ISOMER RATIOS FOR PRODUCTS OF PHOTONUCLEAR REACTIONS on ^{121}Sb

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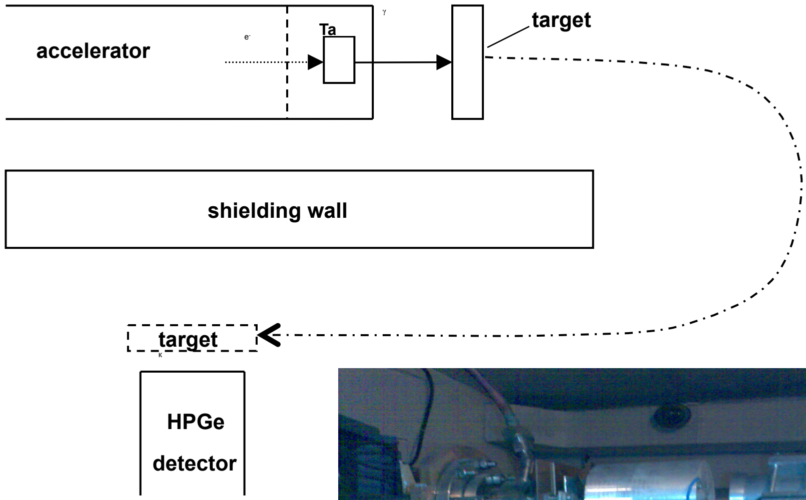
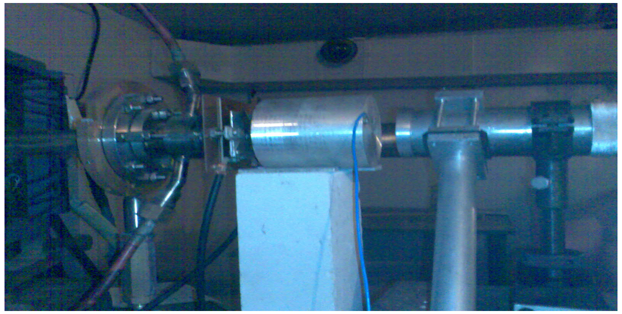
- Over several past years various preequilibrium models for the description of nuclear reactions were developed. Diversified detailed experimental data in the medium excitation energy region for nucleus are needed for reasonable selection among these theoretical models. Lack of experimental data in this energy region does essentially limit the possibilities for analysis and comparison of different preequilibrium theoretical models. To study photonuclear reactions the energy region of interest was covered with the bremsstrahlung within 30-100 MeV.
- Experimental measurements and estimations of isomer ratios for the products of photonuclear reactions with multiple particle escape on ^{121}Sb were performed using the bremsstrahlung source with energies 38, 43 and 53 MeV.
- Method of the activation technique was used. For acquisition of gamma spectra we used HPGe spectrometer with GC2019 detector.
- Linear accelerator of electrons of KIPT LU-40 was a source of bremsstrahlung. Energy resolution of electron beam was about 1% and mean current was within (3.8 – 5.3) μA.

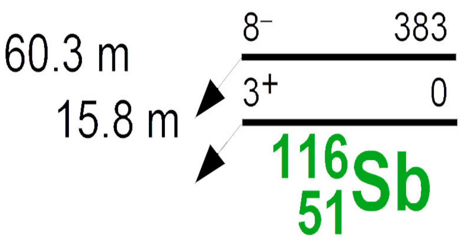
MEASUREMENT OF INDUCED ACTIVITY



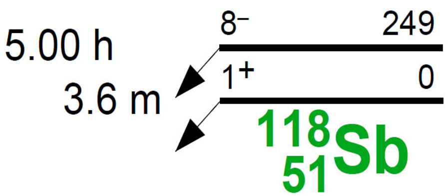


REACTIONS

$^{121}Sb(\gamma,5n)^{116m,g}Sb$



$^{121}Sb(\gamma,3n)^{118m,g}Sb$



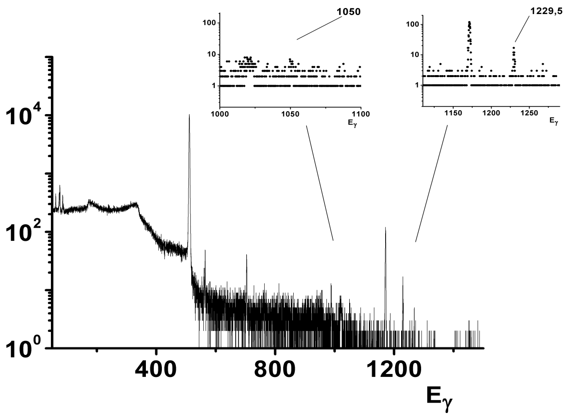
Reaction	E_{max} MeV	I_t	I_m	I_g	d
$^{121}Sb(\gamma,3n)^{118m,g}Sb$	38	5/2+	8-	1+	0.14 ± 0.04
	43	5/2+	8-	1+	0.15± 0.01
$^{121}Sb(\gamma,5n)^{116m,g}Sb$	53	5/2+	8-	3+	0.25 ± 0.03

EXPERIMENTAL HPGe GAMMA SPECTRA (examples)

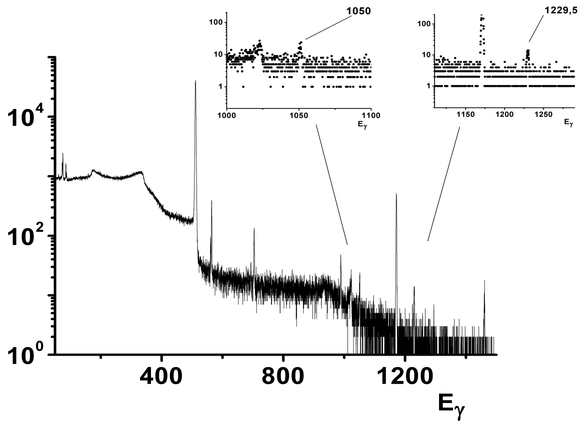
Gamma-ray spectra from the induced activities in the target enriched in antimony

Reaction $^{121}Sb(\gamma,3n)^{118m,g}Sb$

^{118g}Sb



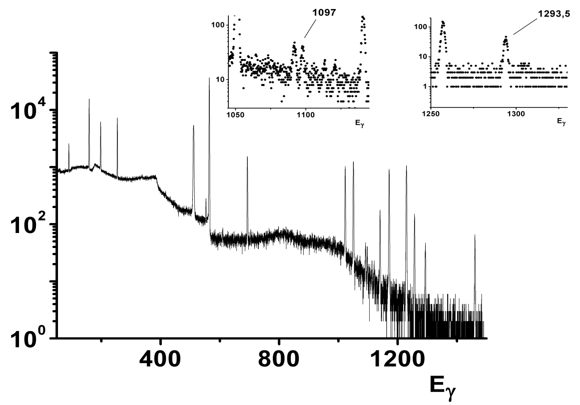
^{118m}Sb



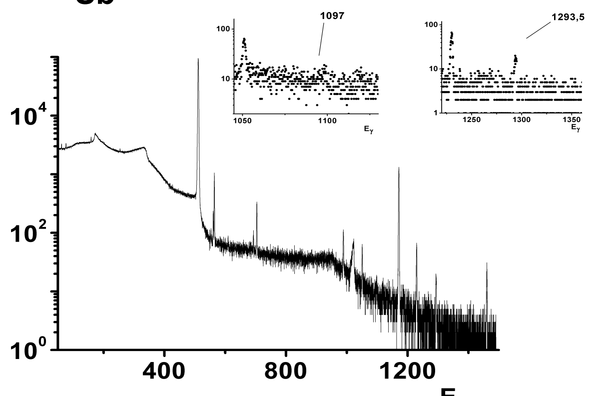
The gamma lines 1050 keV (EC+β+ decay of the isomer state) and 1229.5 keV (common line for decay of the ground and isomer states) were used to obtain the isomer ratio for **^{118m,g}Sb**.

Reaction $^{121}Sb(\gamma,5n)^{116m,g}Sb$

^{116g}Sb



^{116m}Sb



The gamma line 1293.5 keV (common line for EC+β+ decay of the ground and isomer states) were used to obtain the isomer ratio for **^{116m,g}Sb** and the gamma line 1097 keV (β- decay of the isomer state) were used to account contribution of **^{116m,g}In** (reaction $^{121}Sb(\gamma,n\alpha)^{116m,g}In$).

METHODOLOGY (CALCULATION METHODS)

Production of isomeric pairs and their decay are described by the following differential equation system:

$$\begin{cases} \dfrac{dN_m}{dt} = Y_m - \lambda_m \cdot N_m \\ \dfrac{dN_g}{dt} = Y_g - \lambda_g \cdot N_g + p \cdot \lambda_m \cdot N_m \end{cases}$$

where *Ni* –- population of i-state (i=m - isomer state, i=g – ground state), *Yi* – reaction yield, *λm*, *λg*– decay constants for isomer and ground state, *p* – branching factor (transition probability from isomer to ground state)

$$\begin{cases} \dfrac{S_m}{C_m \varepsilon_m f_m} = Y_m \Lambda_3 \Lambda_6 \Lambda_9 \\ \dfrac{S_g}{C_g \varepsilon_g f_g} = Y_g \Lambda_2 \Lambda_5 \Lambda_8 + \\ \qquad + Y_m (\Lambda_1 \Lambda_5 \Lambda_8 + \Lambda_3 \Lambda_4 \Lambda_8 + \Lambda_3 \Lambda_6 \Lambda_7) \end{cases}$$

where *Si*, i=g,m – photo-peak area (in the gamma spectrum of the activation products); C includes self-absorption factor, summation effects of cascade gammas and others, ε - efficiency of gamma ray detection for the analysed gamma-line; *fi*, i=g,m – quantum yield of gamma-line for i-state decay (transition probability for this line); coefficients *Λj*, *j*=1,9 are defined by *t1, t2, t3,* – irradiation time, cooling time and measurement time

Fitting results for experimental points (X, F) of ^{118m,g}Sb nuclei decay (^{121}Sb(γ,3n)^{118m,g}Sb nuclear reaction)

Solving the system results in:

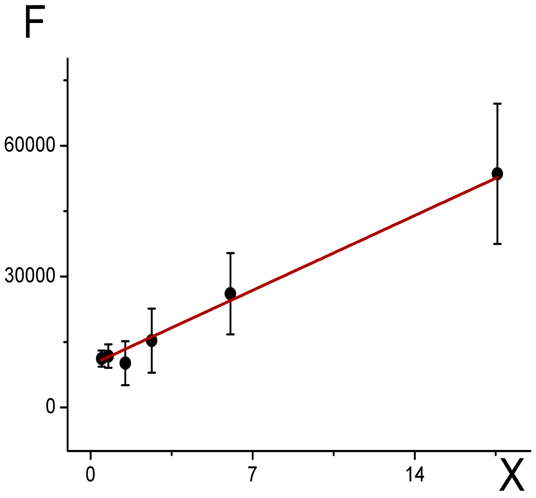
$$F = C(Y_m X + Y_g)$$

where F and X are defined as

$$F = \frac{S}{f_g \Lambda_2 \Lambda_5 \Lambda_8}$$

$$X = \frac{(\Lambda_1 \Lambda_5 \Lambda_8 + \Lambda_3 \Lambda_4 \Lambda_8 + \Lambda_3 \Lambda_6 \Lambda_7) + \dfrac{f_m}{f_g} \Lambda_3 \Lambda_6 \Lambda_9}{\Lambda_2 \Lambda_5 \Lambda_8}$$

with *S=Sg+Sm* peak area sum, *Ym,g= C·Y'm,g* - values, proportional to reaction yields



This method is very efficient for g,m-decays via the same level

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