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Chasing neutrinos a mile underground

*Ralph Massarczyk
(LANL)*

My way to LANL

- 2014: PhD from Dresden University of Technology, Germany
- Experiments at the accelerator of the nuclear research facility in Dresden and at TUNL, NC
- Topic was “pygmy dipole-strength as a function of nuclear deformation”

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Does it really matter if the nucleus is not perfectly round if you bombard it with photons ?
- Then I decided to apply for a postdocs all over the world.

Understanding what the nature of a neutrino is ?

- Neutrinos are the lightest elementary particles
- Created by weak interactions in β^+ and β^- decays
- Common sources are reactors, and the sun
- Weakly interacting

.....

- And a lot of open questions

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- We don't know the exact order.
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... and why does LANL care about it

Ultra rare event searches

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- ...then more or less everything is radioactive

Banana equivalent dose

From Wikipedia, the free encyclopedia

Banana equivalent dose (BED) is an informal measurement of [ionizing radiation](#) exposure, intended as a general educational example to compare a dose of radioactivity to the dose one is exposed to by eating one average-sized [banana](#). Bananas contain naturally occurring [radioactive isotopes](#), particularly [potassium-40](#) (^{40}K). One BED is often correlated to $0.1\ \mu\text{Sv}$; however, in practice, this dose is not [cumulative](#), as the principal radioactive component is excreted to maintain [metabolic equilibrium](#). The BED is only meant to inform the public about the existence of very low levels of natural radioactivity within a natural

A banana contains [naturally occurring radioactive material](#) in the form of [potassium-40](#).

approximately 1% of
ent doses (BED).
is equivalent to
ED (7 mSv). A
A person living 16
ed an average of

Going underground

- Reduction of the cosmic ray component
- First 100 meter water equivalent eliminate hadronic component
- Several miles rock needed to shield muons
- Impossible to shield against neutrinos
- Labs are
 - active / old mines
 - Supply tunnels for dams or other infrastructure
 - Car tunnels

Going underground

MAJORANA

- Search for $0\nu\beta\beta$ -decay
- 30kg of highly enriched germanium detector
- Point Contact detectors

MAJORANA

- Located at SURF (SD, USA)
- Search for $0\nu\beta\beta$ -decay
- 30kg of highly enriched germanium detector
- Point Contact detectors
- Current limits
 - $T_{1/2} > 2.7 \times 10^{25}$ yrs
- Extensive studies on
 - Data analysis
 - Background simulations
 - Studies of remaining cosmogenic background
 - Dark Matter and other beyond the standard model physics

LEGEND-200 & LEGEND-1000

Large Enriched
Germanium Experiment
for Neutrinoless $\beta\beta$ Decay

- Process not found yet
- Next generation experiments
 - Larger
 - Cleaner
 - Large international collaborations
- First 200 kg start data taking next year at LNGS (Italy)

LEGEND-1000

- 1 ton of enriched material
- R&D in
 - Ar readout
 - Radon reduction
 - Electronics, front ends and cabling, including ASICs
 - Alternative shielding/cooling materials (LNe, doped Ar)
 - Active material mounts
 - Alternative cryostat designs
 - Analysis –machine learning, advanced PSD

BEST

- Search for sterile neutrinos at Baksan Underground Lab
- 50 tons of liquid Gallium
- Investigation of the Ga anomaly
- Intense ^{51}Cr source ($3.2 \text{ MCi} == 10^{17} \text{ Bq}$) (amount of Fukushima $^{137}\text{Cs} \sim 10^{12} \text{ Bq}$)
- Measure neutrino disappearance

@LANL

- Cowan & Reines discovered the neutrino while working at LANL
- Today we use the same location (a cold war underground vault)

Checkout <https://www.youtube.com/watch?v=IXTenRohfLw>

From neutrinos to the laboratories mission

Thanks for your attention