KIPT ADS Facility

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EuCARD[2] - Status of Accelerator Driven Systems Research and Technology Development

CERN, February 7-9, 2016

KIPT ADS Facility

- *US Government is supporting the development, construction, and operation of an ADS Facility (KIPT Neutron Source Facility) at Kharkov Institute of Physics & Technology (KIPT) of Ukraine as a part of the Russian Research Reactor Fuel Return (RRRFR) program of the United States Department of Energy.*
- *Argonne National Laboratory is performing this task in collaboration with KIPT.*
- *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 to generate the neutron source driving the subcritical assembly.*
- *The target has tungsten or natural uranium plates cooled with water coolant for generating neutrons.*

KIPT Neutron Source Facility

Objectives:

- Demonstrate accelerator driven systems operation and monitoring techniques,
- Provide capabilities for performing basic and applied research using neutrons,
- Perform physics and material experiments inside the subcritical assembly and neutron experiments including cold neutrons outside the subcritical assembly,
- Produce medical isotopes and provide neutron source to perform neutron therapy procedures, and
- Support the Ukraine nuclear power industry by providing the capabilities to train young specialists.

KIPT Neutron Source Facility Site
February 2012

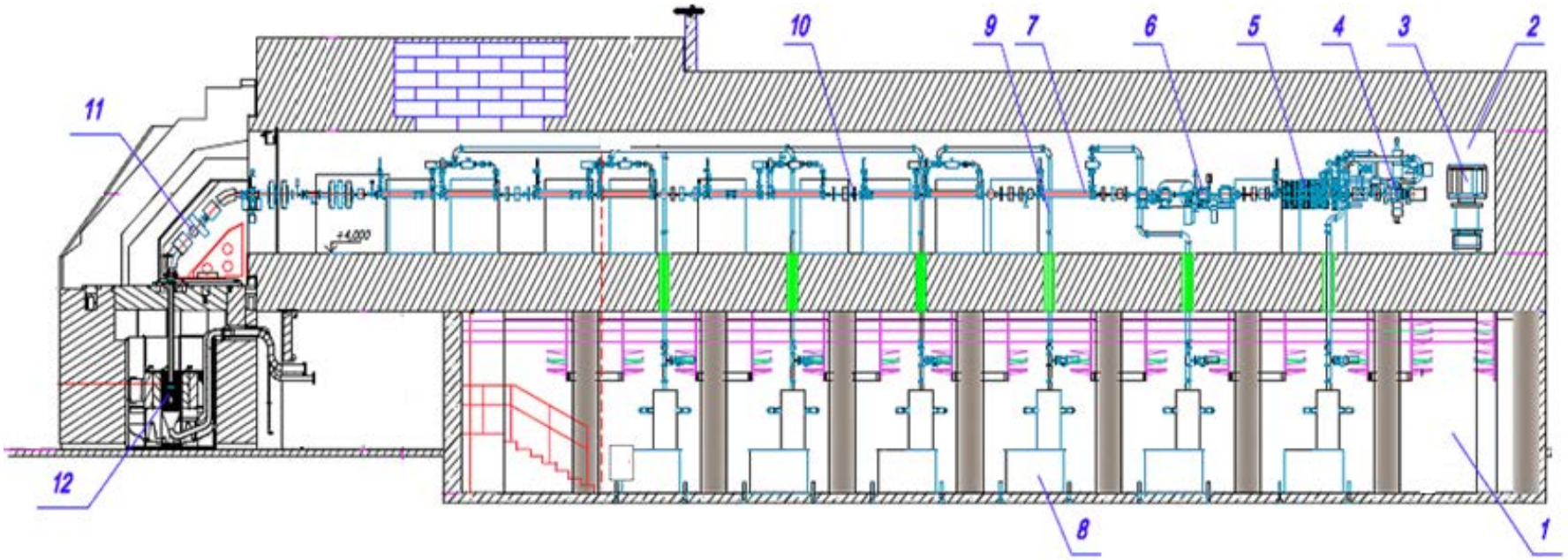
National Nuclear Security Administration

KIOPT Neutron Source Facility Site
February 2014

KIPT Neutron Source Facility Site
June 2016

National Nuclear Security Administration

KIPT Electron Accelerator Configuration



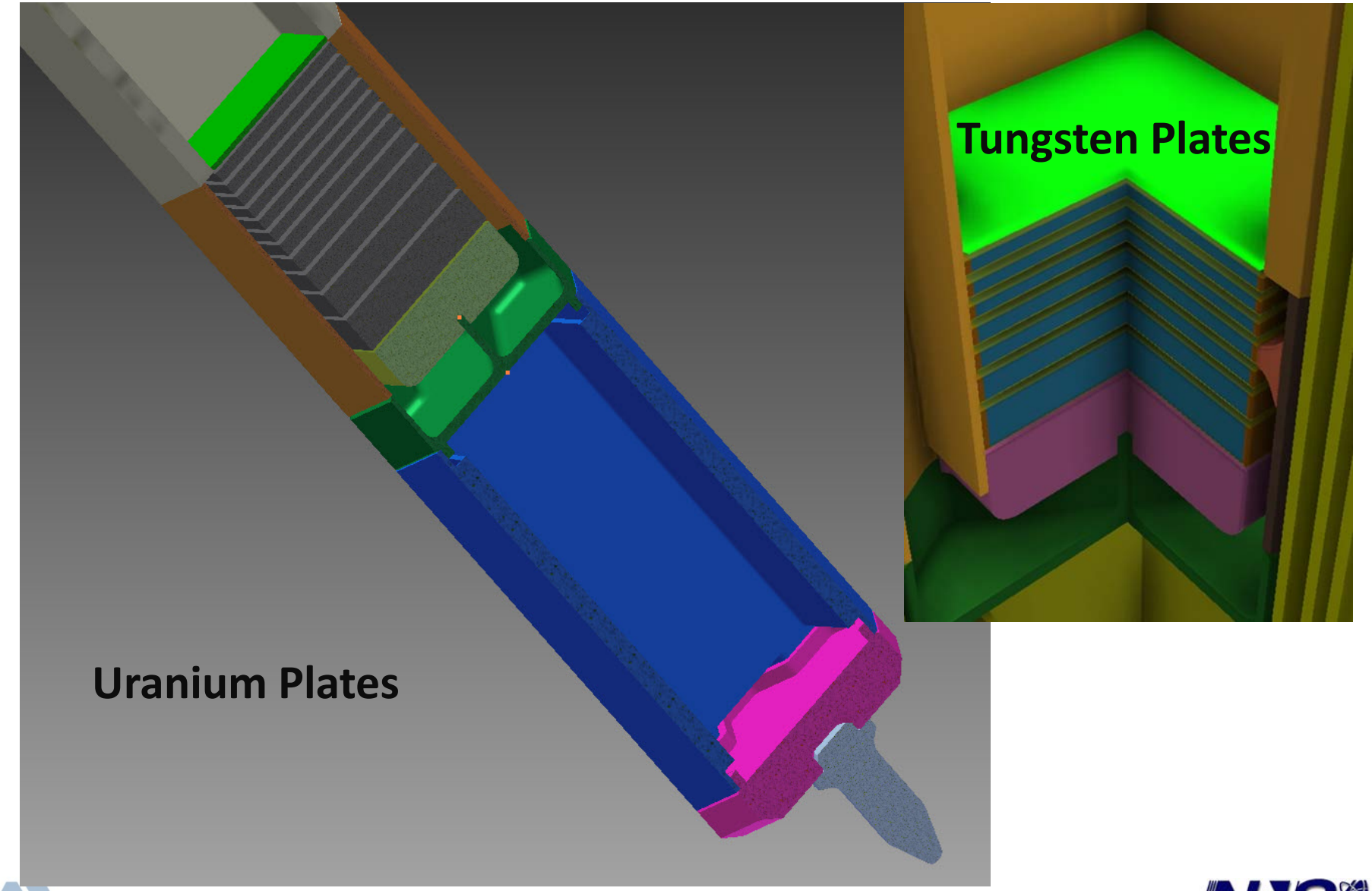
1 - klystron gallery, 2 – Accelerator tunnel, 3 – Power supply, 4 - Electron gun, 5 - First accelerating section, 6 - Energy filter, 7 - Accelerating section, 8 - Klystron amplifier, 9 – Waveguide, 10 - Quadruple triplet magnet, 11 – Electron Transportation channel, 12 – Subcritical Assembly tank

KIPT klystron Gallery and Accelerator Tunnel During Construction

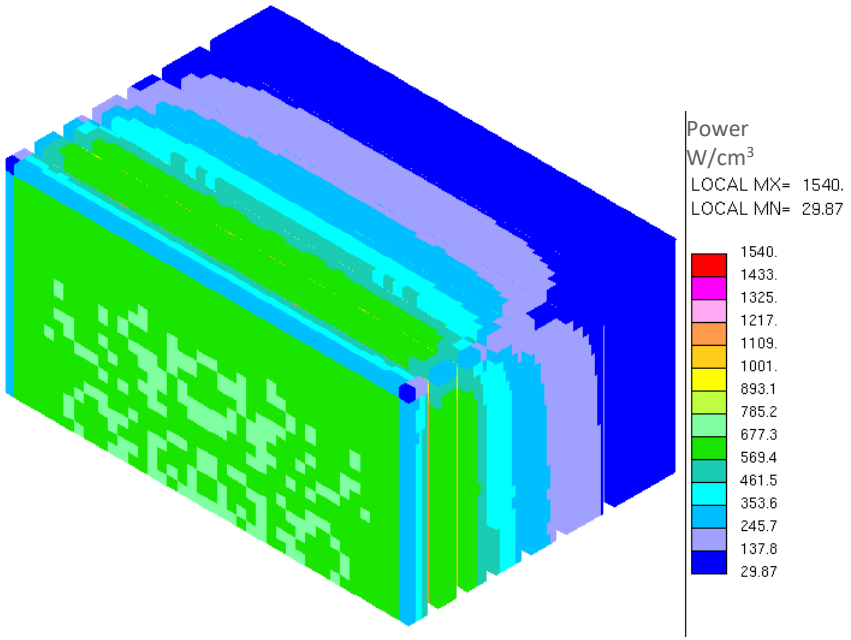
KIPT Target Design

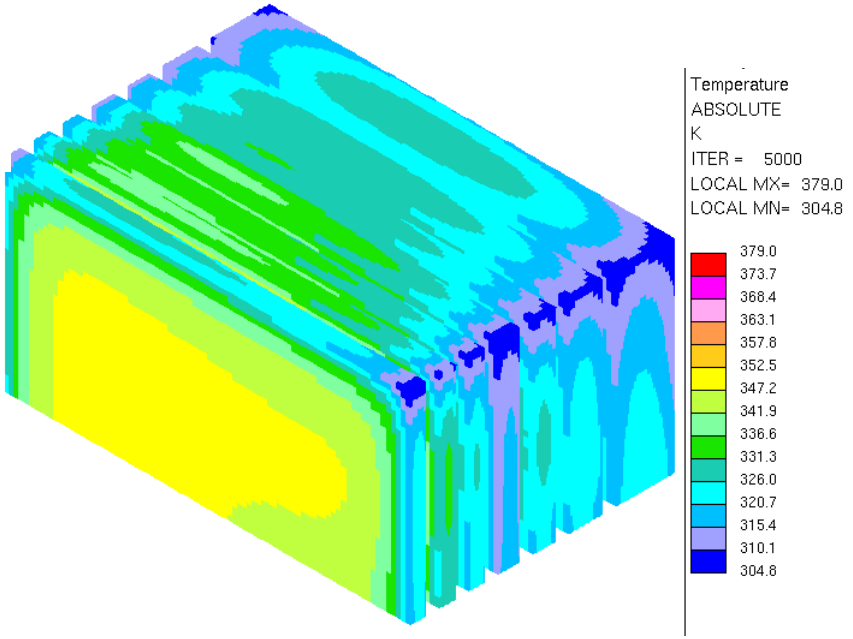
- Tungsten or uranium is the target material for generating neutrons. Water coolant and aluminum alloy structure are used for the target assembly.
- The target assembly configurations developed to accommodate square beam profile and hexagonal fuel geometry.
- The accelerator beam power is 100 KW with 100 MeV electrons.
- Conservative design rules were used for the target assembly design.

KIPT Target Assembly Configurations

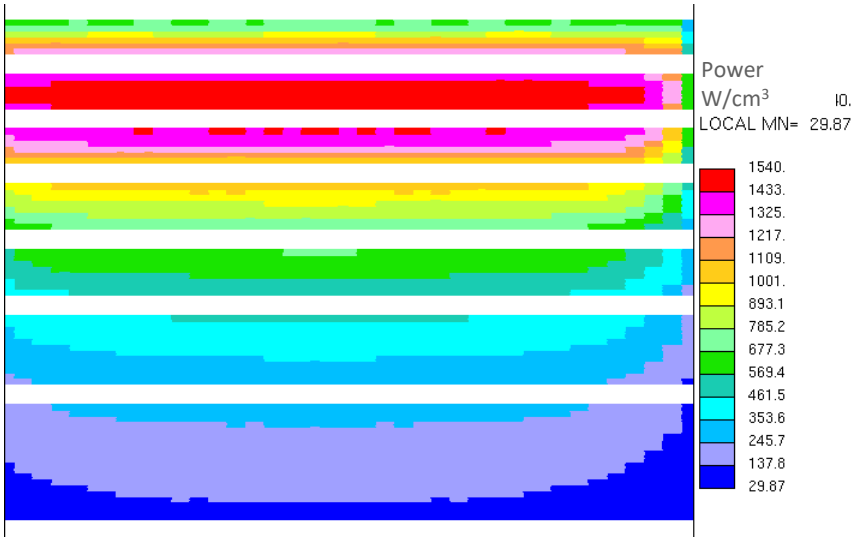


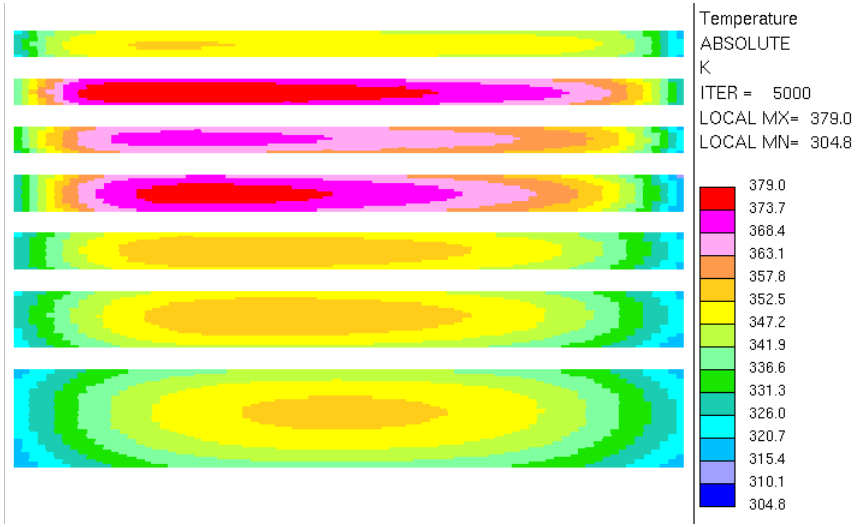
KIPT Power and Temperature Distributions of the Tungsten Target - 1





KIPT Power and Temperature Distributions of the Tungsten Target - 2





Neutron Source Intensity

Tungsten 1.88x10^{14} n/s
Uranium 3.06x10^{14} n/s

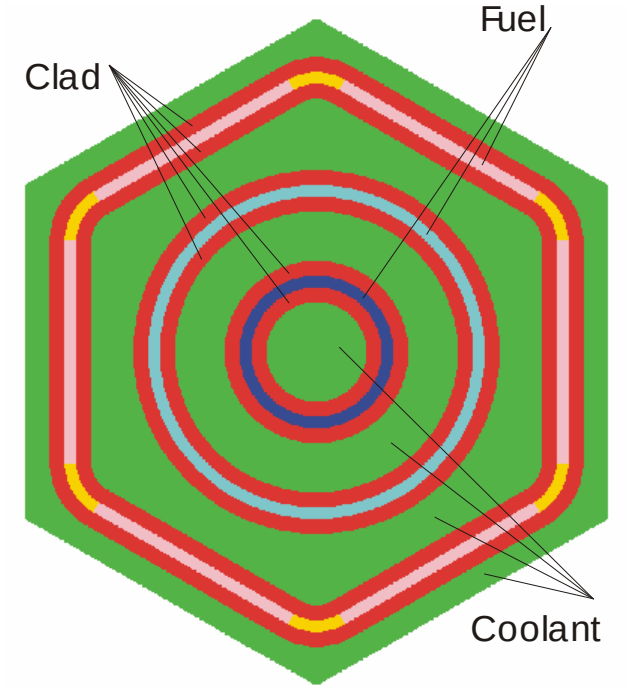
National Nuclear Security Administration

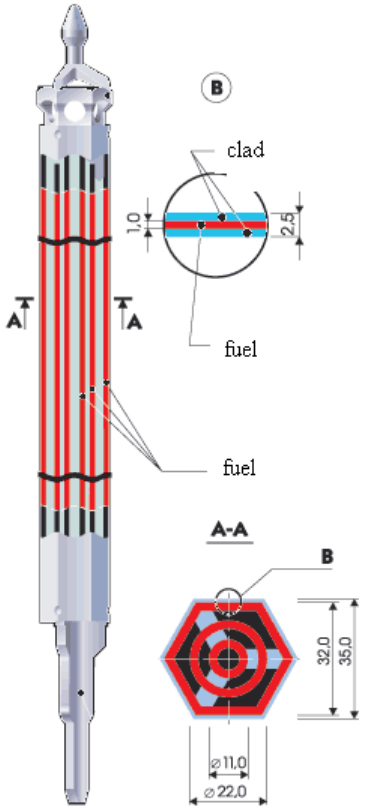
KIPT Electron Beam Parameters and Target Axial Dimensions

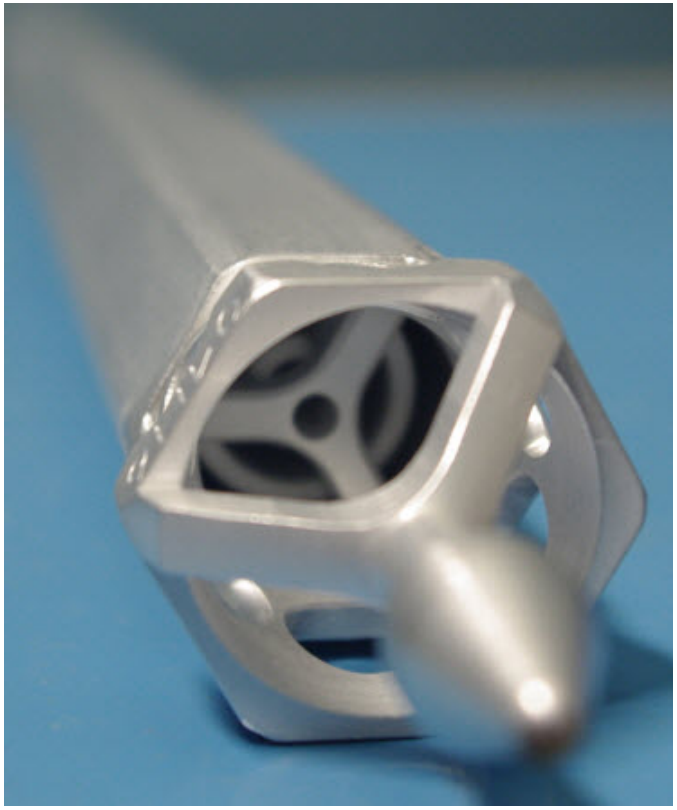
Beam Power:	100 kW
Beam Profile:	Uniform
Electron Energy:	100 MeV
Beam Size:	64×64 mm
Beam Window:	66×66 mm
Coolant:	Water
Water Pressure:	5 atm
Inlet Temperature:	20.0°C
Outlet Temperature:	24.1°C

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 X2
2	1.75	3.0	0.25x2	1.75	2.5	0.95 X2
3	1.75	3.0	0.25x2	1.75	2.5	0.95 X2
4	1.75	4.0	0.25x2	1.75	2.5	0.95 X2
5	1.75	4.0	0.25x2	1.75	3.0	0.7 X2
6	1.75	6.0	0.25x2	1.75	3.0	0.7 X2
7	1.0	10.0	0.25x2	1.75	4.0	0.7 X2
8				1.75	5.0	0.7 X2
9				1.75	7.0	0.7 X2
10				1.75	10.0	0.7 X2
11				1.0	14.0	0.7 X2
Total	12.5	33.0	3.5	19.5	56.5	16.9

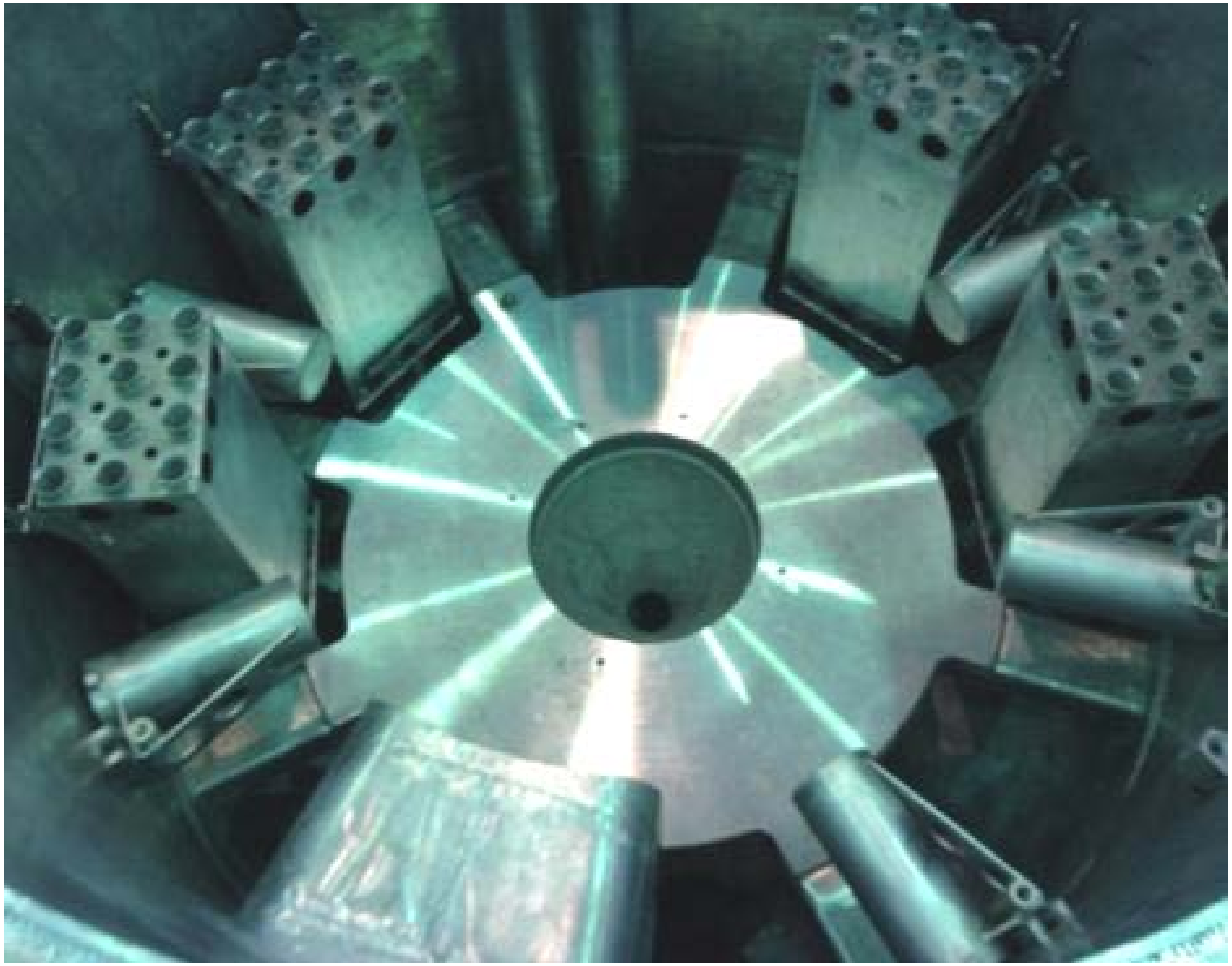
WWR-M2 LEU Fuel Design





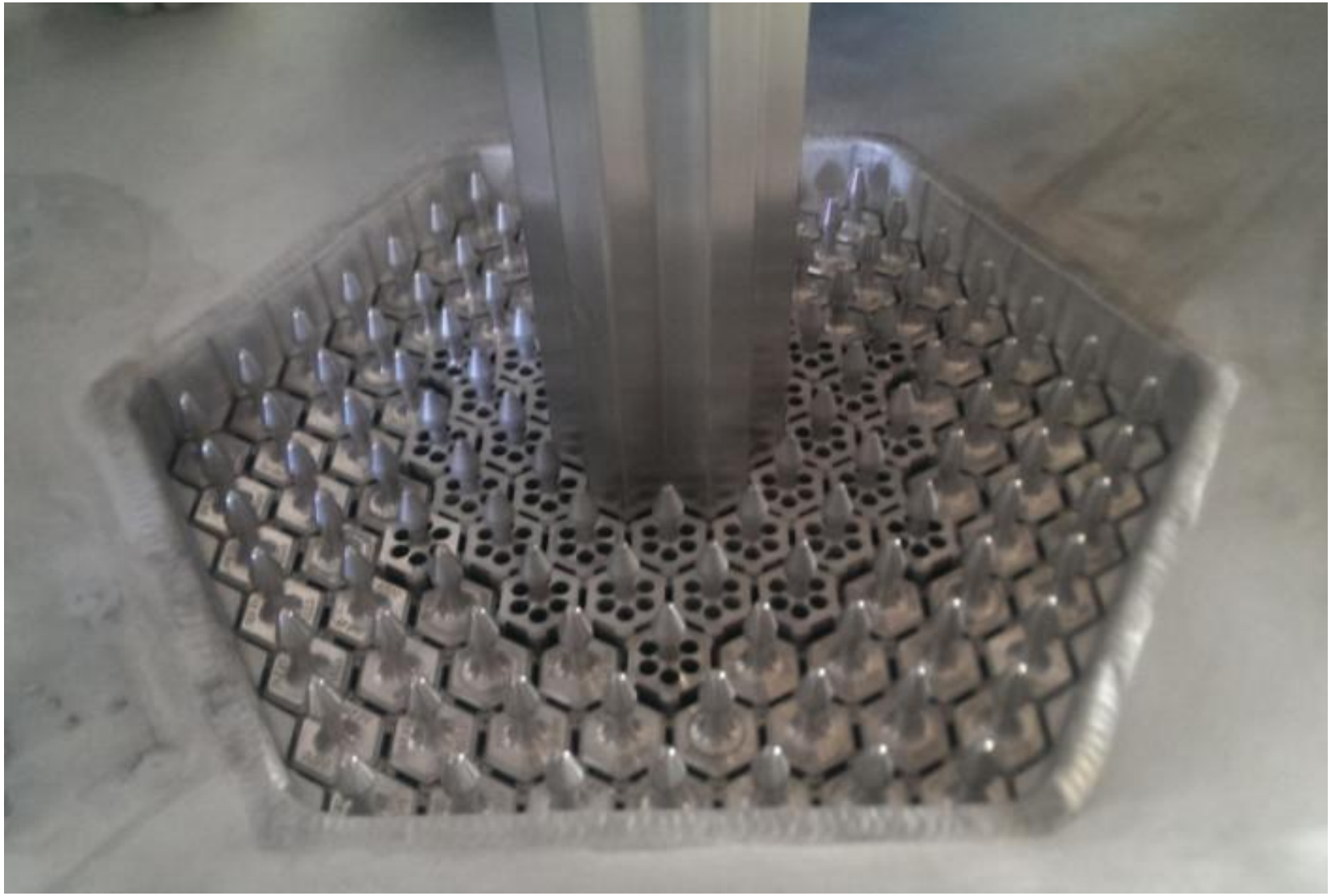


KIPT Subcritical Assembly Tank

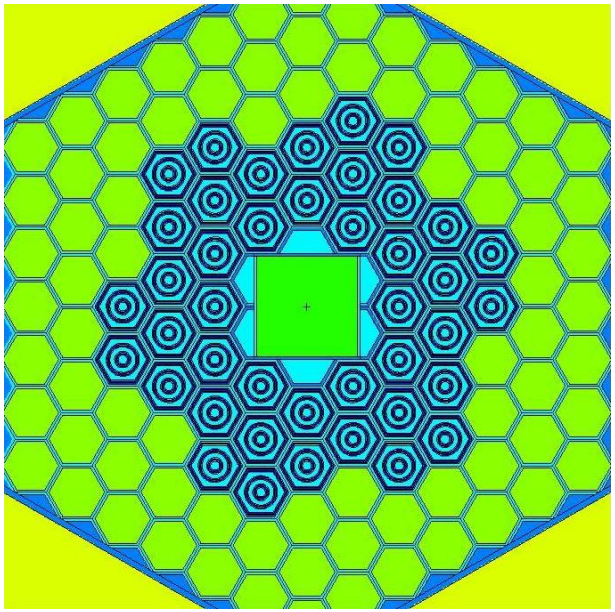


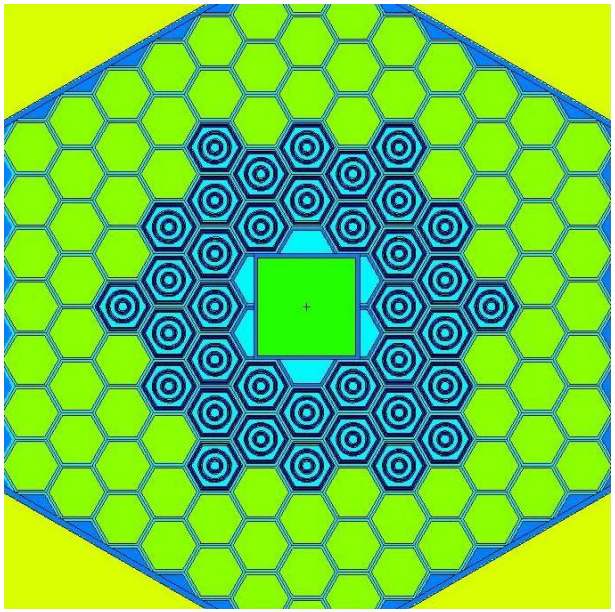
KIPT Subcritical Assembly Tank with the Supporting Grid and the Carbon Reflector Container

KIPT Subcritical Configuration with the Target Assembly



Subcritical Assembly Configurations of the KIPT ADS Utilizing Tungsten and Uranium Target

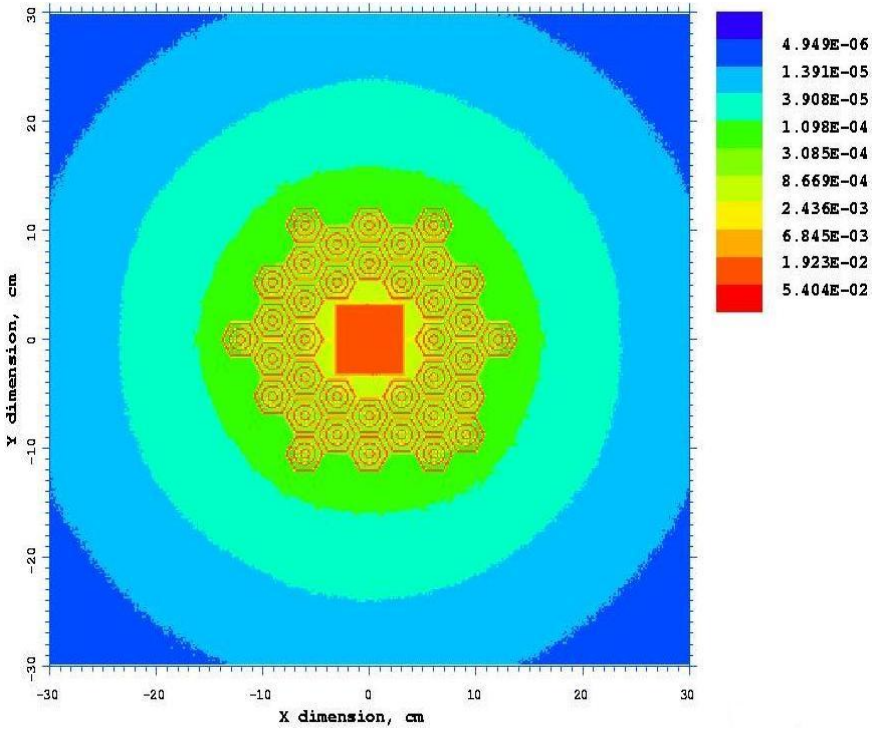


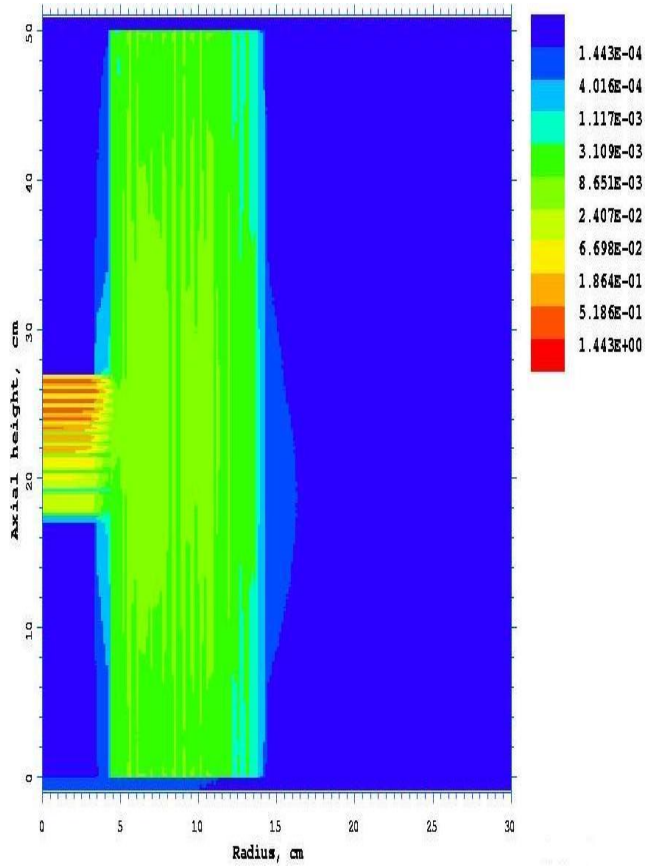


Target	# of FAs	k-eff	Flux along the core ($n/cm^2 \cdot s$)	Flux along the target ($n/cm^2 \cdot s$)	Energy Deposited in the target (KW)	Energy Deposited in the core (KW)	Energy Deposited in the reflector (KW)	Total Energy deposition (KW)
W	42*	0.97855 ±0.00012	1.162e+13 ±0.36 %	1.353e+13 ±0.33 %	84.19 ±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

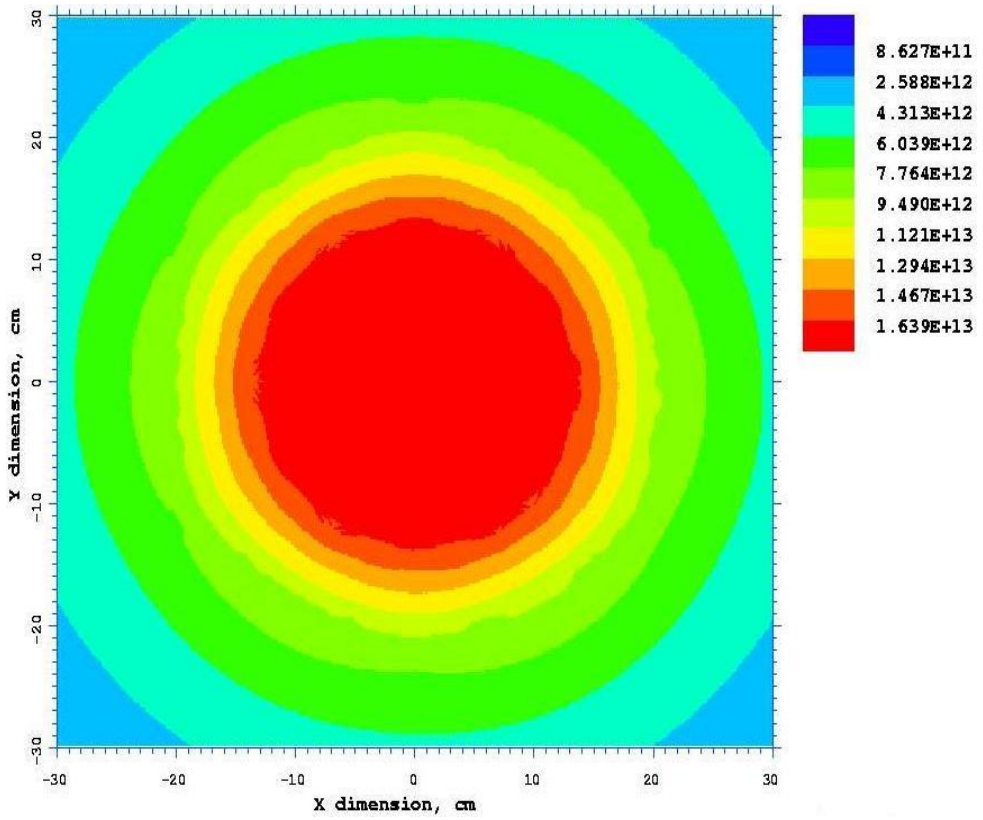
*Number of fuel assemblies reduced to 38

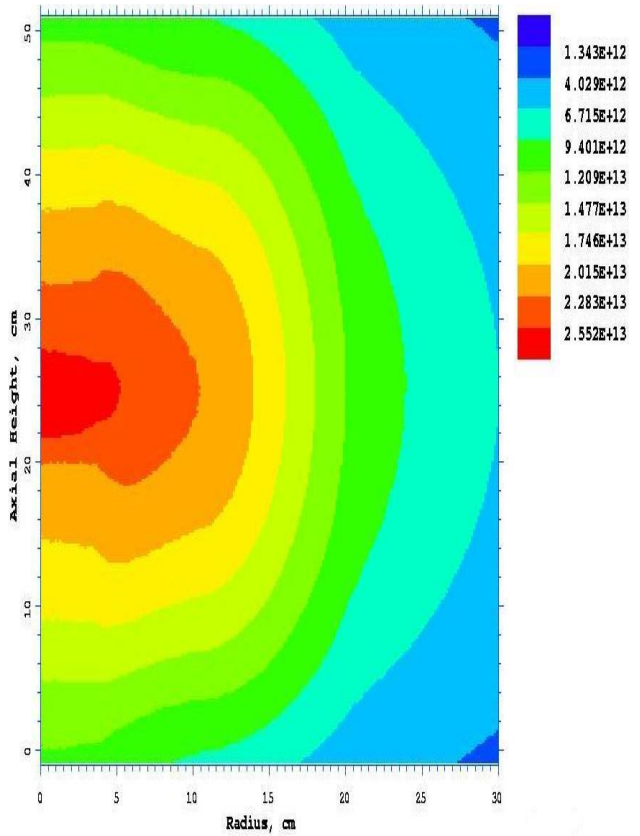
Radial and Axial Energy Deposition for Uranium Target with 37 Fuel assemblies and 100KW/100MeV Electrons (KW/cm^3)





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





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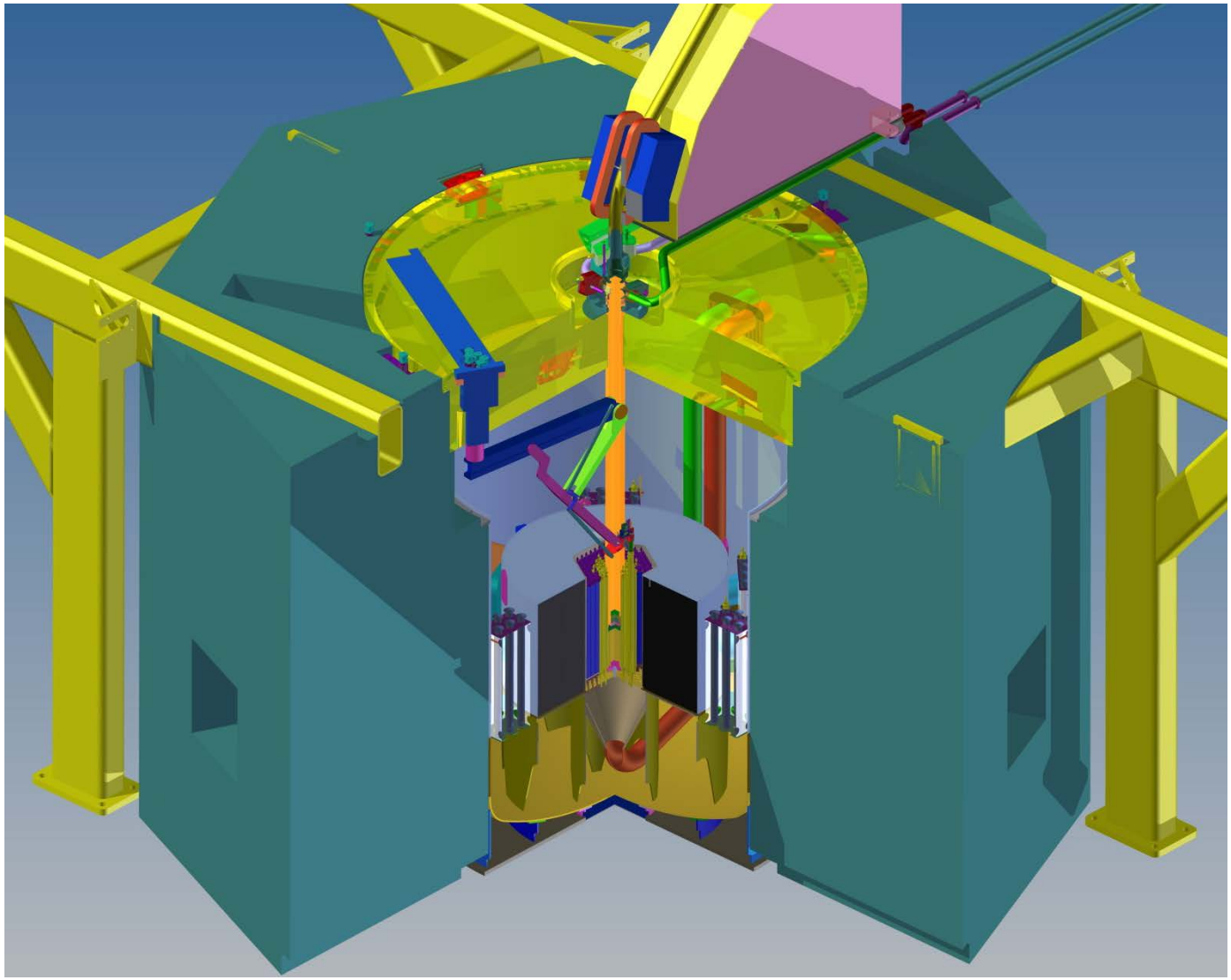
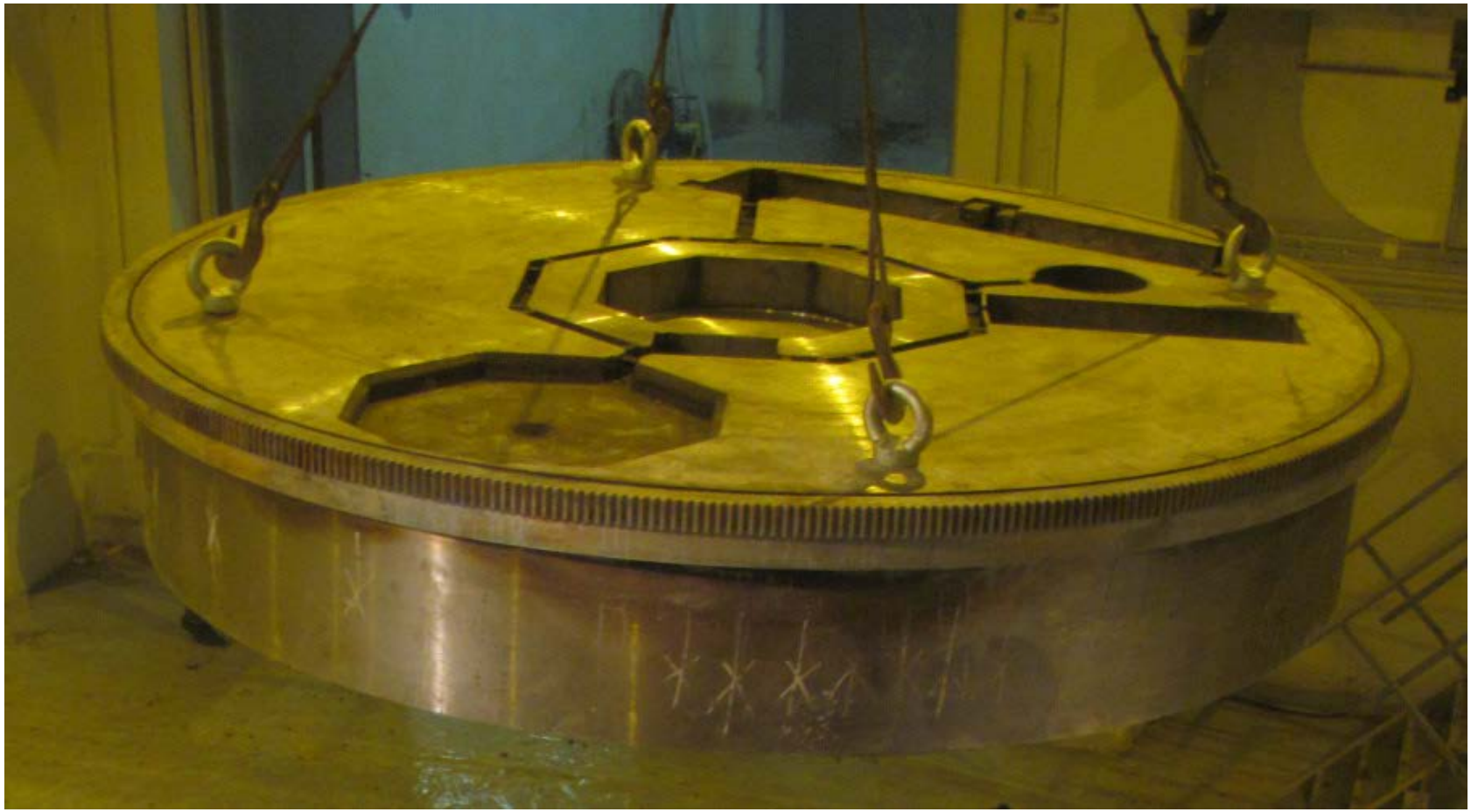
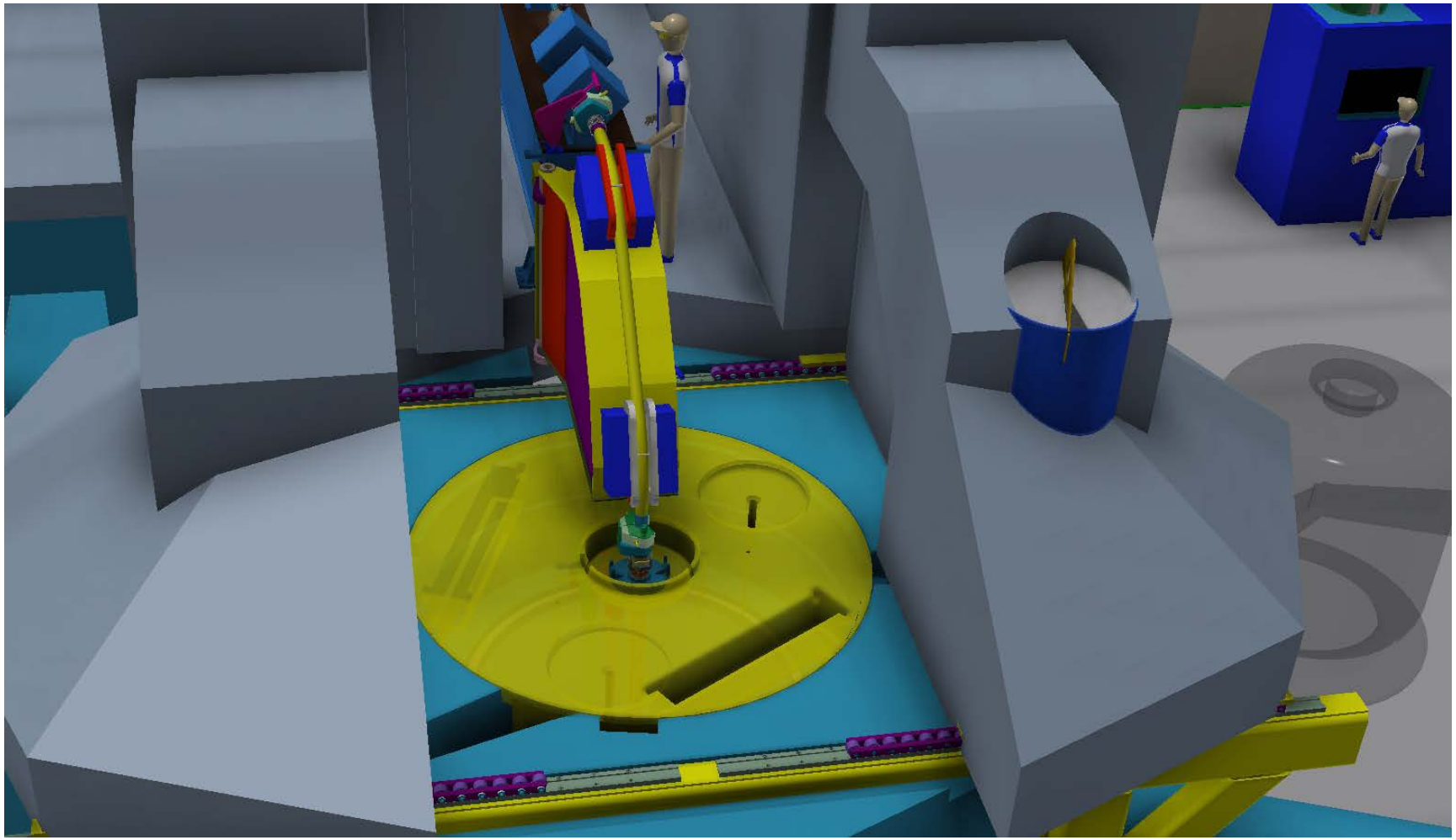
KIPT Subcritical Assembly Overview



The Subcritical Assembly Top Shield Cover



Top Shield, Electron Beam, and Shield Cover



Top Shield Left Section

Top Shield and Bending Magnet View

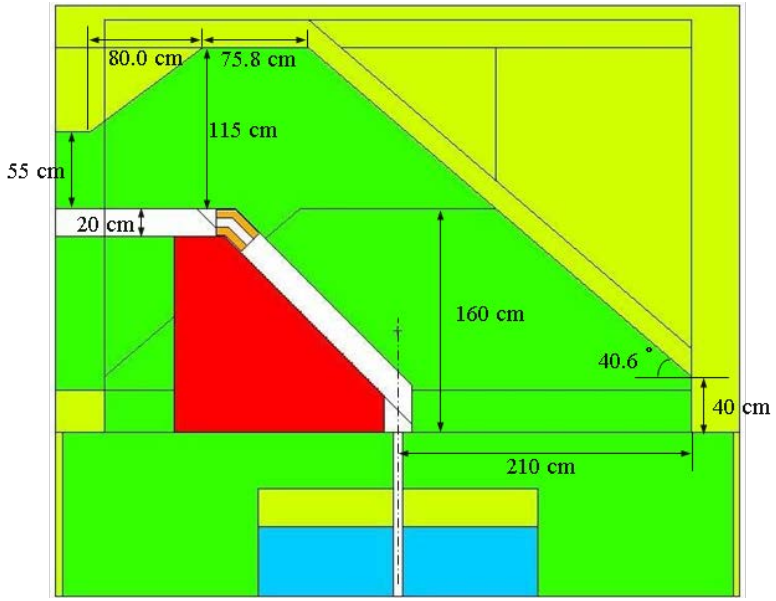
Heavy Concrete Top Biological Shield Dose

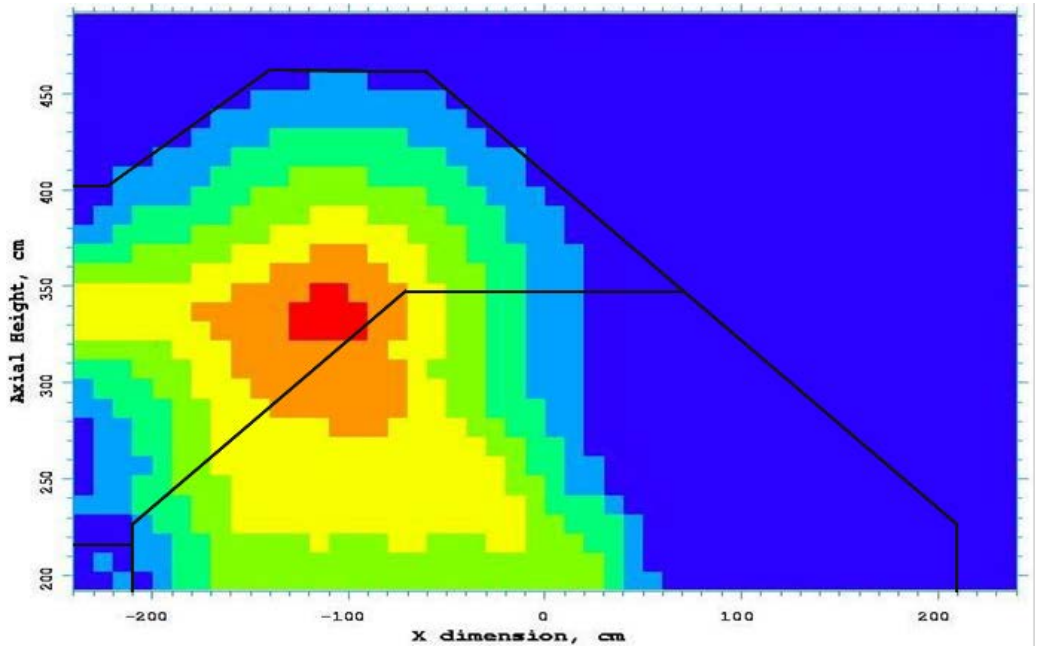
Including neutrons and photons from the Subcritical Assembly and 80 W beam bending losses

Unit : rem/hr

5.000E-04
5.000E-03
5.000E-02
5.000E-01
5.000E+00
5.000E+01

(Concrete density 4.8 g/cm^3)





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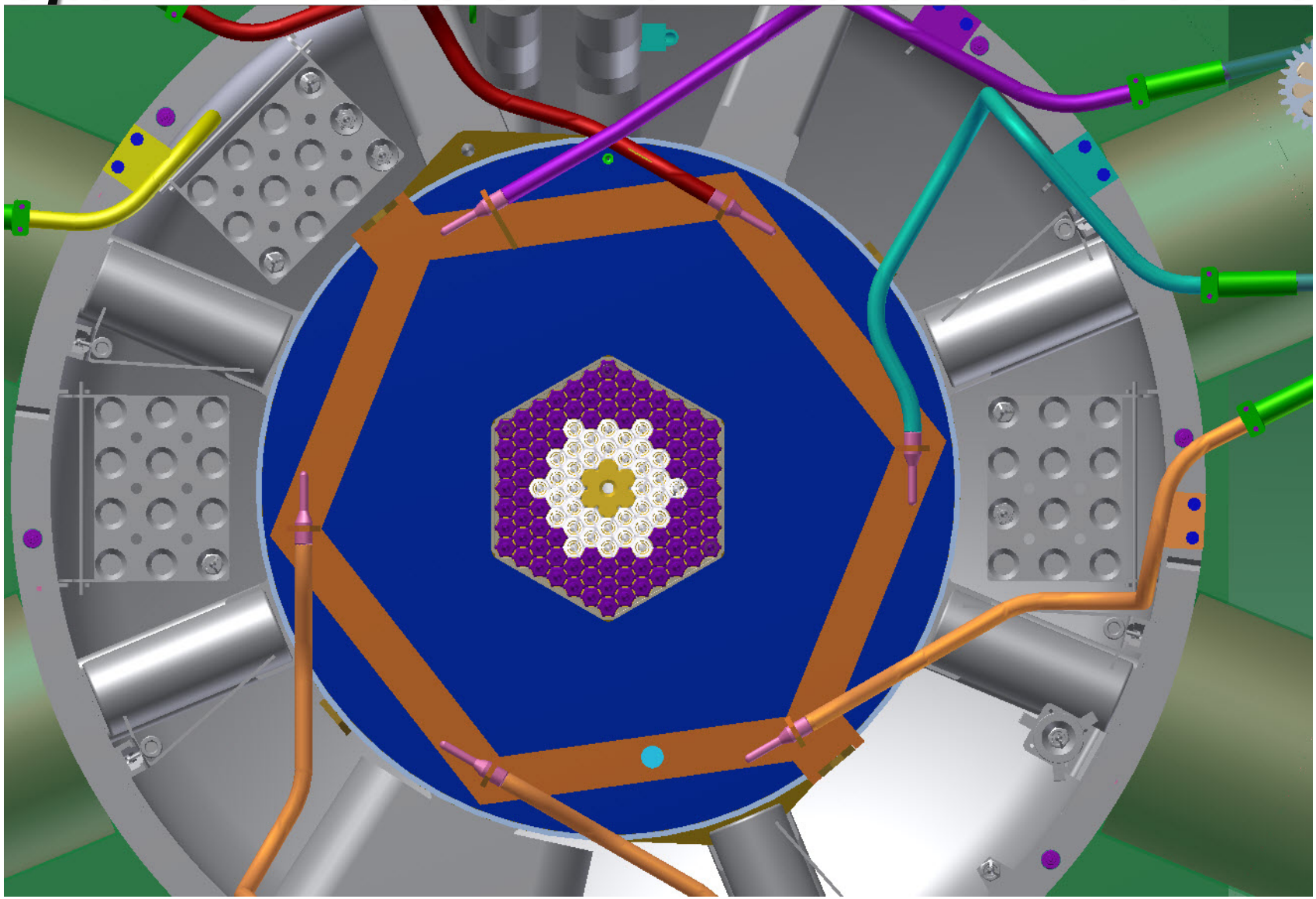
Primary Cooling Loop Equipment

Secondary Cooling Loop Building

Secondary Cooling Loop Equipment

Optimum Neutron Flux Detector Positions



Control Room

Lessons Learned for Future Accelerator Driven Systems

Accelerator Driven Systems design issues, which requires special attention:

- ***The target and the neutron flux detectors impact the fuel machine design and its performance.***
- ***The selection of the neutron flux detector locations.***
- ***The neutron flux detector replacement procedure.***
- ***The beam losses in the accelerator tunnel and the impact on the shield design.***
- ***The beam bending losses above the subcritical assembly and the impact on the top shield design.***
- ***The top shield Mechanical design above the subcritical assembly considering the target replacement and the bending magnet maintenance.***
- ***The target replacement procedure.***
- ***The bending magnet design for target replacement operation.***

KIPT Neutron Source Facility Summary

- The KIPT neutron source facility has been successfully developed, constructed and the commissioning process is underway.
- The facility has a subcritical assembly and it is driven by 100 KW electron accelerator with 100 MeV electrons.
- The subcritical assembly uses low enriched uranium fuel, water coolant, and beryllium-graphite reflector.
- The design satisfies the facility objectives including the possibility for new functions.

Acknowledgements

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