known exactly (~800 m, ~2000 mwe)

Potential of Astroparticle research

The challenge is to develop detectors with very low energy thresholds and excellent control over detector backgrounds.

Technology

- ✔ Charge Coupled Devices (CCDs), Skipper-CCD (SENSEI, DAMIC, OSCURA)
- ✔ Solid-state cryogenic detectors (Ge, Si, ..), operating at T<15 mK, (Edelweiss)
- ✔ Noble Liquid target (Xe, Ar)



Other Research Purposes of great interest in ZA

- Measurement of **extremely low radiation levels**. These very sensitive detectors, able to detect levels of radiation a millionth of the natural radiation of the human body. Researchers involved in this work can contribute to many needs in South Africa for accurate measurements, such as the detection of the radioactive gas radon that has been identified as a major radiation hazard in South African underground mines.

- The research of **endolithic bacteria** and technologies for bio-leaching

- **Astrobiology** , examining the impact of radiation (or the lack of it) to evolutionary processes or formation of bio-aerosols.

- In glaciology, the study of **ice samples from the Arctic, Antarctic** etc. allows mapping of the **evolution of climatic parameters** and contamination both in space and over time for the last centuries. The measurement of 137Cs and 241Am is the only way to get a precise dating of ice.

- The Cape Supergroup (in Natal and the Northern Transkei), where the lab would sit, has been identified as a region of interest for **geothermal research** .

→ see Lucas Terray talk

Conclusion on PAUL opportunity

PAUL is foreseen as an open **international laboratory**, a unique opportunity for Africa devoted to the development of a competitive science in the region. It has the advantage that the location**, the Huguenot tunnel, exists** already and the geology and the environment of the site is appropriate for an experimental facility.

Perform an experiment of direct dark matter detection in an underground laboratory located in the Southern Hemisphere is **to compare the eventual systematic errors or modulation with respect to the same detector in the Northern Hemisphere**. Any systematic error or annual modulation correlated to a seasonal variation will have an opposed phase, giving the opportunity to discriminate them with respect to a dark matter signal. It also opens different regions of parameter space when searching for daily modulations

The other advantage to build an UL facility in South Africa is to **combine the direct detection with indirect dark matter detection from radio astronomy** surveys that South Africa is leading (SKA, MeerKAT, etc.). Therefore, the strong synergy between the astrophysical (indirect) probes and Paarl Africa Underground Laboratory (direct probe) can jointly measure and constrain dark matter effect, which may shed lights on new physics.

Publications and communications in 2023

June 21st: arXiv:2306.12083 [hep-ex]

Paarl Africa Underground Laboratory

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Workshop, congress and conferences

1)- Underground Labs Workshop at Aussois: June 21-23

2)- French Physics Society General Congress, Paris, 3-7 July

3)- EAS Crakow, July 10-14

4) High Energy Astrophysics in Southern Africa (HEASA) July 31st

5) TAUP 2023, August 28 – September 1, 2023

6) African Nuclear Physics Conference, 29 Nov – 3 Dec in Kruger National Park.

Applications

- **May 2023**: 2 year bilateral project, seed budget to start networking: PHC Protea (FR-ZA) application (results in August 2023)
- **June 19th**: CNRS/IN2P3 support for building an IRN (International Research Network)

- **Plan**:

Open call: December 6th: Strengthen the bilateral cooperation on research infrastructures with :HORIZON-INFRA-2024-DEV-01