Measurement of High energy gamma rays in A ~ 90 region using INGA PARIS setup

Vishal Malik, R. Palit, V. Nanal, P. Dey, A. Kundu, A. Sindhu, B. S. Niadu, S. K. Jadhav, A. T. Vazhappilly, Mahesh S Pose
Tata Institute of Fundamental Research, Mumbai - 400005, INDIA

Description of proposed research

A number of heavy ion induced fusion reactions are used to study nuclei near A = 90. Most of the cases, the nucleus does not develop a well-deformed band structure even at high excitation energy. It is also rather surprising that, although the expected angular momentum imparted classically in the heavy-ion fusion evaporation reactions (13 C+ 80 Se @ 60 MeV, 13 C+ 82 Se @ 60 MeV, 28 Si + 65 Cu @ 105 MeV, and 30 Si + 65 Cu@ 120 MeV) [1-5] used in TIFR recently being ~ 40 - 60 ħ, we were not able to observe any further excited states.

We want to point out that the intensity of the transitions depopulating the observed highest spin states in the current experiment is around 5% of the channel strength, which is quite large and the INGA array was sensitive enough to enable observation of transitions with intensities ~1%. This could possibly indicate a large change in structure of this nucleus at high-spin which may involve a highly fragmented decay path consisting of several weak high-energy gamma rays. This suggests a complex fragmentation of the level scheme at high spin and poses experimental challenge for the identification of exotic shapes at high spin. Some of the experimental studies on high spin states in nuclei near A ~ 90 region using gamma-gamma coincidence measurements have already been carried out at PLF, Mumbai.

Using the present INGA setup we can only measure we can only detect gamma rays upto ~ 4 MeV. With the addition of PARIS (Photon Array for studies with Radioactive Ion and Stable beams) detectors for the measurement of high energy-gamma rays and newly developed CsI(Tl) array along with $LaBr_3$(Ce) to INGA, higher experimental sensitivity will be achieved. PARIS is an international research project with the aim of developing and building a novel 4π gamma-ray calorimeter, benefiting from recent advances in scintillator technology. It is intended to play the role of an energy-spin spectrometer, a calorimeter for high-energy photons and a medium-resolution gamma-detector. PARIS is composed of "phoswich" detectors: a frontal part 2"×2"×2" composed by LaBr3:Ce/CeBr3 scintillators coupled to a 2"×2"×6" NaI scintillator [6]. Both scintillators being read with a common photomultiplier (Fig. 1).

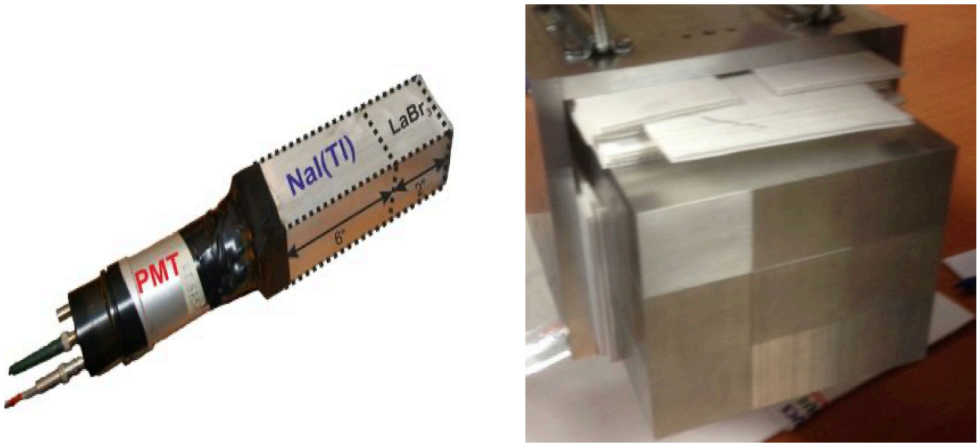

Fig. 1: PARIS phoswich

We want to test the PARIS detector using in-beam experiment coupled to INGA. We are using Pixie based DDAQ. Two different crates, one for clover, CsI and other one for PARIS,$LaBr_3$(Ce) detector will be used and will have to be time synchronized. This improved setup is important to get new insight about the high spin behavior of the isotopes near A = 90.

Experiment

We are planning to populate ^{90}Zr using ^{82}Se(^{13}C, 4n) reaction at 60 MeV. The Indian National Gamma Array (INGA) at TIFR, Mumbai consisting of 18 Compton suppressed clover HPGE detectors along with 14 $LaBr_3$(Ce) and a PARIS detector will be used to detect the emitted gamma-rays. The yield for the ^{90}Zr at this beam energy is 770 mb, based on the PACE4 calculation.

Beam requirements

Type of the projectile: ^{13}C.
Beam energy: 60 MeV.
Beam intensity: 2 pnA.
Beam-time: 4 days (12 shifts)

References

[1] S. Saha et al. Phys. Rev. C 86, 034315 (2012)
[2] P. Singh et al. Phys. Rev. C 90, 014306 (2014)
[3] S. Saha et al. Phys. Rev. C 99, 054301 (2019)
[4] P. Dey et al. Phys. Rev. C 109, 034313 (2024)
[5] P. Dey et al. Phys. Rev. C 105, 044307 (2022)
[6] Paris White Book by F. Camera and A. Maj (2021)