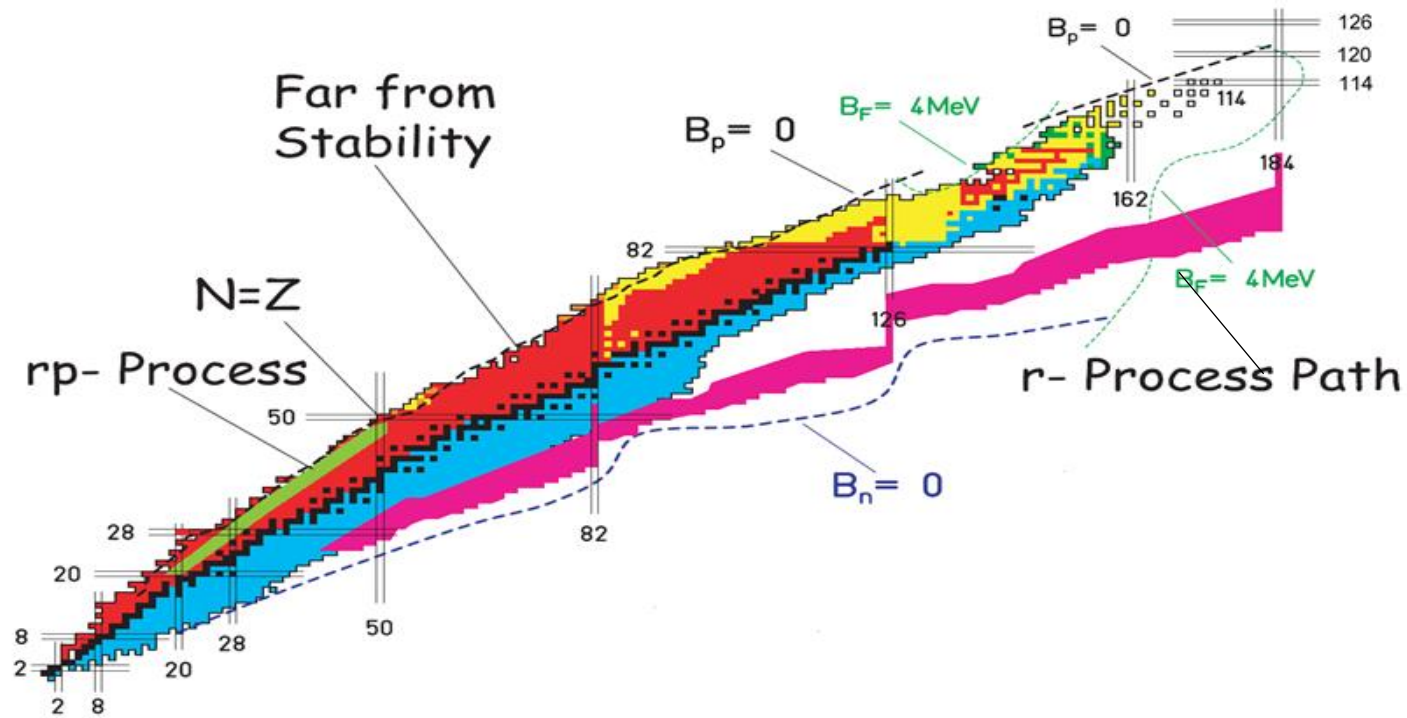
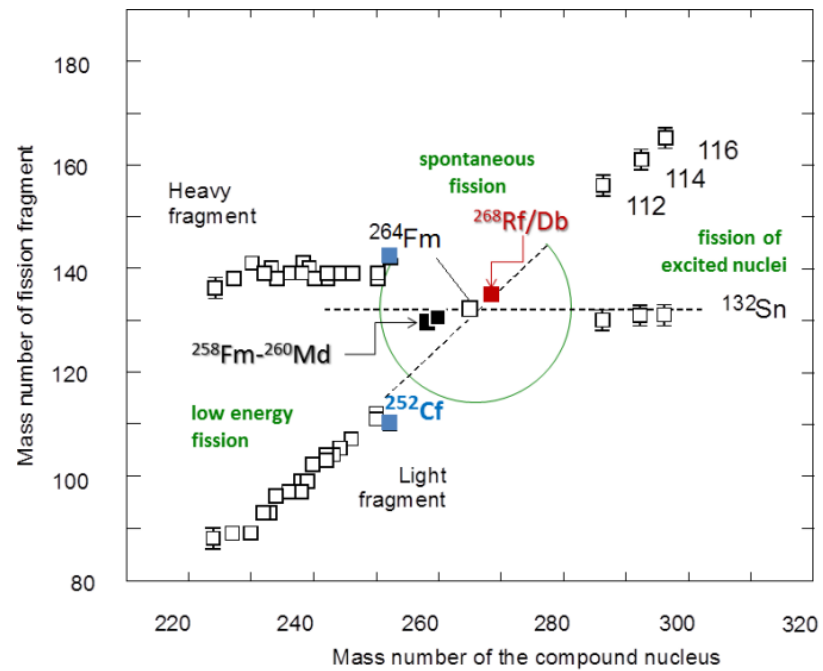


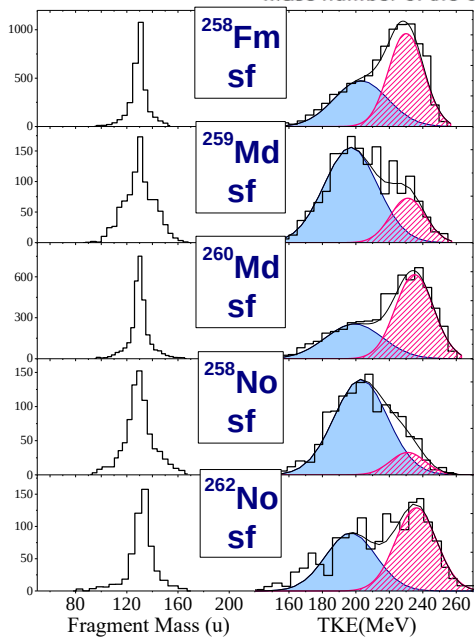
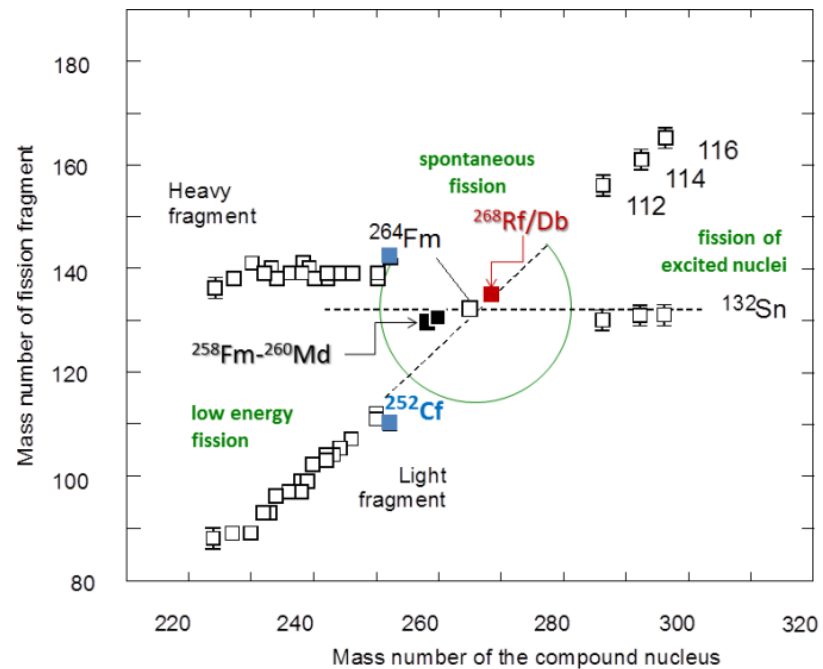


TOWARDS THE ISLAND OF STABILITY:
Study of fission process in the system of ^{132}Ce , ^{263}Bh
and ^{269}Bh

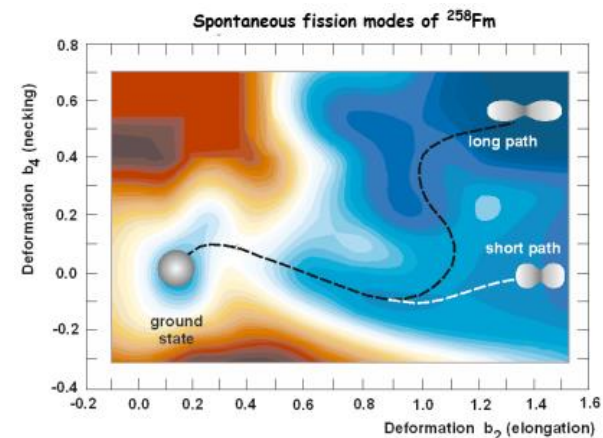
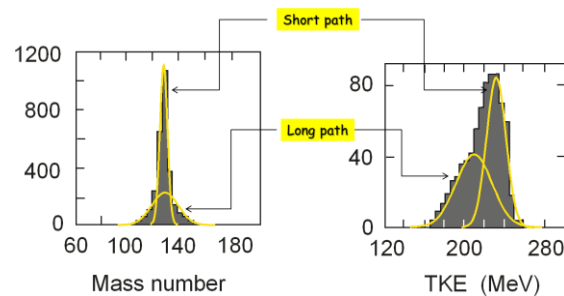
BEHAVIOUR OF FISSION FRAGMENTS



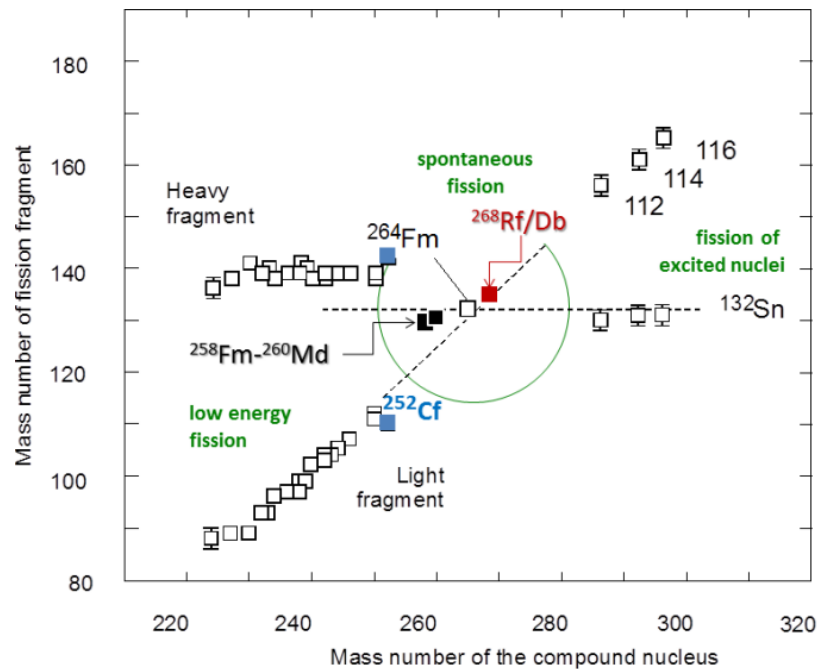
BEHAVIOUR OF FISSION FRAGMENTS



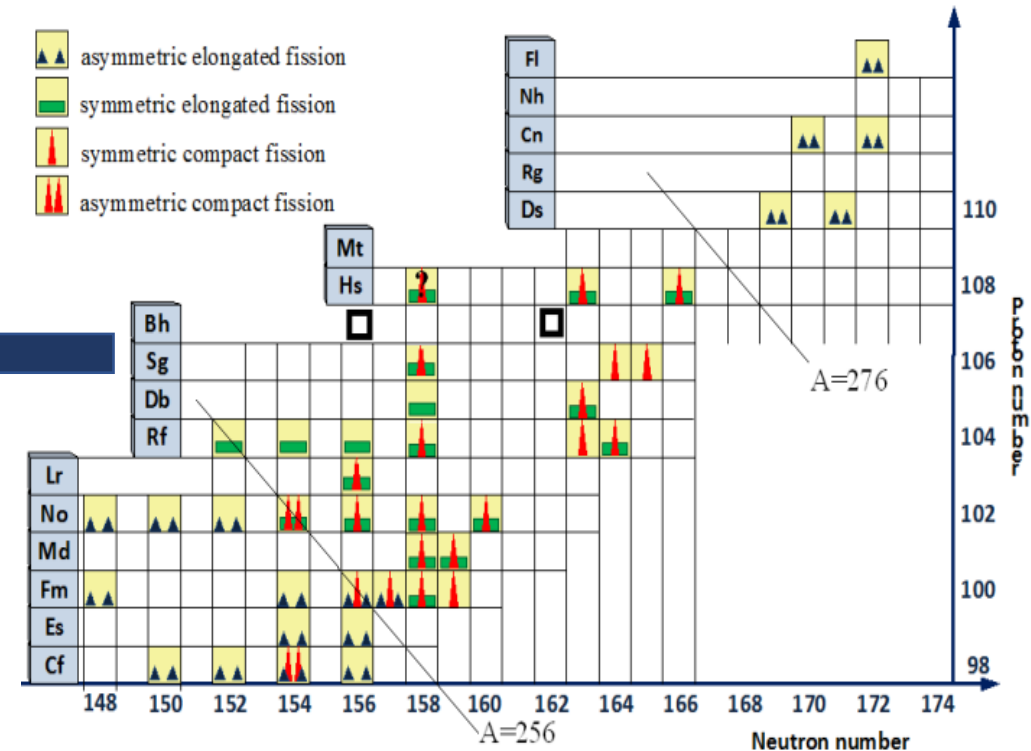
E.K. Hulet *et al.*, Phys. Rev. Lett. **56**, 313 (1986)



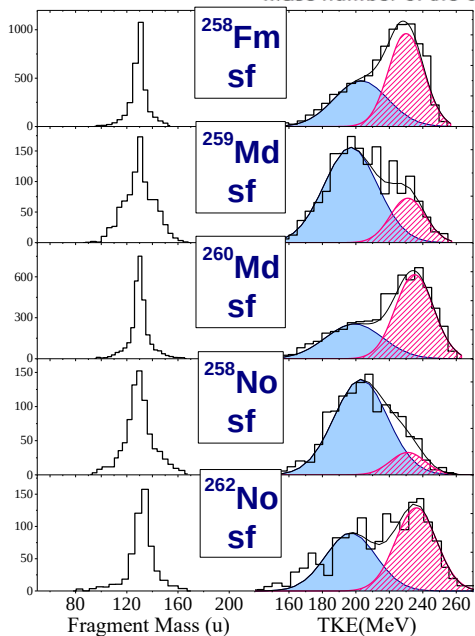
BEHAVIOUR OF FISSION FRAGMENTS



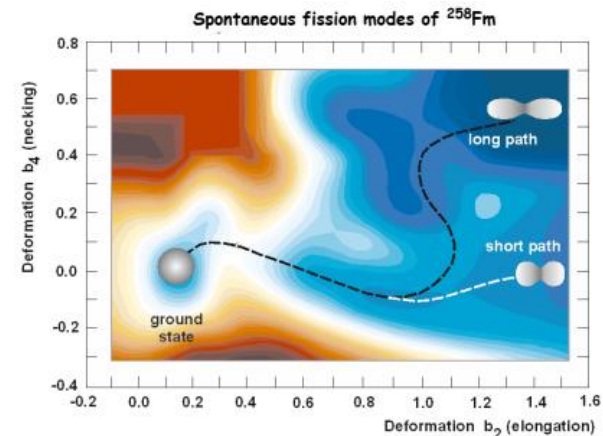
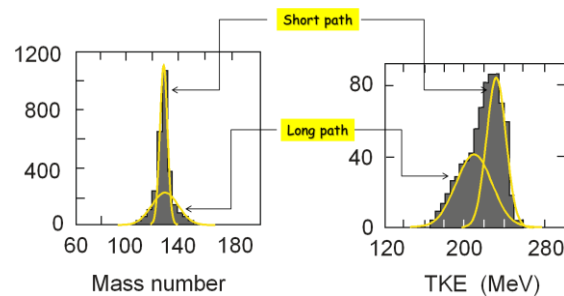
^{263}Bh , ^{269}Bh



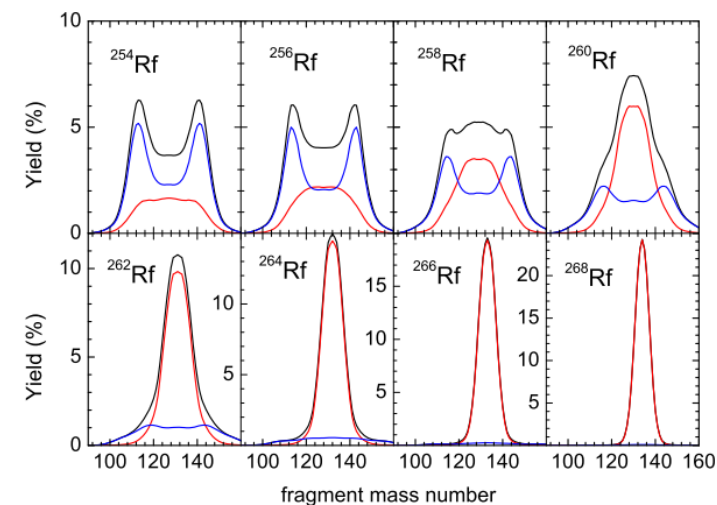
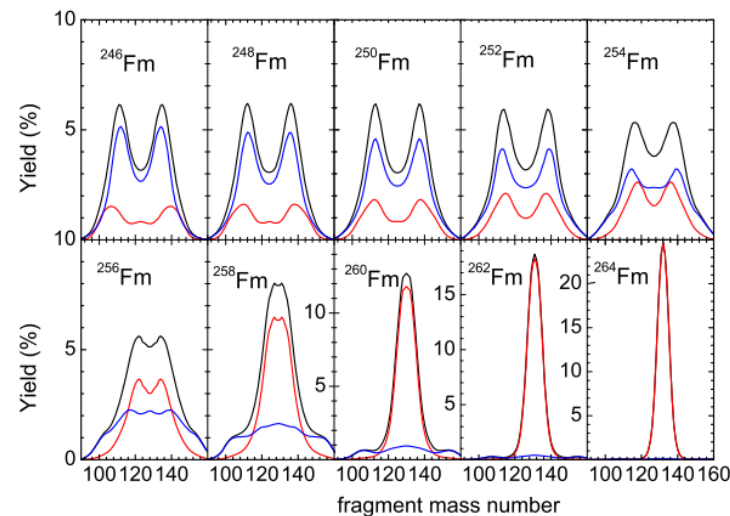
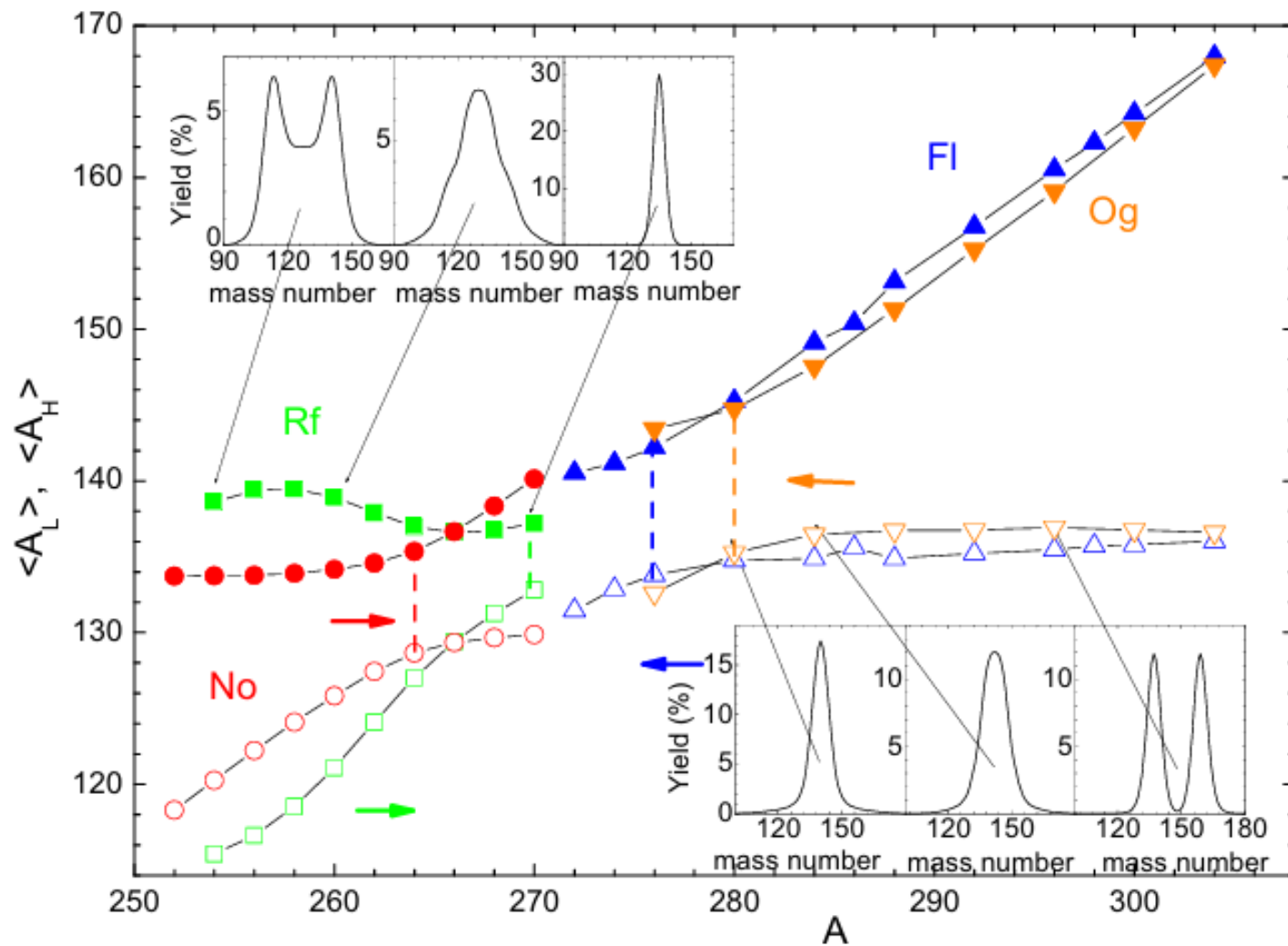
M.G. Itkis, E. Vardaci, I.M. Itkis, G.N. Knyazheva, E.M. Kozulin, Nucl. Phys. A **944** (2015) 204



E.K. Hulet *et al.*, Phys. Rev. Lett. **56**, 313 (1986)



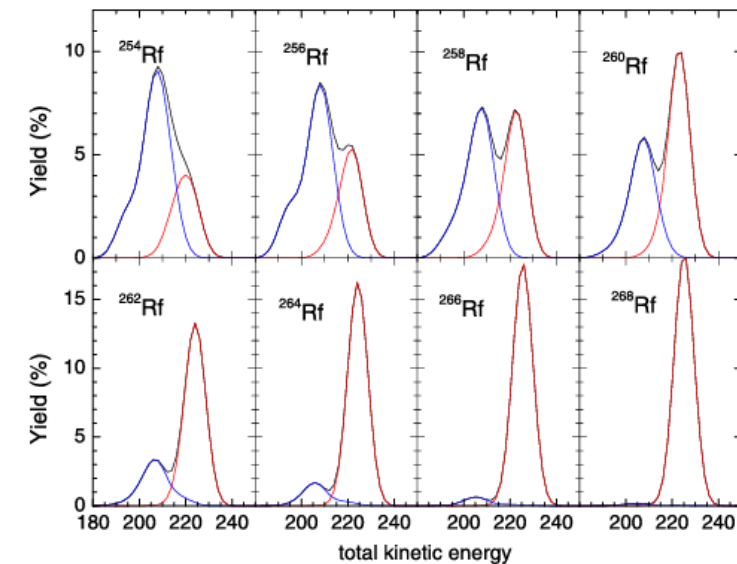
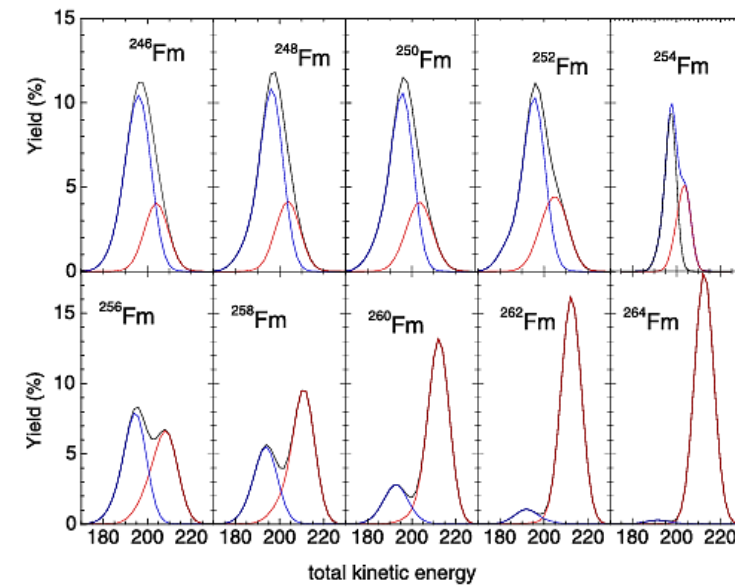
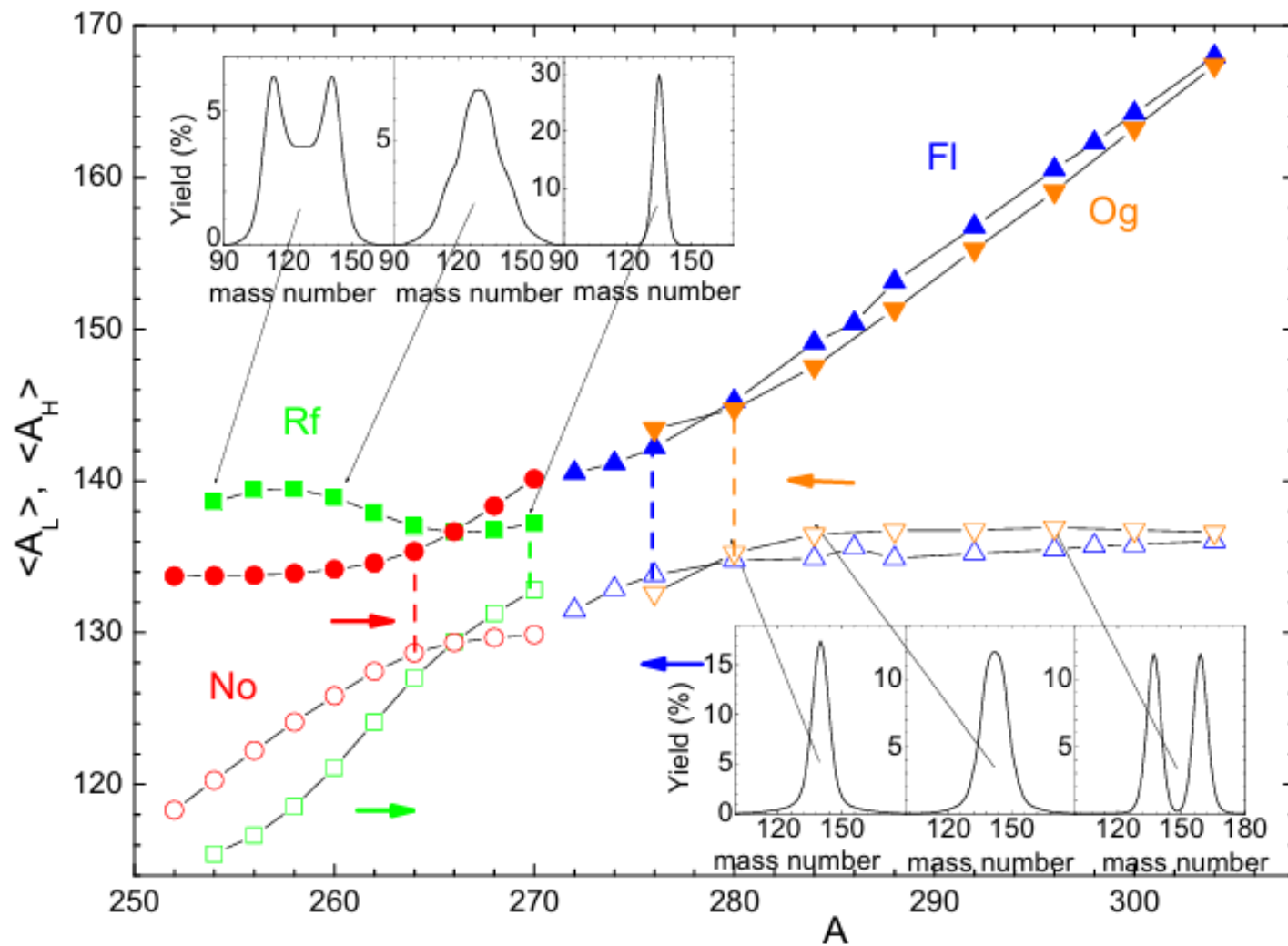
SCISSION POINT MODEL



N. Carjan, F. A. Ivanyuk, and Yu. Ts. Oganessian, PRC 99,064606(2019)

N. Carjan, et al. Nucl. Phys. A 942 (2015) 97–109 (2015)

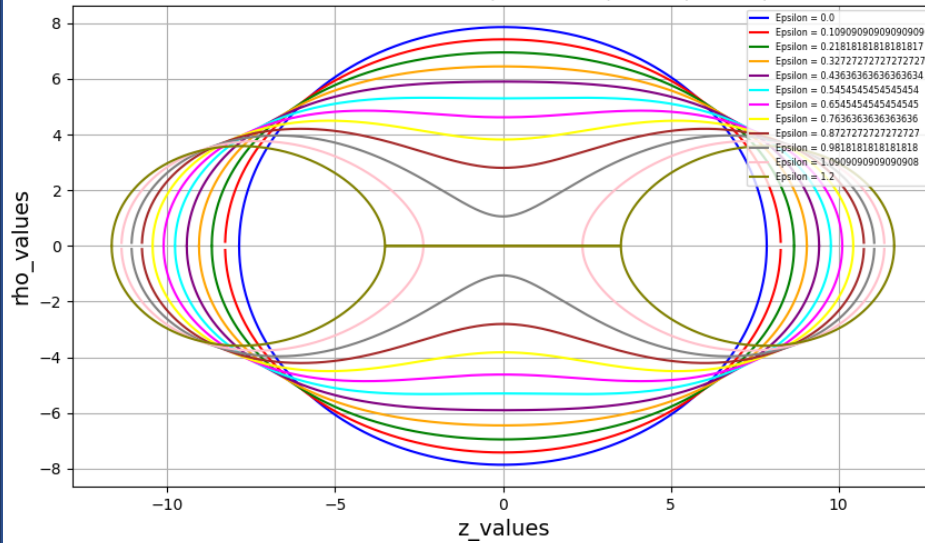
SCISSION POINT MODEL



N. Carjan, F. A. Ivanyuk, and Yu. Ts. Oganessian, PRC 99,064606(2019)

N. Carjan, et al. Nucl. Phys. A 942 (2015) 97–109 (2015)

SHAPE DESCRIPTION OF FISSIONING NUCLEUS



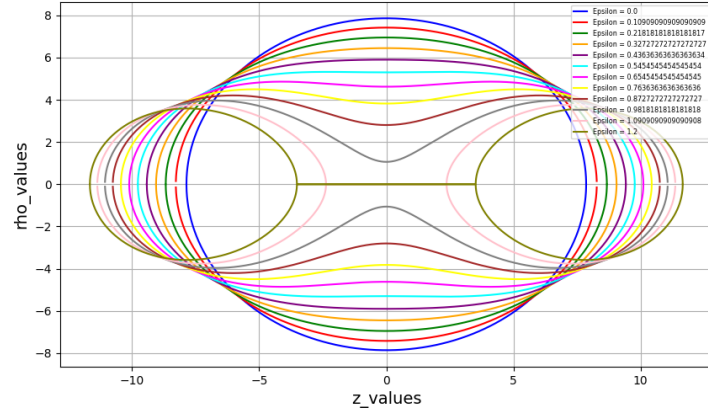
$$\{R, x\} \quad R(x) = R_0 \left[1 + \sum_n \alpha_n P_n(x) \right]$$

- R_0 is the Cassini ovals
- α_n shape's parameters
- P_n Legendre polynomials

The relevant shape parameters are:

- α_1 means the left-right asymmetry
- α_4 acting on the quadrupole deformation

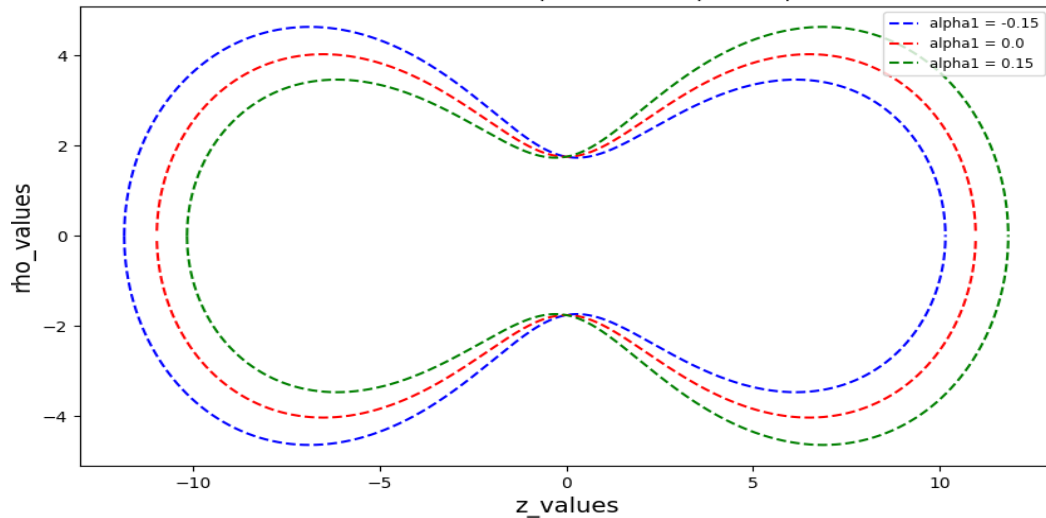
SHAPE DESCRIPTION OF FISSIONING NUCLEUS


 $\{R, x\}$

$$R(x) = R_0 \left[1 + \sum_n \alpha_n P_n(x) \right]$$

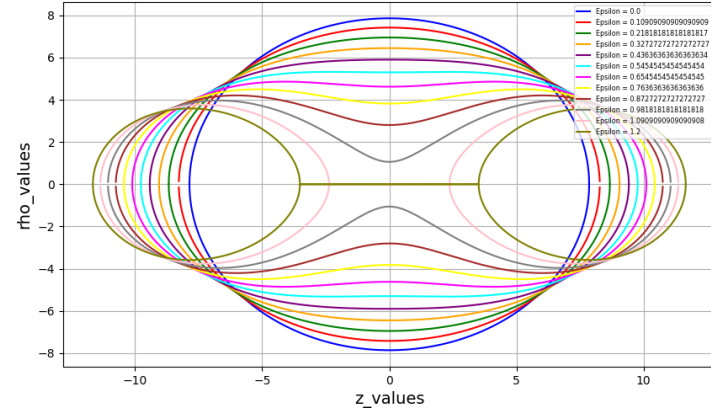
- R_0 is the Cassini ovals
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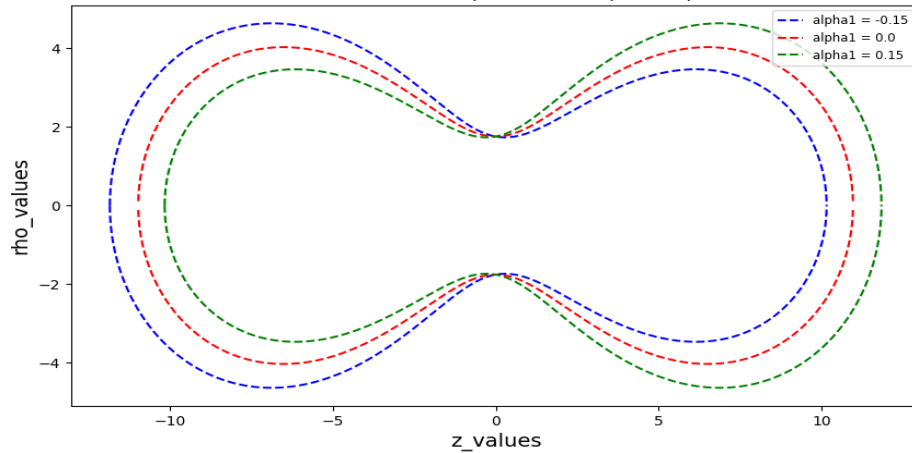
SHAPE DESCRIPTION OF FISSIONING NUCLEUS



$$\{R, x\} \quad R(x) = R_0 \left[1 + \sum_n \alpha_n P_n(x) \right]$$

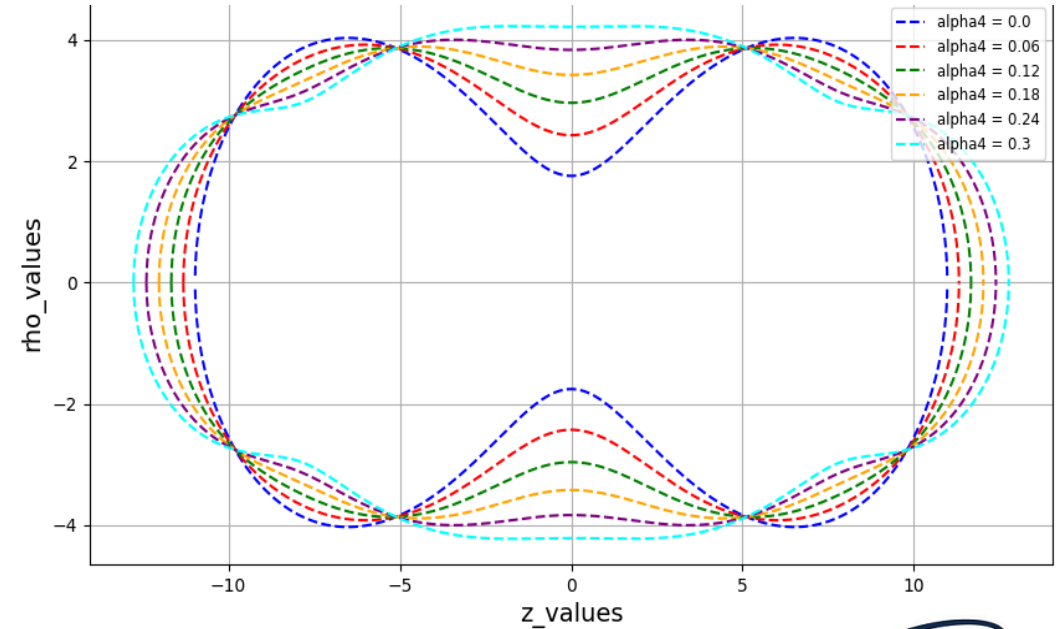
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- α_n shape's parameters
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The relevant shape parameters are:

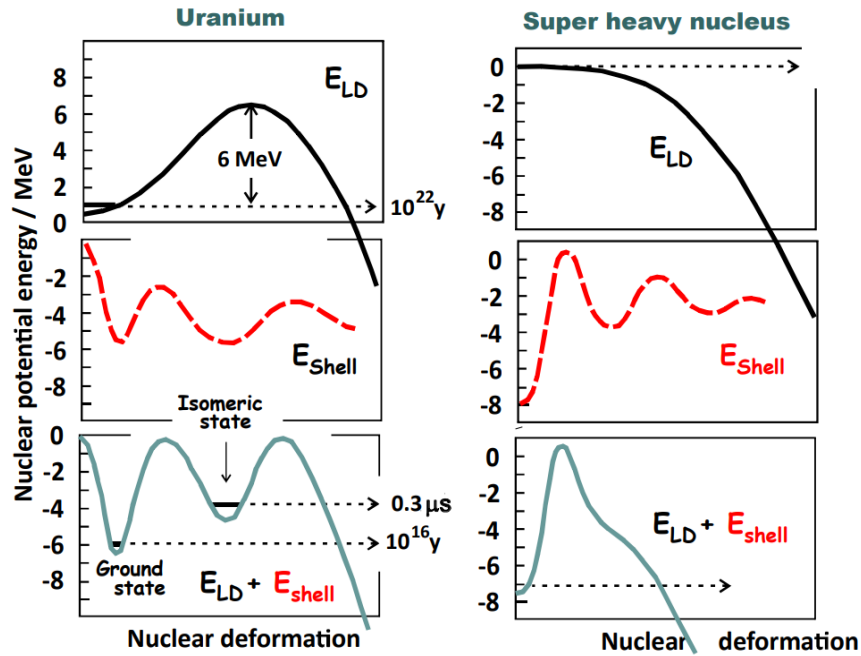


➤ α_1 means the left-right asymmetry

➤ α_4 acting on the quadrupole deformation



ADDING NEW FEATURES Stationary Approach to Fission (SAF)



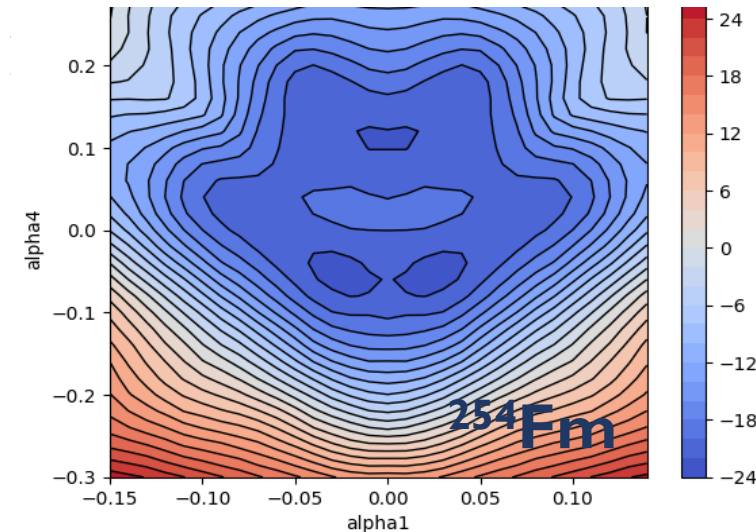
(V.M. Strutinski 1967)

$$E_{def}(shape) = E_{LDM}(shape) + \delta E(shape)$$

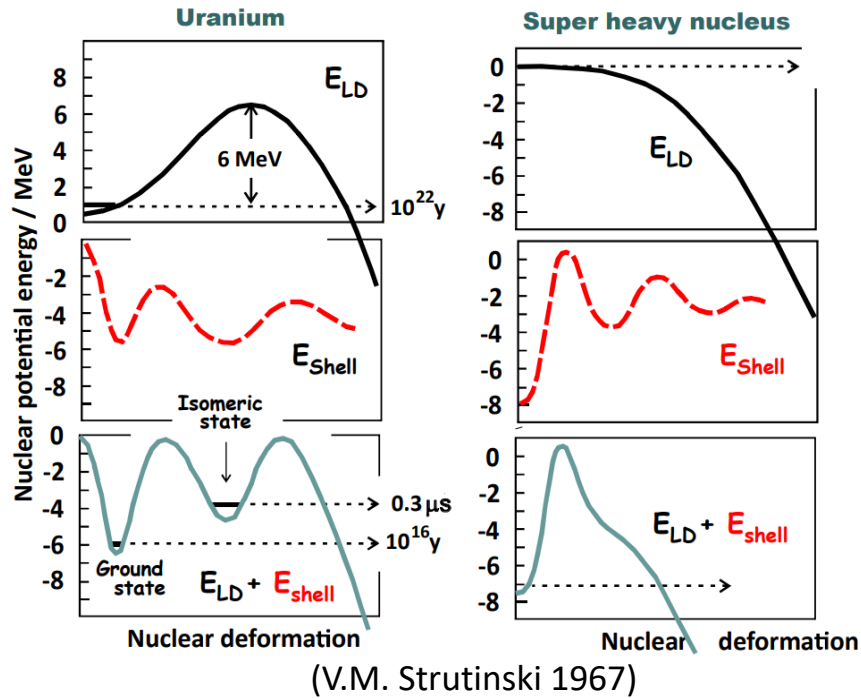
$$Y(\alpha_1) = \frac{\sum_j P(\alpha_{1i}, \alpha_{4j})}{\sum_{ij} P(\alpha_{1i}, \alpha_{4j})}$$

$$Y(TKE) = \sum_{ij} P(\alpha_{1i}, \alpha_{4j}) \cdot \frac{e^{(TKE_{ij} - TKE)^2 / \Delta^2}}{\Delta \cdot \pi}$$

$$P(\alpha_{1i}, \alpha_{4j}) = e^{-E_{def}(\alpha_{1i}, \alpha_{4j}) / T_{coll}}$$



ADDING NEW FEATURES → Stationary Approach to Fission (SAF)

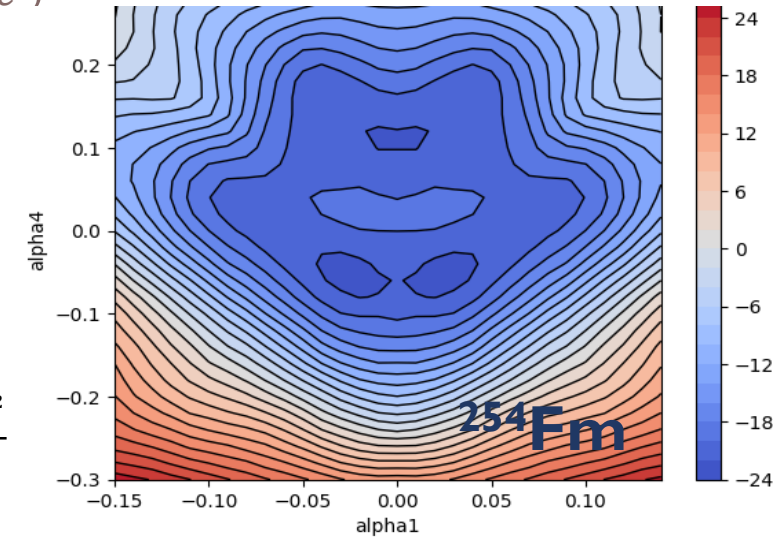


$$E_{def}(shape) = E_{LDM}(shape) + \delta E(shape)$$

$$P(\alpha_{1i}, \alpha_{4j}) = e^{-E_{def}(\alpha_{1i}, \alpha_{4j})/T_{coll}}$$

$$Y(\alpha_1) = \frac{\sum_j P(\alpha_{1i}, \alpha_{4j})}{\sum_{ij} P(\alpha_{1i}, \alpha_{4j})}$$

$$Y(TKE) = \sum_{ij} P(\alpha_{1i}, \alpha_{4j}) \cdot \frac{e^{(TKE_{ij} - TKE)^2 / \Delta^2}}{\Delta \cdot \pi}$$



$$\delta E = \delta E_{shell} + \delta E_{paring}$$

$$f_{F-D} = \frac{1}{1 + e^{\varepsilon_k - \mu/T}}$$

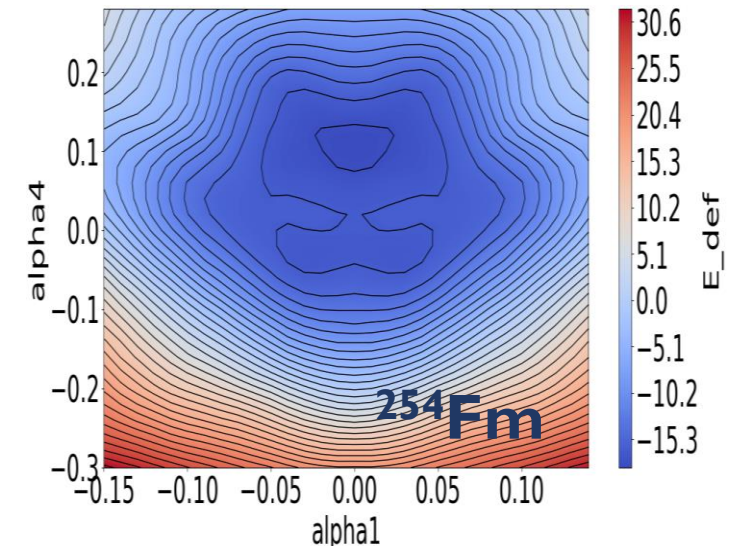
$$E_{rot} = \frac{\langle l \rangle (\langle l \rangle + 1) \hbar^2}{2 \mathfrak{I}_{cm}}$$

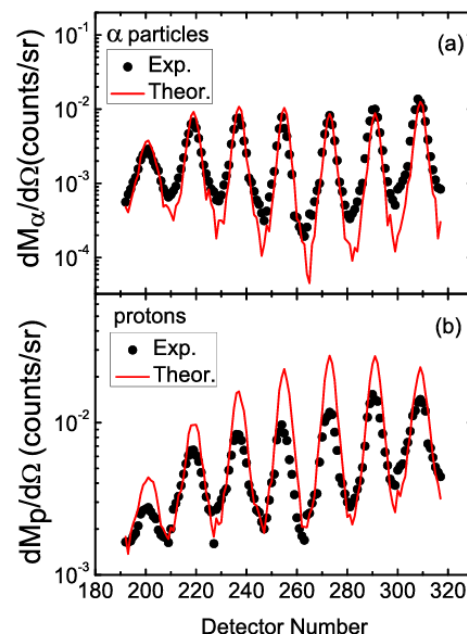
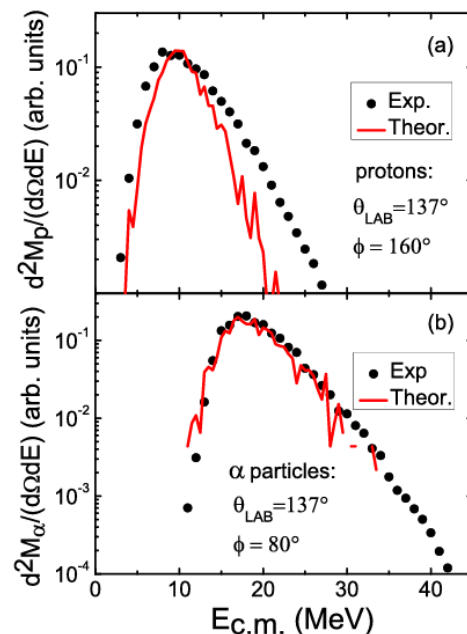
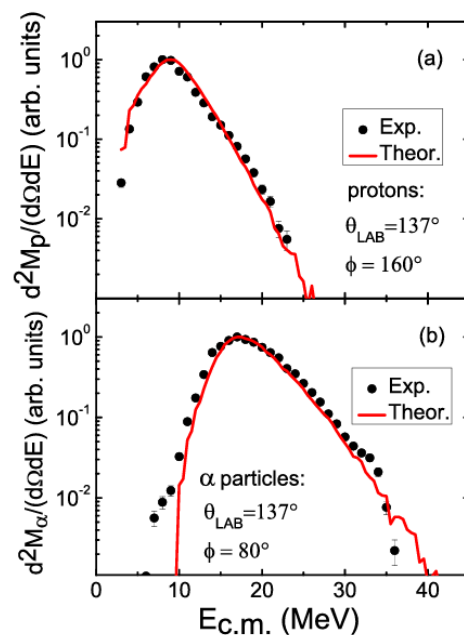
$$\mathfrak{I}_0^1 = \frac{\rho_n \pi}{CV^{54}} \int_{Z_L}^0 [\rho^2 + 4z^2] \rho^2 dz$$

$$\delta E(E^*) = \begin{cases} \delta E(0) & \text{if } |\delta E(0)e^{-E^*/E_d}| \geq |\delta E(0)| \\ \delta E(0)e^{-E^*/E_d} & \text{if } |\delta E(0)e^{-E^*/E_d}| < |\delta E(0)| \end{cases}$$

$$E_{def}(shape) = E_{LDM}(shape) + \delta E(T)(shape) + E_{rot}(shape)$$

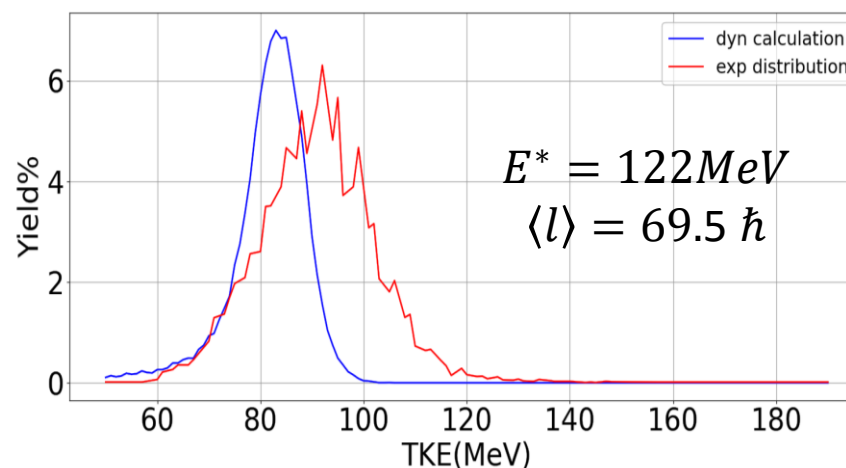
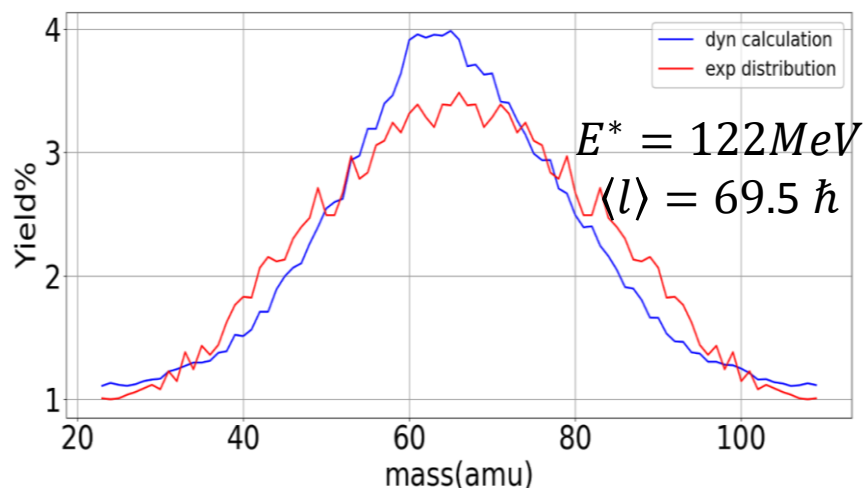
$$TKE_{ij} = \frac{e^2 Z_L Z_H}{D_{cm}} + E_{rot}(shape)$$



CASE OF STUDY: $^{132}\text{Ce}^*$ 

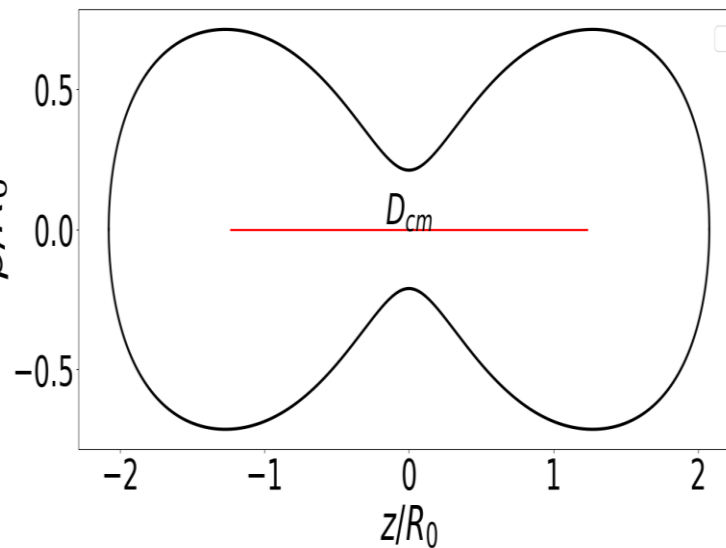
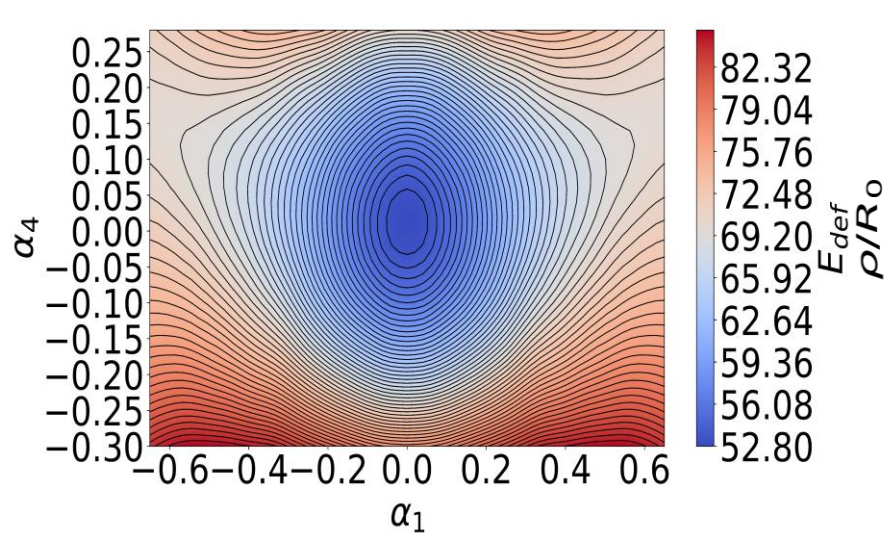
Dynamical model provides a good description of LCP energy spectra in Fusion-Evaporation channel as well as in the Fusion-Fission channel and LCP angular correlation in the Fusion-Evaporation channel

E. Vardaci, P. N. Nadtochy, A. Di Nitto, et al.,
Phys. Rev. C 92, 034610 (2015)



Discrepancies are observed in the mass and TKE distribution

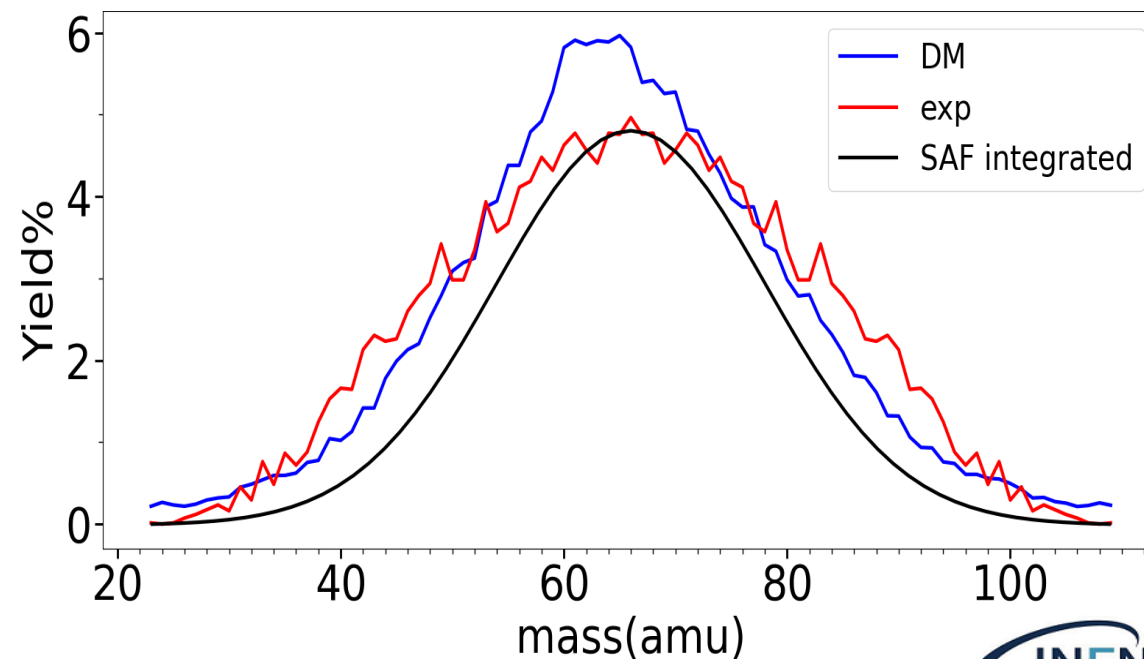
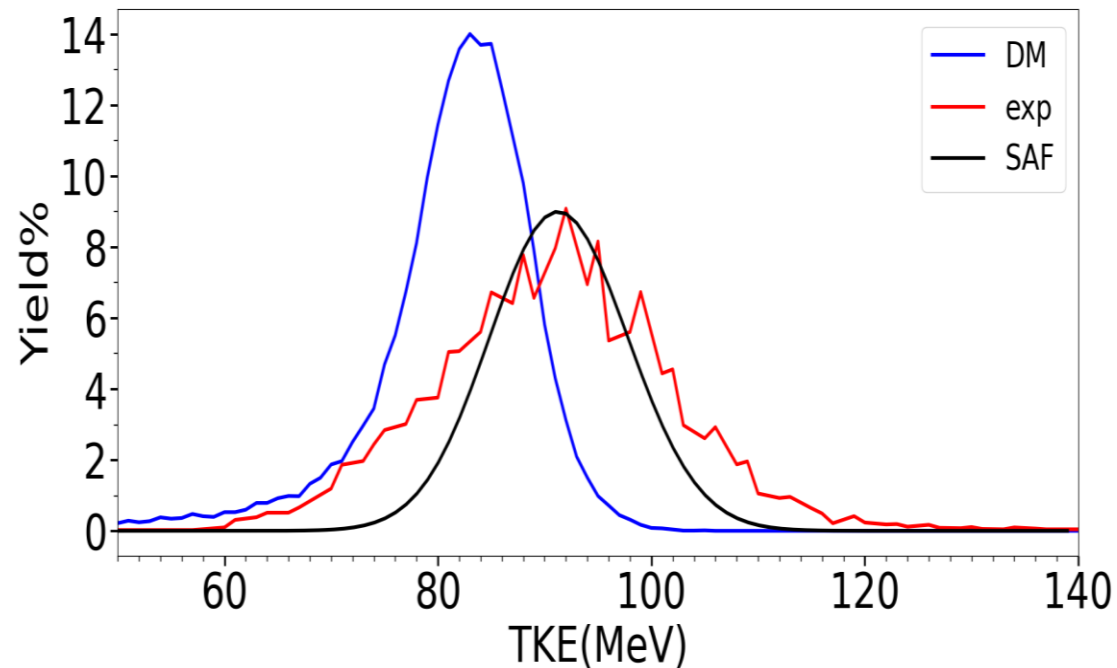
TESTING SAF



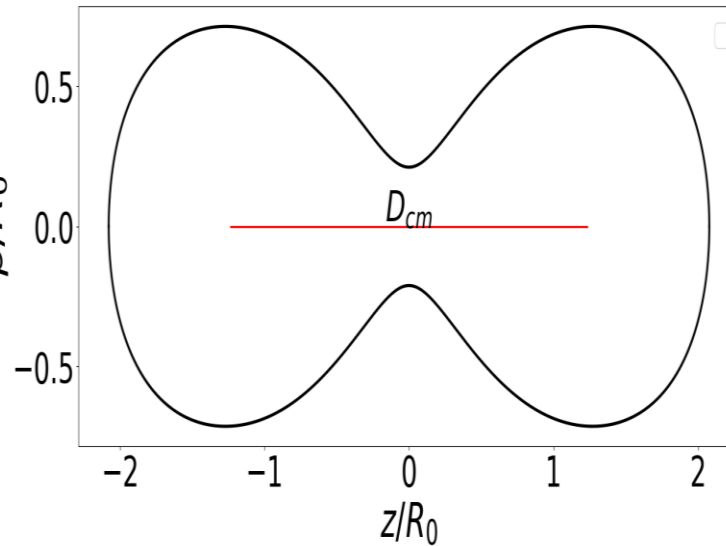
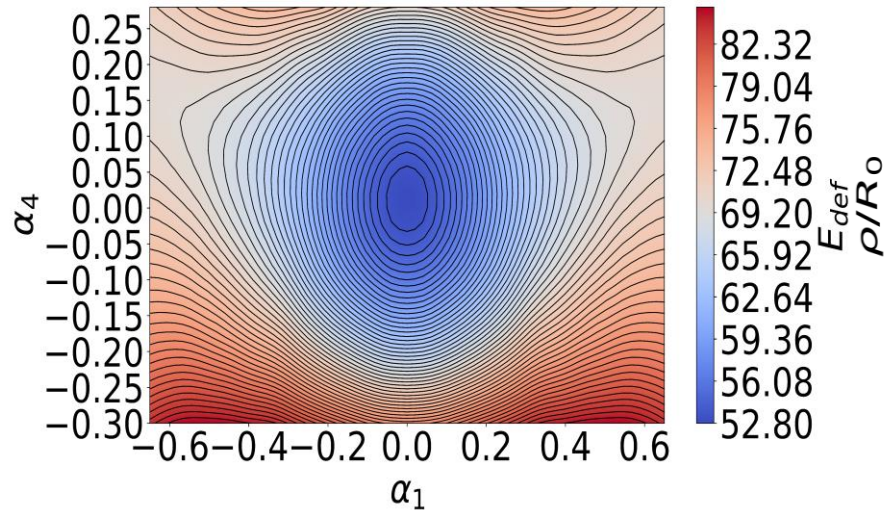
PES minimum:

$$\alpha_1 = 0.041, \alpha_4 = 0.02, \alpha_6 = -0.02$$

and its corresponding shape

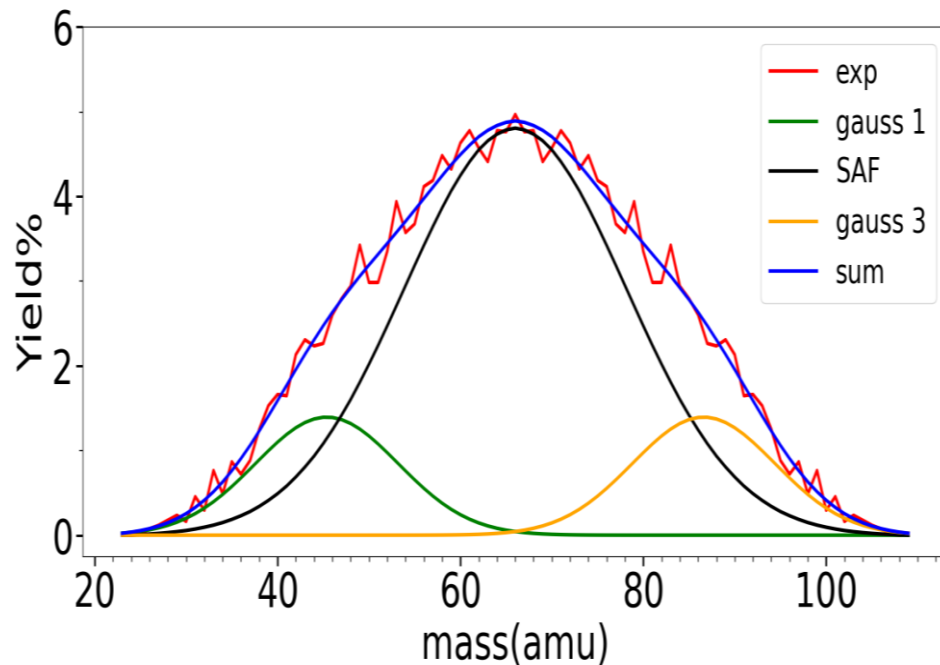


TESTING SAF

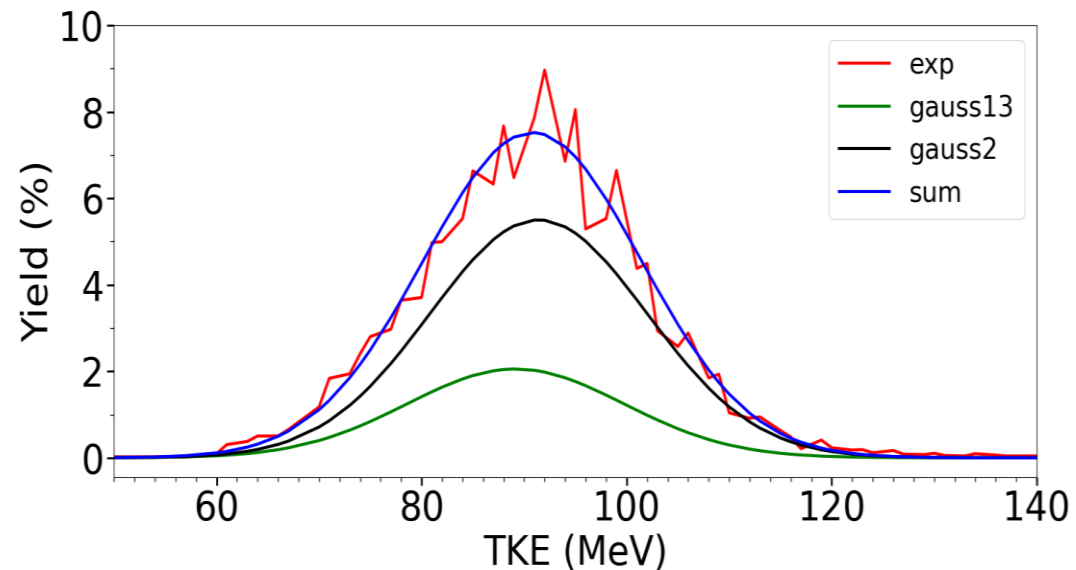


PES minimum:

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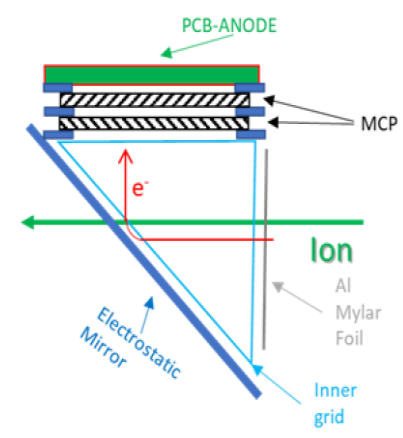
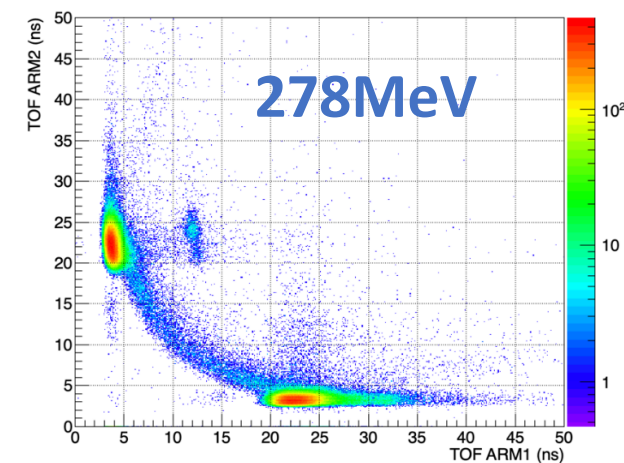
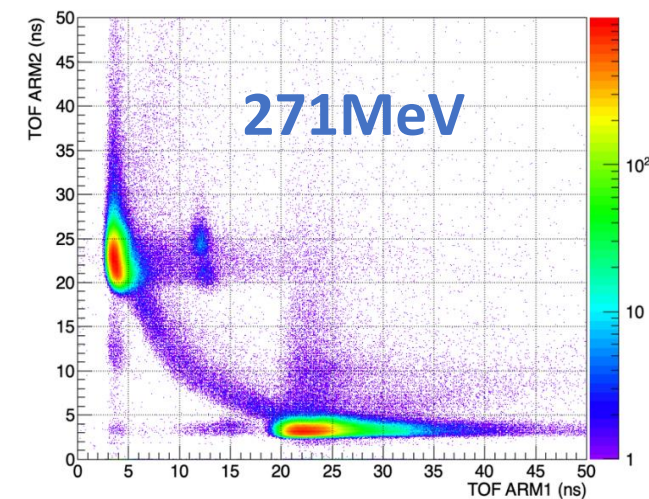
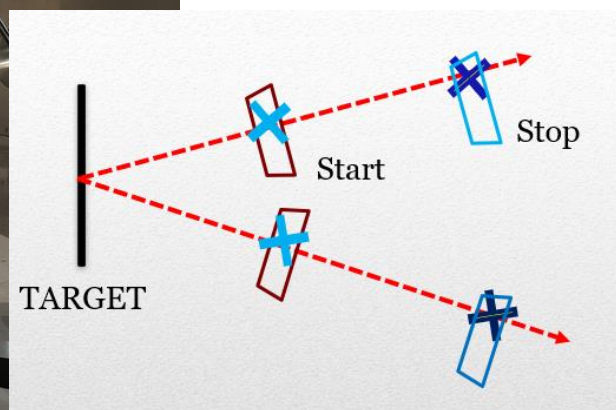
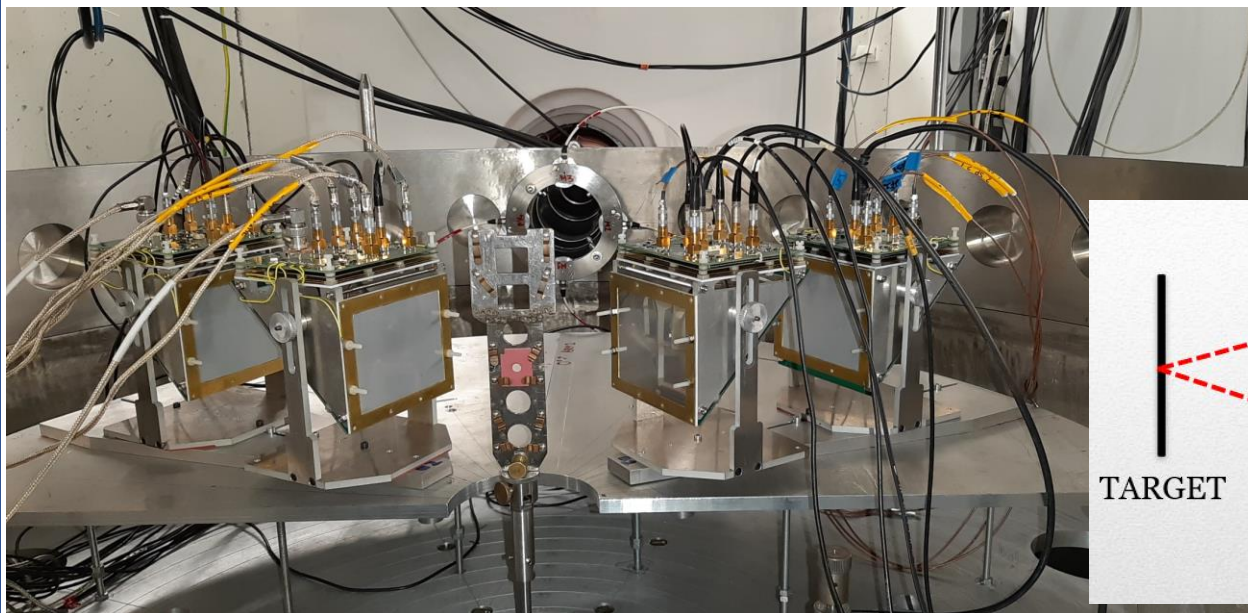


P.A. Setato, et al., Submitted to Phys Rev. C



The better reproduction in the mean value of mass and TKE distribution allows to highlight new components

TIME OF FLIGHT SPECTROMETER FOR BINARY REACTIONS

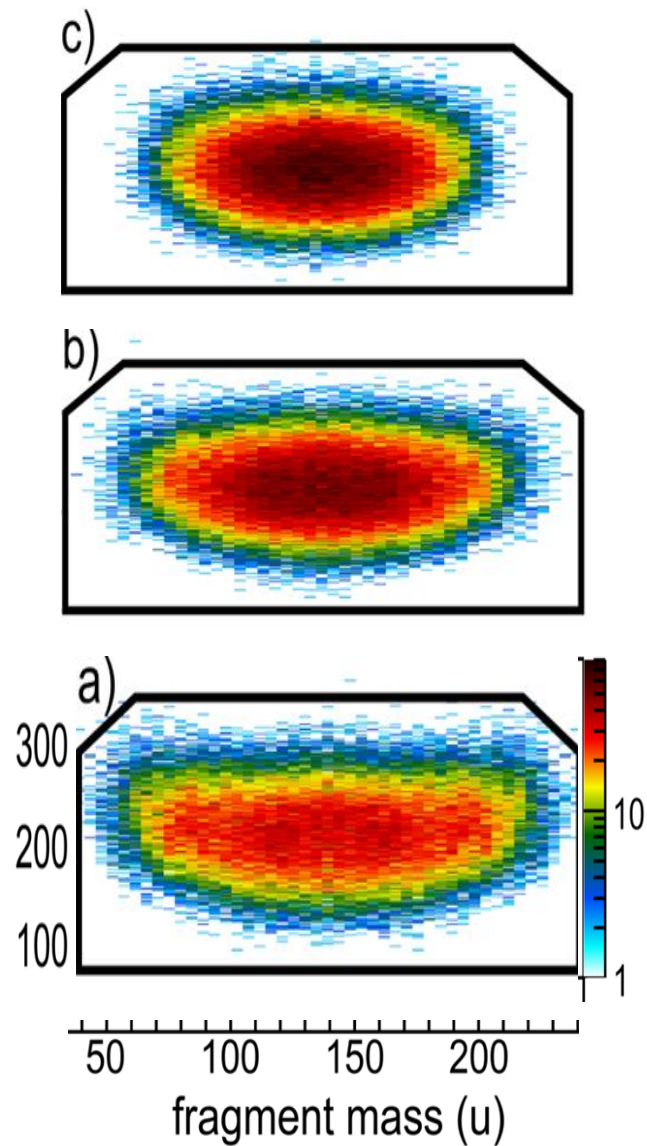


Two arms spectrometer **TOSCA** to measure the flight time and position of both fragments (**ToF-2V method**)

The electrons produced are then collected on an (X,Y) position grid



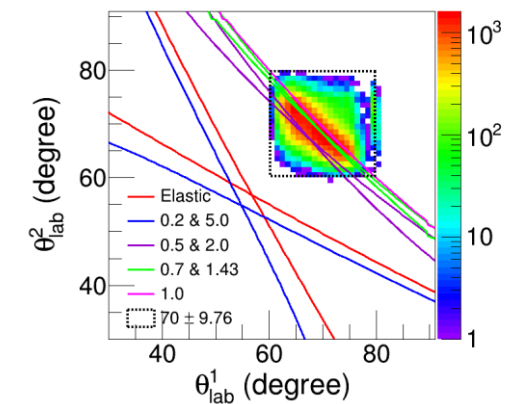
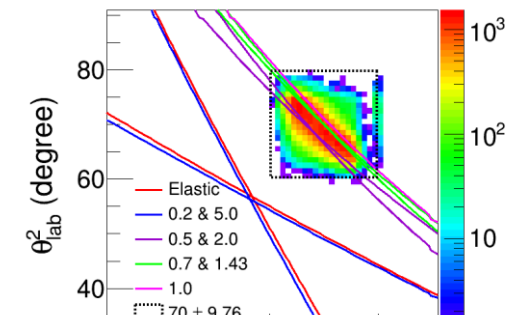
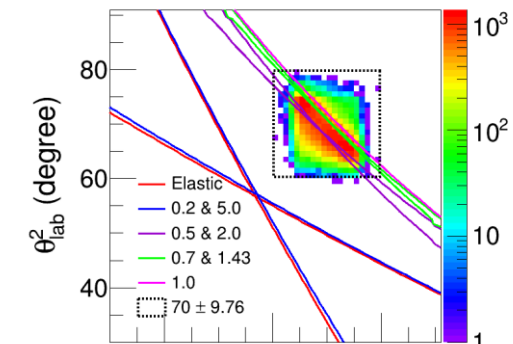
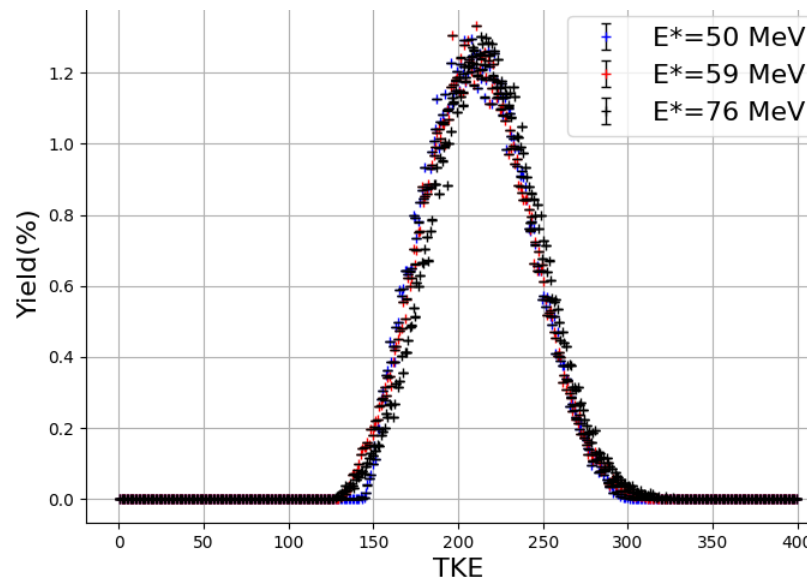
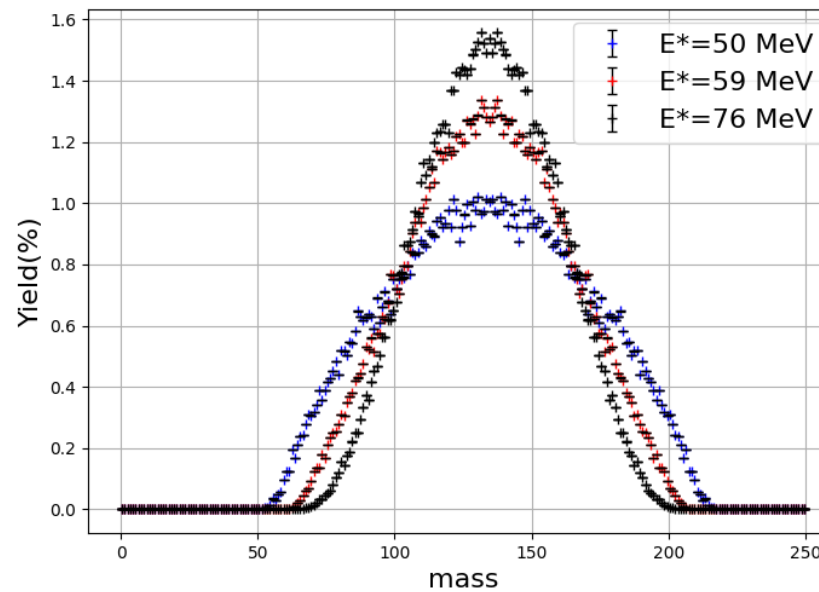
TASCA
WORKSHOP



E*=76Me
V

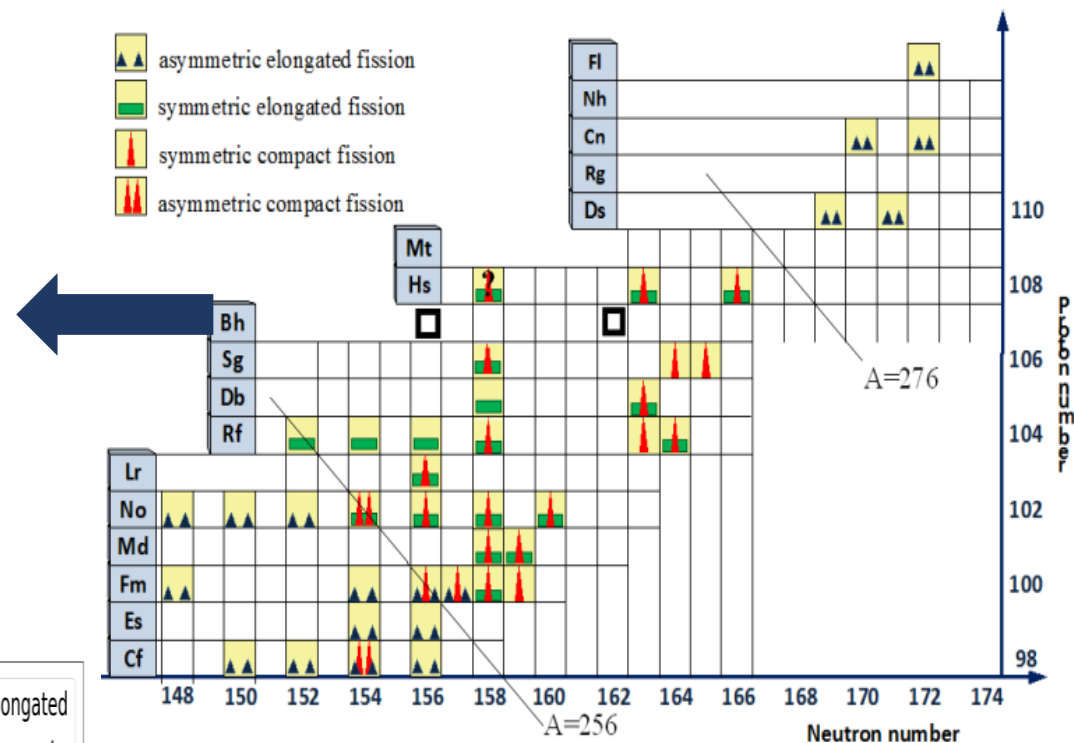
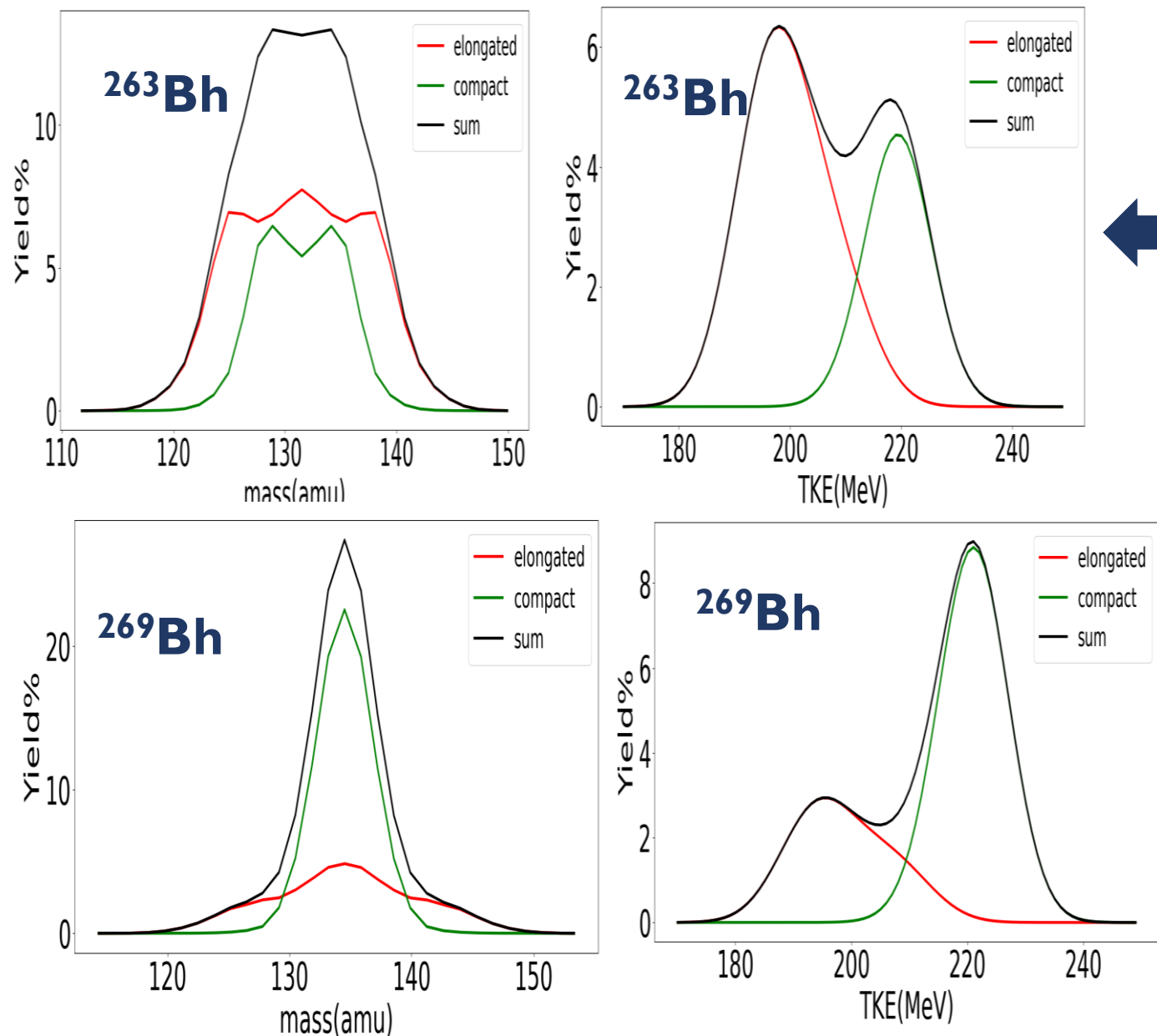
E*=59Me
V

E*=50Me
V



Courtesy of Dr. Tathagata Banerjee

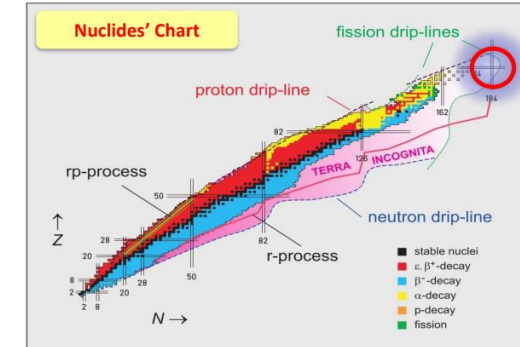
Preliminary SAF results



Fission of ^{263}Bh and ^{269}Bh are studied in approximation of spontaneous or low energy fission

CONCLUSIONS AND PERSPECTIVES

- ✓ New features have been incorporated into the scission-point model
- ✓ The introduction of temperature and angular momentum give significant improvements in the description of the fission process, as demonstrated by the accurate reproduction of the mass and TKE distributions for Ce
- ✓ The mass and TKE distributions of two Bh isotopes, both experimental and theoretical, will soon be included in the transitional region, providing further insights into this area
- ✓ The need for further investigation of the superheavy element region, both theoretically and experimentally, is evident



THANK YOU FOR YOUR ATTENTION



E.Vardaci, A.Di Nitto, G.La Rana, T.Banerjee, M.Ashaduzzaman, G.Alifano, S.Di Costanzo, D.Panico and P.A.Setaro

FORTE (CSN3)



Ministero degli Affari Esteri
e della Cooperazione Internazionale

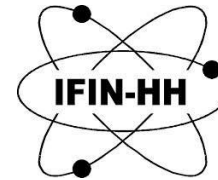
Maeci project



W.Trzaska



S.Heinz, D.Kumar, J.Maurer



C.Petrone, S.Calinescu



N.Carjan