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Validation of In-situ Gamma-ray Spectrometry and sampling on highly contaminated area

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In situ gamma-ray spectrometry

(validation for flat geometry)

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Basic principle

- IAEA TEC DOC 1092

where:

- A_s = surface contamination kBq/m² (inventory)
- N = peak area
- N_b= background
- t = spectrum collecting time, live time (s)
- P_g= gamma photon emission probability (E, nuclide)
- C_f = calibration factor (cm²)

$$A_s(kBq/m^2) = \frac{10 \cdot (N - N_b)}{C_f \cdot t \cdot P_\gamma}$$

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Detector calibration factor

$$C_f = \frac{R_f}{A_s} = \left(\frac{R_f}{R_0}\right)\left(\frac{R_0}{\Phi}\right)\left(\frac{\Phi}{A_s}\right)$$

angular correction factor – correction factor required to account for the detector angular response

response factor - neat peak count rate due to a unit primary photon flux density of energy E incident on the detector (normal to the detector face)

geometrical factor – total photon flux density at the detector per unit concentration or deposition inventory of the radionuclide

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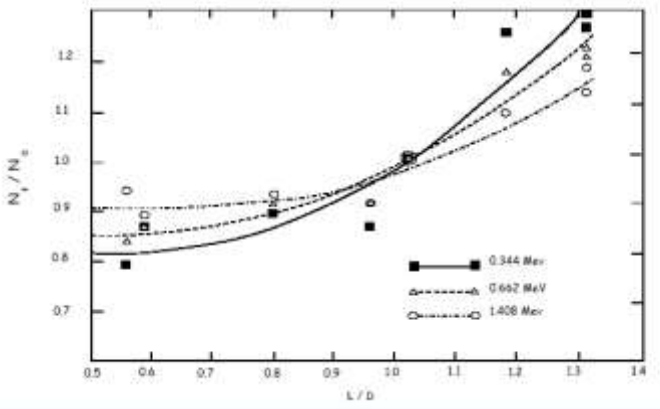
R_f= net count rate

Angular correction factor

Angular correction factor R_f/R_0 as a function of Ge crystal length/diameter L/D ratio at three different energies for a downward facing detector for a uniform with depth source profile in the soil.



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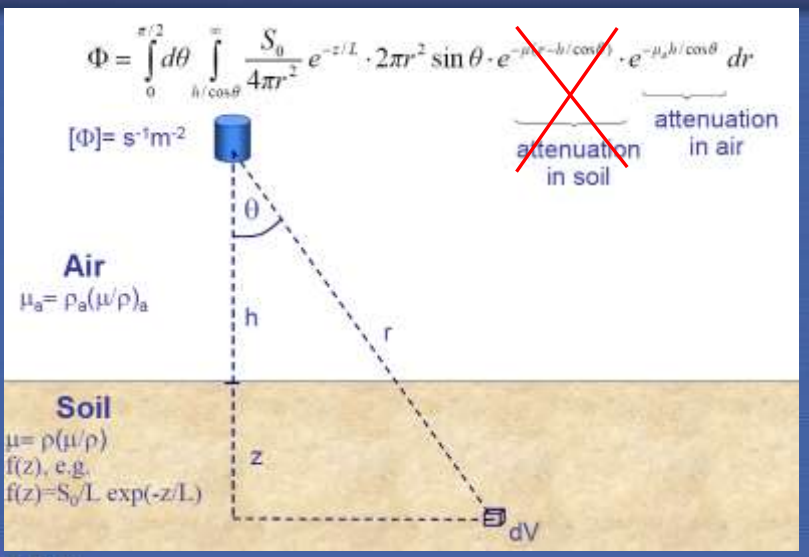
Theoretical model for photon flux calculation



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Test with I-131

- Two different calibration of the detector
  - Mathematical using ISOCS
  - Empirical with point sources
- Control site is a simulated homogeneous surface 20mx20m
  - 441 pieces I-131 source were distributed, total A= 2.460 (50) MBq
  - Pattern 1m x 1m net

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„Source" preparation

- The ^{131}I reference solution was spiked into the ink by gravimetric dilution (4.1 MBq)
- 450 pc. 5x5cm size source were printed
- 29 randomly selected source were tested for homogeneity
- The test site was installed on the dedicated military exercise field

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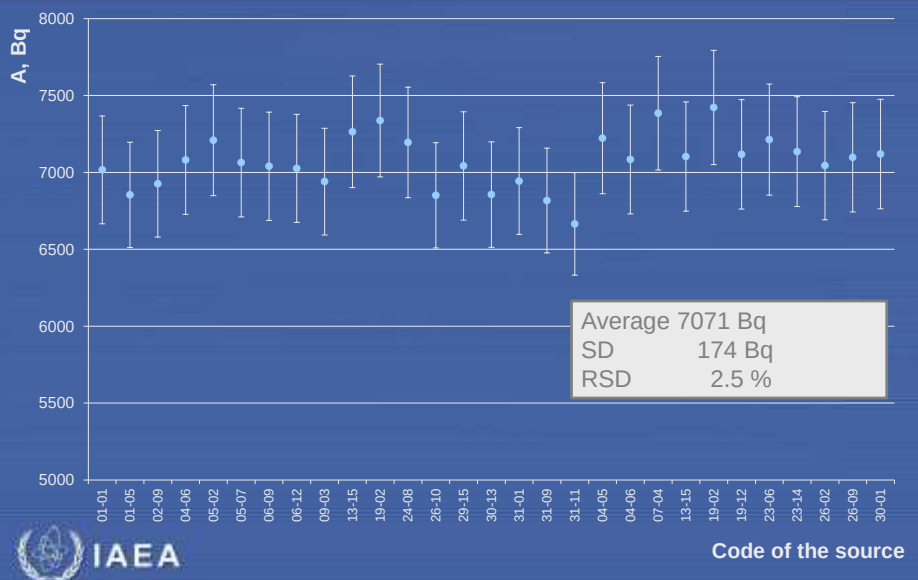
Homogeneity test of 29 piece randomly selected sources, by gamma-ray sp.



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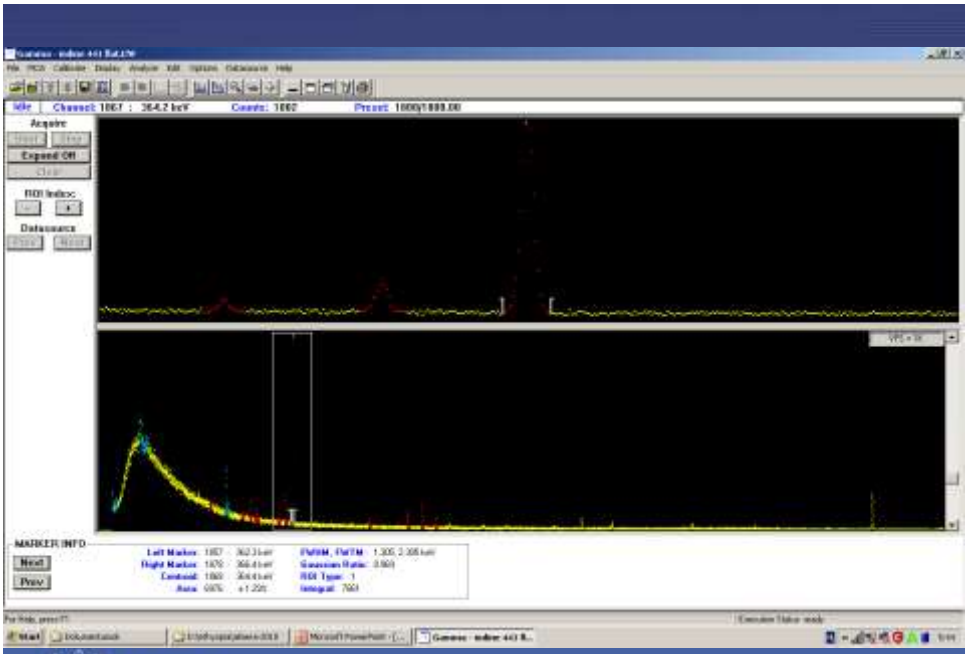

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Results of in situ validation for I-131

Method	Results, MBq	U, % (k=1)	Surface
Numerical	2.71	11	Concrete
ISOCS	2.52	10	Concrete
Numerical	2.63	12	grassland
ISOCS	2.40	10	grassland
Target value	***2.46***	***4***	
Repeatability	3.5 %	From 3 measurements	
Reproducibility	5.7 %	From 2 installations	

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Remarks

- The results have good agreement but the flat distribution is an „easy" geometry
- The recommended reproducibility 50% (TEC DOC 1092)
- There is no significant difference between the „urban" surface and „grassland"
- The numerical approach has a little systematic overestimation
- Next step: to develop a method for profile validation (in near future)

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Off site monitoring of the radioactivity

- Nuclear accident
- Terror attack
- Radiation incident
- Environmental pollution by industrial activity
- Regular environmental control

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Off site monitoring of radioactivity
(methods and tools)

- Airborne exploration
- Surface exploration
  - route monitoring
  - gamma dose rate measurement
  - in-situ gamma spectrometry
  - sampling
  - and sample measurement on field
- Data evaluation and interpretation

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Airborne exploration

- Special high sensitivity detector system with cosmic ray compensation
- Continuous data collection
- GPS location
- Data presentation by GIS

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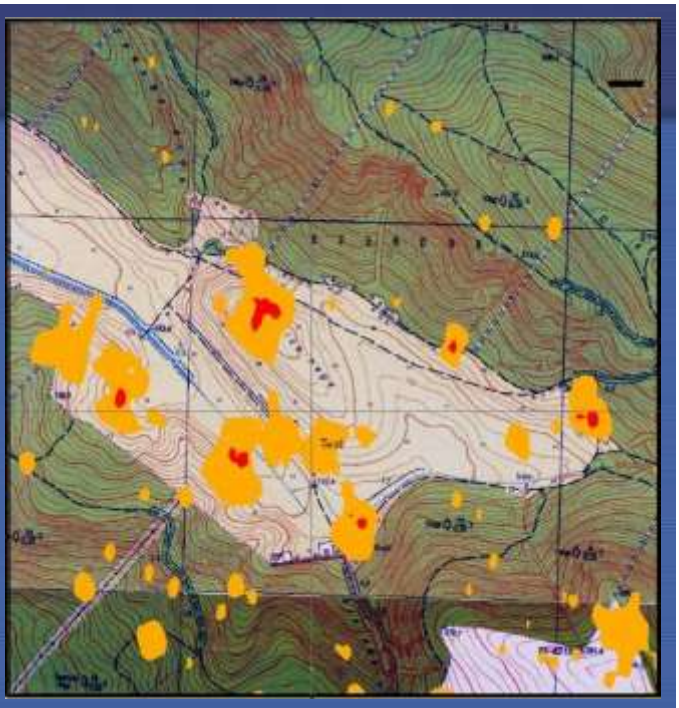
Results of the airborne scanning

- 40 m elevation
- Gamma intensity map
- No any nuclide specific information



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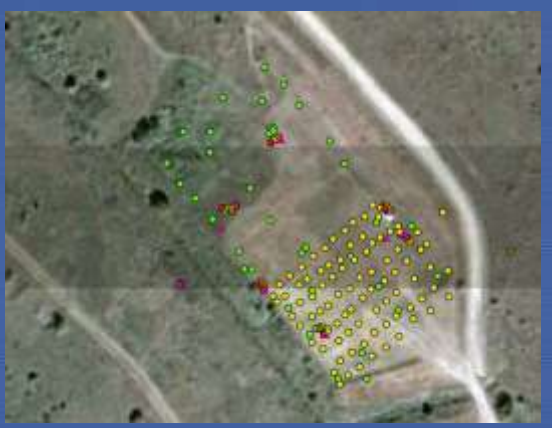
Surface exploration

- Two detector systems
  - sensitive but short time constant (for searching) 3”x3”NaI, LaBr, plastic (gross gamma information)
  - gamma dose rate measurement (non paralysable equipment)
- GPS, GIS
- (Sampling tools)



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In situ gamma-ray spectrometry

General task: Identification of isotopes

- HPGe detector system
  - fast electronics
  - 25-40 % relative efficiency
  - 1800-3600 sec counting time
  - 1 m above the surface
- Prerequisite
  - calibrated detector
  - check list (system parts, battery, GPS, documentation tools)
    handheld radiation monitors
    (surface contamination monitor, gamma dose rate monitor, personal dosimeter**)**
  - decontamination tools
  - Map and task description

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Sampling on highly contaminated area

- Sampling plan (based on the preliminary aerial and surface survey)
  - Goal of the sampling
  - Analysis to be carried out
  - Radiation safety (risk analysis or assessment)
  - Sample transfer and custody
- Sampling team
  - Team leader
  - „Clean" person (administrator)
  - Assistant
  - „Dirty" person (who will perform the sampling)
  - Control persons at the border of the contaminated area
- Prerequisite
  - check list (system parts, battery, GPS, documentation tools)
  - personal dosimeter
  - **handheld radiation monitors**
  - decontamination tools

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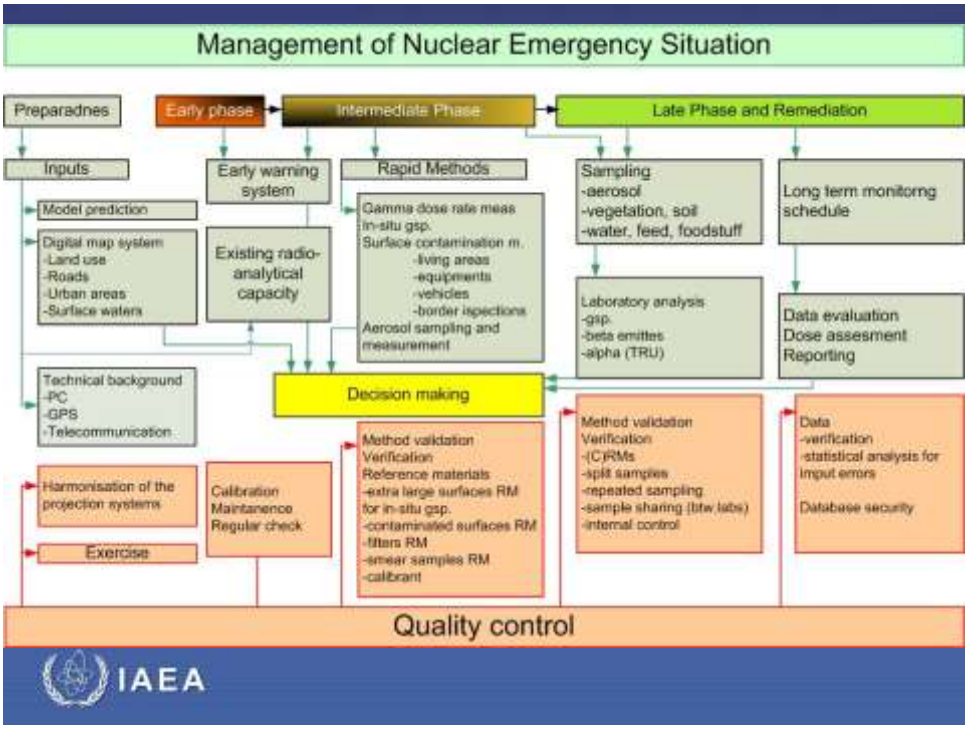

General rules on the contaminated area:

1. Each operation should be practice under inactive conditions!!!

2. Think twice what you are going to touch!!!

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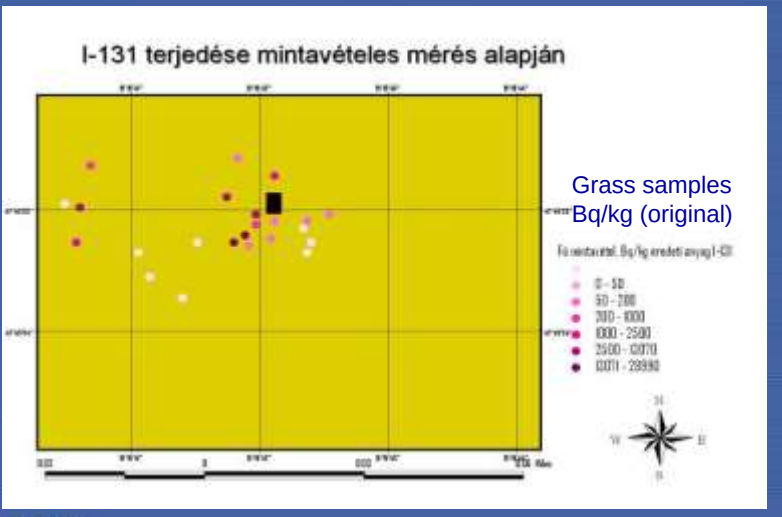
Results

Distribution of I-131 by measurements of samples



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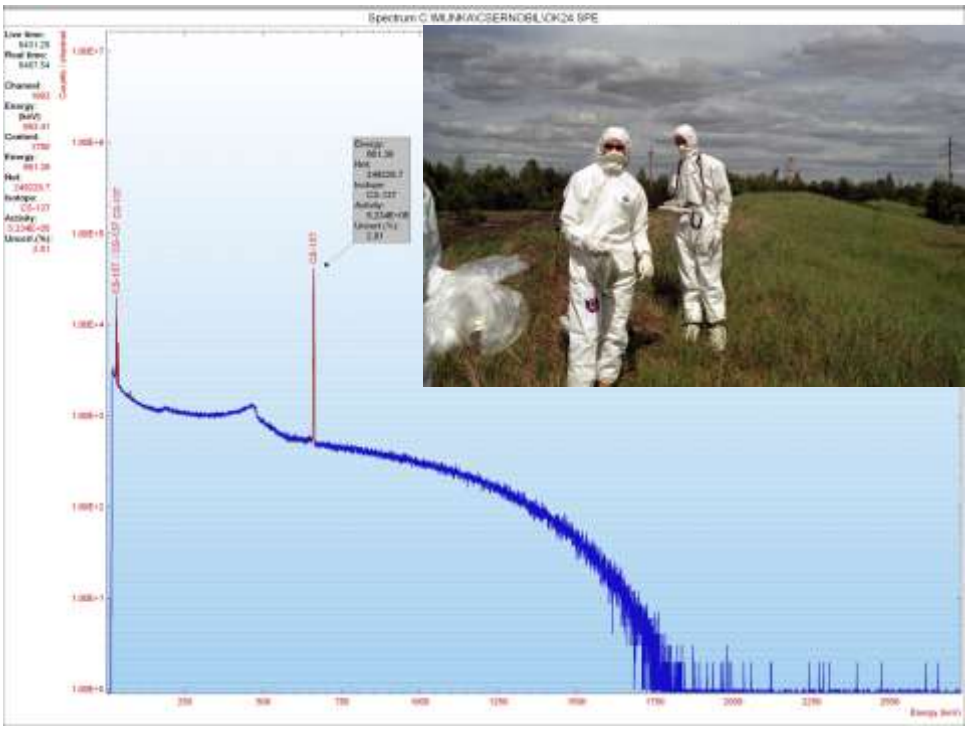
Spectrum C:\MUNIN\CSERNOBIL\CK24.SPE


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Thank you for attention!