GAMMA-SPECTROSCOPY OF ^{231}Pa BY PARTICLE-COINCIDENCES USING A NEW PIN-DIODE DETECTOR ARRAY * **

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(Received December 10, 1996)

The nucleus ^{231}Pa lies outside the calculated region of stable octupole deformation. Investigating the $K = 1/2^-$ g.s. band and transitions therein can serve to test calculations in the quasiparticle-plus-phonon model including small octupole correlations. To this end a ^{231}Pa target was Coulomb-excited by 260 MeV ^{58}Ni projectiles. For background reduction a new PIN-diode-mosaic particle detector was constructed to enable the readout of the 20 germanium detectors of NORDBALL in coincidence with the backscattered particles with good time resolution and position sensitivity. Doppler correction and γ-γ-coincidences help to clarify the structure of ^{231}Pa.

PACS numbers: 23.20. Lv, 21.60. Ev, 27.90. +b, 29.40. Wk

* Presented at the XXXI Zakopane School of Physics, Zakopane, Poland, September 3–11, 1996.

** Work supported by DFG, BMBF, the Volkswagen Foundation, the Polish State Committee for Scientific Research, the Munich and the Niels Bohr Institute Tandem-Accelerator-Laboratories, and the Warsaw Heavy-Ion Laboratory.

1. A new PIN-diode particle detector for NORDBALL

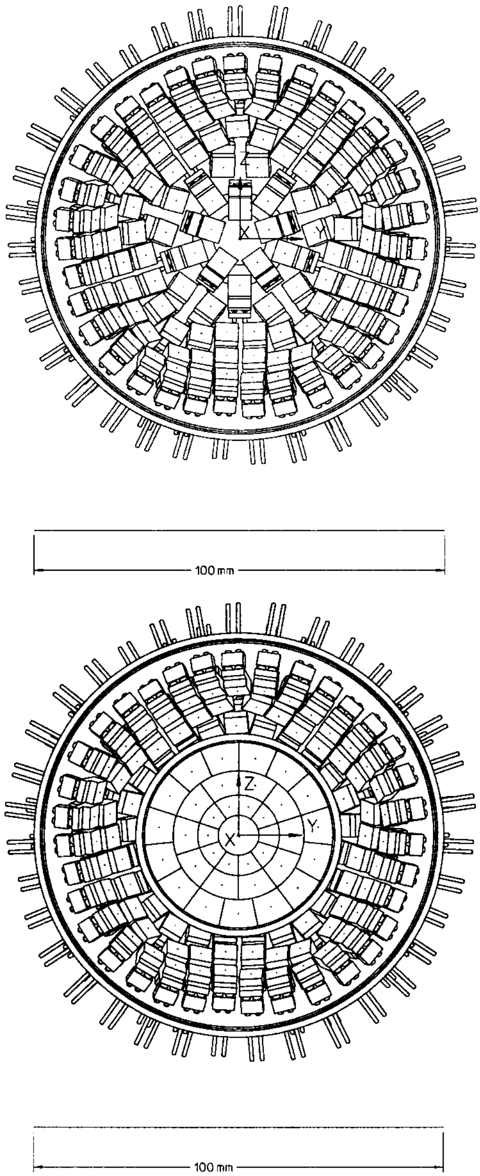

Fig. 1. The modular detector array showing PIN-diodes and mosaic detector looking in the upstream direction with the beam-entrance hole in the center.

Particle-γ-coincidences with good time resolution substantially reduce the background of gammas from the radioactive target ^{231}Pa and from unwanted reaction channels with the oxide on the target and the carbon backing. The reaction kinematics was determined by a position-sensitive particle-detector which also allowed Doppler correction to be applied for good energy resolution. In addition the position sensitivity allows to measure the γ-angular distribution for different scattering angles. To exclude particle hits from α-radioactivity of the target and from backscattering from target contaminants windows were set on the particle energy.

A modular particle-detector system fitting inside the vacuum chamber of NORDBALL has been constructed consisting of up to 110 commercially available PIN-diodes (SFH 870/F170) of $5 \times 5\,\mathrm{mm}^2$ active area and $381 \pm 15\,\mu$m thickness. Alternatively a 35-fold angular segmented silicon detector manufactured at the University of Warsaw could be mounted in the center-part of the detector (see Fig. 1).

Each detector is read out separately and can be replaced individually. The solid angle of the mosaic combined with all PIN-diodes covers 39.2% of the backward hemisphere. Choosing Coulex conditions with a Ni beam exciting a mass $v = 6\%\,c$ the γ-energy resolution after Doppler correction can be reduced to 0.4%. The energy resolution for the particles is determined by the highest energy that can be stopped in the detector. It is better than 100 keV and the time resolution obtained is better than 30 ns FWHM.

2. Gamma-spectroscopy of ^{231}Pa

A $105\,\mu\mathrm{g/cm}^2$ ^{231}Pa oxide target on a $15\,\mu\mathrm{g/cm}^2$ carbon backing was Coulomb-excited by 148 MeV and 260 MeV ^{58}Ni projectiles. The 20 Compton-suppressed germanium detectors of NORDBALL were read out in coincidence with 55 PIN-diodes. Evaluating p-γ-γ coincidences the g.s. band of ^{231}Pa could be followed at least up to $33/2^-$ and side-band-transitions are seen in coincidence with the g.s. band. A typical p-γ-γ coincidence spectrum is shown in Fig. 2.

A more detailed investigation of these spectra is needed to determine the structure of the side-bands and the K mixing responsible for their excitation.

A fit to the rotational model [1] using equations (1) to (3)

$$E_{\mathrm{rot}} = A\{I(I+1) + (-)^{I+1/2}(I+1/2)a(I)\}\,, \tag{1}$$

and a spin-dependent decoupling parameter due to Coriolis interaction given by

$$a(I) = a[1 - \varepsilon^2(I-1/2)(I+3/2)]\,, \tag{2}$$

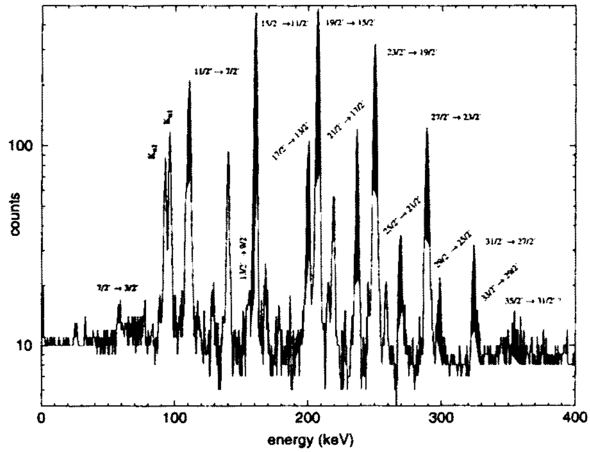

Fig. 2. p-γ-γ-coincidence spectrum of ^{231}Pa + (260 MeV) ^{58}Ni gated on g.s. band transitions, background subtracted.

and a spin-dependent moment of inertia

$$J = J_0(1 - k \cdot I^2) \tag{3}$$

gives a parameter set:

$$A = 6.28(1)\ \text{keV},\ a = -1.39(1),\ \varepsilon^2 = 0.0021(2),\ k = 0.0004(1)\,. \tag{4}$$

Further evaluation is in progress.

More applications of the new detector system at the Munich Tandem-Accelerator and the Warsaw cyclotron are envisaged. A new hotlab at the University of Munich may produce new and better ^{231}Pa targets.

REFERENCES

[1] A.I. Levon *et al.*, *Nuc. Phys.* **A598**, 11 (1996).