Measurement of the ^{162}Er(n,2n)^{161}Er reaction cross section

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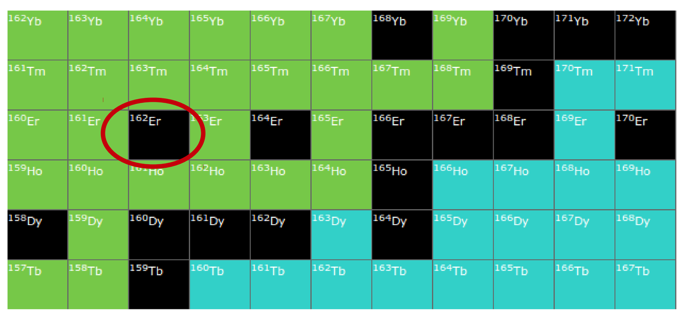
INTRODUCTION

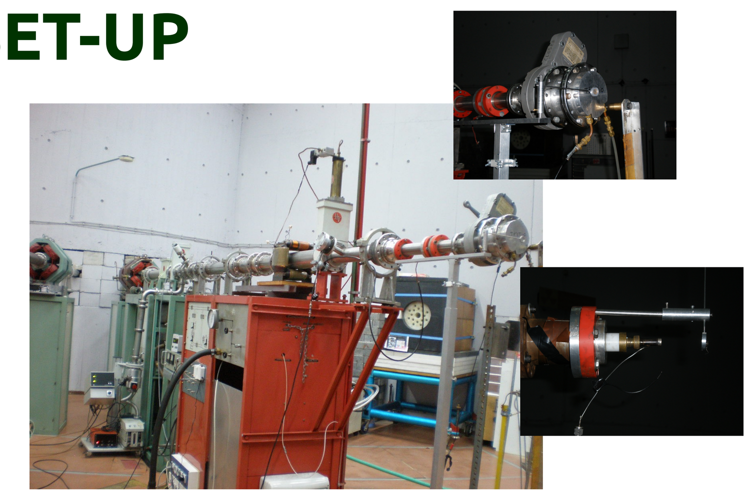
The study of neutron threshold reactions is of considerable importance for testing nuclear models as well as for providing new and updated nuclear data information for Nuclear Physics Applications. Accordingly, the measurement of ^{162}Er(n,2n)^{161}Er reaction cross sections at energies above the reaction threshold is crucial for a better understanding of the compound nucleus models as well as for testing the input parameters of Hauser-Feschbach theoretical calculations. Considering also that ^{162}Er is the lightest stable Erbium isotope the optimization of the model-parameterization



in this region of the chart of nuclides is of special interest. Additionally, Erbium is a commonly used absorbing material in Nuclear Reactor technology. Therefore, the accurate knowledge of the neutron multiplication factor and neutron reaction cross sections is important for the research and development of the next generation fast neutron nuclear reactors. Within the present work the ^{162}Er(n,2n)^{161}Er reaction cross section was measured at four neutron beam energies by means of the activation technique. The sample irradiations as well as the measurement of the induced γ-ray activity was realized at the neutron beam facility of NCSR "Demokritos".

NEUTRON IRRADIATION SET-UP

- Tandem Van der Graaf 5.5 MV accelerator of the Institute of Nuclear Physics NCSR "Demokritos"
- Neutron Reactions : ^{2}H(^{2}H,n)^{3}He & ^{3}H(^{2}H,n)^{4}He
- Neutron production primary target:
  - For the D-D reaction : D_2 gas target (1250 mbar)
  - For the D-T reaction : solid Titanium-Tritide (TiT) target
    - Activity (^{3}H)=373 GBq
    - Nucleus Ratio T/Ti = 1.543
- Neutron beam intensity continuously monitoring with a BF_3 detector
- ^{162}Er pellet target produced by Er_2O_3 powder
- ^{162}Er pellet target diameter : 12.95 mm
- Reference reactions : ^{197}Au(n,2n)^{196}Au, ^{27}Al(n,a)^{24}Na and ^{93}Nb(n,2n)^{92m}Nb
- Irradiation time : 10 h given that $T_{1/2}$ (^{161}Er)=3.21 h



	Q-value (MeV)	E_d (MeV)	E_n (MeV)	Neutron flux (cm^{-2})	Neutron flux Error (cm^{-2})	Samples position
D-D	3.27	8.17	11.0	7.49E+10	0.39E+10	5 cm from D_2 gas target
		8.47	11.3	1.08E+10	0.07E+10	
D-T	17.59	2.50	17.1	1.21E+10	0.08E+10	1.5 cm from TiT target
		3.00	18.1	1.06E+10	0.07E+10	

γ-RAY SPECTROSCOPY SET-UP

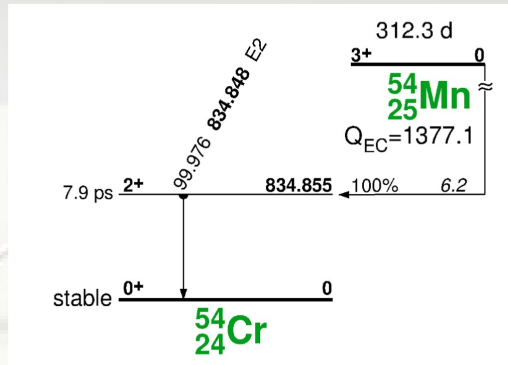
- Off-line measurements of the induced activity of the samples

- Erbium sample : 2x100% relative efficiency HPGe detectors used in close geometry given the minimal abundance (0.139%) in ^{162}Er in the natural sample composition. This dictates the maximum possible efficiency

- Reference foils : one HPGe detector with 16% relative efficiency placed at 7cm distance with with respect to the detector window

Calibration Sources

- 16% HPGe detector : an isotopic point source of ^{152}Eu used in the sample position.
- 2x100% HPGe detectors : one ^{54}Mn point source, which emits a single γ-ray at 834. 8 keV similar to the 826.6 keV γ-ray ,which is the strongest decay line of ^{161}Er.



DATA ANALYSIS

- Decay of ^{161}Er : 826.6 keV the stronger line
- Multiplicity ~ 1 : no summing effects

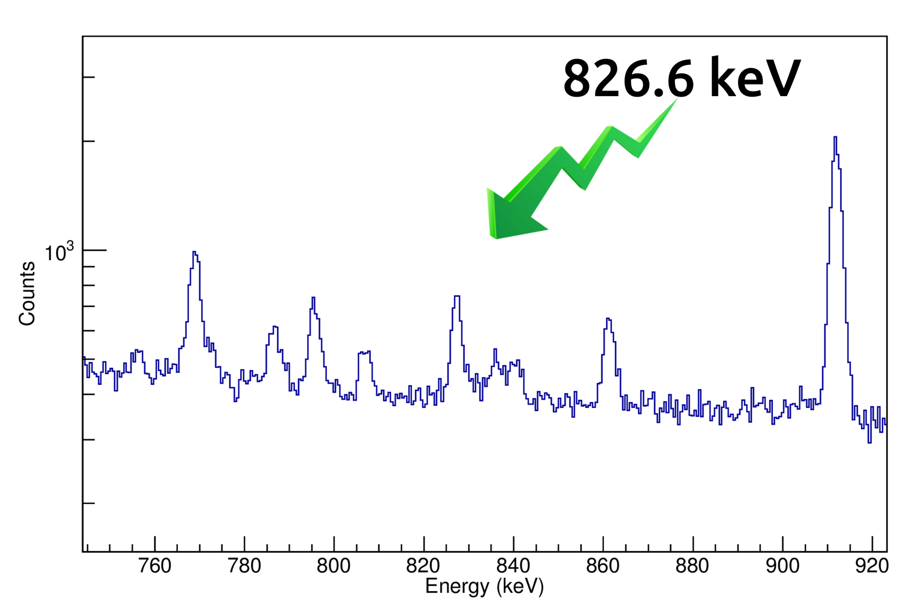
$$counts = \varepsilon \cdot I \cdot N_{act} \cdot e^{-\lambda t_m}\left(1-e^{-\lambda t_m}\right)$$

$$N_{act} = \sigma \cdot N_T \cdot \Phi \cdot f_B$$

where f_B is the correction factor due to ^{161}Er decay during irradiation

$$f_B = \frac{\int_0^{t_{irr}} f(t) e^{\lambda t} dt}{\int_0^{t_{irr}} f(t) dt} e^{-\lambda t_{irr}}$$

$$\sigma = \frac{CF_{SA} \cdot CF_{DT} \cdot counts}{I \cdot \varepsilon \cdot \Phi \cdot N_T e^{-\lambda t_w} \cdot \left(1-e^{-\lambda t_m}\right) \cdot f_B}$$



CONCLUSIONS

- Measurement of the ^{162}Er(n,2n)^{161}Er reaction cross section for the first time at energies 11.0, 11.3, 17.1 and 18.1 MeV
- Activation method + neutron beam facility at NCSR "Demokritos" ➡ high sensitivity of the method ➡ high accuracy cross section data