But an equally critical issue is whether the institutes themselves are willing or able to change. RIKEN proved itself capable of doing so recently, after the international reviewers suggested that the institute's policy of only considering scientists who are 32 years of age or younger for permanent positions was too restrictive. "High promise of future creativity and productivity is rarely established by a scientist before the age of mid-thirties," the review report said. As a result, RIKEN has raised the age to 35.

An even greater problem is the lack of any "mechanism for feedback," says Robert Geller, an associate professor of earth and planetary physics at the University of Tokyo. While the report lauded the physics department as a whole, it found some work was of questionable merit. "But this did not lead to allocating more money, positions, and lab or office space to the people doing good work," says Geller, "or taking it away from the less competent." The external review is a "good first stage," he adds, "but it's not enough."

Perhaps the most serious obstacle, however, is Monbusho's rigidity with respect to hirings and the distribution of core research budgets. Salaries and core research budgets are fixed by rank and are virtually identical throughout the country, so there is no mechanism for linking budgets to performance. Nonetheless, Mitsuo Ito, director general of the Institute for Molecular Science, says the system is moving toward rewarding more productive researchers, thanks to the effects of inflation.

"It is impossible to conduct research with that [core grant] money alone," he says. As a result, programs based on performance, such as Monbusho's rapidly growing research grant program, are playing an increasingly important role, even if Monbusho's budget of $825 million this year was less than 10% of the $10.5 billion spent by the ministry on science and technology.

Then there's the question of what to do about lagging institutions. With virtually all government employees, including faculty members, holding lifetime jobs from the day they are hired, universities have little flexibility to bring about needed change when departments become obsolete or don't perform. And institutions lower down in the scientific pecking order may have little incentive to conduct a rigorous review if they suspect it will be critical.

In spite of these drawbacks, Kozi Nakai, head of experimental planning and program coordination at KEK in Tsukuba, believes opposition to outside reviews is fading but that controversy remains over how and what to evaluate. He is heading a Monbusho working group that hopes to issue a manual outlining how universities might solicit outside input and defining a role for data such as the number of papers and citations received.

Reviews can also help smaller institutions and universities identify particular strengths, says Arima. Indeed, he says, the ability to define a strong specialty may become a necessity if, as expected, the reviews play a part in funneling resources to the more active institutions and groups. "In Japan we often say that everyone should proceed together," he says. "But if we want to promote [science] on an international level, there is no other way than to be strict."

–Dennis Normile

PROFILE

A Straight Line to Success

Experimental particle physics is largely shaped by researchers with forceful egos and and a taste for politics. But theorist Kaoru Yokoya, age 47, doesn't fit the mold. This laconic man who plays a key role in Japan's particle physics community "is 100% scientist," says Kazuo Abe, his colleague at Japan's National Laboratory for High-Energy Physics (KEK).

Known for his mathematical rigor and his keen insights into difficult problems, Yokoya has successfully tackled the phenomenon of "disruption," an effect associated with the bending of particle trajectories under the influence of the oncoming beam, and of the energy loss due to beamstrahlung radiation. The work puts him at the center of one of the hottest projects in physics: designing the JLC (for Japan, or Joint, Linear Collider).

EIJI MIYAZAWA/BLACK STAR

No disruptions. Kaoru Yokoya of KEK is finishing design work on a future linear collider.

Yokoya's early career was marked by dreams thwarted. A schoolboy desire to become an astronomer fell prey to a prevailing view that the field was merely applied physics and, therefore, not worthy of someone who wanted to tackle fundamental problems. After college, his interest in particle theory was squashed by the reality of the workplace: "I wasn't able to get a job," he recalls ruefully. So in 1978 he took a job at KEK in accelerator theory—studying the physics of particle accelerators rather than of the particles themselves—and wrote a doctoral thesis on the dynamics of polarized electron beams in storage rings. That work, and additional studies of the interaction between colliding beams of electrons and positrons, led to his receiving the Nishina prize, Japan's most prestigious laurel in physics.

Yokoya has also written volumes of critical computer code for modeling collider dynamics. The titles of these programs—SODOM, ABEL, and CAIN—bespeak a sober personality streaked with a dark sense of humor. The difficulty of his science, combined with his rigor and economy of style, poses a constant challenge to co-workers. "When he speaks, I listen carefully," says one U.S. collaborator, "because if he can say a thing in three words, he won't say it in four."

His lack of salesmanship hasn't made him the most popular figure among doctoral students at the University of Tokyo, where he has held a joint appointment since 1990. "It is hard to find students in this field," he says. "It is considered to be not pure science but a kind of industrial thing."

One look at Yokoya's style belies that image of the field. Unlike most of his experimentalist colleagues on the JLC project—but typical of theorists—Yokoya has an aversion to hardware. Involved for a time with Japan's "b-factory" now under construction, he left when the design was finalized. "People were talking about things like the size of the magnet to the precision of a millimeter," he laughs. "This doesn't interest me. It's beyond my ability!"

Now that the design work on the linear collider is almost done—next month he will visit the Stanford Linear Accelerator Center to finalize the common parameters of JLC's and SLAC's linear collider designs—Yokoya is wondering what to do next. He ponders such exotica as muon colliders and plasma accelerators that soar beyond current linear colliders in terms of cost, collision energies, and complexity. Big thoughts, perhaps, but he points out that the dreams of a theorist, unlike the machines they engender, cost next to nothing.

–Antonio Regalado

Antonio Regalado is a free-lance science writer in New York City.