Neutron Optics and Shielding Group
TG2 Summary
HEIMDAL Instrument

Review

Date
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2017 TG2 Round for ESS Instruments

Technical Reviewer:
Phil Bentley

Input received from
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Preamble

This document is the review summary of the instrument's optical and shielding system preliminary design. Systems outside of this scope have not been considered, except where they significantly impact on optics and shielding.

1. Executive Summary

The reviewer considers that from the *perspective of optics and shielding systems* the concept of the design is sufficiently complete and mature. However, there are significant deficiencies in working practice and risk assessments.

2. Proposal Grading

For each item, a grade is given for the preliminary system design (column "NOSG Status"),

"GREEN": All aspects of the criterion have been addressed satisfactorily to permit endorsement by the NOSG to the detailed design phase.
"ORANGE": Some aspects of the criterion have not been addressed satisfactorily. However, if minor changes are made to the documentation or system then NOSG endorsement may be possible.
"RED": Some aspects of the criterion have not been addressed satisfactorily, and there are reasons to doubt they can be achieved without significant work. Currently it is not recommended to proceed.

Grades are indicated as traffic lights:  = green,  = orange,  = red.

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Criterion	NOSG Status	Comments
Has adequate planning been done to move the project into Phase 2?		The scope is not at all clear, particularly regarding the cold guide, as detailed below.
Is the proposed budget consistent with the proposed scope?		
Does the preliminary design satisfy the requirements?		Related to the scope
Is the presented baseline technically sound?		
Has anything been forgotten or neglected?		Version control on simulations
In case where several In-kind partners are collaborating – are roles and responsibilities adequately defined and agreed?		
Have safety-related aspects in accordance with ESS-0043330 ref [6] been appropriately considered?		
To what extent have appropriate connections been made with the critical project interfaces, such as software, data storage hardware and sample environment?	NA	
Has the instrument context been appropriately considered in terms of physical interfaces, such as bunker, beam extraction, ICS etc?		
To what extent have available engineering standards been implemented appropriately?		
Are the cost and duration estimates reasonable?		
To what extent has the team planned appropriately for the risks, both technical and otherwise?		

3) Currently Identified Issues

Most of the issues are linked to optics. We felt that the shielding work is of a high standard and more than sufficient at present.

1. **Description of the system**: The instrument team does not include a detailed description of the geometry of the guide in table 1 in the Preliminary System Design (PSD) as the rest of the elements of the instrument in the PSD. The geometry of the transport optics is justified to be elliptic-ballistic in the PSD. However, the separate report on optics only presents an elliptic guide with the comment that it is planned to become ballistic. The parameters of the geometry should have already been determined and described in detail for TG2. It is more important to note that no detailed description of the coating distribution of none of the guides is included in any of the documents. Taking into account that this determines in a great extent the cost and performance of the guide, this must appear in the TG2 documentation in order to review the consistency of the claims made by the team.
2. **Justification of the chosen geometry**: The chosen geometry is justified by comparison with two other alternative configurations (a double ballistic configuration, and a kinked double ballistic configuration) as it is stated in ESS-0059811 in different categories. The assessment is shown in Table 2 of the PSD and no further discussion can be found in both the PSD and in the separate report on optics design. As performance and cost depend strongly on geometry and coating distribution, there is no detailed description of them in any of the studied configurations. There is no discussion of robustness and risk of the options apart from what is said in the table. The conclusions reached are the same as they appear in DREAM. However, in the case of DREAM the choice of a straight beamline with a T0 chopper was a more reasonable option basically because of the length of the instrument. In the case of long instruments, there are examples of instruments with the same need of transporting thermal neutrons that use successfully curved or kinked geometries (like T-REX and MAGIC) with an efficient fast neutron background suppression which are well optimized in performance and cost. Alternative designs inspired on the solutions found in T-REX or MAGIC seem to have been excluded from their analysis. For example, if we check the T-REX optics design report, we would find that their design delivers a brilliance transfer for the same wavelength and solid angle range that is similar to the HEIMDAL thermal guide baseline (this report is available in Indico). The report on optics design says that the team has considered curved geometries and that their performance was the most promising among those losing line of sight, but these weren't included in the analysis of alternative designs in the PSD. There is no alternative guide design comparison of the cold guide despite the report on optics design says it can be

found in a report that has not been included nor in the TG2 documentation, neither in their Confluence page.

3. **Upgrade path of the cold guide**: The TG2 documentation shows that the cold and the thermal guide will be sharing the same vacuum housing after the bunker. This would be a reasonable design constraint to pursue if both cold and thermal guides would have been in the scope of the instrument and would have been installed at the same time. However, that is not the case, and the installation of the upgraded transport optics would involve removing long sections of the thermal guide, gluing the cold guide sections together, and installing and aligning the whole assembly again. The team should consider if such an upgrade path is faster and easier than using separate vacuum housings and making provisions in the guide support design for the easy installation and alignment of the cold guide sections in the future. The ESS considers the cold guide part to be out of scope for the remainder of the report.

4. **Robustness of the cold guide (out of scope)**: The team has written a section in their report on Optics design justifying that the cold guide will be robust enough and that losses by misalignments are acceptable. Regarding the positional misalignments, 2s=50mm is considered a very worst case scenario, which is, according to the experience and consulted experts, far too optimistic. In fact, during the Standard Optical Bench Project, this very worst case scenario was estimated to need an active realignment system, see for example the PID of the project (ESS-0044745). Regarding the floor movements, there are no simulation results to prove that such angular misalignments would lead to acceptable losses, it is only said that the phase space is large enough (in the divergence side) to compensate for such beam losses. This should be easy to implement in a simulation code. The only mitigation strategy observed by the team is to simply increase the m in the coating in strategic places, but there is no more details on where it has to be applied and the uncertainty in the cost of the cold guide due to such strategy. There is no consideration on the increase of the cross section of the cold guide, which would lead to a more efficient and cheaper strategy to mitigate the risk of heavy losses, which was what NMX team did in their case.

5. **Cost estimations**: The budget in Optics is clearly underestimated. 2.5 Meuro is even lower than the budget in BIFROST (estimated in 2.6 MEuro), which is mainly a cold instrument and does not have an extra guide. According to the BIFROST budget, the guide was costing around 2.0 MEuro with the vaccuum housing and supports costing 600 Keuro. However, HEIMDAL estimates the thermal guide cost (in the Optics design report) in 2.2 MEuro, although we don't know if that includes the supports and vaccuum housing. According to our estimations, 26 m of a 2 x 2 cm2 guide with Ni coating and metallic substrate would cost around 300 Keuro, without taking into account vaccuum housings and support. In comparison with other long thermal instruments, like BEER, MAGIC or T-REX, their Transport Optics

budget is in the vicinity of 3 MEuro, the HEIMDAL estimation seems too low to be within the scope.

6. **Risk assessment**: The risk of low optics performance is way underestimated taking into account the robustness issues discussed before, and therefore, accepting lower performance would compromise the scientific success of the instrument. It is also important to note that T0 chopper failure is one of the highest risks estimated by the team, which clearly contradicts their optics assessment in which a guide design with direct view was considered less risky than a kinked guide configuration, which eliminates completely this risk. We don't see how a kinked or a curved guide would be riskier than a straight guide. Finally, late delivery is considered with a likelihood of 1, which we consider too optimistic. We consider this to be highly likely, and possibly a certainty, for latter instruments. The workload of guide suppliers due to other instrument projects within ESS and other projects outside ESS seems to be an important issue to take into account in the risk assessment.
7. **Substrate determination**: According to the team, the instrument will follow the NOSG standards, stating that metallic substrate will be use where necessary. This is a cost uncertainty that has to be taken into account. The report on substrate lifetime (ESS-0097645) can help them on having better estimates in the substrates needed outside the bunker (inside it has to be metallic).
8. **Scope of work**: The instrument team places the optics inside the NBOA inside the scope of ESS. The optics must be inside the scope of the instrument.

4. Detailed/other comments

The project has not followed NOSG procedures on version control [ESS-0059811], i.e. the simulation source code commits do not appear in our repositories.

Additional Notes During Meeting