



HSE

Occupational Health & Safety
and Environmental Protection unit

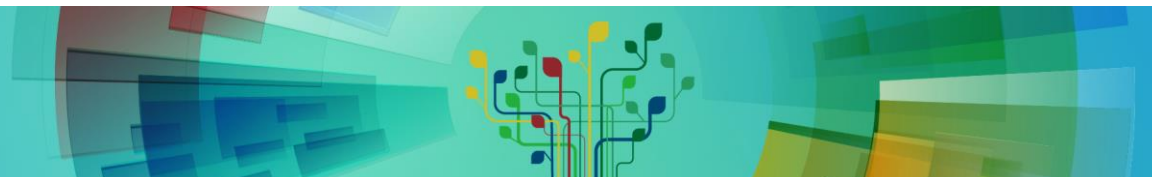


Shielding update for AMBER Drell-Yan at EHN2 – #7

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HSE-RP

09/02/2022

[EDMS 2693669](#)

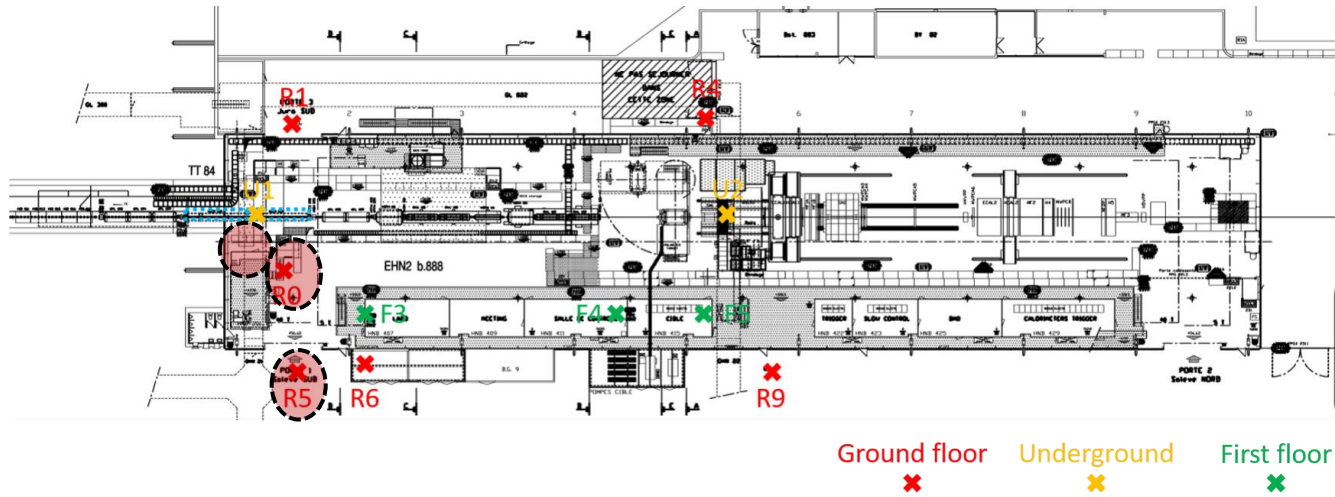


Outline

- 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 to cope with higher intensity runs
- Prompt radiation, skyshine optimization and environmental release
- Air activation and residual radiation assessment

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) / Controlled Area (right)

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) / Controlled Area (right)

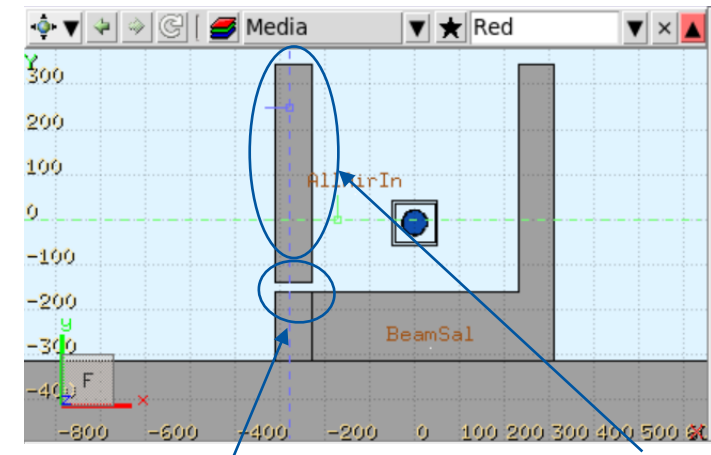
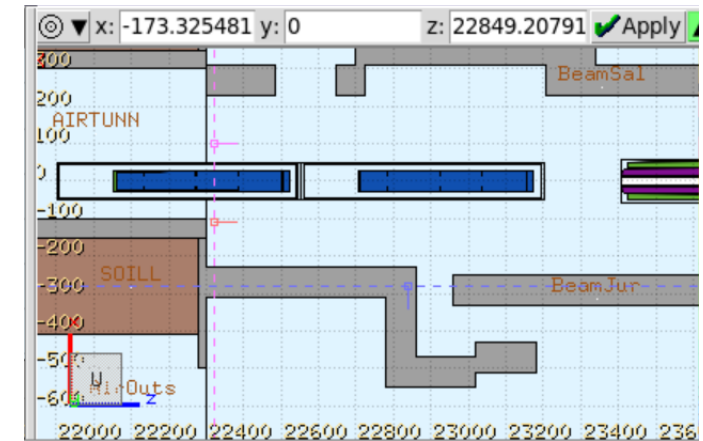
Shielding design

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

Jonction EHN2/TT84



✓ Implemented in FLUKA model



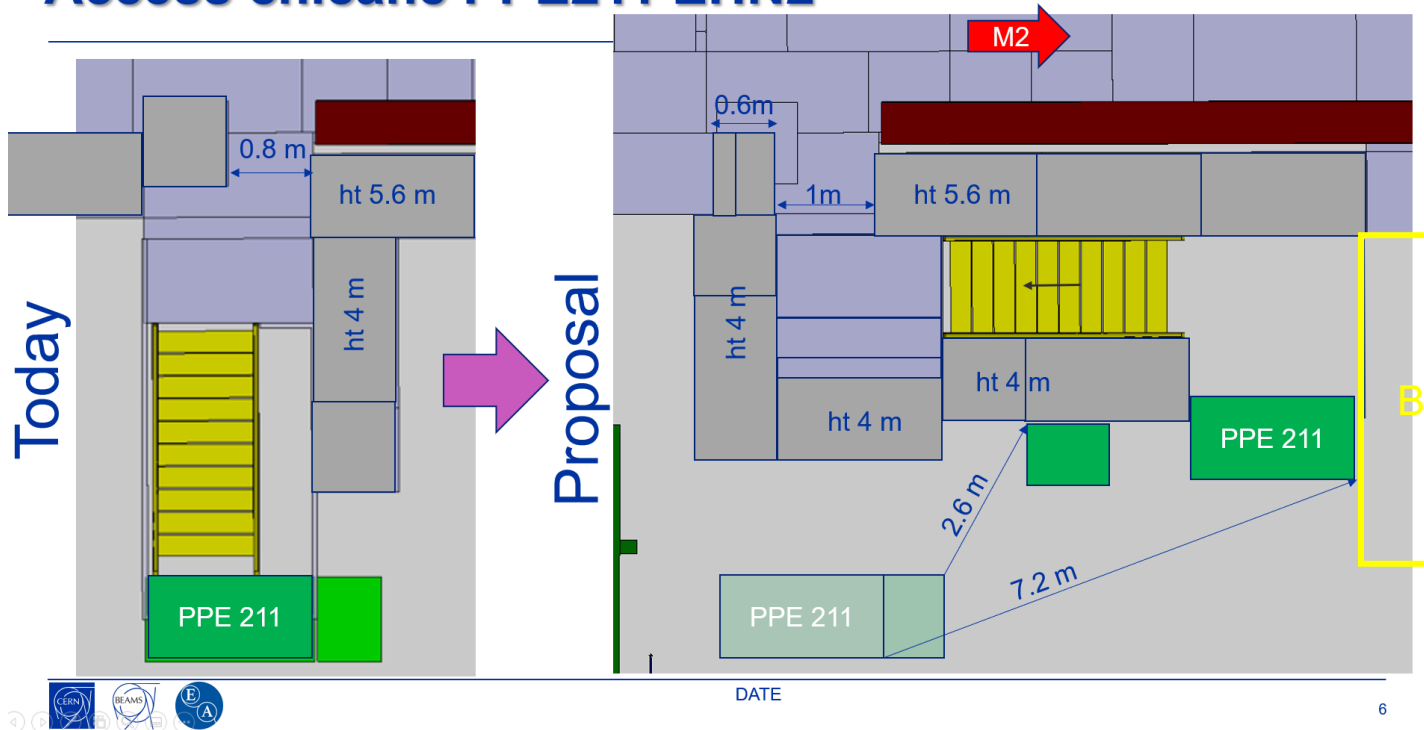
Opening for cables at inside ground level : 40 cm (width) x 20 cm (height)

Concrete bricks to fill gap according to proposal

Shielding design

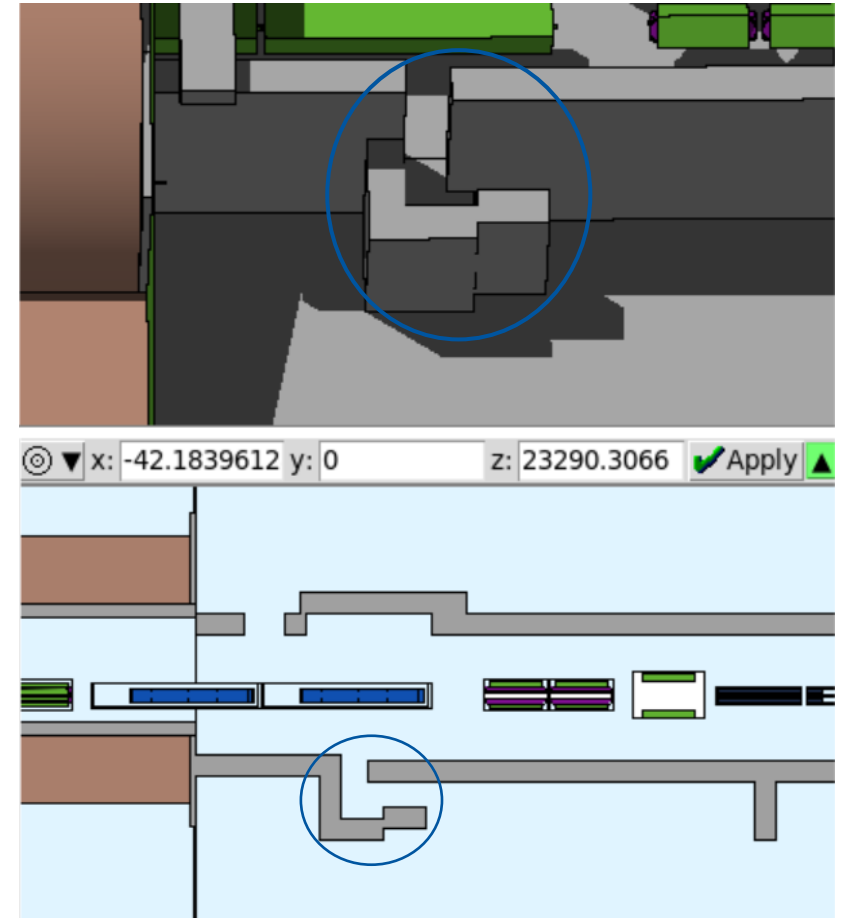
- Chicane PPE211 (Proposal BE-EA):

Access chicane PPE211 EHN2



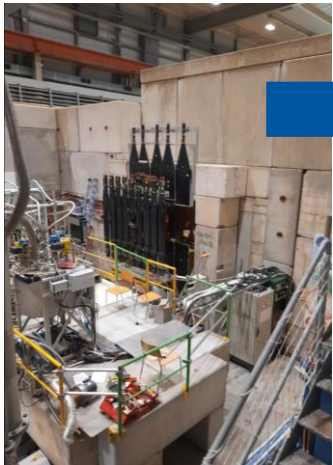
Slide from BE-EA (see [EDMS 2688172](#))

- ✓ Implemented in FLUKA model

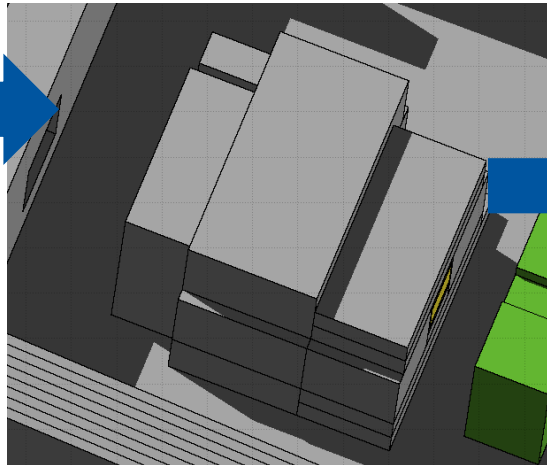


Shielding design

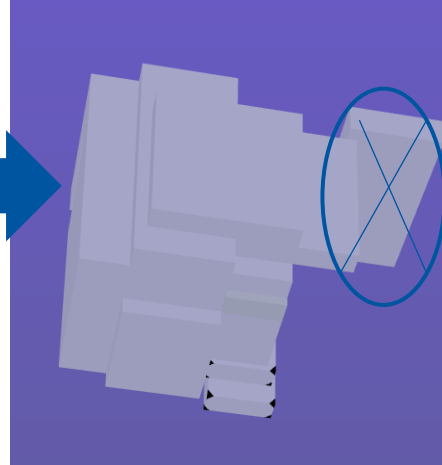
- AMBER Target bunker (proposals evolution)



Current situation

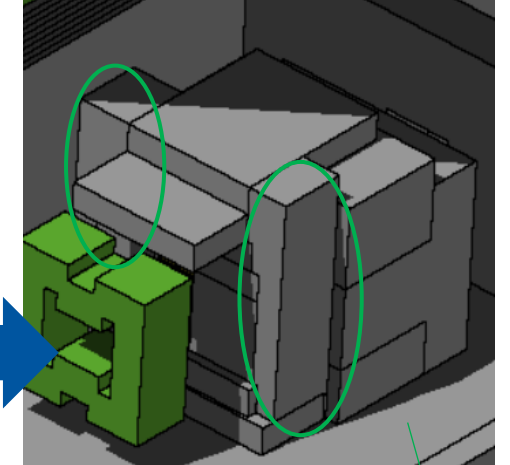
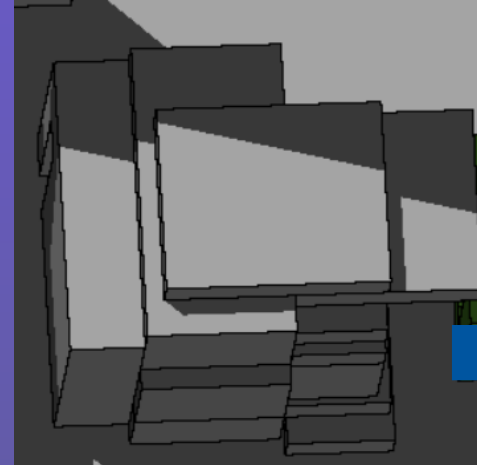


Initial AMBER/RP proposal
(ARP0)



1st preliminary EA design
(EA1)

✓ Lateral shielding not implemented due to space constraints



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

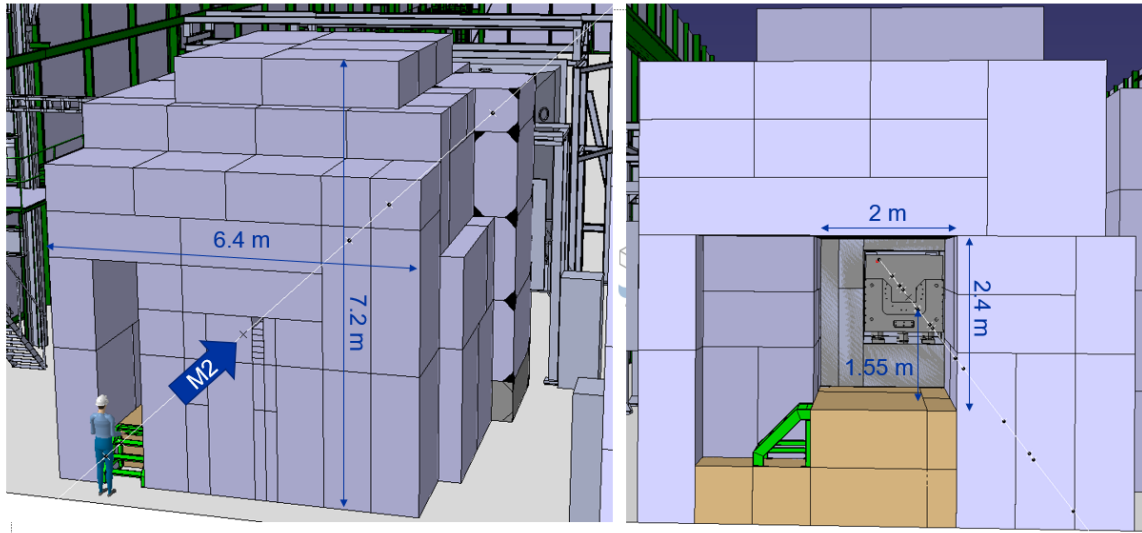
August-October 2021

January 2022

February 2022

Shielding design

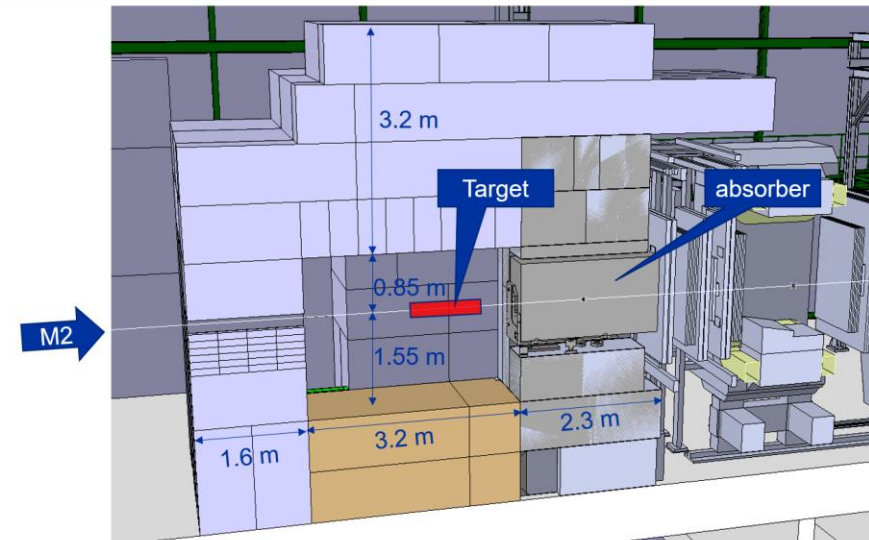
AMBER Drell Yann target bunker (RP2 version)



DATE

8

AMBER Drell Yann target bunker (RP2 version)



DATE

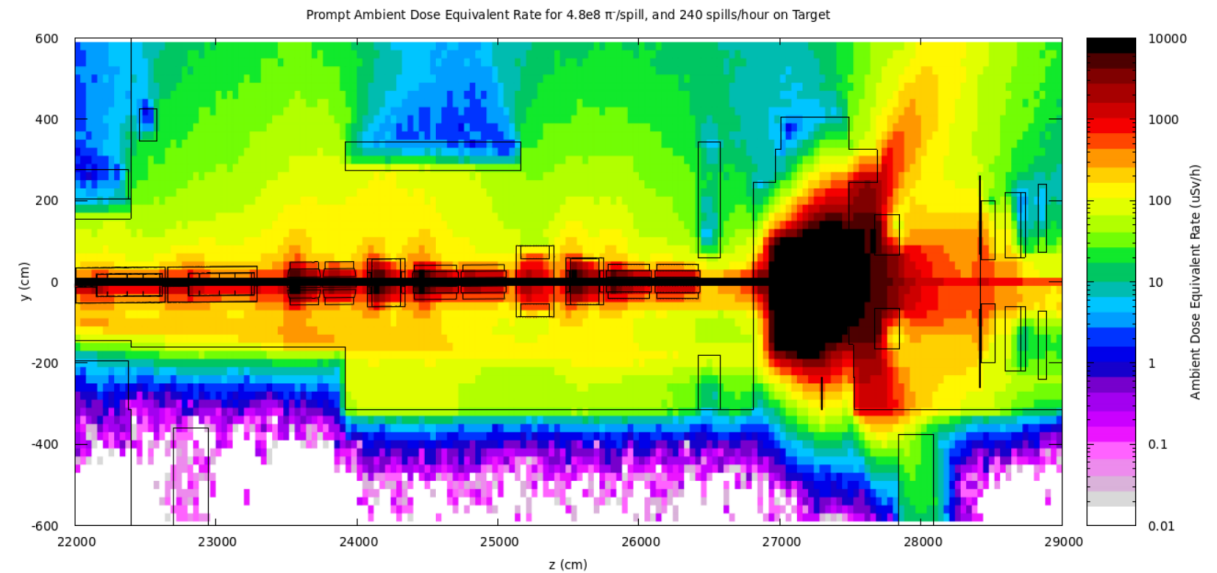
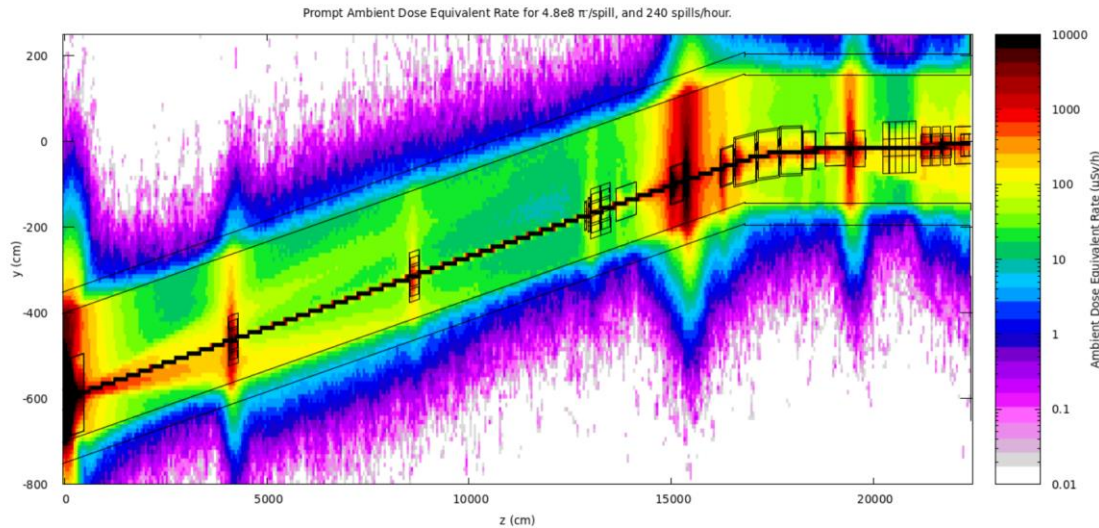
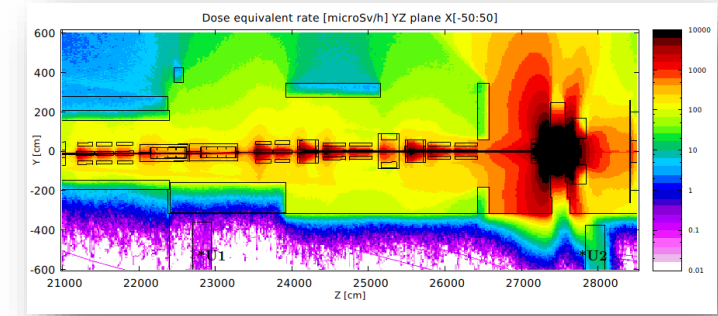
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Slides from BE-EA (see [EDMS 2688172](#))

Preliminary results

- Prompt radiation : successful investigations







- ✓ Source: original source distribution before collimator 5 (adapted to FLUKA 4.x.)
- ✓ Magnetic field: new map file and updated magnetic field strength for QWLs
- ✓ Geometry: latest design for Bunker in AMBER area (RP2)

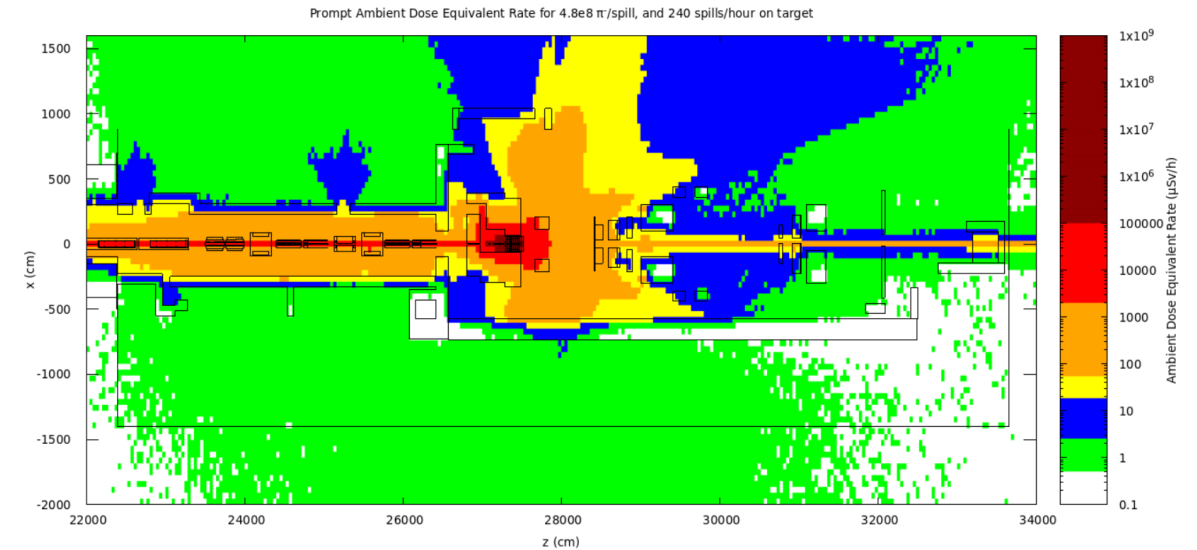
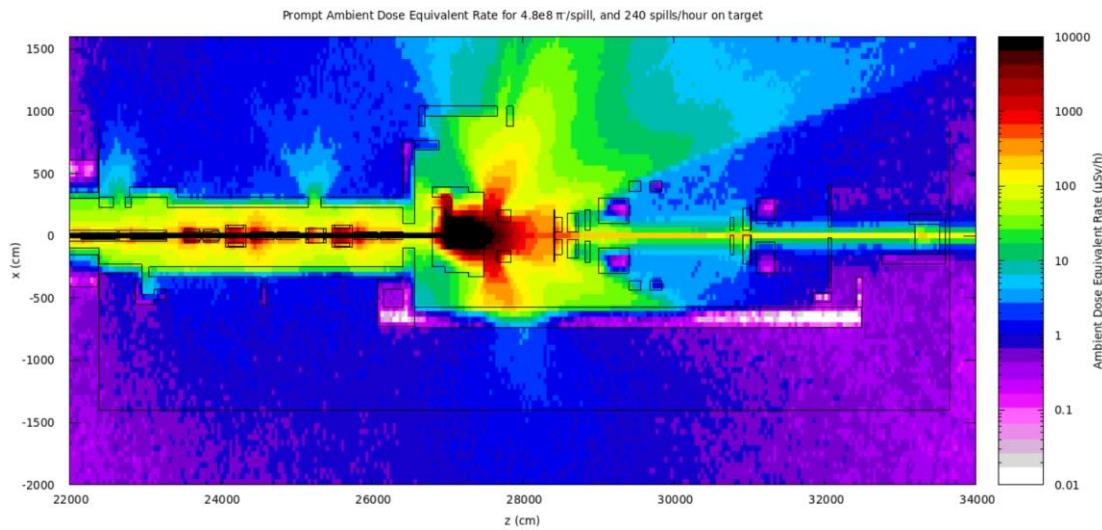


Preliminary results

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

- Source: source.for (190 GeV/c π^- beam from [1])
- Intensity: $4.8 * 10^8 \pi^-$ /spill and 240 spills/h on Target
- Magnetic field: magfld.for from [1] (with *qwl_qea.map* and *updated QWLs strengths*)
- 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		
Radiation Area	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	
				Controlled Area	

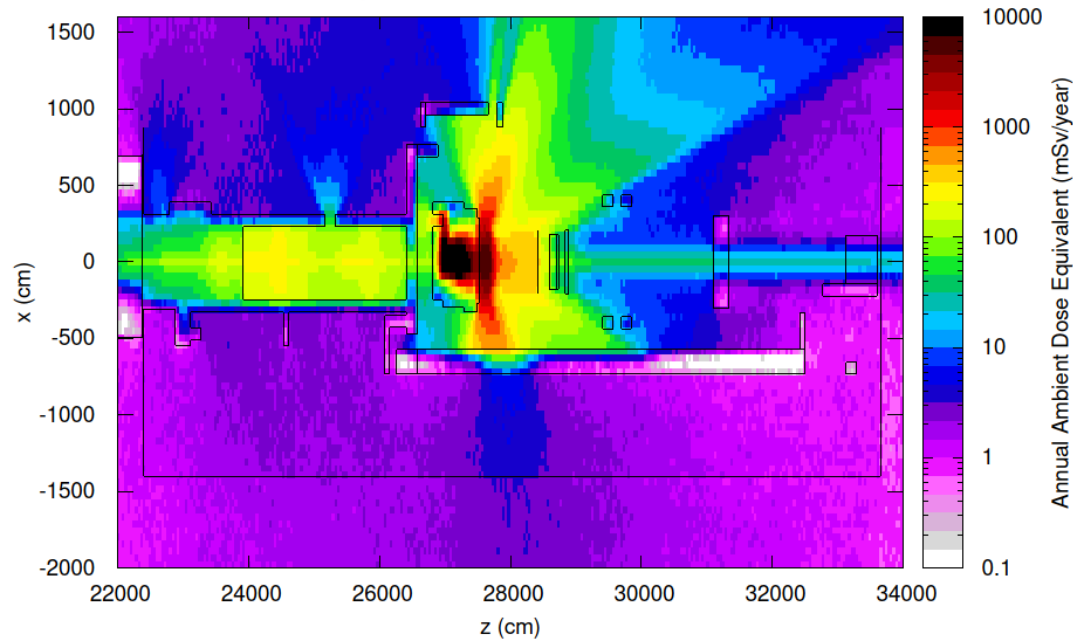


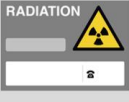

Preliminary results

- Annual dose at **floor level Y[-310;-110]**

- Intensity: $3.07 \times 10^{14} \pi^-/\text{year}$ on Target
- Annual Ambient Dose Equivalent between 1 and 5 mSv outside EHN2 in Jura and Salève sides (low occupancy areas)
- Final design to be discussed with RP group leader**

Prompt Annual Ambient Dose Equivalent at floor level Y[-310;-110] for $3.07 \times 10^{14} \pi^-/\text{year}$ on target

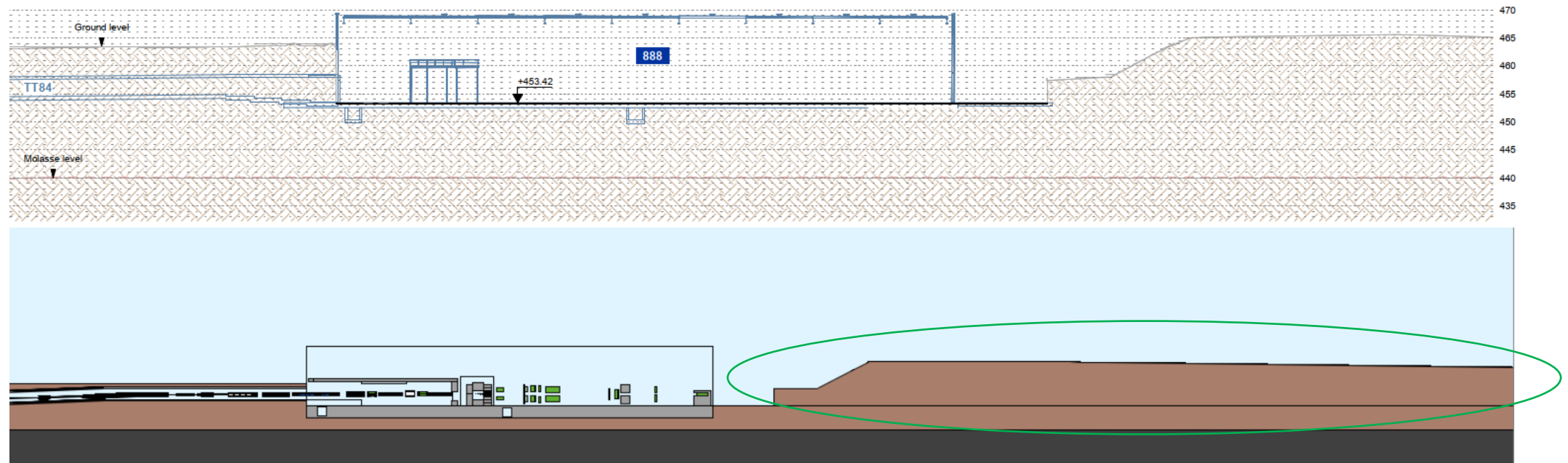


Area	Annual dose limit (year)	Ambient dose equivalent rate		Sign 	
		permanent occupancy	low occupancy		
Non-designated	1 mSv	0.5 $\mu\text{Sv/h}$	2.5 $\mu\text{Sv/h}$		
Radiation Area	Supervised	6 mSv	3 $\mu\text{Sv/h}$	15 $\mu\text{Sv/h}$	Controlled Area 
	Simple Controlled	20 mSv	10 $\mu\text{Sv/h}$	50 $\mu\text{Sv/h}$	
	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](#)

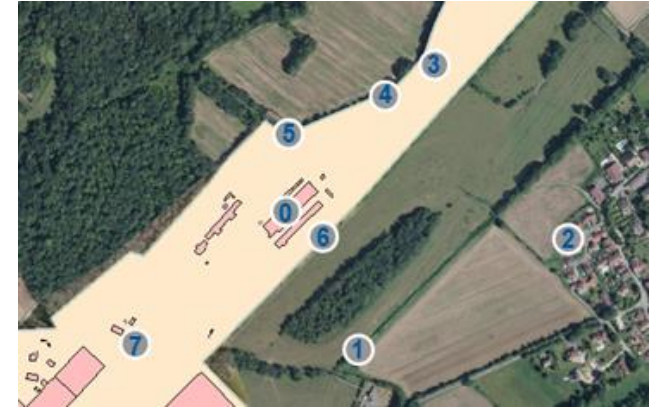


- (0. Target)
- 1. Reference Point S
- 2. Reference Point P
- 3. PMS823
- 4. PMS822
- 5. PMS821
- 6. PMS824
- 7. SMS816
- + additional point on Jura side

Preliminary results

- Skyshine contribution

- Intensity: $3.07 * 10^{14} \pi^-/\text{year}$ on target
- Limit < 1 mSv/year at CERN fence
- Objective < 10 $\mu\text{Sv}/\text{year}$ exposure from CERN contribution to members of the public
- RP2 AMBER area bunker design









#	Name	Distance (m)	Source COLL5	
			Annual Dose ($\mu\text{Sv}/\text{year}$)	Error
1	Reference Point S	265	35.5	6.1%
2	Reference Point Population	485	3.8	14.0%
3	PMS823 (Down)	355	15.5	8.2%
4	PMS822 (Mid)	265	33.6	4.8%
5	PMS821 (Jura)	135	192.0	3.2%
6	PMS824 (Saleve)	75	514.7	2.8%
7	SMS816 (Up)	345	33.3	8.9%

Table 1 : Annual ambient dose equivalent at reference points ($\mu\text{Sv}/\text{year}$) for $3.07e14$ p/year on target

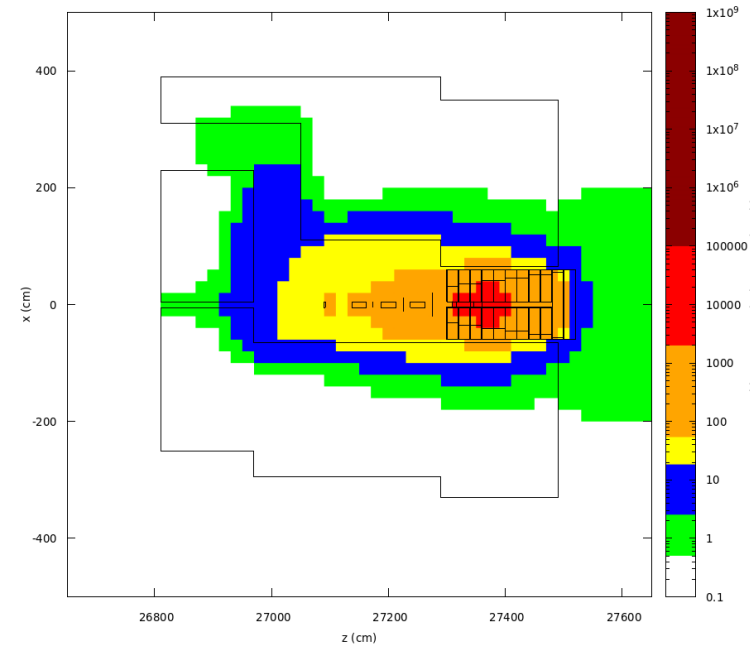
Preliminary results

- Residual radiation

- Decay times:
2 mn / 10 mn / 30 mn / 1h /
3h / 6h / 1d / 3d / 1w /
1month / 6 month / 1 year
- PMI request to monitor residual dose rate inside the bunker before access

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	
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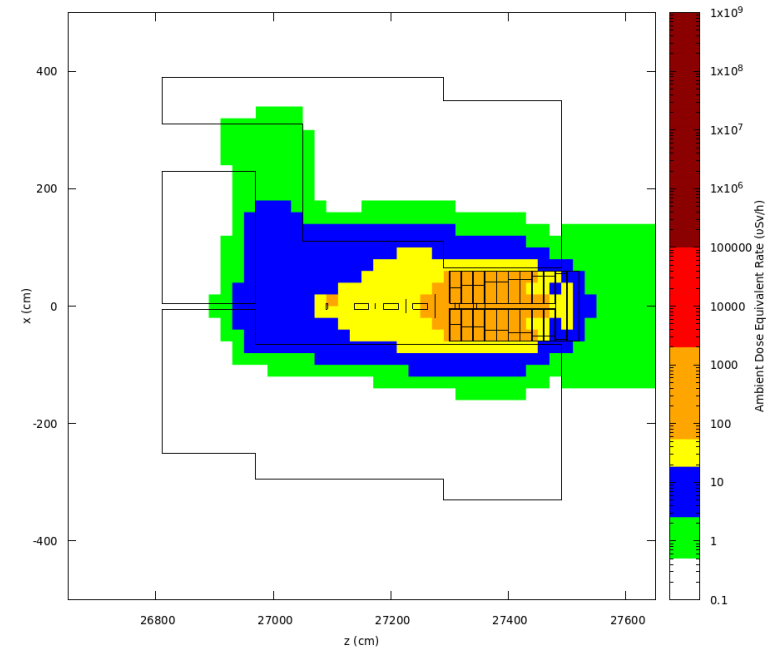
Residual Ambient Dose Equivalent Rate for 4.8e8 π /spill, and 240 spills/hour, 6 month irradiation and 2 mn cool-down time.



2 minutes

(minimum time from access system)

Residual Ambient Dose Equivalent Rate for 4.8e8 π /spill, and 240 spills/hour, 6 month irradiation and 1h cool-down time.



1 hour

Preliminary results

Air Activation:

- Air activation for access to AMBER bunker area :
 - ✓ 1 year irradiation at maximum intensity and no cool-down time
 - ✓ 2 min waiting time before access
 - ✓ Specific airborne activity < 0.1 CA
 - ✓ Inhalation dose < 1 μSv for 1h access inside bunker
- Air activation for access in EHN2 Hall (negligeable)

Environmental release:

- Annual activity in all air volumes :
 - ✓ Below 0.1 TBq/year for 3.07e14 p/year on target



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.
- **Final design to be discussed and confirmed with RP group leader**

Open points:

- *Improve source term (updated source routine)*
 - ✓ *Vertical beam offset investigated. Beam distribution from before collimator 5 shows good behavior up to 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 (to be discussed)*
- *Complete study skyshine and air activation.*
 - ✓ *Skyshine and air activation estimated.*
 - ✓ *Verifications on Jura side shielding and Salève side (under discussion)*
- *Discuss possible mechanical and/or integration constraints*
 - ✓ *Proposal for Jonction EHN2/TT84, Chicane PPE211 and Bunker in AMBER area.*
- *Documentation: RP Technical Note (EDMS 2670569) ongoing 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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