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NUCLEAR ASTROPHYSICS EXPERIMENTS IN INERTIAL CONFINEMENT FUSION FACILITIES: ANALYSIS OF NEUTRON DENSITIES FOR S-PROCESS EXPERIMENTS AND APPROXIMATIONS USED IN LIGHT-ION CROSS-SECTION MEASUREMENTS

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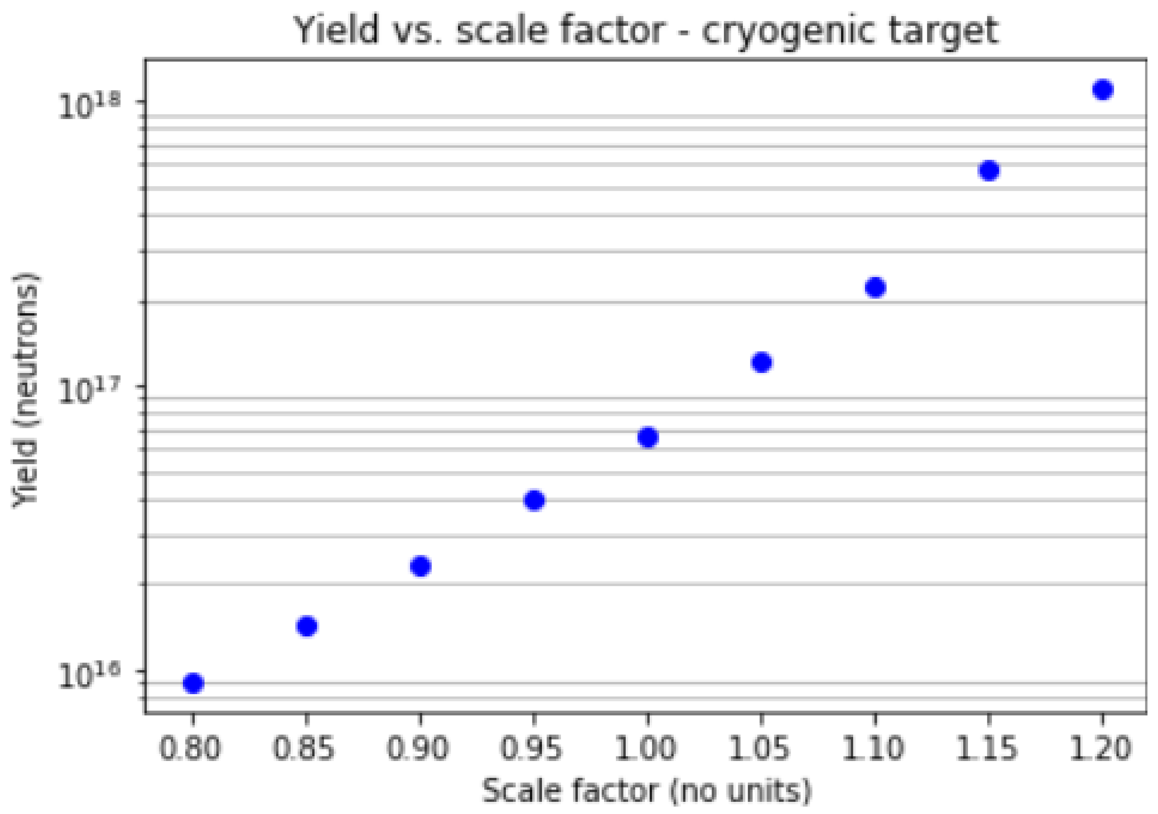
BACKGROUND AND AIMS

The stellar temperatures and intense neutron emissions achieved in Inertial Confinement Fusion (ICF) are ideal for nuclear astrophysical experiments. The thermal distributions and plasma properties present in ICF and stars are advantageous for when measuring reactions with cross-sections too low for particle accelerators. Cross-section measurements for light ion reactions have already taken place and new experiments related to the S-process are being proposed. The work here presented aims to back up the proposal for S-process experiments and assess how results are processed in light ion reactions.(Le Pape et al., 2018)

TABLE 0

Target	Fluence (neutrons/m^2)	Primary %	Dopant mass
Cryogenic DT	1.89e+24	85.2 %	3.79 ng
Gaseous DT	4.68e+22	97.8%	319 ng
Gaseous DD	9.92e+20	95.6 %	392 ng

FIGURE 1



The fluence values in cryogenic are high enough to be able to use a reasonable dopant mass in S-process related experiments. They are, however, not as mono-energetic.

Scaling of dimensions would make the use of gaseous targets possible. DD gas is preferable over DT gas because removing tritium makes for a more mono-energetic source.

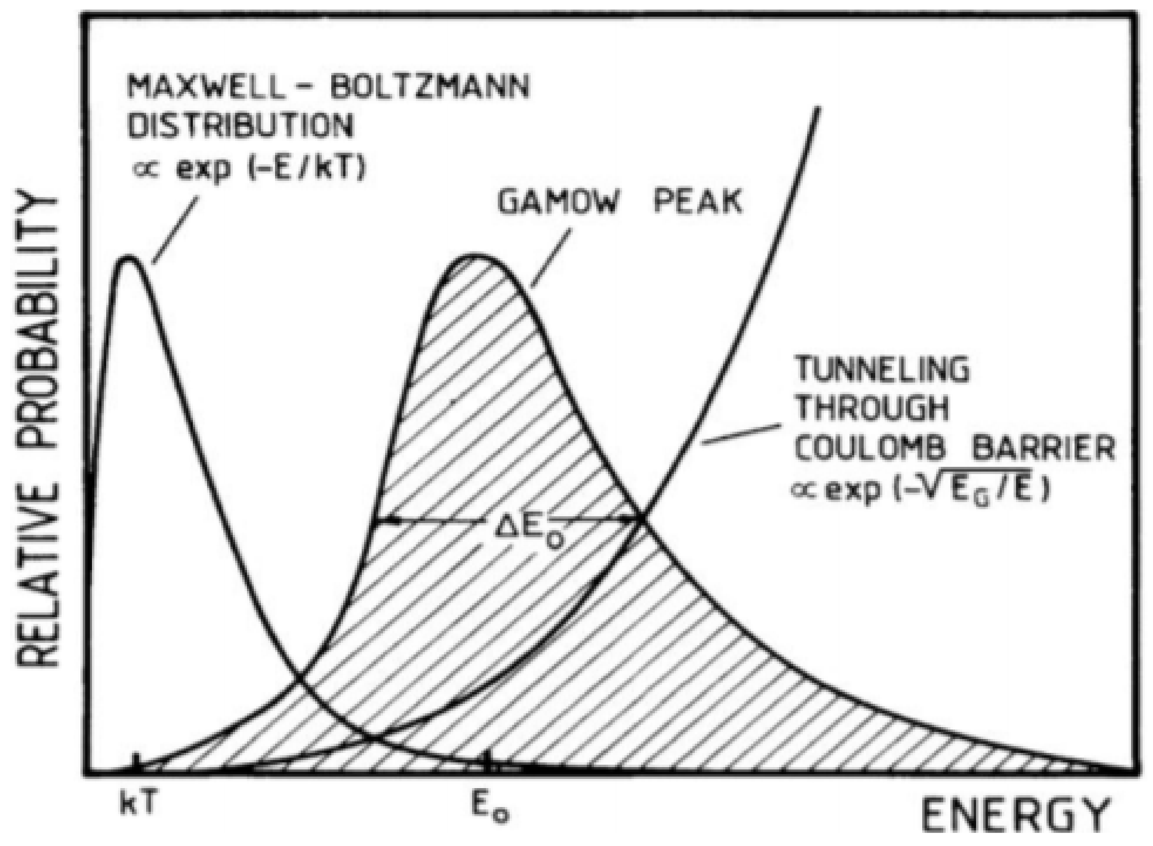
CONCLUSIONS

The fluence values of cryogenic DT targets are enough to perform successful S-process related in ICF platforms but DD gaseous targets would provide a more adequate neutron source after undergoing scaling. Extracting $S_{effective}$ results from yield ratios measured in light-ion reaction experiments sacrifices less accuracy than reactivity calculations.

METHOD

- ► Simulating ICF implosions with Chimera and Minotaur (hydrodynamics and neutron transport)
- ► Evaluate the neutron densities and their energies for different targets.
- ► Quantify the effect of scaling targets to achieve stronger neutron sources.
- ► Compare the accuracy of different approximations used in Zylstra et al., 2020.
- ► Propose a more accurate way of presenting results of light-ion reaction measurements.

FIGURE 2

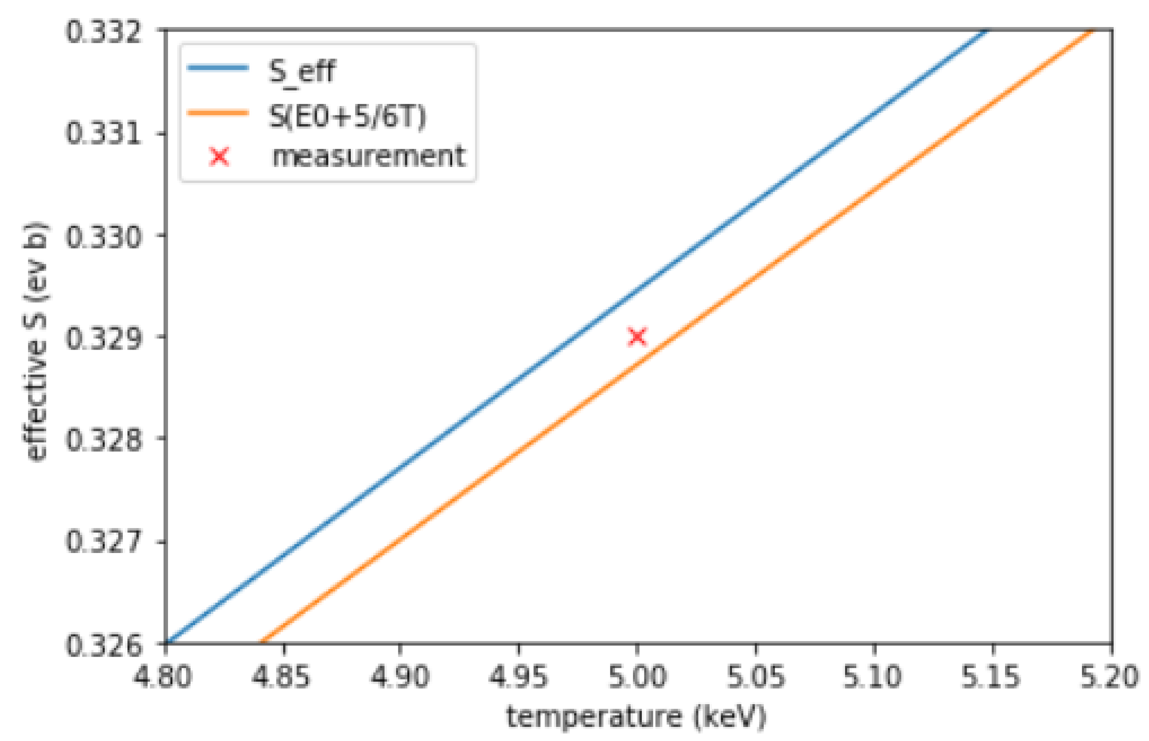


Reacting energies are described by the Gamow peak and are frequently approximated as a Gaussian or a Dirac Delta function. A uniform S-factor can also be assumed. Comparing yield ratio figures from simulated data using these approximations shows the uncertainties they bring up. Image from Rolfs and Rodney, 2006

TABLE 2

	Yield ratio
Measurement	4.75e-5
Uniform S(E)	4.40e-5
Dirac Delta	4.81e-5

FIGURE 3



The effective S-factor is a value weighted over the Gamow peak. Extracting this value from the yield ratio measurements still involves the assumption of a constant S-factor but it does not approximate the shape of the Gamow peak.

Giving the results in $S_{effective}$ instead of reactivity reduces the uncertainty in the processing of results.

REFERENCES

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