Shape Coexistence in the "Island of inversion": Search for the 0_2^+ State in ^{32}Mg applying a Two-neutron Transfer Reaction ◇

K. Wimmer, V. Bildstein, R. Gernhäuser, Th. Kröll, R. Krücken, and the IS470 collaboration

The "Island of inversion" is a region in the nuclear chart around the neutron rich $N = 20$ isotopes of Ne, Na and Mg, where intruder fp-orbitals favoring deformed shapes compete with the normal spherical sd configurations. Along the Mg isotopic chain, at the shore of the island the nearly spherical ground state of ^{30}Mg has as analogue an excited spherical 0^+ state in ^{32}Mg whose ground state is deformed. Despite many attempts, this state has not been observed experimentally so far. Our approach is to apply, starting from ^{30}Mg, a two-neutron transfer reaction which is expected to favor the population of states with a similar particle-hole structure.

We populated states in ^{32}Mg by a (t,p) two-neutron transfer reaction in inverse kinematics with a ^{30}Mg beam at 1.83 MeV/u from REX-ISOLDE impinging on a tritium-loaded Ti target which has been used at REX-ISOLDE for the first time. Recoiling light particles, like protons and tritons, were detected in the new segmented Silicon detector [2] array especially designed for transfer reactions. This is surrounded by the MINIBALL γ detector. The Silicon detector consists of 8 $\Delta E - E$ telescopes, 4 in forward and 4 in backward laboratory direction, and an annular DSSSD covering large backward angles (see Fig. 1). The total solid angles coverage of the setup is 55%.

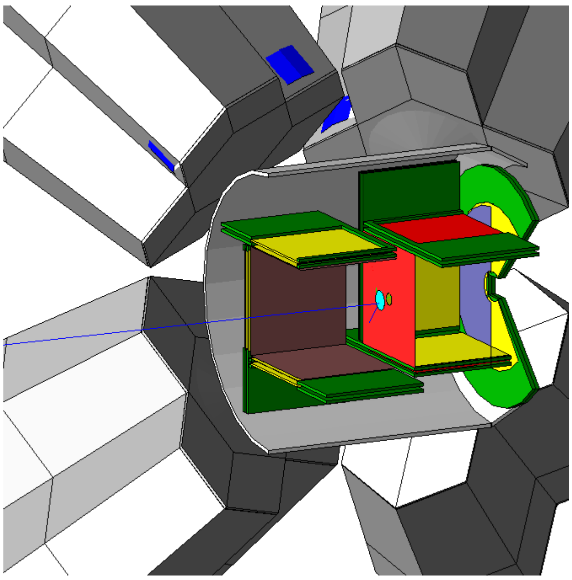

Fig. 1: Setup for transfer reactions at REX-ISOLDE surrounded by the MINIBALL γ detector.

The experiment has been performed successfully in October 2008. With an average beam intensity of $4 \cdot 10^4$ s^{-1} about 1500 protons from transfer reactions have been identified in 150 h of beam time. Fig. 2 shows the $\Delta E - E_{\rm rest}$ particle identification plot for forward angles in the laboratory system.

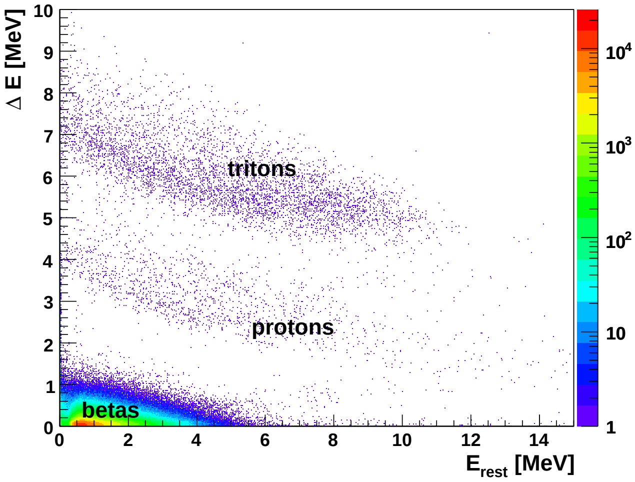

Fig. 2: $\Delta E - E_{\rm rest}$ particle identification plot for forward angles in the laboratory system.

As expected no deuterons have been observed, since the one neutron transfer reaction is suppressed by the large negative $Q = -3.9$ MeV.

Fig. 3 shows the angular distribution of protons for transfer to the ground state of ^{32}Mg in comparison with a DWBA calculation. In the angular range analyzed so far the data are described by the theoretical calculation for a $\Delta L = 0$ transfer to the ground state. This shows that in a more detailed analysis of the characteristic angular distributions the angular momentum transfer in the reaction and thus the spin of the populated states can be determined.

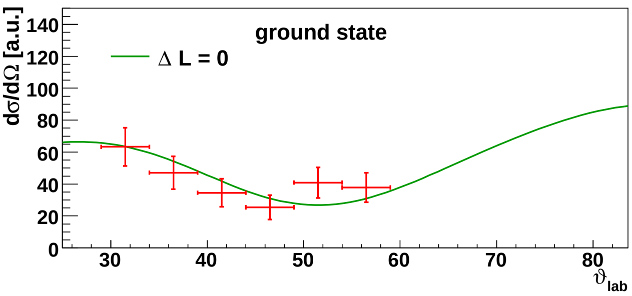

Fig. 3: Angular distribution of protons for the ground state of ^{32}Mg in comparison with a DWBA calculation.

The results of this experiment will add to the understanding of the physics relevant for the formation of the island of inversion. The IS470 experiment has successfully demonstrated that two neutron transfer reactions at REX-ISOLDE are possible and will thus open a new field for studies of shape coexistence and pairing correlations.

References

[1] E.K. Warburton *et al.*, Phys. Rev. **C 41** (1990) 1147
[2] V. Bildstein *et al.*, Prog. Part. Nucl. Phys. **59** (2007) 386

◇ Supported by BMBF 06MT238, RII3-EURONS (contract No. 506065) and the DFG Cluster of Excellence "Origin and Structure of the Universe" (www.universe-cluster.de)