

Custom Vacuum Chambers For The Lab



- AWS and ASME Certified Vacuum Welding Program
- Engineers Trained in Vacuum Applications and Technology
- Project Managers Ensuring On-Time Delivery



Call for a Quote Today
800-352-6431
www.ancorp.com
sales@ancorp.com

A disarmament agenda

Three members of an independent multinational body that analyzes issues related to nuclear disarmament, arms control, and nonproliferation share their views.

A sense of crisis led to the formation of the International Panel on Fissile Materials (IPFM) nearly 10 years ago. "You have to remember that by 2005 the Bush administration had walked back from key arms control and nonproliferation commitments," says Zia Mian of Princeton University. It had come out that Iran was building a uranium enrichment facility and a research reactor that could be used for plutonium production. North Korea also had pulled out of the Nuclear Non-Proliferation Treaty (NPT) and threatened to test nuclear weapons. "And we'd had 9/11," says Mian. "There was a real need to make some kind of collective intervention to stop everything falling apart."

Around the same time, Frank von Hippel, cofounder of Princeton's Program on Science and Global Security, joked to a group of ambassadors at the United Nations that the problems of "nuclear disarmament, nonproliferation, and the prevention of nuclear terrorism are easy. All we have to do is get rid of 2000 tons of stuff." Afterwards, von Hippel says, his comment "sort of rattled around in my brain." He also recalled his experiences working with Russian fusion physicist Evgeny Velikhov in the 1980s. "It was really amaz-

ing how that back channel worked and how brainstorming between physicists who wanted to end the nuclear arms race generated a common agenda."

The combined ideas of working internationally and of using nuclear materials as a common denominator to address different issues led von Hippel to join with a partner to seek funding. He and José Goldemberg of Brazil launched the IPFM in January 2006 with funding from the John D. and Catherine T. MacArthur Foundation. The panel has annual funding of about \$500 000 from the MacArthur Foundation and the Carnegie Corporation.

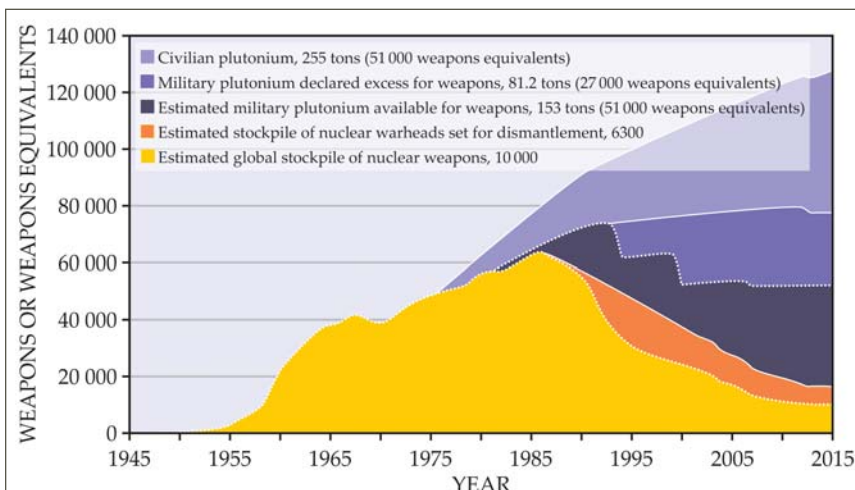
Each year the IPFM updates a comprehensive inventory of global production and stocks of fissile material (see the chart on page 27). In addition, panel members write reports on specific topics. Examples include how to end the reprocessing of spent fuel, the possible implications of the 2005 US-India nuclear deal, the proposed Fissile Material Cutoff Treaty, and the benefits of multinational approaches to uranium enrichment in the Middle East. The panel provides its analyses to policymakers, the United Nations, nongovernment groups, and the press. (See <http://www.fissilematerials.org>.)

This past January Mian, Alexander



Zia Mian (left) and Alexander Glaser (right) are two of the new cochairs of the International Panel on Fissile Materials. Frank von Hippel (center) is a founder and past cochair of the panel, which turns 10 next January.

WWW.RICARDOBARROS.COM



Worldwide estimates of plutonium and highly enriched uranium stockpiles are generated each year by the International Panel on Fissile Materials; the weapons numbers come from the Federation of American Scientists. The numbers in the legend are for 2015. (Based on a figure by the IPFM.)

Glaser (also of Princeton), and Tatsujiro Suzuki of Japan took over from von Hippel and Ramamurti Rajaraman of India as IPFM cochairs. PHYSICS TODAY's Toni Feder spoke by phone with Mian, Glaser, and von Hippel. (See also a review by Matthew Bunn of their recent book, *Unmaking the Bomb: A Fissile Material Approach to Nuclear Disarmament and Nonproliferation*, MIT Press, 2014, written with Harold Feiveson, in PHYSICS TODAY, May 2015, page 50.)

PT: Before getting into the work of the IPFM, could you each tell me a bit about yourself and how you got into this area of work?

VON HIPPEL: I was always interested in nuclear issues. It's in my family—my mother's father, [1925 Nobel Prize recipient] James Franck, was in the Manhattan Project. But I was activated by unrest over the war in Vietnam when I was an assistant professor of physics at Stanford in the 1960s. Reprocessing of spent fuel to recover plutonium for breeder reactors was in vogue at the time, and it was creating a lot of latent nuclear weapon states. Harold Feiveson was already working on that at Princeton. I thought it was a pretty interesting topic, and started working on it with him after I moved to Princeton in 1974. I have been working on nuclear-weapon-related issues ever since.

MIAN: I got interested in nuclear weapons issues in the early 1980s because of the big antinuclear movements in Western Europe and the United States. I was doing physics as an undergraduate in London at the time. People would ask, "So what is all this stuff about? You do physics, you must

know." I didn't! So I started reading up on it and eventually got involved in peace movement activism. I ended up teaching at a university in Islamabad, Pakistan, and organizing on nuclear disarmament and things like that before returning to England, where I continued doing physics and being active with the peace movement. I met Frank in 1993, and in 1997 he recruited me to Princeton.

GLASER: I started my physics undergraduate studies in 1990. I grew up in West Germany, where the Cold War often seemed particularly close. I ended up doing both my undergraduate and PhD theses on arms control physics. My undergraduate thesis was on plutonium disposition and examined options to eliminate excess plutonium that was becoming available from dismantled nuclear weapons. Later, when the FRM-2 research reactor in Garching was built, it was very controversial [because it used highly enriched uranium fuel]. My PhD thesis looked at how this reactor could be converted to low-enriched fuel.

PT: Why are the IPFM members all independent experts?

VON HIPPEL: In debates between governments, the positions are so fixed on some nuclear weapons and fissile-material issues that it means we wouldn't expect very much progress if we left it to government-based scientists.

So we don't have anyone who is a serving government official from any country. Currently there are 29 members from 18 key nuclear states, including nuclear weapon and nonweapon states. About two-thirds of our members are



Touch pro!

Tunable diode lasers play a major role in experimental physics, especially in the field of cold atoms and ions. Their optomechanics have seen a tremendous improvement over the previous years towards more stable and user friendly systems culminating in TOPTICA's *pro* series.

The new digital laser control DLC *pro* now advances the work with tunable diode lasers even one step further: A record-breaking reduction of laser noise and drift as well as convenient remote and touch control allows you to solely focus on the experiment. Enter the digital world and improve your laser performance: **Touch pro!**

Tunable Diode Lasers @ TOPTICA

- ▶ DLC DL *pro* (tunable diode lasers)
- ▶ DLC TA *pro* (amplified tunable diode lasers)
- ▶ DLC TA-SHG *pro* (frequency converted diode lasers)
- ▶ DLC CTL (continuously tunable lasers)



www.toptica.com

physicists. The rest include former ambassadors, nuclear engineers, and a couple of autodidacts.

PT: Please elaborate on some of the key areas you are active in.

MIAN: The first thing is stock taking, where we offer the world our best estimate for who has how much fissile material, what they are doing with it, and what they could do with it. Those numbers now are the numbers that the international community uses most often.

The bottom line is, for almost any policy related to global or national fissile material issues, you have to know where you are starting from to get an idea about what should be your priorities. Under the NPT safeguards system, the nonweapons states have to make their declarations of their fissile material stockpiles and production, so at least the IAEA [International Atomic Energy Agency] knows how much they have. The weapons states do not have this obligation. We try to fill this gap. Making these numbers public can increase accountability and start a useful discussion about what to do with these stocks and how to reduce and eliminate them.

PT: Given limited access, how do you get the information to make your estimates?

MIAN: We go country by country and try to work out and explain the history of their fissile material production program. When did they build their reactors for making plutonium? What was the power rating for those reactors? At what capacity do we think they operated? How much reprocessing capacity did they have? When did those plants operate? And therefore, how much plutonium may they have separated? We do the same kind of analysis for uranium enrichment, and then estimate how much of all this material may have been used in nuclear weapons tests or other things to get a measure of what's left as of today.

PT: What's another key focus?

VON HIPPEL: The Fissile Material Cutoff Treaty. The idea of the FMCT is for the weapon states to put under IAEA safeguards—as in the non-weapon states—their uranium enrichment plants and spent-fuel reprocessing plants, and any fissile materials produced after the treaty comes into force for a country, so the world can be confident that any newly produced highly enriched uranium or plutonium won't be converted to weapons use.

In 1993 the US and Russia finally agreed that they both wanted to have

a treaty cutting off the production of fissile material for weapons, and the UN passed a resolution and asked its Conference on Disarmament [CD] to start negotiations on a treaty. But it hasn't happened, and that's why it's a mixed story.

Our biggest contribution to this has been a draft treaty. It's one of three. One was submitted by the [George W.] Bush administration, but they were convinced that an FMCT can't be verified, so they had no verification. The non-weapon states say that if the FMCT can't be verified, then the NPT can't be verified, so they wanted a treaty with verification. We put one forward, and it is now an official document of the CD. In April of this year, France submitted a third draft treaty.

PT: What has the IPFM done regarding reprocessing and multinational enrichment?

VON HIPPEL: We have done IPFM reports looking at reprocessing programs in Japan, the United States, France, the United Kingdom, as well as on the troubled international experience with fast breeder reactor programs that were the basis for civilian plutonium separation efforts in these countries. We also have studied nonreprocessing options for

SPIE. OPTICS + PHOTONICS



INTERNATIONAL
YEAR OF LIGHT
2015

2015

OPTICS + PHOTONICS

The latest research in optical engineering and applications, nanotechnology, sustainable energy, organic photonics, and astronomical instrumentation

REGISTER TODAY

WWW.SPIE.ORG/2015OP

San Diego Convention Center, San Diego, California, USA
Conferences & Courses: 9–13 August 2015 · Exhibition: 11–13 August 2015

managing spent fuel from nuclear power reactors and methods for disposing of separated plutonium other than its use as reactor fuel, which we believe are likely to prove safer, more effective, and cheaper.

GLASER: In a nutshell, the uranium enrichment dilemma is that any enrichment capacity that is sufficient for a civilian program and is sized to provide even one single power reactor is quite significant in terms of its military potential. As the discussion over Iran's enrichment plant illustrates, one can make several weapon equivalents per year with even such a small enrichment plant.

The best answer, and it's not a new idea, is to operate these plants under multinational control and management.

PT: What about conversion from highly enriched uranium to low-enriched uranium?

VON HIPPEL: What we are trying to do in terms of technical analysis is to show how you can convert research reactors to low-enriched fuel. In most cases, it's possible. It is often political problems that lead to delays. The US Navy is the elephant in the room here.

PT: In what sense are they the elephant in the room?

VON HIPPEL: It's a question of the amount of highly enriched uranium that's being used. They use about 2 tons a year in US naval reactors, which is much more than is used worldwide in research reactors. [See PHYSICS TODAY, May 2015, page 28.]

We have tried to push to get the naval reactor people to look at converting to low-enriched uranium and have had some success.

PT: Is nuclear energy gaining momentum in response to worries about global warming?

VON HIPPEL: It has not been gaining much momentum except in China. In the US, there are four power plants under construction in the Southeast. And in Western Europe there are just a couple. There may be more coming up in the UK. But at the moment, we have retirement [of nuclear power plants] faster than new construction.

PT: What new topics are you planning to focus on?

VON HIPPEL: We are trying to get something going with nuclear archaeology.

GLASER: Maybe the best example is the case of North Korea. Let's say the plutonium inventory is on the order of 50 kg. If we could go back to the Yongbyon reactor and take samples of its graphite, we could probably estimate its past plutonium production to within a few percent uncertainty. So you

would have high confidence that whatever they declared was essentially complete. And you wouldn't have to worry about the bomb in the basement.

MIAN: The nuclear weapons states have a lot of old facilities that were used for making fissile materials for weapons purposes. As part of nuclear disarmament, when we get there, we are going to need to know how much material each state made and where did it go. That is going to involve a whole suite of new forensics techniques.

We can imagine trying to incubate an international nuclear disarmament R&D partnership, with weapons states and nonweapons states and others working at politically safe sites. Then, when we are ready to have negotiations about how to verify nuclear disarmament, at least some of the core tools and techniques might already be available.

PT: You are dealing with grim topics, and yet you all sound so positive. How so? Is it because you are at least doing what you can to improve the situation?

MIAN: We are happy warriors! In part, having this critical mass here at Princeton helps. And secondly, the panel itself is a source of real encouragement. It's very rewarding to be doing this particular kind of work in this particular setting. And time and tide are on our side.

PT: What would you say are the biggest challenges at the moment?

MIAN: All of the nuclear weapons states are modernizing their arsenals. The US has an enormous, trillion dollar, 30-year plan to rebuild everything—new warheads, new missiles, new submarines, new bombers, new pit production, life-extended warheads. One challenge we face is the huge gap between the weapons states and the nonweapons states, which are increasingly determined to see progress on nuclear disarmament.

At the end of the Cold War we were on a glide path of slowly reducing [weapons stockpiles], eventually getting to the point where we would have a treaty that would abolish nuclear weapons. In the last few years, that momentum has stalled.

VON HIPPEL: The whole larger agenda that we are part of is in trouble. In part, it's due to a lack of public engagement. The anti-nuclear-weapons movement demobilized faster at the end of the Cold War than we could demobilize the nuclear weapons establishments, so we still have a sort of frozen US–Russia nuclear doomsday machine. One of our challenges is to get a public constituency for this agenda again. It's a pretty simple agenda: nuclear weapons materials are bad.

Toni Feder

Smartline Vacuum Transducers



Thyracont's Smartline vacuum transducers have set new standards for wide range measurement with precision, functionality, reliability and affordability.

- Models offer a variety of measurement ranges from atmospheric pressure to 5×10^{-10} Torr / hPa / mbar
- Precise, robust sensor combinations include Piezo/Pirani, Pirani/Cold Cathode and Pirani/Hot Cathode
- Choice of communication options: RS485, EtherCAT and 0-10V analog
- Dual, fully configurable process set points
- Models available with a large, intelligent, illuminated display
- Choice of vacuum flange options

THYRACONT
Vacuum Instruments

Thyracont Vacuum Instruments GmbH
direct@thyracont.de • www.thyracont.com