

Canada Catalyzes Research and Recruitment

Aggressive spending in Canada has spruced up research labs and promises an expansion of the Sudbury Neutrino Observatory, but it has also led to a time lag between setting up new equipment and finding money to maintain it.

Brain gain and abundant funds for infrastructure are signs of a far rosier research climate than Canada could boast a few years ago. Key to the about-face are the country's overall budget—Canada is the only G8 country with a surplus—and its goals of doubling the number of graduate students and moving from the world's 15th to 5th biggest R&D spender per capita by 2010. Physics, along with other fields in the sciences and humanities, is benefiting from the new money being injected into research.

"There have been some significant changes that have made Canada more hospitable for basic research," says Pekka Sinervo, a high-energy physicist and interim dean for arts and sciences at the University of Toronto. The low point was the federal belt-tightening of the mid-1990s, he adds. "We had to make cuts, shrinking the entire university by 10%. The situation has improved. There is an engagement of the federal government in a manner that hasn't been seen before." Citing two of the most influential new resources, Thomas Mason, a Canadian who moved to the US a few years ago to oversee construction of the Spallation Neutron Source (SNS) in Oak Ridge, Tennessee, adds, "It seems that every single person I know who is an active researcher has gotten money from the Canada Foundation for Innovation. And every physics department probably has [federally funded] Canada Research Chairs."

Infrastructure infusion

The CFI stands out as having the strongest impact on Canadian research. An independent body established by the government in 1997, and slated for closure in 2010, it has already dished out more than half of its Can\$3.65 billion (US\$2.48 billion). Most CFI grants are for equipment and infrastructure and require 60% in matching funds, which typi-

cally come from the host province and university.

"Probably the most important thing is startup funding," says Sinervo. For example, "in order to attract topflight condensed matter physicists, you have to be able to offer low-temperature refrigerators, high-field magnets, and so on. You are quickly talking about a million dollars. We used to have to find those resources by picking everyone's pockets. The CFI has allowed us to be much more aggressive when searching for people." Of some 2400 CFI grants to date, about 1000—roughly Can\$180 million in total—have gone toward fattening startup packages. "It's not only changed our ability to recruit, but the new scientists have better facilities available to them," Sinervo says. "The payoff will show up in the next five years, as they get scientific results."

The CFI has been a huge boon for established researchers, too. McGill

University's Peter Grütter, for example, is building an atomic manipulation and supercomputer facility with Can\$10 million from the CFI and the province of Quebec. It will be "one of the best facilities for transport studies of molecular systems—buckyballs, alkane thiols, molecular electronics," says Grütter, a Swiss native who came to Canada nine years ago. "What researchers were kicking and screaming about was a lack of infrastructure. If things hadn't gotten better, I would have gone back to Europe. Now, the bottom line is, in terms of infrastructure, Canada is competitive with any place in the world."

"I've been involved in three successful applications" to the CFI, adds Bruce Gaulin of McMaster University in Hamilton, Ontario. "The first was a rather small one, Can\$130 000 for x-ray infrastructure. The second was for Can\$2.5 million, jointly with the University of Toronto, for a lot of new apparatus for probing magnetic and superconducting materials. That was a big shot in the arm, and brought our lab up to an internationally competitive level." Most recently, Gaulin led the successful application to build a

Can\$15 million beam line for studying materials at high temperatures and under stress at the SNS.

Investing internationally

This SNS beam line is one of nine international projects sharing Can\$200 million from the CFI. Six, including the neutron beam line, are Canadian contributions to international projects. The



ANTON DABKOWSKI/MCMMASTER U

Infrastructure large and larger. Thanks in great part to the Canada Foundation for Innovation, Canadian researchers are getting new equipment, from diffractometers (above) for individual investigators to greater participation in international projects, such as KOPIO, the K meson decay experiment at Brookhaven National Laboratory. For KOPIO, Canadian physicists are building, among other things, a prototype drift chamber (right).



MINDY HARKE/KOPIO

other physics-related awards are for Canadian access to the Atacama Large Millimeter Array in Chile; a camera for the James Clerk Maxwell Telescope in Hawaii; and KOPIO, an experiment at Brookhaven National Laboratory in New York that will look at the decay of neutral K mesons to probe charge conjugation-parity violation. Three major facilities in Canada also have CFI support: an icebreaker to study the Arctic Ocean and global climate change, the Advanced Laser Light Source (ALLS), and the expansion of the Sudbury Neutrino Observatory (SNO).

ALLS is planned as a multibeam laser system for manipulating and probing single molecules on the timescale of a chemical reaction. Five beams, four femtosecond and one attosecond, will span the x-ray to infrared spectral range. "It's like having a femtosecond rainbow," says principal investigator Jean-Claude Kieffer of the University of Quebec's National Institute for Scientific Research in Varennes, where ALLS will be built. In a single experiment, different beams could align a molecule, excite intramolecular dynamics, or dynamically probe structural changes. One aim is to grab an electron and diffract it from its parent molecule. "It's using a molecule as its own photocathode," says Paul Corkum of the National Research Council in Ottawa. "The dream is to do imaging of biological molecules that can't be crystallized." The Can\$20 million ALLS is expected to come on line in two years.

Thanks to its role in nailing down neutrino oscillations (see *PHYSICS TODAY*, July 2002, page 13), SNO is being turned from a temporary experiment into a permanent facility, at a cost of around Can\$50 million. The SNO expansion involves digging new caverns to accommodate more experiments. Candidate research thrusts are the low-energy spectrum of solar neutrinos, double beta decay, and dark matter. Leaders in the effort to open an underground lab in the US say they are happy about the SNO expansion, but that it's not a replacement for the much larger lab they envision.

Although ineligible for direct CFI funds, TRIUMF, Canada's nuclear and particle physics lab in Vancouver, benefits when scientists working there win such funding, as in the case of KOPIO. More generally, TRIUMF's budget has grown. "Things were extremely tight at all levels of the federal government in 1995, so we had to have a very strong proposal to get a five-year plan in place," says TRIUMF science director Jean-Michel Poutis-

sou. Coming right after the government nixed a proposal for a kaon factory, the plan for 1995–2000 was a reinvention of TRIUMF. It included building ISAC, one of the world's premier laboratories for radioactive beam studies, and making TRIUMF the hub for Canadian participation in international projects, such as the Large Hadron Collider at CERN. "We got Can\$166 million for the first five years. In the second five-year period, we got a 20% increase," says Poutissou. "We are now preparing the next five-year plan, and we've been told to be bold."

Low profile, high impact

Big facilities like TRIUMF and SNO may be the most visible signs that Canadian physics is thriving, but a host of lower-profile initiatives likely affects more people. To start with, the country's main granting agencies, after suffering budget slashes in the mid-1990s, have seen steady growth since about 1998. For example, this year the Natural Sciences and Engineering Research Council, the traditional funder of physics research, got an increase of Can\$55 million, or about 8%, to a record Can\$770 million. And physics came out ahead in NSERC's recent reallocations, in which 10% of the total grants budget was opened to competition among disciplines (see *PHYSICS TODAY*, April 1998, page 57).

Thanks to a targeted NSERC program, the number of women on physics faculties has "more than doubled in the last 10 years," says Catherine Kallin, a condensed matter theorist at McMaster University. "When departments had to compete [for slots] with other departments on campus, they could suddenly find outstanding women. We have 24 faculty members; 5 are women."

Also enhancing recruitment is the Canada Research Chairs program, under which 2000 endowed chairs are to be established nationwide by 2005. Senior-level chairs come with Can\$200 000 a year for seven-year, renewable terms, while junior chairs get Can\$100 000 annually for five years, renewable once. "The CRCs are extra money that goes to salaries that wasn't there before," says Kallin, who has been nominated for one as part of a retention package. McMaster's other two physics chairs were used to hire the department's first biophysicists as part of a university-wide initiative in biomolecular sciences. The number of CRCs a given university gets is proportional to the grant money mustered by its faculty.

Then there is the Canadian Institute for Advanced Research, which spends about Can\$11 million a year on transportation to conferences and teaching release for selected scientists in selected fields. "The output compared to the money put in is remarkable," says Louis Taillefer of the University of Sherbrooke in Quebec, who heads CIAR's network in quantum materials. "For a thinly populated country like Canada, collaboration is the key." What's more, he adds, "in partnership with Canadian universities, the CIAR has emerged as a powerful recruiting agent." Recruiting of both faculty and students in Canada has, anecdotally, only been helped by the political situation and visa delays in the US.

Growing pains

Not surprisingly, the rapid growth in Canada's research enterprise has bred some tension. Perhaps the most common complaint is a lack of money for operating and maintaining new equipment. "Now that we have all this infrastructure, we make demands," says McGill's Grütter. "We want more technical support staff, secretaries, et cetera. Where are [universities] going to get the money?"

In the overall funding picture, "there is some fragmentation in Canada," says Isabelle Blain, NSERC's vice president for research grants and scholarships. "The metaphor we use is, We have a parking lot full of very nice cars provided by CFI. We have very good drivers—the CRCs. And the pump to put the gas in the tank is usually called NSERC." But swelling numbers of grant applicants have more than made up for NSERC's budget hike, Blain says. And the agency's priority is to fund first-time applicants, so not only hasn't it upped funding for operations, it's put a moratorium on grants for big equipment. To help relieve the operations squeeze, a couple of years ago the CFI began adding 30% to awards, and starting this fall, the federal government will contribute to university overhead costs.

Some catching up may also be needed in the spreading of R&D investments among the provinces. "You'll notice that Ontario, Quebec, Alberta, and British Columbia have lots [of CFI money]. The provinces in eastern Canada and the prairies have less, because of a lack of availability of matching funds," says John de Bruyn, a condensed matter physicist at Memorial University of Newfoundland in St. John's. "Some provinces are more forward-looking than others."

Despite such strains, everyone agrees that Canadian physics is better off now than it was a few years ago. Word of the improvement has reached the public, says Pat Kalyniak, a theoretical particle physicist at Carleton

University in Ottawa, Ontario. "I think the perception of physics has changed. People still may not know what physicists do, but they understand it's a profession—that there are jobs. This didn't use to be the case."

Students are more optimistic these days, Grütter adds. "They are talking about having competitive research careers in Canada. That's very different from five years ago. I hope we can deliver on it."
Toni Feder

Pentagon Revamps Nuclear Doctrine

The US government's plan to overturn a ban on designing new nuclear weapons is generating controversy.

The Department of Defense has asked Congress to abolish the Spratt-Furse provision, a nine-year-old ban on developing new nuclear weapons below 5-kiloton yields. Meanwhile, the Air Force has made a bid for more funding for a separate, new high-yield nuclear weapon to destroy deeply buried, hardened bunkers. The requests are part of the Bush administration's 2004 budget proposal (see the story on page 30). The development of tactical nuclear weapons—high- or low-yield—and the recent mandate that the US Strategic Command take charge of the full range of warfare options for combating foreign weapons of mass destruction increase the likelihood that nuclear weapons will be used, say critics.

The US has not manufactured a new nuclear weapon since 1990. Lifting the ban is supported by the majority of Republicans in Congress, who say they want flexibility in guaranteeing US security. Most of the Democrats oppose the ban, fearing it will lead to an end of the US moratorium on nuclear testing and launch a new arms race.

Richard Garwin, senior fellow at the Council on Foreign Relations in New York, favors US ratification of the Comprehensive Test Ban Treaty (see PHYSICS TODAY, March 1998, page 24, and December 2000, page 44) and says, "it would be unwise in the extreme to manufacture and place such [new] weapons into the stockpile without nuclear tests. There is no need for additional types of weapons at this time."

The repeal of the ban and need for the new air force weapon were hinted at in the Bush administration's unclassified version of the 2002 Nuclear Posture Review. The NPR implies that nuclear weapons could be used in retaliation for attacks involving nuclear, biological, or chemical weapons; against targets able to withstand a nonnuclear attack; or "in the event of surprising military developments."

The NPR strategy was further refined by the public version of National Security Presidential Directive 17, signed by President Bush last year. The directive implies that the US should be prepared to launch a preemptive strike, using all military options to destroy stocks of weapons of mass destruction. Both the NPR and NSPD17 imply that the US might consider breaking international law by using nuclear weapons against a non-nuclear state; such action would violate the 1970 Nuclear Nonproliferation Treaty.

Chilling effect?

The budget request states that the research ban has had a "chilling effect" on weapons research "by impeding the ability of our scientists and engineers to explore the full range of technical options. . . . It is prudent national security policy not to foreclose exploration of technical options that could strengthen our ability to deter, or respond to, new or emerging threats."

Garwin strongly disagrees with this statement. The money would be better spent, he says, on a detailed and objective analysis of the effects following a nuclear weapon's destruction of a bunker full of chemical or biological agents.

Repeal of research restrictions is not the real worry of many scientists

in the arms control community; they are more concerned about future implications described in the NPR. "Generally I am not in favor of inhibitions on R&D," says Michael May, a former director of Lawrence Livermore National Laboratory. "We don't know ahead of time what that R&D will lead to, and we also don't know ahead of time what weapons will be needed." But, he adds, "bringing the possible use of tactical nuclear weapons back into the picture is a big shift in US strategy, in my opinion, especially when coupled with a strategy of preemption." Adds Michael Levi of the Federation of American Scientists, "Developing low-yield nuclear weapons contributes little to deterrence and could only be conceived for warfighting."

"There is little debate," Levi continues, "that developing our own nuclear weapons weakens our hand in diplomatic efforts to combat proliferation. The real debate is over how much it weakens us and whether the military benefits are worth the sacrifice. I don't think they are."

New or adapted weapons

Some 70 countries and more than 1000 known or suspected strategic bunkers are mentioned in the NPR as targets for nuclear weapons. The B61-11—currently the only nuclear weapon in the US arsenal capable of destroying hardened bunkers—has a yield between 0.3 and 340 kilotons and explodes 6 meters underground. The Robust Nuclear Earth Penetrator (RNEP) that the air force hopes to develop would penetrate 30 meters before exploding, causing shock waves that would reach bunkers more than 300 meters beneath the surface. The RNEP would be based on the B61-11, and the air force wants the yield of the new weapon to be similarly variable: An RNEP yield below 5 kilotons would allow troops to move through an area after an explosion and receive minimum radiation poisoning. Research into the RNEP low-yield option is one reason the air force has asked that the Spratt-Furse provision be repealed.

In principle, assuming the RNEP

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A more powerful device could eventually replace the B61-11 bunker buster.