Discussion on 2p-1s Cm-248 calculations

Stella Vogiatzi, 31.03.2022

Ordering transitions in the new calculations

08.02.2022: Natalia's calculations with new quadrupole moment for

$$R = R0 \cdot [0.95, 0.98, 0.99, 0.995, 0.998, 0.999, 1.00, 1.001, 1.002, 1.005, 1.01, 1.02, 1.05]$$

For the different $dR = R/R_0$ values, the ordering of the transitions sometimes changes. So, I order them following the ordering of the dR=1.00 case. The energies (in keV) after ordering can be seen in the table below:

dR=R/R0													
tr	0.95	0.98	0.99	0.995	0.998	0.999	1	1.001	1.002	1.005	1.01	1.02	1.05
1	6693.01749	6506.87606	6446.67716	6416.91362	6416.91362	6393.2616	6387.37056	6381.48826	6375.61468	6358.04607	6328.93777	6271.36089	6103.59384
2	6673.89431	6487.87731	6427.7195	6397.97644	6397.97644	6374.34077	6368.45382	6362.57561	6356.7061	6339.14972	6310.06177	6252.52546	6084.8791
3	7089.90546	6883.76843	6817.1861	6784.28172	6784.28172	6758.14105	6751.63116	6745.13132	6738.64154	6719.23214	6687.08186	6623.51706	6438.52697
4	7046.50546	6840.36843	6773.7861	6740.88172	6740.88172	6714.74105	6708.23116	6701.73132	6695.24154	6675.83214	6643.68186	6580.11706	6395.12697
5	6649.61749	6463.47606	6403.27716	6373.51362	6373.51362	6349.8616	6343.97056	6338.08826	6332.21468	6314.64607	6285.53777	6227.96089	6060.19384
6	6702.57002	6516.22282	6455.95507	6426.15706	6426.15706	6402.47744	6396.57949	6390.6903	6384.8098	6367.22047	6338.07761	6280.43152	6112.45619
7	7170.95506	6959.30918	6890.95694	6857.17982	6857.17982	6830.34678	6823.6646	6816.9928	6810.33136	6790.40895	6757.41	6692.17157	6502.34636
8	6717.29431	6531.27731	6471.1195	6441.37644	6441.37644	6417.74077	6411.85382	6405.97561	6400.1061	6382.54972	6353.46177	6295.92546	6128.2791
9	7214.35506	7002.70918	6934.35694	6900.57982	6900.57982	6873.74678	6867.0646	6860.3928	6853.73136	6833.80895	6800.81	6735.57157	6545.74636
10	7116.97249	6910.5102	6843.80895	6810.8431	6810.8431	6784.65231	6778.12976	6771.6172	6765.11464	6745.6666	6713.45084	6649.75102	6464.32328
11	7052.00004	6846.13178	6779.63998	6746.78103	6746.78103	6720.67681	6714.17604	6707.68533	6701.20468	6681.82271	6649.71823	6586.24541	6401.53421
12	7046.50546	6840.36843	6773.7861	6740.88172	6740.88172	6714.74105	6708.23116	6701.73132	6695.24154	6675.83214	6643.68186	6580.11706	6395.12697
13	7016.57249	6810.1102	6743.40895	6710.4431	6710.4431	6684.25231	6677.72976	6671.2172	6664.71464	6645.2666	6613.05084	6549.35102	6363.92328
14	6657.40518	6471.24217	6411.03274	6381.26329	6381.26329	6357.60625	6351.7139	6345.8303	6339.95537	6322.38266	6293.26717	6235.67461	6067.84992
15	6702.57002	6516.22282	6455.95507	6426.15706	6426.15706	6402.47744	6396.57949	6390.6903	6384.8098	6367.22047	6338.07761	6280.43152	6112.45619
16	6602.17002	6415.82282	6355.55507	6325.75706	6325.75706	6302.07744	6296.17949	6290.2903	6284.4098	6266.82047	6237.67761	6180.03152	6012.05619
17	6757.80518	6571.64217	6511.43274	6481.66329	6481.66329	6458.00625	6452.1139	6446.2303	6440.35537	6422.78266	6393.66717	6336.07461	6168.24992
18	7170.95506	6959.30918	6890.95694	6857.17982	6857.17982	6830.34678	6823.6646	6816.9928	6810.33136	6790.40895	6757.41	6692.17157	6502.34636
19	7115.21232	6904.2219	6836.09853	6802.43782	6802.43782	6775.69886	6769.04033	6762.39223	6755.75456	6735.90373	6703.02517	6638.03154	6448.97296
20	7095.40004	6889.53178	6823.03998	6790.18103	6790.18103	6764.07681	6757.57604	6751.08533	6744.60468	6725.22271	6693.11823	6629.64541	6444.93421
21	7215.61232	7004.6219	6936.49853	6902.83782	6902.83782	6876.09886	6869.44033	6862.79223	6856.15456	6836.30373	6803.42517	6738.43154	6549.37296
22	7111.7615	6905.4701	6838.83906	6805.91088	6805.91088	6779.75144	6773.23689	6766.73242	6760.23801	6740.81483	6708.64189	6645.03297	6459.92067
23	7215.61232	7004.6219	6936.49853	6902.83782	6902.83782	6876.09886	6869.44033	6862.79223	6856.15456	6836.30373	6803.42517	6738.43154	6549.37296
24	7011.3615	6805.0701	6738.43906	6705.51088	6705.51088	6679.35144	6672.83689	6666.33242	6659.83801	6640.41483	6608.24189	6544.63297	6359.52067
25	7165.58815	6954.24265	6885.99074	6852.26381	6852.26381	6825.47092	6818.79878	6812.13701	6805.48562	6785.59332	6752.64456	6687.50649	6497.98184
26	7011.3615	6805.0701	6738.43906	6705.51088	6705.51088	6679.35144	6672.83689	6666.33242	6659.83801	6640.41483	6608.24189	6544.63297	6359.52067
27	7116.97249	6910.5102	6843.80895	6810.8431	6810.8431	6784.65231	6778.12976	6771.6172	6765.11464	6745.6666	6713.45084	6649.75102	6464.32328
28	7265.98815	7054.64265	6986.39074	6952.66381	6952.66381	6925.87092	6919.19878	6912.53701	6905.88562	6885.99332	6853.04456	6787.90649	6598.38184
29	7165.58815	6954.24265	6885.99074	6852.26381	6852.26381	6825.47092	6818.79878	6812.13701	6805.48562	6785.59332	6752.64456	6687.50649	6497.98184
30	6657.40518	6471.24217	6411.03274	6381.26329	6381.26329	6357.60625	6351.7139	6345.8303	6339.95537	6322.38266	6293.26717	6235.67461	6067.84992

Ordering transitions in the new calculations

08.02.2022: Natalia's calculations with new quadrupole moment for

$$R = R0 \cdot [0.95, 0.98, 0.99, 0.995, 0.998, 0.999, 1.00, 1.001, 1.002, 1.005, 1.01, 1.02, 1.05]$$

For the different $dR = R/R_0$ values, the ordering of the transitions sometimes changes. So, I order them following the ordering of the dR=1.00 case. The intensities after ordering can be seen in the table below:

dR=R/R0													
tr	0.95	0.98	0.99	0.995	0.998	0.999	1	1.001	1.002	1.005	1.01	1.02	1.05
1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	0.85444537	0.84183053	0.83774885	0.835731	0.835731	0.83412783	0.83372857	0.83332985	0.83293191	0.83174155	0.82976991	0.82587287	0.81455288
3	0.81695813	0.81838253	0.81868853	0.81880942	0.81880942	0.81889054	0.81890865	0.81892595	0.81894227	0.81898614	0.81904174	0.81908673	0.8186813
4	0.76072848	0.74134165	0.73467556	0.73130593	0.73130593	0.72859293	0.72791232	0.72723077	0.72654825	0.72449514	0.72105474	0.71410571	0.69273908
5	0.38732887	0.37850727	0.37558546	0.37412797	0.37412797	0.37296362	0.37267276	0.37238196	0.37209132	0.37121984	0.36976916	0.36687458	0.35824442
6	0.35136234	0.3510271	0.35091785	0.35086356	0.35086356	0.35082029	0.3508095	0.35079868	0.35078792	0.35075562	0.35070191	0.35059493	0.35027625
7	0.2805558	0.27708896	0.2758513	0.27521743	0.27521743	0.27470325	0.27457373	0.2744438	0.27431353	0.27392036	0.27325748	0.27190417	0.26764699
8	0.21002017	0.20759073	0.20683683	0.2064703	0.2064703	0.20618212	0.20611077	0.20603966	0.20596891	0.20575821	0.20541263	0.20474243	0.20290007
9	0.19335584	0.18541342	0.18272778	0.18137883	0.18137883	0.18029697	0.18002615	0.17975517	0.17948409	0.17867001	0.17731072	0.17458389	0.16636411
10	0.16264315	0.16761203	0.16924943	0.17006226	0.17006226	0.17070925	0.17087051	0.17103153	0.17119238	0.17167357	0.17247089	0.17404594	0.17857148
11	0.13901111	0.13738196	0.13680891	0.13651698	0.13651698	0.13628091	0.13622154	0.13616202	0.13610239	0.13592263	0.1356203	0.13500558	0.13308464
12	0.12123387	0.12246167	0.1228728	0.12307859	0.12307859	0.12324331	0.1232845	0.12332569	0.1233669	0.12349052	0.12369661	0.12410891	0.12534474
13	0.11614376	0.11281479	0.11159283	0.11096052	0.11096052	0.11044442	0.11031397	0.11018293	0.11005136	0.10965316	0.10897808	0.1075852	0.1030694
14	0.1114625	0.11045604	0.11021206	0.11010757	0.11010757	0.11003244	0.11001483	0.10999768	0.10998103	0.10993387	0.10986467	0.10976147	0.1097254
15	0.10727777	0.10813219	0.10841711	0.10855956	0.10855956	0.10867352	0.10870201	0.1087305	0.10875899	0.10884445	0.10898686	0.10927162	0.11012497
16	0.10843039	0.104815	0.10362171	0.10302727	0.10302727	0.10255279	0.10243432	0.10231589	0.10219756	0.10184287	0.1012529	0.10007749	0.0965877
17	0.05230332	0.0529603	0.05324279	0.05339652	0.05339652	0.05352562	0.05355875	0.05359221	0.05362604	0.05372958	0.05390912	0.05429473	0.05566799
18	0.04760368	0.04620947	0.04573202	0.04549108	0.04549108	0.04529731	0.04524873	0.04520009	0.0451514	0.04500502	0.04476001	0.04426632	0.04276147
19	0.0450787	0.04357106	0.04301735	0.04273119	0.04273119	0.04249788	0.04243895	0.04237978	0.04232038	0.04214076	0.04183673	0.04121175	0.03921498
20	0.0421673	0.04100657	0.04061299	0.04041505	0.04041505	0.04025617	0.04021638	0.04017655	0.04013671	0.040017	0.03981694	0.03941488	0.03819478
21	0.0414905	0.03774963	0.03650682	0.0358873	0.0358873	0.03539284	0.0352694	0.03514603	0.03502275	0.03465338	0.03403952	0.03281935	0.02924006
22	0.02487559	0.02546524	0.02567712	0.02578569	0.02578569	0.02587374	0.02589591	0.02591814	0.02594043	0.02600767	0.02612085	0.02635095	0.02705724
23	0.02506386	0.02178088	0.02072726	0.02020895	0.02020895	0.01979857	0.01969658	0.01959483	0.01949333	0.01919032	0.01869035	0.01771	0.0149375
24	0.01057584	0.01049135	0.0104684	0.01045779	0.01045779	0.01044967	0.0104477	0.01044574	0.0104438	0.01043809	0.01042892	0.01041166	0.01036335
25	0.00857593	0.00891779	0.00903701	0.00909766	0.00909766	0.00914668	0.00915901	0.00917136	0.00918374	0.00922106	0.00928382	0.00941145	0.00981058
26	0.00561911	0.00596897	0.0060953	0.00616031	0.00616031	0.00621321	0.00622656	0.00623995	0.0062534	0.00629404	0.00636274	0.00650378	0.00695383
27	0.00404862	0.00527333	0.00572736	0.0059631	0.0059631	0.00615589	0.00620467	0.00625368	0.00630293	0.00645207	0.00670532	0.0072293	0.00893943
28	0.00191073	0.00188745	0.00187964	0.00187573	0.00187573	0.00187261	0.00187182	0.00187104	0.00187026	0.00186791	0.001864	0.00185615	0.00183229
29	0.00172062	0.00175679	0.00176938	0.00177578	0.00177578	0.00178096	0.00178226	0.00178356	0.00178487	0.0017888	0.00179542	0.00180887	0.00185073
30	0.00162161	0.0016283	0.00163126	0.00163288	0.00163288	0.00163425	0.0016346	0.00163496	0.00163532	0.00163643	0.00163835	0.0016425	0.00165729

Ordering transitions in the old calculations

29.12.2021: Natalia's calculations with old/wrong quadrupole moment for $\mathrm{R} = \mathrm{R0} \cdot [0.99, 1.00, 1.01]$

Again, the ordering of the transitions changes for the different $\mathrm{dR} = \mathrm{R}/\mathrm{R}_0$ values. But the ordering also changes (for the same dR value) with regards to the new calculations. See the comparison of the old and new energies after ordering transitions of the old calculations based on the new calculations:

dR=R/R0 = 1.00					
	new Q		old Q		
tr	En (keV)	description	En (keV)	description	compare descriptions
1	6387.37056	F=1/2, 2p3/2, I=4/2 -> F=1/2, 1s1/2, I=0/2	6363.17682	F=1/2, 2p3/2, I=4/2 -> F=1/2, 1s1/2, I=0/2	same
2	6368.45382	F=3/2, 2p1/2, I=4/2 -> F=5/2, 1s1/2, I=4/2	6340.81327	F=3/2, 2p1/2, I=4/2 -> F=5/2, 1s1/2, I=4/2	same
3	6751.63116	F=3/2, 2p3/2, I=0/2 -> F=1/2, 1s1/2, I=0/2	6778.35203	F=3/2, 2p3/2, I=0/2 -> F=1/2, 1s1/2, I=0/2	same
4	6708.23116	F=3/2, 2p3/2, I=0/2 -> F=3/2, 1s1/2, I=4/2	6734.95203	F=3/2, 2p3/2, I=0/2 -> F=3/2, 1s1/2, I=4/2	same
5	6343.97056	F=1/2, 2p3/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	6319.77682	F=1/2, 2p3/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	same
6	6396.57949	F=5/2, 2p1/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	6374.59781	F=5/2, 2p1/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	same
7	6823.6646	F=3/2, 2p3/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	6855.58496	F=3/2, 2p3/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	same
8	6411.85382	F=3/2, 2p1/2, I=4/2 -> F=1/2, 1s1/2, I=0/2	6384.21327	F=3/2, 2p1/2, I=4/2 -> F=1/2, 1s1/2, I=0/2	same
9	6867.0646	F=3/2, 2p3/2, I=4/2 -> F=1/2, 1s1/2, I=0/2	6898.98496	F=3/2, 2p3/2, I=4/2 -> F=1/2, 1s1/2, I=0/2	same
10	6778.12976	F=5/2, 2p3/2, I=4/2 -> F=5/2, 1s1/2, I=4/2	6800.86532	F=5/2, 2p3/2, I=4/2 -> F=5/2, 1s1/2, I=4/2	same
11	6714.17604	F=1/2, 2p3/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	6737.12286	F=1/2, 2p3/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	same
12	6708.23116	F=3/2, 2p3/2, I=0/2 -> F=5/2, 1s1/2, I=4/2	6734.95203	F=3/2, 2p3/2, I=0/2 -> F=5/2, 1s1/2, I=4/2	same
13	6677.72976	F=5/2, 2p3/2, I=4/2 -> F=7/2, 1s1/2, I=8/2	6700.46532	F=5/2, 2p3/2, I=4/2 -> F=7/2, 1s1/2, I=8/2	same
14	6351.7139	F=7/2, 2p1/2, I=8/2 -> F=9/2, 1s1/2, I=8/2	6322.05251	F=7/2, 2p1/2, I=8/2 -> F=9/2, 1s1/2, I=8/2	same
15	6396.57949	F=5/2, 2p1/2, I=4/2 -> F=5/2, 1s1/2, I=4/2	6374.59781	F=5/2, 2p1/2, I=4/2 -> F=5/2, 1s1/2, I=4/2	same
16	6296.17949	F=5/2, 2p1/2, I=4/2 -> F=7/2, 1s1/2, I=8/2	6274.19781	F=5/2, 2p1/2, I=4/2 -> F=7/2, 1s1/2, I=8/2	same
17	6452.1139	F=7/2, 2p1/2, I=8/2 -> F=5/2, 1s1/2, I=4/2	6422.45251	F=7/2, 2p1/2, I=8/2 -> F=5/2, 1s1/2, I=4/2	same
18	6823.6646	F=3/2, 2p3/2, I=4/2 -> F=5/2, 1s1/2, I=4/2	6855.58496	F=3/2, 2p3/2, I=4/2 -> F=5/2, 1s1/2, I=4/2	same
19	6769.04033	F=5/2, 2p3/2, I=4/2 -> F=7/2, 1s1/2, I=8/2	6799.28714	F=5/2, 2p3/2, I=4/2 -> F=7/2, 1s1/2, I=8/2	same
20	6757.57604	F=1/2, 2p3/2, I=4/2 -> F=1/2, 1s1/2, I=0/2	6780.52286	F=1/2, 2p3/2, I=4/2 -> F=1/2, 1s1/2, I=0/2	same
21	6869.44033	F=5/2, 2p3/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	6899.68714	F=5/2, 2p3/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	same
22	6773.23689	F=7/2, 2p3/2, I=4/2 -> F=5/2, 1s1/2, I=4/2	6802.64189	F=7/2, 2p3/2, I=4/2 -> F=5/2, 1s1/2, I=4/2	same
23	6869.44033	F=5/2, 2p3/2, I=4/2 -> F=5/2, 1s1/2, I=4/2	6899.68714	F=5/2, 2p3/2, I=4/2 -> F=5/2, 1s1/2, I=4/2	same
24	6672.83689	F=7/2, 2p3/2, I=4/2 -> F=7/2, 1s1/2, I=8/2	6702.24189	F=7/2, 2p3/2, I=4/2 -> F=7/2, 1s1/2, I=8/2	same
25	6818.79878	F=7/2, 2p3/2, I=8/2 -> F=7/2, 1s1/2, I=8/2	6850.05587	F=7/2, 2p3/2, I=8/2 -> F=7/2, 1s1/2, I=8/2	same
26	6672.83689	F=7/2, 2p3/2, I=4/2 -> F=9/2, 1s1/2, I=8/2	6702.24189	F=7/2, 2p3/2, I=4/2 -> F=9/2, 1s1/2, I=8/2	same
27	6778.12976	F=5/2, 2p3/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	6800.86532	F=5/2, 2p3/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	same
28	6919.19878	F=7/2, 2p3/2, I=8/2 -> F=5/2, 1s1/2, I=4/2	6950.45587	F=7/2, 2p3/2, I=8/2 -> F=5/2, 1s1/2, I=4/2	same
29	6818.79878	F=7/2, 2p3/2, I=8/2 -> F=9/2, 1s1/2, I=8/2	6850.05587	F=7/2, 2p3/2, I=8/2 -> F=9/2, 1s1/2, I=8/2	same
30	6351.7139	F=7/2, 2p1/2, I=8/2 -> F=7/2, 1s1/2, I=8/2	6340.81327	F=3/2, 2p1/2, I=4/2 -> F=3/2, 1s1/2, I=4/2	not same
31			6845.28925	F=9/2, 2p3/2, I=8/2 -> F=9/2, 1s1/2, I=8/2	not same

Transitions Nr 30 and 31 after the new ordering will be ignored in the following calculations.

This should not have an effect in the 2p-1s fitting because their relative intensities are 0.002 with regards to the most intense line.

Ordering transitions in the old calculations

29.12.2021: Natalia's calculations with old/wrong quadrupole moment for $\mathrm{R} = \mathrm{R0} \cdot [0.99, 1.00, 1.01]$

The intensities need to extra normalised to new "tr1". The energies and the scaled intensities of the old values after following the transitions' ordering that is explained in previous slide can be seen in the tables below:

dR=R/R0			
tr	0.99	1	1.01
1	6422.11078	6363.17682	6305.1119
2	6399.7077	6340.81327	6282.78776
3	6844.5644	6778.35203	6713.16521
4	6801.1644	6734.95203	6669.76521
5	6378.71078	6319.77682	6261.7119
6	6433.60435	6374.59781	6316.46004
7	6923.62828	6855.58496	6788.59963
8	6443.1077	6384.21327	6326.18776
9	6967.02828	6898.98496	6831.99963
10	6867.15494	6800.86532	6735.59691
11	6803.25066	6737.12286	6672.0211
12	6801.1644	6734.95203	6669.76521
13	6766.75494	6700.46532	6635.19691
14	6380.99617	6322.05251	6263.97642
15	6433.60435	6374.59781	6316.46004
16	6333.20435	6274.19781	6216.06004
17	6481.39617	6422.45251	6364.37642
18	6923.62828	6855.58496	6788.59963
19	6867.1411	6799.28714	6732.49565
20	6846.65066	6780.52286	6715.4211
21	6967.5411	6899.68714	6832.89565
22	6868.90317	6802.64189	6737.40729
23	6967.5411	6899.68714	6832.89565
24	6768.50317	6702.24189	6637.00729
25	6918.00105	6850.05587	6783.16889
26	6768.50317	6702.24189	6637.00729
27	6867.15494	6800.86532	6735.59691
28	7018.40105	6950.45587	6883.56889
29	6918.00105	6850.05587	6783.16889
30	6399.7077	6340.81327	6282.78776
31	6912.9051	6845.28925	6778.72261

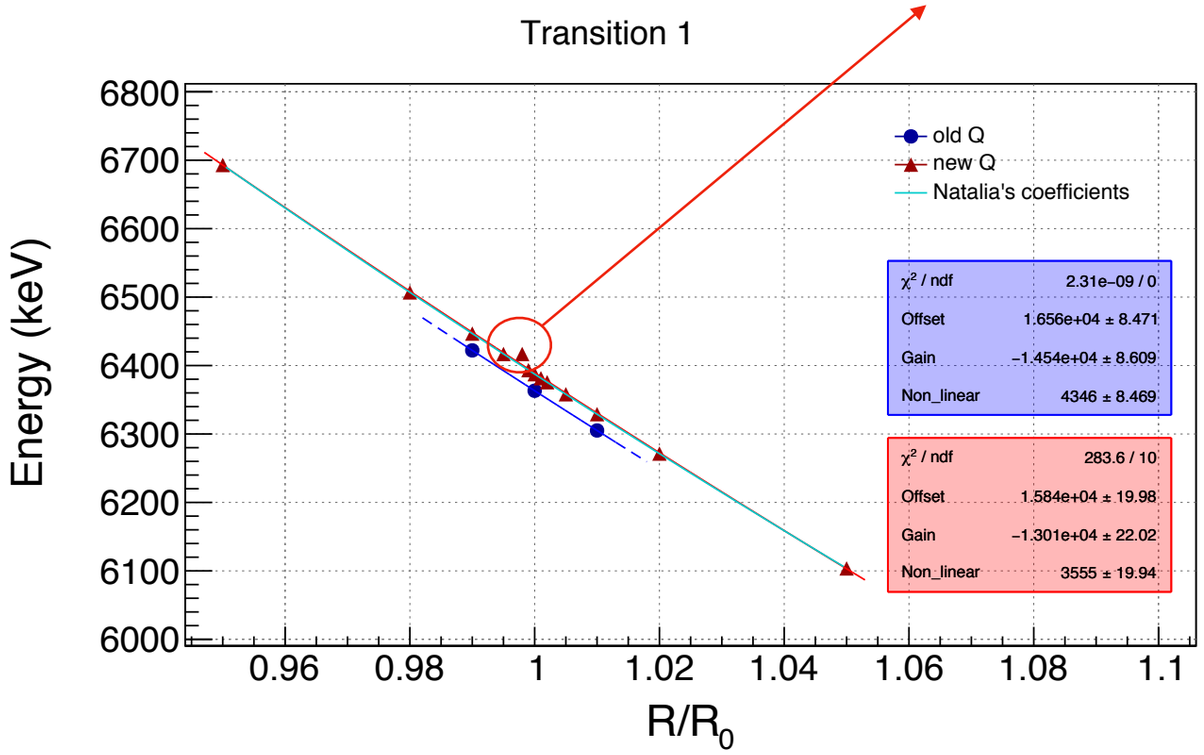
dR=R/R0			
tr	0.99	1	1.01
1	0.91279466	0.91662787	0.92044162
2	1	1	1
3	0.62043087	0.62304242	0.62556559
4	0.62217441	0.61926958	0.61621276
5	0.44843454	0.44715592	0.44584806
6	0.37012193	0.37123685	0.37232537
7	0.31401666	0.31489604	0.31572873
8	0.29048169	0.29081309	0.29116319
9	0.22059753	0.21916618	0.21768159
10	0.22084064	0.22411483	0.22740893
11	0.1563753	0.15658838	0.15677516
12	0.13555335	0.13636732	0.13717407
13	0.1464032	0.14602433	0.14557101
14	0.15058641	0.14982223	0.14908119
15	0.09810255	0.09870317	0.09929877
16	0.13960407	0.13860103	0.13758358
17	0.08168555	0.08180839	0.08195424
18	0.05154937	0.05137206	0.05118314
19	0.05706937	0.05686997	0.05663482
20	0.06072207	0.06051538	0.06029641
21	0.05813295	0.05690796	0.0556595
22	0.02983338	0.03002756	0.03023011
23	0.03450461	0.03328233	0.03206296
24	0.0138056	0.0137489	0.01369539
25	0.00937983	0.00953995	0.0097015
26	0.00881524	0.00896495	0.00912066
27	0.00179306	0.00208346	0.00240162
28	0.00215785	0.00215887	0.00215927
29	0.00177917	0.00179712	0.00181495
30	0.00239822	0.00234357	0.00229006
31	0.0012732	0.00126758	0.00126158

scale intensities to tr1 dR=R/R0			
tr	0.99	1	1.01
1	1	1	1
2	1.09553664	1.09095527	1.086435
3	0.67970476	0.67971141	0.67963636
4	0.68161487	0.67559541	0.66947511
5	0.49127647	0.48782711	0.48438493
6	0.40548214	0.40500279	0.40450732
7	0.34401675	0.3435375	0.34301875
8	0.31823334	0.31726407	0.31632988
9	0.24167268	0.2391005	0.2364969
10	0.24193902	0.24449925	0.24706503
11	0.17131487	0.17083092	0.17032603
12	0.14850366	0.14877064	0.14903071
13	0.16039007	0.15930601	0.15815345
14	0.16497293	0.16344935	0.16196702
15	0.10747494	0.10768074	0.10788166
16	0.15294137	0.15120753	0.14947562
17	0.08948951	0.0892493	0.08903795
18	0.05647423	0.05604462	0.05560716
19	0.06252158	0.06204259	0.06153005
20	0.06652325	0.06601957	0.06550813
21	0.06368678	0.06208404	0.06047043
22	0.03268356	0.03275873	0.03284305
23	0.03780106	0.03630954	0.03483432
24	0.01512454	0.01499943	0.01487915
25	0.01027594	0.01040766	0.01054005
26	0.00965742	0.00978036	0.009909
27	0.00196436	0.00227296	0.0026092
28	0.00236401	0.00235523	0.00234591
29	0.00194914	0.00196058	0.00197182
30	0.00262734	0.00255673	0.002488
31	0.00139484	0.00138287	0.00137063

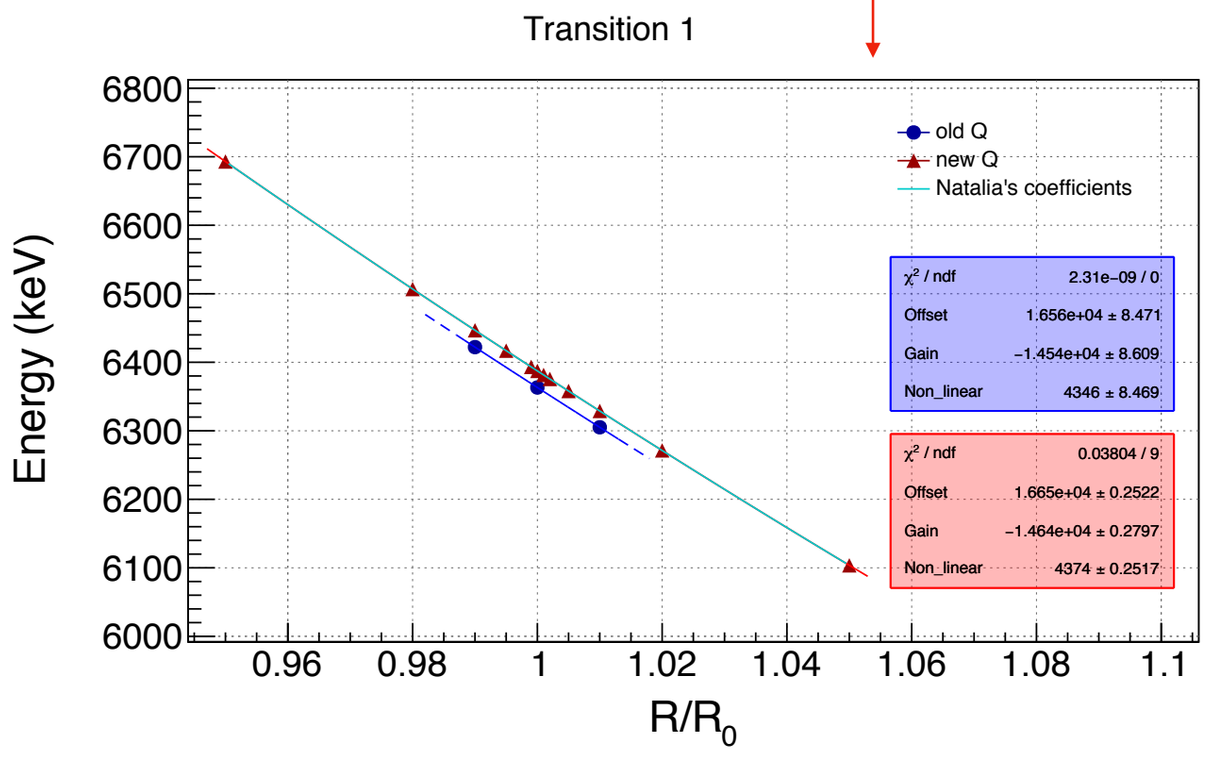
Note that the transitions' ordering here does not indicate the intensity order of the old calculations (29.12.21) but of the new calculations (08.02.2022) for dR=1.00.

Energy VS dR for different Q - discard dR=0.998

These two points (dR=0.995 and dR=0.998) in all energy and relative intensity graphs are the same!



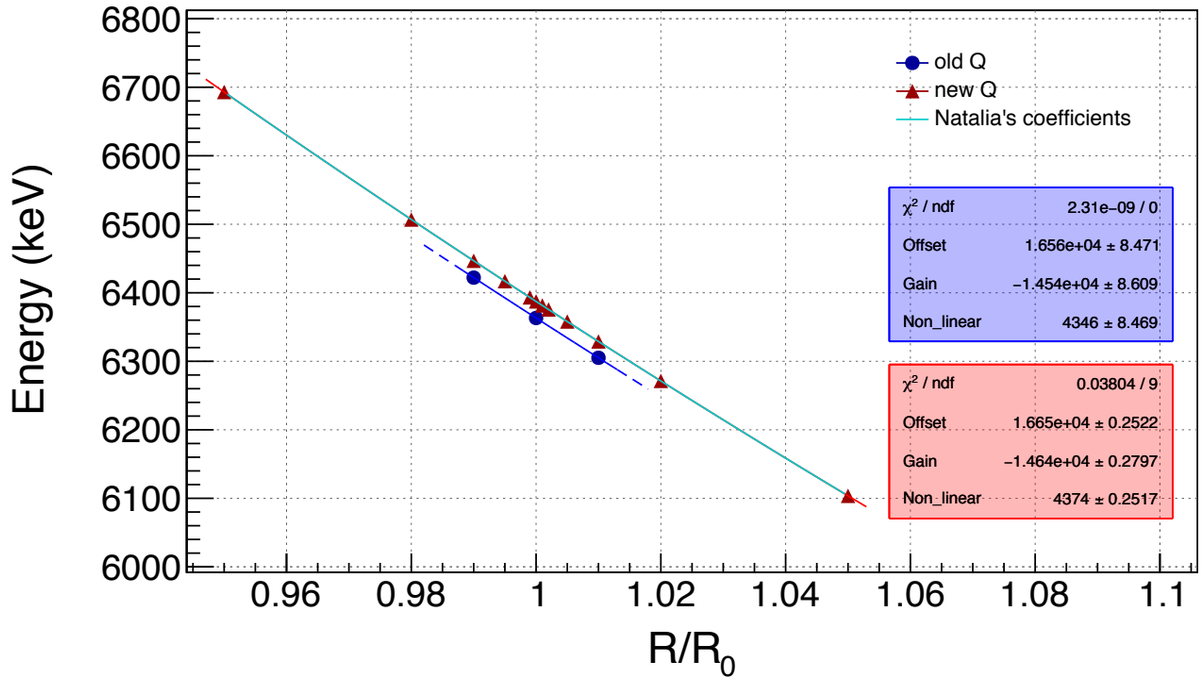
So, I discard the dR = 0.998 point until we have the correct values (also next slides). Now my fit and Natalia's fit fully coincide.



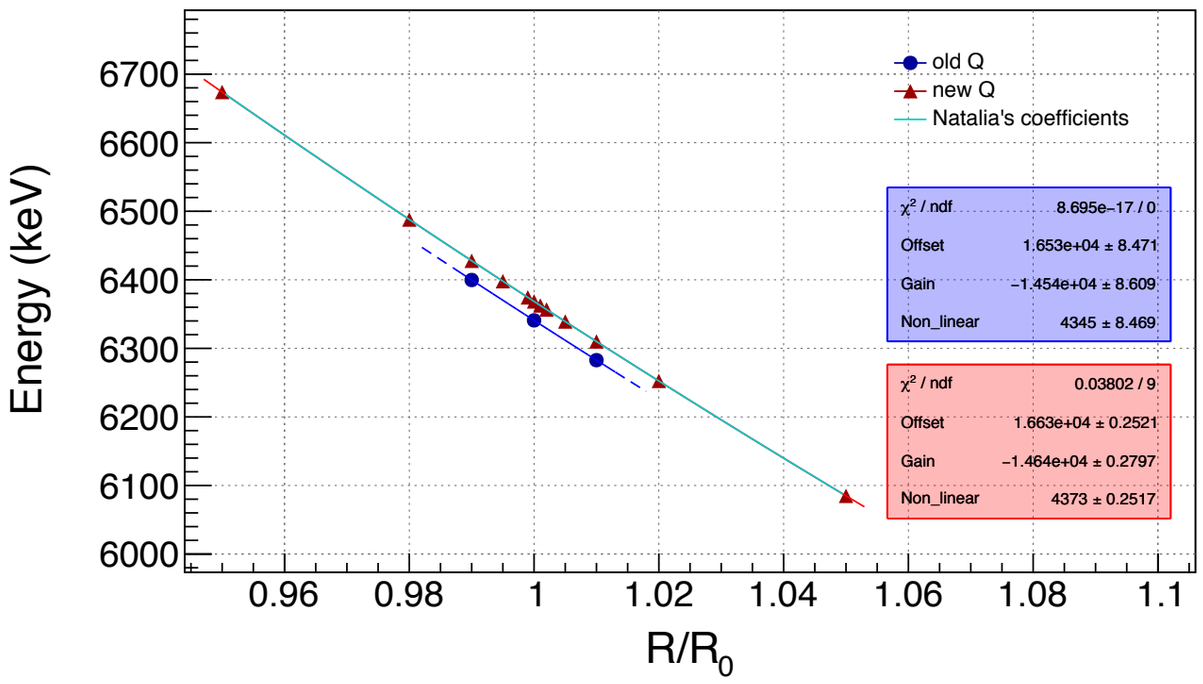
Energy VS dR for different Q - discard dR=0.998

I fit a 2nd degree polynomial (values did not converge)

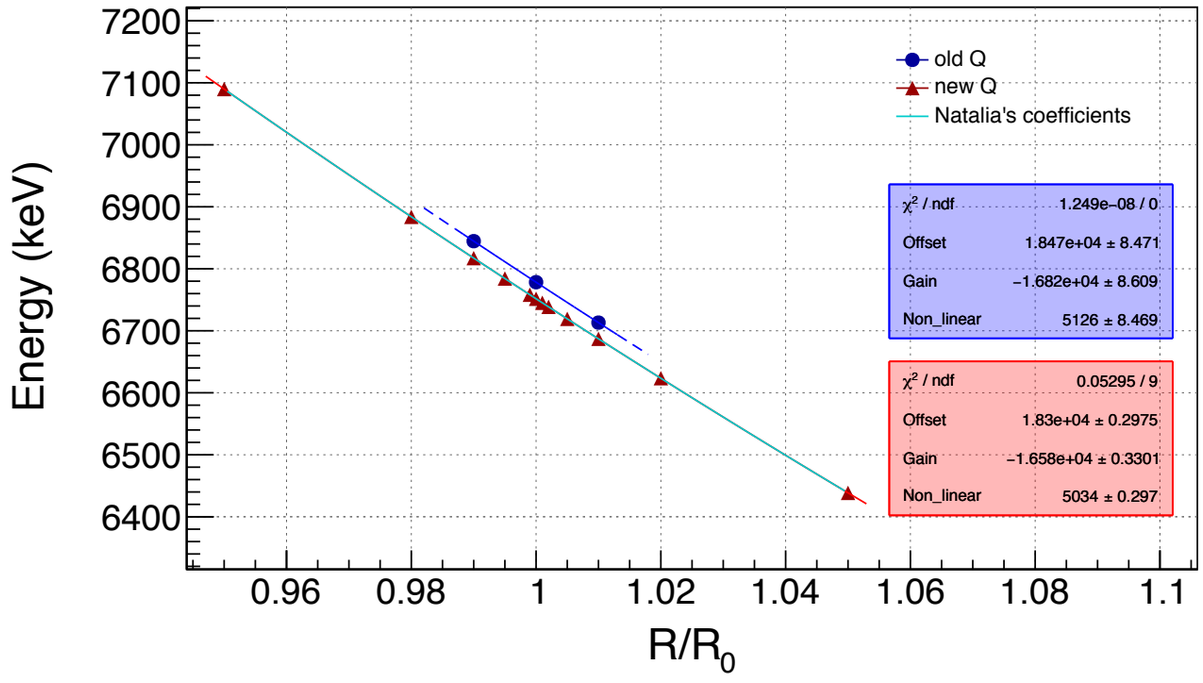
Transition 1



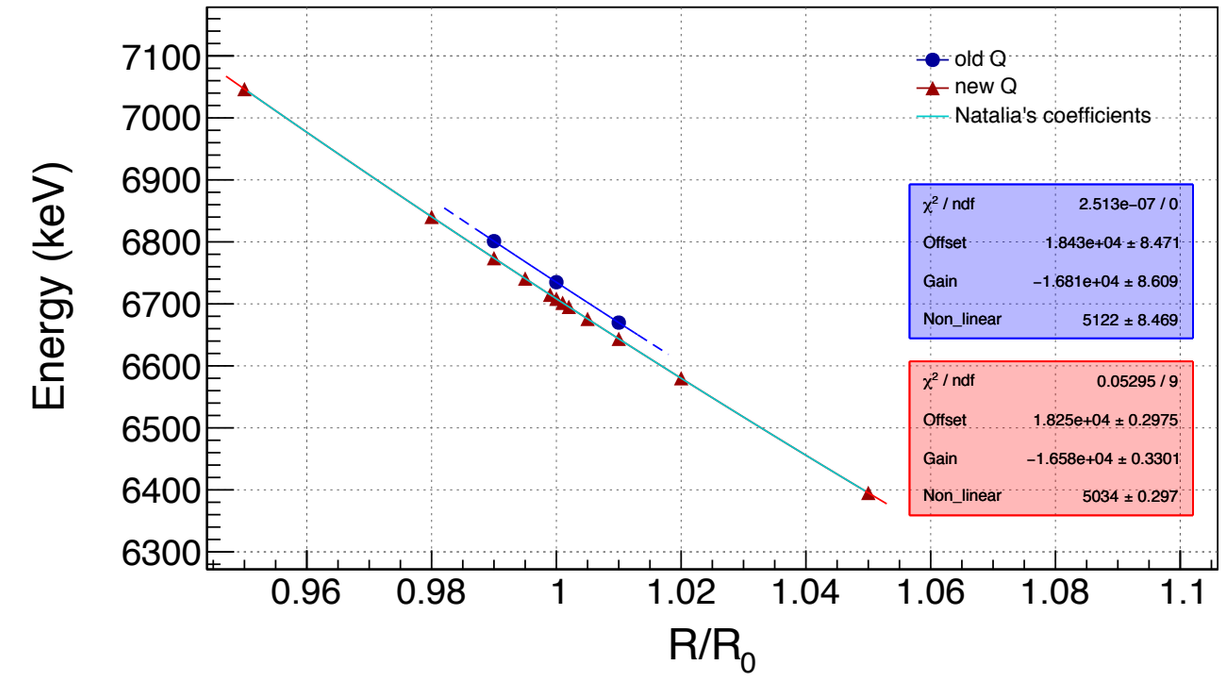
Transition 2



Transition 3

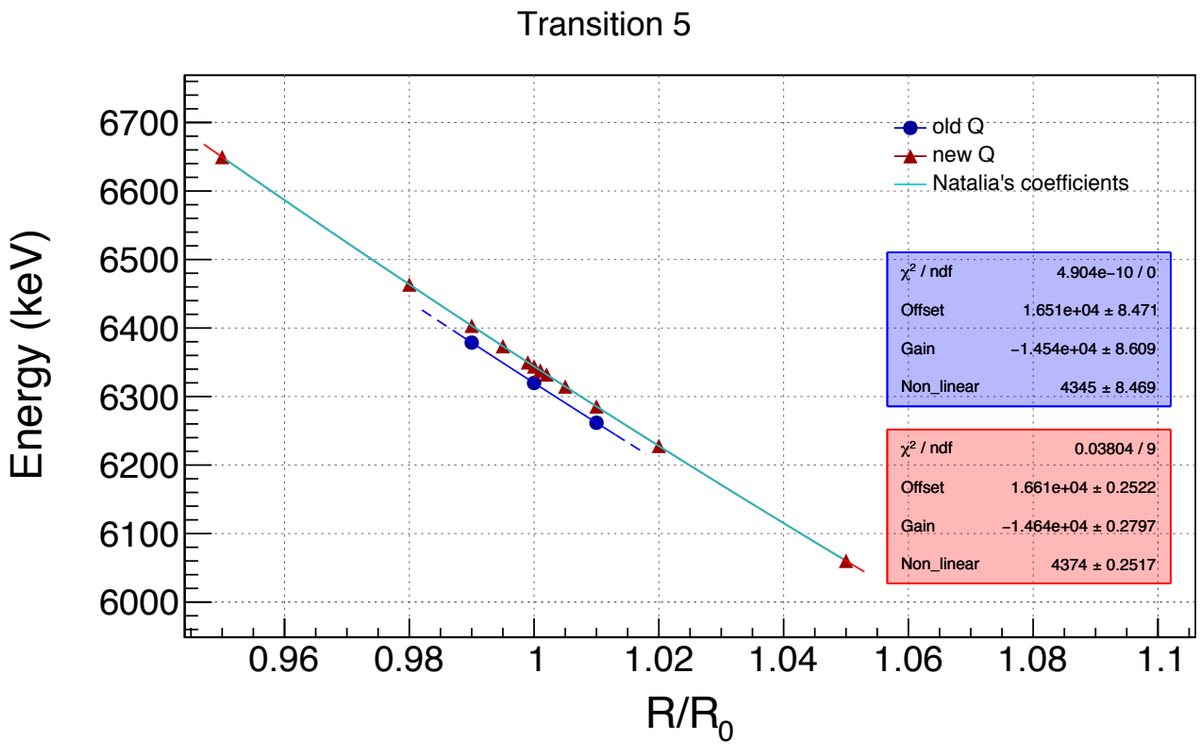


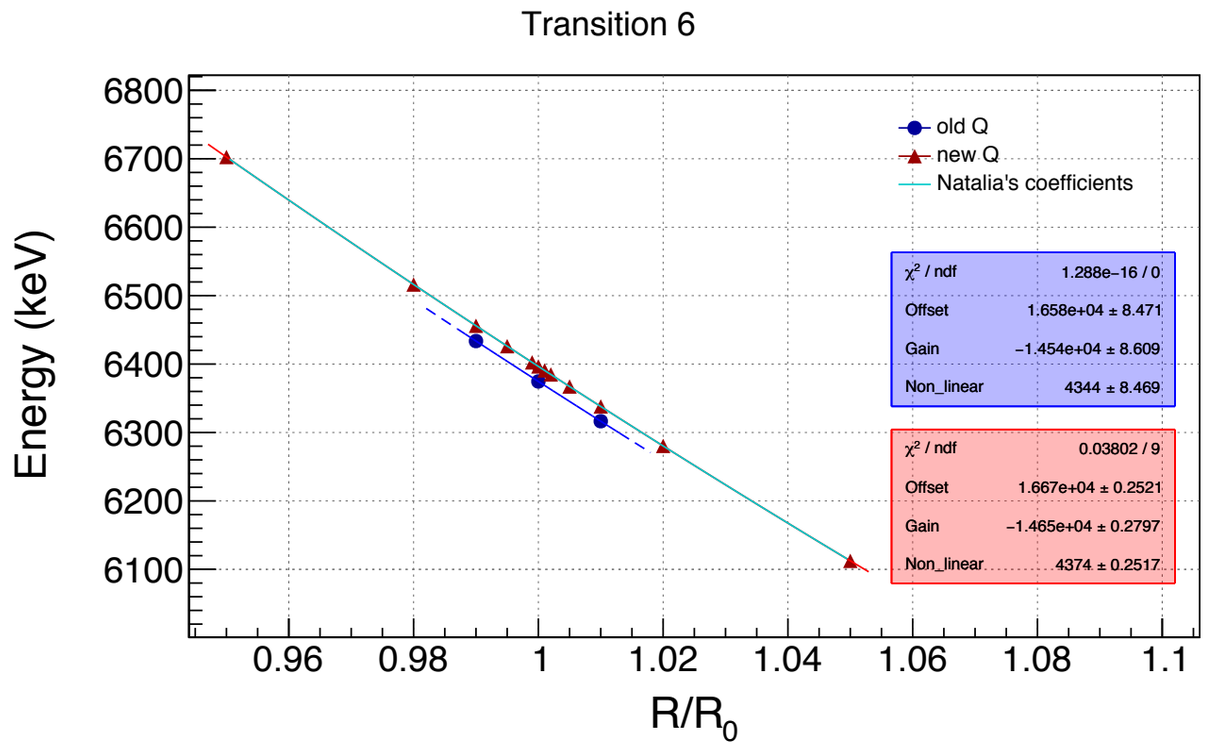
Transition 4

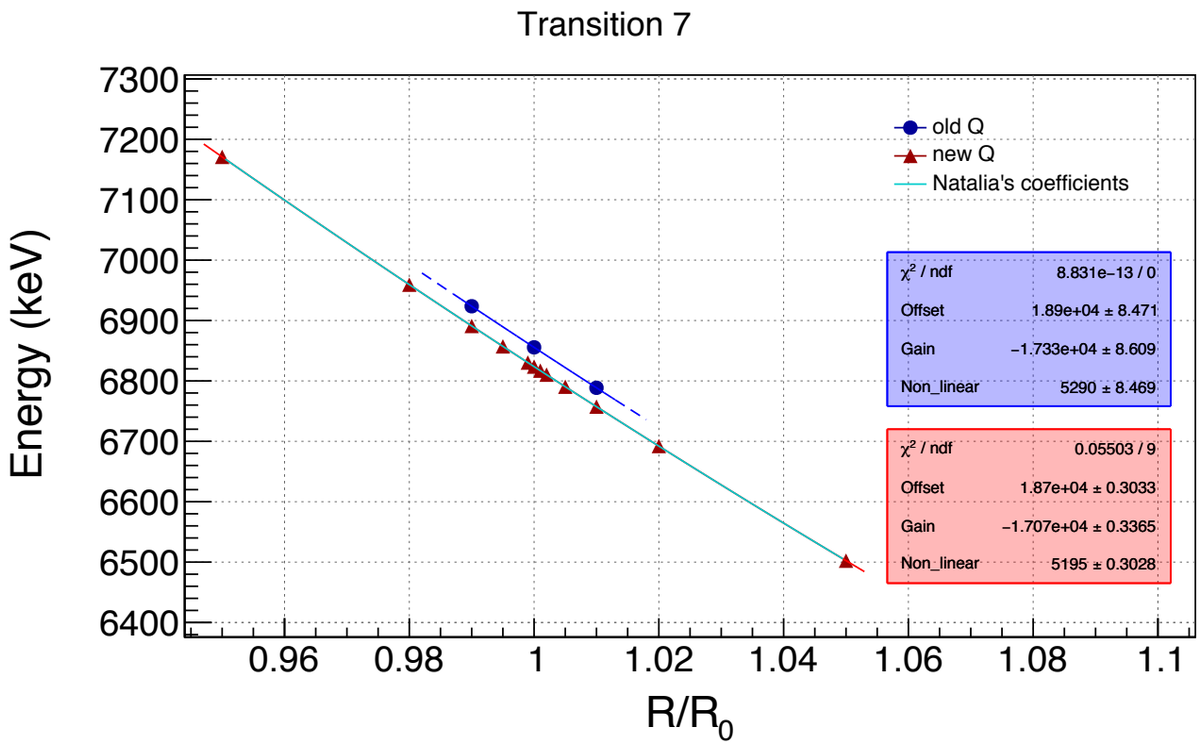


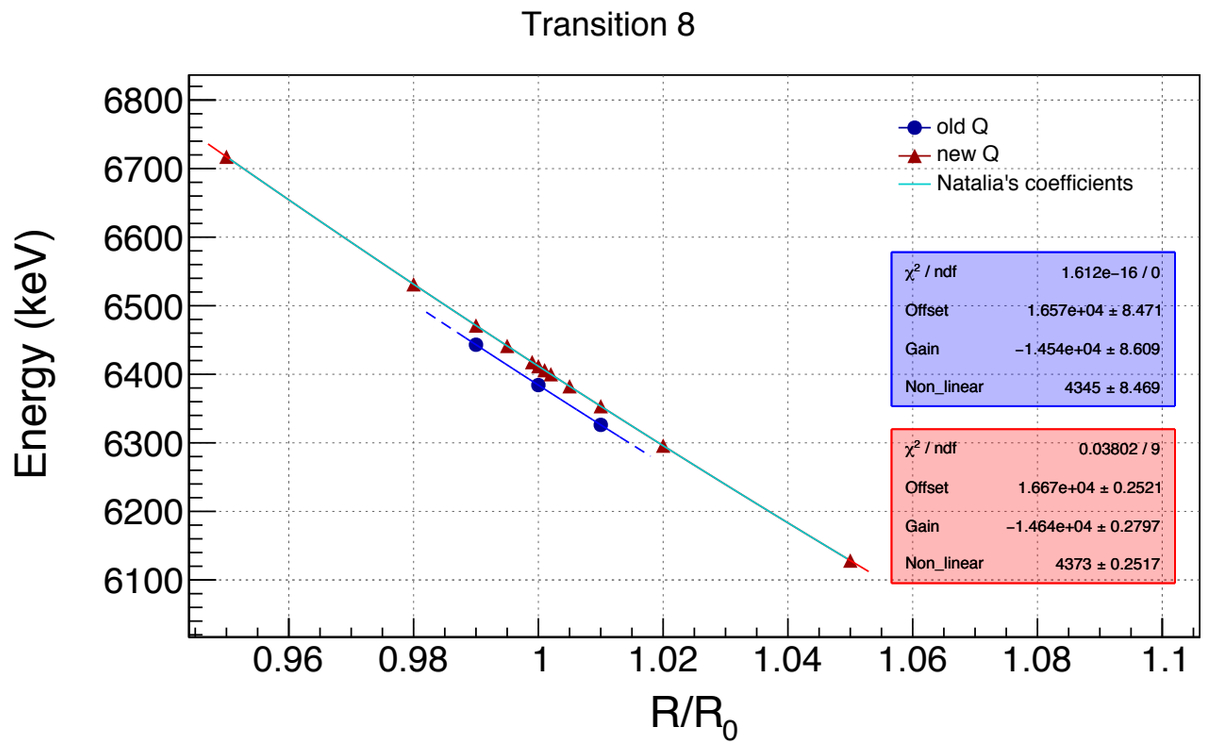
Energy VS dR for different Q - discard dR=0.998

I fit a 2nd degree polynomial (values did not converge)





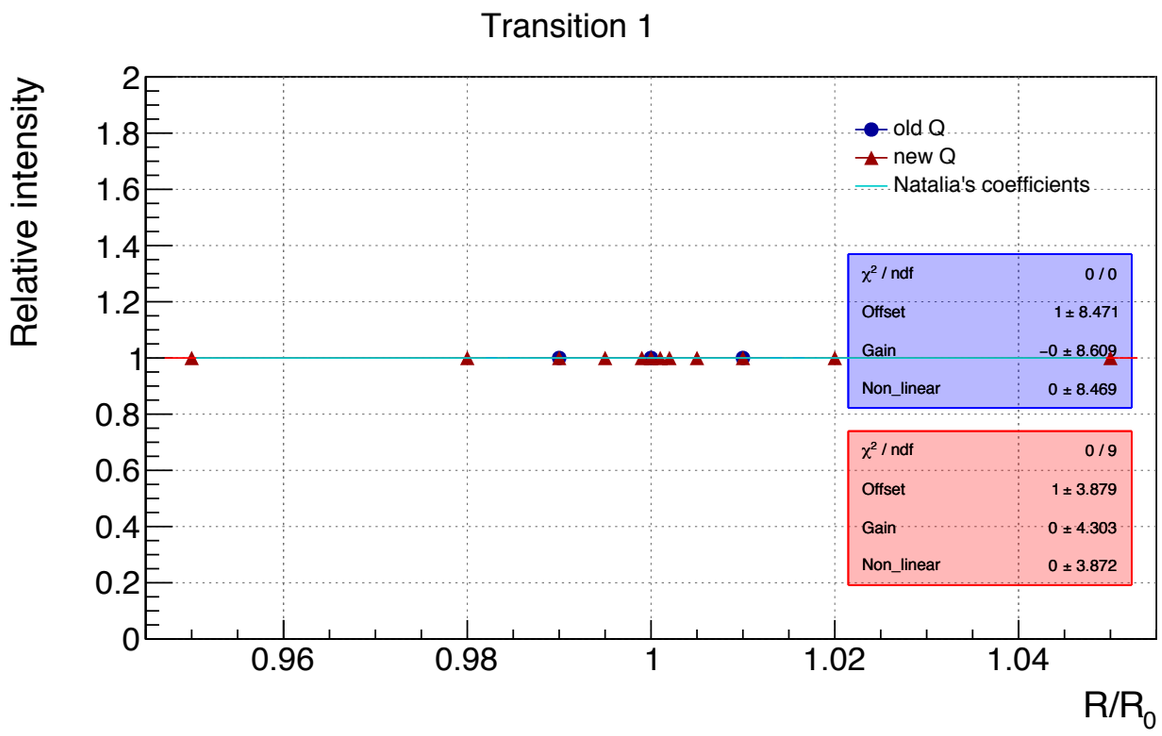


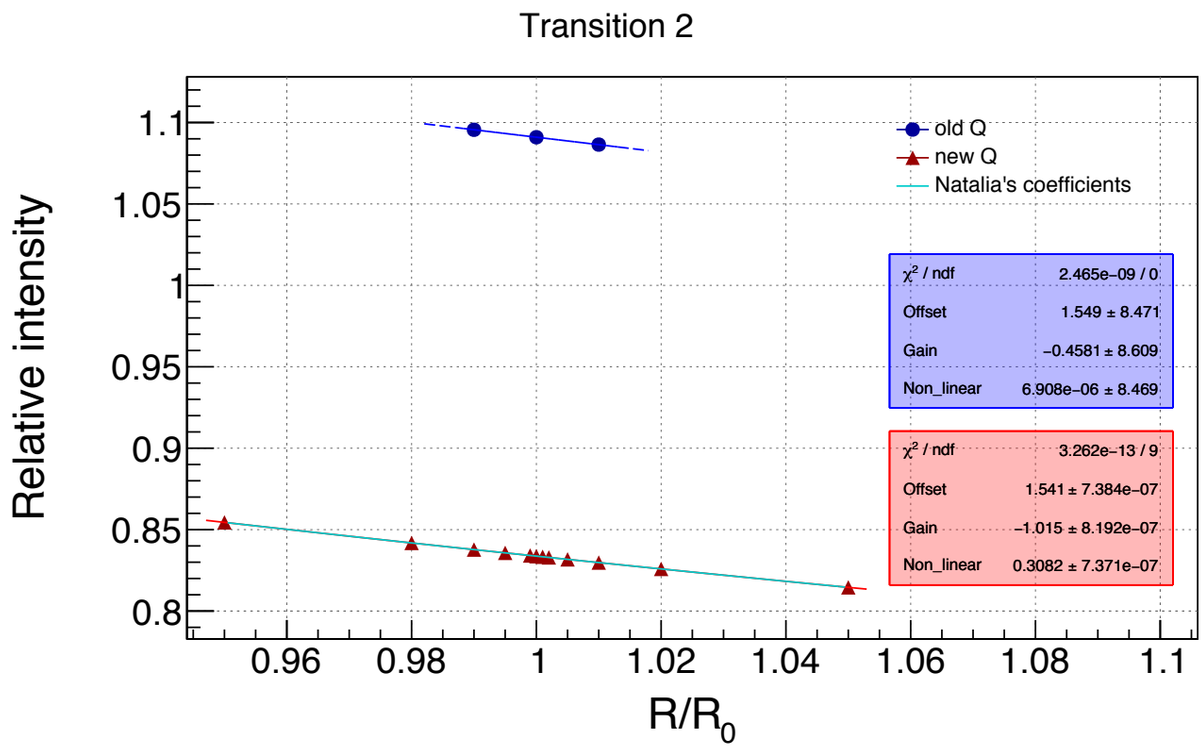


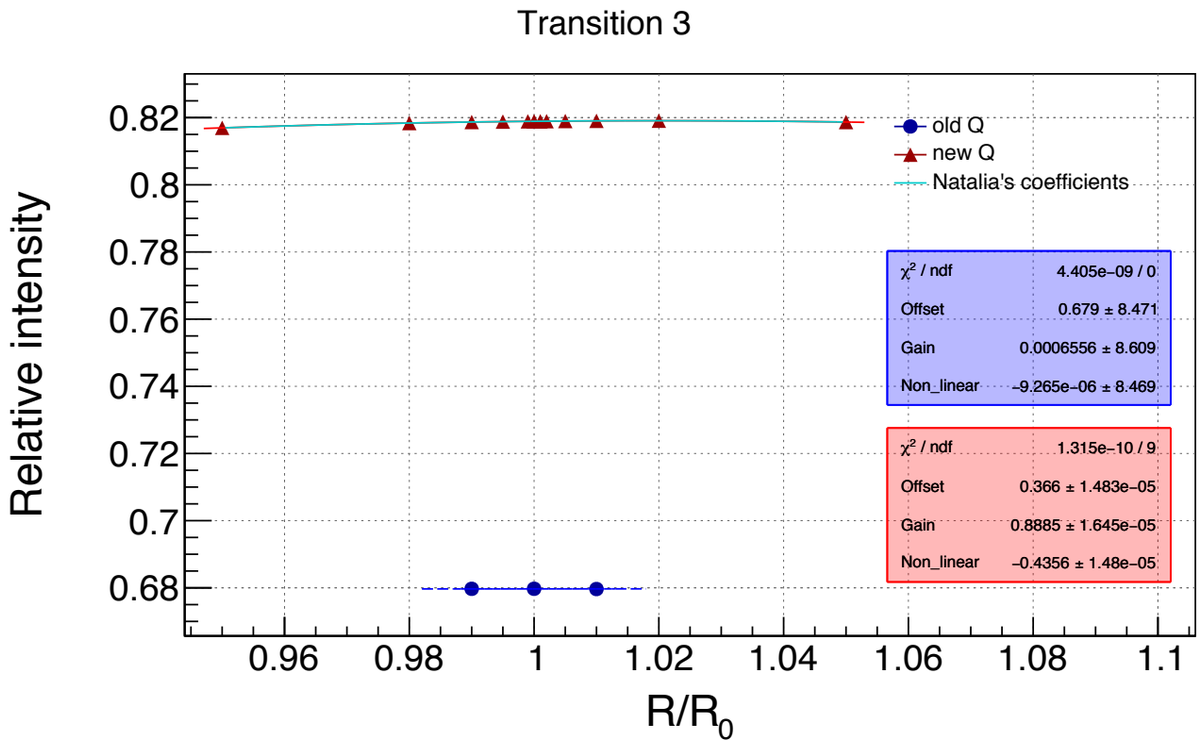
Intensity VS dR for different Q - discard dR=0.998

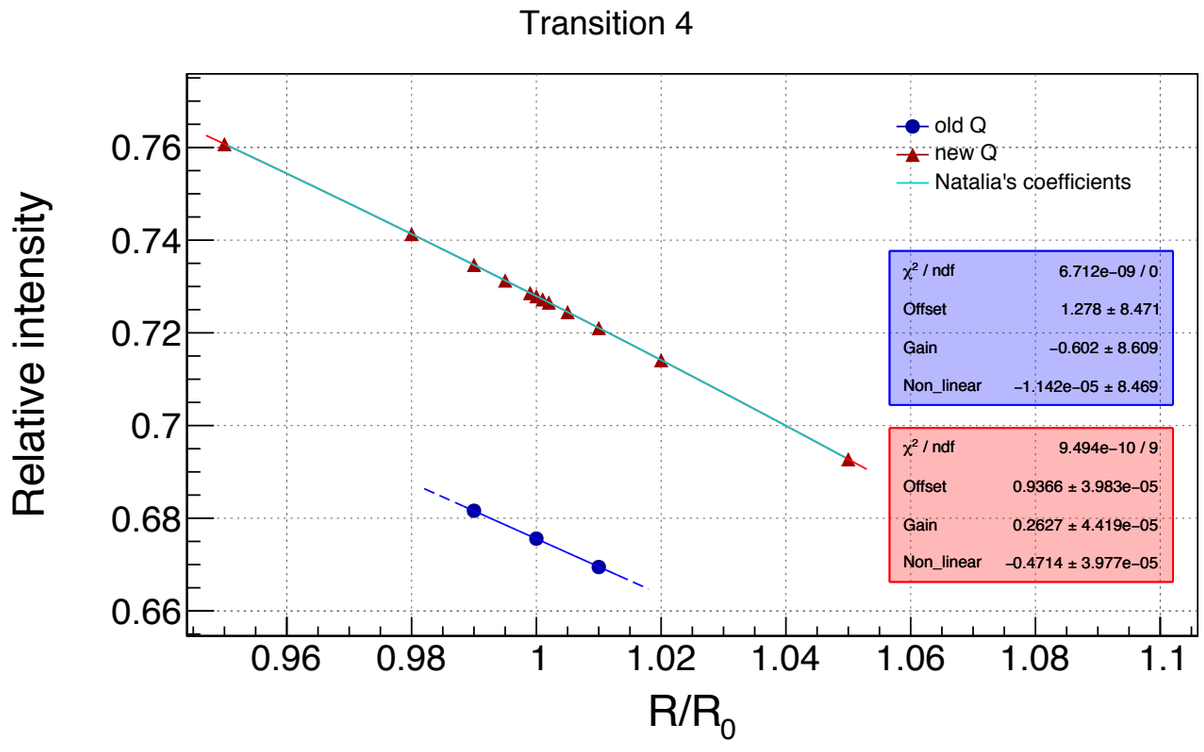
Note that the two relative intensity curves for the two different Q values do not always have the same slope

I fit a 2nd degree polynomial (values did not converge)





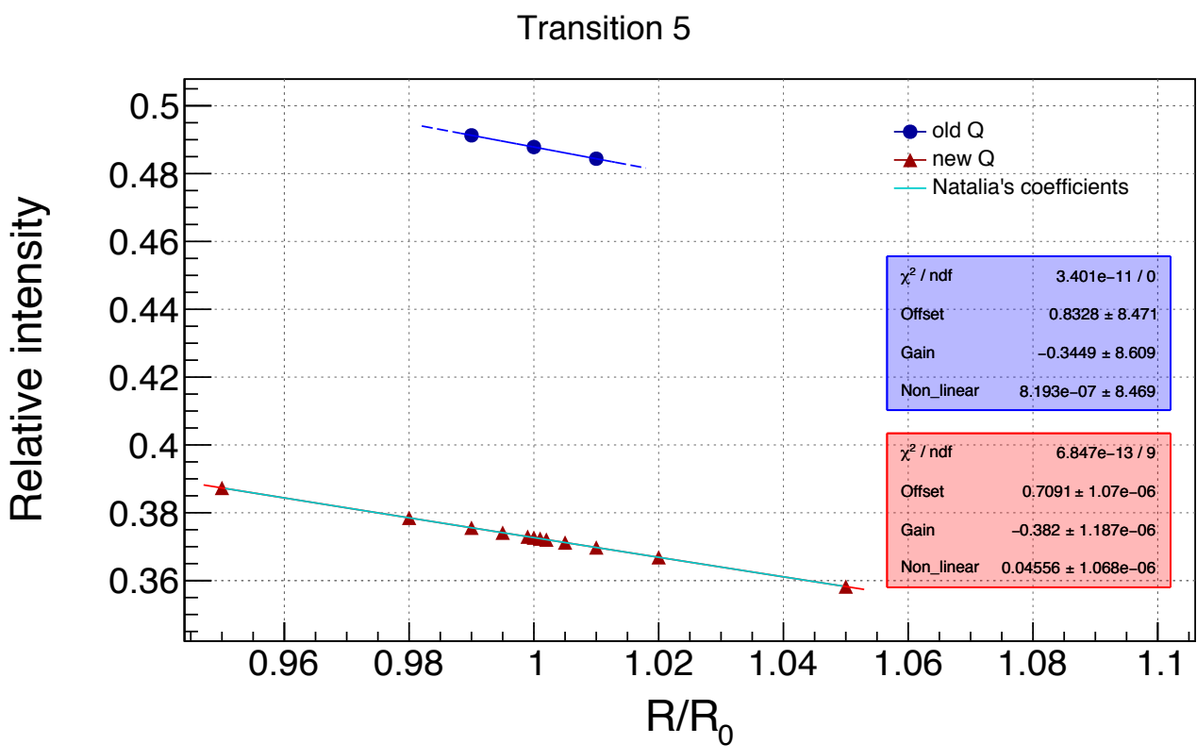


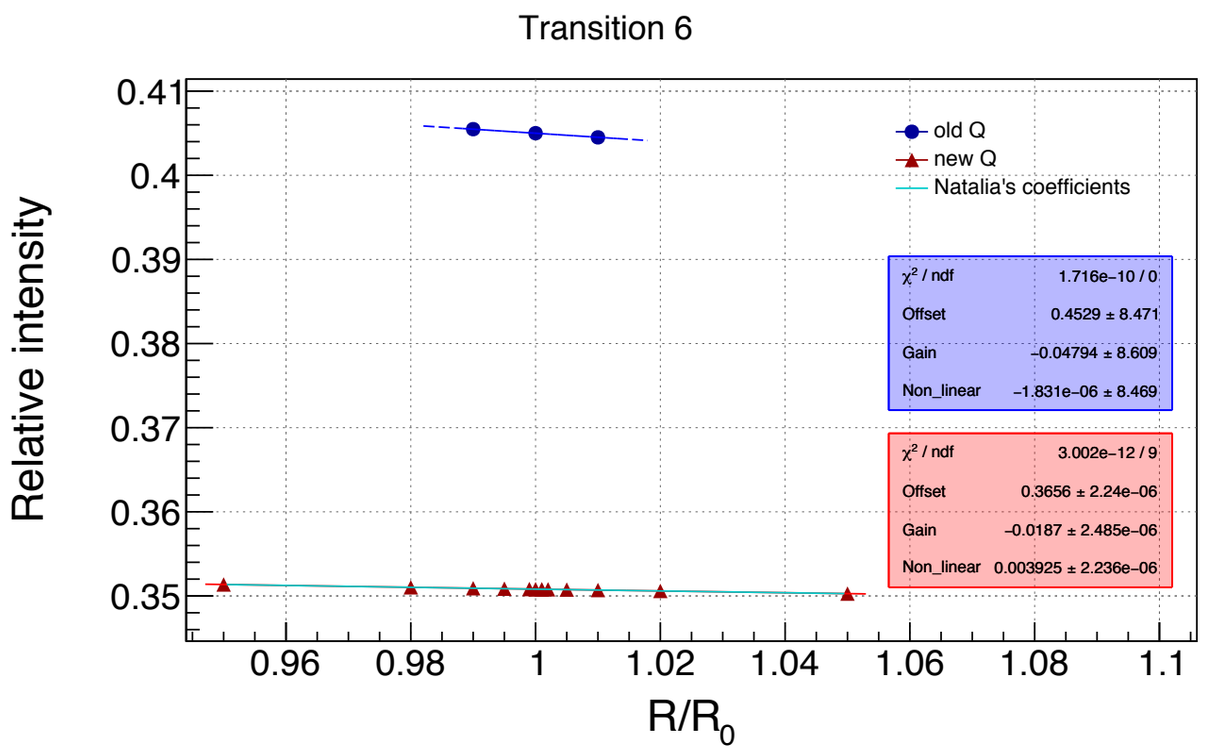


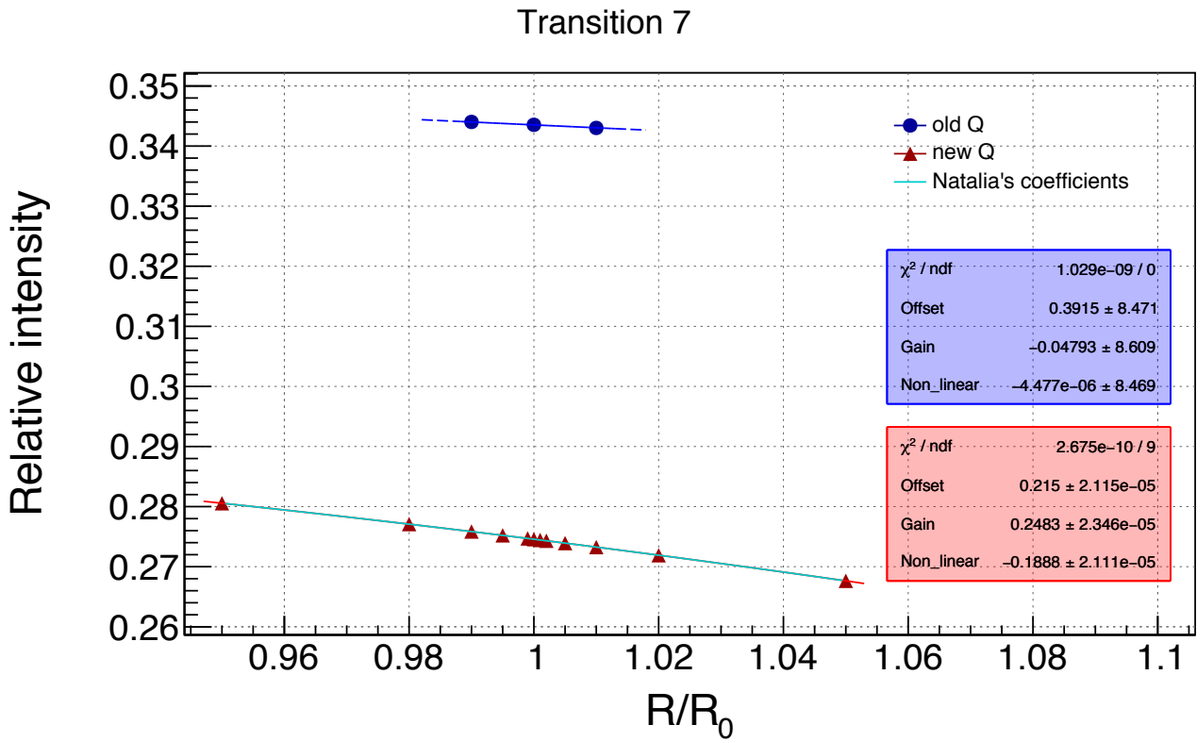
Intensity VS dR for different Q - discard dR=0.998

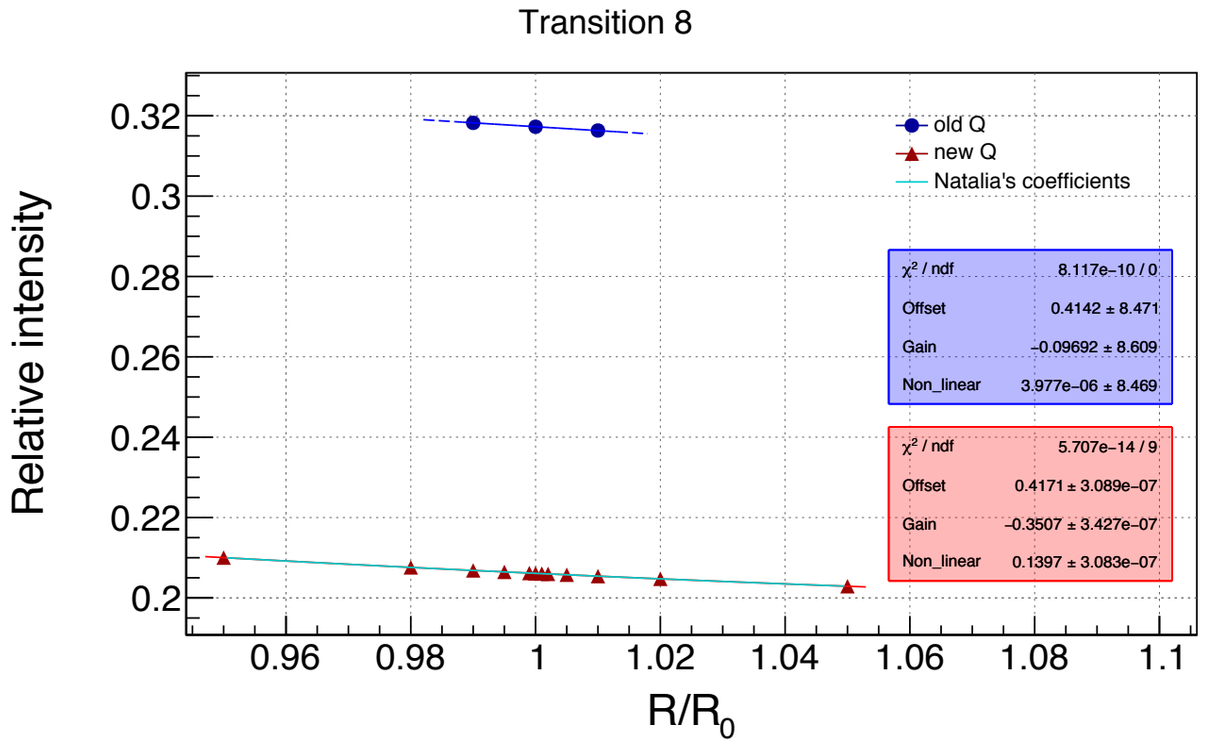
Note that the two relative intensity curves for the two different Q values do not always have the same slope

I fit a 2nd degree polynomial (values did not converge)



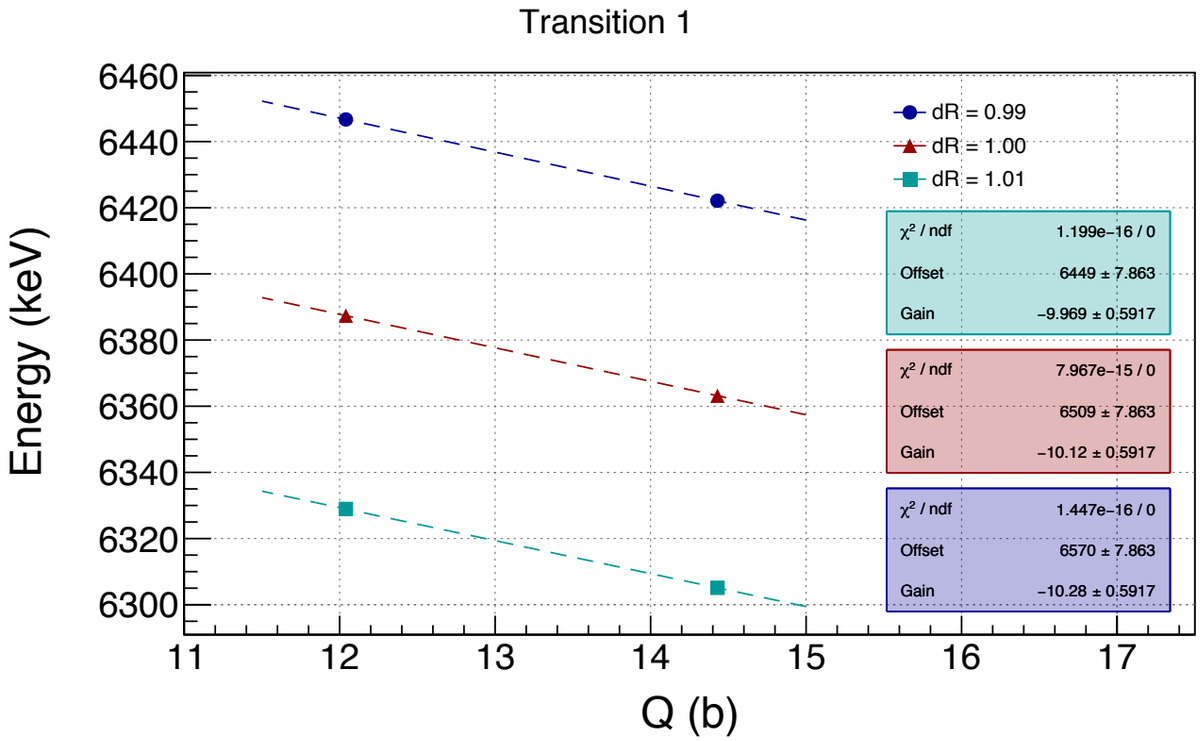


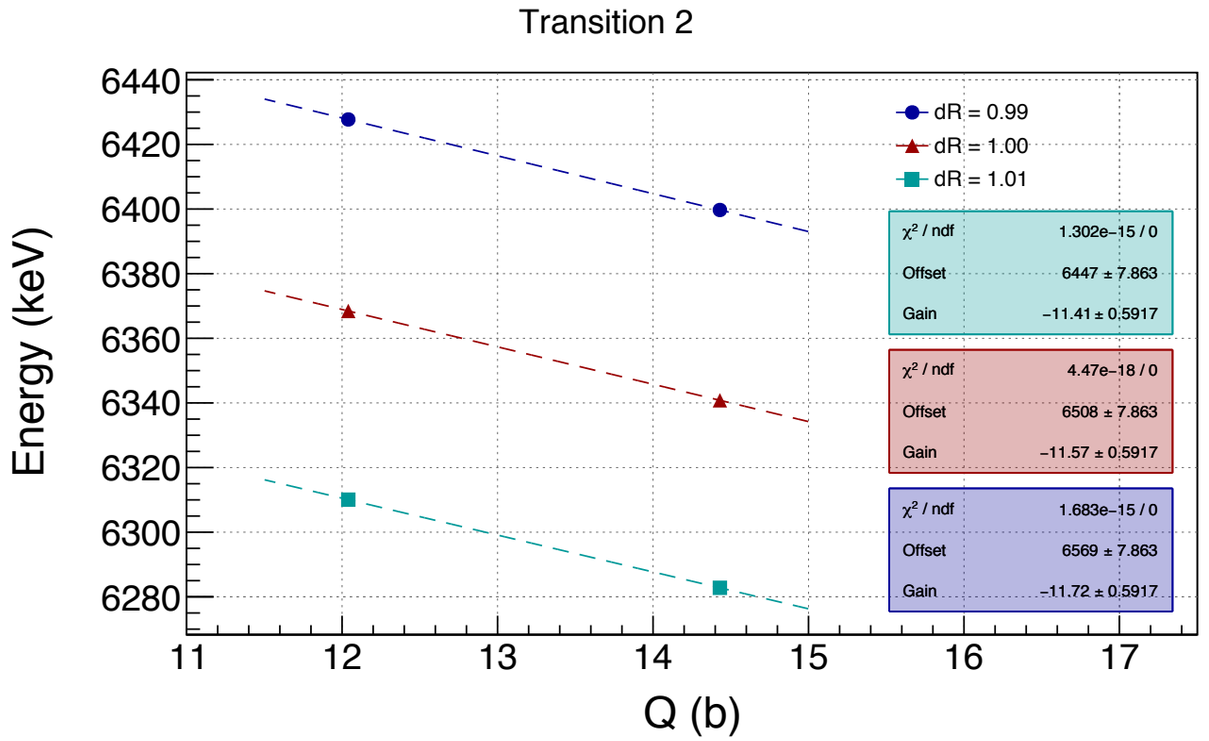


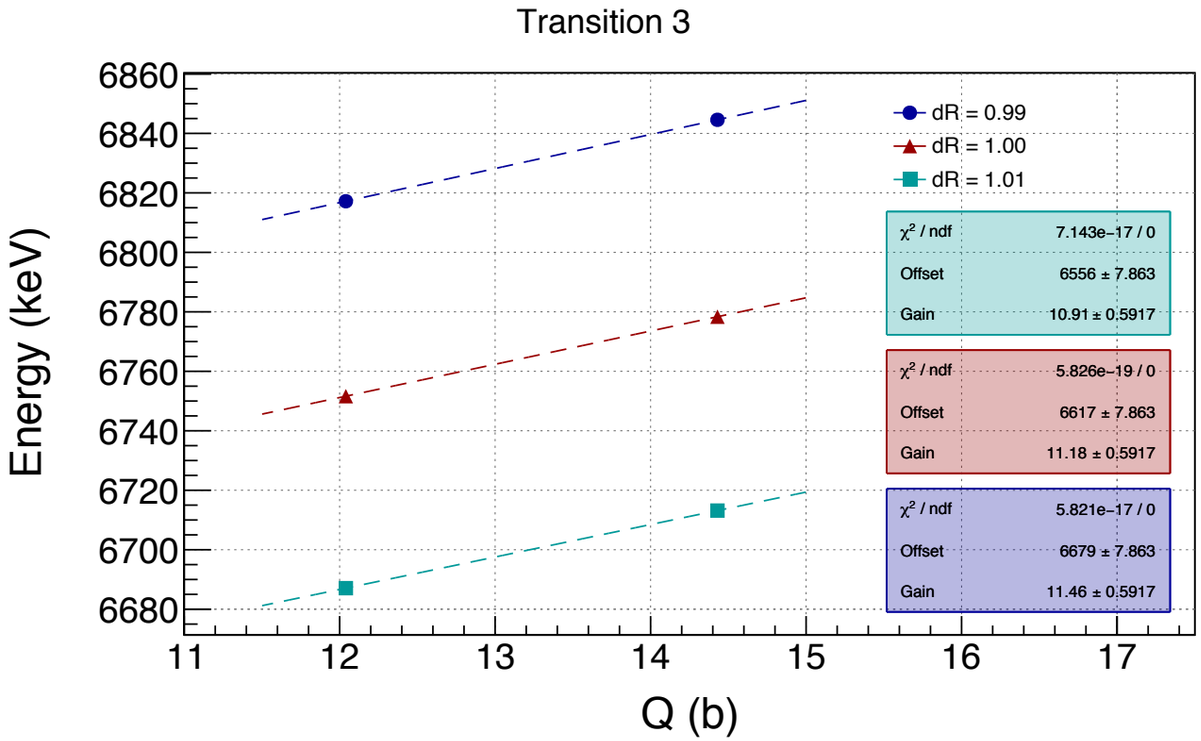


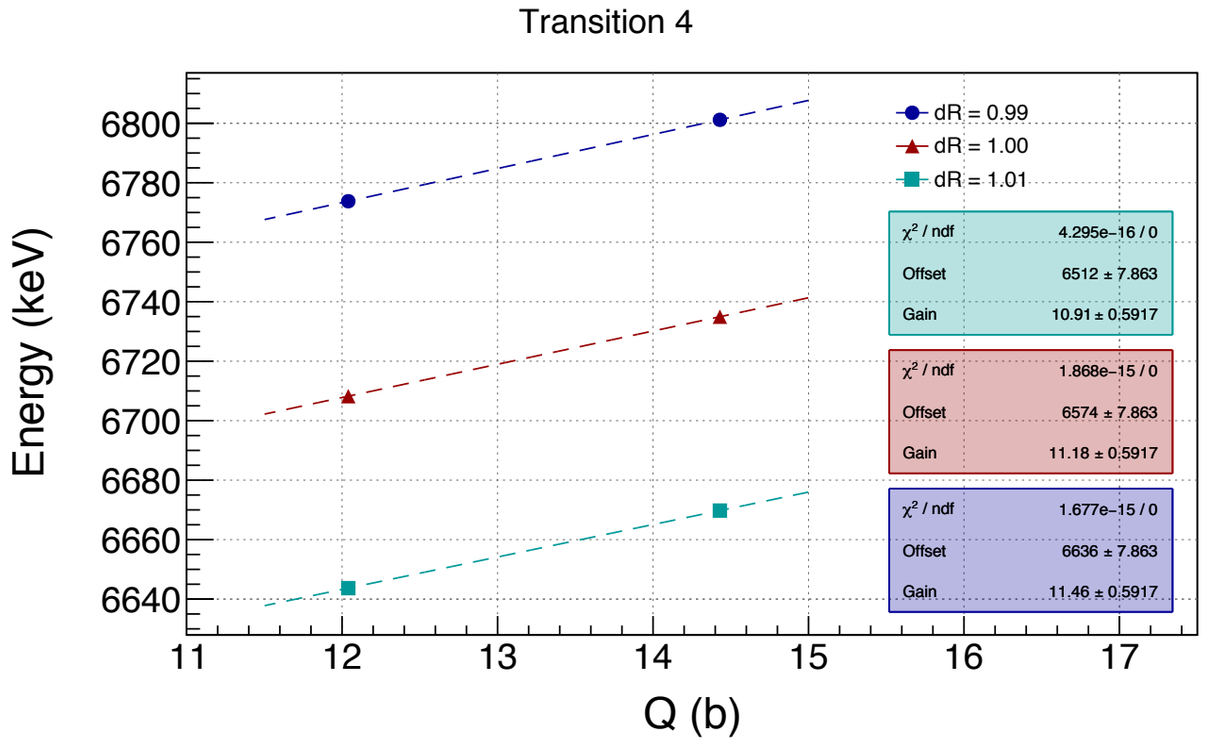
Energy VS Q for different dR

I plot the energy as a function of the “spectroscopic” quadrupole moment Q for the three different dR values, namely 0.99, 1.00, 1.01.



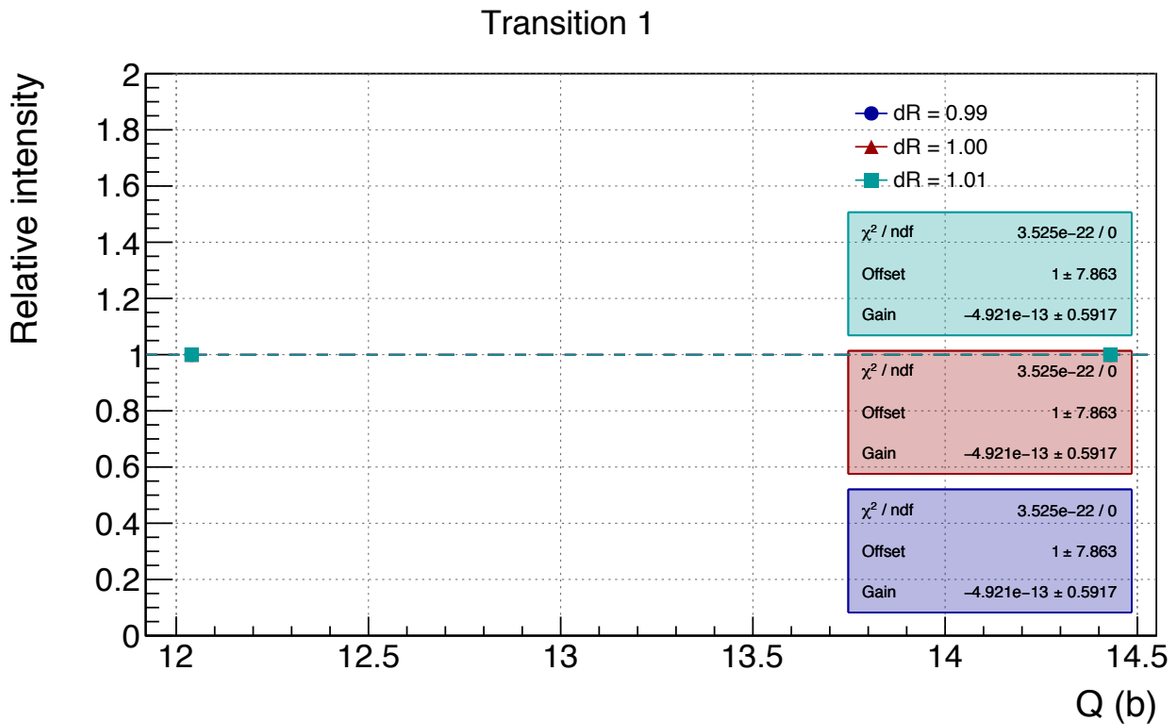


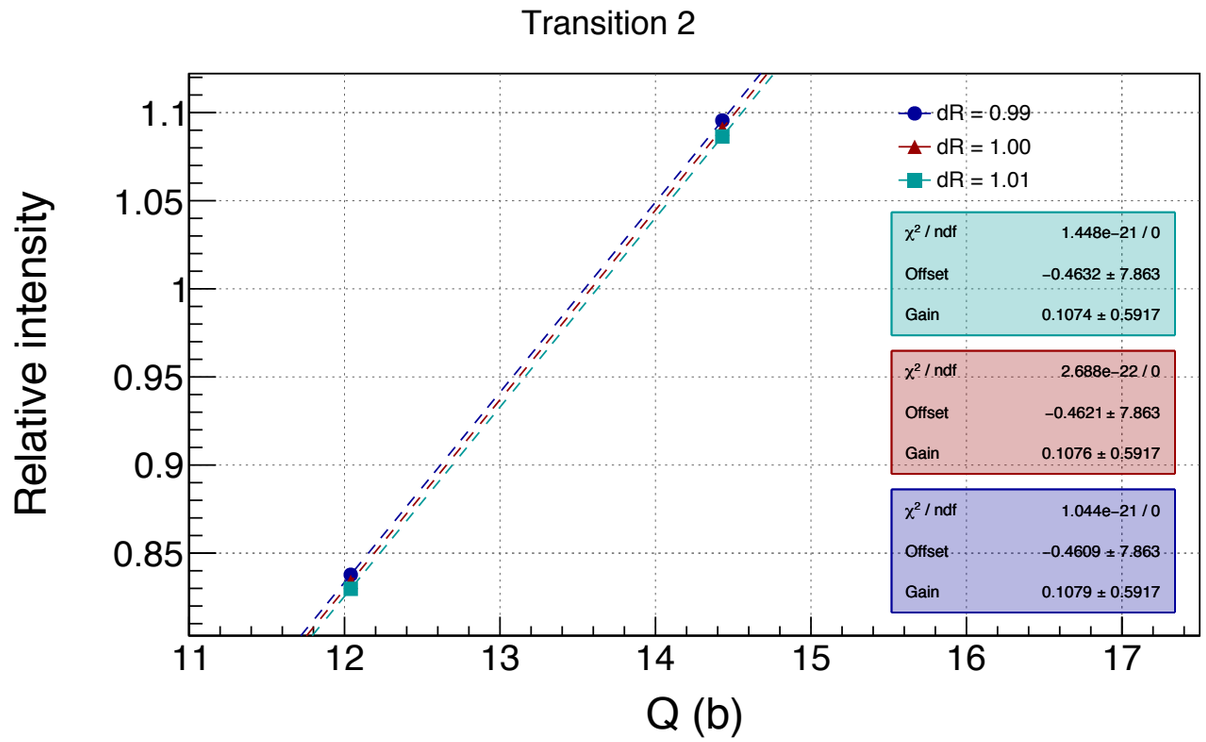


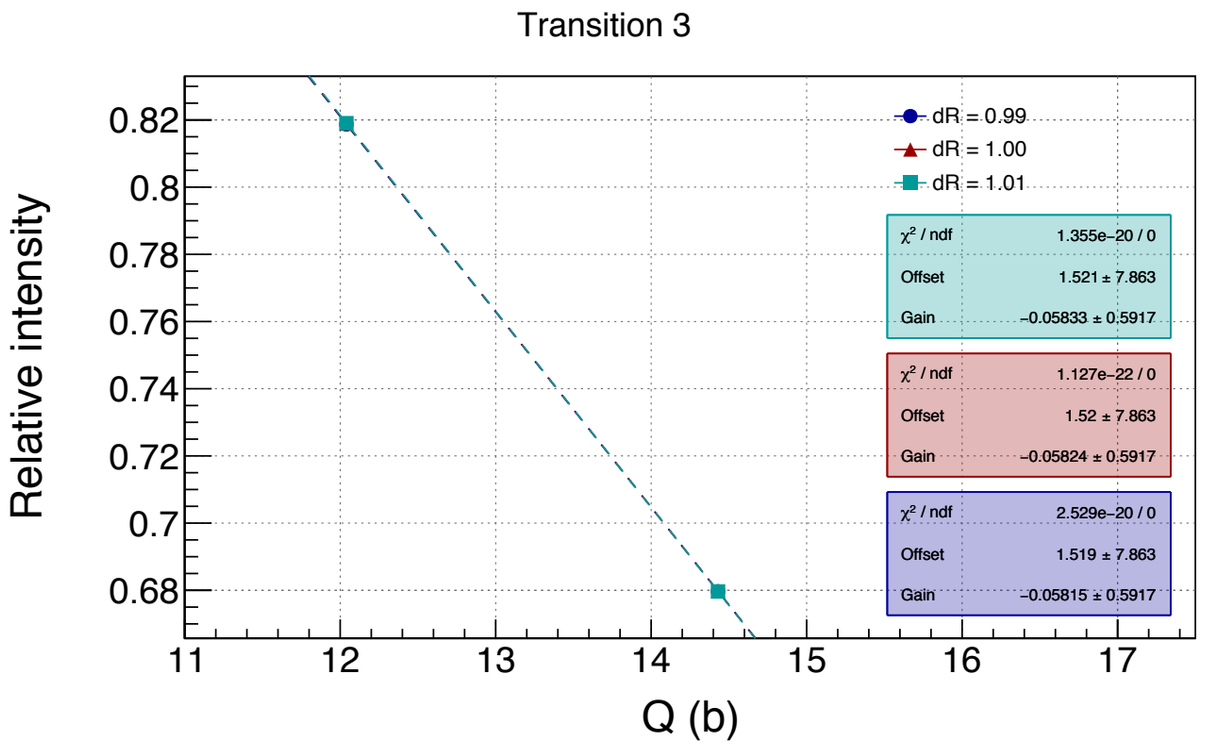


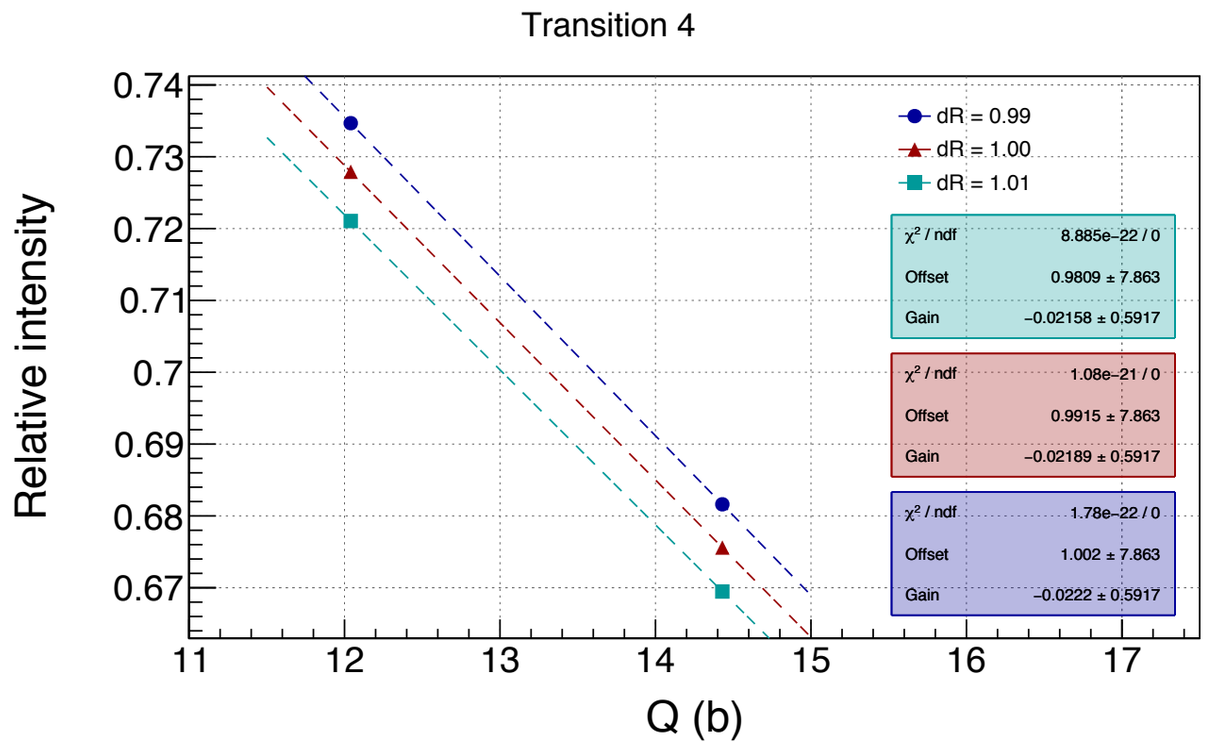
Intensity VS Q for different dR

I plot the relative intensity as a function of the “spectroscopic” quadrupole moment Q for the three different dR values, namely 0.99, 1.00, 1.01.







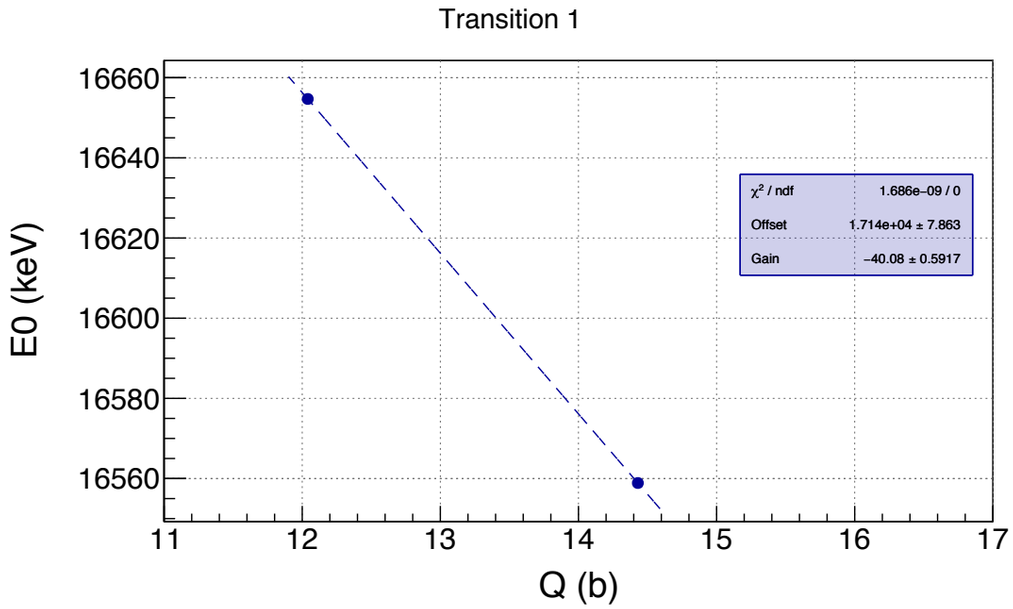


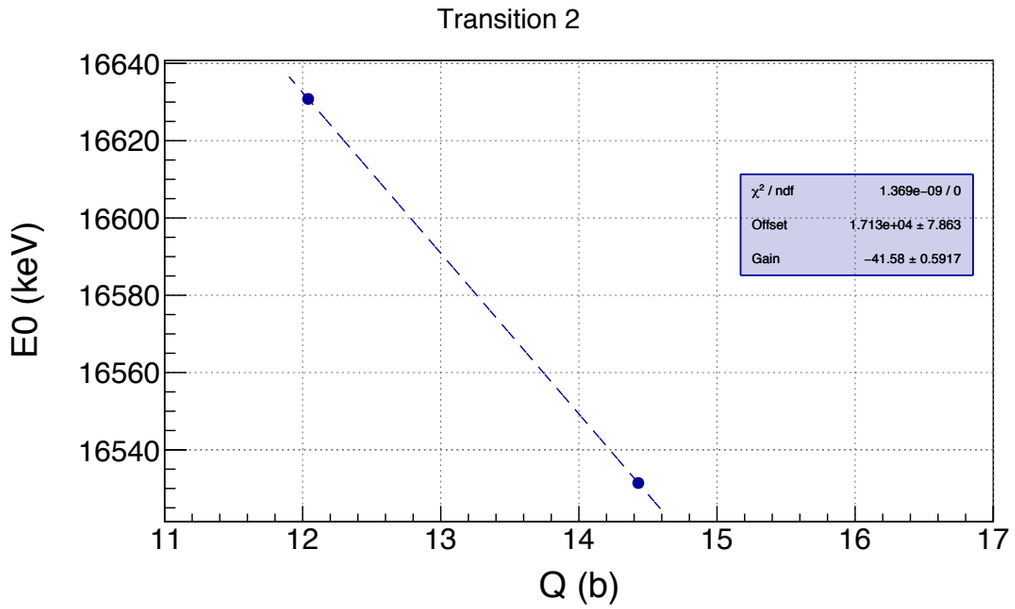
E0 VS Q

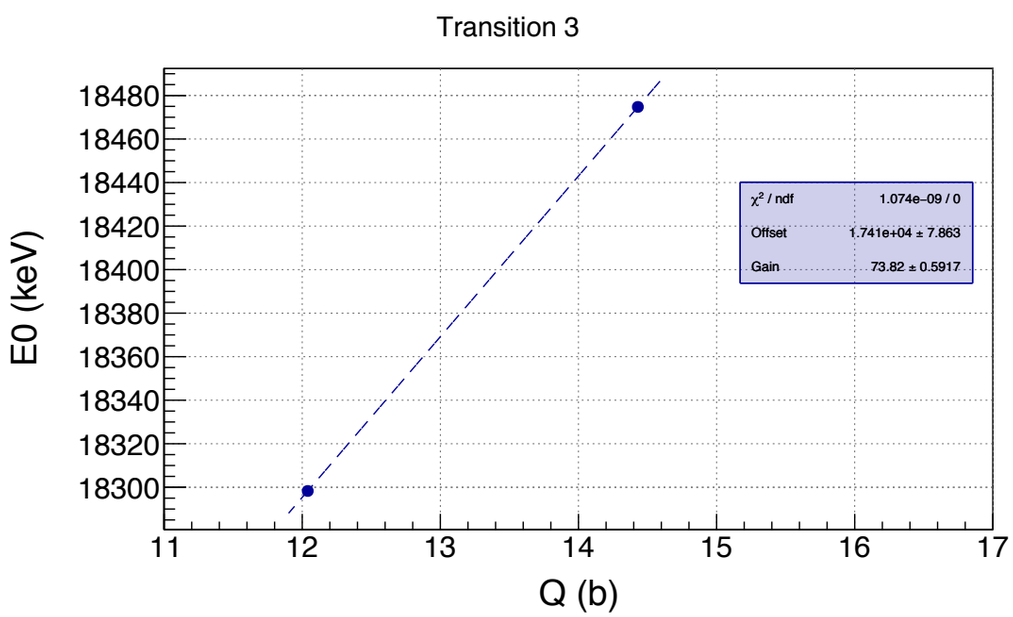
From the fits of the slides 16-19 (for example), we obtained two 2nd degree polynomial functions for each transition, each representing a different Q. Each of these two polynomials is described by a different set of three parameters for each Q value, i.e. $(\mathrm{E0}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{E1}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{E2}^{\mathrm{i}}_{\mathrm{dR}})$ or $(\mathrm{RI0}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{RI1}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{RI2}^{\mathrm{i}}_{\mathrm{dR}})$, so that:

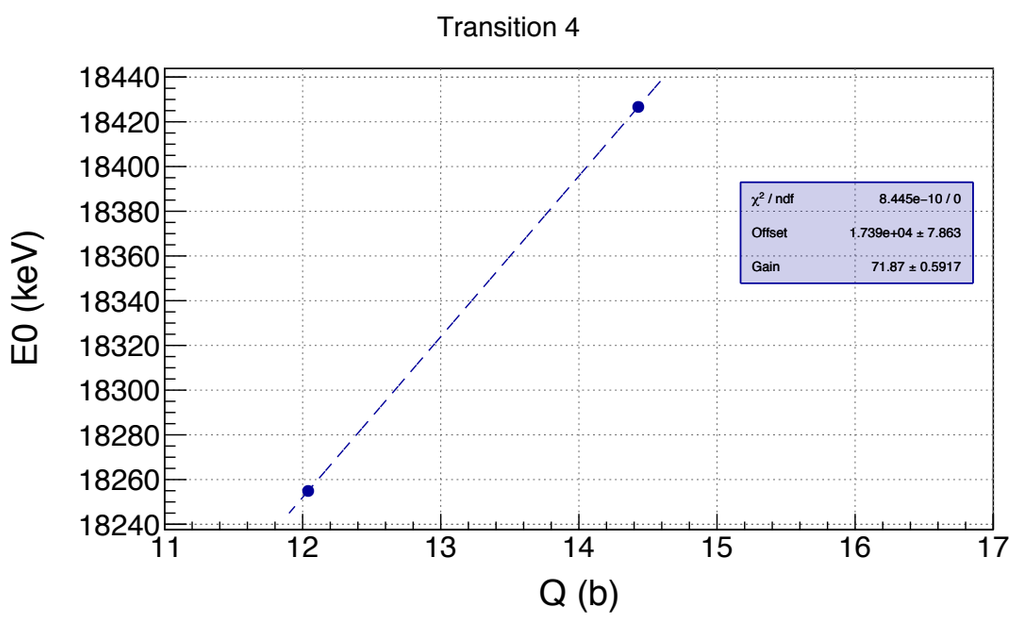
$$\mathrm{E}^{\mathrm{i}} = \mathrm{E0}^{\mathrm{i}}_{\mathrm{dR}} + \mathrm{E1}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR} + \mathrm{E2}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR}^2 \text{ or } \mathrm{RI}^{\mathrm{i}} = \mathrm{RI0}^{\mathrm{i}}_{\mathrm{dR}} + \mathrm{RI1}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR} + \mathrm{RI2}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR}^2$$

For each transition, I plot the three different energy or relative intensity coefficients vs Q separately. Since I only have two Q points, I assume a linear dependence on quadrupole moment and I fit a 1st degree polynomial in each plot.









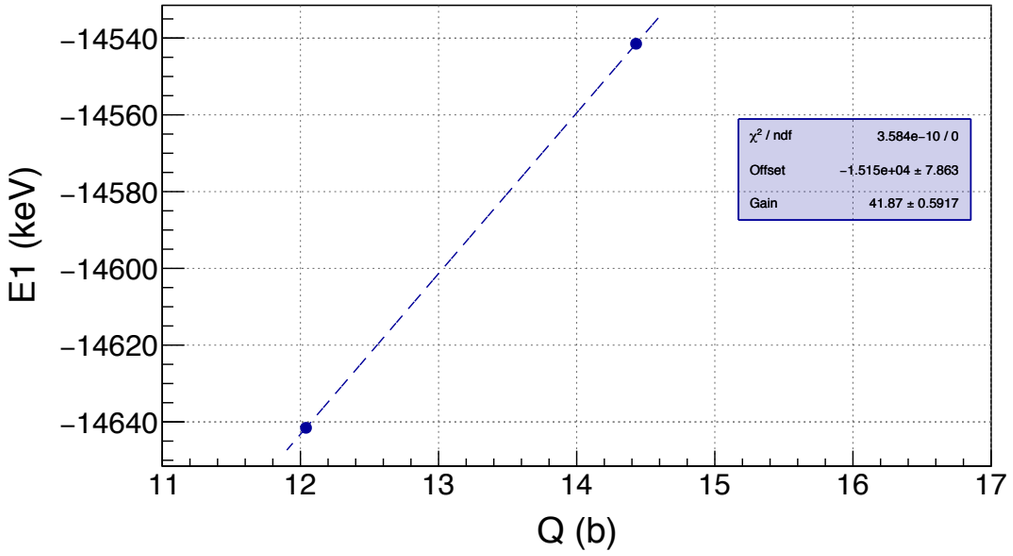
E1 VS Q

From the fits of the slides 16-19 (for example), we obtained two 2nd degree polynomial functions for each transition, each representing a different Q. Each of these two polynomials is described by a different set of three parameters for each Q value, i.e. $(\mathrm{E0}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{E1}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{E2}^{\mathrm{i}}_{\mathrm{dR}})$ or $(\mathrm{RI0}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{RI1}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{RI2}^{\mathrm{i}}_{\mathrm{dR}})$, so that:

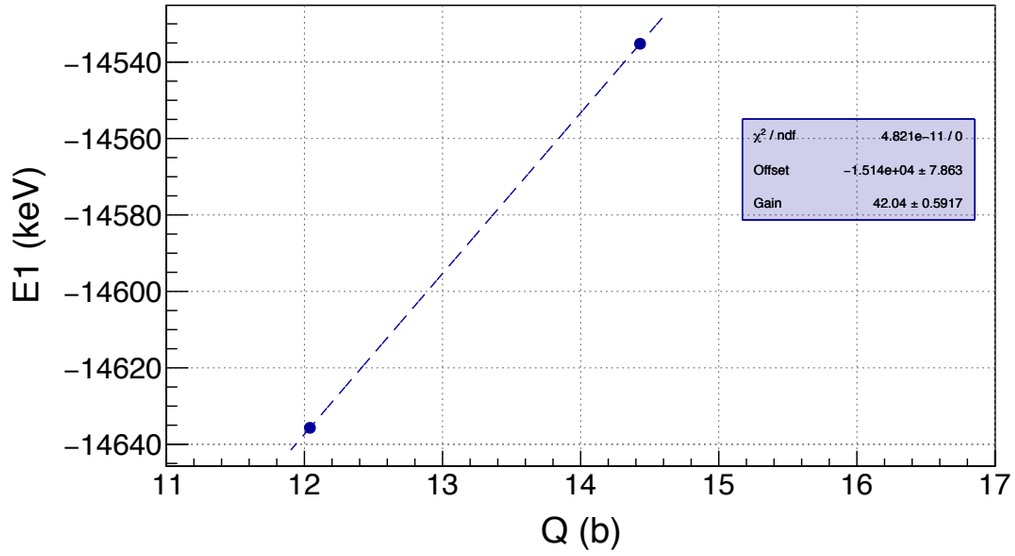
$$\mathrm{E}^{\mathrm{i}} = \mathrm{E0}^{\mathrm{i}}_{\mathrm{dR}} + \mathrm{E1}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR} + \mathrm{E2}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR}^2 \text{ or } \mathrm{RI}^{\mathrm{i}} = \mathrm{RI0}^{\mathrm{i}}_{\mathrm{dR}} + \mathrm{RI1}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR} + \mathrm{RI2}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR}^2$$

For each transition, I plot the three different energy or relative intensity coefficients vs Q separately. Since I only have two Q points, I assume a linear dependence on quadrupole moment and I fit a 1st degree polynomial in each plot.

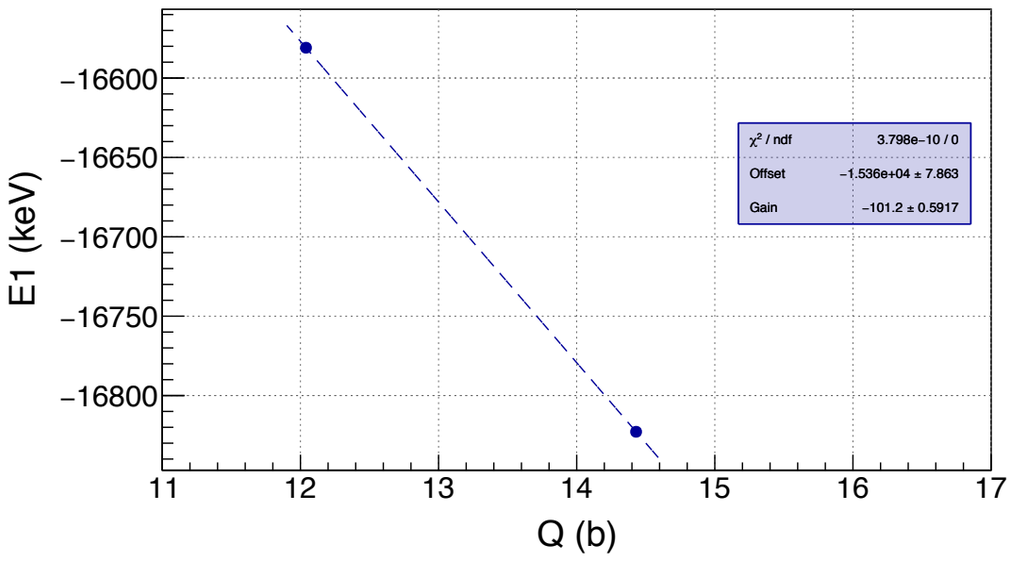
Transition 1



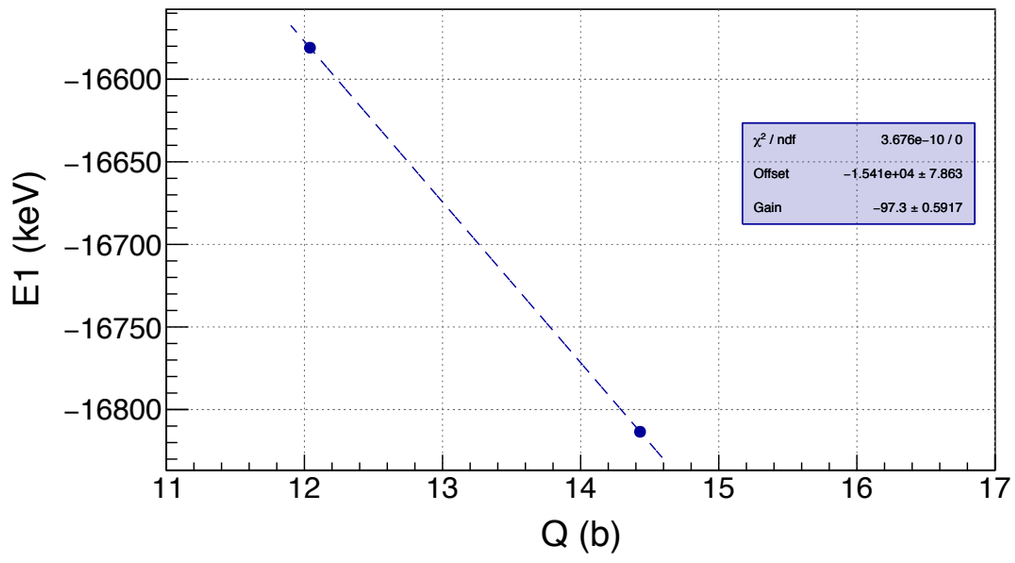
Transition 2



Transition 3



Transition 4



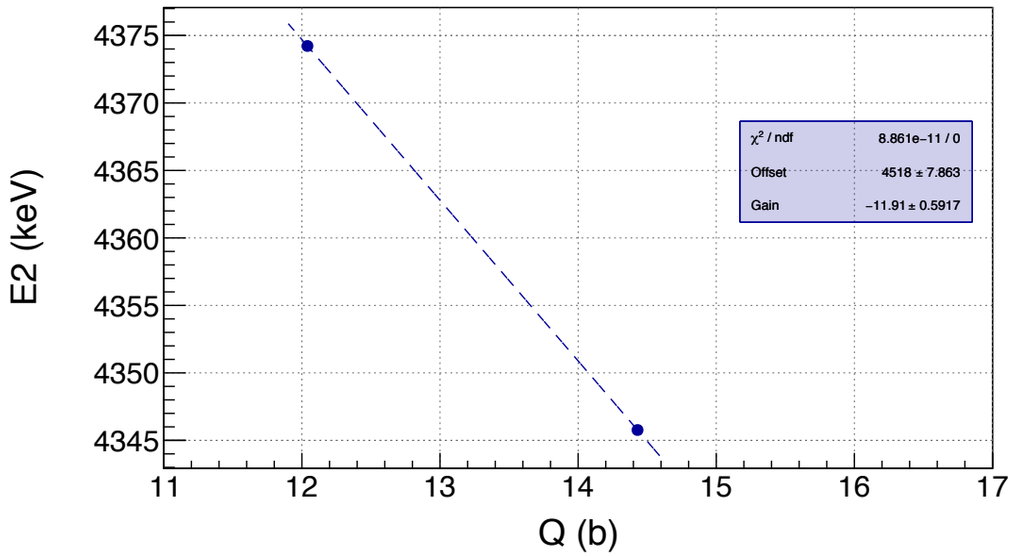
E2 VS Q

From the fits of the slides 16-19 (for example), we obtained two 2nd degree polynomial functions for each transition, each representing a different Q. Each of these two polynomials is described by a different set of three parameters for each Q value, i.e. $(\mathrm{E0}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{E1}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{E2}^{\mathrm{i}}_{\mathrm{dR}})$ or $(\mathrm{RI0}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{RI1}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{RI2}^{\mathrm{i}}_{\mathrm{dR}})$, so that:

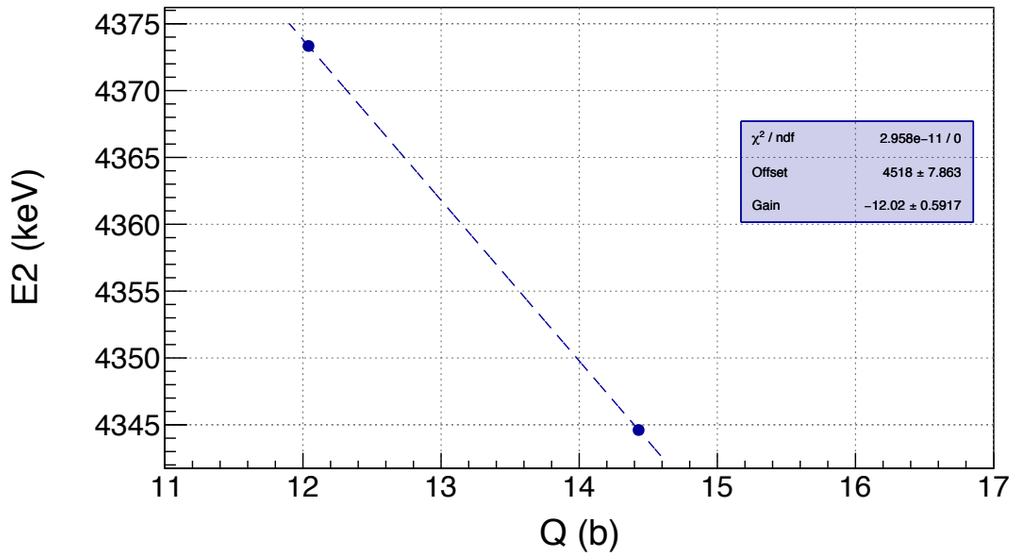
$$\mathrm{E}^{\mathrm{i}} = \mathrm{E0}^{\mathrm{i}}_{\mathrm{dR}} + \mathrm{E1}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR} + \mathrm{E2}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR}^2 \text{ or } \mathrm{RI}^{\mathrm{i}} = \mathrm{RI0}^{\mathrm{i}}_{\mathrm{dR}} + \mathrm{RI1}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR} + \mathrm{RI2}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR}^2$$

For each transition, I plot the three different energy or relative intensity coefficients vs Q separately. Since I only have two Q points, I assume a linear dependence on quadrupole moment and I fit a 1st degree polynomial in each plot.

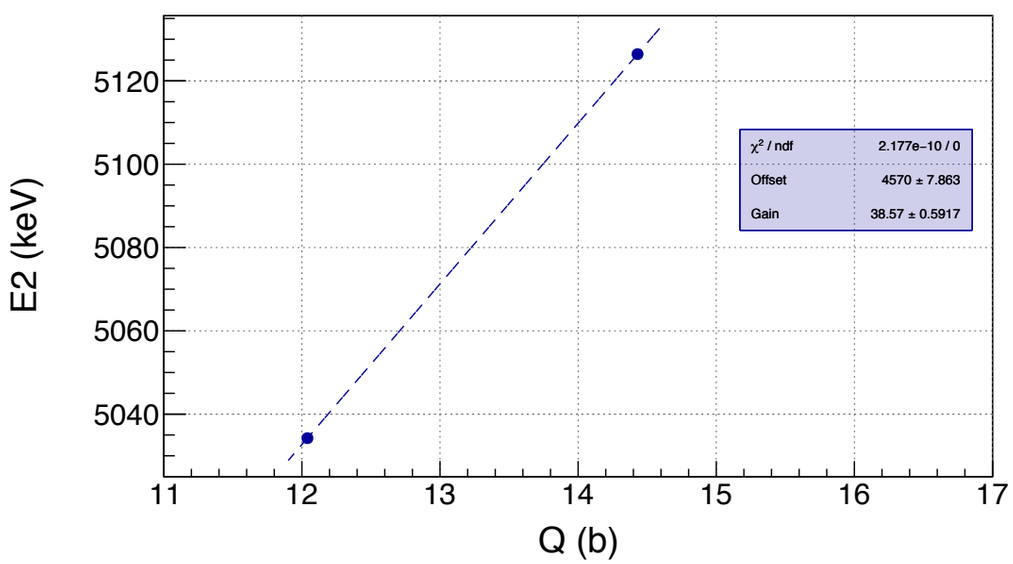
Transition 1



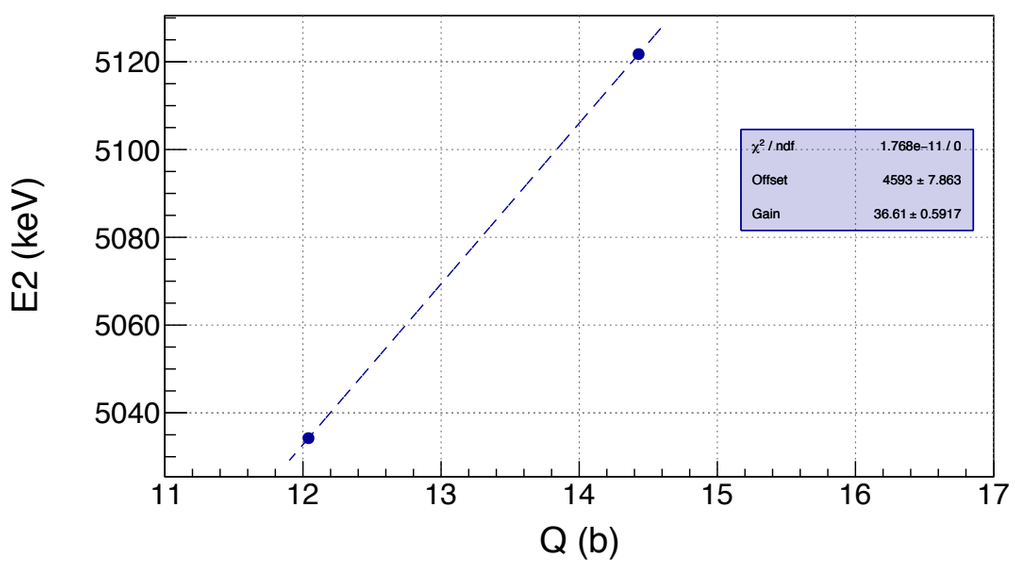
Transition 2



Transition 3



Transition 4



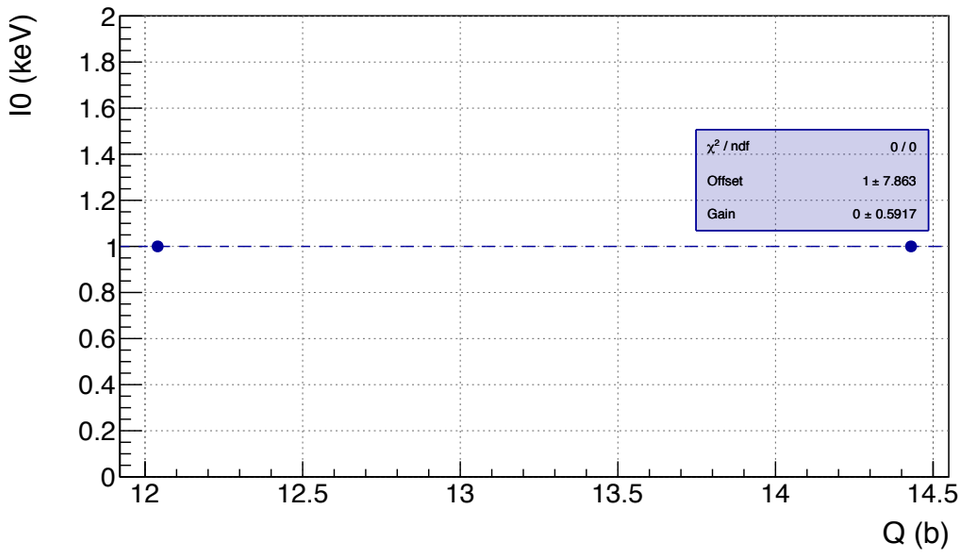
I0 VS Q

From the fits of the slides 16-19 (for example), we obtained two 2nd degree polynomial functions for each transition, each representing a different Q. Each of these two polynomials is described by a different set of three parameters for each Q value, i.e. $(\mathrm{E0}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{E1}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{E2}^{\mathrm{i}}_{\mathrm{dR}})$ or $(\mathrm{RI0}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{RI1}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{RI2}^{\mathrm{i}}_{\mathrm{dR}})$, so that:

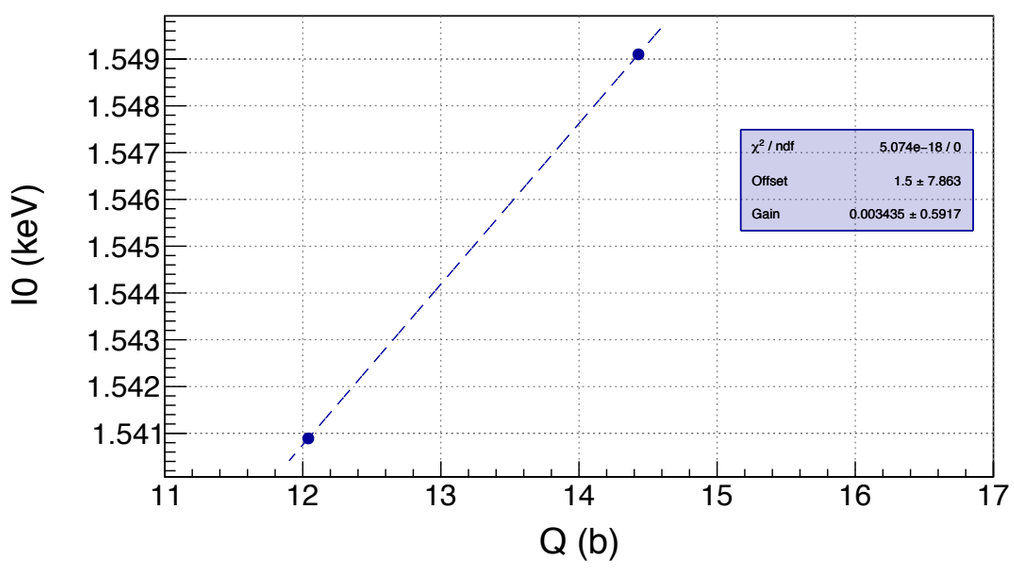
$$\mathrm{E}^{\mathrm{i}} = \mathrm{E0}^{\mathrm{i}}_{\mathrm{dR}} + \mathrm{E1}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR} + \mathrm{E2}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR}^2 \text{ or } \mathrm{RI}^{\mathrm{i}} = \mathrm{RI0}^{\mathrm{i}}_{\mathrm{dR}} + \mathrm{RI1}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR} + \mathrm{RI2}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR}^2$$

For each transition, I plot the three different energy or relative intensity coefficients vs Q separately. Since I only have two Q points, I assume a linear dependence on quadrupole moment and I fit a 1st degree polynomial in each plot.

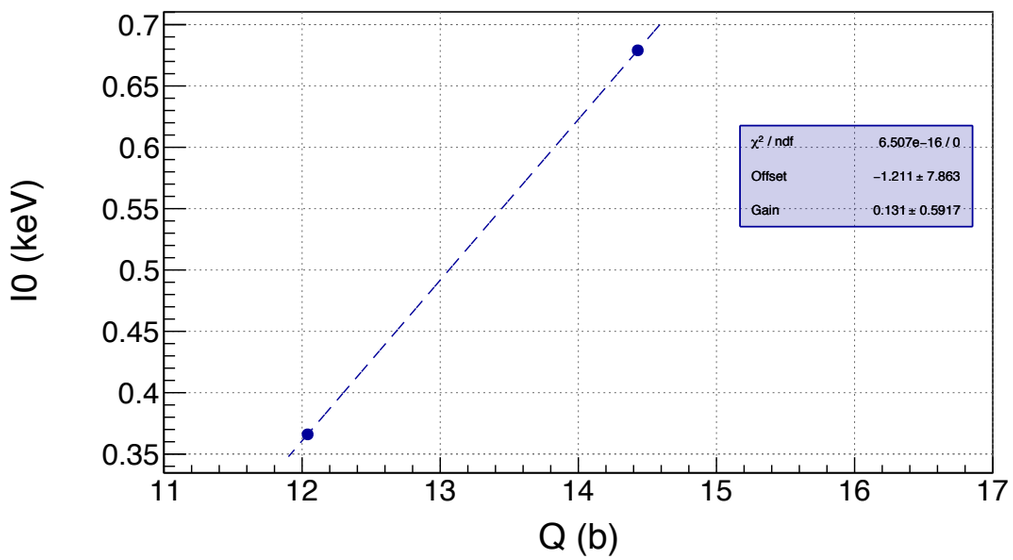
Transition 1



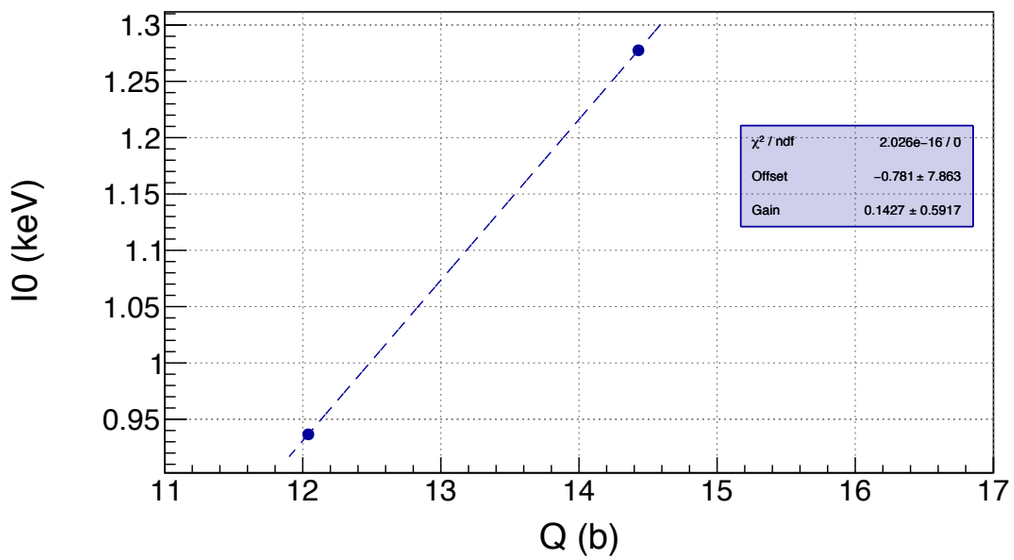
Transition 2



Transition 3



Transition 4

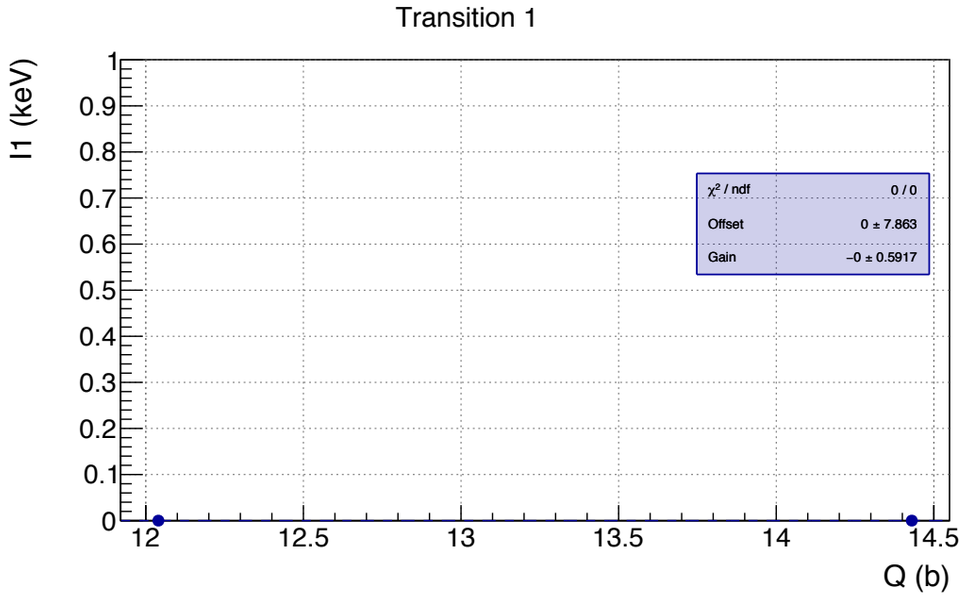


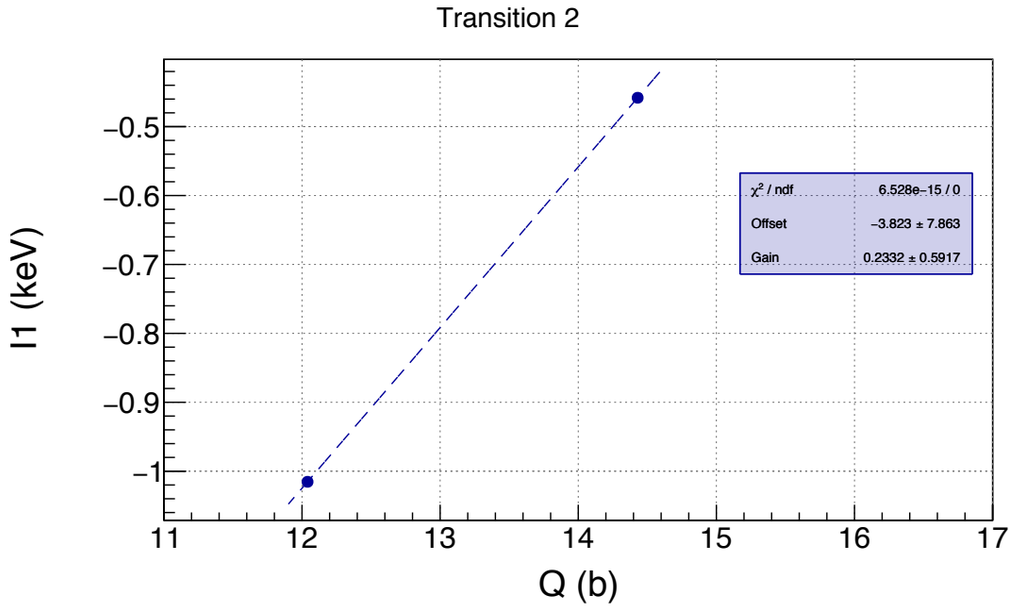
I1 VS Q

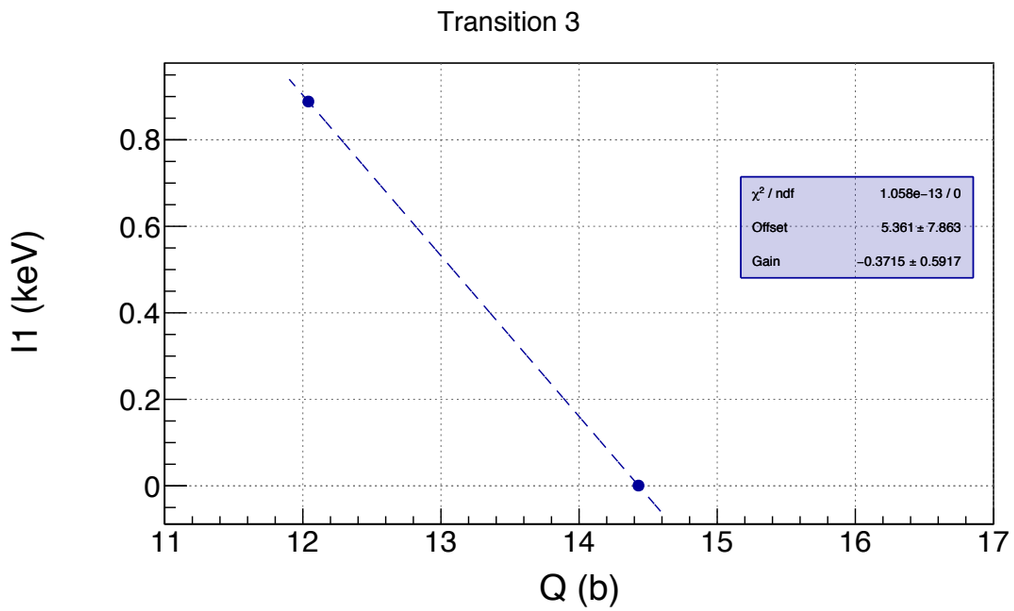
From the fits of the slides 16-19 (for example), we obtained two 2nd degree polynomial functions for each transition, each representing a different Q. Each of these two polynomials is described by a different set of three parameters for each Q value, i.e. $(\mathrm{E0}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{E1}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{E2}^{\mathrm{i}}_{\mathrm{dR}})$ or $(\mathrm{RI0}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{RI1}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{RI2}^{\mathrm{i}}_{\mathrm{dR}})$, so that:

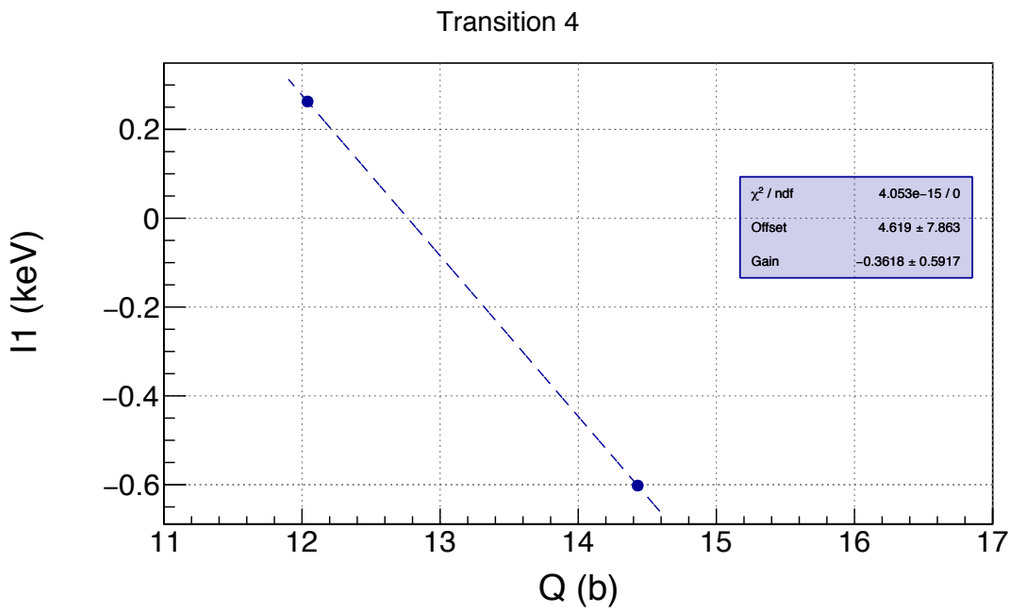
$$\mathrm{E}^{\mathrm{i}} = \mathrm{E0}^{\mathrm{i}}_{\mathrm{dR}} + \mathrm{E1}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR} + \mathrm{E2}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR}^2 \text{ or } \mathrm{RI}^{\mathrm{i}} = \mathrm{RI0}^{\mathrm{i}}_{\mathrm{dR}} + \mathrm{RI1}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR} + \mathrm{RI2}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR}^2$$

For each transition, I plot the three different energy or relative intensity coefficients vs Q separately. Since I only have two Q points, I assume a linear dependence on quadrupole moment and I fit a 1st degree polynomial in each plot.









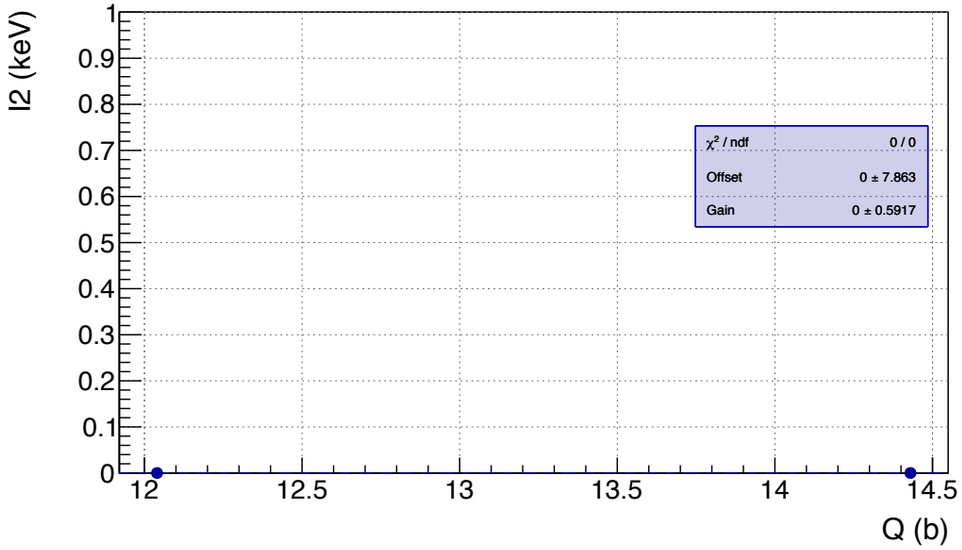
I2 VS Q

From the fits of the slides 16-19 (for example), we obtained two 2nd degree polynomial functions for each transition, each representing a different Q. Each of these two polynomials is described by a different set of three parameters for each Q value, i.e. $(\mathrm{E0}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{E1}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{E2}^{\mathrm{i}}_{\mathrm{dR}})$ or $(\mathrm{RI0}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{RI1}^{\mathrm{i}}_{\mathrm{dR}}, \mathrm{RI2}^{\mathrm{i}}_{\mathrm{dR}})$, so that:

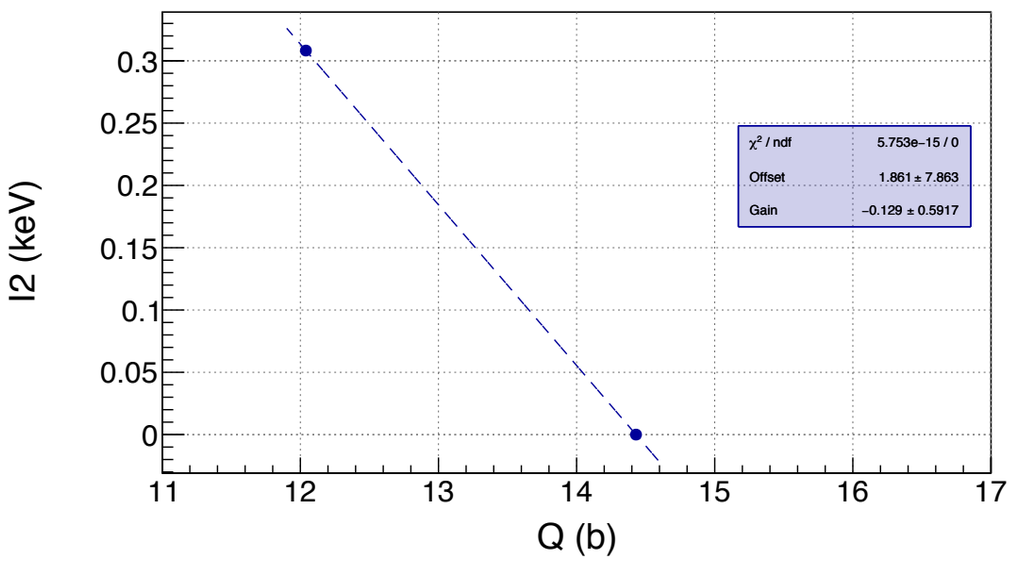
$$\mathrm{E}^{\mathrm{i}} = \mathrm{E0}^{\mathrm{i}}_{\mathrm{dR}} + \mathrm{E1}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR} + \mathrm{E2}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR}^2 \text{ or } \mathrm{RI}^{\mathrm{i}} = \mathrm{RI0}^{\mathrm{i}}_{\mathrm{dR}} + \mathrm{RI1}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR} + \mathrm{RI2}^{\mathrm{i}}_{\mathrm{dR}} \cdot \mathrm{dR}^2$$

For each transition, I plot the three different energy or relative intensity coefficients vs Q separately. Since I only have two Q points, I assume a linear dependence on quadrupole moment and I fit a 1st degree polynomial in each plot.

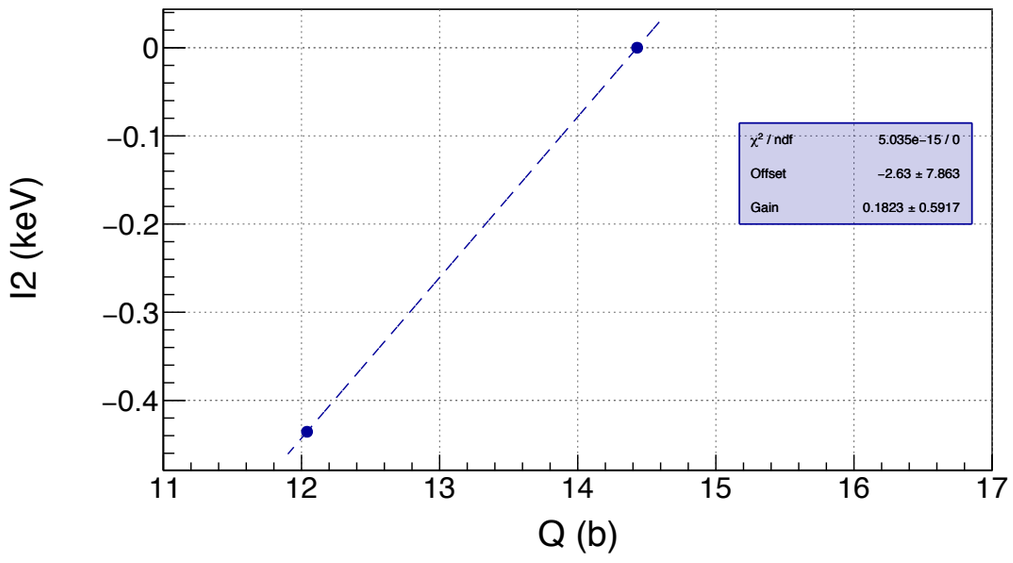
Transition 1



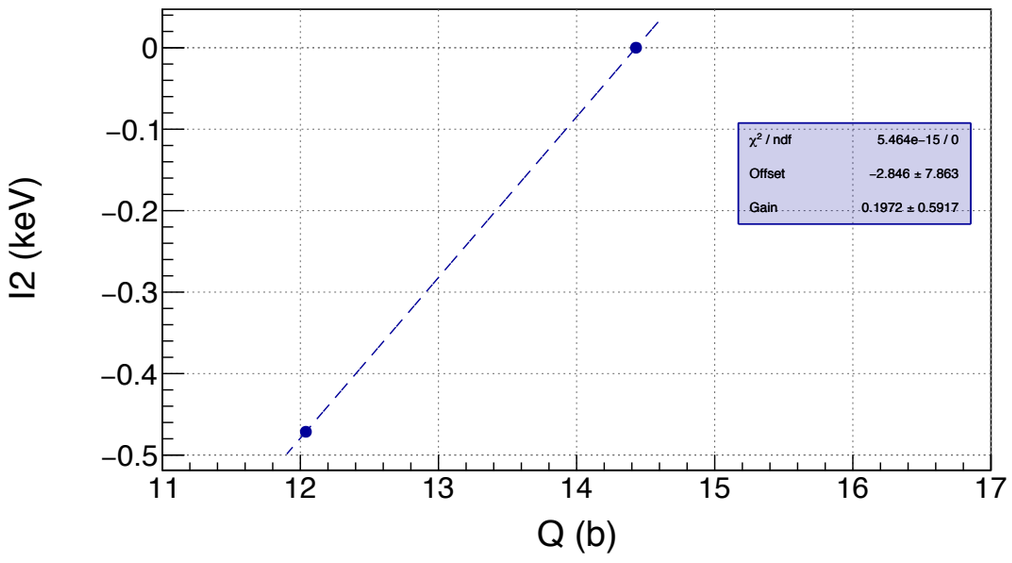
Transition 2



Transition 3



Transition 4



Confirm method - re-plot energy vs dR for different Q

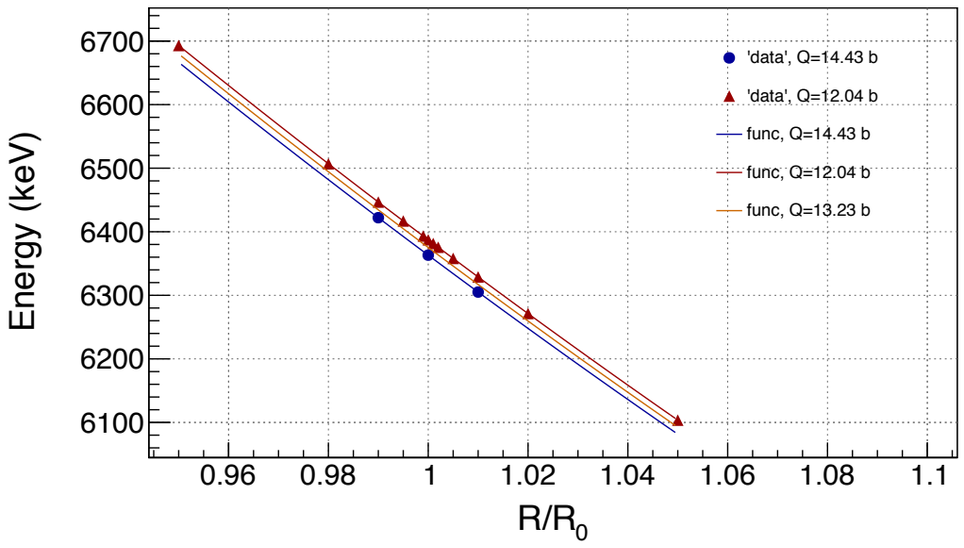
Now the energy/relative intensity of each transition depend both on dR and Q, described by the following polynomial:

$$E^i = E0^i_{dR} + E1^i_{dR} \cdot dR + E2^i_{dR} \cdot dR^2 = (E00^i_Q + E01^i_Q \cdot Q) + (E10^i_Q + E11^i_Q \cdot Q) \cdot dR + (E20^i_Q + E21^i_Q \cdot Q) \cdot dR^2$$

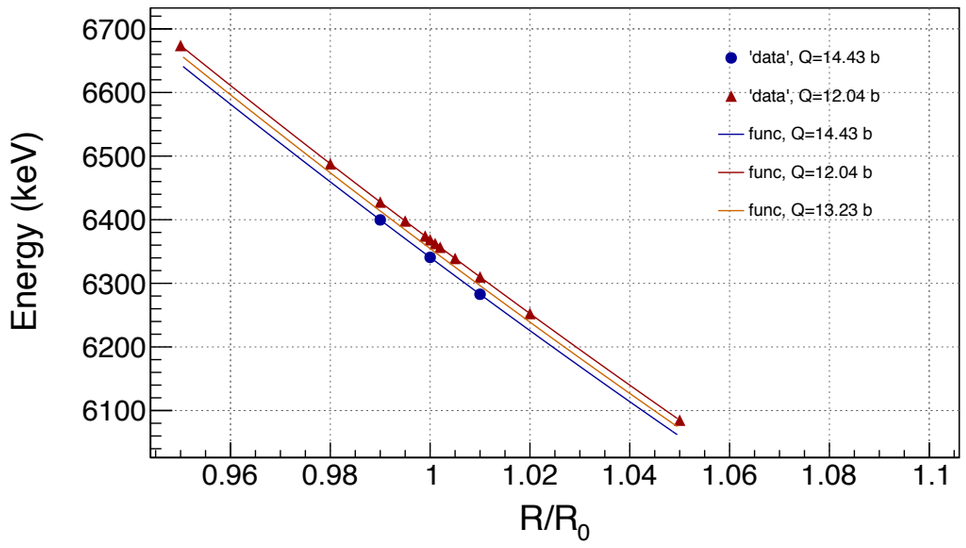
$$RI^i = RI0^i_{dR} + RI1^i_{dR} \cdot dR + RI2^i_{dR} \cdot dR^2 = (RI00^i_Q + RI01^i_Q \cdot Q) + (RI10^i_Q + RI11^i_Q \cdot Q) \cdot dR + (RI20^i_Q + RI21^i_Q \cdot Q) \cdot dR^2$$

Using the above functions, I plot again the energy/relative intensity vs dR curve for each transition together with the data points. The curve is plotted for three different Q values, namely 14.43 b (old Q), 12.04 (new-Q), and their mean. It indeed reproduces the values which means that the functions are correct (at least under the current assumptions).

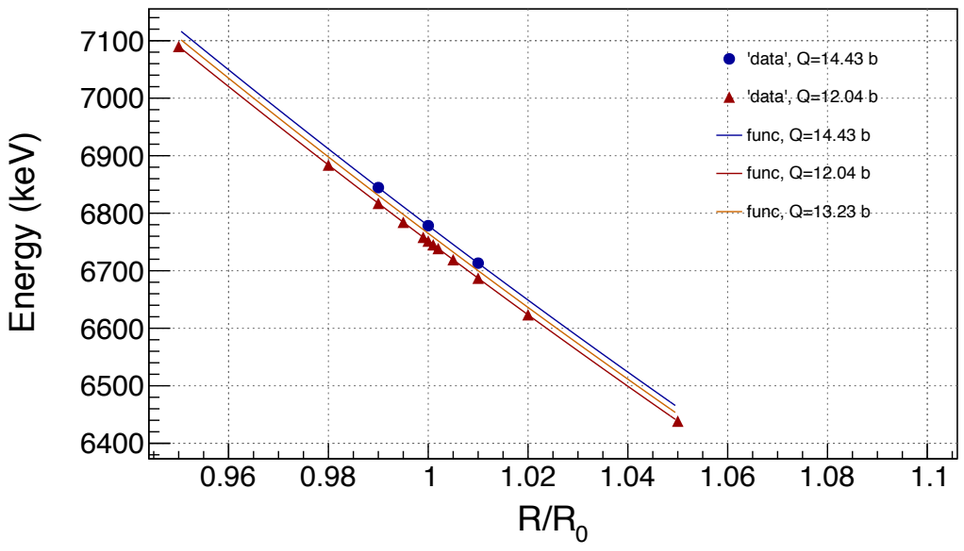
Transition 1



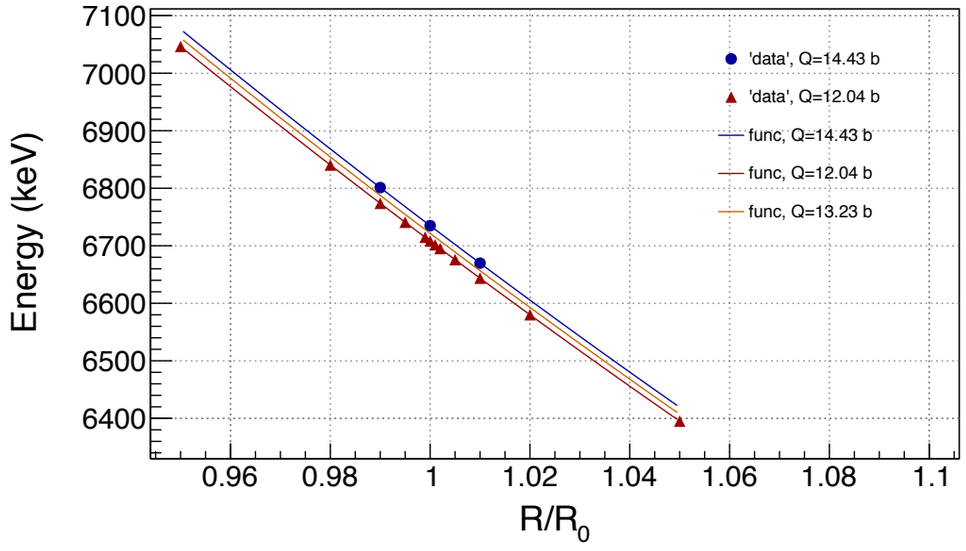
Transition 2



Transition 3



Transition 4



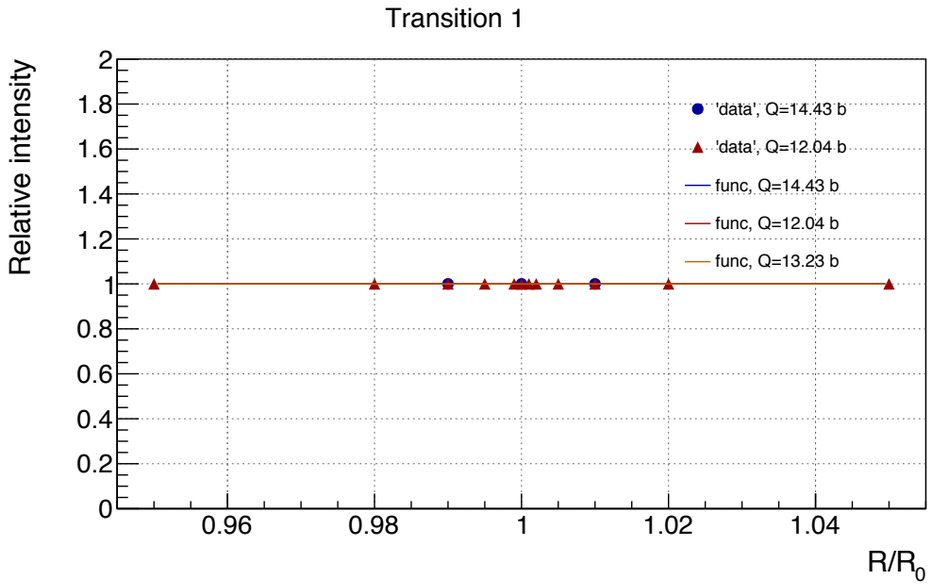
Confirm method - re-plot relative intensity vs dR for different Q

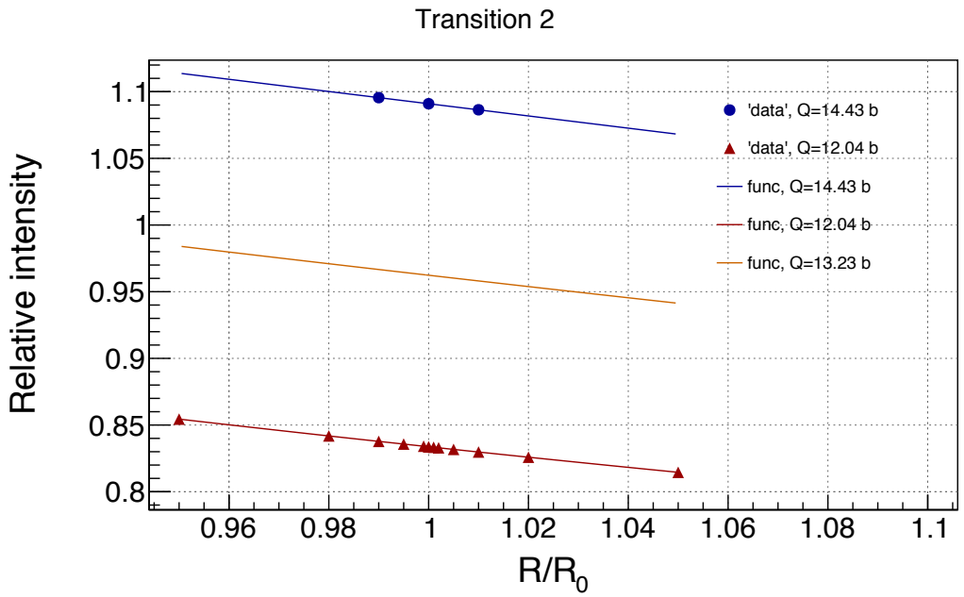
Now the energy/relative intensity of each transition depend both on dR and Q, described by the following polynomial:

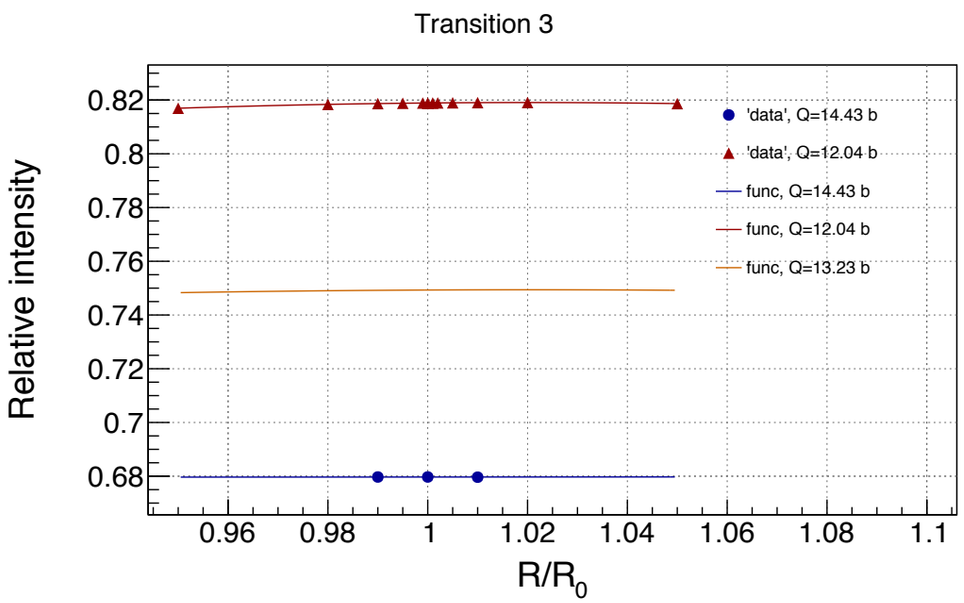
$$E^i = E0^i_{dR} + E1^i_{dR} \cdot dR + E2^i_{dR} \cdot dR^2 = (E00^i_Q + E01^i_Q \cdot Q) + (E10^i_Q + E11^i_Q \cdot Q) \cdot dR + (E20^i_Q + E21^i_Q \cdot Q) \cdot dR^2$$

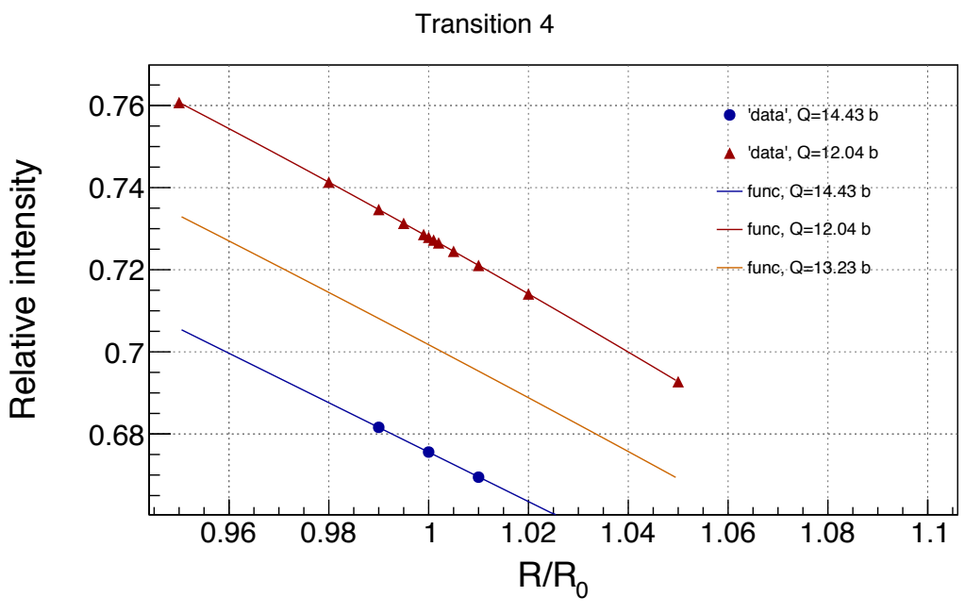
$$RI^i = RI0^i_{dR} + RI1^i_{dR} \cdot dR + RI2^i_{dR} \cdot dR^2 = (RI00^i_Q + RI01^i_Q \cdot Q) + (RI10^i_Q + RI11^i_Q \cdot Q) \cdot dR + (RI20^i_Q + RI21^i_Q \cdot Q) \cdot dR^2$$

Using the above functions, I plot again the energy/relative intensity vs dR curve for each transition together with the data points. The curve is plotted for three different Q values, namely 14.43 b (old Q), 12.04 (new-Q), and their mean. It indeed reproduces the values which means that the functions are correct (at least under the current assumptions).



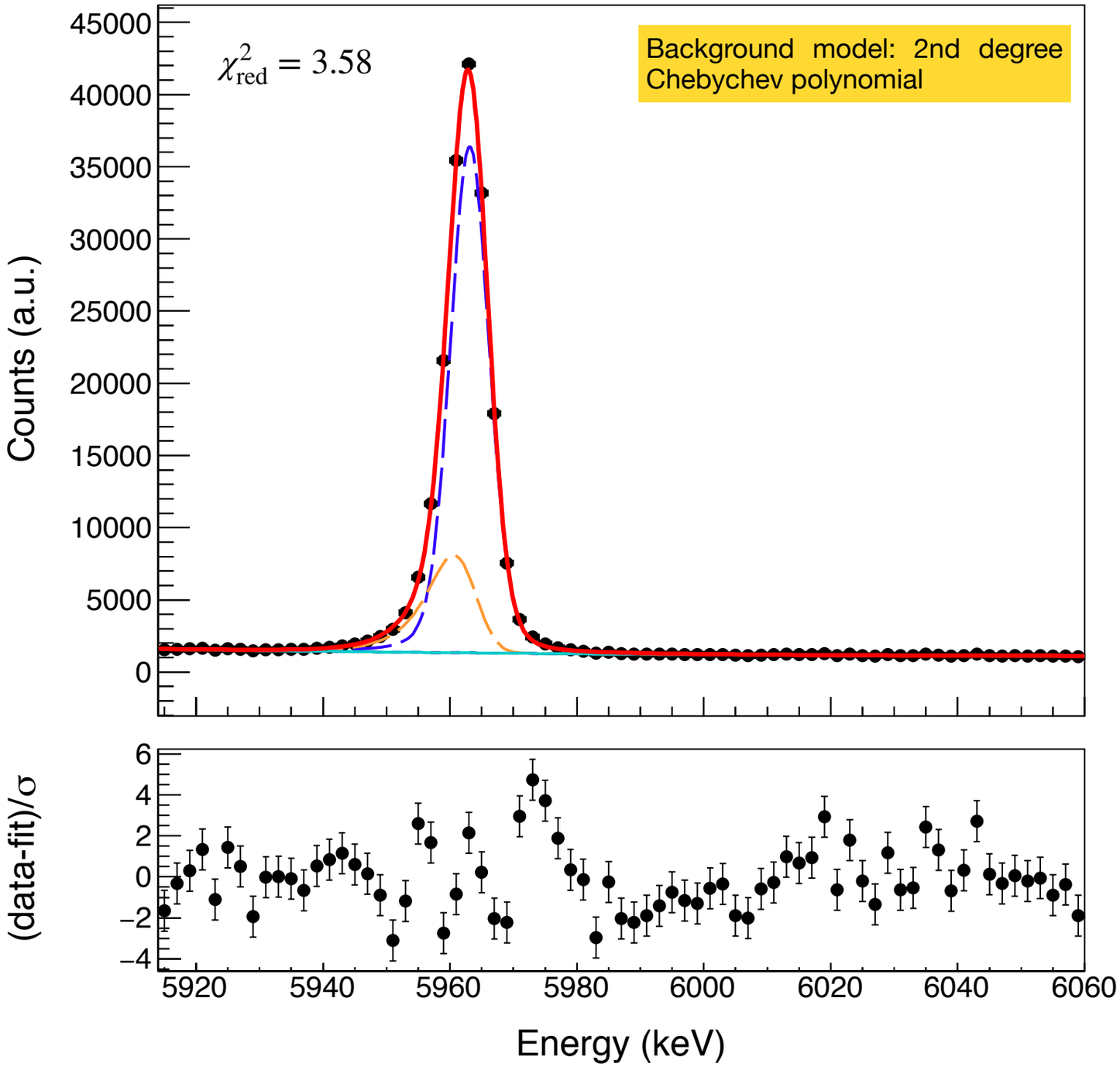


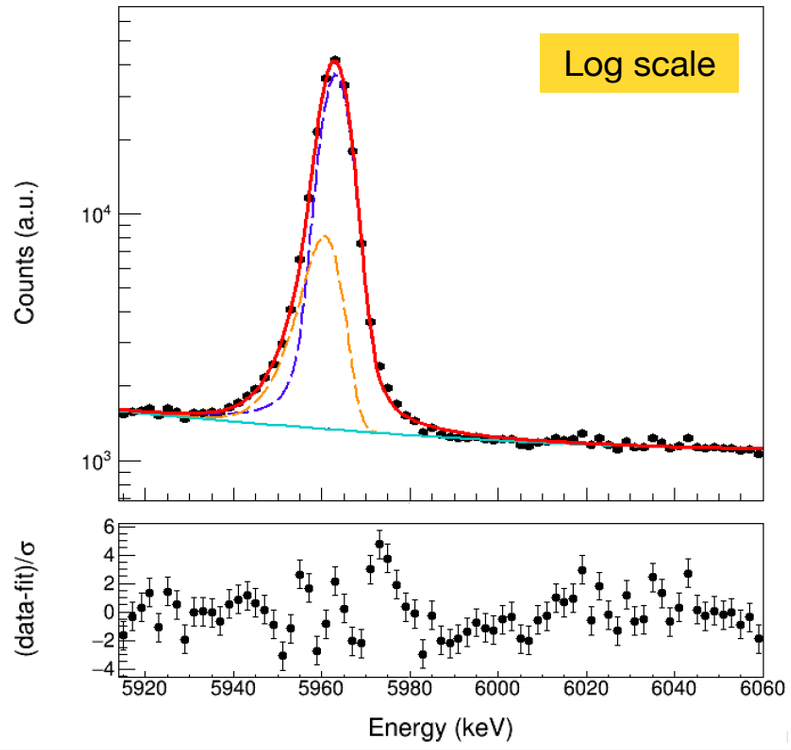




Line-shape — fitting 2p-1s in Pb-208

I fit the $2p_{3/4} \rightarrow 1s_{1/2}$ muonic Pb-208 line in the early spectrum (dt = -2000 to -500 ns) with a (Voigt + Tail + Step) function describing the signal.
The natural line-width was calculate in the past by Natalia (lw~1.23 keV).






```
RooFitResult: minimized FCN value: -2.039e+06, estimated distance to minimum: 7.085e-05
                covariance matrix quality: Full, accurate covariance matrix
                Status : MIGRAD=0 HESSE=0

  Constant Parameter    Value
------------------  ------------
                lw    1.2273e+00

  Floating Parameter  InitialValue    FinalValue +/-  Error      GblCorr.
------------------  ------------  --------------------------  --------
                 A    1.0000e-04    4.2473e-09 +/-  1.00e-06  <none>
                a1    0.0000e+00   -1.8111e-01 +/-  7.47e-03  <none>
                a2    0.0000e+00    4.1803e-02 +/-  6.28e-03  <none>
                 b    3.7000e+00    4.3906e+00 +/-  1.53e-01  <none>
                fG    9.3000e-01    8.0333e-01 +/-  1.11e-02  <none>
                 m    5.9630e+03    5.9631e+03 +/-  3.01e-02  <none>
                nB    1.3627e+05    9.3156e+04 +/-  4.43e+02  <none>
              nSig    1.3627e+05    1.7934e+05 +/-  5.32e+02  <none>
                 s    2.7100e+00    2.7877e+00 +/-  1.43e-02  <none>

A    = 0.00000 +/- 0.00000 keV^-1
b    = 4.391 +/- 0.153 keV
fG   = 0.803 +/- 0.011
m    = 5963.115 +/- 0.030 keV
nB   = 93156.1 +/- 443.2
nSig = 179337.7 +/- 531.6
s    = 2.78771 +/- 0.01428 keV
a1   = -0.1811 +/- 0.0075 keV

chi2_val        = 183.037
NBins           = 73
data_numEntries = 73
parNumber       = 9
reduced_chi2    = 3.58
------------------------

reduced_chi2_incomplete  = 3.14
reduced_chi2_recalculate = 3.58
```

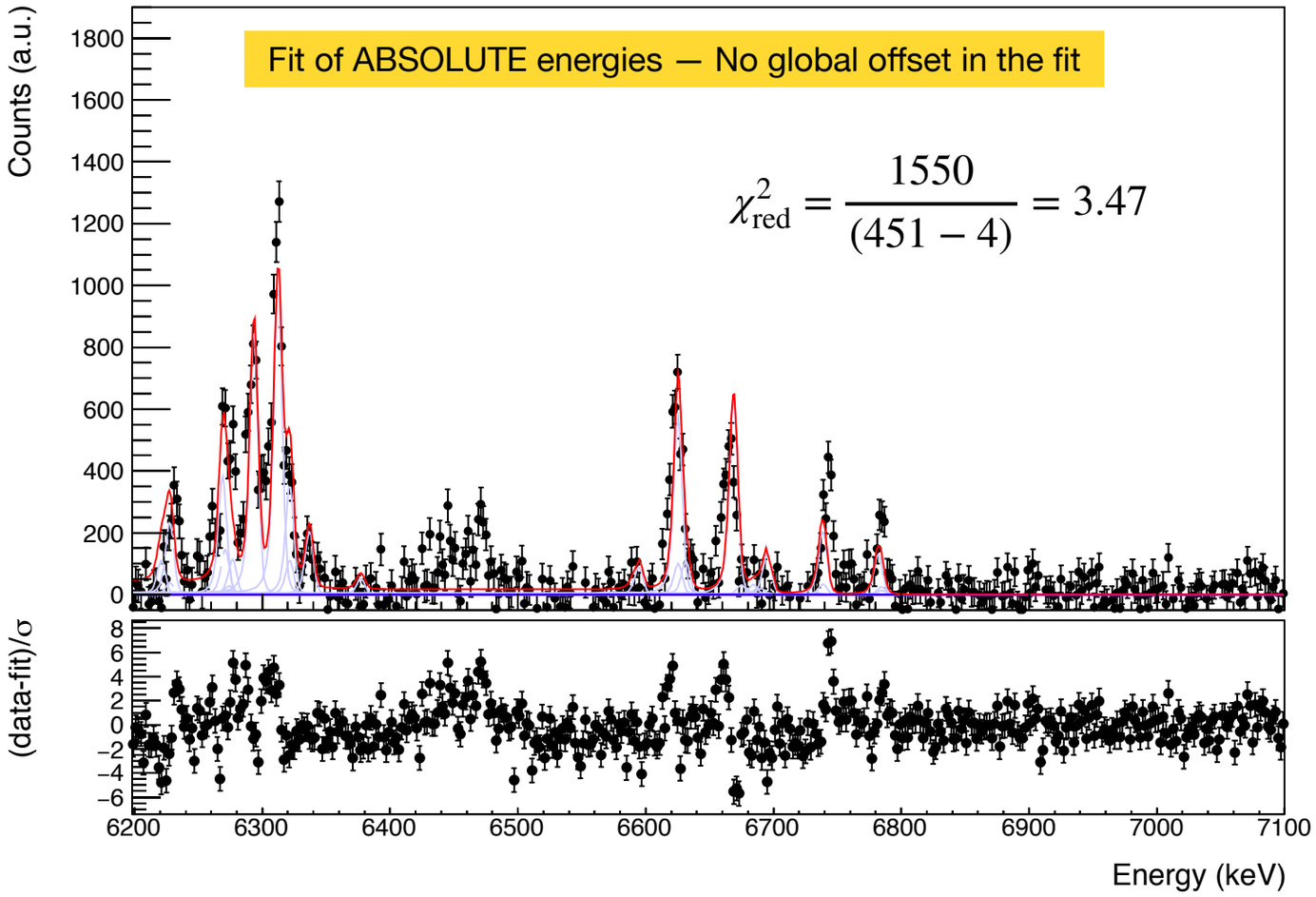
Fitting Cm-248 - Case 8

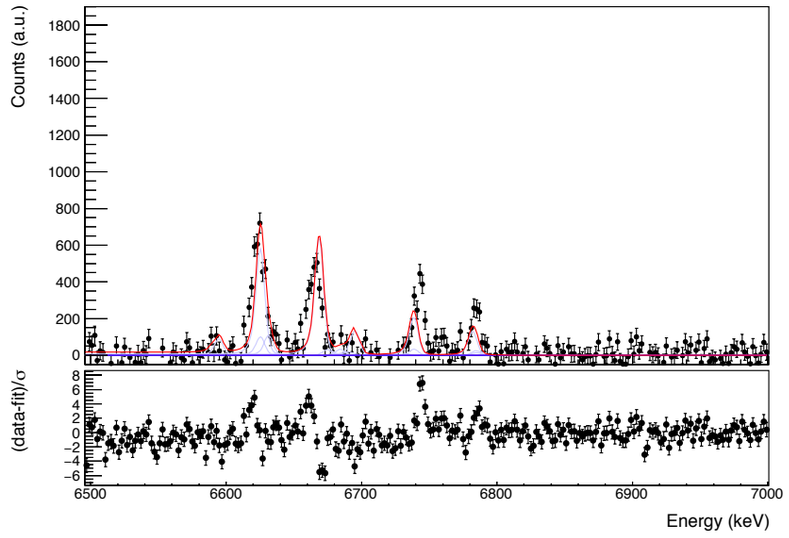
of transitions = 29

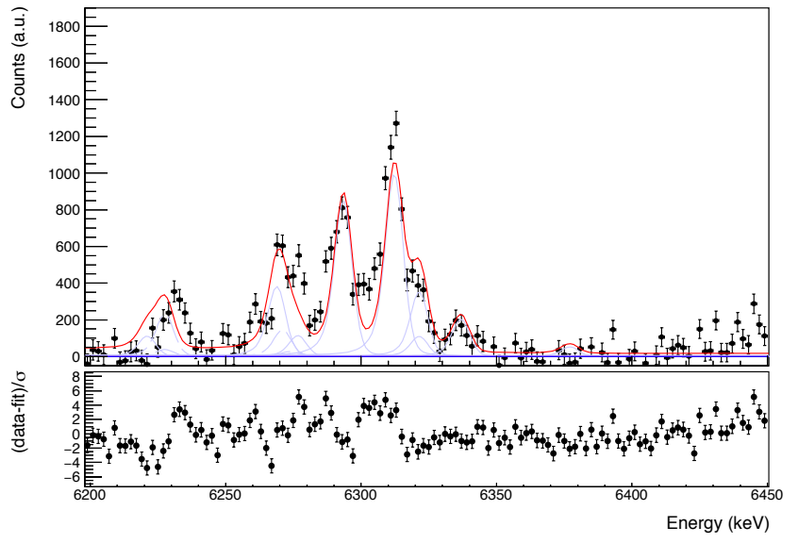
Definition of dR: $dR = \frac{R}{R_0}$

$$E^i = E0^i_{dR} + E1^i_{dR} \cdot dR + E2^i_{dR} \cdot dR^2 = (E00^i_Q + E01^i_Q \cdot Q) + (E10^i_Q + E11^i_Q \cdot Q) \cdot dR + (E20^i_Q + E21^i_Q \cdot Q) \cdot dR^2$$

$$RI^i = RI0^i_{dR} + RI1^i_{dR} \cdot dR + RI2^i_{dR} \cdot dR^2 = (RI00^i_Q + RI01^i_Q \cdot Q) + (RI10^i_Q + RI11^i_Q \cdot Q) \cdot dR + (RI20^i_Q + RI21^i_Q \cdot Q) \cdot dR^2$$







- Using above formulas
- Fixed Q = 12.04 b (new Q)
- Transitions included: all 29 FE + SE (tr 7, 9,18, 21, 23, 25, 28, 29)

Line-shape: (Voigt + Tail + Step)

- Pb-208 line-shape parameters
- A (step) free
- Natural line-width as calculated by Natalia (lw_2p32~1.628 keV, lw_2p12~1.482keV)

```
RooFitResult: minimized FCN value: -1.238e+05, estimated distance to minimum: 3.073e-05
              covariance matrix quality: Full, accurate covariance matrix
              Status : MIGRAD=0 HESSE=0
```

Floating Parameter	InitialValue	FinalValue +/- Error	GblCorr.
A	1.0000e-03	8.3339e-04 +/- 1.76e-05	<none>
Counts	2.0010e+04	5.0686e+03 +/- 2.83e+01	<none>
Nbkg	1.0000e+01	2.9800e+01 +/- 5.26e+00	<none>
dR	1.0130e+00	1.0128e+00 +/- 5.76e-06	<none>

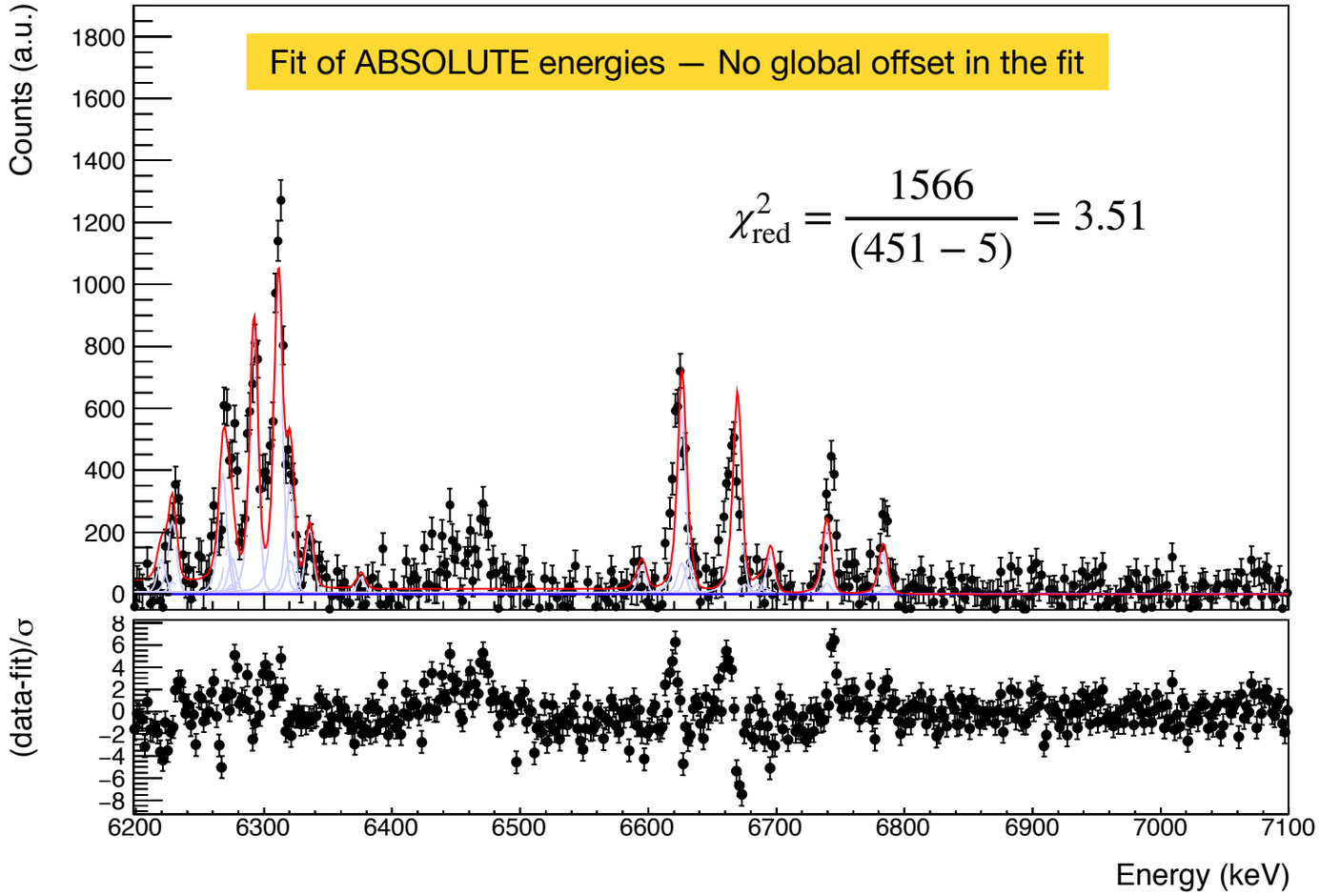
Fitting Cm-248 - Case 9

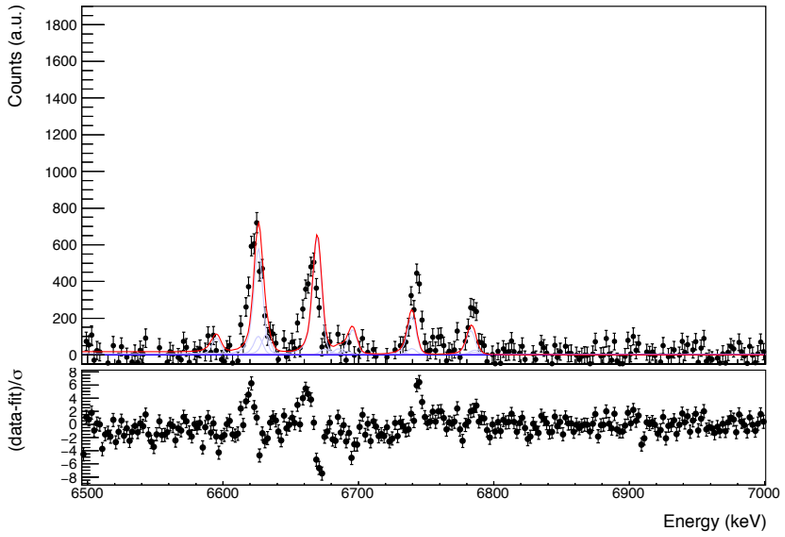
of transitions = 29

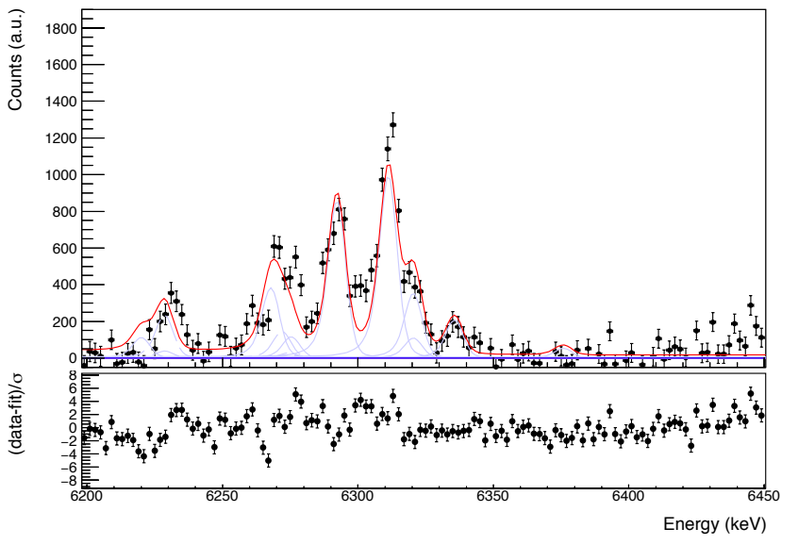
Definition of dR: $dR = \frac{R}{R_0}$

$$E^i = E0^i_{dR} + E1^i_{dR} \cdot dR + E2^i_{dR} \cdot dR^2 = (E00^i_Q + E01^i_Q \cdot Q) + (E10^i_Q + E11^i_Q \cdot Q) \cdot dR + (E20^i_Q + E21^i_Q \cdot Q) \cdot dR^2$$

$$RI^i = RI0^i_{dR} + RI1^i_{dR} \cdot dR + RI2^i_{dR} \cdot dR^2 = (RI00^i_Q + RI01^i_Q \cdot Q) + (RI10^i_Q + RI11^i_Q \cdot Q) \cdot dR + (RI20^i_Q + RI21^i_Q \cdot Q) \cdot dR^2$$







- Using above formulas
- Free Q within 11.5 and 14.5 b
- Transitions included: all 29 FE + SE (tr 7, 9,18, 21, 23, 25, 28, 29)

Line-shape: (Voigt + Tail + Step)

- Pb-208 line-shape parameters
- A (step) free
- Natural line-width as calculated by Natalia (lw_2p32~1.628 keV, lw_2p12~1.482keV)

```
RooFitResult: minimized FCN value: -1.242e+05, estimated distance to minimum: 4.454e-07
              covariance matrix quality: Full, accurate covariance matrix
              Status : MIGRAD=0 HESSE=0
```

Floating Parameter	InitialValue	FinalValue +/-	Error	GblCorr.
A	1.0000e-03	8.0153e-04 +/-	1.71e-05	<none>
Counts	2.0010e+04	5.0370e+03 +/-	2.81e+01	<none>
Nbkg	1.0000e+01	2.9739e+01 +/-	5.23e+00	<none>
Q	1.2120e+01	1.2130e+01 +/-	3.19e-03	<none>
dR	1.0130e+00	1.0128e+00 +/-	5.79e-06	<none>

Open questions

- Why does the intensity of some transitions change so much for different Q? Is this expected?

- Natalia: do we need mixed R and Q grid? or would it be enough to vary R for fix Q and then Q for fixed R? If yes, how many points in both R and Q you need, and which ones?