Gamma-ray spectrometry in STUK

—

Status, applications, development

NKS - GammaSpec 2016 Seminar

Rømskog, Norway

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Environmental Radiation Surveillance and Emergency Preparedness

Numerous changes during past 2 years!

- Budget cut up to year 2017: in total ~ 3 M€
  - Number of personnel reduced
  - Number of laboratories/units reduced
  - Reorganization
  - Research activities reduced, cooperation with universities
  - Focus from research to surveillance

Content

1. Facilities & equipment
2. Software & data management
3. Environmental Surveillance and Measurement laboratory (VAM)
4. Applications
5. Development & future plans

1. Facilities & equipment

- Two separate rooms for counting (γ1 and γ2)
- Special concrete and mortar: low activity concentrations of natural radionuclides

Ra-226 6.2 Bq/kg
Th-232 4.3 Bq/kg
K-40 70.0 Bq/kg

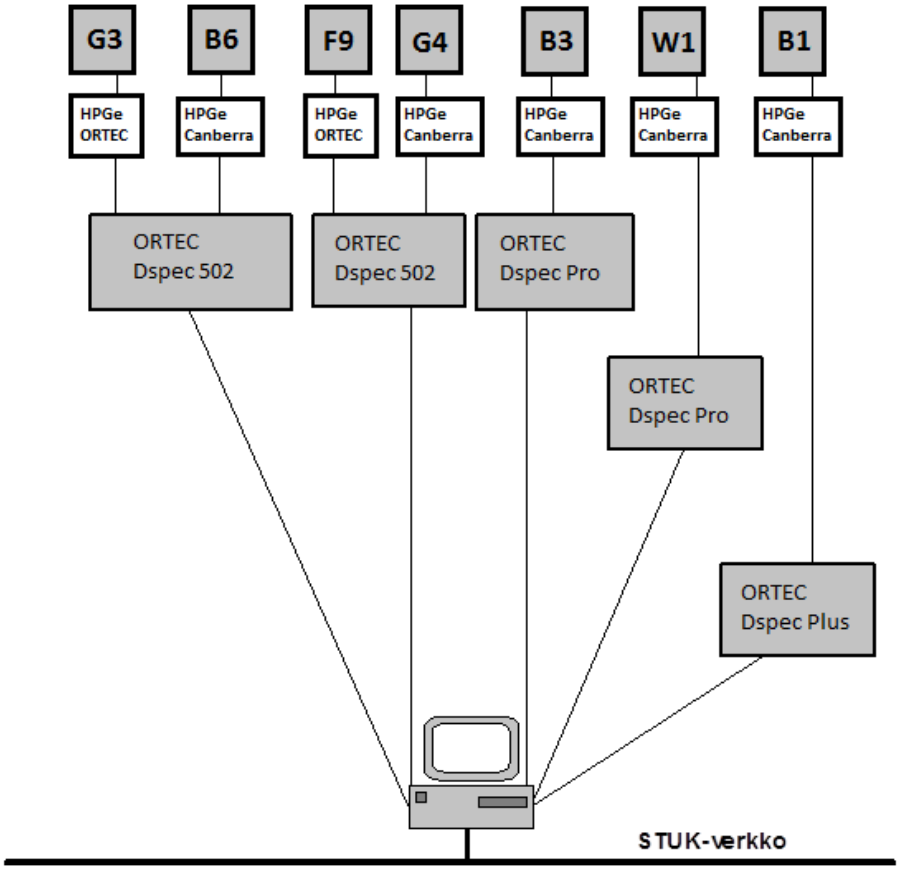
- Access control
- Special air ventilation to decrease (background) radiation from 1) ambient air radon and 2) fallout radionuclides
- Monitoring temperature, humidity, Rn

γ1

γ2

Spectrometers

- 16 HPGe spectrometers (7 Ortec, 9 Canberra)
- 4 electrically cooled, 5 Möbius, 7 Cryo-Cycle
- Digital MCAs (different DSPEC generations)
- Background shielding: 12-14 cm, Cu & Cd liner

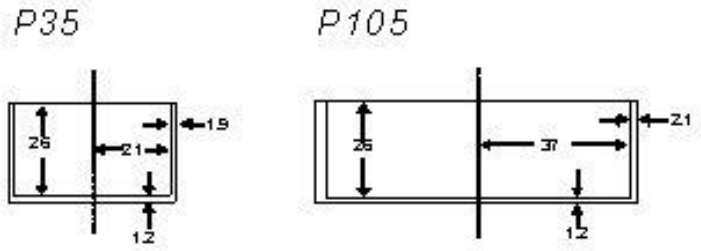


γ1-laboratory

Measurement geometries

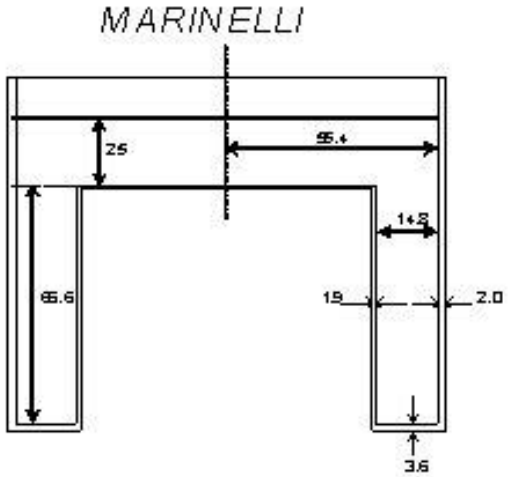
Simple cylindrical:

- P35: 0-30 ml, free sample height
- P105: 0-100 ml, free sample height



Marinelli:

- 0.5 l, fixed sample height



Samples are measured on top of the detector end-cap

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1. Facilities & equipment
2. Software & data management
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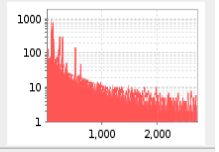
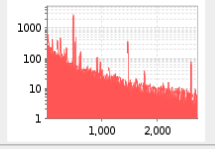
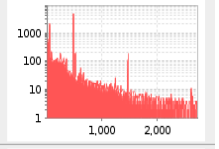
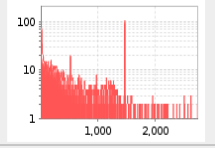
2. Software & data management

- Measurement control: Maestro + NAMIT software
- Measurement data to Linssi database, other data to NAMIT database(s)
- NAMIT is a STUK-made web-based software to manage data flow during the full chain of analysis:

Order of the analysis →
Sampling →
Sample processing →
Measurements (not only γ-spectrometry) →
Spectrum analysis →
Reporting

- Follow-up of the chain (color-coding or by other means)

NAMIT, following measurements

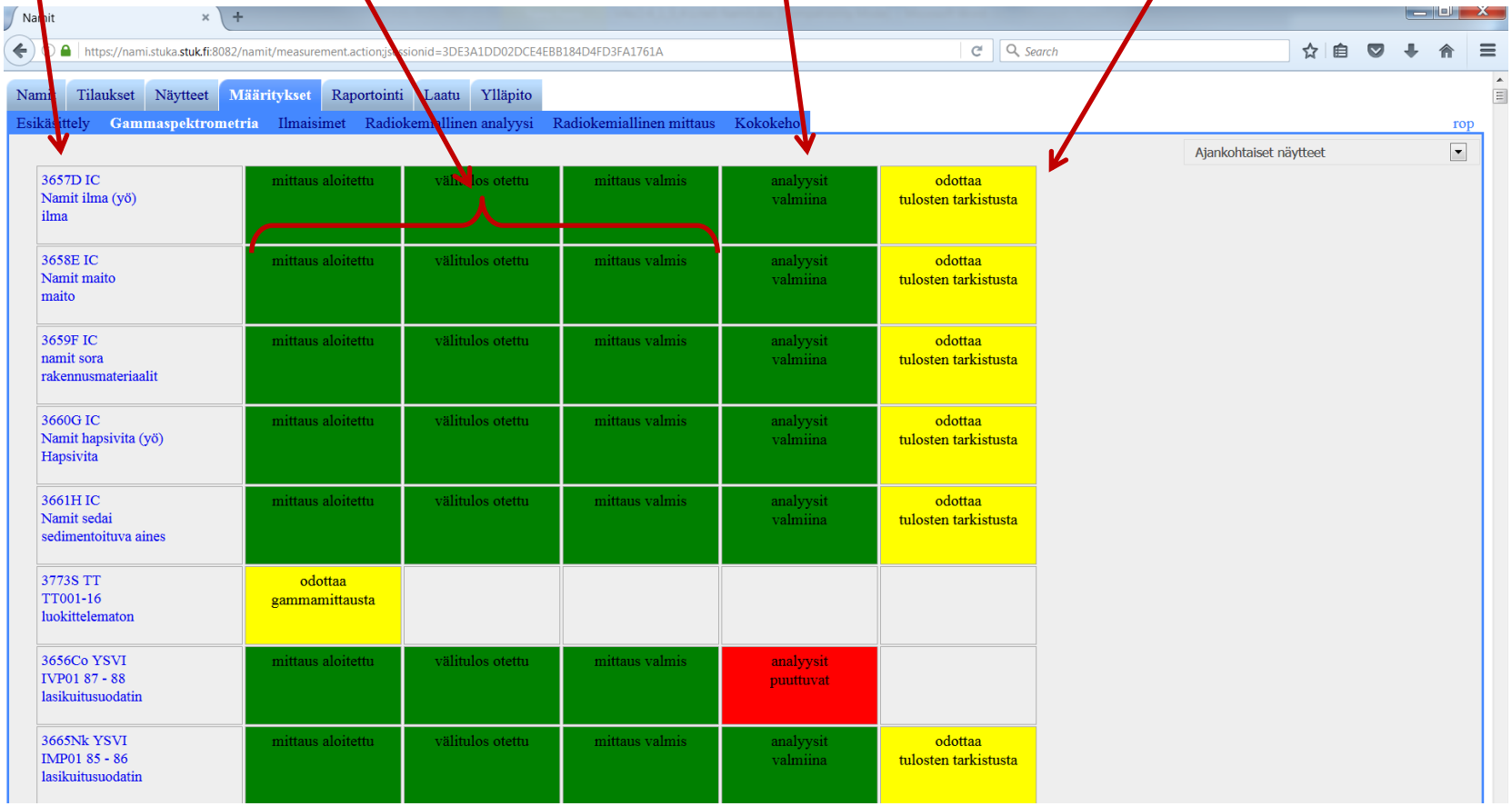
Detectors	Status	NAMIT code	Measurement time	Spectra
F6	mittaus käynnissä	3708P	17:50:16 (64216s) 17:58:06 (64686s)	
F9	mittaus käynnissä	3694Yk	26:18:00 (94680s) 26:18:32 (94712s)	
B3	mittaus käynnissä	3700Ek	26:22:44 (94964s) 26:22:56 (94976s)	
B6	mittaus käynnissä		2:35:26 (9326s) 2:35:30 (9330s)	

Samples

Status of the measurement

Results from automated spectrum analysis

Waiting for checking the analysis result



Yellow waiting for the operation

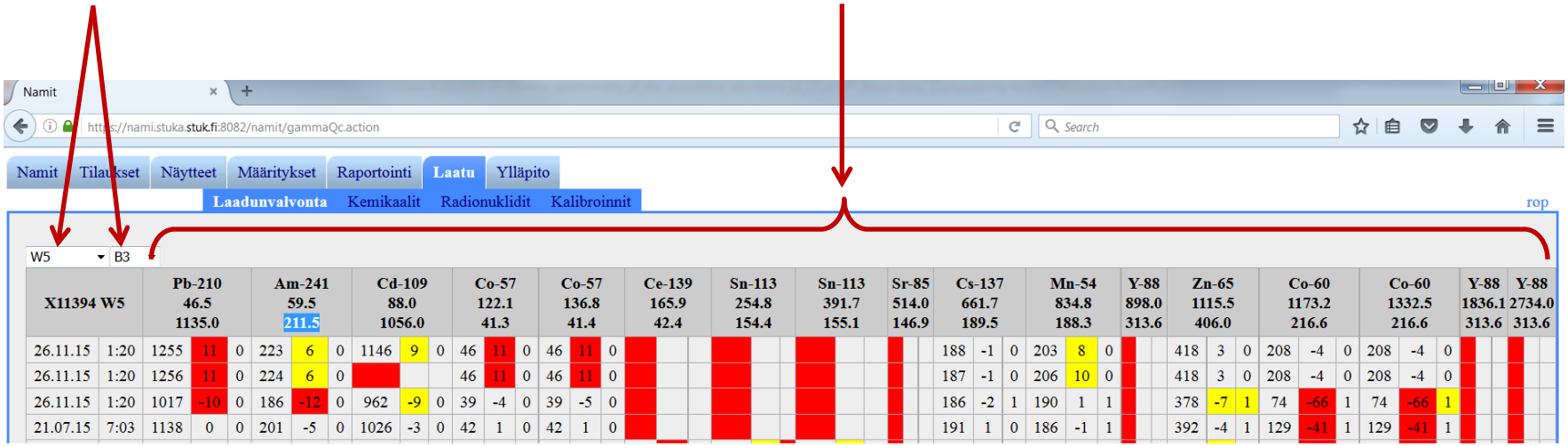
Green done

Red alert

NAMIT & QA

Detector labeled as B3, measurement of a calibration source W5

Nuclides (Energy and Activity) present in the calibration source and deviation of the activity



X11394 W5		Pb-210 46.5 1135.0			Am-241 59.5 211.5			Cd-109 88.0 1056.0			Co-57 122.1 41.3			Co-57 136.8 41.4			Ce-139 165.9 42.4			Sn-113 254.8 154.4			Sn-113 391.7 155.1			Sr-85 514.0 146.9			Cs-137 661.7 189.5			Mn-54 834.8 188.3			Y-88 898.0 313.6			Zn-65 1115.5 406.0			Co-60 1173.2 216.6			Co-60 1332.5 216.6			Y-88 1836.1 313.6		Y-88 2734.0 313.6	
26.11.15	1:20	1255	11	0	223	6	0	1146	9	0	46	11	0	46	11	0													188	-1	0	203	8	0				418	3	0	208	-4	0	208	-4	0						
26.11.15	1:20	1256	11	0	224	6	0				46	11	0	46	11	0													187	-1	0	206	10	0				418	3	0	208	-4	0	208	-4	0						
26.11.15	1:20	1017	-10	0	186	-12	0	962	-9	0	39	-4	0	39	-5	0													186	-2	1	190	1	1				378	-7	1	74	-66	1	74	-66	1						
21.07.15	7:03	1138	0	0	201	-5	0	1026	-3	0	42	1	0	42	1	0													191	1	0	186	-1	1				392	-4	1	129	-41	1	129	-41	1						

NAMIT & Calibrations

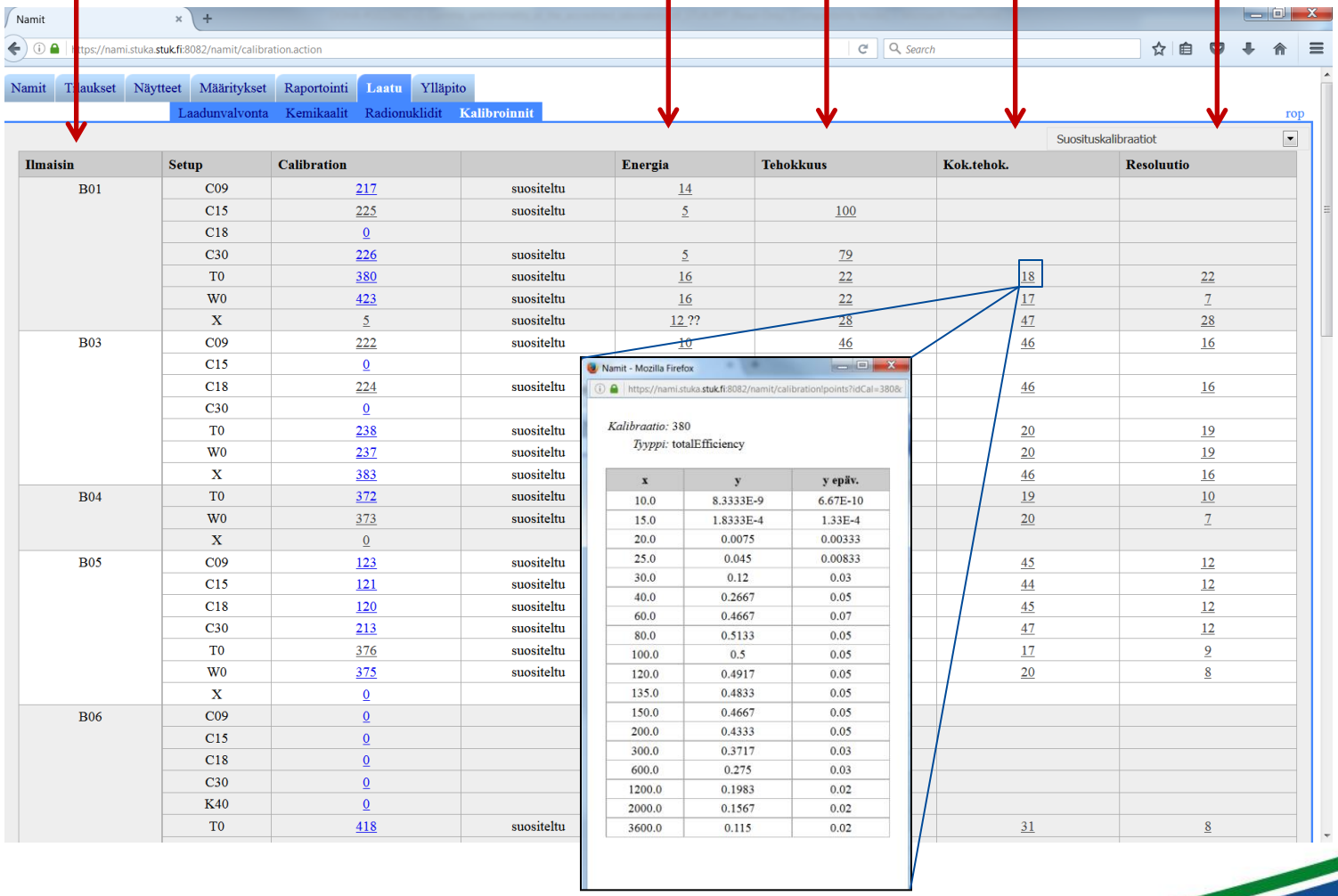
Detectors

Energy

Peak Eff.

Tot. Eff.

Resolution



Ilmaisin	Setup	Calibration		Energia	Tehokkuus	Kok.tehok.	Resoluutio
B01	C09	217	suositeltu	14			
	C15	225	suositeltu	5	100		
	C18	0					
	C30	226	suositeltu	5	79		
	T0	380	suositeltu	16	22	18	22
	W0	423	suositeltu	16	22	17	7
	X	5	suositeltu	12 ??	28	47	28
B03	C09	222	suositeltu	10	46	46	16
	C15	0					
	C18	224	suositeltu			46	16
	C30	0					
	T0	238	suositeltu			20	19
	W0	237	suositeltu			20	19
	X	383	suositeltu			46	16
B04	T0	372	suositeltu			19	10
	W0	373	suositeltu			20	7
	X	0					
B05	C09	123	suositeltu			45	12
	C15	121	suositeltu			44	12
	C18	120	suositeltu			45	12
	C30	213	suositeltu			47	12
	T0	376	suositeltu			17	9
	W0	375	suositeltu			20	8
	X	0					
B06	C09	0					
	C15	0					
	C18	0					
	C30	0					
	K40	0					
	T0	418	suositeltu			31	8

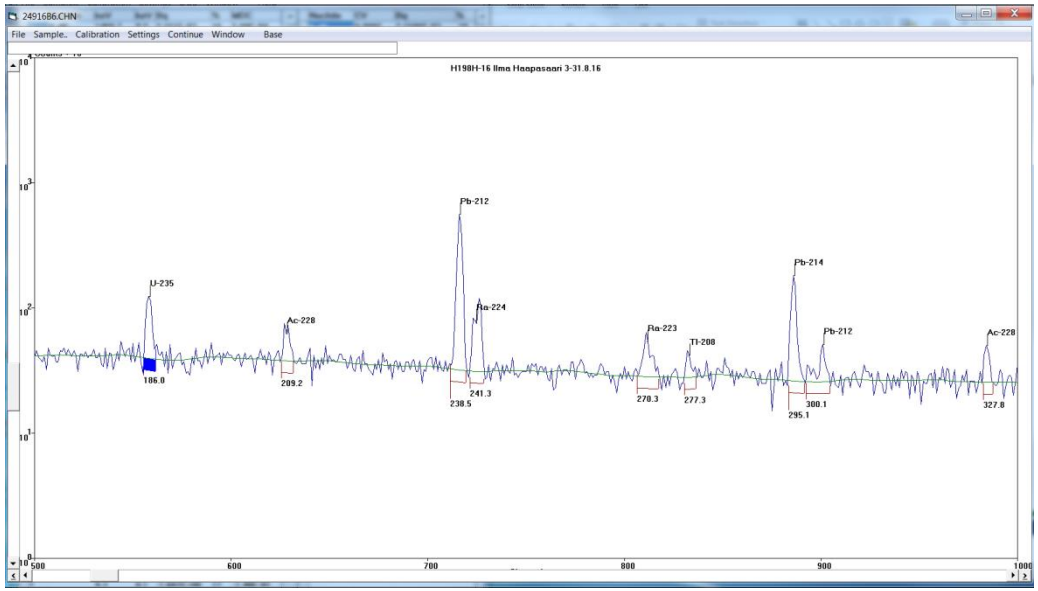
Kalibraatio: 380

Tyyppi: totalEfficiency

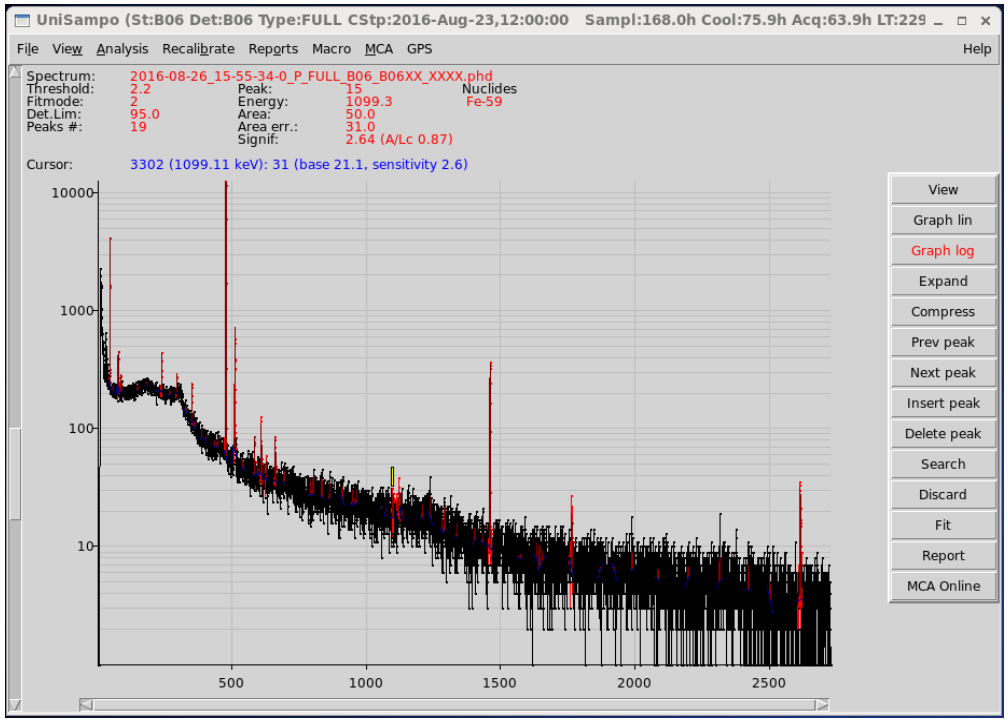
x	y	y epäv.
10.0	8.3333E-9	6.67E-10
15.0	1.8333E-4	1.33E-4
20.0	0.0075	0.00333
25.0	0.045	0.00833
30.0	0.12	0.03
40.0	0.2667	0.05
60.0	0.4667	0.07
80.0	0.5133	0.05
100.0	0.5	0.05
120.0	0.4917	0.05
135.0	0.4833	0.05
150.0	0.4667	0.05
200.0	0.4333	0.05
300.0	0.3717	0.03
600.0	0.275	0.03
1200.0	0.1983	0.02
2000.0	0.1567	0.02
3600.0	0.115	0.02

Spectrum analysis

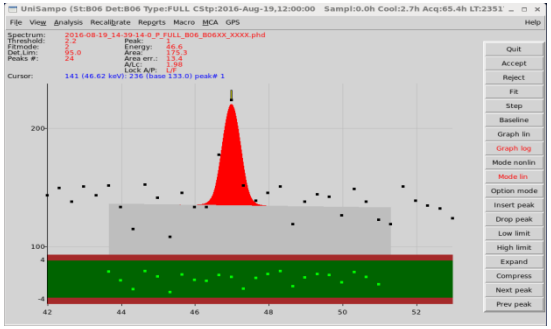
- GAMMA-99 software developed by STUK
  - Windows-version 1997
  - cascade summing correction since 1983 !
  - sample height and density corrections
  - automatic and interactive operation modes



- UniSampo/Shaman
  - UniSampo: peak search, baseline & peak fitting, peak areas
  - Shaman: rule-based peak identification and activity calculation, mimics human analyst



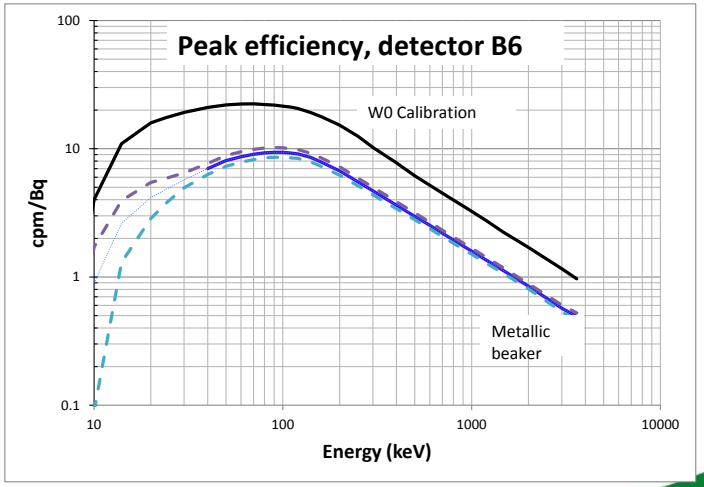
Interactive fitting



Efficiency determination

- Calibration for predetermined geometries using certified sources (thickness 0)
- Sample density and height corrected by analysis software
- Efficiency transfer programs for other geometries
  - Semiempirical, DECCA
    - ✓ Developed in cooperation with NRPA
    - ✓ Validated in ICRM and Euromet projects
  - Monte Carlo, VGSL
    - ✓ Based on MCNP
    - ✓ Developed by CTBTO

DECCA



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3. Environmental Surveillance and Measurement laboratory (VAM)

- All gamma-ray measurements from samples are to be performed in VAM
  - Spectrum analysis: staff of other lab or remotedly
- FINAS accreditation since 1999
  - According to standard EN ISO/IEC 17025
  - Renewed in 4-year periods, next audit 26.10.2016

FINAS
Finnish Accreditation Service
T167 (EN ISO/IEC 17025)

- γ-ray staff in VAM:
  - $\sim$ 4 in spectrum analysis
  - $\sim$ 3 technicians
- Two-grade scope of gammaspectrometric analyses in environmental samples, biological samples, foodstuffs and other samples
  - Routine analyses: Cs-137, Cs-134, I-131, K-40, U- and Th-decay series
  - Advanced analyses: all radionuclides emitting gamma-rays in the energy range of 30-2700 keV
- Emergency preparedness
  - Maintenance and development of equipment and competence for rapid response

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4. Applications

- Surveillance of environmental radiation in Finland
  - Nationwide environmental surveillance: outdoor air, deposition, surface water, drinking water, milk, foodstuffs and in the Baltic Sea (+people)
  - NPP environmental monitoring
  - Surveillance of natural radiation: Building materials, drinking waters, mines
- Contracted services
  - Industry: swipes, building materials, foodstuff
  - Trade: radioactivity certificates e.g. for export of mushrooms, berries, …
  - National and international organisations and institutes: municipalities, universities, Geological Survey of Finland, IAEA Safeguards, CTBTO, ...
- Research

Number of gamma-ray analyses in VAM in 2015

Sample Origin/Programme	Number of γ-ray analyses per year
NPP environmental monitoring	700
Baltic sea monitoring (HELCOM-MORS)	110
Nationwide environmental monitoring	250
Services	600
QA, intercomparisons, proficiency tests, …	150
Total in the laboratory of Environmental Surveillance and Measurement	∼1800
Total + Other STUK labs in 2015	∼3600

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Recent (2015) and ongoing major activities

- γ-ray spectrometers from Rovaniemi to Helsinki
- Staff reorganization, work reorganization
- Cryo-Cycle dewars to 7 detectors, dismantlement of existing fixed N_2 cooling system
- Renewal of FINAS accreditation
- Parallel use of NAMIT – LIMS for data management
- Parallel use of Gamma99 – UniSampo/Shaman for spectrum analysis

Activities in the (very near) future

- NAMIT and UniSampo/Shaman will soon (1.11.2016) be the primary software for data management and spectrum analysis, respectively
- FINAS audit (October 2016)
- Efficiency re-determination for all 16 spectrometers, 2-4 measurement geometries/setups per spectrometer
- Installation and efficiency determination for a well-type spectrometer (MSc. dissertation)
- 2 new measurement geometries (large beaker to be used in BeGe detectors and a test tube for the well detector) will be applied for gamma-ray spectrometry.
- Certification of a new spectrometer for CTBT sample measurements

Activities in the future

- Determination of a full uncertainty budget for selected spectrometers
- Investigation of the possibility to use list-mode data acquisition
- International Committee for Radionuclide Metrology (ICRM)
  - Goal: radiation measurements in Finland are adequately accurate and internationally comparable
  - Maintaining measurement standards to ensure reliability of activity measurements of gamma-ray emitting radionuclides
- Development of NAMIT QA-tools to facilitate following the status of spectrometers, environmental conditions, data quality, etc.