LET THERE BE LIGHT

On two continents, scientists are racing to crack one of the universe's unsolved mysteries.

Their goal: to prove whether DARK MATTER exists.
By Hazel Muir. Photography: Andrew Hetherington

DAN BAUER OF THE AMERICAN TEAM

SOUDAN, MN: 47° 48′ 57″ N 92° 14′ 16″ W

GRAN SASSO: 42° 28′ 0″ N 13° 33′ 0″ E

ELENA APRILE OF THE ITALY-BASED TEAM

JIGG TYPEFACE BY ASHLEY COLBECK (VORM)

COSMIC SECRETS

Dark matter. You can't see it, but hypothetically it's everywhere. It passes through coffee cups, walls and your body. The consensus among cosmologists is that dark matter is a by-product of the big bang, and comprises 85 per cent of the matter of the universe. Yet no one knows what it's made of – and there's no proof that it even exists. Now rival research teams are racing to find evidence of the uncapturable. WIRED joins the cosmic detectives at work on both sides of the Atlantic

OPENING SPREAD BACKGROUND IMAGE: THIERRY LEGAULT

The head-frame of the Soudan mine (*left*) in Minnesota, which houses America's Cryogenic Dark Matter Search (CDMS) project. Its chief rival, XENON100 (*above*), is located deep under Italy's Gran Sasso mountain – the entrance is on the right, just off the tunnel road to Rome

t's 7.30am on a cold April morning in northern Minnesota, the state's vast frozen lakes just starting to melt. A small crowd is gathering at the head-frame above a mineshaft. We put on hard hats then squeeze into the rust-coloured "cage", an old lift that once carried iron-ore miners half a mile underground to hammer away at the seams. Then we descend into the underworld.

The rickety cage rattles downward, the electric hoist screeching and whining overhead. It's pitch black, the darkness broken just occasionally by the fleeting glow of a passing light in the shaft. After nearly three claustrophobic minutes it's a relief to hear the engine's roar subside. The lift comes to a halt and we emerge into a tunnel, where a sign tells us we're on the Soudan mine's 27th level, 2,341 feet below the surface.

More than a century ago, men earned their trade down here by candlelight, mining the iron ore that fuelled an industrial revolution. But they abandoned this maze of tunnels in the 1960s. Today it's physicists who journey down here each day to look for an elusive quarry of their own – invisible particles new to science. These modern miners are looking for "dark matter", clouds of invisible particles left over from the big bang that created the universe.

A scientific consensus has emerged that dark matter makes up more than 80 per cent of all the matter in the entire universe. What it's actually made of, nobody knows. But dark matter might not keep its identity secret much longer. In mines around the world and deep within mountains, teams are now racing to snare the beast in strange traps built from vats of liquid xenon, ultrapure germanium crystals and lead from medieval roofs (it's less radioactive, so is better for screening out background particles).

Two of these experiments are the clear front-runners: the Cryogenic Dark Matter Search (CDMS) here in the Soudan mine, and XENON100, tucked under a mountain in central Italy. This year, both projects have scaled up their experiments to make them more sensitive to dark matter, which both hope to nail within 12 months. "Next year will be an exciting one," says Elena Aprile, team leader for XENON100. "Hopefully we'll have a first result by early 2010 – there's a lot of expectation as to what will happen."

There's a big prize at stake. Whoever wins the race will crack one of nature's most exasperating cryptic codes and plug some gaping holes in our grasp of how the universe evolved.

The dark matter problem has an embarrassingly long history that dates back to the 1930s. The first person to mention it was Fritz Zwicky, a brilliant and eccentric Swiss-American astronomer working at the California Institute of Technology. Zwicky noticed something very odd in 1933 when he measured the speeds of galaxies milling around in the Coma cluster, a group of hundreds of galaxies close together in the northern sky.

The galaxies were all moving under the influence of each other's gravitational pull. But Zwicky found that they were moving unexpectedly fast – as though being pulled by the gravity of something huge and invisible. His observations seemed to make sense only if vast amounts of unseen "cold dark matter" were holding the galaxy cluster together.

Around the same time, Horace Babcock at the University of California noticed the problem too. He measured star speeds in the Andromeda galaxy – the nearest giant galaxy to our own Milky Way – and found that it, too, should fly apart were it not glued together by the gravity of invisible matter telescopes can't see.

But these new observations failed to gain ground, perhaps partly because few astronomers warmed to Zwicky. He came up with many wild ideas – such as using fusion power to rearrange the solar system's planets – and was notoriously abrasive, referring to his colleagues in print as "scatterbrains" and "sycophants". In his 2002 book *The Extravagant Universe*, Harvard astronomer Robert Kirshner recalls Zwicky's fondness for calling his adversaries "spherical bastards" – because they resembled bastards from every angle.

Zwicky's provocative idea gathered dust until Jeremiah Ostriker and Jim Peebles at Princeton University came to the same conclusion. In 1974, they published a report highlighting a startling conundrum – there was evidence that many galaxies, perhaps all of them, are much heavier than their visible stars would imply.

"That produced quite a stir – everyone thought it was crazy," says Ostriker. But as precise observations of galaxies rolled in, gradually more and more astronomers became convinced. Theory backed the idea, too. Calculations showed that dark matter must have existed from the dawn of time, its gravity choreographing the collapse of normal matter into galaxies of stars. Without it, our galaxy the Milky Way, the Sun, planet Earth – none would exist.

There are some dissenters, however. In 1981, physicist Mordehai Milgrom from the Weizmann Institute in Rehovot, Israel, suggested an alternative to dark matter which he called modified Newtonian dynamics (MOND). Perhaps the force of gravity in the outskirts of galaxies becomes stronger than Isaac Newton's theory suggests; that would explain why the stars there orbit faster, without any need for exotic dark matter.

The trouble is that no one has come up with a one-size-fits-all MOND theory that explains all astronomical observations simultaneously. "It's tremendous to have a competing theory because the best scientific work takes place when it's driven by competition," says Rick Gaitskell, from Brown University in Providence, Rhode Island, who has worked on dark matter experiments for two decades. "Unfortunately for MOND, it's not panning out well. It has huge difficulty explaining some astrophysical data."

Today the vast majority of scientists believe in dark matter, says Ostriker: "There are now so many completely independent arguments that all point to dark matter – it's just overwhelming."

Observations of the motions of stars and galaxies, together with theories about how the universe evolved from its origins in the big bang, all point to the same picture. Around 15 per cent of matter is "normal" – the atoms that make up everything familiar such as stars, animals, cans of baked beans. The rest is dark matter. It forms a vast invisible web throughout space in which galaxies of shining stars are embedded, like lights on a Christmas tree.

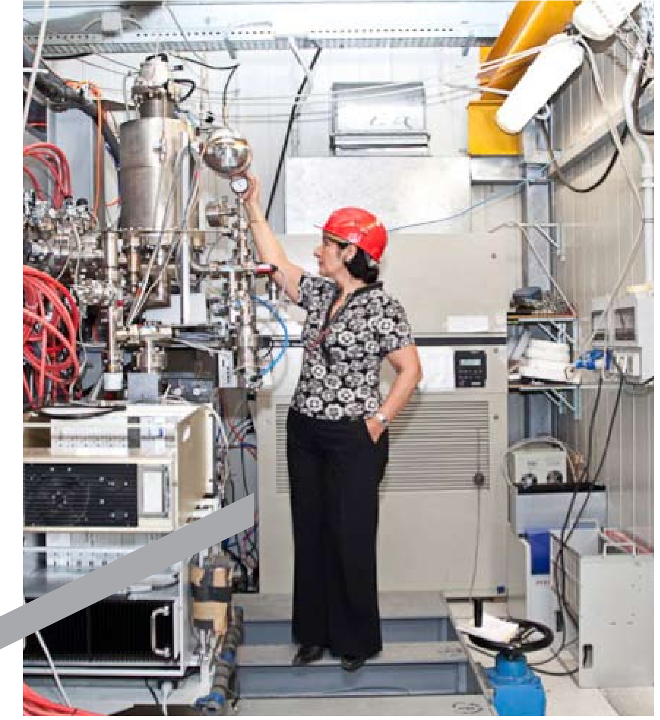
Our own galaxy hypothetically sits in a huge cloud of dark matter that extends well beyond the Milky Way's visible stars. Estimates suggest that locally, a cube of space as wide as our solar system contains something like 900,000 billion tonnes of it.

‘It's considerably more difficult than finding a particular grain of sand in the Sahara’

Dan Bauer in the airlock, where civilian clothes are covered with white "bunny suits" before anyone can enter the detector room

It's deeply enigmatic stuff. Dark matter isn't dark in the sense that a forest is dark on a moonless night. Shine a torch on a tree, and you'd see the leaves glow green in reflected light. The trees are also emitting plenty of light – a warm infrared glow that you can't see. But no torches or night-vision goggles could reveal dark matter. It's profoundly invisible and neither emits nor reflects light.

So what is it? Frankly, nobody knows. "There are multiple theories about what it might be, but theory is a slippery beast," says Dan Bauer from Fermilab, a US government physics lab near Chicago, and project manager for the CDMS experiment. One popular bet, though, is that dark matter is made of "weakly interacting massive particles" or WIMPs.



Top: Elena Aprile and XENON100's cooling system. *Middle:* a tunnel in Gran Sasso. *Bottom:* the door to the cavern housing Soudan's CDMSII experiment

WIMPs are beguiling because they could solve another problem at the same time. Physicists are keen to marry theories of quantum mechanics and gravity into one neat single theory, and one possible way of doing this is via so-called supersymmetry. This theory doubles the number of possible particles in the universe by giving every familiar particle in nature, like the electron or a photon of light, an as-yet-undiscovered partner. One of them – the lightest "neutralino" – is a WIMP that's heavy and stable just like all the dark matter. Could they be the same thing?

Favoured mass estimates for this neutralino are 50 to 1,000 times as heavy as the proton found in an atomic nucleus. Experiments at accelerator laboratories such as CERN on the French-Swiss border should already have manufactured them if they were lighter than 50 protons. If the neutralino is more than about 1,000 times as heavy as a proton, supersymmetry theories stop working.

So far there's not a shred of experimental evidence for neutralinos or any other superparticles. "What we would dearly like is some indication that the theory is right by actually detecting some of this family of supersymmetric particles," says Gaitskell. "We've been wanting this as a Christmas present for decades now, but we've yet to see one."

The trouble is that WIMPs are the very devil to catch. They don't carry any electric charge, which means they don't "feel" normal matter and breeze straight through it without stopping. A gale of dark matter constantly blows right through the Earth. It floods through everything – your house, your sock drawer and your body. So how on earth can you trap something as slippery as a WIMP?

Back in the 1980s, Bernard Sadoulet at the University of California, Berkeley, came up with a cunning plan. He reasoned that scientists might be able to sense a WIMP passing through chilled ultrapure wafers of the element germanium, already developed for the semiconductor industry. Most WIMPs would fly straight through a germanium crystal. But occasionally, though sheer luck, a WIMP might bump a germanium nucleus, making it rattle around. This would liberate a tiny amount of heat that cutting-edge sensors could pick up on the germanium's surface.

From 1996, Sadoulet's team tested this technology in a tunnel under Stanford University in an experiment called the Cryogenic Dark Matter Search. The trouble was that the detectors also registered cosmic rays, particles from space that constantly bombard the Earth's atmosphere. Sadoulet's detector was never going to sense a WIMP amid this cacophony of background noise.

The logical solution was to relocate the entire experiment deep underground, where overlying rock would block most cosmic rays but let the slippery WIMPs pass through. So in 2003, the CDMS experiment moved to a laboratory in the Soudan mine in Minnesota, whose deepest level is nearly half a mile underground.

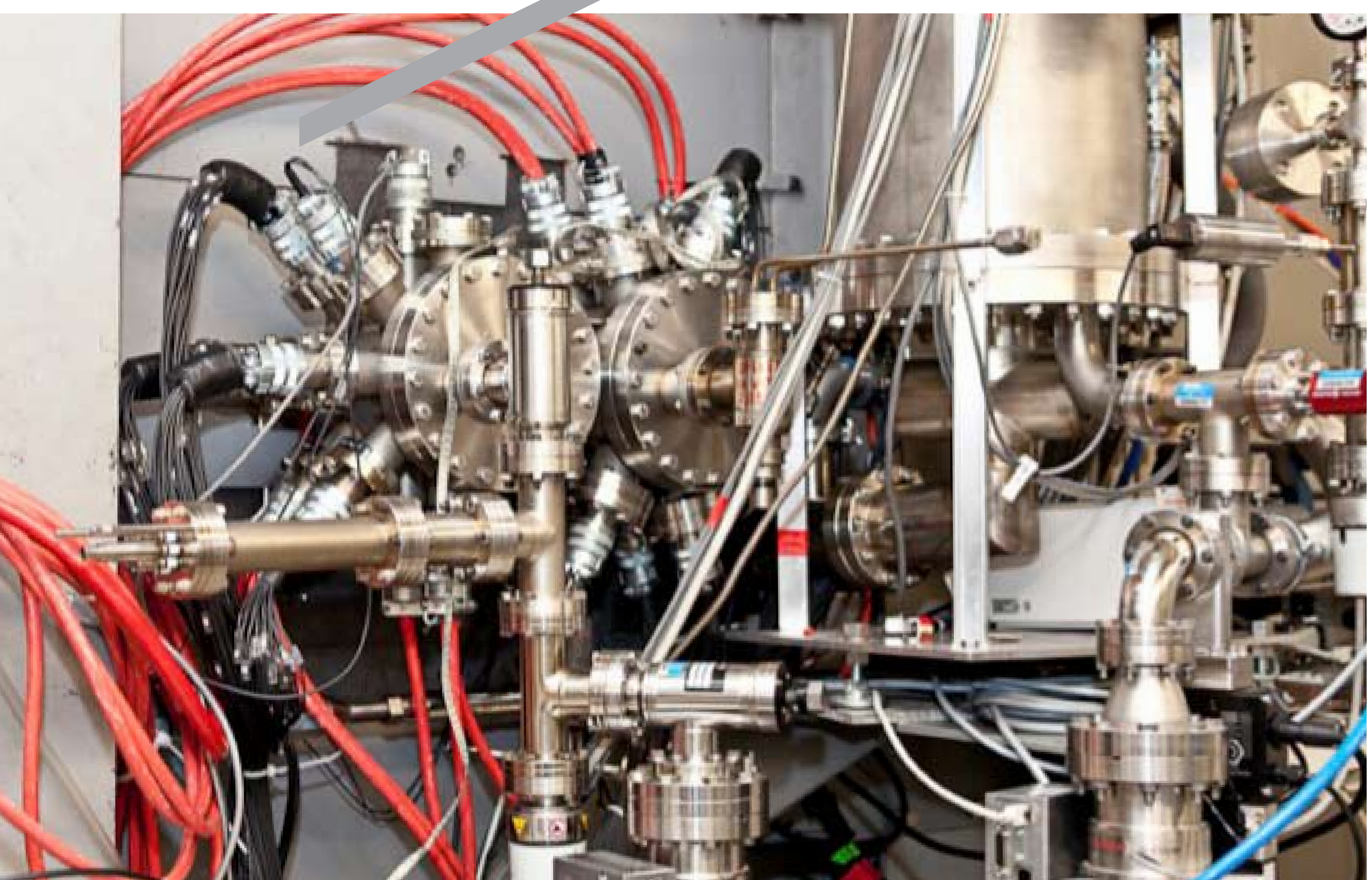
The mine employed around 1,800 miners during its heyday in the 1890s but closed in 1962, when it became cheaper to extract iron from poorer ores closer to the surface.

Scientists saw the mine as an opportunity. Down at its 27th level, the cosmic rays raining down from space are slashed by a factor of 100,000. So around 1980, the University of Minnesota established a laboratory there to house all kinds of experiments that need to hide from cosmic-ray interference.

Nearly 100,000 tonnes of rock were excavated to build the lab, a pair of huge caverns more than 70 metres long. Hauling the rock

(*Above*) The tops of the detector towers in Soudan. Each tube carries six germanium and silicon crystals.

The cooling system (*below*) of XENON100 at the Gran Sasso lab in Italy. It keeps the xenon at a constant -100°C



out took about 17,000 trips in the mine's rickety old elevator – the only way to get anything in or out. All the equipment going back down into the lab had to be smaller than 1.2 by 1.7 metres. The original CDMS experiment is now in its second phase and named CDMSII. Dan Bauer manages a team of around 50 scientists from 15 institutions, mainly in the US, who run the experiment and analyse the results. Most of them visit Soudan from time to time for ten-day shifts, to maintain and upgrade the detector. The lab also has a full-time technician, Jim Beaty, who keeps an eye on the detector all year round.

The lab really is a world away from the monochrome maze of tunnels the miners left behind. You enter it through a thick metal door to find an incongruously bright cavern full of fluorescent light and towering machinery. One huge particle detector called MINOS, more than 12 metres high, fills the entire rear section of one cavern, surrounded by walkways and electronics.

It would be easy to forget you're underground, until you see the cavern's concrete-sprayed walls dotted with little brown lumps. They're bats, mostly dead. Thousands of them inhabit the upper levels of the mine, but down here they seem to dehydrate and die before they can find a way out.

The CDMSII experiment sits in the lab's second cavern, housed inside a "clean room" that aims to keep the detector as dust-free as possible. Although the rock above the lab screens out most cosmic rays, the experiment must be kept ultraclean because particles released by natural radioactivity in dust will trigger the detector.

Even our bodies contain radioactive elements, especially after you eat foods such as tomatoes or bananas, which contain the isotope potassium-40. "Eat a banana and you've just taken in a lot of potassium," says Bauer. "If even a flake of your skin or a hair gets inside the detector, that would be bad."

So we all don pristine white "bunny suits" to go inside, ducking a metal beam that must have knocked a fair few heads (someone has inscribed on it: "Pain, hurt, blood"). Steve Leman, CDMSII team member from MIT, is lying on a platform above the experiment to install some delicate new detectors.

There are five towers of detectors, each containing germanium and silicon discs about 8cm wide. The whole thing sits inside an icebox about the size of a small dustbin. It's no ordinary icebox – it's a highly sophisticated cryogenic refrigeration system that cools the detectors down to an operating temperature of just one-twentieth of a degree above absolute zero. That makes the atoms in the crystals as still and motionless as possible.

Sensitive detectors on the crystal surfaces measure tiny vibrations when a particle comes in and bumps a nucleus. They also measure any electric charge liberated by any particle that disturbs electron clouds around the nuclei. Computers analyse the signals to distinguish an exotic WIMP from run-of-the-mill background particles, which trigger the detector every few seconds. The data travels to Fermilab, where it is stored on computers.

Bauer says he's confident that if WIMPs show up over the next two years, it will be his experiment that nails them. But halfway around the world at an underground lab in Italy, Elena Aprile from Columbia University in New York begs to differ. She's team leader for CDMSII's arch-rival experiment, XENON100, which is hunting for dark matter under the Gran Sasso ("great stone") mountain, 80 miles north-east of Rome.

Built in the 1980s when engineers were boring a road tunnel through the mountain, the Gran Sasso laboratory sits beneath around a mile of rock. This cuts down the interfering cosmic rays by a factor of about a million. Helpfully, the dolomite rocks of the mountain also have relatively low amounts of radioactive uranium and thorium, keeping down the background noise from neutrons. "Gran Sasso is probably the best laboratory in the world for dark matter experiments," says the lab's director, Eugenio Coccia.

But this year has been a traumatic one for the lab's staff. It is only 12 miles from l'Aquila, the Italian town devastated by a magnitude-6.3 earthquake at 3.30am on April 6. Nearly 300 people were killed and 40,000 made homeless. Around 60 of the Gran Sasso lab's 80 permanent staff were among those forced to abandon their houses and live with relatives or friends, in hotels on the Adriatic coast, or in tent camps across the region.

The Gran Sasso laboratory itself survived the earthquake unscathed. It sits halfway along a six-mile road tunnel, where a small slip road leads to a big steel door that could as easily be the entrance to the lair of a James Bond super-villain. As we arrive, a scientist shouts into a microphone to identify himself and the electric door hums as it slides open to let our car pass. Inside, a network of tunnels opens up into three vast halls, each about 100 metres long, housing roughly a dozen particle-physics experiments, some weighing thousands of tonnes.

XENON100 is a much smaller experiment tucked away down one of the side tunnels. The detector itself is a cylinder just 30cm in width and height, containing xenon liquid and gas at -100°C. It's shrouded by copper, lead and polyethylene to block as many normal background particles as possible. If a particle bumps

> 'It will be enormously surprising if these critical particles escape. We'll find them within five years'

a xenon nucleus, it can emit a brief flash of light and liberate electrons. Sensitive detectors measure these signals in both xenon liquid and gas to determine whether a WIMP has passed through or some ordinary, mundane particle like an electron.

From 2006, Aprile's team ran a smaller dark matter detector here with 11lbs of target xenon, but detected no unambiguous footprints of a WIMP. They've scaled the target mass up to 143lbs to improve their chances – the bigger the detector, the more likely it is that a passing WIMP will leave its mark.

Aprile hopes to start gathering data with the upgraded experiment before the end of this year and analyse the first results early next year. Catching a WIMP would be the highlight of a lifetime, she says. "I would feel like it was worth all the pain, giving up time with my daughters, living such a screwed-up life and not sleeping," she says. "You have to be a bit crazy to do this because it really takes 200 per cent."

If WIMPs are still a no-show, however, her team plans to scale the experiment up again to a tonne of xenon. This could make her strategy the front-runner in the race to catch a WIMP.

In the US, their CDMS rivals will up the ante as well. They can only dream of one-tonne-scale crystal detectors, because each of their detector towers takes months to build. Nonetheless, they plan to upgrade from 11lbs of target to 220lbs. For this "super CDMS" experiment they hope to up sticks to a lab in Sudbury mine in Canada, an active nickel mine more than a mile underground – so deep that the Earth's internal heat warms the air to 30°C.

Although CDMSII and XENON100 are currently the clear front-runners in the hunt for dark matter, around a dozen experiments worldwide are jostling for position. Two operate in the UK, both at Boulby potash mine in Yorkshire. Late this year or early next, Rick Gaitskell and others plan to set up another xenon detector called LUX in the Homestake mine, a gold mine under the Black Hills of North Dakota that operated from the 1870s until 2002.

Three other experiments at Gran Sasso – DAMA/LIBRA, CRESST and WARP – are also running. The WARP team, led by Nobel laureate Carlo Rubbia, filled its detector with argon in May and hope to produce results in about a year. And a one-tonne liquid-xenon detector, XMASS, is under construction in a mine in Japan.

Clues about the nature of dark matter could also come from Europe's latest particle smasher, the Large Hadron Collider at CERN. It might actually create dark matter as it slams protons together at nearly the speed of light. The accelerator got off to a bad start last year after an electrical fault, but it should be up and running again by the end of this year. If dark matter particles are born in its collisions, the telltale sign will be that some energy goes "missing" – some particles will just zoom off undetected. That would give the dark matter hunters some clues as to the mass of particles they are looking for.

Space telescopes could also play a role – especially Nasa's Fermi Gamma-ray Space Telescope, launched in June 2008 and the most sensitive gamma-ray space observatory to date. Theory suggests that colliding WIMPs might react with one another to spawn various particles including gamma rays, which the Fermi telescope could detect.

"We're closing in on dark matter on many fronts," says Gaitskell. "It will be enormously surprising if these critical particles escape. My natural tendency is to say we'll find them within five years. I suppose gut estimates are usually optimistic. But I think you can say that ten years from now, this chapter in the story of man's understanding of the cosmos will have been written in its entirety."

Not everyone is quite so optimistic. Asked when he thinks dark matter will be identified, Ostriker is agnostic. "I have no idea," he says, pointing to a sobering lesson from the ancient Greeks. "They knew that there were fundamental particles – atoms – and they had pretty good evidence," he says. "But it took 2,000 years before we figured out what atoms are."

But whenever the hunt seems futile, CRESST team member Sebastian Pfister from the Technical University of Munich draws inspiration from recent history. One dogged scientist has already hunted for invisible particles deep underground. And against all the odds, he found them, and bagged a Nobel prize.

The man was Raymond Davis, a physicist at Brookhaven National Laboratory in New York State. His work formed part of a long-running detective story dating back to the 1920s, when physicists noticed something funny was going on in a radioactive process called beta decay. This reaction's energy didn't add up – somehow a tiny amount of energy just went missing.

In 1930, a brilliant Austrian theoretical physicist, Wolfgang Pauli, realised that this energy must be carried off by some sort of tiny particle, later named the neutrino (Italian for "little neutral one" – see story on page 16), which at that time no one could detect. In the 1950s, physicists finally detected neutrinos flooding from a nuclear reactor in South Carolina.

Natural neutrinos should also be flying through the Earth, generated by nuclear reactions in the heart of our Sun. Davis figured out that it should be possible to catch these solar neutrinos in, of all things, a tank of chlorine-based dry-cleaning fluid, perchloroethylene. Occasionally, a neutrino would react with a chlorine atom and make it decay into an atom of argon.

There were two big catches. To have a chance of catching a few neutrinos, the cleaning-fluid tank had to be the size of a large swimming pool, containing more than 600 tonnes of liquid. And it would have to be deep underground to block cosmic-ray interference. Like the dark matter hunters, Davis had to go down a mine.

Davis was undeterred. In 1966, he began this outlandish neutrino experiment a mile underground in the Homestake mine. Even seasoned physics experts thought his experiment absurdly unrealistic. His vast tank contained about two million trillion trillion chlorine atoms. Every month, just 20 of these would react with neutrinos to leave just 20 telltale argon atoms as evidence that Davis would have to find.

Most scientists say it's about curiosity, the thrill of the chase – and healthy competition

But he was proved right. In 1968, his team announced that they'd detected solar neutrinos for the first time. Davis won a share of the Nobel prize for physics in 2002. The Nobel Foundation described his experiments as "considerably more difficult than finding a particular grain of sand in the whole of the Sahara desert".

Alas, by now he was suffering from Alzheimer's disease. His son delivered the customary Nobel lecture on his behalf.

Davis's work proved that space is awash with neutrinos. And they don't come only from stars like the Sun – space is filled with neutrinos left over by the big bang. There are roughly 300 ancient neutrinos in every cubic centimetre of space. Neutral and weakly interacting, their properties are similar to those of dark matter. So much so, that some scientists suspected up until the 1990s that neutrinos actually *were* the dark matter.

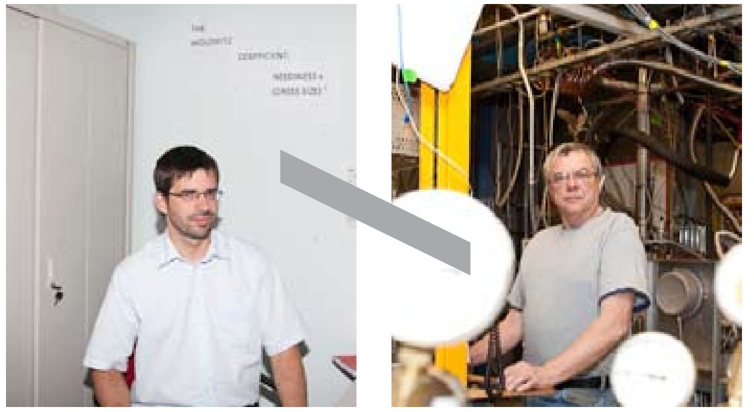
But the theory of the big bang, combined with astronomical observations, suggested that neutrinos are far too lightweight to account for all the dark matter. And they move too fast ever to clump together into blobs lurking in galaxies as dark matter seems to do. So the prime suspect for the dark matter is something like a neutrino, but it must be much heavier and much more sluggish.

Davis did have one advantage over today's underground WIMP hunters. Reactor experiments had already proved that neutrinos do actually interact with matter, albeit occasionally. The dark matter hunters have no such guarantee. It's possible that the dark matter particles feel no force at all except gravity – in which case physicists have no chance of catching them at all.

So what drives people to dedicate careers to this conceivably impossible task? "I have to think we'll find dark matter, it's been a substantial part of my career," says Bauer. "You have to enjoy putting together detectors and making them do things that haven't been done before – that's the fascinating part. Do I think about the problems of dark matter on a daily basis? Not necessarily."

There is certainly no financial incentive. True, the technologies used to hunt dark matter might eventually have useful spin-offs for medical scanners or suchlike. But no one can think of any direct benefit of dark matter itself. Its innate slipperiness makes it untouchable. Even if by some miracle you could build some amazing consumer product using dark matter, it would immediately ruin your day by falling through the centre of the Earth.

Sebastian Pfister (*left*) of CRESST, one of XENON100's on-site rivals at Gran Sasso, and Jim Beaty (*right*) of Soudan



"When I'm on a plane, sometimes people ask me – what's the point of discovering dark matter? And I'm speechless, because I can't tell him or her it's going to help find a cure for cancer," says Aprile. "To most people it probably sounds crazy. But I just think it's important to understand what nature is doing."

Typically, scientists would say it's all about curiosity – the exciting challenge of discovering a whole new component of the universe, another cog in nature's grand design. But they also relish the thrill of the chase, the healthy competition with rivals. "We all want to be first, there's no question of that," says Bauer.

If the rivalry has any kind of zealous or bitter edge, no one lets on. Most readily admit that their experiments do have flaws, and they're just ever so slightly keener to knock their competitors. Gaitskell says his team's LUX detector "will be more sensitive than any other experiment that's currently under construction". But Aprile insists that LUX will have no edge over XENON100: "Anyway, the point is that we're up and running – they're not."

Gaitskell points out that CDMSII is troublesomely small. "They have this fundamental issue that there just isn't very much mass in each detector," he says. Bauer counters that liquid-xenon experiments have trouble rejecting normal particles: "So if there is a small WIMP signal, they wouldn't be able to tell."

CDMSII, by contrast, can reject normal particles completely. "The headline in one magazine after our last result was 'Physicists see nothing', which was a little embarrassing," Bauer laughs. "But even though that's sort of odd, we actually make a virtue out of it because we're the only experiment that can say that for certain."

They all agree that rivalry can only go so far. If any team detects a WIMP, they'll rely on their competitors as expert witnesses. "Ultimately nobody will believe any one experiment that claims dark matter – you'll have to have confirmation from a different type of experiment," Bauer says. The discovery of dark matter will not be a eureka moment. It will almost certainly start off as a contentious, tentative sighting that scientists argue about for years.

The team running the DAMA/LIBRA experiment know this only too well. They announced that they had discovered dark matter in 1998. But to this day, they have had trouble convincing people.

The DAMA experiment, led by Rita Bernabei from the University of Rome Tor Vergata, took a different tack from all the others. They built a detector made of 220lbs of sodium iodide crystals. They hoped to measure tiny flashes of light from nuclei rattled by incoming WIMPs. A lot of normal particles from cosmic rays and radioactivity would trigger light flashes too. But the DAMA team reasoned that the WIMP signal should rise and fall over the course of a year due to the motion of the Earth.

The Sun moves round the Milky Way at about 485,000mph, dragging its orbiting clutch of planets along with it. The Earth has its own motion circling the Sun each year as well. The upshot is that the Earth's total motion through space varies over the year, being about 30 per cent faster in June than December.

In other words, dark matter particles should blow through the Earth more vigorously in June than December. Calculations suggest that roughly 10 per cent more dark matter particles should pass through DAMA's detector in summer than in winter. And sure enough, DAMA did see this signal. The result has been persistent, even when the team upgraded its detector to a bigger, better version called DAMA/LIBRA, with 550lbs of sodium iodide.

Case closed? Far from it. The trouble is that other experiments such as CDMSII should also have detected the WIMP signal. Nobody disputes that DAMA is measuring a real seasonal change in the number of particles triggering their detector. But they could be from some mundane effect below Gran Sasso mountain.

"The frustrating thing about that group and the reason why the community gets a little bit upset with them is that they don't show all of their data," says Bauer. "If they're going to make a claim that what they're seeing is WIMPs, they have a responsibility to show us everything, warts and all. They don't. We would love to be able to prove once and for all whether DAMA is right, but we can't without their data."

To many scientists, the DAMA team seems isolated and lacks the customary spirit of scientific cooperation. But Coccia stresses that they might, in the end, turn out to be right. "The result has to be taken seriously," he says. Physicists, he points out, have dreamed up some theoretical models of WIMPs with special, unexpected properties that could make them register in DAMA's sodium iodide detectors and nowhere else.

The current generation of new experiments should resolve this debate within a year or two, but there's no guarantee that the real WIMPs are going to show up. Still, deep underground, the search for dark matter will go on until there's no hiding place left.

Hazel Muir is a Kent-based science writer who specialises in space technology, astronomy and physics