Fission study using multinucleon transfer reactions

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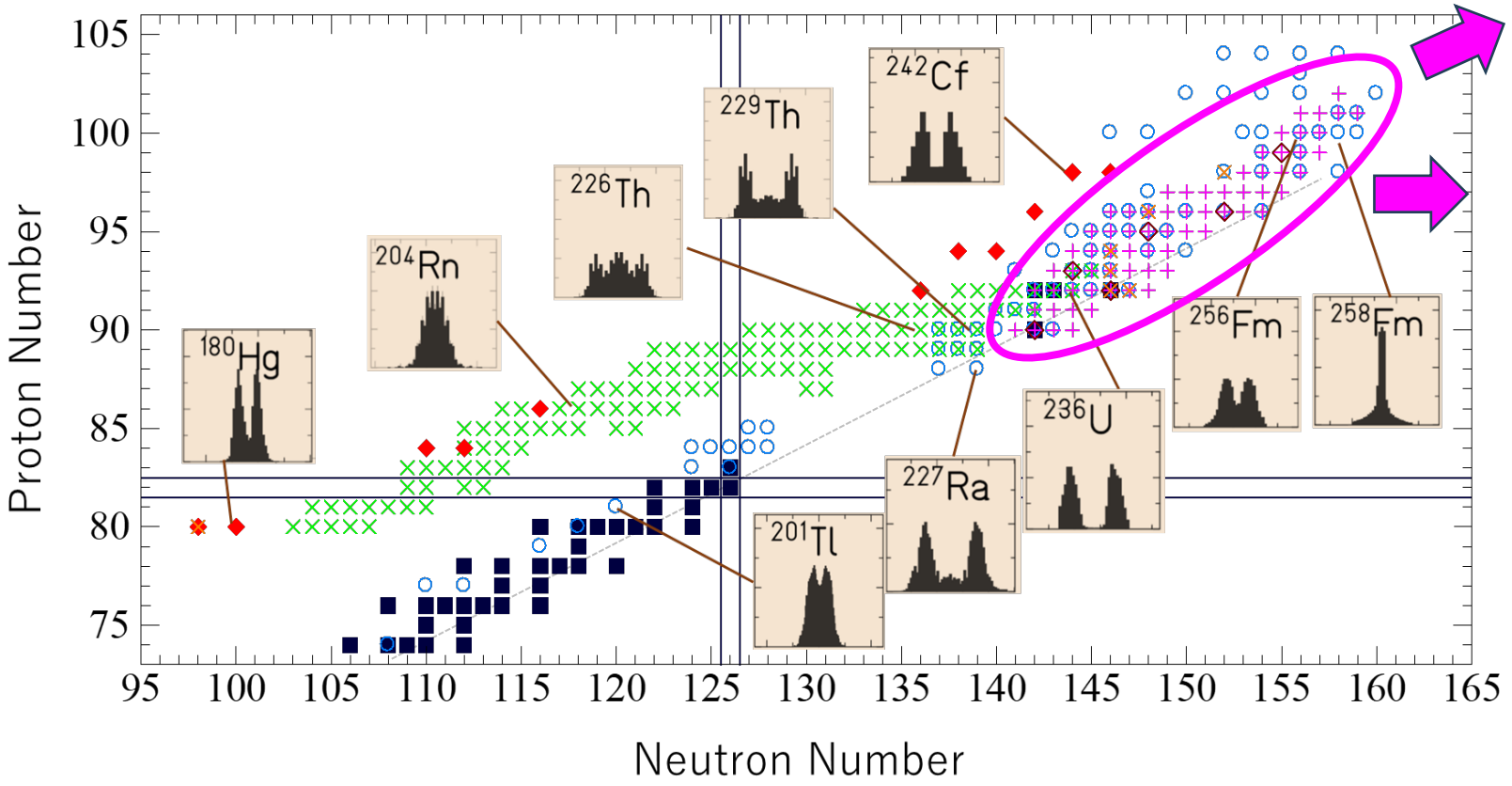
Contents

- ☑ Multinucleon transfer (MNT) reaction for fission study
- ☑ Multichance fission
- ☑ Average spin of compound nucleus produced in MNT reaction
- ☑ Summary

Experiments at the JAEA tandem facility in Tokai, Japan.

Measured fission-fragment mass/charge distributions (2021)



○ n, p capture fission, SF

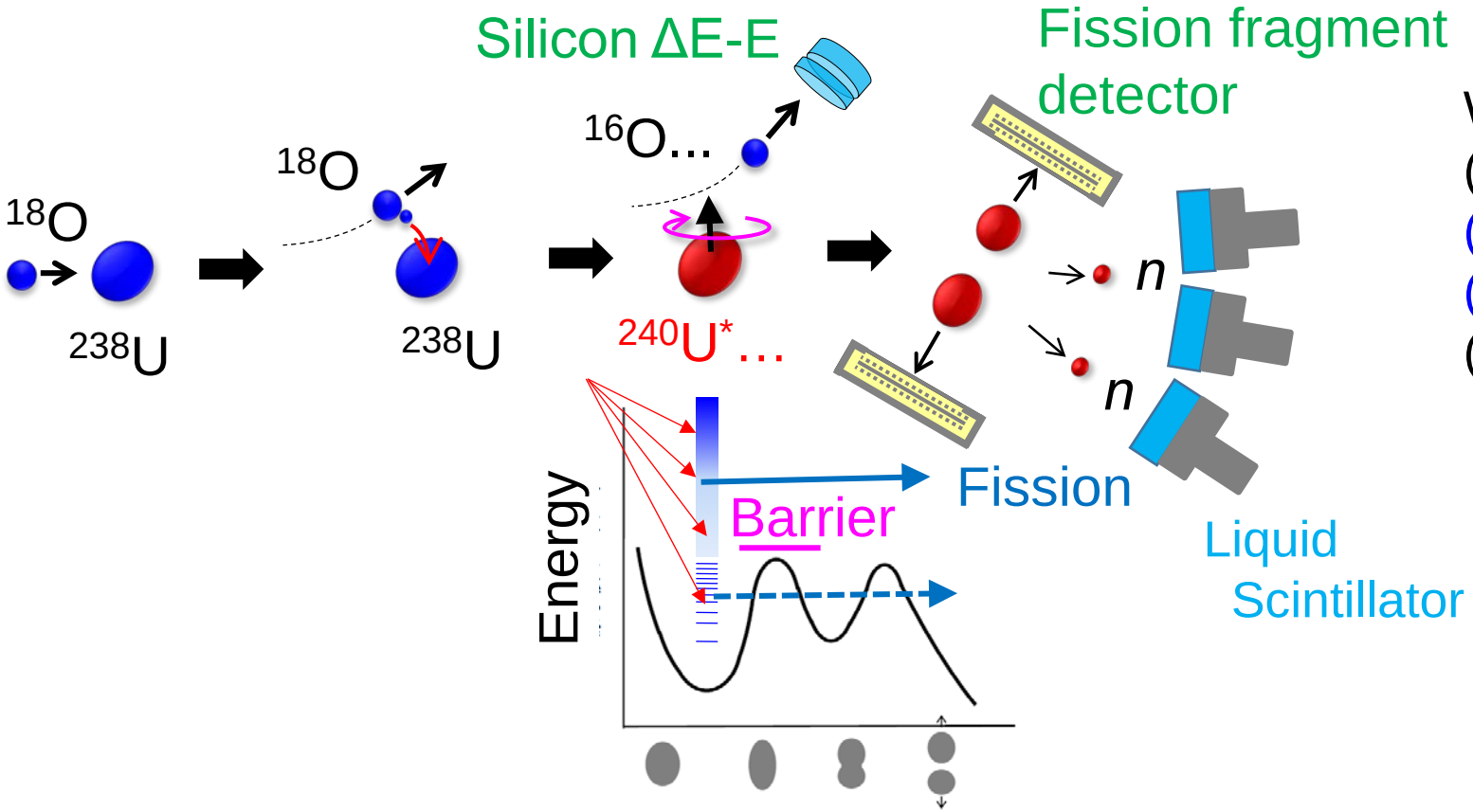
× Coulex-induced fission

◆ β^- -delayed fission

＋ Multinucleon-transfer induced fission
（ Present ）

K. Nishio “*Multinucleon-Transfer-Induced Fission*”, Handbook of Nuclear Physics, Springer Nature

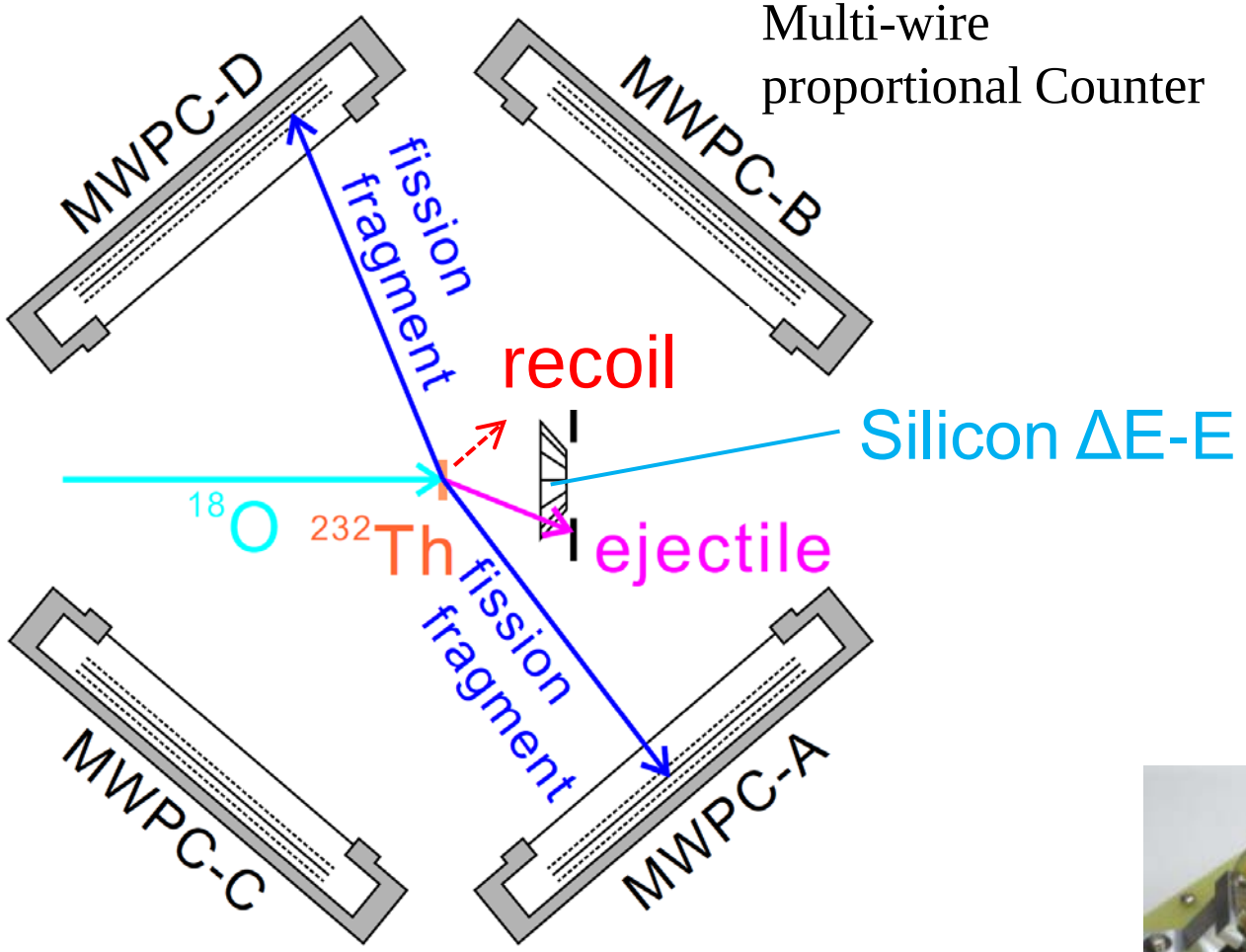
MNT induced fission

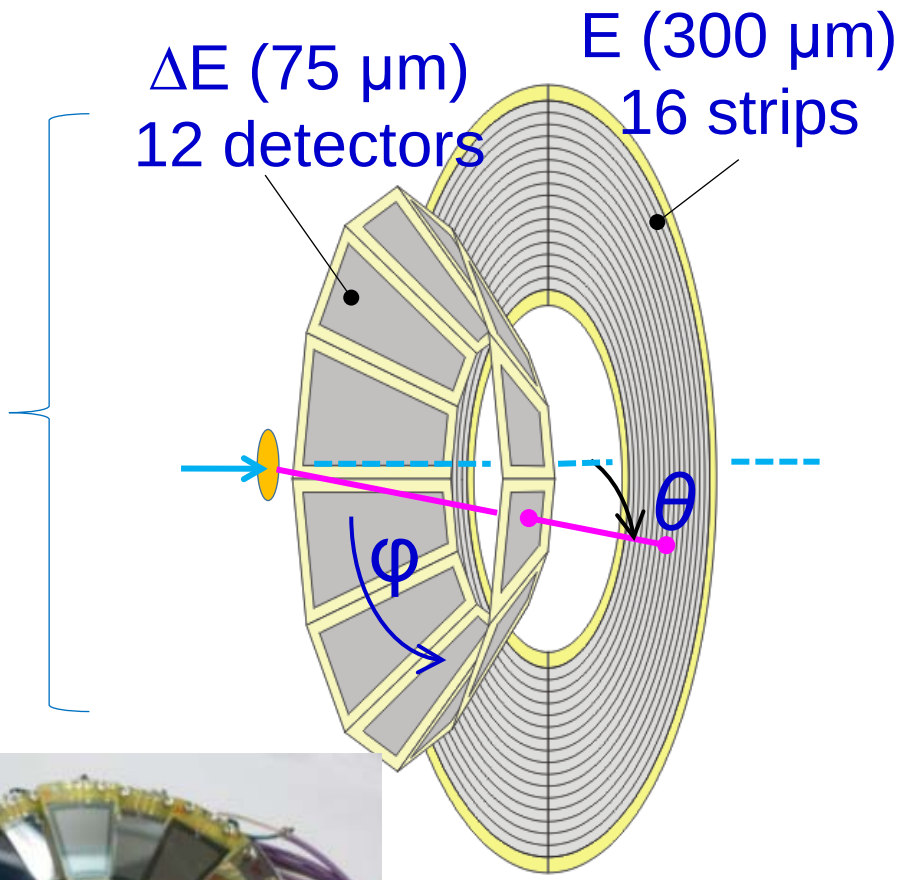


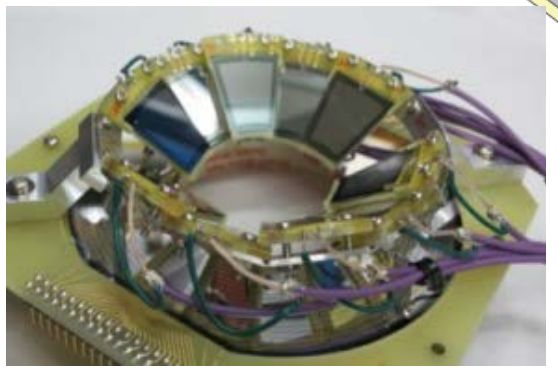
We can obtain
(1) Fission barrier height
(2) Fission fragment mass distributions
(3) Fission fragment angular distribution
(4) Neutron multiplicity in fission

A.N. Andreyev, K. Nishio, K.-H. Schmidt, Rep. Prog. Phys. **81**, 016301(2018*).*

Experimental setup



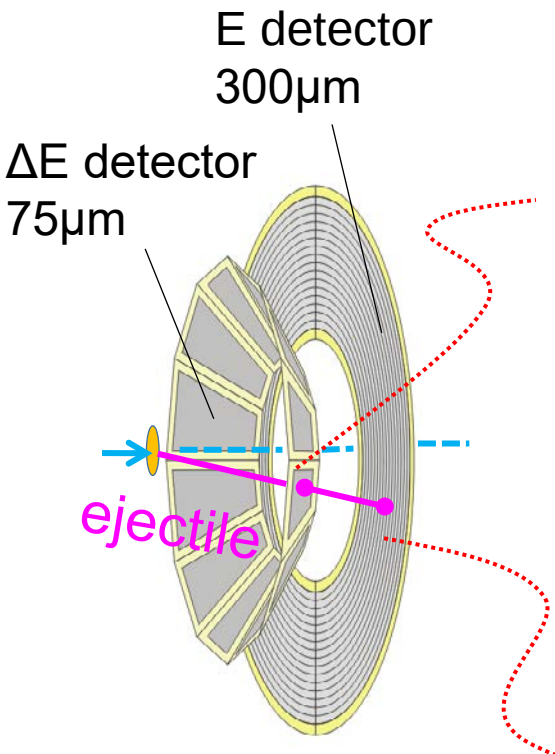


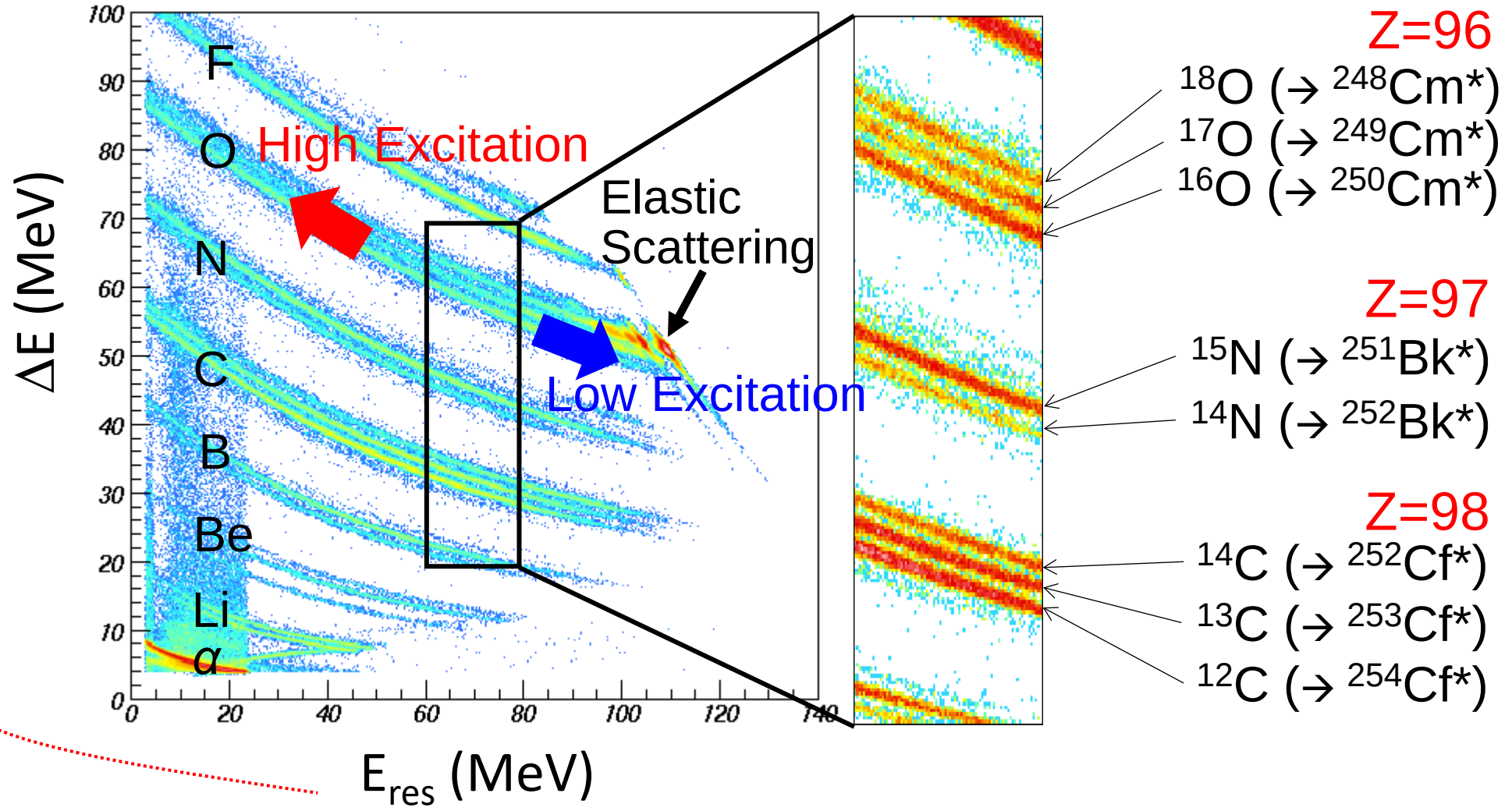


R. Léguillon *et al.*, Phys. Lett. B **761**, 125 (2016).

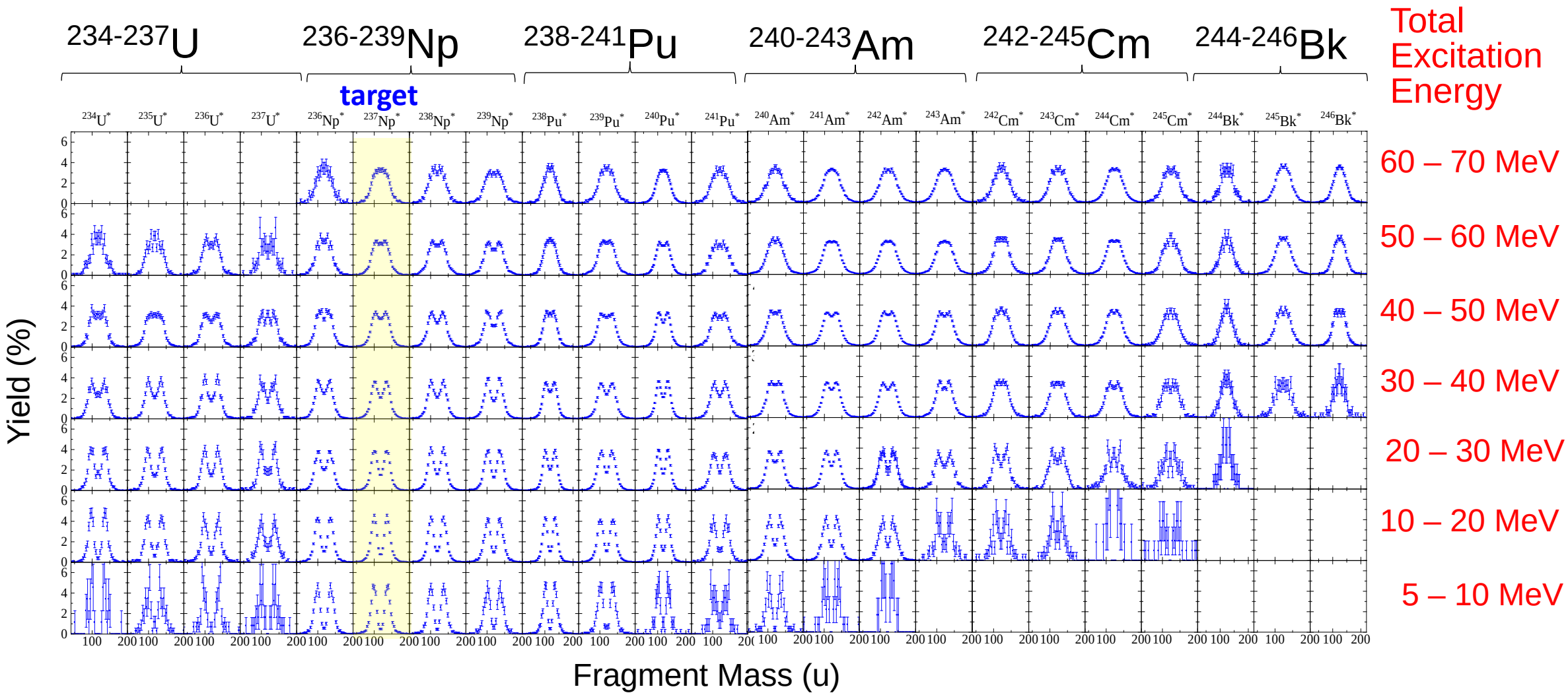
Particle identification using ΔE–E telescope

$^{18}O + {}^{248}Cm$
(E_{beam}= 162MeV)



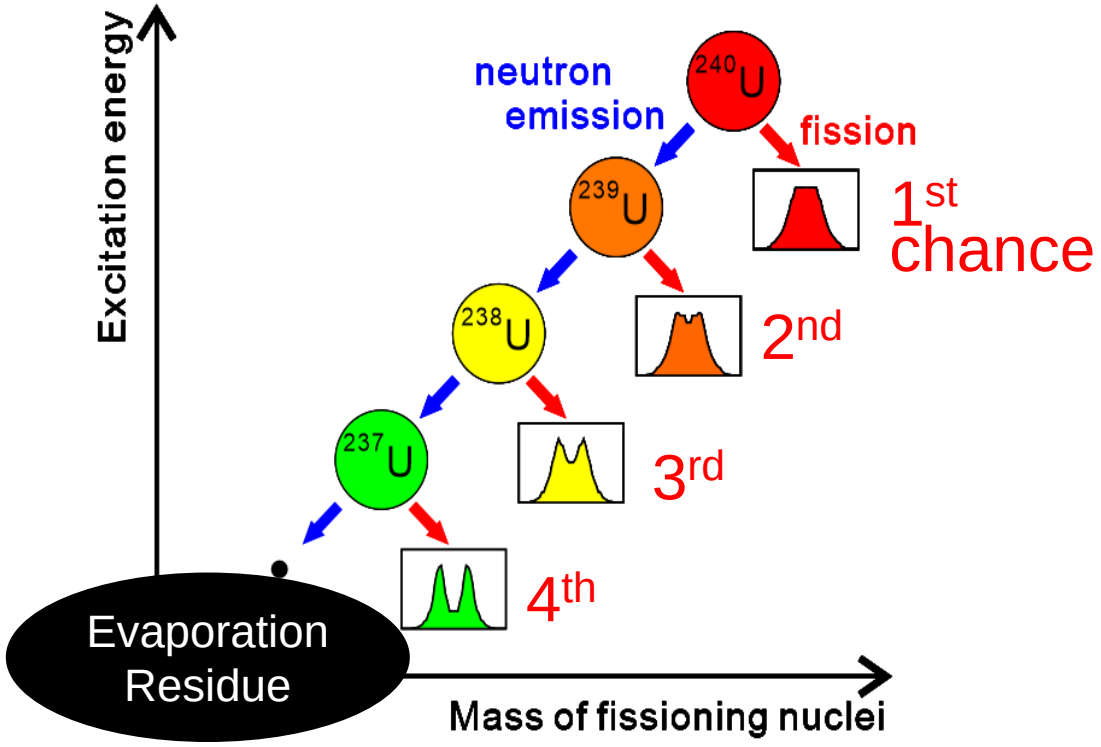


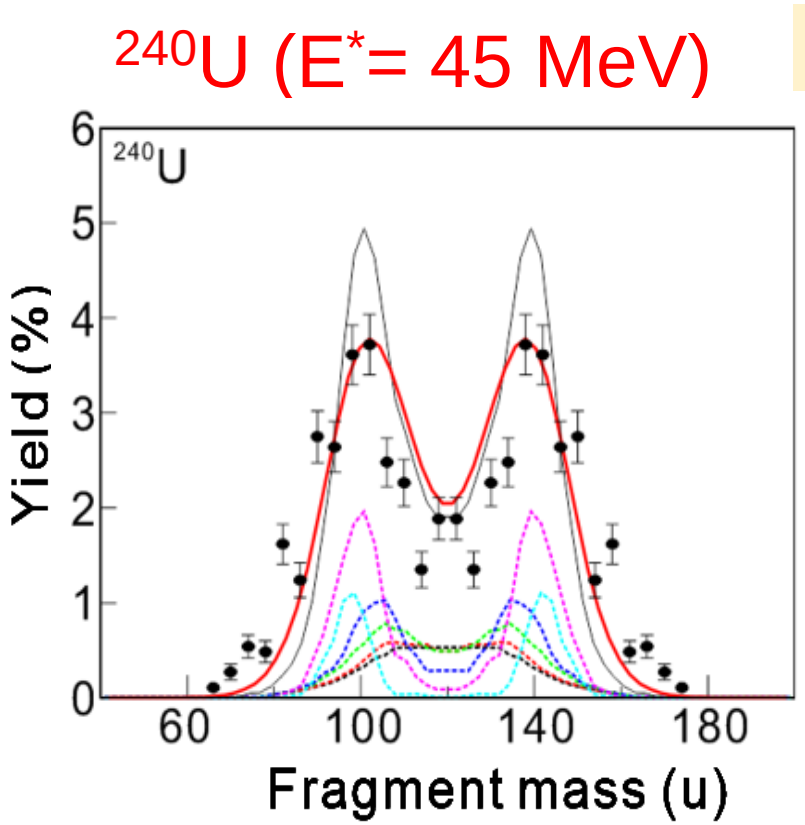
Fission fragment mass distributions obtained in MNT reactions of ^{18}O + ^{237}Np



M.J. Vermeulen et al., Phys. Rev. C **102**, 054610 (2020).

Effects of multichance fission on fission fragment mass distributions





Langevin Calculation

Sum (broadened)

Probability determined by the GEF ode

1st (^{240}U 12.6%)
2nd (^{239}U 13.6%)
3rd (^{238}U 16.8%)
4th (^{237}U 18.2%)
5th (^{236}U 27.1%)
6th (^{235}U 11.7%)

K. Hirose *et al.*, Phys. Rev. Lett., **119**, 222502 (2017).

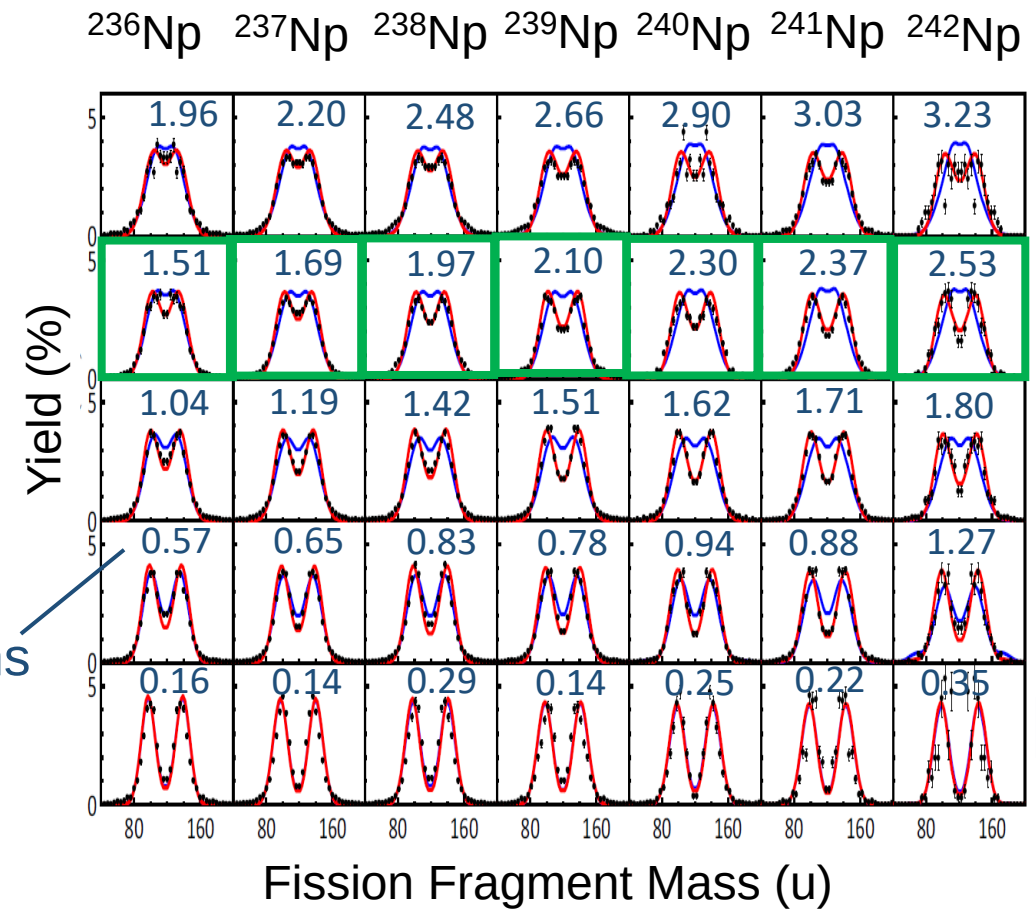
Neutron emission before fission (Multichance fission)

Experimental data

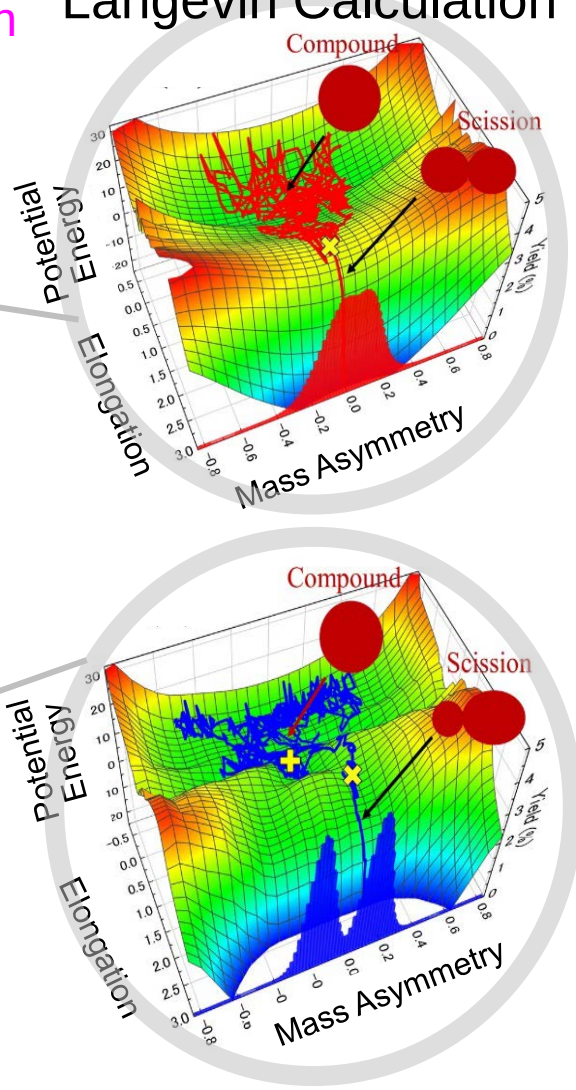
Calcu. Without Multichance Fission

Calcu. With Multichance Fission

Average number of neutrons emitted before fission (Calculated by GEF2016)

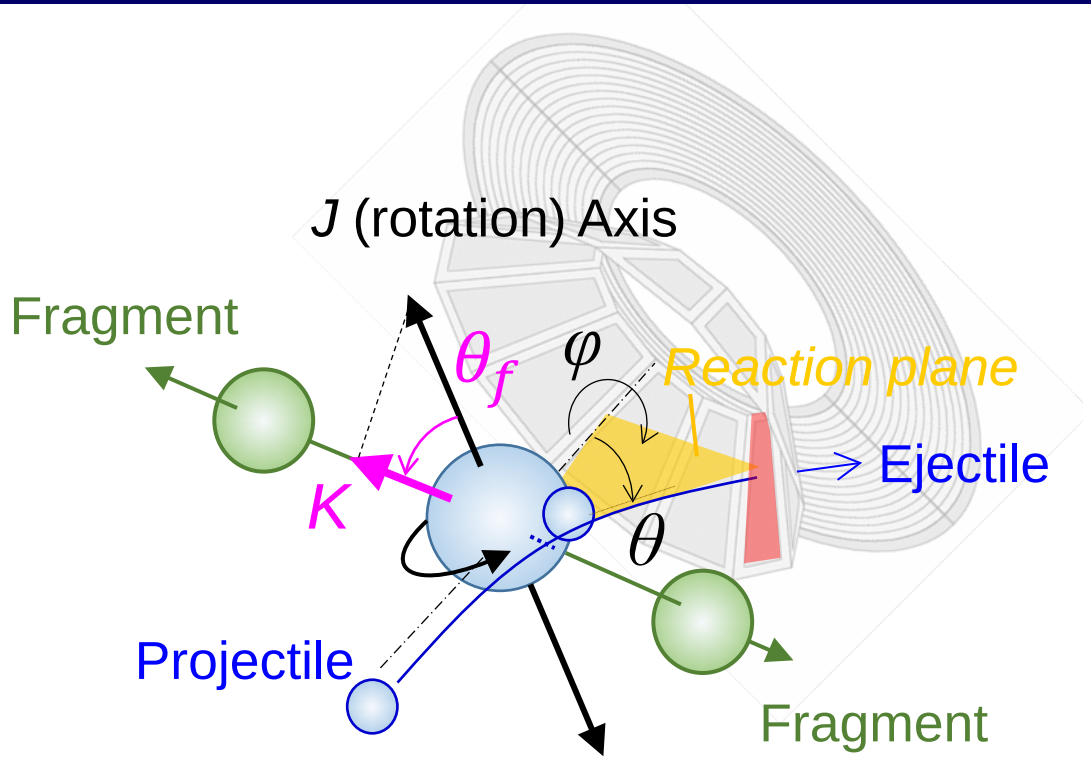


Langevin Calculation

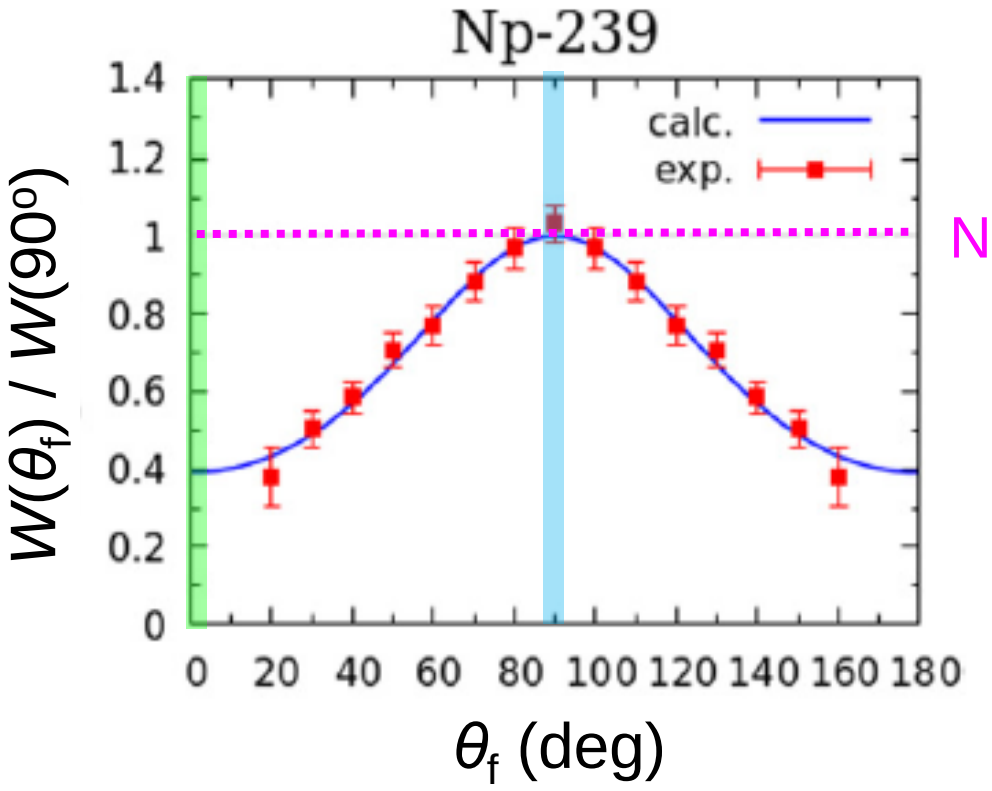


S. Tanaka et al., Phys. Rev. C **100**, 064605 (2019).

Fission fragment angular distribution



$^{237}Np(^{18}O,^{16}O)^{239}Np^*$ fission



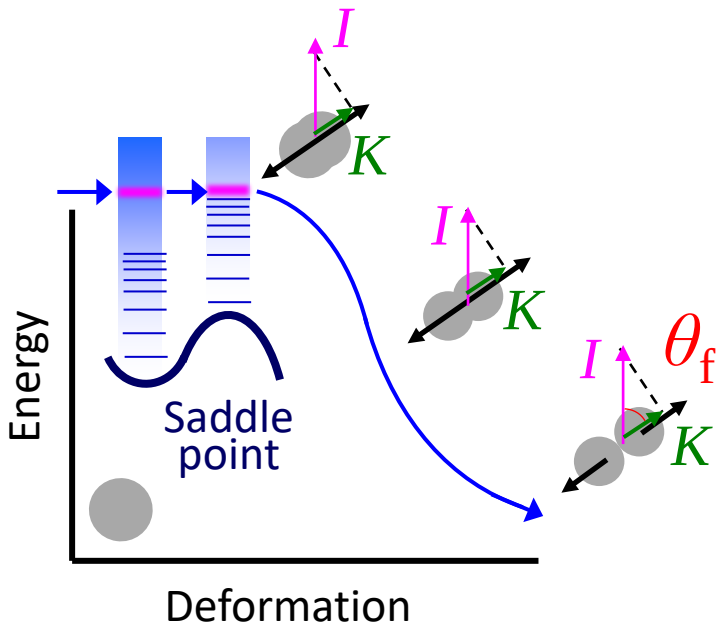
No Rotation

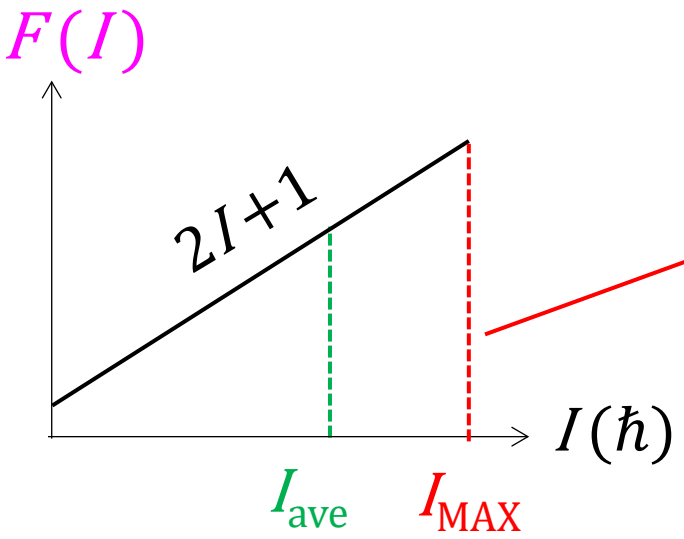
S. Tanaka et al., Phys. Rev. C **105**, L021602 (2020).

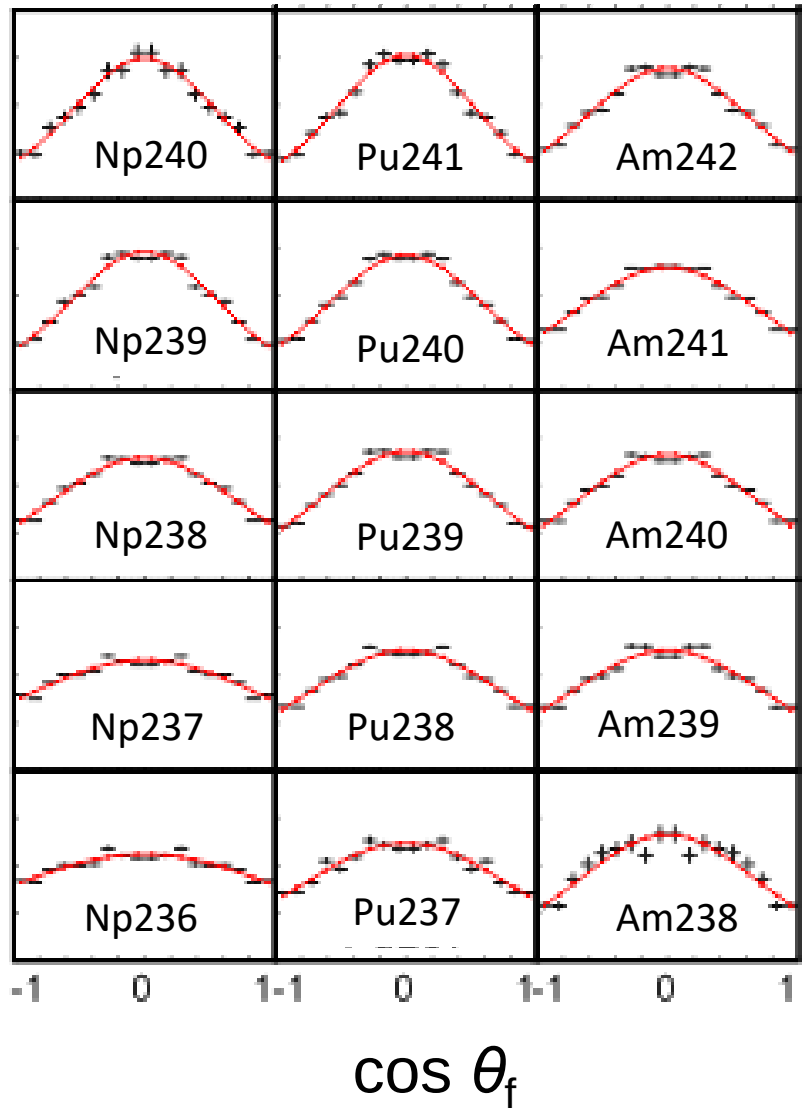
Average spin obtained from fission fragment angular distribution

Statistical saddle point model.

$$W(\theta_f) = \sum_{I=0}^{\infty} F(I) \sum_{K=-I}^{+I} \left\{ \frac{(2I+1)|d^I_{\pm IK}(\theta_f)|^2 e^{-\frac{K^2}{2K_0^2}}}{\sum_{K=-I}^{+I} e^{-\frac{K^2}{2K_0^2}}} \right\}$$







J.R. Huizenga et al., Phys. Rev. **177**, 1826 (1969)

Conclusion

☑ Multinucleon transfer reaction gives fission data more than 20 nuclei, and their excitation-energy dependence can be obtained.

☑ Concept of multichance fission needs to be introduced in fission model.

☑ Average angular momentum of compound nucleus increases with number of transferred nucleons. But it shows a saturating trend.

Thak you