A Wide Spectrum: NKS Gamma Spectrometry Activities Over Two Decades

An overview of gamma spectrometric activities conducted by the NKS since 2000

NKS GammaRayX Seminar, 20 -21 October 2021

DSA

Direktoratet for strålevern og atomsikkerhet

Norwegian Radiation and Nuclear Safety Authority

NKS-B Gamma Spectrometry Overview

Total delivered reports under NKS B - 224

Measurement Strategy, Technology and Quality Assurance - 69

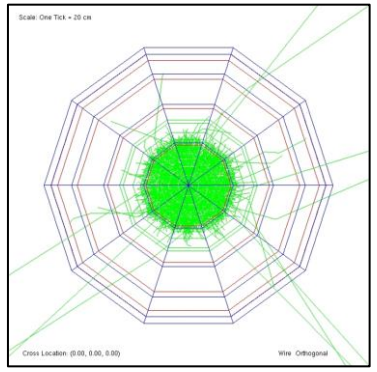
Radiological and Nuclear Emergency Preparedness - 115

184

Gamma Spectrometry included - 129

Gamma Spectrometry focussed specifically – 31

> 53000 downloads for the 31!!



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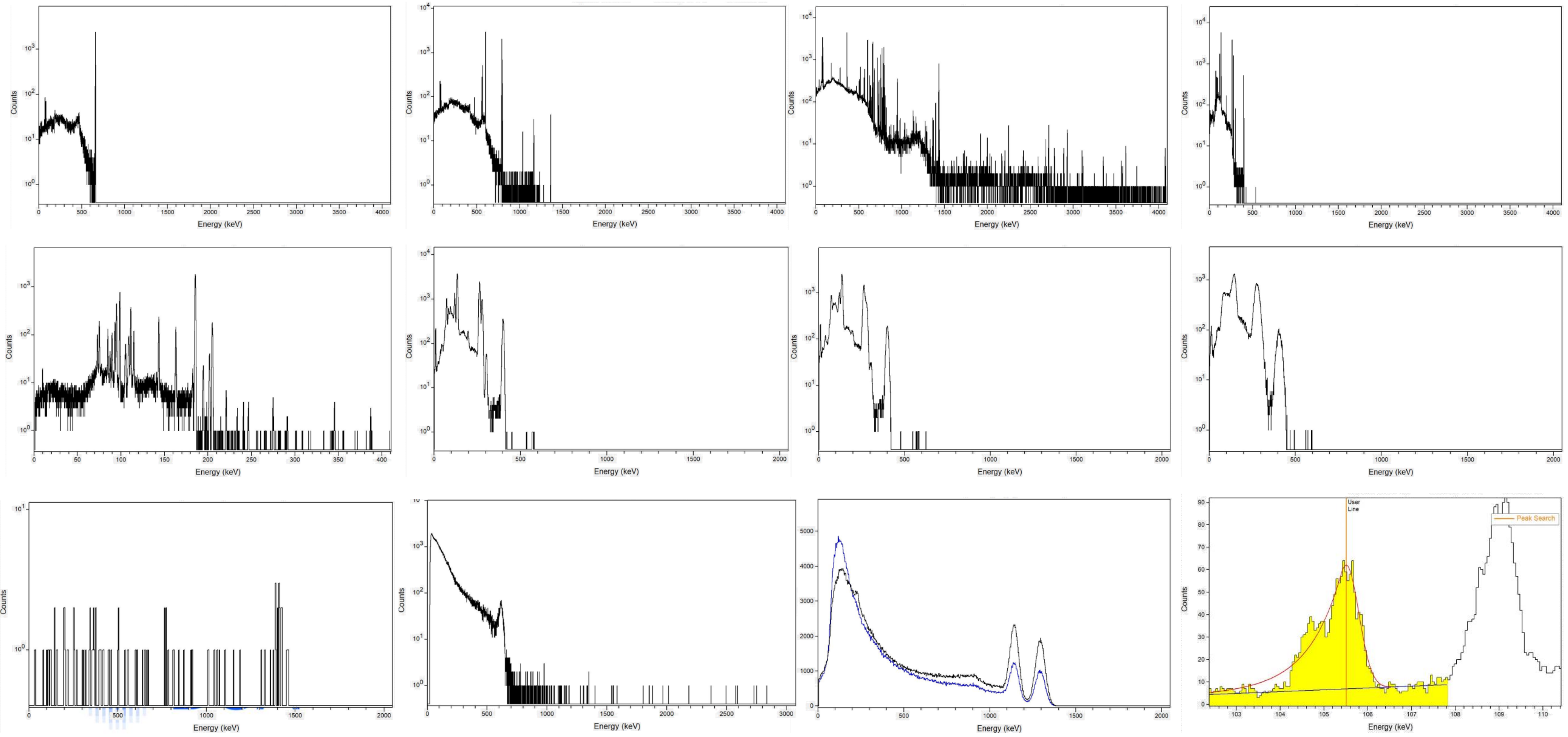
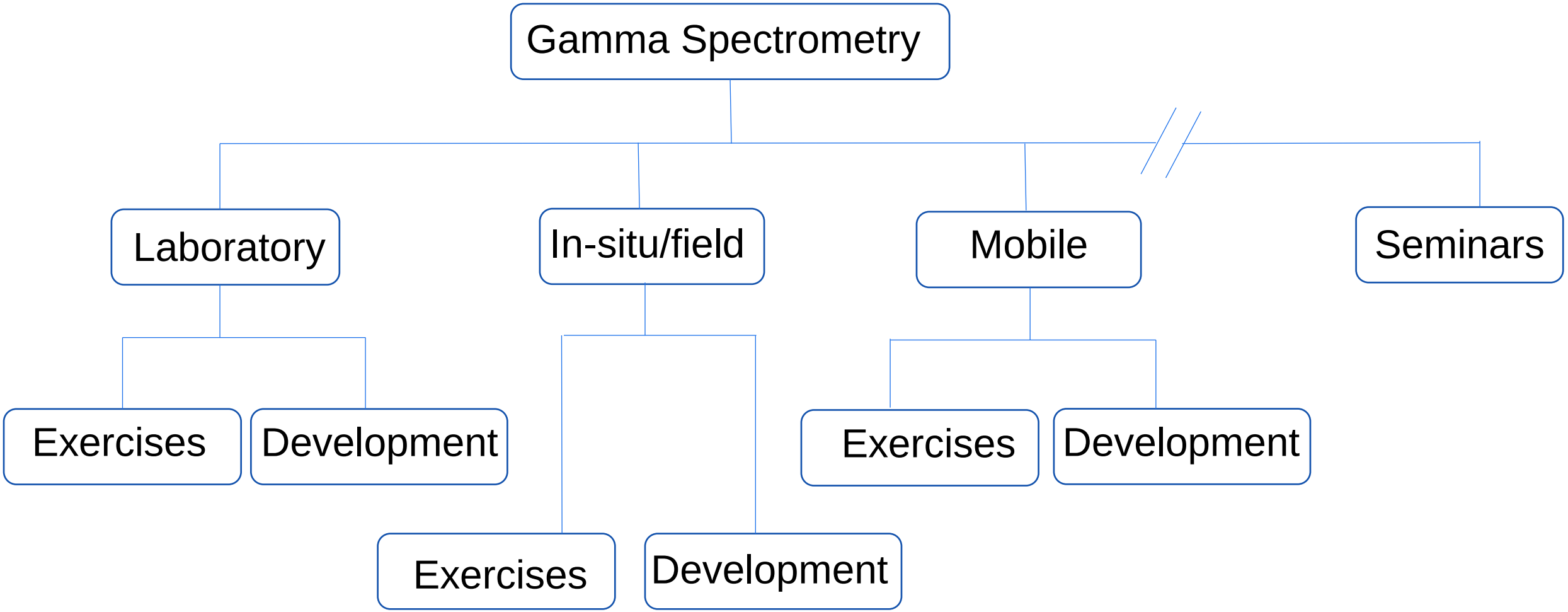
NKS-B Gamma Spectrometry Overview



NKS-B Gamma Spectrometry Overview



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and Nuclear Safety Authority

Laboratory Exercises

Project: The Use of Synthetic Spectra to Test the Preparedness to Evaluate and Analyze Complex Gamma Spectra, 2001, NKS-43

Addressing: the relative scarcity of complex, fallout spectra

Time limited analysis of complex HPGe spectra (VVER-440 accident and a Chernobyl accident spectrum).

First time partially or totally synthetic spectra appear in NKS activities

25 institutes from 9 countries

Nuclide (+- 5-30%)	Bq/sample
Na-22	9.5
K-40	9750
Co-57	11
Co-60	22
Zr-95	235
Nb-95	230
Mo-99	940
Tc-99M	880
Ru-103	1140
Rh-105	21
Rh-106	330
Ag-110M	26
Ag-111	640
Cd-115	50
Sb-125	63
Sb-126	10
Sb-127	230
Te-129	1580
Te-129M	1040
Te-131	41
Te-131M	210
Te-132	6260
I-131	4700
I-132	7550
I-133	260
Xe-133	68
Cs-134	1070
Cs-136A	380
Cs-137	1900
Ba-140	1120
La-140	1320
Ce-141	230
Ce-143	22
Ce-144	160
Nd-147	58
Tl-208	110
Pb-212	170
Pb-214	100
Bi-212	580
Bi-214	390
Ac-228	440
U-235	16
U-237	23
Np-239	660

Laboratory Exercises

Project: Analysis of Remotely Accrued Complex Gamma-ray Spectra – Proficiency Test (REMSPEC), 2009, NKS-188

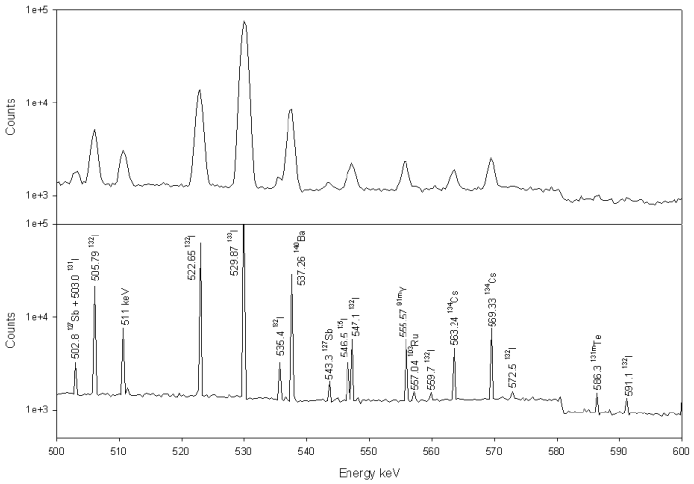
Addressing: Lack of complex, fallout spectra with complex corrections

Time limited proficiency test of a complex, fallout type, wholly synthetic spectrum including true coincidence corrections, density correction, decay corrections

11 participating institutes from 8 countries

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

Table 1. Isotopes and activities modelled for the test spectrum NKSSPEK1.



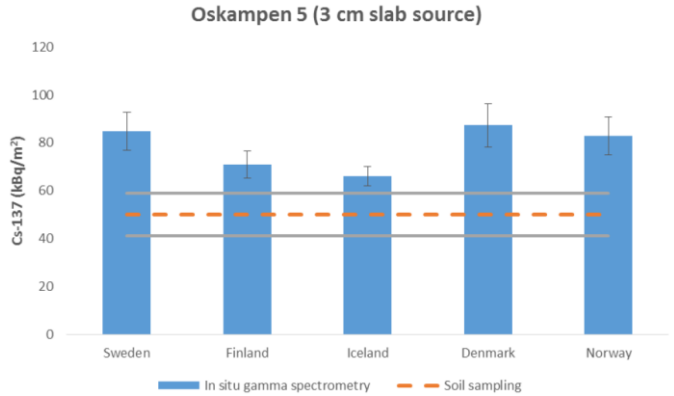
In-situ Exercises

Project: NKS-B Nordic In Situ Gamma Intercomparison (NISI), 2016, NKS-377

Addressing: The need for field exercise opportunities in the area of in-situ measurements

Intercomparison of in-situ measurements by the different NKS countries

Intercomparison of in-situ measurements vs. samples



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In-situ Exercises

Project: Advanced In-situ Gamma Spectrometry Field Activity – Chernobyl (GAMFAC), 2015, NKS-352

Addressing: lack of exercise opportunities in highly contaminated non-Nordic environments

All the NKS countries on tour in the Belarusian Exclusion Zone.

Testing of methodologies and performance:

→ variety of depositional environments,

→ deposition levels,

→ varierty of post depositional behaviours.

In-situ Exercises

Project: Proficiency Test in the Analysis of Gamma Spectra for Malevolent Radiological Situations (*MALRAD*), 2009, NKS-207

Addressing: the need for practice opportunities with field gamma spectrometry in incident response

In-situ measurements where the measurement – both quantitatively and qualitatively - was made difficult by either the context or a perpetrator. Distribution of entirely synthetic spectra from a series of scenarios

18 participating institutes from 10 countries.

In-situ Development

Project: Activity Estimation of Shielded or Hidden Radionuclides in Emergency Conditions (RADSHIELD), 2017, NKS-399

Addressing: the determination of the properties of unknown sources in unknown locations behind an unknown shield.

- Development of methods facilitating the characterization of shielding materials
- Facilitating better estimates of activity of hidden or shielded sources

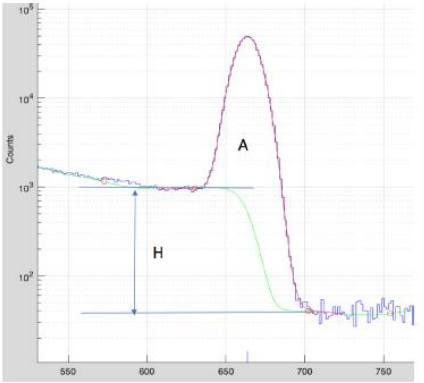


Figure 2.1 Definition of step height *H* (1/keV). *H* can also be understood as an area of a rectangle having width of 1 keV. Measurement ID 2.

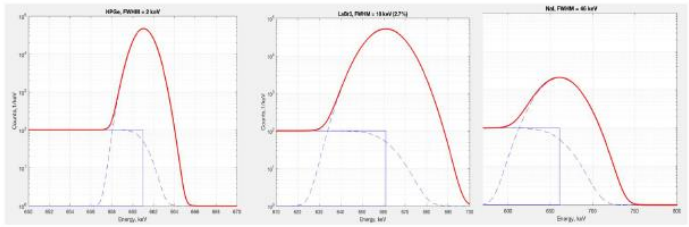
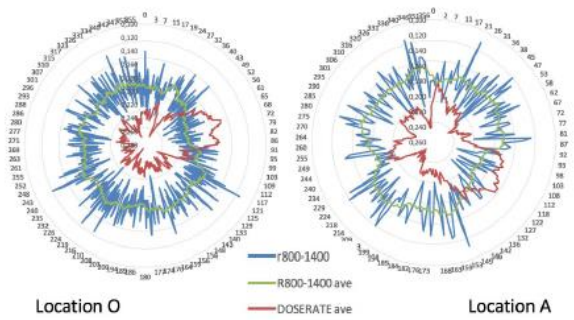


Figure 2.2 Step underneath a Gaussian peak as a function of detector resolution. The step is an inverse erf function with the same shape parameter as the peak itself. *SR* =0.001; (*H* = 100, *A* =100000). The figure shows the convolution of a step (rectangle) and energy peak at 661 keV (delta function) with a Gaussian resolution function characteristic to different detectors.



Mobile Measurement Exercises

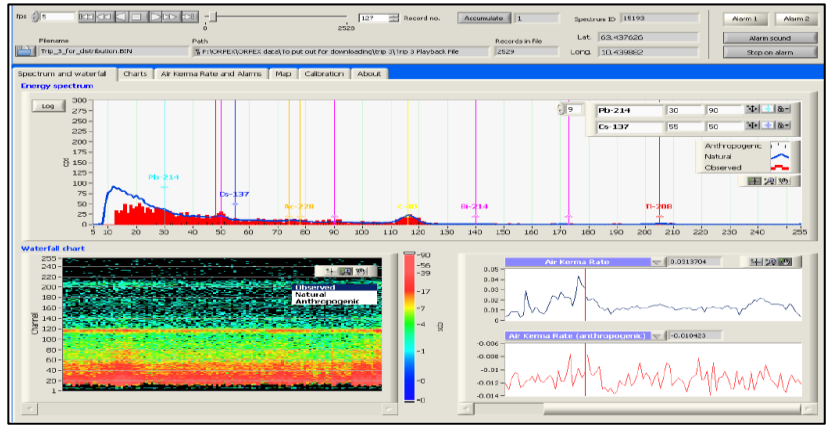
Project: Orphan Sources and Fresh Fallout: Virtual Exercise in Mobile Measurement (*ORPEX*), 2011, NKS-252

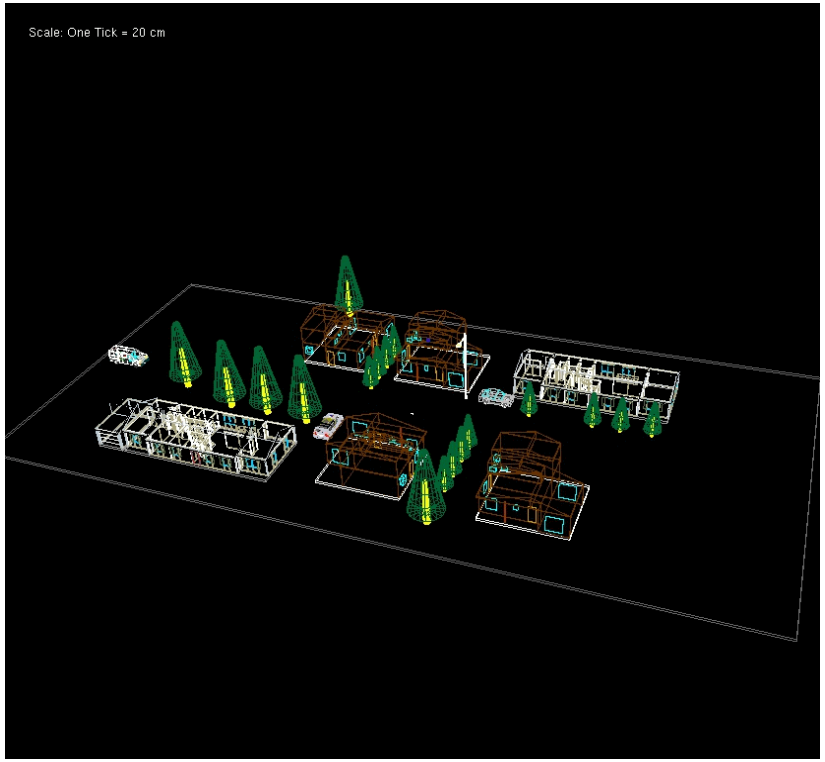
Addressing: need for practice opportunties for mobile measurement for those not typically deploying mobile measurement equioment

Distribution of custom software and mobile measurment datasets from trips along which individual sources had been «hidden» in various configurations as well as a trip through a zone of freshly deposited fallout.

16 participating institutes from 6 countries.

Participants asked to locate, identify and quantify the individual sources and quantify and map the areas of fallout to the best of their ability.





Mobile Measurement Exercises

Project: Mobile Measurement: Field Exercise in Fallout Mapping in the Belarusian Exclusion Zone (*MOBELRAD*), 2014, NKS-320

Addressing: lack of exercise opportunities in areas of high contamination

Participants from all the NKS countries travelled to the Belarusian Exclusion Zone and spend a week conducting mobile measurements along pre-characterized routes.

From the Nordic perspective:

→ New environment,

→ Higher contamination levels

→ Practice in “assistance” type operations

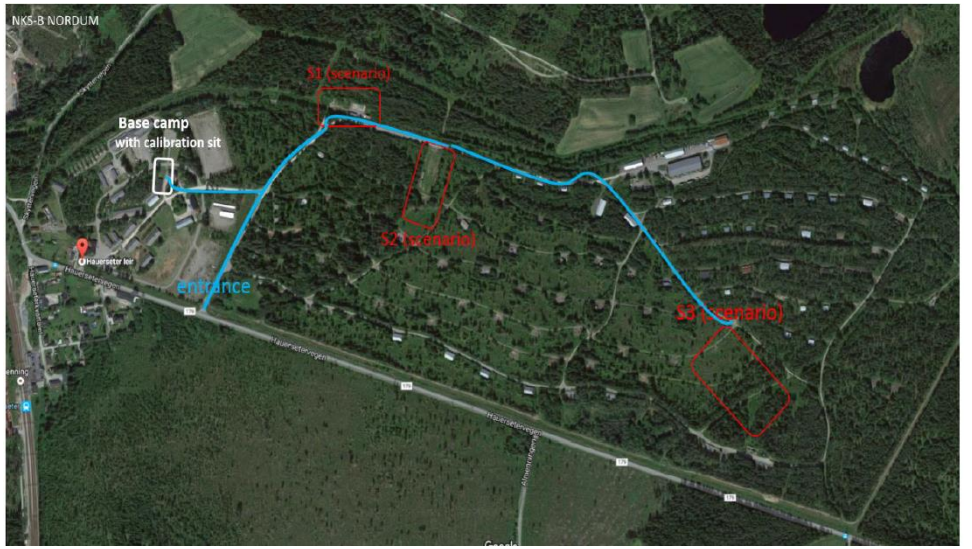
→ Field testing of equipment and procedures.

Mobile Measurement Exercises

Project: Intercomparison of Nordic Unmanned Aerial Monitoring Platforms (*NORDUM*), 2016, NKS-378

Addressing: the lack of opportunities for practicing unmanned aerial measurements in the field

Practical field exercise involving use of aerial platforms for locating, identifying and quantifying point sources in a range of environments.



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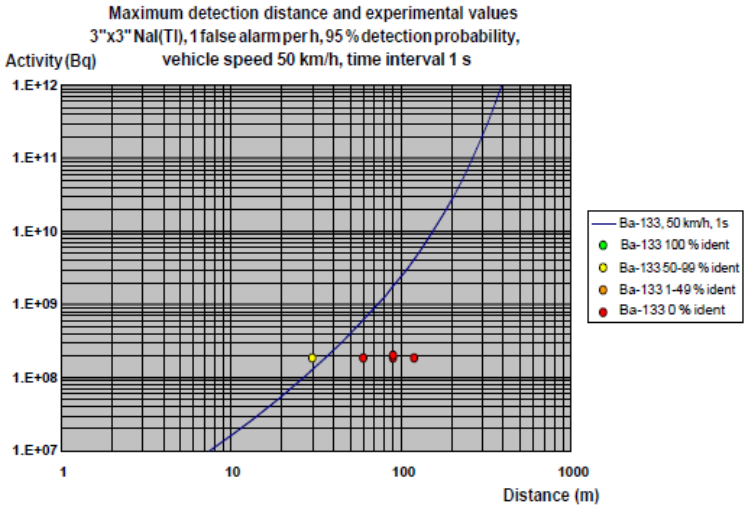
Mobile Measurement Development

Project: Mobile Search of Material Out of Regulatory Control (MORC) –Detection limits assessed by field experiments (MOMORC), 2019, NKS-421

Addressing:

Development of means of calculation of detection limits for sources under various mobile measurement conditions.

Theoretical approaches to the problem of detection limits for mobile measurement systems coupled to field generated data for a number of platforms in use in the NKS region.

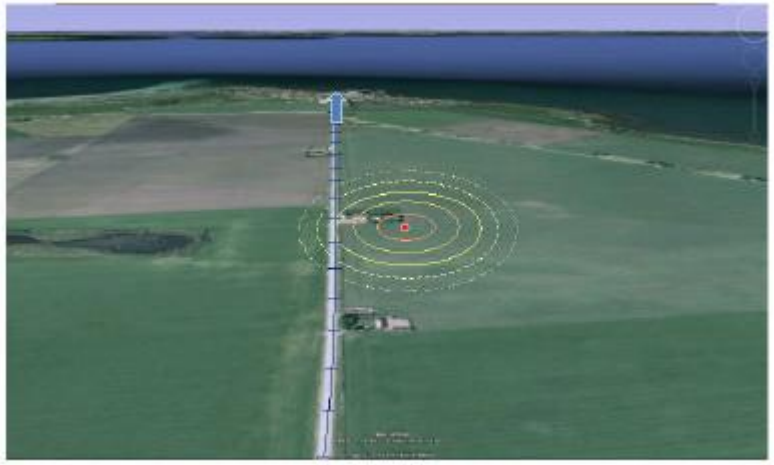


Mobile Measurement Development

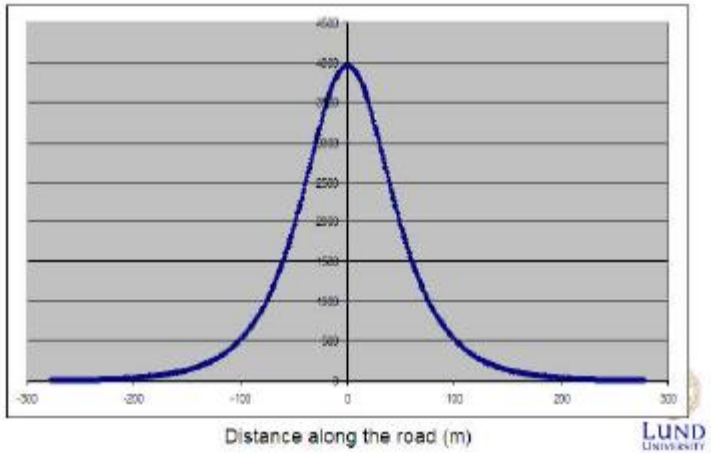
Project: Improvement of Automatic Methods for Identification of Radioactive Material Out of Regulatory Control (MORC) by Mobile Gamma Spectrometric Search Experiments (AUTOMORC), 2017, NKS-422

Addressing: improved methods of rapid registration of sources in mobile gamma ray spectrometry

Bayesian statistical analysis method to determine locations and activities for gammapoint sources in mobile search distance.



The fluence rate (intensity) curve



Mobile Measurement Development

Project: Area Specific Stripping of Lower Energy Windows for AGS and CGS NaI Systems (ASSb), 2005, NKS-109

Addressing: more effective use of large NaI systems in mobile gamma spectrometry

Direct extraction of stripping factors from airborne (AGS) and carborne gamma-ray spectrometry (CGS) data sets without having to calibrate the detector systems beforehand.

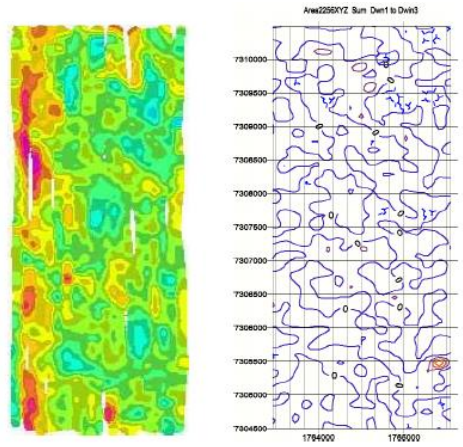


Figure I.1 and I.2. Altitude of SGU AGS equipment during Area 2 measurements (left) and stripped count rate for window 1 to 3 summed (right). The altitude scale is from light blue (below 40 m) to red-violet (above 80 m). The stripped count rate scale goes from –100 to + 300 with most curves representing 0 (surplus) counts.

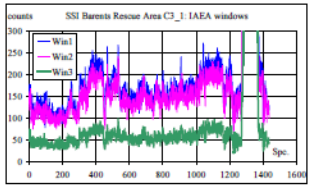


Figure M5. Gross counts Win1-3, C3.

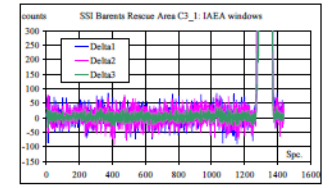


Figure M6. Stripped counts Win1-3, C3.

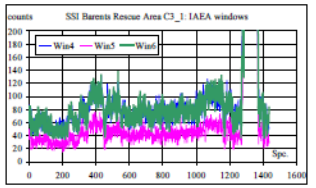


Figure M7. Gross counts Win4-6, C3.

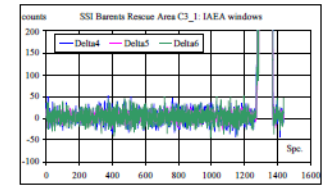


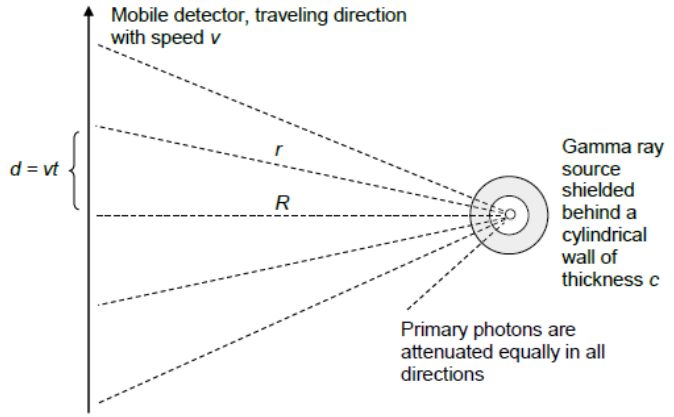
Figure M8. Stripped counts Win4-6, C3.

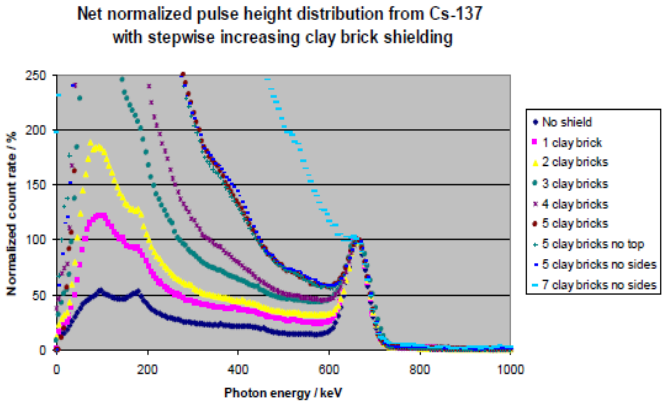
Mobile Measurement Development

Project: SHIELDMORC– Detection distances and methods to locate orphan gamma radiation sources in shielded building geometries by mobile gamma spectrometry (2019), NKS-433

Addressing: the detection of shielded sources by mobile gamma ray spectrometry

Using areas of the spectrum not usually utilized to improve detection capacities for shielded sources during mobile measurement operations





The Ones That Don’t Fit.....

Project: Early Phase Source Term Estimation From Gamma Spectra (*EPHSOGAM*), 2017, NKS-400

Addressing: the problems that were evident in 2017

7 participating institutes from 7 countries.

A series of scenarios involving different types of releases from unknown locations throughout Europe.

Gamma spectra for air filters from different stations and at different times provided to participants.

Participants required to estimate release location, time and amount.

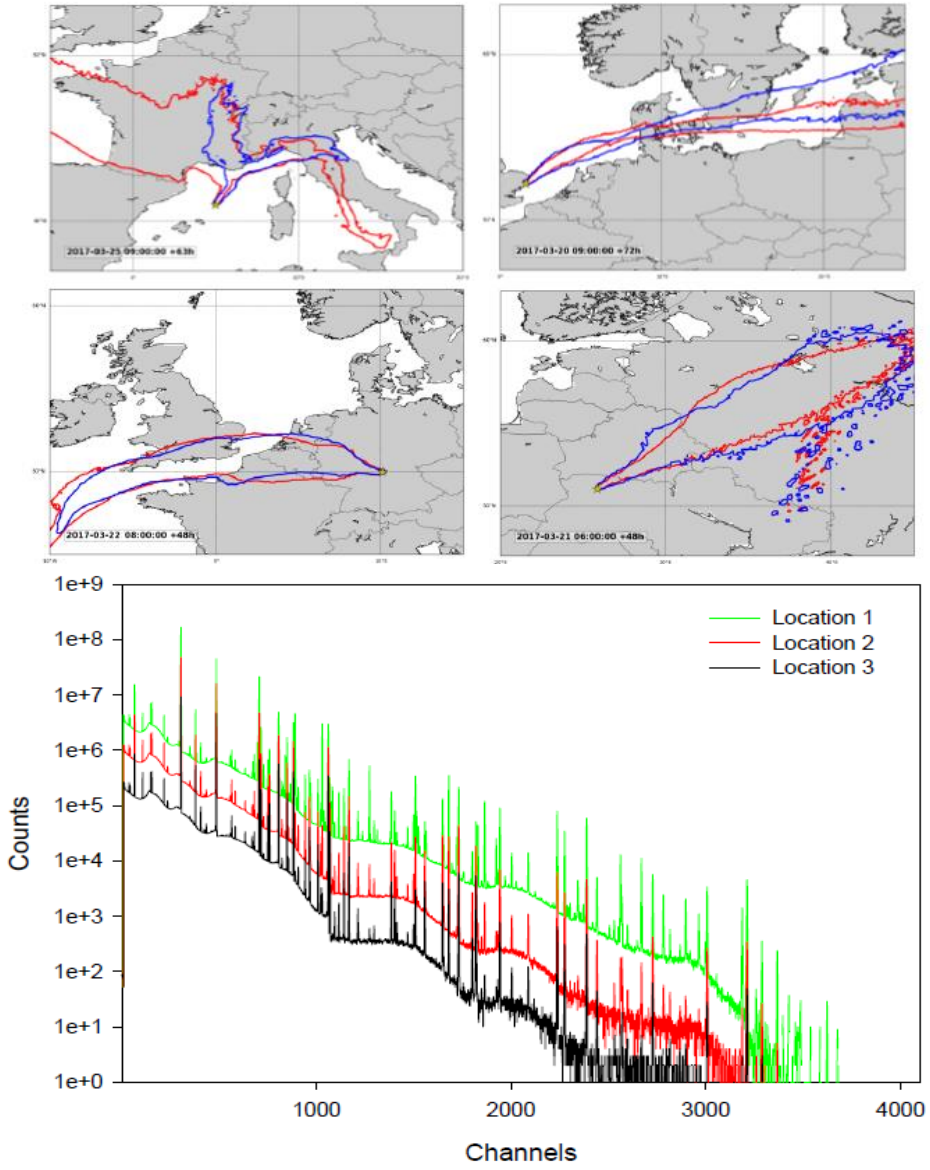


Figure 10. Spectra of the three locations for Scenario 3.

The Ones That Don’t Fit……..

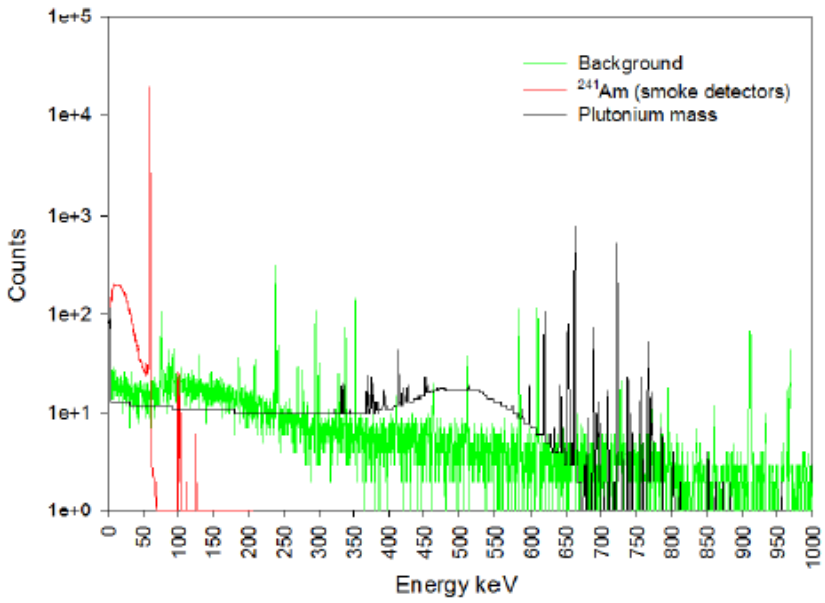
Project: Gamma Spectrometric Discrimination of Special Nuclear Materials (*GASMAT*), 2012, NKS-271

Addressing: lack of exercise opportunities in dealing with gamma spectra from nuclear materials in security contexts

15 institutes from 8 countries – US DoE and NNSA through the TRIAGE programme

Provision of spectra that may or may not indicate the presence of SNM.

- Uranium masked by NORM
- Plutonium masked by smoke detectors
- Depleted uranium within scrap thorium bearing alloys
- Presence of a plutonium gamma surrogate

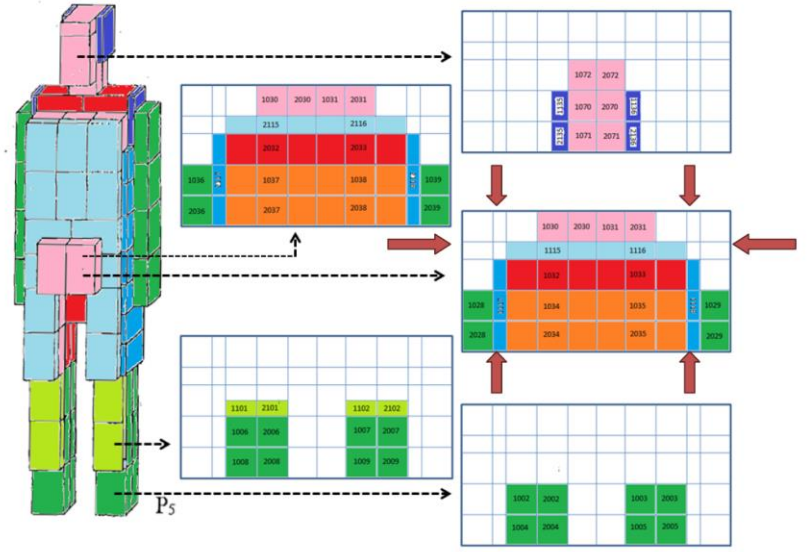


The Ones That Don’t Fit.....

Project: Building a generic voxel phantom of IRINA for Monte Carlo simulations, 2014, NKS-323

Addressing: the tedious task of calibrating whole body gamma ray spectrometers

Generation and distribution of a voxel phantom version of the IRINA phantom for calibration of whole body counters.



NKS-B Gamma-ray spectrometry

What can be said to characterize NKS-B activities in relation to gamma spectrometry?

→ Varied – cover everything from the basics up to more advanced material.

→ Often provide an impetus to improve/develop/expand

→ Not risk averse – willing to take chances on projects that could fall flat.

→ Popular – usually no shortage of participants for gamma spec. activities.

→ Broad appeal – the number of participating countries in NKS gamma spec. activities is often much wider than simply the NKS countries.

→ Forward looking – NKS has historically been able to recognize that gamma spec. is broader than just the usual isotopes in the usual samples by the usual detectors.

→ Durable – the reports are centralized and easily accessed.

NKS-B Gamma-ray spectrometry

Why participate in NKS gamma ray spectrometry activities?

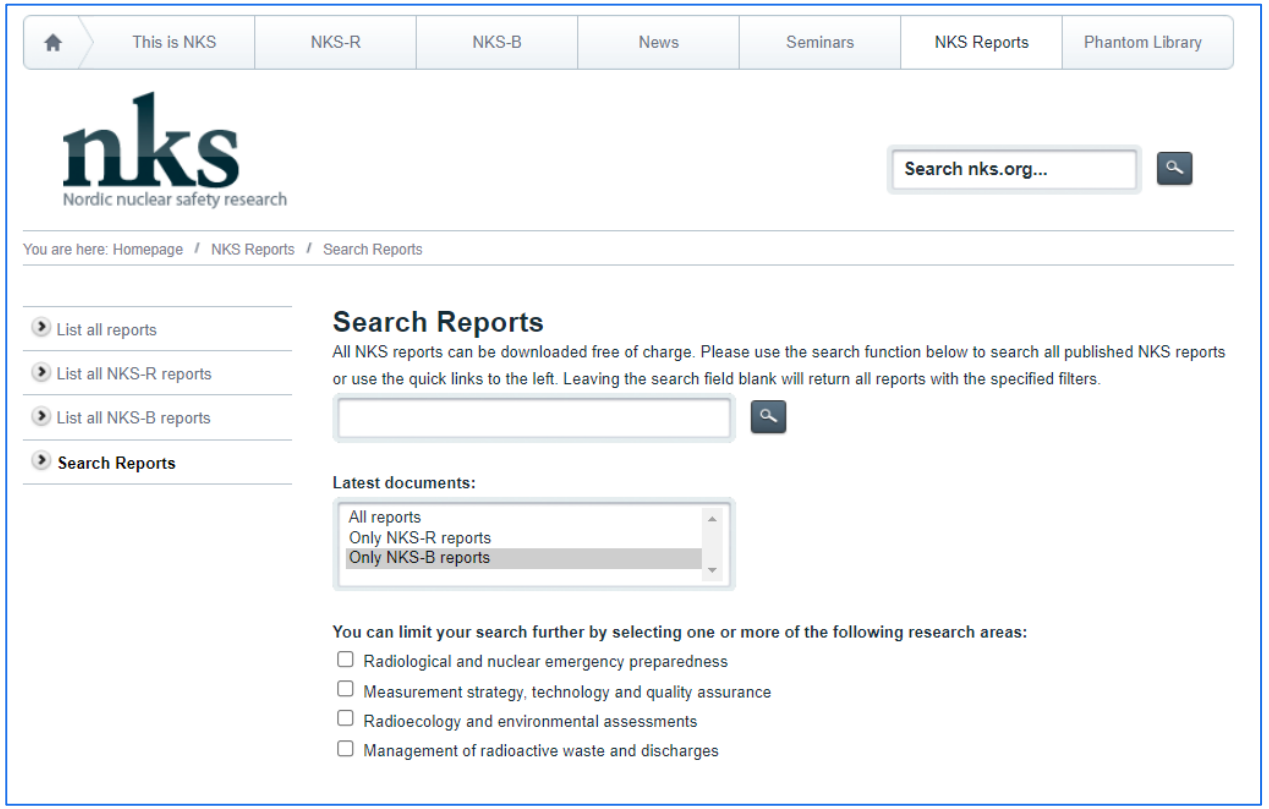
- Informal – no tedious EU-project type meetings
- Miniscule amount of paper work
- Congenial – the NKS gamma ray practitioners are mostly a nice bunch
- Stress free – rarely “proficiency” type activities and most often anonymous

NKS-B Gamma-ray spectrometry

http://www.nks.org/en/nks_reports/search_reports/

http://www.nks.org/en/nksb/supporting_material/

http://halla.gr.is/wiki/GammaWiki/index.php/Main_Page



Many thaks for your attention!
Kærar þakkir fyrir athygli þína!
Tusen takk for oppmerksomheten!
Paljon kiitoksia huomiosta!
Mange tak for din opmærksomhed!
Stort tack för din uppmärksamhet