Third Annual Report

Executive summary

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SOUL

Southern Urals Radiation Risk Research

Instrument IP

Thematic Priority

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Project coordinator name: Dr. *Peter Jacob*
Project coordinator organization name: *HMGU*

Executive summary

Project Objectives

The general objective of the project SOUL is to improve the quantification of health risks due to protracted exposures of ionising radiation. Epidemiological studies are performed for workers and for population groups, who have been exposed due to the production of weapons grade plutonium at the Mayak Production Association (MPA) in Southern Urals.

The main goal of Subproject 1 *External dosimetry for the Mayak worker cohort* (MWC) is to validate external dose values in the dosimetry system *Mayak Doses-2005* and contribute to an improved dosimetry system *Mayak Doses-2008*. Subproject 2 *Internal dosimetry, dosimetry system, and health effects for the Mayak worker cohort* is aimed at improving estimates of organ doses due to incorporation of plutonium, exploring the feasibility of performing epidemiological studies of cancer incidence and of circulatory diseases among Mayak workers, and studying the early pathogenesis of Pu-induced lung cancer. The main goal of Subproject 3 *Dosimetry for the extended Techa River cohorts* is to improve the quality of dosimetric data for members of the Extended Techa River Cohort (ETRC) and the Techa River offspring cohort (TROC), aiming at a new dosimetry system *TRDS-2008*. Subproject 4 *Health effects in the Techa River cohorts* is focused on the creation of the cause-of-death registry for the catchment area of the ETRC follow-up, increase in the statistical power of the radiation risk analysis for the TROC and of the non-cancer mortality risk analysis for ETRC members.

The work of SOUL is coordinated with other projects in Southern Urals supported by the US Department of Energy, the US National Cancer Institute and the German Federal Ministry of the Environment.

Subproject 1 External dosimetry for the Mayak worker cohort (MWC)

In the reporting period the first time preliminary reconstruction of external dose (air kerma) for Mayak workers was made from FISH measurements using tentative estimates of RBE values. The analysis of the comparison with EPR reconstructed doses and Mayak Doses-2005 gave indication that tentative values are possibly overestimating RBE for photon energy above 100 keV. More basic work will be required for more reliable assessment of RBE for FISH measurements.

Mayak Doses-2005 could be confirmed by EPR measurements within ±15% for exposure scenarios at radiochemical plant with isotropic exposure geometry in all monitoring periods and at reactor plant with isotropic exposure geometry in the periods before 1954 and after 1960. For scenarios with AP exposure geometry discrepancy was observed that resulted in modification of this exposure geometry in the new dosimetry system Doses-2008.

The analysis of the currently available data has shown that with tolerating a systematic error of 50% (SD) combined with random error each for Mayak DOSES-2005 and EPR reconstruction, in 96% of cases Mayak DOSES-2005 and reconstructed air kerma by EPR were in agreement. It was agreed that this degree of agreement is acceptable in the present state and do not justify repressing Mayak DOSES-2008 until corrective recommendations for improvement are identified. It is the strategy to analyse data separated by exposure clusters for identification of systematic errors and elaboration of cluster specific recommendations for improvement. Validation should be continued until expected improvement in dose estimates will be less than 30%. Cluster specific recommendations for improvement of Mayak DOSES-2008 will be provided with inclusion of the complete set of EPR and FISH results from SOUL at end of the project in month 48.

The number of EPR and FISH measurements for the about 200 workers that will be performed in the framework of SOUL Project turned out to be most likely sufficient to validate doses for only two of the five

clusters. In order to complete the work for all clusters, there will be a need to carry out measurements within the same extent in future projects. It is essential to perform measurements for those workers who worked in exposure scenarios for which currently not sufficient results are available for validation.

The work in Subproject 1 was performed in the three work packages WP1.1 *EPR for Mayak PA workers*, WP1.2 *FISH measurements for Mayak PA workers* and WP1.3 *Improvement of the Mayak PA dosimetry system and individual dose calculations*.

The main objectives for months 25-36 were: analysis of doses reconstructed with various methods: EPR, FISH and film; deriving of agreed dose estimates; further data extension due to collected samples; contributing to the formation of external dose database DOSES2008. Specific objectives of each WP included:

- WP1.1. Testing of background dose estimation method for 94 Ozyorsk residents considering medical exposure contribution to the individual dose. Completion of photon spectra measurements and unfolding at work places, systematization of obtained results and report compilation. EPR measurement of tooth samples of Mayak workers and Ozyorsk residents, who are acting as a control group for the assessment of background dose to workers. Integrating of EPR results in the SOUL EPR data base, and adding of data on medical exposures and on exposure scenarios at Mayak PA work places from the RF-US Project 2.4.
- WP1.2. The estimation of individual doses to Mayak workers by the FISH technique to compare with doses derived from film badges or EPR. The setting up of the selection protocol, ensuring the production of good preparations and that the scoring criteria between laboratories are consistent, and scoring of samples. Identification of workers, invitation to participate in the study after signing an "Informed consent" form; collection of blood samples. Culturing of lymphocytes of peripheral blood and metaphase spreads preparation on microscope slides. Painting of metaphase spreads by using fluorescent in situ hybridization. Scoring of metaphases for translocations. Check for consistency of translocation yields from each laboratory, combining and converting to dose to bone marrow.
- WP1.3. The development of improved dosimetric modules for individual dose calculations and creation of the database DOSES2008. Integrating and comparison of dose estimates by film badge, EPR and FISH, analysing discrepancies and generating dose estimates in consensus to all methods. Development of modules for reconstruction of individual external dose in dependence on exposure scenario and method of dose assessment; development of a strategy for external dosimetry system improvement for Mayak PA workers.

The work performed in 12 months of the project resulted in the following achievements in accordance with planned objectives:

- WP1.1. During the reported period collection of tooth samples of Ozyorsk residents were completed and sampled teeth were measured (40 samples). EPR database of SOUL was complemented with information on medical exposure of tooth enamel (95 samples), based on which background doses and their uncertainties were estimated for Ozyorsk residents according to the protocol compiled within SOUL. Completion of the template with data on new samples was continued. Measurements of photon spectrum and angle characteristics at work places were completed. In total 431 spectra were measured, 119 of them with photon angle characteristics. Now all measured spectra have been unfolded. Results of the research were published in two peer reviewed journals (Smetanin et al., 2008, Rad. Prot. Dosim., 2008, doi: 10.1093/rpd/ncn204; Smetanin et al., 2007, Nucl. Inst. Meth. A, 580, 694-697). The work on "EPR measurements of tooth enamel" included the following activities: Completion of templates with EPR measurement results and dosimetric information on personnel exposure conditions according to the measurement schedule. At end of the 3rd year of SOUL for 185 MPA workers preliminary data on individual doses with the account of exposure characteristics at work places have been derived and have been transferred to WP1.3 for further analysis. The list of discrepancies between EPR and film dosimeter data has been updated and transferred to the WP1.2 to assess feasibility of FISH measurements, as well as to WP3.4 for Sr content determination. Determination of tooth enamel doses based on Monte Carlo calculations was performed for diagnostic X-ray examination procedures of tooth, skull and cervical

spine radiograph. A manuscript “Dose conversion coefficients due to diagnostic exposure of Mayak PA workers” has been compiled. Doses to tooth enamel are on average about 10 mGy/procedure for all of the three diagnostic procedures if performed after 1970. Information on x-ray examination of Mayak workers and Ozyorsk population has been collected. Information on medical doses for Ozyorsk population has been entered in the template. A “Protocol of corrected EPR and film dose calculation from the annual data of the individual dosimetric monitoring” has been compiled.

- WP1.2. Groups for FISH analysis were defined including: 1) workers chronically exposed to external gamma-rays in doses of 2.0 Gy, 2) workers chronically exposed to external gamma-rays in doses of 0.5 to 2.0 Gy, 3) workers who had EPR dosimetry, 4) workers with significant discrepancy in estimated dose received on the basis of EPR dosimetry and film badge measured dose and 5) Ozyorsk residents with absorbed dose in enamel above 1.5 Gy. This initial definition of groups was later extended to include all persons with available EPR measurements. The group of individuals under investigation includes currently 77 workers of Mayak PA and 7 controls. The blood taken from the selected workers was cultured and metaphase spreads on microscope slides were made. Samples from all persons were distributed to all three laboratories. Slides from the workers were painted in each laboratory and cytogenetic doses were reconstructed. Doses to the red bone marrow were in the range 0.5-3.9 Gy. The translocation yields are measured in lymphocytes derived from blood samples. The samples are cultured to produce metaphase spreads on microscope slides, which are distributed to the three laboratories. Each laboratory paints three chromosomes and scores translocations in 1000 cells from every donor. Thus consistency between laboratories can be checked and the results combined to produce individual estimates of bone marrow dose. The fraction seen of all translocations varies between 33% and 36% depending on the chromosomes painted and the gender of the donor. In a few cases less than 1000 cells were scored and sometimes more.

- WP1.3. Calculated film and EPR doses from WP1.1, as well as FISH doses from WP1.2 were collected in special developed templates. Because of the great number of scenarios (over 40) considered in the database DOSES-2005 there were not sufficient EPR measurements for each scenario for sure comparison of EPR and film badge doses, that is why similar scenarios were grouped in clusters (5 clusters consisting of 3 groups each, distinguished by dosimeter types). Relative safe comparison of EPR, FISH and film badge data was made for two clusters (No. 1 contains 69 workers and No. 5 46 workers). Modules for occupational dose reconstruction by EPR and film methods included in the database DOSES-2008 were confirmed for the exposure scenarios contained in those two clusters, and agreed dose estimates were derived for 132 workers, reconstructed by three methods. Those modules were entered into the database DOSES-2008 for individual dose calculation. But the comparison demonstrated that the individual dose uncertainty due to uncertainty of spectrum and angle characteristics of the radiation filed could be decreased as described in the “Strategy of Improvement of the External Dosimetry System for Mayak PA Workers”. The “List of work places where the personnel was not subjected to the individual dosimetric monitoring” and the “Protocol of dose reconstruction for Mayak PA workers without individual dosimetric monitoring data” have been compiled. A document “Prioritisation of candidates for FISH” has been issued, where recommendations (worker lists) are given to WP1.2 for selection of individuals for FISH measurements. The development of the dosimetric register of external doses to Mayak PA workers DOSES-2008 is being completed in the framework of the RF-U.S. Project 2.4, where performed SOUL activities have been taken into account. Templates have been developed and completed for 132 individuals to compare doses assessments by film badge, EPR and FISH. These templates will serve as a base for construction of modules for individual dose reconstruction. The analysis of the currently available data has shown that with tolerating a systematic error of 50% (SD) combined with random error each for Mayak DOSES-2005 and EPR reconstruction, in 96% of cases Mayak DOSES-2005 and reconstructed air kerma by EPR were in agreement. It was agreed that this degree of agreement is acceptable in the present state and do not justify repressing Mayak DOSES-2008 until corrective recommendations for improvement are identified. It is the strategy to analyse data separated by exposure clusters for identification of systematic errors and elaboration of cluster specific recommendations for improvement. Validation should be continued until expected improvement in dose estimates will be less than 30%. Cluster specific recommendations for improvement of Mayak DOSES-2008 will be provided with inclusion of the complete set of EPR and FISH results from SOUL at end of the project in month 48.

Subproject 2 Internal dosimetry, dosimetry system, and health effects for the Mayak worker cohort

ICRP are currently reconsidering the treatment of lung clearance via particle transport, and plan to incorporate this work into forthcoming recalculations of dose coefficients for workers and members of the public. Of particular relevance to the SOUL project, is the transport of material from the AI region. This proposed new model structure will be used to aid analysis of the Mayak workers.

The main objective of WP2.2 is to validate and verify the best individual internal dose assessment for members of the MWC, for the purposes of reliable epidemiology radiation risk research. For this purpose, dose estimates based on the SIMP (WP2.1) were reviewed and verified jointly with US colleagues. During the reporting period it was performed the comparative analysis of different plutonium biokinetic models to determine which tool is the most appropriate for target organ/tissue dose estimates. The article "Comparison of dose estimation from occupational exposure to ^{239}Pu using different modeling approaches" S.A Romanov, R.A. Guilmette, V.F. Khokhryakov, A.Phipps et.al. was published in *Radiation Protection Dosimetry* (vol.127, №1-4 2007, pp.486-490). Doses for workers who never underwent biophysical examination were estimated by a special developed module for reconstruction of the typical plutonium exposure patterns at certain work places. Moreover, the uncertainties in the individual internal dose estimates were determined using uncertainty calculation software, developed based on Bayes statistical methods during the US-RF collaboration.

The Cause of Death registry gives relevant information on health effects not only within the SOUL project, but also within the respective project of NCI. While studies within SOUL are related to non-cancer effects, emphasis of the NCI studies is put on cancer deaths among ETRC. Further more, a link to a JCCRER project focusing on cancer incidence is about to be established. An important point here could be to add DCO (death certificate only) cases to the incidence data base.

The main objective of WP2.3 is to extend the Cause of Death Registry for Ozyorsk population, to use it in clinical and epidemiological research, and to perform inter-laboratory comparison of the quality of cause of death coding.

The main aim of the first stage of the WP2.4 *Non-cancer effects in Mayak worker cohort* (feasibility study, months 1-18) was to assess feasibility to analyze morbidity and mortality risks from non-cancer diseases in the cohort of Mayak workers first employed at one of the main plants (reactors, plutonium, radiochemical) during 1948-1958. It was concluded from this feasibility study that data for the cohort of Mayak workers employed in 1948-1958 can be used to analyse risks of mortality and morbidity from circulatory diseases due to external and/or internal exposure taking factors such as sex, age, smoking status, etc into account.

The main aims of the next stage of WP2.4 *Non-cancer effects in Mayak worker cohort* (months 19-36) were to:

(i) analyze morbidity and mortality risks from non-cancer effects in the cohort of Mayak workers first employed at one of the main plants during 1948-1958 with follow-up through to 31 December 2000 and

(ii) make an assessment of the feasibility of analyzing morbidity and mortality risks for circulatory diseases in an extended cohort of Mayak PA workers - including workers first employed after 1958 - with the extended follow-up through to 31 December 2005.

In this connection, the main tasks were the following:

- Task 2.4.1 *Identification of the cohort of workers first employed after 1958*
- Task 2.4.2 *Improvement (adjustment, verification, expansion) of the medical and dosimetry database on Mayak PA workers*
- Task 2.4.3 *Quality control of the medical-dosimetry database*
- Task 2.4.4 *Feasibility of analyzing mortality and morbidity risks due to circulatory diseases in the expanded cohort of Mayak PA workers with extended follow-up*

- Task 2.4.5 *Analyses of mortality risk due to circulatory diseases in the cohort of Mayak PA workers first employed during 1948-1958*
- Task 2.4.6 *Analyses of morbidity risk due to circulatory diseases in the cohort of Mayak PA workers first employed during 1948-1958.*

The overall goal of the workpackage 2.5 is to estimate whether it is feasible to provide estimates of radiation-induced carcinogenic risk based on cancer morbidity among workers of the Mayak PA. Epidemiologic risk analyses conducted on the Mayak PA Workers Cohort (MWC) have so far been based on mortality. These analyses have shown significant increases of carcinogenic risk in organs where ^{239}Pu preferentially deposits in the body (lung, liver, bone). So far in the MWC there is no evidence of a ^{239}Pu related leukemia risk. Solid cancer risk in organs other than lung, liver and bone have also been shown to be increased and this increase was related mostly to external gamma-exposure.

The goals for current reporting period (25-37 months of work on the project) were in accordance to tasks as follows: improvement of the database by inclusion of cancer cases diagnosed in Mayak workers initially hired in 1948-1982; inclusion of information on tumor histological type into the database for analysis, quality control procedures, and preliminary analyses of cancer morbidity.

Workpackage 2.6: Within the reporting period morphometric and molecular analyses of lung tissues selected for the study and establishment of the database of study cases for statistical analysis in the later stage of the project was be continued. From Month 42 work on "Identification of trends" will start.

Subproject 3 Dosimetry for the extended Techa River cohorts

Main objectives for months 25-36 were further improvement of the models and experimental techniques that will be used for dose validation and verification, as well as continuation of collection and measurement of samples that will be analysed at the last stage of the project. Specific objectives for each WP included:

- WP3.1 (ISS, GSF, URCRM, IMP, DIFTER). Improvement of the EPR method in the low dose range and the assessment of uncertainty of EPR dosimetry on the basis of the results of intercomparison among the participating laboratories; extension of EPR methodology to measurement of incisors (which are approximately half of the available samples); selection of tooth samples from the URCRM tissue bank and EPR measurements for ETRC members and unexposed Urals residents.
- WP3.2 (GSF, URCRM, ZAO). Measurement of anthropogenic doses in bricks from the church in Metlino. Improved assessment of the background dose for the mill in Musylumovo. Determination of the present gamma-dose rate, averaged over one year, by passive Al_2O_3:C dosimeters for the mill in Muslyumovo and the granary in Metlino. Development and validation of computational models of the Muslyumovo sampling site by Monte Carlo simulations. Calculation of dose responses in brick and in TLD due to anthropogenic nuclides in the environment and natural radionuclides in wall and in the environment. Performing field trips to Metlino and Muslyumovo sampling sites for a collection of TLDs, for assessment of seasonal variation of absorbed dose rate in air and radiation monitoring of the reference site in Muslyumovo. Compilation and analysis of radiation monitoring data for Muslyumovo taken in previous years with high spatial resolution.
- WP3.3 (URCRM, HPA, UF). Improvement of the ICRP-88 foetal biokinetic model for Ca and Sr with allowances made for the Techa-specific situation and integration with the URCRM Sr model for female Techa residents; calculation of dose coefficients for *in utero* exposure from ^{89,90}Sr and ^{137}Cs in data format required for dose assessment; development of a comprehensive skeletal phantom for a newborn; analysis of available data for construction of foetal dosimetric models.
- WP3.4 (GSF, URCRM, ZAO). Measurements of ^{90}Sr concentration in teeth.
- WP3.5 (URCRM, GSF, HPA, ISS). Comparative analysis of the data obtained in the frame of other workpackages as well as reanalysis of FISH and luminescence data have been obtained before.

- WP3.6 (URCRM, HPA, LUMC). Selection of donors in accordance with the established criteria and priorities; medical examinations of potential donors; taking blood samples, preparation of cell suspensions, FISH painting and scoring.

As a result of the work performed, the following achievements have been made in accordance with planned objectives.

- WP3.1. Within the task 3.1.2 detection limits and measurement uncertainty at GSF, ISS and IMO laboratories were estimated baed on the analysis of the intercomparison results described in Deliverable 3.1.4 "Report on results of intercomparison". The performance parameters for both EPR signal amplitude and assessed dose were defined and used as indicators of method quality. An analytical and a Monte Carlo modelling were used for evaluating uncertainties of EPR dosimetric systems. The predicted uncertainty for the three laboratories was validated by blind test. Within the task 3.1.3, in order to extend the EPR methodology to measurement of front teeth, the minimal mass detectable for dosimetry was evaluated. The measurement protocol for incisors was defined for the ISS EPR system. Within Task 3.1.4, the influence of sample chemical treatment on EPR response was also evaluated and the protocol carried out at IMP has been optimized. The measurements of background doses were finalized.
- WP3.2. Absorbed dose was measured at different depths in four brick samples from the belfry of the church in Metlino. Ages of the mill in Muslyumovo (130 a) and of the granary and the church in Metlino (160 a) were assessed by luminescence measurements of six brick samples from well shielded locations. Improved assessment of the background dose for Musylumovo was achieved by combining in-situ gamma spectrometric measurements in the area in front of the mill with Monte Carlo calculations. Finalised anthropogenic doses in the exposed bricks from Muslyumovo were in the range of 200 to 300 mGy. Anthropogenic doses in the exposed bricks from the belfry of the church in Metlino were in the range of 0.4 to 0.8 Gy. Al_2O_3:C dosimeters, that had been (re-)inserted at pre-selected locations in June 2007 in Muslyumovo and Metlino were successfully retrieved after approx. one year of storage. The present gamma-dose rate due to anthropogenic sources varies between 0.5 and 0.7 mGy a^{-1} for the mill in Muslyumovo and between 5 and 10 mGy a^{-1} for the north-western wall of the granary in Metlino. A series of Monte Carlo models and subsequent simulations have been developed in order to assess dose conversion coefficients for bricks and TLDs due to radiation emitted from the brick wall and from radionuclides in the environment (both natural and anthropogenic). Search for available information on contamination of floodplain in Muslyumovo resulted in discovery of detailed monitoring data taken in 1992-1994 (Chesnokov et al., 2000) with high spatial resolution in the Muslyumovo sampling site. Based on the information discovered, the source geometry was verified and source strengths were compared to present day observations. Results of in-situ gamma-spectrometry in Muslumovo sampling site obtained during 2007 field trip have been processed and concentrations of radionuclides in soil have been estimated. The extensive transport calculations resulted in calculation of source-detector response matrices, which are used to calculate dose responses in bricks and in air at shoreline. The results of transport calculations have been validated with annual dose values recorded by TLD. Analysis of existing data on dose rate above shoreline in various years is going. Information on early contamination of the Techa river and Metlino village have been discovered in historical reports of the PO "Mayak" and will contribute to a development of a model of the Metlino site.
- WP3.3. Paper on the approaches to dose calculation to the TROC members (foetal and infant doses) was published in Radiation Protection Dosimetry Journal. Paper on the reconstruction of ^{90}Sr intake for the first six months of live was published. Sensitivity analysis of calcium and strontium transfer to the foetus was implemented and a standard foetal biokinetic model for strontium was established to assess doses from strontium radionuclides to members of the TROC. The results of foetal modelling work were described in Milestone 3.3.2 (month 36). Dose coefficients from maternal ingestion of strontium radionuclides were calculated with the established foetal biokinetic model and a dosimetric model currently used by the ICRP. The dose coefficients for ^{89,90}Sr were calculated in data format required for dose assessment. A scientific paper was prepared on the current scientific evidence related to bone dosimetry in foetus and infant (month 30). Analysis of dose coefficients for *in utero* exposure from non-Sr radionuclides for different schedule of maternal intake was conducted. Dose coefficients for important for TROC exposure non-Sr radionuclides (^{137}Cs) were calculated using the ICRP models in data format

required for dose assessment. Work on development of the comprehensive skeletal phantom of a newborn was completed.

- WP3.4. In total ^{90}Sr concentrations were measured in 121 samples.
- WP3.5. Distribution of the external dose at the Metlino area of the upper Techa River region was evaluated with the use of luminescence measurements of building materials. Paper on this topic was published. Comparative analysis of FISH data obtained at GSF in 1995 and at HPA in 2005 and EPR data for the residents of Metlino was performed.
- WP3.6. Two groups of potential donors from the Techa River were selected in accordance with the established criteria; the priorities were identified. Blood sampling, preparation of cell suspensions and slides, FISH painting and scoring has been started.

The most important problems during the reporting period and corrective actions taken/suggested were the following.

Original project work programme included only two URCRM and HPA as the SOUL partners; however, analysis of the current status of the bone dosimetry of foetus and newborns revealed that the available dosimetric models could not be used in the Techa River studies because of a number of their deficiencies. A new dosimetric model was required; however, neither HPA nor URCRM was capable of development of such a model due to the absence of measurements, sophisticated programs and experience. For this reason URCRM and HPA proposed inclusion of a new partner, the University of Florida, to provide reliable bone dosimetric models for foetal and newborn exposure. The PMG agreed to include UF as a partner in SOUL because it would allow reliable quantification of the dose from ^{89,90}Sr exposure in *in utero* and also in *postnatal* life. Thus, the UF has been involved in the work on WP3.3.

Subproject 4 Health effects in the Techa River cohorts

WP 4.1: The objective of WP4.1 is to extend the Cause of Death Registry to include information on deceased residents of Kataisky and Dalmatovsky raions in Kurgan Oblast for the period from 1988 through 1999, and, also, to conduct an inter-laboratory comparison of the quality of coding causes of death assigned to ICD9 classes of malignant neoplasms and diseases of the circulatory system.

WP 4.2: The long-term objective of the WP4.2 is to estimate the preliminary risks of morbidity and mortality from cancer and leukemia in the Techa River Offspring Cohort in relation to external and internal exposures received in utero and postnatally.

Over last 12 months of the SOUL project, we continued our efforts to improve and validate data quality in the Techa River Offspring Cohort through verification of potential cohort members' date and place of birth, updating vital status of the current cohort members, expanding cancer incidence catchment area and follow-up period, identifying new cancer cases among the cohort members, and performed regular quality control checks. Currently, the Techa River Offspring Cohort includes 21,509 subjects born in 5 raions of Chelyabinsk and 2 raions of Kurgan Oblasts through which the Techa River flows and where many exposed residents were resettled from the radioactively contaminated area. The follow-up period was expanded through 31 December 2003.

WP4.3: The modified aim for WP4.3 is to analyze the mortality from non-cancer diseases for members of the ETRC and investigate how these rates depend on doses received, and, also, on non-radiation risk factors (gender, age at exposure, attained age, ethnicity, residence oblast, and, where possible, on such factors as smoking and alcohol). We will study overall mortality from all non-cancer diseases and specific ICD9 classes.

After the results of our work were reviewed by the Commission of Experts in 2007, a suggestion was made that the analysis of mortality associated with DCS in the Techa River cohort would be enhanced to include all non-cancer causes of death. In addition, plans were made to extend the follow-up period through 2003, and to expand the catchment area to include cohort members who has migrated from the seven-raion catchment area to other areas of Chelyabinsk and Kurgan oblasts. The implementation of this plan will enable us to increase the statistical power of the study and to analyze mortality from non-cancer disorders.

Expected End Results and Impact

External dose values from the dosimetry system *Mayak Doses-2005* for the MWC will be evaluated with *in situ* gamma-ray measurements at workplaces, EPR measurements of absorbed doses in teeth and FISH measurements of peripheral blood lymphocytes. Integration of individual dose estimates by film badge, EPR and FISH in order to develop improved dosimetry modules for the new dosimetry system *Mayak Doses-2008* and issue of recommendations for the further improvement of the external dosimetry system and the uncertainty reduction of individual dose estimates for Mayak PA workers. Internal dose estimates from inhalation of plutonium will be improved by further development of biokinetic models. The pathogenesis of Pu-induced lung cancer will be better understood concerning the relation to fibrosis and concerning histological and molecular indicators of precancerous and cancerous lesions. Individual dose assessments based on a new dosimetry system *Mayak Doses-2008* will be available for epidemiological studies by the end of October 2008. The long-term objectives of the epidemiological studies are analyses of rates of mortality and morbidity from circulatory diseases in the MWC, subject to age, gender, both external and internal exposures, and non-radiation risk factors such as smoking, alcohol, initial health status, body mass index and risk analyses of morbidity from leukaemia and solid cancers in the MWC, subject to age, gender, external gamma radiation, internal alpha radiation due to internally deposited Pu, and non-radiation risk factors.

External dose values in the dosimetry system *TRDS-2000* for the ETRC will be evaluated with luminescence measurements of absorbed doses in bricks and with EPR measurements of absorbed doses in teeth. Internal dose estimates for TROC members will be improved concerning *in utero* exposure and concerning the breast milk pathway after ^{89,90}Sr intakes by the mother. Individual dose assessments based on a new dosimetry system *TRDS-2008* will be available for epidemiological studies. A considerable increase in the statistical power of the epidemiological studies of Techa River cohorts will be achieved through expansion of the cohorts, extension of the follow-up period and the catchment area. The long-term objectives are to estimate the preliminary risks of morbidity and mortality from cancer and leukemia in the TROC in relation to external and internal exposures received in utero and postnatally and to analyze the mortality from non-cancer diseases for members of the ETRC and investigate how these rates depend on doses received, and, also, on non-radiation risk factors (gender, age at exposure, attained age, ethnicity, residence oblast, and, where possible, on such factors as smoking and alcohol).

Epidemiological studies of the cohorts in the Southern Urals will considerably improve the knowledge on health risks due to protracted exposures to plutonium, strontium and external radiation with doses of several 100 mGy. The new results will relate to exposures for the whole age range from fetal to adult ages and to a variety of diseases including cancer and diseases of the circulatory system. These results are of direct relevance for the radiation protection system for workers and the public in the European Union.

Contractors involved

Participant Role*	Participant Number	Participant name	Participant short name	Country	Date enter project	Date exit project
CO	1	Helmholtz Zentrum München - German Research Center for Environmental Health	HMGU	Germany	month 1	month 48
CR	2	Health Protection Agency	HPA	UK	month 1	month 48
CR	3	Urals Research Center for Radiation Medicine	URCRM	RF	month 1	month 48
CR	4	Southern Urals Biophysics Institute	SUBI	RF	month 1	month 48
CR	5	Karolinska Institutet	KI	Sweden	month 1	month 48
CR	6	Closed Corporation "Company GEOSPETSECOLOGIA"	ZAO	RF	month 1	month 48
CR	7	Istituto Superiore di Sanità	ISS	Italy	month 1	month 48
CR	8	Bundesamt für Strahlenschutz	BFS	Germany	month 1	month 18
CR	9	Technische Universität München	TUM	Germany	month 1	month 48
CR	10	Aristotle University of Thessaloniki	AUTH	Greece	month 1	month 36
CR	11	Leiden University Medical Center, Division 5	LUMC	The Netherlands	month 1	month 48
CR	12	Westlakes Scientific Consulting	WSC	UK	month 1	month 48
CR	13	Institute of Metall Physics	IMP	RF	Month 6	month 48
CR	14	Universita di Palermo	UNIPA	Italy		month 48
CR	15	University of Florida	UF	USA	Month 30	month 48

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