innovative training and education for large laser infrastructures

Co-funded by the Erasmus+ Programme of the European Union

Course:

"Radiation Safety of Particle Accelerators and High Power Laser Facilities"

1. The aim of the course

Training Course on "Radiation Safety of Particle Accelerators and High Power Laser Facilities" is developed in the frame of IT-ELLI Project "Innovative Training and Education for Large Laser Infrastructures" within the Erasmus+ Program. Its target group is the facility staff of Large Laser Infrastructures. The course would be held mainly in the form of lectures in interaction with trainees, complemented with facility visits and hands-on sessions using specific equipment.

The facility staff will need to be provided with the appropriate information, instruction and training on several fields of protection and safety including radiation safety. These persons will be employed in wide range of jobs and responsibilities. Some of them are potentially exposed to ionizing radiation at high levels, other may occasionally be exposed to low levels of radiation and other persons may not be occupationally exposed but their work may have an impact on the levels of exposure of other workers or members of the public. Trainings should be carefully designed to ensure that the participants have a clear understanding of the specific hazards and risks associated with nuclear and radiation safety in specific installations. Furthermore, a regular schedule of training is necessary to ensure that competence is maintained or enhanced.

By completing the course trainees will not only be eligible to work with radioactive materials, ionizing radiation-producing equipment or manage nuclear activities but also could be eligible to work as radiation protection officers (RPO) of the high energy laser facility or as radiation protection experts (RPE) participating in the design, operation and implementation of such facilities. (For the detailed definition of RPEs and RPOs see articles 82 – 84 of European Council Directive 2013/59/EURATOM.)

2. The course structure

2.1 Ionizing radiation – basics (3 h)

1.1. Introduction.
1.2. Fundamentals of nuclear physics in relation to radiation protection.
1.3 Ionizing radiation sources: types and basic characteristics (including laser generated)

1.4 Interaction of radiation with matter

Learning Objectives: To gain a basic knowledge of nuclear physics and understand the mechanisms of laser-matter interaction.

Topics:

- Atomic Structure
- Radioactivity
- Radionuclides
- Half life
- Nuclear reactions and induced radioactivity
- Ionizing radiation. Classification
- Types and basic characteristics of ionizing radiation sources (including laser generated)
- Interaction of radiation with matter
- Photoelectric effect
- Compton scattering
- Pair production
- Muon production, electromagnetic, hadronic cascades
- Electron reflux
- Alpha, beta, gamma radiation through substance
- Half value layer
- Shielding systems

2.2 Dosimetric and radiation protection quantities (2 h)

2.1. Dosimetric quantities and units.
2.2. Radiation protection quantities. Operational quantities

Learning Objectives: To understand dosimetric and radiation protection quantities and their units and to perform simple calculations. To be familiar with operational quantities.

Topics:

- Dosimetric quantities
- Exposure (rate)
- Kerma (rate)
- Absorbed dose (rate)
- Linear energy transfer (LET)

- Radiation protection quantities
- Equivalent dose (rate); radiation weighting factor (w_R)
- Effective dose, tissue weighting factor (w_T);
- Operational quantities: ambient dose equivalent; personal dose equivalent; dose constraints
- External and internal dose, intake; committed dose

2.3 Biological effects of ionizing radiation (1 h)

3.1. Effects of radiation at the molecular and the cellular level.
3.2. Deterministic effects.
3.3. Stochastic effects.

Learning Objectives: To become familiar with the mechanisms of different types of biological effects following exposure to ionizing radiation.

Topics:

- Effects of radiation on cells
- Deterministic effects
- Effects of whole body irradiation
- Effects of partial body irradiation
- Stochastic effects
- Stochastic somatic effects
- Stochastic hereditary effects
- Epidemiological studies

2.4 Radiation detection and measurement. Detectors. (3h + practical)

2.4.1. Principles of radiation detection and measurement – dosimetry and analysis
2.4.2. Passive and active radiation detectors.
2.4.3. Detectors for high fluence pulsed field radiation generated by high power lasers

Learning Objectives: To be familiar with different types of radiation detectors and their operating principles, their characteristics and applicability.

Topics:

- Principles of radiation detection

- Passive radiation detectors: films (RCF), TLD, OSL, CR39, bubbles, IP…
- Active detectors: Geiger–Müller counters, ionization chambers, proportional counters and solid state detectors (scintillators, semiconductors)
- Radiation survey meters
- Personal dosimeters
- Measurement techniques and parameters
- Practical applications. Practical use of measurement devices. Measurement of dose rate. Variation of dose with distance
- Neutron measurements
- Issues with measuring short pulse radiation
- EMP issues

2.5 international guidance and European directives for radiation protection (2 h)

2.5.1. Principles of radiation protection.
2.5.2. The role of international organizations in radiation protection.
2.5.3. Directive 2013/59/EURATOM. Regulatory control.
2.5.4. National regulations (country specific)

Learning Objectives: To become familiar with international recommendations on radiation protection and the safe use of radiation sources. To become acquainted with the elements of a national regulatory infrastructure in this field.

Topics:

- The ICRP Basic Framework
- International organizations
- Principles of radiation protection
- Justification of a practice
- Optimization of protection
- Individual dose limits
- European directives on radiation protection
- Regulatory system
- The development of safety culture
- To be detailed for national regulation submodule

2.6 Accelerators, lasers and related radioprotection issues (5 h)

1st Submodule:

2.6.1. Accelerator systems. Components of accelerators.
2.6.2. Types of accelerators.
2.6.3. Radiation protection issues associated to particle accelerators.

2nd Submodule:

2.6.4. High power laser.
2.6.5. Laser-matter interaction and laser-generated particle beams)
2.6.6. Radiation protection issues associated to laser particle acceleration.

Learning Objectives: To gain a basic knowledge of particle accelerators and basic requirements for safety associated to the equipment.

Topics:

- Overview of particle accelerators
- Types and components of accelerators
- Ion source and ion extraction
- Beam transport and magnets
- Electrostatic accelerators
- RF-accelerators
- High power laser acceleration
- Accelerators as source for radiation and radioactivity
- Overview of high power laser
- Solid target interactions – ion acceleration and photon production
- Gas target interaction – electron acceleration
- Impact on source measurement
- Activation issues

2.7 Sealed and unsealed, orphan and vulnerable radioactive sources. (2 h)

2.7.1. Types of radioactive sources.
2.7.2. Categorization of radioactive sources.
2.7.3. Safety and security of sources.

Learning Objectives: To be familiar with different types of radioactive sources and their characteristics. To be able to

apply the radiation protection principles to using of radioactive sources.

Topics:

- Sealed radioactive sources
- Production of radioactive sources
- Types of sealed sources: beta, alpha, gamma, X ray and neutron sources
- Categorization of radioactive sources.
- Technical performance requirements for radioactive sources
- Unsealed radioactive sources
- Risks associated with the use of the unsealed sources
- Management of radioactive sources: administrative and operational activities involved in receipt, storage, use, transfer, transport, maintenance or disposal of radioactive sources (for disposal - reference to next module only).

2.8 Radioactive waste management (2 h)

2.8.1. Radioactive waste arising. Waste classification. Exemptions and clearance
2.8.2. Safety requirements for waste disposal.
2.8.3. Management of disused sealed radioactive sources.
2.8.4. Decommissioning of the radiological facilities.
2.8.5. Contamination and decontamination.

Learning Objectives: To become aware of the management of disused radioactive sources. To become acquainted with basics of decommissioning of the radiological facilities.

Topics:

- Sources of radioactive waste. Waste types
- Waste classification. Waste characterization
- Principles of radioactive waste management
- Management of disused sealed sources
- Decommissioning of the radiological facilities
- Design for decommissioning
- Management of waste from decommissioning
- Clean-up of contaminated areas – in relation to laser experiments too

2.9 Radiological accidents. (2 h)

2.9.1. Radiological accidents.
2.9.2. Case studies.

Learning Objectives: To develop an awareness of the causes and consequences of radiological accidents and approaches to mitigate their consequences.

Topics:

- Examples of radiological accidents
- Case studies
- Possible accident scenarios at laser facilities
- Lessons learned
- Prevention of incidents and emergency response

2.10 Practical session/visits (6 + 2 h)

2.11 Q&A session (1 h)

2.12 Evaluation (1 h)