

Neutron shielding concrete - 2

V.Giusti, R.Ciolini

University of Pisa / INFN

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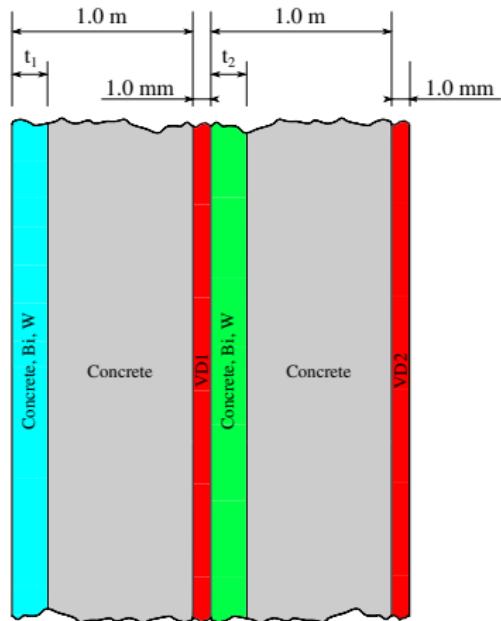
Geometry

A pencil beam of monoenergetic neutrons strikes normally on a shield made of two slabs, 1 m each. Two virtual detectors, 1 mm thick, are located between the slabs (VD1) and downstream the shield (VD2). Neutrons and photons entering the virtual detectors are counted.

Borated baryte concrete (1%w B₄C) is the reference material for the shield.

To improve the shielding performance, part of the concrete (layers t_1 and t_2) has been replaced by Bi and/or W.

Table below summarizes thicknesses, materials and energy values considered for the layers t_1 and t_2 .



Layer thickness (cm)	Layer material	Beam energy (MeV)
0, 10, 20	Bi, W	10.0, 100.0

Neutron counts

Reference case is configuration #1:

Two slabs of borated baryte concrete (1%w B₄C). Each slab is 1m thick.

#	Material & thickness		Incident neutron energy: 10 MeV				Incident neutron energy: 100 MeV			
	t ₁	t ₂	VD1	VD2	VD1	VD2	VD1	VD2	VD1	VD2
1	None ^a	None ^a	5.396E-04	0.4%	2.228E-08	41.8%	2.212E-01	0.0%	7.345E-03	0.1%
2	None ^a	Bi, 20cm	6.998E-04	0.4%	2.612E-08	40.3%	4.526E-01	0.0%	4.164E-03	0.2%
3	Bi, 10cm	Bi, 10cm	6.335E-04	0.4%	1.704E-08	45.4%	2.740E-01	0.0%	4.160E-03	0.2%
4	Bi, 20cm	Bi, 20cm	6.793E-04	0.5%	4.501E-08	33.5%	2.624E-01	0.0%	2.364E-03	0.3%
5	Bi, 10cm	W, 10cm	6.150E-04	0.4%	7.479E-09	72.1%	2.941E-01	0.0%	2.476E-03	0.3%
6	Bi, 20cm	W, 20cm	6.223E-04	0.4%	0.000E+00	0.0%	2.424E-01	0.0%	8.349E-04	0.4%
7	None ^a	W, 20cm	6.399E-04	0.4%	0.000E+00	0.0%	4.178E-01	0.0%	1.464E-03	0.3%
8	W, 10cm	W, 10cm	2.103E-04	0.8%	0.000E+00	0.0%	1.849E-01	0.1%	1.534E-03	0.3%
9	W, 20cm	W, 20cm	7.023E-05	1.3%	0.000E+00	0.0%	9.465E-02	0.1%	3.150E-04	0.7%
10	W, 10cm	Bi, 10cm	2.160E-04	0.8%	6.700E-09	70.9%	1.723E-01	0.1%	2.588E-03	0.2%
11	W, 20cm	Bi, 20cm	7.626E-05	1.4%	0.000E+00	0.0%	1.025E-01	0.1%	8.988E-04	0.4%

#	Material & thickness		Incident neutron energy: 10 MeV				Incident neutron energy: 100 MeV			
	t ₁	t ₂	VD1 ^b	VD2 ^b	VD1 ^b	VD2 ^b	VD1 ^b	VD2 ^b	VD1 ^b	VD2 ^b
1	None ^a	None ^a	-	-	-	-	-	-	-	-
2	None ^a	Bi, 20cm	29.7%	17.2%	104.6%	-	-	-	-	-
3	Bi, 10cm	Bi, 10cm	17.4%	-23.5%	23.9%	-	-	-	-	-
4	Bi, 20cm	Bi, 20cm	25.9%	102.0%	18.7%	-	-	-	-	-
5	Bi, 10cm	W, 10cm	14.0%	-66.4%	33.0%	-	-	-	-	-
6	Bi, 20cm	W, 20cm	15.3%	-100.0%	9.6%	-	-	-	-	-
7	None ^a	W, 20cm	18.6%	-100.0%	88.9%	-	-	-	-	-
8	W, 10cm	W, 10cm	-61.0%	-100.0%	-16.4%	-	-	-	-	-
9	W, 20cm	W, 20cm	-87.0%	-100.0%	-57.2%	-	-	-	-	-
10	W, 10cm	Bi, 10cm	-60.0%	-69.9%	-22.1%	-	-	-	-	-
11	W, 20cm	Bi, 20cm	-85.9%	-100.0%	-53.6%	-	-	-	-	-

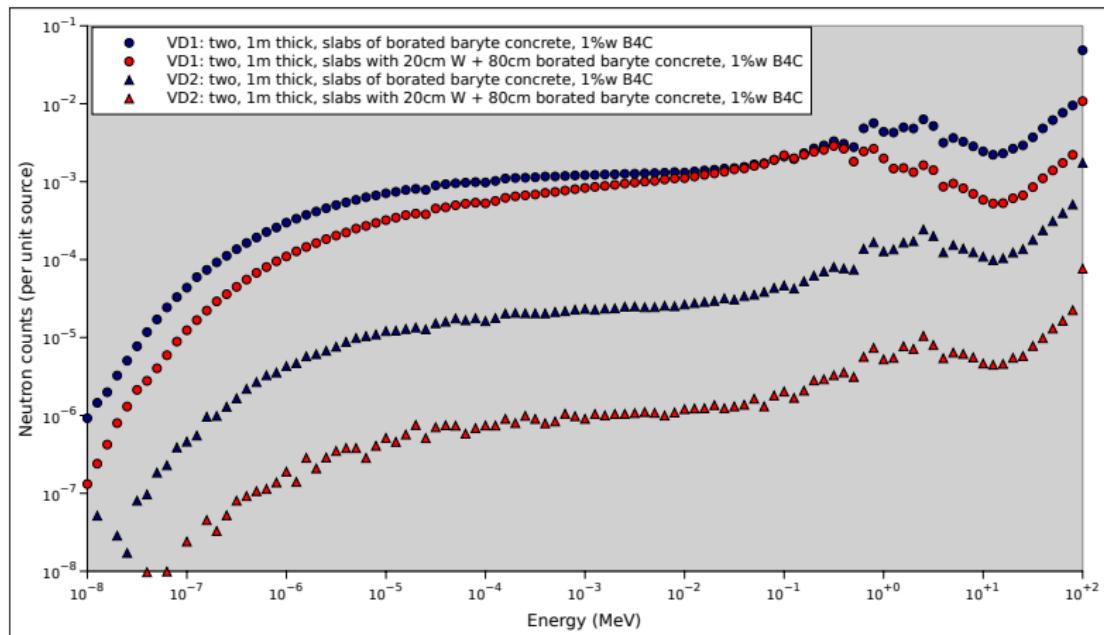
^a The slab is 1m of concrete (i.e. no other materials).

^b Difference with respect to configuration #1 (the reference case).

Neutron energy spectra

#9 ($t_1 = 20\text{cm W}$; $t_2 = 20\text{cm Bi}$) vs #1 (whole concrete shield)

Incident neutron energy: 100 MeV



Photon counts

Reference case is configuration #1:

Two slabs of borated baryte concrete (1%w B₄C). Each slab is 1m thick.

#	Material & thickness		Incident neutron energy: 10 MeV				Incident neutron energy: 100 MeV			
	t ₁	t ₂	VD1	VD2	VD1	VD2	VD1	VD2	VD1	VD2
1	None ^a	None ^a	2.267E-04	0.7%	1.000E-08	100.0%	5.381E-02	0.1%	1.863E-03	0.3%
2	None ^a	Bi, 20cm	2.364E-04	0.7%	1.000E-08	100.0%	7.288E-02	0.1%	1.055E-03	0.4%
3	Bi, 10cm	Bi, 10cm	2.243E-04	0.7%	9.985E-09	100.0%	4.975E-02	0.1%	1.060E-03	0.4%
4	Bi, 20cm	Bi, 20cm	2.205E-04	0.7%	2.000E-08	70.7%	4.257E-02	0.1%	6.043E-04	0.5%
5	Bi, 10cm	W, 10cm	2.241E-04	0.7%	0.000E+00	0.0%	5.393E-02	0.1%	6.285E-04	0.5%
6	Bi, 20cm	W, 20cm	2.192E-04	0.7%	0.000E+00	0.0%	4.297E-02	0.1%	2.146E-04	0.9%
7	None ^a	W, 20cm	2.329E-04	0.7%	1.000E-08	100.0%	7.359E-02	0.1%	3.732E-04	0.7%
8	W, 10cm	W, 10cm	7.727E-05	1.2%	0.000E+00	0.0%	3.394E-02	0.1%	3.900E-04	0.6%
9	W, 20cm	W, 20cm	2.722E-05	2.1%	0.000E+00	0.0%	1.679E-02	0.1%	8.046E-05	1.4%
10	W, 10cm	Bi, 10cm	7.739E-05	1.2%	0.000E+00	0.0%	3.130E-02	0.1%	6.647E-04	0.5%
11	W, 20cm	Bi, 20cm	2.769E-05	2.1%	0.000E+00	0.0%	1.665E-02	0.1%	2.307E-04	0.8%

#	Material & thickness		Incident neutron energy: 10 MeV				Incident neutron energy: 100 MeV			
	t ₁	t ₂	VD1 ^b	VD2 ^b	VD1 ^b	VD2 ^b	VD1 ^b	VD2 ^b	VD1 ^b	VD2 ^b
1	None ^a	None ^a	-	-	-	-	-	-	-	-
2	None ^a	Bi, 20cm	4.3%	0.0%	35.4%	-	-	-	-	-
3	Bi, 10cm	Bi, 10cm	-1.1%	-0.2%	-7.5%	-	-	-	-	-
4	Bi, 20cm	Bi, 20cm	-2.7%	100.0%	-20.9%	-	-	-	-	-
5	Bi, 10cm	W, 10cm	-1.1%	-100.0%	0.2%	-	-	-	-	-
6	Bi, 20cm	W, 20cm	-3.3%	-100.0%	-20.1%	-	-	-	-	-
7	None ^a	W, 20cm	2.8%	0.0%	36.8%	-	-	-	-	-
8	W, 10cm	W, 10cm	-65.9%	-100.0%	-36.9%	-	-	-	-	-
9	W, 20cm	W, 20cm	-88.0%	-100.0%	-68.8%	-	-	-	-	-
10	W, 10cm	Bi, 10cm	-65.9%	-100.0%	-41.8%	-	-	-	-	-
11	W, 20cm	Bi, 20cm	-87.8%	-100.0%	-69.1%	-	-	-	-	-

^a The slab is 1m of concrete (i.e. no other materials).

^b Difference with respect to the reference case.

Photon energy spectra

#9 ($t_1 = 20\text{cm W}$; $t_2 = 20\text{cm Bi}$) vs #1 (whole concrete shield)

Incident neutron energy: 100 MeV

