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DESIGN AND COMMISSIONING RESULTS OF 100 MeV/100 KW LINEAER ELECTRON ACCELERATOR OF THE NSC KIPT SUBCRITICAL FACILITY “NEUTRON SOURCE”

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on behalf

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ANS Conference
13th International Topical Meeting on Nuclear Applications of Accelerators

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NSC KIPT SUBCRITICAL FACILITY “NEUTRON SOURCE”

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NSC KIPT Neutron Source Milestones

2010 - NSC KIPT declaration of intention of NSC KIPT Neutron Source construction.

2011 - public hearings in NSC KIPT and city government resolution №298/11 from 18.05.2011, that approved the facility construction site in KIPT.

2012 - resolution of К М У №100 from 15.02.2012, official approval of NSC KIPT Neutron Source Technical Task у .

2012 - the State expertise of the facility design project has been completed PSAR of the facility has been approved by State Regulator (resolution №19 from 27.12.2012).

2013 - К М У №370-р resolution from 27.05.2013, facility design project was approved, license № Е О 001018 Г И Я Р У on NSC KIPT Neutron Source construction and commissioning has been issued.

2014 – test and commissioning of the facility

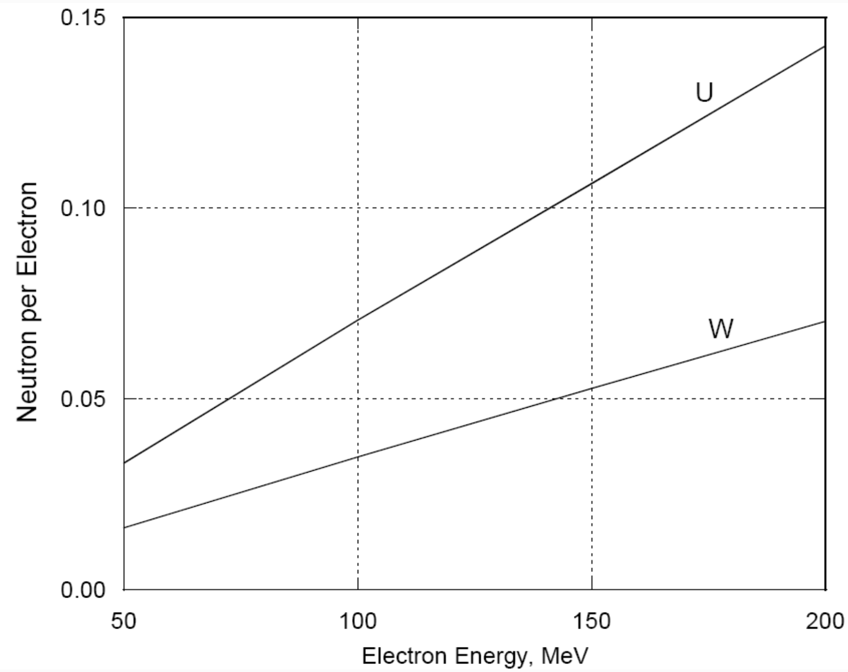
2017 - start of operation

NSC KIPT Neutron Source

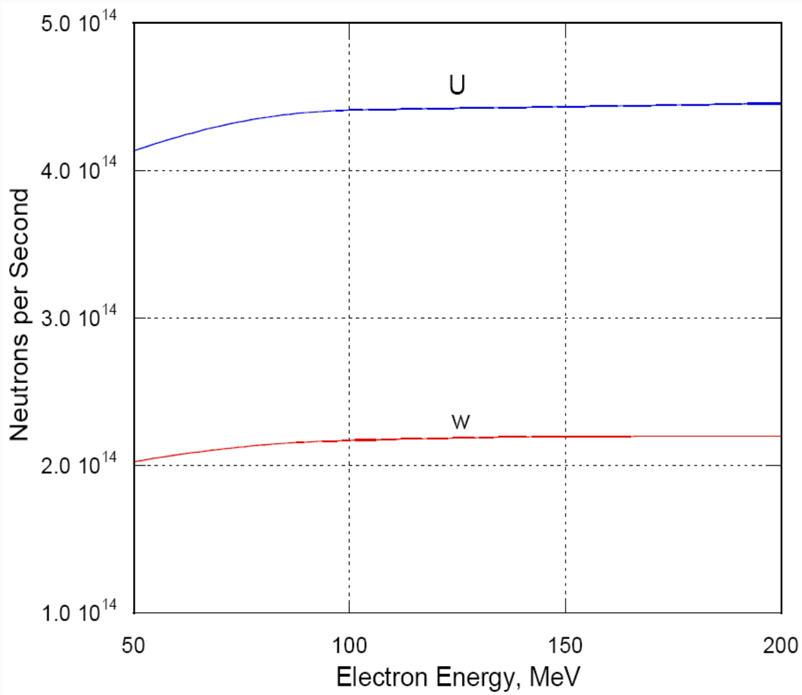
Electrons produce neutrons through bremsstrahlung of electron in heavy metal target and then with photo-neutron reaction (ɣ-n).
For 100 MeV electron beam the neutron yield is about 1 neutron per 100 electrons.
So, the proton beam is as much as 10^4 more effective then electron beam.
Due to much low cost Electron Accelerator Driven Systems can be used as:

- prototypes for the future proton machine
- design end development of future power plant technological systems
- neutron sources for the scientific investigations

NSC KIPT Neutron Source



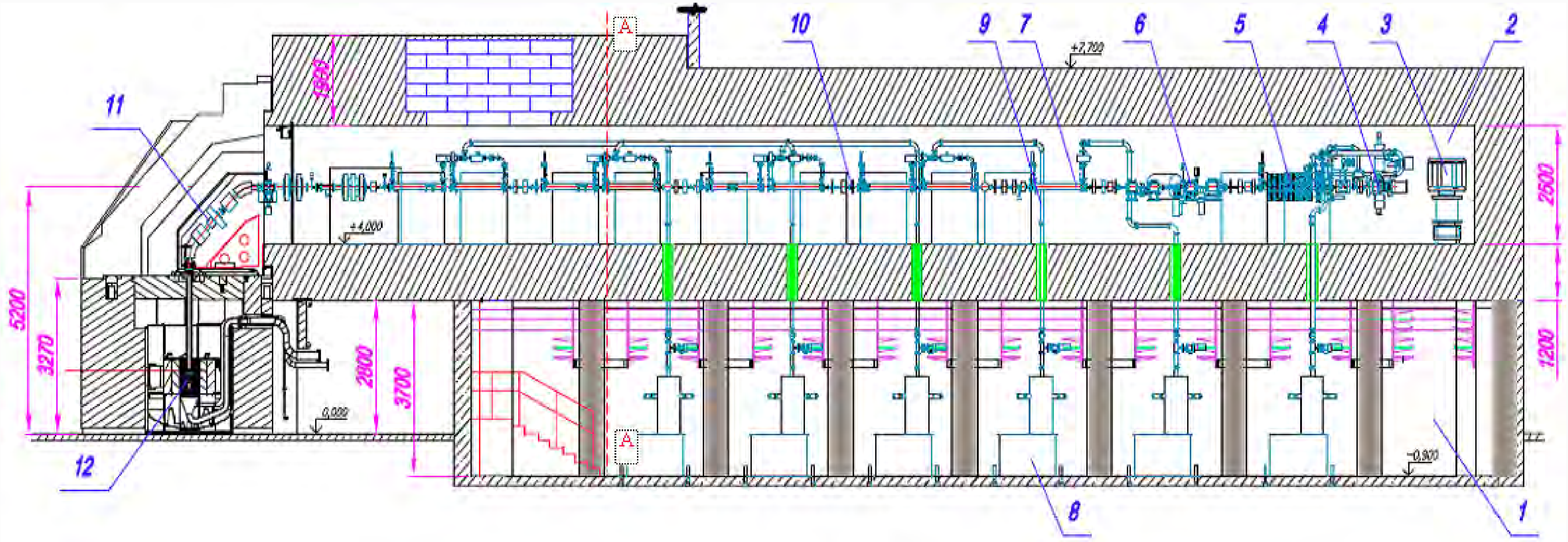
Neutron yield per electron as a function of the electron energy for natural uranium and tungsten target materials.



Neutron source strength as a function of the electron energy for 100 kW beam power from natural uranium and tungsten target materials.

Facility layout

The electron energy is 100 MeV.
The average current is 1 mA.
The average power of the beam is 100 kW.
To minimize losses during beam transport to the target, the energy distribution must not exceed 2 % with acceptable emittance.

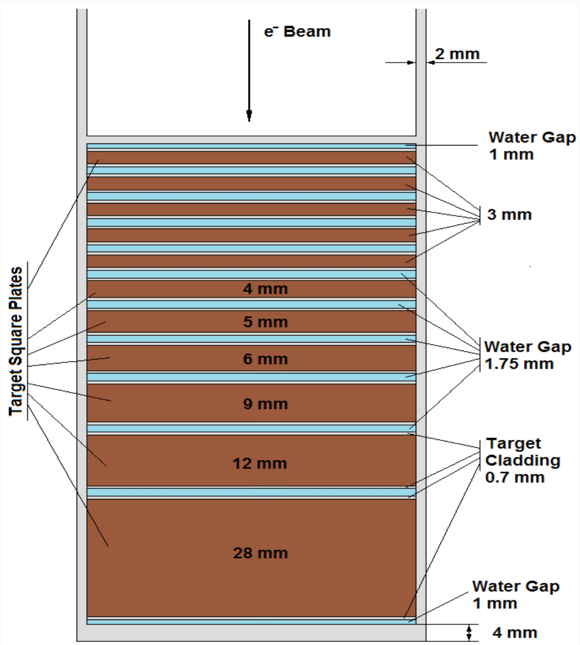


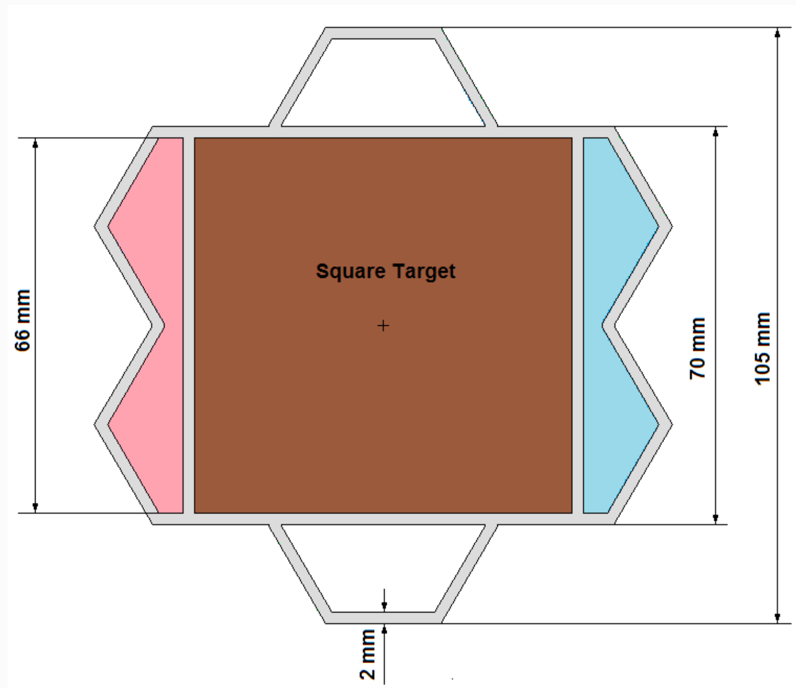
1 – klystron gallery, 2 – tunnel, 3 – HV power supply, 4 – electron gun, 5 – injector accelerating section, 6 – chicane, 7 – accelerating sections, 8 – klystrons, 9 – wave guides, 10 – quadrupole triplets, 11 – transportation channel, 12 – SCA tank

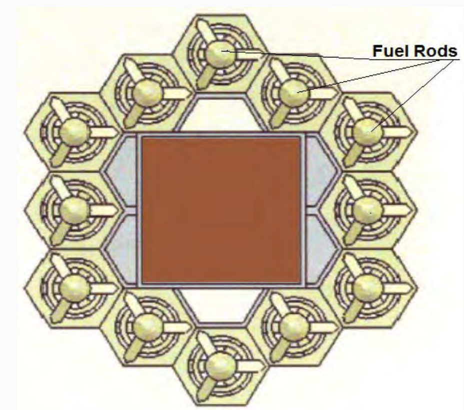
Main Facility Parameters

#	Parameter	Value
1	Electron beam power, kW	100
2	Electron beam energy, MeV	100
3	Neutron yield from the target (U/W), n/sec	$3.28 \cdot 10^{14}/1.91 \cdot 10^{14}$
4	Target material	U^{238} / W
5	Fuel U^{235} enrichment, w/o	$\leqslant$ 20
6	Total neutron flux density in the fuel region, n/cm^2 sec	~ $2.4 \cdot 10^{13}$
7	Total neutron flux density in the reflector region, n/cm^2 sec	~ $2 \cdot 10^{13}$
8	Maximum fast neutron flux density in the fuel region with E > 0.1 MeV, n/cm^2 sec	~$1.3 \cdot 10^{13}$
9	Moderator	H_2O
10	Reflector material, Reflector material density, g/cm^3	carbon 2.3
11	Total power deposition in the fuel element region, kW	~ 230
12	Maximum power deposition in the reflector, kW	~ 20
13	Maximum power deposition in the sub-critical assembly, kW	~350

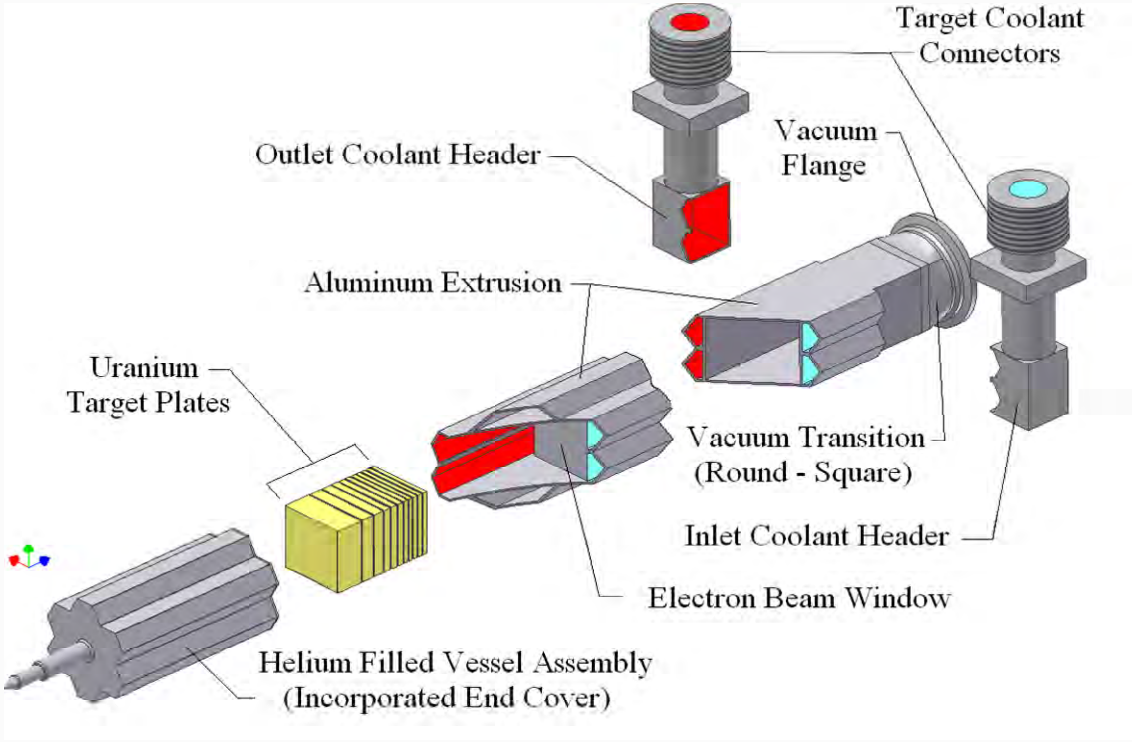
Neutron Generating Target







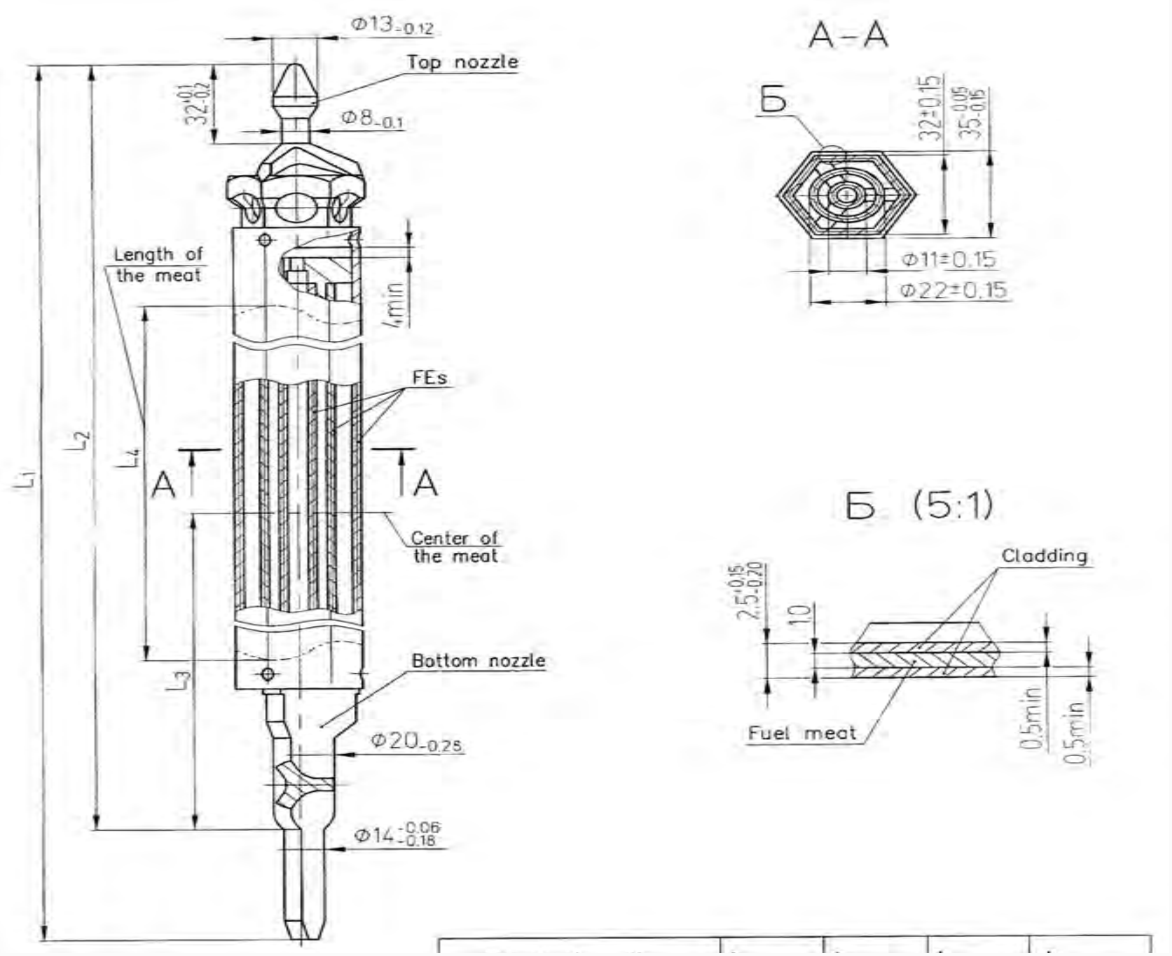
Neutron Generating Target



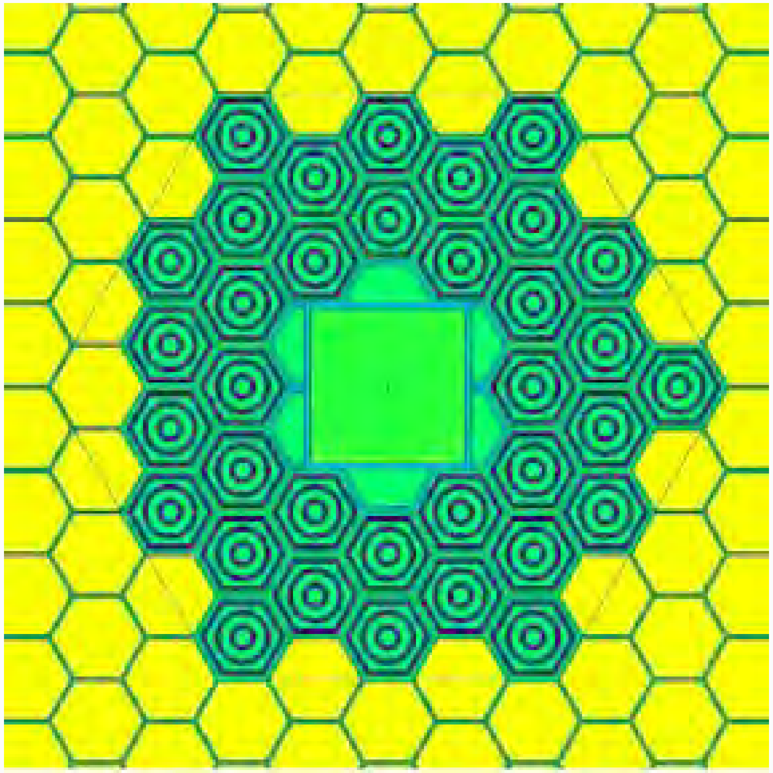
Target assembly

Fuel

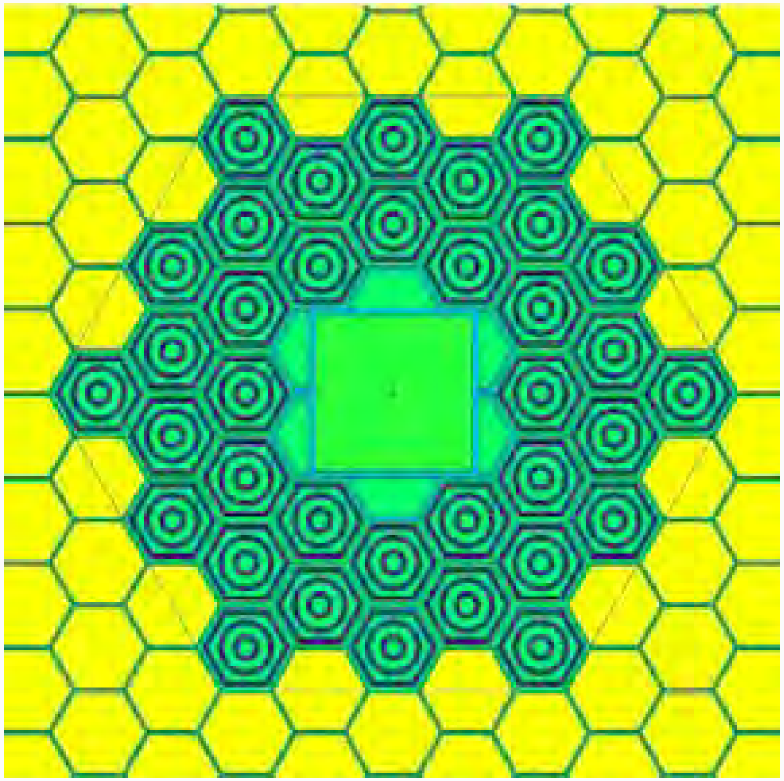
A three-section WWR-M2 fuel assembly has been selected as reference design of the sub-critical fuel assembly (FA). The FA consists of three concentrically located tubular fuel rods. The outer fuel rod is a hexagonal tube and the two inner rods are round tubes. The load-carrying component of the FA is the outer fuel rod connected to the FA top and bottom nozzles by crimping and welding. On top of the FA top nozzle there is a protruding part designed for gripping the FA during its fueling and refueling. The lowermost part of the FA bottom nozzle has a guide and support element for directing the FA and its installing in the sub-critical assembly support grid-plate. The inner fuel rods have freedom of axial movement in response to changes in length within the available axial clearance. FAs are separated by spacing elements on the end fittings.



Sub-Critical Assembly

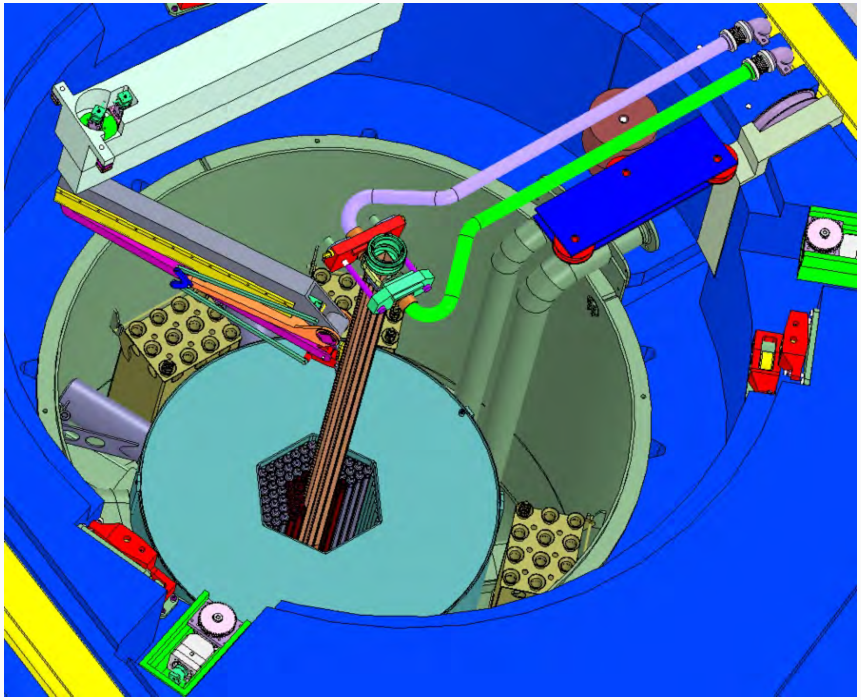


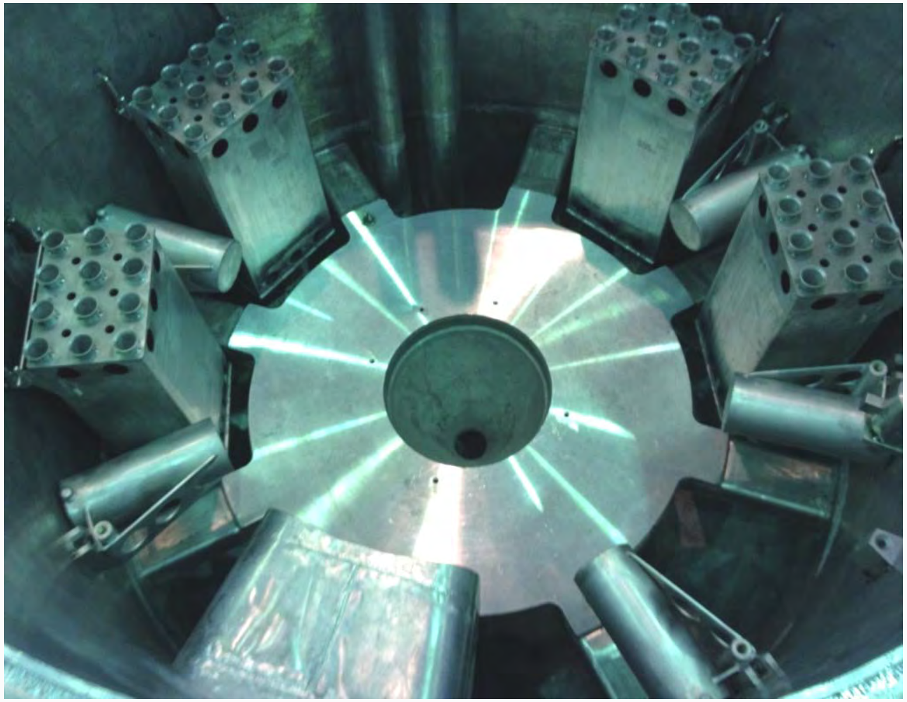
35 fuel assemblies



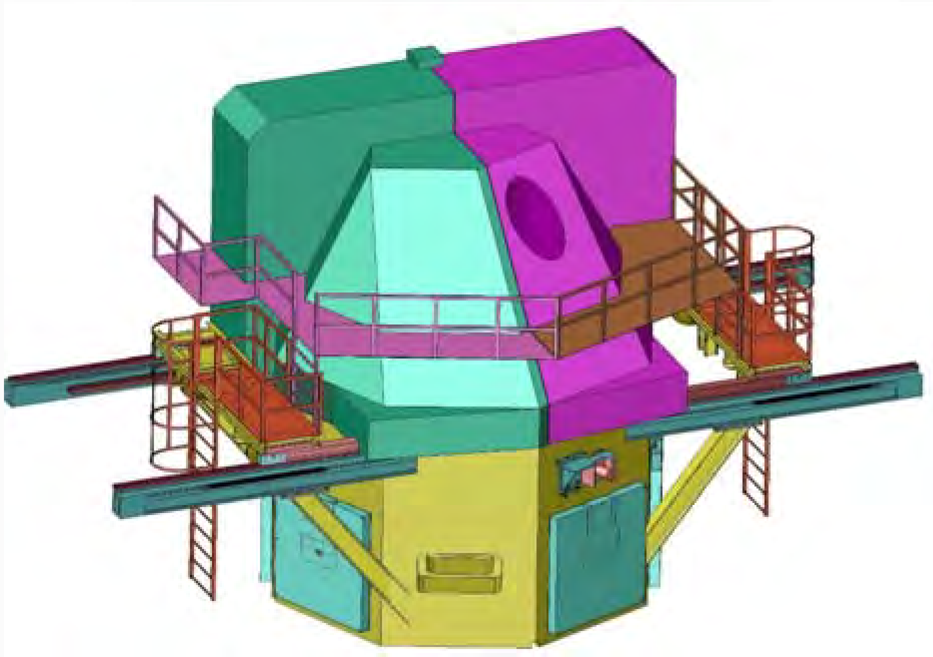
36 fuel assemblies

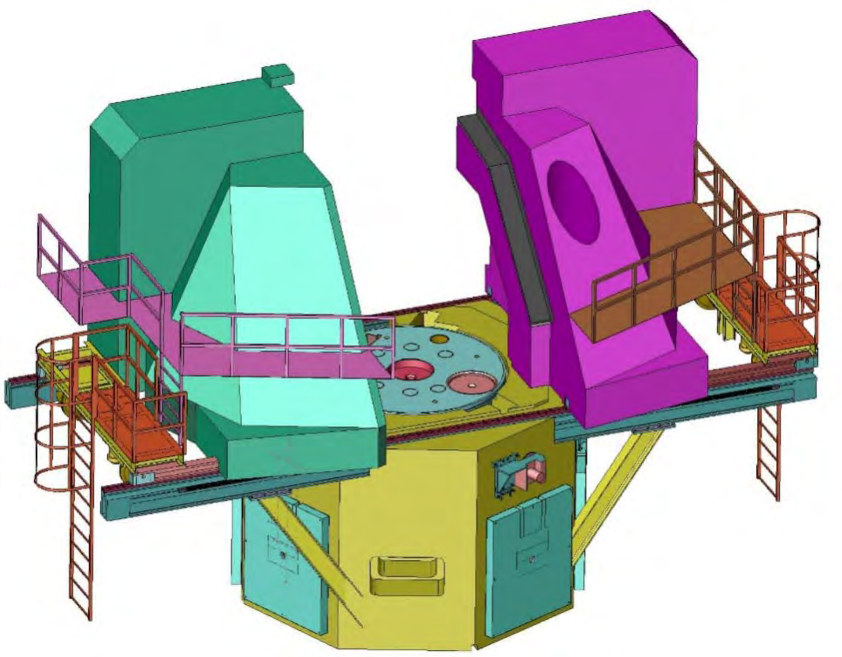
Sub-Critical Assembly



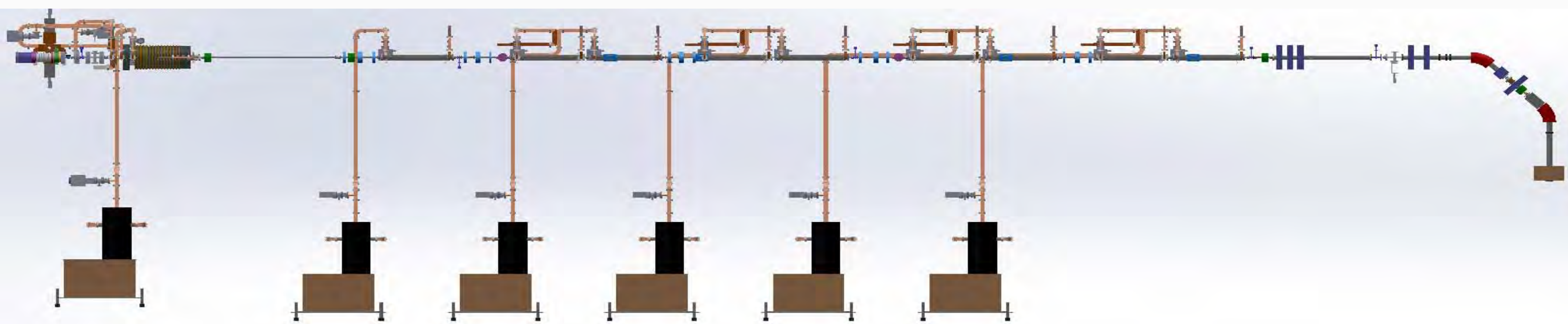


Radiation Shielding





Accelerator



Status

Building

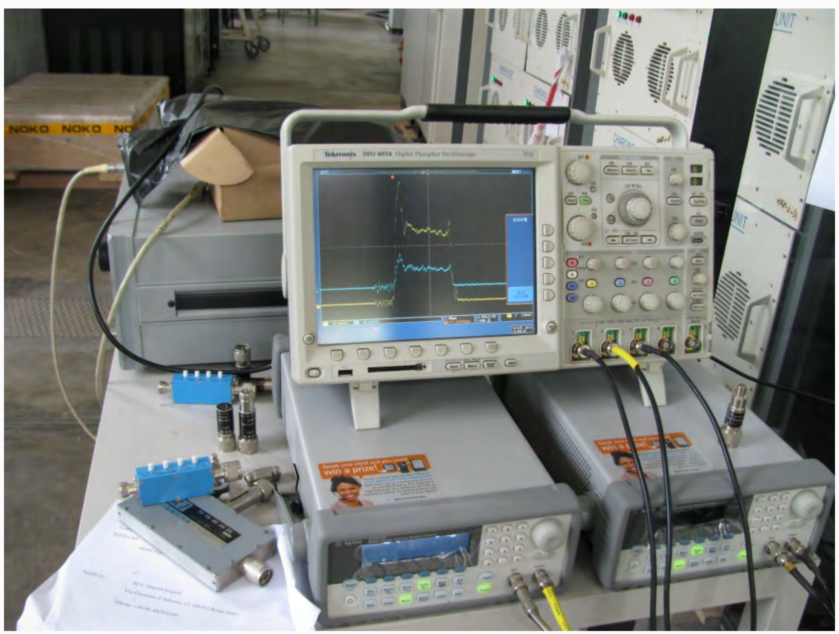
Status

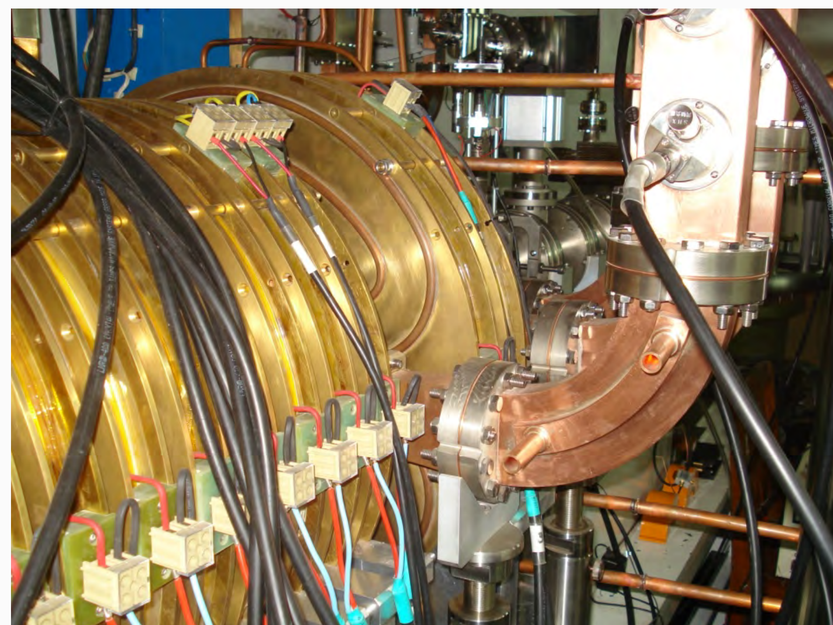
Cooling systems

Status
Accelerator

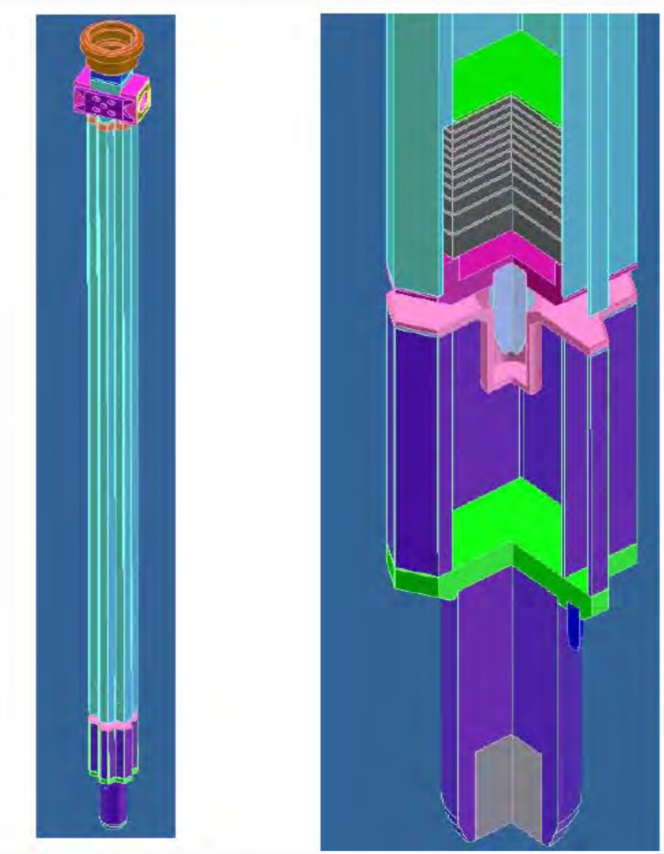
Injector test – 15.04.2012 – 15.12.2012

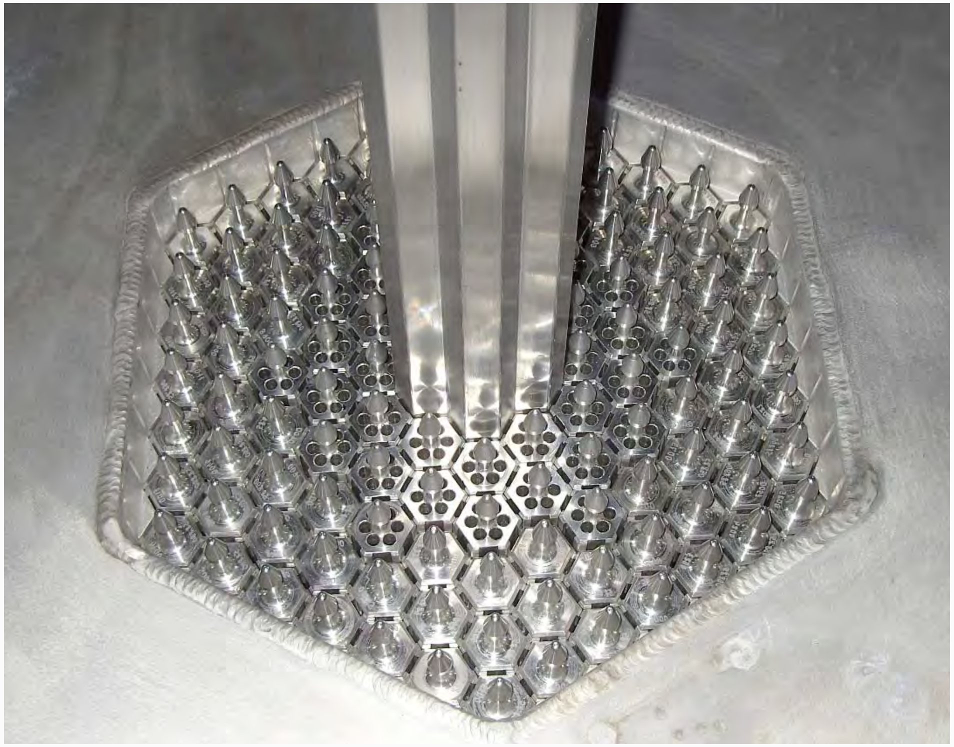
- Start of delivery – 15.03.2013
- Delivery – 28.06.2013
- Assembling 10.06.2013 – 15.q1.2014
- Test and commissioning – 15.11.2014



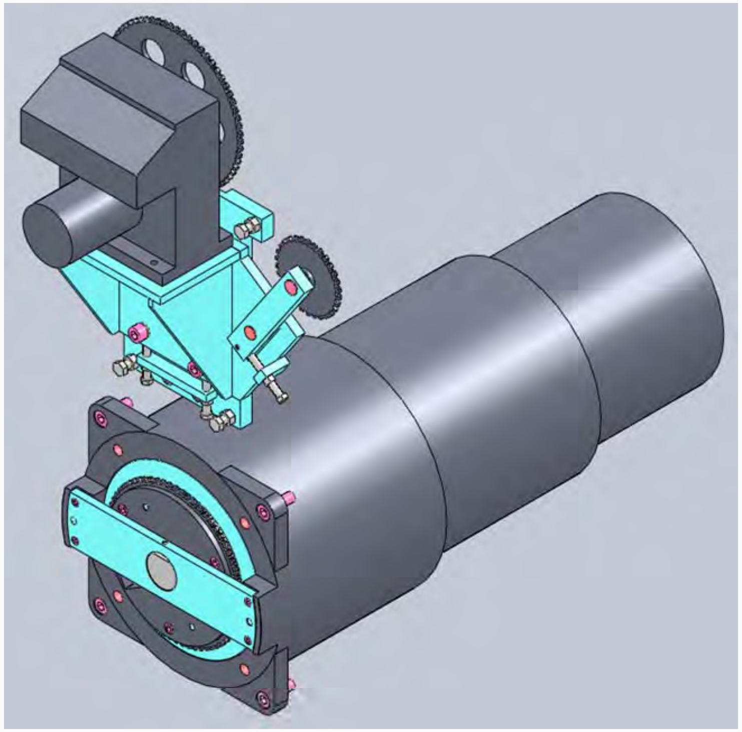


Status
Target

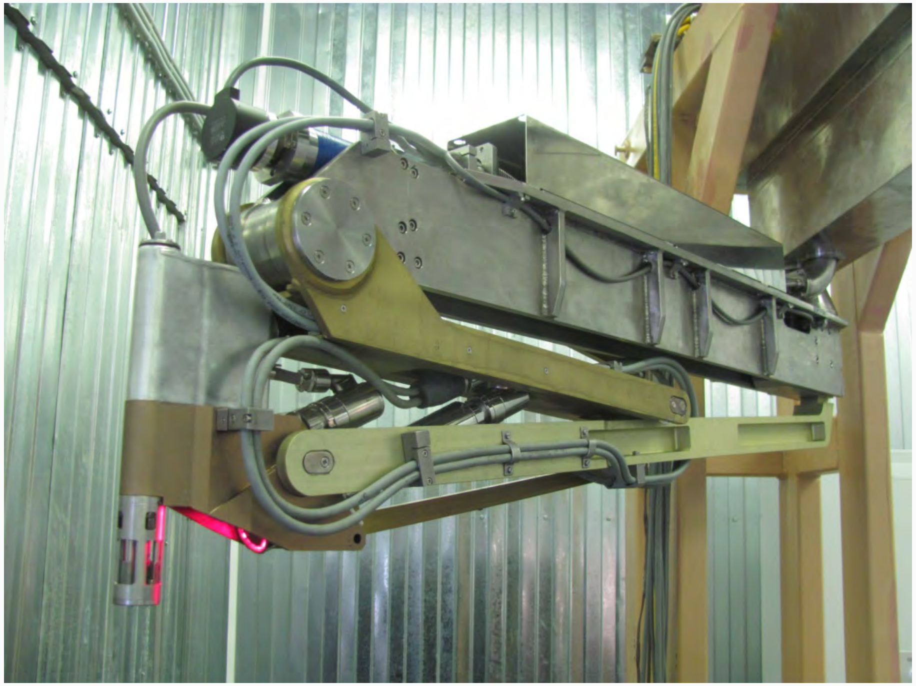


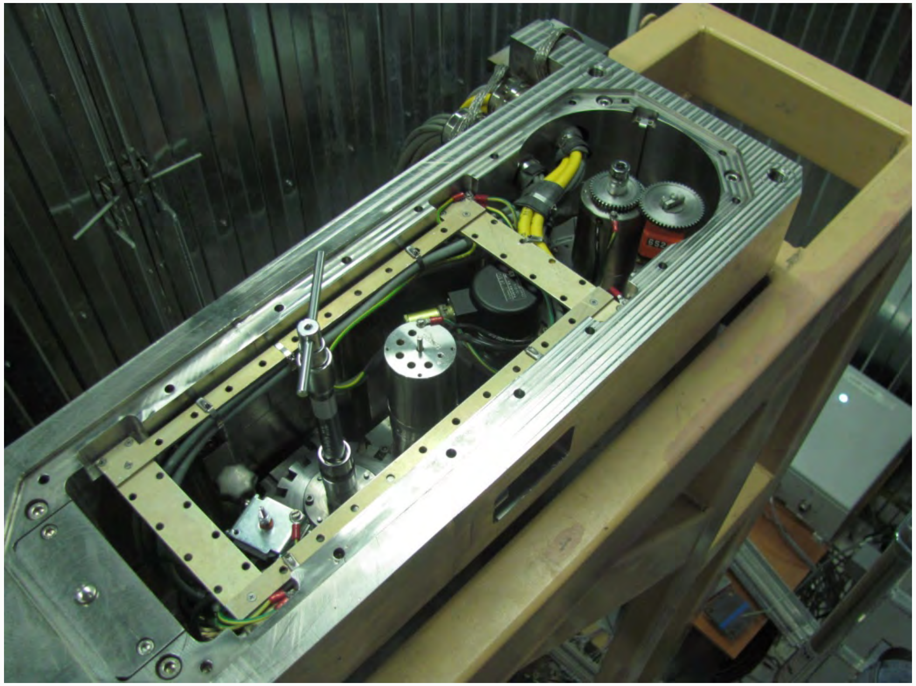


Status
Biological Shielding

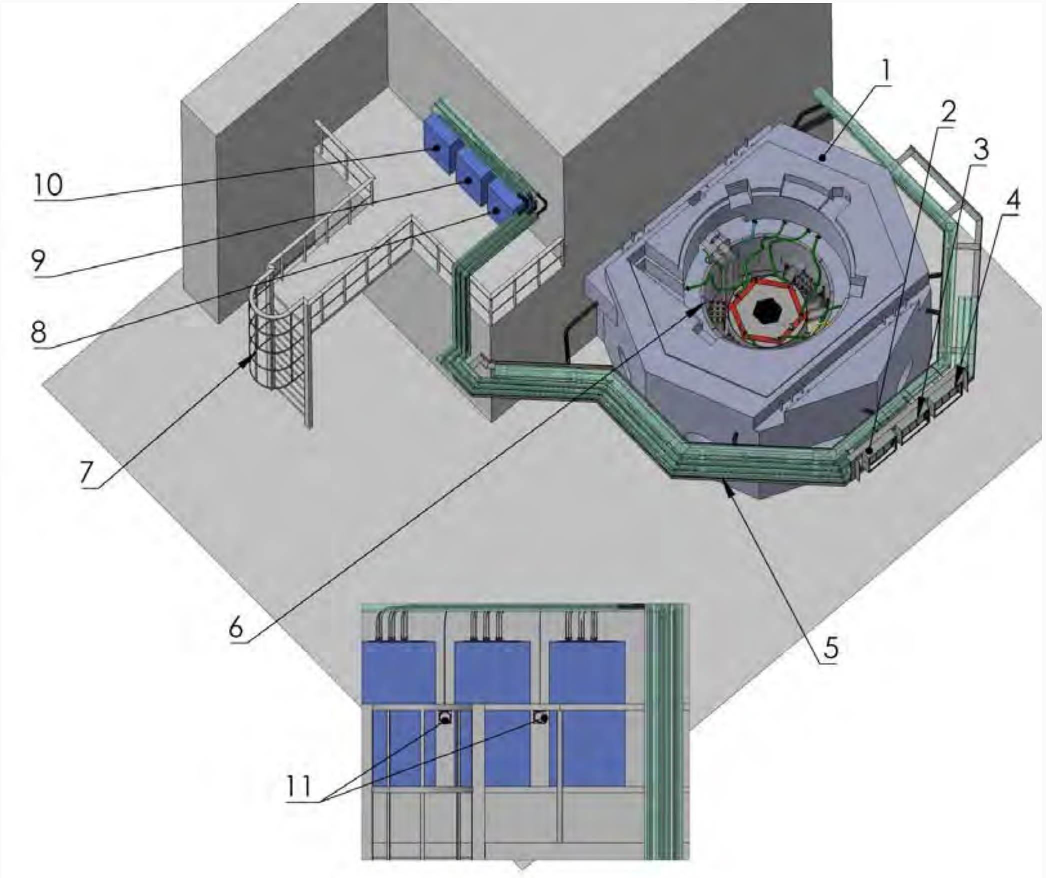


Status
Fuel Machine



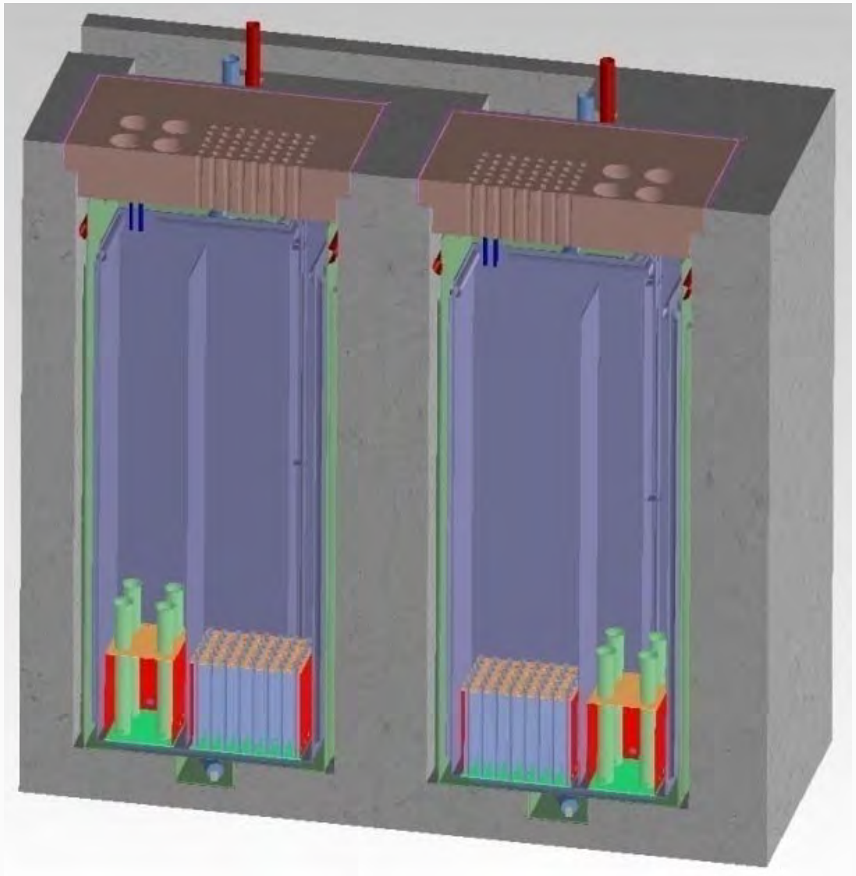


Status
Neutron Flux and Criticality measurement system

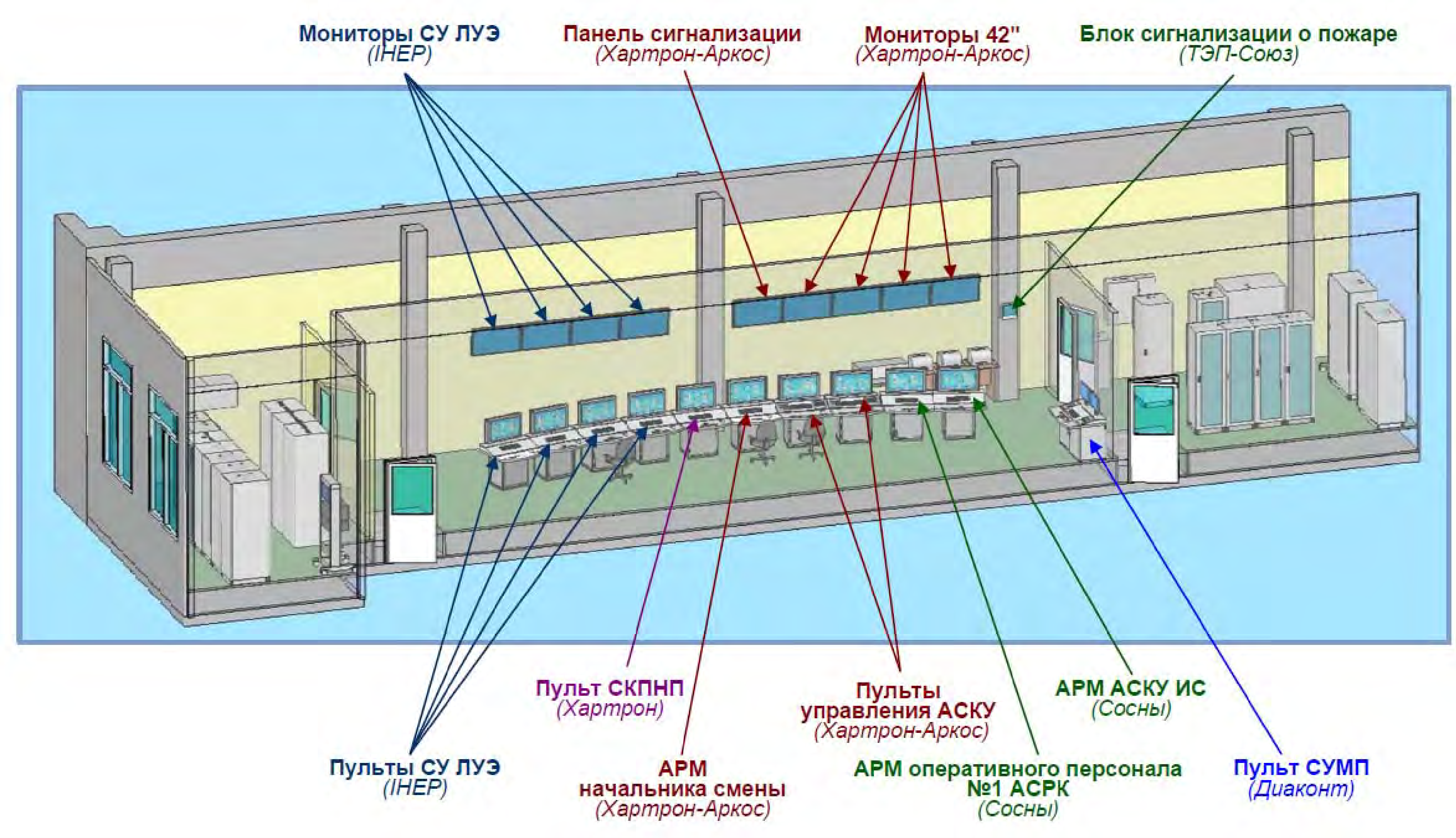


3D model of the NSC KIPT Neutron Source neutron flux measurement system equipment layout: 1 is bio shielding with neutron sensors, 2-4 are control cabinets, 5 are cable lines, 6 is SCA tank with neutron sensors, 7 is ladder, 8-10 are measuring cabinets, 11 is commutation boxes.

Status
Storage Pools

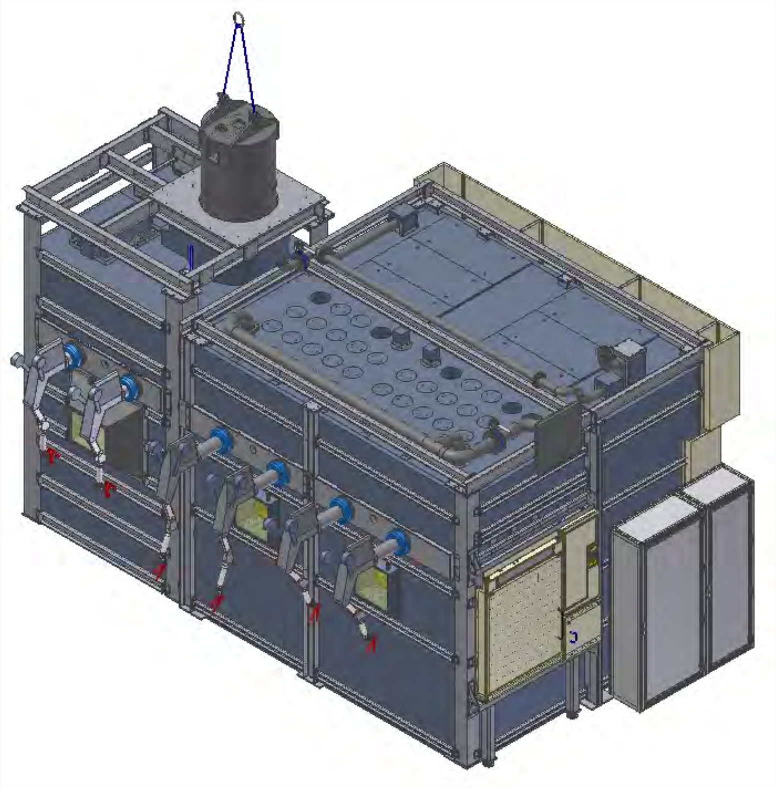


Status
Control system

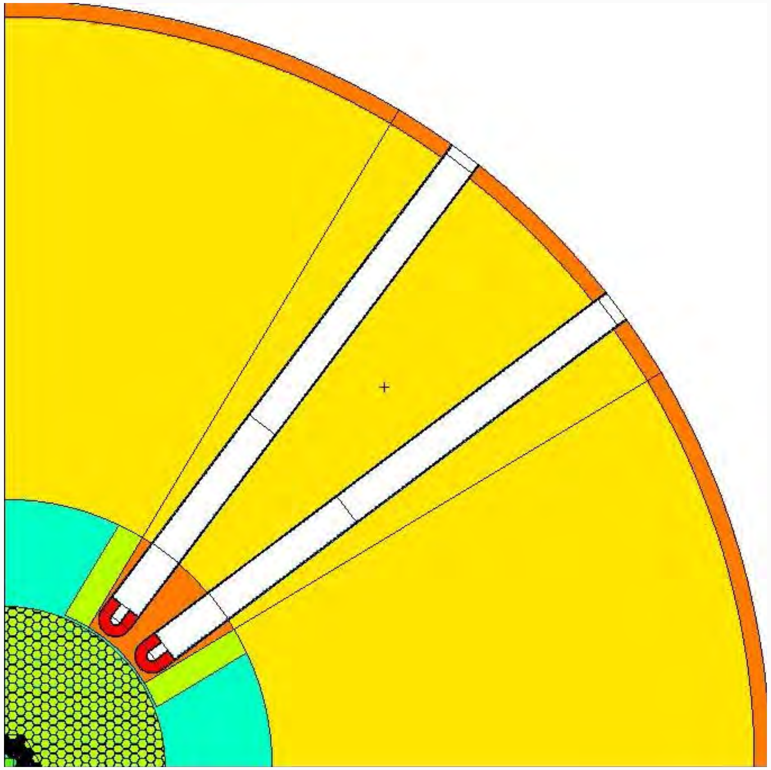


Status
Control system

Status
Hot cells



Status
Cold Neutron Channel



Neutron source configuration with two moderator bulbs and two cold neutron source channels

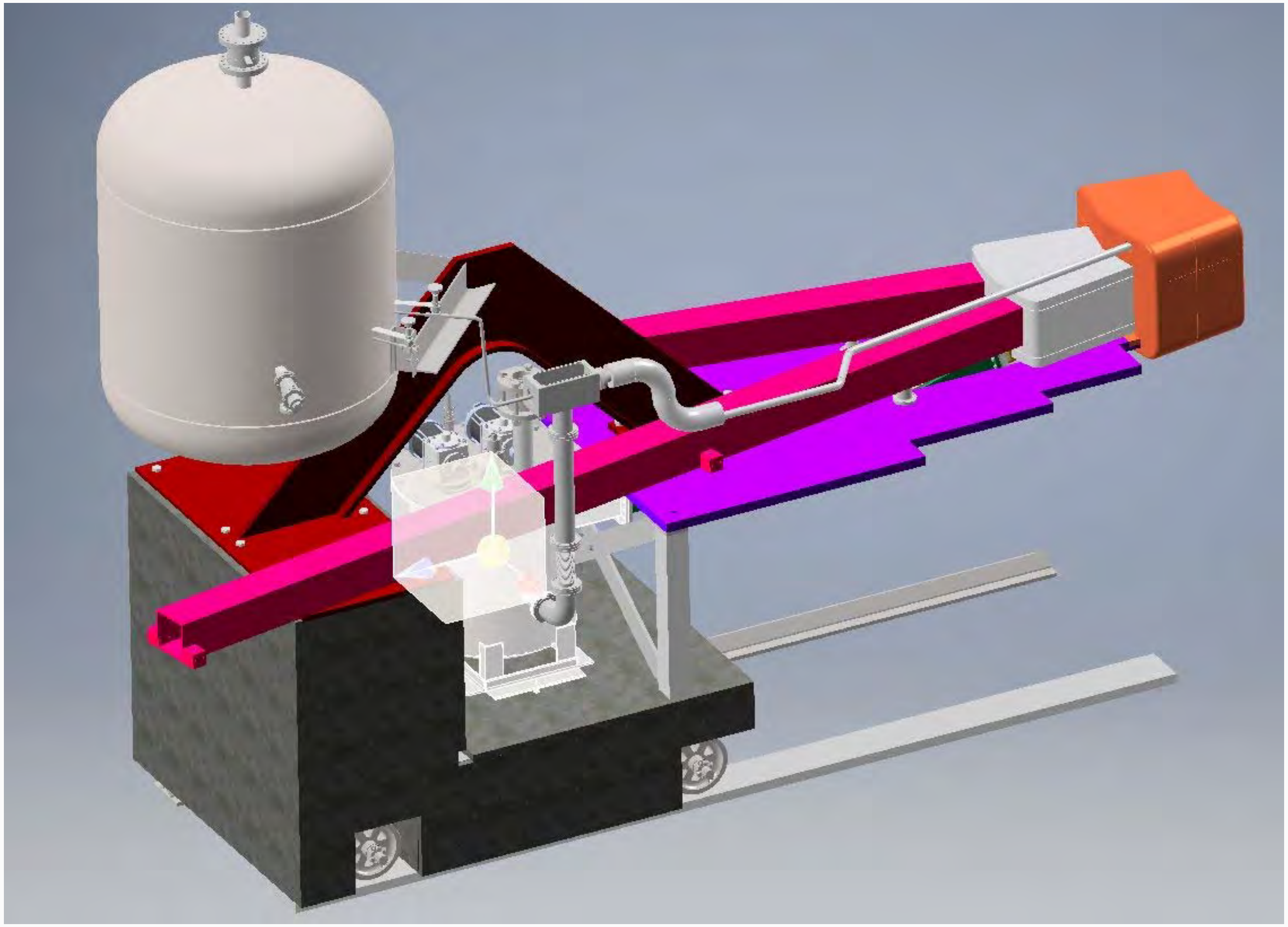
$F(E, \Omega) = 1.80588 \times 10^5$ n/(s $\cdot$cm^2),
for $0 < E < 1$ MeV

$B = 1.44 \times 10^8$ n/cm^2-s-MeV-ster

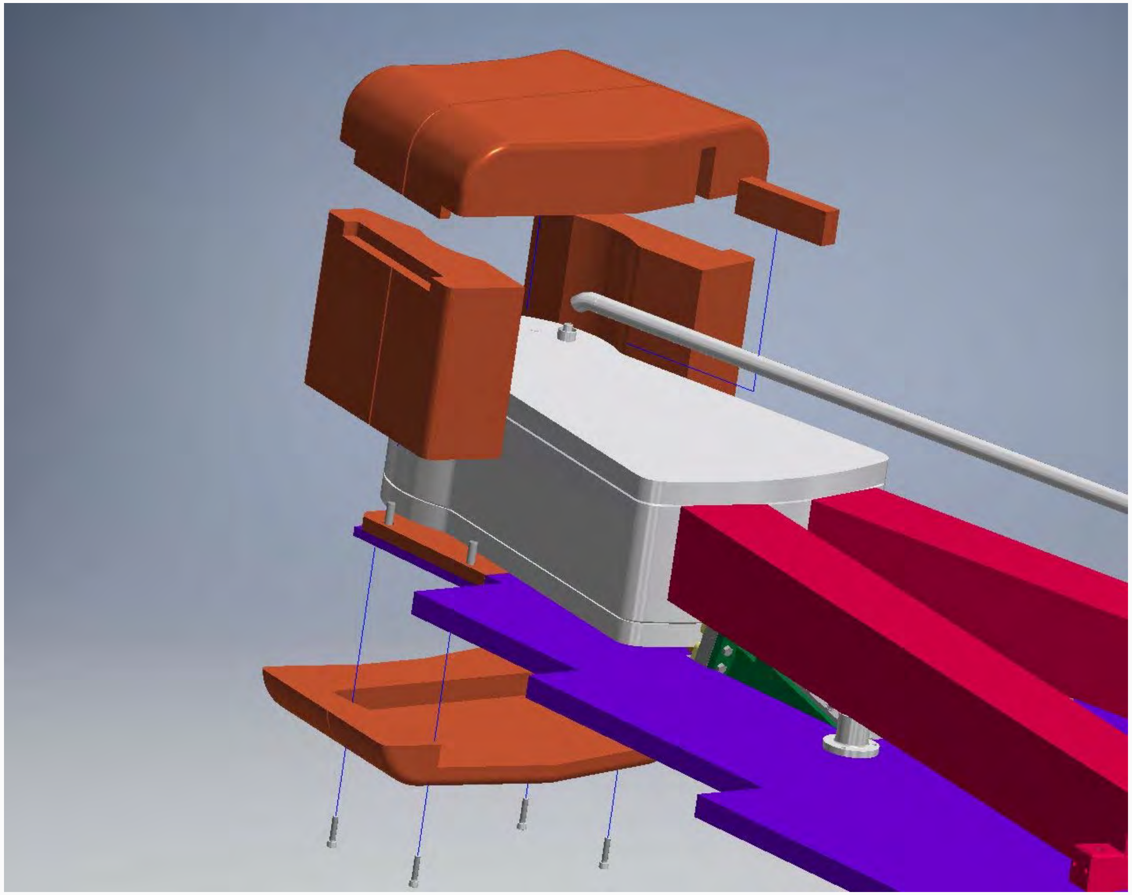
The outer radius of the half sphere cold moderator is 6.2 cm, and the para-LH2 moderator is selected with thickness of 3.6 cm.
The lead shield thickness is 5 cm is front of the CNS

Status

Cold Neutron Channel



Status
Cold Neutron Channel



THANK YOU !