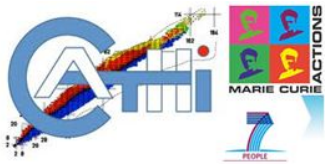


CATHI Final Review Meeting

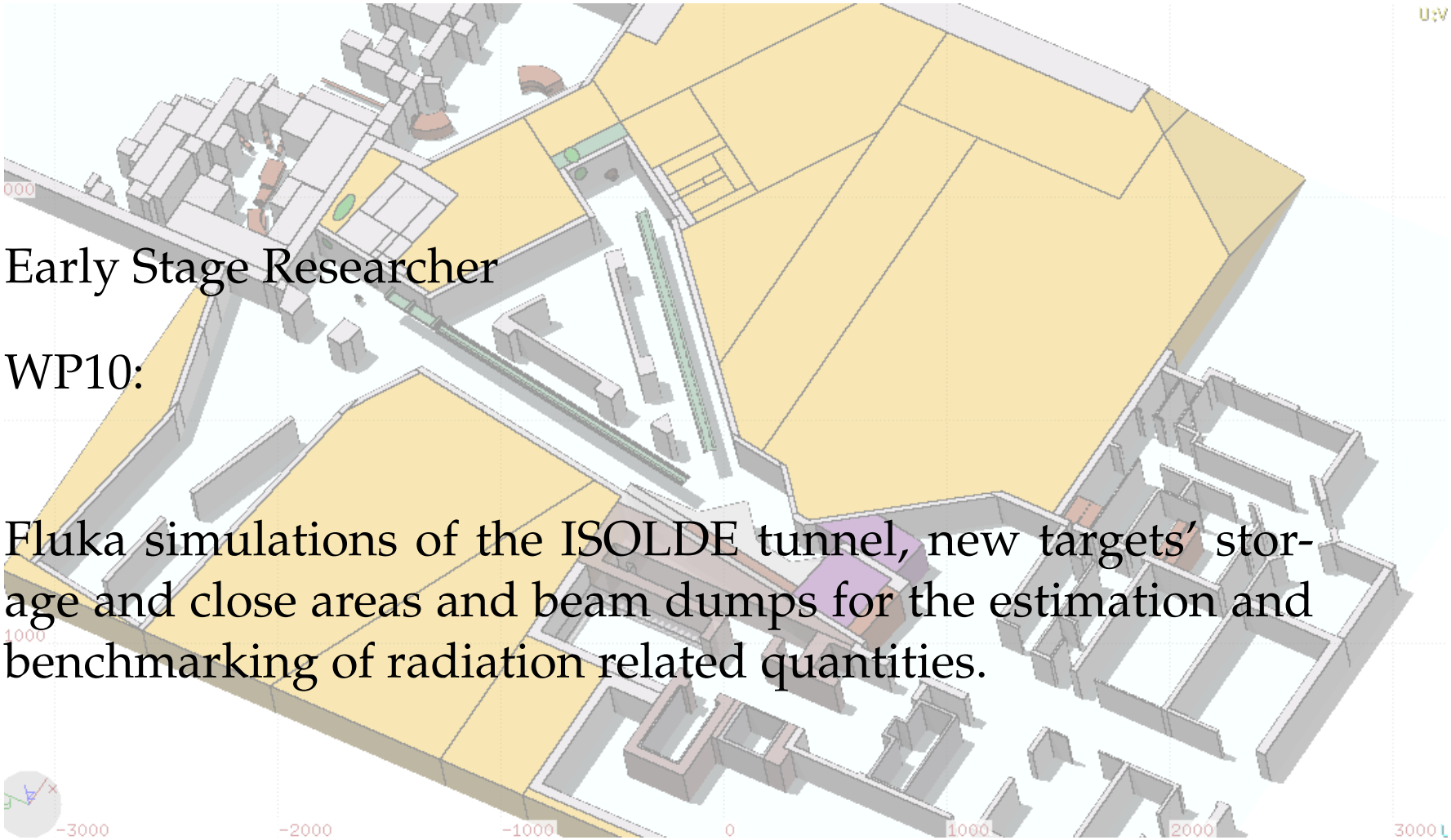
Dose from FLUKA simulations on ISOLDE tunnel and MEDICIS areas

Leonel R. Morejon

Supervisor:
Vasilis Vlachoudis

*The research leading to these results has received funding from the European Commission under the FP7-PEOPLE-ITN-2010-ITN project CATHI (Marie Curie Actions - ITN). Grant agreement no. PITN-GA-2010-264330

MY ROLE WITHIN CATHI



Early Stage Researcher

WP10:

Fluka simulations of the ISOLDE tunnel, new targets' storage and close areas and beam dumps for the estimation and benchmarking of radiation related quantities.

ISOLDE TUNNEL STATS.

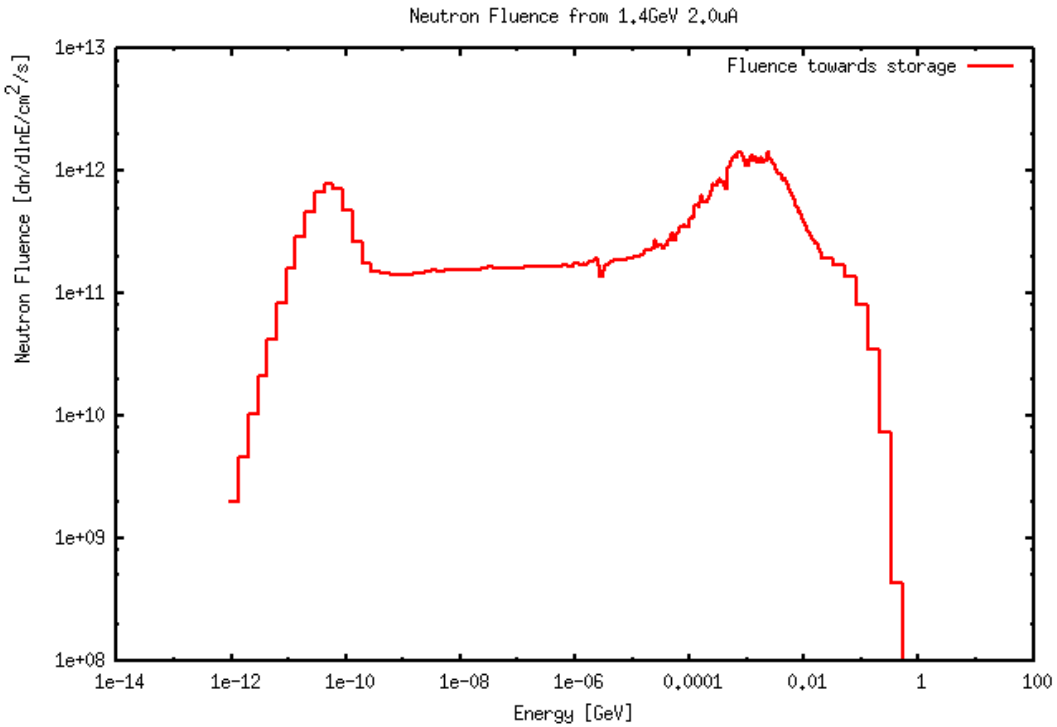
ISOLDE tunnel 2013

- 2 uA protons of 1.4 GeV hitting targets
- 7 uA protons of 2.0 GeV hitting targets (HIE-ISOLDE)
- Target stats: U, Ta, W, Pb, thickness of about $\sim 50 g/cm^2$

ISOLDE TUNNEL STATS.

ISOLDE tunnel 2013

- 90% protons into dump $\sim 2.6kW$
- neutron fluence of order $\sim 10^{13} n/cm^2/s$
- neutron iso-lethargic spectrum as shown



ADDRESSED ISSUES

Areas concerned here:

- MEDICIS-Storage
- Stored Targets
- Beam dumps
- Activation

OVERVIEW

NEW STORAGE SHIELD

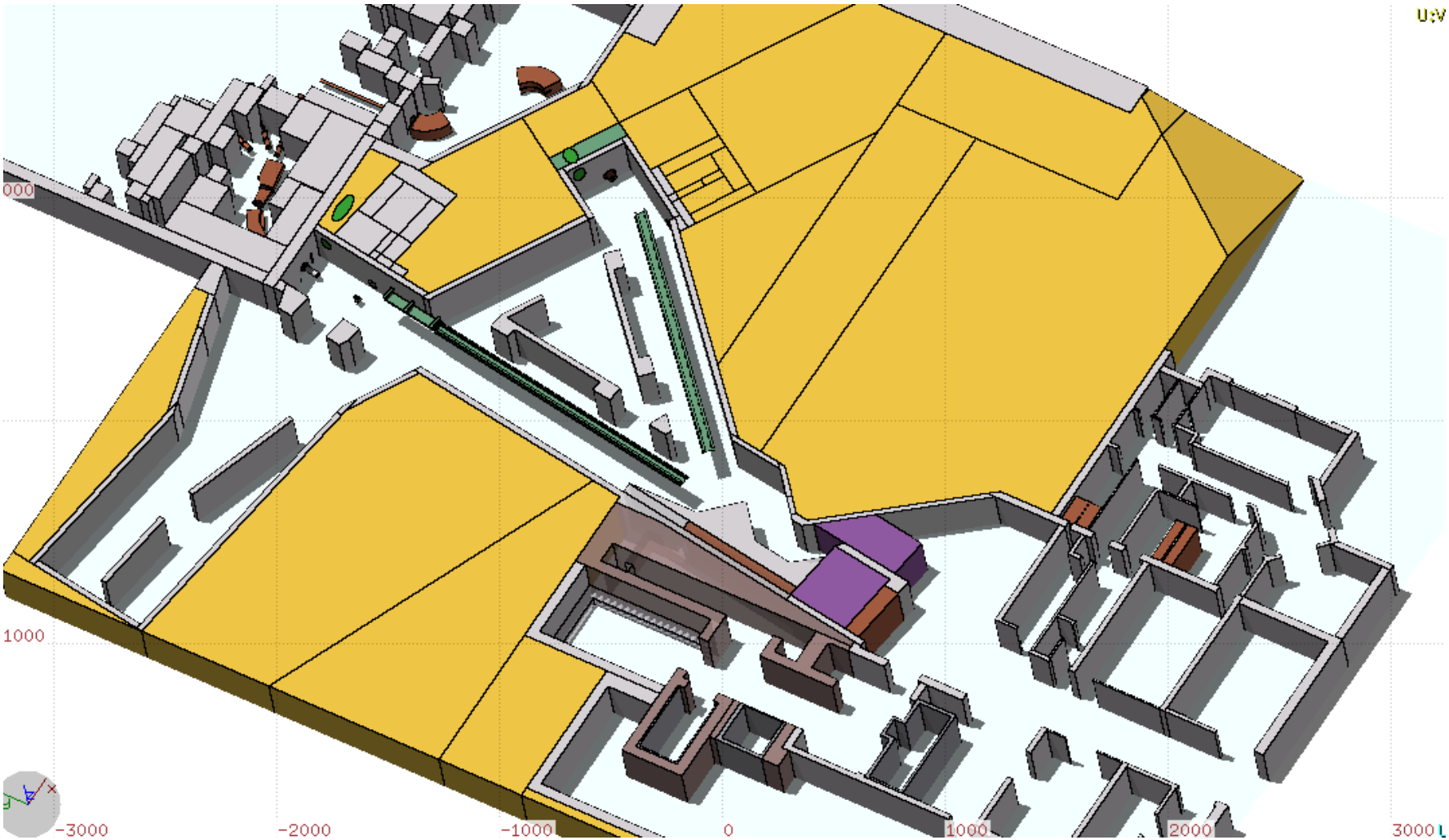
HOT TARGETS

ACTIVATION

BENCHMARKING

BEAM DUMPS

SHIELDING FOR NEW STORAGE



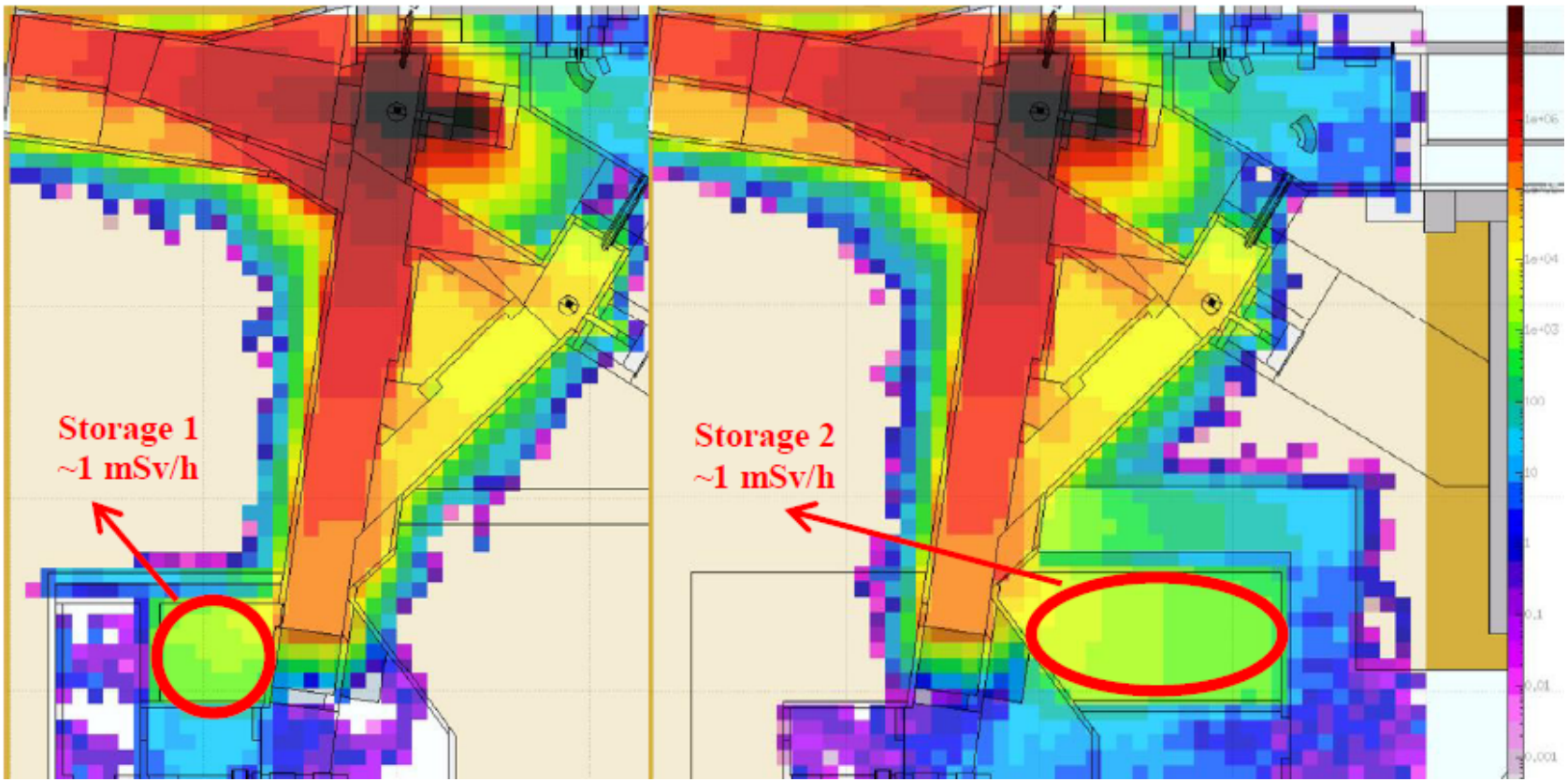
BRIEF DESCRIPTION...

ISOLDE tunnel 2013

- Addition of a new building for MEDICIS and targets storage
- Closeness to tunnel, needs dose evaluation while design

BETTER SUITED LOCATION

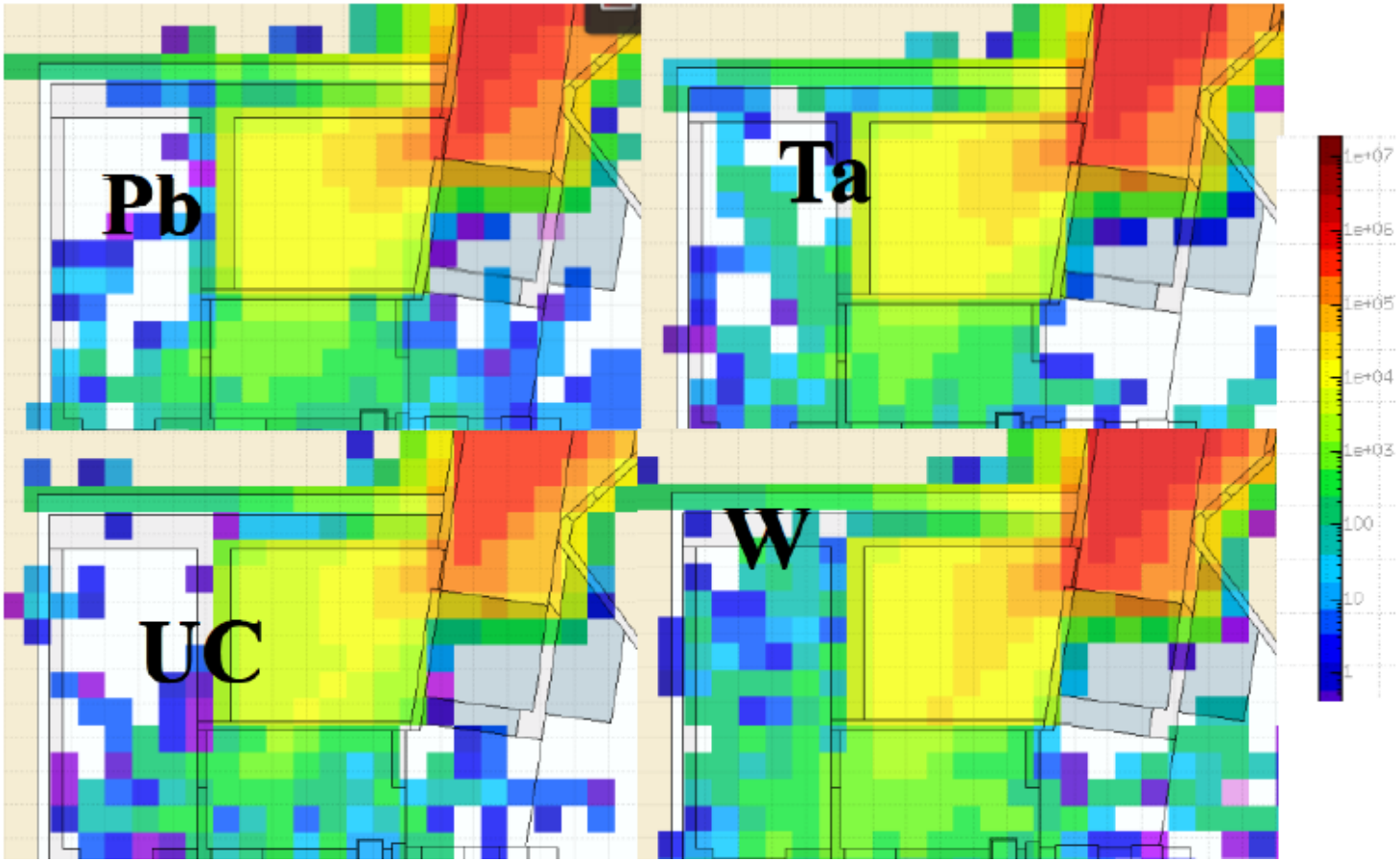
Combinations of targets, and beam incidence simulated to compare left vs right position of Storage



Simulations not conclusive on more protected position.

DIFFERENCE IN TARGETS

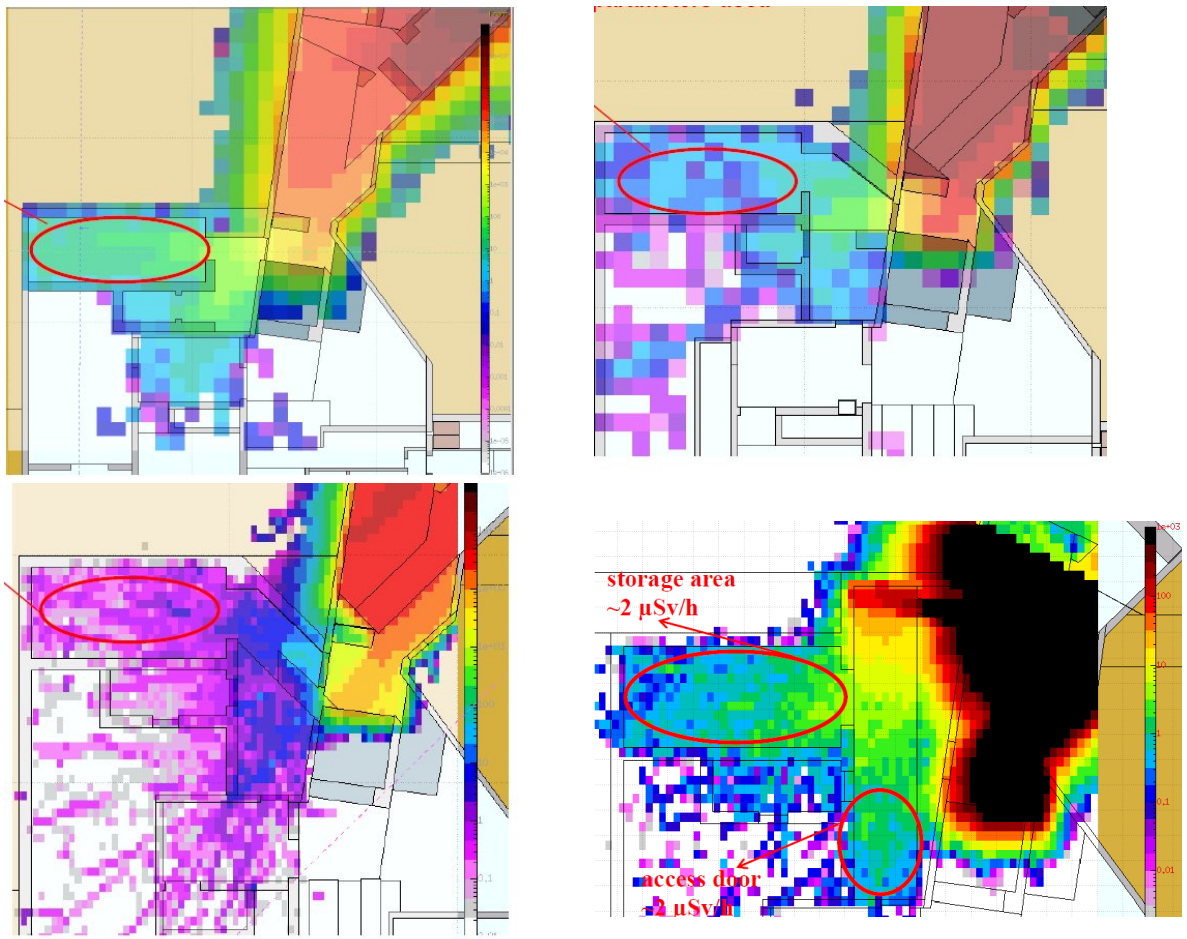
Combinations of targets, and beam incidence simulated to compare left vs right position of Storage



Tungsten slightly worse scenario.

SOME PRE-DESIGNS' EVALUATION

Several designs and shielding options simulated



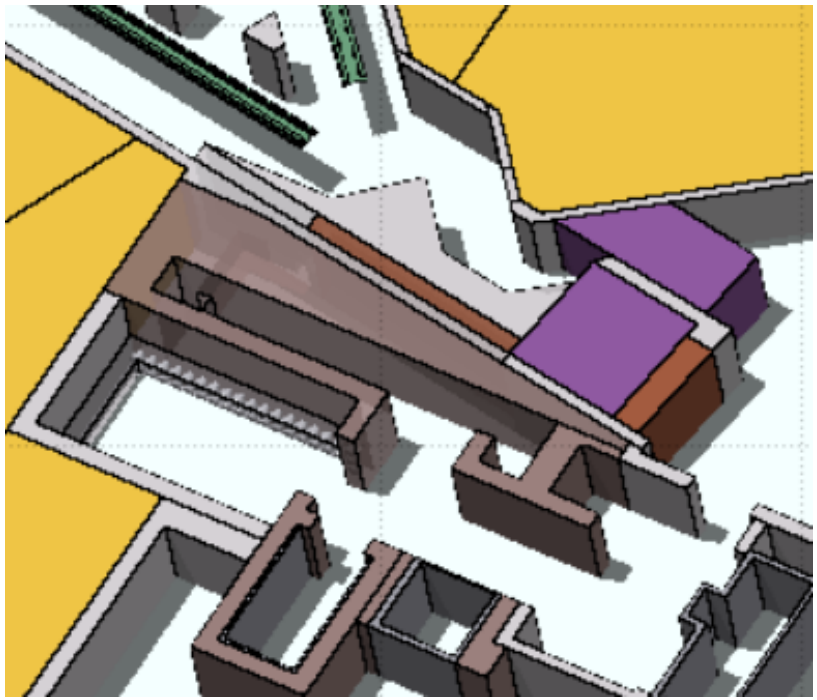
Design was refined and shielding grew effective

RADICAL CHANGE ON DESIGN

INCLUSION OF A STRONG SHIELDING

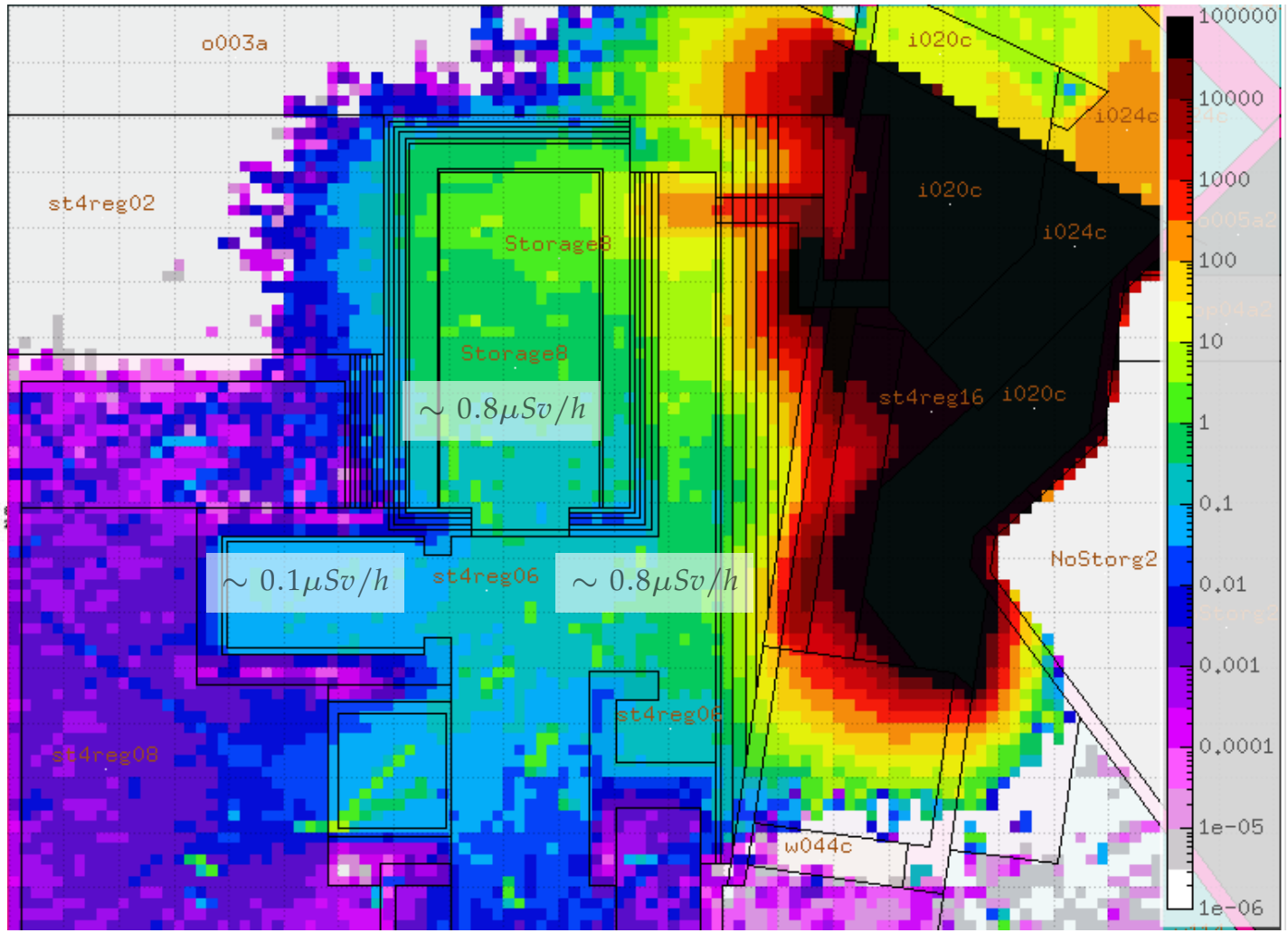
A need for a stronger shielding

- 3m average depth
- Concrete (ρ 4.5 g/cm3)
- 60cm thick iron layer

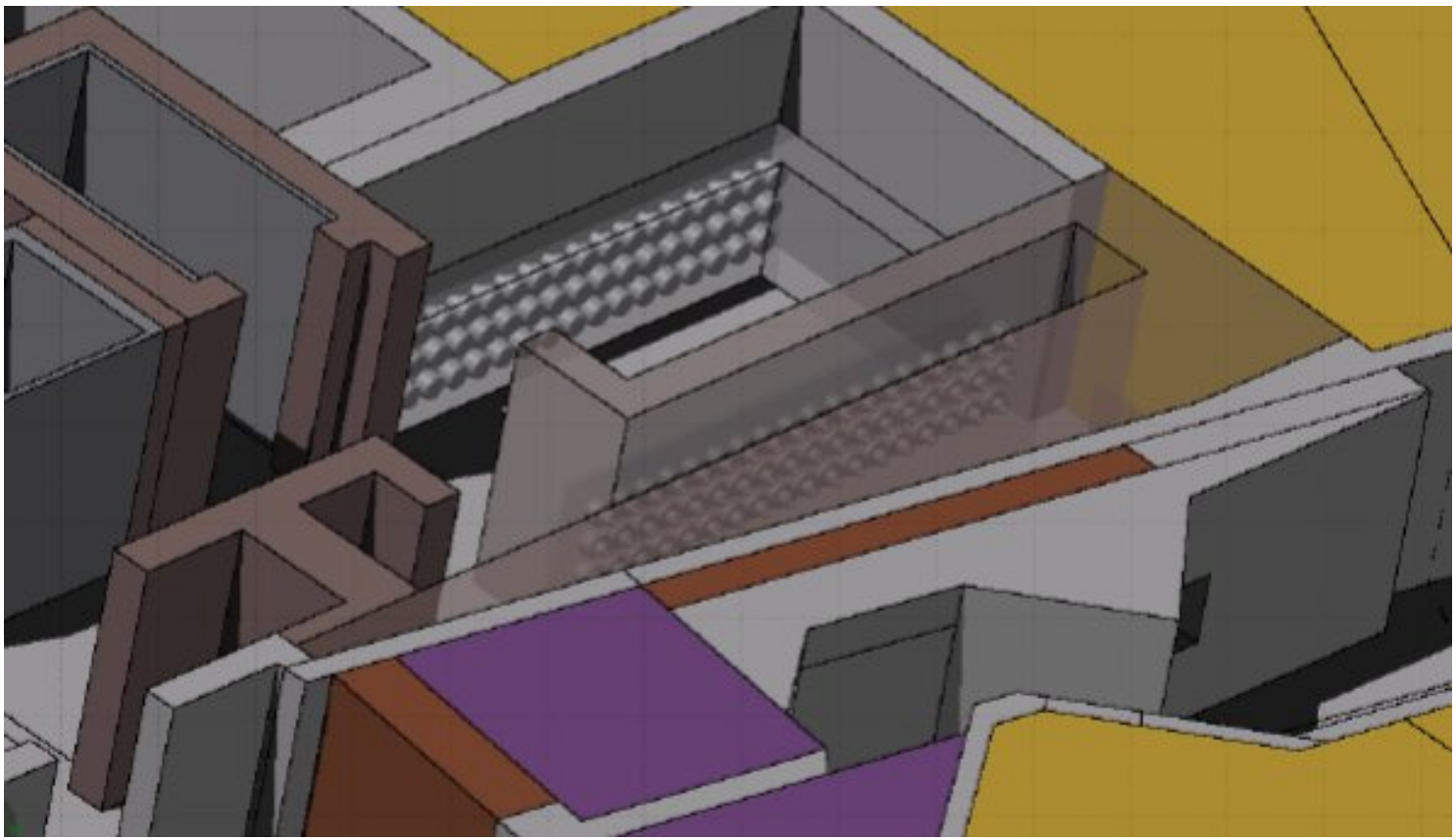


DOSE DISTRIBUTION FOUND

VALUES OF INTEREST FROM NEUTRONS



HOT TARGETS

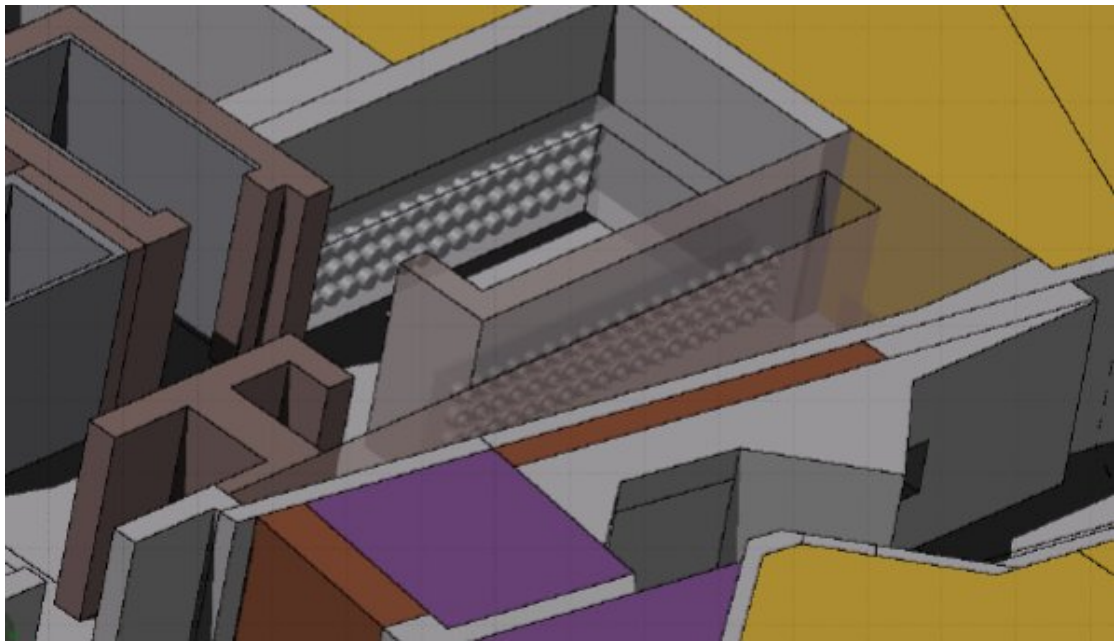


BRIEF DESCRIPTION

DETERMINING STORED TARGETS DOSE

Dose from targets

- 108 "Hot" targets expected
- Different decay times foreseen $(6m, 1y, 2y)$
- Several target types (W, Ta, U, Pb)

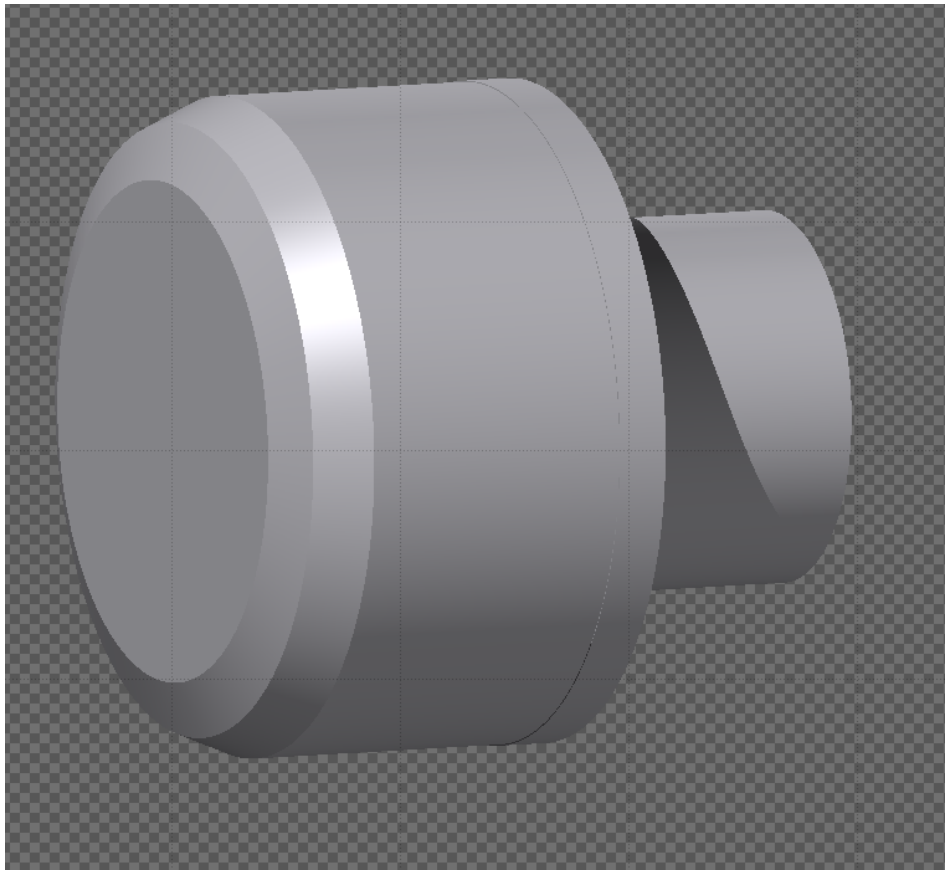


DOSE VALUES OBTAINED

ALL TARGETS SIMULATED FROM ONE SPECTRUM

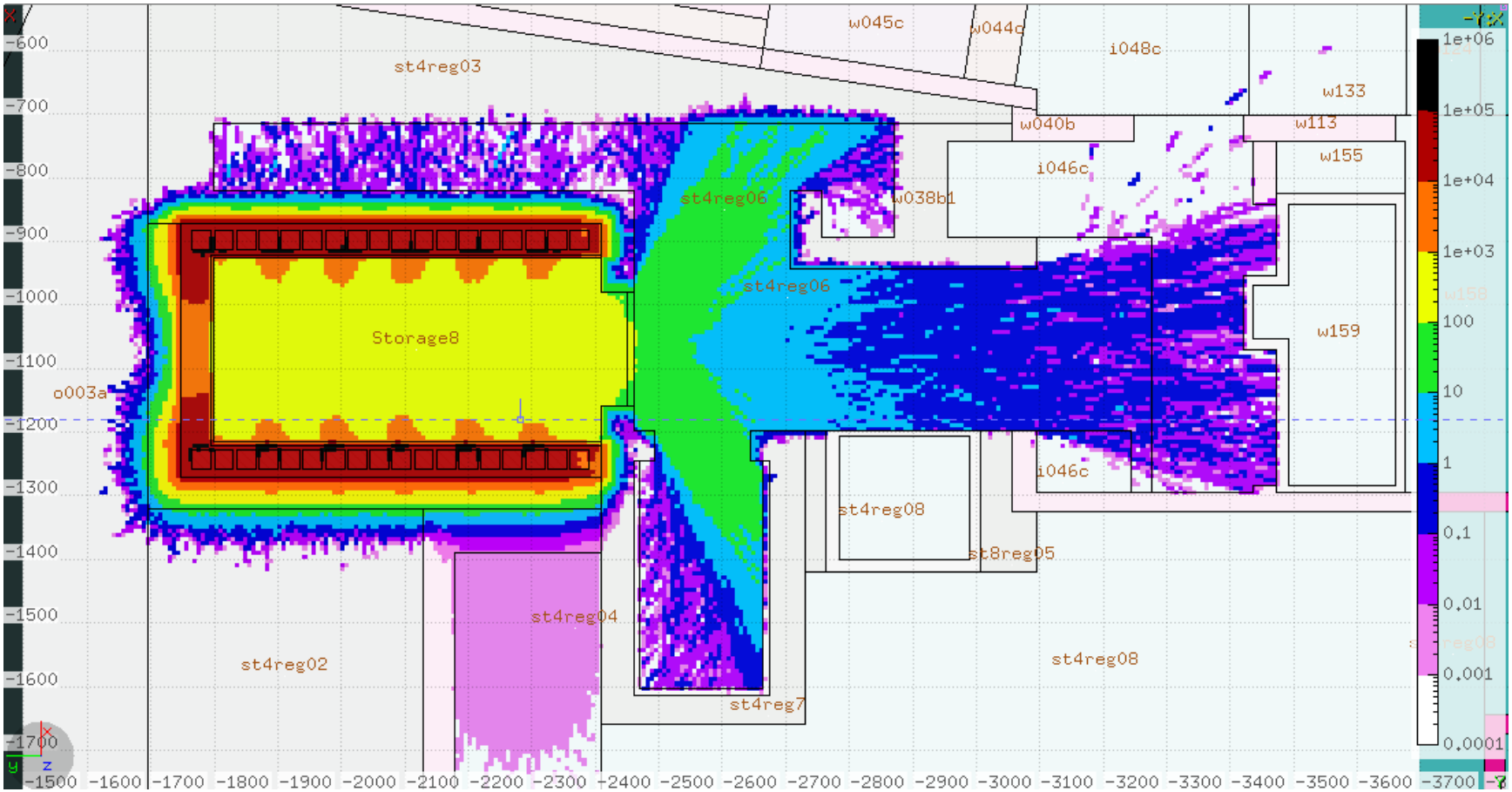
Values from only one target

- Target irradiated for 6 months
- Spectra form target decay scored
- Several decay times scored



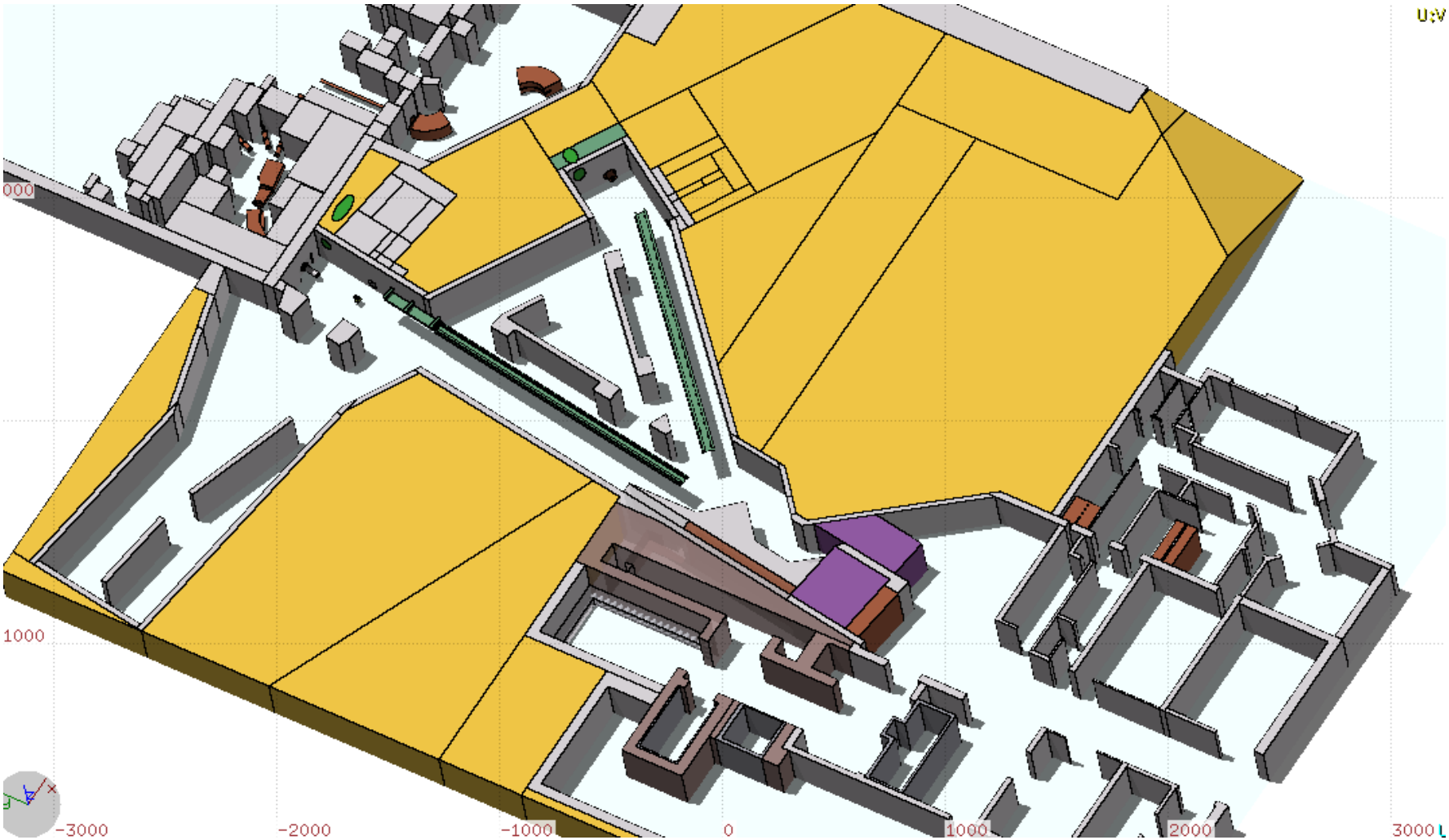
DOSE VALUES OBTAINED

DOSE FROM ALL TARGETS TOGETHER



108 targets, divided in 3 rows, in 2 sides. Dose in $\mu Sv/h$

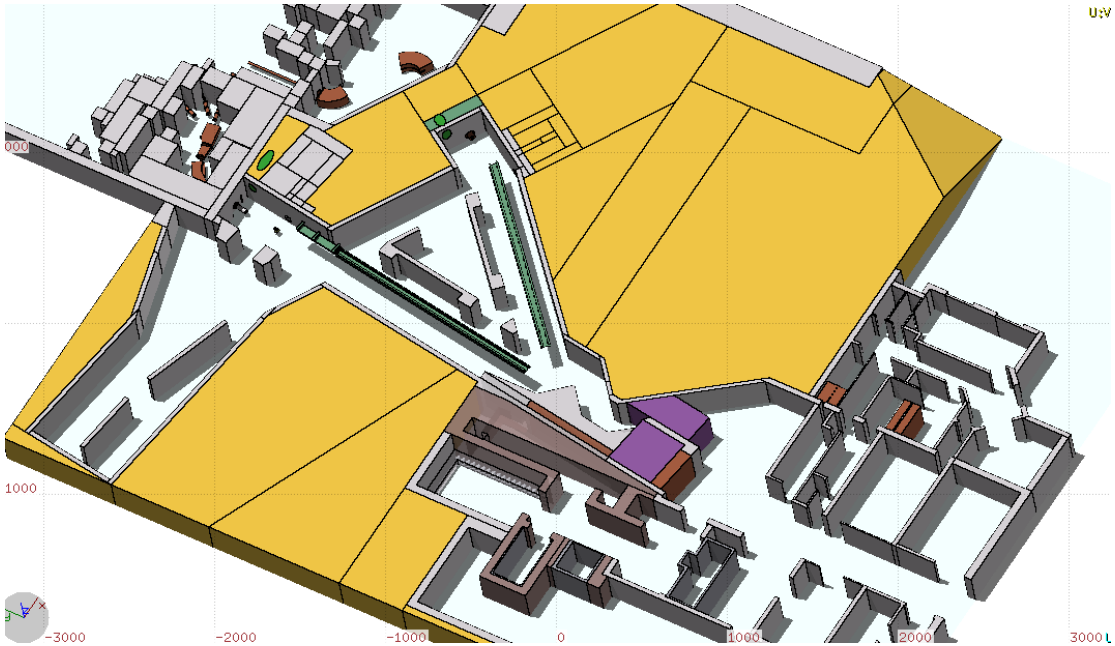
ACTIVATION



BRIEF DESCRIPTION...

Irradiation conditions considered

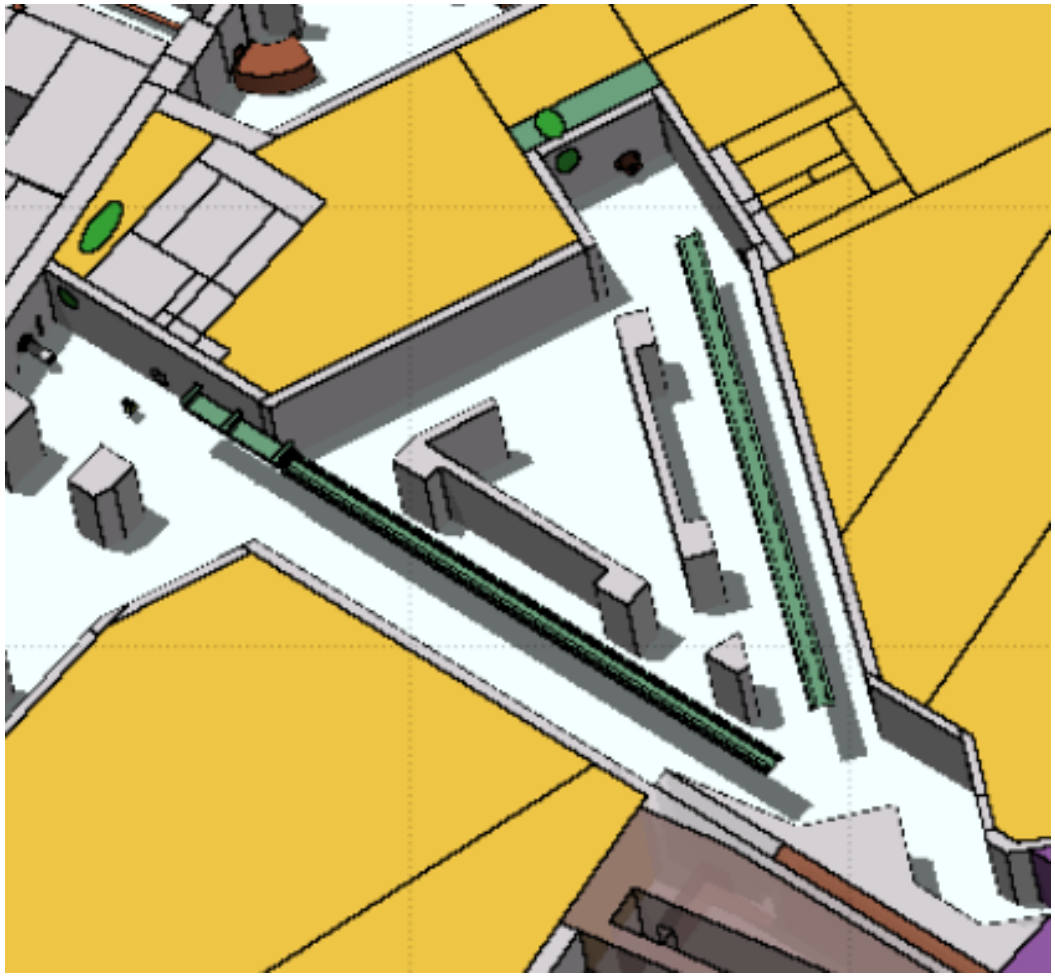
- ISOLDE operation 1.4 GeV
- 3 years operation
- 9 months beam on, 3 months beam off
- 2 uA averaged over $\frac{1}{3}$ of the time: $0.7\mu A$



ROBOT RAILS

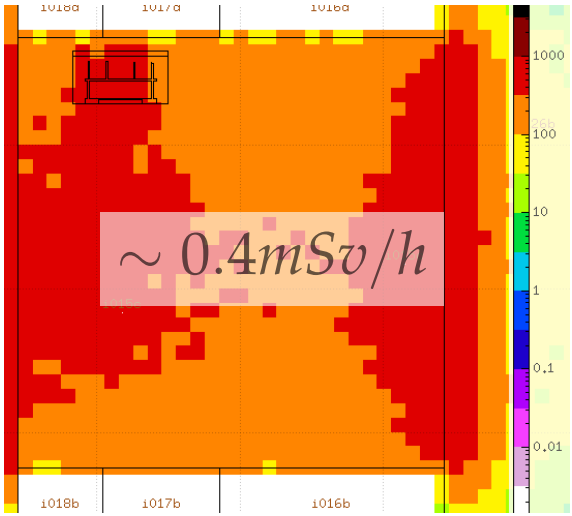
Brief description...

- New robot rails to exchange targets
- Rails with high content of iron
- GPS rail ∼12 m
- HRS rail ∼17 m

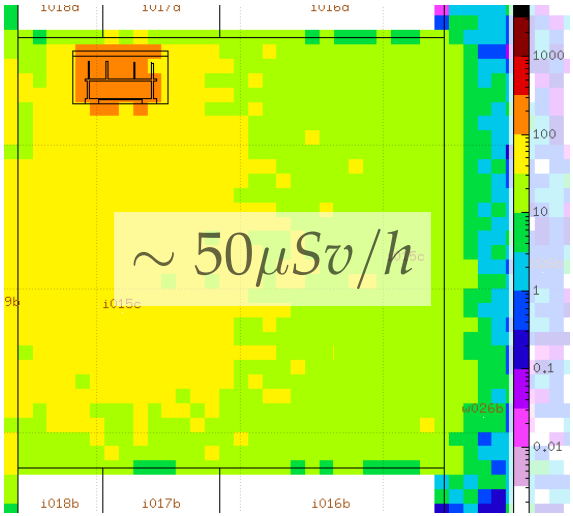


DOSE OBTAINED FROM ACTIVATION: GPS

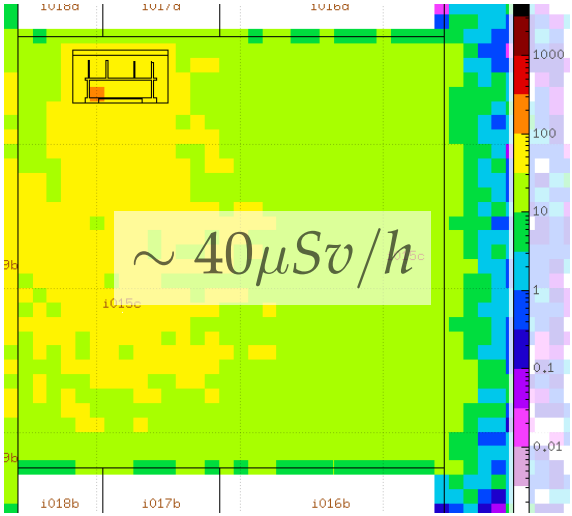
Several cooling times, dose in mSv/h across rail in the most activated position



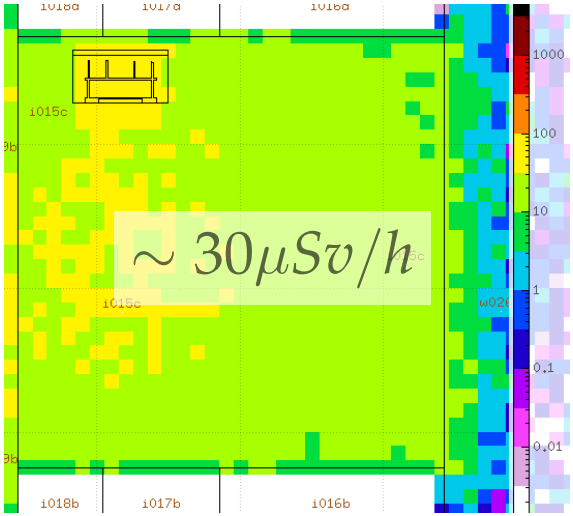
1 day



1 month



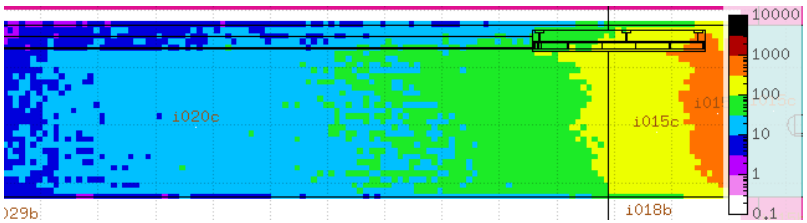
6 months



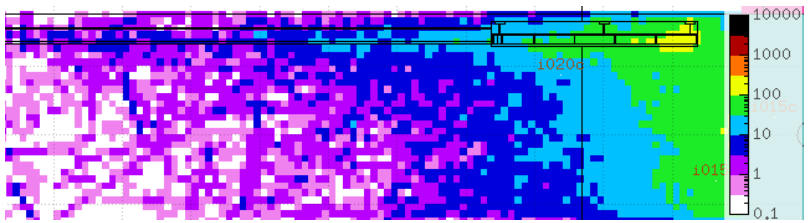
1 year

DOSE OBTAINED FROM ACTIVATION: GPS

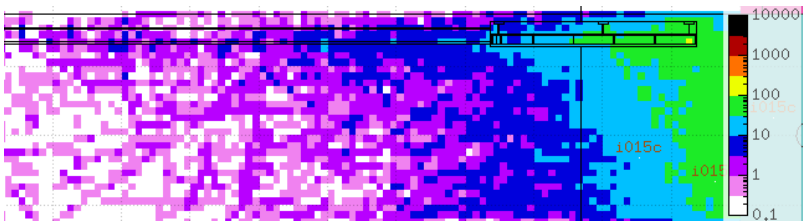
Several cooling times, dose in mSv/h along the rail



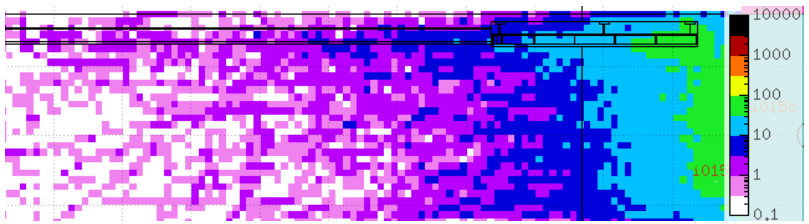
1 day



1 month



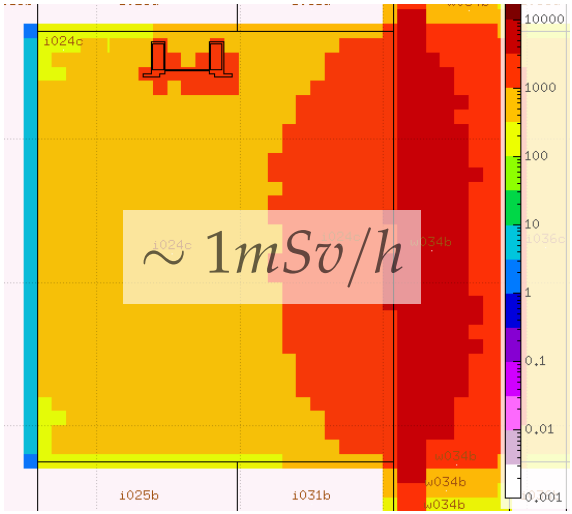
1 months



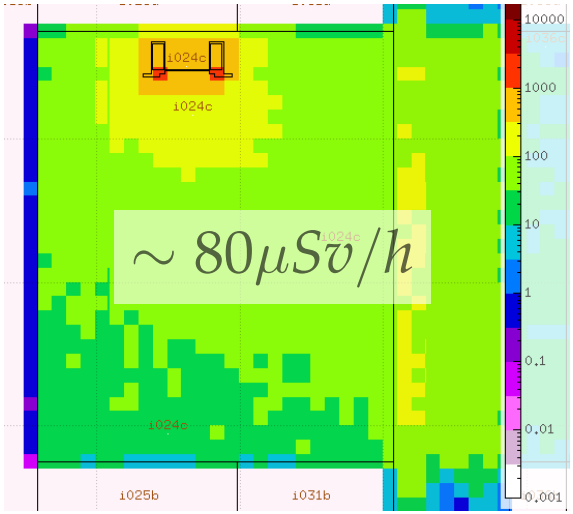
1 year

DOSE OBTAINED FROM ACTIVATION: HRS

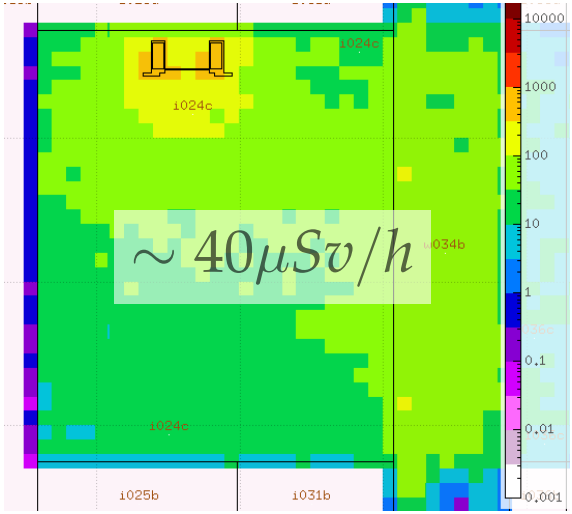
Several cooling times, dose in mSv/h across rail in the most activated position.



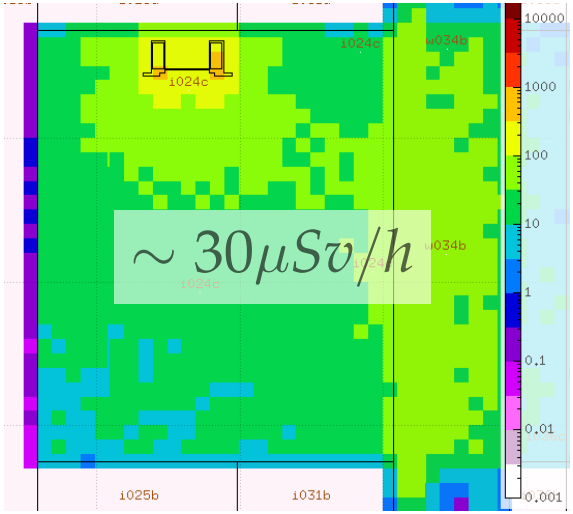
1 day



1 month



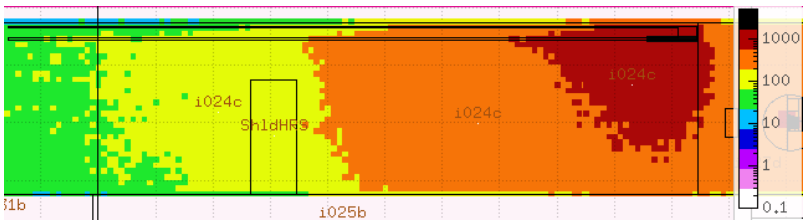
6 months



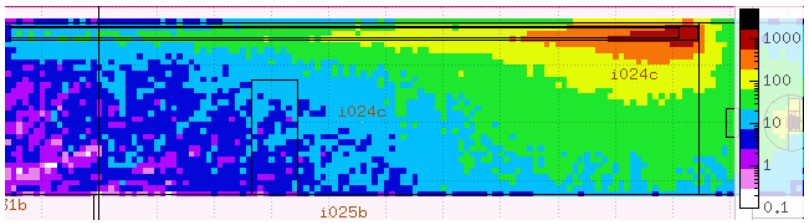
1 year

DOSE OBTAINED FROM ACTIVATION: HRS

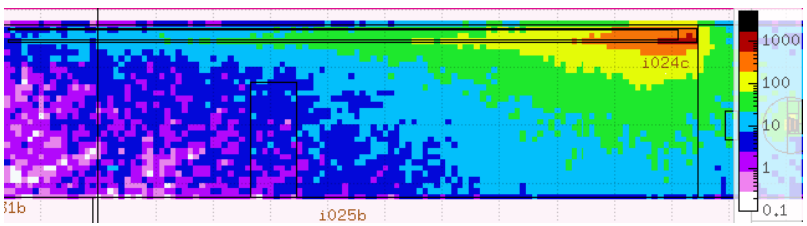
Several cooling times, dose in mSv/h along the rail



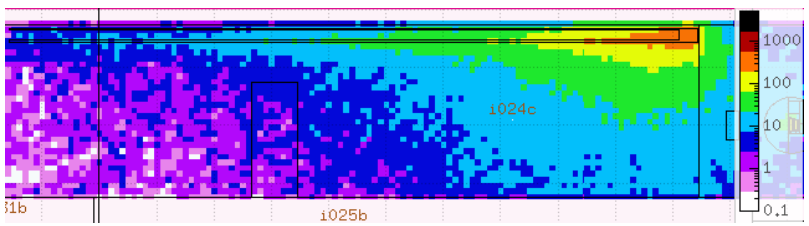
1 day



1 month



1 months



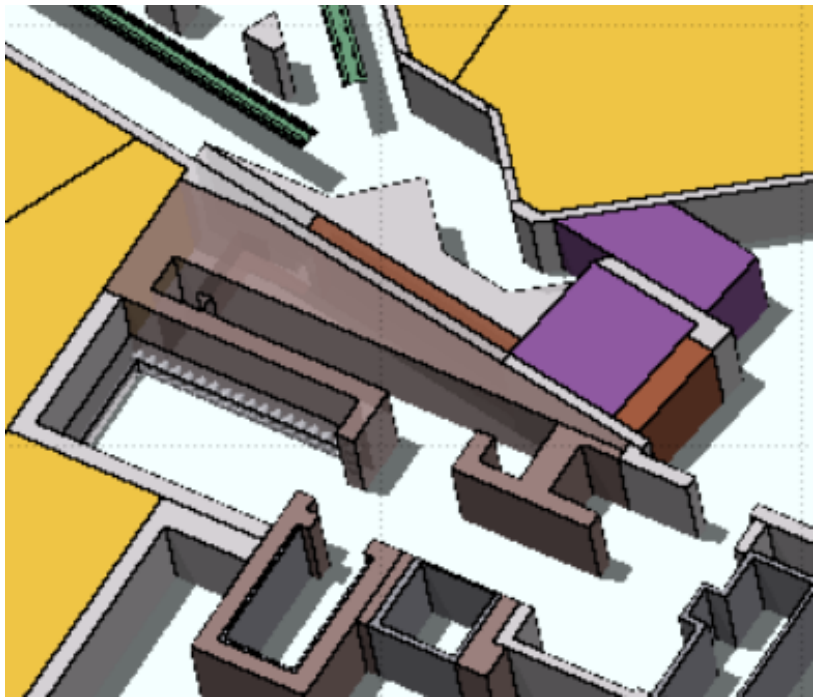
1 year

SHIELDING DOSE

INCLUSION OF A STRONG SHIELDING

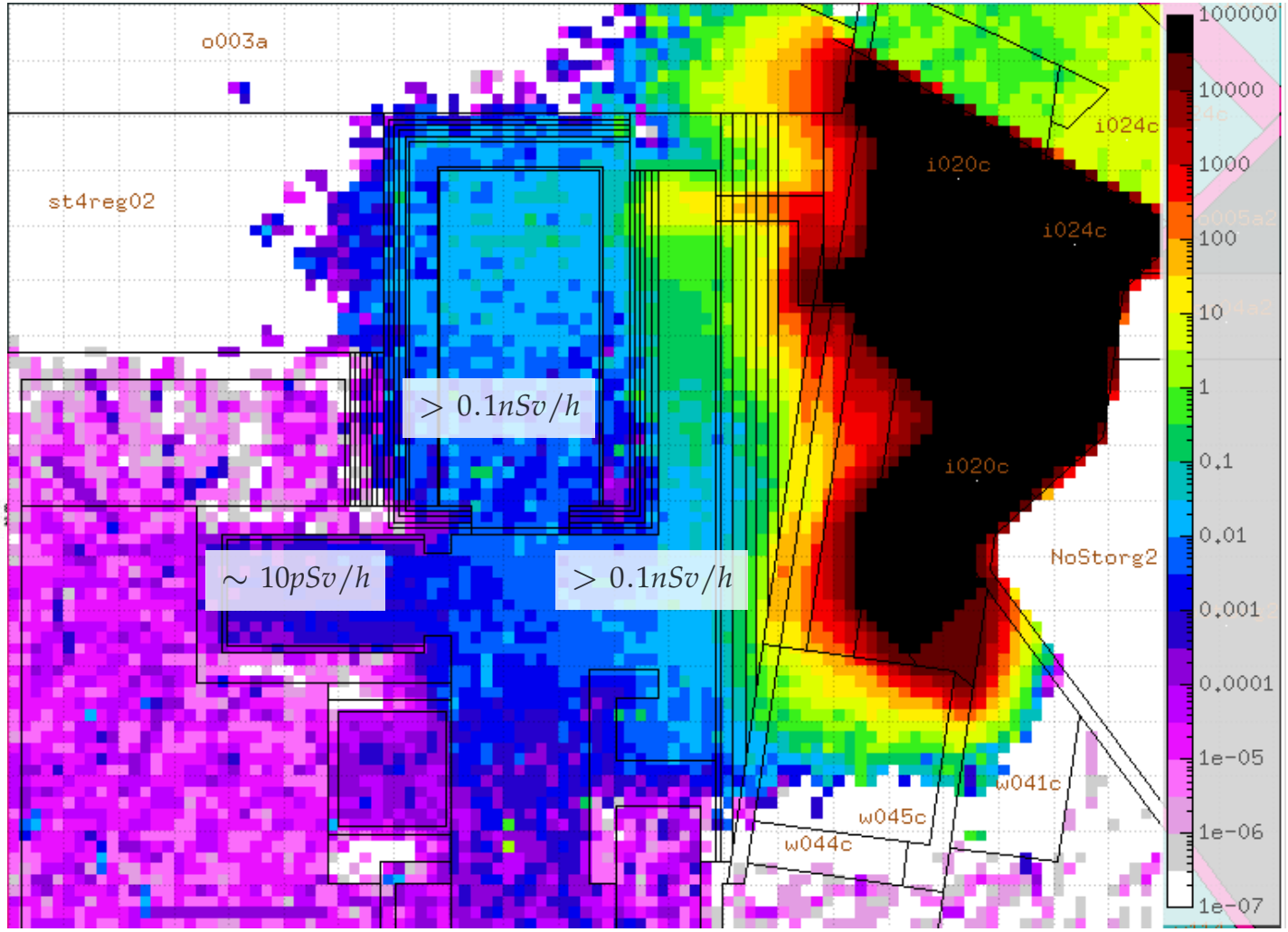
Reviewing shielding features...

- 3m average depth
- Concrete (ρ 4.5 g/cm3)
- 60cm thick iron layer



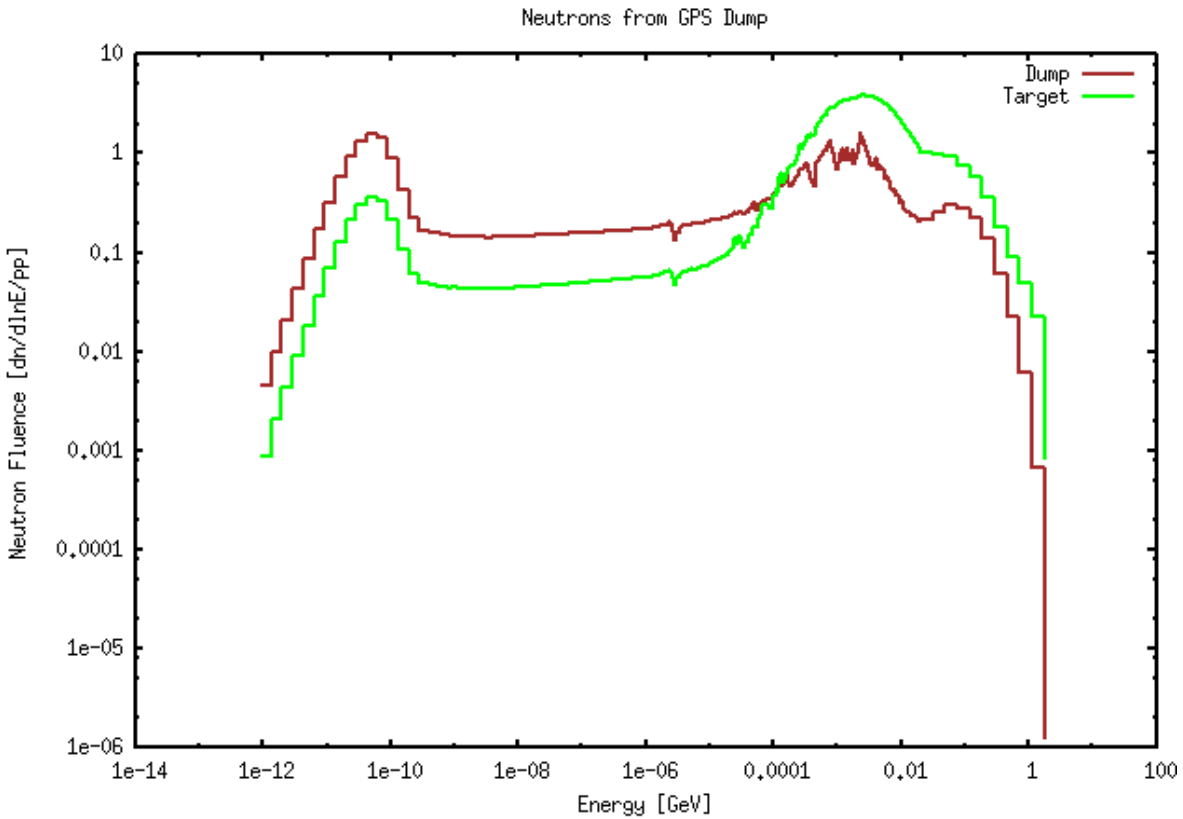
SHIELDING DOSE

DOSE IN nSv/h OBTAINED FROM ACTIVATION: 1 DAY DECAY TIME



BRIEF DESCRIPTION

AIR ACTIVATION BY NEUTRONS



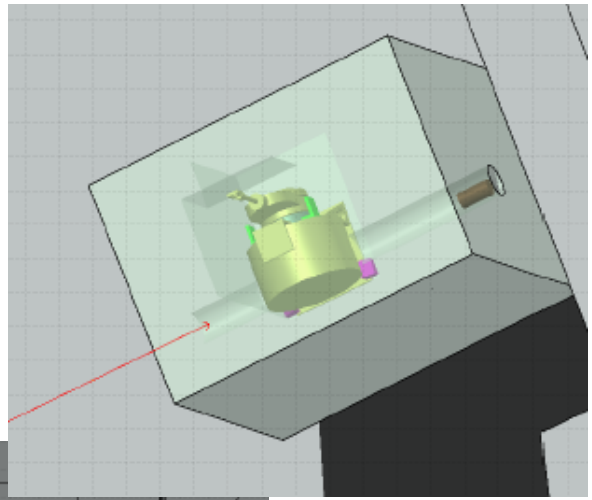
Dump contributes much more to lower Energy neutrons, but more difficult to cover.

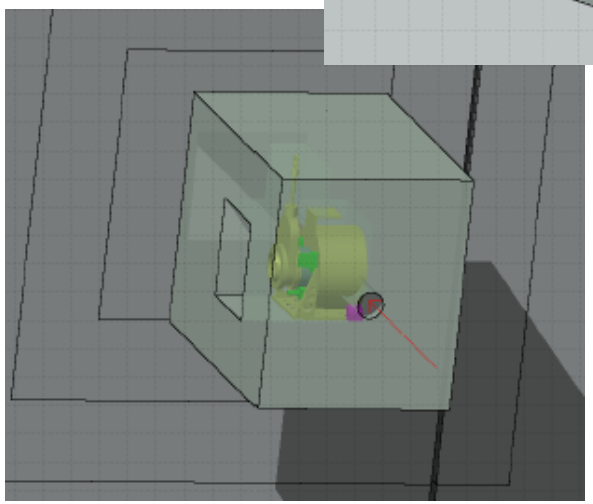
BRIEF DESCRIPTION

AIR ACTIVATION BY NEUTRONS FROM TARGET

Conceptual study for target cover

- 10-30cm thick cover
- Borated Polyethylene
- MEDICIS and ISOLDE targets included





PROPOSAL FOR REDUCTION: EFFECTIVE BUT INFEASIBLE

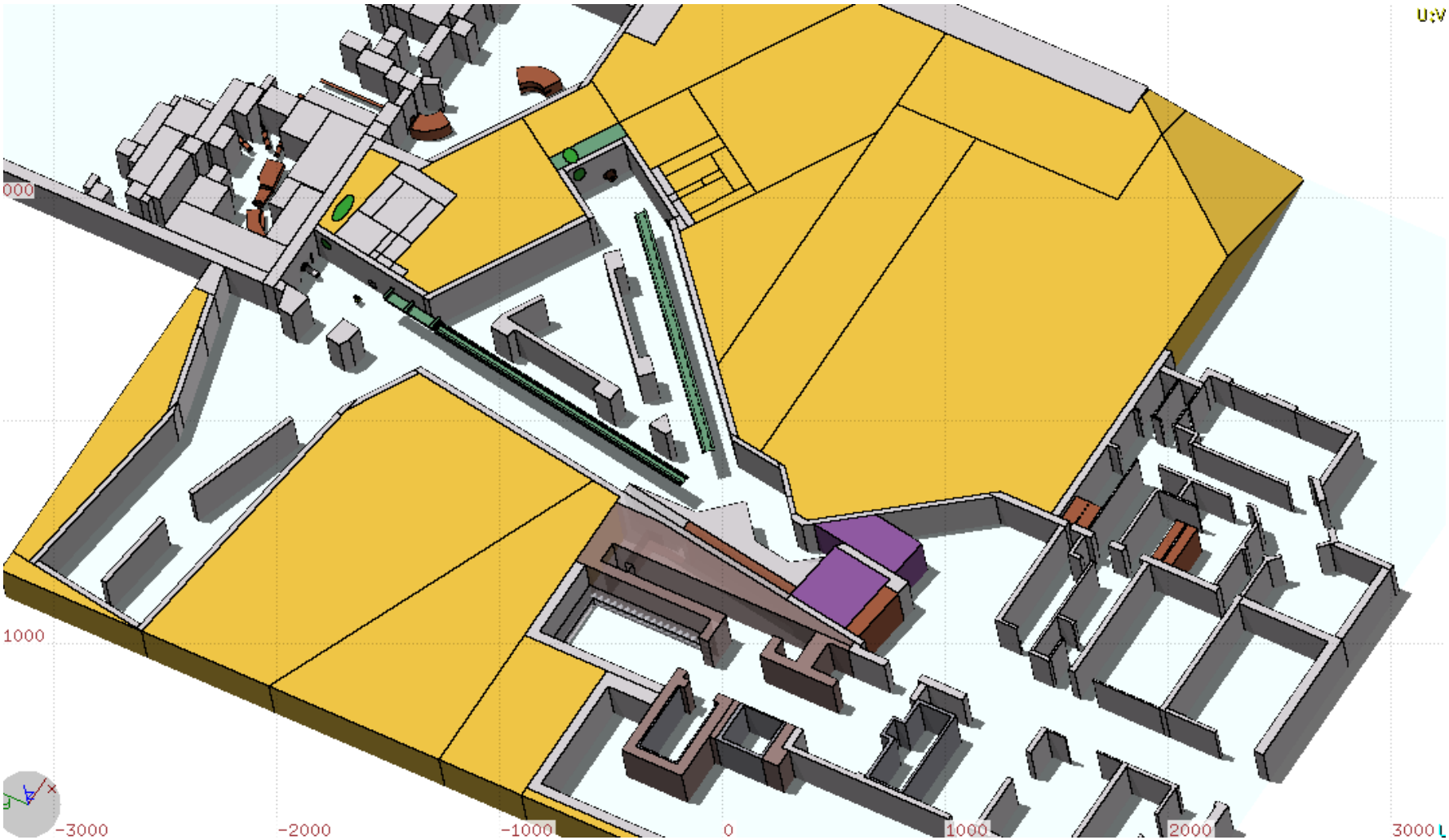
Activity with target in GPS in $Bq/m^3/pp$

Zone	Unwrapped	Wrapped	Ratio
GPS Fcage	1.73E-11	5.26E-12	3.30
HRS Fcage	8.30E-14	1.54E-14	5.37
Tunnel	2.18E-11	4.71E-12	4.63

Activity with target in HRS in $Bq/m^3/pp$

Zone	Unwrapped	Wrapped	Ratio
GPS Fcage	1.90E-13	3.45E-14	5.51
HRS Fcage	1.44E-11	4.49E-12	3.20
Tunnel	1.95E-11	4.09E-12	4.79

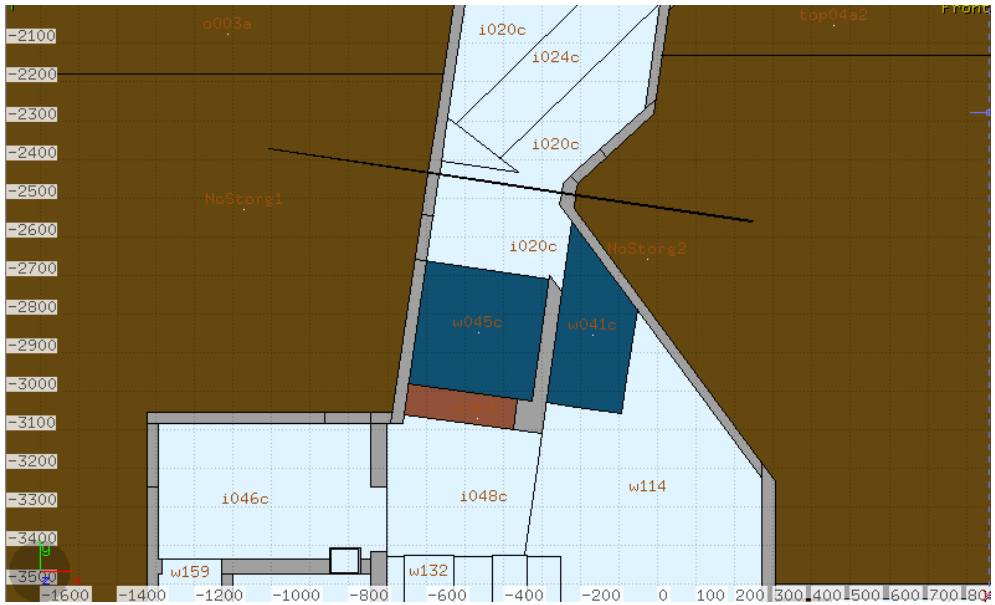
BENCHMARKING



VERIFYING FLUKA RESULTS

Big geometry, multiple scattering

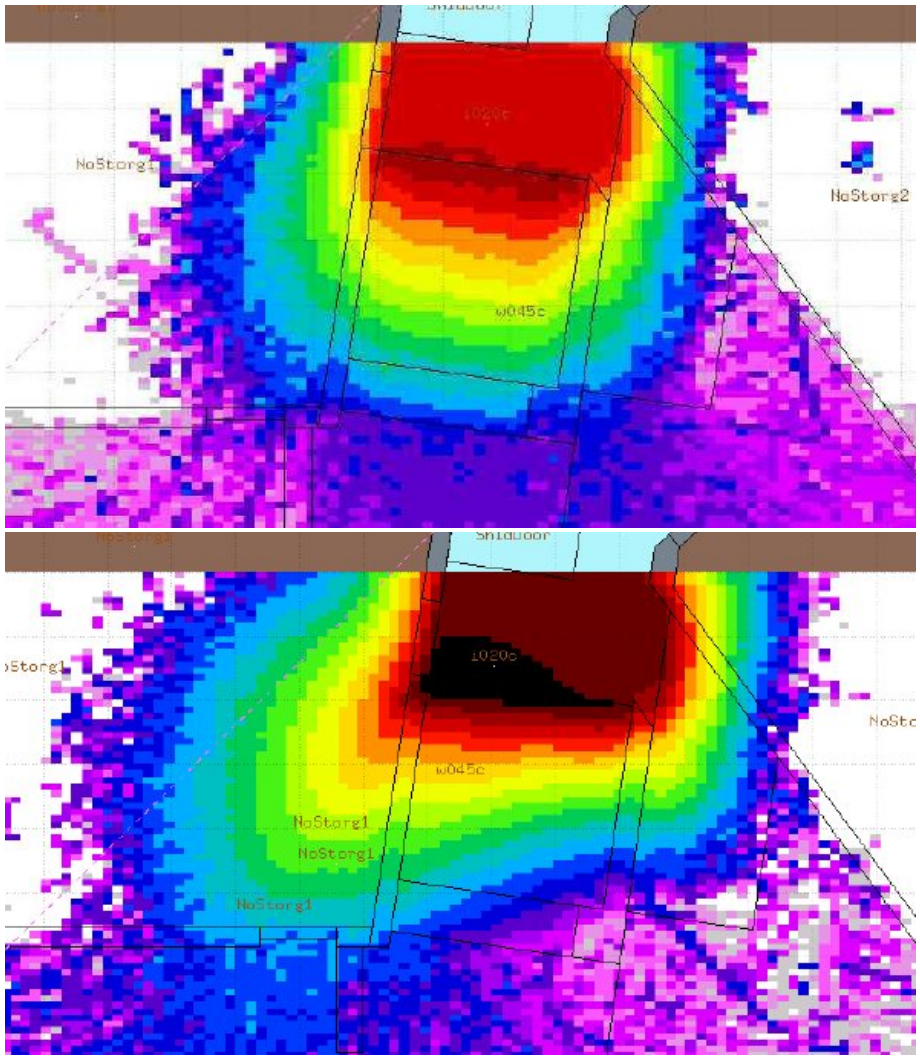
- Materials composition not verifiable
- Large scale geometry and high density materials
- Neutrons transport cross section dependent



RESULTS FROM FLUKA SIMULATIONS COMPARISON

Simulation conditions:

- Results compared to document EDMS1142606
- Normalized to $1.4GeV$ and $1\mu A$



RESULTS FROM FLUKA SIMULATIONS

Comparison of values in nSv/h

Pos	Target	Fluka	Measurement
GPS	417TA	$\sim$40	1169 ± 11 %
GPS	438UC2-C	$\sim$40	1538 ± 5 %
HRS	431UC2-C	$\sim$30	373 ± 11 %
HRS	437UC2-C	$\sim$30	426 ± 10 %

Comparison mismatch, possible origin:

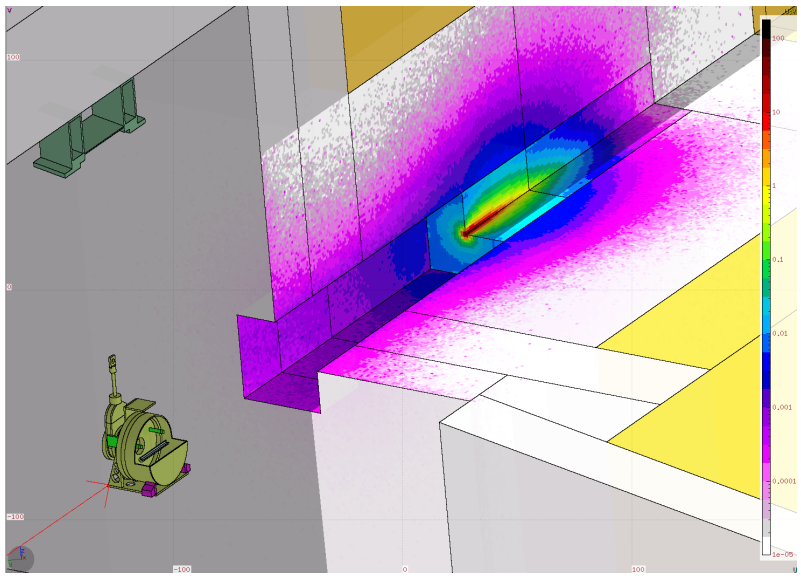
- Shielding not completely tight
- Composition uncertainties

BEAM DUMPS CHECKING

ENERGY DEPOSITION SIMULATED...

... and used as input for thermo-mechanical simulations

- Beam power 5 times higher
- Current: max 2.8 kW
- HIE-ISOLDE: max 14 kW



More information on CDS
(CERN-ACC-NOTE-2014-0039 and CERN-ACC-NOTE-2014-0040)

SUMMARY

Multiple scenarios and dose values evaluated

- Dose on targets' storage: neutrons + targets + activation
- Tunnel activation: rails + new shielding + air
- Dumps energy deposition

Only final benchmarking simulations remaining.

THANKS AND QUESTIONS

Thanks for your attention.

Special thanks to Vasilis, Yacine, Seamus, the Fellows and the ISOLDE collaboration.

It has been a great experience!