Measurement of elastic backscattering differential cross sections for protons on ^{nat}O in the energy range E= 4- 6 MeV, suitable for EBS

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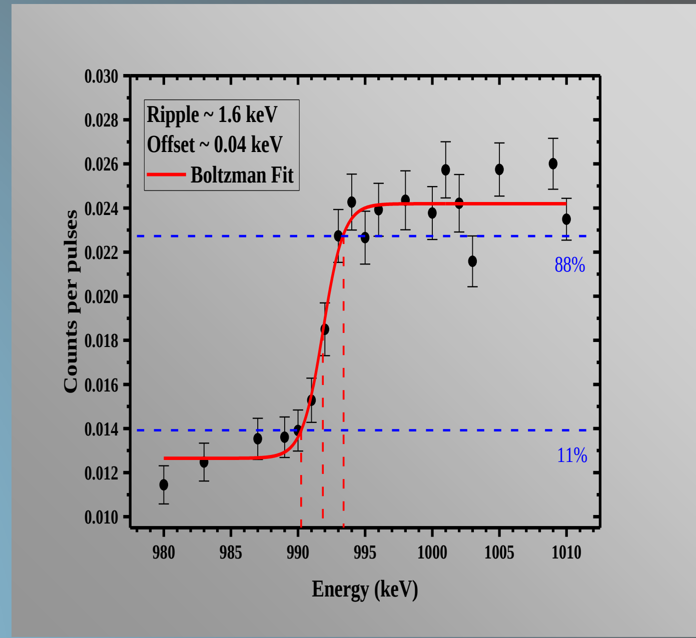
Motivation

- Oxygen is one of the most abundant light elements on Earth, ever present in practically all complex materials, either as a constituent or as a contaminant
- There is an ever growing need for accurate depth profiling in larger depths, in order to determine the exact concentrations of oxygen in various samples like superconductors, geological materials etc.
- p – EBS is the most suitable technique for this purpose
- We collected new experimental differential cross section data at six different angles, never measured before, aiming at obtaining a new set of coherent measurements.
- We will use these data to expand the current evaluation beyond 4 MeV.

Experimental setup

- **5.5 MV Tandem Van de Graaff accelerator** and high precision goniometer (~0.1°) of N.C.S.R. Demokritos in Athens, Greece .
- **Proton energy beam** from **4-6 MeV** with energy step **5-15 keV**.
- Beam energy determined via NMR and verified by the 991.89 keV resonance of the ^{27}Al(p,γ) reaction. **Ripple ~ 1.6 keV, magnet offset ~ 0.04 keV**.
- **6 Silicon surface Barrier detectors** at angles 120°-170° with a 10° step.



The target

Self supporting thin foil consisted of three layers:

- **^{12}C** foil (backing of the target).
- **Na_2HPO_4** oxygen enriched evaporated on top of ^{12}C foil.
- **^{197}Au** evaporated on the top surface for normalization purposes.

Target was constructed at N.C.S.R. "Demokritos".

Target stoichiometry

- Measurements for **$E_{p,lab}$= 2000, 3200 and 3900 keV, θ= 140°, 150°, 160°, 170°** (evaluated differential cross section data will be used for all elements from Sigma Calc 2.0).
- Use **SIMNRA** code [1] to simulate experimental spectrum.

Fig 1: Scattering chamber with the Au+ Na_2HPO_4 + ^{12}C target and 6 detectors. Small aluminum tubes used to reduce background from scattered particles on the goniometer walls and faraday cup.

Fig 2: Tandem Van de Graaff accelerator at "Demokritos".

Data analysis

The relative measurement technique was used to calculate the excitation functions [2]

$$\left(\frac{d\sigma}{d\Omega}\right)_{E,\theta}^{nat\,O} = \left(\frac{d\sigma}{d\Omega}\right)_{E',\theta,Au} \cdot \frac{Y_{16O}}{Y_{Au}} \cdot \frac{N_{t,\,Au}}{N_{t,nat\,O}}$$

Factor yet to be determined!

- $\left(\frac{\mathrm{d}\sigma}{\mathrm{d}\Omega}\right)_{\mathrm{E},\theta}^{\mathrm{nat}\mathrm{O}}$: Differential cross section of the $^{nat}O(p,p_0)$ for scattering angle θ and energy at half of the target thickness E (after machine calibration)
- $\left(\frac{d\sigma}{d\Omega}\right)_{E',\theta,Au}$: Screened Rutherford differential cross section of the $Au(p,p_0)$ scattering for the final ion beam energy E′.
- $\mathbf{Y}_a$: integrated yield of the experimental elastic peak of ^{16}O and Au
- N_t: Total number of ^{197}Au and ^{16}O nuclei present in the target

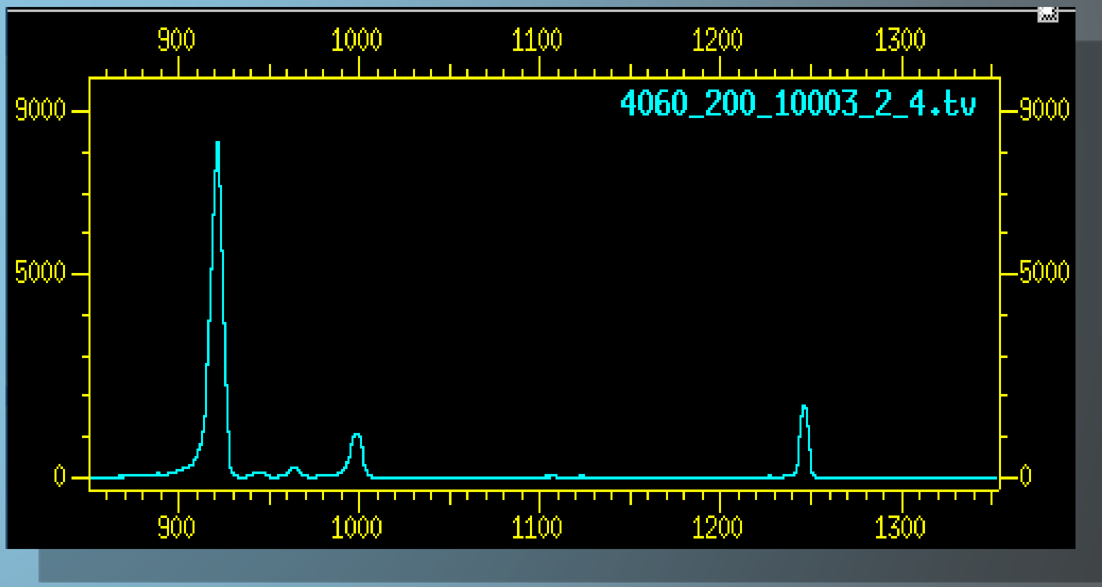
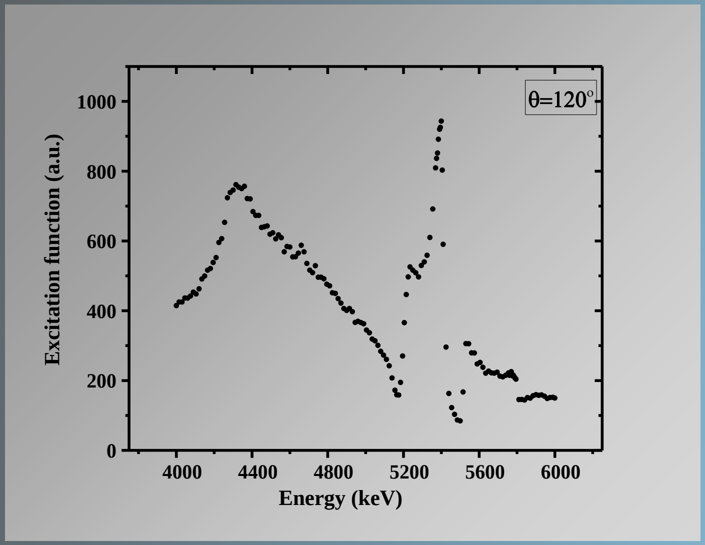
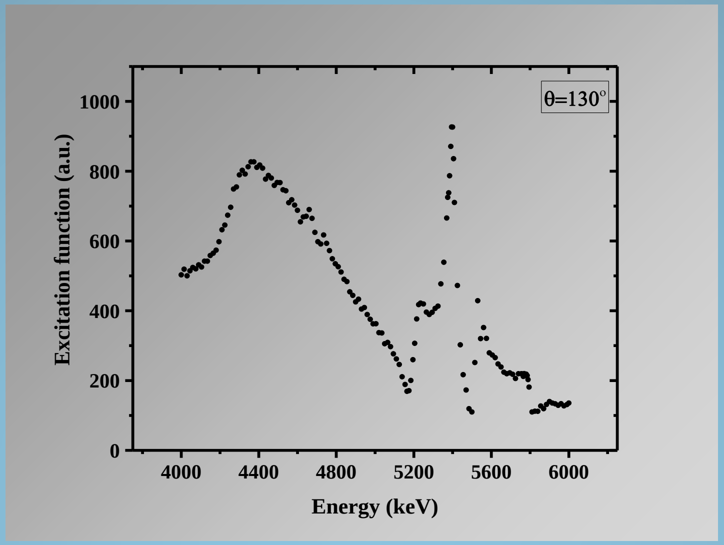
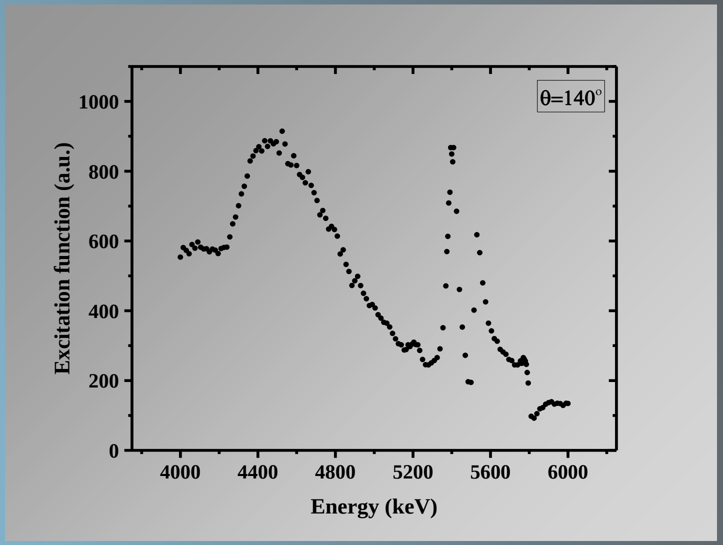


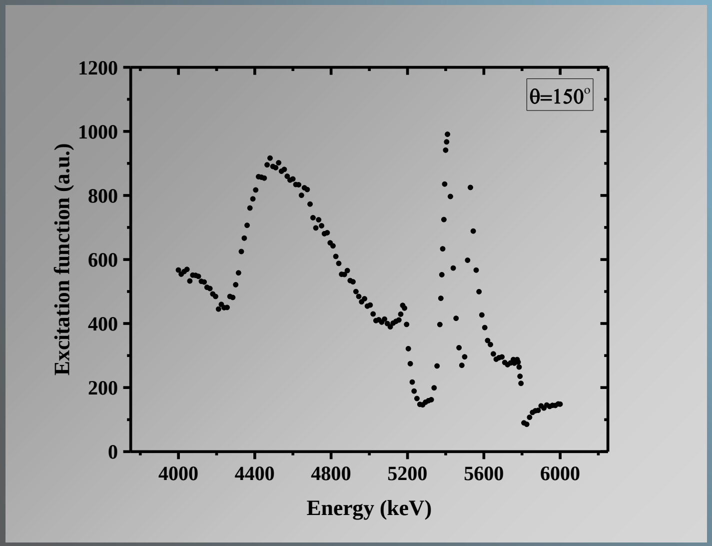
Fig 3: Typical spectrum at 4060 keV proton lab energy and θ=150° . The TV spectroscopy code was used to analyze the experimental spectra.

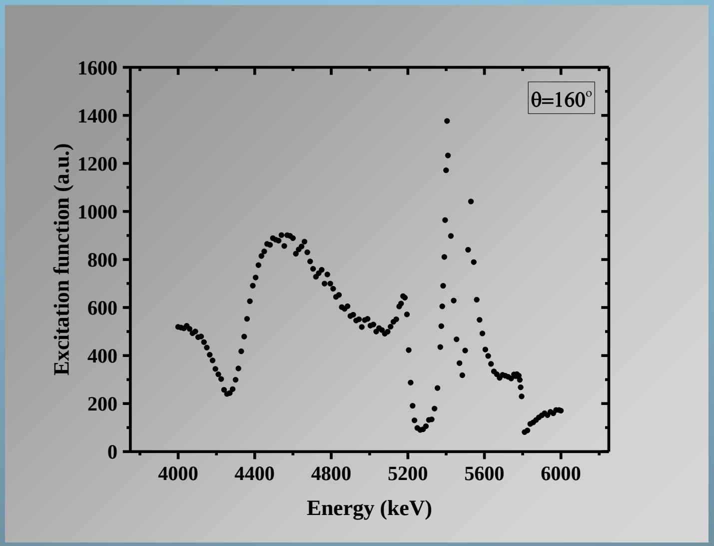
Preliminary results

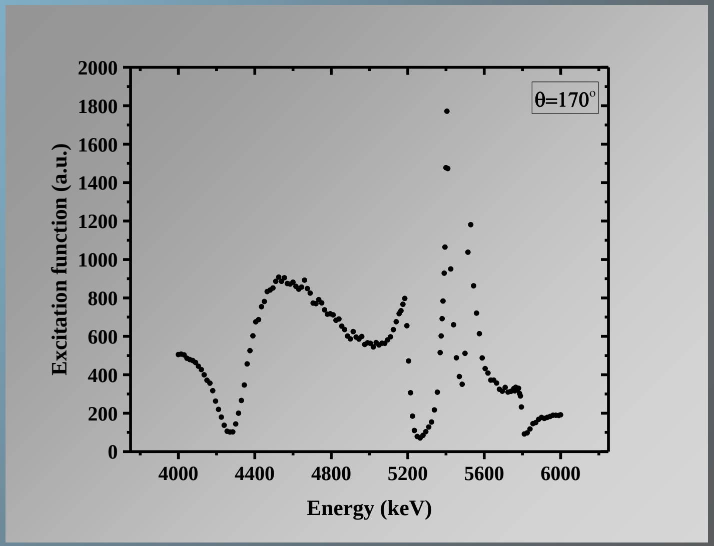












Summary & Future perspectives

- The $^{16}O(p,p_0)^{16}O$ elastic scattering excitation functions were determined for 6 backscattering angles in the 4–6 MeV proton energy range
- The target stoichiometry will be determined via the dedicated measurements and the SIMNRA code.
- We will derive the differential cross section values of $^{16}O(p,p_0)$ at the six backscattering angles measured, creating a coherent set of cross section data.
- R-matrix calculations for the theoretical reproduction of the data will be performed aiming at the expansion of the current evaluation for proton energies 4 - 6 MeV.

REFERENCES

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[2] Preketes-Sigalas, K. & Ntemou, E. & Kokkoris M., Differential cross-section measurements of the elastic $^{7}Li(d,d_0)$ scattering for analytical purposes, NIM B, 2017, Pages 99-103