

LoKI Progress Update

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1 Overview

Even in the current circumstances, the progress of the LoKI project remains good, with manufacturing complete for some major components and underway for most of the rest, and more detector testing and data processing currently underway. In this report we outline the progress on engineering matters and address progress on the action items raised by the STAP in April 2020.

2 Issues for advice

- Scientific Question – The LoKI team have drafted a document detailing data processing work flows for hot commissioning, calibration and a general data reduction procedure for time-of-flight SANS. We would appreciate if members of the STAP could review the document (available on indico), and give any feedback, either for the STAP meeting itself, or separately via email.

3 Engineering

3.1 Covid Impact

- ISIS design team mostly working from home (working at ~85% efficiency due to remote access limitations)
- Pre-build work underway. Reduced personnel, logistical challenges, and difficulties problem solving with design team is slowing progress to ~80%
- Major procurements
 - Guide – significant impact due to lack of neutrons needed for testing and development
 - Large Vessels – no significant impact (FAT & SAT hindered)
 - Jaw set – no significant impact
 - Sample stack – no significant impact
 - Detector tubes – no significant impact (FAT & SAT hindered)
 - ADCs – no significant impact
- Bespoke Manufacture – all progressing well but with 1-2 months lost in most instances
- ESS staff remain WFH, back in the office 1-2 days a week. Delays within the technical groups expected, but not yet completely understood.

3.2 General Progress on the Instrument Components

A more detailed breakdown of the progress of each of the LoKI components has been given below. Briefly, manufacture is complete or underway for the NBOA, guide and vacuum vessels, choppers, in bunker remote handling structures, heavy shutter, collimation and detector vessels, jaw sets, sample stack, straw tube detectors, and beam stop mechanism; manufacture is about to begin for sample snout; detailed design is complete for the shielding; and, finally, instrument hutch, bunker to cave shielding and external infrastructure are undergoing detailed design. Some photos of progress so far are shown in Figure 3.1.

3.2.1 NBOA

- Order placed
- Design completed and sub-TG3 approved

- Manufacture of guide section completed however ~60% of copper substrate sections were scrapped as they did not pass the reflectivity test.
- SNAG is now on process iteration 4. SNAG have good results from sample sections but complete guide sections with this new process have not yet been tested
- All alignment devices manufactured

3.2.2 Guide and Vacuum Vessels (in-bunker and bunker-cave)

- Order placed
- Design completed and sub-TG3 approved
- Manufacture underway

3.2.3 Chopper 1

- Manufacture complete
- Pre-build underway

3.2.4 In-Bunker Remote Handling Structures

- Manufacture complete
- Pre-build underway

3.2.5 Heavy Shutter

- Manufacture complete
- Tests and integration underway

3.2.6 Bunker Wall Feedthrough (plug & alignment devices not included in guide order)

- Manufacture underway

3.2.7 Chopper 2

- Manufacture complete
- Pre-build underway

3.2.8 Collimation Selector Vessel

- Manufacture complete
- SAT completed at ISIS

3.2.9 Jaw Sets

- Manufacture underway by JJ X-ray

3.2.10 Sample Snout

- Design completed and sub-TG3 approved
- Soon to be sent out for manufacture

3.2.11 Sample Stack

- Manufacture underway by JJ X-ray

3.2.12 Detector Vessel

- Manufacture underway (AVS, Spain)

3.2.13 Straw Tubes

- After initial Covid delays, deliveries are rapidly arriving to site
- Construction and test of modules underway at ISIS (~50% of rear carriage complete)

3.2.14 Detector Mechanical Systems including Beamstop Mechanisms

- Manufacture complete
- Pre-build underway

3.2.15 Bunker to Cave Shielding

- 1st pass neutronics completed
- Detailed design completed
- Issues with floor loading, leading to a potential delay

3.2.16 Cave Shielding

- Detailed neutronics completed
- Detailed design completed
- Issues with floor loading, leading to a potential delay

3.2.17 Hutch

- First tender rejected
- Second tender underway after detailed discussion with potential manufactures (ESS responsibility)

3.2.18 External Access & Supporting Systems (crane, goods lift, suspended floor)

- Concept design underway

3.2.19 Service Routes & Racks

- Instrument requirements defined
- Routes defined
- Concept layout generated



Figure 3.1 Photos of some key LoKI components currently under manufacture or pre-assembly at ISIS

3.3 ESS work packages

A number of key ESS work packages are now progressing well:

- Vacuum system design generated – Availability of kit for FAT & SAT now look like the only real remaining areas for concern
- PSS concept and interface definitions largely complete – Design completion for final TG3 looks at risk. Technical challenges seem to be under control
- Chopper controller design progressing well – no obvious risk to instrument project progress
- Detector software in development
- Bunker design and manufacture progressing well – now very few unknowns that effect instrument project progress

A number of key ESS work packages are behind schedule:

- Motion control hardware (control racks & cables, test racks and cables for FAT & SAT)
- Motion safety
- Sample environment
- Mechanical and electrical utilities
- Bunker procedures and concepts of operation (particularly for maintenance and alike)
- General procedures and concepts of operation (particularly for maintenance and alike)

3.4 Installation Planning

With pre-building well-underway at ISIS, we have begun installation meetings coordinated with each of the ESS technical groups (who are responsible for the installation on site). The main purpose of these meetings is to clarify the participation and scope of each group. These meetings will also concern more detailed activities related to installation. We should have access to instrument hall (D03) in the first quarter 2021, with components arriving from ISIS mid-2021, and with main construction September 2021 onwards.

4 Detectors

The straw tube detectors are progressing with manufacture, and building of the modules well underway. Integration of the data processing firmware is being coordinated with STFC and the ESS detector group. Data processing pipelines are being developed in the new data reduction software SCIPP.

4.1 Procurement

- PTI delivered all the tubes necessary to build the rear and the middle detectors: all the 1000 mm and 500 mm long tubes. They have started making the 1200 mm long tubes for the front detectors. The first batch of 32 tubes is due soon.
- Most of the mechanics to assemble the detector modules is at ISIS. The only outstanding items are the boxes at the back of each detector module.
- We have enough B4C shielding to build half of the rear detector, the production for the second half will start soon.
- All the HT boards have been delivered.
- 50% of the preamp boards have been delivered we will start to test them soon
- We are talking to several companies to manufacture the multiplexing boards.
- We will order asap the Ethernet cables that go inside the detector modules.
- CAEN delivered all the ADCs; we will start testing them very soon.

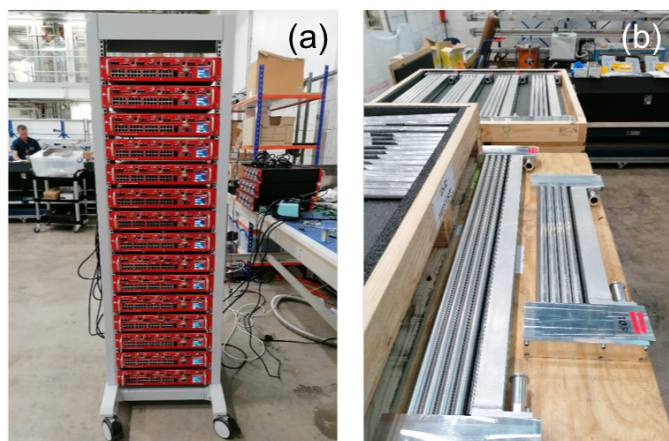


Figure 4.1 (a) R5560 LoKI ADCs ready for testing; (b) Straw tube eight packs (1000 and 500 mm) fully assembled

4.2 Assembly

- We assembled nine packs (8 tubes/pack) of the 1000 mm long for the rear detector, 28 packs will complete the rear detector.
- We assembled two 500 mm long packs.

4.3 Detector tests

- We physically measured all the tubes (1000 mm and 500 mm long): length, diameter, O-ring groove diameter. A few tubes have an O-ring groove diameter smaller than had been specified in the drawings (by $\sim 200\mu\text{m}$). These tubes were used to assemble the first pack. It passed all the vacuum and pressure test that we performed.
- We collected a pulse height spectrum from all the tubes that we received. Five tubes out of 384 had some issues that need more investigation.

- The eleven packs already completed have been vacuum tested. All the packs have a helium leak rate in the order of 10^{-9} mbar/l/s.
- Three packs have been successfully pressure tested at 2 bar for more than 24h.

4.4 Next steps

- Keep building and vacuum test the 1000 mm long packs for the rear detector.
- Test the HT and Preamp boards.
- Get the B4C shielding for the rest of the rear detector.
- Order the multiplexing boards and the Ethernet cables.
- Integrate the detector firmware with the firmware developed by STFC Technology department to transmit data to the back-end electronics.

4.5 Data reduction with SCIPP

As reported at the previous STAP meeting, the data reduction framework SCIPP is now forming the foundation of processing ESS event mode data, replacing Mantid due to significant gains in speed. Currently, Scipp runs as jupyter notebook scripts, with a few Mantid dependencies (e.g. loading NeXus files). The current documentation for SCIPP can be found here: <https://scipp.github.io>

Since April, we have been working closely with the SCIPP software developers (Simon Heybrook, Neil Vaytet) to build and test the data reduction pipeline for time-of-flight SANS data, as well as replicating Richard's script for determining the "direct beam function". The LoKI data measured on the Larmor ISIS beamline is being used to test the work-flows directly.

As the implementation of SANS data reduction in SCIPP has been from the ground up, we have had a reasonably steep learning curve. Some challenges, such as visualisation of the instrument, individual or groups of detector straws, detector masks, have undergone a lot of improvement. However, many features are still under development, such as batch processing.

From the LoKI scientist's perspective, our greatest concern is the usability and reproducibility of the jupyter notebook in its current form. A lot of development is still needed to make it user-friendly, and to deliver all the features that we will eventually need. Nevertheless, the advantages in terms of processing speed are clear, and the team at DMSC have been quick to support any problems we have had so far. Progress is however inevitably slow as the small DMSC team is developing and coding new features for us.

In addition to cross-checking any results against the LoKI test data from Larmor reduced in Mantid, we are also intending to implement SANS2D data reduction in SCIPP. This will have the benefit of allowing us to test the merging of two detectors, details of coordinate corrections, plus being a direct bench mark against Mantid.

Finally, Wojciech, who has recently joined the team as SANS data scientist, will be taking the lead of SANS data reduction in SCIPP.

4.6 Detector simulations

Most of the work in the past 6 months has focused on the data reduction software and data reduction pipeline, as a result the simulation work has stalled. Milan Klaus, a former PhD student in the ESS Detector Group who developed straw tube simulations in Geant4, has just joined the LoKI team to pick up the work already started taking McStas and Geant4 simulations, and feeding the results into Mantid/Scipp for analysis. Specifically, he will be focused on: (a) detector characterisation; and (b) helping to develop calibration and data reduction routines.

5 Monitors

5.1 Design

The design of all of the monitors is well advanced

- The design of both chopper monitors (M0 & M1) is completed
- The design for the halo monitor (M2) is completed
- The beam monitors (M3 & M4) after the sample position are currently under design

5.2 Manufacture

The prototype of the chopper monitor has been built and connected to the first version of the preamplifier. It will be tested on the beam at ISIS the week starting the 12th of October.

Several parts of the halo monitor have been manufactured and successfully vacuum tested. The next step will be to assemble the GEM inside this monitor.

5.3 Electronics

The first version of the preamps has been manufactured and connected to the monitor. The gain and the board layout need some changes to make it more stable and easier to couple to the monitor. The test on the beam of the 12th of October has the main aim to quantify the gain reduction.

5.4 Next steps

- Design, manufacture and test a new preamp board
- Assemble the halo monitor
- 3D print the mechanics of the monitors after the sample position to check assembly procedure