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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Letter of Clarification to the ISOLDE and Neutron Time-of-Flight Committee

for HIE-ISOLDE Proposal P-366 CERN-INTC-2012-065.

Study of the unbound proton-rich nucleus ^{21}Al with resonance elastic and inelastic scattering using an active target

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At its 43rd meeting held on the 31st of October 2012 the INTC reviewed our proposal P-366. The physics case was found interesting, but it was not deemed clear by the committee which device, MAYA or ACTAR-TPC [1] is the best suited for the proposed studies. As requested, we are addressing a Letter of Clarification to the INTC which treats this issue.

In this Letter we discuss the main performances of MAYA and their impact on the feasibility of the proposed experiment. The original proposal stressed that the experiment is ready to run using MAYA. As it will be shown below, the proven performance of MAYA is more than adequate for the proposed experiment. The low beam intensity (50pps induces very low dead-time), the two-body nature of the reaction (therefore only two tracks) and the fact that the states are well separated in energy (only moderate energy resolution required) means that the experiment can be performed routinely with MAYA.

The quantities to be measured are : a) the "Full Track" of the beam-like fragment (defined here as the sum of the two components: the beam track up to the point where the reaction takes place and the track of the beam-like residue from the reaction point), b) the total kinetic energy (TKE) of the protons and c) the position of the protons.

a) The measurement of the Full Track is needed to distinguish between elastic and inelastic channels, to separate from the unwanted carbon background and the isobaric contamination as well as to discriminate protons from the decaying nuclei coming from the emission beyond proton threshold of the unbound system. The resolution in the measurement of this quantity is important, in particular, to distinguish between the elastic and inelastic scattering of ^{20}Mg. These states are 1.59 MeV apart, which translates into 4mm separation between both Full Tracks (see Fig. 3 in the proposal P-366). The measured resolution of MAYA is 2 mm FWHM [2, 3], fulfilling the needs of the experiment.

b) The highest cross section for the elastic channel corresponds to backward angles in the center of mass (CoM) and thus forward angles in the laboratory. This corresponds to highly energetic protons that reach the Si-CsI detectors and do not significantly ionise the active volume. Therefore the proton energy will be measured in the ancillary detectors of MAYA with a resolution of $\simeq$ 200 keV in the laboratory, that becomes roughly $\simeq$ 50 keV in the CM, enough to separate the states predicted to be $\simeq$ 500 keV apart, as shown in (Fig. 2 in the proposal P-366).

c) The information on the proton angle will come from the position measurement in a small drift chamber placed at the end of the active volume of the MAYA detector, that together with the energy-angle kinematical correlation at different beam energies will be used to obtain the θ_{lab}. The position resolution of the drift detector being $\sim$ 1 mm will result in a θ_{lab} resolution of $\simeq 2^0$ FWHM.

Concerning the counting rate, the singles rate is expected to be low owing to the limited beam intensity (50 pps of ^{20}Mg). The highest cross section is, unsurprisingly, for the elastic channel. Our estimations for this particular channel, based on realistic yields already measured at ISOLDE [4], give 2x10^{-4} reactions/s for ^{20}Mg and 0.2 reactions/s for the ^{20}Na contaminant. The dead time associated with MAYA is in the order of $\sim$ 1 ms and thus, the only coincidence event that could cause some background, corresponds to an elastic proton from a reaction with the contaminant ^{20}Na and the elastic fragment ^{20}Mg. This is calculated to have an event rate of 10^{-8} cps at this yield. The contributions

from other background events are even smaller and they can easily be distinguished in the detector due to the different energy and path correlations.
Finally, and rather importantly, the ACTAR-TPC is still a "R & D" project and to be used in actual experiments is not foreseen before 2016. However, the proposed experiment does not require this development since this reaction is well suited for MAYA, which is an already existing and well performing detector.

References

[1] ACTAR-TPC Conceptual Design Report. http://pro.ganil-spiral2.eu/spiral2/instrumentation/actar-tpc/actar-tpc-cdr-2012/view

[2] C. E. Demonchy Ph. D. Thesis, University of Caen (2003).

[3] T. Roger, Ph. D. Thesis, University of Caen (2009).

[4] IS507-Study of the beta decay of ^{20}Mg (2010)