Nuclear reactions studies around the Coulomb barrier with light nuclei at CNA

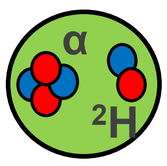
A. Vegas-Díaz[1,2], L. Garrido-Gómez[1], B. Fernández[1,2], F. J. Ferrer[1,2], J. P. Fernández-García[1], M. A. G. Alvarez[1] and V. Godinho[3]

[1]Departamento FAMN, University of Sevilla , 41080 Sevilla, Spain
[2]Centro Nacional de Aceleradores, University of Sevilla, Junta de Andalucía- CSIC, 41092 Sevilla, Spain
[3]Instituto de Ciencia de Materiales de Sevilla (ICMS), CSIC-US, Sevilla, Spain

Motivation

The Basic Nuclear Physics (FNB) unit at National Accelerators Center (CNA) is focusing its efforts on improving their target development and characterization capabilities. In addition, upgrades of the experimental line, installed at the +30º exit of the 3 MV tandem accelerator at CNA, is being carried out. The objective is to study nuclear reactions with weakly bound projectiles and light targets using low-energy ion beams at CNA. An experimental setup using Double Sided Silicon Striped Detector (DSSSD) and Passivated Implanted Planar Silicon (PIPS) detectors in single configuration have been mounted and validated with the measurement of the $^{6}Li+^{12}C$ reaction at energies around the Coulomb barrier.

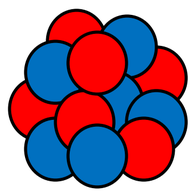
First measurement: $^{6}Li+^{12}C$



^{6}Li

- Weakly bound
- Cluster structure

Q_α = -1.474 MeV



^{12}C

- Tightly bound

Q_α = - 7.367 MeV

Measurements at $E_{c.m.}$ **of 3.6, 4.0, 4.3, 4.6, 5.0 and 5.3 MeV** around the Coulomb barrier energy (V_B).

V_B(c.m.) ~3.0 MeV

Main reaction channels:
$^{12}C(^{6}Li,\alpha)^{14}N$ and $^{12}C(^{6}Li,^{2}H)^{16}O$

Fragments identification

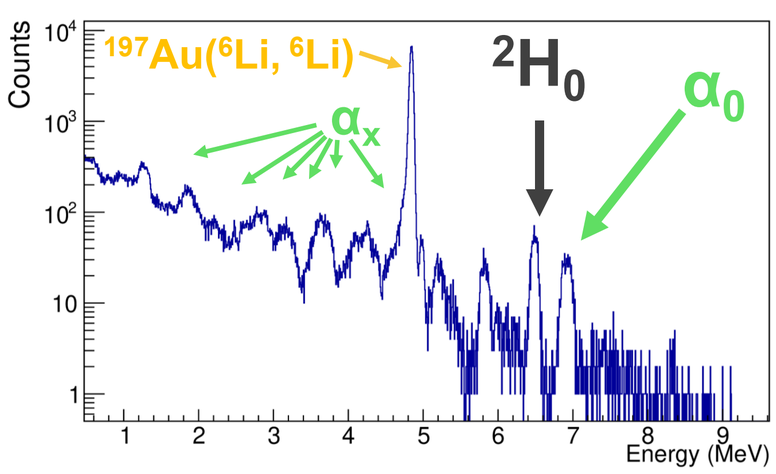
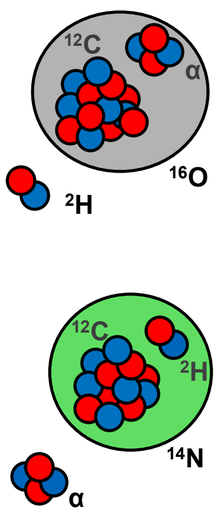


Fig. 5: Spectrum for vertical strip 9 (~135º) of the $^{6}Li+^{12}C$ reaction at 5.5 MeV.

- ✓ α_0 from $^{12}C(^{6}Li,\alpha_0)^{14}N_{g.s}$
- ✓ α_x from $^{12}C(^{6}Li,\alpha_x)^{14}N^{*}$
- ✓ $^{2}H_0$ from $^{12}C(^{6}Li,^{2}H_0)^{16}O_{g.s}$
- ✓ ^{6}Li from $^{197}Au(^{6}Li,^{6}Li)^{197}Au$
- ✗ ^{6}Li from $^{12}C(^{6}Li,^{6}Li)^{12}C$ due to kinematics.



Experimental setup: Detection & DAQ system

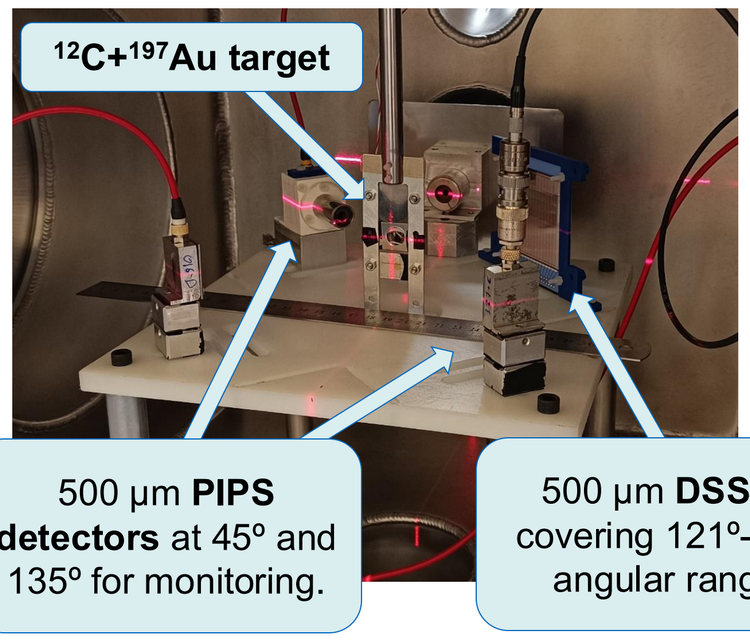


Fig. 1: Experimental setup inside FNB experimental line chamber at the 3MV tandem accelerator at CNA.

- ^{12}C target with very thin layer of ^{197}Au evaporated at the ICMS for normalization purposes.
- The thickness and composition characterization at CNA by Ion Beam Analysis techniques.

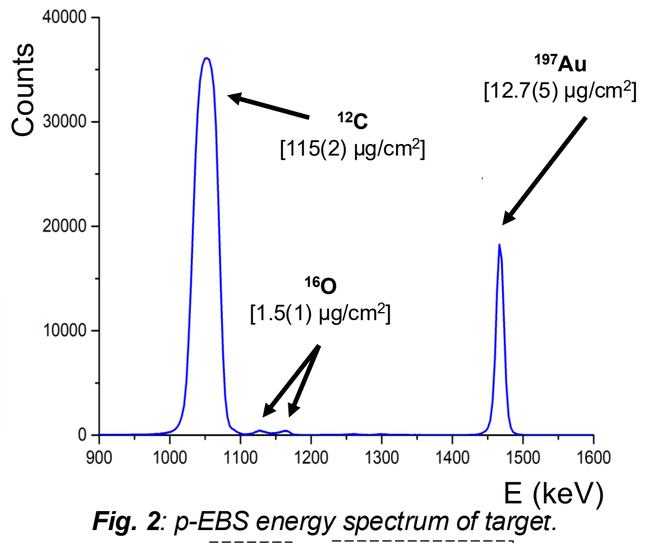


Fig. 2: p-EBS energy spectrum of target.

DSSSD resolution <30 keV

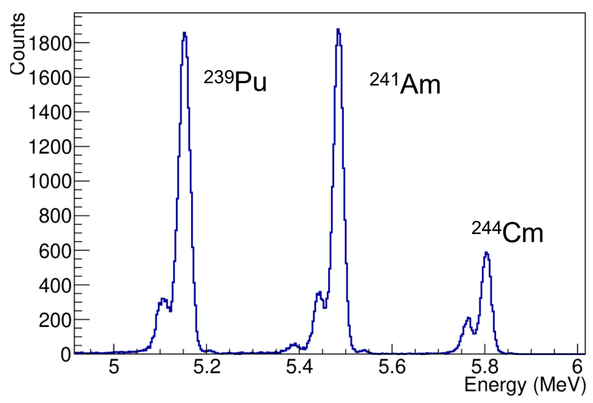


Fig. 3: 3-α source energy spectrum with the 500 µm DSSSD.

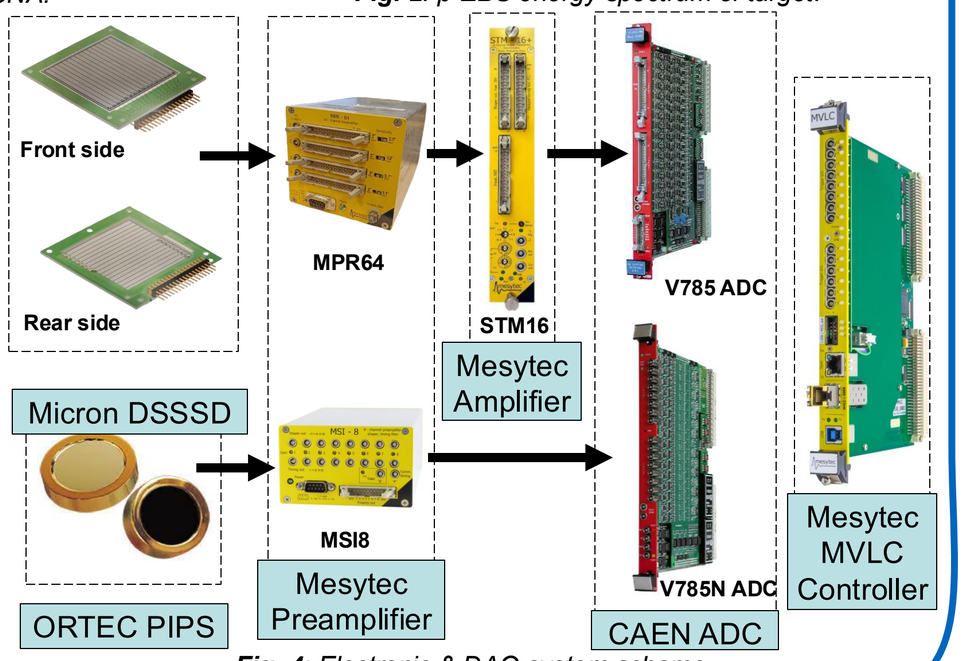


Fig. 4: Electronic & DAQ system scheme.

Preliminary results

- The preliminary cross section for $^{12}C(^{6}Li,\alpha_0)^{14}N_{g.s}$ results are consistent with the results obtained by J. Schwenzel et al. [1], besides being more precise.
- There is an increase of the projectile dissociation at the energy predicted by L. Garrido-Gómez et al. [2]:

$$E_b^{op} \approx V_b(c.m.) + |Q_{bu}| = 4.5\ MeV$$

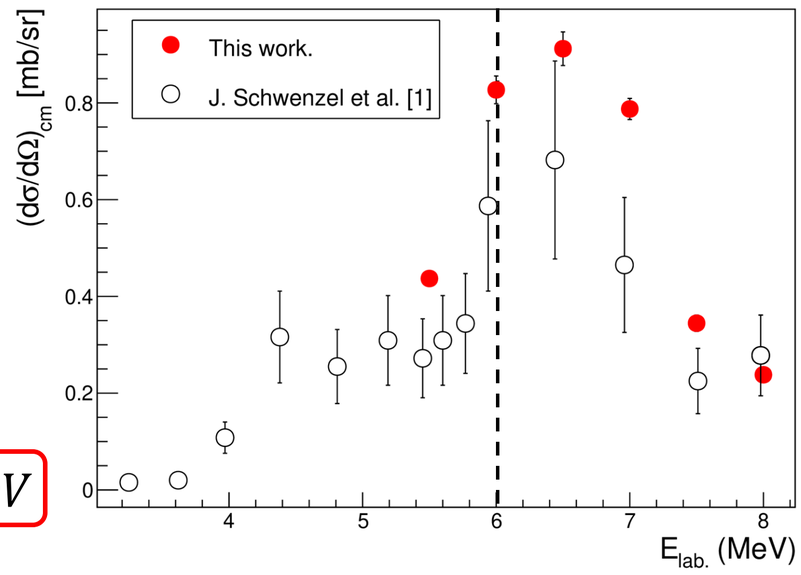


Fig. 6: Excitation function of the $^{12}C(^{6}Li,\alpha_0)^{14}N_{g.s}$ reaction channel.

Outlook

FNB experimental line upgrade:

- **S/DSSSD in a telescope configuration** for better identification of reaction fragments.
- **New motorized target manipulator** to improve target positioning precision.
- **Magnetron sputtering** to develop our own targets, including **self-supported ^{4}He targets** [3], that will be applied for different reactions and physical studies.

Future measurements:

- New **measurements of α and ^{2}H in coincidence** to study the $^{6}Li+^{12}C$ breakup channel.
- Measurements with **^{7}Li and ^{9}Be beams**, including ejectiles coincidences, at energies around the Coulomb barrier using telescope configuration.

References

[1] J. Schwenzel et al. *Nucl. Phys. A* ***367****, 145-156 (1981).*

[2] L. Garrido-Gómez et al. *Phys. Rev. C* ***109****, 054608 (2024).*

[3] F.J. Ferrer et al. *Eur. Phys. J. Plus* ***135****, 465 (2020).*

Work supported by the Spanish Ministry of Science and Innovation project PID2021-123879OB-C21 and the European Social Fund+ and State Investigation Agency.

Contact: avegas@us.es

European Nuclear Physics Conference 2025