MEDICAL IMAGING

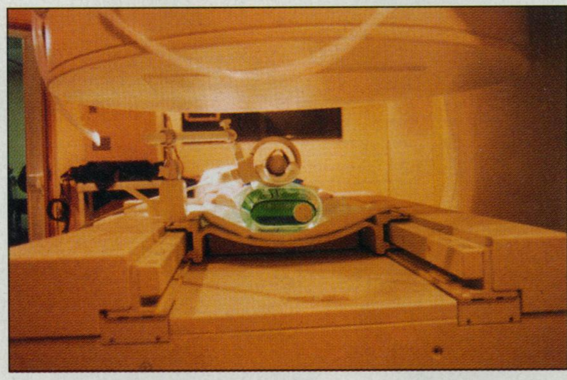
New Dynamic Duo: PET, MRI, Joined for the First Time

Looks will only get you so far, at least when it comes to medical imaging. Connecting the appearance of internal tissues to their function is an ongoing struggle for imaging researchers. Magnetic resonance imaging (MRI) excels at providing high-resolution anatomical maps, while positron emission tomography (PET) can better gauge the actual function of tissues by using a radioactive tracer to highlight metabolism. But never have the twain met in one machine: The powerful magnetic fields generated by MRI wreak havoc with the electronic detectors of PET scanners. That has made it hard on researchers studying the effects of drugs on particular tissues, for example. Now, however, things finally seem to be coming together.

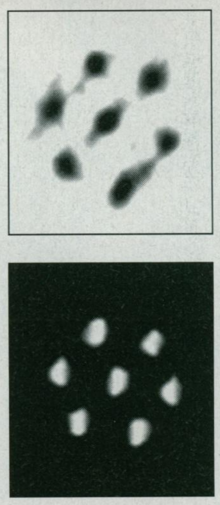
A team of researchers at the Crump Institute for Biological Imaging at the University of California, Los Angeles (UCLA), has created a small PET prototype that is able to distance its vital electronics from MRI's high magnetic fields, thanks to fiber optic lines and highly sensitive detectors based on a crystalline material never before used in PET. This week, at the Society of Nuclear Medicine meeting in Denver, the team demonstrated its results: the first-ever simultaneous PET and MRI images, which show both structural features of a test object and PET-detected radioactivity highlighting those features.

"It's absolutely fascinating work," says Michael Green, an imaging physicist at the National Institutes of Health's Clinical Center in Bethesda, Maryland. Currently, researchers and clinicians must make the two kinds of images separately, then use mathematical techniques to weave them together, "a nontrivial task" that is prone to errors, Green says. But with the new setup, "you can relate functional changes to pieces of anatomy without ambiguity." Some scientists do caution that while the system should work well for animals, it may lose sensitivity when scaled up to human size. Still, "doing something like this has been discussed in the community for a long time," says Paul Lauterbur, an MRI expert at the University of Illinois, Urbana-Champaign.

This attempt at synergy was not the group's original goal, says UCLA physicist Simon Cherry, who led the team. It came as a by-product of their pursuit of a higher resolution PET scanner. PET scanners distinguish between metabolically active and inactive tissue by picking up gamma rays from a radioactive compound that is injected into a subject and taken up by active tissues. An array of detectors—typically made from crystals of a bismuth, germanium, and oxygen (BGO) compound—surround the subject, and these crystals give off a burst of photons when they are hit by the gamma rays. These photons are picked up by photomultiplier tubes (PMTs) that amplify the weak emission so it can be converted into an electric signal and ultimately integrated by a computer into an image of the active tissue.



PHOTOS BY CHERRY ET AL.



Two for one. A new type of PET detector can be integrated with MRI *(above)*, yielding aligned images of both structure *(right, top)* and PET-related activity *(below)* in a test sample.

But PET scanners with BGO-based detectors currently can only resolve the source of a signal to within a volume of about 64 cubic millimeters—about the size of a pencil eraser. That limit is not quite sharp enough to distinguish between tissues in the tiny organs of mice and rats, animals used to model drug activity or disease. To improve this situation, Cherry and his colleagues wanted to halve the size of the crystals—they are usually about 4 millimeters on a side—and pack them closer together. "That's possible to do" with BGO, says Cherry. But because the PMTs normally sit just behind the crystals, the tubes would also have to shrink if the crystals were packed more tightly. There's the rub, says Cherry: "There are no photomultiplier tubes that are that small."

Cherry and his colleagues realized that they could get around this size constraint by connecting 2-millimeter-thick optical fibers to the back side of their reduced crystals and piping photons to PMTs tens of centimeters away. That, however, created another problem: Optical fibers absorb some photons, and BGO doesn't emit many to begin with, so there aren't enough left at the end of the line to drive the PMTs. To get past this obstacle, the UCLA team decided to use alternative crystals that can emit four times as many photons as BGO does after each gamma ray absorption. The new crystals, made from lutetium, silicon, and oxygen, or LSO, were discovered 6 years ago by Chuck Melcher and his colleagues at Schlumberger Limited, an oil services conglomerate that specializes in precision measurement.

LSO, says Cherry, "allowed all of the pieces to fit together." The new, closely packed detectors have a resolution of approximately 6 cubic millimeters, or about 10 times sharper than current detectors. And by arranging their detectors in a ring and using the long fiber optic lines to place the rest of the PET electronics a safe distance away, the researchers were able to put the ring inside an MRI machine and get PET and MRI images at the same time. They produced aligned cross-sectional images of a plastic cylinder drilled with a series of 1-millimeter-diameter holes, each of which was filled with a radiolabeled fluorine solution.

The group is still assembling a machine with a more complex array of detectors for a series of studies with small laboratory animals, such as investigating the interactions of cocaine with certain dopamine-producing cells in the brain. But performing related feats in people may be difficult, says Z. H. Cho, an MRI and PET expert at the University of California, Irvine. Among the problems, says Cho, is that to get a high-resolution image, each PET crystal must pick up a high density of gamma ray hits. The UCLA scanner accomplishes this in part by shrinking the diameter of its ring of detectors—which means each detector covers a relatively large percentage of the ring and collects more gamma rays. But the researchers will have to enlarge the ring to accommodate people, dropping the number of gamma rays that hit each detector.

One way around this would be just to add more detectors, says Cherry, although he concedes that this could make the machines overly expensive. So the device may not be able to do everything. Researchers may have to settle for two things at once.

–Robert F. Service