AIDA-2020-D15.8

AIDA-2020

Advanced European Infrastructures for Detectors at Accelerators

Deliverable Report

Cold irradiations at Birmingham

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10 April 2018

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Advanced European Infrastructures for Detectors at Accelerators

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DELIVERABLE REPORT

COLD IRRADIATIONS AT BIRMINGHAM

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Abstract:

The University of Birmingham irradiation facility is now operational and requires a new cold box with higher cooling power to cope with higher beam currents during irradiation. To achieve the cooling requirement, a more powerful LN_2 cooling system and control DAQ has been installed by The University of Sheffield in Birmingham.

Over the course of the current AIDA-2020 project, different prototype cold boxes have undergone extensive evaluation, the concept is proven to work reliably, preventing silicon sensor annealing [5]. The new thermal box has been fully tested in Sheffield and the final "production" cold box is now ready for installation at Birmingham pending a suitable major maintenance shut down.

AIDA-2020 Consortium, 2018
For more information on AIDA-2020, its partners and contributors please see www.cern.ch/AIDA2020

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Delivery Slip

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Executive summary

The University of Birmingham [U.o.B] irradiation facility is now fully operational and requires a new cold box with a larger volume and target window size. To cope with the increase in irradiation beam current, to reduce irradiation period duration, a more powerful LN_2 cooling system has been purchased and installed with increased nitrogen gas circulation to reduce cold box humidity before and after irradiation running. The corresponding DAQ and temperature control systems are manageable via a user friendly GUI. The performance of the Cartesian robotic scanning system has also been modified to allow for an increased duty cycle to operate at higher speeds.

The University of Birmingham Cyclotron irradiation facility operational schedule provides limited access to enable new development of the system. To ease pressure on the schedule of development for the new, improved cold box without disruption of the University of Birmingham sensor irradiation schedule, a duplicate Cartesian robotic scanning system and cold box has been produced by The University of Sheffield [USFD] and then installed in the new Sheffield Robotics Foundry laboratory. This system is an exact copy of the University of Birmingham system, originally developed by Sheffield, and includes the robotic scanning system and control. The system is additionally used for staff training and the remote debugging of live issues encountered during operational running at Birmingham.

Over the course of 2018, using irradiation running data and evaluation in Sheffield, the prototype cold box has been fully tested and proven to work reliably with better cooling to prevent silicon sensor annealing. The final cold box design components are now produced and the full, new system ready and has been tested in Sheffield. The completed system will be moved to Birmingham in May 2018 when a planned break in the facility operation schedule allows for the installation. Post installation activities will be the subsequent testing and evaluation of the system in the operational environment.

1. INTRODUCTION

The prototype thermal chamber has been successfully installed by the University of Sheffield [USFD] group and has been used for irradiations of silicon sensors [1,2,3], adhesives and components at The University of Birmingham [U.o.B], providing sensor characterisation measurements [4,5,6] comparable to other irradiation facilities. This prototype has now been developed into the final production cold box, due for installation at Birmingham.

The liquid nitrogen evaporative cooling system [2,5,6] and DAQ tested in the production cold box [see Figure 1], can now easily achieve and maintain stable operational temperatures of -25˚C [3], comparable with more powerful prototype cold box short-term cooling power -48˚C, within the thermal chamber [Figure 2]. The thermal chamber configuration, operation parameters and DAQ have been tested and irradiations for qualification of the Birmingham facility are now completed. The facility is now fully qualified [5,6] with stable and optimised running of the system.

The final cold box design (fixed in MS36) and associated components are now produced, ready for installation. Installation, now planned to take place in May 2018, will align with a break in operational schedule of the irradiation facility to allow for the subsequent testing and evaluation in the operational environment.

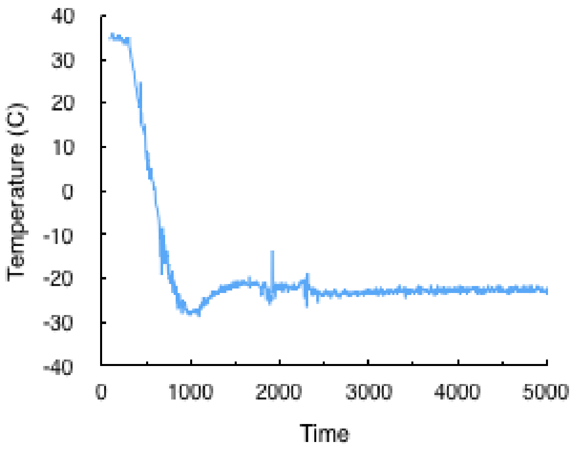

Figure 1: Temperature within the final thermal chamber cooling to a stable operating temperature of -25ºC (2018) [5].

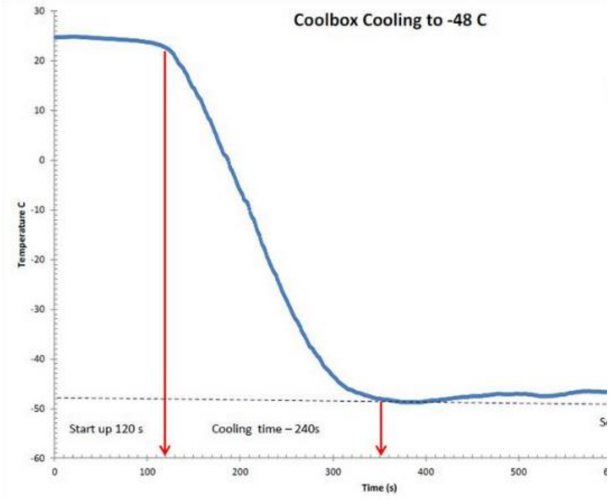

Figure 2: Temperature within the prototype thermal chamber cooling to a stable minimum temperature of -48ºC (2017) [2,4].

2. SUMMARY OF ACTIVITIES

Activities have been slowed down during 2017-18 by the third and final staged relocation of all laboratories within the USFD Department of Physics. This was compensated for by advancing the CAD design and production of all parts needed for the final thermal chamber over this closure period [see Figure 3].

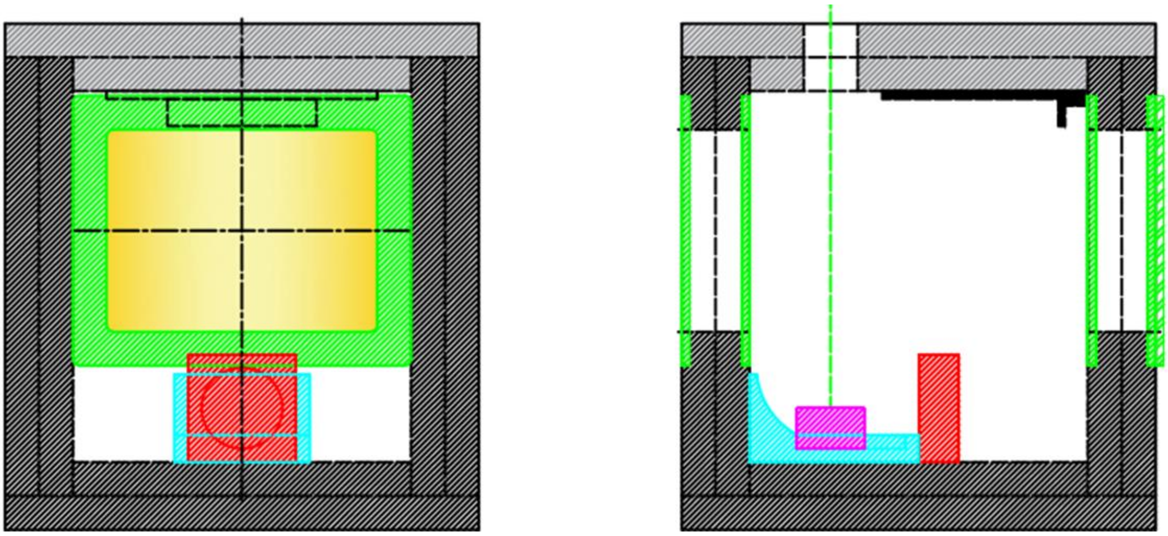

Figure 3: CAD rendering of final cold box design to be installed at University of Birmingham. Front view (left-hand side) and lateral view (right-hand side).

The Irradiation facility at University of Birmingham is now fully operational [1,3,5,6,7]. Access to make any changes to the thermal box has proven to be difficult, finding suitable maintenance halts are not easy to schedule due to the ongoing irradiation of silicon sensors and components taking place. Repeated failures of the Cartesian Robotic system [2,5,7] required prioritisation over thermal chamber development. When operating at higher beam currents, the lifting pillar used to scan objects through the beam failed due to its motor duty cycle being exceed. USFD constructed a new lifting pillar with a higher operating speed [Figure 4]. To accommodate a more powerful servo motor, the pillar could not be as compact as the previous unit. Therefore, the prototype thermal chamber design, required significant modifications, fixed in MS36, when compared with the previous unit shown in Figure 5.

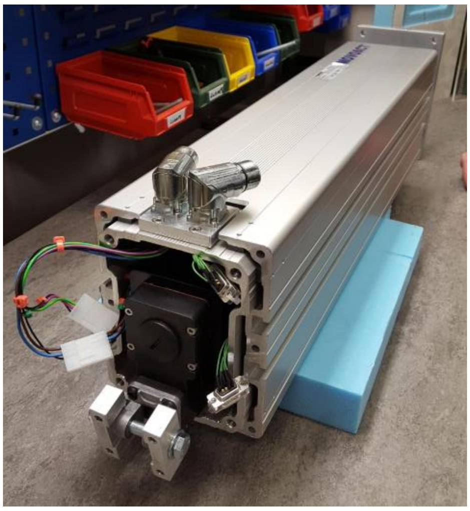

Figure 4: New scanning system lifting pillar developed in Sheffield Robotics.

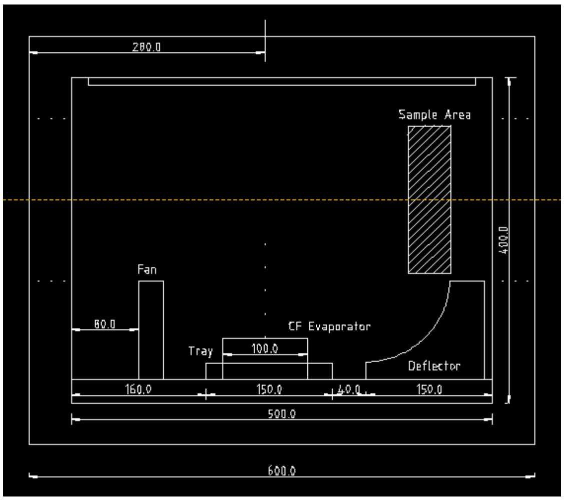

Figure 5: prototype design fully tested through use at U.o.B (2016).

To mitigate delays foreseen and correctly utilise resources in parallel with University of Birmingham activities, spares from the duplicate second scanning system robot [Figure 6] and control system [Figure 7] within the new USFD "Robotics Foundry" were used to keep U.o.B operational whilst the new pillar and adapted thermal box design and testing were undertaken. This duplicate system has continually solved both travel and more importantly access issues faced by USFD working at University of Birmingham with the ongoing active irradiations of silicon sensors and passives [1,3,6].

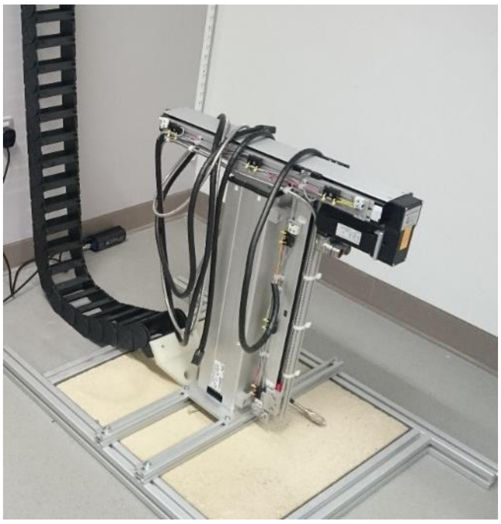

Figure 6: Duplicate Cartesian Robot at USFD.

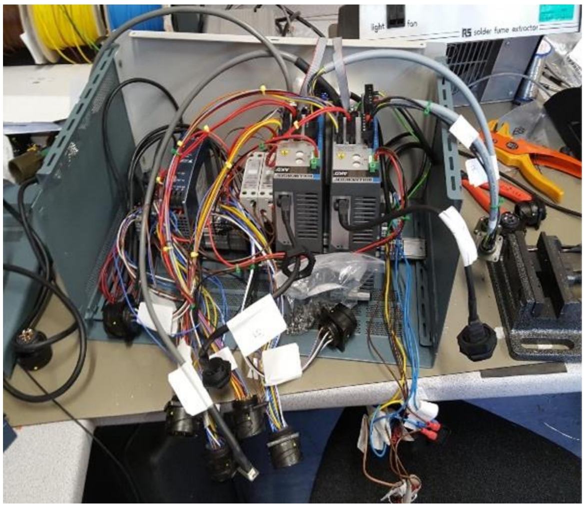

Figure 7: 2017 Reworking of control system for lifting pillar.

The new thermal box or cold box has been fully tested, the concept of cold box evaluated and design fixed. The final production cold box [Figure 8] is now ready for assembly and later installation at Birmingham pending a suitable major maintenance shut down. The new Cartesian Robotic system is now under evaluation at USFD [2,5], any features such as limit and positional sensors are now also being optimised and incorporated into the final production cold box.

Figure 8: New part assembled cold box.

Figure 9: New servo lifting pillars.

3. CONCLUSION

Over the duration of 2017-18, the design of the cold box for the Cyclotron Irradiation facility at the University of Birmingham has been fully evaluated and proven to work reliably with better cooling to prevent silicon sensor annealing [1,2,3,5,6]. An improved servo motor powered robotic system [Figure 9] has been constructed by, and is under test at USFD to allow parallel development whilst maintaining an ongoing irradiation programme at Birmingham.

The final cold box design is now completed and ready for installation. Installation will take place in May 2018 during a break in operation at Birmingham, and the next stages of final testing and evaluation will conclude the project. The deliverable is successfully on schedule

The research and development hardware work carried out by Sheffield, now operational at Birmingham can be copied and deployed in other irradiation facilities, such as IRRAD at CERN. The hardware for generic cold box design developed by Sheffield for D15.8, the commercial off the shelf LN_2 cooling system available from Norhoff and the Cartesian robotic scanning system (USFD) are all proven to work in radioactive environments and with minor software changes, easily reproducible.

4. PUBLICATIONS

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