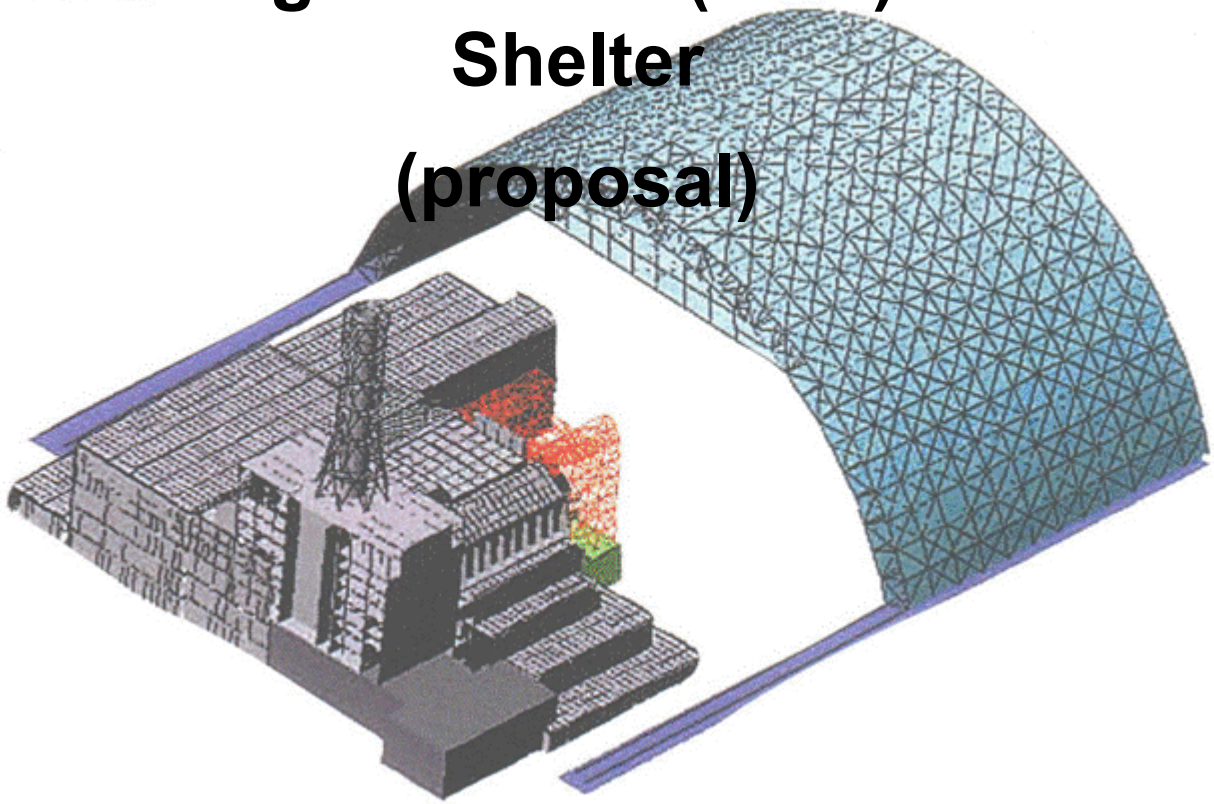
STCU Project # 4207

Long-term prognosis of transformation of the fuel-containing materials (FCM) in Chernobyl Shelter

(proposal)



The main aim of the project is creation of a model predicting the long-term (50-100 years) behaviour of the radioactive dust in Shelter. The model will describe both:

- transformation of the existing fuel dust;

- the processes of the dust formation from the main types of FCM in the Shelter conditions

Institution involved:

Ukrainian Institute of Agricultural Radiology (UIAR) NAU

Institute of Safety Problems of Nuclear Power Plants (ISP NPP) NASU

Project duration: 2.5 years

The main tasks:

1. Study of the mechanisms of formation of the Chernobyl hot particles (HP) and their classification according to the physical-chemical characteristics. Modernization and update of the database «Hot particles»

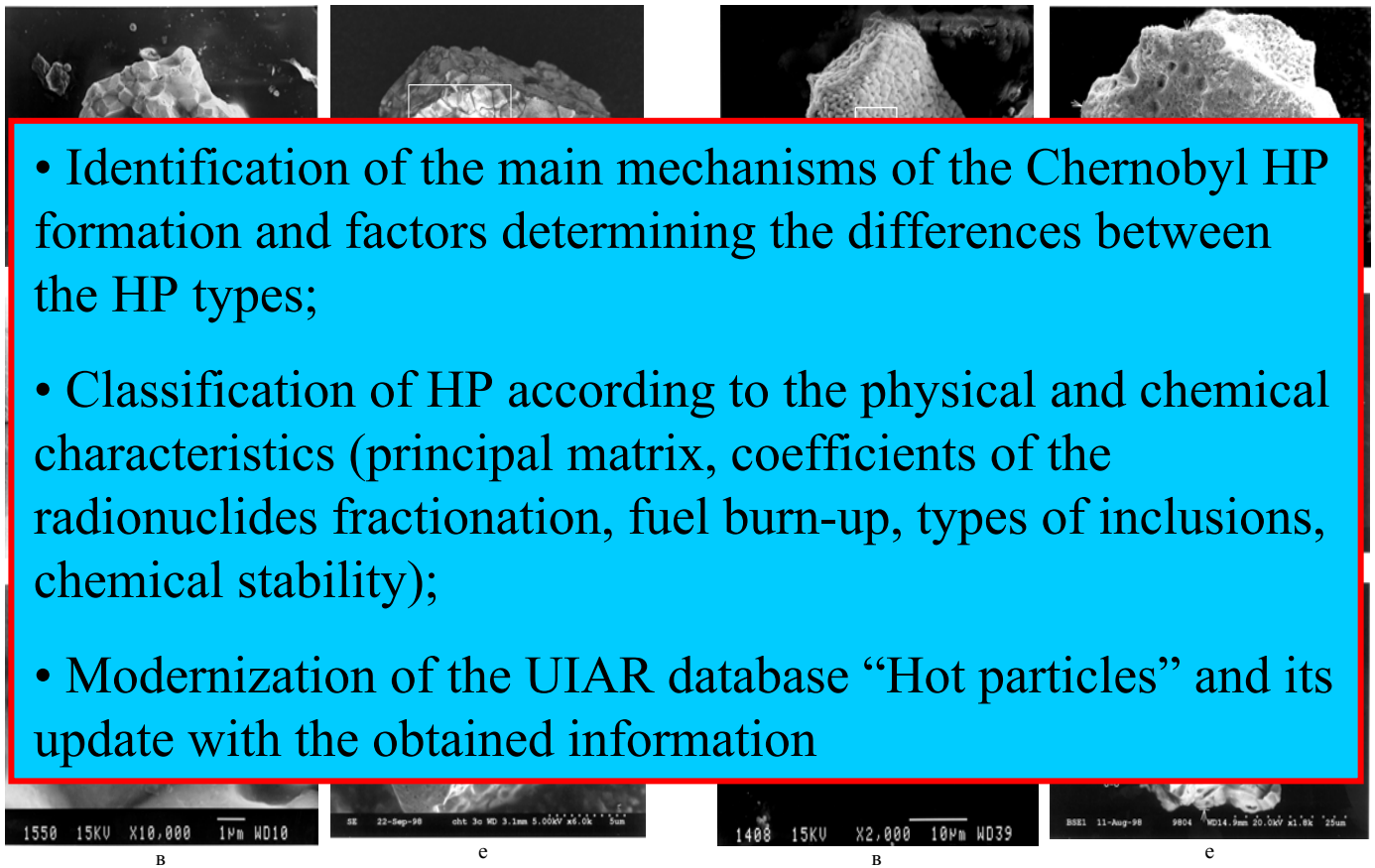
2. Study of the characteristics and behaviour of radioactive aerosols (RA) and water in Shelter

3. Experimental study of the fuel particles (FP) destruction rate and its dependence on the matrix characteristics (oxidation degree of uranium) and media properties

4. Creation of a model of the FP transformation under the Shelter conditions

5. The long-term prognosis of the Shelter radioactive dust behaviour on the basis of the obtained results and data by Kurchatov Institute (KI, Russia) and the fate of the Shelter FCM during the transformation of the Shelter into an ecologically safe system.

1. Study of the mechanisms of formation of the Chernobyl hot particles (HP) and their classification according to their physical and chemical characteristics. Modernization and update of the database «Hot particles»



- Identification of the main mechanisms of the Chernobyl HP formation and factors determining the differences between the HP types;
- Classification of HP according to the physical and chemical characteristics (principal matrix, coefficients of the radionuclides fractionation, fuel burn-up, types of inclusions, chemical stability);
- Modernization of the UIAR database “Hot particles” and its update with the obtained information

Low-transformed FP **Transformed FP**

Typical SEM-images of the fuel particles (FP) from the UIAR collection (by NLH (Norway) and IRSN (France)

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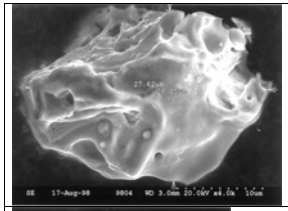
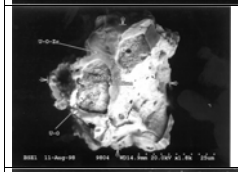
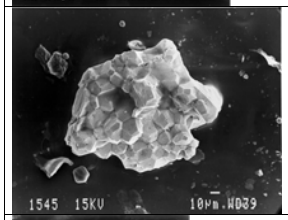


U-Zr-O

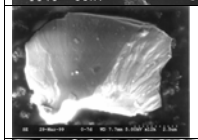
Super stable

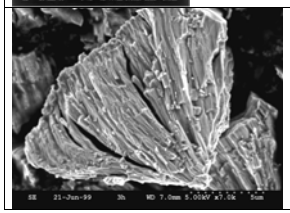




UO_2

Stable





UO_{2+x}

Non-stable

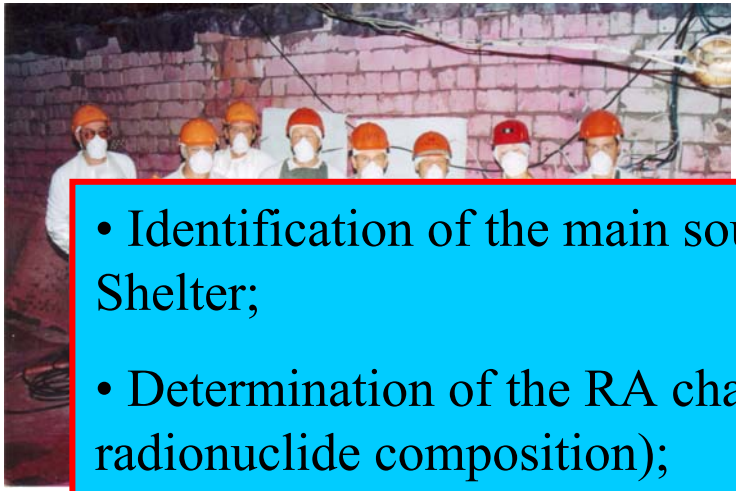
•Chemically super stable fuel particles (FP) (**U-Zr-O)** formed as a result of the high-temperature melting of the construction materials (zirconium cladding covers of the fuel elements) and their fusion aggregation with UO_2. These FP were formed during the initial explosion on 26.04.86 and were mainly deposited along the narrow western trace of release zone;

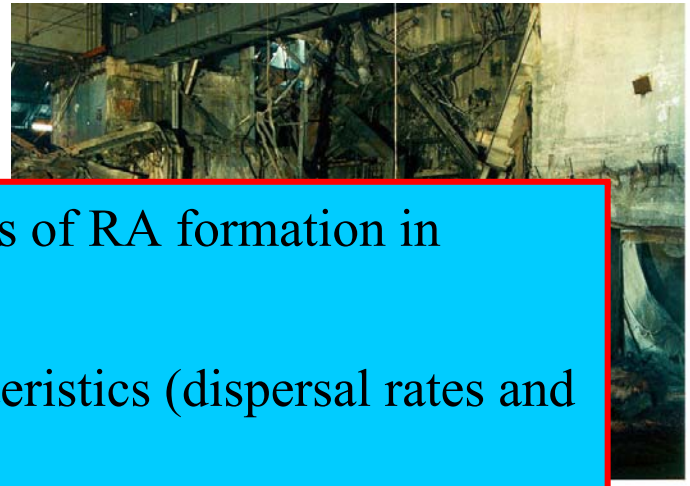
•Non-oxidized chemically stable FP (**UO_2**) of the first release (26.04.86) formed as a result of the mechanical destruction of the nuclear fuel. These FP were mainly deposited along the narrow western trace of release. The fission products leakage from these FP was minimal, which is confirmed by the fixed radionuclides activity ratios;

•Chemically non-stable FP (**UO_{2+x}**) formed as a result of the nuclear fuel oxidation in the period of 26.04.86-5.05.86. These FP were mainly deposited at the northern and southern traces of release zone.

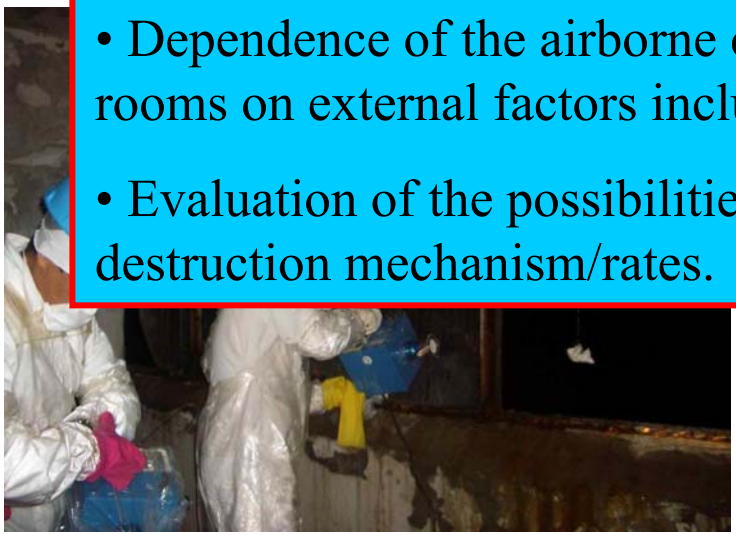
1. Study of the mechanisms of formation of the Chernobyl hot particles (HP) and their classification according to their physical and chemical characteristics. Modernization and update of the database «Hot particles»

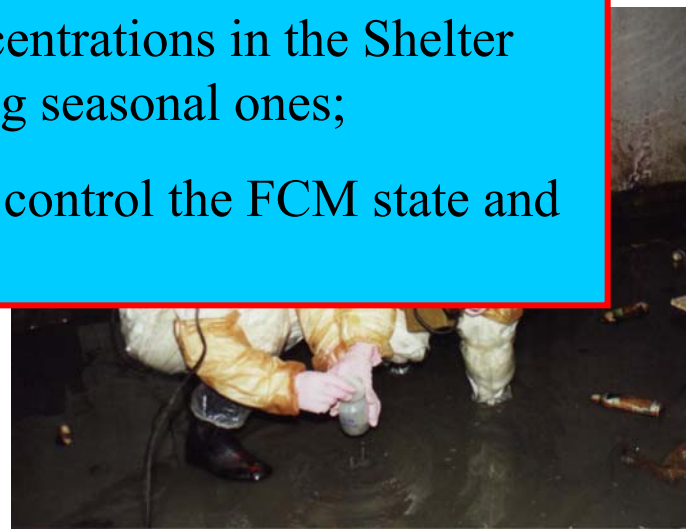
2. Study of the characteristics and behaviour of radioactive aerosols (RA) and water in Shelter



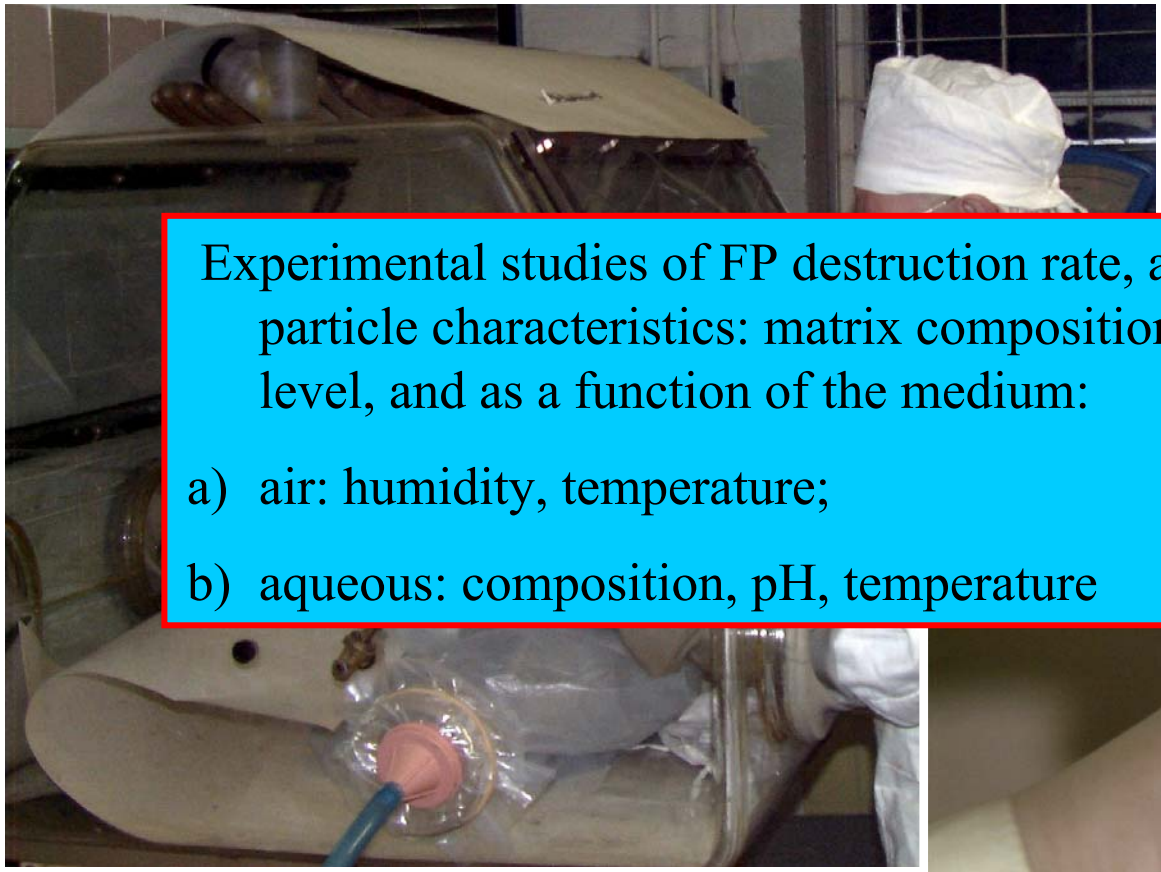


- Identification of the main sources of RA formation in Shelter;
- Determination of the RA characteristics (dispersal rates and radionuclide composition);
- Dependence of the airborne concentrations in the Shelter rooms on external factors including seasonal ones;
- Evaluation of the possibilities to control the FCM state and destruction mechanism/rates.





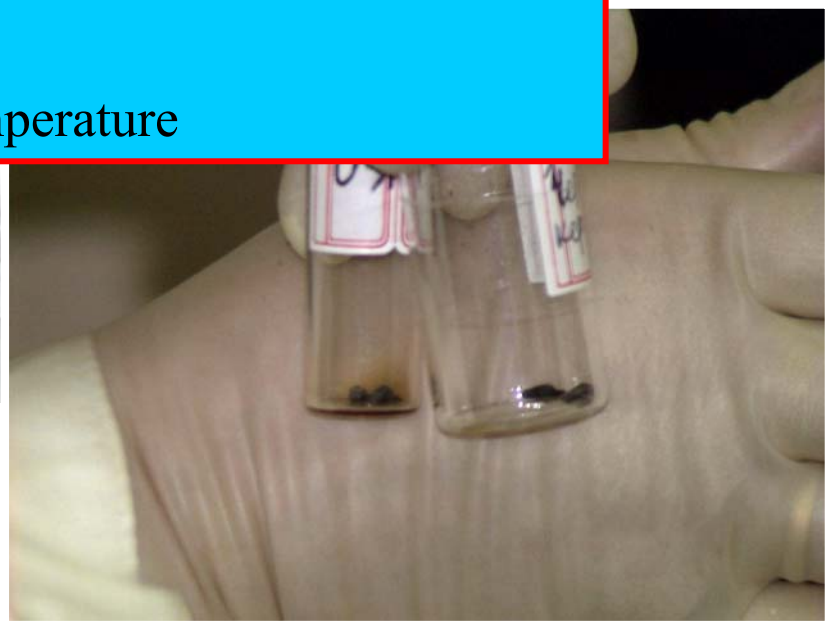
3. Experimental study of the fuel particles (FP) destruction rate, its dependence on the matrix characteristics (oxidation degree of uranium) and media properties



Experimental studies of FP destruction rate, as a function of particle characteristics: matrix composition, oxidation level, and as a function of the medium:

a) air: humidity, temperature;

b) aqueous: composition, pH, temperature



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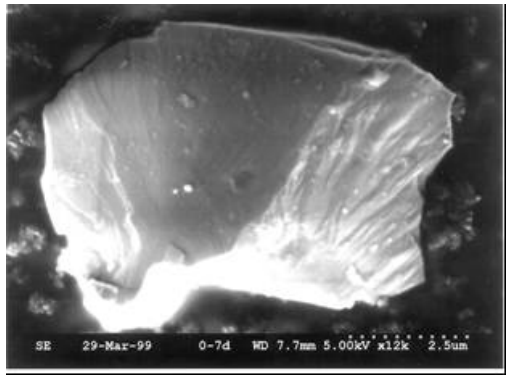
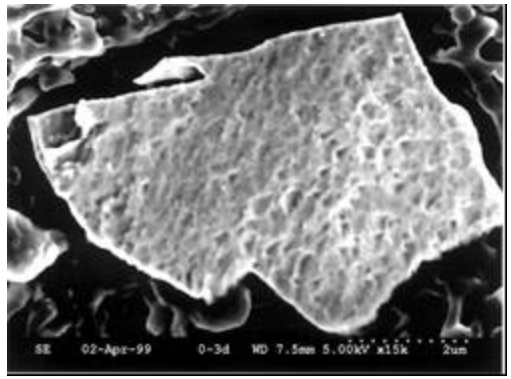
Before dissolution

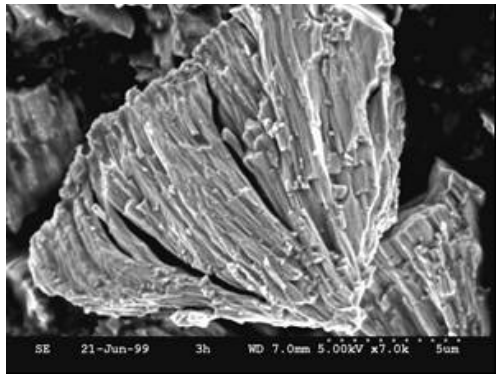
After dissolution

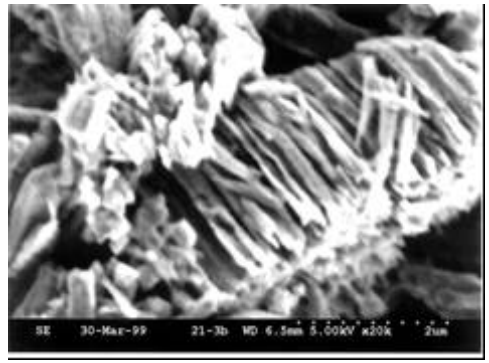
Non-oxidized FP (UO_2)





Oxidized FP (UO_{2+x})





3. Experimental study of the fuel particles (FP) destruction rate, its dependence on the matrix characteristics (oxidation degree of uranium) and media properties

Our recent publications:

- **Kashparov V.A., Lundin S.M., Zvarich S.I., Yoschenko V.I., Levtchuk S.E., Khomutinin Yu.V., Maloshtan I.N., Protsak V.P. Territory contamination with the radionuclides representing the fuel component of Chernobyl fallout //*The Science of The Total Environment*, vol.317, Issues 1-3, 2003, pp. 105-119.**
- **Kashparov V.A. Hot Particles at Chernobyl //*Environmental Science and Pollution Research*, v.10 Special (1), 2003, pp.21-30.**
- **Kashparov V.A., Ahamdach N., Zvarich S.I., Yoschenko V.I., Maloshtan I.N., Dewiere L. Kinetics of dissolution of Chernobyl fuel particles in soil in natural conditions. //*Journal of Environmental Radioactivity*, v.72, Issue 3, 2004, p.335-353.**
- **Dewiere L., Bugai D., Grenier C., Kashparov V., Ahamdach N. 90Sr migration to the geo-sphere from a waste burial in the Chernobyl exclusion zone //*Journal of Environmental Radioactivity*, v.74, Issue 1-3, 2004, p.139-150.**
- **Kashparov V.A., Protsak V.P., Ahamdach N., Stammose D., Peres J.M., Yoschenko V.I., Zvarich S.I. Dissolution kinetics of particles of irradiated Chernobyl nuclear fuel : influence of pH and oxidation state on the release of radionuclides in contaminated soil of Chernobyl //*Journal of Nuclear Materials*, v. 279, 2000, p.225-233.**
- **Kashparov V.A., Ivanov Yu.A., Zvarich S.I., Protsak V.P., Khomutinin Yu.V., Kurepin A.D., Pazukhin E.M. Formation of Hot Particles During the Chernobyl Nuclear Power Plant Accident. //*Nuclear Technology*. – 1996.- v.114, N1.- pp.246-253.**

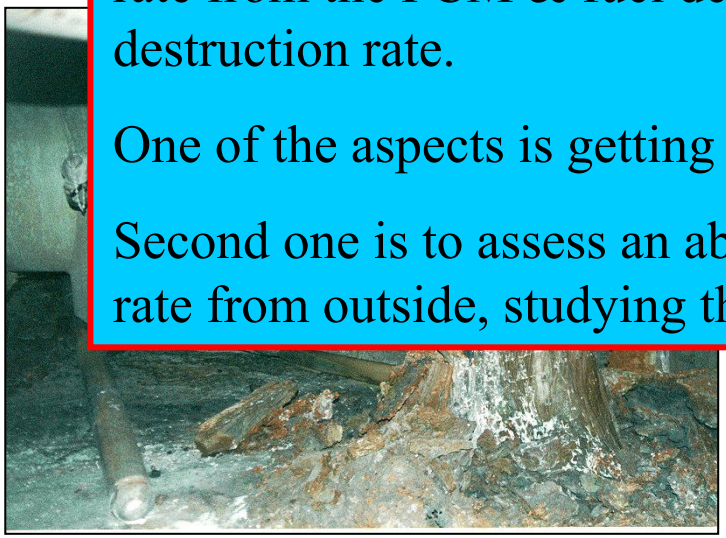
4. Creation of a model of the FP transformation under Shelter conditions

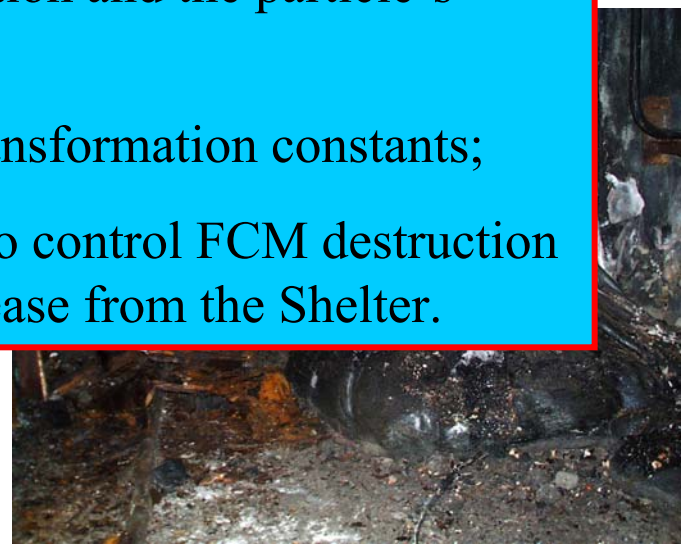
The model will be created for description of the long-term transformation of the fuel dust under Shelter conditions (FP destruction, changing composition of dispersed material and leaching of the radionuclides)

The model should be able to predict the particles formation rate from the FCM & fuel degradation and the particle's destruction rate.

One of the aspects is getting FP transformation constants;

Second one is to assess an ability to control FCM destruction rate from outside, studying the release from the Shelter.





5. The long-term prognosis of the Shelter radioactive dust behaviour on the basis of the obtained results and data by Kurchatov Institute (KI, Russia) on the fate of the Shelter FCM during the transformation of Shelter into an ecologically safe system

The task aim is providing the long-term prognosis of the behaviour and transformation of the fuel dust as the potentially most dangerous radioactive material in Shelter (because of its high mobility). Both theoretical and experimental results of the project will be applied for completion of this task.

Also, according to the preliminary agreement, UIAR will utilize the results of the KI studies within the frameworks of the SIP and CHESS projects, which describe the long-term behaviour of various types of the Chernobyl lavas.