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UPGRADING BEER TO THE FULL SCOPE

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1. SCOPE

This document outlines the arguments for completing the BEER instrument to the full scope. The impact on the science case, cost estimates, schedule and risk analysis are discussed.

2. INTRODUCTION

In the full scope, the BEER (**B**eamline for **E**uropean **M**aterial **E**ngineering **R**esearch) instrument, as proposed at the beginning of 2014, is a multi-scale, multi-purpose instrument that will enable the state-of-the-art analysis of components and engineering processes in the material research field or within the industry framework.

During the scope-setting meeting held at ESS in 2016, the instrument's full scope was reduced by removing parts, which significantly reduced the scientific performance and abilities of the BEER instrument. To ensure high BEER instrument competitiveness within engineering instruments worldwide, the instrument has been designed from the beginning to accommodate the re-scoping easily, and its systems are able to integrate the descoped parts without major delays during the operation period.

The extension of the descoping can be depicted from the instrument sketch below, where most of the descoped items are marked with white colour. Scientifically speaking, BEER lost, in comparison to the proposed scope, the following performances/capabilities:

- The high-flux option
- More than half of the in-plane detector coverage
- Off-plane detector coverage
- SANS option
- Flexible sample orientation and variable gauge volume
- Precision of the sample alignment

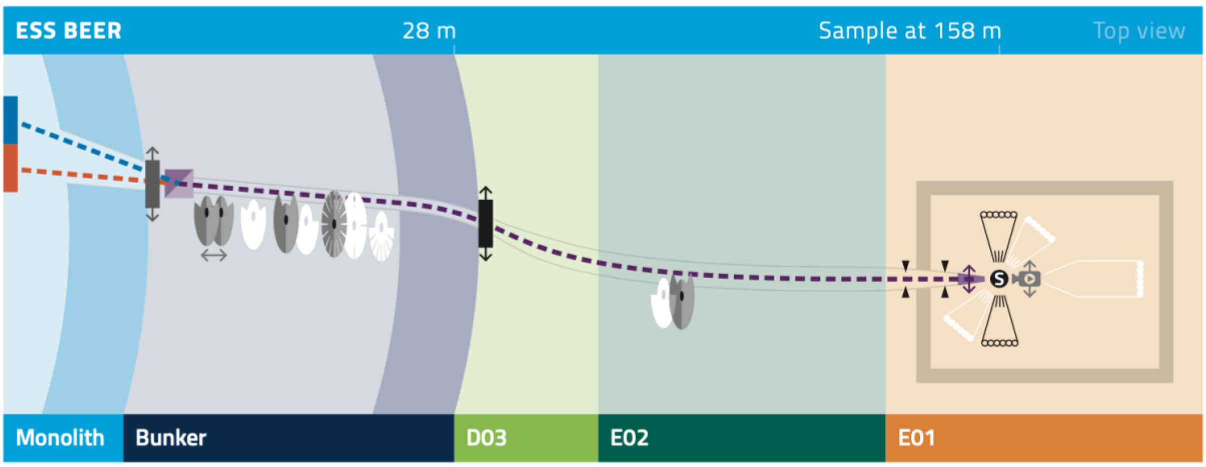

Figure 2-1 Sketch of the BEER instrument (top view) showing the descoped parts in white

3. SCIENCE CASE TO BE ENABLED

The descoped parts can be divided into several groups, each of which has a dedicated and common influence on the instrument's scientific performance. Further below is a description of each group, together with its scientific impact and a short description of the necessary hardware.

3.1. High-intensity and additional multiplication choppers

The additional choppers will extend the resolution/intensity range of the instrument. They will allow for **fast in-situ** and **in-operando** measurements with relaxed resolution using pulse shaping mode, giving access to the 1s time scale of studied **dynamical processes** as envisaged in the original proposal. The additional modulation chopper will enable two more multiplication options, leading to **double intensity** at **high resolution** or, alternatively, a wider separation of modulation peaks needed in the case of materials with complex composition or low crystallographic symmetry. This modulation technique is not used anywhere else and is bound to the long ESS pulse. By widening the options in which it can be used together with the high-flux option in the pulse-shaping mode, BEER will become the world-leading engineering diffractometer.

The hardware consists of only two additional chopper axes and the control units. However, both disks are high-speed disks (168 Hz and 70-280 Hz). The instrument is ready accommodate them (space in chopper racks, vacuum housings, guides, media connections, etc.).

3.2. Off-plane (texture) detectors

Information about texture and its development during the thermomechanical loading of materials is essential for the correct interpretation of observed lattice strains. The off-plane detectors will allow to **follow the texture evolution** even in-situ during mechanical testing with less or even **without rotation** of the sample, which is usually not possible for complex sample environment.

The hardware consists of three small (0.5 x 0.5 m^2) detectors which are placed on the arc over the ±90° detectors. The frame of the main detectors will be ready to support the load together with the floor, etc. There is flexibility in choosing the neutron detection technology to complete this option.

3.3. SANS option

SANS, in combination with diffraction detectors, will significantly **widen the scale range** accessible by the instrument. This will enable, for example, to follow early stages of phase transformations (e.g. chemical partitioning and precipitates growth) before their signature can observed in the diffraction, while monitoring at the same time the evolution of lattice strains and phase composition. Both **SANS and diffraction** can be measured quasi-**simultaneously** (one pulse for diffraction, one pulse for SANS), which will make BEER a widely versatile instrument.

Hardware is not only the SANS detector tank (1 m^2 detector 6 m away from the sample position; the cave is ready for it), but also three additional choppers (all quite slow rotating, maximum 70 Hz). The chopper housing and all infrastructure are ready to accommodate additional choppers.

3.4. Doubling the detector area + backscattering

The detector area extension will not only **increase the rate of data** collection (important especially for the in-situ measurements), but also **widen the d-range** in one pulse (now limited to about 1.7 Å), improve the resolution limit and give access to the peaks which may have too low intensity at the ±90° detectors due to strong texture.

Hardware includes two 1 m^2 detectors, which are placed in the sample plane, and a 0.5 x 0.5 m^2 back-scattering detector. The floor spacing and connection plates are ready for those detectors. The neutron detection technology will be the same as for the off-plane (texture) detectors.

3.5. Other descoped items

There are also other descoped items which seem small, but they have a huge impact on performance expectations, worldwide competitiveness, and user-friendliness of the BEER instrument. Here is a short list of the most important: an extended sample tower **z-movement** (up-down), an additional set of **radial collimators** for a wider variety of gauge volumes and a sample alignment. The **sample alignment system** will increase the accuracy of the positioning, which is essential for strain mapping, for example, in the case of complex-shaped samples prepared by additive manufacturing processes. It will also further increase the speed of measurements due to the automatic positioning of the samples and the planning of experiments in advance.

4. FACILITY SUPPORT OF BEER USER PROGRAM

Besides the instrument's capabilities, there is one important facility-related aspect of engineering instruments worldwide, and it is the sample environment and especially the user-made sample environment. As the sample environment was fully descoped from the instruments, the re-scoping should be concentrated on the second aspect of the above-mentioned, that is, the allowance and simplification of the **experiments with the user-made sample environment**.