KIPT ACCELERATOR DRIVEN SYSTEM DESIGN AND PERFORMANCE

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KIPT ACCELERATOR DRIVEN SYSTEM DESIGN AND PERFORMANCE

- *US Government is supporting the development and the construction of an experimental neutron source facility at Kharkov Institute of Physics & Technology, Ukraine.*
- *Argonne National Laboratory is collaborating with National Science Center Kharkov Institute of Physics & Technology of Ukraine to construct this facility.*
- *The facility consists of an accelerator driven subcritical system utilizing low enriched uranium oxide fuel with water coolant and beryllium-carbon reflector.*
- *An electron accelerator is utilized for generating the neutron source driving the subcritical assembly. The accelerator provides 100 KW beam using 100 MeV electrons.*
- *The target material is tungsten or natural uranium cooled with water.*
- *The facility startup date is March 2014.*

KIPT Experimental Neutron Source Facility

Facility Objectives

- Provide capabilities for performing basic and applied research using neutrons
- Perform physics and material experiments inside the subcritical assembly and neutron experiments using cold neutrons
- Produce medical isotopes and provide neutron source for performing neutron therapy procedures
- Support the Ukraine nuclear power industry by providing the capabilities to train young specialists

KIPT Experimental Neutron Source Facility

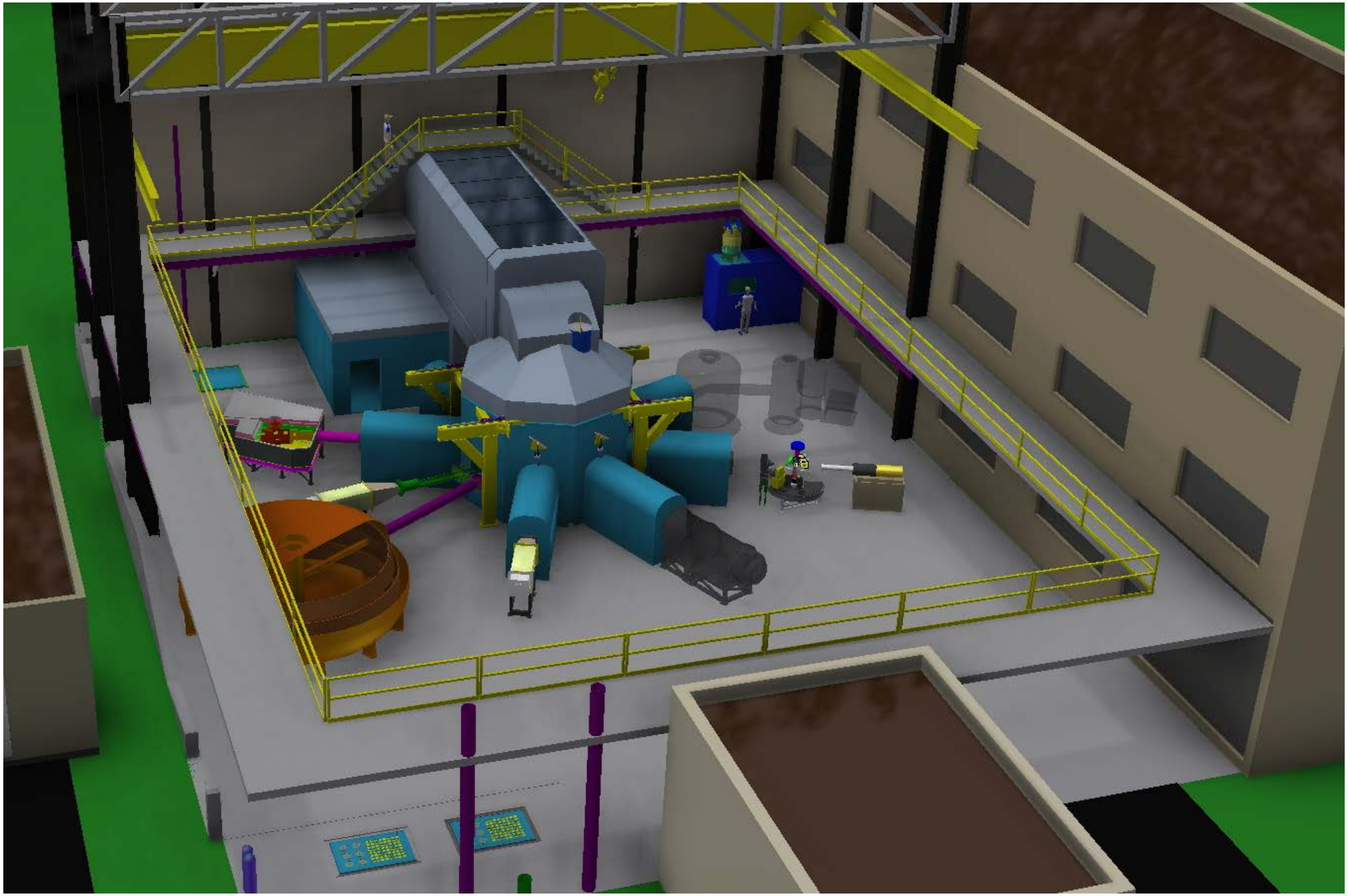
Main Components

- Electron accelerator
- Electron transport channel
- Target Assembly for generating neutrons
- Subcritical assembly with low enrichment uranium fuel, Beryllium-carbon reflector, and water coolant
- Heavy concrete biological shield
- Radial neutron channels and cold neutron source for basic and applied neutron research
- Auxiliary equipments including the target and the subcritical assembly coolant loops
- Supporting facilities

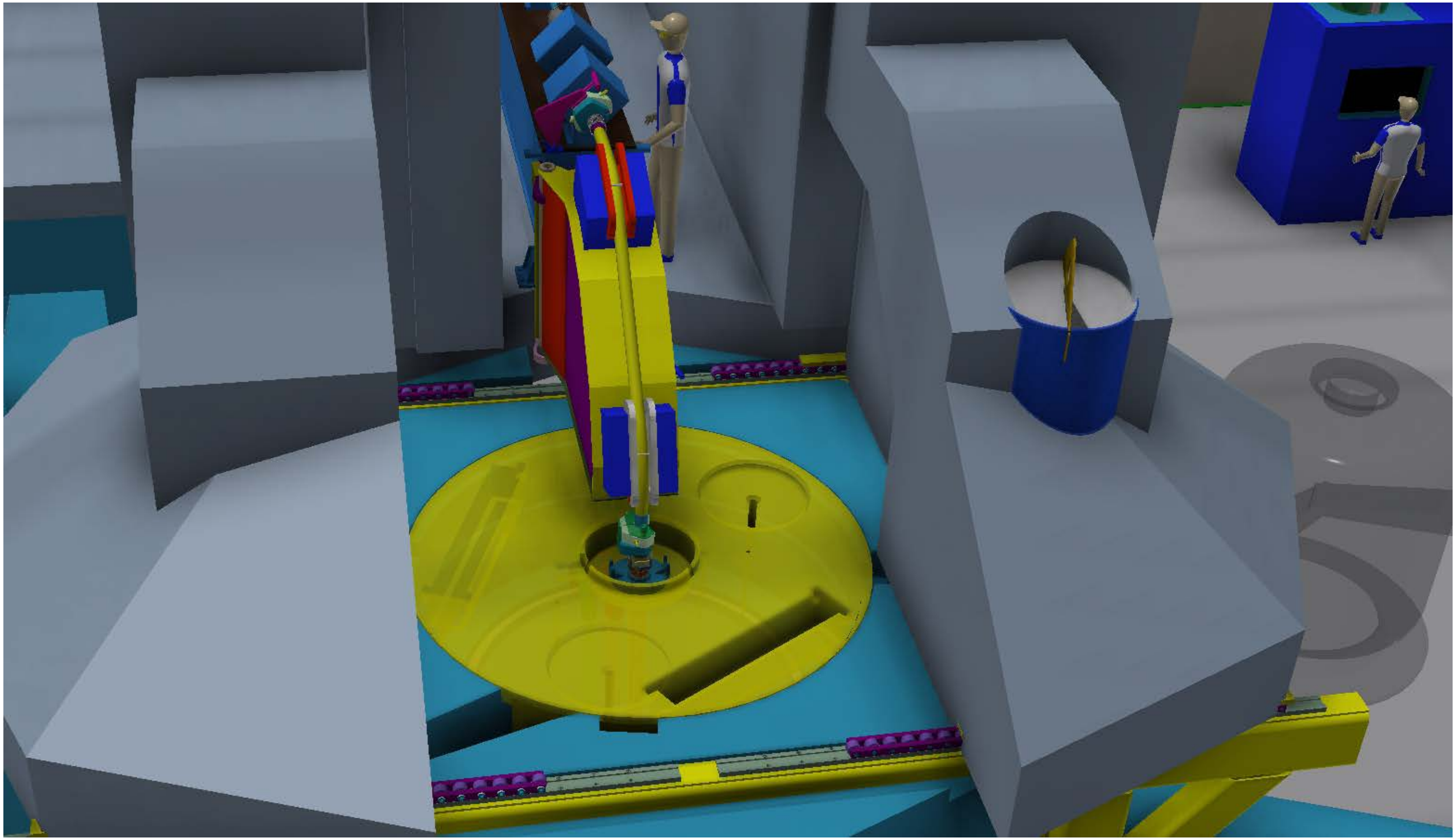
KIPT Experimental Neutron Source Facility

KIPT Experimental Neutron Source Facility

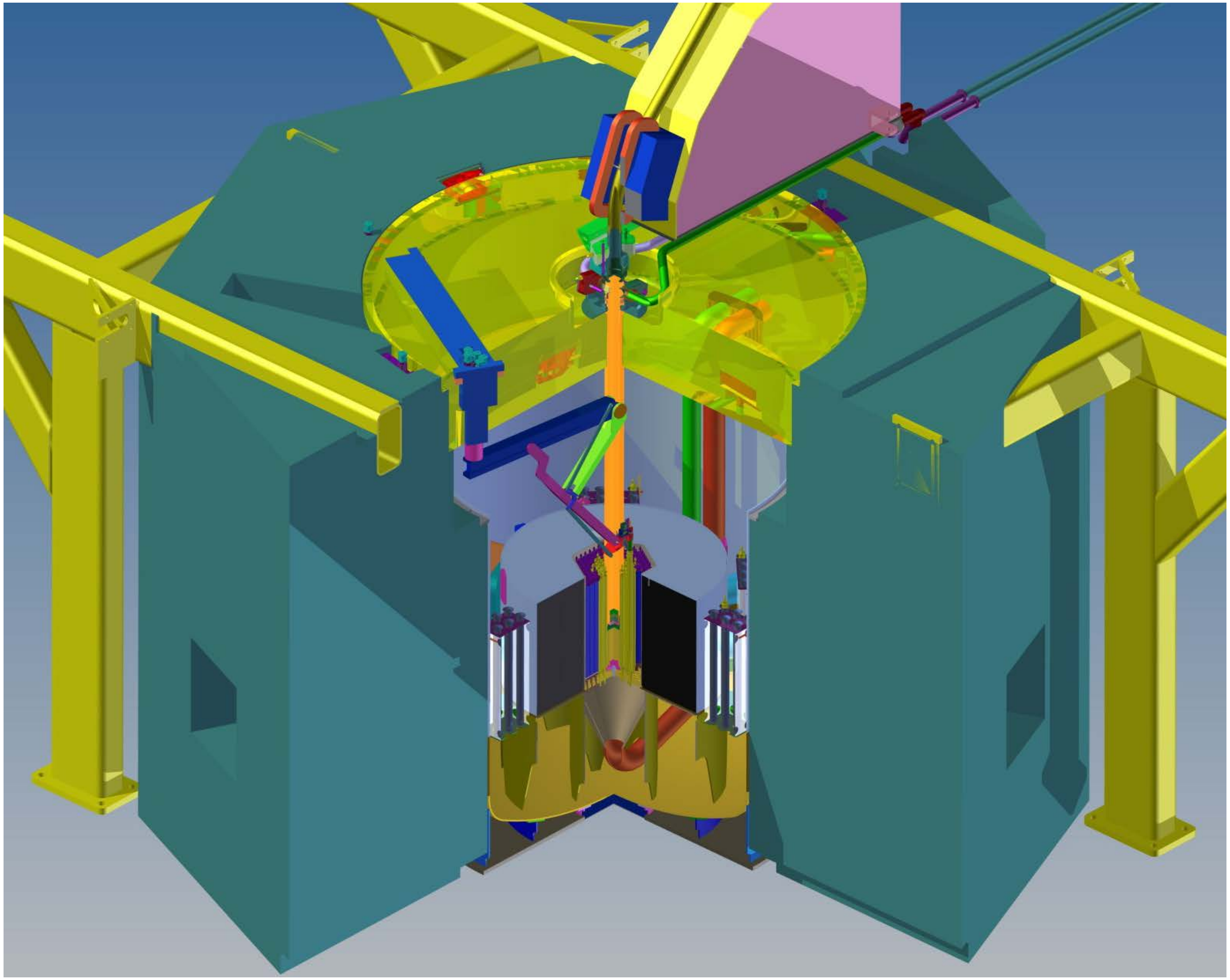
KIPT Experimental Neutron Source Facility Overview - 1



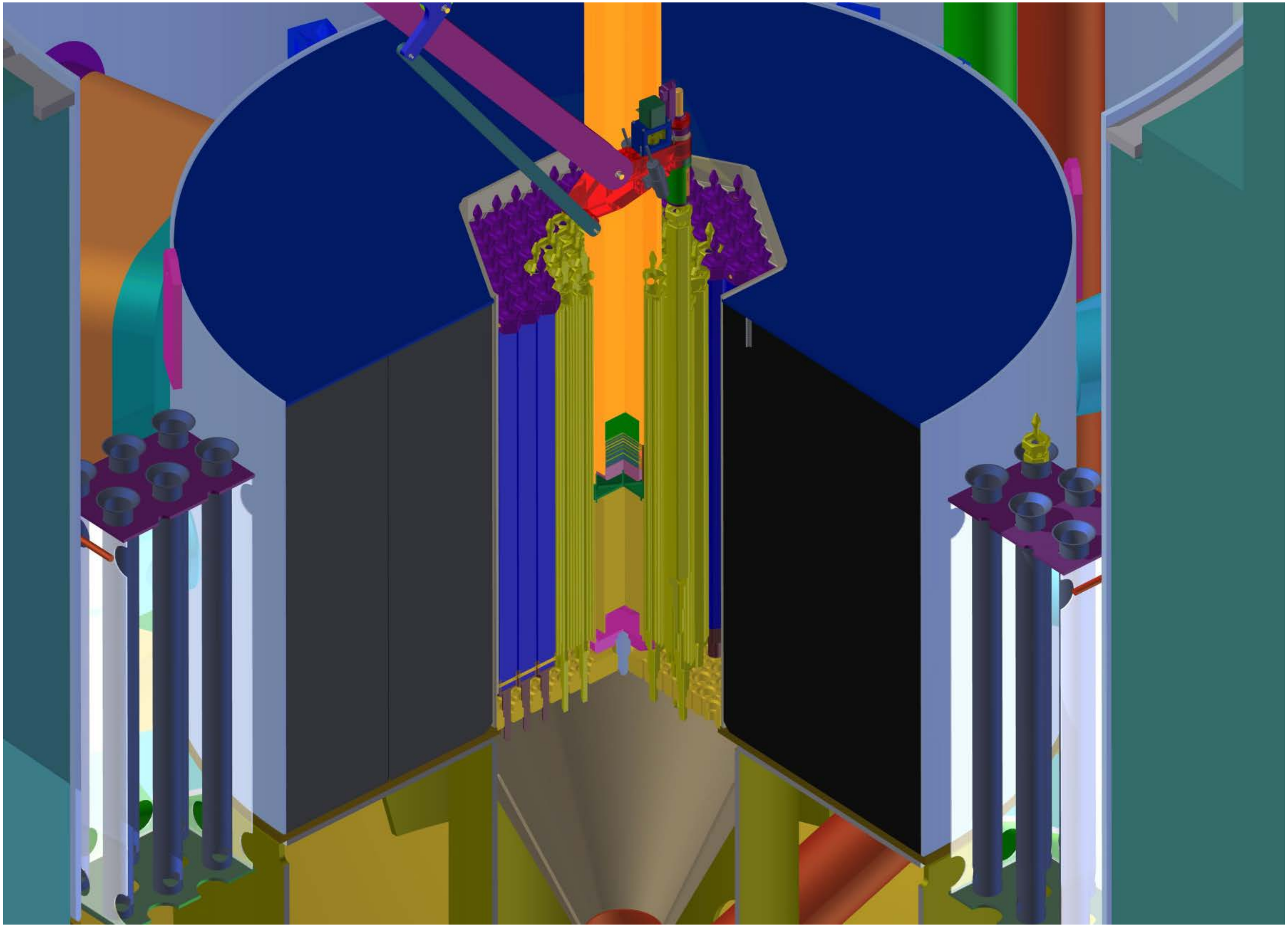
KIPT Experimental Neutron Source Facility Overview - 2



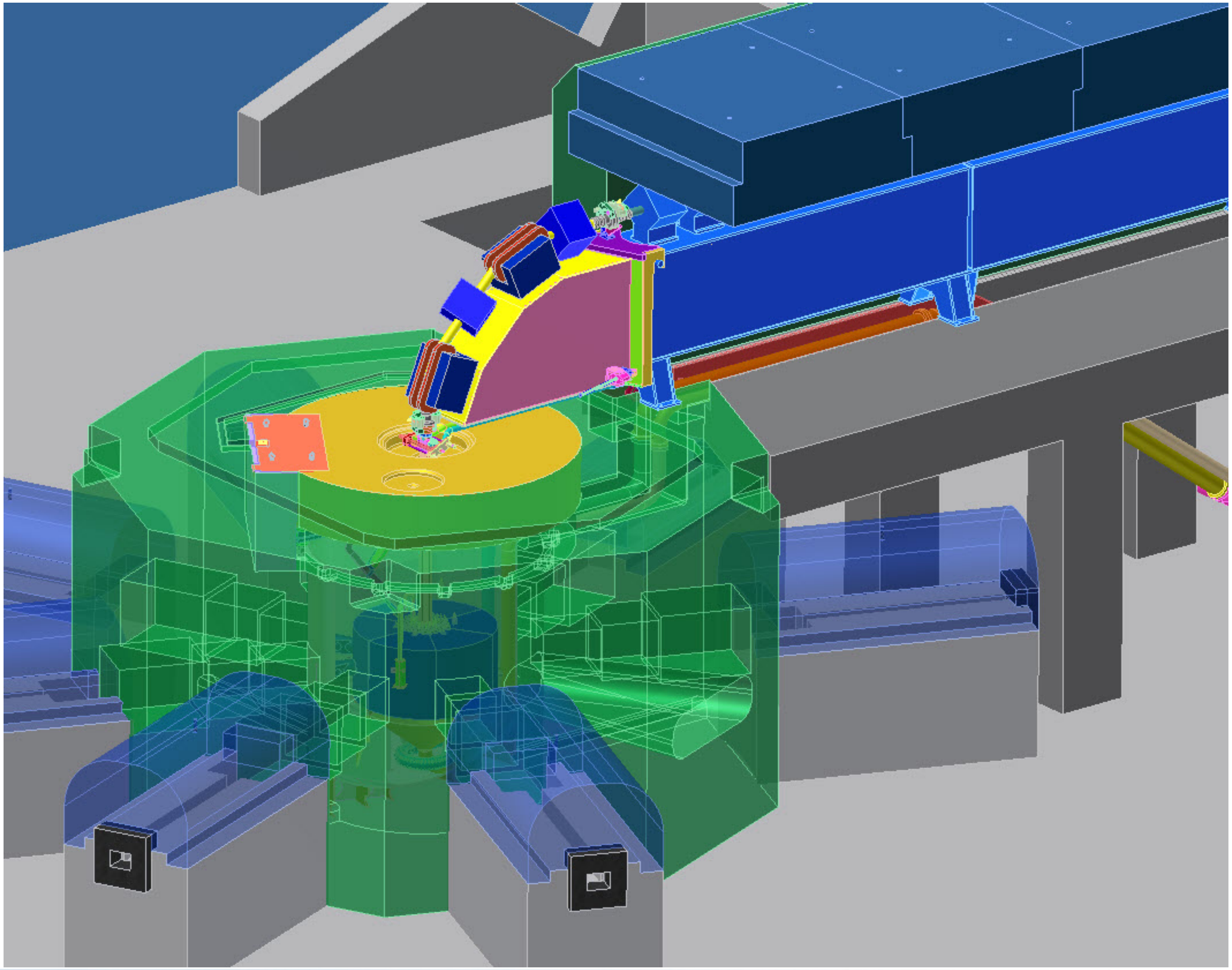
KIPT Subcritical Assembly Overview - 3



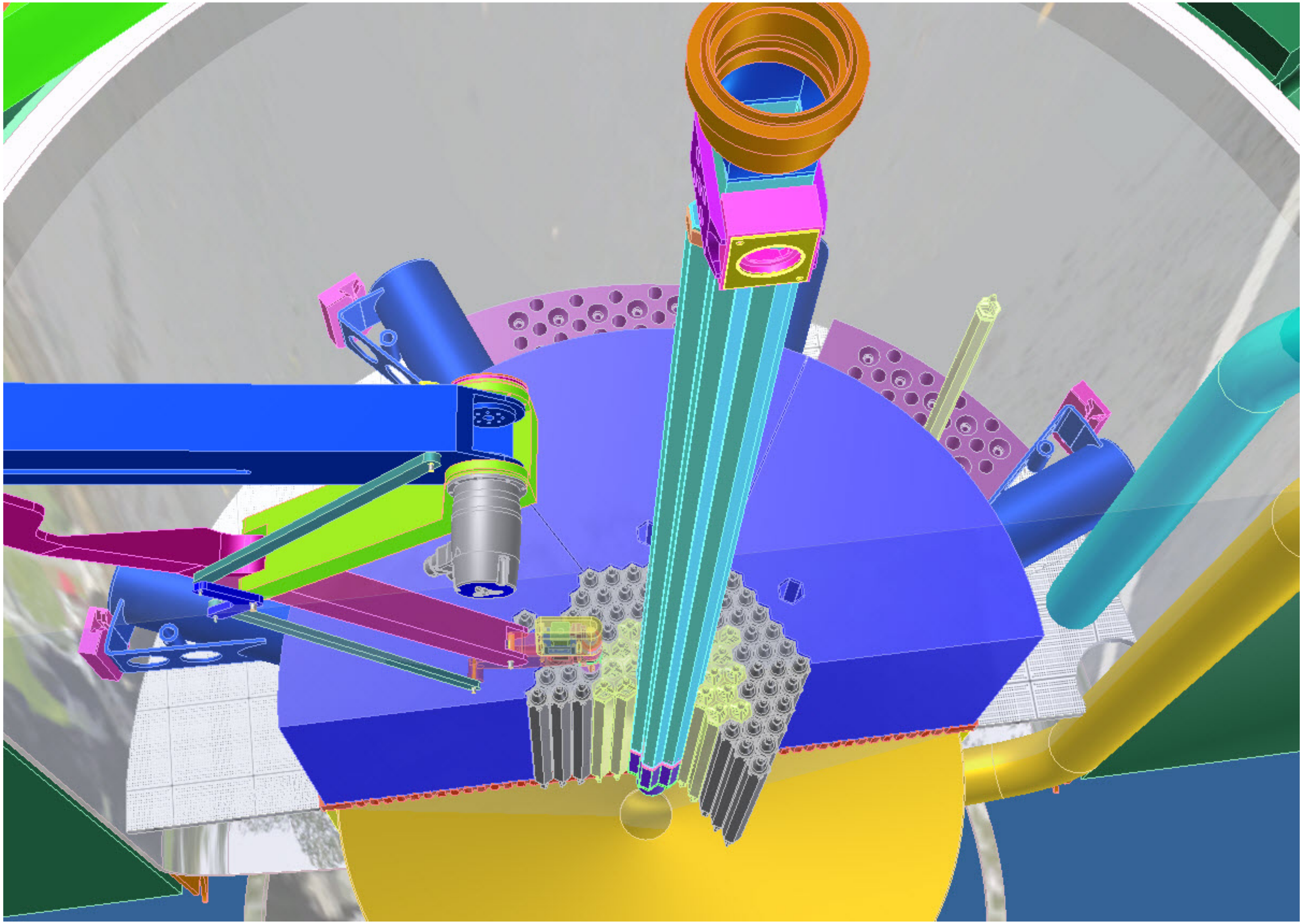
KIPT Subcritical Assembly Overview - 4



General View of the Subcritical assembly and the Electron Beam transport Channel

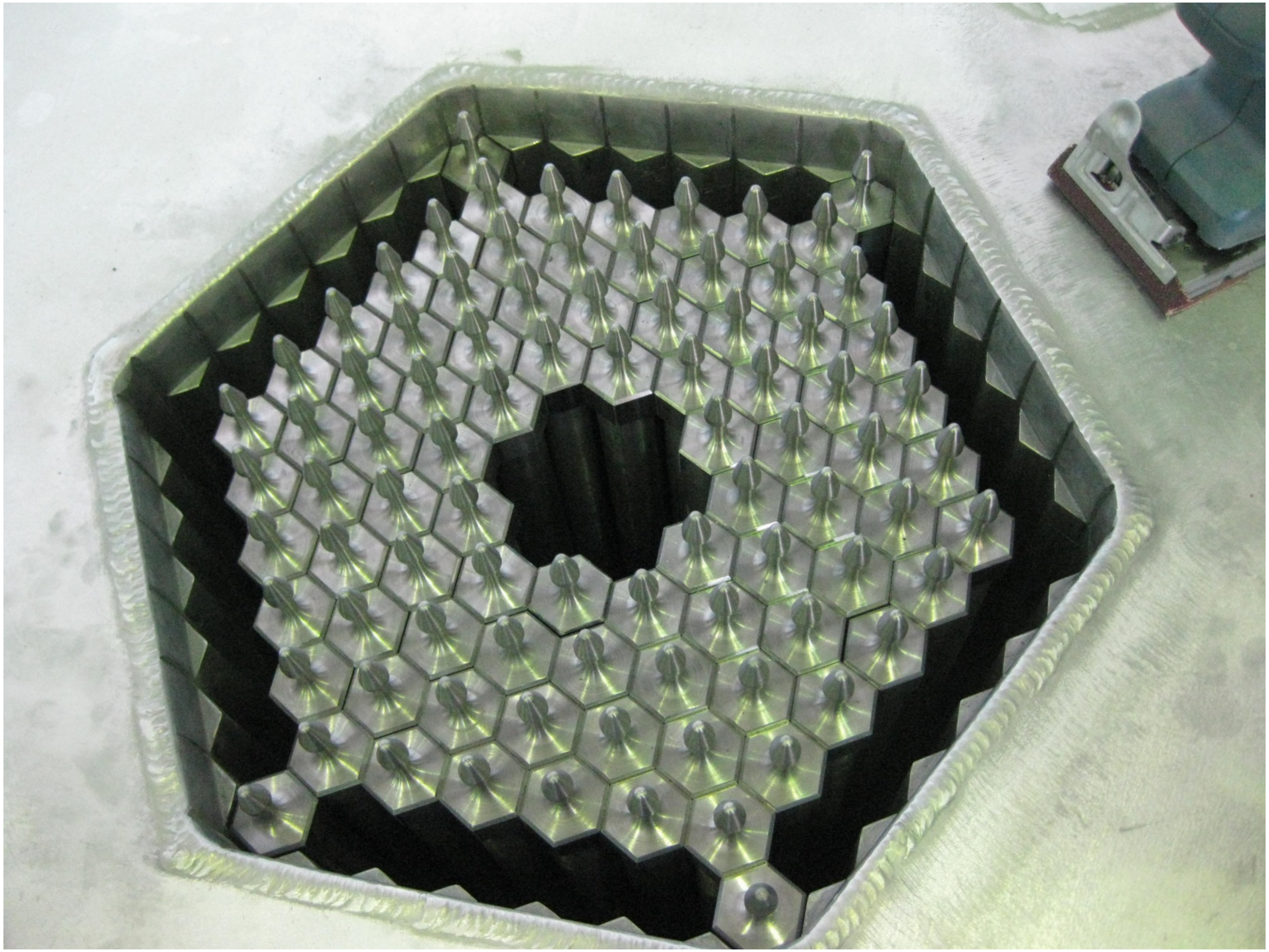


General View inside the Subcritical Assembly



The Fabricated Subcritical Assembly Tank

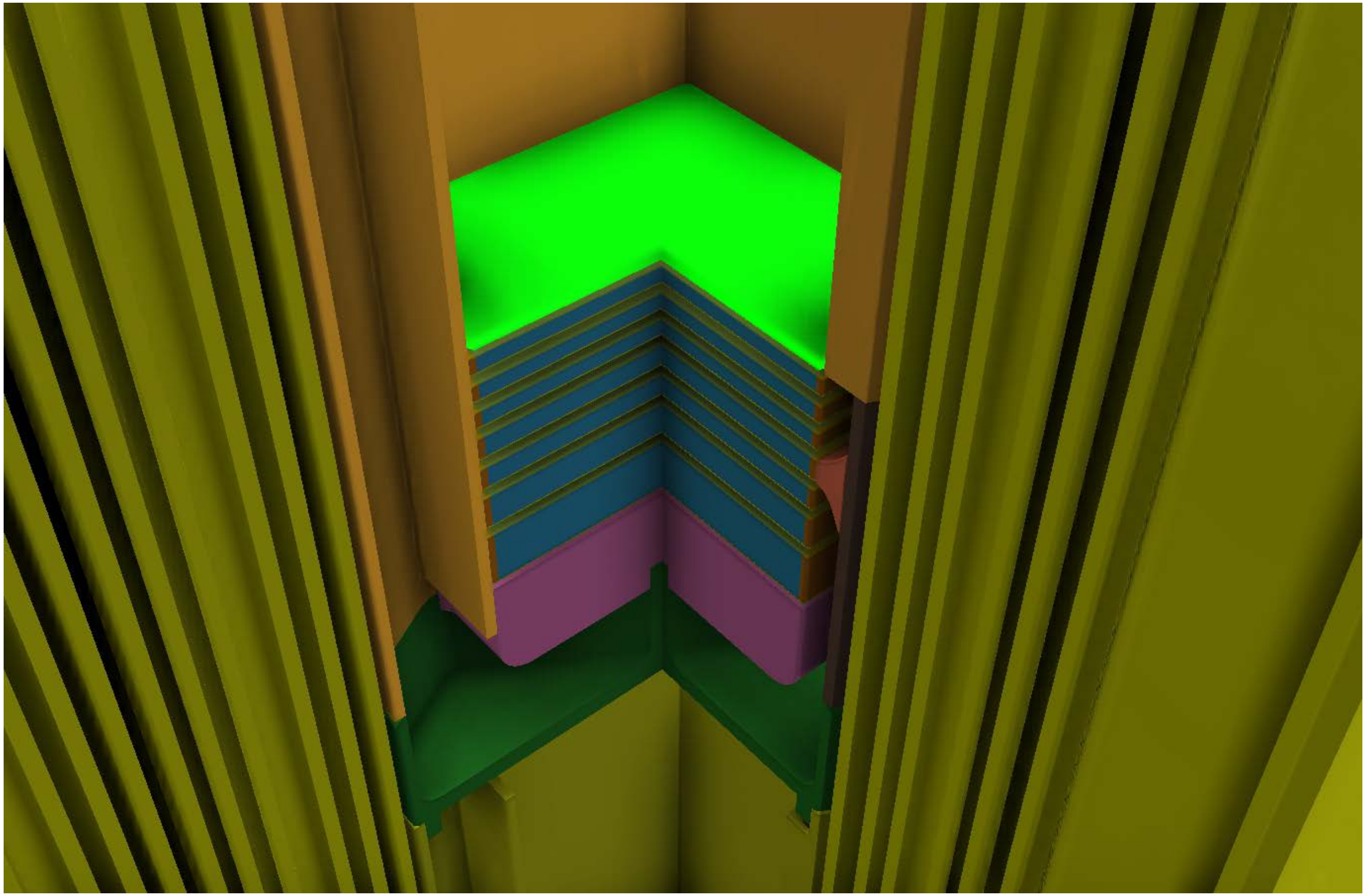
Graphite Ring Reflector Loading Test



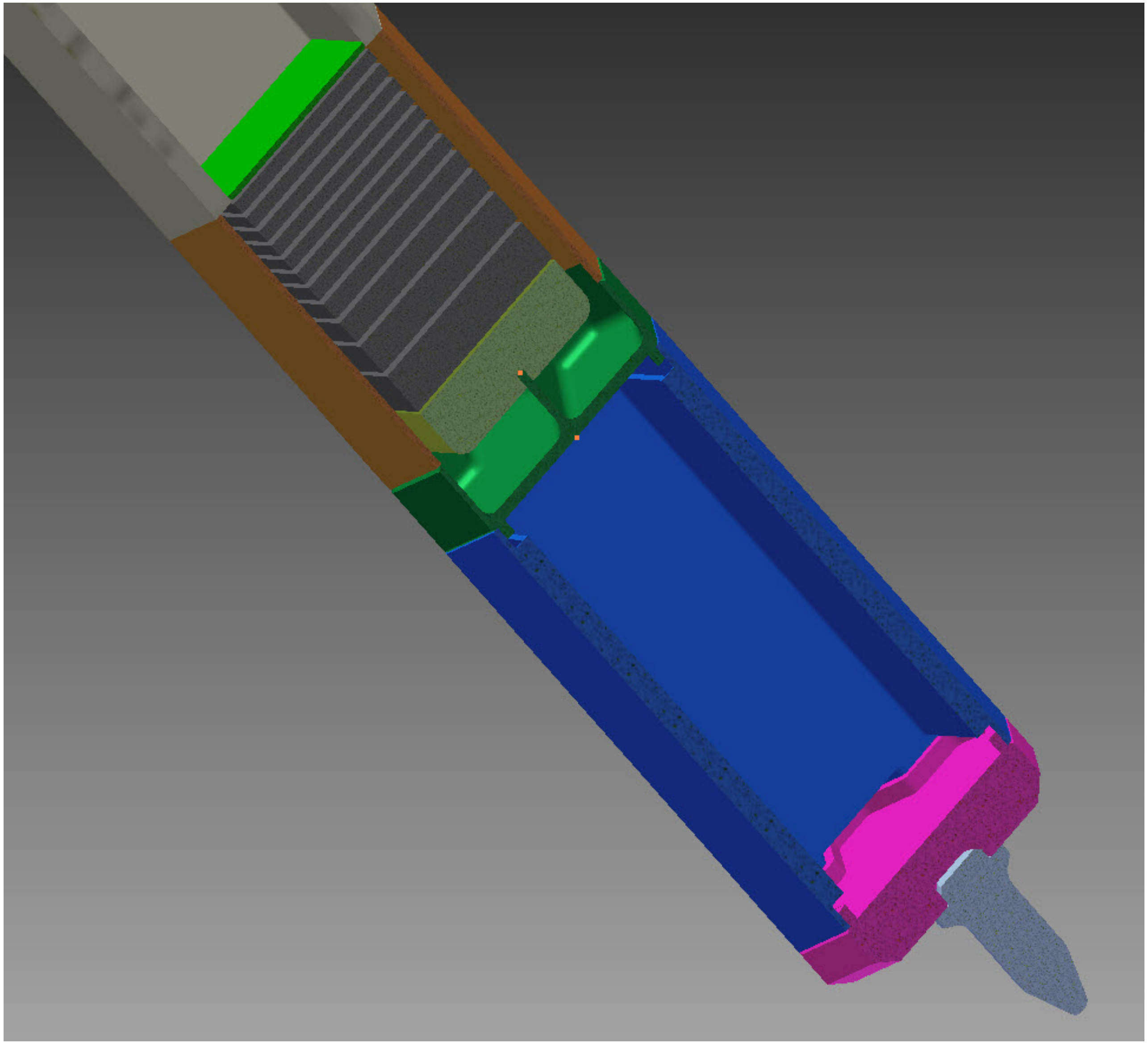
Target Assembly for generating neutrons

- Tungsten(1st) and uranium(2nd) are the target materials for generating neutrons. Water coolant and aluminum alloy structure are used.
- The target assembly configurations were developed to accommodate square beam cross sections and hexagonal fuel geometry.
- The accelerator produces 100 KW beam with 100 MeV electrons.
- Conservative design rules were used for the target assembly design.

Tungsten Target Plates



Uranium Target Configuration

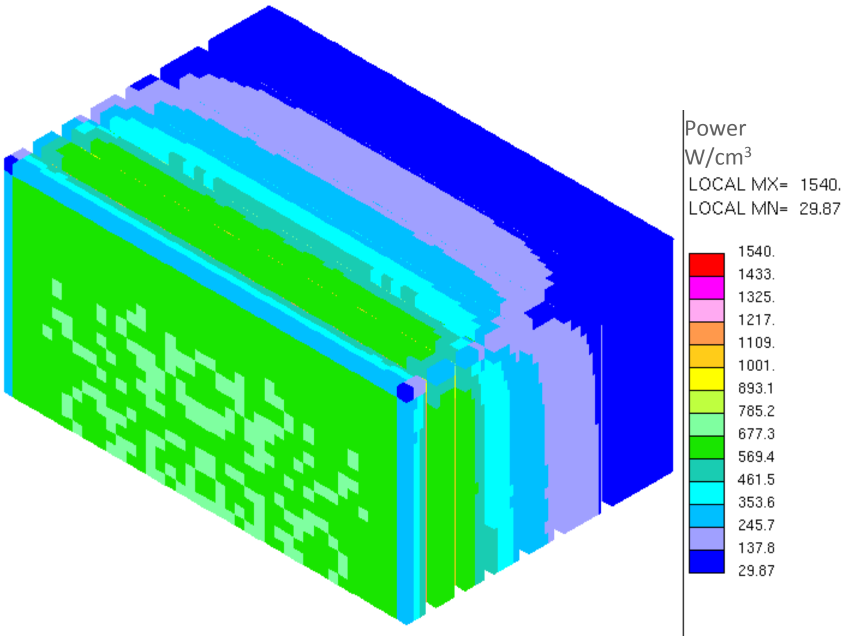


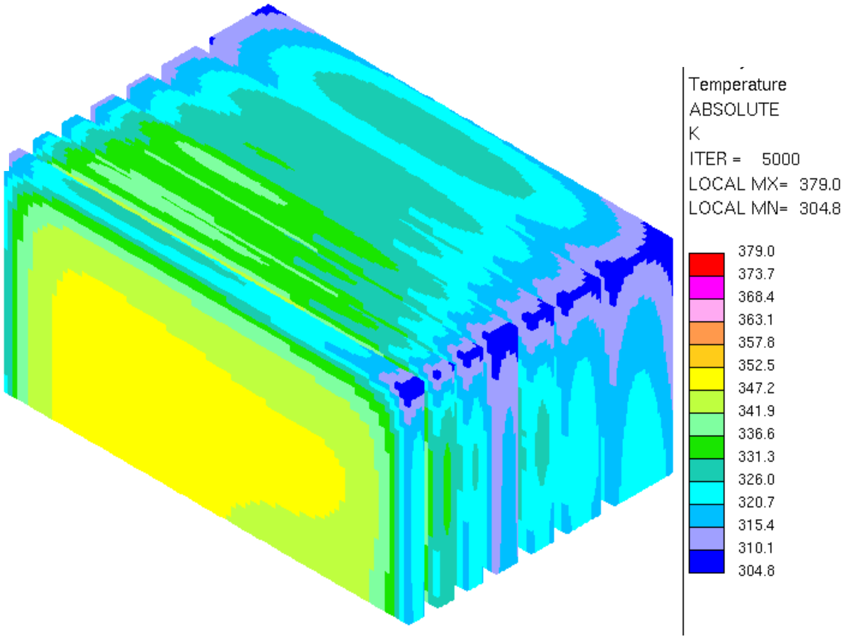
Main Electron Beam and Target Geometry Parameters

Beam Power:	100 kW
Distribution:	Uniform
Electron Energy:	100 MeV
Beam Size:	64 × 64 mm
Target Plate:	66 × 66 mm
Coolant:	Water
Pressure:	5 atm
Inlet Temperature:	20.0 C
Outlet Temperature:	24.1C

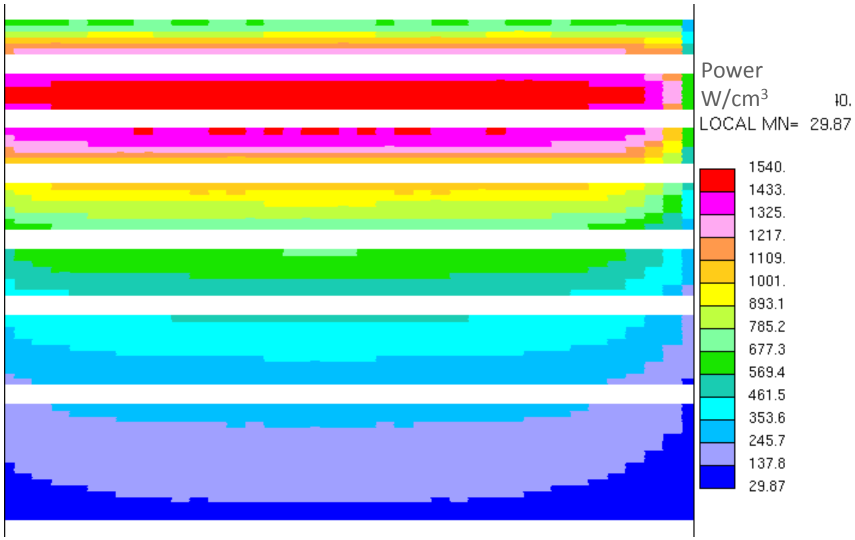
Channel Number	Tungsten Target			Uranium Target		
	Water Channel Thickness mm	Target Plate Thickness mm	Clad Thickness mm	Water Channel Thickness mm	Target Plate Thickness mm	Clad Thickness mm
0	1.0			1.0		
1	1.75	3.0	0.25x2	1.75	3.0	0.7 ×2
2	1.75	3.0	0.25x2	1.75	2.5	0.95 ×2
3	1.75	3.0	0.25x2	1.75	2.5	0.95 ×2
4	1.75	4.0	0.25x2	1.75	2.5	0.95 ×2
5	1.75	4.0	0.25x2	1.75	3.0	0.7 ×2
6	1.75	6.0	0.25x2	1.75	3.0	0.7 ×2
7	1.0	10.0	0.25x2	1.75	4.0	0.7 ×2
8				1.75	5.0	0.7 ×2
9				1.75	7.0	0.7 ×2
10				1.75	10.0	0.7 ×2
11				1.0	14.0	0.7 ×2
Total	12.5	33.0	3.5	19.5	56.5	16.9

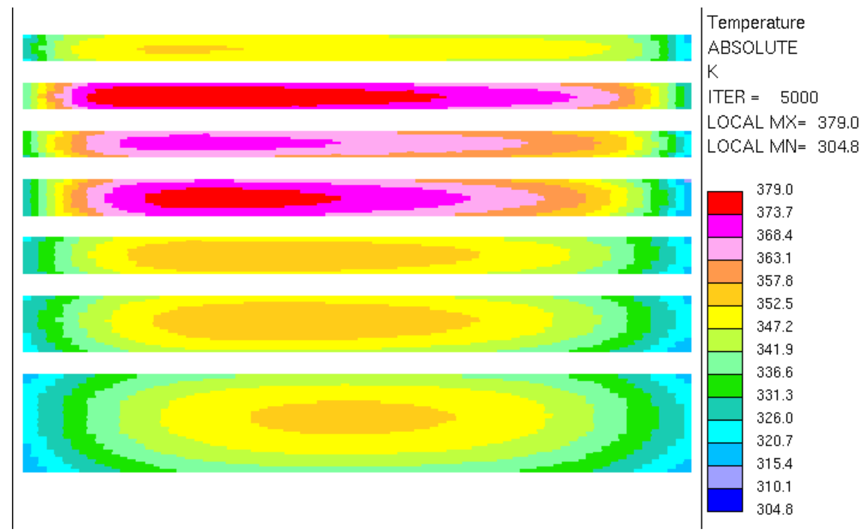
Power and Temperature Distributions of the Tungsten Target - 1





Power and Temperature Distributions of the Tungsten Target - 2

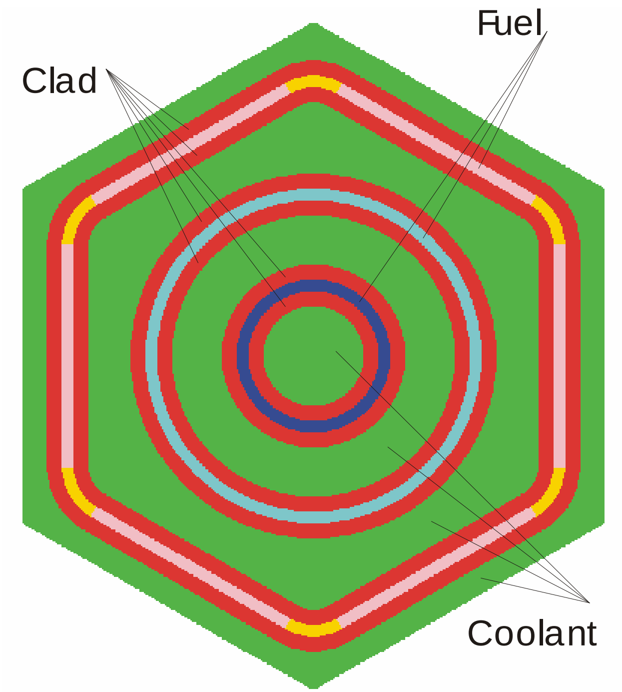


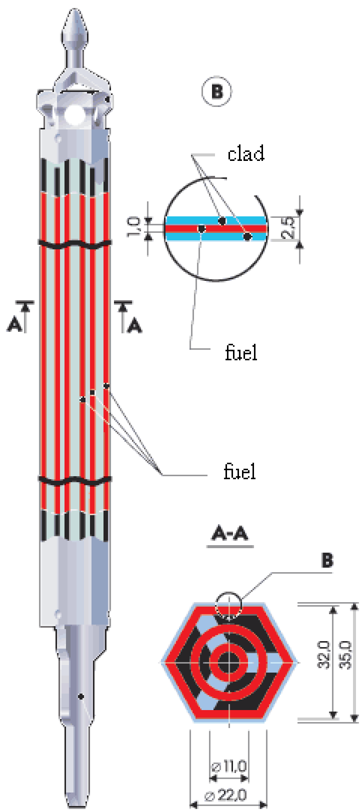


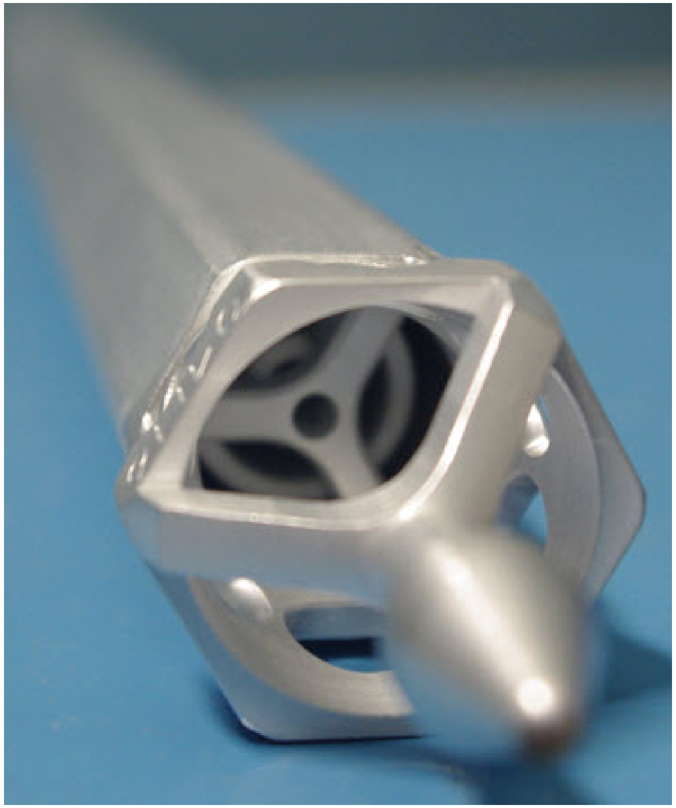
Neutron Source Intensity

Tungsten 1.88x1014 n/s
Uranium 3.06x1014 n/s

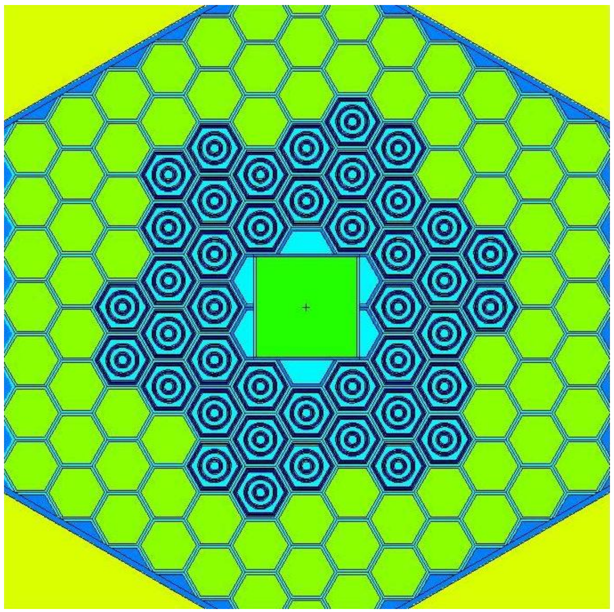
WWR-M2 LEU Fuel Design

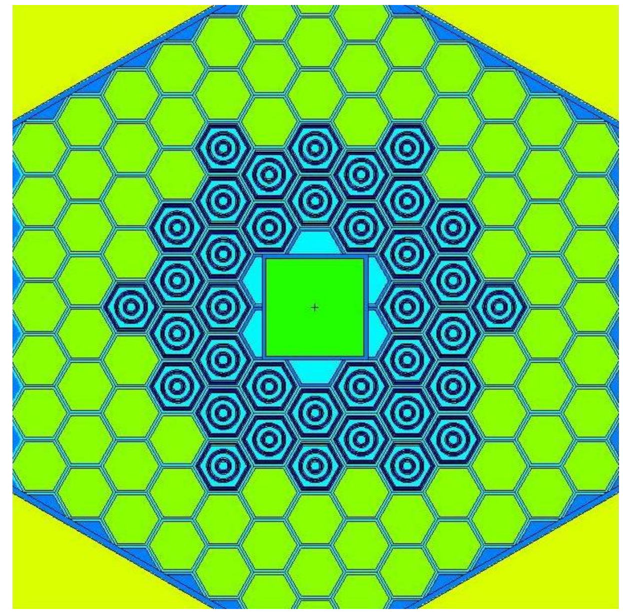






Configuration, Neutron Flux and Energy Deposition for the KIPT ENSF utilizing Tungsten and Uranium Target Driven by 100 kw/100 MeV electron beam

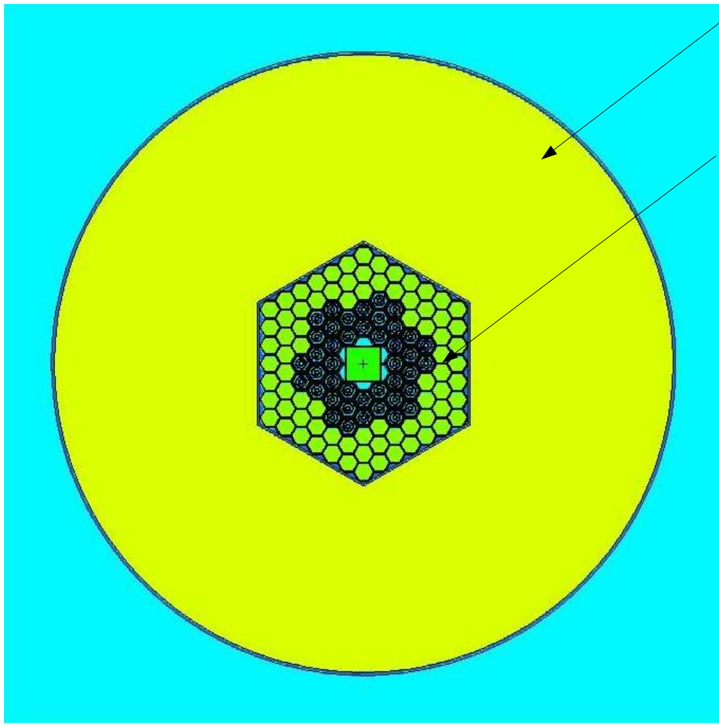




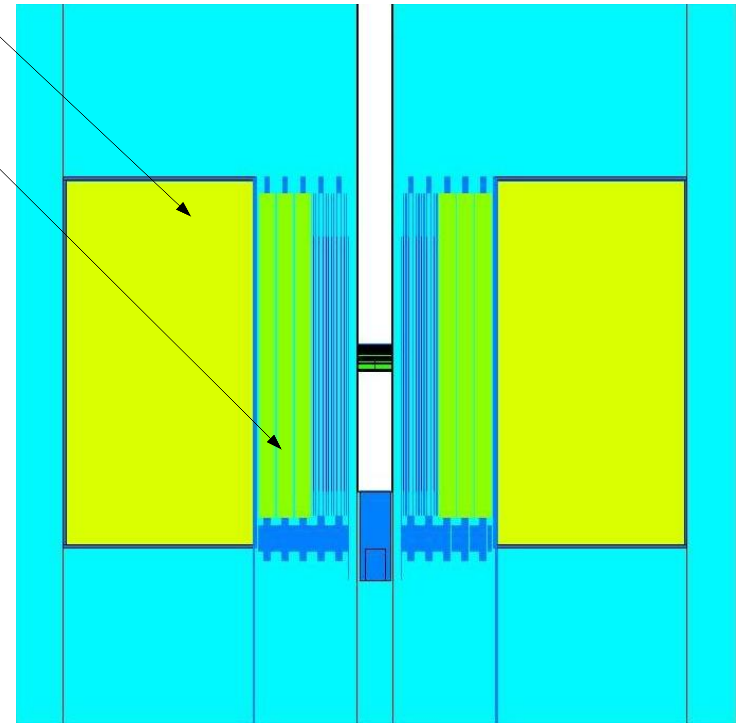
Target	# of FAs	k-eff	Flux along the core ($n/cm^2 \cdot s$)	Flux along the target ($n/cm^2 \cdot s$)	Energy Deposited in the target (KW)	Energy Deposited in the core (KW)	Energy Deposited in the reflector (KW)	Total Energy deposition (KW)
W	42*	0.97855 ±0.00012	1.162e+13 ±0.36 %	1.353e+13 ±0.33 %	84.19 ±0.01 %	134.77 ±0.35 %	8.10 ±0.22 %	227.06
U	37	0.97547 ±0.00012	1.965+13 ±0.26 %	2.470e+13 ±0.25 %	88.42 ±0.01 %	196.89 ±0.35 %	11.57 ±0.19 %	296.89

*Number of fuel assemblies reduced to 38

Subcritical Assembly Geometrical Model

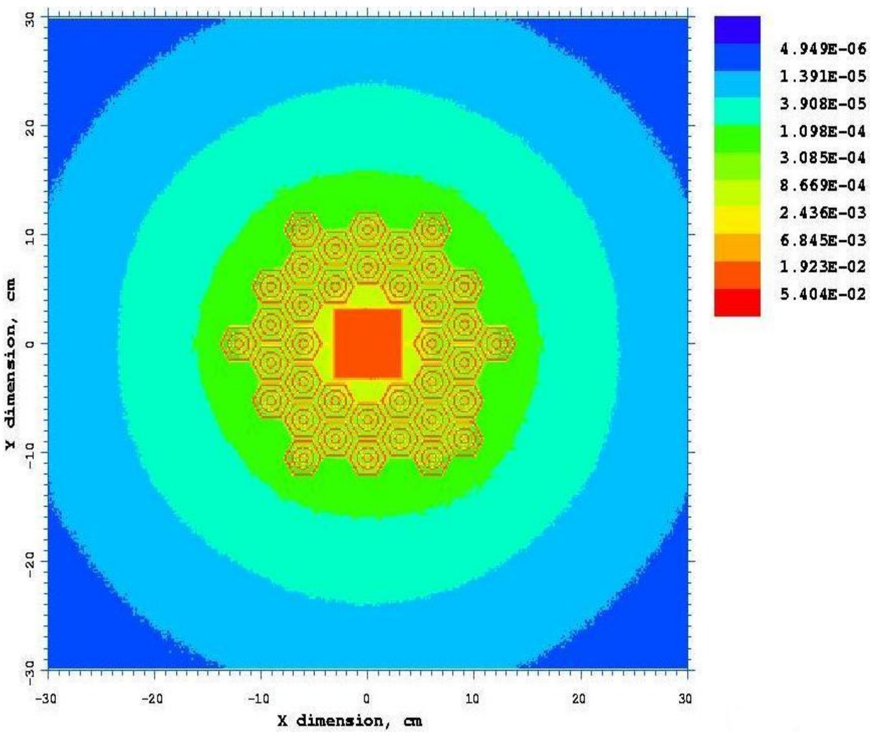


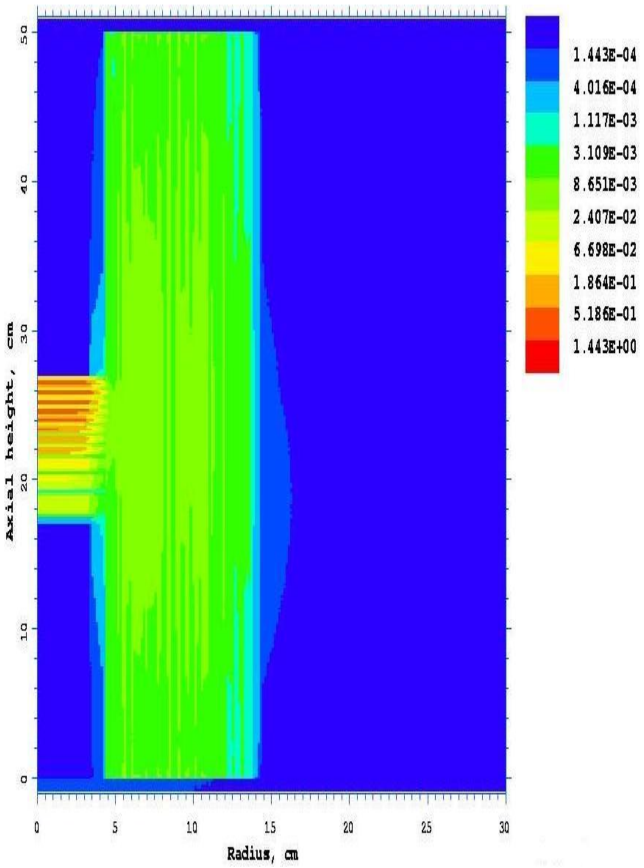
Horizontal Cross Section View



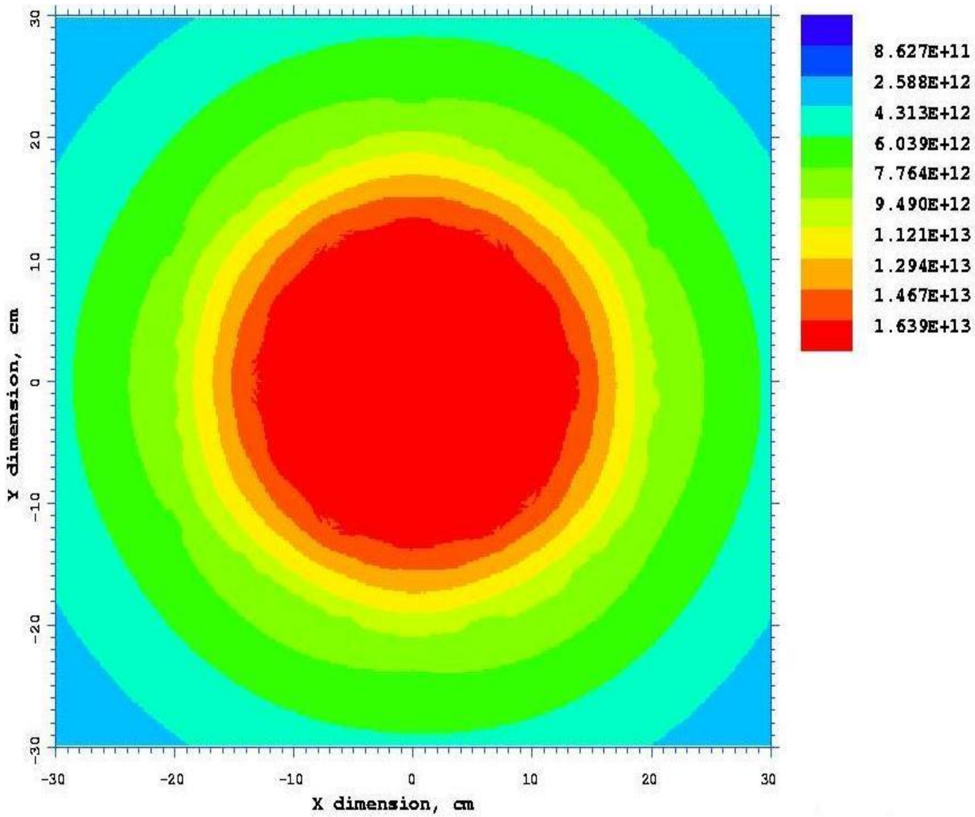
Vertical Cross Section View

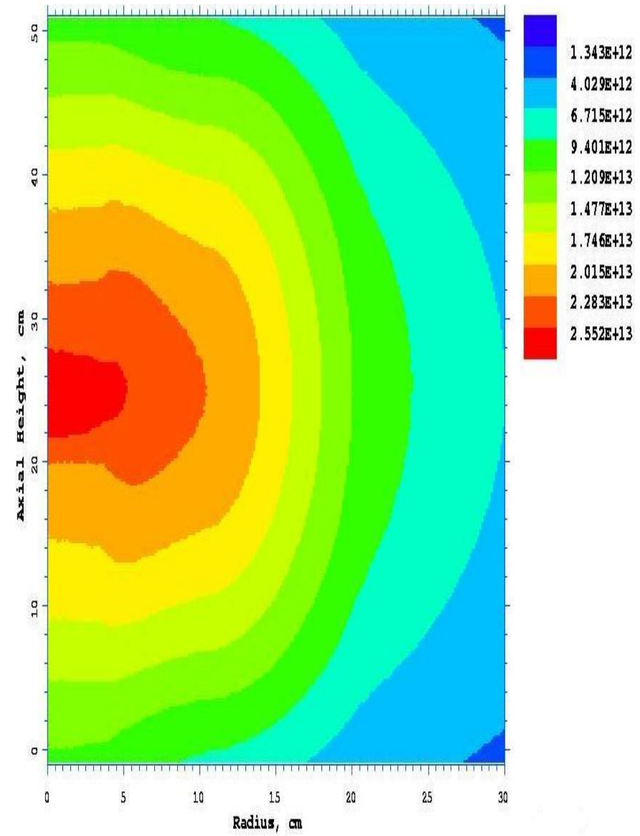
Radial and Axial Energy Deposition for Uranium Target with 37 Fuel assemblies and 100KW/100MeV Electrons (KW/cm^3)



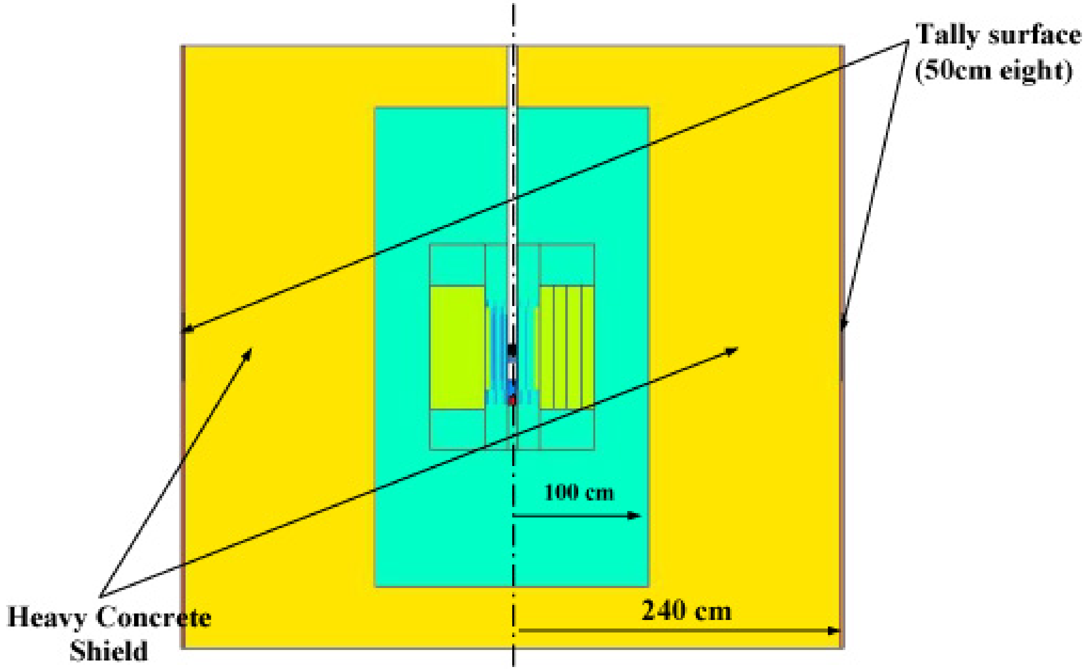


Radial and Axial Total Neutron Flux Distributions Using Uranium Target with 100KW/100MeV Electrons ($n/cm^2 \cdot s$)



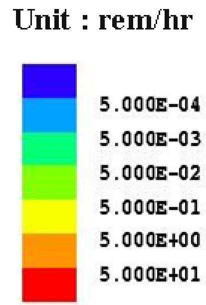


Heavy Concrete Radial Biological Shield (Density 4.8 g/cm^3)

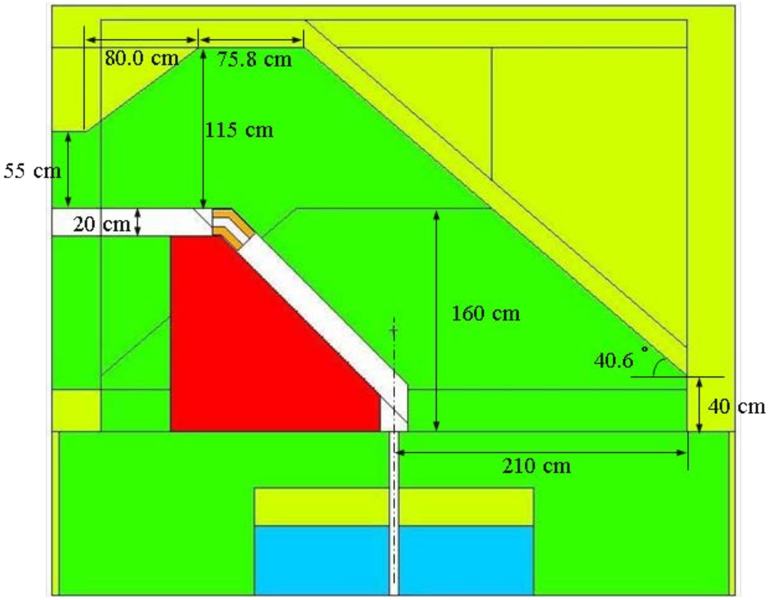


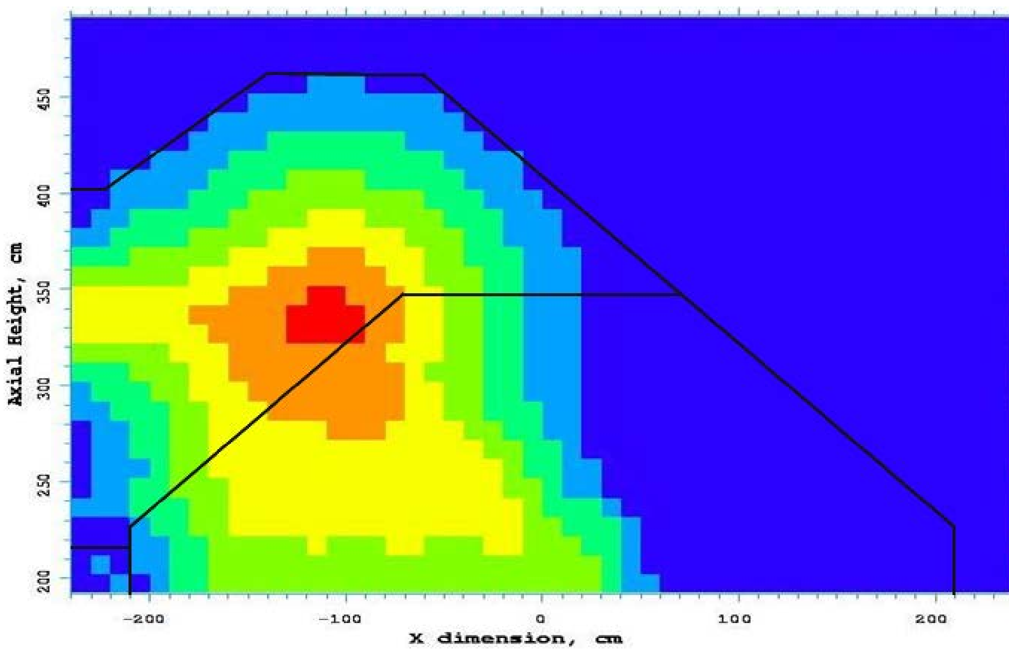
Target	Radiation Source	Radiation Dose (mrem/hr)
Uranium	neutron	0.206 (± 7.24%)
	Photon	0.056 (± 4.63%)
	Total	0.262
Tungsten	neutron	0.326 (± 0.51 %)

Heavy Concrete Top Biological Shield
(Neutrons and photons from the Subcritical Assembly)
(Density 4.8 g/cm^3)



Biological Dose due to 80 W beam losses at the bending magnet





KIPT Neutron Source Facility Summary

- *The KIPT neutron source facility has been successfully developed and it is under construction.*
- *The facility has a subcritical assembly and it is driven by 100 KW electron accelerator. The electron energy is 100 MeV.*
- *The subcritical assembly uses low enriched uranium fuel, water coolant, and beryllium-graphite reflector.*
- *The design satisfies the facility objectives and it has flexibility for future new functions.*
- *The startup is planned for March 2014.*

Acknowledgements

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National Nuclear Security Administration