# Chapter 43
# Examining the Helium Cluster Decays of the $^{12}$Be Excited States by Triton Transfer to the $^{9}$Li Beam


**N. Vukman, N. Soić, P. Čolović, M. Uroić, M. Freer, T. Davinson, A. Di Pietro, M. Alcorta, D. Connolly, A. Lennarz, C. Ruiz, A. Shotter, M. Williams and A. Psaltis**

**Abstract** We present the first results of the experiment: "Examining the helium cluster decays of the $^{12}$Be excited states by triton transfer to the $^{9}$Li beam" (spokespersons: N. Soić, M. Freer), done at TRIUMF, Vancouver, CA, with the main goal of providing precise experimental data on the internal structure of the $^{12}$Be excited states.

## 43.1 Motivation and the Experimental Method

Light nuclei, due to the small number of relevant degrees of freedom, present excellent framework in which to study the basic principles of nuclear interactions and structure: from single-particle dynamics to the appearance of clustering in the nuclei [1]. Structure of the $^{12}$Be excited states decaying to the helium isotopes has been studied in several experiments so far, with scarce and contradictory results [2]. In recent years, considerable theoretical effort and advances have been made, indicating the existence of exotic clustering in $^{12}$Be, namely molecular $\alpha$-4n-$\alpha$ structure [3]. Due to it's importance for understanding the structural changes in neutron-rich light nuclei, precise experimental data is needed. Prior to the experiment MC simulations

N. Vukman (✉) · N. Soić · P. Čolović · M. Uroić
Ruđer Bošković Institute, Zagreb, Croatia
e-mail: nvukman@irb.hr

M. Freer
University of Birmingham, Birmingham, UK

T. Davinson
University of Edinburgh, Edinburgh, UK

A. Di Pietro
INFN-Laboratori Nazionali del Sud, Catania, Italy

M. Alcorta · D. Connolly · A. Lennarz · C. Ruiz · A. Shotter · M. Williams
TRIUMF, Vancouver, BC, Canada

A. Psaltis
McMaster University, Hamilton, ON, Canada



J.-E. García-Ramos et al. (eds.), *Basic Concepts in Nuclear Physics: Theory, Experiments and Applications*, Springer Proceedings in Physics 225,
https://doi.org/10.1007/978-3-030-22204-8_43

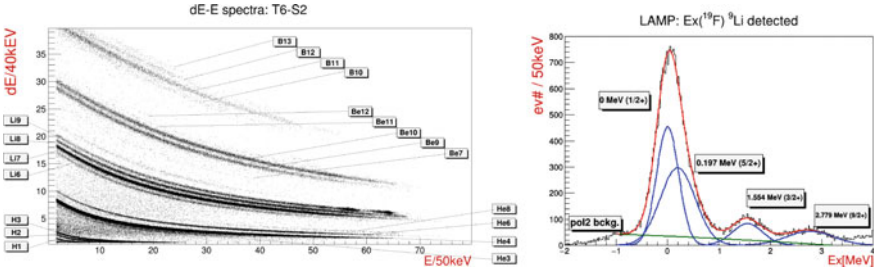


**Fig. 43.1** ΔE-E (telescope 6, strip 2) and excitation spectra of $^{19}$F from $^{19}$F($^{9}$Li, $^{9}$Li)$^{19}$F reaction

were carried out in AUSA code, developed by Aarhus University, DK, to optimize the setup and efficiency for kinematically complete measurement. The $^{9}$Li beam (75 MeV), provided by ISAC-II accelerator facility at TRIUMF, CA, was hitting the $^{7}$LiF target (1 mg/cm$^2$). Two set of YY1 wedge detectors of thickness 65 $\mu$m and 1500 $\mu$m, arranged as ΔE-E telescopes, were positioned in the LAMP configuration inside the TUDA chamber, covering $\theta$ range from 16° to 48°.

## 43.2 Calibration Process and Preliminary Results

We obtained the energy calibration using an $\alpha$ source and $^{9}$Li elastic scattering on the Au target, taking into account the relevant energy losses. This calibration is then used for the fine tuning of the measured geometry. The 2-body reactions excitation spectra of $^{7}$Li and $^{19}$F (see Fig. 43.1) are obtained, with the right position of ground state and first few excited states verifying the quality of the calibration. The next step in the analysis is to study the coincident helium isotopes detected from the break-up of the $^{12}$Be* ($^{12}$Be* $\rightarrow$ $^{6}$He+$^{6}$He, $^{12}$Be* $\rightarrow$ $^{8}$He+$^{4}$He) and produced predominantly via reactions on $^{7}$Li ($^{4}$He recoil, Q $>$ 0) or less frequently on $^{19}$F ($^{16}$O recoil, Q $<$ 0). Due to the large Q-value differences those two cases can be separated in the analysis.

## References

1. M. Freer et al., Rev. Mod. Phys. **90**, 035004 (2018)
2. M. Freer et al., Phys. Lett. B **775**, 58 (2017); Z.H. Yang et al., Phys. Rev. Lett. **112**, 162501 (2014); Z.H. Yang et al., Phys. Rev. C **91**, 024304 (2015); A. Saito et al., Nucl. Phys. A **738**, 337 (2004); R.J. Charity et al., Phys. Rev. C **76**, 064313 (2007); M. Freer et al., Phys. Rev. Lett. **82**, 295 (1999)
3. P. Maris, M.A. Caprio, J.P. Vary, Phys. Rev. C **91**, 014310 (2015); M. Ito, K. Ikeda, Rep. Prog. Phys. **77**, 096301 (2014); M. Ito et al., Phys. Rev. Lett. **100**, 182502 (2008); Y. Kanada-En'yo, H. Horiuchi, Phys. Rev. C **68**, 014319 (2003)