The best of both worlds. Another strategy combines the advantages of solution-based synthesis with the ease of extraction that comes from attaching the molecules to a solid support. One of the most provocative of these hybrid combinatorial schemes binds small-molecule building blocks to a polymer chain that has the ability to dissolve in certain solvents with the small molecules still attached. That allows scientists to carry out small-molecule synthesis in solution, and then change the solvent causing the polymer to be insoluble, so it—and its attached compounds—can be easily fished out.

The chain is known as polyethyleneglycol, or PEG. Kim Janda and his colleagues at the Scripps Research Institute reported last year in the 3 July issue of the *Proceedings of the National Academy of Sciences* that they used it to anchor arylsulfonamides, a class of known antibiotics, that they built up combinatorial step by combinatorial step in a solution of methylene chloride. When these reactions were complete, the researchers then added ether to their mixture, which caused the PEG molecules and their small molecular attachments to precipitate out of solution. They could then simply be filtered out. Using a related strategy, Armstrong and his colleagues use an all solution-based synthesis to construct libraries of small molecules. They then add insoluble polymers that contain linker groups specifically designed to home in on the target molecules. Once this attachment is made, the researchers simply filter out the polymers, and the small molecules come along for the ride.

Stephen Kaldor, who heads combinatorial chemistry research at Eli Lilly in Indianapolis, calls such hybrid schemes "very powerful," for they "combine the best of both worlds" of solution and solid-phase combinatorial chemistry. But at this point, many researchers believe that it's too early to tell whether hybrids or one of the solution-only techniques will end up edging out the competition in the race to become the combinatorial standard. "We now have a lot of different options people can use," says Kahne. And the options, like chemical building blocks themselves, can be combined in many different ways.

–Robert F. Service

RADIOASTRONOMY

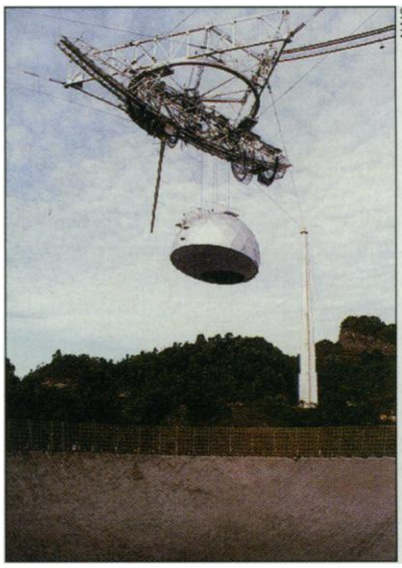
Upgrade to Improve Arecibo's Vision

Poking through the early morning mists on 16 May, a faceted aluminum shell the size of a six-story building rose slowly to its place at the center of a curved, 90-meter arm sitting 137 meters above a huge dish. "It was a perfect operation," says Cornell University astronomer Paul Goldsmith about the telescope that residents of nearby Arecibo, Puerto Rico, call El Radar.

The shell is part of a $26 million upgrade that will sharpen the eyesight of the combination radio telescope and radar facility operated by Cornell's National Astronomy and Ionosphere Center (NAIC), which Goldsmith directs. Funded by the National Science Foundation and NASA, the improvements to the 33-year-old facility are expected to allow researchers to search for superfast radio pulsars, understand in greater detail the nature of the whirling gases in galaxies of the early universe, and learn more about the chemistry of the cloudy birthplaces of stars within the Milky Way. "The future looks pretty bright for us," says Alexander Wolszczan, a pulsar observer at Pennsylvania State University. The upgrade will also extend Arecibo's lead as "the world's most powerful radar," says Don Campbell, NAIC's associate director, allowing it to map nearby astronomical objects in ever-finer detail.

The shell, or dome, that was moved into place this month lets radio waves stream through a 13-meter "pupil hole" on its underside to the 305-meter-diameter dish nestled in the Puerto Rican hills. It will contain two strangely curved reflectors along with powerful new transmitting and receiving equipment—the equivalent of an optics package—that will greatly extend the observatory's high-frequency vision and boost its sensitivity across the spectrum.

The package will largely replace a more cumbersome and limited system based on "line feeds"—dangling lengths of leaky wave guides. Most parabolic antennas can be rotated to focus radiation to a single point, but Arecibo is too large to move. Instead, its dish was given a spherical shape that focuses a given beam of radiation into a line parallel to its original direction. The line feeds are tapered waveguides up to 29 meters long with "zillions of slots" to let radiation in and out, says Michael Davis, project scientist for the upgrade. They hang from a moveable feed arm and reshuffle the waves to bring them in phase to a receiver at the top of the feed. But each feed works only over a narrow band of frequencies, and they perform poorly at wavelengths shorter than about 10 centimeters—just where many astrophysical studies start to get interesting.


NAIC

Moveable feast. The new dome houses reflectors that will give astronomers a better look into space.

The new setup, says Davis, "does it with mirrors"—a pair of reflectors that will bring the radiation to a point. Because the reflectors don't rely on reshuffling the phases, they can work over a continuous range of wavelengths. Incoming radiation will stream upward from the dish and bounce off the reflectors in succession, focusing at a chosen radio receiver within the dome. The observatory's high-frequency vision will then be limited only by the millimeter-size irregularities in the dish, limiting reception to wavelengths of 2 or 3 centimeters, corresponding to frequencies of 10 billion to 15 billion hertz. "Instead of having a narrow, blinkered view of the universe," says Goldsmith, "we'll be able to look at any frequency we want."

The new reflectors can also handle radiation from a larger area of the dish, providing up to a sevenfold increase in the observatory's sensitivity for radioastronomical studies. Radar studies of asteroids, comets, and planetary surfaces will also benefit from a new, megawatt transmitter housed in the dome, helping to boost the overall radar sensitivity by a factor of 20. This increase, for example, will allow radar astronomers to map asteroids millions of kilometers away to a resolution of 15 meters. The extra high-frequency reception is also just what astronomers need to study phenomena ranging from very fast pulsars to the birth of stars and planets in the largest molecules of dense, dark, cold clouds.

The upgrade is expected to be completed later this summer after the installation of a second reflector now sitting in an assembly plant in Sterling, Virginia. But astronomers can hardly wait to add to Arecibo's already illustrious track record, which includes the discovery of millisecond pulsars and planets around a pulsar, as well as the first accurate determination of Mercury's rotation rate. Says Cornell's Martha Haynes: "I asked [Goldsmith] at lunch today, 'So now that the dome is lifted, when are the proposals due?' We're ready."

–James Glanz