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Exercises on PIGE for the Thursday session

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Exercise n. 1

Perform the energy calibration of a gamma-ray detector using the spectrum collected with a 60Co radioactive source (open spectrum Ecalib_60.asc in Spectra_A\ directory). Save the calibration.

Exercise n. 2

Determine the full peak absolute efficiency of the gamma-ray detector using the spectrum collected with a 152Eu radioactive source (open spectrum Efficiency_152Eu.asc in Spectra_A\ directory).

i) Looking at the “Gamma emission” table in the Eu-152_tables.pdf file select the more intense gamma-rays (i.e. intensity > 1 %) and calculate the peak areas for those lines. If necessary refine the energy calibration.
ii) Find the 152Eu life-time. Calculate the present source activity knowing that the initial activity was 370 kBq (uncertainty 5%), the time elapsed till the measurement is 10 years and the measurement lasted 4000 s.
iii) With a spreadsheet calculate and plot the detector full peak absolute efficiency as a function of gamma-ray energy. Calculate the uncertainty.
iv) Fit the measured efficiency with a polynomial function in the argument of 1/Egamma

Exercise 3

Perform the energy calibration of a gamma-ray detector using the PIGE spectrum collected by bombarding a thick Al target with proton (open spectrum Al.asc in Spectra_B\ directory). Save the calibration.

Exercise 4

Calculate the Na (actually Na2O) content in archeological glass by PIGE measurements with 3 MeV protons in an external beam set-up (this is an exercise on the application of PIGE thick target elemental analysis with comparison to standards).

i) Using certified thick standards of glass calculate the relationship between the Na2O percent by weight and the yield of the 441 keV gamma-ray line from the 23Na(p,p'g)23Na reaction (open spectra multicomp_glass_1412.asc, soda_lime_621.asc and trace_el_glass_610.asc in Spectra_B\ directory). Use the values reported under the “Norm. factor” column in the Guide to spectra.xls file to normalize the 441 keV peak areas and calculate the yields (and the uncertainties). As a zero-order approach, neglect the correction for the stopping powers. Plot the data and fit them with a line.

ii) Check the possible contribution from beam induced gamma-ray background to the 441 keV gamma-ray line and eventually calculate it (open spectrum background_beam.asc in Spectra_B\ directory).

iii) Calculate the yield (and the uncertainty) of the 441 keV gamma-ray line from the 23Na(p,p'g)23Na reaction from the PIGE spectra of the 11 unknown samples (open spectra red*.asc, green*.asc, blue*.asc, azure*.asc and yellow*.asc in Spectra_B\ directory).

iv) Calculate the Na2O percent by weight (and the uncertainty) in the unknown samples using the yields from step iii) and the measurement on the standards from step i).

Exercise 5

Implement the correction for the stopping power in the different matrices in the analysis of PIGE measurements of glass standards.

i) Using SRIM calculate the actual proton beam energy on the target knowing that the proton beam energy in vacuum is 3 MeV and the beam passes through a 7.5 micron Kapton extraction window and a path of 10 mm of He before striking the target.

ii) Determine the “E1/2” energy using the thick target yield of the 23Na(p,p'g)23Na reaction (Egamma = 441 keV) retrieved from IBANDL.

iii) Calculate the stopping powers (for example in keV/µg/cm^2) for protons of “E1/2” energy in the different matrices of the glass standards, using the composition shown in the Glass standards.xls file in Spectra_B\ directory and converting percent in weight of the oxides to atomic percent of the elements (if needed use the weighttoatomicconversion.xls calculator).

iv) Replot the relationship between the Na2O percent by weight of the glass standards and the yield of the 441 keV gamma-ray line from the 23Na(p,p'g)23Na reaction upon correction for the stopping power.

Exercise 6

Using the composition of the multicomponent glass standard (NIST SRM 1412) and the table of reactions with prompt emission of gamma-rays incuced by protons, identify the gamma-ray lines and the emitting isotopes in the PIGE spectrum of multicomponent glass standard (open spectrum multicomp_glass_1412.asc in Spectra_B\ directory).

Exercise 7

Identify the gamma-ray lines and the emitting isotopes in the spectrum of natural background radiation (open spectrum nat_background.asc in Spectra_A\ directory).