NN2015 @ Catania, Italy, 21-26June 2015
“Fusion and Fission(14:30-16:40)”

Fission study by multi-nucleon transfer reaction at JAEA

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Contents

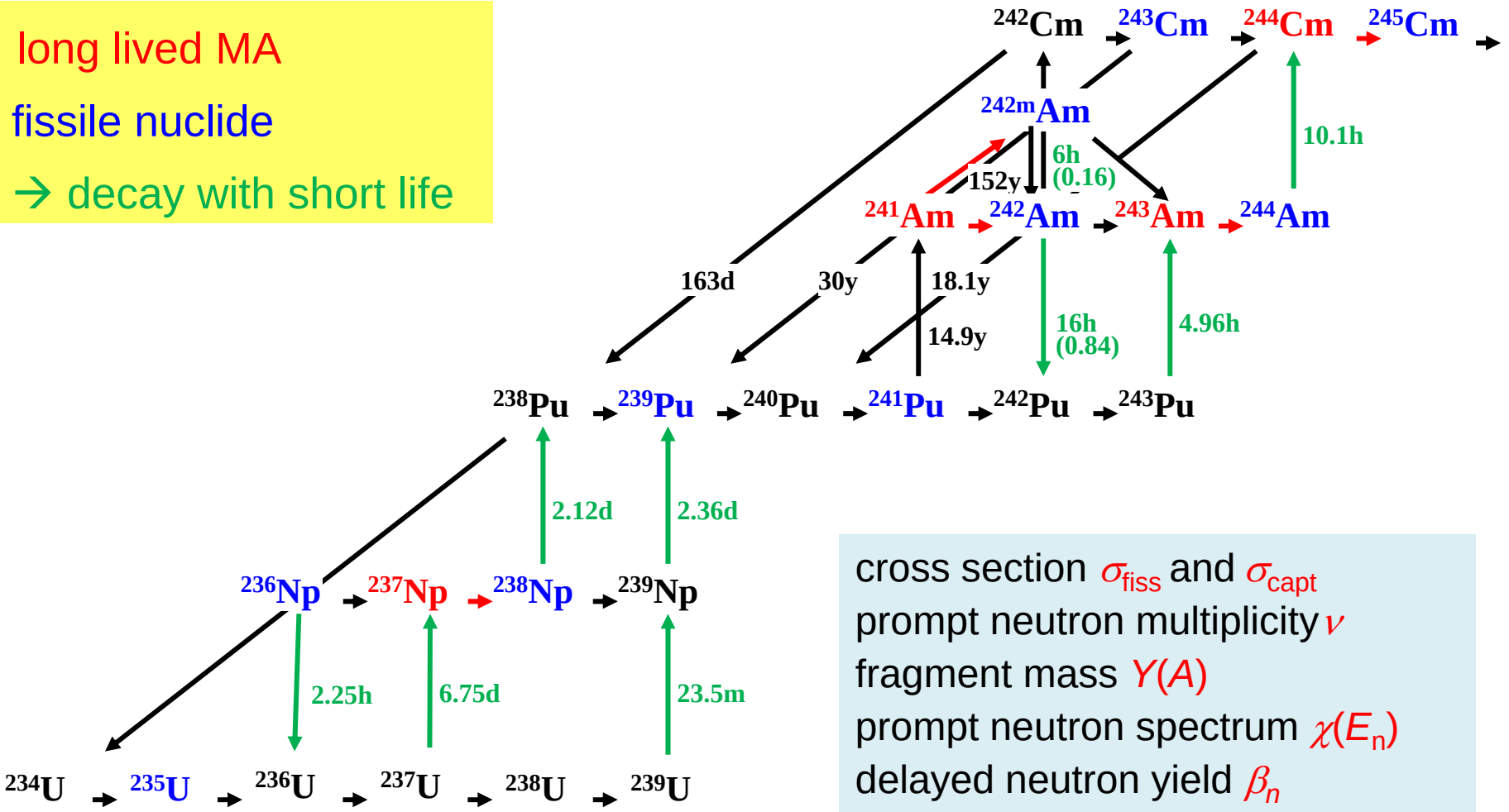
- Introduction
- Measurement at JAEA Tandem accelerator facility
- Preliminary results of fission fragment mass distributions obtained in $^{18}O+^{248}Cm$
- Some other experimental data

Nuclides in reactor and decay network

long lived MA

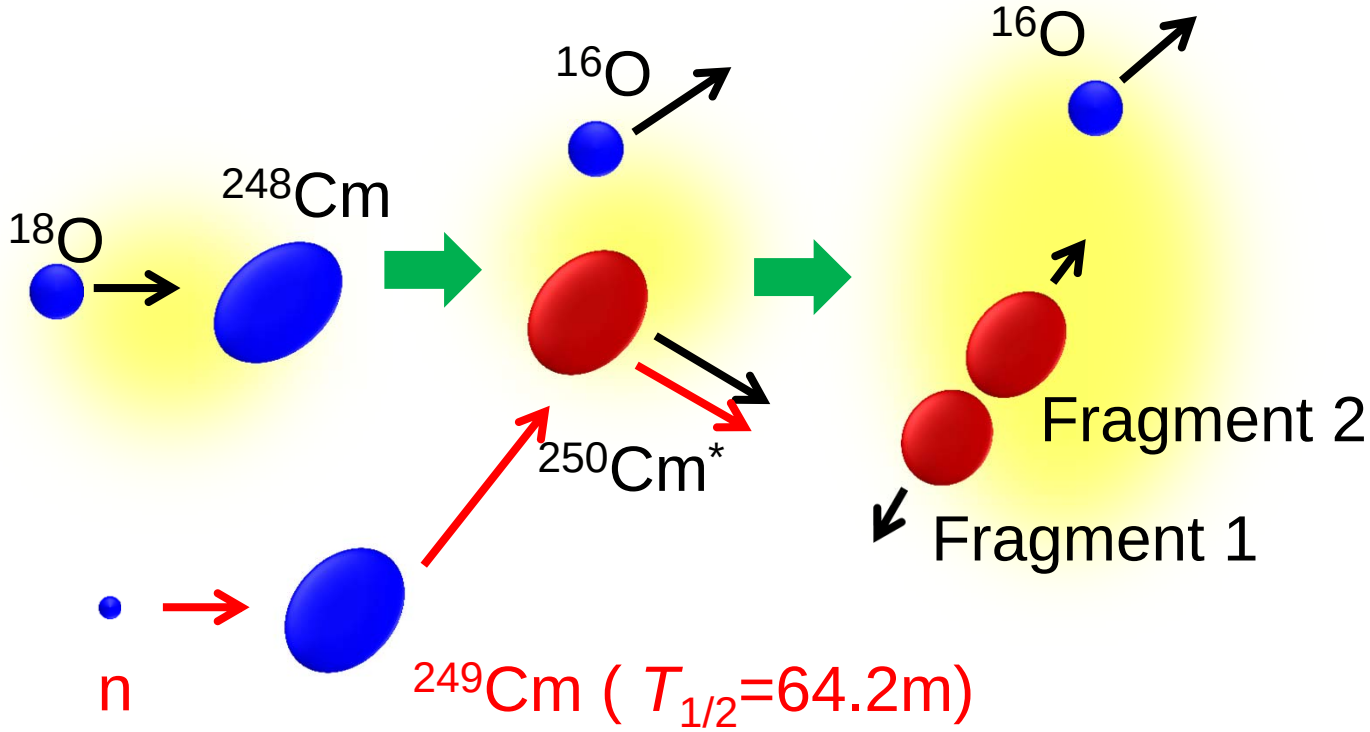
fissile nuclide

→ decay with short life



cross section σ_{fiss} and σ_{capt}
prompt neutron multiplicity ν
fragment mass $Y(A)$
prompt neutron spectrum $\chi(E_n)$
delayed neutron yield β_n

Nucleon-transfer fission

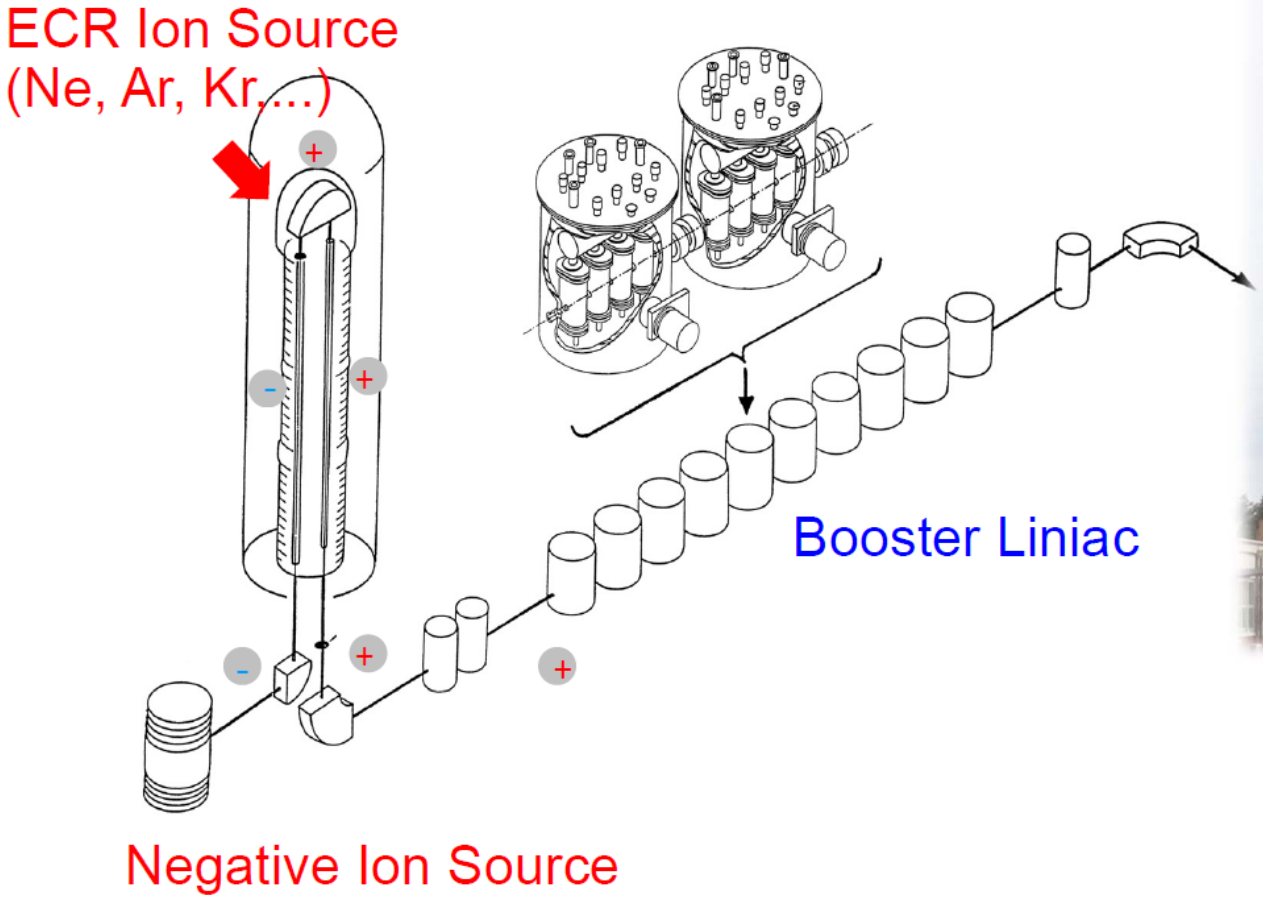


5 year program supported by the Ministry of Education, Culture, Sports, Science and Technology

FY2012 U238
FY2013 Th232
FY2014 Cm248
FY2015 Np237

JAEA tandem facility

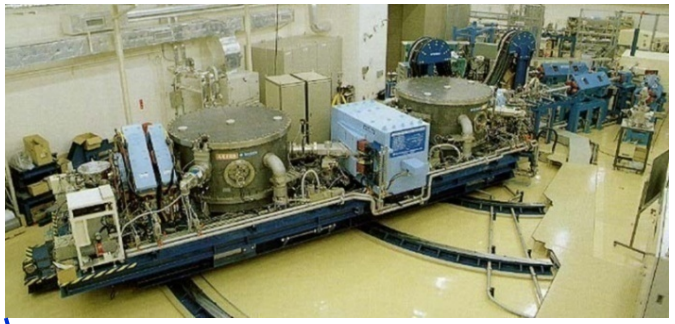
20 MV terminal voltage (20UR)
Super-conducting booster LINIAC
ECR ion-source on the terminal



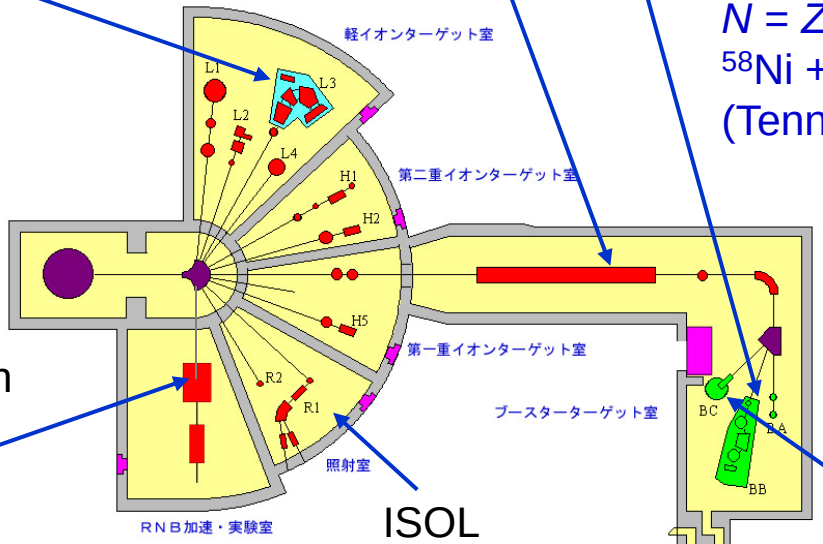
Magnetic Spectrometer

Booster Linac

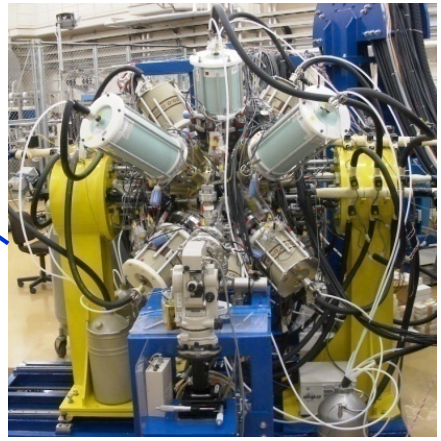
Recoil Mass Separator



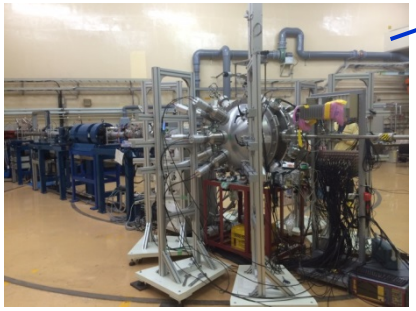
Search for the heaviest
$N = Z$ nuclei beyond ^{100}Sn,
^{58}Ni + ^{58}Ni, ^{58}Ni + ^{54}Fe
(Tennessee /ORNL /JAEA /York)



Ge-detector array

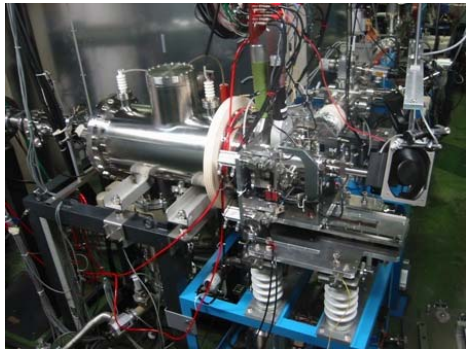


In beam fission and reaction



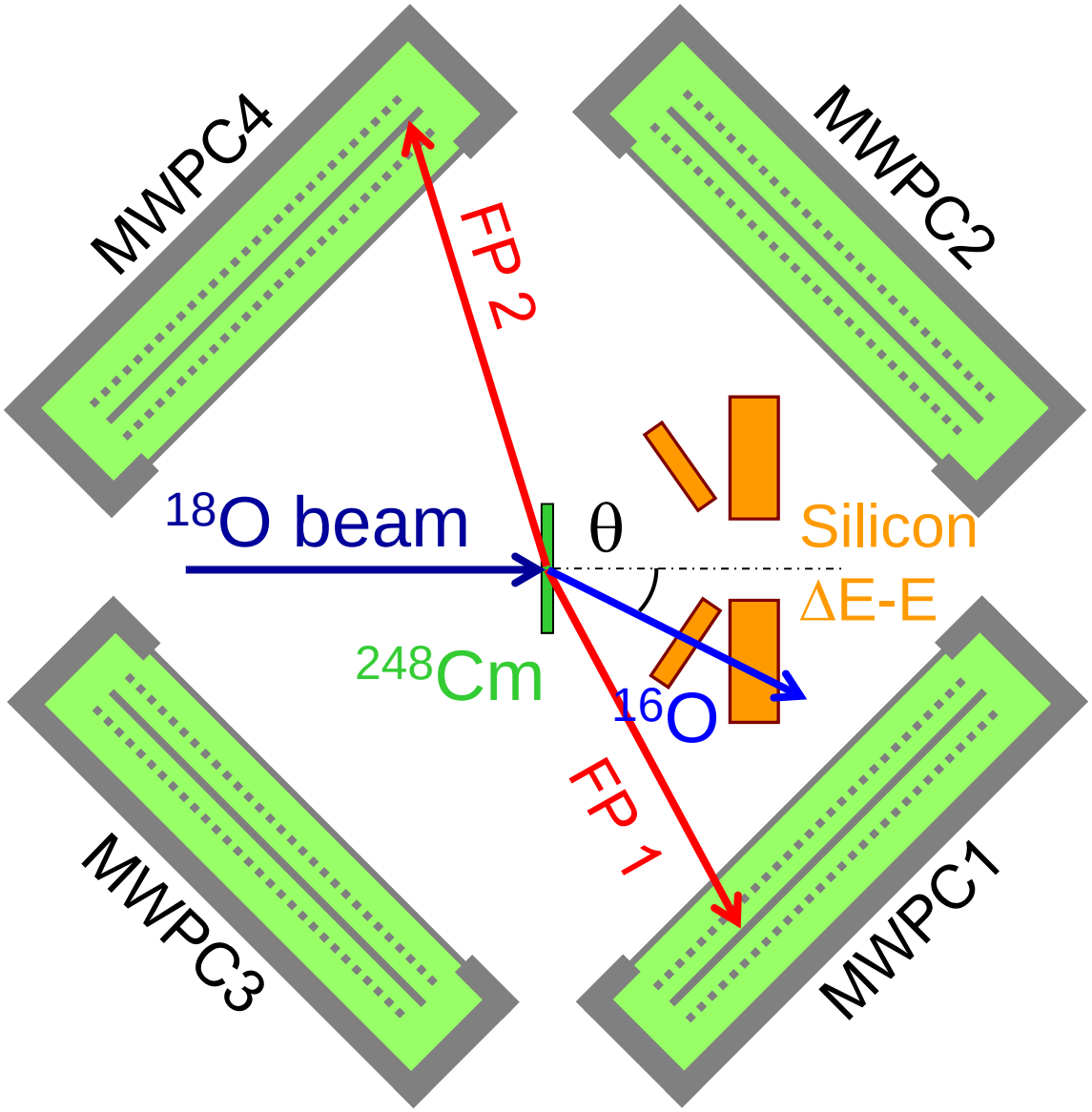
Radioactive materials can be used
Np, Am, Cm, Cf

ISOL
p + ^{238}U & Gas-jet coupled



First Ionization potential of Lr (Z=103).
T.K. Sato *et al*., *Nature*, **520**, 209 (2015)

Experiment



^{248}Cm 35ug/cm^2
^{18}O 162MeV, 0.5-1pnA

Silicon ΔE-E telescope

- PID for scattering particle
- kinetic energy
- recoil angle

→ Identify the compound

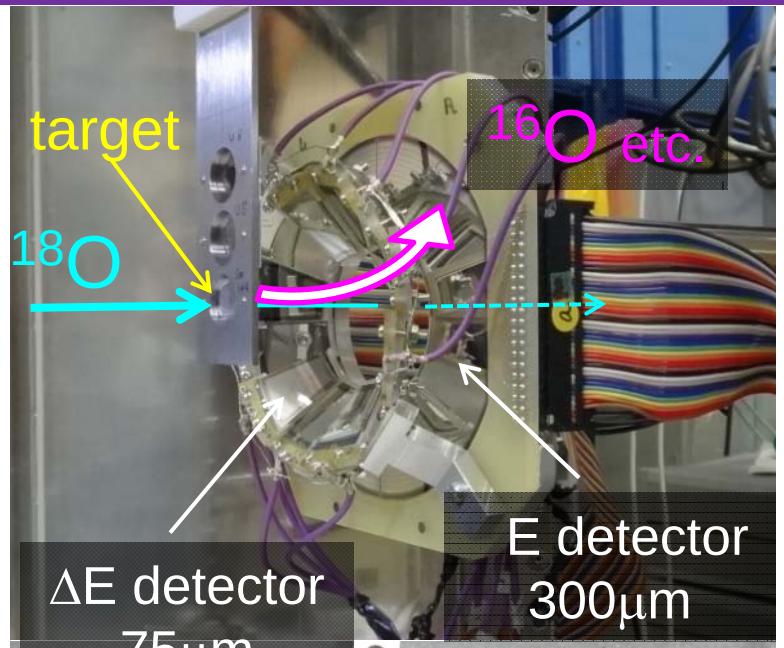
- momentum
- excitation energy

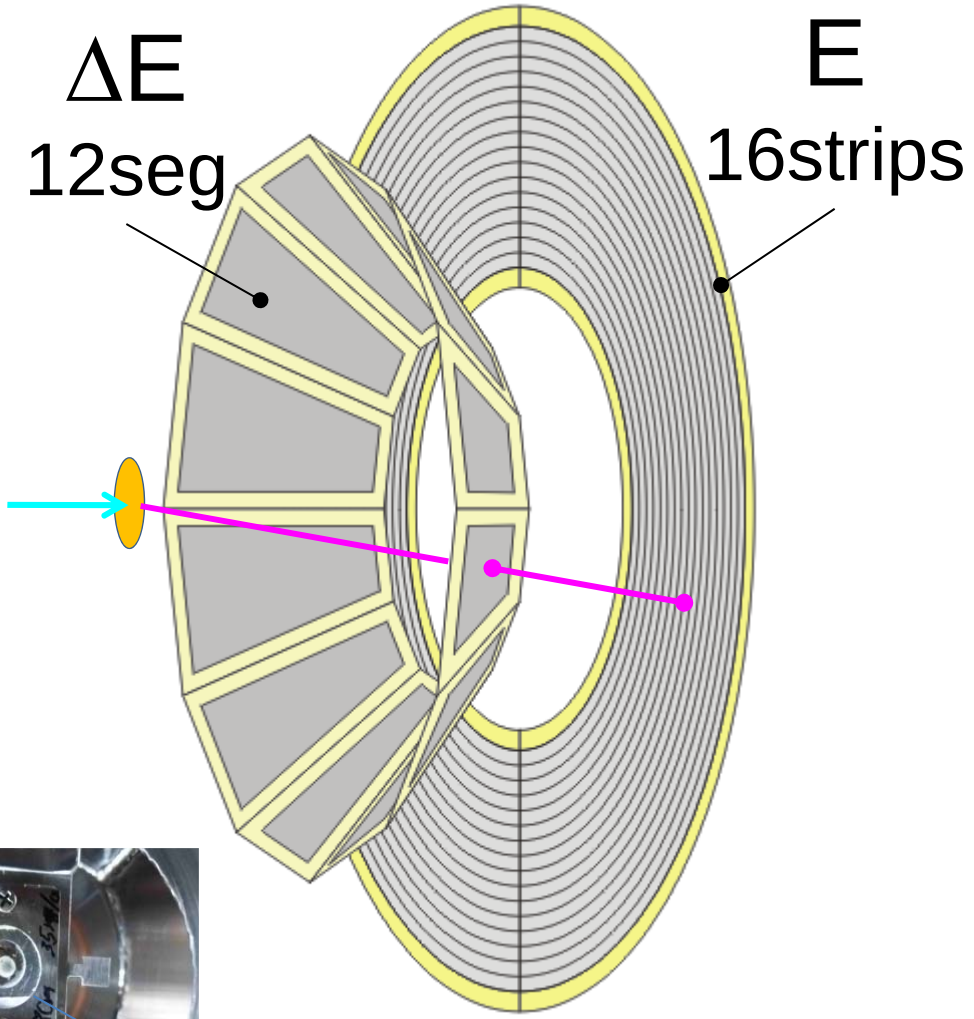
MWPCs

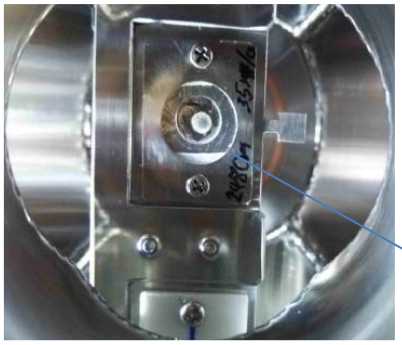
- fission events
- angle (Δθ~1.5deg)
- time dif. FP1 and FP2

→ momentum of FPs
masses of FPs

ΔE-E Si telescope



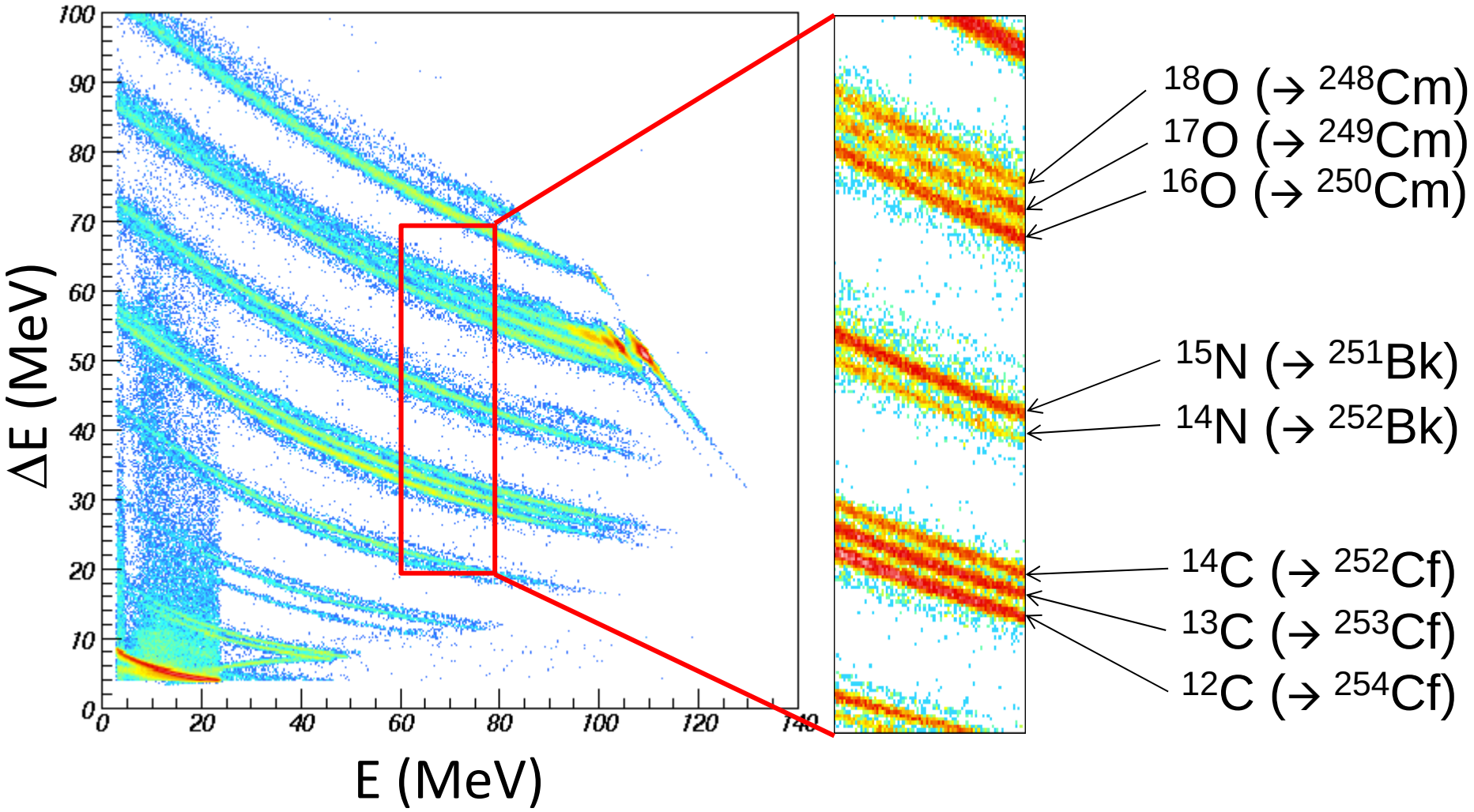




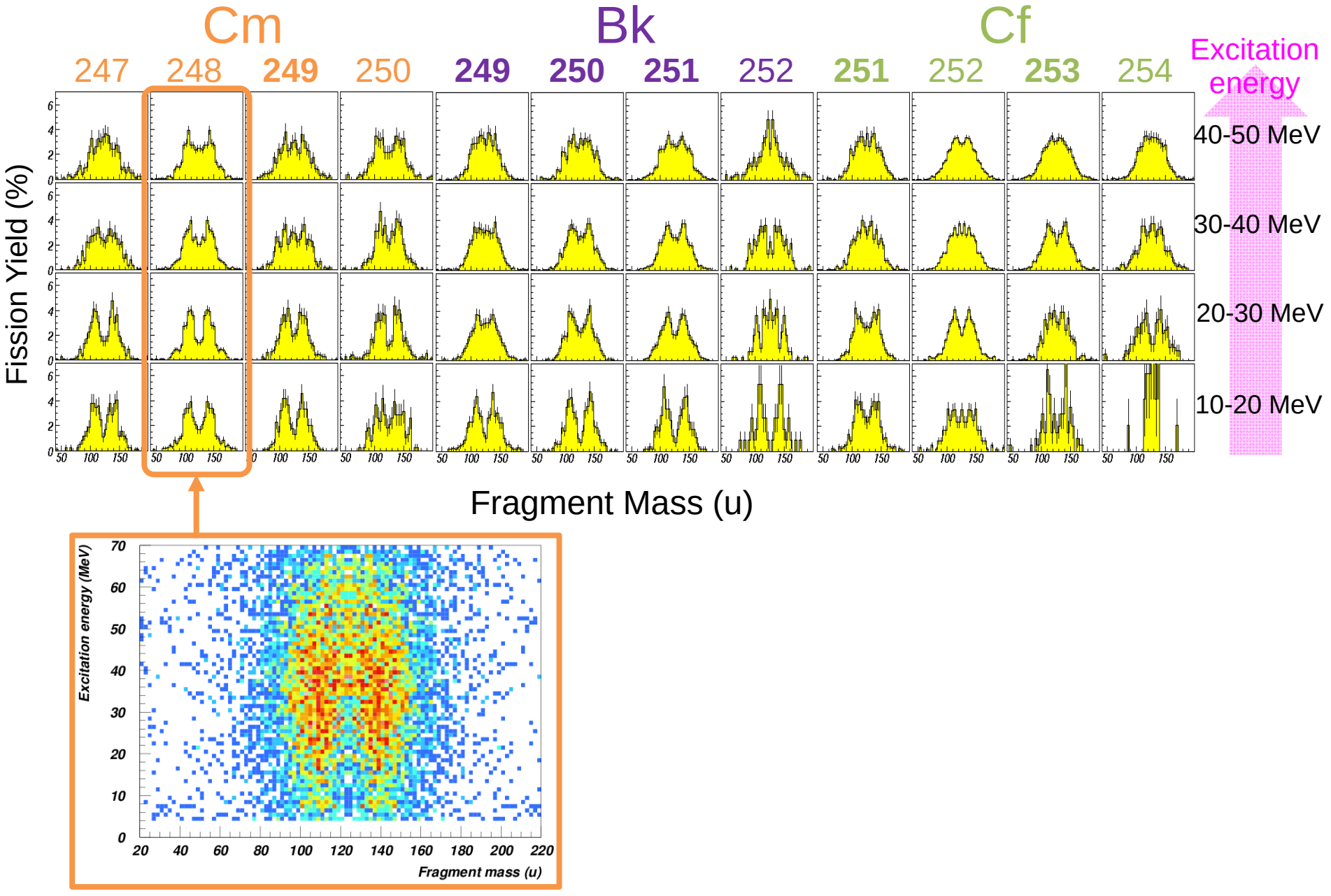
Cm248 target

ΔE-E spectrum

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

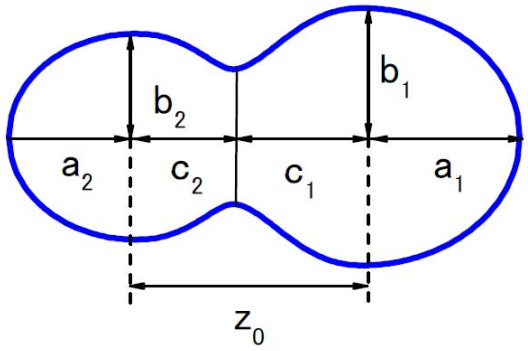


Mass distribution in $^{18}O+^{248}Cm$



Calculation by fluctuation-dissipation model

Potential energy calculation based on Two Center Shell Model
Shape evolution was calculated by solving Langevin equation



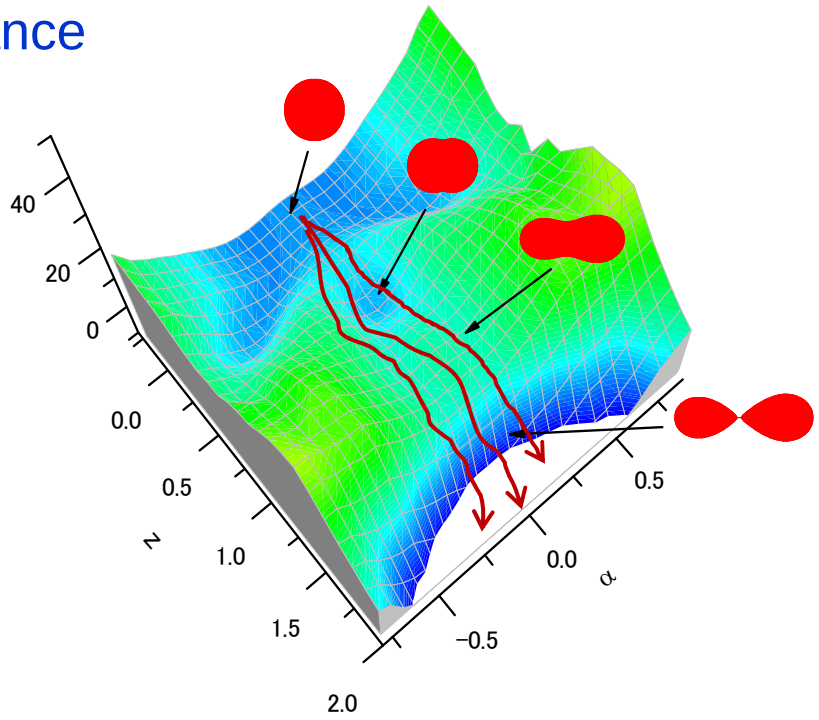
Deformation
Charge-center distance
Mass-asymmetry

$$V(q,L,T) = V_{LD}(q) + \Delta E_{Shell}(q,T)$$

$$\Delta E_{Shell}(q,T) = \Delta E^{0}_{shell}(q)\Phi(T)$$

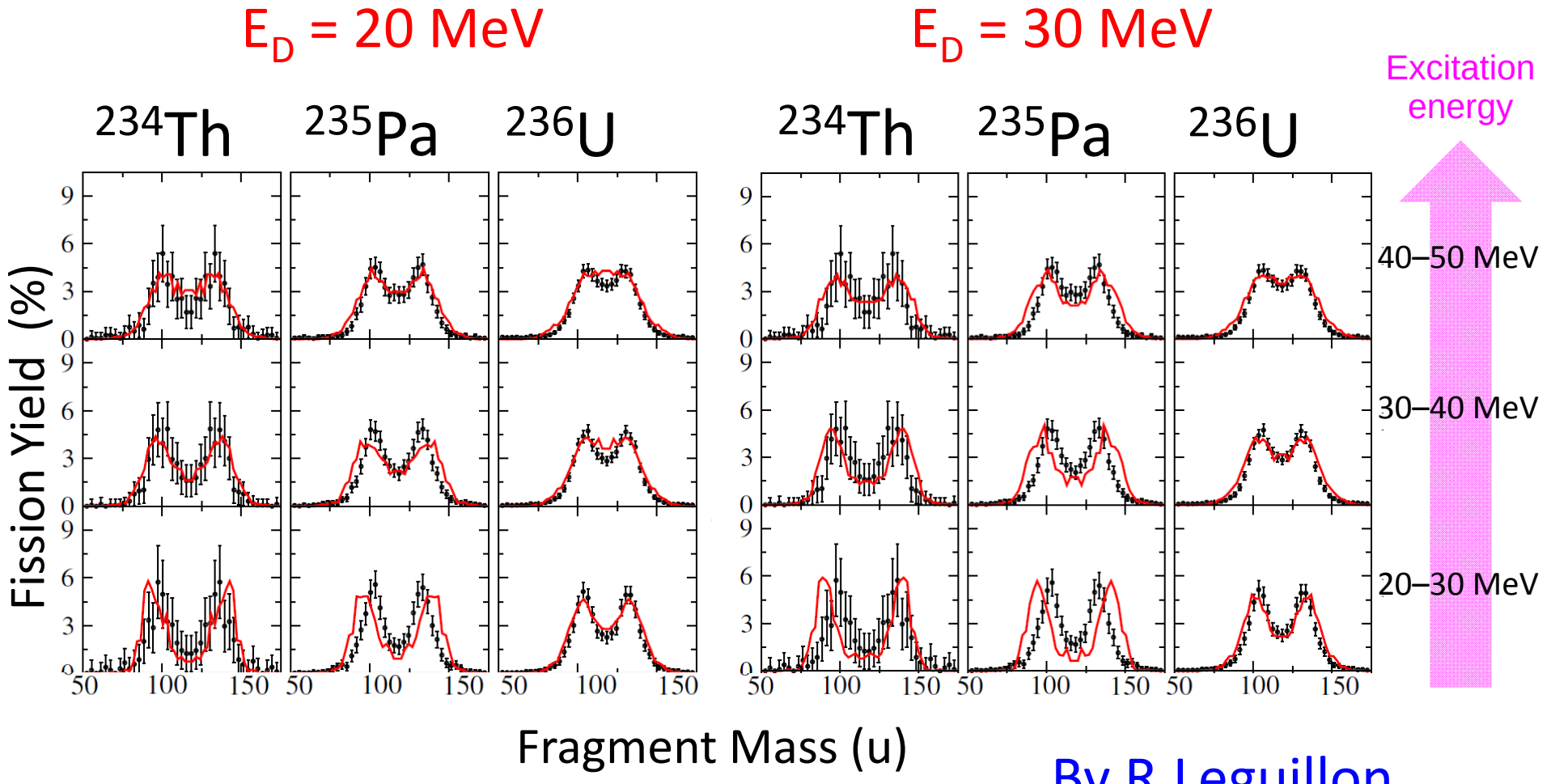
$$\Phi(T) = \exp\left\{-\frac{E^{*}}{E_D}\right\}$$

Shell damping energy



Calculated by Y.Aritomo

Exp. and Calc. (^{18}O + ^{232}Th)

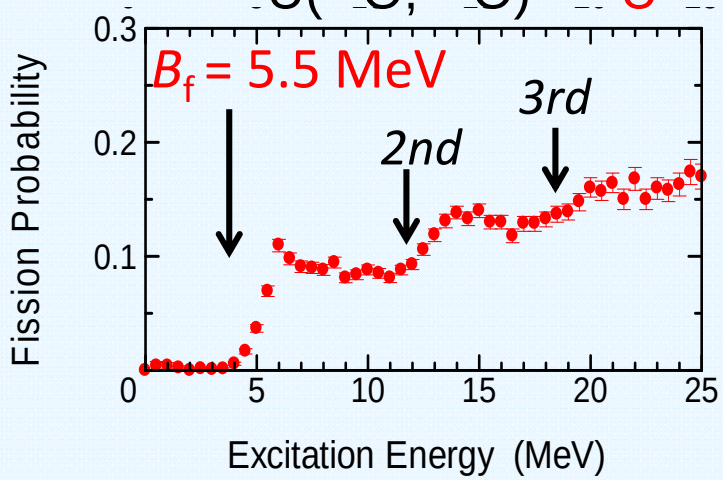


By R.Leguillon

Fission Data from Multi-nucleon Transfer-induced Fission

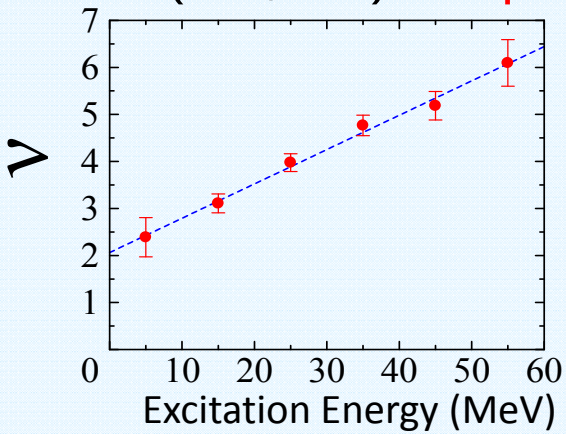
Fission Barrier Height

$^{238}U(^{18}O, ^{16}O)$ $^{240}U^*$



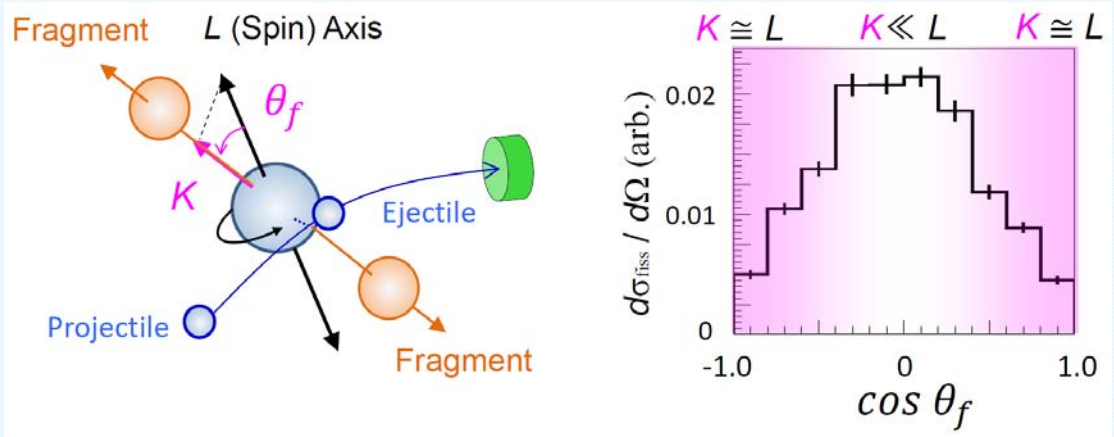
Fission Neutron Multiplicity

$^{238}U(^{18}O, ^{17}N)$ $^{239}Np^*$

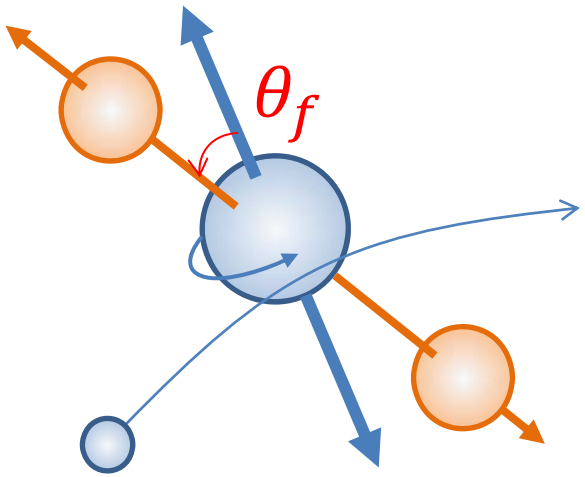


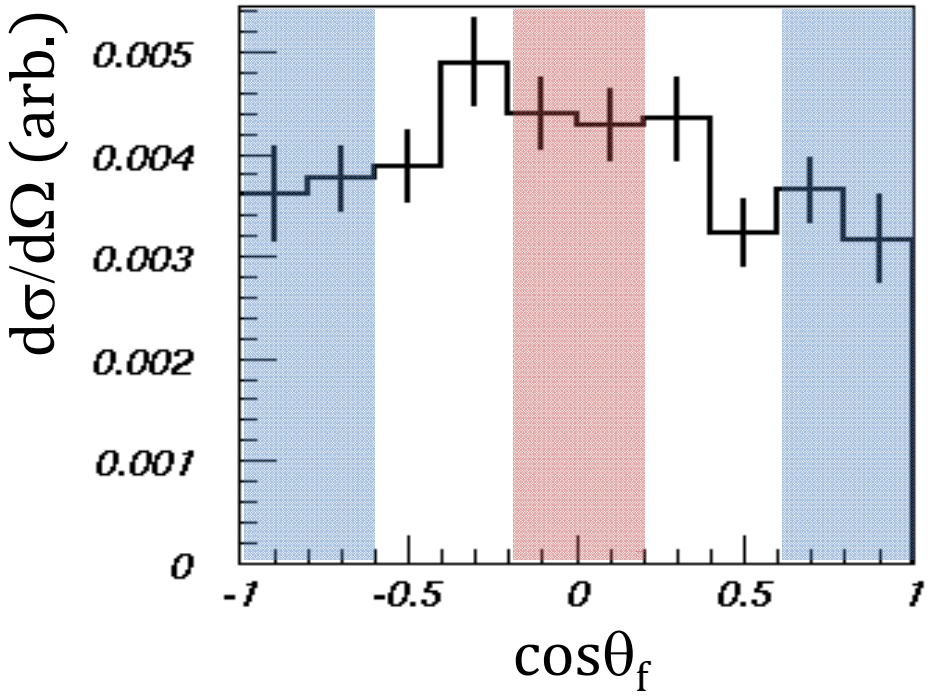
Fission Angular distribution

^{238}U $(^{18}O,^{16}O)$ $^{240}U^*$



Fission angular distribution





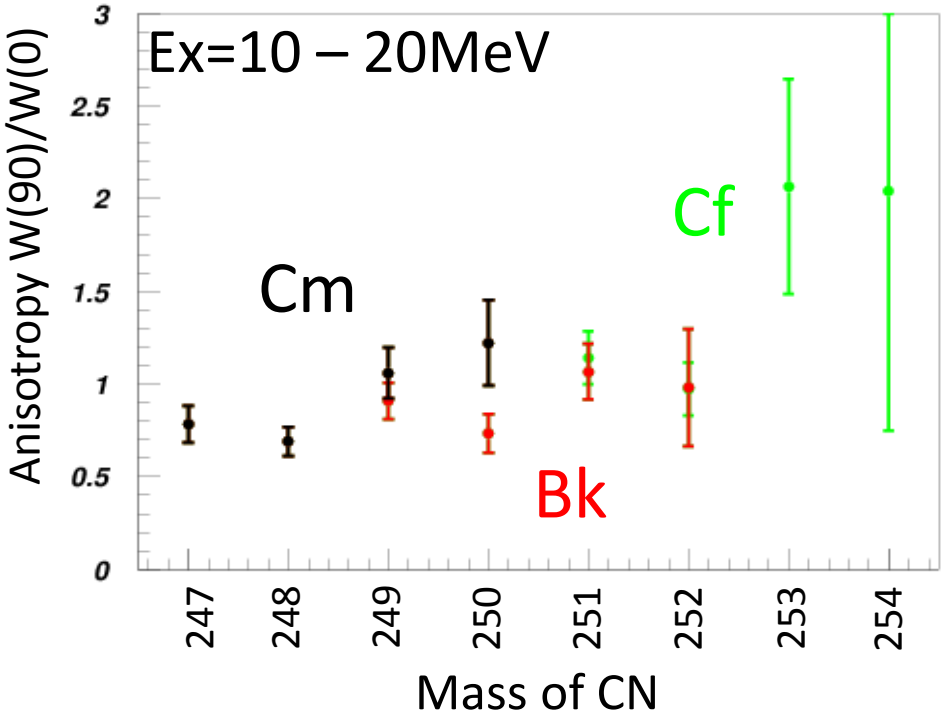
Transfer reaction

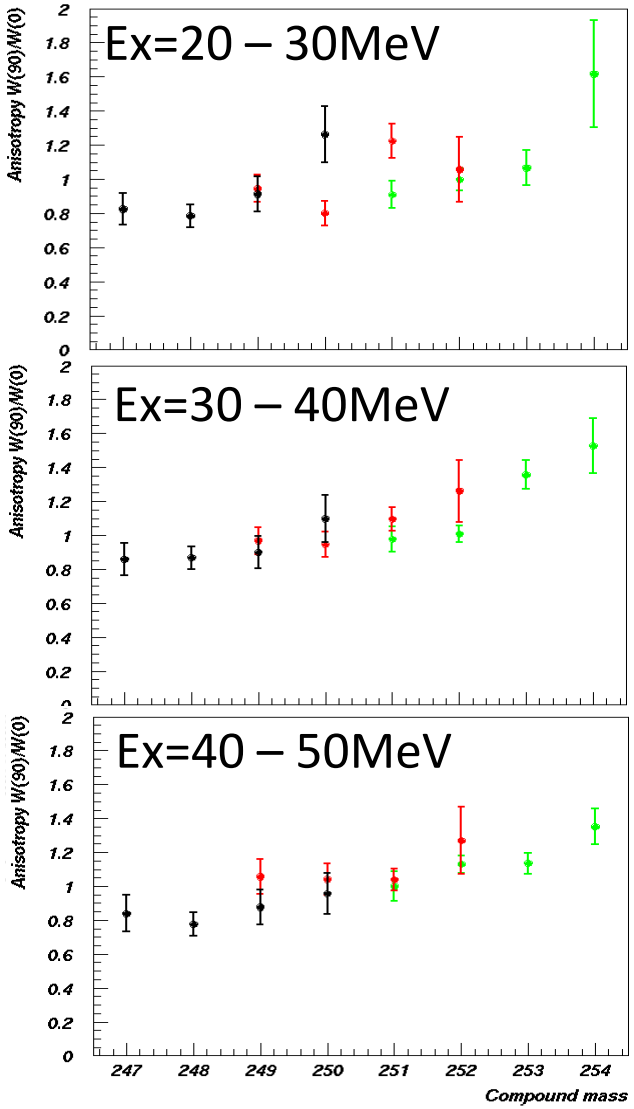
→Fission direction to the angular momentum transfer can be defined.

Anisotropy

$$\frac{W(90°)}{W(0°)} \equiv \frac{ave.\ of}{ave.\ of}$$

Anisotropy

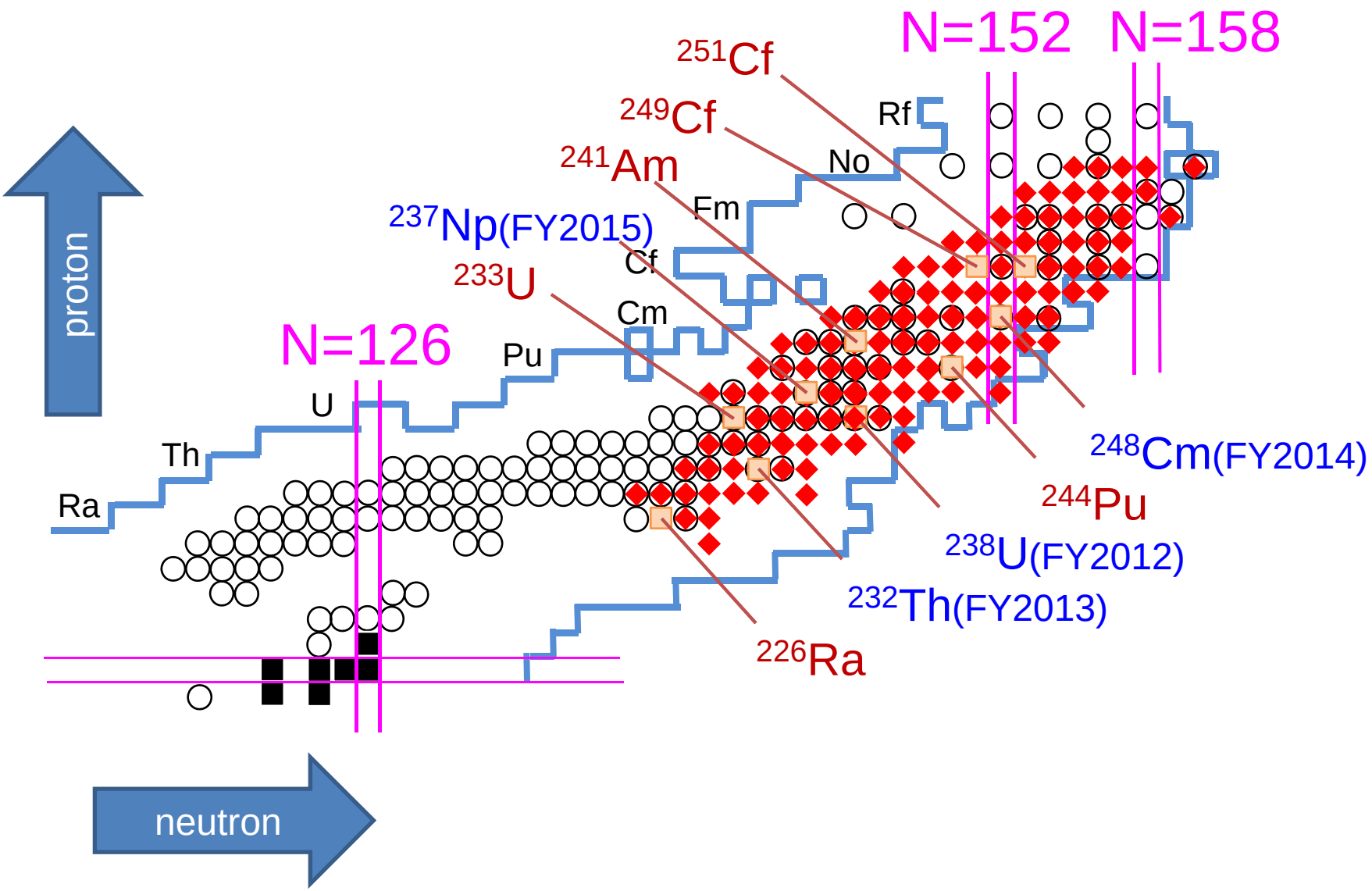




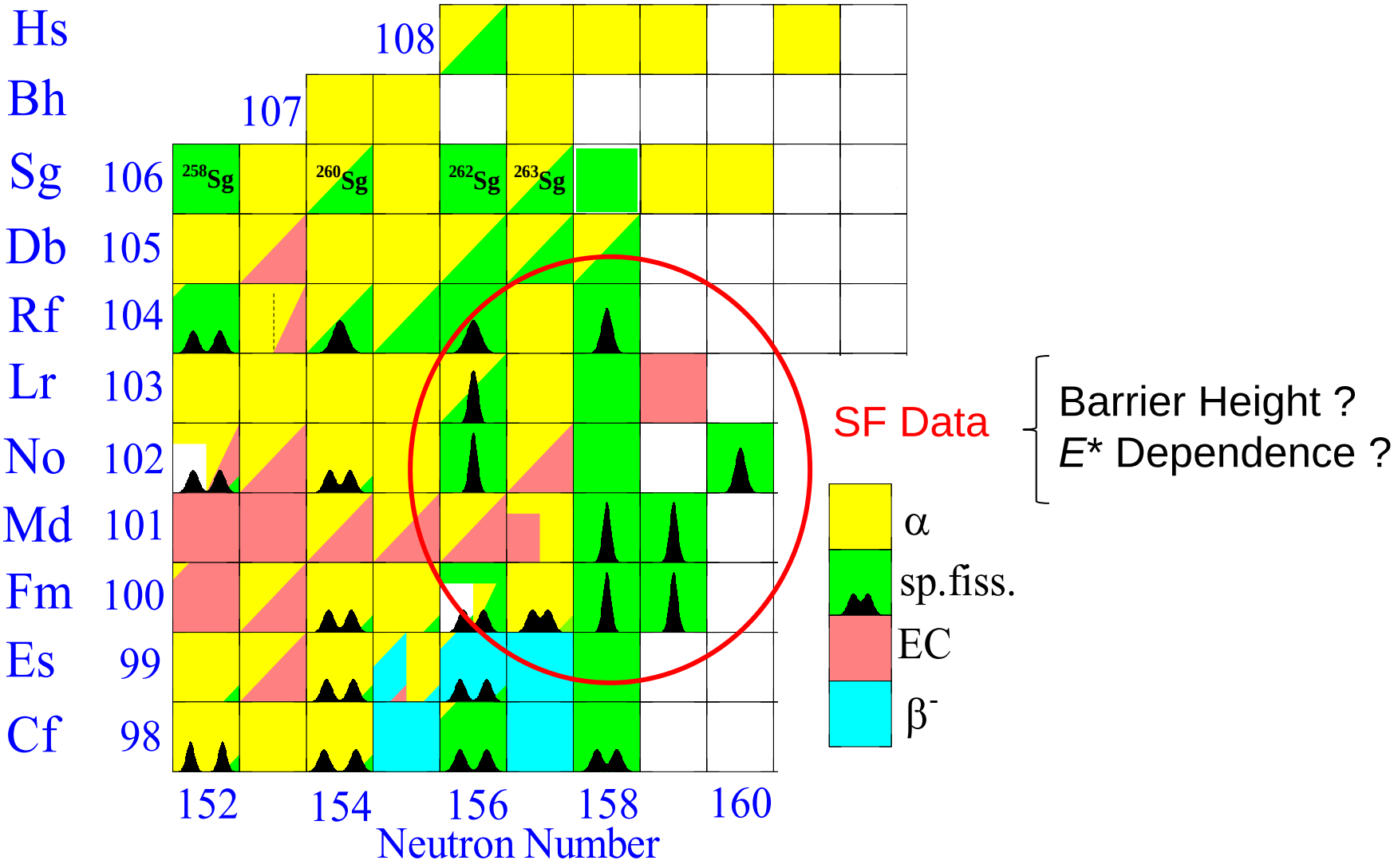
Heavier compound, Larger anisotropy

Reflection of the angular momentum transfer.
A hint to extract how much the angular momentum was transferred.

future measurement



Transition from asymmetric to symmetric fission



Thank you for paying attention!