SAD TARGET and REACTOR simulations

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TARGET

SIMULATION SET-UP

Several simulations of the SAD target have been done by the CIEMAT group, now using the last version of the code MCNPX.2.e (1st march 2004) including:

1. Ciemat input using the updated INCL4/ABLA physic model in the mcnpx25e code.
2. Fixing errors in Neutron flux tables in the appendix.

RESULTS OF THE SIMULATIONS

- **Neutron flux**

Using the CIEMAT input the next Figures 1 to 4 show the neutron flux depth dependence using seven different physics models at high energies for four cells of the target.

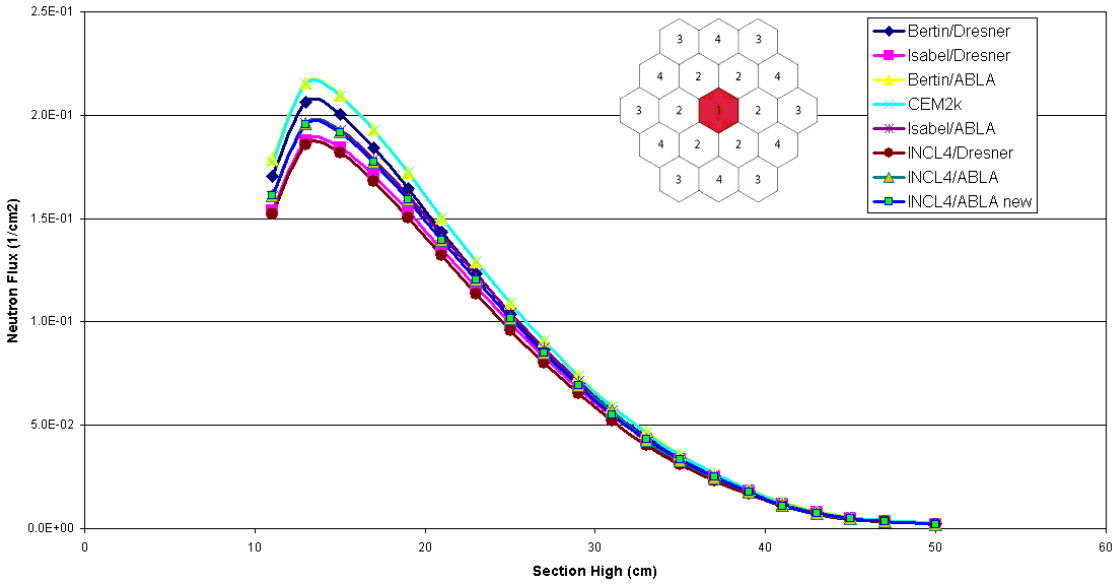

Figure 1. Neutron flux depth dependence for the central cell of the target

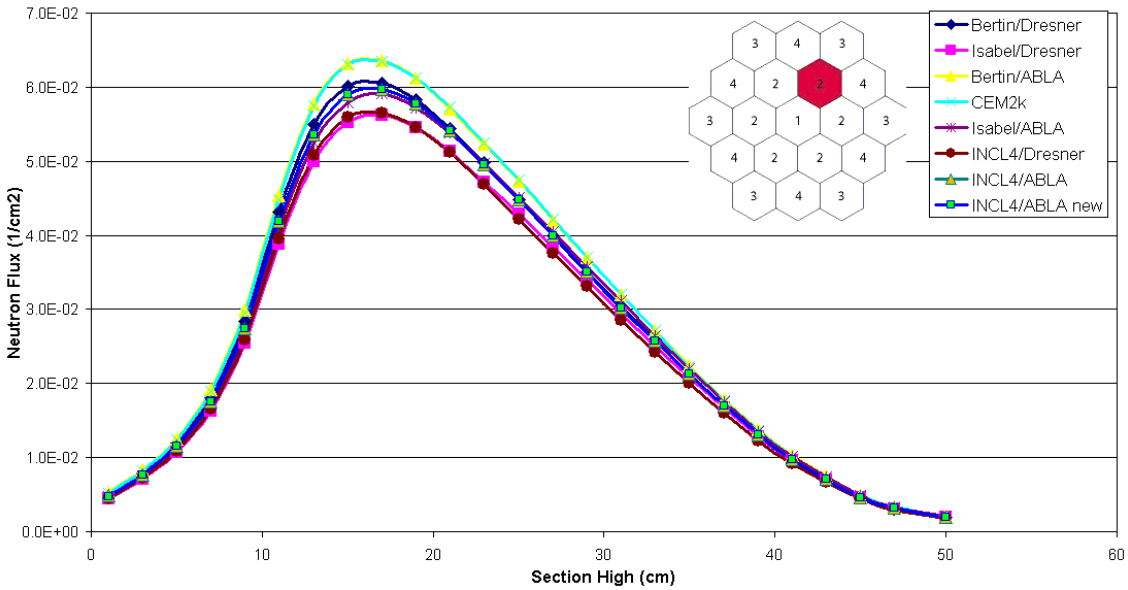

Figure 2. Neutron flux depth dependence for the cell #2 of the target

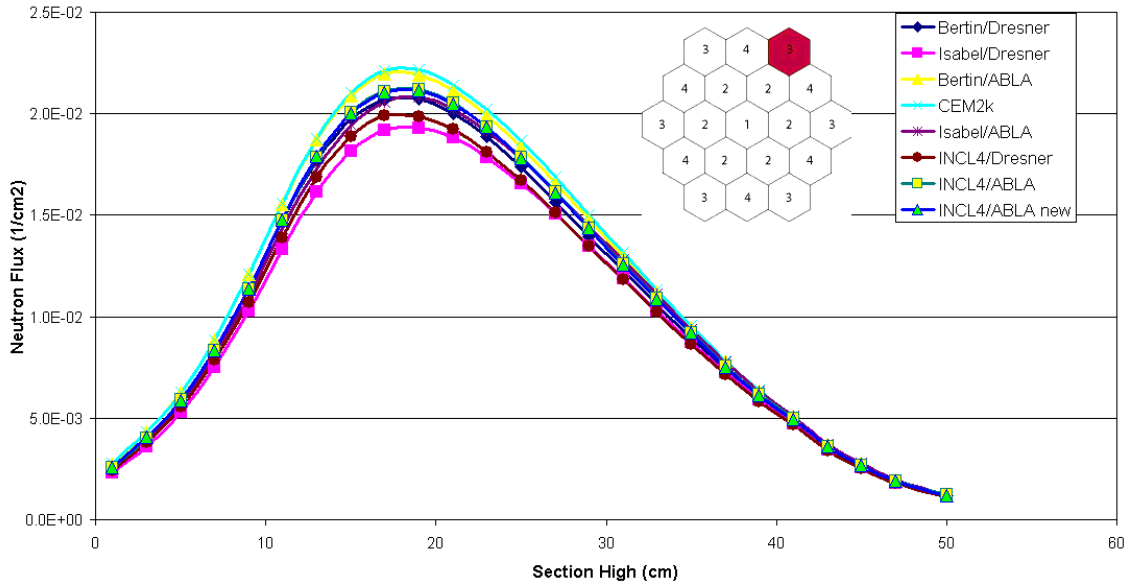

Figure 3. Neutron flux depth dependence for the cell #3 of the target

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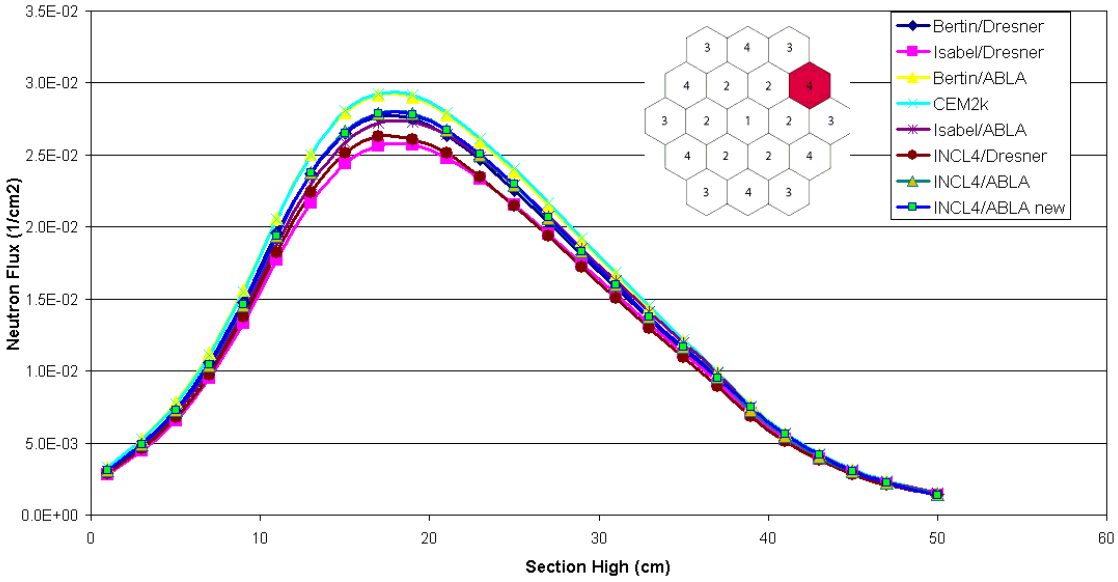

Figure 4. Neutron flux depth dependence for the cell #4 of the target

Detailed results of the simulations using different physics models including the updated INCL4/ABLA are shown in the tables.

Surface	Bertin/Dresner	Isabel/Dresner	Bertin/ABLA	CEM2k	Isabel/ABLA	INCL4/Dresner	INCL4/ABLA	INCL4/ABLA updated
Bottom	2.3449E-03	2.1113E-03	2.5051E-03	2.4377E-03	2.2483E-03	2.1215E-03	2.2807E-03	2.28258E-03
Top	8.8471E-04	8.7047E-04	9.3741E-04	8.7993E-04	9.2253E-04	7.9770E-04	8.4817E-04	8.47991E-04
Perimeter	5.2596E-03	4.9555E-03	5.5842E-03	5.5200E-03	5.2458E-03	4.9200E-03	5.2641E-03	5.26154E-03

Table R1. Averaged neutron flux in the bottom, top and perimeter surfaces

Table R1 shows the averaged neutron flux in the bottom, top and perimeter surfaces and Table R2 the integrated number of neutrons crossing the bottom, top and perimeter surfaces.

Surface	Bertin/Dresner	Isabel/Dresner	Bertin/ABLA	CEM2k	Isabel/ABLA	INCL4/Dresner	INCL4/ABLA	INCL4/ABLA updated
Bottom	5.3264E-01	4.8021E-01	5.7017E-01	5.5341E-01	5.1212E-01	5.1212E-01	4.8130E-01	5.18822E-01
Top	1.9548E-01	1.9345E-01	2.0721E-01	1.9581E-01	2.0438E-01	2.0438E-01	1.7675E-01	1.88195E-01
Perimeter	1.2595E+01	1.1851E+01	1.3372E+01	1.3212E+01	1.2552E+01	1.2552E+01	1.1761E+01	1.25800E+01

Table R2. Integrated number of neutrons escaping from the lead target by the bottom, top and perimeter surfaces.

The deviations between different physics models in both tables range from 13% to 17%.

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SAD REACTOR

NEW RESULTS

- Increasing of the reflector to 60 cm of radius, instead of the approximated actual 20 cm and removing 26 fuel assemblies. **This is our old reference case for the analysis in this document. *"No Boron-10 case".***
  Removed fuel assemblies positions:
  (-8 –4 0), (-4 –4 0), (4 4 0), (8 4 0), (-1 7 0), (1 7 0), (-7 1 0), (7 –1 0),
  (6 –7 0), (6 1 0), (-6 7 0), (-6 –1 0), (-1 –6 0),(7 –6 0), (1 6 0), (-7 6 0),
  (7 –5 0), (5 2 0), (5 –2 0), (-7 5 0), (-2 –5 0), (7 –2 0), (4 3 0), (-7 2 0),
  (5 –7 0), (-5 7 0)

Keff CIEMAT	0.94783± 0.000104

- Increasing of the reflector to 60 cm of radius, instead of the approximated actual 20 cm and removing 26 fuel assemblies and **adding 10% of B-10** to the first 10 cm of width of concrete close to lead reflector. **This is our first new reference case for the analysis in this document. *"Concrete Boron-10 case"***
  Removed fuel assemblies positions:
  (-8 –4 0), (-4 –4 0), (4 4 0), (8 4 0), (-1 7 0), (1 7 0), (-7 1 0), (7 –1 0),
  (6 –7 0), (6 1 0), (-6 7 0), (-6 –1 0), (-1 –6 0),(7 –6 0), (1 6 0), (-7 6 0),
  (7 –5 0), (5 2 0), (5 –2 0), (-7 5 0), (-2 –5 0), (7 –2 0), (4 3 0), (-7 2 0),
  (5 –7 0), (-5 7 0)

Keff CIEMAT	0.94195 ± 0.000110

- Increasing of the reflector to 60 cm of radius, instead of the approximated actual 20 cm and removing 24 fuel assemblies and **adding 10% of B-10** to the first 10 cm of width of concrete close to lead reflector.
  Removed fuel assemblies positions:
  (-8 –4 0), (-4 –4 0), (4 4 0), (8 4 0), (-1 7 0), (1 7 0), (-7 1 0), (7 –1 0),
  (6 –7 0), (6 1 0), (-6 7 0), (-6 –1 0), (-1 –6 0),(7 –6 0), (1 6 0), (-7 6 0),
  (7 –5 0), (5 2 0), (5 –2 0), (-7 5 0), (-2 –5 0), (7 –2 0), (4 3 0), (-7 2 0)

Keff CIEMAT	0.95027 ± 0.000108

- Increasing of the reflector to 60 cm of radius, instead of the approximated actual 20 cm and removing 25 fuel assemblies and **adding 10% of B-10** to the first 10 cm of width of concrete close to lead reflector.
  Removed fuel assemblies positions:
  (-8 –4 0), (-4 –4 0), (4 4 0), (8 4 0), (-1 7 0), (1 7 0), (-7 1 0), (7 –1 0),
  (6 –7 0), (6 1 0), (-6 7 0), (-6 –1 0), (-1 –6 0),(7 –6 0), (1 6 0), (-7 6 0),
  (7 –5 0), (5 2 0), (5 –2 0), (-7 5 0), (-2 –5 0), (7 –2 0), (4 3 0), (-7 2 0),
  (5 –7 0)

Keff CIEMAT	0.94563 ± 0.000108

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- Increasing of the reflector to 60 cm of radius, instead of the approximated actual 20 cm and removing 22 fuel assemblies and **adding 0.5% of B-10** to the internal lead reflector and **1.0% of B-10** to the bottom and top plates. **<u>This is our second new reference case for the analysis in this document. *"Internal Boron-10 case"*</u>**

  Removed fuel assemblies positions:
  (-8 –4 0), (-4 –4 0), (4 4 0), (8 4 0), (-1 7 0), (1 7 0), (-7 1 0), (7 –1 0),
  (6 –7 0), (6 1 0), (-6 7 0), (-6 –1 0), (-1 –6 0),(7 –6 0), (1 6 0), (-7 6 0),
  (7 –5 0), (5 2 0), (5 –2 0), (-7 5 0), (-2 –5 0), (7 –2 0)

Keff CIEMAT	0.95089 ± 0.000108

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If we do a comparison between the “No B-10 case” reference configuration and the “ Concrete B-10 case”, neutrons are absorbed in the concrete and are less reflected to the core, so the keff is slower.

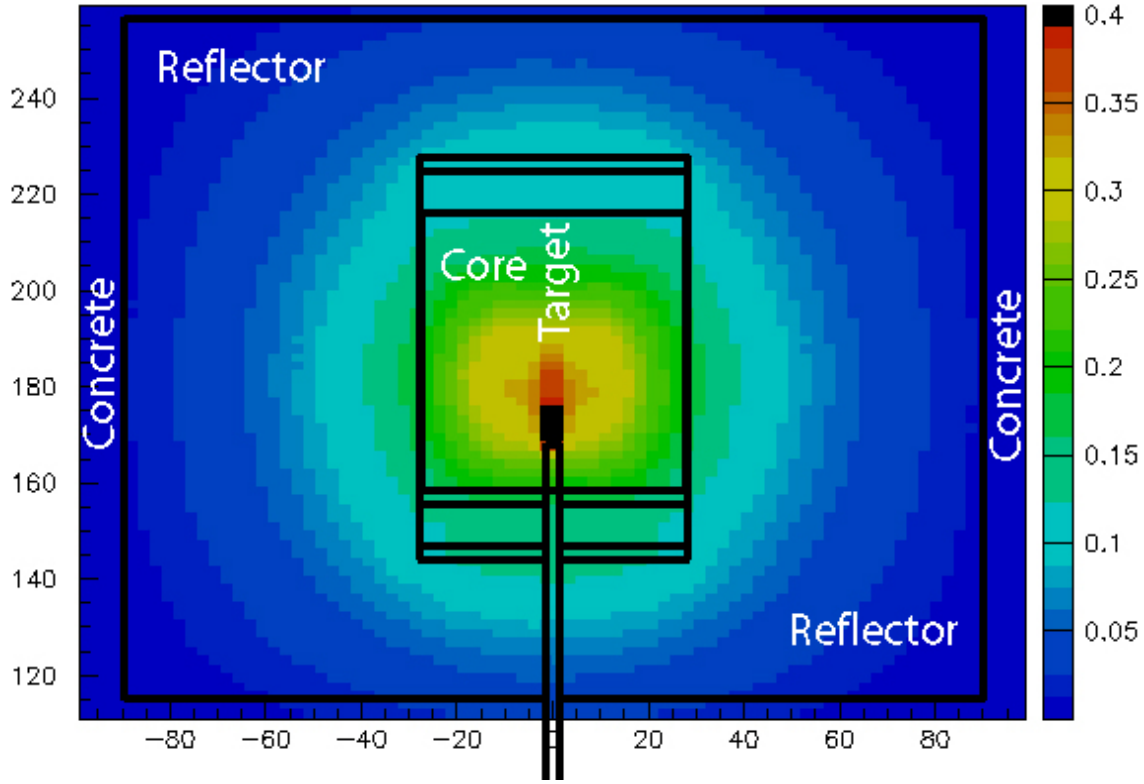

Figure 5. “No B-10 case” configuration. Neutron flux. Side view. (neutron/cm2/sec)

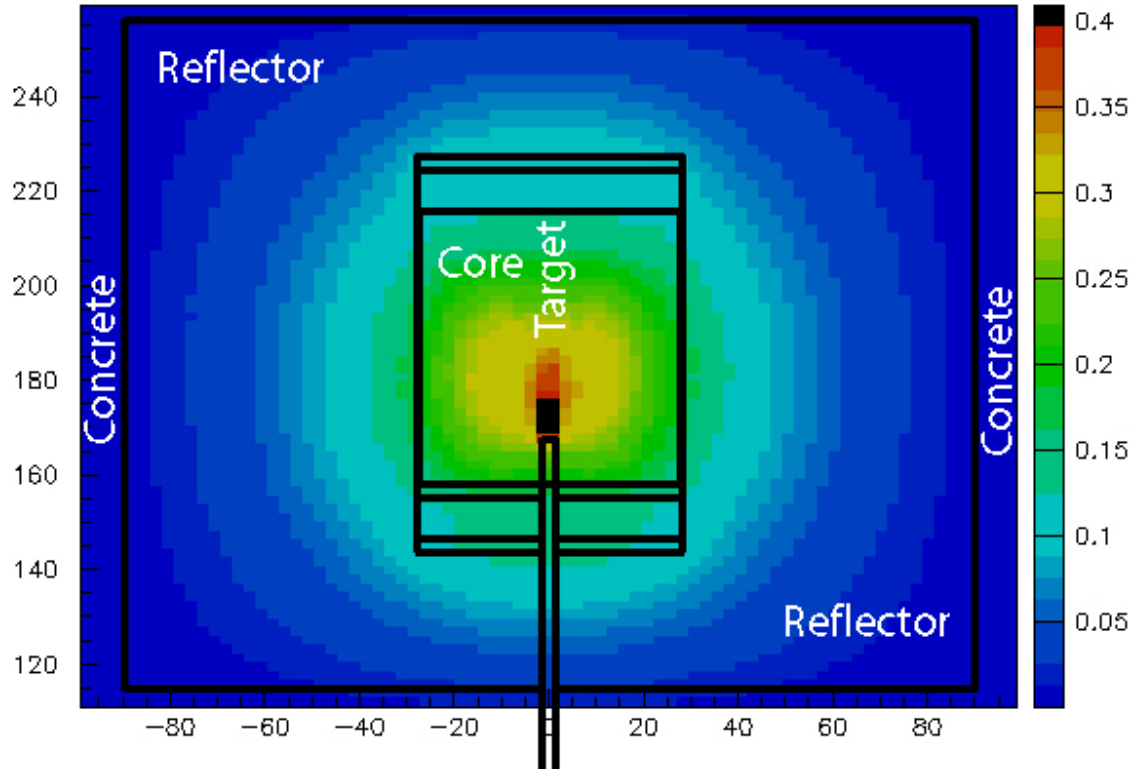

Figure 6. “Concrete B-10 case” configuration. Neutron flux. Side view. (neutron/cm2/sec)

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Next two figures show the proton flux in the “No B-10 case” and the “Concrete B-10 case”.

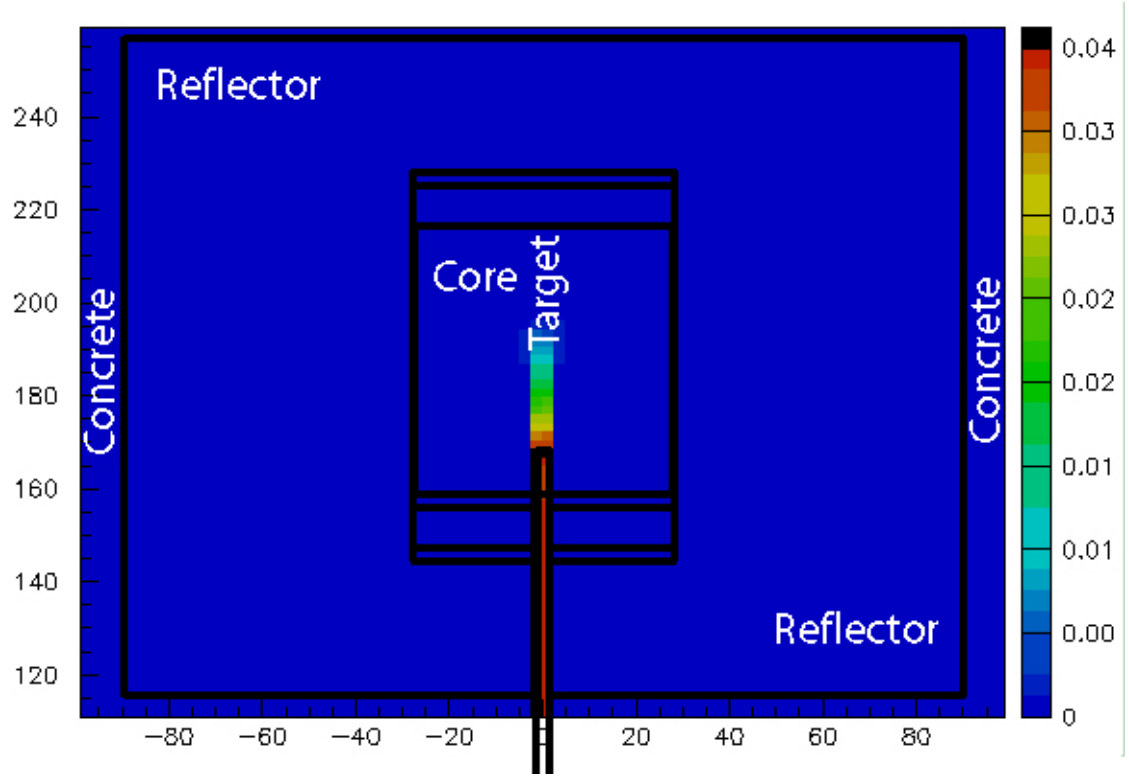

Figure 7. “No B-10 case” configuration. proton flux. Side view. (proton/cm2/sec)

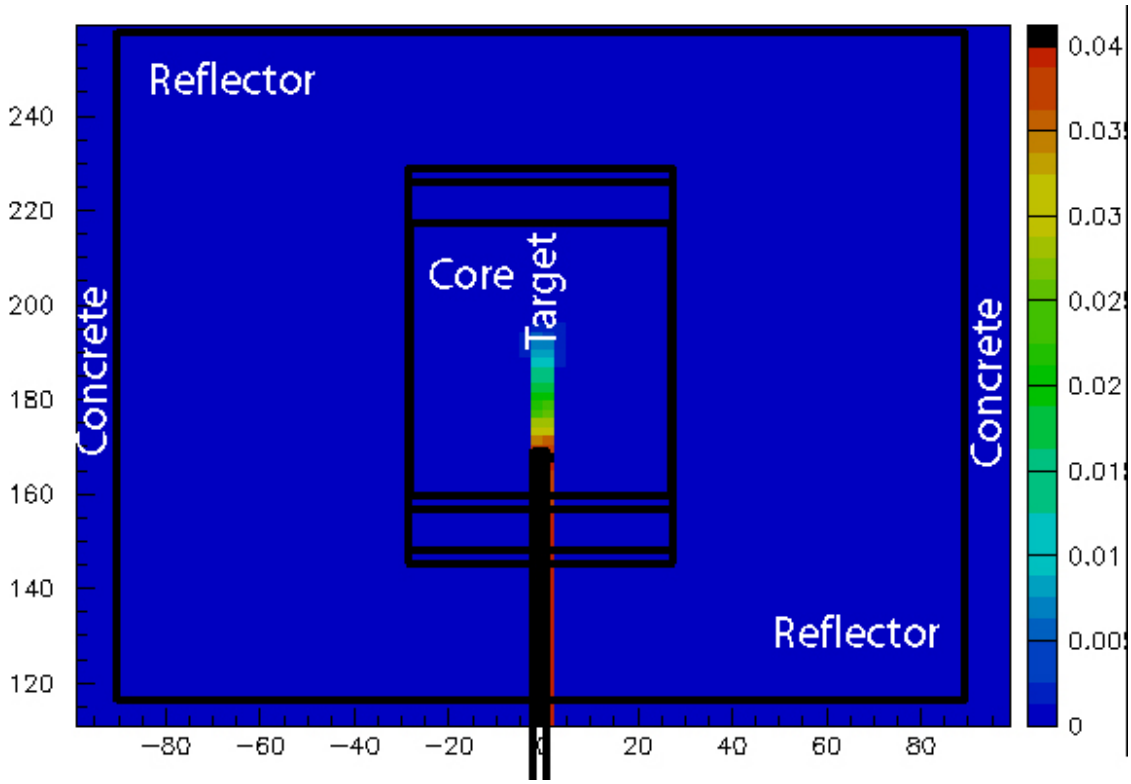

Figure 8. “Concrete B-10 case”configuration. proton flux. Side view. (proton/cm2/sec)

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Next two figures show the Energy deposited in the "No B-10 case" and the " ConcreteB-10 case"

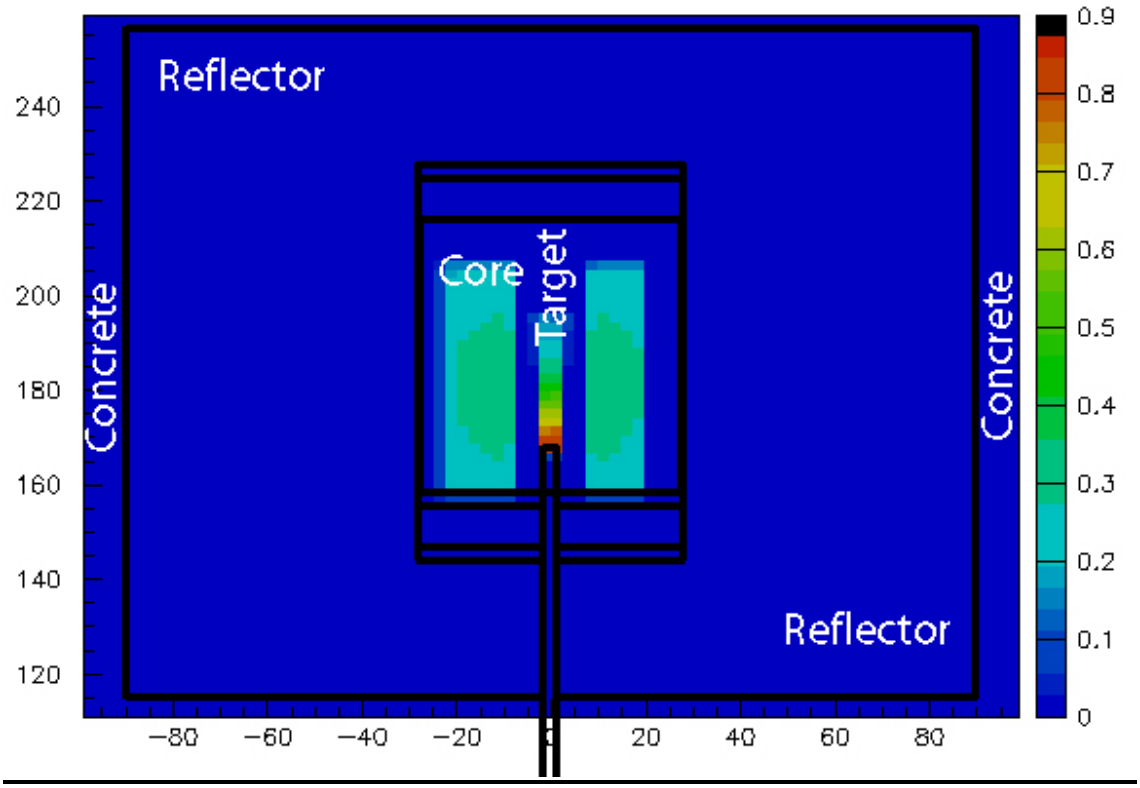

Figure 9. "No B-10 case" configuration. Energy deposited per mesh cell volume (MeV/cm^3/proton-source)

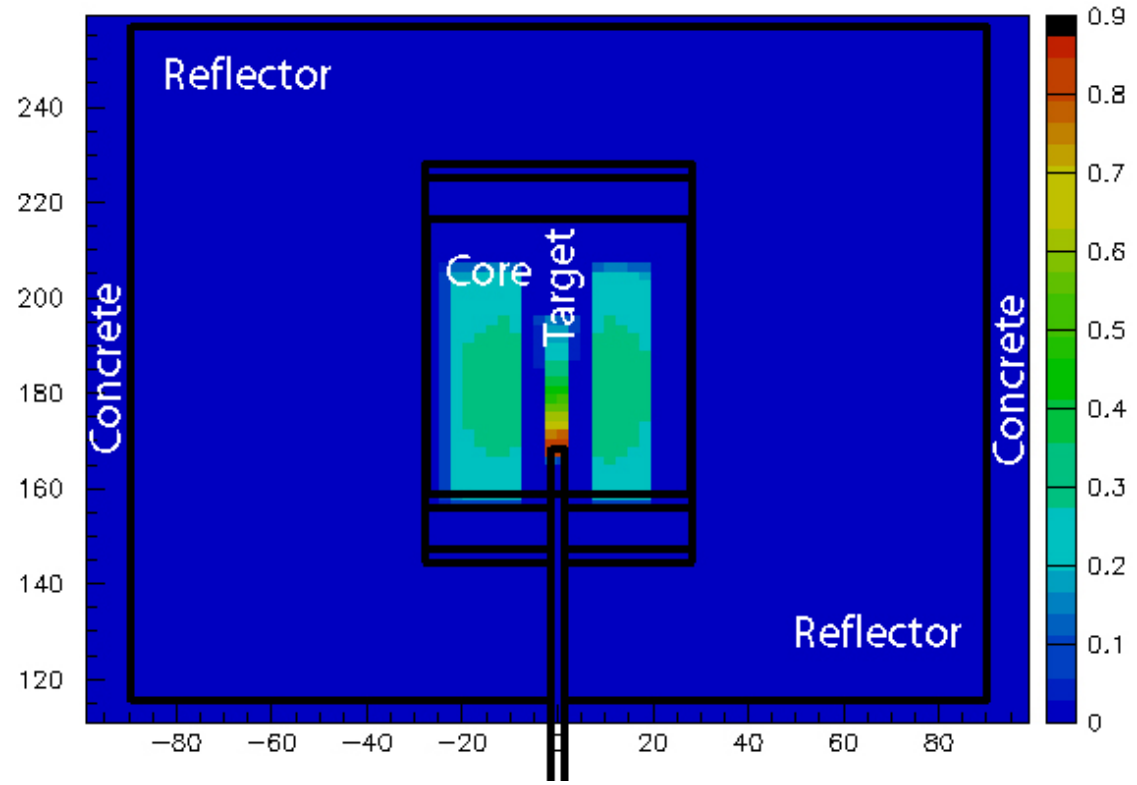

Figure 10. "Concrete B-10 case" configuration. Energy deposited per mesh cell volume (MeV/cm^3/proton-source)

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Neutron time response

A detailed study was done with reactor comparing the configuration called "No B-10 case", "Concrete B-10 case" and "Internal B-10 case". This study evaluates the Uranium 235 fission rate along the three experimental channels placed in the core of the reactor. For that purpose, these three experimental channels were segmented in 10 zones of 6 cm each one. The obtained results are presented in the following figure. Very similar results were obtained for corresponding segments of the three channels.

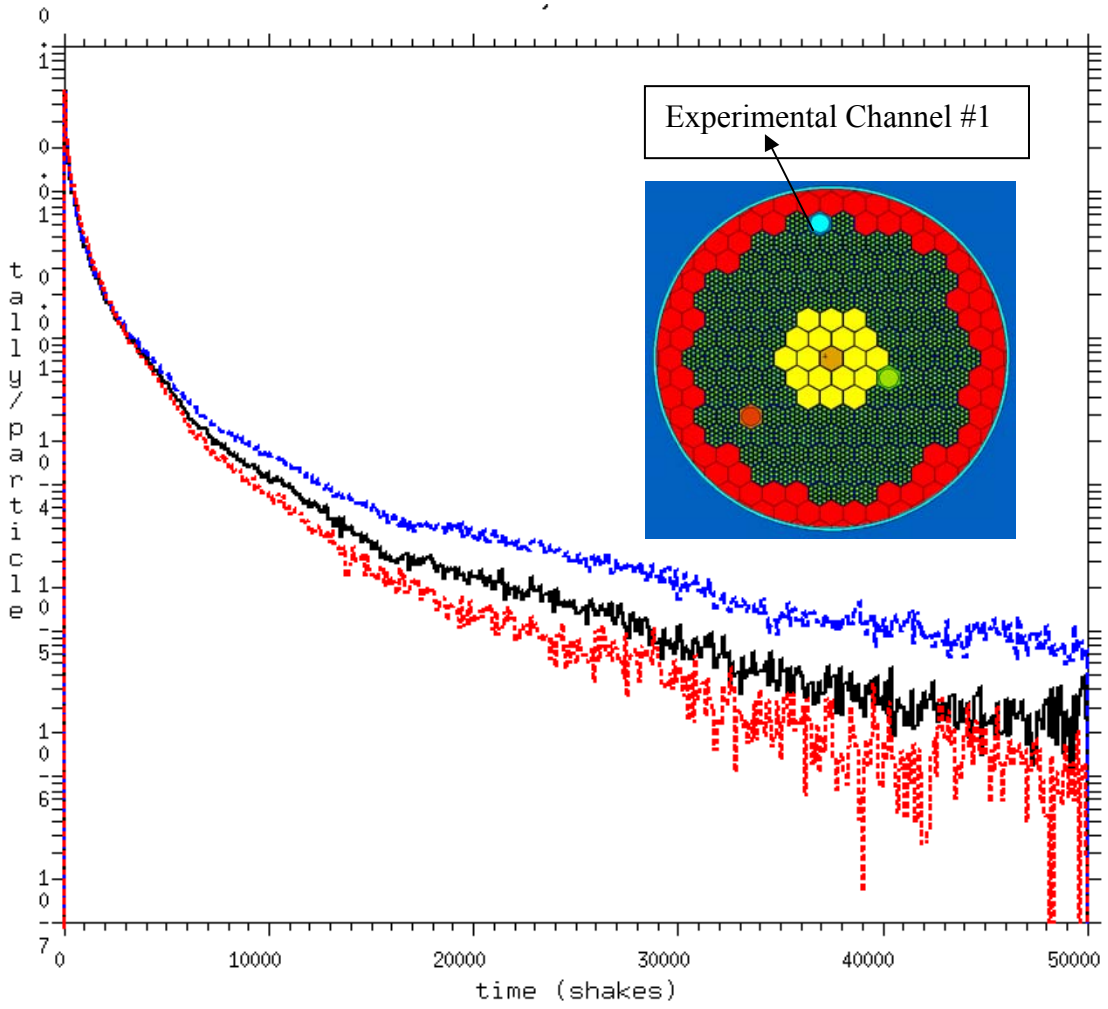

Figure 11. Neutron time response in the experimental channel #1 at central height for the including all energies. Virtual U-235 detectors were placed in the center of the experimental channels in order to evaluate the fission rate. **Blue** = "No B-10"; **Black** = "Concrete B-10"; **Red**="Internal B-10"

NOTE: SHAKES = 10^{-8} s = 10 ns.

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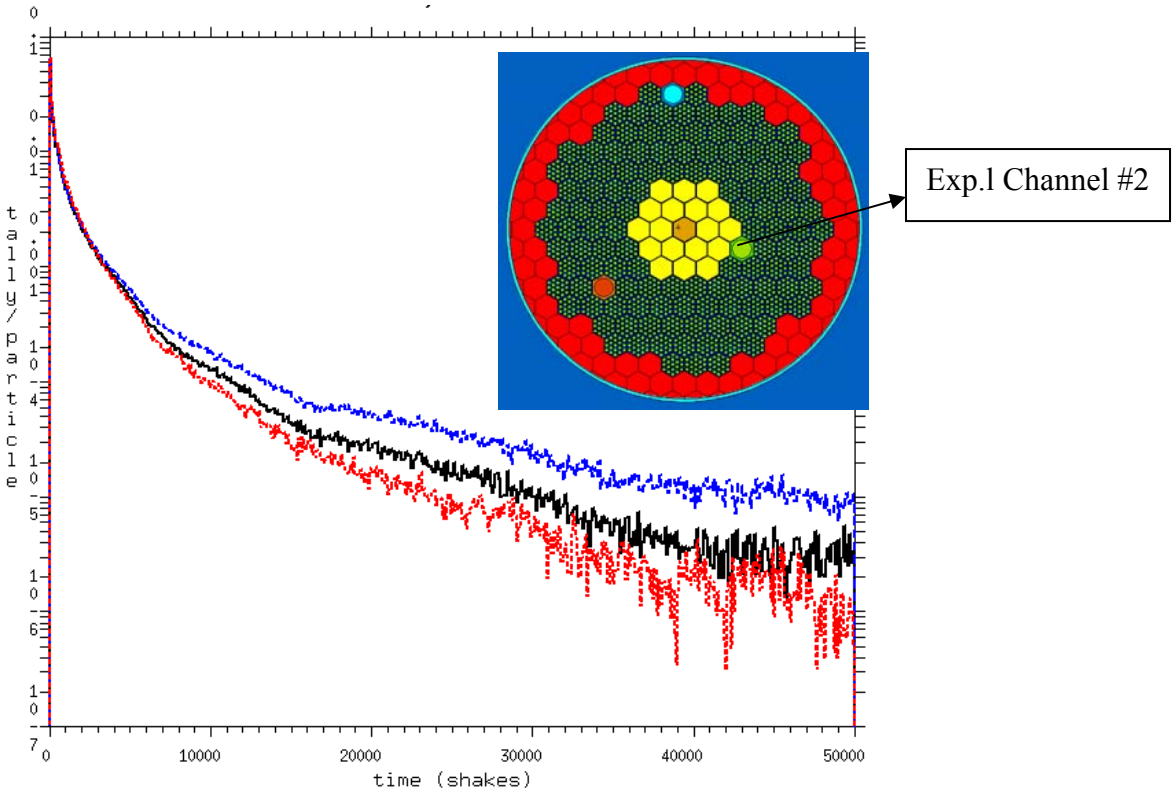

Figure 12. Neutron time response in the experimental channel #2 at central height for the Total energy. Virtual U-235 detectors were placed in the center of the experimental channels in order to evaluate the fission rate.
Blue = "No B-10"; **Black** = "Concrete B-10"; **Red**="Internal B-10"

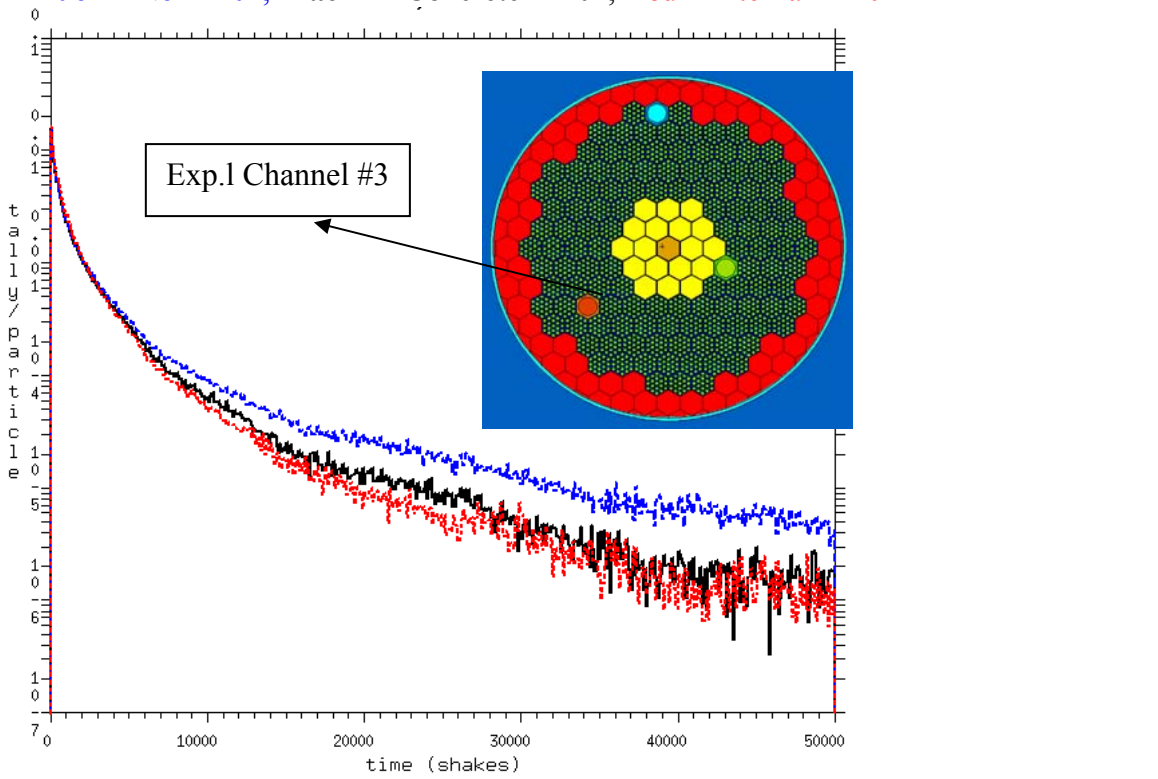

Figure 13. Neutron time response in the experimental channel #3 at central height for the Total energy. Virtual U-235 detectors were placed in the center of the experimental channels in order to evaluate the fission rate.
Blue = "No B-10"; **Black** = "Concrete B-10"; **Red**="Internal B-10"

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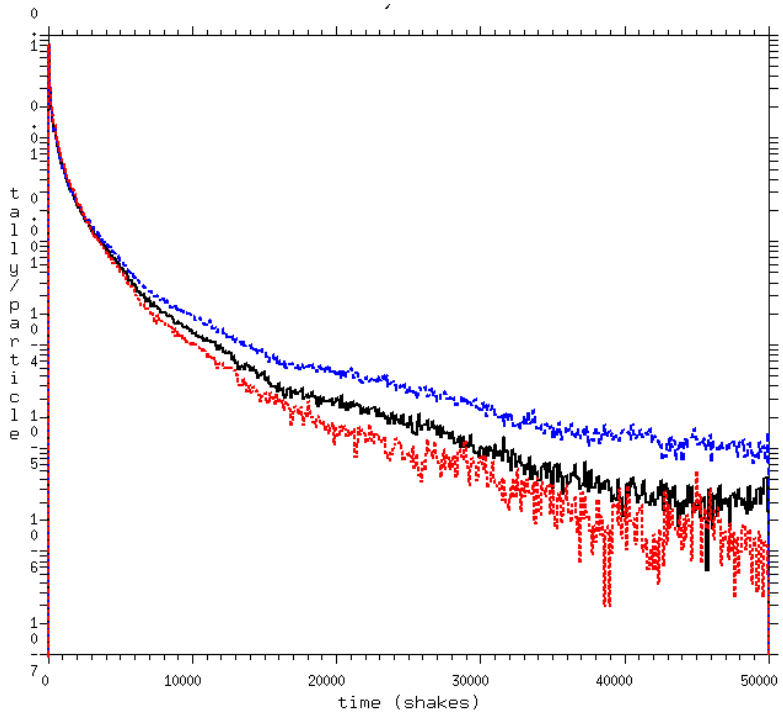

Figure 14. Neutron time response in the external experimental channel placed in the lead reflector (cell 9986) at central height for the Total energy. Virtual U-235 detectors were placed in the center of the experimental channels in order to evaluate the fission rate.
Blue = "No B-10"; **Black** = "Concrete B-10"; **Red**="Internal B-10"

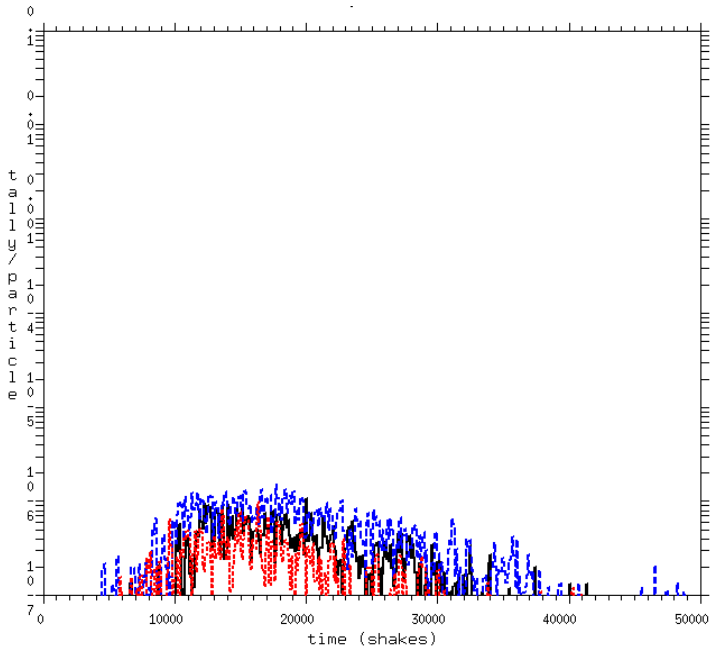

Figure 15. Neutron time response in the experimental channel #1 at central height for the energy bin between 1E-6 MeV and 1E-5 MeV. Virtual U-235 detectors were placed in the center of the experimental channels in order to evaluate the fission rate.
Blue = "No B-10"; **Black** = "Concrete B-10"; **Red**="Internal B-10"

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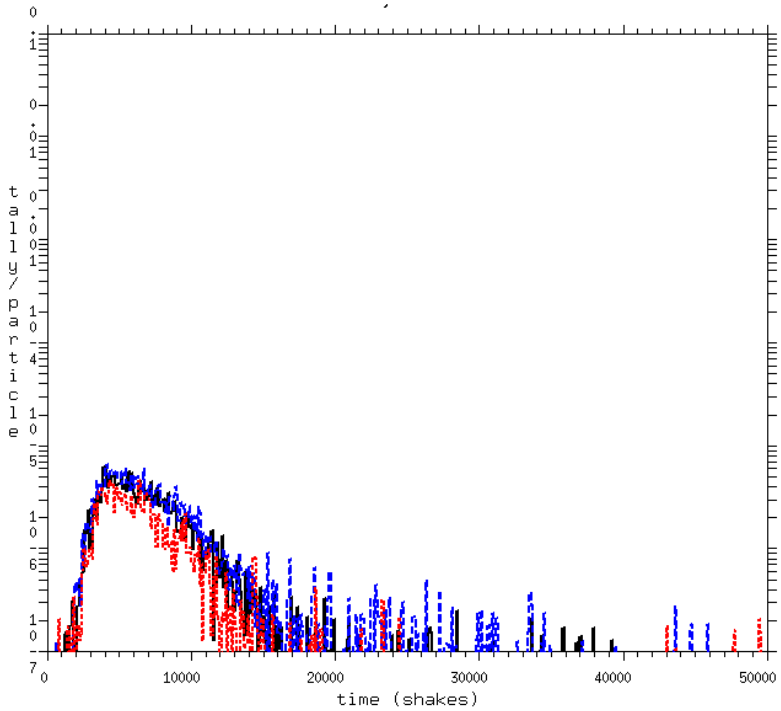

Figure 16. Neutron time response in the experimental channel #1 at central height for the energy bin between 1E-5 MeV and 1E-4 MeV. Virtual U-235 detectors were placed in the center of the experimental channels in order to evaluate the fission rate.
Blue = "No B-10"; **Black** = "Concrete B-10"; **Red**="Internal B-10"

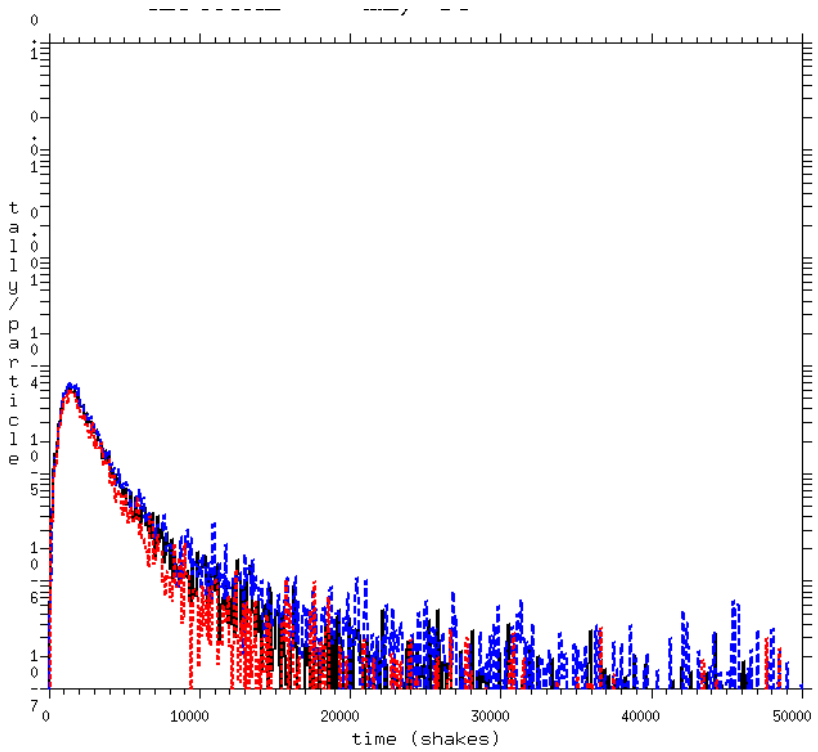

Figure 17. Neutron time response in the experimental channel #1 at central height for the energy bin between 1E-4 MeV and 1E-3 MeV. Virtual U-235 detectors were placed in the center of the experimental channels in order to evaluate the fission rate.
Blue = "No B-10"; **Black** = "Concrete B-10"; **Red**="Internal B-10"

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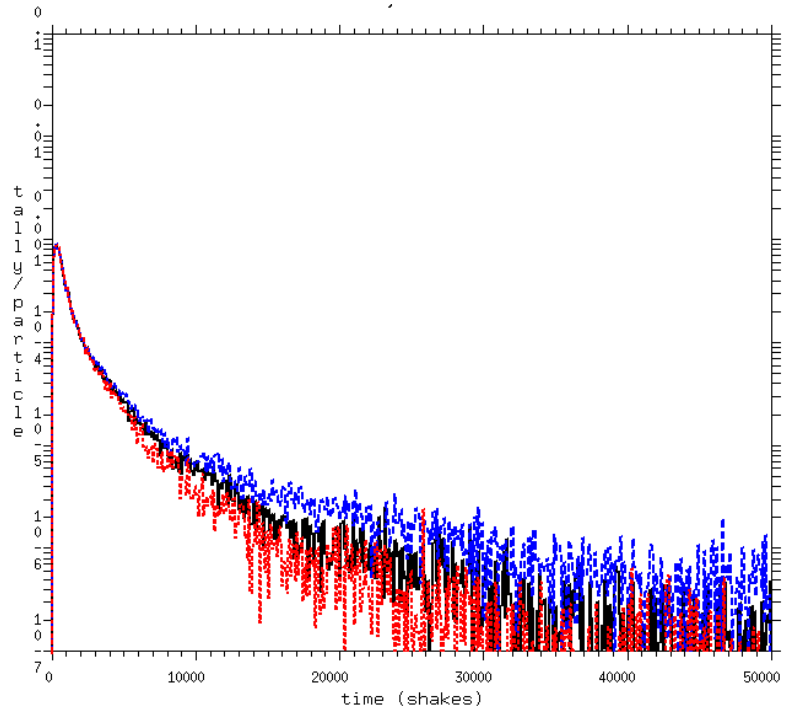

Figure 18. Neutron time response in the experimental channel #1 at central height for the energy bin between 1E-3 MeV and 1E-2 MeV. Virtual U-235 detectors were placed in the center of the experimental channels in order to evaluate the fission rate.
Blue = "No B-10"; **Black** = "Concrete B-10"; **Red**="Internal B-10"

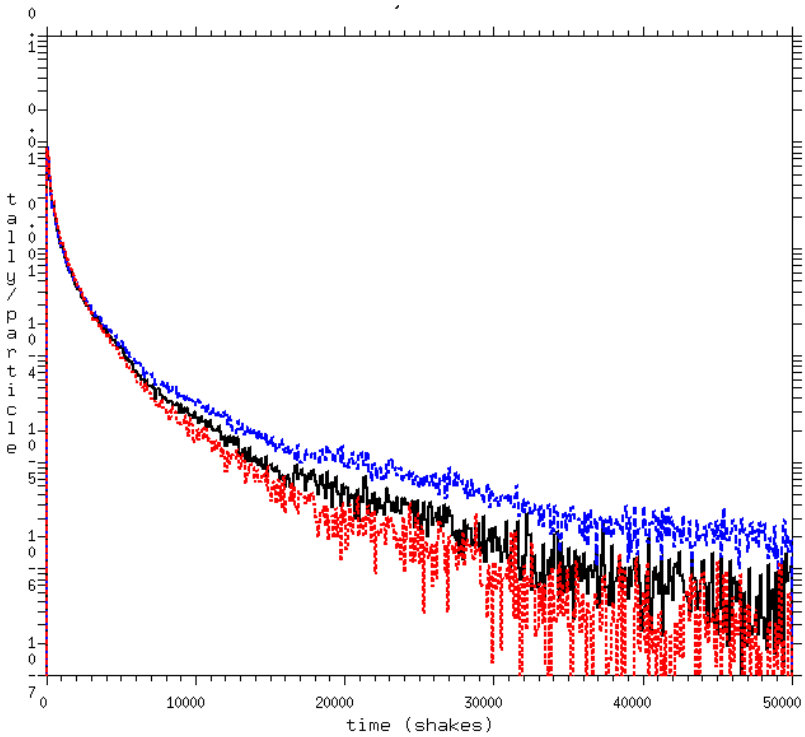

Figure 19. Neutron time response in the experimental channel #1 at central height for the energy bin between 1E-2 MeV and 1E-1 MeV. Virtual U-235 detectors were placed in the center of the experimental channels in order to evaluate the fission rate.
Blue = "No B-10"; **Black** = "Concrete B-10"; **Red**="Internal B-10"

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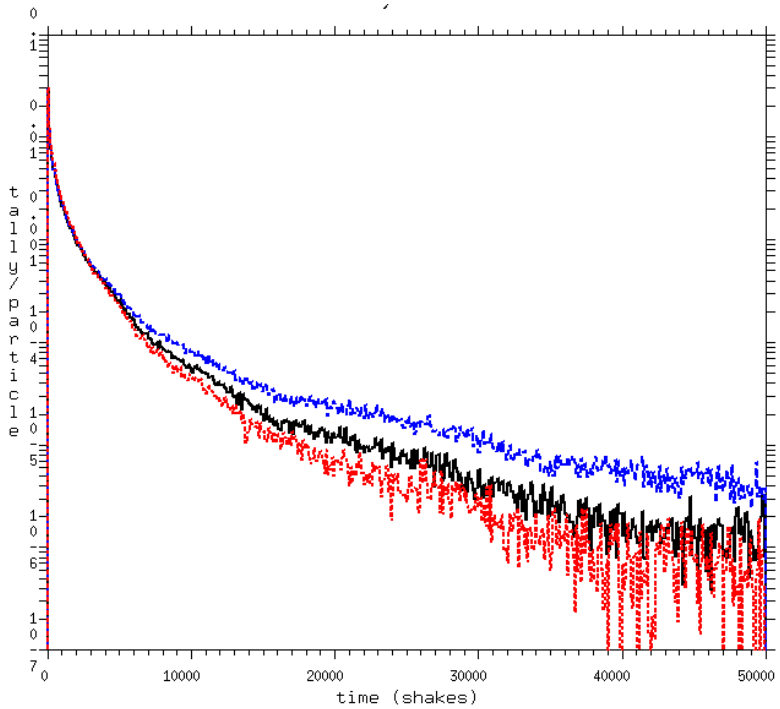

Figure 20. Neutron time response in the experimental channel #1 at central height for the energy bin between 1E-1 MeV and 1 MeV. Virtual U-235 detectors were placed in the center of the experimental channels in order to evaluate the fission rate.
Blue = "No B-10"; **Black** = "Concrete B-10"; **Red**="Internal B-10"

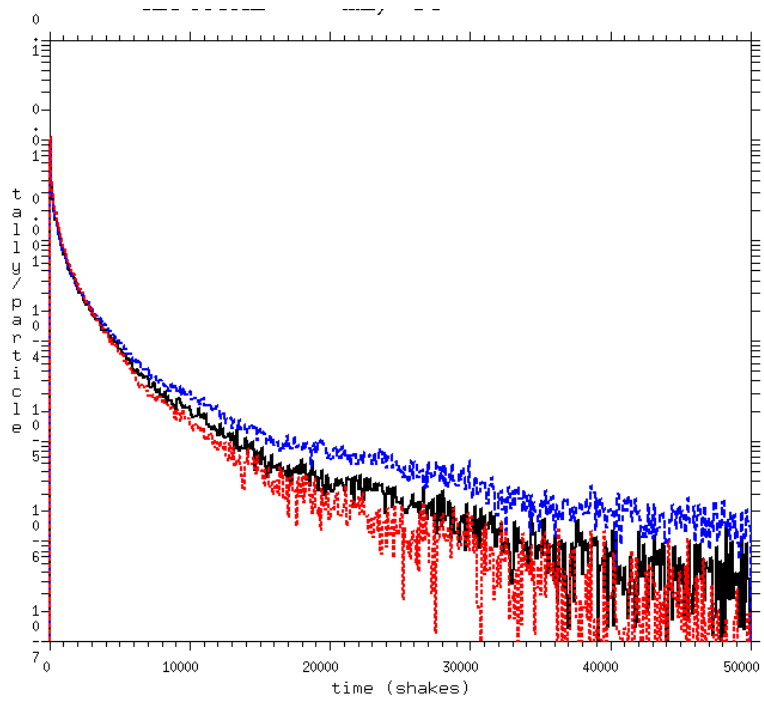

Figure 21. Neutron time response in the experimental channel #1 at central height for the energy bin between 1 MeV and 10 MeV. Virtual U-235 detectors were placed in the center of the experimental channels in order to evaluate the fission rate.
Blue = "No B-10"; **Black** = "Concrete B-10"; **Red**="Internal B-10"

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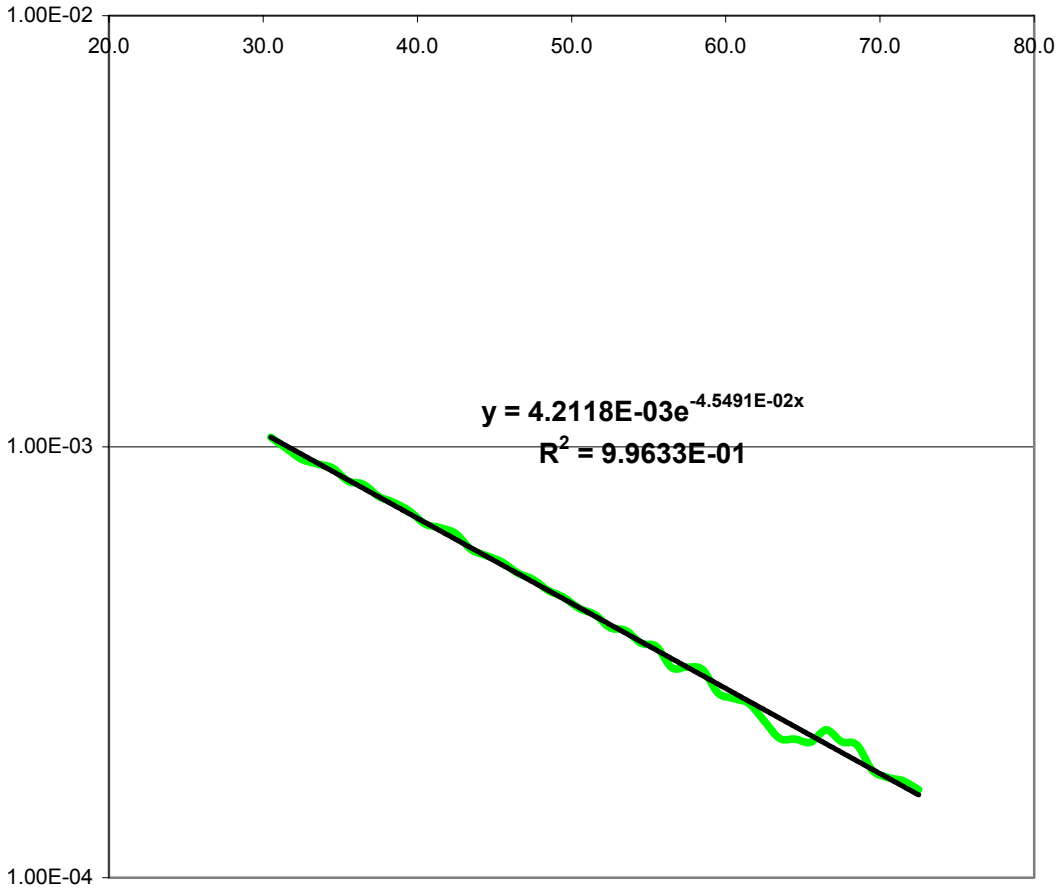
If a exponential fit is performed to the U235 fission rate in the "internal B-10 case", in the range from 40 to 75 μs, we obtain a good fit agreement with α=45800 s^{-1}. Taking into account the MC prediction of Λ=0.9543 μs and β=350 pcm for this system, we could calculate the reactivity as $\rho(\$) = 11.40$, or, $K_{eff} = 0.962$.



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APENDIX I – TARGET – EXERCISE 2

RESULTS (Ciemat input using Bertin/Dresner physic model)

- Neutron Flux of the central element #1subdivided in different segments

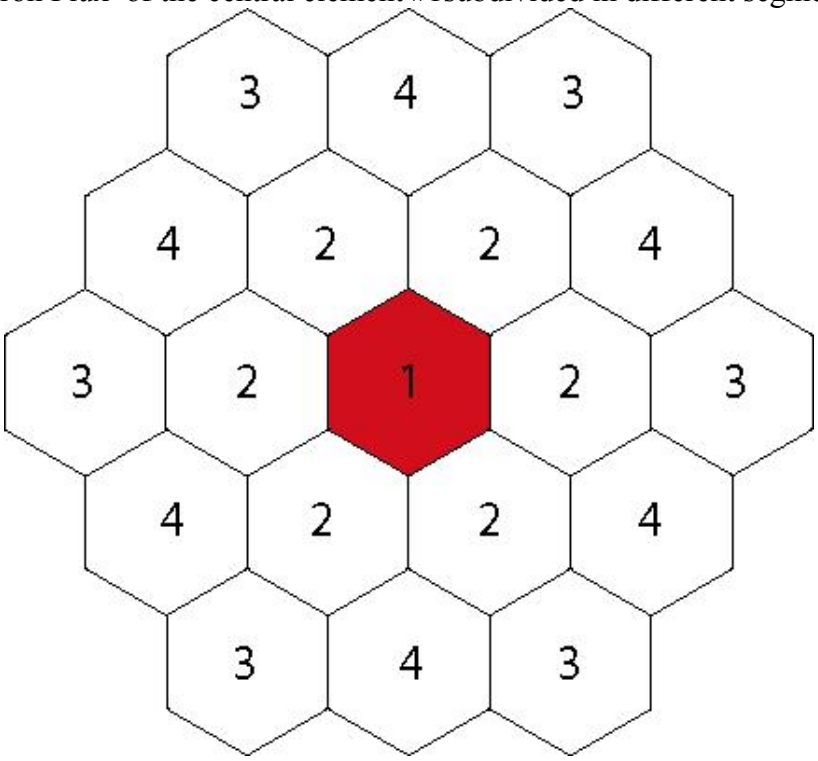

Figure 23. Top view of the SAD target. The results shown in this section are given for the target assembly #1 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
10 – 12	1.70462E-01	30 – 32	5.60664E-02
12 – 14	2.06085E-01	32 - 34	4.41479E-02
14 - 16	2.00436E-01	34 – 36	3.40850E-02
16 – 18	1.84187E-01	36 – 38	2.54972E-02
18 – 20	1.64449E-01	38 – 40	1.83105E-02
20 – 22	1.43494E-01	40 – 42	1.19790E-02
22 – 24	1.23042E-01	42 – 44	7.83392E-03
24 – 26	1.03533E-01	44 – 46	5.08842E-03
26 – 28	8.62850E-02	46 – 48	3.66566E-03
28 - 30	7.02186E-02	48 - 51	2.22288E-03

Table 1. Neutron flux results for the element #1 at different heights.

- Neutron Flux of the element #2 subdivided in different segments

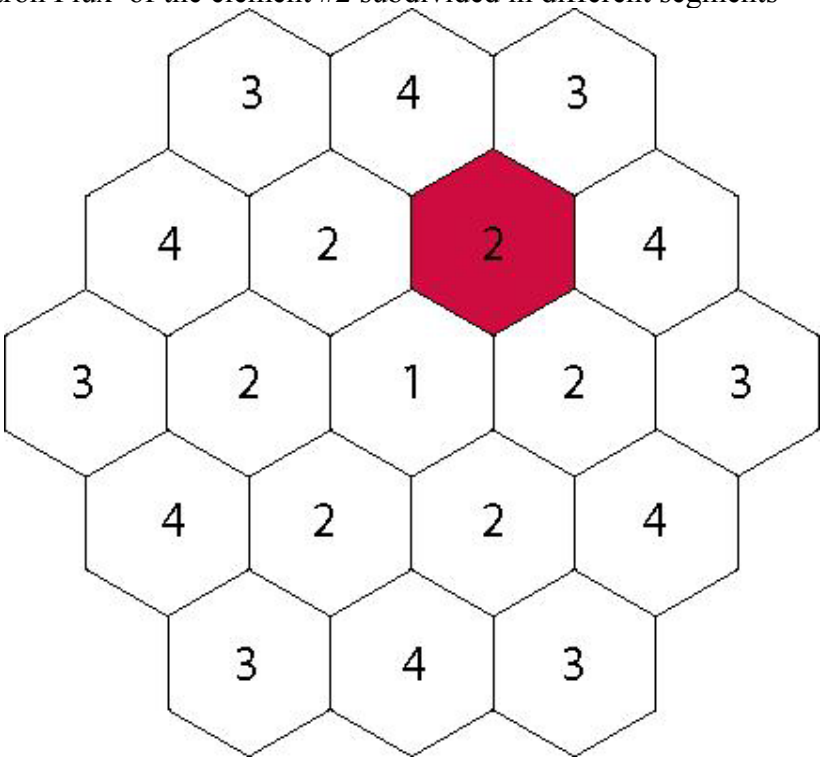

Figure 24. Top view of the SAD target. The results shown in this section are given for the target assembly #2 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	4.94772E-03	26 – 28	3.99840E-02
2 – 4	7.87415E-03	28 - 30	3.51260E-02
4 - 6	1.19335E-02	30 – 32	3.04222E-02
6 – 8	1.81524E-02	32 - 34	2.58424E-02
8 – 10	2.83603E-02	34 – 36	2.13145E-02
10 – 12	4.30776E-02	36 – 38	1.69825E-02
12 – 14	5.50217E-02	38 – 40	1.30960E-02
14 - 16	6.01250E-02	40 – 42	9.80262E-03
16 – 18	6.05096E-02	42 – 44	7.10827E-03
18 – 20	5.82431E-02	44 – 46	4.67349E-03
20 – 22	5.44232E-02	46 – 48	3.16550E-03
22 – 24	4.98194E-02	48 - 51	1.95867E-03
24 – 26	4.48517E-02		

Table 2. Neutron flux results for the element #2 at different heights.

- Neutron Flux of the element #3 subdivided in different segments

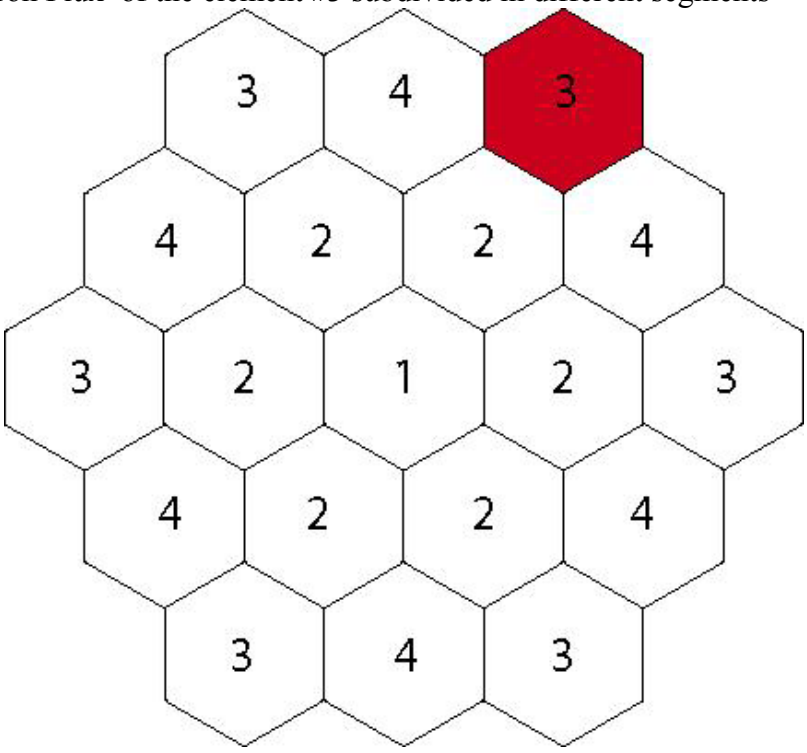

Figure 25. Top view of the SAD target. The results shown in this section are given for the target assembly #3 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	2.56537E-03	26 – 28	1.56573E-02
2 – 4	4.02968E-03	28 - 30	1.39648E-02
4 - 6	5.87899E-03	30 – 32	1.22883E-02
6 – 8	8.32187E-03	32 - 34	1.06081E-02
8 – 10	1.13769E-02	34 – 36	8.92866E-03
10 – 12	1.47655E-02	36 – 38	7.41742E-03
12 – 14	1.77177E-02	38 – 40	6.03873E-03
14 - 16	1.97317E-02	40 – 42	4.85608E-03
16 – 18	2.07044E-02	42 – 44	3.52996E-03
18 – 20	2.07186E-02	44 – 46	2.63541E-03
20 – 22	2.00190E-02	46 – 48	1.86601E-03
22 – 24	1.88545E-02	48 - 51	1.18557E-03
24 – 26	1.73795E-02		

Table 3. Neutron flux results for the element #3 at different heights.

- Neutron Flux of the element #4subdivided in different segments

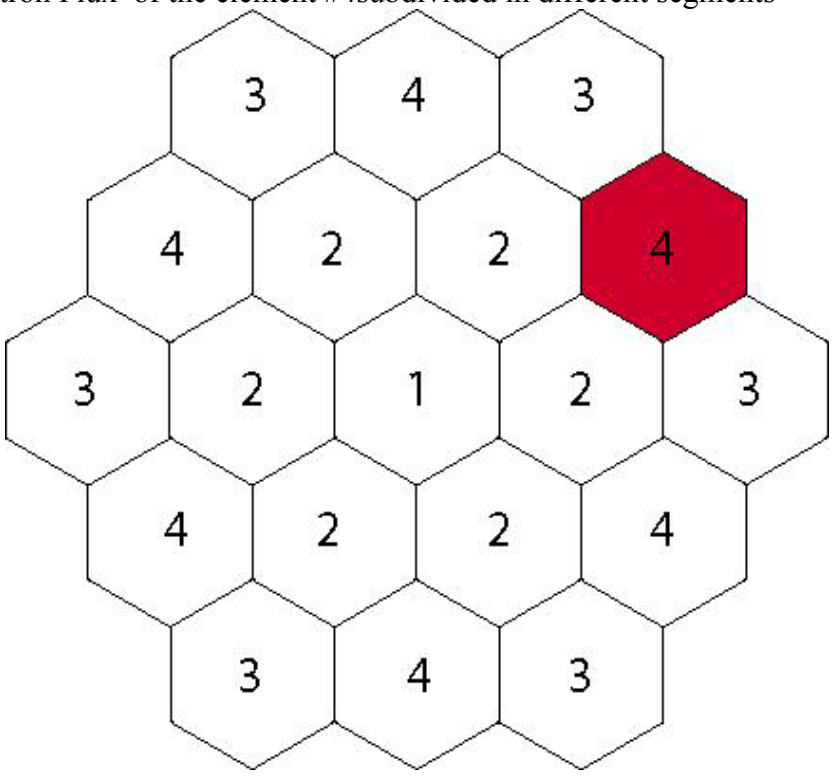

Figure 26. Top view of the SAD target. The results shown in this section are given for the target assembly #4 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	3.13609E-03	26 – 28	2.03177E-02
2 – 4	4.99345E-03	28 - 30	1.80709E-02
4 - 6	7.33590E-03	30 – 32	1.57600E-02
6 – 8	1.05531E-02	32 - 34	1.35964E-02
8 – 10	1.47691E-02	34 – 36	1.14779E-02
10 – 12	1.95534E-02	36 – 38	9.42423E-03
12 – 14	2.37242E-02	38 – 40	7.19995E-03
14 - 16	2.64979E-02	40 – 42	5.41084E-03
16 – 18	2.76381E-02	42 – 44	4.01142E-03
18 – 20	2.74848E-02	44 – 46	2.98970E-03
20 – 22	2.63291E-02	46 – 48	2.23016E-03
22 – 24	2.46787E-02	48 - 51	1.41618E-03
24 – 26	2.25249E-02		

Table 4. Neutron flux results for the element #4 at different heights.

APENDIX I – TARGET – EXERCISE 3

RESULTS (Ciemat input using Isabel/Dresner physic model)

- Neutron Flux of the central element #1subdivided in different segments

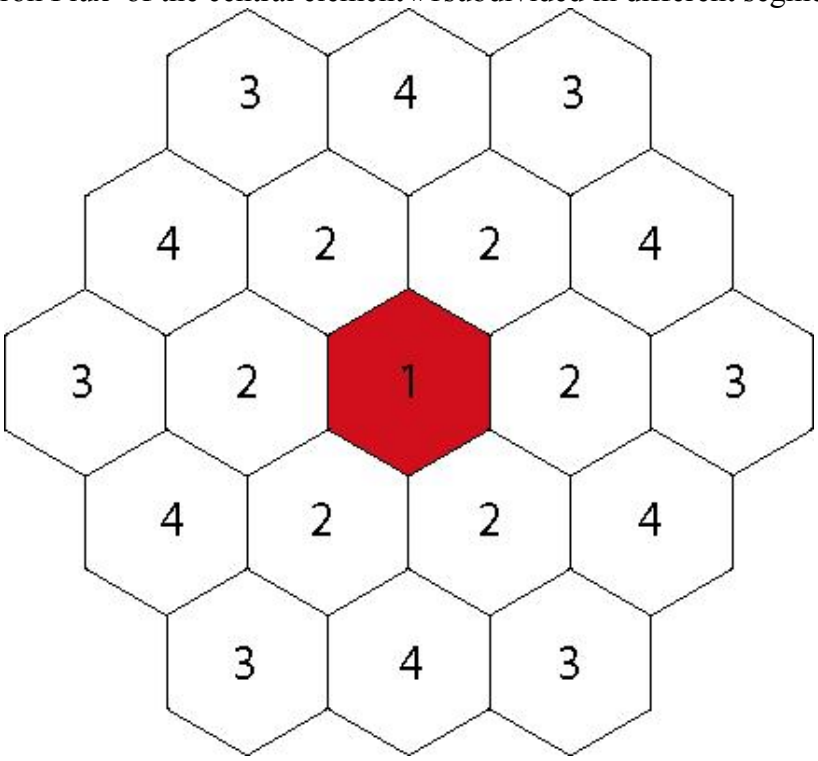

Figure 36. Top view of the SAD target. The results shown in this section are given for the target assembly #1 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
10 – 12	1.53713E-01	30 – 32	5.45342E-02
12 – 14	1.87644E-01	32 - 34	4.31096E-02
14 - 16	1.84325E-01	34 – 36	3.34103E-02
16 – 18	1.71048E-01	36 – 38	2.49807E-02
18 – 20	1.53636E-01	38 – 40	1.79396E-02
20 – 22	1.35233E-01	40 – 42	1.17363E-02
22 – 24	1.16837E-01	42 – 44	7.67523E-03
24 – 26	9.90217E-02	44 – 46	4.98534E-03
26 – 28	8.29336E-02	46 – 48	3.59140E-03
28 - 30	6.79089E-02	48 - 51	2.17785E-03

Table 5. Neutron flux results for the element #1 at different heights.

- Neutron Flux of the element #2 subdivided in different segments

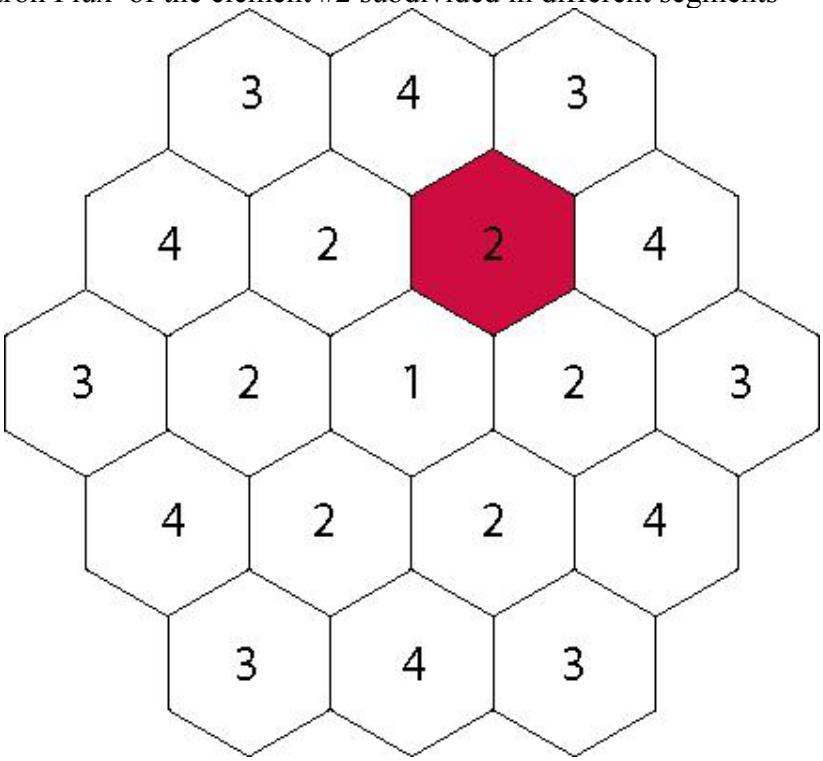

Figure 37. Top view of the SAD target. The results shown in this section are given for the target assembly #2 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	4.43070E-03	26 – 28	3.84291E-02
2 – 4	7.06540E-03	28 - 30	3.39404E-02
4 - 6	1.06678E-02	30 – 32	2.94954E-02
6 – 8	1.62793E-02	32 - 34	2.51036E-02
8 – 10	2.54689E-02	34 – 36	2.08184E-02
10 – 12	3.87920E-02	36 – 38	1.66325E-02
12 – 14	4.99728E-02	38 – 40	1.28261E-02
14 - 16	5.51912E-02	40 – 42	9.60059E-03
16 – 18	5.61923E-02	42 – 44	6.96177E-03
18 – 20	5.44934E-02	44 – 46	4.57717E-03
20 – 22	5.12906E-02	46 – 48	3.10026E-03
22 – 24	4.72445E-02	48 - 51	1.91830E-03
24 – 26	4.28589E-02		

Table 6. Neutron flux results for the element #2 at different heights.

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- Neutron Flux of the element #3 subdivided in different segments

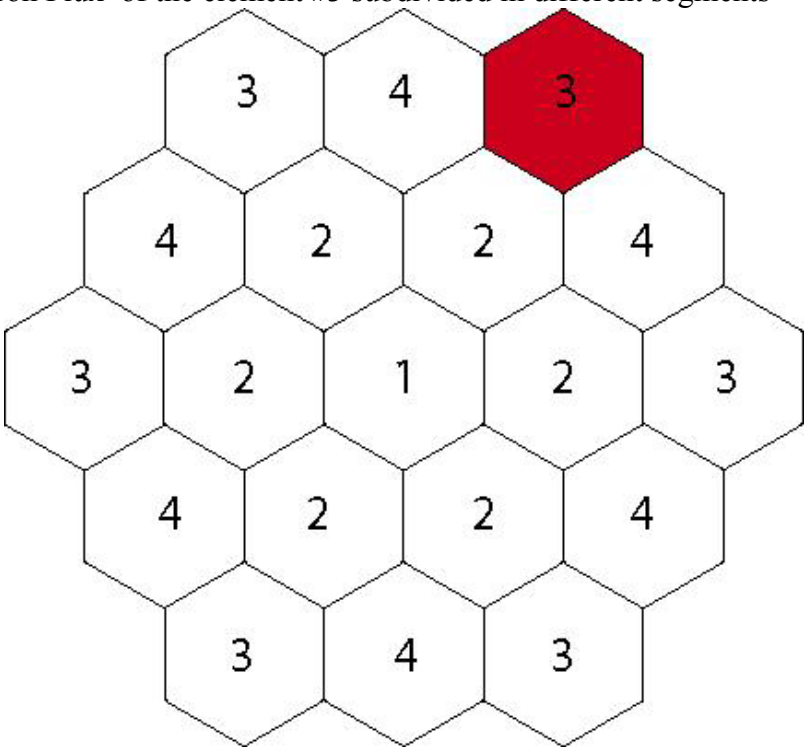

Figure 38. Top view of the SAD target. The results shown in this section are given for the target assembly #3 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	2.30681E-03	26 – 28	1.50562E-02
2 – 4	3.62580E-03	28 - 30	1.35025E-02
4 - 6	5.30052E-03	30 – 32	1.18687E-02
6 – 8	7.52545E-03	32 - 34	1.03088E-02
8 – 10	1.02889E-02	34 – 36	8.75405E-03
10 – 12	1.33137E-02	36 – 38	7.23718E-03
12 – 14	1.61617E-02	38 – 40	5.89199E-03
14 - 16	1.81549E-02	40 – 42	4.73808E-03
16 – 18	1.92036E-02	42 – 44	3.44418E-03
18 – 20	1.93121E-02	44 – 46	2.57137E-03
20 – 22	1.88086E-02	46 – 48	1.82067E-03
22 – 24	1.78543E-02	48 - 51	1.15676E-03
24 – 26	1.65381E-02		

Table 7. Neutron flux results for the element #3 at different heights.

- Neutron Flux of the element #4subdivided in different segments

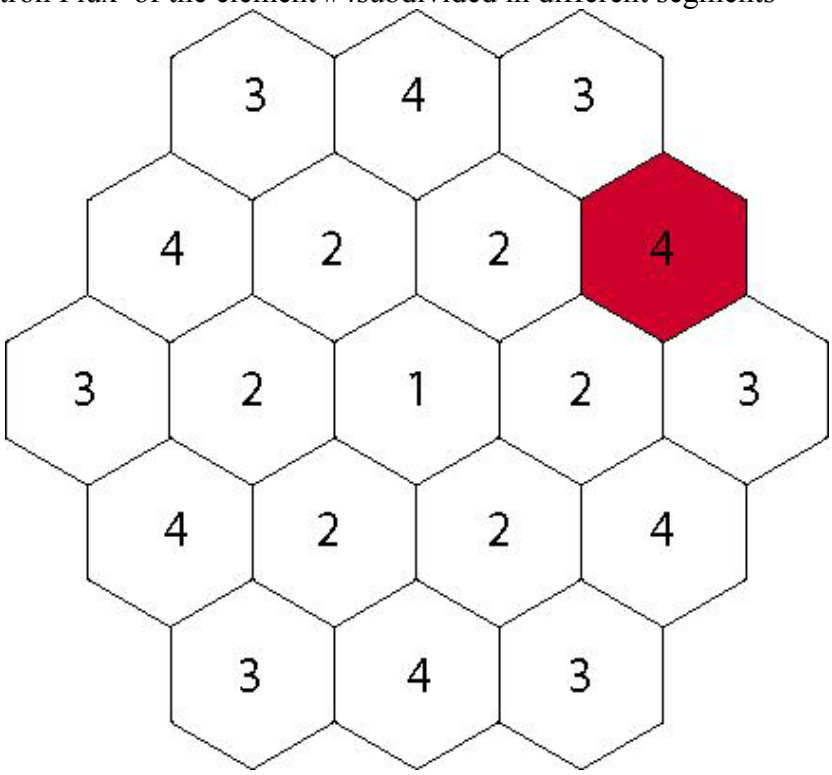

Figure 39. Top view of the SAD target. The results shown in this section are given for the target assembly #4 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	2.82174E-03	26 – 28	1.95444E-02
2 – 4	4.47568E-03	28 - 30	1.74513E-02
4 - 6	6.58592E-03	30 – 32	1.53053E-02
6 – 8	9.51208E-03	32 - 34	1.32304E-02
8 – 10	1.33114E-02	34 – 36	1.12283E-02
10 – 12	1.76963E-02	36 – 38	9.20485E-03
12 – 14	2.17014E-02	38 – 40	7.03235E-03
14 - 16	2.43899E-02	40 – 42	5.28488E-03
16 – 18	2.56590E-02	42 – 44	3.91804E-03
18 – 20	2.56857E-02	44 – 46	2.92010E-03
20 – 22	2.48010E-02	46 – 48	2.17825E-03
22 – 24	2.33377E-02	48 - 51	1.38321E-03
24 – 26	2.15267E-02		

Table 8. Neutron flux results for the element #4 at different heights.

APENDIX I – TARGET – EXERCISE 4

RESULTS (Ciemat input using Bertin/ABLA physic model)

- Neutron Flux of the central element #1subdivided in different segments

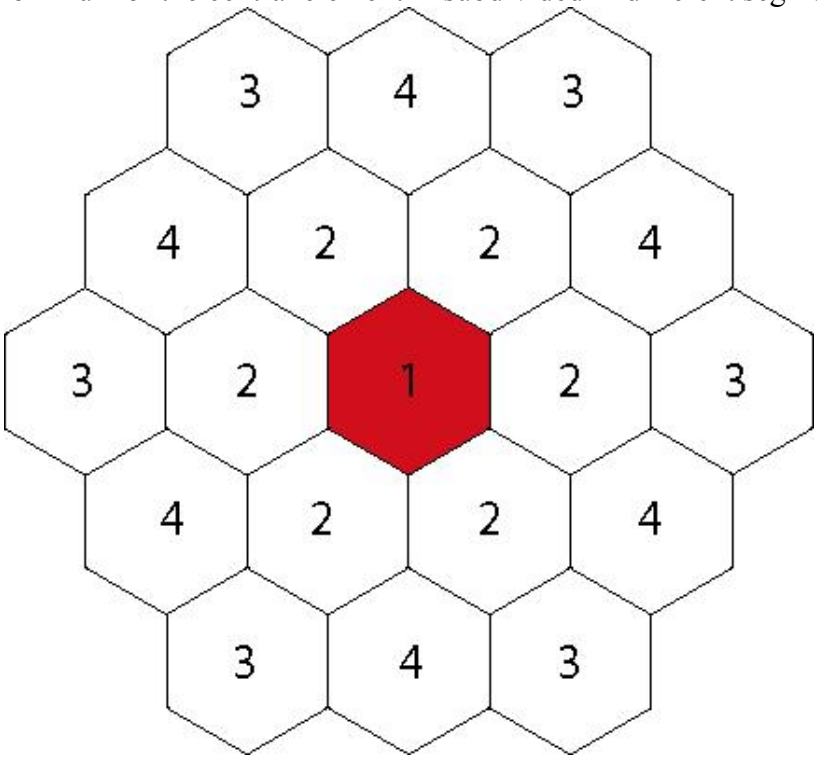

Figure 49. Top view of the SAD target. The results shown in this section are given for the target assembly #1 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
10 – 12	1.78962E-01	30 – 32	5.90640E-02
12 – 14	2.15645E-01	32 - 34	4.65412E-02
14 - 16	2.09708E-01	34 – 36	3.59482E-02
16 – 18	1.92931E-01	36 – 38	2.67080E-02
18 – 20	1.72394E-01	38 – 40	1.91800E-02
20 – 22	1.50532E-01	40 – 42	1.25479E-02
22 – 24	1.29139E-01	42 – 44	8.20593E-03
24 – 26	1.08833E-01	44 – 46	5.33006E-03
26 – 28	9.07209E-02	46 – 48	3.83973E-03
28 - 30	7.39195E-02	48 - 51	2.32844E-03

Table 9. Neutron flux results for the element #1 at different heights.

- Neutron Flux of the element #2 subdivided in different segments

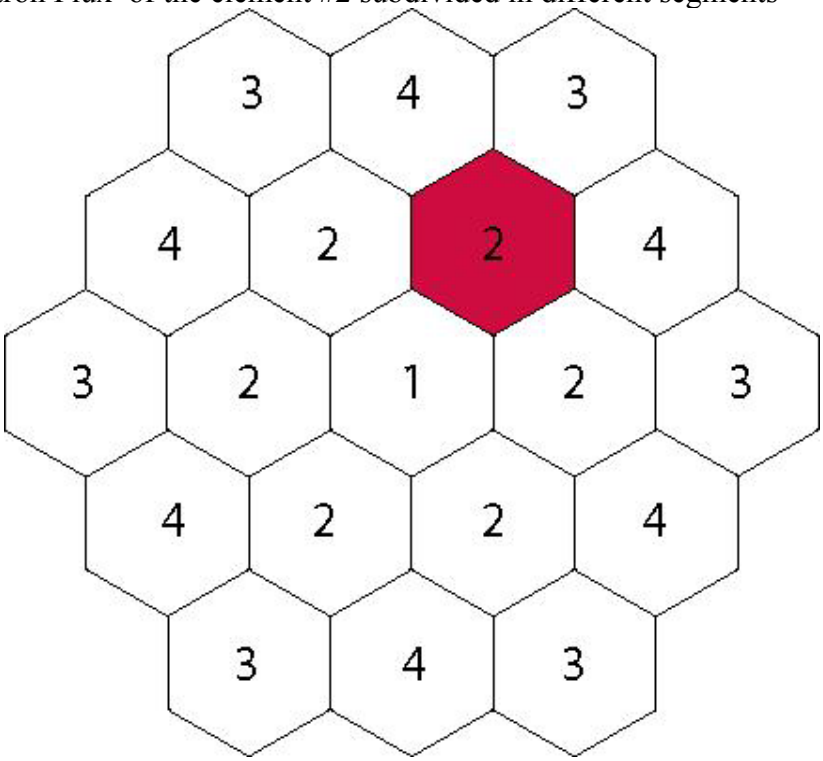

Figure 50. Top view of the SAD target. The results shown in this section are given for the target assembly #2 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	5.25348E-03	26 – 28	4.20891E-02
2 – 4	8.31658E-03	28 - 30	3.69938E-02
4 - 6	1.25707E-02	30 – 32	3.20147E-02
6 – 8	1.91745E-02	32 - 34	2.71209E-02
8 – 10	2.99059E-02	34 – 36	2.24065E-02
10 – 12	4.53298E-02	36 – 38	1.77948E-02
12 – 14	5.77295E-02	38 – 40	1.37224E-02
14 - 16	6.31651E-02	40 – 42	1.02715E-02
16 – 18	6.36464E-02	42 – 44	7.44827E-03
18 – 20	6.12173E-02	44 – 46	4.89703E-03
20 – 22	5.71190E-02	46 – 48	3.31691E-03
22 – 24	5.23591E-02	48 - 51	2.05236E-03
24 – 26	4.72587E-02		

Table 10. Neutron flux results for the element #2 at different heights.

- Neutron Flux of the element #3 subdivided in different segments

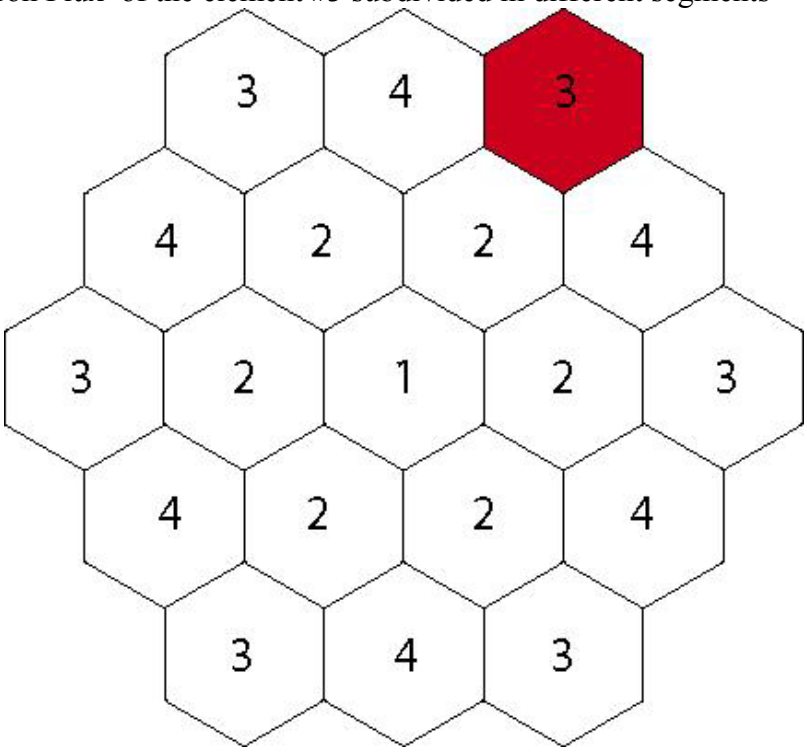

Figure 51. Top view of the SAD target. The results shown in this section are given for the target assembly #3 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	2.75204E-03	26 – 28	1.65839E-02
2 – 4	4.32400E-03	28 - 30	1.48064E-02
4 - 6	6.28025E-03	30 – 32	1.29814E-02
6 – 8	8.84906E-03	32 - 34	1.11966E-02
8 – 10	1.20704E-02	34 – 36	9.47970E-03
10 – 12	1.55538E-02	36 – 38	7.80082E-03
12 – 14	1.87067E-02	38 – 40	6.35087E-03
14 - 16	2.08939E-02	40 – 42	5.10709E-03
16 – 18	2.19574E-02	42 – 44	3.71242E-03
18 – 20	2.19263E-02	44 – 46	2.77163E-03
20 – 22	2.11591E-02	46 – 48	1.96246E-03
22 – 24	1.98921E-02	48 - 51	1.24685E-03
24 – 26	1.83417E-02		

Table 11. Neutron flux results for the element #3 at different heights.

- Neutron Flux of the element #4subdivided in different segments

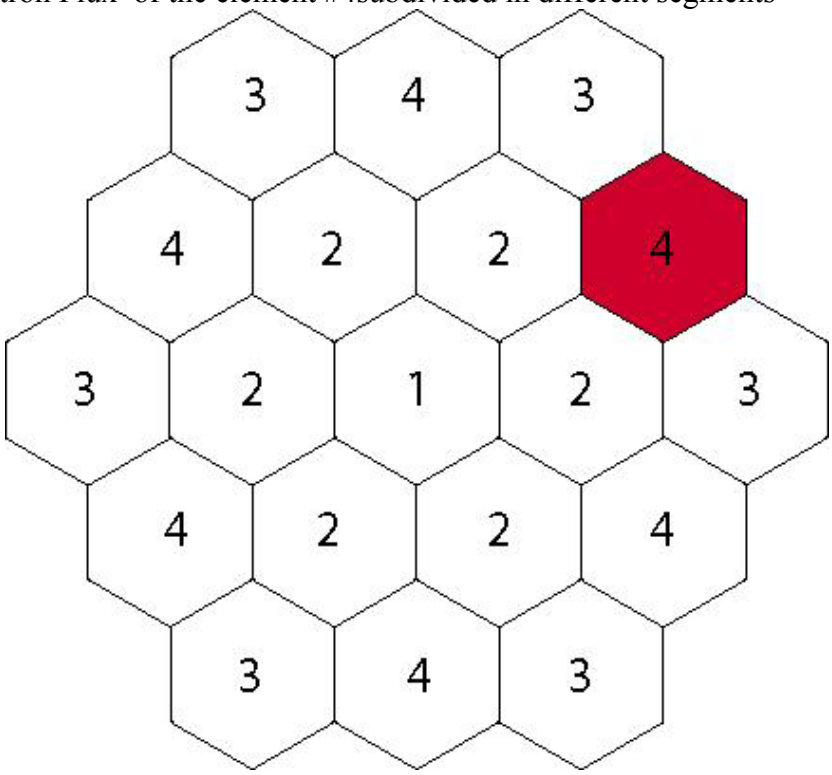

Figure 52. Top view of the SAD target. The results shown in this section are given for the target assembly #4 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	3.33292E-03	26 – 28	2.14923E-02
2 – 4	5.29320E-03	28 - 30	1.90914E-02
4 - 6	7.81949E-03	30 – 32	1.66878E-02
6 – 8	1.12082E-02	32 - 34	1.43343E-02
8 – 10	1.56017E-02	34 – 36	1.21307E-02
10 – 12	2.05999E-02	36 – 38	9.95194E-03
12 – 14	2.50757E-02	38 – 40	7.60311E-03
14 - 16	2.79541E-02	40 – 42	5.71382E-03
16 – 18	2.92006E-02	42 – 44	4.23604E-03
18 – 20	2.90041E-02	44 – 46	3.15711E-03
20 – 22	2.77870E-02	46 – 48	2.35504E-03
22 – 24	2.59576E-02	48 - 51	1.49548E-03
24 – 26	2.38489E-02		

Table 12. Neutron flux results for the element #4 at different heights.

APENDIX I – TARGET – EXERCISE 5

RESULTS (Ciemat input using CEM2k physic model)

- Neutron Flux of the central element #1subdivided in different segments

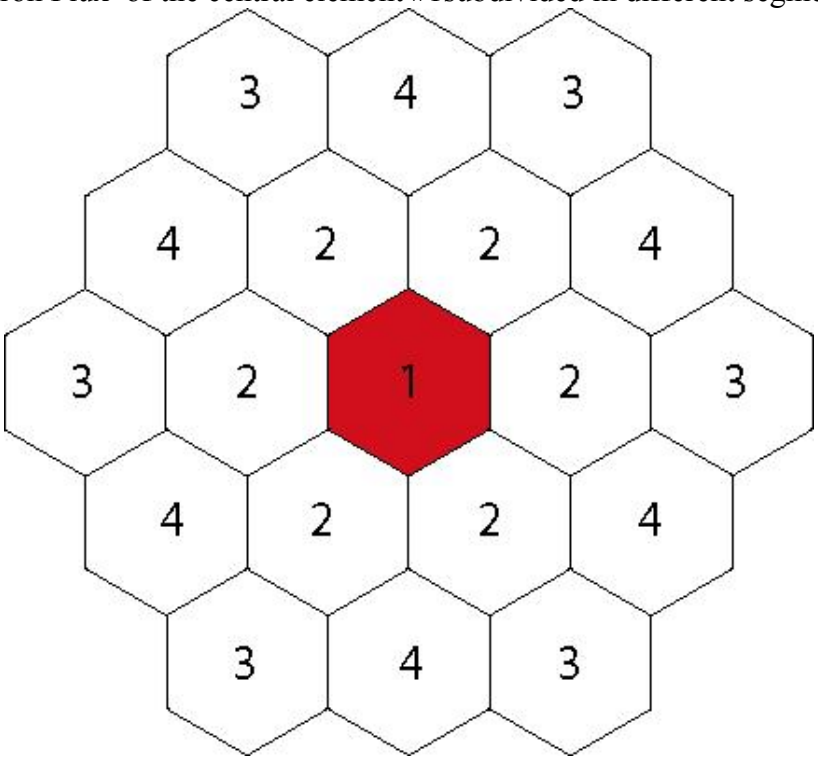

Figure 62. Top view of the SAD target. The results shown in this section are given for the target assembly #1 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
10 – 12	1.77222E-01	30 – 32	5.89028E-02
12 – 14	2.15228E-01	32 - 34	4.61960E-02
14 - 16	2.09334E-01	34 – 36	3.55247E-02
16 – 18	1.92535E-01	36 – 38	2.63100E-02
18 – 20	1.72265E-01	38 – 40	1.88942E-02
20 – 22	1.50264E-01	40 – 42	1.23609E-02
22 – 24	1.29043E-01	42 – 44	8.08365E-03
24 – 26	1.08810E-01	44 – 46	5.25063E-03
26 – 28	9.07337E-02	46 – 48	3.78251E-03
28 - 30	7.37671E-02	48 - 51	2.29374E-03

Table 13. Neutron flux results for the element #1 at different heights.

- Neutron Flux of the element #2 subdivided in different segments

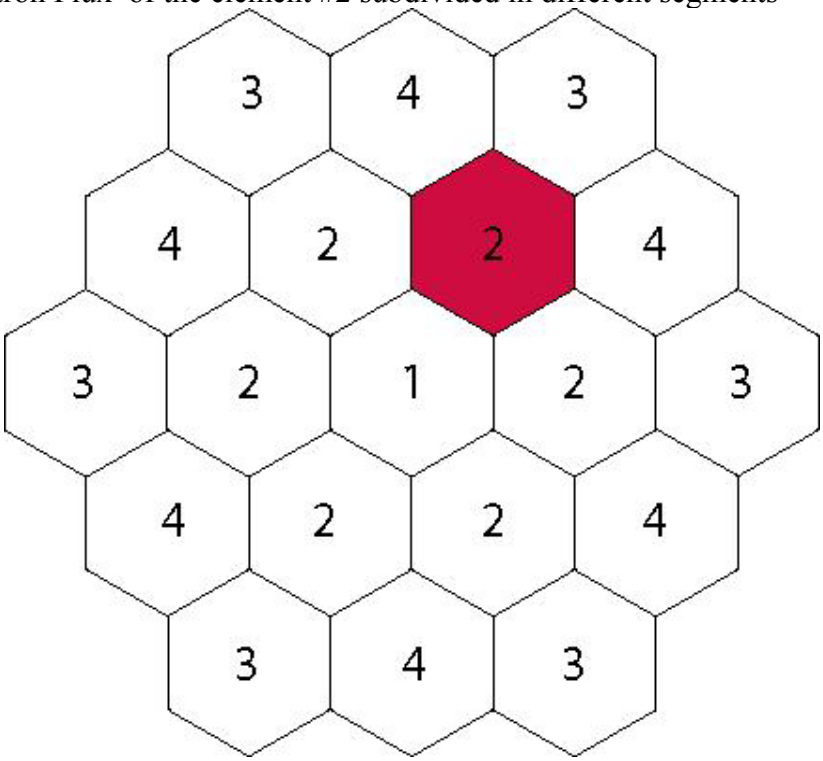

Figure 63. Top view of the SAD target. The results shown in this section are given for the target assembly #2 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	5.12882E-03	26 – 28	4.22273E-02
2 – 4	8.20388E-03	28 - 30	3.70320E-02
4 - 6	1.24041E-02	30 – 32	3.20304E-02
6 – 8	1.88775E-02	32 - 34	2.70724E-02
8 – 10	2.94960E-02	34 – 36	2.22785E-02
10 – 12	4.48694E-02	36 – 38	1.76579E-02
12 – 14	5.75186E-02	38 – 40	1.36168E-02
14 - 16	6.29893E-02	40 – 42	1.01925E-02
16 – 18	6.35159E-02	42 – 44	7.39097E-03
18 – 20	6.12645E-02	44 – 46	4.85936E-03
20 – 22	5.72936E-02	46 – 48	3.29139E-03
22 – 24	5.25006E-02	48 - 51	2.03657E-03
24 – 26	4.74267E-02		

Table 14. Neutron flux results for the element #2 at different heights.

- Neutron Flux of the element #3 subdivided in different segments

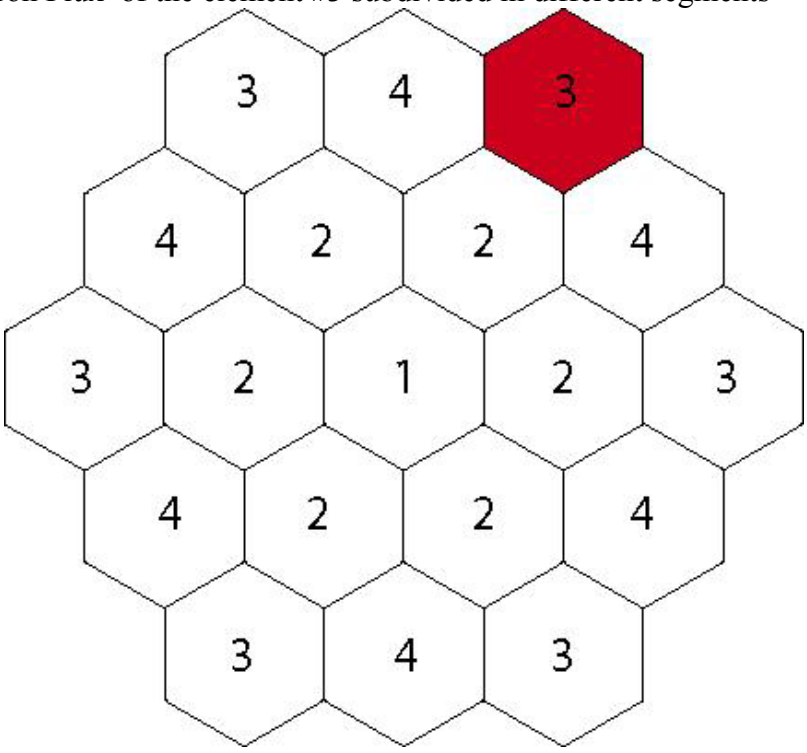

Figure 64. Top view of the SAD target. The results shown in this section are given for the target assembly #3 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	2.75454E-03	26 – 28	1.68889E-02
2 – 4	4.31277E-03	28 - 30	1.50415E-02
4 - 6	6.29839E-03	30 – 32	1.31604E-02
6 – 8	8.83858E-03	32 - 34	1.13390E-02
8 – 10	1.21046E-02	34 – 36	9.58377E-03
10 – 12	1.55994E-02	36 – 38	7.81529E-03
12 – 14	1.87946E-02	38 – 40	6.36265E-03
14 - 16	2.10415E-02	40 – 42	5.11656E-03
16 – 18	2.21425E-02	42 – 44	3.71931E-03
18 – 20	2.21756E-02	44 – 46	2.77677E-03
20 – 22	2.14061E-02	46 – 48	1.96610E-03
22 – 24	2.02049E-02	48 - 51	1.24916E-03
24 – 26	1.86575E-02		

Table 15. Neutron flux results for the element #3 at different heights.

- Neutron Flux of the element #4subdivided in different segments

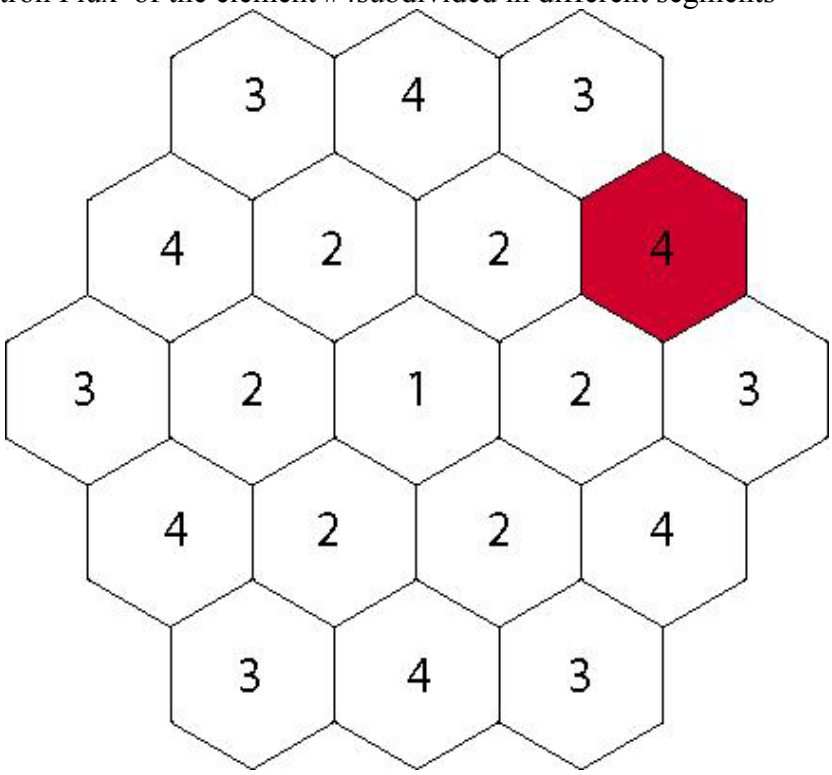

Figure 65. Top view of the SAD target. The results shown in this section are given for the target assembly #4 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	3.31452E-03	26 – 28	2.16712E-02
2 – 4	5.24739E-03	28 - 30	1.92163E-02
4 - 6	7.72049E-03	30 – 32	1.68305E-02
6 – 8	1.10736E-02	32 - 34	1.45121E-02
8 – 10	1.54772E-02	34 – 36	1.21699E-02
10 – 12	2.05041E-02	36 – 38	9.91121E-03
12 – 14	2.50058E-02	38 – 40	7.57199E-03
14 - 16	2.80528E-02	40 – 42	5.69044E-03
16 – 18	2.92685E-02	42 – 44	4.21870E-03
18 – 20	2.91854E-02	44 – 46	3.14419E-03
20 – 22	2.79769E-02	46 – 48	2.34540E-03
22 – 24	2.61455E-02	48 - 51	1.48936E-03
24 – 26	2.40474E-02		

Table 16. Neutron flux results for the element #4 at different heights.

APENDIX I – TARGET – EXERCISE 6

RESULTS (Ciemat input using Isabel/ABLA physic model)

- Neutron Flux of the central element #1subdivided in different segments

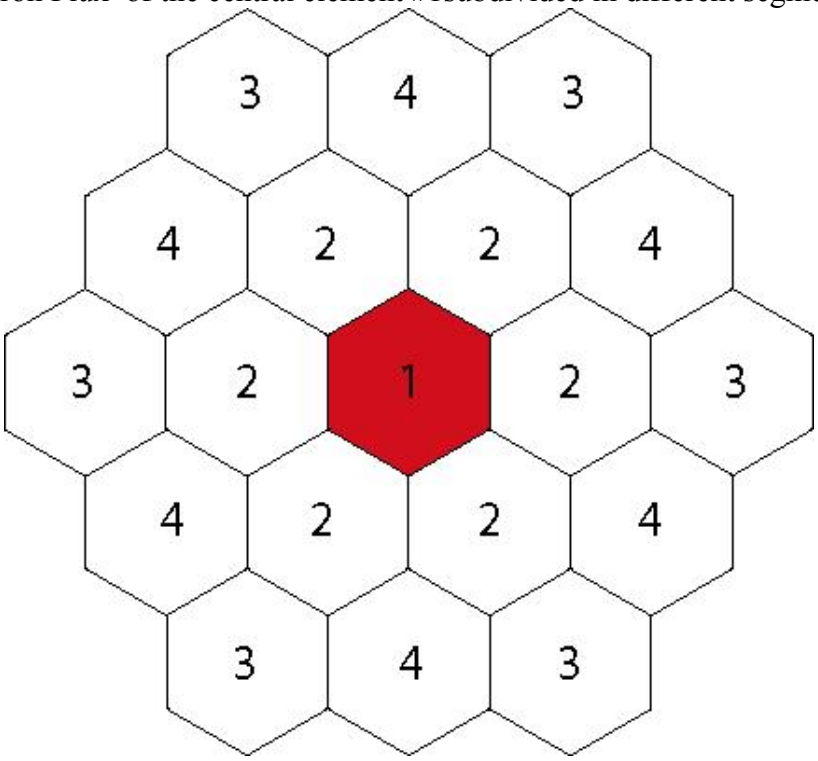

Figure 75. Top view of the SAD target. The results shown in this section are given for the target assembly #1 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
10 – 12	1.60844E-01	30 – 32	5.70282E-02
12 – 14	1.96055E-01	32 - 34	4.15066E-02
14 - 16	1.92606E-01	34 – 36	3.19186E-02
16 – 18	1.78896E-01	36 – 38	2.36392E-02
18 – 20	1.60904E-01	38 – 40	1.69762E-02
20 – 22	1.41772E-01	40 – 42	1.11061E-02
22 – 24	1.22746E-01	42 – 44	7.26307E-03
24 – 26	1.03913E-01	44 – 46	4.71763E-03
26 – 28	8.71979E-02	46 – 48	3.39855E-03
28 - 30	7.14581E-02	48 - 51	2.06090E-03

Table 17. Neutron flux results for the element #1 at different heights.

- Neutron Flux of the element #2 subdivided in different segments

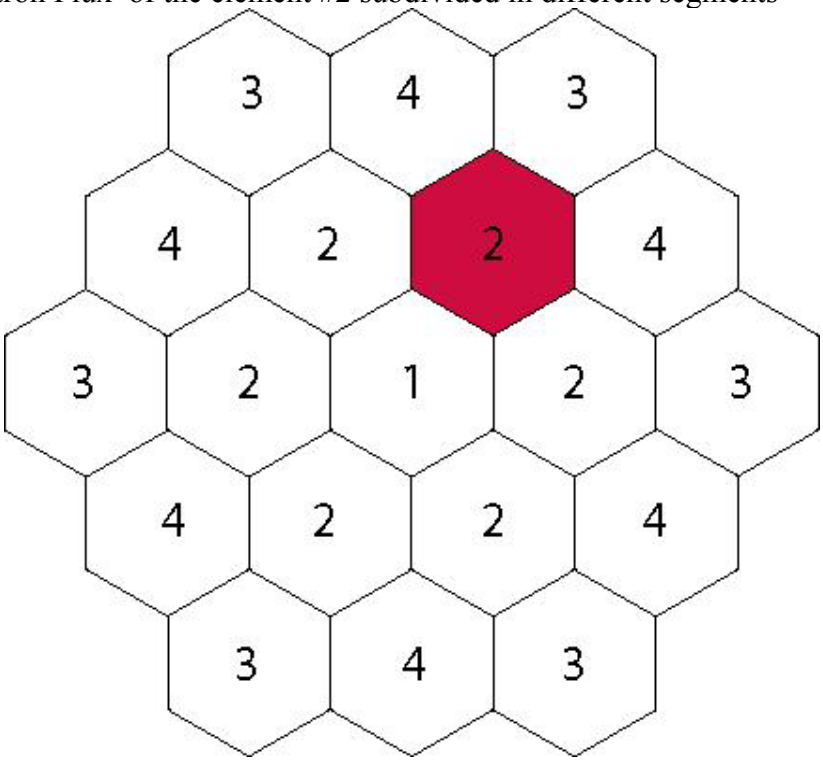

Figure 76. Top view of the SAD target. The results shown in this section are given for the target assembly #2 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	4.71010E-03	26 – 28	4.04361E-02
2 – 4	7.50300E-03	28 - 30	3.57800E-02
4 - 6	1.12692E-02	30 – 32	3.11152E-02
6 – 8	1.71732E-02	32 - 34	2.65048E-02
8 – 10	2.68261E-02	34 – 36	2.19415E-02
10 – 12	4.08010E-02	36 – 38	1.75068E-02
12 – 14	5.24302E-02	38 – 40	1.35003E-02
14 - 16	5.78670E-02	40 – 42	1.01053E-02
16 – 18	5.91244E-02	42 – 44	7.32772E-03
18 – 20	5.72590E-02	44 – 46	4.81777E-03
20 – 22	5.39221E-02	46 – 48	3.26323E-03
22 – 24	4.96656E-02	48 - 51	2.01914E-03
24 – 26	4.50378E-02		

Table 18. Neutron flux results for the element #2 at different heights.

- Neutron Flux of the element #3 subdivided in different segments

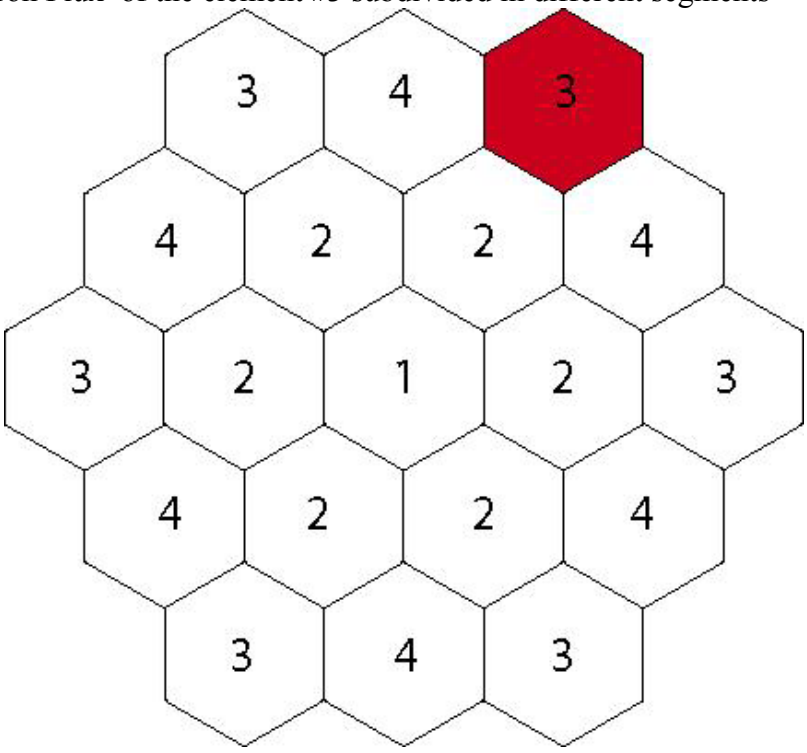

Figure 77. Top view of the SAD target. The results shown in this section are given for the target assembly #3 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	2.52326E-03	26 – 28	1.61617E-02
2 – 4	3.96606E-03	28 - 30	1.44581E-02
4 - 6	5.74055E-03	30 – 32	1.27854E-02
6 – 8	8.06320E-03	32 - 34	1.10886E-02
8 – 10	1.10115E-02	34 – 36	9.36405E-03
10 – 12	1.43326E-02	36 – 38	7.78764E-03
12 – 14	1.73060E-02	38 – 40	6.34014E-03
14 - 16	1.94369E-02	40 – 42	5.09846E-03
16 – 18	2.06017E-02	42 – 44	3.70615E-03
18 – 20	2.08079E-02	44 – 46	2.76695E-03
20 – 22	2.01968E-02	46 – 48	1.95915E-03
22 – 24	1.91606E-02	48 - 51	1.24474E-03
24 – 26	1.78062E-02		

Table 19. Neutron flux results for the element #3 at different heights.

- Neutron Flux of the element #4subdivided in different segments

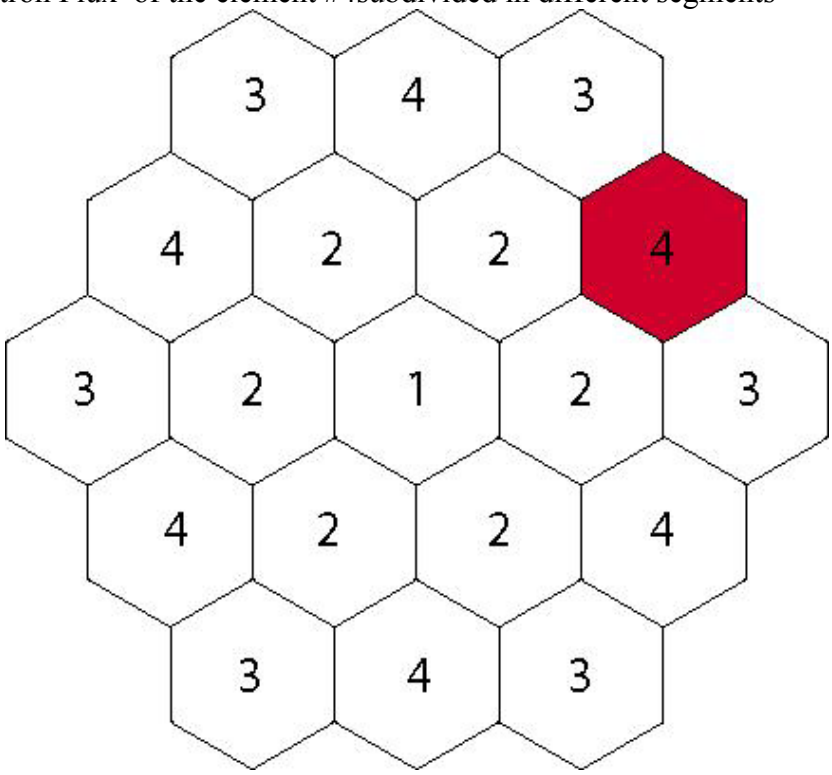

Figure 78. Top view of the SAD target. The results shown in this section are given for the target assembly #4 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	3.02028E-03	26 – 28	2.07719E-02
2 – 4	4.77348E-03	28 - 30	1.85338E-02
4 - 6	7.04555E-03	30 – 32	1.62891E-02
6 – 8	1.01167E-02	32 - 34	1.40797E-02
8 – 10	1.41420E-02	34 – 36	1.19507E-02
10 – 12	1.87623E-02	36 – 38	9.84546E-03
12 – 14	2.29772E-02	38 – 40	7.52176E-03
14 - 16	2.58368E-02	40 – 42	5.65269E-03
16 – 18	2.71986E-02	42 – 44	4.19072E-03
18 – 20	2.73057E-02	44 – 46	3.12333E-03
20 – 22	2.64412E-02	46 – 48	2.32984E-03
22 – 24	2.48380E-02	48 - 51	1.47948E-03
24 – 26	2.28796E-02		

Table 20. Neutron flux results for the element #4 at different heights.

APENDIX I – TARGET – EXERCISE 7

RESULTS (Ciemat input using INCL4/Dresner physic model)

- Neutron Flux of the central element #1subdivided in different segments

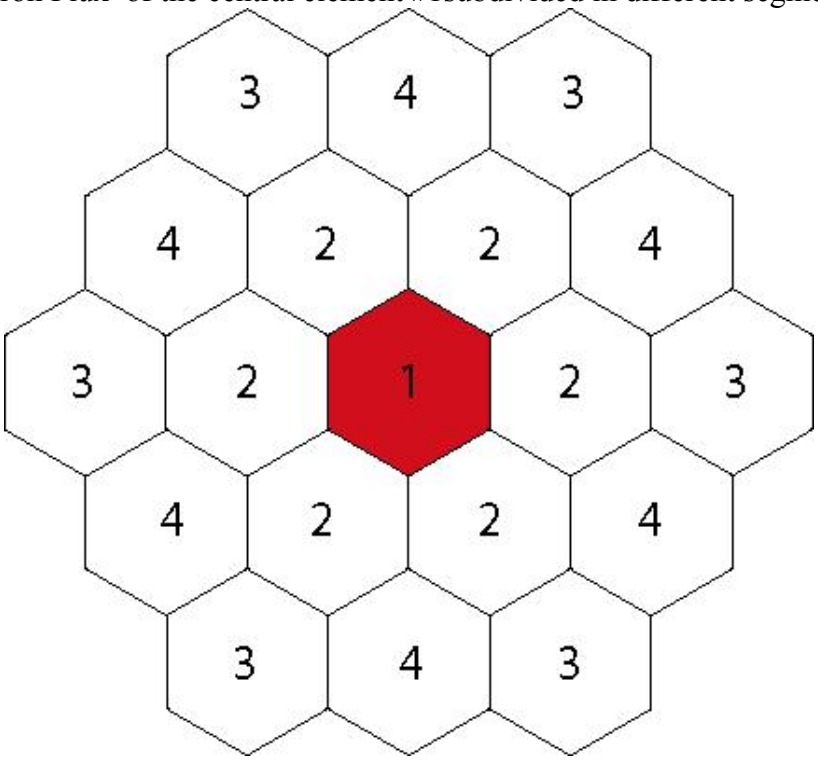

Figure 88. Top view of the SAD target. The results shown in this section are given for the target assembly #1 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
10 – 12	1.52363E-01	30 – 32	5.22588E-02
12 – 14	1.85425E-01	32 - 34	4.03850E-02
14 - 16	1.81621E-01	34 – 36	3.10561E-02
16 – 18	1.67815E-01	36 – 38	2.30005E-02
18 – 20	1.50515E-01	38 – 40	1.65175E-02
20 – 22	1.31974E-01	40 – 42	1.08060E-02
22 – 24	1.13421E-01	42 – 44	7.06681E-03
24 – 26	9.57928E-02	44 – 46	4.59015E-03
26 – 28	7.99324E-02	46 – 48	3.30671E-03
28 - 30	6.51807E-02	48 - 51	2.00521E-03

Table 21. Neutron flux results for the element #1 at different heights.

- Neutron Flux of the element #2 subdivided in different segments

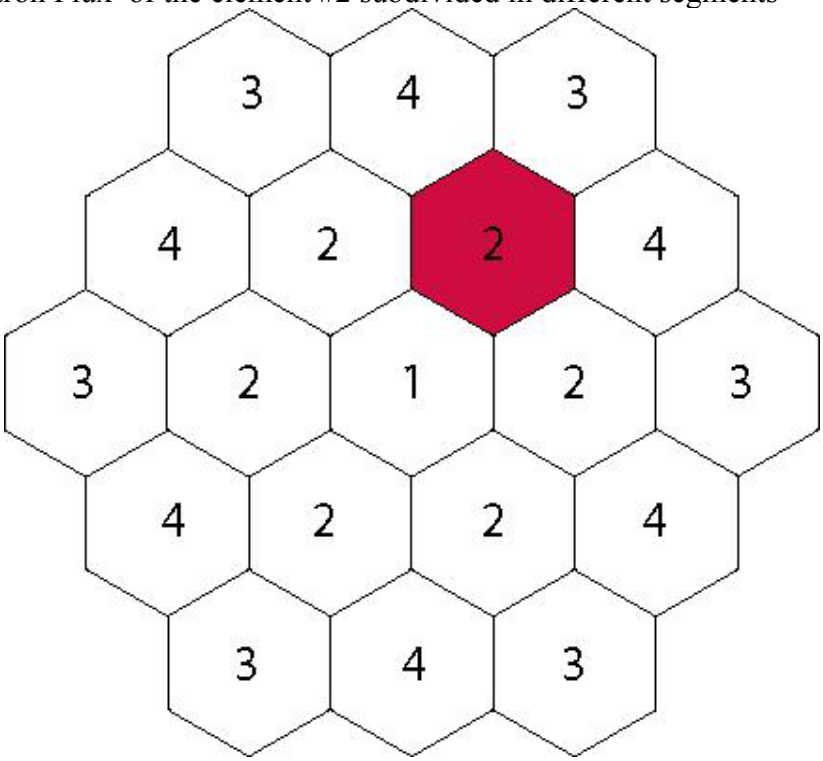

Figure 89. Top view of the SAD target. The results shown in this section are given for the target assembly #2 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	4.48917E-03	26 – 28	3.76354E-02
2 – 4	7.18249E-03	28 - 30	3.30698E-02
4 - 6	1.08497E-02	30 – 32	2.85475E-02
6 – 8	1.65231E-02	32 - 34	2.42116E-02
8 – 10	2.58618E-02	34 – 36	1.99704E-02
10 – 12	3.95045E-02	36 – 38	1.59686E-02
12 – 14	5.08045E-02	38 – 40	1.23141E-02
14 - 16	5.58966E-02	40 – 42	9.21738E-03
16 – 18	5.65212E-02	42 – 44	6.68389E-03
18 – 20	5.45791E-02	44 – 46	4.39447E-03
20 – 22	5.11627E-02	46 – 48	2.97651E-03
22 – 24	4.68454E-02	48 - 51	1.84173E-03
24 – 26	4.22011E-02		

Table 22. Neutron flux results for the element #2 at different heights.

- Neutron Flux of the element #3 subdivided in different segments

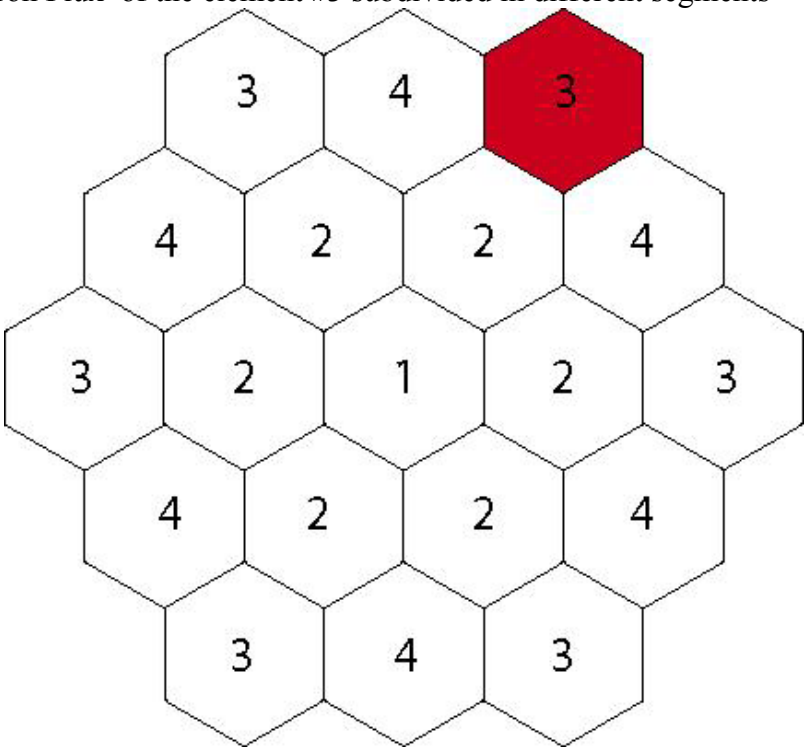

Figure 90. Top view of the SAD target. The results shown in this section are given for the target assembly #3 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	2.40541E-03	26 – 28	1.51427E-02
2 – 4	3.78840E-03	28 - 30	1.34798E-02
4 - 6	5.54093E-03	30 – 32	1.18422E-02
6 – 8	7.84944E-03	32 - 34	1.02354E-02
8 – 10	1.06992E-02	34 – 36	8.63809E-03
10 – 12	1.38657E-02	36 – 38	7.13133E-03
12 – 14	1.68602E-02	38 – 40	5.80582E-03
14 - 16	1.88924E-02	40 – 42	4.66878E-03
16 – 18	1.98865E-02	42 – 44	3.39381E-03
18 – 20	1.98659E-02	44 – 46	2.53376E-03
20 – 22	1.92280E-02	46 – 48	1.79404E-03
22 – 24	1.81046E-02	48 - 51	1.13984E-03
24 – 26	1.67271E-02		

Table 23. Neutron flux results for the element #3 at different heights.

- Neutron Flux of the element #4subdivided in different segments

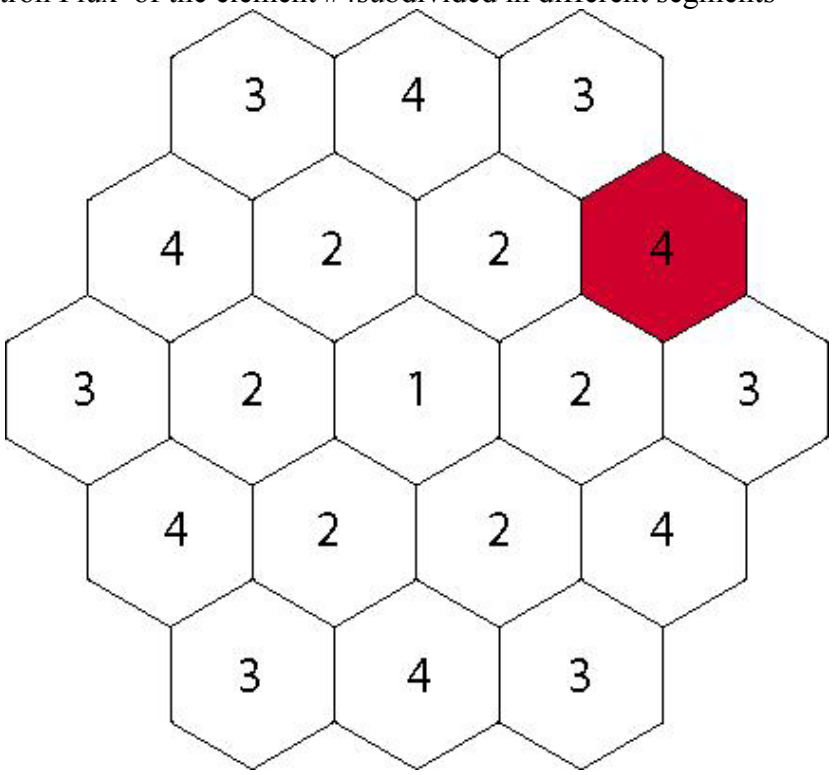

Figure 91. Top view of the SAD target. The results shown in this section are given for the target assembly #4 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	2.88710E-03	26 – 28	1.93724E-02
2 – 4	4.61363E-03	28 - 30	1.72391E-02
4 - 6	6.77666E-03	30 – 32	1.50693E-02
6 – 8	9.73974E-03	32 - 34	1.29618E-02
8 – 10	1.37223E-02	34 – 36	1.09477E-02
10 – 12	1.82421E-02	36 – 38	8.95643E-03
12 – 14	2.23614E-02	38 – 40	6.84256E-03
14 - 16	2.51134E-02	40 – 42	5.14226E-03
16 – 18	2.62607E-02	42 – 44	3.81230E-03
18 – 20	2.60984E-02	44 – 46	2.84130E-03
20 – 22	2.51396E-02	46 – 48	2.11946E-03
22 – 24	2.34705E-02	48 - 51	1.34588E-03
24 – 26	2.14506E-02		

Table 24. Neutron flux results for the element #4 at different heights.

EXERCISE 8

RESULTS (Ciemat input using INCL4/ABLA physic model)

- Neutron Flux of the central element #1subdivided in different segments

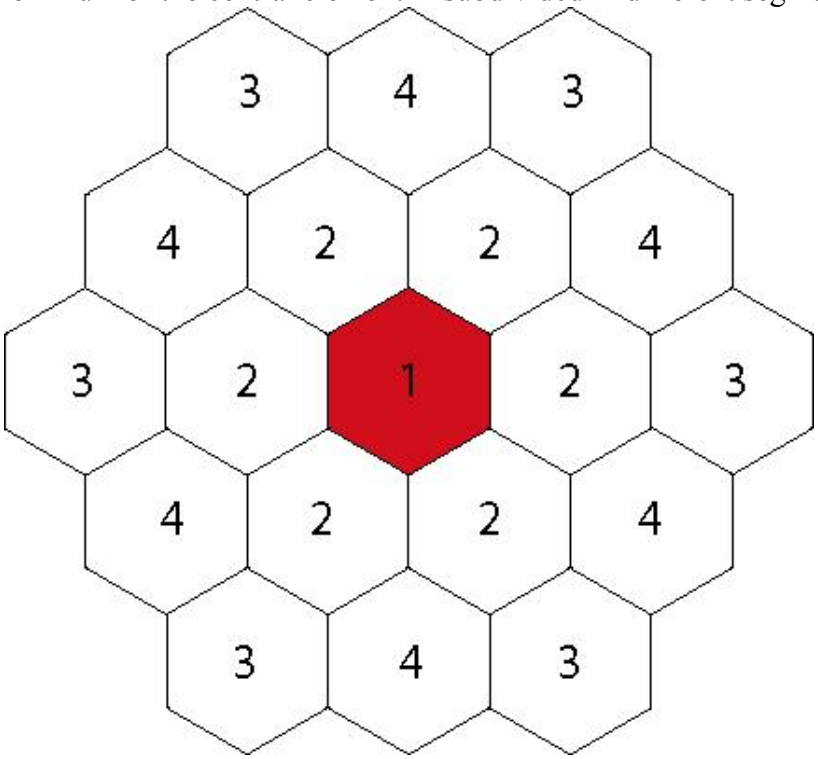

Figure 101. Top view of the SAD target. The results shown in this section are given for the target assembly #1 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
10 – 12	1.61101E-01	30 – 32	5.71861E-02
12 – 14	1.95731E-01	32 - 34	4.27959E-02
14 - 16	1.91833E-01	34 – 36	3.29100E-02
16 – 18	1.77268E-01	36 – 38	2.43735E-02
18 – 20	1.59001E-01	38 – 40	1.75036E-02
20 – 22	1.39433E-01	40 – 42	1.14511E-02
22 – 24	1.20154E-01	42 – 44	7.48868E-03
24 – 26	1.01657E-01	44 – 46	4.86417E-03
26 – 28	8.49095E-02	46 – 48	3.50411E-03
28 - 30	6.91782E-02	48 - 51	2.12492E-03

Table 25. Neutron flux results for the element #1 at different heights.

- Neutron Flux of the element #2 subdivided in different segments

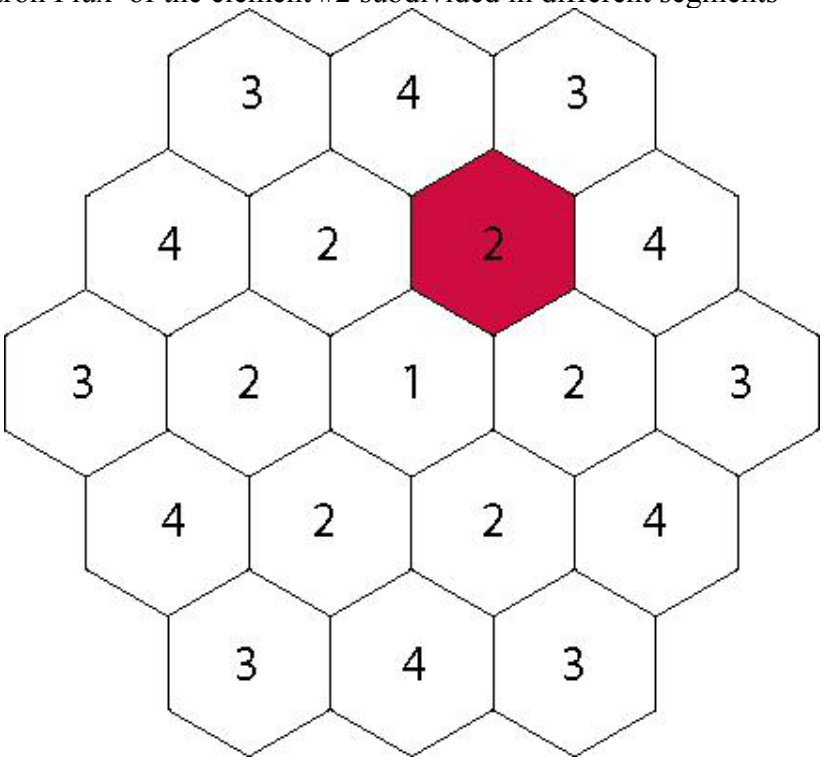

Figure 102. Top view of the SAD target. The results shown in this section are given for the target assembly #2 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	4.81342E-03	26 – 28	3.99398E-02
2 – 4	7.61179E-03	28 - 30	3.50786E-02
4 - 6	1.14997E-02	30 – 32	3.02515E-02
6 – 8	1.74976E-02	32 - 34	2.57023E-02
8 – 10	2.74105E-02	34 – 36	2.12536E-02
10 – 12	4.18197E-02	36 – 38	1.69276E-02
12 – 14	5.36165E-02	38 – 40	1.30537E-02
14 - 16	5.89976E-02	40 – 42	9.77093E-03
16 – 18	5.96947E-02	42 – 44	7.08529E-03
18 – 20	5.77341E-02	44 – 46	4.65838E-03
20 – 22	5.40947E-02	46 – 48	3.15527E-03
22 – 24	4.95587E-02	48 - 51	1.95234E-03
24 – 26	4.48444E-02		

Table 26. Neutron flux results for the element #2 at different heights.

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- Neutron Flux of the element #3 subdivided in different segments

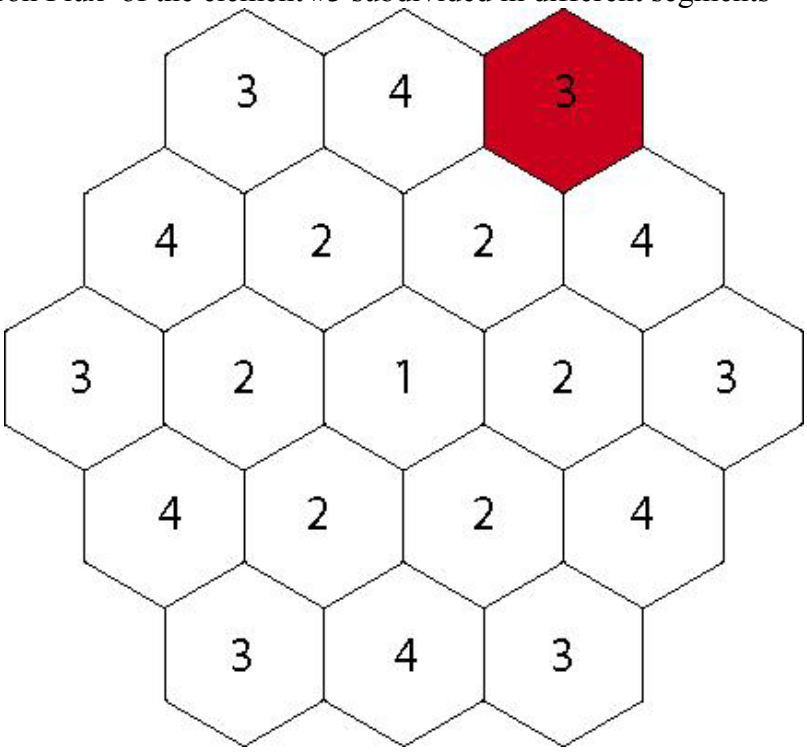

Figure 103. Top view of the SAD target. The results shown in this section are given for the target assembly #3 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	2.56124E-03	26 – 28	1.61281E-02
2 – 4	4.03312E-03	28 - 30	1.43443E-02
4 - 6	5.89392E-03	30 – 32	1.25977E-02
6 – 8	8.32919E-03	32 - 34	1.08923E-02
8 – 10	1.13715E-02	34 – 36	9.22304E-03
10 – 12	1.47711E-02	36 – 38	7.58601E-03
12 – 14	1.78609E-02	38 – 40	6.17598E-03
14 - 16	2.00505E-02	40 – 42	4.96645E-03
16 – 18	2.11079E-02	42 – 44	3.61019E-03
18 – 20	2.11976E-02	44 – 46	2.69531E-03
20 – 22	2.04995E-02	46 – 48	1.90842E-03
22 – 24	1.93417E-02	48 - 51	1.21252E-03
24 – 26	1.78559E-02		

Table 27. Neutron flux results for the element #3 at different heights.

- Neutron Flux of the element #4subdivided in different segments

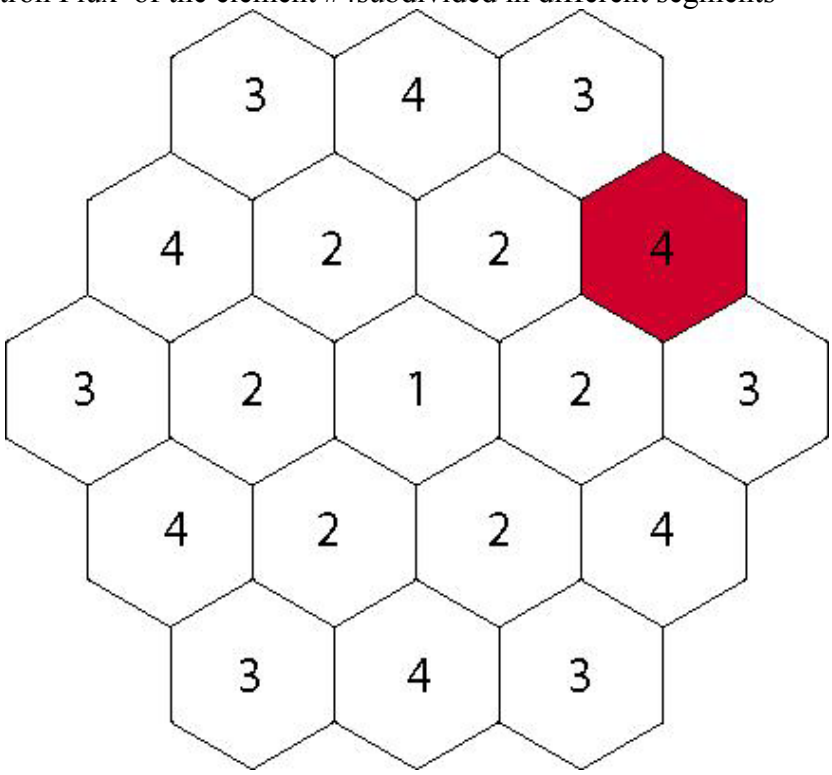

Figure 104. Top view of the SAD target. The results shown in this section are given for the target assembly #4 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	3.09258E-03	26 – 28	2.06312E-02
2 – 4	4.91620E-03	28 - 30	1.82973E-02
4 - 6	7.25749E-03	30 – 32	1.60035E-02
6 – 8	1.03626E-02	32 - 34	1.37850E-02
8 – 10	1.45659E-02	34 – 36	1.16635E-02
10 – 12	1.93757E-02	36 – 38	9.54434E-03
12 – 14	2.37608E-02	38 – 40	7.29171E-03
14 - 16	2.66367E-02	40 – 42	5.47980E-03
16 – 18	2.78350E-02	42 – 44	4.06254E-03
18 – 20	2.78365E-02	44 – 46	3.02780E-03
20 – 22	2.66925E-02	46 – 48	2.25858E-03
22 – 24	2.50083E-02	48 - 51	1.43423E-03
24 – 26	2.29235E-02		

Table 28. Neutron flux results for the element #4 at different heights.

EXERCISE 9

RESULTS (Ciemat input using the updated INCL4/ABLA physic model)

In the mcnpx input the target is composed by 19 lead assemblies. Due to the geometrical repetition, we can group these 19 cells into 4 repeated cells as the figure shows.

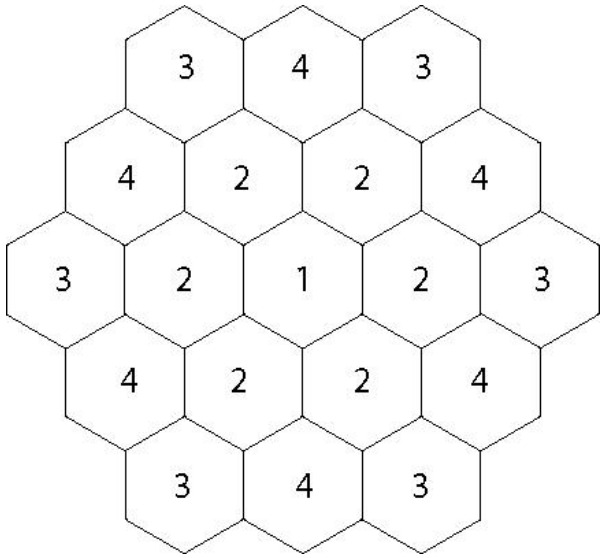

Figure 99. Top view of the target. Cells subdivisions of the simulated SAD target.

For tally purposes each target assembly was divided in segments of 2 cm of height, except the most banished one, from the proton beam impact, which height is of 3 cm. Figure 100 shows these subdivisions for tally purposes.

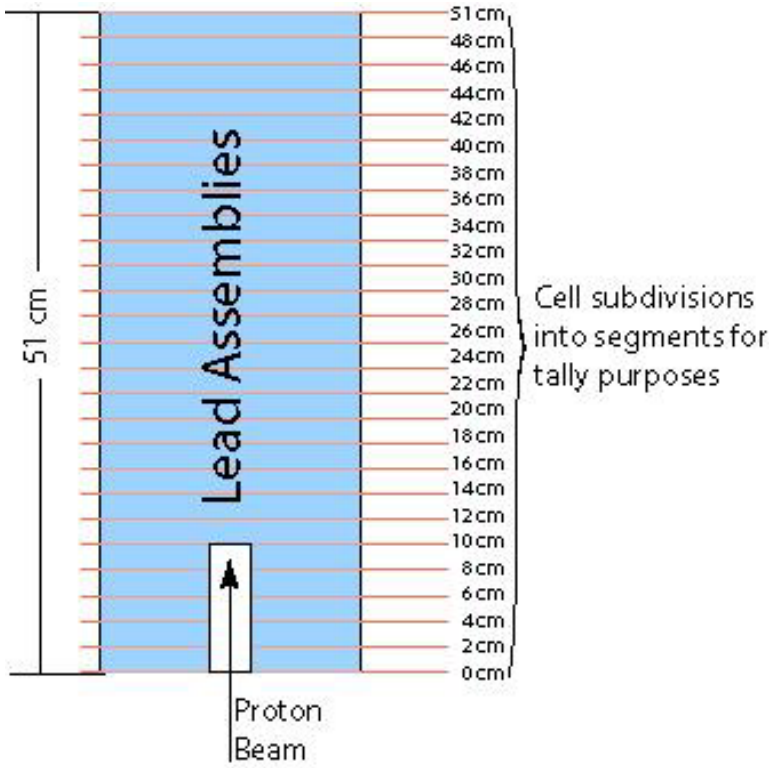

Figure 100. Side view of the SAD target. Cells subdivisions of the simulated SAD target

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- Neutron Flux of the central element #1subdivided in different segments

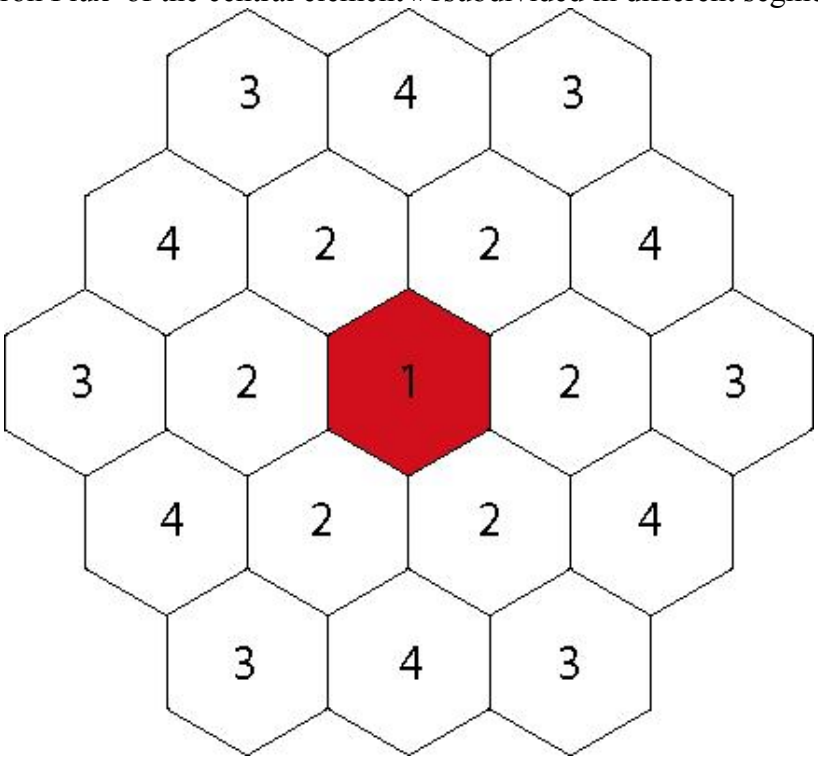

Figure 101. Top view of the SAD target. The results shown in this section are given for the target assembly #1 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
10 – 12	1.61186E-01	30 – 32	5.51685E-02
12 – 14	1.95723E-01	32 - 34	4.34606E-02
14 - 16	1.91745E-01	34 – 36	3.35871E-02
16 – 18	1.77285E-01	36 – 38	2.51855E-02
18 – 20	1.59042E-01	38 – 40	1.75515E-02
20 – 22	1.39527E-01	40 – 42	1.09135E-02
22 – 24	1.20224E-01	42 – 44	7.24666E-03
24 – 26	1.01593E-01	44 – 46	5.03768E-03
26 – 28	8.48040E-02	46 – 48	3.55129E-03
28 - 30	6.91192E-02	48 - 51	2.11366E-03

Table 25. Neutron flux results for the element #1 at different heights.

- Neutron Flux of the element #2 subdivided in different segments

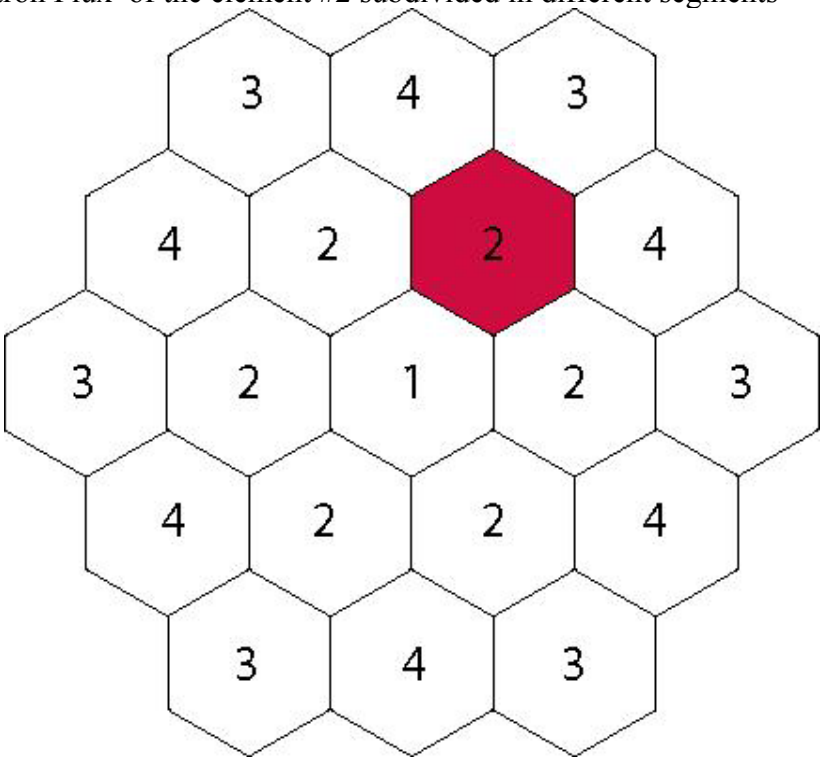

Figure 102. Top view of the SAD target. The results shown in this section are given for the target assembly #2 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	4.79623E-03	26 – 28	3.99450E-02
2 – 4	7.64058E-03	28 - 30	3.50635E-02
4 - 6	1.15250E-02	30 – 32	3.02110E-02
6 – 8	1.75145E-02	32 - 34	2.56865E-02
8 – 10	2.74501E-02	34 – 36	2.12311E-02
10 – 12	4.18281E-02	36 – 38	1.69088E-02
12 – 14	5.36380E-02	38 – 40	1.30392E-02
14 - 16	5.90283E-02	40 – 42	9.76008E-03
16 – 18	5.97225E-02	42 – 44	7.07742E-03
18 – 20	5.77498E-02	44 – 46	4.65321E-03
20 – 22	5.41508E-02	46 – 48	3.15176E-03
22 – 24	4.96037E-02	48 - 51	1.95017E-03
24 – 26	4.47952E-02		

Table 26. Neutron flux results for the element #2 at different heights.

- Neutron Flux of the element #3 subdivided in different segments

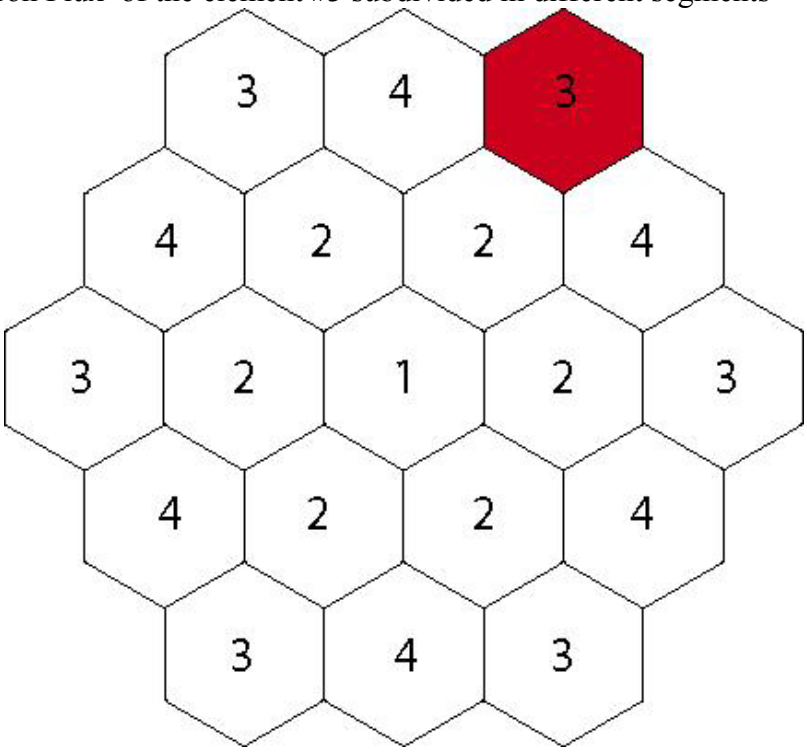

Figure 103. Top view of the SAD target. The results shown in this section are given for the target assembly #3 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	2.58180E-03	26 – 28	1.60955E-02
2 – 4	4.06834E-03	28 - 30	1.43432E-02
4 - 6	5.88972E-03	30 – 32	1.25727E-02
6 – 8	8.33081E-03	32 - 34	1.08612E-02
8 – 10	1.13892E-02	34 – 36	9.18759E-03
10 – 12	1.47863E-02	36 – 38	7.52881E-03
12 – 14	1.78773E-02	38 – 40	6.12942E-03
14 - 16	2.00212E-02	40 – 42	4.92901E-03
16 – 18	2.10559E-02	42 – 44	3.58297E-03
18 – 20	2.11441E-02	44 – 46	2.67499E-03
20 – 22	2.04859E-02	46 – 48	1.89403E-03
22 – 24	1.93292E-02	48 - 51	1.20337E-03
24 – 26	1.77866E-02		

Table 27. Neutron flux results for the element #3 at different heights.

- Neutron Flux of the element #4subdivided in different segments

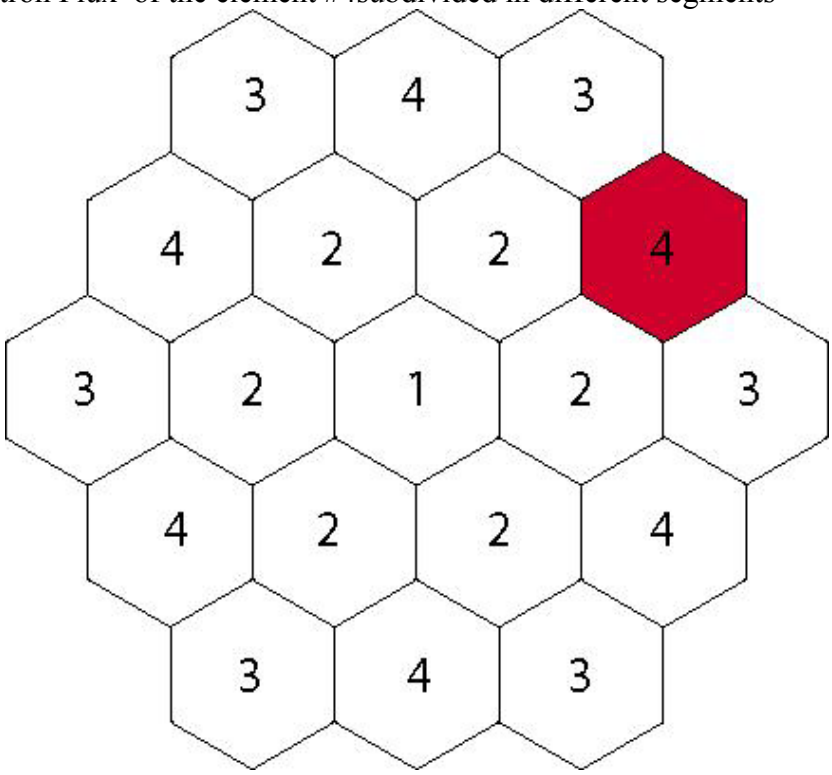

Figure 104. Top view of the SAD target. The results shown in this section are given for the target assembly #4 (in red in this figure)

Section Height (cm)	Neutron flux (1/cm^2)	Section Height (cm)	Neutron flux (1/cm^2)
0 – 2	3.08410E-03	26 – 28	2.06701E-02
2 – 4	4.92332E-03	28 - 30	1.83050E-02
4 - 6	7.25174E-03	30 – 32	1.60169E-02
6 – 8	1.04408E-02	32 - 34	1.37745E-02
8 – 10	1.45835E-02	34 – 36	1.16438E-02
10 – 12	1.93622E-02	36 – 38	9.51016E-03
12 – 14	2.37351E-02	38 – 40	7.48098E-03
14 - 16	2.65046E-02	40 – 42	5.62811E-03
16 – 18	2.78736E-02	42 – 44	4.18059E-03
18 – 20	2.78323E-02	44 – 46	3.05006E-03
20 – 22	2.67185E-02	46 – 48	2.21837E-03
22 – 24	2.50578E-02	48 - 51	1.37893E-03
24 – 26	2.29634E-02		

Table 28. Neutron flux results for the element #4 at different heights.

- Averaged neutron flux in the whole lead target.

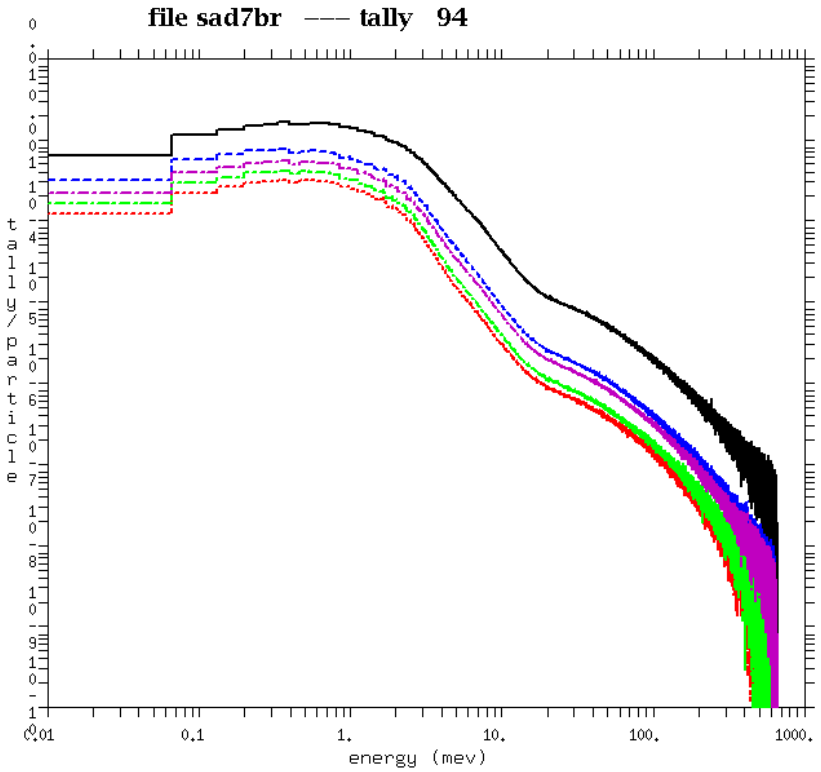

Figure 105. Neutron flux spectrum in the lead target. Black = cell #1; Blue = cell #2 (6 cells); Red = cell #3 (6 cells); Green =cell #4 (6 cells); Purple = All core (19 cells)

- Averaged proton flux in the whole lead target.

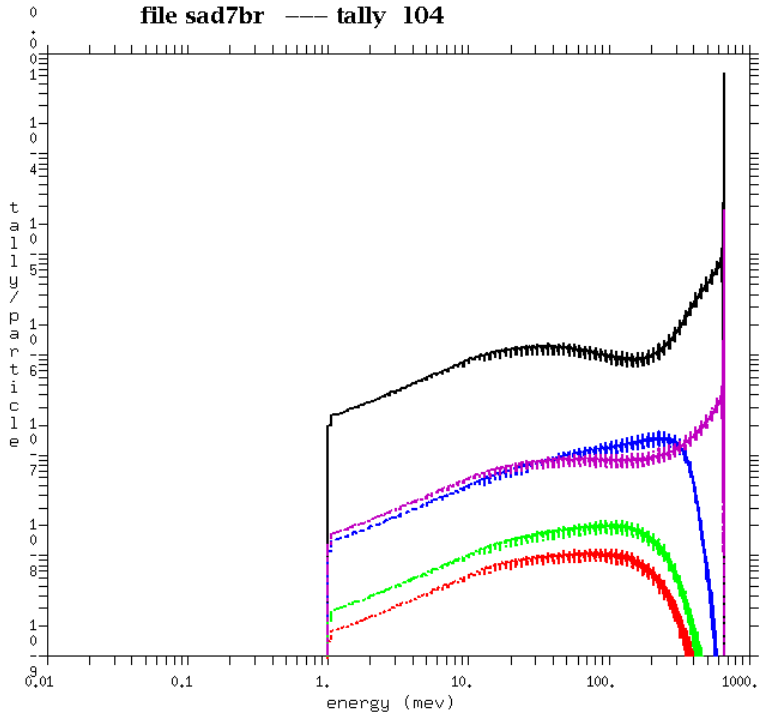

Figure 106. proton flux spectrum in the lead target. Black = cell #1; Blue = cell #2 (6 cells); Red = cell #3 (6 cells); Green =cell #4 (6 cells); Purple = All core (19 cells)

- Averaged neutron flux in the top, bottom and perimeter surfaces of the lead target.

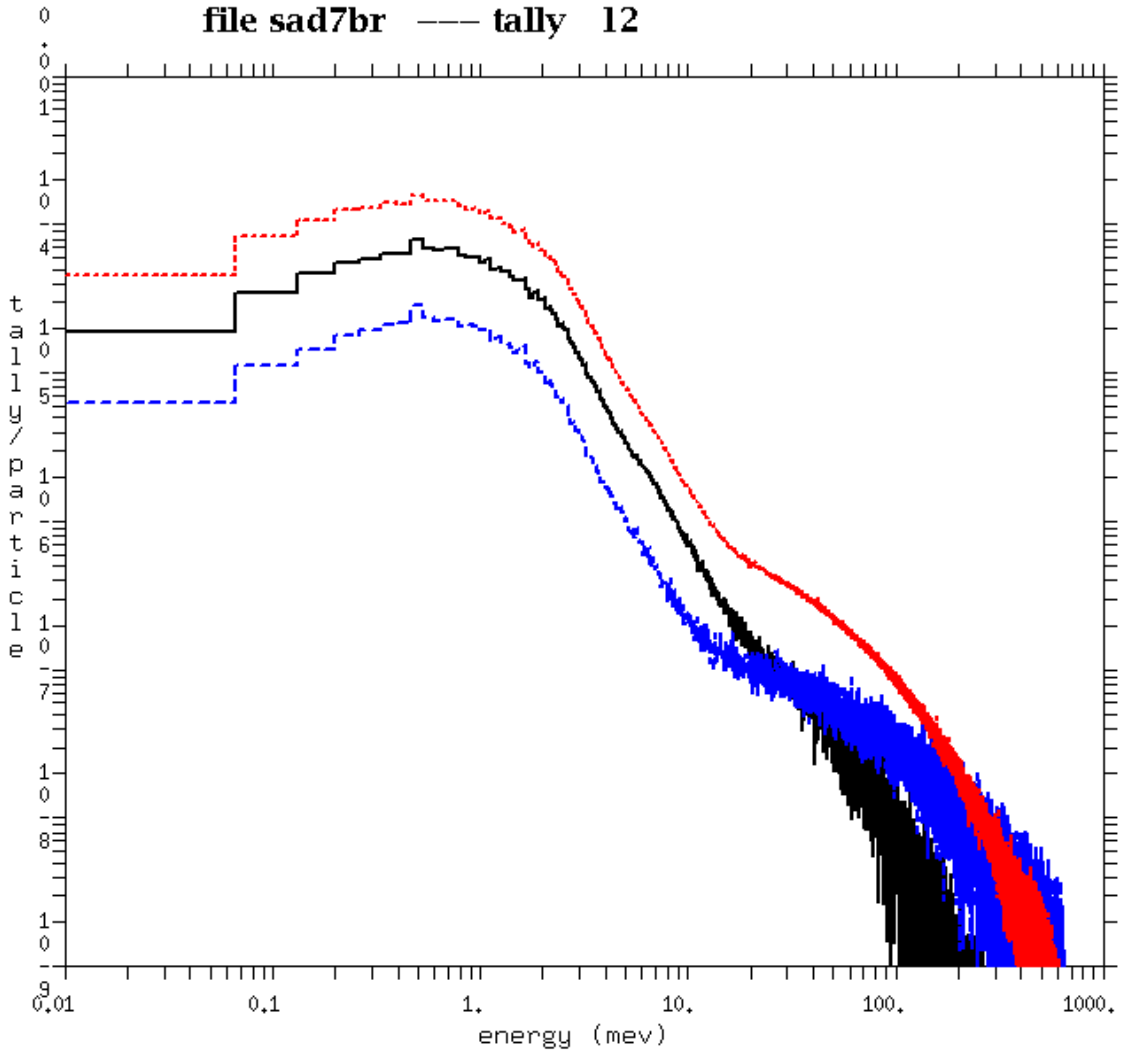

Figure 107. Averaged Neutron flux spectrum in the lead target
Black = Bottom; Blue = Top; Red = Perimeter

Surface	Averaged Neutron flux (1/cm^2)
Bottom	2.28258E-03
Top	8.47991E-04
Perimeter	5.26154E-03

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- Number of particles crossing the top, bottom and perimeter surfaces of the lead target. Number of particles (protons) histories = 2500000

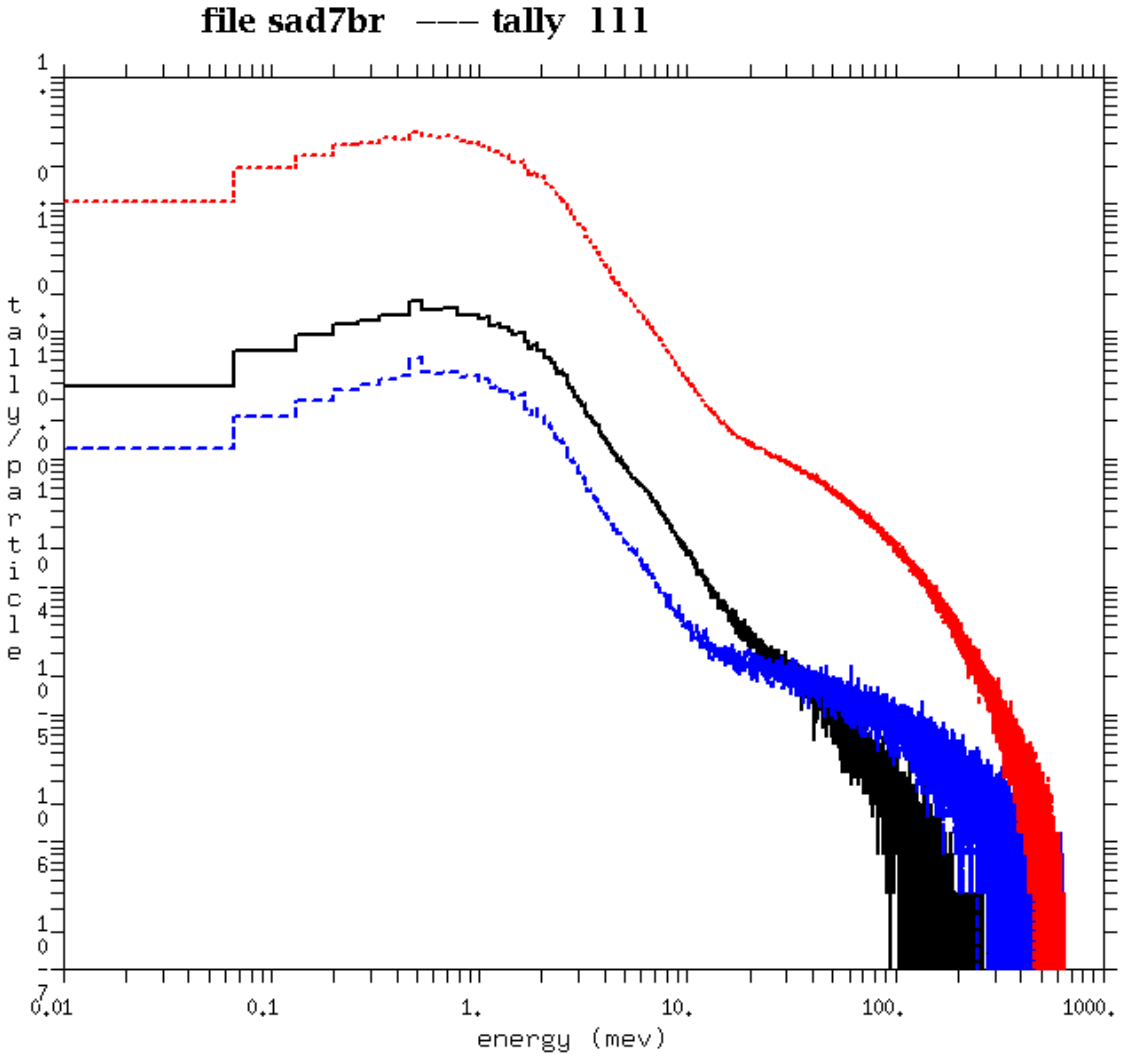

Figure 108. Integrated Neutron current spectrum in the lead target
Black = Bottom; Blue = Top; Red = Perimeter

Surface	Integrated neutron current
Bottom	5.18479E-01
Top	1.88367E-01
Perimeter	1.25866E+01

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- Energy deposited in Mev/gram of the lead target = 1.52000E-04

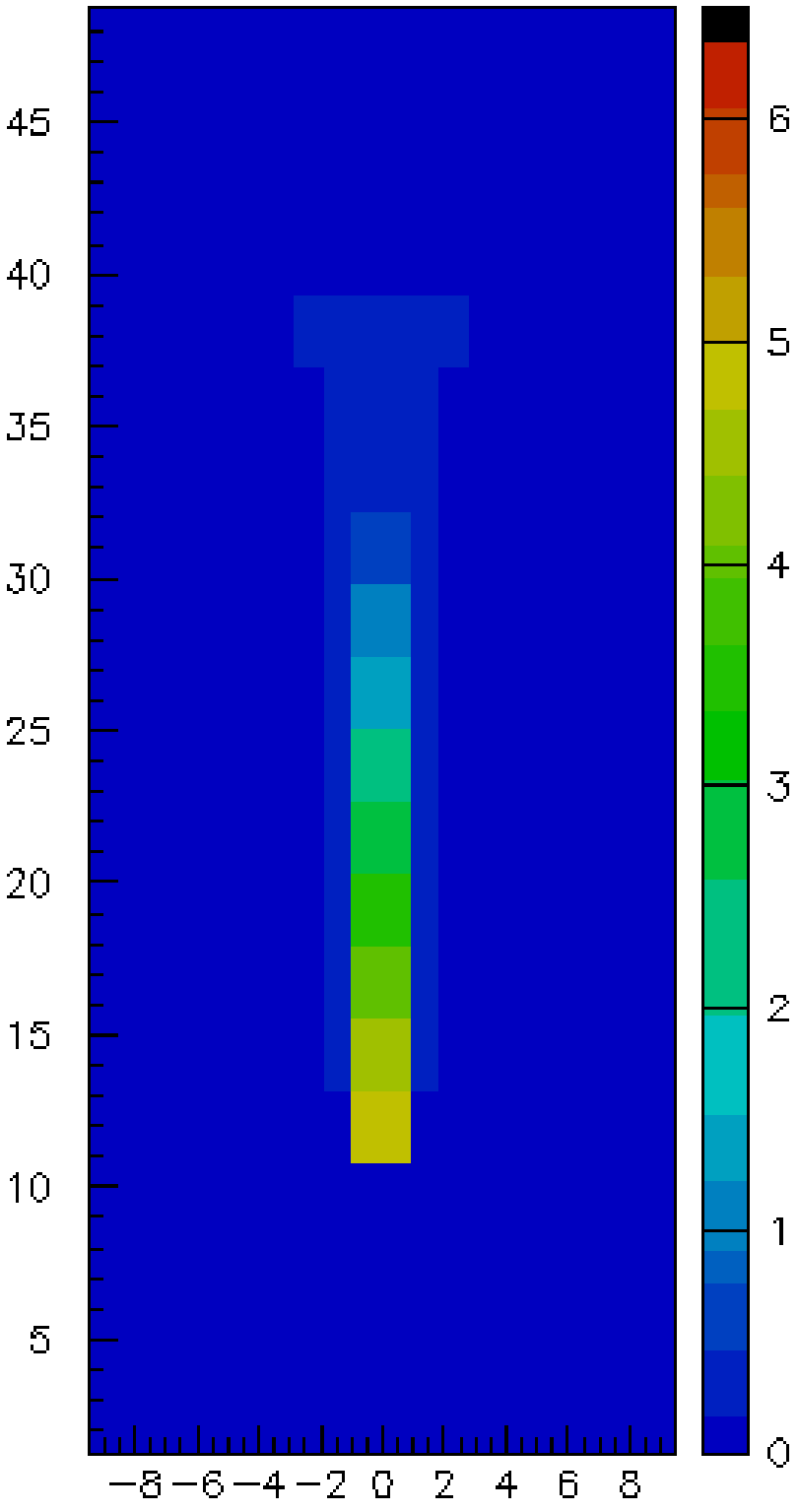

Figure 109. Energy deposited per mesh cell volume (MeV/cm^3/proton-source)

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- *Neutron flux distribution*

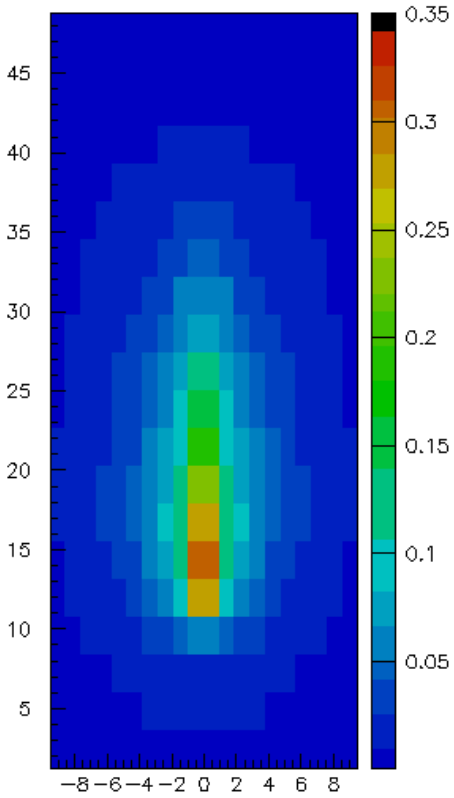

Figure 110. Mesh neutron flux. Side view along the beam direction axe in the middle of the lead target. (neutron/cm^2/sec)

- *Proton flux distribution*

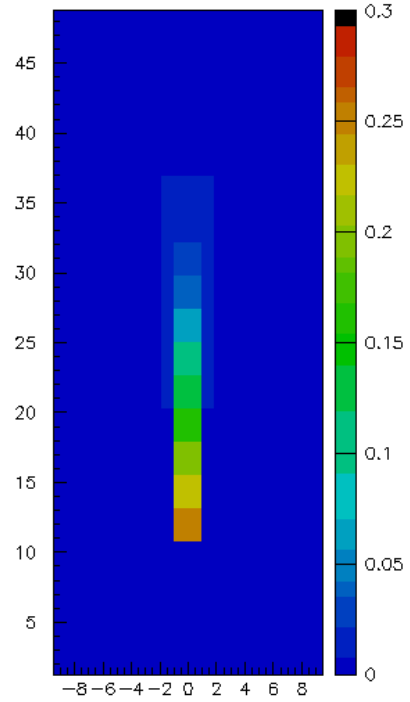

Figure 111. Mesh proton flux. Side view along the beam direction axe in the middle of the lead target. (proton/cm^2/sec)

- *Summary of balance of neutron, proton, photon and pion.*

neutron creation	tracks	weight (per source particle)	energy
source	0	0.	0.
nucl. interaction	33638943	1.3456E+01	1.9906E+02
particle decay	0	0.	0.
weight window	0	0.	0.
cell importance	0	0.	0.
weight cutoff	0	0.	0.
energy importance	0	0.	0.
dxtran	0	0.	0.
forced collisions	0	0.	0.
exp. transform	0	0.	0.
upscattering	0	0.	0.
photonuclear	0	0.	0.
(n,xn)	2075165	8.2705E-01	1.2213E+00
prompt fission	0	0.	0.
delayed fission	0	0.	0.
tabular boundary	1139	4.5560E-04	9.0833E-03
tabular sampling	1212555	4.8502E-01	2.6045E+00
total	36927802	1.4768E+01	2.0289E+02

neutron loss	tracks	weight (per source particle)	energy
escape	33276067	1.3287E+01	1.0095E+02
energy cutoff	0	0.	0.
time cutoff	0	0.	0.
weight window	0	0.	0.
cell importance	0	0.	0.
weight cutoff	0	0.	0.
energy importance	0	0.	0.
dxtran	0	0.	0.
forced collisions	0	0.	0.
exp. transform	0	0.	0.
downscattering	0	0.	1.0177E+01
capture	0	2.1728E-02	6.7470E-02
loss to (n,xn)	1009180	4.0231E-01	5.4750E+00
loss to fission	0	0.	0.
nucl. interaction	2641416	1.0566E+00	8.6210E+01
particle decay	0	0.	0.
tabular boundary	1139	4.5560E-04	9.0833E-03
total	36927802	1.4768E+01	2.0289E+02

proton creation	tracks	weight (per source particle)	energy
source	2500000	1.0000E+00	6.6000E+02
nucl. interaction	4625370	1.8501E+00	1.7233E+02
particle decay	0	0.	0.
weight window	0	0.	0.
cell importance	0	0.	0.
weight cutoff	0	0.	0.
energy importance	0	0.	0.
dxtran	0	0.	0.
forced collisions	0	0.	0.
exp. transform	0	0.	0.
tabular sampling	161171	6.4468E-02	2.9753E+00
photonuclear	0	0.	0.
elastic recoil	0	0.	0.
(gamma,xgen_chg)	0	0.	0.
total	7286541	2.9146E+00	8.3531E+02

proton loss	tracks	weight (per source particle)	energy
escape	68963	2.7585E-02	4.0142E+00
energy cutoff	4742047	1.8968E+00	1.8968E+00
time cutoff	0	0.	0.
weight window	0	0.	0.
cell importance	0	0.	0.
weight cutoff	0	0.	0.
energy importance	0	0.	0.
dxtran	0	0.	0.
forced collisions	0	0.	0.
exp. transform	0	0.	0.
multiple scatter	0	0.	4.0744E+02
bremsstrahlung	0	0.	0.
nucl. interaction	2175862	8.7034E-01	4.1217E+02
elastic scatter	0	0.	4.8743E-02
particle decay	0	0.	0.
capture	138498	5.5399E-02	3.4858E+00
tabular sampling	161171	6.4468E-02	6.2526E+00
total	7286541	2.9146E+00	8.3531E+02

photon creation	tracks	weight (per source particle)	energy
source	0	0.	0.
nucl. interaction	16146674	6.4587E+00	6.3356E+00
particle decay	0	0.	0.
weight window	0	0.	0.
cell importance	0	0.	0.
weight cutoff	0	0.	0.
energy importance	0	0.	0.
dxtran	0	0.	0.
forced collisions	0	0.	0.
exp. transform	0	0.	0.
from neutrons	18803531	8.0656E+00	1.0939E+01
bremsstrahlung	51003990	2.1419E+01	1.1760E+00
p-annihilation	4054968	1.7265E+00	8.8224E-01
photonuclear	0	0.	0.
electron x-rays	0	0.	0.
1st fluorescence	49037410	2.0451E+01	1.1016E+00
2nd fluorescence	10139384	4.2263E+00	5.1633E-02
(gamma,xgamma)	0	0.	0.
tabular sampling	1203093	4.8124E-01	5.9560E-01
total	150389050	6.2828E+01	2.1082E+01

photon loss	tracks	weight (per source particle)	energy
escape	1854395	7.8215E-01	1.1651E+00
energy cutoff	645	2.5800E-04	4.5370E-03
time cutoff	0	0.	0.
weight window	0	0.	0.
cell importance	0	0.	0.
weight cutoff	0	0.	0.
energy importance	0	0.	0.
dxtran	0	0.	0.
forced collisions	0	0.	0.
exp. transform	0	0.	0.
compton scatter	0	0.	7.8890E+00
capture	146506526	6.1183E+01	9.3726E+00
pair production	2027484	8.6323E-01	2.6502E+00
photonuclear abs	0	0.	0.
total	150389050	6.2828E+01	2.1082E+01

pi_+ creation	tracks	weight (per source particle)	energy
source	0	0.	0.
nucl. interaction	199405	7.9762E-02	6.7239E+00
particle decay	0	0.	0.
weight window	0	0.	0.
cell importance	0	0.	0.
weight cutoff	0	0.	0.
energy importance	0	0.	0.
dxtran	0	0.	0.
forced collisions	0	0.	0.
exp. transform	0	0.	0.
tabular sampling	0	0.	0.
photonuclear	0	0.	0.
elastic recoil	0	0.	0.
(gamma,xgen_chg)	0	0.	0.
total	199405	7.9762E-02	6.7239E+00

pi_+ loss	tracks	weight (per source particle)	energy
escape	6858	2.7432E-03	2.2305E-01
energy cutoff	0	0.	0.
time cutoff	0	0.	0.
weight window	0	0.	0.
cell importance	0	0.	0.
weight cutoff	0	0.	0.
energy importance	0	0.	0.
dxtran	0	0.	0.
forced collisions	0	0.	0.
exp. transform	0	0.	0.
multiple scatter	0	0.	4.8958E+00
bremsstrahlung	0	0.	0.
nucl. interaction	37345	1.4938E-02	1.5759E+00
elastic scatter	0	0.	0.
particle decay	155202	6.2081E-02	2.9127E-02
capture	0	0.	0.
tabular sampling	0	0.	0.
total	199405	7.9762E-02	6.7239E+00