New Trojan Horse study of the $^{18}F(p,\alpha)^{15}O$ reaction at astrophysical energies

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The first experiment on the application of the Trojan Horse Method[1,2] was to measure the cross section of an astrophysically important reaction, namely $^{18}F(p,\alpha)^{15}O$ at nova energies[3,4] via the $^{18}F(p,\alpha^{15}O)n$ reaction with three bodies in the final state, using a radioactive beam. This experiment has been recently published in Ref. 5 and it is also presented in this report.[6] Indeed, the whole idea of the Trojan Horse Method is to study a suitably chosen reaction proceeding via a quasi-free mechanism with three body in the final state, in the present case $^{18}F(d,\alpha^{15}O)n$, in order to infer pieces of information on the process of astrophysical interest, $^{18}F(p,\alpha)^{15}O$ in this case.

In order to improve the statistics as well as the quality of data, a new measurement was performed at the RIKEN Nishina Center using the CRIB apparatus from the University of Tokyo during October-November 2015. As in 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 $\mu g/cm^2$) CD_2 targets. The distance between the PPACs was optimized on the basis of the experience acquired in the previous experiment. In addition, the detection system based on the ASTRHO (A Silicon Array for Trojan HOrse) setup[7] was upgraded. In particular eight double position sensitive silicon detectors (45×45 mm^2 active area, 500 μm thick) mounted on a square geometry were used to detect outgoing particles with an exit angle of roughly 10 to 40 deg. Another set of two double sided multi strip silicon detectors (50 $\times$ 50 mm^2, 500 μm thick) was used to detect particles with exit angles ranging from approximately 4 to 10 deg.

One of the main problems encountered in the data analysis of the previous work came from the existence of various reaction channels with different sets of three particles in the final state. Though it was shown that it is possible to disentangle the events coming from the reaction channel of interest from the others by applying various kinds of cuts in the phase space[5], the possibility of having a direct identification in Z of the outgoing particles, at least for the heavier ones, was one of the major improvements in this measurement. To this end, a 20 μm thick silicon strip detector was used as ΔE stage in front of each of the aforementioned double sided multi strip detectors, such that the ΔE-E telescopes cover angles from roughly 4 to 10 deg. This will also result in a higher detection efficiency because we expect that we will be able to recover regions of the phase space that had to be discarded in the previous data analysis.

As already mentioned, the experiment was successfully performed in fall 2015 over a period of 18 days divided into two runs. Given the much longer period of actual data acquisition (15 days vs 2) and the higher detection efficiency, we also expect that we will be able to significantly increase the accumulated statistics with respect to the previous experiment. The data analysis of the new set of data has started and we expect to obtain preliminary results within fall 2016.

References

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