

MultiGrid Detector Technology Review, August 27-28

Recommendations of the panel

Review Panel:

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Foreword

The MultiGrid Detector Technology Review took place on August 27-28, 2020 and was carried out as an online event. The ESS detector group gave a total of twelve presentations to the review panel over two afternoons. These dealt largely with all aspects of MultiGrid technology that are essential for the successful construction of a detector, as well as the results that were achieved with various prototypes. While this technology is to be used in several ESS instruments, particular emphasis was placed on the development, construction and performance of the detector that is planned for day-1 of the CSPEC Instrument.

The review should consider whether the performance demonstrated by the MultiGrid detector is sufficient to start production for ESS instruments. The review should also ascertain whether ESS has the capability to start production. Additionally the review should identify if there are recommendations on further investigations of performance that could be looked at whilst construction is ongoing, to enable a smooth hot commissioning period for the instruments.

Review:

As a general comment, it should be said that the panel was extremely impressed by the material presented and the results shown and congratulated the ESS and its detector group on their excellent and enormous work. The MultiGrid detector technology has been developed and analyzed comprehensively and systematically in the 10 years since its invention. In particular, the production of high-quality, large-area B₄C coatings was perfected during this period and brought to industrial maturity. The performance of the MultiGrid detector has been extensively studied through simulations and tests with various prototypes and is considered to be well understood.

In general the panel considers the presented performance adequate for the planned ESS instruments. No critical show stoppers were identified. The panel therefore recommends starting the construction of the MultiGrid detector for CSPEC now, especially taking into account the installation plan for CSPEC presented and the lack of a suitable detector alternative.

Based on the material presented, the panel is of the opinion that the ESS detector group has the technical and personnel expertise to start building the detectors. However, in the opinion of the panel, the group needs a substantial increase in suitable personnel in order to be able to manage the construction and commissioning of the CSPEC detector in the planned time frame.

With regard to the high-level requirements for the ESS instruments, some of them, e.g. the detection efficiency for neutrons, the energy resolution, the gamma suppression or the long-term stability are clearly considered to be achieved in the prototype tests. Other high-level requirements such as the background noise, the distortion of the shape of the elastic line or the count rate capability seem to have been achieved individually in independent measurements that were carried out at SNS and HZB with MG prototypes each with different configurations. However, all of the requirements as a whole have not yet been met with a single prototype configuration in these measurements.

The panel therefore strongly recommends performing the measurements planned with the MQSeq2 prototype on the LET instrument at ISIS as soon as possible. The configuration of the prototype should be as close as possible to the configuration of the "final" detector planned for CSPEC, especially with regard to background noise and distortion of the elastic lineshape due to internal scattering.

We would recommend a set of measurements be carefully made to evaluate the inelastic line shape, signal to background level and performance of internal neutron shielding. We suggest those tests could include

- 10% scatterer Vanadium plate measured in a high resolution and high flux mode at the peak CSPEC wavelength 3\AA (9.1meV) and 6.5\AA (1.9meV) to allow careful analysis of the elastic line shape in the common CSPEC operating windows. Ideally two runs will be done near 6.5\AA , one just above and one just below the aluminium cut-off so that the magnitude of the lineshape anomaly can be understood in detail.
- 4-methyl pyridine has regularly been used to assess the resolution at discrete energy transfers very close to the elastic line on LET (and many back-scattering machines). This system has quantum oscillator transitions at energy transfers of 0.47meV, 0.52meV and 0.55meV Here the sample needs to be cooled to low temperatures (~5K).
- A suitable sample that has an excitation between 1-10meV should be identified. The criteria should be (i) non-dispersive (or nearly so), and (ii) isolated from other excitations such as phonons that will obscure the lineshape. A rare-earth crystal field excitation in a single crystal would be ideal. For example, PrAl₃ has an excitation at 4.5meV and little phonon scattering (see J. Phys. Condens. Matter 15 3257), for example. The Panel advises the detector team to consult with the LET instrument scientists about a suitable material that may already have been run on LET.
- If time allows a room temperature measurement of D₂O could be made in a non-optimal RRM mode to evaluate the module's response and sensitivity to up-scattered neutrons appearing in the incorrect data frame.
- Careful consideration of the placement of the test module should be made such that the detector is in an optimized position in scattering angle to ensure a meaningful inelastic measurement can be made.

While the ESS should start preparation and recruitment for production, the panel strongly recommends that the plan allows flexibility and time to respond to the lessons learned from the LET measurements. Given that it will be the first time that the tests will be performed on a module that incorporates all the modifications from the previous tests, it seems likely that there will be further improvements required as a consequence of the tests.

In view of the current status of the development of the front-end electronics based on the VMM3a-ASICs and the tight schedule for the completion of the CSPEC detector, the panel recommends paying special attention to the development and testing of the front-end electronics. In particular, extensive test measurements should be carried out as soon as possible with the VMM3a based front-end electronics with the first manufactured "full-size" detector module in order to be able to make any necessary changes to the other modules in time.