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Interference of natural radionuclides and detector/shielding neutron interactions with the detection of CTBT-relevant radionuclides

Arend Harms, Carla Pires, Eric Nguelem, Jana Meresova, Jonathan Bare*, Nolasco Mlwilo, Seokryung Yoon and Gerard Rambolamanana*

CTBTO Preparatory Commission
(* separated from service)

CTBTO PREPARATORY COMMISSION | PUTTING AN END TO NUCLEAR EXPLOSIONS

INTRODUCTION AND MAIN RESULTS

Several natural radionuclides and those induced by neutron interactions with components of the detector shielding and the detector itself, may interfere with the detection, peak identification and quantification of CTBT relevant radionuclides. This study looks at the peak identification and outlines the methods employed by the IDC radionuclide analysts to mitigate these issues during the review process resulting in Reviewed Radionuclide Reports (RRRs).

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Introduction

The CTBTO's International Data Centre (IDC) collects, processes and analyses data originating from the facilities of the CTBTO's International Monitoring System (IMS), which uses four complementary verification methods (including radionuclide) to detect nuclear explosions. Radionuclide technique is the last step to validate whether a nuclear explosion has been carried out. Data from the 73 currently operational radionuclide particulate IMS stations consist of a daily gamma ray spectrum from each station. They are sent to the IDC, where they undergo an automated analysis process. After this, the IDC radionuclide analysts refine the results during an interactive review process resulting in the production of Reviewed Radionuclide Reports.

Several natural radionuclides, such as Pb-212 and its progeny (called Pb-212F), Bi-214, Ac-228 and Pa-234m, and those induced by neutron interactions with components of the detector shielding and the detector itself, may interfere with the detection, peak identification and quantification of CTBT relevant radionuclides, such as Mn-54, Zn-65, Zr-95/Nb-95, Tc-99m, I-131, Cs-134 and Ba-140/La-140 (among other CTBT-relevant radionuclides). This study looks at the peak identification issues and explains what methods the IDC radionuclide analysts are applying to address these issues using the new iNSPIRE 2.31.0 software.

Neutron interactions with the detector/shielding

Naturally-occurring neutron interactions with the components of the detector shielding and the detector itself may result in the observation of spectral peaks that obscure or mimic genuine radionuclide peaks, thus complicating the spectral interpretation. Although not exhaustive, the following interactions represent the most prominent examples.

Germanium:	Ge-71m, Ge-74, Ge-75m and Ge-76
Copper:	Cu-63, Cu-64 and Cu-65
Lead:	Pb-204m, Pb-206, Pb-207m and Pb-208
Aluminium:	Al-27 and Al-28
Cadmium:	Cd-114

Not all interactions are observable in the spectra of all stations, as visibility depends on detector and shielding type, station location/altitude and natural radioactivity levels.

While most neutron interactions do not affect the identification of CTBT relevant radionuclides, those that may interfere are listed to the right, together with naturally occurring radionuclide interferences.

Listed in blue are interferences that are covered by IDC identification rules.

Major interferences

CTBT relevant	Interference
Mn-54 (834.83 keV)	Pb-212F (835.80 keV) or Ac-228 (835.70 keV)
Zn-65 (1115.55 keV)	Cu-65 (1115.55 keV)
Nb-95 (765.78 keV)	Pa-234m (766.36 keV)
Tc-99m (140.51 keV)	Ge-75m (139.68 keV)
I-131 (364.48 keV)	Cu-63 (365.20 keV)
Cs-134 (795.85 keV)	Ac-228 (794.94 keV)
Ba-140 (537.31 keV)	Pb-206 (537.45 keV)
Rb-84 *(881.61 keV)*	*Pb-206 (881.01 keV)*
Zr-97 *(743.33 keV)*	*Pa-234m (742.81 keV)*
Co-60 *(1173.24 keV)*	*Ni-62 (1172.91 keV) or Sn-120 (1171.27 keV) or Ni-60 (1173.24 keV)*
Co-60 *(1332.50 keV)*	*Ni-60 (1332.50 keV)*

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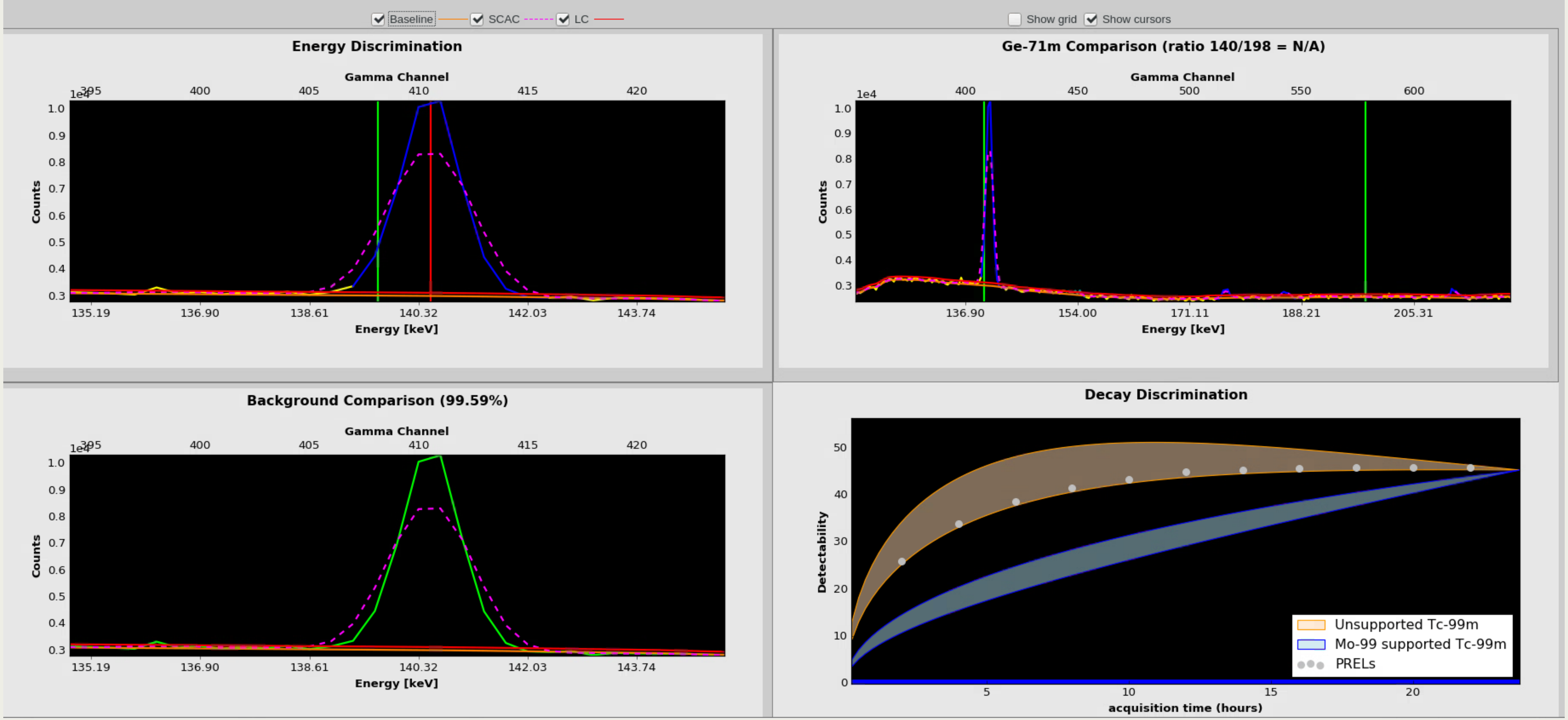
Tc Tool to identify Tc-99m or Ge-75m



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Cu-65 / Zn-65 interference

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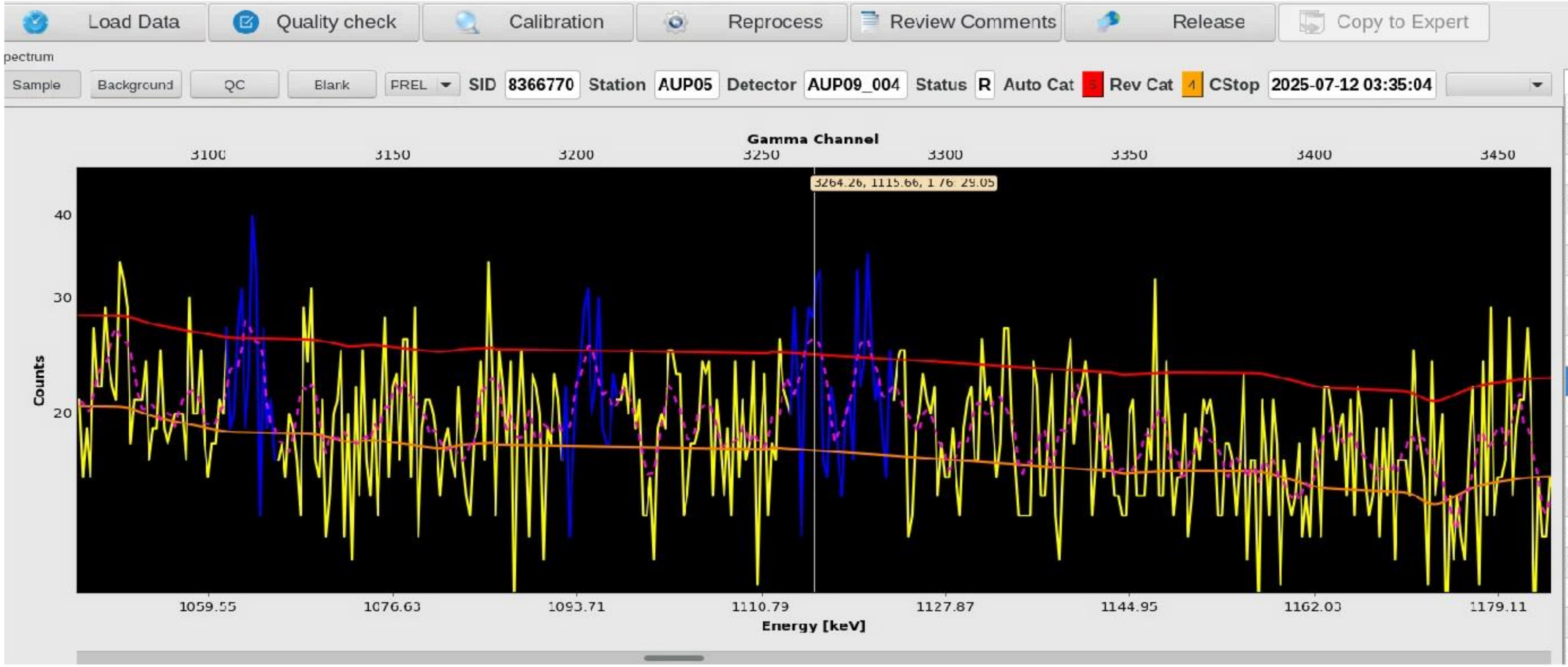

Energy	Centroid	G_Area	FWHM	Nuclide
910.97	2665.11	111.45	1.60	AC-228
1778.94	5206.02	95.12	2.26	AL-28
477.61	1396.71	59699.06	1.24	BE-7
609.35	1782.27	252.10	1.35	BI-214
1120.50	3278.42	64.61	1.77	BI-214
1764.21	5162.09	65.75	2.25	BI-214
669.80	1959.21	112.91	1.40	CU-63
962.21	2815.10	91.16	1.64	CU-63
1327.35	3883.94	84.01	1.93	CU-63
1115.66	3264.26	68.32	1.76	CU-65
198.35	579.44	450.81	0.97	GE-71M
139.67	407.72	258.37	0.91	GE-75M
1460.78	4274.55	468.37	2.03	K-40
1368.72	4005.04	176.86	1.96	NA-24
2754.70	8063.20	86.58	2.95	NA-24
802.97	2348.98	198.67	1.51	PB-206
880.73	2576.57	66.07	1.58	PB-206
569.89	1666.80	105.33	1.32	PB-207M
1063.52	3111.63	63.30	1.72	PB-207M

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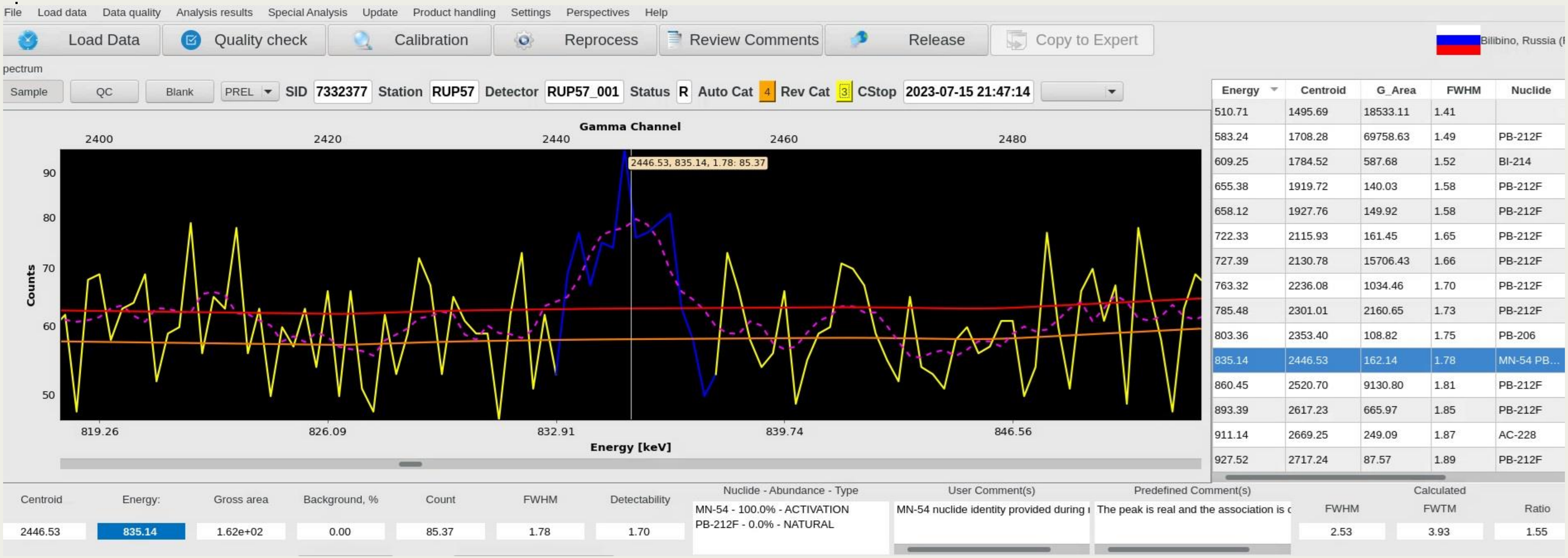
Mn-54 / Pb-212F interference



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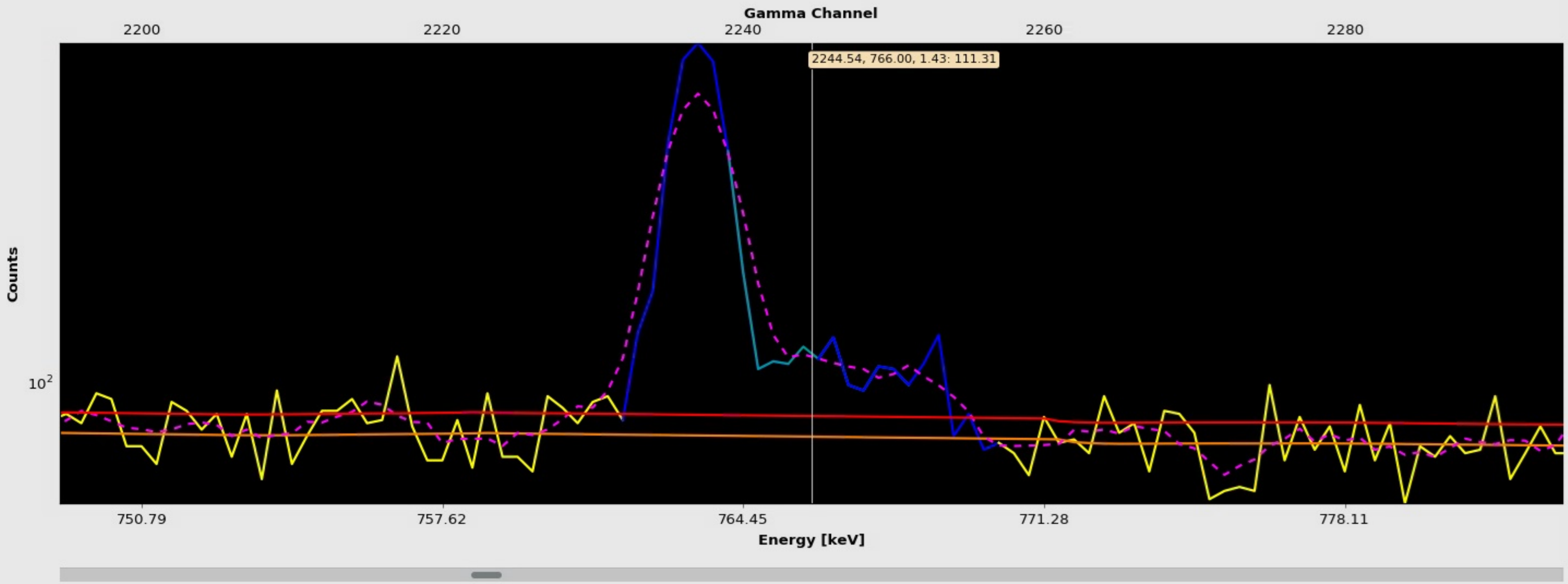
Nb-95 / Pa-234m interference (this sample did contain Nb-95 according to lab analysis!)

Load Data | Quality check | Calibration | Reprocess | Review Comments | Release | Copy to Expert | Stockholm, Sweden (S

pectrum

Sample | QC | Blank | PREL | SID 5706227 | Station SEP63 | Detector SEP63_004 | Status R | Auto Cat 5 | Rev Cat 5 | CStop 2020-06-23 08:56:54



Energy	Centroid	G_Area	FWHM	Nuclide
473.45	1387.70	167.52	1.22	PB-212F
477.58	1399.81	44387.83	1.22	BE-7
496.86	1456.27	259.29	1.23	RU-103
510.73	1496.90	20910.61	1.24	
569.57	1669.21	140.97	1.29	CS-134
583.20	1709.14	74361.97	1.30	PB-212F
604.79	1772.38	457.62	1.31	CS-134
609.32	1785.63	1261.01	1.32	BI-214
656.16	1922.82	190.72	1.35	PB-212F
658.20	1928.79	250.14	1.35	PB-212F
661.62	1938.81	458.37	1.35	CS-137
722.26	2116.43	127.41	1.40	PB-212F
727.36	2131.35	16393.92	1.40	PB-212F
763.43	2237.00	1248.08	1.42	PB-212F
766.00	2244.54	175.90	1.43	
768.15	2250.85	139.52	1.43	BI-214
785.58	2301.88	2339.79	1.44	PB-212F
795.81	2331.86	442.19	1.45	CS-134
803.00	2352.91	108.27	1.45	PB-206

Centroid	Energy:	Gross area	Background, %	Count	FWHM	Detectability
2244.54	766.00	1.76e+02	0.00	111.31	1.43	1.71

Nuclide - Abundance - Type

User Comment(s): This peak was inserted to correct a perc Pa-234m

Predefined Comment(s)

Calculated		
FWHM	FWTM	Ratio
7.41	9.36	1.26

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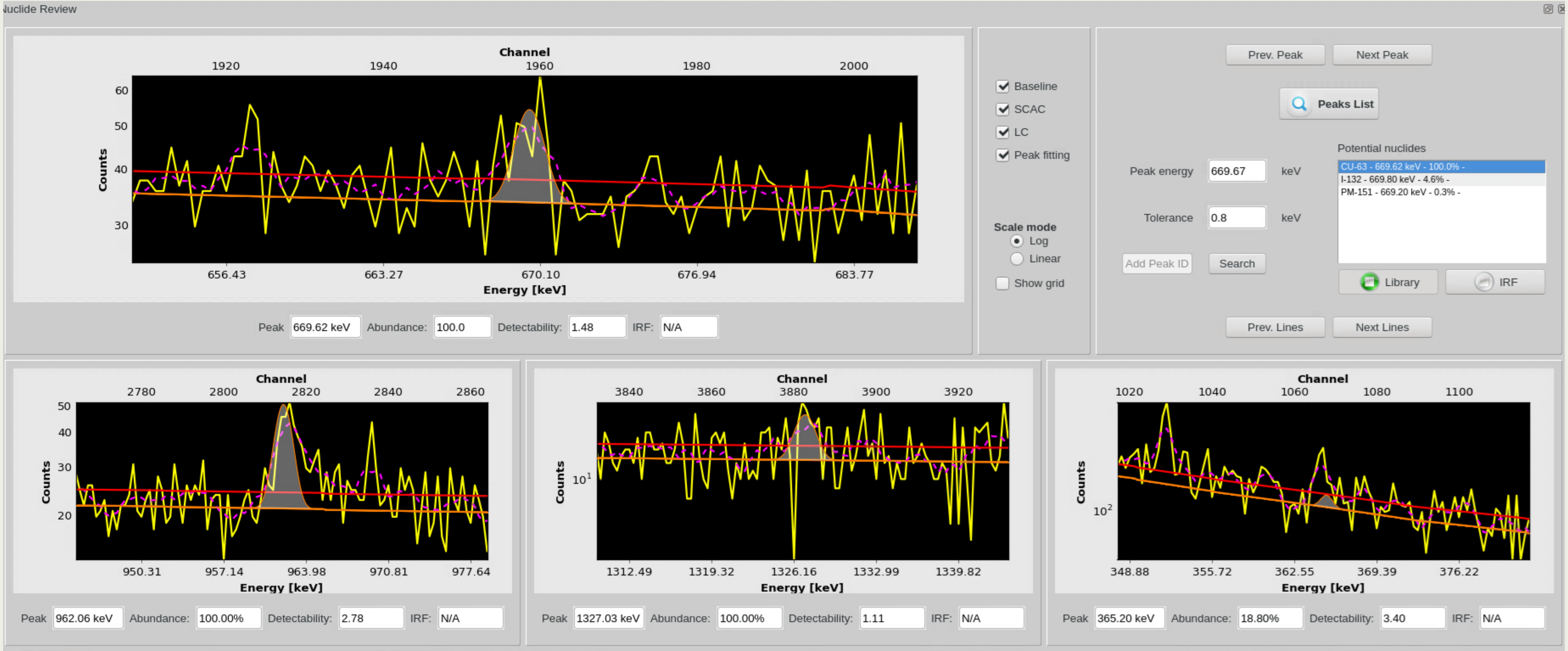
I-131 / Cu-63 interference at 365 keV at a station where I-131 is unlikely



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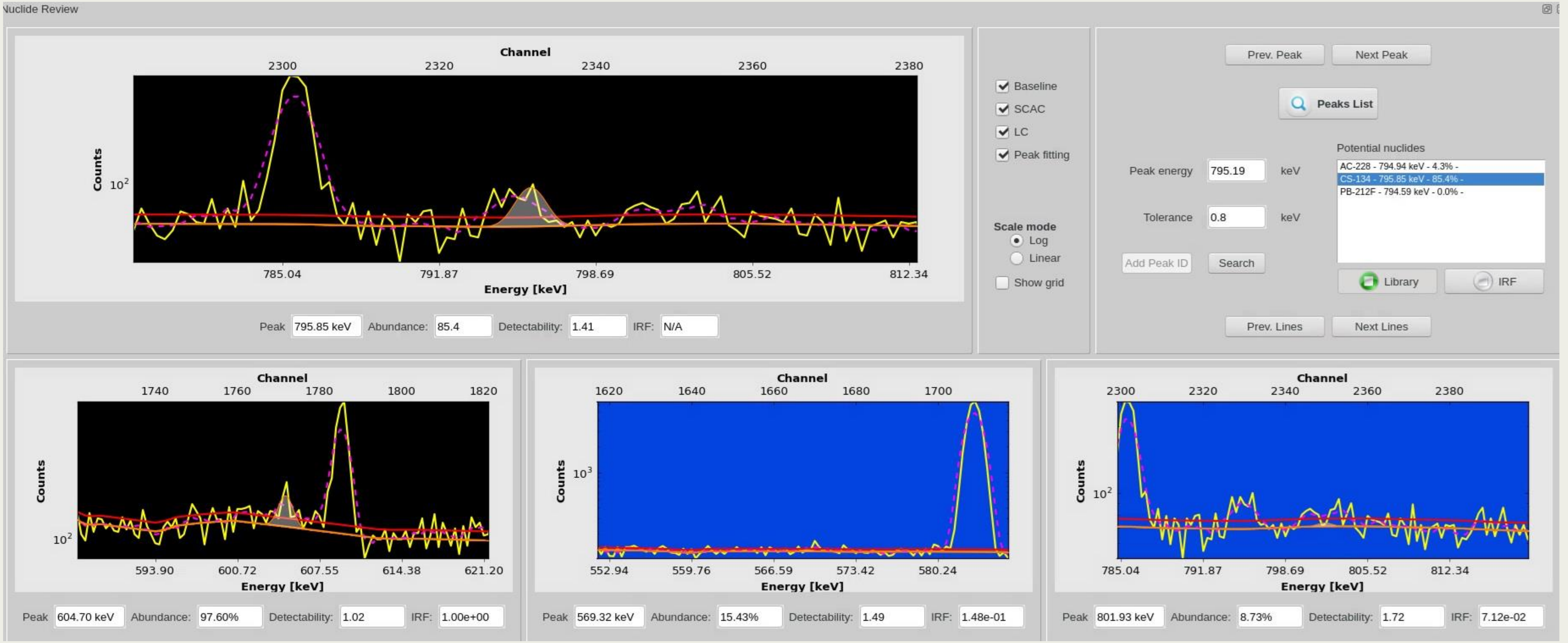
Cs-134 / Ac-228 interference at 795 keV



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Cs-134 / Ac-228 interference at 795 keV