



INVESTIGATION OF THE EFFECT OF COPPER COOLING ROD ON DETECTOR EFFICIENCY WITH MONTE CARLO METHOD IN HPGe DETECTORS

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SCOPE

- **Gamma Spectrometry – HPGe Detector**
- **Full Energy Peak Efficiency (FEPE)**
- **Monte Carlo (MC) Simulation Methods**
 - **PHITS MC Simulation Program**
- **Copper cooling rod effects**

Gamma Spectrometry – HPGe Detector

Gamma spectrometry is a system that allows the pulses, which are proportional to the energy of the gamma rays reaching the detector crystal, to be processed in a preamplifier and amplifier, and then digitized in the analog digital converter (ADC) and recorded as a spectrum in the memory of the multi-channel analyzer (MCA).



Gamma Spectrometry – HPGe Detector

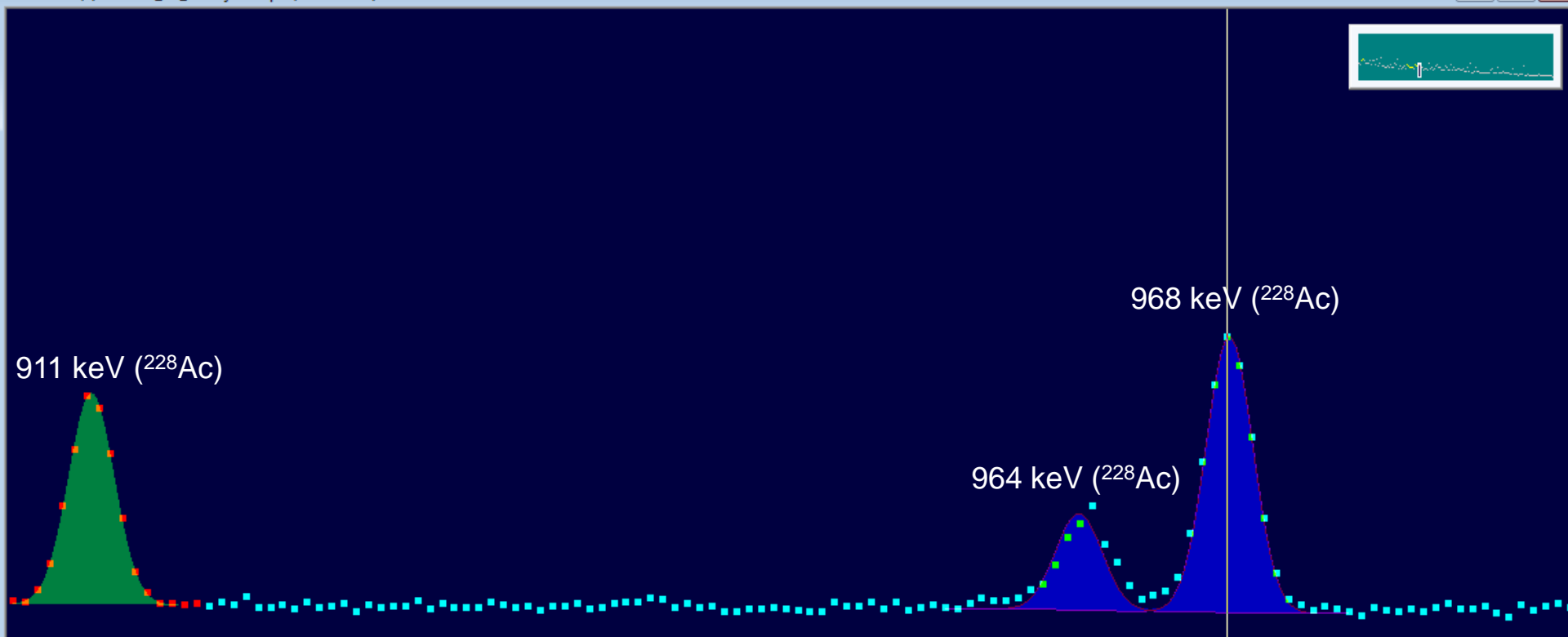
GammaVision - 1.ÖLÇÜM-KS.SPC (BL-2a_KS_1.ÖLÇÜM_plastik kapak yok_örnek tutucu ile)

File Acquire Calibrate Calculate Analyze Library Services ROI Display Window

Analysis Results Table

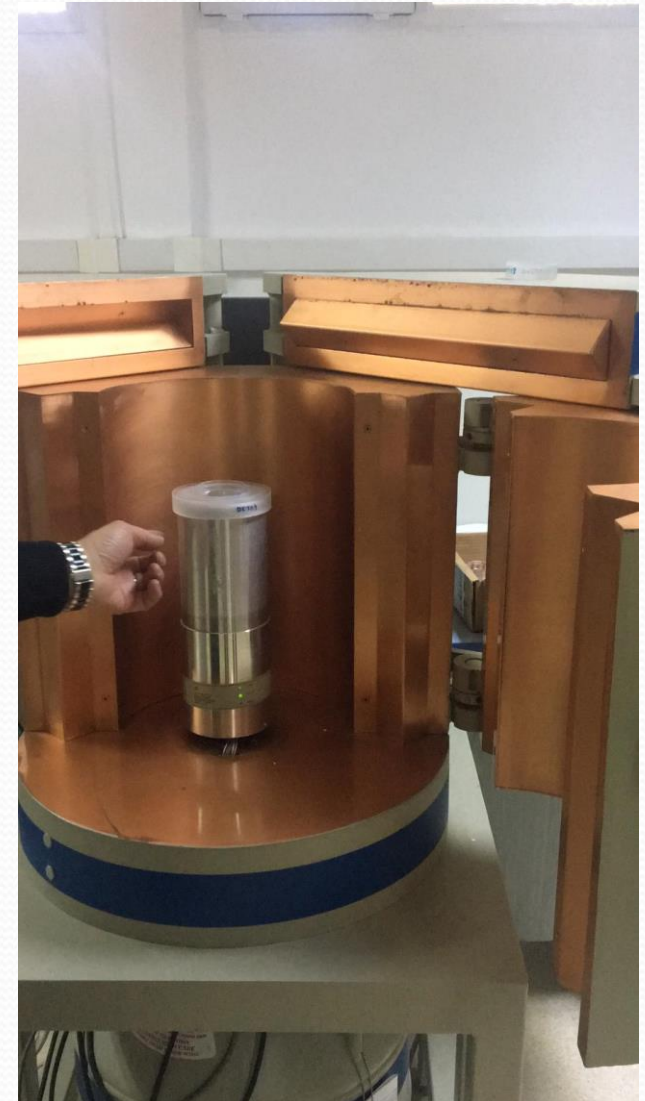
Energy	FWHM (keV)	Area	Background	Nuclide	Bq
933.49	1.73	4442	3612	<Unknown>	
963.79	1.68	2054	2411	<Unknown>	
968.41	1.69	5890	2207	<Unknown>	
1000.41	1.63	1631	2898	<Unknown>	

Buffer(1) - DL-1a_KS_1.ÖLÇÜM.Spe (DL-1A.KS)



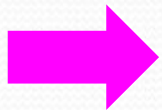
HPGe Detector – Manufacturer value

Basic Detector dimensions		
Detector diameter	94.8	
Detector length	87.2	
Detector end radius	Hole diameter/2, nominal	
Hole diameter	11.2	
Hole depth	73.4	
Hole bottom radius	8 mm, nominal	
Miscellaneous Detector dimensions and materials		
Description	Dimension	Material
Mount cap length	130	Aluminum
End cap to crystal cap	5	N.A.
Mount cap base	3.2	Aluminum
End cap window	1.5	Aluminum
Insulator/shield	0.03	Mylar/Aluminized mylar
Outside contact layer	0.7	Lithium
Hole contact layer	0.003	Boron
Mount cap wall	0.76	Aluminum
End cap wall	1.3	Aluminum



FULL ENERGY PEAK PEAK EFFICIENCY

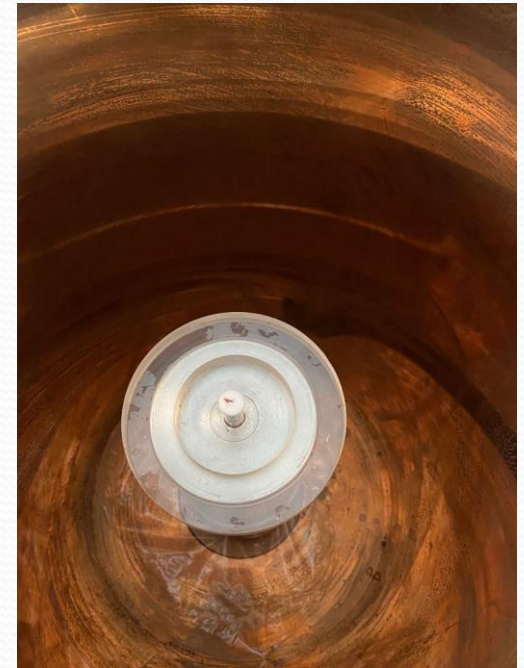
The efficiency of the detector must be determined in order to obtain the activity value of the radionuclide of interest in the sample.



It is the ratio of the photopic count at a given energy to the number of gamma rays emitted from the source.

- ⦿ Source type
- ⦿ The shape and active volume of the detector crystal
- ⦿ Source-detector geometry
- ⦿ interactions with the materials around the detector (detector window, other scatterers/absorbers).

FULL ENERGY PEAK PEAK EFFICIENCY



Efficiency calibration for a particular detector-source geometry is not valid for other source-detector geometries. Therefore, efficiency calibration curves should be created for different source-detector geometries.

FULL ENERGY PEAK PEAK EFFICIENCY

The full energy peak efficiency can be determined in two ways:



Experimental method



Monte Carlo simulation method

- ✓ **The experimental method** is costly and time consuming, as well as the difficulties of accurately realizing measurement conditions such as measurement geometry, sample type and volume.
- ✓ Instead of the experimental method, which has many disadvantages such as being time consuming and costly, the use of the **Monte Carlo method** is increasingly common.

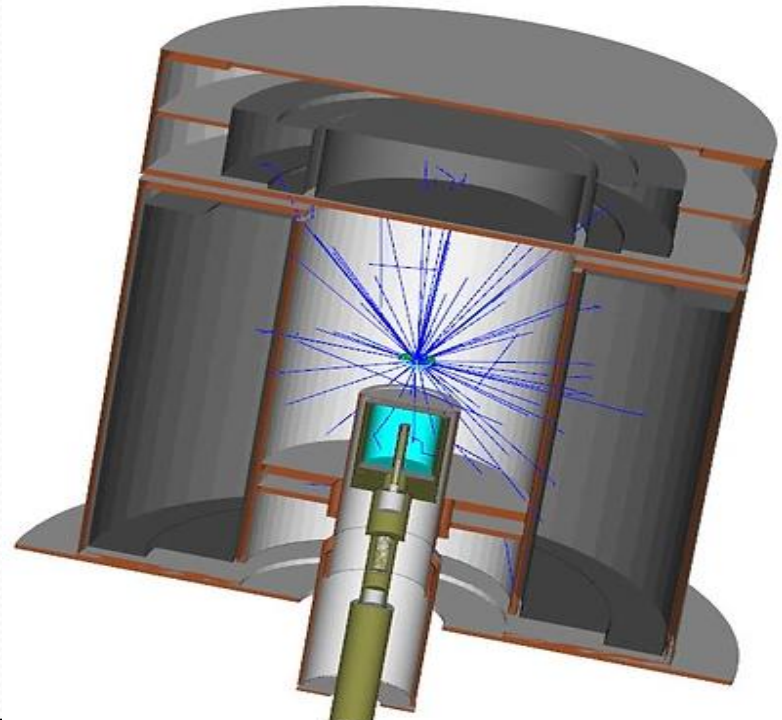
MODELING OF HPGe DETECTORS WITH PHITS MC

In HPGe detector modeling with MC simulation;

- ✓ Detector diameter and length,
- ✓ Hole diameter and depth,
- ✓ End cap to crystal gap,
- ✓ End cap window material and dimension
- ✓ **Detector end radius (rounded or sharp edge geometry)**
- ✓ **Dead layer thickness**
- ✓ **Copper cooling rod thickness**

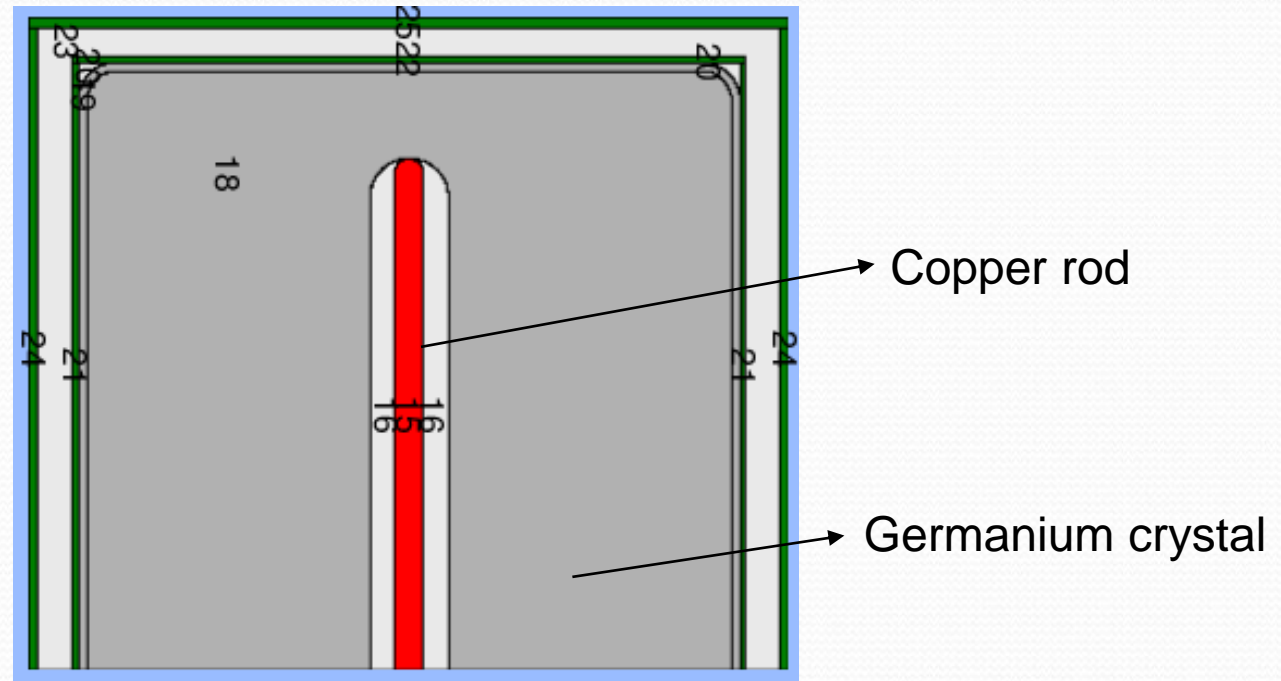
such as geometric parameters need to be determined accurately.

★ The detector parameters provided by the manufacturer are of great importance in modeling the detector with the MC method



COPPER COOLING ROD

In this study, the effect of the copper cooling rod in the middle of the detector hole and providing thermal conductivity on the detector efficiency was investigated. **This copper rod thickness is not given by any manufacturer.**



COPPER COOLING ROD

The effect of copper cooling rod thickness on detector efficiency was investigated by using PHITS MC simulation program both at different copper rod radii.

PHITS

Particle and Heavy Ion Transport code System

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Last Update : 2018/04/16

What is new?

2018/01/16: Sample user-defined tally for [t-deposit] with outout=deposit is uploaed ([detail](#))

2018/01/09: Publication on the latest PHITS (Ver.3.02) ([detail](#))

2017/08/24: Lecture notes were updated ([detail](#))

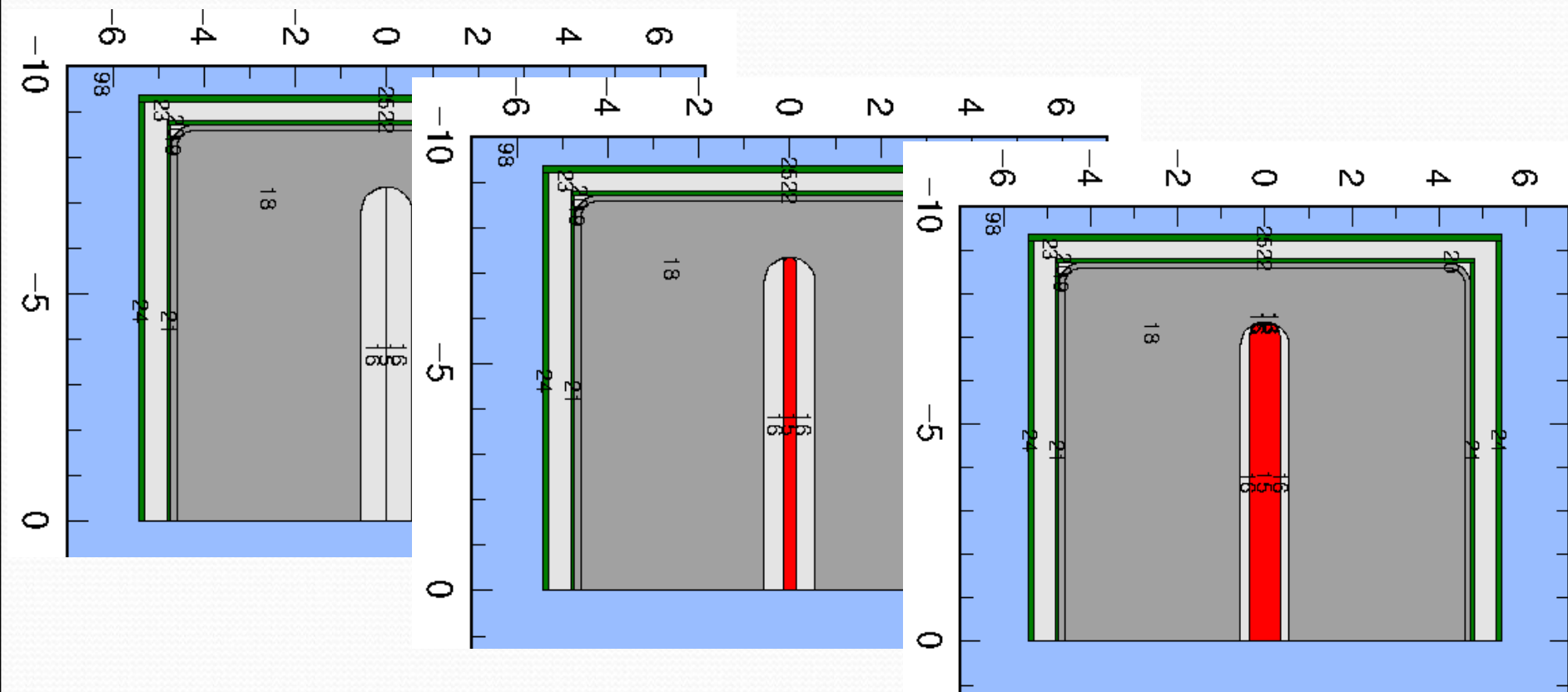
2017/08/03: Tutorial schedule page was uploaded ([detail](#))

2017/02/02: **Registration of PHITS 2.88 in OECD/NEA Databank**

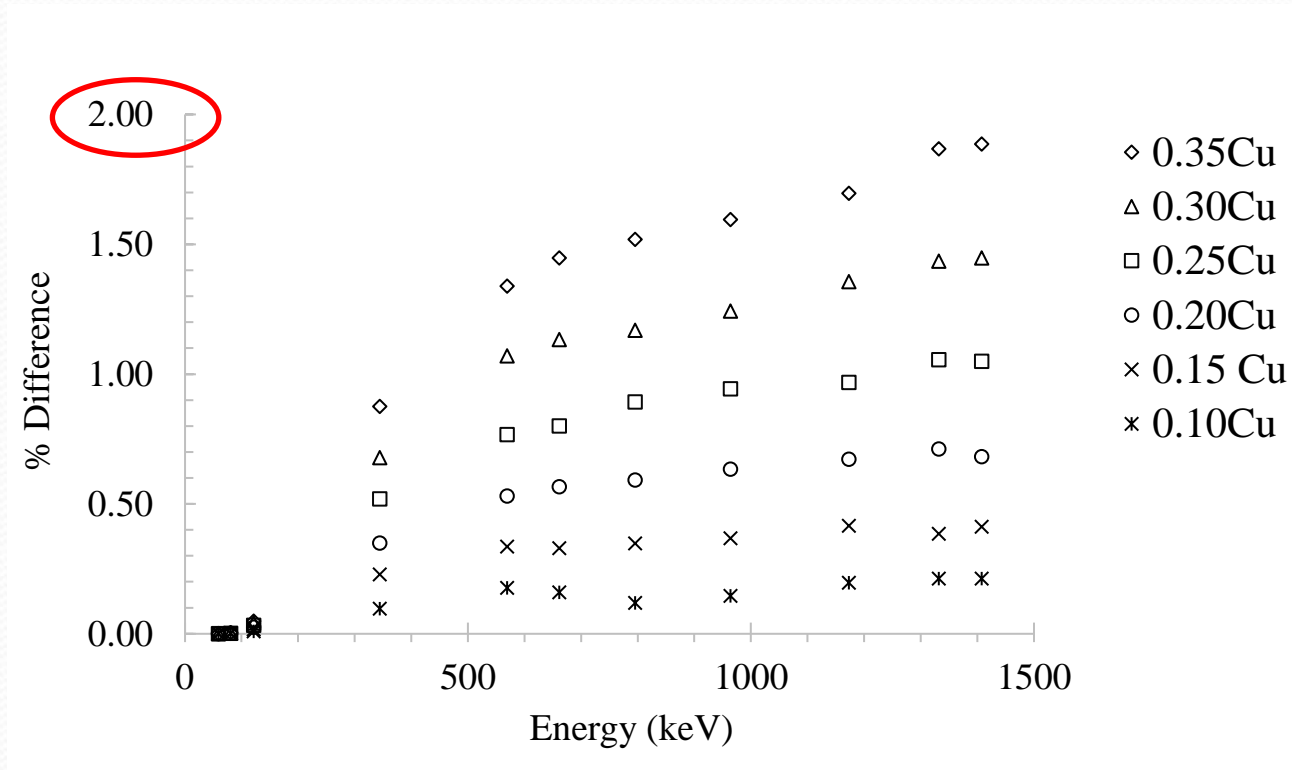
PHITS is an MC code that can transport most particle types with energies up to 1 TeV using several nuclear reaction models and data libraries.

COPPER COOLING ROD

By using radioactive sources with energies in the range of 59.5 keV-1408 keV, first of all; Efficiency values were calculated for copper rod radius increased from 1 mm to 3.5 mm at 0.5 mm intervals by modeling the detector without the copper rod.



COPPER COOLING ROD



According to the results, it has been determined that the presence of copper rod causes a change in detector efficiency up to 2%, especially in the high energy region, and has no effect on the detector efficiency in the low energy region.

DISCUSSION

Since low energy photons (<100 keV) are absorbed before they reach the copper rod, the copper rod has no effect in this region.

The reason for the decrease in efficiency values with the presence of copper rod in the high energy region is that Compton and pair production events are dominant in this region.



As a result, the copper cooling rod should be taken into account in detector efficiency calculations at high energies.



Thanks for your attention