Callio Lab, a new deep Underground Laboratory in the Pyhäsalmi mine

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Callio Lab, a new deep Underground Laboratory in the Pyhäälmi mine

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Abstract. A new underground laboratory, Callio Lab, has been established to manage the non-mining related operations in the Pyhäälmi mine in Pyhäälvi, Finland. The very deep laboratory space, called Lab 2 of Callio Lab, has been finished in spring 2016 at the depth of 1430 meters (4100 m.w.e.) and it has the area of approximately 120 m$^2$ and the height of 8 meters.

We present the structure of Callio Lab and the main technical characteristics of the deep Lab 2. We also review the current activities related to astroparticle and radiation physics, such as EMMA muon observatory and C-14 liquid scintillator research. An Open Call process has been opened to invite new scientific experiments to Callio Lab.

1. Callio Lab and the Pyhäälmi mine

Callio Lab is a new deep underground laboratory, founded in the Pyhäälmi Mine in Pyhäälvi, Finland. The mine is still an active copper and zinc mine, owned by First Quantum Minerals Ltd and operated by Pyhäälmi mine Oy. Since the foundation of the mine in 1962, excavation activities have created a network of hundreds of kilometers of tunnels extending down to the depth of 1441 m (4100 m.w.e) in the granite rock bed. Callio Lab was created as project by the universities of Oulu and Jyväskylä, the municipality of Pyhäälvi and Pyhäälmi mine Oy in order to administer the use of the vacant underground facilities for scientific and commercial use.

Currently the main level of maintenance, supporting the mining operations, is at the level 1400 (depth in meters), where there are excellent facilities for a variety of activities, such as vehicle maintenance and storage halls, conference facilities, lunch restaurant and washing facilities. There are also a mobile phone network and an optical cable connection, which provides high speed internet access also for the intermediate levels of the mine. All of the mine is covered by a two-way radio communication network for security reasons.

The level 1400 is accessible either by a 3 minute elevator ride from the surface building or by a car or even a truck, using the 11 km long service road. The road provides access also to the tunnels in the intermediate levels. The previous maintenance levels of the mine have been located at the levels 990, 600, and 440 (meters), which can be still used to support scientific or industrial infrastructures for any part of the tunnel network. Currently the active mining operations are limited between levels 990 and 1400.
2. Physics Research in Callio Lab

During the summer of 2016 there were three physics projects utilizing Callio Lab’s facilities at different levels:

**EMMA** – Experiment with MultiMuon Array studies the mass composition of cosmic rays at and above the knee region. Currently EMMA consists of 11 detector stations (15m²) assembled in the caverns at the depth of 75 and 45 meters. It it is capable of measuring the multiplicity and the lateral distribution of underground muons and the arrival direction of the air shower [1]. Level 75 is called Lab 1.

**Radon tent** testing in level 990 (Lab 3) is a commercial technology development project aiming to test and develop thin foils, which can be easily assembled in a form of a tent in order to rapidly
construct a radiation protective environment. The lowering of the radon and other background radiation is studied with long term measurements and in various conditions.

**C-14 - Experiment** has been constructed during spring and summer of 2016 in order to measure C14 concentrations in various liquid scintillator samples [2]. The experiment consists of a specifically constructed cylindrical container, which has Photomultiplier tubes at both ends. The purpose is to be able to measure very low $^{14}\text{C}/^{12}\text{C}$ ratios down to $10^{-18}$ utilizing the newly founded Lab 2 in the deepest level 1430 of the Pyhäsalmi mine. The astroparticle physics team of the University of Oulu, leading the experiment, participates also the scintillator working group of the JUNO experiment [3].

### 3. Lab 2 the new deep laboratory for Physics research

Lab 2 provides one of the best protected and most easily accessible low cosmic ray background environments [4] in the world. The space was finalized for scientific use during spring 2016. The specifications for the space have been measured, such that

**Area (Volume)**
- Measuring hall 120 m$^2$ (volume $\sim 1080$ m$^3$)
- Entrance hall 120 m$^3$ ($\sim 700$ m$^3$)

**Electricity**
- 160 kVA, entrance hall
- 25 kVA, measuring hall
- 3 kVA UPS, measuring hall

**Background radiation**
- $\mu$-flux of $1.1 \cdot 10^{-4}$ m$^{-2}$s$^{-1}$ [5]
- Average U (0.8 ppm) and Th (3.2 ppm) in rock [6]
- Radon on average $\sim 70$ Bq/m$^3$
- Microseismic activity $\sim 100$ events per day (released energy $-1$ in moment magnitude scale)

**Other**
- Total Fresh air flux 130 m$^3$/s
- Access from the surface by a lift to the main level 1400 and 500 m by walking or by a car
- Connectivity: Optical GBLAN and 100MB internet

*Open call for Scientific activities during 2016:*

Scientific and commercial teams are invited to locate their operations in the laboratories of Callio Lab. Letters of Interest can be submitted to calliolab.com/open-call.

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