Experimental report

10/09/2018

Proposal: 3-17-13 **Council:** 4/2017

Title: Low-spin spectroscopy of 205Pb and207Pb by the thermal neutron capture reactions: 204Pb(n,gamma)205Pb and 206Pb(n,gamma)207Pb

Research area: Nuclear and Particle Physics

This proposal is a new proposal

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Samples: 204Pb
206Pb

Instrument	Requested days	Allocated days	From	To
FIPPS	16	6	01/07/2018	07/07/2018

Abstract:

We propose to perform a low-spin gamma-ray spectroscopy study of 205Pb and 207Pb by employing the gamma-gamma coincidence technique, making use of the neutron capture reactions: 204Pb(n,gamma)205Pb and 206Pb(n,gamma)207Pb, respectively, and the FIPPS germanium array at ILL. The setup will consist of 8 HPGe clover detectors, in annular geometry around the target. The reactions will populate a large number of excited states of 205Pb and 207Pb up to the neutron binding energies (both at 6.7 MeV), within a few units of spin. The new data on these three- and one-valence-neutron-hole nuclei (with respect to the doubly magic core 208Pb) will provide a testing ground for various theoretical approaches.

EXPERIMENT 3-17-13

The experiment 3-17-13 “Low-spin spectroscopy of ^{205}Pb and ^{207}Pb by the thermal neutron capture reactions: ^{204}Pb(n,gamma)^{205}Pb and ^{206}Pb(n,gamma)^{207}Pb” was performed using FIPPS prompt gamma rays facility at ILL. The goal of this experiment was to study the low-spin excitations of three-neutron-hole ^{205}Pb nucleus by gamma-coincidence technique. The second part of this proposal, devoted to the studies of the ^{207}Pb nucleus, is going to be resubmitted as a separate proposal according to the suggestion from ILL Scientific Council.

The setup consisted of 60 HPGe crystals: 8 clovers of FIPPS arranged in annular geometry around the target and 7 clovers provided by IFIN-HH (Bucharest), placed at 45º with respect to the beam-line.

The experiment started on the 02/07/2018 and finished on the 05/07/2018, which was earlier than planned, due to the unexpected shutdown of the reactor. The total of 65 hours of ^{204}Pb(n,gamma)^{205}Pb measurement was performed. The 229.75-mg target of ^{204}Pb (66% enriched) was used. The target was put in the holder inside the Li tube to prevent from the scattered neutrons, as shown in Fig.1.

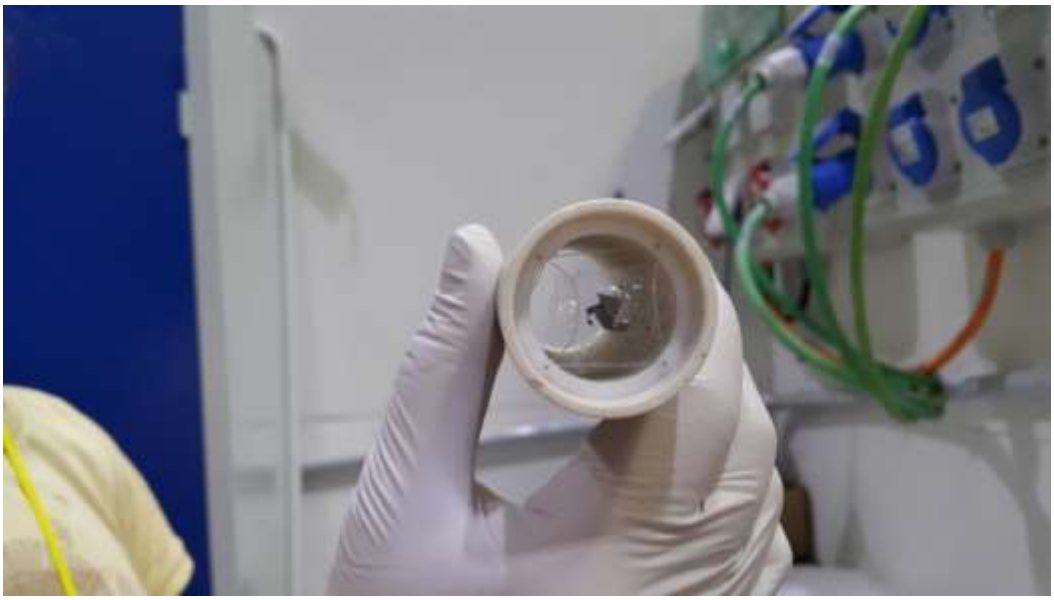

Fig.1. The placement of the target in the target holder.

The calibration runs with a 300-mg ^{27}Al target were taken before and after the experiment and the energy calibration of the detectors was performed. During the experiment a significant drift of the detectors was observed resulting in a large broadening of the peaks in the sorted gamma-gamma matrix. This effect, caused by the improper working of the electronic cards, is seen on the spectrum recorded in one HPGe crystal at the beginning and at the end of the experiment (Fig. 2). Due to this problem, it was not possible to sum all the runs and sort the data into the gamma-gamma coincidence matrix to include all the statistics. In order to do this, an additional step of the analysis (realigning of the spectra) will be required.

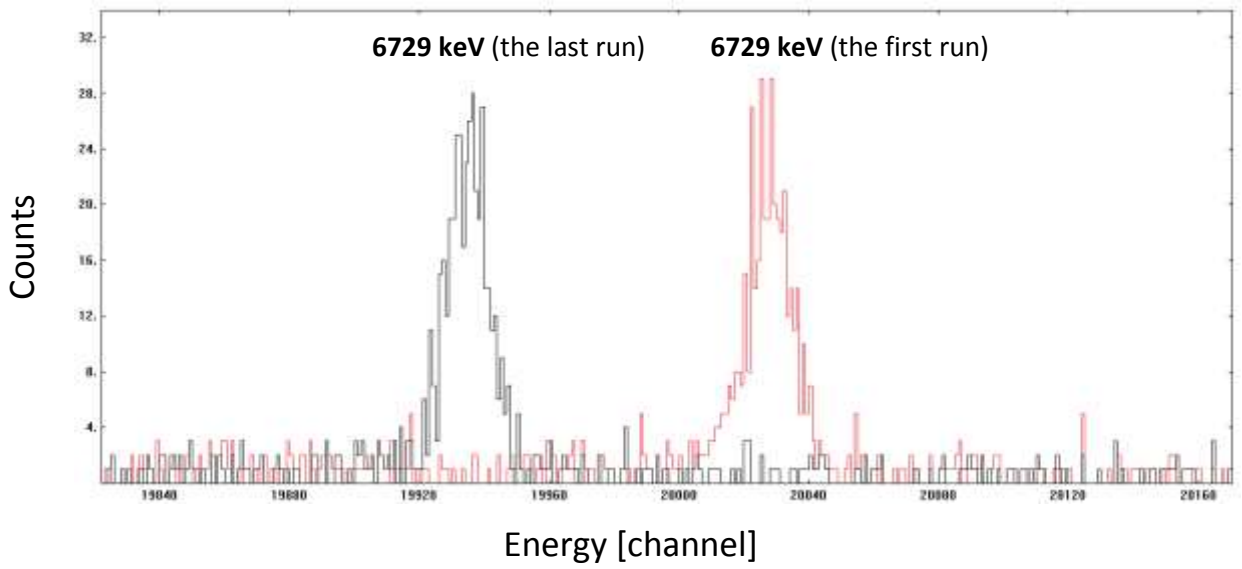

Fig.2. The example of the shift of the peaks positions during the ^{204}Pb(n,gamma)^{205}Pb measurement: the transition of 6729 keV (from ^{205}Pb) seen in the first and in the last run of the experiment in the same HPGe crystal (crystal No. 5).

A part of the data, small enough to avoid the large broadening of the peaks caused by the drift of the detectors, was sorted into a gamma-gamma coincidence matrix. The example of the spectrum is shown in Fig. 3. The gate was set on the already known, 1372-keV transition (marked in green in Fig. 4) deexciting the 1374-keV state in ^{205}Pb. The 5357-keV transition, a primary gamma ray feeding this level, is easily seen. Moreover, two new transitions, not observed so far, were identified: the 713- and 743-keV gamma rays, most probably feeding the 1374-keV excitation from the states at 2088 and 2118 keV, respectively. Their placement in the level scheme established in the previous experiments [1,2] is shown in Fig. 4.

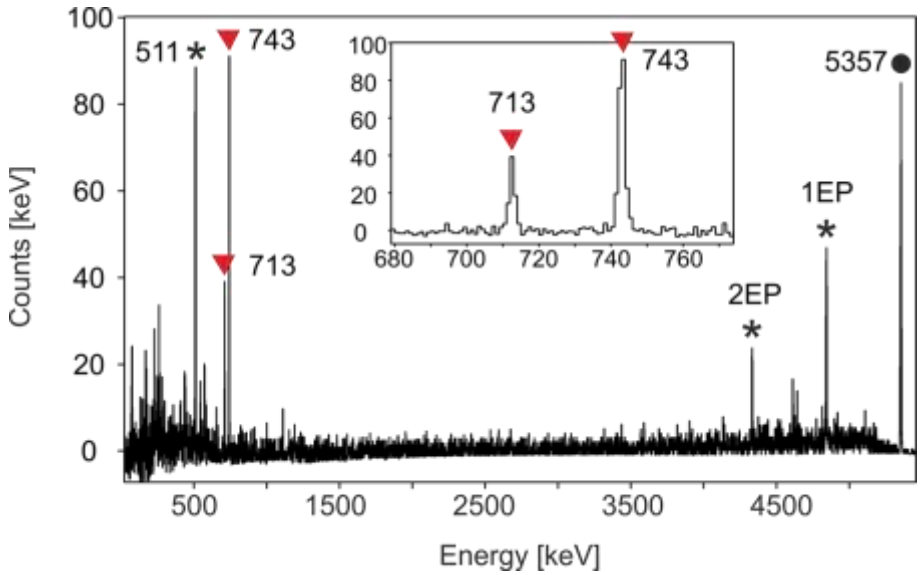

Fig.3. The example of the coincidence spectrum: the gate was set on the 1372-keV transition. The previously known primary gamma ray is marked by the black circle. The newly observed transitions are marked by the red triangles. The contaminations, for example the escape peaks, are marked by the asterisks.

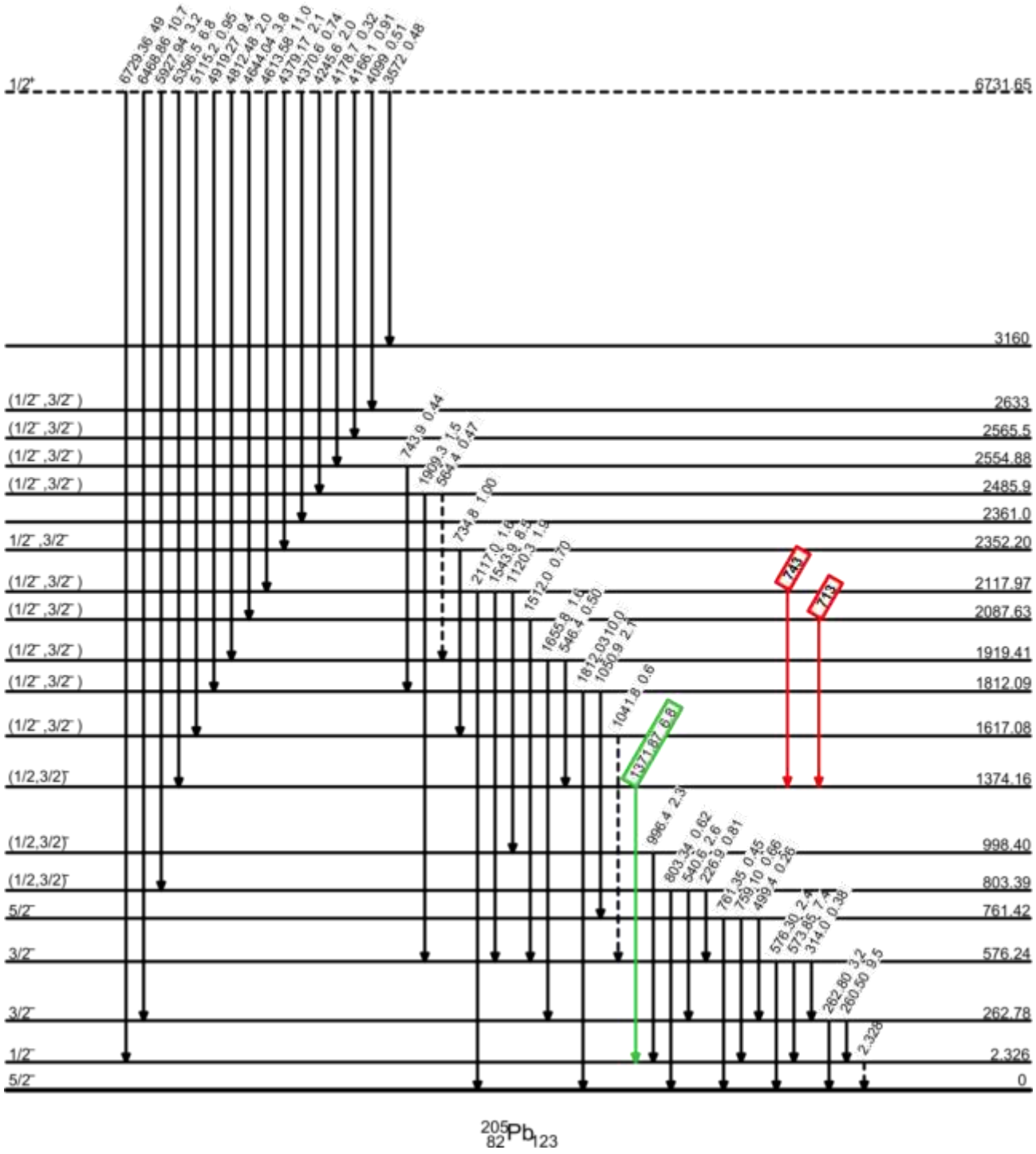

Fig.3. The level scheme of ^{205}Pb known from previous experiments with (n,gamma) reaction as in ENSDF [3]. The new transitions from the very preliminary analysis of the present data (713 and 743 keV, see Fig. 3) are marked in red, while the gating transition (1372 keV, see Fig. 3) is marked in green.

The further step of the analysis, that is the realigning of the spectra, will allow to sum all the runs from the 65 hours of performed experiment. The analysis of the gamma-coincidence matrix and cube will help to extend the information on the decay scheme of the capture state in ^{205}Pb. However, the shorter than planned time of measurement may not be sufficient for studying less populated levels and weaker branches, especially, by using gamma-angular correlations technique, providing information on the spins of the states but requiring rather large statistics.

[1] E.T. Jurney, H.T. Motz, and S.H. Vegors Jr., Nucl. Phys. A94, 351 (1967)
[2] P. Hungerford, T. von Egidy, H.H. Schmidt, S.A. Kerr, H.G. Borner, and E. Monnand, Z. Phys. A313, 349 (1983)
[3] http://www.nndc.bnl.gov/