And in doing so, it will reanalyse a muon anomaly that has puzzled physicists for more than a decade. If the experiment confirms that the anomaly is real, then the most likely explanation is that it is caused by virtual particles that do not appear in the existing physics playbook — the standard model.

"It would be the first direct evidence of not only physics beyond the standard model, but of entirely new particles," says Dominik Stöckinger, a theorist at the Technical University of Dresden, Germany, and a member of the Muon g–2 collaboration.

Physicists are crying out for a successor to the standard model — a theory that has been fantastically successful yet is known to be incomplete because it fails to account for many phenomena, such as the existence of dark matter. Experiments at the Large Hadron Collider (LHC) at CERN, Europe's particle-physics lab near Geneva, Switzerland, have not revealed a specific chink, despite performing above expectation and carrying out hundreds of searches for physics beyond the standard model. The muon anomaly is one of only a handful of leads that physicists have.

Measurements of the muon's magnetic moment — a fundamental property that relates to the particle's inherent magnetism — could hold the key, because it is tweaked by interactions with virtual particles. When last measured 15 years ago at the Brookhaven National Laboratory in New York, the muon's magnetic moment was larger than theory predicts. Physicists think that interaction with unknown particles, perhaps those envisaged by a theory called supersymmetry, might have caused this anomaly.

Other possible explanations are a statistical fluke, or a flaw in the theorists' standard-model calculation, which combines the complex effects of known particles. But that is becoming less likely, says Stöckinger, who says that new calculation methods and experimental cross-checks make the theoretical side much more robust than it was 15 years ago.

"It would be the first direct evidence of entirely new particles."

"With this tantalizing result from Brookhaven, you really have to do a better experiment," says Lee Roberts, a physicist at Boston University in Massachusetts, who is joint leader of the Muon g–2 experiment. The Fermilab set-up will use 20 times the number of muons used in the Brookhaven experiment to shrink uncertainty by a factor of 4. "If we agree, but with much smaller error, that will show definitively that there's some particle that hasn't been observed anywhere else," he says.

To probe the muons, Fermilab physicists will inject the particles into a magnetic field contained in a ring some 14 metres across. Each particle has a magnetic property called spin, which is analogous to Earth spinning on its axis. As the muons travel around the ring at close to the speed of light, their axes of rotation wobble in the field, like off-kilter spinning tops. Combining this precession rate with a measurement of the magnetic field gives the particles' magnetic moment.

Since the Brookhaven result, some popular explanations for the anomaly — including effects of hypothetical dark photons — seem to have been ruled out by other experiments, says Stöckinger. "But if you look at the whole range of scenarios for physics beyond the standard model, there are many possibilities."

Although a positive result would give little indication of exactly what the new particles are, it would provide clues to how other experiments might pin them down. If the relatively large Brookhaven discrepancy is maintained, it can only come from relatively light particles, which should be within reach of the LHC, says Stöckinger, even if they interact so rarely that it takes years for them to emerge.

Indeed, the desire to build on previous findings is so strong that to avoid possible bias, Fermilab experimenters will process their incoming results 'blind' and apply a different offset to each of two measurements that combine to give the magnetic moment. Only once the offsets are revealed will anyone know whether they have proof of new particles hiding in the quantum soup. "Until then nobody knows what the answer is," says Roberts. "It will be an exciting moment." ■

ATMOSPHERIC SCIENCE

Rain forecasts go mobile

Analysis of wireless communications data could give accurate weather at street level.

BY JEFF TOLLEFSON

Meteorologists have long struggled to forecast storms and flooding at the level of streets and neighbourhoods, but they may soon make headway thanks to the spread of mobile-phone networks.

The strategy relies on the physics of how water scatters and absorbs microwaves. In 2006, researchers demonstrated that they could estimate how much precipitation was falling in an area by comparing changes in the signal strength between communication towers[1]. But mobile-phone companies were reluctant to give researchers access to their signal data, and the field progressed slowly. That is changing now, enabling experiments across Europe and Africa.

The technology could lead to more-precise flood warnings — and more-accurate storm predictions if the new data are integrated into modern weather-forecasting models. Proponents also hope to use this approach to expand weather services in developing countries.

The newest entry into this field is ClimaCell, a start-up company in Boston, Massachusetts, that launched on 2 April. The 12-person firm says that it can integrate data from microwave signals and other weather observations to create more-accurate short-term forecasts. It notes it can provide high-resolution, street-level weather forecasts three hours ahead, and will aim to provide a six-hour forecast within six months. The company has yet to make information on its system public or publish it in peer-reviewed journals.

ClimaCell will start in the United States and other developed countries, but plans to move into developing countries, including India, later this year. "The signals are everywhere, so basically we want to cover the world," says Shimon Elkabetz, ClimaCell's chief executive and co-founder.

But the fledgling company faces competition from researchers in Europe and Israel who have tested systems at multiple scales, including countries and cities, over the past several years. The scientists recently formed a consortium to advance the technology using open-source software. Coordinated by Aart Overeem, a hydrometeorologist at the Royal Netherlands Meteorological Institute in De Bilt, the group is seeking nearly €5 million (US$5.3 million) from the European Commission to create a prototype rainfall-monitoring system that could eventually be set up across Europe and Africa.

"There is a lot of evidence that this technology works, but we still need to test it in more regions with large data sets and different networks," Overeem says. Although ClimaCell has made bold claims about its programme, Overeem says he cannot properly review the

NICHOLE SOBECKI/PANOS

People in the developing world could benefit from improved precipitation forecasts.

company's technology without access to more data.

"The fact that a start-up company and commercial investors are willing to put money into this technology is good news, but I believe there is room for all," says Hagit Messer, an electrical engineer at Tel Aviv University in Israel, who led the 2006 study. She is part of the research consortium led by Overeem.

Previous projects by group members that tested the technology have met with success. In 2012, for instance, Overeem and his colleagues showed that the technology could be applied at the country level using commercial microwave data in the Netherlands[2]. And in 2015, the Swedish Meteorological and Hydrological Institute (SMHI), headquartered in Norrköping, launched a prototype real-time 'microweather' project in Gothenburg. It collects around 6 million measurements in the city each day in partnership with the telecommunications company Ericsson and a cellular-tower operator. The result is a minute-by-minute estimate of rainfall on a 500-metre-resolution map that encompasses the city.

A BRAVE NEW WORLD

Jafet Andersson, an SMHI hydrologist, says that the project has helped to advance the technology. For example, he notes that microwave data often overestimate rainfall by as much as 200–300%. But the team has worked out how to correct for that bias without relying on reference measurements from rain gauges or ground-based radar. This will make it easier to extend the technology to developing countries.

"It will take some time, but we are in the process of industrializing it on a country scale, or even a global scale," Andersson says.

Researchers with the consortium have deployed the technique in African countries that do not have access to ground-based radar and extensive rain-gauge networks. A team led by Marielle Gosset, a hydrologist at the French Institute for Development Research in Toulouse, demonstrated a proof-of-concept system in Burkina Faso[3] in 2012 and has since branched out to other countries, including Niger and Cameroon.

The technology is attracting interest in Africa because conventional weather-monitoring systems such as radar are too expensive, Gosset says. Weather forecasts based on microwave signals give developing countries a similar system, but for less money, she says.

Access to commercial data is getting easier, too. Researchers say that telecoms companies are beginning to see the value of releasing the data, and the consortium plans to create a central repository for processing the information. Project scientists hope to create a model that will enable a smooth partnership with the industry.

"I think that this door is just about to open," says Andersson. ■

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MICROBIOTA

Fish live longer on 'young poo'

Gut microbes of young killifish can extend lives of older ones.

BY EWEN CALLAWAY

It may not be an appetizing way to extend life, but researchers have found that older fish live longer after eating microbes from the poo of younger fish. The findings were posted to the bioRxiv preprint server on 27 March by Dario Valenzano, a geneticist at the Max Planck Institute for Biology of Ageing in Cologne, Germany, and his colleagues (P. Smith *et al.* Preprint on bioRxiv at http://doi.org/b5kq; 2017).

'Young blood' experiments have found that joining the circulatory systems of a young and an old rat can extend the older one's life. But the latest study looked at the effect of transplanting gut microbiomes. Previous work has hinted at links between gut microbes and lifespan: humans and mice lose some gut microbial diversity with age, and once-rare and harmful species can take over. The same holds in the turquoise killifish (*Nothobranchius furzeri*). To test whether the changes had a role in ageing, Valenzano and his colleagues transplanted gut microbes from 6-week-old fish into middle-aged, 9.5-week-old fish.

First, they gave the middle-aged fish antibiotics to clear out their gut flora, and then put them in a sterile aquarium with the gut contents of young fish for 12 hours. Killifish don't usually eat faeces, Valenzano notes, but they bit at the gut contents, ingesting microbes in the process.

These microbes recolonized the guts of the middle-aged fish. At 16 weeks old, the middle-aged fish that received 'young microbes' had gut microbiomes that resembled those of the 6-week-olds. The transplant also dramatically affected longevity: median lifespan was 41% longer in fish that received 6-week-old microbiomes than in control fish exposed to microbes from similarly aged animals. Microbes from older fish had no lifespan effect on young fish.

How microbes influence lifespan is hazy, Valenzano says. One possibility is that immune systems wear out with age, allowing harmful microbes to take root. A transplant might reset a middle-aged fish's microbiome, he says.

In humans, faecal transplants can treat some recurring infections. But Valenzano says it is much too early to consider transplants for life extension. "This is really early evidence that this has a potential positive effect," he says. ■