Proton inelastic scattering cross-sections on ^{16}O and ^{28}Si

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PRESENTATION OUTLINE

WE USED A QUARTZ (SiO_2) TARGET

^{16}O(p, $p\gamma$)^{16}O + ^{28}Si(p, $p\gamma$)^{28}Si experiment

- ❑ scientific motivation
- ❑ experimental setup
- ❑ data analysis procedure
- ❑ results: (p,p') data discussion - ^{16}O and ^{28}Si
- ❑ future work

SCIENTIFIC MOTIVATION

- ^{16}O and ^{28}Si are nuclei of interest for nuclear applications: Nuclear Data HPRL
- physical reasons: $\longrightarrow$ Precise nuclear reaction modelling

$\longrightarrow$ $^{28}Si(n, n\gamma)^{28}Si$ versus $^{25}Mg(\alpha, n\gamma)^{28}Si$ Phys. Rev. C **88**, 034604 (2013)

$\longrightarrow$ Bohr hypothesis & isospin symmetry

PRESENT EXPERIMENT:

$^{16}O(p, p\gamma)^{16}O$ versus $^{16}O(n, n\gamma)^{16}O$ $\uparrow$

- measured at EC-JRC Geel
- data analysis ongoing

^{16}O: N=Z nucleus

$^{28}Si(p, p\gamma)^{28}Si$ versus $^{28}Si(n, n\gamma)^{28}Si$ $\uparrow$

- measured at EC-JRC Geel
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^{28}Si: N=Z nucleus

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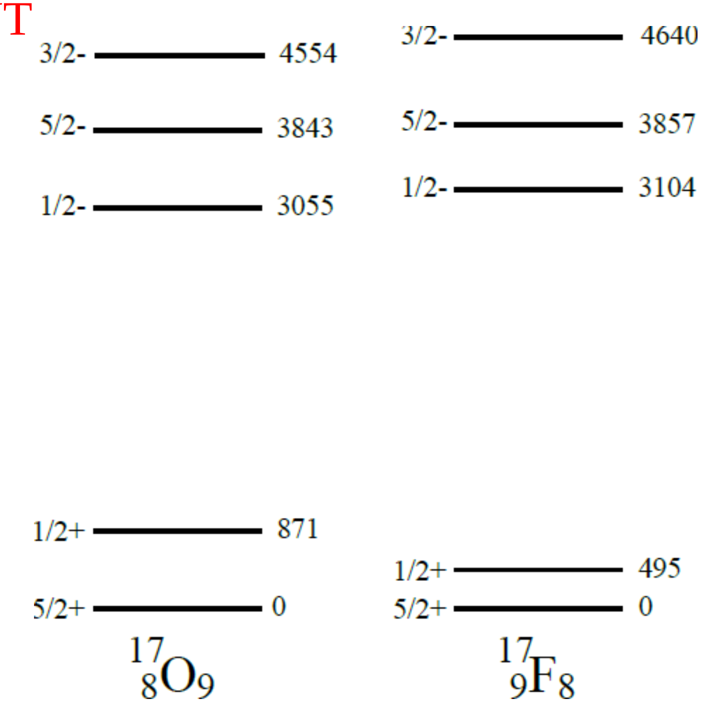
Partial level schemes



- **main goals** of the present experiment:

⟶ to determine the proton inelastic scattering cross-sections

⟶ to investigate if and to which extent the neutron cross-sections can be inferred from the ones induced by charged particles (i.e. protons in our case)

⟶ to extract information about the manifestation of the isospin symmetry in the reaction mechanism itself (i.e CN) but also on the values of the cross sections

EXPERIMENTAL SETUPS

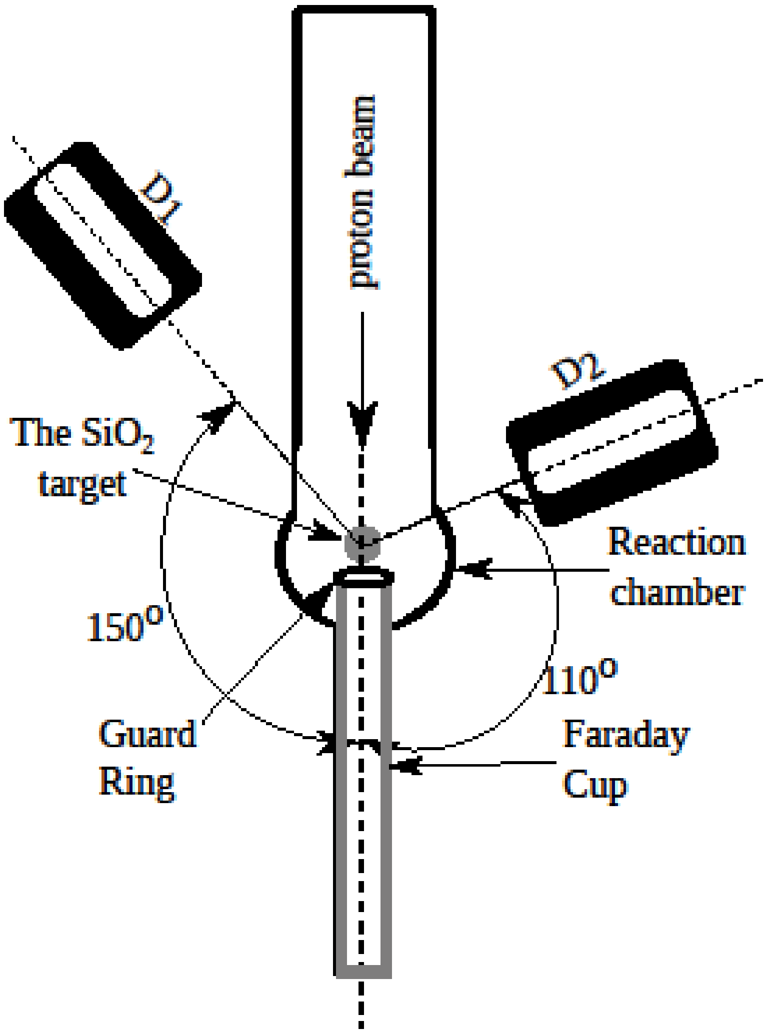
➢ **Nuclear reactions:**

⟶ *Neutron* inelastic scattering cross section measurements (EC-JRC Geel)

⟶ *Charged particles* inelastic scattering cross section measurements (IFIN-HH, Bucharest)

EXPERIMENTAL SETUP

TANDEM facility, IFIN-HH, Bucharest



- at IFIN-HH, Tandem facility in November 2015
- two HPGe detectors
- 100% relative efficiency
- placed at 110° and 150°
- distance: 18.25 cm and 15.45 cm
- target: SiO_2 (quartz) with an areal density 41.93 mg/cm^2
- $E_p \longrightarrow$ 7-17 MeV, with 1 MeV steps
- efficiency measurements for the respective distances using a ^{152}Eu calibration source
- acquisition system: TNT2 digitizer with a sampling frequency of 100 MHz

EXPERIMENTAL SETUP

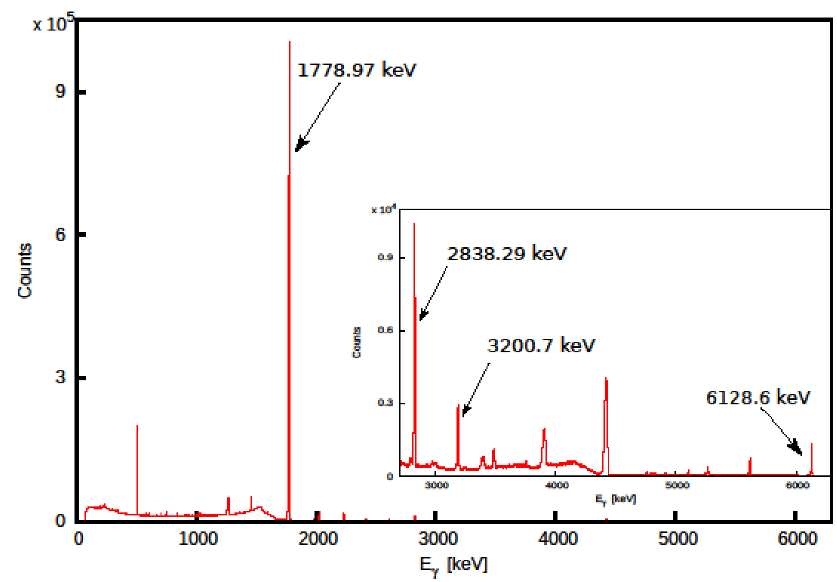
TANDEM facility, IFIN-HH, Bucharest

DATA ANALYSIS

DATA ANALYSIS

gamma spectroscopy techniques ⟶ *absolute* γ-production cross sections

HPGe detectors + Faraday Cup



INTEGRATED PROTON BEAM CURRENT

DATA ANALYSIS

$$\frac{d\sigma}{d\Omega} = \frac{1}{4\pi} \frac{N_\gamma \cdot A}{N_p \cdot \varepsilon_{\text{det}} \cdot \rho_x \cdot f} \cdot d$$

where:

$\frac{d\sigma}{d\Omega}$ $\longrightarrow$ Differential cross section

Ω $\longrightarrow$ Solid angle

N_p $\longrightarrow$ Number of incident protons on the target

ε_{det} $\longrightarrow$ HPGe detector efficiency

ρ_x $\longrightarrow$ Areal density of the target

f $\longrightarrow$ Atomic mass scaling factor

d $\longrightarrow$ Dead time correction factor

N_γ $\longrightarrow$ Number of counts from a given gamma peak

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Experimental efficiencies

$$\frac{d\sigma}{d\Omega} = \frac{1}{4\pi}\frac{N_\gamma \cdot A}{N_p \cdot \varepsilon_{\mathrm{det}} \cdot \rho_x \cdot f} \cdot d$$

The efficiency was determined using a method that combines an <u>experimental</u> curve obtained via :

- we used a ^{152}Eu calibration source

$$\varepsilon_{\mathrm{det}} = \frac{N_\gamma(^{152}Eu)}{\Lambda \cdot I_\gamma \cdot t_m}$$

and <u>MCNP6 simulations</u> – for the *extrapolation* to higher gamma energies

Dead time corrections

$$\frac{d\sigma}{d\Omega} = \frac{1}{4\pi} \frac{N_\gamma \cdot A}{N_p \cdot \varepsilon_{\det} \cdot \rho_x \cdot f} \cdot d$$

Again, remember that **d** represents the dead time correction factor and *not* the dead time itself !!!

In a statistical framework we showed how the correction factor (d) can be accurately calculated by assuming that the counting rate ($R_{\det}$) follows a Poisson distribution

The probability distribution satisfied by the arriving time interval of the incoming events (Δt) is an *exponential distribution*

exploited this fact in calculating the *rate losses*

d correction factor

Differential cross section:

$$\frac{d\sigma}{d\Omega} = \frac{1}{4\pi} \frac{N_\gamma \cdot A}{N_p \cdot \varepsilon_{\det} \cdot \rho_x \cdot f} \cdot d$$

Quadratic Gaussian method + Legendre polynomial series expansion

Integrated cross section:

$$\sigma_{\mathrm{int}} = 2\pi[w_{110^\circ} \cdot \frac{d\sigma}{d\Omega}(110^\circ) + w_{150^\circ} \cdot \frac{d\sigma}{d\Omega}(150^\circ)]$$

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✓

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✓

RESULTS AND DISCUSSION

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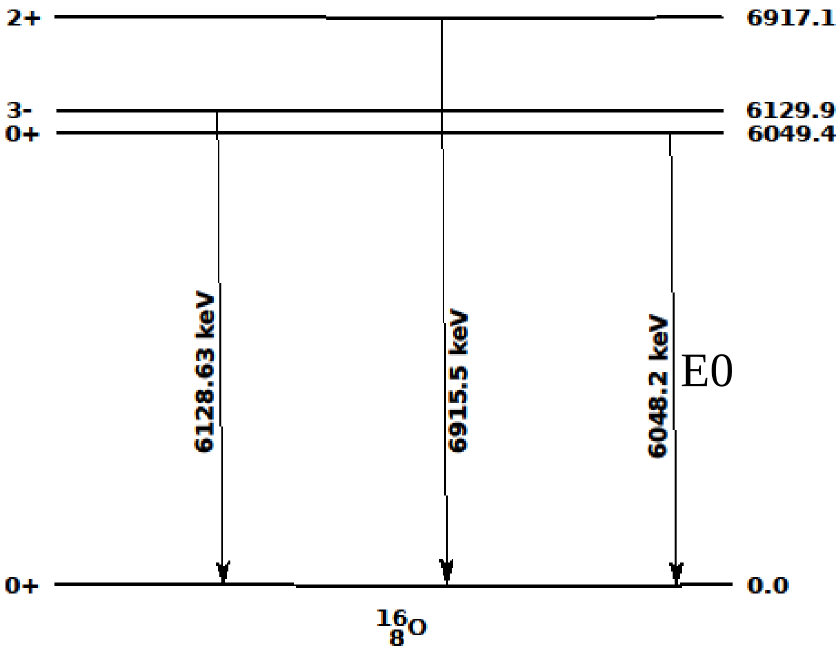
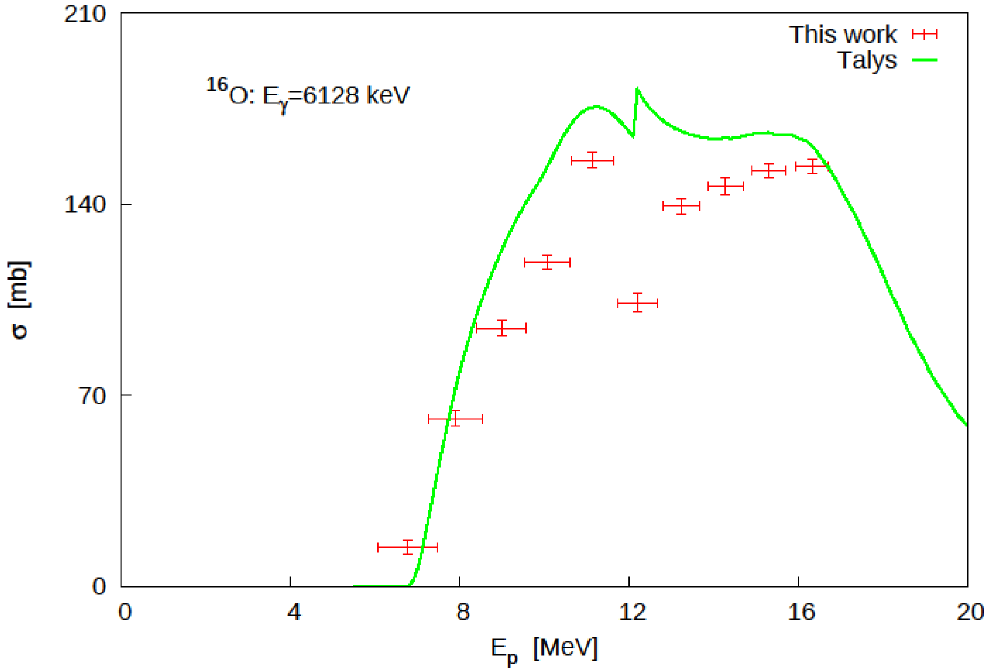
$^{16}O(p, p\gamma)^{16}O$





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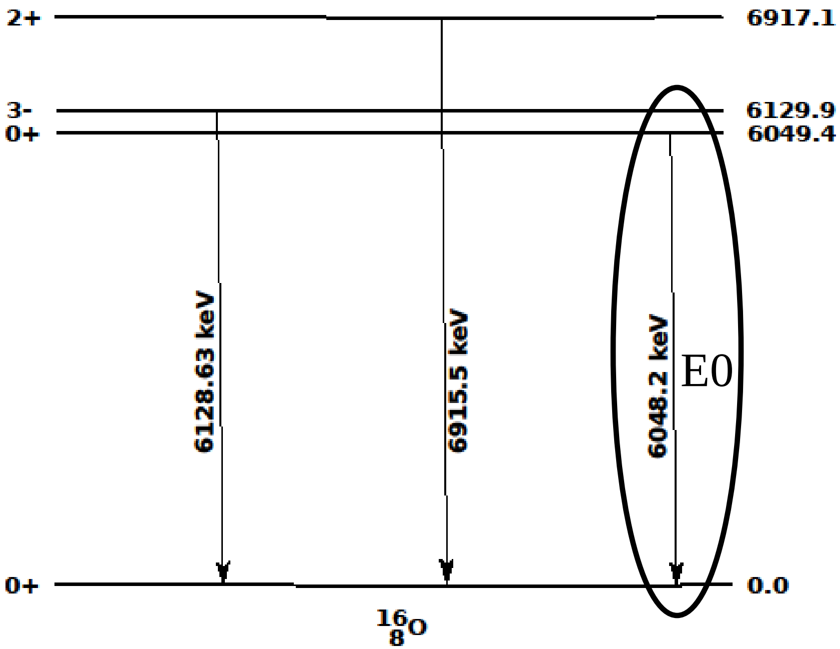

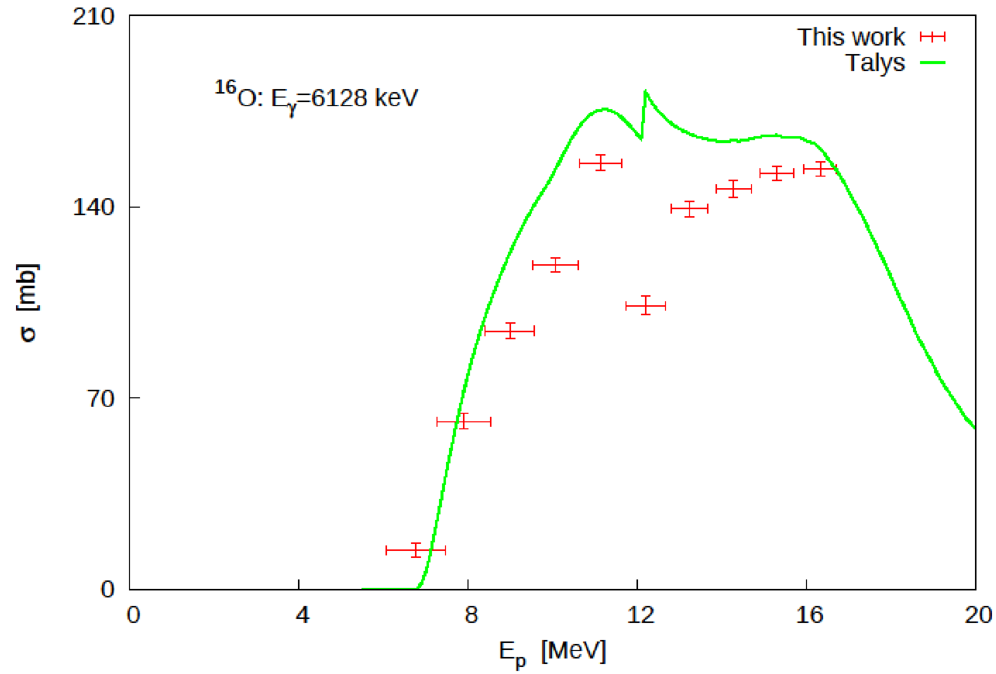

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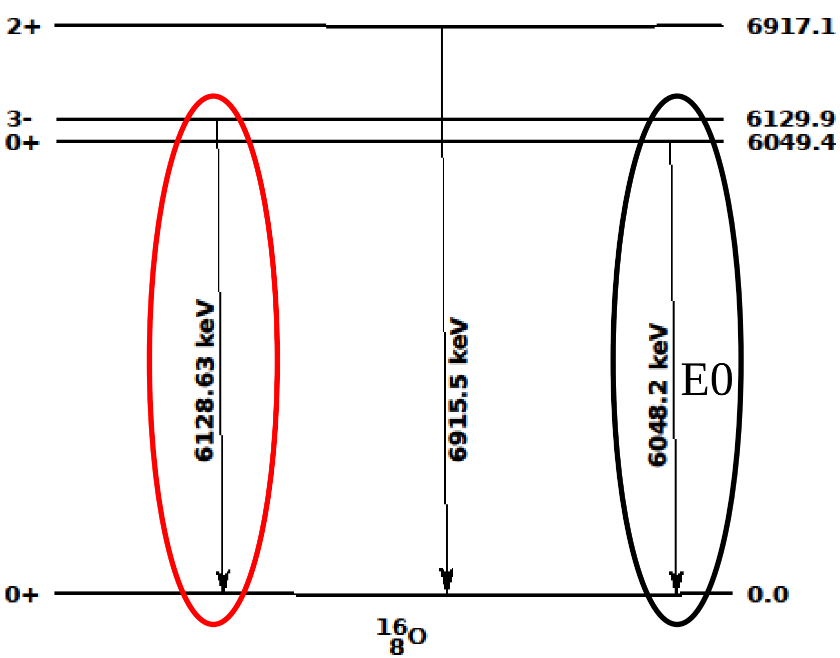

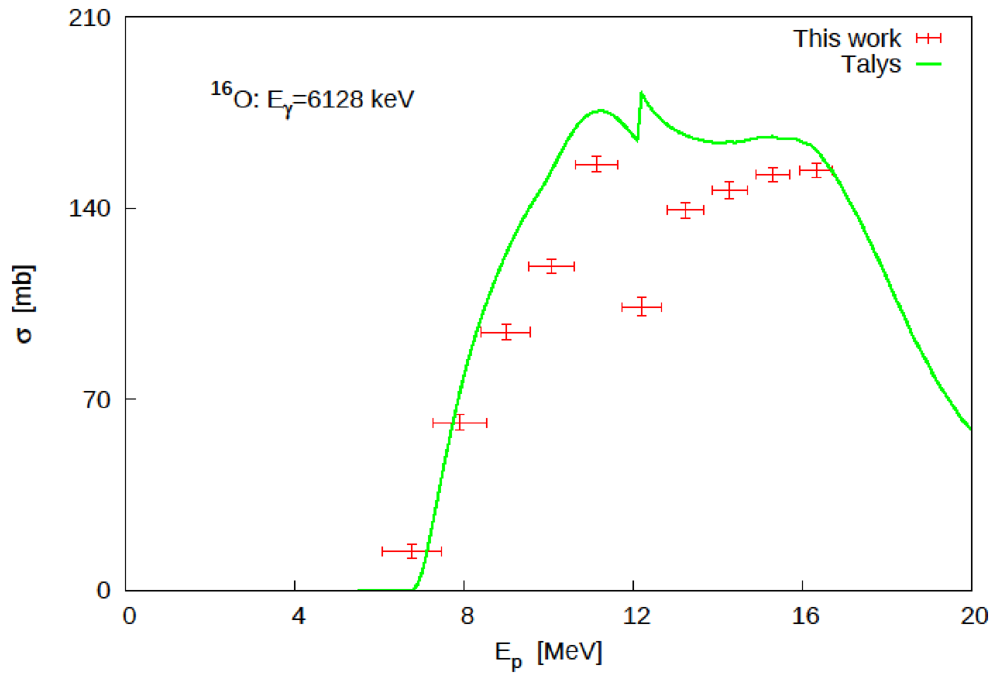

RESULTS AND DISCUSSION

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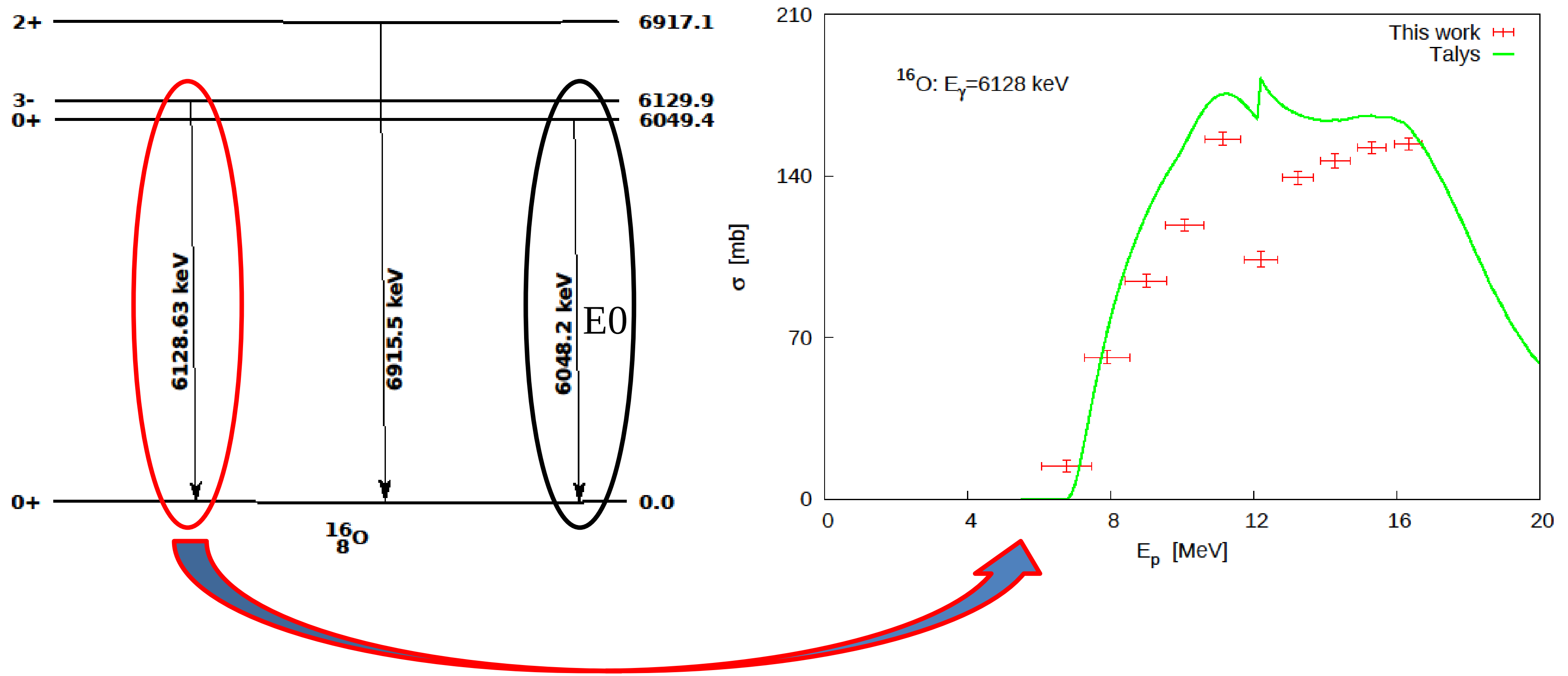
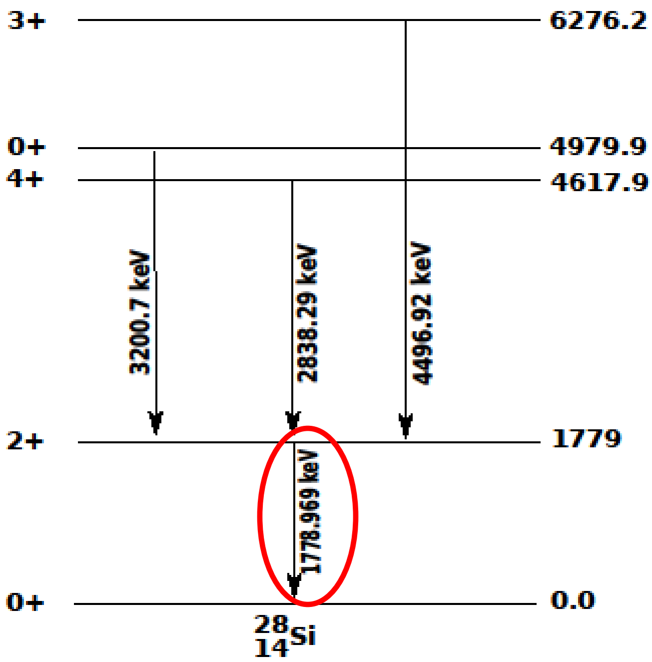
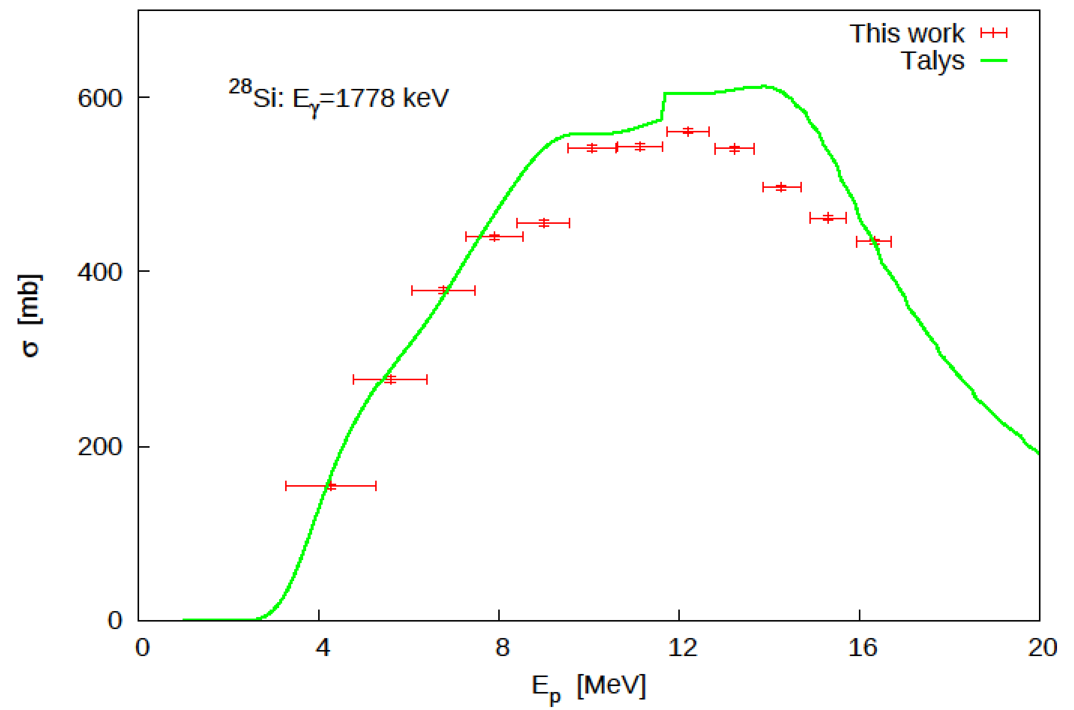


$^{28}Si(p, p\gamma)^{28}Si$





RESULTS AND DISCUSSION

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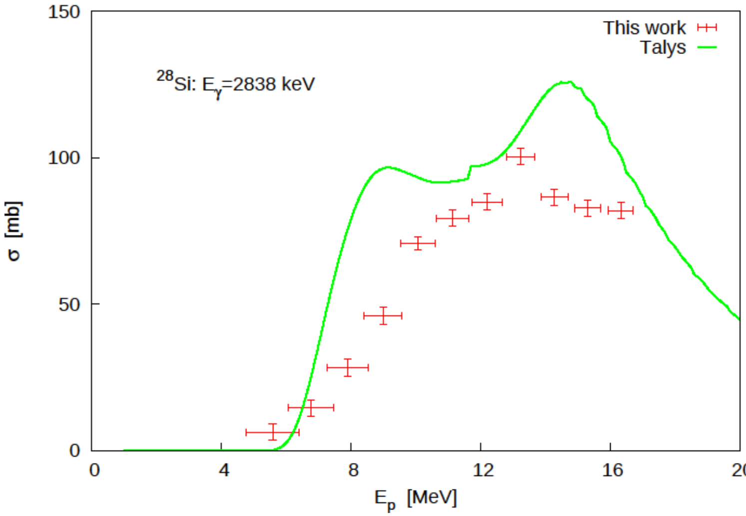

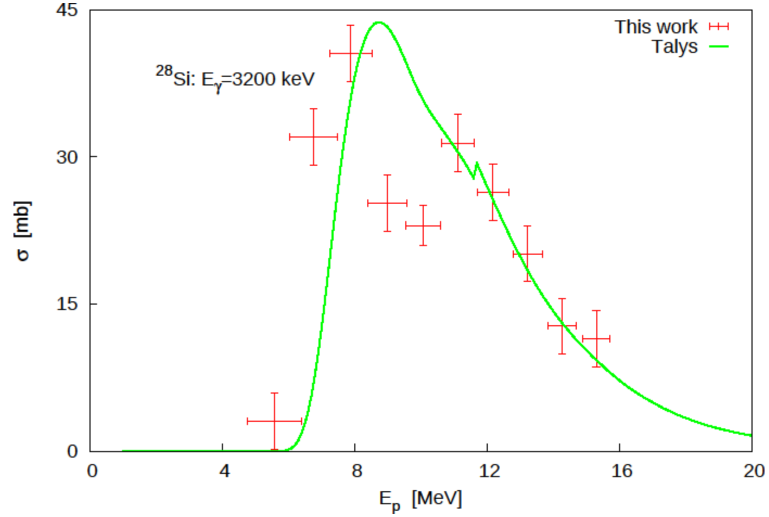

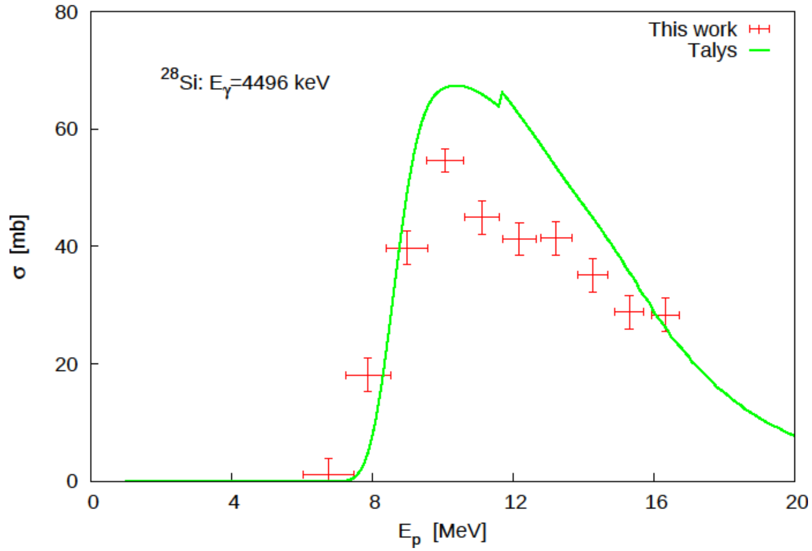

FUTURE WORK

- EXTENSIVE COMPARISON WITH *TALYS 1.8* code & OTHER AVAILABLE EXPERIMENTAL DATA (EXFOR...)

- DETAILED COMPARISONS AND DATA DISCUSSION OF THE CROSS SECTIONS FROM THE CORRESPONDING (*p*, *p*γ) AND (*n*, *n*γ) EXPERIMENTS:

$$^{28}\mathrm{Si}(p, p\gamma)\,^{28}\mathrm{Si} \quad \text{vs.} \quad ^{28}\mathrm{Si}(n, n\gamma)\,^{28}\mathrm{Si}$$

and

$$^{16}\mathrm{O}(p, p\gamma)\,^{16}\mathrm{O} \quad \text{vs.} \quad ^{16}\mathrm{O}(n, n\gamma)\,^{16}\mathrm{O}$$

- PUBLISHING THE RESULTS

THANK YOU!

SCIENTIFIC MOTIVATION