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NSS zoning document - part I (safety)

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1. PURPOSE

This document describes the zoning for the experimental halls, laboratories and workshops. In order to describe our reasoning behind the zoning and the flexibility to adjust zoning to the expected work scope, we had to consider operational sub-modes for NSS. These sub-modes have to be thoroughly discussed with all affected partners (NSS, TD, AD) and aligned with already existing documentation.

2. BACKGROUND

This document describes safety considerations with regards to user operations and the radiological zoning for the experimental halls, instruments, instrument specific laboratories, general user labs, radioactive materials lab (RML) and workshop buildings attached to the experimental halls (Figure 1). The proposed zoning is intended to create a safe work environment for users and ESS staff, while facilitating an easy work flow for personnel movement as well as transporting samples, materials, equipment between different work areas in and around the experimental halls.

This document is focused on a general description of radiological zoning planned for the above listed areas with regards to user and staff movements during “normal operations”. There will be three defined zones (ESS-0001786): non-designated (public) zone, supervised zone, and Blue, Yellow and Red controlled zones. Users will not have access to Yellow and Red Controlled Zones unless specified in the experimental safety review (ESS-0024107) and with additional training.

A definition with regards to area definition, dose rates and exposure tolerances can be found in ESS-0001786 “Definition of Supervised and Controlled Radiation Areas”. The radiological zoning document was developed based on procedures described in ESS-0033188 “ESS procedure for determining the radiological zoning of an area”.

3. AREAS INCLUDED IN RADIOLOGICAL ZONING

Areas that will be regularly accessed by users and ESS staff are indicated in Figure 1. This includes the following buildings: experimental halls D01, D02, D03, E01 and E02 (divided into sectors N, E, S, and W), lab/workshop buildings attached to these halls: D04, D07, D08, E03, and E04. It is estimated that during the run cycle in normal operations there will be about 200 entries by 50 different people per day in the areas shown in Figure 1. A lot of the movement will be “back-and-forth” between instrument halls and labs and will involve movement of sample environment equipment (SEE) and samples. The movement should be facilitated by a radiological zoning plan that will ease workflow without compromising safety.

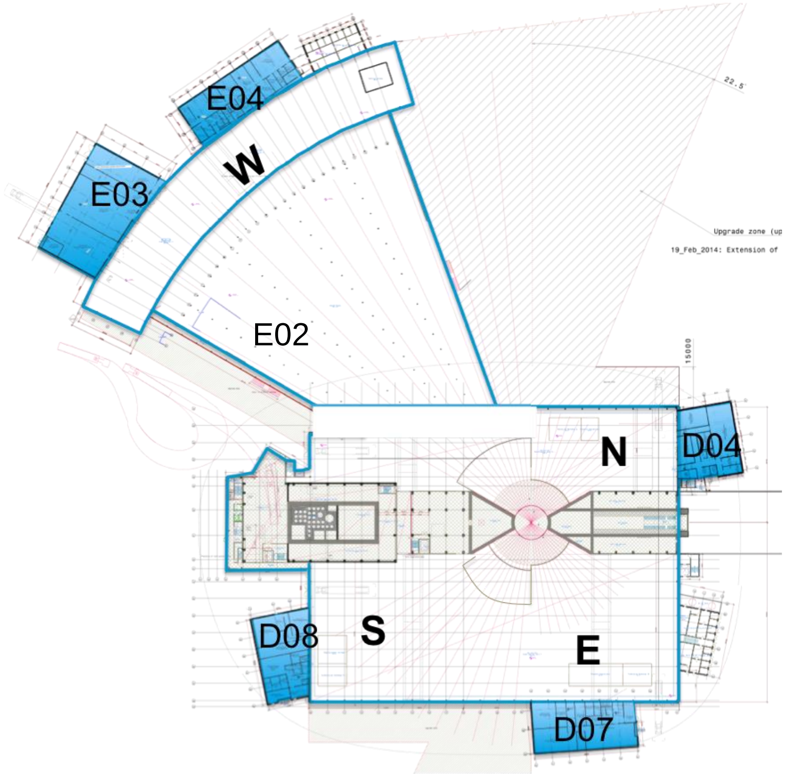

Figure 1. *Schematic layout of experimental hall areas (W, N, E, S) and associated lab buildings (D04, D07, D08, E03, E04). N – north sector of D03 ('hall 2'); E – east sector of D01 ('hall 2'); S – south sector of D01 ('hall 2'); W – west sector (E01 or 'hall 3').*

3.1. Areas in Supervised Zone ("all in one" concept)

To enter the lab buildings from the outside, users and personnel will be able to access non-designated (public) areas directly (such as offices, fika rooms, bathrooms, stairwells). This will be limited to one entrance per building. Fewer possibilities for entry/exit out of buildings minimizes both the cost of fixed radiation monitoring equipment and improves control over activated sample/component removal from experimental hall areas. From the grey areas you can only enter the green supervised zone, these entrances will be access controlled e.g. with badge readers (yellow stars in Figure 2). The areas included in the supervised zone are indicated as green in Figure 2. You will not be able to pass from a non-designated area to a controlled area without passing through the supervised zone. The supervised zone is proposed to be an "all in one" area so that users and ESS staff can freely move between labs and instruments during the course of the day. When leaving the supervised zone you will pass a portal monitor (gamma detection), hand-and-foot detector and badge reader (yellow stars in Figure 2).

Safety and a comfortable workflow in the supervised zone is controlled though a number of engineering and administrative controls.

Administrative controls will include:

- Implementation of safety review procedures and the sample management system (reviewed procedures can be found in ESS-0024109, ESS-0024107, ESS-0024112). This includes approved work procedures, hazard analysis, safety review.
- Wearing of personal dosimeters, facility and safety training, general workplace radiation monitoring.

Engineering controls will include:

- Implementation of PSS (personnel safety systems) on all instruments involving interlock systems, alarms, scram buttons.
- Control of entry/exit through radiation monitors and badge readers.

Figure 2. *Proposed zoning for user and ESS staff movements during "normal operations". Green: Supervised Zone, Blue: Blue Controlled Zone, Yellow: Yellow Controlled Zone, Red: Red Controlled Zone. Yellow star: entry/exit for Supervised Zone, Red start: entry/exit for Yellow Controlled Zone. Note – there are several emergency exits and doors only accessible for selected ESS personnel to allow for easy goods transport.*

3.2. Areas in the Controlled Zone.

The radiological materials lab (RML) is located in D08, adjacent to sector S of D01 (Figure 1, 3). The RML and HVAC adjacent to it will be zoned as a Blue Controlled Zone. A definition of Blue Controlled Zone can be found in in ESS-0001786 “Definition of Supervised and Controlled Radiation Areas”.

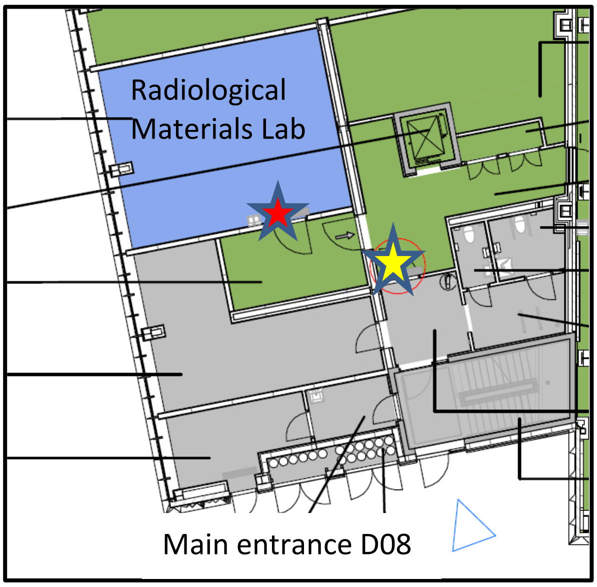

Figure 3. Radioactive materials laboratory in building D08, adjacent to south sector of D01. Orange circle is a proposed area to house a portal monitor (gamma detection), the pink square is a hand and foot monitor (alpha, beta detection). Yellow star: entry/exit for Supervised Zone, Red start: entry/exit for Blue Controlled Zone.

Activities in the RML will involve the handling of radioactive samples, either intrinsically radioactive or activated samples due to exposure in the neutron beam. Sample handling can include sample loading/unloading in and out of sample holders, mounting of sample in SEE, sample processing & characterization and sample preparation. Entry/exit from the RML will pass through the supervised zone.

Safety of activities in the RML will be controlled through administrative controls similar to the Supervised zone as described earlier. Access to the RML will require additional training, hazard analysis, and work documents suitable to the kinds of procedures and samples handled. Engineering controls will include portal monitors (gamma detection) and hand and foot monitors (alpha, beta detection) and badge readers

3.3. Flexible Zoning

The concept of flexible zoning allows the change of a zone from supervised to controlled zone and back when needed in a reasonable amount of time. These changes will be following procedures to ensure that no radioactive contamination or activation is left when downgrading the zone from controlled to supervised. At the same time, there will be procedures on how to control the temporarily controlled zone within the supervised zone to assure access control, necessary surveys and training of the workers. This will be defined in more detail at a later point in time.

3.4 Sample location

The inside of the instrument cave will be zoned as supervised while the shutter is closed. The area in the cave where the sample is located, called during an experiment “sample location” can temporarily be designated a controlled zone (blue,yellow,red) if required due to the type of activation of the sample. The sample location can be the sample can, a cryostat or other SEE, and could be as complicated as a ventilated tent over the sample during an experiment. The extent of the sample location will be defined during the experimental safety review procedure (ESS-00224107) and controls will be implemented as needed and appropriate. In a temporarily controlled area, contamination is allowed, as long as it is below the stated thresholds in ESS-0001786 “Definition of Supervised and Controlled Radiation Areas”. Once the experiment is concluded and the flexible controlled zone will become supervised again, it will be surveyed or swabbed as needed and released by health physics (ESH) if free of radioactive material.

3.5 Laboratories/workshops

Similarly as for the sample location, a flexible controlled zone can also be established in a lab or workshop within the supervised zone. This must be possible as activated samples, SEE or minor instrument components may have to be taken to the lab or workshop for characterization/conditioning and repair. Again the controls and sample handling will be defined by the experimental safety review procedure (ESS-0024107) and additional training might be required.

3.6 Maintenance work on instrument components

When maintenance work on activated instrument components has to be performed, it might be necessary to temporarily declare small areas next to the respective instrument as controlled zones so that maintenance work can be done in the vicinity of the instrument. This is especially attractive if it minimises the time the workers are being exposed to the activated component, e.g. when not having to move heavy equipment throughout the experimental hall to the technical workshops for minor, brief maintenance.

4. OPERATIONAL STATES

The ESS will operate under 5 defined states (ESS-0003640 “Concepts of operations for the ESS System”). Briefly, there will be “Production”, “Studies”, “Studies on Target”, “Start up”, “Shutdown”.

“Shutdown” and “Studies” will be 140 days a year and do not include beam on target. They are treated the same from the perspective of zoning in the experimental halls and lab/workshop buildings (shown in Figure 1 and 2) since no prompt radiation from the target arises. These periods will be used to do maintenance in areas that cannot be open to workers during operation of the target.

Most activities will happen during “Production”, “Studies on Target” and “Start up”, this will be 225 days a year. This will include setting up samples/equipment on the instruments, neutron scattering experiments, maintenance on instruments if doable and other testing with the instrument in its operational configuration. Some of these activities may happen during “Studies on Target” if reliable beam can be extracted.

4.1. Sub-modes for NSS activities

We define seven NSS sub-modes that should be considered to affect the possibility to use flexible radiological zoning in the work areas of the experimental hall and the instruments. Detailed examples for the “Work to be performed in radiological zone” can be found in chapter 5. Additional scenarios and activities will be added as needed.

NSS Sub-modes under these main operational modes are described in the subchapters below. Procedures on how to change between the various NSS sub-modes will be developed.

4.1.1 “Normal operations (shutter open)”

State: The instrument is in its operation configuration with the PSS in the approved state, armed and functional. The shutter is open. The experimental cave/zone is secured and inaccessible.

Example: this is the state for normal measurements on instruments. This state will be used when beam is on target during “Start-up” and “Production”, as well as during “Studies on Target” since useable beam can be extracted and used for various purposes, such as detector calibration, short tests or measurements even if beam is not at full power.

4.1.2 “Normal operations (shutter closed)”

State: The instrument is in its operation configuration with the PSS in the approved state, armed and functional. The shutter is closed. The experimental cave/zone is accessible.

Example: This is commonly the state between measurements when samples/sample environment equipment is changed. This state occurs when the shutter is closed after being in “Normal operations (shutter open)” state. Work in the experimental cave/zone can be performed, but the sections of the beamline upstream from that area are still secured by the PSS.

4.1.3 "Maintenance I (independent of neighbour)"

State: The instrument is in open configuration. The beam is stopped upstream of the maintenance area and prompt radiation is reduced to a level that allows personnel access to the area downstream of the devices stopping the beam. These beam-stopping devices are locked out and the PSS system upstream of those devices is armed and functional. The PSS downstream of these devices is disarmed and shielding can be removed to perform maintenance.

Example: This covers a number of maintenance activities that require removal of shielding to get access to beamline components. "Maintenance I" can occur during all phases of ESS facility operational modes. "Maintenance I" activities have to occur independently of a neighbouring instrument, e.g. prompt radiation from a neighbouring instrument cannot cause the radiation levels in the maintenance area to exceed the limits of an unrestricted controlled area. Exceeding radiation limits may occur during maintenance when instruments are sharing shielding or are located on a split beamline. In that case that work will fall under "Maintenance II" below.

4.1.4 "Maintenance II (dependent of neighbour)"

State: "Maintenance II" activities occur when maintenance on one instrument (X) is influenced by the operational state of one or more other beamlines. The beam is stopped upstream of the maintenance area on instrument X. All other beamlines contributing to radiation levels in the maintenance area of instrument X need to be in a state where radiation is reduced to a safe working level. This could be achieved by stopping the beam in the other beamlines by using shutters or beam stops in order to reduce the prompt radiation in the maintenance area of instrument X to a level that allows personnel access. The beam-stopping devices of all concerned instruments are locked out and the PSS systems upstream of these devices are armed and functional. The PSS of instrument X downstream of these devices is disarmed.

Example: This is for more involved maintenance in a situation where two beamlines share part of a guide (split or parasitic beamline), shutter or shielding. Depending on how many beamlines are affected, this type of maintenance work will preferably be done during "Shutdown" and "Studies (beam dump)". If not possible due to time pressure then the work can proceed when there is beam on target ("Studies on Target", "Start-up", "Production"), providing necessary lock-out procedures are followed and additional special safety precautions are taken to protect workers and equipment. Mitigations that include temporary shielding or additional beam stopping devices are to be defined before work is performed.

4.1.5 “Maintenance III (Bunker)”

State: All light shutters in the bunker have to be closed and locked out when maintenance in the bunker is performed. The accelerator has also to be locked out to prevent beam from hitting the target.

Example: This work will involve removing the bunker roof to allow access to instrument components in the bunker. This work can only be performed during “Shutdown” mode and “Studies (on beam dump)” mode.

4.1.6 “Construction (beam port plugged)”

State: This mode covers work on an instrument in the experimental hall outside the bunker while the instrument’s beam port in the monolith is plugged. The penetration through the bunker wall for the instrument needs to be secured by the PSS and it has to keep the radiation levels in the accessible parts of the experimental hall to that of a supervised zone. If this is not the case, additional shielding secured by the PSS can be used to achieve the radiation limit for a supervised zone.

Example: Many instruments will be built after initial operations have started and this will continue during all ESS facility operational modes. This sub-mode covers construction work in the experimental hall, like installation of shielding, instrument hutches, experimental caves, beam guides and instrument components and so on. As long as the beam port is plugged, work can continue in the presence of beam on target and so during all ESS operational states.

4.1.7 “Construction in the bunker (beam port unplugged)”

State: This mode covers work on an instrument in the bunker or in the experimental hall while the instrument’s beam port is unplugged. The accelerator has to be locked out to prevent beam from hitting the target and radiation levels from exceeding normal levels in the experimental hall and permissible levels in the bunker.

Example: Critical stages in instrument construction are the installation of the beam guide from the beam port of the monolith through the bunker wall or the installation of heavy or light shutters. This work has to be scheduled during “Shutdown” and “Studies (beam dump)” as we cannot have beam on target. This work may also require additional temporary shielding.

4.2. NSS sub-modes and ESS operational modes

Table 1 shows which NSS sub-modes can be performed when ESS is in each of its five operational states.

Table 1. ESS facility operational modes and sub-modes for activities in experimental halls.

Sub-modes → / **Facility modes ↓**	Normal operations (shutter open)	Normal operations (shutter closed)	Maintenance I (indep. of neighbour)	Maintenance II (dep. on neighbour)	Maintenance III (Bunker work)	Construction (beam port plugged)	Construction (beam port unplugged)
Shutdown	No	No	Yes	Yes	Yes	Yes	Yes
Studies (beam dump)	No	No	Yes	Yes	Yes	Yes	Yes
Studies on Target	Maybe	Maybe	Yes	Maybe	No	Yes	No
Start-Up	Yes	Yes	Yes	Maybe	No	Yes	No
Production	Yes	Yes	Yes	Maybe	No	Yes	No

5. WORK TO BE PERFORMED IN RADIOLOGICAL ZONES

Following the zoning procedure, we will define the work that is to be performed in the work areas and to implement the necessary administrative and engineering controls to keep the experimental hall and laboratories/workshops a supervised area. A few examples of detailed work scenarios for instruments are given in the following subchapters. These will become more exhaustive and organized as the technical groups add their maintenance scenarios. It is the aim to have in the end few but well- defined scenarios that can be easily adapted and modified as needed.

5.1. Instrument start-up in preparation for beam (shutter closed)

"Normal operations (shutter closed)" state: experimental hall is supervised zone, instrument inside the shielding is a Yellow or Red controlled area, experimental cave/zone is supervised area.

Testing and calibration of equipment (e.g. detectors), prepare instrument to take neutron data (turn on pumps, check power supplies, control computers, align sample position, calibrate detector response with solid source, mount and align a dummy sample).

5.2. Set-up sample and equipment for experimental neutron measurement (shutter can be open or closed)

Normal operations (shutter open) or Normal operations (shutter closed) state: experimental cave is Red controlled area (shutter open) or supervised area (shutter closed)

Loading samples in appropriate sample holders for neutron measurements, align sample/holder in the beam; load sample/holder into the instrument or sample environment equipment (SEE), mount entire assembly on instrument and align in beam.

5.3. Experimental neutron experiment (shutter open)

Normal operation (shutter open): the whole instrument is Red controlled area.

Sample and possibly SEE is in beam, instrument cave is secured with PSS, shutter is open. Data is being collected.

5.4. Maintenance activities (shutter closed)

Normal operation (shutter closed): experimental zone/cave is supervised zone, instrument inside the shielding is Yellow or Red controlled area.

Maintain equipment in/around instrument cave, beamline itself, labs, workshop, instrument specific sample preparation area adjacent to instrument.

6. GLOSSARY

Term	Definition
SEE	Sample Environment Equipment
RML	Radioactive Materials Laboratory
PSS	Personnel Safety Systems

7. REFERENCES

[1] ESS-0001786 “Definition of Supervised and Controlled Radiation Areas”.

[2] ESS-0033188 “ESS procedure for determining the radiological zoning of an area”.

[3] ESS-0024107 “ESS Experiment Safety Review procedure”.

[4] ESS-0003640 “Concepts of operations for the ESS System”.

DOCUMENT REVISION HISTORY

Revision	Reason for and description of change	Author	Date
1	First issue	Zoë Fisher	2016-02-19
2	Second issue – zoning has changed – document updated	Monika Hartl	2019-03-19