
CSPEC DETECTOR TECHNOLOGY DECISION.

	Name	Role/Title
Owner	Pascale Deen (ESS/TUM) Daria Noferini (ESS/TUM) Wiebke Lohstroh (TUM) Stephane Longeville (LLB)	Senior Scientist for Spectroscopy, CSPEC Lead scientist. CSPEC instrument scientist. TUM Scientific Consultant CSPEC. LLB Scientific Consultant CSPEC.
Reviewer	Andrew Jackson Rasmus Toft-Petersen Richard Hall-Wilton	Group leader for neutron instrument division. Instrument class coordinator, spectroscopy. ESS detector group leader.
Approver	Jon Taylor	Acting head of NSS.

Table of Contents

1. Introduction	2
2. LET test April 2022.....	4
2.1. Detector components.....	4
2.2. Detector performance requirements	4
3. Success	5
3.1. Experimental success	5
3.2. Confidence to achieve CSPEC requirements for complete detector scope.	5
4. Failure.....	5
5. Decision	5
6. Glossary	5
7. references	5

1. INTRODUCTION

The detector technology for the cold chopper spectrometer of the ESS, CSPEC, was agreed, in 2019, to be based on the Multigrid (MG) ^{10}B technology. A contract for the CSPEC detectors was signed (ESS-3640301) between ESS and TUM for the ESS Detector Group (DG) to deliver the detector technology and a scope transfer was returned to the ESS by the LLB for the manufacture of the detector vessels. Within the TUM/ESS contract, a number of milestones were agreed, see Table 1, the most important of which is #6 ‘pilot test completed’, known as LET test, in November 2020, to ascertain that the scientific requirements will be met by the ^{10}B MG detector. LET, the cold chopper spectrometer of the ISIS neutron and muon source, is the most suitable instrument to perform a comparative test for the CSPEC detectors. The full-scale manufacture of the CSPEC detectors should start only after the successful completion of the LET test.

Milestone ID	Short description	Date	Notes
#1	Tenders/Requests For Quotations (RFQs) for key components submitted	Apr 20	¹⁰ B ₄ C Powder/Target. Pure Aluminium Blade cutting/cleaning
#2	Sub-TG3: Grid design, Vessel design	Aug 20	Vessels excluded from the scope of this agreement. Vessel design MS included for reference. (Not included in Table 3)
#3	Key Components delivered to Suppliers	Aug 20	Aluminium delivered to Blade Cutting company. ¹⁰ B ₄ C powder delivered to the target manufacture.
#4	Tender for Vessels submitted	Sep 20	Vessels excluded from the scope of this agreement. MS included for reference (Not included in Table 3)
#5	¹⁰B₄C Coating for MG.CSPEC Started	Nov 20	Al Blade sheets/ ¹⁰ B ₄ C targets delivery started to the ESS Linköping Coating Facility.
#6	Pilot Tests completed	Nov 20	Subject to access to LET is granted in Sep 2020
#7	¹⁰B₄C coated blades for 1st Detector completed	Dec 20	ESS Linköping
#8	Construction of CSPEC Detectors started.	Dec 20	¹⁰ B ₄ C coated blades delivered to ESS Utgård
#9	1st Detector Vessel FAT	Dec 20	Vessels excluded from the scope of this agreement. MS included for reference (Not included in Table 3)
#10	1st Detector Vessel delivered to ESS	Jan 21	Vessels excluded from the scope of this agreement. MS included for reference (Not included in Table 3)
#11	Sub-TG3: Readout electronics and shielding design finalised for CSPEC	Jan 21	Electronics components are ready to order All necessary data packages (including the updated System verification plan (FAT / SAT) are provided and agreed upon.
#13	1st Detector Assembly completed	Feb 21	
#14	Testing of 1st Detector started	Feb 21	Detector 1 readout electronic integration completed.
#15	25% of CSPEC Detectors tested and ready for Installation, FAT	May 21	

Table 1: Milestones #1-#15 for the CSPEC detectors as outlined in the CSPEC Detector contract (ESS-3640301).

An unsuccessful LET was performed in November 2020 and this has significantly stretched the timeline for successful completion of the CSPEC MG detector and thus the entire instrument. It has been agreed that a further LET test will be performed in April 2022. The results of the April 2022 LET test will determine whether the CSPEC team will continue to follow the MG technology or whether a plan B will be implemented. This document outlines the requirements and agreement between the CSPEC team and the ESS DG group for the successful completion of the CSPEC detector.

2. LET TEST APRIL 2022

2.1. Detector components

A second LET test will be performed on the LET spectrometer, ISIS, on a MG detector with:

- (1) the final 1.5 m detector vessel, a limited height vessel that will eventually be placed under the CSPEC beamstop.
- (2) the final grid design with the completed shielding and back plate concept.
- (3) the complete and final electronics.
- (4) the complete data acquisition chain inclusive of the timing signal with the Event Formation Unit (EFU) connected between the VMM electronics and the ECDC software.

The ¹⁰B MG results shall be compared directly to ³He detectors.

The only difference between the final design and this pilot detector is the coating of the side blades which we are testing for background efficiency. The two modules will thus have different coating thickness of the side blades.

CSPEC agrees that a test on a reduced height detector (1.5 versus 3.5 m) is acceptable under the conditions set in 3.2. A full height detector vessel cannot be tested with neutrons, on any chopper spectrometer worldwide, due to space constraints.

2.2. Detector performance requirements

The 1.5 m LET test will test the following requirements:

Table 1. Essential CSPEC detector performance requirements.

Specification Description	Requirements
Linewidth, intensity as a function of time-of-flight for an incoherent scatterer, measured at 2K, in the region $3\sigma < \lambda < 5\sigma$	Shall be ≤ 2.5 times ³ He detectors (essential) Should be equivalent to ³ He detectors (desirable)
Detection Efficiency	Shall be $\geq 60\%$ detection efficiency at 4Å
Geometrical/angular coverage 3.5m from the sample position	Shall be $5^\circ \leq 2\theta \leq 97.7^\circ$ in the horizontal plane Shall be $\pm 26.5^\circ$ in the vertical plane
Count rate capability	Shall be 50 times $>$ ³ He detectors Should be 100 times $>$ ³ He detectors
Dark noise across all detector	Shall be < 0.35 Hz/m ² (essential) Should be < 0.14 Hz/m ² (desirable)
Scattering signal to noise (total) The signal is defined as the peak neutron intensity on detectors by an incoherent scatterer, such as Vanadium, and compared to the noise defined as the neutron intensity at a time when the signal has decayed to background levels	Shall be 10^4 at 5Å (essential) Should be $\sim 10^5$ at 5Å (desirable)
Gamma efficiency	Shall be $\leq 10^{-6}$

Table 2: The detector specifications agreed upon between CSPEC and ESS DG.

3. SUCCESS

3.1. Experimental success

The LET tests will be considered a success if the LET tests:

- (1) take place under the conditions outlined in section 2.1.
- (2) the data analysis provides the performance requirements outlined in section 2.2. (Table 1). The responsibility for the data analysis is held by the CSPEC team.

3.2. Confidence to achieve CSPEC requirements for complete detector scope.

In the case of success, the CSPEC team will determine whether the results gained on the 1.5 m detector will be sufficient to provide confidence in the 3.5 m high detectors, required for the CSPEC detector scope. In order to do so the CSPEC team need a clear overview of the differences between the 1.5 and 3.5 m detectors, how these differences will affect the detector performance, in addition to how adequate tests will be performed to satisfy the high-level requirements. In particular it is crucial that the detector technology does not compromise the scientific capability of CSPEC.

4. FAILURE

A plan B will be considered in the case of failure. Failure is understood as not complying with section 2 and/or a lack of confidence in the ability of the DG group to deliver the 3.5m detectors, section 3.2.

Plan B is a return to former technology, ^3He , shown feasible in document ESS- 3640421: Detector technology assessment for CSPEC.

In the case of plan B:

- (1) the transfer of scope from LLB to the ESS DG for the detector vessels must be returned.
- (2) TUM/ESS DG contract is null and void.

5. DECISION

A final decision will be made week 17, 2022, following a workshop that outlines all the details of the LET tests and results.

6. GLOSSARY

Term	Definition
ESS	European Spallation Source
DG	Detector group

7. REFERENCES

Document Type Decision
Document ESS-3638474
Number
Revision 1 (1)

Date Sep 10, 2021
State Preliminary
Confidentiality Level Internal

- [1] ESS-3640301 CSPEC detector delivery agreement
- [2] ESS-3640421: Detector technology assessment for CSPEC.

DOCUMENT REVISION HISTORY

Revision	Reason for and description of change	Author	Date
1	First issue	P.Deen	2021-09-13
