Update on the BIFROST spectrometer
STAP meeting, 21st of October

This document briefly outlines the progress of the BIFROST spectrometer since April 2020, where the last update was given.

Cave

The cave construction was commenced in August 2020, the second cave to be installed in the E01 hall. The company MICO won the contract, and they have designed a modular cast-on-site solution, that features virtually gapless cave walls while at the same time being fully decommissionable. The installation were foreseen to take 6 weeks in total, but were delayed due to production delays in the Czech Republic and due to COVID-19. Installation is projected to be finished in the mid of October. Once the cave has been installed, the installation of the tank can commence. In addition, the cave being installed allows us to start the design of cabling infrastructure, electrical power, network cabling, false floors and safety interlock system. The cave walls are 120 cm thick, while the roof blocks are 90 cm thick. There will be two access labyrinths, one on the E01 floor level for maintenance access and one roughly 1.5 meters above the sample position for routine sample changes. The beamstop is in transit, to be installed once the cave is in place.

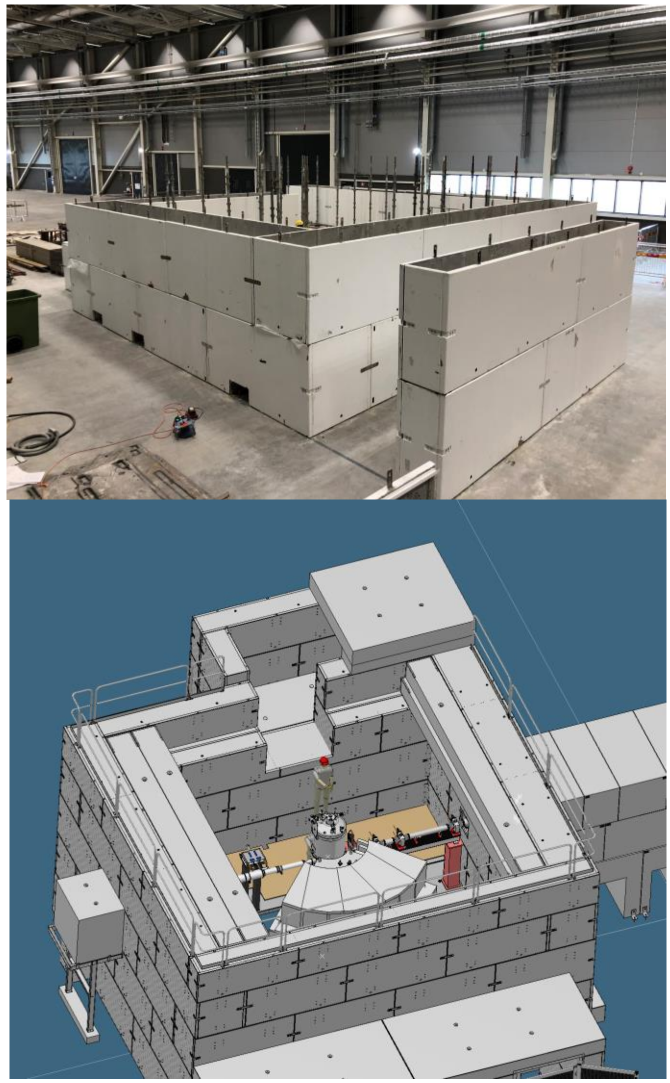

Figure 1: (top) Picture of cave installation work, with preacst panels being put in place to be filled with concrete. Installation in still ongoing. (Bottom) CAD screendump of the soon to be finished cave.

Spectrometer tank

The spectrometer tank production is nearly completed and the tank base, the rails and the motion system has been assembled at the AVS facility in Spain. Some initial tests were been made, moving the 7-ton tank with a hand-driven lever, and the tank moves smoothly. The motor has been delivered, but the proper cables for the factory acceptance test is still needed. The factory acceptance test will take place in October 2020. Depending on when the cave installation is finished, the tank is likely to be installed in November 2020, and the contract will be completed. In early 2021, we will start lining the tank with cadmium, installing the cross talk shielding elements and the analyser holder plate. This allows us to manufacture and test the analyser mounting system in good time. The tank will likely not be fully bolted to the floor this year, as a proper alignment is contingent on exact knowledge of the sample position in the target coordinate system, which is not yet available.

Figure 2: The spectrometer tank assembly

Sample stack

We have placed orders for the sample stack components. The goniometer has been delivered, and looks good. The sample table has been produced, but awaits the shipping of cables for the FAT test to proceed. The orange cryostat has been ordered as well, with fast-cooling heat exchanger and an additional sample stick. Leading up to the delivery of the cryostat in the spring 2021, we will install the sample table and goniometer, and then be able to test the motion and handling of the full sample stack assembly.

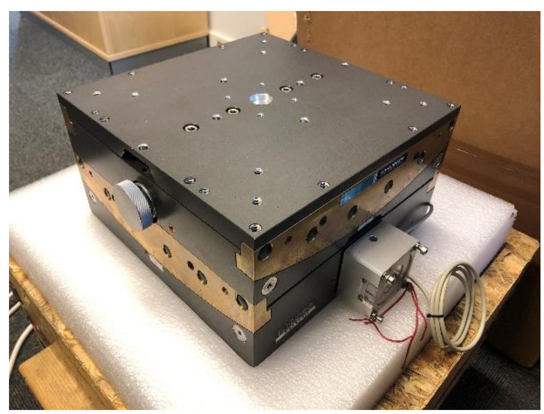

Figure 3: The goniometer to be used with the orange cryostat

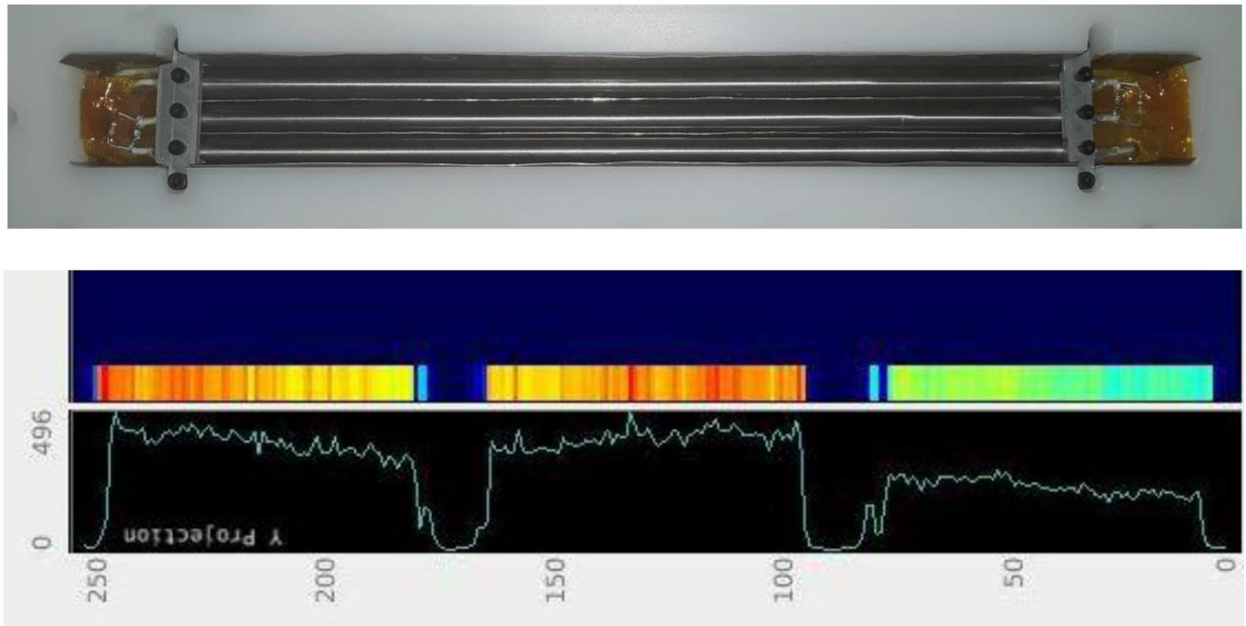

Figure 4: (Top) Detector prototype assembly. (Bottom) Pulse height versus position (arbitrary units)

Detector prototype

The first tests of the detector triplet prototype were performed at the ILL. They revealed a grounding problem that necessitates a redesign of the detector mount and its coupling to a floating ground. This is ongoing, and we expect the design to be finished at the end of the year. The separation of the tubes works well, though.

Prospects for procurement and installation

The installation of the secondary spectrometer progresses nicely, but the chopper and guide deliveries are still on the critical path. We have signed a contract for the guide, and the preliminary design with the company is all but completed. The chopper contract is expected to be in place during October 2020. The order for the detector tubes have not been placed, but that is expected by the end of the year. Once the triplet grounding design is completed, the prototype will be sent to the ESS for testing with backend electronics, to take place in 2021. Having the cave in place early though, allows us to get the design and installation of much of the infrastructure in a manageable pace, which constitutes some of the more complicated interfaces with the ESS.

Commissioning plan

We will likely be ready to accept neutrons in the beginning of 2023. We are however still prioritizing procurement over hot commissioning planning but we hope to present a detailed plan at the next STAP in April 2021. This plan would include:

- Radioprotection measurements

- Hot commissioning of chopper system (phasing, timing and bandwidth at the sample position), using the monitors
- Absolute flux measurements at all PSC settings
- Beam characterization at the sample position (divergence and beam profile) for all settings
- Vanadium scans for analyzer normalization
- Crystal field measurements for normalization, and energy resolution determination.
- Testing inelastic Q-resolution using high velocity phonons
- Background determination (prompt pulse, thermal background and gamma background)
- Tank alignment using Bragg peaks on powder samples with diffraction detector
- Detector performance: Crosstalk and strong Bragg peaks.
- Analyser performance: Uniformity of energy and angle-resolution
- Finally, a couple of tests using highly scattering well modelled magnetic systems.
- Test of backgrounds and other effects from sample environment (will the spectrum with a 15 T magnet be as clean as in an orange?)

Early science planning

Even at 200 kW proton power, there will be enough flux to investigate even low spin systems. However, we are likely to commission the instrument with considerably less power than that. For early science, we have an orange cryostat, a 15 T cryomagnet and pressure cells via the SAD group. We thus have plenty of options for demonstrating extreme environment capabilities. In the year leading up to first protons, we plan to work with our partners at PSI, EPFL, DTU, LLB, IFE and KU, to make concrete plans for early science – using the partner scientists and their collaborators as a first step. It goes without saying that scientific impact and demonstrating the capabilities of BIFROST should be the twin focus of early science. We still propose having two distinct plans for low at high flux respectively

- Low flux (< 100 kW): We choose science cases among systems where either large magnetic moments or large crystals are available. We remain focused on demonstrating extreme environment capabilities, but are less willing to rely on the flux-cutting settings of BIFROST (high E-resolution, high energy transfer). We should still be able to do spectroscopy in pressure cells at low power – this should be a priority.

- High flux (> 100 kW): We choose science cases among the most flux-demanding systems in the literature (cuprates, low-spin systems, disorder, organic superconductors), to demonstrate experiments that are borderline feasible even at flagship facilities. We aim for demonstrating the full performance range of the instrument, including very high resolution and high energy transfer (albeit with less demanding systems).

Polarization analysis

We are progressing in the upgrade plan for polarized neutrons. Wa i Tung Lee has been kind enough to calculate the guide fields on BIFROST, including the steel/stainless steel shielding envelopes around the beamline. We plan for the incident polarizer to be 22 meters from the sample position, with an almost 21 meter resulting guide field. This seems to be relatively straightforward to implement. Inside the cave we have, due to the magnet, chosen a Halbach coil array. The initial design is still ongoing, but we plan to have a costable option before the next STAP. Erik Knudsen has implemented an S-bender in the BIFROST McStas code, and initial simulations show a decent transmission, while retaining beam characteristics. This S-bender will be optimized in the months to come, to find the sweet spot with regards to performance and cost. However, we are still considering alternative options such as V-cavities.

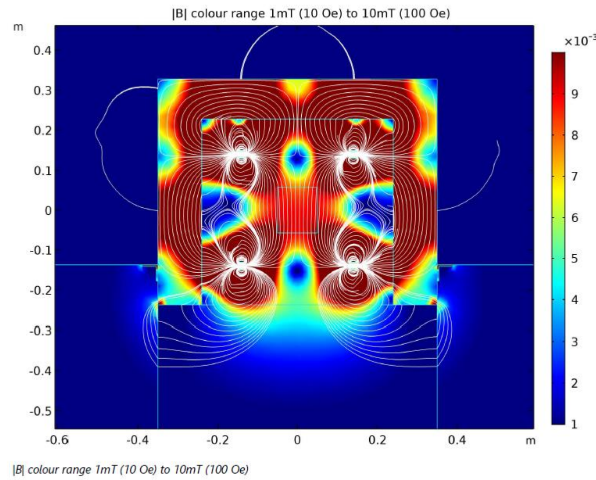

Figure 5: Calculation of field lines in a four-magnet setup around the beamline. Field uniformity in the guide is evident.

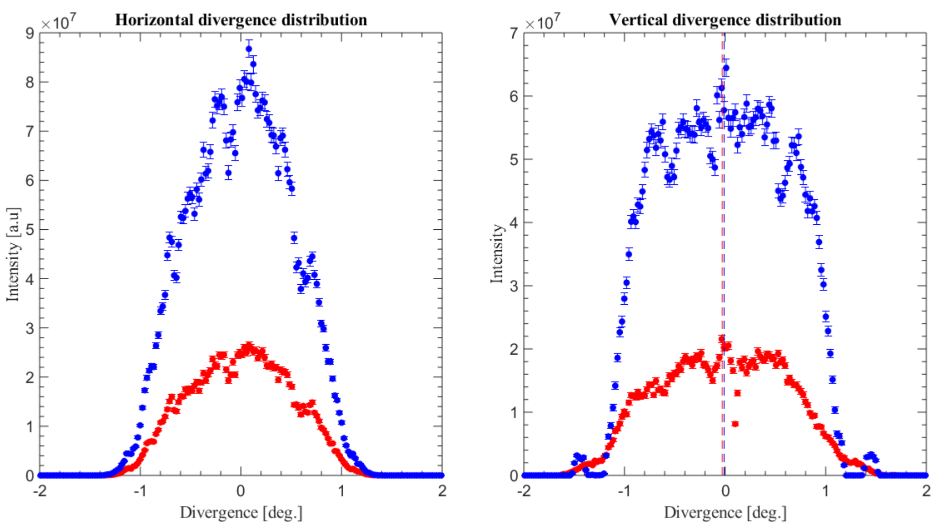

Figure 6: Simulated divergence profile with (red) and without (blue) a bender.