Preface

The Forschungszentrum Dresden-Rossendorf (FZD) is a multidisciplinary research centre and part of the Wissenschafts-Gemeinschaft G. W. Leibniz (WGL), one of the German agencies for extra-university research. FZD is active in materials research, in the life sciences and in environmental research. The **Institute of Radiation Physics** *(ISP for "Institut für Strahlenphysik") within the FZD avails for its research the coupling of radiation to matter in subatomic dimensions as well as to tissue, to cells, and to their components. Its research in the field of* **Subatomic Physics** *is part of the FZD-program* **Structure of Matter** *and its investigations concerning the interaction of* **Biostructures and Radiation** *contribute to the* **Life Science** *program of the FZD. In this field the ISP exploits possibilities to transfer efforts on experimental and theoretical techniques from particle and nuclear physics to projects in radiobiology and biophysics. Much of this kind of interdisciplinary transfer is connected to the Radiation Source ELBE at the FZD. With its super-conducting accelerator for relativistic electrons this large installation provides photons in the wide wavelength range from fm to mm - i.e. bremsstrahlung for the investigation of photonuclear processes, hard X-rays for radio-biological and other studies and infrared light from FEL's for research on the structural dynamics of bio-molecules. The investigation of radiation-induced processes not only dominates the projects in nuclear astrophysics as pursued at ELBE, it also is a central theme of the experimental and theoretical research performed by the ISP in close connection to the heavy ion synchrotron SIS and the upcoming FAIR facility at Darmstadt. The Annual Report presented here shows last year's progress as obtained at the ISP in these various fields and their interconnections.*

Experiments performed at the high energy heavy-ion accelerators at GSI-FAIR observe the consequences of increasing nuclear density and theoretical concepts based thereon are an important ingredient for the understanding of the Big Bang and other high density cosmic scenarios. This branch of hadron physics is one of the research activities in subatomic physics at the ISP. It studies the strong (nuclear) interaction in the nuclear medium and especially in high density phases of hadronic matter. As partner of the international HADES-CBM project the Institute is heavily involved in respective experiments and also various theoretical research at the ISP relates to these experiments.

The experimental conditions at ELBE are very favourable for photon-induced processes in the excitation energy range characteristic for the environments relevant to the cosmic production of the chemical elements. This holds for the time shortly after the Big Bang when first nuclei are formed and it is especially so for hot scenarios in heavy stars, novae or super-novae where the formation of high-Z elements can take place. As there the "p-process" and thus photodisintegration becomes important, detailed experimental investigations on electro-magnetic dipole strength distributions in various nuclei near $Z = 40$ *and* $N = 50$ *were performed. The analysis is presently ongoing and a reliable parameterization of the strength is in view. It shall establish conclusive extrapolations to exotic nuclei on the paths of the element production processes. Using the photo-activation technique interesting results were obtained for some nuclides with presently unexplained discrepancies to abundance predictions. First studies related to the* R^3B*-LAND facility open the path towards the electromagnetic disintegration of radioactive nuclei which will be available abundantly at FAIR. Compact bunches of secondary neutrons, i.e. pulsed neutron beams in the MeV-range to be produced at ELBE, will also play a role in this field as well as in basic nuclear physics research dedicated to processes of importance for future nuclear power installations. Initiated by the ISP and the Safety Research Institute (IfS) at FZD, ELBE offers new possibilities for studies related to the removal of radioactive waste by transmutation.*

In its second part this Report describes the research in the life sciences, mainly performed using accelerator based technology. Conceptual design studies for the free electron lasers (FEL) at ELBE including detailed investigations on transport and control of the infrared (IR) and THz beams have since long been part of the work in the Institute. The ISP biophysics department has concentrated on the use of IR radiation in the study of bio-molecular dynamics under non-destructive and native-like conditions. Fundamental aspects of the structure and conformational changes of pharmacologically relevant receptor proteins and of DNA play a key role in these investigations. Novel approaches using FEL pump and visible probe beams have been established to study the motion of the DNA backbone. IR-studies on actinide-molecule complexes have been performed together with radio-chemists from the FZD-Institute IRC.
In the past the ISP contributed essentially to the field of tumour-conform radiotherapy by exploring on-line positron emission tomography. The successful operation of a PET scanner simultaneously to the irradiation of tumours with heavy ion beams considerably improved the reliability and reproducibility of the radiation therapy with fast ions. This in-situ PET as developed at the ISP has been shown to also allow the control of irradiations performed with other beams like ^{3}He and even photons, as shown by numerical and first experimental studies. Beams from ELBE have been developed for another interesting field: Quasi-monochromatic X-rays of easily variable energy as produced in electron channeling have been investigated systematically by varying thickness and orientation of the channelling crystal. Thus, the studies of the elementary processes causing radiation-induced cell damage can at ELBE now been transferred from X-ray tubes to a monochromatic source.

The interaction between different scientific fields at the ISP has led to considerable synergy effects, e.g. with respect to hardware for the experimental investigations or in the field of computer simulations needed for their interpretation. The transfer of information and expertise from the large international particle and nuclear physics communities to the life sciences has been continuously promoted by the ISP. Thus the Institute's speciality of combining various areas of research reaching from laboratory studies on cosmic processes to the interaction of radiation with bio-structures has contributed essentially to its progress.

This report documents the progress of the research at the Institute of Radiation Physics mainly through two types of contributions:

1. Every PhD student (as well as some of the Diploma candidates) has included one or two pages representing the present status of her resp. his thesis work.
2. From each publication which appeared – or was submitted – in 2006 one or two figures were combined with some short text from the paper to generate a report.

By this means the current status of research is demonstrated without producing additional graphs or text.

The scientific activities of the Institute have benefited from various support. We gratefully acknowledge the close and fruitful collaboration with GSI/FAIR Darmstadt and with the Technical University (TU) Dresden. These contacts and those to many other scientific institutions in Germany and abroad are of vital importance for the Institute. Specific investigations were subsidized by the Federal Ministry for Education and Research (BMBF), the Saxon Ministry for Science and Art (SMWK), GSI Darmstadt and Forschungszentrum Jülich. We express our gratitude to them as well as to the Deutsche Forschungs-Gemeinschaft (DFG) and to the European Union (EU) for the support of various research projects initiated by the Institute.

Eckart Grosse

Collaborations

Hadron Physics

- **HADES and CBM Collaborations:**

GSI Darmstadt
Univ. Frankfurt
TU München
Inst. of Physics Bratislava, Slovakia
LPC and Univ. Blaise Pascal Clermont, France
Jagellonian Univ. Cracow, Poland
Univ. degli Studi di Milano, Italy
INR Moscow, Russia
Inst. de Physique Nucleaire d'Orsay, France
Univ. of Santiago de Compostela, Spain
FZD
Univ. Giessen
Univ. Heidelberg
LNS Catania, Italy
Univ. of Cyprus, Cyprus
JINR Dubna, Russia
ITEP Moscow, Russia
MEPhI Moscow, Russia
Nuclear Physics Inst. Rez, Czech Republic
Univ. of Valencia, Spain

- We still benefit from previous contributions to other hadron experiments like KaoS, FOPI, COSY-TOF and COSY-ANKE, from which interesting results come to publication continuously.

Nuclear Physics

- GSI Darmstadt
- TU Dresden
- TU Darmstadt
- GSI Darmstadt
- Univ. Köln
- Univ. Michigan State
  EFNUDAT Collaboration (EU-I3), USA
- TU Dresden
- INRNE and Univ. Sofia, Bulgaria
- Laboratorio di Gran Sasso, Italy
- Charles Univ. Prague, Czech Republic
- Univ. of Notre Dame, USA
- Univ. of Washington at Seattle, USA

Structural Dynamics of Biomolecules

- Rockefeller Univ., New York, USA
- Univ. Orenburg, Russia
- IITM, Chennai, India
- MPI für Zellbiologie und Genetik, Dresden
- MPI für Molekulare Physiologie, Dortmund
- TU Dresden
- FU Berlin
- LMU München

Cell Radiobiology

- GSI Darmstadt
- TU Dresden
- OncoRay Dresden
- PTB Braunschweig / BESSY II
- Univ. Göttingen
- Humboldt Univ. Berlin
- Marie-Sklodowska-Curie Memorial Center of Oncology, Gliwice, Poland

In-beam PET for Quality Assurance of Charged Hadron Therapy

- DKFZ Heidelberg
- Univ. Heidelberg
- GSI Darmstadt
- Soltan Inst. for Nuclear Studies, Otwock Swierk, Poland
- MedAustron, Wiener Neustadt, Austria
- Atominst. der Österreichischen Univ. an der TU Wien, Austria
- Univ. Claude Bernard Lyon 1, France
- CERN, Genf, Switzerland
- Harvard Medical School, Boston, USA