Safety Form
Proton Express Science Show

PERFORMING EXPERIMENTS IN EDUCATION CONTEXTS

DESCRIPTION OF THE SCIENCE SHOW

What is happening, what are the different steps?

- **Introduction:** the guide welcomes the audience, informs them of the format of the show (duration – 45 min, language, translation (optional), emergency exits and safety measures) and introduces CERN, fundamental questions and particle physics.
- **Getting the protons:** demonstration with a Wimshurst Machine (one optional participant) and a candle that we can get the protons from plasma with the help of an electrical current.
- **Accelerating the protons:** demonstration with a Van de Graff Generator that we can accelerate charged particles with an electrical current.
- **Circular acceleration:** show how magnets can bend the path of charged particles with a CRT TV and permanent magnets
- **Electromagnets:** demonstrate how electromagnets can be used to create a magnetic field that can be switched on and off (one optional audience participant)
- **Superconductors:** present safety challenges of using cryogenic liquid to cool down the superconductors: liquid nitrogen presentation, fragility: hammering a frozen rubber tube, pressure: pouring liquid nitrogen in a kettle, shrinking metal ring and ball apparatus (ball doesn't fit through the ring after cooling the ring). Finale with the superconducting levitating train.
- Use of a laptop for the presentation

Who is involved in the experiment and what is their status?

Name of person involved	Role
Guide/presenter	Presenting the show and doing the experiments. Guides with medical condition (pregnancy, heart conditions, sensitive medical devices) may not perform the show.
SG Education team on duty (management team)	Presenting the show and doing the experiments - on duty means this person might do the show if there is no guide available. Members of the team with medical conditions (pregnancy, heart conditions, sensitive medical devices) may not perform the show.
Translator (optional)	Translating the show but not participating in any experiments.
Participant (optional)	Volunteer from the audience, selected for specific experiments People with medical conditions (pregnancy, heart conditions, sensitive medical devices) may not volunteer.
Audience	General public (visitors) - seated in the auditorium, not participating in any of the experiments.
Technical team	Responsible for transporting the show equipment between the storage room and the stage, set up the show equipment on the stage table. Trained for transport and refill of liquid nitrogen dewars.

☒ Minors (<18 years), if yes, specify minimum age: recommended minimum age for audience and participants is 8 years old. No strict age limitation.

LIST OF POTENTIALLY HAZARDOUS MATERIALS THAT ARE REQUIRED

For details, please refer to corresponding appendices

☒ Hazardous chemicals – If yes, indicate type and quantity used during the experiment and amount: liquid nitrogen (-196°C, 1 dewar with 11 litres) - *Appendix 7*

☐ Gas – If yes, indicate the type and quantity:

☒ Ignition sources (naked flames, hot surface, sparks, static electricity): lighter, candle, Wimshurst machine (up to 120 kV) -*Appendix 2*, Van der Graaff generator (up to 150 kV) - *Appendix 3*

☐ Pressure equipment (> 0.5 bar)

☐ Vacuum equipment (< -0.5 bar)

☒ Heavy objects – If yes, specify: liquid nitrogen dewar - *Appendix 7*, flightcase with CRT TV - *Appendix 4*, magnetic train track - *Appendix 5*

☐ Unprotected sharp edges – If yes, specify:

☒ Magnetic fields – If yes, indicate the type, field strength, quantity: **neodymium magnets for the CRT TV** experiment (NdFeB, 46x30x10mm, holds approx. 29 kg, neodymium, N40, nickel-plated, remanence Br 12600-12900 G/ 1.26-1.29T) and **magnetic track for the superconducting train** (63 magnets, NdFeB, 46x30x10mm, holds approx. 29 kg, neodymium, N40, nickel-plated, remanence Br 12600-12900 G/ 1.26-1.29T) - *Appendix 5*, **electromagnet** to produce a magnetic field (<15mT) - *Appendix 6*

Note limits for medical implants (<0.4 mT) & exposure for general public and pregnant women (<40 mT)

☒ Hot materials (> 50°C) – If yes, specify: electromagnets get warm during operation - *Appendix 6*, candle - *Appendix 2*

☒ Cold or cryogenic materials (< 0°C) – If yes, specify: Liquid nitrogen (-196°C, dewar with 11 litres) - *Appendix 7*

☒ Electrical equipment – If yes, specify type, voltage, current, exposed live parts: Wimshurst machine (static electricity up to 120 kV) - *Appendix 2*, Van de Graaff generator (static electricity up to 150 kV) - *Appendix 3*, CRT TV (up to 25kV) - *Appendix 4*, Electromagnet (adjustable AC DC voltages max 20V AC, maximum load 6A, and fixed voltage 12V AC, max. Load 1.8 A) - *Appendix 6*

☐ RF, microwaves

☐ IR light – If yes, specify power:

☐ Laser – If yes, specify class, wavelength and power:

☐ UV light – If yes, specify wavelength and power:

☐ Radioactive sources/objects – If yes, specify isotope, radiation type and activity:

☐ X-ray sources – If yes, specify energy and dose rate:

☒ Lithium batteries – If yes, specify: laptop for presentation - *Appendix 8*

☐ Small items that can be swallowed (only relevant if young children are involved)

☐ Other (e.g. mercury lamps, loud noise, dust of combustible solids, heights, other chemicals, …):
superconductor disc (YBCO, Ø 45mm, H 8mm, seeded material, composition: Y1.65Ba2Cu3O7-x – bulk, additional performance: Surface stabilization, the magnetic properties of the HTS elements: levitation: 80 - 90 N at 0.5 mm distance, trapped field: 0.9 - 1.2 T (77K, 1.4 T excitation)) - *Appendix 7c*

IDENTIFICATION AND HANDLING OF THE RISKS

What are the risks for the people involved in the experiment and how they are handled? (prevention measures, PPE, good practices, emergency and first aid instructions, include storage and transport)

(1) General safety information: at the beginning of the show, the guide provides important information regarding emergency exits in the auditorium and outlines the appropriate actions to take in the event of an alarm (with the help of the slide below). Only the selected participant may come to the stage when invited; nobody else from the public is allowed to come on the stage. Individuals who are pregnant, have sensitive medical devices such as a pacemaker, or suffer from heart conditions are asked not to volunteer as the experiments are using static high-voltage equipment. All visitors are kept away from strong magnets (including participants).



For the following experiments – see corresponding appendices

(2) Wimshurst Machine
(3) Van de Graaff Generator
(4) Cathode Ray Tube TV
(5) Magnets
(6) Electromagnets
(7) Liquid Nitrogen,
  a. Rubber tube and hammer experiment
  b. Kettle experiment
  c. Superconductors
(8) Laptop for presentation – Lithium battery

What are the risks for the room/building in which the experiment takes place and how they are handled? (prevention measures, good practices, emergency instructions, include storage and transport)

Fire risks: The experiments take place on two tables in the center of the stage, wrapped on the sides by black cloths. These tables, as well as the black cloths, have passed the fire class M1 test (non-flammable or very low flammability (highly resistant to ignition)).

Fire risks from electrical equipment and open flames are minimized by following the guidelines in the appendices. In the event of a small fire, a CO_2 or dry chemical fire extinguisher is available at the side of the stage for immediate use. For larger fires, the audience must be evacuated through the emergency exits, the alarm activated, and emergency services contacted immediately.

Access to the stage is restricted using red/white barrier tape which informs people that they are not allowed to access the stage area. Between the shows, all hazardous materials are hidden from public view: dewars with liquid nitrogen are stored beneath the demonstration table, and the whole table, including all

equipment, the Wimshurst machine, the Van de Graaff generator and the CRT TV, are covered with M1 black cloth.

Emergency instructions and experiment guidelines have been provided to the guides during their training and are shared with the audience at the beginning of the science show.

Transportation: the transport between the storage rooms and the auditorium is done by the technical team. They have followed the training Cryogenic Safety - Fundamentals (Training rank code: 10170). They also take care of refilling liquid nitrogen dewars when needed.

Appendices

(2) Wimshurst Machine		
Description: Static electricity experiment producing high voltage (up to 120 kV), Max. arc length: 100mm. Dimensions: 450 x 520 x 240mm (W x H x D), Mass: 5100g, Manual motor. This experiment requires the use of a lighter and a candle with a naked flame.		
Only trained guides and an invited audience participant (optional) should operate the Wimshurst machine. They should not wear metallic accessories (watch, jewelry) and should not have any medical conditions (pregnancy, sensitive medical device, heart condition).		
Hazards	**Protective equipment and precaution**	**Emergency action**
Electric shocks The machine generates high-voltage static electricity, which can result in electric shocks. Although the current is low, the high voltage can cause painful shocks (it does not produce thermal burns or damage to cells).	The machine is placed on a **non-conductive surface** to prevent unintended grounding and reduce the risk of electric shocks. Do not touch the high voltage components (or any metal parts) while using the machine, and **discharge** the Wimshurst machine, by connecting the two balls, before touching any metal parts. The machine is clearly **labeled** with a high voltage sign to remind operators to exercise caution. **Give clear instructions** to the (optional) participant: they should only activate the lever by turning it clockwise and must not touch any other part of the machine.	Any electric shock produced by the Wimshurst machine should only be uncomfortable to slightly painful. If someone receives an electric shock, ensure they are not in contact with the machine before touching them to avoid being shocked yourself. If they lose consciousness or show severe symptoms, call emergency services immediately.
Fire risks Sparks produced by the machine can ignite flammable gases or materials in the vicinity. The naked flame can ignite nearby flammable materials	The machine is operated in a dry, well-ventilated environment, away from any flammable or combustible materials (e.g., gases, solvents, paper), or water. The candle is placed on a stable, heat-resistant surface away from flammable materials, and is **extinguished** when the experiment is over.	In case of fire: stop using the machine immediately and use a fire extinguisher (CO_2, dry chemical) to put out the fire, if trained to do so. For larger fires, activate the alarm, evacuate the area and call emergency services.
Burns The flame or hot wax can cause burns if touched or spilled.	Be careful when handling the lighter and the candle. The burning candle is never left unattended. The flame is always **extinguished** when the experiment is over.	If anyone sustains a burn, cool the affected area under cool running water for 10-20 minutes, and seek medical attention for severe burns.

(3) Van de Graff Generator		
Description: Static electricity experiment producing high voltage (up to 150 kV), Short circuit current: approximately 7 µA, Conductor sphere: 22 cm, Manual motor or connected to 230 V		
Only trained guides operate the Van de Graff generator, no public participation. The operator should not wear metallic accessories (watch, jewelry) and should not have any medical conditions (pregnancy, sensitive medical device, heart condition).		
Hazards	**Protective equipment and precaution**	**Emergency action**
Electric shocks generates high-voltage static electricity, which can result in electric shocks. Although the current is low, the high voltage can cause painful shocks.	Ensure that all metal parts of the generator are properly grounded to prevent dangerous shocks. Use the **grounded electrode to discharge** the generator before handling. Do not touch the high voltage components (or any metal parts) while using the machine. Avoid running the generator for extended periods, as this increases the risk of large sparks or overheating. The generator is clearly **labeled** with a high voltage sign to remind operators to exercise caution.	The electric shock produced by the generator should only be uncomfortable to slightly painful. If someone receives an electric shock, ensure they are not in contact with the machine before touching them to avoid being shocked yourself. If they lose consciousness or show severe symptoms (chest pain, difficulty breathing), call emergency services immediately.
Fire risks Sparks produced by the machine can ignite flammable gases or materials in the vicinity.	The generator is operated in a dry, well-ventilated environment, away from any flammable or combustible materials (e.g., gases, solvents, paper) or water.	In case of fire: stop using the generator immediately and use a fire extinguisher (CO_2, dry chemical) to put out the fire, if trained to do so. For larger fires, activate the alarm, evacuate the area and call emergency services. If anyone sustains a burn, cool the affected area under cold running water for 10-20 minutes, and seek medical attention for severe burns.
Physical injuries Moving parts such as the belt inside the generator can trap hair, clothing, or fingers, if they come into contact with exposed mechanisms.	Maintain a **safe distance** from the device while it's running, keep long hair, loose clothing, and accessories away from the generator to avoid getting caught in moving parts.	Seek medical attention for severe injuries.

(4) Cathode Ray Tube TV		
Description: Cathode Ray Tube Television modified to show interior behind see-through cover for explaining particle acceleration and demonstrating the effect of a magnet on the beam of electrons. High voltage (up to 25kV) exposed parts are shielded by plastic cover. Connected to 230V		
Only trained guides operate the TV, no public participation. The operator should not wear metallic accessories, should not have any medical conditions (pregnancy, sensitive medical devices, heart conditions).		
Hazards	**Protective equipment and precaution**	**Emergency action**
Electric shocks CRT TVs can contain voltages up to 25 kV in their flyback transformers and other components.	The TV has a **plastic casing** to prevent the operator from touching any live parts. This casing also protects the CRT TV from dirt and residue that could cause bridging between exposed pins and damage the set. The operator only turns the CRT TV on and off, uses the know at the front to move the magnet at the back, and holds a magnet close to (but not touching) the screen. The TV is **turned off** after the demonstration. The TV is clearly **labelled** with a high voltage sign. The operator should **not wear metallic accessories, should not have any medical conditions** (pregnancy, sensitive medical devices, heart condition).	If someone receives an electric shock from a CRT TV, immediately disconnect the power source if possible. Avoid touching the person if they are still in contact with the TV, to avoid being shocked yourself. Call emergency services if the person is unconscious, has burns, or experiences severe symptoms such as chest pain or difficulty breathing.
Fire risks Sparks produced by the TV can ignite flammable gases or materials in the vicinity.	The TV is operated in a dry, well-ventilated environment, away from any flammable or combustible materials (e.g., gases, solvents, paper) or water.	In case of fire: stop using the TV immediately, disconnect from power supply, and use a fire extinguisher (CO_2, dry chemical) to put out the fire, if trained to do so. For larger fires, activate the alarm, evacuate the area and call emergency services. If anyone sustains a burn, cool the affected area under cold running water for 10-20 minutes, and seek medical attention for severe burns.
Glass implosion The CRT is a vacuum tube, meaning it is under low pressure. If the glass is damaged or broken, it can implode, sending sharp glass shards flying.	The back of the TV is protected by plastic casing. The TV is only used in ambient (room) temperatures. If it is has become very cold, it is given time (up to a couple of days) to warm up inside before being powered on. CRTs generate a lot of heat, and coupling this with very cold glass could potentially cause an area of the glass to expand quicker than the rest and break the tube.	In the event of glass breakage or an implosion, evacuate the area immediately to avoid flying shards. After the area is safe, seek for professional services to clean up any broken glass using gloves and dispose of it properly.
Heavy weight CRT TVs are heavy, leading to a risk of back strain or injury if not lifted properly.	The CRT TV is installed on the top of a flight case with wheels, so it does not need to be lifted / carried / moved (other than when the whole flight case is moved). This is only done by trained technicians.	In case of serious injury, contact the emergency services
Toxic materials The CRT contains potentially hazardous materials and other toxic chemicals that can be harmful if the glass is broken.	The plastic casing protects the operator from any hazardous materials or chemicals.	If toxic phosphor powder or other materials are exposed, wear a mask and avoid inhaling dust. Ventilate the area and seek professional hazardous waste disposal services if needed.

(5) Magnets

Description: magnets are used to show how we can change the path of charged particle, and to demonstrate levitation properties with superconductors.
Neodymium magnets used for the CRT TV experiment: NdFeB, 46x30x10mm, holds approx. 29 kg, neodymium, N40, nickel-plated, remanence Br 12600-12900 G/ 1.26-1.29T, recommended distance for pacemaker *(<0.4mT)*: 18cm - for general public and pregnant women *(<40mT):* 3cm. [1]
Magnetic track used for the superconducting train: 3 lines of 21 magnets, NdFeB, 46x30x10mm, holds approx. 29 kg, neodymium, N40, nickel-plated, remanence Br 12600-12900 G/ 1.26-1.29T. For a single magnet: recommended distance for pacemaker *(<0.4mT)*: 18cm - for general public and pregnant women *(<40mT):* 3cm
When not in use, the neodymium magnet is **stored in labeled wooden boxes and** the magnetic train track **covered by a labeled wooden protection** to prevent pinching, unintended metal attraction, and public contact, ensuring a safe distance is maintained.

Only trained guides use strong magnets, no public participation.
The operator should not wear metallic accessories (watch, jewelry), should not have any medical conditions (pregnancy, sensitive medical device, heart condition).

Hazards	Protective equipment and precaution	Emergency action
Pinching/crushing injuries Strong magnets can snap together with significant force, potentially pinching or crushing skin or fingers if they are powerful enough.	**Handle magnets carefully**. Use both hands to handle large magnets and keep fingers clear of the magnetic surfaces to prevent pinching or crushing injuries.	If a magnet causes a crush or pinch injury, carefully separate the magnets, if possible, to release the affected area. Seek medical attention for severe injuries.
Metal object attraction Magnets can attract nearby metal objects (tools, jewelry, etc.), leading to unexpected impacts, injuries, or damage.	**Keep magnets away from ferrous objects** in the area to prevent accidental attractions and collisions. The operator should **not wear metallic accessories** (watch, jewelry).	If a magnet attracts a nearby metal object and causes an injury, assess the injured area. Seek medical attention for severe injuries.
Damage to electronics Magnets can interfere with or damage electronic devices, including smartphones, computers, medical devices (e.g., pacemakers), and credit cards with magnetic strips.	Maintain a **safe distance (at least 30 cm)** between magnets and sensitive electronics, including computers, phones, credit cards, and medical devices like pacemakers. **Nobody with sensitive medical devices is allowed on stage**.	If it is suspected that a magnet has interfered with a medical device, move away from the magnet immediately and see professional medical help. If the person experiences serious symptoms (e.g., dizziness, shortness of breath), call emergency services.
Magnet fragmentation If large magnets collide or are mishandled, they can chip, crack, or shatter, sending sharp fragments flying.	**Handle magnets carefully**. Dispose of old or damaged magnets properly according to local waste disposal guidelines. If magnets are damaged and fragmented, handle the pieces carefully with **protective gloves** to avoid injury from sharp edges.	If a magnet breaks or shatters, evacuate the area to avoid injury from flying shards. Seek professional services to vacuum the area thoroughly, using caution with magnetic fragments to avoid injury.
Magnetic field hazards Strong magnetic fields can interfere with medical equipment. The limits for medical implants (<0.4 mT) & exposure for general public	As the strength of the magnets are higher than authorized limits for the general public, **no volunteers or other members of the public are allowed to manipulate the magnets. Only the guide can use them, and only if they have no medical conditions** that prevents them from handling magnets (pregnancy, sensitive medical devices, heart condition).	If it is suspected that a magnet has interfered with a pacemaker, defibrillator, or other medical device, move away from the magnet immediately and seek medical advice. If the person experiences symptoms (e.g., dizziness, shortness of breath), call emergency services.

[1] Safety distances have been calculated following the protocol established by our provider supermagnete.ch: https://www.supermagnete.ch/eng/faq/How-do-you-calculate-the-magnetic-flux-density

and pregnant women (<40 mT)	**Only participants without medical conditions are allowed on stage**, and only at the opposite side of the magnets (>2m)	
Heavy weight the magnetic train track is heavy, leading to a risk of back strain or injury if not lifted or handled properly.	The magnetic train track is installed on wheels, and it does not need to be lifted / carried / moved by anybody except the trained technicians.	In case of serious injury, contact the emergency services

(6) Electromagnets		
Description: demonstrate how electromagnets can be used to create a magnetic field that can be switched on and off. **Electromagnet**: constructed of enameled copper wire; approximate resistance 0.5 Ohms wound on the tube, Umax 36V AC, or 60V DC, length 110mm, diameter 30mm, fitted with 4mm sockets, magnetic iron core length 160mm, diameter 15mm. RoHS compliant **Power source:** variable extra-low voltage transformer (adjustable AC DC voltages max 20V AC, maximum load 6A, and fixed voltage 12V AC, max. Load 1.8 A). Connected to 230V. Overload protected with circuit breakers. All outputs galvanically isolated from the mains, floating. Electrical isolation: Isolating transformer in accordance with DIN EN 61558-2-6, (compliant to German RiSU)		
Only trained guides operate the electromagnets. A participant (optional) can touch the electromagnet when switched off. The operator should not wear metallic accessories (watch, jewelry), should not have any medical conditions (pregnancy, sensitive medical device, heart condition).		
Hazards	**Protective equipment and precaution**	**Emergency action**
Short circuit & overheating A short circuit could cause components to overheat, potentially leading to burns, melting wires, or damage to the generator or connected devices. Prolonged use or excessive current can cause the electromagnet's coil to overheat, which could result in burns or start an electrical fire.	The power supply is **protected by a fuse** (T 1.25) and overcurrent circuit breaker for variable outputs, thermomagnetic cutout at 6A. Overcurrent circuit breaker for fixed-voltage output, thermal cutout at 1.8 A (at an ambient temperature of 20 °C) The operator should **check the temperature** of the electromagnet by gently feeling it with the back of their hand before handing it to the participant. The electromagnet is **switched off** once the demonstration is done, before it gets too hot. The electromagnet is operated in a dry, well-ventilated environment, away from any flammable or combustible materials (e.g., gases, solvents, paper) or water.	If the electromagnet overheats and begins to smoke or catch fire, immediately turn off the power supply and disconnect the equipment from the power source. Use a fire extinguisher (CO_2, dry chemical) to put out the fire, if trained to do so. For larger fires, activate the alarm, evacuate the area and call emergency services. If someone receives a burn from overheated components or electrical malfunctions, cool the affected area with cool running water for 10-20 minutes. For severe burns, seek medical attention immediately.
Magnetic field hazards Strong magnetic fields can interfere with medical equipment. The limits for medical implants (<0.4 mT) & exposure for general public and pregnant women (<40 mT)	**Only the guide can operate the electromagnet, and only if they have no sensitive medical conditions** that prevents them from handling magnets (pregnancy, sensitive medical device, heart condition). The guide can then hand over the unplugged electromagnet to the participant (no magnetic field anymore)	If you suspect a magnet has interfered with a pacemaker, defibrillator, or other medical device, move away from the magnet immediately and seek medical advice. If the person experiences severe symptoms, call emergency services.

(7) Liquid Nitrogen		
Description: Non-flammable, non-toxic, colorless, odorless, LN2 cryogenic liquid (77K = -196°C) Quantity: 11L dewar, guides handle small quantities up to 2 liters from a smaller dewar.		
Only trained guides can handle liquid nitrogen, no public participation. The operator should wear closed shoes and long trousers, and not wear any jewelry or metallic accessories on their hands and forearms, and should wear the appropriate PPE (goggles, gloves when handling larger quantities)		
Hazards	**Protective equipment and precaution**	**Emergency action**
Cryogenic burns and frostbite Direct contact with liquid nitrogen or surfaces cooled by it can cause severe cold burns, as it rapidly freezes living tissue. Eye injuries: Splashing or vapor from liquid nitrogen can cause serious damage to the eyes, leading to frostbite or even blindness if not immediately treated. Cold gas is invisible but produces cold mist in contact with ambient air.	**Personal protective equipment (PPE):** Always wear appropriate PPE -**Cryogenic gloves** (when pouring liquid nitrogen from the 11L dewar to the 2L dewar) -**Safety goggles** (all the time) -**Closed-toe shoes and long trousers**. In case the presenter exceptionally forgets long trousers, the cryo-apron can be used to provide protection. This does not cover the feet, so closed shoes are still required. All **jewelry and metallic accessories** on hands and forearms (rings, watches…) must be removed. Lanyards / long chains should also be removed prior to using liquid nitrogen. Never allow liquid nitrogen or cold gas to come into contact with skin and eyes. **Be cautious of condensation** on containers, which may appear harmless but could cause burns. **Avoid inhalation** of vapor or mist.	In case of spillage of larger quantities (> 5L): evacuate all persons from the immediate danger area and call the fire brigade if necessary. Ventilate the area. In case of cold burns (skin or eyes): immediately seek a tap with tepid water. Keep rinsing the affected part with tepid water for minimum 15 minutes and call emergency services.
Asphyxiation In an enclosed space, liquid nitrogen can displace oxygen as it evaporates into nitrogen gas, leading to an oxygen-deficient atmosphere and the risk of asphyxiation.	Science show area and gas storage room are well-ventilated areas to avoid the build-up of nitrogen gas. The gas storage room is clearly labeled with Oxygen deficiency signs and cryogenic product signs. Excess liquid nitrogen is disposed of by allowing it to evaporate in a well-ventilated area. Liquid nitrogen dewars can be transported in goods elevators BUT no person is allowed to use the elevator at the same time.	If exposed to low oxygen concentration: move the affected person into fresh air; if not breathing, give artificial respiration. Call the emergency services.
Explosions from trapped liquid If liquid nitrogen is trapped in a sealed or poorly vented container, it can rapidly expand as it vaporizes, potentially causing the container to explode.	Liquid nitrogen is stored in clearly labeled containers designed for cryogenic liquids (dewar flasks), that can handle extreme cold and that allow for the safe release of pressure.	If you suspect a container may be over-pressurized (e.g., swelling or making an unusual noise), evacuate the area immediately and avoid approaching the container until it has been safely vented or handled by professionals.
Heavy weight A full Nitrogen dewar is heavy, leading to a risk of back strain or injury if not lifted properly.	Transportation is only done by the trained technical team. When liquid nitrogen is transported, approved containers are used, which include safety vents, and they are secured properly to prevent tipping or spilling. When pouring liquid nitrogen from the 11L dewar to the 2L dewar, handle the dewar carefully, don't allow it / cause it to fall.	In case of serious injury, contact the emergency services

(7a) Rubber tube and hammer experiment		
In addition to liquid nitrogen hazard specified in (7)		
Description: hammering a rubber tube that has been dipped into liquid nitrogen (the tube is therefore rigid and brittle, and shatters when hammered)		
Only trained guides can handle liquid nitrogen, no public participation. The operator should wear closed shoes and long trousers, should not wear any jewelry or metallic accessories on their hands and forearms, and should wear the appropriate PPE.		
Hazards	**Protective equipment and precaution**	**Emergency action**
Fountain effect	Make sure there is a **knot** at the end of the rubber tube and dip the other end into the liquid nitrogen.	In case of cold burns (skin or eyes): immediately seek a tap with tepid water. Keep rinsing the affected part with tepid water for minimum 15 minutes and call the emergency services.
Projectiles When shattering the rubber tube, pieces (projectiles) scatter in all directions.	Wear **safety goggles** to protect eyes from potential shards of rubber tube. Hit the tube **gently**, to avoid the shards from flying too far off the table.	In case of serious injury, call the emergency services.

(7b) Kettle experiment		
In addition to liquid nitrogen hazard specified in (7)		
Description: putting liquid nitrogen into a kettle to demonstrate pressure		
Only trained guides can handle liquid nitrogen, no public participation. The operator should wear closed shoes and long trousers, should not wear any jewelry or metallic accessories on their hands and forearms, and should wear the appropriate PPE.		
Hazards	**Protective equipment and precaution**	**Emergency action**
Cryogenic burns The pressure builds up quickly in the kettle, and the gas can produce mist in contact with ambient air.	Do not fill the kettle completely with liquid nitrogen (maximum half full, but less is recommended). Be careful **not to touch the metal** parts of the kettle as they can get very cold - use the handle. **Don't put your face** directly in front of the kettle as the mist created is very cold.	In case of cold burns (skin or eyes): immediately seek a tap with tepid water. Keep rinsing the affected area with tepid water for a minimum of 15 minutes and call emergency services immediately.

(7c) Superconductors		
In addition to liquid nitrogen hazard specified in (7)		
Description: ceramic superconductor material – YBCO (Yttrium barium copper oxide). This is a high-temperature superconductor, that becomes superconducting below the boiling point of liquid nitrogen (at about 90K; -180°C). **YBCO disc used inside the plastic train**: Ø 45mm, H 8mm, seeded material, composition: Y1.65Ba2Cu3O7-x – bulk, additional performance: Surface stabilization, the magnetic properties of the HTS elements: levitation: 80 - 90 N at 0.5 mm distance (77K, 0.4 T PM, standard magnet in Germany), trapped field: 0.9 - 1.2 T (77K, 1.4 T excitation)		
Only trained guides can handle liquid nitrogen, no public participation. The operator should wear closed shoes and long trousers, and should not wear any jewelry or metallic accessories on their hands and forearms, and should wear the appropriate PPE.		
Hazards	**Protective equipment and precaution**	**Emergency action**
Material brittleness Superconductors (especially high-temperature superconductors) are often brittle and can crack or shatter when handled improperly. Humidity can increase brittleness of superconductors	**Be careful when handling** the superconducting train; do not let the train fall as this could break the YBCO ceramic and cause pieces to be exposed. The superconducting train is stored in a dry environment.	If the ceramic falls and breaks, use gloves to pick up the pieces. Ensure that all pieces are removed from the area and wash hands with soap and water. Dispose of YBCO in accordance with local and national regulations. This should be done by a trained professional.
Toxic materials While YBCO in form of a pellet is not considered a hazardous chemical, powders are considered toxic if ingested and might cause skin, eyes or respiratory system irritations.	YBCO is secured within a plastic train structure and **should not be touched directly.** If handling of the superconductor is needed, use the **gloves** provided in the flightcase. If the YBCO breaks and powder is released, make sure nobody inhales or touches the powder and ensure safe distance.	Wash hands thoroughly with soap and water if there is any direct contact with the YBCO material. Call emergency service in addition to the action below if YBCO enters the eyes, is ingested or inhaled: Eyes: rinse several minutes, remove contact lenses if present and easy to do so. Inhalation: remove the affected person to fresh air and keep at rest Ingestion: rinse mouth with water

(8) Laptop for presentation		
Description: a laptop with lithium battery is used for the presentation of the show		
Only trained guides operate the computer, no public participation.		
Hazards	**Protective equipment and precaution**	**Emergency action**
Electric shocks A damaged charger or power supply could expose live electrical components.	Regularly inspect the charger and cables for damage. The laptop and all power cords and accessories are secured and kept away from water/liquid nitrogen	If someone receives an electric shock, immediately disconnect the power source if possible. Avoid touching the person, to avoid being shocked yourself. Call emergency services if the person is unconscious, has burns, or experiences severe symptoms such as chest pain or difficulty breathing.
Overheating Prolonged use or exposure to heat may cause the laptop to overheat, potentially leading to battery failure or even fire.	The laptop is kept on a flat, hard surface for proper ventilation. The laptop is not used near hot sources. Avoid leaving the laptop on charge when not used.	If the laptop becomes too hot to touch, turn it off immediately, unplug it, and allow it to cool down. Do not use it until it has been inspected for damage. In case of fire: stop using the laptop immediately and use a fire extinguisher (CO_2, dry chemical) to put out the fire, if trained to do so. For larger fires, activate the alarm, evacuate the area and call emergency services.
Battery leakage or swelling Physical damage or manufacturing defects in lithium-ion batteries can cause swelling, leakage of harmful chemicals, or even explosions in rare cases.	Regularly ensure the laptop is in good working condition, paying close attention to the battery.	In the event of battery leakage, avoid touching the leaking substance. Ventilate the area and use gloves if cleanup is needed. Dispose of the battery following hazardous waste guidelines.