Transport system for large objects at Ljubljana JSI TRIGA reactor

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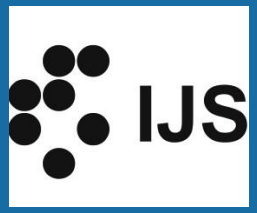
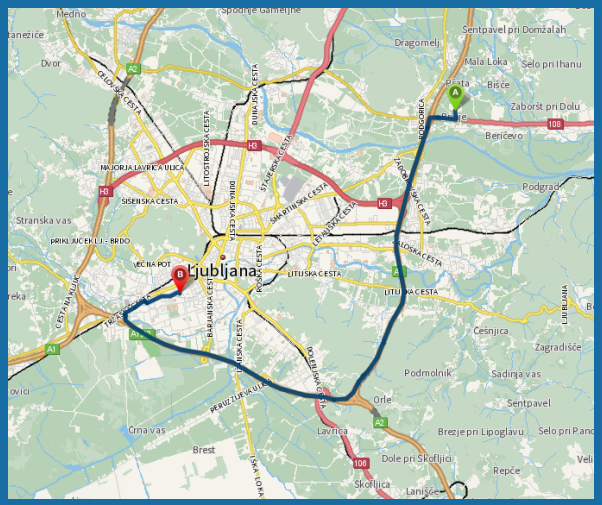
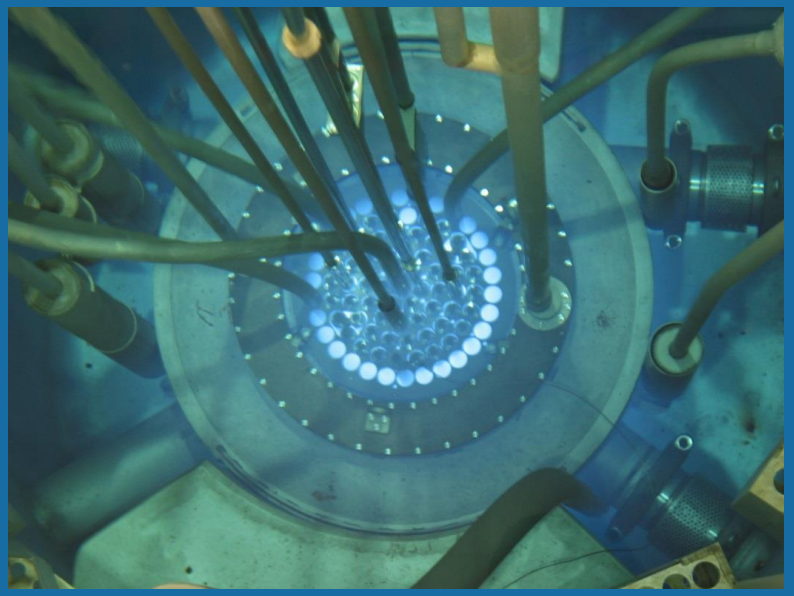


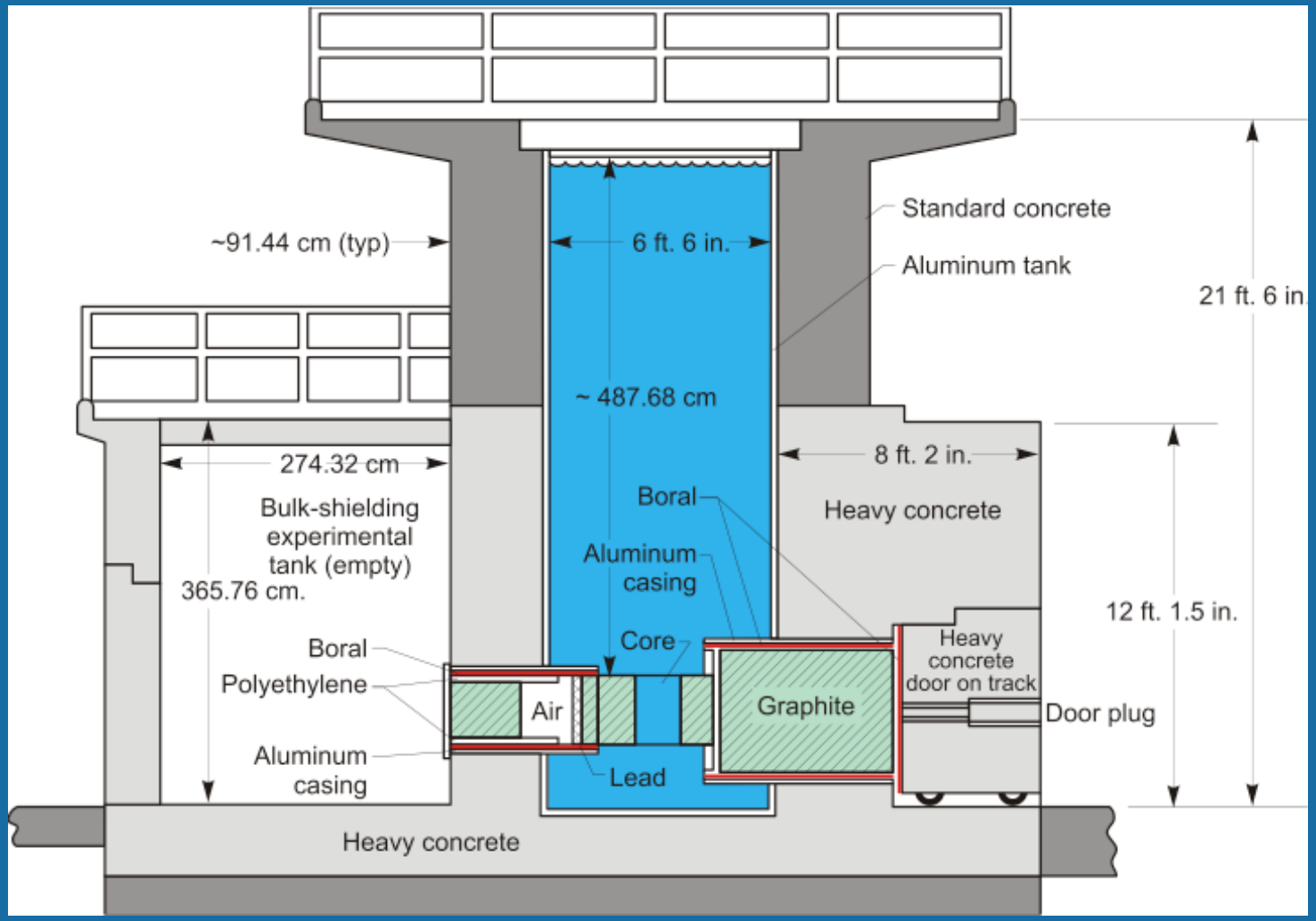
TRIGA MarkII Reactor

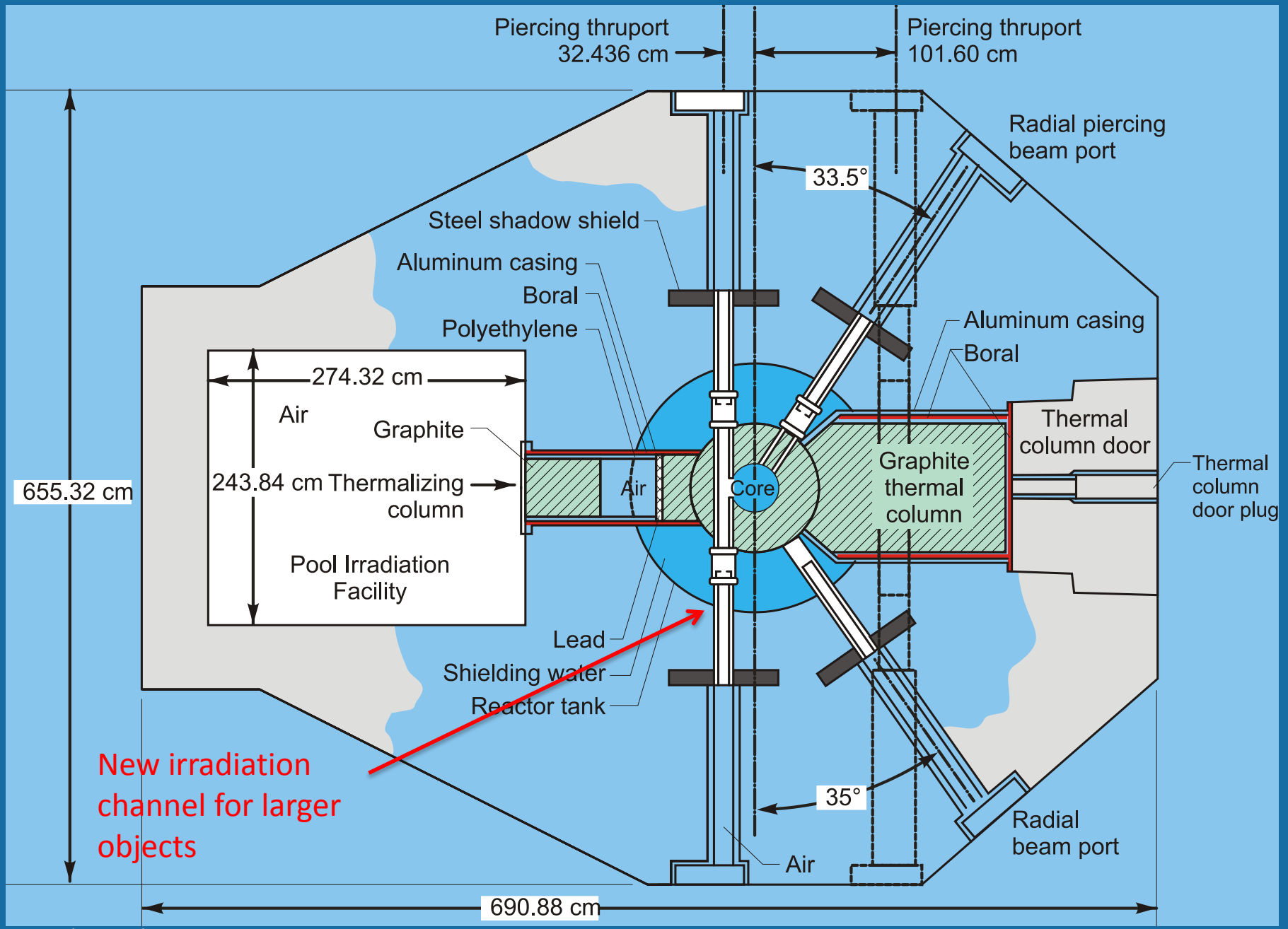


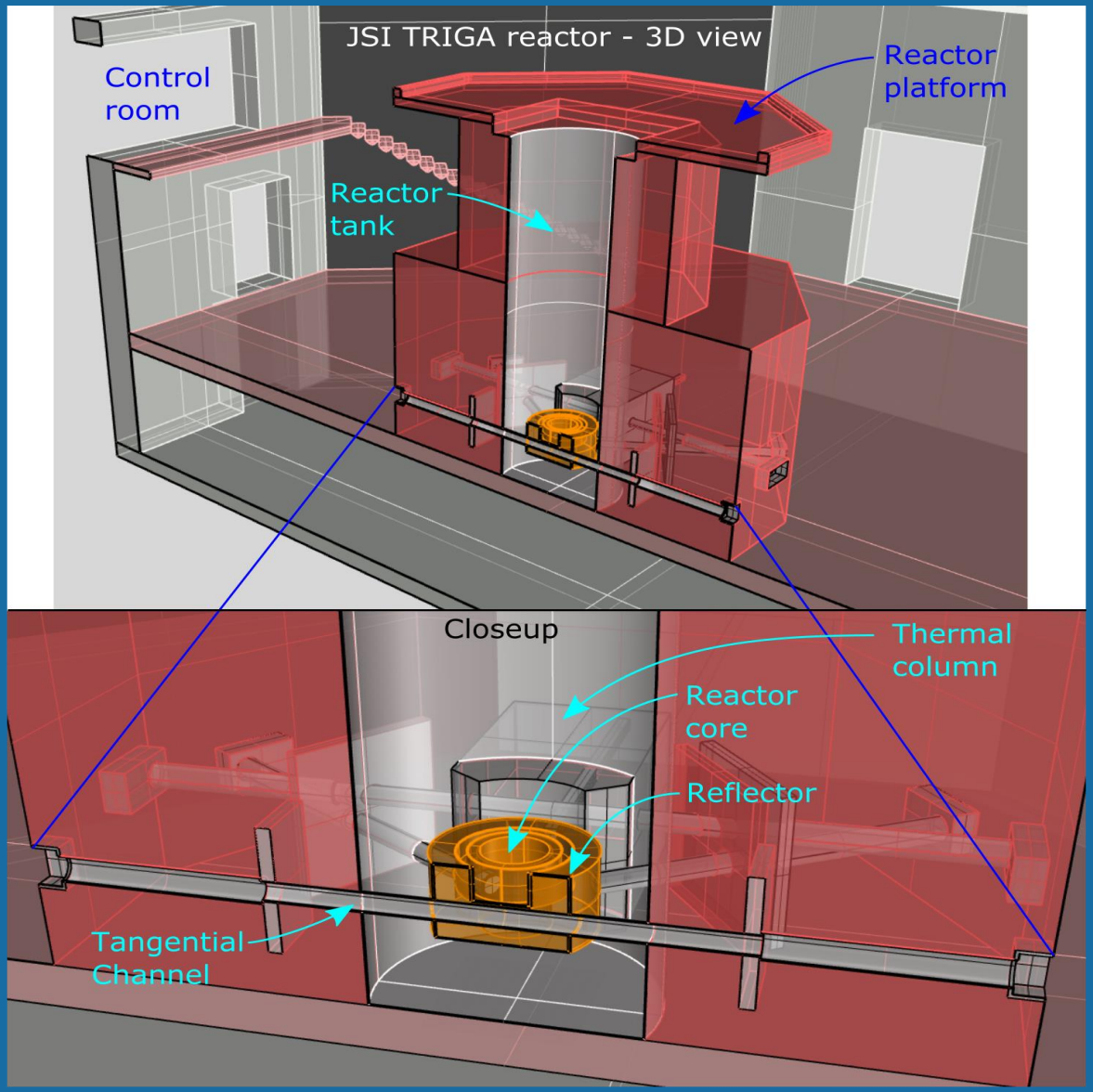
- started operation 1966, built by General Electrics
- reconstructed and equipped for pulse operation in 1991
- infrastructure center established and financed by the Ministry of Higher Education, Science and technology and managed by Jožef Stefan Institute
- light water pool reactor cooled by natural convection
- power (and flux) variable from 1 W to 250 kW
- in pulse mode power peaks at 1800 MW, energy of pulse 23 MWs



- vertical channels with access directly into the core
- F19 (small) – cylindrical containers with 24 mm or 19 mm internal diameter and 110 mm length
- access to samples with 7 – 8 m cables possible
- 1 MEV NIEL flux up to 1.54 10^{12} ncm^{-2} measured with bulk damage current in Si diode
- TID ≈ 1 kGy at 10^{14} $n_{eq}cm^{-2}$
- "large" channel with quasi elliptical shape ≈ 7.5 cm x 4.5 cm
- no standard containers
- 1 MEV NIEL flux up to 3.6 10^{12} ncm^{-2}
- Irradiations up to several 10^{17} ncm^{-2} are possible

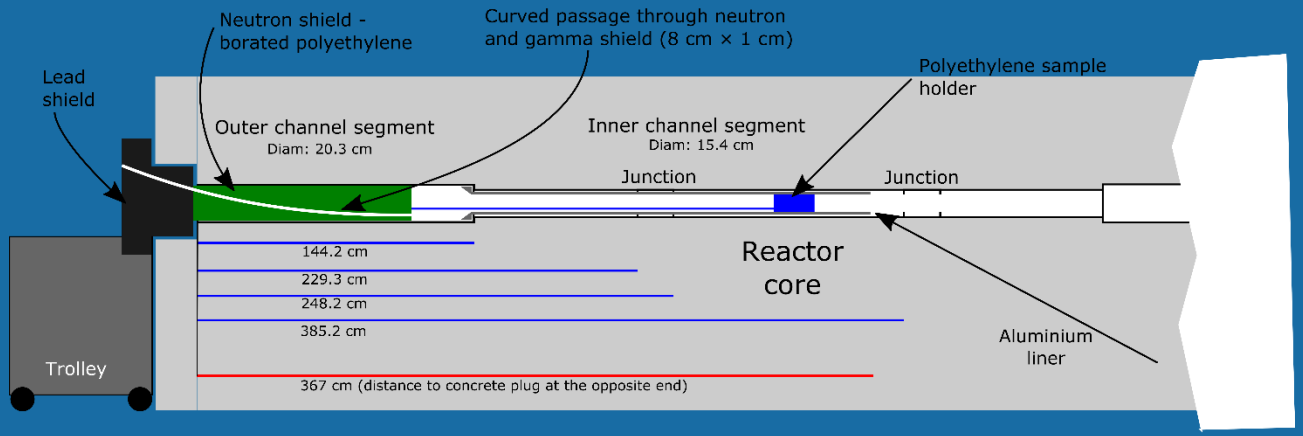

~91.44 cm (typ)
6 ft. 6 in.
Standard concrete
Aluminum tank
21 ft. 6 in.
~ 487.68 cm
274.32 cm
8 ft. 2 in.
Boral
Heavy concrete
Bulk-shielding
experimental
tank (empty)
365.76 cm.
Aluminum
casing
12 ft. 1.5 in.
Core
Heavy
concrete
door on track
Boral
Polyethylene
Air
Graphite
Door plug
Aluminum
casing
Lead
Heavy concrete

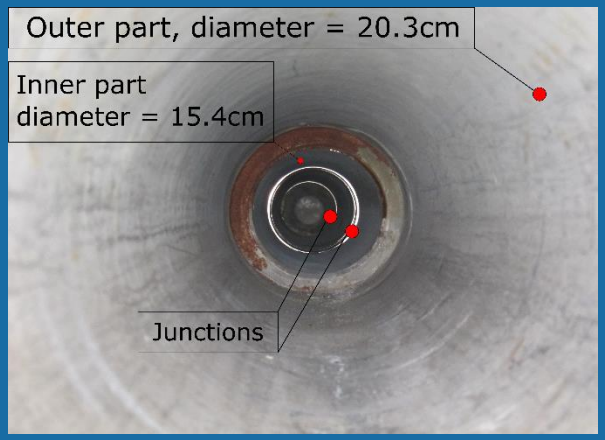

Piercing thruport
32.436 cm
Piercing thruport
101.60 cm
Radial piercing
beam port
33.5°
Steel shadow shield
Aluminum casing
Boral
Polyethylene
Aluminum casing
Boral
274.32 cm
Air
Graphite
655.32 cm
243.84 cm Thermalizing
column
Pool Irradiation
Facility
Air
Core
Graphite
thermal
column
Thermal
column door
Thermal
column
door plug
Lead
Shielding water
Reactor tank
New irradiation
channel for larger
objects
35°
Radial
beam port
Air
690.88 cm


JSI TRIGA reactor - 3D view
Control room
Reactor platform
Reactor tank
Closeup
Thermal column
Reactor core
Reflector
Tangential Channel

- extraction of cold neutron source used in the past for neutron diffractometry
- decontamination and inspection of channel interior
- documentation needed to obtain the authorization for the installation of the irradiation device from TRIGA reactor Safety Committee and Slovenian Nuclear Safety Administration
- authorization granted in August 2016
- channel completed in October 2016

TRIGA reactor Tangential channel fitted with irradiation device

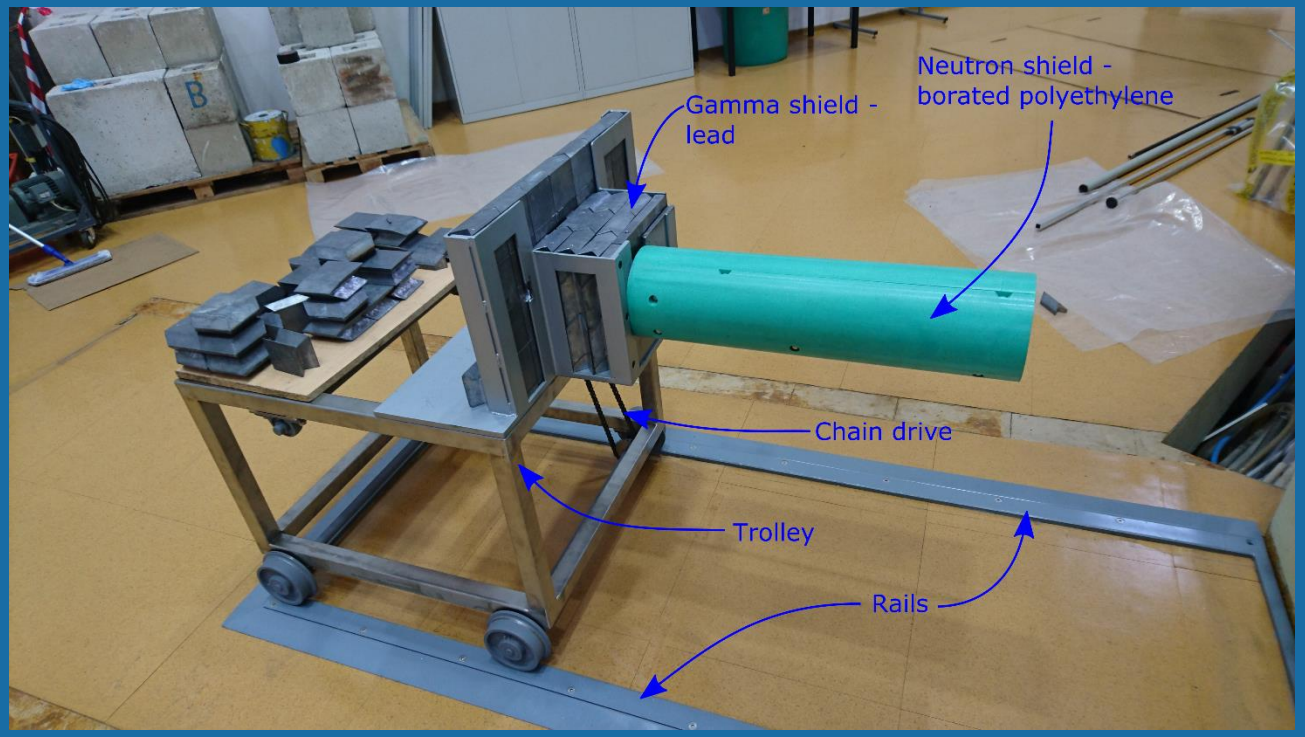


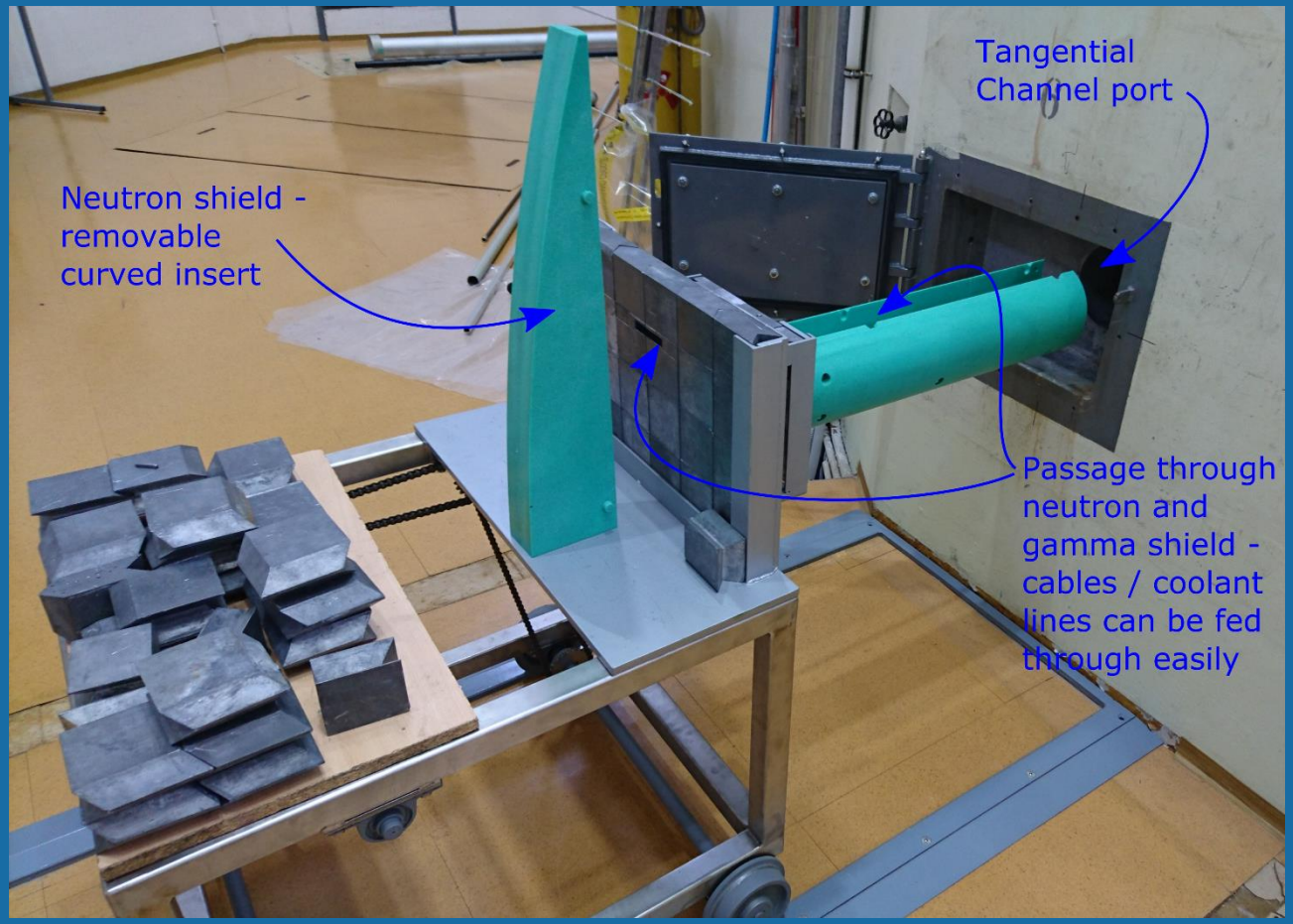


- aluminum liner with inside diameter 14.6 cm
- protection of internal components
- facilitates insertion and withdrawal of samples

- sample support structure made from PE100 material
- support for sample should be custom made!
- allows routing of cables to the sample

- neutron shield made from borated polyethulene
- gamma dose rate at the surface of Pb ≈ mSv/h
- concrete bricks

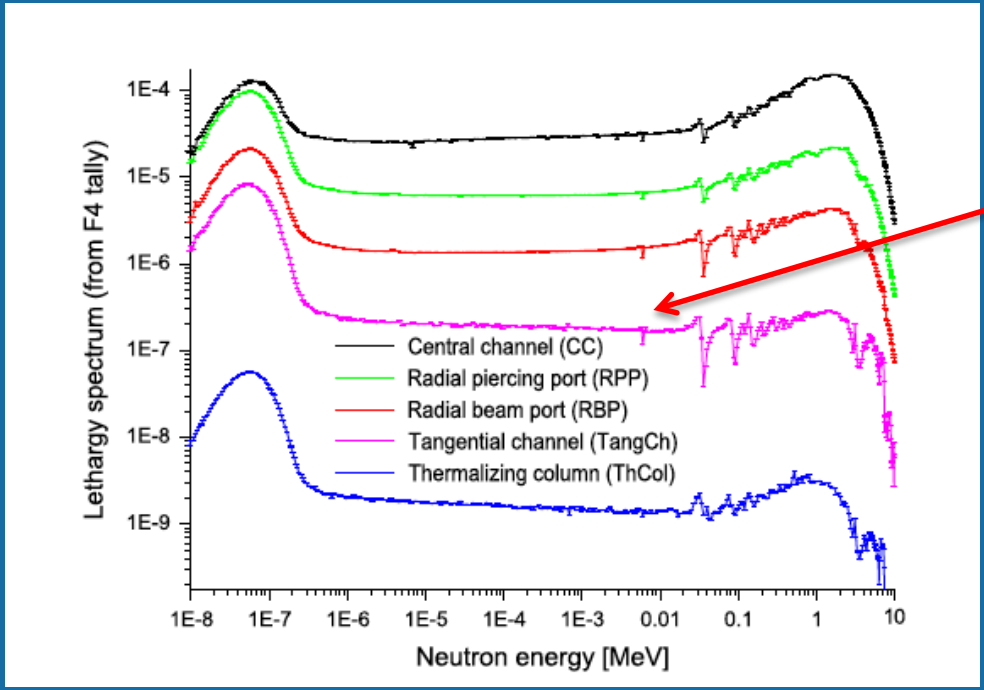



Tangential
Channel port
Neutron shield -
removable
curved insert
Passage through
neutron and
gamma shield -
cables / coolant
lines can be fed
through easily


POZOR SEVANJE
BP
BP
BP
B
B
B

Neutron fluxes and spectra

- computational analysis with MCNP code (X-5 Monte Carlo Team 2004)
- published in L. Snoj et al. (Applied radiation and Isotopes 70 (2012) 483-488



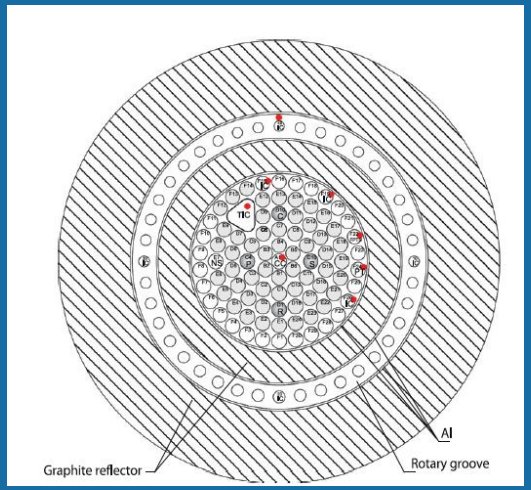
Tangential channel

- Thermal neutrons <0.625 eV
- Epithermal neutrons 0.625 eV – 0.1 MeV
- Fast netrons > 0.1 MeV

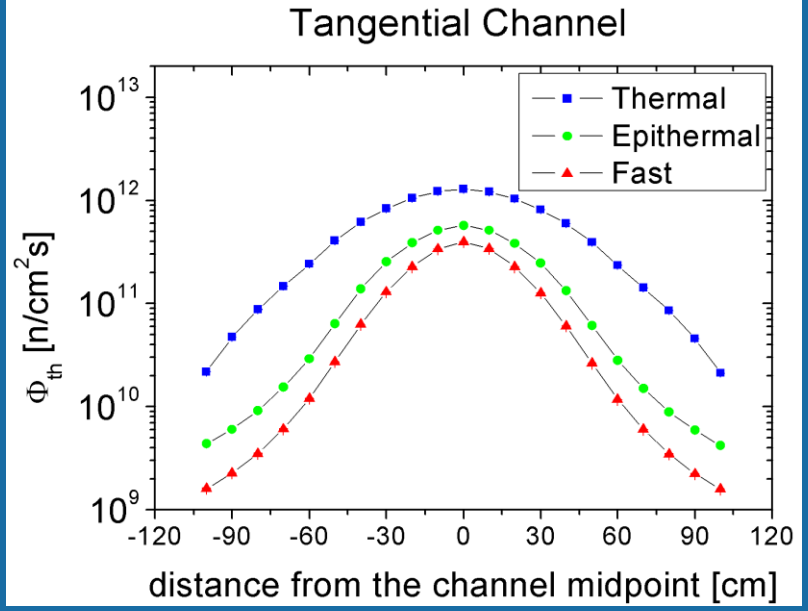
computation

	$\Phi_{th}(10^{12}cm^{-2}s^{-1})$	$\Phi_{epi}(10^{12}cm^{-2}s^{-1})$	$\Phi_{fast}(10^{12}cm^{-2}s^{-1})$	$\Phi_{tot}(10^{12}cm^{-2}s^{-1})$
small channel (F19)	3.66	1.86	1.81	7.32
large channel (TIC)	4.46	3.45	3.85	11.7
Tang. Ch.	0.75	0.33	0.23	1.31

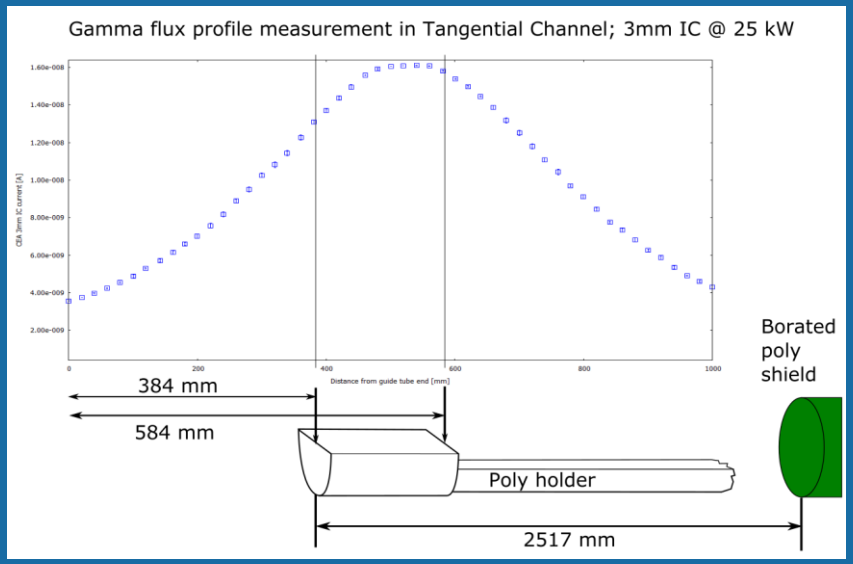
Agreement with measurement in small channel within 10 %

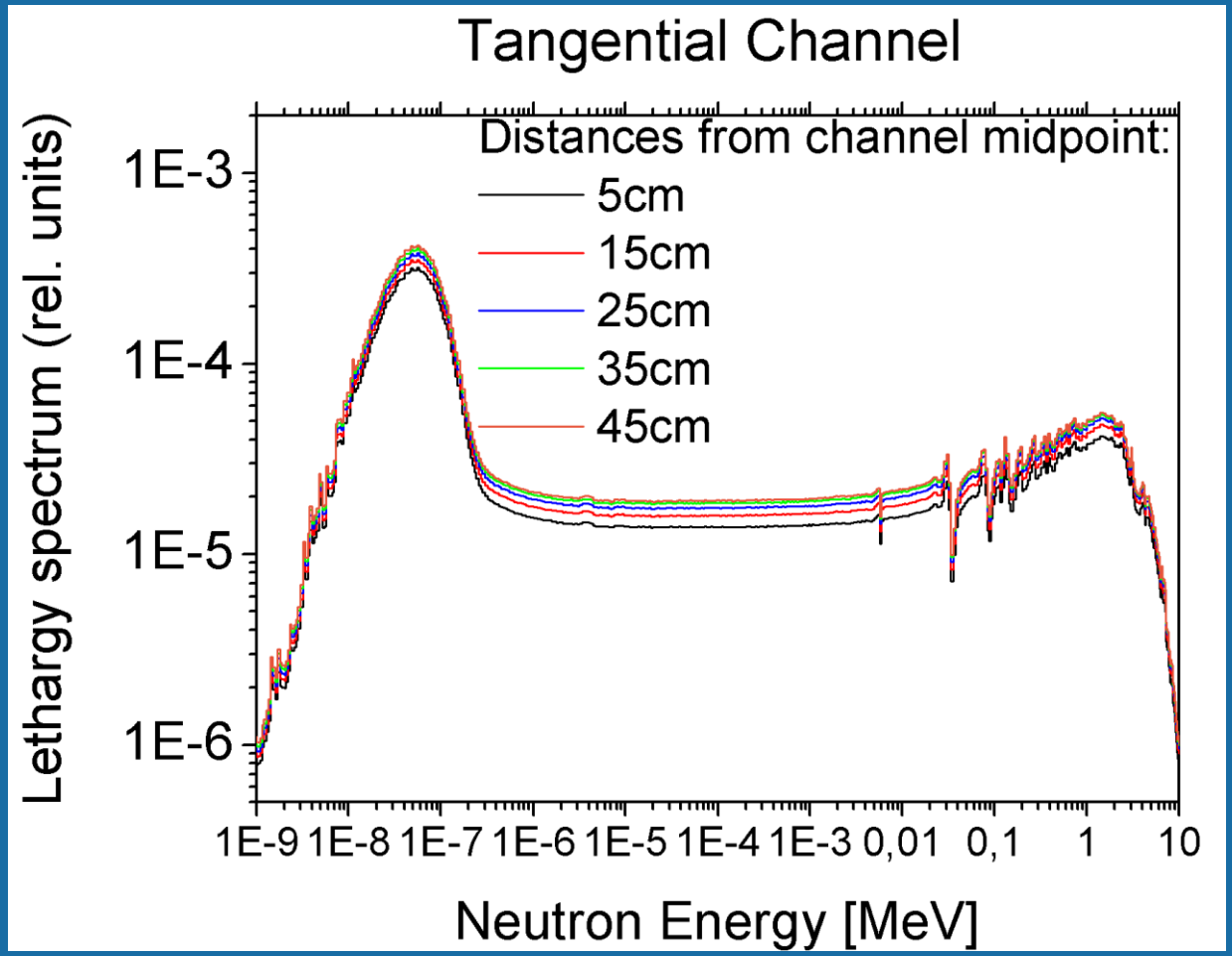


- calculated neutron fluxes



- measured gamma flux profile
- dose rate several 10 kGy/h (very preliminary!!)




Tangential Channel
Distances from channel midpoint:
5cm
15cm
25cm
35cm
45cm
Lethargy spectrum (rel. units)
1E-3
1E-4
1E-5
1E-6
1E-9 1E-8 1E-7 1E-6 1E-5 1E-4 1E-3 0,01 0,1 1 10
Neutron Energy [MeV]

Plans and conclusion

- measurement of 1 MeV NIEL fux in preparation
- new facility will allow irradiation of 12 x 20 cm samples
- 10^{15} n cm^{-2} (fast) in approx. 1.5 h
- ready to receive samples!