Analysis of Remotely Accrued Complex Gamma ray Spectra – Proficiency Test (REMSPEC).

M.Dowdall (NRPA)

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NKS Seminar, Stockholm 26-27 March 2009

Why practice?

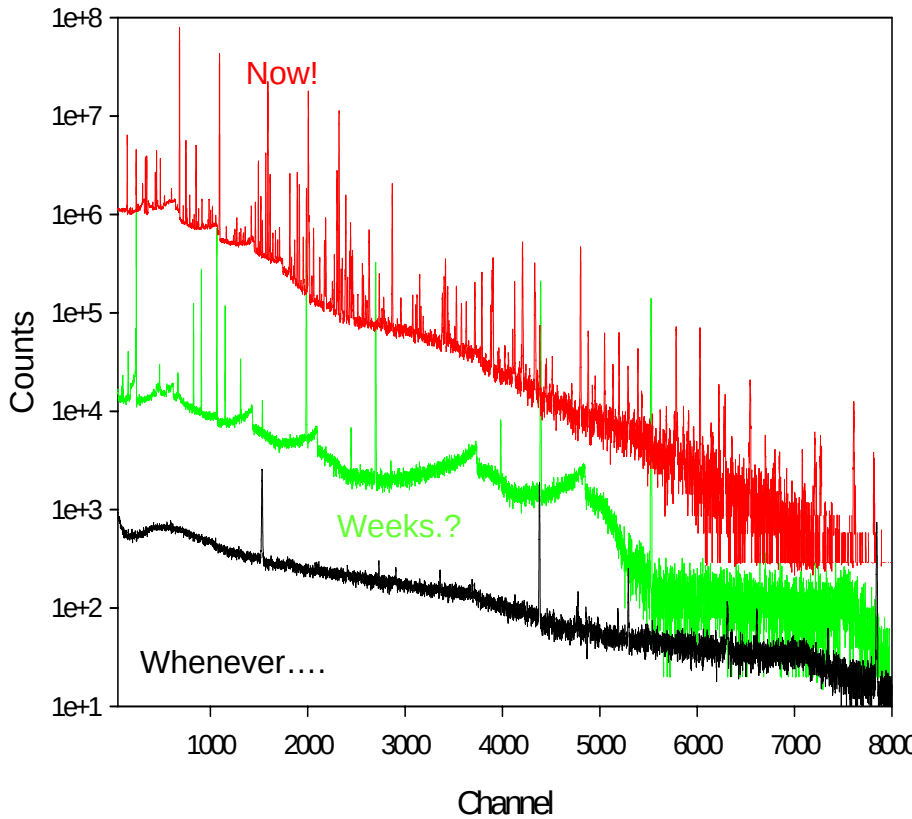
Analyst demographics → older age.

Commercial software not always optimal for accident situations.

Need to be able to provide assistance → requires practice in analysing data from other peoples instruments.

Lack of practice opportunities.

Familiarity → ”contempt”.



Why practice with synthetic spectra?

Logistics – difficult to organise distribution of high activity ”real” samples.

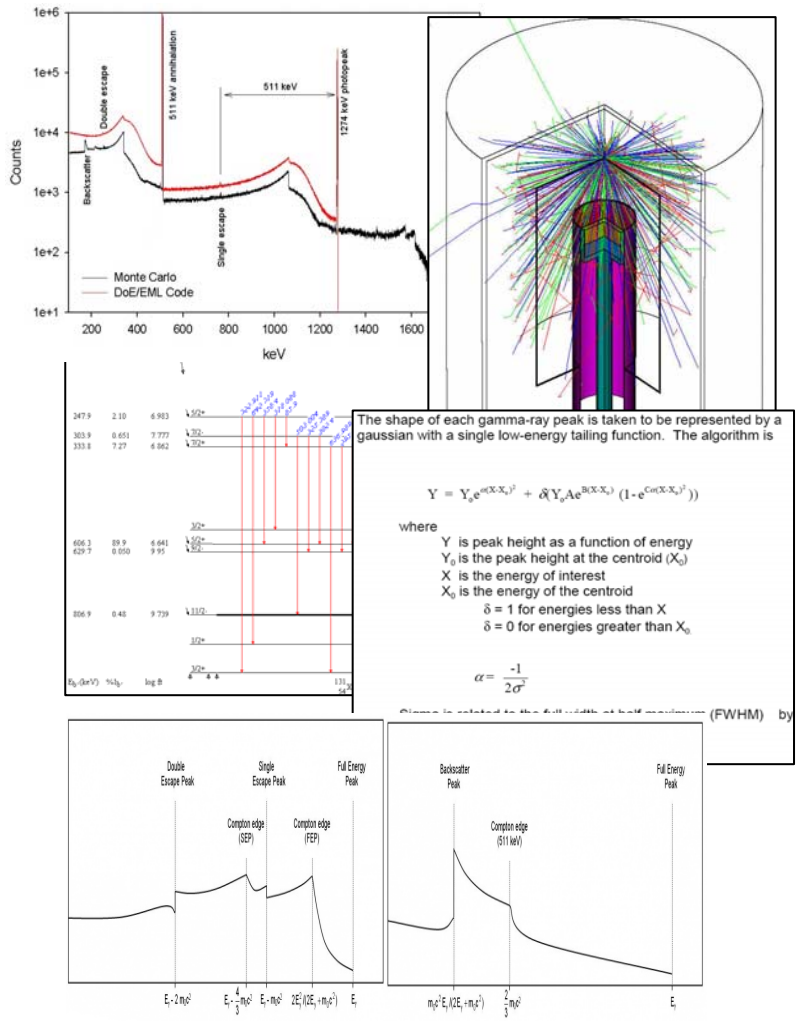
Time – problems with short lived isotopes.

Cost – practicing with real samples is not cheap.

Dose – ALARA principle.

Activity – many labs (non-nuclear countries) are low level labs. May be reluctant to work with high activity samples.

Control – can define exactly what is in a ”sample” and how much (plus ”exotic” isotopes).



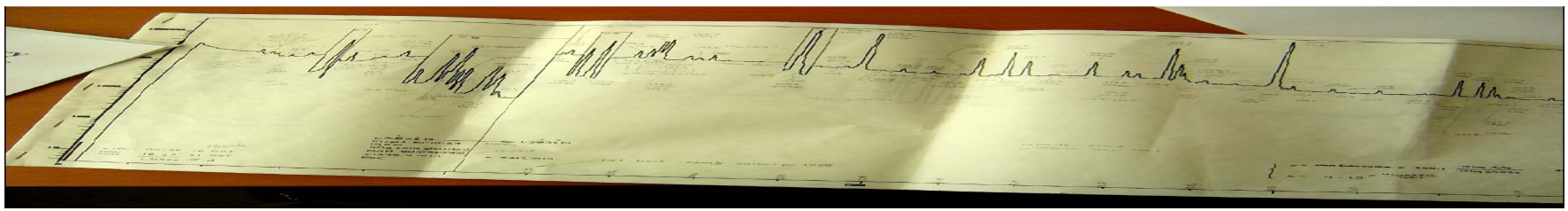
Previous examples

NKS (M.Nikkinen) project from 2001.

"*The Use of Synthetic Spectra to Test the Preparedness to Evaluate and Analyze Complex Gamma Spectra*."

CTBTO PTE 2003 - *Proficiency test for IMS stations 2003.*

Based on airfilter measurements conducted 14 km over Sweden on Monday the 27th of October 1980, 11 days after a hydrogen bomb test at Lop Nor in China.



Nikkinen, M., (2001), The Use of Synthetic Spectra to Test the Preparedness to Evaluate and Analyze Complex Gamma Spectra, NKS Report No. 43, Nordic Nuclear Safety Research, Roskilde, Denmark, ISBN 87-7893-096-0, 80 p.; P. Karhua, P., De Geer, L.-E., McWilliams, E., Plenteda, R., Werzia, R., (2006) Proficiency test for gamma spectroscopic analysis with a simulated fission product reference spectrum, Applied Radiation and Isotopes 64 1334–1339.

NKS REMSPEC 2008

NKS Project : ”*Analysis of remotely accrued complex gamma ray spectra – proficiency test*”

Main Objectives:

- To exercise with a complex post-event gamma spectrum under time constraint to simulate an early phase situation,
- To exercise with data generated by personnel and equipment remote from the laboratory,
- To enhance/exercise analytical competence,
- To enhance competence with respect to exercising.
- Enjoyment.....?

NKS REMSPEC 2008

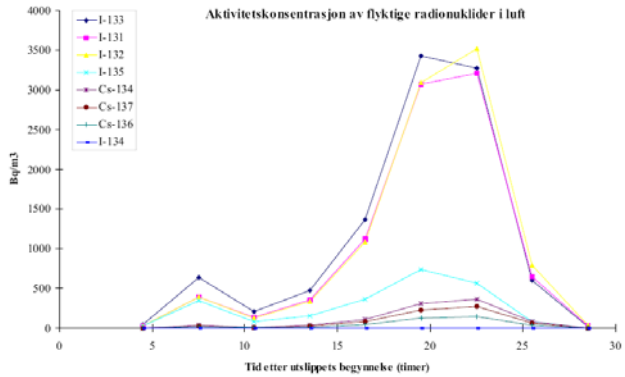
The Exercise Scenario.

Release from the Kola NPP - airfilter measurements conducted in Kirkenes 20 hours (?) after the release Began – deliberately vague.

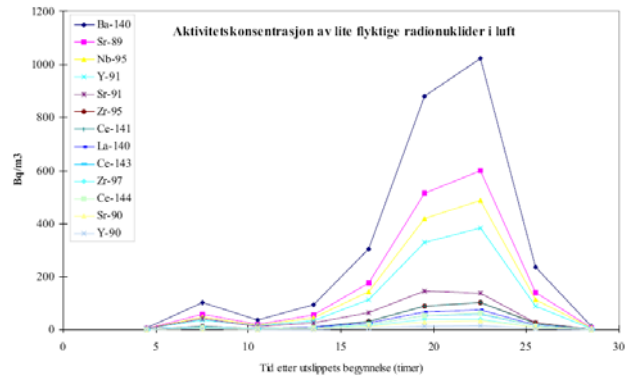
Filters measured by HPGe and assistance sought in analysing the spectra.

Data sent to other agencies/countries with a request for results within 3 hours.

The basis for the spectrum and what it contained was the simulation of Larsen et al (1999).



Aktivitetskonsentrasjon av flyktige radionuklider i luft i Kirkenes kort tid etter et tenkt utslipp ved Kola kjernekraftverk.



Aktivitetskonsentrasjon av lite flyktige radionuklider i luft i Kirkenes kort tid etter et tenkt utslipp ved Kola kjernekraftverk.

Larsen, E., Naadland Holo, E., Saltbones, J., Stokke, E. 1999. Kola konsekvensanalyse. Vurdering av dosemessige konsekvenser av en eventuell ulykke ved Kola kjernekraftverk. StrålevernRapport 1999:Nr 10. Østerås: Statens strålevern, 1999.

The REMSPEC spectra: calibration spectrum

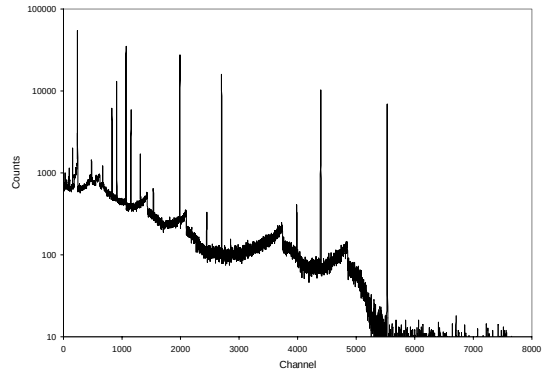
Two spectra: a calibration spectrum and a test spectrum.

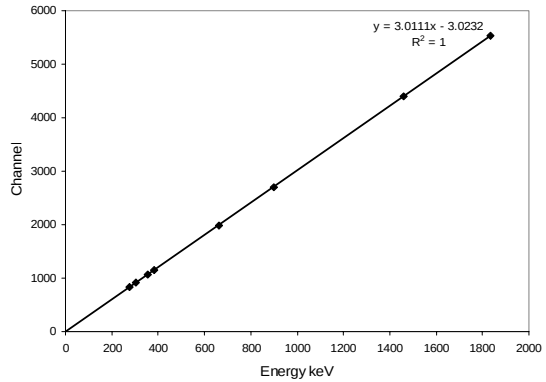
Calibration spectrum: ~100 Bq each of ^{133}Ba, ^{137}Cs, ^{88}Y and ~1000 Bq av ^{40}K ”counted” for” ~ 10 hours.

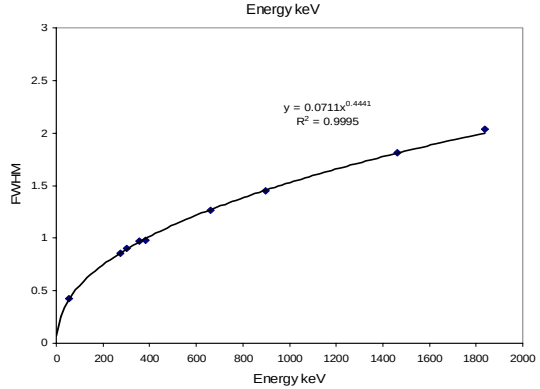
Calibration spectrum was sent *ca*. 2 weeks before the test spectrum: qualitative information but <u>not</u> quantitative.

Efficiency data (both peak and total) was also sent.

Objective: energy and shape calibration, making of calibration files, etc.







The REMSPEC spectra: test spectrum

23 isotopes in 1 m^3 of air from Kirkenes.

Total: 827 photopeaks and 184 x-rays.

Simulated to represent 1 hour live time.

Lab background not simulated: short counts/normal shielding.

All transitions simulated except for EC in ^{134}Cs and IT in ^{131m}Te (no significant gamma contribution).

Pb-x-ray radiation was not included (shielding).

All other relevant processes were simulated – annihalation and true coincidence summing (for both gamma-gamma and gamma – x-ray).

Parent-daughter pairs were included (no assumptions as to equilibrium conditions).

No significant decay corrections required.

Isotope	Modeled activity Bq/m^3.
^{131}I	3046.50
^{132}I	2937. 0
^{133}I	2443.60
^{135}I	217.6
^{134}Cs	321.9
^{136}Cs	73.4
^{137}Cs	251.8
^{103}Ru	297.8
^{127}Sb	218.0
^{140}Ba	914.1
^{140}La	209.1
^{141}Ce	66.4
^{143}Ce	43.0
^{91}Y	376.0
^{91}Sr	58.9
^{95}Zr	80.6
^{95}Nb	409.3
^{131m}Te	202.0
^{132}Te	2850.0
^{131}Te	45.6
^{91m}Y	36.9
^{135}Xe	193.0
^{133}Xe	27.6

The REMSPEC spectra

Spectra were simulated using the CTBTO's modified MCNP code.

Nuclear data (ENSDF filer) from NNDC as of March 2008.

Detector model: standard HPGe detector, characterised and validated earlier.

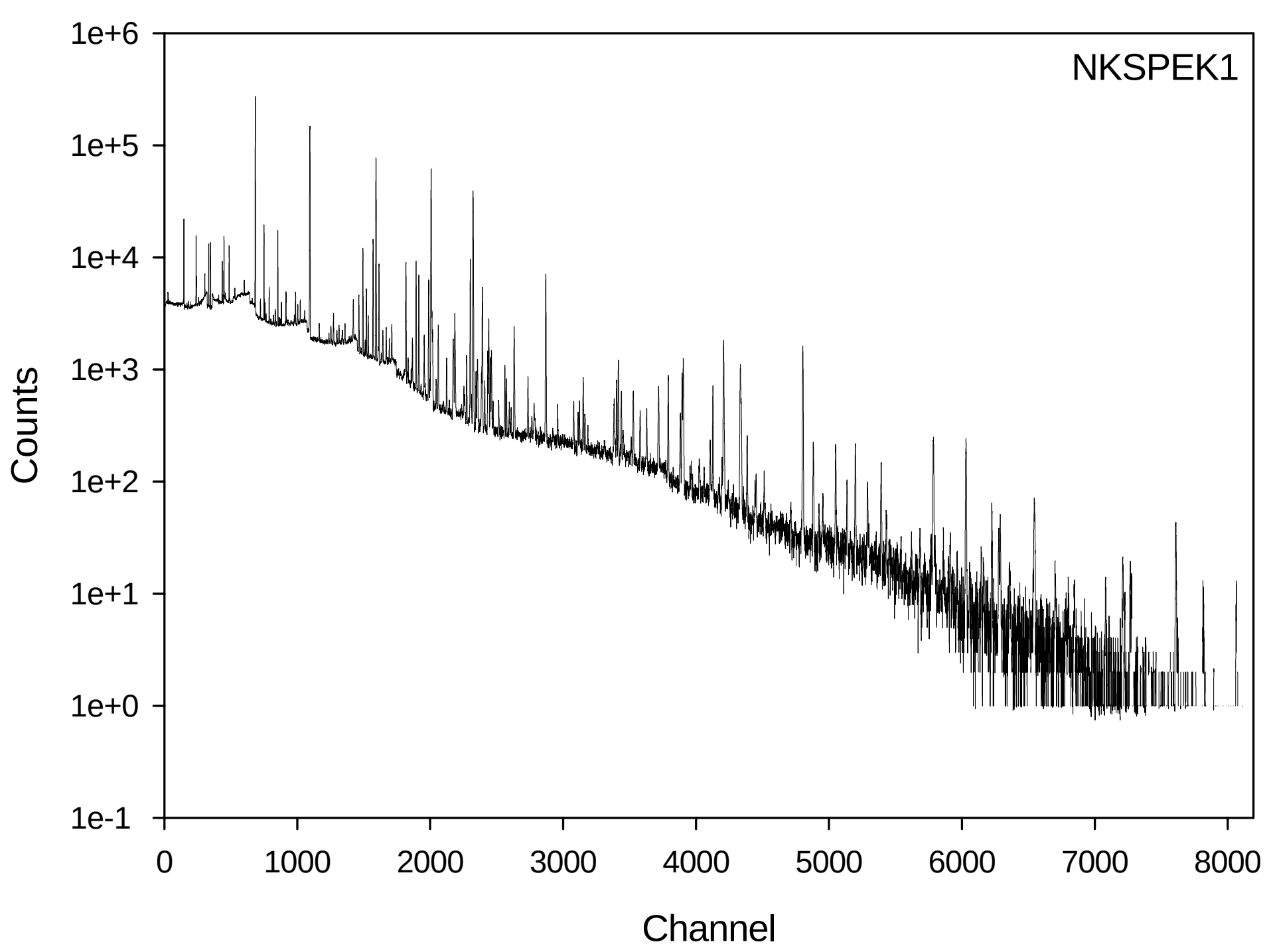
Spectra generated in RMS format first and converted to Canberra (.cnf), Ortec (.chn, .spc), standard .csv, Accuspec (.dat),International MCA (.iec), old EG&G (.mcs), IMS 1.0 (.rms), IAEA (.spe) and text.

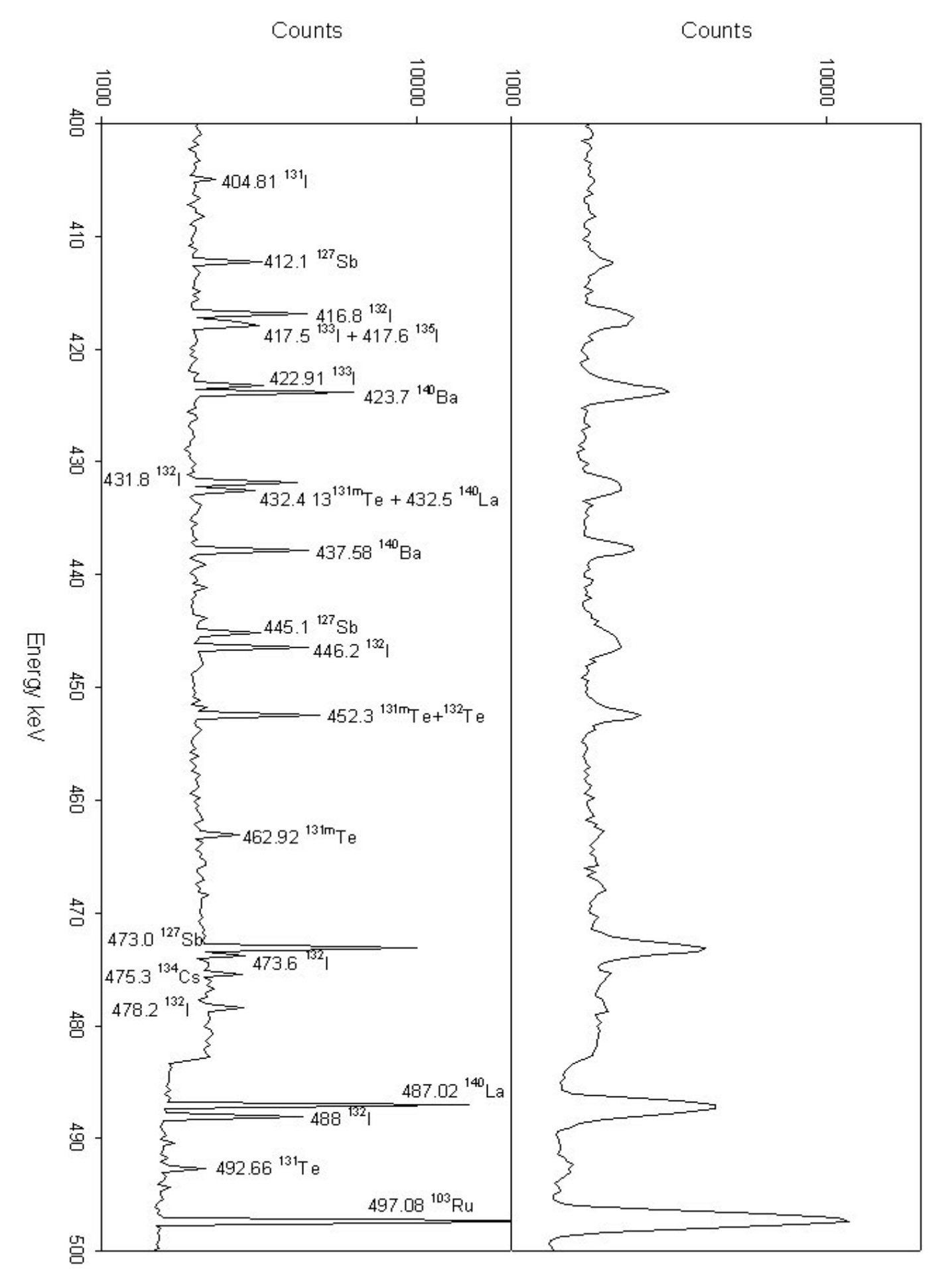
Spectrum fully analysed and coincidence factors checked with the TRUECOINC code before dispatch .

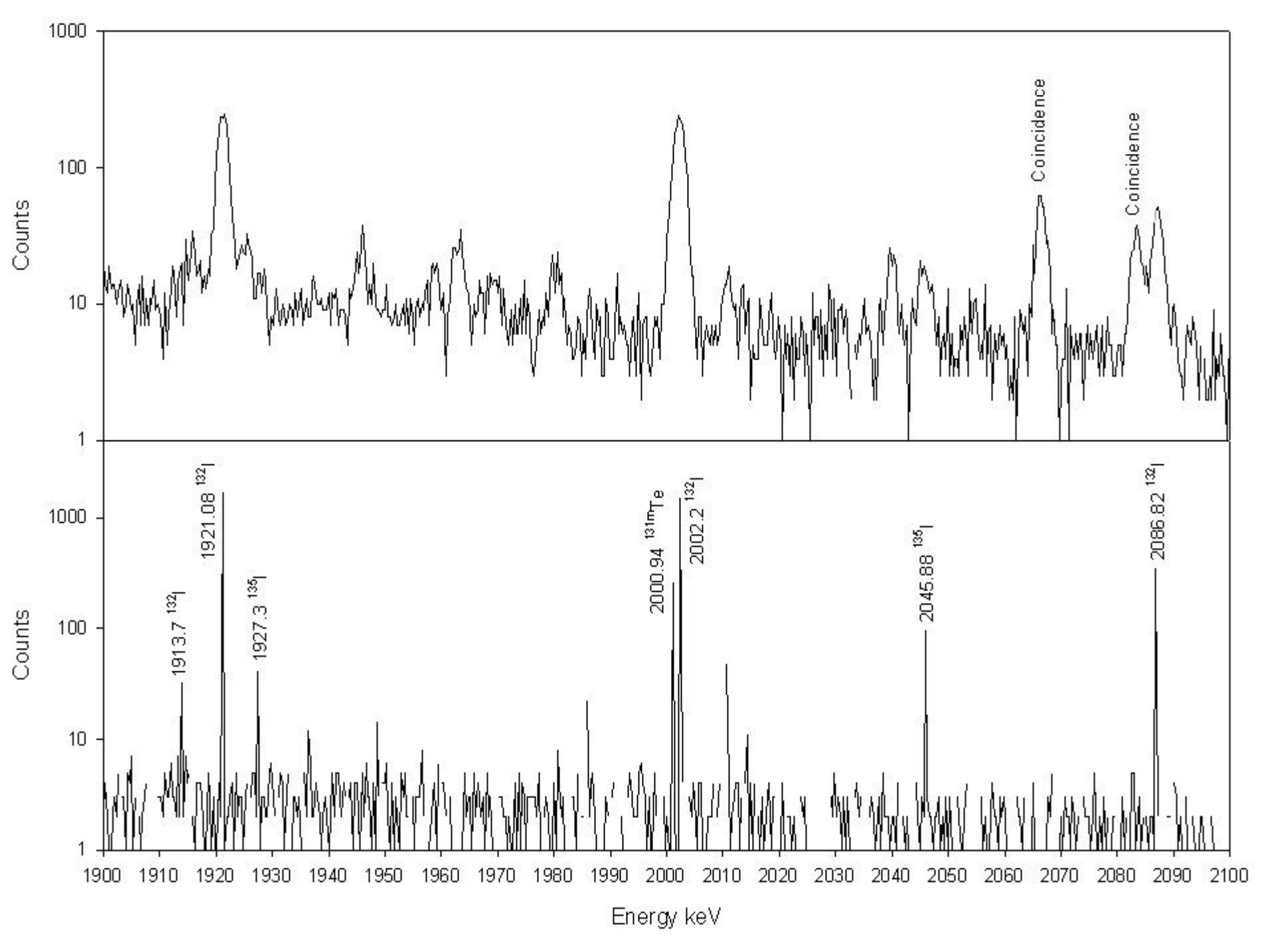
Participants given 3 hours to report and 1 week for further reporting if desired.

Plenteda, R., 2002, A Monte Carlo Based Virtual Gamma Spectroscopy Laboratory. Universitaetsbibliothek der Technischen Universitaet Wien, Resselgasse 4, A-1040 Wien, Austria. 118 p.; Sudár, S., 2002, "Truecoinc", a software utility for calculation of the true coincidence correction, IAEA Tecdoc 1275, International Atomic Energy Agency, Vienna, 37-48.

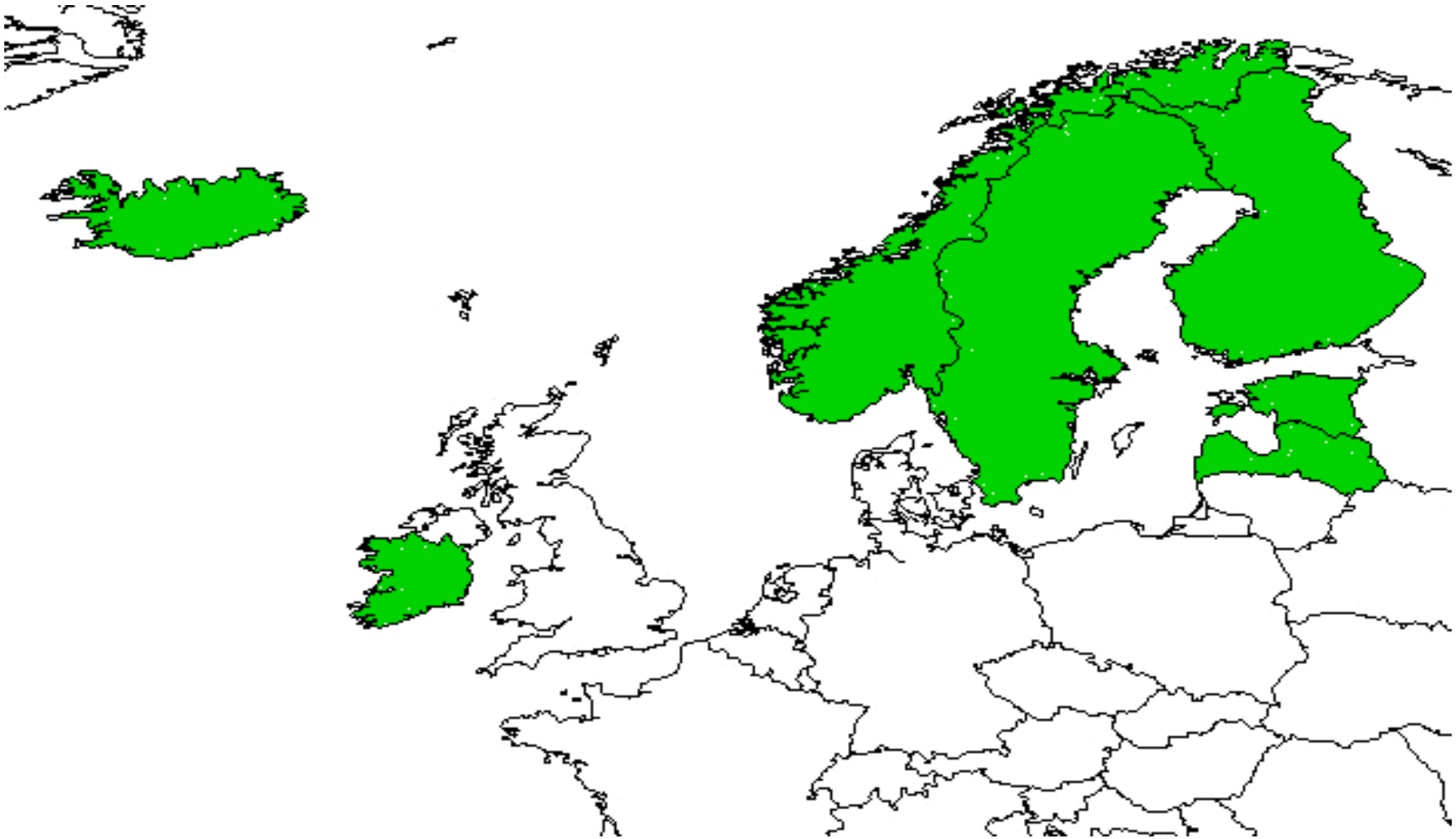
Isotope	Energy keV	Monte Carlo TCC factor	TRUECOINC TCC factor
Cs-134	475.37	1.229	1.210
Cs-134	563.25	1.281	1.240
Cs-134	569.33	1.288	1.250
Cs-134	604.72	1.162	1.140
Cs-134	795.86	1.164	1.140
Cs-134	801.95	1.253	1.220
Cs-134	1167.97	0.917	0.880
Cs-134	1365.19	0.799	0.805
La-140	68.92	1.333	1.290
La-140	109.42	1.338	1.290
La-140	173.54	1.239	1.190
La-140	266.54	1.317	1.250
La-140	432.49	1.254	1.230
La-140	487.02	1.185	1.170
La-140	751.64	1.107	1.100
La-140	815.77	1.042	1.090
La-140	1596.21	1.164	1.145
La-140	2521.40	0.947	0.944
Sb-127	61.10	1.173	1.150
Sb-127	412.10	1.042	1.070
Sb-127	473.00	1.023	1.023
Sb-127	603.50	1.130	1.120
Sb-127	685.70	1.003	1.004
Sb-127	698.50	1.000	1.000
Sb-127	783.70	1.000	1.000


NKSPEK1
Counts
1e+6
1e+5
1e+4
1e+3
1e+2
1e+1
1e+0
1e-1
0
1000
2000
3000
4000
5000
6000
7000
8000
Channel


Counts
1000
10000
Counts
1000
10000
400
410
420
430
440
450
460
470
480
490
500
Energy keV
404.81 131I
412.1 127Sb
416.8 132I
417.5 133I + 417.6 135I
422.91 133I
423.7 140Ba
431.8 132I
432.4 13131mTe + 432.5 140La
437.58 140Ba
445.1 127Sb
446.2 132I
452.3 131mTe+132Te
462.92 131mTe
473.0 127Sb
473.6 132I
475.3 134Cs
478.2 132I
487.02 140La
488 132I
492.66 131Te
497.08 103Ru

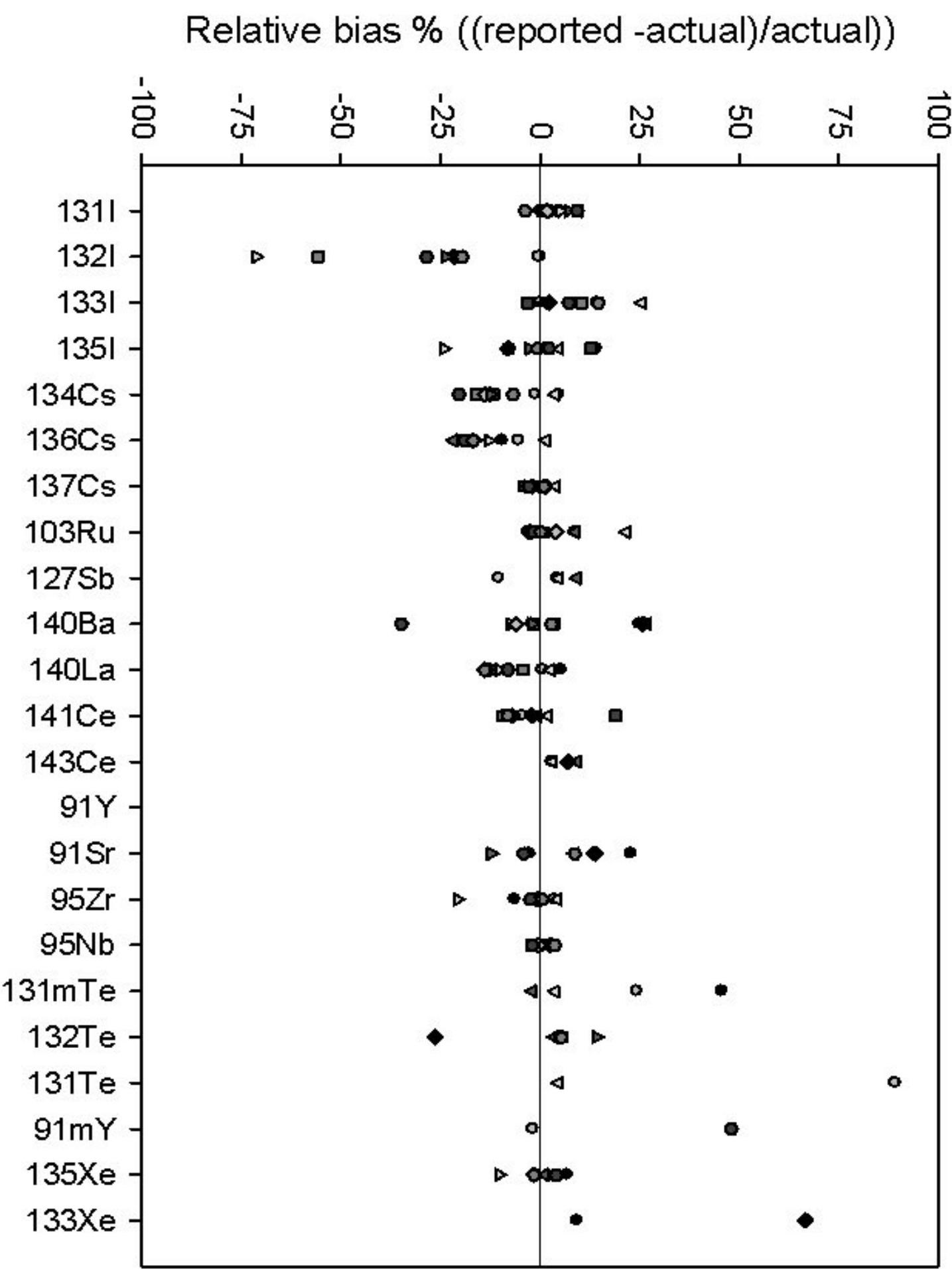

Counts
1000
100
10
1
Coincidence
Coincidence
Counts
1913.7 132I
1921.08 132I
1927.3 135I
2000.94 131mTe
2002.2 132I
2045.88 135I
2086.82 132I
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Energy keV

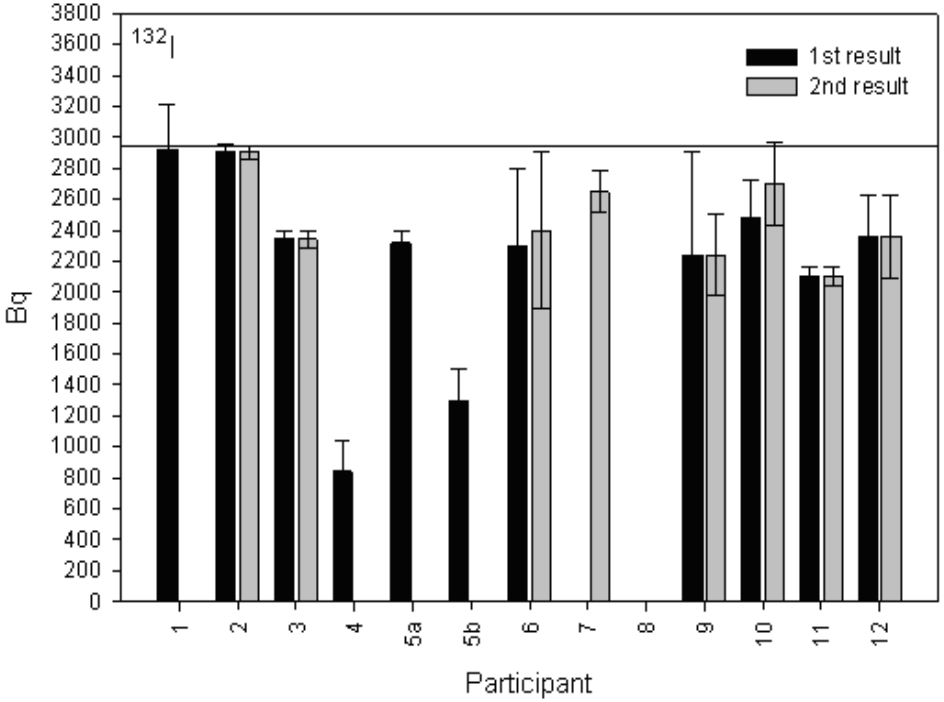
Participants

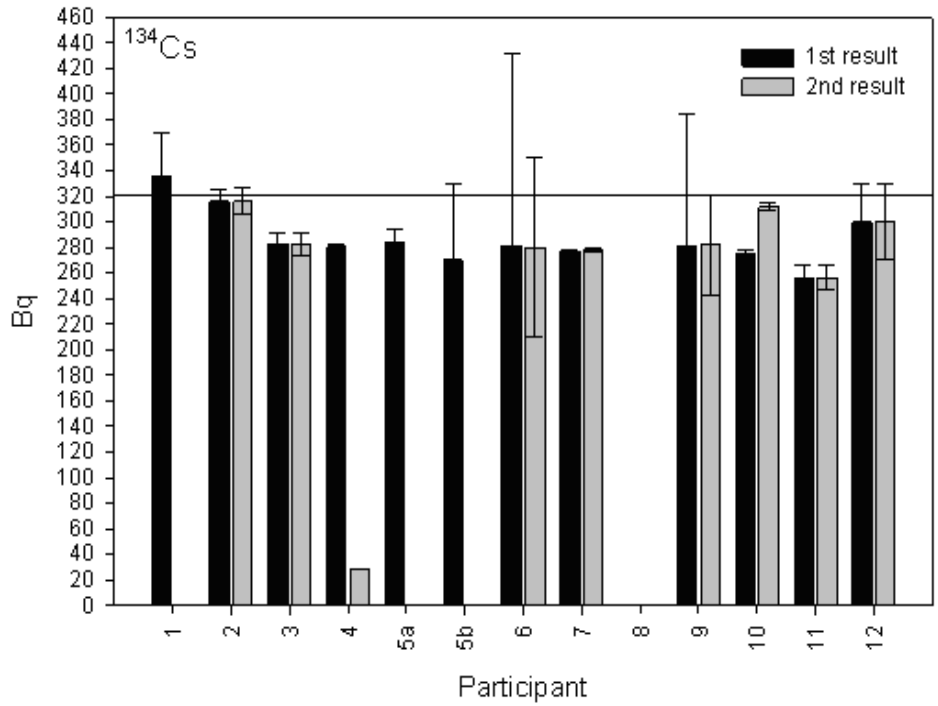


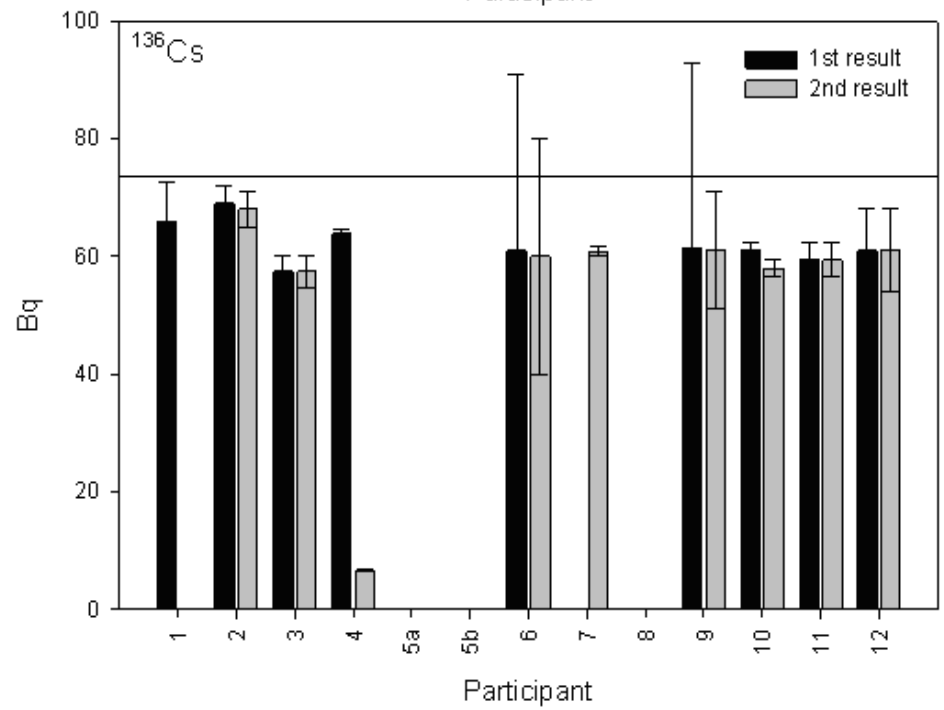
Results within three hours

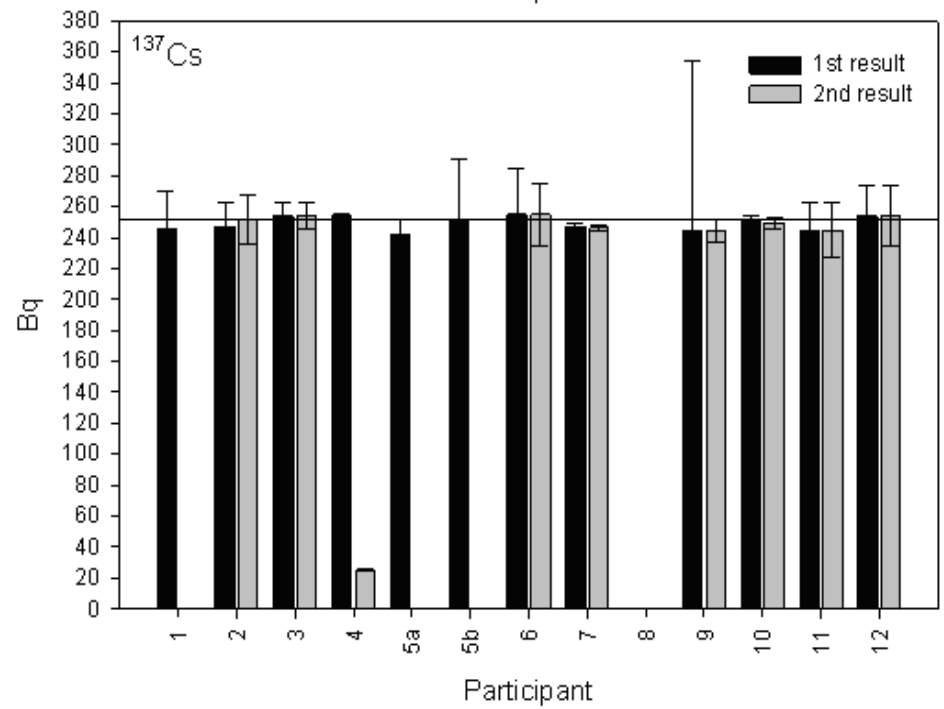
Participant	1	2	3	4	5	5	6	7	8	9	10	11	12
Isotope					1	2							
^{131}I	■	■	■	■	■	■	■	■		■	■	■	■
^{132}I	■	■	■	■	■	■	■			■	■	■	■
^{133}I	■	■	■		■	■	■				■	■	■
^{135}I	■	■		■	■	■	■			■	■	■	■
^{134}Cs	■	■	■	■	■	■	■	■		■	■	■	■
^{136}Cs	■	■	■	■			■			■	■	■	■
^{137}Cs	■	■	■	■	■	■	■	■		■	■	■	■
^{103}Ru	■	■	■	■		■	■	■			■	■	■
^{127}Sb	■	■	■								■		
^{140}Ba	■	■	■	■	■	■	■	■		■	■	■	■
^{140}La	■	■	■	■	■	■	■	■			■	■	■
^{141}Ce	■	■	■		■	■	■	■			■	■	■
^{143}Ce	■	■	■				■				■		
^{91}Y										■			
^{91}Sr	■	■	■	■			■			■		■	■
^{95}Zr	■	■	■	■	■	■	■	■			■	■	■
^{95}Nb	■	■	■		■	■	■	■			■	■	■
^{131m}Te	■	■	■								■		
^{132}Te	■	■	■			■	■			■		■	■
^{131}Te		■	■								■		
^{91m}Y		■										■	
^{135}Xe	■		■	■			■					■	■
^{133}Xe	■						■					■	


Relative bias % ((reported -actual)/actual))
-100
-75
-50
-25
0
25
50
75
100
131I
132I
133I
135I
134Cs
136Cs
137Cs
103Ru
127Sb
140Ba
140La
141Ce
143Ce
91Y
91Sr
95Zr
95Nb
131mTe
132Te
131Te
91mY
135Xe
133Xe


^{132}I
1st result
2nd result
Bq
Participant
1
2
3
4
5a
5b
6
7
8
9
10
11
12


^{134}Cs
1st result
2nd result
Bq
Participant
1
2
3
4
5a
5b
6
7
8
9
10
11
12


^{136}Cs
1st result
2nd result
Bq
Participant
1
2
3
4
5a
5b
6
7
8
9
10
11
12


^{137}Cs
1st result
2nd result
Bq
Participant
1
2
3
4
5a
5b
6
7
8
9
10
11
12

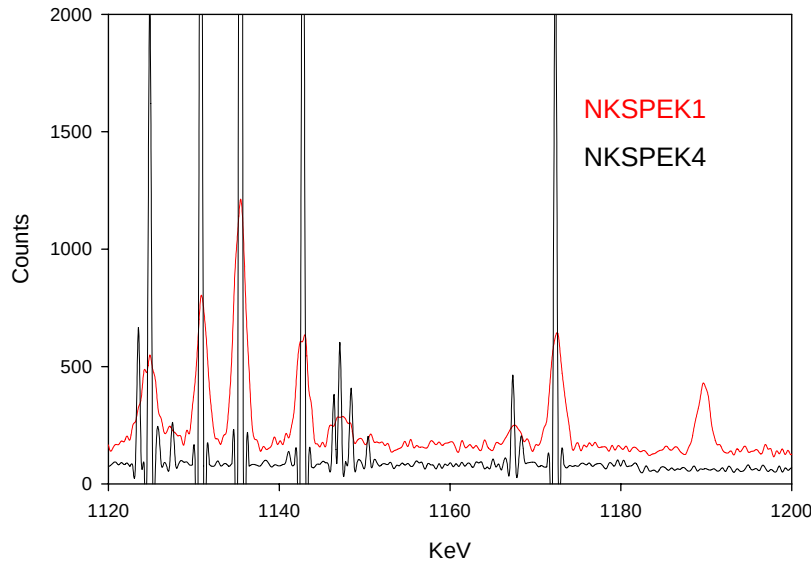
Follow-up

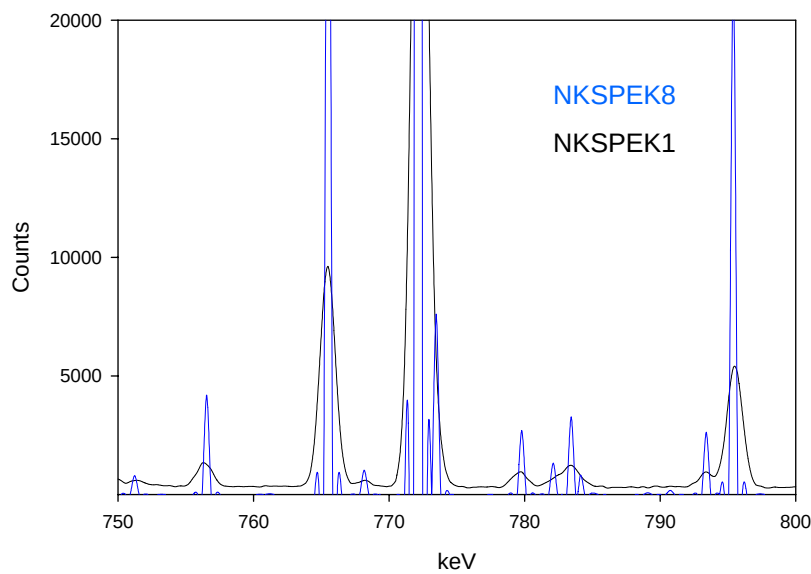
After all results were received, a series of spectra were sent for participants to use however they wanted.

These included various combinations of the test spectrum with high resolution, no coincidence effects, just photopeaks or just the continuum.

Intended useage:

- Further analysis
- Training
- Testing





Some findings.....

- Relatively low implementation of TCS corrections – users who write their own software seem to be better able to correct for it - awkward implementations in commercial software do not help,
- Some problems evident with file types/entering efficiency data,
- Low numbers of false positives correlated with high numbers of correct identifications,
- Wide range of uncertainties reported for the same input data,
- Some difficulties with less frequently encountered isotopes,

Otherwise …. A reasonable performance if viewed within the context of what would be required in the early phase of an accident.

What to do ?

Follow-up exercise with the same type of scenario but with a more challenging analysis - full range of corrections, efficiency transfers, etc etc, different amounts or types of information).

Similar type of exercise with different source term to improve analysis capabilities and experience regarding other "scenarios" - different accident types, scenarios (malevolent acts, orphan sources etc.), sources (different isotopes), different detectors.

Activities related to improvement of what information can be provided – determination of what kind of radioactive material is present, the shielding material, the possible origin, possible age etc.

Establishing procedures for efficient international/interlaboratory assistance - how to make use of the capacity and capability of others in emergency scenarios.

REMSPEC

Report should be available on the NKS website.

Acknowledgements: F.Ugletveit, Ø.G.Selnæs, R.Plenteda, NKS.

All the participants for their efforts.

Questions?