Shell evolution at $N = 40$ towards ^{60}Ca: Spectroscopy of ^{62}Ti

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Experimental evidence collected in the last years show the disappearance of the shell closures at $N = 8$, 20 and 28 in various neutron-rich isotopes, as well as the appearance of new magic numbers, such as $N = 32$ and 34 for Ca isotopes.[1,2] Given that $N = 40$, which corresponds to the filling of the fp neutron shells, is predicted to be a sub-shell closure, the study of the structure of $N = 40$ isotones can provide insight into the mechanism governing shell evolution. A low collectivity is observed in ^{68}Ni, consistent with the magic character of $N = 40$.[3] However, for the Fe and Cr isotopes, a monotonous decrease of the 2^+ energy with increasing neutron number is observed.[4,5] Such a decrease, which extends beyond $N = 40$, indicates a rapid increase of collectivity when removing protons from the $f_{7/2}$ shell. For the case of the Ti isotopes, measurements of the 2^+ energy of ^{58,60}Ti[6,7] do not show an unexpected decrease towards $N = 40$, although it has been suggested that full consideration of the $g_{9/2}$ orbital is required to understand the structure at $N = 40$.[7] To further understand the shell evolution in $N = 40$ isotones towards the supposedly doubly-magic ^{60}Ca, the measurement of the first excited 2^+ state of ^{62}Ti is necessary.

In the third SEASTAR campaign, ^{62}Ti was produced by proton knock-out of ^{63}V at 250 MeV/nucleon on the MINOS liquid hydrogen target.[9] The ^{63}V isotopes were produced by fragmentation of a 345 MeV/nucleon primary beam of ^{70}Zn impinging on a 10-mm Be target and separated using the BigRIPS spectrometer. The average intensity of the Zn beam was 250 pnA, and the average rate of ^{63}V was 3 pps. The MINOS target, of 150 mm length, was placed at the F13 experimental area, in front of the SAMURAI magnet. Reaction products were identified on an event-by-event basis using the standard SAMURAI detectors.[8] NEBULA and NeuLAND neutron detectors were also used during the experiment. γ-rays emitted by the reaction products were detected using the upgraded DALI2+ array,[10] consisting of 226 NaI detectors surrounding MINOS. The ongoing data analysis has already provided the incoming particle identification as shown in Fig. 1.

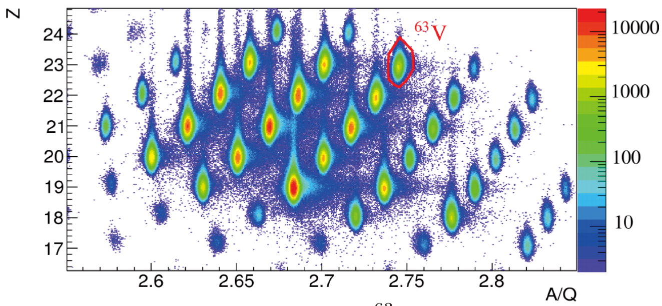

Fig. 1. Incoming particle ID. ^{63}V is labeled in red.

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