

# LESSONS LEARNED – SURPRISES DURING RADIOLOGICAL CHARACTERIZATION AND CLEARANCE

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# CONTENT

1. Introduction
2. Surprises in radiological characterization
3. Surprises during clearance procedure
4. Summary

# 1. INTRODUCTION

## Surprise

= experience of an unexpected situation

### resulting from:

- insufficient knowledge or information
- expectations / anticipation
- mistakes

# 1. INTRODUCTION

## Handling of surprises

- notice them
  - comparison with expectations
  - implausible findings
- take them seriously
  - don't classify it as an outlier too early
- look for reasons
- draw conclusions
- corrective actions if necessary

# 1. INTRODUCTION

## Typical steps of radiological characterization and clearance

1. Historical survey
2. Preliminary survey
3. Determination of nuclide vector
4. Qualification of measurement procedures
5. Decision measurements for clearance

## Experiences in

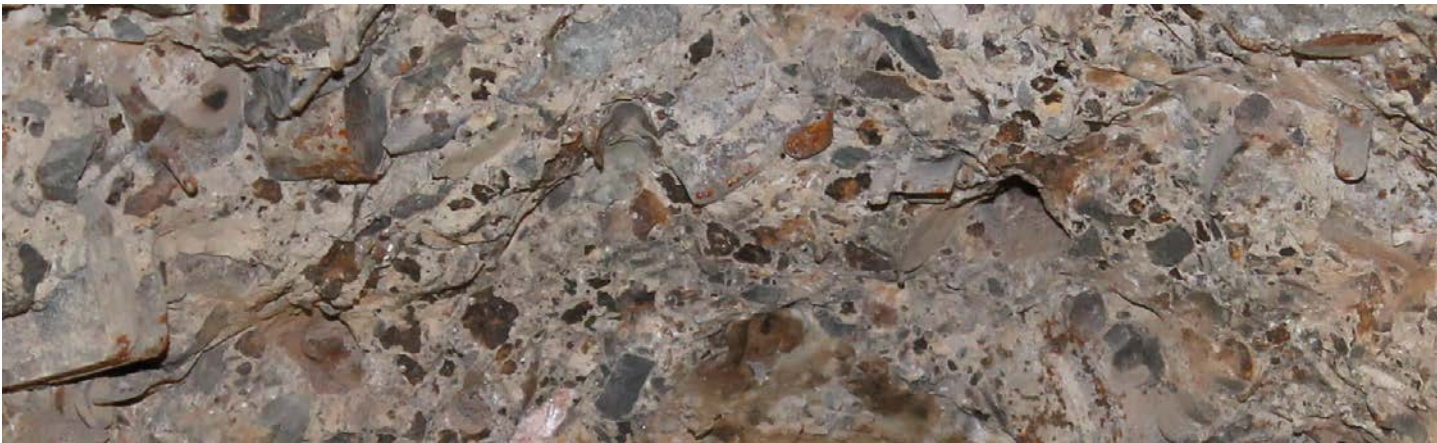
- research reactors
- nuclear power plants
- fuel element production plants
- radionuclide laboratories
- waste and waste water treatment

## 2. SURPRISES IN RADIOLOGICAL CHARACTERIZATION

### Historical survey

**old and new reference documentation** (e.g. construction drawings)

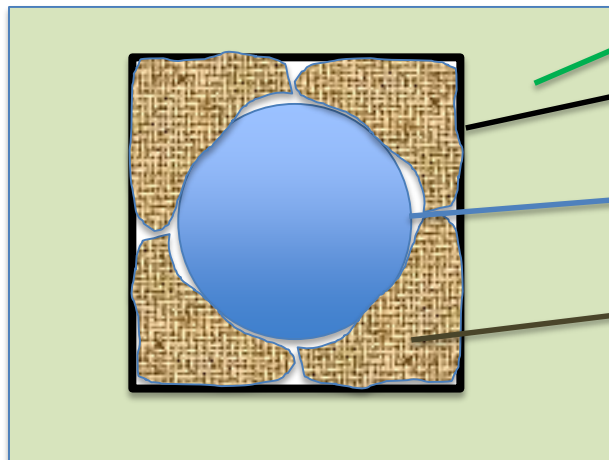
- Rossendorf research reactor: biological shield
  - drawing:
    - barite concrete (barite  $\text{BaSO}_4$ )
  - measurement:
    - gamma spectrometry: no Ba-133
    - XRF: no Ba
  - inspection: **concrete with steel scrap (0,5 – 4 cm) → high density**



## 2. SURPRISES IN RADIOLOGICAL CHARACTERIZATION

### Historical survey

old and new reference documentation (e.g. construction drawings)



biological shield (concrete)

opening for tube of primary circuit

tube of primary circuit

shielding bag with **barite**

**gamma spectrometry: Co-60, but no Ba-133**

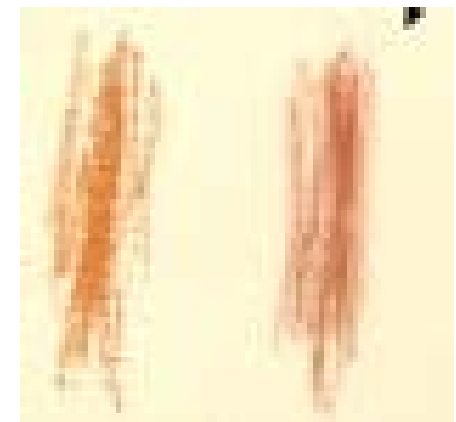
**→ inspection**



~~barite~~



**iron ore (limonite + haematite)**



streak colour

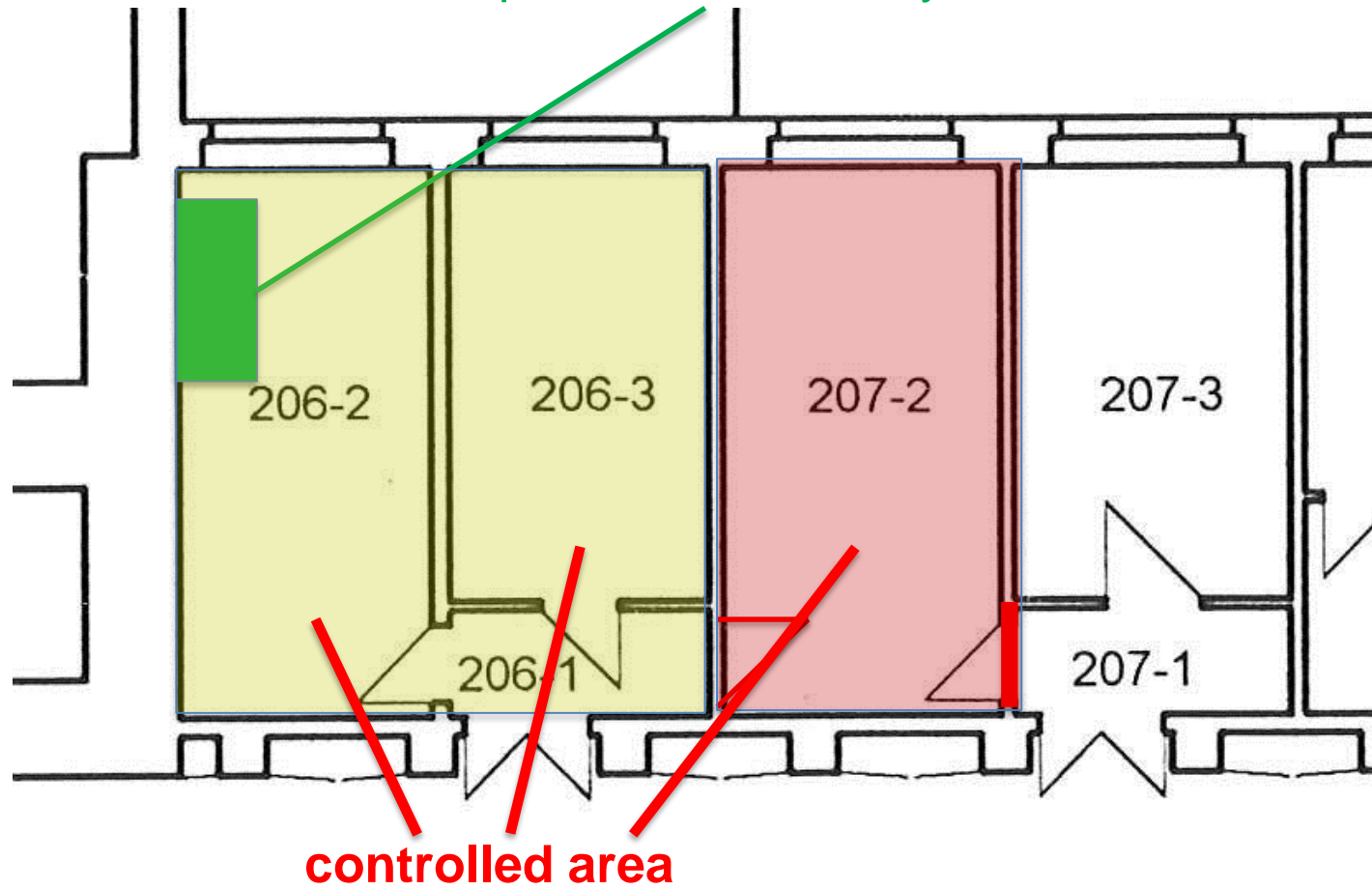


## 2. SURPRISES IN RADIOLOGICAL CHARACTERIZATION

### Historical survey

#### information about use of the rooms

- laboratories at the **pneumatic rabbit system** from research reactor



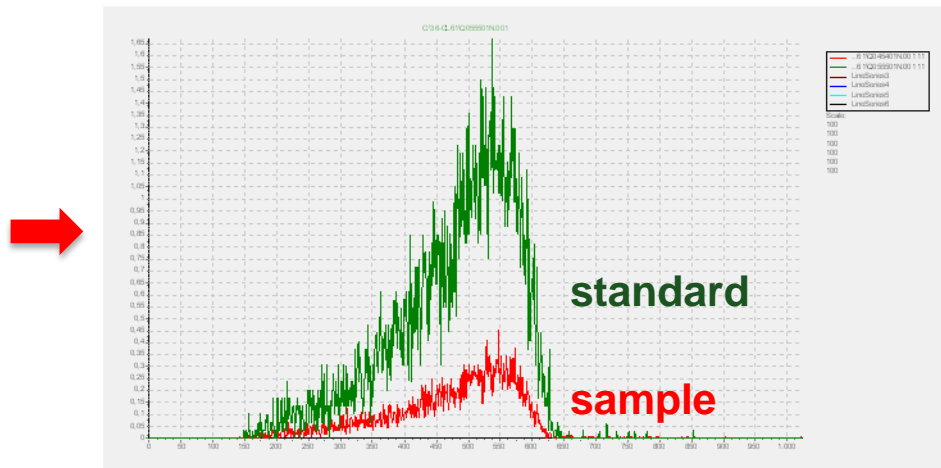


## 2. SURPRISES IN RADIOLOGICAL CHARACTERIZATION

### Preliminary survey

#### unexpected contamination

- room in controlled area of a nuclear research centre
  - was used since 1957 only for “work without radionuclides”
- clearance for exchange of windows
  - checking by surface contamination measurement → **high beta count rate**
  - sample checked by gamma spectrometry → **no gamma emitter**
  - sample checked by liquid scintillation counting with step by step standard addition of different radionuclides



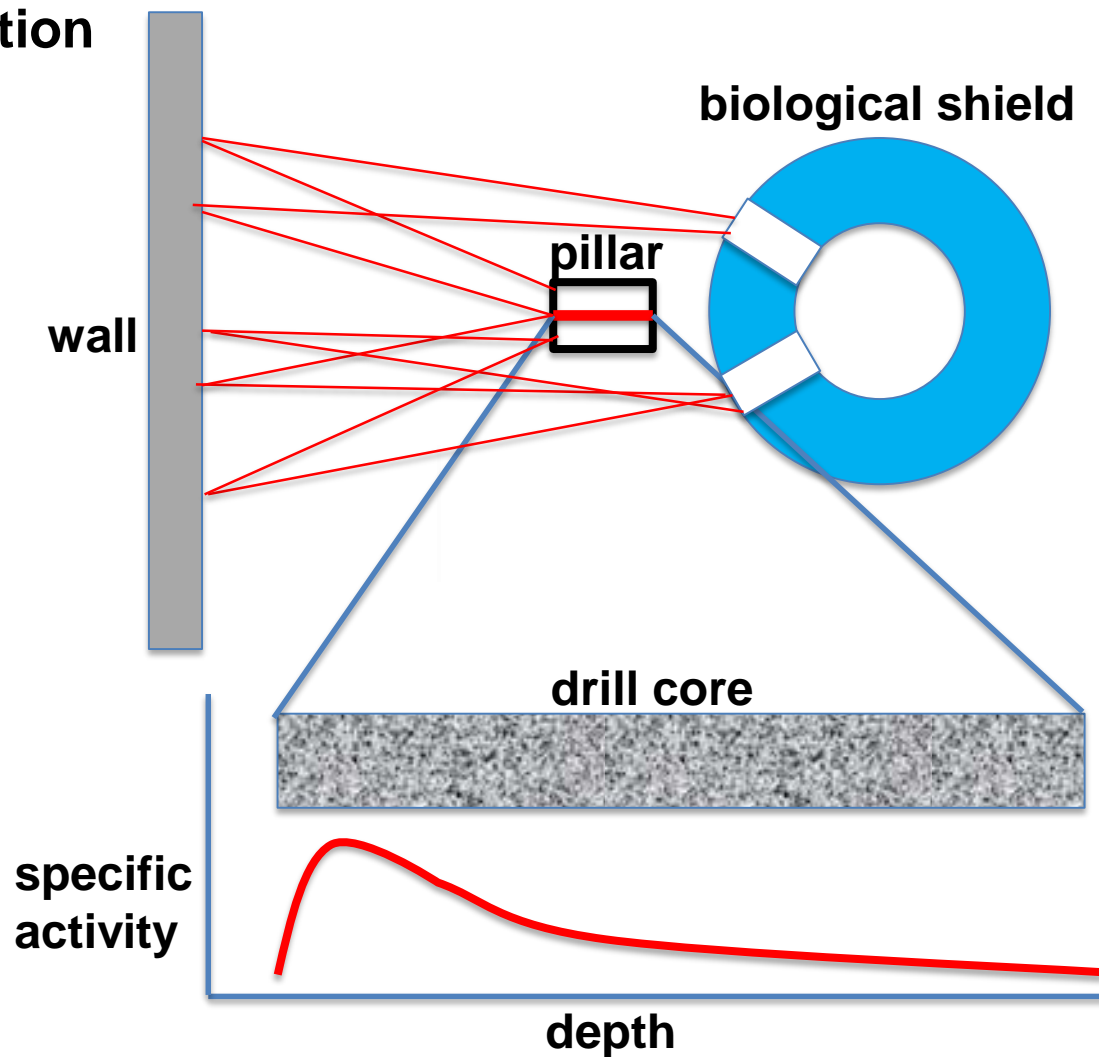
→ **identified nuclide:  
Cl-36**

some colleagues  
remembered  
**an experiment went  
wrong in the 60<sup>th</sup>**

## 2. SURPRISES IN RADIOLOGICAL CHARACTERIZATION

### Preliminary survey

unexpected activation



### 3. SURPRISES IN RADIOLOGICAL CHARACTERIZATION

#### Representative sampling

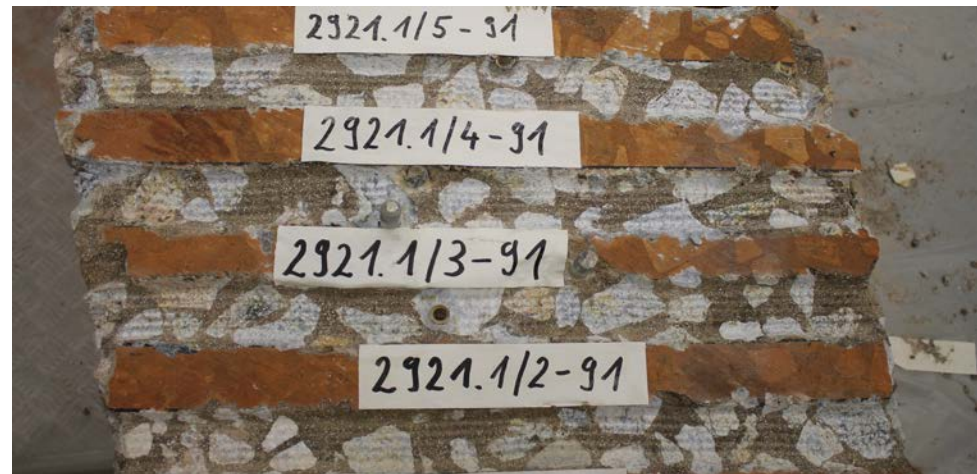
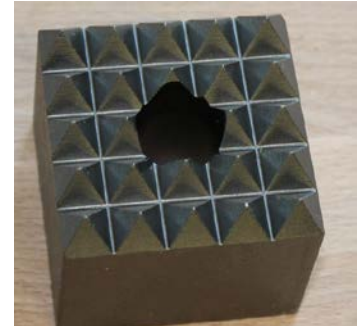
Nuclide ratios of concrete samples scattering in an unexpectedly wide range

➔ Search for the reason: documentation incl. pictures

~~drilling~~



chiselling  
(german: stockern)



## 2. SURPRISES IN RADIOLOGICAL CHARACTERIZATION

### Determination of nuclide vectors

**analysis: neutron generator** (with tritium targets)

- tritium H-3
- concrete with paint

<b>fraction</b>		<b>component 1</b>	<b>component 2</b>
<b>wipe test</b>	<b>[Bq/cm<sup>2</sup>]</b>	<b>1540</b>	<b>74</b>
<b>exchange with water</b>	<b>[Bq/g]</b>	<b>19</b>	<b>141</b>
<b>heating</b>	<b>[Bq/g]</b>	<b>290</b>	<b>240000</b>

<b>heating temperature [°C]</b>	<b>percentage H-3 [%]</b>	
	<b>sample 1</b>	<b>sample 2</b>
<b>200</b>	<b>6</b>	<b>0,1</b>
<b>500</b>	<b>86</b>	<b>29</b>
<b>900</b>	<b>100</b>	<b>100</b>

## 2. SURPRISES IN RADIOLOGICAL CHARACTERIZATION

### Determination of nuclide vectors

#### calculation of nuclide vector

sample	percentage in nuclide vector [%]			
	Co-60	Cs-137+	Sb-125+	Am-241
before decontamination	90,7	9,3	0,009	0,001
after 1 <sup>st</sup> decontamination	80,8	8,2	8,0	3,0
after 2 <sup>nd</sup> decontamination	50,1	7,0	28,2	14,7

sample	specific activity [Bq/g]			
	Co-60	Cs-137+	Sb-125+	Am-241
before decontamination	534,0000	55,0000	< 0,0510	< 0,0055
after 1 <sup>st</sup> decontamination	0,0138	0,0014	< 0,0014	< 0,0005
after 2 <sup>nd</sup> decontamination	0,0018	0,0003	< 0,0010	< 0,0005

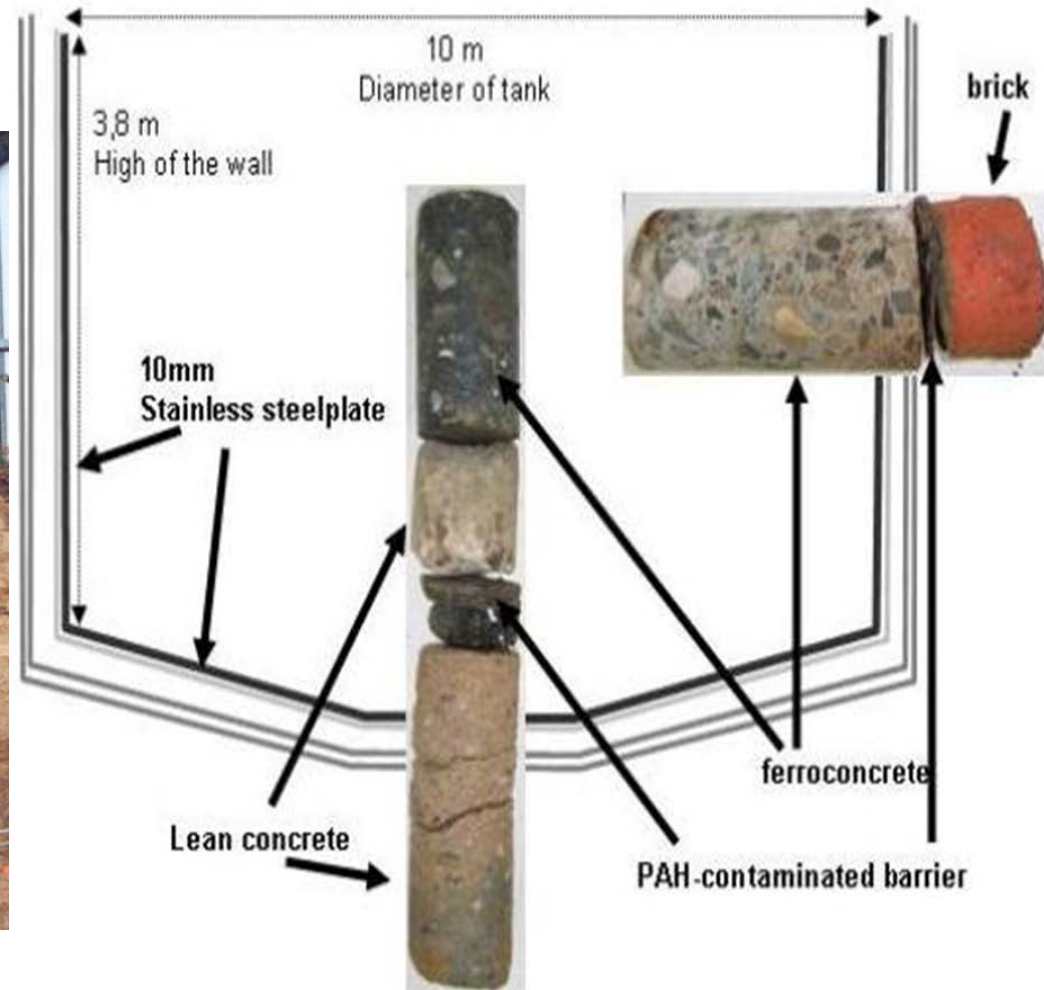
sample	percentage in nuclide vector [%]			
	Co-60	Cs-137+	Sb-125+	Am-241
before decontamination	90,7	9,3	0,0	0,0
after 1 <sup>st</sup> decontamination	90,8	9,2	0,0	0,0
after 2 <sup>nd</sup> decontamination	91,0	9,0	0,0	0,0



## 2. SURPRISES IN CHARACTERIZATION

### Non-radioactive hazardous substances

#### Underground tanks for liquid radioactive waste in VKTA





## 2. SURPRISES IN CHARACTERIZATION

### Non-radioactive hazardous substances

#### Underground tanks for liquid radioactive waste in VKTA

Results:

- Polycyclic aromatic hydrocarbons (PAH) in building materials
  - PAH in coating (sum PAH 50 000 ... 120 000 mg/kg)
    - ➔ **dangerous waste** (> 1000 mg/kg)
  - Mobile in eluate (sum PAH 210 µg/l)
    - ➔ **above inspection value** (0,2 µg/l)
- **Serious danger for ground water**
  - Water table 1 – 2 m below building

Decision:

➔ **Removal of the buildings**

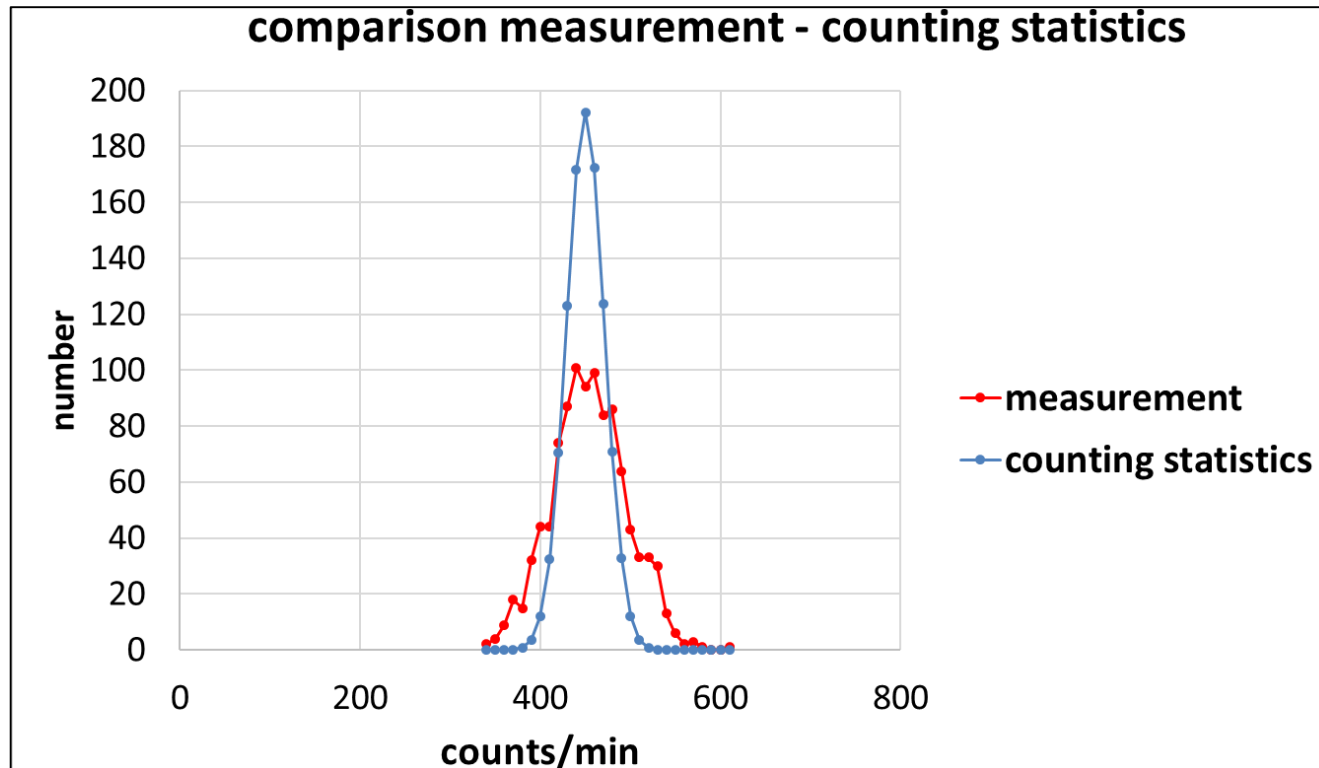


### 3. SURPRISES DURING CLEARANCE PROCEDURE

#### Qualification of measurement procedures

#### surface contamination monitor – background

- background measurement beta/gamma channel (1022 x 60 s)
- expected: uncertainty = counting statistics ( $u = \sqrt{N}$ )



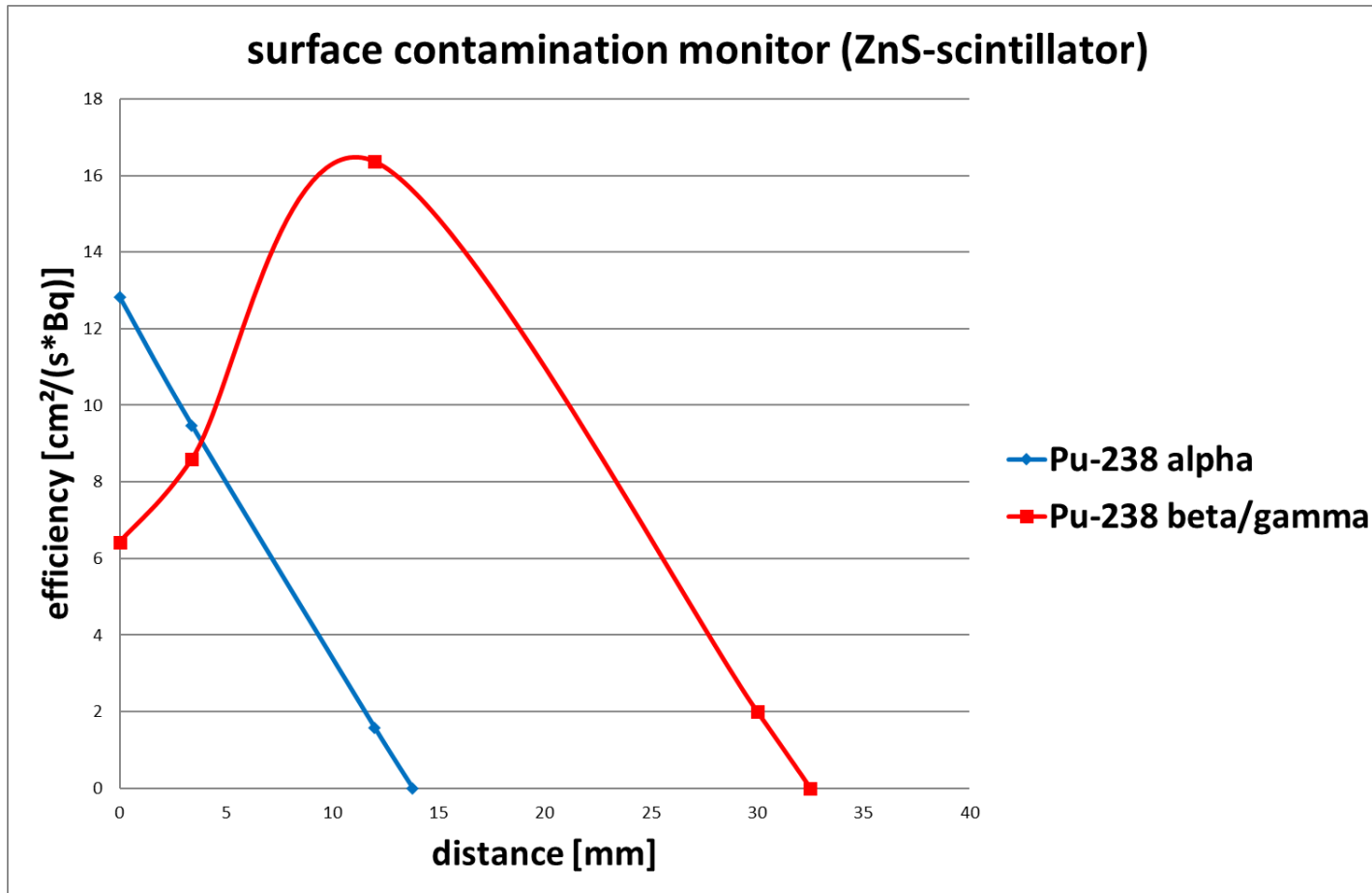
- **uncertainty = 2 x counting statistics** (reason: signal processing)

### 3. SURPRISES DURING CLEARANCE PROCEDURE

#### Qualification of measurement procedures

#### surface contamination monitor (ZnS + plastic scintillator) – efficiency

- measurement of pure alpha emitters in beta/gamma channel



### 3. SURPRISES DURING CLEARANCE PROCEDURE

#### Decision measurements

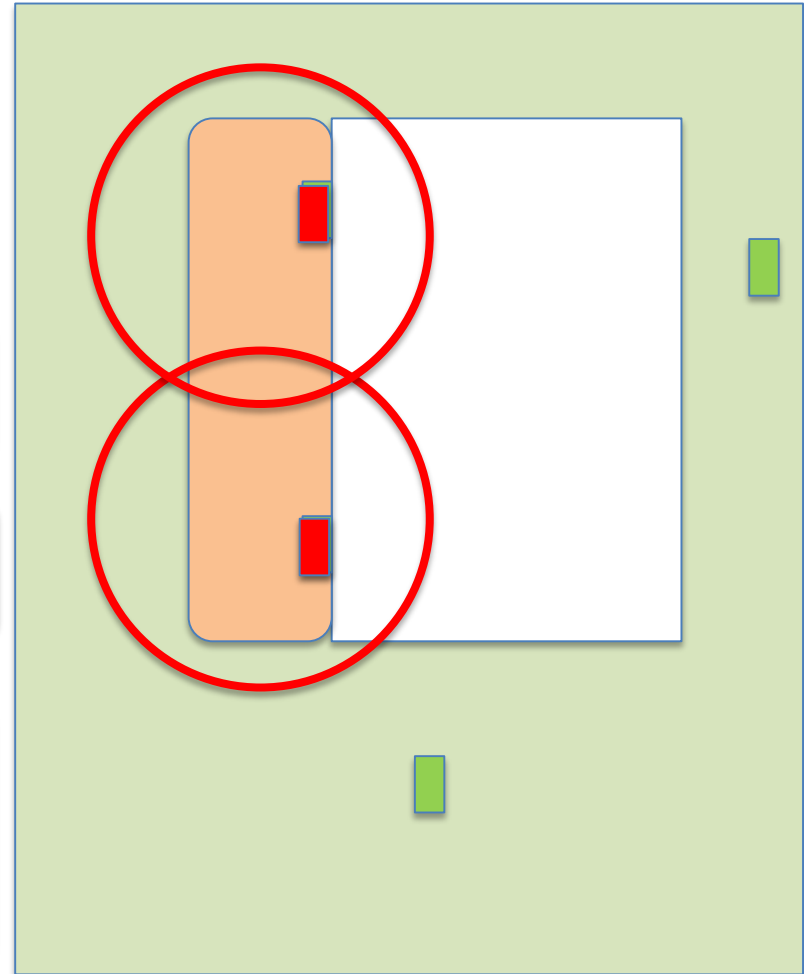
#### inconsistent results of different methods

- smooth wall in a nuclear installation
- opening for a former glove box
  - already dismantled
  - closed with a steel plate

• surface contamination measurement  
➔ elevated count rates

• in-situ-gamma spectrometry  
➔ no contamination from operation

• sampling  
• gamma spectrometry  
➔ no contamination from operation  
➔ **higher specific activity of Ra-226 in new gypsum plaster**



# 3. SURPRISES DURING CLEARANCE PROCEDURE

## Decision measurements

### inconsistent results of different methods

- surface contamination measurement
  - gross count rates in the map
- sampling and analysis
  - ➔ no enhanced specific activity
- inspection inside the building
  - ➔ cyclone for dust retention during decontamination inside

0	2	2	4	7	8	3	4	2	7	
2	3	3	10	11	7	4	4	6	7	
2	3	3	9	14	8	4	4	5	7	
			10	30	8	8	4	5	7	
			10	39	26	8	4	7	7	
			10	90	80	8	4	7	8	
			23	52	62	13	5	8	8	
			26	31	47	14	5	8	8	
			55	25	41	13	7	8	10	
			41	28	29	14	11	8	10	
			42	35	32	14	11	4	9	
			43	35	28	15	13	7	10	
			42	37	32	28	14	8	10	
			67	51	47	33	11	9	10	
			118	75	54	68	12	10	9	
			197	117	107	78	14	10	9	
			141	188	246	98	15	11	8	
			149	343	623	167	47	12	9	
			116	360	1003	198	53	13	12	
							156	53	13	12
							105	37	12	13
							92	31	11	15
							70	32	11	12
							43	31	13	14
							34	29	17	14
							20	18	14	14
							8	17	13	6
							6	14	4	9
							6	8	4	7
							3	0	1	0
							3	0	-3	0

### 3. SURPRISES DURING CLEARANCE PROCEDURE

#### Decision measurements

#### Check of influence of a nuclear fuel (MOX) production facility

nuclear fuel production  
**U**

nuclear fuel production  
**MOX (customer)**

trench

samples

nuclide	site 4	site 3	site 2	site 1
U-238	470	< 12	24	16
U-234	730	< 12	24	16
Ra-226	11	11	20	10
Pb-210	50	70	190	480

radiochemical processing plant  
Ra-226 ...

Rn-222

enriched U

excess Pb-210 → Rn-222



## 4. SUMMARY

- be attentive for **surprises**
- take them seriously
- look for reasons
- draw conclusions
- corrective actions if necessary

**Radiological characterization  
is like  
“Radio-Archeology”**

## **Workshops “Radiological Characterization” and “Clearance”**

- each 3 days, 15 – 20 participants, tailor-made program, on site
- 50 % lectures, 50 % group work on real problems
- Karlsruhe, Bangkok, Hanoi, CERN, Paul-Scherrer-Institute (CH), NPPs

## **Training course “Sampling”**

- 1 week or more, 8 – 12 participants, on site, hands on
- lectures, SOP, demonstration, training, supervision
- german NPPs

**I wish you success  
in detecting and smart handling  
of surprises!**

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