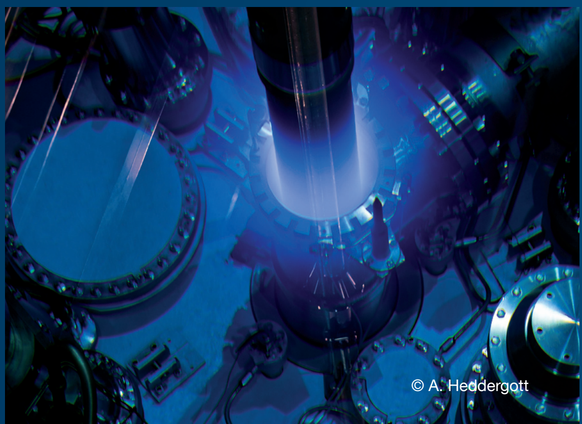
The neutron source in Garching

The Heinz Maier-Leibnitz neutron source (FRM II) in Garching of the Technische Universität München is operational since 2005. Neutrons of various energies on more than 20 different scientific instruments enable a broad spectrum of applications. All instruments are operated by research teams from German universities, the Max-Planck-Society or the Helmholtz research institutes. The FRM II offers not only unique possibilities of interdisciplinary basic research for international scientists, but also a comprehensive spectrum for the medical and industrial use.

Neutrons easily penetrate massive metals. They tell us, where the atoms are located, how they move and what defines their inner magnetism, working completely non-destructively. The FRM II offers the highest neutron flux density in Germany. Further seven irradiation facilities mainly for medical and industrial purposes are in service.

The reactor is operated in cycles of 60 days for about 240 days per year. Industrial customers get access on short notice, to conduct measurements, irradiate samples or analyse component parts.



The fuel element is changed after 60 days.

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FRM II
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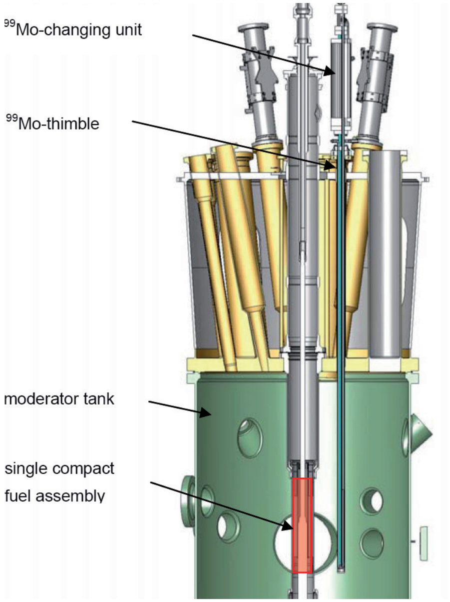
Production of molybdenum-99 for medicine at the neutron source Heinz Maier-Leibnitz (FRM II)

^{99}Mo

Motivation to produce molybdenum-99

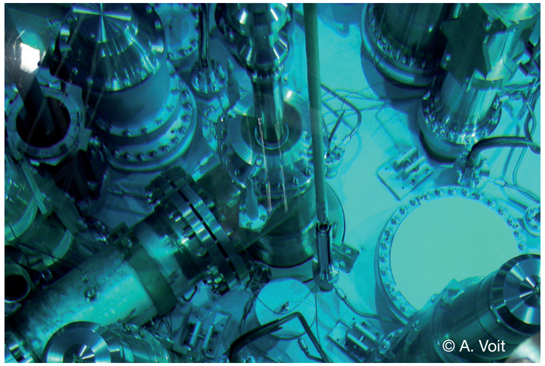
The radioisotope technetium-99m (^{99m}Tc) is by far the most widely used isotope in nuclear-medicine; it emits gamma radiation with a low energy of 140 keV and exhibits a short half life of 6 h. These features predestine it for diagnostic imaging of various organs. Throughout the world, more than 35 million patients are diagnosed and treated per year with radioisotopes. Out of those 70 percent with ^{99m}Tc.
The most common way for the production of ^{99m}Tc is based on the irradiation of enriched uranium in a neutron source which results in the generation of molybdenum-99 (^{99}Mo), the mother isotope of ^{99m}Tc. ^{99}Mo is a rather short lived isotope with a half life of 66 h which makes any stockpiling of ^{99}Mo/^{99m}Tc for weeks impossible and even uneconomical for days.



Moderator tank at FRM II with ^{99}Mo production facility.

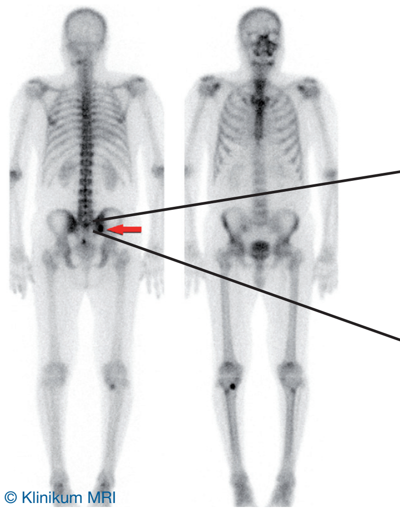
The five major neutron sources, which produce ^{99}Mo worldwide, are between 43 and 53 years old and will be decomissioned from 2015 until 2025. Because of maintenance works, the two most powerful sources in the Netherlands and in Canada have been repeatedly out of order causing a shortfall crisis of ^{99m}Tc.

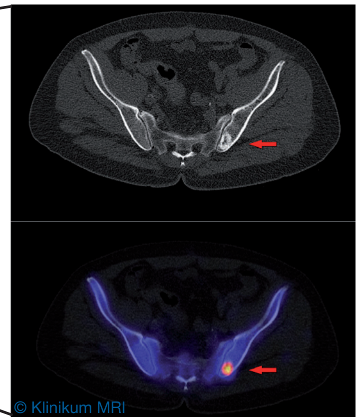
Results of feasibility study at FRM II



Position of the ^{99}Mo facility in the reactor pool.

A feasibility study for a possible irradiation facility at the FRM II finished in 2009 and approved the technical as well as logistical realisation up to the year 2014. The new irradiation position will be able to produce 17 kCi of ^{99}Mo activity per week, which corresponds to 50 percent of the European needs. The FRM II will provide the irradiated targets, which will be transported to a processing facility.
Special care has been taken that a realisation does not interfere with the scientific use of the neutron source. The total costs of the installation is calculated to 5.4 million Euros.





Scintigraphy of a whole body (left) and 2-dimensional section to identify and localize a tumour with the use of ^{99m}Tc (right).

Characteristics of ^{99}Mo facility

average flux density within 'meat' of target	$2.0 \cdot 10^{14}$ cm^{-2}/s
thermal fission cross section (rate averaged)	470 barn
target amount, ^{235}U	max 60 g/ 15 targets
power of target per fission event	< 193 MeV
total power in target stacks	< 430 kW
total activity of ^{99}Mo after 6 days of irradiation and 7 days of decay	3 kCi

Typical applications of ^{99m}Tc:

- brain imaging (neurodegenerative diseases, Parkinson)
- cardiac imaging (coronary artery disease)
- lung scintigraphy
- bone imaging (inflammation)