XXII International Scientific Conference of Young Scientists and Specialists

Estimation of $^{238}U(\gamma,F)$ and $^{238}U(\gamma,n)$ reactions cross sections

Belyshev S.S.[1], Khankin V.V.[2], Kuznetsov A.A.[1,2], Popova M.M.[1]

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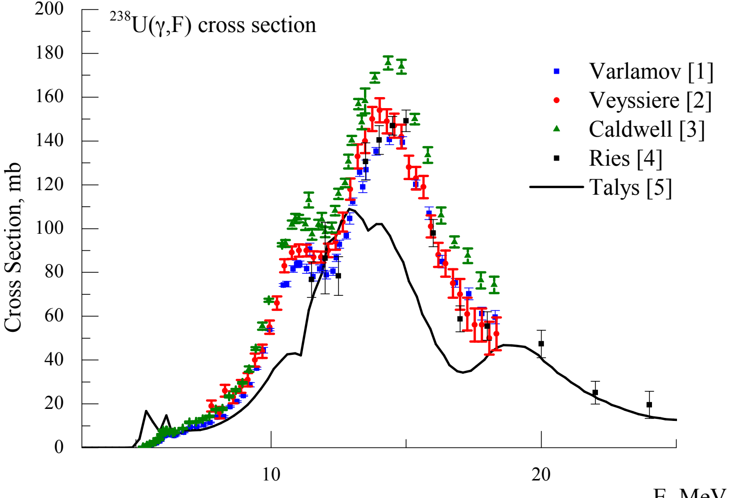
[1] Lomonosov Moskow State University, Faculty of Physics, Russia, Moskow
[2] Skobeltsyn Institute of Nuclear Physics, Russia, Moskow

Our goal



[1] Varlamov V. V., Peskov N. N. Preprint MSU SINP 2007-8/829 Moscow (2007)
[2] A. Veyssiere, H. Beil, R. Bergere, P. Carlos, A. Lepretre, K. Kernbath, Nucl.Phys. 199:45 (1973)
[3] Caldwell JT, Dowdy EJ, Bcrman BL, Alvarez RA, Meyer P (1980), Phys. Rev. C 21:1215 (1980)
[4] H.Ries,G.Mank,J.Drexler,etal.,Phys.Rev.C 29:2346 (1984)
[5] Duijvestijn M.C. Konig A.J., Hilaire S. Proceedings of the international conference on nuclear data for science and technology. april, 22–27, 2007. page 211. EDP Sciences.

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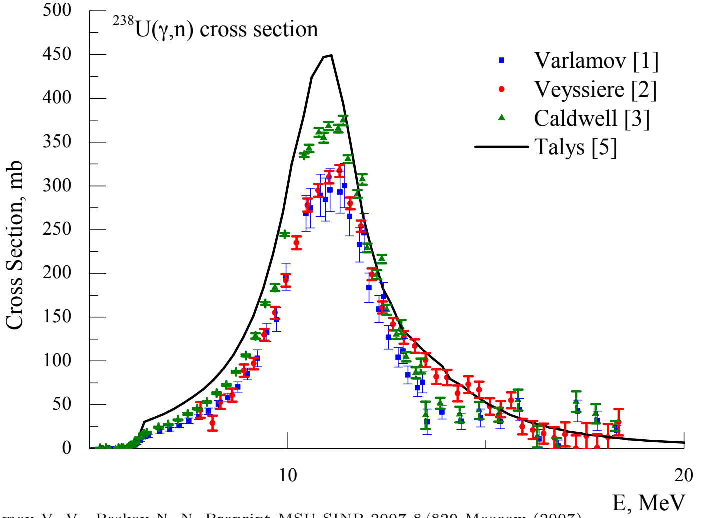

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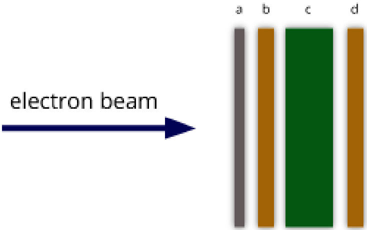
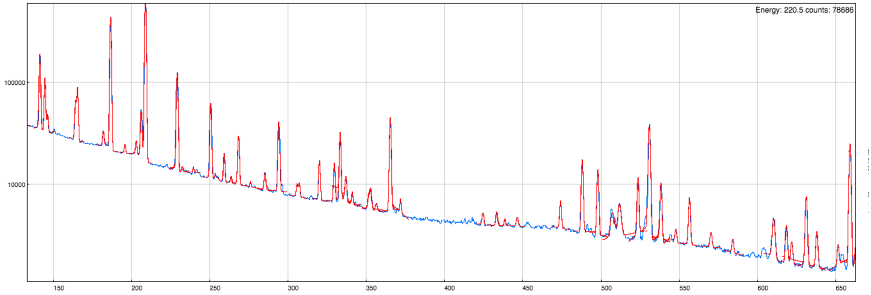
Irradiation and measurement parametra

- Electron beam 55.6 MeV
- Geometry of irradiation
  - Bremsstrahlung target (a) 0.2 mm
  - Copper monitor 1 (b) of surface density 0.0967±0.0012 g/sm^2
  - Uranium oxide powder into a container (c) made of a 25x25 mm aluminium frame 1.88 mm thick with a 14.90 mm hole diameter. The lid of the container was made of 0.2 mm aluminium foil. The weight of the empty container is 2.7046 g. The mass of the oxide powder is 0.613 g (excluding the mass of glue). The mass of uranium, estimated from its activity before irradiation is 0.458 g.
  - Copper monitor 2 (d) of surface density 0.0980±0.0013 g/sm^2
- Germanium detector GC3019



Gamma-activation technique



$$S = k \int_{t_2 - t_1}^{t_3 - t_2} \lambda N(t) \frac{t_{live}}{t_{real}} dt \qquad Y = \alpha\eta \int_{E_{thr}}^{E_e} \phi(E_\gamma, E_e)\sigma(E_\gamma) dE_\gamma$$

One channel:

$$\frac{dN_1}{dt} = -\lambda_1 N_1 + I(t) Y_1$$

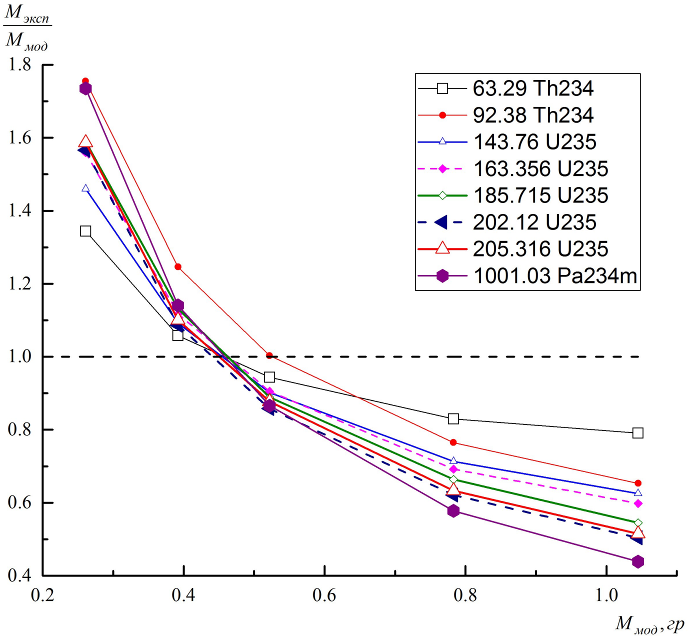
Two channels:

$$\begin{cases} \dfrac{dN_1}{dt} = -\lambda_1 N +_1 I(t) Y_1 \\[2ex] \dfrac{dN_2}{dt} = -\lambda_2 N_2 + \lambda_1 N_1 + I(t) Y_2 \end{cases}$$

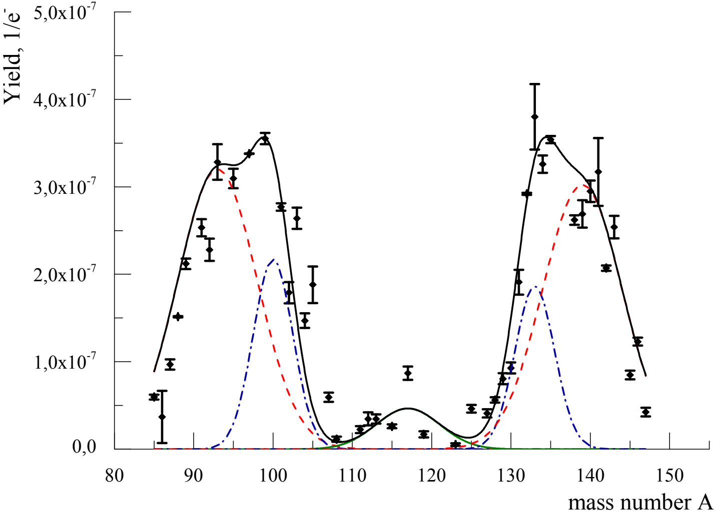
$N_{1,2}$ – number of radioactive nuclei, $\lambda_{1,2}$ – decay constants, $Y_{1,2}$ – reaction yields, I(t) – accelerator current. Copper monitor was used to determine the absolute value of the measured current.

$$Y_1 = \frac{N_{10}}{e^{-\lambda t_1} \int\limits_0^{t_1} I(t) e^{\lambda t} dt}, \quad Y_2 = \frac{N_{20}}{e^{-\lambda_2 t_1} \int\limits_0^{t_1} I(t) e^{\lambda_2 t} dt} - \frac{\lambda_1 N_{10} \int\limits_0^{t_1} e^{(\lambda_2 - \lambda_1)\tau} \int\limits_0^{\tau} I(\tau) e^{\lambda_1 \tau} d\tau dt}{\int\limits_0^{t_1} I(t) e^{\lambda_2 t} dt \int\limits_0^{t_1} I(t) e^{\lambda_1 t} dt}$$

Uranium mass and Detector efficiency estimation



The results: ^{238}U fission mass distribution at the mean excitation energy 15.75 MeV



The results: ^{238}U(γ,F) and ^{238}U(γ,n) reactions yields

Yields: experimental and calculated with TALYS and available absolute experimental values for $\sigma(^{238}$U(γ,F)) and $\sigma(^{238}$U(γ,n)) [quasimonoenergetic photons, neutron detection]

	Y_{exp}, $1/e^-$	Y, $1/e^-$ [1]	Y, $1/e^-$ [2]	Y, $1/e^-$, [3]	Y_{TALYS}, $1/e^-$
^{238}U(γ,n)	$(7.9 \pm 0.1) \cdot 10^{-6}$	$1.3 \cdot 10^{-5}$	$1.4 \cdot 10^{-5}$	$1.6 \cdot 10^{-5}$	$2.0 \cdot 10^{-5}$
^{238}U(γ,f)	$(5.4 \pm 0.2) \cdot 10^{-6}$	$8.5 \cdot 10^{-6}$	$8.8 \cdot 10^{-6}$	$1.1 \cdot 10^{-5}$	$8.4 \cdot 10^{-6}$
(γ,f)/(γ,n)	$(0.68 \pm 0.03) \cdot 10^{-6}$	0.65	0.65	0.63	0.41

Available absolute experimental values for $\bar{\sigma}(^{238}U(\gamma,n)) = \frac{\Sigma\phi\sigma}{\Sigma\phi}$, ϕ – photon flux [gamma activation technique]

E, MeV	[5], mb	[3], mb	TALYS, mb
8	10.6	16.8	23.3
10	49.0	48.4	83.9

Y(^{238}U(γ,F)) with cross section from [6] [quasimonoenergetic photons, fission fragment detection]

Energy range, MeV	Y, $1/e^-$
0-30 (extrapolated)	$9.13 \cdot 10^{-6}$
11.5-30 (experimental range)	$7.13 \cdot 10^{-6}$
0-18 (extrapolated)	$7.78 \cdot 10^{-6}$

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[5] H. Naik et al. J. Radioanal Nucl. Chem. 298:1065 (2013)
[6] H.Ries,G.Mank,J.Drexler,etal.,Phys.Rev.C 29:2346 (1984)

Thank you for your attention!