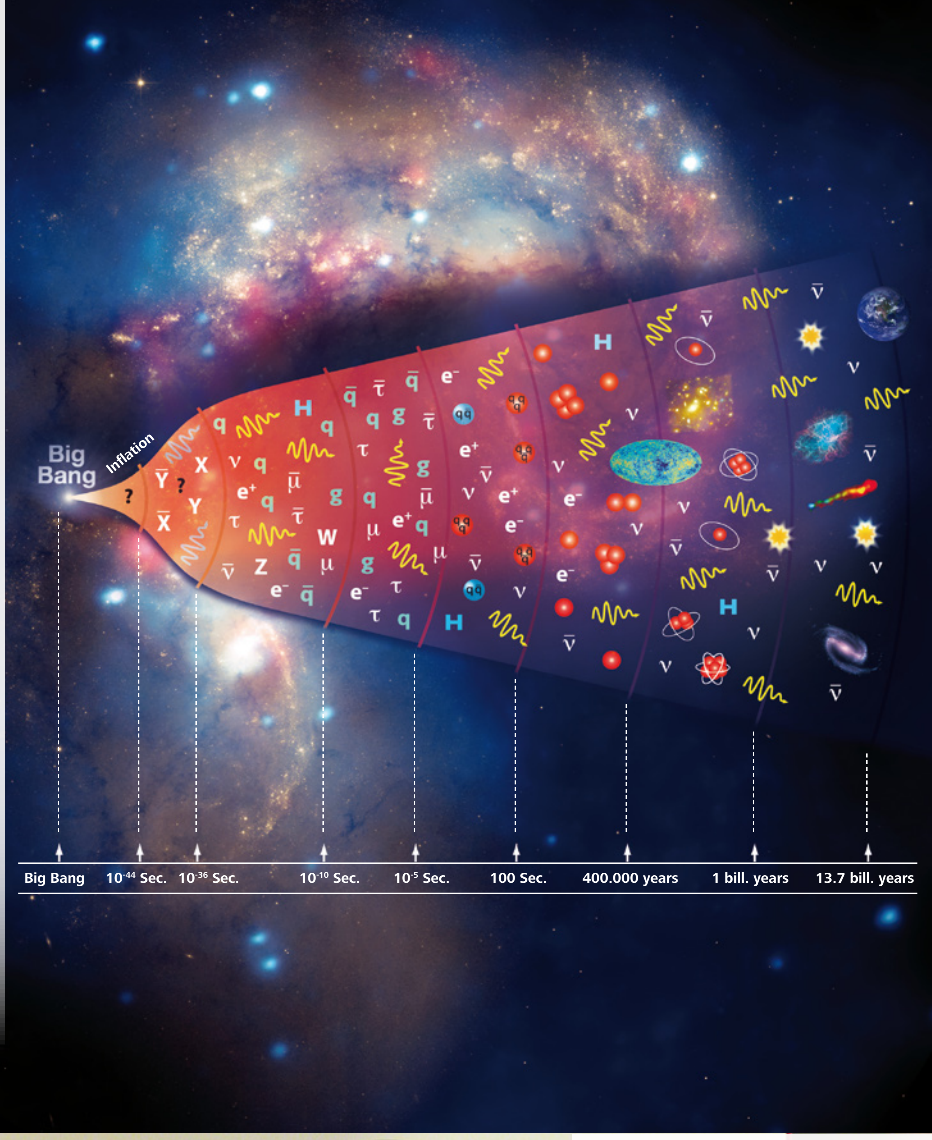
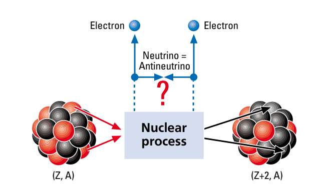
Are neutrinos identical to their antiparticles?
Are they responsible for the lack of antimatter in the universe?
What are their masses?
How did neutrinos influence the formation of structures in the visible universe?

Through the observation of an extremely rare decay process, the GERDA experiment should give answers to these questions.

Next to photons, neutrinos are the most abundant particles in the universe. Still, they are almost invisible to us since they interact with matter extremely weakly. Their most remarkable feature is currently only an assumption and still awaits verification - neutrinos could be their own antiparticles. This property would confirm theoretical preconceptions and would significantly change our current understanding of the structure of matter and of the development of the universe. The GERDA experiment (Germanium Detector Array) should get to the bottom of this hypothesis.

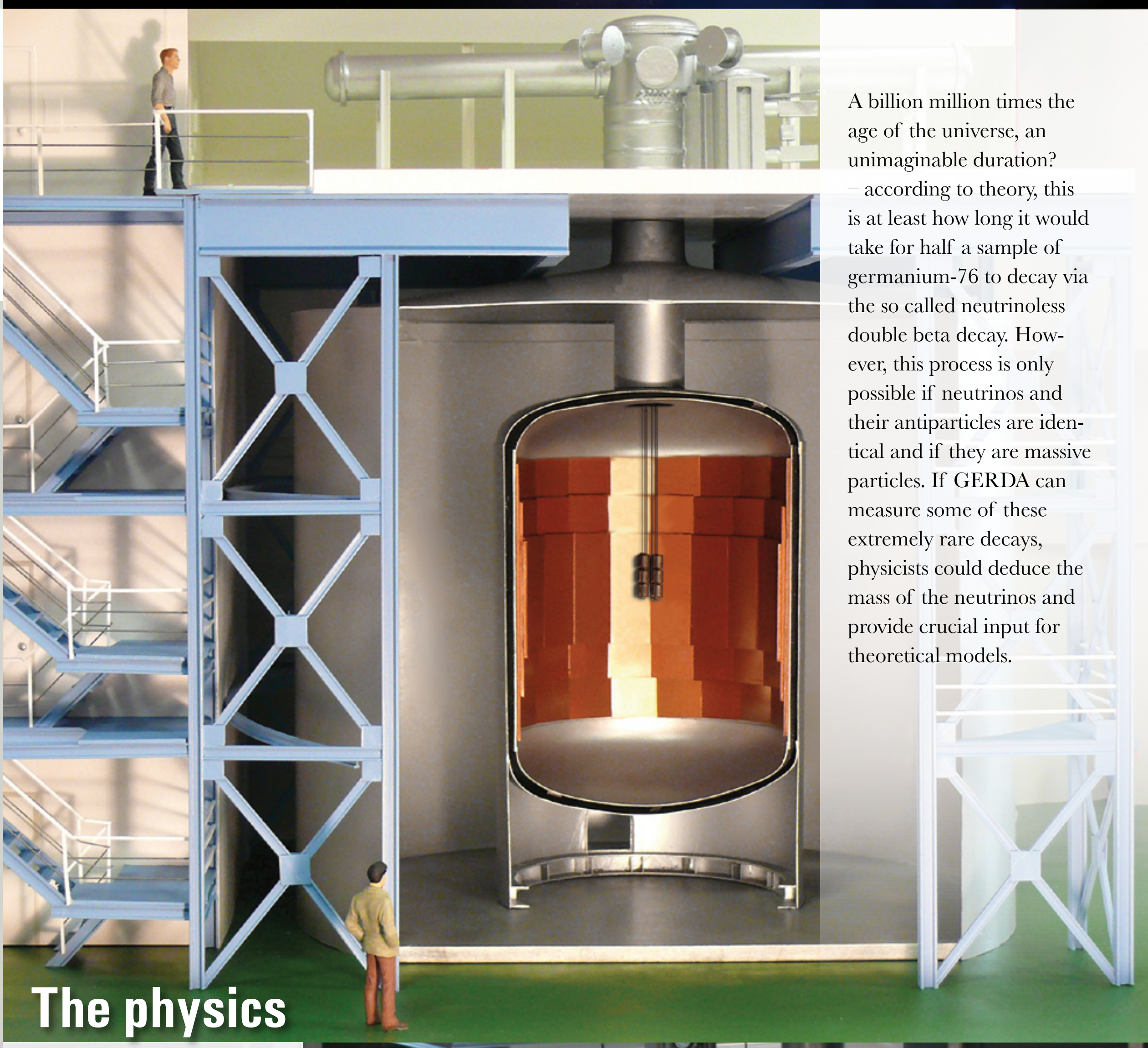



# The mission



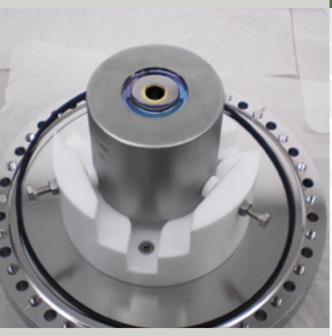

In neutrinoless double beta decay, two neutrons are converted into two protons and two electrons simultaneously. Two neutrinos are also created that cancel each other out if they are their own antiparticles.

Right: Model of the GERDA Experiment.



# The physics

A billion million times the age of the universe, an unimaginable duration? – according to theory, this is at least how long it would take for half a sample of germanium-76 to decay via the so called neutrinoless double beta decay. However, this process is only possible if neutrinos and their antiparticles are identical and if they are massive particles. If GERDA can measure some of these extremely rare decays, physicists could deduce the mass of the neutrinos and provide crucial input for theoretical models.



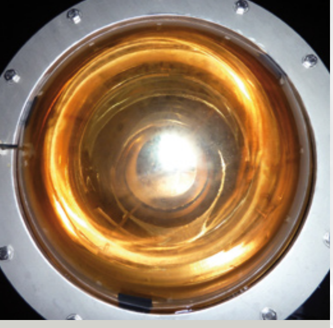
Germanium serves not only as the source for neutrinoless double beta decay but also as the detector.

Right: The clean room used for preparing the detectors.

In GERDA, the detectors have two functions: they provide the germanium-76 atoms for the search for neutrinoless double beta decay as well as measuring the energy of these decays. The detectors weigh approximately 2 kg and are the size of a beverage can. The detectors are made of high-purity germanium crystals that are enriched with the heavier isotope germanium-76. Occasionally a germanium-76 nucleus could decay through neutrinoless double beta decay, leaving behind traces in the detector.

# The experiment

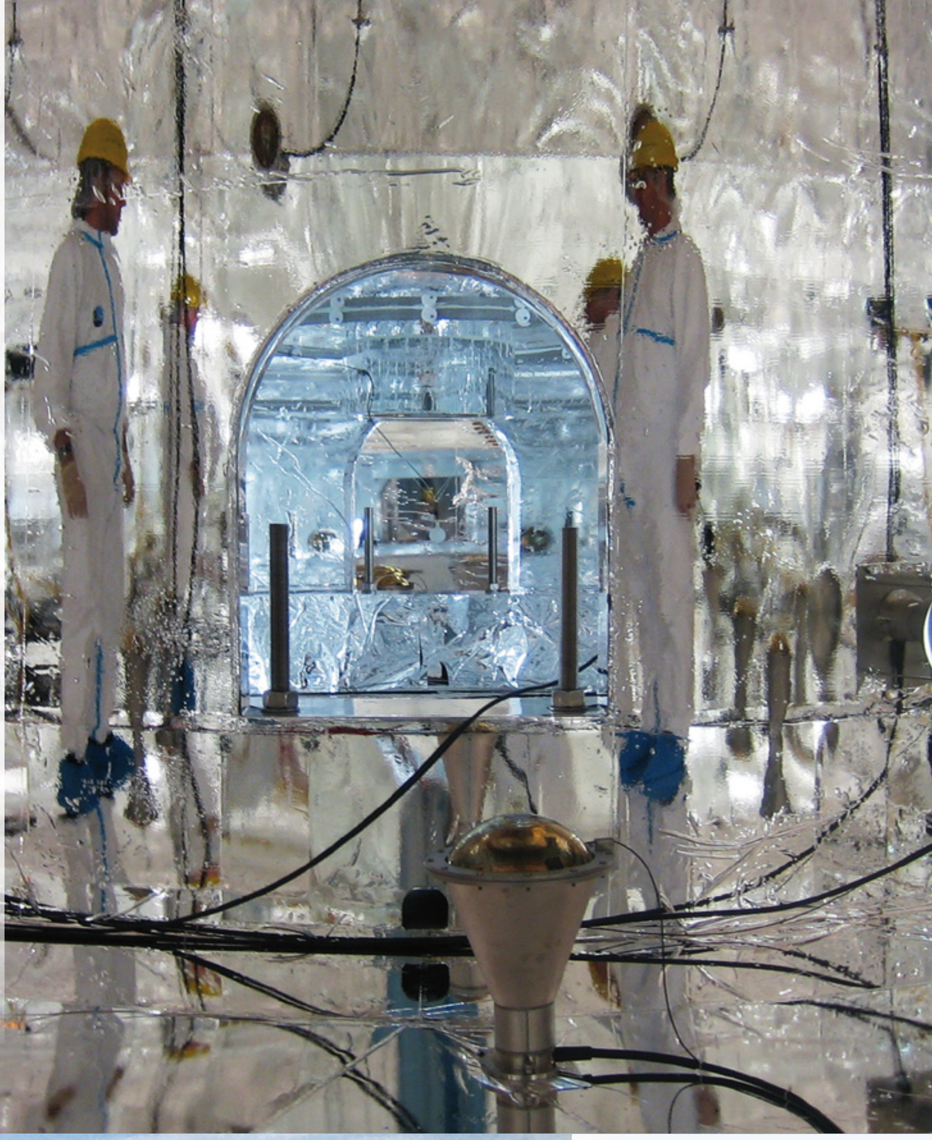
# GERDA
## Germanium Detector Array



Photomultiplier for identifying background radiation.

Right: View into the empty water tank designed to shield the experiment from ambient radiation.

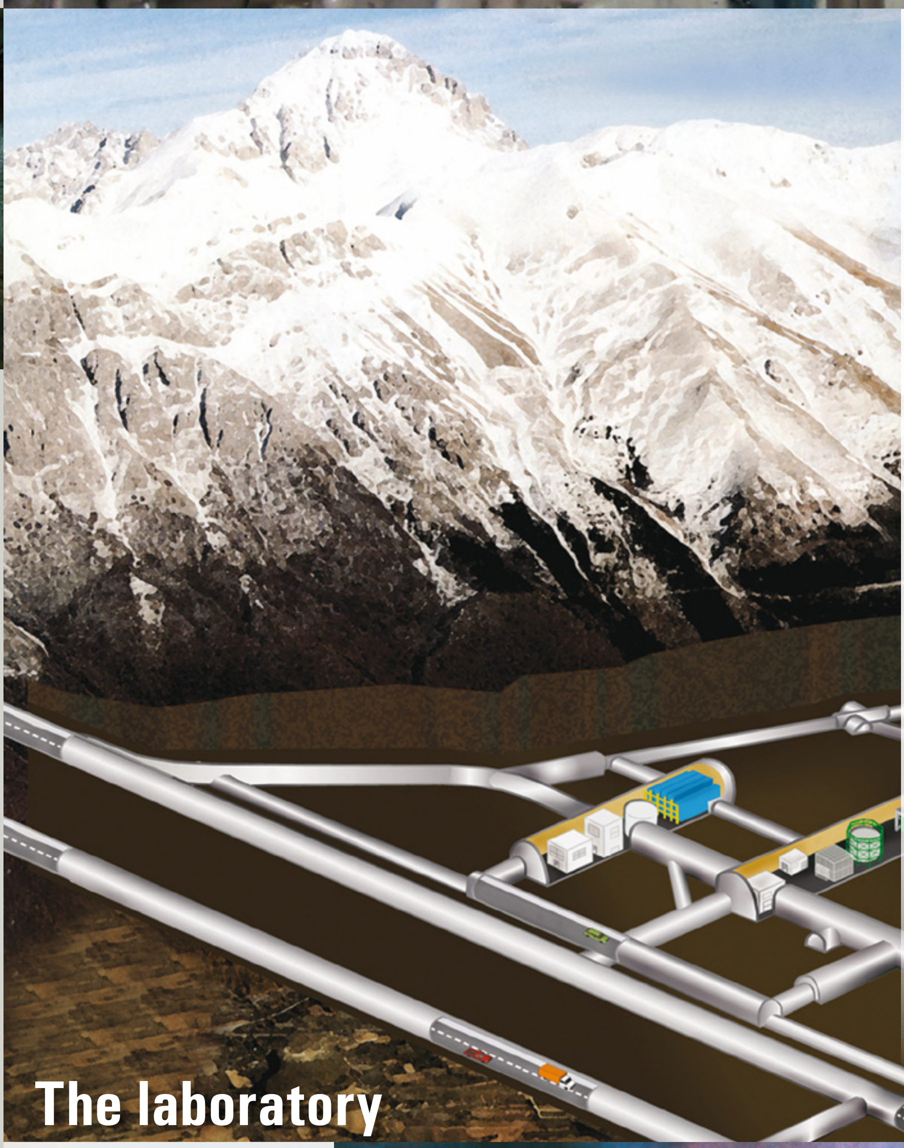
The GERDA physicists expect less than one neutrinoless double beta decay per year per kilogram of detector material. Therefore, they have to shield the experiment very carefully. The experiment is constantly bombarded with particles from space or from the surrounding rock that could distort the results of the measurement. For this reason, the germanium detectors hang in a six meter high, four meter wide tank filled with cold liquefied argon. To increase shielding even more, this cryo-tank sits in yet another water-filled tank ten meters in diameter by ten meters high.



## The tank

A deep tunnel leads beneath the Italian Abruzzo region into the largest underground laboratory in the world.

Right: The kilometer-long tunnel system leads into three experimental halls.



The Gran Sasso National Laboratory of the Italian National Institute for Nuclear Physics (INFN) is the largest underground laboratory for astro-particle physics in the world. It is located under the highest peaks of the Italian Appenines and shielded by an average of 1400 meters of rock. The rock absorbs the radiation from space making it possible for physicists to operate very sensitive measuring equipment.
In addition to GERDA, about 15 experiments are being conducted in the three underground halls, each of them one hundred meter long.

## The laboratory

Today, the only way to realize large experiments in physics is through international cooperation. A total of 15 institutions are participating in the GERDA experiment:

- Gran Sasso National Laboratory, Assergi, Italy
- Institute for Nuclear Research, Moscow, Russia
- Jagellonian University, Cracow, Poland
- Institute for Theoretical and Experimental Physics, Moscow, Russia
- Technische Universität Dresden, Dresden, Germany
- Kurchatov Institute, Moscow, Russia
- Joint Institute for Nuclear Research, Dubna, Russia
- Max-Planck-Institut für Physik, Munich, Germany
- Institute for Reference Materials and Measurements, Geel, Belgium
- INFN-Padova, Università di Padova, Padova, Italy
- Max-Planck-Institut für Kernphysik, Heidelberg, Germany
- Eberhard Karls Universität Tübingen, Tübingen, Germany
- INFN-Milano, Università di Milano, Milan, Italy
- Universität Zürich, Zurich, Switzerland
- INFN-Milano Bicocca, Università di Milano Bicocca, Milan, Italy

## The team

# GERDA
Germanium Detector Array

**Imprint**

**Publisher:**
**GERDA-collaboration**

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**GERDA on the web:**
**www.mpi-hd.mpg.de/gerda**

Editor:
Bernd Müller, www.bemueller.de
Design:
Vasco Kintzel, www.kintzel.com
Photos:
NASA, LNGS, MPI für Kernphysik, Excellence Cluster 'Universe', Universität Tübingen

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