Scientific and Technical Advisory Panel (STAP) Report 'Imaging and Engineering'

October 15 & 16, 2019

Panel Members:
Sven Vogel (Chair), LANSCE
Javier Santisteban, Centro Atómico Bariloche (not attending)
Francesco Grazzi, CNR
Luise Theil Kuhn, DTU (not attending)
Stephen Hall, Lund University
Nikolay Kardjilov, HZB

Date of report:
17 October 2019

Participants

The meeting was held in person with four STAP member (Grazzi, Hall, Kardjilov, Vogel) and representatives of ESS, HZG &NPI (BEER), and TUM & PSI (ODIN) present in person.

Executive Summary

We wish to thank Premysl Beran and Bea Linnenberg for organizing the meeting.

The STAP was pleased to observe a positive energy in both BEER and ODIN teams. The pairs of groups seem to be working together seamlessly and efficiently with much less problems reported between teams as well as between teams and ESS. From an outside perspective, witnessed as annual snapshots, it appears as if the team members grew together.

The level of technical details and project management details reported by the instrument teams is concurrent with stage of the project in our opinion. Aureliano Tartaglione, replacing Michael Lerche who left in spring 2019, was very well integrated and the STAP commends the TUM team for finding such an excellent solution for Michael's departure.

Two issues jeopardizing the progress with BEER were reported: The change of criteria to determine dose outside the cave for working condition (H1) and worst case (H2) were changed based on review of the originally chosen scenarios by the IDR in December 2018. This lead to an increase of concrete wall thickness and the need for steel walls for the BEER cave. The resulting delay as well as increased design and construction cost turned out to be outside the budget for the combined design and construction contract BEER had and the contract needed to be cancelled before construction. To resolve this issue, the BEER team needs a mechanical engineer to help in particular in creating new procurement documentation. The ESS in-kind review of the BEER instrument and signature of the technical annex by NPI are not completed due to the unresolved budget issue for the cave construction and the resulting legal concerns. This problem requires in our opinion immediate attention from ESS to avoid any delays.

The second major issue for the BEER project is that the contract between ESS and HZG is still not signed. Per report from the HZG team, HZG has advanced about two years' worth of funding now and may end advancing funding soon, thus halting the efforts by the HZG team which immediately jeopardizes the progress of the entire BEER project. This contract issue also needs to be resolved as soon as possible.

On the other hand, the STAP is pleased that the MOU between TUM, PSI, and ESS is signed. The issue whether value added tax is to be paid by PSI delayed progress of procurements from PSI. Indications were communicated to the STAP that this issue was resolved during our meeting. If this is not true, the matter also requires immediate attention. Some minor budget issues with the guide system tender were reported, but solutions seemed possible.

ESS reports a likely three months delay of beam on target due to delays in the installation of beam inserts into the monolith. The STAP was pleased to hear that otherwise the overall ESS project is on track. The delay does not significantly affect the schedules for BEER and ODIN.

The teams pointed out that the relatively late announcement by ESS of the changes of the requirements for dose calculations, driving the shielding design, caused problems. While ODIN could resolve the resulting changes, the BEER team suddenly was faced with construction cost outside their budget as mentioned above. . Requirements for the electrical installations are another example reported. The

consensus was that ESS appears to be reactive rather proactive when defining such standards. The STAP points out the opportunity for improvement by changing this posture.

Several charges for the ESS arose that likely affect all ESS instruments, not only ODIN and BEER: Both teams reported that to their knowledge first responders such as fire department or paramedics cannot access the experimental areas due to lack of training. The STAP recommends to the ESS to resolve this problem and communicate the outcome. As a results of the inaccessibility of experimental areas by firemen, the teams were charged by ESS to install sprinkler systems. The STAP recommends to the ESS to evaluate whether the combustible load in the caves warrants this burden. This appears to be an issue affecting all instruments at ESS, but to the knowledge of the BEER and ODIN teams, such an assessment was not done. Similarly, all ESS instrument conducted the operational condition and worst case radiation dose simulations. However, the location of the ESS site wide γ-monitors appears to be disconnected from this effort, omitting potential optimized locations for γ-monitors informed by the locations most likely to indicate abnormal conditions that should lead to an alarm.

Both teams agreed that engineering, procurement, and installation of equipment common to all instruments such as utility panels, beamline hutches, stairs for multi-level hutches etc. could be done by ESS to produce a template from which minor deviations can be defined by the beamline teams, yet still leading to overall cost savings in design efforts, vendor selection, and procurement from the same vendor viz. all instrument teams conducting this effort redundantly.

Progress towards early science is commensurate with the timeline in the opinion of the STAP. A crucial part for both projects is data reduction and data analysis software. Especially data reduction is quite different from existing neutron sources and requires dedicated effort. The STAP is of the opinion that data reduction and analysis requires dedicated resources (DMSC), to which Robin Woracek can be key to the success of this crucial part as he is experienced in both engineering diffraction for BEER and Bragg-edge analysis for ODIN. The STAP recommends to assign required resources as soon as possible to DMSC (and to have them work closely with Robin once he returns from paternity leave as well as the instrument teams) to ensure that data analysis software is available on day one of instrument operation. Both instruments require software that at present does not exist to reach their full design goals or even for basic operation. The budget needs to be made available (to DMSC) to support this effort.

All of these issues are discussed in more detail below.

Charge

- Comment on the progress of the instrument projects in the context of their schedule:

  While ODIN seems to be on track for its operation as one of the first three ESS instruments, the STAP is concerned with the possible delays caused by the increased shielding requirements for the BEER cave, which drove the cost above budget, as well as the threat to the continuation of the HZG efforts due to the lack of a signed contract between HZG and ESS.

- Provide advice on early science for the instruments:

  The STAP agrees that the approach to first characterize and benchmark the capabilities of the instruments against design goals (e.g. resolution, validation of the data reduction etc.) and then

focus on early science is perfectly fine and both teams are on track. Several early science projects were discussed and are outlined below.

- Provide feedback to the instrument teams on their progress and actions to be taken:

  The executive summary listed above was communicated to the instrument teams present at the end of the meeting. Besides the two substantial concerns with the BEER cave and the HZG contract, the STAP sees no major issues with both projects. Both problems are in the opinion of the STAP outside the powers of the instrument teams an require ESS intervention.

- Provide feedback to the Science Director on the progress of the instrument class and any management actions that are needed to support the instrument projects:

  We hope that this report serves this purpose. Actionable items for ESS are listed in detail at the end of the ESS section.

- The findings and recommendations should be formulated in a written report which will be presented at the next SAC meeting October 23-24, 2019:

  See this report, a presentation based on this report to the SAC is scheduled for THU October 24, 2019.

ESS

Andreas Schreyer provided an update on the ESS overall project. A delay of likely three months for the entire ESS project was reported due to problems with beam inserts into the monoliths, but 2023 is still planned to see the start of early science and first users with an anticipated completion of the project in 2025. Andreas reported that 61% of the project milestones are completed, the linac is commissioned, and 2019 saw peak construction activity. The hall where BEER will be located was handed over to start installations there. Ken Anderssen will leave the ESS project and move to Oak Ridge National Lab in the U.S. and will likely be replaced by an ESS internal hire. Kevin Jones joined ESS management from Oak Ridge National Lab. Six out of the eight first ESS instrument have passed their in-kind review with BEER being one of the instruments still missing the in-kind review.

Premek Beran of the BEER team continues to reach out to industry and the ESS User Office appears to support him with guidance as to how access for industry to BEER would happen as well as how investment by industry, e.g. contributing a GLEEBLE thermo-mechanical tester for in situ neutron diffraction, would be rewarded by beam time and support to conduct measurements. This was an issue in the past and seems to be on track to be resolved. During the discussions with the instrument teams, several actions items for ESS management arose that are listed below.

Action Items:

- The changes in definitions of the worst case radiation accident scenarios and resulting requirements for simulations of the operational and worst case radiation doses resulted in a delay of the design of an increased wall thickness for the BEER cave. This drove the project outside the combined budget for design and construction and a contract had to be terminated

as a result. The contract termination leaves the BEER team without engineering support, significantly hampering the ability to even produce new procurement documents. This clearly threatens the progress of the BEER project and needs to be addressed by ESS.

- The HZG team reported that a contract between ESS and HZG is still not signed. HZG has advanced the funds for the BEER project in the past two years, but may end this soon, essentially halting the BEER project. This situation needs urgent resolution by the ESS and HZG management.
- The teams pointed out that the policy of requiring approval for considered scenarios for shielding design was implemented after conclusion of the detailed design of the BEER cave, leading to changes in definitions of worst case radiation accidents scenarios, in turn driving requirements for the shielding calculations, and resulting in changes of the cave design and delays. The change in policy for shielding calculations was communicated by ESS in early summer of 2019, relatively late. While ODIN could accommodate the required changes, for BEER the changes by ESS lead to the aforementioned situation. The design of the distributions systems for electric power and other utilities is ongoing, however, the instrument teams have uncertainties about applicable requirements. Similarly, a decision by ESS to move the bunker wall lead to a redesign of ODIN choppers originally located outside the bunker to accommodate access now within the bunker. The consensus between the teams was the ESS acts reactive rather than proactive with respect to such policies and requirements. The teams point out that such changes incur cost that stretches the instrument budgets or can lead to upset as is the case for the BEER cave now. The STAP sees this as an opportunity for improvement for the ESS.
- The instrument teams point out that all ESS instruments spend resources on common, repetitive tasks such as design and procurement of instrument hutches (for users, control of the data acquisition etc.), utility distribution, neutron beam monitors etc. These could be done to a large fraction by ESS as they are common to all instruments, with only minor modifications by the instrument teams. In the opinion of the STAP, such an approach offers great potential for substantial cost and effort savings and also mitigate the uncertainties of the instrument teams with applicable codes and regulations. The ESS “common monitor projects” appears vastly dormant to the instrument teams.
- In several instances it was pointed out that the information exchange between all ESS instrument teams during the recent IKON meeting was very useful. Vendors for shielding, solutions for the phase stability problem of the chopper cascades, or information on the PSS systems were examples. While more frequent meetings are not desired, it begs the question to the STAP whether ESS could facilitate information flow otherwise, e.g. by mailing lists where questions such as “What prices do other teams get in quotes for shielding material?” or “Does

anyone have insight on question X related to the PSS system?" could be posted or announcements to all members of the instrument teams can be made in an informal way.

- The instrument teams reported that first responders such as firemen and potentially paramedics will not have access to experimental areas due to lack of training. This requires a solution from ESS and should be communicated to the instrument teams.
- Related to the former limited access by firemen to the experimental area, the instrument teams were charged with installing sprinklers in the instrument caves. The STAP suggests to evaluate the combustible load in the caves to see if this substantial effort is actually required.
- The instrument teams reported that γ-monitors in the experimental areas will be installed in locations that are independent of the shielding locations. It appears to the STAP that hereby an opportunity is missed since the calculations provide the most likely hot spots indicating abnormal conditions and therefore unnecessary exposure of personnel and users. The STAP suggest to ESS to consider the outcome of shielding calculations to inform the locations for γ-monitors.
- The BEER detector team requires the format of ESS facility time stamps from the ICS team to continue development of soft- and hardware for the BEER detector development.
- The distinguishing feature of the ODIN beamline are the wavelength dependent imaging modes. For material characterization, in particular pixel-by-pixel Bragg edge analysis is in the opinion of the STAP absolutely crucial for the success of ODIN as ODIN otherwise competes with the NEXT imaging beamline at ILL with little chances of being superior. Similarly, the data reduction for the BEER beamline has never been tried. The STAP therefore wishes to emphasize to ESS that support for software development for ODIN as well as BEER should receive as much support as possible. While data reduction for BEER affects all diffraction beam lines, ODIN can only fulfill its promise if suitable Bragg-edge analysis tools are developed.

ODIN & BEER

Both beamlines are interfacing with the ESS project management and lead engineer. Allocation of resources for installations etc. appears to be on a good path from the information presented to the STAP.

Data reduction is crucial for both instruments and in particular data analysis for ODIN of Bragg-edges is essential for the success of ODIN. Due to his experience with Bragg-edges as well as the data processing of diffraction data for BEER from the V20 beamline at HZB, return of Robin Woracek, on paternal leave at present, is deemed crucial by the STAP for data reduction on both BEER and ODIN. Appropriate resources need to be made available to support this software effort, guided by experimental data and experience as well as simulated data (to which Robin should act in coordination role).

Action Item: ESS need to ensure that data reduction and data analysis receives required resources (DMSC) to process data on day 1.

ODIN

The STAP is pleased to experience that the transition from Michael Lerche to Aureliano Tartaglione was successful. The STAP stresses that this was crucial for the continuity of the ODIN project.

The TUM part of ODIN has completed the shielding calculations for operational and worst case conditions and revised the cave design accordingly. The main issue appeared with the floor loading

requirement of maximum 14tn/sqm, but a preliminary solution was found by increasing the footprint without scarifying the cave interior useful area. The wall will now consist of 300mm steel and 300mm concrete, plus an interior lining of 5-10mm of borated absorber. Chicanes for cable access etc. were presented. The heavy shutter was selected from one of the concept designs proposed by ESS, however, the STAP was somewhat surprised by the design goal of only 98% reliability for such a crucial component. If the shutter is moved 10 times per day, every ten days a failure will occur. Is this reasonable?

Action Item: Clarify the reliability requirement for the heavy shutter.

Testing of the prototype T0 chopper (DREAM version) will commence in June 2020 (ESS-Mirrotron contract) with contracts signed with Airbus for disks chopper systems. Collaboration with Airbus improved the system design.

PSI had published the tender for the guide systems and received an offer from Axilon/Swiss Neutronics which is under negotiations, e.g. to reduce cost by receiving approval from ESS to use glass substrate instead of metal substrate. The cave interior design lead by the PSI team is evolving. Time-of-flight imaging detector concepts from ISIS, J-PARC and UC Berkeley are evaluated. The ODIN team stated that the decision of a detector technology will be delayed as long as possible to be able to procure the most recent generation available. While the STAP agrees with this decision, we suggest to inquire with the potential vendors about their lead time and possible collaborations on technology developments and derive a drop dead date for the procurement from this information.

Action Item: Inquire about lead time for detector procurement for each vendor and estimate date for procurement.

The issue of whether PSI has to pay value added tax for in kind contributions was not officially resolved, but word was received during the meeting that a solution for this long standing problem is finally imminent. The issue of beam monitors, in particular to monitor chopper status to control the chopper cascade, continues to be worked on with different approaches discussed. As pointed out above, this problem is shared with other instruments, offering an opportunity for ESS to offer a standard solution for beam monitoring with the concomitant opportunities for cost savings in design, procurement, interfacing with data acquisitions, and maintenance.

The issues of the number and location of beam monitors for ODIN, reported as an unsolved question in the now three previous STAP meetings, is has been resolved and three locations were identified. While the exact solution is still under design, a solution was found that allows to control the chopper cascade as well as provide data to normalize with the incoming flux.

Action Item: Provide update on beam monitors as these may affect design as well as data reduction strategies.

The PSI instrument scientist will move to Lund in June 2021 with monthly presence of one week at Lund until then. This appears commensurate given that construction of ODIN cannot commence until then.

Software development, mostly driven by PSI, reports ramping up of the collaboration with DMSC. PSI software development moves towards being more specific to ODIN rather than more general neutron radiography and CT like muhRec. The team starts to develop the Bragg-edge analysis – core capability of

ODIN. So far the only available solution, the Japanese RITS code, is somewhat buggy and hard to use. Software investment for ODIN should be centered on Bragg-edges, i.e. the distinguishing feature of ODIN, to avoid competition with the CW imaging at ILL, and is crucial.

The ODIN team presented ideas on early science and first experiments. Since imaging is distinctly suitable to communicate "scientific accomplishments" to the general public, the STAP commends these plans as they can provide "brownie points" from ESS to ODIN by providing positive headlines for ESS. While not utilizing the ESS beam in particular, characterizing famous objects the general public can relate to such as the Nebra disk, components such as nails from the Vasa ship, or parts of the destroyed Moranti (?) freeway bridge in Italy using neutron imaging are likely to cause the desired attention in the public. Outreach to plan such experiments should continue (archeologists at Lund Universty?) with the obvious caveat that scheduling high value samples such as the Nebra disk should only occur after operational reliability has been established.

BEER

The STAP is pleased to observe that Premek Beran's move to Lund a year ago has provided great benefits for the project. The STAP specifically commends Premek for continuing to reach out to industry for engagement in the BEER instrument and especially providing capabilities such as a Gleeble machine. A new design for such a device is available from the vendor, but questions remain open how much adaptation for in situ neutron diffraction experiments are required and possible. Previous issues, such as policies for industry engagement, the alignment of samples as well as the type of collimators (pre-fabricated fixed geometry vs. motion controlled slits) progress towards a solution, e.g. by visits to the TAKUMI beamline at J-PARC.

Action Item: Continue to work with ESS on defining policies to reward and define legal commitments with industry for providing capability (Gleeble) as well as long term engagement. Continue to reach out to existing engineering diffraction instruments for information on their incident collimation and sample alignment solutions (what works, what would the teams at these instruments do better).

The shielding calculations were concluded with the resulting issue of the budget for the combined design and construction contract discussed above. This clearly needs a solution as soon as possible, in particular an engineer assigned to the BEER project.

Action item: Work with ESS and others to produce procurement documents for the cave to avoid delay of the construction.

The cave interior design continued with more detector positions, chicanes for access, floor load management etc. being presented to the STAP. An issue between the participating teams relating to liability of the two partner institutions for failures of the other team was reported. This legal issue should be resolved between ESS, NPI and HZG.

Action item: Work with ESS, HZG and NPI to clarify liability.

Due to the aforementioned problem with the absence of a signed contract between HZG and ESS, the NBOA procurement was taken over by ESS to avoid delays. For the STAP, such measures are concerning. Per report given to STAP, HZG has advanced the funding for the project for two years now. Given that procurements, in bunker installations etc. are imminent and delays are already reported, resolution of this situation is of paramount importance.

Action item: Resolve the contract situation between ESS and HZG.

The detector development lead by HZG is proceeding with several tests reported to the STAP, including mechanical stability of the large detector panels. The ESS ICS team needs to send the format of the timing stamps to the HZG team for incorporation in the detector output data format to continue testing. The BEER team has provided simulated data to DMSC for development of the data reduction.

Action item: Continue to work with ICS team to obtain timestamp data format for detector.

For early science, measurement of bulk textures was presented. The STAP commends this proposal as this is in Europe at this time not routinely offered by neutron diffraction and thus interrogating cm^3 volume is a niche BEER can strive to fill. We suggest to participate in the current neutron texture round robin and characterize the suite of samples of this round robin as this will either establish the suitability of BEER for bulk texture and microstructure characterization or identify problems that need to be tackled. As a connection with local science it might be useful to explore the potential to study texture evolution in ice to validate deformation models for glaciers – there seems to be a group at Lund University potentially interested and neutrons are uniquely suited to study this. Movement of glaciers affects rising of sea levels and thus would offer a rare opportunity to contribute with neutrons directly to climate research. Potentially a cryogenic temperature deformation rig could be developed (or taken over from LANSCE) for in situ studies on either H_2O or D_2O ice. Similarly, there seem to be opportunities to utilize the large cave to characterize geological drill cores non-destructively. This has been done with neutrons on sample prepared out of the cores, but might be possible on BEER non-destructively. Again, a group at Lund University exists that has interest in such studies.

Action item: Establish connections with international texture round robin as well as scientists at Lund interested in deformation of ice and geological drill cores.

For strain measurements the STAP suggest to install the detectors early on also in the back scattering location and demonstrate the resolution for strain e.g. with CTE measurements in a furnace.

V20 ESS Test Beamline at HZB

The V20 beamline has ~two months left and beamtime for ODIN development is scheduled.