Ultrafast_RAZipol Deliverable Report

Ultrafast Laser with Radial and Azimuthal Polarizations for High-efficiency Micro-machining Applications

Context		
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2. Introduction

An important part of the laser development activities within the Ultrafast_RAZipol project is the packaging of the individual laser sub-systems. The integrated systems will be used for demonstrating state-of-the-art applications later in the project. Therefore, they need to be enclosed in a robust housing that enables reliable long-term operation of the systems. Within task 1.4 and 1.5, Lumentum will build the prototypes enclosures of the high repetition rate (HRR) amplified laser system and the low repetition rate (LRR) amplified laser system, respectively. This deliverable report will cover both tasks, since the two systems have a lot of similarities concerning the integration concept. The main differences will be highlighted in separate sections.

In both cases, the amplifier sub-systems and components will be provided from the partners engaged in the amplifier development. Lumentum will develop an overall housing and simple interfacing, which will include electrical connectors and connectors for the cooling water. The integration task will require a strong interaction between the laser development partners CNRS-LCF, FIB, USTUTT, as well as with the scanner development partner NSTBVBA in the case of the HRR system. The finished HRR prototype will be delivered to SLV, the LRR prototype will be delivered to C4L. In both cases the prototypes will be used to develop and demonstrate beyond state-of-the-art applications.

3. Considerations and concept for the integrated system

The housing needs to fulfil a series of important requirements:

- The housing should be dust-sealed to make the system long-term reliable.
- The sub-components need to be easily accessible for the build-up, installation and potential service.
- The housing should be as compact as possible without compromising the functionality or accessibility.

The first idea was to develop a two-level system to keep the footprint more compact. This approach would have potentially enabled an integration of the laser source into the machine for the applications. On the other hand it was clear that some parts of the laser system need realignment. Further, the typical space in a machine is very limited.

Therefore an approach with two separate boxes placed on a laser table outside the machine was chosen as the better option. The first box contains the seed oscillator, the pulse picker(s) for the modulation / repetition rate reduction and the single-crystal fiber (SCF) amplifier. The second box contains the thin-disk multi-pass amplifier. Figure 1 shows a schematic layout of the HRR system to give an understanding of the general layout. The two boxes are placed on a laser table with the dimensions 1.25 m x 2.5 m. The beam between the two boxes is guided with adjustable mirrors. The beam exiting the TD amp is guided to the machine using a final turning mirror. The dimensions for the two boxes of the LRR system are the same. The only difference between the two systems regarding the layout is the second input / output between the boxes on the HRR system. This feature is potentially needed for the high power modulation on the HRR system.

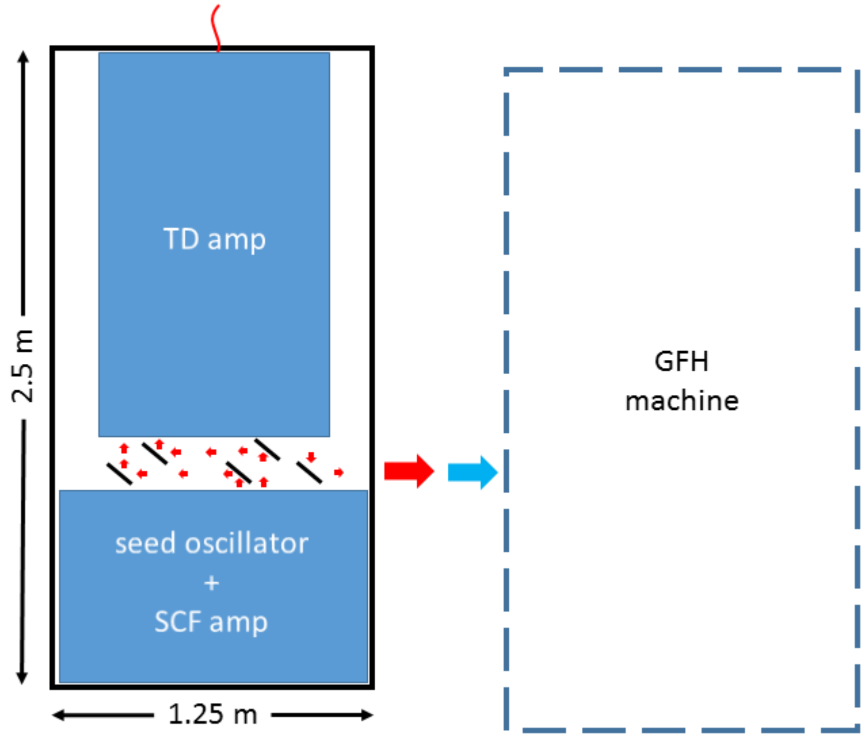

Figure 1: Schematic layout of the HRR system on the laser table.

4. Design and layout details of the housings

4.1 Concept and features of the housings

The two boxes are both based on an optical breadboard. To attach the breadboards to the laser table, posts are mounted underneath. On the topside edge of the breadboard, sealing tape is used to later seal the housing against dust, as shown in Figure 2.

A steel housing is then mounted on top of the breadboard on the sealing tape and screwed down with M6 screws. The housing have a folding lid with a sealing lip. This easy-to-open lid facilitates the build-up, realignment and potential service of the system. The steel housings for the two boxes need to fulfil different functionalities in both cases and will be described in more detail in the subsequent sections.

In both cases, the housings need to have dust-sealed connectors or feed-through ports for all cables and the cooling water supply. The input- and output-windows also need to be dust-sealed and large enough for the according beam size. Further, they need to be anti-reflection coated and ideally wedged to avoid any back-reflections. Both housings are also equipped with connectors for pressurized air input. By applying a slight over-pressure to the housing via these ports, dust and other contaminations can be further reduced.

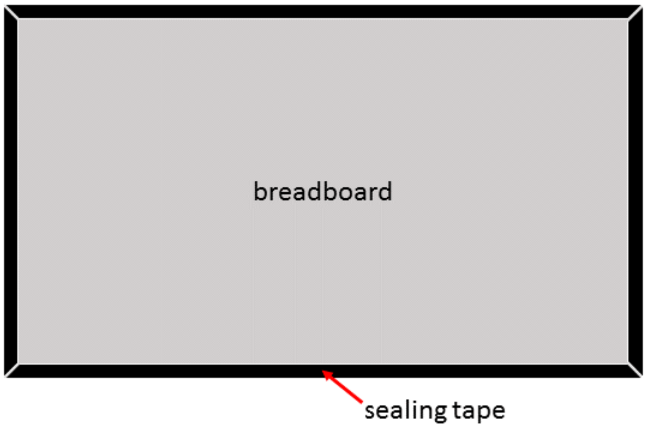

Figure 2: Schematic of the breadboard and the sealing of the breadboard against dust.

4.2 Details of the HRR system

The following section will focus on specific features of the HRR system. Both boxes of the system will be described in more detail.

4.3 Details pre-amp box

The first box contains the seed oscillator, the two acousto-optic modulators (AOMs) for the high-power modulation and the SCF amplifier. Figure 3 shows the schematic layout inside the HRR pre-amp box. All beam-shaping, -routing and other optics between the seed, the AOMs and the SCF amplifier are directly mounted on the breadboard.

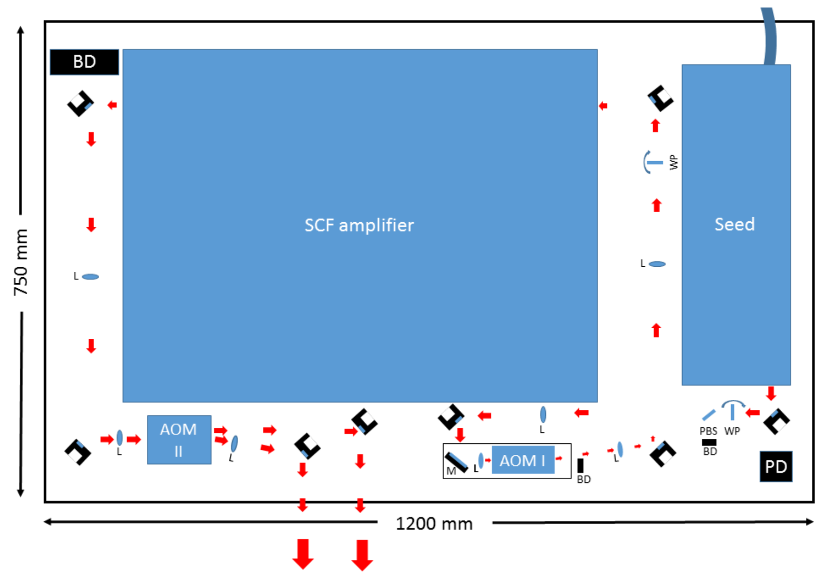

Figure 3: Schematic layout of the first box (HRR) with the seed oscillator, AOMs and SCF amplifier; top view.

In Figure 4, a drawing of the housing and the lid of the first box are shown. Visible are all the openings for the different connectors and the output windows in the housing and the pressurized air connectors in the lid. One of the major challenges for the pre-amp housing is the non-detachable umbilical of the seed oscillator. To ensure that the housing around the umbilical is dust-sealed, a combination of a separate lid and sealing tape was chosen, as depicted in Figure 5.

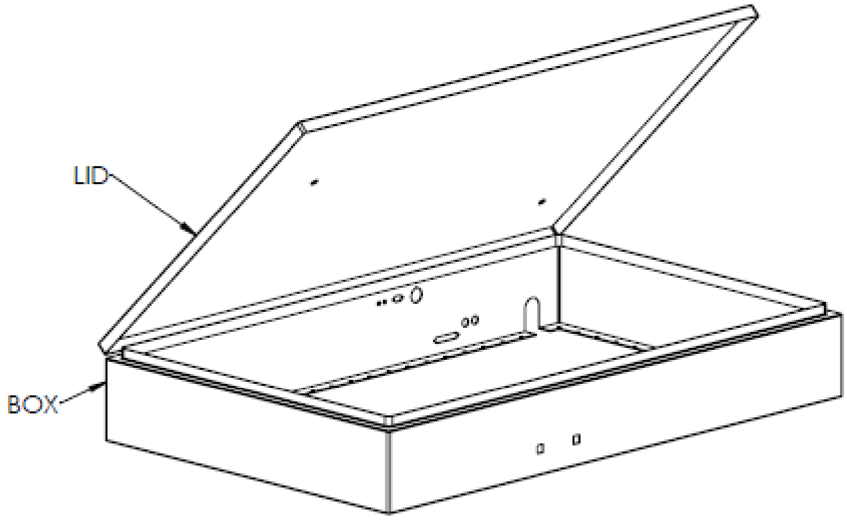

Figure 4: Drawing of the housing for the first box (HRR) with the seed oscillator and the SCF amplifier. The lid can be opened for easy access to the breadboard.

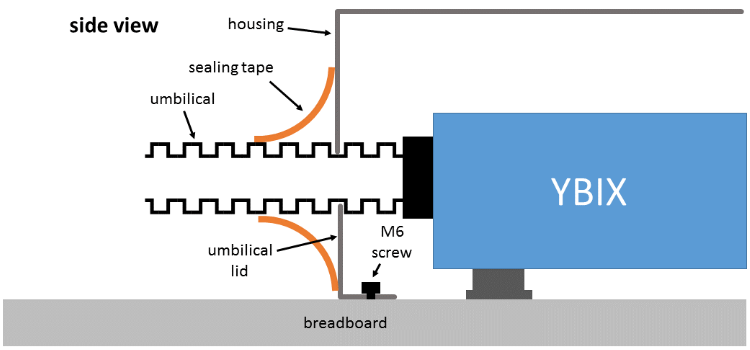

Figure 5: Schematic of the dust sealing method for the seed oscillator umbilical.

4.4 Details TD amp box

The second box contains the TD multi-pass amplifier. Figure 6 shows a schematic layout of the multi-pass amplifier. The shown layout is similar to the final layout, but is only meant to give an overview.

A drawing of the housing for the TD amplifier is displayed in Figure 7. Like the housing of the first box, it has openings for all relevant connectors and the input- and output-windows. A special connector on the right-hand side holds the optical fiber, which delivers the pump light from the laser diode to the thin-disk pump optics. Further, the housing has removable side covers, which enable a quick re-alignment of the amplifier without opening the lid. These side panels are also individually dust-sealed. Additionally, the housing has a transparent, Plexiglas top window which allows to monitor the disk while re-aligning the amplifier.

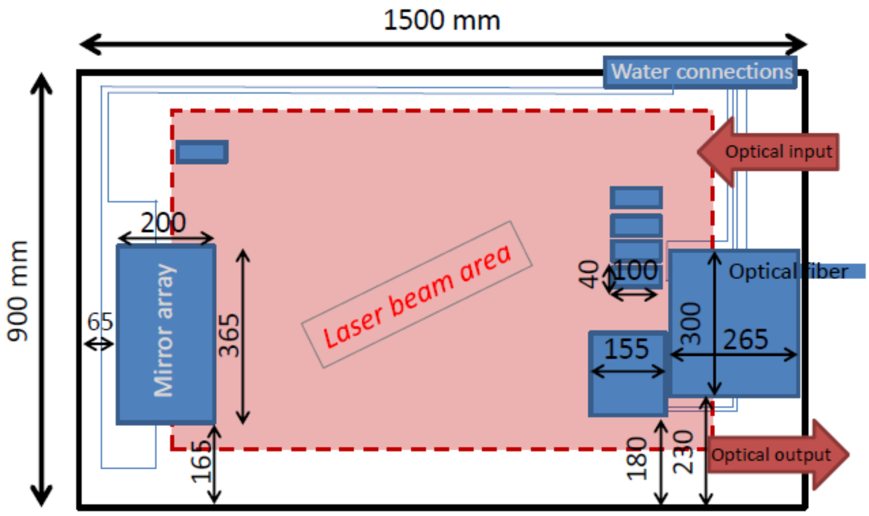

Figure 6: Schematic layout of the second box with the TD amplifier; top view.

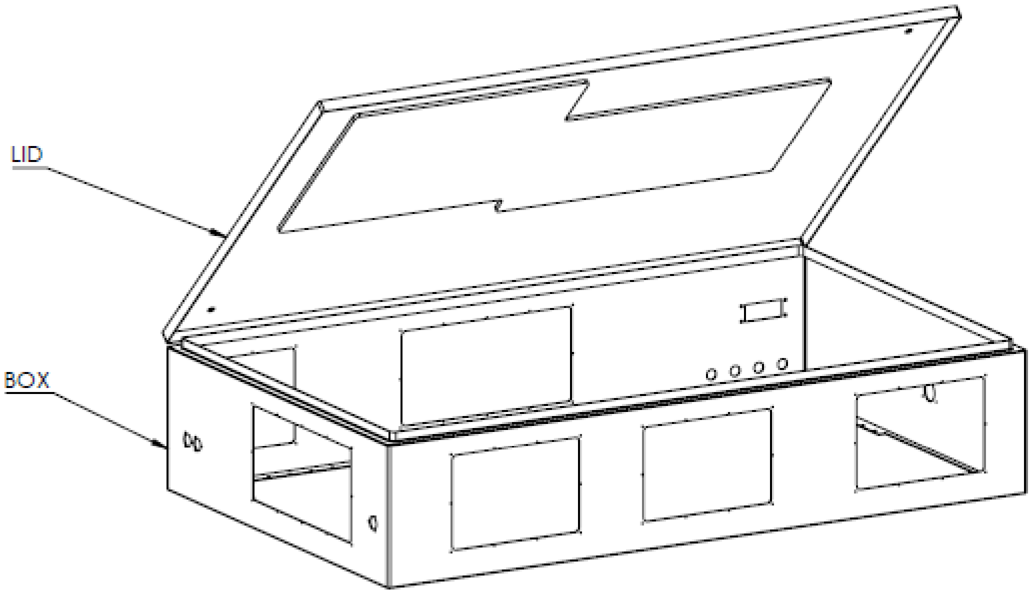

Figure 7: Drawing of the housing for the second box (HRR) with the TD amplifier.

To give an impression of how the complete system looks, Figure 8 shows two photographs of the HRR in the labs at USTUTT. The picture on top shows the first box with the lid open. The blue box is the seed oscillator, the large silver box is the SCF amplifier. In the background the second box is visible. On the left hand side are the power supplies for the oscillator and the modulation electronics. The second picture on the bottom is a photograph of the TD amp housing with the lid closed and all side-panels installed.

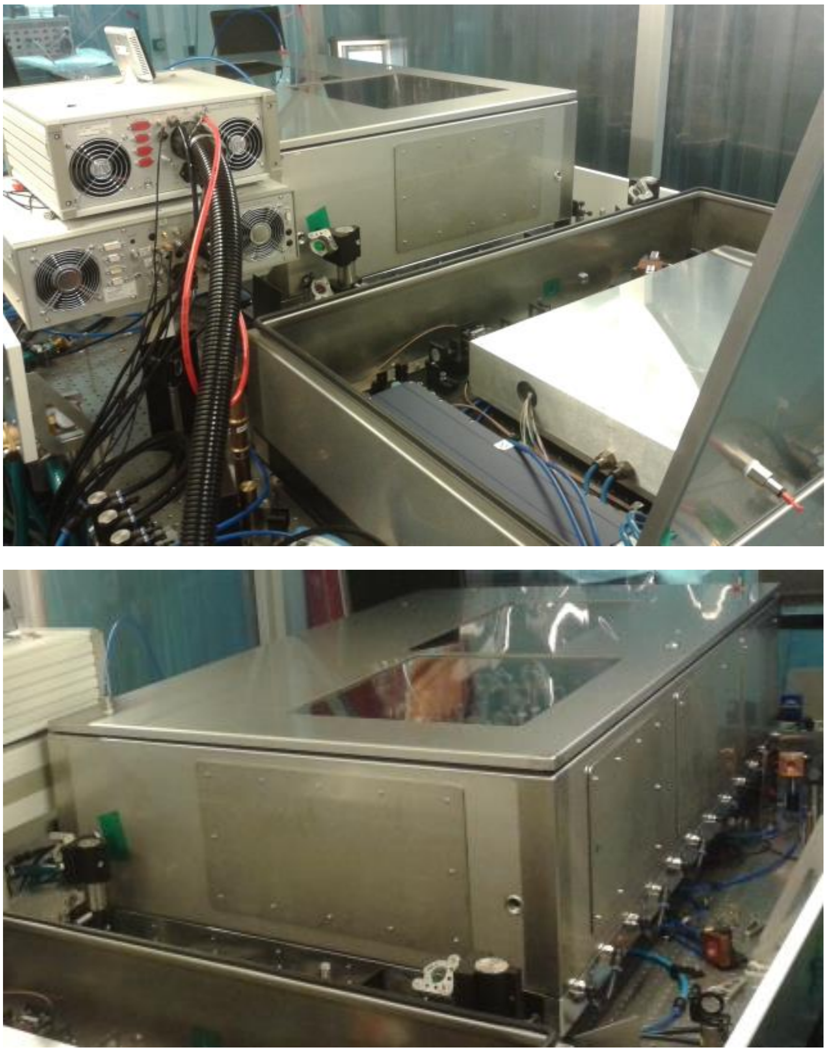

Figure 8: Photographs of the integrated HRR system. Top: First box with the lid open and the second box in the background. Bottom: Second box with the lid closed and installed side panels.

4.5 Details and major differences LRR system

The following section will focus on specific features of the LRR system. The differences compared to the HRR system will also be addressed.

4.6 Details and differences pre-amp box

On the LRR system, the first box contains the seed oscillator, a transmission grating stretcher, an acousto-optic modulator (AOM) used as a pulse-picker for the repetition rate reduction and the SCF amplifier. Figure 9 shows the schematic layout inside the pre-amp box for the LRR system.

The housing itself is identical to the HRR system and thus not shown again. The extra exit port, which is not needed in this case, is sealed. Since the seed oscillators for the two systems have an identical housing / umbilical, the same sealing method is used for the umbilical as previously described.

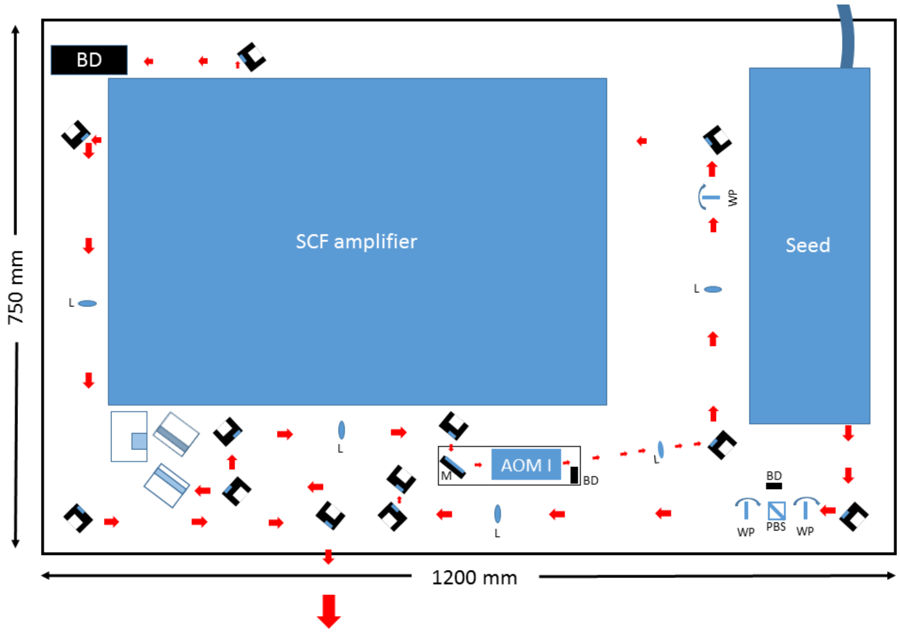

Figure 9: Schematic layout of the first box (LRR) with the seed oscillator, grating stretcher, AOM and SCF amplifier; top view.

4.7 Details and differences TD amp box

Like for the HRR system, the second box contains the TD amplifier. The optical layout of the TD amp is similar to the HRR system and is therefore not shown again. The housing for the second box needed to be modified. It is mirrored and has extra connectors and input- / output-windows for more flexibility. Figure 10 shows a drawing of the modified housing for the LRR TD amp.

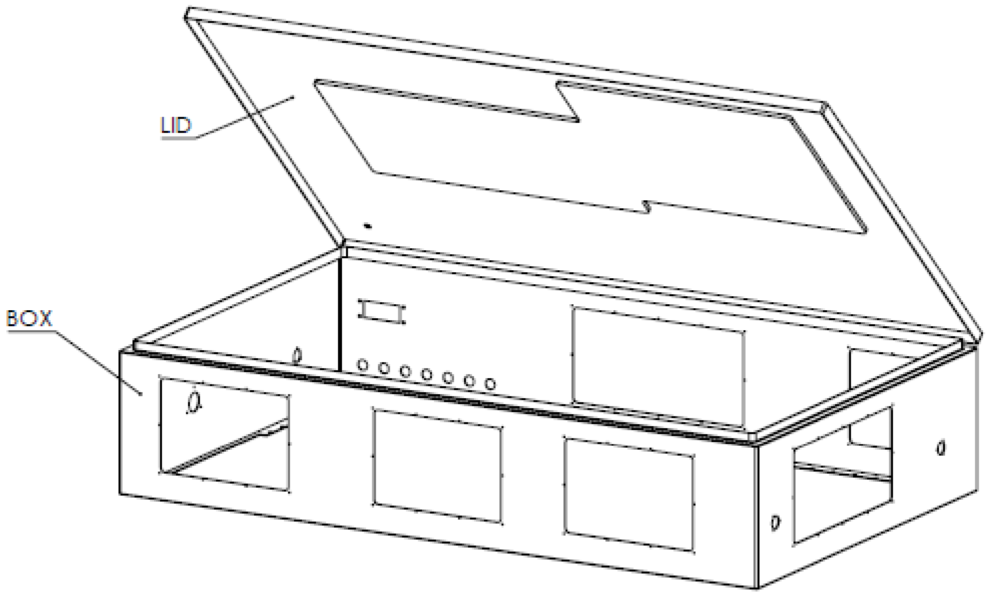

Figure 10: Drawing of the housing for the second box (LRR) with the TD amplifier.

5. Conclusion

In these tasks, a concept for the integration of the complete HRR and LRR amplifier systems was developed and implemented. In both cases, the integrated systems were each built up on two independent breadboards. A robust and dust-sealed housing has been developed to enclose these breadboards and thus enable reliable long-term operation of the systems. The housing includes all necessary connectors and interfaces. The successful implementation of the system integration was important to be able to demonstrate applications later on in the project.

The two deliverables D1.4 and D1.5 are complete. The finished HRR prototype has been successfully installed at the facilities of SLV. It will be used in the next months to develop and demonstrate applications for the HRR system. The LRR prototype has also been completely assembled and tested in the labs of USTUTT. It is currently awaiting the shipment to the labs of C4L. Once it arrives there it will be installed by the involved project partners and used to demonstrate applications for the LRR system.