Deconvoluting the internal contamination of the LaBr$_3$:Ce crystal

Peder Kock

Department of Medical Radiation Physics Malmö, Lund University, Sweden

LUND UNIVERSITY
Faculty of Science

Aim of the study

• To investigate the components of the internal background of the LaBr3:Ce crystal by
• Simulation of the ^{138}La and ^{227}Ac decay-chains within a 3x3" crystal

The Monte Carlo simulations will allow for the individual spectral components of the complex internal background to be studied.

Introduction

During the last decade a new scintillating material, LaBr$_3$:Ce, has been presented. LaBr$_3$:Ce offers a better energy resolution, a higher density and a shorter decay time of the scintillation pulse than the NaI(Tl). The drawback of LaBr$_3$:Ce is that it is internally contaminated with ^{138}La and ^{227}Ac. While the decay of ^{138}La to ^{138}Ce and ^{138}Ba (EC and β$^-$) generates β continua and some γ lines below 1.6 MeV, the decay series of ^{227}Ac through ^{227}Th down to ^{207}Pb mainly generate α decays showing up above 1.6 MeV (Fig. 1).
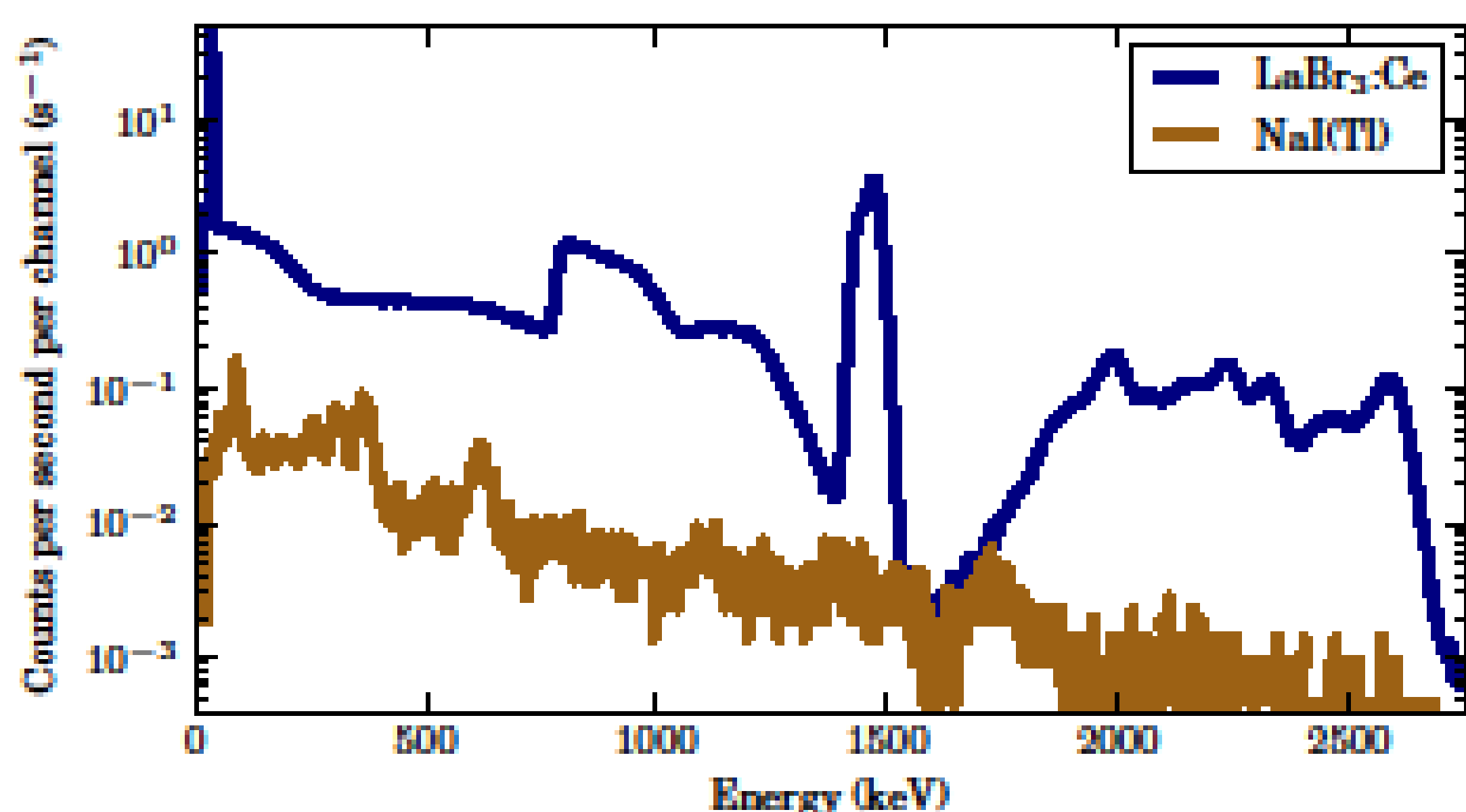

Figure 1. The internal background of a 3x3" LaBr$_3$:Ce crystal simulated in this study. The background of an equally sized NaI(Tl) included for reference.

Materials & methods

Using the GATE package for the GEANT4 Monte Carlo code a 3x3" LaBr$_3$:Ce was modelled. Utilizing the 'radioactive decay' module of GATE, the beta+gamma decay from ^{138}La was easily simulated. However, for the ^{227}Ac series decays, GATE was only used to simulate Compton profiles. Due to the complex alpha-decay response of the detector, known as quenching, a manual convolution of the individual alpha-peaks was needed. For this purpose a MATLAB script was written.

Results

The results of the GATE ^{138}La simulations can be seen in Fig. 2, while the MATLAB convolution of the alpha peaks using a gaussian kernel can be seen in Fig. 3. Both simulations are scaled to fit the measured count rate, presented in Fig 1. The ^{138}Ba x-ray + gamma peak around 1.5 MeV is well modelled by GATE, c.f. Fig 2, but some discrepancies between the model and measurement can also be seen in the beta-continua in the same figure. Fig. 3 presents the contribution from each alpha peak from the actinium series. In order to achieve better agreement between the model and measurement, a 'scatter' component was added to the model; one third of the peaks' intensities were removed from the full-energy peak and inserted at ¾ of the peak energy.

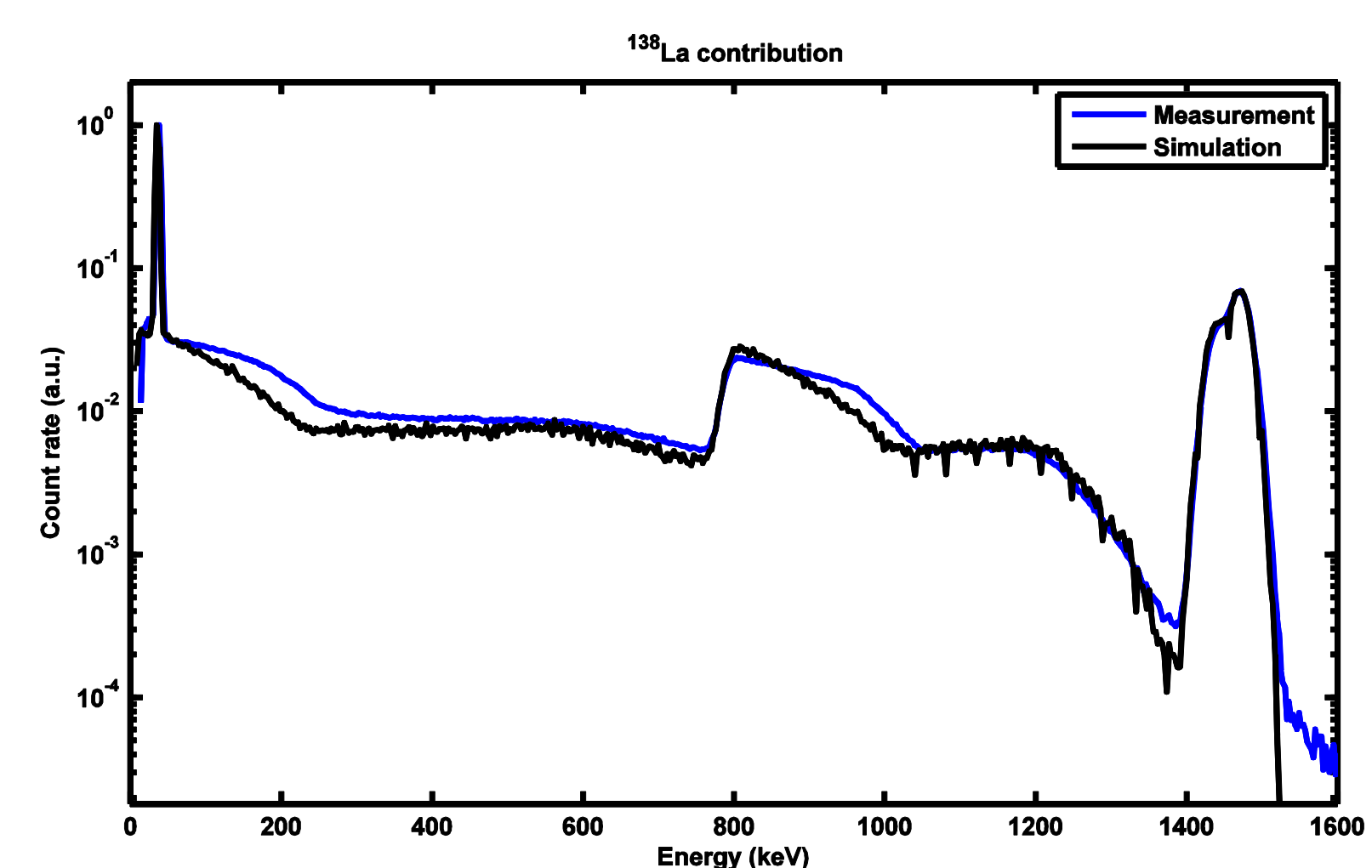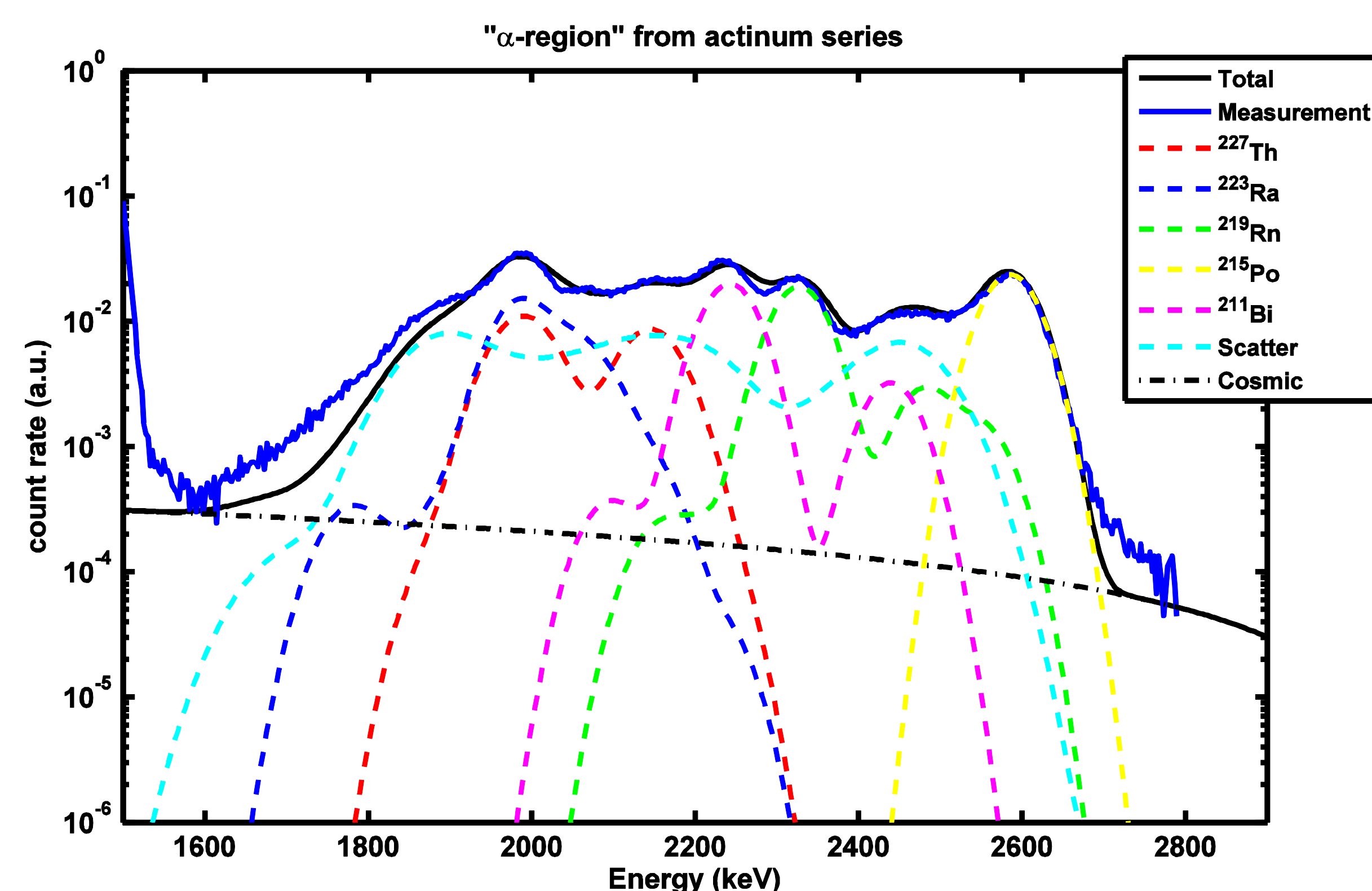**Figure 2.** The energy region below 1.6 MeV due to decays from ^{138}La and its daughters.

Figure 3. The alpha-region above 1.6 MeV due to the actinium series