RP studies for the CENF secondary beam design

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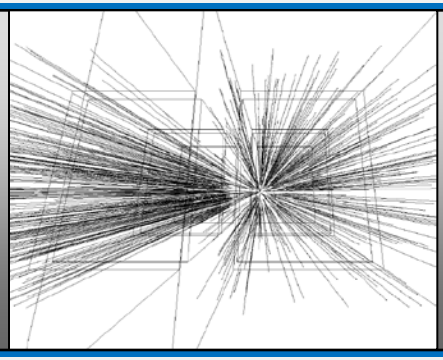


CENF/LBNE meeting

11th April 2014

Overview

1. Prompt dose
2. Residual dose
3. Air/He activation
4. Waste zoning
5. Soil activation

› *Based on FLUKA studies*

RP evaluation of the secondary beam layout has been based on FLUKA simulations

Beam scenario 1

100 GeV/c protons
200 kW
1.25e13 p/s
180 days operation/year
1.9e20 POT/year

- Prompt dose rates
- Residual dose rates
- Air/He activation
- Preliminary soil activation

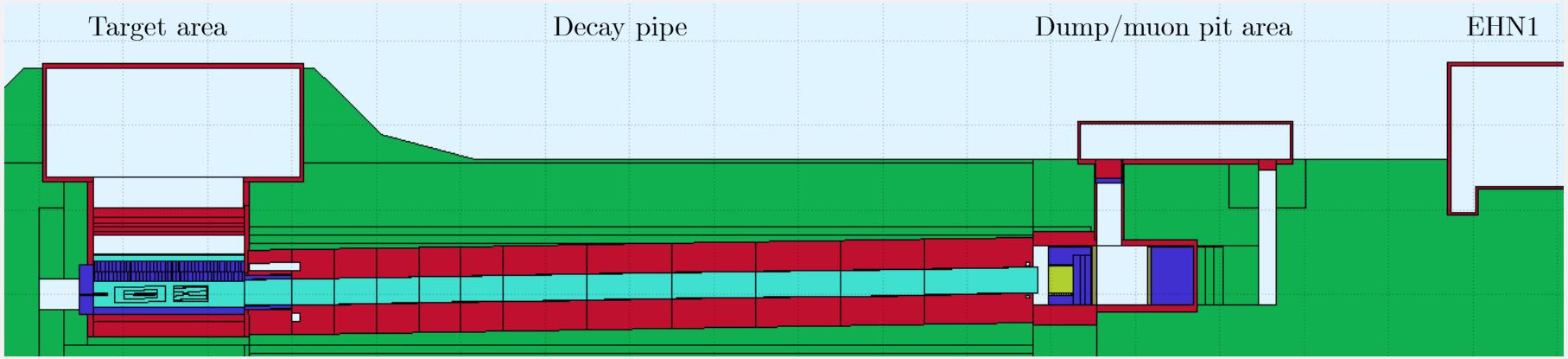
Beam scenario 2

100 GeV/c protons
96 kW
0.6e13 p/s
87 days operation/year
4.5e19 POT/year
5 years of operation

- Waste zoning
- *Final soil activation*

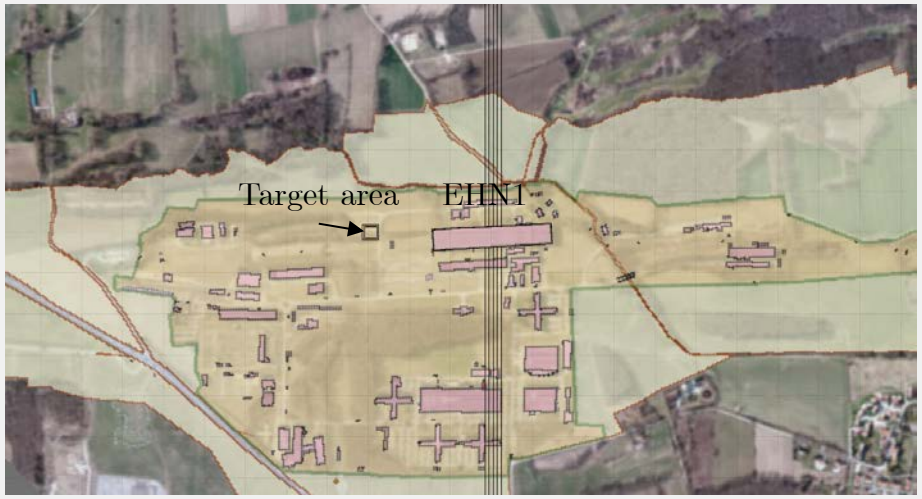
Overview of the CENF geometry as used in the FLUKA simulations

Side view



Top view

Including GIS map of the surrounding

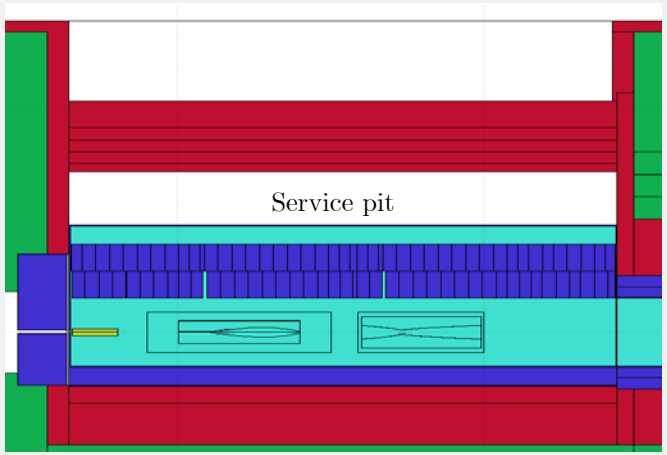


- Complexity of the CENF facility due to proximity to ground level, other experimental facilities and CERN fence
- FLUKA geometry is constantly updated in collaboration with the EN department
- Note that the following results are based on different FLUKA versions

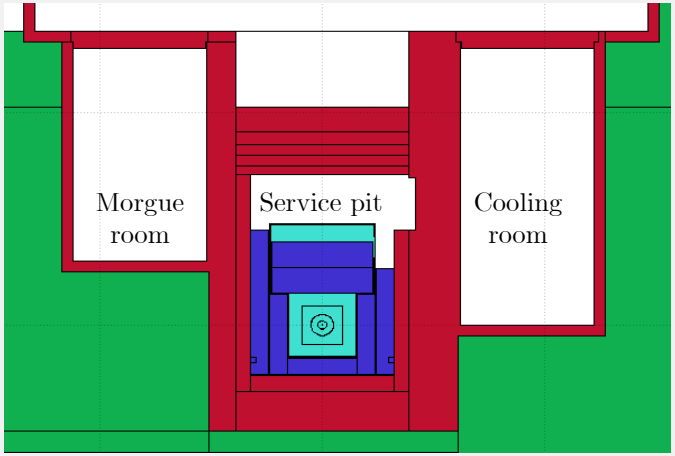
1 Prompt dose

Prompt dose was studied for the different areas of the CENF secondary beam line

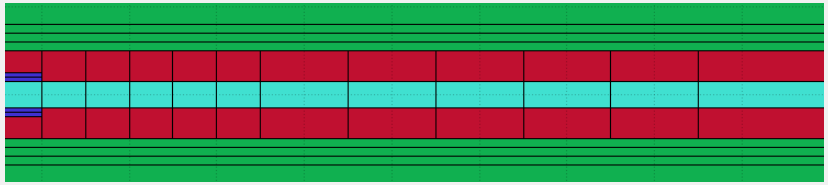
Target area, side view



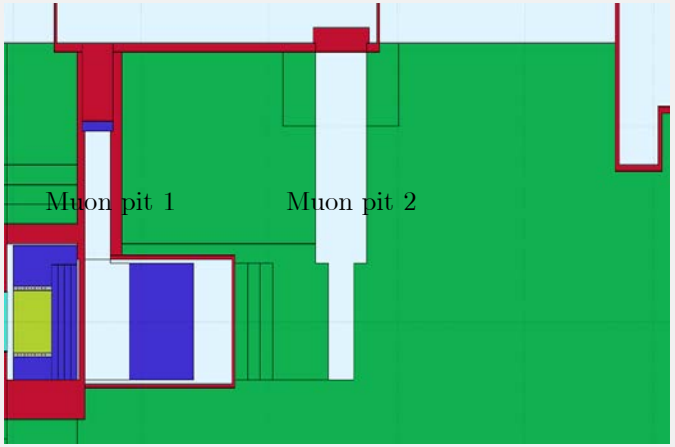
Target area, front view



Decay pipe area

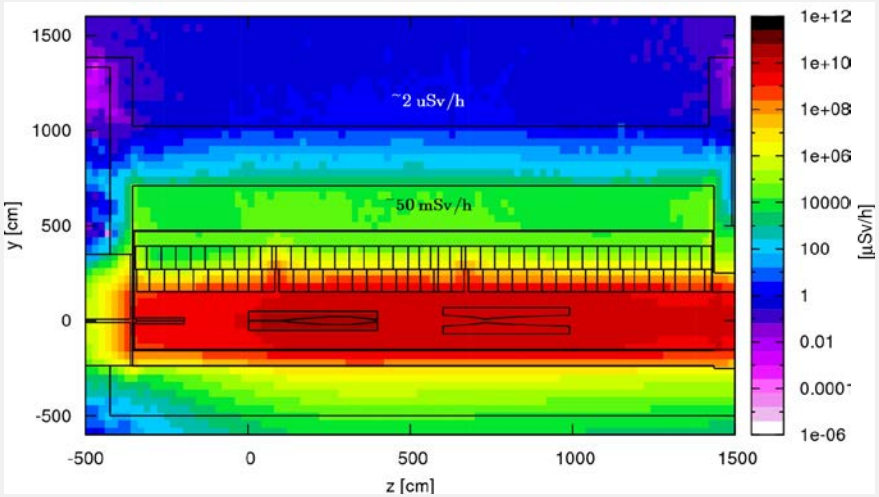


Dump/muon pit area

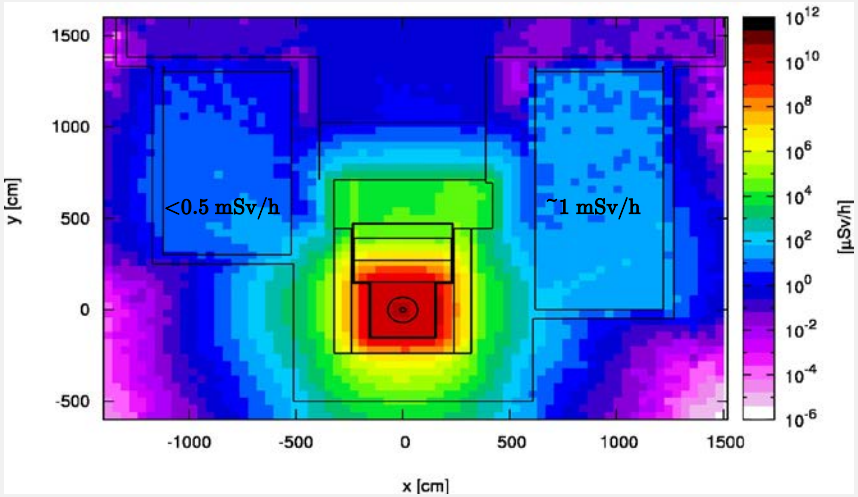


Prompt dose was studied for the different areas of the CENF secondary beam line

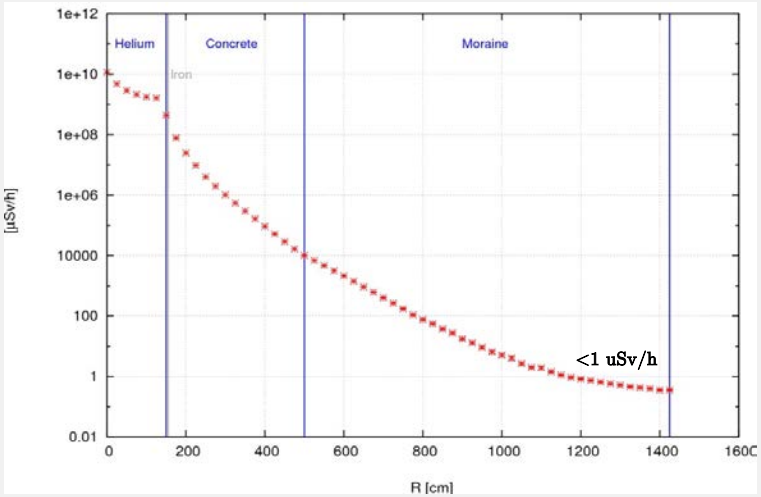
Target area, side view, [uSv/h]



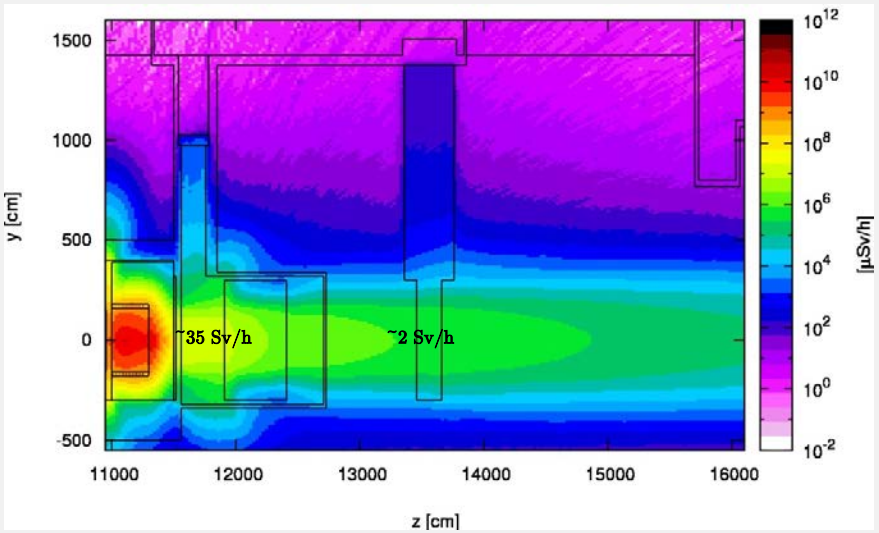
Target area, front view , [uSv/h]



Decay pipe area, [uSv/h]

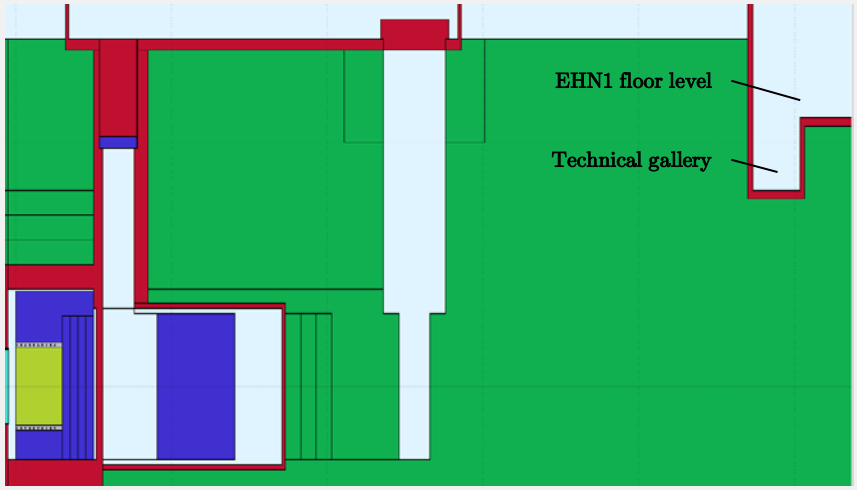


Dump/muon pit area, [uSv/h]

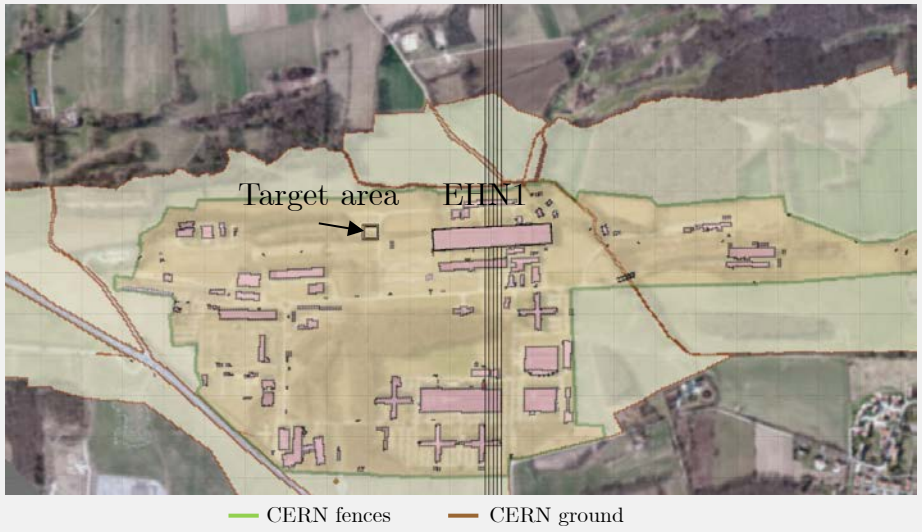


Prompt dose was also evaluated for the surrounding experimental and public areas

EHN1 experimental area

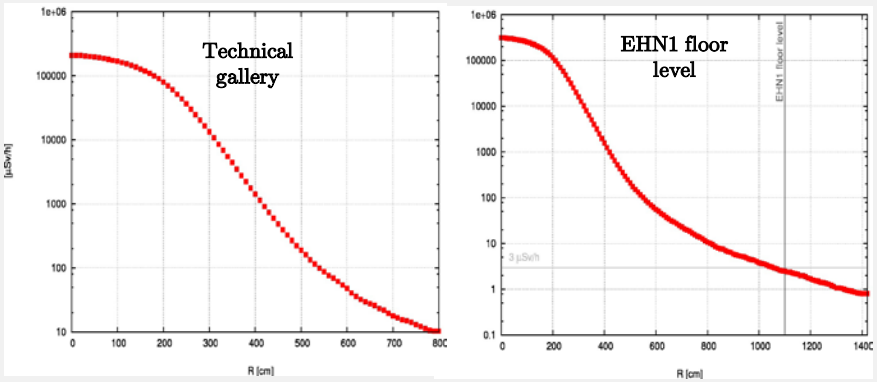


Public area

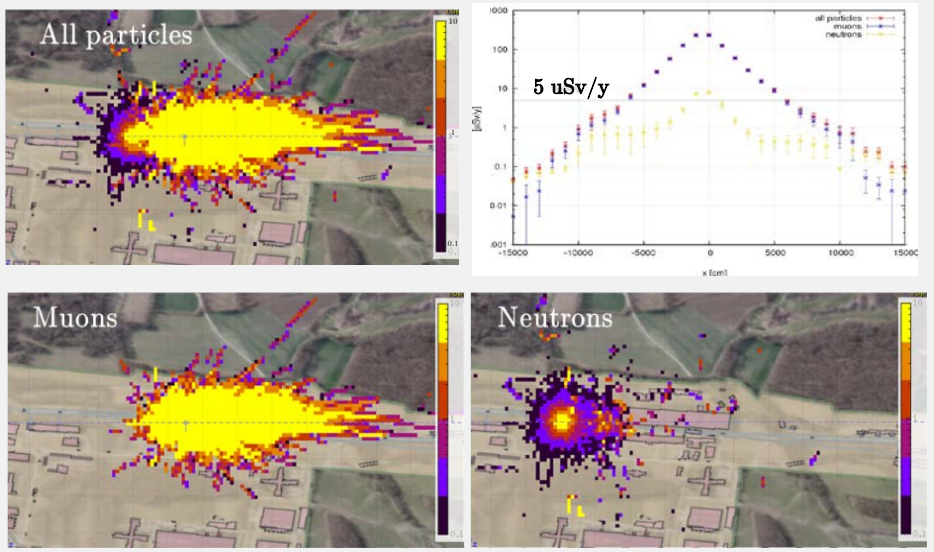


Prompt dose was also evaluated for the surrounding experimental and public areas

EHN1 experimental area, [uSv/h]



Public area, [uSv/y]

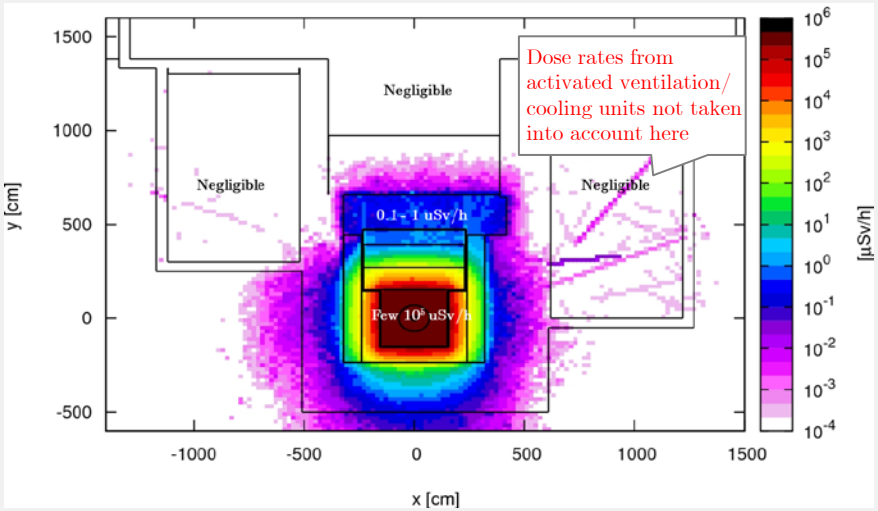


- Dose rates are brought down to 10uSv/h
- Dose rates lie below the envisaged 3 uSv/h
- Dose rates lie below the envisaged 5 uSv/y

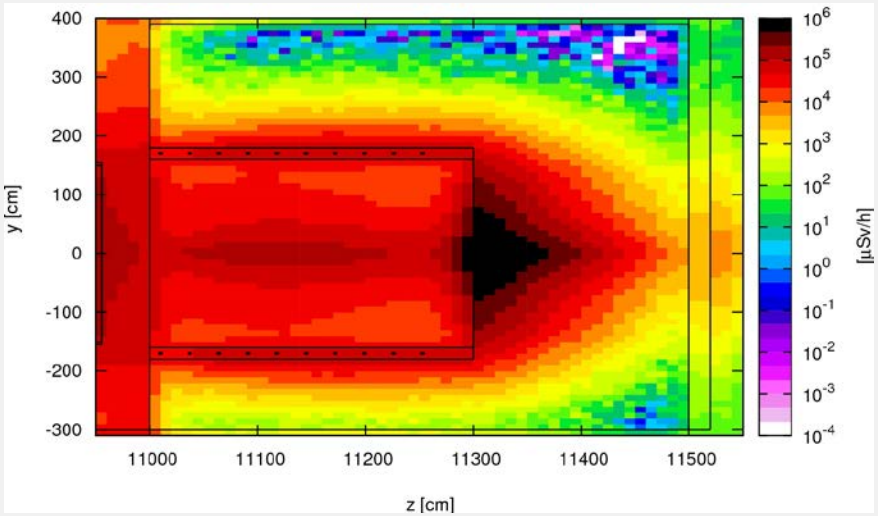
2 Residual dose

Residual dose was studied for the different accessible areas of the CENF secondary beam line

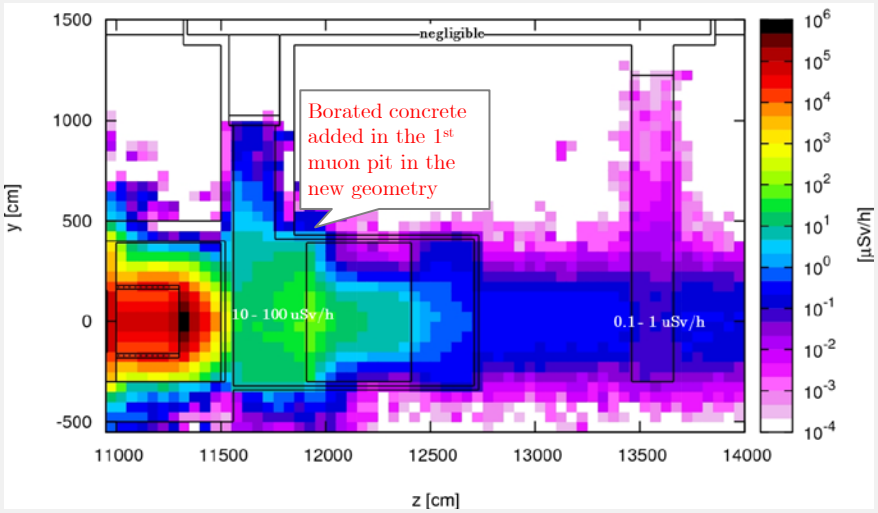
Target area, e.g. 1 day cooling



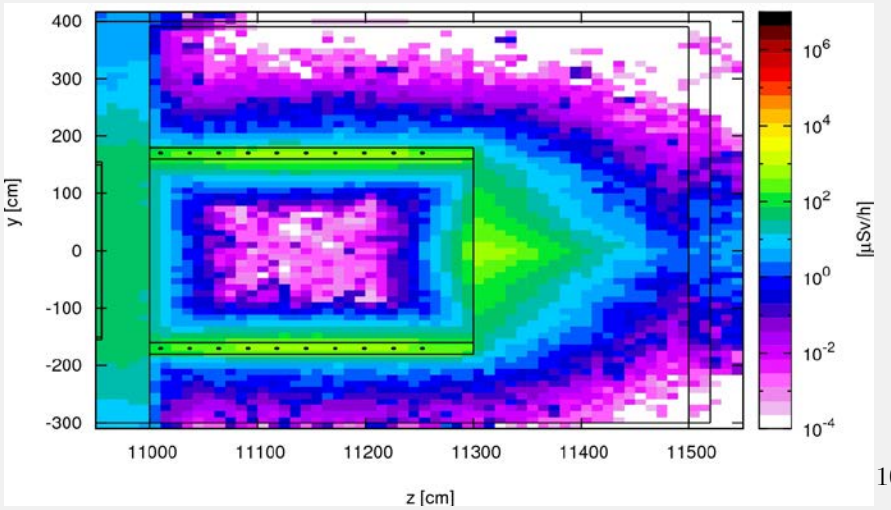
1st beam dump, centre, 1 day cooling



Muon pit area , e.g. 1 day cooling

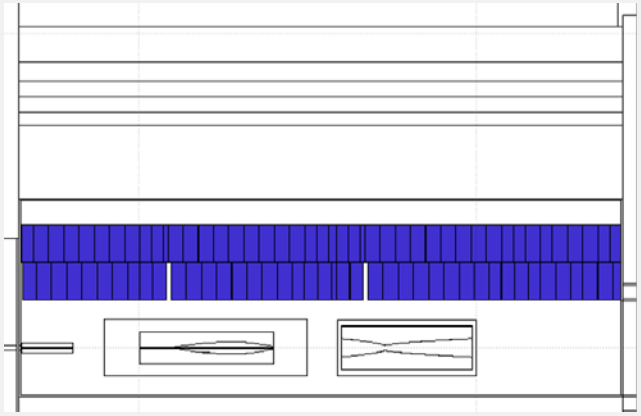


1st beam dump, centre, 10 years cooling



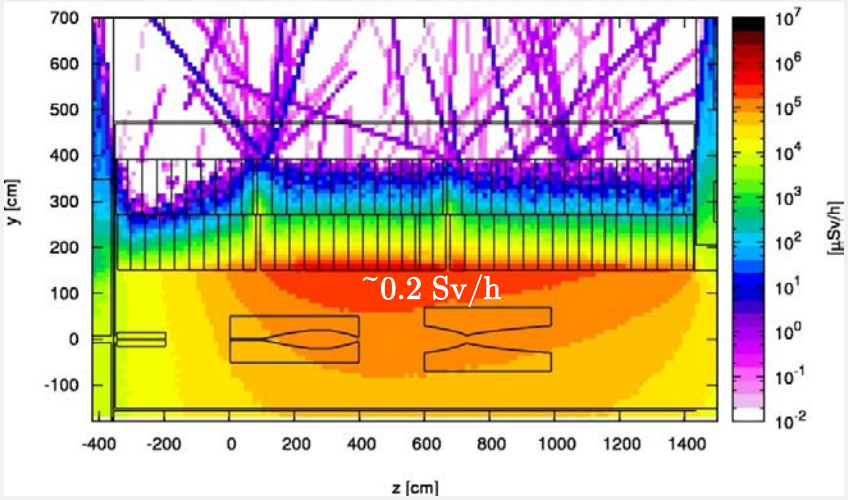
Residual dose of removable shielding as well as the target and horn has further been evaluated standalone

Removable iron shielding in target area

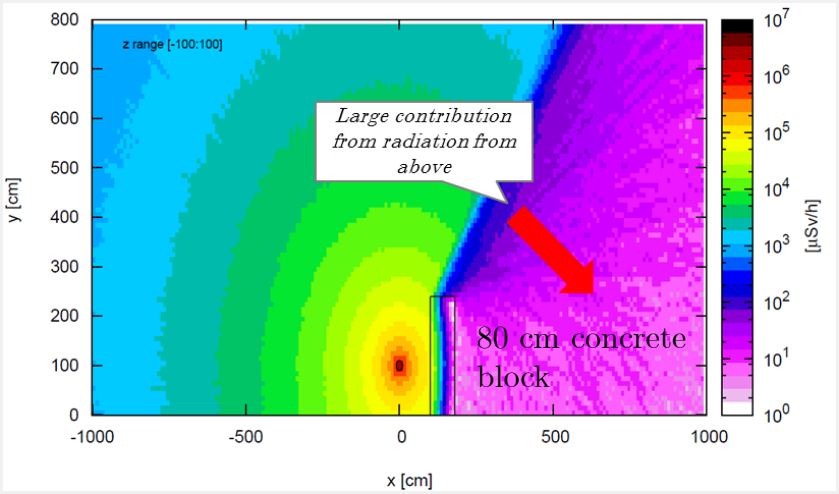


- Dose rates from the shielding blocks strongly vary depending on the location
- The iron shielding blocks reach dose rates of up to ~0.2 Sv/h after 1 day of cooling
- The concrete shielding blocks show low activation at the very bottom rising up to 10 uSv/h after 1 day of cooling
- Dose rates from the target and horn are of the order of 1 Sv/h after 1 day of cooling

Residual dose from iron shielding , e.g. 1 day cooling



Shielding required for movement of hot objects, e.g. target of 1 Sv/h



3 Air/He activation

Air activation has been evaluated for all air regions of the CENF secondary beam line

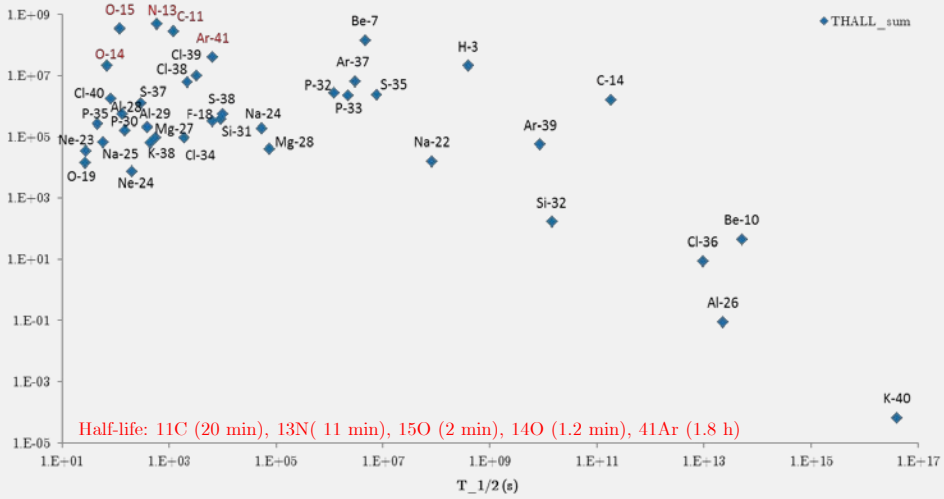
Air activation of areas filled with air

After 180 days of operation and isolated zones

	Activity [Bq]
Target hall	1.5E+3 ± 8%
Cooling room	1.4E+5 ± 10%
Morgue room	5.0E+3 ± 8%
Service pit	1.4E+9 ± 0%
B757	1.4E+1 ± 73%[1]
Pit1	2.9E+7 ± 1%
Pit2	3.5E+4 ± 2%
1st dump	5.0E+9 ± 0%

Produced radioactivity in the service pit

Activity in Bq after 0s cooling time as a function of half-life

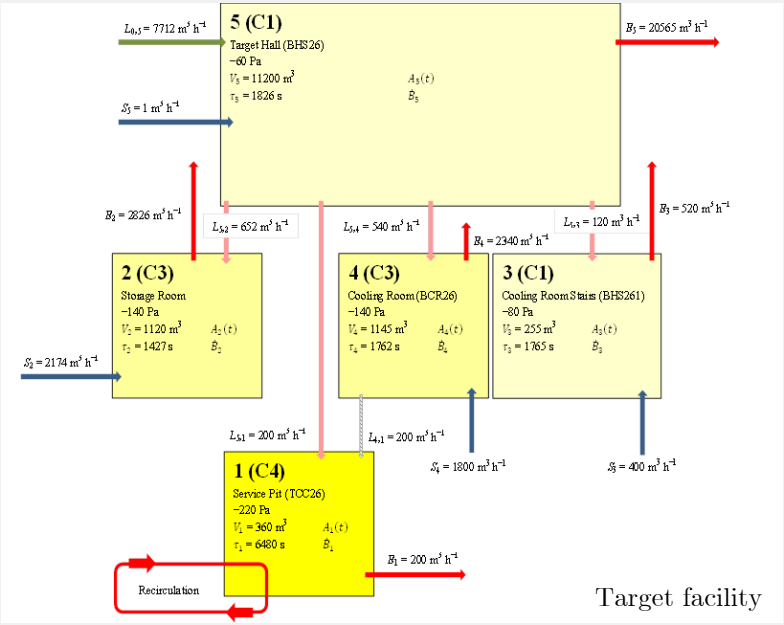


Production rates used for detailed environmental impact studies performed by SEE

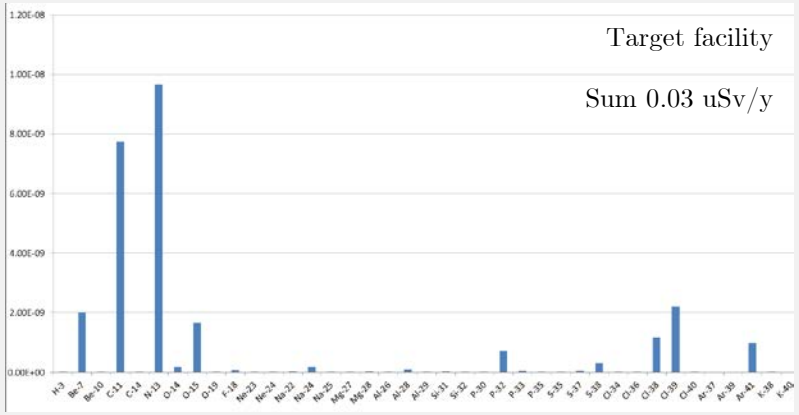
1. Values given only for completeness due to poor statistics

Emission of activated air into the environment and its dosimetric impact on the public was evaluated (P. Vojtyla DGS-SEE)

Scheme of multi-compartment model



Annual effective dose [Sv] due to emissions



Inputs:

- Production rates [Bq/s] in each compartment
- Designed extraction and leak rates
- Wind directions and hypothetical houses along the fence of the site

Assumption:

- 180 days with 4.5e19 POT

Objective:

- To stay below 10 TBq of short-lived radioactive gases that cannot be retained by filters
- To stay below 5 uSv/y together with the other sources of radiation

- Calculations result in releases of ~0.6 TBq of short-lived gases from all air-filled regions of the facility
- Resulting effective doses from emission of activated air amounts to 0.03 uSv/year

Furthermore, the activation of the He-filled regions has been evaluated

Activation of He and air inside the He-regions

	100% He-filling [Bq]	100% air filling [Bq]
He-vessel	5.3E+09 ± 0%	3.9E+11 ± 0%
Decay Pipe	5.7E+09 ± 0%	6.9E+11 ± 0%
Decay Pipe cooling	7.5E+07 ± 0%	4.9E+9 ± 0%

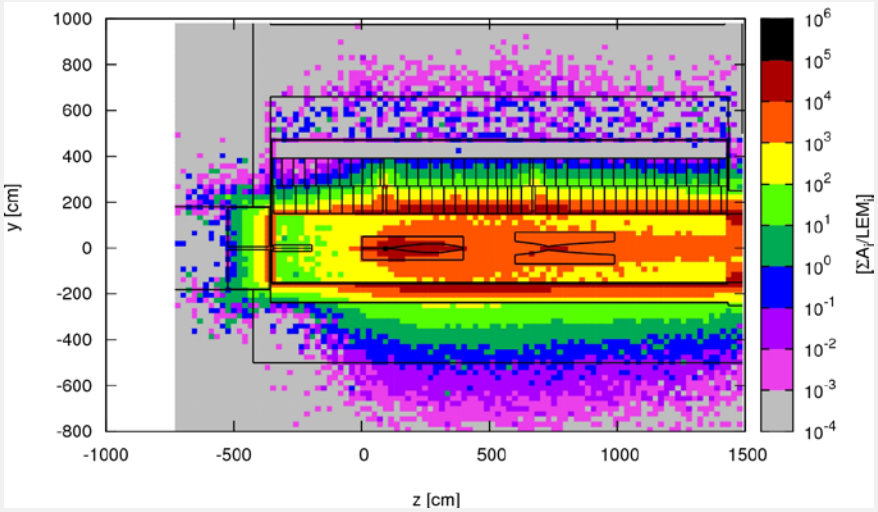
- Activation of the He-filled regions has been evaluated for two scenarios:
  - 100% He-filling
  - 100% air-filling
- The 2nd scenario allows to define the acceptable air contamination in He (e.g. 1%, 0.1%, ppm-level)
- As expected, the activation of air results in much higher total activity than of He
- Also the radiological impact from air is much higher than for He

➢ Preliminary environmental impact studies show that a 0.1% air contamination should at least be envisaged (~7.6 TBq/y and ~0.3uSv/y)

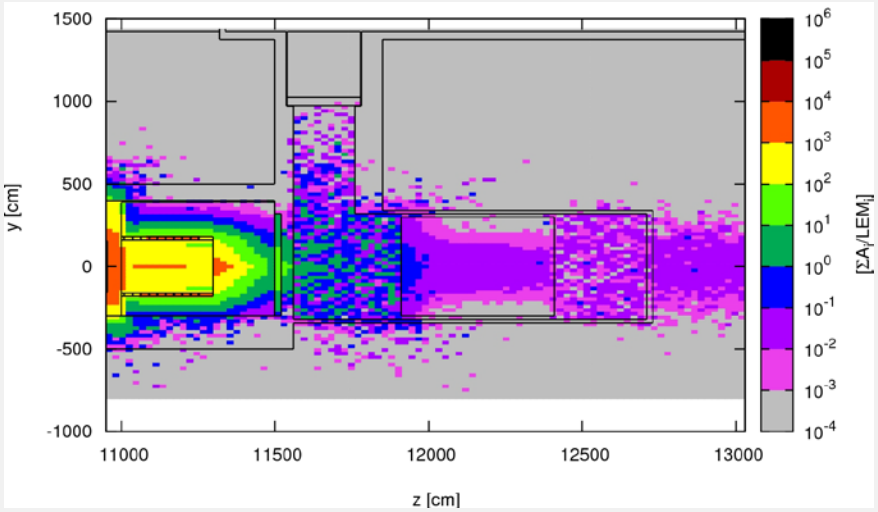
4 Waste zoning

A waste study has been performed to predict the amount and characteristics of radioactive waste produced at CENF

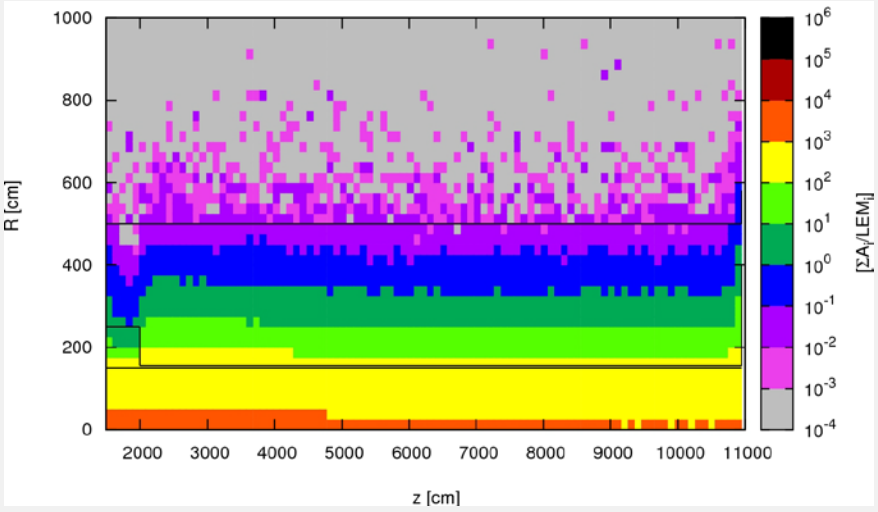
Target area, e.g. 10 years cooling



Muon pit area, e.g. 10 years cooling



Decay pipe, e.g. 10 years cooling



— To exempt a material containing a mixture of radio-nuclides of artificial origin from any further regulatory control, the following sum rule should be complied:

$$\sum_{i=1}^{n} \frac{a_i}{LE_i} < 1$$

a_i - specific activity (Bq/kg) or total activity (Bq) of the i^{th} radio-nuclide
LE_i - respective CERN exemption limit[1] for the radio-nuclide i
n - number of radio-nuclides present

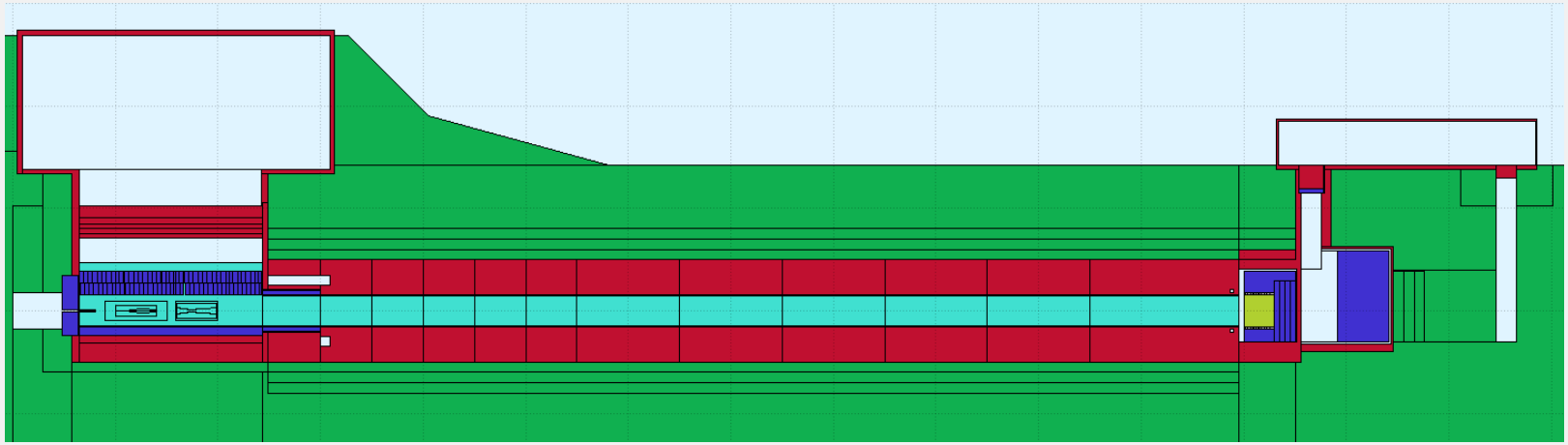
— If the sum rule is not fulfilled, the material is radioactive

1. Exemption limits for design studies have been used, which are lower or equal to limits that will be adopted by future European Directives and national legislations

5 Soil activation

Soil activation and leaching of radioactivity into surface water is currently under investigation

Current geometry



Environmental considerations
(P. Vojtyla, DGS/SEE)

- Geo-membrane shall include all zones with
  - H-3 > 10 Bq/kg
  - Na-22 > 2 Bq/kg
  - Na-24 > 2 Bq/kg
  - V-48 > 7 Bq/kg

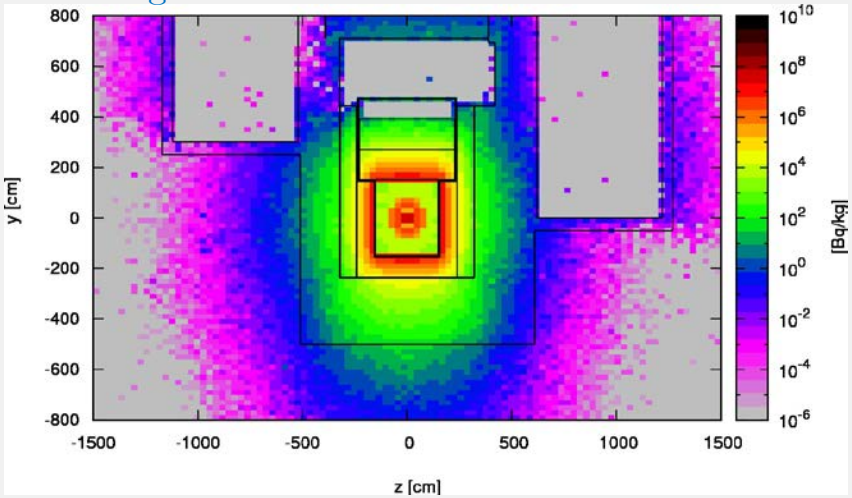
FLUKA studies

- FLUKA studies were based on the **worst case scenario** with 180 days of operation assuming 1.25e13 p/s
- Soil composition has been based on elemental analyses of soil samples taken during site investigation

Preliminary studies of soil activation show relatively low activation

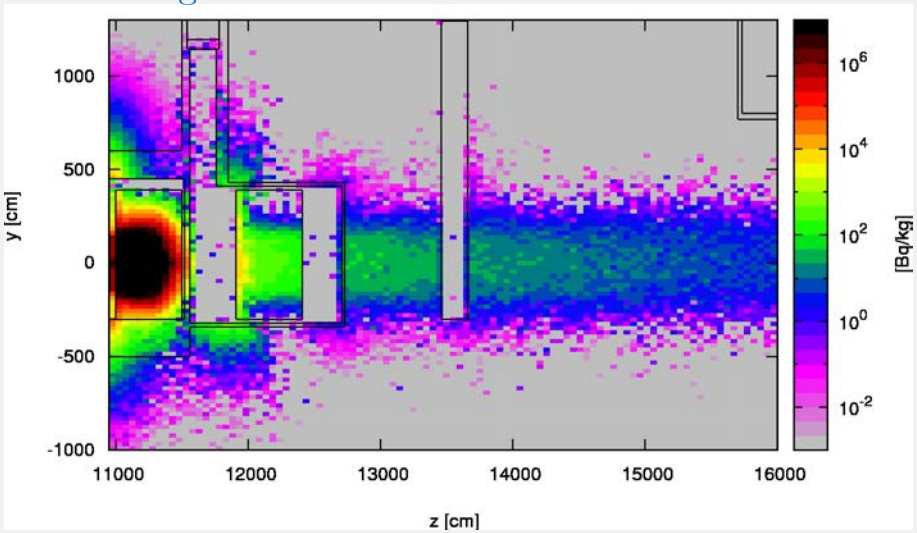
Preliminary H-3 activation in target area

1 s cooling



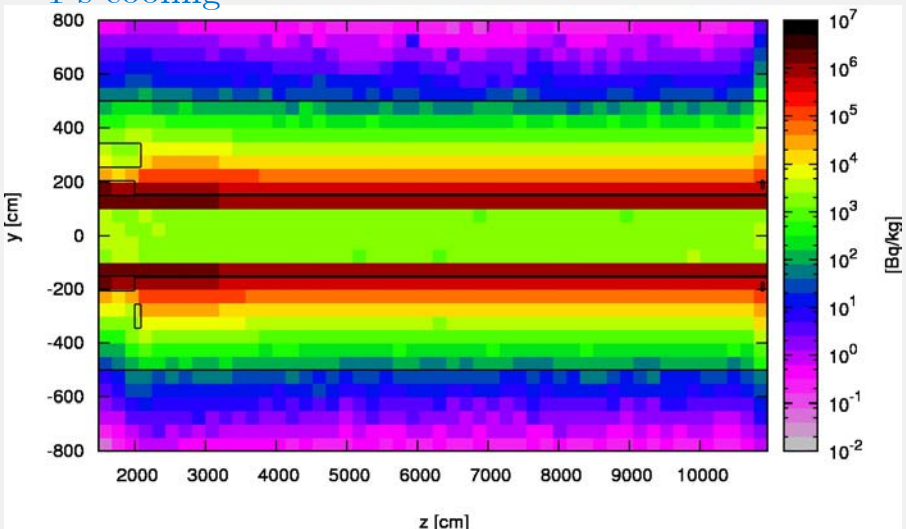
Preliminary H-3 activation around the dump area

1 s cooling



Preliminary H-3 activation around decay pipe

1 s cooling



- Preliminary soil activation studies show that critical areas lie below the target area, around the 1st and behind the 2nd beam dump
- Areas should be enclosed by a geo-membrane
- Evaluation of the environmental impact still ongoing

Summary

In order to respect the applicable CERN radiation protection legislation regarding doses to personnel as well as the environmental impact, a full radiological assessment of the CENF facility is carried out

Studies include:

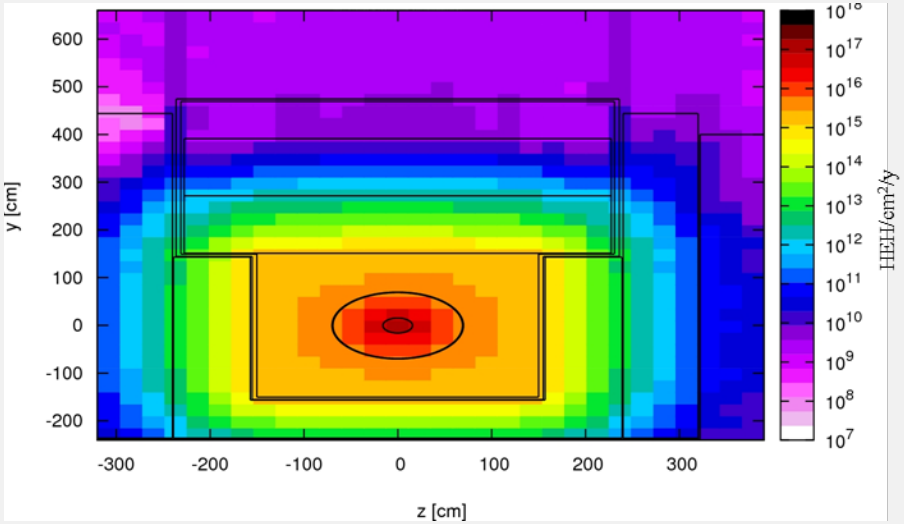
- Prompt dose rates
- Residual dose rates
- Air activation
- Waste zoning
- Soil activation
- High energy hadrons and cumulated dose (not discussed here)

Results are being used for optimizing the CENF design with regards to radiation protection

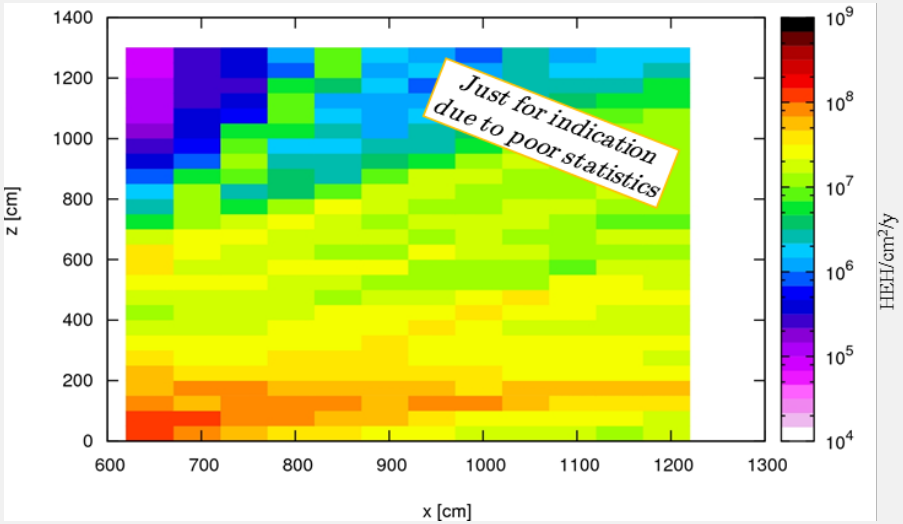
Backup slides

Overview of studies connected to the cumulated HEH fluence and dose

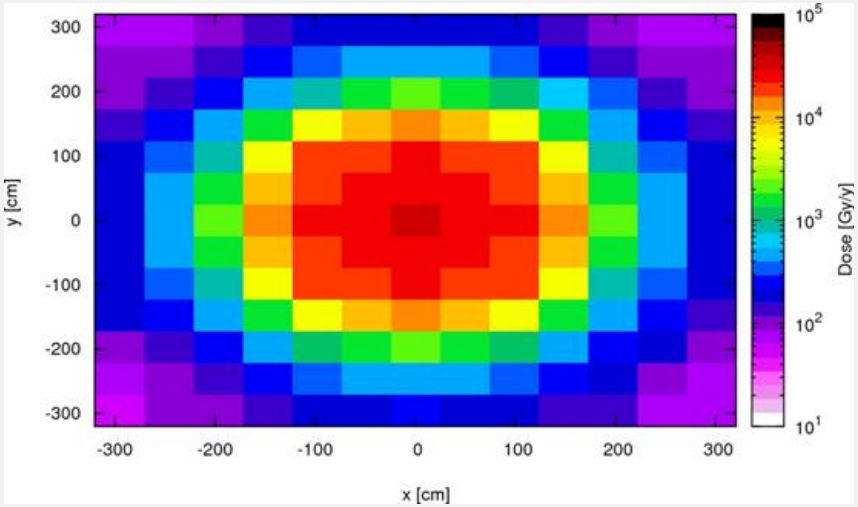
Target area, e.g. HEH at reflector



Target area, e.g. HEH in cooling room



Muon pit area, e.g. dose in 1st muon pit



Muon pit area, e.g. dose in 2nd muon pit