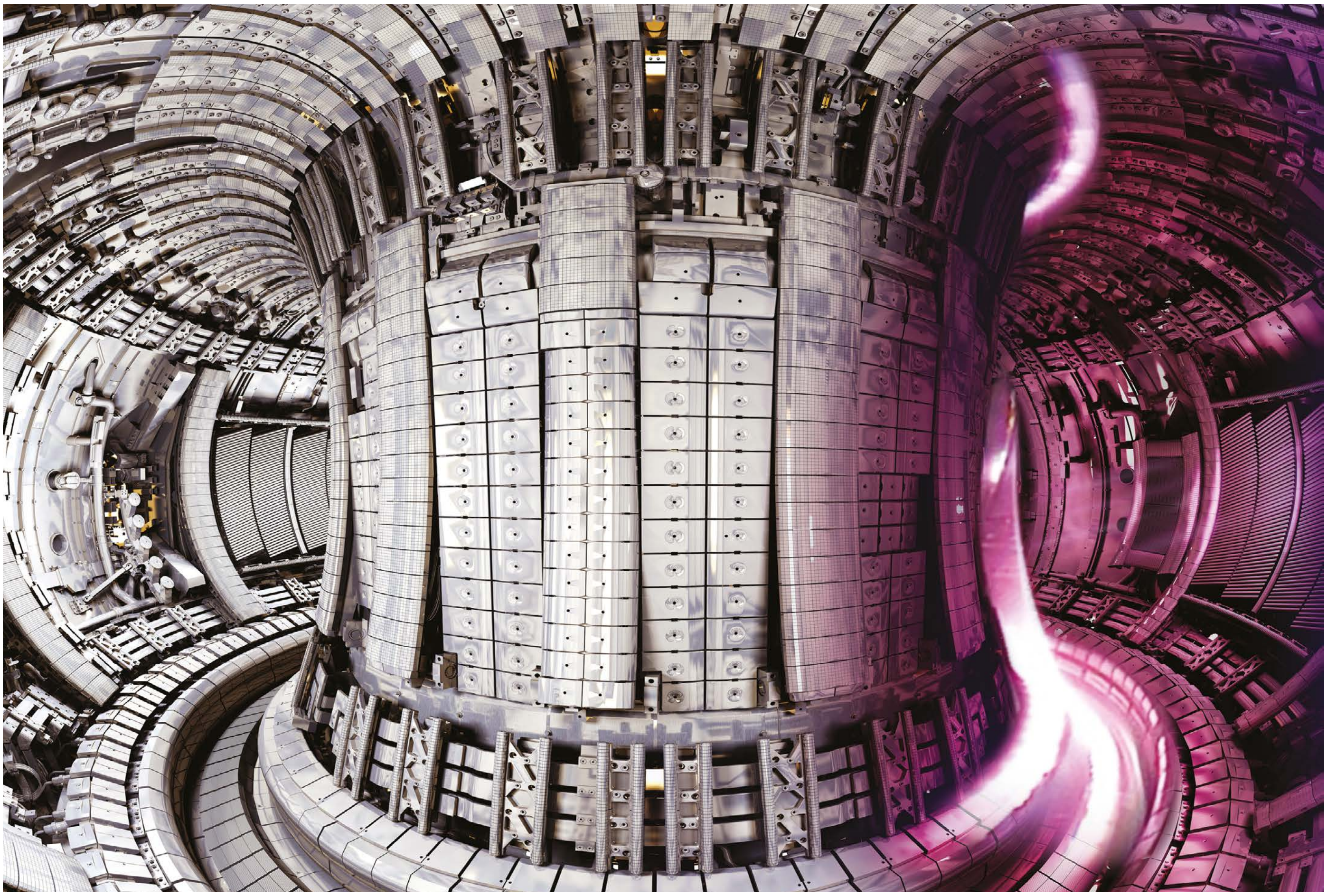
News in focus



The Joint European Torus has started conducting experiments with tritium fuel.

FUEL FOR WORLD'S LARGEST FUSION REACTOR IS SET FOR TEST RUN

Nuclear fusion experiments with deuterium and tritium at the Joint European Torus are a crucial dress rehearsal for the mega-experiment.

By Elizabeth Gibney

A pioneering reactor in Britain is gearing up to start pivotal tests of a fuel mix that will eventually power ITER – the world's biggest nuclear-fusion experiment. Nuclear fusion is the phenomenon that powers the Sun and, if physicists can harness it on Earth, it would be a source of almost limitless energy.

In December, researchers at the Joint European Torus (JET) started conducting fusion experiments with tritium – a rare and radioactive isotope of hydrogen. The facility is a one-tenth-volume mock-up of the US$22-billion ITER project and has the same doughnut-shaped 'tokamak' design – the world's most developed approach to fusion energy. It is the first time since 1997 that researchers have done experiments in a tokamak with any significant amount of tritium.

In June, JET will begin fusing even quantities of tritium and deuterium, another isotope of hydrogen. It is this fuel mix that ITER will use in its attempt to create more power from a fusion reaction than is put in – something that has never before been demonstrated. The reactor should heat and confine a plasma of deuterium and tritium such that the fusion of the isotopes into helium produces enough heat to sustain further fusion reactions.

"It's very exciting now to, at last, get to the point where we can put into practice what we've been preparing all these years," says Joelle Mailloux, who co-leads the scientific programme at JET. "We're ready for it."

JET's experiments will help scientists to predict how the plasma in the ITER tokamak will behave and to craft the mega-experiment's operating settings. "It's the closest we can get to achieving ITER conditions in present-day machines," says Tim Luce, chief scientist at ITER, near Cadarache in France. The experiments are the culmination of around two decade's work, says Luce. ITER will begin operations with low-power hydrogen reactions in 2025. But from 2035, it will run on a 50:50 mix of deuterium and tritium.

Both ITER and JET, which is based at the Culham Centre for Fusion Energy (CCFE) near Oxford, use extreme magnetic fields to confine plasma into a ring and heat it until fusion occurs. The temperatures in JET can reach 100 million degrees, many times hotter than the Sun's core.

The world's last tokamak fusion experiments with tritium also took place at JET. The goal then was to hit peak power, and the facility succeeded in achieving a record ratio of power out to power in (known as a Q value) of 0.67. That record still stands today; 1 would be break-even. But this year, the aim is to sustain a similar level of fusion power for 5 seconds or more, to eke out as much data from the experiments as possible and to understand the behaviour of longer-lasting plasmas.

Working with tritium poses unique challenges — JET researchers have spent more than two years refitting elements of their machine and preparing to handle the radioactive material. The isotope decays quickly, so it occurs only in trace amounts in nature and is usually made as a by-product in nuclear-fission reactors; the world's supply is just 20 kilograms.

Tritium pulses

Part of the challenge of handling tritium is that its reactions with deuterium produce neutrons at a much higher rate than deuterium reactions alone. Commercial reactors will capture the energy of these neutrons to generate electricity, but in JET, the high-energy particles will pepper the machine's interior and damage diagnostic systems. That means that the JET team has had to move cameras and other instruments behind concrete shielding, says Ian Chapman, who leads the CCFE.

"We've had to refresh and renew all of our processes", from storage to handling, Chapman says. Once tritium experiments start, neutron bombardment will make the inner facility radioactive, so it will become a no-go zone for humans for 18 months. Staff have therefore had to get used to a mindset similar to that of the engineers who send craft into space: "You can't just go in and fix things, it has to work first time," Chapman says.

JET's campaign will use less than 60 grams of tritium, which it will recycle. Fuel containing a fraction of a gram of tritium will be pulsed into the tokamak 3–14 times a day. Each of these discharges will be an individual experiment with slightly different parameters, and will generate between 3 and 10 seconds of useful data, says Mailloux. "What we are after is physics information that we can use to validate our understanding, and then we can apply that to preparing the future machine," she says.

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Some experiments will use just tritium; others will combine deuterium and tritium in equal proportions. Both types of experiment are important, because a key goal is to understand the effect of tritium's larger mass on plasma behaviour (tritium has two neutrons in its nucleus, whereas deuterium has one and hydrogen has none). That will help in predicting the impact of using different isotopes in ITER. The mass of the isotopes influences the conditions — such as magnetic field, current and external heating — needed for the plasma to reach a crucial state known as confinement. (In this state, the highest-energy particles remain within the ionized gas, and that is important for sustaining the plasma's temperature.) "We want to explore this and understand why," says Anne White, a plasma physicist at the Massachusetts Institute of Technology in Cambridge.

Another major difference from the 1997 experiments is that JET has been refitted so that the inner materials that protect the machine against the effects of heat and neutron bombardment, and remove impurities from the plasma, match those in ITER's design. Because these materials could radiate back into the plasma and cool it down, understanding how they interact with the fusion process is crucial.

The latest generation of fusion scientists has never worked with tritium, which makes it all the more important to do the experiments, says Chapman. "It's a big deal. People are watching," adds Luce.

WHY COVID VACCINES ARE SO DIFFICULT TO COMPARE

Despite the widespread roll-out of several vaccines, it could be months before they can be ranked.

By Heidi Ledford

Yusuff Adebayo Adebisi knows that a vaccine that offers 70% protection against COVID-19 could be a valuable tool against the coronavirus pandemic in Nigeria — especially if that vaccine is cheap and doesn't have to be stored at extremely cold temperatures. But what if another vaccine — one that is more expensive to buy and to store — was 95% effective?

"Should we send the less-effective vaccine to Africa? Or should we look for a way to strengthen the cold storage?" asks Adebisi, director for research at African Young Leaders for Global Health, a non-profit organization based in Abuja.

These are the kinds of question facing researchers and government leaders worldwide, as they take stock of the emerging selection of coronavirus vaccines and try to decide which will be most useful in putting an end to a pandemic that has already taken nearly 2.5 million lives. It is a decision shaped by limited supplies and hampered by limited data, says Cristina Possas, a public-health researcher at the Oswaldo Cruz Foundation in Rio de Janeiro, Brazil. "It is not possible to compare these vaccines at this point," she says.

In Bangladesh, health economist Shafiun Shimul at the University of Dhaka worries about the risks if governments delay vaccinations for months to build cold-chain infrastructure. "If you want to control infection, you have to rely on something that is contextually doable for you — it's not only about effectiveness," he says. "If they wait for perfection, I think it will be a long wait."

The 'best' vaccine

Given the demand for speed amid limited supplies, any effort to rank the vaccines must take into account not only their reported effectiveness, but also supplies, costs, the logistics of deploying them, the durability of the protection they offer and their ability to fend off emerging viral variants. Even so, many people might find it hard to look away from