β-decay of ^{68}Mn: Probing the N = 40 Island of Inversion

R. Umashankar[1,2], B. Olaizola[3], V. Vedia[2], A.B. Garnsworthy[2], and the S1723 collaboration
[1]Department of Physics and Astronomy, University of British Columbia
[2]TRIUMF
[3]CERN

Motivation

One of the more well-known divergences from the independent-particle shell model description of the nucleus is the existence of Islands of Inversion (IoI). These are characterized by the presence of deformed multi-particle multi-hole (*npnh*) ground states instead of the *0p0h* configurations predicted by spherical mean-field calculations at stability. Consequently, the features normally observed in regions with a large shell or sub-shell closure disappear.

N = 40 Island of Inversion

The relatively large gap separating the *pf* shell from the neutron $g_{9/2}$ orbital points towards a strong sub-shell closure at N = 40 which has been supported by observation of a high-lying 2^+ state and low *B(E2)* value in ^{68}Ni (Z = 28). However, systematics of $E(2^+)$ and *B(E2)* values have indicated a sudden increase in collectivity below Z = 28 when approaching N = 40, seen especially in the rapid drop of $E(2^+)$ in Fe (Z = 26) and Cr (Z = 24) isotopes.

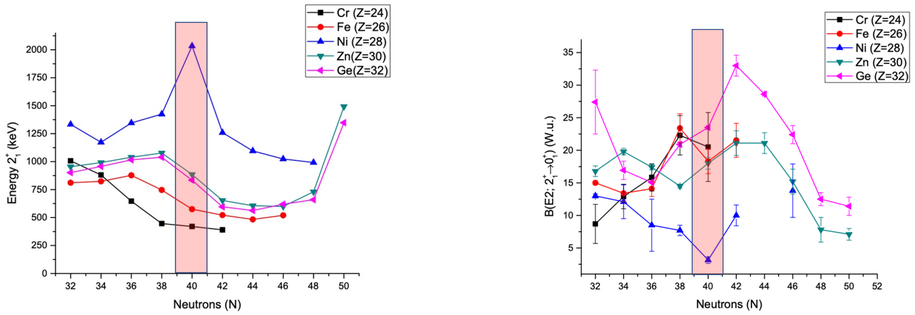
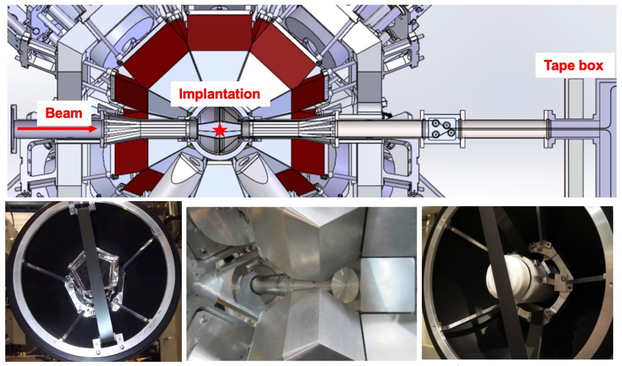


Figure 1: (*Left*) The energy of the first 2^+ state in ^{68}Ni is high, a characteristic often seen with shell and sub-shell closures, while other isotopic chains in the area do not show the same behaviour.
(*Right*) B(E2; $2_1^+ \rightarrow 0_1^+$) values show the onset of collectivity in Fe and Cr isotopes when approaching the N = 40 IoI.



SCEPTAR for β tagging | $LaBr_3$(Ce) for fast γ-ray timing | ZDS for fast coincidence β timing

Figure 2: (*Top*) A schematic of the GRIFFIN γ-ray spectrometer.
(*Bottom*) The various ancillary detectors that complement the HPGe array.

Experiment

The S1723 campaign was carried out at TRIUMF-ISAC using the state-of-the-art GRIFFIN γ-ray spectrometer. It utilized the β and β-n decay of ^{68}Mn to populate excited states in ^{67,68}Fe, ^{67,68}Co and ^{67,68}Ni.
In addition to HPGe clovers of GRIFFIN, the experiment also used ancillary detectors for fast γ-ray timing and β tagging.

Preliminary Analysis and Goals

- Detailed β-decay spectroscopy with higher statistics compared to previous experiments.
  - ~10^5 higher statistics than the EURICA campaign at RIKEN.
- Confirmed γ-ray energies from previous studies with new lines being placed in the level scheme.
- Firm assignment of low-lying spins aided by the measurement of γ-γ angular correlations.
- Re-measure the beta-delayed neutron emission probability and extract the lifetimes of excited states.

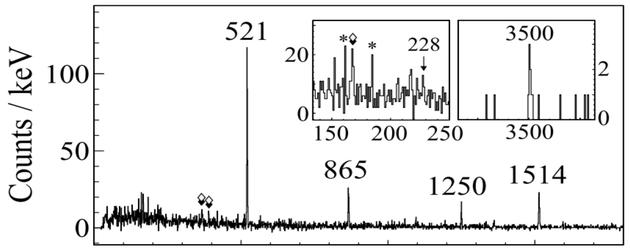


Figure 3: γ singles energy spectrum obtained from the β-decay study of ^{68}Mn carried at RIKEN using the EURICA γ spectrometer.

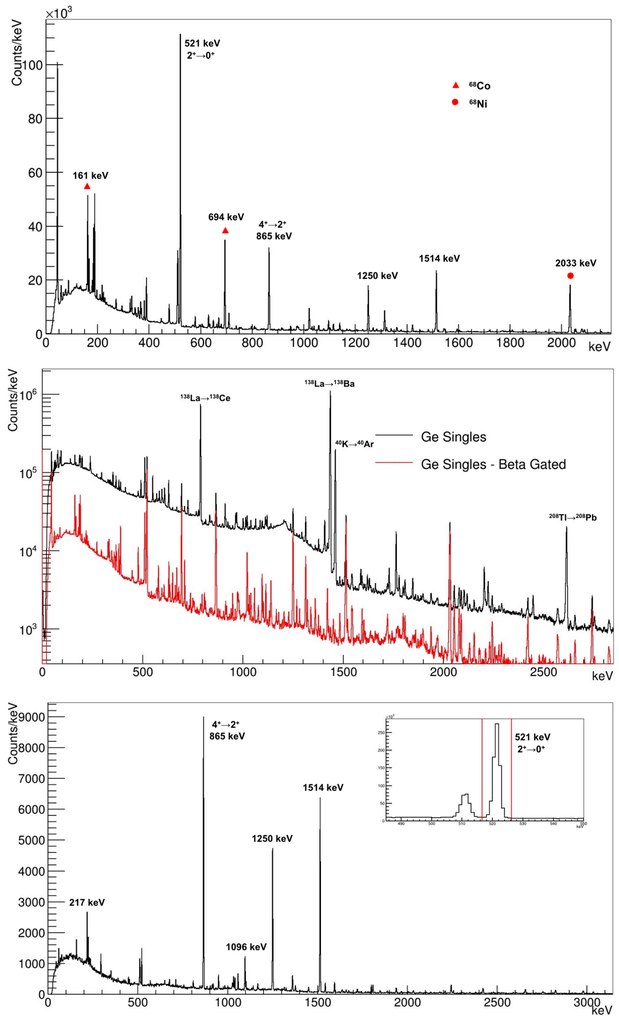


Figure 4: (*Top*) γ singles energy spectrum from S1723.
(*Middle*) β tagging using ancillary β detectors considerably reduces the room background.
(*Bottom*) γ-γ coincidence analysis gating on the $2^+ \rightarrow 0^+$ transition.

Discovery, accelerated