



1

Linac4 Ion Source – Safety Aspects HT, Gas, Cs, Electrical, Fire

A. Funken – J. Lettry

On behalf of the Ion Source team

L4 Ion Source Review

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CERN



- Hazards inventory
- Risk control measures
- Safety documentation
- Conclusion and outlook

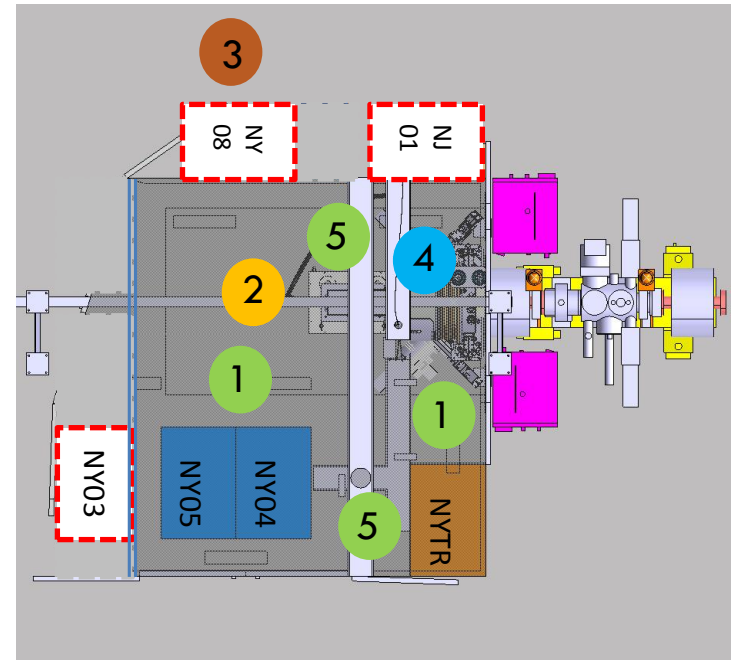
- 1 **Electrical hazards:**
 - High voltage (10kV to 50 kV)
 - Capacitor banks (20J/50 kV)

➤ **Electrocution, electrical shocks, fire**
- 2 **Non ionizing radiations:**
 - High power RF 2 MHz (RF power amplifier in the Klystrons hall)

➤ **Electrical shocks, tissue burns**
- 3 **Flammable gas:**
 - Hydrogen (2 x 10 liter 200 bar gas bottles)

➤ **Explosion, fire**
- 4 **Mechanical hazards:**
 - Pressurized pipelines (0.5-3 bars H₂)
 - Equipment under vacuum (up to 10⁻⁷ mbars)

➤ **Release of gas, explosion; hearing loss, material projection**



Closed Faraday cage

- 5 **Chemical hazards:**
 - Oil
 - Caesium (with plasma Cs source)

➤ **Pollution**

➤ **Fire, explosion, intoxication, chemical burns**



Risk control measures



4

Based on HSE Launch Safety Agreement (equivalent to [EDMS 1218116](#) for Linac4 ion source):

This document is an overview of the **applicable Safety requirements for the ion source** (based on the CERN Safety rules or if not existing, on Host States regulations, European Directives, international standards and best practices).

Fields	Safety requirements
Electrical safety	<ul style="list-style-type: none">➤ Safety Code C1 - Electrical safety code➤ Safety Instruction IS24 – Regulation applicable to electrical installations
Non ionizing radiations (RF)	<ul style="list-style-type: none">➤ European Directive 2013/35/EU➤ French Decret n°2002-775 of 3 Mai 2002
Flammable gas (H2)	<ul style="list-style-type: none">➤ Explosive atmospheres (GS-C2)
Mechanical safety (Pressure, vacuum)	<ul style="list-style-type: none">➤ Safety Regulation on mechanical equipment (SR-M)➤ General Safety Instruction (GSI-M2) – Standard pressure equipment
Chemical safety (Cs)	<ul style="list-style-type: none">➤ Safety Regulation on chemical agents (SR-C)➤ General Safety Instruction (GSI-C1) on prevention and protection measures➤ General Safety Instruction (GSI-C3) on monitoring of exposure to hazardous chemical agents in workplace atmospheres

Electrical safety and RF



Equipment are located inside the closed Faraday cage having a protection index IP3X according to IEC60529.

- Faraday cage equipped with an access interlock system ([EDMS 1212106](#)), PLC-based.

In case of access, the high-voltage power converters and the 2 MHz RF generator are disabled. Racks automatically grounded. Warning signs posted on the doors indicating that access is restricted to specialists.

- Faraday cage equipped with **AUL** (local emergency stop)
- Linac4 tunnel equipped with **AUG** (general emergency stop)



Flammable gas safety Explosion risk assessment: [EDMS 1261469](#)

The gas rack itself is classified as ATEX zone 2, in line with [Safety Guideline C-2-0-3](#).

- The maximum volume of a **hydrogen leak** is **2 m³** with one gas bottle (the full content of one 10 liter, 200 bar bottle).

In case of a gas leak: the ventilated volume around the ion source is considered as large enough (2'500 m³) so that no explosive hazards can arise outside the rack. Hence, **gas detection system is not necessary**.

The ventilation system is supervised from the CCC.

In case a failure of the ventilation system, the standby service is called (specific written procedures).

- The gas distribution system can be fully vented with clean nitrogen so that no flammable gas will remain in the system at the operational state "Stop".



Fire safety

- Tunnel
- Fire detection system : activation of one detector triggers a level-3 alarm and the intervention of the fire brigade
 - Fire alarm (evacuation) in case of activation of two fire detectors
 - Interlocks with the ventilation system
 - Smoke extraction system (started by the fire brigade)

Faraday cage ➤ Fire detection system + Fire alarm

Evacuation plans posted on site

Fire extinguishers and
fire-fighting system (RIA)



Chemical safety

Oil



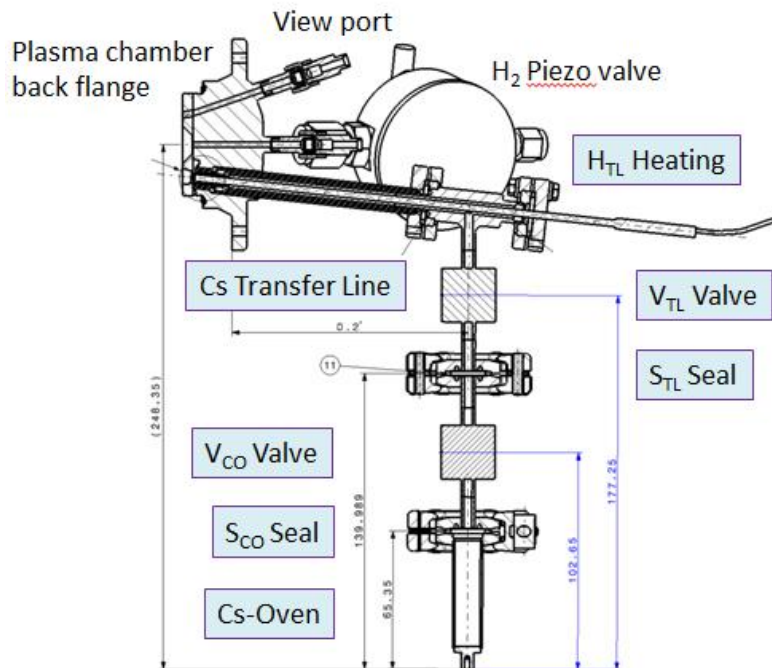
The transformers of the three HV pulsed power converters are immersed in oil:

- Sealed oil tanks
- Oil type **MIDEL 7131** (3 x 95L): not toxic, high fire point ($> 300^{\circ}\text{C}$)
- 100L retention bund at rack bottom 1
- Monitoring of oil pressure, temperature, levels includes in the interlock chain of the power converters.

Chemical safety

Caesium (Quantity in the LINAC4 source: 100 mg to 5 g)

- Chemical risk assessment (to be released).
- Specific procedures to handle the caesium in Linac4 (In Work): installation, multi month operation and exchange of Cesium ion sources.



- The **Cs-load** and **condensed Cs vapours** are **confined** within the dispenser and the ion source vacuum tanks.
- **Coupling the Cs-dispenser to the source** will be done according to a procedure.
- Maintenance of the component inside the vacuum tank will be done in a **dedicated laboratory** (Cs-test stand – building 357).
- All **transport** will be under inert atmosphere enclosed in dedicated hoods.
- **Personnel protective equipment** is foreseen (gloves, goggles) and will be adapted to the tasks.



Safety documentation



11

The safety documentation is included in the Safety Folder of Linac4 which consists of 4 main parts:

Parts	Contents	Ref. EDMS	Status
Descriptive	Description of the facility in terms of safety, access modes, dismantling and disposal	1227231	<i>Approval process closed</i>
Demonstrative	Hazards inventory, risks induced, risk control measures, risk assessments	1280742	<i>Under Engineering Check</i>
Operational	Inventory of information notes, operational instructions and procedures related to safety, description of the project phase and organisation	1280745	<i>In Work</i>
REM (Record, Experience, Monitoring)	Inventory of all feedbacks, inspections, safety reports, non-conformities, near-misses, incidents, accidents and experience gained	1280750	<i>In Work</i>



Safety documentation



12

Status of the safety procedures for the Linac4 ion source:

Procedures	Released	To be released	In work
High voltage safety and Interlocks of the Linac4 Ion Source Test Procedure	EDMS 1314944		
Access and work in the H- source cage		X	
Safety lock-out of the Ion Source power converters		X	
Fire brigade emergency intervention			X
Procedure in case of failure of the ventilation system of the Linac4 tunnel		X	
Replacement of the H2 bottle	EDMS 1261469		
Emergency procedure in case of problem during operation of the LINAC4 gas system	EDMS 1320768		
Operation instruction of the gas system: how to connect remotely	EDMS 1320770		
Caesium related procedures			X



Conclusion and outlook



13

- All systems are being documented within CERN safety rules and regulations.
- Manpower needs for the remaining safety documentation:
 - IS-02 (plasma Cs-surface) : 2 months, 0.5 FTE
 - IS-03 (Magnetron) : 4 months, 0.5 FTE



Thank you for your attention

