



ELSEVIER

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

SCIENCE @ DIRECT®

Nuclear Physics A 761 (2005) 190–199

NUCLEAR  
PHYSICS A

## Production of $^3\text{He}$ and $^6\text{He}$ fragments in the interaction of $^{12}\text{C}$ with $^{93}\text{Nb}$ at 400 MeV

L.J. Mudau<sup>a,b</sup>, F. Cerutti<sup>c</sup>, E. Gadioli<sup>c,\*</sup>, A. Mairani<sup>d</sup>, S.V. Förtsch<sup>a</sup>,  
E.Z. Buthelezi<sup>a</sup>, G.F. Steyn<sup>a</sup>, S.H. Connell<sup>e</sup>, J.J. Lawrie<sup>a</sup>,  
R. Neveling<sup>a</sup>, F.D. Smit<sup>a</sup>, E. Sideras-Haddad<sup>e</sup>

<sup>a</sup> *iThemba Laboratory for Accelerator Based Sciences, Somerset West, South Africa*

<sup>b</sup> *Department of Physics, University of the Western Cape, Bellville, South Africa*

<sup>c</sup> *Dipartimento di Fisica, Università di Milano and INFN, Sezione di Milano, Italy*

<sup>d</sup> *Dipartimento di Fisica Nucleare e Teorica, Università di Pavia and INFN, Sezione di Pavia, Italy*

<sup>e</sup> *School of Physics, Witwatersrand University, Johannesburg, South Africa*

Received 17 May 2005; received in revised form 5 July 2005; accepted 14 July 2005

Available online 2 August 2005

### Abstract

Spectra of inclusive double differential cross sections of  $^3\text{He}$  and  $^6\text{He}$  fragments produced in the interaction of  $^{12}\text{C}$  with  $^{93}\text{Nb}$  at 400 MeV are measured and analyzed. As was found for the production of intermediate mass fragments in this and similar reactions involving light projectiles, the spectra can to a large extent be satisfactorily reproduced only by considering the contribution of projectile break-up as well as nucleon coalescence.

© 2005 Elsevier B.V. All rights reserved.

PACS: 25.70.Gh; 25.70.Mn

**Keywords:** NUCLEAR REACTIONS  $^{93}\text{Nb}(^{12}\text{C}, ^3\text{He}X)$ ,  $(^{12}\text{C}, ^6\text{He}X)$ ,  $E = 400$  MeV; measured particle spectra,  $\sigma(E, \theta)$ ; deduced projectile break-up and nucleon coalescence contributions.

\* Corresponding author.

E-mail address: [gadioli@mi.infn.it](mailto:gadioli@mi.infn.it) (E. Gadioli).

## 1. Introduction

In previous studies we have measured and analyzed the spectra of Li, Be and B fragments produced in the interaction of  $^{12}\text{C}$  with nuclei in the mass range of about 60 to 200, at energies up to about 35 MeV/nucleon [1,2].

These and other investigations concerning the interaction of  $^{16}\text{O}$  with  $^{59}\text{Co}$  and  $^{93}\text{Nb}$  [3,4] revealed that, in reactions induced by light ions at energies in this energy range, the intermediate mass fragments (IMFs) are mainly produced by two distinct and unrelated mechanisms: projectile fragmentation and nucleon coalescence. The latter occurs during *thermalization* induced by the cascade of nucleon–nucleon interactions by which the excited composite nuclei created in the primary two-ion interaction reach a statistical equilibrium state. The main mechanisms to be considered in this respect are found to be the complete fusion and the break-up-fusion (or incomplete fusion), i.e., projectile break-up followed by the absorption of one of the produced fragments by the target nucleus.

Other important conclusions of these studies were the recognition that, before breaking-up, the projectile may suffer a quite significant energy loss and that it may break-up in many different ways. These binary fragmentations occur with non-negligible probabilities so that, for instance, the break-up of  $^{12}\text{C}$  into  $\alpha$ -type fragments, although giving an important contribution, is by no means the only break-up mode to be taken into account in the theoretical calculations.

In this note, we present and analyze additional data concerning the spectra of  $^3\text{He}$  and  $^6\text{He}$  fragments produced in the interaction of  $^{12}\text{C}$  with  $^{93}\text{Nb}$  at 400 MeV incident energy. In Section 2 of the paper we briefly discuss the experimental procedure. Section 3 is devoted to the theoretical analysis of the data and Section 4 to the conclusions.

## 2. Experimental procedure

In order to ascertain the relative importance of quasi-elastic fragmentations and inelastic fragmentations of  $^{12}\text{C}$ , an experiment was devoted to measuring the correlations between  $^8\text{Be}$  fragments and  $\alpha$ -particles emitted in the interaction of  $^{12}\text{C}$  with  $^{93}\text{Nb}$  at 400 MeV incident energy. The procedure of the data analysis was as follows. Only the prescaled singles events which represent 5% of all the events detected in the  $\alpha$ -particle detector telescope were analysed in the present study. In order to test the energy calibrations and efficiencies of this detector telescope, the singles  $\alpha$ -particle events were compared and normalized to results from a previous measurement of the double differential  $\alpha$ -particle cross sections [5]. The same normalization factor obtained from the double differential  $\alpha$ -particle cross sections was also used to extract double differential cross sections for  $^3\text{He}$  and  $^6\text{He}$ . It is the scope of this paper to show and analyze these last spectra. Another paper will be devoted to the discussion of the results of the correlation experiment.

The experiment made use of a 400 MeV  $^{12}\text{C}$  beam supplied by the cyclotron facility of iThemba LABS, Somerset West, South Africa. The beam was focused to a spot of less than 3 mm in diameter on the target mounted at the centre of a 1.5 m diameter scattering cham-

Download English Version:

<https://daneshyari.com/en/article/9850832>

Download Persian Version:

<https://daneshyari.com/article/9850832>

[Daneshyari.com](https://daneshyari.com)