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Radiological Characterization of Buildings at the Ranstad Uranium Works

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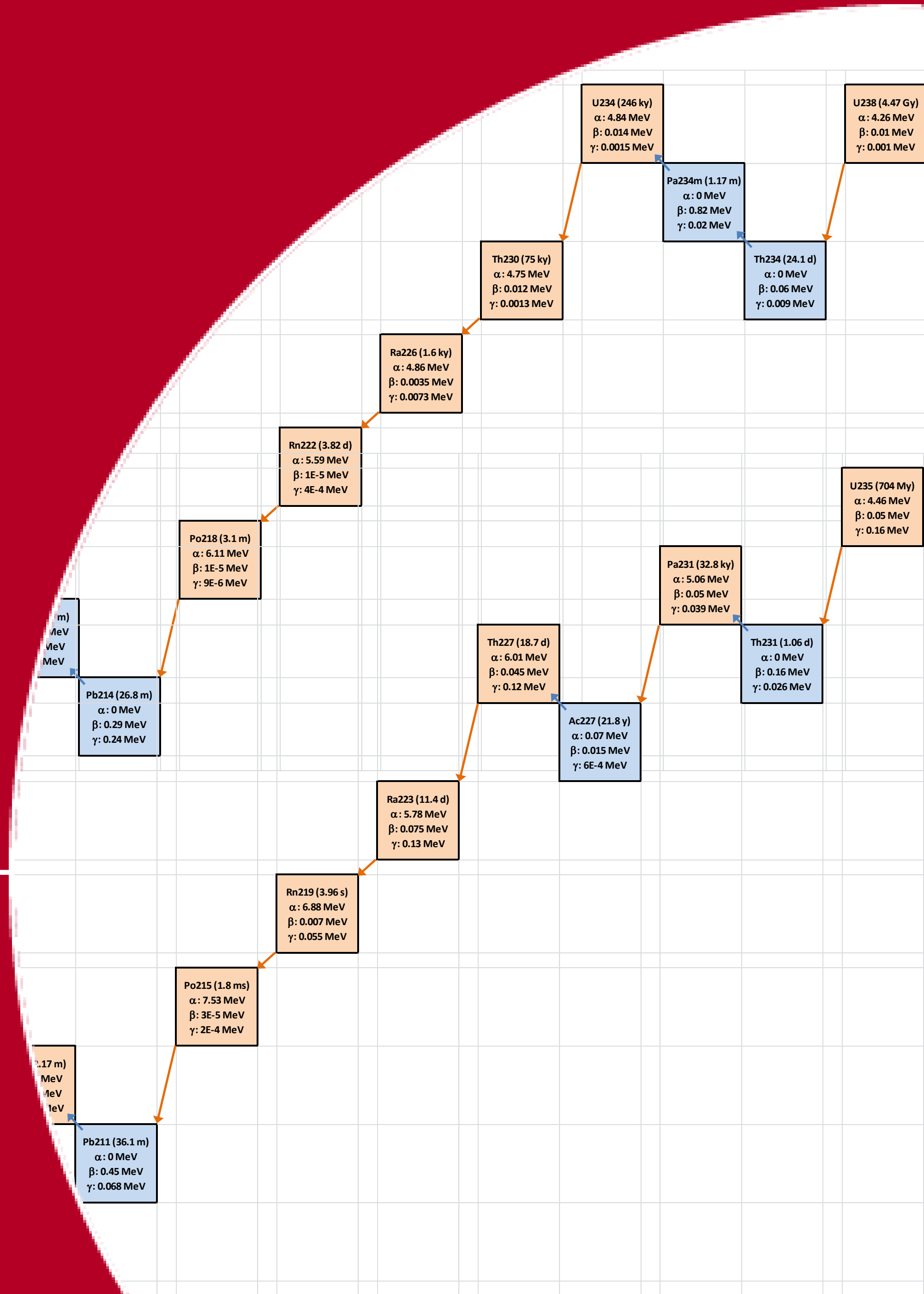

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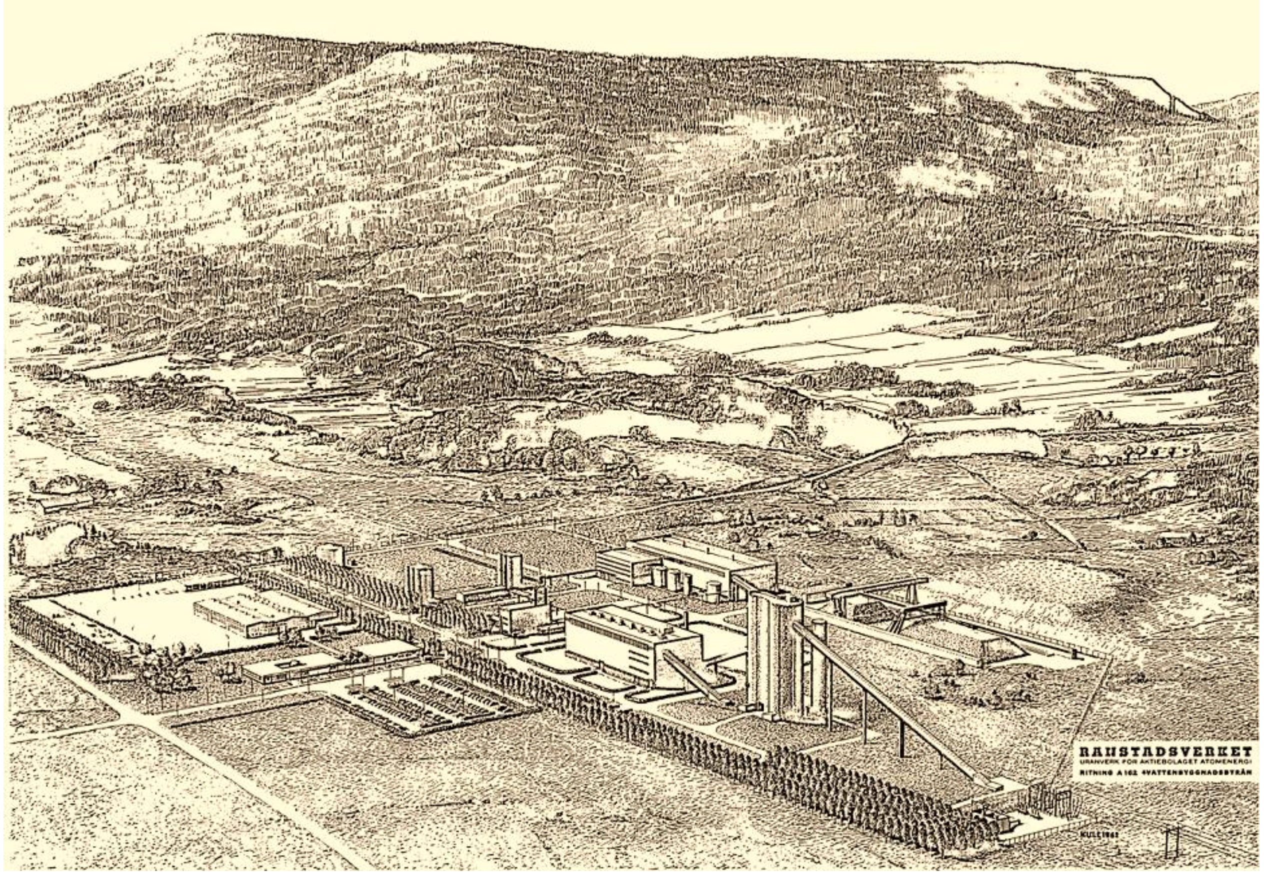

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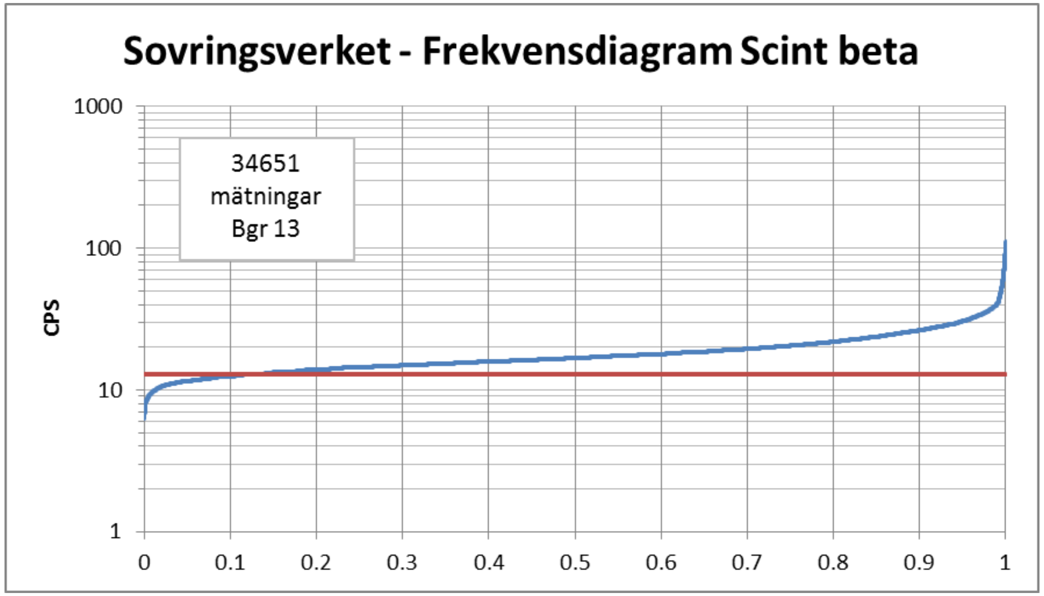
INVENTORY OF RADIONUCLIDES AT RANSTAD SITE

Scintillation detector measurements

- Totally 110000 measurements
  - Office/lab 8000, Sorting works 34600, Leaching plant 35100, Uranium extraction plant 19600
  - Buildings divided into squares
  - 32 measurements in each square
- Sorting works:
  - Mostly low degree of contamination
  - Some local accumulations of shale, can be decontaminated
  - Blue concrete occurs



Nuclide vectors compared to in situ gamma spectrometric data (ISOCS)

Measured activities of K40 and nuclides in the Th232-chain can be explained by the activity in concrete

Increased values in the U238 chain indicates contamination or blue concrete

- Th234 >> Ra226 → Indicates U concentrate

	Kontors- och Laborationsdel, kBq/kg					Sovringsverket, kBq/kg			Lakverket, kBq/kg		RMA, kBq/kg		Betong kBq/kg
Nuklid	Rum 2.74	Rum 2.75	Rum 2.05	Rum 2.18	Rum 2.67	Ruta 162	Ruta 128	Ruta 157	Rum 110	Rum 113	LVJ 109G42	LVJ 113GM2	
K-40	1.1E+00	9.6E-01	8.9E-01	1.0E+00	1.2E+00	1.0E+00	1.1E+00	1.1E+00	8.6E-01	9.6E-01	8.5E-01	7.9E-01	7.7E-01
Sönderfallskedja Th-232													
Tl-208	1.5E-02	9.9E-03	9.1E-03		1.9E-02	1.2E-02	1.3E-02	9.9E-03	1.7E-02	1.6E-02	1.4E-02	1.1E-02	1.7E-02
Bi-212			4.0E-02	3.9E-02		3.8E-02			8.8E-02		3.9E-02		4.8E-02
Pb-212	5.2E-02	2.7E-02	2.8E-02	3.0E-02	5.5E-02	4.3E-02	2.8E-02	3.9E-02	7.8E-02	5.2E-02	6.0E-02	5.0E-02	4.8E-02
Ac-228	4.2E-02	2.9E-01	2.9E-02		4.9E-02	3.7E-02	3.7E-02		6.9E-02	4.5E-02	4.9E-02	4.4E-02	4.8E-02
Sönderfallskedja U-238													
Bi-214	7.3E-02	9.5E-02	4.1E-02	4.8E-01	2.7E-01	3.7E-02	4.1E-02	5.8E-02	9.3E-02	4.8E-02	4.1E-02	3.8E-02	4.9E-02
Pb-214	6.7E-02	1.9E-01	3.8E-02	3.0E-01	1.5E-01	3.5E-02	4.4E-02	7.0E-02	1.1E-01	5.0E-02	4.7E-02	4.3E-02	4.9E-02
Ra-226	1.3E-01	4.3E-01	4.3E-02	4.4E-01	1.8E-01	7.4E-02	4.0E-01		3.7E-01	8.6E-02			4.9E-02
Pa-234m				1.4E+00	3.2E+00	6.5E-01			1.2E+00		7.2E-01	5.2E+00	4.9E-02
Th-234					8.5E-01	2.1E-01	4.8E-01		3.4E-01		2.4E-01	1.5E+00	4.9E-02

Nuclide vectors compared to the spectrophotometric laboratory measurements

Most samples show the expected nuclide vector e.g. shale.
Individual samples show increased uranium levels, in some cases suggested enriched uranium.
Trace quantities of "reactor nuclides" e.g. Cs137, Co60 and Am241 found in single samples in low levels relative to the expected nuclides.

kBq/kg	Kontors- och Laborationsdel		Sovringsverket						Lakverket			RMA	NVIA-Golvbrunnar	Ångcentralen	Personalbyggnaden		
	KL2.79 KL2.74 KL2.67	KL rest	SV408	SV201, SV301	SV rest	SV kulvert 3	slam SVKS	SV-övrigt	LV-övrigt	MTRL LV	LVLS1	LVJ-204 - LVJ-212	NVIA9	ÅC rest	PA2045	PA rest	Skiffer
K-40	0.56	0.31	0.47	0.43	0.6	0.61	0.99	0.42	0.65	0.41	1.1	0.17	< 0.32	0.3	0.16	0.26	1.24
Cs-137					0.011		0.003		0.029					0.0028			
Co-60												0.02					
U-238		< 0.57	1.9	3	< 0.99	1.3	1.4	1.5	5.8	270	1.5	190	< 3.2	< 0.84		< 1.4	3.70
Ra-226	0.026	0.12	1.3	1.4	1.3	1.4	2.3	1.4	0.3	1.4	2.7	0.073	< 0.47	0.048	0.016	< 0.17	3.70
Pb-210	0.038	0.17	0.81		0.74		< 2.7	0.58	0.35	2.7	3.1	< 0.23		0.06	0.024	< 0.34	1.81
U-235	0.014	0.018	0.092	0.13	0.072	0.062	0.067	0.057	0.81	11	< 0.072	24	< 0.026	< 0.011	< 0.0036	< 0.01	0.17
Pa-231		< 0.1			0.09	0.087	0.16	< 0.14	< 0.13	< 0.4	< 0.28	1.1	< 0.64	< 0.12		< 0.26	0.17
Ac-227		< 0.023			0.044	0.068	0.11	< 0.03	< 0.027	< 0.078	0.13	< 0.06	< 0.11	< 0.015		< 0.053	0.17
Ra-228		< 0.013		0.027	0.023	0.023	0.036	0.019	0.03	0.053	< 0.035	< 0.031	< 0.077	0.013	0.0091	< 0.033	0.01
Th-228	0.0055	0.0092	0.02	0.025	0.021	0.023	0.034	0.015	0.028	0.042	0.031	0.055	< 0.031	0.0099	0.0087	< 0.019	0.01
Am-241									0.019								
Anrikn.		0.49%	0.76%	0.68%	1.14%	0.75%	0.75%	0.59%	2.18%	0.64%	0.75%	1.97%	0.13%	0.20%		0.11%	

Meassured values for filtering gravel
Total about 1,000 tons

HALTER Bq/g	N1					N2					N4				
	M	SW	NE	NW	SE	M	SW	NE	NW	SE	M	SW	NE	NW	SE
U-238	6.00E-01	6.94E-01	1.24E+00		1.39E+00	6.69E-01	6.83E-01	2.03E+00	1.47E+00	9.88E-01	3.31E+00	2.83E+00		2.68E+00	7.12E+00
U-235		1.53E-01	7.60E-02		7.19E-02		2.93E-02	1.23E-01	1.02E-01	4.39E-02	2.05E-01	1.44E-01		1.38E-01	3.15E-01
Ra-226	3.55E+00	4.65E+00	4.59E+00		3.71E+00	5.94E+00	3.76E+00	3.70E+00	2.71E+00	3.23E+00	2.50E+00	2.65E+00		1.99E+00	2.58E+00
Bi-214	2.78E+00	5.92E+00	4.61E+00		3.42E+00	3.99E+00	4.82E+00	3.41E+00	2.04E+00	3.40E+00	2.02E+00	2.47E+00		1.94E+00	1.78E+00
Ra-226 / U-238	5.92E+00	6.70E+00	3.70E+00		2.68E+00	8.88E+00	5.51E+00	1.82E+00	1.84E+00	3.27E+00	7.55E-01	9.36E-01		7.43E-01	3.62E-01

Various ratio U238/Ra226 → Various ratio leaching rest / uranium concentrate

The magnitude of activity is as in alum shale

“System identities”

- Same magnitude of contamination
- One general nuclide vector
- Material is relatively homogenous
- If decontamination is needed, one common method is used for all material
- All waste from the decontamination of one system identity can be disposed of in the same way

Nuclide vector for shale

- K: 4 weight-% (SGI)
- U_nat: 300 ppm (SGI et.al.)
- Th_nat: 8 ppm (”low content”)
- Measurements show some ventilation of Rn and Rn–daughters:
  - U238-chain: 51%
  - Th232-chain: 32%

U_nat	Bq/kg	Th_nat	Bq/kg	K_nat	Bq/kg
Tl207	1.70E+02	Tl208	7.89E+00	K40	1.24E+03
Pb210	1.81E+03	Pb212	2.19E+01		
Pb211	1.71E+02	Bi212	2.19E+01		
Pb214	1.81E+03	Po212	1.40E+01		
Bi210	1.81E+03	Po216	2.19E+01		
Bi211	1.71E+02	Rn220	2.19E+01		
Bi214	1.81E+03	Ra224	3.23E+01		
Po210	1.81E+03	Ra228	3.23E+01		
Po214	1.81E+03	Ac228	3.23E+01		
Po215	1.71E+02	Th228	3.23E+01		
Po218	1.81E+03	Th232	3.23E+01		
Rn219	1.71E+02				
Rn222	1.81E+03				
Ra223	1.71E+02				
Ra226	3.70E+03				
Ac227	1.71E+02				
Th227	1.68E+02				
Th230	3.70E+03				
Th231	1.71E+02				
Th234	3.70E+03				
Pa231	1.71E+02				
Pa234m	3.70E+03				
U 234	3.70E+03				
U 235	1.71E+02				
U 236	0.00E+00				
U 238	3.70E+03				
Total	**3.86E+04**	**Total**	**2.71E+02**	**Total**	**1.24E+03**
Total - α	**3.08E+04**	**Total - α**	**1.94E+02**	**Total - α**	**0.00E+00**
	MeV/s,kg		**MeV/s,kg**		**MeV/s,kg**
Alpha	1.40E+05	Alpha	9.97E+02	Alpha	0.00E+00
Beta	8.74E+03	Beta	4.48E+01	Beta	6.45E+02
Gamma	7.03E+03	Gamma	7.91E+01	Gamma	1.94E+02

Leaching remains

- U_nat: 100 ppm
- Except for U, the same activity as in shale, however:
  - 45 years of decay time
  - Corresponding ventilation of radon and radon-daughters as in shale
- Similar specific activity as in shale

U_nat	Bq/kg	Th_nat	Bq/kg	K_nat	Bq/kg
Tl207	1.70E+02	Tl208	2.96E+00	K40	1.24E+03
Pb210	2.44E+03	Pb212	8.23E+00		
Pb211	1.71E+02	Bi212	8.23E+00		
Pb214	2.44E+03	Po212	5.27E+00		
Bi210	2.44E+03	Po216	8.23E+00		
Bi211	1.71E+02	Rn220	8.23E+00		
Bi214	2.44E+03	Ra224	1.21E+01		
Po210	2.44E+03	Ra228	1.21E+01		
Po214	2.44E+03	Ac228	1.21E+01		
Po215	1.71E+02	Th228	1.21E+01		
Po218	2.44E+03	Th232	1.21E+01		
Rn219	1.71E+02				
Rn222	2.44E+03				
Ra223	1.71E+02				
Ra226	3.70E+03				
Ac227	1.71E+02				
Th227	1.68E+02				
Th230	3.70E+03				
Th231	5.69E+01				
Th234	1.23E+03				
Pa231	1.71E+02				
Pa234m	1.23E+03				
U 234	1.26E+03				
U 235	5.69E+01				
U 238	1.23E+03				
Total	**4.37E+04**	**Total**	**1.21E+02**	**Total**	**1.24E+03**
Total - α	**2.58E+04**	**Total - α**	**7.27E+01**	**Total - α**	**0.00E+00**
	MeV/s,kg		**MeV/s,kg**		**MeV/s,kg**
Alpha	1.17E+05	Alpha	3.74E+02	Alpha	0.00E+00
Beta	6.49E+03	Beta	1.68E+01	Beta	6.45E+02
Gamma	6.93E+03	Gamma	2.97E+01	Gamma	1.94E+02

Effectiveness of the scintillation detector

- Scintillation effectiveness $= \frac{\Delta Bq_x}{\Delta CPS} \cdot \frac{total\ {}^{Bq}/_{m^2}}{Bq_x}$

Area and weight data

- Area and weight data is used to quantify the activity at the Ranstad works. Area and weight data are given by layouts, onsite measurements and known densities.

Inventory of nuclides

SV.1.1	Sorting works ground floor
LV.8.1	Filtering gravel at bottom of leaching pools N1 and N2
RMA.1.2	Ground floor of the uranium extraction plant

Another 20 nuclides are used but not shown

Identity	**SV.1.1**			**LV.8.1**		**RMA.1.2**		
Total activity (cont.+NORM) [Bq]	1.1E+10			6.5E+09		3.3E+09		
Specific activity [Bq/kg]	2.0E+03			3.1E+04		2.1E+03		
Contamination [Bq]	1.1E+08			6.5E+09		2.6E+08		
Concentration of specific activity [Bq/kg]	2.0E+01			3.1E+04		1.7E+02		
Uranium contamination [g]	8.0E+02			1.8E+04		1.1E+03		
Total uranium content (cont.+NORM) [ppm]	4.2E+00			8.8E+01		4.7E+00		
	Surface activity	Contamination	Total activity	Specific activity	Contamination	Surface activity	Contamination	Total activity
Nuclide	**[Bq/m^2]**	**[Bq]**	**[Bq]**	**[Bq/kg]**	**[Bq]**	**[Bq/m^2]**	**[Bq]**	**[Bq]**
K40	1.09E+03	3.3E+06	4.10E+09	1.09E+03	2.29E+08	0.00E+00	0.00E+00	1.20E+09
Tl208	6.94E+00	2.1E+04	9.22E+07	6.93E+00	1.46E+06	1.05E+03	1.87E+06	2.88E+07
Pb212	1.93E+01	5.9E+04	2.57E+08	1.93E+01	4.06E+06	2.91E+03	5.21E+06	8.02E+07
Bi212	1.93E+01	5.9E+04	2.57E+08	1.93E+01	4.06E+06	2.91E+03	5.21E+06	8.02E+07
Po212	1.24E+01	3.8E+04	1.64E+08	1.23E+01	2.60E+06	1.86E+03	3.33E+06	5.13E+07
Po216	1.93E+01	5.9E+04	2.57E+08	1.93E+01	4.06E+06	2.91E+03	5.21E+06	8.02E+07
Rn220	1.93E+01	5.9E+04	2.57E+08	1.93E+01	4.06E+06	2.91E+03	5.21E+06	8.02E+07
Ra224	2.84E+01	8.6E+04	2.57E+08	2.84E+01	5.98E+06	4.28E+03	7.67E+06	8.26E+07
Ra228	2.84E+01	8.6E+04	2.57E+08	2.84E+01	5.98E+06	4.28E+03	7.67E+06	8.26E+07
Th230	3.26E+03	9.9E+06	2.71E+08	3.25E+03	6.85E+08	3.10E+03	5.55E+06	8.20E+07
Th231	1.50E+02	4.6E+05	1.25E+07	5.00E+01	1.05E+07	1.75E+03	3.13E+06	6.65E+06
Th234	3.26E+03	9.9E+06	2.71E+08	1.08E+03	2.28E+08	7.49E+03	1.34E+07	8.98E+07
Pa231	1.50E+02	4.6E+05	1.25E+07	1.50E+02	3.16E+07	7.24E+02	1.30E+06	4.82E+06
Pa234m	3.26E+03	9.9E+06	2.71E+08	1.08E+03	2.28E+08	7.49E+03	1.34E+07	8.98E+07
U234	3.26E+03	9.9E+06	2.71E+08	1.11E+03	2.33E+08	4.47E+04	8.00E+07	1.56E+08
U235	1.50E+02	4.6E+05	1.25E+07	5.00E+01	1.05E+07	1.75E+03	3.13E+06	6.65E+06
U236	0.00E+00	0.0E+00	0.00E+00	0.00E+00	0.00E+00	2.40E+02	4.30E+05	4.30E+05
U238	3.26E+03	9.9E+06	2.71E+08	1.08E+03	2.28E+08	7.49E+03	1.34E+07	8.98E+07
	Source	**Factor**		**Source**	**Factor**	**Source**	**Factor**	
	Alum shale	8.79E-01		Leaching remains	8.78E-01	U ext. plant	7.49E+03	
Volyme [m^3]	2302			191		673		
Area [m^2]	3044			957		1790		
Weight [kg]	5293850			210667		1547515		

Inventory of nuclides

Another 20 nuclides are used but not shown

Activity inventory [Bq]

Bq	Sorting works			Leaching hall			Uranium extraction plant			Summary		
	Contamination	Concrete	Total	Contamination	Concrete	Total	Contamination	Concrete	Total	Contamination	Concrete	Total
K40	7.1E+06	1.2E+10	1.2E+10	1.6E+09	1.7E+10	1.9E+10	0.0E+00	4.2E+09	4.2E+09	1.6E+09	3.3E+10	3.5E+10
Tl208	4.5E+04	2.6E+08	2.6E+08	1.0E+07	3.9E+08	4.0E+08	2.9E+07	9.5E+07	1.2E+08	3.9E+07	7.5E+08	7.9E+08
Pb212	1.3E+05	7.3E+08	7.3E+08	2.8E+07	1.1E+09	1.1E+09	8.2E+07	2.7E+08	3.5E+08	1.1E+08	2.1E+09	2.2E+09
Bi212	1.3E+05	7.3E+08	7.3E+08	2.8E+07	1.1E+09	1.1E+09	8.2E+07	2.7E+08	3.5E+08	1.1E+08	2.1E+09	2.2E+09
Po212	8.0E+04	4.7E+08	4.7E+08	1.8E+07	7.0E+08	7.2E+08	5.2E+07	1.7E+08	2.2E+08	7.0E+07	1.3E+09	1.4E+09
Po216	1.3E+05	7.3E+08	7.3E+08	2.8E+07	1.1E+09	1.1E+09	8.2E+07	2.7E+08	3.5E+08	1.1E+08	2.1E+09	2.2E+09
Rn220	1.3E+05	7.3E+08	7.3E+08	2.8E+07	1.1E+09	1.1E+09	8.2E+07	2.7E+08	3.5E+08	1.1E+08	2.1E+09	2.2E+09
Ra224	1.8E+05	7.3E+08	7.3E+08	4.1E+07	1.1E+09	1.1E+09	1.2E+08	2.7E+08	3.9E+08	1.6E+08	2.1E+09	2.2E+09
Ra228	1.8E+05	7.3E+08	7.3E+08	4.1E+07	1.1E+09	1.1E+09	1.2E+08	2.7E+08	3.9E+08	1.6E+08	2.1E+09	2.2E+09
Th230	2.1E+07	7.7E+08	7.9E+08	4.7E+09	1.1E+09	5.9E+09	8.7E+07	2.7E+08	3.6E+08	4.8E+09	2.2E+09	7.0E+09
Th231	9.7E+05	3.5E+07	3.6E+07	8.7E+07	5.1E+07	1.4E+08	4.9E+07	1.2E+07	6.1E+07	1.4E+08	9.9E+07	2.4E+08
Th234	2.1E+07	7.7E+08	7.9E+08	1.9E+09	1.1E+09	3.0E+09	2.1E+08	2.7E+08	4.8E+08	2.1E+09	2.2E+09	4.3E+09
Pa231	9.7E+05	3.5E+07	3.6E+07	2.2E+08	5.1E+07	2.7E+08	2.0E+07	1.2E+07	3.3E+07	2.4E+08	9.9E+07	3.4E+08
Pa234m	2.1E+07	7.7E+08	7.9E+08	1.9E+09	1.1E+09	3.0E+09	2.1E+08	2.7E+08	4.8E+08	2.1E+09	2.2E+09	4.3E+09
U234	2.1E+07	7.7E+08	7.9E+08	1.9E+09	1.1E+09	3.0E+09	1.3E+09	2.7E+08	1.5E+09	3.2E+09	2.2E+09	5.3E+09
U235	9.7E+05	3.5E+07	3.6E+07	8.7E+07	5.1E+07	1.4E+08	4.9E+07	1.2E+07	6.1E+07	1.4E+08	9.9E+07	2.4E+08
U236	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.7E+06	0.0E+00	6.7E+06	6.7E+06	0.0E+00	6.7E+06
U238	2.1E+07	7.7E+08	7.9E+08	1.9E+09	1.1E+09	3.0E+09	2.1E+08	2.7E+08	4.8E+08	2.1E+09	2.2E+09	4.3E+09
Activity [Bq]	2.3E+08	3.0E+10	3.0E+10	4.6E+10	4.4E+10	9.0E+10	4.0E+09	1.1E+10	1.5E+10	5.0E+10	8.5E+10	1.4E+11
Uran [kg]	1.7E+00	6.2E+01	6.4E+01	1.5E+02	9.0E+01	2.4E+02	1.7E+01	2.2E+01	3.9E+01	1.7E+02	1.7E+02	3.5E+02
Weight [kg]			1.6E+07			2.9E+07			5.7E+06			5.0E+07

Jonatan Jiselmark, Studsvik ALARA Engineering

DISPOSAL OF CONTAMINATED MATERIAL

Alternatives considered for disposal of the contaminated material

- Clearance for free use without restrictions
- Use of only slightly contaminated building rubble for construction purposes within the Ranstad site
- Depositing of contaminated building rubble on a for the purpose constructed landfill for inert waste at the Ranstad site
- Depositing of contaminated building rubble, metallic objects and other materials at a regular landfill for hazardous waste
- Depositing in a deep geological repository for long lived radioactive waste of minor amounts of contaminated material

Tommy Norberg, Chalmers University of Technology

STATISTICAL METHODS USED FOR CLEARANCE

Basic parameters

The basic equation for the *mean activity* in a system identity is

$$a = r_N \gamma_D \qquad \left[\mathrm{Bq/m^2}\right]$$

where

$$r_N = r_T - r_B \qquad [\mathrm{c/s}]$$

is the mean of the *net radiation* and γ_D is the *detector efficiency*.

Basic parameters

Most parameters of interest are proportional to the mean activity $a = r_N \gamma_D$, for instance,

- the clearance factors $a_F = ab_F$ and $a_R = ab_R$
- the total amount of uranium waste $g_U = ac_U$

Basic parameters

Notice,

- neither the total r_T or the background r_B are known with certainty, so also the net radiation $r_N = r_T - r_B$ is uncertain
- also the detector efficiency γ_D is uncertain
- the proportionality constants b_F, b_R and c_U are also uncertain

Parameter uncertainties Frequency approach

Assume we have measurements of the total and background radiation, and also calibration measurements. We may then calculate estimates of r_N and γ_D and, by multiplying them, an estimate

$$\widehat{a} = \widehat{r}_N \widehat{\gamma}_D$$

of the mean activity a.

Parameter uncertainties Frequency approach

From upper confidence limits for r_N and γ_D, we may calculate an upper confidence limit for a.

There are drawbacks with this approach, of which the main one is that it is difficult to calculate the confidence in the upper limit.

It is also difficult to take into account uncertainties in the proportionality constants that add to the total in the estimates of a_R and other parameters of interest.

For these reasons a Bayesian approach that uses Monte Carlo simulation as the main computational tool is advocated.

Parameter uncertainties Monte Carlo approach

In a Monte Carlo simulation point values are replaced by probability densities, and the resulting uncertainty is calculated by simulation.

The uncertainty in the input parameters r_N, γ_D and the various proportionality constants, may be assessed in essentially two ways:

1. By Bayesian inference techniques
2. By expert judgement

Bayesian inference techniques

The uncertainties in the mean net radiation r_N and the detector efficiency γ_D are assessed by Bayesian statistical methods.

Expert judgement

The uncertainties in the proportionality parameters b_F, b_R and g_U are difficult to measure. They depend on uncertainties in the specific activities of the radionuclid chains, and on other parameters like the weight of the demolition masses.

We assessed the uncertainty in the specific activities and the weight of the demolition masses by expert judgement.

The fact that we were forced to use expert judgements is another argument for calculating uncertainty with Monte Carlo simulation.

Bayesian methodology

Yet another argument for the Bayesian approach is the possibility to predict the outcome of a next observation x_N of a measurement of the net radiation r_N.

This is not possible with statistical methods based on frequency.

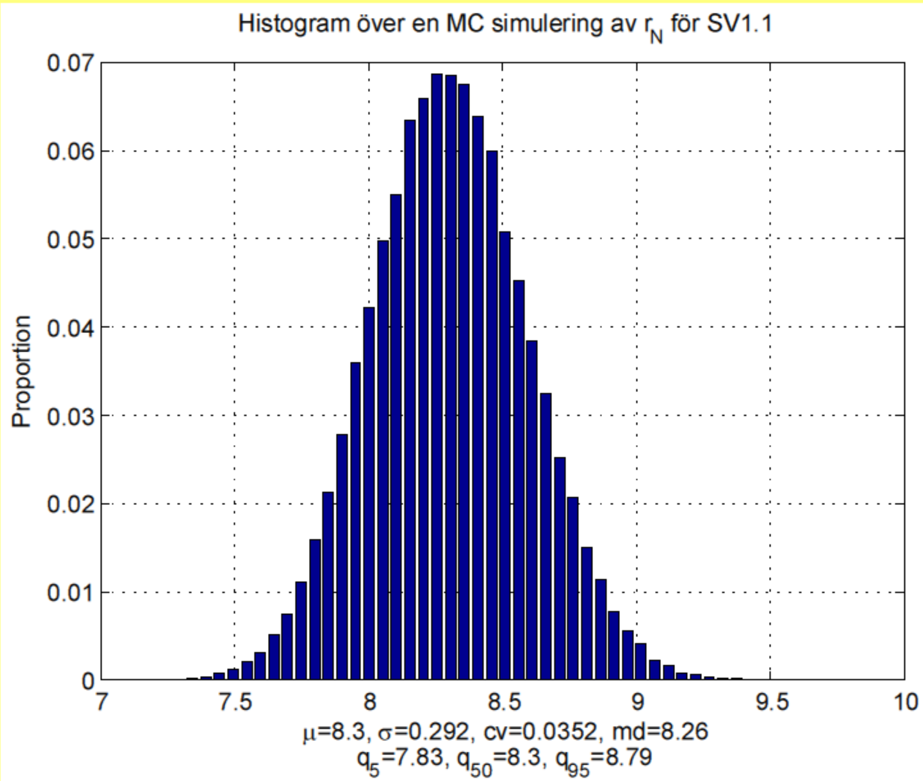
Bayesian methodology

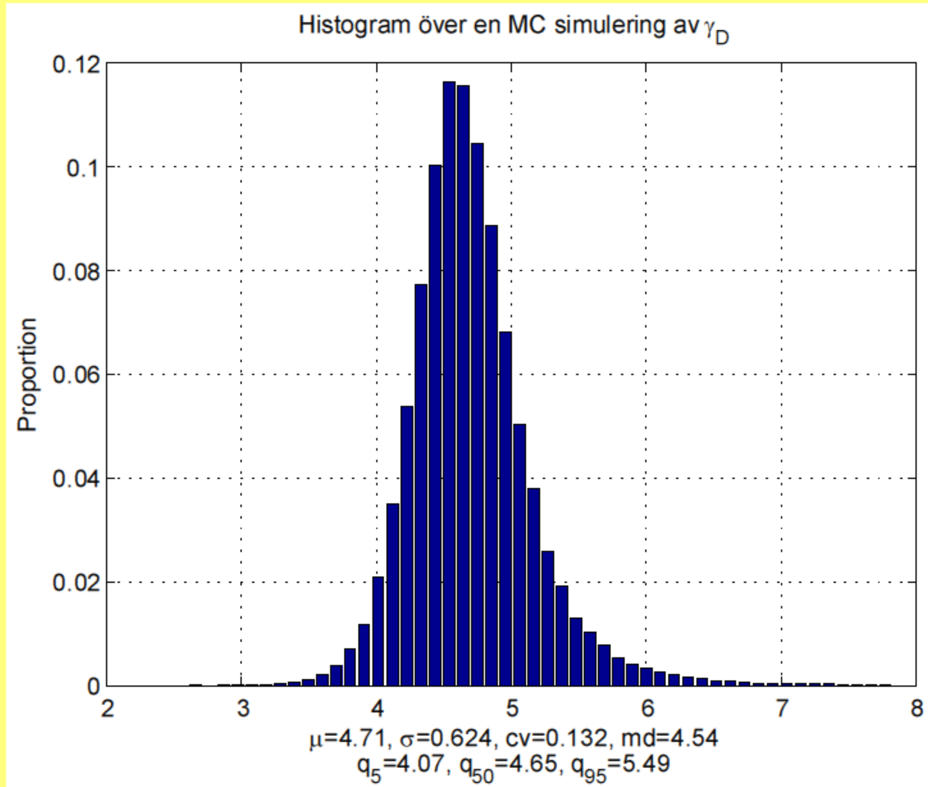
Yet another argument for the Bayesian approach is the possibility to predict the outcome of a next observation x_N of a measurement of the net radiation r_N.

This is not possible with statistical methods based on frequency.

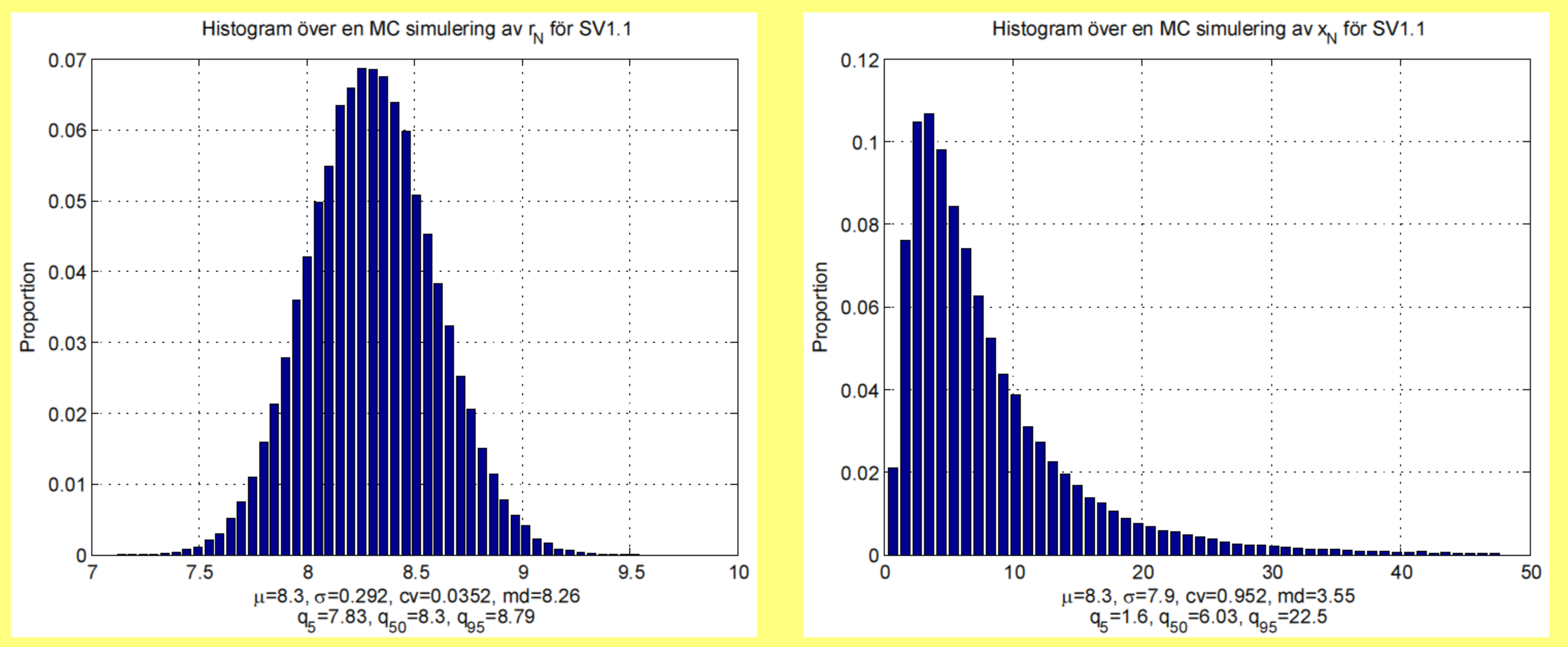
On the next couple of slides, some results from the Monte Carlo simulations are displayed.

The net radiation r_N and the detector efficiency γ_D

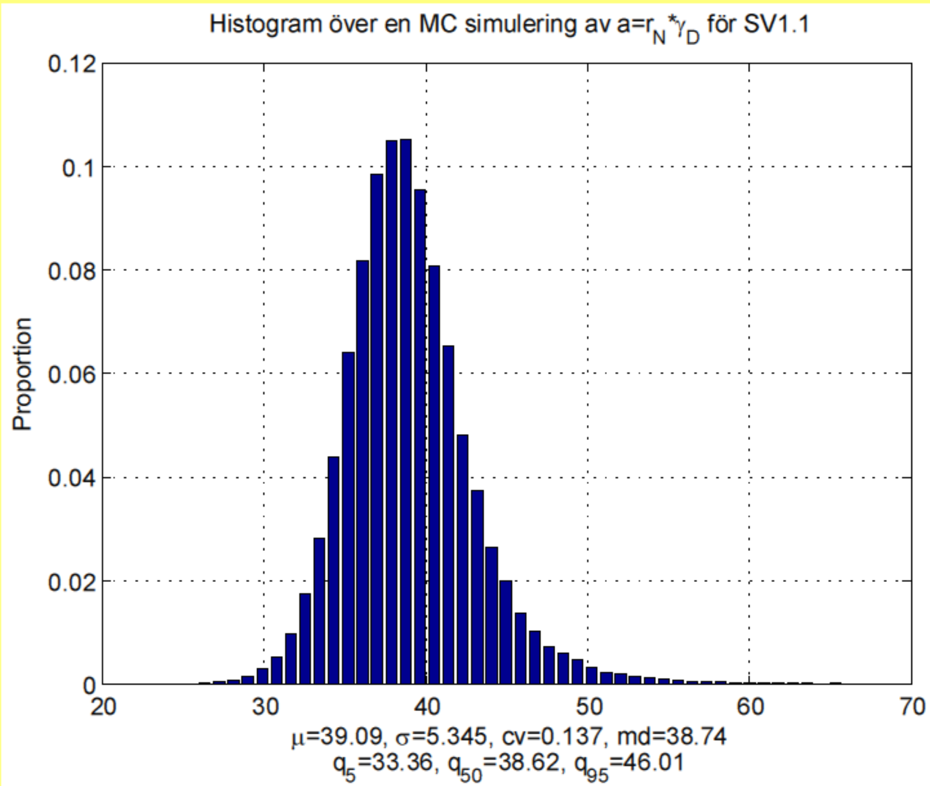


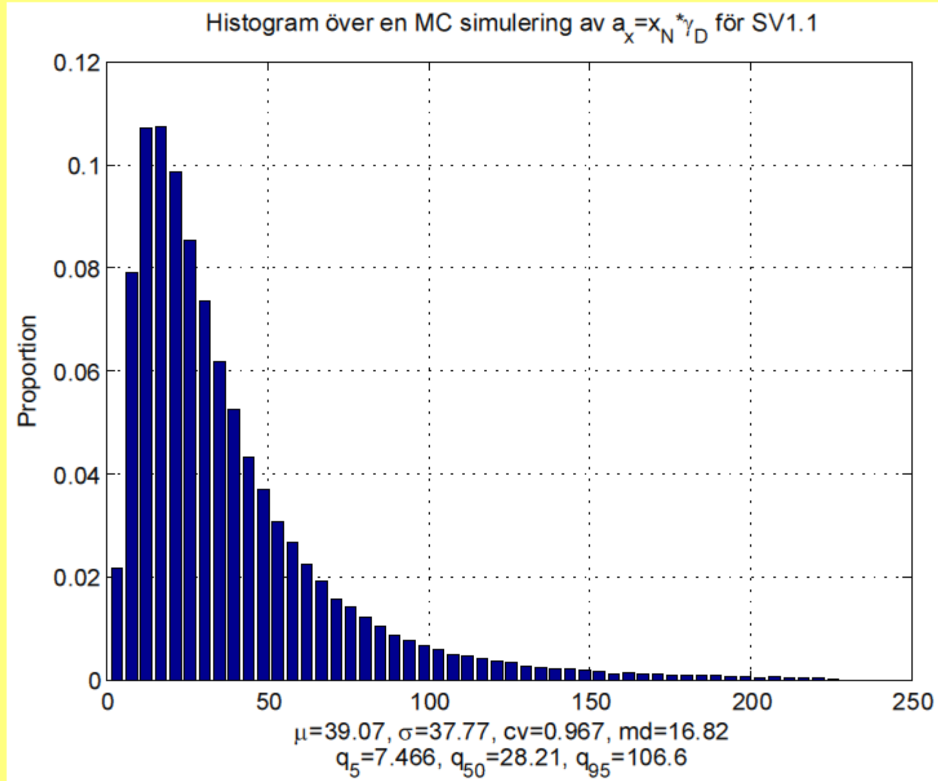


The net radiation r_N and the next measurement x_N

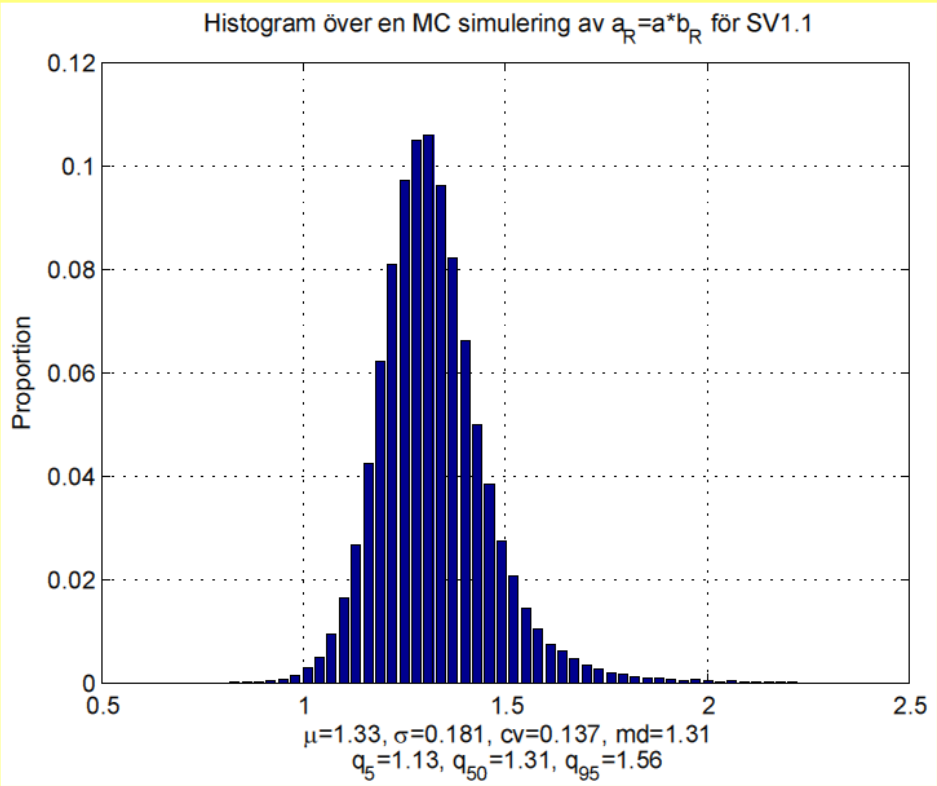


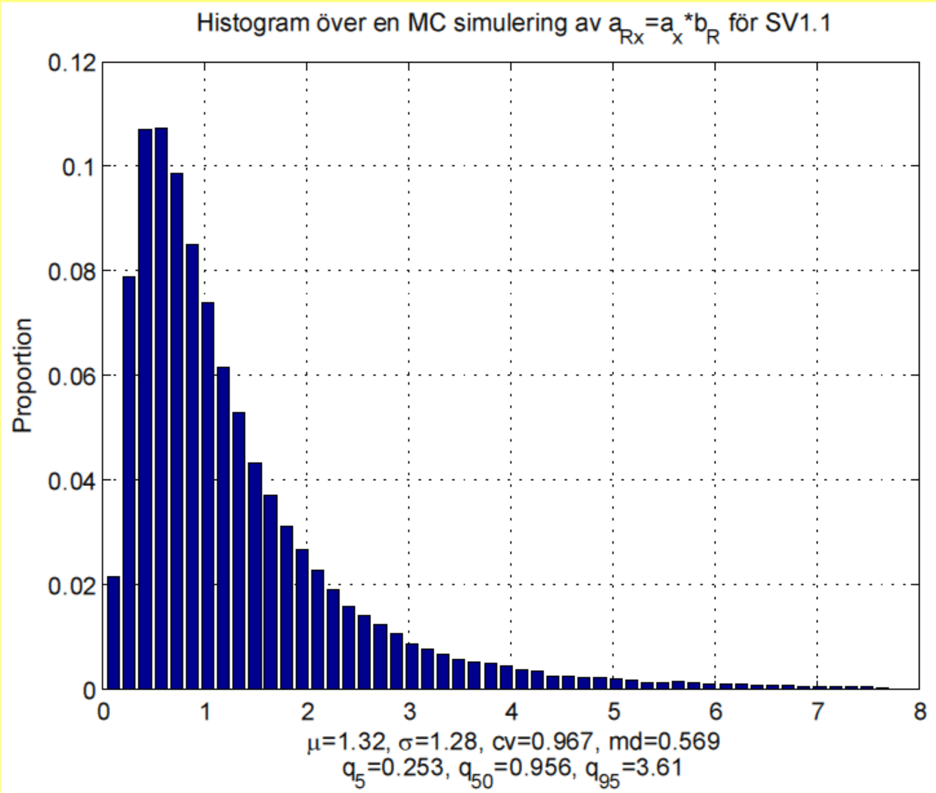
The mean activity $a = r_N \gamma_D$ and $a_x = x_N \gamma_D$





The clearance factor $a_R = b_R a$ and $a_{Rx} = b_R a_x$





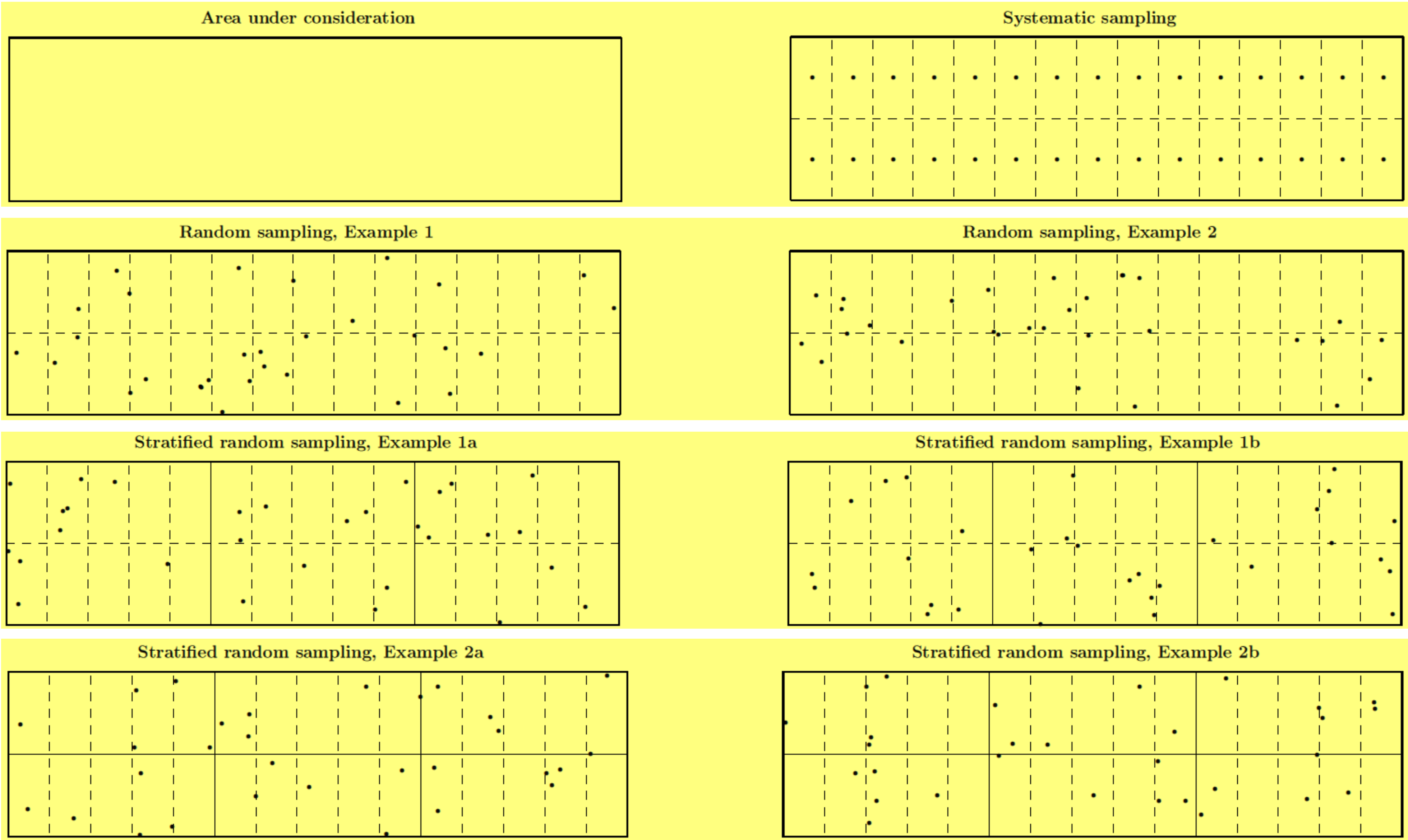
Sampling Considerations

It is important for the Bayesian methods to work well that the sampling of squares to measure is random.

Stratification is ok, if not recommended, but systematic sampling is not.

On the following slide a sampling example is given.

Sampling example



Contamination of the Sorting Works

- SV.1.1 Floors at ground level
- SV.1.2 Floors abov ground level
- SV.2 Walls and columns
- SV.4.1 Conveyor belt tunnel