

Experiences with accreditation of variable-geometry gamma-spectrometry

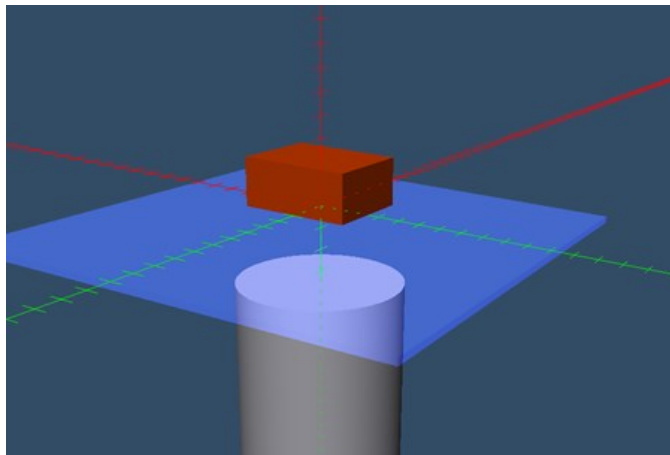


19. september 2023

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Specialkonsulent

Dealing with irregular geometries and unknown sample compositions



Periodic Table of the Elements

Atomic Number → **13** ← Symbol
 Name → **Aluminum** ← Atomic Weight
 Electrons per shell → **2, 8, 3**

State of matter (color of name)
 GAS LIQUID SOLID UNKNOWN

Subcategory in the metal-metalloid-nonmetal trend (color of background)
 Alkali metals Lanthanides Metalloids
 Alkaline earth metals Actinides Reactive nonmetals
 Transition metals Post-transition metals Noble gases Unknown chemical properties

1 IA H Hydrogen 1.008	2 IIA He Helium 4.0026																	18 VIIIA He Helium 4.0026
3 IA Li Lithium 6.941	4 IIA Be Beryllium 9.0122																	10 VIIIA Ne Neon 20.180
11 IA Na Sodium 22.990	12 IIA Mg Magnesium 24.305																	18 VIIIA Ar Argon 39.948
19 IA K Potassium 39.098	20 IIA Ca Calcium 40.078	21 3 Sc Scandium 44.956	22 4 Ti Titanium 47.88	23 5 V Vanadium 50.942	24 6 Cr Chromium 51.996	25 7 Mn Manganese 54.938	26 8 Fe Iron 55.845	27 9 Co Cobalt 58.933	28 10 Ni Nickel 58.693	29 11 Cu Copper 63.546	30 12 Zn Zinc 65.38	31 13 Ga Gallium 69.723	32 14 Ge Germanium 72.64	33 15 As Arsenic 74.922	34 16 Se Selenium 78.96	35 17 Br Bromine 79.904	36 18 Kr Krypton 83.80	
37 IA Rb Rubidium 85.468	38 IIA Sr Strontium 87.62	39 3 Y Yttrium 88.906	40 4 Zr Zirconium 91.224	41 5 Nb Niobium 92.906	42 6 Mo Molybdenum 95.94	43 7 Tc Technetium 98	44 8 Ru Ruthenium 101.07	45 9 Rh Rhodium 102.91	46 10 Pd Palladium 106.42	47 11 Ag Silver 107.87	48 12 Cd Cadmium 112.41	49 13 In Indium 114.82	50 14 Sn Tin 118.71	51 15 Sb Antimony 121.76	52 16 Te Tellurium 127.6	53 17 I Iodine 126.91	54 18 Xe Xenon 131.29	
55 IA Cs Cesium 132.91	56 IIA Ba Barium 137.33	57-71 3 Lanthanides	72 4 Hf Hafnium 178.49	73 5 Ta Tantalum 180.95	74 6 W Tungsten 183.84	75 7 Re Rhenium 186.21	76 8 Os Osmium 190.23	77 9 Ir Iridium 192.22	78 10 Pt Platinum 195.08	79 11 Au Gold 196.97	80 12 Hg Mercury 200.59	81 13 Tl Thallium 204.38	82 14 Pb Lead 207.2	83 15 Bi Bismuth 208.98	84 16 Po Polonium [209]	85 17 At Astatine [210]	86 18 Rn Radon [222]	
87 IA Fr Francium [223]	88 IIA Ra Radium [226]	89-103 3 Actinides	104 4 Rf Rutherfordium [261]	105 5 Db Dubnium [262]	106 6 Sg Seaborgium [263]	107 7 Bh Bohrium [264]	108 8 Hs Hassium [265]	109 9 Mt Meitnerium [266]	110 10 Ds Darmstadtium [267]	111 11 Rg Roentgenium [268]	112 12 Cn Copernicium [269]	113 13 Nh Nihonium [270]	114 14 Fl Flerovium [271]	115 15 Mc Moscovium [272]	116 16 Lv Livermorium [273]	117 17 Ts Tennessine [274]	118 18 Og Oganesson [276]	
57 3 La Lanthanum 138.91	58 4 Ce Cerium 140.12	59 5 Pr Praseodymium 140.91	60 6 Nd Neodymium 144.24	61 7 Pm Promethium [145]	62 8 Sm Samarium 150.36	63 9 Eu Europium 151.96	64 10 Gd Gadolinium 157.25	65 11 Tb Terbium 158.93	66 12 Dy Dysprosium 162.50	67 13 Ho Holmium 164.93	68 14 Er Erbium 167.26	69 15 Tm Thulium 168.93	70 16 Yb Ytterbium 173.05	71 17 Lu Lutetium 174.97				
89 3 Ac Actinium [227]	90 4 Th Thorium 232.04	91 5 Pa Protactinium 231.04	92 6 U Uranium 238.03	93 7 Np Neptunium [237]	94 8 Pu Plutonium [244]	95 9 Am Americium [243]	96 10 Cm Curium [247]	97 11 Bk Berkelium [247]	98 12 Cf Californium [251]	99 13 Es Einsteinium [252]	100 14 Fm Fermium [257]	101 15 Md Mendelevium [258]	102 16 No Nobelium [259]	103 17 Lr Lawrencium [260]				

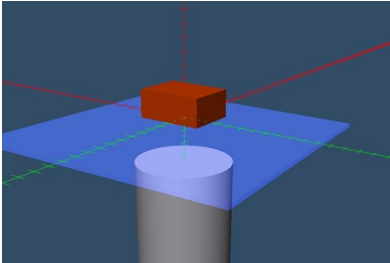
Terms



The client must agree on the proposed geometry model and assumed elemental composition.

The client must accept errors caused by deviations between the real sample and the used geometry model (LabSOCS), regarding:

- Dimensions and form (detailed structure)
- Distribution of radioactivity
- Self-absorption (elemental composition)



This was accepted by the accreditation authorities, **but**:

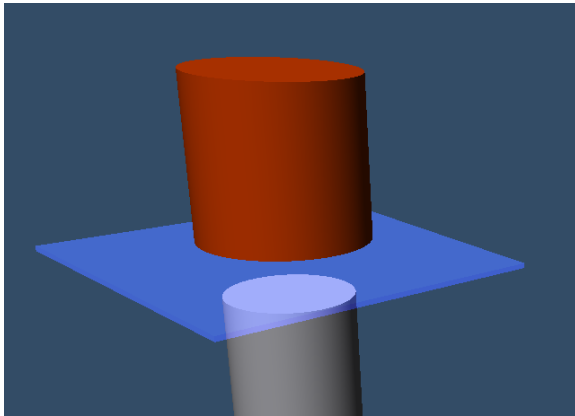
The lab must assist in trying to identify/justify the material composition and must provide guidance on magnitude of potential errors.

Therefore, sensitivity analysis was performed.

Energy-dependent sensitivity analysis (LabSOCS)

Assumed e.g.:

SiO₂ (quartz)
10x10 cm cylinder



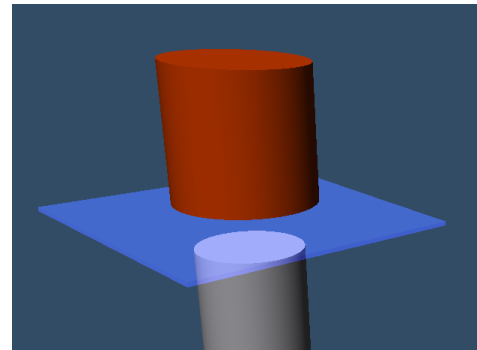
↓ .GIS file

Eff(E)

$$A_0(E) = 1/\text{Eff}$$

What if:

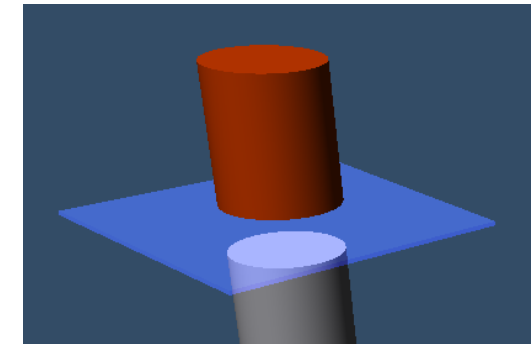
BaSO₄ (barite)



↓ .GIS file

$$A_i(E) = ?$$

10x8 cm cylinder

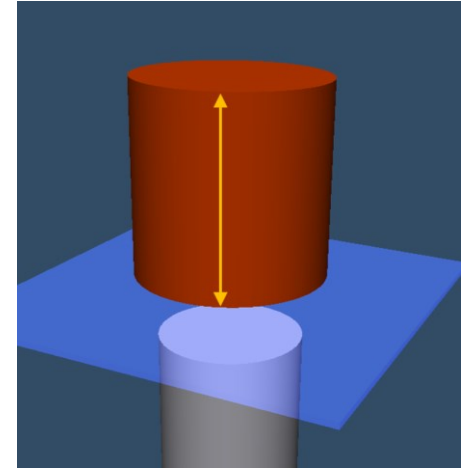
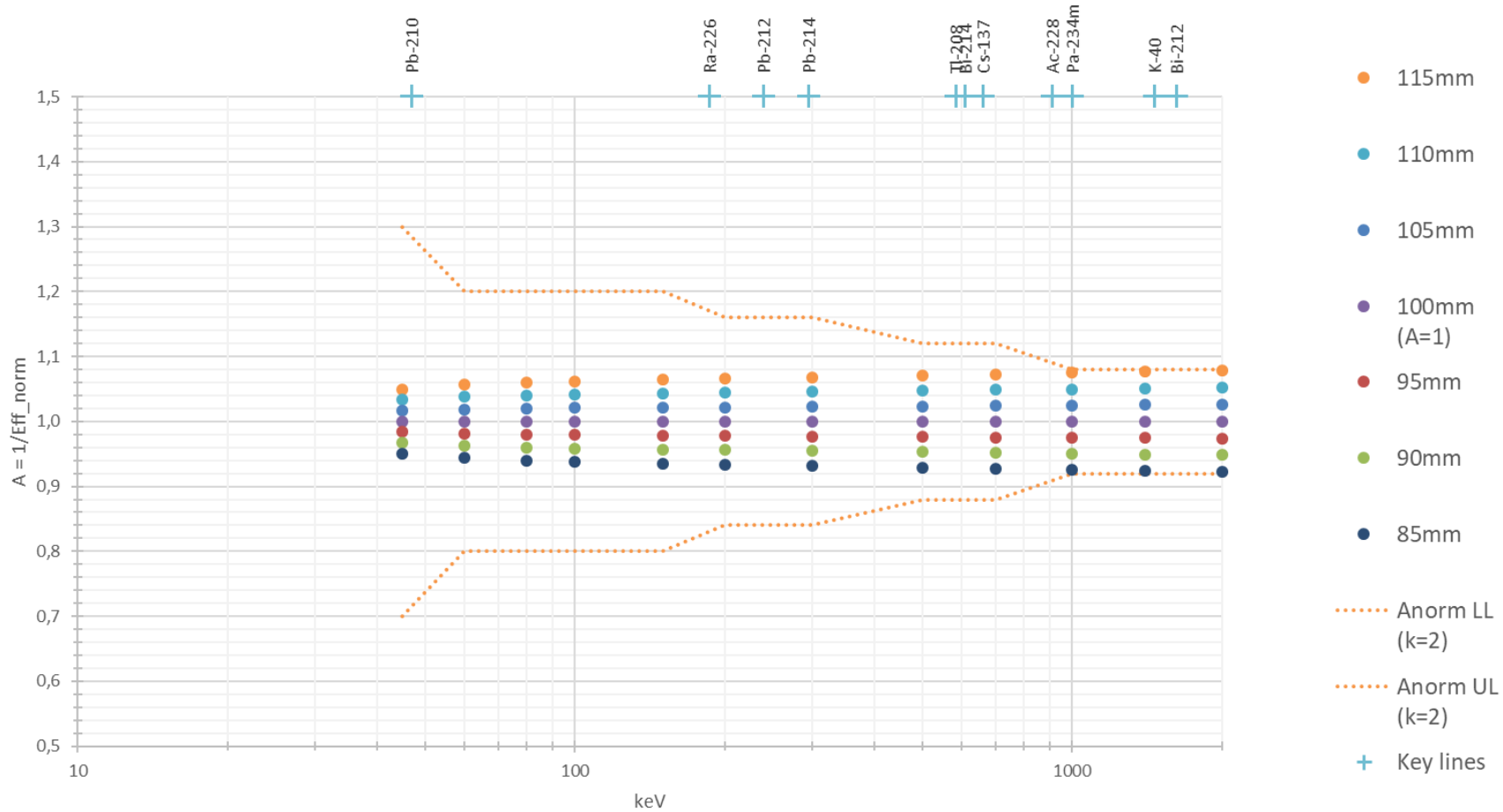


↓ .GIS file

$$A_i(E) = ?$$

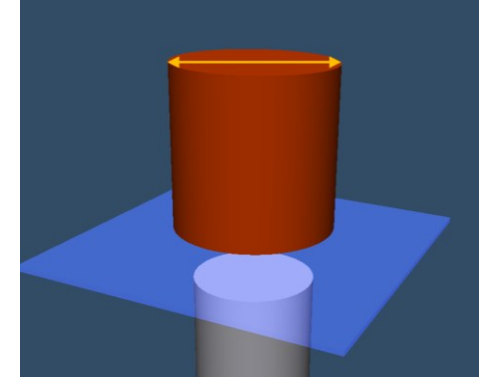
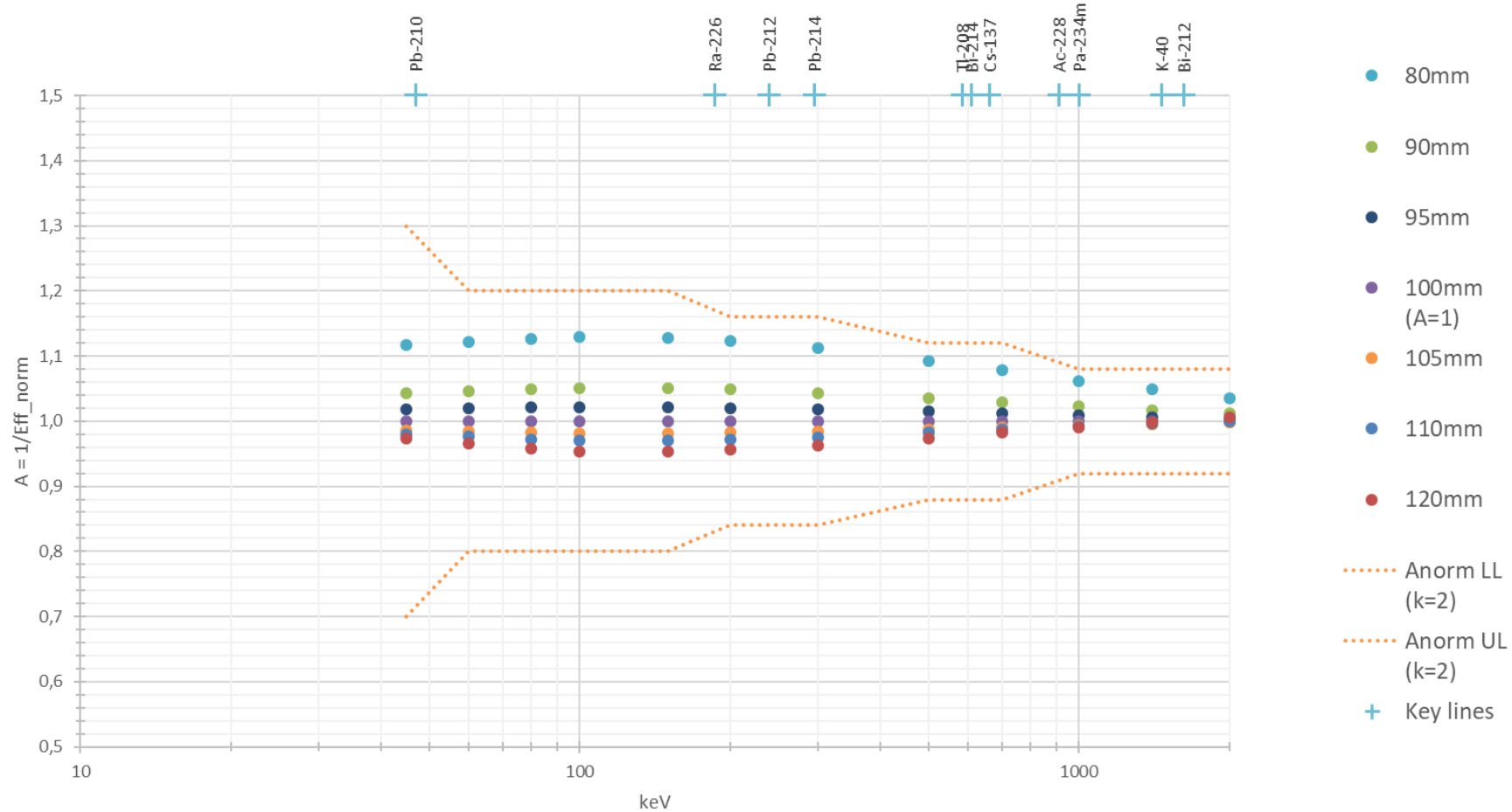
Sample height

Water. CoAx60 H1CVE Diam 10cm. Constant mass. Normalized activity if true fill height is



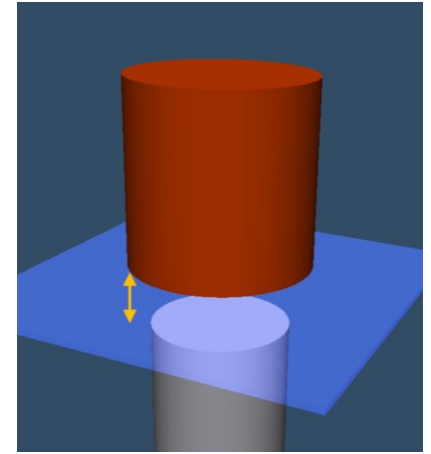
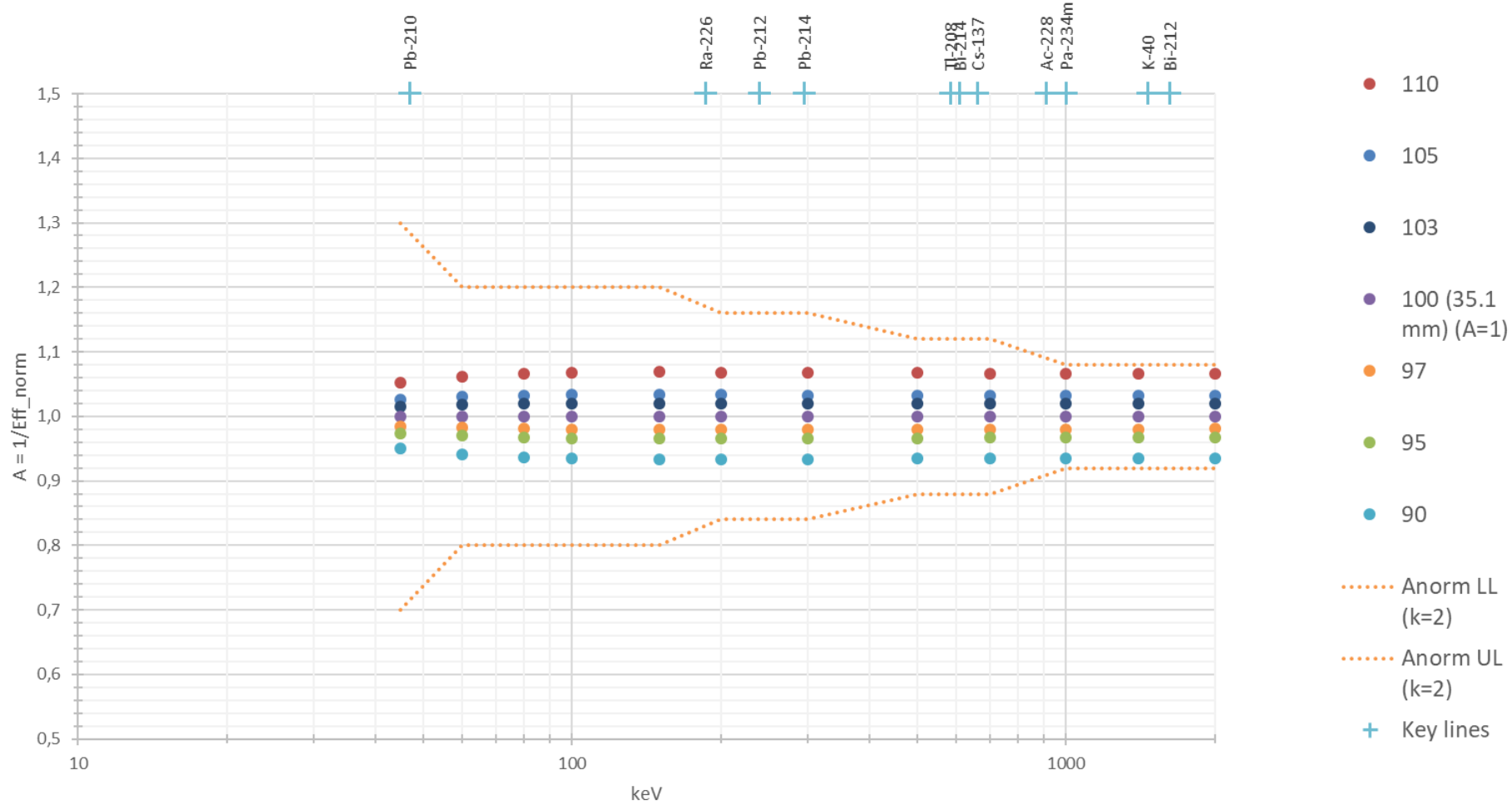
Sample diameter

Water. CoAx60 H1CVE Height 10cm. Constant mass. Normalized activity if true diameter is



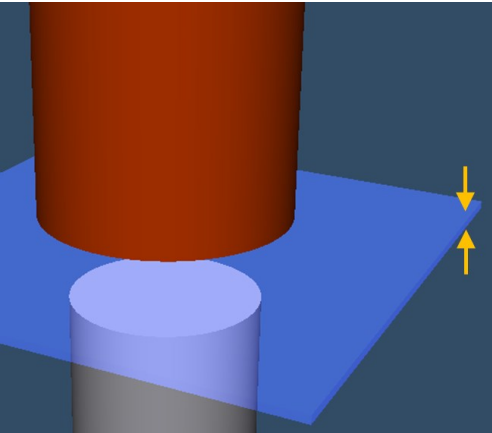
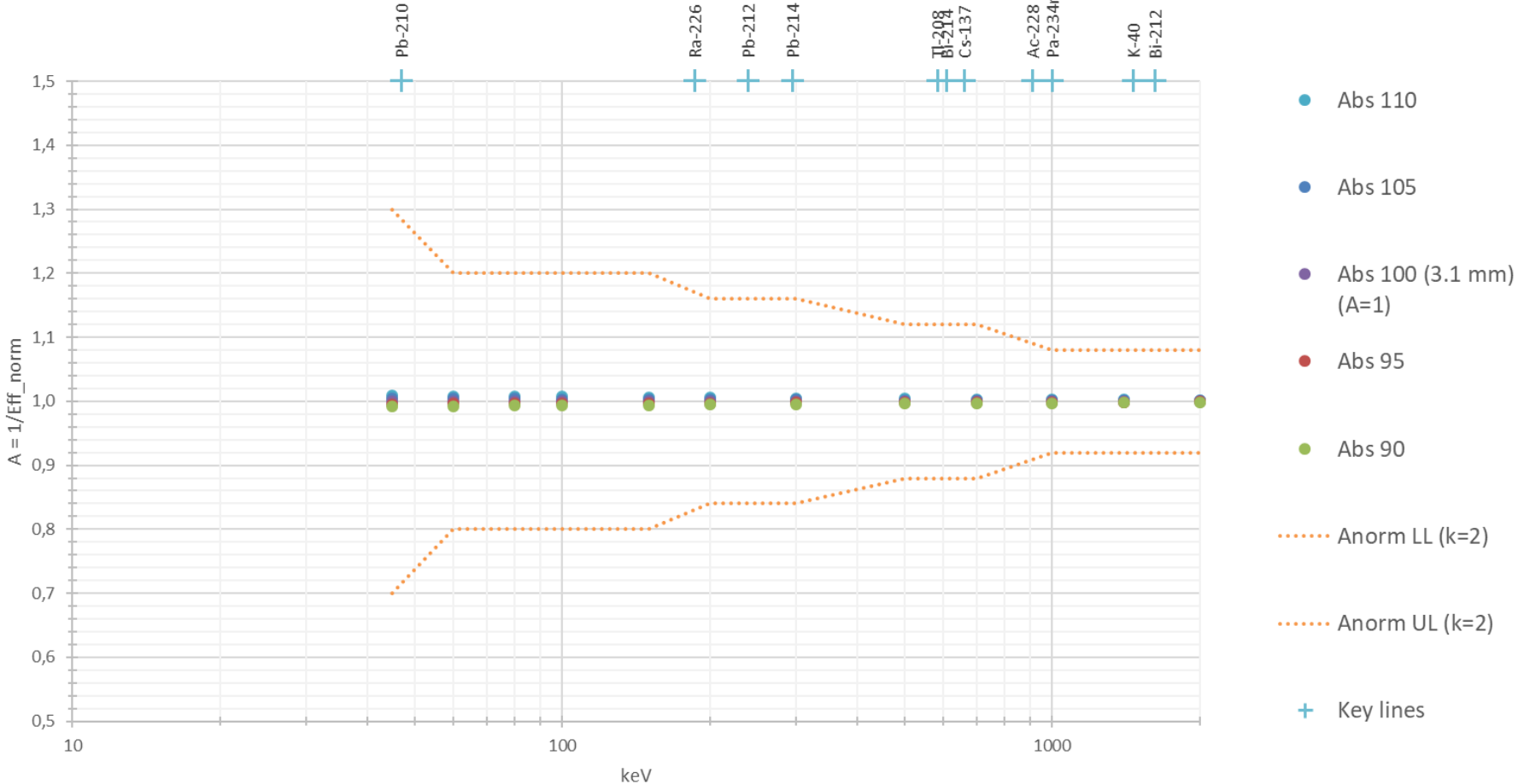
Source-detector distance

Water. CoAx60 H1CVE 10x10cm. Normalized activity if true detector distance is



Absorber thickness

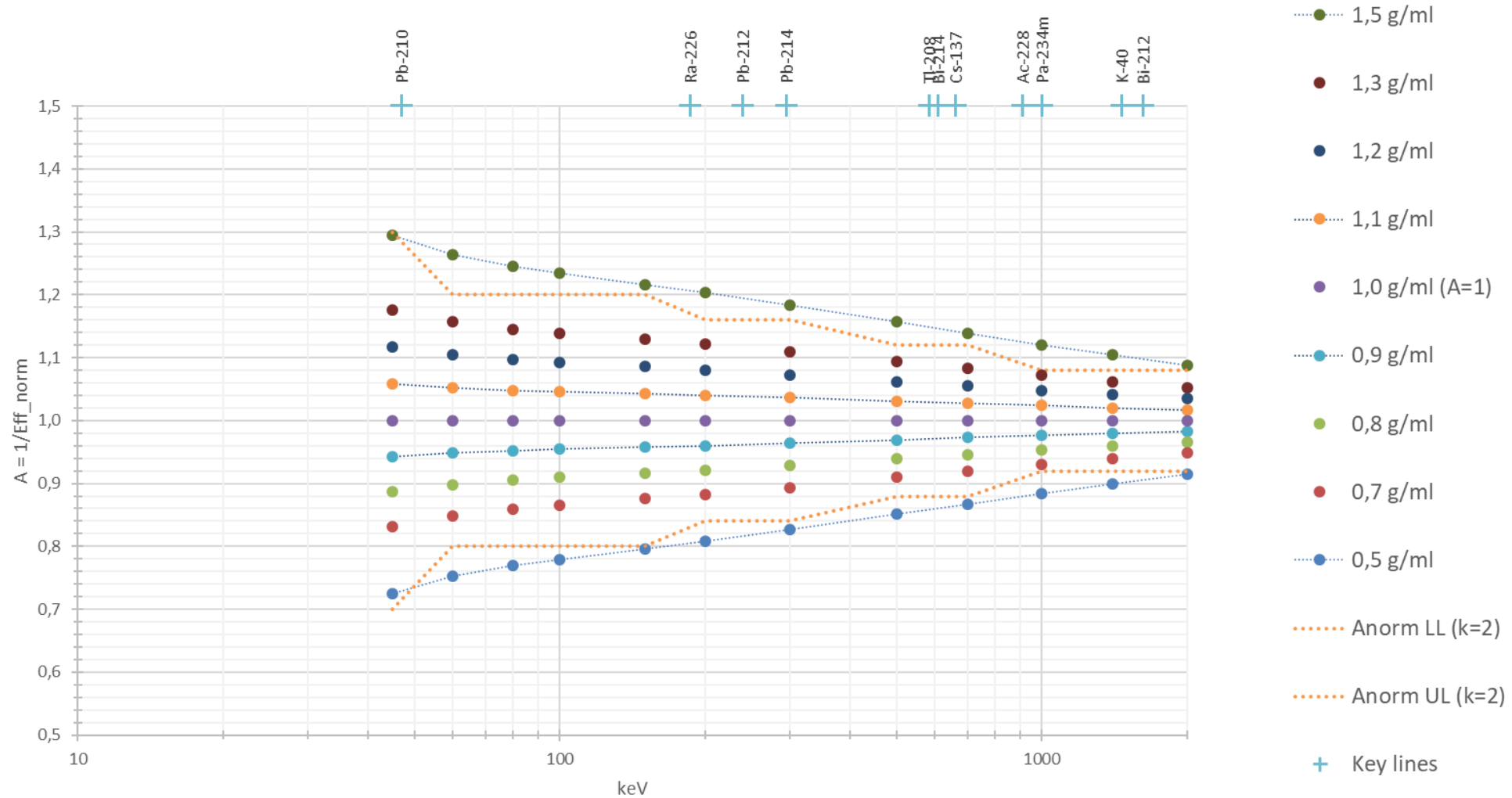
Water, CoAx60 H1CVE 10X10cm. Normalized activity if true absorber thickness is



plexiglas

Sample density

Water. CoAx60 H1CVE 10x10cm. Constant volume. Normalized activity if true density is



Minerals

Density: 2-5 g/ml



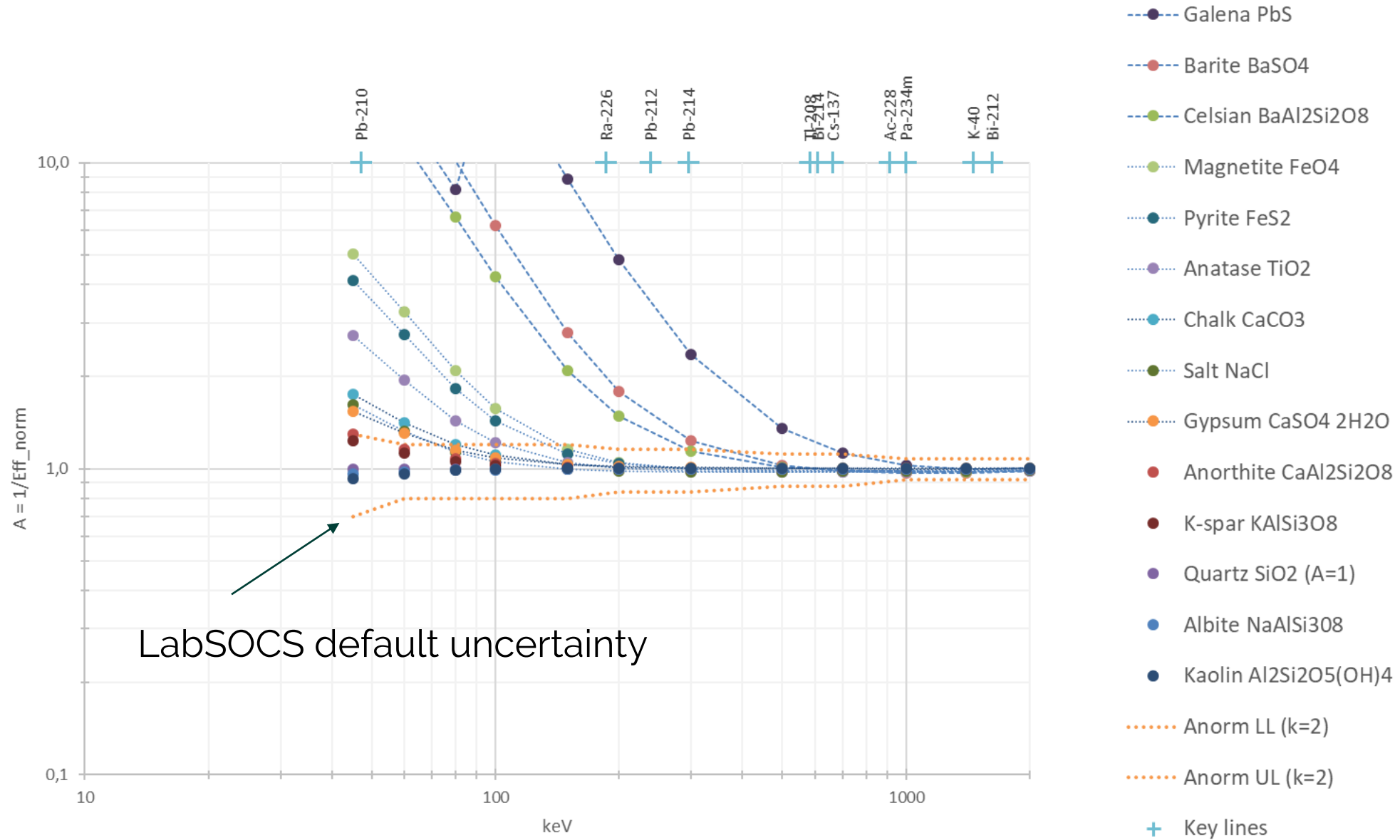
"Tugtupit"
2,35 g/ml



"Apatit"
2,8 g/ml



Minerals. CoAx60 H1CVE 10x10cm. Constant density (2.6g/ml). Normalized activity if true material is



Polymers



PE
(polyethylene)
0,93 g/ml



PVC
1,38 g/ml
(+ chlorine)



PP
(polypropylene)
0,91 g/ml



Silicone
0,95-1,20 g/ml
(+ silicium)

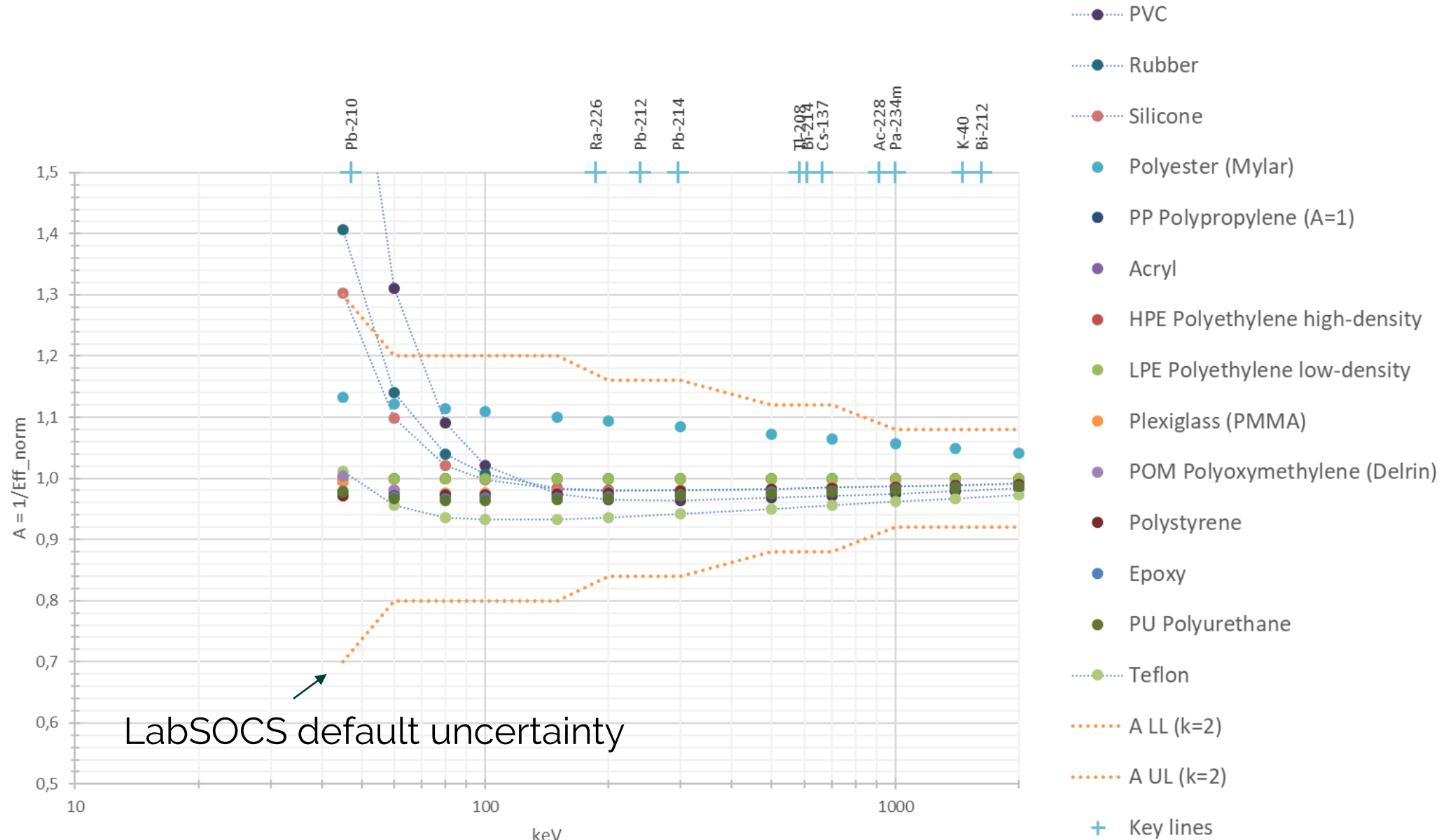


PU
1,0 -1,3 g/ml



Rubber
1,34 g/ml
(+ sulphur)

Plastics, CoAx60 H1CVE 10x10cm. Constant density (1 g/ml). Normalized activity if true material is



Metals and alloys



Steel / iron
ca. 8 g/ml



Stainless
ca. 8 g/ml



Brass
ca. 8,5 g/ml



Zinc
7,1 g/ml

(Surface only?)

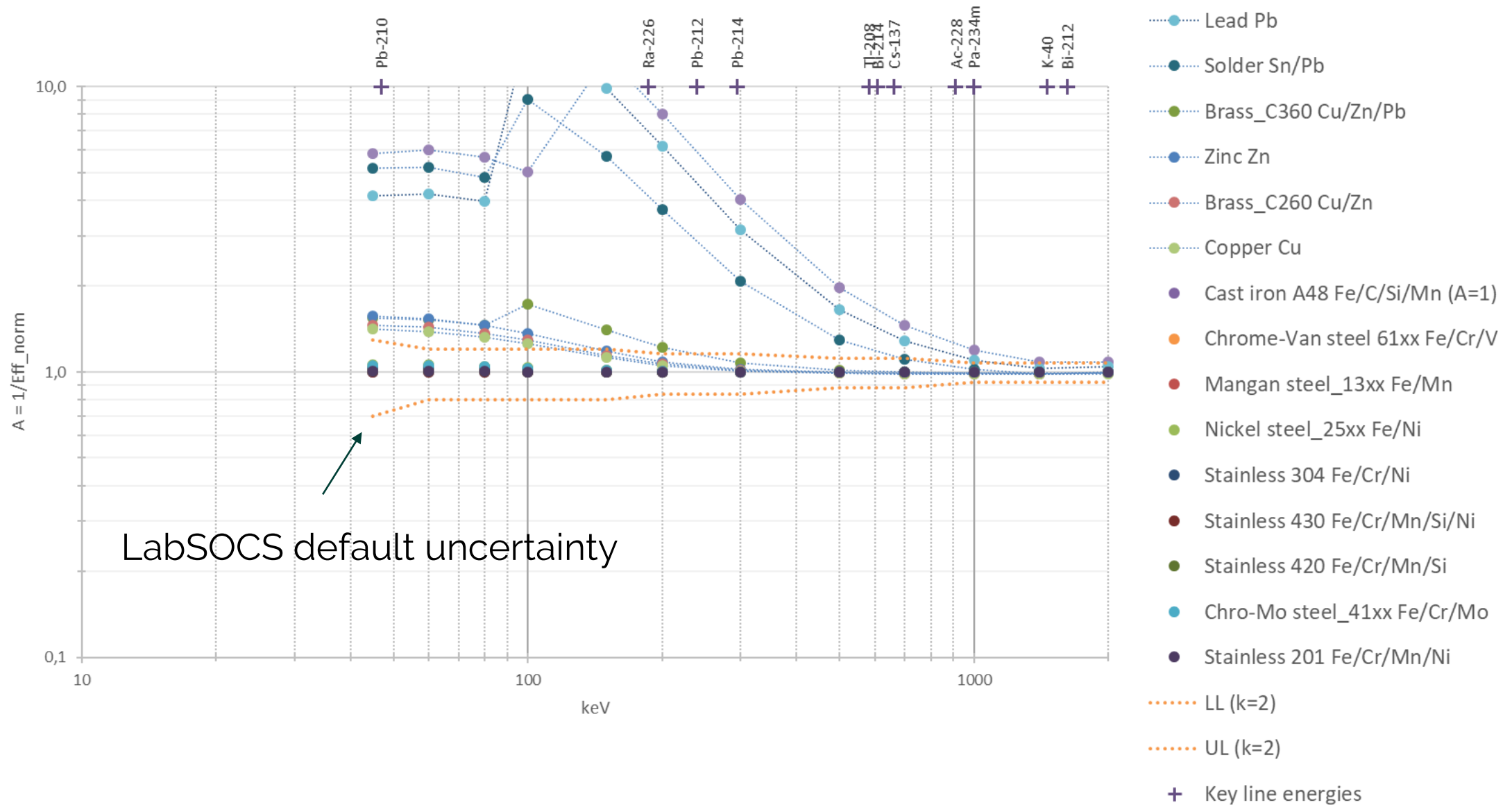


Lead
11,3 g/ml



Copper
9 g/ml

Iron_Steel. CoAx60 H1CVE 10x10 cm. Constant density (7.8g/ml). Normalized activity if true material is



Light-metal alloys



Carbon
2,26 g/ml



Magnesium
1,7 g/ml



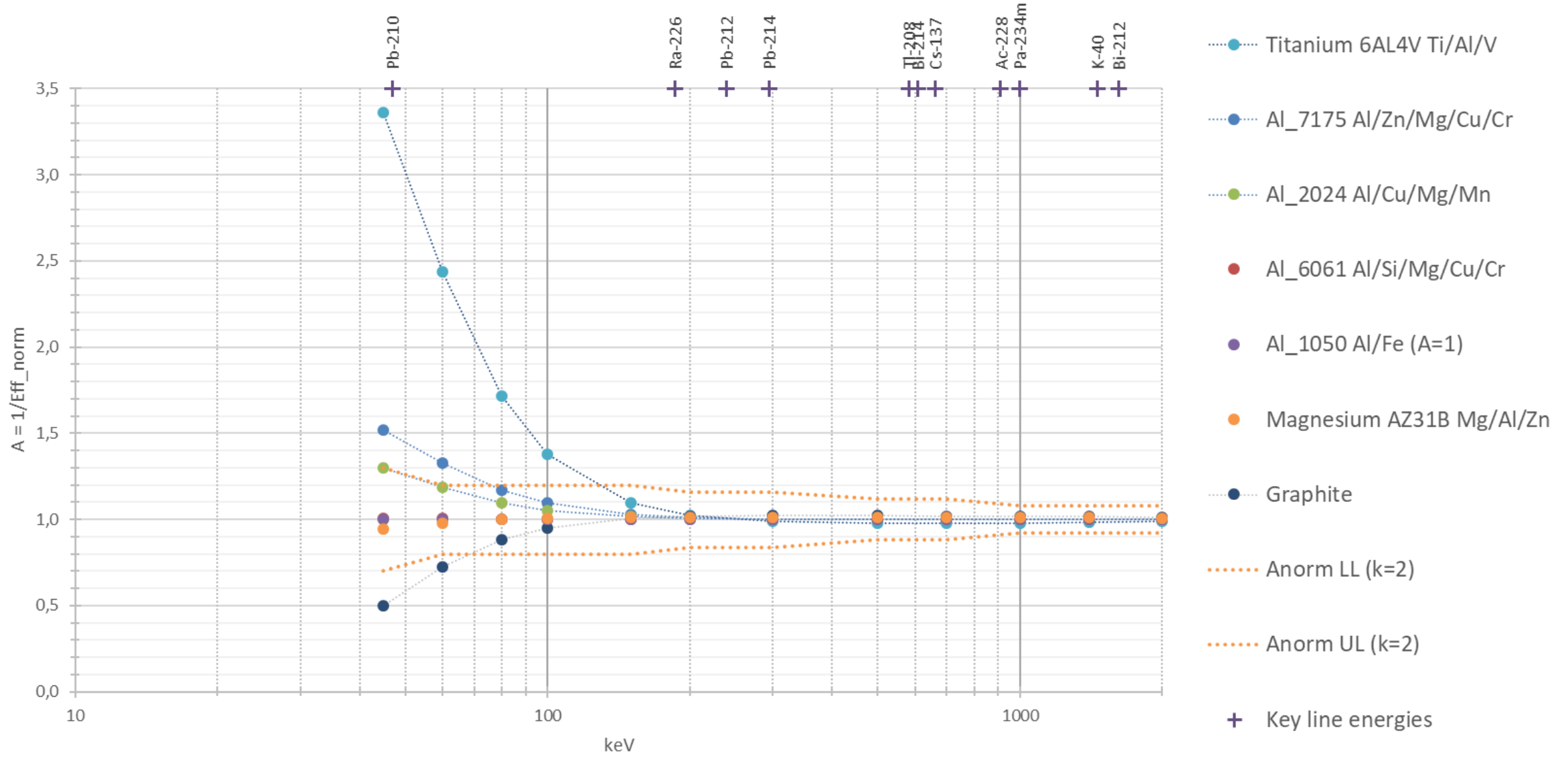
Aluminium
2,7 g/ml
(evt. + Zn, Cu, Mg, Fe, Cr)



Titanium
4,5 g/ml



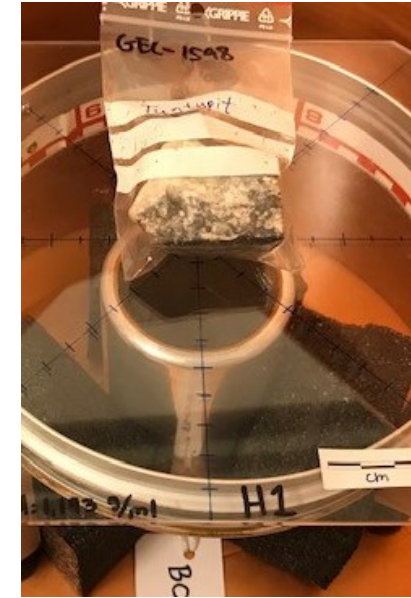
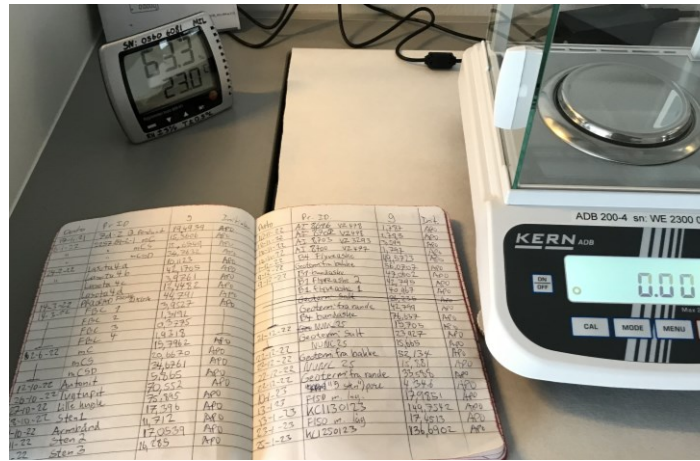
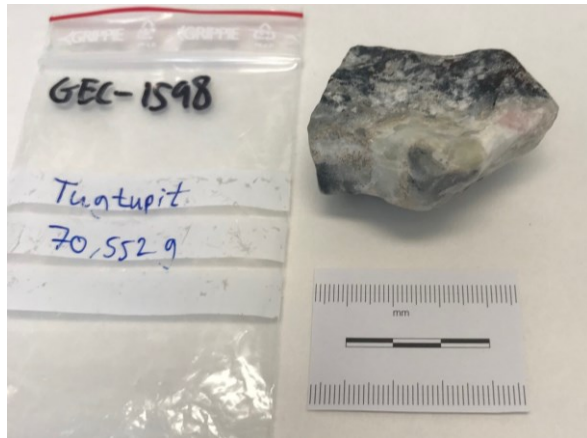
Light metals. CoAx60 H1CVE 10x10 cm. Constant density (2.8g/ml). Normalized activity if true material is



Conclusions

- Material-knowledge is important.
- Light elements can be excluded based on observed density (porosity is possible - compression is not) .
- Variation in sample dimensions and density typically leads to errors that are within LabSOCS default uncertainty.
- Unknown presence of heavy elements in e.g. minerals, light-metal alloys and plastics can lead to significant under-reporting of activity – primarily for $E < 200$ keV (e.g. Pb-210).
- Variations in steel-alloys have little or insignificant effect.

Documentation



Notatskema for gammalspektrometri (dd-mm-yyy) Ref: DokID 5386

Udfyldt af: AP0 Dato: 26-10-22 Indskannet

Projekt-titel: Krystaller 12-10-22 SIS nr.: GEC-1598

Prøve ID: Tugtupit Ref. dato: 12-10-22 12:00

Anvendt vægt: GR-202 sn 14226971 EK-3000i sn P1871910

Total vægt: 70,552 g Beholder vægt: 0,001 g

Sample Quantity: 70,552 Unit: g u: 0,001 u ref. DokID 4941

Holder: "H1" 3.1 mm plexigls (+ 32 mm) "PLEX" 5 mm plexigls (+ 16 mm) "CAP" 3 mm delrin (+ 16 mm +...)

Detektor: B08006 (GEC.) B20128 (GEC.) 13000044 (FAL-) 13000328 (FAL2-)

Repræsentativ Tilnærmet

Template: Cust. General Purp. Beaker CGB Cust. Simplified Beaker CSB Cylinder CVE Cylinder From Side CHQ Disk DSK Gen. Purpose Beaker DGB Gen. Purp. Marinelli Beaker GMA Point PNT Simplified Beaker DSB Simplified Box SBX Simplified Marinelli Beaker SMA Simplified Sphere SPH

Fyldehøjde: 50 mm "Contour file": 2044 .BKR

Vol (b*h*d, r²*pi*h, r³*pi*4/3): 50*40*22 2044 44 cm³

Beregnet densitet: 70,552/44 = 1,603 g/ml

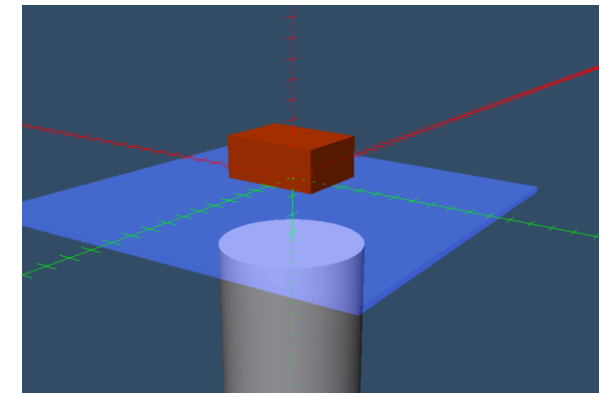
d \ X \ X	mm	Materiale	Densitet (g/ml)	Evt. vægt (g), Rel. Conc.
1.1	0	none		
1.2	50	none		
1.3	40	none		
2.1	0	none		
3.1	22	Feldspar	1,603	
4.1	3,1	plexigls	1,2	
5.1	35,1			

Geometri-model (GIS udtræk).

Template:	'SIMPLIFIED_BOX'				Kontur:	na
Geo file:	'c:\genie2k\isocs\data\geometry\laboratory\simplified_box\gec-1598_h1sbx.geo'					
Detektor:	B08006	Description:		GEC-1598 H1SBX		
Ambient pres.:	760	Amb. temp.:	22	Rel. hum. (%):	30	
MC Conv. (%):	1	L. units:	mm	Density units:	g/cu.c	(cu.c = ml)
D	.1	.2	.3	.4	Material	Density
1.	na	50	40	na	na	na
2.	na	na	na	na	na	na
3.	22	na	na	na	FELDSPAR	1,603
4.	na	na	na	na	na	na
Abs1	3,1				na	na
Abs2	na				na	na
Source-Det.	35,1					
X-Offset	na					

Sammensætning (mu01_8lb.txt udtræk)

Material 1:	na	na
Material 2:	na	na
Material 3:	FELDSPAR	KALSI308:33.00% NAALSI308:33.00% CAAL2SI208:34.00%
Material 4:	na	na
Absorb. 1:	PLEXIGLS	C5H8O2:100.00%
Absorb. 2:	na	na
Rapport ID:	GEC-1598-K1-Tugtupit [18-09-2023 15:43:12]	



Dimensions

