# UCN beamlines at PSI

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## Contents

# 1 Introduction

For a general introduction to the UCN source at the Paul Scherrer Institute see e.g. Refs. [1-3].

Three UCN beamlines are available for experiments at PSI, dubbed 'West-1' and 'West-2', and 'South'.

West-1 and South extract UCN from the bottom of the UCN storage vessel, West-2 extracts UCN from the top. Both beamlines have a 100 micrometer thick vaccum separation window made from AlMg3 towards the UCN source vacuum.

The window causes a low-end UCN energy cutoff at about 50 neV. During the proton beam pulse neutron energies well above 220 neV are present, after some storage time the high energy cutoff is given by the NiMo coating of the guide system around 220 neV.

West-1 and South have a typical intensity of about 13 Mill. UCN after a 4s beampulse delivered over several hundreds of seconds, West-2 shows a factor 10 fewer UCN counts which end about 40 s after the beam pulse. West-2 has a 100 cm vertical fall to accelerate the UCN towards the separation foil.

Typical operation of the UCN source is pulsed with pulses of 3 seconds length with a repetition period of 340s, or 4s length with a repetition period of 440 s.

Every UCN beam pulse is headed by a 5ms long fullbeam pulse which checks the centering of the proton beam. If approved, the full beam pulse is fired 10 s later.

Beam background is present during the time of the proton pulse onto the UCN spallation target, but within 2 seconds after the pulse radiation falls to background levels.

A typical delivery of UCN to a detector covering the full 180 mm diamter of the West-1 guide is shown below.

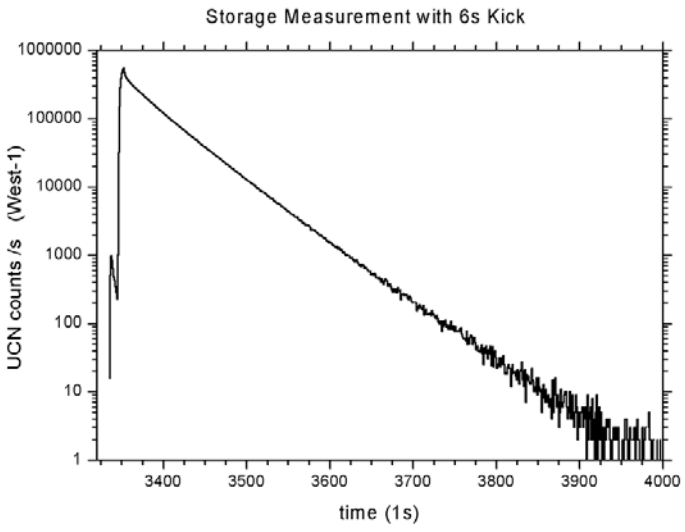


Fig.1: UCN observed in area West-1 with a large Cascade detector. The short pilot pulse already delivers a few UCN. 10s later the main beam pulse is on for a few seconds, the UCN rate increase rapidly. UCN shutters are then closed and the UCN delivery follows the emptying curve of the UCN source storage vessel.

Electronic TTL signals indicate 1s before the beam pulse the UCN arrival. The beamline shutter can be operated with a TTL signal and opens / closes in about 1s. It can only be opended if the experiment side vacuum is below 1 mbar pressure.

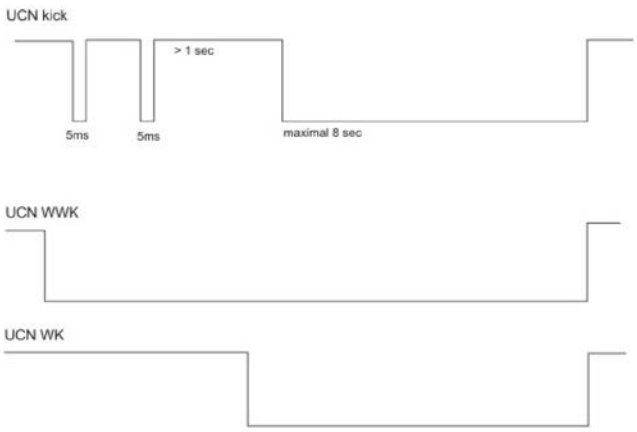


Fig.2: Beamline TTL signals

3 TTL signals are delivered from accelerator control:

kick: is true during any proton beam hitting the UCN spallation target.

WWK: start 1s before the first UCN beam kick in a pilot pulse, and lasts up to the end of the main kick.

WK: starts 1s before the main proton beam kick, and lasts up to the end of the main kick.

In case of a beam interrupt, all signals are reset to 0.

# 2 Entering and exiting the UCN experimental hall

## 2.1 Radiation area – Zone 0

You are only allowed in the UCN experimental hall if you carry the PSI issued dosimeter and passed the corresponding instruction.

There is a small shelf at the entrance close to the radiation monitor where you may temporarily store drinking bottles.


Fig.3: Entrance to UCN hall - experimental areas

The radiaton monitor behind the door and the escape path are declared Zone 0.

Fig.4: Radiaton monitor. On the top left the shelf where temporary storage of drinking bottles is allowed.

## 2.2 Radiation area – Zone 1 – Experimental Hall

**In Zone 1 absolutely no food or drinks are allowed.**

**Absolutely no-smoking and no chewing gums !**

The nEDM experimental hut is inside Zone-1 .

Fig.5: Entrance Zone – 1 : Area West


Fig.6: Entrance Zone – 1 : Area South

## 2.3 Exiting with the radiation monitor:

Whenever you exit the experimental hall you have to use the radiation monitor.

Step onto the device and put your two hands into the slits as indicated.


Fig.7: personal scanning device

**Possible messages on the display:**


*ready for measurement*


*please put in hands*


count-down of 5 seconds during measurement


*not contaminated*


*please do not step onto the monitor*
you were too fast, step down and wait for message "MESSBEREIT"

Fig.8: Display messages in German and English

You may exit then unless a contamination warning appears.

In that case measure again and if the contamination warning appears again, call the radiation group (SU) – phone numbers are on the monitor

SU West:

Othmar Morath - phone: 4186

Pascal Meyer - phone: 3355

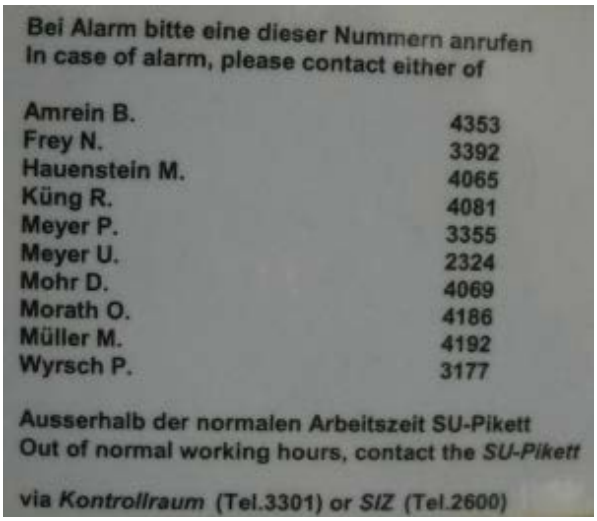


Fig.9: all contact numbers of the radiation protection group: call as described in case of contamination warnings.

Outside normal working hours contact the radiation protection unit via the accelerator control room (phone 3301) or safety central (phone 2600 ).

## 2.4 Taking materials out of the experimental area – only after SU check

**All materials and items which were used in the experimental hall have to be checked by radiation safety (SU) before taking them out of the hall.**

- put the materials on the SU desk in area South

- call SU West:
Othmar Morath - phone: 4186
Pascal Meyer - phone: 3355
They usually respond very fast.

Fig.10: Check out table in area South. Checking out materials: put all items on or next to the SU table and call responsibles.

# 3 Experimental Area West

Area responsible: B. Lauss (Phone: 4647)

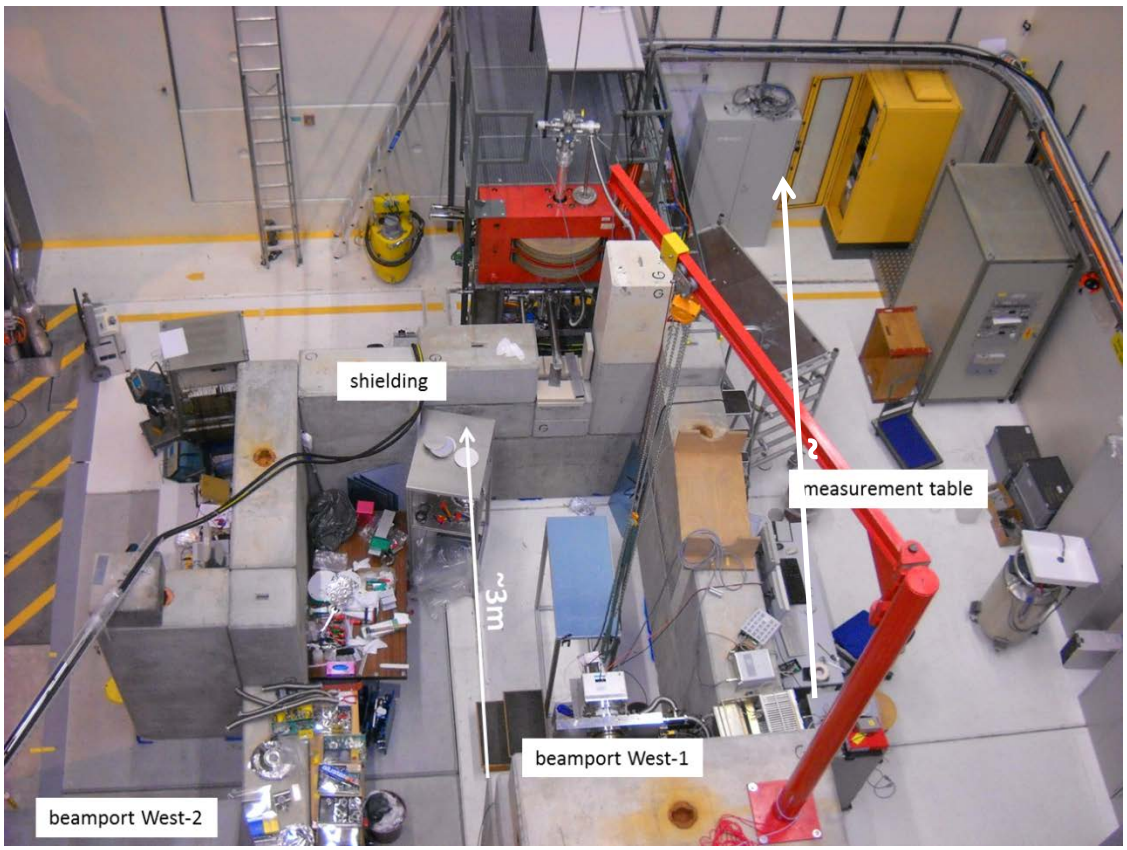


Fig.11: Top view of experimental area West.

One can see the experiment area with mobile concrete shielding blocks. The measurement table is on the right side. A small red crane (80 kg capacity), a red dipole magnet and a yellow beamline control rack are shown.

Fig.12: Concrete block shielding the spallation target between area West-1 and West-2. The slits on the wall are a source of background radiation for the experiments.

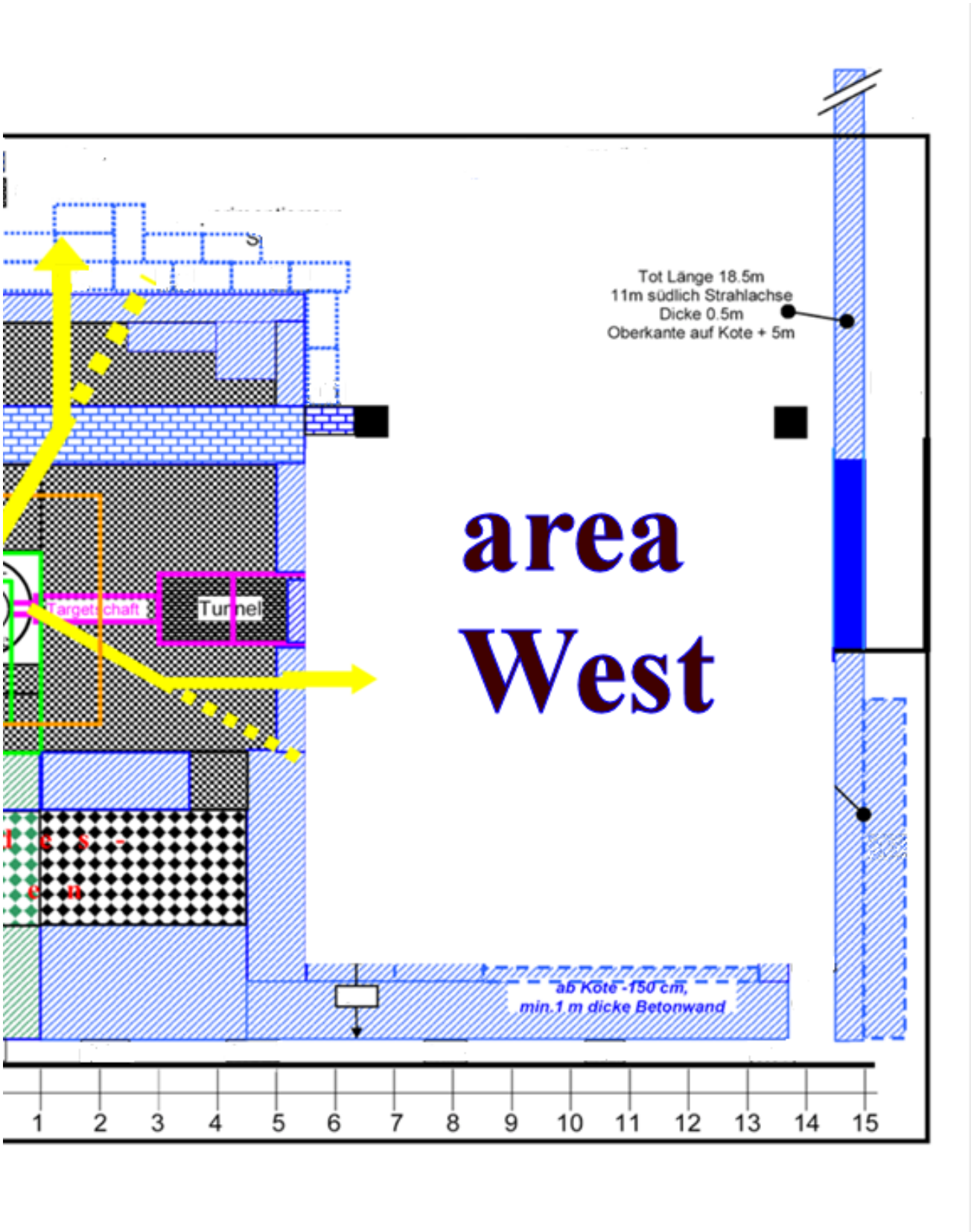


Fig.13: Floor map of area West. Scale on the bottom is in meter.

# 4 Beamline West-1

Area responsible: B. Lauss (Phone: 4647)

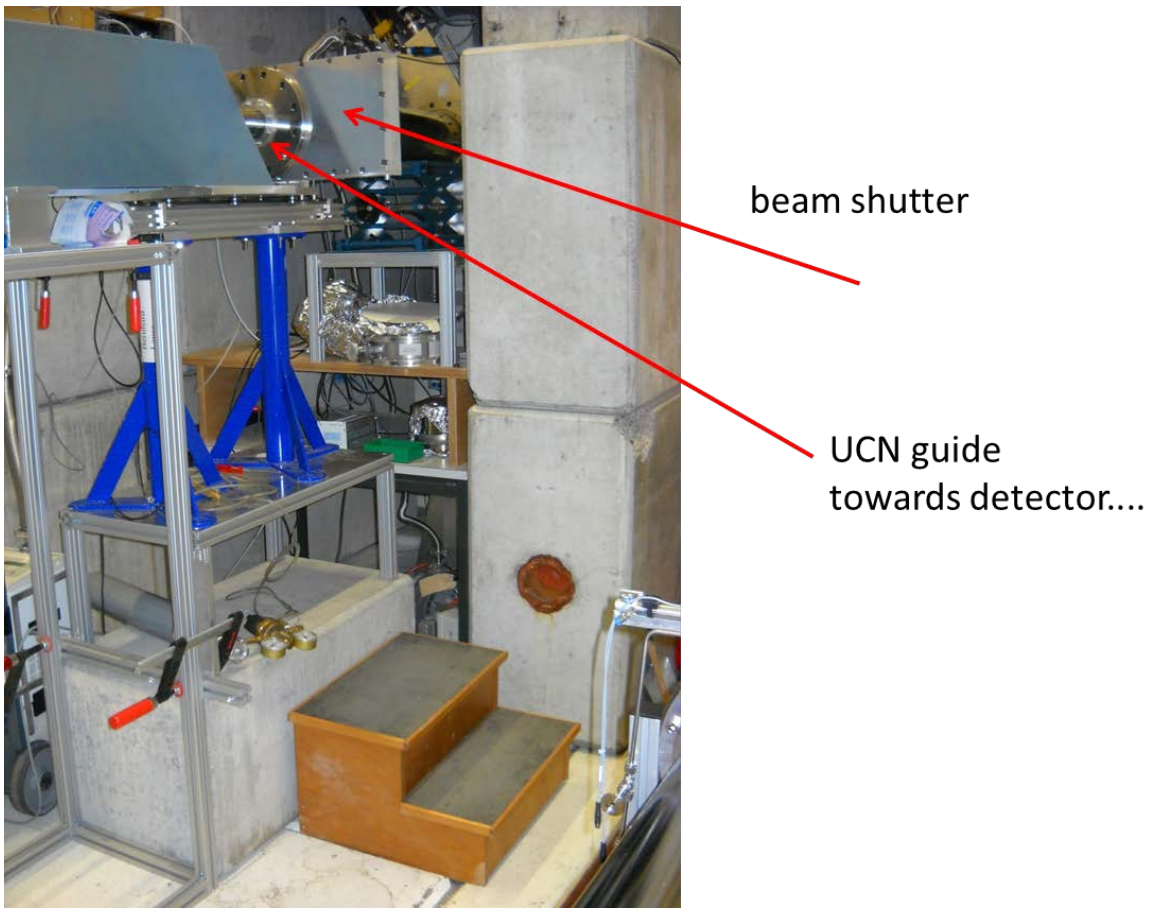


Fig.14: View of the beam shutter on beamline West-1.

The height of the center of the horizontal UCN guide is 180 cm above the ground of the experimental hall. Typical UCN fluxes are several hundreds of kHz after the beam pulse.

Typical integral UCN intensities are above 10 Million UCN per 3s beam pulse.

# 5 Beamline West-2

Area responsible: B. Lauss (Phone: 4647)

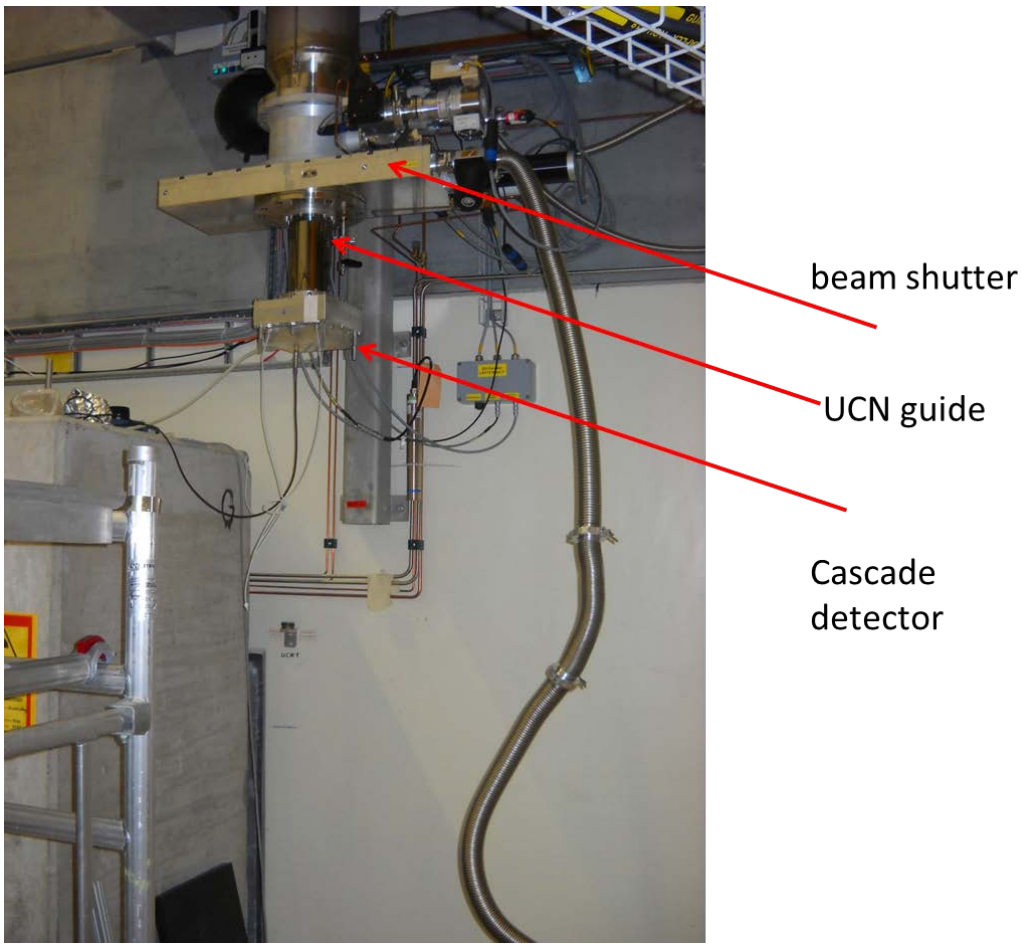


Fig.15: Beamline West-2 exits vertically with a 1 meter drop of the UCN in order to increase the transmission of the vacuum end window. The figure shows a 110 mm diameter extraction guide and a Cascade UCN detector at the end.

Due to the extraction on top of the UCN storage vessel, beamline West-2 provides UCN only for about 40 s after the beam kick.

The beamline shutter is mounted 255 cm above the ground. This is 120 cm below the center of the upper UCN guide.

Typical UCN rates are several tens of kHz immediately after the beam pulse. Integral UCN intensity is a few hundred thousand UCN in the first 40 s after the beam pulse.

# 6 Area South

Area South responsible: P. Schmidt-Wellenburg (Phone: 5680)

Fig.16: beam port area south - the 5 Tesla super-conducting magnet in blue

Fig.17: area south beamline and thermally stabilized hut of the nEDM experiment

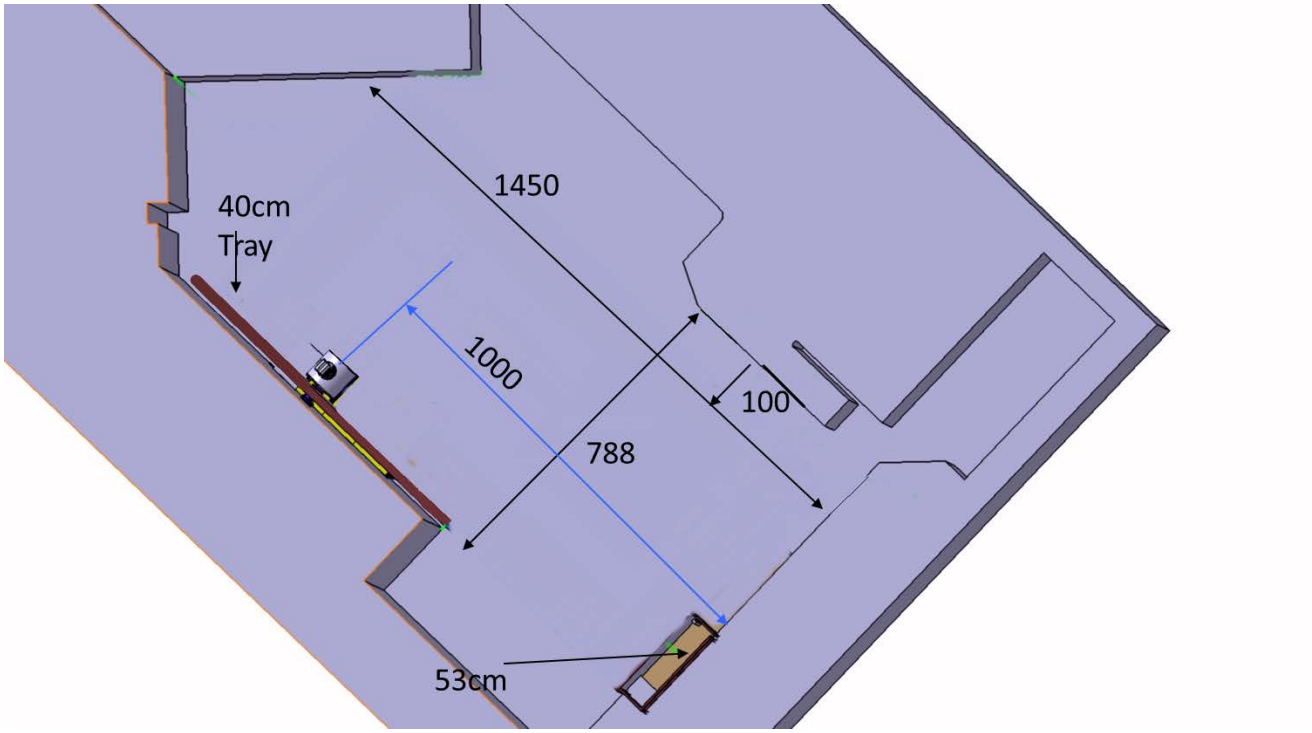


FIg.18: Floor map of area South (dimensions in cm).

# 7 Mounting onto the PSI beamline

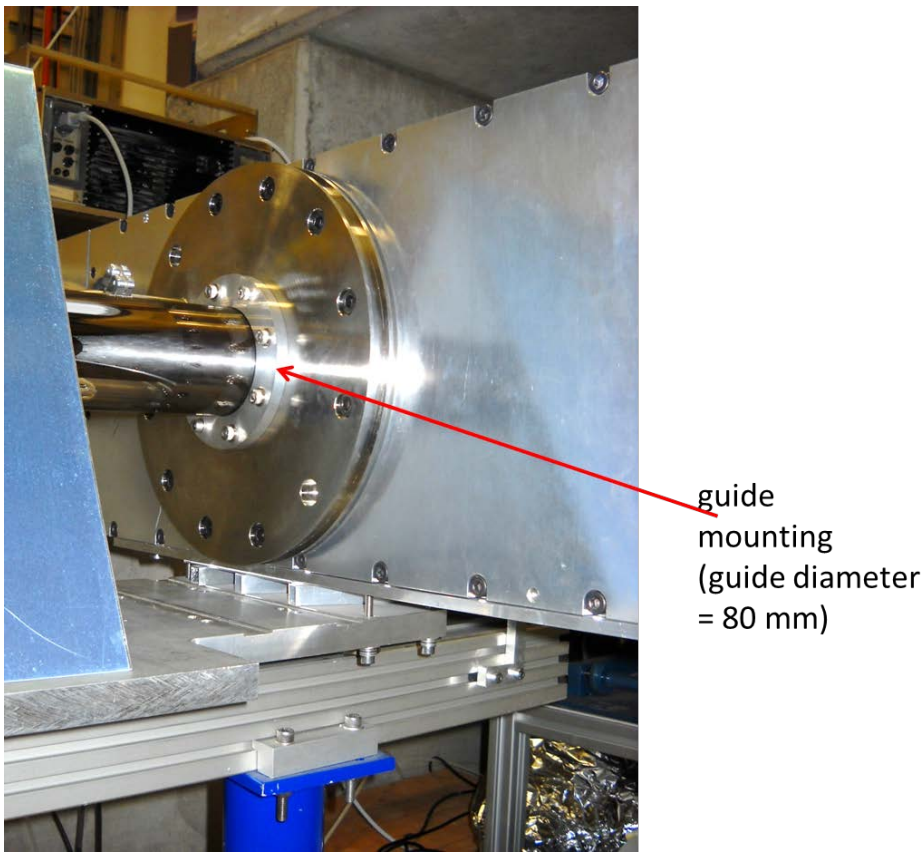


Fig.19: Mounting using a Wilson-type flange onto the PSI UCN beamline West-1 and West-2.

Mounting flanges onto the beam ports for tubular UCN guides of outside diameters 70mm, 80mm and 110mm are available. Other diameters have to be discussed well in advance.

To mount to the full diameter of 180 mm, please ask your PSI contact for exact drawings in order to construct an adapter flange.

# 8 Area Safety for UCN

PSI's general safety and emergency instructions can be found at

http://www.psi.ch/useroffice/safety-at-psi

with all safety regulations listed at

http://www.psi.ch/useroffice/regweis

Before doing an experiment you have to discuss the involved safety with your PSI contact. Your experiment and all its components have to comply with PSI's safety standards. This applies in particular to electrical safety, pressure safety, laser safety and handling of hazardous materials.

The spokesperson of an experiment has to sign the PSI safety declaration.

download at http://www.psi.ch/useroffice/safety-at-psi

The spokesperson has to make sure that all of her/his collaborators working in the PSI experimental hall are aware that they have to inform themselves about regulations and up-to-date safety instructions. PSI approved experimenters can be present in the experiment hall during beam operation.

Area West has an additional concrete shielding and a target shielding block. A small red-and-white chain separates the inside of the experimental area towards the experimental hall.

During the few seconds beam pulse one should leave the the separated experimental area in area West, however, radiation levels are also below applicable limits inside the concrete shielding.

## 8.1 Beam monitor

Note: the full beam pulse is not at time = 0 !

The beam monitor display the count down to the next proton beam pulse onto the UCN spallation target. Note that at time = 0 the countdown starts, 10s later the first pilot pulse will be fired, if the centering is approved, another 10s later the full beam pulse will be fired.


Fig.20: Beammonitor

Status:

- STOP = beam operation halted

- run = beam is operating

Fig.21:

permanent radiation monitoring at the beam lines.

Note: they will issue a warning light (and sound) during the proton beam onto the UCN spallation target.

-> this does not indicate any problem

## 8.2 Gas bottles / pressurized air / liquid nitrogen

In case you intend to use any of the above, talk to your PSI contact person.

Gas bottles need to be stably mounted with a chain or lever.

Pressurized air (up to 6 bar) is available for use at specific ports.

Liquid nitrogen dewars may be brought in and used, but regulations for cryogenic fluids at PSI have to be obeyed.

http://www.psi.ch/useroffice/regweis

(only available in German on 2015 – 06 – 01)

## 8.3 Fire alarm

in case of fire, note that fire extinguishers are located right next to the radiation monitor for exiting.

call immediately: 3333 (PSI interenal emergency number)

## 8.4 Vacuum / Venting

Experiments to be mounted on the UCN beam port have to provide good vacuum conditions. This means, that the evacuated volumina may not contain any heavily outgassing materials. Otherwise, a vacuum separation window has to be provided. Discuss this with your PSI contact.

The beamline shutter only opens, when the experiment is pumped below 1 mbar pressure.

Make sure, by checking on the beam line pressure reading.

**IMPORTANT: close the beamline shutter before venting the experiment, otherwise the shutter will be blocked and not reopen before resetting by a responsible.**

**In case this happens, call your area responsible.**

## 8.5 High voltage operation

In case your eperiment involves high voltage applications make sure that the person involed has high voltage training.

Discuss with the area responsible beforehand who will supply contact information to PSI specialists in case of need.

## 8.6 Radioactive sources

The use of low-activity radioactive sources for detector tests in the experimental area is possible if the relevant PSI rules are obeyed. Discuss beforehand with the area responsible.

# 9 Crane operation

Two cranes are available for serving the experimental areas.

In case of need, contact your area responsible, as crane operation has to be announced in advance and may only be done by Swiss approved crane operators.


Fig. 22: Crane serving partially area West and area South

# References

[1] Ultracold Neutron Production at the Second Spallation Target of the Paul Scherrer Institute, Physics Procedia, Volume 51, pp 98–101 (2014).

[2] Startup of the high-intensity ultracold neutron source at the Paul Scherrer Institute, Hyperfine Interactions 203 (2011).

[3] The PSI ultra-cold neutron source, Nucl. Instr. Meth. A 611 (2009) 272.