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Project Report

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Summary

The aim of this report is to give an overview of my work during the summer student programme at CERN. My project was a work of 8 weeks (16/06 to 8/08 2014) in the Radiation Protection group of the Occupational Health & Safety and Environmental Protection Unit and was supervised by M. Robert Froeschl.

1 Introduction

The Linac2 currently injects protons with a kinetic energy of 50 MeV into the PS Booster (PSB). After its connection in LS2, the future Linac4 will inject H^- atoms with a kinetic energy of 160 MeV into the PSB which will subsequently accelerate them to an ejection energy of 2 GeV. In order to cope with the increase of the beam intensity and energy after the connection of the Linac4, the PSB main dump has recently been replaced during LS1 and new injection dumps will be implemented during LS2.

When a new configuration (upgrades, etc.) of a facility is planned, from a radiation protection point of view, an assessment has to include, among others, the following points:

- Air activation computation
- Annual release of radioactivity to the environment
- Resulting annual effective dose to members of public

As the first step of my work, a technical note resulting of this study has been written [1].

In a second step, a analysis of effective dose resulting of the air activation to personnel during access has to be done as well. The goal is to evaluate the external effective dose due to external exposure and the internal effective dose due to inhalation of activated air. This analysis have been done for the following facilities at the Meyrin site:

- PSB injection region for the new configuration
- AD target area
- East area CHARM

A second technical note resulting of this study has been written as well [2].

2 First Air Activation Assessment for the PS Booster after Linac4 connection with the new Main Beam Dump and the future H^0/H^- Injection Dumps [1]

2.1 Overview

The Linac2 currently injects protons with a kinetic energy of 50 MeV into the PS Booster (PSB). After its connection in LS2, the future Linac4 will inject H^- atoms with a kinetic energy of 160 MeV into the PSB which will subsequently accelerate them to an ejection energy of 2 GeV. In order to cope with the increase of the beam intensity and energy after the connection of the Linac4, the PSB main dump has recently been replaced during LS1 and new injection dumps will be implemented during LS2.

A previous technical note [3] presenting the assessment about the recently installed PSB main dump has been done.

The proposed injection system to be installed in LS2 uses a gold foil to strip electrons from the H^- atoms and the remaining protons are merged with the already circulating proton beam. Since the stripping efficiency of this setup is assumed to be 98%, approximately 2% of the beam from Linac4 will not be usable for the PSB. This fraction of beam will be sent to 4 internal dumps (one per PSB ring), denoted *injection dumps*.

Since the ventilation is shared all over the different locations in the PSB, the air activation in the PSB tunnel is assumed to be the simple sum of the contribution of the main dump and the injection dumps. Other contributions to the air activation are neglected.

A comparison of the different contribution to the air activation in the PSB tunnel is performed in [1]. Furthermore, the air activation, the annual release of radioactivity to the environment and the resulting annual effective dose to members of the public for the future PSB configuration (recent installed main dump and future injection dumps) are assessed as well.

The analysis of the effective dose to personnel due to inhalation and external exposure at different locations in the PSB tunnel during access will be performed in a second note [2].

2.1.1 Setup

The beam parameters for the main dump and injection dumps used for this assessment are given in Tab. 1, the irradiation time per year is assumed to be spread uniformly over 300 days. During the commissioning year after the connection of Linac4 to PSB in LS2, the number of protons sent to the main dump can increase by up to a factor 5 [4].

Table 1: Beam parameters.

Parameters	Main dump [4]	Injection dumps [5]
Proton kinetic energy	2 GeV	160 MeV
Protons sent - Normal operation	$5 \cdot 10^{19}/\mathrm{y}$	$5.47 \cdot 10^{18}/\mathrm{y}$

Main dump The new main dump is located in the same cylindrical cavern as the previous beam main dump before the transfer tunnel towards ISOLDE. The horizontal cavern is 5 m deep and has a diameter of 1 m. The dump core is a copper cylinder with a length of 150 cm and a diameter of 40 cm. There is an air gap of a 5 cm radial distance between the copper core and the cylindrical ring shielding out of iron and concrete. At the back of the dump core, there is a 20 cm space before reaching the end of the cavern. Therefore, the front face of the dump is at a distance of 320 cm from the entry plane of the cavern. FLUKA simulations [6, 7] have already been performed [3]. All configuration parameters regarding the main dump such as beam intensity, cavern air volume, production yield for each radionuclide, etc, are taken from [3].

Injection dumps Loading assumptions for beam dumps of Linac4 PSB injection have been defined in [5]. The beam intensity for the future injection dumps is evaluated to be $5.78 \cdot 10^{18} \mathrm{p}^{+}/\mathrm{y}$ (per ring) and the irradiation time per year is assumed to be spread over 300 days. FLUKA simulations [8] have been done by following a specific methodology (described in Sec. 3).

Parameter of ventilation circuit A recent and realistic model of the PSB ventilation, denoted *continuous extraction model*, assumes that 11000 m^3/h are continuously extracted from the total air volume of 5200 m^3. For this model, any corrections for the decay due to the transport time to the release point are omitted. This leads to an overestimation of the annual release.

2.2 Results

The release and the resulting annual effective dose to members of the public will be still dominated by the new main dump. The contribution from the injection dumps is 8% and 11%, respectively.

The annual effective dose to members of the public will still be much smaller than the design goal of 1 μSv/y.

3 Comparison of Internal and External Exposure from Activated Air in various facilities at the Meyrin site [2]

3.1 Overview

In this part, a dose analysis resulting of the air activation to personnel during access is performed. The goal is to evaluate the effective dose due to external exposure and the internal committed effective dose due to inhalation of activated air. This analysis have been done for different facilities in the Meyrin site:

- PSB injection region for the new configuration
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Because the goal of this report is to show an overview of the work rather than explicit explications, a list of different theoritical computations which leads to the results are cited below, the full developpment is done in [2]:

- Radioactive decay
- Internal exposure
- External exposure
- Ratio and over estimation definitions

3.2 Results

This analysis have been done for different facilities in the Meyrin site. For each facilities we have a table which shows the external and internal dose rate per radionuclide for the facility, because the results are convidential, tables are not shown in this report but can be found in [2].

For all facilities, external, internal exposure, the ratio for each radionuclide and the total ratio have been computed. The results show as expected a strong dependency of the dose on the geometry of the volume considered (which ideally represent exactly the region studied but is approximated to be a parallelepiped) and on the point which the point-kernel integral is calculated (which is the position of where we compute the dose).

Under normal condition, the effective dose is dominated by short

References

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