Plans for the utilization of the new research reactor FRM II

W. Gläser
Physik-Department, Technische Universität München
D-85747 Garching - Germany

ABSTRACT

The construction of the new research reactor FRM II is close to completion. The start of nuclear operation is planned for the year 2001. After a short description of the concept and figures of merit of the facility the scientific instrumentation and user installations for basic and applied research, worked out largely by the German user community and being under construction will be summarized. Besides the introduction of several new techniques considerable progress in the performance of standard neutron techniques is envisaged.

1. Introduction

The FRM II is a new beam tube research reactor being built by the Technische Universität München to replace the research reactor FRM at Garching after more than 40 years of operation.

Intense neutron beams are a useful tool for materials research in its general meaning. They are complementary to other radiation tools like X-rays, Synchroton radiation and light, for some applications they are irreplaceable. The utilization of a high flux neutron source covers many fields in basic and applied research in physics, chemistry, materials research, molecular biology and medicine.

Construction of the FRM II as a multidisciplinary future national neutron source and basis for international cooperation was strongly recommended by the German Wissenschaftsrat in 1989. Consequently many research groups of universities and research centers are actively participating in the scientific instrumentation of the facility.

2. Concept and present status of FRM II

The goal to reach a maximum thermal neutron flux of the order of 10^{15} n/cm^{2}sec with relative low power of 20 MW has been achieved by using a very compact reactor core cooled by light water surrounded by a large heavy water tank taking advantage of the experience collected during the last 3 decades in designing high flux research reactors.

The fission neutrons leak out of the undermoderated core in the heavy water moderator where they built up a high flux level of a thermal neutron spectrum in a large usable volume. The flux to power ratio will be higher than at all existing research reactors offering advantages for the installation of special inpile devices like spectrum shifters and also with respect to reactor safety.

Due to the first construction permit given in 1996 the reactor building is completed by now. The second partial license covering the completion of the facility - including the nuclear installations - was issued in October 1997. Installations and construction of special inpile devices are underway. The „cold start" of the complete facility is planned for the end of the year 2000 and „nuclear start up" is expected for the beginning of 2001 [1].

Parallel to the reactor construction planning, design and construction of the scientific instrumentation takes place. The German user community was actively involved in the selection of the first generation of the scientific instrumentation, influencing also the optimization of beam ports etc..

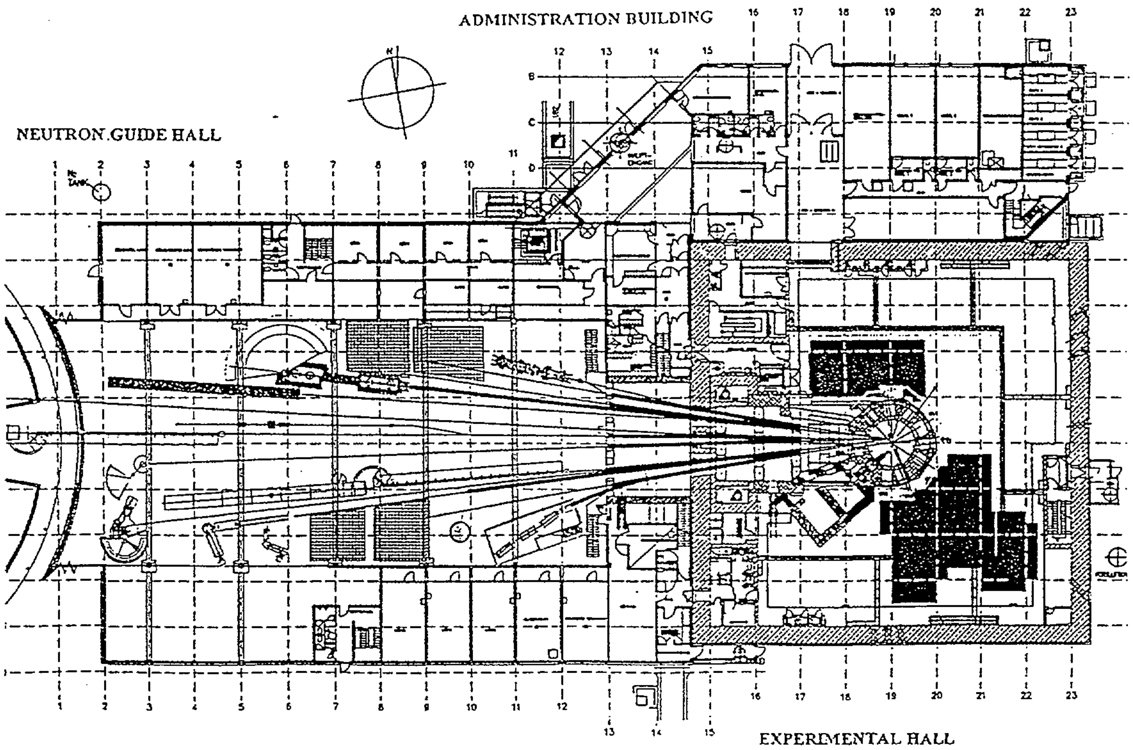

Fig. 1: illustrates the experimental floor and the neutron guide hall.

3. Scientific projects in basic research
3.1. Condensed matter research

A large fraction of the beam capacity will be devoted to advanced neutron scattering techniques for the investigation of the structure and dynamics of condensed matter. Ten instruments decided for this purpose and allready under construction are listed in table 1.

Table 1: Neutron scattering instruments under construction

Cold Neutrons	
1. Nuclear Resonance Spinecho Spectrometer	(Gähler, München)
2. Advanced Backscattering Spectrometer	(Richter, Jülich)
3. Three-Axis Spectrometer (with Polarization Analysis)	(Löwenhaupt, Dresden)
4. High resolution Time-of-Flight-Spectrometer	(Petry, München)
5. Small Angle Scattering Instrument	(Ewen, Mainz)
6. Reflectometer for soft matter	(Kampmann, Geesthacht)
Thermal Neutrons	
7. Three-Axis Spectrometer (with Polarisation Analysis)	(Eckold, Göttingen)
8. Single Crystal Diffractometer	(Frey, München)
9. Powder Diffractometer	(Fueß, Darmstadt)
Hot Neutrons	
10. Single Crystal Diffractometer	(Heeger, Aachen)

With some of these optimized instruments intensity gains of up to an order of magnitude compared to existing instruments are expected.

Main fields of research envisaged are e.g. polymer research, biological macromolecules and magnetic materials. Here methodical progress in energy resolution and intensity of polarized neutrons have to be emphasized. There is also a new type of on-line positron source for solid state and surface physics under construction which will surpass the so far available intensity by several orders of magnitude.

3.2. Nuclear and particle physics

The preparation of two larger projects for nuclear and particle physics has been started.

3.2.1. Fission fragment accellerator

Based on preparatory work at the ILL a special throughole has been implemented in the reactor block for the generation of ions beams - fission fragment beams of high intensity, which have been not available up to now [2].

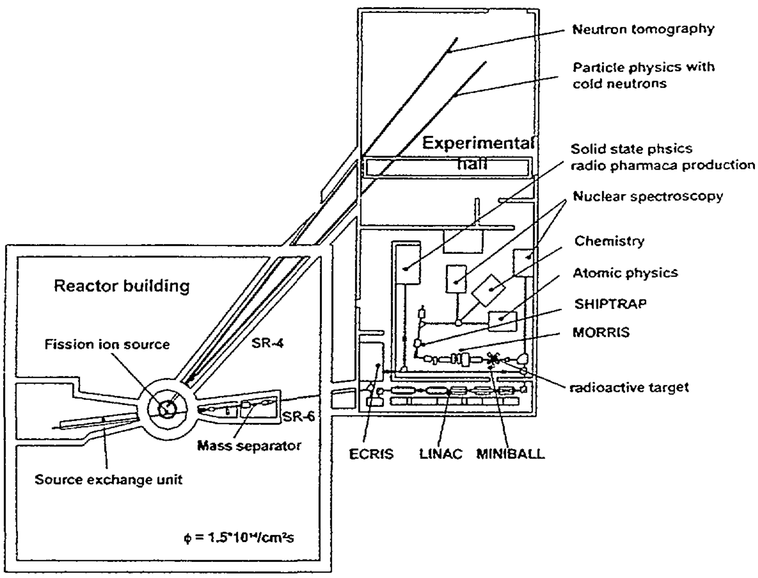

Fig. 2: Layout of the fission fragment accelerator within the reactor building and the eastern experimental hall.

With this accellerated neutron rich fission nuklid beam it is intended to synthesize neutron rich and superheavy nuclei and contribute to the understanding of the r-process of nuclei synthesis in astrophysics. This beam line seems to be of interest also for the production of supportfree special radioisotopes for nuclear medicine. The organization of an international collaboration for this project has been started.

3.2.2. Source of ultracold neutrons

Due to our experience in building the UCN source at the ILL a new concept for the generation of an order of magnitude higher intensity has been designed and will be constructed. With this new source precission experiments on weak interaction and symmetry breaking issues are planned.

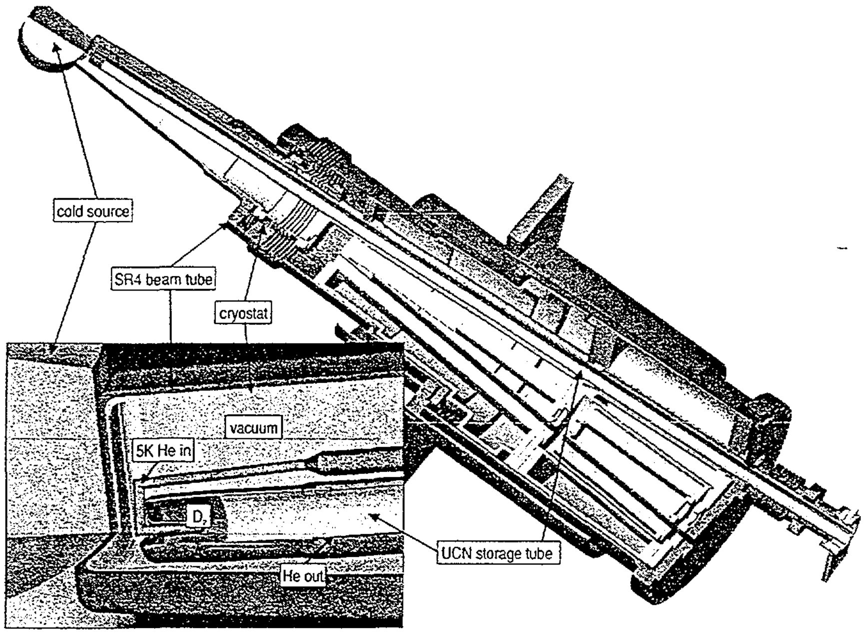

Fig. 3: Scheme of the new UCN source

4. Applied research and applications
4.1. Characterization of materials and non-desructive testing

The instrumentation and techniques for basic neutron scattering research are of growing interest for structural chemistry and engineering applications to characterise new materials. Besides neutron small angle scattering on technical materials high resolution neutron diffraction offers one of the few possibilities to scan non-destructively stress and strainprofiles inside the bulk of engineering components. For this application a special high resolution materials-diffractometer is under construction and will form the basis for a center of non-destructive analysis of engineering components.

4.2. Radiography and tomography with neutrons

Because of the large penetration depth of neutrons they have been used since a long time complementary to X-rays for radiographing engineering components. With the event of high resolution 2-dimensional position sensitive detectors we extended this technique for tomographic applications. That is the reconstruction of a 3-dimensional image of the inner of an otherwise opaque workpiece [3].

The present setup at the FRM suffers from intensity. At the new reactor with two orders of magnitude higher intensity routine applications can be predicted. Two tomography facilities one for thermal and one for fast neutrons will be installed.

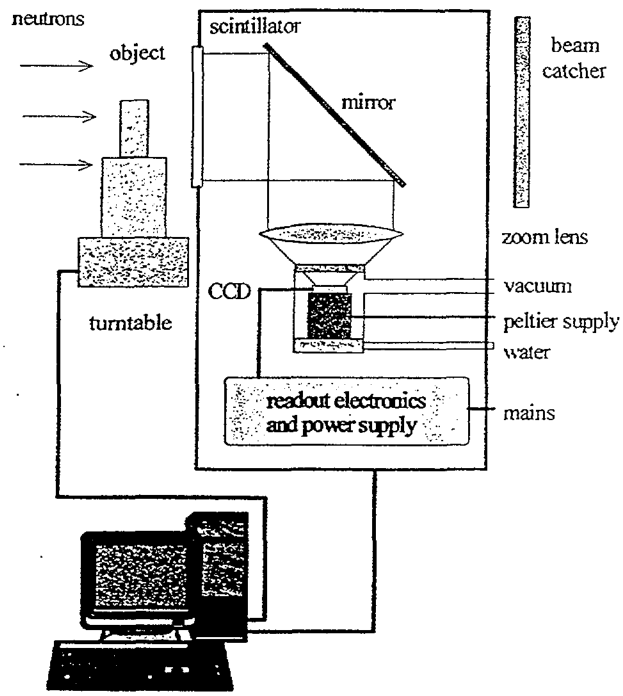

Fig. 4: Scheme of the tomography-setup

5. Irradiation facilities

At the FRM II 5 modern irradiation facilities taking advantage of the available high flux are under construction. Some of them will be available for neutron activation analysis one of the most sensitive techniques of multielement analysis of purified materials and for environmental studies.

Isotope production will concentrate on the production of nuklids for radiopharmaca needed in nuclear medicine for diagnosis and therapy. A special irradiation facility for homogenoeous transmutation doping of silicon will be installed.

For the therapy of near surface tumors a special irradiation facility with an strongly filtered epithermal neutron beam based on experience with a pilot-facility at the FRM is under construction [4].

The effective use of these variety of multidisciplinary facilities requests the setup of qualified service teams in addition to the reactor operation staff. For the expected large number of applications in basic research a suitable selection procedure is under discussion.

References

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