Trojan Horse Method-based study of the $^{18}F(p,\alpha)^{15}O$ reaction at astrophysical energies: update on the 2015 run

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The first experiment where the Trojan Horse Method (THM)[1,2] was applied to measure the cross-section of an astrophysically important reaction, namely $^{18}F(p,\alpha)^{15}O$ at nova energies,[3,4] using a radioactive beam was published in Phys. Rev. C **92**, 015805 (2015).

To improve the results of that study, a new experiment was performed at the RIKEN Nishina Center using the CRIB apparatus from the University of Tokyo during the fall of 2015. Similar to the previous work, the primary beam of ^{18}O delivered by the AVF cyclotron was used to produce a ^{18}F radioactive beam with intensity in the range of 10^5–10^6 pps.

After the standard CRIB apparatus, the radioactive beam of ^{18}F was tracked by two PPACs and finally used to bombard thin (100–200 μg/cm^2) CD_2 targets. The THM aimed to study a suitably chosen reaction proceeding via a quasi-free mechanism with three bodies in the final state[1] ($^{18}F(d,\alpha^{15}O)n$ in this case) to infer pieces of information for the purpose of astrophysics, $^{18}F(p,\alpha)^{15}O$ in this case.

The distance between the PPACs was substantially optimized on the basis of the experience acquired in the previous experiment. Additionally, detection system based on the ASTRHO (Array of Silicons for Trojan HOrse) setup was upgraded. In particular, 8 bidimensional position sensitive silicon detectors (45 × 45 mm^2 active area, 500 μm thick, made by Hamamatsu Photonics K. K., Solid State Division) mounted in a square geometry were used to detect the outgoing particle with an exit angle of approximately 10° to 40°. A set of two double-sided multi-strip silicon detectors (50 × 50 mm^2, 500 μm thick, produced by Micron Semiconductor Ltd) was used to detect the particles with exit angle ranging from approximately 4° to 10°.

One of the main problems encountered in the analysis of data in the previous work came from the existence of various reaction channels with three particles in the final state. Although it was shown that the events originating from the reaction channels of interest could be disentangled from those from other channels by applying various types of cuts in the phase space, the possibility of having a direct identification in the Z of the outgoing particles, at least for the heavier ones, was a major goal in this experiment. To this end, a ΔE stage was added in front of the double-sided multi strip detectors mentioned above to ensure that a ΔE-E telescope covered the angles ranging between approximately 4° to 10°. This resulted in a higher detection efficiency because we could accept regions of the phase space that had to be discarded in the previous data analysis.

The 2015 experimental run was also optimized to cover the phase of space region relevant to the neutron induced $^{18}F(n,\alpha)^{15}N$ reaction. The importance of having a method to measure the cross-sections of the reaction induced by neutrons on radioactive species is clear, specially if the half-life of the radioactive isotopes involved in the entrance channel of the reaction are of the order of 1 h or less.

The experiment was successfully performed in the fall of 2015 over a period of 18 days divided into two runs. Unfortunately, while we expected to obtain highly enhanced accumulated statistics with respect to the previous experiment, the number of relevant THM events only increased by a factor of approximately 2. In contrast, the events that can be associated with the $^{18}F(n,\alpha)^{15}N$ reaction in the THM framework, were abundant and well discriminated.

The analysis of both channels is being finalized. Some preliminary results have been presented at various meetings and conferences, and we plan to publish the final results of these studies within this year.

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