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To whom it may concern:

In this memo, I review the doctoral dissertation of Mr. Mateusz Fila, M.Sc. from the University of Warsaw titled "Study of $^{16}O(\gamma,\alpha)^{12}C$ nuclear reaction with the Warsaw TPC detector." The dissertation describes measurements and analysis of $^{16}O(\gamma,\alpha)^{12}C$ carried out at the Triangle Universities Nuclear Laboratory HIγS facility.

I find the dissertation to be thorough and carefully written. This work has significantly advanced the state of the art in the use of Time Projection Chambers (TPCs) for the measurement of photon-induced nuclear reactions. For the specific reaction studied, $^{16}O(\gamma,\alpha)^{12}C$, the angular distributions reported in Fig. 5.28 are of substantially higher systematic and statistical quality than has ever been reported before.

Mr. Mateusz Fila has clearly spelled out his specific contributions to the experiment and analysis in Sec. 1.7 of the dissertation. I find that the significance of the research, quality of the analysis and writing, and amount of effort invested exceed the thresholds that would be considered at Ph.D.-granting universities in the United States of America. I have been asked to draw conclusions regarding two considerations, which I address in the following paragraphs.

Consideration (1):

> The doctoral dissertation presents the candidate's general theoretical knowledge in a discipline or disciplines as well as the ability to independently conduct scientific work.

I conclude that **yes**, this dissertation fulfills this standard. Chapter 1 indicates broad knowledge of the nuclear physics and astrophysical context to the problem under study, and also of the prior work done on the problem. Chapters 2, 3, and 4 indicate a thorough understanding of the operation of the TPC detector and other experimental equipment. Appendices A and B show clear knowledge of the kinematics and coordinate systems used for the experiment and analysis. Evidence of independent scientific work is provided by

the analysis in chapters 5 and 6 and his significant contributions to the software described in the appendices. I also note that Mr. Mateusz Fila was significantly involved in detector testing, planning, and data taking for the measurements reported in his dissertation.

Consideration (2):

> The subject of the doctoral dissertation is an original solution to a scientific problem or an original solution in the field of applying the results of own scientific research in the economic or social sphere.

I likewise conclude that **yes**, this dissertation fulfills this standard. The scientific goal is accurate measurements of the $^{12}C(\alpha,\gamma)^{16}O$ reaction (or its inverse) that can be utilized to better determine the fusion rate in astrophysical applications. There has only been one previous measurement using TPC technology, Ref. [9] in this dissertation. The statistical quality of data in the present work is much higher. The angular distributions obtained in the dissertation far exceeds the quality that has been obtained previously using any technique. New algorithms for the analysis of TPC data have been developed. I also note that the measurements of the total cross section also show promise for advancing the state of the art. In the dissertation they are presented in un-normalized form (and presumably are preliminary), but this technique should eventually be able to provide highly accurate absolute cross sections.

While reading the dissertation, I did notice a few places where the document could be improved. I want to emphasize that these are *minor* considerations that in no way impact the conclusions given above. I include them here because they may be helpful for revising this dissertation and/or subsequent documents.

(1) In Sec. 1.3, the previous experiments are reviewed. I find the second paragraph is somewhat misleading, since there are many more important experiments than are not referenced. I suggest including another sentence along the lines of "Only representative experiments have been mentioned above. For a complete review of the experimental literature, the reader is referred to Ref. [1]."

(2) In Sec. 1.3, the third paragraph states "The consensus is that..." I feel that this is an overstatement. There are a variety of opinions regarding the direction the field should move. I am aware of experimental groups planning lower-energy measurements, precision measurements (including the present dissertation), and indirect methods.

(3) Regarding Fig. 4.1 on page 38. A +/- one standard deviation band is given. It is not clear to me why the single events almost never lie outside this band. For a Gaussian distribution, one would expect about 1/3 of the events to lie outside of one standard deviation.

(4) On page 91, first paragraph, "$l = 1$ (δ_1) and $l = 1$ (δ_2)" should be "$l = 1$ (δ_1) and

$l = 2$ (δ_2)".

(5) One page 91, the dissertation states "The scattering angles were established by Plaga [70] and are widely accepted by the community." I am not sure what this statement means. Elsewhere in the dissertation, Ref. [72] (Tischhauser) is also included. I believe that most workers in the field would agree that [72] is an improvement upon [70], although I am aware of no particular problems with the Plaga data. Also, I believe "scattering angles" should be "scattering phases".

(6) In Fig. 6.1 on page 100, it is not clear how the energy binning for each E_γ is performed.

(7) Page 100. In addition to pointing out and discussing that the data do not agree exactly with the R-matrix fit in Fig. 6.1, it should also be pointed out the data from different E_γ do not agree exactly where they overlap. This must be due to some systematic issue in the data.

In closing, I would like to congratulate Mr. Mateusz Fila for producing an excellent dissertation. I look forward to seeing these results published in a professional journal at some point in the future.

Sincerely,

Carl R. Brune