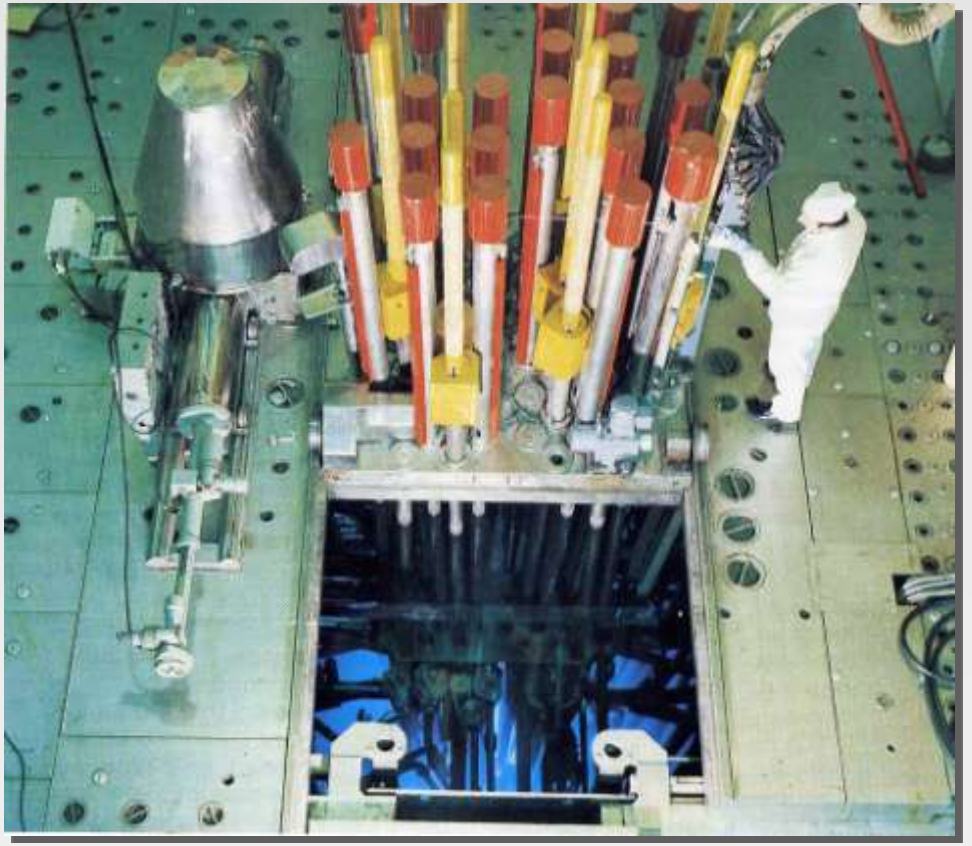
NATIONAL RESEARCH CENTRE
"KURCHATOV INSTITUTE"
Moscow, Russia

Methods of radiation survey with using of the collimated spectrometer systems for maintenance of works on MR reactor decommissioning

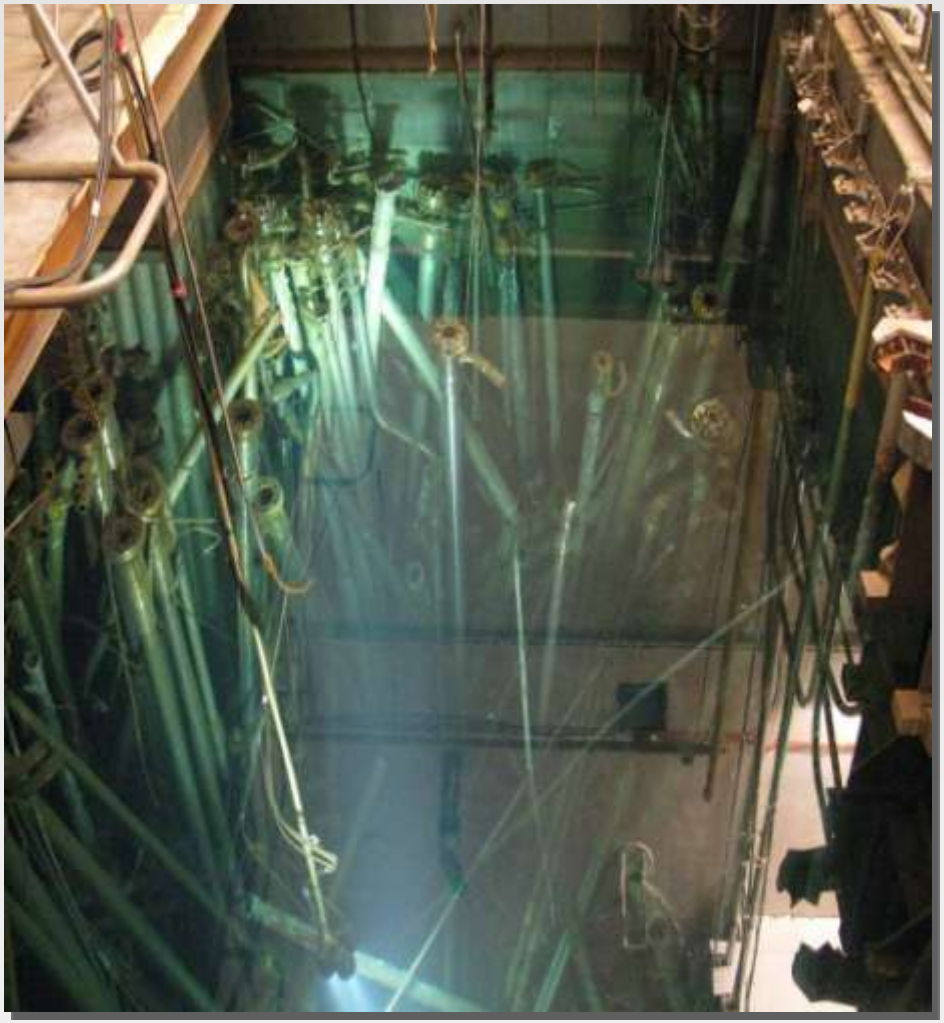
Authors: Alexey Danilovich, Oleg Ivanov, Victor Potapov, Sergey Smirnov, Vyacheslav Stepanov, Anatoly Volkovich

ATOMECO-2013, October 30 – 31 · Moscow, Russia

The Research Reactor MR
(Material Testing Reactor)



Problems of Project



- Strong radioactive contamination of main and auxiliary equipment of reactor
- High and nonuniform background radiation
- High-density of the equipment
- Lack of technical documentation for equipment

Tasks for consideration

1. A survey of high-level solid radioactive waste storages
2. Characterization of canisters with solid RW and sorting them by presence of uranium in them.
3. Scanning of facilities in technological rooms
4. Underwater measurements

Gamma-ray Imaging Devices

Pinhole
Gamma-camera

Collimated
Spectrometric
Scanning System

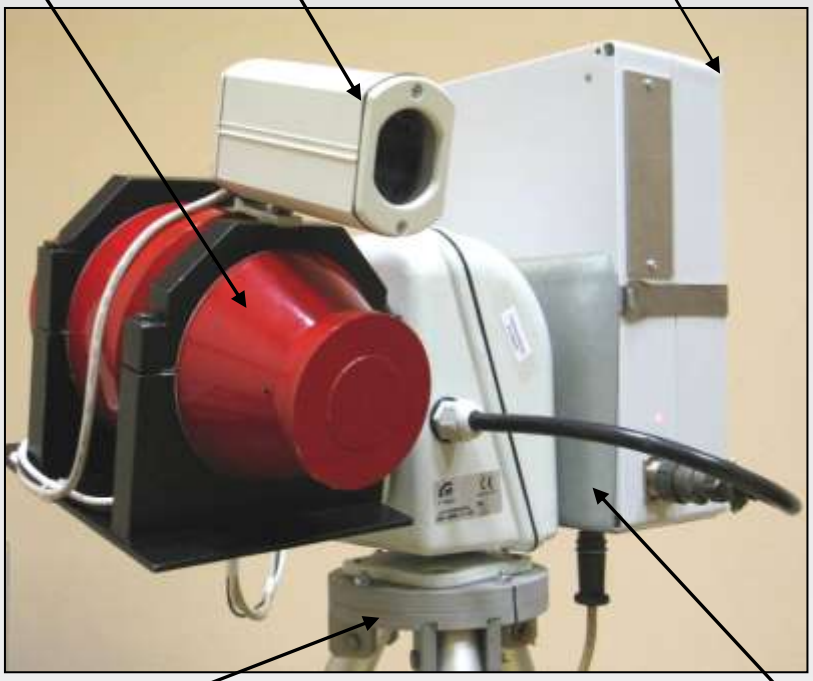
Coded Aperture
Gamma-camera

Gamma-Locator – remote controlled collimated detector of gamma-radiaiton

Collimated detector

USB video-camera

Control unit



Tripod

Pan&Title table

CsI(Tl) detectors (5 and 20 cm^3)

CdZnTe detector (60mm^3)

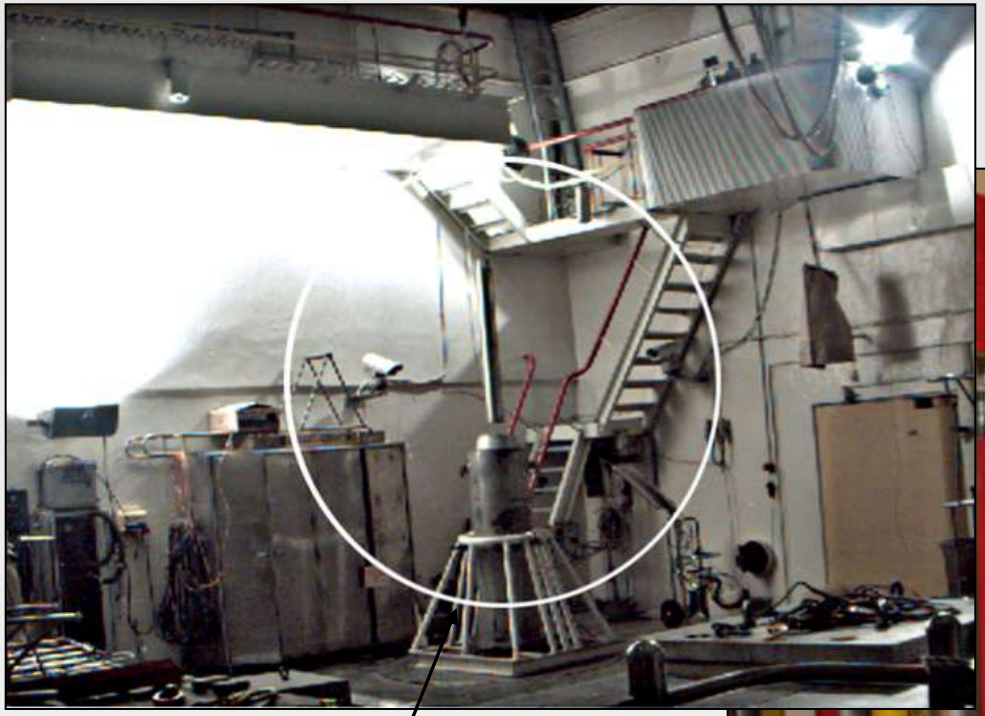
Detector	Sensitivity, (pulse·s^{-1})/(uSv·h^{-1})		Resolution, %
	Gamma-ray line, keV		
	662 (Cs-137)	1173.3 (Co-60)	662 (Cs-137)
CsI(Tl), V_{sc}=20 cm^3	760	212	8.4
CsI(Tl), V_{sc}=5 cm^3	250	64	8.8
CdZnTe	9	-	1.7

Connection to operator's PC via cable ~ 100m, or radiochannel~200m

Video survey and dose rate measurements for RW, SNF in cells of near reactor waste storage with Brokk-Pioneer

Characterization of RW - loop elements with Gamma-Locator

Measurements of spectral characteristics of irradiated loop channel



Device’s FoV

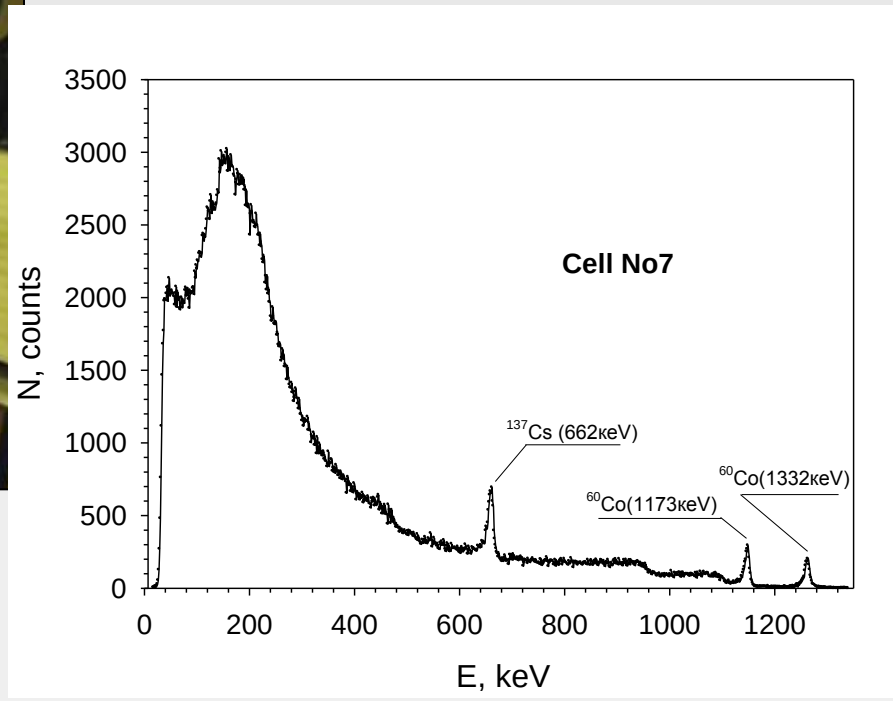
Dose rate at device location ~20 mSv/hr

Measurements of spectral characteristics and activity of SNF and RW with Gamma Locator

Inside operator room

Control blocks of Gamma Locator measuring system Brokk-Pioneer

Radiation spectrum of penal with RW

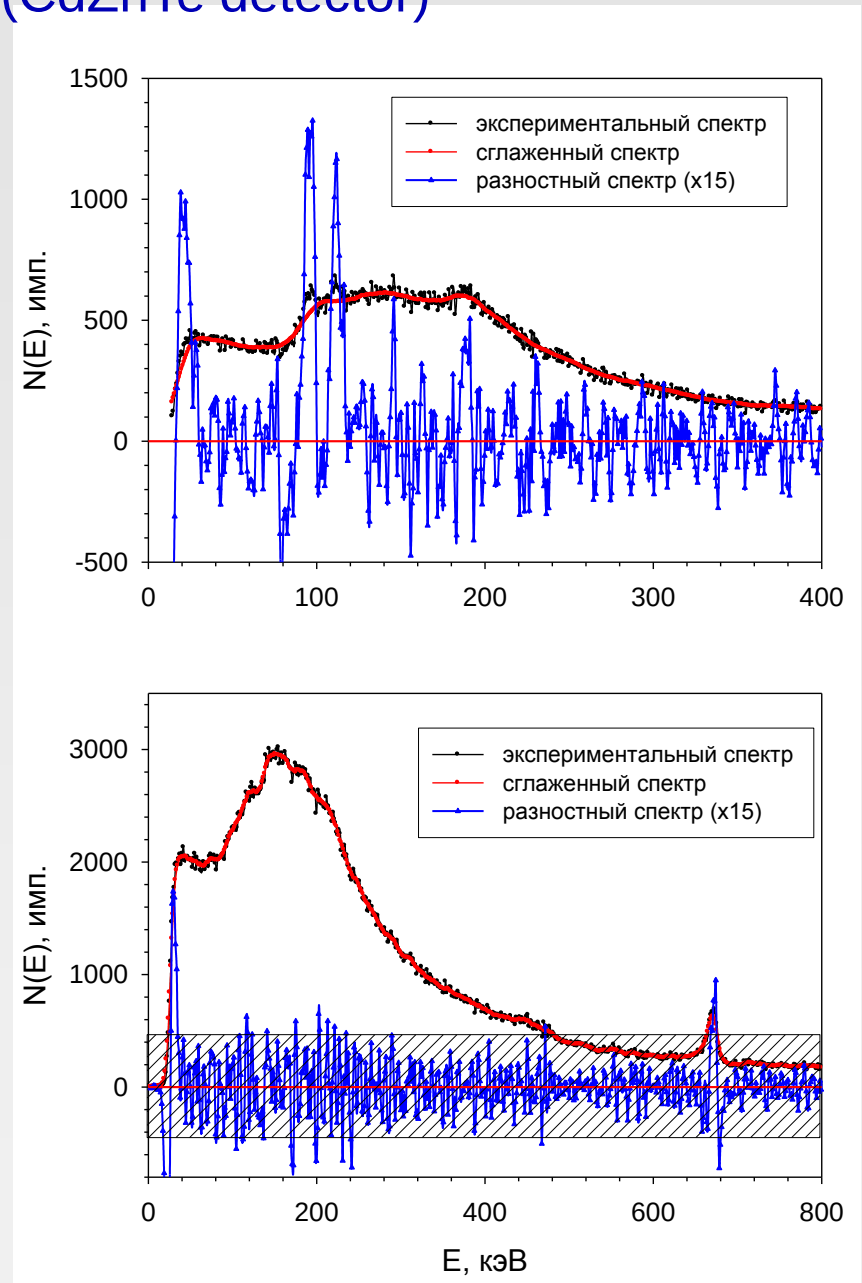


Amplitude spectrum of SRW

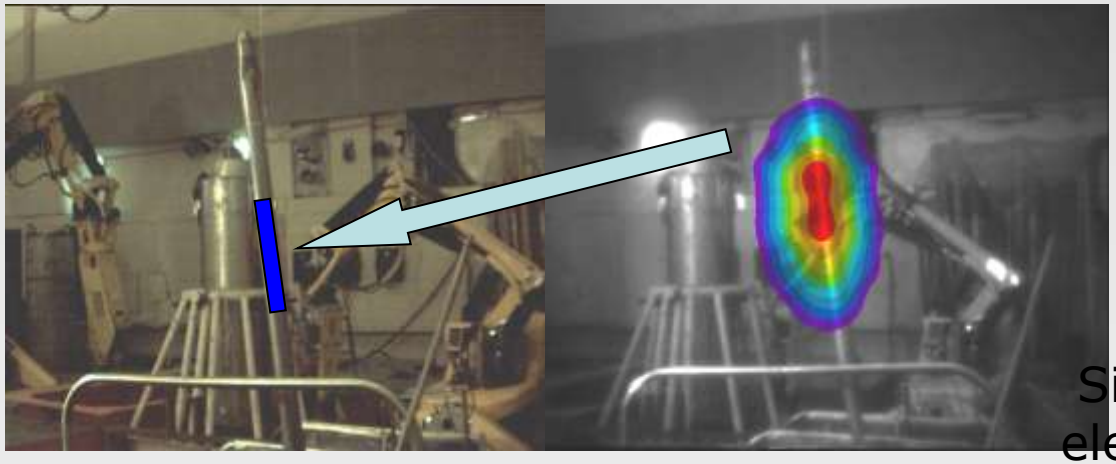
(CdZnTe detector)

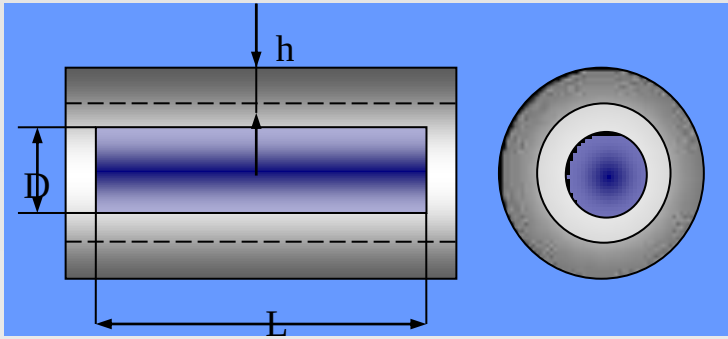
Uranium X-Ray lines

Line	E, keV	Intensity, %
$UK_{\alpha 2}$	94.65	28.3
$UK_{\alpha 1}$	**98.43**	**45.8**
$UK_{\beta 3}$	110.42	5.64
$UK_{\beta 1}$	111.30	10.7
$UK_{\beta 5}$	111.96	0.396
$UK_{\beta 2}$	**114.45**	**4.14**
$UK_{\beta 4}$	114.84	1.48



Unknown highly activated sample of loop, possibly with SNF



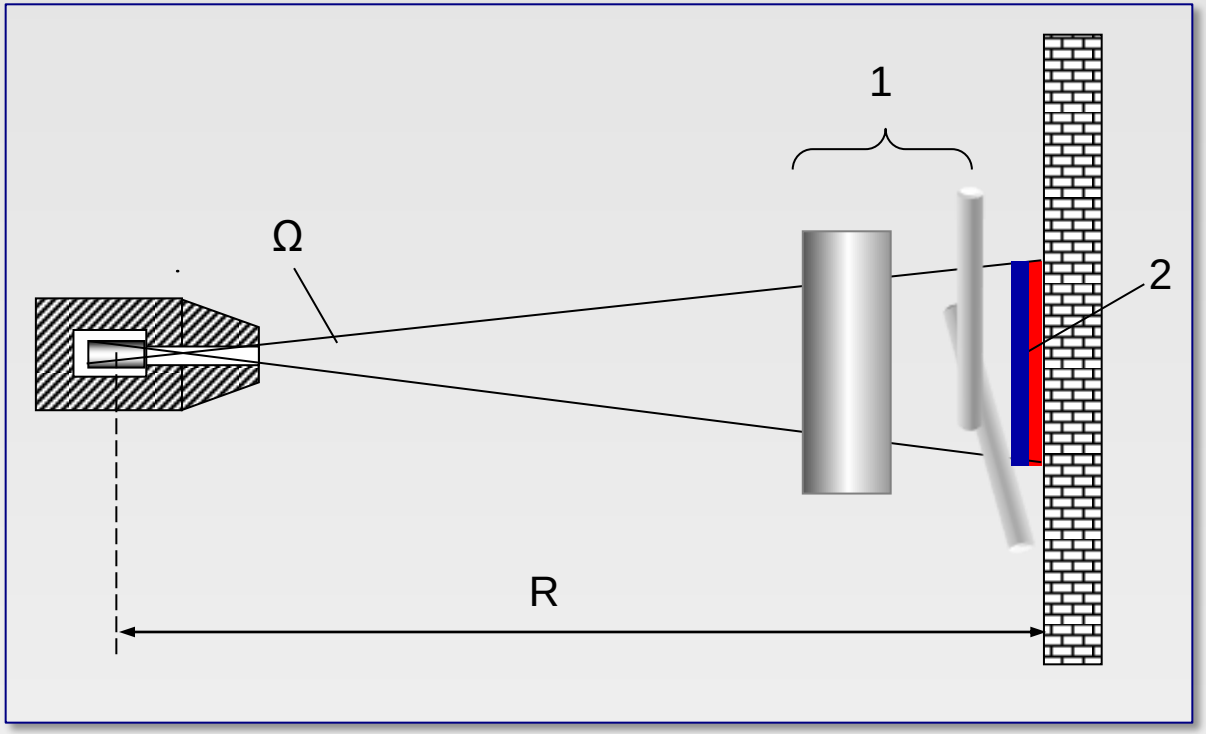


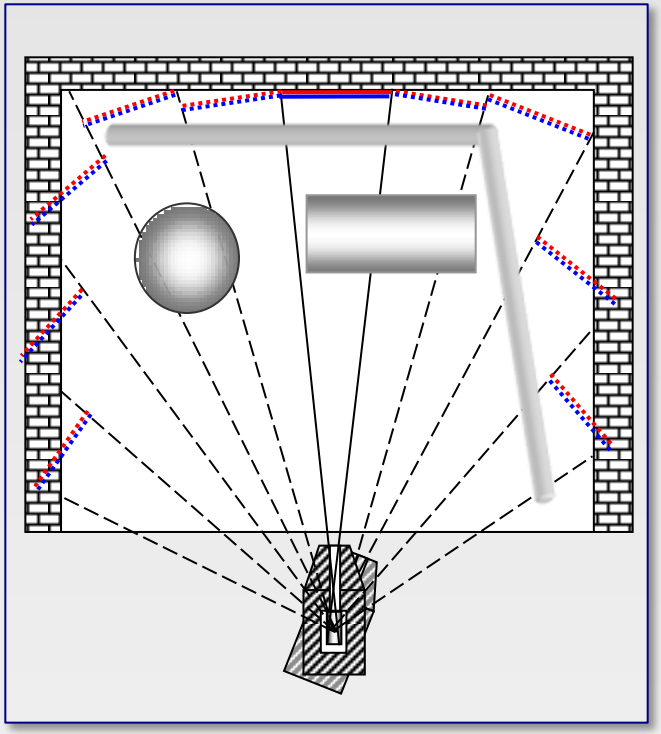
Simulated model – cylindrical SN element in steel shielding

The way to estimate U mass in SNF sample with spectrometric measurements

$$\left.\begin{array}{l} n_{Cs} \rightarrow N_{Cs} \rightarrow N_{0Cs} \rightarrow m_b \\ \dfrac{n_{K\alpha,\beta}}{n_{Cs}} \rightarrow \nu \end{array}\right\} \rightarrow \left[M_U^A = (1-\nu)\frac{m_b}{\nu} \right]$$

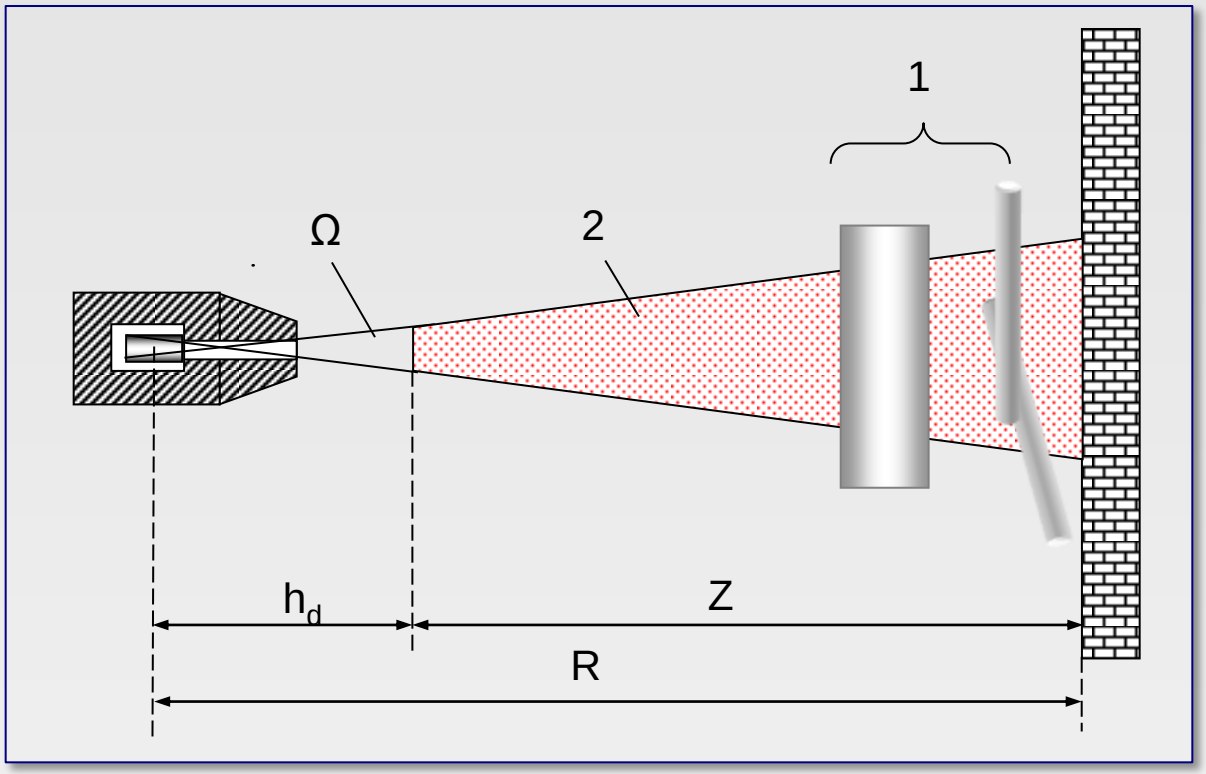
The Method of Surface Activity Distribution

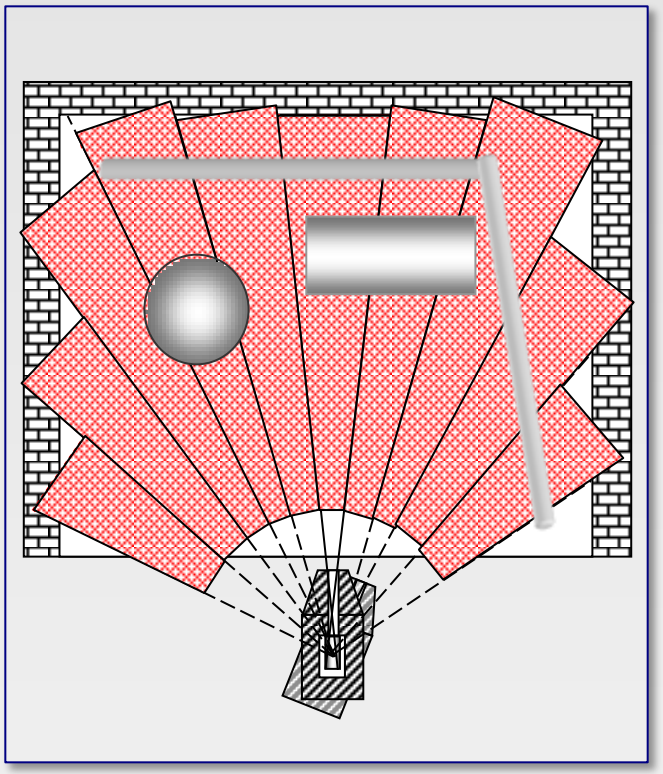




1. Technological equipment (piping system etc.)
2. Equivalent surface pceudosource (red) with additional steel filter (blue)

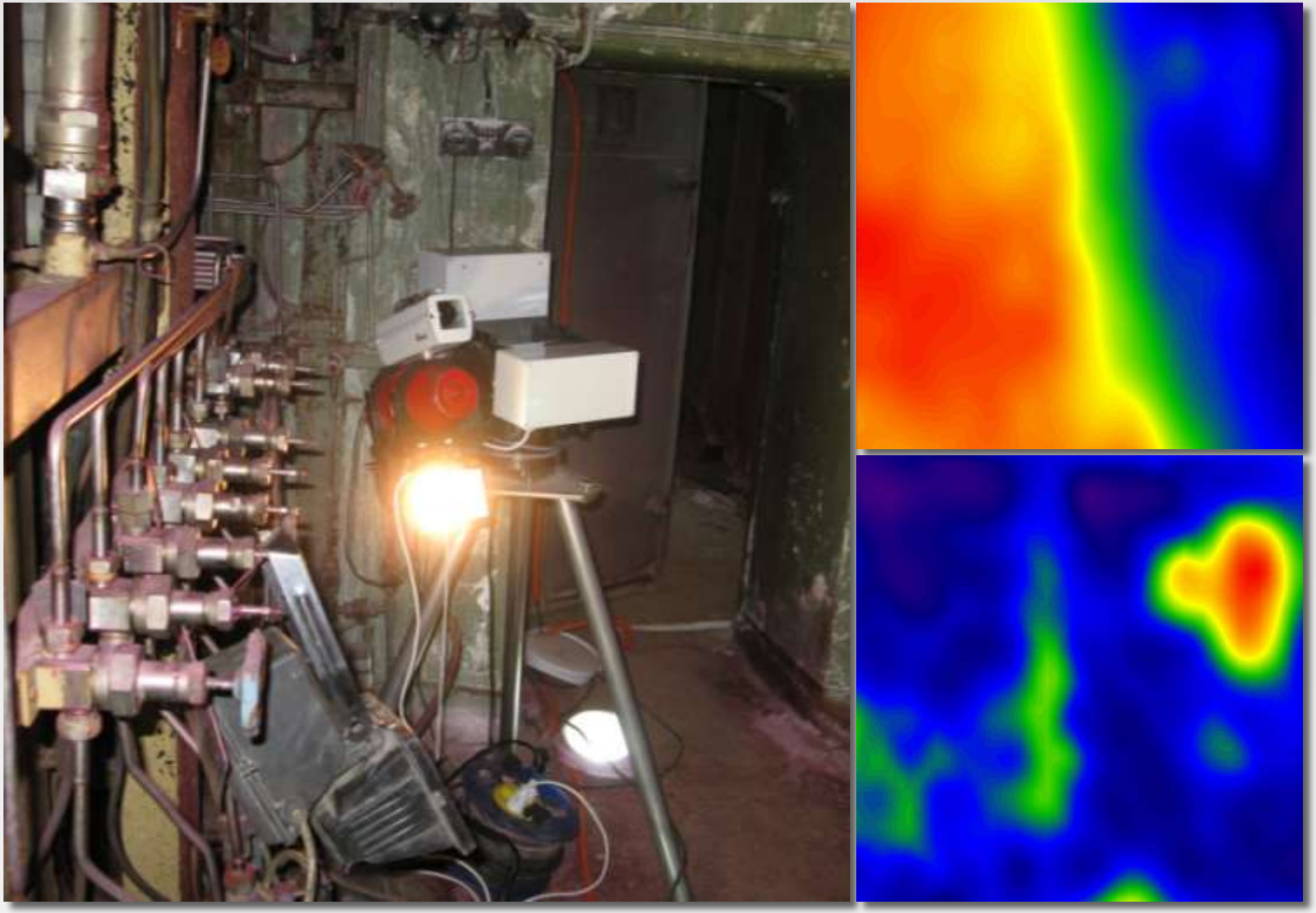
The Method of Volume Activity Distribution





1. Technological equipment (piping system etc.)
2. Equivalent volume pceudosource

Survey in Technological Premises



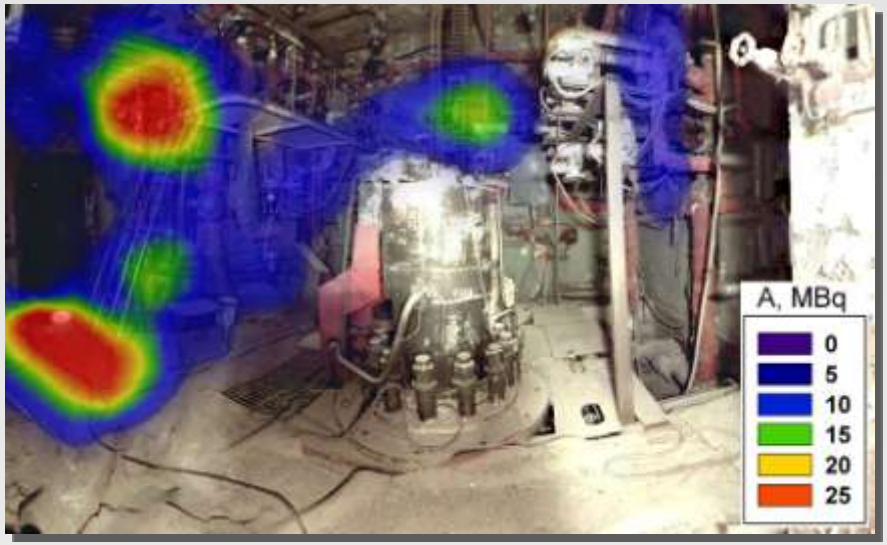
Scanning Parameters

Dose rate in the device placement: 150uSv/h
Horizontal step: 5 degrees
Vertical step: 5 degrees
Number of horizontal steps: 26
Number of vertical steps:16
Exposition time for each spectrum: 2 minutes

As Result Were Obtained

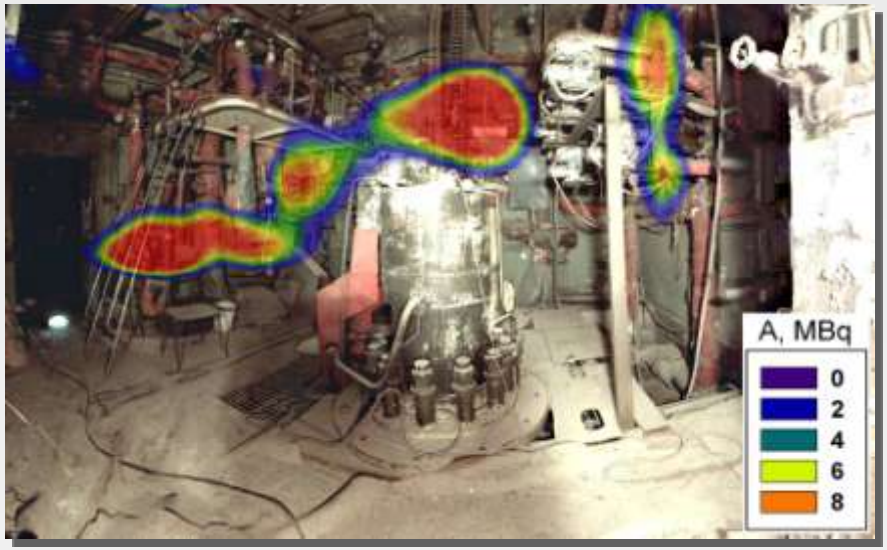
416 photo
416 spectrums for opened collimator
416 spectrums for closed collimator
416 difference spectrums

Maps of Activity Distribution

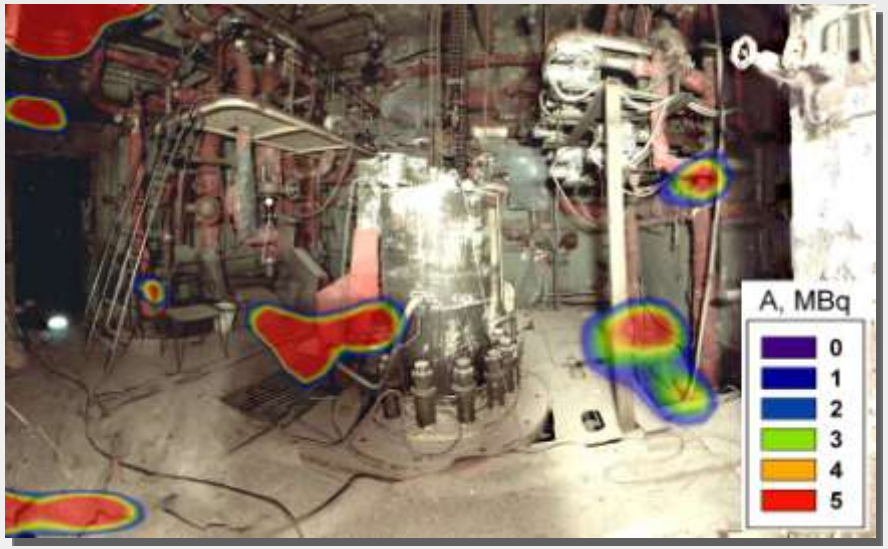


Total Activity of ^{60}Co: $1.36 \cdot 10^{9}$Bq

Total Activity of ^{137}Cs: $3.82 \cdot 10^{9}$Bq



Total Activity of ^{60}Co: $5.73 \cdot 10^{8}$Bq
(After modeling of dismantling works)



Total Activity of ^{137}Cs: $3.54 \cdot 10^{8}$Bq
(After modeling of dismantling works)

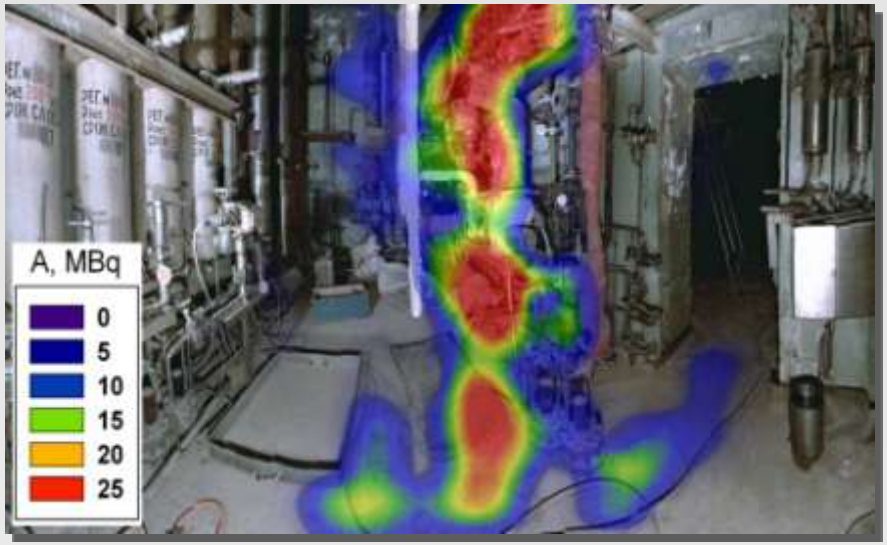
Scanning Parameters

Dose rate in the device placement: 500uSv/h
Horizontal step: 5 degrees
Vertical step: 5 degrees
Number of horizontal steps: 37
Number of vertical steps:16
Exposition time for each spectrum: 2 minutes

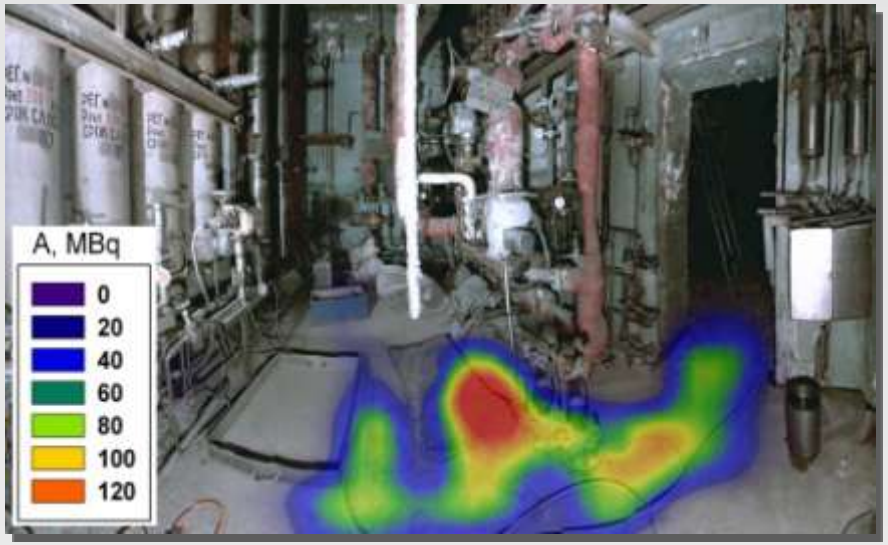
As Result Were Obtained

592 photo
592 spectrums for opened collimator
592 spectrums for closed collimator
592 difference spectrums

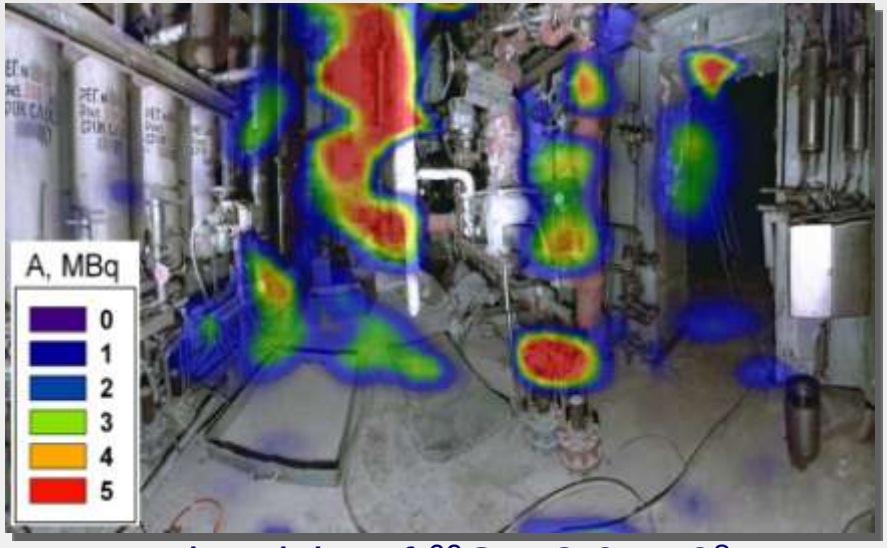
Maps of Activity Distribution



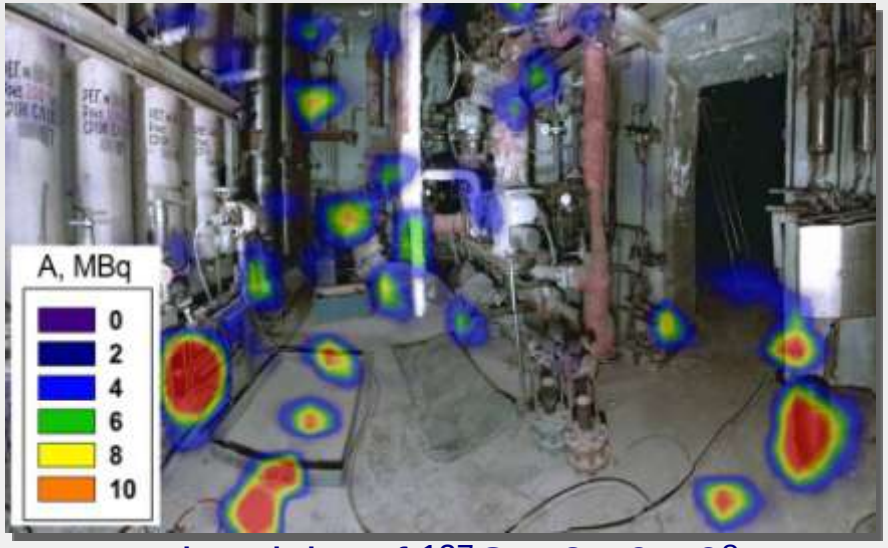
Total Activity of ^{60}Co: $2.12 \cdot 10^{9}$Bq



Total Activity of ^{137}Cs: $5.9 \cdot 10^{9}$Bq

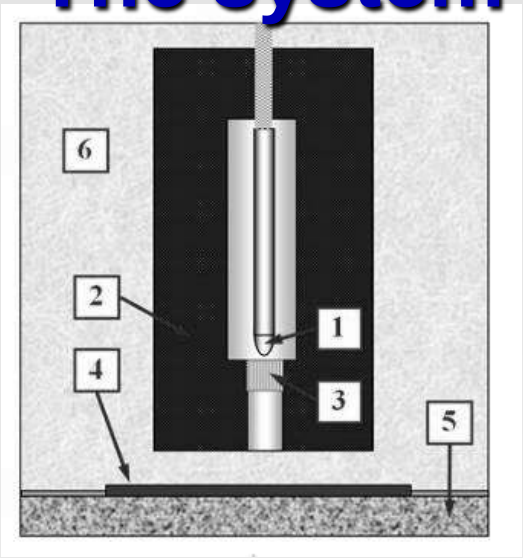


Total Activity of ^{60}Co: $3.67 \cdot 10^{8}$Bq
(After modeling of dismantling works)

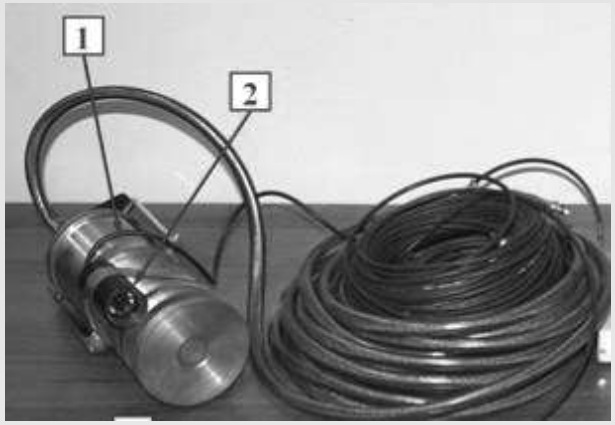


Total Activity of ^{137}Cs: $2.59 \cdot 10^{8}$Bq
(After modeling of dismantling works)

The system for underwater measurements

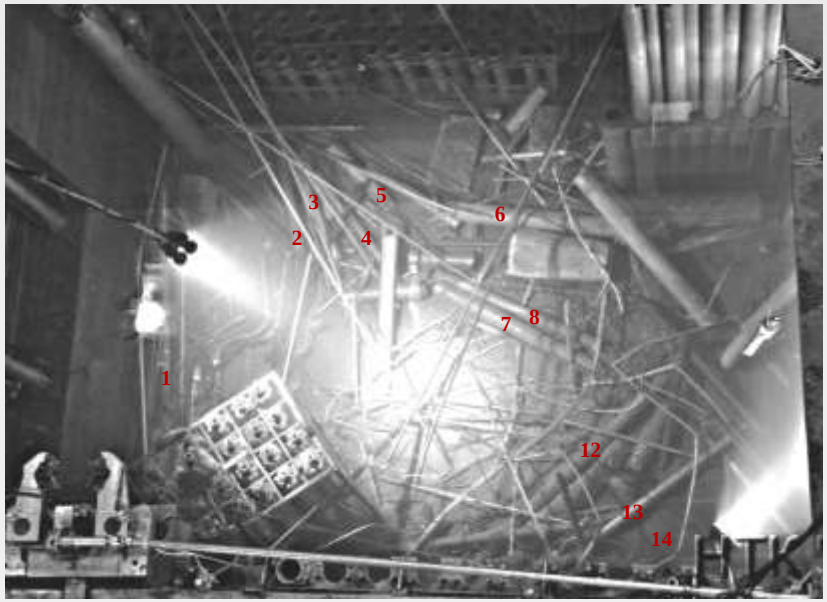


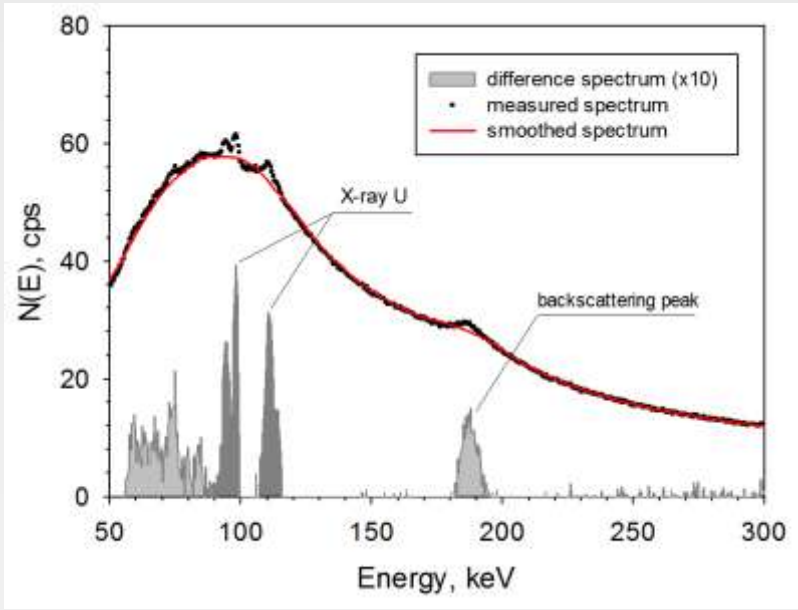
1 – CZT detector,
2 – shielding,
3 – filter,
4 – studied object,
5 – bottom of the pond,
6 – water of pond .



1 – measuring block of system; 2 – video camera

Measurements in the storage pond of MR





Conclusions

- Methods of radiation survey on the basis of the collimated spectrometer systems are applied in project on decommissioning MR reactor at all stages of work.
- Use of spectrometric system allowed to carry out optimal separation on activity of highly active fragments of channels taken from pond of storage.
- The survey of storage made after removal of loopback channels by means of the underwater collimated system showed existence at the bottom of storage the uranium-containing materials.
- The received results are important for scheduling on cleanings of a bottom of storage and obtained experience may be useful at work at other reactor ponds with complex contamination.

Aknowledgments

The authors wish to acknowledge for the valuable help provided by staff of the “Rehabilitation” department of NRC “Kurchatov Institute” during measurements in high dose rate conditions.