Feasibility study on SUNLAB - Sieroszowice Underground Laboratory

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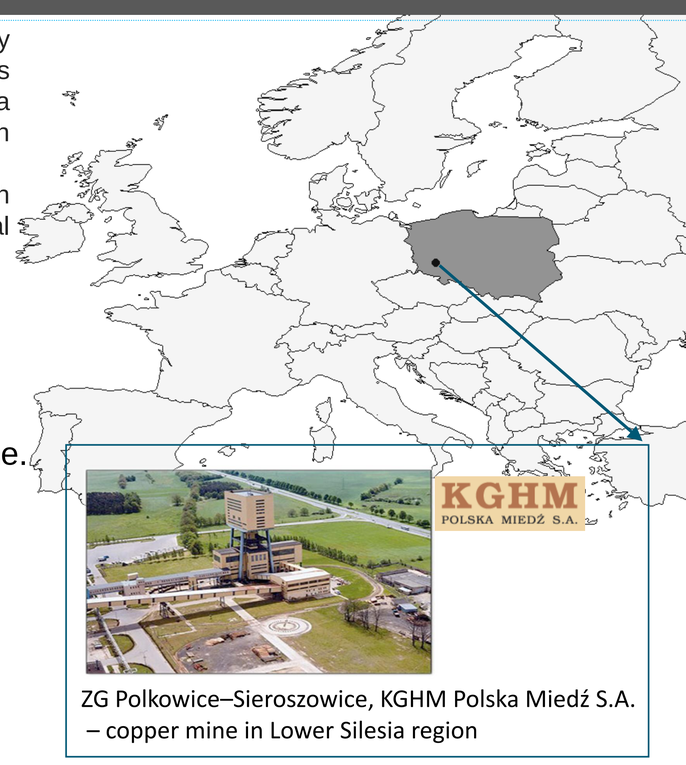
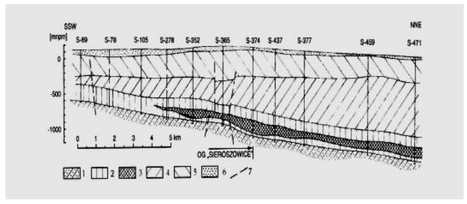
In the years 2008 – 2011 several sites in Europe were considered as candidate hosts of the next generation large volume neutrino observatory within the LAGUNA FP7 design study. The SUNLAB - Sieroszowice Underground Laboratory in thePolkowice-Sieroszowice mine in Poland was discussed as one of them Physics-oriented studies, including sensitivity calculations focused on the delta CP measurement and performed using the GLOBES package for a large LArTPC detector at a distance of 950 km from CERN in a long baseline neutrino experiment, have been completed based on a grant from the Polish National Science Centre (DEC-2011/03/N/ST2/01971). The results of those studies are presented.

Independently, a project of a small low background underground laboratory has been prepared and included in the Polish Roadmap of Research Infrastructures. The SUNLAB laboratory will be placed 950 meters below the Earth‘s surface, in a salt-rock characterised by an extremely low level of natural radioactivity. The concept of the laboratory and results of the measurements of natural radioactivity are also presented.



ZG Polkowice–Sieroszowice, KGHM Polska Miedź S.A. – copper mine in Lower Silesia region



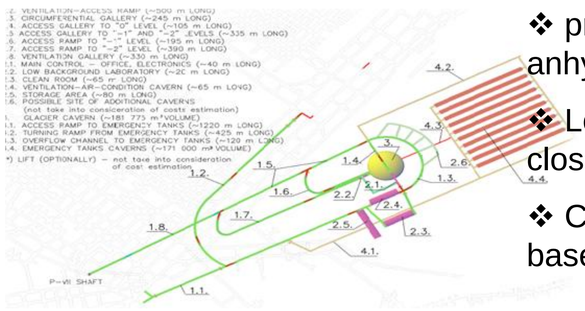
Geological profile of the Sieroszowice mine region:

- Good knowledge of geomechanical behaviour – monitored by the KGHM mine for a long time.
- Thick and stable layers of salt and anhydrite rock over coper deposit.
- Water-bearing clay situated at a shallower level - no water in anhydrite and salt strata.
- Large salt caverns at 950 m b.s. level

950 m bs = 2200 m w.e. - cosmic muon flux: ~50 muons per day per m ^{2}

Large underground observatory

studied as long baseline experiment in 2011-2015

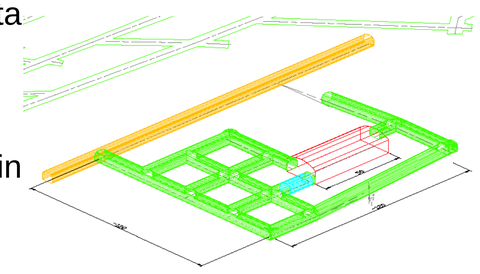


- ❖ project of the GLACIER-LAr type cavern in anhydrite, studied within LAGUNA
- ❖ Located 600 m b.s., geologicaly stable and close to large shaft - convinient for construction.
- ❖ Coupled with CERN neutrino beam – long baseline experiment with 950 km baseline

Low-background underground laboratory

on the Polish Roadmap for Reasearch Infrastructure 2015

- ❖ Project of small laboratory in salt-rock strata in region of low mining activities.
- ❖ Low level of natural radioactivity.
- ❖ Experience gained during measurements in existing large underground salt caverns.

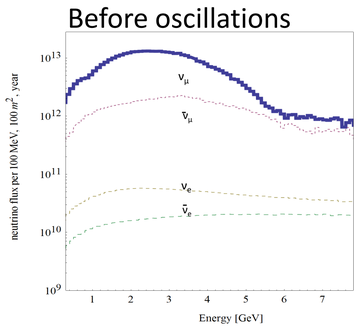


Simulation of the long baseline experiment

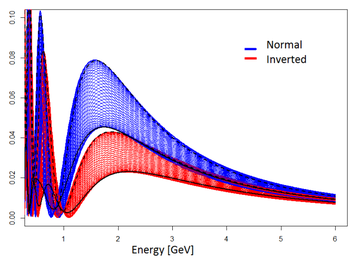
Source (ν_μ) ν_μ -> ν_e Detector (ν_e CC)

950 km

Before oscillations

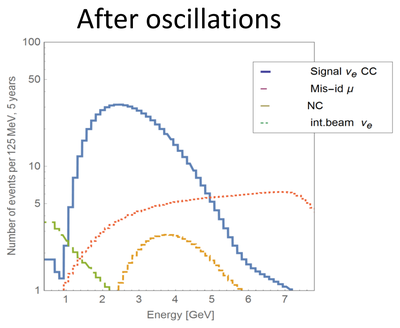


Neutrino flux for optimised focusing system, at 100 km distance for 100 m^2



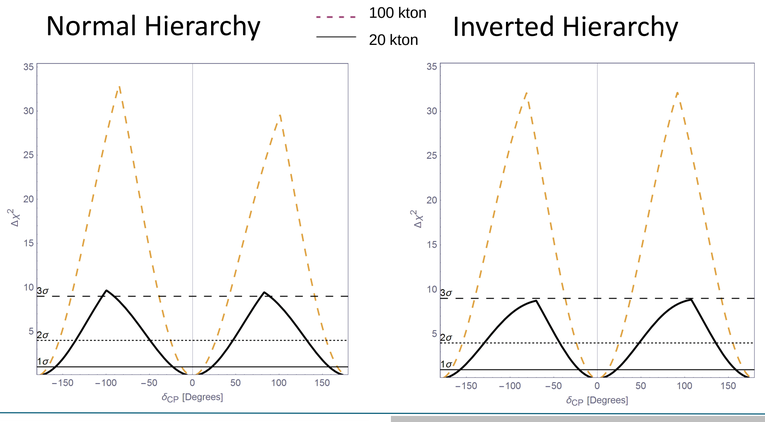
Oscillation probability for a baseline of 950 km. First oscillation maximum at 1.92 GeV. Normal and inverted hierarchy, δ (–π,π).

After oscillations



Number of ν_eCC signal and background events for 5 years of neutrino run in 100 kton of LAr – TPC detector.

δCP measurement potential for SUNLAB



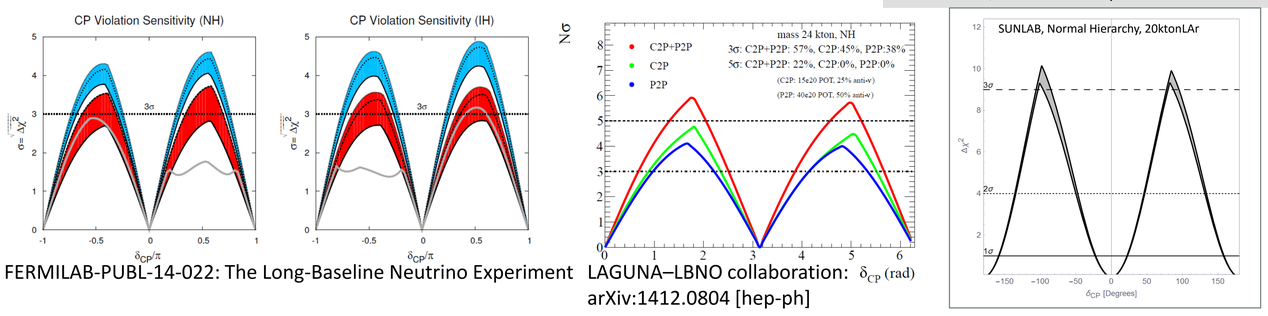
Sensitivity for the CPV discovery presented as a function of the value of delta CP, assuming the known mass hierarchy and standard set of oscillation parameters. Assumed 10 years of data taking - 5 years for both, neutrino and antineutrino beams. Calculations done using GLOBES package. The results are given for two detector masses: 20 kton and 100 kton.

DUNE - **1300km** Fermilab- Sanford Lab
10 kton LAr, 6x6x10^{20} p.o.t.

Comparison studies - first phases: DUNE, LAGUNA-LBNO, SUNLAB

SUNLAB - **950 km** CERN-Sieroszowice
20 kton LAr, 10 x1.4x10^{20} p.o.t.

LBNO - **2300 km** CERN-Pyhasalmi
24 kton LAr, 10x1.4x10^{20} p.o.t.



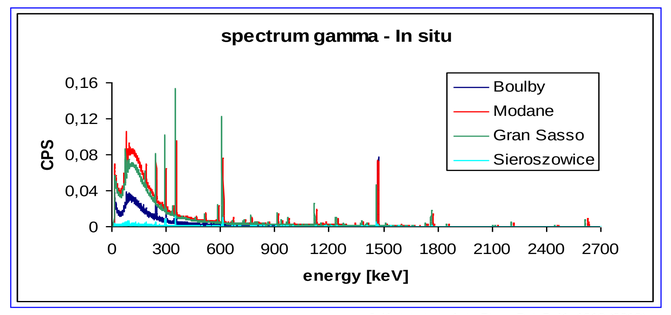
FERMILAB-PUBL-14-022: The Long-Baseline Neutrino Experiment

LAGUNA–LBNO collaboration: δ_{CP} (rad) arXiv:1412.0804 [hep-ph]

Measurements in the salt cavern in the Sieroszowice region.

❖ **Gamma spectrometry- *in situ* measurements**

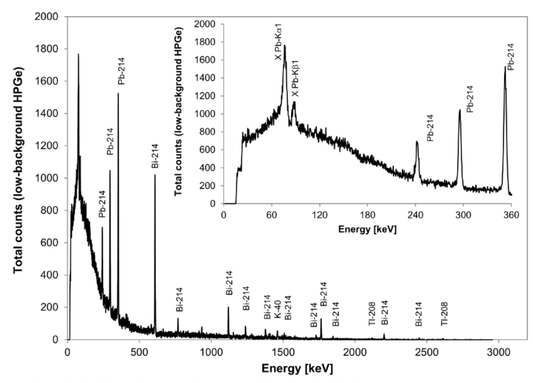
Integral background counting rates 50 –2700 keV [CPS/keV*kg]	
Sieroszowice	**2.30 (0.02)**
Gran Sasso	57.68 (0.02)
Modane	66.06 (0.03)
Boulby	23.83 (0.05)

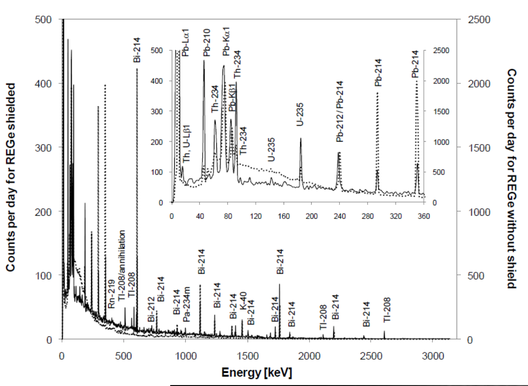


J. Kisiel et al., Acta Phys. Pol. B 41, 1813 (2010)

Gamma background measurements using two Ge spectrometers:

- Low-background high-purity detector (HPGe) manufactured at IFJ PAN
- Portable GR4020 Canberra spectrometer with and without lead shielding





K.Polaczek-Grelik, J. Kisiel , et al., accepted for JRNC,(2015),

24 hour long measurement in P1 salt cavern.

Only K-40 line comes from external source (salt), Uranium and Thorium series come from internal impurities - confirmed also by alfa spectrometry measurement.

❖ **Dose 8 months**

1.8 nGy/h

❖ **Alfa spectrometry of salt rock samples**

U-238: 0.0165+-0.0030 Bq/kg
U-234: 0.0225+-0.0030 Bq/kg
Th-232: 0.008+-0.001 Bq/kg
K-40: 4.0 +-0.9 Bq/kg

NNN 2015, Stony Brook University October 28-31, 2015

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