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^{25}Na and ^{25}Mg fragmentation on ^{12}C at 9.23 MeV per nucleon

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Abstract. The multidetector HERACLES studies heavy-ion collisions at TRIUMF, with ion beams with an energy range between 8 to 15 MeV per nucleon. Seventy-eight detectors are axially distributed around the beam axis in 6 rings allowing detection of multiple charged fragments from nuclear reactions. Experimental data was collected by HERACLES from a radioactive ^{25}Na beam and a stable ^{25}Mg beam at 9.23 MeV per nucleon on a carbon target. For analysis, we compare experimental data with a hybrid code. Antisymmetrized Molecular Dynamics (AMD) treats the dynamics of colliding systems and GEMINI for the statistical deexcitation of fragments.

1 Introduction

Accelerated beams of short-lived radioactive nuclei have been available for a few years from different facilities around the world. Heavy-ion collisions using radioactive ion beams (RIB) give the possibility to study the equation of state of nuclear matter with different neutron-to-proton (N/Z) ratios. RIB are available with energies up to 15 MeV per nucleon at TRIUMF from the ISAC II superconducting linear accelerator [1]. A radioactive ^{25}Na beam and a stable ^{25}Mg beam at 9.23 AMeV have been run on a carbon target using the multidetector HERACLES. The microscopic AMD model is used to compare with experimental data.

2 HERACLES

The multidetector HERACLES [2] has been developed to detect charged particles from beams with energies between 8 AMeV and 15 AMeV. It is composed of 6 rings covering polar angle between 4.8° and 46°. The charge of ions is identified in the first 4 rings. Light particles are isotopically identified in rings 4 and 5. See figure 1 and table 1 for more details.

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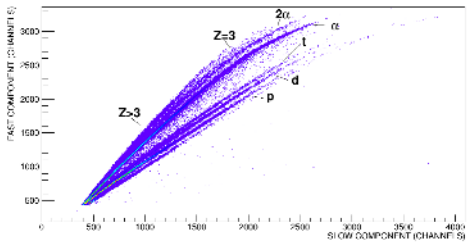

Figure 1. Fast-slow representation of a CsI(Tl) detector for $^{25}Mg +^{12}C$ at 9.23 AMeV.

Table 1. Configuration of detectors in HERACLES. θ is the polar angle from the beam axis, N is the number of detectors per ring , ϕ is the azimuthal angle.

Ring No.	ΔE detector	E detector	θ_{min} (°)	θ_{max} (°)	N	$\Delta\phi$ (°)	ΔE thickness (μm)
0	BC408	BaF_2	4.8	6	6	15	100
1	Si	CsI(Tl)	6	10	8	18	50
2	BC408	BC444	10.5	16	16	22.5	100
3	BC408	BC444	16	24	16	22.5	100
4	-	CsI(Tl)	24	34	16	22.5	-
5	-	CsI(Tl)	34	46	16	22.5	-

3 AMD+GEMINI

To study the dynamics of reactions, the microscopic AMD model [3] is used. In order to compare with experimental data, AMD is coupled with GEMINI [4] for the deexcitation of fragments. AMD is used for the first 300 fm/c of the collision. Fragments are then identified using a coalescence algorithm in phase-space. The charge, mass, angular momentum, excitation energy and momentum are identified. GEMINI is used after to deexcite fragments primarily by evaporation of light particles.

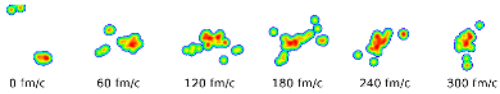

Figure 2. AMD simulation of $^{25}Na +^{12}C$ at 9.23 AMeV up to 300 fm/c.

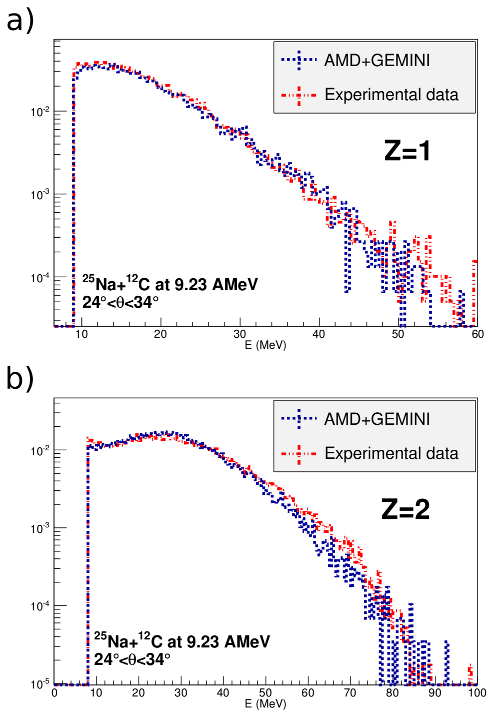

Figure 3. a) Kinetic energy of Z=1 particles detected between 24° and 34° from the beam axis for $^{25}Na +^{12} C$ at 9.23 AMeV. b) Kinetic energy of Z=2 particles detected between 24° and 34° from the beam axis for $^{25}Na +^{12} C$ at 9.23 AMeV.

4 Results

The study of the kinetic energy of light particles detected in rings 4 and 5 shows great agreement between the AMD simulation and the experimental data. Figure 3a shows the kinetic energy for hydrogen and figure 3b for helium. For the isotopic ratio of hydrogen isotopes, we compare the results from $^{25}Na +^{12} C$ and $^{25}Mg +^{12} C$ reactions. Both the experimental data and AMD simulation show an increase in the yield of deuterium and tritium for the $^{25}Na +^{12} C$ reaction compared with $^{25}Mg +^{12} C$. But, the AMD simulation underestimates for both reactions the yield of deuterium and tritium, see figure 4.The comparison between experimental data with the results of the simulation is still underway.

5 Conclusion

Experimental data from the $^{25}Na,^{25}Mg+^{12}C$ at 9.23 AMeV experiment is still under analysis. Another experiment took place in July 2013 with $^{20}Ne,^{22}Ne +^{12} C$ at 11.7 AMeV.

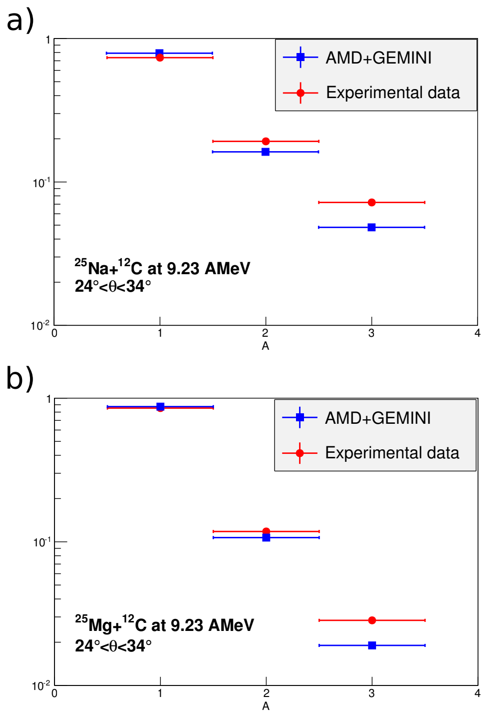

Figure 4. a) Isotopic ratio of hydrogen isotopes detected between 24° and 34° from the beam axis for $^{25}Na +^{12} C$ at 9.23 AMeV. b) Isotopic ratio of hydrogen isotopes detected between 24° and 34° from the beam axis for $^{25}Mg +^{12} C$ at 9.23 AMeV.

6 Acknowledgments

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