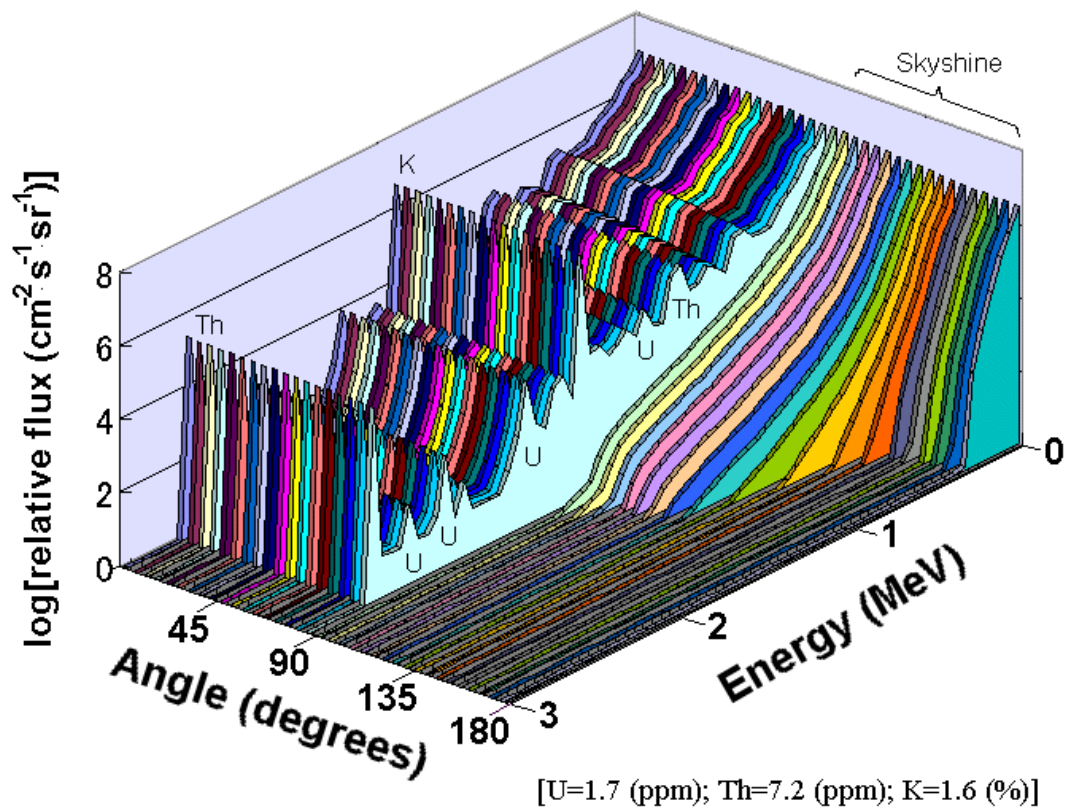


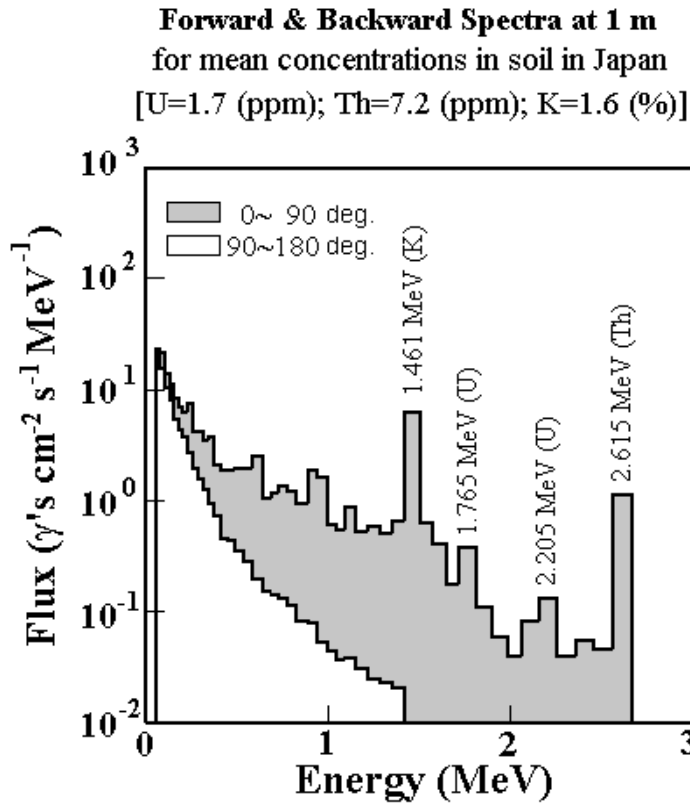
Terrestrial γ Ray Field at 1 m above the Ground



土壌一様線源によるエネルギー分布 1 Energy distribution of terrestrial gamma rays 1

MONARIZA/G2 (Volume source)								
Detector at 1 m above the ground								
1,000,000 histories each								
Bin No.	Energy (MeV)				Flux (/cm ² .s.MeV)			
	E _l	E _u	<E>	ΔE	1% K	1 ppm U	1 ppm Th	
1	0.050	0.075	0.063	0.025	7.17E+00	5.93E+00	3.16E+00	
2	0.075	0.100	0.087	0.025	6.29E+00	4.90E+00	2.65E+00	
3	0.100	0.125	0.113	0.025	4.73E+00	3.44E+00	1.63E+00	
4	0.125	0.150	0.138	0.025	3.70E+00	2.58E+00	1.20E+00	
5	0.150	0.175	0.162	0.025	2.75E+00	2.06E+00	9.08E-01	
6	0.175	0.200	0.188	0.025	2.19E+00	1.72E+00	7.13E-01	
7	0.200	0.228	0.214	0.028	1.98E+00	1.25E+00	6.38E-01	
8	0.228	0.252	0.240	0.024	1.70E+00	1.24E+00	7.82E-01	
9	0.252	0.281	0.267	0.029	1.39E+00	8.81E-01	3.73E-01	
10	0.281	0.309	0.295	0.028	1.12E+00	1.05E+00	3.00E-01	
11	0.309	0.337	0.323	0.028	9.64E-01	5.47E-01	2.81E-01	
12	0.337	0.367	0.352	0.030	8.29E-01	1.04E+00	2.30E-01	
13	0.367	0.406	0.387	0.039	6.76E-01	3.27E-01	1.70E-01	
14	0.406	0.445	0.425	0.039	6.09E-01	3.14E-01	1.50E-01	
15	0.445	0.490	0.468	0.045	5.44E-01	2.87E-01	1.45E-01	
16	0.490	0.530	0.510	0.040	4.52E-01	2.40E-01	1.54E-01	
17	0.530	0.584	0.557	0.054	4.22E-01	2.32E-01	1.68E-01	
18	0.584	0.638	0.611	0.054	3.60E-01	7.13E-01	1.26E-01	
19	0.638	0.685	0.661	0.047	3.33E-01	1.38E-01	5.74E-02	
20	0.685	0.728	0.707	0.043	2.98E-01	1.13E-01	7.74E-02	
21	0.728	0.770	0.749	0.042	2.90E-01	1.57E-01	8.82E-02	
22	0.770	0.822	0.796	0.052	2.86E-01	1.39E-01	8.44E-02	
23	0.822	0.886	0.854	0.064	2.72E-01	7.51E-02	7.09E-02	
24	0.886	0.936	0.911	0.050	2.57E-01	9.57E-02	2.02E-01	
25	0.936	0.996	0.966	0.060	2.30E-01	8.84E-02	1.55E-01	
26	0.996	1.042	1.019	0.046	2.53E-01	6.52E-02	1.96E-02	
27	1.042	1.087	1.065	0.045	2.16E-01	7.07E-02	2.07E-02	
28	1.087	1.153	1.120	0.066	2.45E-01	2.76E-01	1.54E-02	
29	1.153	1.220	1.187	0.067	2.19E-01	8.11E-02	1.24E-02	
30	1.220	1.288	1.254	0.068	2.13E-01	1.16E-01	1.66E-02	
31	1.288	1.355	1.321	0.067	2.21E-01	5.15E-02	1.16E-02	
32	1.355	1.422	1.389	0.067	2.18E-01	1.51E-01	1.10E-02	
33	1.422	1.500	1.461	0.078	4.06E+00	4.52E-02	2.10E-02	
34	1.500	1.574	1.537	0.074	0.00E+00	6.03E-02	2.60E-02	
35	1.574	1.647	1.611	0.073	0.00E+00	4.25E-02	5.40E-02	
36	1.647	1.721	1.684	0.074	0.00E+00	5.57E-02	1.50E-02	
37	1.721	1.809	1.765	0.088	0.00E+00	2.24E-01	5.88E-03	
38	1.809	1.895	1.852	0.086	0.00E+00	4.34E-02	6.34E-03	
39	1.895	1.982	1.938	0.087	0.00E+00	6.65E-03	6.17E-03	
40	1.982	2.067	2.025	0.085	0.00E+00	4.10E-03	5.24E-03	
41	2.067	2.154	2.111	0.087	0.00E+00	2.17E-02	5.03E-03	
42	2.154	2.256	2.205	0.102	0.00E+00	6.04E-02	5.63E-03	
43	2.256	2.356	2.306	0.100	0.00E+00	4.42E-03	5.23E-03	
44	2.356	2.458	2.407	0.102	0.00E+00	1.33E-02	5.17E-03	
45	2.458	2.558	2.508	0.100	0.00E+00	8.94E-03	5.53E-03	
46	2.558	2.672	2.615	0.114	0.00E+00	0.00E+00	1.57E-01	
47	2.672	2.786	2.729	0.114	0.00E+00	0.00E+00	0.00E+00	

土壌一様線源によるエネルギー分布 2 Energy distribution of terrestrial gamma rays 2



土壌一様線源による高度分布 Height distribution of terrestrial gamma rays

Uniformly distributed volume source

Gamma ray flux and dose rate in air
 (% relative to 1 m values)

	Height (meters)					
	0	1	10	30	100	300
Flux						
K-40	101	100	98	88	65	21
U-238 series	101	100	93	83	60	14
Th-232 series	101	100	93	82	59	16
Typical natural field	101	100	95	86	61	18
Dose rate						
K-40	102	100	89	74	44	12
U-238 series	102	100	89	73	42	10
Th-232 series	102	100	89	74	43	12
Typical natural field	102	100	89	74	44	12

Beck, H.L. (1975) The physics of environmental gamma radiation fields, Natural Radiation Environment II, Vol. 1, pp.101-133, USERDA Report CONF-720805-P1.

土壤一様線源による角度分布 1 Angular distribution of terrestrial gamma rays 1

Uniformly distributed volume source

Gamma rays at 1 m above ground level

*** MONARIZA/G2 *** 1% K

--- At 100 (cm) ---

Angle (Degrees)	Flux ($\text{cm}^{-2}\cdot\text{s}\cdot\text{sr}$)	Dose Rate (nGy/h/sr)
0 - 10	1.720E-01	1.910E+00
10 - 20	1.760E-01	1.872E+00
20 - 30	1.823E-01	1.955E+00
30 - 40	1.829E-01	1.931E+00
40 - 50	1.816E-01	2.043E+00
50 - 60	1.781E-01	1.999E+00
60 - 70	1.666E-01	1.864E+00
70 - 80	1.579E-01	1.776E+00
80 - 90	1.613E-01	1.728E+00
90 - 100	9.539E-02	4.298E-01
100 - 110	8.058E-02	2.896E-01
110 - 120	7.442E-02	2.315E-01
120 - 130	7.217E-02	1.889E-01
130 - 140	6.550E-02	1.512E-01
140 - 150	6.064E-02	1.338E-01
150 - 160	6.013E-02	1.246E-01
160 - 170	5.849E-02	1.185E-01
170 - 180	5.326E-02	1.159E-01

*** MONARIZA/G2 *** 1 ppm U

--- At 100 (cm) ---

Angle (Degrees)	Flux ($\text{cm}^{-2}\cdot\text{s}\cdot\text{sr}$)	Dose Rate (nGy/h/sr)
0 - 10	1.059E-01	7.691E-01
10 - 20	1.097E-01	7.693E-01
20 - 30	1.107E-01	8.020E-01
30 - 40	1.078E-01	7.975E-01
40 - 50	1.073E-01	7.663E-01
50 - 60	1.092E-01	8.257E-01
60 - 70	1.018E-01	7.675E-01
70 - 80	9.967E-02	7.282E-01
80 - 90	8.991E-02	6.478E-01
90 - 100	6.347E-02	1.915E-01
100 - 110	5.113E-02	1.350E-01
110 - 120	4.618E-02	1.050E-01
120 - 130	4.257E-02	8.934E-02
130 - 140	3.903E-02	7.857E-02
140 - 150	3.791E-02	7.431E-02
150 - 160	3.822E-02	6.879E-02
160 - 170	3.912E-02	7.064E-02
170 - 180	3.866E-02	6.886E-02

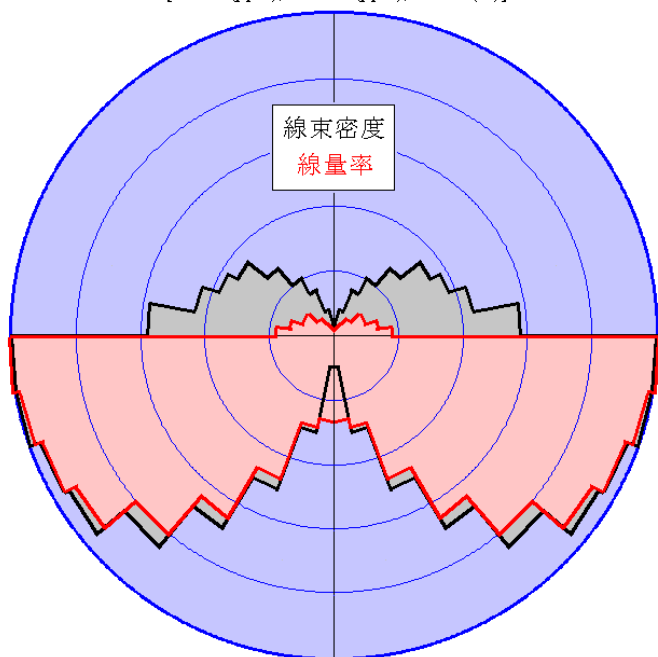
*** MONARIZA/G2 *** 1 ppm Th

--- At 100 (cm) ---

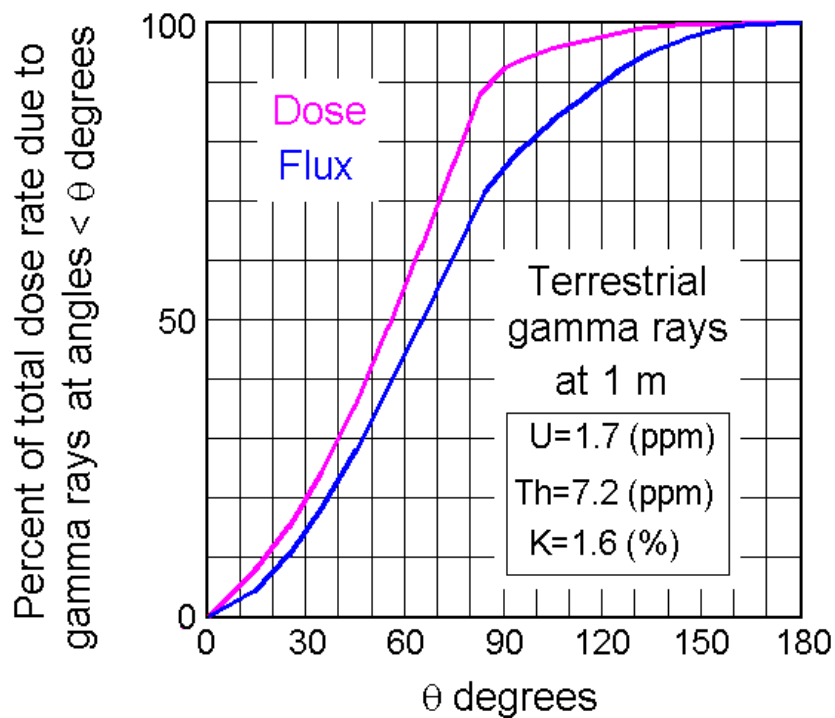
Angle (Degrees)	Flux ($\text{cm}^{-2}\cdot\text{s}\cdot\text{sr}$)	Dose Rate (nGy/h/sr)
0 - 10	5.182E-02	3.891E-01
10 - 20	5.391E-02	3.992E-01
20 - 30	5.396E-02	4.043E-01
30 - 40	5.300E-02	3.929E-01
40 - 50	5.303E-02	3.972E-01
50 - 60	5.208E-02	4.069E-01
60 - 70	4.676E-02	3.759E-01
70 - 80	4.684E-02	3.539E-01
80 - 90	4.528E-02	3.494E-01
90 - 100	2.861E-02	8.655E-02
100 - 110	2.395E-02	6.630E-02
110 - 120	2.177E-02	5.054E-02
120 - 130	2.082E-02	4.338E-02
130 - 140	1.883E-02	3.665E-02
140 - 150	1.828E-02	3.550E-02
150 - 160	1.797E-02	3.192E-02
160 - 170	1.739E-02	3.211E-02
170 - 180	1.550E-02	2.661E-02

土壤一様線源による角度分布 2 Angular distribution of terrestrial gamma rays 2

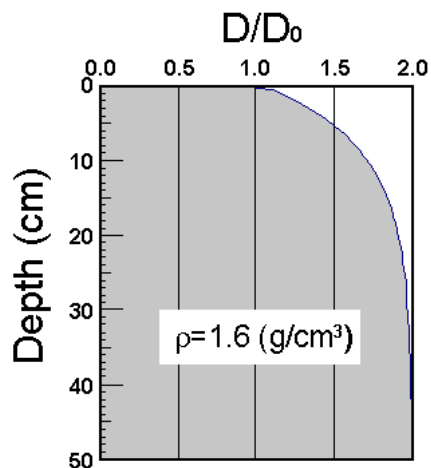
地表 γ 線の角度分布
 (10° 当たり全方位角:地上1m)
 [U=1.7 (ppm); Th=7.2 (ppm); K=1.6 (%)]



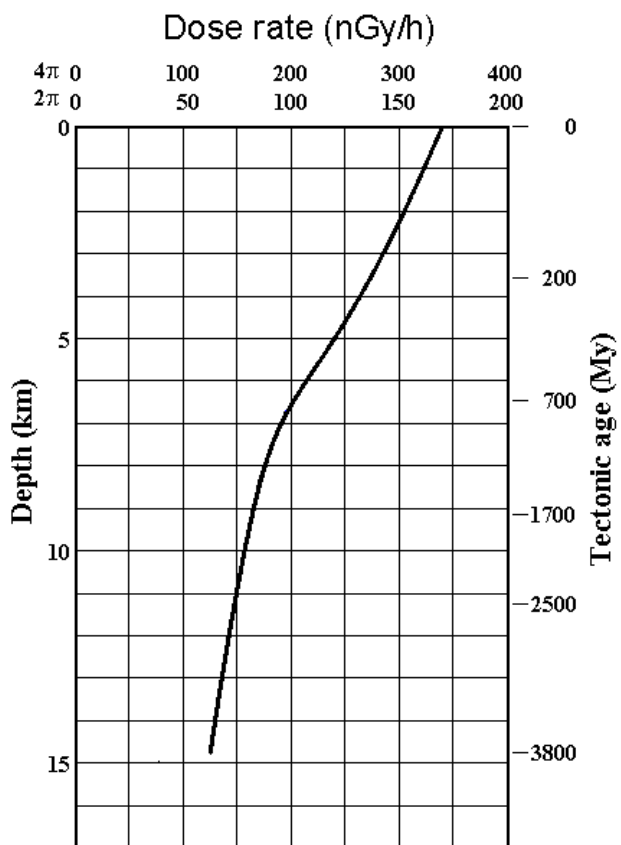
土壤一様線源による角度分布 3 Angular distribution of terrestrial gamma rays 3



土壌一様線源による線量率の深さ分布 Depth distribution of terrestrial gamma ray dose rate

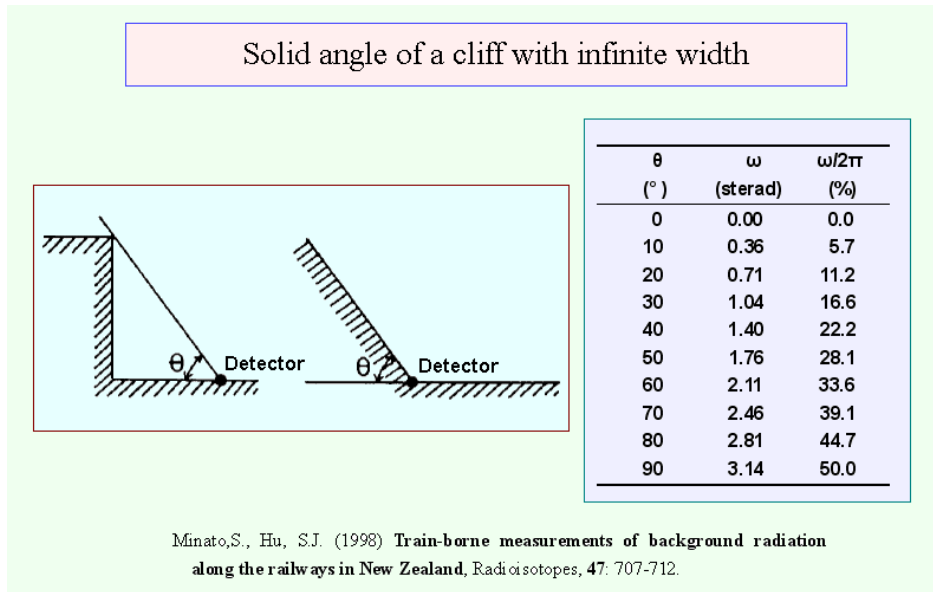


大深度地下での自然 γ 線量率 Natural gamma ray dose rate at large depths



漢 進 (2004) 地殻侵食モデルによる地下 15 km
 までの自然ガンマ線量率の推定, 放地研特別寄稿
 シリーズ, SCS-0002, 放射線地学研究所

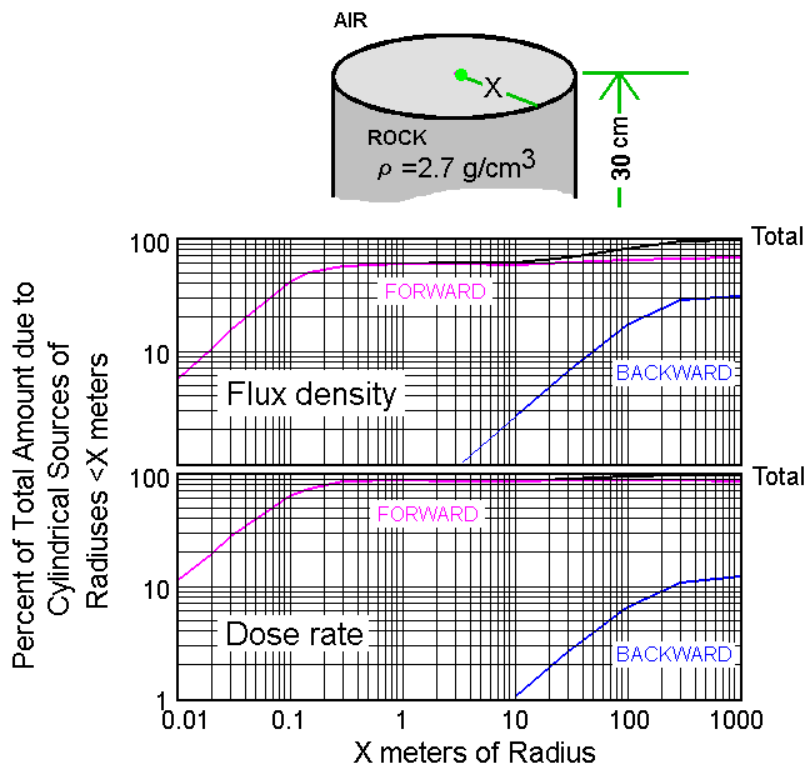
崖の立体角 Solid angle of a cliff



有限物質表面 (例えば岩石) Finite material surface (e.g. Rock surface)

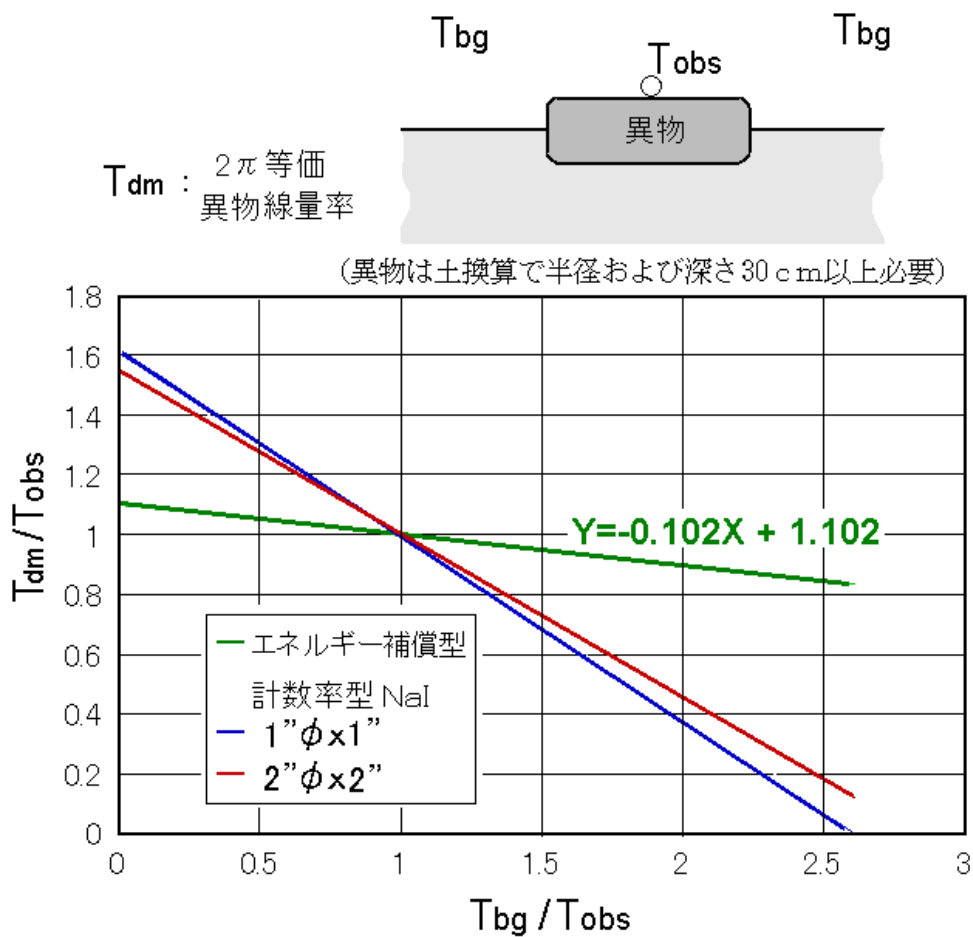
Detector at the center of the front surface of a cylindrical source

Rock density = 2.7 g/cm^3 [Typical rock composition]

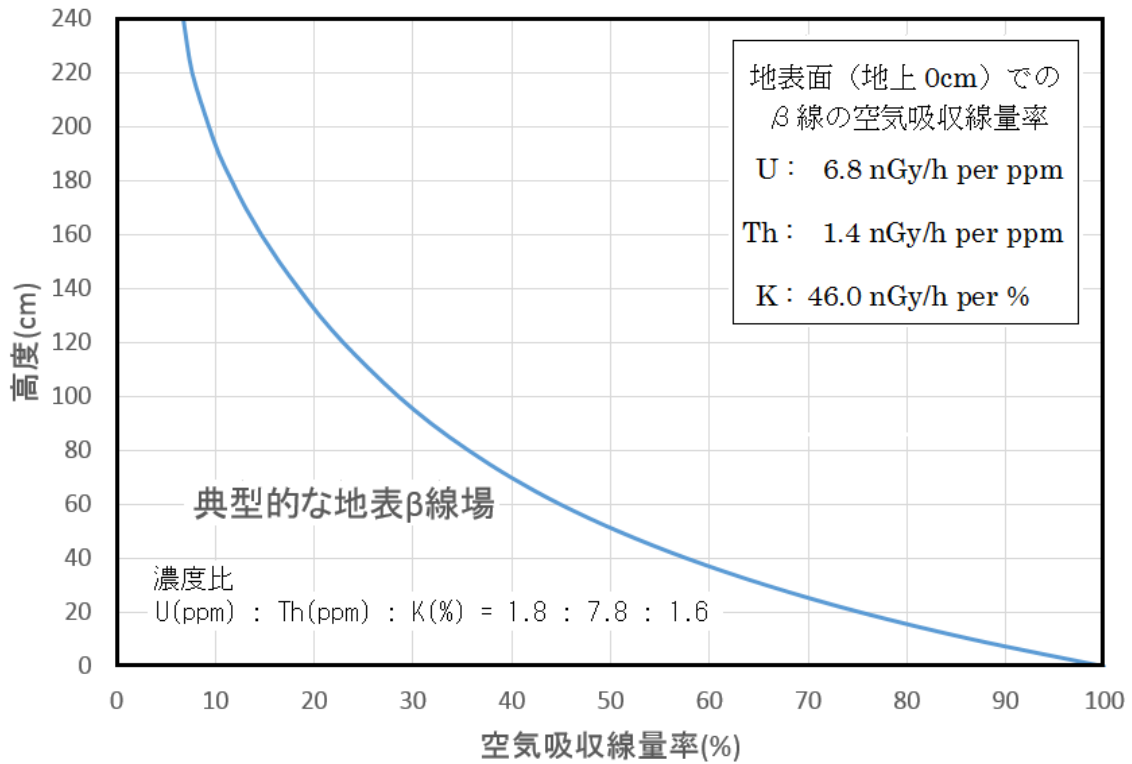


有限異物測定から 2π 等価 (半無限) 線量率を計算する方法 Method to calculate 2π equivalent (Semi-infinite) dose rate from a finite material measurement

有限異物表面での線量率から 2π 等価線量率を計算する方法



土壤一様線源による地表β線の高度分布 Height distribution of terrestrial beta rays



Deduced from

Minato,S., Hayashi,K., Ikebe,Y. (1978) **Numerical evaluation of terrestrial beta radiation field in natural environment**, Health Physics, 34: 673-683.

* 地表β線量率の簡易計算法

測定地点の地表γ線量率を D_γ (nGy/h) とする (D_γ は地表面から地上数 m までは一定とみて差し支えない)。地表面（地上 0m）でのβ線量率は

$$D_\beta(0) \approx 1.9D_\gamma \quad (\text{nGy/h})$$

と表される。この値と上図から高度分布を計算できる。