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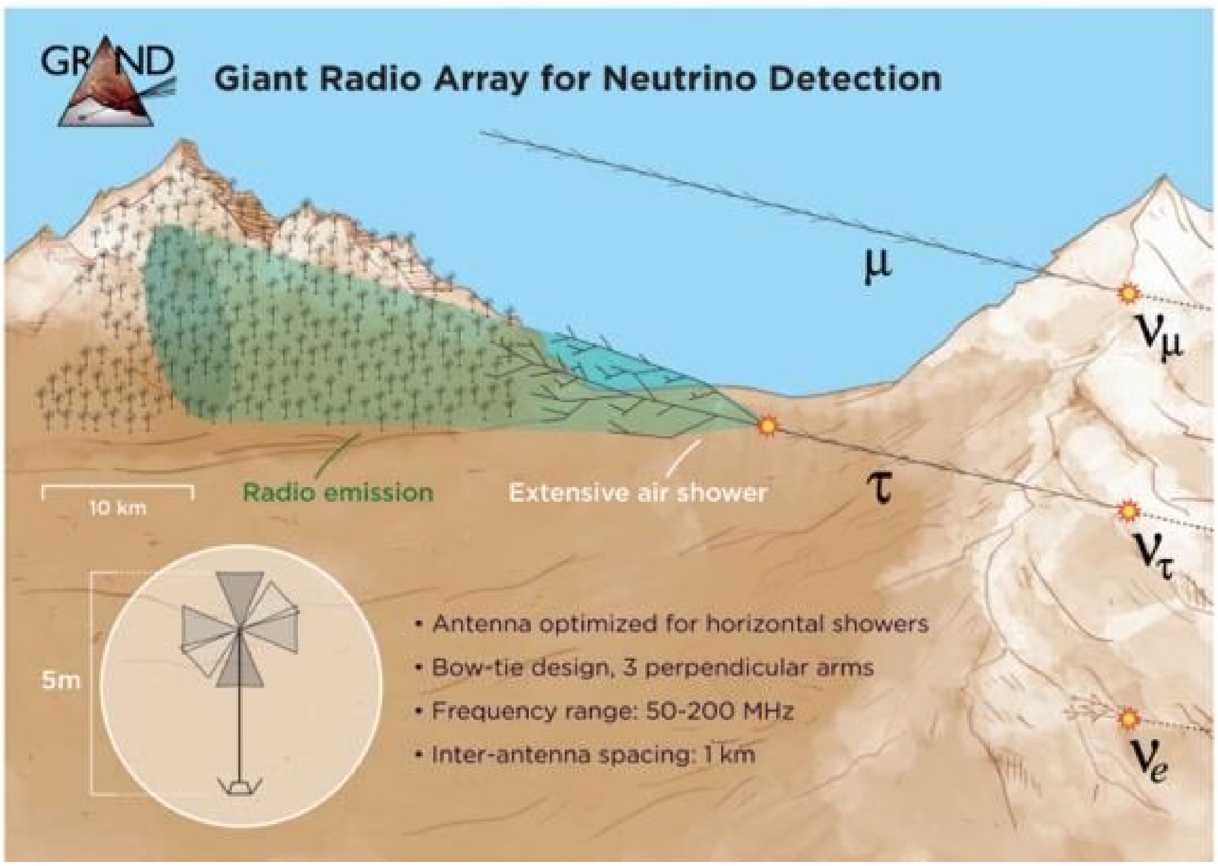
A proposal for a neutrino detection array spanning 200,000 square kilometers

December 23 2020, by Andy Tomaswick



Graphic from the paper describing GRAND that shows the different types of neutrinos and how the "air shower" will be used to detect them. Credit: Sijbrand de Jong / GRAND Collaboration

Sometimes in astronomy, the acronym for a project fits it particularly well. That would absolutely be the case for the Giant Radio Array for Neutrino Detection, which researchers hope to scale up to a size of 200,000 km^2 in an effort to measure ultra-high-energy tau neutrinos. Is it ambitious? Yes, but that doesn't really stop humanity from exploring when it wants to.

The project is the brainchild of the GRAND Collaboration, hosted by CNRS, France's Center for Scientific Research. The collaboration has already had some workshops, and developed a roadmap to reach their truly ambitious scale. To understand the roadmap, though, it is first helpful to understand what the project is looking for.

GRAND will look for what are known as ultra-high-energy neutrinos. These neutrinos play a large role in the standard model of particle physics, but so far have evaded detection at the energy levels where they are primarily predicted. They can come from two sources. The first is directly from ultra-high-energy (UHE) cosmic rays, while the second is when the UHE cosmic rays interact with the cosmic microwave background that pervades the universe.

The specific type of neutrino that GRAND is looking for is called a tau neutrino. These are not a direct result of the neutrino-formation events described above, but they are a subsequent form of the muon and electron neutrinos these events do create. As such, some of those particles would "oscillate" into tau neutrinos.

The reason tau neutrinos are of interest is that they have a high chance of being detected. Essentially, the project scientists would be relying on the relatively high probability that UHE neutrinos interact with ordinary matter. Of the three types of neutrino UHE cosmic rays create, the electron simply gets stuck in any ordinary matter it interacts with, while the muon continues to travel through the ordinary matter. The "sweet spot" of detection is the tau neutrino, which does interact with regular matter and decays within about 50 km of the interaction site.

The GRAND telescope can pick up that decay, and will be especially well placed to do so. The term for the decay of such a tau neutrino is called an "air shower," in which the tau neutrino is then detectable. But first, it has to interact with some form of normal matter, and what better mass of normal matter do we have than the Earth itself?

The idea of using the Earth to create an air shower of tau neutrinos isn't new, but setting up numerous arrays in mountainous terrain to consistently detect that decay is the basis of what the GRAND Collaboration is trying to do with their telescope. They are trying to catch the decay of tau neutrinos that have skimmed off a few kilometers of the Earth's crust and happen to decay in the atmosphere rather than deep underground.

In order to perform this detection, the array will make use of 200,000 pieces of specially designed equipment for the completed array.

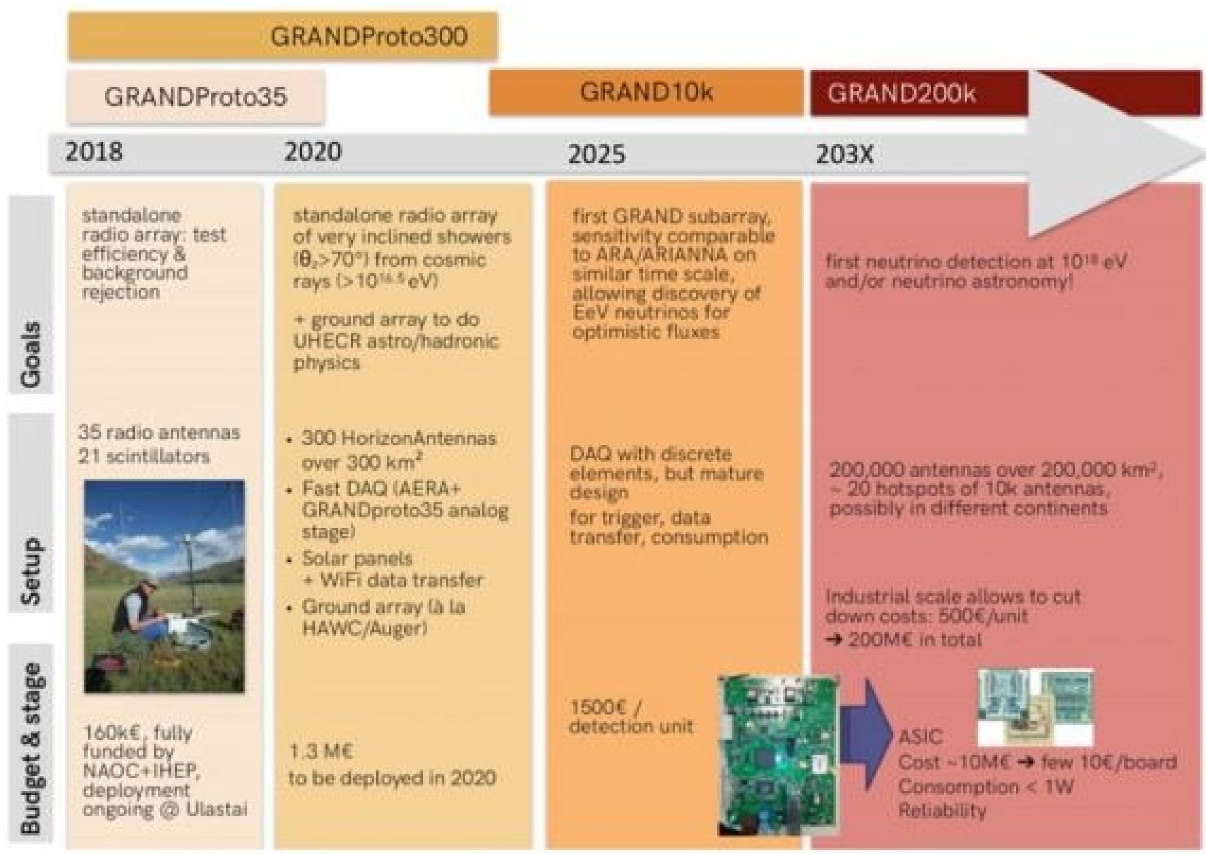
That doesn't mean the project intends to cover a 200,000 km^2 area (three times the size of the Czech Republic, where they recently held a virtual meeting) in detecting equipment. They would simply need a single detection station per km^2.

Each detection station consists of a specially designed antenna, an amplifier, and some associated data acquisition hardware. The project team has developed an early prototype, but point out that they have a long way to go in terms of cost and resiliency before their prototype is ready to be fully deployed at 200,000 sites.

This is where the collaboration's roadmap comes in. The team has already received around €160k and completed a set of 35 connected prototypes. In 2020, they embarked on a prototype program called

GRANDProto300 with €1.6 in funding to cover a 300-km^2 area in prototype kit. Over the next five to 10 years, they hope to drop the cost of a full antenna and data acquisition system to around $500. That price point would fund the entire project, with 20 hotspots each with one antenna for each of 10,000 km^2, for a total price tag of €200m.

A prototype data collector and transceiver for the GRAND system. Credit: Sijbrand de Jong / GRAND Collaboration



Grand Roadmap detailing plans for the project for the next 10+ years. Credit: Sijbrand de Jong / GRAND Collaboration

The GRAND project is certainly ambitious, but it could answer some interesting questions about the standard model. The team even points out that if they don't detect any of these decaying tau neutrinos, that itself is a revolutionary finding for the standard model, and would prompt a rethink of how these neutrinos work.

Even more interestingly, if you happen to be interested in pushing the bounds of experimental particle physics, the team is looking for new collaborators, and would welcome the additional help as they reach for their audacious goal. If nothing else, any new collaborators can rest assured that they will be working with a team that knows how to brand astronomy projects.

More information: arXiv : Giant Radio Array for Neutrino Detection (GRAND)

CNRS: Grand Collaboration

Source Universe Today

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