Researchers develop algorithm to see inside materials with subatomic particles

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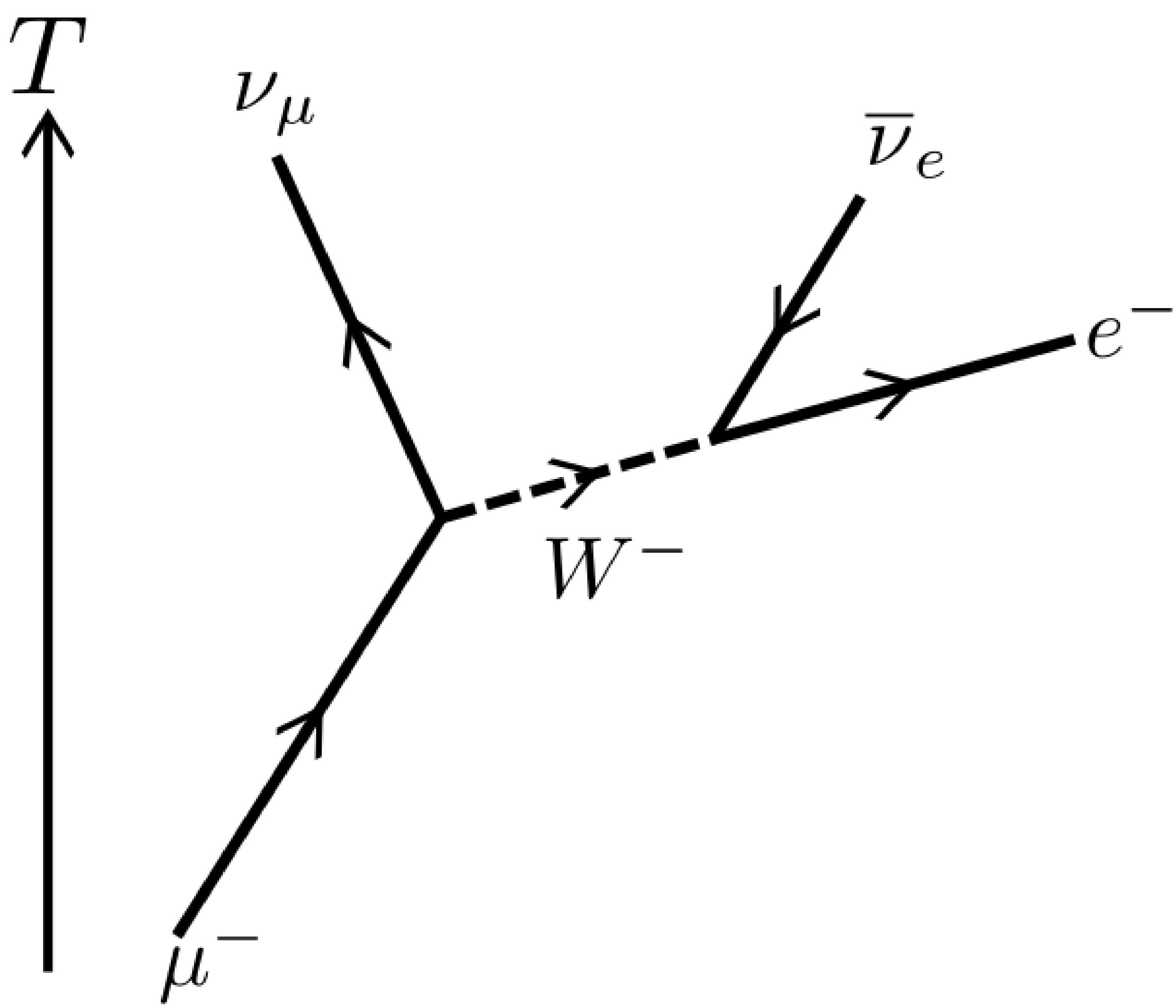

The most common decay of the muon. Credit: Public Domain

The University of Kent's School of Physical Sciences, in collaboration with the Science and Technology Facilities Council (STFC) and the Universities of Cardiff, Durham and Leeds, have developed an algorithm to train computers to analyze signals from subatomic particles embedded in advanced electronic materials.

The particles, called muons, are produced in large particle accelerators and are implanted inside samples of materials in order to investigate their magnetic properties. Muons are uniquely useful as they couple magnetically to individual atoms inside the material and then emit a signal detectable by researchers to obtain information on that magnetism.

This ability to examine magnetism on the atomic scale makes muon-based measurements one of the most powerful probes of magnetism in electronic materials, including 'quantum materials' such as superconductors and other exotic forms of matter.

As it is not possible to deduce what is going on in the material by simple examination of the signal, researchers normally compare their data to generic models. In contrast, the present team adapted a data-science technique called Principal Component Analysis (PCA), frequently employed in Face Recognition.

The PCA technique involves a computer being fed many related but distinct images and then running an algorithm identifying a small number of "archetypal" images that can be combined to reproduce, with great accuracy, any of the original images. An algorithm trained in this way can then go on to perform tasks such as recognizing whether a new image matches a previously-seen one.

Researchers adapted the PCA technique to analyze the signals sent out by muons embedded in complex materials, training the algorithm for a variety of quantum materials using experimental data obtained at the ISIS Neutron and Muon source of the STFC Rutherford Appleton Laboratory.

The results showed the new technique is equally as proficient as the standard method at detecting phase transitions and in some cases could detect transitions beyond the capabilities of standard analyses.

Dr. Jorge Quintanilla, Senior Lecturer in Condensed Matter Theory at Kent and leader of the Physics of Quantum Materials research group said, "Our research results are exceptional, as this was achieved by an algorithm that knew nothing about the physics of the materials being investigated. This suggests that the new approach might have very broad application and, as such, we have made our algorithms available for use by the worldwide research community."

More information: T Tula et al, Machine learning approach to muon spectroscopy analysis, *Journal of Physics: Condensed Matter* (2021). DOI: 10.1088/1361-648X/abe39e

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