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Cave design in the E01 hall
Instrument: HEIMDAL

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CONTENTS

Summary:

This report describes the cave design for the instrument HEIMDAL placed in the experimental hall E01, position W8. Two access ways to the instrument cave are foreseen; 1) though the roof of the cave for fast sample changes and large sample environment installation and 2) a side door for full access to the detector area for sample environment installation and maintenance of the instrument. The space occupied by the cave and control hutch in the E01 hall is described along with the foreseen stairs and access routes. A floor load estimate is given using a wall thickness of 1000 mm for the concrete walls.

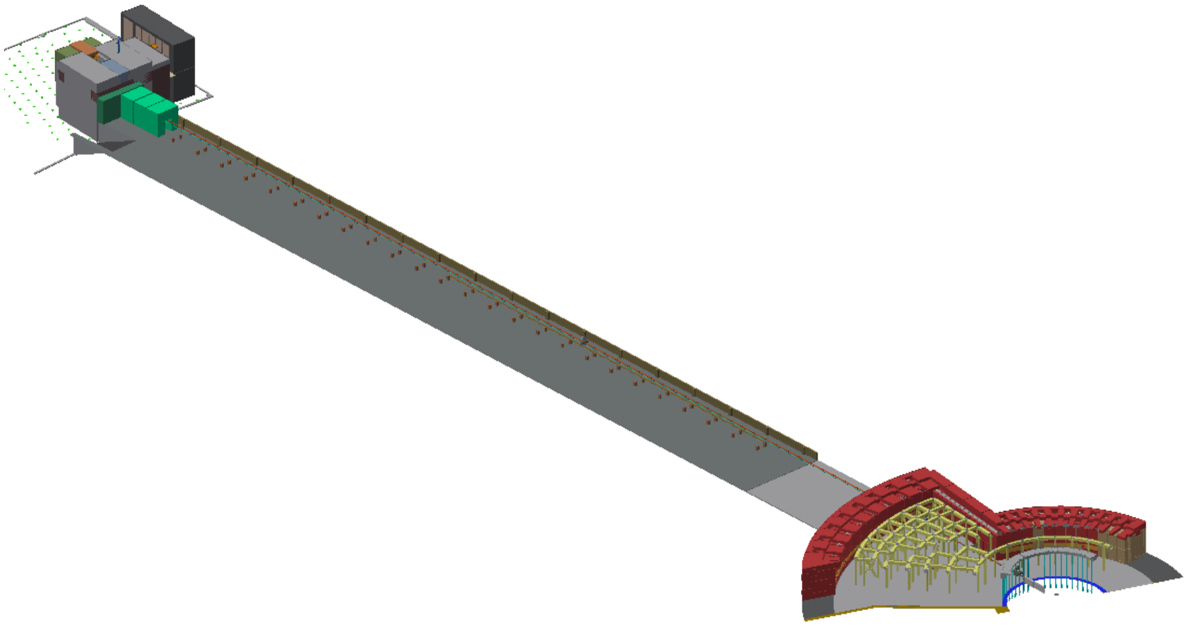

Fig. 1 Sketch of the HEIMDAL instrument in the different halls.

1. INTRODUCTION

HEIMDAL is the W8 instrument and placed at the north end of building E01. The instrument is very close to the outer wall in the pillars hall E02. It has only one neighbor to the left-hand-side W7, T-Rex. HEIMDALs position at W8 has given rise to several major constrains concerning monolith and bunker feedthrough. The support pillars for the beam guide in E02 are lined up with an angle of 20° in the Target Coordinate System TCS. This also applies to Bunker Wall Segments. However, the beam must follow more or less a direction of 19° from Beam Port Coordinate System, BPCS, consequently it must follow the direction of the North raw of pillars. The disadvantage of this construction is that the support to hold the guide will be asymmetrical and provides challenges with placing guide shielding appropriately. An advantage is that guides move further away from the ramp between the pillars in hall E02 and cave hall E01, effectively creating more space for the experimental cave and reduce overlap with T-Rex.

The HEIMDAL instrument is complicated and very challenging with two beam guides and a long SANS tank. The SANS tank is currently not within the project scope of the day-1 instrument, but it must be included in the preliminary design to ensure upgradability in the future.

The thermal guide is straight and within direct-line-of-sight of the source, and requires heavy shutter and a large and heavy beamstop behind the get lost tube after the sample position. The avaliable floor space must hold the beamstop and host the SANS tank.

A large entrance port at the east end wall of hall E01 will cause frequent and heavy traffic, for transporting components to the neighboring instruments. Consequently sufficient space behind the instrument must be allocated for traffic and transportation. Not only is there need for space behind the instrument at floor level, but it is also necessary to leave space above the instrument for craning various components.

1.1 Budget

Current budget estimate of the cave including shielding, false floor, trap door, beamstop, instrument hutch, and PSS is 1292 k€.

2. SPACE IN E01 HALL FOR CAVE AND HUTCH

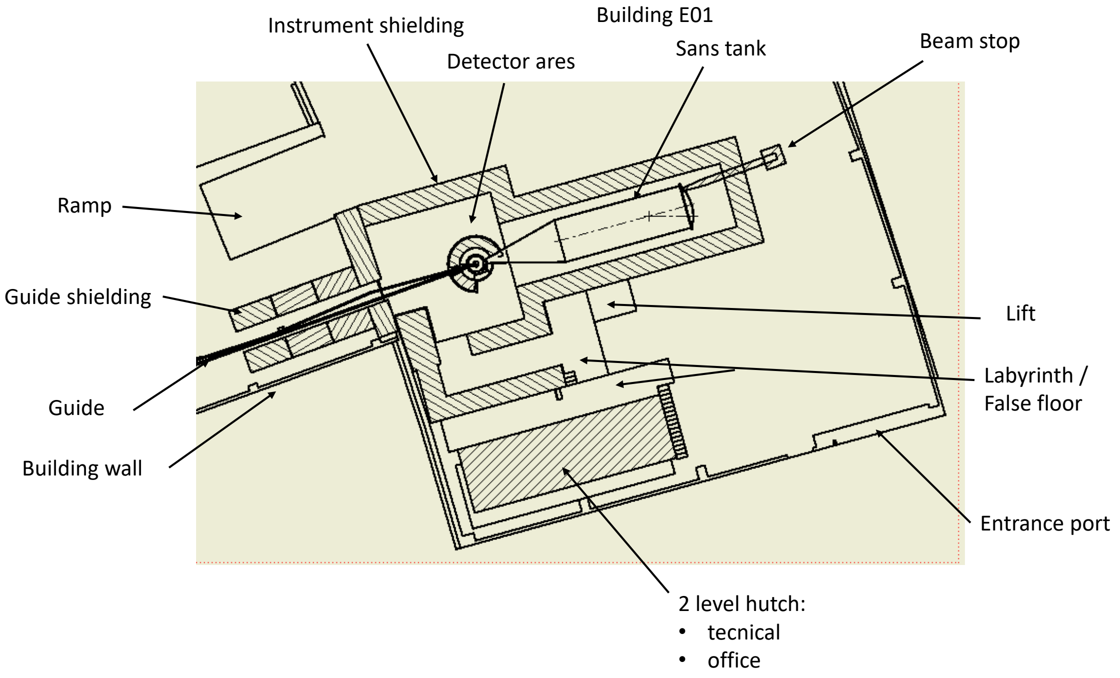

Fig 1. Cross section overview Heimdal sample area.

The HEIMDAL instrument features a very challenging setup with two guides a cold and a thermal used for two different experimental techniques Thermal Neutron Poweder

Diffraction (TNPD) and a long small angle neutron scattering (SANS) tank. The thermal guide is straight and gives direct-line-of-sight between the sample and the moderator. Consequently, safety features includes a special designed long, large and heavy beamstop dump the neutron beam after interacting with the sample. Support of the beamstop must be at floor level and dependents on the necessary size of the SANS tank.

The cave can in principle be split into two parts. One is the cave for the sample area, including the diffraction detectors and SANS tank with SANS detector. The wall thickness for the sample area cave is in the current design 1000 mm concrete everywhere. While for the SANS cave the roof is reduced to 500 mm. Recent FLUKE calculations suggest that the wall thickness can be reduced to 850 mm for the diffraction cave, while the SANS part can be reduced to 650 mm. The reduction in wall thickness is important for floor load and cost.

3. CAVE DESIGN

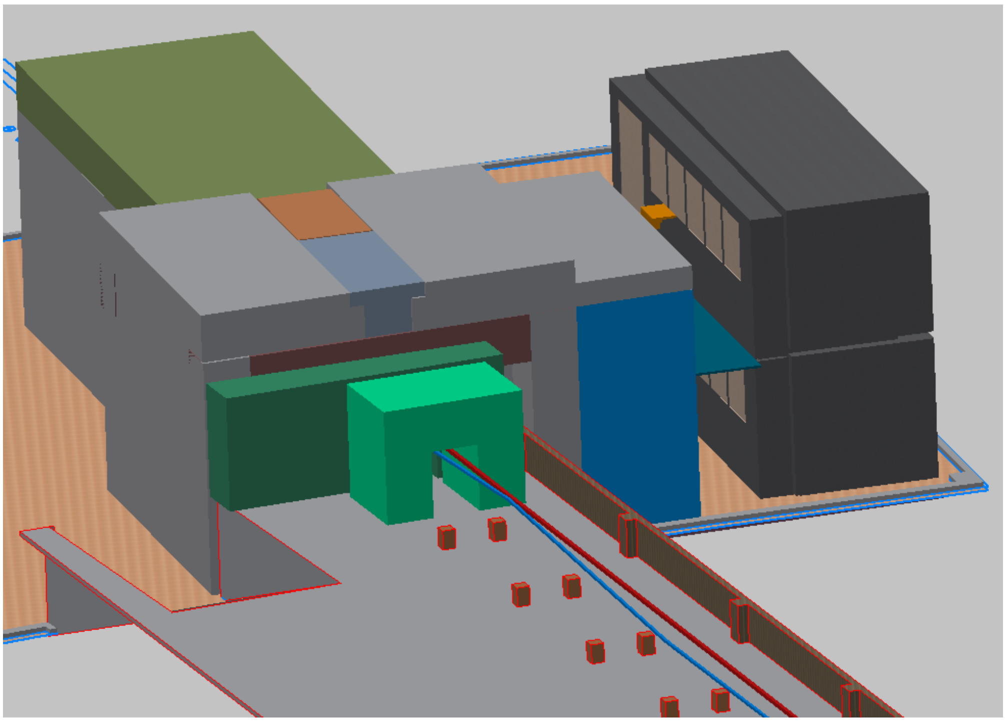

Fig 3. View at Heimdal cave from pillar hall E02.

For convenience and easy access to the sample area to change samples or sample environment. The cave can be accessed either at beam level or from the roof. The access at beam level is through a labyrinth, while a moveable trapdoor in the roof insures access from the top.

A false floor in the cave is extended into the labyrinth and creates a platform in front at the same level. This allows easy transportation of heavy equipment in and out of the cave e.g. nitrogen or helium Dewars or control racks for sample environment. From here there will be access to the hutch platform and hall floor by stairs.

3.1 Arrangement for Detector Area

In general it a challenge to support detectors, collimators and sample environment with beam centre 3200 mm above the floor level of E01. Every part needs its own support for an individual size, weight and movements.

As large magnets will be used at the sample position, all components must be manufactured from non-magnetic material whenever possible. No motors can be placed within 1m of the sample centre. Additionally the area will see high radiation levels, therefore attention must also pay to possible activation of materials used in the cave and support design.

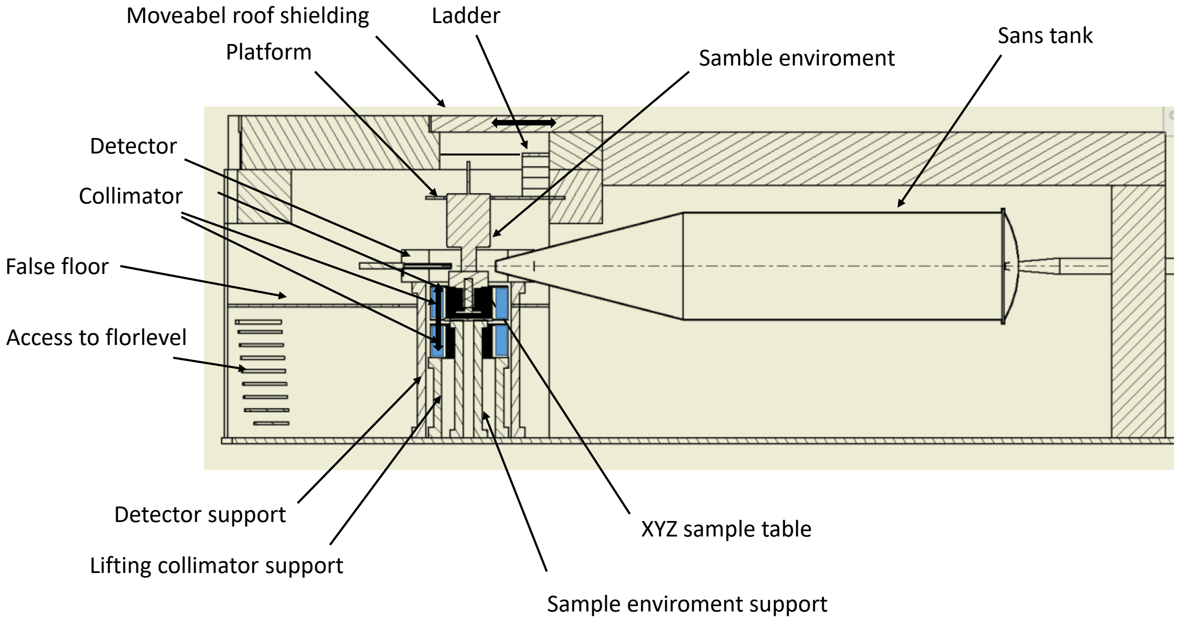

Fig 3. Cross section of detector area including the SANS tank.

For service and handling sample environment, access is viable via the labyrinth with the false floor or through the sliding hatch in the roof.

Sample environment equipment (SEE) is craned into place through the hatch. Initially it was considered to use the hall gantry crane, however after discussion with ESS engineers a better solution be to install a mini-crane on rail support of the gantry crane. The small crane will have a maximum capacity of 1000 kg. It may be worthwhile to check-up on Swedish law regarding training of crane drivers and maximum loads. Due to the thickness of the shielding roof, a platform is mounted at the top of the sample environment accessible from the top by a ladder, for easy sample change.

3.2 Sample Environment Support

The current sample table is designed to carry a maximum load of up to 1000 kg. For correct position the sample environment and in order to perform diffraction tomography experiments it needs an X,Y,Z adjusting table and ω-rotation. In the current design we intend to use a table similar to the one used at instrument ZEBRA@PSI. The sample table needs support in the form of a slim pillar arranged below the false floor and connected directly to level 0 of E01. The support system will be surrounded by the lifting system for the radial collimators.

3.3 Radial Collimator Support

The radial collimator arrangement is a set of two collimators stacked above is other. The purpose is to interchange the collimators by a vertical motion. The movement of the collimator arrangement allows placing one or the other collimator in the operation position in front of the detectors. Since the collimators are 700 mm high, it is necessary that the lifting system can handle at least 1400 mm in height. This can be fulfilled by placing the collimator system below the false floor directly on level 0 of E01, as there is sufficient space below the instrument. Due to the large inner diameter, the collimator can bypass the standard sample environment.

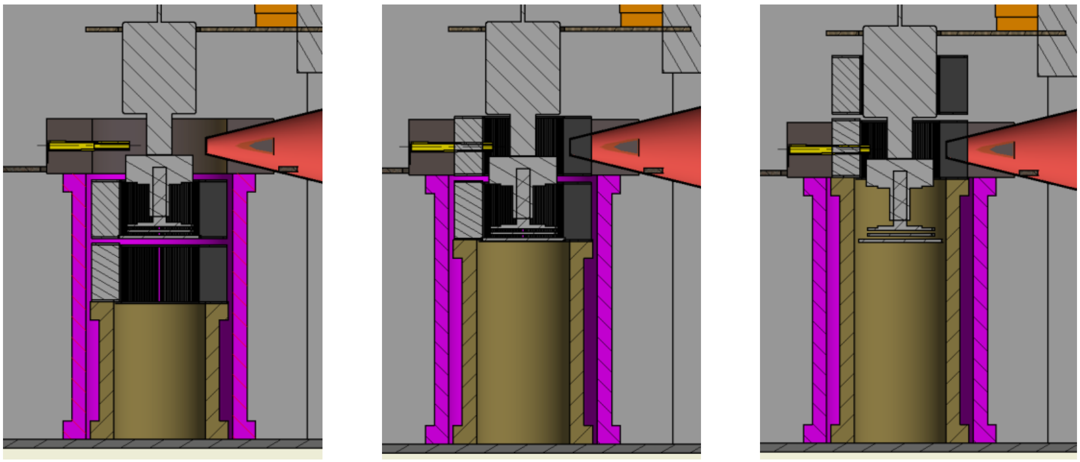

Fig 4. Position for Collimators: 1) No collimator at detector level. 2) Fist collimator set in front of the detectors. 3) Second collimator set at detector level.

3.4 Detector Support

The detector design is particularly weak against physical impact. Therefore, this must be taken into account, when designing the detector support. Likewise is it important to have easy accessibility during installation and service, and a good shielding to reduce the background. A fence around the detectors may be necessary during normal operation and general use to avoid misalignment and damaging of the detectors.

The detectors have their own support, which is placed directly onto the cave floor. Between the detector support and the support of the sample table, the oscillation table for the collimator will be installed.

3.5 False Floor

A false floor is placed at a reasonable height of the cave detector area to allow operating around the sample without too many restrictions.

The false floor must be decoupled from all detector support to avoid vibrational ‘noise’ in the experimental hall. The false floor fills up the hole detector area and provides space for necessary equipment as electronics rack, pumps, nitrogen/helium dewars etc.

A hatch in the false floor gives access to the cave floor, where cabling and utilities can be distributed conveniently.

As staying in detector area will happen often and over time, it is necessary to careful choice of materials due to activation.

3.6 Lifting and Craning

Heavy equipment is lifted from the hall floor up to the false floor with a lift, *e.g.* elevator or scissor lifting platform. This allows changing of dewars and similar equipment without the need of the crane. It also allows access to the cave for persons with disabilities.

Bulky sample environment is craned into the cave through the roof using a small crane mounted on the rails of the large gantry crane of the E01 hall. HEIMDAL will have its own crane an not rely on the gantry crane. It is assumed that during user operation the usage of sample environment can be planned in such a way that the crane would be needed around 1-2 times peer week.

3.7 SANS Area and Beamstop

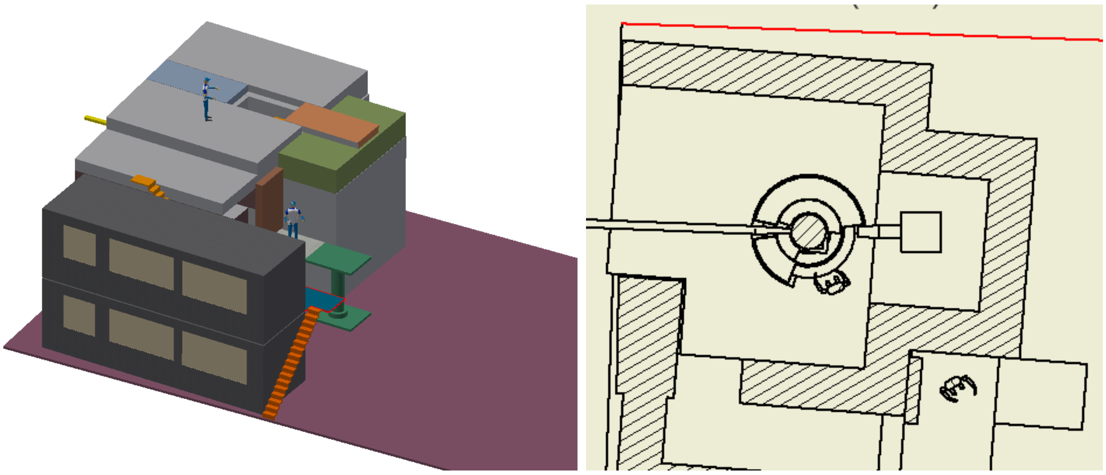

Fig 5. Cave layout without SANS tank. The cave roof hatch is shown in orange.

Layout without SANS tank, it is necessary to be aware, that there needs to be enough roof to slide out the cave roof hatch. This addition space could be used to fit beamstop inside the cave, however it is likely that it is better to place the beamstop outside the cave to minimize the background collected by the diffractoin detectors. The SANS cave can be extended at a later point in time, however consideration regarding floor load is important at this stage. It is also likely that it would make most sense to install the cave immediately.

Without the SANS tank, the SANS cave is shorted by 8 m, which gives a saving of 95.2 m^3 of concrete.

3.8 SANS Upgradeability

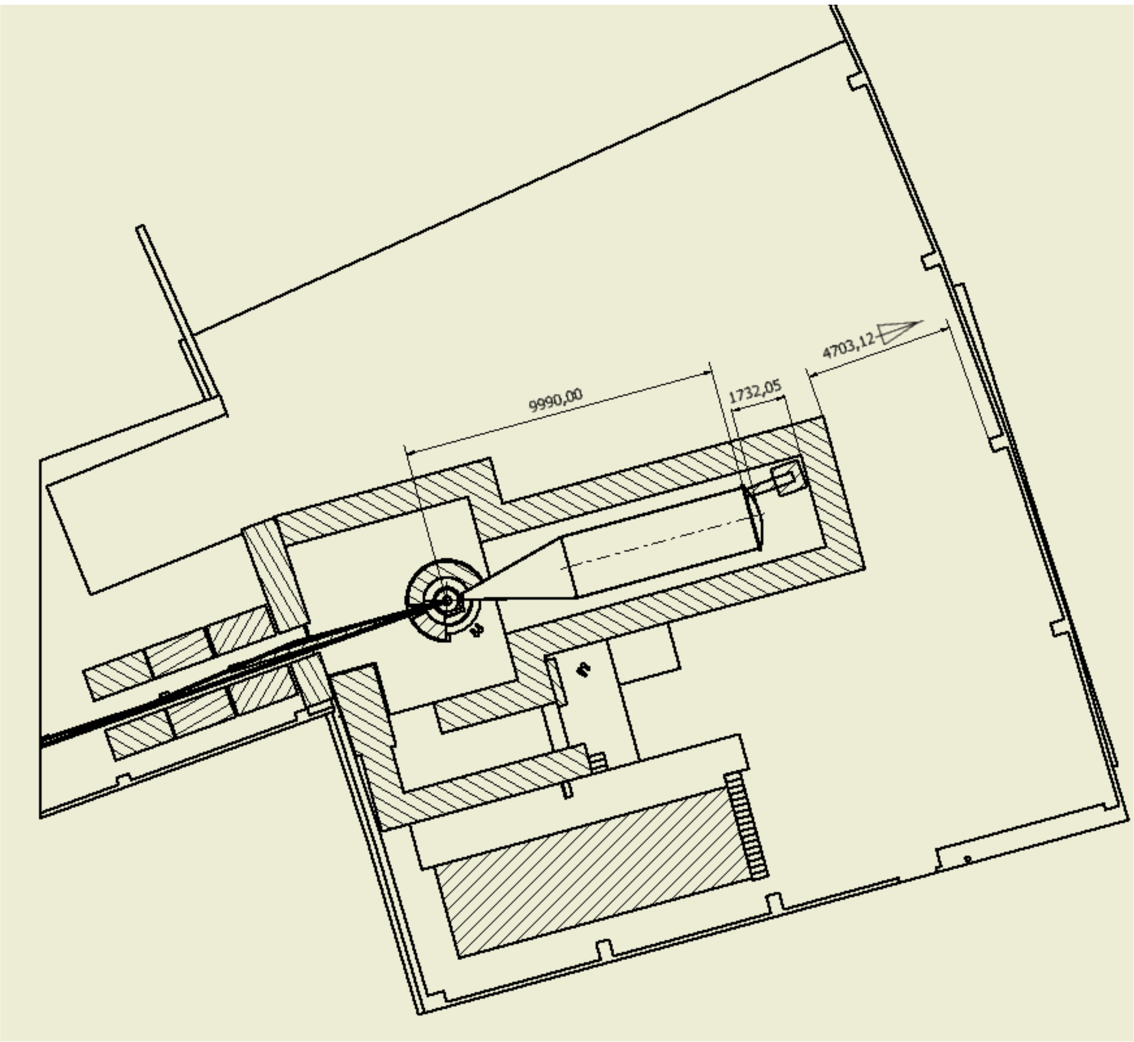

Fig 6. Design with SANS tank and build-in beamstop.

Main design including the SANS tank. The final size of SANS tank is not yet determined, but current calculations provide a tank of 10 m length, with the detector plane placed 500 mm from the end of the tank. This is to verify necessary spacing around the instrument. Also to calculate the difference in price for necessary shielding with and without SANS tank.

In the illustrated design, it is attempted to build in beamstop in the SANS tank cave. This solution avoids additional shielding for beamstop and offers a simple solution, however it is very likely that the beamstop would pollute the signal detected on the SANS detector. The SANS tank is accessible for service by dismounting the ‘get lost tube’ and beamstop.

4. ACCESS TO THE CAVE

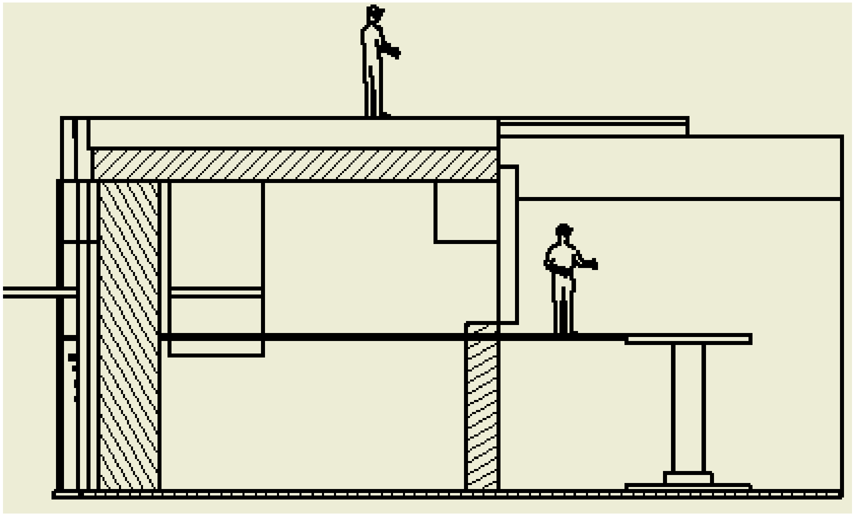

Fig 7. Access to cave.

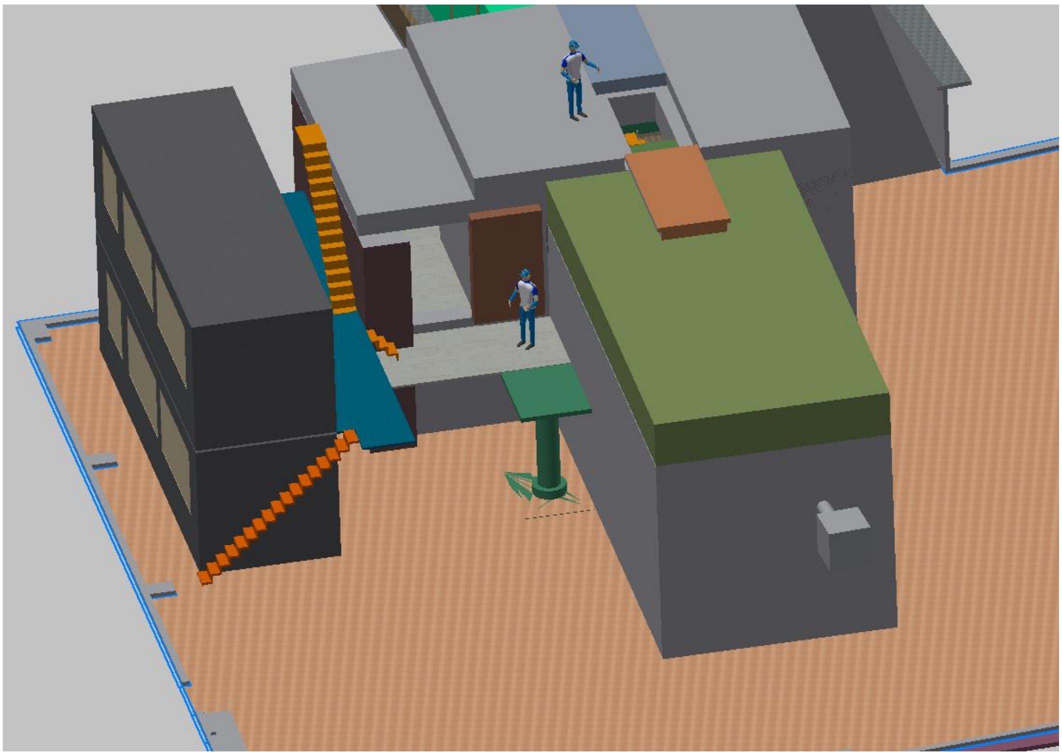

Fig 8. Access to cave.

Access to the cave is via stairs to the platform, and staircases to the different levels from the platform. Because of the difference in the height of the false floor in the cave and the floor level of the upper office hutch, an additional platform is necessary. From the platform at the office hutch, a staircase leads up to the roof of the cave, and another one down to the false floor. It is necessary to set up fences around platforms and operation area of the cave roof. On the cave roof, a possible falling risk is fixed with fences, considering the clearance for craning. The fence should not disturb most craning operation, if need be a removable fence can be considered. Distance from beam center to the top of the roof is 2.8 m.

4.1. Roof Access

The hatch in the roof is slideable utilizing the level difference to SANS tank shielding. The hatch itself is motorized on rails and made of heavy concrete or lead to reduce the thickness, but maintaining shield efficiency and avoid magnetic attraction of potential sample environment. The size of the hatch must be large enough to get sample environment through, and provide access to the service platform at the top of cave. Hatch must be designed to avoid gamma and neutron streaming paths, this issue is not fully included in the current design, but we are well aware of the issue.

4.2. Side Access

A sliding door gives access to the beam level necessities from the cave labyrinth, reducing the radiation within the labyrinth. The entrance at hall floor level will be sealed with concrete blocks that can be craned away.

5. FLOOR LOADS

The most heavily loaded wall is the wall of the cave in the labyrinth. It has to carry half of the cave roof and half of the labyrinth roof. In the current design we use 1 m thick cave wall, cave roof 1 m and labyrinth roof 0.5 m. Cave wall height is 3.9 m, with the roof of the cave spanning 8 m and the roof of the labyrinth spanning 2.5 m. This gives an equivalent concrete column of 9.525 m. With a concrete density of 2.3 t/m^3, the load end at 21.9 t/m^2. Just above the allowable 20 t/m^2 average floor load. There has not yet been investigated whether there are piling below, to remedy the overload. Likewise are we looking into the possibility of reducing the wall thickness and thereby reducing the floor load.

6. EXPERIMENTAL HUTCH AND SAMPLE PREPARATION AREA

The intention is to obtain two standard office pavilions, placed on top of each other. One below for instrument control rack and space for sample preparation. Size of container LxWxH 9600x3000x3000 mm.

The containers are isolated and equipped with doors and windows. All other infrastructure such as power, air-conditioning *etc.* has to be added.

7. STAIR, LIFT AND ACCESS ROUTES

The description of stairs, lifts and access routes were given in section 3.6 Lift and section 4. Access to Cave. Free access space behind the instrument is available for passage of large object up to 3.7 m. There is access to the ramp to the guide hall E02 on the side instrument cave.

8. UTILITIES DISTRIBUTIONS SYSTEM

The instrument has to be equipped with power board distribution, cooling water, compressed air and vacuum as described in a dedicated report. Also point suction and access to different gases is necessary for conducting experiments, in addition helium recovery should also be considered.

Cabling and wiring from cave to outside and control hutch is intended pulled through the labyrinth corridor, below the false floor. This gives fewer demands on the design of cable and pipe entry feedthrough. One thing is to perform cabling and piping when assembling the instrument, but it must be possible at a later state to change and adapt to new demands.

9. SUPPORT INFRASTRUCTURE

The necessary utilities and infrastructure follow from the equipment placed within the experimental cave, more information and details are found the sample environment report. Again cabling for network and fiber optics for the detectors can be placed below the false floor of the cave and be distributed via the office platform to the control racks in the barracks.

10. PERSONAL SAFETY SYSTEM

ESS PSS group provide standards experimental cave safety to fulfill with Swedish regulations. The security system deals with security against radiation and access during operation with security door, gas alarm, electric warning and shutters. Necessary vacuum, cryogenic liquids and magnetic field safety measure shall be taken within ESS safety regulations.

Cave access must only be possible, when heavy beam shutter is closed and no significant radiation above background is measured behind the shutter.

A security procedure must be in place to ensure that no people are inside the cave, when the doors are closed and the beam could be switched on.

(ESS-0002381, ESS-0034035 and ESS-0001786).