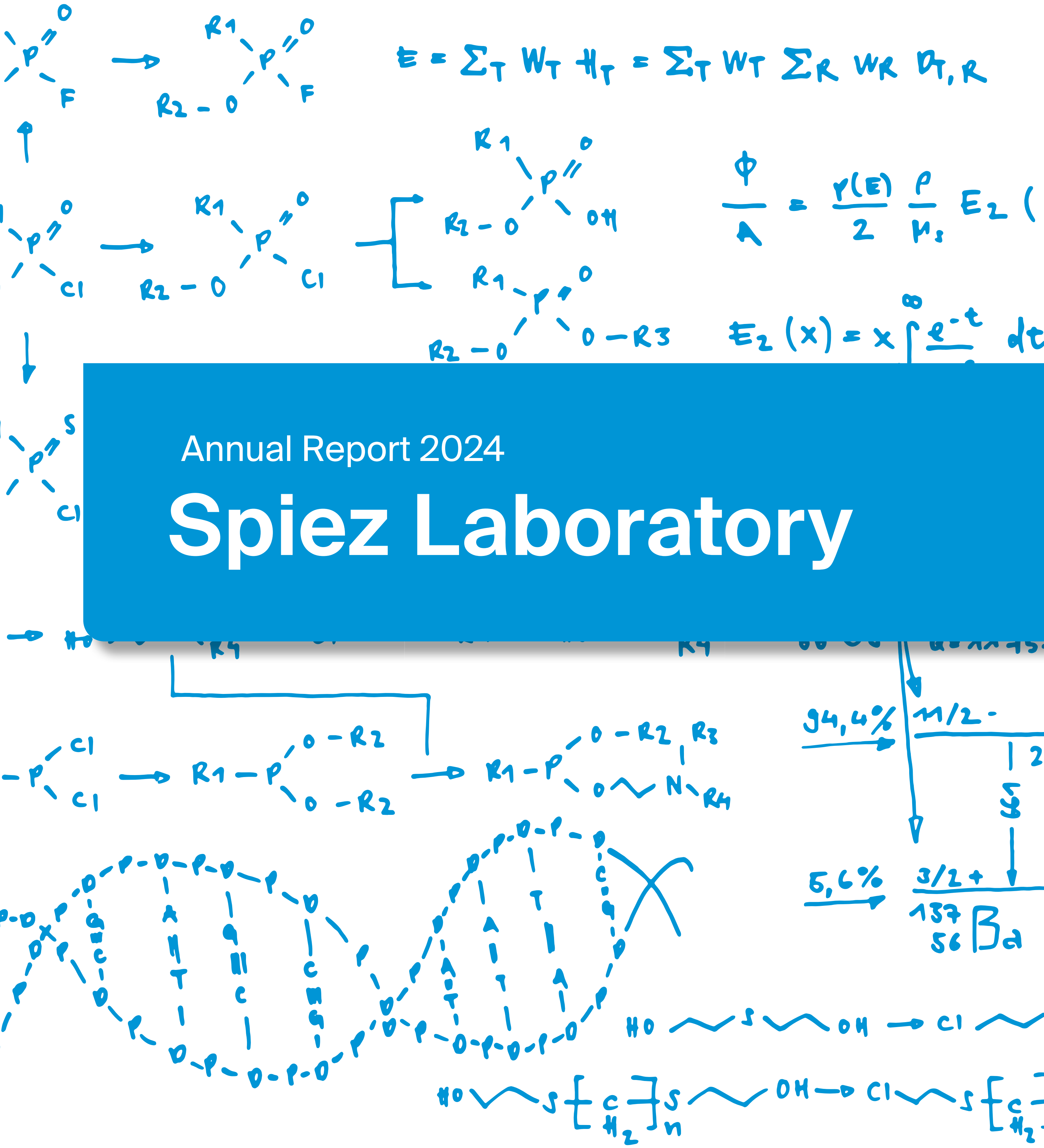


Annual Report 2024

Spiez Laboratory

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of Defence,
Civil Protection and Sport DDPS
Federal Office for Civil Protection FOCP
SPIEZ LABORATORY

Content

25 April 2024

Dear Readers,

Marc Cadisch
Director Spiez Laboratory

Out of a professional and personal interest, I follow global security developments closely – and form my own opinions on them. I suspect that most of you are in a similar situation: we have to acknowledge that the geopolitical situation has changed fundamentally in recent years, and especially since Russia's attack on Ukraine. With Donald Trump's presidency in the United States, this development has gained further momentum. Values and structures that were long considered firmly established are changing rapidly. The law of the strongest is increasingly prevailing across the globe. This makes it all the more important for Switzerland to be able to guarantee its own security. In addition, it is called upon to make a significant contribution to security in Europe and worldwide.

At Spiez Laboratory, we want to contribute to the field of NBC protection. For many years our scientific expertise has been in demand at national and international level to ensure prevention and preparedness for effective NBC protection. However, in light of recent developments, we too must adapt our approach and further develop our expertise. We are taking on more and more operational tasks and bringing our expertise in NBC protection directly to the frontline, for example in specific threat situations, analysing suspicious objects and, above all, ensuring NBC protection at international conferences in Switzerland. We work closely with the police and other emergency response organisations. This 2024 annual report contains several articles relating to the operational tasks of Spiez Laboratory.

The operational capacity of Spiez Laboratory must be ensured in the future. The existing infrastructure no longer guarantees this in the long term. I am therefore delighted that we are on track with the project for the modernisation of Spiez Laboratory: the comprehensive tender process for the construction of a new building is in its final phase, and the winning project will be selected before the end of this year. This will be followed by the political process to approve the necessary funding. For such a project to be successful, the departments involved within the DDPS and beyond must work together effectively. I am very grateful that we have achieved this so far and would like to take this opportunity to express my sincere thanks to all those involved, especially armasuisse Real Estate.

01

Monitoring environmental radioactivity: a contribution to protecting the population

Numerous above-ground nuclear weapons tests were carried out during the 1950s. As a consequence, radioactivity levels increased significantly worldwide. Against this background, a network for monitoring measurements was established in Switzerland in 1956. Since 1986, the Federal Office of Public Health (FOPH) has the legal mandate to monitor ionising radiation and radioactivity in the environment. Based on this mandate, the FOPH draws up an annual sampling and measurement programme, to which Spiez Laboratory contributes with radioanalytical analyses of soil, grass, milk and water samples.

Cédric von Gunten
Marc Stauffer

Every year, Spiez Laboratory, on behalf of the FOPH, analyses around 80 samples from various Bernese sites and from the waste water of Swiss nuclear power plants (NPPs) for certain radionuclides. At the sites in the Bernese Oberland (Fahrni, Gimmelwald, Lauterbrunnen, Mürren) and in the Jura (Diesse), the path of radionuclides from the environment into food is being monitored. For this purpose, soil, grass and milk samples are analysed for the nuclides in question. Even today, these radionuclides still originate primarily from nuclear weapons tests conducted above the earth's surface and from the accident at the NPP in Chernobyl. In addition, water samples from the Bern wastewater treatment plant are analysed for specific radionuclides that are used in medical therapies.

In addition to Spiez Laboratory, other institutes support the FOPH in this environmental radioactivity monitoring programme (ERA), to cover other regions of Switzerland and other spheres of life that are relevant to radiation protection. The results are published by the FOPH in special annual reports.

Elaborate strontium analysis in the laboratory

Various radionuclides are measured in the laboratory using different analytical methods. While some nuclides can be detected directly using gamma spectrometry, the analysis of other

nuclides requires methods such as mass spectrometry.

A particularly relevant radionuclide is strontium 90 (Sr-90), which is one of the main products of the nuclear fission of uranium. With a half-life of almost 29 years, it remains in the environment for a long time. Due to its chemical similarity to calcium, it follows the calcium cycle in nature: it enters plants such as grass via the soil, then into the milk of grazing animals and finally into the human body. Like calcium, it is deposited in the bones where it remains for a long time. These properties make Sr-90 an important marker for environmental radioactivity.

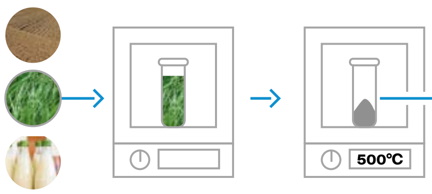
Because Sr-90 is a pure beta emitter, the nuclide cannot be detected using gamma spectrometry. In the future, MS/MS technology might make it possible to measure it using mass spectrometry - at present, however, it is still determined using the classic radiochemical analysis method (see graphic on page 8).

The beta radiation from different nuclides cannot be distinguished directly. A low-level counter can therefore not distinguish whether a decay originates from Sr-90 or, for example, Y-90. In order for the strontium measurement to be reliable, one must therefore ensure that only Sr-90 is present in the sample. Due to the complex sample preparation and a measurement period of 60 hours, the determination of Sr-90 takes around three weeks; the additional determination of Sr-89 even requires approximately 6 weeks.

Seawater sampling, Fukushima Daiichi nuclear power plant in the background on the left

Classic radiochemical analysis method

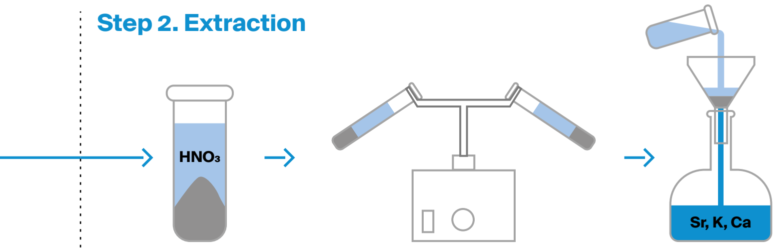
Step 1. Sample preparation



The milk, soil and grass samples are dried (milk by freeze drying).

Subsequently, they are incinerated at above 500° C in a muffle furnace.

Step 2. Extraction

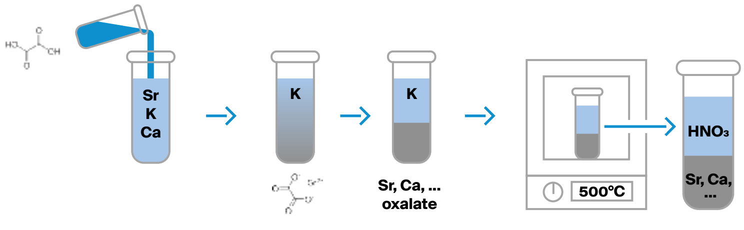


The ash is being extracted using nitric acid.

Inactive strontium is added in order to verify the yields in the subsequent steps.

Solid residues are removed by centrifugation and filtration.

Step 3. Oxalate-Precipitation (Rough Separation)



Poorly soluble Sr oxalate is precipitated using oxalic acid.

The Sr oxalate is separated by washing and centrifugation steps. This eliminates potassium and other elements that would interfere with the following steps.

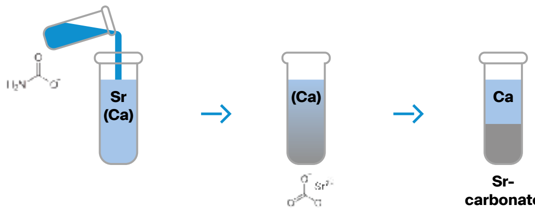
The Sr oxalate is incinerated again at over 500°C in the muffle furnace and the remaining Sr is dissolved in nitric acid.

Step 4. Strontium Separation

Using a special strontium column (Sr resin), strontium is separated from the remaining elements, which were not separated by the oxalate precipitation.

Strontium and any remaining calcium are washed off the column using water.

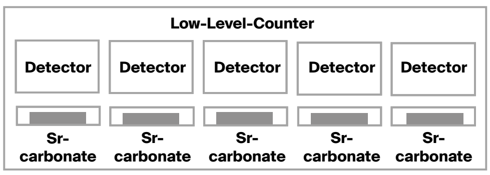
Step 5. Carbonate Precipitation



For the measurement, the strontium needs to be present in solid form. To this end, ammonium carbamate, phenol phthalein and ammonia are used to precipitate strontium carbonate, and a measurement preparation is so produced.

The carbonate precipitation separates the strontium from any remaining impurities.

Step 6. Measurement



The remaining sample is being analysed in a low-level counter over a period of several days.

In this way, even minute Sr-90 activities of 0.2 mBq/kg can so be determined - this corresponds to approximately one radioactive decay every 1.5 hours per kilogramme of sample.

Step 7. Optional: Strontium 89

If the short-lived (half-life 50.5 days) Sr-89 is also suspected in the sample, it, too, can be determined using the method described above. The measurement in step 6 then corresponds to the Sr-90 + Sr-89 signal.

A waiting period of 20 days is used to allow the daughter of Sr-90, yttrium 90 (Y-90), to grow in. This is then specifically separated from strontium via oxine precipitation and measured again using LLC. This allows conclusions to be drawn about the Sr-90 signal. The Sr-89 can then be calculated from the difference between the first measurement (Sr-90 + Sr-89) and the second measurement (Sr-90 via Y-90).

Long-term protection of the population and incident management

The ERA programme plays a central role in the monitoring of environmental radioactivity in Switzerland. Through precise measurements and detailed analyses, Spiez Laboratory makes a significant contribution to the quality and reliability of the data collected. It is always guided by the latest scientific advancements and continuously develops its measurement methods - for example, by including the accepted whole-body measurement in the ERA programme since 2024.

The monitoring programme is primarily aimed at the long-term health protection of the population. In addition, the data also benefits civil protection: in the event of incidents with increased radioactivity, it forms an essential basis for well-founded decision making in incident management.

Interested observers during the sampling in Mürren.

2024 new in the programme: Incorporation measurements using a whole-body counter

The GZ building, which houses the Spiez Laboratory's incorporation measurement centre, was inaugurated in 2023 (see Spiez Laboratory Annual Report 2023, p. 33). The measurement technology consists of a so-called whole-body counter that can measure gamma radiation. This allows radionuclides in a person's body to be determined directly; their quantity is then determined using model calculations. Since 2024, the Spiez laboratory has also been measuring around 50 people per year as part of the FOPH's environmental radioactivity monitoring programme. In particular, employees of the Spiez Laboratory and members of the NBC defence companies are available as test subjects. The data collected is collated by the FOPH and can be used for comparison in the event of an incident.

IAEA-Missions for radioactivity monitoring in Fukushima

In addition to contributing to the monitoring of environmental radioactivity in Switzerland, Spiez Laboratory has also been participating in campaigns and measurements by the International Atomic Energy Agency (IAEA) in Fukushima since 2019. In October 2024, Spiez Laboratory accompanied one of the Japanese sampling campaigns around the stricken Fukushima Daiichi NPP. The sampling covers seawater, seaweed, fish and sediment. The aim is to cover the dispersion paths of the release since 2011. As a result, it should be possible to make a statement about the radioactivity remaining in the environment and estimate possible consequences (e.g., ingestion dose through fish consumption). The analysis data show that the measures taken to safeguard the damaged reactors are still effective.

Further information on radioactivity in the environment

02

Launch of the BioFire system for the detection of pathogens relevant to bio-terrorism

As the COVID pandemic has shown, the detection of SARS-CoV-2 RNA using polymerase chain reaction (PCR) is the method of choice for tracking the incidence of infection in the population in terms of sensitivity, specificity, sample throughput and cost. At Spiez Laboratory, the diagnosis of highly pathogenic viral and bacterial pathogens is also based on PCR technology. In recent years, numerous detection systems have been developed in-house to cover the spectrum of agents relevant to biological events. With the new BioFire system, samples can be analysed within one hour for pathogens that are particularly relevant in the context of bioterrorism.

Olivier Engler
Kristina Schmidt
Matthias Wittwer

Depending on the issue at hand and the timing of the analysis in relation to an event, different detection technologies are used in an incident: If the pathogen has already been identified unambiguously, a high-throughput PCR system is more likely to be used – a method which can detect the respective pathogen with a high level of specificity and sensitivity.

Identification of unknown pathogens

During the initial phase of an incident, it is usually not yet known which pathogen is involved. To identify an unknown pathogen, genome sequencing (Whole Genome Sequencing WGS) is the method of choice. However, WGS methods require a great deal of technical effort and time and are also very expensive. In time-critical situations, PCR-based methods are therefore often used, which can test a sample for a whole spectrum of pathogens with a high level of sensitivity in a single test run.

In a clinical context, the selection of the range of PCR detection systems (panels) depends on the symptoms (e.g., respiratory, gastrointestinal, neurological, etc.). In the context of a bioterrorism scenario, such as when investigating a suspicious laboratory or a letter containing white powder, the panels used cover the pathogens particularly relevant to bioterrorism. This approach focusses on the pathogens listed as Category A and Category B agents by the US Centers for Disease Control and Prevention (CDC).

PCR detection on a chip

In order to further improve its services in this area, Spiez Laboratory introduced in 2024 a new multiplex PCR test system, the BioFire FilmArray system. The technology has been certified by the US and European regulatory authorities. The FilmArray system uses a 'lab-on-a-chip' approach to detect 16 pathogens relevant to bioterrorism. All process steps are carried out in a closed system: from digestion of the pathogens to extraction of the pathogen genome (RNA or DNA), amplification of specific genome segments, detection of the amplified DNA using fluorescent dyes all the way to analysis. The result of a sample analysis is available in just over an hour.

The system is based on a microfluidic process in which all reagents for mechanical digestion, DNA/RNA extraction, reverse transcription and PCR analysis are contained in lyophilised form in reaction compartments enclosed in a foil (blister). The reagents are brought into solution by vacuum distribution of

FilmArray Device

buffer. The sample is channelled through the compartments under instrument control, and the RNA/DNA is extracted and amplified for a first time using a variety of pathogen-specific PCR primers.

The detection of the pathogens takes place on an array chip where a second pathogen-specific PCR reaction is run on individual fields of the array, based on the first PCR product (nested PCR). In this step, a fluorescent dye is integrated into the resulting PCR fragment. The PCR fragment is checked again using a SYBR Green-based melting curve analysis. Several genome sections are amplified for each pathogen to ensure specificity. The high sensitivity is achieved by the nested PCR approach. In addition to the pathogen-specific primer systems, positive and negative controls for the individual process steps are included in the FilmArray system.

High sensitivity and operational fitness

The performance of the system was tested using relevant bacterial and viral pathogens and compared with our accredited PCR systems. The bacteria tested were *B. anthracis* (anthrax), *Y. pestis* (plague), *F. tularensis subsp. tularensis* (tularaemia) and *F. tularensis subsp. holarctia* (tularaemia).

The sensitivity of virus detection was investigated using infectious vaccinia viruses, i.e. a relatively harmless surrogate for smallpox viruses (variola), in various sample materials. The data were evaluated using inactivated Ebola and Marburg viruses as well as genetic material from various other highly pathogenic viruses. The sensitivity of the FilmArray Biothreat Panel matches that of the in-house PCR systems. In some cases, the FilmArray system is even superior to accredited in-house PCR systems when it comes to matrix interference.

The BioFire FilmArray system is particularly well suited to analysing samples in time-critical situations thanks to its broad pathogen spectrum, short analysis time and sample processing in a closed system. With the introduction of the new system, Spiez Laboratory has significantly enhanced its biodefence capabilities and can now provide its partners with even better and, above all, faster support in the event of an incident deployment.

PCR results

FilmArray
BioThreat Panel

BIO FIRE
BY BIOMÉRIEUX
www.BioFireDefense.com

Run Summary

Sample ID:	marv ebov ct26 sample1	**Run Date:**	29 Aug 2024 2:16 PM
Detected:	Ebola Zaire Marburg virus	**Controls:**	Passed

Result Summary

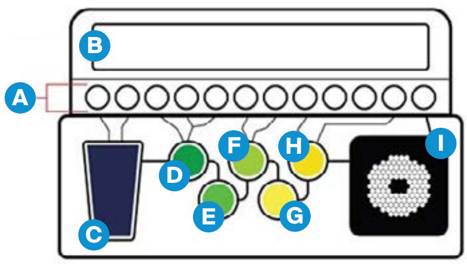
	Bacteria
Not Detected	*Bacillus anthracis*
Not Detected	*Brucella melitensis*
Not Detected	*Burkholderia mallei/pseudomallei*
Not Detected	*Coxiella burnetii*
Not Detected	*Francisella tularensis*
Not Detected	*Rickettsia prowazekii*
Not Detected	*Yersinia pestis*
	Viruses
✓ Detected	Ebola Zaire
✓ Detected	Marburg virus
Not Detected	Orthopox genus virus
Not Detected	Variola virus
Not Detected	EEE virus
Not Detected	VEE virus
Not Detected	WEE virus
	Toxins
Not Detected	*Clostridium botulinum*
Not Detected	*Ricinus communis*

Run Details

Pouch:	BioThreat Panel v2.5	**Protocol:**	BT PBS v3.0
Run Status:	Completed	**Operator:**	
Serial No.:	d02918469	**Instrument:**	2FA09805
Lot No.:	240221		

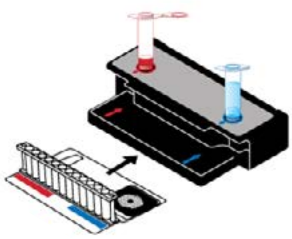
BioFire Biothreat cartridge

Schematic diagram of the cartridge

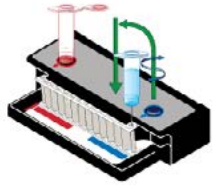


- **A** Insert with freeze-dried reagents
- **B** Piston – releases the reagents to the blisters
- **C** Sample preparation with homogenisation
- **D** Washing
- **E** Blister for collecting the magnetic beads
- **F** Elution
- **G** Mulitplex-Blister for the outer PCR
- **H** Dilution blister
- **I** PCR-Array for specific Detection

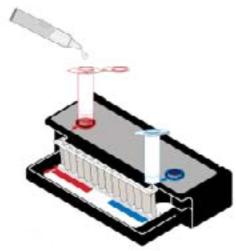
Sequence for using BioFire



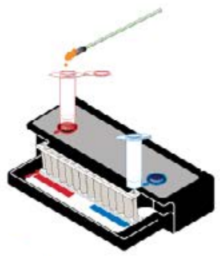
1 Insert Pouch into Loading Station



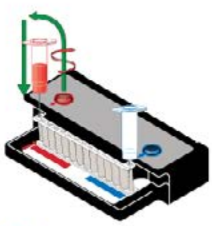
2 Inject Hydration Solution into Pouch



3 Add Sample Buffer to Sample Vial



4 Add Raw Sample to Sample Vial



5 Inject Sample into Pouch

6 Insert Pouch into FilmArray and Start Run

03 A benefit for both: the collaboration between SHA and Spiez Laboratory

Both the Swiss Humanitarian Aid Unit (SHA) and Spiez Laboratory can look back on a long history in their respective areas of expertise. For decades, Spiez Laboratory has supported the SHA in dealing with radiological, chemical or biological challenges in a humanitarian context, particularly in the areas of consulting, training, equipment testing and sample analyses.

Ádám Kimák

Sample taking at a sewage treatment plant in the Kutupalong refugee camp. DPHE staff disinfect the sampling container.

After the 1982 Lebanon War, the population in the region suffered from a lack of access to drinking water and food, and inadequate medical care. Public health was severely jeopardised and an epidemic was looming. Against this backdrop, the International Committee of the Red Cross (ICRC) and the then Swiss Disaster Relief Corps - now the Swiss Humanitarian Aid Unit (SHA) within the Swiss Agency for Development and Cooperation (SDC) - launched a joint relief mission: a large-scale disinfection campaign and a water quality assessment programme were implemented in the greater Beirut area. The participation of an employee of Spiez Laboratory in this mission in 1983 marked the beginning of the collaboration between Spiez Laboratory and the SHA, which has been enhanced and expanded continuously ever since.

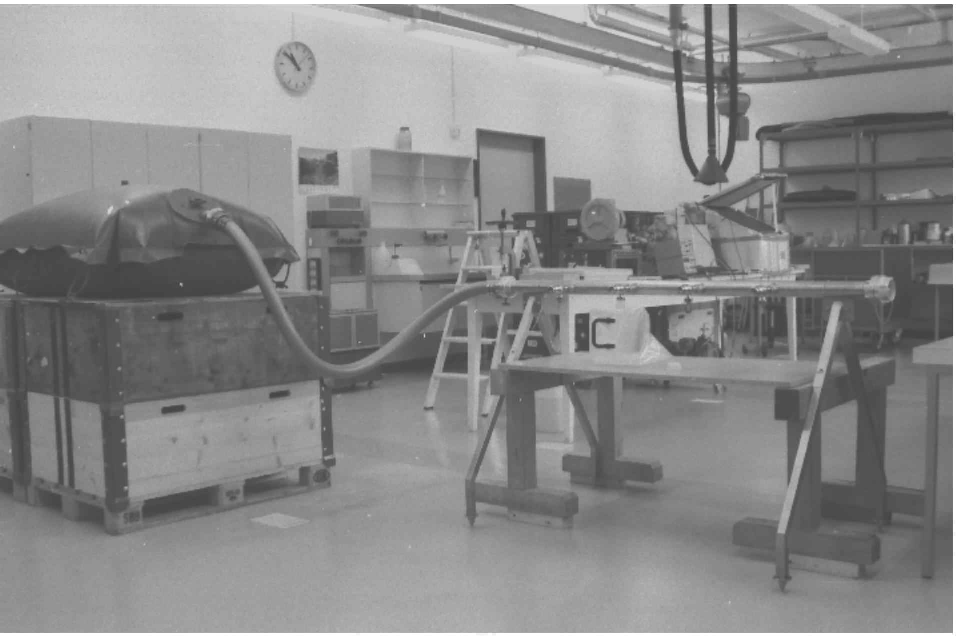
A major SHA mission with the participation of Spiez Laboratory took place in 1992 in northern Ukraine: Even years after the Chernobyl reactor disaster, the population in the affected regions remained very unsettled. In this situation, a team of SHA members and radioactivity specialists from Spiez Laboratory were on site for an extended period of time with a mobile measuring vehicle. This allowed the local population to have their individual radioactive dose measured by an independent authority.

Since 2019: Collaboration under the Backstopping-Mandate

In the following years, the cooperation was further expanded through training courses and additional field missions. The focus was increasingly on the challenges in the areas of water availability and quality, hygiene and sanitation in emergency situations. A backstopping mandate was concluded between the Federal Office for Civil Protection (FOCP) and the SDC in 2019 to put the cooperation on a secure and permanent footing.

Residents collect water from a destroyed water pipe in Beirut, 1983.

Test of a mobile water distribution system in Spiez, 1984.



The activities of the SHA's Water and Environmental Sanitation expert group (WASH) include finding and collecting groundwater, constructing or renovating water treatment installations, storing and distributing water, treating wastewater and checking water quality. When deployed in a disaster area, they carry out analyses and take the necessary measures. This includes, amongst others, the training of local personnel and cooperation with the local authorities and other partner organisations involved.

Advice and training for capacity building

How can water quality be improved quickly and efficiently? Which simple laboratory tests are suitable for field use? How can the efficiency of a field laboratory be improved with limited resources? When solving such problems, it is important to consider both the requirements for field use and the laboratory perspective. Spiez Laboratory provides the SHA WASH with the necessary laboratory capacities and scientific expertise. With its broad expertise in NBC protection, Spiez Laboratory is predestined for interdisciplinary cooperation; the various departments complement and support each other.

These advisory services provided by Spiez Laboratory cover a wide range of topics; this includes fundamental questions such as: What is the best available technology for measuring the anion content in water? Or very specific questions to improve a concrete problem on site, such as whether water pollution by heavy metals is due to natural or anthropogenic sources.

In 2017, the SHA began setting up the Faecal Sludge Field Laboratory (FSFL). This enables primary water quality parameters such as pH value, chemical oxygen demand and electrical conductivity to be analysed. The aim is to provide data for the maintenance and monitoring of water treatment plants with simple means and as little effort as possible, thereby helping to improve the regional sanitation. In collaboration with Spiez Laboratory, the SHA has continuously enhanced the FSFL; it currently provides more than ten chemical and biological parameters. Due to the increasing complexity, theoretical instructions and practical training are also essential building blocks for successful deployment. Spiez Laboratory therefore organises a training course for new users every two years in Spiez.

New water laboratory for the largest refugee camp of the world

In spring 2022, experts from Spiez Laboratory played a key role in an SHA aid project in the Kutupalong refugee camp near the city of Cox's Bazar in Bangladesh. Set up informally in 1991, the camp has grown considerably since 2017 due to the influx of Rohingya refugees from Myanmar. The number of refugees in the camp is currently estimated at 700,000 to 900,000, which corresponds to a population density of 53,000/km². This makes Kutupalong the largest refugee camp in the world.

The SHA project in Kutupalong, implemented together with the local water authorities (Department of Public Health Engineering DPHE), aimed to establish a water laboratory with the analytical and organisational capacity to collect and analyse samples from faecal sludge treatment plants in the refugee camp. Experts from the SHA and Spiez Laboratory also organised a one-week workshop for local professionals. It deepened their theoretical knowledge and practical skills for chemical and biological analysis methods. It also helped establish the necessary standards in sampling, quality management and biosafety. The laboratory has been fully and independently functioning since summer 2024, bringing the SHA project to a successful conclusion.

Demanding logistics tasks

In the field of humanitarian aid, the logistical challenges are generally demanding: diplomatic requirements and local political and socio-cultural circumstances must be taken into account. Extreme time pressure and special climatic conditions often cause additional difficulties.

The SHA's deployment kits also contain chemicals, which need to be transported and stored under refrigeration. For this purpose, the necessary cooling units must be organised and carried along; a protected location with power supply must then be organised on site and maintenance ensured. In order to minimise this effort as far as possible, Spiez Laboratory has analysed the functionality of test kits depending on the storage conditions - with the result that certain test kits function reliably over a certain period of time even without refrigeration. Based on such findings, the logistical demand for SHA deployments can be significantly reduced, thereby considerably increasing efficiency.

How do you run a laboratory where there are several power cuts a day? How do you train people without experience for a specific task in a limited time? How do you take care of equipment when dispatch is blocked for weeks or months? How do you communicate with the local population in a crisis situation? The members of the SHA are confronted daily with crisis situations and the resulting challenges. These are completely different from the scientific, technical, organisational and socio-cultural tasks of normal day-to-day work at Spiez Laboratory. The staff of Spiez Laboratory involved in a crisis response benefit from this experience, also with regard to possible deployments for incident management in Switzerland.

Both sides thus benefit from the collaboration between the SHA and Spiez Laboratory: The partnership promotes continuous learning, innovation and a deeper understanding of complex challenges both in the laboratory and in the field.

Ultrafiltration system: Water is mechanically pressed through a close-meshed filter (white cylinders), which separates dirt and bacteria. Downstream chlorination kills viruses and bacteria. This makes the water drinkable.

In the event of a terrorist biological attack in Switzerland, the DDPS Emergency Response Team (EEVBS) of Spiez Laboratory supports the emergency response organisations at the scene.

04

Strengthening the UN Secretary-General Mechanism through international exercises

For years, Spiez Laboratory has been supporting the further enhancement of an important UN instrument for investigating suspected uses of biological weapons. By organising exercises, Switzerland is making a significant contribution to strengthening the global security architecture. At the same time, the exercises allow Spiez Laboratory and other federal agencies to expand and optimise their own processes for cooperation with partners. Established processes are central to the investigation of a bioterrorist attack.

Maximilian Brackmann
Cédric Invernizzi

In 1987, shortly before the end of the Iran-Iraq war, the United Nations Secretary-General's Mechanism for Investigation of Alleged Use of Chemical and Biological Weapons (UNSGM) was established. This mechanism gives the UN Secretary-General authority to initiate an investigation at the request of a member state to determine violations of the 1925 Geneva Protocol or other relevant rules of customary international law. As the UNSGM is not a permanent body, UN Member States nominate experts and analytical laboratories that can be called upon to support an investigation if necessary.

The UNSGM was last activated in 2013 to investigate allegations of the use of chemical weapons in Syria. The 'Sellström Mission' confirmed the use of chemical weapons beyond doubt. The results of the analytical laboratories played a key role in this. This investigation mission was able to rely on the laboratory network of the Organisation for the Prohibition of Chemical Weapons (OPCW). The designated OPCW laboratories - including Spiez Laboratory - are accredited and subject to strict OPCW quality controls.

International coordination exercise

To date, there is no international organisation that could carry out an investigation mission to implement the ban on biological weapons. In this area, it is therefore the direct responsibility of the UN Member States to actively support the implementation and further development of the UN Secretary-General's Mechanism. In particular, the UNSGM should be in a position also to carry out fact-finding missions in the biological field; for this purpose, it must be possible to examine suspected samples in recognised analytical laboratories so that the results are fully accepted by political as well as scientific audiences.

Under the leadership of the USA and Switzerland, an exercise was held in Geneva in June 2024 with participants from all regions of the world. The scenario chosen was a bioterrorist attack with a bacterial pathogen in a shopping centre. The main purpose of the Table Top Exercise (TTX) was to review and practise cooperation between the organisational units involved. The focus was on coordinating the UNSGM processes with national health and safety guidelines. Conflicting objectives exist, for example, between the need to inform the public as quickly, transparently and completely as possible about a disease outbreak, and the requirement not to disclose any information needed for criminal prosecution. In order to protect the integrity and independence of an international investigation, a UNSGM mission team must not disclose any information to the public during the mission. However, once the mission has been completed, the full investigation report will be made public and will then be available to UN Member States and thus also to their law enforcement authorities. With these requirements, the participants in the exercise discussed what information can be exchanged, when, and under what conditions.

The exercise provided important insights for the further operationalisation of the UNSGM. Equally important, however, is the added value for Switzerland achieved through the exercise: the exercise made it clear that the measures for actual incident management and the interests of law enforcement must be carefully and in detail weighed up and coordinated. In this sense, the exercise also made an important contribution to strengthening the interfaces of the population protection system in Switzerland.

Outlook

Spiez Laboratory will continue to work towards strengthening the UNSGM. The focus here is on two aspects in particular: firstly, the further development of the formal and legal framework, and secondly, the optimisation of the interfaces between investigation missions and analytical laboratories.

In addition to exercises, Spiez Laboratory has been organising for around 10 years an annual UNSGM Designated Laboratories Workshops. The main aim is to build a network of trusted and recognised laboratories. The workshops in Spiez connect and strengthen a multidisciplinary community of dedicated laboratories spread across the globe. Particularly in view of the current very tense international security situation, Switzerland is thus making an important professional contribution to international arms control and disarmament - in line with the vision of Spiez Laboratory: 'A world without weapons of mass destruction'.

05 Sample preparation for the 55th Official OPCW Proficiency Test

As one of 30 Designated Laboratories worldwide, Spiez Laboratory regularly supports the Organisation for the Prohibition of Chemical Weapons (OPCW) in the off-site analysis of suspect samples. Thanks to its expertise and excellent analytical instrumentation, Spiez Laboratory has passed the analytical proficiency tests organised by the OPCW for more than 25 years with very good results. The OPCW relies on the support of Designated Laboratories for the preparation of test samples for proficiency tests. In spring 2024, Spiez Laboratory prepared the samples for the 55th Official OPCW Proficiency Test. It was awarded the highest rating by the OPCW for this work.

Peter Siegenthaler

The OPCW is responsible for ensuring compliance with the Chemical Weapons Convention (CWC). To this end, the OPCW has at its disposal worldwide networks of Designated Laboratories for the analysis of environmental as well as for clinical samples. Since 1996, the OPCW has organised two annual proficiency tests to review the performance of existing and designate new trusted laboratories for environmental sample analysis. As part of these proficiency tests, participants must analyse a set of samples for the presence of chemical warfare agents and submit their results to the OPCW within two weeks.

In order to obtain and maintain OPCW designation, a laboratory must fulfil two main requirements: Firstly, it must provide evidence of internationally recognised accreditation under ISO/IEC 17025 for the analysis of chemicals relevant to chemical warfare agents. Secondly, it must either successfully participate once a year in one of the two annual proficiency tests, or alternatively support the OPCW in carrying out proficiency tests or analysing authentic samples from OPCW missions.

Spiez Laboratory has fulfilled these requirements since 1996 and was one of the first eight institutes to be designated in 1998. In 2023, it had reason to celebrate the 25th anniversary of its OPCW designation. Of the 30 Designated Laboratories for environmental samples (as at the end of 2024), Spiez Laboratory is one of only three institutes that have been able to maintain designation without interruption for a period of more than 20 years.

The team of the Analytical Chemistry Branch of Spiez Laboratory and the two representatives of the OPCW laboratory (2nd/3rd from the left) before the dispatch of the sample sets for the 55th Official OPCW Proficiency Test.

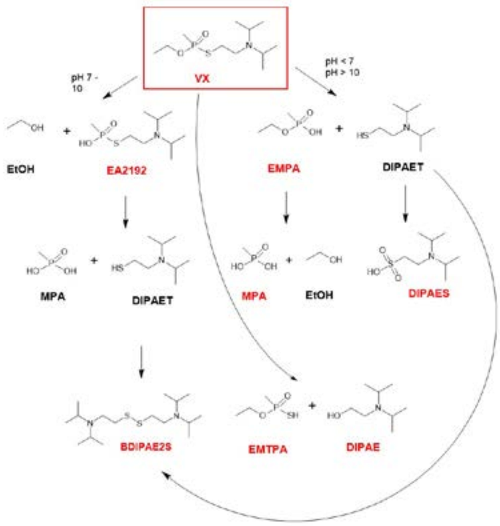
Prescribed process and strict quality requirements

To carry out proficiency tests, the OPCW relies on the support of trusted Designated Laboratories for the preparation of samples and the evaluation of the participants' analysis reports. Spiez Laboratory has regularly supported the OPCW in carrying out proficiency tests since 1996. Thus, after 1996, 1998, 2009 and 2016, it agreed again in February 2023 to prepare the samples for a proficiency test for the fifth time.

The tasks of the sample preparation laboratory and the strict quality requirements for the test samples are described in a work instruction for the preparation of samples for OPCW Proficiency Tests. This is intended to ensure that all participants receive samples with an identical composition and thus have the same starting conditions for the analysis. Both the guarantee and the verification of the requirements regarding the homogeneity of the samples as well as the purity and stability of the chemicals lead to considerable efforts for the sample preparation laboratory. The development of a test scenario and extensive preliminary experimental studies took place between June 2023 and March 2024.

According to the fictitious scenario of the 55th Official OPCW Proficiency Test, a State Party has submitted a request to the OPCW in accordance with Article IX of the CWC for a challenge inspection of a facility suspected of conducting chemical weapons research. The OPCW Director-General sent a team of inspectors to the suspected facility. There, the inspectors seized two liquid samples from waste containers. The

Decomposition scheme of the nerve agent VX (in red box) and the degradation products of VX formed. The abbreviations of the chemicals used in the samples are labelled in red.



samples were then divided into aliquots at the OPCW laboratory and sent to the Designated Laboratories for analysis.

On 16 and 17 April 2024, the Analytical Chemistry Branch at Spiez Laboratory prepared the samples for the proficiency test under the supervision of two representatives from the OPCW laboratory. As usual, two sample sets were prepared, each consisting of three samples that could not be distinguished externally. This largely corresponds to OPCW practice in an investigation case, where in addition to the authentic verification sample ('Sample'), an additional positive control sample ('Control') and a negative control sample ('Blank') are sent to the Designated Laboratories for analysis. According to the scenario, the two sample sets were 'solvent waste' and 'decontamination waste'. The sample matrices consisted of water and various organic solvents.

A challenging test – positive feedback

A total of 30 sample kits of six liquid samples of 5 ml each were prepared. For this purpose, water and various organic solvents were spiked with minute quantities of chemical warfare agents and related chemicals. The two 'samples' and the two 'controls' were spiked with a number of CWC-relevant chemicals unknown to the participants, whereas the two 'blanks' by definition did not contain any relevant chemicals.

The spiked chemicals were the nerve agent VX and a selection of its degradation products, which are formed during the decomposition of VX. To make the analysis more challenging, the samples were additionally spiked with substances intended to simulate impurities in the samples; diesel oil, a mixture of

Tasks and procedures for sample preparation for the 55th Official OPCW Proficiency Test

2023

February
Confirmation to the OPCW for sample preparation for the 55th Official OPCW Proficiency Test

March
Development of test scenario

June/July
Purity control of potential test chemicals for spiking ("Purity Checks")

July 2023 – February 2024
Stability studies of potential test chemicals in neat solvents and in the sample matrices with and without impurities

2024

January/February
Definition of the final sample composition

Stability studies of test chemicals in spiked samples

February
Discussion of the results of the preliminary studies and approval of the final sample composition as well as the test scenario by the OPCW

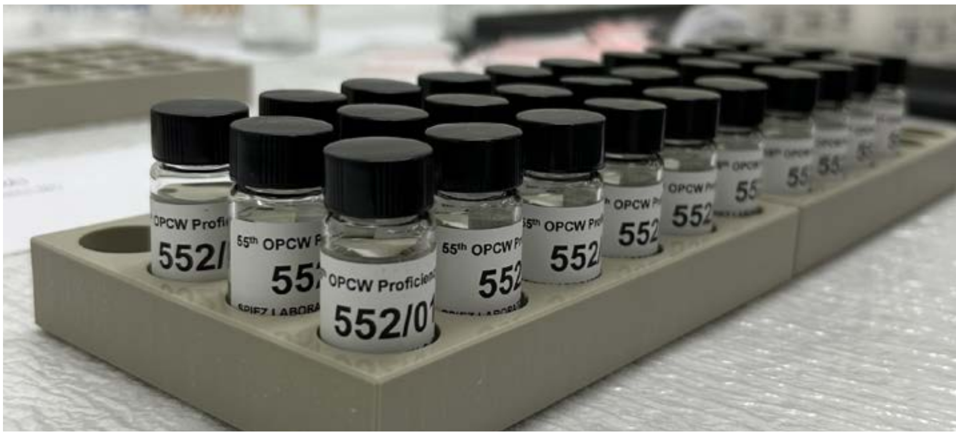
Signature of the agreements on confidentiality and sample preparation

February/March
Clarification of customs formalities regarding packaging and transport of samples

aliphatic amines, polyethylene glycol and common salt were used for this purpose. In contrast to previous proficiency tests, the matrix composition of the two 'samples' differed from that of the 'controls' and the 'blanks'. On the one hand, this is closer to reality, and on the other hand, it made the work of the laboratories conducting the analyses even more challenging.

The sample sets were packaged on 18 April 2024 in accordance with the applicable transport regulations and sent to the twelve participants in the test, the OPCW and the evaluation laboratory on 19 April. Further sample sets randomly selected in advance by the OPCW representatives were regularly analysed qualitatively and quantitatively at Spiez Laboratory over the following weeks. This allowed checking the homogeneity of the samples and the concentration of the spiked chemicals.

On 16 July 2024, the evaluation meeting for the 55th Official OPCW Proficiency Test took place at OPCW headquarters in The Hague, where the results were made public: With four A ratings and two B ratings, half of the twelve regular participants successfully passed the test. The feedback from the OPCW and the evaluation laboratory but also from the participants, on the test scenario and the samples, was consistently positive. In general, the test was judged to have been challenging, but scenario-based, realistic and fair. The OPCW expressed its thanks for the extensive preparatory work and the meticulous planning and sample preparation in accordance with the 'Swiss Quality Standard', which, according to the OPCW, contributed significantly to the smooth implementation of the test. The Spiez Laboratory was rewarded by the OPCW with the maximum A rating for its support in carrying out the 55th Official OPCW Proficiency Test.



The positive control samples of the 'solvent waste' samples filled in 6 ml glass vials and coded with '552'.

March/April
Preparation of several sample sets with the final composition for qualitative analysis and the quantitative stability and homogeneity tests ("Pre-Dispatch Analysis")

April/May
Stability and homogeneity tests with three sample sets assigned by the OPCW during 34 days ("Post-Dispatch Analysis")

May
Analytical clarifications in connection with the categorisation of additional chemicals, which were reported by participants in addition to the spiked chemicals

3 June
Submission of the reports on the preparation of the test samples and on the «Purity Checks» of the chemicals to the OPCW

15-19 April
Discussion of the results of the "Pre-Dispatch Analysis" and "Purity Checks" with representatives of the OPCW Laboratory

Preparation, initial analysis and aliquoting of the proficiency testing samples (30 kits of 6 samples each)

Shipment of sample packages to the participants, the OPCW Laboratory and the evaluation laboratory by courier

16 July
Presentation of the work on the preparation of the samples and the purity tests of the test chemicals at the Evaluation Meeting for the 55th Official OPCW Proficiency Test at the OPCW headquarter in The Hague (Netherlands)

06 Spiez Laboratory at the scene

According to the Federal Act on Civil Protection and Civil Defence (CPDA), the Confederation is obliged to support the cantons with specialised emergency organisations in the NBC sector. Spiez Laboratory contributes significantly to the fulfilment of this legal mandate with its DDPS Emergency Response Teams (EEVBS). The deployments of the EEVBS have increased significantly in recent years: on the one hand to ensure NBC protection at international conferences in Switzerland, and on the other hand to secure and correctly analyse 'unknown samples'.

Beat Aebi
Kurt Münger

The DDPS Emergency Response Teams (EEVBS) ...

In 1995, 13 people were killed in the Tokyo subway in a terrorist attack with the chemical agent sarin; several hundred people were severely injured. At the time, Switzerland would not have been equipped to deal with such an event. Neither the federal government nor the cantons had emergency services that could bring the necessary expertise and resources to the incident scene. This realisation led to the creation of a DDPS emergency response team (EEVBS) at Spiez Laboratory to deal with a chemical terrorist incident. Today, there are three specialised EEVBS for A, B and C incidents. The three EEVBS each comprise around 20 employees of Spiez Laboratory, who are available on a voluntary on-call basis for operations and consultations. They have at their disposal specific equipment for incidents involving radioactivity, hazardous biological agents and toxic chemicals. If necessary, the task forces support cantonal emergency services and other federal emergency services. The operational area covers the whole of Switzerland and the Principality of Liechtenstein.

... Sample Receipt Facility (SRF)

The Sample Receipt Facility (SRF) at Spiez Laboratory is intended for the examination of suspicious NBC material. The SRF, too, was a response to specific terrorist incidents: It was set up after a whole series of attacks involving the biological agent anthrax were carried out in the USA in 2001. The events summarised under the coinage 'Amerithrax' also changed the way suspicious letters and parcels are handled in Switzerland. Initially, Spiez

Radioactivity measurement with the mobile measuring equipment of the RN-EEVBS on an access road to the Summit on Peace in Ukraine on the Bürgenstock.

Exercise of the B-EEVBS and EOD Command at Spiez NBC Centre.

Laboratory and the NBC defence forces each set up their own system - with rather improvised structures. Since 2016, there has been a fully-fledged SRF building, which is used for the operational tasks of Spiez Laboratory.

The SRF fulfils two different purposes: Firstly, it is used to safely and correctly analyse 'unknown samples'. This refers to samples that need to be analysed for an NBC hazard, whereby the type of potential hazard is not known at the outset. In addition, in the case of suspicious letters and parcels containing powders and liquids it is often unclear at the outset whether mechanical devices for the distribution of NBC substances or even explosives as unconventional detonation or incendiary devices are present. In such a case, the EOD command of the NBC EOD Centre of Excellence can provide direct on-site support with specialist knowledge and material. Secondly, the SRF is used by Spiez Laboratory and the NBC defence forces to deal with major NBC incidents. At the SRF, a large number of samples with a known hazard can be correctly received, managed and prepared for measurement in a specialised laboratory. Overall, the SRF therefore serves to fulfil the tasks and needs of both the civilian and military partners of the Spiez NBC Centre.

To ensure that the EEVBS and SRF operations run smoothly, regular training and operational exercises are carried out with external partners. Since 2009, the C-EEVBS alone has completed around 35 external deployment exercises with its partners in Switzerland and Germany.

EEVBS-deployment to provide protection for the Bürgenstock Conference

In 2024, the EEVBS was deployed several times, in particular to protect major international events in Switzerland. In such deployments, the EEVBS teams advise the local emergency services on protection against radioactivity, biological hazards and chemical warfare agents. For the high-level conference on peace in Ukraine on 15 and 16 June 2024 on the Bürgenstock in the canton of Nidwalden, a comprehensive NBC protection plan was implemented with the significant involvement of the EEVBS. The biggest task was in the area of A monitoring: even before the conference, the A-EEVBS carried out comprehensive radioactivity measurements on the access roads using mobile measuring equipment. Stationary measuring probes were set up in the vicinity of the conference site. Access to the conference rooms was also monitored. In addition, in order to identify possible hazards from B or C substances, specialists from the B and C EEVBS were on site to advise the participating emergency organisations as experts and to intervene immediately in the event of a suspected case.

Spiez Laboratory also carried out similar missions to protect major international events in January 2024 during the visit of Ukrainian President Zelensky to Bern and subsequently at the WEF in Davos.

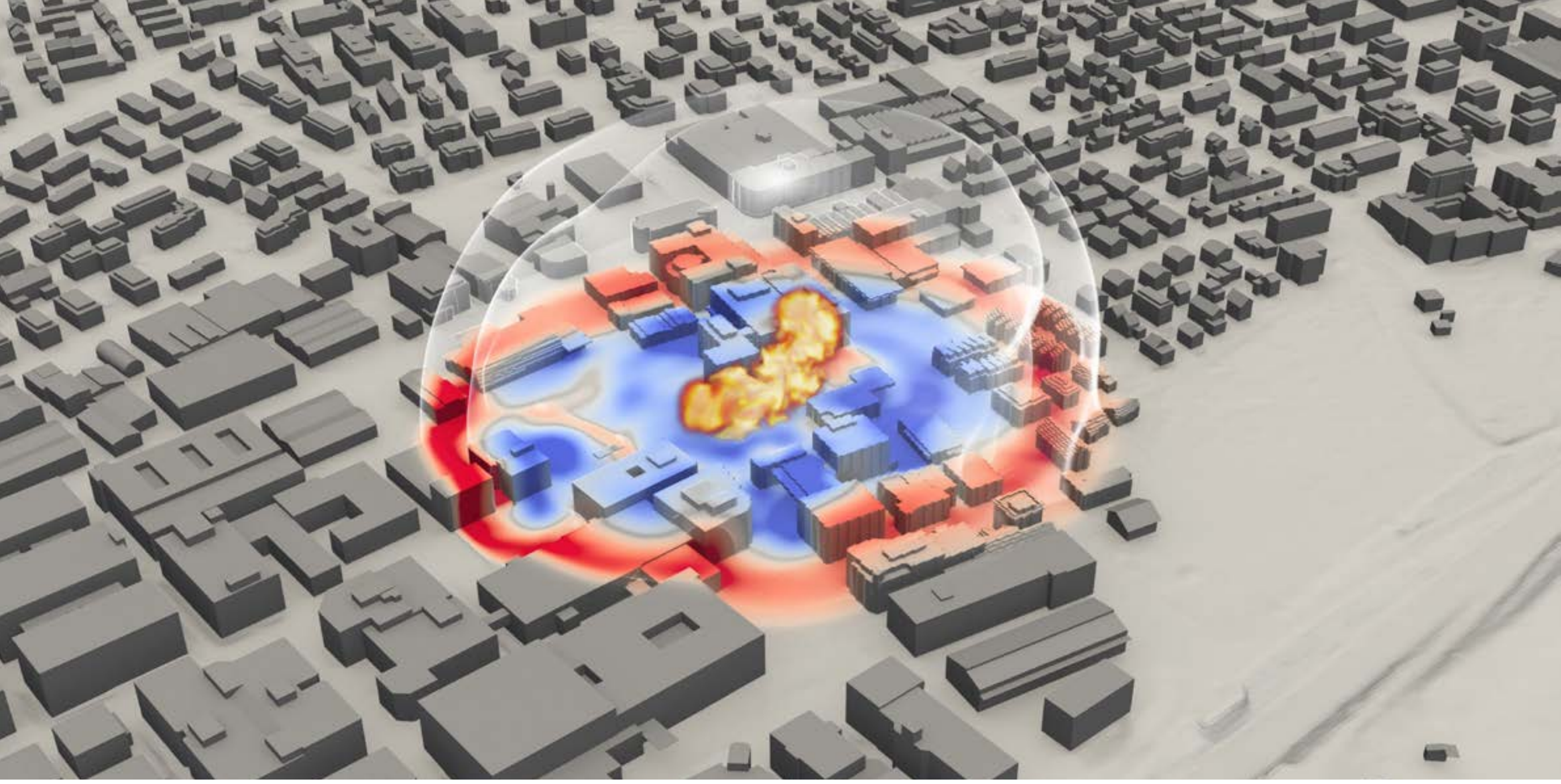
Change in the NBC threat worldwide and in Switzerland

The global security situation and the associated NBC threat landscape are constantly changing. Sarin, Novichok or other highly toxic substances, radioactive materials or even dangerous biological pathogens can be used for criminal, terrorist or military actions also in the future. Anonymous shipments of suspicious powders and liquids must be taken seriously - even though they have so far mainly been disruptive hoaxes.

Since the Russian attack on Ukraine, additional aspects and NBC hazards have emerged. The number of cases in which Spiez Laboratory has been called to clarify a suspected NBC case has increased since then, and the number of SRF missions to analyse ‘unknown samples’ has risen steadily in recent years. Against this backdrop, Spiez Laboratory must continue to develop its expertise and capacities for dealing with missions over the next few years, in coordination with its partners.

State visit in 2024: Emergency vehicles of Spiez Laboratory and other blue light organisations together on standby in the event of an NBC incident.

A bottle with suspicious contents is analysed on site by the C-EEVBS and classified as harmless.



07

Numerical simulation of the pressure effect in the event of total failure of a high-pressure natural gas pipeline in an urban area

An unintentional, sudden release of methane from a high-pressure natural gas pipeline (HPNGP) leads to a high-pressure free jet with an accompanying gas cloud formation. The pressure effect of the free jet or a possible explosion due to a subsequent ignition can be significant and have corresponding effects on exposed buildings and people. Spiez Laboratory uses numerical flow simulations to help determine the magnitude of pressure loads in the event of such an incident and to define suitable protective measures.

Lorenz Brenner

In Switzerland, natural gas is transported from neighbouring countries to local gas suppliers via the HPNGP network of regional companies at pressures of up to 70 bar. Actions of third parties, ground movements, or corrosion and more specifically material faults can cause the release of gas from the HPNGP network. In the event of a total failure of the HPNGP, a high-pressure free jet is created, which generates a flammable cloud that can ignite instantly or with a time delay.

In Switzerland, the protection of the population and the environment from serious damage caused by major accidents is regulated in the Major Accidents Ordinance (MAO). Since 2013, the Ordinance also covers high-pressure natural gas and oil pipelines, with around 2,307 km of pipelines affected (as of 2021). In order to minimise the risks to people and the environment, the owners or operators of the pipelines are obliged to investigate the risks and take appropriate protective measures if necessary. As a further increase is to be expected in the future in the density and hence size of the population in areas where HPNGPs already exist, the potential extent of damage in the event of incidents increases, and thus does the risk.

Definition of a scenario and numerical simulations

With the involvement of various experts, the Federal Office for the Environment (FOEN) is currently working on a special project to produce an Environment-Knowledge-Publication that identifies suitable property protection measures for planned buildings in areas affected by HPNGP. With regard to incidents, experiments under real conditions cannot be realised at all or only with enormous effort. Therefore, the pressure effect caused by a total failure of an HPNGP was analysed using Computational Fluid Dynamics (CFD) simulations.

The project group has defined the following scenario: A full-bore rupture of a 12 inch / 54 bar HPNGP, in which an 8 m long section of pipeline is destroyed and the two ends of the pipeline (straight break) protrude from the ground at different angles of inclination. An industrial area of a city, where a corresponding pipeline has been laid, serves as the urban environment.

For the numerical calculations, Spiez Laboratory used the APOLLO Blast Simulator software, which was specially developed for the simulation of explosions, pressure waves and gas dynamics. Various gases and corresponding reaction models are implemented in the programme, including for methane-air mixtures. In a first step, similar problems such as the calculation of the free jet from scientific publications were simulated; the results were analysed and compared in depth. These preparatory analyses were necessary as no experimental analyses were carried out in the project, and this was the only way to check the plausibility of the simulations.

In the second step, the defined outflow scenario from two pipeline ends was simulated and the resulting methane distribution was integrated into the urban

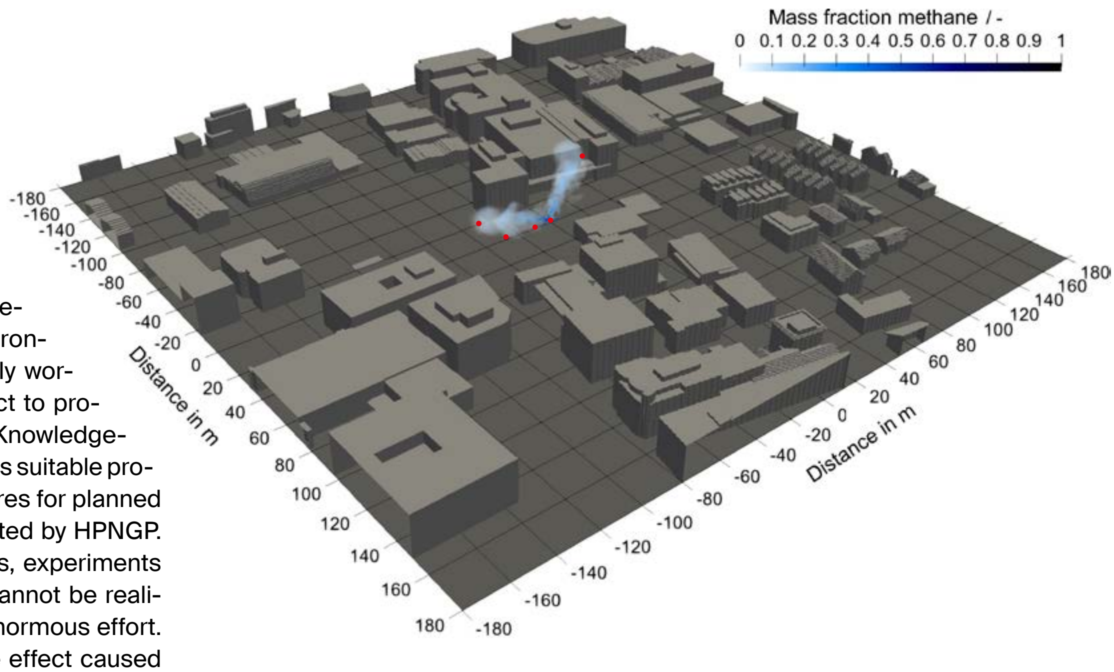


Fig. 1: Exemplary 3D model of the investigated scenario with the methane gas cloud after 1 s outflow time (blue scale) and the investigated ignition points (red dots).

environment to calculate the gas cloud explosion. Building and topography data from the Federal Office of Topography (swisstopo) served as the basis. Since there is no 'standard incident' and in order to be able to make as general a statement as possible regarding the pressure effect, a parameter study was carried out with a total of 40 simulations with variations of various boundary conditions such as the ignition location (see Fig. 1).

Results and conclusions

Fig. 2 shows an example of a contour plot of the mean peak overpressures across all simulations carried out. It can be seen that the greatest pressure effect is to be expected in the immediate vicinity of the methane outlet (see Fig. 2, coordinate 0 / 0 m). Here, the pressure effect can be significant even without ignition, due to the outflow of the gas. Due to pressure wave reflections, there are increased pressures of around 0.14 to 0.16 bar at the buildings close to the HPNGP failure site and at the building to the south of it (see Fig. 2, coordinate 20 / -80 m). An additional area with increased peak overpressures occurs in the open field between the buildings (see Fig. 2, coordinate 0 / -60 m). Assuming rigid buildings, the pressure effect is significantly reduced for the buildings at a greater distance due to shadowing effects.

According to the damage models used, the calculated pressure effect would destroy standard glazing, among other things. This would create openings in the building envelope through which the heat radiation from the combustion of the gas cloud could reach the interior of the building unhindered. Reinforced window systems can be used to reduce this risk. This is a key finding for significantly reducing the risk in buildings in the vicinity of such systems. It is therefore explicitly addressed in the Environment-Knowledge-Publication.

For obvious reasons, experimental investigations of explosion effects in urban areas are almost impossible to realise. Against this background, the numerical analyses of the project were able to provide great scientific added value: The phenomena of the blast wave propagation could be visualised and investigated in detail. Based on this, suitable property protection measures can be defined.

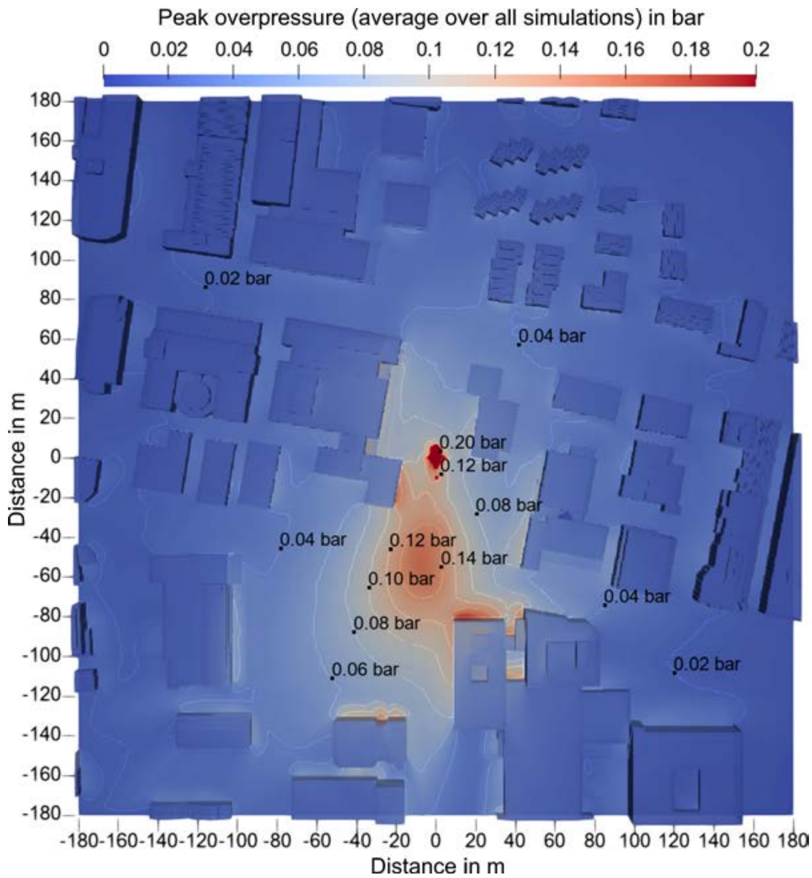


Fig. 2: Exemplary pressure contour plot of the mean values of all peak overpressures across all simulations of the parameter study in the urban area analysed (top view). The centre of the model (coordinate 0 / 0 m) corresponds to the location of the total failure of the HPNGP.

Work in the biological safety laboratory BSL 3

8 Serological research with third-generation smallpox vaccines

Following the global outbreak of Mpox in 2022, various smallpox vaccines were authorised for pre- and post-exposure prophylaxis against the monkeypox virus, which causes the disease Mpox. At Spiez Laboratory, serum samples from laboratory workers who had been immunised with a first or third generation smallpox vaccine were tested for cross-protective neutralising antibodies against the monkeypox virus.

Damian Jandrasits
Roland Züst

The monkeypox virus (MPXV) was first detected in 1958 in monkeys at a Danish research centre. The first human infection was documented in 1970. MPXV belongs to the orthopoxvirus genus, like the variola virus, the causative agent of smallpox, and is endemic in Central and West Africa. There are two main strains of the virus: Clade I (Central Africa) and Clade II (West Africa). Clade II infections

1. Huang, Y., L. Mu, and W. Wang, *Monkeypox: epidemiology, pathogenesis, treatment and prevention*. Signal Transduct Target Ther, 2022. **7**(1): p. 373.
2. Kumar, N., et al., *The 2022 outbreak and the pathobiology of the monkeypox virus*. J Autoimmun, 2022. **131**: p. 102855.
3. Deputy, N.P., et al., *Vaccine Effectiveness of JYNNEOS against Mpox Disease in the United States*. N Engl J Med, 2023. **388**(26): p. 2434-2443.

are generally milder, with lethality rates of around 1%, while Clade I infections can be fatal in up to 10% of cases.[1]

Individual cases of Mpox were previously mostly attributed to the import of animals or the return of travellers from endemic regions, and affected only a few people. However, the outbreak in 2022 was unusual: For the first time, people with no history of travelling to MPXV endemic areas also tested positive for the virus. This indicates increased human-to-human transmission, including through sexual contact.[2] Also in Switzerland, numerous people tested positive for Mpox, with the first case confirmed by molecular biology at Spiez Laboratory.

First-generation smallpox vaccines proved to be very effective and made a decisive contribution to the global eradication of smallpox in 1980. However, these vaccines had severe, sometimes life-threatening side effects, especially in immuno-deficient individuals. The second- and third-generation vaccines should be safer in this respect. All smallpox vaccines are based on the vaccinia virus (VACV), another member of the orthopoxvirus genus. The first-generation vaccines used active vaccinia virus that can replicate in the human body. Third-generation vaccines, on the other hand, are based on modified vaccinia Ankara (MVA), an attenuated and replication-deficient VACV strain.[3] Because viruses of the orthopox genus are very similar to each other, smallpox vaccines can also be authorised for pre- and post-exposure prophylaxis against Mpox.

Serum neutralisation tests for the determination of neutralising antibodies

Antibodies are produced by the so-called B cells of the immune system. Neu-

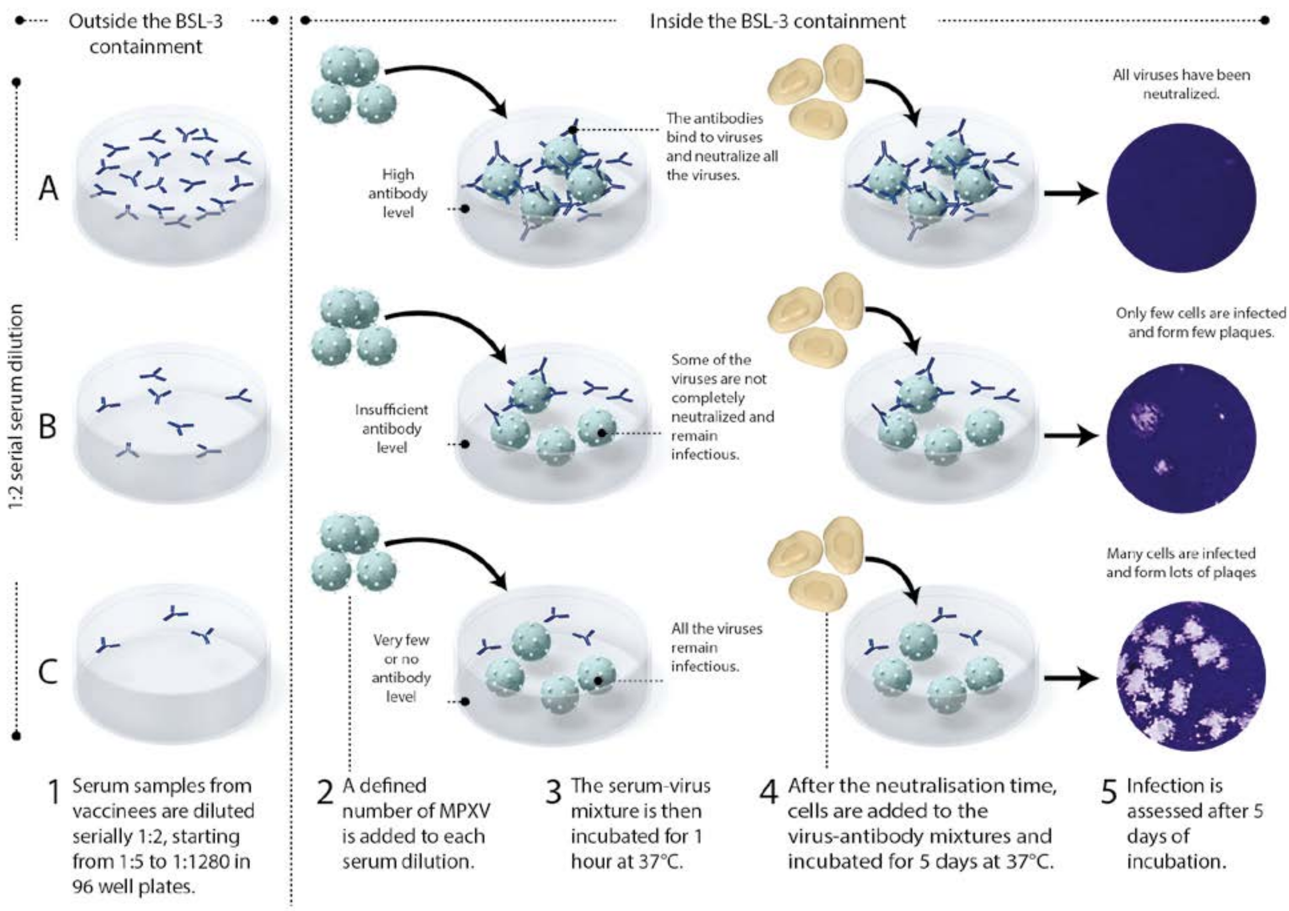


Fig. 1: MPXV Neutralisation test

tralising antibodies can bind to viral surface proteins and thus block the virus entry into the host cells. A serum neutralisation test is used to detect these neutralising antibodies in the serum. A defined quantity of virus particles is mixed with various dilutions of sera from test persons. The maximum serum dilution at which 50% of the virus particles are still neutralised is determined. The test serves as an indicator of successful immunisation through the vaccination.

Because MPXV is classified as a risk group 3 pathogen, all work with infectious MPXV must be carried out in a biological safety laboratory level 3 (BSL-3). The test sera are diluted from 1:5 to 1:1280 outside the biosafety laboratory. Inside the BSL-3 laboratory, the defined amount of virus is mixed with the serum samples and incubated for 1 h at 37°C. During this time, the antibodies in the serum can be analysed. During this time, the antibodies in the serum can neutralise the virus. The virus-serum mixture is then transferred to cells and incubated at 37°C for 2 (VACV) or 5 (MPXV) days and then stained. Incomplete neutralisation results in plaques - visual gaps in the cell layer that are counted to determine the neutralising antibody titres (see Fig. 1).

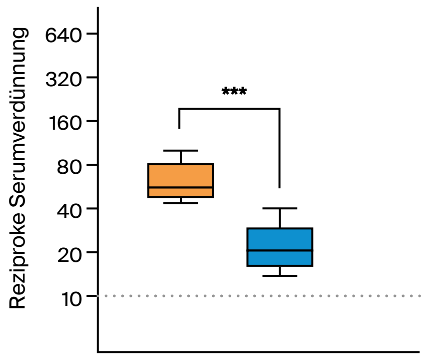
First-generation vaccinations produce higher MPXV-neutralising antibody titres

The results of the serum neutralisation tests showed that first-generation vaccines induced higher titres of neutralising antibodies against MPXV than third-generation vaccines. The antibody titre against VACV was higher in both vaccine groups than against MPXV, which was to be expected due to the respective vaccine formulation (see Fig. 2).

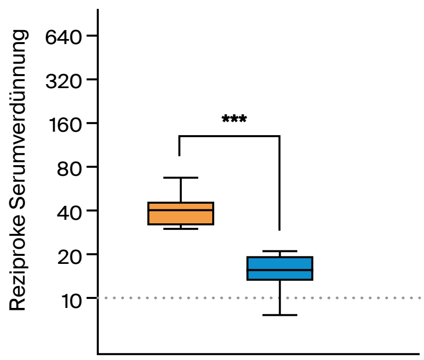
In addition, serum samples from subjects who were initially immunised with a first-generation vaccine and later received a booster dose of a third-generation vaccine were analysed. In comparison with people who did not receive an additional dose, the booster vaccination did not result in a significant increase in neutralising antibody titres.[4]

Despite the lower antibody titres, the third-generation vaccines showed an effect on the MPXV isolate responsible for the outbreak, which indicates at least partial protection against the disease. In order to maintain this protection in the long term, regular booster vaccinations are required. In addition, the third-generation vaccines offer the possibility of protecting immunodeficient individuals without the risk of complications due to their better tolerability.

Neutralisierende Antikörper gegen Vaccinia



Neutralisierende Antikörper gegen MPXV



Pockenimpfstoff der ersten Generation
Pockenimpfstoff der dritten Generation

Fig. 2: VACV and MPXV neutralising antibody titres in the serum of laboratory workers immunised with a first or third generation smallpox vaccine.

4. Jandrasits, D., et al., *Third-generation smallpox vaccines induce low-level cross-protecting neutralizing antibodies against Monkeypox virus in laboratory workers.* Heliyon, 2024. **10**(10): *p. e31490.*

09

The scientific collaboration in CBRN defence on the example of France and Switzerland

When it comes to the field of defence, and particularly defence technologies, it may at first seem counter-intuitive to imagine nations collaborating closely. It is important to acknowledge the significant advancements in scientific and technological knowledge, which have led to a growing complexity that often exceeds the capacities of individual organisations to process, develop and integrate. Fundamental research is dependent on collaboration, nationally and internationally, and the same is true for industry, which is essential for achieving a finished and integrated product. Similarly, it is advised that the applied research of government research institutes and the laboratory testing services offered in support of armament programmes should collaborate.

César Metzger

The Spiez Laboratory has successful collaborations with several comparable institutes in various partner nations. For many years, France and Switzerland have been collaborating in the field of applied CBRN research. With the DGA (French Procurement agency) for CBRN control, the Spiez Laboratory has established a partner in the fields of protective materials, synthetic and analytical chemistry, and microbiology. Through the exchange of ideas, interpretations, and conclusions, we have the opportunity to test our own working hypotheses, gain external perspectives, and occasionally offer a different point of view on developments in our scientific field. Beyond the exchange of ideas and information, the sharing of methods or even materials (chemical products, microbial strains or reference materials) enables our laboratories to work more efficiently and often achieve cost savings by avoiding the need to perform certain tasks independently, such as the synthesis of complex chemical products, which can be both time-consuming and costly.

Considerations at government level

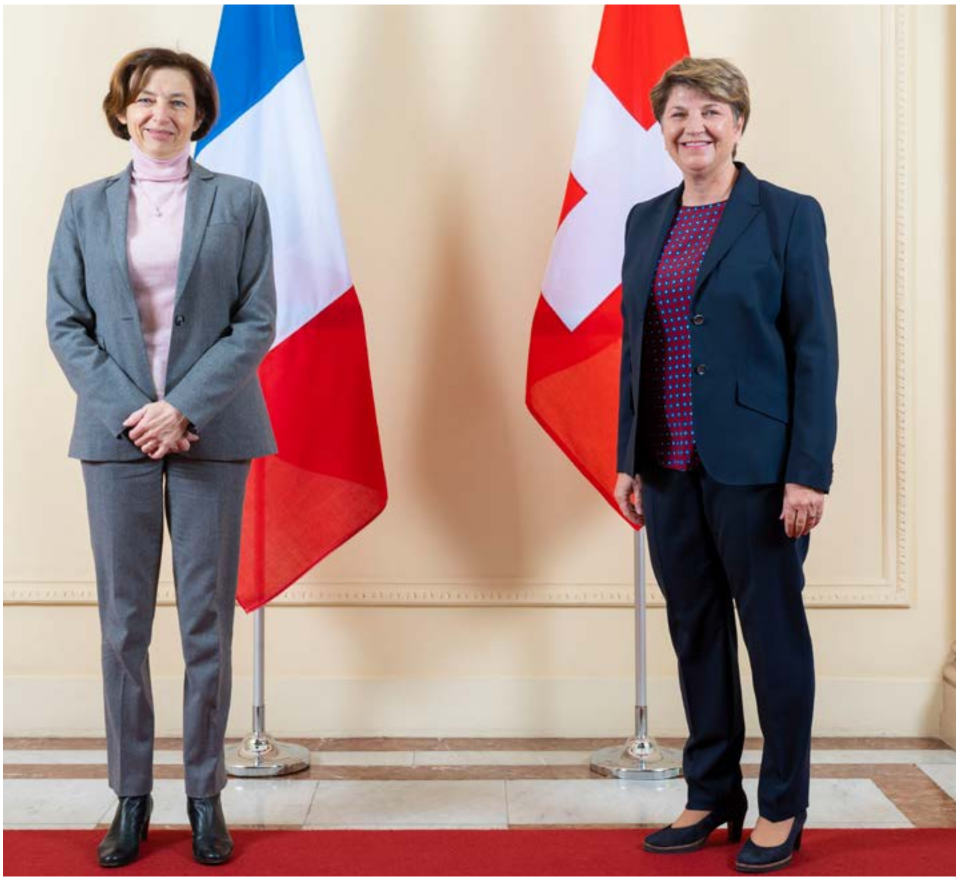
In the domain of biological sciences, where subject matter cannot be synthesised, the sharing of microbial strains between laboratories is imperative. Furthermore, to ensure that our work and methods meet the highest quality standards, it is important to compare and measure them through inter-laboratory tests. For instance, as part of a European collaboration under the aegis of the European Defence Agency (EDA), Switzerland and France – as well as other nations – are working to standardise certain areas of quality measurement in CBRN protective equipment.

The collaboration between the DGA for CBRN control and the Spiez Laboratory has attracted the attention at a political level. This can be attributed in part to the significant achievements and the discussions that have been conducted over the years.

Thus, in 2018, the French Minister of Defence Florence Parly and her Swiss counterpart, Federal Councillor Guy Parmelin, met to discuss security policy issues and evaluate bilateral cooperation in the military and security domains.

Following on from this, Florence Parly and Federal Councillor Viola Amherd highlighted the significance of the CBRN domain. They stated their intention to strengthen the collaboration between our two nations in this complex field.

Since then, the efforts have been continued and intensified. Consequently, there have regularly been visits from French and Swiss scientists to their counterparts in the partner laboratories. These exchanges involve a range of formal interactions, including the sharing of information and methods. A variety of materials and chemicals have been exchanged and further exchanges are planned. Video-conference seminars have been held, when the subjects discussed allowed it. The directors of the institutes also regularly convene to assess the progress and status of the collaborative efforts. Beyond direct exchanges, the two institutes also meet through their participation in various international endeavours, projects, conferences and committees.



The French Minister of Defence Florence Parly and Federal Councillor Viola Amherd during an official visit in 2021.

In addition to its collaboration with the DGA CBRN Control, the Spiez Laboratory maintains partnerships with numerous other institutes in Europe and worldwide.

10 Characterisation of fissile material in the service of disarmament verification

In a world where major powers act increasingly unilateral, disarmament initiatives are currently not politically realistic. Despite the difficult global situation, it is important to find and develop practical solutions for the technical and procedural challenges of effective verification of nuclear disarmament - and thus demonstrate their feasibility. Future arms control agreements should not only reduce the number of operational nuclear weapons. The dismantling of nuclear warheads and the disposal of weapons-grade fissile material, too, must be credibly controlled.

Christoph Wirz
Rolf Althaus

The International Partnership for Nuclear Disarmament Verification (IPNDV) is an ongoing initiative involving more than 25 nuclear and non-nuclear weapons states. Together, the partners identify and analyse challenges in connection with the verification of nuclear disarmament. Between 11 and 29 September 2023, a measurement campaign called BeCamp2 took place at the Belgian nuclear research centre SCK CEN, in which ten measurement teams from all over the world took part. In 2024, the measurements were evaluated in detail by the participating research teams and the findings were shared and further analysed at various IPNDV conferences and events. A final report is in preparation.

As part of BeCamp2, various objects unknown to the measurement teams were measured, which contained the fissile materials uranium, plutonium or other radioactive sources. The objects were partially shielded with lead, cadmium or polyethylene. Each of them had a base area of half a square metre and a height of two metres; each was placed under a green fabric shroud (Fig. 1). As the fabric cover was not to be removed, only non-destructive measurement methods could be used. The different detectors were placed around the green cuboid.

The measurement results were used to answer the following three typical questions:

- Is fissile material present that is suitable for building a nuclear weapon?
- Can the measurement of an object be assigned to a known pattern?
- Is it possible to confirm the absence of nuclear material by the measurement?

The second question is relevant because the disarmament process is intended to verify whether the item under investigation is actually a nuclear weapon of an agreed type.

Spiez Laboratory took part in the campaign with two portable ultra-pure germanium detectors, which were set up so that each detector covered a different energy range for the detection of gamma radia-tion. These different settings are necessary for optimum evaluation of the spectra using special evalu-ation programmes. Uranium-based nuclear weapons contain very highly enriched uranium, i.e. with a very high proportion of uranium-235. Fig. 2 shows a typical uranium spectrum.

In addition to two commercial programmes (FRAM and MGAU), Prof. Kalthoff's code, for which the source code is accessible, was also used for the analysis. With this code it is possible to determine the ratio of the isotopes uranium-238 to uranium-235 from the signature in a narrow energy range of the spectrum (marked in Fig. 2, see Fig. 3).

The measurements carried out by Spiez Laboratory at BeCamp2 have shown that the characterisation of fissile material based on uranium can be particularly challenging. The energy range with the charac-teristic signature can be relatively easily masked by suitable shielding. Therefore, higher energy rang-es must be used for the assessment. A very good resolution of the ultra-pure germanium detector and a well-developed line spectrum are therefore essential for reliable conclusions.

The data obtained in BeCamp2 help to improve the evaluation programs and optimise the measure-ment process. The comparison of different measurement methods and analysis strategies leads to improved and more efficient verification processes. The long-term goal is a reliable evaluation of the measured spectra without the need for an expert present, and without making the measured spectra visible. The measurement should only answer the question posed, but not provide any further in-for-mation. In this sense, Spiez Laboratory can make a contribution to nuclear disarmament without having weapons-grade fissile material at its disposal.

Fig. 1: Measuring object covered with a green shroud. Measuring devices are placed around it. In the foreground there are detectors for measuring neutrons, in the background the detectors of Spiez Laboratory for measuring gamma radiation.

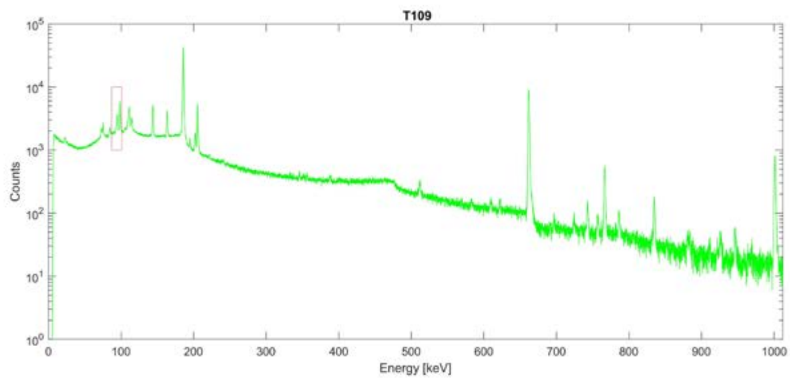


Fig. 2: Uranium spectrum: Special evaluation programmes are required to determine the ratio between the two isotopes uranium-235 and uranium-238.

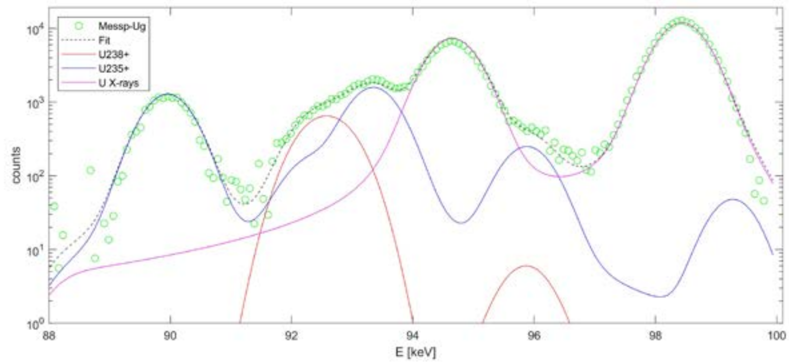
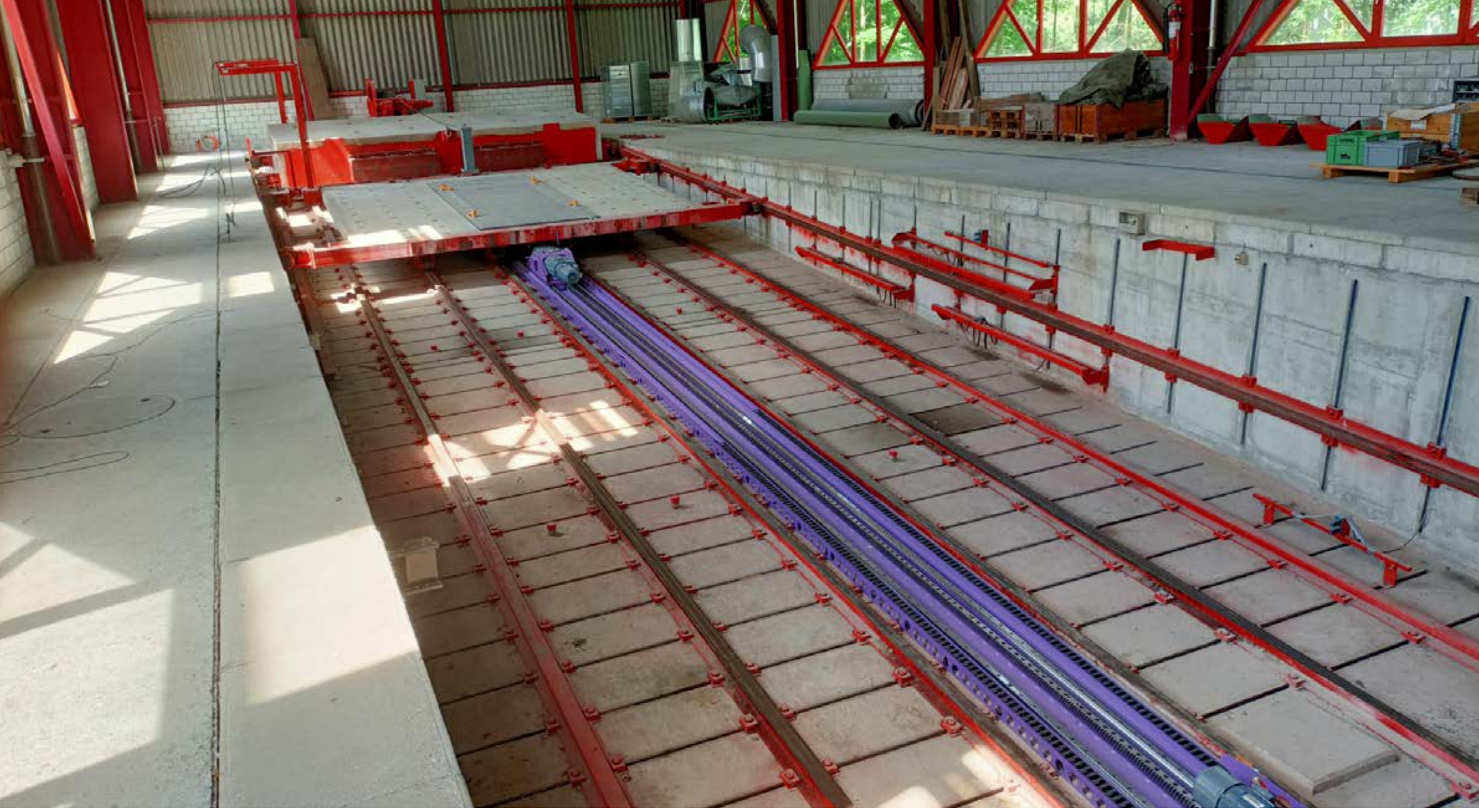


Fig. 3: The measured signature is approximated by three curves. These three curves consist of a total of 14 individual peaks, grouped according to their origin. Uranium-238 and daughter products (red curve), uranium-235 and daughter products (blue curve), X-ray fluorescence (violet curve).



Horizontal shock-testing system

11 Refurbishment of the horizontal shock testing system

Switzerland pursues a shelter programme that is unique in the world: every person living in Switzerland must have a place in a shelter when necessary. To ensure the required quality of the shelters, the Federal Office for Civil Protection (FOCP) issues approvals for civil defence components. The central basis for this is practical testing carried out by Spiez Laboratory. To this end, it operates unique test rigs such as the horizontal shock testing facility (HOSPA). These should always be state of the art and therefore must be regularly modernised and further developed.

Christian Blaser

In the sixties and seventies of the last century, Switzerland established the shelter programme that is still in force today. A central component of this programme is the shelter concept, which stipulates that every person living in Switzerland is entitled to a place in a shelter. In concrete terms, the implementation of this concept means that Switzerland currently has around

370,000 shelters and around 9 million shelter places for the civilian population. (For more information, see the FOCP website.) Spiez Laboratory was and is an important player and source of expertise in the implementation and maintenance of the shelter programme.

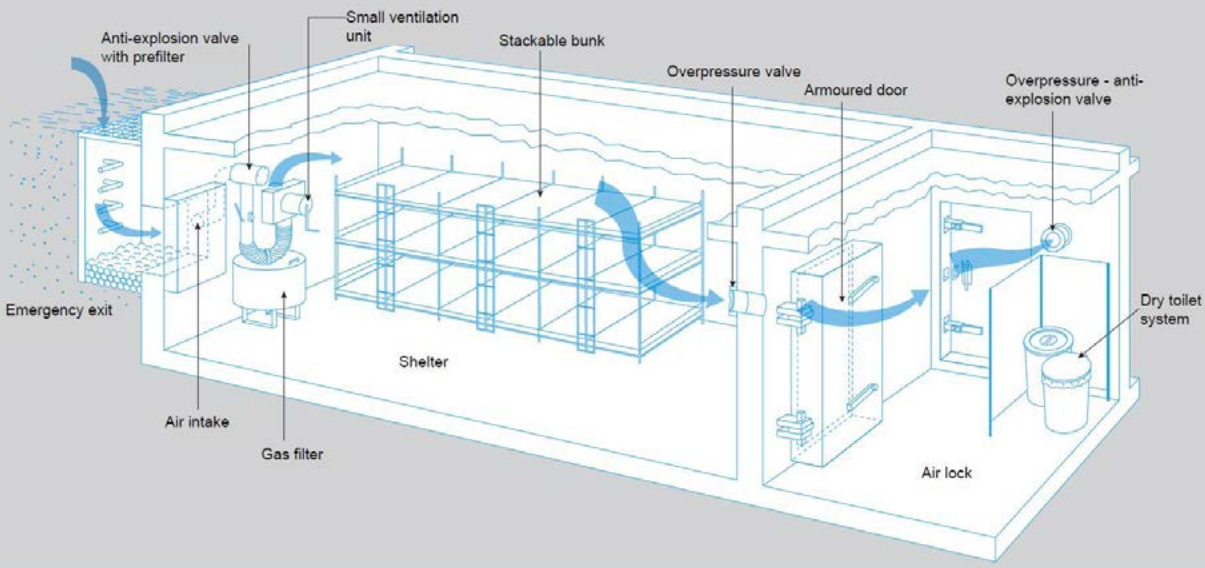
Testing of shelter components

In order for a shelter to provide the intended protection against armed conflicts or disasters, the components installed must fulfil certain requirements, particularly with regard to shock resistance, resistance to pressure surges and ventilation technology. The FOCP approval centre issues the relevant certifications for shelter components to manufacturers and suppliers. The central prerequisite for approval is the availability of qualification tests by accredited testing laboratories. Spiez Laboratory currently operates three accredited test laboratories in its CBRNe Protection Systems Department for this purpose. As the Swiss protection system programme is unique in the world, specific test methods and test facilities had to be created. Due to their dimensions, functionalities and performance data, the test facilities of the test centre for NBC protection material as well as equipment and installations of protective structures (STS 0055) stand out. These are all customised products.

In order to carry out the required shock tests on large test specimens such as emergency power generators or air conditioning units, correspondingly large test rigs are required, with the STS 0055 test centre operating three shock test rigs. The test centre also operates two shock tubes, a ventilation test bench and numerous other small test benches to test the air shock and ventilation properties of the components.

Classic shelter model

Cutaway view through a classic shelter model. The potentially contaminated air is drawn in by a ventilation unit and cleaned by a gas filter before it enters the shelter and leaves it again via a pressure relief valve. Most of the components shown must be tested for shock resistance.



Strategic refurbishment as part of the programme to preserve the value of protective structures

Civil defence, and therefore also the testing and approval of components, has increasingly become the focus of interest in recent years due to the aggravated security policy situation. Most of the existing protective structures are several decades old; many components have reached the end of their service life and need to be replaced. This is the only way to maintain the value and usefulness of the facilities and thus sustain the intended protection. The basis for keeping up this value is to be created with a revision of the Civil Defence Ordinance; the consultation process is currently underway.

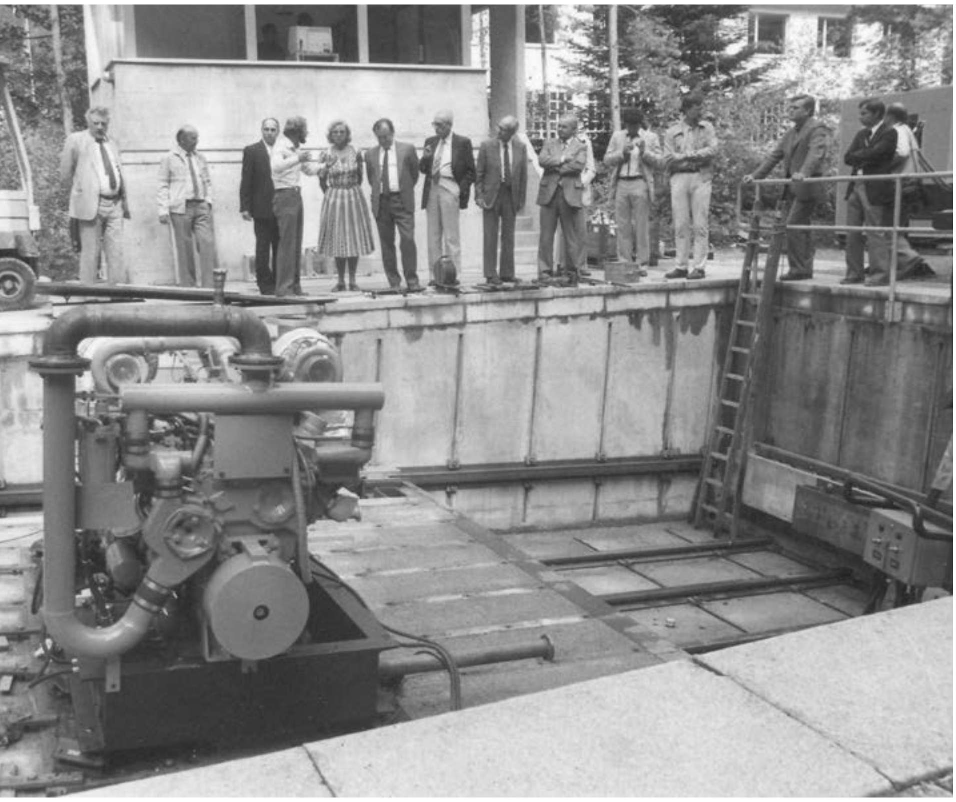
Already a few years ago, Spiez Laboratory began refurbishing and further developing the testing facilities at the STS 0055 test centre in order to ensure it can continue operating the testing facilities using state-of-the-art technology. This is essential in order to meet the upcoming qualitative and quantitative challenges of implementing the programme to maintain the value of the protective structures.

One of the last systems concerned is the horizontal shock test system HOSPA. It was designed in 1980 as an open-air test rig. In this test facility, two enormous masses collide in a foundation of solid reinforced concrete that has an inclination of around 4.2°. The impact mass - which weighs 40 tonnes - is hoisted onto a rail system, released and then, due to the inclination, rolls in the direction of the stationary test mass. Shortly before the impact, the brakes of the test mass - on which the test specimen is also located - are released and a controlled impact occurs. The test specimen is subjected to a dynamic, very brief but controlled acceleration, the so-called shock.

Over the years, a hall was added to the HOSPA and the measurement technology was modernised. In the meantime, however, the then new technologies have also become outdated, which is why the system is undergoing a complete refurbishment. The two masses are now brought into position by a carriage system using helical gearing via a gear rack. In addition, the system control, the hydraulics and the measuring and evaluation infrastructure will be modernised. These measures will not only bring the system up to date from a technical point of view, but also in terms of occupational safety. An enclosure with stairs and platform completes the measures to guarantee a modern safety standard.

The renovation work is currently being finalised. The refurbishment will enable Spiez Laboratory to ensure that STS 0055 can meet the ever-increasing demands of the future and also deals with new problems.

A delegation from the Military Commission of the National Council inspects a shock test at HOSPA on 11 August 1983. At that time, HOSPA was still being operated in the open without a cover.



President Pavel writes in the guest book of Spiez Laboratory: ‘What a pleasure to visit such a unique institution, which is very close to my former professional background!’

State visit to Spiez Laboratory

12

The President of the Czech Republic Petr Pavel and his wife Eva Pavlová were received in Switzerland for a state visit on 5 and 6 November 2024. On the first day, the President of the Swiss Federation Viola Amherd and the high-ranking delegation of visitors visited Spiez Laboratory and were informed about the tasks and activities of the Swiss Federal Institute for NBC Protection.

Nick Wagner

On a tour of the laboratory, Dr Marc Cadisch, Director Spiez Laboratory, briefed the guests about the core services provided by Spiez Laboratory and gave them an insight into selected laboratories. The programme included a tour of mobile radioactivity measuring equipment and the chemical and biological safety laboratories.

At the end of his visit to Spiez, President Pavel emphasised his gratitude and recognition of the laboratory's work in the guest book with the words: ‘You are doing a great job here, and I sincerely hope that we will expand our cooperation for the benefit of both nations and our partners.’

Marc Cadisch welcomes the visitors at Spiez Laboratory.

President Viola Amherd and President Petr Pavel inspect the new A-EEVBS mobile measuring device for radioactivity.

Marc Stauffer, Head of the Nuclear Chemistry Department, in conversation with President Pavel.

Isabel Hunger-Glaser, Head of the Biology Department, guides the interested visitors through the corridor of the biological safety laboratory.

President Petr Pavel, Eva Pavola and President Viola Amherd turn their attention to Stefan Mogl, Head of the Chemistry Department.

L.t.r.:

Colonel GS Nicolas Roduit, Commander NBC EOD Centre of Excellence

Urs Bucher, Swiss Ambassador to the Czech Republic

Jolanda Brunner, Mayor of Spiez

Petr Pavel, President of the Czech Republic

Viola Amherd, President of the Swiss Confederation and Head of the DDPS

Eva Pavlová, Wife of President Petr Pavel

Tomáš Jan Podivínský, Czech Ambassador to Switzerland

Michaela Schärer, Director of the FOCP

Marc Cadisch, Director Spiez Laboratory

13 10 Years Spiez CONVERGENCE

In September 2024, Spiez CONVERGENCE celebrated its tenth anniversary with its sixth edition. The conference series was launched in 2014 on the recommendation of the Scientific Advisory Board of the Organisation for the Prohibition of Chemical Weapons (OPCW), given the importance of convergence in chemistry and biology. This created a platform to reflect upon scientific and technological developments from the perspectives of the Chemical and Biological Weapons Conventions.

Sophie Reiners
Stefan Mogl

Participants of the 6th Spiez CONVERGENCE, 2024.

The conference is organised every two years by Spiez Laboratory in collaboration with the Center for Security Studies (CSS) at ETH Zurich. In 2024, 76 invited experts from 13 countries and 4 international organisations took part. In view of the changing security policy situation, it is becoming increasingly important to assess the dual-use potential of the rapidly advancing developments in science and technology. The conference assesses the potential for misuse, as well as analyses how new developments can contribute to protection against chemical and biological weapons. Due to its uniqueness, Spiez CONVERGENCE is becoming increasingly important.

The importance of a continuous consideration of scientific developments

Over the course of its ten-year history, Spiez CONVERGENCE has covered a wide range of new scientific findings and technologies. The choice of topics is always based on an intensive literature research in new scientific publications and a subsequent careful selection by the organising committee. Both new developments and topics that have already been covered in the past are of interest. The following three examples are intended to illustrate the importance of continuous horizon scanning in order to recognise possible effects on arms control at an early stage.

One topic that has been pursued continuously since the beginning of the conference series is editing technologies, especially in the biological field. Although genome editing has been possible for some time, the publication of the CRISPR/Cas9 molecular scissors in 2012 received a lot of attention due to its simplicity. Genome editing technologies were added to a US list of security threat in 2016, which led to additional attention in arms control. Research pro-

Spiez CONVERGENCE

Report on the sixth conference, 29, 30 August and 8–11 September 2024

At a side event of the OPCW Executive Council Meeting in March 2025, Sophie Reiners from CSS at ETH Zurich and Max Brackmann from Spiez Laboratory presented the Spiez CONVERGENCE conference series. The event was chaired by the Swiss Ambassador to the Netherlands, Corinne Cicéron Bühler.

gressed from a basic understanding of the technology to concrete applications in various fields of medicine and natural sciences. At the end of 2023, CRISPR/Cas9 technology was first approved as a genome editing technology for the treatment of the hereditary diseases sickle cell anaemia and beta thalassaemia.

The convergence of biological and chemical sciences with computer sciences, too, was addressed as early as 2014. The focus here was on the design and engineering of biological systems using computer modelling and programming languages. In the years that followed, the integration of digitalisation, automation and artificial intelligence (AI) in chemistry and biology has become increasingly important. These technologies open up new possibilities, for example for exploring the chemical and biological space or for expanding the variety of materials that can be synthesised, tested and optimised. Cloud labs, biofoundries and self-driving laboratories have increasingly emerged in recent years. By integrating AI and robotics, they make it possible to carry out experiments automatically and remotely.

DNA origami, the self-folding of DNA into 3D nanostructures, has been another recurring theme at Spiez CONVERGENCE. It was first discussed in 2016 as emerging basic research, initially focussing on user-defined simple DNA constructs. At that time, it was unclear to what extent the technology could really be relevant for Spiez CONVERGENCE. In 2018, DNA origami moved further into the focus of arms control as applications for the targeted delivery of therapeutic and toxic molecules emerged. Over the years, the field of application has further expanded. The latest developments make it possible, for example, to encode genes in DNA origami.

Topics of Spiez CONVERGENCE 2024

The sixth edition of the conference focussed on the following topics:

Precision editing of molecules in chemistry and biology

Reprogramming the genetic code makes it possible to insert non-natural amino acids into proteins and thus significantly expand the range of possible proteins. Nature uses 20 natural amino acids to synthesise proteins. By changing the system of how cells read genetic information, proteins with desired properties that do not occur in nature can be produced.

Skeletal editing makes it possible to make changes not only to the outer parts of small molecules or polymers, but also to the nucleus or 'skeleton' of a molecule. Properties can be refined by adding or removing atoms from the skeleton.

Epigenetic editing was also discussed. The epigenome consists of chemical changes to DNA and the proteins that bind to it, which regulate gene expression. Epigenetic editing is a technique that makes it possible to change gene expression without modifying the DNA. It therefore offers potential for the treatment of certain diseases.

RNA editing is another editing technique. Enzymes can be used to modify specific nucleosides in double-stranded RNA, which can affect cellular regulatory mechanisms.

Digitalization, automation and artificial intelligence

AI and machine learning (ML) accelerate increasingly the discovery of new chemicals. These tools suggest which chemicals can be produced and how they can be synthesised. Large Language Models (LLMs) are used in drug discovery and in the prediction of reactions and properties. One example is *ChemCrow*, an LLM chemistry agent that is able to plan and control the execution of syntheses.

Self-driving laboratories (SDLs) combine AI tools and robotics to carry out experiments and bioengineering tasks autonomously. This shortens the time it takes to discover potential candidates in drug research, chemical synthesis, materials science or bioengineering. SDLs are also able to optimise proteins autonomously.

Vaccines development is another field of AI application; it is used to fight diseases with pandemic potential. Various AI tools aim to significantly reduce the time it takes to identify a suitable vaccine candidate.

Chemicals Manufacturing

Biocatalysis for the production of complex organic molecules is a recurring theme at Spiez CONVERGENCE. What is new is that, in addition to biocatalysts isolated from nature, researchers can design and develop enzymes with desired properties more quickly, using various bioinformatic tools and new capabilities in protein engineering.

Click chemistry was another topic: a chemical synthesis method in which molecular building blocks are assembled efficiently and quickly. In addition to applications in chemistry, such as polymer synthesis or drug discovery, click chemistry is also used in living systems, for example for the controlled timing of active substances through *in vivo* click release.

Electrosynthesis is becoming increasingly important as a sustainable alternative to traditional chemical synthesis. It enables the synthesis of chemicals through electron transfer.

Therapeutic applications and release of active ingredients

Advances in the field of drug delivery aim to personalise treatments and deliver drugs precisely to target organs. This includes the engineering of bacteria for the targeted delivery of active substances to tumours. Using a system similar to a nanosyringe, the bacteria can inject various proteins into the tumours, which then cause for example cell death.

3D printing is another development of interest; it can produce medicines with personalised doses and designs for individual patients.

DNA origami is a recurring theme (see above). New developments include the formation of DNA origami shells that encapsulate viruses or the possibility of encoding genes in DNA origami.

Threat-agnostic biodefence

Threat-agnostic biodefence is a concept that enables the detection of unknown threats without prior knowledge. In the case of an unknown or emerging pathogen, it offers a robust approach that does not rely on specific lists and sequence data for identification, but on common mechanisms or characteristics of pathogens. Instead of identifying the pathogen, it asks whether and how dangerous it is.

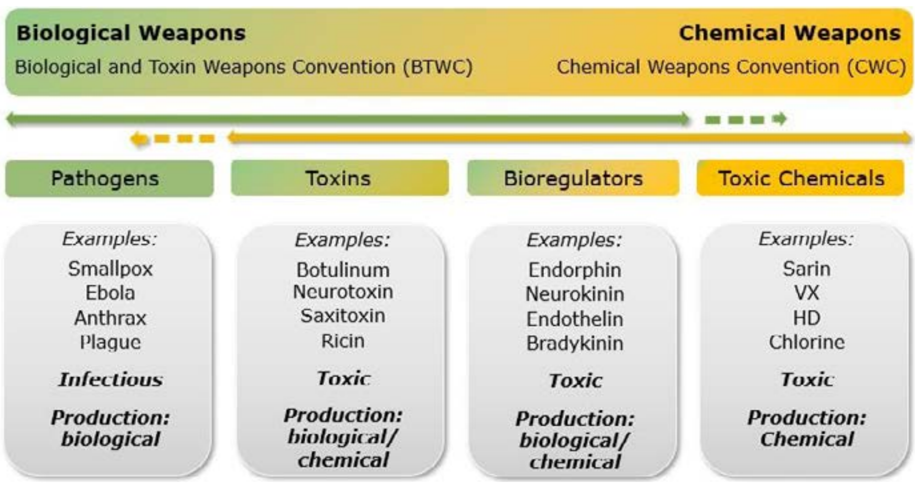
Significance for arms control

In summary, the following statements can be made after the sixth edition of Spiez CONVERGENCE from an arms control perspective:

- AI and machine learning enable efficient and targeted exploration of vast molecular spaces; however, confirmation through a laboratory experiment is still necessary.
- Laboratory experiments are increasingly being carried out automatically.
- Threat-agnostic methods are being developed that focus more on functionality and less on list-based approaches to identify pathogens and toxins.
- Advances in science and technology bring enormous societal benefits and help to improve protections against chemical and biological weapons. Furthermore, these advances offer potential for misuse, but would need to be tested and further developed for such applications; the necessary resources are usually only available to state actors.

Even though there is a lot of talk about the latest developments in science and technology, Spiez CONVERGENCE is not a pure science conference. The participants endeavour to place new scientific developments in the context of the Biological and Chemical Weapons Conventions.

These two corner-stone arms control treaties are based on global norms and values and aim to ensure the abolition of biological and chemical weapons also in the future. The Spiez CONVERGENCE conference series aims to provide a basis for 'informed' policy decisions that take into account the latest developments in science and technology. It thus makes a contribution to Swiss science diplomacy.



Increasing overlap between biology and chemistry

14 Scientific publications 2024

Schütz S, **Brackmann M, Liechti N, Moser M, Wittwer M**, Bruggmann R

Functional characterization of *Francisella tularensis subspecies holarctica* genotypes during tick cell and macrophage infections using a proteogenomic approach

Front. Cell. Infect. Microbiol., 2024, 14:1355113

Picard Antoine, Florent Barbecot, Gérard Bardoux, Pierre Agrinier, Marina Gillon, **José A. Corcho Alvarado**, Vincent Schneider, Jean-François Hélie, Frédérick de Oliveira

The Potential of Isotopic Tracers for Precise and Environmentally Clean Stream Discharge Measurements

Hydrology, 2024, 11(1):1

Wong, E., H. J. Tan, **J. A. Corcho-Alvarado**, E. Loh, J. Ong, C. Y. Ong, D. Toh, **S. Röllin, R. Gosteli, H. Sahli, V. Furrer, S. Kradolfer, J. Ossola, C. von Gunten, M. Stauffer**

Natural and anthropogenic radionuclides in selected environmental radioactivity monitoring sites in Singapore

J. Radioanal Nucl Chem, 2025, 1433-1443

Lin, Mu, Jingjing Wang, Peter Steier, **José Antonio Corcho Alvarado, Stefan Röllin**, Tengxiang Xie, Minhan Dai, Jian Zheng, Jixin Qiao

Pacific Proving Grounds-Derived ^{236}U and ^{233}U: Potential Tracers for Western North Pacific Ocean Dynamics'

Environ. Sci. Technol. 2025, 59, 2, 1399–1410

Isabelle Radgen-Morvant, **Christophe Curty**, Natalie Kummer, Olivier Delémont

Effects of Chemical & Biological Warfare Agent Decontaminants on Trace Survival: Impact on DNA profiling from Blood and Saliva

Forensic Sci. Int., 2024, 112206–11220

Jandrasits Damian, Züst Roland, Siegrist Denise, Engler Olivier B., Weber Benjamin, Schmidt Kristina M., Jonsdottir Hulda R

Third-generation smallpox vaccines induce low-level cross-protecting neutralizing antibodies against Monkeypox virus in laboratory workers

Heliyon 2024, Volume 10, Issue 10, e31490

Stefan Mogl

Investigating Terrorist Chemical Weapons Use: The Experience of the OPCW-UN Joint Investigative Mechanism

CBWNet Working Paper No. 11 Chemical and Biological Terrorism and the Norms of the CBW Prohibition Regimes, 2024

Denzler D, **Seitz A, Brenner L**, Tillenkamp F, **Zahnd A**

Development of an internal shock tube imaging procedure for the analysis of structural behavior of NBC protection components during air blast loading

19. ISIEMS (International Symposium on Interaction of the Effects of Munitions with Structures), 2024

Siegrist, Denise, Hulda R. Jonsdottir, Mendy Bouveret, Bernadett Boda, Samuel Constant, and **Olivier B. Engler**

Multidrug Combinations against SARS-CoV-2 Using GS-441524 or Ivermectin with Molnupiravir and/or Nirmatrelvir in Reconstituted Human Nasal Airway Epithelia

Pharmaceutics, 2024, 16(10):1262

Kälin Dana, Angela Becsek, Helen Stürmer, Claudia Bachofen, **Denise Siegrist, Hulda R. Jonsdottir**, and Angelika Schoster

Immune Response after Vaccination against Tick-Borne Encephalitis Virus (TBEV) in Horses

Vaccines, 2024, 12(9):1074

Wirz C, Althaus R

Challenges and limitations of isotope determination of uranium using high-resolution gamma spectrometry in the BeCamp2 measurement campaign from the perspective of the Swiss team

Conference Paper to the Alva Myrdal Conference, Uppsala, Sweden, June 2024

Klomfass A, **Zahnd A**

CFD Analysis of the blastwave generated in the SHIELD-test

19. ISIEMS (International Symposium on Interaction of the Effects of Munitions with Structures), 2024

Cavelti B, **Zahnd A**

Survivability of people exposed to a large blast in the Swiss modular protective system

19. ISIEMS (International Symposium on Interaction of the Effects of Munitions with Structures), 2024

Schuler D, **Zahnd A**

Load-bearing behavior of anchor systems under shock loading

19. ISIEMS (International Symposium on Interaction of the Effects of Munitions with Structures), 2024

15 Accredited laboratories

Spiez Laboratory operates six testing laboratories accredited by the Swiss Accreditation Service (SAS) in accordance with the EN ISO/IEC 17025 standard.

Nuclear Chemistry Division

STS 0028	Testing laboratory for the determination of radionuclides and elemental analysis

Biology Division

STS 0054	Testing laboratory for the detection of biological agents

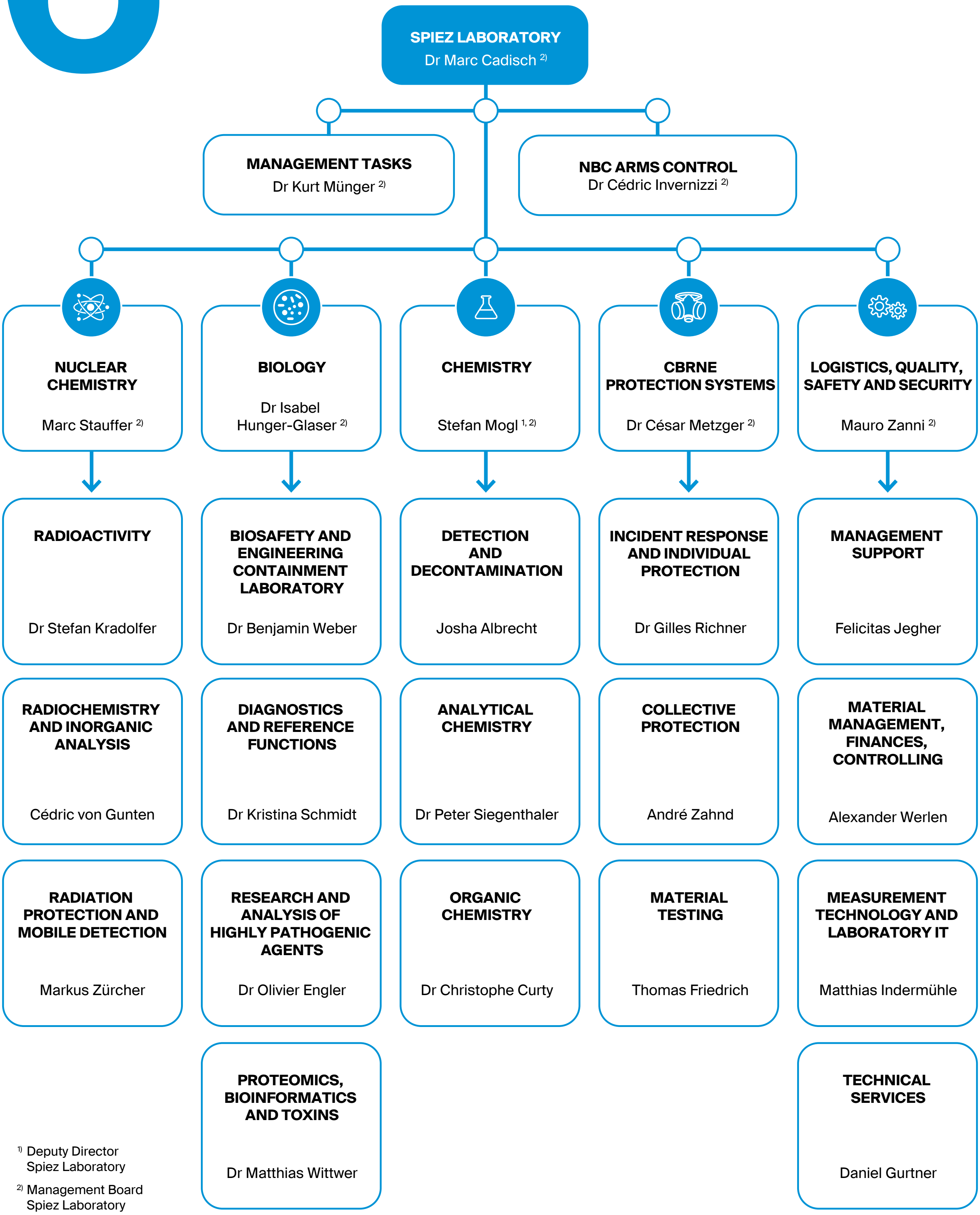
Chemistry Division

STS 0019	Testing laboratory for the analysis of samples for the presence of chemical warfare agents and related compounds

CBRNe Protection Systems

STS 0022	Testing laboratory for adsorbents and breathing apparatus filters
STS 0036	Testing laboratory for Plastics and Rubber, and for the Protection Performance of Polymers, Rubber and Textiles against Chemical Warfare Agents
STS 0055	Testing laboratory for NBC protection material, shelter equipment and shelter installations

16 Organisation chart



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[2] Management Board Spiez Laboratory

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DDPS: pp. 35, 41, 42, 43.
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