

PRESS RELEASE

Weighing the invisible, the challenge of the KATRIN project: with the new TRISTAN neutrino detector, in search of the mysteries of dark matter

After the first 1,000 days of neutrino mass measurements, a new detector designed and built by the DEIB RadLab group will enable the search for a hypothetical fourth type of neutrino, the most elusive one

Milan, 26 May 2026 – An international experiment that has already broken several records. **The KATRIN project (KARlsruhe TRItium Neutrino Experiment)**, led by KIT–Karlsruhe Institute of Technology in Germany and involving 20 institutions from seven different countries, including the Politecnico di Milano, **celebrated the achievement of 1,000 days of neutrino measurements with the inauguration of phase 2** of the project: the commissioning of a **new and more sophisticated detector, TRISTAN**. The **RadLab group of the Department of Electronics, Information and Bioengineering – DEIB at Politecnico di Milano, led by professors Carlo Fiorini and Marco Carminati** (the latter being the national coordinator for the experiment), also supported by the National Institute for Nuclear Physics, **made a significant contribution to the creation of the new detector** by designing and developing the detection modules and the low-noise, highly compact readout electronics of the SDD detector.

The adoption of the new detector will allow KATRIN to address **a second scientific challenge, namely the search for a hypothetical fourth type of neutrino, known as “sterile”**, as it is even more elusive than the other three. The TRISTAN detector upgrade will in fact make it possible to explore a broader parameter space compared to what is currently achievable, as demonstrated by the **publication of the project’s first results in the journal “Nature”**. «In this way, it will be possible to search for traces of this hypothetical particle within a range of values (mass on the order of keV, i.e. one thousand electronvolts, and mixing angle of one part per million) that would make it **a promising candidate for explaining dark matter** – comments Professor **Marco Carminati** – Precisely identifying the neutrino mass, and finding the sterile neutrino, would be two fundamental objectives confirming that the current description of matter and standard interaction forces between particles is incomplete».

ALL KATRIN’S RECORDS

The KATRIN project is an international scientific collaboration aimed at measuring the neutrino mass in the laboratory using a model-independent method. To date, **it represents the most precise “scale” in the world designed to directly measure the neutrino mass**. Several records have been achieved since measurements began in 2019, including **the world record that**

established an upper limit of $8 \cdot 10^{-37}$ kg (corresponding to 0.45 eV/c²) for the neutrino mass after the first 269 days of data collection, and published in the journal “**Science**” last year.

Neutrinos are highly elusive particles, meaning that they interact weakly with matter and are therefore difficult to detect, yet they are fundamental for understanding the evolution of the cosmos. They influence the formation of large-scale galaxy structures, while in particle physics their extremely small mass serves as an indicator of previously unknown physical processes. The precise measurement of neutrino mass is therefore essential for a complete understanding of the fundamental laws of nature.

Although they are very abundant in the universe, they have an extremely small mass, less than one millionth of the electron mass. **Measurement through KATRIN is carried out by studying the decay of tritium** (a radioactive isotope of hydrogen). When tritium decays, it emits an electron and a neutrino: by measuring with extreme precision the maximum energy of the produced electrons, it is possible to deduce by difference how much energy (and therefore mass) has been carried away by the neutrino.

TRISTAN – Technical data:

The TRISTAN detector consists of an array of 9 detection modules, each composed of a monolithic array of 166 Silicon Drift Detectors, for a total of 1494 spectroscopic pixels. This type of detector, invented in the 1980s by Emilio Gatti, Professor Emeritus of the Politecnico di Milano (who passed away in 2016) and founder of the university’s school of Electronics, offers excellent low-noise performance and is well established for X-ray detection, particularly in spectroscopic applications. The novelty of this project is the use of SDD arrays for electron spectroscopy. Furthermore, it is the largest array of detectors of this type ever built, overcoming major challenges for the front-end electronics in terms of compactness, noise, signal integrity, and ultra-high vacuum and high magnetic and electric field operating conditions.

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