

Safety aspects: electrical and gas safety, Cs handling, radiation & fire protection

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Linac4 ISWP review, 2011/06/07

Introduction

For the Linac4 IS and the IS / PG test stands at Bt. 357, a **safety concept** must be developed:

gas safety



electrical safety



fire protection



Cs handling



radiation protection



Aim:

- ✓ identification of possible hazardous risks
- ✓ define mitigation methods
- ✓ optimize personal safety and machine protection

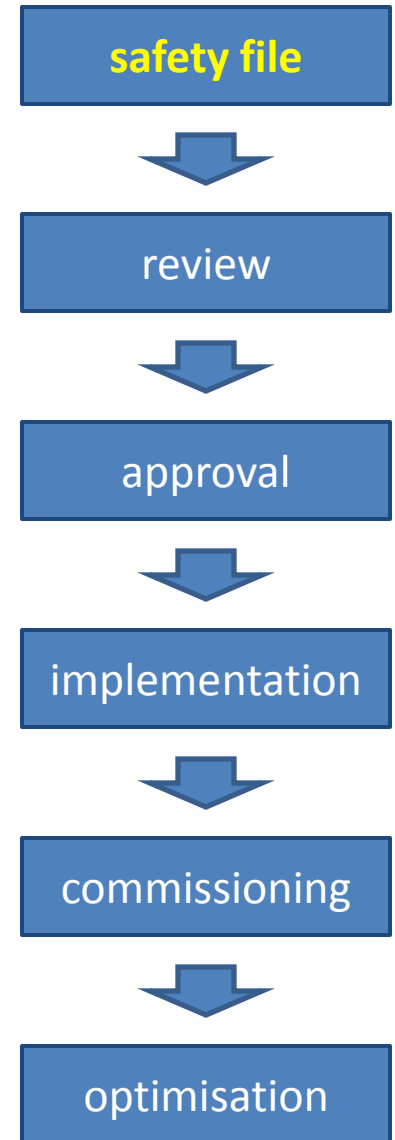
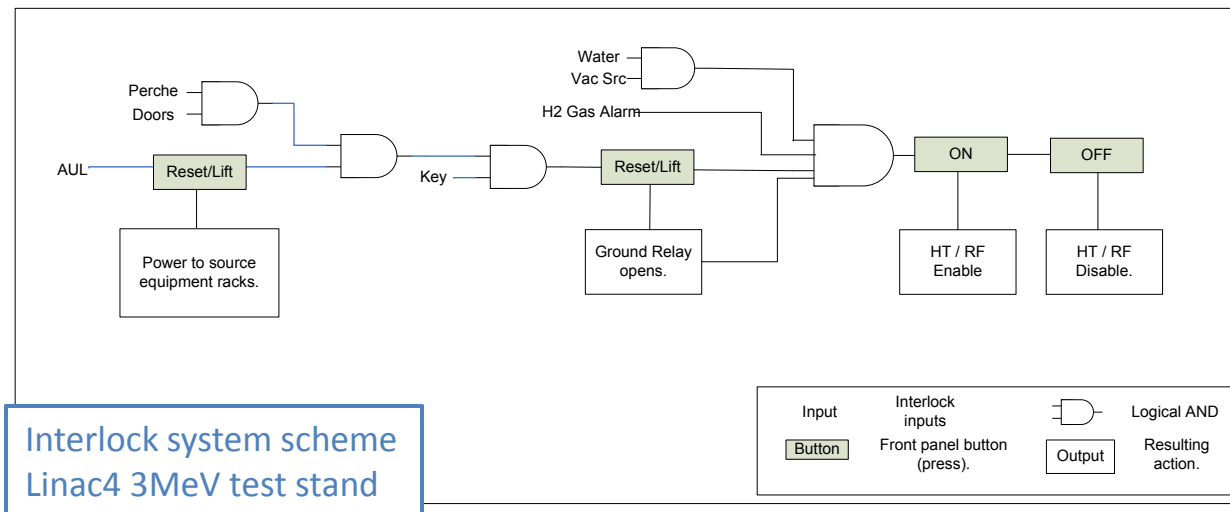
Introduction

	potential hazards	personnel	machine
H ₂	gas accumulations in closed volumes	x	
	fire	x	x
	explosions	x	x
HV & RF equipment	electrocution	x	
	sparks		x
	fire	x	x
radiation	release of radioactive material	x	
	internal & external exposure	x	
	activation of materials, contamination	x	x
fire	destruction of equipment		x
	intoxication, asphyxiation	x	
Cesium	fire, explosions	x	x
	intoxication	x	
	corrosion		x
	chemical burns	x	

⋮

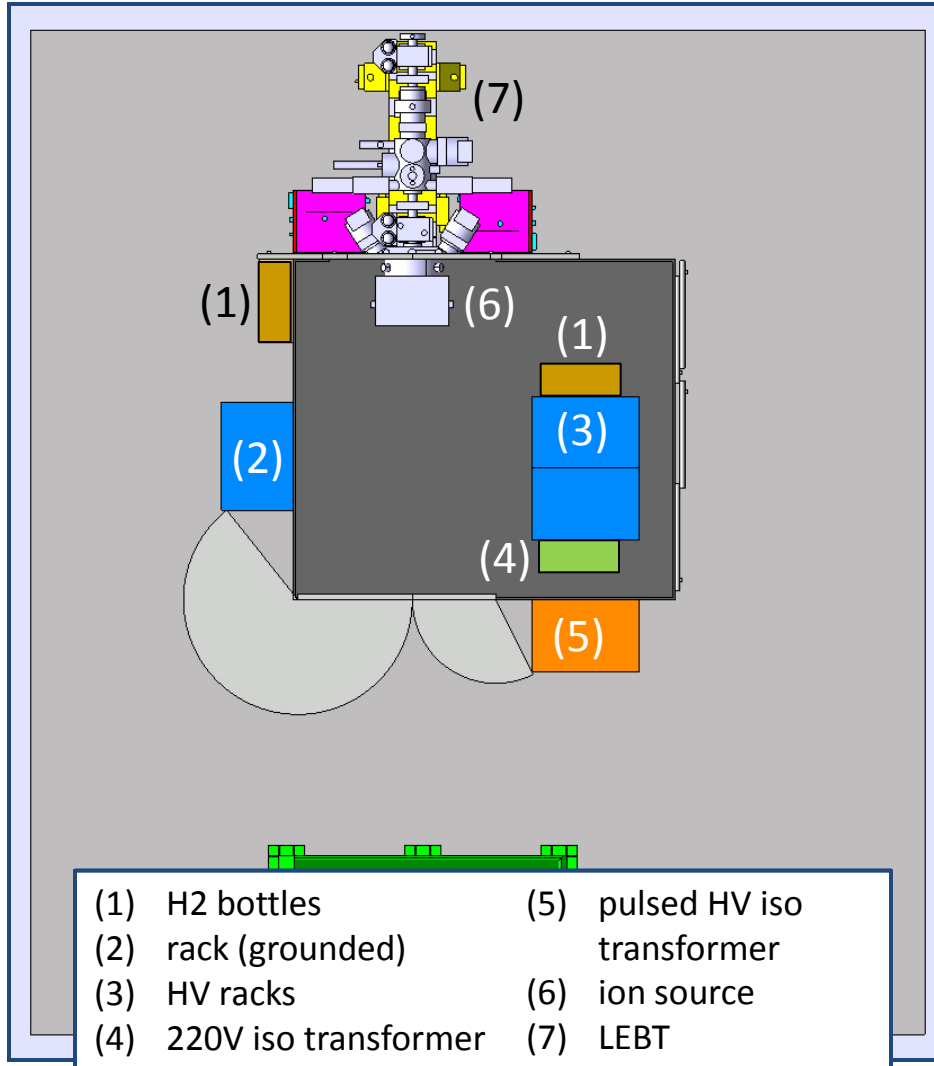
electrical safety: concept

- ✓ HV equipment contained in a protected volume (HV protection cage)
- ✓ PLC-based safety interlock system for RF and HV
- ✓ safety file & procedures according to CERN safety regulations
- ✓ training & information



electrical safety: Linac4

Linac4 HV protection cage (proposed outline):



size: $\approx 3 \times 3 \times 4 \text{ m}^3$

contains:

- ✓ ion source
- ✓ HV racks (controls, power supplies)
- ✓ RF matching network
- ✓ H₂ bottle (location tbc)

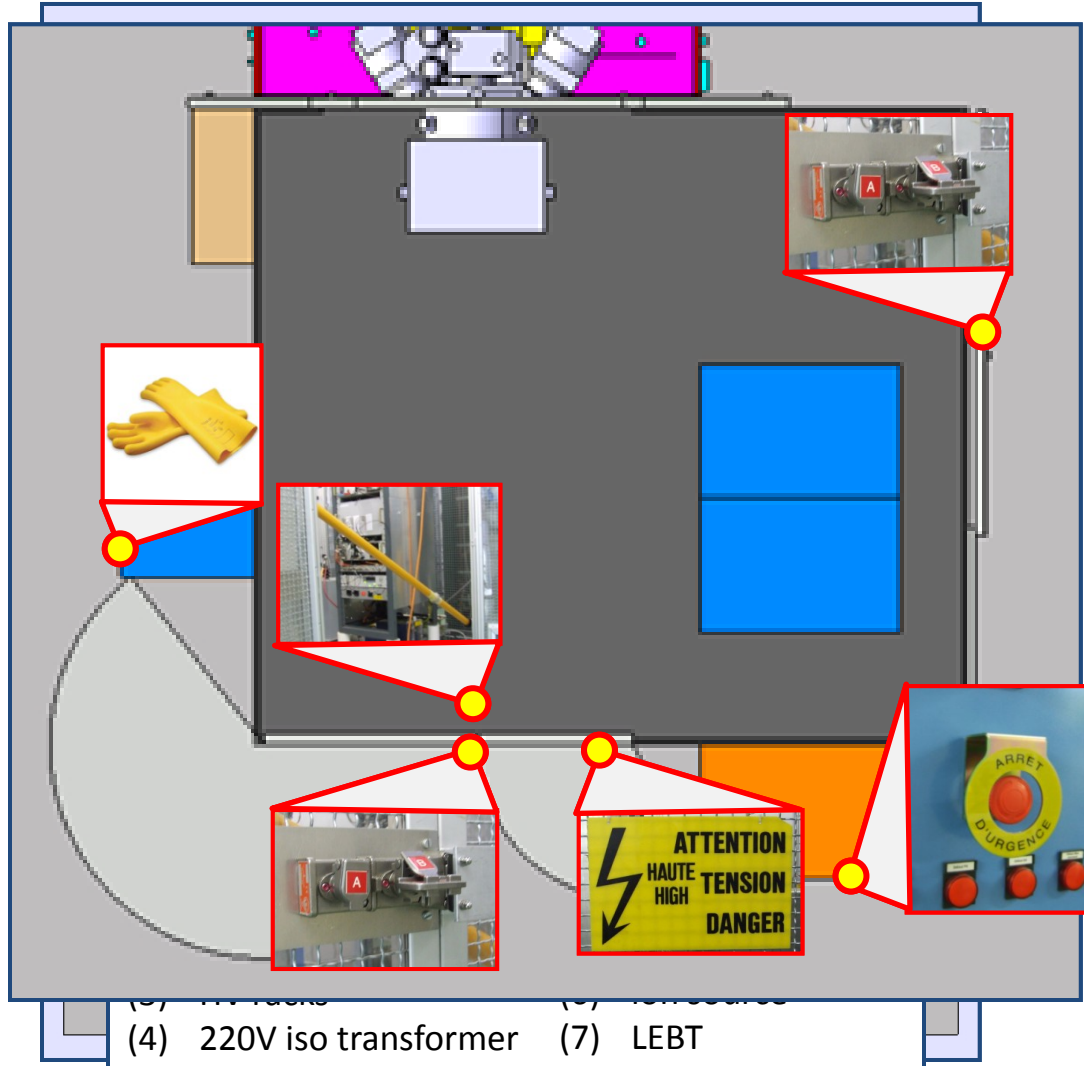
features:

- ✓ overhead crane for heavy equipment
- ✓ three access doors

isolation transformer stored outside of cage to gain space

electrical safety: Linac4

Linac4 HV protection cage (proposed outline):



general safety concept:

- ✓ no access to any HV equipment unless it is safe
- ✓ if access is forced
- HV and RF must be cut

safety installations:

- ✓ warning signs
- ✓ door switches
- ✓ grounding rod
- ✓ local emergency stop
- ✓ safety gloves & hook

machine protection:

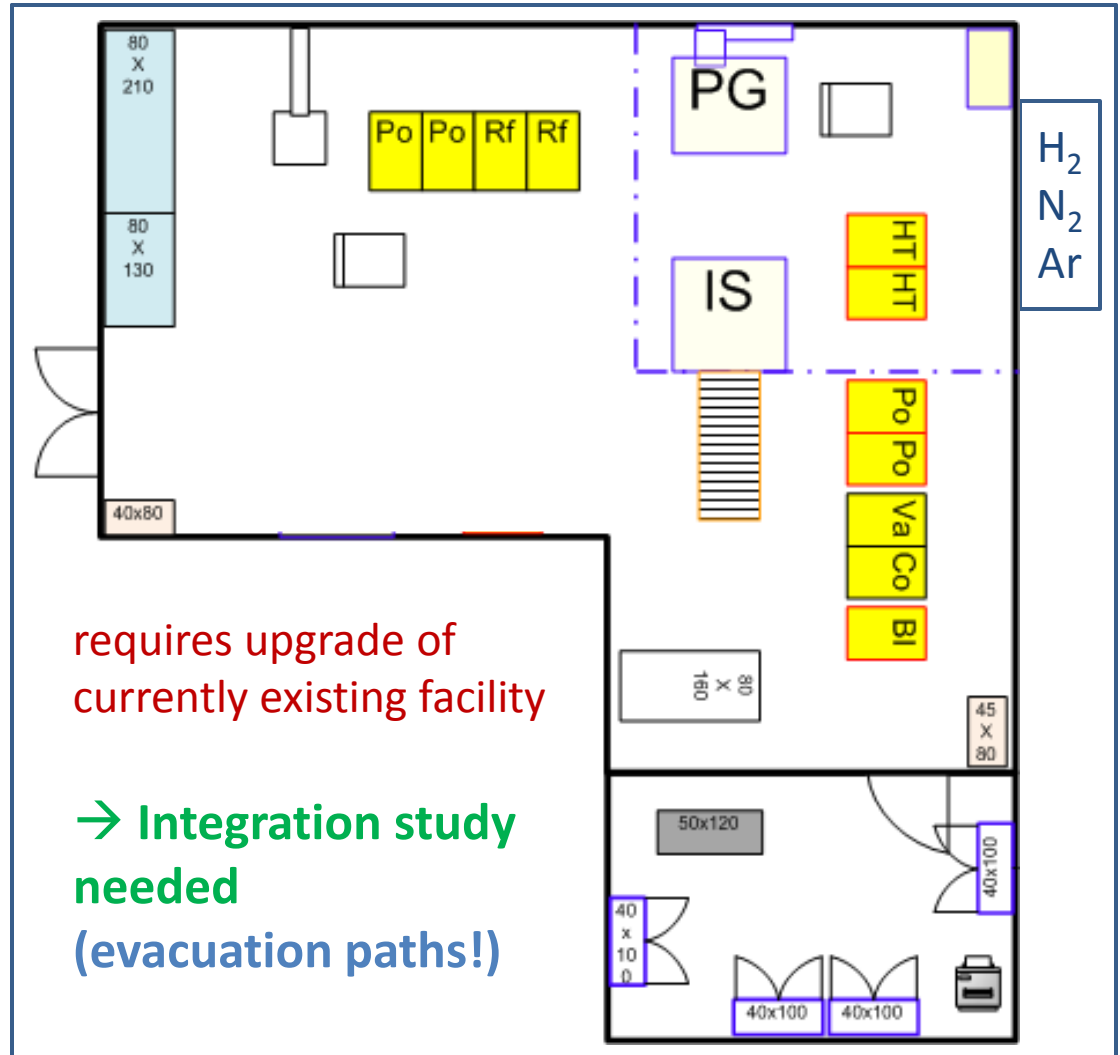
- ✓ prevent sparking between equipotential HV equipment during breakdowns
- calculate equivalent circuit

electrical safety: test stand

IS & PG test stand HV protection cage (proposed outline):

differences to Linac4:

- ✓ two separate test stands:
 - ✓ ion source test stand (incl. beam extraction + LEBT)
 - ✓ Plasma generator test stand (low-kV extraction)
- ✓ H₂ bottle stored outside of building
- ✓ no crane



requires upgrade of currently existing facility

→ Integration study needed (evacuation paths!)

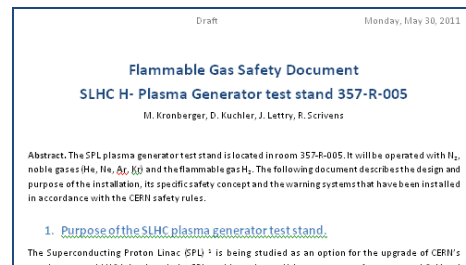
Gas safety: concept



minimize risk of H₂ release
minimize risk of explosions

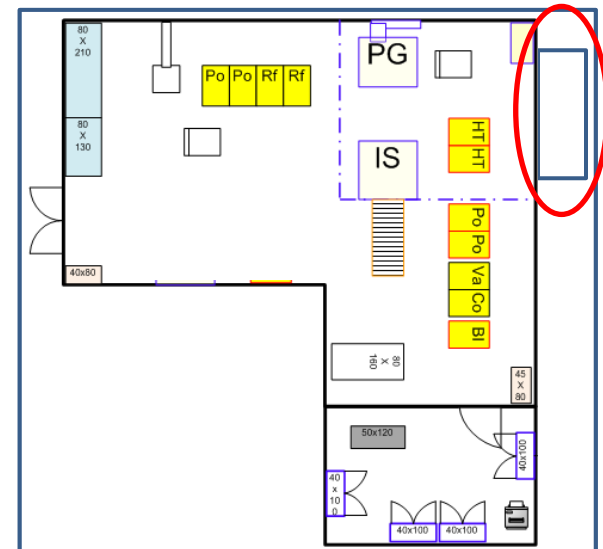
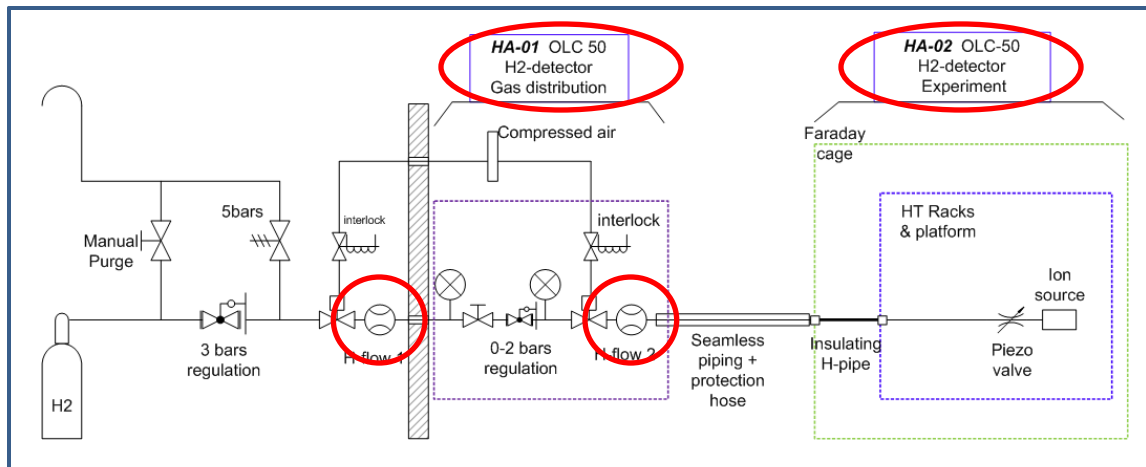
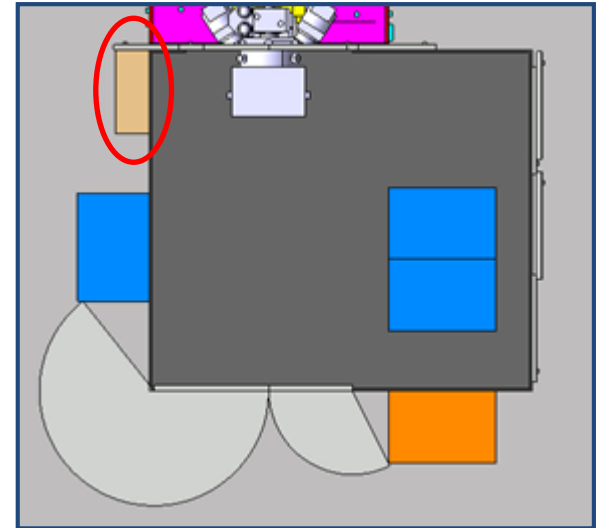


- ✓ use of appropriate hardware
- ✓ exhaust gas in vented areas
- ✓ use gas detectors coupled to an interlock system to detect accidentally released H₂
- ✓ limit gas flow
- ✓ follow up gas consumption
- ✓ safety file
- ✓ procedures for installation, operation & maintenance of gas system
- ✓ training & information



Gas safety: Linac4 & Bt. 357

- ✓ H₂ bottles stored in a **safe location** (Linac4: fire cabinet; 357: outside of building)
- ✓ H₂ lines intercepted with redundant **flow meters** and **electro valves** to close gas line when sudden changes in gas flow are detected (leaks!)
- ✓ **Flammable gas detectors** at positions of potential gas release
- ✓ **Acoustic & visual alarms**

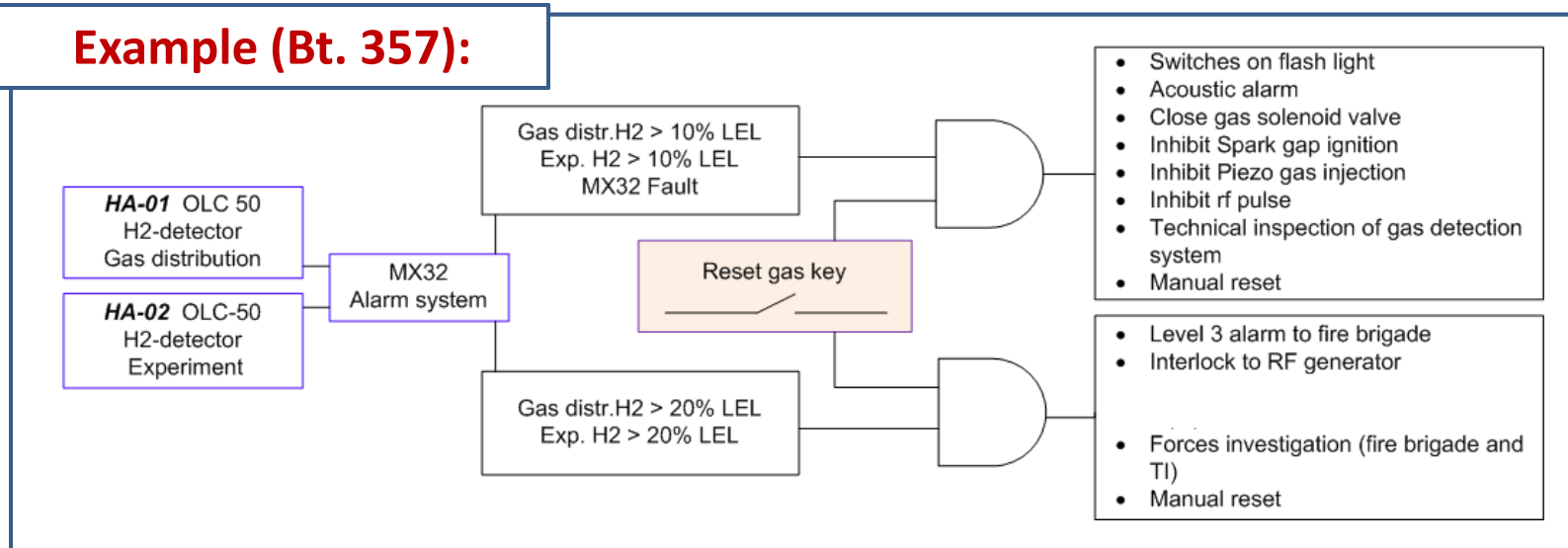


Gas safety: interlock system

Activated when gas detector measures an **H₂ concentration**
≥ 10% of the Lower Explosive Limit (LEL).

(LEL_{H₂} = 3.6 vol.% H₂ in air)

Example (Bt. 357):



LEL = 10%:

- ✓ activate warning signs
- ✓ switch off gas supply
- ✓ inhibit RF pulse, gas injection & ignition
- ✓ Technical inspection

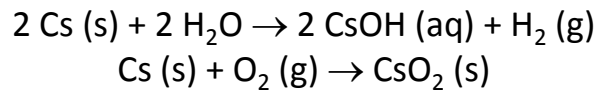
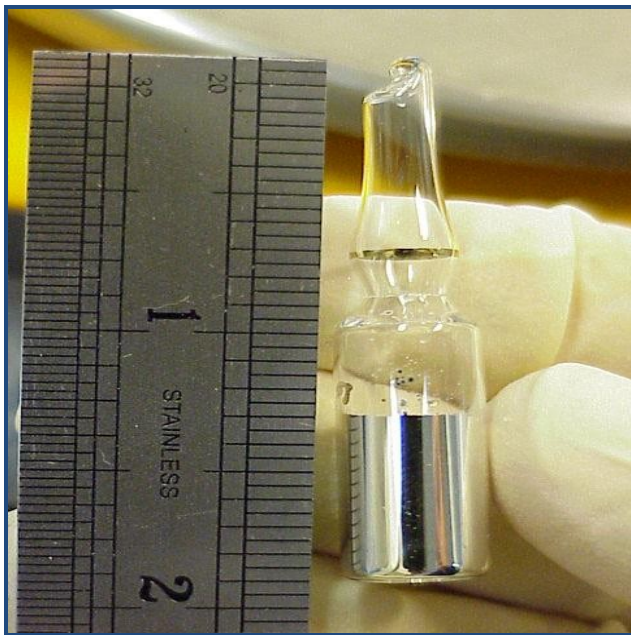
LEL = 20%:

- ✓ call to fire brigade
- ✓ RF generator interlock
- ✓ Investigation by TI and fire brigade

Cs handling

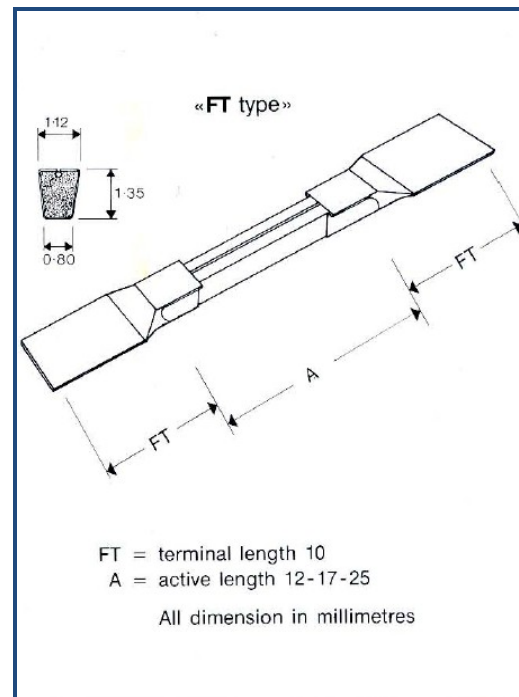
Cesium:

- ✓ water reactive
- ✓ pyrophoric



Cesium chromate:

- ✓ toxic



(see also presentation of H. Pereira)

Cs handling: risk mitigation

storage:

- ✓ in accordance to CERN Safety Guideline C-1-0-1
 - ✓ **elemental Cs**: metal cabinet for water reactivities
 - ✓ **Cs chromate**: locked cupboard

handling:

- ✓ only inside an inert gas-filled **glove box** (Ar or N₂)

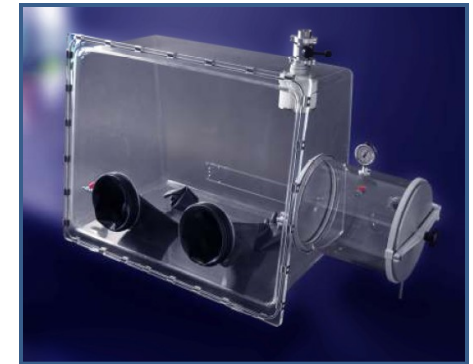
transportation:

- ✓ **road**: sealed transport container under inert atmosphere
- ✓ **test stand**: Ar bag

detailed **procedures** for:

- ✓ **Cs handling**
- ✓ **installation and removal** of cesiated equipment
- ✓ **cleaning & disposal**

Training & information



Cs lab, disposal

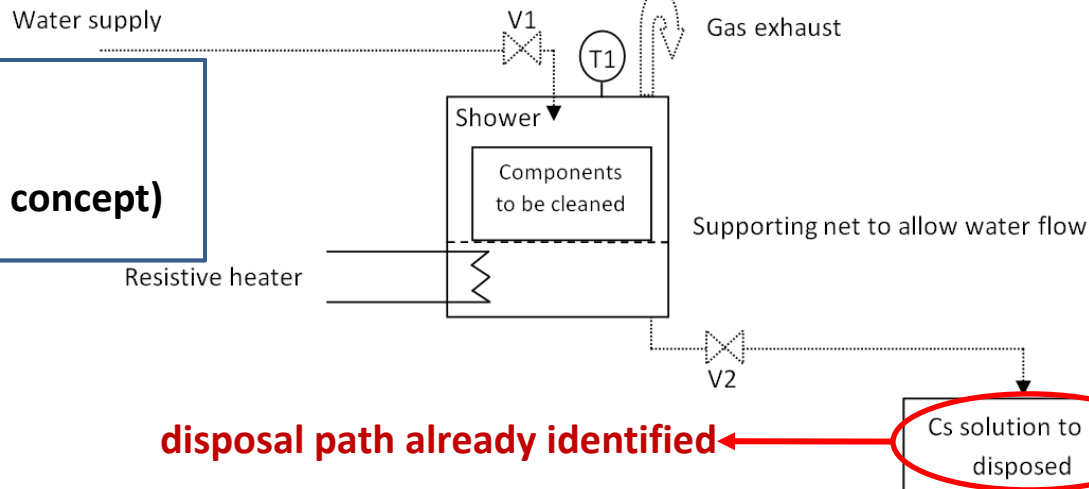
Lab safety:

- ✓ glove box + extracting hood
- ✓ storage cupboards
- ✓ fire extinguishers (class D)
- ✓ safety-eye wash fountain (EN 15154-2)
- ✓ fire detectors
- ✓ floor drains covered with solid lid, NO water sprinklers

CLASSES OF FIRES	TYPES OF FIRES	PICTURE SYMBOL
A	Wood, paper, cloth, trash & other ordinary materials.	
B	Gasoline, oil, paint and other flammable liquids.	
C	May be used on fires involving live electrical equipment without danger to the operator.	
D	Combustible metals and combustible metal alloys.	
K	Cooking media (Vegetable or Animal Oils and Fats)	

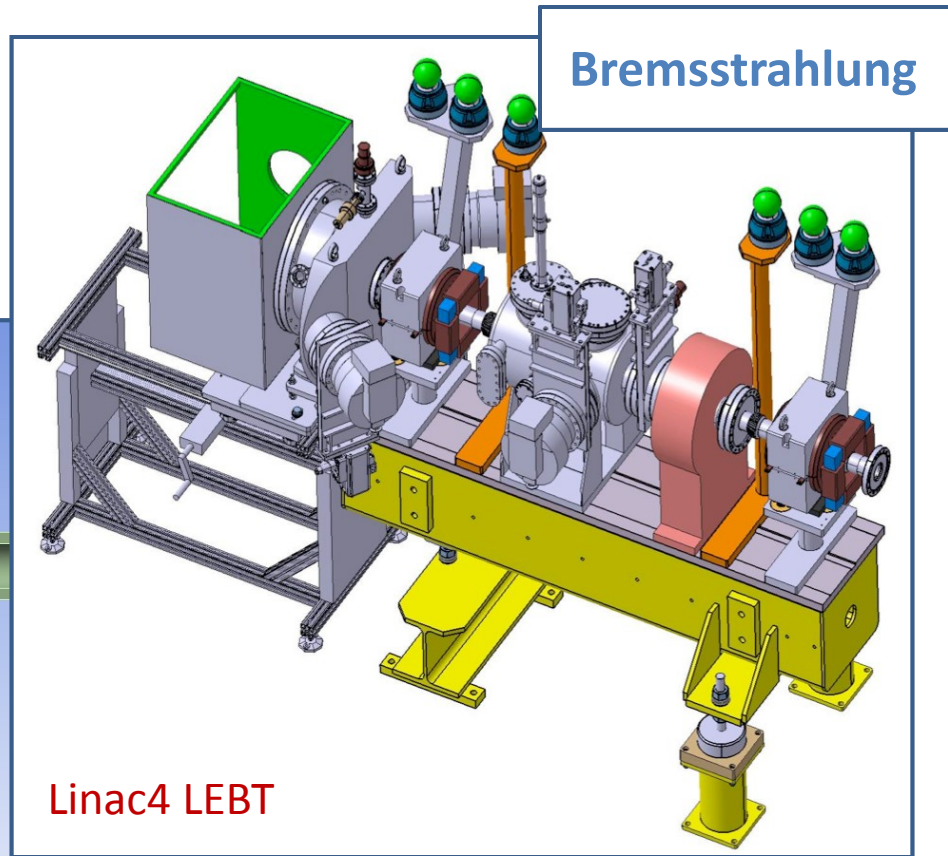
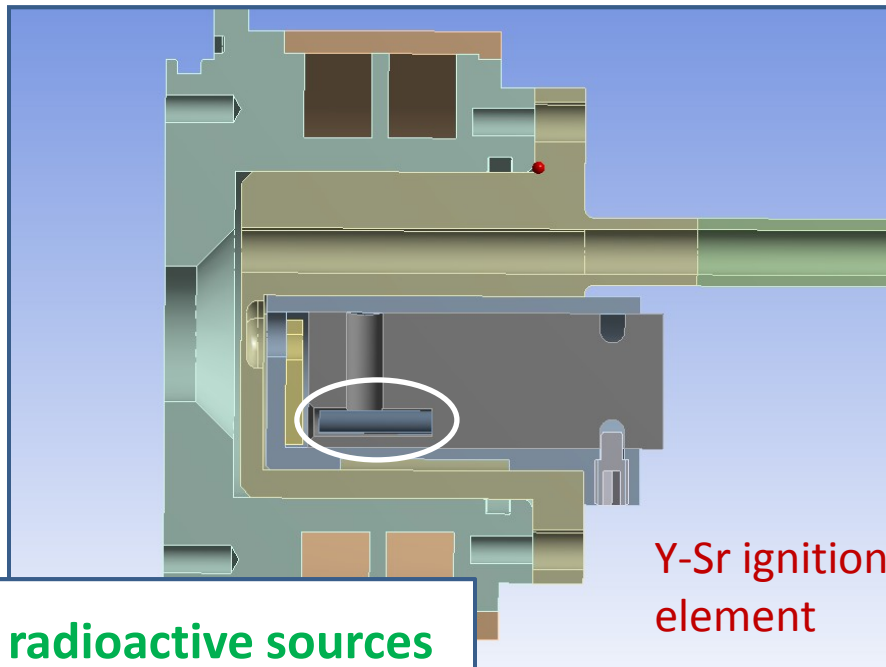


Disposal: (based on ISIS concept)



radiation protection

Sources of radiation:



Linac4 LEBT

radiation & fire protection

radiation protection:

- ✓ Application of CERN rules for **transportation, handling, and storage** of radioactive components
- ✓ **Procedures** for operation & manipulation
- ✓ Adequate **shielding** (LEBT!)
- ✓ **monitoring** of personal and environmental dose



fire protection:

- ✓ **smoke detectors**
- ✓ Audible and visible **fire alarms**
- ✓ **Fire protection equipment**
- ✓ **Manual firefighting means**
- ✓ **evacuation plan**



Costs & manpower

(Linac4 tunnel + IS/PG test stand)

		costs (kCHF)	manpower (FTE)
HV protection cage	material costs + installation	see presentation of D. Steyaert	
	electrical safety	30	0.5
	safety file, procedures		0.2
	calculation of HV protection cage equivalent circuit		0.5
Gas safety	installation of gas systems	200	0.4
	safety equipment + installation	20	0.1
	safety file, procedures		0.4
Cs lab	equipment	see presentation of H. Pereira	
	installation		
	safety file, procedures		0.4
Radio protection	equipment, installation, maintenance	15	0.1
fire protection	equipment	10	0.1

Sum: 275 kCHF, 2.7 FTE

Deliverables & Milestones

(Linac4 tunnel + IS/PG test stand)

	HV	gas	Cs	radiation	fire
End 2011	move PG test stand to final location	modification of Bt 357 gas distribution	Cs lab	radiation protection Bt 357	fire protection Bt 357
		gas safety Bt 357	Cs oven test stand		
Mid 2012	HV protection cage Bt 357	connect IS test stand + LEBT, functionality test			
	electrical safety Bt 357				
End 2012	HV protection cage Linac4	gas distribution Linac4 (H2, N2)			fire protection Linac4
		gas safety Linac4			
Feb. 2013	electrical safety Linac4	Connect gas distribution in Linac4 building			

Conclusions

- ✓ operation of Linac4 and the IS/PG test stands require the **development of a safety strategy** according to CERN regulations:
 - ✓ gas safety
 - ✓ electrical safety
 - ✓ radio & fire protection
 - ✓ Cs handling
- ✓ estimated costs & manpower: **275k CHF, 2.7 FTE**
- ✓ **Deliverables:**
 - ✓ **End 2011:** Cs lab, Cs oven test stand
 - ✓ **Mid 2012:** IS test stand Bt. 357
 - ✓ **End 2012:** Linac4 HV protection cage & gas distribution
 - ✓ **Feb 2013:** finish work at Linac4