2018 Tollgate 2: FREIA
Detector Systems Review

Date: 17 January 2018
Reviewer: Francesco Piscitelli, Richard Hall-Wilton

Preamble:

This document is the review of the Tollgate 2 document of the instrument technologies for the proposed instrument "FREIA".

Executive Summary

The reviewers looked from the *perspective of detector technologies* at the Tollgate 2 documents. The documentation is in general clear and complete. The reviewers note that the level of detail mainly about beam monitors and sometimes about detectors is sparse in the Tollgate 2 documents provided, and would benefit greatly from more.

Therefore, the reviewers **grade the TG2 documentation: "GREEN".** See comments for details of what needs to be added. Most of the comments relate to the clarification of some points in the documents provided; based upon discussions - many of these have already been clarified.

The summary of the review is as follows:

- The reviewers consider that from the *perspective of detector system technologies* the preliminary design is sufficiently complete and mature.
- **Maturity:** The requirements need to be expanded in more detail to commence the detailed engineering design phase. However, the requirements for detectors are presented in a clear understandable fashion. Requirements for beam monitors must be clarified.
- **Compatibility:** The plan is compatible with ESS standards, if executed as expected.
- **Feasibility:** The overall system performance requirements presented in the concept are technically feasible solutions. The complexity of the system outlined in the

base proposal is moderate. The one exception is the beam monitor requirement, which needs to be described in more details.

- **Risks:** The principal risk is of a lack of a beam monitor system that matches the requirements, this could affect the schedule if a development plan is needed.
- **Budget:** The total cost indicated for the detector systems is considered to be well estimated within a suitable uncertainty expected for this at this stage.
- **Schedule:** The schedule appears reasonable.
- **Communication:** The team has communicated effectively with the detector group.

Detailed comments:

About Beam Monitors

- In the document Concepts of Operations Description p.12, the need for adequate diagnostics in the neutron optics and chopper systems is expressed but it needs more details why are needed in exactly these positions and where, and if, can be omitted along the line. The requirements and purpose need to be stated.
- In the Preliminary System Design Description for the FREIA instrument p. 20, diagnostic monitors should be ideally included in front of every chopper, we discourage the use of too many monitors along the guide in positions of not easy access for maintenance/fault repair purposes. However, whether those monitors can be retracted from the beam or left permanently or parasitic measurements can be taken, if cost permits, this will change the design and the number of monitor that are allowed in inaccessible areas.
- If monitors are moving, it should be noted that the reliability of this should be considered, and moving monitors in/out should not be encouraged, unless strongly needed.
- In the document System Requirement Specification for FREIA instrument p. 7, the requirement for measuring the flux at major optical components in the neutron delivery system and prior to the sample is a must without causing a significant reduction in neutron flux or increased background, this must be quantified as well as how much a certain amount of flux reduction or background affect the science.

About Detectors

- The system requirements for the detector system are reasonable, however the counting rate capability exceeds the current state of the art technology of a few

orders of magnitude. Moreover, the spatial resolution needed is 3 times smaller than that of the state of the art technology. The Multi-Blade technology has been stated as the preferred option for the FREIA detector system, which is being developed and has already achieved the needed spatial resolution; about the requirement on rate capability, there is no technology at present that can handle this rate and however the Multi-Blade is designed to achieve these rates it has not directly measured yet. Moreover, anything above that should be considered as a plus.

The implications of achieving something which is between the state-of-the-art but below the full requirement for the instrument should be stated. It will be difficult to verify the rate requirement as stated prior to operation of ESS at maximum power.

- In the document Work Package Specifications p. 8, define detector vessel and the tank, i.e. the vessel to reduce the air scatter in the secondary flight path, to avoid confusion.
- In the Preliminary System Design Description for the FREIA instrument p. 25, and in other documents, both the vessel to reduce the air scatter in the secondary flight path and the enclosure of the detector itself are called vessel in the text. Whether these two are the same item or not a different name would help to clarify the text. We call here tank the vessel to reduce the air scatter in the secondary flight path and vessel the detector enclosure.

  We can foresee two options:

  1. a detector vessel inside the tank at its bottom or a tank
  2. a detector vessel which is outside the tank and attached to its bottom through an interface that can also be the detector window.

  We recommend the 2nd option for maintenance and routing purposes.

  Note that in both options the tank in in vacuum or Ar atmosphere whereas the detector vessel is flushed with Ar/CO2 near to atmospheric pressure (100mbar above atmospheric pressure). Even in option 1 the two atmospheres must be distinct.

  Moreover, a gas inlet and gas outlet must be present plus an Ar/CO2 supply at the detector position, either gas bottle or from elsewhere. The gas consumption is foreseen to about 1 detector vessel volume per day <100l/day.

  In general, the detector vessel should be connected to the outside world with either 2 or 3 bellows. One should be strictly dedicated to cooling services (liquid) and only this. The other two are for both inlets and outlets of services and allow an additional air flow. Recommend is 3 bellows. The services in the 2-remaining bellows are:

  - 2 gas pipes (in/out) diam. 6mm each.

  - Optical fibers 5cm diam. in total

- LV 5cm diam.
- HV 7cm diam. in total.
- Extra space for future services and expansions.

We strongly recommend to electrically insulate the detector vessel to anything else for grounding/noise reasons, so in both options the vessel should not be electrically connected to the tank. The grounding must comply with the ESS grounding guidelines.

- In the document System Requirement Specification for FREIA instrument p. 8-9, requirement specification 25 (efficiency), 26 (spatial resolution), 27 (ToF resolution), 28 (Angular resolution), 29 (Angular coverage), 30 (Detector positioning range), 31 (Detector positioning), 34 (Detector Noise) and 36 (Beam centre determination) are feasible. In particular 26 (spatial resolution) has been achieved with the Multi-Blade detector technology beyond what is possible with technologies at present.
  On 32 (neutron selectivity) those are figures measured with the Multi-Blade and not requirements. A figure must be set according to the acceptable level of fast neutron and/or gammas that can be detected without affecting the science, in the particular configuration, performed at the instrument.
  On 33 (rate capability), there is no technology at present that can handle this rate and however the Multi-Blade is designed to achieve these rates it has not directly measured yet. Moreover, anything above that should be considered as a plus.
- On 35 (secondary scattering), this requirement is vague and must be quantified, a different level of acceptable secondary scattering can drastically change the engineering of the secondary flight path. It must be stated clearly what is the key point for the scientific case to minimize the window scattering.
- In the Preliminary System Design Description for the FREIA instrument p. 24, about the requirement on rate capability, there is no technology at present that can handle this rate and however the Multi-Blade is designed to achieve these rates it has not directly measured yet. Moreover, anything above that should be considered as a plus.

Notes:

- In the document, Initial operation and staging plan p. 10, the full divergence option has been tested on CRISP at ISIS with the Multi-Blade detector. On rates a test will be held this year at SNS, current limitation on rates is the DAQ.
- Initial operation and staging plan p. 11, the detector will be fully built and only a part of the electronics will be installed at day 1, this makes the upgrade relatively simple.
- In the document, Initial operation and staging plan p. 9, there is no technology at present that can cover the requirements for the GISANS detector.