Principles of radiation protection, activation and radiation monitoring

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Safety Commission

Radiation Protection Group

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Outline

- Radiation Protection principles
- Activation issues
- Radiation Monitoring System for CTF3

Radiation Protection Principles

Justification

All exposure to ionising radiation needs to be justified.

Limitation

The dose of any individual must not exceed the legal limits.

Optimisation

Individual as collective dose have to be reduced to a reasonable minimum. (ALARA = "As Low As Reasonable Achievable").

All stages optimised !

Considerations to be done at all stages of a project:

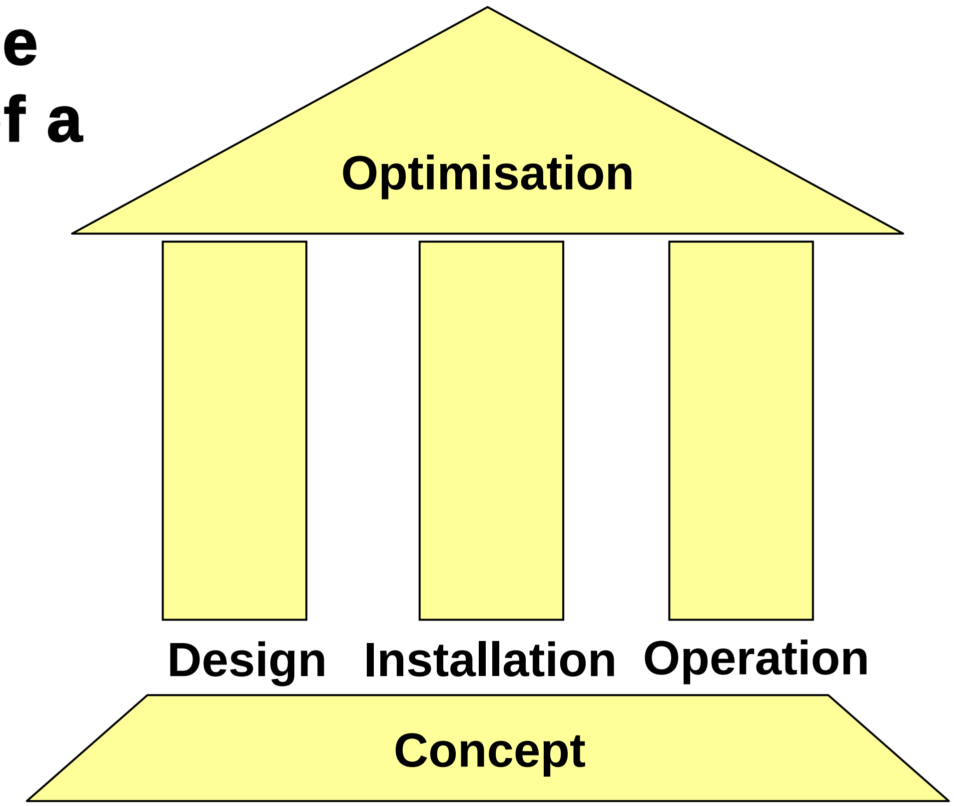
Concept

Design phase

Installation

Operation

Decommissioning



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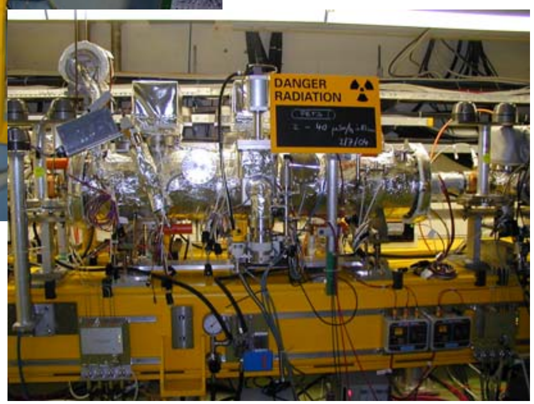
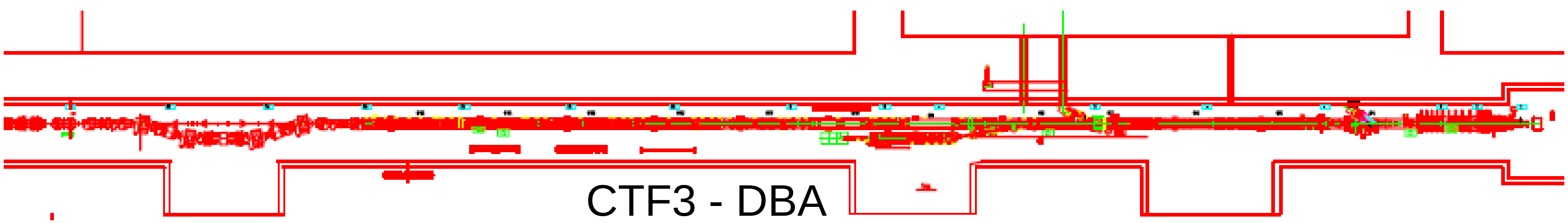
Production of radioactivity



Activation of accelerator components by high energy bremsstrahlung and neutrons.

Production of various nuclides from nuclear reactions: (γ,n) (γ,np) (n, γ) ...



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Activation and Decay

Activation

$$\frac{dN_y}{dt} = \varphi \cdot \sigma \cdot N_x$$

Flux

Cross section

Decay

$$\frac{dN_y}{dt} = -\lambda_y \cdot N_y$$

$$N_y = \frac{\varphi \cdot \sigma \cdot N_x}{\lambda_y} \cdot \left(1 - e^{-\lambda_y t_{irr}}\right)$$

$$A_y = \varphi \cdot \sigma \cdot N_x \cdot \left(1 - e^{-\lambda_y t_{irr}}\right)$$

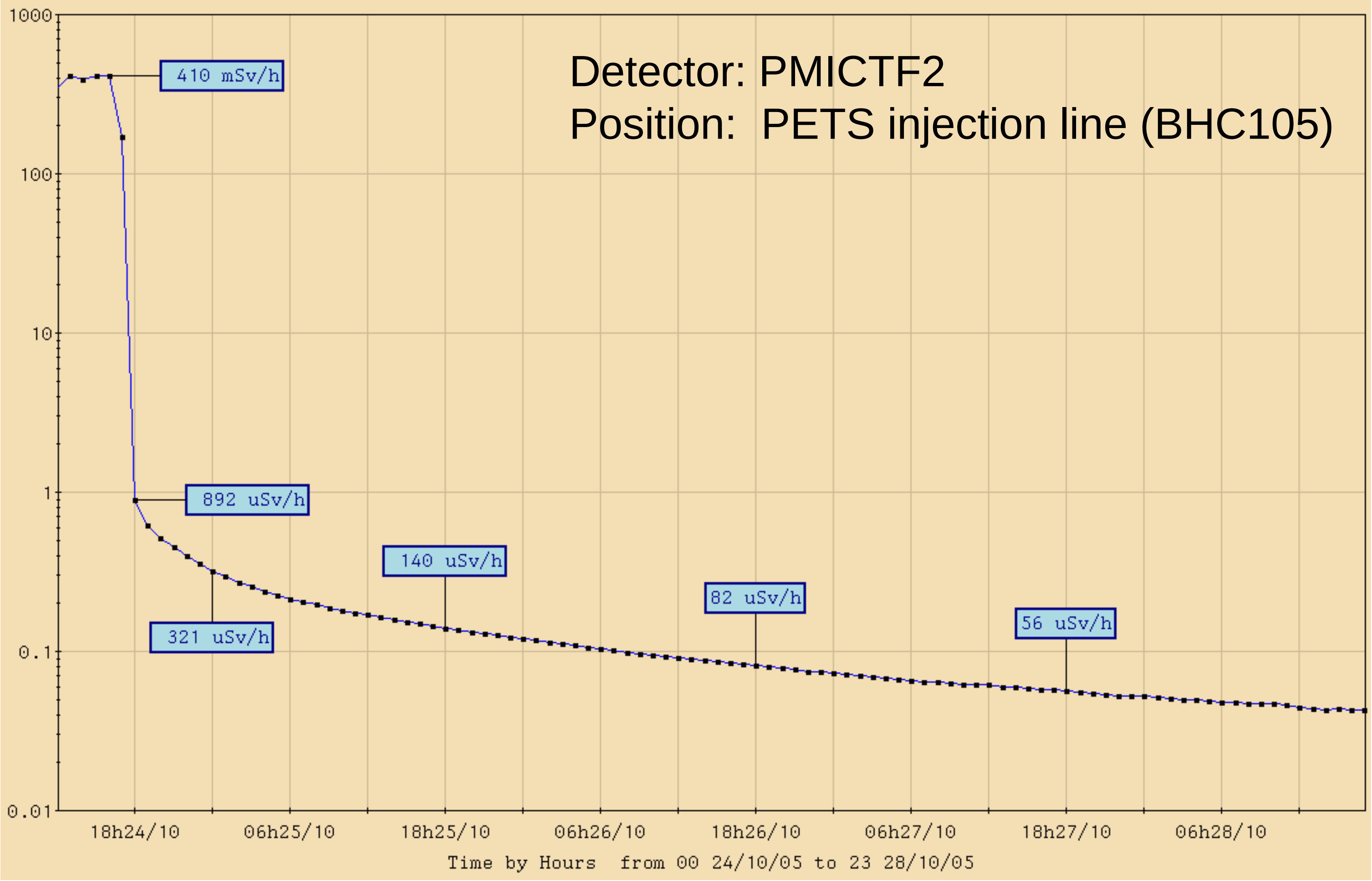
reduce flux

use light and specific materials

use less material

reduce irradiation time

Decay



Detector: PMICTF2
Position: PETS injection line (BHC105)
1000
100
10
1
0.1
0.01
410 mSv/h
892 uSv/h
321 uSv/h
140 uSv/h
82 uSv/h
56 uSv/h
18h24/10
06h25/10
18h25/10
06h26/10
18h26/10
06h27/10
18h27/10
06h28/10
Time by Hours from 00 24/10/05 to 23 28/10/05

Radionuclide production

Most important isotopes produced in steel and iron from high energy electron beams:

Reaction	**Halflife**	**h_{10} [mSv/h/GBq]**	**γ Energy [keV]**
Ni-58(γ,n)Ni-57	36 h	0.278	1377, 127, 1920
Ni-57(decay)Co-57	272 d	0.021	122
Co-59(γ,n)Co-58	71 d	0.147	810
Mn-55(γ,n)Mn-54	312 d	0.126	835
Fe-56(γ,np)Mn-54	312 d	0.126	835
Cr-52(γ,n)Cr-51	28 d	0.005	*320*
Co-59(n,γ)Co-60	5.3 a	0.366	1332, 1173

Minimising activation

Reduce dose rates

Reduce radioactive waste → Reduce individual and collective doses

Factors to act on:

- Best choice of material
- Careful installation and alignment
- Consider ergonomics for installation of components in the building.
- Beam control and diagnostic instrumentation

Radiation Monitoring System

Existing System

ARCON (developed for LEP)

6 monitors for stray radiation survey

3 monitors for induced activity

→not possible to extent to future needs.

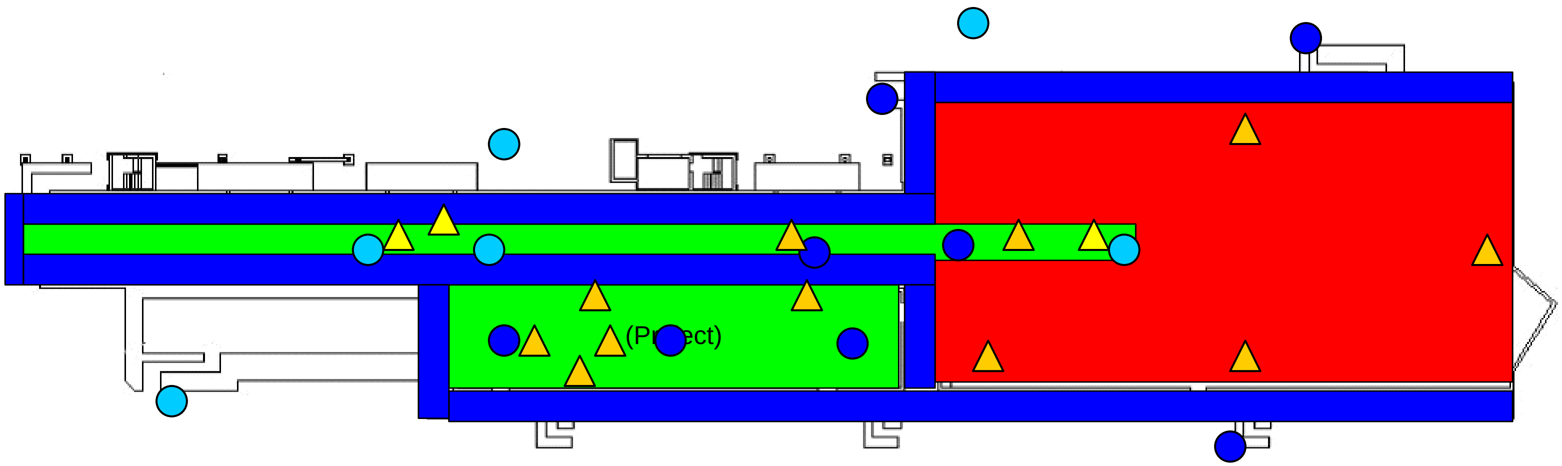
Future system for CTF3 operation with CR and CLEX:

RAMSES (developed for LHC and CNGS)

8 additional detectors for stray radiation survey

11 additional detectors for induced activity monitoring

Radiation monitoring system
(preliminary)



Area radiation monitor (γ, n) (14 channels)

Induced Activity Monitor (γ) (14 channels)

New channels

Existing channels

- Survey at points of weak shielding
- Survey at known or expected loss points

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Cost estimate

Item	Number of items	Total (kCHF)
Area monitors	14	175
Induced activity monitors	14	70
Monitoring stations	4	24
RAMSES console	1	3
Mains, Ethernet		6
Cabling		70
Sum		348

Installation will be staged with the progress of the CR and CLEX.

Summary

- Optimisation is everybody's task in all parts of the project
- Activation is an issue at CTF3. This must be considered for the installations of the CR and CLEX.
- A more extensive radiation monitoring system is required. The size of the new system is mainly determined by the constraints of the existing infrastructure and the complex beam line installations.

... Limitation

Annual limits

Categorie A workers: 20 mSv/year

Categorie B workers: 6 mSv/year

Public: 1 mSv/year

Derived limits (constraints)

Design constraint: 6 mSv/year

Guideline values

Ambient dose rate values for different areas:

Supervised Area	0.5 µSv/h	2.5 µSv/h
Simple Controlled Area	3 µSv/h	10 µSv/h

... Optimisation

Process to minimise doses to persons:

1. Previsional radiological risk estimation:
   - Beam losses → activation level estimation
   - Dose constraint → Intervention planning
   - Determination of max. admissible losses and minimum decay times.
2. Comparison of different scenarios and solutions in order to minimise the radiological impact.
3. Consideration of social, scientific and economical aspects.
4. Documentation

Activation and decay