MIRACLES: STAP Spectroscopy report (April – September 2020)

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General information

The MIRACLES project is moving ahead with the incorporation of the new lead engineer, Jorge González, two months ago. Unfortunately, there was a significant delay in the recruitment process, because of the policy mentioned in the previous report for priority reassignment in the Spanish Administration due to the COVID-19 outbreak.

The outcome of this issue is the delay in some of the calls for tender verification (CTV) processes, an ESS review procedure of the technical specification documents used for tenders that include detailed design + manufacturing. Nevertheless, an engineering team formed by mechanical and electrical engineers has been incorporated to the project to speed up the MIRACLES works comprised in this detailed design phase.

A summary of the progress is described below, from source downstream.

Beamline optics

The Neutron Beam Optical Assembly, NBOA, (section of the neutron beam extraction system that goes through the ESS monolith) is suffering significant delays, due to the unavailability of neutron sources to carry out reflectivity tests. This is a general issue affecting all instruments that have an NBOA (almost all ESS instruments).

The CTV of the Bunker Wall Insert (BWI) was approved last August, so it is now ready to tender. Such tender is scheduled to be launched by October.

The CTVs for the out of bunker guide and the in-bunker guide are scheduled for December 2020 and February 2021, respectively.

The MIRACLES engineering team is also carrying out works oriented to deliver a detailed design of the guide supports and guide housing alignment concept. This work is being performed with fluent feedback with the responsible of alignment and metrology at the ESS, Fabien Rey.

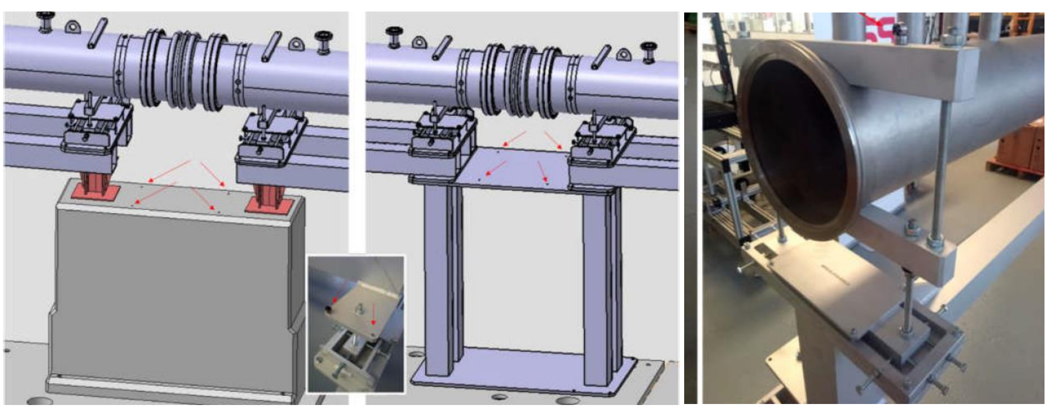

Figure 1. Concept for guide supports at the bunker (concrete and aluminum), with laser tracker holder holes. Also, prototype of the design concept for housing alignment. 3D preliminary design of the current concept

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Choppers

The CTV of the chopper cascade was approved last July. The tender process is now in the legal procedure stage, and hopefully will be launched by Q4-2020.

It should be mentioned that in the tender documentation, it is explicitly stated that the slow choppers will have a strong interface with the beam monitors, to be defined once the monitor technology is set. We then will be ready for any beam monitor that will be attached there.

The MIRACLES team has expressed their interest in joining the ESS choppers common project, for provision of the racks. The kick-off meeting was held in June, and the transfer of scope will take place during Q4-2020.

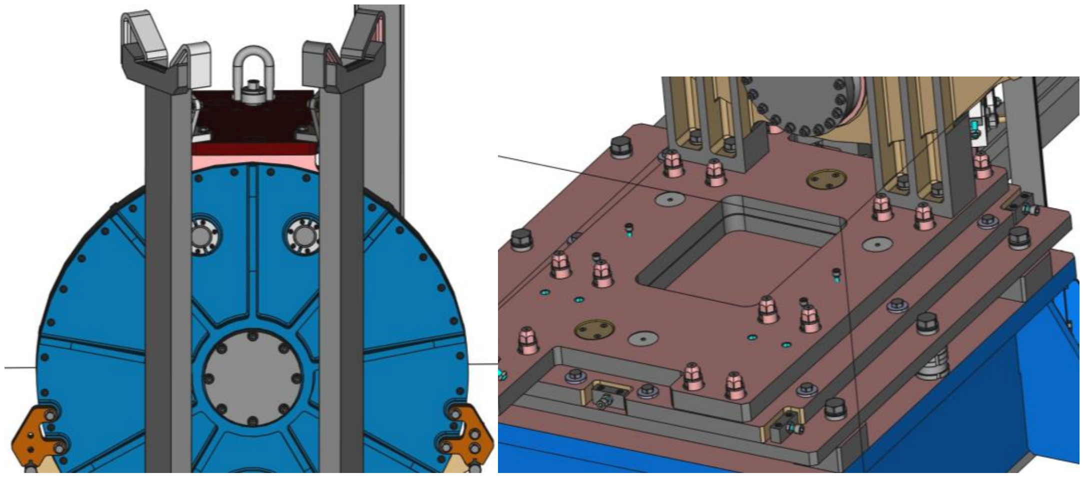

Figure 2. (Left) In-bunker chopper module, with proposal of possible mechanical assemblies for remote handling (rails, lifting eye,…) ; (Right) Base of the chopper module with alignment features

Secondary Spectrometer

Besides the ongoing tasks involving the design of the secondary spectrometer components (mainly devoted to give shape to the equipment around the sample environment), we have received in 2020 two essential inputs to give final shape to such design:

(a) One from the technical design review held in March, which final recommendations were endorsed by the STAP;
(b) the other from the outcome of the ESS Polarization Workshop, in which the ESS Polarization team and the MIRACLES team worked together to integrate the polarization capability into the MIRACLES design.

Many of the recommendations from the review panel referred to the design of the vessel. This is an ongoing work, given the fact that the lead engineer recently incorporated to the team. Nevertheless, we can outline some of the modifications that are being implemented:

- The vacuum level has been improved down to ~10^{-4} mbar to minimize the air scattering. To this purpose, it is planned to incorporate two turbomolecular pumps.
- The final diameter of the vessel has been reduced to ~6 m, reducing the space between lateral walls and analyzer support. With this, lateral access to the vessel is removed, and another access has been implemented from the bottom.
- Mechanical analysis is ongoing to reduce the tank deformations that could affect the sample position and in-vessel components.

- A laser-based alignment protocol for the analyzer, is being drafted. Positioners have been designed to be handled from the front of the analyzer. The idea is that every set of 2 panels (column of top-bottom panels) have translation movement, whereas every panel has independent angular movements (pitch and roll, yaw does not seem to be necessary).

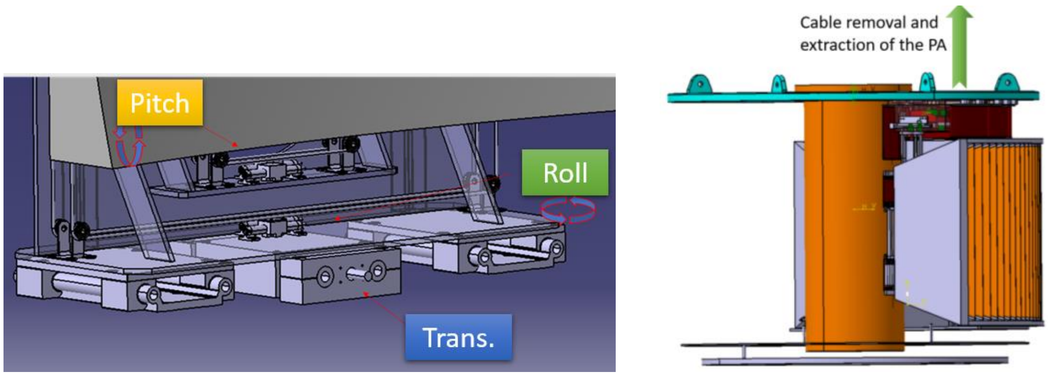

Figure 3. (Left) Proposal for positioning and alignment system of the analyzer panels (Right) In-vessel components around the sample environment: detectors frame, (upper) preamp boxes, and radial collimator.

Additionally, the panel endorsed the experimental strategies presented by the instrument scientist to test the U-connection of ^{3}He tubes to the detector electronics as well as to optimize the gluing procedure of the Si(111) crystals. However, the activities are subjected to future access next year to neutron facilities.

Current advances in the design of the in-vessel components include easy access to the installation and removal of the detector preamps corresponding to the top detectors from the top flange. A similar proposal is dedicated for the slit, which allows direct extraction from the top for maintenance. The top lid can provide extraction of the whole assembly detectors+preamps.

On the other hand, the lower flange will be used to install and remove the bottom detectors+preamps assembly, as well as the radial collimator and its stage.

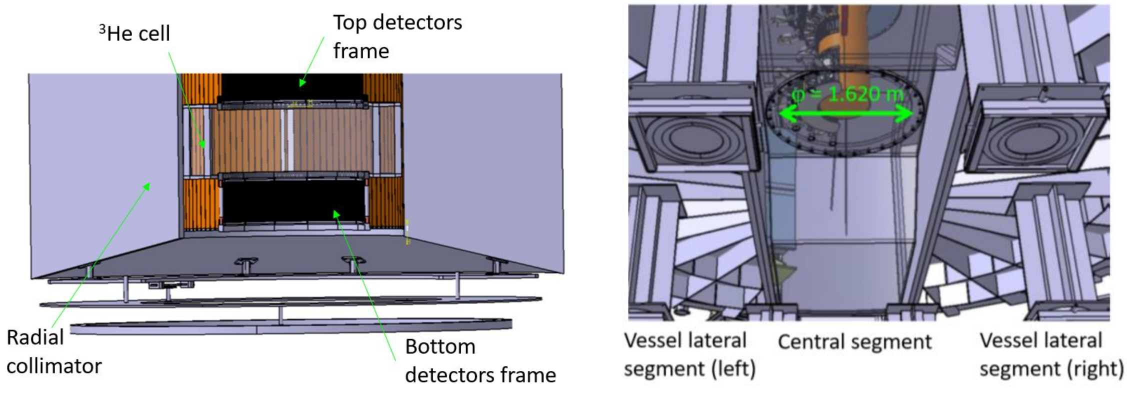

Figure 4. (Left) CAD model of the in-vessel components (radial collimator, detector frames) with the ^{3}He cell implemented. (Right) Bottom of the vessel showing the new dimensions of the bottom flange, used to install and extract the bottom in-vessel detectors and the radial collimator.

Recent calculations have given shape to an advanced version of the radial collimator. However, its dimensions (and subsequently the dimensions of several parts of the vessel) have been modified due to the works carried out last month to implement neutron polarization capabilities in MIRACLES.

The main consequence of the implementation of polarization equipment is that the vessel should make room to host a ^{3}He cell, of about 70 mm thickness, located between the detectors and the radial collimator. This pushes the inner radius of the collimator further from the detectors (up to r_m=350 mm). To keep the same focus size of 70 mm (sample bore of a cryostat) the outer radius must be R_M=805 mm. For installation and extraction of the radial collimator, the lower flange should have a clearance of about twice the outer radius. This increases the final dimensions of the central segment of the vessel, at the expenses of the lateral segments' dimensions.

Additionally, during the meeting it was pointed out that MIRACLES, due to the easiness of design integration, the timeline of the project, and the potential scientific outcome, could be a good candidate to have polarization capabilities on day one.

Experimental cave and control room

The most remarkable evolution in the design of the cave in the last months is related to the design of utilities and routing, and their integration with the facility.

The next months will be important to give final shape to the cave. This final design will receive the feedback from the personnel safety system (PSS) strategies. Preliminary thoughts suggest that the entrance doors to the interior of the cave for commissioning and maintenance, as well as the access to the sample area will be interlocked and connected to the PSS.

On the other hand, the control room, attached to the cave and the experimental areas, will have a separate room for the racks and the communication/network. Also, another room for storage of equipment is under consideration.

It is expected that the experimental cave and the control room will have their CTVs in early Q1-2021.

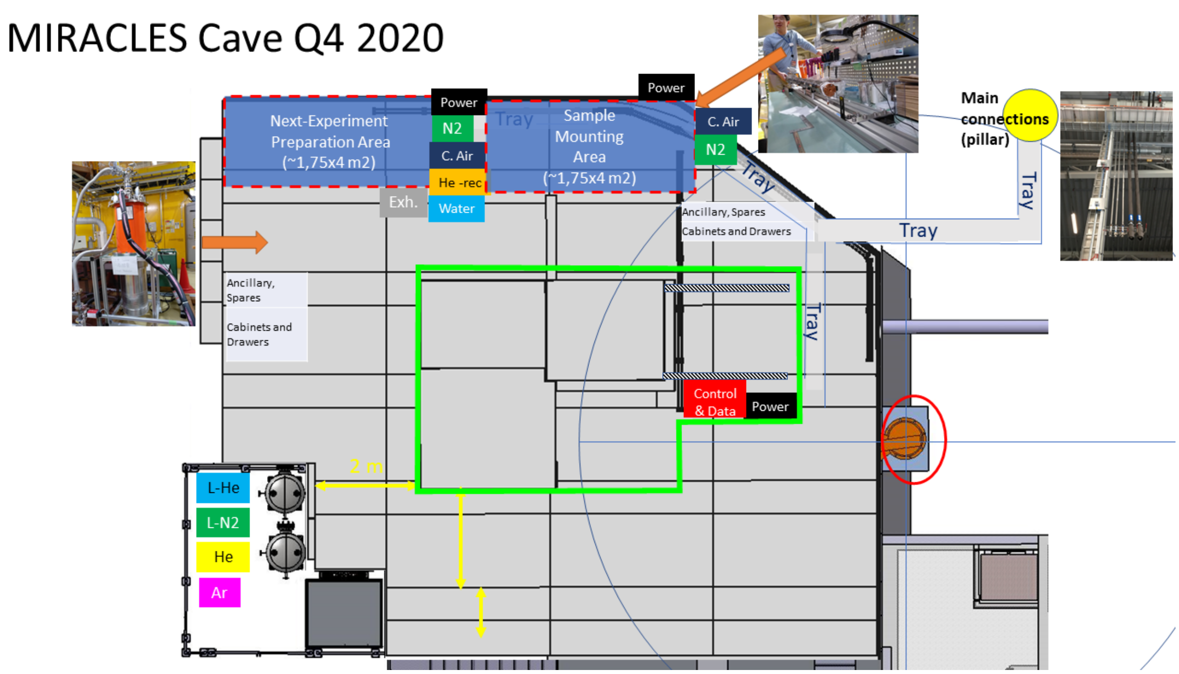

Figure 5. Sketchy illustration of the cave's roof, indicating the location of the experimental areas and the distribution of the utility supplies. Implementation into the CAD model is ongoing.

Motion control and electrical engineering

Recently, we have made some progress in the specification of the radial collimator. The radial collimator of the MIRACLES ESS backscattering spectrometer requires two different rotatory movements (equatorial) over the vertical sample axis of the collimator:

(i) Oscillation (rocking), needed to average the shadowing effect of the absorbing foils. Typically, it has a range according to the position sensitivity (tube diameter for spectrometers). For MIRACLES, this range is 3.24º.

(ii) Removal (long rotation). In some experiments, the radial collimator needs to be removed from the neutron scattering pathway. For MIRACLES, the proposal consists of retiring the collimator by applying a rotation of 180º behind the sample (by the get-lost tube side).

The oscillation period is not fast, but it should be significantly small and negligible compared to typical measurement times. Frequencies of about 0.1 Hz (oscillation time of 10 s) will be sufficient. Moreover, since all the detectors should have a collimation channel during oscillation, it is intended that the radial collimator shall have 49 channels (48 tubes+1).

The oscillation can be achieved by a linear motor (e.g. stepper motor) which motion is converted to a rotary motion (using e.g. a Scotch yoke[i] drive mechanism). The motor and the stage/table (aluminum plate) will be located in the vacuum vessel. Lubrications of driving elements are done with a commercial ultrahigh vacuum grease. The motor is connected using electrical feedthrough to the logic controller (e.g. PLC) that controls the position and speed with accuracy. Like in the mechanical design, the maximum deviation from the nominal metric and angular values are ±0.2 mm and ±0.1º, respectively.

Shadowing effects are unavoidable in the deadtime when the collimator changes its direction of movement. To minimize this, a short dead time is required (t ~ 20-100 ms). Additionally, an option similar to the shift mode in the 4SEASONS spectrometer is under consideration and could be useful for the MIRACLES users.[ii]

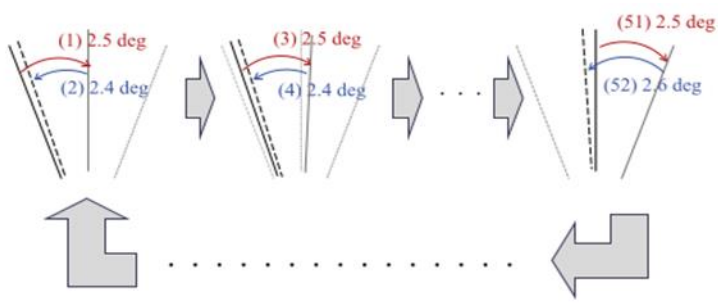

Figure 6. 4SEASONS collimator shift mode mechanism

With respect to electrical design, an updated version of the piping and instrumentation diagram (P&ID) has now a certain level of detail.

Also, a document describing the power and rack distribution in the different buildings occupied by the MIRACLES instrument has been drafted.

Finally, the MIRACLES team has had several conversations to define the level of involvement into the ESS common electrical project. Discussions are ongoing, and a final decision will be done before the end of this year.

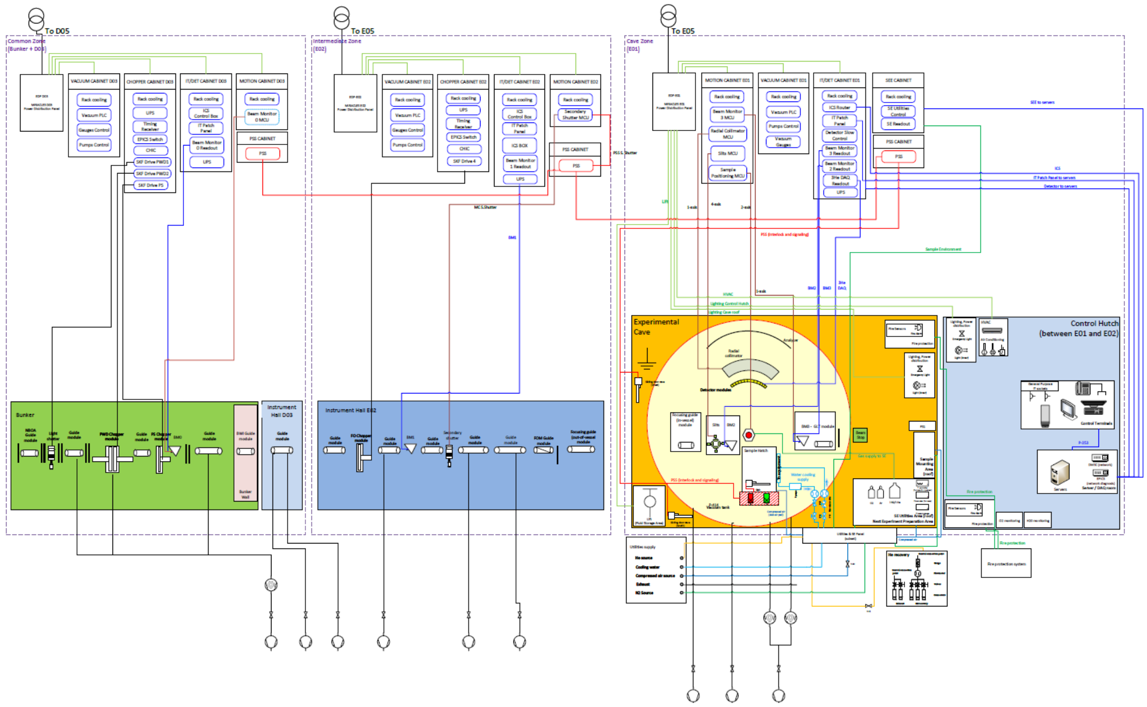

Figure 7. Current version of the P&ID for MIRACLES

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[i] M.B. Stone et al., Rev. Sci. Instrum. 85, 085101 (2014)

[ii] M. Nakamura et al., Physica B 551, 480-483 (2018)