In-beam spectroscopy close to the proton drip line

J. Kownacki[d], D. Seweryniak[a], B. Cederwall[b,c], J. Nyberg[a], J. Blomqvist[b], C. Fahlander[a], A. Johnson[b,c], A. Kerek[b], L-O. Norlin[b], E. Adamides[e], A. Ataç[f], H. Grawe[g], E. Ideguchi[h], R. Julin[i], S. Juutinen[i], W. Karczmarczyk[d], S. Mitarai[h], M. Piiparinen[f], R. Schubart[g], G. Sletten[f], S. Törmänen[i], A. Virtanen[i]

[a] The Svedberg Laboratory and Department of Radiation Sciences, Uppsala University, Uppsala, Sweden
[b] Manne Siegbahn Institute of Physics, Stockholm, Sweden
[c] Department of Physics, The Royal Inst. of Tech., Stockholm, Sweden
[d] Institute of Experimental Physics, University of Warsaw, Warsaw, Poland
[e] National Centre for Scientific Research, Ag. Paraskevi, Attiki, Greece
[f] The Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark
[g] Hahn-Meitner Institute, Berlin, Germany
[h] Dep. of Phys., Faculty of Science, Kyushu University, Fukuoka, Japan
[i] Dep. of Phys., Univ. of Jyväskylä, Jyväskylä, Finland

The effective nucleon- nucleon interactions in nuclei is most easily studied in the neighbourhood of doubly magic nuclei. There are just a few regions of this kind and that makes it the more important to try to reach and study also those near the ^{100}Sn, which lie some distance away from the stable nuclei. There has been considerable progress recently in the experimental investigation of nuclei close to the double magic ^{100}Sn, especially of the heavy N=50 isotones. At present however, we still do not have enough experimental data on the single hole (particle) energies relative to the ^{100}Sn core and the effective two-body interactions. An attempt to approach this region has been made by means of "in-beam" spectroscopical studies in low bombarding energies experiments with proton, ^3He and α-particles on ^{106}Cd target, reaching relatively low spins and excitation energies [1].
In order to extend the amount of information towards the higher spins and excitations the experiments had also been performed with the NORDBALL detector array using firstly [1] the reactions $^{19}F(^{92}Mo,xnyp)$, $^{19}F(^{96}Ru,xnyp)$ and $^{16}O(^{96}Ru,xnyp)$, and then finally the $^{58}Ni(^{54}Fe,xnyp)$ reaction at 270 MeV leading to compound nucleus ^{112}Xe. Obviously the reaction channels with the emission of the charged particles are strongly favourized in this region. In the lattermost experiment the detector system was equipped with 15 Ge-BGO spectrometers, one of which was a LEP detector, a 4π charged particle detector consisting of 21 ΔE-type Si detectors, a 2π γ-ray calorimeter consisting of 30 BaF_2 crystals in the upstream hemisphere and a $\sim 1\pi$ neutron detector array comprising 11 liquid scintillator detectors in the downstream hemisphere. A total amount of about 420 milion $\gamma-\gamma$-coincidence events containing information about the detected γ-rays, neutrons, protons and α particles were collected [2].
In the data analysis, γ-γ-coincidence matrices gated by different multiplicities of detected neutrons, protons and α particles were sorted. The intensity ratios of observed γ-ray transitions in different matrices depend on the multiplicities of particles accompanying γ-rays

emission and on the particle detection efficiencies. Since the detection efficiency for a specific type of evaporated particle depends very weakly on the reaction channel, comparison of such ratios with ratios for γ-rays from previously known nuclei that were populated in the experiment make the assignments of the final nuclei possible [2].
Using the above method a total of 29 different exit channels were identified including 7 light Sb, Te and I isotopes not observed before [2]. The experimental yield for e.g. ^{104}In was estimated to be 0.9% of the total production (0.004% for the weakest observed channel ^{100}Cd). Multipolarities for observed transitions were obtained by means of a γ-γ correlation analysis. The γ-γ-coincidence projections (gated with the proper combination of evaporated particles) were sorted for the two inequivalent detector angles with respect to the direction of the beam: 143° and 79°/101°. The ratios of intensities corresponding to different angles were calculated and compared to those obtained for transitions of known multipolarity.
As an illustration we present here (fig.1) the first results concerning the spectroscopic studies of $^{102,104}In$ nuclei. High spin states of ^{102}In and ^{104}In were populated in $2\alpha pn$ and $\alpha 3pn$ channels respectively. The proposed level schemes of ^{102}In and ^{104}In resemble each other in the low energy part of excitations. However they differ from a pattern observed for $^{106-116}In$ nuclei [3]. The present results are being analyzed and will be discussed within the framework of the spherical shell model (with the emphasis on the role of the $\nu h_{11/2}$ orbital), as well as the known systematics of the heavier odd-odd indium nuclei. In our case the observed states correspond most likely to the $\pi g_{9/2}^{-1} \otimes \nu d_{5/2}$ and $\pi g_{9/2}^{-1} \otimes \nu g_{7/2}$ multiplets giving rise to positive parity states. Negative parity states are lying higher in excitation energy and can be formed out of 2qp multiplet $\pi g_{9/2}^{-1} \otimes \nu h_{11/2}$ (states 8^-, 9^- and 10^-). The higer spin (12-17$\hbar$), negative parity states must consist of configurations in which more then 2 quasi-particles are involved. The similar preliminary in-beam studies of ^{104}In were also announced by Ogawa et al.[4].

References:

[1] J.Kownacki et al.to be published

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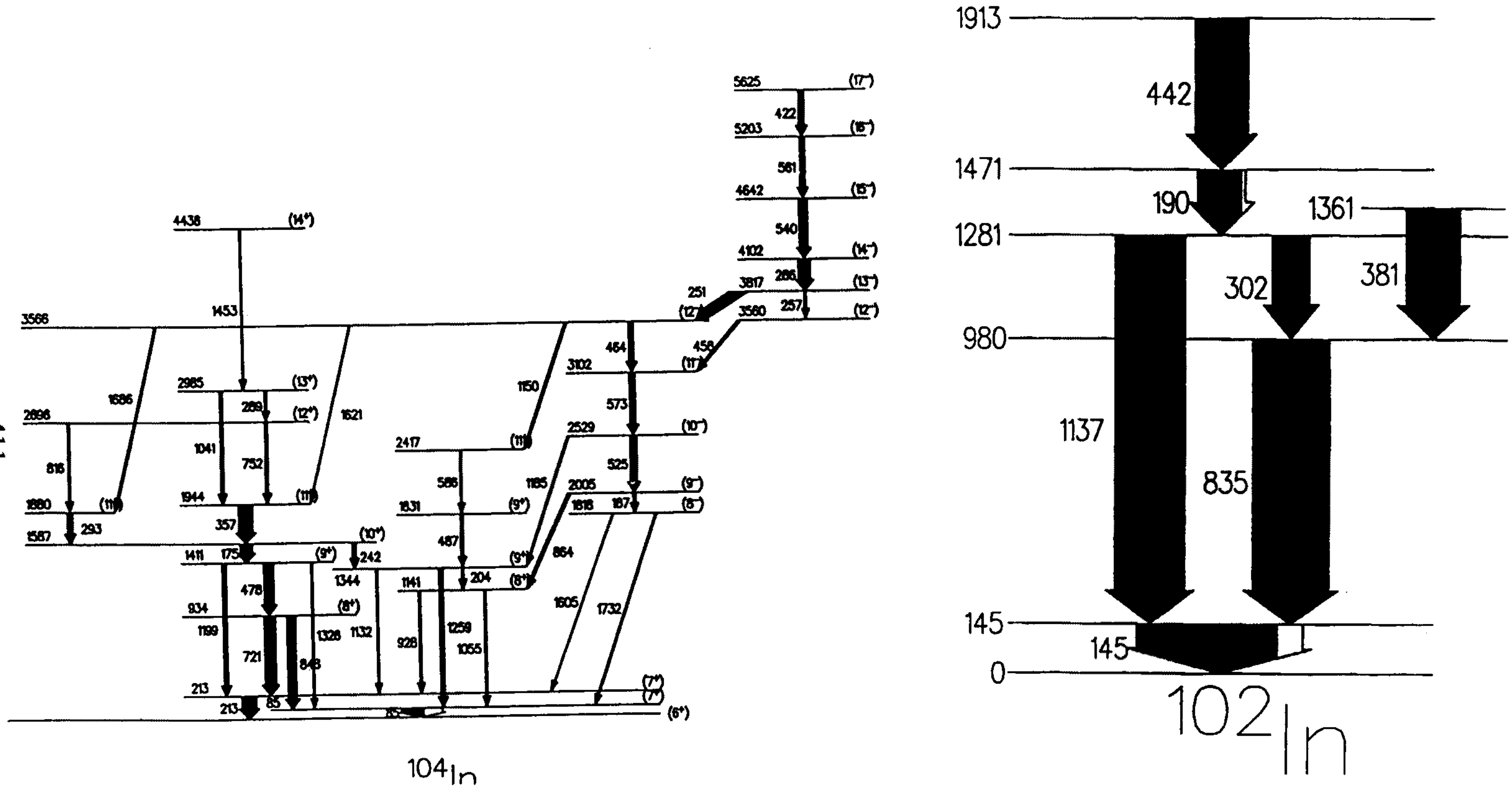

Fig.1 Preliminary level schemes of ^{102}In and ^{104}In nuclei based on present results.