

# AWAKE: Operational Safety in a Proton Driven Plasma Wakefield Facility

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## Abstract

AWAKE is installed in the underground former “CERN Neutrino to Gran Sasso” facility. Making the CNGS area compatible with the operation of a proton driven plasma wakefield experiment is challenging and costly. The high energy of the drive beam (400GeV/c) causes radiation safety issues, but also fire safety, evacuation routes and integration of emergency equipment needed reassessment. Specifics of AWAKE cause additional safety issues, including the underground use of oil and Rubidium, and the running of electron source and laser during general installation periods. This poster shows how chemical, fire, evacuation, laser and radiation safety issues were addressed and implemented, leading to a successful start-up of AWAKE's protons-plus-laser operation in December 2016 and the preparation towards operating AWAKE safely with protons, laser and electrons from 2018 on.



## Fire & Evacuation

Fire & evacuation are AWAKE's major safety issues. Evacuating AWAKE is a 1km uphill walk, followed by a 60m upstairs climb.

### Reduce fire risk

- Minimal fuel load, e.g. nonburnable plasma cell heating fluid
- Regular removal of left-over burnable material

### Simplify evacuation

- Obligatory AWAKE safety course (incl. emergency evacuation)
- Clear on-site evacuation lights and signs
- Regular evacuation exercises

### Help fire detection and firefighting

- Extended smoke detection & fire water system
- Eight new fire compartments with smoke extraction
- Regular fire brigade visits and evacuation drills



## Ionising Radiation

AWAKE's radiation risk means there is no tunnel access when the proton beam is ON. The access system is interlocked with the proton beam and an additional radiation-veto limits access to the higher dose rate areas until a radiation survey shows dose values have dropped. Shielding is present to minimise the dose rate during access, e.g. towards the high dose rate CNGS area, around the electron source and towards the diagnostics room. Equipment design and material choice minimises the remnant dose rate. Dose rate and air monitoring allow remote assessment of the radiological situation after beam. Radioactive waste is sorted and treated according to CERN rules.



## Electron Source & Klystron

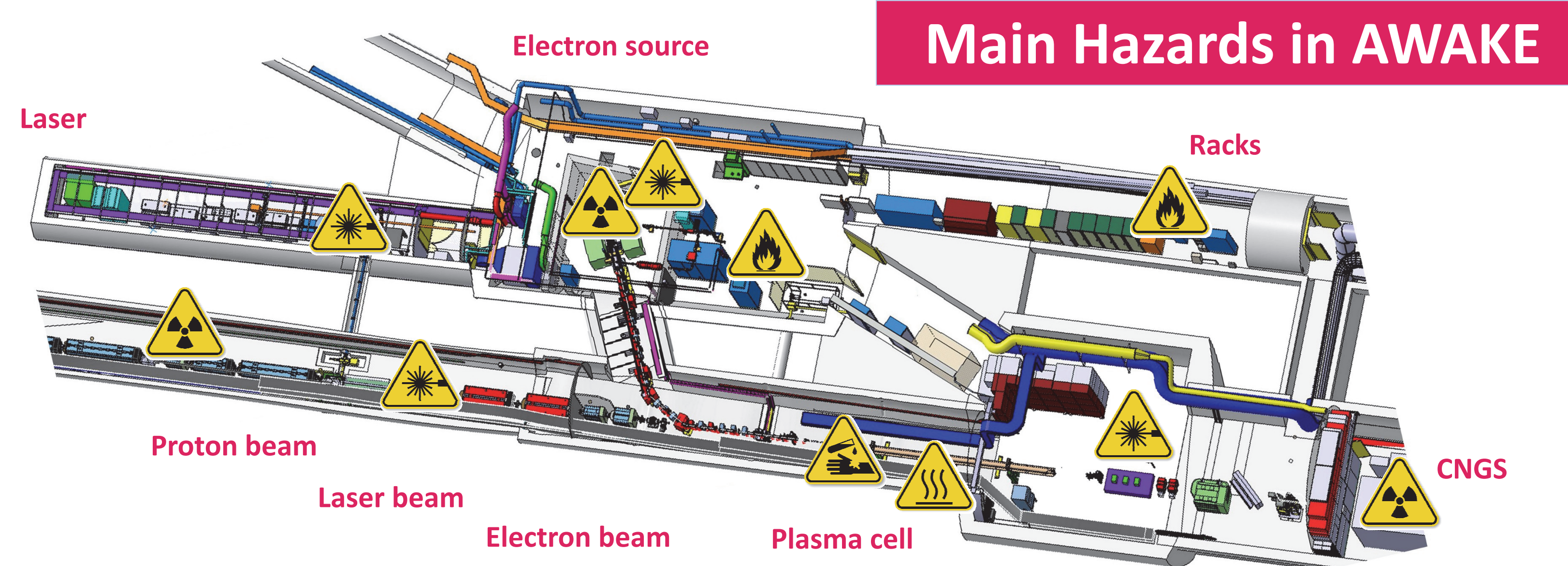
The AWAKE electron source uses a UV-laser and produces X-rays when in operation. The klystron's high voltage components are installed in a mineral oil bath to avoid dielectric breakdown (700l, flashpoint 140C).

### Protect from X-rays and laser from electron source

- Shielding encloses electron source, allowing access to surrounding area when source is on
- Interlock switches off electron source and laser when shielded door to enclosure is opened

### Reduce fire risk from klystron insulating oil

- Temperature measurement is interlocked with klystron power and switches system off when  $T > 50C$ .
- Heat resistant oil retainer



## Plasma Cell & Rubidium

The plasma consists of ionised Rubidium, a highly reactive and slightly radioactive element, at 200C.

### Reduce risks and protect from Rubidium

- Argon flushes system in case of breach of containment
- Valves separate Rubidium reservoirs from plasma cell
- Special fire extinguisher (type D) and sand nearby
- Activities near plasma cell restricted when under vapour (separation valves opened)
- Handling of Rubidium in dedicated lab outside of tunnel with glovebox

### Protect from heating fluid at 200C

- Permanent Plexiglas protection and warning signs
- Activities near plasma cell restricted when warm



## Access Control, PPE (\*) & Dosimeter

### Access control

- Key access with turnstile
- Patrols before beam
- Checks whether valid safety course & activity

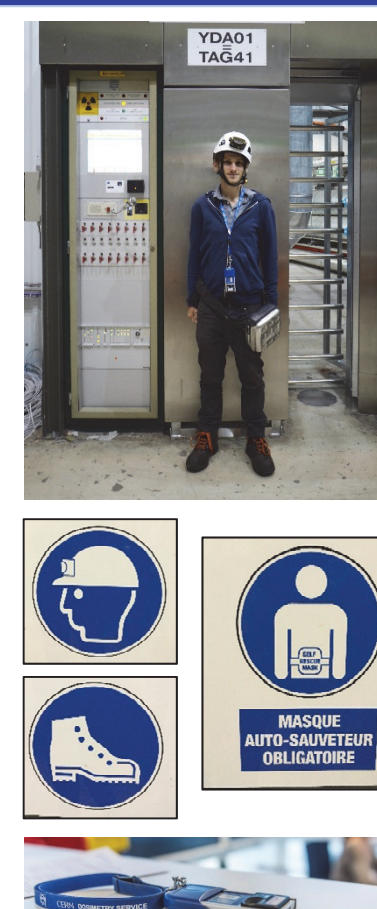
### PPE - obligatory

- Hard hat with light
- Breathing apparatus
- Safety shoes

### Dosimeter - obligatory

- Personal dosimeter

(\*) Personal Protection Equipment



## Laser



The AWAKE laser is housed in a Class 4 laser room. Shutters block the laser at different points along the line, allowing access to other areas.

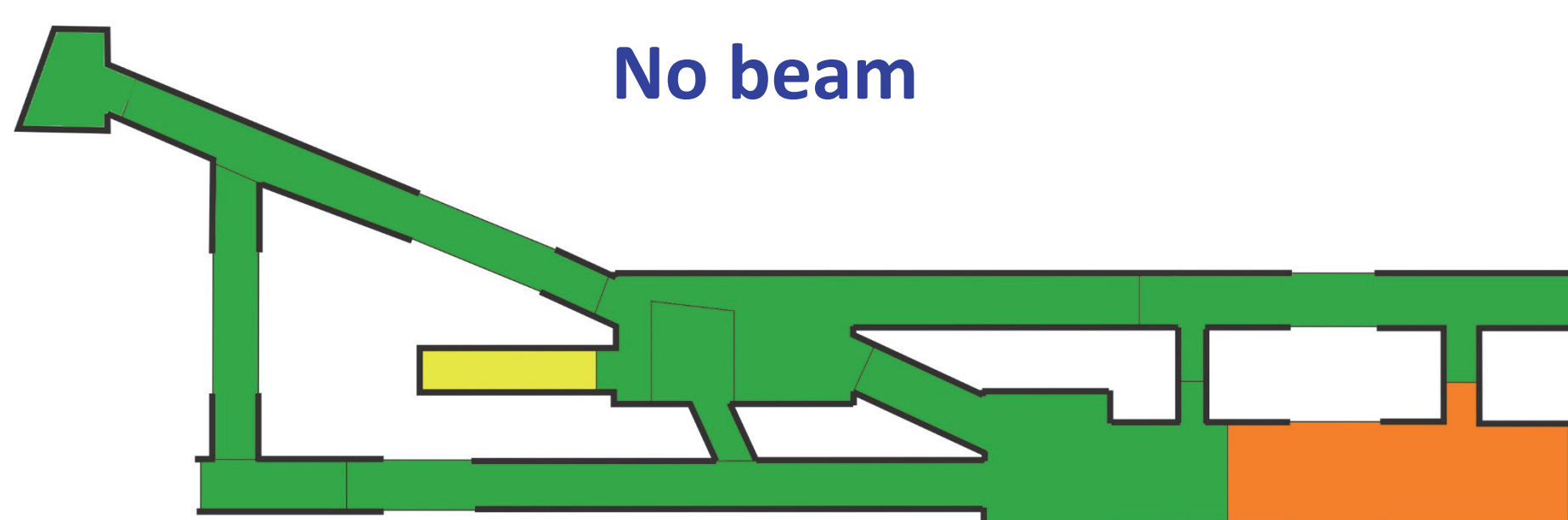
### Protect from laser inside laser room

- Interlock switches off laser when door to laser room is opened without using expert-only code
- Warning signs and protective laser goggles

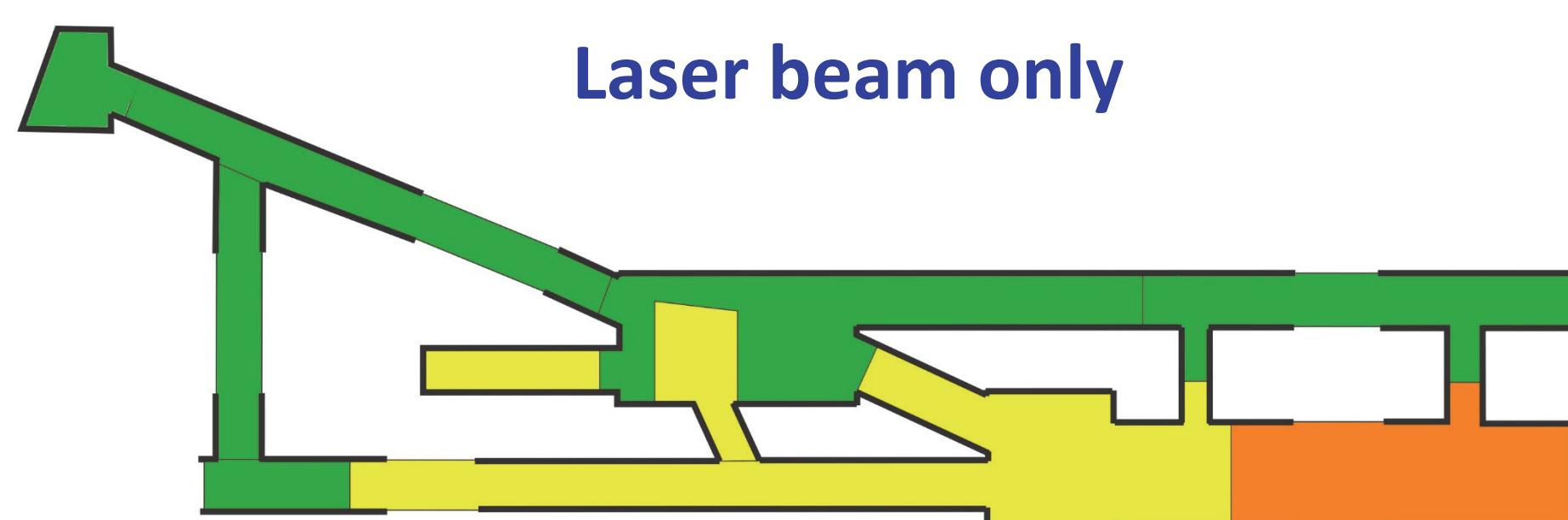
### Protect from laser outside laser room

- Access system and laser doors keep extent of laser area to minimum
- Interlock switches off laser when laser room door is opened without expert-only key

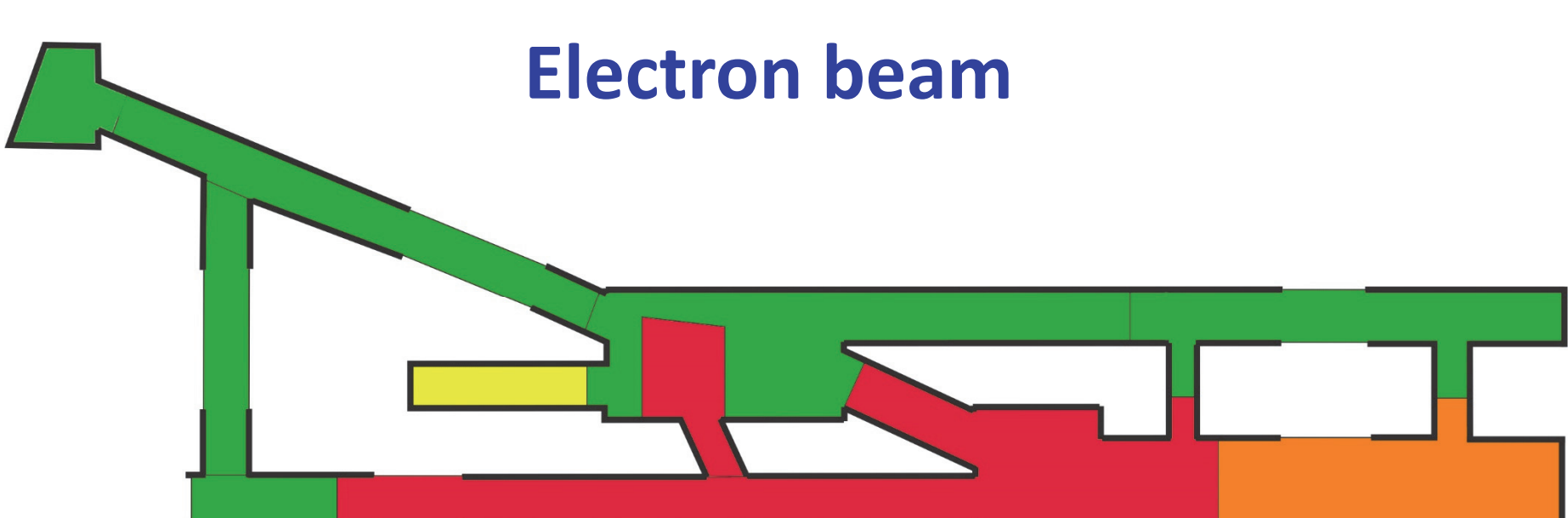
### No beam



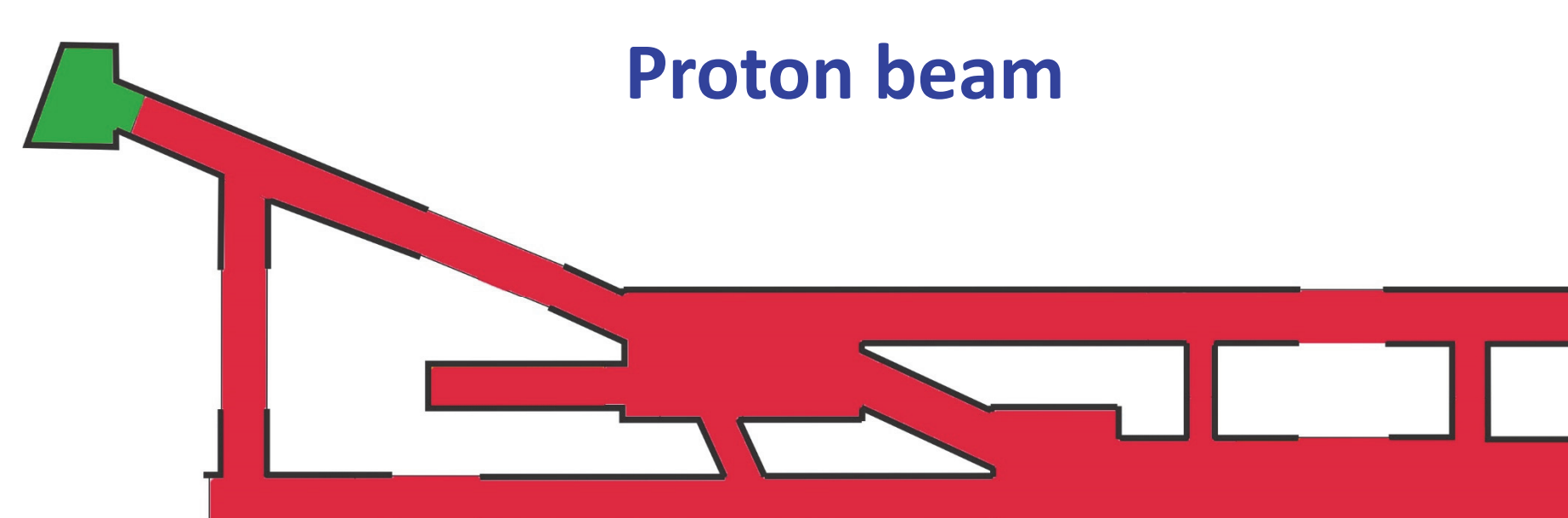
### Laser beam only



### Electron beam



### Proton beam



## AWAKE Access Conditions

AWAKE 's access system, combined with permanent radiation shielding ensures a maximum extent of accessible areas during each AWAKE operation phase. Access doors are interlocked with proton, laser and electron beam safety elements. If a door into a forbidden or limited access area is forced, the interlocks ensure that the beam is interrupted, creating safe access conditions.



- Free access for radiation workers
- Access only for laser experts
- Emergency evacuation passage
- Access forbidden