Risk analysis from a user perspective of the beamline BALDER, MAX IV Laboratory

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The main purpose of this report is to identify, evaluate and if possible, suggest reduction methods to the risks from which users at the beamline BALDER, MAX IV Laboratory are exposed to during their visit. Identified risks includes radiation, fire, electricity, gases and miscellaneous risks such as the overhead crane. The evaluation indicates that the handling of toxic gases inside the experimental hutch is the highest risk for users to be considered at BALDER. To improve the user safety at BALDER, investigating the gas handling of gas cabinet nr. 5 is of great importance. Also, looking over the safety instruction routines for arriving users and an installment of a passage to the exp. hutch are to consider.

What is the MAX IV Laboratory and what is its purpose?: The MAX IV Laboratory consists of the old MAX-lab and the new MAX IV facility (in short MAX IV). The technique behind both facilities are quite similar and both are in general called synchrotron facilities. The first synchrotron was already built in 1945 and today, many later generations synchrotrons all around the world have been constructed in order to perform basic research. The research is within many different areas of expertise including physics, chemistry and biology. When MAX IV is inaugurated in june 2016, its light source will have the highest brilliance in the world (at certain energies), see 1. This will lead to a higher resolution of the experiments meaning more detailed and accurate results.

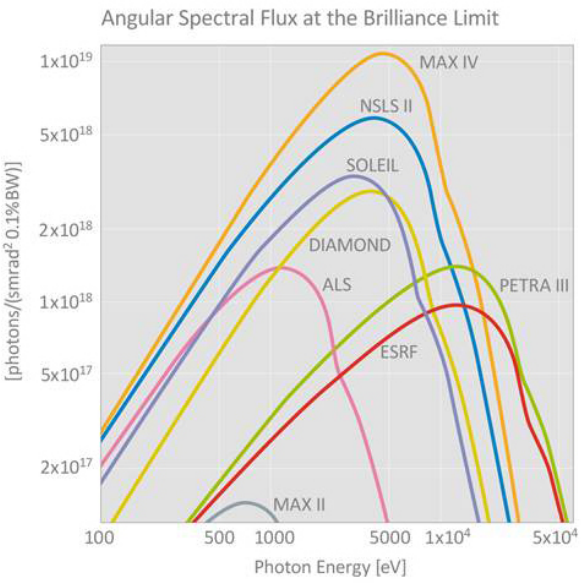

Fig. 1 *The figure illustrates the brilliance as a function of photon energy for some of the world leading synchrotron radiation facilities. The MAX IV Laboratory's main contribution is around 1-50 keV (corresponding to 0.4-1.2 nm in photon wavelength).*

How does a synchrotron work?: The basics behind a synchrotron involves an electron accelerator, a storage ring and different experimental stations called beamlines. The purpose of the electron accelerator is to increase the energy of the electrons passing through by applying a radio frequency (RF) wave to the electrons. The electrons are lead through cavities which, if calibrated correctly, is timing the RF wave so the electrons gets a "push" forward and thereby increase their energy. This process can be described similar to a surfer riding a wave.

Next, the high energy electrons are directed into the storage ring where they are "stored" while traveling around in the orbit. At some locations around the way, they pass through so called undulators and wigglers. These machines makes the electrons loose some of their energy as photons. These photons form what is called synchrotron light, which contains of a broad spectra of energies. These photons are then lead out of the ring in their current longitudinal direction to a beamline. After certain optic measures, the synchrotron light is narrowed down to the desired energies within the x-ray range. The x-rays are then used in spectroscopy to irradiate different samples at the different beamlines such as BALDER.

What is BALDER more specifically?: BALDER is one of the first beamlines that are about to be built at MAX IV. Every beamline has its specialties and at BALDER, experiments can be performed with gases under high pressure. The beamline mainly consists of the optics hutch, the experimental hutch, the control room and the preparation lab seen in figure 2 along with the full floor plan of MAX IV.

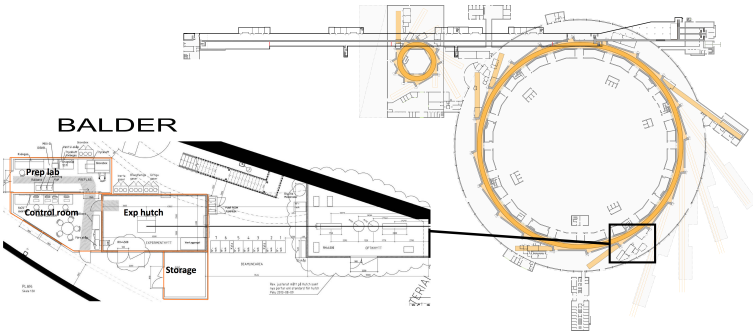

Fig. 2. A floor plan over MAX IV and BALDER.

What is the purpose of this master thesis?: The report *A risk and safety analysis regarding guest scientists at beamline BALDER, MAX IV Laboratory* is produced in order to identify and evaluate the types of risks that users can be exposed to, and to say what types of measures that can and is made to prevent them from happening. This report has focused on the beamline called BALDER. The reason of choosing BALDER is because it is considered covering most risks at MAX IV and is one of the few beamlines where the construction has started. As mentioned, it also has the capacity to perform experiments with gases under high pressure. Other risks include for example radiation, electricity and fire. In other words, the purpose of this report is to make BALDER a safe workplace as possible by proposing risk reducing suggestions for the risks users can be exposed to.

How was this risk analysis carried out?: To perform this risk analysis, the risks were first identified. To identify the risks, it was necessary to analyze the user pattern according to:

- Where are the users during their beamtime?
- What are they doing?
- How are they doing it?

This was mainly carried out by following users during their experiments and by interviews with staff and users. Also, by analyzing existing safety measures and systems, and previous incident reporting, was contributing to the risk analysis.

What is the result of this risk analysis?: The result of the risk analysis is seen in figure 3 as a risk matrix of the main identified risks and how they are evaluated according to the definitions in the table. As seen from the figure, to get exposed to synchrotron radiation in the exp. hutch is considered as a relatively low risks compared to handle toxic gases within the hutch which is evaluated as the highest risk.

Are any suggestion of improvements made?: Some of the suggestion of improvements made are:

- Investigate the gas handling of the gas cabinet inside the hutch (cabinet nr. 5) to prevent toxic leakages.
- A passage between the prep. lab, control room and the hutch preventing unnecessary contamination by samples.
- Look over the safety instruction routines for arriving users.
- PSS buttons may be placed on the exp. table for a better view.

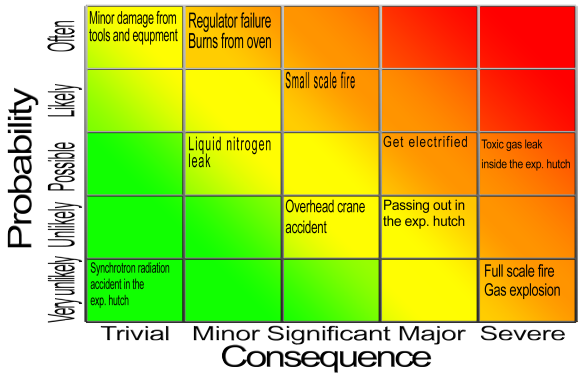

Fig. 3 *The matrix shows some of the most noticeable risks for users at BALDER evaluated in a risk matrix. The table below describes the meaning of the different probabilities and consequences.*

Probability	Event occurring interval (years)	Consequence	Description
Very unlikely	>50	Trivial	No treatment required
Unlikely	31 - 50	Minor	Minor injury requiring First Aid treatment
Possible	16 - 30	Significant	Injury requiring medical treatment
Likely	6 - 15	Major	Serious injury requiring special medical treatment
Often	≤ 5	Severe	Loss of life or permanent disability

- Look over the gas transportation routines between BALDER and the gas storage room.
- Mirrors around the beamline to prevent collisions.
- Apply systematic incident reporting.
- Urge for incident and damage reporting by users (possibly in the safety course).

References

1 Hultberg, Patrik. *A risk and safety analysis regarding guest scientists at beamline BALDER, MAX IV Laboratory*. 2015