

**THE NEW NEUTRON SOURCE FRM-II**

W. Waschkowski, K. Böning

Technical University of Munich Reactorstation, D-85747 Garching, Germany

The Munich Research Reactor FRM in Garching was the first nuclear facility in Germany. It went critical on October 31st, 1957 as a service institute of the Technical University of Munich for fundamental research and basic education. This neutron source became famous by outstanding experimental achievements in diverse fields of physics, chemistry, biology and other disciplines.

The FRM is beginning to lose its scientific attraction in many fields of research. Being able to keep up with the international competition, it would require a higher neutron flux density, a more suitable neutron spectrum and modern scientific installations.

For these reasons, the Technical University of Munich is planning to build a new neutron source, the FRM-II, which will satisfy the needs of research in Germany for the next three decades or longer.

Conceptual Design

The core of the FRM-II reactor (see Fig. 1) will consist of a single fuel element of only 24 cm in diameter and an active height of about 70 cm. It will contain about 8 kg of highly enriched uranium in the form of an aluminium-uranium silicide dispersion.

The fuel element is positioned in the center of a heavy water moderator tank, to build up outside of the uranium zone a large volume of high thermal neutron flux, which is accessible for experimental purposes. The moderator tank is located in the reactor pool containing light water. For radiation shielding the wall of the reactor pool is made of 1.5 m thick heavy concrete. The outer diameter of the pool is 8 m. There are 10

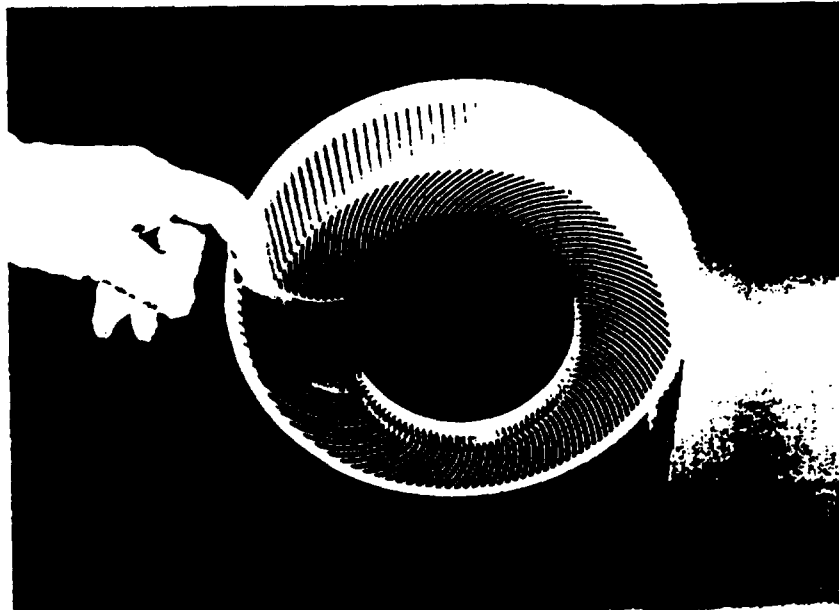


Fig. 1: The fuel element of the FRM-II contains 113 involute plates with an uranium silicide dispersion of 93 % enrichment.

horizontal and 2 inclined beam tubes which supply the experiments in the experimental and the guide hall with neutrons of various spectra. As secondary facilities the FRM-II will have 1 cold source, 1 hot source, 1 converter facility producing a fission spectrum, 2 silicon doping units, several pneumatic systems for specimen irradiations, 1 positron source and other installations and options (see Fig. 2). Fig. 3 shows a lay-out of the experimental and guide hall.

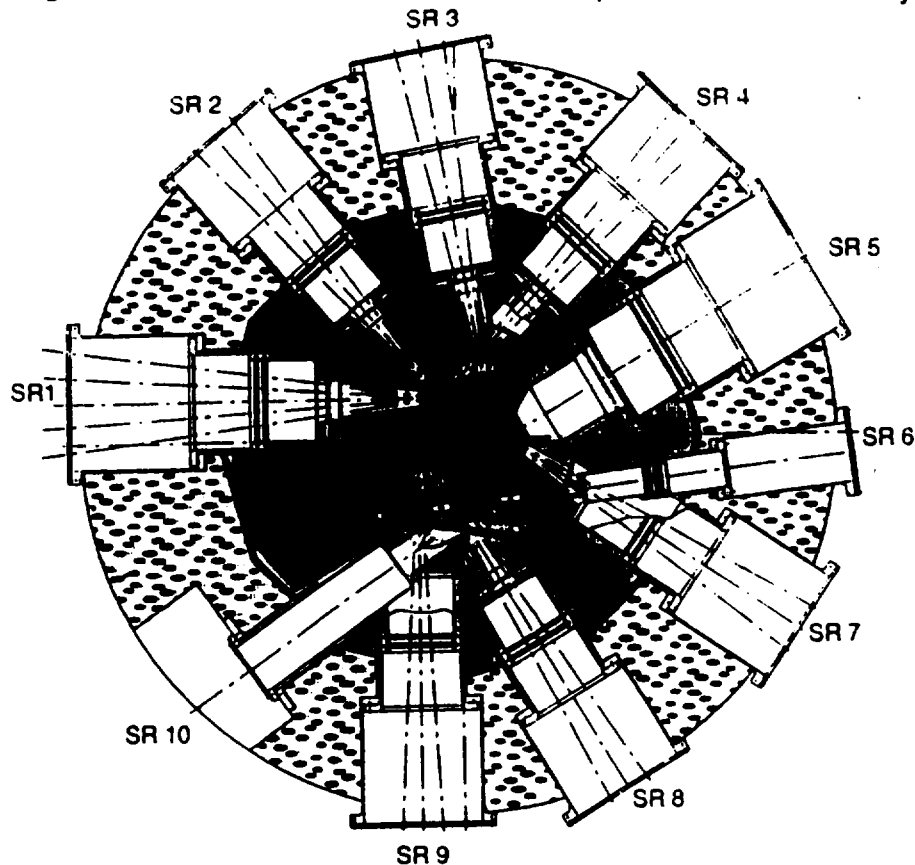


Fig. 2: Horizontal cut through the reactor pool, the moderator tank, the beam tubes and irradiation channels.

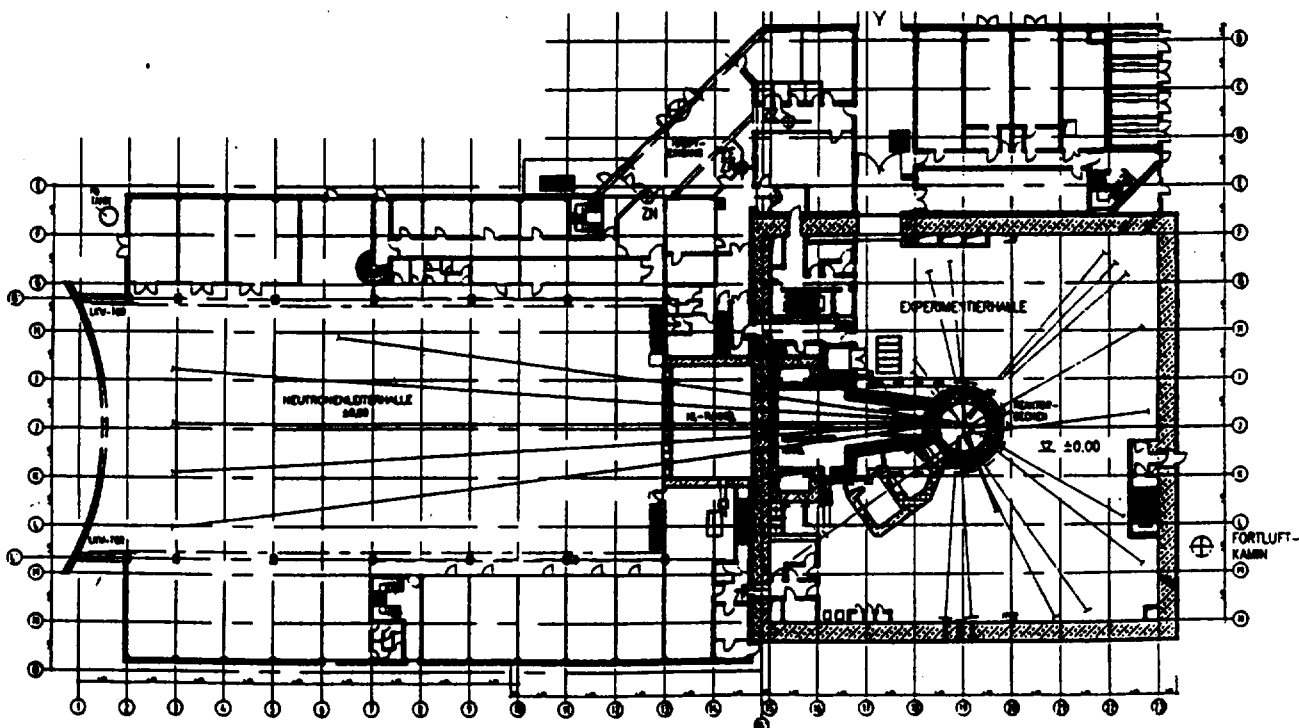


Fig. 3: Lay out of the experimental hall and the guide tube hall.

Modern Technology

One of the most important aims at the FRM-II project was the optimisation of the high neutron flux at a minimum of reactor power, capital investment and operating expenses. The attained quality of high thermal neutron flux density ($8 \cdot 10^{14}$ n/cm²s)

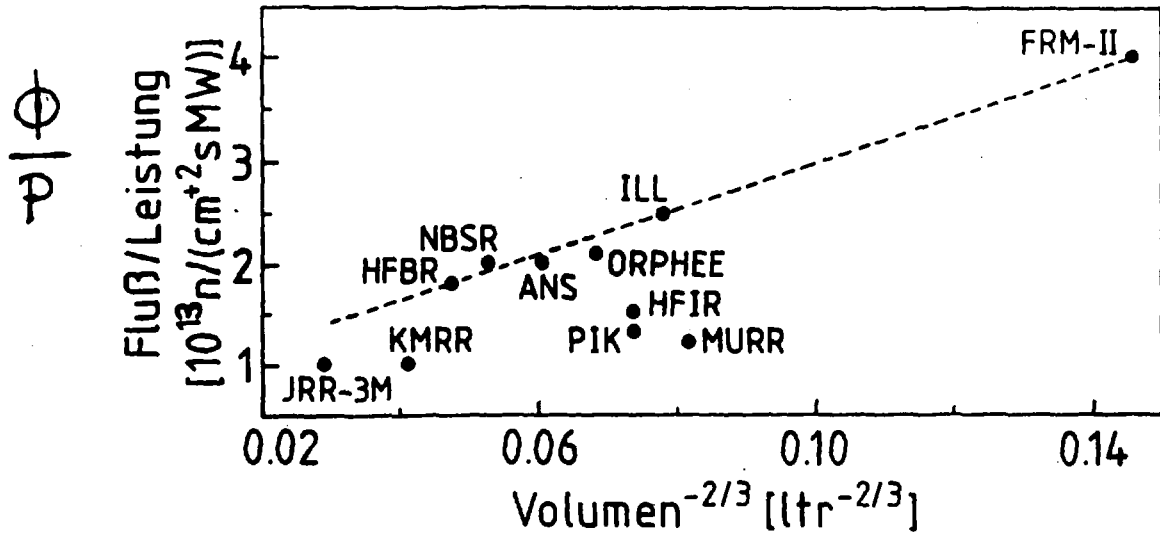


Fig. 4: Ratio of maximum thermal neutron flux outside of the core to power for the FRM-II in comparison with other reactors. The FRM-II will have the world highest ratio of flux to power. This is a consequence of the FRM-II having the smallest core.

at a relative low reactor power (20 MW) make sense in both an economical and ecological way, because the radioactive inventory and the nuclear waste are minimized. Fig. 4 (being taken from US sources) characterizes the high quality of the FRM-II compact core concept: as can be seen, the FRM-II worldwide has the best ratio of flux to power and the smallest core.

The very compact core and its design resulted in two also very remarkable safety features. First, the reactor power is so small that the removal of the decay heat provides no difficulty; that means, the natural convection under water is strong enough to prevent a melt down of the core (nevertheless, there will be a special forced convection cooling for about three hours after a shut down). A hypothetical „steam explosion“ can be ruled out by reasons of basic physics. Second, the core will only work in its planned surrounding; that means, in light water only the fuel element would not become critical. This behaviour belongs to the passive or „inherent“ safety, based on physical laws, which cannot fail. That means, in case, e.g., of leakage in the moderator tank the reactor will shut down by itself without any active operation of protection mechanisms.

This outstanding properties of the FRM-II can only be realized by using highly enriched uranium (93 % U-235) in combination with high U-density. This material allows to design a particularly compact core and to operate the reactor - as already

mentioned - at relatively low power (20 MW), which gives another additional advantage, namely the γ -heat production is small enough that the heat sensitive cold source can be put very close to the maximum of thermal neutron flux near the core. This argument is of special importance, since more than 40 % of all experiments of the FRM-II will be supplied with neutrons from the cold source.

Present Status of the Project

The formal nuclear licensing procedure was started in 1993 with the submission of the safety report. The document was made public for the legal period of two months. About 80 persons studied this report. Formal objections came from 14 communities, from 314 individualists (being able to write down own arguments), and from about 50000 hangers-on (demonstrating their antipathy by their signatures on blanket lists). By German law, these objections had to be discussed in a public hearing. This hearing has taken place in May 1994 in a specially prepared sport hall, where all objectors were invited. On the first morning about 700 people participated, and their number decreased continuously to about 20 on the last of totally five days. Meanwhile the basic design documents have partly been reviewed by the TÜV (Technischer Überwachungsverein), an official control institute in Germany. Until now, the design concept seems to be consistent with the nuclear safety requirements; we hope to get the first partial permission to begin with the construction of the reactor building at the end of this year.

The political acceptance of the project has also grown because of its strong support by the state of Bavaria. The total costs of the facility (including a basic scientific instrumentation) are estimated to 720 MDM (million German marks). About one third will be payed by the Federal Government from the Research and Technology budget, the rest will be granted by the Federal Education and Science budget and the State of Bavaria. The general contract for the construction of the FRM-II has been signed by the Technical University of Munich and the Siemens company in summer 1994.

Site of Garching

Open research is more a matter of universities than of research centers, since the detailed and interdisciplinary discussion of all research projects in combination with an inexhaustible pool of motivated students establish a particularly „fertile“ structure for that. The site in Garching is distinguished by the integration of numerous institutes of two big universities and of various research institutions in the direct vicinity, together with a concentration of high-tech industry in the area around Munich. In summary, the infrastructure is very promising and all interested groups will be able to participate in the basic and applied research as well as in other applications of the new neutron source FRM-II.

Of course the FRM-II is planned to be open for all interested German neutron researchers as well as for guests from other countries. Over decades cooperation relations with foreign scientists have developed at our old reactor FRM, which must be continued and expanded at the new FRM-II.