Fission-fragment mass distribution in neutron-deficient Po at low excitation energy

Shilpi Gupta[1,2],* C. Schmitt[3], A. Shrivastava[1,2], K. Mahata[1,2], P. Sugathan[4], A. Jhingan [4], K.S Golda[4], N. Saneesh[4], A. Chatterjee[4,5], Gurpreet Kaur[4], Divya Arora[4], Mohit Kumar[4], Louise Stuttge[3], S.K Duggi[6], Prashant N. Patil[7], Kavita [8], Kavita Rani[9], Honey Arora[9], Devinder Pal Kaur[9], and Vivek Mishra[10]

[1]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*
[2]*Homi Bhabha National Institute, Anushaktinagar, Mumbai - 400094, INDIA*
[3]*Institut Pluridisciplinaire Hubert Curien (IPHC), CNRS/IN2P3, 23 rue du Loess, B.P. 28, F-67037 Strasbourg, France*
[4]*Nuclear Physics Group, Inter University Accelerator Centre, Aruna Asaf Ali Marg, Post Box 10502, New Delhi 110067, India*
[5]*Department of Physics, The M.S. University of Baroda, Vadodara 390002, India.*
[6]*Department of Nuclear Physics, Andhra University, Visakhapatnam 503003, India.*
[7]*Department of Physics, Karnatak University, Dharwad 580003, India.*
[8]*Department of Physics, Kurukshetra University, Kurukshetra-136119, India.*
[9]*Department of Physics, Panjab University, Chandigarh 160014, India. and*
[10]*Department of Physics, Banaras Hindu University, Varanasi-221005, India.*

Introduction

Fission fragment mass distribution is one of the probes widely used to get information about fission dynamics and potential energy landscape. While the low-energy fission of (trans-) actinides is understood in terms of shell effects in nascent fragments [1], the origin of asymmetric fission of n-deficient Hg [2], and more generally, pre-actinides in the Lead region [3], remains un-explained. According to liquid drop model as well as from the consideration of shell correction in the nascent fragments, proton rich ^{180}Hg was expected to exhibit symmetric mass distribution centered around semi magic ^{90}Zr. However, in contrast to the anticipation, low energy fission of ^{180}Hg showed a pronounced asymmetric mass distribution, suggesting that shell structures other than those of the fragments may play a vital role in shaping fission outcomes. Different theoretical models proposed to explain these results give contradictory interpretations. Need to understand the fission dynamics and its variation with excitation energy has lead to a renewed interest in heavy-ion fusion-fission studies in this mass region [4–6]. Additionally low-fissility makes the study in this region very challenging. The present measurement aimed at contributing to the worldwide intense effort in the field. The Po chain is ideally situated mid-way between Hg and actinides. Recent measurements have reported a triple-humped structure for ^{194,196}Po and single gaussian structure for ^{208,210}Po [3] making ^{198}Po an interesting system to observe the transition from multimodal fission to symmetric fission.

Experimental Details

The experiment was performed using the 15UD Pelletron LINAC accelerator at IUAC, New Delhi by bombarding a 200 $\mu g/\text{cm}^2$ thick ^{170}Yb target (30 $\mu g/\text{cm}^2$ C backing) with ^{28}Si beam of three sub-barrier energies. Two large-area (11 $\times$ 16 cm^2) multi-wire proportional counters (MWPCs) [7] placed at 70° on each side of the beam axis at a distance of 30 cm from the target, inside the scattering chamber of the NAND facility were used to measure the time-of-flight(TOF) with respect to the RF filtered with fission and (x,y) position information of fragments in coincidence. Cathode sig-

*Electronic address: shilpi.gupta640@gmail.com

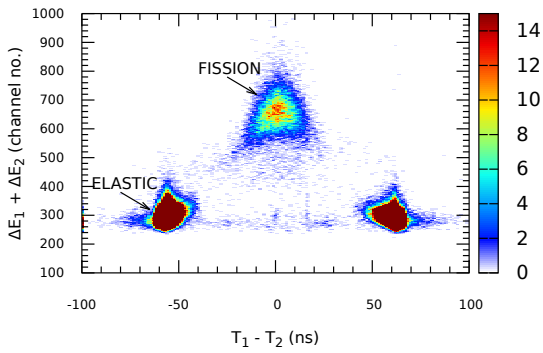

FIG. 1: TOF difference vs total energy loss spectra for incident beam energy of 130 MeV.

nals were recorded using QDC also to get the energy loss information of each fragment in the active volume of detector. Two solid-state detectors, mounted at ±13° with respect to the beam axis, were used to monitor and position the beam at the center of the target in each run.

Analysis and Summary

The fission events were selected by putting two dimensional gates in TOF difference(T_1-T_2), where T_1 and T_2 are TOF of fragments detected in MWPC 1 and 2 resp. vs energy loss spectra shown in Fig. 1.

The calibrated positions and the TOF information from the MWPCs were used to obtain the fragment emission angles and velocities. A correlation plot of the folding angle and azimuthal angle along with parallel and perpendicular components of velocities of the fragments (not shown) were used to ensure the selection of fission events.

Fission fragment mass distributions were deduced using the TOF difference method [8] assuming two body kinematics. Further these obtained masses were corrected on event by event basis for energy loss inside the target considering reaction had taken place at the center of the target. The experimental fission fragment mass-angle correlation at the three measured energies are shown in Fig. 2.

Average total kinetic energies observed $\langle TKE \rangle$ = 144 MeV is in good agreemnt with

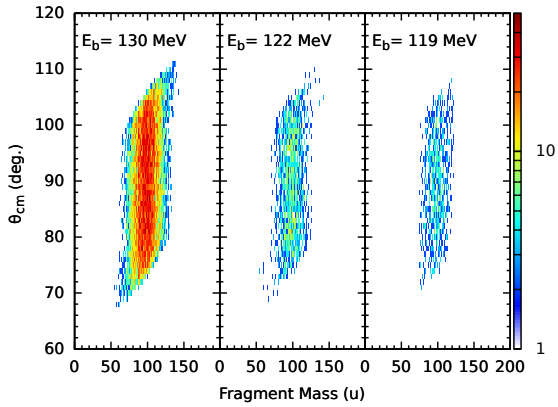

FIG. 2: Fission fragment mass angle correlation for ^{28}Si+ ^{170}Yb at three incident energies.

the systematics [9]. Further analysis and interpretetion of the result are in progress.

Acknowledgments We thank IUAC, Pelletron LINAC accelerator staff at Delhi for providing steady and uninterrupted beam.

References

[1] A.N. Andreyev, K. Nishio, and K.-H. Schmidt, Rep. Prog. Phys. **81** 016301 (2018).
[2] A.N. Andreyev *et al.*, Phys. Rev. Lett. **105** 252502 (2010).
[3] L. Ghys *et al.*, Phys. Rev. C **90** 041301 (2014).
[4] K. Nishio *et al.*, Phys. Letts. B **748**, 89 (2015).
[5] R. Tripathi *et al.* Phys. Rev. C **92**, 024610 (2015).
[6] E. Prasad *et al.*, Phys. Rev. C **91**, 064605 (2015).
[7] A. Jhingan *et al.*, Proceedings of the DAE-BRNS Symp. on Nucl. Phys. **60**, 936 (2015)
[8] R.K Choudhury *et al.*, Phys. Rev. C **60**, 054609 (1999).
[9] B. D. Wilkins *et al.*, Phys. Rev. C **14**, 5 (1976)