Renewed whole-body counting chamber in STUK

NKS - GammaSpec 2017 Seminar

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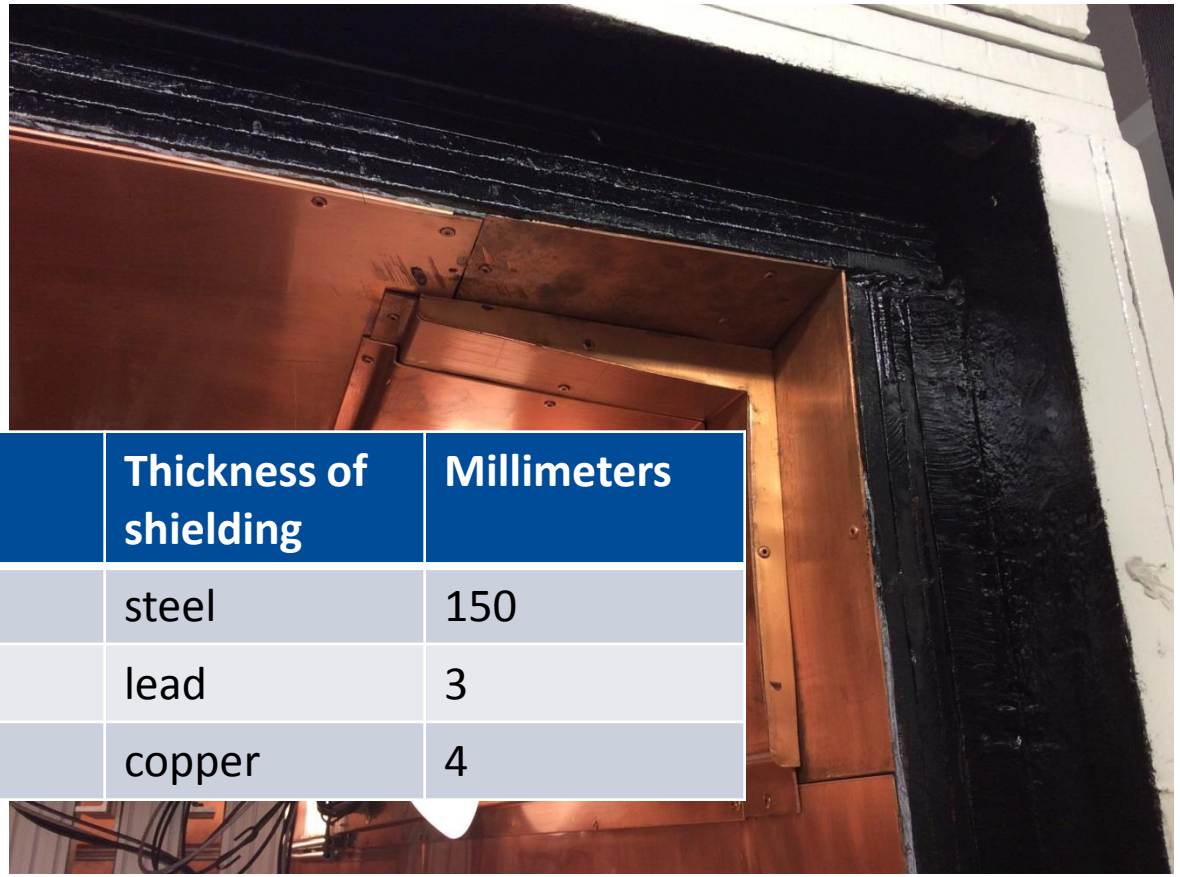
Environmental Radiation Surveillance and Emergency Preparedness

Whole-body counting facilities at STUK

- ’Whole-body counting’ : measurements of X-ray – and γ-radiation emitted from radionuclides in the human body.
- STUK -Radiation and Nuclear Safety Authority has two whole-body counting systems for measurement of internal contamination. Both systems use high purity germanium detectors.
  - The stationary system is installed inside a 50 ton **steel room** and the
  - **mobile unit** is built on a truck chassis.
- Both counters are used to assess the internal exposure of radiation workers and the exposure of the Finnish public.
- Part of the emergency response organisation.
- The **steel room** was disassembled in 2013 and renewed in 2016


MITTAUS
KÄYNNISSÄ

Dimensions of the steel room



Inside dimensions	Meters	Thickness of shielding	Millimeters
length	2.5	steel	150
width	2.0	lead	3
height	2.3	copper	4

Original design targets

- To reduce the activity concentrations of all construction materials
  - 50 tons of steel from scrabber gasometer, build before 1930, was used to outread Co-60
  - Constructed on special concrete* – activity concentrations of K-40, uranium and thorium decay series were 1/8 of normal concrete
- To reduce the contamination in an acute fallout situation
- To reduce the concentration of radon isotopes and their decay products entering the room
  - Over-pressurized and air-conditioned
- To minimize the influence of other radiation sources
  - Clean laboratory: can only be assessed using shoe covers

*olivine (magnesium iron silicate) used as ballast material

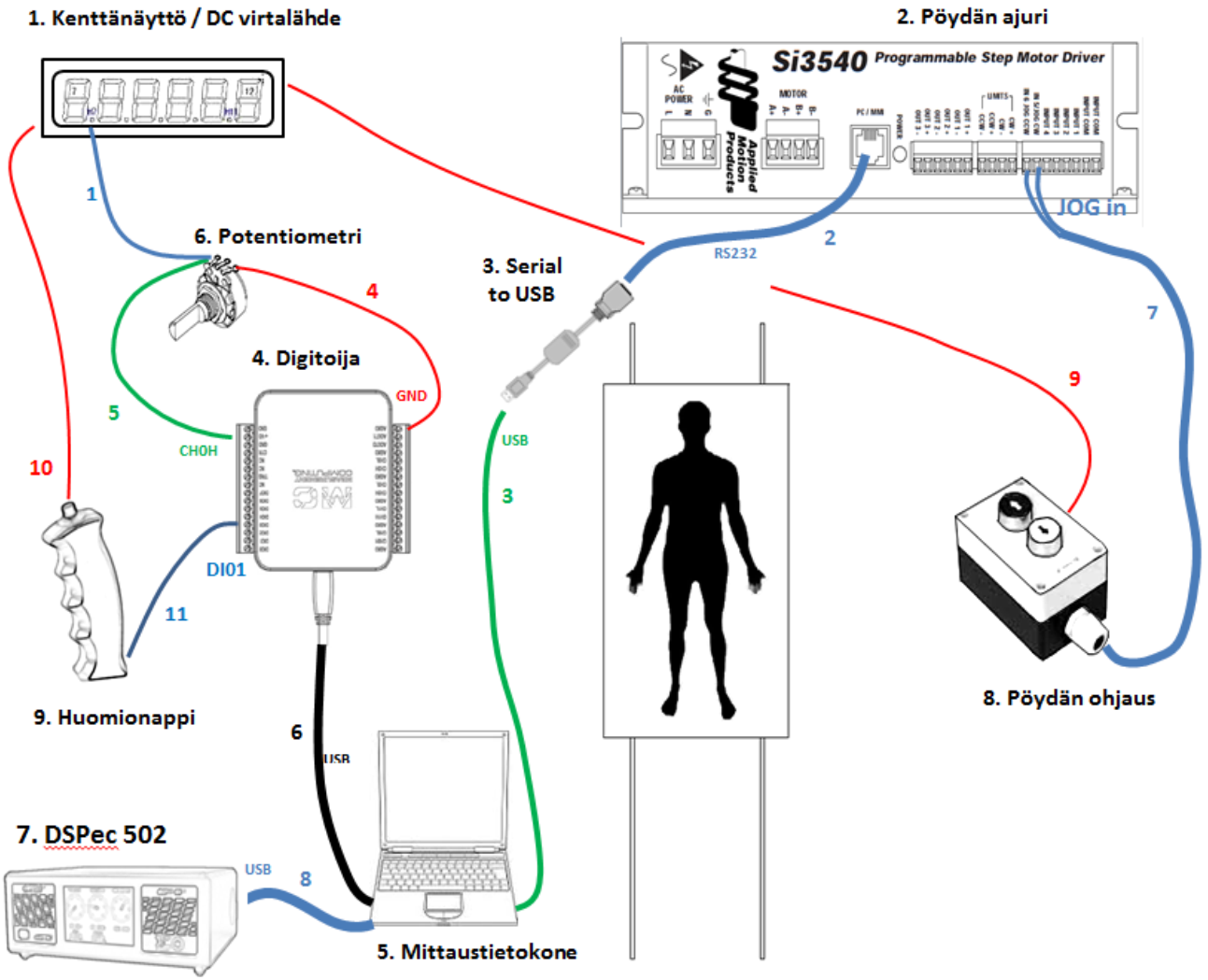
2009

2017

Low-background compared to outside

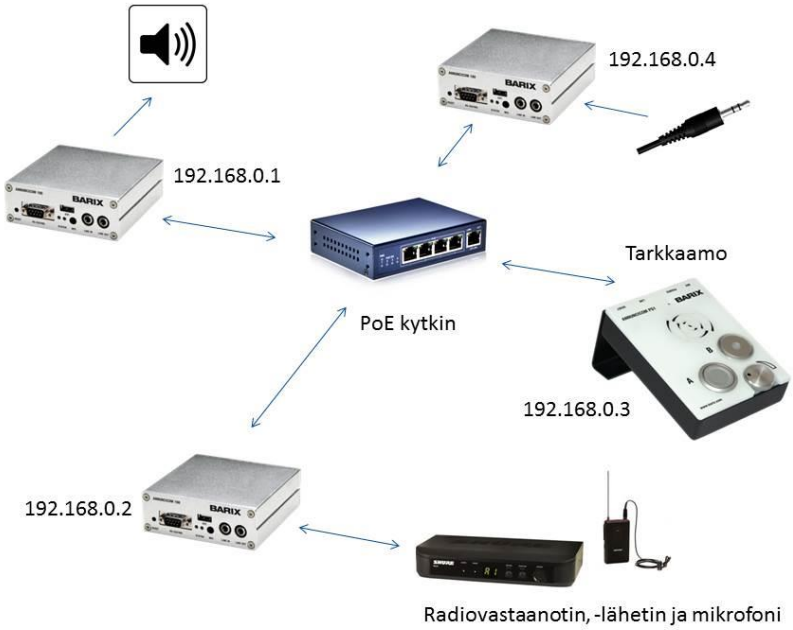
PHOTOPEAK PULSE RATES	E (keV)	Chamber (CPM)	Lab outside (CPM)	COMPARED TO OUTSIDE
K-40	1461	0.22 ± 0.02	27.9 ± 0.2	< 1 %
Cs-137	662	< MDC	1.55 ± 0.08	-
Tl-208	2615	0.08 ± 0.01	4.89 ± 0.05	< 2 %
Pb-212	239	0.45 ± 0.03	12.33 ± 0.12	~ 4 %
Pb-214	352	0.66 ± 0.03	13.55 ± 0.14	~ 5 %
Bi-212	726	< MDC	1.30 ± 0.07	-
Bi-214	609	0.56 ± 0.03	13.45 ± 0.13	~ 4 %
Ac-228	911	< MDC	4.25 ± 0.09	-
Th-234	93	2.93 ± 0.06	5.18 ± 0.26	~ 56 %
U-235/Ra-226	186	1.17 ± 0.05	4.87 ± 0.04	~ 24 %
No. of all peaks…No. of identified nuclides		21…7	52…12	

Control of the measurement room



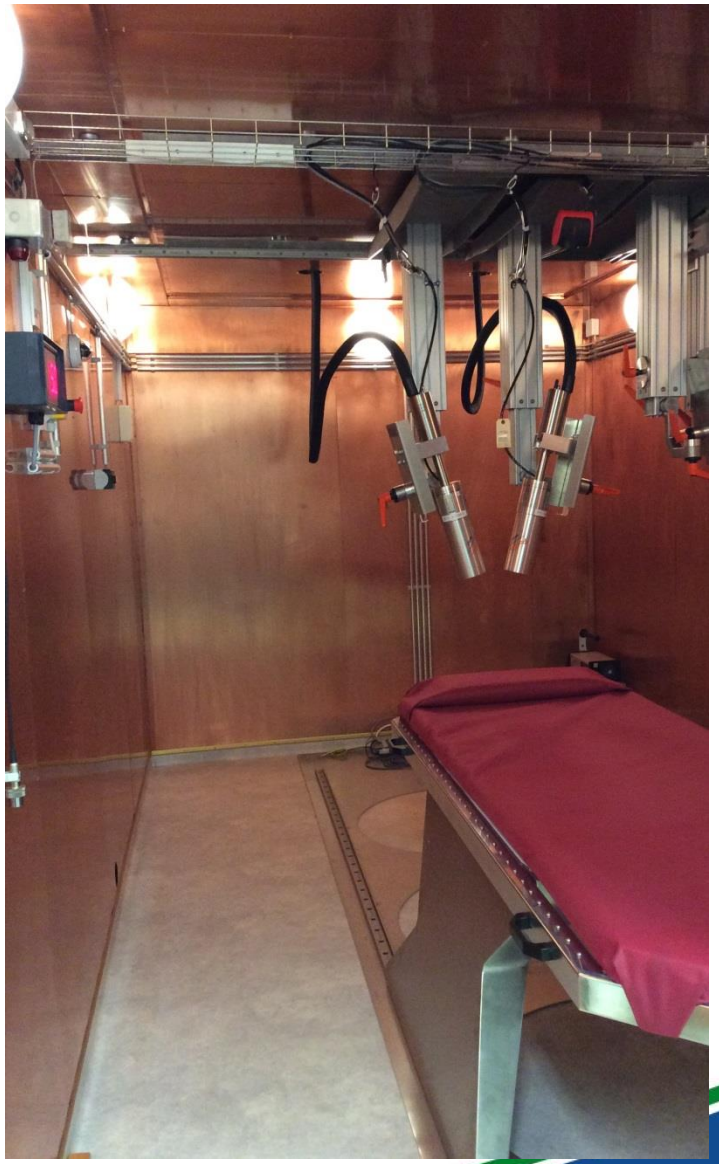
Communication system

Two-way audio communication and web-camera based monitoring



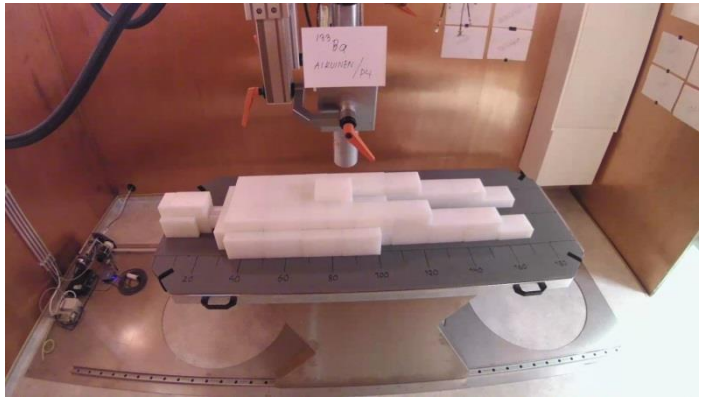
Spectrometers

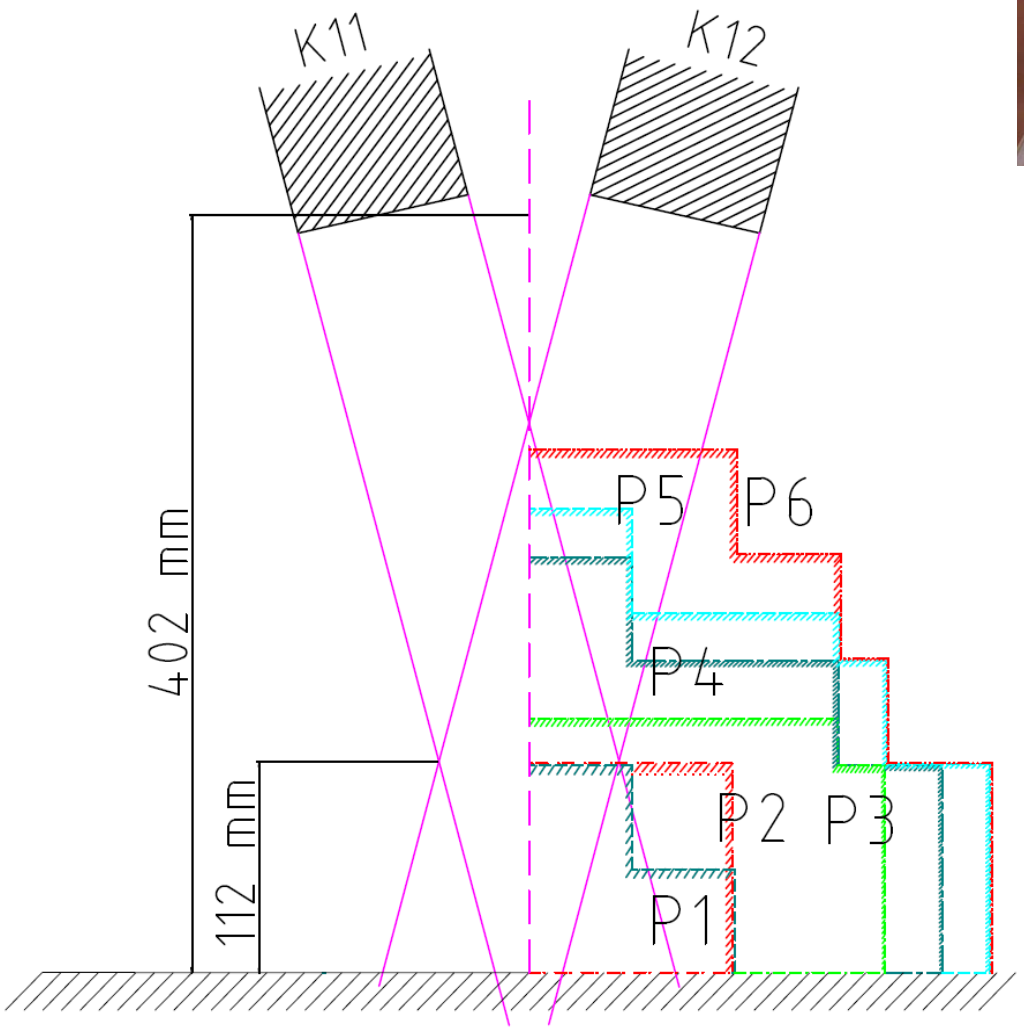
- 2 HPGe-detectors for whole-body counting
- 2 B-S-HPGe* detectors for lung counting (coming)
- Coolers are on the roof
- Digital MCAs (DSPEC-502)



*S is for ”semi-planar” profile of the crystal, B is for thin Be-window

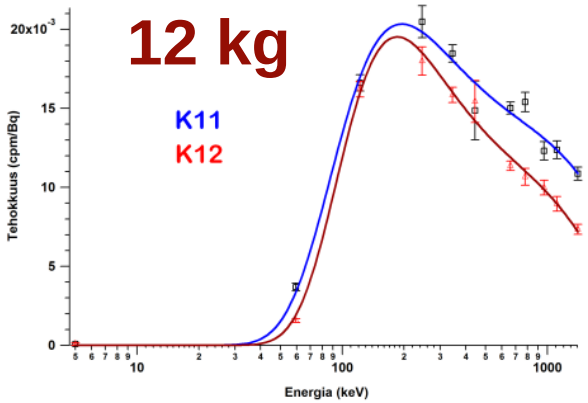
Calibration geometries

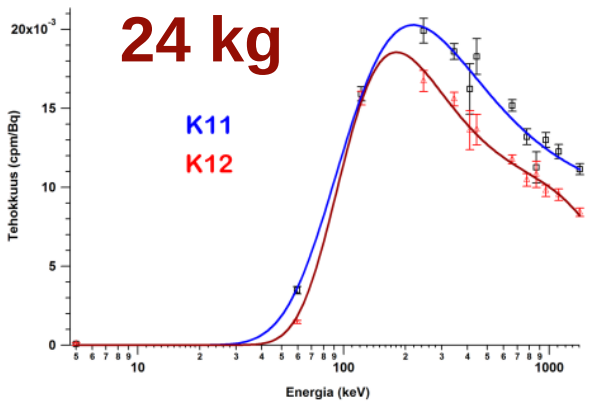


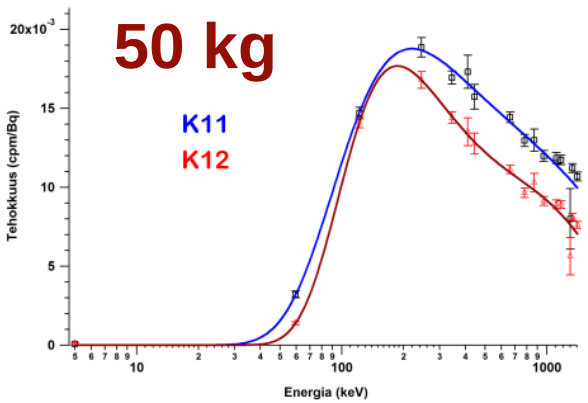


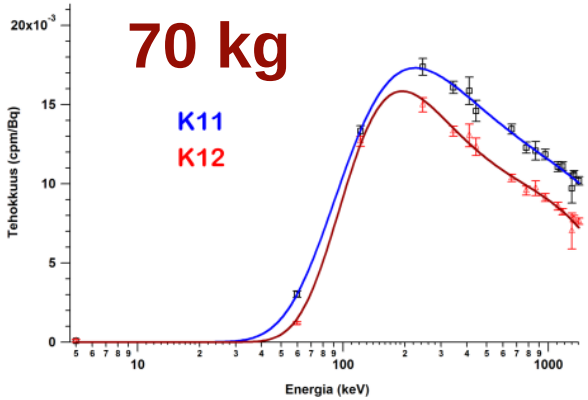
- 6 different sized phantoms in laying position
- 3 different sized neck phantoms for thyroid calibrations
- 5 calibration nuclides to reach energy range 120 – 1500 keV

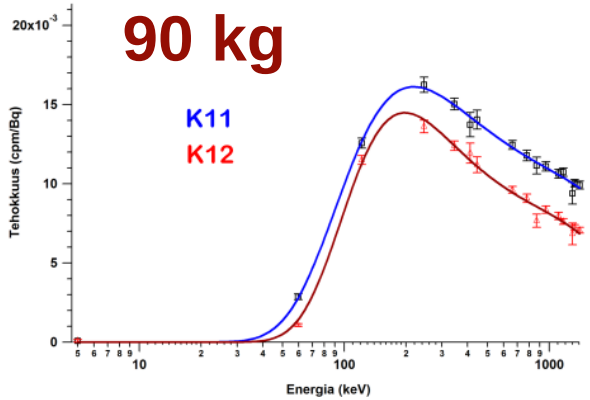
Efficiency curves according to the body size

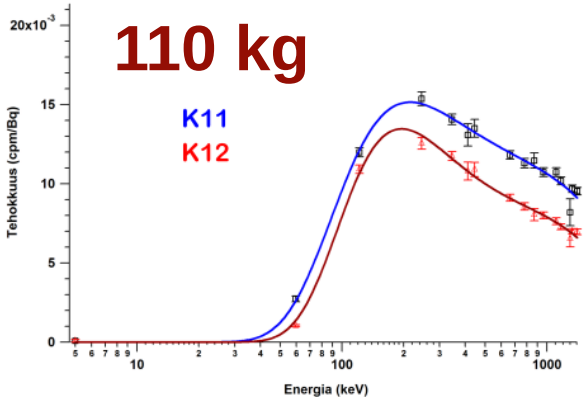












Performance of the whole-body detectors: MDA's for measurement time of 30 min

			LEFT		RIGHT
Nuclide	E (keV)	cpm	MDA (Bq)	cpm	MDA (Bq)
^{137}Cs	661.70	0.43	58	0.34	67
^{60}Co	1173.20	0.23	47	0.17	55
^{60}Co	1332.50	0.21	47	0.16	58
^{131}I	364.50	0.82	67	0.61	71
^{110m}Ag	657.80	0.36	49	0.28	55
^{110m}Ag	884.70	0.27	60	0.20	68
^{58}Co	810.80	0.29	45	0.21	51
^{54}Mn	834.90	0.32	47	0.22	52
^{40}K	1460.80	1.21	997	0.82	1182

Efficiency $\epsilon(E)$ for the whole-body detection was used to calculate the MDA:s $\alpha(E)$

$$\alpha(E) = \frac{4.6\sqrt{N_B} + 2.7}{I(E)\epsilon(E)T}$$

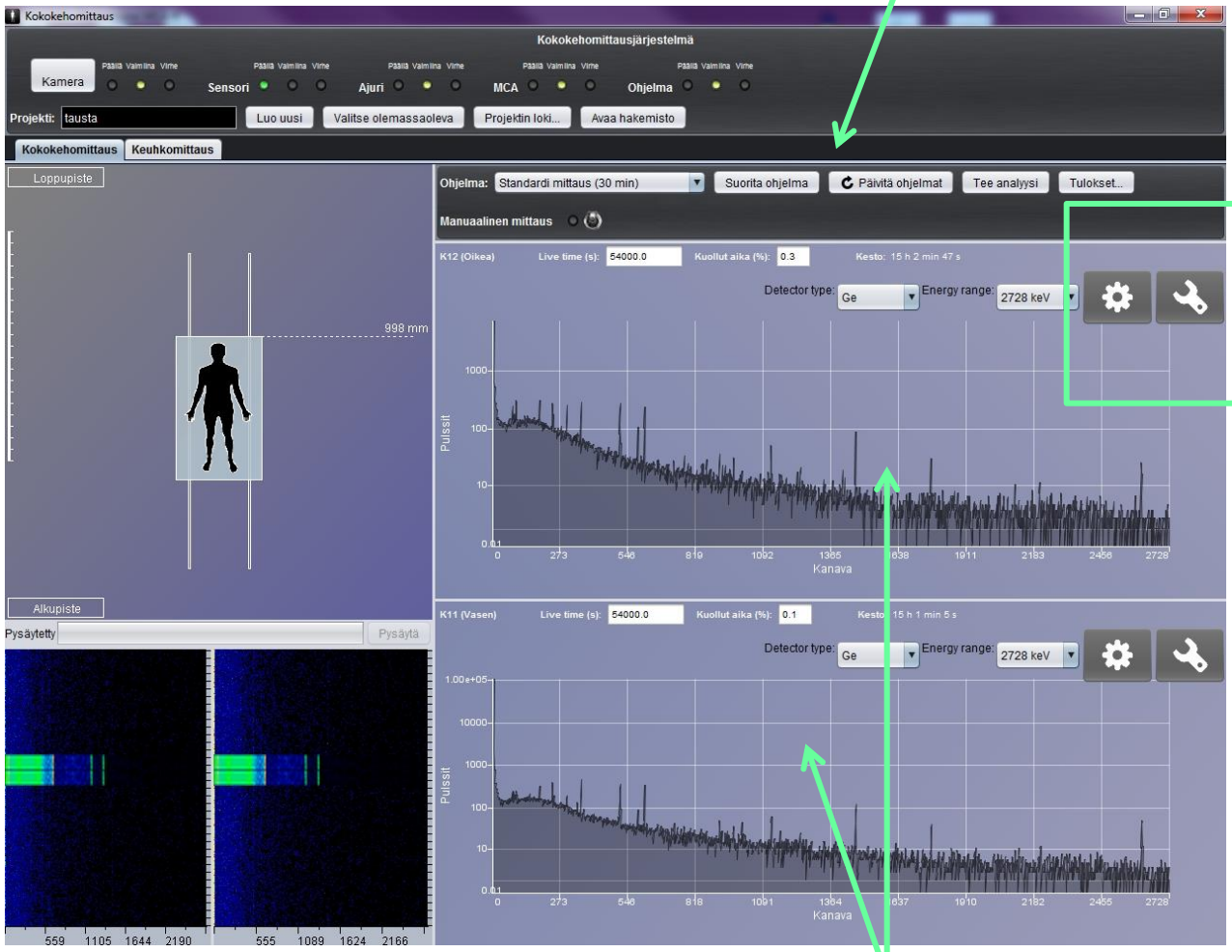
Software & data analysis

Selection of scan function or program

Project management tools

Measurement table movement control & view

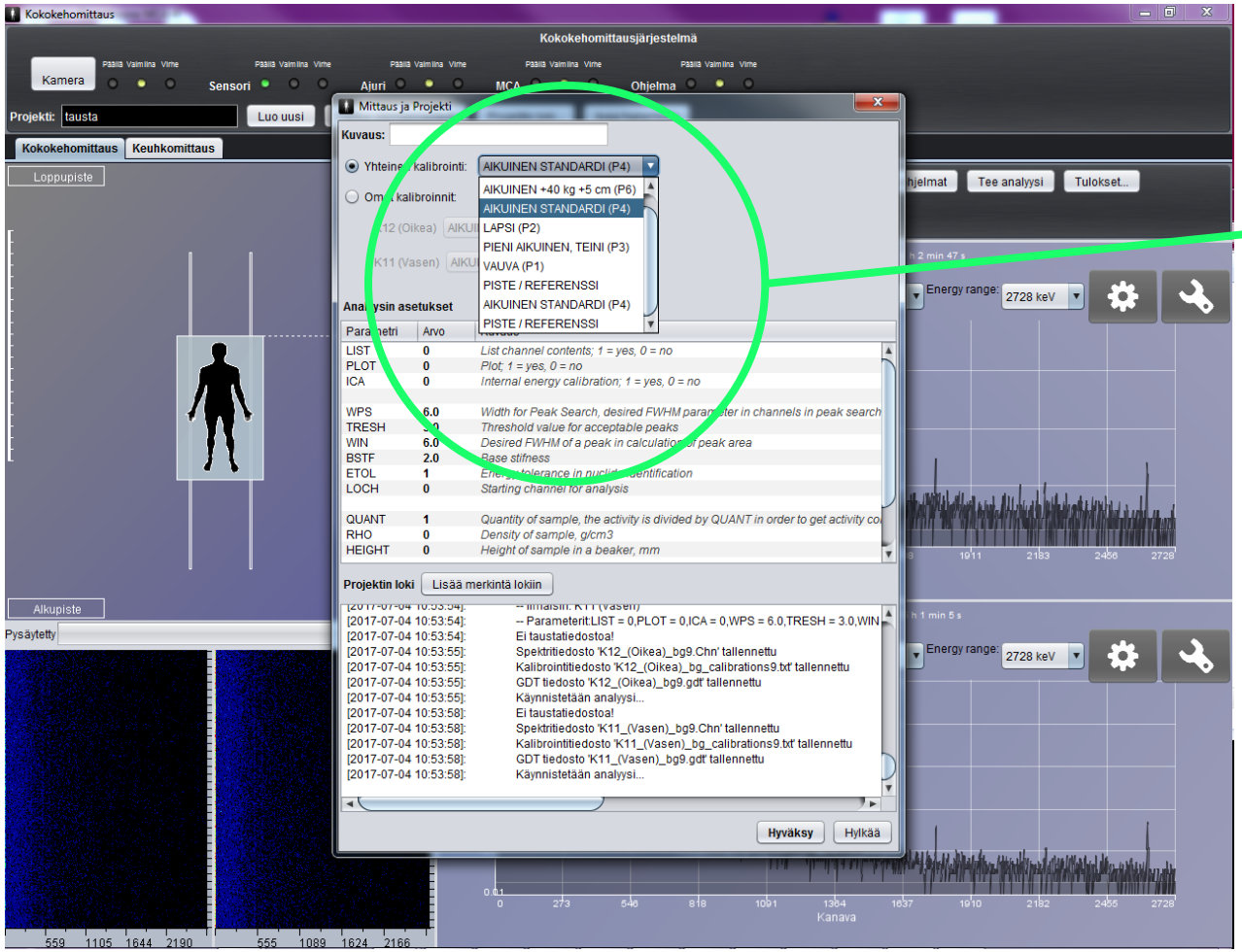
Spectrum colormap time-series view



Spectrum and data management tools

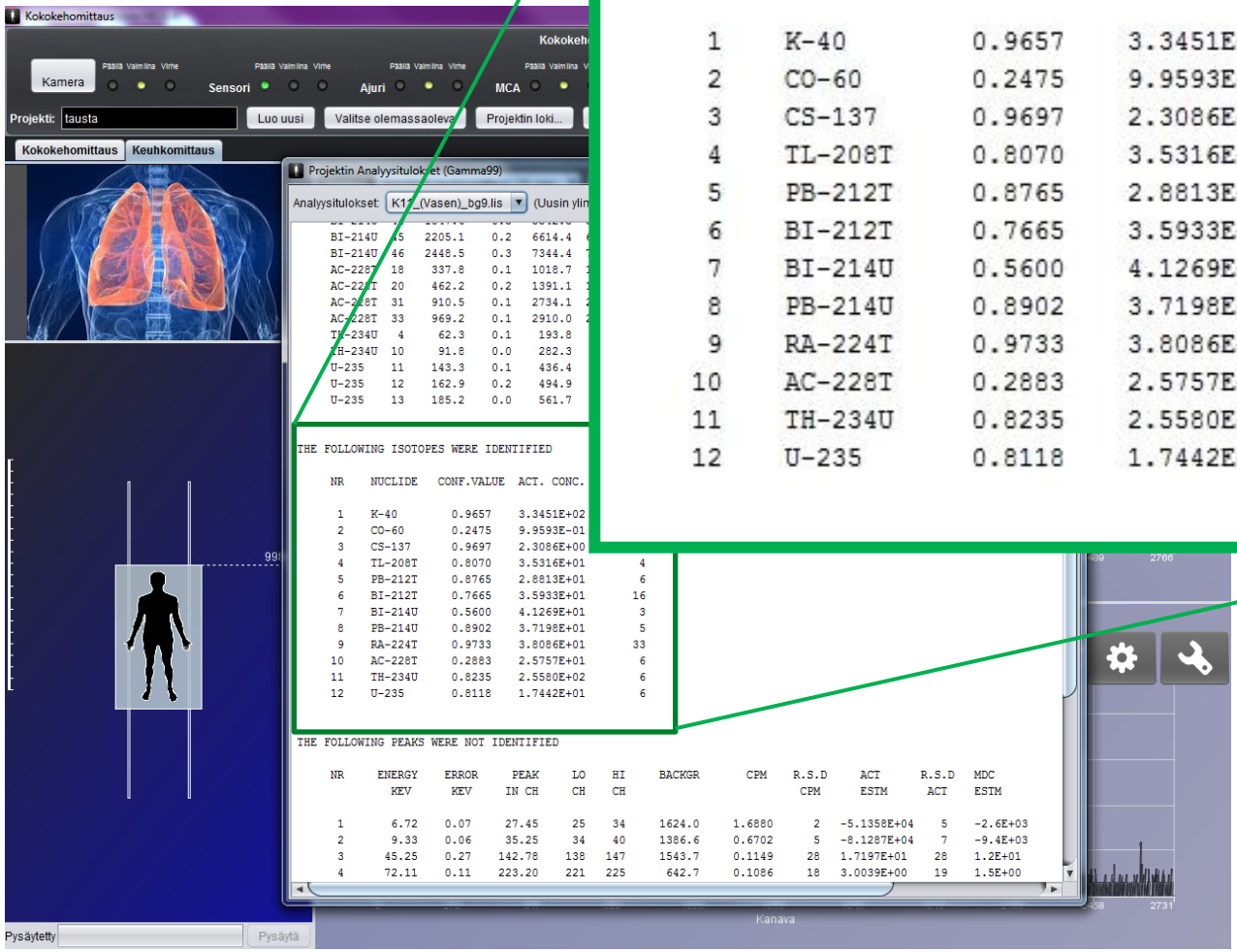
Spectrum view

Selection of efficiency calibration



6 body sizes or point source

Results listing



THE FOLLOWING ISOTOPES WERE IDENTIFIED

NR	NUCLIDE	CONF.VALUE	ACT. CONC.	R.S.D.
1	K-40	0.9657	3.3451E+02	5
2	CO-60	0.2475	9.9593E-01	26
3	CS-137	0.9697	2.3086E+00	22
4	TL-208T	0.8070	3.5316E+01	4
5	PB-212T	0.8765	2.8813E+01	6
6	BI-212T	0.7665	3.5933E+01	16
7	BI-214U	0.5600	4.1269E+01	3
8	PB-214U	0.8902	3.7198E+01	5
9	RA-224T	0.9733	3.8086E+01	33
10	AC-228T	0.2883	2.5757E+01	6
11	TH-234U	0.8235	2.5580E+02	6
12	U-235	0.8118	1.7442E+01	6

Development & future plans

- Integration into STUK in-house data flow management system NAMIT
- Spectrum analysis with Unisampo/Shaman
- Complete work flow

Order from the customer →
Measurement plan →
People search or add into the database →
Measurements →
Spectrum analysis →
Evaluation of dose →
Results into the database →
Reporting to customer

Thank you!