Preface

The Forschungszentrum Rossendorf (FZR) at Dresden is a research centre within the Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz (WGL), one of the German national institutions responsible for extra-unversity research. Using radiation and radioactivity the centre is active in investigations on the structure of matter as well as in the life sciences and in environmental research. The **Institute of Nuclear and Hadron Physics (IKH)** *in the FZR is engaged in fundamental research on the structure of subatomic systems and it strongly pursues the transfer of knowledge to other fields of science. It especially investigates and exploits the possibilities for introducing experimental and theoretical techniques from particle and nuclear physics to the life sciences.*

Experimental and theoretical physicists closely work together in various fields related to research at accelerators and secondary radiation as produced by accelerator beams. With these tools sub-nuclear degrees of freedom, the dynamics of nuclei and their collisions as well as complex biological systems on much larger scales are investigated together with their absorption or emission of electromagnetic radiation. An important advantage of connecting studies in seemingly unconnected fields is due to the fact that theoretical procedures as well as experimental techniques as applied to objects of such different size and structure nonetheless show large similarities. The coupling to radiation together with the importance of many-particle aspects or medium effects establish an important link in theoretical studies. A remarkable example of interdisciplinary transfer is the institute's work on the Radiation Source ELBE at the FZR. This instrument is centered around a superconducting electron linac; thus nuclear physicists could contribute with their experience gained at accelerators outside of Rossendorf. From the electron beam of 1 mA at up to 40 MeV intense secondary radiation is produced: for the medium and far infrared (IR) the free electron laser (FEL) principle will be used, whereas keV-X-rays can be produced via electron channeling or Compton backscattering. Bremsstrahlung photons in the MeV range are a very interesting probe for investigations in nuclear spectroscopy and astrophysics and they allow for the generation of fast neutrons, of interest for many applications.

The interaction between the different areas of research at IKH is especially important with respect to soft- and hardware for running and analyzing the experimental investigations; here the transfer of information from the large international particle and nuclear physics community to the life sciences already has led to considerable synergy effects. Thus there are ample interconnections between the various research projects of the institute -reaching from laboratory studies related to cosmic processes all the way to the interactions of various types of radiation with bio-molecules and cells.

The following R&D projects of the FZR are directed by the institute's research groups. Those indicated by (*) are pursued in collaboration with other FZR institutes under the direction of scientists from the IKH:

Structure of Matter -
Nuclear and Hadron Physics

- *Nuclear structure*
- *Nuclear astrophysics*
- *A pulsed source of fast neutrons**
- *Rare hadronic processes*

Life Sciences -
Biostructures and Radiation

- *Radiation induced cell damage*
- *Photon activation therapy**
- *Structural dynamics of biomolecules*
- *Tomography and tumour-conform radiotherapy*

In this Scientific Report of the Institute of Nuclear and Hadron Physics these projects are presented by several articles. Other contributions describe the progress made in the production of the different kinds of secondary radiation at ELBE, and on the experimental equipment to be installed for their use. The conceptual design studies for the IR-FEL and the detailed work on a magnetic undulator constitute a very important contribution to the FEL aspect of ELBE, *which very likely will be attractive to many outside users. Similarly, the numerical simulations performed for the optimization of the X-ray and the MeV-photon production stations and the experimental areas indicate that in both fields ELBE is apt to allow experiments with high sensitivity and favourable background conditions.*

Nuclear and Hadron Physics at the IKH - as described in the first part of this report - deals with the strong (nuclear) interaction as such and also within the hadronic medium. Experiments related to such questions were performed at the heavy-ion synchrotron SIS at Darmstadt. Theoretical studies refer to these experiments and to data obtained at higher energy accelerators where a phase transition to a quark gluon plasma has been predicted to occur. Understanding the high density phases of hadronic matter is an important step towards understanding the Big Bang and the evolution of the universe. Experimental and theoretical research on low energy electromagnetic processes in nuclei plays an important role in the simulation of processes occuring during the stellar synthesis of the elements. Photon or electron induced fission will be of interest as the source of neutron rich nuclei whose properties are of special importance for the detailed understanding of the stellar element cooking; here neutron beams in the MeV range play a role as well. They and especially the bremsstrahlung photons from ELBE will also allow investigations on specific nuclear structure problems, and they pave the way to many interesting analytical studies, e.g. in the life sciences and materials research.

In its second section this Report comprises research on biomedical problems, mainly performed by using nuclear technology. In the past the main contribution of the institute to this field came from Positron Emission Tomography (PET) and the outstanding achievement here is the successful operation of a PET scanner simultaneously to the irradiation of tumors with heavy ion beams. A significant number of patients was treated at GSI in the last years and the reliability and reproducibility of such radiation therapy had been improved considerably by in-situ PET, as developed at the IKH. In the upcoming years biomedical research will be performed increasingly with the beams coming from ELBE: The quasi-monochromatic X-rays of easily variable energy as produced in electron channeling will be used as a probe for the elementary processes responsible for radiation damage in tissue and for first experiments related to photon activation therapy (PAT). For such studies a cell laboratory is installed at ELBE, which will also be used for investigating the interactions of cells with the tunable FEL-radiation in the infrared - as available at ELBE. Interesting research in biophysics and biochemistry will become possible; here the rather low damage caused by IR combined with its sensitivity to selected bio-molecular bonds will play an increasing role.

The scientific activities of the institute have benefitted from generous support from various sources. First of all, we gratefully acknowledge the close and fruitful collaboration with the Technical University (TU) Dresden and many other scientific institutions in Germany and abroad; such contacts are of vital importance for our institute. Specific projects were subsidized by the Federal Ministry for Education and Research (BMBF), the Saxon State Ministry for Science and Art (SMWK), Forschungszentrum Jülich and GSI Darmstadt. We express our gratitude to all these as well as to the Deutsche Forschungsgemeinschaft (DFG) and to the European Union (EU) for the support of several research projects initiated by the institute.

E. Grosse