Center for the Advancement of Natural Discoveries using Light Emission

Radiation Safety for AREAL Phase 1

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Contents

Radiation Exposure Limits

Application	Dose limit Occupationally exposed person	Dose limit Member of public (other than workers)
Effective dose	20 mSv per year averaged over a period of 5 consecutive calendar years	1 mSv in a year
Equivalent dose to: (a) lens of the eye	150 mSv in a year	15 mSv in a year
Skin	500 mSv in a year	50 mSv in a year
The hands and feet	500 mSv in a year	No limit specified

Even the smallest exposure has some probability of causing a stochastic effect, such as **cancer**. This assumption has led to the general philosophy of not only keeping exposures below recommended levels or regulation limits but also maintaining all exposure **"as low as reasonable achievable" (ALARA).**

[1] Radiation Control Regulation 2013 under the Radiation Control Act 1990

Equivalent Dose Thresholds for AREAL Phase 1

1. Measured natural background radiation level near AREAL is (0.17÷0.23 μSv/h)

2. Taking into account fluctuations **~0.06 [μSv/h]** of natural background radiation alarm level of equivalent dose in affected areas should be set to **0.3[μSv/h]** that corresponds to cumulative dose not greater than **50 μSv** per week

3. For members of the general public protective measures must ensure that radiation levels in affected areas do not give rise to an equivalent dose greater than **40 μSv/h** per week

The fact that alarm level 0.3 μSv/h was chosen doesn't mean that for us permanent dose levels between (0.23÷0.3) μSv/h are satisfactory. It was chosen higher In order to prevent alarm system working because of fluctuations.

We will monitor radiation around AREAL and in case of detection of high dose levels between (0.23÷0.3) μSv/h (that wasn't caused by fluctuations) we will perform necessary actions in order to protect workers.

Possible Scenarios of Beam Loss

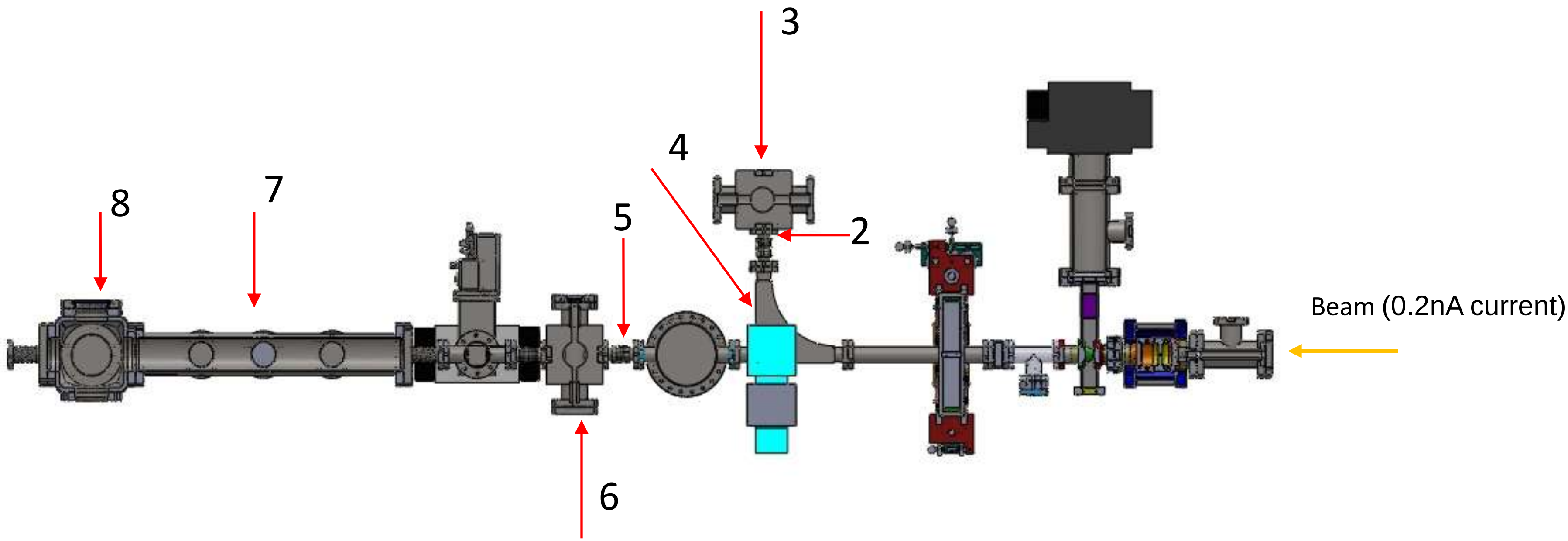


Fig.1 (1,4) Dipole chamber, (2,5) FC (Faraday Cup),
(3,6,8)-YAG Screen with mirror, (7) Tungsten mask inside a PPT

Table 1. Materials that were used in simulations

PPT Tube	Dipole Chamber	Mirror	Yag Screen	FC (Faraday Cup)	Tungsten mask
SS316LN (Stainless Steel)	SS316LN (Stainless Steel)	SiO2 (Silicon Dioxide)	Y3Al5O12	Al (Aluminum)	Tungsten

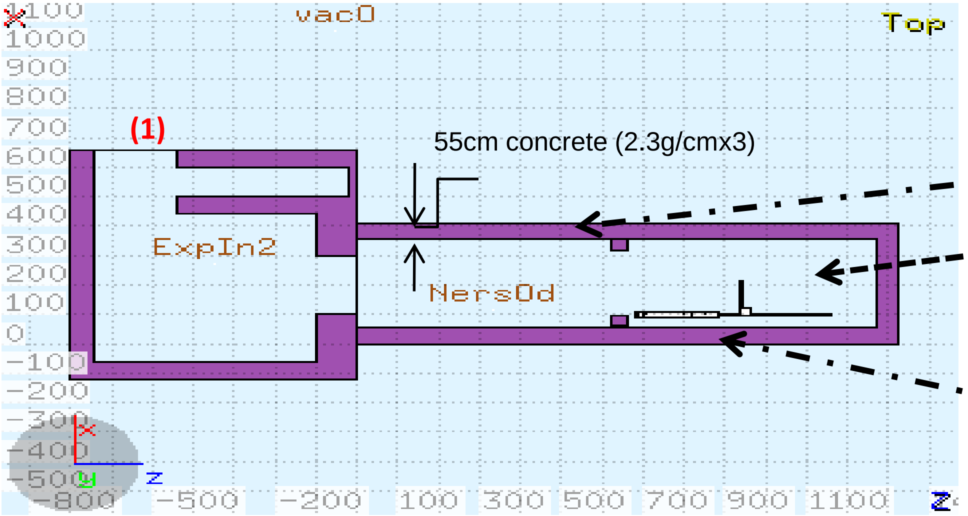


Fig. (2) Tunnel (XZ), (1) tunnel entrance (gates)

Fig. (3) Communication hole with concrete canopy, (ZX)

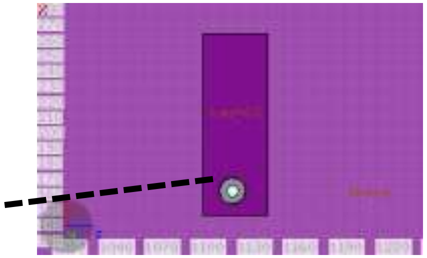


Fig. (4) Laser room hole with concrete and lead shielding, (ZX)

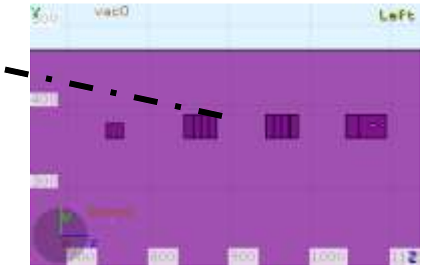


Fig. (5) RF room holes with concrete shielding, (ZY)

Radiation Levels **without shielding** in front of holes

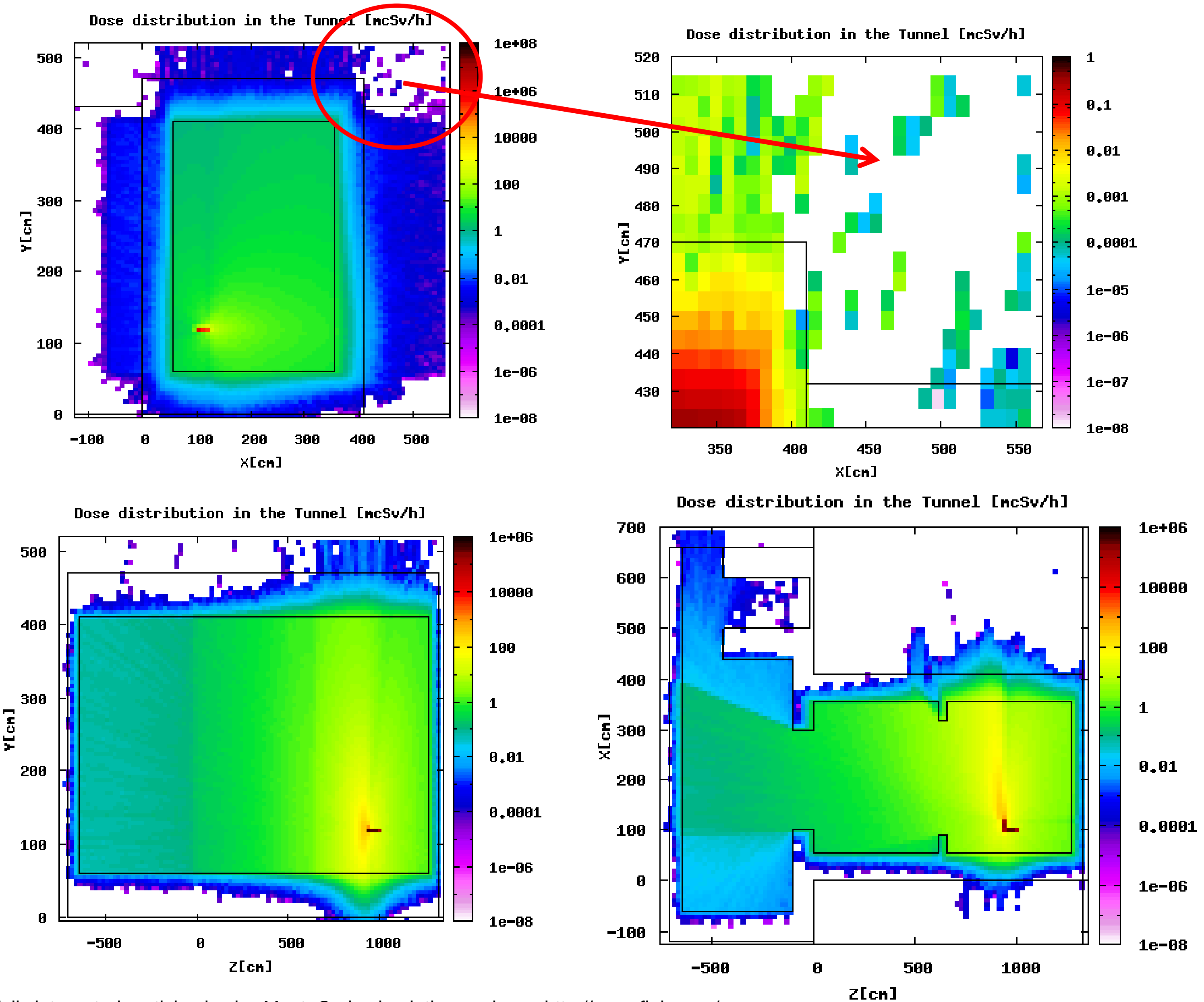
Table 2. Dose rates produced by AREAL operation without shielding

Gates Fig. (2)	<0.01[µSv/h]
Communication hole Fig. (3)	0.02-0.07[µSv/h]
Laser Room Hole Fig. (4)	0.01-0.2[µSv/h]
RF room holes Fig. (5)	0.05-0.5[µSv/h]

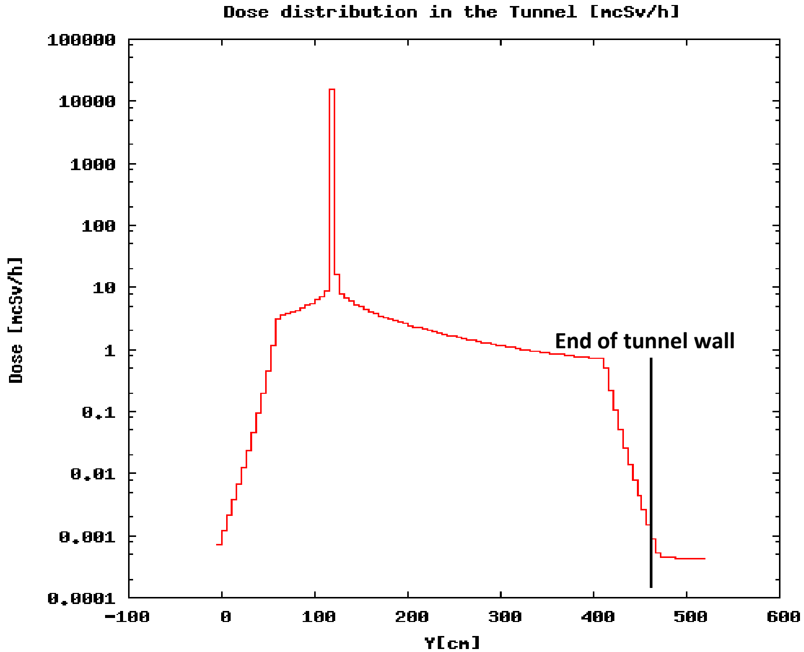
Exaggeration of dose is possible in front of holes so additional arrangements should be done in order to keep radiation level according recommendation by Act of Radiation Control Regulation 2013 [1]

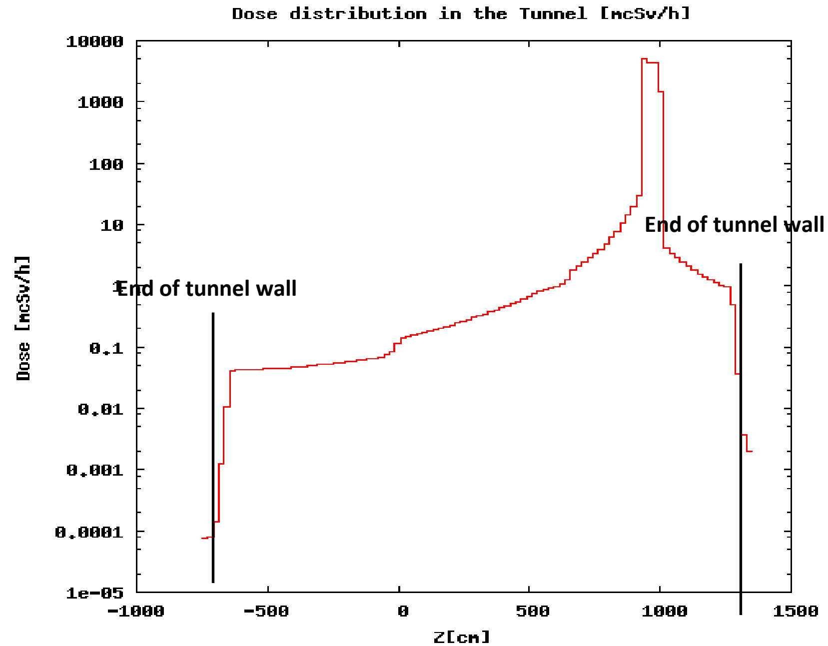
[1] Radiation Control Regulation 2013 under the Radiation Control Act 1990

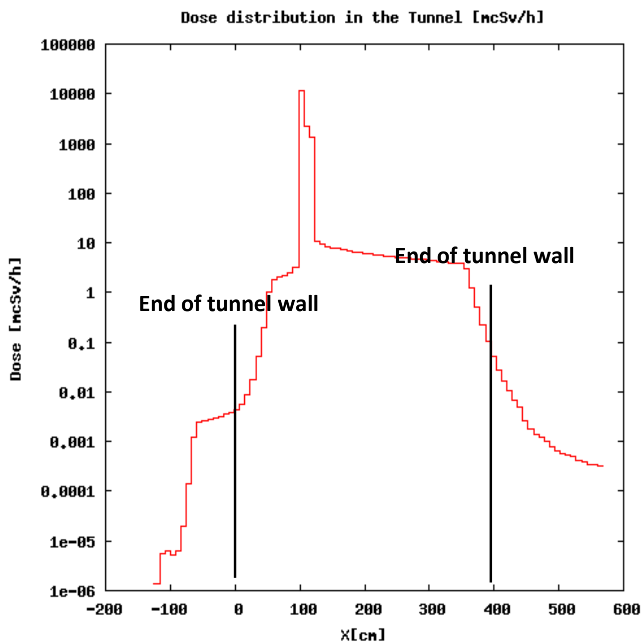
Dose Distribution **with shielding,** [μSv/h]

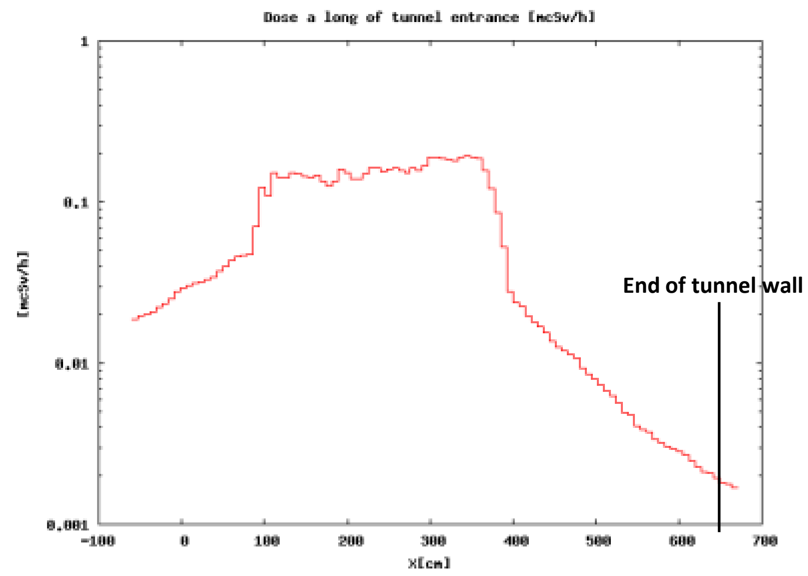


[2] FLUKA. A fully integrated particle physics MonteCarlo simulation package, http://www.fluka.org/



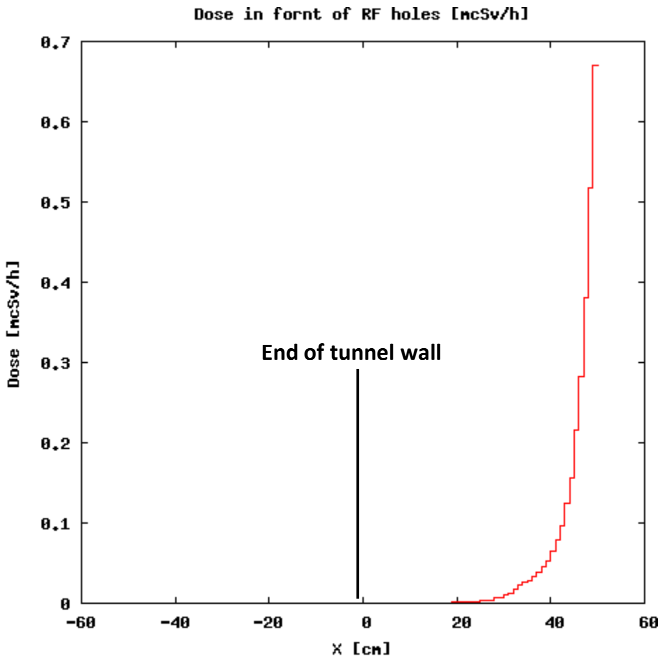


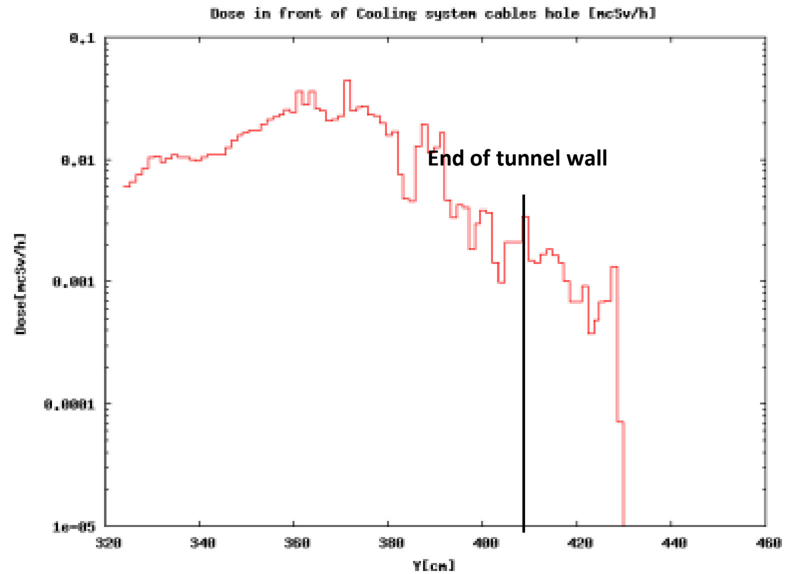




[2] FLUKA. A fully integrated particle physics MonteCarlo simulation package, http://www.fluka.org/

Dose in front of holes of the tunnel





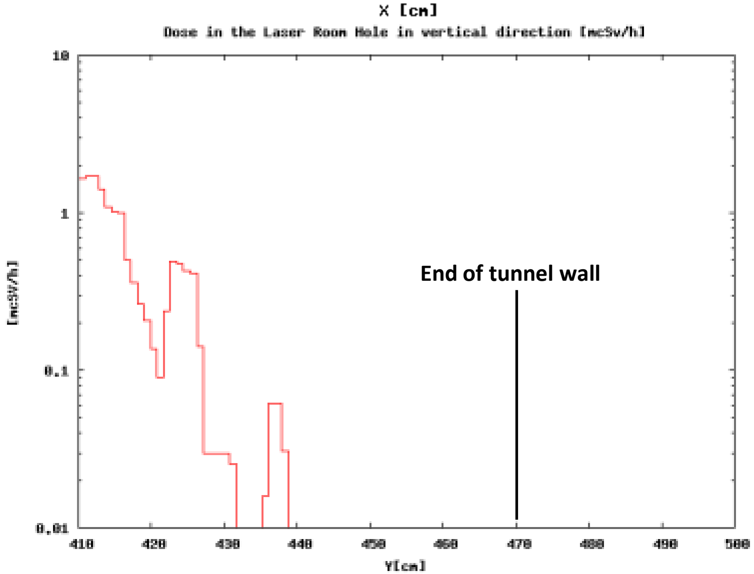


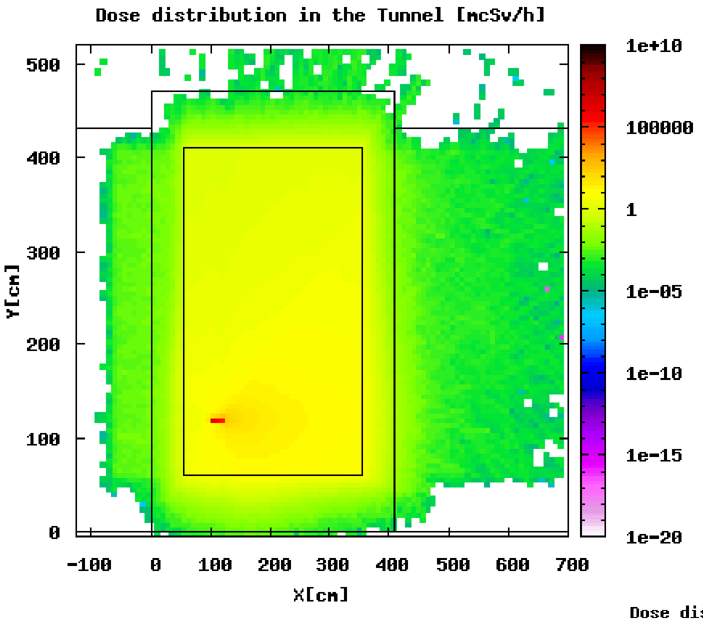
Table 3. Dose rates produced by AREAL operation with shielding

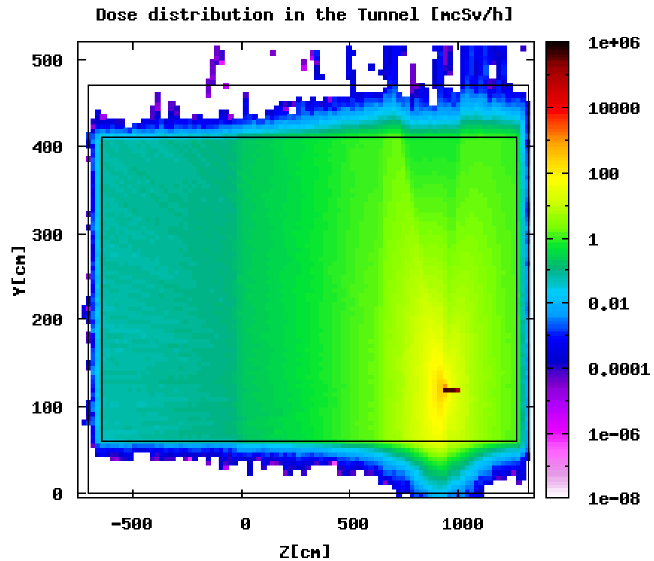
RF room holes Fig. (3)	<0.001 [μSv/h]
Laser room hole Fig. (4)	<0.001[μSv/h]
	≤0.01[μSv/h] when beam hits the dipole chamber walls
Communication hole Fig.(5),	<0.001 [μSv/h]

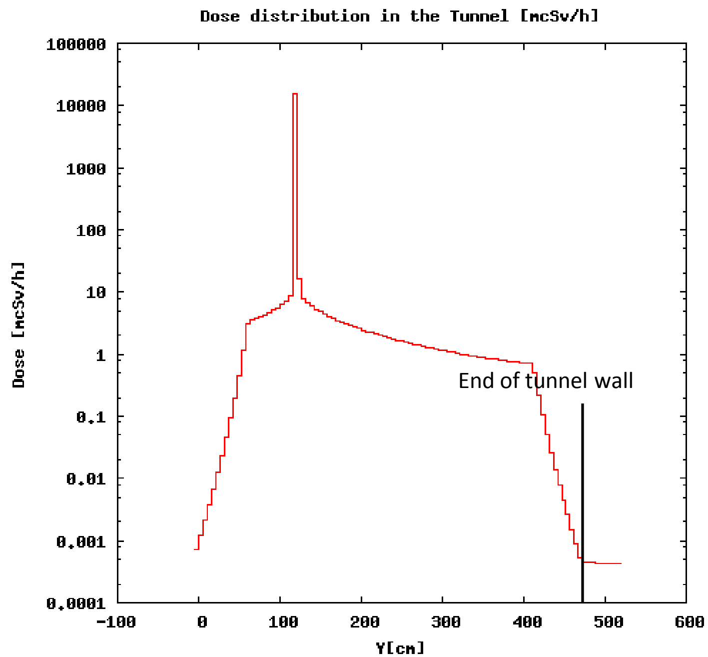
Dose rates produced by areal are less than natural background fluctuations **0.06 [μSv/h]**

[2] FLUKA. A fully integrated particle physics MonteCarlo simulation package, http://www.fluka.org/

Dose Distribution in the Tunnel with 20x10x6cm Lead Canopy Placed Onto Hit Point







With canopy dose can be reduced about **5-10 times** depending on sizes of canopy

[2] FLUKA. A fully integrated particle physics MonteCarlo simulation package, http://www.fluka.org/

Radiation Monitoring

“SOEKS Defender”

“Gamma-Scout”

Interlock System

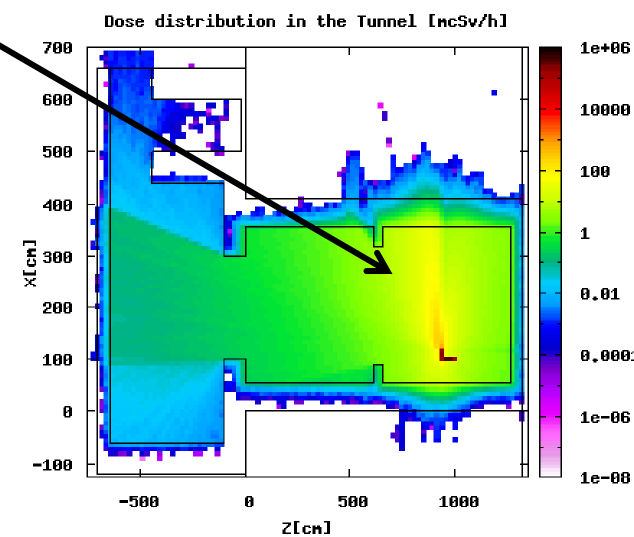


Table 4. “SOEKS Defender”

Operating Range	0.1 µSv/h up to 1000.00 µSv/h
Minimal Gamma Detection	from 0.1Mev
Measurment range of cumulative dose, SV	Up to 1000Sv
Time of measuremnts, seconds	20

Table 5. “Gamma Scout”

Operating Range	0.01 µSv/h up to 1000.00 µSv/h
Minimal Gamma Detection	from 30 keV
Minimal Beta Detection	0.2 MeV
Minimal Alpha Detection	from 4 MeV
Connection with PC	USB

What do we have in order to prevent radiation exposure?

Lead bricks

Concrete bricks

1. Lead ≈ 1000Kg
2. Concrete(M400) Bricks (20x10x6cm)– 850pcs.

Summary

1. Detailed simulations were done for AREAL building using FLUKA.
2. Areas where radiation hazard is possible were figured out and necessary arrangements were planned in order to prevent radiation exposure outside of the tunnel.
3. Radiation level produced by AREAL will be less than fluctuations of natural background radiation and will not represent any danger for environment.
4. Necessary detectors were ordered so we can do monitoring and reveal dangerous exposure and perform immediate actions in order to prevent exposure of personnel.
5. Shielding in laser room is completed

Next to do

1. Mounting dosimeters in the tunnel and testing
2. Completing RF holes shielding when RF waveguide position will be fixed
3. Putting concrete canopy onto communication hole of cooling system when mounting will be finished

Thank You!