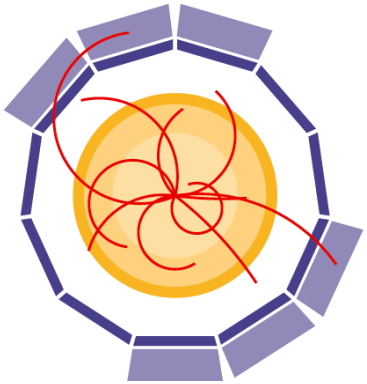

AIDA 2020

Transport System for Large objects at Ljubljana JSI TRIGA Reactor

(part of WP15.5)

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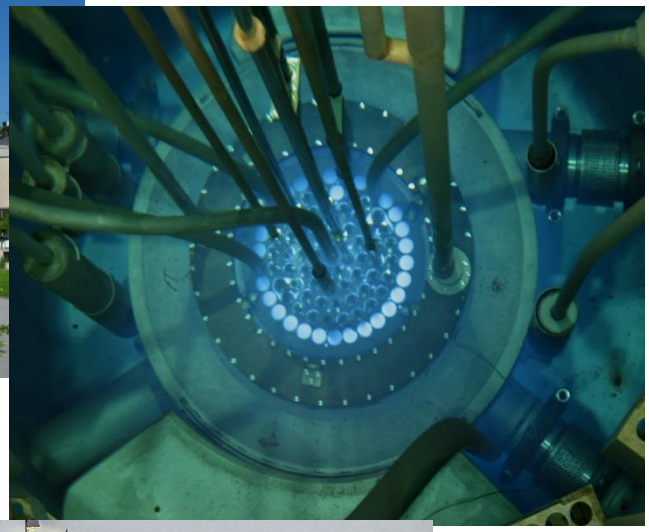
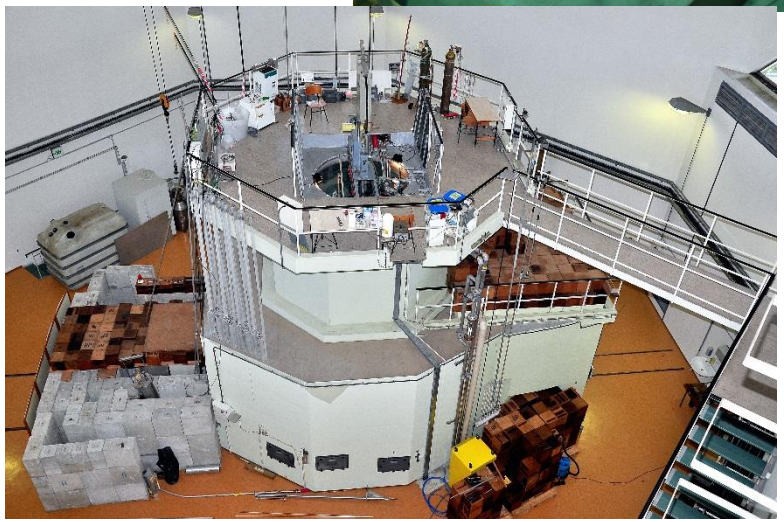
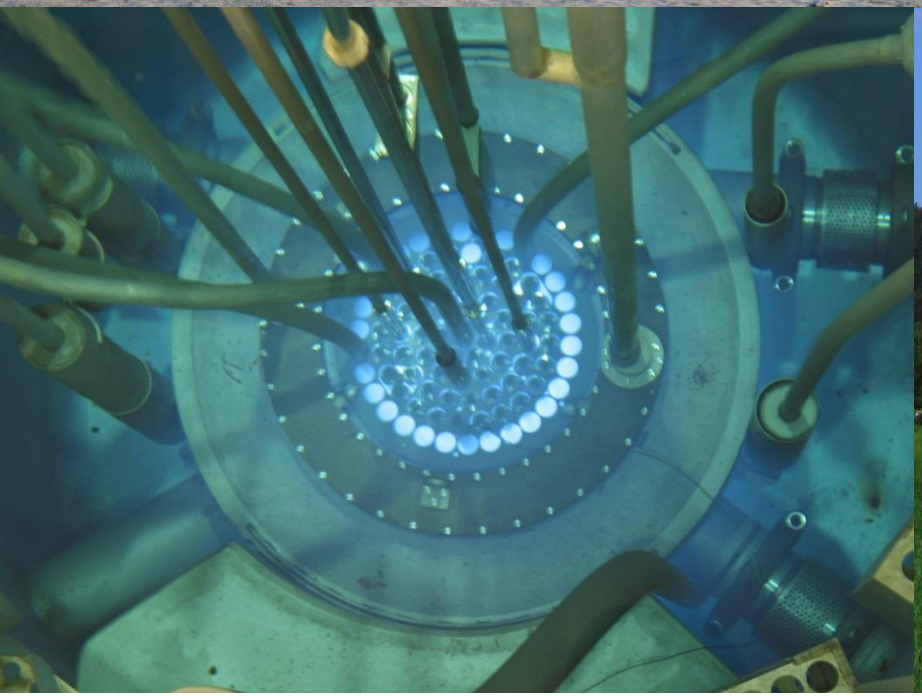
AIDA2020 2nd Annual Meeting, Paris, April 4, 2017

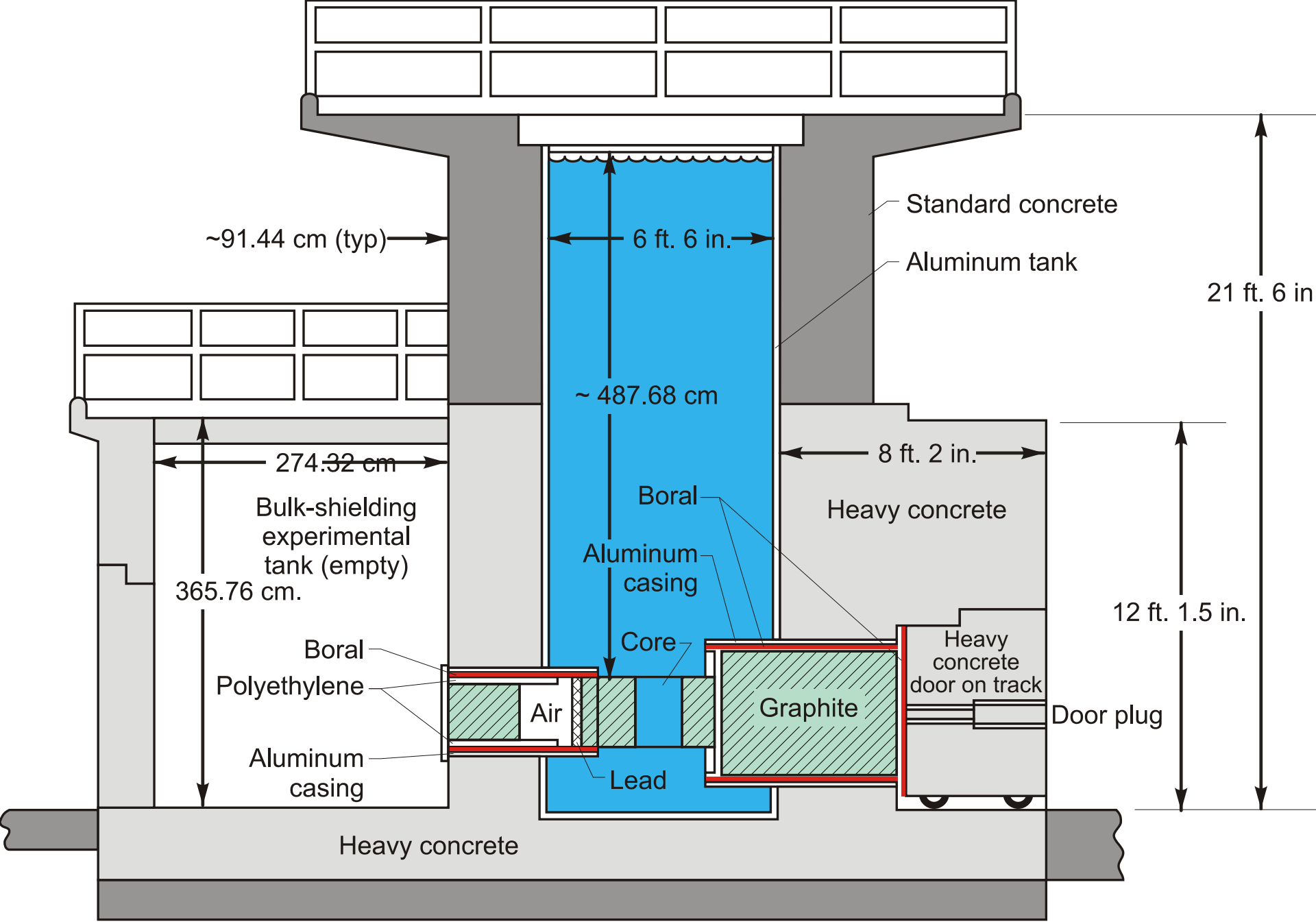
TRIGA Mark II Reactor

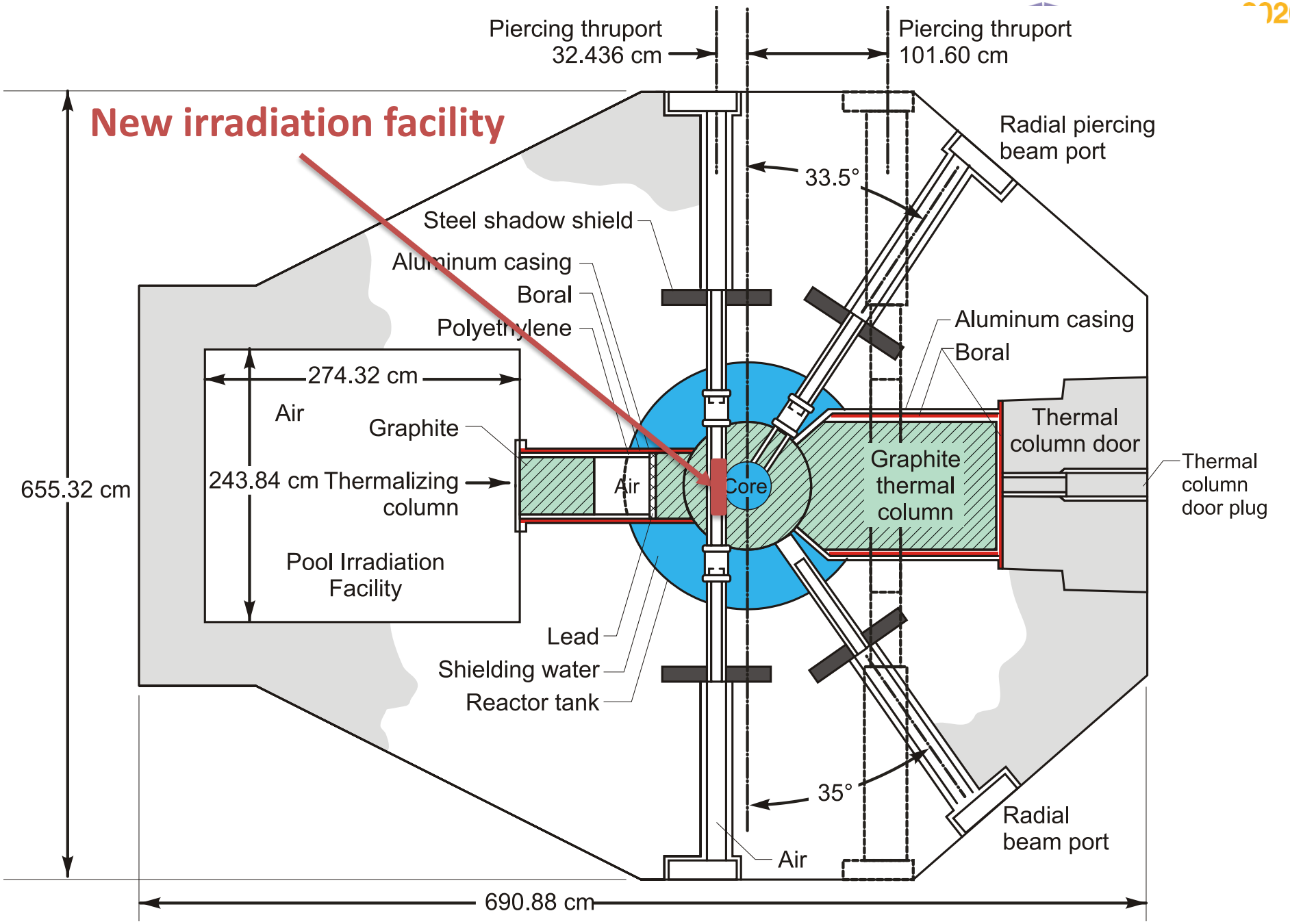


- 1st criticality:
  - 31st May, 1966
- P_{max}
  - 250 kW (steady state)
  - 1 GW (pulse)
- Fuel
  - UZrH (12 wt. % U)
  - enrichment = 20 %

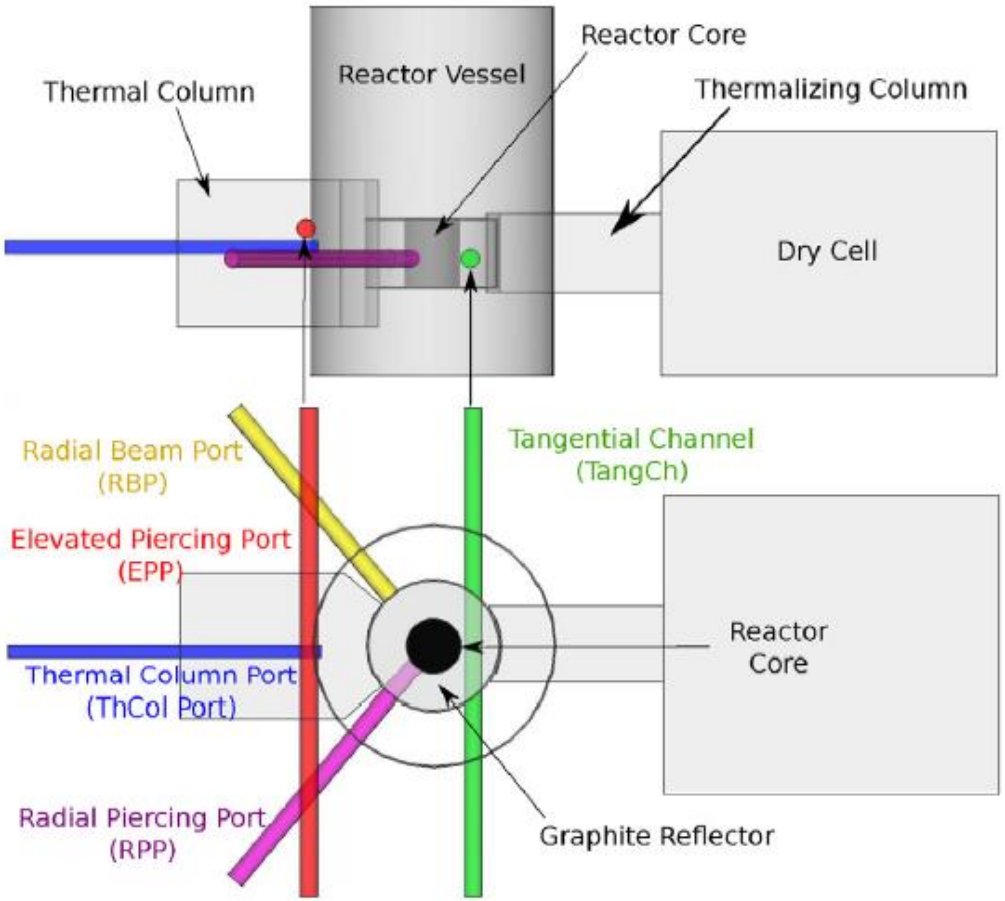





~91.44 cm (typ)
6 ft. 6 in.
Standard concrete
Aluminum tank
21 ft. 6 in
~ 487.68 cm
274.32 cm
Bulk-shielding
experimental
tank (empty)
365.76 cm.
8 ft. 2 in.
Heavy concrete
Boral
Aluminum
casing
Core
12 ft. 1.5 in.
Boral
Polyethylene
Air
Graphite
Heavy
concrete
door on track
Door plug
Aluminum
casing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


New irradiation facility
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
243.84 cm Thermalizing
column
Pool Irradiation
Facility
655.32 cm
Air
Core
Graphite
thermal
column
Thermal
column door
Thermal
column
door plug
Lead
Shielding water
Reactor tank
35°
Radial
beam port
Air
690.88 cm

TRIGA Irradiation Channels



Goal

- Develop and install a large sample irradiation (2R < 15 cm) facility in the tangential channel of the JSI TRIGA reactor

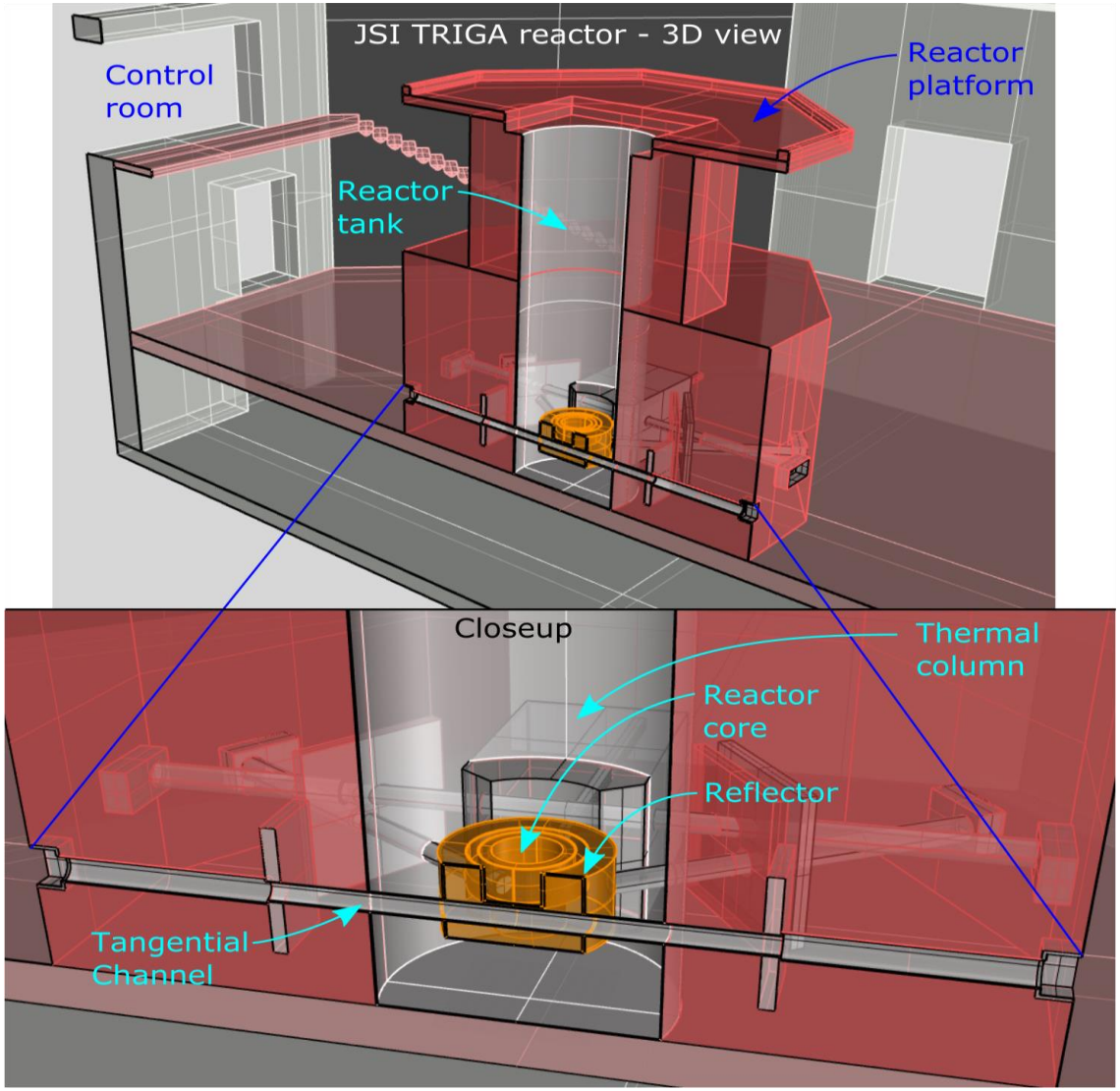
Deliverable 15.9 in M18

D15.9	JSI TRIGA Reactor Transport system	WP15	M18	04/11/2016	Achieved

Transport system for neutron irradiation of large objects at JSI:

- *In the framework of the AIDA-2020 project, Work Package 15 - Upgrade of beam and irradiation test infrastructure, a new irradiation device / transport system which will enable the irradiation of larger samples, up to 12 cm in diameter, has been installed in the Tangential Channel of the JSI TRIGA reactor in Ljubljana, Slovenia. This report documents the design and installation of the irradiation device / transport system.*

3-d Modelling



Chronology

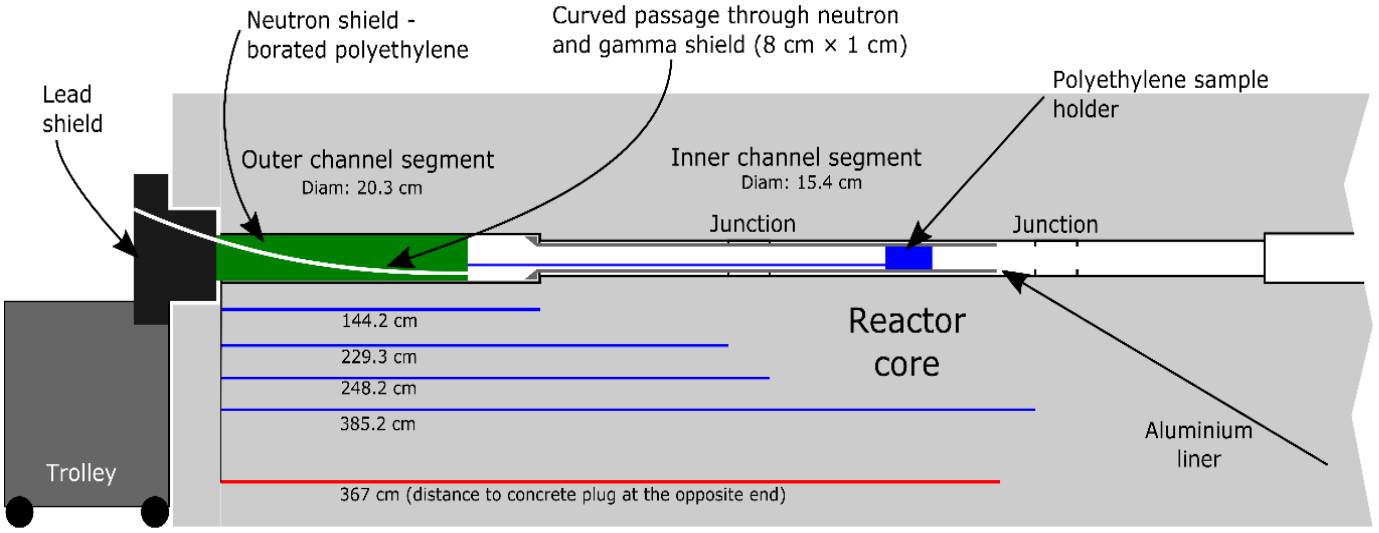
- Extraction of cold neutron source used in the past for neutron diffractometry
- Decontamination and inspection of channel interior

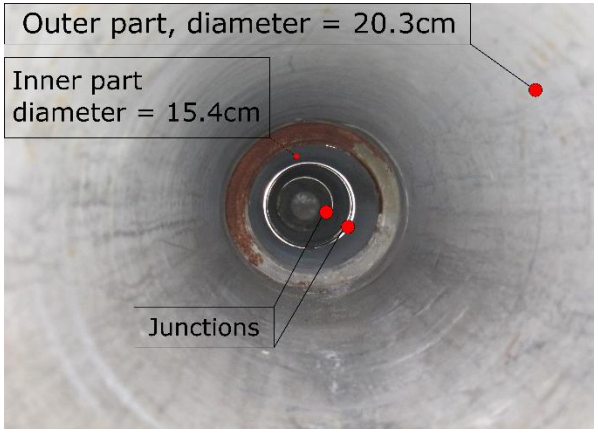
- Documentation required to obtain the authorization for the installation of the irradiation device from TRIGA Reactor Safety Committee and Slovenian Nuclear Safety Administration

- Authorization granted in August 2016
- Channel completed in October 2016

Detailed View

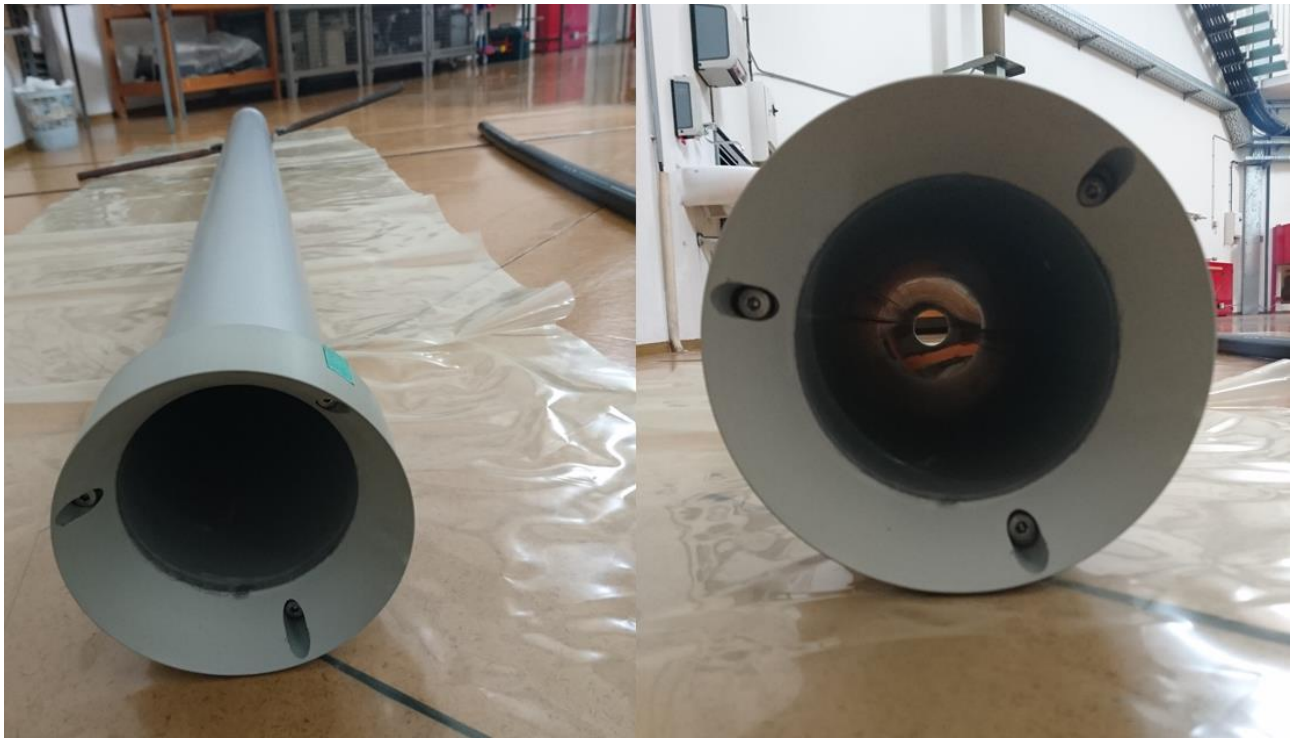
TRIGA reactor Tangential channel fitted with irradiation device





Insertion Tube

- Aluminium liner with 14.6 cm inside diameter
- Protection of internal components
- Facilitates insertion and withdrawal of samples

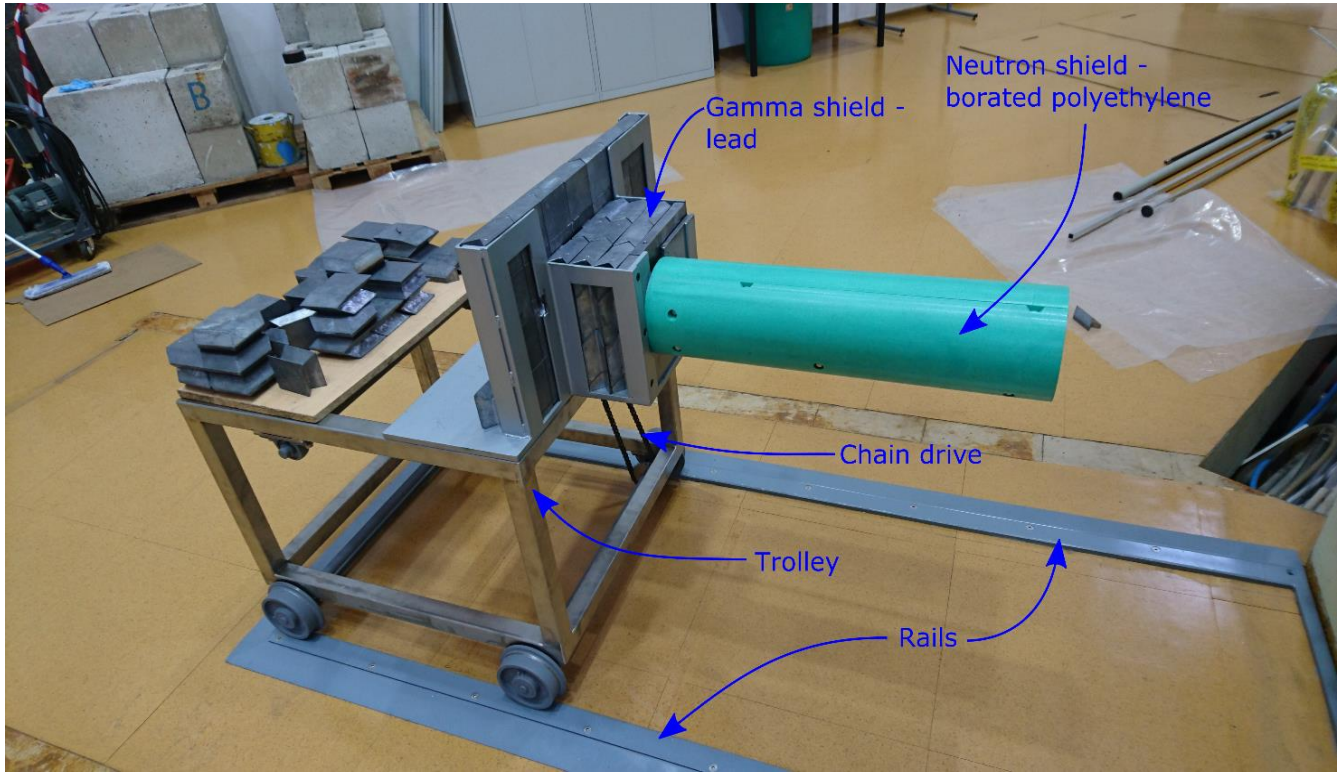


Sample Support Structure

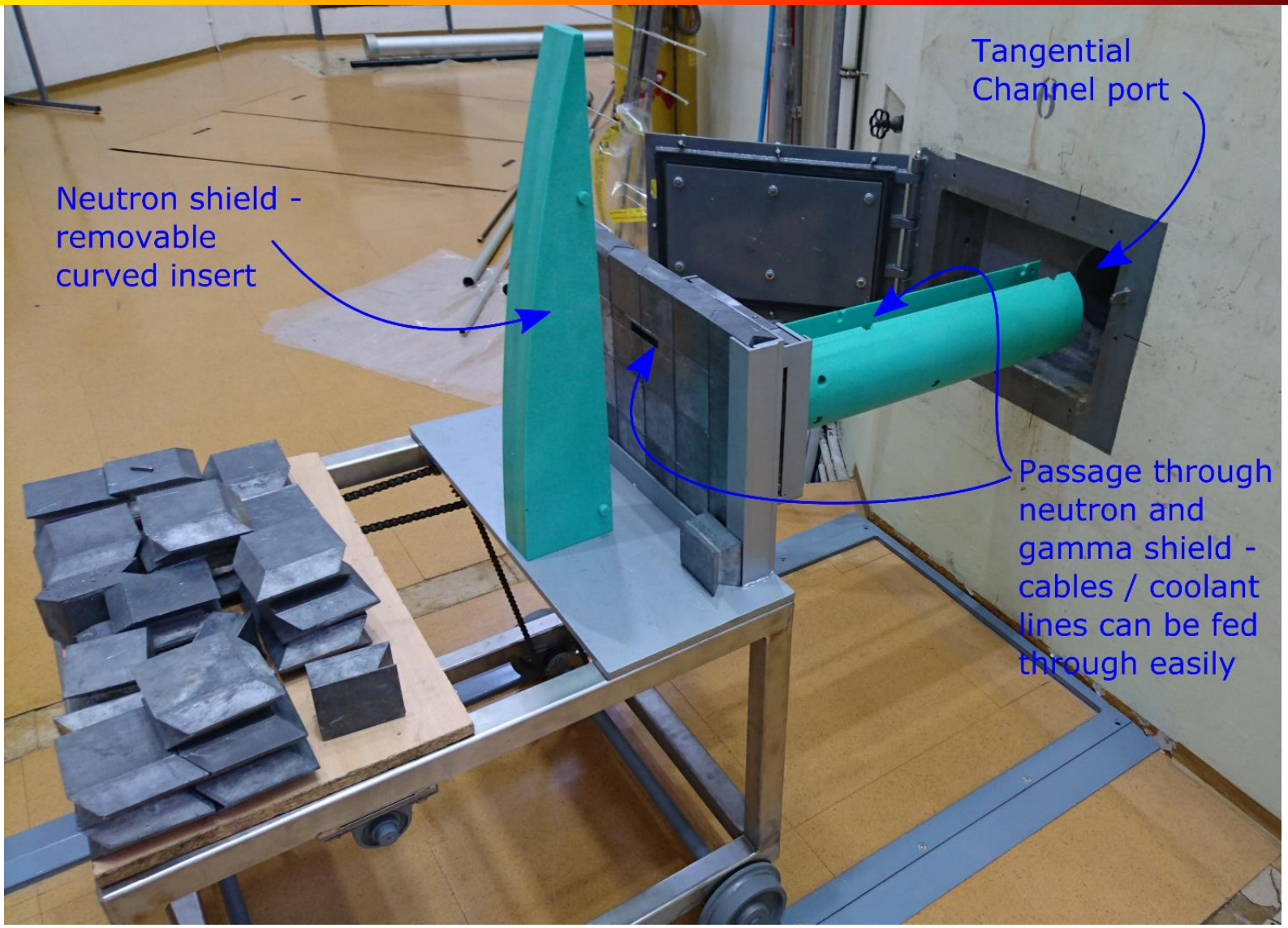
- Sample support structure made from PE100
- Support jig for sample should be custom made !
- Allows routing of cables to the sample

Shielding Plug

- Neutron shield made from borated polyethylene
- Gamma dose rate at surface of Pb ≈ mSv/h
- Concrete bricks



Plug Insertion

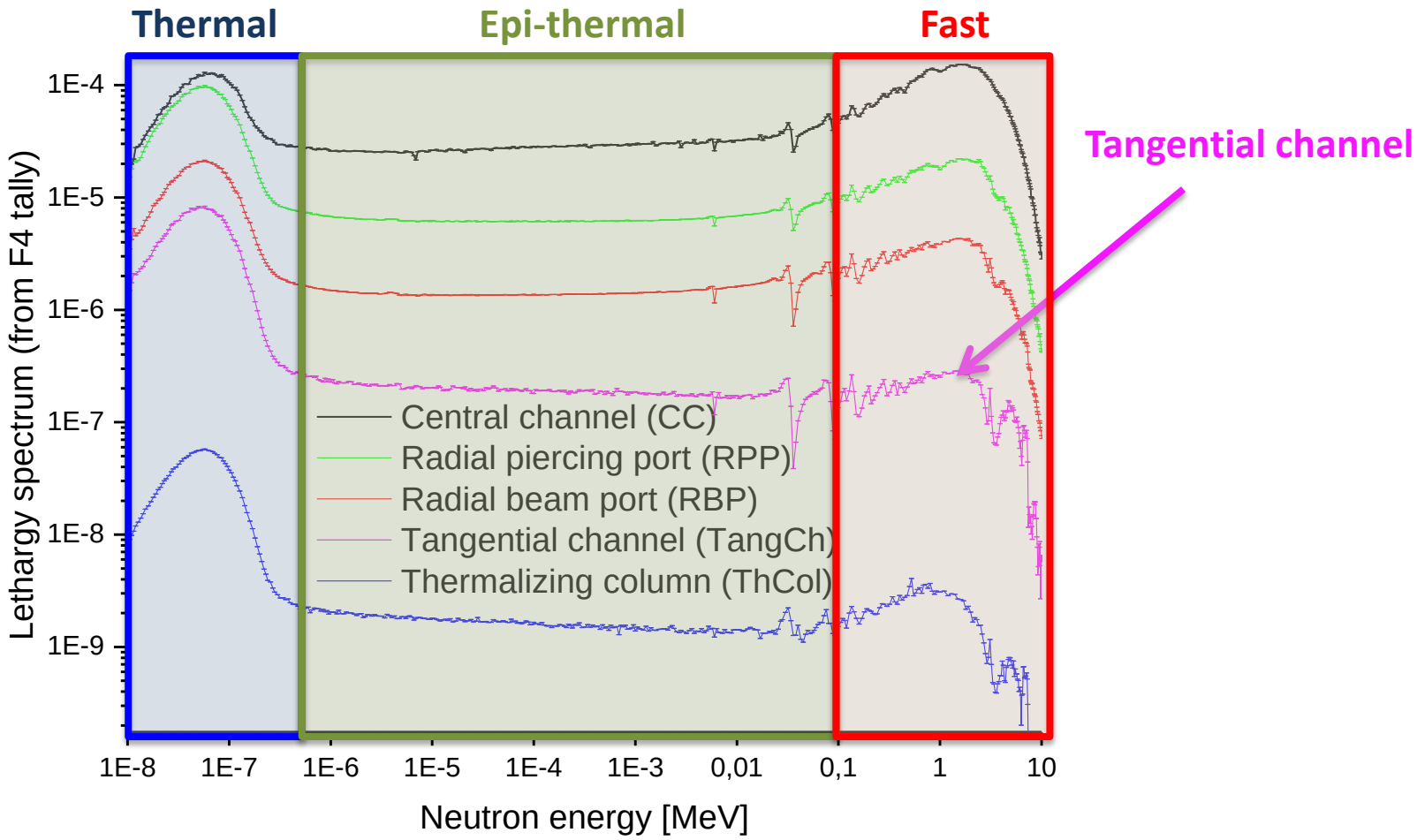


Channel Closed

Channel Characteristics

- Inner diameter: 14 cm
- Neutron flux characterisation:
  - L. Snoj et al., Appl. Rad. Isot. 70 (2012) 483–488
- Predicted neutron flux: 1.3e12 n/cm^{2}s
  - Thermal (E<0.625 eV): 58 %
  - Epithermal (0.625 eV < E < 100 keV): 25 %
  - Fast (E > 100 keV): 17 % -> 2.3e11 n/cm^{2}s
    - 1e15 n_{eq}/cm^2 in 1 ½ hours

Neutron Spectra



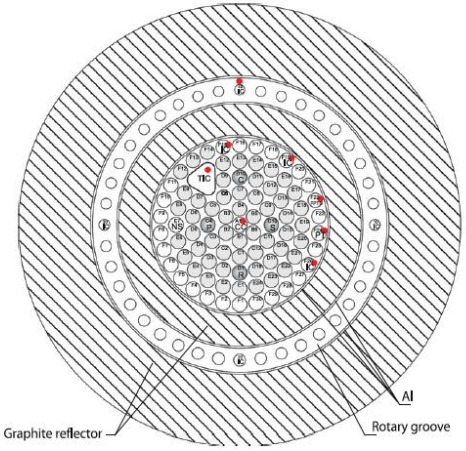
Predicted Fluxes

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

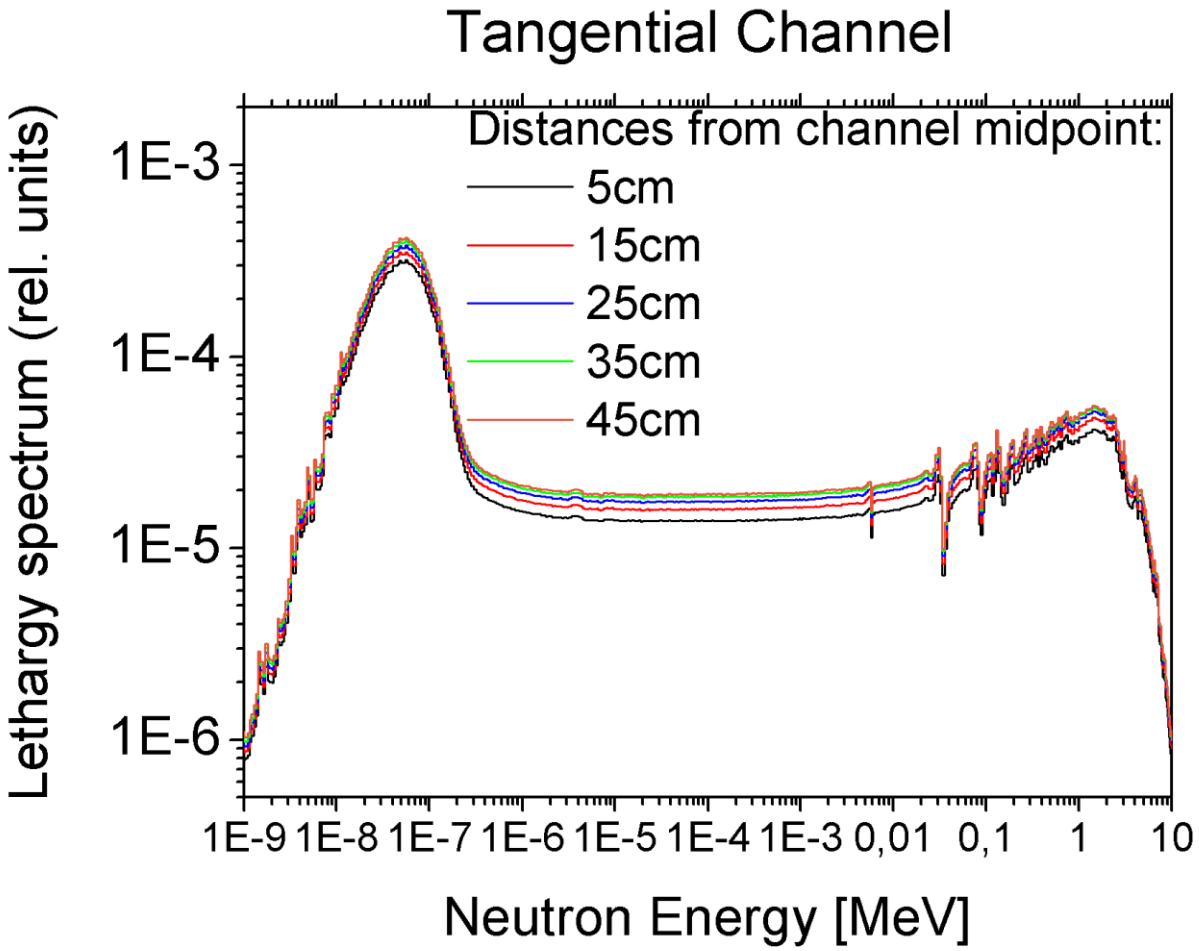
Core simulation

	$\Phi_{th}(10^{12}cm^{-2}s^{-1})$	$\Phi_{epi}(10^{12}cm^{-2}s^{-1})$	$\Phi_{fast}(10^{12}cm^{-2}s^{-1})$	$\Phi_{tot}(10^{12}cm^{-2}s^{-1})$
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

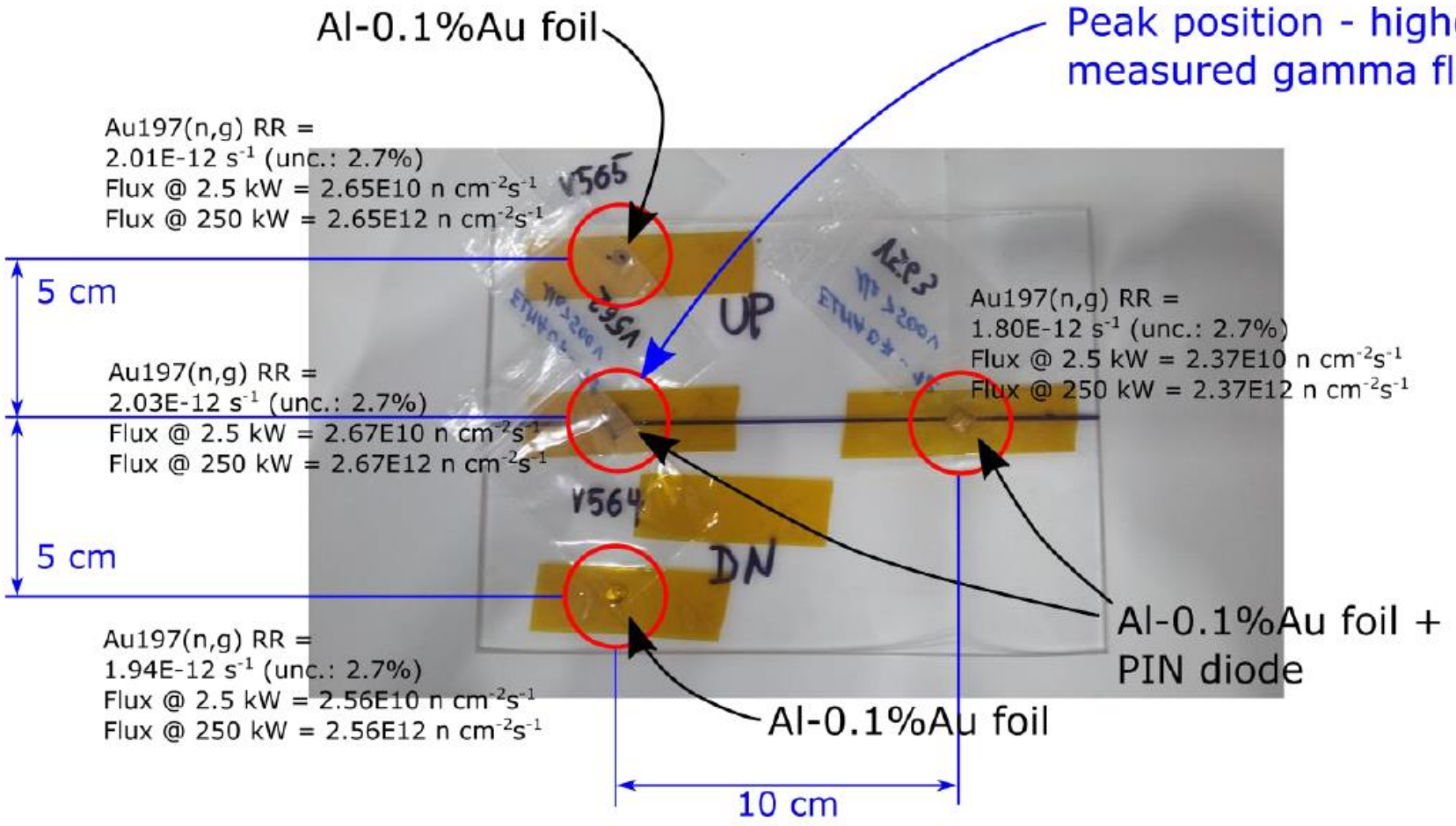
Agreement with measurements in small channel within 10 %



Flux Along Channel



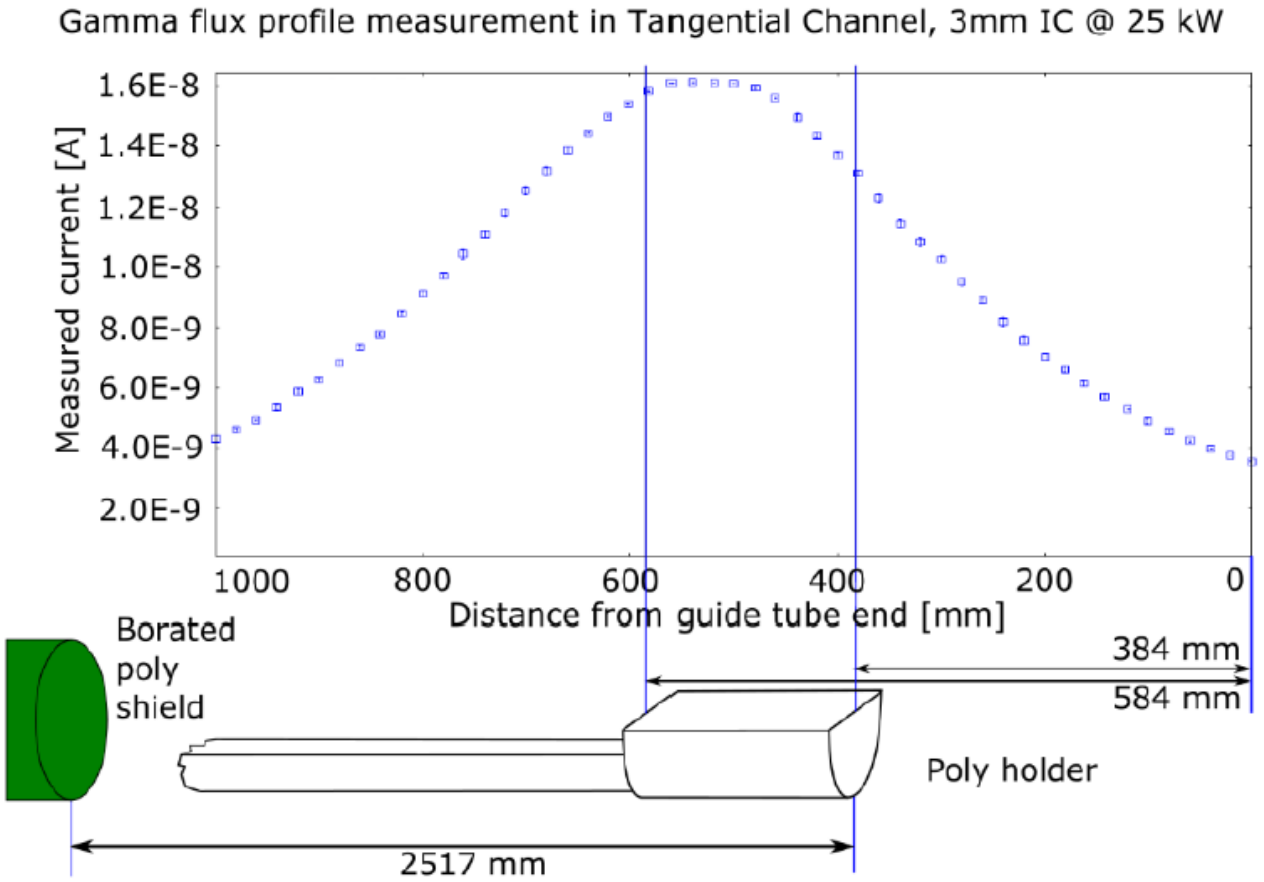
Neutron Flux Measurement



Neutron Flux

- Flux measured by Au 197(n,γ)
  - measures (mostly) thermal flux
  - scaled by simulated spectrum to total flux
- Au - measured total flux 2.67e12 n/cm^{2}s
  - uniformity < 10 % on 10 cm x 10 cm
- PIN - measured NIEL flux 3.9e11 n/cm^{2}s
  - NIEL hardness factor for total spectrum 0.146
  - hardness factor for E_n > 0.1 MeV: 0.83
- Twice the predicted value !

Gamma Flux



- Measured gamma flux profile
- Dose rate several 10 kGy/h (very preliminary!!) –
- Resulting in several kGy for 10^{14} $n_{eq}cm^{-2}$

Summary

- New irradiation facility at JSI reactor installed and being commissioned
  - characterization in progress
  - first measurements indicate 2x predicted flux

- Allows irradiation of ~12 x 20 cm samples
  - services possible
- 10^{15} $n_{eq}cm^{-2}$ in less than one hour
- Ready to receive samples!