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# DELIVERABLE REPORT

## JSI TRIGA REACTOR TRANSPORT SYSTEM

**DELIVERABLE: D15.9**

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**Abstract:**

This report documents the design and installation of the Transport system for neutron irradiation of large objects at the JSI TRIGA reactor – Deliverable 15.9.
AIDA-2020 Consortium, 2016
For more information on AIDA-2020, its partners and contributors please see www.cern.ch/AIDA2020

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<table>
<thead>
<tr>
<th>Author</th>
<th>Name</th>
<th>Partner</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authored by</td>
<td>V. Radulović</td>
<td>JSI</td>
<td>12/10/16</td>
</tr>
<tr>
<td>Edited by</td>
<td>L. Snoj, S. El yacoubi</td>
<td>JSI/CERN</td>
<td>12/10/16</td>
</tr>
<tr>
<td>Reviewed by</td>
<td>V. Cindro, M. Mikuž [Task coordinator], F. Ravotti [WP coordinator], M. Stanitzki [WP coordinator], D. Bortoletto [Deputy Scientific coordinator]</td>
<td>JSI/CERN/DESY/UOXF</td>
<td>20/10/16</td>
</tr>
<tr>
<td>Approved by</td>
<td>F. Sefkow [Scientific coordinator], Steering Committee</td>
<td></td>
<td>04/11/2016</td>
</tr>
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EXECUTIVE SUMMARY

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.

1. INTRODUCTION

The irradiation capabilities of the JSI TRIGA reactor are a vital part of the AIDA-2020 project and serve as a reference for neutron irradiations for the high-energy physics community. Alone in the scope of AIDA, 68 projects consuming 600 access units (irradiation hours) were carried out, with an additional 31 projects (160 a.u.) following in the first year of AIDA-2020. Currently two irradiation channels are in use for irradiation tests, namely the F19 channel in the outer (F) ring of the reactor core, 31.6 mm in diameter, and the triangular irradiation channel (TIC), closer to the core center, which has a lateral dimension of around 60 mm. The motivation for the performed activities described herein is the creation of a new location in the JSI TRIGA reactor, which would enable irradiation testing of larger components, up to 12 cm in size.

2. PAST ACTIVITIES

The activities performed previously at the JSI in the context of Deliverable D 15.9 are described in detail in the Milestone report [1], submitted in April 2016. A brief summary is given in the list below:

- Extraction of cold neutron source used in the past for neutron diffractometry.
- Decontamination and inspection of channel interior.
- Development of a conceptual design of the irradiation device.
- Test neutron and gamma dose rate measurements with a mock-up of the proposed neutron and gamma shield.
- Procurement of materials for the device construction.

The past activities served as a basis to prepare all the necessary documentation [2] required to obtain the authorization for the installation of the irradiation device from the TRIGA reactor Safety Committee and the Slovenian Nuclear Safety Administration. The authorization was granted in August 2016 and work started on the procurement and construction of the components. The construction was finished in late September 2016 and the installation was completed in early October 2016.

3. IRRADIATION DEVICE

The installed irradiation device consists of: an aluminium liner (outside diameter 15 cm, inside diameter 14.6 cm) which serves to protect the internal components of the Tangential Channel and to facilitate the insertion and withdrawal of samples, and a combined neutron and gamma shield mounted on a trolley on rails. 3D views of the JSI TRIGA reactor and its main components are shown in Figure 1. A schematic drawing of the Tangential Channel fitted with the irradiation device is shown in Figure 2.
3.1. CHANNEL LINER
The aluminium liner fits into the narrow section of the Tangential Channel. The liner is equipped with a mounting flange, machined out of solid aluminium, with an interior conical section. The mounting flange has three retractable mounting points, which hold the liner in place by friction in the channel interior and prevent it from slipping on sample insertion / withdrawal. The surface of the liner has an anodized finish. Photographs of the channel liner are shown in Figure 3.

![JSI TRIGA reactor - 3D view](image)

*Fig. 1: 3D view of the JSI TRIGA reactor components – vertical section through the Tangential Channel.*
3.2. NEUTRON AND GAMMA SHIELD

The combined neutron and gamma shield was designed to shield the reactor hall from neutron and gamma radiation from the reactor. The neutron shield is a cylindrical plug manufactured out of high density borated polyethylene, obtained from the ShieldWerx company\(^1\) which fits into the outer, wider section of the channel, 20.3 cm in diameter. The borated polyethylene material was obtained from ShieldWerx.

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\(^1\) [http://www.shieldwerx.com/](http://www.shieldwerx.com/) 4529 Arrowhead Ridge Dr. SE, Rio Rancho, NM 87124, United States
in the form of a 2-inch thick plate. The shield, 75 cm in length, was constructed by joining four polyethylene plates and turning the assembly to the required diameter (20 cm). A curved passage (8 cm \times 1 \text{ cm}) through which cables and coolant lines can be fed to the irradiated samples, was machined in the inner two plate sections. The top part of the inner two plates was made to be removable, in order to facilitate the cable / coolant line feedthrough. The gamma shield is constructed out of V–profiled lead bricks to eliminate gaps. The curved passage in the neutron shield extends into the gamma shield.

The neutron and gamma shield are mounted onto a sturdy trolley on wheels, manufactured out of stainless steel. The trolley runs on rails and can be moved with ease using a chain drive, which runs one of the trolley axles. Photographs of the trolley with the combined neutron and gamma shield are shown in Figures 4-5.

![Fig. 4: Photograph of the neutron and gamma shield.](image-url)
Fig. 5: Photograph of the neutron and gamma shield with the curved insert removed for easy cable / coolant line feedthrough.

4. NEUTRON FLUX CHARACTERIZATION

The neutron flux profile in the Tangential Channel has been determined within the computational characterization of the JSI TRIGA reactor [3-4], using the Monte Carlo particle transport code MNCP [5]. The average value of the neutron flux in the interior of the Tangential Channel at full reactor power (250 kW) is around $1.3 \times 10^{12} \text{ n cm}^{-2} \text{ s}^{-1}$, the thermal, epithermal and fast neutron fractions being 58 %, 25 % and 17 % respectively. The calculated neutron flux profiles in 10 cm sections along the channel are shown in Figure 6 and the calculated neutron spectra in Figure 7. Although the calculated fluxes are expected to be reliable at the 10 % level, the neutron and gamma flux profiles in the device will be also characterized with experimental measurements using both activation foils and fission / ionization chambers, thus providing validation of the Monte Carlo simulation results.
**Fig. 6:** Calculated neutron flux profiles in 10 cm sections along the Tangential Channel

**Fig. 7:** Calculated neutron spectra in 10 cm sections along the Tangential Channel
The refurbished irradiation channel with its shielding, transport mechanism and service feed-troughs is finished and ready to accept users. This deliverable enhances the scope of Transnational Access to Irradiation Facilities (AIDA-2020 WP11) with access to neutron irradiation of larger objects, indispensable for testing of complete module prototypes for the LHC high-luminosity upgrade.

5. CONCLUSIONS

The design and construction of the irradiation device / transport system for large object irradiations at the JSI TRIGA reactor (Deliverable 15.9) has been successfully achieved. The maximum lateral dimension in the channel is 14.6 cm. The device is operational and enables on-line irradiation testing of samples in a fast neutron flux exceeding $2 \times 10^{11} \text{ n cm}^{-2} \text{ s}^{-1}$ and online monitoring of the irradiation conditions. The experimental verification of the neutron spectra and neutron and gamma flux profiles in the device will take place in early 2017.
6. REFERENCES


## ANNEX: GLOSSARY

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<tr>
<td>JSI</td>
<td>Jožef Stefan Institute</td>
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<td>TRIGA</td>
<td>Training, Research, Isotopes, General Atomics (reactor type)</td>
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