A Setup for Experiment in the Cross-link of Atomic and Nuclear Physics

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Introduction

Heavy ion beams at low to intermediate energies have been extensively used to study the nucleus-nucleus interactions. In contrast, hardly any attention has been put up to study the nucleus-electron interaction, a field in the cross-link of nuclear and atomic physics. Thus we have started an experimental journey since last decade [1][2], to venture in such an interdisciplinary field of research.

Experimental Setup

Experiments were performed in a wide range of energies starting from deep sub-barrier to above the barrier for different beam and target combinations at General Purpose Scattering Chamber, IUAC, New Delhi. Well-collimated ion beam of ^{58}Ni at 41.6-156 MeV and ^{56}Fe at 40-136 MeV were bombarded on 80 μg/cm^2 natural carbon placed at 45° to the beam axis. The x-rays as well as particles like α and C were planned to detect as shown in FIG.1.

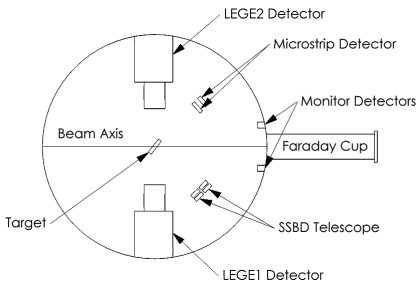

FIG. 1: Schematic of Experimental Setup

X-rays produced in reactions were detected in two Low Energy Germanium (LEGe) detectors, placed at ±90° to the beam axis to minimize the Doppler shift and kept outside the chamber at 16 cm (LEGe1) and 65 cm (LEGe2) away from the target. A typical x-ray spectra observed with LEGe1 detector for Ni on C at 156 MeV is shown in FIG.2.

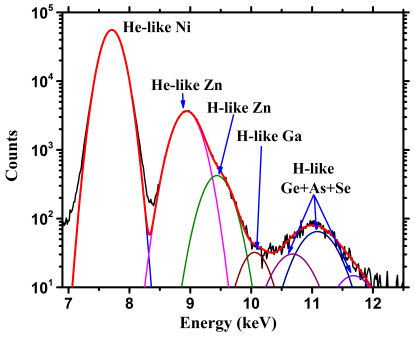

FIG. 2: X-ray Spectra observed in the reaction ^{12}C(^{58}Ni,X) at 156 MeV

Silicon Micro-Strip Detector (SMSD) and Silicon Surface Barrier Detector (SSBD) were used for particle identification. SMSD tele-

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scope placed at 30° at one side of the beam axis & 46 cm away from the center. Whereas, at the other side two sets of SSBD telescopes were placed at 27 ° & 33 ° at a distance of 27.2 & 23.8 cm from the center respectively. Thickness of △E and E detectors were 40 μm & 300μm respectively. To normalize the spectra two 300μm thick SSBD detectors were placed at 10° to the beam axis. Calibration for SSBD & SMSD was done using a ^{241}Am α-source.

Results and Discussion

Besides the projectile x-ray peak shown in FIG.2, some other peaks are also observed due to α, Li & 2α capture events. Since x-ray spectroscopy provides a reliable technique to find the charge state origin during any atomic collisions [3].

TABLE I: Observed x-ray energies, corresponding charge states and probable reaction channel

X-ray line (keV)	PLF ions & charge states	Probable Reaction
7.71	He-like Ni	^{12}C(^{58}Ni,^{58}Ni)
8.94	He-like Zn	^{12}C(^{58}Ni,^{62}Zn)
9.43	H-like Zn	^{12}C(^{58}Ni,^{62}Zn)
10.05	H-like Ga	^{12}C(^{58}Ni,^{64}Ga)
10.68	H-like Ge	^{12}C(^{58}Ni,^{66}Ge)
11.08	H-like As	^{12}C(^{58}Ni,^{69}As)
11.68	H-like Se	^{12}C(^{58}Ni,^{70}Se)

Comparison between the charge states measured at t=0 and predictions from a theoretical calculations [4] is displayed in FIG.3. Observed projectile and PLF ions with their charge state are listed in TABLE I.

Mean charge state of the PLF ions is higher than that of the projectile ions, which can be justified by the model[1]. In this work, nuclear techniques were also employed for studying multinucleon transfer processes. A typical 2D spectra between 1st and 3rd strip of SMSD is shown in FIG.(4). The central globe indicates the ^{8}Be decaying to two α's, a detailed analysis is in progress.

Conclusions

The highlights of the results obtained from the novel approach indicate that useful studies can be made on the nucleus-electron interactions.

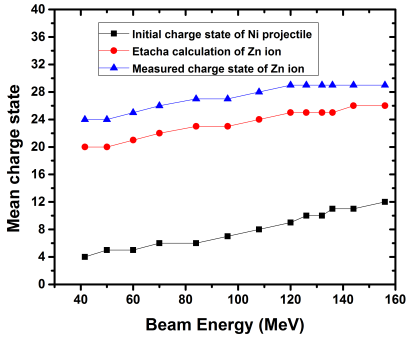

FIG. 3: Comparison between measured and theoretical mean charge state of the ions using ETACHA code [4] for Ni on 80 μg/cm^2 C

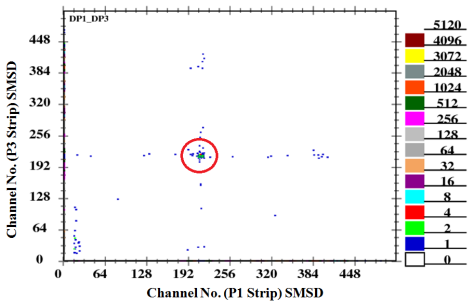

FIG. 4: A typical 2D SMSD spectra observed in ^{58}Ni on ^{12}C for 1st and 3rd strip

Acknowledgments

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References

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