

Application of photonuclear reactions for identification of illicit fissile materials

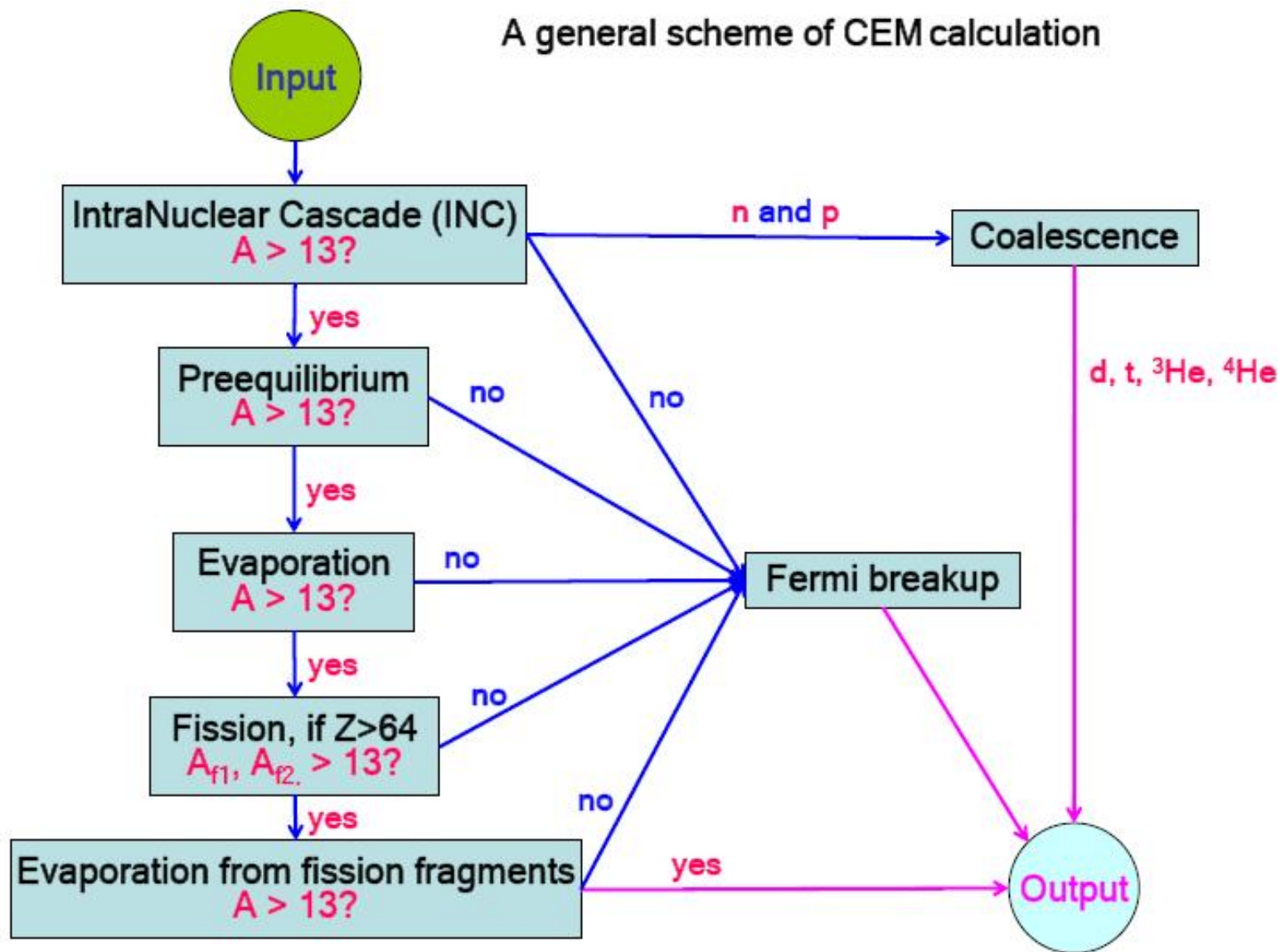
M. I. Baznat, K. K. Gudima,
Institute of Applied Physics, Academy of Science of
Moldova,
Chişinău, Moldova

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One of methods of identification of fissible materials, which may be the object of illicit trafficking, can be based on the use of new generation of electron accelerators. In a system with electron accelerators, there is a heavy metal (W, Ta, U) converter target to convert the electrons to gamma rays and then gamma rays to neutrons. The generated gamma rays and neutrons produced in (γ, xn) reactions would be used to initiate fission reactions, which are accompanied by emission of fast neutrons and by wide mass spectrum of fission fragments. The nuclear interactions of the produced neutrons (thermal (n, γ) capture process or inelastic neutron scattering $(n, n' \gamma)$) on various nuclides provide relatively strong γ -ray signatures of present elements. The additional information of the presence of fissible materials are provided by delayed neutrons emitted from fission fragments. On the basis developed Cascade Exciton Model (CEM) [1] extended to describe the photonuclear reactions [2] we propose the code, which is planning to include into transport code SHIELD[3] to resolve such problems.

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A general scheme of CEM calculation



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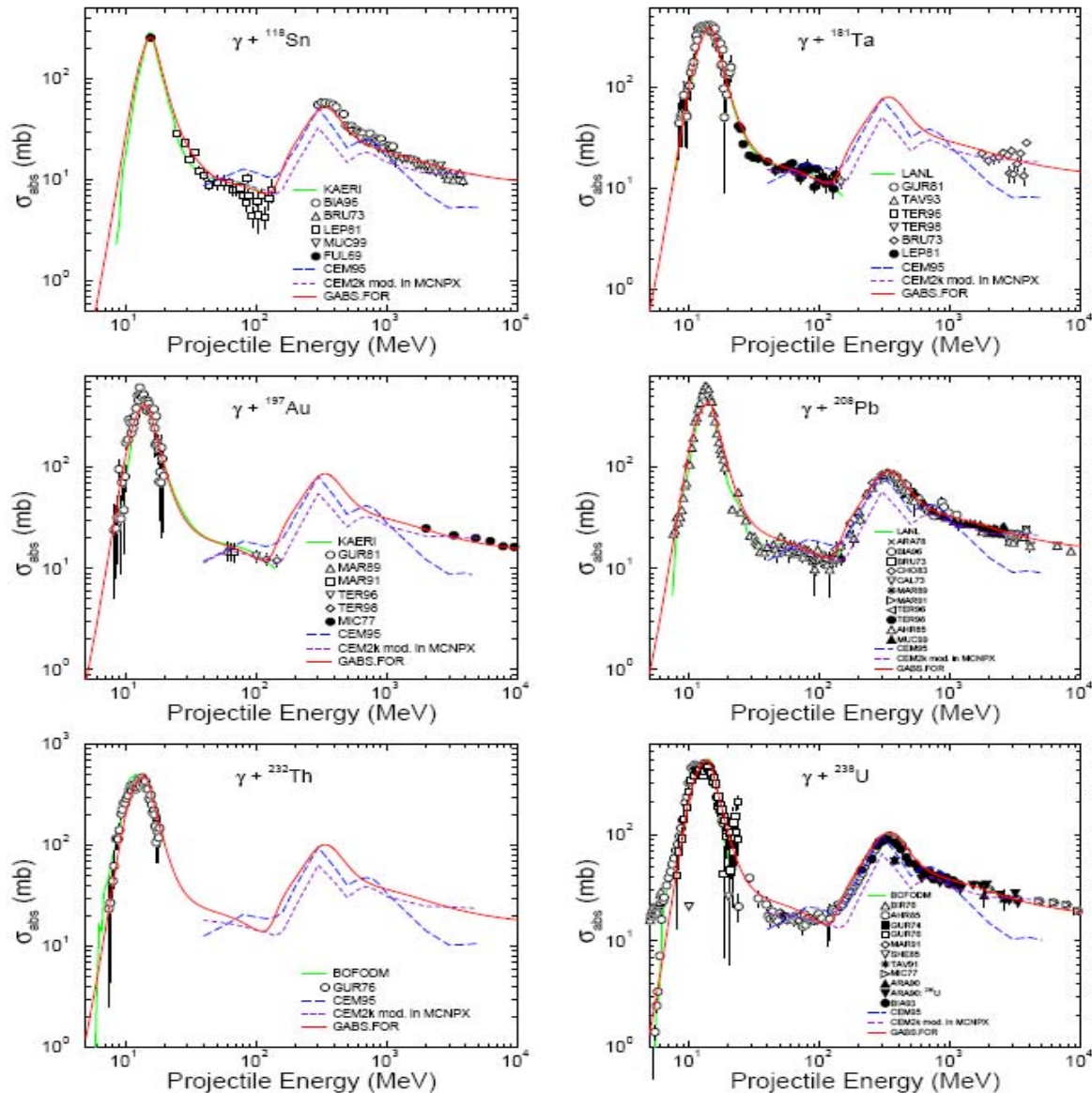


Fig.2.Examples of total photoabsorbtion cross sections for as function of photon energy. The thick solid red lines are our results.

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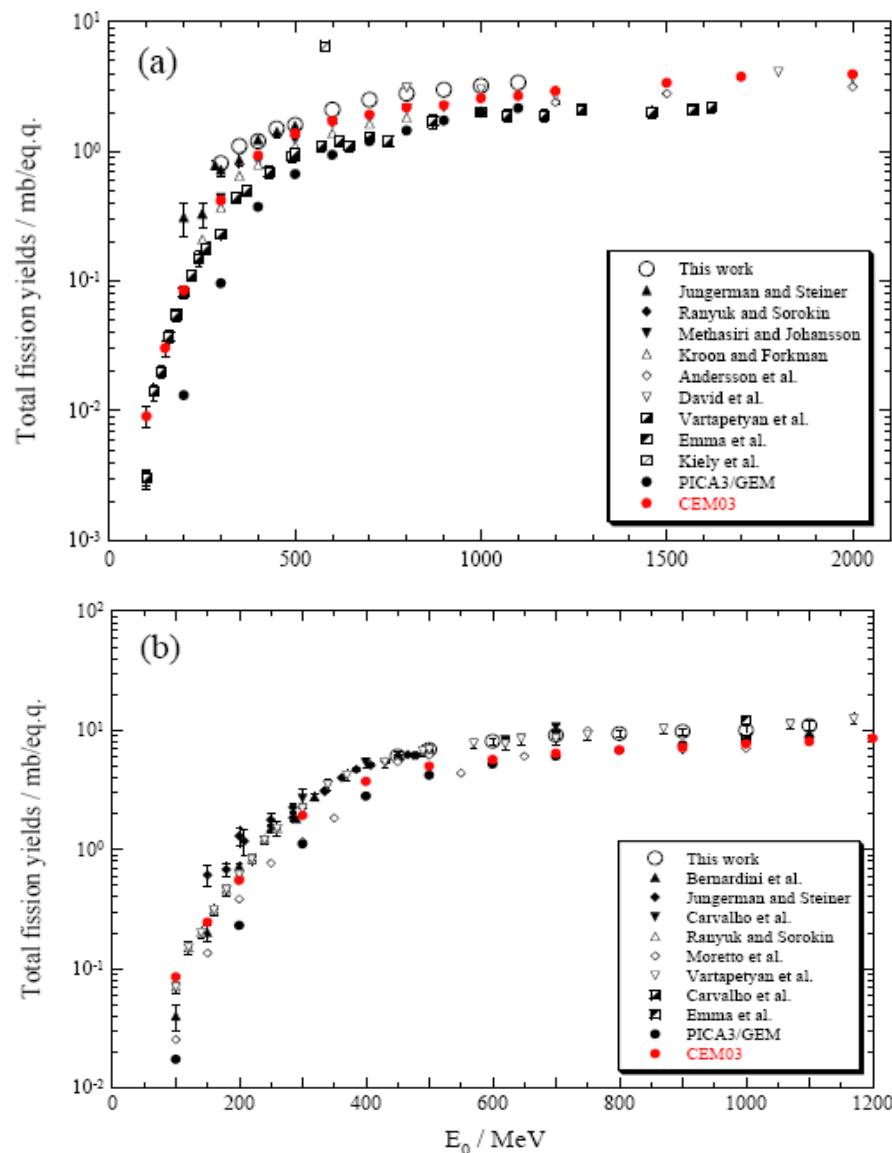


Fig.3. Bremsstrahlung-induced fission cross sections of ^{197}Au (a) and ^{209}Bi (b) as functions of the end-point energy E_0 . The CEM03 results are shown as solid red circles.

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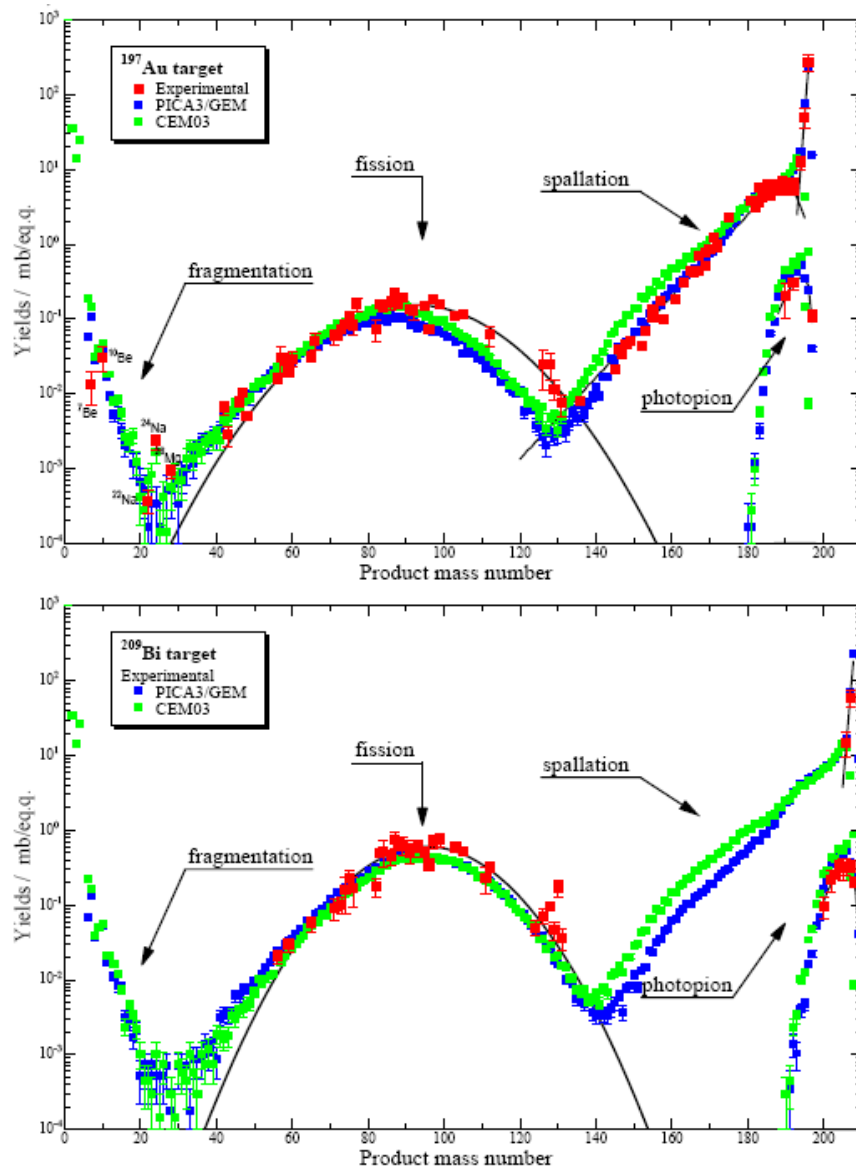


Fig. 4. Comparison of CEM03 results (green symbols) for the isotopic yields of products from bremsstrahlung reactions on ^{197}Au and ^{209}Bi at $E_0 = 1$ GeV with experimental data (red symbols) from the review [6] and calculations by PICA3/GEM (blue symbols);

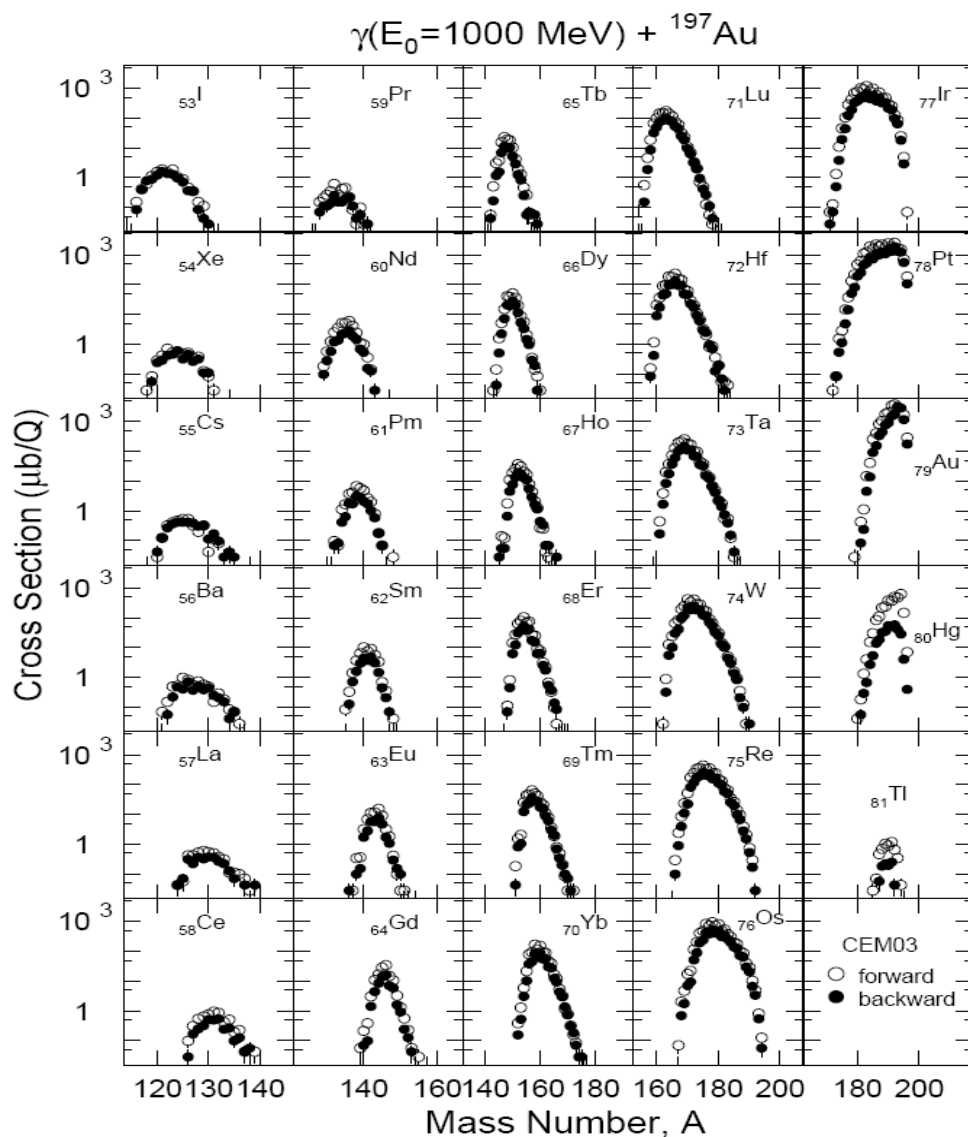


Fig. 5. Predicted cross sections of the spallation products from $E_0 = 1 \text{ GeV}$ bremsstrahlung photon-induced reaction on Au. Open circles show the yield of the products produced in the forward direction in the laboratory system, while the black circles show results for backward products.

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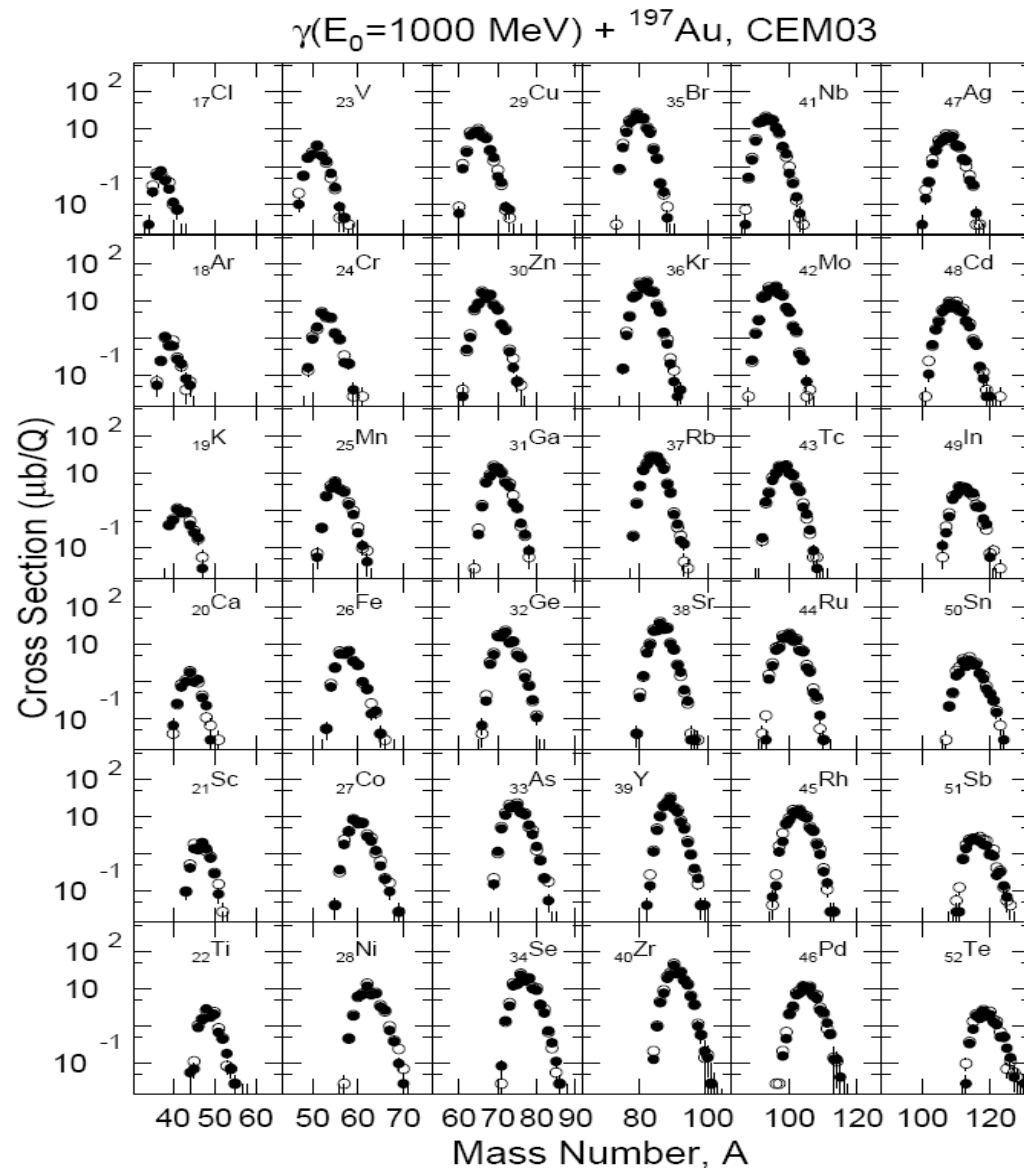


Fig. 6. The same as figure 5, but for fission and fragmentation products.

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$$\gamma(E_{\max}=100 \text{ MeV}) + {}^{137}\text{Cs}$$

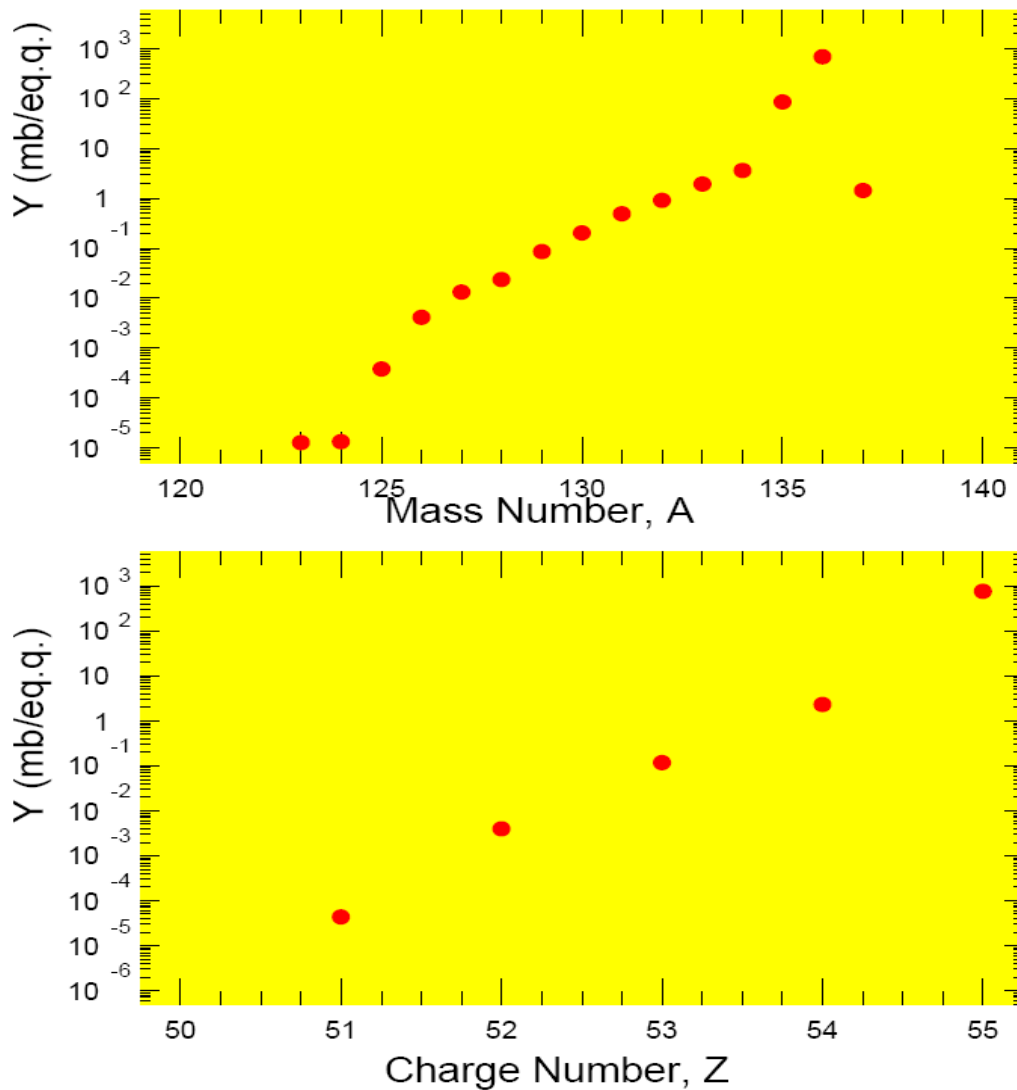


Fig. 7. Predicted cross sections of the spallation products from $E_0 = 100$ MeV bremsstrahlung photon-induced reaction on ${}^{137}\text{Cs}$:

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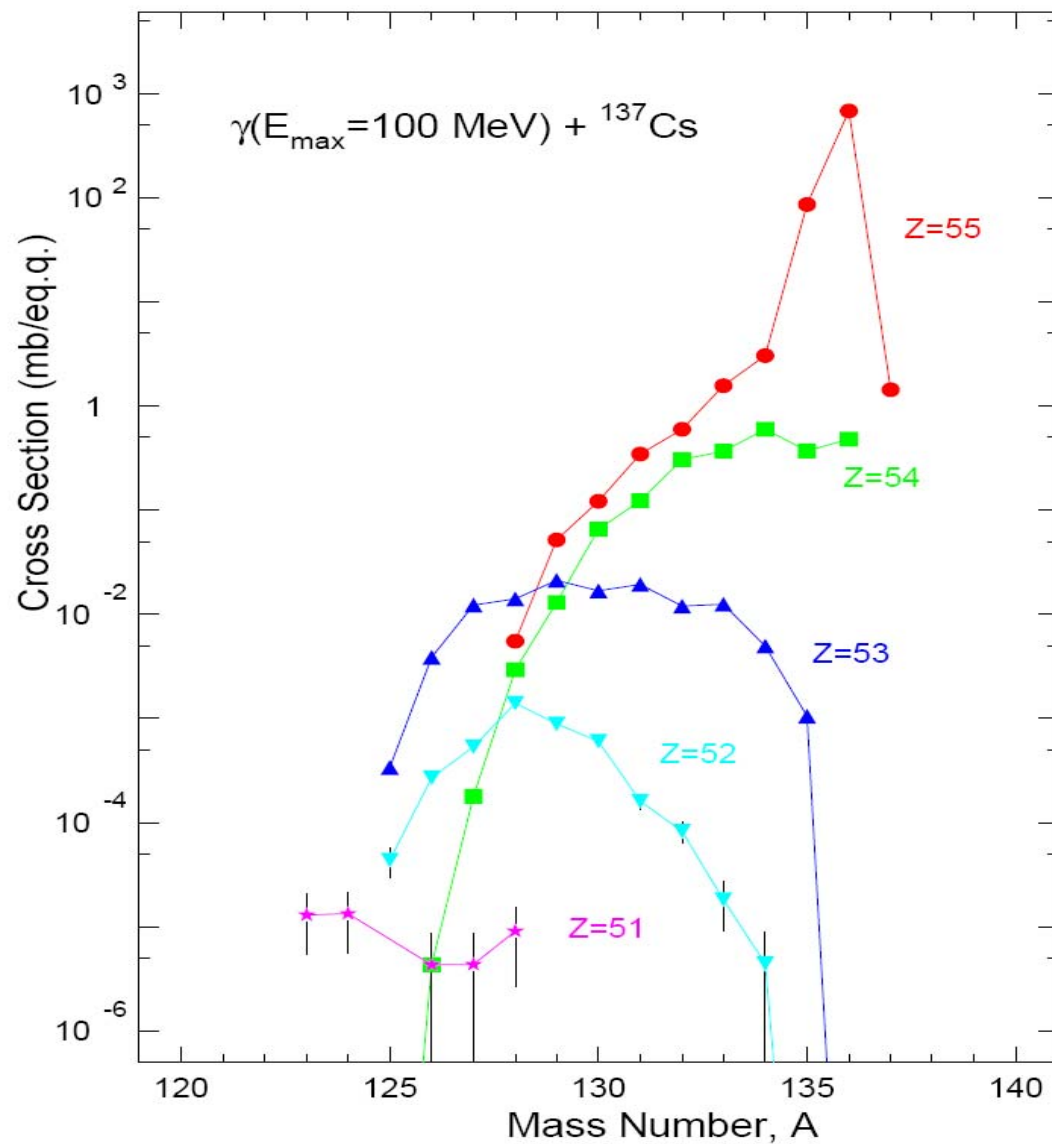


Fig. 8. The same as figure 7, but for individual isotopes

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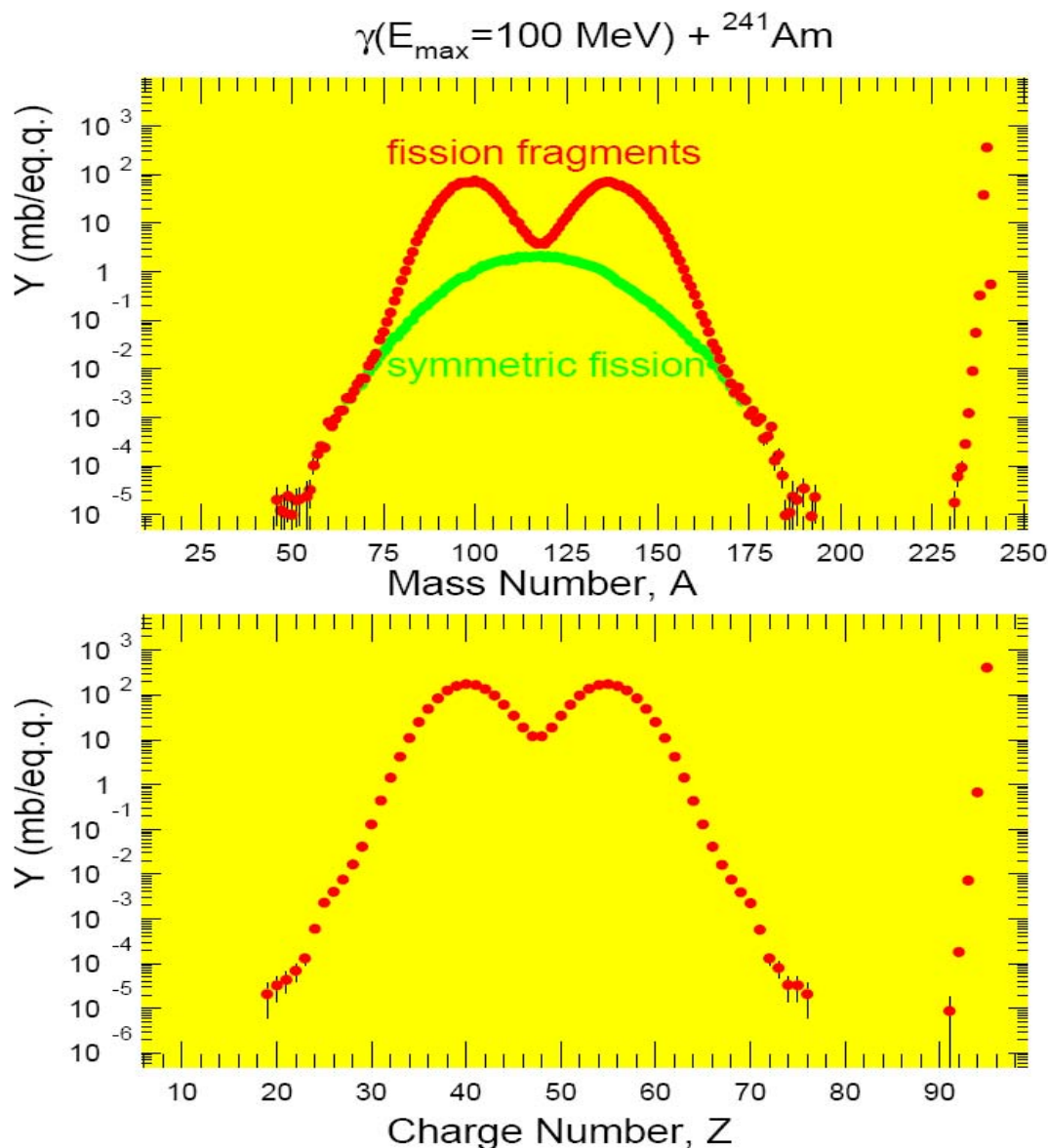


Fig. 9. Predicted cross sections of the spallation products (right points) and of fission fragments from $E_0 = 100 \text{ MeV}$ bremsstrahlung photon-induced reaction on ${}^{241}\text{Am}$

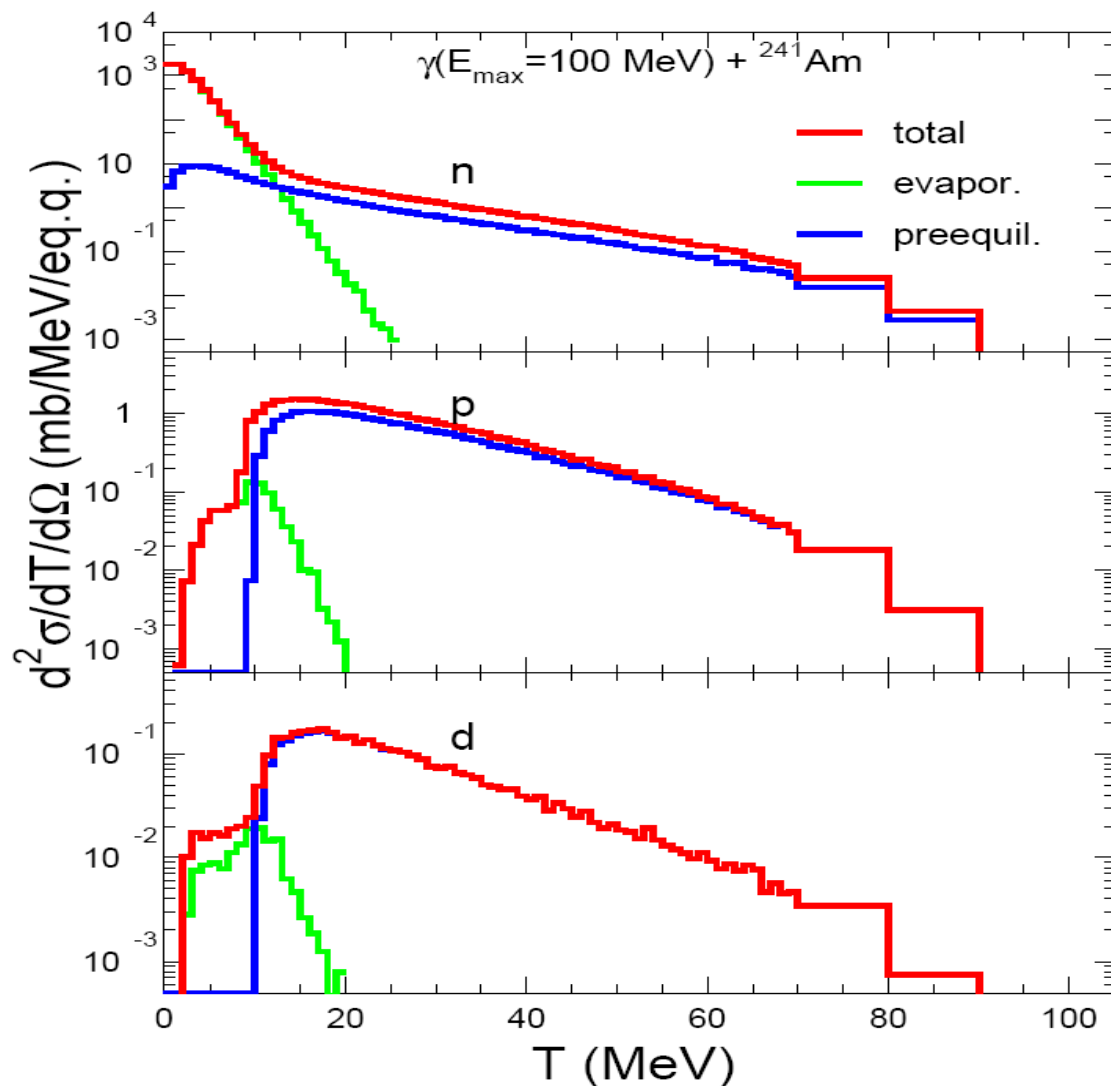


Fig. 10. Predicted angle integrated energy spectra of neutrons, protons and deuterons from $E_0 = 100$ MeV bremsstrahlung photon-induced reaction on ^{241}Am .

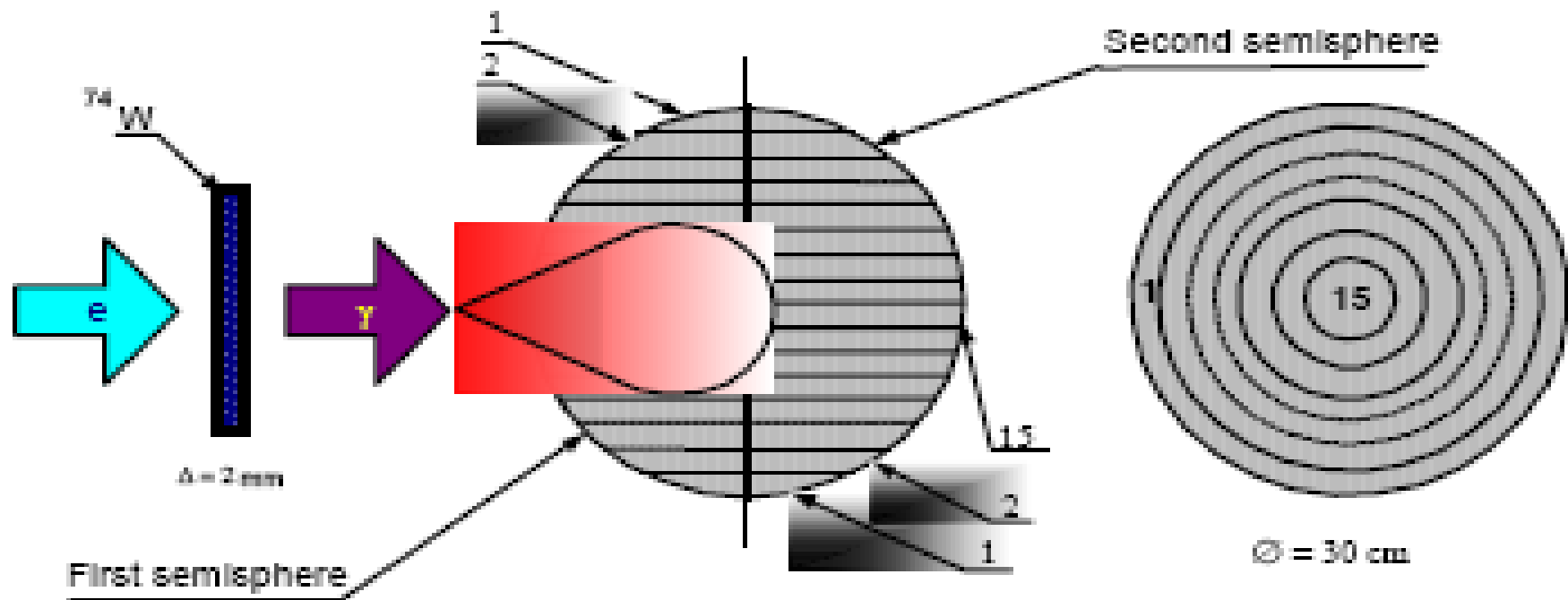


Fig. 11. The geometry of experiment on the direct photo-transmutation [4].

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References

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