

200 MeV/nucleon driver accelerator is half the energy of RIA's, and FRIB will lack the multi-user capability of RIA, a feature that was deemed duplicative. FRIB also will be equipped with less experimental equipment than RIA, Gelbke said. Some of NSCL's equipment is compatible with the smaller FRIB driver and will be incorporated into the new machine for additional savings.

The origins of FRIB can be traced to a 1996 long-range planning exercise by NSAC, which first identified a need for a next-generation nuclear structure and astrophysics laboratory in the US. In the wake of RIA's cancellation, a National Research Council study commissioned by the two agencies confirmed that a more powerful rare isotope beam instrument was needed if the US was to remain competitive in nuclear physics, and said that a machine could be designed without overlapping with existing and planned nuclear science capabilities abroad. With those findings in hand, NSAC produced a review in 2007 affirming that "technical advances" made since RIA's design would permit

"a world class facility" to be built at half the earlier machine's estimated cost, albeit with a more limited suite of capabilities. The NSAC urged that development and construction of FRIB's linac, which it said accounts for about 80% of the project costs, get underway as soon as possible.

Other applications

The research conducted at FRIB will involve experimentation with intense beams of rare isotopes, and in addition to basic research is expected to have applications in materials science, medicine, and nuclear weapons stockpile stewardship and nonproliferation. The facility will be especially well-suited to generating sizeable amounts of short-lived isotopes for nuclear medicine, and Gelbke said he expects to have "fruitful interactions" with MSU's nuclear medicine group. But FRIB is likely to be too expensive to become a source for commercial quantities of radioisotopes. DOE's weapons labs have shown interest in FRIB's ability to mimic on a tiny scale isotopic changes that occur in ma-

terials during underground nuclear tests; experimental results could help designers further refine the codes they use to simulate nuclear explosions. So too might FRIB be useful for helping determine how the high-energy neutrons to be produced in Lawrence Livermore National Laboratory's National Ignition Facility will activate component materials of the 192-beam laser, Gelbke added.

MSU recently embarked on an NSCL upgrade that includes a new low-energy linac for nuclear astrophysics experiments and a 10 000-square-foot expansion of experimental space. Due for completion in 2010, the upgrade will allow experimenters to use fast, stopped, and re-accelerated beams of rare isotopes. That capability will give researchers new tools to work with until FRIB's completion.

The university still must negotiate a cooperative agreement with DOE and complete a required environmental review of the site. As with all multi-year federal projects, funding is contingent on annual appropriations by Congress.

David Kramer

Commercial optical traps emerge from biophysics labs

Traditionally custom-built, optical tweezers are now available off-the-shelf for single-molecule research and clinical applications.

What if determining your blood type took a few seconds and a few dozen red blood cells instead of several minutes and milliliters of blood? To that end, one company is building on a two-decades-old invention that harnesses laser radiation to noninvasively trap and manipulate submicroscopic particles.

Arryx Inc, which is developing the new assay, is among a handful of companies that have begun to commercialize optical tweezers. An invention by Bell Labs physicists, optical tweezers are best known for their role in determining DNA's elasticity and other benchmark single-molecule studies. Those experiments were done with custom-built instruments with diffraction-limited resolution, and some with subpiconewton sensitivity. Now new commercial optical tweezers are being targeted to researchers and medical institutions that don't want to build their own.

The AFM analogy

In an optical tweezer system, a particle is pushed by the momentum from a tightly focused laser beam and trapped by the gradient forces of the beam's refracted light. The trapping force acts against

thermal fluctuations, light scattering forces, or—in the case of some single-molecule force measurements—motile biological specimens that are tethered to an optically trapped spherical substrate. In addition to an IR laser source, chosen to minimize photodamage to biomolecules, modern optical tweezers are often fitted with high-powered optical microscopes, electro/acousto-optic feedback devices, software controls, and microfluidic chambers.

Up until the 1990s, many people were still building atomic force microscopes by themselves, says physicist Torsten Jähnke, chief technology officer of Germany-based JPK Instruments AG. The company makes AFMs and also optical tweezers designed for particle-tracking and force measurements. Jähnke adds that the reason people are buying AFMs now is because "they are flexible, modular, and easy to use," which, he says, is now happening with optical tweezers.

"There's been quite some competition coming up in the tweezers market in the last two or so years," says Michael Gögler, a product manager at German microscope manufacturer Carl Zeiss AG.

Coupled with a UV laser, Zeiss's optical tweezers can, among other things, guide sperm to egg for in vitro fertilization. A similar instrument was available in the 1990s from now defunct Cell Robotics Inc. The demise of that company, says Gögler, may be blamed in part on its premature entry into an unprepared market. Back then, optical tweezers were a tool almost exclusive to physicists, he says. "But with the growing popularity of interdisciplinary research, a lot more techniques get to be known to the biology community."

The current market for optical tweezers is in biological research, says Kishan Dholakia, a biophysicist at Scotland's University of St. Andrews. At this stage, Dholakia says he thinks optical tweezers are "a top-end research tool." His own optical tweezers patent uses acousto-optic modulators to generate multiple traps. He says that single-molecule force measurements and the building of tissue scaffolds are among the applications for the instrument, which has been commercialized by UK-based equipment provider Elliot Scientific Ltd.

"Truly exciting new results about the



A commercial optical tweezers system is being tuned by JPK Instruments applications specialist Joost van Mameren.

dynamics of complex biochemical systems have emerged from the use of optical tweezers in the last three to five years," says Carlos Bustamante, a biochemist at the University of California, Berkeley and a pioneer of optical tweezer studies of DNA and RNA. Bustamante is looking to commercialize a mini-tweezers system that is "about the size of a coffee pot" and says making optical tweezers widely available "would be terrific for science." For his research, though, he doubts that current commercial tweezers can do the job. "Traps are easy to make. But

which use spatial light modulators to create up to 200 three-dimensional optical traps, can determine blood type in "only 5 to 10 seconds" from simultaneous force measurements on several dozen red blood cells, says Grier. And recently added to the company's pipeline is licensed NIST technology to detect blood pathogens at femtomolar concentrations.

Laser focus

Research-grade sensitivity is not the only challenge facing commercial optical tweezers. Optical traps in general are not very selective, says NIH staff

scientist Keir Neuman, who studied transcription processes with optical tweezers research pioneer Steven Block. "Anything that can fall into a trap *will* fall into a trap, if it has a larger index of refraction than the surrounding media," he says. NIST researcher Kristian Helmerson, one of the inventors of the recently-licensed blood pathogen detection technology, says optical tweezers are "extremely sensitive" biosensors, but are relatively slow for cell-sorting applications. Cost is also a concern: Most of the commercial systems run between \$100,000 and \$350,000. Grier, however, notes that systems are becoming cheaper with the availability of low-cost lasers and inexpensive, high-quality consumer electronics.

Retired Bell Labs physicist Arthur Ashkin, who led the first demonstration of optical tweezers in 1986, says he's happy about progress being made to commercialize the technology. "I never thought it would be practical, because I thought the laser would destroy living things," he says. Energy secretary Steven Chu, a coauthor with Ashkin of the

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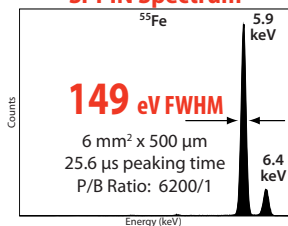
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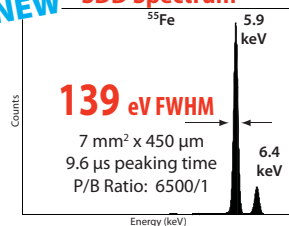
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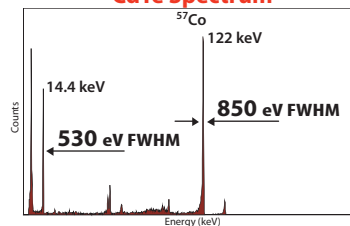
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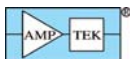
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1986 paper, had been conducting single-molecule biological research with optical tweezers at UC Berkeley prior to his recent appointment. "The focus [in the 1980s] was on trapping atoms," says Chu, who shared a Nobel Prize with William D. Phillips and Claude Cohen-Tannoudji for that work. "But Art [Ashkin] just continued to play with the single-focus laser beams to move bacteria and his [latex] beads."

Is there another Nobel Prize in store for optical trapping? "I would not be surprised," says Chu. "In the coming decade there could be a truly great dis-

covery using optical tweezers, or some other single-molecule technique."

But JPK application specialist Joost van Mameren says that optical tweezers must be made more broadly available and the benchmark single-molecule experiments with optical tweezers should be successfully repeated with commercial systems to convince researchers to buy them. "Spending two or three years to build a system from scratch was enjoyable," says van Mameren, who worked with optical tweezers for his PhD. "But that does not produce many papers."

Jermev N. A. Matthews

Holdren appointment confirms Obama's climate change focus

President Barack Obama chose a physicist who has specialized in science policy to become his science adviser and director of the White House Office of Science and Technology Policy (OSTP). John Holdren, who has run the science, technology, and public policy program at Harvard University's Belfer Center since 1996, also worked as a theoretical plasma physicist at Lawrence Livermore National Laboratory.

Announcing Holdren's nomination on 20 December during his weekly radio address, Obama fulfilled a campaign pledge to have his science adviser selected by inauguration. Although the science adviser position does not officially require Senate confirmation, the OSTP appointment does, and past nominees have held off science advising until after confirmation to avoid potential objections from senators. Pending his confirmation, Holdren declined through a spokesperson to be interviewed.

Holdren is no stranger to advising the White House. He was a member of the President's Council of Advisors on Science and Technology from 1994 through 2001 and chaired two PCAST subcommittees that addressed energy research. A 1995 PCAST subcommittee review identified fusion energy as an attractive clean energy option and potentially cheaper than photovoltaics. A 1997 report from PCAST called for additional federal R&D funding for a panoply of energy sources, including fission, fusion, and fossil and renewable fuels, and advocated increased spending devoted to reducing the amount of energy used in buildings, in transportation, and in industry.

Holdren has also been active in the

arms control and nuclear nonproliferation policy arenas. He led a PCAST study that addressed US-Russian cooperation to protect nuclear materials from theft. For 10 years he headed up the National Academy of Sciences' Committee on International Security and Arms Control. During that time CISAC produced reports that addressed the disposition of surplus plutonium, future US nuclear weapons policy, and the means for verifying reductions in the world's nuclear weapons arsenals.

Passionate on climate

Holdren would have been considered a leading candidate for the science adviser post had Vice President Al Gore prevailed in the 2000 election. Like Gore, Holdren is, in Obama's words, "one of the most passionate and consistent voices of our time about the growing threat of climate change." He has particular expertise in fusion energy and its environmental impacts, issues he researched while at Lawrence Livermore National Laboratory.

"John Holdren is eminently qualified" for the post, said John Marburger, President Bush's science adviser and

OSTP director for nearly eight years. "His background as a physicist is typical of former science advisers, and his long history of scholarship in energy and environmental policy fits well with President-elect Obama's priorities." Marburger said he has deduced from Holdren's speeches and writings that "he will fit well in the forthcoming administration."

"John Holdren is a terrific pick," said Senator Jeff Bingaman (D-NM), chairman of the Committee on Energy and Natural Resources. Many provisions of the 2005 and 2007 energy acts originated in the Holdren-led PCAST studies, Bingaman noted in a statement. Reaction from academics, with whom Holdren has spent most of his career, was also adulatory. "He has the experience, skills, and broad knowledge of science and technology to help fulfill the president-elect's commitment to science, research, and innovation," said Robert Berdahl, president of the Association of American Universities. Berdahl further praised Obama's decision to restore to the science adviser post the "assistant to the president" title and cabinet-level status.

Holdren's selection brings to three the number of top appointees who will help Obama formulate and implement policies to address the interrelated issues of energy and climate change. The president has appointed Carol Browner, former administrator of the Environmental Protection Agency, to the newly created position of assistant to the president for energy and climate change, and Steven Chu, the Lawrence Berkeley National Laboratory chief, to head the Department of Energy (see PHYSICS TODAY, January 2009, page 22). Just how Holdren will interact with Browner and Chu remains to be seen. But Neal Lane, who worked with Holdren when Lane was science adviser to President Clinton, says that each will bring different and complementary expertise to the table: Chu's Nobel Prize-winning science and an understanding of the national labs, Browner's legal and regulatory experience, and Holdren's policy expertise.

David Kramer



Holdren

TOM FITZGIBBONS

Spilhaus's long run at AGU helm ends

Fred Spilhaus was executive director of the American Geophysical Union for nearly 40 years. He stepped down at the end of last month, but will stay involved in an emeritus role. Robert van Hook, of Transition Management Con-

sulting Inc, is serving as interim executive director until the post is filled. Says AGU president Tim Grove, a geologist at MIT, "The AGU is indebted to Fred for his excellent service, his leadership, and his dedication. He has really