Neutron Detection by Large NaI Crystal

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In present days new neutron detection methods are under development due to the global shortage of ^3He and the toxicity of BF_3.

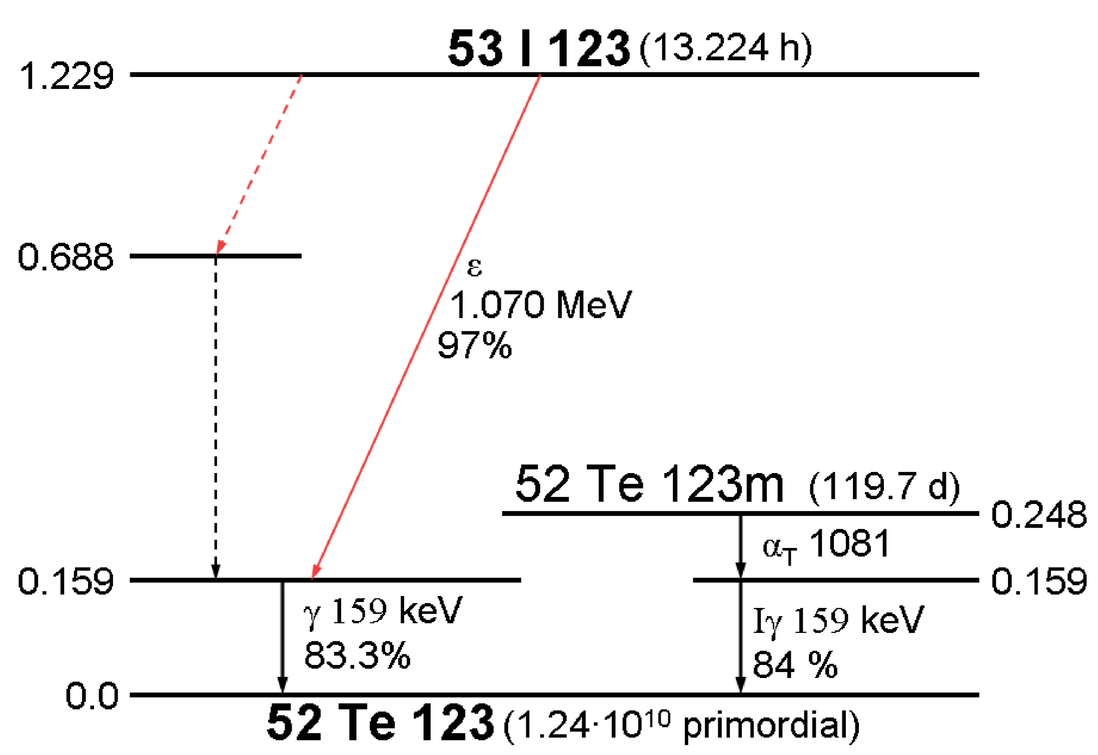
Neutrons can be indirectly detected by high-energy photons. The performance of a cylindrical NaI crystal, 4" diameter and 8" length as indirect neutron detector have been investigated. Measurements were performed with ^{252}Cf source with bare and shielded NaI detector. With a proper converter and moderator structure for the NaI detector, the detection efficiencies and the minimum detectable activities are improved, making the method very interesting for security applications. The indirect detection of neutrons by photons has several advantages. First, this method can in principle be suited by any gamma spectrometer with only slight modications that do not compromise its gamma spectrometry measurements. Second, fission neutron sources and neutron generators can be discriminated thanks to their different gamma energy spectra, a discrimination easily done by NaI spectrometer.

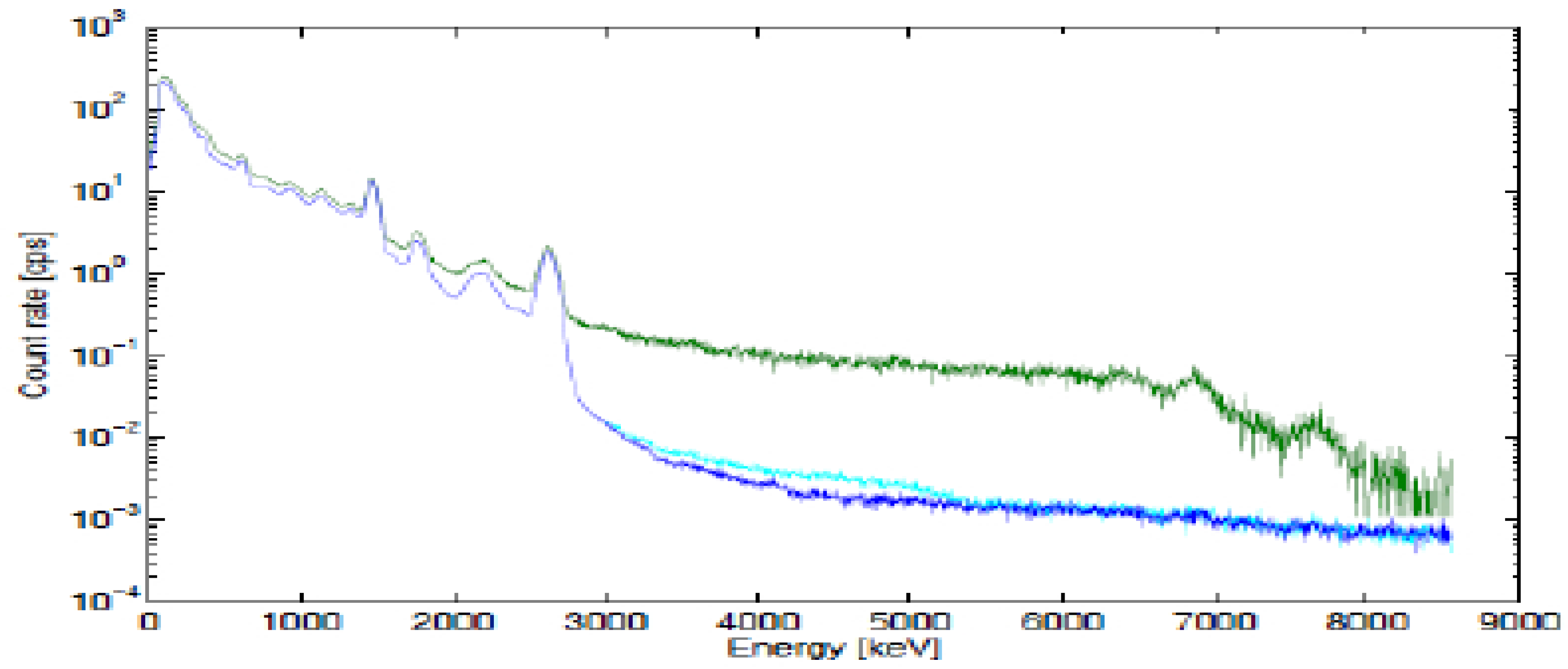
$$^{127}I + n \longrightarrow \overset{T_{1/2}=25\ \mathrm{min}}{^{128}I + \gamma} \xrightarrow{\beta^-} {^{128}Xe}(93.1\%)$$

$$^{128}I \xrightarrow{EC+\beta^+} {^{128}Te}(6.9\%)$$

$$^{23}Na + n \longrightarrow \overset{T_{1/2}=15\ \mathrm{h}}{^{24}Na + \gamma} \xrightarrow{\beta^-} {^{24}Mg}$$

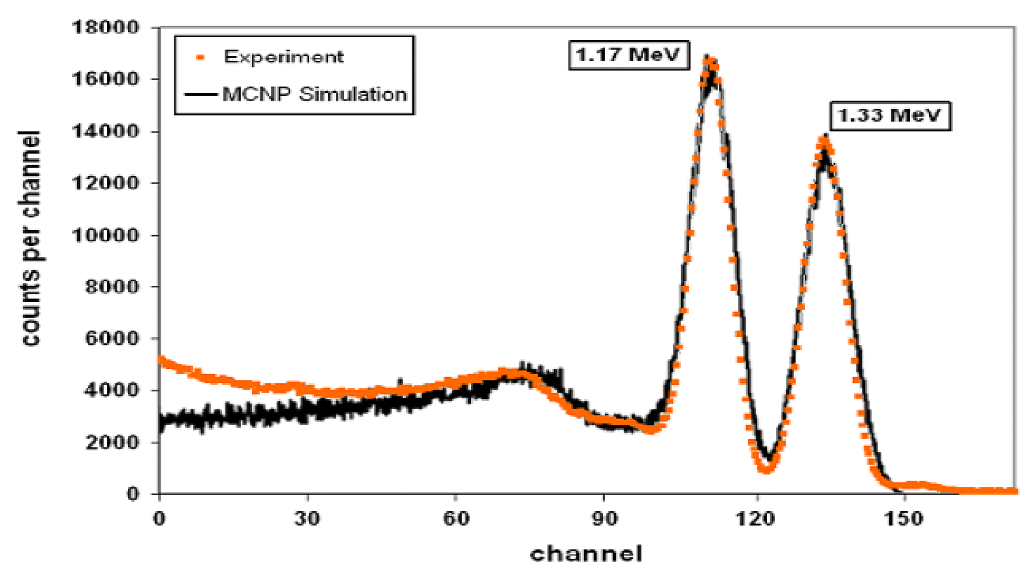
Main neutron induced reactions inside NaI crystal and, under, the decay mode of ^{123}I



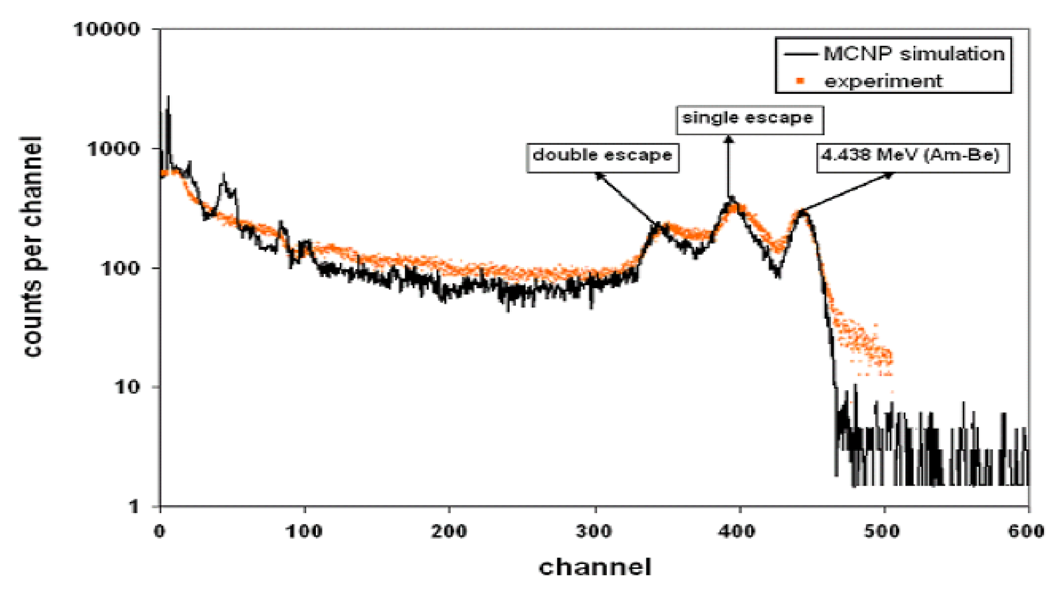


Gamma detection taken with a NaI cylinder 4" diameter, 8" length. The green line shows the for ^{252}Cf spectra, the dark blue line shows the background, the light blue line shows the same background measurement taken after the neutron source measurement: the increasing counting rate from around 2.0 up to 5 MeV in the background indicates that the NaI crystal was slightly activated by the neutron flux.

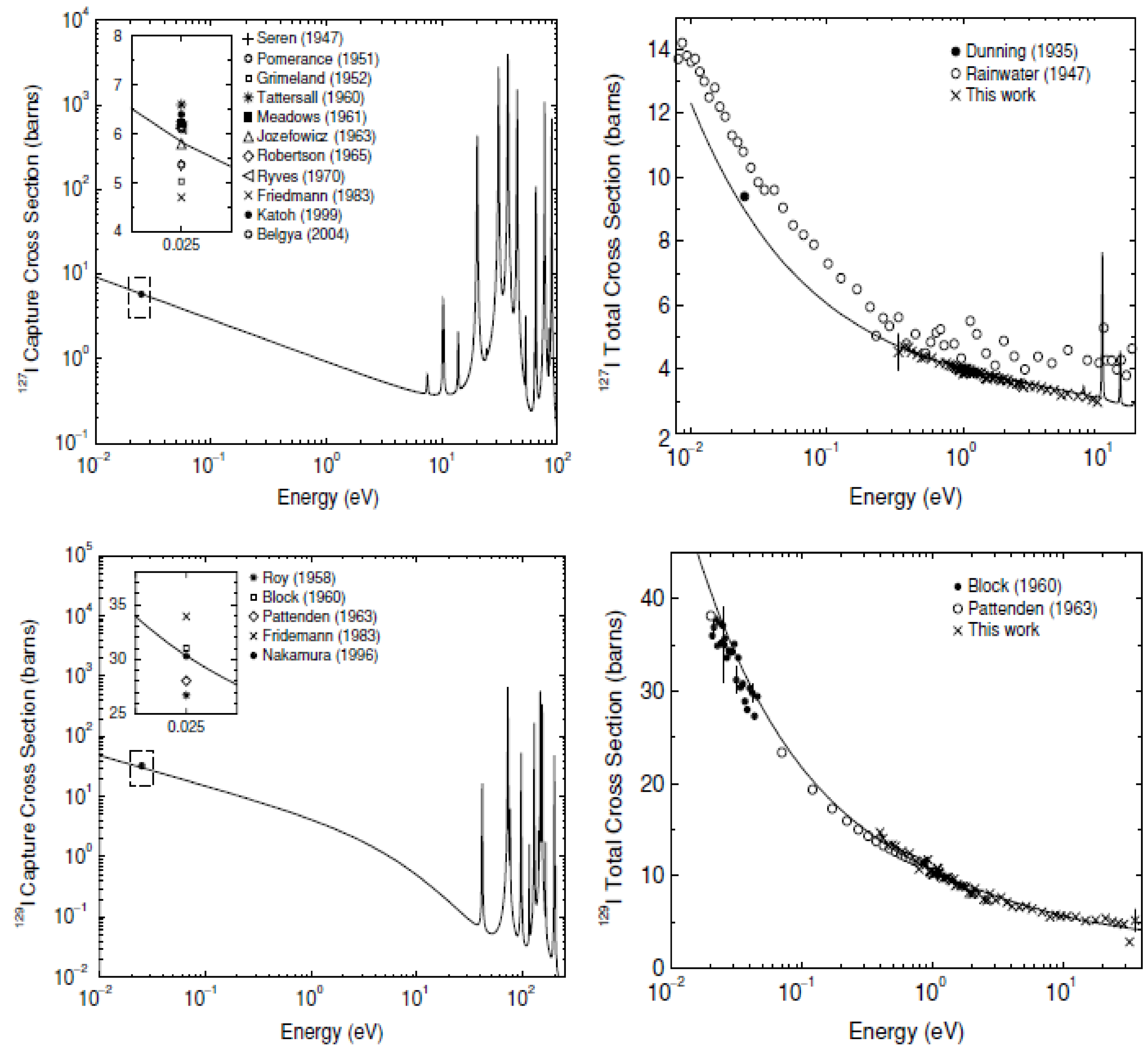
Crystal calibration



Comparison between simulation and experimental gamma-ray spectrum of ^{60}Co source



Comparison between simulation and gamma spectrum from ^{241}Am-Be neutron source



Solid curves represent the Reich-Moore description of the low energy neutron range of the ^{127,129}I capture and total cross section (from G. Noguere et al PRC 74,054602(2006))