2020東海・重イオン科学シンポジウム—タンデム加速器成果報告会—,
2020年1月15－16日, 原子力機構, 東海村

オンライン同位体分離装置ISOLを用いた重アクチノイド核の核分裂・核構造研究

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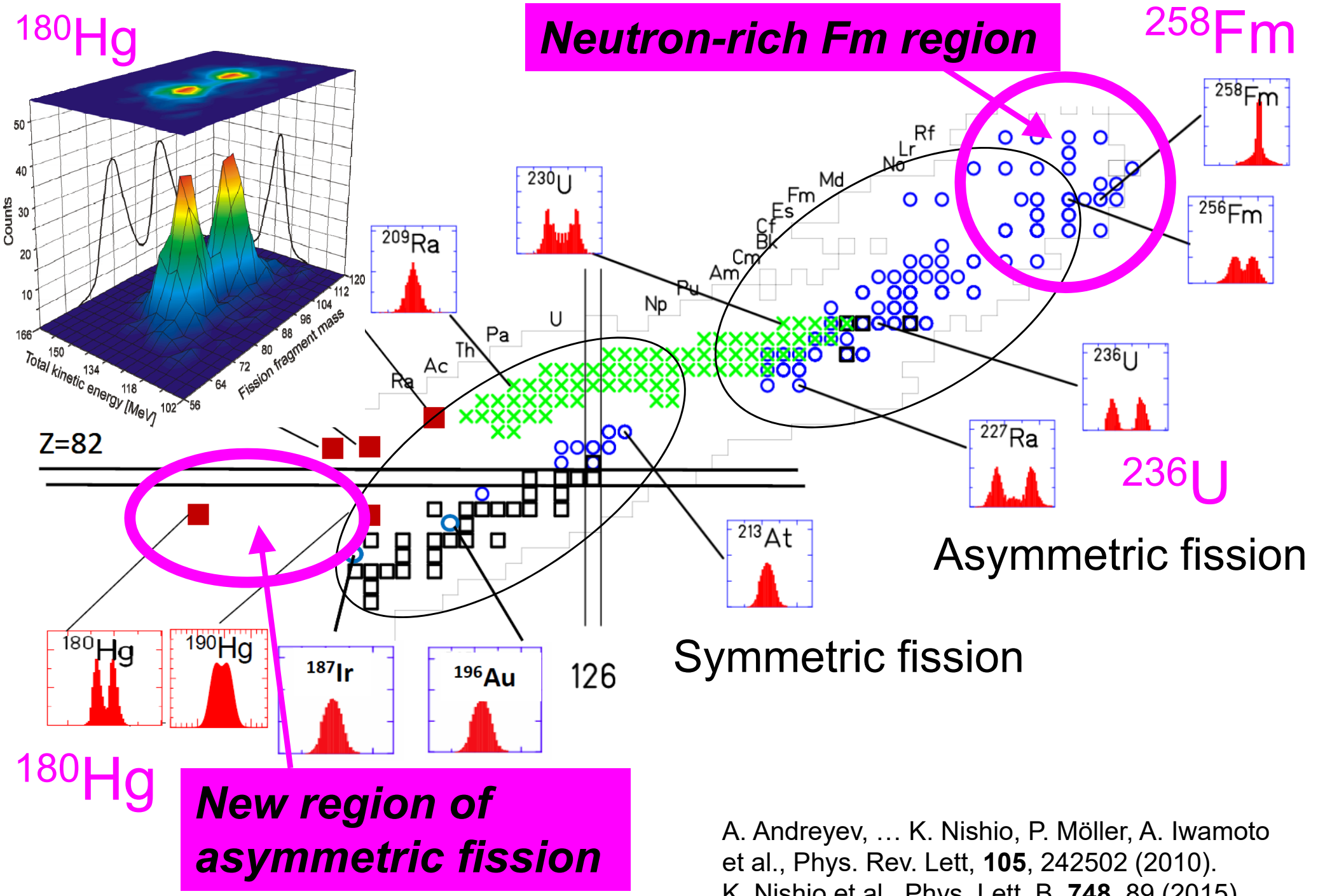
1. 中性子過剰Fm領域核の自発核分裂測定
2. 中性子欠損核^{234}AmのEC崩壊核分光

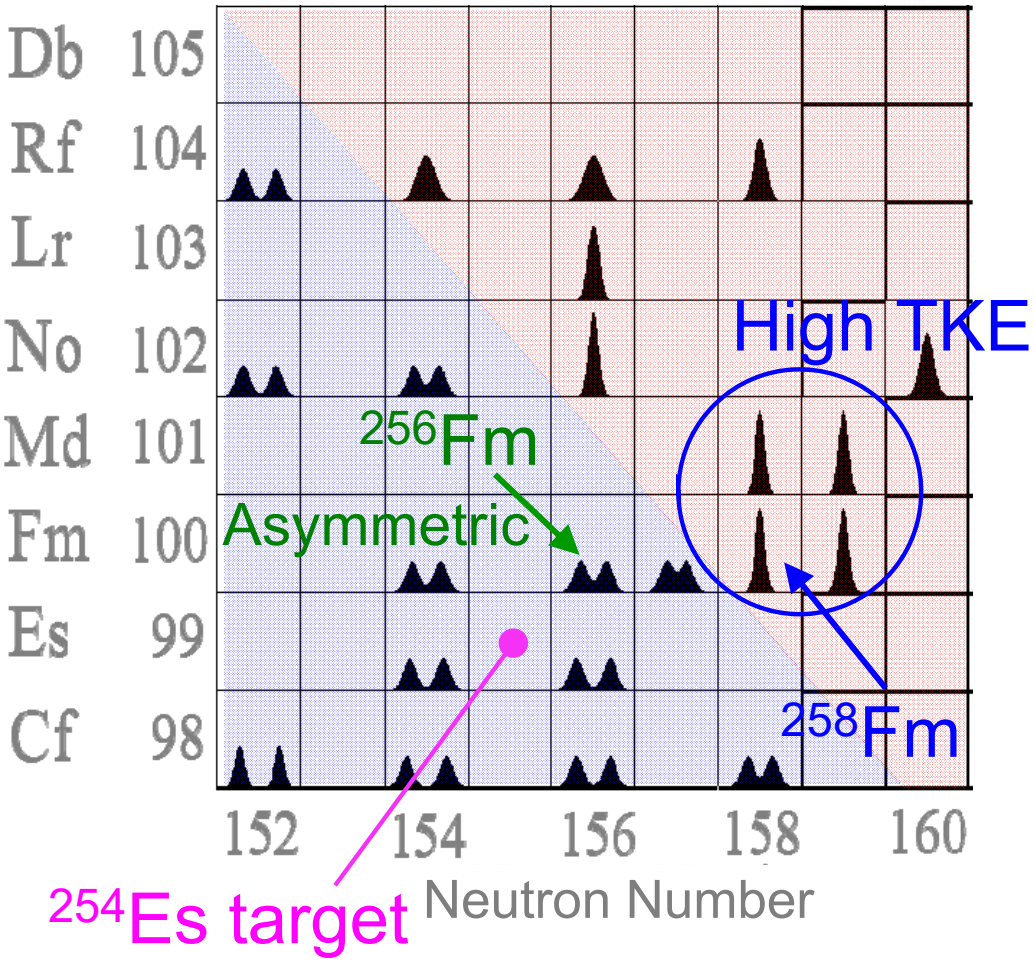
Landscape of nuclear fission



A. Andreyev, … K. Nishio, P. Möller, A. Iwamoto et al., Phys. Rev. Lett, **105**, 242502 (2010).
K. Nishio et al., Phys. Lett. B, **748**, 89 (2015).

Fission studies in the Fm region

Fission-fragment mass distribution

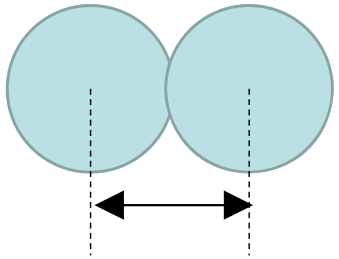


^{256}Fm ⇔ ^{258}Fm

Asymmetric — Symmetric

High TKE

$^{264}Fm = {}^{132}Sn + {}^{132}Sn$



Both fragments are spherical
Compact configuration

⇓

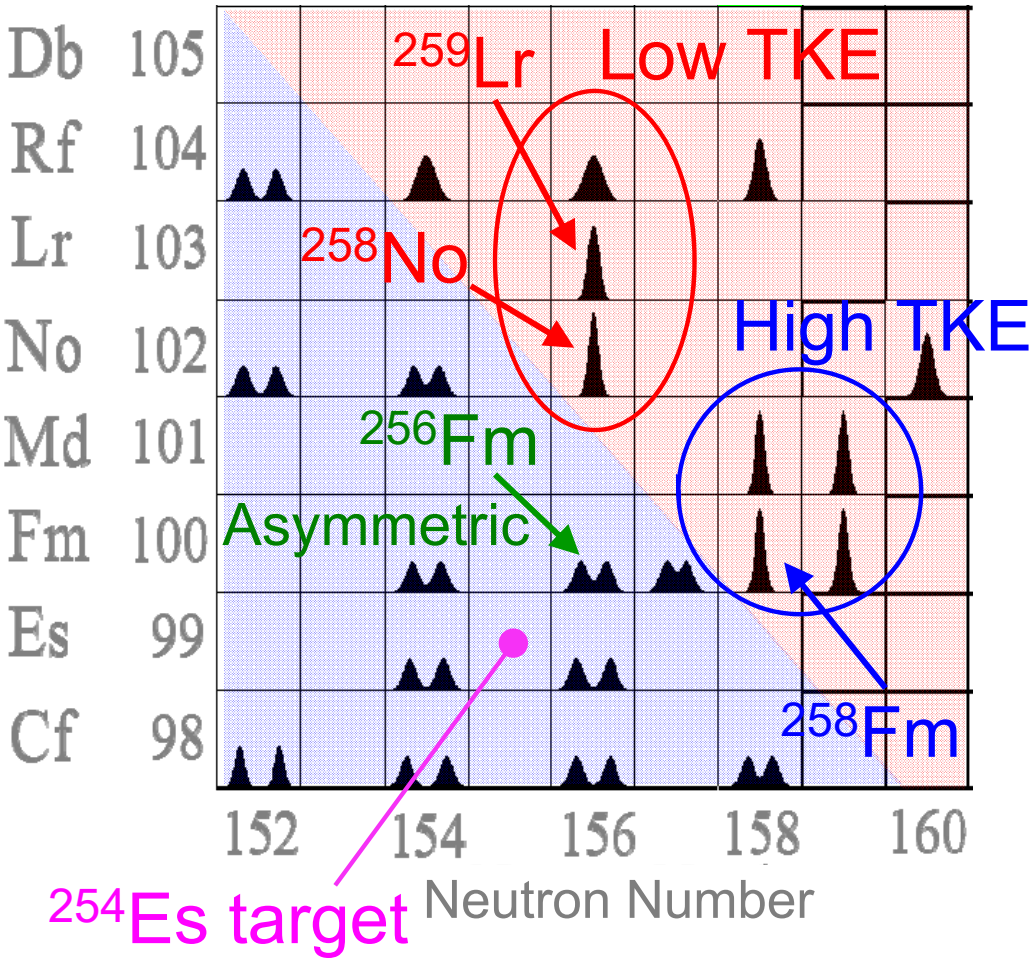
High TKE

TKE: Total Kinetic Energy

M.R. Lane et al., PRC 53 (1996) 2893.

Fission studies in the Fm region

Fission-fragment mass distribution

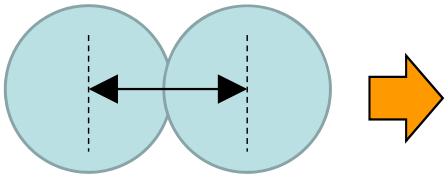


^{258}Fm ⇔ ^{258}No, ^{259}Lr

Symmetric — Symmetric

High TKE — Low TKE

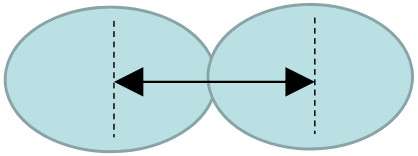
$^{258}Fm = {}^{129}Sn + {}^{129}Sn$



High TKE

Spherical + Spherical

$^{258}No = {}^{129}Sb + {}^{129}Sb$

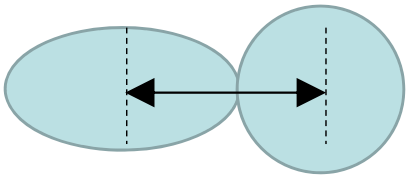


Low TKE

Deformed + Deformed

Three types of fission coexist

^{256}Fm

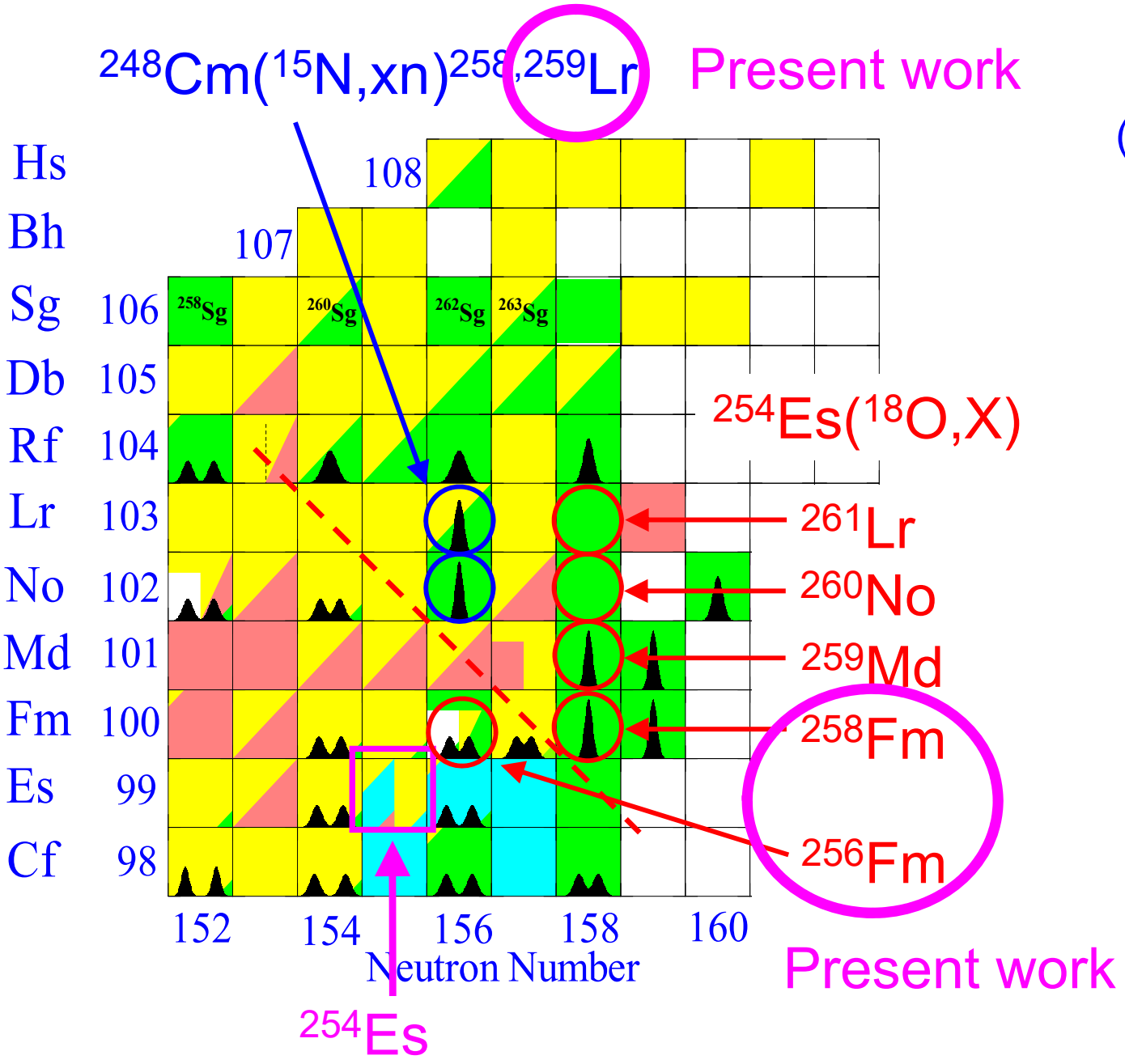


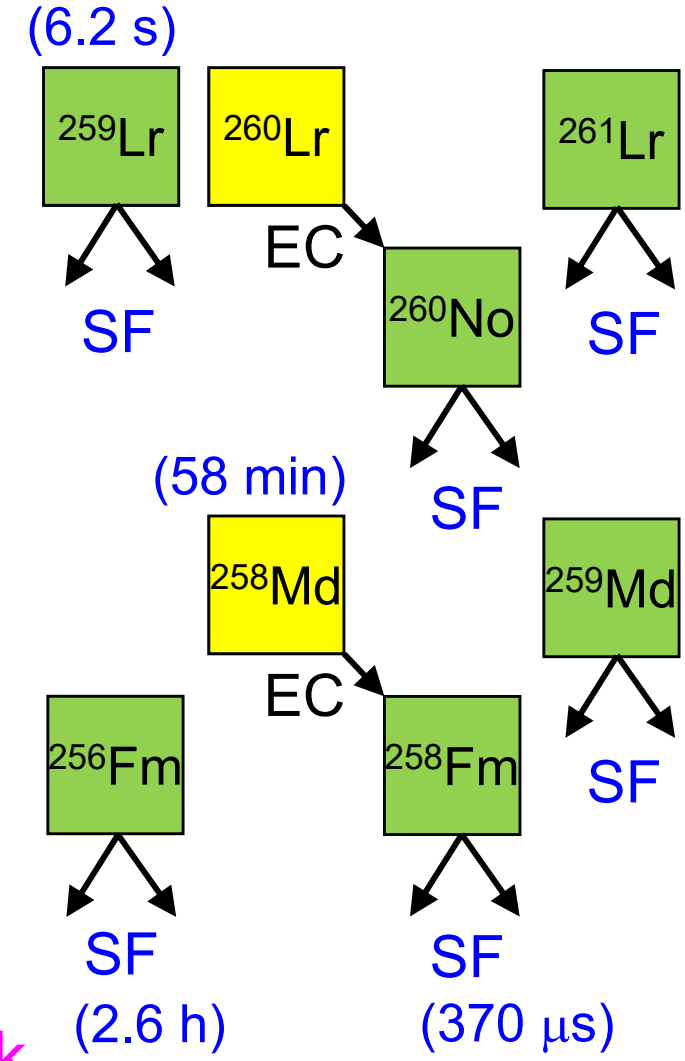
Asymmetric

Deformed + Spherical

M.R. Lane et al., PRC 53 (1996) 2893.

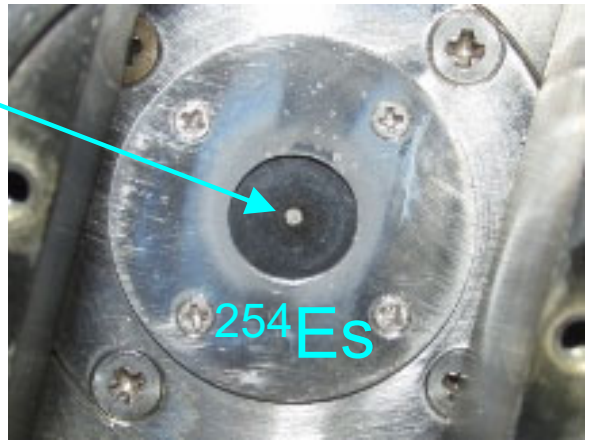
SF measurements for Fm, Md, No, and Lr isotopes using ^{254}Es target and JAEA-ISOL

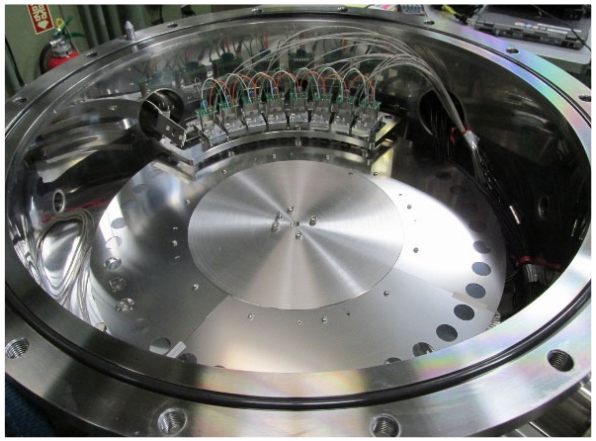




Spontaneous fission measurements using ^{254}Es target

^{254}Es target
0.8 mmϕ (30 ng)





Rotating wheel system

He/CdI_2 gas

Target ^{254}Es

^{197}Au

Beam ^{18}O

120 MeV

Md

Reaction products

^{254}Es(^{18}O,X)^{258m}Md→^{258}Fm

^{258m}Md

Si detectors

257

259

JAEA Tandem Accelerator

Surface ion source

Magnet

Gas-jet transport

M^+

Differential pumping

Extractor

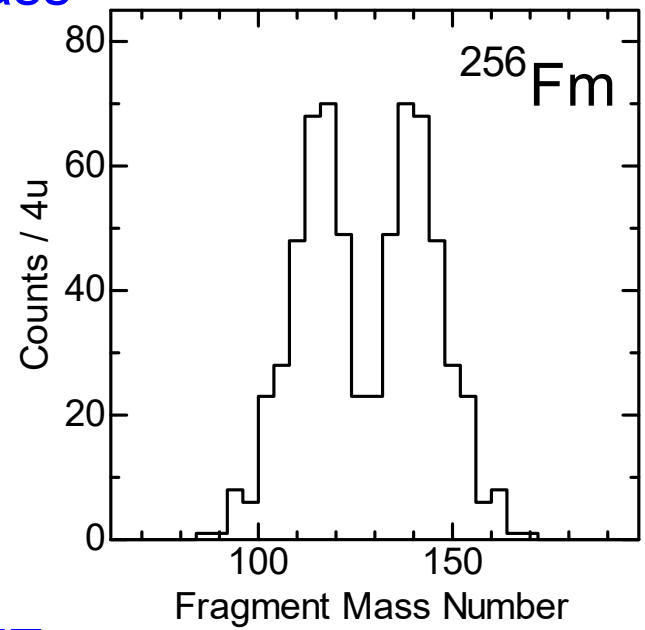
On-line isotope separator (JAEA-ISOL)

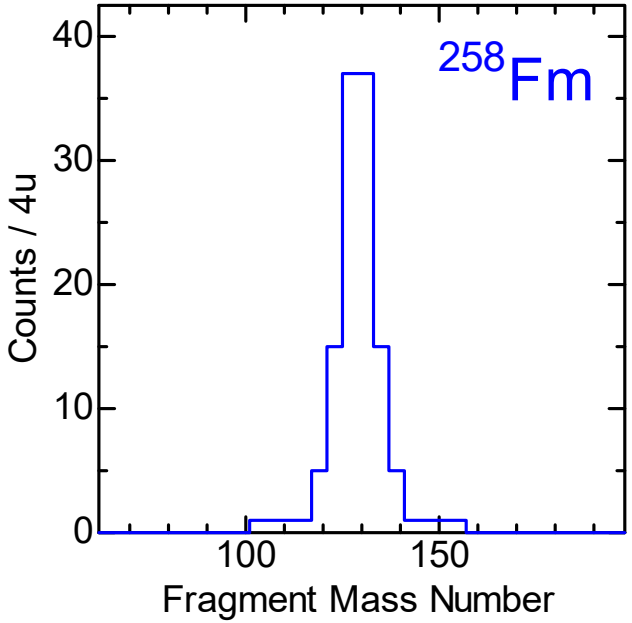
Fragment mass and TKE distributions for SF of ^{256,258}Fm and ^{259}Lr

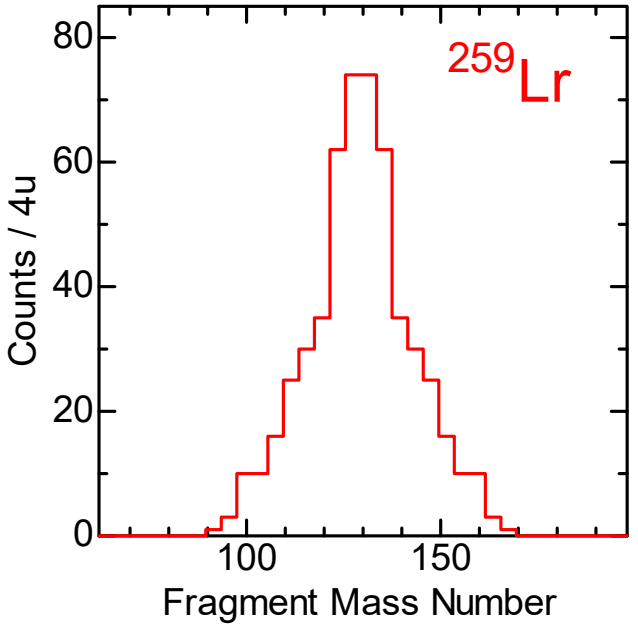
^{254}Es(^{18}O,X)^{256,258}Fm

^{248}Cm(^{15}N,4n)^{259}Lr

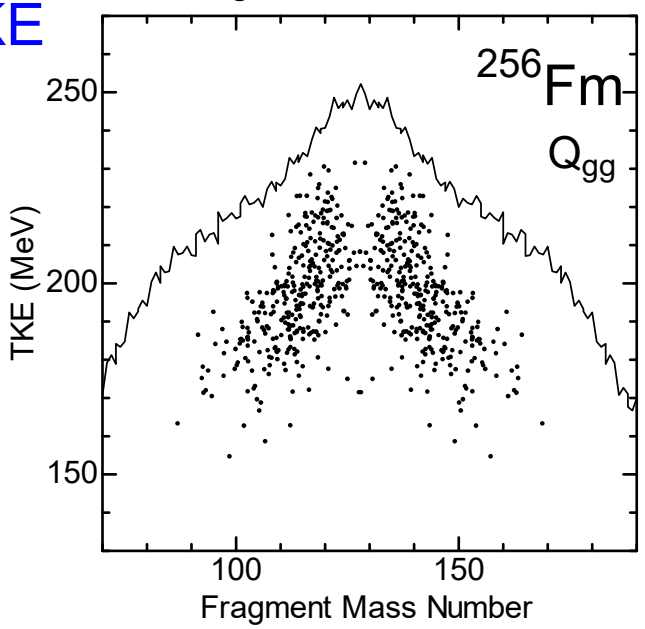
Mass

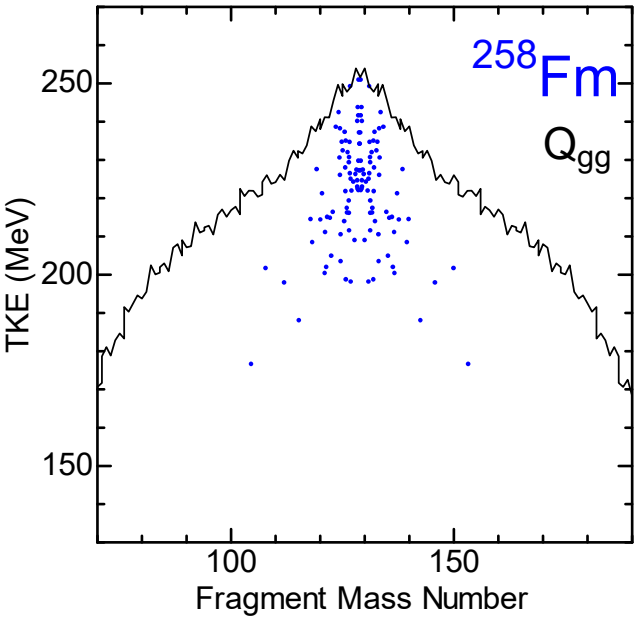


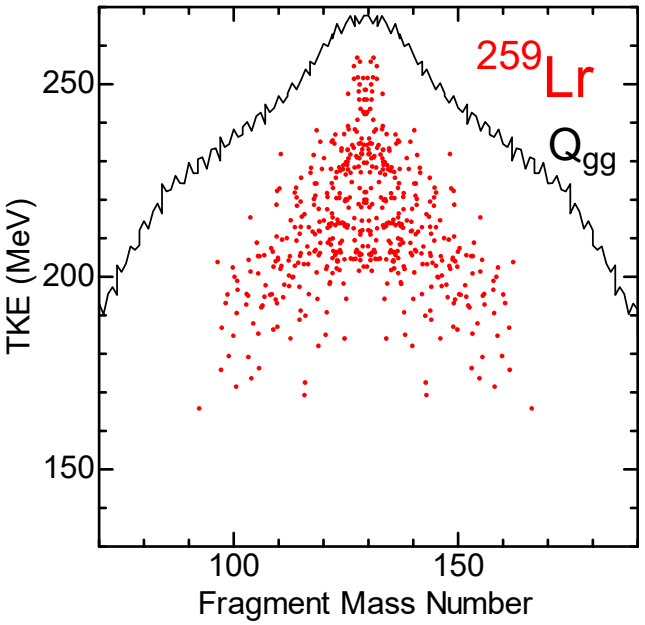




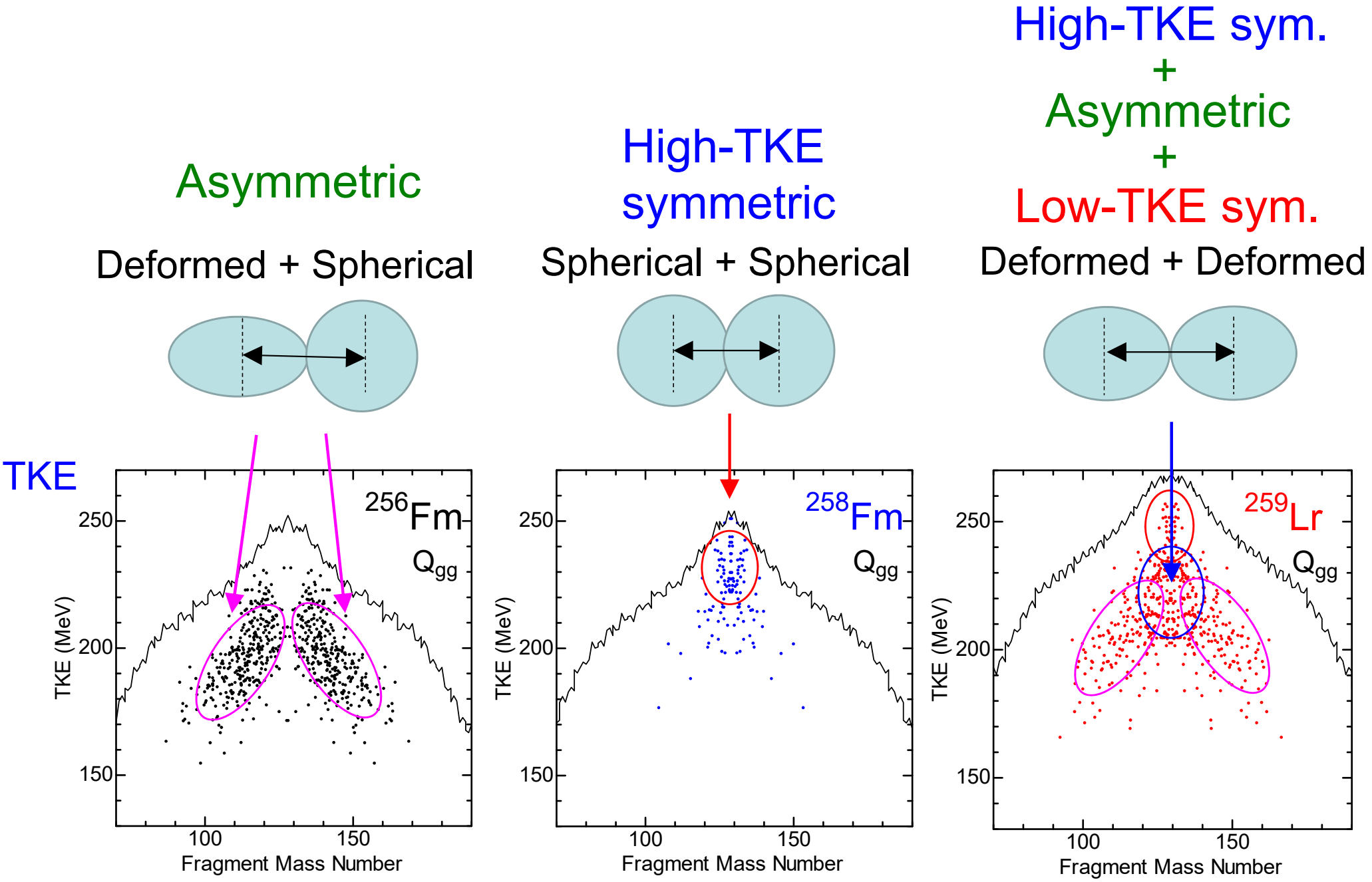
TKE





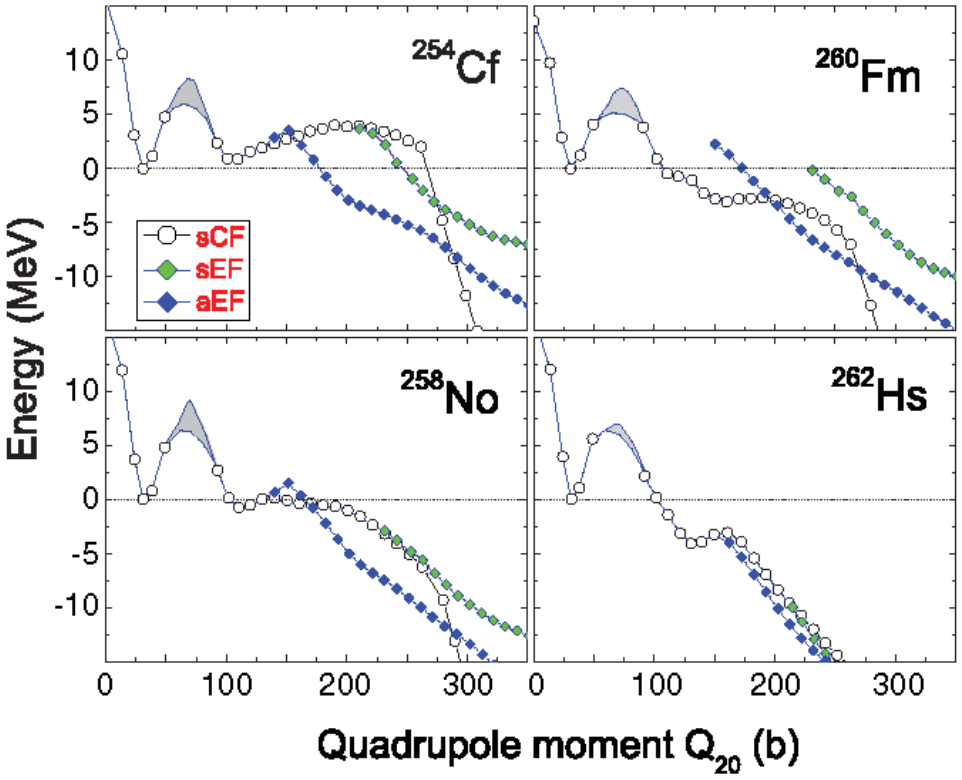


Fragment mass and TKE distributions for SF of ^{256,258}Fm and ^{259}Lr



Calculations with Density Functional Theory (DFT)

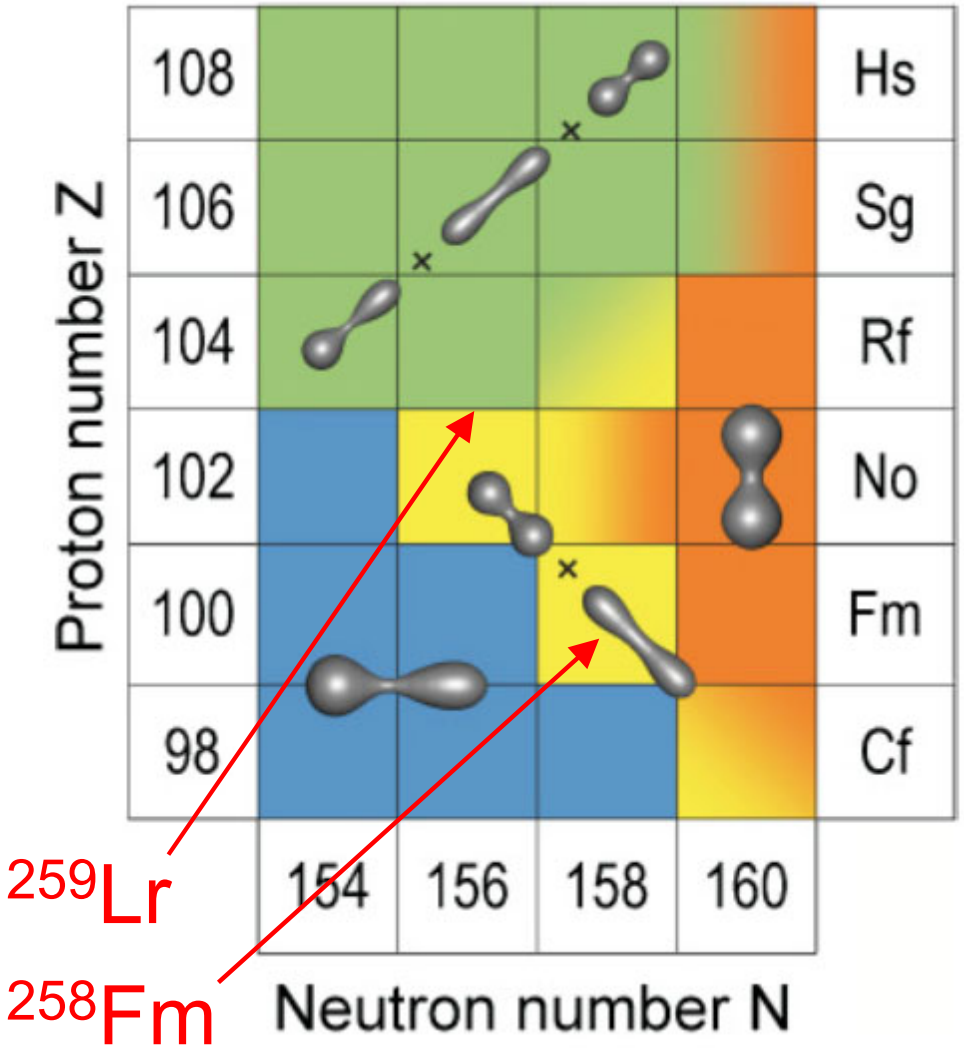
A. Staszczak et al., PRC 80 (2009) 014309.



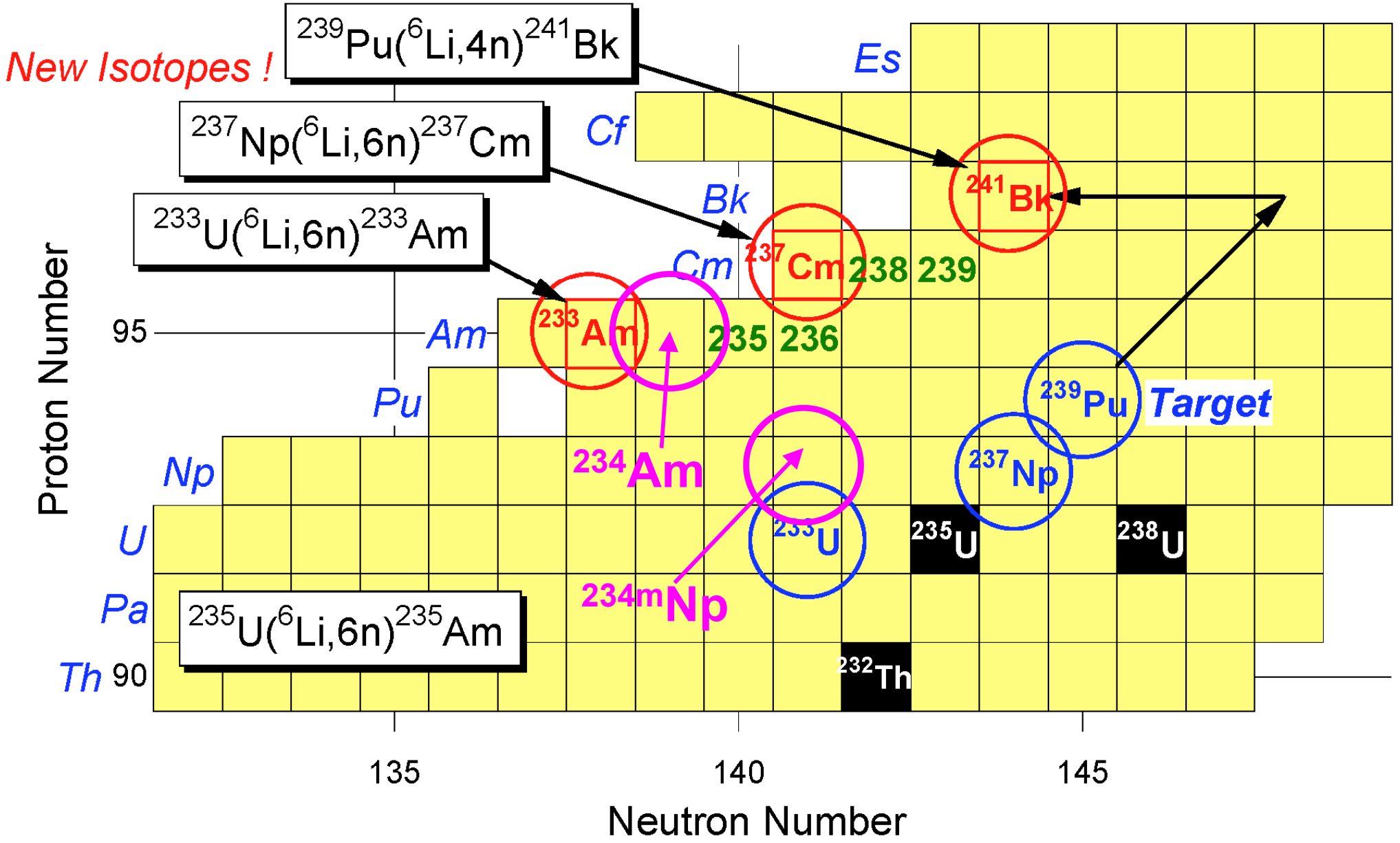
○ Symmetric Compact

◆ Symmetric Elongated

◆ Asymmetric Elongated

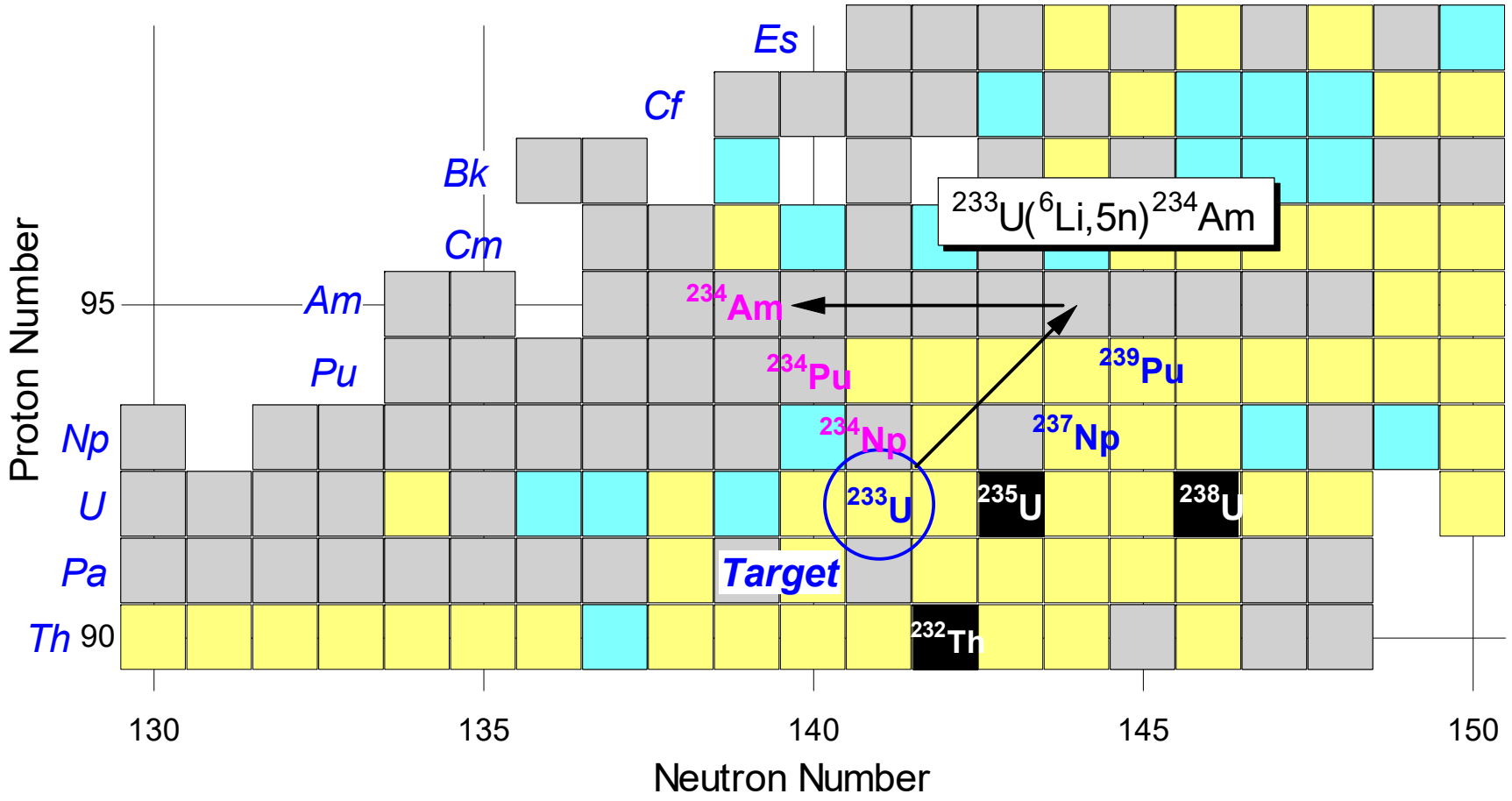


Spectroscopy of neutron-deficient Am isotopes



Spectroscopy of neutron-deficient Am isotopes

Chart of the nuclides in neutron-deficient actinide region

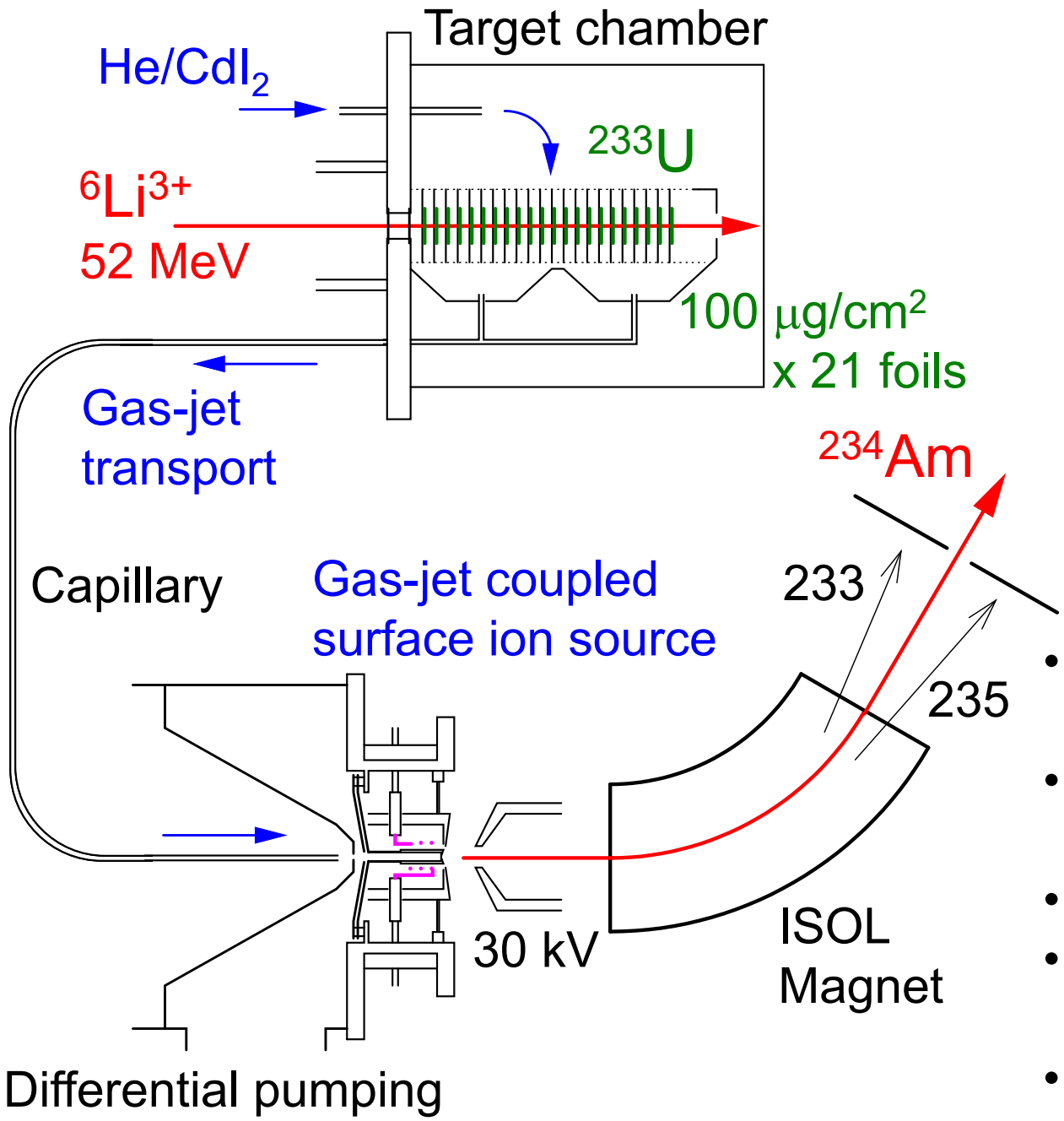


Nuclei whose excited states and their spin-parities are well known.

Nuclei for which only 1 or 2 excited states are known.

Nuclei whose excited states are not known.

Decay spectroscopy of ^{234}Am and new isomer ^{234m}Np



- ^{233}U(^{6}Li,4n)^{234}Am reaction
- ^{234}Am: $T_{1/2}$ = 2.32 min
- EC-decay γ-ray meas.

- ^{234m}Np: $T_{1/2}$ = 9.0 min
- γ-ray and conversion electron meas.

- First observation of excited states in ^{234}Pu
- Discovery of new isomers in ^{234}Np and ^{234}Am
- Octupole deformation in ^{234}Pu
- Excitation energy and spin-parity assignments for ^{234m}Np
- Nuclear structure of ^{234}Am

Summary

- Spontaneous fission of ^{256,258}Fm and ^{259}Lr were successfully measured with on-line isotope separator (ISOL) and ^{254}Es target.
- TKE and fragment mass distributions were measured with good energy resolution and no contamination by other nuclei using ISOL.
- TKE and fragment mass distributions of SF of ^{259}Lr seem to consist of three different components.

- EC-decay spectroscopy of ^{234}Am was performed.
- Two EC decaying states were found in ^{234}Am.
- Excited states in ^{234}Pu were established for the first time.
- A new isomer in ^{234}Np was discovered.

See Poster !