Proposal for an experiment at TANDEM

Study of reaction cross section induced by ^{6}Li on silicon using the transmission method

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The present proposal is part of a project that studies the fusion reactions induced by loosely bound projectiles and/or projectiles with a pronounced cluster structure. Many experiments have been performed with such projectiles, especially ^{6}He and ^{8}He and the measured fusion cross section was reported in some cases to increase, in other to behave like fusion with a “normal”, fairly bound projectile. The project proposes to use two different techniques for measuring the fusion cross section: the activation method and the transmission method.

In the **spring campaign**, an **activation experiment** was performed at the Tandem for the ^{6}Li+^{194}Pt reaction and the data are now being processed. For the **next campaign** we would like to test the other technique, **the transmission**.

The experimental setup is fairly simple (see the attached pdf file for a detailed scheme): the ^{6}Li beam is monitored by a first transmission Si detector, then it hits the target which is another thin (300 μm) Si detector acting as an active target. This is placed inside a large-volume NaI-based absorption spectrometer detecting the gamma rays issued in the reaction and which will be operated in coincidence with the active target. The NaI detector is placed inside a heavy shielded box to limit the natural background. The non-interacted beam is further detected by a third Si detector placed downstream at a certain distance from the shield of the NaI crystal and having a large area to account for the angular straggling produced by the target.

This experimental approach can only be used if the intensity of the beam is low enough to be supported by the Si detectors while avoiding a high pileup rate. Special tests have been performed at the Tandem to obtain a stable beam with a reduced intensity of 1000-3000 particles per second. Ti sieves with equidistant (3 mm) holes with a diameter of 10 μm were placed before the analyzing magnet with the possibility to rotate them. The results will be described in more detail in a subsequent publication. A protocol was established allowing the development of such a low-intensity ^{6}Li beam, including the control of the beam intensity with a movable plastic scintillator before sending it to the Si detectors of the experiment.

Another preparation for this transmission experiment concerned the NaI spectrometer whose readout (PM tubes , optical contact, voltage dividers) was totally refurbished.

Besides, the beam tube that will host the detectors will be fragmented in few segments to allow rapid intervention in case that we need to replace one of the detectors (execution plans given to the workshop).

The proposal has primarily the aim of testing the whole experimental assembly (controlled reduction of beam intensity, check of the digital data acquisition system including tests for each detector and coincidence tests, dead time evaluation). Also, the possibility of using coincidences of the first Si detector with the NaI spectrometer will be tested, for the further use of non-active targets. After the test, we intend to perform the true measurement of ^{6}Li on Si at various energies, starting above barrier and decreasing the energy to under-barrier values.

The proposed experiment will be done in close collaboration with our colleagues from FLNR-Dubna. Complementary experiments using ^{6}He beams are equally planned in Dubna.

Figure 1: Evaporation residue cross section for the $^{6}Li+^{28}Si$ reaction.

We ask for two days of beam time (6 UT) for the tests and four days (12 UT) for the measurements, **in all 18UT**.

Realistically one may consider the efficiency (determined essentially by the NaI spectrometer) close to 50%. In these conditions, at above barrier (B_c=7 MeV) energies where the cross section is roughly 1 barn, we expect about one detected reaction event every 2 seconds for a beam intensity of 1000 particles/s. If we want to go below barrier in a region where the cross section drops by 3 orders of magnitude (see Fig. 1), the useful counting will drop to one per hour. For a minimal statistics of 25 counts (20% statistical error), one needs one day of measurements at these bombarding energies.

The first measurements will be done at **12 MeV** and then, successively at **10, 9, 8, 7, 6, 5, 4, 3 MeV**.

The expected intensity of the beam: **30pna analysed**.

In the case of a successful test and experiment, after processing the obtained data we will probably ask another beam time for a more detailed exploration of the under barrier region.

Attached to the proposal is a layout of the experimental setup (pdf file).