Investigation of the Double Proton Decay of ^{17}Ne $^\diamond$

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Experimental evidence for the long-searched double proton decay mode has been found in a first experiment for the decay of the first excited state in ^{17}Ne [1] and a lifetime of $\tau_{2p} = 2.9^{+1.6}_{-1.3}$ ps for this decay mode was obtained. However, the low statistics and the limited energy resolution required a further investigation to confirm this evidence. Thus a second experiment at the NSCL has been performed, optimized for high detection efficiency of this specific reaction. The exotic (60 A*MeV) ^{17}Ne beam was produced via projectile fragmentation from a (100 A*MeV) ^{20}Ne beam bombarding a ^{9}Be target [1] and further purified with a Wien filter.

The first excited state in ^{17}Ne was populated via Coulomb excitation on a 112 mg/cm^2 ^{197}Au target. The incoming ^{17}Ne was identified with TOF - measurements and the trajectory was measured by two CRDC's [2] in front of the target.

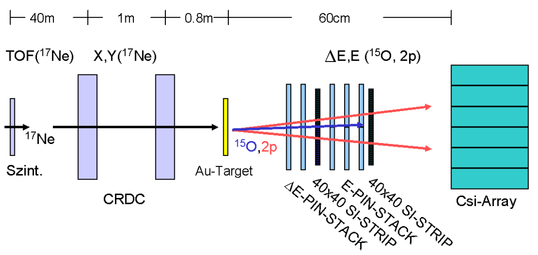

Fig. 1: Experimental Setup

A complete kinematic detection of all reaction products was performed using a highly segmented multi stage particle telescope as shown in fig. 1. The incoming ^{15}O was identified by a ΔE measurement in a stack of two quadrant Pin diodes and the energy measurement in a stack of three quadrant Pin diodes. In between those stacks a 40x40 double sided strip detector (DSSD) was placed to measure the position of the heavy projectile. The protons penetrated these detectors and were then identified by the ΔE of a second 40x40 DSSD before depositing their energy in a CsI-array consisting of 6x6 crystals. The signal of the first DSSD was split and one signal was amplified with a higher gain to detect protons and ^{15}O simultaneously in this detector. The improved granularity of the Pin diodes allowed to accept a 4 times higher rate compared to the previous experiment, while the better position resolution resulted in a improved energy resolution in the reconstructed decay energy spectrum. The increased granularity of the CsI - array reduced two proton hits in the same CsI crystal, which had to be rejected previously. With the position measurements of the interaction points of the protons in the DSSD's and in the CsI-array one could determine the interaction point in the target by backtracking - and this time also getting a measurement of the breakup point of the two protons along the beam axis. This allowed us to distinguish between breakup reactions in the target, in flight and in the detectors.

The particle identification was performed analog to the previous experiment [3]. In the preliminary analysis one observes a large background of breakup reactions in the detectors, where especially breakup events in the first Pin-detector play an important role. This effect is strongly enhanced in the new experiment due to the decreased target and the increased detector thickness. If the ^{17}Ne breaks up in the first Pin one expects there only a slightly higher energy loss. Thus it is difficult to exclude these events by an energy gate. But with the measured breakup-position along the beam axis one can apply a strict gate on reactions in the target to obtain the decay energy spectrum, see fig. 2.

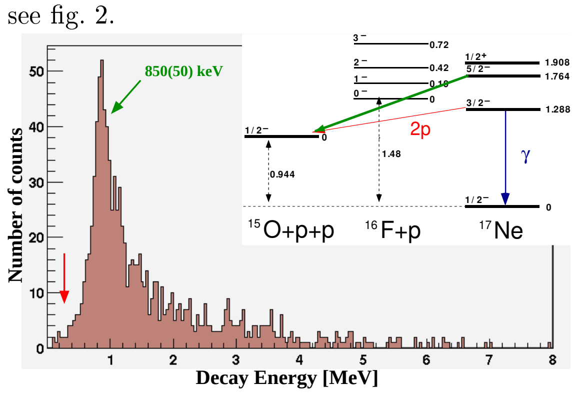

Fig. 2: Decay Energy Spectrum

One can see a peak around 850$\pm$50keV corresponding to transitions from the $\frac{5}{2}^-$ state in ^{17}Ne. But the peak around 300keV expected for the double proton decay can not be observed though significant intensity can be found in this energy region before gating on the interaction point, those events are correlated with breakup events in the first Pin detector, as a gate on the breakup position clearly shows. Thus the evidence for a double proton decay of the first excited state in ^{17}Ne to the ground state in ^{15}O with a lifetime of 3ps can not be confirmed. The decay must proceed at least two orders of magnitudes slower, now agreeing with barrier penetration calculations [4]. Assuming the predicted lifetime of 360ps we would still expect around 10 double proton transitions from the first excited state in ^{17}Ne. Those events would then decay in flight around 3cm behind the target. With the very accurate backtracking between the two DSSD's we hope to extract those events in the future analysis.

References

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