"demonstrate a commitment to mitigate the effects of burning fossil fuels".

"I'm happy with this outcome; it's a sign of progress," says David Frank, an environmental ethicist at NYU. He signed a petition in support of divestment, and says that the campaign is raising awareness about the problem, even if it does not provide any specific solutions.

Others complain that divestment misses the central role of fossil fuels in modern life. "How can you vilify the consumption of something that you use every day?" says Frank Wolak, an economist at Stanford University in California.

He and others hope to shift students' attention to what they consider a more effective strategy for weaning universities — and the world — off fossil fuels. On 20 April, Yale University in New Haven, Connecticut, announced plans to develop an internal carbon tax to reduce emissions. Wolak has proposed a similar approach at Stanford, and his team aims to develop a network of universities dedicated to the idea.

Such a network will not have a major impact on global carbon dioxide emissions, but economists have called for the same approach on a global scale. If fossil-fuel emissions were assigned a fee on the basis of their environmental impact, then dirty energy would become more expensive than cleaner alternatives. That would naturally shift investment toward cleaner sources.

At Yale, the carbon fee would be revenue neutral, similar to national proposals from think tanks in Washington DC. Money would be transferred from departments that have higher greenhouse-gas emissions than the university average to those that perform better. Students could participate by helping to cut emissions.

The idea is to give students and faculty members experience that they can carry into the real world, says William Nordhaus, an economist at Yale who led the development of the proposal. Nordhaus expects the university to start a pilot programme in the coming academic year, and to expand to all operations within three years.

"If you want to do something about climate change, then you have to do something about prices," he says. "You are not going to solve the problem by beating up on companies." ■

SEE EDITORIAL P.6

PARTICLE PHYSICS

Mysterious galactic signal points LHC to dark matter

High-energy particles at centre of Milky Way now within scope of Large Hadron Collider.

BY DAVIDE CASTELVECCHI

It is one of the most disputed observations in physics. But an explanation may be in sight for a mysterious excess of high-energy photons at the centre of the Milky Way. The latest analysis[1] suggests that the signal could come from a dark-matter particle that has just the right mass to show up at the world's largest particle accelerator.

The Large Hadron Collider (LHC), housed at the CERN particle-physics laboratory near Geneva, Switzerland, is due to restart colliding protons this summer after a two-year hiatus. Physicists there have told *Nature* that they now plan to make the search for such a particle a top target for the collider's second run.

A positive detection would resolve the source of the galactic γ-rays. But it would also reveal the nature of dark matter, the invisible stuff thought to make up around 85% of the Universe's matter, and would be long-sought evidence for supersymmetry, a grand way to extend the current standard model of particle physics.

"This could very well be the single most promising explanation for the Galactic Centre proposed to date," says Dan Hooper of the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois, although he adds that "there are quite a few others that are not too far behind".

In 2009, Hooper and Lisa Goodenough, then a graduate student at New York University, were the first to spot the signal[2], in data from NASA's Fermi Gamma-Ray Space Telescope. They proposed that the bump was a signature of dark matter. Two colliding dark-matter particles would annihilate each other, just as ordinary matter does with antimatter. The annihilation would generate a succession of short-lived particles that would eventually produce γ-rays.

But the proposed particle, which has been dubbed the hooperon or gooperon after its proponents, soon ran into problems with physicists' favourite version of supersymmetry. Although the minimal supersymmetric standard model (MSSM) allows for dark-matter particles with the estimated mass of hooperons — about 25–30 gigaelectronvolts (1 GeV is roughly the mass of a proton) — multiple experiments had suggested that the particles must be heavier. To accommodate hooperons, MSSM would have to be modified to an extent that makes many physicists uncomfortable. "It would have required a completely new theory," says Sascha Caron, a particle physicist at Radboud University Nijmegen in the Netherlands, who leads the team behind the latest calculations.

Sceptics suggested that the γ-ray excess spotted in the Fermi data had more-mundane explanations, such as emissions from neutron stars or from the remnants of exploded stars.

But in late 2014, it emerged that calculations for the range of dark-matter-particle masses ▶

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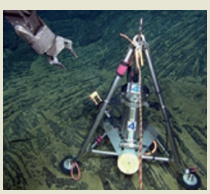

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Q&A

DANIEL BEREHULAK/NYT/REDUX/EYEVINE

How scientists are aiding quake recovery in Nepal go.nature.com/3mdjma that would be compatible with the Fermi bump were too conservative. Fresh estimates of the γ-ray 'noise' produced by known sources, provided by the Fermi science team[3] and others[4], allow for much heavier particles. "The excess can be explained with a particle of up to 200 GeV," says Simona Murgia, a physicist at the University of California, Irvine, and a leading scientist in the Fermi team.

BIG-BANG FIT

Armed with this insight, Caron and his collaborators recalculated the predictions of the MSSM theory and found another potential explanation for the excess — an existing dark-matter candidate called a neutralino. The neutralino was heavy enough not to be excluded by previous experiments, yet light enough to potentially be produced in the second run of the LHC.

Caron's model also produces a prediction for the amount of dark matter that should have been created in the Big Bang that is compatible with state-of-the-art observations of the cosmic microwave background — the relic radiation of the Big Bang — performed by the European Space Agency's Planck probe (see *Nature* http://doi.org/38k; 2014). This cannot be a coincidence, he says. "I find this quite amazing."

"This could very well be the single most promising explanation for the Galactic Centre."

Caron's team is not the only one reanalysing the Fermi bump in light of the new estimates. Similar but less-detailed calculations done by Fermilab physicist Patrick Fox and his colleagues last November[5] also revealed the neutralino as a potential cause of the Fermi γ-rays. And Katherine Freese, director of Nordita, the Nordic Institute for Theoretical Physics in Stockholm, says that she and her collaborators have calculated that the excess could be caused by a type of dark matter that features in a less-popular theory of supersymmetry.

Resolution may be just around the corner. In addition to being produced at the LHC, the neutralino could also be within the shooting range of next-generation underground experiments that are trying to catch dark-matter particles that happen to fly through Earth, says physicist Albert De Roeck, who works on the CMS, one of the two LHC detectors that will hunt for dark matter. If such a particle is indeed the cause of the γ-rays, he says, "it seems that the dark-matter signals should be observed very soon now". ■

1. Achterberg, A. *et al.* Preprint at http://arxiv.org/abs/1502.05703 (2015).
2. Goodenough, D. & Hooper, D. Preprint at http://arxiv.org/abs/0910.2998 (2009).
3. Murgia, S. Talk given at the Fifth Fermi Symposium, Nagoya, 20–24 October 2014; available at go.nature.com/wfwhh6.
4. Calore, F., Cholis, I. & Weniger, C. Preprint at http://arxiv.org/abs/1409.0042 (2014).
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PALAEOGENETICS

Mammoth genomes hold recipe for Arctic elephants

Catalogue of genetic differences reveals how ice-age giants braved the cold.

BY EWEN CALLAWAY

Woolly mammoths, unlike their elephant cousins, were creatures of the cold, with long hairy coats, thick layers of fat and small ears that kept heat loss to a minimum. Now, for the first time, scientists have comprehensively catalogued the hundreds of genetic variations that gave rise to these differences.

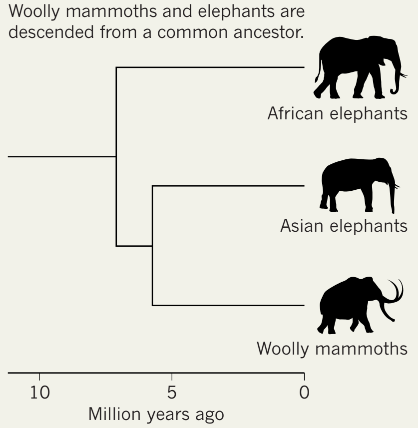
The research reveals how woolly mammoths (*Mammuthus primigenius*) evolved from the ancestor they share with Asian elephants (*Elephas maximus*; see 'Mammoth divergence'). It could even serve as a recipe for engineering elephants to live in Siberia. "These are genes we would need to alter in an elephant genome to create an animal that was mostly an elephant, but actually able to survive somewhere cold," says Beth Shapiro, an evolutionary geneticist at the University of California, Santa Cruz, who was not involved in the latest research. As fanciful as it sounds, such an effort is at a very early stage in a research lab in Boston, Massachusetts.

The first woolly mammoth genome[1] was published in 2008, but contained too many errors to reliably pinpoint how it differs from the elephant genome. Other studies singled out variations in mammoth genes that would have led to light-coloured coats[2] and oxygen-carrying haemoglobin proteins that work in the cold[3].

In the latest study, a team led by Vincent Lynch, an evolutionary geneticist at the University of Chicago in Illinois, describe how they sequenced the genomes of three Asian elephants and two woolly mammoths (one died 20,000 years ago, another 60,000 years ago). They found that about 1.4 million DNA letters differ between mammoths and elephants, which altered the sequence of more than 1,600 protein-coding genes. The study[4] was posted on the biology preprint server bioRxiv.org on 23 April.

MAMMOTH DIVERGENCE

Woolly mammoths and elephants are descended from a common ancestor.



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A search for what those proteins do in other organisms revealed genes that could be relevant to life in the Arctic. Several were involved in setting the circadian clock, a potential adaptation to living in a world with dark winters and 24 hours of daylight in summer. The mammoth genomes also contained extra copies of a gene that controls the production of fat cells, and some of the genes that differ between the two species are involved in sensing heat and transmitting that information to the brain.

In the case of one heat-sensing gene, which encodes a skin protein called TRPV3 that also regulates hair growth, the team 'resurrected' the mammoth version. They inserted the gene sequence into human cells in the lab, which then made the protein. Exposing the mammoth TRPV3 to different temperatures revealed that it is less responsive to heat than the elephant version is. The next step, says Lynch, is to insert the same gene into elephant cells that have