

# Efficiency calibration : Experimental approach

## AÇORES Software

$$N_{net}(E) = A \cdot I(E) \cdot \varepsilon_P(E) \cdot \prod_i C_i$$

- $N_{net}(E)$  Net count rate recorded at energy E (s<sup>-1</sup>),  
 $A$  Activity of the standard radionuclide (Bq),  
 $I(E)$  Emission intensity of photons with energy E,  
 $\varepsilon_P(E)$  Full Energy Peak (FEP) efficiency for energy E,  
 $\prod C_i$  Product of corrective factors depending on the measurement conditions :  
decay,  
coincidences,  
absorption and self-absorption,  
pile-up,  
geometry.

Thus :

$$\varepsilon_P(E) = \frac{N_{net}(E)}{A \cdot I(E) \cdot \prod_i C_i}$$

# Fitting functions

Using different radionuclides -> series of discrete values of efficiency  
(only valid for the calibration conditions)

Question : knowledge of  $\varepsilon_p$  for any E ?  $\varepsilon_p(E) = f(E)$

- APOLOG 
$$\ln(\varepsilon) = \sum_{k=1}^P a_k \cdot (\ln(E))^{k-1}$$
- APOCOPE 
$$\ln(\varepsilon) = \sum_{k=1}^P a_k \cdot \left(\frac{1}{E}\right)^{k-1} = \sum_{k=1}^P a_k \cdot (E)^{1-k}$$

Fitting using least squares method taking into account correlations between input data : for one radionuclide we may use several energies – common uncertainties (activity ..)

# ACORES

Previously : « EFFIGIE » (J. Morel *et al.*) (APOLOG)

Now : « AÇORES » (Ajustement des COurbes de REndement pour la Spectrométrie) with visual interface and correlation between input data taken into account

AÇORES was developed using MATLAB (version 7.3), under Windows® environment.

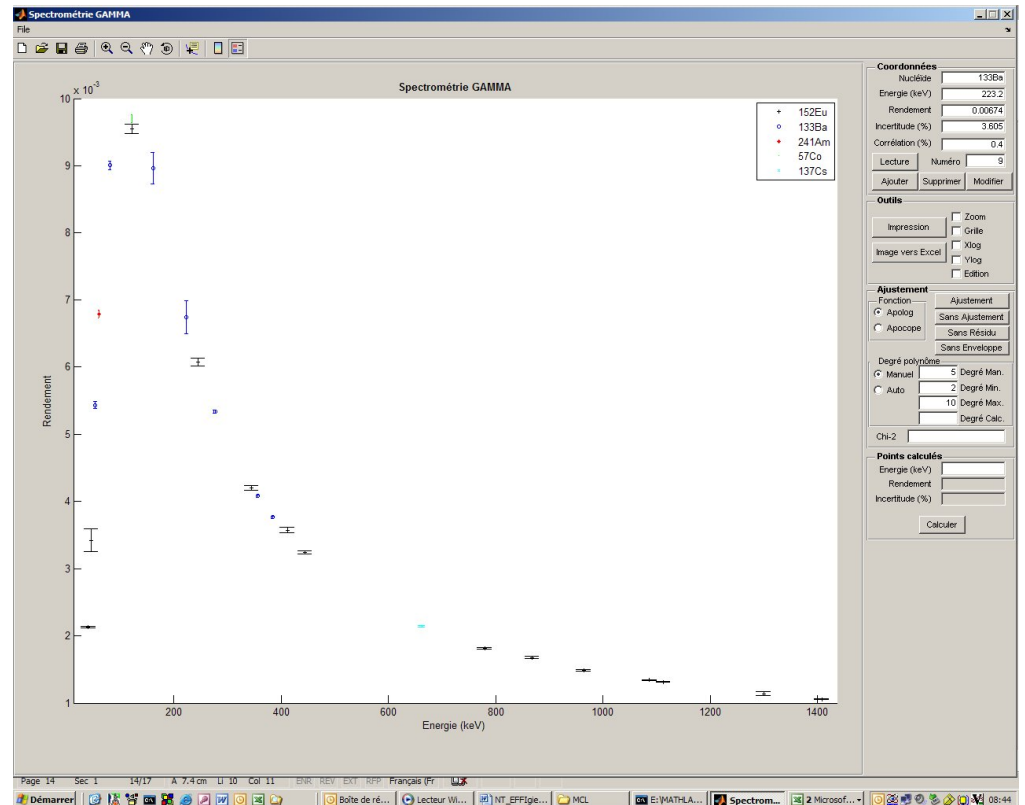
MATLAB uses matrix calculation to easily develop the fitting procedure

The visual facilities allows control of the fitting results

# Input data

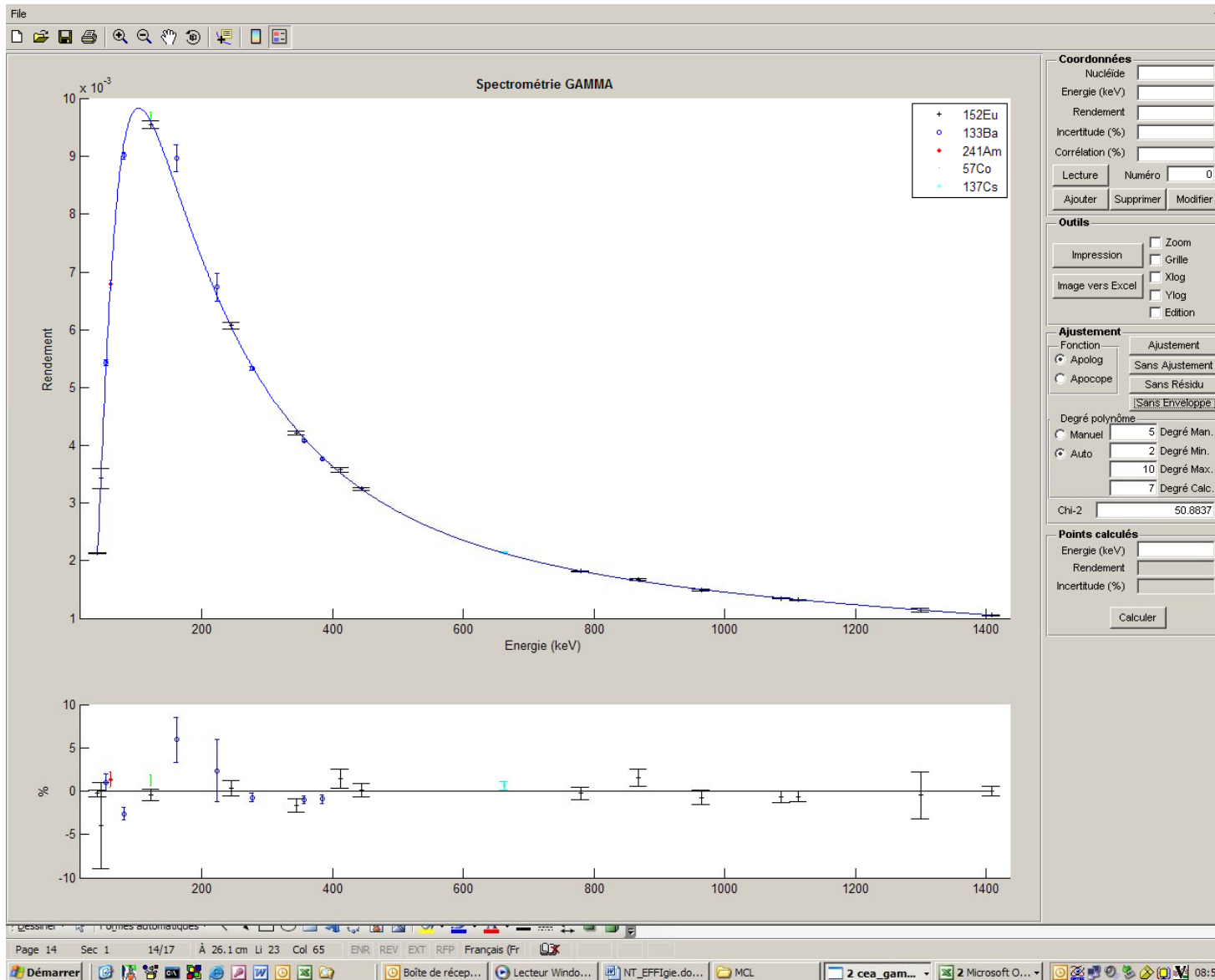
- « Excel » file : energy, efficiency, relative uncertainty (%), correlation

Radionuclide	Energy	Efficiency	Uncertainty (%)	Correlation
152Eu	39.9	2.13E-03	0.423	0.3
152Eu	45.7	3.42E-03	4.971	0.3
133Ba	53.2	5.43E-03	0.994	0.4
241Am	59.6	6.79E-03	0.898	0
133Ba	81	9.01E-03	0.700	0.4
152Eu	121.8	9.55E-03	0.701	0.3
57Co	122.1	9.70E-03	0.598	0
133Ba	160.6	8.96E-03	2.600	0.4
133Ba	223.2	6.74E-03	3.605	0.4
152Eu	244.7	6.07E-03	0.906	0.3
133Ba	276.4	5.34E-03	0.506	0.4
152Eu	344.3	4.20E-03	0.809	0.3
133Ba	356	4.08E-03	0.490	0.4
133Ba	383.8	3.76E-03	0.505	0.4
152Eu	411.4	3.57E-03	1.092	0.3
152Eu	444	3.24E-03	0.802	0.3
137Cs	661.7	2.14E-03	0.514	0
152Eu	778.9	1.82E-03	0.716	0.3
152Eu	867.4	1.67E-03	1.016	0.3
152Eu	964	1.49E-03	0.805	0.3
152Eu	1086.6	1.34E-03	0.671	0.3
152Eu	1112.1	1.32E-03	0.608	0.3
152Eu	1299.1	1.14E-03	2.719	0.3
152Eu	1408	1.06E-03	0.569	0.3



Experimental relative  
uncertainties : 0,42 % to 2,6 %

# VISUALISATION OF RESULTS



# RESULTING FILE

Radionuclide	Energy	Efficiency	Uncertainty	Corr elation	Fitted Efficiency	Fitted Uncertainty	Residual
152Eu	39.9	0.00213	0.423	0.3	0.002136	0.57	0.26
152Eu	45.7	0.00342	4.971	0.3	0.003563	0.68	4.01
133Ba	53.2	0.005433	0.994	0.4	0.005380	0.77	0.98
241Am	59.6	0.00679	0.898	0	0.006704	0.73	1.29
133Ba	81	0.009006	0.7	0.4	0.009249	0.59	2.62
152Eu	121.8	0.009551	0.701	0.3	0.009593	0.58	0.44
57Co	122.1	0.009704	0.598	0	0.009587	0.58	1.23
133Ba	160.6	0.00896	2.6	0.4	0.008457	0.58	5.95
133Ba	223.2	0.00674	3.605	0.4	0.006584	0.58	2.37
152Eu	244.7	0.006073	0.906	0.3	0.006052	0.57	0.35
133Ba	276.4	0.005335	0.506	0.4	0.005374	0.55	0.73
152Eu	344.3	0.004201	0.809	0.3	0.004272	0.53	1.67
133Ba	356	0.00408	0.49	0.4	0.004121	0.52	1.00
133Ba	383.8	0.003763	0.505	0.4	0.003798	0.52	0.92
152Eu	411.4	0.003571	1.092	0.3	0.003520	0.52	1.44
152Eu	444	0.003243	0.802	0.3	0.003239	0.52	0.13
137Cs	661.7	0.002142	0.514	0	0.002129	0.55	0.62
152Eu	778.9	0.001815	0.716	0.3	0.001819	0.54	0.24
152Eu	867.4	0.001674	1.016	0.3	0.001649	0.55	1.54
152Eu	964	0.00149	0.805	0.3	0.001501	0.57	0.72
152Eu	1086.6	0.001342	0.671	0.3	0.001351	0.59	0.64
152Eu	1112.1	0.001315	0.608	0.3	0.001323	0.59	0.614
152Eu	1299.1	0.00114	2.719	0.3	0.001145	0.60	0.46
152Eu	1408	0.001055	0.569	0.3	0.001055	0.68	0.03

# Influence of threshold and correlations

Energy (keV)	Efficiency / 10 <sup>-3</sup>	Efficiency / 10 <sup>-3</sup> (with threshold)	Efficiency / 10 <sup>-3</sup> (with correlation)	Efficiency / 10 <sup>-3</sup> (with correlation and threshold)
100	9.827 (0.41%)	9.823 (0.59%)	9.822 (0.39%)	9.822 (0.56%)
200	7.190 (0.40%)	7.186 (0.58%)	7.227 (0.40%)	7.227 (0.58%)
500	2.842 (0.34%)	2.839 (0.54%)	2.847 (0.33%)	2.847 (0.54%)
1000	1.451 (0.35%)	1.449 (0.55%)	1.453 (0.39%)	1.453 (0.57%)
1400	1.059 (0.54%)	1.057 (0.68%)	1.061 (0.52%)	1.061 (0.67%)