



Department of Physics
School of Applied Mathematical
and Physical Sciences
NTU of Athens

Tandem Accelerator Laboratory
Institute of Nuclear and
Particle Physics
NCSR - "Demokritos"



Development of a simulation code for material analysis using the PIGE technique

K. Preketes-Sigalas, A. Lagoyannis, M. Axiotis

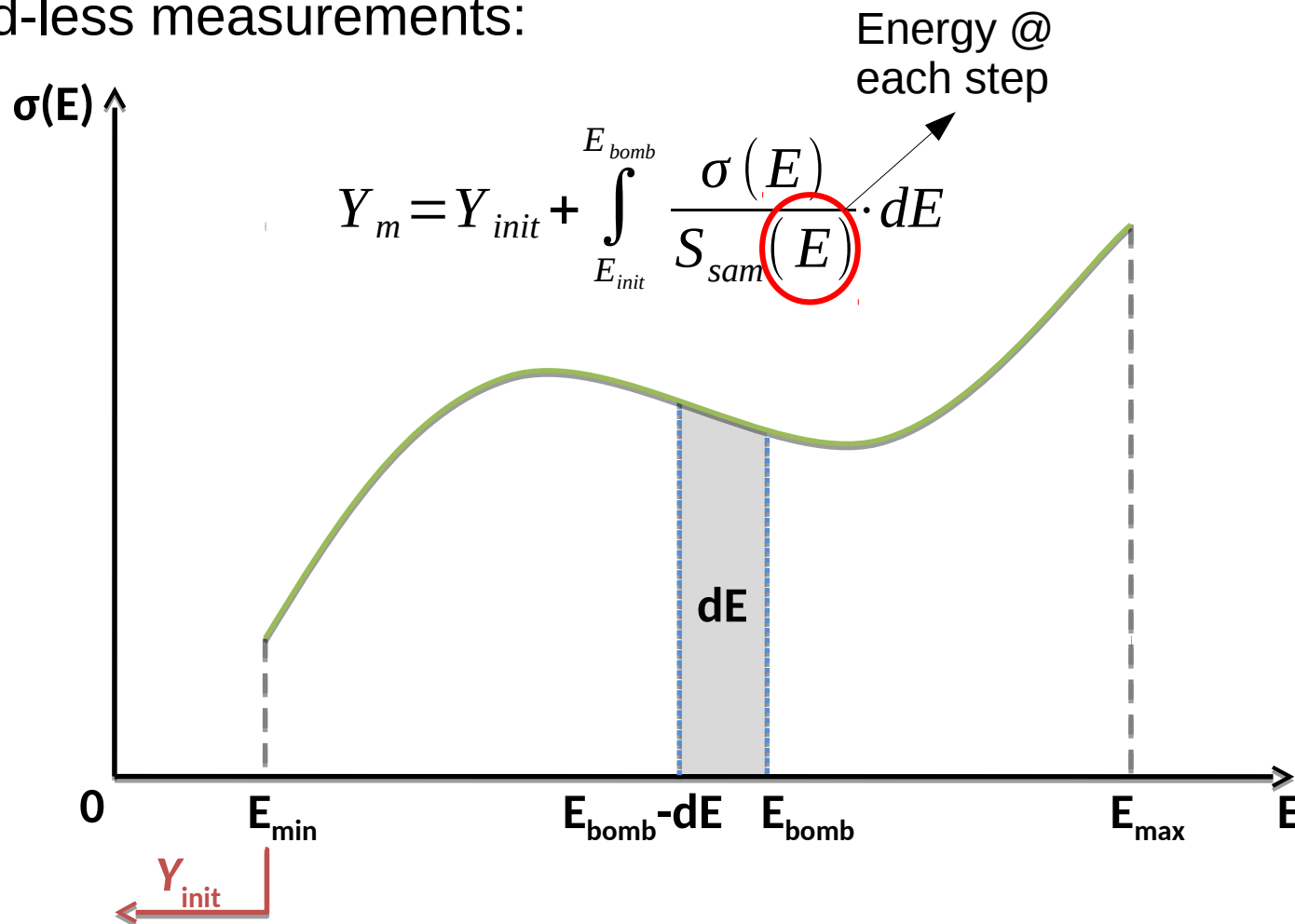
PIGE

- **Particle Induced Gamma-ray Emission**
 - Light element analysis (e.g., Li, B, F, Mg etc.)
 - Resonant-PIGE: depth profiling
- Drawback: Use of standards
 - Stopping power → Similar-matrix standards
 - **Need of several standards in each lab**
- Solution: Standard-less measurements
 - Well-measured cross sections
 - **Missing: Code**
 - ERYA code → Windows (64-bit), LabVIEW
 - not compatible with R33 files
 - not working well

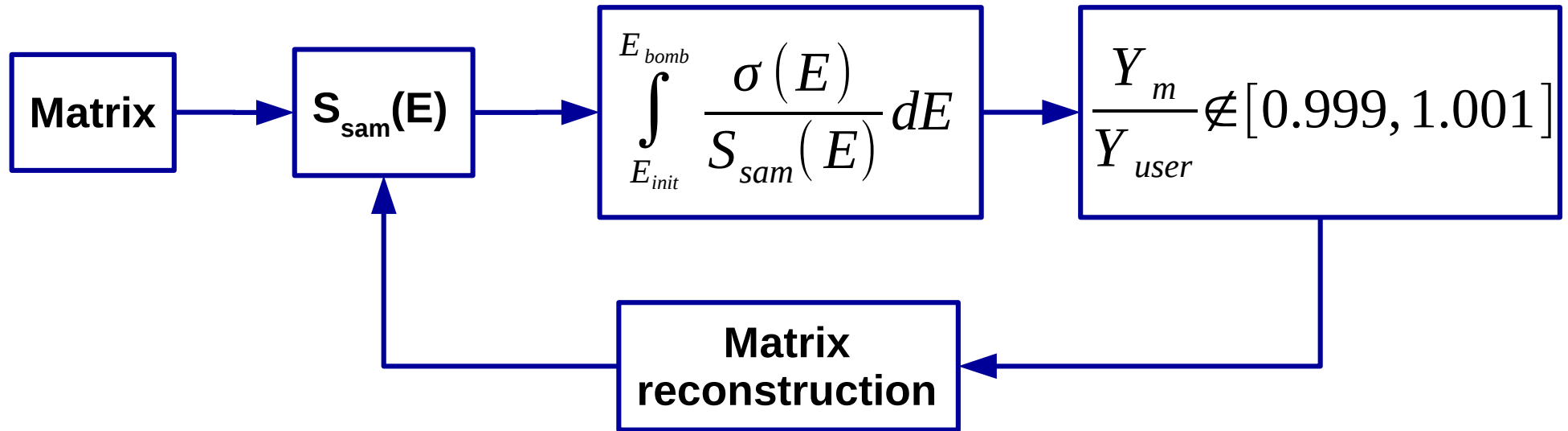
Yield calculation

- Using standards:
$$Y_{sam}(E_{bomb}, \varphi) = Y_{std}(E_{bomb}, \varphi) \cdot \frac{C_{sam}}{C_{std}} \cdot \frac{S_{std}(E_{bomb})}{S_{sam}(E_{bomb})}$$

- Standard-less measurements:



PiGreCo program

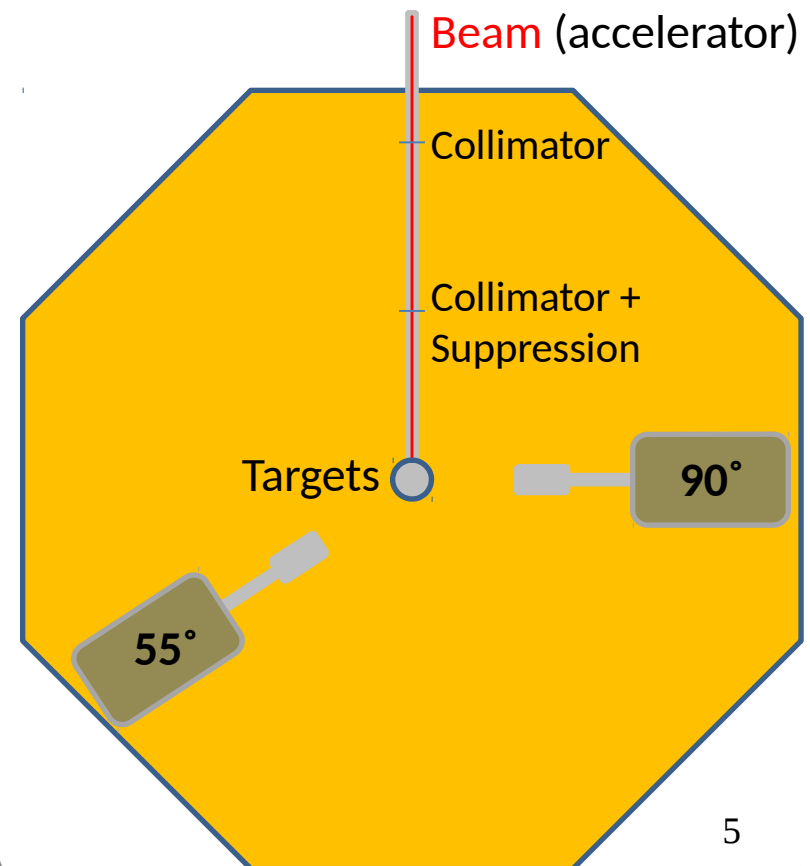
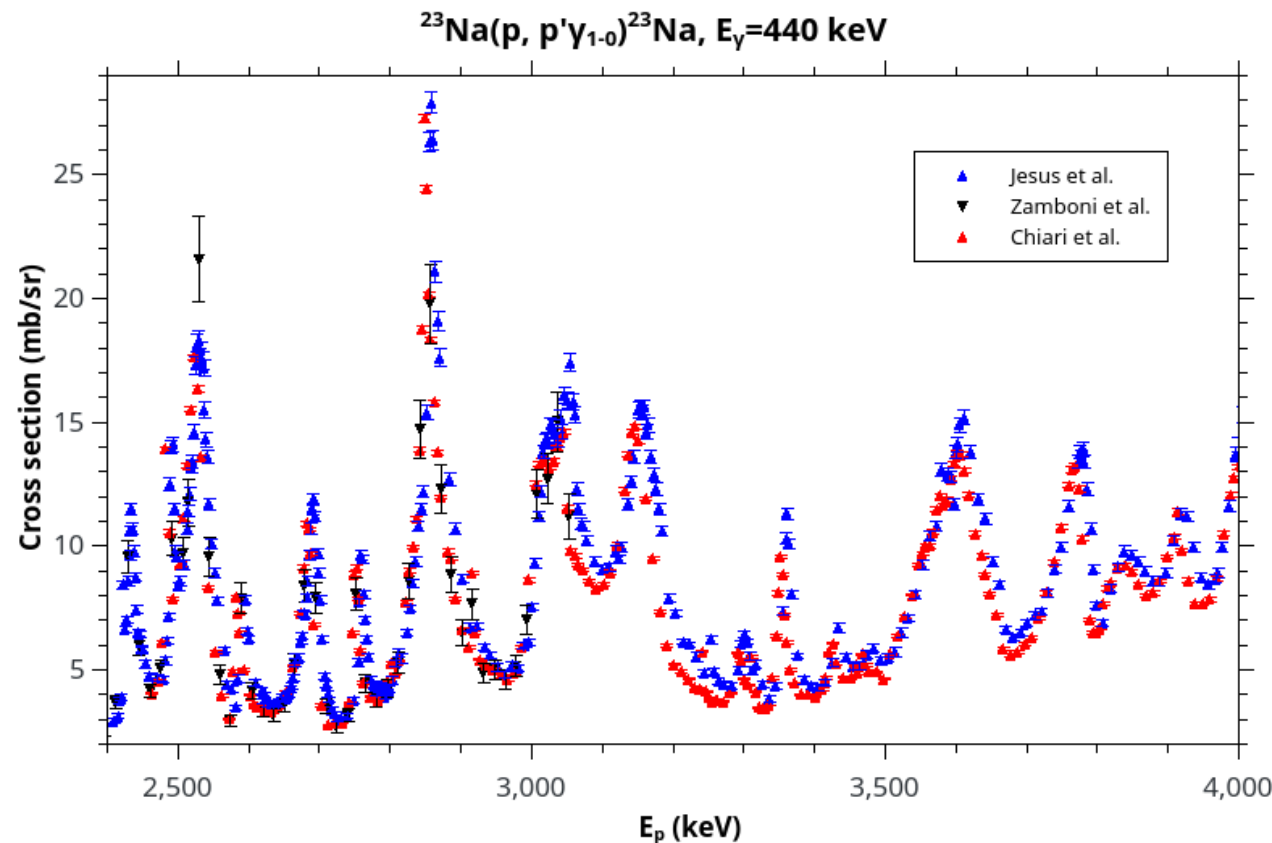


- Programmed in C++ / Qt Libraries for GUI
- Distributions for Windows/Linux/Mac
- Homogeneous monolayer matrix
- Stopping power:
 - Elemental: ZBL/SRIM compilations
 - Compound: Bragg's rule
- Cross sections: R33 files, **compatibility with IBANDL**

Testing the code

- 3 standard samples
 - Phosphate rock (NIST, SRM 120b)
 - Multicomponent glass (NIST, SRM 1412)
 - ST NaF (5.3% Na, 5.3% F in C)
- $E_p = 1.5 - 4.0$ MeV (variable steps)

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ST NaF (one fitting element)

Target Composition

Na 0.19700

Fit

Add Element Remove Element

Calculation Parameters

Select Reaction

Bombarding Energy 4000.00

Egamma = 441

Cutoff Energy 2498.00 Cutoff Yield 6010000.00 Measured Yield 81312.50 Efficiency 0.00317

Fitting

Fit

Number of iterations: 1
C 0.889069
Na 0.0579313
F 0.053

Number of iterations: 2
C 0.893022
Na 0.0539776
F 0.053

Number of iterations: 3
C 0.893136
Na 0.0538635
F 0.053

Number of iterations: 4
C 0.89314
Na 0.0538602
F 0.053

Reaction Chooser

Choose	Gamma	Angle	Energy region	Source
<input type="checkbox"/>	440	135	2213.3 - 5199.33	23Na(p,pg1-0)23Na Source: A. Cacioli et al., I
<input type="checkbox"/>	440	135	1894.66 - 3053.27	23Na(p,pg1-0)23Na Source: I. Zamboni et al., I
<input type="checkbox"/>	440	135	1894.66 - 3053.27	23Na(p,pg1-0)23Na Source: I. Zamboni et al., I
<input type="checkbox"/>	441	90	2463.33 - 4101.05	23Na(p,pg1-0)23Na Source: M. Chiari et al., t
<input type="checkbox"/>	441	0	2463.33 - 4101.05	23Na(p,pg1-0)23Na Source: M. Chiari et al., t
<input checked="" type="checkbox"/>	441	45	2463.33 - 4101.05	23Na(p,pg1-0)23Na Source: M. Chiari et al., t

OK

Save Results

ST NaF (two fitting elements)

The screenshot displays the PiGreCo v2.0 software interface, which is used for calculating and fitting nuclear reaction data. The interface is divided into several sections:

- Target Composition:** Shows the target element as Na with a concentration of 0.10000. It includes buttons for 'Add Element' and 'Remove Element'.
- Calculation Parameters:** Includes a 'Select Reaction' button and input fields for 'Bombarding Energy' (4000.00), 'Cutoff Energy' (2463.33), 'Cutoff Yield' (0.00), 'Measured Yield' (5271910.00), and 'Efficiency' (0.07958). The efficiency value is circled in blue. A mathematical expression $\frac{1}{4\pi}$ is shown above the efficiency field with an arrow pointing to it.
- Fitting:** Contains a 'Fit' button and a list of fitting results. The results are grouped by iteration number (3, 4, 5, 6, 7). The results for iteration 7 are circled in blue, showing values for C (0.894328), F (0.0518326), and Na (0.0538396).
- Reaction Chooser:** A dialog box showing a table of reactions. The selected reaction is highlighted in blue:

Choose	Gamma	Angle	Energy region	Source
<input type="checkbox"/>	110	135	1932.38 - 3053.12	19F(p,pg1-0)19F Source: I. Zamboni et al., Nucl. Phys. A 101, 1 (1965)
<input type="checkbox"/>	197	135	1932.38 - 3053.12	19F(p,pg2-0)19F Source: I. Zamboni et al., Nucl. Phys. A 101, 1 (1965)
<input type="checkbox"/>	197	135	823.978 - 2708.84	19F(p,pg2-0)19F Source: A.P. Jesus et al., Nucl. Phys. A 101, 1 (1965)
<input type="checkbox"/>	197	360	1660 - 4340	19F(p,pg2-0)19F Source: A.Ranken, T.W.Bonrath, Phys. Rev. 101, 1 (1952)
<input checked="" type="checkbox"/>	197	45	2463.33 - 4101.05	19F(p,pg2-0)19F Source: M. Chiari et al., to be published

Other elements in the interface include a 'Target' dropdown, 'Options' menu, and a 'Save Results' button at the bottom.

To do list...

- Near future
 - Fixing of possible bugs
 - Analysis of the other two standards
 - Up to 5 fitting elements
 - Adding straggling
- Distant future
 - Extra features on demand
 - Weight percentage \leftrightarrow Atomic percentage
 - Multilayer targets (resonant-PIGE) / ill-posed problem...

Thank you for your attention!