Study the Neutron Shell Structure of ^{68}Ni via Missing Mass Spectroscopy

Authors...

Affiliations...

Introduction

The motivation is to investigate the diffuseness of the neutron Fermi surface at the neutron number N=40, which is part of the magic numbers like 8 and 20. Studying the occupancy of the neutron orbitals can characterize the magicity of the nucleus. ^{68}Ni with 28 proton and 40 neutron is a good candidate to study N=40 shell gap the occupancy and vacancy for N=40 nuclei is shown in Figure 1. Shell gap of N=50 at N=40 nucleus ^{68}Ni is also studied using neutron adding reactions, Figure 2.

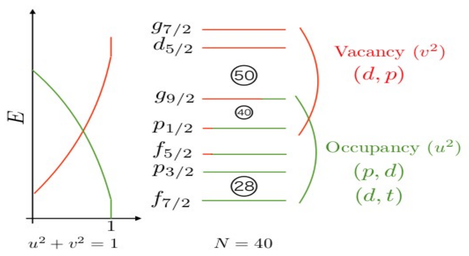


Figure 1: Occupancy and Vacancy for N=40 nuclei [1]

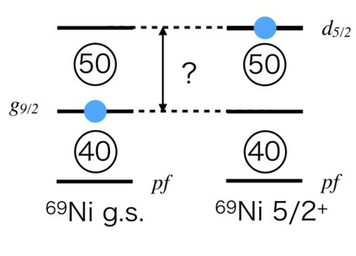


Figure 2:Valance neutron occupancy at 69Ni

- In ^{68}Ni(d,p)^{69}Ni reaction with determining the $2d_{5/2}$ strength, the spacing between the $g_{9/2}$ and $d_{5/2}$ neutron orbitals at N=40 is investigated. The reaction was studied before and $2d_{5/2}$ is measured at 2.5 MeV [2]. The state is suggested to be doublet at 2.1 and 2.8 MeV. The aim is to determine the excitation energies and confirm the ΔL of 2.8 MeV state, Figure 2.

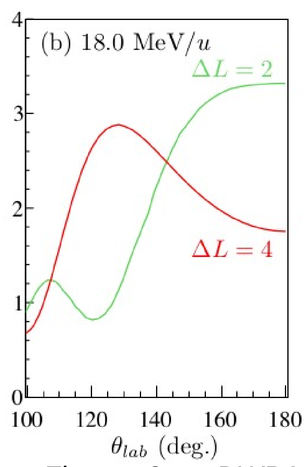


Figure 3 : DWBA calculations for 2.8 MeV state with ΔL =2 and 4 [1].

- In neutron removal ^{68}Ni(d,t)^{67}Ni and ^{68}Ni(p,d)^{67}Ni reactions, we aimed to measure the occupancy of the neutron orbitals in ^{68}Ni, especially the f-p shells but also the possible partial occupancy of the $1g_{9/2}$ orbital using the prompt-delay γ-ray spectroscopy. The cross sections directly populated hole state in 67Ni measured using the known first four states from Ref [3].

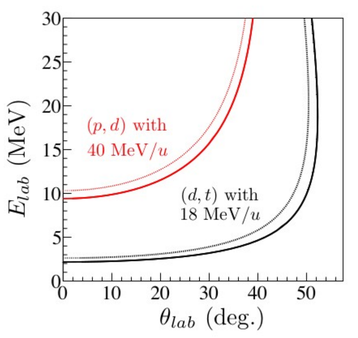
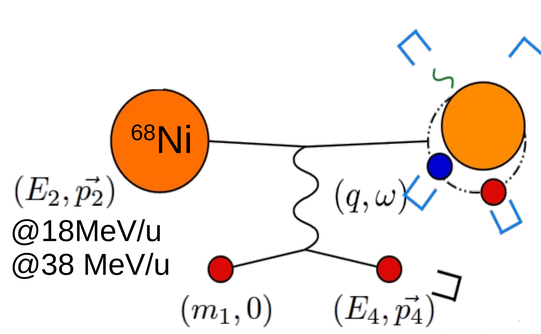


Figure 4 : Kinematics of 67Ni g.s. (solid) and 1.& MeV e.s. shown for two different reaction [1]

Experimental Setup

For this experiment inverse kinematics reactions are used in two different energies .

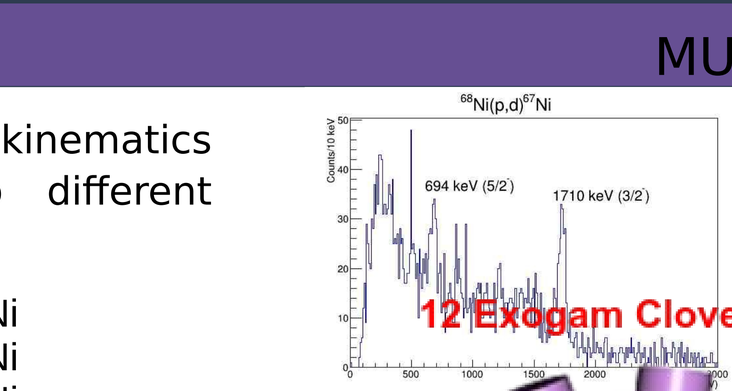


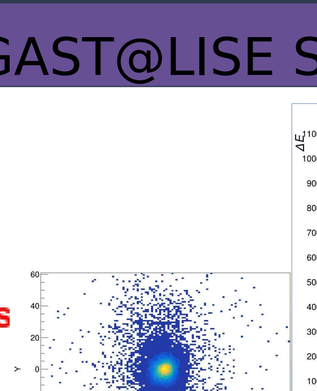
$E_x \uparrow$
$\gg S_n, S_p$

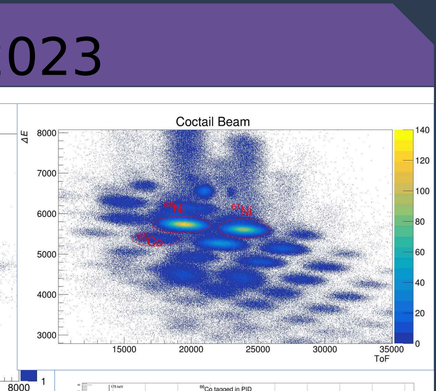
CD_2 (0.5 mg/cm^2)
CH_2 (5 mg/cm^2)

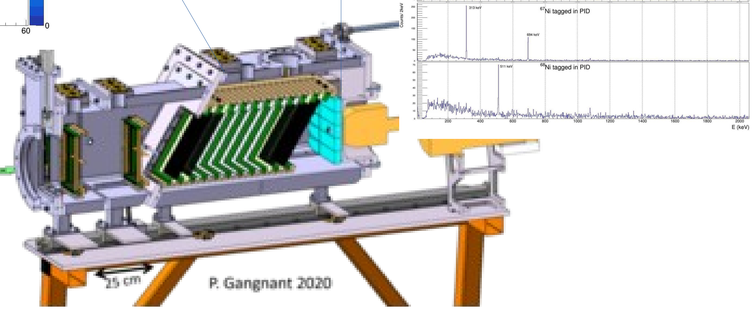
Missing mass
p, t, d,...

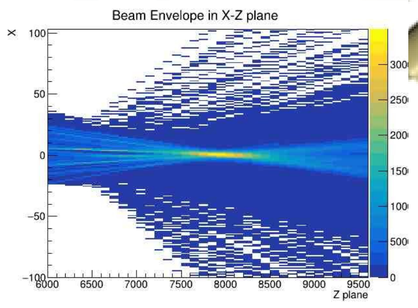
- The ^{68}Ni secondary beam at 40 MeV/u produces from ^{70}Zn primary beam of 62MeV/u with 500µm thick Be primary target placed in the LISE spectrometer.
- For 18MeV/u beam additional Be degrader is placed at D4 in LISE.





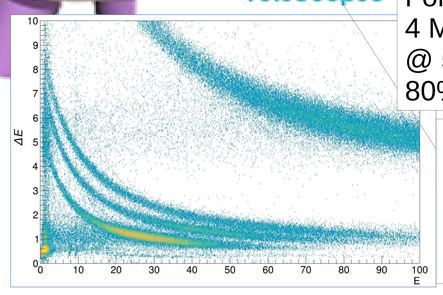






CATS1 &2
- Secondary beam E=10-50 MeV
- For reconstructed beam position on target
- ToF

Mugast & MUST2 Telescopes



For (d,t) &(p,d) reactions
4 MUST2 telescope
@ 5^o – 40^o
80% acceptance

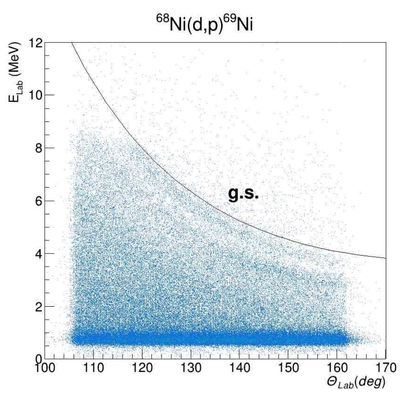
For (d,p) reaction
5 trapezoidal DSSDs (GRIT)
@ 110^o-170^o,
60% acceptance

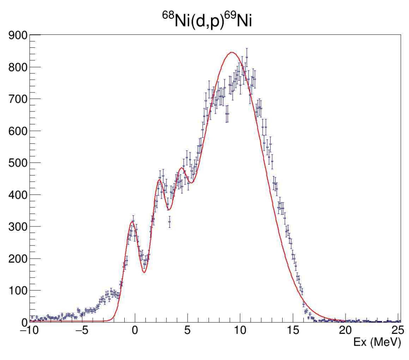
ZDD

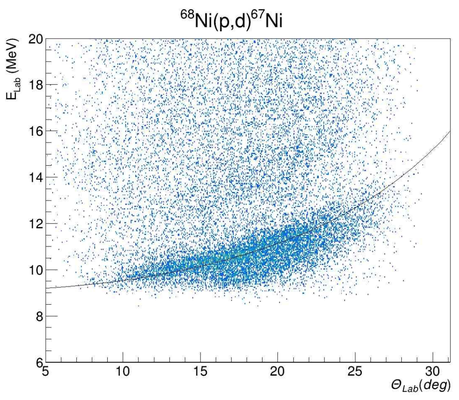
- Pair of Drift Chambers (DC) for XY position measurement
- 10 tilted foils ionizing chambers coupled (IC) for ΔE energy loss and the PID
- 5 Plastic Scintillators for Energy and clean up the reaction residue.
- 1 Exogam Clover (HpGe) for tagging the isomeric decays

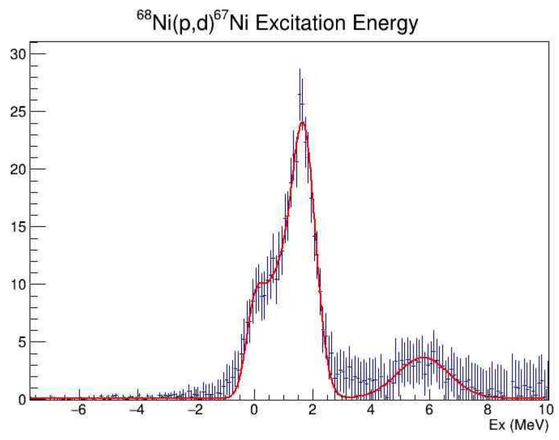
Results & Conclusion

The experiment was successfully performed in May 2023, around 22 UT beam time was used for the physics data. Two different beam energies are used for CD_2 and CH_2 target. Also Carbon target is used for the background information. The preliminary results for Kinematics and Missing mass excitation energies are shown in below Figures









References

[3] J. Diriken et al, PRC 91 054321