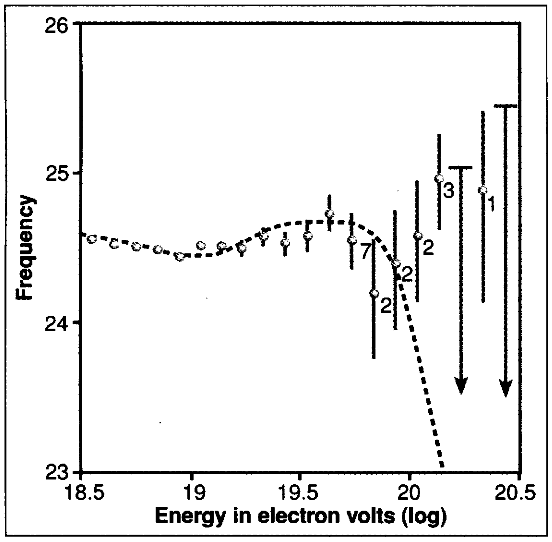
ray traveling through space with an energy above about 5×10^{19} electron volts (eV) would tangle with the photons of the microwave background—the low-energy radiation that pervades the universe—and gradually lose energy. This process should set an upper limit to

SOURCE: TAKEDA *ET AL.*, *PRL*



Topping the limit. Cosmic rays from the distant universe should peter out at about 10^{20} electron volts (red), but AGASA has detected six events at higher energies.

the energies of cosmic rays originating in the distant universe, called the Greisen-Zatsepin-Kuz'min (GZK) limit for the scientists who described it. But the AGASA findings, reported in the 10 August *Physical Review Letters*, show that "there is really no evidence for the GZK cutoff," says Cronin. The finding suggests that the particles originate from some unidentified sources close to our galaxy and sets a puzzle for a new generation of cosmic ray detectors to probe.

AGASA, the current state of the art, is made up of 111 detectors scattered over 100 square kilometers around the mountain town of Akeno in Yamanashi Prefecture, about 120 kilometers west of Tokyo. When an ultrahigh-energy cosmic ray particle—a proton or an atomic nucleus—slams into the atmosphere, it sets off a cascading chain reaction of particle collisions that ends in a shower of electrons or positrons falling on the detectors. Computer analysis can derive the original particle's approximate energy and direction of travel from this jumble of data.

AGASA is currently the world's largest facility for detecting the most energetic cosmic rays. Even so, particles above 10^{20} eV are so rare that it has detected just six of them since 1990. But Masahiro Takeda, an astrophysicist at the University of Tokyo's Institute for Cosmic Ray Research, which heads the collaboration, says that's enough to suggest that the GZK limit can be topped by statistically significant numbers of events.

If the microwave background does set a limit to the energies of cosmic rays coming from great distances, then these highest energy cosmic rays must be coming from within about 50 megaparsecs, or 163 million light-years, of Earth—somewhere among the nearby galaxies. Just where is the question, says Raymond Protheroe, an astrophysicist at the University of Adelaide in Australia. "We have this problem of trying to find what objects could possibly accelerate particles to such energies," he says.

Tracking down the mystery sources will require larger arrays that can quickly gather statistically meaningful numbers of these rare events. One, the High-Resolution Fly's Eye project, based in Utah, is partly operational and when completed in late 1999 will be capable of picking up five or six events greater than 10^{20} eV per year. An even more ambitious project that has been on the drawing boards since 1992, the Pierre Auger Project, passed a significant milestone in late July when the U.S. Department of Energy and the National Science Foundation approved $7.5 million in funding for design and engineering work on the first phase of the project: building an array of 1600 detectors on a 3000-square-kilometer site in Argentina. The $50 million array will be 30 to 40 times as sensitive as AGASA.

Construction could start as early as this October, says Cronin, who is the spokesperson for the project, which involves 40 institutions in 19 countries. If the effort continues to secure funding, the array could be completed in 4 years. Later, the collaboration hopes to build a second array of a similar size in Utah. Cronin says the recent AGASA results "show that what we started 6 years ago was really on the right track."

–DENNIS NORMILE

MICROELECTRONICS

IBM Puts Fast Chips on a New Footing

IBM announced last week that it will soon begin producing microprocessor chips embodying a technology that it says could boost operating speeds by as much as 35%. The new chips are also expected to use about a third less electricity than today's microprocessors, extending battery life for portable devices such as cellular phones and handheld computers. Competitors say IBM is betting on the wrong horse. But if the gamble pays off, the new chips could help extend Moore's law, the famous trend of performance improvements that has driven advances in microelectronics

ScienceScope

NASA Woos Astronomer at Caltech for Top Science Job

NASA officials have been hunting fruitlessly for a new space science chief since spring, when Wes Huntress announced he would leave the agency this fall after a 5-year stint in the job (*Science*, 27 February, p. 1293). But they are hoping they have found a successor in Charles Beichman, an infrared astronomer with the California Institute of Technology (Caltech) in Pasadena.

Beichman directs a Caltech center that handles data from a number of NASA satellites carrying infrared instruments. He also has specialized in the search for planets outside the solar system, a favorite topic of Administrator Daniel Goldin. NASA officials and Beichman declined comment, but sources close to the selection process say they hope to have him on board soon to run the $2-billion-a-year program. One person long familiar with Beichman noted that although he is not well known in the space science community, he is politically savvy.

NASA/AMES RESEARCH CENTER

Artist's view of NASA's Galileo.

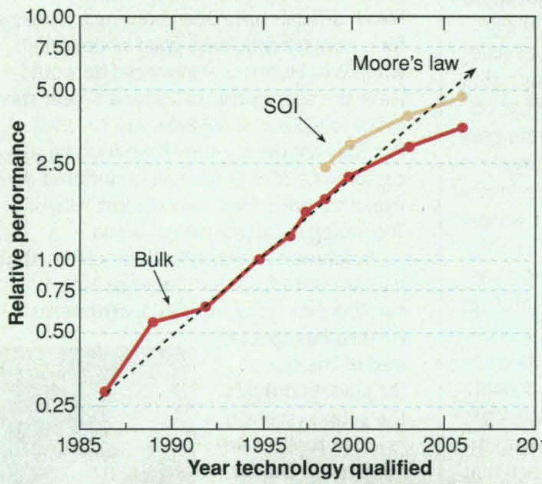
Scientists Lose Round in Database Privacy Fight

House and Senate lawmakers are headed for a fall showdown over controversial legislation that would extend to electronic collections of information the same legal protections afforded creative works such as books and films. Some scientists say the measure will stifle data sharing and make it a crime to conduct research on everything from computer viruses to database security.

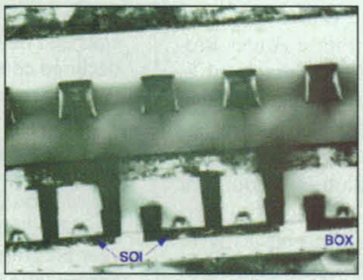
Last week, the House approved a bill that would bring the United States into compliance with the World Intellectual Property Organization Internet copyright treaty, which aims to prevent theft of electronic information (*Science*, 25 October 1996, p. 494). The vote rebuffed scientists who say the measure would hinder research. "No one even wanted to discuss our concerns," says Purdue University's Eugene Spafford, one of 50 computer scientists who signed a 1 August plea to House leaders for changes in the bill. The Senate will consider how to reconcile its markedly different version with the House bill in September.

for decades but is expected to begin flattening out soon (see graph).

The key change comes in the base on which transistors and other chip-based circuitry sit. For transistors to switch on, they



SOURCE: IBM



Back on track? IBM is counting on SOI chips (*right*) to extend Moore's law.

IBM

must electrically "charge up" the silicon beneath them. In conventional microprocessors, built atop a slab of crystalline silicon, that's a time-consuming and energy-draining process. But in the new chips, IBM engineers embed an insulating layer just below the surface, leaving an ultrathin silicon film on top. This thin silicon layer allows silicon-on-insulator (SOI) chips to charge up much more quickly and efficiently.

"I believe IBM is right on the money on this one," says Dimitri Antoniadis, an electrical engineer at the Massachusetts Institute of Technology, who adds that the high-end workstations that are widely used by scientists will likely be early beneficiaries of the new chips. But other industry observers say SOI isn't all it's cracked up to be. Mark Bohr, an electrical engineer with Intel in Hillsboro, Oregon, says his company has looked closely at the new technology and decided that it's not ready for prime time.

SOI is hardly new. The technology has been around for 30 years and is already used in chips for niche applications, such as those aboard satellites, as well as some types of computer memory. But persistent problems have stood in the way of broader use. For one, the top silicon film often ends up riddled with performance-lowering defects, because creating the underlying insulating layer requires injecting ions into the silicon at great speeds, disrupting the top surface's perfect crystalline order. The insulating layer can also cause transistors on the chip to misfire. It electrically isolates the top silicon layer, which enables it to conduct even when the transistor is turned off.

Bijan Davari, IBM's head of advanced logic technology development, says it took company researchers 15 years to get around these problems. To make the new wafers, IBM researchers inject molecular oxygen just beneath the silicon surface, using a machine called an ion implanter, to form an insulating layer of silicon dioxide. The IBM team then uses a proprietary recipe for processing the wafers—including baking them at about 1400° Celsius for nearly 12 hours—to anneal the damage this causes to the silicon surface, creating a defect-free film atop the insulating layer. Finally, they alter the doping of the semiconductors to minimize misfiring of the transistors, says Davari.

The changes result in SOI chips that achieve 35% gains in speed and efficiency without the drawbacks of earlier SOI devices. Davari argues that this will give IBM about a 2-year lead in the race to pack more computing power into less real estate, as it allows the same-sized transistors to operate at faster speeds. But not everyone agrees. "I think that's optimistic," says Simon Wong, a Stanford University electrical engineer. "The bulk [silicon] technology is very good" and improving rapidly, says Wong. Davari counters that IBM leads in improving bulk silicon chips as well, and their work convinced them that improvements in these chips would soon begin leveling off.

Bohr argues, however, that because the extra processing steps mean higher costs, "a lot of companies have decided that [SOI] will never be the way to go." Perhaps, says Antoniadis. "But it's possible that when they see gigahertz processors coming along on SOI, they will have to pay attention."

–ROBERT F. SERVICE

ASTRONOMY

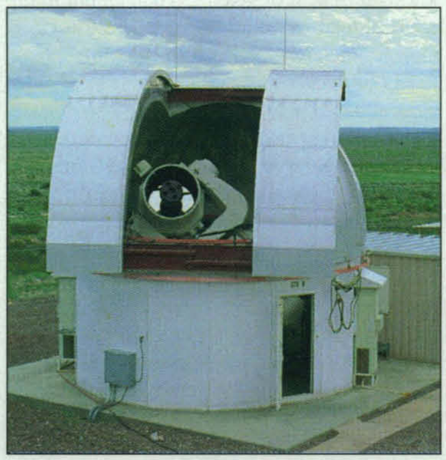
Asteroid Searchers Streak Ahead

With comets and asteroids menacing Earth in movie theaters around the world this summer, the once-arcane field of tracking potential threats from near-Earth objects, or NEOs, is suddenly in the limelight. As it happens, it's also making unprecedented progress. NASA's budget for hunting space rocks doubled to $3 million this fiscal year, and the U.S. Air Force recently unveiled a search system that is bagging NEOs at an unprecedented clip. This week, Air Force and NASA scientists will convene to consider boosting the Air Force's role still further, and other search efforts are also steaming ahead. "The scientists doing the work are really making strides," says Tom Morgan, discipline scientist for planetary astronomy at NASA headquarters in Washington, D.C. "One can afford to be reasonably optimistic about this whole process."

But even with their new search power, astronomers are settling in for a long hunt. They have so far spotted less than 10% of the estimated 2000 large NEOs, notes Brian Marsden, director of the Minor Planet Center at the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts. Even after researchers locate the rest, they'll need at least 20 years to track their motions to determine whether any endanger the planet, says Marsden. And for now, no one knows how much technological might the Air Force will ante up—or how long asteroids will remain a high priority at NASA.

Four years ago, as Comet Shoemaker-Levy 9 blasted into Jupiter, the U.S. Congress asked NASA to devise a 10-year plan to catalog 90% of all asteroids a kilometer across or larger that have orbits approaching Earth's. A team led by the late planetary scientist Eugene Shoemaker said that such a goal would require a $4 million per year search program—quadruple NASA's asteroid survey budget at the time—as well as help from Air Force space-surveillance experts. Now both elements are falling into place.

In particular, Air Force–sponsored research at the Massachusetts Institute of Technology's Lincoln Laboratory in Lexington has yielded an ultrasensitive and fast charge-coupled device (CCD), an electronic imaging chip similar to those in video cameras. The



U.S. AIR FORCE/MIT LINCOLN LABORATORY

Space spy. Astronomers track potentially dangerous asteroids with this 1-meter telescope at the White Sands Missile Range in New Mexico.