CSPEC STAP report
May 2022.
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In this STAP report we will first answer some questions that were raised by the Spectroscopy STAP (Spectroscopy STAP report, October 2021) before providing an overview of the state of the project.

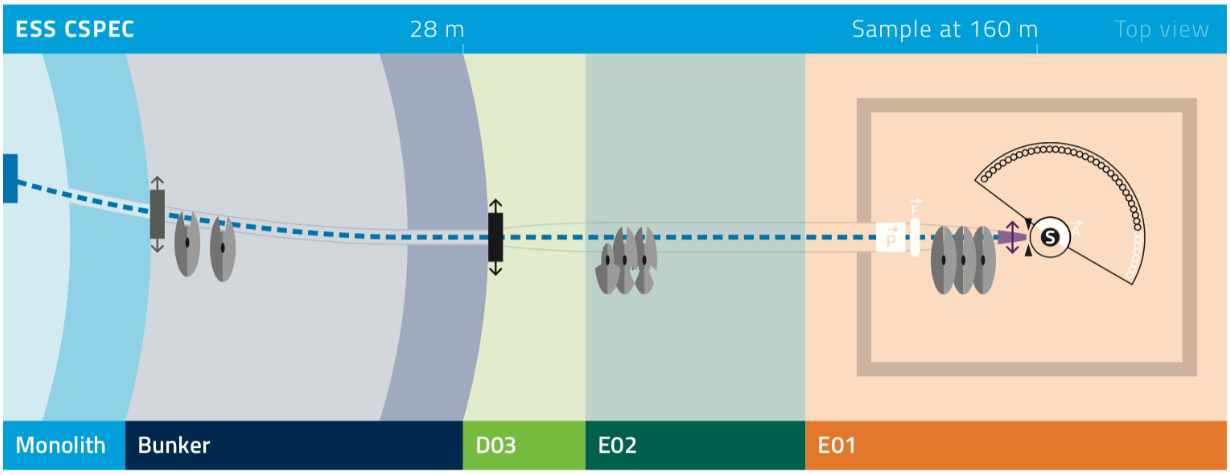


Figure 1: Cartoon overview of CSPEC. In white are upgrades (Polarisation analysis and detector coverage)

Questions raised by Spectroscopy STAP:

(1) We are wondering if the delays in guide production and guide tests due to COVID restrictions have an impact on the project schedule?

It is true that the TUM guide production is delayed but this, currently, does not have an impact on TG5 (Completion of instrument).   Out of bunker guide installation is foreseen September 2022.

(2) CSPEC and T-REX teams are discussing a common technical solution for an optimised normalisation monitor for both instruments.

The discussions have stalled due to a lack of manpower.
After considerable consultation the following, currently available, monitors are suitable for CSPEC:
Fission chamber (FC): well understood technology with excellent gamma discrimination for a low price. At the edge of the performance capability for 2 MW ESS power, in event mode. High attenuation.
Ionisation beam chamber (IBM). New technology. Handles both low and high fluxes with good intrinsic gamma discrimination. Can handle 5MW ESS beam power. Very low attenuation. Expensive. Testing planned at neutron sources (ISIS).
N2 tube: Well understood low cost technology. Cannot tune efficiency and will saturate but can be used for chopper opening/phasing . A low efficiency would be problematic for gamma discrimination.
ILL Multitube: A 2D boron/gas monitor with variable efficiency that could be a possibility for the M monitor. Testing is needed (ILL). 2D spatial resolution is coarse (7 mm in 1 dimension).

At this moment in time we consider the following monitors for CSPEC day 1+ (100 kW - 2 MW).

BM	Zone	Fixed/movable	Technology
0	6 m, in bunker	Fixed	Ionization beam monitor (IBM, CDT)
1	28 m, after BW chopper	Movable (automatic system)	IBM
2	105.6 m, after PS chopper	Movable (automatic system)	IBM or N2 tube (if budget constrains)
3	158.5 m, after M chopper	Fixed	IBM or suitable better alternatives (e.g. PSD or with less attenuation) from possible in house projects
4	After sample	Movable (by hand)	Neutron camera

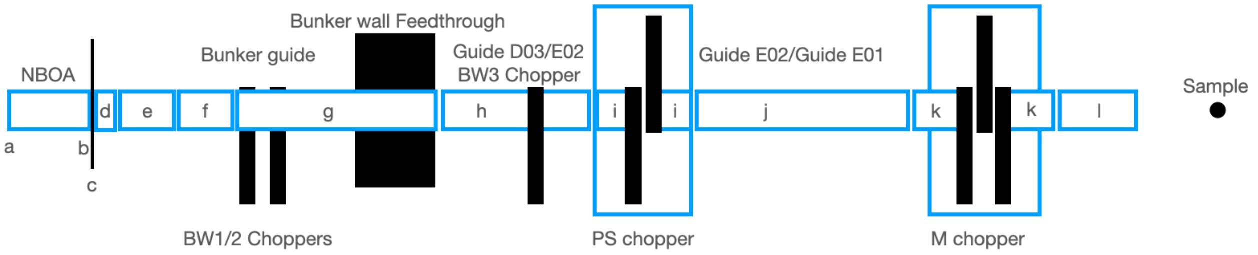
A further commissioning monitor will be needed at the sample positions/ beam dump for preliminary determination of E_i.

(3) The French project partner (LLB) agreed to make an additional in-kind contribution to the project in the form of a 12T cryomagnet.

The magnet is incorporated into the ESS timeline (P6) but may be postponed.
In the meantime the sample environment group and CSPEC are keen to pursue a preliminary study and pricing estimate which we can use to procure a suitable magnet in the future. The sample environment group will try to alter the HZB 6.5 T magnet (the current tails are too wide for CSPEC) to fit into the CSPEC sample environment pot for day 1 experiments.

(4) We are wondering if the team could provide an update on the combined losses through all aluminium windows along the beamline and gaps for monitors and shutters.

(1) Aluminium windows:
The cumulative Al thickness along the CSPEC beam line is 16.2 mm, see Figure 2. The CSPEC team have tried to limit the Al thickness along the beam path but we are limited by safety regulations. The exact window configuration of the guide prior to the sample is not finalised but the worst case scenario (2 x 0.5 mm) is considered. CSPEC will have flux losses of 15, 25 and 35 % for 5, 10 and 15 Å, considering a cumulative Al window thickness of 16.2 mm. These numbers are extrapolations from transmission measurements performed on D17 (ILL) for 75 and 50 mm Al samples. The inset graph in Figure 2 shows extrapolations for 2, 16.2 and 20 mm ($\lambda > 5$ Å only considered in this case).



Position	Component	Thickness (mm)
a	NBOA front	1,5
b	NBOA end	1,5
c	NBOA Protection	4,2
d	Light shutter	1,0
e	Guide in remote access bunker region	1,0
f	Guide in remote access bunker region	1,0
g	Guide separate bunker environment from D03/E02	1,0
h	D03/E02 (78 m)	1,0
i	High vacuum chopper environment	1,0
j	E02/E01 (50 m)	1,0
k	High vacuum chopper environment	1,0
l	Final guide piece (currently 1,0 mm may reduce)	1,0
Cumulative		16,2

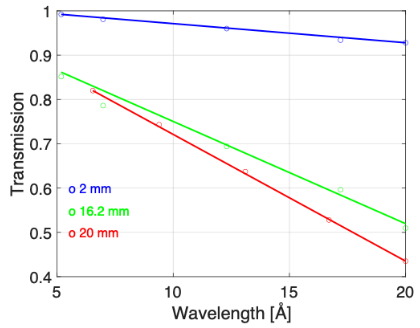


Figure 2: Overview of Al windows along the CSPEC instrument. Windows denoted by letters with letters d-l representing the front and end window of each guide and component (0.5 mm each).

(2) Gaps in the guides:
The gaps between guide housings do not exceed 2 mm and are therefore negligible.
The gaps for the shutter and monitors are as follows:
After the light shutter (component d in Figure 1): 25 mm
Bandwidth chopper 1: 30 mm
Bandwidth chopper 2: 30 mm
Bandwidth chopper 3: 30 mm
PS chopper gap: 106.5 mm (includes space for removable monitor)
M chopper gap: 74 mm.

The most significant gaps are those that incorporate the PS and M choppers. The losses, relative to zero guide gaps, are:

Chopper group	Gap between guides (mm)	Flux loss at 3 Å	Flux loss at 10 Å
PS choppers	106.5	3.3 %	7.2 %
M chopper	74	3 %	6 %

(3) Resultant flux:
On Figure 2 we show the CSPEC flux on detector (McStas incorporating all windows and gaps) relative to IN5 as a function of the, currently envisaged, ESS power ramp up and time in months after beam on target (BOT). CSPEC is novel in its class since it will employ repetition rate multiplication (RRM) in a unique manner by accumulating incident pulses to gain flux. IN5 is a reactor instrument that cannot perform RRM and therefore can only be compared in single pulse mode. However, IN5 is compared to CSPEC as the current most intense flux cold chopper

spectrometer worldwide. The ability to measure in single pulse mode is also possible on CSPEC. CSPEC considers that RRM will be employed 80 % of the time and single pulse mode for 20%. The day-one 1 scope detector coverage is 50%. Further flux losses are derived from the first day implementation of an unoptimised moderator (BF2) due to unresolved cooling issues. BF1, the optimised moderator will be installed as soon as possible.

Figure 3 shows the CSPEC flux on detector, relative to IN5 flux, as a function of ESS power ramp-up for three different configurations: (1) a fully optimised instrument and BF1 moderator (2) fully optimised instrument with the BF2 moderator and (3) current instrument and moderator configuration (BF2). A fully optimised CSPEC will provide 24 times more flux than IN5 (E_i = 3 meV, ΔE = 100μeV) with ESS at 5 MW with a full detector bank, (McStas incorporating guide gaps and Al windows), considering 20% single pulse mode (reactor mode) + 80% Repetition Rate Multiplication (RRM) (with 6 incident pulses), see red curve Figure 3. CSPEC will start operation with a reduced detector bank (50%) and with the BF2 moderator. The resultant, significant, losses for CSPEC are shown. ESS management are fully engaged to provide a full detector array and optimised moderator for the instruments.

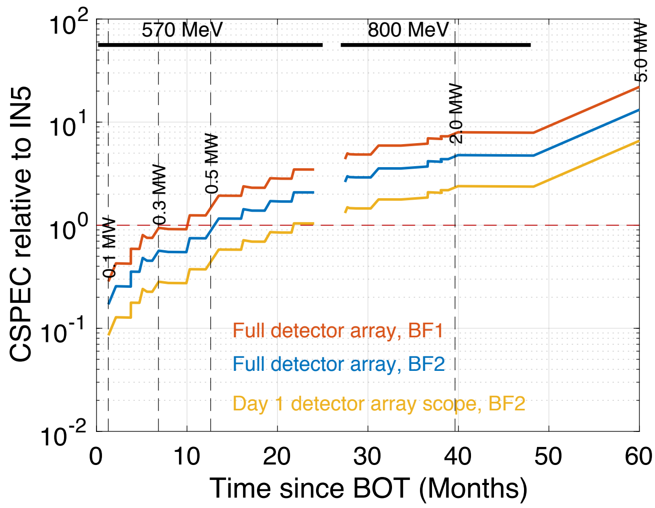


Figure 3: Performance ramp up on detector for CSPEC relative to IN5.

MG detector test:

In September 2021, a further agreement between the CSPEC instrument and NSS on an updated timeline towards the CSPEC detector was reached (CHESS document ESS-3638474). The CSPEC team accepted the conduction of a final pilot test of the MG detector, using the LET cold chopper spectrometer, before manufacturing of the full-scale detectors upon success. The agreed date for the performance of the test has been April 2022 / updated to May 2022. ESS and the CSPEC team agreed that an alternative solution will be considered in the case of test failure (ESS-3638474).

As outlined in the aforementioned document, a successful LET test comprises:

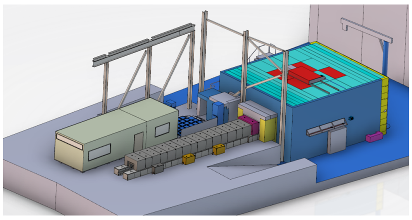
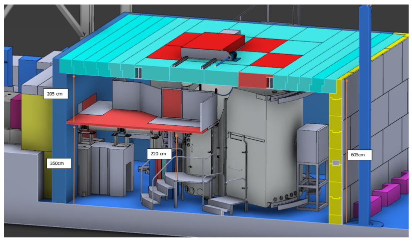
(1) the final 1.5 m detector vessel, a limited height vessel that will eventually be placed under the CSPEC beamstop.
(2) the final grid design with the completed shielding and back plate concept.
(3) the complete and final electronics. The VMM front-end electronics and ESS backend readout will be used. 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.
(4) The processed EFU data will be calibrated against data extracted independently.

Following the recent review panel for the VMM electronics (25.03.2022), NSS have been advised that the VMM electronics are suitable for the MG detector. However, the current configuration is not suitable and must be reassessed. A timeline of at least 2 years is proposed for this development by the review panel (members from ISIS and ILL detector groups).

The LET prototype detector test can therefore not be performed with the complete and final electronics and conditions 3 and 4 cannot be met. **The MG LET test has failed and an alternative solution must be considered to ensure the timely success of the CSPEC instrument.**

Shielding:

Primary spectrometer shielding: 95 % of the primary spectrometer shielding has been delivered to ESS.

		
Figure 4 (left): CSPEC Pulse shaping chopper housing.	Figure 4 (middle): CSPEC cave and control cabin, external view.	Figure 4 (right): CSPEC cave and control cabin, internal view.

Secondary spectrometer shielding:

Tender documentation for the cave, control cabin and crane is under review at the LLB and will be published shortly. Cave installation December 2023.

Beam transport system:

Beam wall insert, see Fig. has been delivered to ESS. Installation June 2022, see Figures 6.
NBOA / BBG (First guide components): manufactured, final acceptance test will be performed shortly.
Guide manufacturing is continuing at TUM. Guide verification is now performed at PSI due to cold source problems, and thus lack of neutrons, at TUM. D03/E02 guide installation foreseen February 2023. This has been delayed by 18 months due to COVID.
Tender for in-bunker guide housing delayed due to lack of staff. TG5 not affected.
Instrument shutter under testing procedure at TUM, see Figure 5.

Figure 5: CSPEC instrument shutter (at 28.5 m after bunker wall). Incorporates the shutter and a moveable monitor.

Choppers: Successful critical design review. Under manufacture. Installation foreseen July 2023.
Detector tank: Successful critical design review by SDMS (Valence, France), see Figure 7. Material procurement causing difficulties due to lack of world supply of Al (Covid & war in Ukraine). Installation foreseen April 2024, includes delays mentioned. The detector tank conforms to the requirements for ^{3}He detectors.
Collimator: Successful critical design review. Under manufacture.
Electrical and conventional utilities: CSPEC joins the ESS common utilities project. Little progress with preliminary documentation due to lack of staff.
Sample environment: Tenders not yet published due to lack of staff. Does not impact TG5.
Data acquisition and analysis: See document by G. Tucker.
Hot commissioning: We submitted a hot commissioning document to the STAP in April 2021. This document remains the most up to date considerations for hot commissioning. We will further align with the generic ESS commissioning documents, under preparation, once these are completed.

General project timelines.

We have had staffing difficulties with one member of staff (L. Laoiza, TUM) on indefinite leave of absence due to illness and our other team member (G. Fabreges, LLB) on parental leave. At the moment, this leaves only our lead engineer, F. Moreira for the entire CSPEC project. Recruitments are on-going and solutions are being considered.

CSPEC TG5 is foreseen as October 2024.

CSPEC High-level installation schedule:

Figure 6: (left) Beam wall insert for CSPEC.

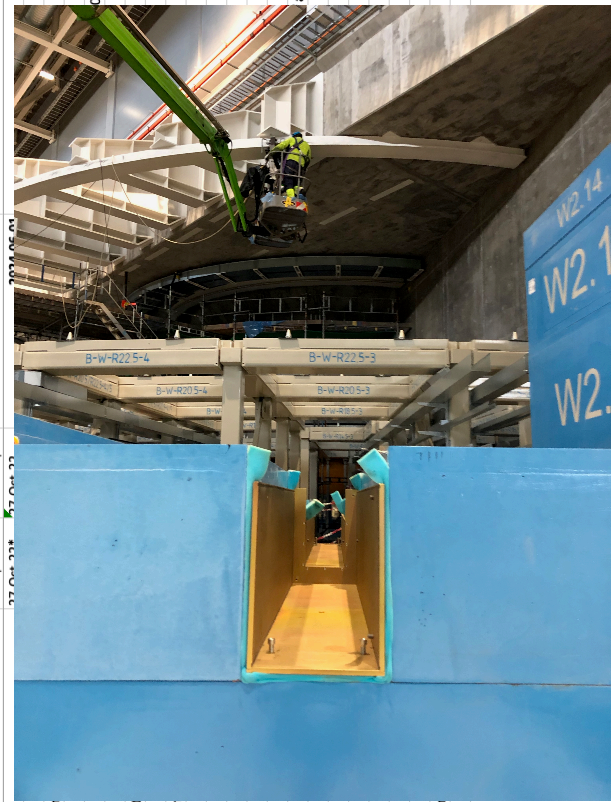


Figure 6: (right) Insert position for CSPEC beam wall insert.

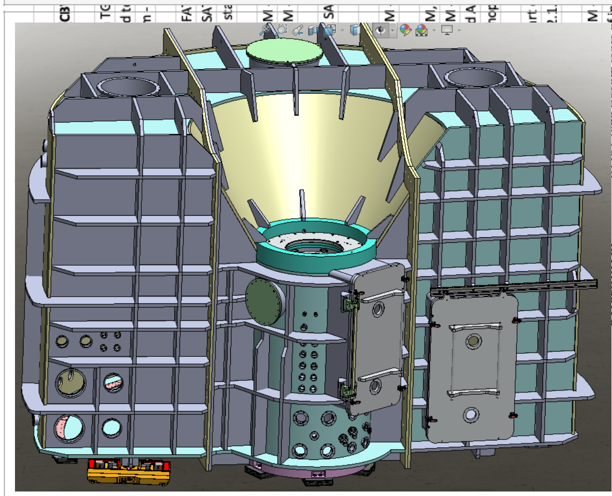


Figure 7: (left) Final detector tank design.

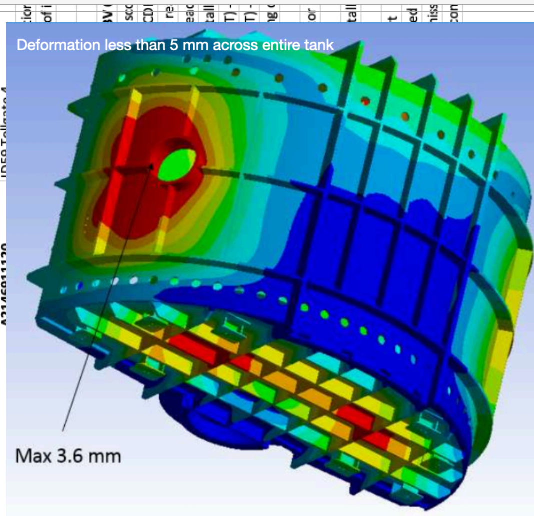


Figure 7 (right) Deformation of the tank under evacuation showing that the deformation specifications have been reached.

Risk register:

We present the top risks for CSPEC:

Project Title: CSPEC

Ref No.	Risk title	CAUSE - Risk Description: ("As a result of…")	EVENT ("There is a risk that…")	CONSEQUENCE ("Resulting in…")	Risk to	Owner	Partner	Status	Current Untreated Impact	Current Untreated Probability	Current Untreated Rating	Risk treatme
8	Late delivery of detectors	As a result of in-house development of the MG detec	There is a risk that detector delivery will be delayed, ultimately delaying the production of the final detector modules to be installed on the instrument	Resulting in a delay in the installation and integration of the detector system, possibly delaying TG5	Schedule		ESS	Open	Very high	Very likely	25	Reduce
9	Delayed development of detector backend electronics	As a result of the many interfaces in the development in the signal processing chain (from	There is a risk that the development will be delayed	Resulting in an un-tested signal processing chain causing delays to hot commissioning	Schedule		ESS	Open	Very high	Very likely	25	Reduce
23	Detector electronics not adequate	untested signal processing chain	the detector electronics is not adequate	insufficient instrument performance	Quality		ESS	Open	Very high	Very likely	25	Reduce
24	Detector technology not adequate	unrealistic performance expected and insufficient testing of the MG	the detector technology is not adequate or mature enough at TG5	insufficient instrument performance	Quality		ESS	Open	Very high	Very likely	25	Reduce
5	Detector tank budget overrun	A a result of mismatch between costs estimated at the scope setting meeting (4 years ago) and those received after the tender process.	There is a risk that the budget will not be sufficient.	Cost overrun	Cost		LLB	Open	High	Very likely	20	Reduce
7	Unsuitable normalization monitor	Due to lack of interaction between instrument team and detector group.	Risk that we are unable to commission the intrument and have reliable normalisation during operation, especially for more technically demanding experiments.	Unsuitable technology.	Quality		ESS	Open	High	Very likely	20	Reduce
4	Delayed delivery of detector tank	Due to technologically complex manufacturing	There is a risk that the detector tank will be delayed	An overall delay in TG5	Schedule		LLB	Open	High	Likely	16	Reduce
12	Lack of installation resources	As a result of a very compressed NSS installation schedule and unrealistic staff levels set at scope setting	there is a risk that too few installation resources are available at critical times	resulting in installations being delayed, pushing back TG5	Schedule		CSPEC	Open	High	Likely	16	Reduce
21	Risk of personnel leaving	As a result of people dissatisfied with the working conditions and ESS requirements.	there is a risk that key personnel from the core team or partner teams leaves	resulting in delays to the work being handled by the person in question being delayed	Schedule		CSPEC	Open	High	Likely	16	Observe
25	Delayed delivery of the cave	Due to long procurement times and lack of staff	There is a risk that the cave will be delaye	resulting in a delay of TG5 and problems with general integration	Schedule		LLB	Open	High	Likely	16	Reduce
6	Unsuitable monitors	Due to a lack of suitable technology procured.	Risk that we are unable to commission the intrument.	Unsuitable technology.	Quality		ESS	Open	Moderate	Very likely	15	Reduce
10	Software development mismatched to user requirements	As a results of software development being a complex joint effort between a DMSC data scientist, University of Copenhagen and the core team	risk of software not targeted sufficiently to this instrument	resulting in a lower quality user experience	Quality		ESS	Open	High	Significant	12	Reduce
11	Infrastructure costs running up	As a result of strict and changing infrastructure requirements from the ESS (electrical installations, drawings, fire suppression, etc)	There is a risk that the infrastructure costs go beyond budget	resulting in a risk for cost overrun	Cost		ESS	Open	High	Significant	12	Reduce
16	Installation delayed by Corona-crisis	As a result of the ongoing pandemic	delay to installation due to difficulties encountered by external staff with respect to covid uncertainties.	resulting in a delayed and compressed installation schedule	Schedule		CSPEC	Open	High	Significant	12	Observe
17	Quality non-acceptance	Due to many quality requirements, like CE-marking, being enforced at the ESS	there is a risk that a long lead time component will be rejected by the ESS, due to lack of quality assurance	resulting in a delay of TG5/early science	Schedule		ESS	Open	High	Significant	12	Reduce