NUCLEAR NONPROLIFERATION

Reactor Project Presses Ahead Despite Protests

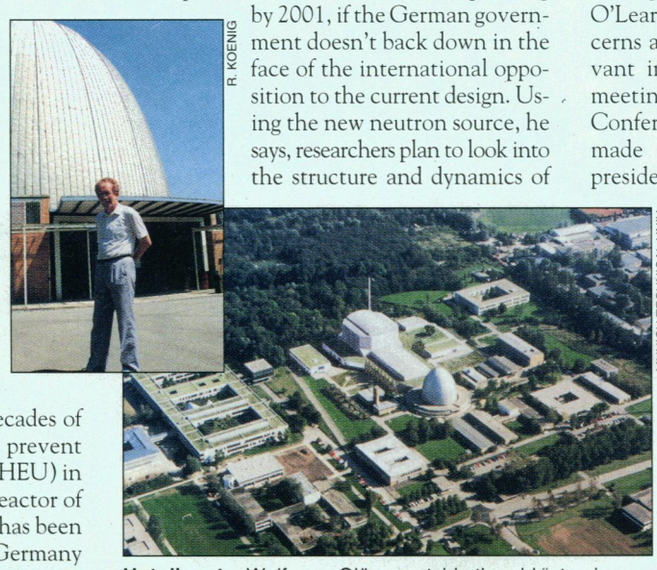
GARCHING, GERMANY—Since 1957, the egg-shaped dome of Germany's oldest operating nuclear reactor has towered over the campus of Munich's Technical University in this quiet suburb. The research reactor, called FRM and nicknamed "the atomic egg," has had a distinguished history, but it is reaching the end of its useful life, and physicists at the university are eager to replace it with a state-of-the-art machine. For the past 10 years, they have been putting together a design for a $520 million reactor, FRM-II, that would be used as a source of neutron beams to probe the structure and properties of matter—everything from steel girders to superconductors to DNA. They have rounded up government funding and are now within sight of their goal: The reactor has just one hurdle to go—environmental clearance to allow licensing for nuclear fuel—before construction can begin, possibly by the end of the year.

But, just as victory seemed assured, the project has become engulfed in a political row that has the potential to strain relations between Germany and the United States. The reason? The Garching experts designed the reactor to use highly enriched, or "bomb-grade," uranium as fuel. Such a design would buck the trend of nearly 2 decades of effort by arms-control agencies to prevent the use of highly enriched uranium (HEU) in civilian reactors. No new research reactor of over 1-megawatt power using HEU has been built in the West for 15 years, and Germany is under intense behind-the-scenes pressure—particularly from the United States—to redesign the reactor. Such a redesign would add tens of millions of dollars and several years to the project—and, FRM-II's backers say, result in a less capable machine.

Paul L. Leventhal, president of the Nuclear Control Institute (NCI), an anti-proliferation pressure group based in Washington, D.C., argues that the FRM-II "is a blatant violation of a crucial nonproliferation norm. It would break the taboo against bomb-grade uranium fuel, increase the risk of nuclear terrorism, and inevitably lead to demands for similar fuel from less trustworthy nations." And last month, U.S. Energy Secretary Hazel O'Leary confirmed that the United States has been trying to persuade the German government to change FRM-II's design.

The uproar puts many scientists in a difficult position: Most of those interviewed by *Science* believe that a neutron source like FRM-II is needed and that the reactor's "compact-core" design, which requires HEU, would be very effective. But they are mostly reticent in coming out in full support of the current design because they do not want to appear to be encouraging nuclear proliferation. "The Garching reactor has a beautiful design and would be an excellent second-generation neutron source," says Andrew Taylor, director of the ISIS neutron source at the U.K.'s Rutherford Appleton Laboratory.

Fueling controversy. Wolfgang Gläser, a prominent physicist at Munich's Technical University who helped develop the new reactor, predicts that FRM-II will be operating by 2001, if the German government doesn't back down in the face of the international opposition to the current design. Using the new neutron source, he says, researchers plan to look into the structure and dynamics of macromolecules, analyze new materials, and form special isotopes for medical applications.



R. KOENIG

MUNICH TECHNICAL UNIV.

Hot dispute. Wolfgang Gläser outside the old "atomic egg." Model of proposed FRM-II reactor is superimposed next to the atomic egg on campus photo.

So far, Germany's federal research ministry and the Bavarian state government have both solidly backed FRM-II and its present design. The German government is committed to paying about $280 million of the project's costs, with the state of Bavaria footing the remaining $240 million. Germany's five existing research reactors—in Berlin, Braunschweig, Jülich, Geesthacht, and Munich—were built in the 1950s and '60s and, even though some have been modernized, "their further use is limited," says Harald Müller, the research ministry's chief spokesperson. Scientific advisory groups, such as the government's Science Council, have also come out in support of the project.

Although the building of FRM-II has become something of a matter of national pride, there has been a considerable amount of domestic opposition to the project from environmental groups and key members of the main opposition party, the Social Democrats. And last year, 52 German scientists—most of them physicists—signed a letter urging that the reactor be redesigned to use low-enriched uranium. The scientists warned that "the damage that the construction of this reactor would do to the world's political situation far outweighs the scientific gain that could supposedly be made by using HEU."

However, the most vociferous opposition to FRM-II has come from overseas. NCI's Leventhal says that the Garching reactor "has major international security implications and should not be decided solely by nuclear scientists and local politicians." Earlier this year, NCI wrote to O'Leary asking her to exert more pressure on Germany to redesign FRM-II. In her reply last month, O'Leary wrote that she had expressed concerns about the reactor to the top civil servant in Germany's research ministry at a meeting of the International Atomic Energy Conference in Vienna last September. "We made clear our commitment to the president's policy on minimizing the use of highly enriched uranium and offered U.S. assistance in redesigning the FRM-II," she said.

The Department of Energy's case against FRM-II has, however, been weakened by the fact that until recently it was planning to fuel what would have been the most powerful facility in the world, the Advanced Neutron Source, with HEU. But the Clinton Administration, citing cost and proliferation concerns, canceled the project earlier this year (*Science*, 17 February, p. 952).

Critics say the FRM-II's use of HEU flies in the face of the 1978 Reduced Enrichment for Research Test Reactors (RERTR) agreement, which calls for research reactors to convert to low-enriched uranium (LEU) and for new reactors to be designed for LEU use. Several countries have active RERTR programs which assist this process. Jon Wolfsthal, the Department of Energy's RERTR project manager, confirms that the department "has offered, and remains willing, to assist in redesigning the FRM-II to run on LEU."

Asked if the Garching reactor would set a bad precedent, Wolfsthal says: "The construction of a new HEU-fueled reactor would be inconsistent with recent international trends in research reactors." Leventhal adds that the dozen Western research reactors on which construction has begun since 1980

have been designed to use non-weapons-grade fuel. The only two HEU-fueled reactors over 1 megawatt built in recent years were in China and Libya.

U.S. officials have made it clear that they will not supply HEU to the new Garching reactor. In 1992, Congress passed a law that bars export of U.S. HEU except in cases where using low-enriched uranium (LEU) is not currently feasible—and even then, the reactor operator would have to be committed to developing and using a suitable LEU fuel. Faced with this barrier, Garching officials secured a guarantee for a 10-year HEU supply (400 kilograms) through an arm of Euratom, the European Union's nuclear agency. Euratom officials say that the HEU will come from nonmilitary sources in western Europe, but experts say some of that HEU originated in the United States, which now has no jurisdiction to stop its use at Garching.

The need for neutrons. Neutron-scattering researchers are slower to condemn the building of FRM-II. The field itself is in a bit of a bind: Older sources are rapidly being retired, and the building of new ones is being slowed by budget pressures. Indeed, a shortage of neutron sources is anticipated as researchers wait for the so-called "third-generation" sources, such as the proposed European Spallation Source (ESS), to be built. Spallation sources do not use reactors to produce neutrons; they rely on a newer alternative method that uses particle-accelerator technology. The ESS, if approved, is not expected to begin operating before 2010.

Researchers argue that less powerful facilities like FRM-II will be needed to help fill the neutron shortage and complement the third-generation sources once they are built. "It is not only feasible but essential to have both second- and third-generation facilities. To feed top-quality experiments into the world-class machines requires other, lesser neutron sources—such as Garching. If you need great speed, you fly the Concorde. But for most travelers—as with many experiments—a 747 will do quite well," says Taylor of ISIS, currently the world's most powerful spallation source.

According to Reinhard Scherm, director of the Institut Laue-Langevin (ILL) in Grenoble, France, home of the world's most powerful reactor source, "it makes sense" for Germany to improve its neutron research. He says the new Garching neutron source would help bolster Germany's program and would complement the ILL by feeding quality experiments into its system. Says Munich's Gläser: "To make effective use of such an international source, one needs an excellent home-country source where researchers can collect experience to make good proposals that will be accepted at Grenoble."

"It is useful to have good-quality national reactors—such as this one—in addition to the international facilities," agrees physicist Daniel Cribier, who led France's Orphée reactor project from 1977 to 1980 and now chairs an advisory group for France's national research center, the CNRS. Gabriel Aeppli, a neutron-scattering expert at AT&T Bell Laboratories in New Jersey, predicts the new Garching reactor "will help further cement the Europeans' lead" in neutron sources. "The Europeans have two world-class neutron facilities [ILL and ISIS], and the U.S. has none."

Will redesign work? Most critics of the project accept the argument that Germany needs to bolster its neutron research. They are not calling for the project to be scrapped, but for FRM-II to be redesigned to use LEU. Gläser contends, however, that such a redesign, while theoretically possible, would add more than $145 million to the construction cost, delay the project by 3 to 4 years, and greatly increase operating costs.

The problem is that the "compact core" reactor design—requiring only 20 megawatts of power—would have to be changed radically, and the power increased to 40 megawatts, to allow usage of LEU fuel, Gläser says. One of the main attractions of FRM-II's design is that it is optimized to produce slow-moving, or "cold," neutrons, which are key to many types of experiments. Cold neutrons are produced by positioning a block of moderating material close to the reactor core to slow down the fast neutrons that emerge. "To get a high cold-neutron flux, it is critical that this 'cold source' is placed as close to the core as possible," says Gläser. "The higher the power of the reactor, the more problematic becomes the design and operation of that cold source."

Armando Travelli, RERTR program manager at the Argonne National Laboratory in Illinois, says experts there calculate that "it is possible to design an LEU-fueled FRM-II with the same performance as the current design, but with a power of 30 megawatts instead of 20, and using seven cores per year instead of five." However, Taylor of ISIS says the compact-core reactor design at Garching "just wouldn't work" with low-enriched uranium fuel. ILL's Scherm, while declining to comment on the nonproliferation debate, agrees. "It makes sense, from a technical perspective, to use HEU in Garching."

Researchers at Garching say they are confident that the political storm will pass and their new neutron source will be in place in 6 years. And what will become of the venerable "atomic egg"? The building will be connected to the new FRM-II, but Gläser says the old reactor will survive only as "a monument."

–Robert Koenig

Robert Koenig is a writer based in Berlin.

Will FRM-II Hinder Conversion?

If Germany's proposed FRM-II reactor goes ahead under the current design, which is based on the use of weapons-grade nuclear fuel, critics contend it would not only set a bad precedent for future reactors (see main text), but it would also jeopardize efforts to take care of an old problem. They argue that it would take some of the wind out of the sails of a partially successful 17-year-old program to convert existing research reactors from highly enriched uranium (HEU) to low-enriched fuel—the 1978 Reduced Enrichment for Research Test Reactors (RERTR) agreement.

Armando Travelli, RERTR program manager at the Argonne National Laboratory in Illinois, says nine reactors in the United States and 15 reactors abroad (including one in Geesthacht, Germany) have so far been converted to low-enriched uranium (LEU) from HEU. But, Travelli adds, there are still 32 research reactors with a power of 1 megawatt or more using highly enriched uranium of Western (mainly U.S.) origin—eight in the United States and 24 located abroad.

Four of those HEU reactors are in Germany, but Travelli says that at two of them—in Berlin and Jülich—"very concrete steps [have been taken] toward LEU conversion," and it has been announced that another will be shut down in 1998. In addition, the aging FRM reactor in Munich will be converted to LEU before it is shut down when the new reactor comes on line in 6 years, says Wolfgang Gläser of Munich's Technical University.

According to research at Argonne, the last time construction began on a new Western research reactor (of a power of 1 megawatt of more) using HEU was in 1978. The Scarabee reactor in France and the TR-2 reactor in Turkey both began construction that year, Travelli says.

Russia has also recently embarked on its own RERTR program, and U.S. Department of Energy Secretary Hazel O'Leary recently signed a letter of intent with Chinese officials to foster cooperation between U.S. and Chinese RERTR programs. "With these new developments," Travelli says, "we have come much closer to the objective of eliminating the use of HEU for civilian purposes worldwide."

–R.K.