ERYA
Tutorial

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Welcome to ERYA

ERYA offers an intuitive way for quantitative analysis of light elements in thick samples by PIGE. ERYA avoids the use of standards in the analysis, using a formalism similar to the one used for PIXE analysis, where the excitation function of the nuclear reaction related to the gamma-ray emission is integrated along the depth of the sample.

To get started with ERYA, just open it, and add the inptuts. Before you know it, you have a complete PIGE analysis.
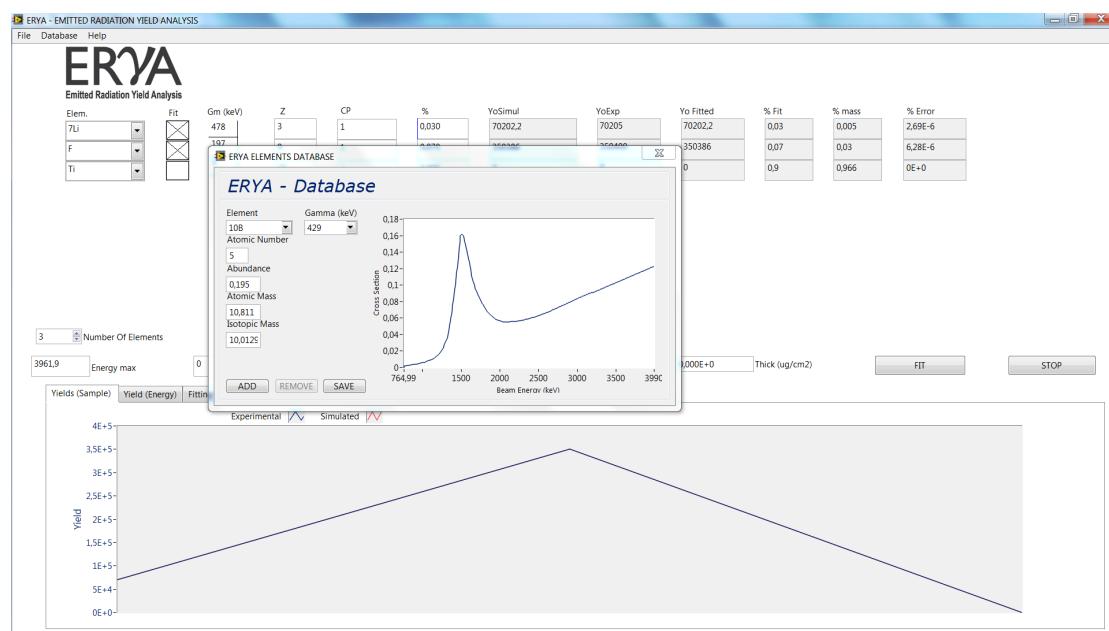
This tutorial provides instructions to help you accomplish specific tasks in ERYA. In addition to this manual other resources are available to help you.

Video tutorials will be available soon.
Facebook:
https://www.facebook.com/pages/ERYA/1376482575960068?skip_nax_wizard=true

The Nuclear Reactions Group is always improving the ERYA program.

Introduction

ERYA (Emitted Radiation Yield Analysis) is a Labview program dedicated to PIGE (Particle Induced Gamma-ray Emission). ERYA calculates the mass fraction of the elements present in a given sample, by integrating the relevant nuclear reaction cross sections along its depth.
The free version of ERYA can be found at the website. No Labview software is needed.

ERYA Calculation

The gamma yield Y emitted by an isotope i of an element e within a thick target bombarded by a proton beam of energy E_0 may be written as:

$$Y(E_0) = \varepsilon_{abs}(E_\gamma)N_p f_m f_i N_{av} A^{-1} \int_0^{E_0} \frac{\sigma(E)}{\varepsilon(E)} dE \qquad (1)$$

where $\varepsilon_{abs}(E\gamma)$ is the absolute efficiency of the detection system at the emitted energy $E\gamma$, Np is the number of incident protons, f_m and A^{-1} are the mass fraction (concentration) and the inverse of the atomic mass of the element e, f_i is the abundance of isotope i, N_{av} is the Avogadro's number, $\sigma(E)$ is the nuclear reaction cross section and $\varepsilon(E)$ is the stopping cross section of the sample in units of energy area per mass. The last two variables depend on the energy E of the incident proton. In order to perform the integration, the target is divided in n layers parallel to the sample surface. Stopping power calculations were made using semi-empirical equations of Ziegler et al. and the Bragg rule.

Remarks:
 ERYA uses 1 µC for beam fluence;
 ERYA will automatically normalize to 1 the atomic fraction.

ERYA package includes:
 Detector Efficiency;
 Ziegler parameters.

All these .txt files can be changed by the user.
Bug reports and suggestions are very welcome.
Email me at micaelafonseca (add @fct.unl.pt).
Credits:
This code was written in collaboration with Dr. Nuno Franco.

ERYA tools

This chapter introduces you to the windows and tools you use to work on ERYA.

ERYA fitted Outputs
% (stoichiometry)
% mass (mass fraction)
% Error (fit uncertainty)

Add calibration parameter

ERYA yield fitted

Choose the gamma-rays

ERYA yield simulation

Add elements

Choose which elements
you want to fit

The Z appears

Add first stoichiometry guess

Add experimental yields

Thin or thick target
For thin target Add thickness

Add number of elements

Charge

Choose FIT

Group or Ungroup elements

Minimum energy

Yield Charts

Maximum energy

Database

To open the "Elements Database" Chooser window:
Choose Database > "Elements".

View and edit the Elements Database or Ziegler Parameters Database
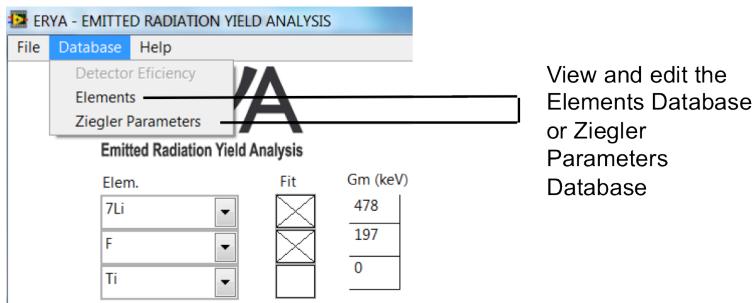
The Elements Database window appears
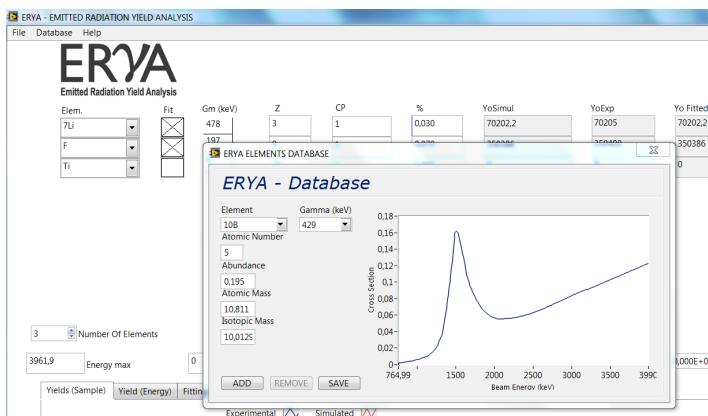
Make changes to the elements database as desired.

1. To add an element, write the new element, and choose EDIT.
   All the fields appear as zero. Make changes as desired, and after choose OK.
2. To modify the cross section choose the element and the gamma-ray. (see ^{25}Mg example). The cross section appears. Choose EDIT.
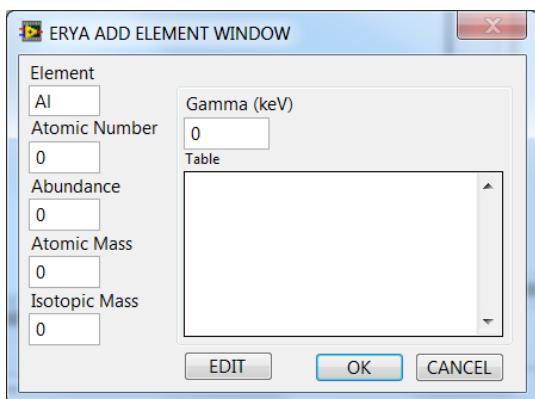
3. Change any energy or cross section value, or select all and paste the new cross section.
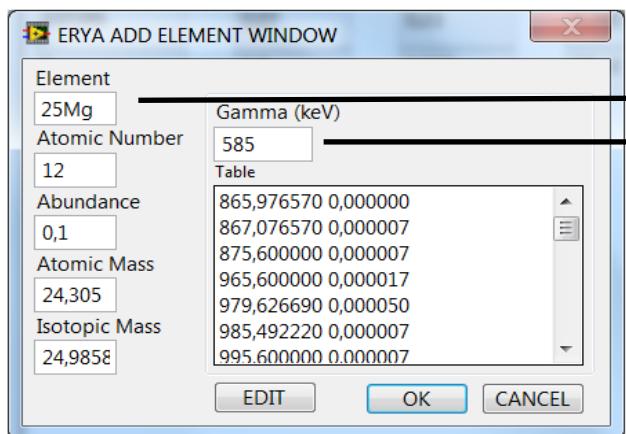
Choose the element
Choose the Gamma-ray
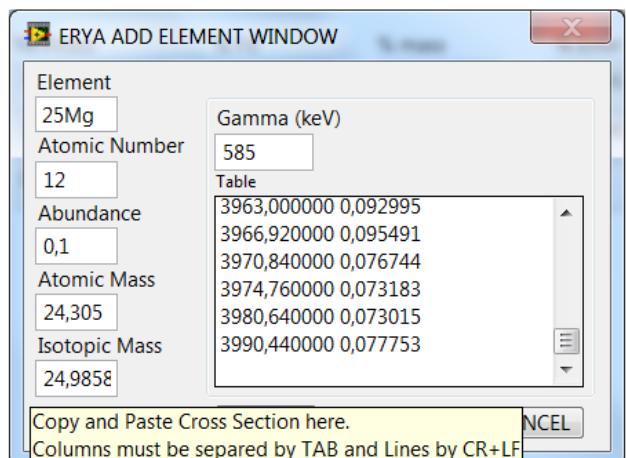
4. Choose ok and the new window will be updated.
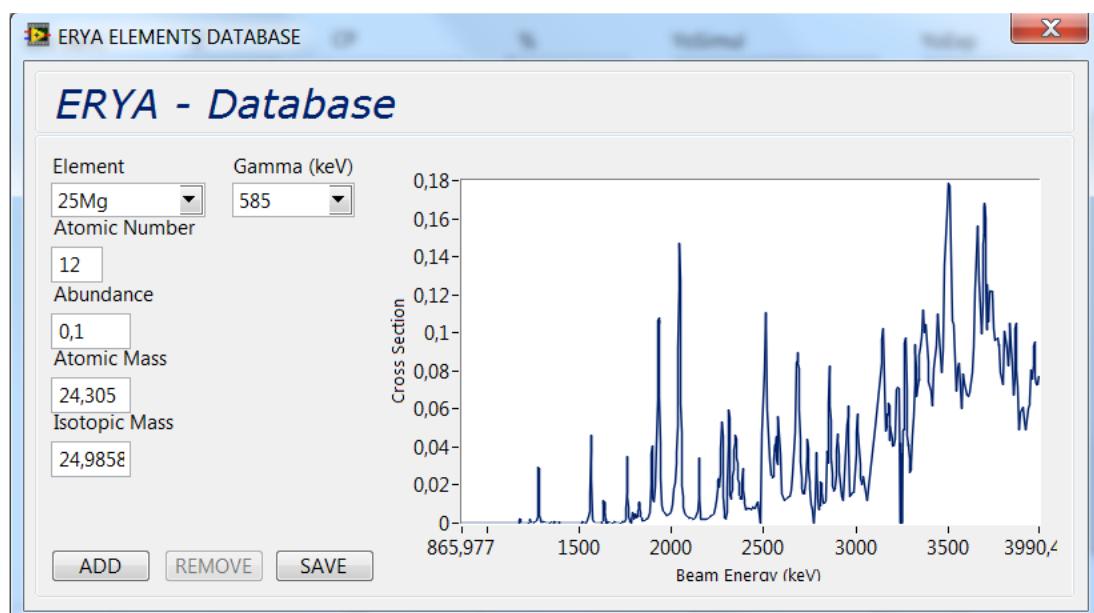
Setting up the analysis

1. Choose the number of elements present in your sample.
2. Choose Group elements or Ungroup elements.
3. For thin target, add thickness.
4. Add maximum energy.
5. Add minimum energy (just for thick target)
6. Add elements present in your sample, including trace elements.
7. Choose which gamma-rays for each element are present in your experiment.
8. Choose which elements do you want to perform the fitting.
9. Add Calibration Parameter.

### What are the calibration parameters?

ERYA, calculating the yield versus mass fraction through the equation (1) produces results which are directly affected by systematic uncertainties of cross section values, detector efficiency, absolute value of the collected charge and stopping powers.

In order to decrease these uncertainties, one may calibrate the analytical system, in a similar way done for PIXE, by using samples of known composition and establishing ratios between experimental and simulated yields. These ratios, which must be obtained for all the light elements of interest, are the calibration parameters which may be introduced as input in ERYA. Being dependent on the detector efficiency and charge collection system, these ratios are specific of each laboratory. However, once determined, they may be used for as long as the analytical conditions are kept the same.

Also, as it is done for PIXE, one should use a control sample in order to verify that the detector and charge collection systems remain unaltered.

10. Add stoichiometry. The stoichiometry is normalized to 1.
11. Add experiment yield, normalized to 1 uC.
12. Choose FIT.

Example:
Pressed pellet : Ag +LiF
Energy: 3961.9 keV
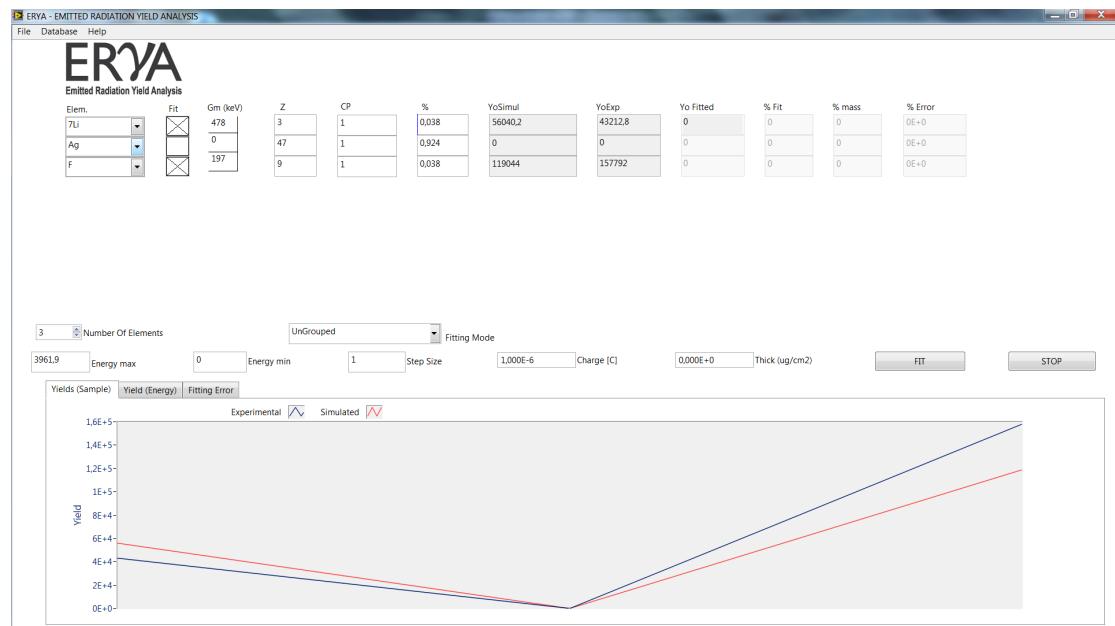
Choose FIT
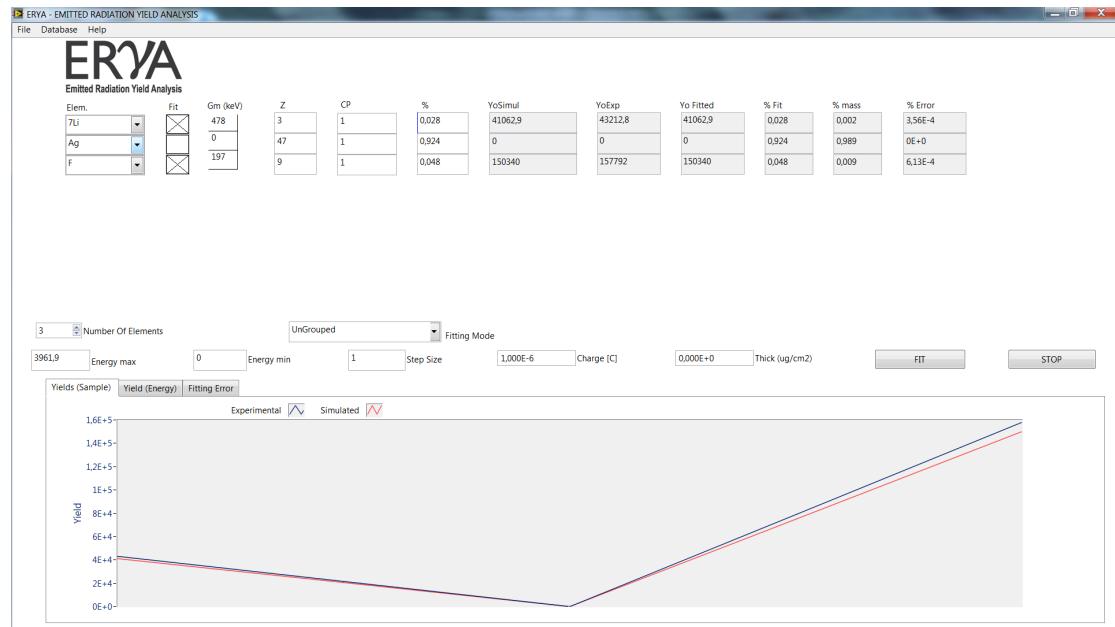
Related Bibliography

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- PhD thesis: "Análise de elementos leves por reacções nucleares com produção de radiação gama", Maria Micaela Leal da Fonseca, Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (2010).
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- J. F. Ziegler, J. P. Biersack, U. Littmark, in "The Stopping and Ranges of ions in Solids", Vol. 1, Pergamon Press, New York, 1985.
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