



HSE
Radiation Protection

RP studies and operational experience from the decommissioning of the CNGS target area

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EDMS 3536520

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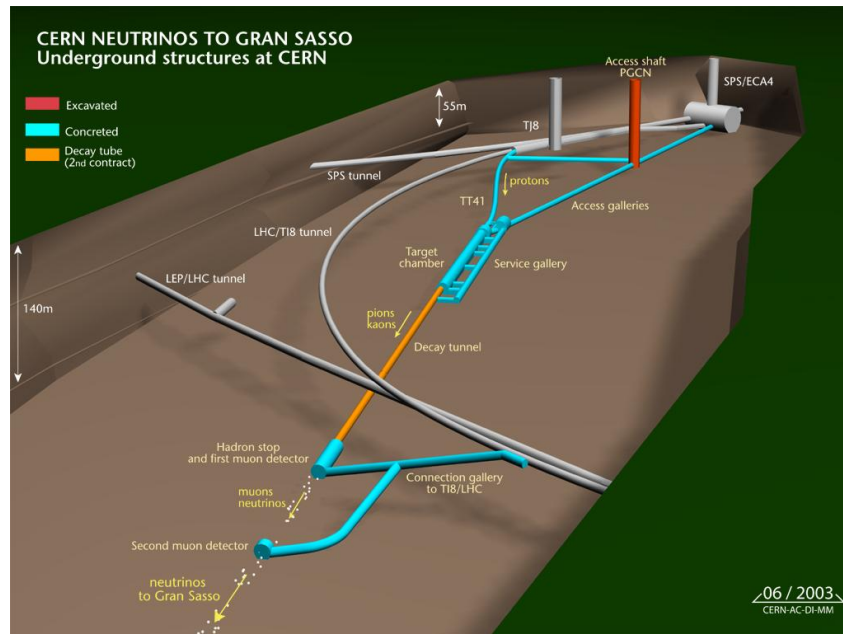
Introduction

CNGS & Target Area Decommissioning



Introduction

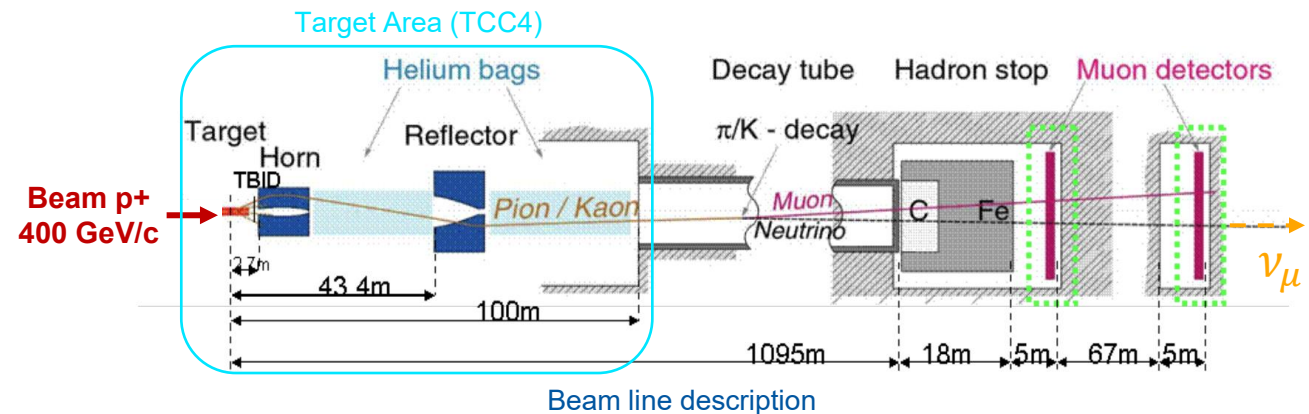
- The CNGS experiment (2006-2012) aimed at detecting muon-to-tau neutrino oscillations with an intense muon-neutrino beam generated at CERN directed over 732 km towards the Gran Sasso National Laboratory in Italy.



732 km

Gran Sasso (Italy)

Detectors: OPERA & ICARUS



Year	Mode	Protons on target (pot/year)
2006	Commissioning	0.08E+19
2007	Commissioning	0.08E+19
2008	Physics	1.78E+19
2009	Physics	3.52E+19
2010	Physics	4.04E+19
2011	Physics	4.84E+19
2012	Physics	3.90E+19
TOTAL		1.82E+20

Beam intensities

Introduction

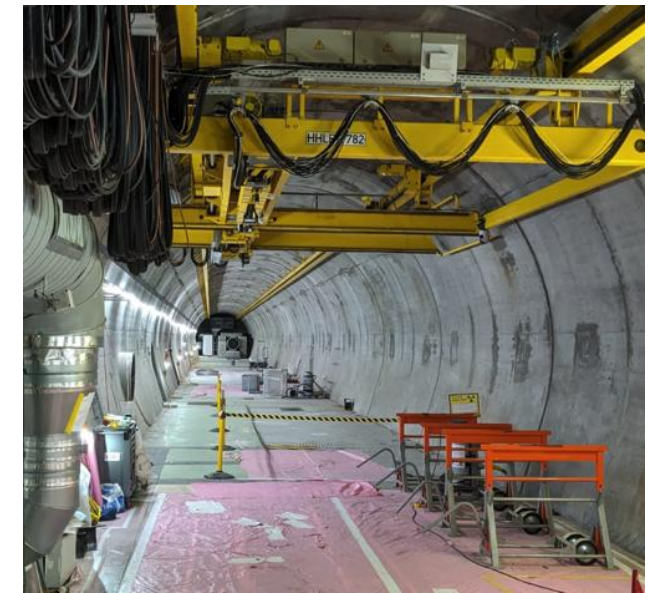
- Motivations of CNGS Target Area Decommissioning (2025-2026, 12 MCHF):
 - Extension of the [AWAKE](#) experiment after LS3
 - Re-use of standard shielding blocks for other CERN facilities (400 m³)
 - Minimize CERN on-site radioactive storage (VLLW 81 m³, LILW 102 m³)



November 2025



January 2026



October 2026

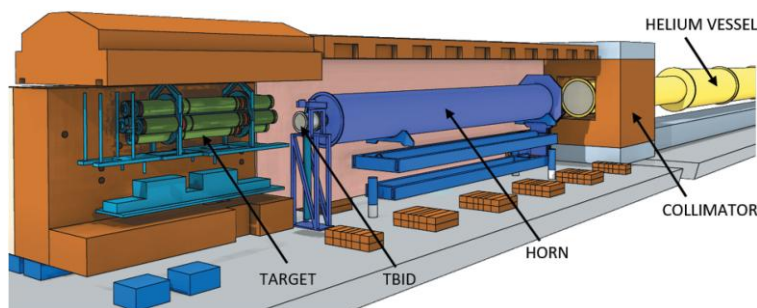
Characterization

Studies & validation

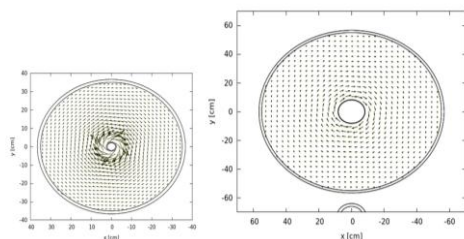


Characterization – studies

• FLUKA Model

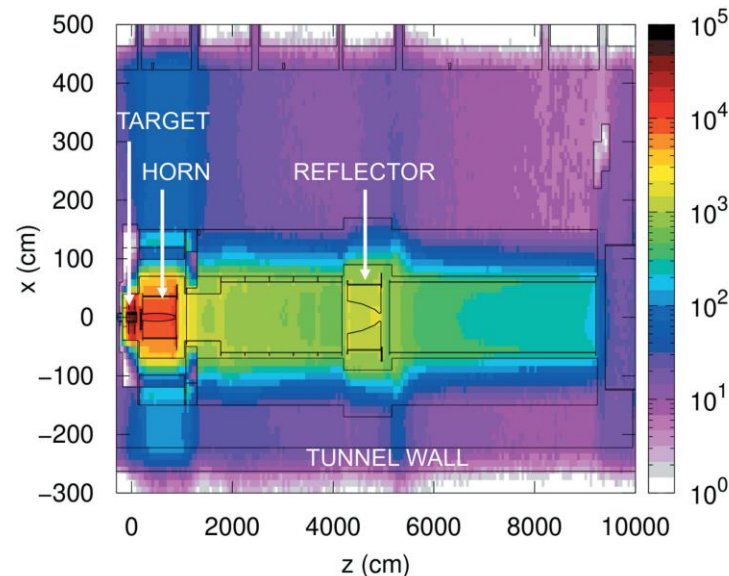


- Detailed CSG model with CNGS beam line components, supports, shielding and concrete tunnel floor/walls

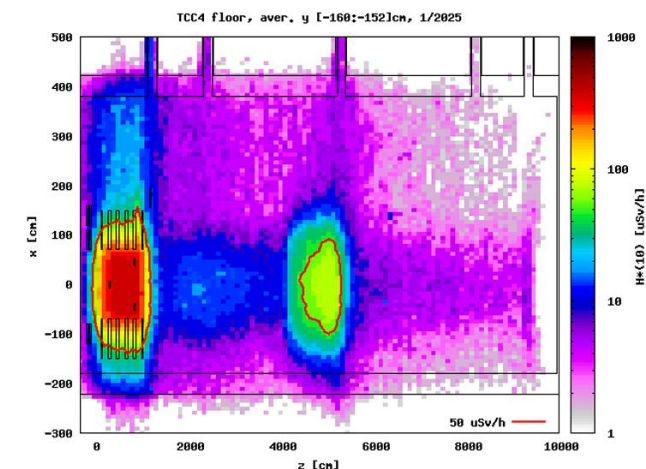


- User routine (*magfld.f*) generating a toroidal magnetic field $B_\phi(r) = \frac{\mu_0 I}{2\pi r}$ in the Horn ($I=150$ kA) and in the Reflector ($I=180$ kA)

• Scoring residual dose rate and activities



- Residual dose rate after 11 years of cooling (December 2023) with all components



- Residual dose rate in the empty tunnel (April 2026) (using ASSIGNMAT card to assign a different material at decay)

Reflector Al inner and outer conductor
 ASSIGNMAT Mat: Al-6082 Reg: R0088 to Reg: R0088
 Mat(Decay): AIRDEC Step: 1. Field: off
 ASSIGNMAT Mat: Al-6082 Reg: R0749 to Reg: R0749
 Mat(Decay): AIRDEC Step: 1. Field: off

Characterization – validation

- Material composition (concrete):



XRF measurements



Sampling of concrete



Gamma Spectrometry

Results of the XRF for the concrete composition of the shielding, tunnel walls and floor

Mass %	Ca	Si	Al	Fe	K	P	S	Ti
Shielding	24.4	8.12	1.52	1.33	1.54	0.122	0.323	0.088
Wall	15.6	15.2	3.32	2.28	1.36	0.0815	2.1	0.161
Floor	18.1	11	3.35	2.39	1.36	0.102	3.51	0.155

- FLUKA + Activiz 3 simulations vs results from Gamma Spectrometry main radionuclides

Results of the Activiz and Gamma spectrometry for the concrete floor

	ACTIWIZ 3 estimates [Bq/g] (1σ)	Gamma spec report [Bq/g] (2σ)
Na-22	4.659 (3.03%)	4.82 (5.63%)
Co-60	0.654 (1.72%)	0.652 (5.29%)
Eu-152	1.899 (2.24%)	1.93 (3.46%)
Eu-154	0.154 (2.05%)	0.179 (14.88%)
Mn-54	0.0543 (5.47%)	0.0381(29.33%)
Cs-134	0.109 (6.42%)	0.125 (9.66%)



The resulting concrete composition (wt %) of the floor is as follows: O 53%, Ca 18.1%, Si 11%, C 3.96%, Al 3.35%, Fe 2.39%, S 3.51%, Mg 1.39%, K 1.36%, H 0.6%, Na 1%, Ti 0.155%, P 0.102%, Mn 0.033%, Co 0.00028% , Cs 0.00022%, Eu 3.8E-05%.



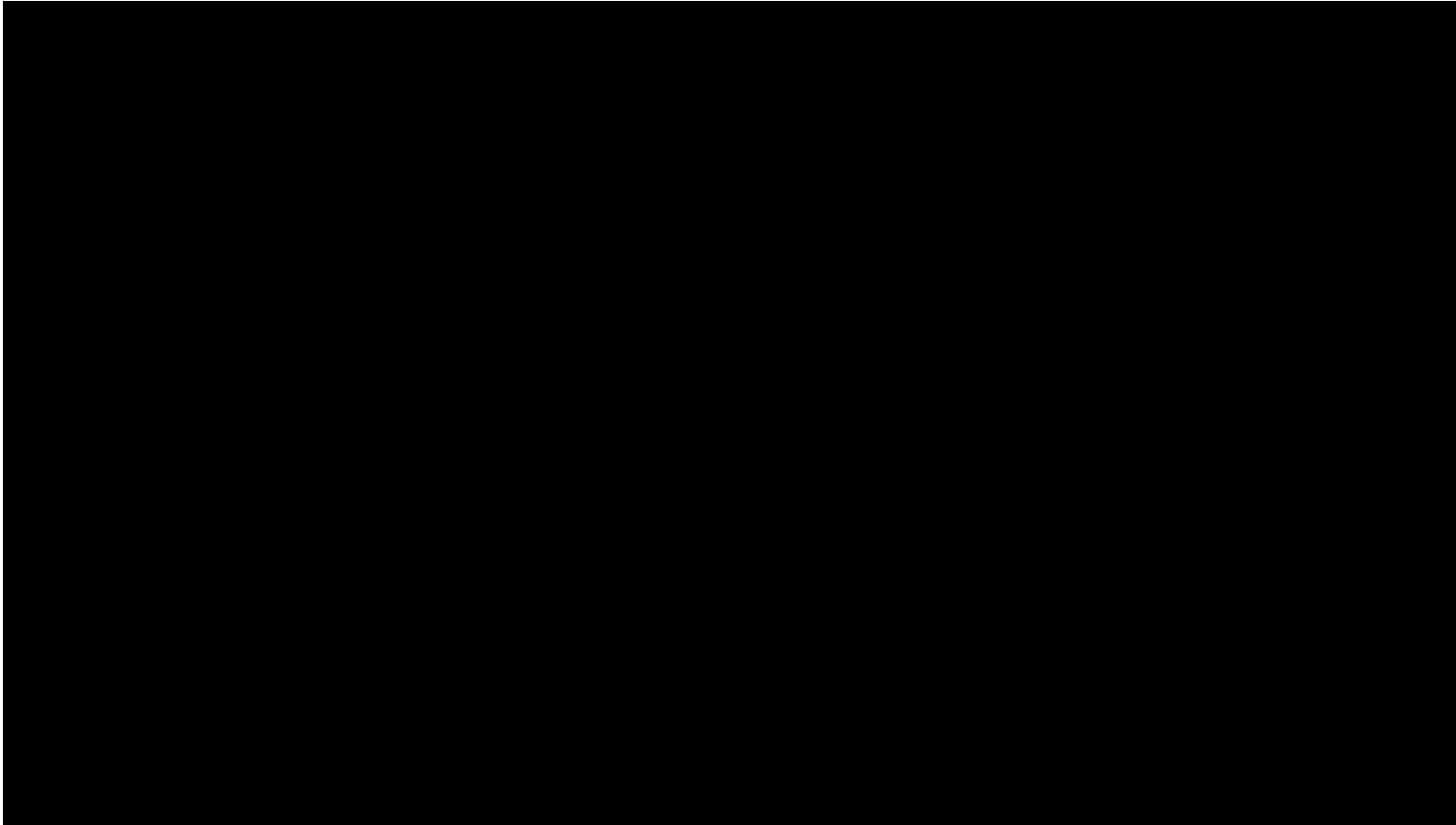
Benchmark

Target, Horn & Empty tunnel



Benchmark – Target

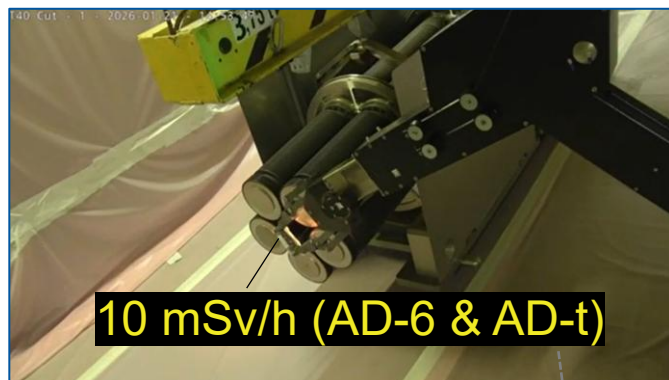
- Video overview of the handling, survey, cutting and packing of CNGS target station



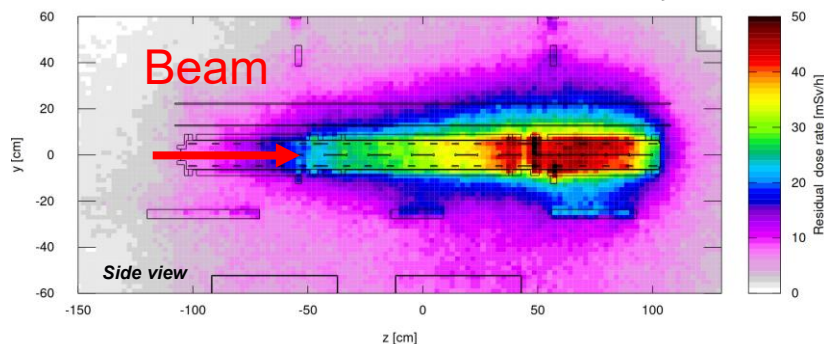
Source: [EDMS 3408902](#)



Benchmark – Target



Side view of the residual dose rate at the target location.
Averaged on $X=[-5;5]$



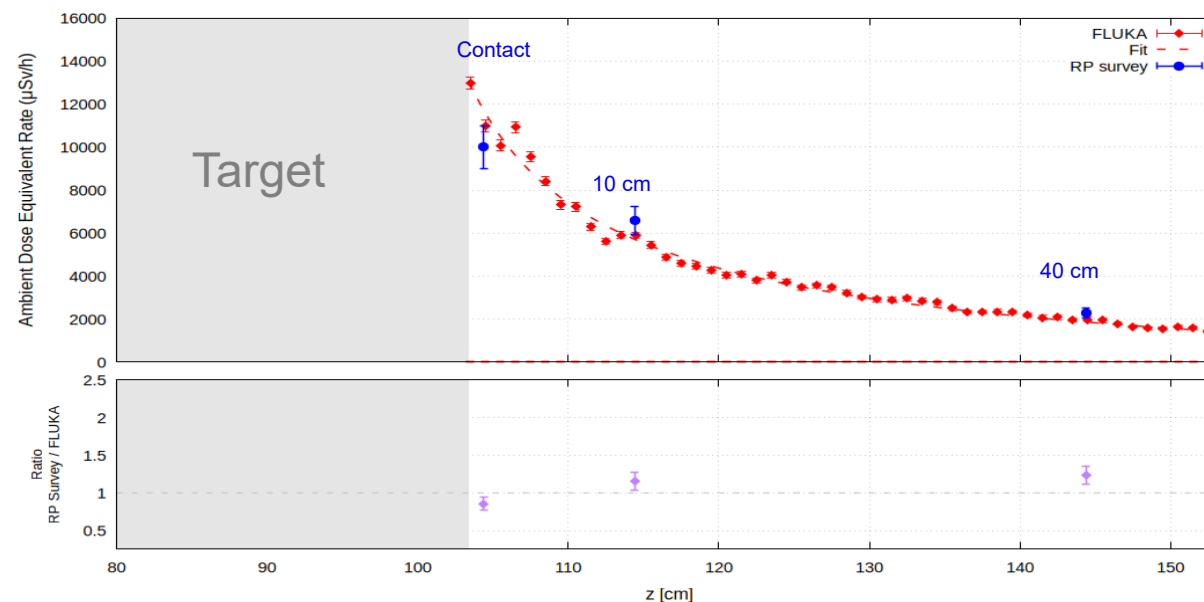
Cool-down time for benchmark: January 2026

- **Downstream:**

- RP Survey performed with an AD-6 ([Automess 6150AD](#)) on a robot
- Ratio RP Survey / FLUKA ~ 1.2 (at 10 cm and 40 cm)



Residual dose rate at different distances from the downstream face. Averaged on $X=[-5;5]$, $Y[15;20]$

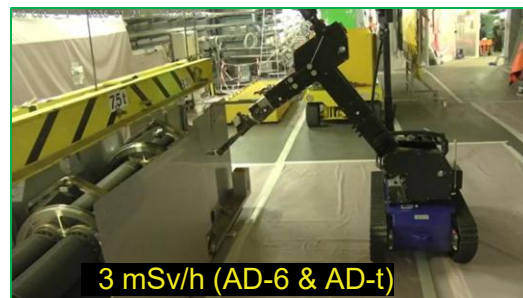


Benchmark – Target

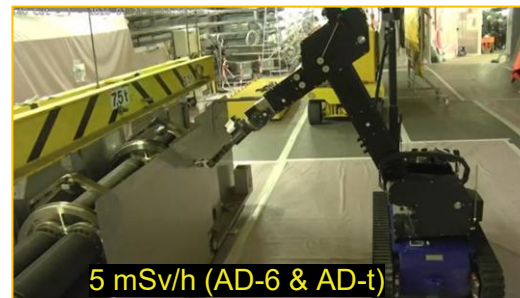
- **Lateral:**

- Measurement at 10 cm laterally from the target station on the TCC4 corridor side at 3 locations (upstream, middle, downstream).

(lateral upstream)



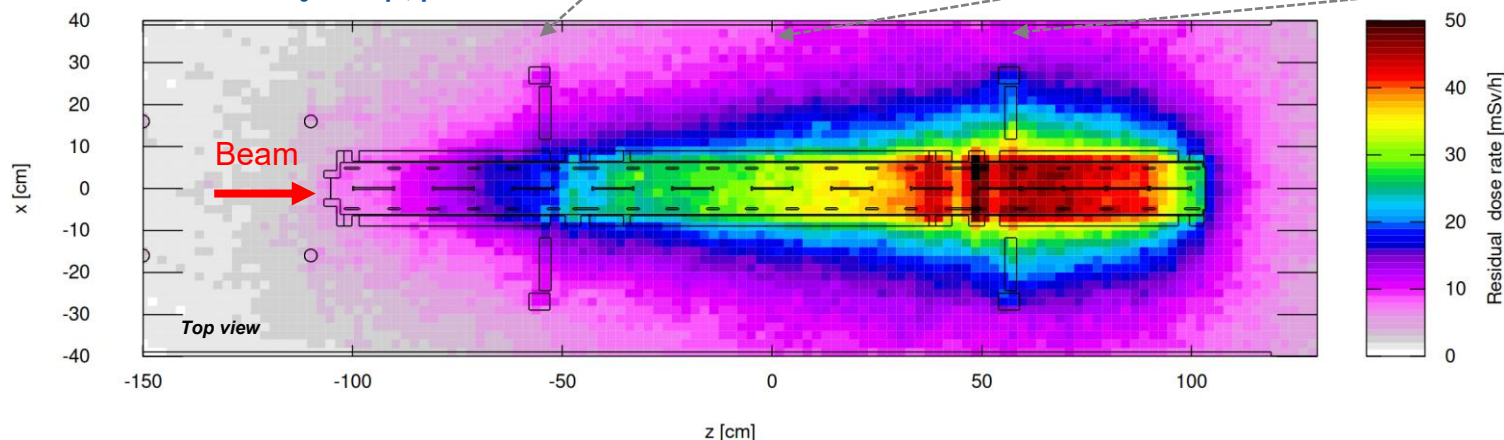
(lateral middle)



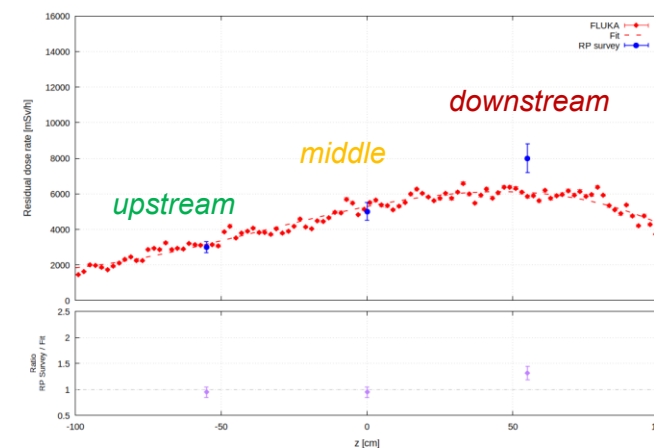
(lateral downstream)



Top view of the residual dose rate at the target location. Averaged on $Y=[-5;5]$



Cool-down time for benchmark: January 2026



Residual dose rate from center along beam axis. Averaged on $X=[30;40]$, $Y[20;30]$

Benchmark – Horn

- **RP Survey:**

- Using an AD-t ([Automess 6112AD](#))
- Upstream, downstream and laterally (both corridor and wall sides) at 3 distances (“contact”, 10cm, 40cm)



- **Ratio RP Survey / FLUKA:**

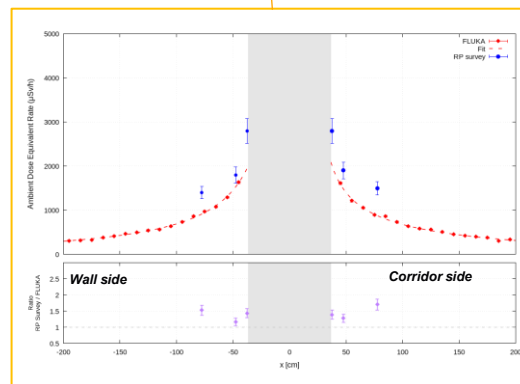
- Up to a factor of 2

- **Possible causes (under investigation):**

- Simplified geometry / materials
- Distances during survey

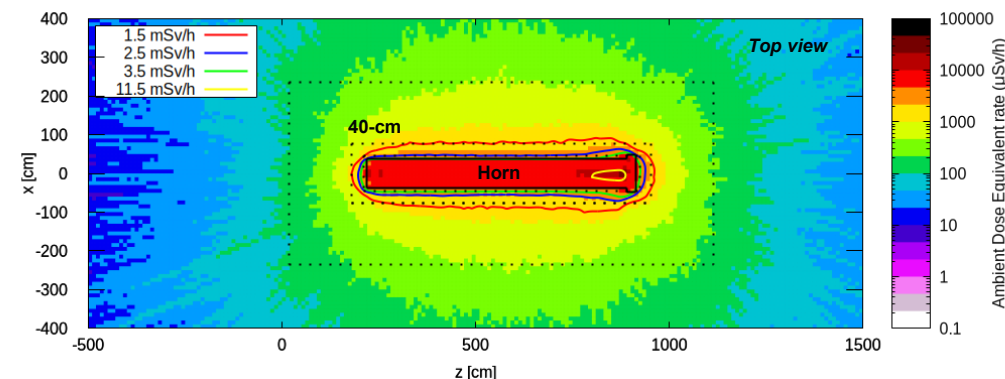
- **Implications:**

- Extra dose at removal (+0.5 p.mSv)
- Additional shielding for on-road transport

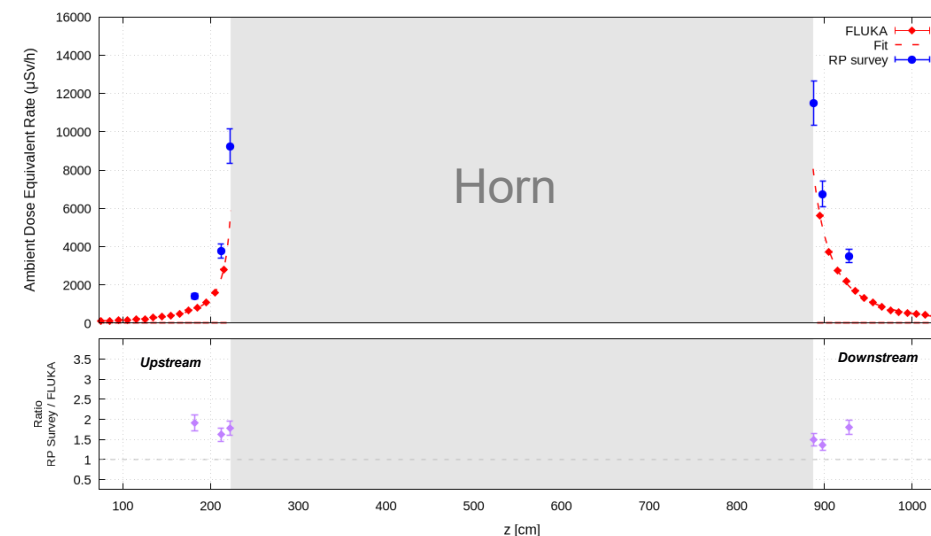


Residual dose rate laterally of the Horn. Averaged on $Y[-5;5]$

Cool-down time for benchmark: July 2026

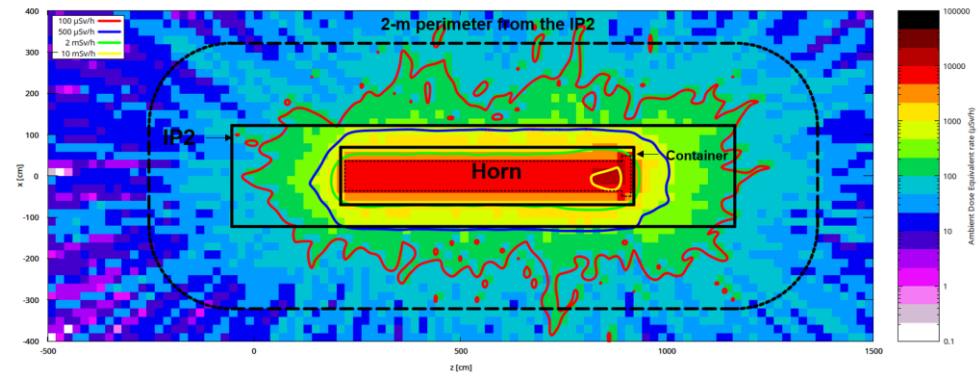
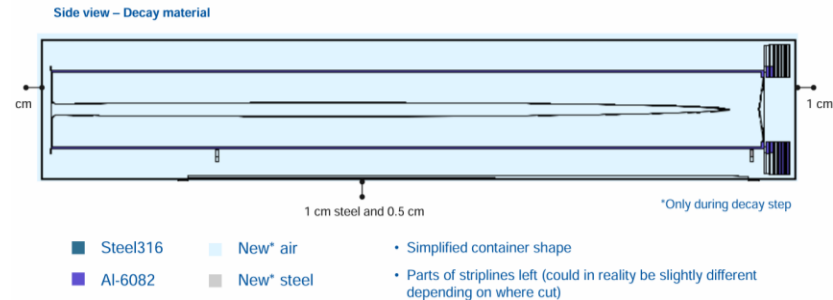


Residual dose rate upstream and downstream of the Horn. Averaged on $X=[-5;5]$, $Y[-5;5]$



Benchmark – Horn

Horn container and Truck in FLUKA for on road transport



Residual dose rate around truck containing the horn in its container with an additional 12 mm Pb-equivalent layer

Bin size Z=20cm, X=20 cm, averaged in Y=[-10;10] - Scaled with RP survey (factor 2)

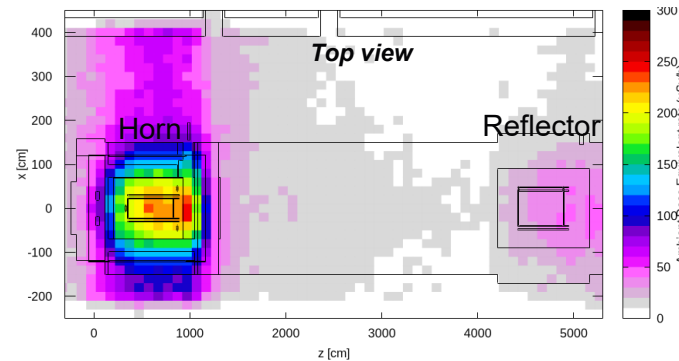
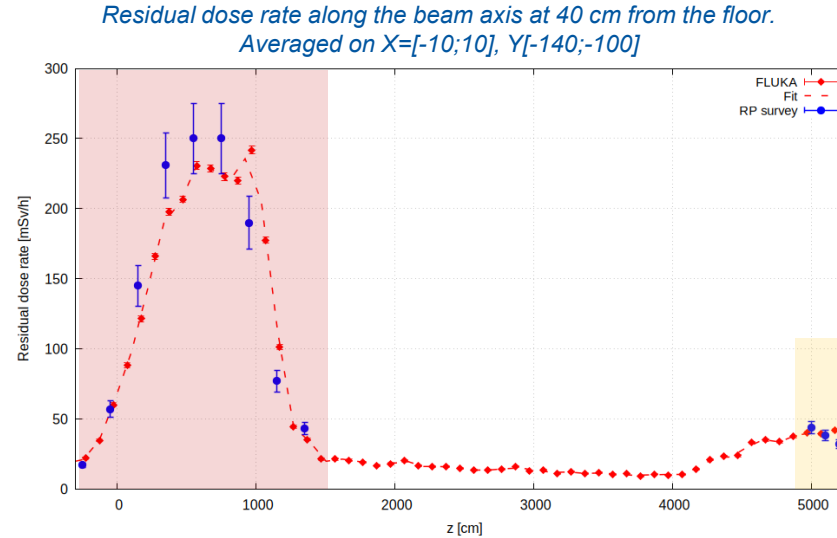
Top view at beam level



Benchmark – Empty Tunnel



Empty tunnel floor below the target & horn



Cool-down time for benchmark: September 2026

• RP Survey (09/2026):

- Measurement with 3 AD-6 ([Automess 6150AD](#)) mounted on mechanical arm with 3 distances ("contact", 40cm, 100cm)
- Identification of areas $>50 \mu\text{Sv/h}$ at 40 cm

✓ Good agreement with FLUKA simulation (activities still ongoing)



Empty tunnel floor below the reflector



Feedback

Planning & Contamination



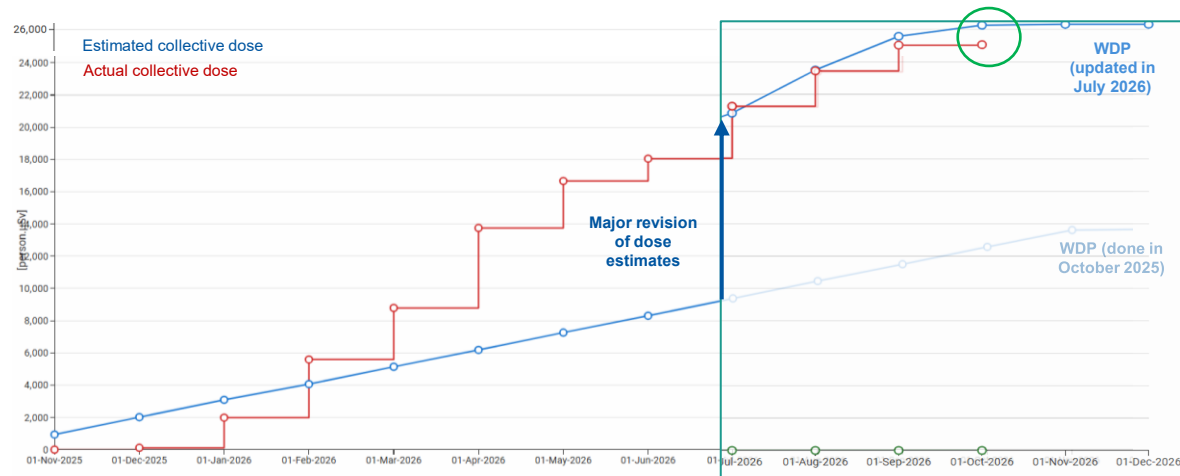
Feedback – Work and Dose Planning

- **Strategy:**

- No safety factor used for dose estimates → early detection in case of deviation
- Safety margin of 20% in the planning → currently with +1 month behind schedule after 10 months.
- Presentation to an ALARA committee as per CERN procedure (>5 p.mSv or >1 mSv) → ensure optimization measures.

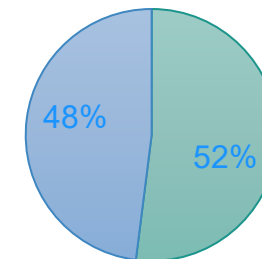
- **Lessons learnt:**

- Collective dose estimate went from 14 p.mSv (initial) to 26 p.mSv (current) → major review in July 2026
- Safety factors could have been used in critical activities for which hard limits apply (ex: on-road transport or max individual dose)
- Foresee slots in the planning for backup options (ex: removal of the Horn)



Additional collective dose (+12.5 p.mSv)

- Activities not considered in the initial scope
- Operational difficulties



Feedback – Contamination

- **Items *contaminated*:**

- 136 (currently) → Marble, Concrete, Iron shielding and Aluminium beam line components facing the beam. Mainly associated with degradation of the material (rust, dust, sweat).

- **Limits applied:**

- $> 1 \text{ Bq/cm}^2$ (unidentified β/γ) or $> 0.1 \text{ Bq/cm}^2$ (unidentified α).
For identified radionuclides $> 1 \text{ CS}$ (values derived from Swiss legislation)
- If after cleaning or decontamination still above the limits → packaged or contamination fixed.

- **Main actions:**

- The most radioactive items were wrapped or placed in dedicated containers.
- The Helium Tanks (Aluminium) were cut and decontaminated (ASPIGEL).
- Contamination fixed on concrete blocks $< 600 \mu\text{Sv/h}$ at contact (CONTAFIX),

Target



TBID



Fix contamination (spray) vs. decontamination (gel) on concrete



Helium Tank
(decontaminated)



Reflector (wrapped)



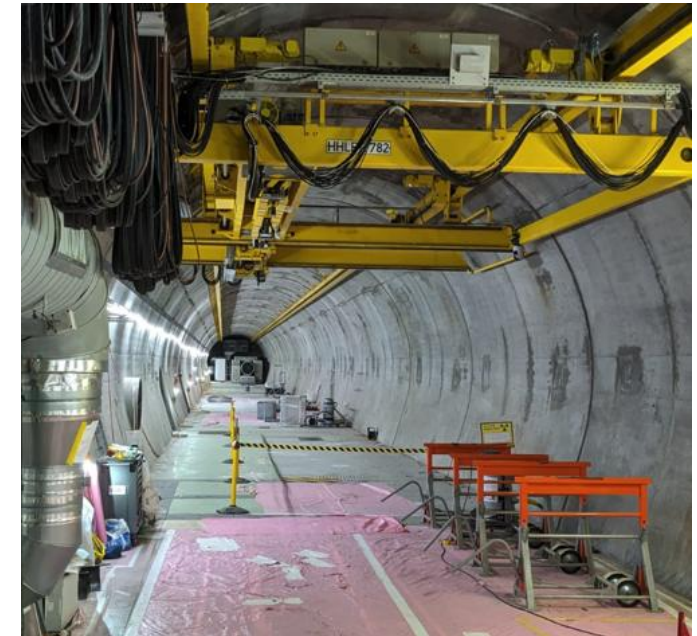
Conclusion



Conclusion

- The **CNGS Target Area** is being **decommissioned (2025-2026)** for the extension of the *AWAKE* experiment.
- **Characterization studies** were done in preparation of the activity. Current collective dose estimate is **26 p.mSv** (14 p.mSv initially).
- **Benchmark** results on residual dose rates show an agreement between RP survey and FLUKA generally within a **factor of 2** (mainly underestimation).
- Operational activities carried out by a specialized nuclear dismantling contractor: **a lot of lessons learnt!**

After the decommissioning of the Target Area, it will only remain from CNGS the 1-km decay tube and the hadron stop chamber (200 m³ of iron...)



to be continued...





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