Investigation of high spin states and isomeric decays in doubly odd ^{210}Fr

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As our knowledge of the nuclear chart is extended towards the proton drip line, away from the valley of stability, new experiments become increasingly difficult mainly due to low production cross-section ($\sim$ 10 mb or less) of evaporation residue (ER) in presence of very high fission background. For many of these nuclei, only the ground state spin and parity are known from their g-factor/magnetic moment measurements, and perhaps a few low lying excited states are observed so far. Exploring the nuclear structure of these nuclei provides a big challenge for the expermentalists. Experimental investigation of the high spin states of quite a few trans-lead neutron deficient nuclei ($Z > 82$, $N \leq 126$) have been of interest recently [1–4]. Lots of nuclear phenomena from core excited single particle states to the existence of shears band in these extreme proton rich heavy nuclei were observed. A systematic study of such nuclei will possibly reveal many other interesting features. However, a detailed shell model calculation for these trans-lead nuclei is still a distant possibility.

Although our experiment was aimed at exploring the nuclear structure of ^{208}Fr, the yield of ^{210}Fr (for which almost no nuclear structure data exists) at 88 MeV was found to be significant to establish its level scheme. The experiment to produce ^{208,209,210}Fr was carried out at the Inter-University Accelerator Centre (IUAC), New Delhi, using the Indian National Gamma Array (INGA) of clover detectors at three different beam energies (100, 94 and 88 MeV). Relevent details of this experiment have been reported in ref [4]. From the online data taken at 88 MeV beam energy, after energy calibrating and gain matching, the $\gamma\gamma$ matrices, Francium X-ray gated $\gamma\gamma$ matrices, the prompt and various delayed $\gamma\gamma$ matrices and the γ-gated $\gamma\Delta T$ matrices were constructed for establishing the level scheme and locating the isomeric transitions. To get the information on the spin and parity, DCO mesurements were performed with the data taken at (90°, 148°) and (90°, 123°) angle pairs. Based on the earlier observation [5] of a couple of low lying transitions (208 and 316

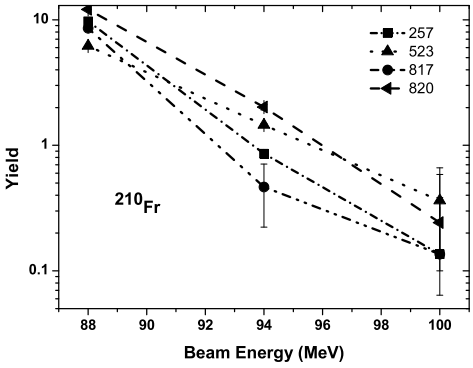

FIG. 1: excitation function for ^{210}Fr

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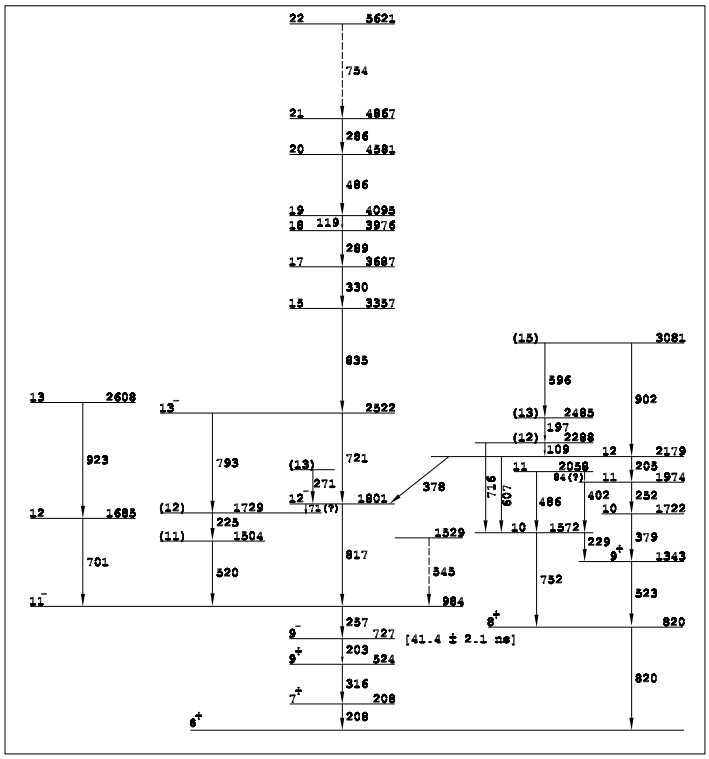

FIG. 2: Tentative level scheme of ^{210}Fr

keV) from the $\alpha - \gamma$ coincidence experiments, connecting the 6^+ ground state of ^{210}Fr, and a few strong transitions (203, 257, 520, 701, 721, 793 and 817) reported in [3], that could not be assigned to other Fr isotopes, the excitation function studies of ^{210}Fr at three different energies are done [Fig. 1] and found to be in good agreement with similar studies made from independent offline radio active decay analysis reported in our earlier paper [4]. The strong 820 keV transition and all the lines in series with that, are new and observed for the first time. Assignment of these γ-rays to ^{210}Fr is based on the excitation function measurements, and is validated by the observation on γ-X rays and $\gamma\gamma$ coincidences.

Based on our analysis of $\gamma\gamma$ and $\gamma\gamma\gamma$ coincidence and DCO ratio measurements, a preliminary level scheme for ^{210}Fr upto ~ 5.5 MeV excitation energies and $\sim 22\hbar$ angular momentum could be established for the first time as shown in Fig. 2.

From our $\gamma\gamma\Delta T$ correlation analysis, we could find a new low lying isomer of 41.4 ± 2.1 ns for the first time. Further refinement of analysis, interpretation of the results based on nuclear structure calculations are currently undertaken.

References

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