Probing fission fragments of $^{182,183}Hg$ nuclei at energies around coulomb barrier

Meghashree Cheralu House
FLNR, JINR, Dubna

- *Mercury mass-asymmetry*
- *Deformed mercury isotopes $^{182,183}Hg$*
- *Experimental set-up*
- *Results and comparison*
- *Summary and outlook*

Asymmetry region in Nuclear Chart

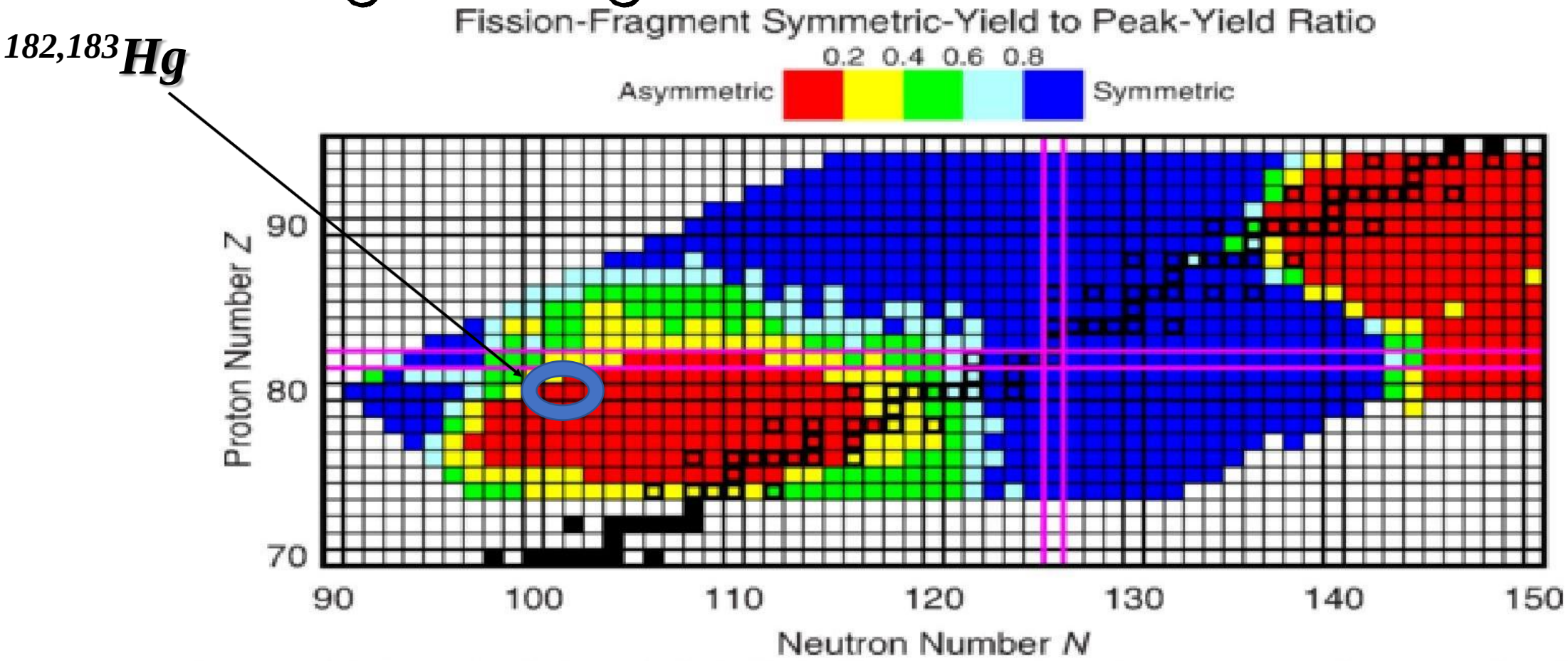
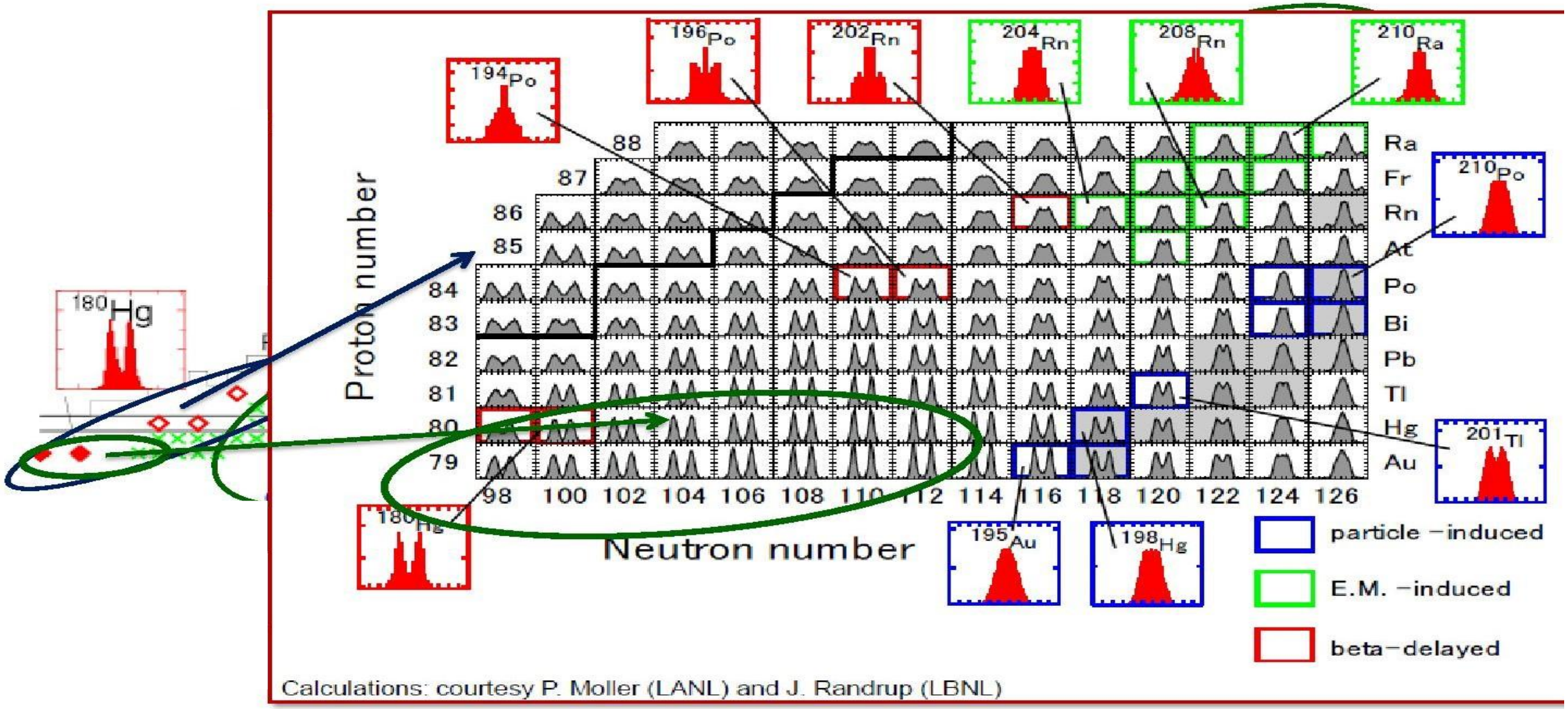


Figure. Calculated symmetric-yield to peak-yield ratios for 987 fissioning systems. Black squares (open in colored regions, filled outside) indicate β-stable nuclei. We find a new, contiguous region of asymmetric fission separated from the classical location of asymmetric fission in the actinides by an extended area of symmetric fission.

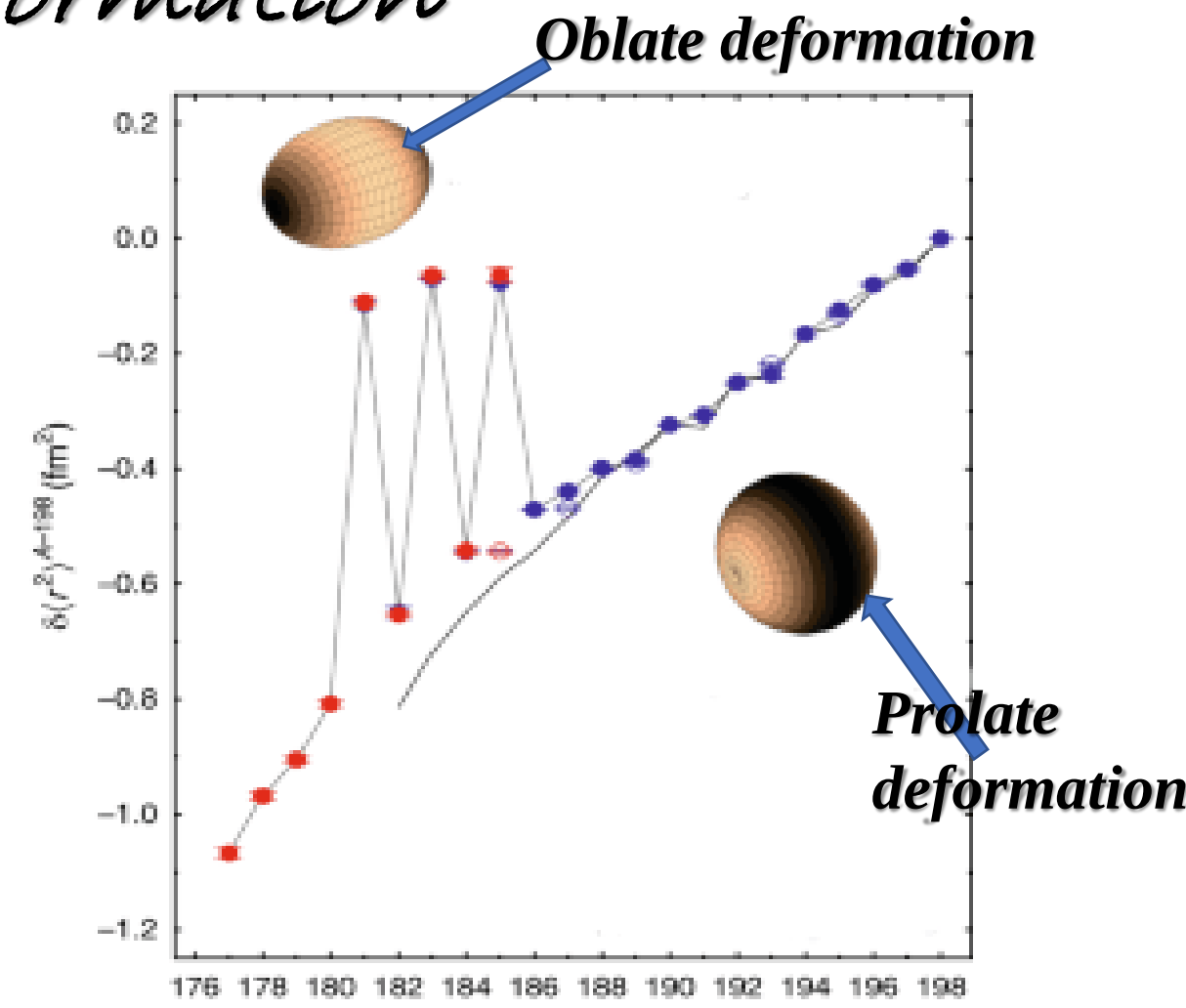
P. Möller, J. Randrup, Phys. Rev. C 91 (2015) 044316.

Asymmetric fission in Sub-Lead region



^{182,183}Hg deformation

- *Probability of asymmetric fission for deformed nuclei is higher compared to spherical nuclei.*
  - ***^{182}Hg - Prolate $\delta\langle r^2\rangle$ (-0.7)***
  - ***^{183}Hg - Oblate $\delta\langle r^2\rangle$ (-0.1).***
- *Mean-square charge radii calculated with respect to $A=N+Z=198$.*



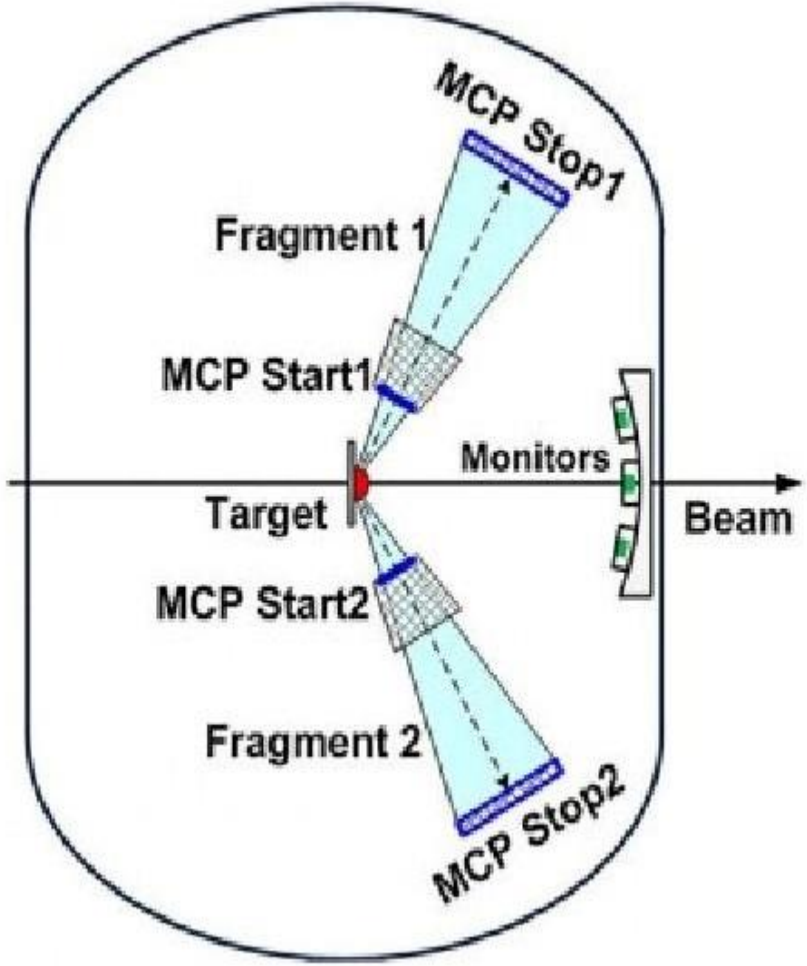
*B.A.Marsh Nature Physics **14**, pages1163–1167(2018)*

Experimental details

- *Experiment was conducted in FLNR CORSET setup, ^{40}Ca beam extracted from U-400 cyclotron*
- *Energy - 172,192,212 and 244 MeV*
- *Energy resolution - 2%*
- *Target thickness:*

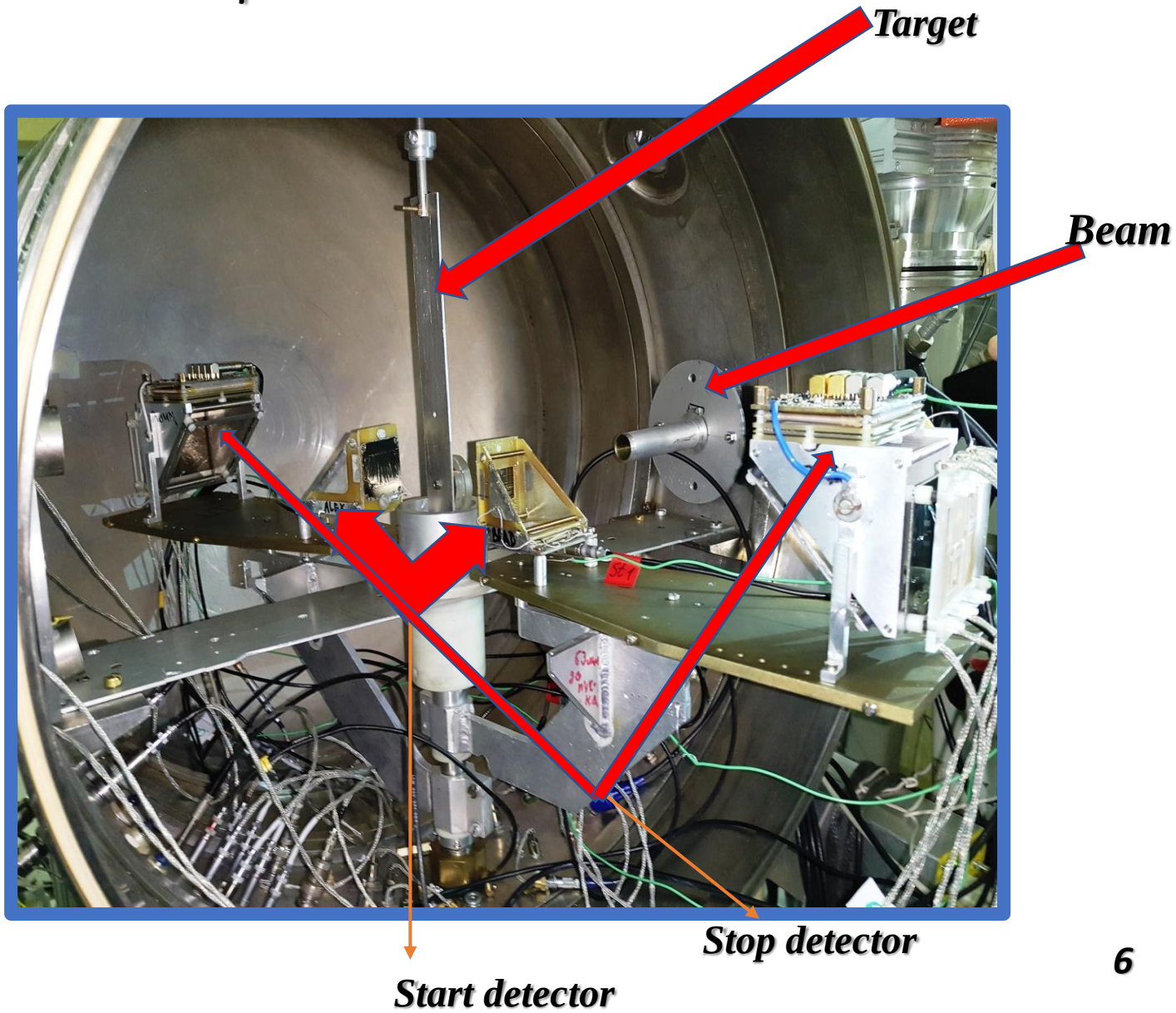
  ^{142}Nd - 225 $\mu g/cm^2$

  ^{143}Nd - 196 $\mu g/cm^2$
- *Carbon backing- 30 $\mu g/cm^2$*
- *Beam Intensity - 80-100 nA*

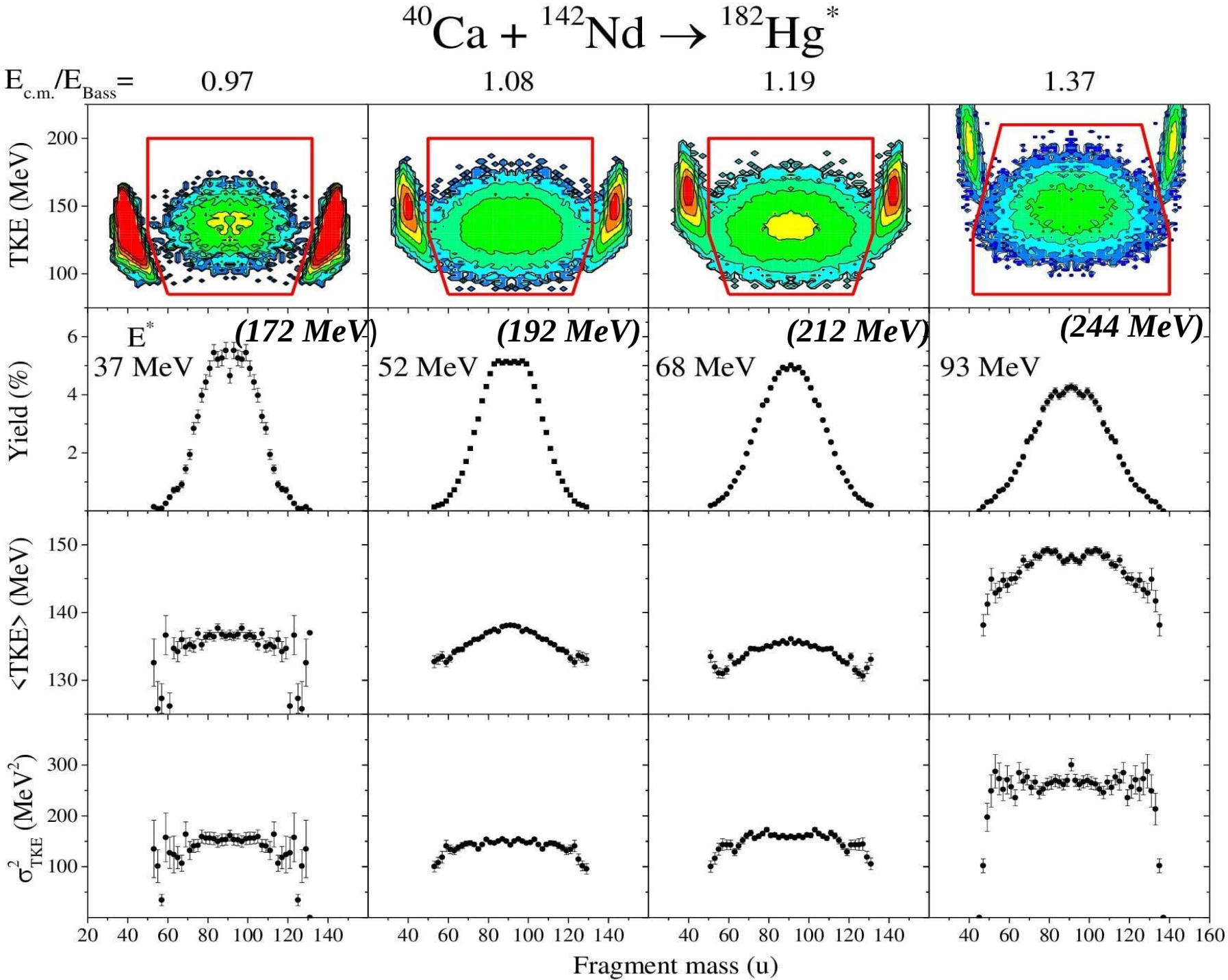


Experimental setup & Procedure

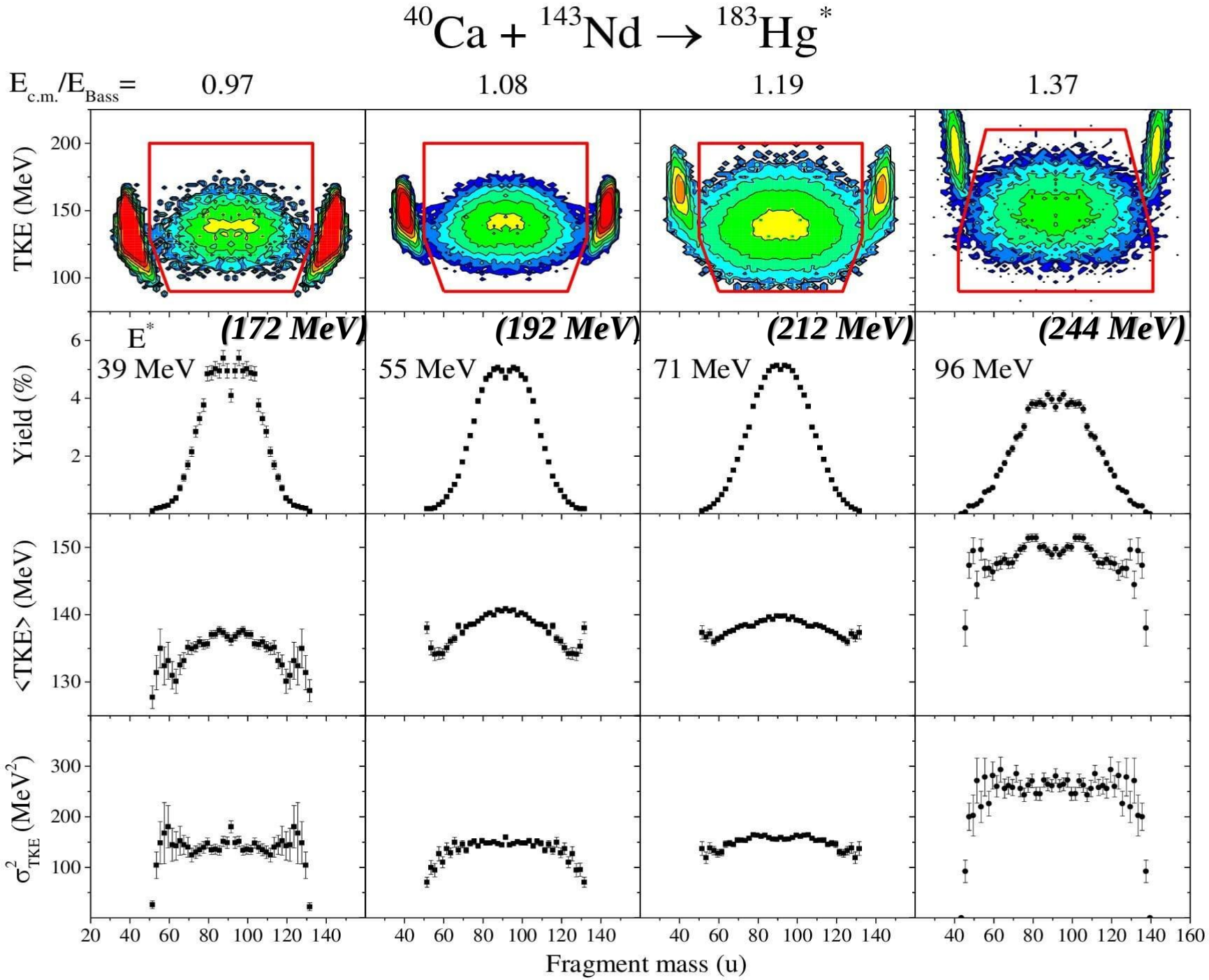
- *Double-arm TOF(time-of-flight)* ***CORSET*** *spectrometer which functions on the basis of 2V method was used*
- *Time resolution - 150 ps*
- *Angular resolution - 0.3º*
- *Position sensitive MCP's are used to detect the particle in the stop detector.*
- *To analyse and process the data we use standard two-body kinematics.*
- *Energy losses due to start detector foil and target backing are taken into account during the data analysis.*



Results for ^{182}Hg

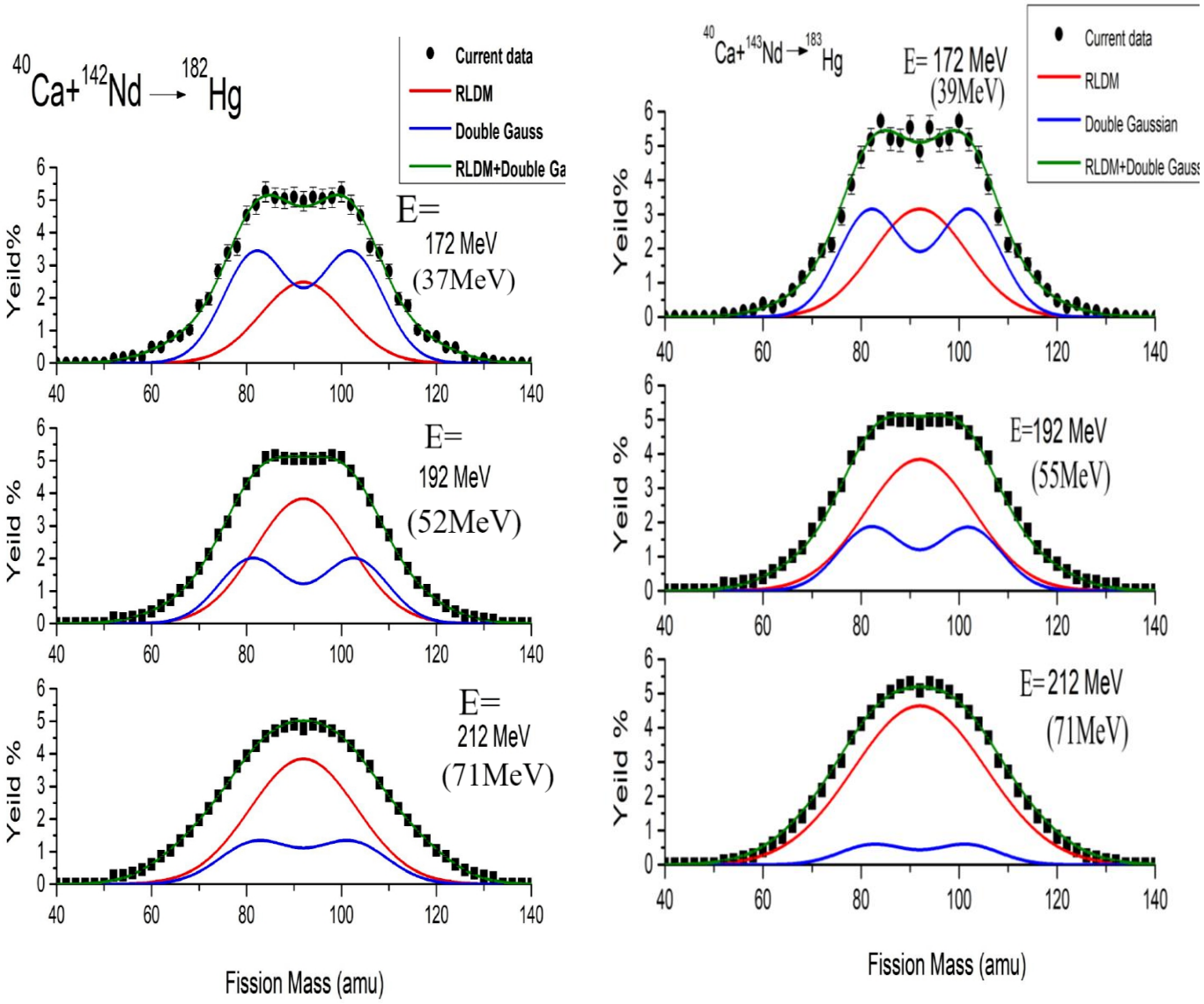


Results for ^{183}Hg



Mass distribution

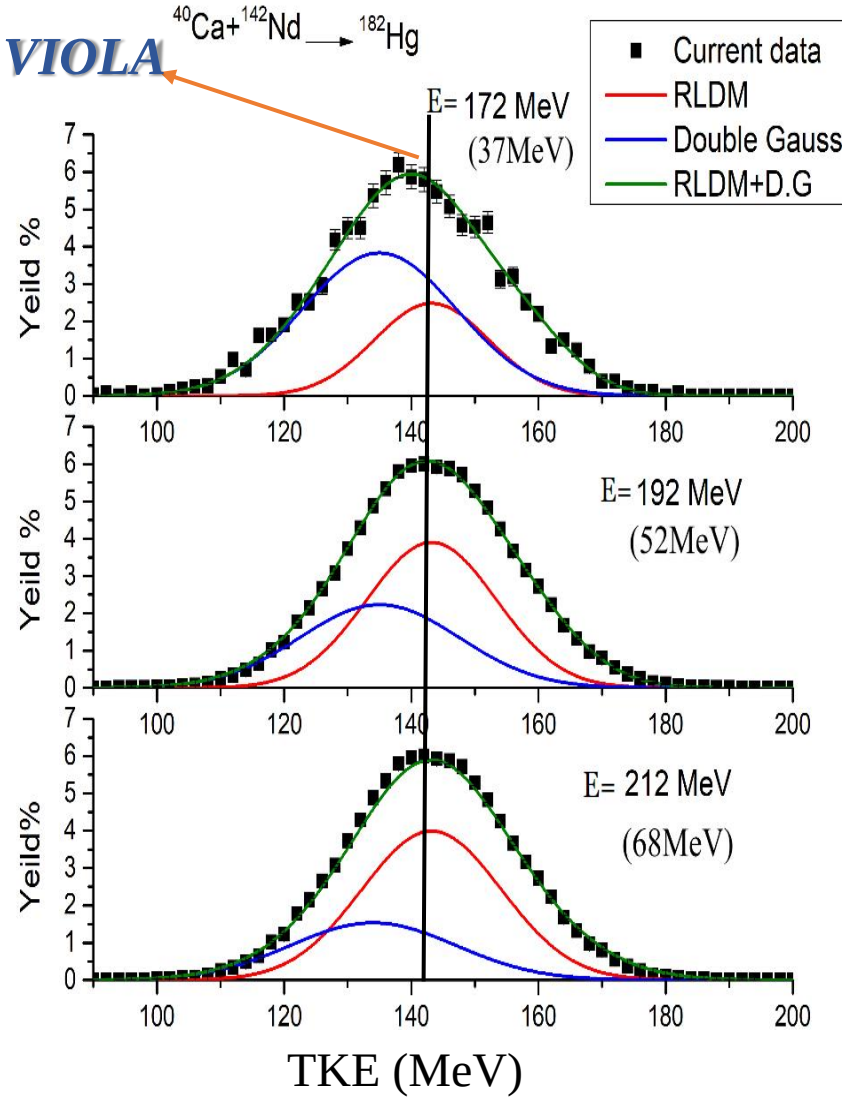
- *For ^{182}Hg and ^{183}Hg asymmetric peaks are observed at 81 and 101 (±1).*
- *Asymmetric component contribution diminishes with increase in energy*
- *No additional difference observed for ^{183}**Hg**.*

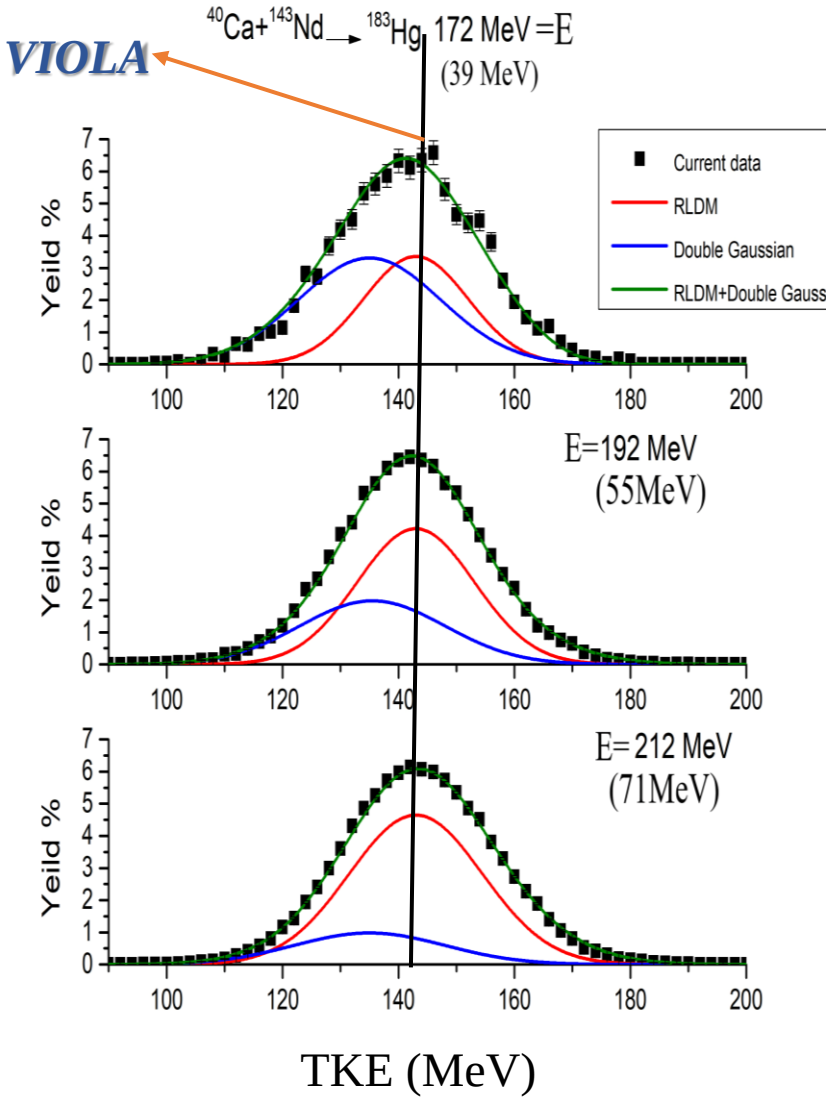


TKE distribution

VIOLA

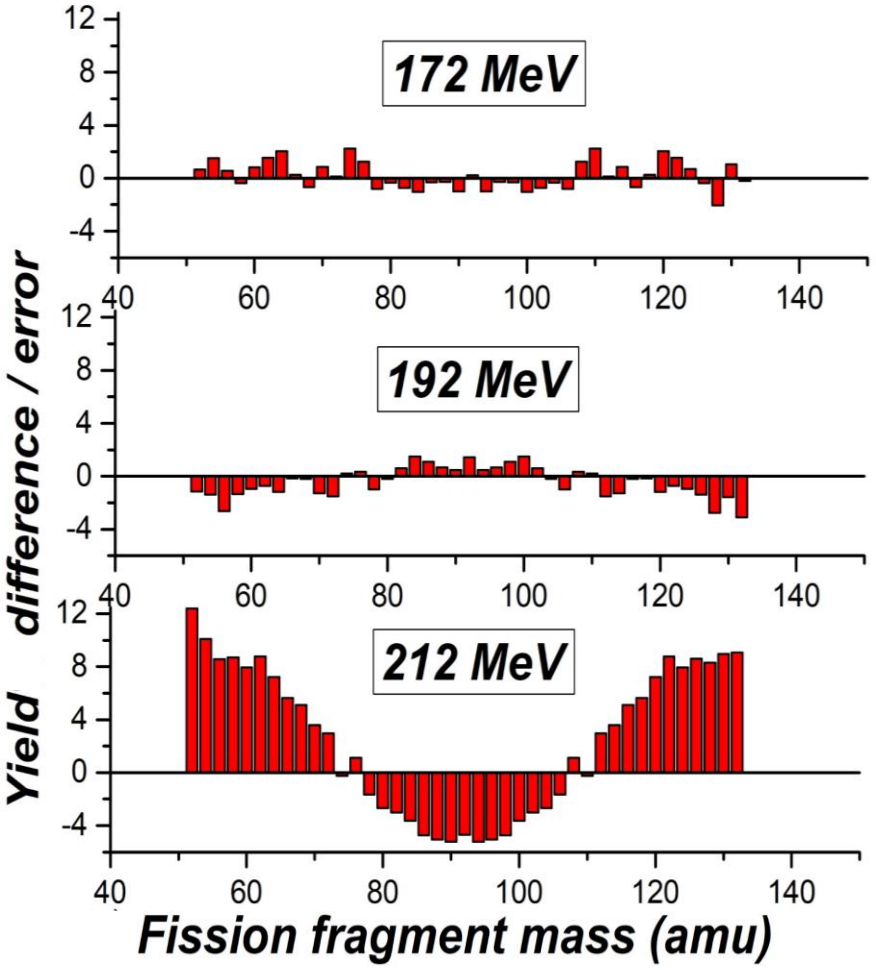
- ***143.2 MeV - ^{182}Hg***
- ***143 MeV - ^{183}Hg***



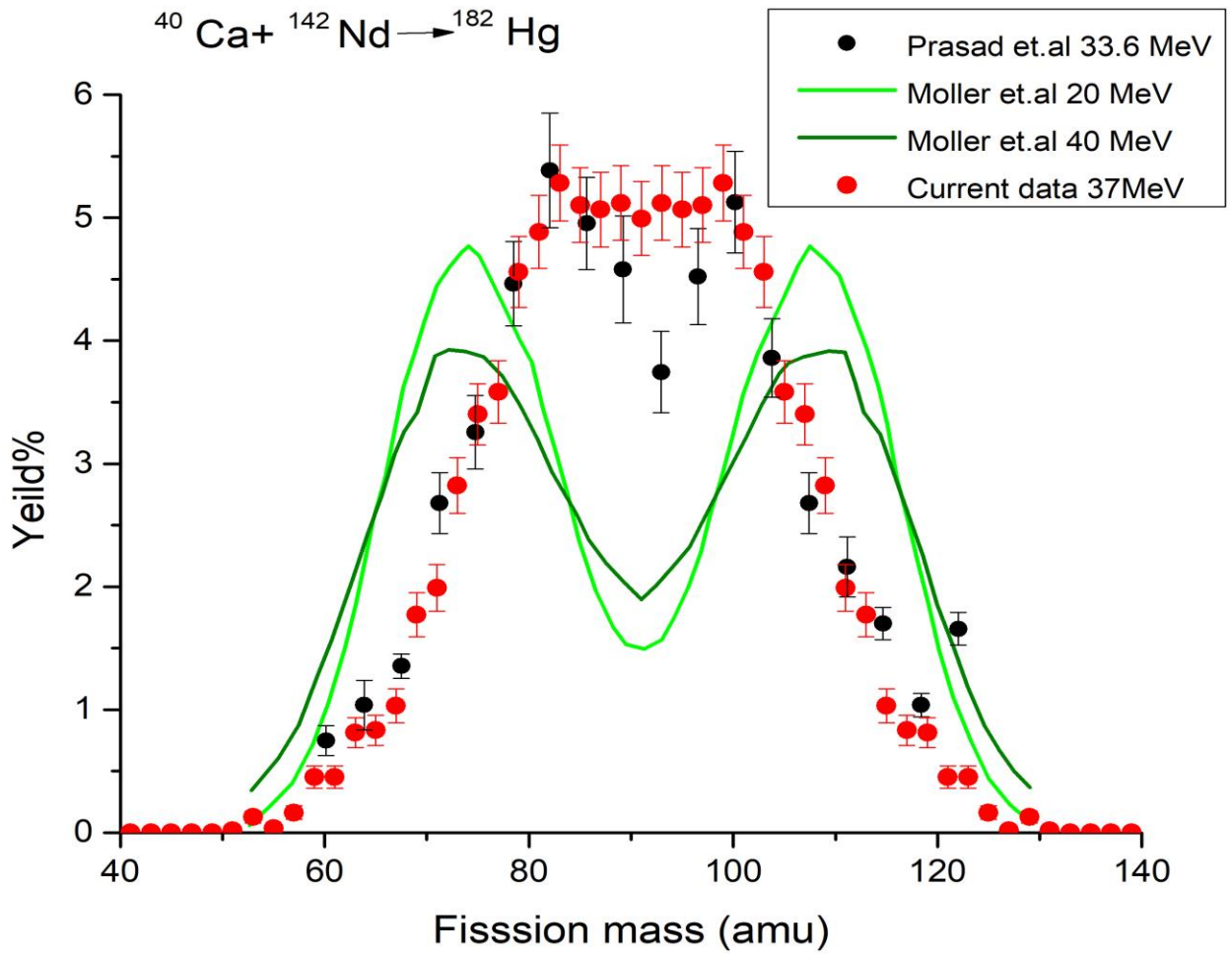


Comparison of ^{182}Hg and ^{183}Hg fission mass distribution

- *Largest deviation in yield is found for lab energy 212 MeV.*
- *We find appreciable agreement for lab energies 172 and 192 MeV .*



Comparison with theory and previous experiment



Summary & Outlook

- *Mass-TKE distributions as we measured have been measured within 37-96 MeV excitation energy for* ^{182,183}***Hg***, *populated using* $^{40}Ar+^{142,143}Nd$ *respectively.*
- *Our study indicates unique fission behavior, where prolate deformed nuclei shows identical result with oblately deformed nuclei and the result contradicts the previous observation of fission of deformed nuclei.*
- *Analysis was made using Rotational Liquid Drop and Double Gaussian model.*
- *At lab energy 244 MeV, where mass distribution is very wide, we are expecting fast-fission since the asymmetric contribution is low.*
- *Comparative analysis showed that only at lab energy 212 MeV the difference in the yield is higher compared to the rest of the energies yield difference.*
- *The presence and effect of deformation on the fission fragment mass distribution in higher excited energy needs to be investigated.*

Thank you..

Collaboration

Cheralu M.[1,*], Kozulin E.M.[1], Itkis I.M[1] , Kumar D.[1], Knyazheva G.N.[1] , Itkis M.G.[1] , Novikov K.V.[1], Banerjee T.[1] , Kozulina N.I.[1] , Diatlov I.N.[1] , Pchelintsev I.V.[1], Tikhomirov R.[1], Vorobiev I.V.[1], Pan A.N.[1,2], Maiti M.[3], Kumar Prajapar R.[3], Kumar R.[3], Sarkar G.[3], Singh P.P.[4], Sahoo R.N.[4], Vardaci E.[5], Andreev A.[6] , Mitu A.[7], Harca I. [7] , Trzaska.W.H. [8]

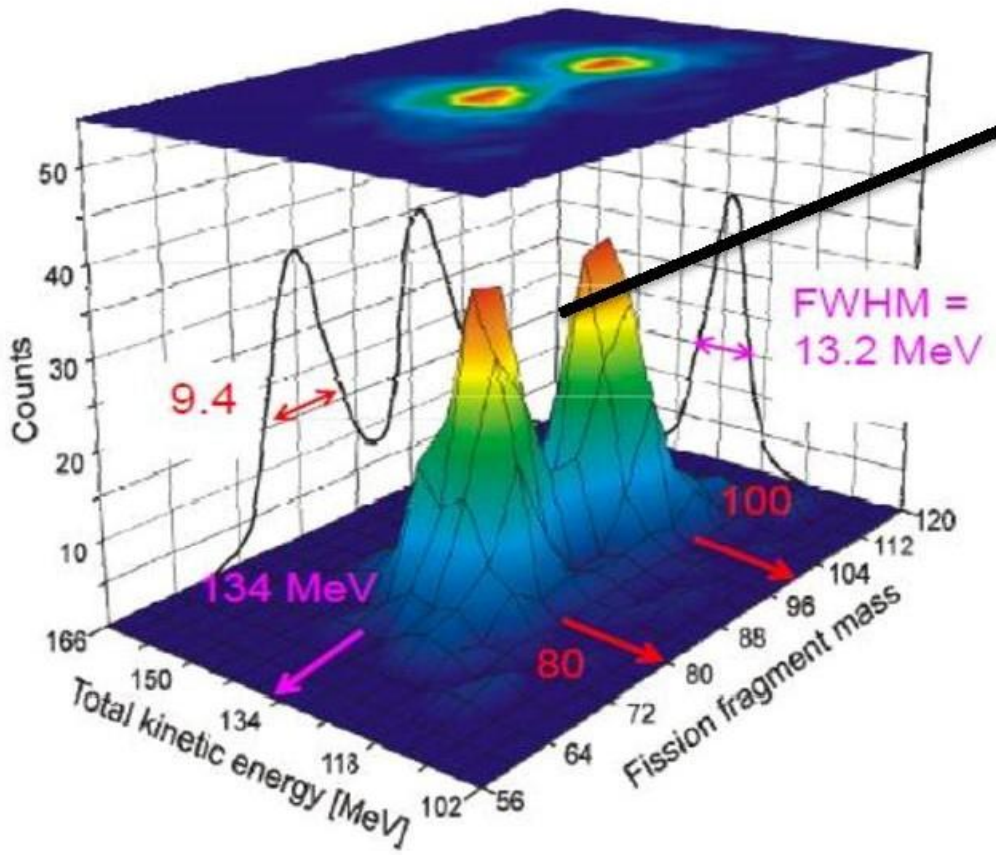
[1,*] *Joint Institute for Nuclear Research, Dubna, 141980 Russia*
[2] *Institute of Nuclear Physics, Almaty, Kazakhstan*
[3] *Department of Physics, Indian Institute of Technology Roorkee, Roorkee, India*
[4] *Department of Physics, Indian Institute of Technology Ropar, Punjab, India*
[5] *Dipartimento di Scienze Fisiche and INFN, Napoli, Italy*
[6] *Department of Physics ,University of York ,York YO10 5DD,UK*
[7] *IFIN-HH, Bucharest - Magurele, Romania*
[8] *Department of Physics, University of Jyvaskyla, Finland*

Comparison

Reaction	E_{lab}, MeV	E_{cm}/E_B	E^*, MeV	<l> (ħ)	σ_M (amu)	σ_E (amu)	L_{cr}, ħ
$^{40}Ca+^{142}Nd \rightarrow ^{182}Hg$	172	0.97	37	9	9	9.1	-
($L(B_f=0)$ = 69 ħ)	192	1.08	52	30	10.2	10.1	49±6
TKE_{Viola} =143.2 MeV	212	1.19	68	46	11.2	11.4	67±7
	244	1.37	93	62	15.4	12.9	87±10
$^{40}Ca+^{143}Nd \rightarrow ^{183}Hg$	172	0.97	39	10	9.6	9.1	-
($L(B_f=0)$ = 70 ħ)	192	1.08	55	32	10.26	10.1	50±7
TKE_{Viola} =143 MeV	212	1.19	71	48	14.2	11.5	68±8
	244	1.37	96	66	15.6	13.6	88±10

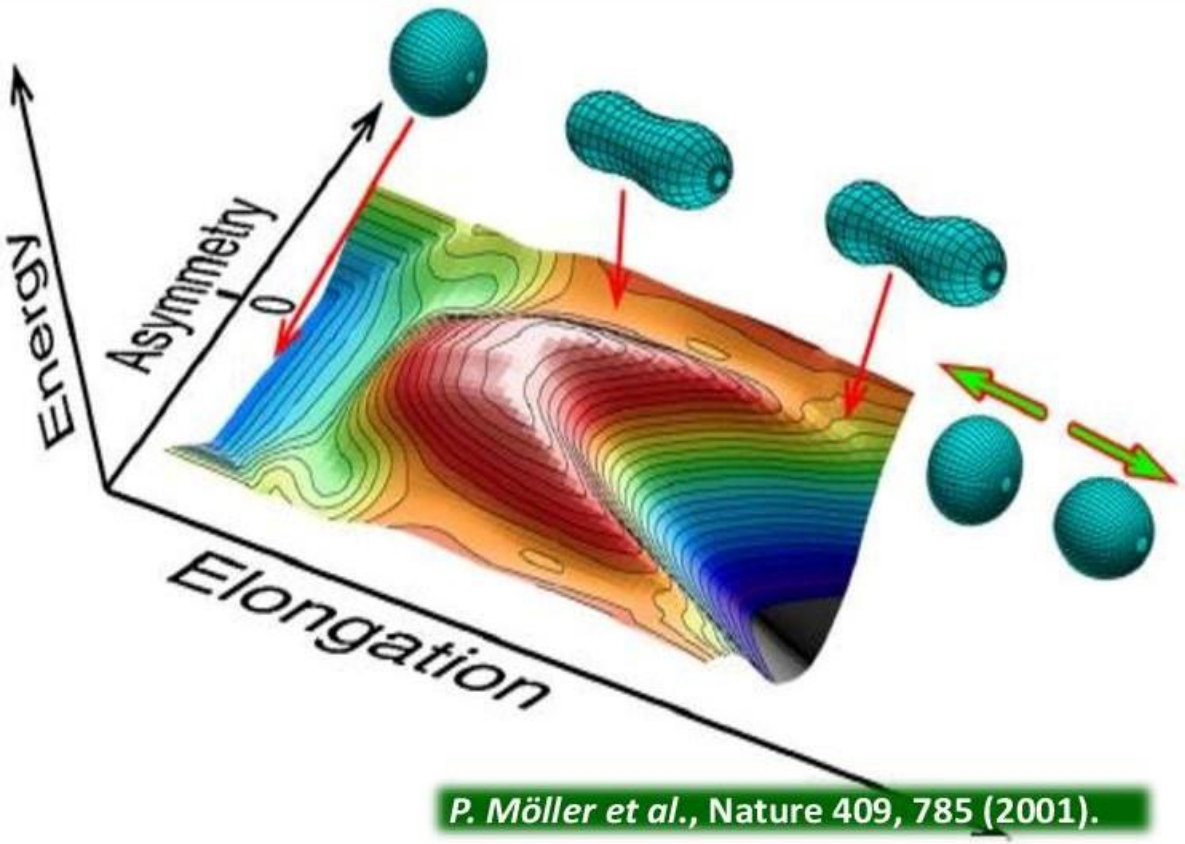
Asymmetric fission in Mercury

Asymmetric mass distribution was observed in spite of a mass symmetric split that could lead to two ^{90}Zr fragments, with magic N=50 & semimagic Z=40.



$^{180}_{80}Hg_{100} \rightarrow {}^{90}_{40}Zr_{50} + {}^{90}_{40}Zr_{50}$?

A.N. Andreyev et al., Phys. Rev. Lett. 105 (2010) 252502.



P. Möller et al., Nature 409, 785 (2001).