Calculation of results for Ra-226 in water by alpha spectrometry

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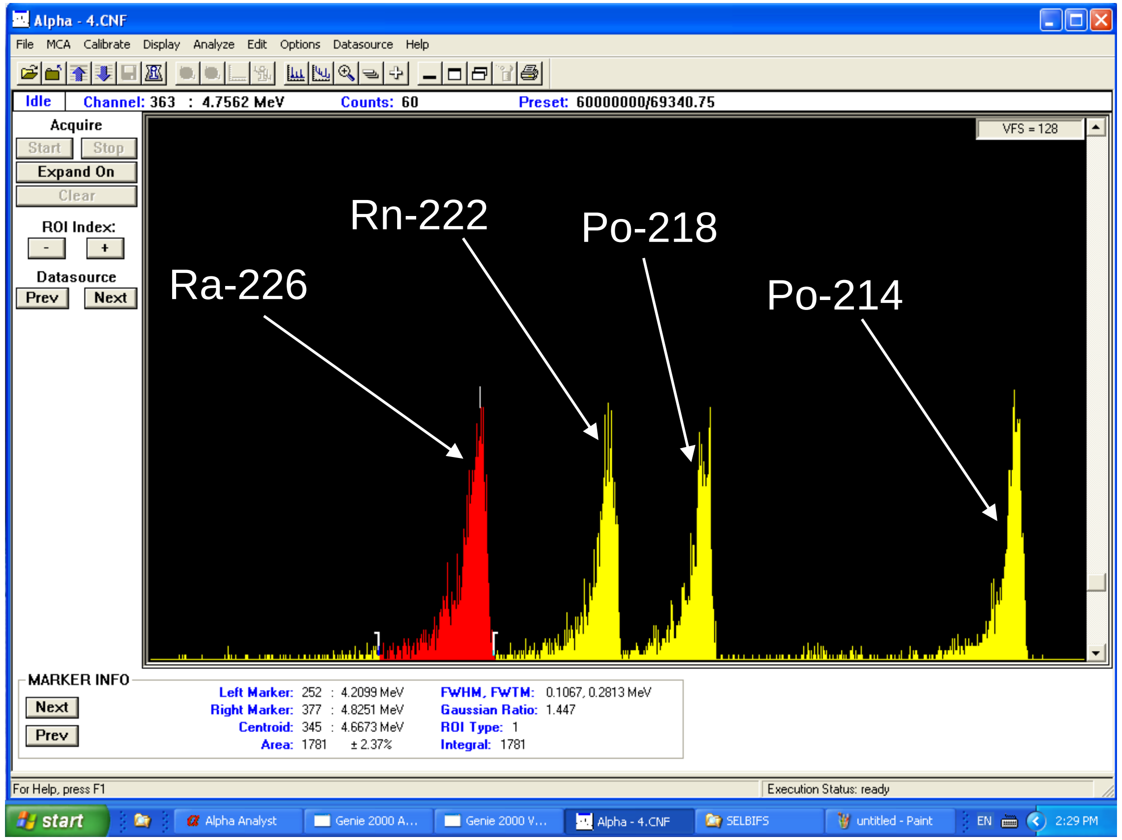
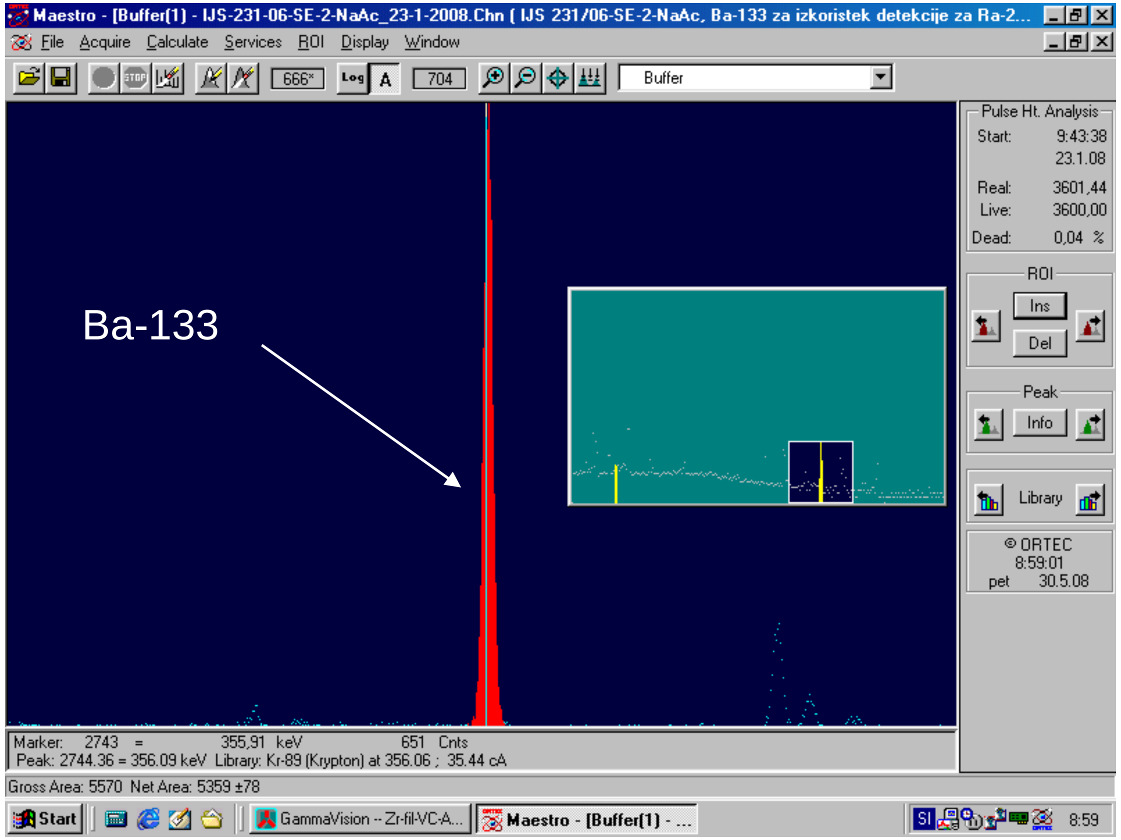
Ra-226 alpha spectrum and Ba-133 gamma spectrum





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Calculation of results

$$A_{\mathrm{Ra-226}} = \frac{\left(R_{\mathrm{Ra-226}} - R_{\mathrm{b,U-226}}\right)}{\eta_{\mathrm{Ra-226}}\ \varepsilon_{\mathrm{Ra-226}}\ V_{\mathrm{s}}} \qquad (1)$$

$$R_X = \frac{N_{\mathrm{X}}}{t_{\mathrm{m}}} \qquad (2)$$

$$\eta_{\mathrm{Ra-226}} = \frac{N_{\mathrm{s,Ba-133}} - N_{\mathrm{b,Ba-133}}}{N_{\mathrm{st,Ba-133}} - N_{\mathrm{b,Ba-133}}}\ , \qquad A_{\mathrm{st,Ba-133}} = A_{\mathrm{s,Ba-133}} \text{ and } t_{\mathrm{st}} = t_{\mathrm{s}} \qquad (3)$$

$A_{\mathrm{Ra-226}}$ → activity concentration of Ra − 226 [Bq/L]

$R_{\mathrm{Ra-226}}$ → Ra − 226 count rate [1/s]

$R_{\mathrm{b,Ra-226}}$ → Ra − 226 background count rate [1/s]

$\eta_{\mathrm{Ra-226}}$ → Ra − 226 chemical recovery

$\varepsilon_{\mathrm{Ra-226}}$ → Ra − 226 detection efficiency

$R_{\mathrm{b,U-232}}$ → U − 232 background count rate [1/s]

V_{s} → sample volume [L]

R_{X} → count rate of radionuclide X or background [1/s]

N_{X} → number of counts of radionuclide X or background

t_{m} → measurement time [s]

$N_{\mathrm{s,Ba-133}}$ → number of Ba − 133 counts in sample

$N_{\mathrm{b,Ba-133}}$ → number of background Ba − 133 counts

$N_{\mathrm{st,Ba-133}}$ → number of Ba − 133 counts in standard

$A_{\mathrm{st,Ba-133}}$ → activity of added Ba − 133 tracer in standard [Bq]

t_{st} → measurement time for standard [s]

$A_{\mathrm{s,Ba-133}}$ → activity of added Ba − 133 tracer in sample [Bq]

t_{s} → measurement time for sample [s]

Calculation of measurement uncertainty

$$u_{\mathrm{c,Ra-226}} = A_{\mathrm{Ra-226}} \sqrt{\left(\frac{u_{R_{\mathrm{Ra-226}}-R_{\mathrm{b,Ra-226}}}}{R_{\mathrm{Ra-226}} - R_{\mathrm{b,Ra-226}}}\right)^2 + \left(\frac{u_{\eta_{\mathrm{Ra-226}}}}{\eta_{\mathrm{Ra-226}}}\right)^2 + \left(\frac{u_{\varepsilon_{\mathrm{Ra-226}}}}{\varepsilon_{\mathrm{Ra-226}}}\right)^2 + \left(\frac{u_{V_{\mathrm{s}}}}{V_{\mathrm{s}}}\right)^2} \quad (4)$$

$$u_{R_{\mathrm{Ra-226}}-R_{\mathrm{b,Ra-226}}} = \sqrt{\left(u_{R_{\mathrm{Ra-226}}}\right)^2 + \left(u_{R_{\mathrm{b,Ra-226}}}\right)^2} \quad (5)$$

$$u_{R_{\mathrm{X}}} = \frac{1}{\sqrt{N_{\mathrm{X}}}} \quad (6)$$

$$u_{\eta_{\mathrm{Ra-226}}} = \sqrt{\left(\frac{\sqrt{N_{\mathrm{s,Ba-133}} + N_{\mathrm{b,Ba-133}}}}{N_{\mathrm{s,Ba-133}} - N_{\mathrm{b,Ba-133}}}\right)^2 + \left(\frac{\sqrt{N_{\mathrm{s,Ba-133}} + N_{\mathrm{b,Ba-133}}}}{N_{\mathrm{st,Ba-133}} - N_{\mathrm{b,Ba-133}}}\right)^2} \quad (7)$$

$u_{\mathrm{c,Ra-226}} \rightarrow$ combined standard uncertainty for $\mathrm{U} - 226[\mathrm{Bq/L}]$

$u_{\mathrm{X}} \rightarrow$ standard uncertainty of X

Reporting of the results

$$U_{\text{Ra}-226} = k\, u_{\text{c,Ra}-226} \quad (8)$$

$U_{\text{Ra}-226} \rightarrow$ expanded uncertainty for Ra − 226 activity concentration [Bq/L]

$k \rightarrow$ coverage factor ($k = 2$ for 95% coverage)

$$A_{\text{Ra}-226} = A_{\text{Ra}-226} \pm U_{\text{Ra}-226}$$

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