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### SOME FURTHER EVIDENCE ON TERNARY FISSION

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#### Summary

*The angular distribution of  $^{24}\text{Na}$  formed from proton induced fission of natural uranium suggests that the mechanism is true ternary fission.*

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Recently in this laboratory, Alstad *et al.*<sup>1</sup> measured the cross section of formation of  $^{28}\text{Mg}$  and  $^{24}\text{Na}$  from 170 MeV proton induced fission of uranium. The yields of these nuclides were shown to result from ternary fission. In addition, Johansen<sup>2</sup> has measured the yields of  $^{24}\text{Na}$  from proton fission of uranium as a function of excitation energy. The excitation function curve of  $^{24}\text{Na}$  has the same general trend as previously observed<sup>3</sup> for  $^{28}\text{Mg}$  and  $^{38}\text{S}$ . Iyer and Cobble<sup>3</sup> suggested that both  $^{28}\text{Mg}$  and  $^{38}\text{S}$  resulted from ternary fission.

In order to obtain further evidence for ternary fission, we have studied the angular distribution of  $^{24}\text{Na}$  as function of excitation energy. The recoil technique has been employed and the experimental arrangement is shown in Fig. 1. The target foil T had dimensions  $0.9 \times 1.8 \text{ cm}^2$  and the catcher foils  $f_c$ , blank foils  $f_b$  as well as guard foils  $f_g$  had dimensions  $1.0 \times 2.0 \text{ cm}^2$ . The carbon foils were 0.005 cm thick. The impurities in the uranium target and carbon foils were very small<sup>4</sup>.

Irradiations were performed at the 170 MeV proton synchrotron at the Gustaf Werner Institute, Uppsala. After each irradiation, the recoil assembly was transported to the Department of Chemistry at the University of Oslo for analysis of its  $\gamma$ -radiation. The decay of  $\gamma$ -activities was followed with a  $25 \text{ cm}^3 \text{ Ge (Li)}$  detector in conjunction with a 4096 ADC Laben. The Laben ADC was connected to a NORD 1 computer to allow recording of spectral data on magnetic tape. All catcher foils were measured in the same geometry for a period of 4-6 hours. The spectral data were recorded on magnetic tape

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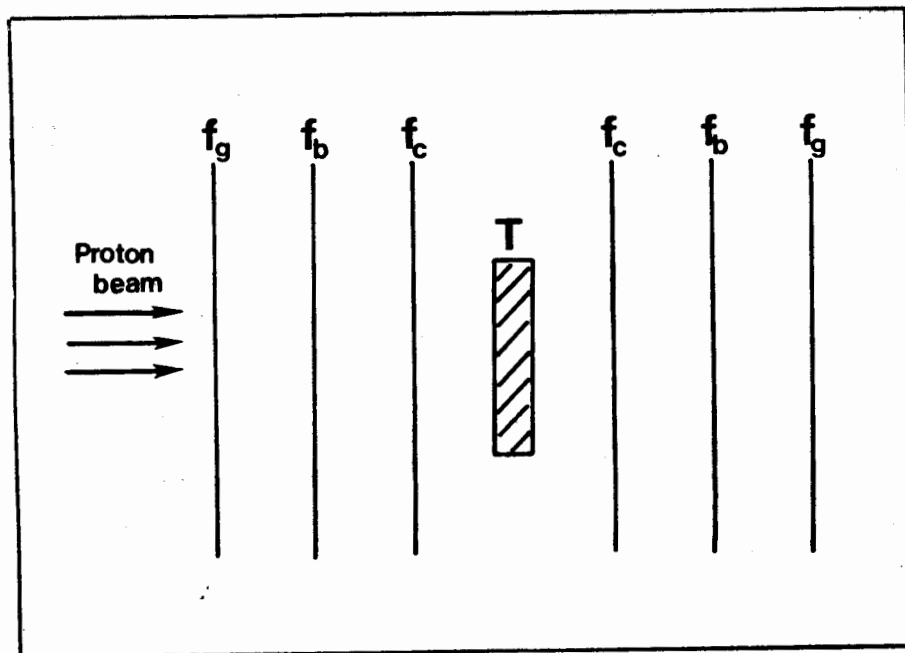


Fig. 1 The recoil assembly. For explanation see text.

and subsequently analysed with the CDC 3300 computer using a GAMMANL programme<sup>5</sup> to locate the peaks and to calculate net peak areas after subtraction of background.

When the blank foils were analysed for  $\gamma$ -activities no  $^{24}\text{Na}$  was found. Results of forward to backward ratios (F/B) of the yields of  $^{24}\text{Na}$  in the catcher foils are given in the table below.

TABLE I

Proton Energies (MeV)	F/B
100	$1.27 \pm 0.13$
150	$1.19 \pm 0.22$

The evidence seems to show that the angular distribution of the formation of  $^{24}\text{Na}$  is isotropic and independent of excitation energy. The independence of excitation energy could not be observed for spallation. Muzychka *et al.*<sup>6</sup> have proposed that there are two possible mechanisms in ternary fission, the cascade fission and true ternary fission. In our work, the experimental observations on the mass distribution<sup>1</sup>, cross section for

production of  $^{24}\text{Na}$  and its excitation function<sup>2</sup> as well as angular distribution of  $^{24}\text{Na}$ , suggest that the mechanism for this process is true ternary fission.

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### บทคัดย่อ

การกระจายเชิงมุมของ  $^{24}\text{Na}$  จากการแตกตัวของยูเรเนียมในธรรมชาติโดยโปรตอนชักนำ บ่งให้เห็นว่ากลไกเป็นการแตกออกเป็นสามส่วนอย่างแท้จริง