disease therapy is barely in its infancy. Many problems will have to be solved before their application becomes widespread. The discovery that monoclonal antibodies against I-A antigens could kill monkeys was unexpected in view of the apparent safety of other types in limited trials in humans. Nevertheless, McDevitt is hopeful that a safe way of treating autoimmune disease with the antibodies can be found. He points out, "I wouldn't have done the experiments if I didn't think that I would ultimately get to the point where I could treat someone."

—**Jean L. Marx**

Science Underground

An underground laboratory could house ultrasensitive experiments; Los Alamos wants to build one at the Nevada nuclear test site

Spurred by the predictions of the grand unified field theories, and by the astrophysical conundrum of the missing solar neutrinos, a number of physicists are now arguing that the United States should build a permanent, dedicated laboratory at least 1 kilometer underground, where a new generation of ultrasensitive experiments could be shielded from cosmic rays and mechanical disturbances. The Los Alamos National Laboratory is in fact pushing hard for such a laboratory, a $45-million "National Underground Science Facility" that it would build and operate in an unclassified portion of the nuclear weapons test range in Nevada.

The possible uses of an underground facility were laid out last fall at an international conference in Los Alamos;* then again last spring in the report† of an ad hoc advisory committee to Los Alamos director Donald M. Kerr; and yet again last month in a discussion before HEPAP, the Department of Energy's High Energy Physics Advisory Panel (*Science*, 22 July, p. 344). Some highlights:

• *Nucleon decay*. This most famous prediction of the grand unified theories is currently being tested by some ten dedicated experiments in deep tunnels and mines around the world. No definitive events have yet been forthcoming. However, even if nothing is found in the existing detectors, physicists will still want to extend the limits with more sensitive, second-generation detectors. And if nucleon decay *is* found, they will want new detectors to test the theories all the harder with detailed measurements of the decay modes.

• *Solar neutrinos*. Raymond Davis's pioneering experiment in neutrino astronomy is as baffling as ever. Astrophysicists say that nuclear reactions in the sun should produce neutrinos at a certain calculable rate. But Davis and his colleagues from the Brookhaven National Laboratory have spent more than a decade running their detector in South Dakota's Homestake Gold Mine, and still find neutrinos at only a fraction of that rate. On the other hand, Davis's detector is sensitive only to the relatively energetic neutrinos produced in one of the sun's minor side reactions. So perhaps the astrophysicists are wrong, their models of the sun too coarse to give the right answer for such a small detail. Perhaps Davis is wrong, his experiment concealing some subtle flaw that no one has yet noticed. (His apparatus is essentially a huge tank of perchloroethylene cleaning fluid, wherein solar neutrinos convert chlorine-37 into argon-37; elaborate radiochemical techniques are needed to find and measure the argon.) Or perhaps the solar neutrinos are doing something exotic, oscillating from one form to another on their journey to Earth. Whatever is going on, everyone agrees that the only way to resolve the question is to measure the low-energy neutrino flux from the sun's main powerhouse, the proton-to-helium reaction. The most promising technique involves some 50 tons of gallium and the neutrino-induced transformation of gallium-71 to germanium-71. The scale of the experiment is certainly worthy of a national facility: the germanium alone would cost some $25 million. Fortunately, it could be resold at the completion of the experiment.

• *Cosmic-ray neutrinos*. Energetic neutrinos produced by cosmic rays high in the atmosphere *will* penetrate the underground laboratory. In fact, a directional detector could measure the number of neutrinos coming down through the 1 or 2 kilometers of rock over the laboratory, then compare it with the number coming up through the 12,900-kilometer diameter of the earth, and thereby derive a very sensitive test of the neutrino oscillation idea. A large detector might also be able to localize astronomical sources of energetic neutrinos to within 5°—in effect, serving as a neutrino telescope. (This would be far more difficult to do with the much lower energy solar neutrinos, unfortunately.)

• *Gravitational physics*. A number of attempts are under way in surface laboratories to detect gravity waves. For very low frequency waves (less than 100 hertz), however, sensitivity is limited by changing gravitational gradients from nearby moving objects. What is needed is an exceptionally quiet location underground. Such an environment would also be conducive to improved measurements of the gravitational constant and its hypothetical variation over time, as well as to precise tests of the inverse-square law. (Some theories predict deviations from this law at laboratory distances.)

The underground science facility idea has been persuasive overseas: the Soviet Union has constructed such a laboratory near Baksan in the Caucasus, Italy is constructing one in the Gran Sasso tunnel in the Apennines, and the French are completing a third in the Frejus tunnel in the Alps. In the United States, the underground facility has been championed since 1981 by neutrino physicist Alfred K. Mann of the University of Pennsylvania, who conceived of the notion as he was developing ideas for second-generation nucleon decay detectors. "These things are complex and huge," he says, "and when I thought about trying to do it all in some mine, with water dripping over everything and a half-day wait at the lift, and without the resources and technical support I was used to at the national labs, I got discouraged—until I thought, 'Just build a national lab underground.' "

Ultimately he was led to the Nevada Test Site, where there is plenty of land, where the geology and hydrology is thoroughly understood, where support facilities are already available, and where

Science Underground (Los Alamos, 1982) (American Institute of Physics, New York, 1983).

†"Report of the Advisory Committee for the Proposed National Underground Science Facility," Norman F. Ramsey, chairman, 15 April 1983 (Los Alamos National Laboratory, 1983).

underground bomb tests have given the engineers a lot of practice at deep excavations. The DOE officials in charge of the test site were amenable; indeed, they had been stressing diversification, and had already set aside a portion of the site for nonclassified research.

From there, Mann was led to Los Alamos. "I felt it would be a mistake to try to make the underground lab self-standing," he says. "The permanent staff would be no more than 10 or 15 people, and the operating budget would be only 5 or 10 percent of, say, Fermilab's. I thought the best way to make it happen was to make it part of an existing national lab's agenda." Los Alamos, as it happens, is itself strong in the geophysical arts: the laboratory has long been involved in developing an underground nuclear waste disposal facility. Moreover, the Los Alamos engineers are used to working at the Nevada Test Site.

The Los Alamos leadership has taken to the idea enthusiastically, making the underground facility one of their top priorities. Indeed, they have chosen to call it an underground *science* facility in hopes of attracting additional users from non-physics fields, such as geophysics and biology. Last fall's conference on underground science was one fruit of their efforts; another was a formal proposal to the DOE last September.

The idea has not taken off as fast as many had hoped, however, in part because "nonaccelerator physics" is a relatively new development and as yet has no natural home within the DOE bureaucracy. In addition, the high energy physics community has been distracted of late by the commitment to the 20-TeV supercollider and the need to decide the fate of troubled ISABELLE.

But Mann, among others, is an optimist. "In the next 6 months," he says, "now that the major decisions on the accelerators have been made, people can begin to look at the underground facility with some care."

—M. MITCHELL WALDROP

A Solar System at Vega?

Serendipitously, almost in passing, the Infrared Astronomy Satellite (IRAS) has discovered the first direct evidence for solid particles in orbit around another star. The material may well be a youthful solar system on the verge of forming planets—if it has not done so already.

The star is Alpha Lyrae, better known as Vega; on clear summer evenings residents of the northern temperate zone can see it as a blue-white point of light almost directly overhead. Vega lies just 26.5 light years from Earth, which makes it a close neighbor by galactic standards, and it is a member of a relatively abundant group known as spectral class A. Astronomers estimate its age to be roughly a billion years, less than a quarter of the 4.6 billion years of our own sun. However, Vega is about 2.5 times as big as the sun, more than three times as massive, and about 58 times as luminous.

Vega also happens to be the fifth brightest star in the sky, and one of the best-studied stars, which is why IRAS scientists H. H. Aumann of the Jet Propulsion Laboratory and Fred Gillett of Kitt Peak National Observatory decided to use it for calibrating the telescope in the months after the January launch. To their surprise, however, Vega's image in the 20-, 60-, and 100-micrometer channels turned out to be considerably brighter than anyone expected from an A-type star. Moreover, it was brighter than the infrared images of similar stars.

One possible explanation considered by Aumann and Gillett was that, by absurd coincidence, some previously unknown galaxy just happened to lie behind Vega along the line of sight. But after repeated observations they found no parallax as Earth moved around the sun. So the infrared emitter had to be located *at* Vega. Another possibility was that Vega was undergoing mass loss, spewing streams of warm particles into interstellar space. Many stars in fact do this, and reveal their actions by, among other things, an enhanced infrared spectrum. The problem was that Vega shows no other evidence of mass loss whatsoever. So the infrared emitter was not streaming outward; it had to be in orbit around the star.

With further observations, Aumann and Gillett found that the emissions were quite symmetrical around Vega and about 20 arc seconds in extent. Presumably these were thermal emissions from material being warmed by the central star. If so—and there seemed no other viable alternative—Aumann and Gillett concluded that the cloud particles were dark objects having a temperature of some 90 K and an average distance from Vega of roughly 13 billion kilometers (80 astronomical units).

They also estimated the minimum size of the particles from the Poynting-Robertson effect, a subtle tendency for tiny orbiting particles to spiral into their parent body as they radiate away heat. The smaller the particle the faster the spiral. Since Vega is 100 million to 1 billion years old, the scientists argued, anything smaller than a millimeter or so—"buckshot"—is long gone.

Aumann and Gillett then estimated the mass in the Vega cloud by assuming that the number of particles of a given size decreases roughly as the cube of the size. A similar distribution is valid in our own solar system for objects up to the size of asteroids. Their answer came out to be 10^{-3} the mass of the sun, which happens to be roughly the mass of all the planets and asteroids in our solar system taken together.

So are there planets around Vega? Alas, IRAS cannot say. "You could hide a couple of Jupiters in this cloud, and a couple of Earths, too," concedes Aumann, "but their surface area would be too small to see. The other problem is that present theories suggest that big objects like planets take about a billion years to form, which is a bit longer than the lifetime of Alpha Lyrae."

So perhaps Vega is on the verge of planets. It is curious, however, that the cloud is so symmetric about the star. Spherical clouds tend to collapse into disks, much like the material in Saturn's rings or, for that matter, the material in the solar nebula that gave rise to our own planetary system. Aumann, for one, suspects that the Vega cloud *is* a disk and that we just happen to be looking at it face on. Presumably the disk would lie in the plane of Vega's equator, which makes it suggestive that astronomers have been unable to detect any rotation in Vega—implying that its axis is pointed straight at us. Follow-up studies now being planned at ground-based observatories should help resolve this question, and perhaps help determine the true distribution and composition of the material.—**M.M.W.**