Neutron measurments for grafhite DPA evaluation

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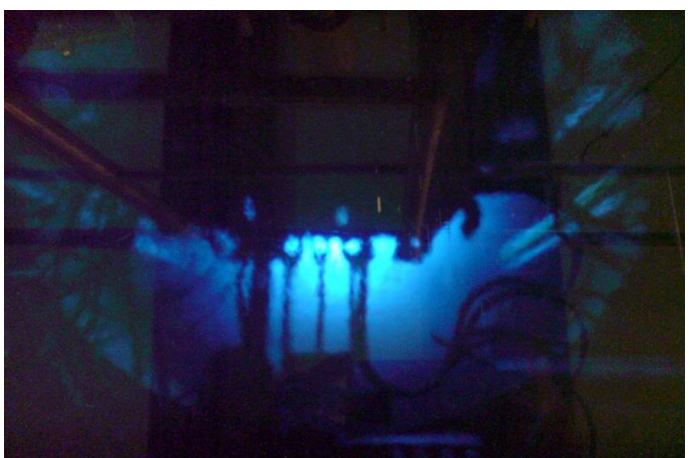
The goal of this work was determination of neutrun flux density between reflector graphite blocks of Maria Research Reactor. This quantity is crucial to aging menagment of reactor core elements. After evaluation of neutron density flux we can calculate displacement per atom-DPA and is related with radiation damege caused by nautron raddiation in graphite blocks.

MARIA reactor

The main characteristics and data of MARIA reactor are as follows:

· nominal power	30 MW,		
· thermal neutron flux	3×10^{14} n/cm^2·s,		
· moderator	H_2O, beryllium,		
· cooling system	channel type,		
· output thermal neutron flux density at horizontal channel	$3 \div 5 \times 10^9$ n/cm^2·s,		
· fuel assemblies (MC type)	-	material:	U_3Si_2 alloy
	-	enrichment:	19,75%
	-	cladding:	aluminum
	-	shape:	concentric tubes
	-	active length:	1000 mm



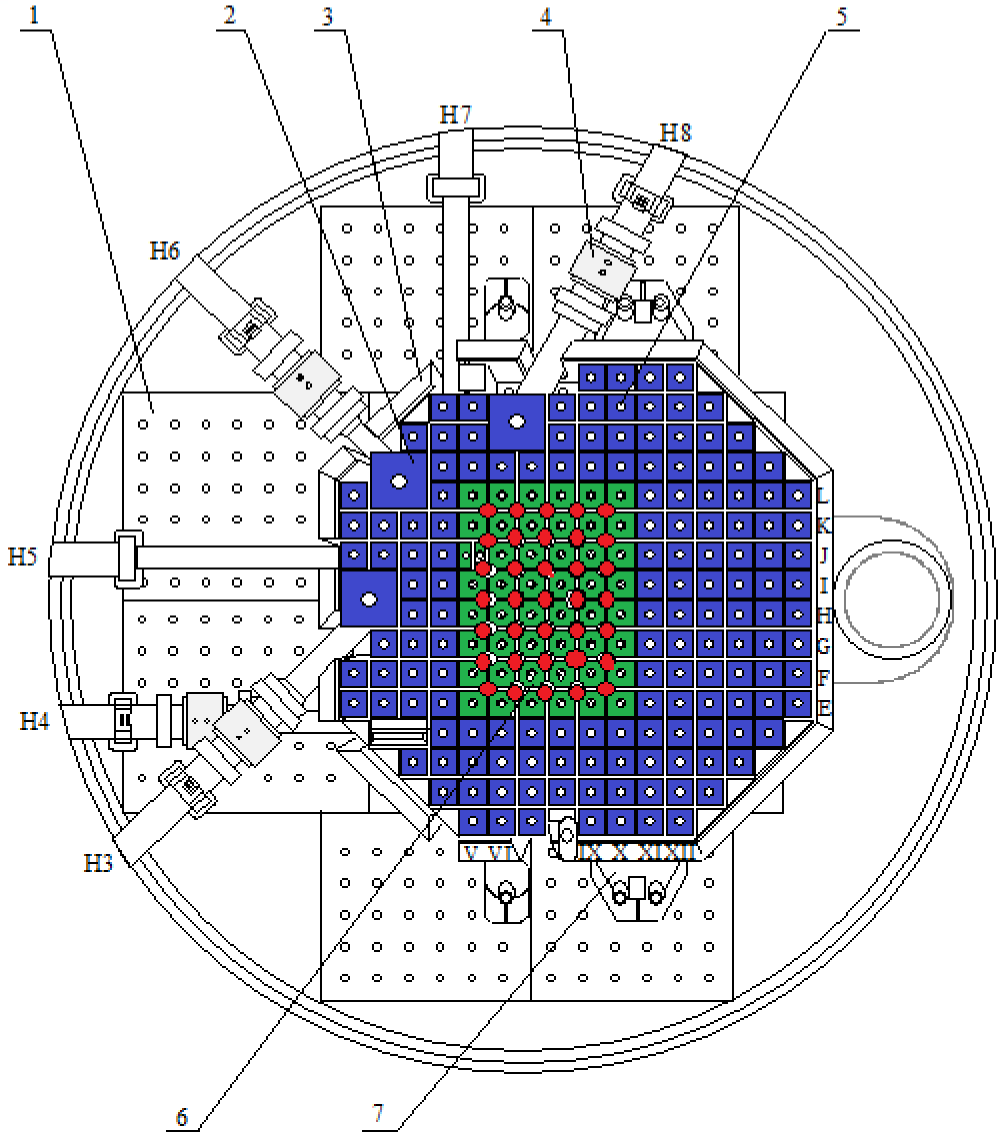
Construction of MARIA Research Reactor core

Main components of the MARIA RR core, are:

-fuel elements,

-beryllium blocks,

-graphite blocks.



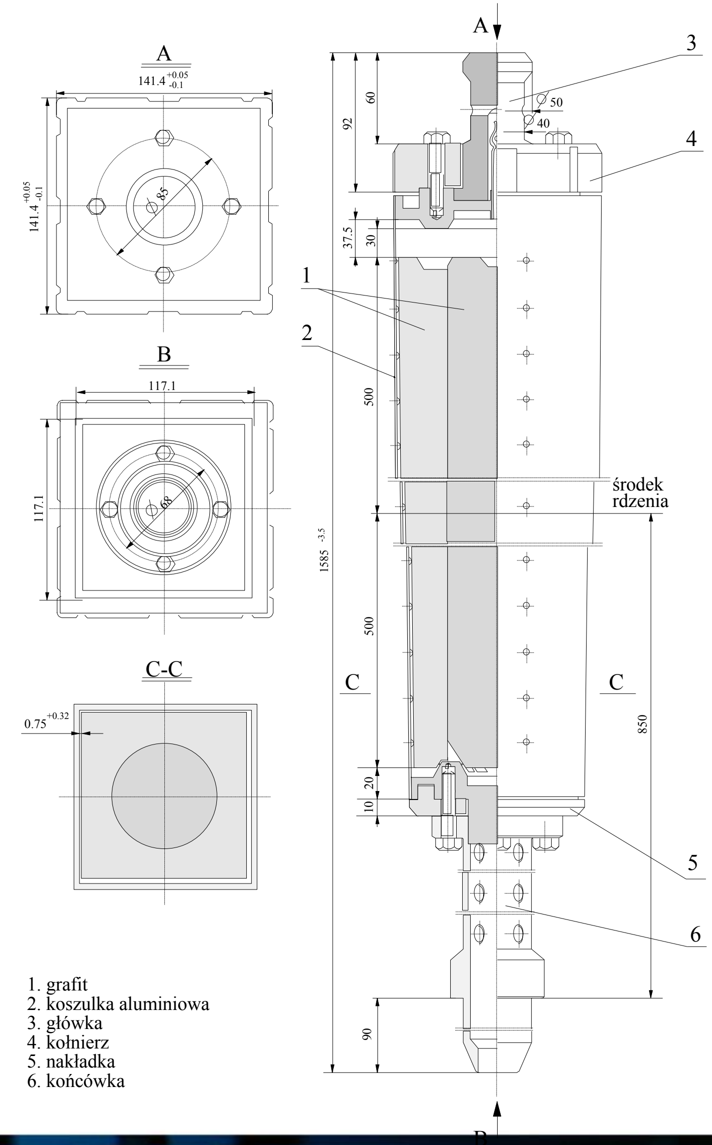
1. stół
2. blok grafitowy wielokrotny
3. obudowa
4. kompensator
5. blok grafitowy
6. blok berylowy
7. osłona komór jonizacyjnych

Graphite block diagram

The graphite blocks are in an aluminum clading.

In an ideal situation, blocks lean each other at the outer flanges.

The top dimension of the block (overlay) is 140 mm, and 120 mm bottom. The height of the blocks with the pads is 1585 mm.



Neutron measurments

Activation detectors:

-AlCo (0,1%),

-Ni.

The neutron induced reaction’s for these detectors:

$$^{59}Co(n,\gamma)\ ^{60}Co$$

$$^{58}Ni(n,p)\ ^{58}Co$$

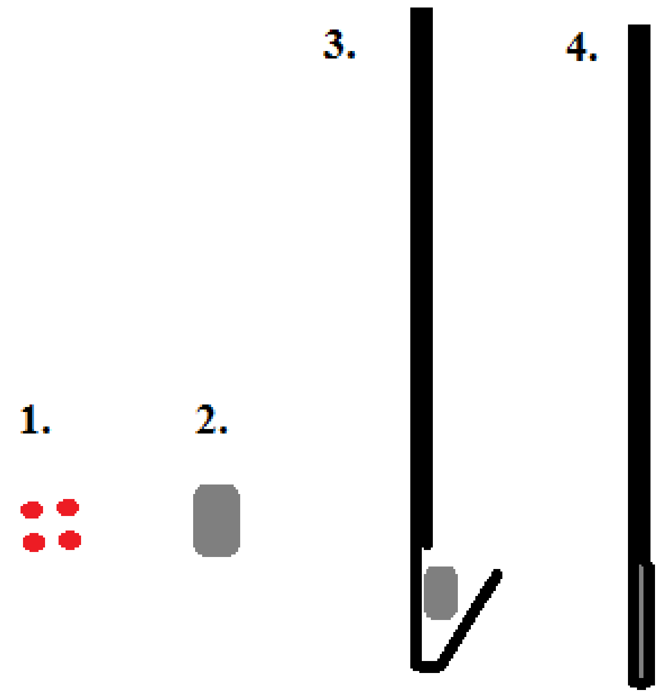
Neutron measurments

Four detectors (1) were placed in aluminum foil (2), then were placed in measuring plate, tip then was bended in the press.

Plate dimensions:

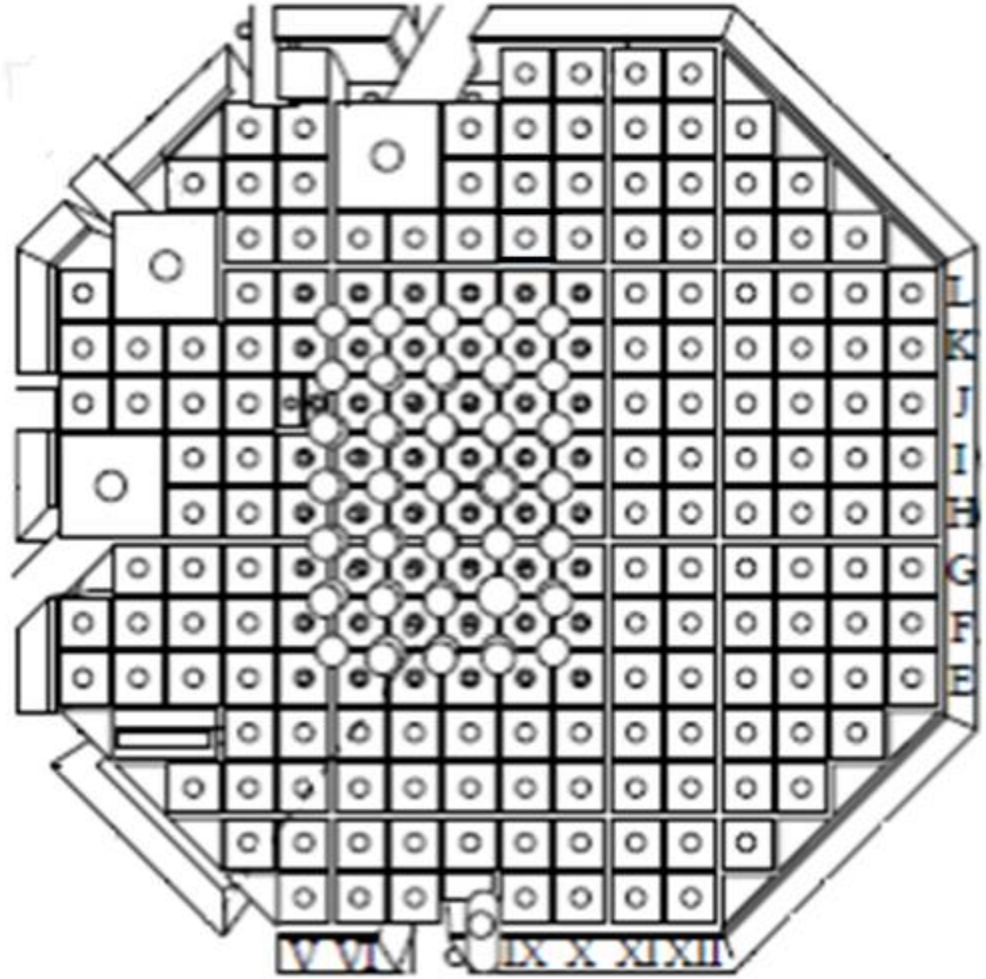
length – 550mm,
width – 20mm,
thickness – 2mm.

In one plate we inserted two AlCo and two Ni detectors.

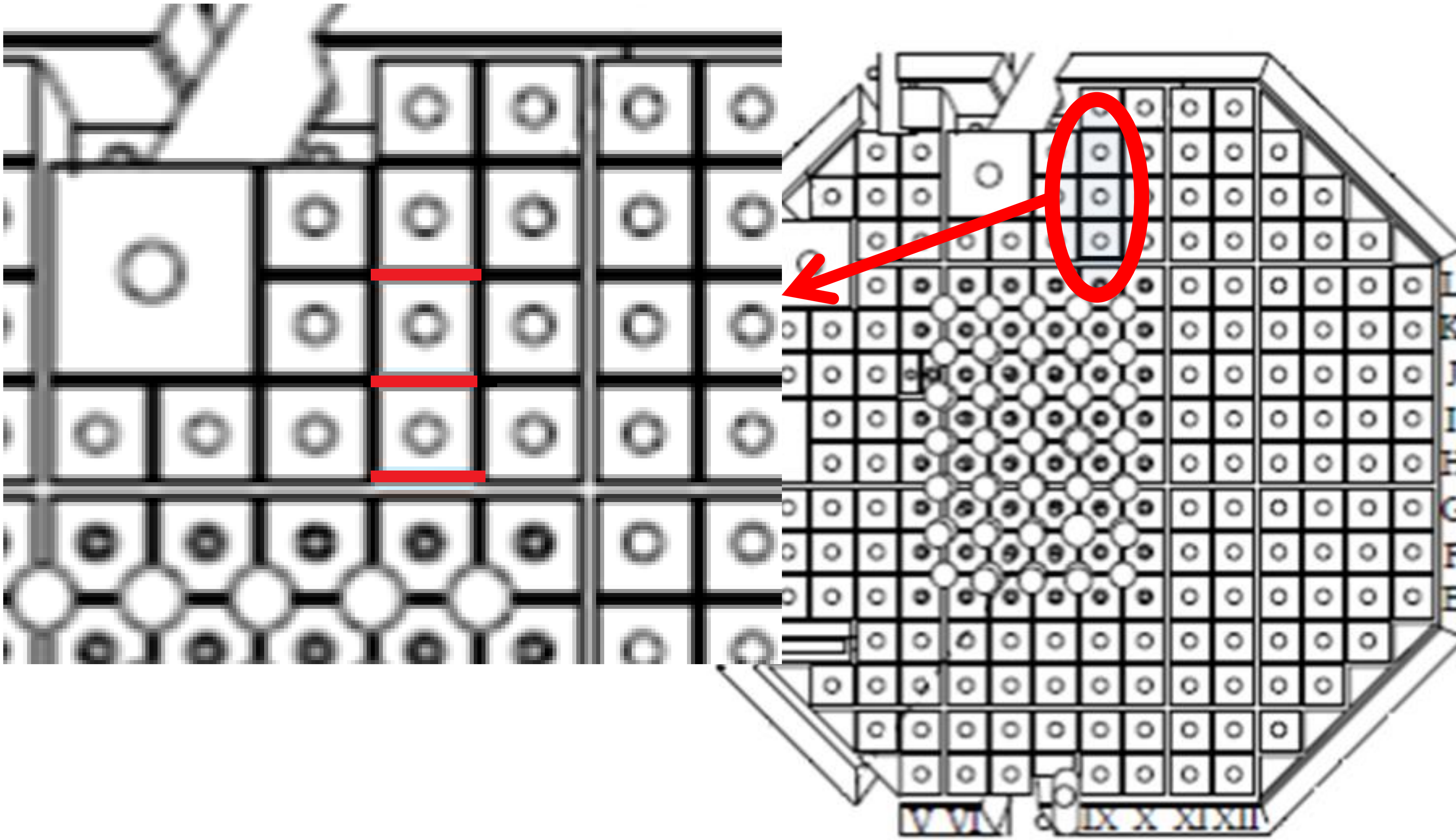


Neutron measurments

Plate with neutron detectors was then placed at selected locations, between graphite blocks



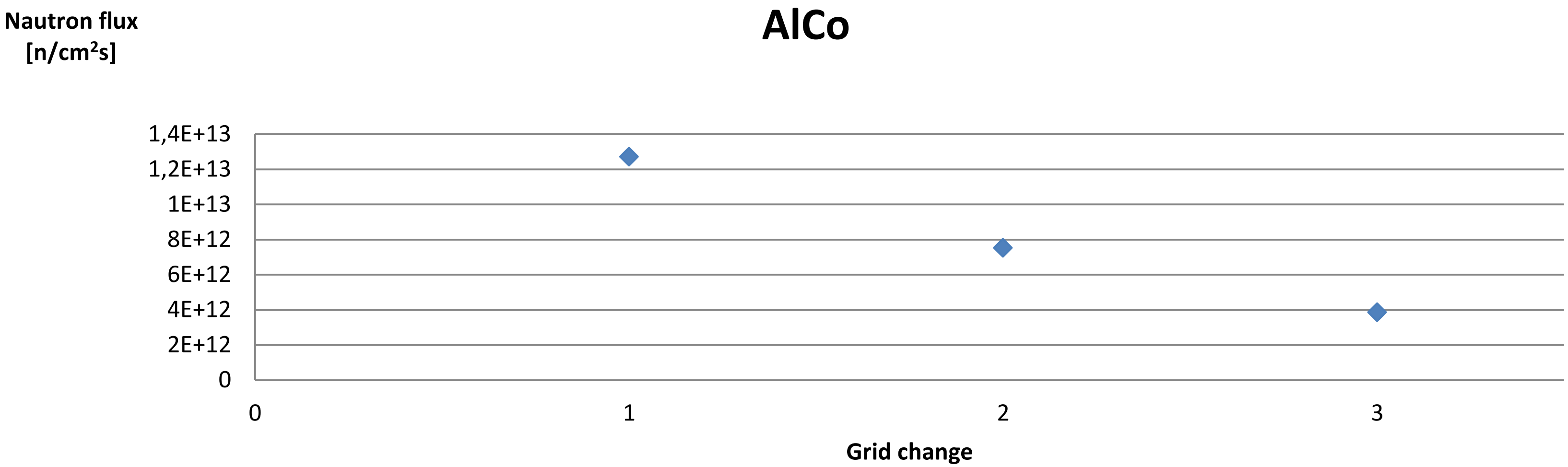
Neutron measurments

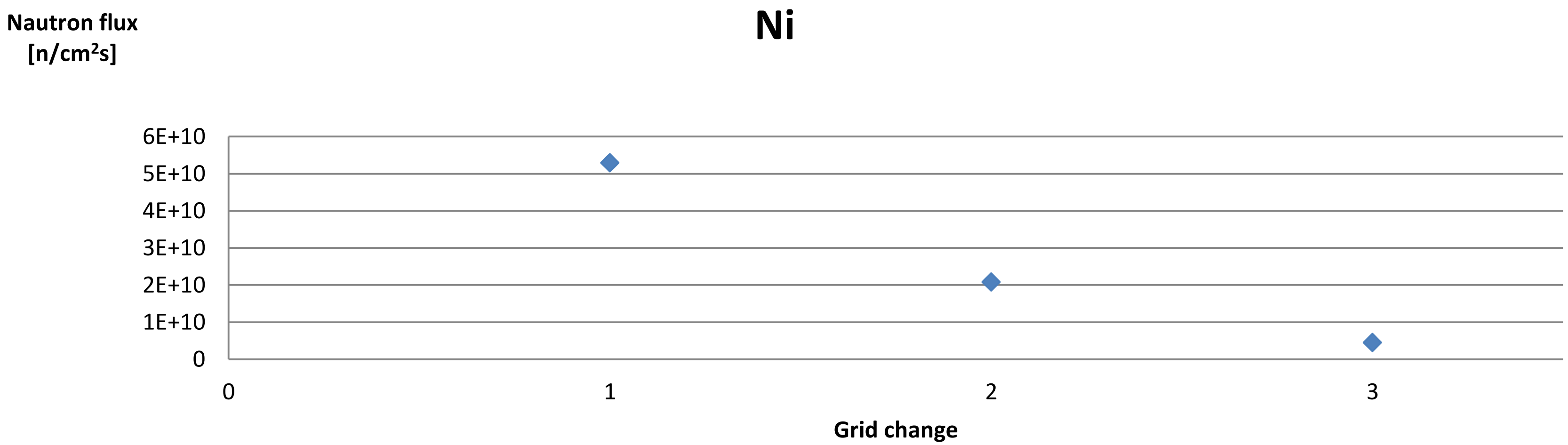


Neutron measurments

Measurements were carried out between May 28 June 2. Reactor operated for 118 hours, with thermal power 24MW. In the summer period we calculate neutron flux.

Results


Nautron flux
[n/cm²s]
AlCo
1,4E+13
1,2E+13
1E+13
8E+12
6E+12
4E+12
2E+12
0
0
1
2
3
Grid change


Nautron flux
[n/cm²s]
Ni
6E+10
5E+10
4E+10
3E+10
2E+10
1E+10
0
0
1
2
3
Grid change

Next step

The next step of calculations will be evaluation of DPA for graphite blocks.

Why DPA?

Neutrons are particularly efficient at causing the two effects:

-impurity production,

-atom displacement.

In our case, the dominant effect is atom displacement. The greatest part is caused by fast neutrons.

DPA is the parameter commonly used to correlate displacement damage.

Radiation Effects in Graphite

Graphite is a lead candidate for the target design

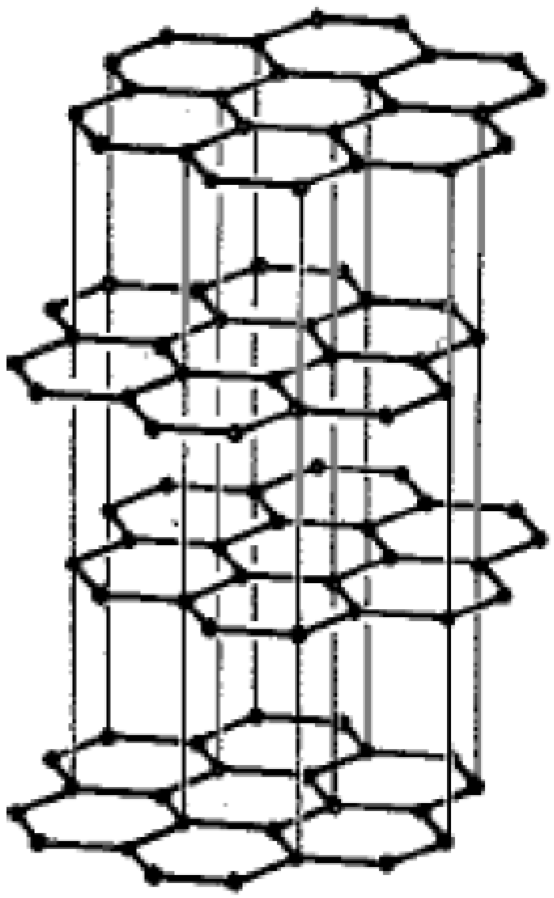
Neutron irradiation of graphite produces a large population of carbon interstitial atoms and vacancies, forming vacancies and interstitial clusters, dislocation loops or new graphitic planes

–Interstitials move between layer planes and are mobile at temperatures as low as 70 K

–Vacancies move in the layer planes and are mobile only at temperatures above 1000 K

–Radiation effects in graphite are determined by the formation of defect structure.

Radiation effect studies in graphite have primarily focused on displacement.



Thank you for your attention!