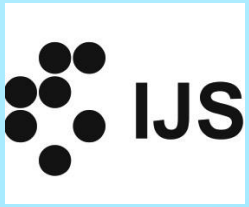
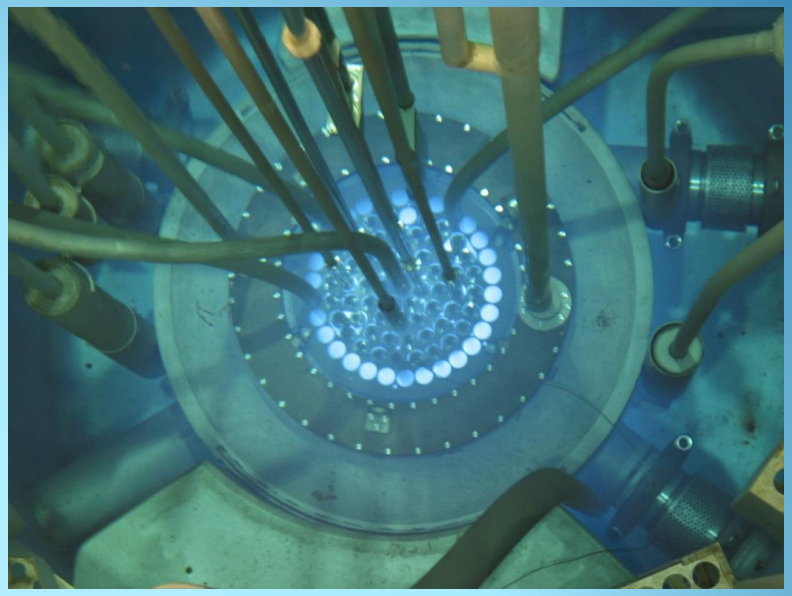
Transport system for large objects at Ljubljana JSI TRIGA reactor

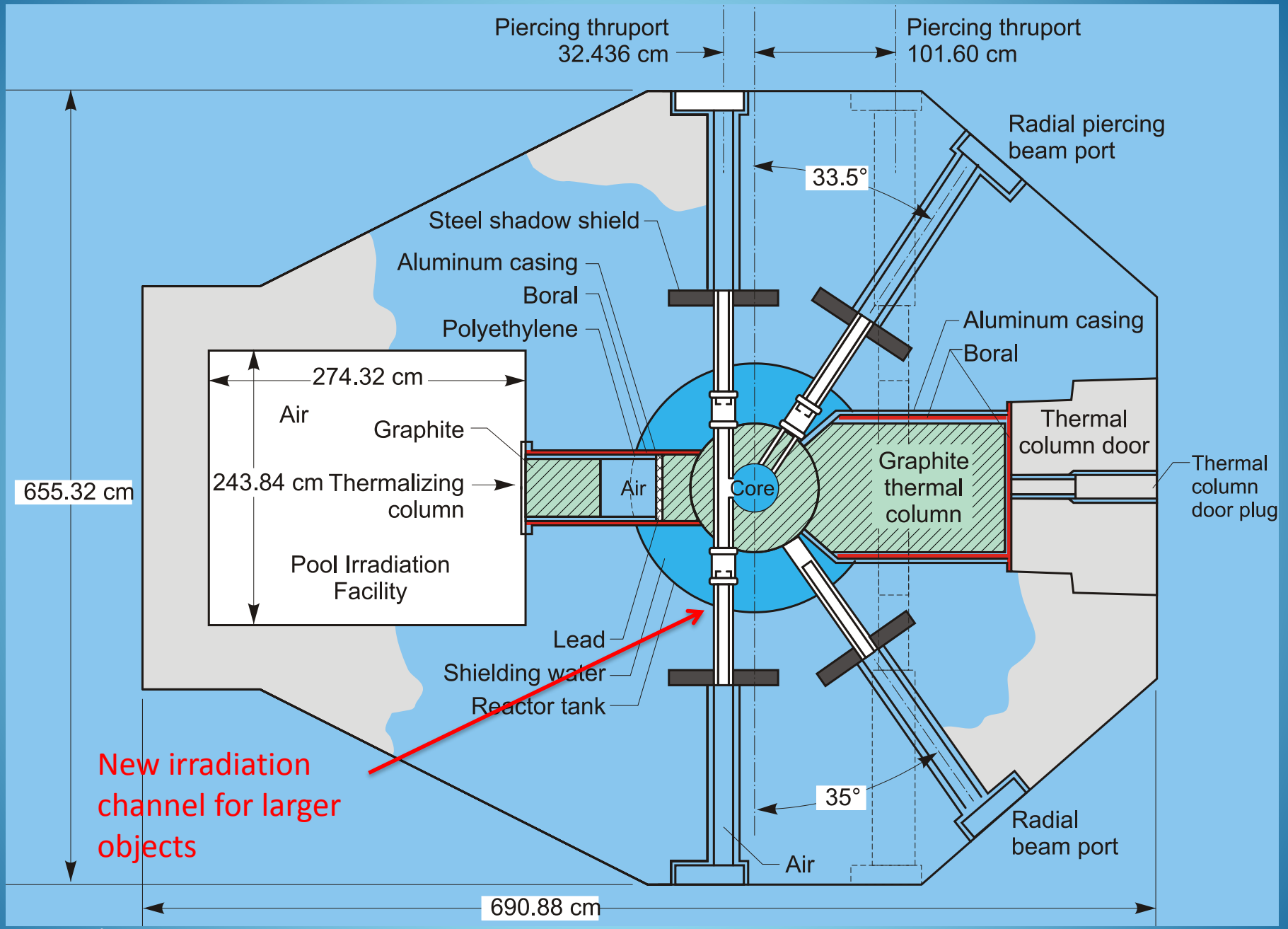
Vladimir Cindro et al.

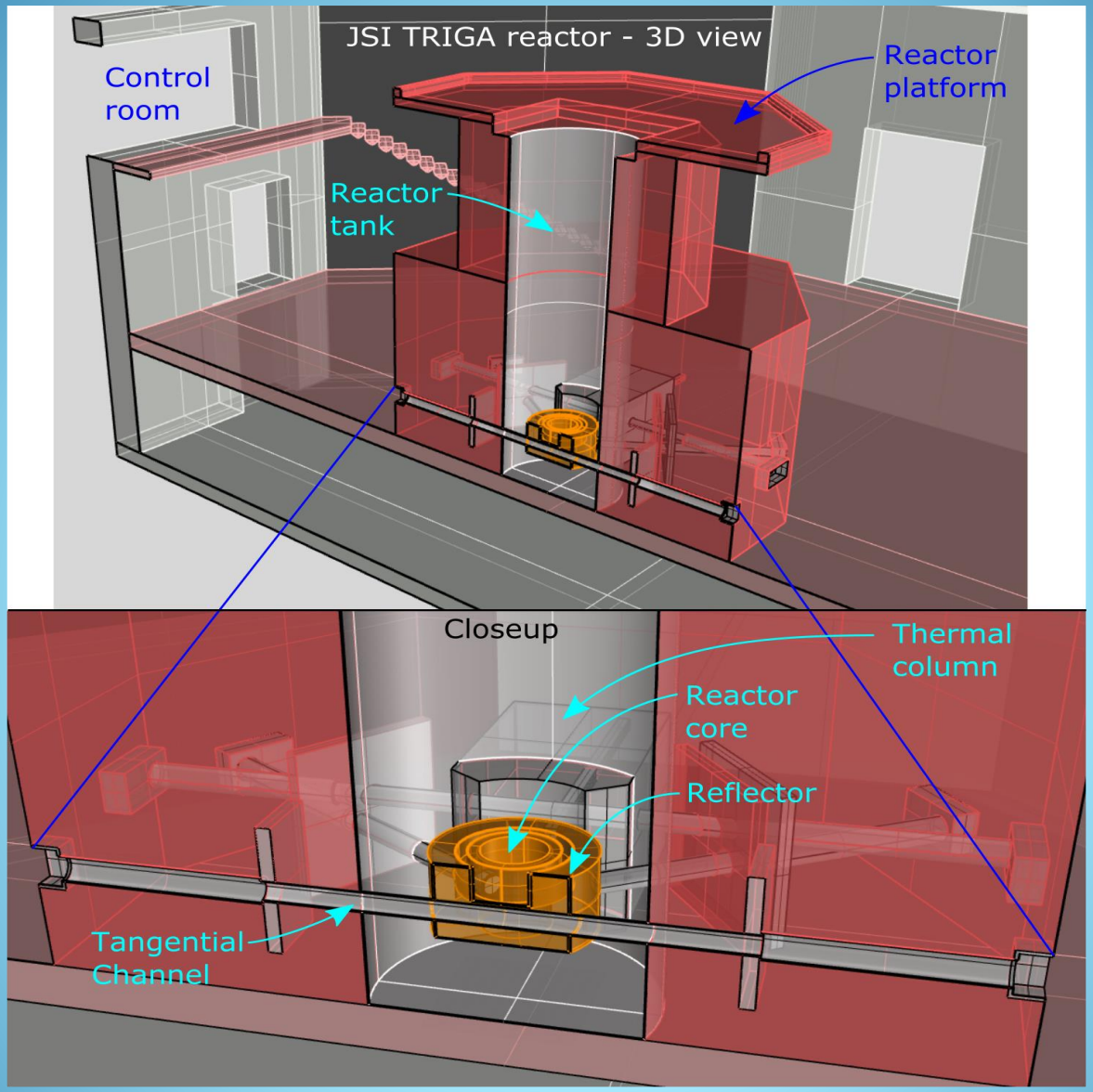
Jožef Stefan Institute, Ljubljana, Slovenia





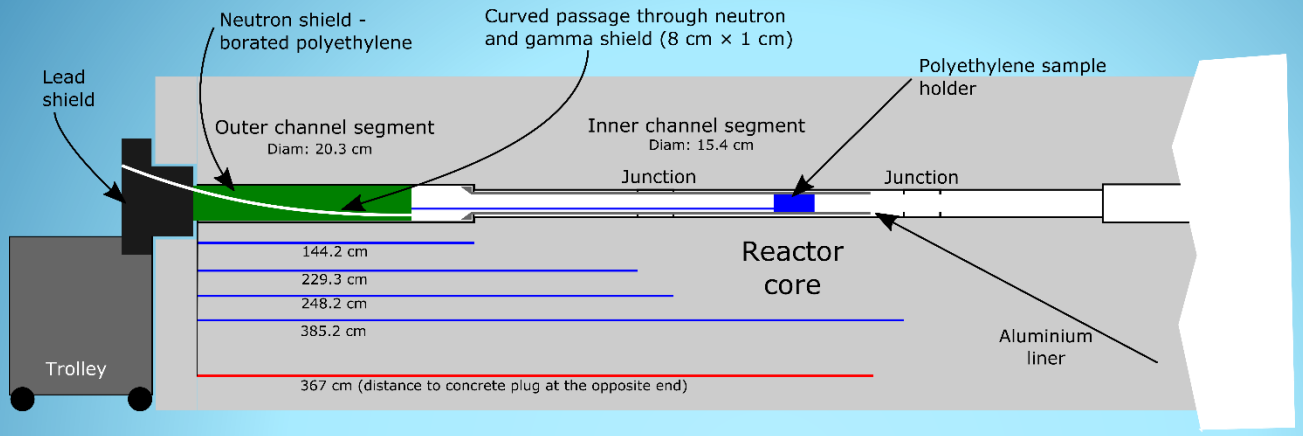
- vertical channels with access directly into the core
- F19 (small) – cylindrical containers with 24 mm or 19 mm internal diameter and 110 mm length
- access to samples with 7 – 8 m cables possible
- 1 MEV NIEL flux up to 1.54 10^{12} ncm^{-2} measured with bulk damage current in Si diode
- TID ≈ 1 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

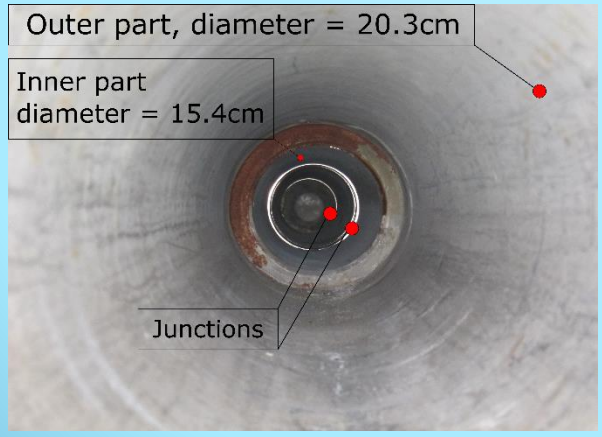

Piercing thruport
32.436 cm
Piercing thruport
101.60 cm
Radial piercing
beam port
33.5°
Steel shadow shield
Aluminum casing
Boral
Polyethylene
Aluminum casing
Boral
274.32 cm
Air
Graphite
655.32 cm
243.84 cm Thermalizing
column
Pool Irradiation
Facility
Air
Core
Graphite
thermal
column
Thermal
column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



- channel completed in October 2016

TRIGA reactor Tangential channel fitted with irradiation device

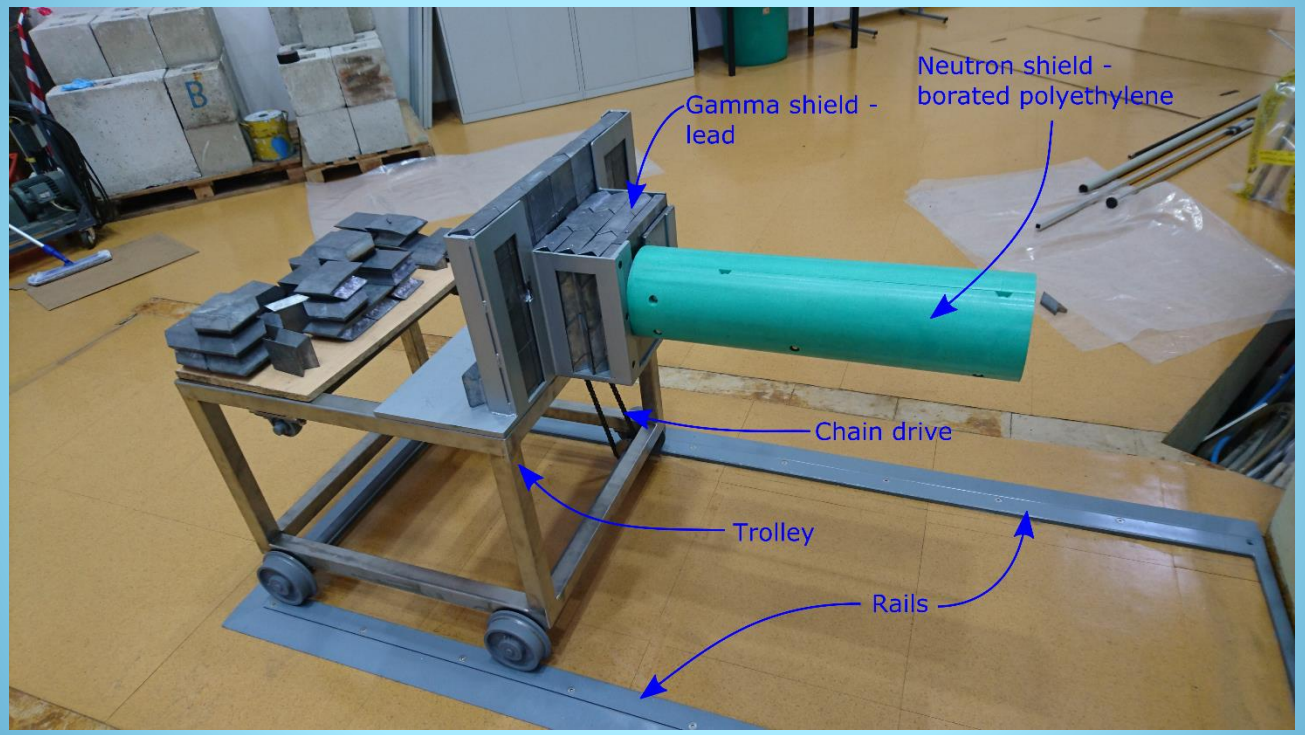


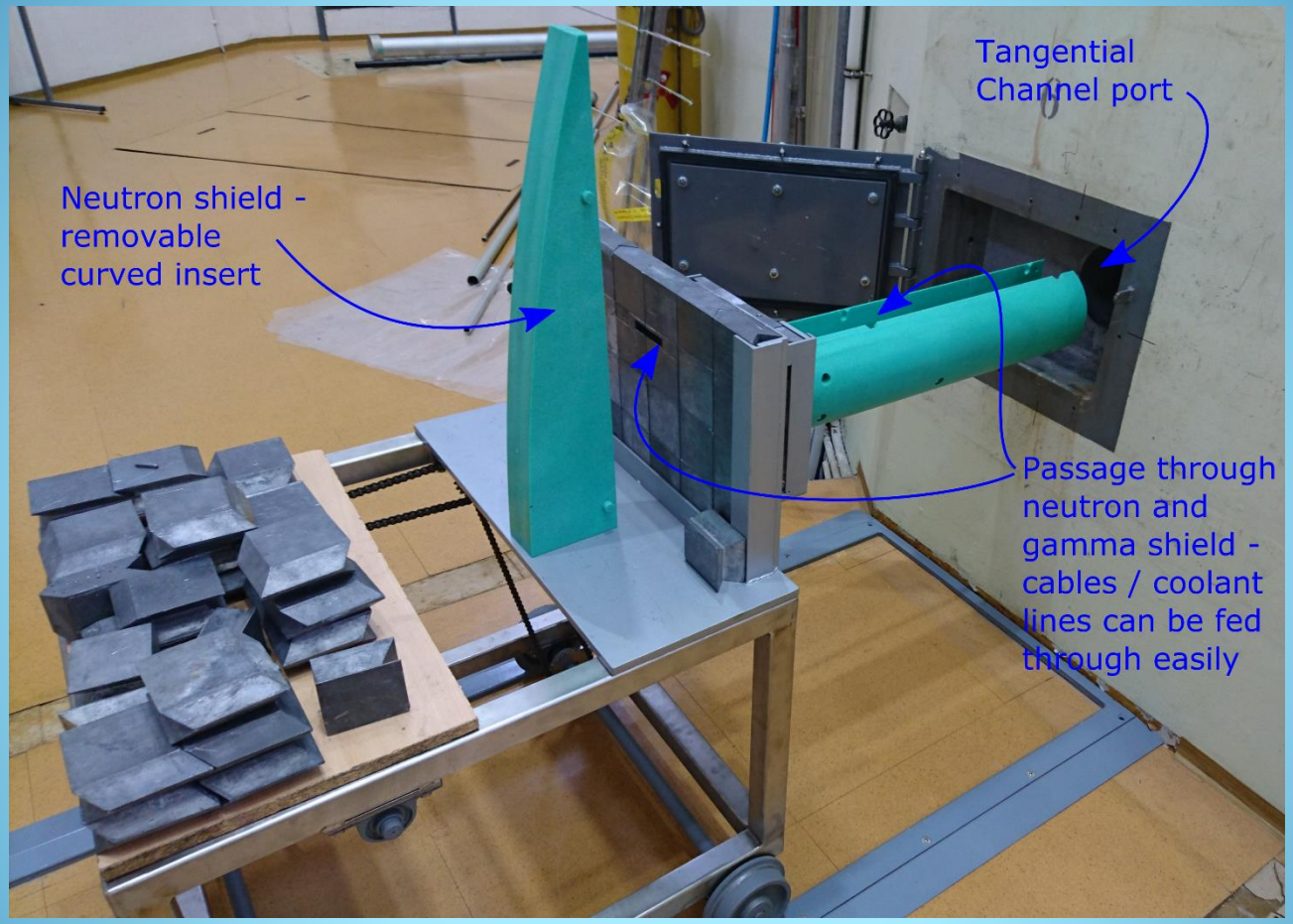


- aluminum liner with inside diameter 14.6 cm
- protection of internal components
- facilitates insertion and withdrawal of samples

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

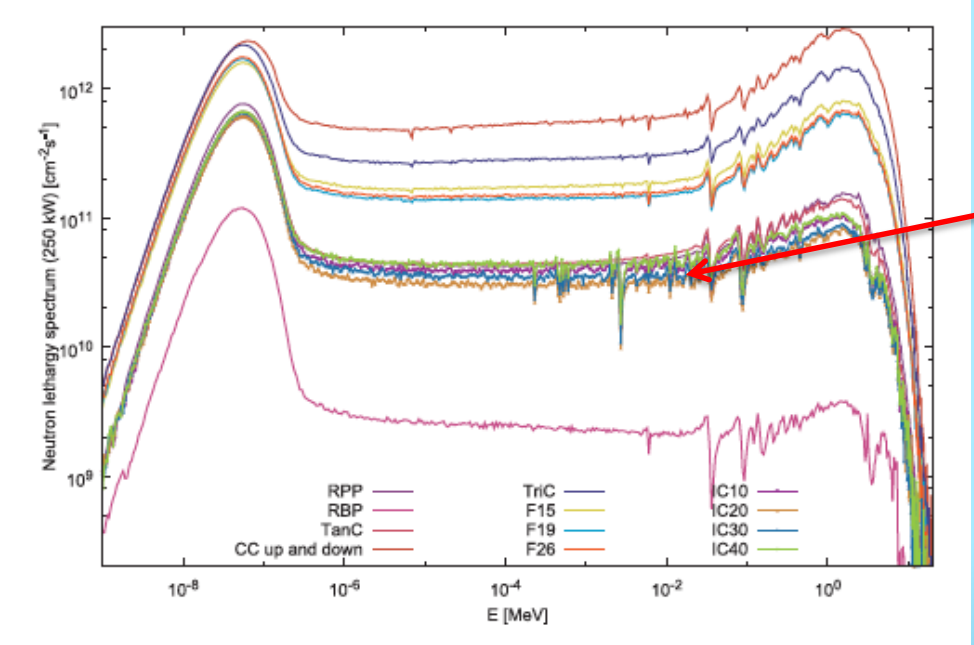
- neutron shield made from borated paraffin (≈ 5% of boron)
- gamma dose rate at the surface of Pb ≈ mSv/h
- concrete bricks




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

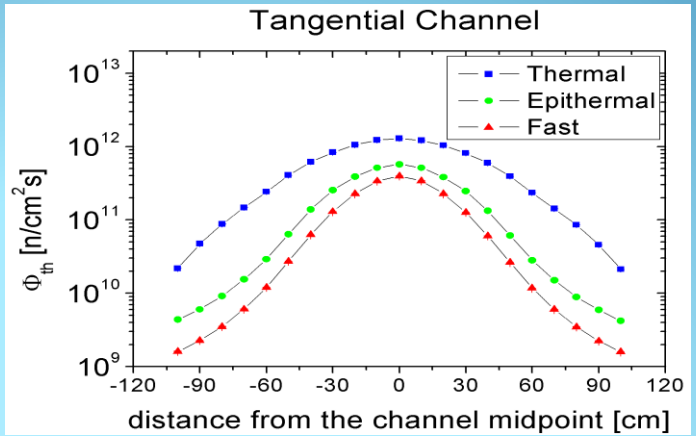
Neutron fluxes and spectra

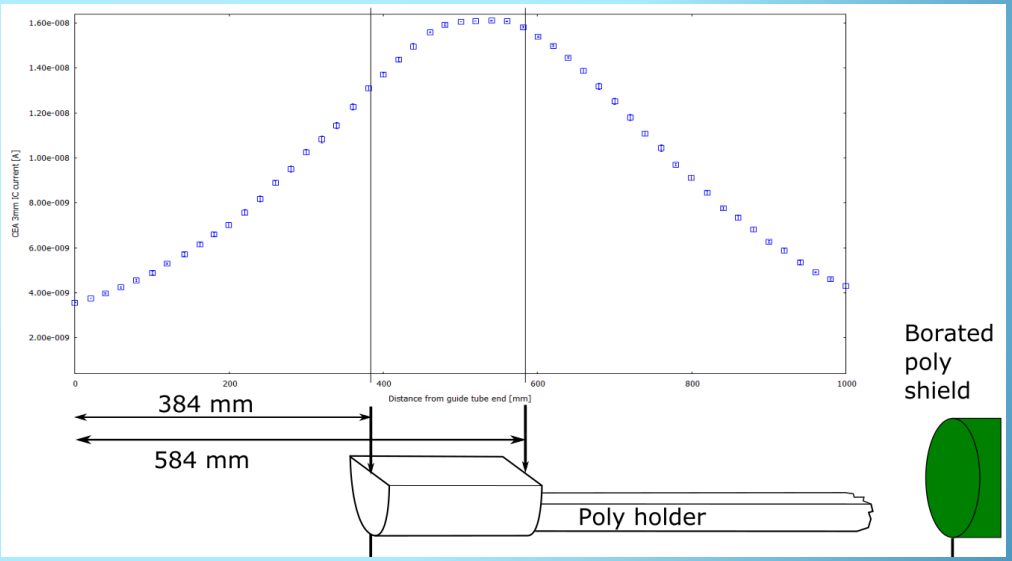
- computational analysis with MCNP code (X-5 Monte Carlo Team 2004)
- published in K. Ambrožič et al. (Applied Radiation and Isotopes 130 (2017) 483-488



Tangential channel

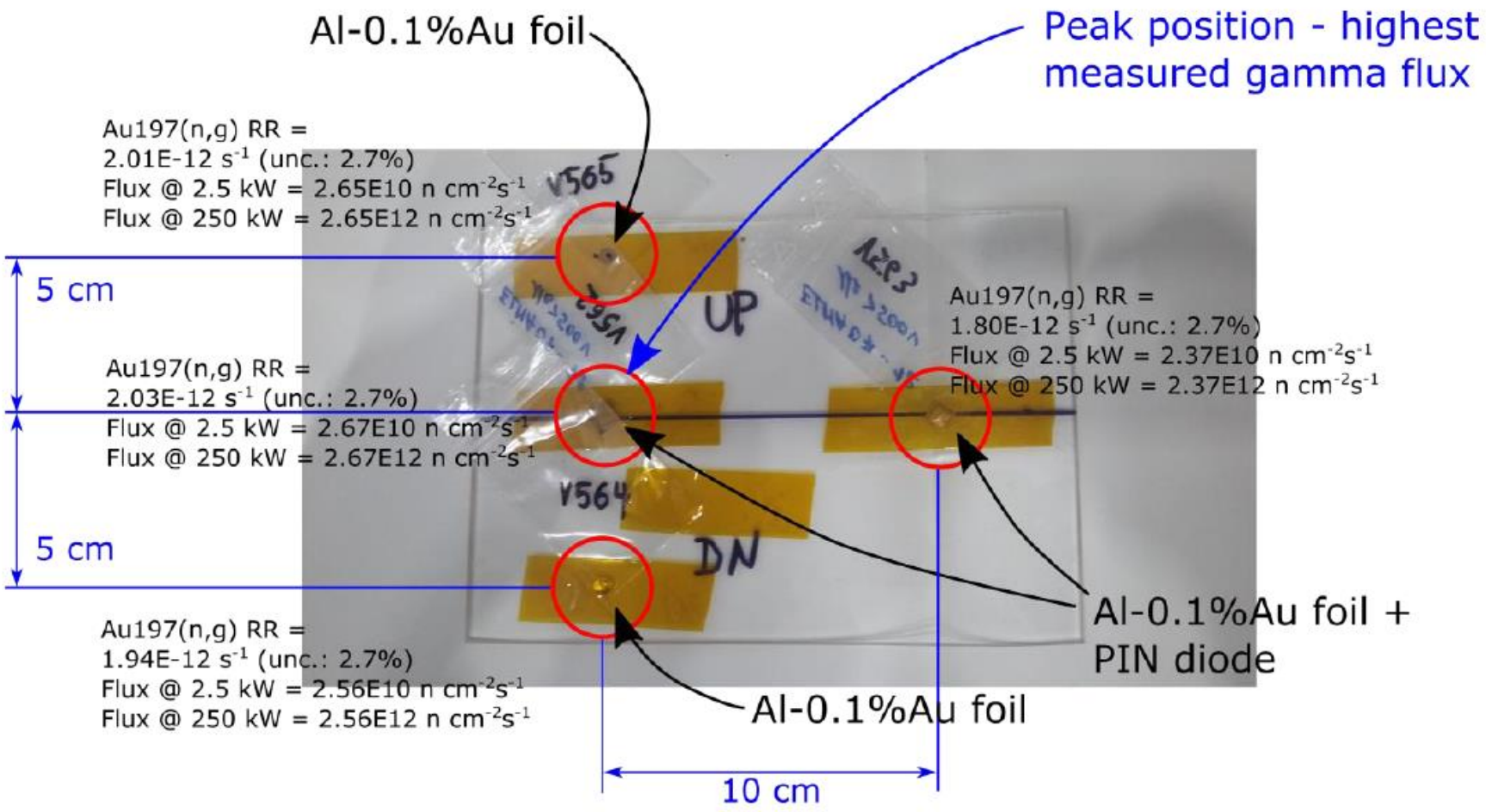
- calculated neutron fluxes





- measured gamma flux profile
- dose rate several 10 kGy/h
- resulting in several kGy for 10^{14} $n_{eq}cm^{-2}$

Neutron Flux Measurement

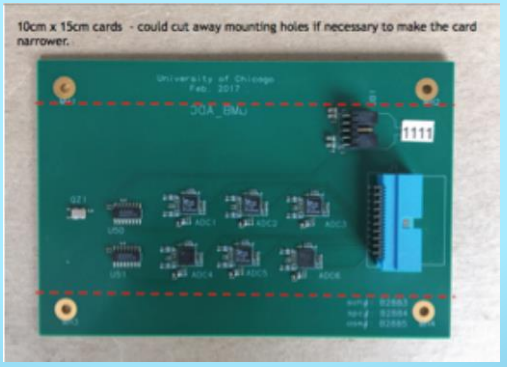


Neutron Flux

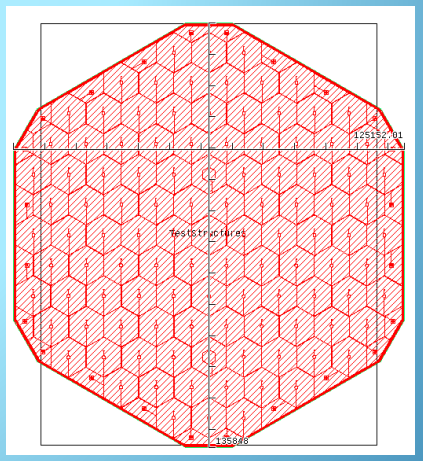
- Flux measured by Au 197(n,γ)
  - measures (mostly) thermal flux
  - scaled by simulated spectrum to the total flux
- Au - measured total flux 2.67e12 n/cm^{2}s (15% higher than simulation)
  - uniformity < 10 % on 10 cm x 10 cm
- PIN - measured NIEL flux 3.9e11 n/cm^{2}s
  - NIEL hardness factor for total spectrum 0.146
  - hardness factor for E_n > 0.1 MeV: 0.83

Irradiations in tangential channel (2017):

- ATLAS - silicon wafers (DESY)
  - thermo-mechanical studies (2e15 n/cm^2)
- Atlas Tile calorimeter upgrade
  - shaper/digitizer card (8e12 n/cm^2



- CMS calorimeter upgrade – Si sensors July 2018
  - hexagonal sensor coming from an 6“ wafer with the dimensions of 12.6 x 13.6 cm (and a thickness of 320micron
  - 18 sensors, 2 pieces each of 3 types and 3 fluences (2*3*3)
  - up to 7.5 10^{14} n/cm^2

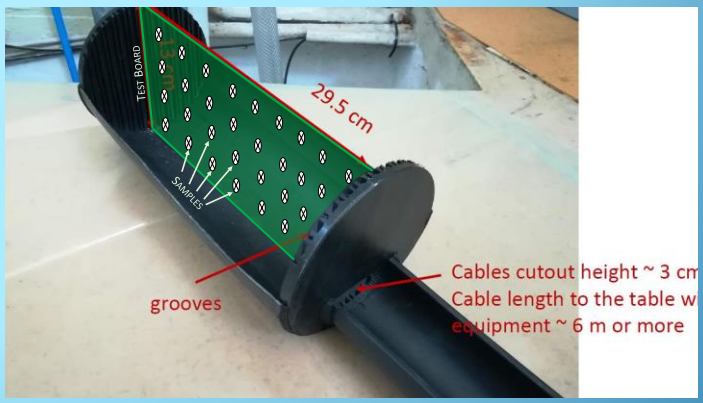


Irradiation of Atlas full size sensor

- irradiation to 5 10^{14} n_{eq} (May 2018)
- approximate size 98 x 98 mm^2
- more irradiations planned

Irradiation of electronic components

- different components irradiated and monitored during irradiation (RD CERN)
- optocouplers, NPN Transistors, a voltage reference and a current source
- campaign end of October 2018



Summary

- new irradiation facility at JSI reactor installed and commissioned in 2016
- allows irradiation of ~ 12 x 25 cm^2 samples
  - services possible
- 10^{15} $n_{eq}cm^{-2}$ in less than one hour
- 5 irradiation projects completed, more in the pipeline
- AIDA-2020-CONF-2017-003
  - **Large Object Irradiation Facility In The Tangential Channel Of The JSI TRIGA Reactor (V. Radulović et al.) .** European Research Reactor Conference 2017, Rotterdam, Netherlands, 14 - 18 May 2017
- AIDA 2020 funds exhausted – request for more