RECENT RESULTS FROM THE SARI ARRAY WITH RITU AT JYFL*

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A compact array of segmented clover detectors has been used in conjunction with a high transmission recoil separator. Prompt gamma-rays are detected by the array, and the subsequent recoiling nucleus by a position sensitive silicon detector at the separator focal plane. Isomeric gamma-ray transitions were also detected by germanium detectors at the focal plane. Transitions from the ^{166}Er(^{28}Si, $4n$)^{190}Pb thin-target reaction at 143 MeV were studied. Both prompt and isomeric states were observed associated with spherical, oblate and prolate configurations.

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1. Introduction

Nilsson–Strutinsky calculations [1,2] for the neutron-deficient lead nuclei show a potential consisting of a spherical minimum corresponding to the $Z = 82$ closed shell, an oblate minimum composed of a pair of protons from the $s_{1/2}$ orbital to the high-Ω intruder orbitals, and a prolate minimum from four-proton, four-hole excitations.

Experimentally, deformed structures in the light even-mass lead isotopes have been studied by alpha-decay [3], associating an oblate minimum down to ^{188}Pb [4]. Prolate structures have been observed for the lighter lead isotopes by using a recoil-filter device for ^{188}Pb and ^{186}Pb [5, 6]. From energy systematics of the even-mass lead region, ^{190}Pb sits at the point where the

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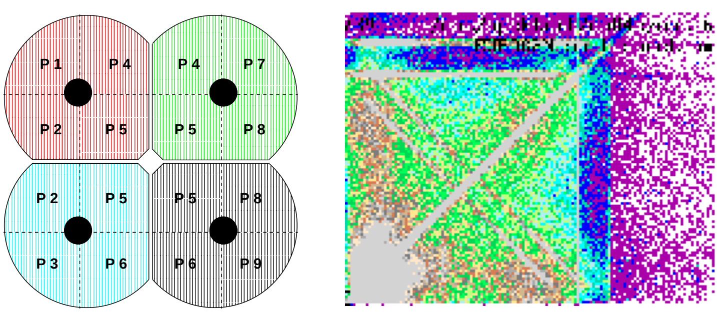
prolate minimum holds some significance, but is unfavoured. Recent measurements by Dracoulis *et al.* [7] using pulsed beams and backed targets, indicate this. However due to the complexity of the nucleus, involving isomeric states, a thin target experiment was performed allowing the prompt and isomeric states to be separately measured.

2. The SARI array

SARI, "Segmented Array at RITU", consists of the latest type of composite detectors - segmented Clover detectors. These are based on the EUROGAM type of clover detector, of four separate n-type germanium crystals in the same cryostat. The outer contacts of the crystals are electrically segmented into nine sub-elements allowing for the measurement of the energy deposited into a specific volume of the detector (figure 1(a)). In this way, the detector can be isolated into 16 segments. Due to the small size of each of the divided segments, effects of Doppler broadening are reduced for in-beam gamma-ray spectroscopy, allowing in the case of SARI, detectors to be placed nearer to the target position, and hence resulting in a large photopeak efficiency. Three such detectors were used in the SARI array, two at 135° and one perpendicular with respect to the beam axis, at a distance of crystal face to target position of 10 cm. The overall photopeak efficiency of the array is 3% at 1.3 MeV.



(a) (b)

Fig. 1. (a) — Schematic of the segmented clover showing the separate crystals, and their respective segmentation. (b) — Plot of crystal versus outer contact energy. Localised events lie on the 45° line.

3. Experimental techniques

In using the segmented Clover, one needs to determine which segment or segments has been "hit". Due to the compactness of each detector, each segment is subtended with a large solid angle by its neighbours. Thus an incident gamma-ray can scatter from one segment to another before its total energy is deposited. As the detector is composite, if a gamma-ray scatters from one crystal to another, both crystals contain the Compton scattered energies. The need to track the gamma-ray from its scatters is required to obtain the full energy of the initial event. By comparing the energies of each of the four detector crystals with the energies of each of the nine outer contacts in a self-consistent manner, the incident gamma-ray position and full energy can be determined. This reduces the background from otherwise mistaken Compton scatters, and enables a reduction in Doppler width for in-beam studies from the determined angle.

4. Spectroscopy of ^{190}Pb

The RITU gas-filled recoil separator [8] was used to separate the reaction products from the ^{166}Er(^{28}Si, $4n$)^{190}Pb reaction at 143 MeV bombarding energy on a 0.5 mg/cm^2 target. Recoils were focused to a position sensitive silicon detector at the focal plane. Situated in close geometry at the focal plane were four TESSA-type germanium detectors for the detection of isomeric transitions. The SARI array was employed at the target position for detection of prompt transitions.

The prompt transitions from SARI were localised and corrected for Doppler shift. Timing information was available from the recoil and from RF-pulsing of the beam. Each transition could thus be assigned to being prompt or isomeric, and the relative time difference between them analysed.

Figure 2 shows the deduced transitions from the data set. Using prompt–delayed and prompt–prompt coincidence data sets, transitions above and below the isomers can be assigned. The ground state transitions are fed from both the isomeric states (11^- and 12^+) above and also promptly from the two structures on the left and right hand side of the figure.

The data are in agreement with those proposed by Dracoulis *et al.* [7]. The weak structure, tentatively assigned as the prolate band has been extended (figure 3), and is consistent with energy systematics for the even lead isotopes.

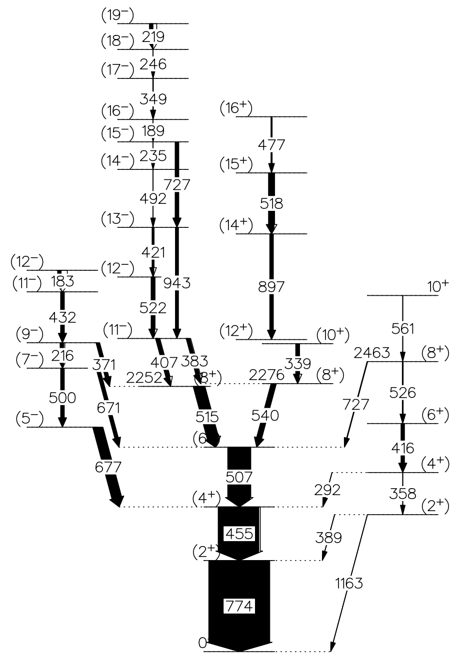


Fig. 2. Deduced level scheme of ^{190}Pb

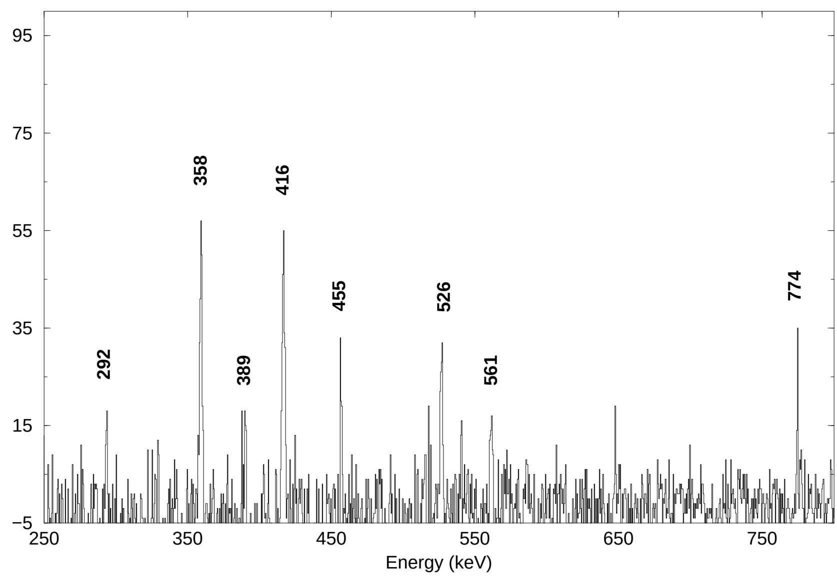


Fig. 3. Adopted prolate band members gated on first three band members

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