# A general Monte Carlo based model for calibration of the HPGe detector "Detective EX 100"

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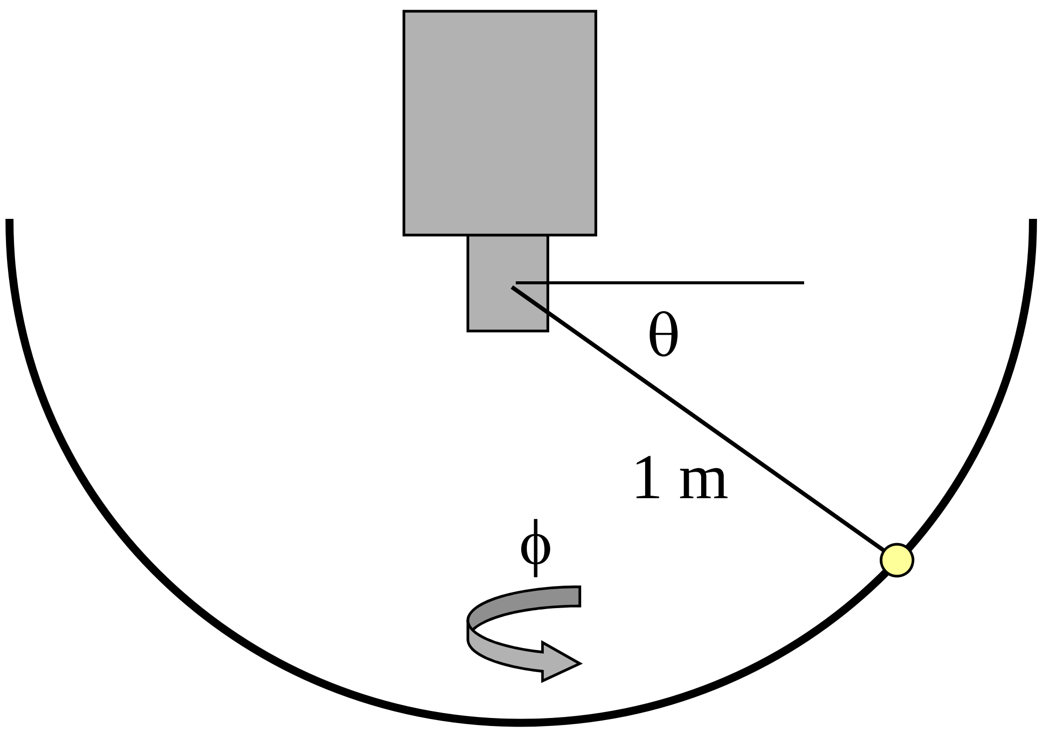
# Objective

- The aim of this work was to create a general method for *in situ* calibration of the HPGe detector Ortec Detective EX 100 based both on measurements and on simulations with the general purpose Monte Carlo model MNCP5.

# Materials and Methods

# Measurements

A device was built that allowed for measurements at different inclination (0-180 degrees) and azimuth (0-360 degrees) angles

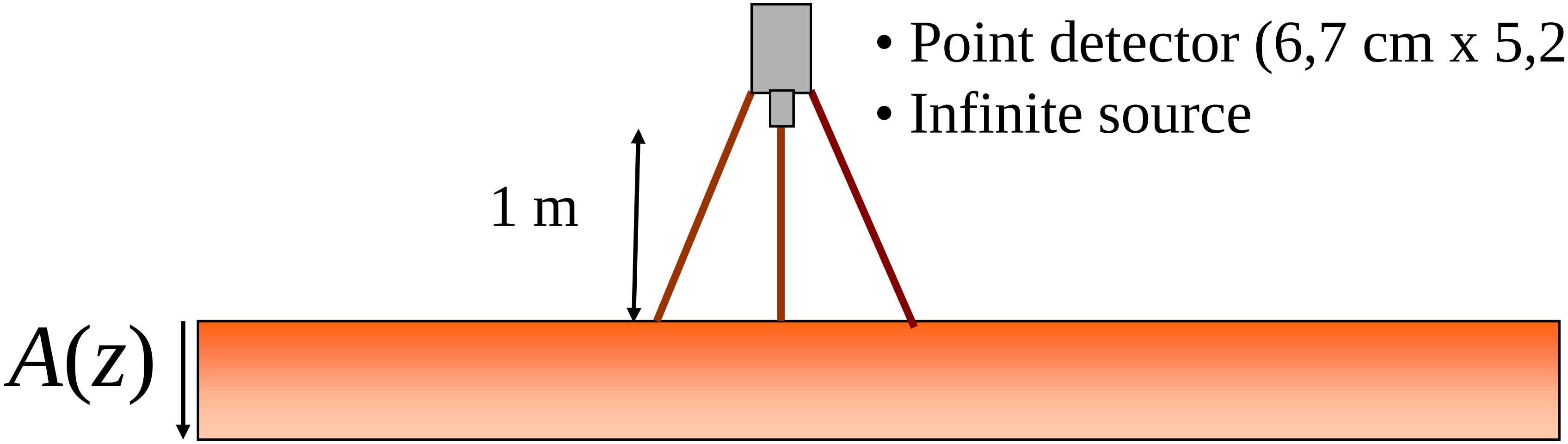


Radionuclides:

| | |
|---|---|
| $^{241}Am$ | 60 keV |
| $^{57}Co$ | 122 keV |
| $^{137}Cs$ | 662 keV |
| $^{60}Co$ | 1173 keV |
| | 1333 keV |

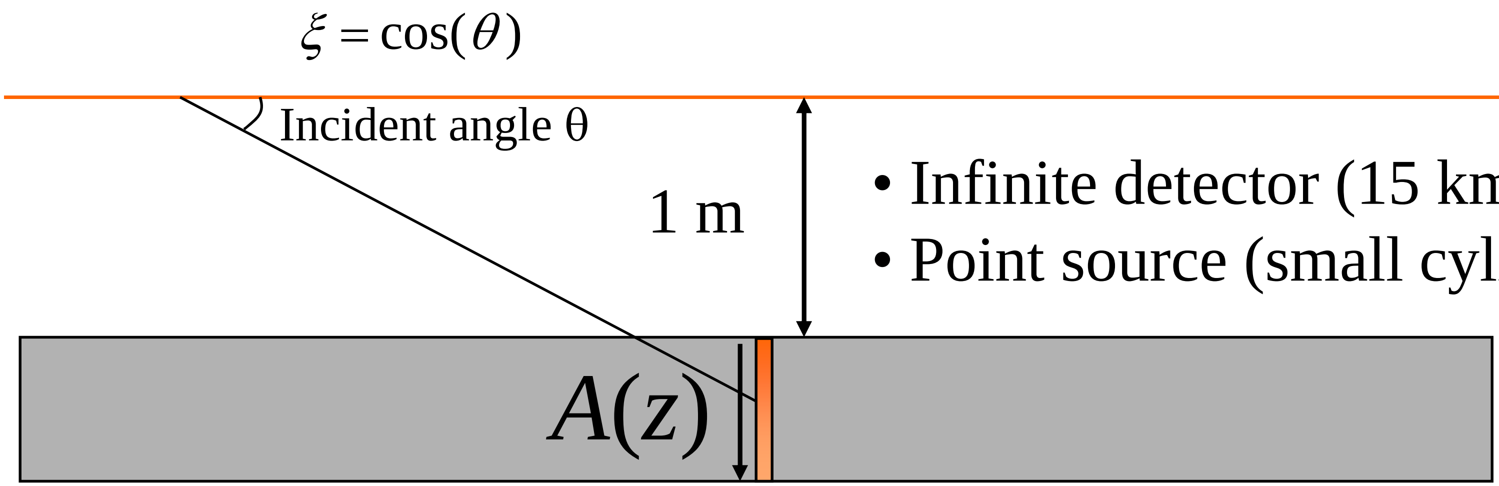
15 minutes
1% uncertainty

# Monte Carlo geometry




- Point detector (6,7 cm x 5,2 cm)
- Infinite source

# Monte Carlo geometry




- Infinite detector (15 km)
- Point source (small cylinder)

Surface distribution (point source)

Homogeneous distribution (top 3 dm layer)

Exponential distribution

Kastlander and Bargholtz 2005

Lemercier *et al* 2007

# Mathematical relation to calculate calibration factor

$$k(E) = \left[ 2\pi \int_0^{\infty} \frac{1}{\xi} \, \varepsilon(E,\xi) \, \eta(E,\xi) \, d\xi \right]^{-1}$$

Correction for different solid angles in the two geometries

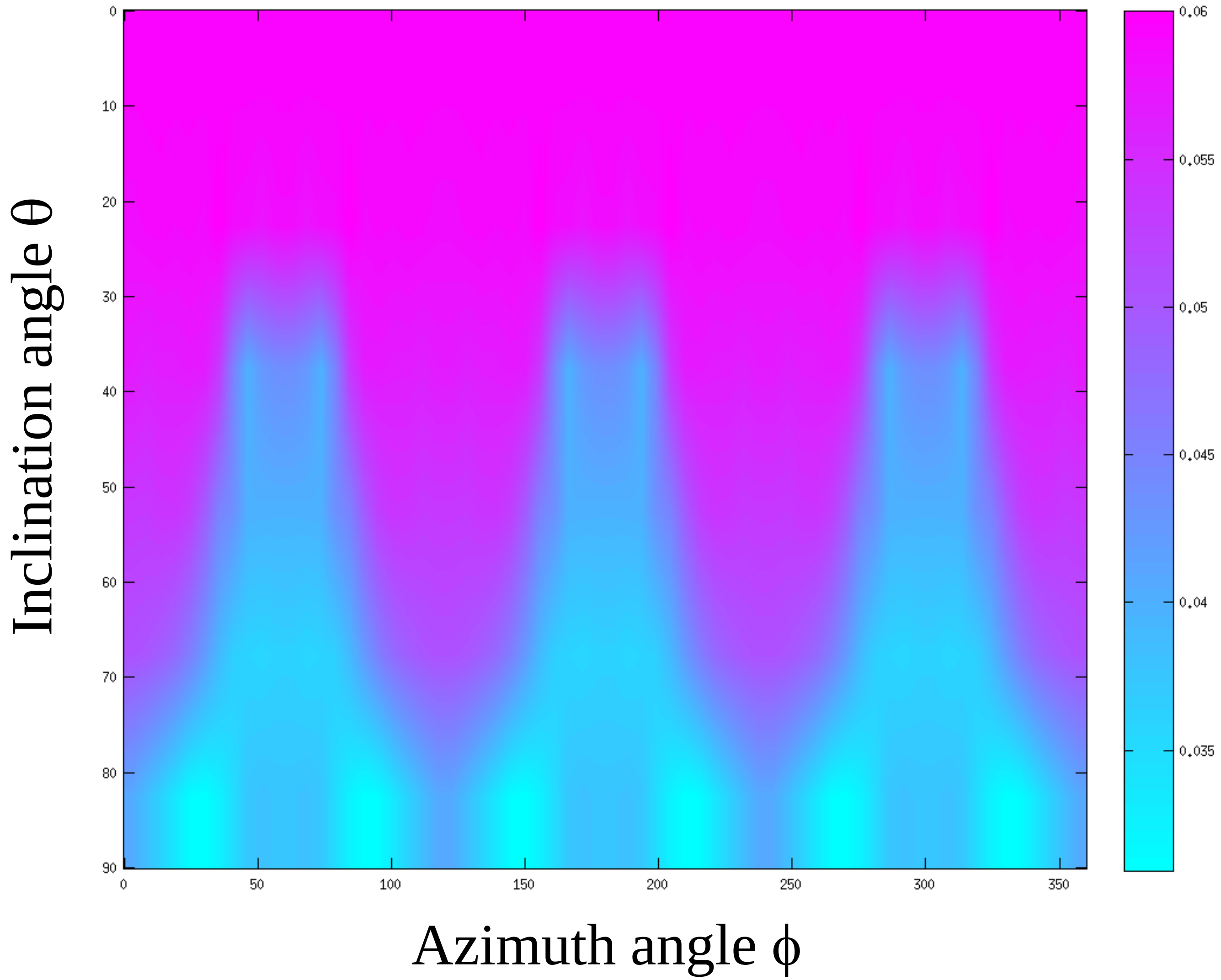
$\xi = \cos(\theta)$

Energy-angle sensitivity from measurement

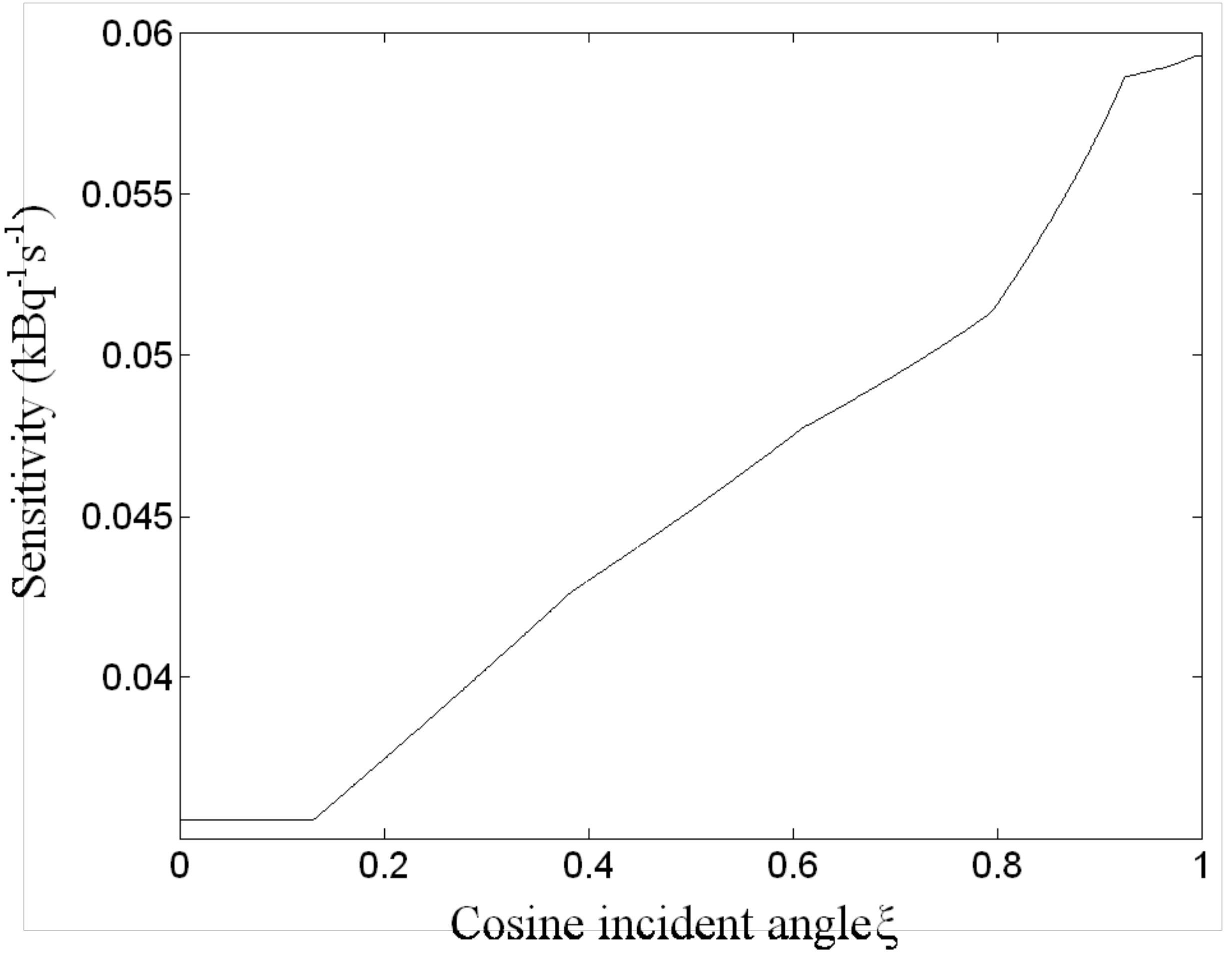
Energy-angle distribution from Monte Carlo simulation

# Results

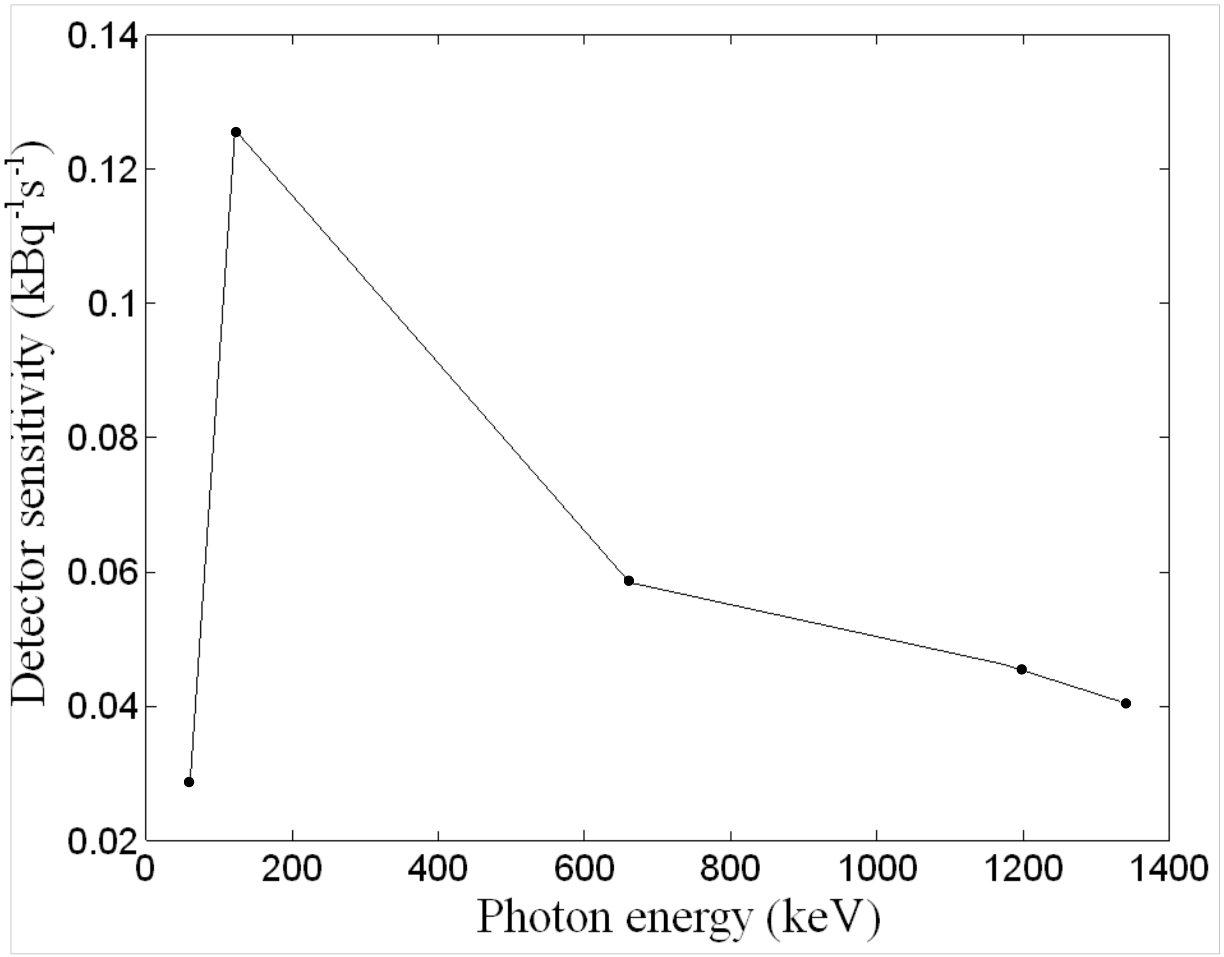
# Measured angular sensitivity at 662 keV



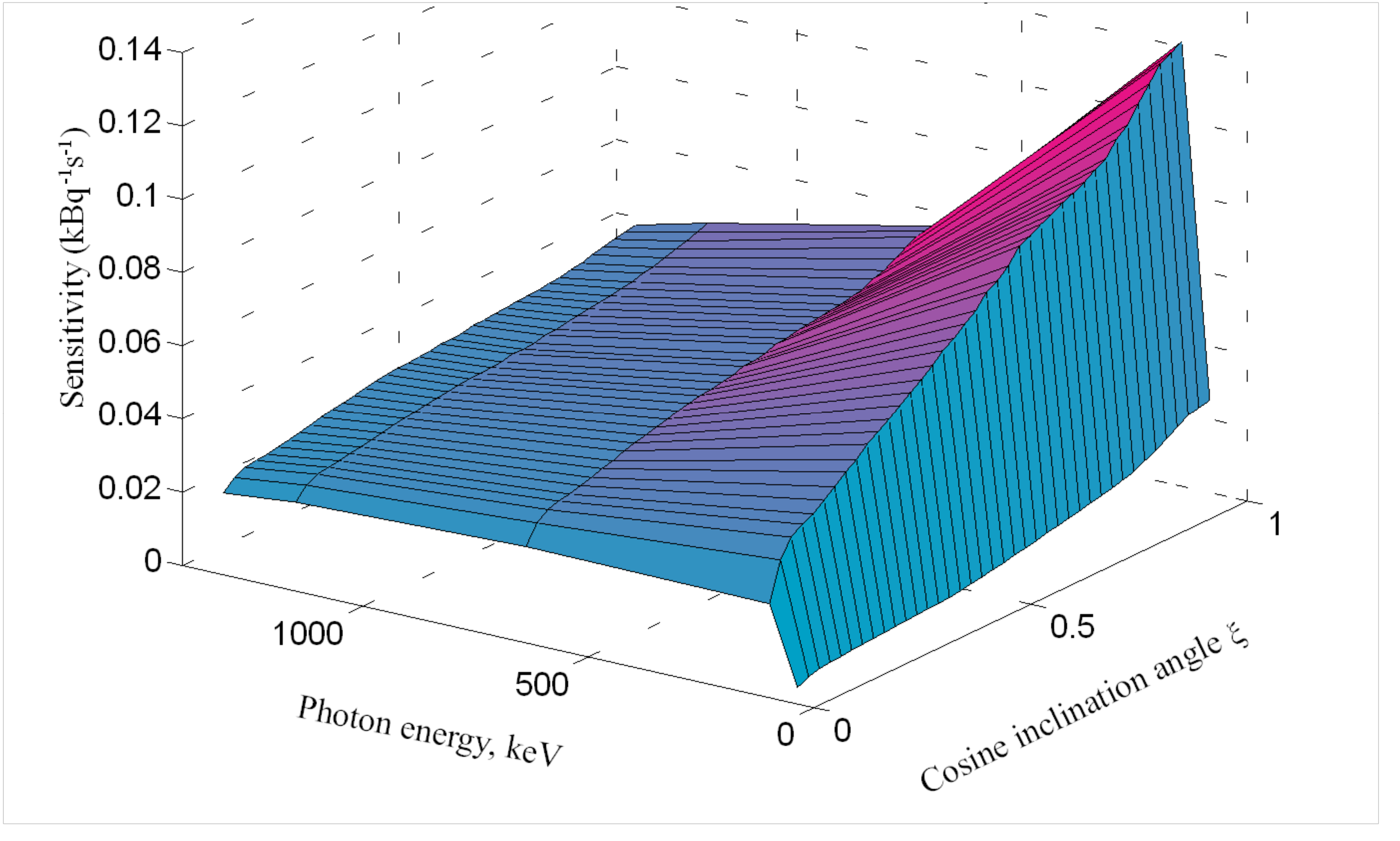
# Measured $\varepsilon(\xi)$ at 662 keV



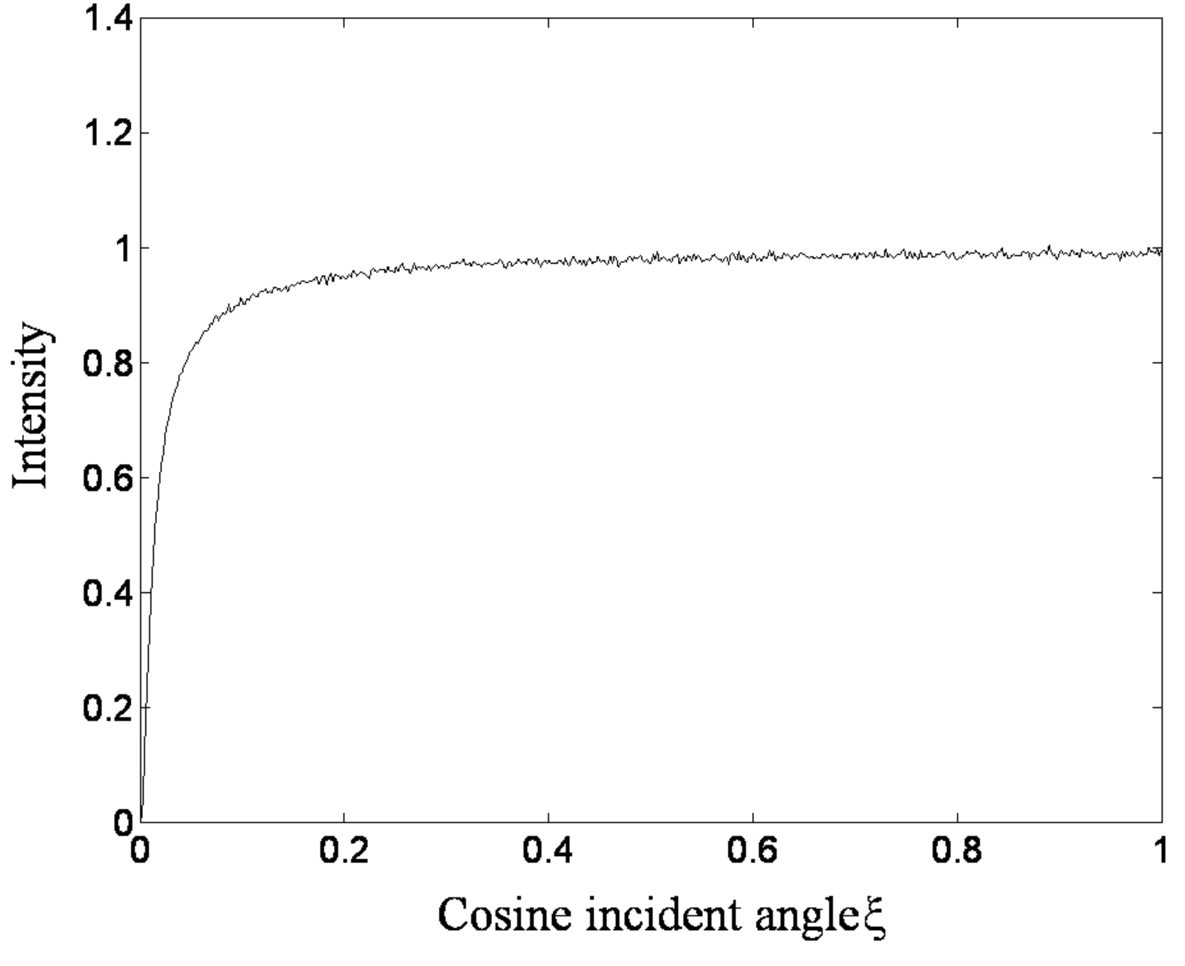
# Measured ε(E) at ξ=1 keV



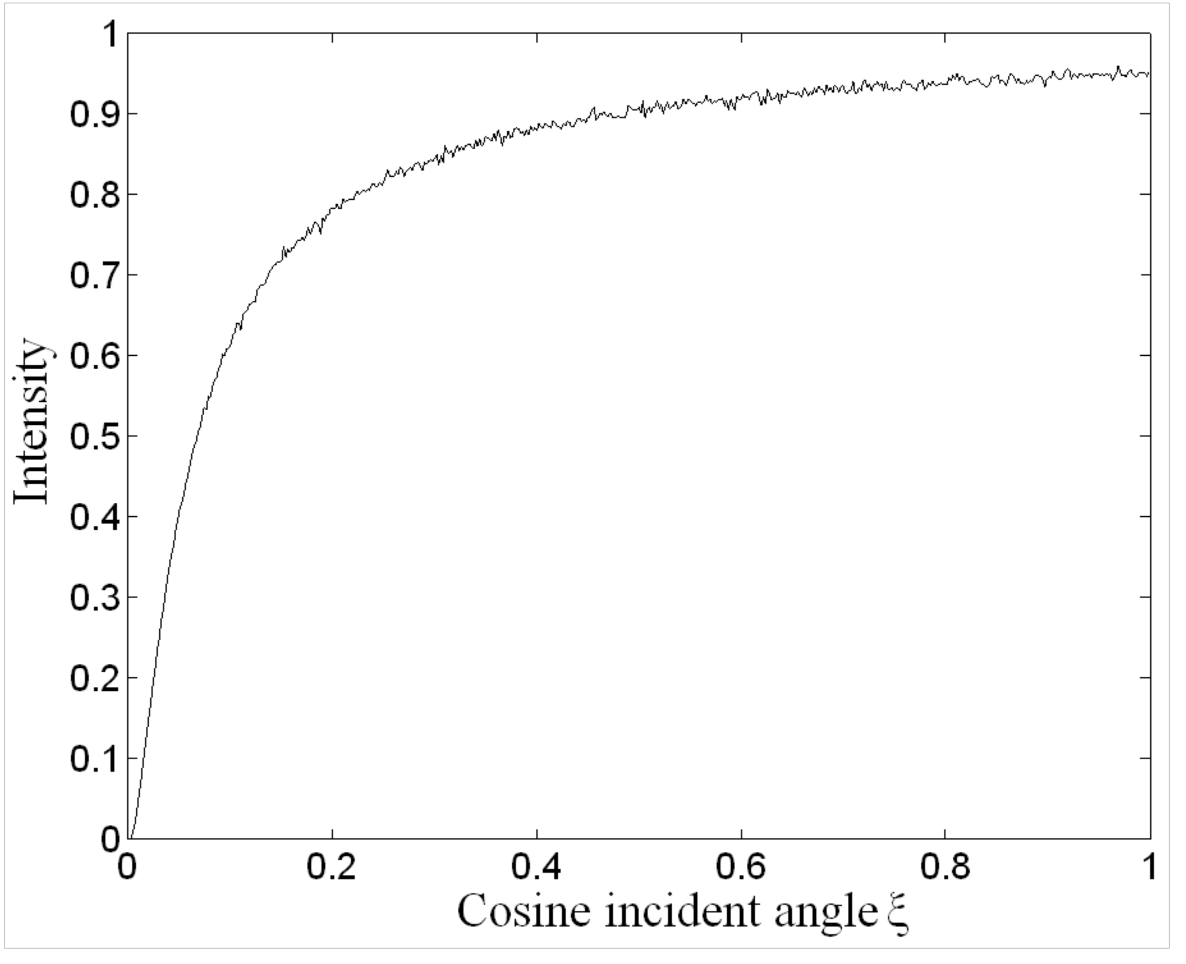
# Measured ε(E,ξ)



# $\eta(\xi,E)$ from Monte Carlo (surface distribution $^{137}Cs$)

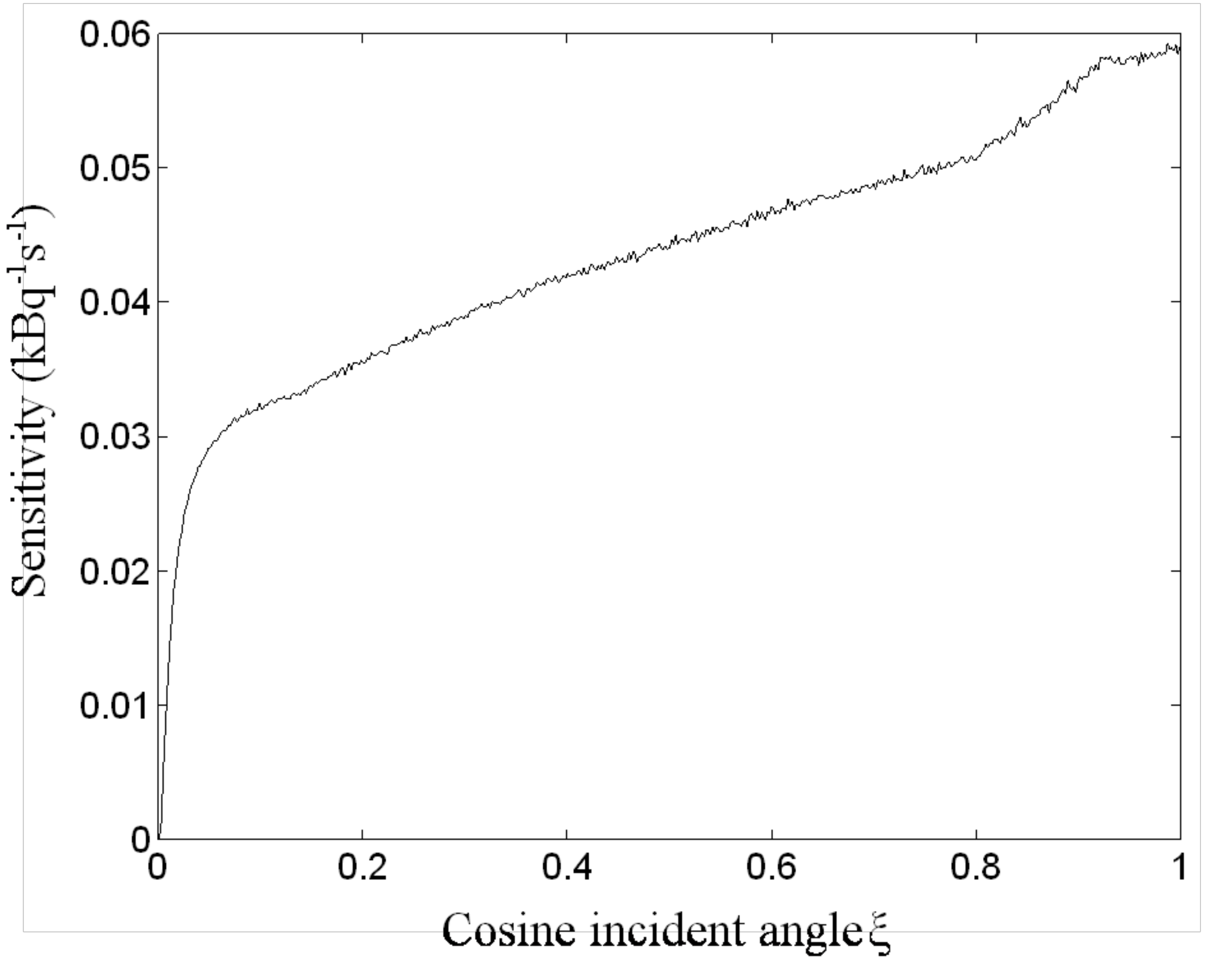


# $\eta(\xi,E)$ from Monte Carlo (exponential distribution $^{137}Cs$) $\alpha=0.0625\ kg/m^2$



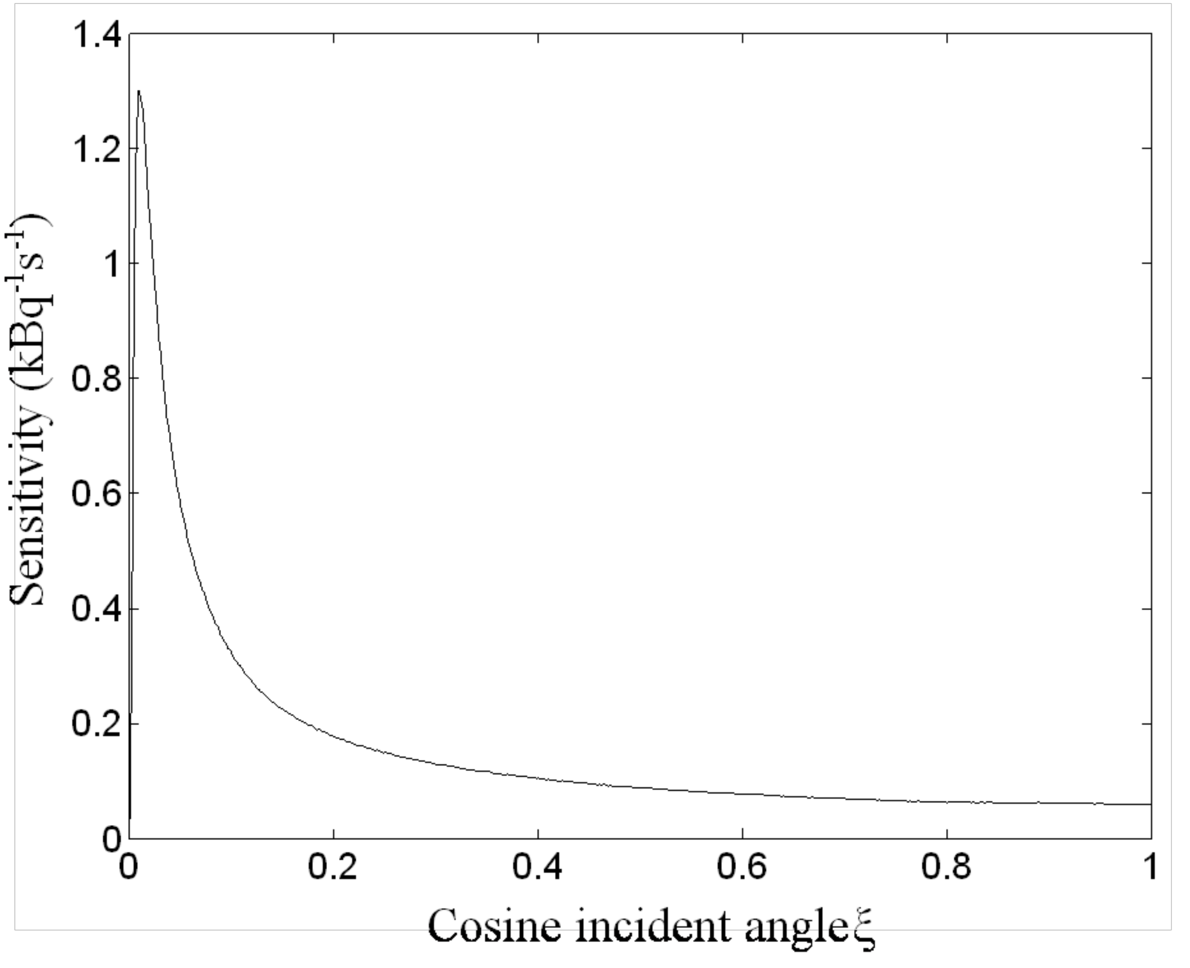
# Total sensitivity

## without solid angle correction, surface distribution $^{137}Cs$

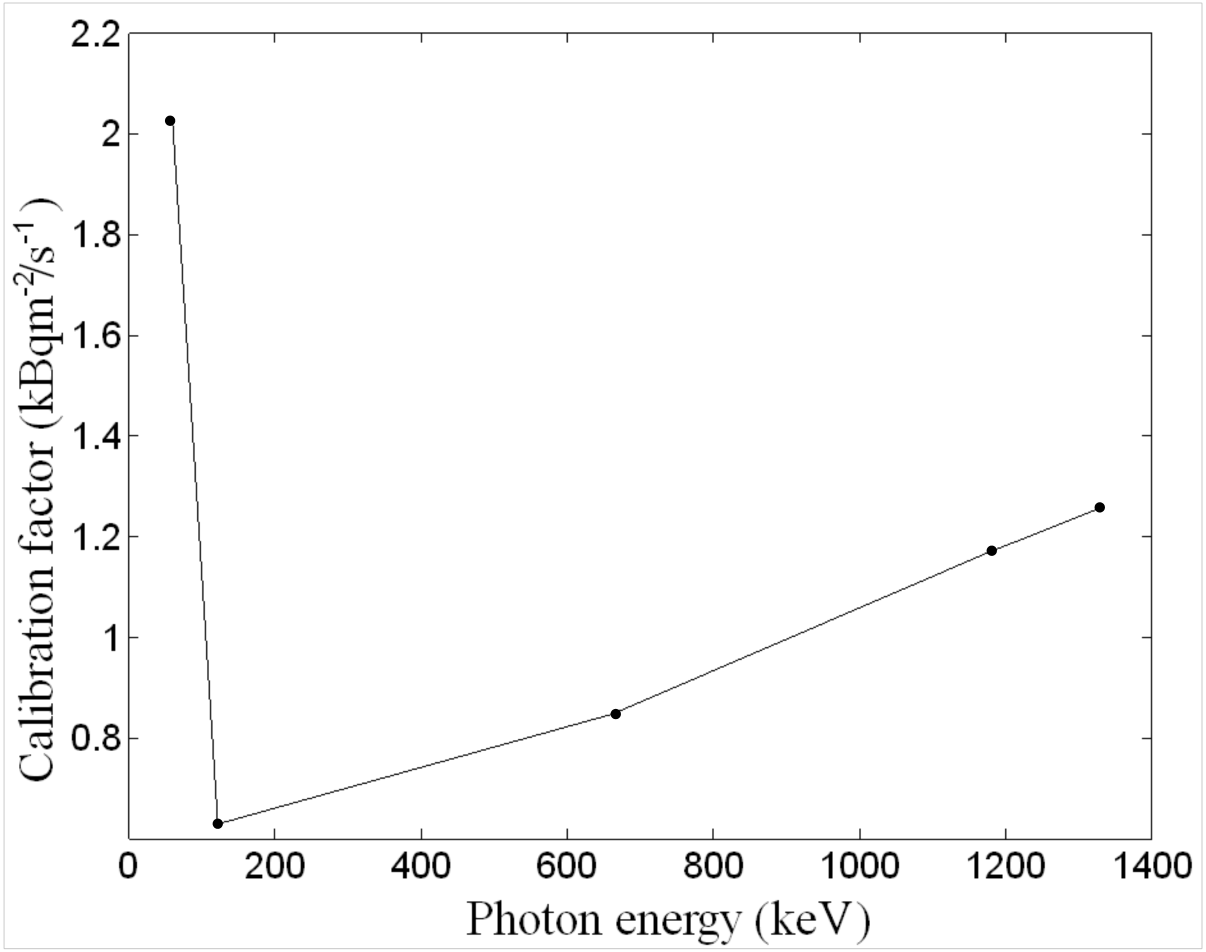


# Total sensitivity

## with solid angle correction, surface distribution $^{137}Cs$



# Calibration factor function (E)



# Calibration factors table

| | Calibration factors ($kBqm^{-2}/s^{-1}$) for different radionuclides | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | Energy (keV) | $\gamma$ probability | Surface | Homogeneous | Exponential |
| 7-Be | 477 | 0,1 | 8,48 | 79,97 | 12,72 |
| 18-F | 511 | 0,97 | 0,87 | 8,24 | 1,31 |
| 85-Kr | 151 | 0,75 | 0,84 | 11,9 | 1,32 |
| 131-I | 365 | 0,82 | 0,77 | 10,88 | 1,21 |
| 132-Te | 668 | 0,99 | 0,86 | 8,08 | 1,29 |
| 132-Te | 773 | 0,76 | 1,12 | 10,52 | 1,67 |
| 132-Te | 1399 | 1,76 | 0,72 | 5,45 | 1,04 |
| 134-Cs | 605 | 0,98 | 0,87 | 8,16 | 1,3 |
| 134-Cs | 796 | 0,86 | 0,99 | 9,3 | 1,48 |
| 137-Cs | 662 | 0,85 | 1 | 9,41 | 1,5 |
| 99-Mo | 141 | 0,89 | 0,71 | 10,03 | 1,11 |
| 95-Zr | 766 | 1 | 0,85 | 8 | 1,27 |
| 103-Ru | 497 | 0,9 | 0,94 | 8,89 | 1,41 |
| 106-Ru | 512 | 0,21 | 4,04 | 38,08 | 6,06 |
| 106-Ru | 622 | 0,1 | 8,65 | 81,61 | 12,98 |
| 140-Ba | 1596 | 1,1 | 1,15 | 8,72 | 1,67 |
| 140-Ba | 487 | 0,5 | 1,7 | 15,99 | 2,54 |
| 141-Ce | 145 | 0,49 | 1,28 | 18,21 | 2,02 |
| 239-Np | 106 | 0,27 | 2,31 | 32,8 | 3,63 |
| 239-Np | 228 | 0,23 | 2,76 | 39,13 | 4,34 |
| 239-Np | 278 | 0,14 | 4,37 | 61,96 | 6,87 |
| 241-Am | 60 | 0,36 | 5,62 | 132,52 | 10,08 |

# Conclusion

- Our Monte Carlo based model presented here is a fast, general, and feasible method for calibration of *in situ* HPGe detectors such as Ortec Detective EX 100. The general nature of the model also allows for calibration of different
  - Detectors
  - Types of soil or sand
  - Distributions of radionuclides

# Future work

- The results presented here are preliminary, and our model needs further benchmark and experimental validation.