ing the audacity" to reopen the question at Roc de Marsal and La Ferrassie.

Within the team today, the clashing views come down to different notions about the default hypothesis: Turq, Maureille, and other like-minded researchers say that for relatively intact Neandertal skeletons, the default hypothesis should be that they were buried deliberately. But other team members start with the opposite view. "The default hypothesis is that it's not a deliberate burial unless you have positive evidence that it is," says archaeologist Dennis Sandgathe of Simon Fraser University in Burnaby, Canada, who was the first author of the *JHE* paper.

Dibble thinks the key question is not whether a burial was deliberate, but whether archaeologists confront "a burial or a funeral." A burial, Dibble says, is simply a "disposal" of a body, while a funeral, complete with ritual activity, is a real "symbolic" act. An additional criterion is whether a "cultural pattern" can be detected, says team member Shannon McPherron, an archaeologist at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. Prehistoric modern human burials, particularly those more recent than the time of the Neandertals, routinely include beads and red ochre, but "there is no patterning in this [Neandertal] stuff," McPherron says.

Was I buried, or not? Some researchers say that the Roc de Marsal Neandertal child (reconstructed, *right*) was not buried deliberately.

But Pettitt, like many others who are not ready to embrace the doubts of Dibble and his colleagues, says that "we archaeologists can set the bar too high." The only "serious way to deal with this issue," he says, "is to excavate." And that is just what the team at La Ferrassie is doing, as it attempts to figure out how seven individuals found here a century ago came to this last resting place.

–MICHAEL BALTER

LASER FUSION

Ignition Facility Misses Goal, Ponders New Course

The National Ignition Facility (NIF), a $3.5 billion laser fusion lab in California, looks certain to miss its deadline at the end of this month for achieving ignition, a self-sustaining fusion reaction that yields more energy than was put in to make it happen. This milestone is considered key for NIF's twin goals: demonstrating the feasibility of fusion energy, and ensuring the reliability of the U.S. nuclear weapons stockpile. By law, the National Nuclear Security Administration (NNSA), part of the U.S. Department of Energy, has until 60 days after the deadline to produce a report explaining what barriers to ignition remain, how they can be overcome, and what implications there are for the stockpile.

Managers at Lawrence Livermore National Laboratory, the home of NIF, are playing down the significance of the end of the National Ignition Campaign (NIC), the series of experiments due to run until the end of fiscal year 2012 on 30 September. "The NIC is a milestone, and we're not going to achieve that milestone. But we will continue to explore and continue to do ignition science experiments," says Livermore Director Penrose Albright. Others view the missed deadline differently. "It's going to be a big deal here," says a congressional aide who asked to remain anonymous.

Meanwhile, to prepare the report for Congress, dozens of researchers from five NNSA-funded national laboratories and from industry are examining NIC in detail and may recommend a new direction for research at NIF. "We're working very hard to describe the state of understanding and the path forward," says Mary Hockaday, deputy associate director for weapons physics at Los Alamos National Laboratory in New Mexico, who is leading the first draft of the report.

Dead center. At the end of a positioner arm, the tiny target sits in the center of NIF's 10-meter-wide reaction chamber.

NIF uses an approach called inertial confinement fusion (ICF) in which a huge laser—NIF's is the most energetic in the world—fires beams from many directions at a tiny capsule containing a mixture of the hydrogen isotopes deuterium and tritium. The powerful laser pulse causes the capsule to implode, crushing the hydrogen fuel to a density 100 times that of lead and heating it to millions of degrees. In theory, the hydrogen nuclei should fuse to

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produce helium, neutrons, and a lot of energy.

The hard part is getting the capsule to implode smoothly and symmetrically enough to create a central hot spot where fusion will ignite. The burn should then provide its own heat as it propagates outward, consuming most of the fuel. Researchers have been trying to perfect the process since the 1960s, but so far the energy output has fallen far short of the energy of the laser pulse that causes the implosion—1.8 megajoules in the case of NIF's laser.

NIF has been controversial from the start. When first proposed in the early 1990s, it marked a huge leap over existing technology. What made it fly was that Livermore gave it two roles: showing that fusion power plants are possible, and recreating the conditions in a nuclear explosion so weapons scientists can validate their computer simulations and gauge how well sensors and components withstand blasts. (The United States stopped conducting actual nuclear tests in 1992.)

Opponents of NIF, including researchers at other ICF labs, argued that NIF had chosen the wrong laser technology and type of target, and they contested NIF's value for stockpile stewardship. "I've expected this day," says Christopher Paine, head of the nuclear program at the Natural Resources Defense Council, an environmental group in Washington, D.C. "A number of experts have predicted it would be a boondoggle. Solid-state lasers are a dead end."

Serious technical problems during NIF's construction delayed completion by 7 years and more than tripled the cost (*Science*, 17 April 2009, p. 326). In 2005, to keep things on track, the NNSA adopted the NIC: a 2-year road map to ignition. NIC included preparatory experiments at other facilities and relied heavily on computer simulations. Since experiments began at NIF in 2010, NIC has taken up 80% of the facility's laser shots.

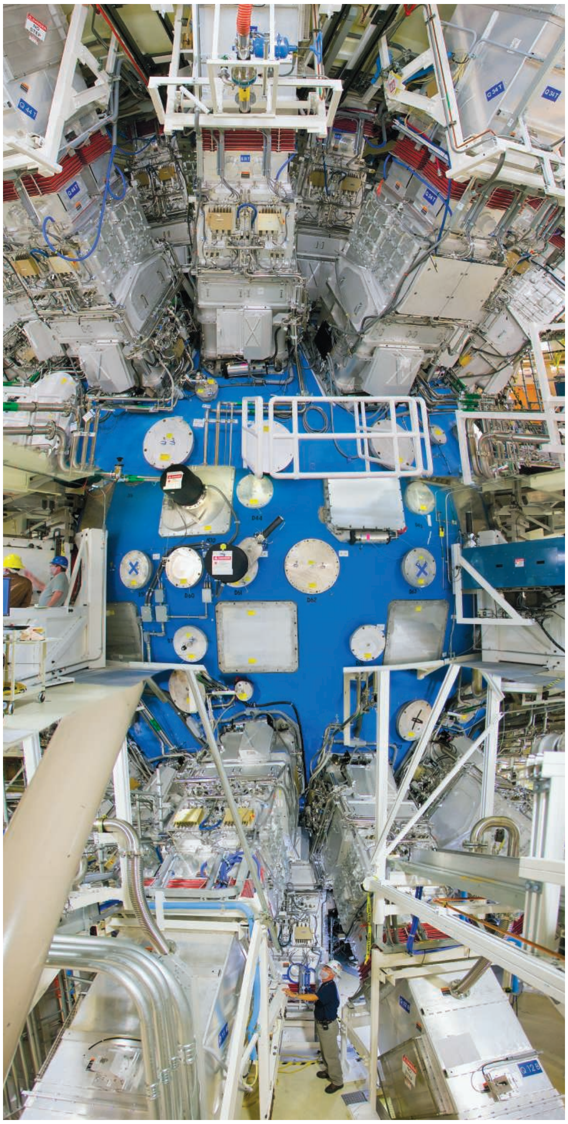
Despite widespread praise for the quality of the facility, Mother Nature has refused to play along. Numerous unforeseen physical effects have slowed progress toward ignition (*Science*, 28 October 2011, p. 449). Scientists chart progress with a measure called the experimental ignition threshold factor (ITFX). An ignited plasma would have an ITFX of 1 or greater. When NIC experiments began, the ITFX was 0.001; now it is 0.1 but has stubbornly remained there since last year. Paine is scathing: "Since there is no ignition, let alone gain, even the value of the facility for stockpile stewardship is compromised. They've wasted over $5 billion."

Weapons scientists and basic researchers are doing valuable work on NIF because, even without ignition, it can produce unprecedented conditions of temperature and pressure, but the congressional aide estimates that if ignition remains elusive NIF will start to outlive its usefulness for stockpile stewardship in a couple of years.

The most recent internal NNSA review of NIF, dated 19 July—aggregating the views of 10 experts from other labs and universities—concluded that the probability of achieving ignition before the end of December is "extremely low." Even the lesser target of observing helium nuclei from fusion reactions heating the surrounding fuel was deemed "challenging." The reviewers highlighted several problems, but their most pressing concern was that Livermore's computer simulations were not accurately predicting what the researchers were seeing. The simulations say that the shots NIF is doing now should be igniting, but the ITFX values show they are far from it. This mismatch means the simulations "are of limited utility in choosing the next set of experiments to perform," the reviewers said.

Christopher Deeney, assistant deputy administrator for stockpile stewardship at NNSA, says managers there decided in the spring that a new approach was needed. A workshop held in May identified 19 areas that require more research. And now the researchers drawing up the report for Congress are also looking at alternative approaches for NIF's future. One is "direct drive," in which the laser beams shine directly onto the capsule. (In NIF's indirect-drive method, the beams illuminate a metal can around the capsule, causing it to emit x-rays that then cause the implosion.) Direct drive is championed by other ICF labs such as the University of Rochester's Laboratory for Laser Energetics and the Naval Research Laboratory. It gets more of the beam energy onto the capsule but requires higher beam quality to ensure symmetry. Deeney says some direct-drive experiments are planned at NIF in 2013.

The specialist groups that have been working on the report to Congress delivered their conclusions to Hockaday and her fellow "ICF execs" from the other national labs on 14 September, and the execs must deliver a first draft of the report to NNSA by 1 October. What future path NIF will take will have to wait for Energy Secretary Steven Chu to deliver the report to Congress on 30 November. It seems certain, however, that the schedule-driven and simulation-reliant approach of the NIC will give way to a more scientifically methodical one. Deeney says the program will adopt a "discovery science mode, to find out why there is a difference between prediction and experiment."



All change? Optical assemblies that guide NIF's laser beams might need costly reconfiguration if the lab shifts to direct drive.

Whatever happens, the pace of progress toward ignition is likely to slow as weapons scientists are clamoring to get more time on the machine. Having made do with 20% so far, they will be getting more than 50% of the shots starting in January 2013.

–DANIEL CLERY