IKON19

DETECTORS

REPORT FOR IKON19

Author(s): Detector Group

Date/time of session: Wednesday, *30 September 2020*

1. REPORT ON DETECTORS

From the beginning of September, there has been a reorganisation within the Detector Group. The Detector Production Section has been formed, whose responsibility is to produce, install and cold commission the detectors constructed in Lund, namely CSPEC, ESTIA, TREX and FREIA.

Recruitment is now ongoing to be able to provide the personnel resources necessary to deliver these detectors according to their installation schedules.

1.1. Background Sensitivity

The paper determining the sensitivity of Helium-3 and Helium-4 detectors to fast neutrons, as shown at the last IKON, is now published in Eur. Phys. J. Plus 135, 577 (2020), and is available on arXiv:2002.08153.

This now means that there is a complete set of evaluations of the sensitivity of both Boron-10 based and Helium-3 based detectors to all of the backgrounds expected on ESS instruments. Some of the findings are relevant for improving S:B at existing instruments elsewhere.

1.2. Multi-Blade Progress

Recently performance results from the evaluation of the Multi-Blade demonstrator at the AMOR instrument has been published in J. Instrumentation 15 (2020) P03010. This completes the performance evaluation. All instrument requirements for ESTIA and FREIA are met.

The final mechanical design for the integration of the detector into the ESTIA instrument is progressing well. The figure below shows how the detector integrates into the flight tube.

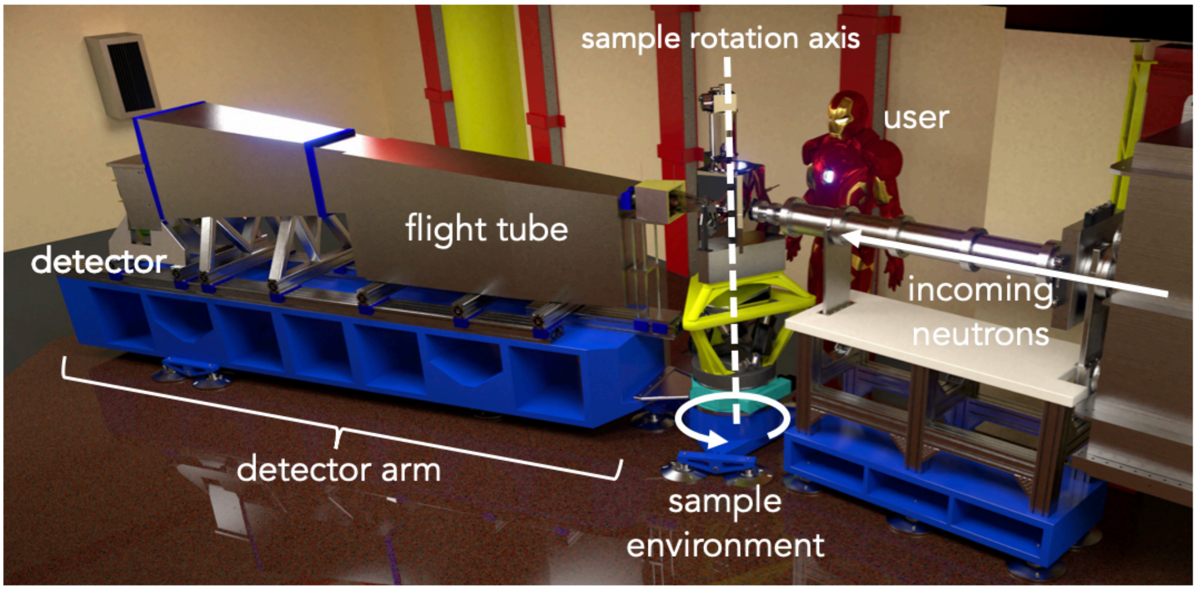

Figure 1. The Multi-Blade detector integrates into the flight tube

The final demonstrator for the Multi-Blade, the MB.300L was built since IKON.

This demonstrator is to verify the mechanical precision and to build full height prototype, with the same blade dimension on ESTIA and FREIA. It's shown in the photos below. Also shown is the jigging and the tooling for the Multi-Blade developed.

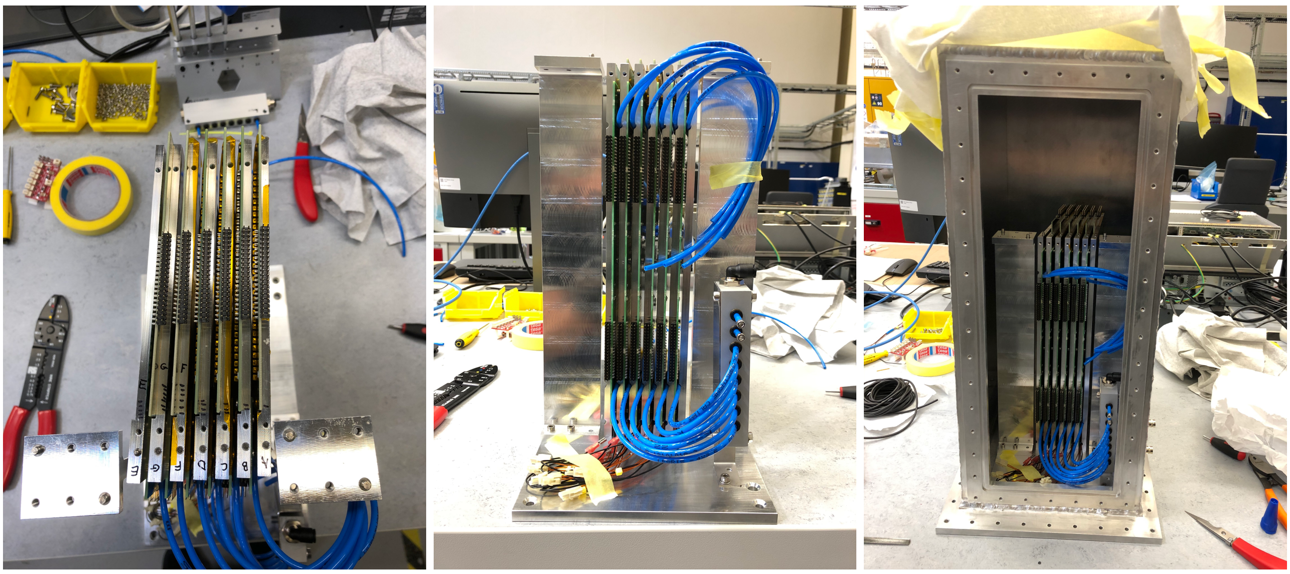

Figure 2: MB300L full height prototype

Figure 3. The assembly tooling for Multi-Blade: KV-1

Figure 4: Multi-Blade test on AMOR instrument at PSI, September 2020. The top row of pictures show the MB.300L under test. The bottom row shows the 10x10cm MB18 prototype which was left on the AMOR beamline for commissioning.

The MB300L demonstrator was tested at PSI during September 2020. Analysis is ongoing but initial results are encouraging. It was delayed by ca. 3-6 months due to COVID related delays. This is the final test prior to starting detector construction.

As well as testing the MB.300L demonstrator, the MB18 10x10cm prototype was left on the AMOR beamline at PSI for instrument commissioning. This will lead to invaluable commissioning and operational experience which will help with ESS commissioning later.

1.3. Multi-Grid Progress

Key personnel have been secured for the Multi-Grid activities. Ramsey Al Jebali now has a permanent contract in the detector group. Additionally, Alexander Backis has started a PhD on Multi-Grid Performance as a joint topic between Glasgow University and ESS.

Demonstrator Test at LET

A demonstrator test is planned at LET of a MG.SEQUOIA module. The MG.SEQUOIA module design was originally optimised for thermal wavelengths. A module has been rebuilt with radio pure Aluminium and with the radially orientated blades also coated, as shown in the photos below of it under construction, and under initial tests in Utgård. The lessons learnt during the evaluation of the SEQUOIA data were fed into the rebuild - and as can be seen in the data presented to the right hand side - the data is now relatively smooth in the rebuilt module (top) compared to several features seen in the original module (bottom).

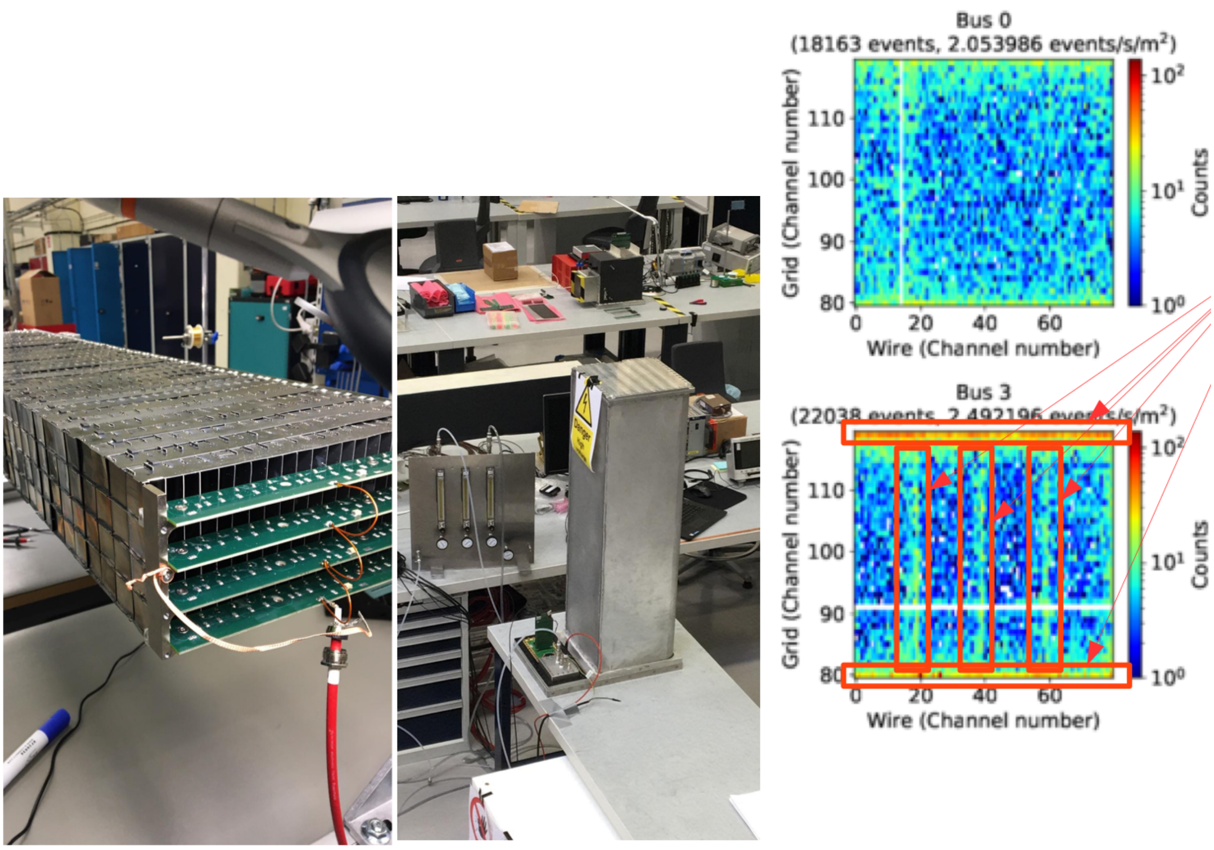

*Figure 5. Rebuilt MG.SEQUOIA module with radio pure Aluminium and with **coated radial blades***

Unfortunately, due to the COVID-19 situation, the tests have been delayed until at least November.

Analysis: V20 Data

Tests of the MG.SEQUOIA modules were done at the V20 beam line in HZB in September 2019, as requested by the CSPEC team and the Spectroscopy STAP. Results have been obtained on re-verifying the Multi-Grid efficiency, determining the effect of the radial blades on suppressing scattering, and also on extraction the fundamental time resolution of the Multi-Grid and Helium-3 tubes. Additionally the rate capability of the Multi-Grid detector was determined to be greater than 2 MHz/cmˆ2 incident on the detector, with no signs of saturation starting. The Helium-3 tubes saturated well- below this: as expected. The efficiency and the time resolutions measured were as expected from calculations. The results on scattering verified the result seen from the SEQUOIA data and in the detector simulations that the coating of the radial blades in the Multi-Grid has a highly significant effect on suppressing internal scattering.

The results from the tests at V20 are written up in a manuscript submitted to J. Measurement Science and Technology (arXiv:2006.01484).

Prototype Mechanical Detector Vessel

The prototype mechanical detector vessel for CSPEC has arrived in Utgård from CECOM, Italy. This is intended as a verification of the design, and of the QA procedures necessary to qualify it. Over the coming months it will be combined with the ca. 300 (280 in 2 columns of 140 each and >20 training) grids assembled last summer to finalise the QA and assembly procedures for the Multi-Grid detector for both TREX and CSPEC. The prototype vessel dimensions are: 3985mm (height) x 322mm (width) x 288mm (depth) with a weight of 350kg.

Figure 1. The prototype mechanical detector vessel for CSPEC in Utgård, Lund.

Additionally, 2 additional wooden mockup vessels for CSPEC have been constructed. These will be invaluable in validating alignment installation and maintenance procedures, as well as fine tuning the interface with the CSPEC vacuum tank.

Figure 7. The wooden mockup vessels for CSPEC

1.4. Status of Jalousie Detectors for Diffraction instruments

DREAM, MAGIC and HEIMDAL instruments will use the Jalousie detector design from CDT GMBH. This itself divides into 4 sub-categories of distinct detector designs based upon the Jalousie concept: a) DREAM barrel design, b) DREAM endcap design and, c) DREAM high resolution design, d) MAGIC-type design (for MAGIC and HEIMDAL). The Jalousie detector is a B-10 thin film detector design, with a ca. 10 degree incident angle between the scattered neutron and the thin film boron carbide converter. The design is optimised for the requirements of diffraction instruments. The design was originally conceived for the POWTEX instrument at FRM-II and was developed between the POWTEX instrument team and CDT.

At the time that the technology was chosen for the diffraction instruments at ESS, it was expected that results would be available from POWTEX commissioning at FRM-II. This has unfortunately not been possible. A detailed test of a POWTEX module at POWGEN at SNS was limited due to transport damage to the test module. To be able to overcome the lack of this commissioning data, the pre-production series of DREAM detectors was launched in 2017. However, it has been possible to analyse data from the POWTEX module tested at POWGEN, and the results are very encouraging.

There is a reasonable amount of performance data on the key detector performance parameters, i.e. position resolution and efficiency. This is mostly evaluated with single (non-overlapping) modules on detector-orientated test beamlines. This gives reasonable confidence in the position resolution and efficiency performance. The data from these tests is partially available to the detector group. An additional test was planned for May at the TRIGA reactor in Mainz; due to COVID this is cancelled - and might take place in autumn, or winter.

Given the complex detector design, the detector group has made available 1 FTE-level of effort to help evaluate this detector design since 2014. A substantial portion of this effort has been directed towards understanding the geometry and simulating the detector performance. This has led to a much improved understanding of the efficiency, the position resolution and the scattering. Recently the results on understanding the performance of HEIMDAL for diffraction was published (I. Stefanescu et al., J instrumentation 14 (2019) P10020 doi: https://doi.org/10.1088/1748-0221/14/10/P10020). Similar studies are currently being done for DREAM.

In terms of evaluating the performance of these detectors for the instruments in terms of their scientific performance, data is limited. A test was done on the V20 beamline last year. The setup was limited for evaluating the diffraction performance and only a single 12 degree endcap segment (4 sub-modules) was available. The setup is shown in the photograph below. Analysis of the data showed that peaks can be reconstructed in approximately the right locations from a number of representative samples. Wavelength frame multiplication and basic stitching of the resultant data has been done. However the details of the peak shape were not possible to discern with the configurations possible on the V20 beamline.

These tests, combined with the encouraging results from the POWTEX module at POWGEN, allow confidence in the design to proceed with construction for the DREAM mantle and EndCap detectors and the MAGIC-B detector.

Figure 8. Jalousie detectors test on the V20 beamline

Additionally, given the complex geometry and voxel projection of these detectors, significant work is needed on understanding how to utilise and analyse the data. Initial work is promising - including both looking at the V20 data and work done on simulating the full data off the design - however this needs to be continued to avoid a very long commissioning period for these ESS instruments. This is effort which is cross group, involving the instrument team, DMSC groups, and the detector group.

1.5. A1-CLD detector and Am-CLD demonstrator detector by HZG

The delivery date of the development contract with HZG is delayed by 6 months due to COVID-19.

1.6. Coatings

In the beginning of 2020 CDT asked if ESS Detector Coatings Workshop in Linköping could provide them with coatings for MAGiC-B. The coating team suggested to use the production process from MG detectors and also to adjust the samples so that they could fit one of the holder set that will be used for CSPEC. This lowered both the production cost and the production time substantially. It was decided that the Coatings Workshop in Linköping would provide CDT with 67% of the coatings needs for MAGiC-B. The production was conducted during Aug 2020 and with such a great outcome that CDT asked for the remaining 33% to be coated as well during Sep 2020.
The ESS Coatings Workshop in Linköping will most probably also do coatings for CDT and DREAM in the near future.

1.7. Detector simulations

A major update to NCrystal is finished, enabling state-of-the-art inelastic physics based on scattering kernels and phonon frequency spectra. NCrystal is a library which enables calculations for Monte Carlo simulations of thermal neutrons in crystals and other materials, supporting a range of physics including both coherent, incoherent, elastic and inelastic scatterings in a wide range of materials, including powders, mosaic single crystals, pyrolytic graphite and liquids. It can be used standalone (from C/C++/Python) or as a physics backend in McStas and Geant4, enabling realistic simulations of neutron instruments and specific components like detectors.

Details can be found at the following references:
* https://doi.org/10.1016/j.cpc.2019.07.015 [Detailed description of the NCrystal framework]
* https://github.com/mctools/ncrystal/releases/tag/v2.0.0 [the new release with inelastic physics]

1.8. Electronics

The summary table of the front-end integration into the backend electronics was presented at IKON18. This is shown in the table below updated for the expected delay from the COVID-19 situation. There has been 3-6 months delay on these dates due to availability of equipment, people and workshops during this time. The schedule of integration is not critical for any of the instruments and doesn't approach critical path.

Instrument	Front-End	Integration Agreed?	Integration Model	Integration Started?	Estimate for Integration Demonstration
CSPEC	VMM	Yes	A	Yes: Nov19	Oct 2020
TREX	VMM	Yes	A	Yes: Nov19	Oct 2020
ESTIA	VMM	Yes	A	Yes: Nov19	Oct 2020
FREIA	VMM	Yes	A	Yes: Nov19	Oct 2020
NMX	VMM	Yes	A	Yes: Nov19	Oct2020
DREAM	CIPIX	Yes	C	Yes: Oct19	Oct 2020
MAGIC	CIPIX	Yes	C	Yes: Oct19	Oct 2020
HEIMDAL	CIPIX	Yes	C	Yes: Oct19	Oct 2020
LOKI	ISIS PREAMP/CAEN R5560	Yes	C	Yes: Jun19	Oct 2020
BIFROST	ILL PREAMP / CAEN R5560	Yes	C	No: May20	Nov 2020
VESPA	*PREAMP / CAEN R5560 (TBC)*	No	C (tbc)	No	tbd
MIRACLES	PREAMP / CAEN R5560	No	C	No	Feb 2021
SKADI	IDEAS	Yes	X	Partially: Aug19/Jan20	Jan 2021
ODIN	Custom Camera+EPICS & TIMEPIX 3	Partially	XX & C	No	tbd
BEER	Delay Line + Custom FPGA	Yes	C	No	tbd
Beam Monitors	PREAMP / PINK BOX	Yes	B	Yes	Complete
TestBeam Line	Custom	No	tbd.	No	No

Table 1. Summary table of Front-End integration

One of the key pieces of integration has been working to integrate the VMM hybrid into the ESS Assistor. This is close to demonstrating proof of concept.

57 VMM hybrids became available, a full silicon wafer worth of VMM ASICs. These have been assembled with cooler in Lund, shown in the figures below. Testing, QA and QC procedures have been developed, as well as assembly manuals.

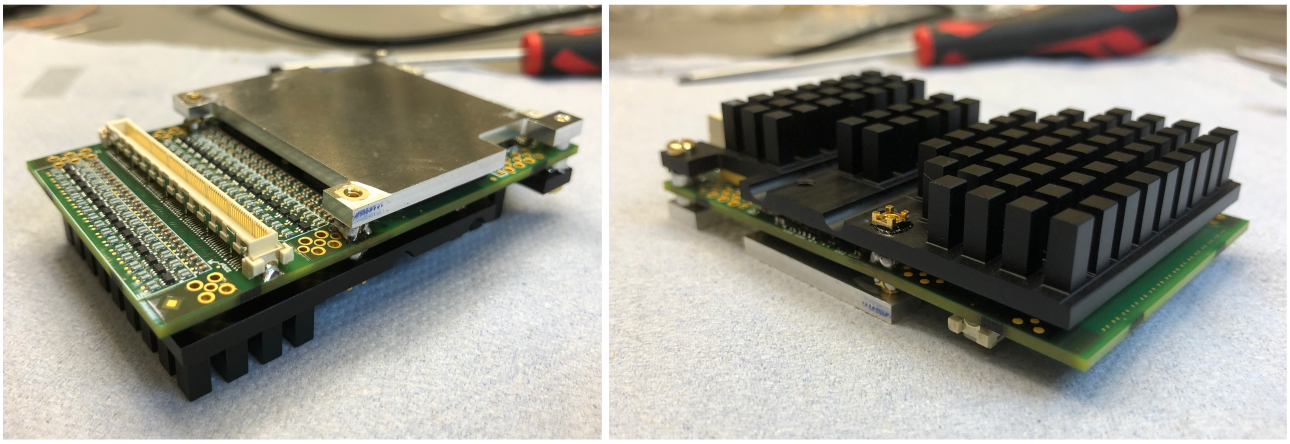

Figure 9. VMM cooler mounted. 128 channels/board.

Figure 10. First 50 hybrid boards assembled. Electronics and data testing, QA/QC protocols written and done. Procedures in place.

The yield of optimum quality ASICs is about 80%, and optimum quality hybrids about 70%. This is a good yield for a complex ASIC.

Detailed integration of these devices into the detector designs has started.

Scott Kolya left ESS to start a business since March. Recruiting his replacement and the other planned personnel for electronics will be essential for delivering the detector electronics for instruments according to schedule.