



HSE
Occupational Health & Safety
and Environmental Protection unit

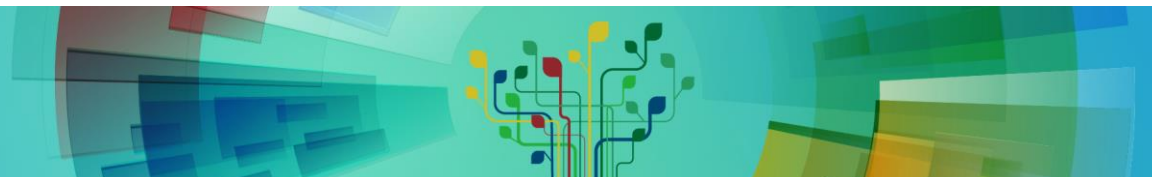


Shielding update for AMBER Drell-Yan at EHN2 – #6

A. Devienne and C. Ahdida
HSE-RP

28/01/2022

[EDMS 2685411](#)

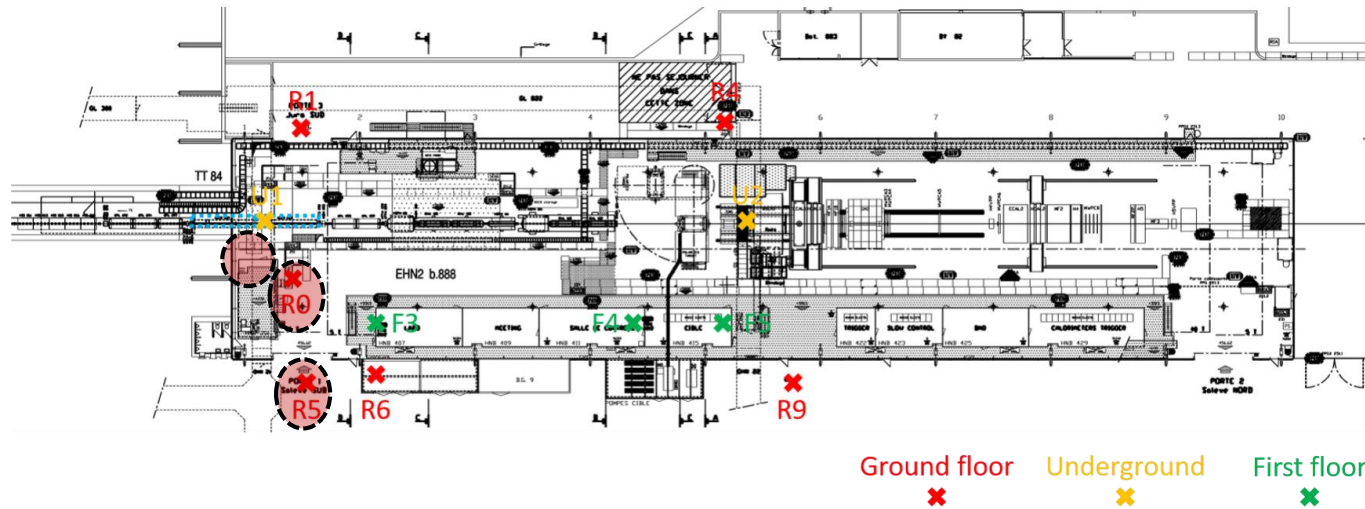


Outline

- Context
- Objective
- Shielding design
- Preliminary results
- Conclusions

Context

- Preliminary studies available for EHN2 with geometry, source term and beam losses [1]
- High prompt dose rates measured in operation at several accessible EHN2 locations [2],[3]
- Optimization of environmental impact at CERN reference points [4]









Objective

- Additional shielding at strategic EHN2 locations to comply with radiation area classification
- Design new shielding bunker for AMBER Drell-Yan
- Air activation assessment
- Skyshine optimization

Area	Annual dose limit (year)	Specific airborne radioactivity	Specific surface contamination
Non-designated	1 mSv	0.05 CA	1 CS
Supervised	6 mSv	0.1 CA	1 CS
Simple Controlled	20 mSv	0.1 CA	1 CS
Limited Stay	20 mSv	100 CA	4000 CS
High Radiation	20 mSv	1000 CA	40000 CS
Prohibited	20 mSv	> 1000 CA	> 40000 CS

Radiation Area (left side) / Controlled Area (right side)

Area	Annual dose limit (year)	Ambient dose equivalent rate		Sign
		permanent occupancy	low occupancy	
Non-designated	1 mSv	0.5 µSv/h	2.5 µSv/h	
Supervised	6 mSv	3 µSv/h	15 µSv/h	
Simple Controlled	20 mSv	10 µSv/h	50 µSv/h	
Limited Stay	20 mSv	-	2 mSv/h	
High Radiation	20 mSv	-	100 mSv/h	
Prohibited	20 mSv	-	> 100 mSv/h	

Radiation Area (left side) / Controlled Area (right side)

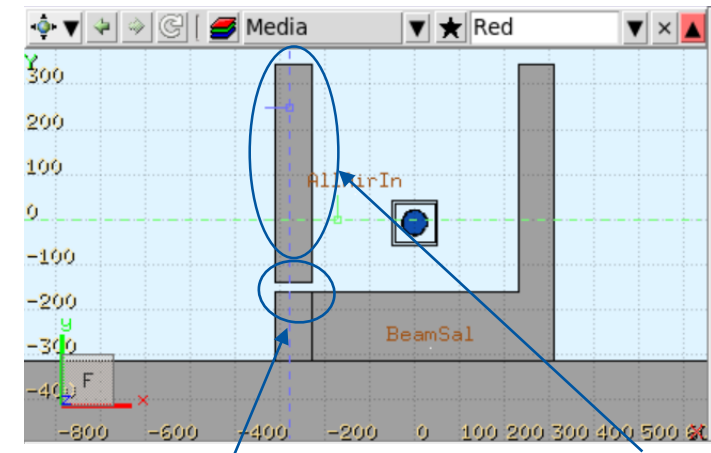
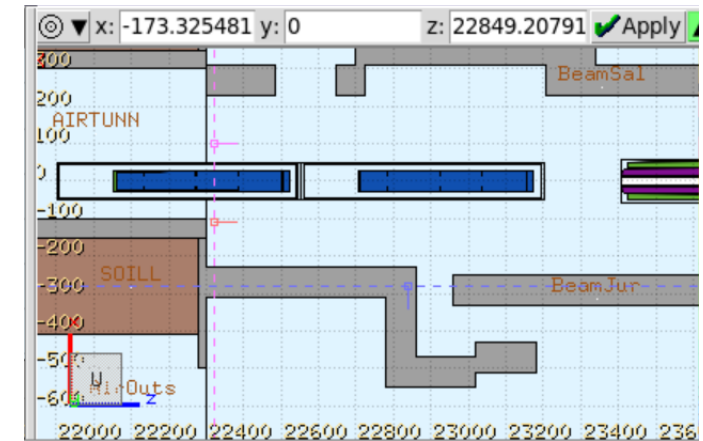
Shielding design

- Jonction EHN2/TT84 (Proposal BE-EA):

Jonction EHN2/TT84



✓ Implemented in FLUKA model

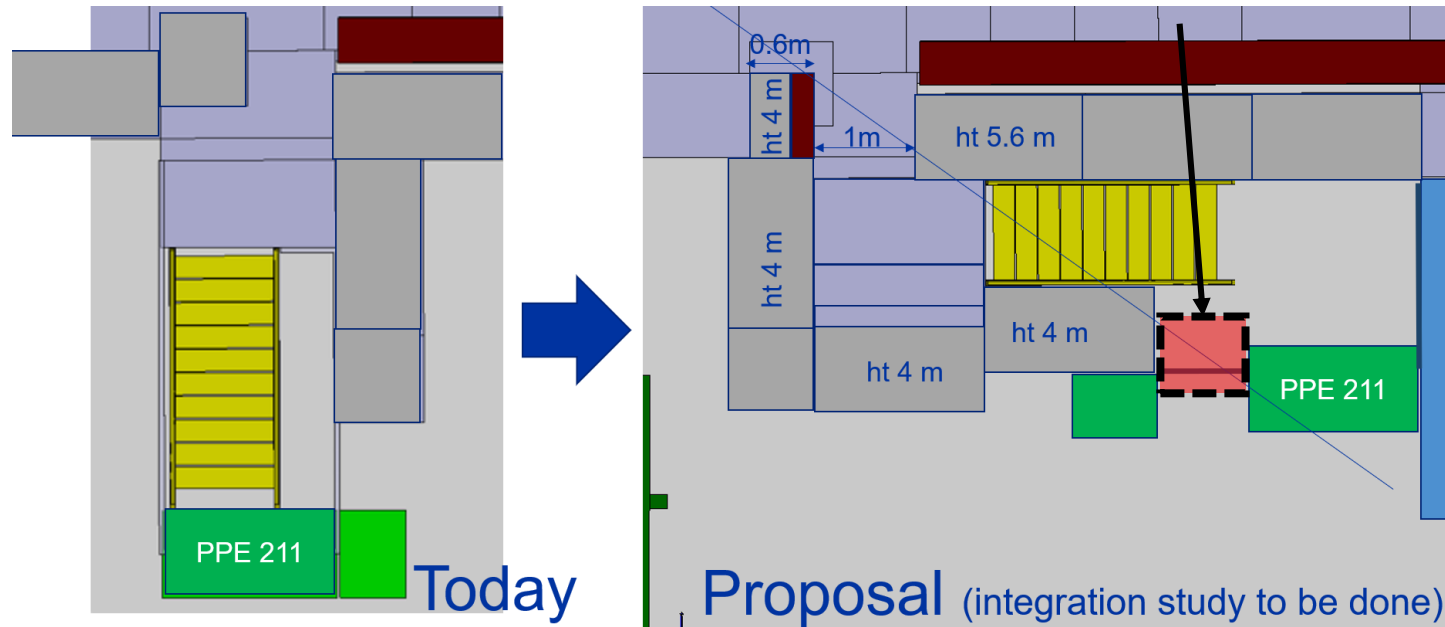


Opening for cables at inside ground level : 40 cm (width) x 20 cm (height)

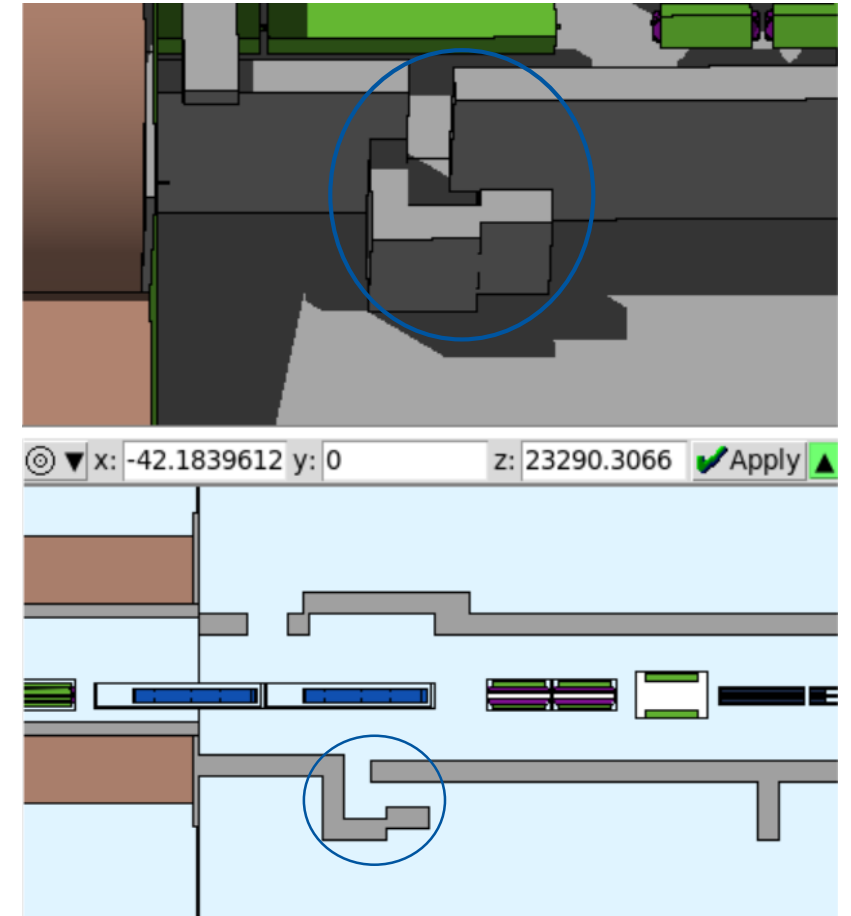
Concrete bricks to fill gap according to proposal

Shielding design

- Chicane PPE211 (Proposal BE-EA)



✓ Implemented in FLUKA model

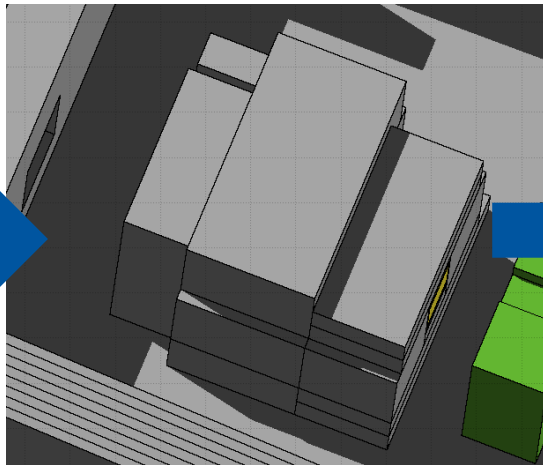


Shielding design

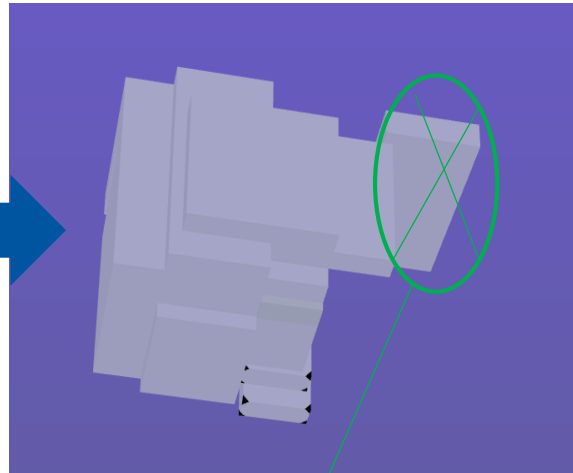
- AMBER Target bunker (proposals evolution)



Current situation

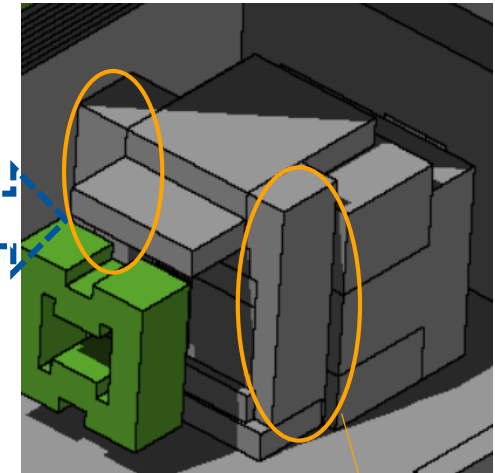
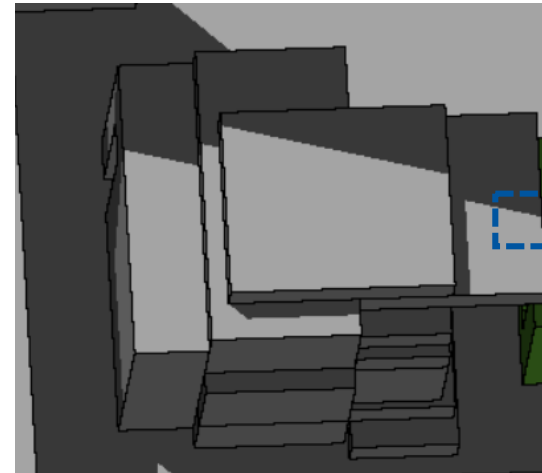


Initial AMBER/RP proposal
(ARP0)



1st preliminary EA design
(EA1)

✓ Lateral shielding not implemented due to space constraints
(see discussion from last meeting on 18.02)



2nd RP proposal for Test
(RP2)
✓ Top laterals reinforced

Preliminary results

- Prompt radiation : successful investigations

Auxiliary files (V56)

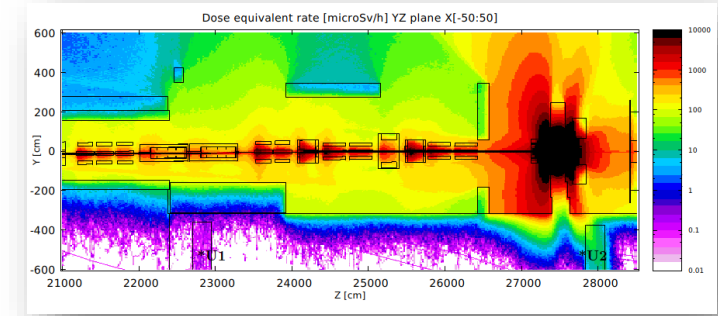
- dist_px
- dist_py
- dist_xxpr
- dist_yypr
- mbn_mea
- mbp → (last MBP scaling factor 1.5)
- qpl_qps_v2
- qwl

- ✓ Magnet aperture MBP reverted from 14 cm to 11 cm following discussion with BE-EA
- ✓ Original map file *mbp.map* modified for last MBP magnetic field (+50%) to correct losses and center beam vertically in target
- ✓ RP initial proposal for AMBER Bunker (RP1)

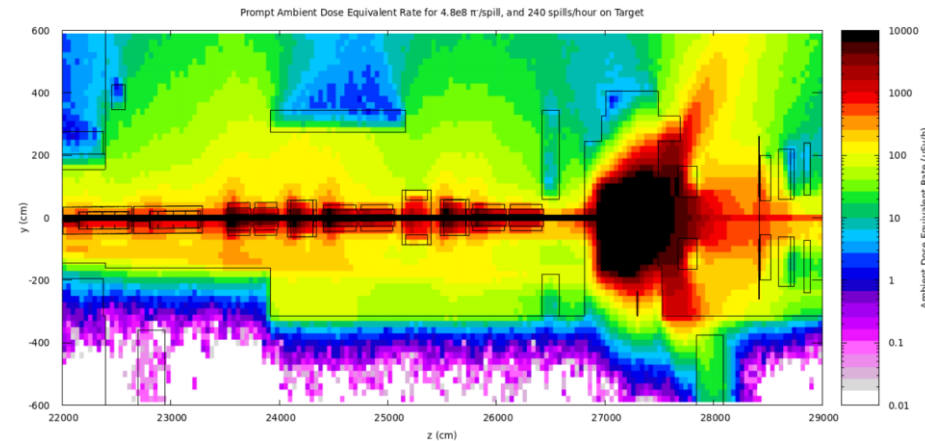
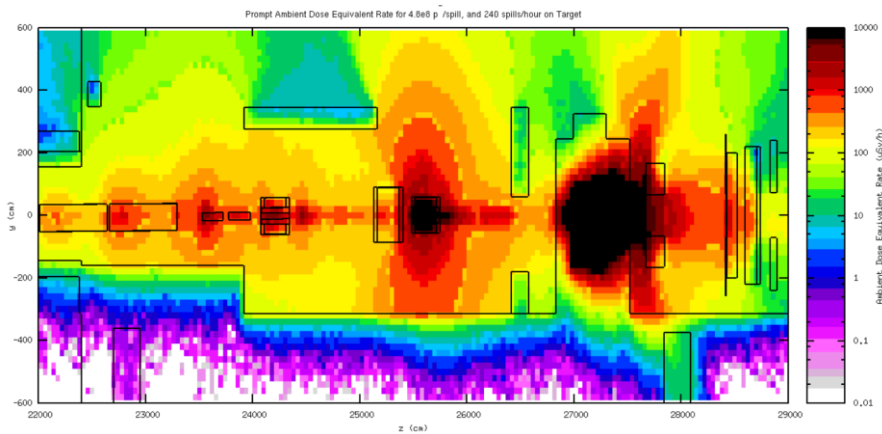
Auxiliary files (V65)

- dist_px
- dist_py
- dist_xxpr
- dist_yypr
- mbn_mea
- mbp
- qpl_qps_v2
- qwl → qwl_qea (+ updated magnetic strength for qwl quads)

- ✓ New *qwl_qea.map* file (*qwl.map* actually contained zeros, meaning magnets OFF) and updated magnetic field strength for QWLs – Thanks again to M. Van Dijk and D. Banerjee !
- ✓ Original map file *mbp.map* – no modification
- ✓ EA design proposal for AMBER Target bunker (EA1)









Results from previous study [1]

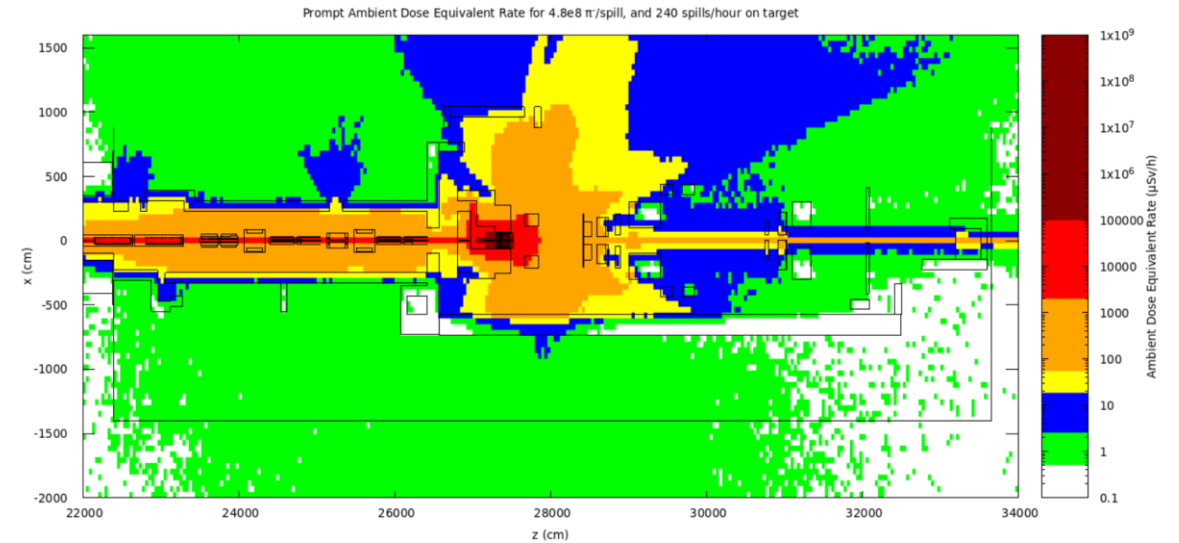
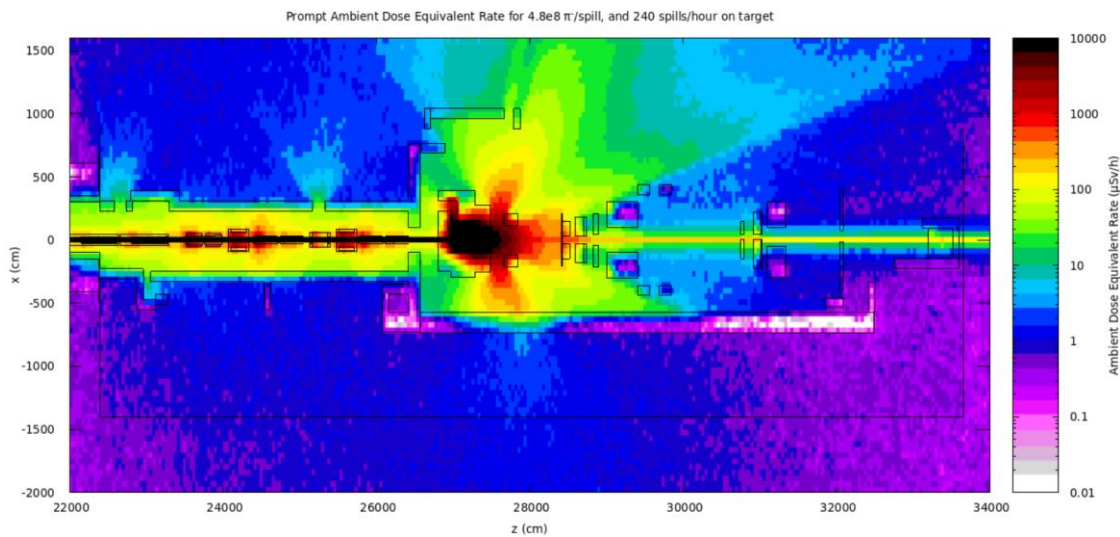


Preliminary results

- Prompt radiation at **beam level Y[-30;30] – V65**

- Source: source.for (190 GeV/c π^- beam from [1])
- Magnetic field: magfld.for (using *qwl_qea.map* and *updated QWLs strengths*)
- Intensity: $4.8 * 10^8 \pi^-$ /spill and 240 spills/h on Target
- Currently less than 10% losses from COLL5 source to target (8.5% up to CEDARs and **<1%** from CEDAR up to target)
- Plots are scaled with **intensity on Target**

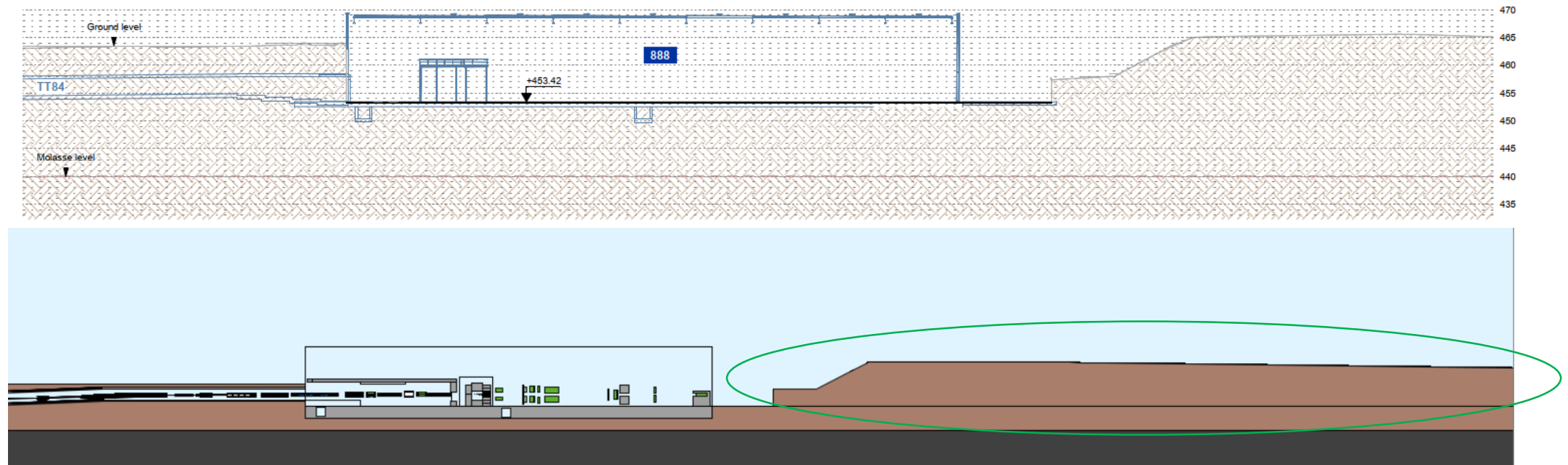
Area	Annual dose limit (year)	Ambient dose equivalent rate		Sign 
		permanent occupancy	low occupancy	
Non-designated	1 mSv	0.5 μ Sv/h	2.5 μ Sv/h	
Supervised	6 mSv	3 μ Sv/h	15 μ Sv/h	
Simple Controlled	20 mSv	10 μ Sv/h	50 μ Sv/h	
Limited Stay	20 mSv	-	2 mSv/h	
High Radiation	20 mSv	-	100 mSv/h	
Prohibited	20 mSv	-	> 100 mSv/h	



Preliminary results

- Prompt radiation

- EHN2 ground profile obtained from SCE-SAM-TG + GIS
- Simplified model with Soil region included for prompt radiation downstream EHN2
- Model completed up to CERN fence for attenuation of straight radiation



Preliminary results

- Skyshine

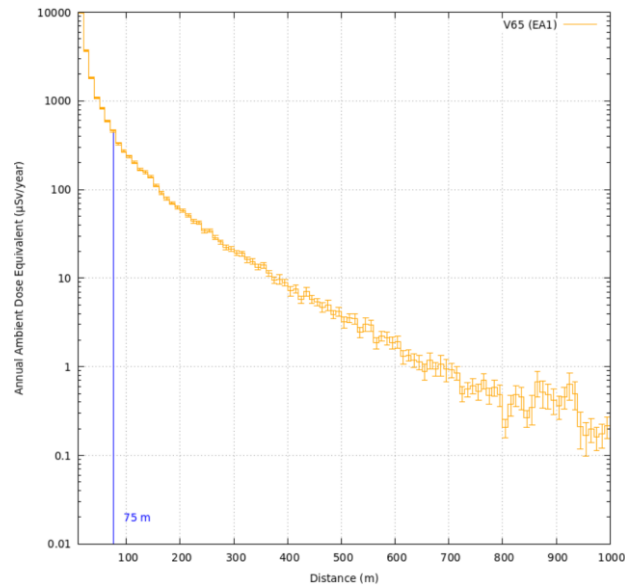
- Monitoring stations (5) and reference group points (2) coordinates from [GIS Environment](#)



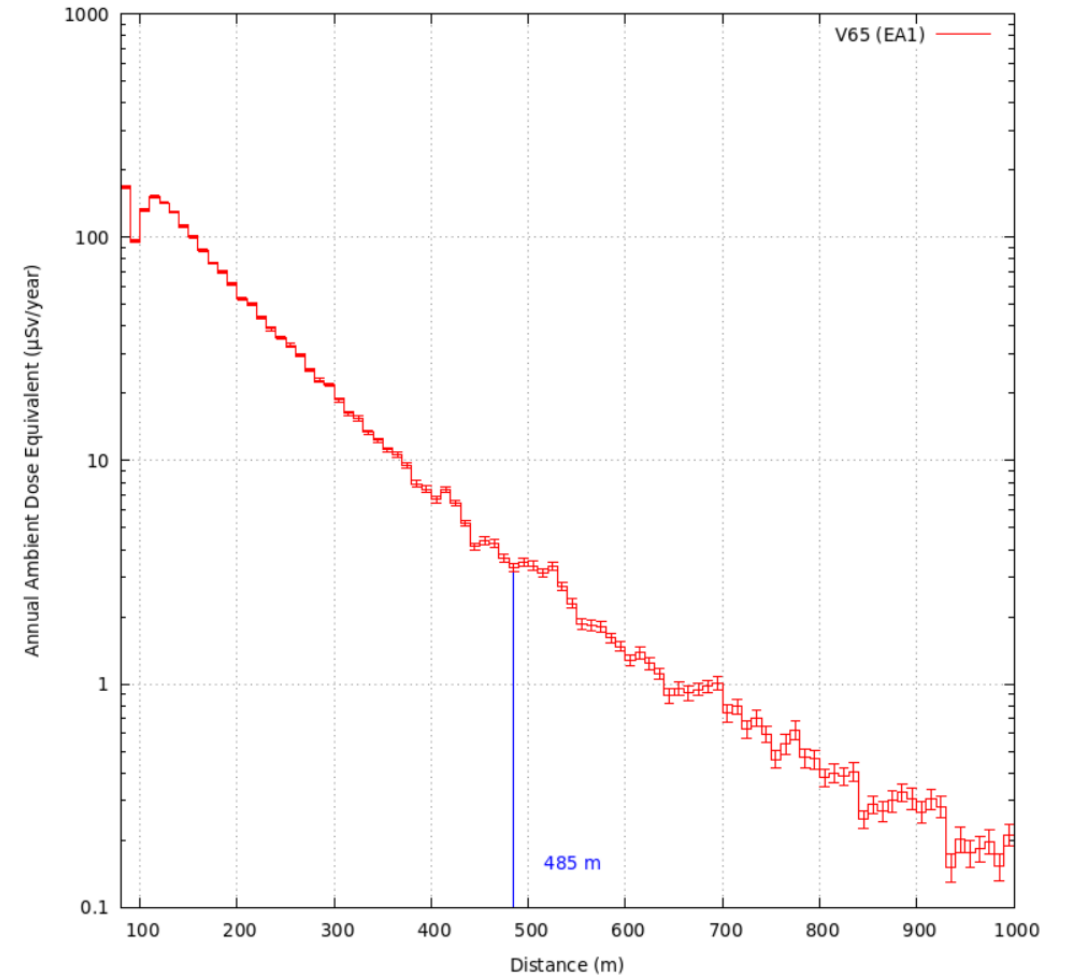
- (0. Target)
- 1. Reference Point Storage
- 2. Reference Point Population
- 3. PMS823
- 4. PMS822
- 5. PMS821
- 6. PMS824
- 7. SMS816 (added)

Preliminary results

- Skyshine contribution
- Intensity: **3.07e14 p/year on target**
 - Limit < 1 mSv/year at CERN fence
 - Objective < 10 μ Sv/year exposure from CERN contribution to members of the public



Skyshine contribution at reference point PMS824 (Salève) direction (-90°)



Skyshine contribution at reference point Population direction (-75°)

Preliminary results

- Skyshine contribution
- Intensity: **3.07e14 p/year on target**
 - Limit < **1 mSv/year** at CERN fence
 - Objective < **10 µSv/year** exposure from CERN contribution to members of the public
 - ARP0 (AMBER/RP initial proposal), EA1 (EA design), RP2 (RP reinforced), NO (No bunker)



#	Name	Distance (m)	Target Only (µSv/year)			Source COLL5 (µSv/year)			Target Only (Error)			Source COLL5 (Error)		
			ARP0	EA1	RP2	EA1	RP2	NO	ARP0	EA1	RP2	EA1	RP2	NO
1	Reference Point Storage	265	36.1	35.8	31.1	39.4	35.5	792.6	5.0%	5.2%	4.8%	4.6%	6.1%	1.0%
2	Reference Point Population	485	3.6	3.3	3.3	4.7	3.8	122.4	9.2%	10.6%	14.8%	11.7%	14.0%	1.8%
3	PMS823 (Down)	355	13.0	11.2	10.2	14.4	15.5	404.9	7.4%	6.7%	8.1%	6.8%	8.2%	1.2%
4	PMS822 (Mid)	265	28.4	28.2	23.4	41.2	33.6	976.2	5.5%	5.0%	4.9%	4.4%	4.8%	0.9%
5	PMS821 (Jura)	135	199.2	177.2	164.4	217.7	192.0	5310.4	2.6%	2.5%	2.6%	2.7%	3.2%	0.5%
6	PMS824 (Saleve)	75	437.5	487.9	396.5	561.1	514.7	12122.8	2.4%	2.4%	2.6%	2.3%	2.8%	0.4%
7	SMS816 (Up)	345	2.6	2.6	1.9	37.3	33.3	33.0	24.0%	25.1%	28.8%	7.9%	8.9%	6.3%

Table 1 : Comparison of results in µSv/year depending on the geometry and source for 3.07e14 p/year on target

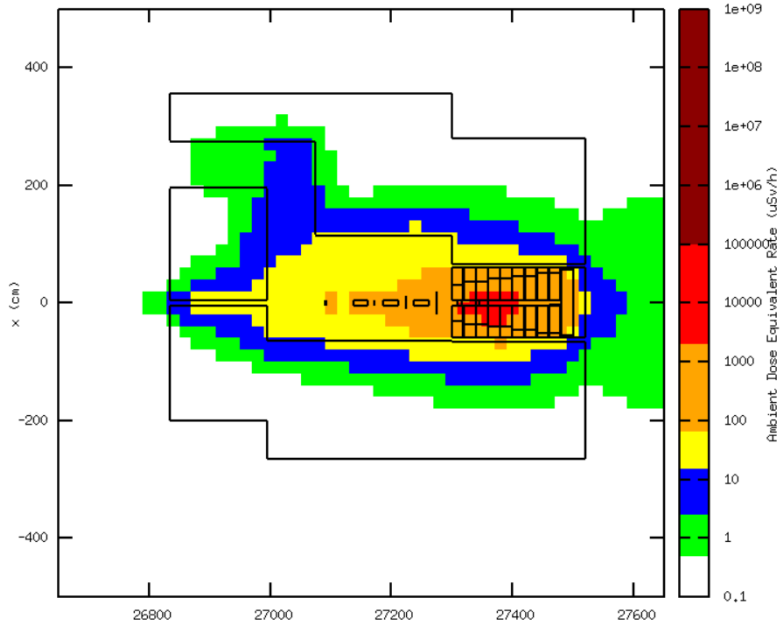
Table 2 : Statistical errors in FLUKA

Preliminary results

- Residual radiation – (from V56)

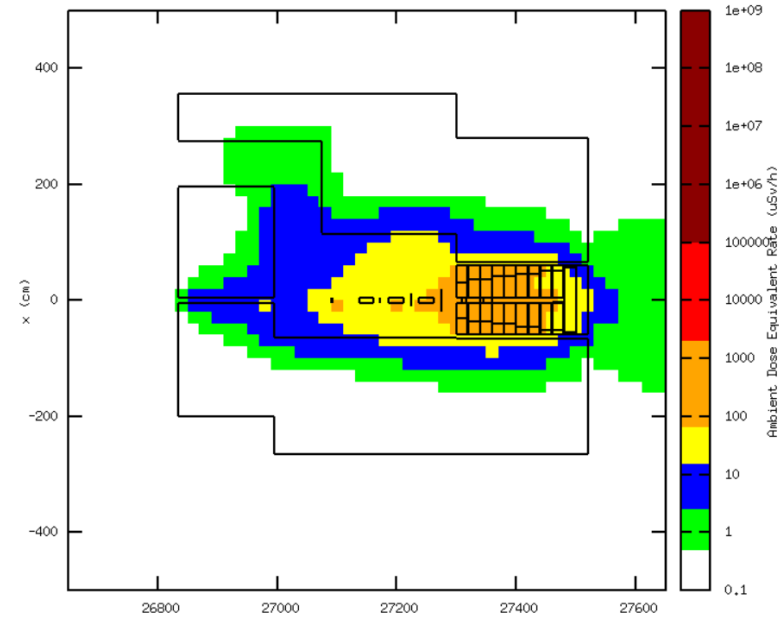
- Decay times: 2mn (minimum time for access) / 10 mn / 30 mn / 1h / 3h / 6h / 1d / 3d / 1w / 1month / 6 month / 1 year

Residual Ambient Dose Equivalent Rate for 4,8e8 p/spill, and 240 spills/hour on Target, 6 month irradiation and 2 mn cool-down time.



2 minutes

Residual Ambient Dose Equivalent Rate for 4,8e8 p/spill, and 240 spills/hour on Target, 6 month irradiation and 30 mn cool-down time.



30 minutes

Preliminary results

Air Activation – *(from V56)*

- Air activation for access in AMBER bunker area:
 - ✓ 1 year irradiation, no cool-down time
 - ✓ Results show values **below 0.1 CA**
 - ✓ Main contributors N-13, O-15, C-11, Ar-41
- Air activation for access in EHN2 Hall (**negligeable**)
- Annual activity of the EHN2 air volumes and release to environment : **calculations done** and **revision ongoing** with final design.

Conclusions

- Shielding design for EHN2 – AMBER Drell-Yan should be in agreement with radiation area classification.
- Additional shielding elements and new designs: Jonction EHN2/TT84, Chicane PPE211, AMBER Bunker.
- Preliminary results showed for prompt and residual radiation, skyshine contribution and air activation.

Open points:

- *Improve source term (updated source routine)*
 - ✓ *Vertical beam offset investigated. Beam distribution from before collimator 5 shows good behavior up to the target.*
 - ✓ *RP test with source term before CEDAR provided by BE-EA shows similar results than source before collimator 5.*
 - ✓ *BE-EA to get updated maps for MBN magnets from TC and improve beamline model (middle term – to be discuss)*
- *Complete study skyshine and air activation*
 - ✓ *Skyshine and air activation estimated.*
 - ✓ *Verifications on Jura side shielding.*
- *Discuss possible mechanical and/or integration constrains*
 - ✓ *Proposal for Jonction EHN2/TT84, Chicane PPE211 and Bunker.*
- *Documentation: RP Technical Note (EDMS 2670569) started and ECR (RP part) draft completed.*

References

- [1] Shielding studies for EHN2 with FLUKA, S. Cholak. Internal report (2018)
- [2] COMPASS - 2018 Radiation Protection Survey, C. Ahdida, M. Casolino, H. Morimoto. Survey Note (2019)
- [3] COMPASS - 2018 Radiation Protection Survey 2, C. Ahdida, H. Morimoto (2021)
- [4] Report on Annual Radiation levels calculations for Amber experiment, P. Correia (2020)



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