

agency highlights.

**National Science Foundation.** The science foundation receives \$5.6 billion, which amounts to a 3% increase of \$165 million in its overall budget. The increase is a comeback from the nearly 2% drop in last year's budget, and the \$5.6 billion figure matches what NSF received in 2004. So NSF is back to where it was two years ago, but the 2006 budget includes polar icebreaking costs that were previously paid for in the US Coast Guard's budget.

NSF's R&D budget totals \$4.2 billion, an increase of \$108 million, or 2.7%, over FY 2005. The research and related activities account receives a 3.7% increase of \$155 million, but the largest jump within R&RA is the \$48 million in non-R&D money to cover the takeover of the icebreaker ships.

The major research equipment and facilities construction (MREFC) account receives a \$19 million increase to \$193 million. There will be no new projects started in FY 2006, and funding was provided for four of the five existing projects—Scientific Ocean Drilling, Atacama Large Millimeter Array, EarthScope, and the IceCube Neutrino Observatory. The Rare Symmetry Violating Processes project is not funded (see PHYSICS TODAY, October 2005, page 27).

**Department of Homeland Security.** DHS receives a 4.1% increase to \$1.3 billion for R&D. Although that is better than most other R&D agencies, it is a dramatic scaling down of the budget increases the relatively new department saw in its first few years. The FY 2005 R&D budget of \$1.2 billion was \$102 million more than the department asked for and a nearly 20% increase over FY 2004.

Almost all of the DHS R&D money goes to the Directorate of Science and Technology. The budget shifts money away from programs such as rapid prototyping and vulnerability assessments and toward countermeasures programs for radiological, nuclear, chemical, and explosives threats.

**Department of Energy.** Beyond the problems with funding DOE's nuclear physics program, the R&D budget includes a 6.1% increase in fusion funding and a 2% increase in advanced scientific computing research. About \$56 million of the increase in fusion money was intended to go to ITER, the international fusion reactor project. But Sherwood Boehlert (R-NY), chairman of the House Committee on Science, threatened to kill US participation in ITER if it was funded at the expense of existing US fusion programs. As a result, \$30 million was moved from ITER into domestic fusion projects.

High-energy physics receives \$724 million, a cut of 1.7%. The cut would have been worse, but Congress gave the physics program \$10 million more than the administration requested.

DOE's defense R&D is down from FY 2005, with its Weapons Activities Program at \$2.9 billion, a decrease of 4.9%. An attempt by Sen. Pete Domenici (R-NM) to kill the National Ignition Facility failed, and the project received nearly \$142 million (see PHYSICS TODAY, August 2005, page 28). There are no funds for the Robust Nuclear Earth Penetrator project, but \$25 million was authorized for the Reliable Replacement Warhead, a new program intended to develop a new warhead design using existing nuclear weapons.

**NASA.** The space agency receives an

overall increase of 1.3%, or \$215 million, but R&D funding jumps 7.3% to \$11.5 billion. That increase appears largely because of mid-year cuts to the R&D budget when money was shifted to the space shuttle program for the July 2005 mission that was to mark the program's return to flight status.

The 7.3% increase in R&D funding will go entirely to the new Constellation Systems Program to develop the president's Moon-Mars vision. Physical and biological research and a propulsion technologies program see sharply reduced funding.

**Department of Commerce.** R&D at the National Oceanic and Atmospheric Administration (NOAA) is up \$18 million, or 2.7%, but the funding includes \$51 million in congressional earmarks for Alaska fisheries and marine mammals R&D. NOAA's oceanic and atmospheric research unit receives a 3.8% cut to \$325 million.

NIST R&D falls by 2.7%, but the institute's scientific and technical research and services program, which funds the NIST research labs, is up 5.4% to \$334 million. The Advanced Technology Program, an annual target for elimination by the administration, is cut 43%, but survives with \$80 million in funding. The Manufacturing Extension Partnership receives \$106 million, well above the \$47 million in phase-out money the administration requested.

Another \$49 million goes to major renovations of NIST facilities in Maryland and Colorado as part of the construction and research facilities unit. But, according to AAAS analysts, \$127 million in congressional mandates was included for building projects in states that don't have NIST research facilities.

**Jim Dawson**

## Mauna Kea Telescopes Step Up Collaborations

If the Gemini and Subaru observatories pull off a proposed joint Wide-Field Multi-Object Spectrograph (WF MOS), the collaboration would epitomize nascent trends in astronomy toward both time-swapping and large "campaign" projects.

The observatories on Mauna Kea have dabbled in time-swapping for a couple of years. Since the beginning of last year, for example, Gemini and Keck have traded five nights a semester. The arrangement gives Keck users access to Gemini's mid-infrared imager and spectrometer, and the Gemini community uses Keck's high-resolution optical spectrograph. On a smaller scale, Keck and Subaru have

**Tight budgets and pricey instruments are spurring a trend among observatories to swap time. To work, though, cultural, technical, financial, and administrative wrinkles need to be ironed out.**

swapped nights here and there, and, starting later this year, Gemini and Subaru plan to exchange five nights a semester.

But the WF MOS collaboration would be much more ambitious, says Gemini acting director Jean-René Roy. "Japan effectively becomes a new partner in Gemini, and Gemini becomes a new partner in Subaru. This is really a new paradigm." The twin 8.1-meter Gemini telescopes, one on Mauna Kea and the other in Chile, have seven member countries, with

the US holding a 50% share. Subaru is Japan's only 8-meter-class telescope; the country's next-largest telescope is 1.88 meters in diameter.

### "Joined at the hip"

The idea for WF MOS came from the Gemini community. A key motivation for the instrument is to probe dark energy in a new way, by measuring the distribution of galaxies (see the story on page 32). "We would measure what amounts to a fundamental scale in the universe at different epochs—before

and after the switch 5 billion years ago from a matter-dominated to an energy-dominated universe,” says Doug Simons, Gemini’s associate director for instrumentation. “The point is not just to conclude we are in an accelerating universe, but to figure out the rate at which the universe is accelerating.”

WFMOS would also be used for a second science campaign, on galactic archaeology. From the abundance of elements and stellar velocities revealed in star spectra, stars would be traced back to the specific molecular clouds where they were born, says Simons. “The idea is to DNA-type one or two million stars, and thus decompose the family history of our galaxy, and for the first time make an assessment of how the galaxy was put together. We’ve never seen a galaxy forming.”

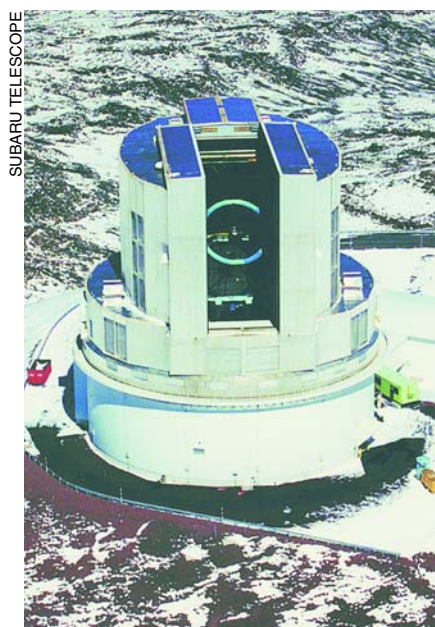
But WFMOS, which would have around 10 spectrographs to record 20 000 spectra per night, is too bulky for Gemini. “Gemini is light, fragile, dynamic. It could not accommodate such an instrument without a major transformation,” says Roy. “The cost would have been outrageous.”

It turns out that Subaru’s rigid, sturdy structure is a good fit. Moreover, the Subaru community was already planning to enlarge its telescope’s wide-field corrector for a new imager, HyperSuprime-Cam, which would give the widest field of view on any 8-meter or larger telescope. Now Gemini and Subaru are looking into designing the corrector to be compatible with WFMOS too. A weak-field gravitational-lensing survey planned for HyperSuprime-Cam, says Satoshi Miyazaki, the lead designer for the imager, “directly probes dark matter, and the distribution of dark matter depends on dark energy.” The two instruments, adds Simons, “are joined at the hip politically, scientifically, and technically.”

In exchange for hosting WFMOS, the Japanese astronomy community would get access to both Gemini telescopes for perhaps a total of half the number of nights that Subaru devotes to the joint projects; over five years or so, a couple hundred nights each would go to the dark-energy survey and the galactic archaeology project. The partners would split the cost of WFMOS—estimated by Gemini at \$65 million—and would build it jointly.

## Campaigns and collaboration

With instruments growing in complexity and price, it’s no longer affordable for each telescope to be outfitted with every type of instrument. “The trend is to concentrate on a few instruments where we think [a par-



ticular] telescope is best designed to produce the highest performance,” says Roy. Campaign science with large telescopes, he adds, “is a shift. We are moving in the direction of particle physics, the way it happened in the 1960s and 1970s. The questions are bigger, and you need bigger tools.”

One downside of campaign science, the squeezing out of principal investigators, is diluted by collaborating; with WFMOS, that burden would be spread across three telescopes—Subaru and the Gemini twins. “I feel we have to keep at least 50% of the time on all our telescopes for PI science,” says Roy.

Competition with Europe’s Very Large Telescope in Chile adds fuel to the move toward sharing telescopes in the North, Roy says. “[The Europeans] have basically decided that they will cream the US. They want more papers, more citations. They have a huge machine. We cannot be balkanized anymore.” In the future era of 30-meter-class and larger telescopes, adds Subaru director Hiroshi Karoji, “we will all be partners. So it’s natural to start sharing the coverage of wavelengths and resolving power among several telescopes.”

But for the WFMOS collaboration to go forward, scientific, technical, financial, political, and logistical details need to be worked out. In the WFMOS design, a balance needs to be struck between the technical demands of the campaigns and the broader needs of PI science. And the two observatories will have to coordinate development of future instruments so that they are attractive for both user communities, says Karoji.

**Japan’s Subaru telescope** is ideal for hosting a big heavy instrument that the country may collaborate on with the Gemini Observatory.

In the swaps undertaken so far, observatories select proposals from their own community to use the other facility, and time is allocated and data are archived according to the host observatory’s rules.

Other logistical challenges include designing, building, and managing the instrument and agreeing on how to share credit for any major discoveries. Those issues are not showstoppers, says Doug Welch, an astronomer at McMaster University in Hamilton, Ontario, and the incoming chair of the Gemini board. “The challenge right now for Gemini and the Japanese community is to figure out a timely process for getting WFMOS under way.”

## Sanity checks

Gemini has put the science case for WFMOS “through numerous reality checks and sanity checks,” Welch says. In Japan, the debate over WFMOS is just heating up. While there are theoretical physicists in Japan who focus on dark energy, among traditional users of Subaru the field is “almost nonexistent,” says Karoji. “So it’s a hard task for me to convince the community to do this.” Swapping time “drastically changes the mode of life” for Japanese astronomers, he adds. “To have limited access to Subaru, and have to go to Gemini for observing, is a huge change. It’s normal that there is a debate.”

Subaru is about five times oversubscribed, and Japanese astronomers worry that by devoting time to the WFMOS campaigns, other instruments on their telescope will be shut out. Some say they simply aren’t interested in the instruments available on Gemini. They worry, too, that grant money for fields outside of dark energy and cosmology will dry up. “By far the most important factor to achieve consensus of the Subaru users’ community,” says University of Tokyo cosmologist Yasushi Suto, a supporter of the project, “is the visibility of Japanese participants in planning and running WFMOS science.”

Despite the challenges, says Karoji, “I think a compromise, mutual understanding, is possible, because [WFMOS] could be used in many ways and in many fields of science. Dark energy is one of them, but large-scale structure development, the evolution of galaxy morphology, these basic



questions are favorite themes in the Japanese astronomy community.” Through Gemini, Japanese astronomers would gain access to the southern sky. And the WFMOS project would announce Japan as a major player in astronomy. “It is a good opportunity for Subaru to have a big international collaboration,” says Naoshi Sugiyama, an astronomer at Subaru’s parent body, the National Astronomical Observatory of Japan.

At this point, says Karoji, “I have not one yen [to pay for WFMOS]. We need two things, approval in the community and approval from the NAOJ headquarters for funding.” Gemini and Subaru are moving forward with design plans and seeking money. The plan is to have a conceptual design by spring 2007 and a decision on going ahead later that year.

Another project in the making for a bit further in the future would use optical fibers to link a half dozen Mauna Kea telescopes into an optical interferometer. “The classic way to have done that with multiple telescopes would be to build great big tunnels between them and have optical rays in vacuum pipes,” says Keck director Fred Chaffee. With fibers, he adds, “The technical challenge is inversely proportional to the wavelength, so with optical wavelengths a million times shorter than radio, everything becomes literally a million times more difficult. It’s a completely different ball game.” The two Keck telescopes were linked last year, demonstrating the proof of principle. The project is called OHANA (Optical Hawaii Array for Nanoradian Astronomy), the Hawaiian word for “family.”

**Toni Feder**

## Probing Dark Energy Through Baryon Acoustic Oscillations

**D**ark energy makes up more than 70% of the universe, but no one knows what it is. Its existence was inferred in the 1990s to explain why the expansion of the universe is accelerating, which was determined from observations of supernovae of known luminosity, or “standard candles.” Now scientists want to learn more about how dark energy behaves by using a “standard ruler.”

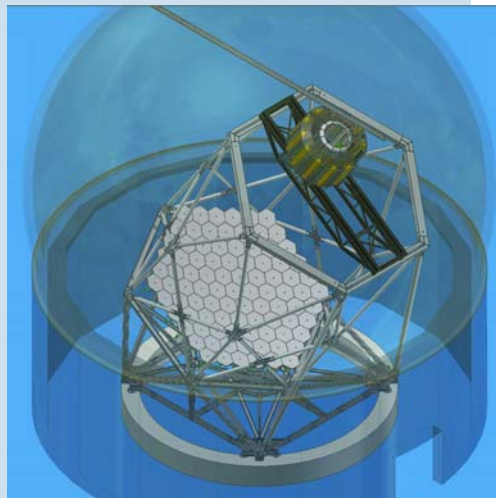
The standard-ruler approach involves measuring the traces of the primordial baryon acoustic oscillations in the large-scale structure of the universe at different times in history. The oscillations are remnants of sound waves in the first 300 000 or so years after the Big Bang, and are imprinted in the distribution of galaxies.

The Wide-Field Multi-Object Spectrograph (WFMOS), a proposed collaboration between the Gemini and Subaru telescopes (see the story on page 30), will use baryon acoustic oscillations and spectroscopic redshifts to probe dark energy. The most serious scientific competition so far probably comes from the proposed Hobby-Eberly Telescope Dark Energy Experiment (HETDEX). Both are surveys that involve “cartography of galaxies through space and time,” says the University of Texas at Austin’s Gary Hill, a principal investigator of HETDEX. “We will measure the distances between galaxies, Fourier transform that distribution, and for every galaxy, look where others are relative to it.” WFMOS will consider two time epochs, around redshifts 1 and 3, while HETDEX will look at a continuum of redshifts in the range 1.8 to 3.7.

WFMOS will use preselected galaxies, whereas HETDEX will take spectra of every point in its smaller field of view, and then use the spectra to select galaxies for analysis. “There is no a priori advantage to either approach,” says the University of Pennsylvania’s Gary Bernstein, a member of a dark-energy task force set up by NASA, NSF, and the US Department of Energy.

Neither experiment has full funding yet, but if both proceed on the time scales they’ve sketched out for themselves, HETDEX will start in 2009 and WFMOS around 2012.

**Toni Feder**



**VIRUS** (Visible Integral-field Replicable Unit Spectrograph), the instrument that would carry out a proposed dark-energy survey using the Hobby-Eberly Telescope, would consist of 145 copies of a unit spectrograph. (Artist’s rendering courtesy of the HETDEX Team, McDonald Observatory, Texas.)

## Evolution Wins in Pennsylvania, Loses in Kansas

**A** few years ago, registered nurse Bernadette Reinking, weary after three decades of working with physicians and the medical system, retreated into her house in central Pennsylvania to, as she puts it, “raise my grandbabies”—all seven of them. Then, after two years of full-time grandmothering, she said, “I opened my door and found all of this mess.”

The mess was the Dover Area School Board, where, according to Reinking, the school board members “were not very kind to people who were offering other opinions.” Reinking, whose four children had gone through the Dover school system, decided to run for a seat on the board.

**A slate of “real-world” candidates swept the intelligent design majority off the Dover, Pennsylvania, school board, while in Kansas antievolutionists not only weakened science standards, but redefined science itself.**

So did Bryan Rehm, a high-school physics teacher who was angered by school board members “calling people names and spouting Bible scripture at people who disagreed with them.” Rehm said the school board also stopped funding school field trips, ended student participation in a national robotics competition, and was cutting back on other activities he thought were important.

Although many parents in the school district were concerned about

those actions, the issue that crystallized the opposition was a requirement enacted by the board that biology teachers in the school district read a statement to students saying evolution is “not a fact” and that students can learn about other theories, including intelligent design, by reading antievolution material in the school library.

The nine-member board approved the statement over objections from its own scientific standards committee. Rehm and 10 other parents sued,