Safety Form
Journey through a Detector 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 and particle detectors.
- **Body detectors:** presentation of our body's detectors, and how we can detect the invisible air with a Vortex cannon (one participant). Explanation of the limitation of our eyes as detectors with the help of changes of colored lights (red/blue) in the auditorium (or on slides).
- **The tracker**: presentation of the first layer of the CMS detector using a standard remote control to show that cameras can detect IR light, displays of a silicon detector prototype, and a pixel detector with weakly radioactive rock to show particle tracks.
- **Calorimeters**: comparison between two blocks: a plastic scintillator and an ordinary see-through plastic block by shining light with a RGB light and a UV light (one participant), display of a scintillator prototype. Demonstration of the photomultiplier effect with dominoes (one optional participant)
- **Muon system**: show a drift tube of a muon chamber prototype, experiment with the Geiger-Müller counter using different substances (one participant) to show detection of radiation coming from everyday objects.
- **Magnets**: Demonstration of how we bend the path of a charged particle with CRT TV and magnets
- A laptop is used 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 conditions (pregnancy, heart conditions, sensitive medical devices) may not use the CRT TV with the magnets.
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 use the CRT TV with the magnets.
Translator (optional)	Translating the show but not participating in any experiments.
Participant (optional)	Volunteer from the audience, selected for specific experiments.
Audience	General public (visitors) - seated in the auditorium, not participating in any of the experiments.
Technical team	Responsible for transporting show equipment between the storage room and the stage and set up the show equipment on the stage table.

☒ Minors (<18 years), if yes, specify minimum age: recommended minimum age for audience and participants is 12 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:
☐ Gas – If yes, indicate the type and quantity:
☐ Ignition sources (naked flames, hot surface, sparks, static electricity):
☐ Pressure equipment (> 0.5 bar)
☐ Vacuum equipment (< -0.5 bar)
☒ Heavy objects – If yes, specify: flightcase with CRT TV - *Appendix 7*
☐ 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) - *Appendix 8*
Note limits for medical implants (<0.4 mT) & exposure for general public and pregnant women (<40 mT)
☐ Hot materials (> 50°C) – If yes, specify:
☐ Cold or cryogenic materials (< 0°C) – If yes, specify:
☒ Electrical equipment – If yes, specify type, voltage, current, exposed live parts: CRT TV (up to 25kV) - *Appendix 7*
☐ RF, microwaves
☒ IR light – If yes, specify power: standard remote control with IR LED (<1mW)
☐ Laser – If yes, specify class, wavelength and power:
☒ UV light – If yes, specify wavelength and power: UV-LED (1W, powered by 2 x CR123A battery, wavelength ranges from 390 nm to 395 nm. Class 1M LED product according to IEC 60825-1) - *Appendix 5*
☒ Radioactive sources/objects – If yes, specify isotope, radiation type and activity: slightly radioactive everyday objects (none of them needed registration as radioactive sources at CERN) for Geiger counter experiment and pixel detector - *Appendix 4*
☐ X-ray sources – If yes, specify energy and dose rate:
☒ Lithium batteries – If yes, specify: laptop for presentation - *Appendix 9*
☐ 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, …): Vortex canon - *Appendix 2*, red/blue light switch - *Appendix* 3, lead scintillator prototype - *Appendix* 6

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.



For the following experiments – see corresponding appendices

(2) Vortex cannon
(3) Red/blue light switch
(4) Slightly radioactive materials
(5) UV light
(6) Lead scintillator prototype
(7) Cathode Ray Tube TV
(8) Magnets
(9) 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 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, the table, including all equipment, and the CRT TV, are covered with a 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 room and the auditorium is done by the technical team.

Appendices

(2) Vortex Canon		
Description: The guide uses the vortex cannon to demonstrate airflow by directing it at a selected participant. By striking the flexible membrane of the cannon, the guide generates a quick burst of air that exits through a circular opening, forming a toroidal vortex. This invisible air vortex travels through the air and moves the participant's hair.		
The participant must wear the safety goggles		
Hazards	**Protective equipment and precaution**	**Emergency action**
Air pressure and impact The concentrated air blast could cause discomfort if directed at sensitive areas at close range.	The operator must give **safety goggles** to the participant to protect their eyes. Maintain **safe distance** between the cannon and the participant (about 1m) Brief the participant beforehand on what to expect.	Reassure the participant and check for any visible irritation or discomfort.
Obstruction inside the cannon If there are objects or debris inside the cannon, they could become projectiles.	Inspect the vortex cannon for debris or foreign objects inside the chamber. The safety goggles also protect from dust or debris.	Apply first aid if necessary, such as flushing the eye with water if dust is involved. In case of serious injury, contact the emergency services.

(3) Red/Blue light switch		
Description: Explanation of the limitation of our eyes as detectors with the help of changes of colored lights (red/blue) in the auditorium and/or on slides.		
Hazards	**Protective equipment and precaution**	**Emergency action**
Photosensitive epilepsy triggers Rapid color changes could trigger seizures in individuals with photosensitive epilepsy	The color changes occur gradually, avoiding rapid flashing—particularly within the 5–60 Hz range—that could trigger seizures. The maximum transition frequency is approximately 4 Hz. Strobe function of the lights is deactivated; changes are controlled manually or through slide animations.	If a seizure occurs, immediately stop the light effects and turn on steady, dim lighting. Assist the affected person by ensuring they are safe from injury (e.g., lying on their side) and seek medical assistance if the seizure lasts more than 5 minutes or if it's their first seizure.

(4) Slightly radioactive materials		
Description: participants take measurements with a Geiger counter of cosmic radiation and of some slightly radioactive everyday objects (potassium salt) and non-radioactive substances (salt, sugar, chocolate colored powder, turmeric and graphite). Use of a weakly radioactive rock whose activity is just above background radiation, for the demonstration of the pixel detector (no participant, sealed in plastic case, activity below 1 Bq/g, weight 5g)		
Only the guide handles the rock (in its plastic box). No direct contact with any of the materials.		
Hazards	**Protective equipment and precaution**	**Emergency action**
Radioactive materials slightly radioactive materials emit ionising radiation, though at low levels. Extended or close exposure to these materials could pose a minimal radiation risk if not handled properly.	Only materials with activities **below the Swiss clearance limit** are used. There is **no direct contact** with any radioactive materials, the participant only holds the Geiger counter device above the different substances (contained in petri dishes), without touching the substances, and just for a short amount of time. Only the guide handles the rock, which is always sealed in its plastic box. **Reassure** the audience by explaining the low level of risk involved with the demonstration materials.	If there is direct contact with radioactive materials, wash the affected area with soap and water thoroughly. If there is prolonged skin contact or suspected contamination, seek medical advice and inform the radiation protection service.

(5) UV Light		
Description: The guide and one selected participant use an RGB flashlight and a UV light to demonstrate the role of scintillators (by shining the lights on plastic and scintillator blocks). **UV light:** 1W UV-LED, powered by 2 x CR123A battery, wavelength ranges from 390 nm to 395 nm. Class 1M LED product according to IEC 60825-1. **UV-blocking safety goggles:** uvex i-vo UV blocking until 400nm, lens material - PC, 3 mm thick, IR/UV filter with full color recognition. Lens coating: infadur plus, Optical class 1, Shock resistance to low energy impacts: F (45 m/s), Fog-free: N, Resistance to high-velocity particles: T, Surface resistance: K. Standards: En166 1FT KN CE, EN169		
Both the guide and the participant wear UV-blocking safety goggles		
Hazards	**Protective equipment and precaution**	**Emergency action**
UV Light Exposure prolonged exposure to UV light can harm the eyes and the skin, potentially causing irritation or damage to the cornea	The operator must give **UV-blocking safety goggles** to the participant to protect their eyes when handling the UV light. The guide also wears UV-blocking safety goggles to protect their own eyes. Do not chose a young child (< approx. 12 years) as a participant, to ensure that the participant can follow the safety rules correctly: **inform** participants about the purpose of the demonstration and the need to avoid direct exposure to the UV flashlight; instruct them to always keep the flashlight pointing downwards and never to shine the torch towards anyone's eyes. **Limit the duration** of UV exposure to minimize risks (switch off after the demonstration).	If there is eye exposure to UV light, advise the individual to avoid rubbing their eyes. Seek medical attention if symptoms such as pain, redness, or vision changes occur.

(6) Lead scintillator prototype		
Description: The guide shows a lead scintillator, like those used in our detectors. The guide can give the closed case containing the scintillator to participants to notice the weight of the scintillator.		
Only the guide can open the case to show the scintillator, without touching the scintillator		
Hazards	**Protective equipment and precaution**	**Emergency action**
Lead Toxicity Prolonged contact with lead surfaces may transfer contamination to the skin.	Neither the guide nor participants should handle the lead scintillator directly. The scintillator should aways stay in its case. The case should be handled with care to prevent it from falling and damaging the scintillator inside. The case is clearly labeled with the sigh "**Do Not Touch**"	Skin Contact: Wash the affected area with soap and water. Ingestion: Seek medical attention promptly if lead particles, dust or residue are accidentally ingested. Inhalation: Move to fresh air and seek medical advice if symptoms such as coughing or difficulty breathing occur.

(7) Cathode Ray Tube TV		
Description: Cathode Ray Tube Television modified to show the interior behind a 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 a 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 condition).		
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 the 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. After the area is safe, seek 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 TV 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.

(8) Magnets		
Description: magnets are used to show how we can change the path of charged particle **Neodymium magnet** 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 *(<0.4 mT)*: 18cm - for general public and pregnant women *(<40 mT)*: 3cm.[1] When not in use, the neodymium magnet is **stored in labelled wooden boxes** to prevent pinching, unintended metal attraction, and public contact, ensuring a safe distance is maintained.		
Only trained guides use the magnets, no public participation. The operator should not wear metallic accessories, 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, jewellery, etc.), leading to unexpected impacts, injuries, or damage.	**Keep magnets away from ferrous objects** (iron, steel) in the area to prevent accidental attraction and collisions. The operator should **not wear metallic accessories** (watch, jewellery).	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** between magnets and sensitive electronics, including computers, phones, credit cards, and medical devices like pacemakers. The operator may **not have any sensitive medical device.**	If it is suspected that a magnet has interfered with a medical device, move the affected person away from the magnet immediately and see professional medical help. If the person experiences serious symptoms, 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 and pregnant women (<40 mT)	As the strength of the magnets are higher than authorized limits for the general public and pregnant women, **no volunteers or other members of the public are allowed to manipulate the magnets.** Only the guide can handle them, and only if they have **no medical conditions** that prevents them from handling magnets (pregnancy, sensitive medical device, heart condition).	If it is suspected that a magnet has interfered with a pacemaker, defibrillator, or other medical device, move the affected person away from the magnet immediately and seek medical advice. If the person experiences symptoms, call the 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

(9) 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	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.