Search for the Di-Proton-Decay of the First Excited State in ^{17}Ne

M. J. Chromik, P. G. Thirolf, M. Thoennessen [a], A. Azhari [a], J. A. Brown [a], M. Fauerbach [a], T. Glasmacher [a], R.W. Ibbotson [a], R. A. Kryger [a], D. J. Morrissey [a], H. Scheit [a], M. Steiner [a], P. J. Woods [b], and S. Yokoyama [a]

[a] National Superconducting Cyclotron Laboratory, Michigan State University
[b] The University of Edinburgh,Edinburgh EH9 3JZ, United Kingdom

The proton-dripline nucleus ^{17}Ne is one of the candidates for a simultaneous 2p-emitter, since the first excited state of ^{17}Ne is bound with respect to one proton emission and unbound with respect to two proton emission. This decay-mode is in direct competition with the γ-decay back to the ground state in ^{17}Ne. The latest results from the measurement of the γ-decay branch (see e.g. ref. [1]) leave room for the existence of a 2p-branch. The experiment to search for the 2p-branch was performed at the NSCL and is described in detail in the last annual report [2], including the description of the multi-stage particle telescope.

The energy calibration for the reaction products was performed using ^{15}O beams and proton beams with different energies. For the calibration the multi-stage particle telescope and the target were in the same configuration as during the real experiment. The A1200 fragment separator was operated without a degrader, so that many other fragments produced from the primary beam ^{20}Ne down to ^{12}C reached our detector setup. These were used as an additional check of the calibration.

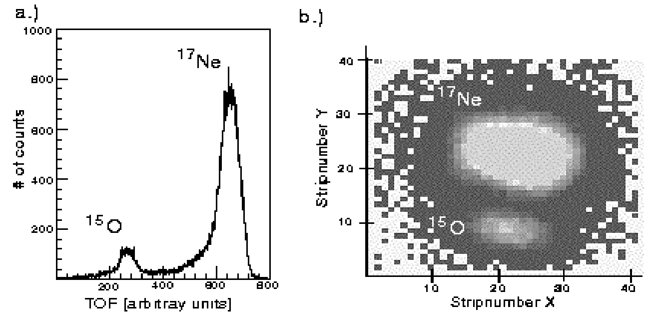

Fig. 1: Identification of the incoming ^{17}Ne particles by a) time-of-flight and b) by geometrical separation in a position sensitive Si-strip detector

To identify the incoming particle we used the TOF (fig. 1a), between a plastic scintillator (45m upstream) and the Si-PIN-detector. Additional separation was achieved after the bending magnet at the end of the Wien-filter where the secondary ^{17}Ne beam was spatially separated from the biggest contaminance ^{15}O [2]. A geometrical gate was set on the 40x40 strip detector as shown in (fig. 1b). An algorithm was developped to extract the particle trajectories from the hit pattern in the segmented detectors.

Fig 2a shows the ΔE(PIN)-E(Si5) spectrum gated on incoming ^{17}Ne. One can clearly see the ^{17}Ne peak and also channeling events in the 5mm thick Si-detector (Si5) or in the PIN-detector. Under the ^{17}Ne peak is a little enhancement corresponding to ^{15}O fragments from the (^{17}Ne,^{15}O) reaction. A gate on events in coincidence with two protons cleans up the spectrum and two peaks are visible (fig. 2b). One corresponds to ^{17}Ne, which goes through the ΔE-detectors as ^{17}Ne and breaks up into ^{15}O and two protons in the Si5. So these events have the same ΔE as incoming ^{17}Ne but less energy is deposited in the Si5. The other peak corresponds to events where ^{17}Ne breaks up in ^{15}O and two protons in the target, including the candidates for the di-proton decay mode.

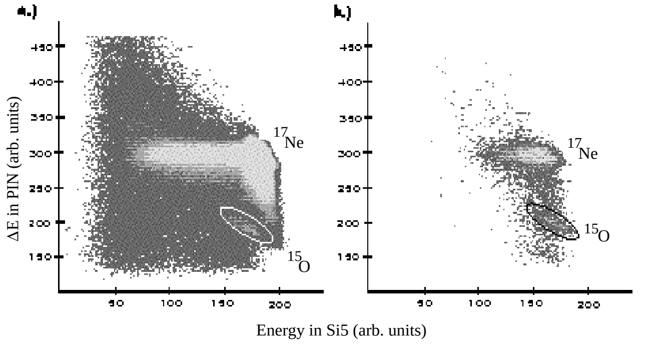

Fig. 2: Identification of the ^{15}O reaction fragments via ΔE-E in a 300μ PIN-diode and a 5mm thick Si(Li) detector. a): gated on incoming ^{17}Ne, b): additional condition on 2 protons identified in the exit channel.

In fig. 3 the sum of the ΔE in all the strips of the 16x16 detector is plotted against the sum of the deposited energy in all CsI detectors. In a spectrum gated on incoming ^{17}Ne (fig. 3a) the p- and d-bands can be seen. A bright band, for events where ΔE and E have both doubled values compared to the protons can be identified with the 2p-band. At even larger energyloss and energy one can see also the ^{3}He and ^{4}He bands. If one applies an additional condition for two-particle events, where the 16x16 strip detector was hit by two particles in different pixels, the spectrum is dominated by the 2p-band (fig. 3b).

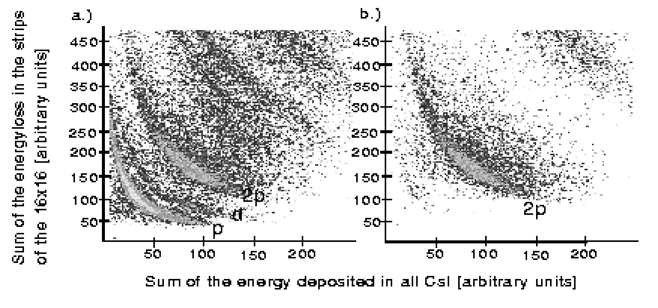

Fig. 3: Identification of the 2p-reaction channel via ΔE-E in the second strip detector and the CsI array. a): gated on incoming ^{17}Ne, b): additional coincidence with two-particle hits in the second strip detector.

After removal of remaining background, the next step in the analysis will be the transformation of the four-momenta of the ejectiles into the center of mass system using the reconstructed trajectories of the whole reaction. This will lead to the excitation energy of the events, which is required to answer the question of a possible di-proton decay of ^{17}Ne.

References

[1] M.J. Chromik *et al.*, Phys. Rev. **C55** (1997) 1676
[2] P.G. Thirolf *et al.*, Jahresbericht 1996, p. 17