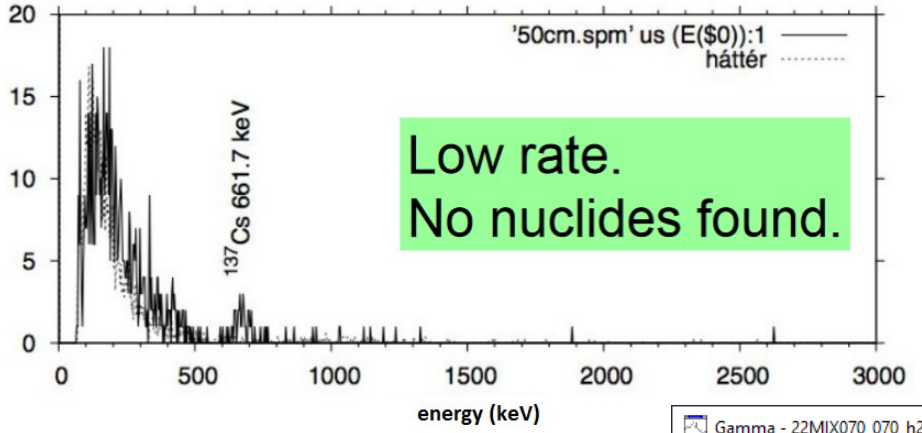
Improvement of reliability of evaluation of gamma-spectra by simultaneously applied computer codes

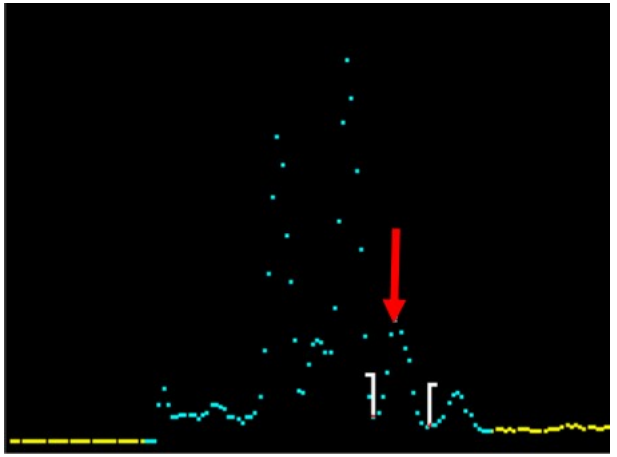
András Kocsonya

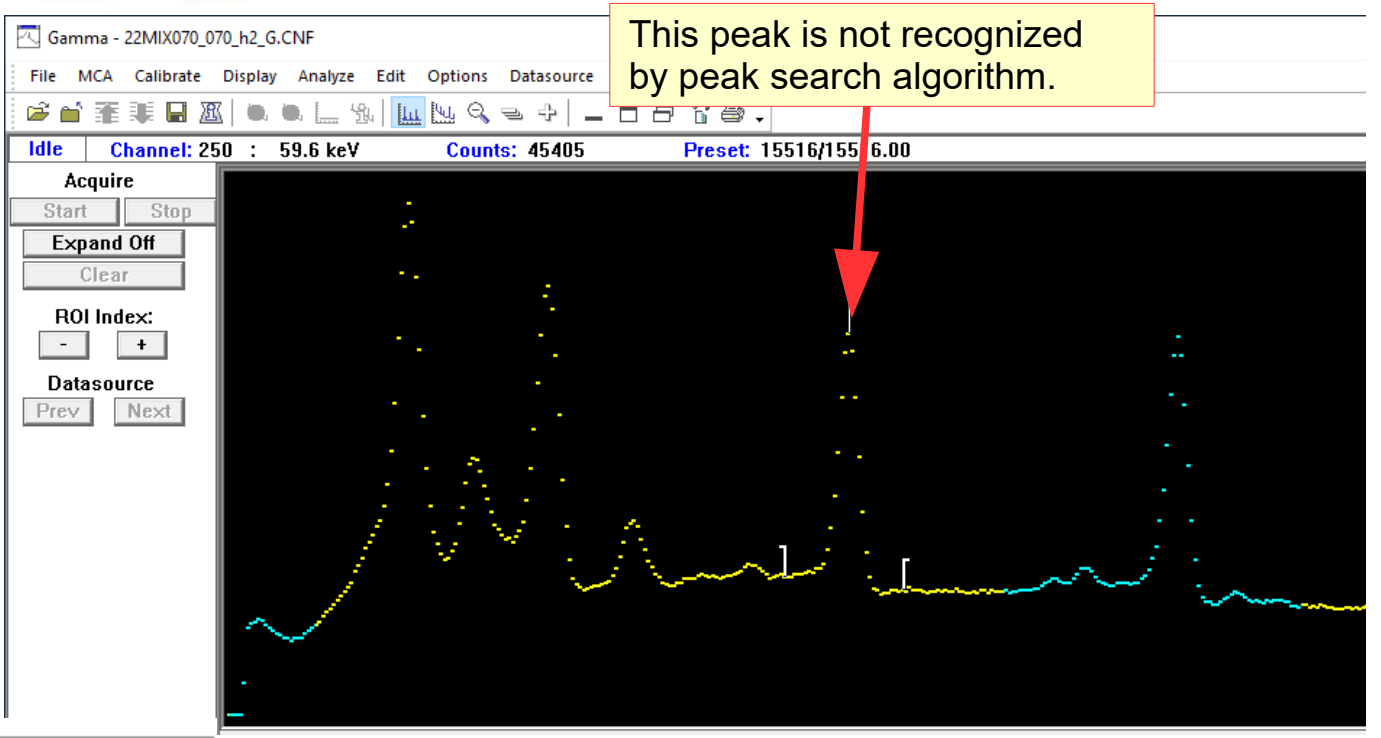
HUN-REN Centre for Energy Research (earlier KFKI), Budapest, Hungary

GammaAI 2025 seminar DTU Lyngby Campus, Denmark, October 8 - 9, 2025

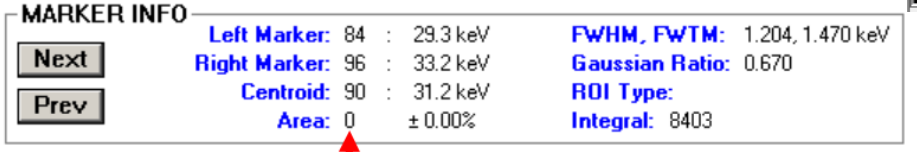
Automated algorithms are available but sometimes makes mistakes







This peak is not recognized by peak search algorithm.

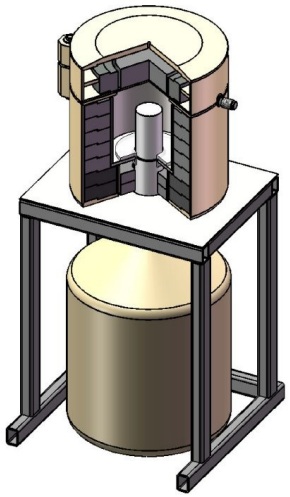


Clear peak but zero peak area.

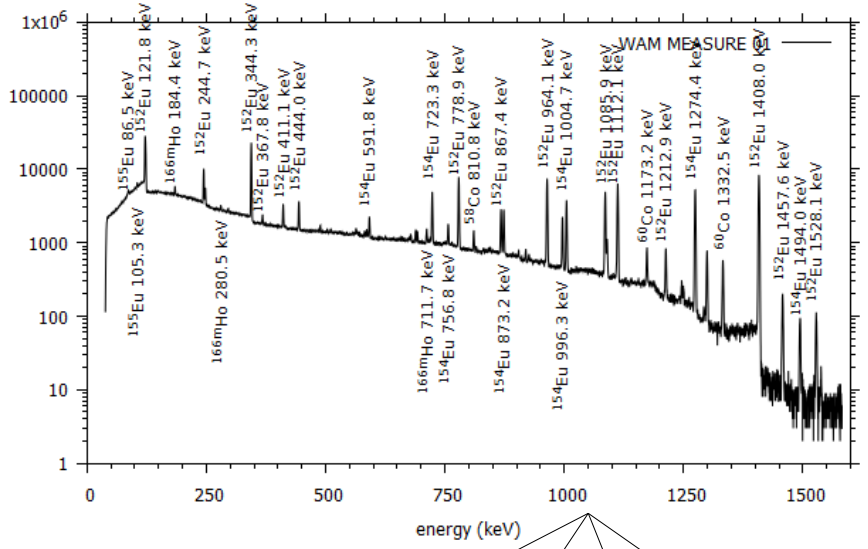
This measurement is repeated 8 times.

In 7 cases the result of automatic analysis was satisfactory.
But in this case something was failed.

Improvement of reliability of spectrum evaluation by simultaneous codes



measurement



In case of individual specra, interactuve evaluationm, human contro is to be applied.

In case of huge amount of similar spectra, some machine-based check is preferred.

e.g: environmental monitoring,
internal dosimetry

In these studies, the majority of spectra contains nothing interesting.
But the opposite cases should be observed with high enough confidence.

code 1 | code 2 | code 3 | ...

Intercomparison of results

If the evaluation results are identical within reasonable differences, the evaluation result can be considered as acceptable.

Specrtum evaluation codes to be used

The selection of spectrum evaluation code is base on availablility and personal preferences.
In case of interactive spectrum evaluation, even different code can be used for different steps of evaluation.

software		author / institution	remark
FitzPeaks		Jim Fitzgerald JF Computing Services	free 'evaluation copy' my favourite spectrum evaluation sofware
InterSpec		Sandia National Laboratories	free, good experiences
GSanal		Institute of Nuclear Techniques, Budapest University of Technology and Economics Péter Zagyvai / Ákos Fehér	authors are available
Hyperlab		Hyperlab Software Simonits András. Östör József, Kálvin Sándor, Fazekas Béla	authors are former colleagues of Institute of Isotopes (Budapest, Hungary)
SAMPO 90 /SHAMAN		Lawrence Livermore National Laboratory	worldwide known software developed since 1969 Still I have no experience with it, but I intend to learn.

Intercomparison of 5 algorithms

Canberra GX3018

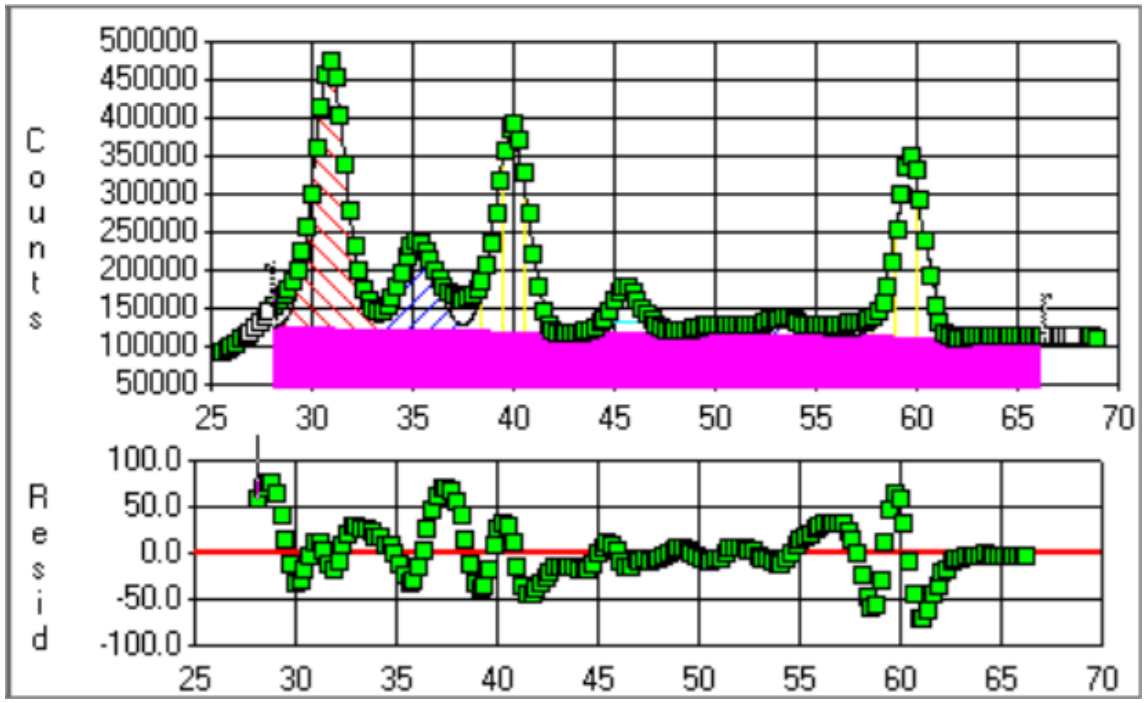
MIX 2018-014	A (kBq)
^{241}Am	396,1
^{152}Eu	502,4
^{133}Ba	484,5
^{60}Co	980,8
^{137}Cs	696,0
ref. date:	2018-06-01

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1					avg. Of 4 methods			Genie-2000 2nd diff.			Genie-2000 VMS Standard			FitzPeaks			InterSpec			Genie-2000 interactive		
2	nuclide	energy	Ig	remark	AVG	STDEV	rel.dev.	AVG	STDEV	rel. dev.	AVG	STDEV	rel. dev.	AVG	STDEV	rel. dev.	AVG	STDEV	rel. dev.	AVG	STDEV	rel. dev.
3		(keV)																				
4	Cs-Ka	30,85	99,50%		330 150	20 355	6,17%	359 029	8 898	2,48%	311 540	3 583	1,15%	322 783	27 921	8,65%	327 249	22 506	6,88%			
5	Cs-Kb	35,14	21,91%		100 077	24 882	24,86%	125 400	8 351	6,66%	114 929	5 271	4,59%	89 699	3 871	4,32%	70 280	7 538	10,73%			
6	Sm-Ka	39,91	59,40%		259 350	21 146	8,15%	279 257	6 487	2,32%	275 391	4 354	1,58%	245 950	2 116	0,86%	236 804	2 298	0,97%			
7	Sm-Kb	45,55	14,28%		58 145	610	1,05%	57 611	2 684	4,66%	57 622	2 285	3,96%	58 660	1 197	2,04%	58 686	1 011	1,72%			
8	Ba-133	53,16	2,20%		15 092	6 129	40,61%	24 261	2 328	9,59%	12 600	4 988	39,59%	11 512	461	4,00%	11 995	457	3,81%	8 649	952	11,01%
9	Am-241	59,54	35,94%		205 855	11 210	5,45%	221 257	2 960	1,34%	206 583	13 933	6,74%	199 927	1 485	0,74%	195 653	1 253	0,64%	200 381	1 576	0,79%
10	Ba-133	81,00	36,68%		214 532	8 676	4,04%	207 538	2 492	1,20%	227 197	12 992	5,72%	212 149	6 790	3,20%	211 245	2 867	1,36%			
11	Eu-152	121,8	28,58%		213 430	1 533	0,72%	211 788	4 025	1,90%	214 028	463	0,22%	215 266	931	0,43%	212 640	847	0,40%	214 712	1 416	0,66%
12	Ba-133	160,6	0,65%		4 247	278	6,55%	4 114	785	19,08%	3 923	949	24,19%	4 525	449	9,92%	4 427	612	13,82%			
13	Ba-133	223,2	0,45%		2 493	199	7,98%	2 251	308	13,67%	2 670	308	11,55%	2 641	461	17,45%	2 411	418	17,35%			
14	Eu-152	244,7	7,58%		44 298	187	0,42%	44 359	564	1,27%	44 164	468	1,06%	44 535	500	1,12%	44 133	233	0,53%			
15	Ba-133	276,4	7,16%		35 403	179	0,51%	35 350	411	1,16%	35 345	697	1,97%	35 664	505	1,42%	35 254	439	1,24%			
16	Ba-133	302,9	18,33%		84 719	439	0,52%	84 736	538	0,64%	84 395	308	0,36%	85 334	344	0,40%	84 410	307	0,36%			
17	Eu-152	344,4	26,50%		124 610	395	0,32%	124 738	403	0,32%	124 132	454	0,37%	125 069	565	0,45%	124 503	448	0,36%			
18	Ba-133	356,0	62,05%		257 637	847	0,33%	257 800	685	0,27%	256 561	815	0,32%	258 619	903	0,35%	257 569	762	0,30%	256 208	934	0,36%
19	Eu-152	367,8	0,86%		3 918	95	2,43%	3 828	159	4,15%	3 879	490	12,64%	4 051	208	5,14%	3 916	213	5,45%			
20	Ba-133	383,9	8,94%		35 084	73	0,21%	35 170	335	0,95%	35 000	394	1,13%	35 109	273	0,78%	35 055	280	0,80%			
21	Eu-152	411,1	2,23%		9 256	282	3,04%	9 018	292	3,24%	9 664	437	4,52%	9 184	291	3,17%	9 157	272	2,97%			
22	Eu-152	444,0	3,15%		12 478	107	0,85%	12 400	355	2,86%	12 621	513	4,07%	12 496	411	3,29%	12 393	295	2,38%			
23	Eu-152	488,7	0,42%		1 440	56	3,92%	1 373	235	17,12%	1 475	240	16,25%	1 497	137	9,19%	1 416	176	12,44%			
24	Eu-152	564,0	0,49%		1 677	289	17,23%	1 976	314	15,88%	1 342	446	33,22%	1 541	121	7,88%	1 850	219	11,81%			
25	Eu-152	586,3	0,46%		1 600	99	6,21%	1 599	263	16,47%	1 460	433	29,66%	1 672	58	3,49%	1 670	190	11,37%			
26	Cs-137	661,7	85,12%		406 281	1 172	0,29%	406 588	922	0,23%	404 745	737	0,18%	407 572	743	0,18%	406 218	815	0,20%	404 691	763	0,19%
27	Eu-152	678,6	0,47%		1 014	126	12,46%	895	287	32,04%	915	348	37,99%	1 122	168	14,94%	1 125	122	10,82%			
28	Eu-152	688,7	0,86%		2 506	161	6,41%	2 269	410	18,07%	2 622	232	8,86%	2 546	78	3,06%	2 586	141	5,44%			
29	Eu-152	719,3	0,34%		878	134	15,21%	699	182	26,02%	1 022	164	16,09%	889	147	16,50%	902	96	10,65%			
30	Eu-152	778,9	12,94%		35 632	89	0,25%	35 579	234	0,66%	35 630	186	0,52%	35 759	226	0,63%	35 562	186	0,52%			
31	Eu-152	810,5	0,32%		823	118	14,32%	908	332	36,58%	939	332	35,34%	747	116	15,58%	699	123	17,56%			
32	Eu-152	867,4	4,25%		10 920	82	0,75%	10 845	195	1,79%	11 025	265	2,40%	10 945	206	1,88%	10 866	133	1,22%			
33	Eu-152	919,3	0,43%		966	161	16,61%	901	174	19,35%	1 196	313	26,14%	944	159	16,86%	825	85	10,32%			
34	Eu-152	964,1	14,61%		35 449	238	0,67%	35 474	214	0,60%	35 219	386	1,10%	35 771	473	1,32%	35 334	234	0,66%			
35	Eu-152	1005,3	0,65%		1 627	67	4,13%	1 663	227	13,63%	1 567	231	14,72%	1 575	175	11,09%	1 704	216	12,70%			
36	Eu-152	1085,9	10,21%		23 255	207	0,89%	23 129	147	0,63%	23 548	246	1,04%	23 252	241	1,04%	23 091	141	0,61%			
37	Eu-152	1089,7	1,73%		3 905	85	2,18%	3 918	217	5,54%	3 814	304	7,97%	4 016	124	3,09%	3 872	183	4,73%			
38	Eu-152	1112,1	13,64%		31 603	207	0,65%	31 826	425	1,34%	31 328	286	0,91%	31 656	549	1,73%	31 601	210	0,66%			
39	Co-60	1173,2	99,98%		305 069	1 111	0,36%	304 750	795	0,26%	304 229	823	0,27%	306 702	1 019	0,33%	304 595	777	0,26%	303 770	846	0,28%
40	Eu-152	1212,9	1,42%		2 989	43	1,43%	2 975	139	4,66%	3 051	120	3,92%	2 954	115	3,91%	2 977	153	5,13%			
41	Eu-152	1299,1	1,62%		3 213	69	2,15%	3 126	71	2,27%	3 294	49	1,50%	3 205	83	2,59%	3 226	68	2,12%			
42	Co-60	1332,5	99,97%		281 519	687	0,24%	281 225	1 044	0,37%	281 072	1 012	0,36%	282 544	1 175	0,42%	281 234	1 211	0,43%			
43	Eu-152	1408,0	21,01%		40 086	86	0,21%	40 033	191	0,0047616	40 048	214	0,53%	40 214	151	0,37%	40 049	204	0,51%			
44	Eu-152	1457,6	0,50%		848	138	16,29%	939	29	0,0310938	651	213	32,79%	854	52	6,10%	949	40	4,20%			

Spectrum of GammaAI Seminar 2025 Data Analysis Intercomparison

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	ref. date		2022-01-01											
2	meas. Da		2025-03-12		elapsed time	1 166	days	3,19	years					
3	livetime	LT=	1 102 212	s										
4	sample mass		475,36	g =	0,475	kg								
5														
6					net peak area								ref. date	
7	nuclide	energy	branching r.	det.eff.	FitzPeaks	InterSpec	HyperLab	average	Std. Dev	activity (Bq)	T 1/2 (y)	decay corr.	activity	act.conc.
8	K-40	1460,8	10,55%	0,007848	188 647	188 758	188 801	188 735	79	206,82	1,25E+09	1,0000	206,82	435,09
9	Ba-133	356	62,05%	0,026876	1 433	1 602	1 434	1 490	97	0,08	10,539	0,8106	0,10	0,21
10	Cs-137	661,7	85,01%	0,014888	6 194	5 993	6 211	6 133	121	0,44	30,018	0,9289	0,47	1,00
11	Eu-152	344,28	26,59%	0,027766			291	291		0,04	13,522	0,8490	0,04	0,09
12														
13	Bi-214	609,3	45,49%	0,016005	76 452	76 232	76 180	76 288	144	9,51				20,00
14	Pa-234m	1001	85,00%	0,010728	796	794	783	791	7	0,08				0,17
15	Pb-210	46,54	4,25%	0,033547	21 830	23 792	22 403	22 675	1 009	14,43				30,35
16	Pb-214	351,9	35,60%	0,027181	113 621	113 776	114 465	113 954	449	10,68				22,48
17	Ra-226	186,2	3,56%	0,046921	32 406	32 397	32 928	32 577	304	17,69				37,22
18														
19	Ac-228	911,2	26,20%	0,011523	31 442	31 385	31 461	31 429	40	9,44				19,87
20	Bi-212	727,33	6,65%	0,013753	10 467	10 498	10 474	10 480	16	10,40				21,87
21	Pb-212	238,6	43,60%	0,038747	185 122	180 566	185 033	183 574	2 605	9,86				20,74
22	Tl-208	583,2	85,00%	0,016651	49 591	49 114	49 487	49 397	251	3,17				6,66
23														
24														
25	U-235	185,7	57,00%	0,047011	32 406	32 397	32 928	32 577	304	1,10				2,32
26	U-235	143,8	10,94%	0,055404	3 499	3 809	3 745	3 684	164	0,55				1,16

Thank you for your attention!



András Kocsonya, PhD
senior research scientist
kocsonya@rmki.kfki.hu
HUN-REN Centre for Energy Research, Budapest, Hungary