HYbrid Recoil mass Analyzer (HYRA) coupled to TIFR 4π Spin spectrometer facility at IUAC

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Introduction

The study of fusion around barrier for heavy compound nuclei through evaporation residue (ER) measurements can shed light on channel coupling effects, entrance channel effects, fission hindrance, effects of shell closure on ER survival probability and onset of other processes competing with complete fusion. The combined measurement of ER excitation function and spin distribution is desirable but not much data exist due to the difficulty in selecting the ERs in the direction of beam and in getting an efficient ER tagging signal for spin distribution measurements, in the presence of overwhelming fission. The recent commissioning of gas-filled mode of HYRA [1] and the setting up of 4π spin spectrometer at TIFR [2] opened up the possibility of coupling these two equipments at IUAC for simultaneous and efficient measurement of ER excitation function and spin distribution in heavy systems and spin and/or ER gated GDR measurements. With these goals in mind, the 4π spin spectrometer consisting of 32 NaI detectors (20 hexagons and 12 pentagons) has been coupled to HYRA (Fig. 1) at IUAC.

A special mounting arrangement was designed and fabricated at IUAC [3] to properly align the spin spectrometer with provisions for sideways movement of the two halves of the array. Modifications were made to the HYRA beam line making a portion of it telescopic to have more access and to incorporate a fixed collimator and an entrance window (2 μm thick carbon foil). A small aluminium chamber was adapted to the HYRA system with provisions for mounting monitor detectors at forward angles and for providing helium gas inlet during gas-filled operation of HYRA.

Up to 29 detectors were used in measurements. The photomultiplier tubes of five forward NaI detectors were covered with a thin μ-metal sheet which brought down the fringing field of first quadrupole magnet of HYRA to tolerable limits while all other detectors were unaffected. This shows that the planned coupling of HYRA and INGA [4] in the future should have no issues of quadrupole fringing field as we would be using clover detectors only at 90° and backward angles).

A facility test (^{16}O + ^{184}W) and three experiments (^{16}O + ^{180}Hf, ^{208}Pb and ^{30}Si + ^{170}Er) have been successfully taken up with the coupled system.

Transmission efficiency of HYRA

A novel method of extracting the transmission efficiency (η_{HYRA}) of heavy residues through HYRA by comparing the higher γ fold events in the ER gated and singles spectra has been proposed and successfully checked for the ^{16}O + ^{180}Hf system. Fig. 2 shows the comparison of the two which gives a transmission efficiency of 7.5 %. Fig. 3 shows the TAC spectrum for the same system that was used to select the ERs.

Summary

The combination of gas-filled separator HYRA and 4π spin spectrometer is unique and

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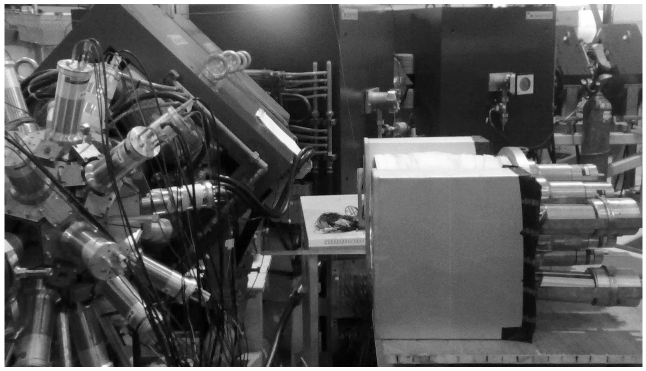

FIG. 1: HYRA-TIFR 4π Spin spectrometer combined facility at IUAC; The IUAC high energy gamma ray spectrometer HIGRASP can be seen on the right side.

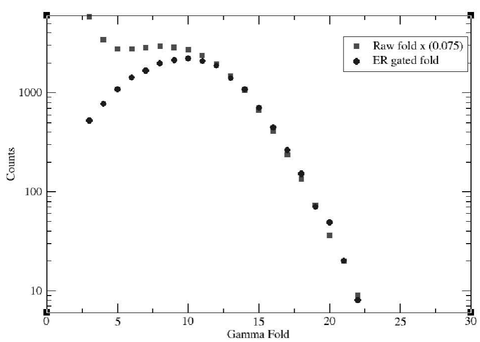

FIG. 2: Raw γ fold scaled down to 7.5 % (filled squares) superimposed on ER gated γ fold (filled circles) for ^{16}O + ^{180}Hf fusion evaporation reaction at 120 MeV lab energy. Matching higher folds imply η_{HYRA} = 7.5 % for the selected ERs.

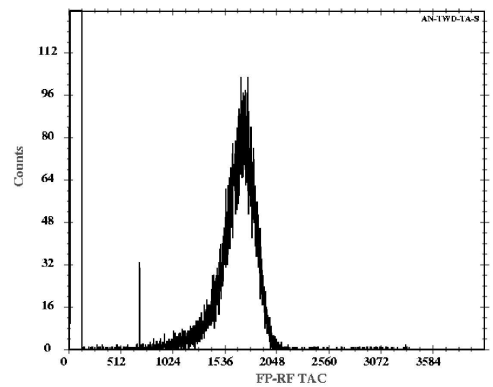

FIG. 3: TAC spectrum separating ERs (prominent peak on the right) and scattered beam particles (short, sharp peak on the left).

has vast potential to probe the limits of angular momentum in heavy nuclei which survive fission. The details of the HYRA-spin spectrometer combined facility, extracted HYRA transmission efficiency and other results will be elaborated.

Acknowledgments

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