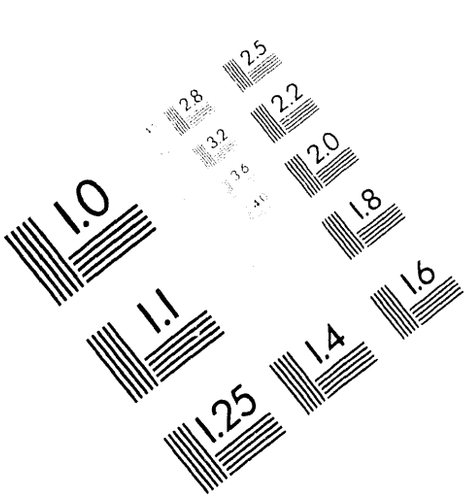

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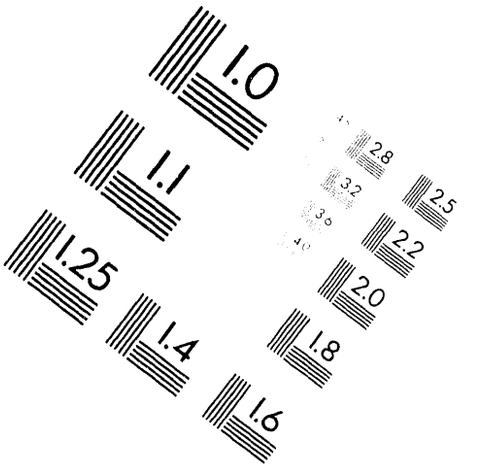

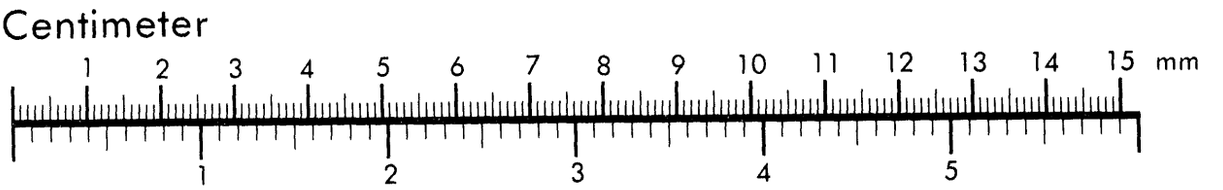

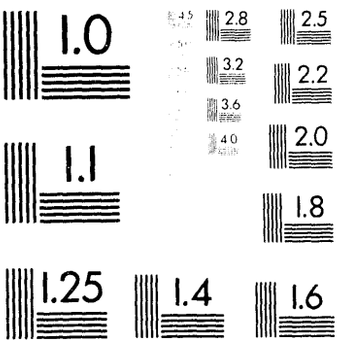

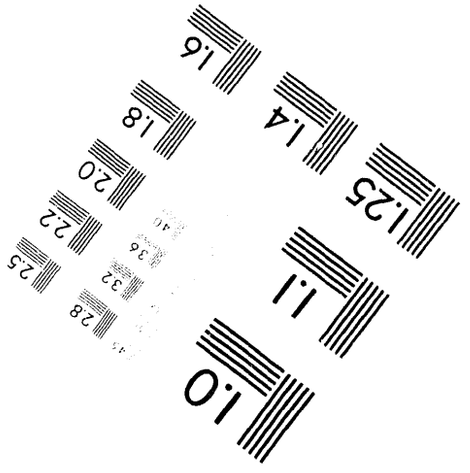

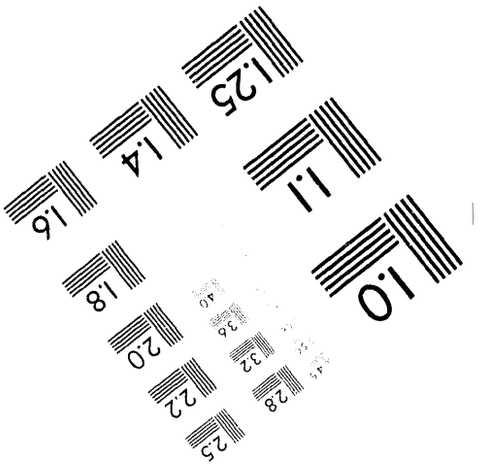

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Title: THE ^{59}Co(n,alpha) REACTION FROM THRESHOLD TO 30 MeV

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THE $^{59}Co(n,\alpha)$ REACTION FROM THRESHOLD TO 30 MeV

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ABSTRACT

Neutron–induced reactions that result in alpha–particle emission have been investigated for the target nucleus ^{59}Co over the neutron energy range from threshold to 30 MeV with the spallation neutron source at WNR/LAMPF. Double–differential cross sections were measured at alpha–particle emission angles of 30, 60, 90 and 135°. Integrated cross sections agree well with activation data below 14 MeV where only the $^{59}Co(n,\alpha)^{56}Mn$ reaction contributes to alpha–particle emission. At higher energies, the integrated alpha–particle emission cross section exceeds the activation data. The results will be interpreted in terms of statistical and pre–compound reaction mechanisms. The sensitivity to nuclear level density parameters will be discussed.

I. INTRODUCTION

The WNR facility provides pulsed beams of neutrons spanning a wide range of neutron energies. A data station at 90° L has been instrumented at 10 m for the study of (n,z) reactions induced by neutrons between 5 and 50 MeV. Recent measure–

ments have been on the neutron–induced alpha particle–producing reactions on ^{59}Co.

Measurements of the emitted alpha particles are particularly important because activation measurements cannot cover all exit channels. For the present case, studies of the activation cross section of ^{56}Mn can give the ^{59}Co(n,α)^{56}Mn cross section and define alpha production at low energy, but channels such as ^{59}Co(n,n'α) and ^{59}Co(n,npα) lead to stable nuclei and cannot be detected using activation. The ^{59}Co(n,nα) reaction is likely to be especially important between 10 and 20 MeV, and its omission would lead to a serious underestimate of the total alpha–particle production cross section.

II. PROCEDURE AND RESULTS

The pulsed beam of WNR allows the energy of the neutron inducing the reaction to be deduced from the time–of–flight over a 10 m flight path. Charged–particle–detection was accomplished through use of a ΔE–E telescope at each of four angles: 30, 60, 90 and 135°. The ΔE detector was a thin window gas proportional and the E

detector was a 500 μm thick silicon detector. This combination can stop alpha particles up to 33 MeV, but the pulses for alpha particles up to 50 MeV can be separated from other particles and used to find the cross section in the 33–50 MeV neutron energy range.

The basic characteristics of the spectra are consistent with a reaction mechanism which is dominantly compound nuclear. At all bombarding energies, the alpha spectrum is peaked near the Coulomb barrier and is nearly isotropic in this energy region, although at energies above 25 MeV a tail extends to higher energies which is somewhat forward peaked. This part is, like the lower portion, fairly smooth. Finally, the total alpha yield rises smoothly with bombarding energy, indicating a tendency for increased excitation energy to yield more low energy particles rather than a constant number with increasing average energy.

At neutron energies below E_n = 12 MeV, where the only alpha–particle production comes from the $^{59}Co(n,\alpha)^{56}Mn$ reaction, the present cross section agrees well with activation data. Because of the large number of activation measurements in this region (a dozen or so), they are not presented here but rather by the evaluated ENDF/B–VI curve. At energies above 14 MeV, activation data do not include other alpha–particle production channels. Our data shows a much smoother increase with energy then ENDF/B–VI for the integrated alpha–production cross section. The evaluation shows a cusp at about 16.5 MeV bombarding energy which is not seen in the data.

Previous total alpha–emission measurements have been made by Fisher et al.[1] These were made at E_n = 14.1 MeV and are based on a particularly complete angular distribution (16 angles). As can be seen from Fig. 2, very good agreement can be seen for the integrated cross section.

A calculation of the alpha cross section based on an assumed compound nucleus reaction mechanism with preequilibrium corrections[2] was made using the code GNASH.[3] Reactions from a Fermi gas

parameters of Gilbert and Cameron[4] were used. It was necessary to lower the nuclear temperature inferred from matching the Gilbert and Cameron Fermi gas parameters with the known level structure of ^{56}Mn by about 350 keV to match the peak of the alpha spectra. As can be seen in Fig. 1 good agreement between calculation and data is found at energies below 40 MeV. The slight fall off in the calculation compared to data at higher energies may indicate a need for more compound nuclei in the calculation or perhaps results from inadequacy of the optical model potentials used at higher energies.[5]

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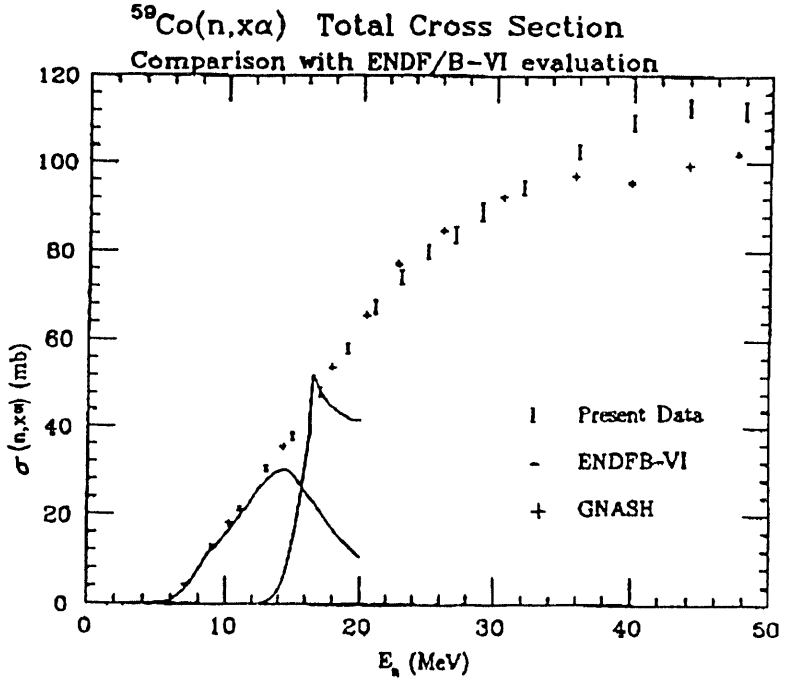

Fig. 1: Angle and outgoing–energy integrated cross section for $^{59}Co(n,x\alpha)$ as a function of neutron energy. The results are compared with the calculations using GNASH described in the text. Also shown is the ENDFB–VI evaluation, with the lowest energy peak denoting the $^{59g}Co(n,\alpha)^{56}Mn$ reaction and the second peak the $^{59}Co(n,n'\alpha)^{55}Mn$ reaction.

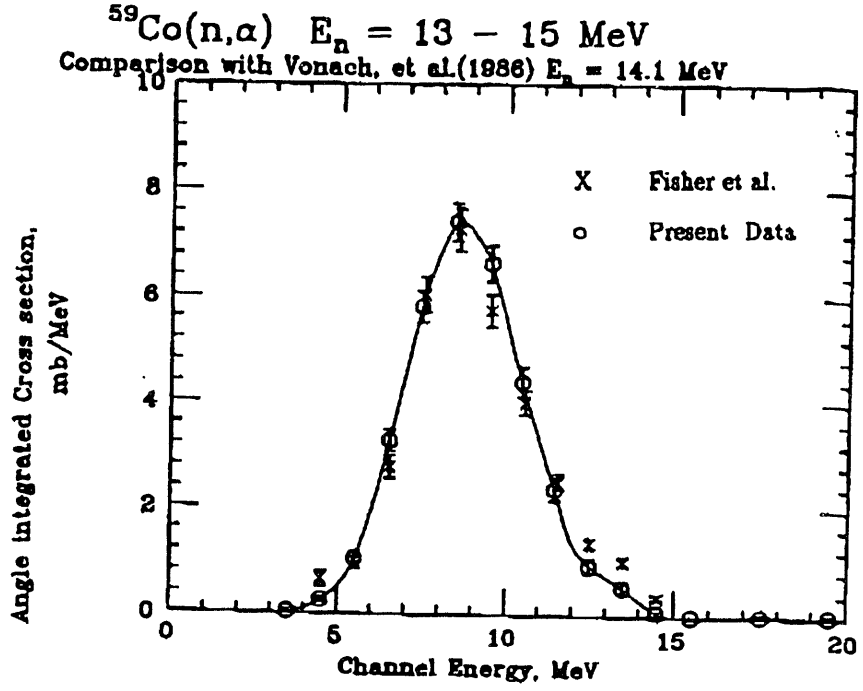

Fig. 2: Comparison of the shape and magnitude of the $^{59}Co(n,x\alpha)$ cross section at 14 MeV with the results of Fischer et al.

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