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Total Attenuation of Various Elements at Different Photon Energies

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Abstract: ***The use of radiation has exponentially increased in a lot of industries such as Nuclear, Medical and Agriculture. Radiation are highly hazardous for not only human beings but for all living organisms. Hence, there is a need for good radiation shielding material. Radiation Shielding is the concept of reduction of radiation by interposing a shield of absorbing material between any radioactive source and the living organism or work area. The reduction in the strength of radiation is known as Total attenuation. In this research paper, the total attenuation of various elements at different photon energies is determined from the data obtained from the WinXCom computer program.***

Keywords: Radiation, Radiation Shielding, Radioactive Source, Total Attenuation, WinXCom

I. INTRODUCTION

Radiation is used in a lot of industries such as Nuclear, Agriculture, Medicine etc [1]. The usage of radiation has exponentially increased in the recent years. In physics, radiation is the emission or transmission of energy in the form of waves or particles through space or through a material medium.

This includes electromagnetic radiation such as radio waves, microwaves, visible light, x-rays, and gamma radiation(γ), particle radiation such as alpha radiation(α), beta radiation(β), and neutron radiation (particles of non-zero rest energy). Depending on the energy of the radiated particles, they are classified as Ionizing radiation and Non-ionizing radiation. Ionizing radiation is the radiation with sufficiently high energy which can ionize atoms; that is to say it can knock electrons off atoms, creating ions. Ionization occurs when an electron is stripped (or "knocked out") from an electron shell of the atom. Because living cells and, more importantly, the DNA in those cells can be damaged by this ionization, exposure to ionizing radiation is considered to increase the risk of cancer. Ionizing radiation carries more than 10 eV.

Some of the ionizing radiations are Ultraviolet radiation, X-ray, Gamma radiation, Alpha radiation, Beta radiation, Neutron radiation and cosmic radiation. The kinetic energy of particles of non-ionizing radiation is too small to produce charged ions when passing through matter.

This type of radiation only damages cells if the intensity is high enough to cause excessive heating. Some of the Non-ionizing radiations are visible light, Infrared, Microwave, Radio waves, Very low frequency, Extremely low frequency and thermal radiation. Coherent scattering is also known as elastic scattering. It is one of three forms of photon interaction which occurs when the energy of the X-ray or gamma photon is small in relation to the ionisation energy of the atom. The only change is a change of direction (scatter) of the photon, hence 'unmodified' scatter. It has been proved that gamma radiation can alter the morphological and optical properties of materials [2]. Some research papers have also proved that the gamma radiation can alter the mechanical properties of materials [3], [4], [6]. The gamma radiation has the capability to alter the electrical properties as well [5]. Thus, radiation not only affects the living organisms, they affect all sorts of material with sufficient energy [1-7].

II. METHODOLOGY

Lead is one of the most commonly used radiation shielding material due to its high density and total attenuation. It is also highly feasible. The elements chosen for this study are the materials which have density higher than lead and also some of the commonly used metals.

Density is one of the important factors considered for radiation shielding. The computer program WinXCom was used to determine the total attenuation of the elements under study. The photon energy from 1 MeV to 10^5 MeV was used for this study. The various elements used for this study are Lead, Aluminium, Mercury, Copper, Gold, Iron, Tungsten, Silver, Osmium and Iridium.

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III.DENSITY

As said earlier, Density is one of the important factors considered for radiation shielding. The densities for the elements under study are as follows,

Metal or alloy	Density (kg/m^3)
Lead	11340
Aluminum	2712
Mercury	13593
Copper	8940
Gold	19320
Iron	7850
Tungsten	19600
Silver	10490
Osmium	22610
Iridium	22650

IV.TOTAL ATTENUATION

The reduction in the strength of radiation is known as Total attenuation. Total attenuation is one of the parameters specified for radiation shielding materials. Using the WinXCom computer program, the total attenuation of the various elements has been computed.

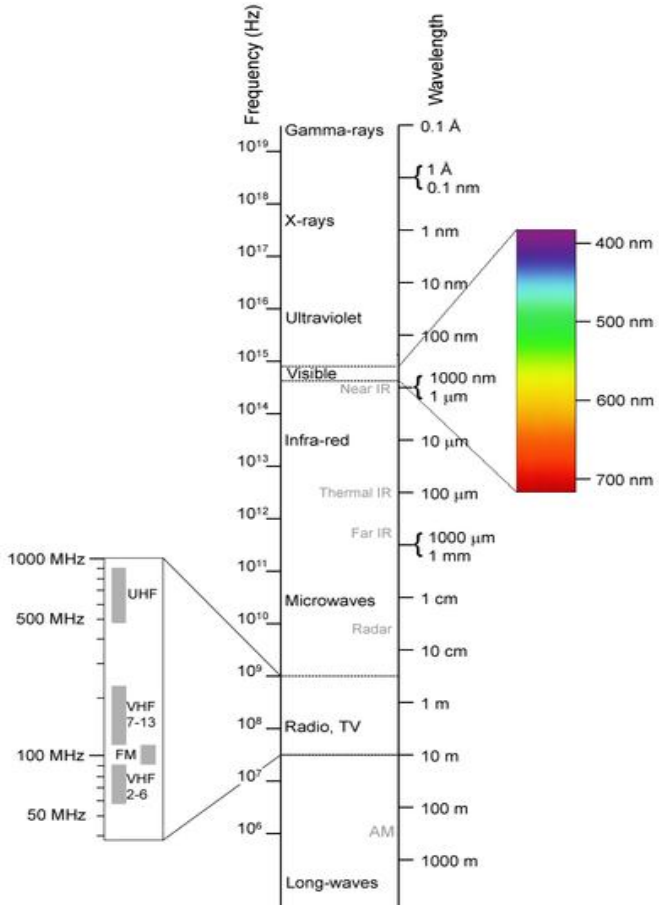

Fig. 1 The Electromagnetic spectrum

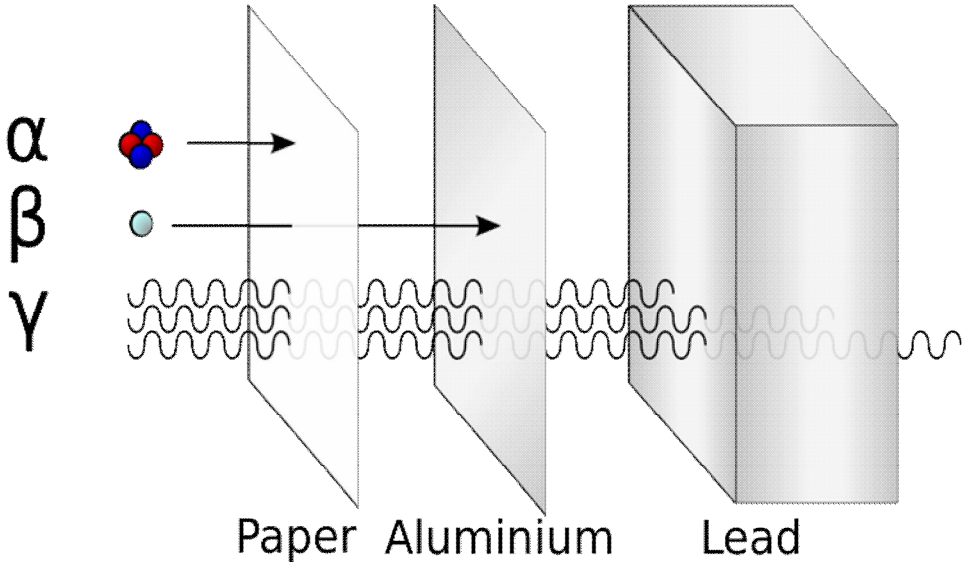

Fig. 2 Illustration of the relative abilities of three different types of ionizing radiation to penetrate solid matter.

A. Lead

Photon Energy	Tot. w/ Coherent	Tot. wo/ Coherent
1.000E+00	7.102E-02	6.803E-02
1.022E+00	6.962E-02	6.676E-02
1.250E+00	5.875E-02	5.682E-02
1.500E+00	5.222E-02	5.088E-02
2.000E+00	4.607E-02	4.530E-02
2.044E+00	4.577E-02	4.504E-02
3.000E+00	4.234E-02	4.200E-02
4.000E+00	4.198E-02	4.178E-02
5.000E+00	4.272E-02	4.260E-02
6.000E+00	4.391E-02	4.382E-02
7.000E+00	4.528E-02	4.522E-02
8.000E+00	4.675E-02	4.670E-02
9.000E+00	4.823E-02	4.819E-02
1.000E+01	4.972E-02	4.969E-02
1.100E+01	5.117E-02	5.114E-02
1.200E+01	5.260E-02	5.257E-02
1.300E+01	5.397E-02	5.396E-02
1.400E+01	5.532E-02	5.530E-02
1.500E+01	5.658E-02	5.656E-02
1.600E+01	5.778E-02	5.776E-02
1.800E+01	6.001E-02	6.000E-02
2.000E+01	6.206E-02	6.205E-02
2.200E+01	6.394E-02	6.393E-02
2.400E+01	6.569E-02	6.569E-02
2.600E+01	6.730E-02	6.730E-02
2.800E+01	6.881E-02	6.881E-02
3.000E+01	7.022E-02	7.022E-02
4.000E+01	7.610E-02	7.610E-02
5.000E+01	8.056E-02	8.056E-02
6.000E+01	8.408E-02	8.408E-02
8.000E+01	8.934E-02	8.934E-02
1.000E+02	9.310E-02	9.310E-02
1.500E+02	9.909E-02	9.909E-02
2.000E+02	1.027E-01	1.027E-01
3.000E+02	1.069E-01	1.069E-01
4.000E+02	1.093E-01	1.093E-01
5.000E+02	1.109E-01	1.109E-01
6.000E+02	1.121E-01	1.121E-01
8.000E+02	1.136E-01	1.136E-01
1.000E+03	1.146E-01	1.146E-01
1.500E+03	1.160E-01	1.160E-01
2.000E+03	1.168E-01	1.168E-01
3.000E+03	1.177E-01	1.177E-01
4.000E+03	1.181E-01	1.181E-01
5.000E+03	1.184E-01	1.184E-01
6.000E+03	1.186E-01	1.186E-01
8.000E+03	1.188E-01	1.188E-01
1.000E+04	1.190E-01	1.190E-01
1.500E+04	1.192E-01	1.192E-01
2.000E+04	1.194E-01	1.194E-01
3.000E+04	1.195E-01	1.195E-01
4.000E+04	1.196E-01	1.196E-01
5.000E+04	1.196E-01	1.196E-01
6.000E+04	1.196E-01	1.196E-01
8.000E+04	1.197E-01	1.197E-01
1.000E+05	1.197E-01	1.197E-01

Fig. 3 Total attenuation of lead from 1 MeV to 10^5 MeV

XCOM

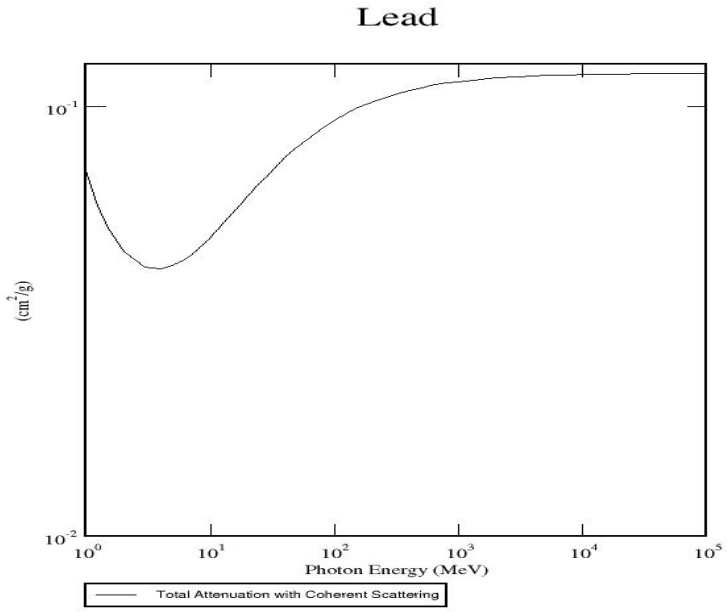

Fig.4 Total attenuation of Lead at various Photon Energies

B. Osmium

Photon Energy	Tot. w/ Coherent	Tot. wo/ Coherent
1.000E+00	6.705E-02	6.446E-02
1.022E+00	6.580E-02	6.332E-02
1.250E+00	5.625E-02	5.458E-02
1.500E+00	5.034E-02	4.917E-02
2.000E+00	4.458E-02	4.392E-02
2.044E+00	4.427E-02	4.364E-02
3.000E+00	4.100E-02	4.071E-02
4.000E+00	4.065E-02	4.048E-02
5.000E+00	4.134E-02	4.123E-02
6.000E+00	4.244E-02	4.237E-02
7.000E+00	4.373E-02	4.368E-02
8.000E+00	4.511E-02	4.507E-02
9.000E+00	4.656E-02	4.647E-02
1.000E+01	4.791E-02	4.788E-02
1.100E+01	4.928E-02	4.926E-02
1.200E+01	5.065E-02	5.063E-02
1.300E+01	5.196E-02	5.194E-02
1.400E+01	5.322E-02	5.320E-02
1.500E+01	5.442E-02	5.440E-02
1.600E+01	5.554E-02	5.553E-02
1.800E+01	5.766E-02	5.765E-02
2.000E+01	5.956E-02	5.956E-02
2.200E+01	6.134E-02	6.134E-02
2.400E+01	6.301E-02	6.300E-02
2.600E+01	6.454E-02	6.454E-02
2.800E+01	6.597E-02	6.596E-02
3.000E+01	6.730E-02	6.730E-02
4.000E+01	7.288E-02	7.288E-02
5.000E+01	7.709E-02	7.709E-02
6.000E+01	8.046E-02	8.046E-02
8.000E+01	8.548E-02	8.548E-02
1.000E+02	8.904E-02	8.904E-02
1.500E+02	9.478E-02	9.478E-02
2.000E+02	9.819E-02	9.819E-02
3.000E+02	1.022E-01	1.022E-01
4.000E+02	1.045E-01	1.045E-01
5.000E+02	1.061E-01	1.061E-01
6.000E+02	1.071E-01	1.071E-01
8.000E+02	1.086E-01	1.086E-01
1.000E+03	1.096E-01	1.096E-01
1.500E+03	1.109E-01	1.109E-01
2.000E+03	1.116E-01	1.116E-01
3.000E+03	1.125E-01	1.125E-01
4.000E+03	1.129E-01	1.129E-01
5.000E+03	1.132E-01	1.132E-01
6.000E+03	1.134E-01	1.134E-01
8.000E+03	1.136E-01	1.136E-01
1.000E+04	1.138E-01	1.138E-01
1.500E+04	1.140E-01	1.140E-01
2.000E+04	1.141E-01	1.141E-01
3.000E+04	1.142E-01	1.142E-01
4.000E+04	1.143E-01	1.143E-01
5.000E+04	1.143E-01	1.143E-01
6.000E+04	1.144E-01	1.144E-01
8.000E+04	1.144E-01	1.144E-01
1.000E+05	1.144E-01	1.144E-01

Fig.5 Total attenuation of Osmium from 1 MeV to 10^5 MeV

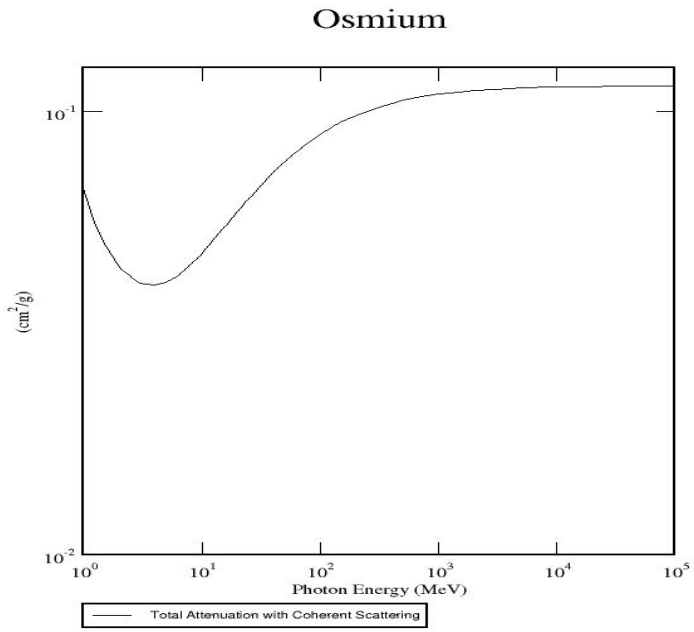

Fig.6 Total attenuation of Osmium at various Photon Energies

C. Iridium

Photon Energy	Tot. w/ Coherent	Tot. wo/ Coherent
1.000E+00	6.794E-02	6.528E-02
1.022E+00	6.667E-02	6.412E-02
1.250E+00	5.687E-02	5.515E-02
1.500E+00	5.084E-02	4.964E-02
2.000E+00	4.502E-02	4.434E-02
2.044E+00	4.470E-02	4.405E-02
3.000E+00	4.139E-02	4.108E-02
4.000E+00	4.104E-02	4.087E-02
5.000E+00	4.174E-02	4.163E-02
6.000E+00	4.286E-02	4.279E-02
7.000E+00	4.418E-02	4.412E-02
8.000E+00	4.558E-02	4.554E-02
9.000E+00	4.700E-02	4.697E-02
1.000E+01	4.844E-02	4.841E-02
1.100E+01	4.982E-02	4.980E-02
1.200E+01	5.119E-02	5.118E-02
1.300E+01	5.251E-02	5.249E-02
1.400E+01	5.378E-02	5.376E-02
1.500E+01	5.502E-02	5.501E-02
1.600E+01	5.616E-02	5.614E-02
1.800E+01	5.830E-02	5.830E-02
2.000E+01	6.024E-02	6.024E-02
2.200E+01	6.206E-02	6.205E-02
2.400E+01	6.373E-02	6.373E-02
2.600E+01	6.530E-02	6.530E-02
2.800E+01	6.674E-02	6.674E-02
3.000E+01	6.809E-02	6.808E-02
4.000E+01	7.372E-02	7.372E-02
5.000E+01	7.804E-02	7.804E-02
6.000E+01	8.143E-02	8.143E-02
8.000E+01	8.648E-02	8.648E-02
1.000E+02	9.012E-02	9.012E-02
1.500E+02	9.592E-02	9.592E-02
2.000E+02	9.938E-02	9.938E-02
3.000E+02	1.035E-01	1.035E-01
4.000E+02	1.058E-01	1.058E-01
5.000E+02	1.073E-01	1.073E-01
6.000E+02	1.084E-01	1.084E-01
8.000E+02	1.099E-01	1.099E-01
1.000E+03	1.109E-01	1.109E-01
1.500E+03	1.122E-01	1.122E-01
2.000E+03	1.130E-01	1.130E-01
3.000E+03	1.138E-01	1.138E-01
4.000E+03	1.142E-01	1.142E-01
5.000E+03	1.145E-01	1.145E-01
6.000E+03	1.147E-01	1.147E-01
8.000E+03	1.150E-01	1.150E-01
1.000E+04	1.151E-01	1.151E-01
1.500E+04	1.153E-01	1.153E-01
2.000E+04	1.155E-01	1.155E-01
3.000E+04	1.156E-01	1.156E-01
4.000E+04	1.156E-01	1.156E-01
5.000E+04	1.157E-01	1.157E-01
6.000E+04	1.157E-01	1.157E-01
8.000E+04	1.158E-01	1.158E-01
1.000E+05	1.158E-01	1.158E-01

Fig.7 Total attenuation of Iridium from 1 MeV to 10^5 MeV

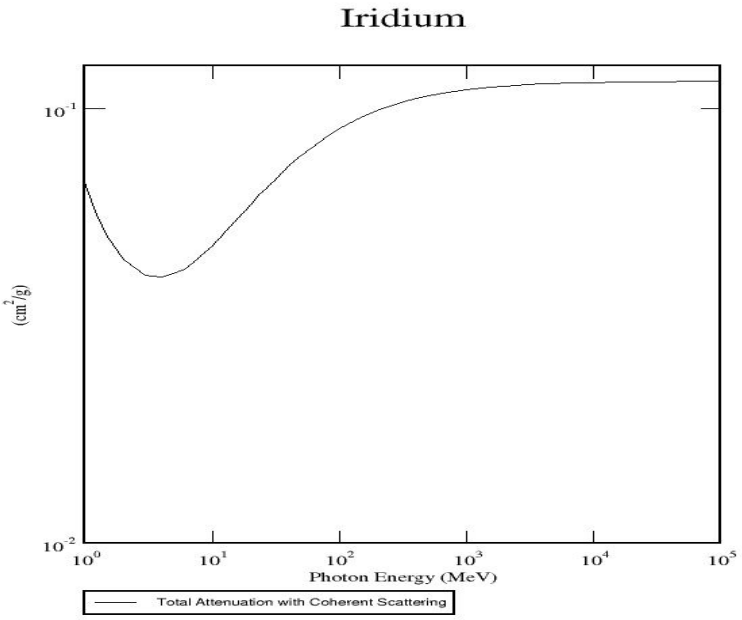

Fig.8 Total attenuation of Iridium at various Photon Energies

D. Tungsten

Photon Energy	Tot. w/ Coherent	Tot. wo/ Coherent
1.000E+00	6.618E-02	6.370E-02
1.022E+00	6.497E-02	6.259E-02
1.250E+00	5.576E-02	5.417E-02
1.500E+00	5.000E-02	4.888E-02
2.000E+00	4.433E-02	4.370E-02
2.044E+00	4.404E-02	4.343E-02
3.000E+00	4.075E-02	4.047E-02
4.000E+00	4.038E-02	4.022E-02
5.000E+00	4.103E-02	4.093E-02
6.000E+00	4.210E-02	4.203E-02
7.000E+00	4.337E-02	4.332E-02
8.000E+00	4.472E-02	4.468E-02
9.000E+00	4.610E-02	4.607E-02
1.000E+01	4.747E-02	4.745E-02
1.100E+01	4.882E-02	4.880E-02
1.200E+01	5.016E-02	5.015E-02
1.300E+01	5.144E-02	5.142E-02
1.400E+01	5.269E-02	5.268E-02
1.500E+01	5.384E-02	5.383E-02
1.600E+01	5.499E-02	5.498E-02
1.800E+01	5.704E-02	5.703E-02
2.000E+01	5.893E-02	5.892E-02
2.200E+01	6.069E-02	6.068E-02
2.400E+01	6.233E-02	6.232E-02
2.600E+01	6.383E-02	6.382E-02
2.800E+01	6.524E-02	6.524E-02
3.000E+01	6.653E-02	6.653E-02
4.000E+01	7.201E-02	7.201E-02
5.000E+01	7.619E-02	7.619E-02
6.000E+01	7.949E-02	7.949E-02
8.000E+01	8.444E-02	8.444E-02
1.000E+02	8.796E-02	8.796E-02
1.500E+02	9.363E-02	9.363E-02
2.000E+02	9.702E-02	9.702E-02
3.000E+02	1.010E-01	1.010E-01
4.000E+02	1.033E-01	1.033E-01
5.000E+02	1.048E-01	1.048E-01
6.000E+02	1.059E-01	1.059E-01
8.000E+02	1.073E-01	1.073E-01
1.000E+03	1.082E-01	1.082E-01
1.500E+03	1.096E-01	1.096E-01
2.000E+03	1.103E-01	1.103E-01
3.000E+03	1.111E-01	1.111E-01
4.000E+03	1.115E-01	1.115E-01
5.000E+03	1.118E-01	1.118E-01
6.000E+03	1.120E-01	1.120E-01
8.000E+03	1.122E-01	1.122E-01
1.000E+04	1.124E-01	1.124E-01
1.500E+04	1.126E-01	1.126E-01
2.000E+04	1.128E-01	1.128E-01
3.000E+04	1.129E-01	1.129E-01
4.000E+04	1.129E-01	1.129E-01
5.000E+04	1.130E-01	1.130E-01
6.000E+04	1.130E-01	1.130E-01
8.000E+04	1.131E-01	1.131E-01
1.000E+05	1.131E-01	1.131E-01

Fig.9 Total attenuation of Tungsten from 1 MeV to 10^5 MeV

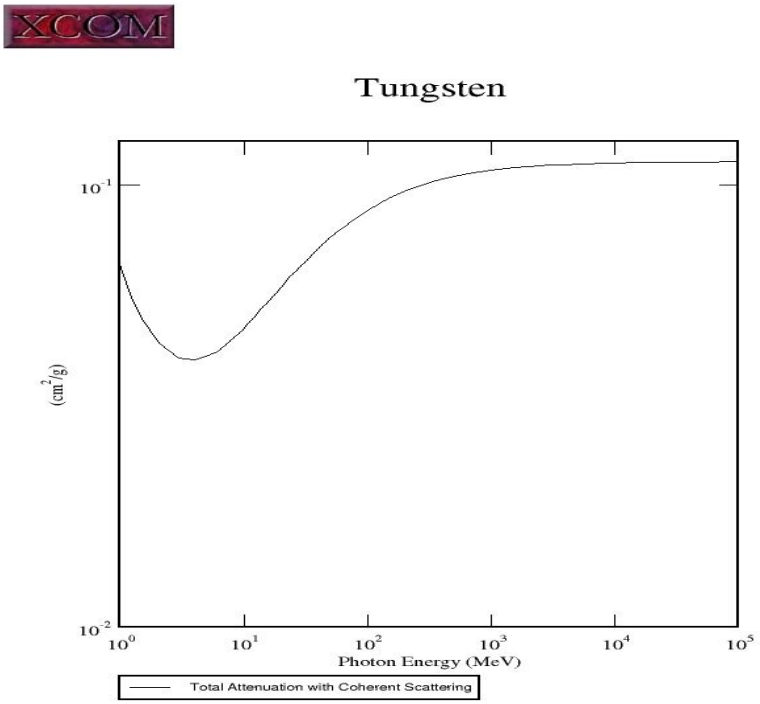

Fig.10 Total attenuation of Tungsten at various Photon Energies

E. Iron

Photon Energy	Tot. w/ Coherent	Tot. wo/ Coherent
1.000E+00	5.995E-02	5.951E-02
1.022E+00	5.928E-02	5.887E-02
1.250E+00	5.350E-02	5.322E-02
1.500E+00	4.883E-02	4.864E-02
2.000E+00	4.265E-02	4.254E-02
2.044E+00	4.224E-02	4.213E-02
3.000E+00	3.621E-02	3.616E-02
4.000E+00	3.312E-02	3.309E-02
5.000E+00	3.146E-02	3.144E-02
6.000E+00	3.057E-02	3.056E-02
7.000E+00	3.011E-02	3.010E-02
8.000E+00	2.991E-02	2.991E-02
9.000E+00	2.987E-02	2.986E-02
1.000E+01	2.994E-02	2.994E-02
1.100E+01	3.007E-02	3.007E-02
1.200E+01	3.025E-02	3.024E-02
1.300E+01	3.044E-02	3.044E-02
1.400E+01	3.068E-02	3.068E-02
1.500E+01	3.092E-02	3.092E-02
1.600E+01	3.118E-02	3.118E-02
1.800E+01	3.171E-02	3.170E-02
2.000E+01	3.224E-02	3.223E-02
2.200E+01	3.277E-02	3.277E-02
2.400E+01	3.327E-02	3.327E-02
2.600E+01	3.377E-02	3.377E-02
2.800E+01	3.423E-02	3.423E-02
3.000E+01	3.469E-02	3.469E-02
4.000E+01	3.666E-02	3.666E-02
5.000E+01	3.828E-02	3.828E-02
6.000E+01	3.961E-02	3.961E-02
8.000E+01	4.172E-02	4.172E-02
1.000E+02	4.329E-02	4.329E-02
1.500E+02	4.592E-02	4.592E-02
2.000E+02	4.756E-02	4.756E-02
3.000E+02	4.952E-02	4.952E-02
4.000E+02	5.069E-02	5.069E-02
5.000E+02	5.146E-02	5.146E-02
6.000E+02	5.202E-02	5.202E-02
8.000E+02	5.278E-02	5.278E-02
1.000E+03	5.327E-02	5.327E-02
1.500E+03	5.399E-02	5.399E-02
2.000E+03	5.438E-02	5.438E-02
3.000E+03	5.482E-02	5.482E-02
4.000E+03	5.505E-02	5.505E-02
5.000E+03	5.521E-02	5.521E-02
6.000E+03	5.530E-02	5.530E-02
8.000E+03	5.544E-02	5.544E-02
1.000E+04	5.552E-02	5.552E-02
1.500E+04	5.565E-02	5.565E-02
2.000E+04	5.572E-02	5.572E-02
3.000E+04	5.578E-02	5.578E-02
4.000E+04	5.581E-02	5.581E-02
5.000E+04	5.585E-02	5.585E-02
6.000E+04	5.586E-02	5.586E-02
8.000E+04	5.588E-02	5.588E-02
1.000E+05	5.589E-02	5.589E-02

Fig.11 Total attenuation of Iron from 1 MeV to 10^5 MeV

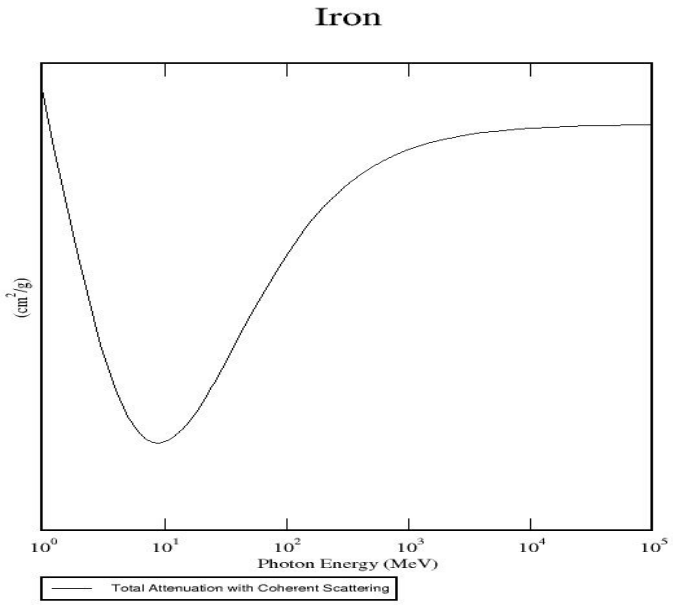

Fig.12 Total attenuation of Iron at various Photon Energies

F. Gold

Photon Energy	Tot. w/ Coherent	Tot. wo/ Coherent
1.000E+00	6.953E-02	6.672E-02
1.022E+00	6.820E-02	6.551E-02
1.250E+00	5.793E-02	5.612E-02
1.500E+00	5.167E-02	5.041E-02
2.000E+00	4.570E-02	4.498E-02
2.044E+00	4.536E-02	4.467E-02
3.000E+00	4.202E-02	4.170E-02
4.000E+00	4.166E-02	4.148E-02
5.000E+00	4.239E-02	4.228E-02
6.000E+00	4.355E-02	4.347E-02
7.000E+00	4.490E-02	4.485E-02
8.000E+00	4.633E-02	4.629E-02
9.000E+00	4.780E-02	4.776E-02
1.000E+01	4.926E-02	4.923E-02
1.100E+01	5.067E-02	5.065E-02
1.200E+01	5.209E-02	5.207E-02
1.300E+01	5.344E-02	5.342E-02
1.400E+01	5.476E-02	5.474E-02
1.500E+01	5.598E-02	5.597E-02
1.600E+01	5.717E-02	5.716E-02
1.800E+01	5.937E-02	5.936E-02
2.000E+01	6.136E-02	6.136E-02
2.200E+01	6.322E-02	6.321E-02
2.400E+01	6.493E-02	6.492E-02
2.600E+01	6.654E-02	6.654E-02
2.800E+01	6.800E-02	6.799E-02
3.000E+01	6.940E-02	6.939E-02
4.000E+01	7.517E-02	7.517E-02
5.000E+01	7.955E-02	7.955E-02
6.000E+01	8.303E-02	8.303E-02
8.000E+01	8.819E-02	8.819E-02
1.000E+02	9.191E-02	9.191E-02
1.500E+02	9.780E-02	9.780E-02
2.000E+02	1.014E-01	1.014E-01
3.000E+02	1.055E-01	1.055E-01
4.000E+02	1.079E-01	1.079E-01
5.000E+02	1.095E-01	1.095E-01
6.000E+02	1.106E-01	1.106E-01
8.000E+02	1.121E-01	1.121E-01
1.000E+03	1.131E-01	1.131E-01
1.500E+03	1.145E-01	1.145E-01
2.000E+03	1.152E-01	1.152E-01
3.000E+03	1.161E-01	1.161E-01
4.000E+03	1.165E-01	1.165E-01
5.000E+03	1.168E-01	1.168E-01
6.000E+03	1.170E-01	1.170E-01
8.000E+03	1.172E-01	1.172E-01
1.000E+04	1.174E-01	1.174E-01
1.500E+04	1.176E-01	1.176E-01
2.000E+04	1.178E-01	1.178E-01
3.000E+04	1.179E-01	1.179E-01
4.000E+04	1.180E-01	1.180E-01
5.000E+04	1.180E-01	1.180E-01
6.000E+04	1.180E-01	1.180E-01
8.000E+04	1.181E-01	1.181E-01
1.000E+05	1.181E-01	1.181E-01

Fig.13 Total attenuation of Gold from 1 MeV to 10^5 MeV

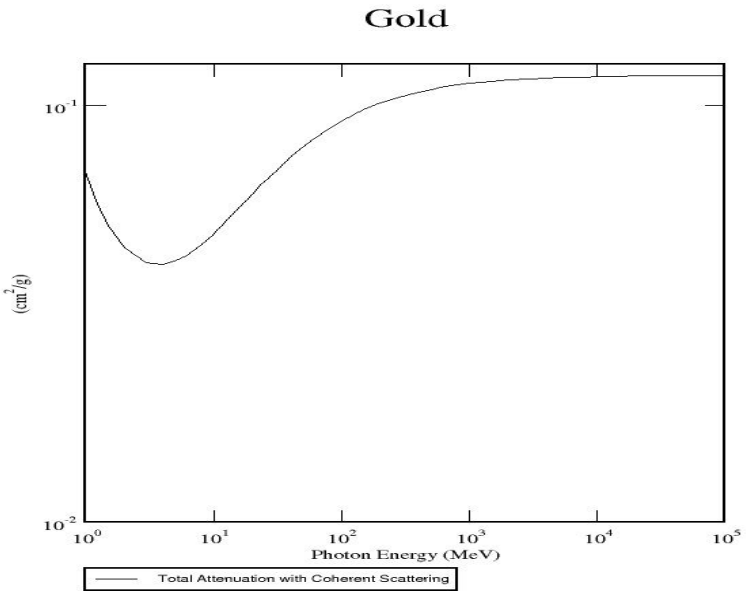

Fig.14 Total attenuation of Gold at various Photon Energies

G. Silver

Photon Energy	Tot. w/ Coherent	Tot. wo/ Coherent
1.000E+00	5.921E-02	5.804E-02
1.022E+00	5.844E-02	5.733E-02
1.250E+00	5.216E-02	5.141E-02
1.500E+00	4.754E-02	4.702E-02
2.000E+00	4.209E-02	4.180E-02
2.044E+00	4.176E-02	4.148E-02
3.000E+00	3.754E-02	3.741E-02
4.000E+00	3.606E-02	3.599E-02
5.000E+00	3.577E-02	3.573E-02
6.000E+00	3.601E-02	3.598E-02
7.000E+00	3.654E-02	3.652E-02
8.000E+00	3.723E-02	3.721E-02
9.000E+00	3.801E-02	3.800E-02
1.000E+01	3.883E-02	3.881E-02
1.100E+01	3.965E-02	3.964E-02
1.200E+01	4.047E-02	4.046E-02
1.300E+01	4.127E-02	4.126E-02
1.400E+01	4.204E-02	4.203E-02
1.500E+01	4.276E-02	4.276E-02
1.600E+01	4.348E-02	4.348E-02
1.800E+01	4.483E-02	4.483E-02
2.000E+01	4.609E-02	4.609E-02
2.200E+01	4.729E-02	4.729E-02
2.400E+01	4.840E-02	4.840E-02
2.600E+01	4.944E-02	4.944E-02
2.800E+01	5.040E-02	5.040E-02
3.000E+01	5.132E-02	5.131E-02
4.000E+01	5.513E-02	5.513E-02
5.000E+01	5.808E-02	5.808E-02
6.000E+01	6.044E-02	6.044E-02
8.000E+01	6.405E-02	6.405E-02
1.000E+02	6.665E-02	6.665E-02
1.500E+02	7.086E-02	7.086E-02
2.000E+02	7.341E-02	7.341E-02
3.000E+02	7.646E-02	7.646E-02
4.000E+02	7.818E-02	7.818E-02
5.000E+02	7.934E-02	7.934E-02
6.000E+02	8.019E-02	8.019E-02
8.000E+02	8.130E-02	8.130E-02
1.000E+03	8.205E-02	8.205E-02
1.500E+03	8.312E-02	8.312E-02
2.000E+03	8.365E-02	8.365E-02
3.000E+03	8.430E-02	8.430E-02
4.000E+03	8.463E-02	8.463E-02
5.000E+03	8.484E-02	8.484E-02
6.000E+03	8.501E-02	8.501E-02
8.000E+03	8.517E-02	8.517E-02
1.000E+04	8.533E-02	8.533E-02
1.500E+04	8.550E-02	8.550E-02
2.000E+04	8.561E-02	8.561E-02
3.000E+04	8.566E-02	8.566E-02
4.000E+04	8.572E-02	8.572E-02
5.000E+04	8.577E-02	8.577E-02
6.000E+04	8.577E-02	8.577E-02
8.000E+04	8.583E-02	8.583E-02
1.000E+05	8.583E-02	8.583E-02

Fig.15 Total attenuation of Silver from 1 MeV to 10^5 MeV

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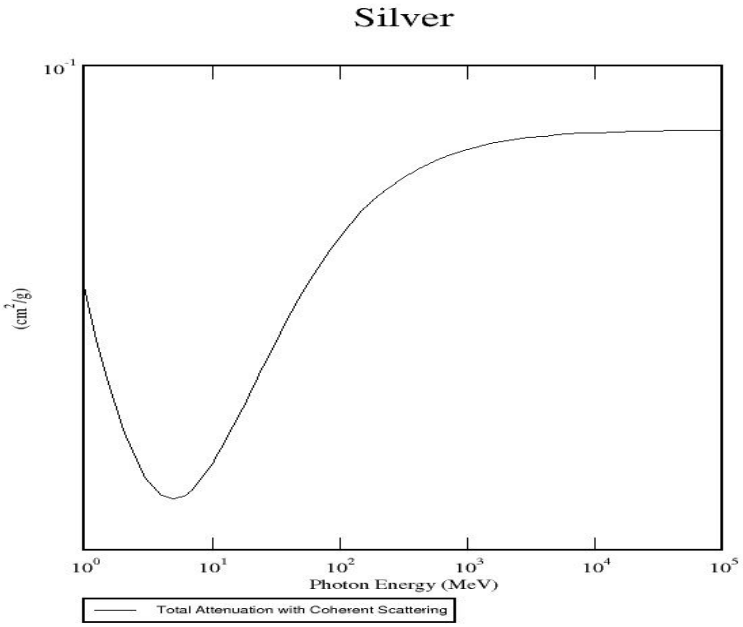

Fig.16 Total attenuation of Silver at various Photon Energies

H. Aluminum

Photon Energy	Tot. w/ Coherent	Tot. wo/ Coherent
1.000E+00	6.146E-02	6.132E-02
1.022E+00	6.080E-02	6.067E-02
1.250E+00	5.496E-02	5.486E-02
1.500E+00	5.006E-02	5.000E-02
2.000E+00	4.324E-02	4.320E-02
2.044E+00	4.277E-02	4.274E-02
3.000E+00	3.541E-02	3.539E-02
4.000E+00	3.106E-02	3.105E-02
5.000E+00	2.836E-02	2.836E-02
6.000E+00	2.655E-02	2.655E-02
7.000E+00	2.529E-02	2.528E-02
8.000E+00	2.437E-02	2.437E-02
9.000E+00	2.369E-02	2.369E-02
1.000E+01	2.318E-02	2.318E-02
1.100E+01	2.279E-02	2.279E-02
1.200E+01	2.249E-02	2.249E-02
1.300E+01	2.226E-02	2.225E-02
1.400E+01	2.208E-02	2.208E-02
1.500E+01	2.195E-02	2.195E-02
1.600E+01	2.185E-02	2.184E-02
1.800E+01	2.173E-02	2.173E-02
2.000E+01	2.168E-02	2.168E-02
2.200E+01	2.168E-02	2.168E-02
2.400E+01	2.172E-02	2.172E-02
2.600E+01	2.179E-02	2.179E-02
2.800E+01	2.187E-02	2.187E-02
3.000E+01	2.196E-02	2.196E-02
4.000E+01	2.251E-02	2.251E-02
5.000E+01	2.306E-02	2.306E-02
6.000E+01	2.358E-02	2.358E-02
8.000E+01	2.447E-02	2.447E-02
1.000E+02	2.517E-02	2.517E-02
1.500E+02	2.641E-02	2.641E-02
2.000E+02	2.724E-02	2.724E-02
3.000E+02	2.825E-02	2.825E-02
4.000E+02	2.888E-02	2.888E-02
5.000E+02	2.931E-02	2.931E-02
6.000E+02	2.961E-02	2.961E-02
8.000E+02	3.004E-02	3.004E-02
1.000E+03	3.032E-02	3.032E-02
1.500E+03	3.074E-02	3.074E-02
2.000E+03	3.098E-02	3.098E-02
3.000E+03	3.123E-02	3.123E-02
4.000E+03	3.139E-02	3.139E-02
5.000E+03	3.148E-02	3.148E-02
6.000E+03	3.154E-02	3.154E-02
8.000E+03	3.161E-02	3.161E-02
1.000E+04	3.168E-02	3.168E-02
1.500E+04	3.175E-02	3.175E-02
2.000E+04	3.179E-02	3.179E-02
3.000E+04	3.182E-02	3.182E-02
4.000E+04	3.184E-02	3.184E-02
5.000E+04	3.186E-02	3.186E-02
6.000E+04	3.186E-02	3.186E-02
8.000E+04	3.189E-02	3.189E-02
1.000E+05	3.189E-02	3.189E-02

Fig.17 Total attenuation of Aluminum from 1 MeV to 10^5 MeV

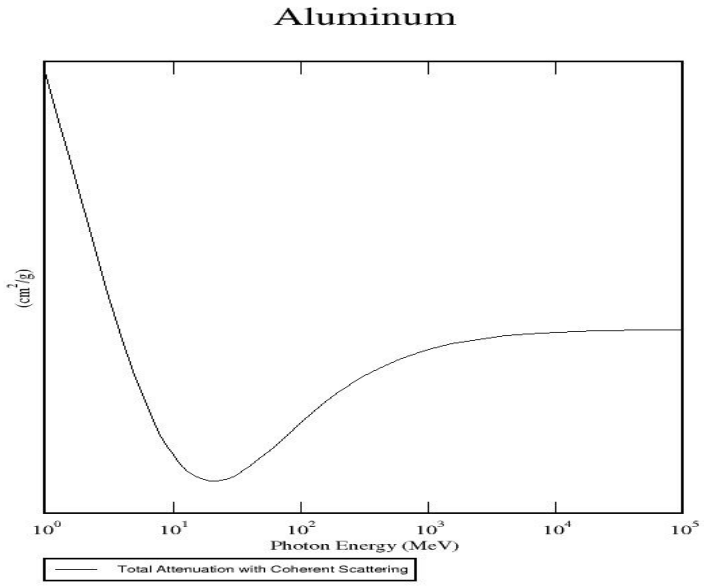

Fig.18 Total attenuation of Aluminum at various Photon Energies

I. Mercury

Photon Energy	Tot. w/ Coherent	Tot. wo/ Coherent
1.000E+00	6.993E-02	6.706E-02
1.022E+00	6.859E-02	6.584E-02
1.250E+00	5.813E-02	5.628E-02
1.500E+00	5.179E-02	5.050E-02
2.000E+00	4.575E-02	4.502E-02
2.044E+00	4.544E-02	4.474E-02
3.000E+00	4.207E-02	4.175E-02
4.000E+00	4.172E-02	4.154E-02
5.000E+00	4.246E-02	4.234E-02
6.000E+00	4.362E-02	4.354E-02
7.000E+00	4.498E-02	4.492E-02
8.000E+00	4.643E-02	4.639E-02
9.000E+00	4.788E-02	4.785E-02
1.000E+01	4.937E-02	4.934E-02
1.100E+01	5.080E-02	5.078E-02
1.200E+01	5.221E-02	5.219E-02
1.300E+01	5.356E-02	5.354E-02
1.400E+01	5.487E-02	5.486E-02
1.500E+01	5.613E-02	5.611E-02
1.600E+01	5.732E-02	5.731E-02
1.800E+01	5.953E-02	5.952E-02
2.000E+01	6.154E-02	6.153E-02
2.200E+01	6.338E-02	6.337E-02
2.400E+01	6.511E-02	6.511E-02
2.600E+01	6.672E-02	6.672E-02
2.800E+01	6.821E-02	6.820E-02
3.000E+01	6.961E-02	6.960E-02
4.000E+01	7.538E-02	7.538E-02
5.000E+01	7.979E-02	7.979E-02
6.000E+01	8.329E-02	8.329E-02
8.000E+01	8.850E-02	8.850E-02
1.000E+02	9.221E-02	9.221E-02
1.500E+02	9.814E-02	9.814E-02
2.000E+02	1.017E-01	1.017E-01
3.000E+02	1.059E-01	1.059E-01
4.000E+02	1.083E-01	1.083E-01
5.000E+02	1.098E-01	1.098E-01
6.000E+02	1.110E-01	1.110E-01
8.000E+02	1.125E-01	1.125E-01
1.000E+03	1.135E-01	1.135E-01
1.500E+03	1.149E-01	1.149E-01
2.000E+03	1.156E-01	1.156E-01
3.000E+03	1.165E-01	1.165E-01
4.000E+03	1.169E-01	1.169E-01
5.000E+03	1.172E-01	1.172E-01
6.000E+03	1.174E-01	1.174E-01
8.000E+03	1.176E-01	1.176E-01
1.000E+04	1.178E-01	1.178E-01
1.500E+04	1.181E-01	1.181E-01
2.000E+04	1.182E-01	1.182E-01
3.000E+04	1.183E-01	1.183E-01
4.000E+04	1.184E-01	1.184E-01
5.000E+04	1.184E-01	1.184E-01
6.000E+04	1.184E-01	1.184E-01
8.000E+04	1.185E-01	1.185E-01
1.000E+05	1.185E-01	1.185E-01

Fig.19 Total attenuation of Mercury from 1 MeV to 10^5 MeV

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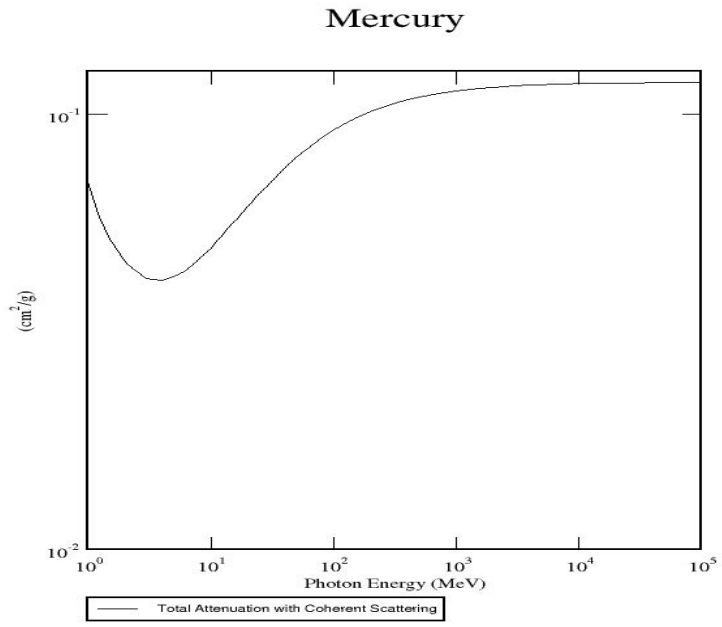

Fig.20 Total attenuation of Mercury at various Photon Energies

J. Copper

Photon Energy	Tot. w/ Coherent	Tot. wo/ Coherent
1.000E+00	5.901E-02	5.848E-02
1.022E+00	5.834E-02	5.784E-02
1.250E+00	5.261E-02	5.228E-02
1.500E+00	4.803E-02	4.780E-02
2.000E+00	4.205E-02	4.191E-02
2.044E+00	4.166E-02	4.153E-02
3.000E+00	3.599E-02	3.593E-02
4.000E+00	3.318E-02	3.315E-02
5.000E+00	3.177E-02	3.175E-02
6.000E+00	3.108E-02	3.106E-02
7.000E+00	3.080E-02	3.078E-02
8.000E+00	3.074E-02	3.073E-02
9.000E+00	3.084E-02	3.083E-02
1.000E+01	3.103E-02	3.102E-02
1.100E+01	3.127E-02	3.126E-02
1.200E+01	3.154E-02	3.153E-02
1.300E+01	3.183E-02	3.182E-02
1.400E+01	3.215E-02	3.215E-02
1.500E+01	3.247E-02	3.247E-02
1.600E+01	3.279E-02	3.279E-02
1.800E+01	3.344E-02	3.344E-02
2.000E+01	3.408E-02	3.408E-02
2.200E+01	3.470E-02	3.470E-02
2.400E+01	3.530E-02	3.530E-02
2.600E+01	3.588E-02	3.587E-02
2.800E+01	3.642E-02	3.642E-02
3.000E+01	3.694E-02	3.694E-02
4.000E+01	3.920E-02	3.920E-02
5.000E+01	4.103E-02	4.103E-02
6.000E+01	4.253E-02	4.253E-02
8.000E+01	4.486E-02	4.486E-02
1.000E+02	4.659E-02	4.659E-02
1.500E+02	4.943E-02	4.943E-02
2.000E+02	5.118E-02	5.118E-02
3.000E+02	5.326E-02	5.326E-02
4.000E+02	5.448E-02	5.448E-02
5.000E+02	5.529E-02	5.529E-02
6.000E+02	5.587E-02	5.587E-02
8.000E+02	5.665E-02	5.665E-02
1.000E+03	5.717E-02	5.717E-02
1.500E+03	5.790E-02	5.790E-02
2.000E+03	5.831E-02	5.831E-02
3.000E+03	5.875E-02	5.875E-02
4.000E+03	5.899E-02	5.899E-02
5.000E+03	5.913E-02	5.913E-02
6.000E+03	5.924E-02	5.924E-02
8.000E+03	5.938E-02	5.938E-02
1.000E+04	5.947E-02	5.947E-02
1.500E+04	5.959E-02	5.959E-02
2.000E+04	5.965E-02	5.965E-02
3.000E+04	5.973E-02	5.973E-02
4.000E+04	5.976E-02	5.976E-02
5.000E+04	5.978E-02	5.978E-02
6.000E+04	5.979E-02	5.979E-02
8.000E+04	5.982E-02	5.982E-02
1.000E+05	5.983E-02	5.983E-02

Fig.21 Total attenuation of Copper from 1 MeV to 10^5 MeV

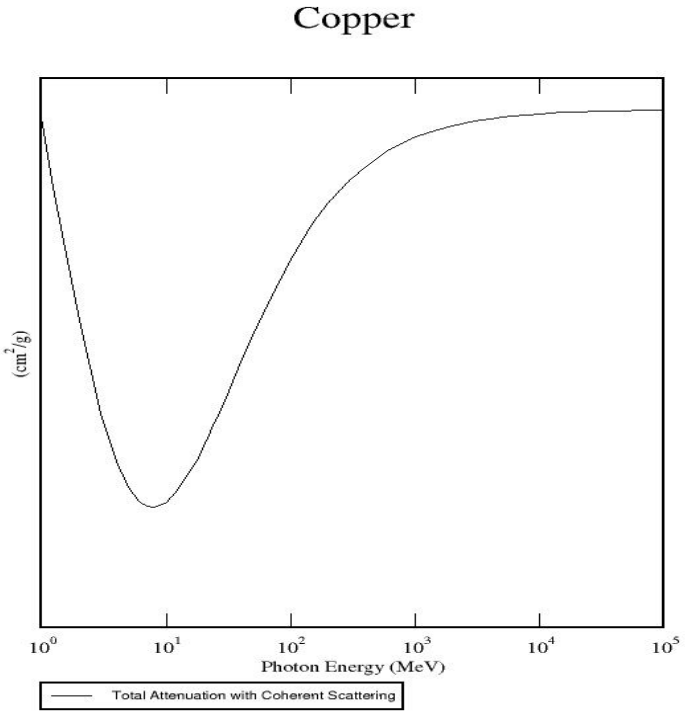

Fig.22 Total attenuation of Copper at various Photon Energies

V. CONCLUSION

The total attenuation for the earlier said elements were computed using the WinXCom computer program. Although a lot of elements had density higher than lead, from 1 MeV to 10^5 MeV photon energy, lead showed the best total attenuation results as shown in the tables and graphs. Lead is also highly feasible and hence its common use in radiation shielding is justified. The total attenuation of the commonly used metals such as iron, aluminum and copper were lower than that of lead. Although the total attenuation of some elements were near the value lead, they are not feasible since their cost is very high. Hence, until an economical material is proposed for radiation shielding, the use of lead as radiation shielding will continue.

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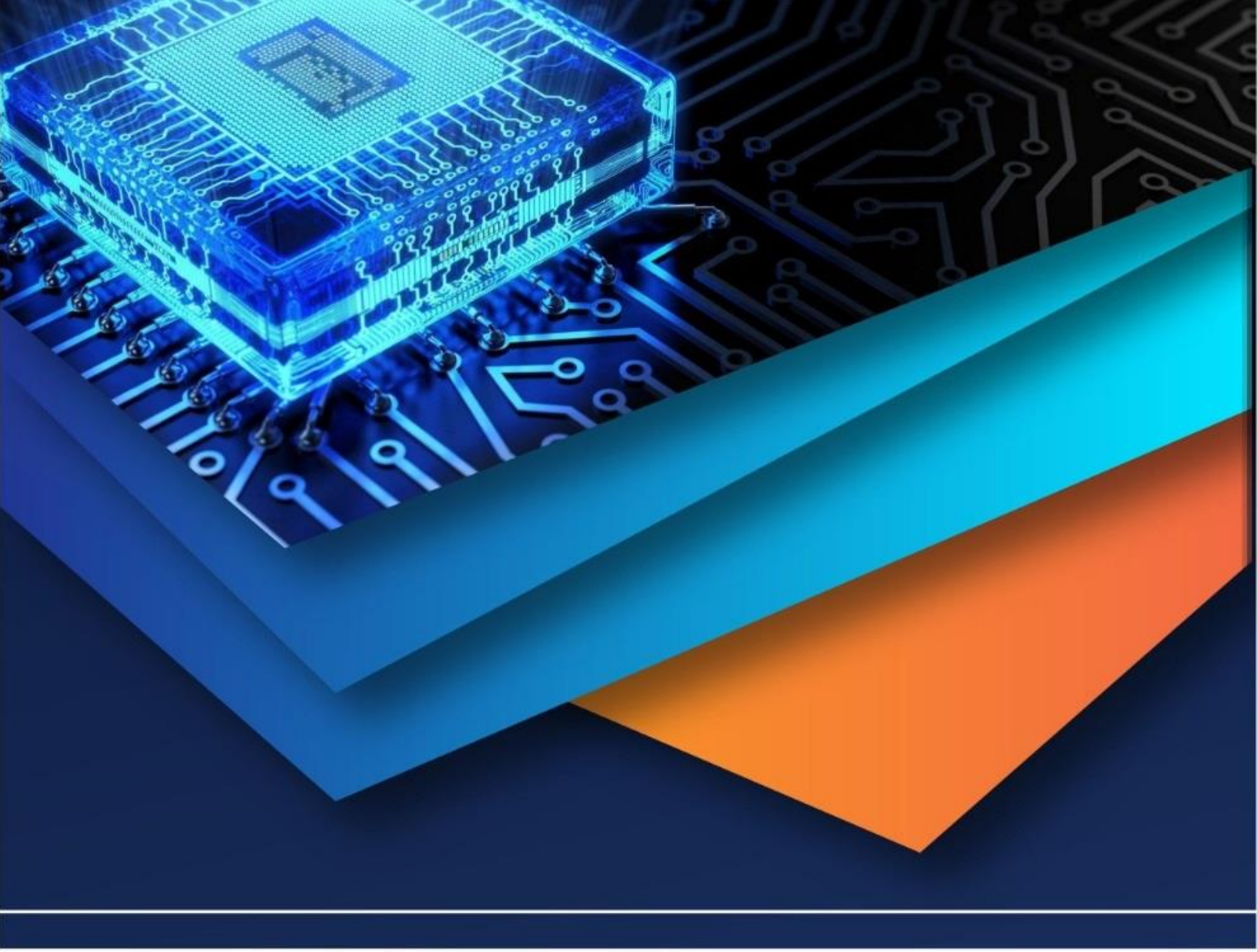

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