# Study of Neutron-rich Nuclei Using Deep-inelastic Reactions

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Neutron-rich nuclei are of particular interest since they might reveal new aspects of nuclear structure associated with an excess of neutrons, such as a neutron skin, a modified shell structure and new modes of excitation. These nuclei are difficult to produce, particularly in high-spin states. However, using deep-inelastic reactions together with the new gamma-ray detector arrays, one expects to have enough sensitivity, in spite of the low cross sections, to reach these nuclei in high-spin states.

We have carried out the reaction $^{48}$Ca + $^{176}$Yb at a beam energy of 250 MeV. A thin target was used to allow both the projectile- and target-like fragments to decay outside the target so that gamma rays from short-lived high-spin states can be observed as sharp lines after Doppler-shift correction. An annular silicon-strip detector was used to detect the scattered fragments. The early implementation of Gammasphere with 36 detectors was used to detect the gamma-rays. Coincidence events with at least one fragment and two Compton-suppressed gamma rays detected were taken at a rate of 1000/sec.

Two- and three-fold gamma-ray-coincidence data were analyzed for the gamma rays from the target-like fragments, and about 10 different nuclei were observed. In this data set, we were able to study nuclei produced with a cross section as low as 0.1 mb/sr. The gamma-ray yield of Yb nuclei as a function of spin is shown in Fig. 1. The sensitivity of the current setup allowed states with spin as high as 20 to be observed.

Before this study, only three levels in the yrast band were known in $^{175,177}$Yb and $^{178}$Yb. This work extends the yrast band of $^{178}$Yb to spin 12 and the yrast bands in $^{175,177}$Yb to spin 37/2 and 33/2, respectively. These new transitions allow us to study the systematics of back bending in neutron rich Yb nuclei. The $i_{13/2}$ band in the odd-mass nuclei provided an experimental reference for the extraction of the Routhians in the neighboring even-mass nuclei. The experimental Routhians compare well with cranked shell model calculations[1].

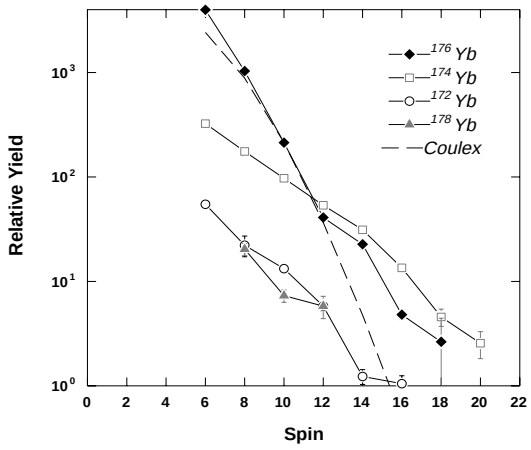


Figure 1: Gamma-ray yield of Yb nuclei as a function of spin

## References

[1] R. Bengtsson, S. Frauendorf and F.-R. May, Atomic Data and Nuclear Data Tables, 35 (1986)15.