Vol. 42 (2011) *ACTA PHYSICA POLONICA B* No 3–4

STUDY OF HIGH-LYING STATES IN ^{208}Pb WITH THE AGATA DEMONSTRATOR*

R. Nicolini[a,b], A. Bracco[a,b], D. Mengoni[c,d], S. Leoni[a,b], F. Camera[a,b]
D. Bazzacco[c], E. Farnea[c], A. Gadea[e], F. Birocchi[a], A. Camplani[a]
A. Corsi[a,b], F.C.L. Crespi[a,b], A. Giaz[a,b], L. Pellegri[a,b], S. Riboldi[a,b]
V. Vandone[a,b], G. Benzoni[b], N. Blasi[b], C. Boiano[b], S. Brambilla[b]
B. Million[b], O. Wieland[b], M. Bellato[c], A. Gottardo[c], R. Isocrate[c]
C. Michelagnoli[c], D. Montanari[c], F. Recchia[c], C. Ur[c], D. Bortolato[f]
E. Calore[f], P. Molini[f], D.R. Napoli[f], E. Sahin[f], J.J. Valiente-Dobon[f]
M. Ciemala[g], M. Kmiecik[g], A. Maj[g], S. Myalski[g], A. Bürger[h]
R. Kempley[i], P. Reiter[j]

and the AGATA Collaboration

[a]Dipartimento di Fisica, Università degli Studi di Milano
Via Celoria 16, 20133, Milano, Italy
[b]INFN, Sezione di Milano, Via Celoria 16, 20133, Milano, Italy
[c]Università di Padova e INFN, sezione di Padova, Padova, Italy
[d]School of Engineering and Science, University of the West of Scotland
Paisley, Scotland, UK
[e]IFIC, Valencia, Spain
[f]INFN, Laboratori Nazionali di Legnaro, Legnaro, Padova, Italy
[g]The H. Niewodniczański Institute of Nuclear Physics PAN
31-342, Kraków, Poland
[h]University of Oslo, Norway
[i]University of Surrey, Guildford, UK
[j]Institut für Kernphysik, Universität zu Köln, Germany

(Received February 22, 2011)

An experiment aiming at the study of the gamma decay from the Giant Resonance region in the nuclei ^{208}Pb, ^{90}Zr has recently been performed with the AGATA Demonstrator coupled to an array of large volume scintillators ($LaBr_3$:Ce, BaF_2) to increase the overall gamma detection efficiency. The ^{208}Pb and ^{90}Zr nuclei were excited with the inelastic scattering of ^{17}O at the incident energy of 20 MeV/u. The ejectiles were detected in a pair of silicon E–ΔE telescopes placed at forward angles. Preliminary results concerning the first partial analysis of the measurement with the ^{208}Pb target are here presented.

DOI:10.5506/APhysPolB.42.653
PACS numbers: 24.30.Cz, 25.70.–z

* Presented at the Zakopane Conference on Nuclear Physics "Extremes of the Nuclear Landscape", August 30–September 5, 2010, Zakopane, Poland.

1. Introduction

Giant Resonances are fundamental high frequency modes of excitation of nuclei, and have been studied over the years since they provide useful information on nuclear structure and on the effective nucleon–nucleon interaction [1]. They can be excited employing different probes, including heavy ions [2]. In particular, the inelastic scattering of ^{17}O has been successfully used to populate the Giant Quadrupole Resonance in ^{208}Pb, making it possible to study its gamma decay and its coupling to low-lying collective states [3]. More recently, detailed studies at very high resolution [4,5,6,7,8] have provided evidence for fine structures below and above particle threshold. These structures are expected to carry relevant information on the microscopic nature of the Giant Resonance modes. A tool expected to provide a better understanding of the fine structure of Giant Resonances is the gamma decay, which is very sensitive to the multipolarity of the resonance and to its coupling to specific states.

Motivated by this interest, an experiment with the AGATA Demonstrator was performed using inelastic scattering of ^{17}O at bombarding energy of 20 MeV/u. This beam energy is optimal for the excitation of the Giant Quadrupole resonance [2]. The beam current was limited to about 0.5 pnA in order to cope with the high count rate in the detectors. Most of the data were obtained with two different targets, one of ^{208}Pb 2 mg/cm^2 thick and the other of ^{90}Zr 2.6 mg/cm^2 thick.

2. Experimental setup and data analysis

The scattered ^{17}O ions were detected by two segmented silicon E–ΔE telescopes [9] (cooled to $-20°$C), made of detectors 1000 μm and 200 μm thick. Each detector had an active area of 20×50 mm^2 divided in 60 pads of 4×4 mm^2, half of which were read out and acquired. The telescopes, mounted symmetrically with respect to the beam axis, were placed at 12° for the ^{208}Pb reaction and at 8° for the ^{90}Zr reaction.

The Total Kinetic Energy (TKE) of the ion was obtained by summing the E and ΔE detectors signal, pixel by pixel. The ΔE –TKE correlation is given in Fig. 1, top panel, left, showing a good separation of the O isotopes. A portion of the energy spectrum of the inelastically scattered ^{17}O is shown in the top panel, right, of Fig. 1; the large bump centered around the energy of 329 MeV ($E^* \sim 11$ MeV) is known to be dominated by the Giant Quadrupole Resonance [3].

The gamma rays were detected with 3 triple clusters of the AGATA Demonstrator [10], an array of 3 clusters of BaF_2, and an array of 3 cylindrical crystals of $LaBr_3$:Ce (one 3"× 3" and two 3.5" × 8").

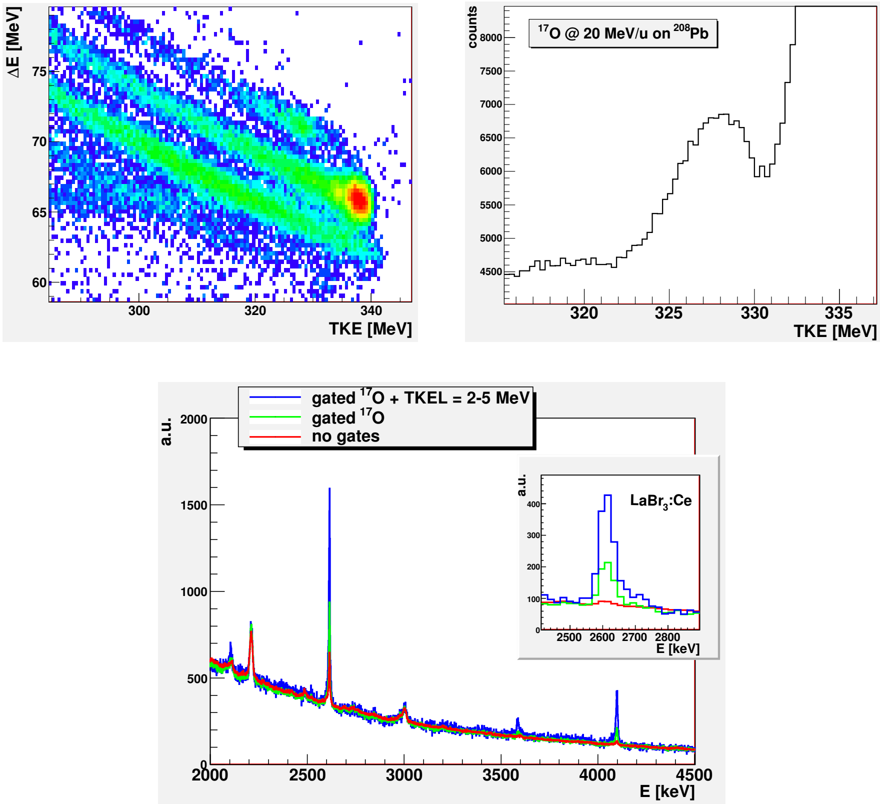

Fig. 1. Top left panel: TKE–ΔE matrix obtained in the Si telescopes. Top right panel: Kinetic energy spectrum of ^{17}O. Bottom panel: Gamma-ray energy spectra measured with the AGATA Demonstrator under various gating conditions, as described in the legend, and normalized to the total number of counts. The inset shows the energy spectrum around the 2615 keV line measured with one crystal of $LaBr_3$:Ce under the same gating conditions.

The energy spectrum of γ-rays obtained with the AGATA Demonstrator after selecting the inelastically scattered ^{17}O events is shown (in light grey (green)) in Fig. 1 together with the spectrum obtained without any gating condition (in dark grey (red)). It is evident that this condition enhances the intensity of the ^{208}Pb γ-ray transitions at 2615 keV (3^-) and at 4085 keV (2^+).

The second step of the analysis was to correlate the total kinetic energy loss (TKEL) with the gamma-ray energy spectrum measured in coincidence with ejectiles, since in the case of the reaction studied in this work the TKEL roughly corresponds to the excitation energy of the target. For example, the black (blue) spectrum in Fig. 1 is obtained by requiring TKEL between 2 and 5 MeV. This spectrum, when compared to the others (all are normalized to the total number of counts), clearly shows a further enhancement of the peaks due to gamma transitions in ^{208}Pb with respect to the background. The inset in Fig. 1 shows the 2615 keV transition measured with a crystal of LaBr$_3$:Ce under the same gating conditions described above.

After having checked that the data gated by lower values of excitation energy present the expected behavior it is interesting to see the gamma rays associated with a TKEL between 5 and 10 MeV, corresponding to a similar range of excitation energy in the target, region in which "pygmy" structures have been identified with (γ,γ') experiments [4]. In this spectrum, in black (blue) in Fig. 2, some peaks are clearly visible, possibly associated with pygmy structures in ^{208}Pb. In particular, the peak at 6.26 MeV and the peak at 5.52 MeV have already been identified by (γ,γ') experiments, while the other peak at $\sim$ 6.20 MeV is not yet identified; the structures at $\sim$ 5.7 MeV could be related to the first escape peak of the doublet. The scintillator spectra under the same gating conditions confirm the presence of these structures, seen also in a test experiment performed at LBL with a smaller detection efficiency [11]. Further investigations are of course needed, in particular taking into account the response function of the detectors.

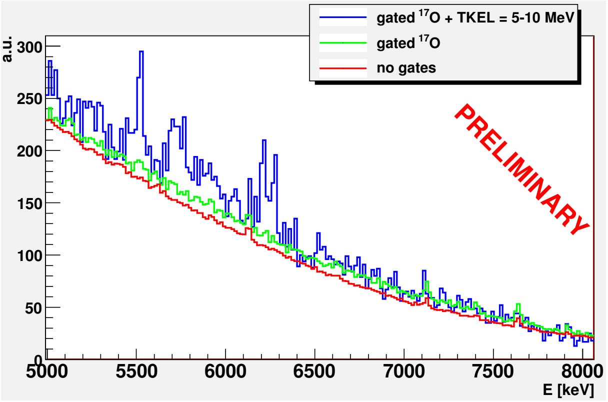

Fig. 2. Gamma-ray energy spectra measured with the AGATA Demonstrator under various gating conditions, as described in the legend. All the spectra have been normalized so that they have the same area over the 0–15 MeV range.

3. Conclusions

Some preliminary results of an experiment focused on the gamma decay from the inelastic scattering of ^{17}O at the energy of 20 MeV/u on a ^{208}Pb target have been presented. Some interesting results on the population of the pygmy resonance are found, for which further analyses will be carried out. All in all, with the planned work we expect to make another step toward a better understanding of the underlying structure of giant resonances.

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