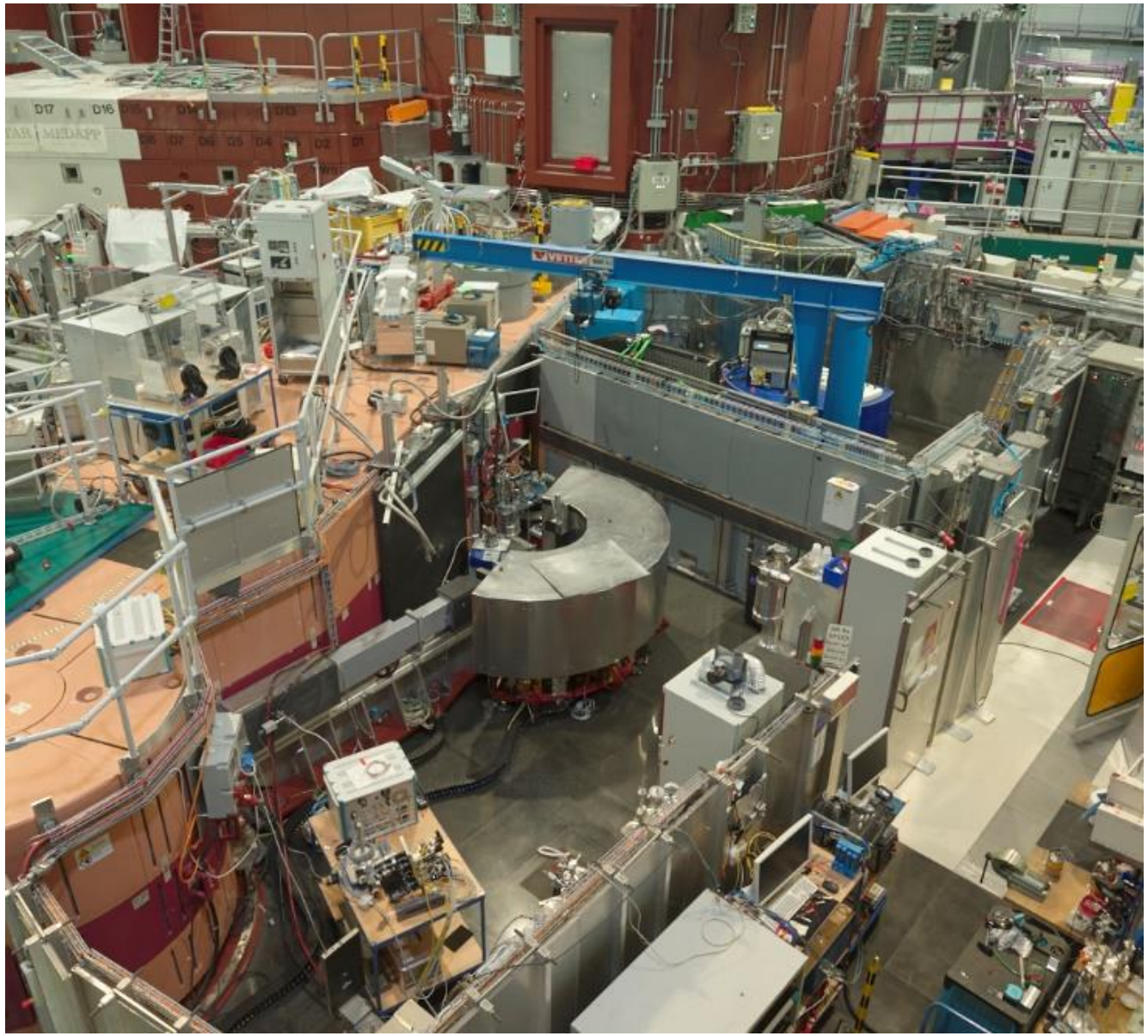
Simulations of the new shielding @ SR8 with SERPENT2

Christoph Hauf

01.09.2022

@ SERPENT UGM 2022

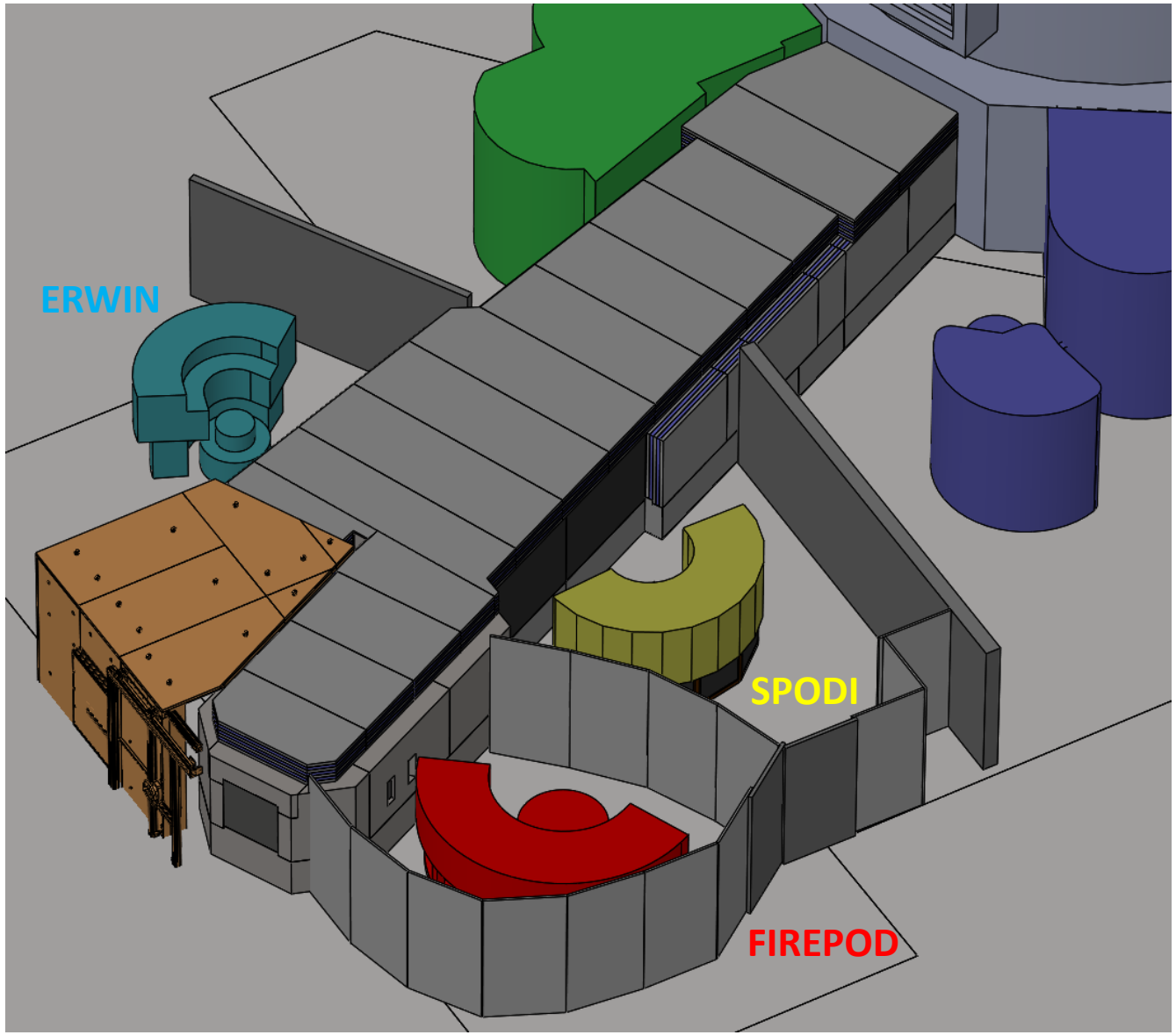
SPODI + FIREPOD + ERWIN @ MLZ



Current beamline SR8 with the powder diffractometer SPODI

One of the most productive instruments @ FRM-II

SPODI + FIREPOD + ERWIN @ MLZ



Beamline SR8 will be completely rebuilt to host the independent powder diffractometers SPODI, FIREPOD and ERWIN.

Requirements for a good biological shielding

Has to shield users and instruments from:

Neutrons + γ from the reactor core / from secondary reactions

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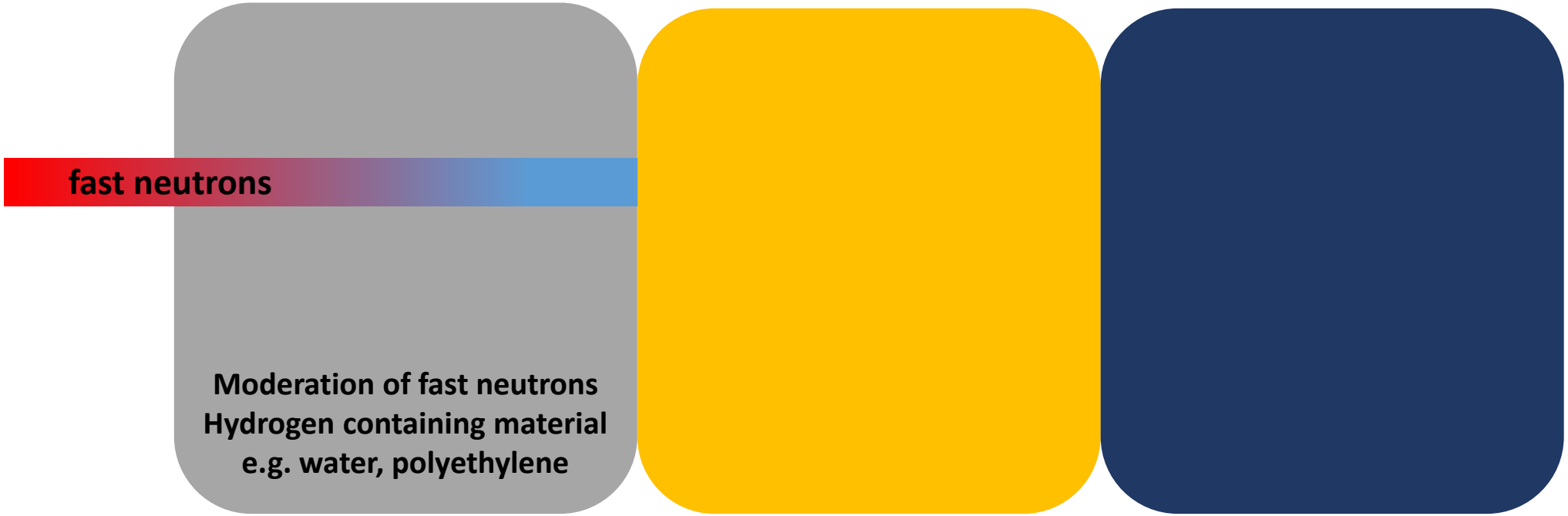

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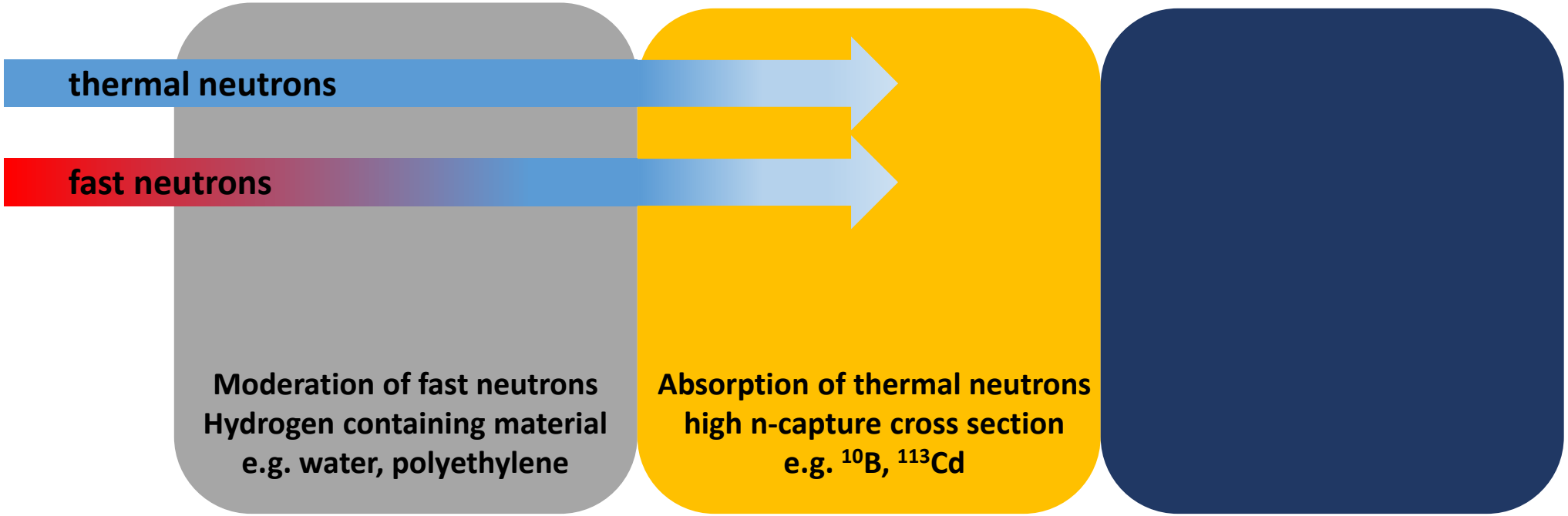

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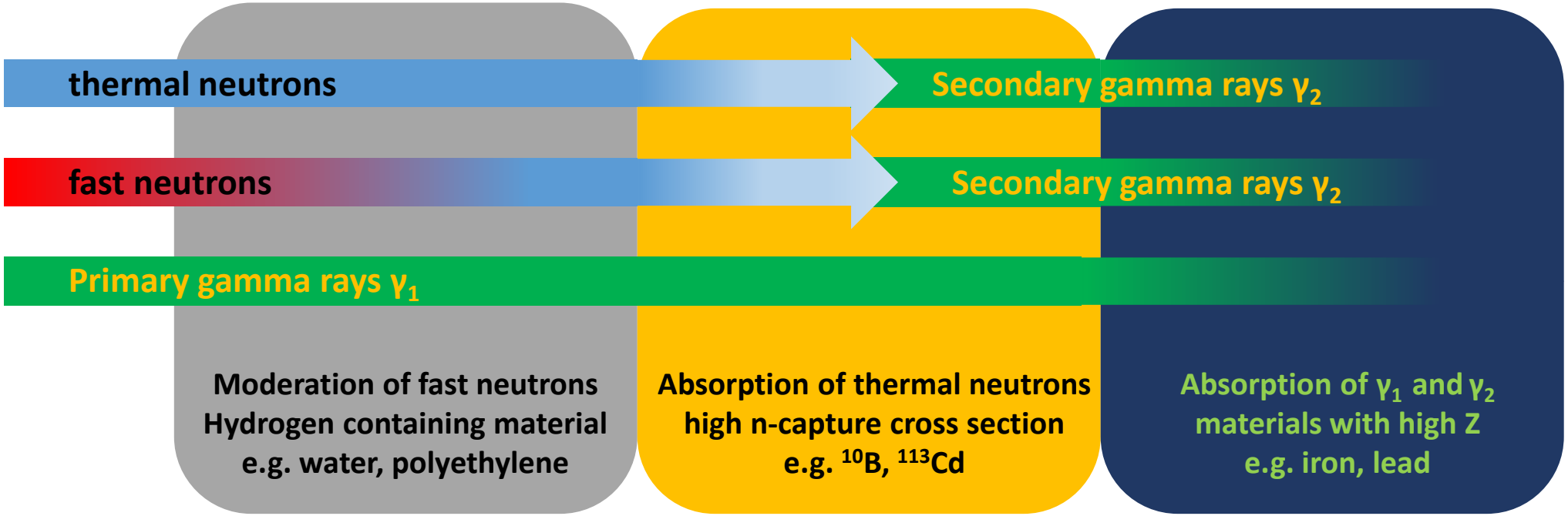

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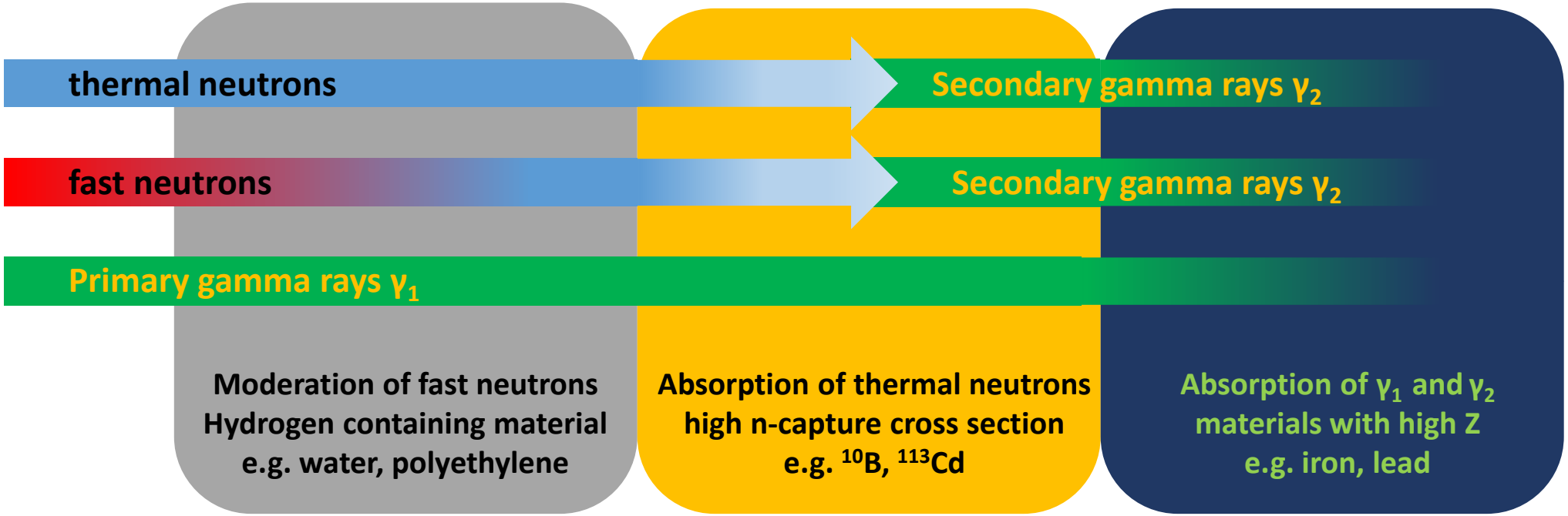
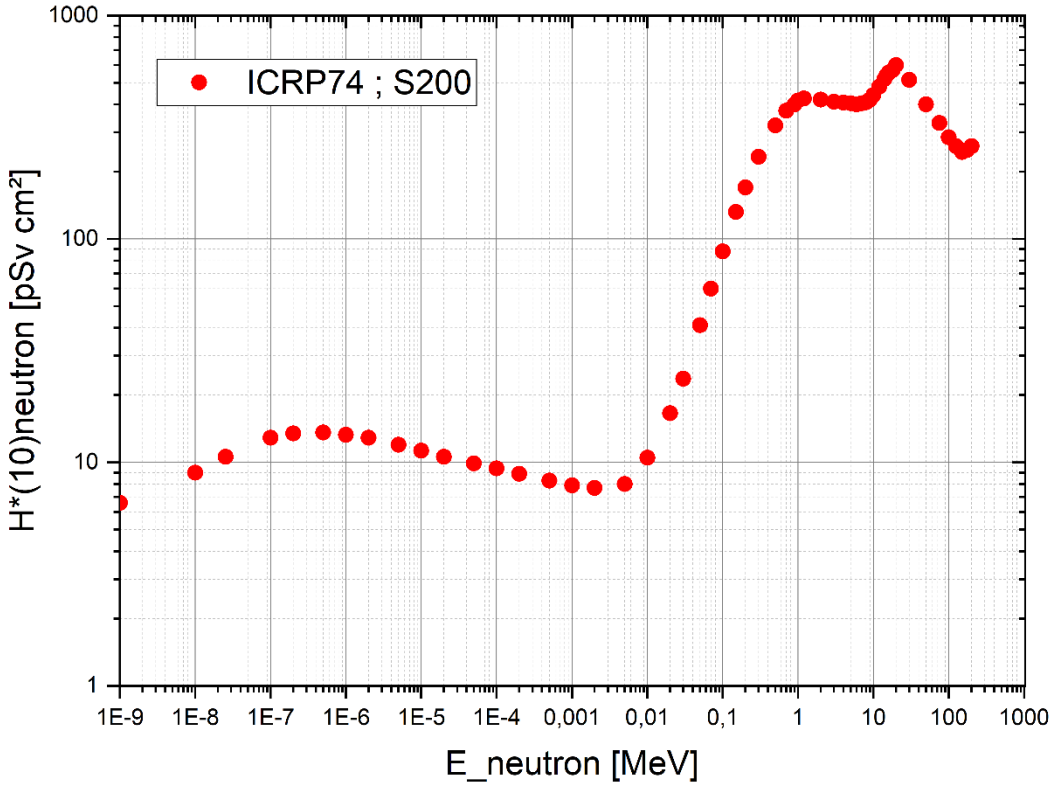
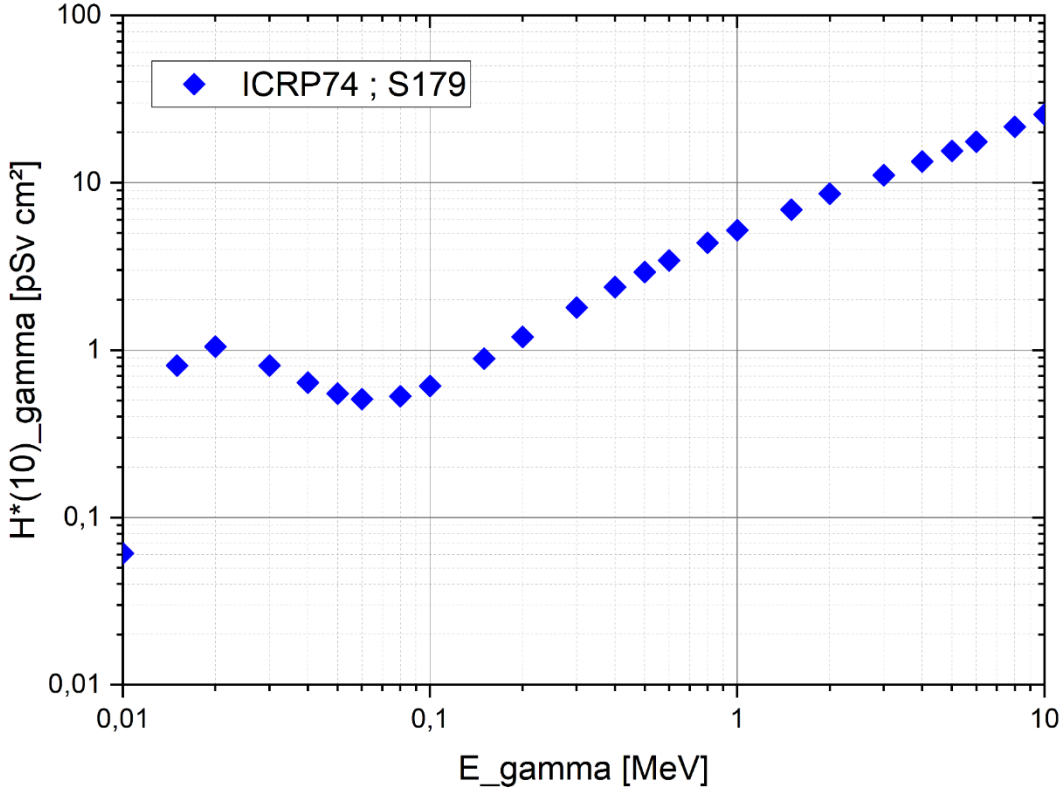


Goal: Total dose rate ideally **below 3 µSv/h at the entire bounding surface** of the shielding

How to obtain the dose rate?





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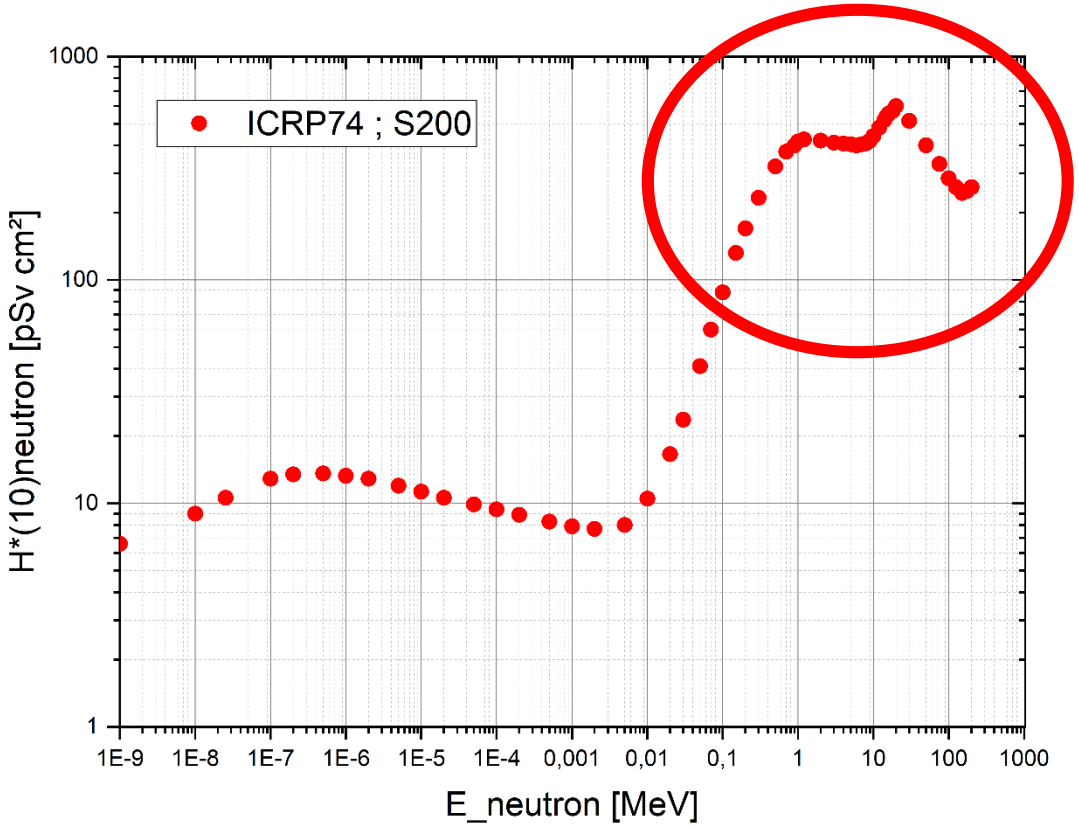
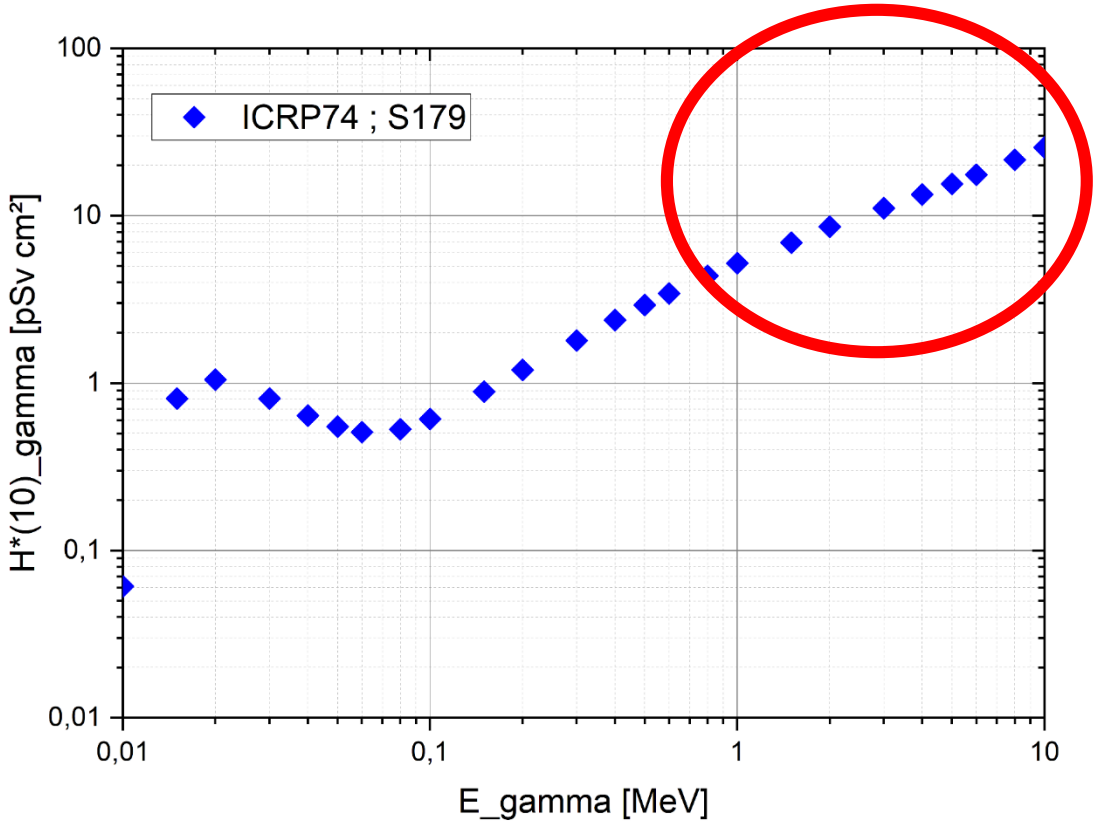




Particle Flux -> dose rate

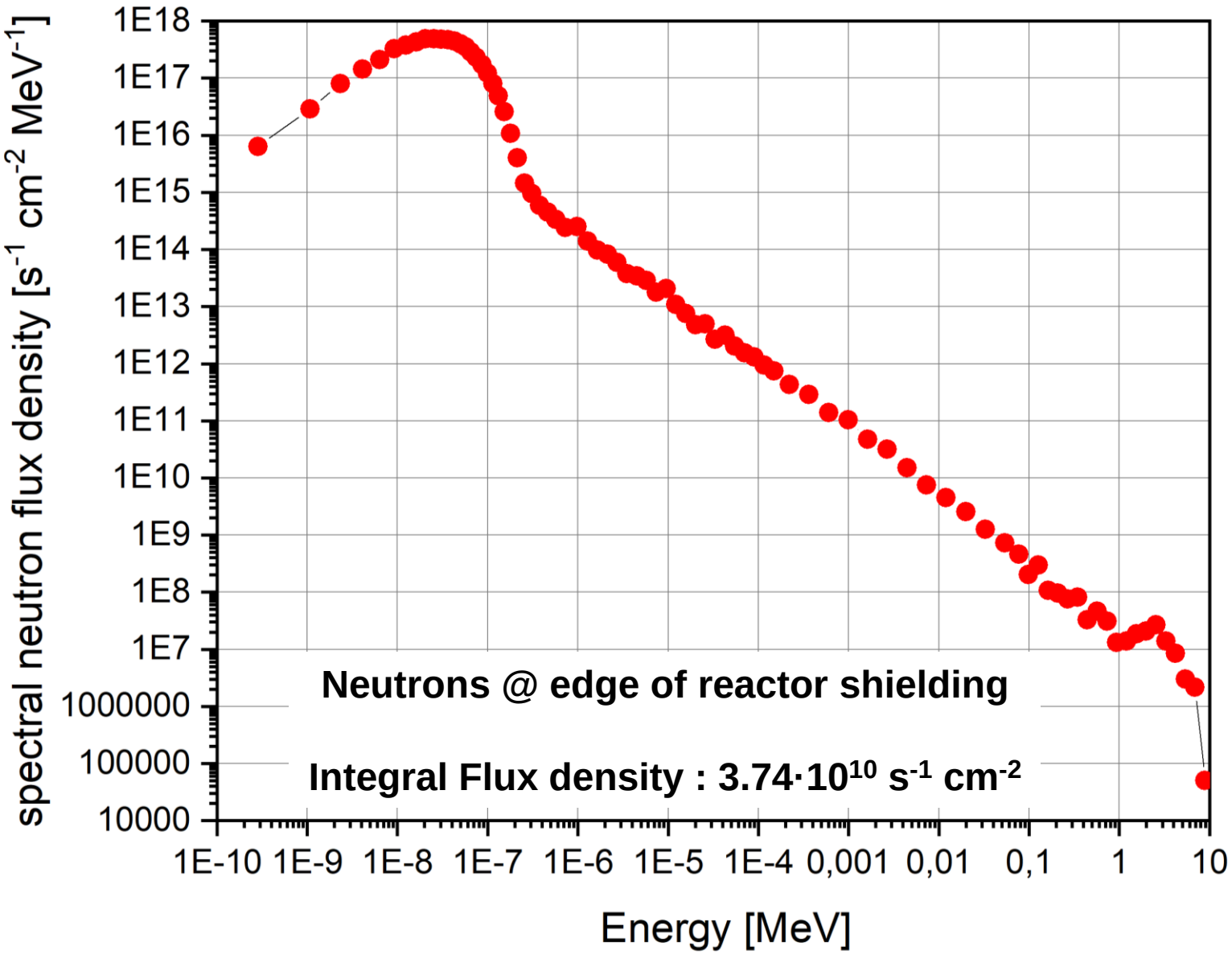
Simulate particle trajectories through geometry from “birth” to “death ”

Particles are “born” in virtual external sources (!!no reactor physics!!)

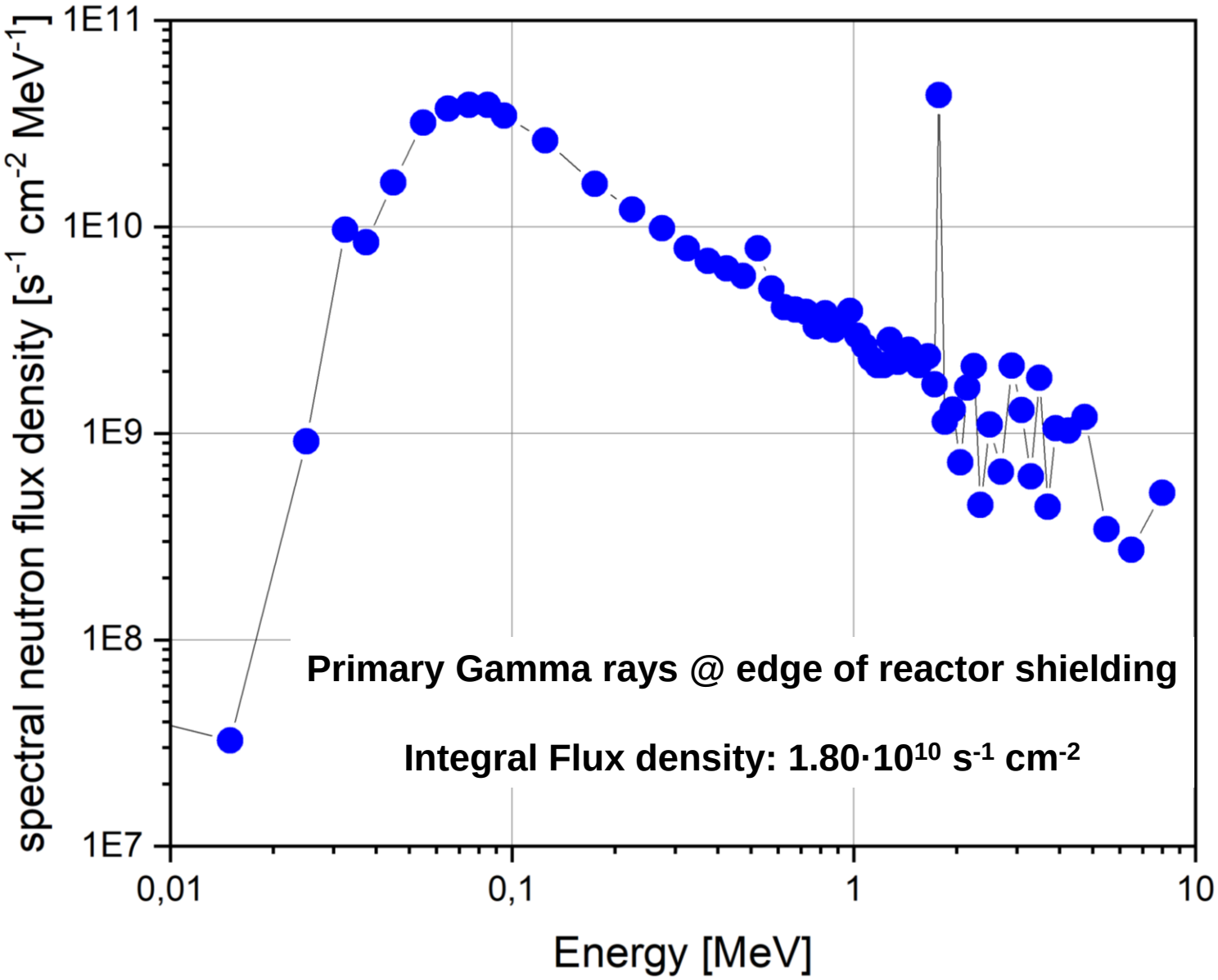
Tally flux at each point of geometry

Conversion from flux to dose

Spectral flux density for neutrons



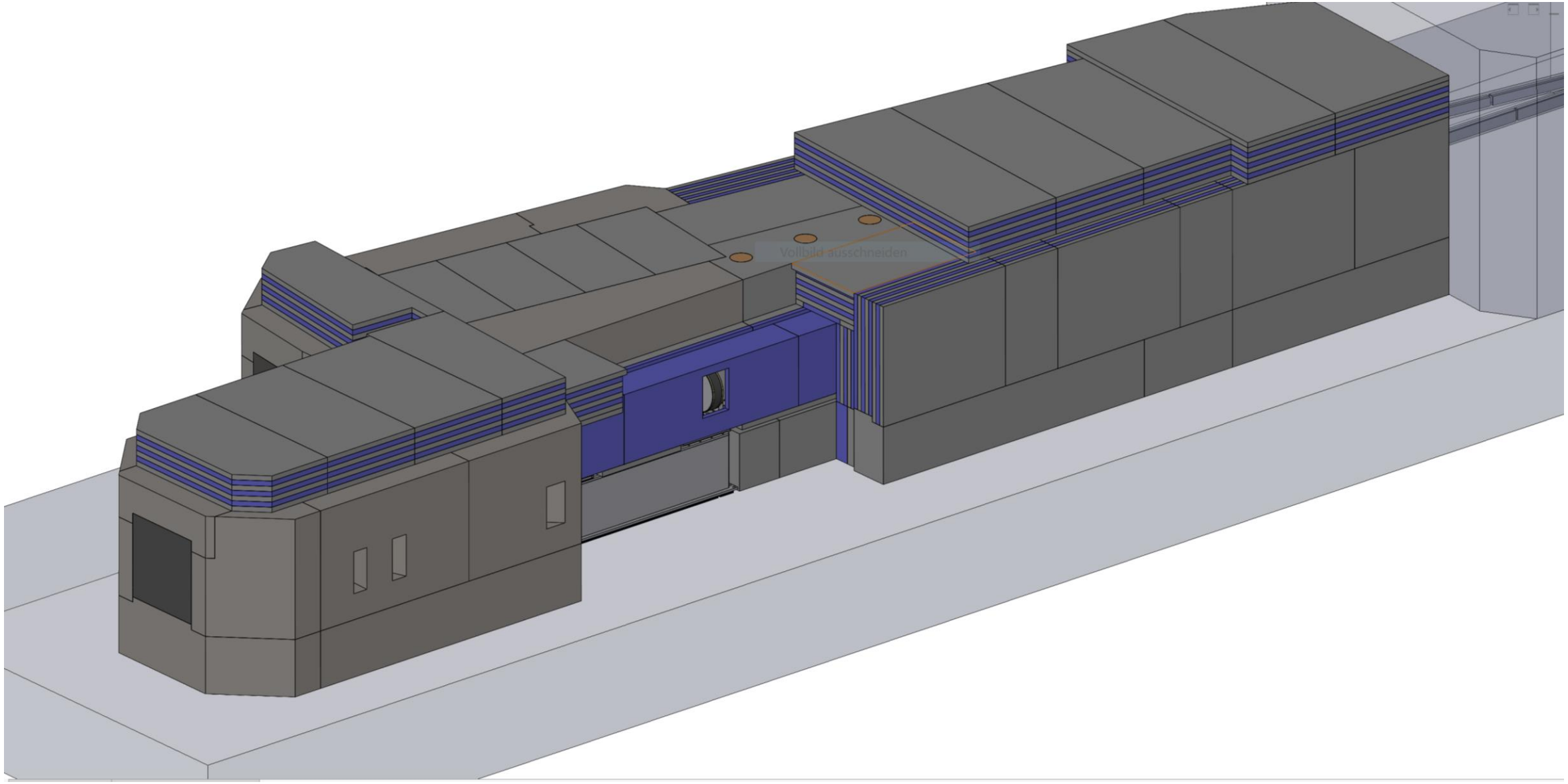
Spectral flux density for primary γ



New SR8 shielding

Position of the two instruments SPODI and FIREPOD

New SR8 shielding



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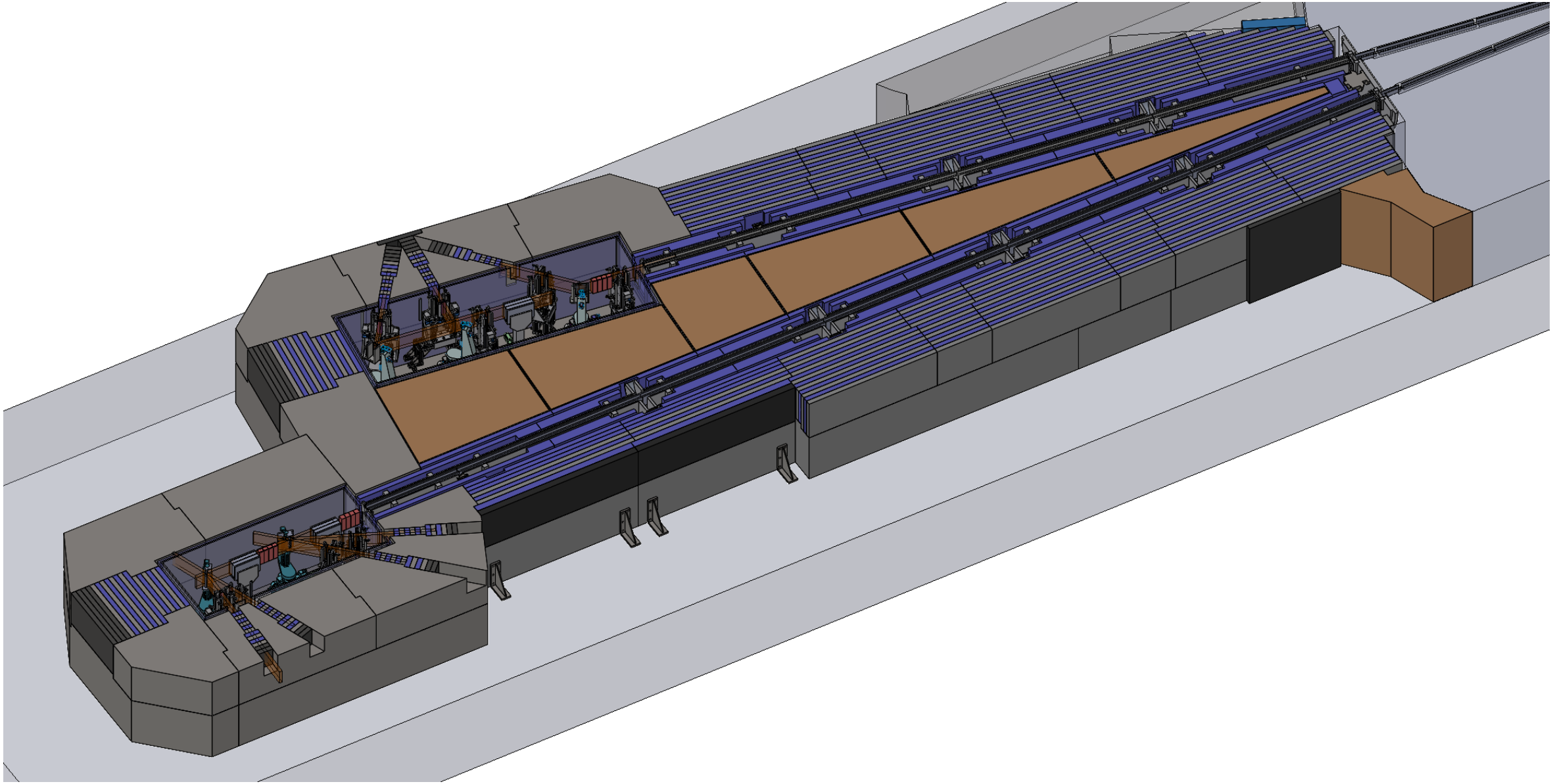
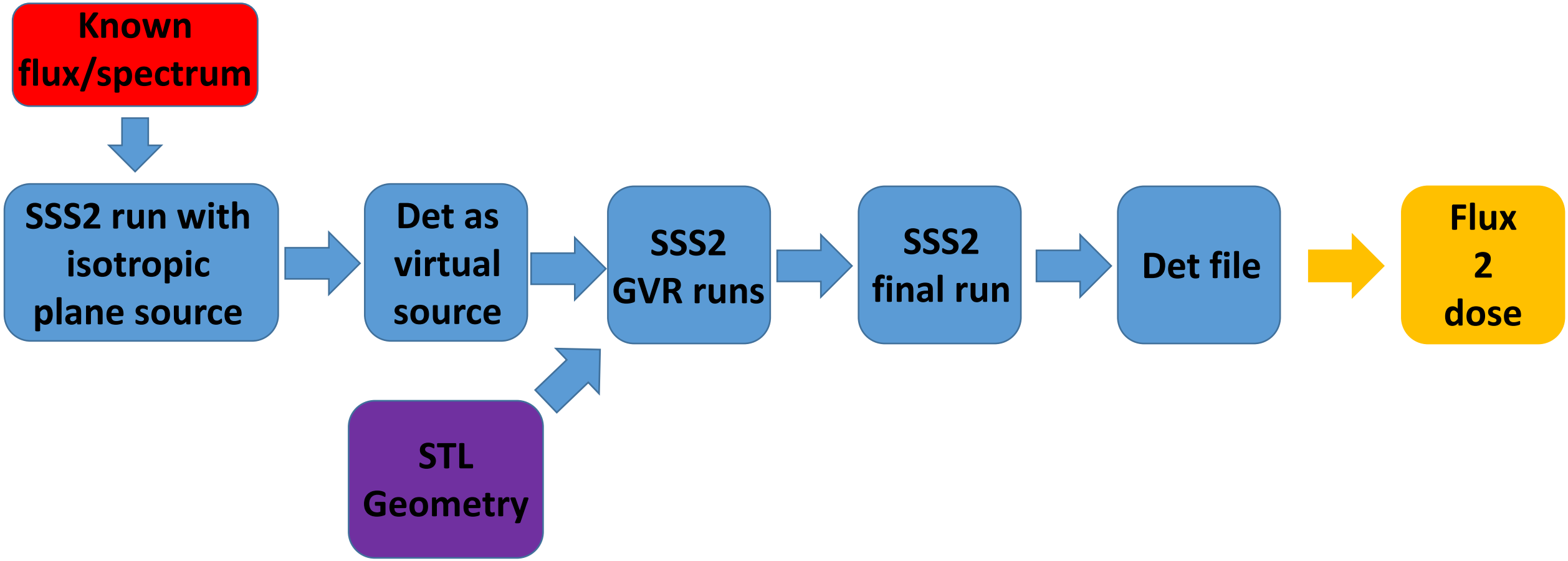
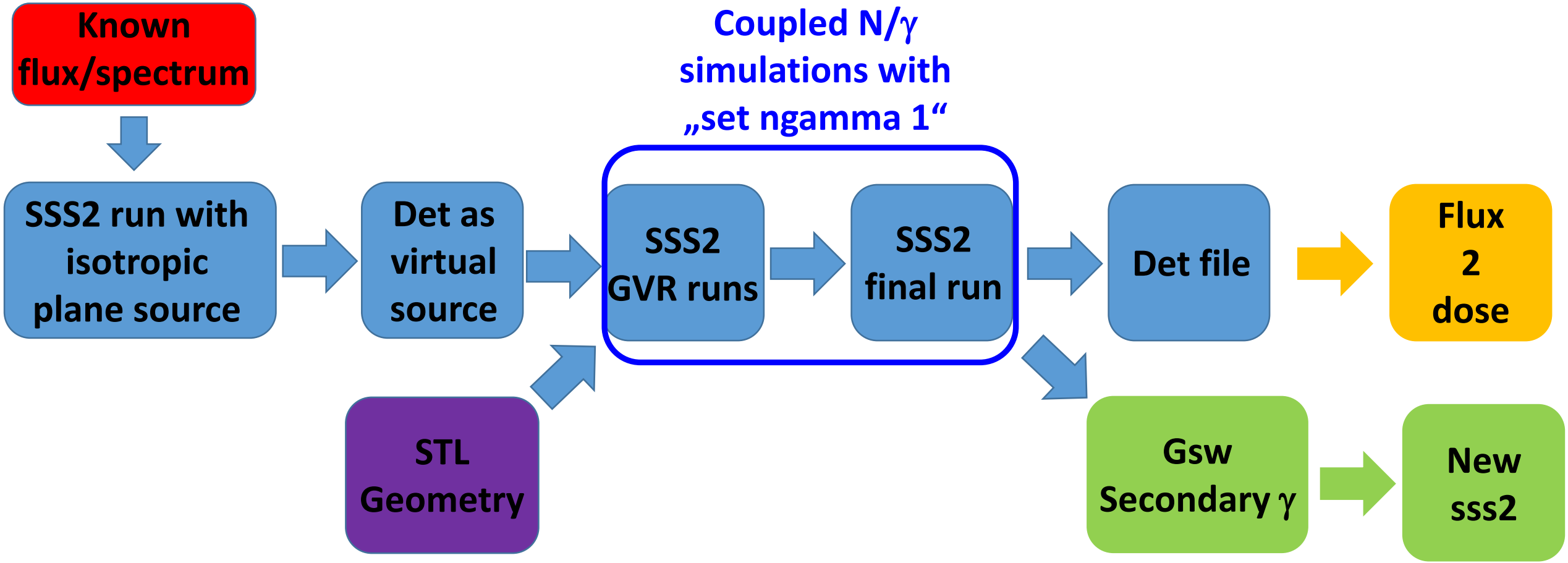


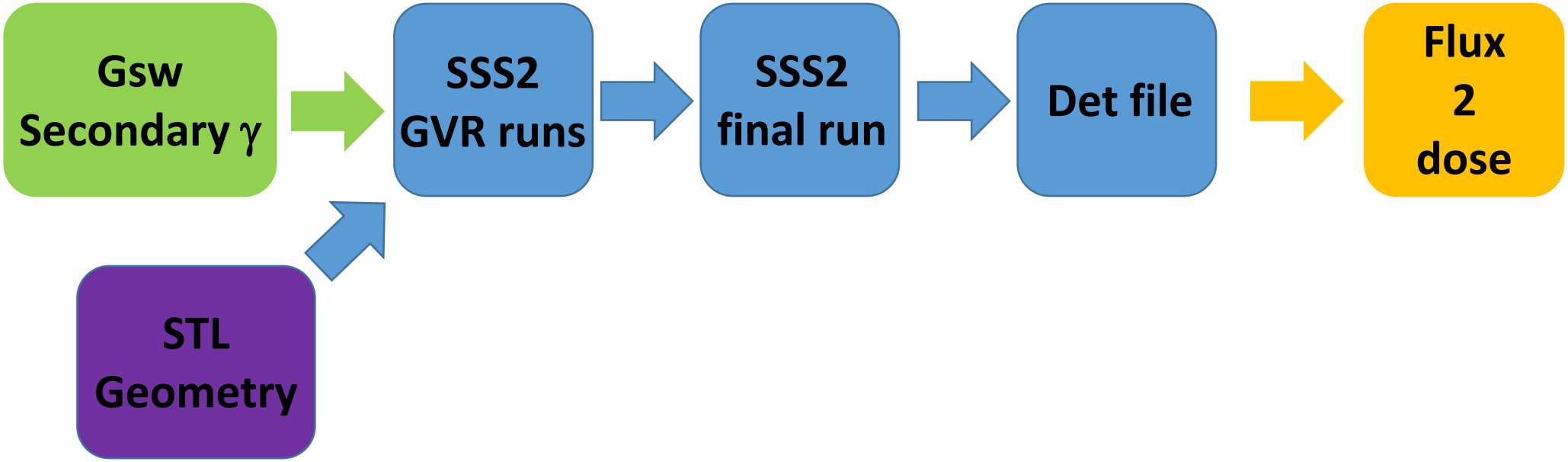
Workflow Primary Gammas



Workflow Neutrons



Workflow Secondary Gammas



New SR8 shielding – Geometry from STL files

Generate box in which everything lives

```
surf 1     cuboid   390  1880  -340  140  -200 130
cell 1     0 fill 1  -1                          % Fill box with mesh based universe
cell 2     0 outside  1                          % Outside of the box is outside
```

20% B-PE; Steel; concrete; heavy concrete Al; Na-Float; Boro-Float; vacuum; ANTARES-boxes; reactor-shield HEIDI/POLI; lead

New SR8 shielding – Geometry from STL files

Create the background universe (filled with air)

surf 3 inf
cell 4 2 air -3

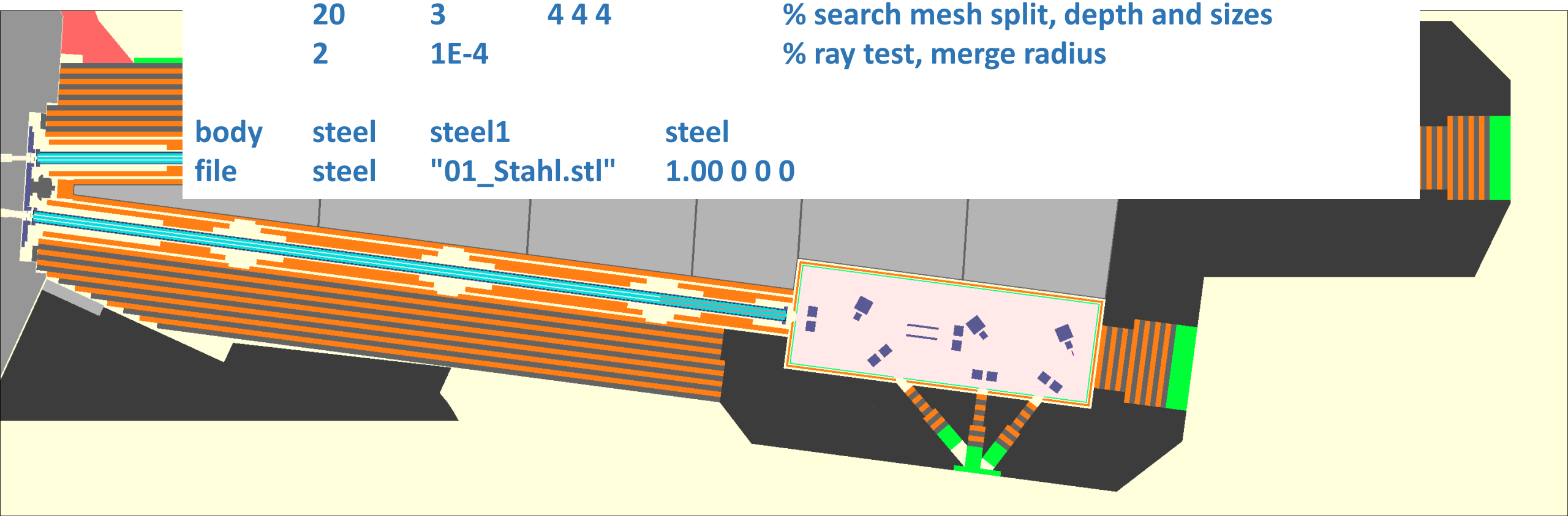
20% B-PE; Steel; concrete; heavy concrete Al; Na-Float; Boro-Float; vacuum; ANTARES-boxes; reactor-shield HEIDI/POLI; lead

New SR8 shielding – Geometry from STL files

Create the STL-solids

```
solid    2      1      2          % type, universe, background universe
         20     3      4 4 4      % search mesh split, depth and sizes
         2      1E-4              % ray test, merge radius

body     steel  steel1             steel
file     steel  "01_Stahl.stl"     1.00 0 0 0
```



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New SR8 shielding – Geometry from STL files

Create the STL-solids

Creates an STL-based geometry universe

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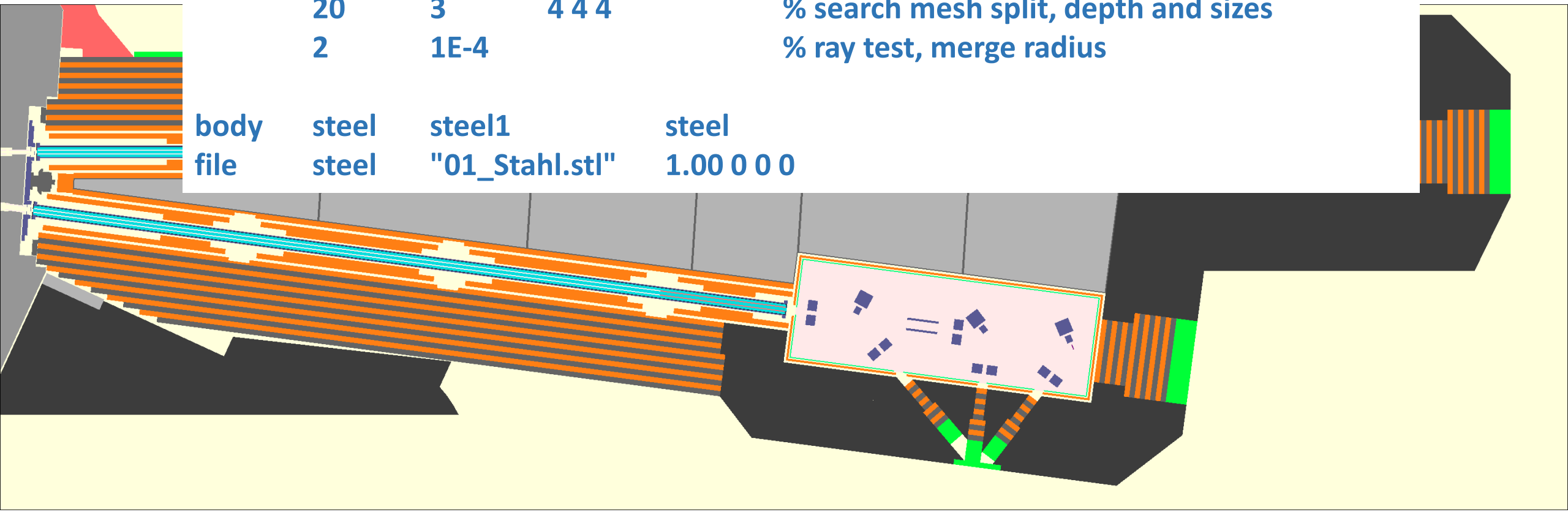

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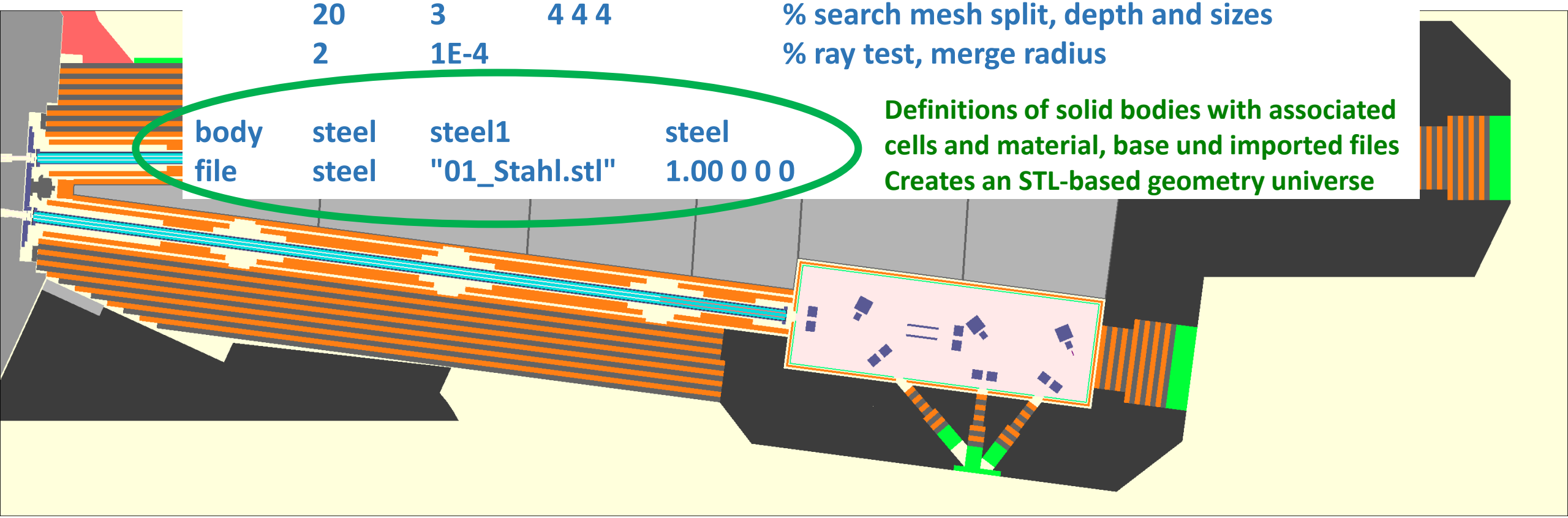
```

Definitions of solid bodies with associated cells and material, base und imported files
Creates an STL-based geometry universe



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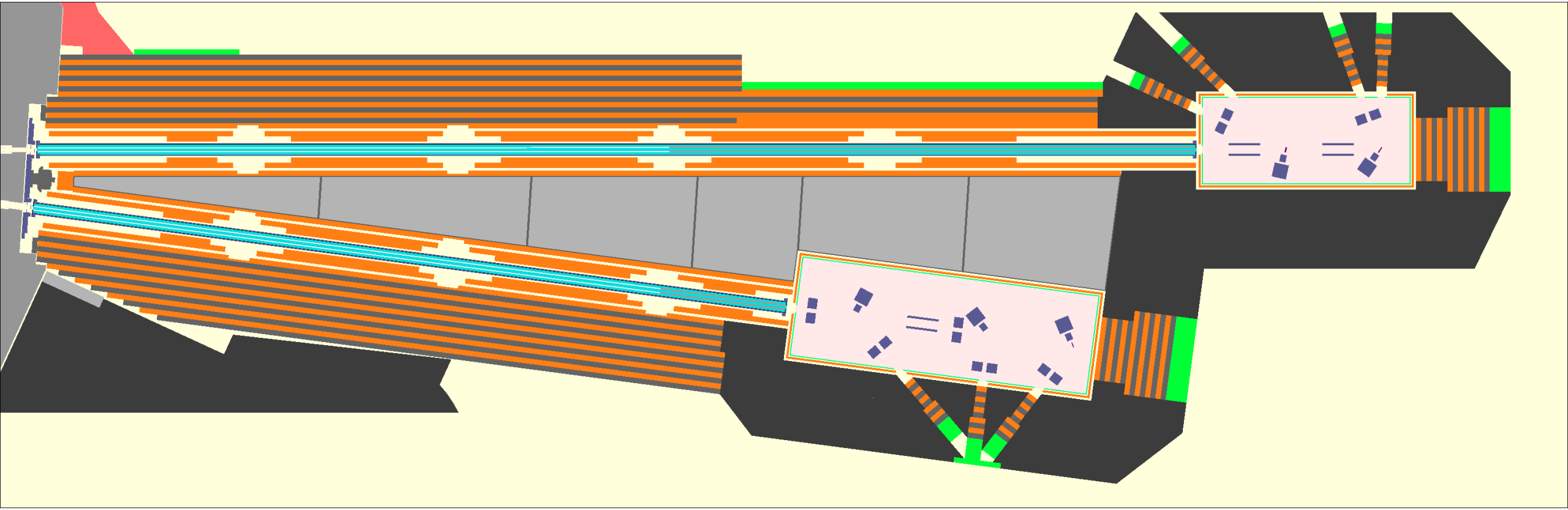

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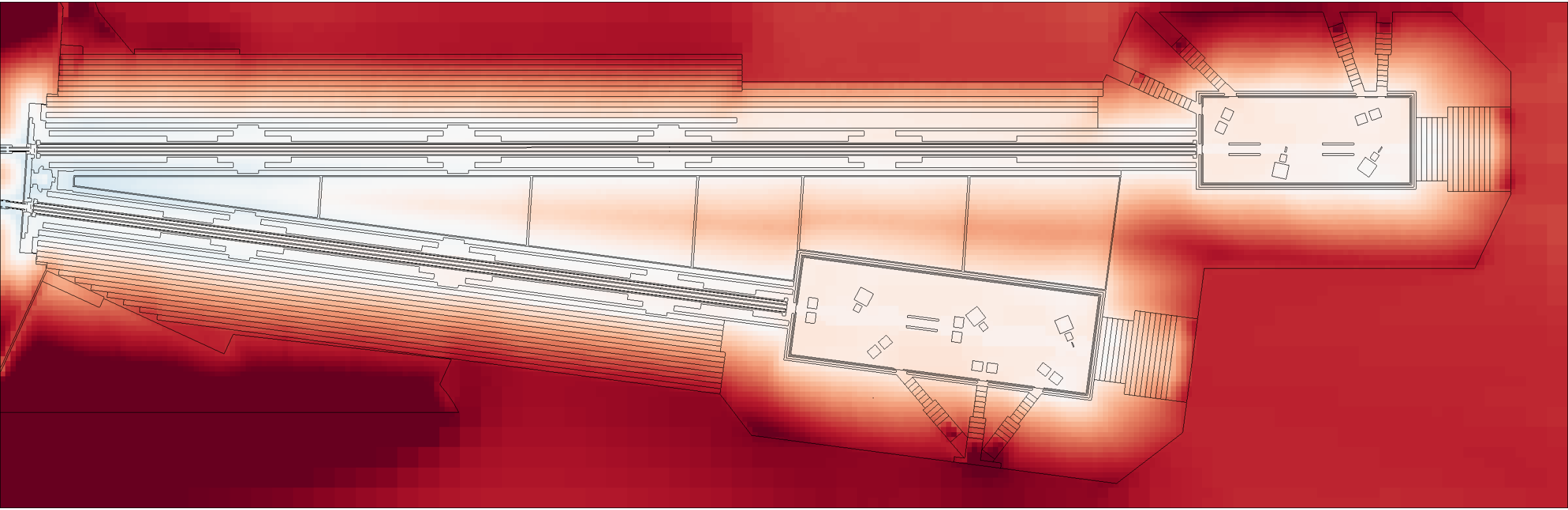
Global Variance Reduction with adaptive mesh

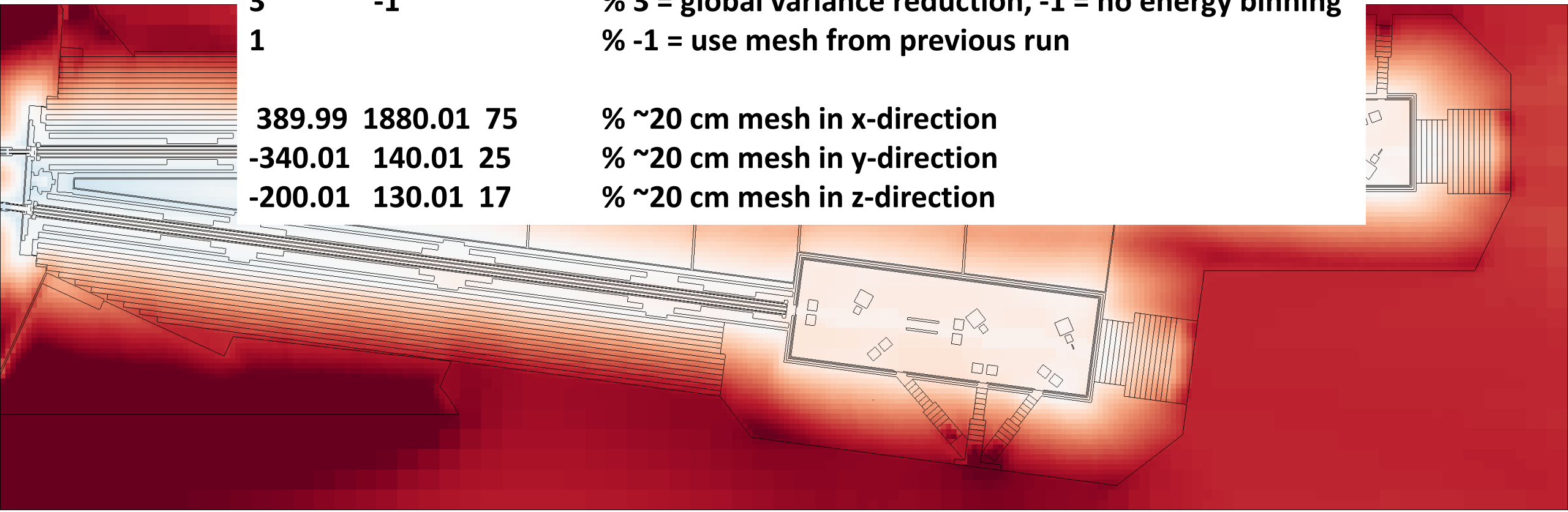


Global Variance Reduction with adaptive mesh


```
wwgen wwgen_gvr        % wwgen identifier

1E-10     30000        % convergence criteria ; number of iterations
3          -1          % 3 = global variance reduction, -1 = no energy binning
1                      % -1 = use mesh from previous run

 389.99  1880.01  75   % ~20 cm mesh in x-direction
-340.01   140.01  25   % ~20 cm mesh in y-direction
-200.01   130.01  17   % ~20 cm mesh in z-direction
```



Global Variance Reduction with adaptive mesh

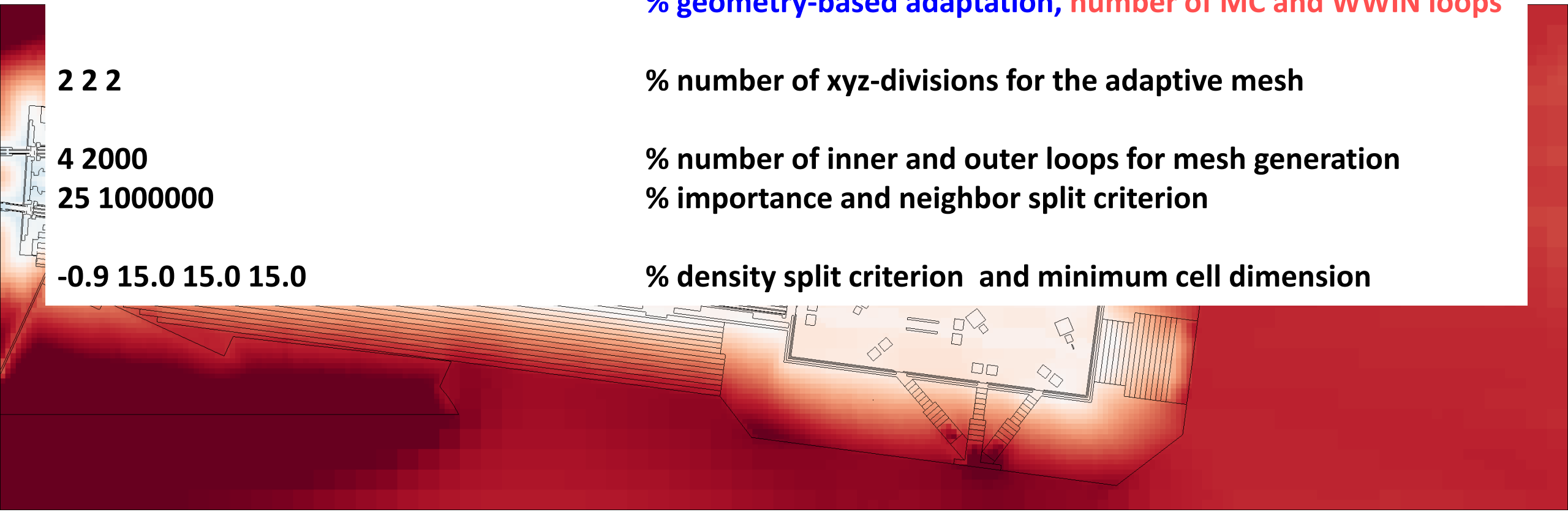

```
wwin     wwin_grv                    %wwin (weight window mesh definition)

wi       2          2     wwgen_gvr  % Weight-window iterations, adaptive mesh with
                                      % geometry-based adaptation, number of MC and WWIN loops

2 2 2                                 % number of xyz-divisions for the adaptive mesh

4 2000                                % number of inner and outer loops for mesh generation
25 1000000                            % importance and neighbor split criterion

-0.9 15.0 15.0 15.0                   % density split criterion  and minimum cell dimension
```



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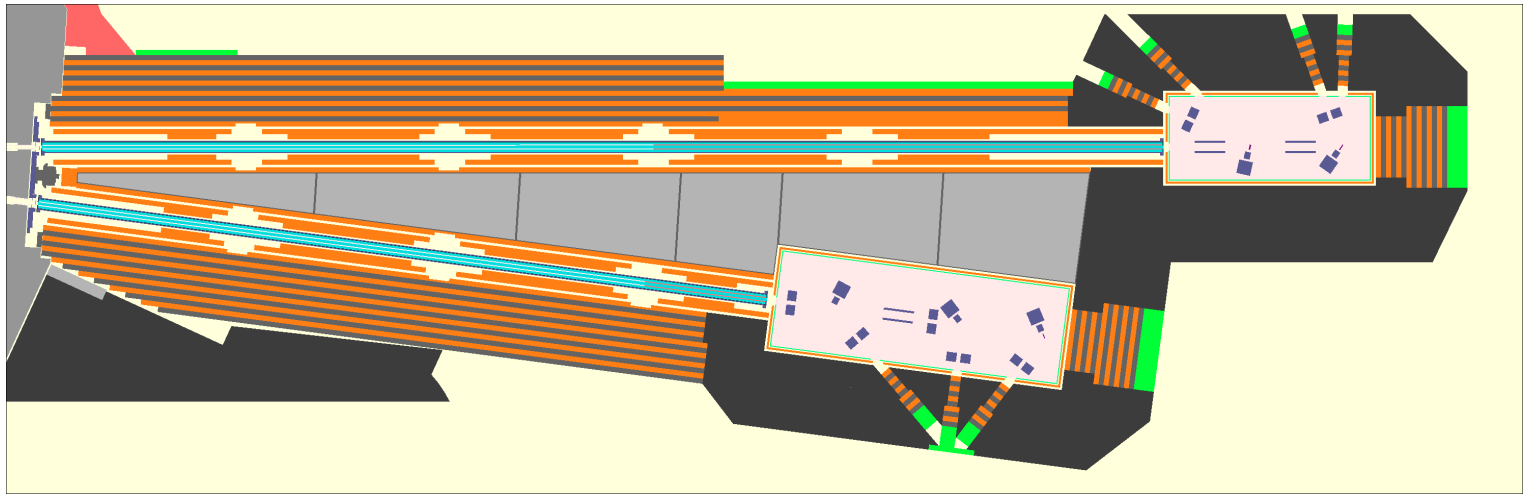

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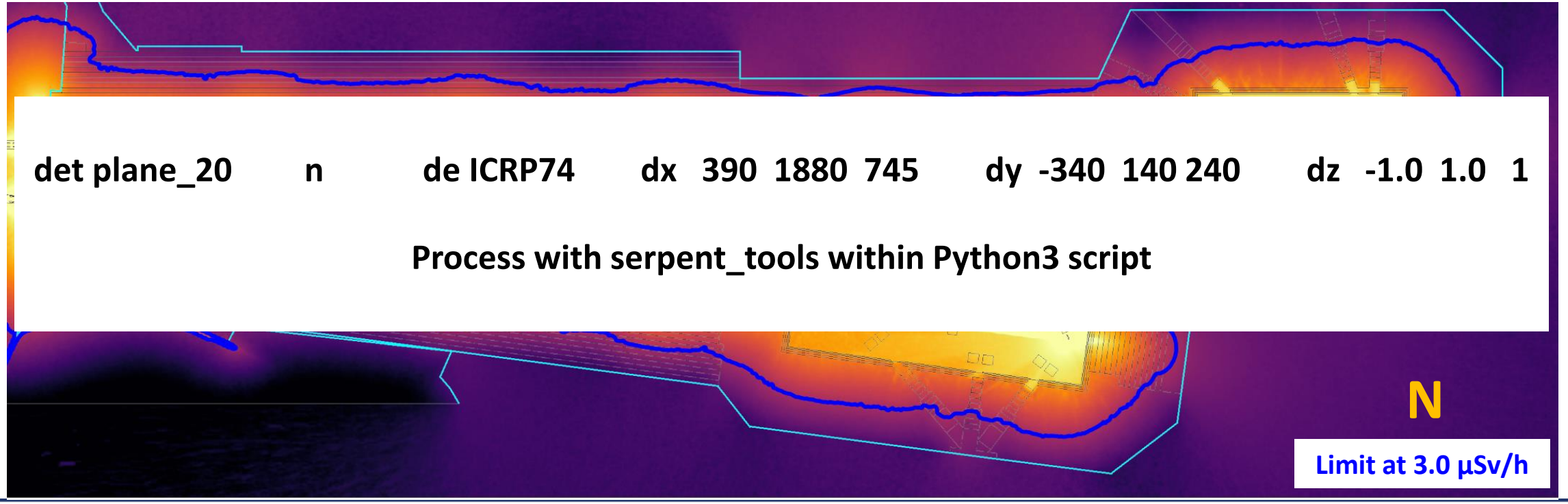
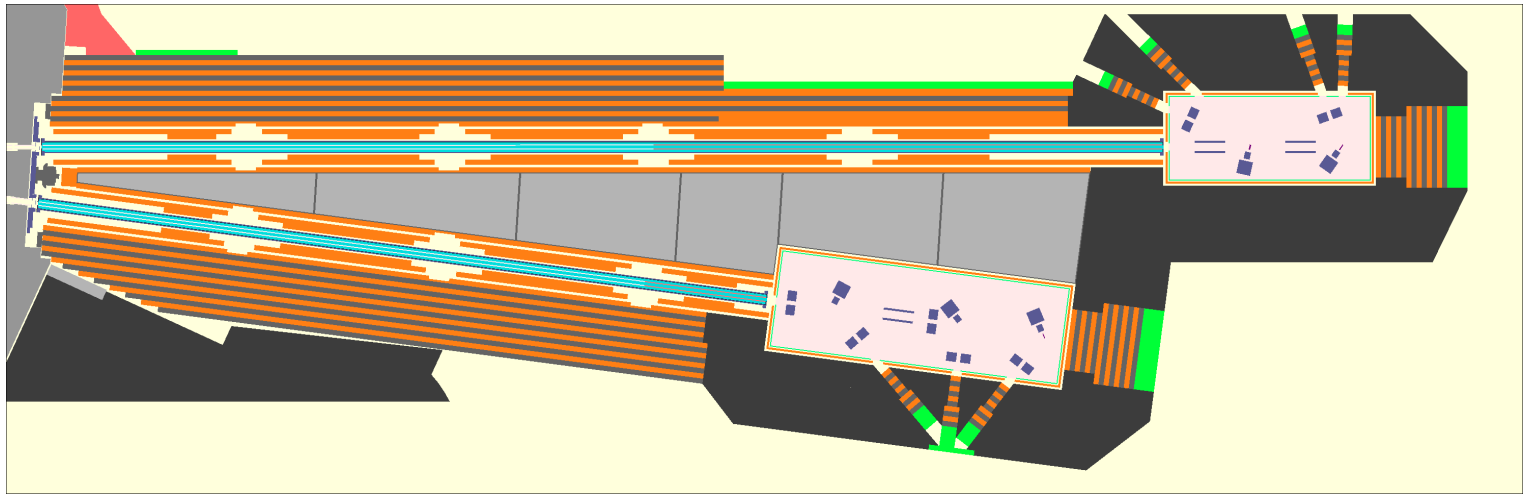



```
det plane_20      n      de ICRP74      dx   390  1880  745      dy  -340  140 240      dz   -1.0  1.0   1
```

Process with serpent_tools within Python3 script

New SR8 shielding



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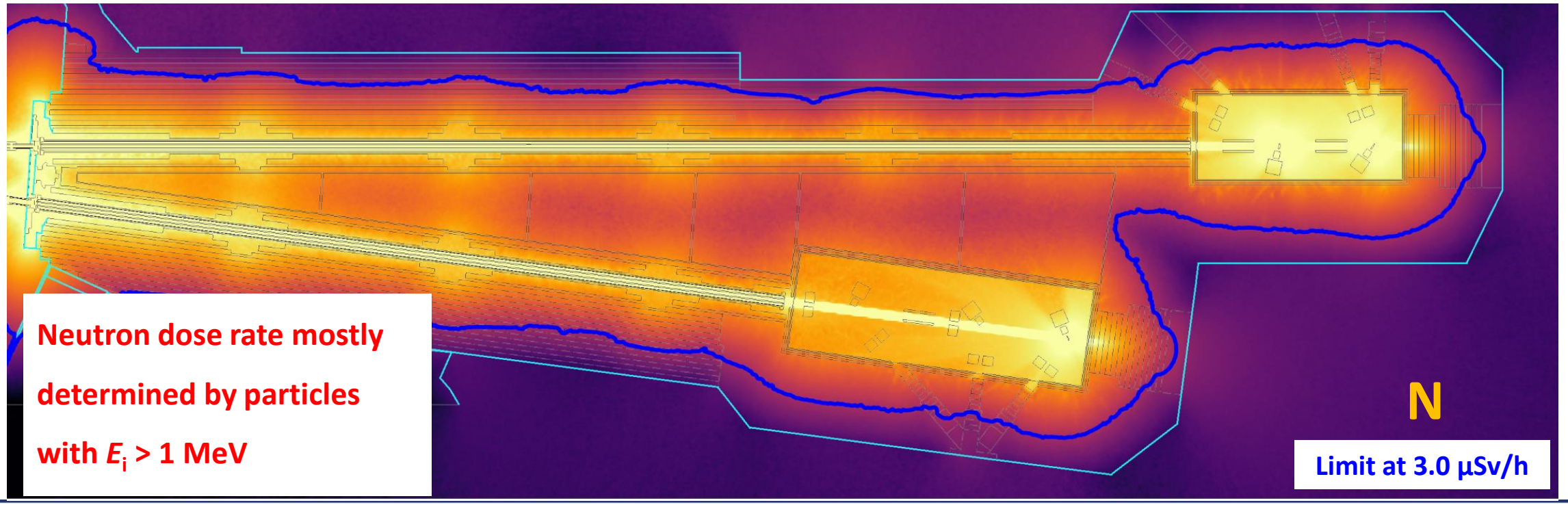
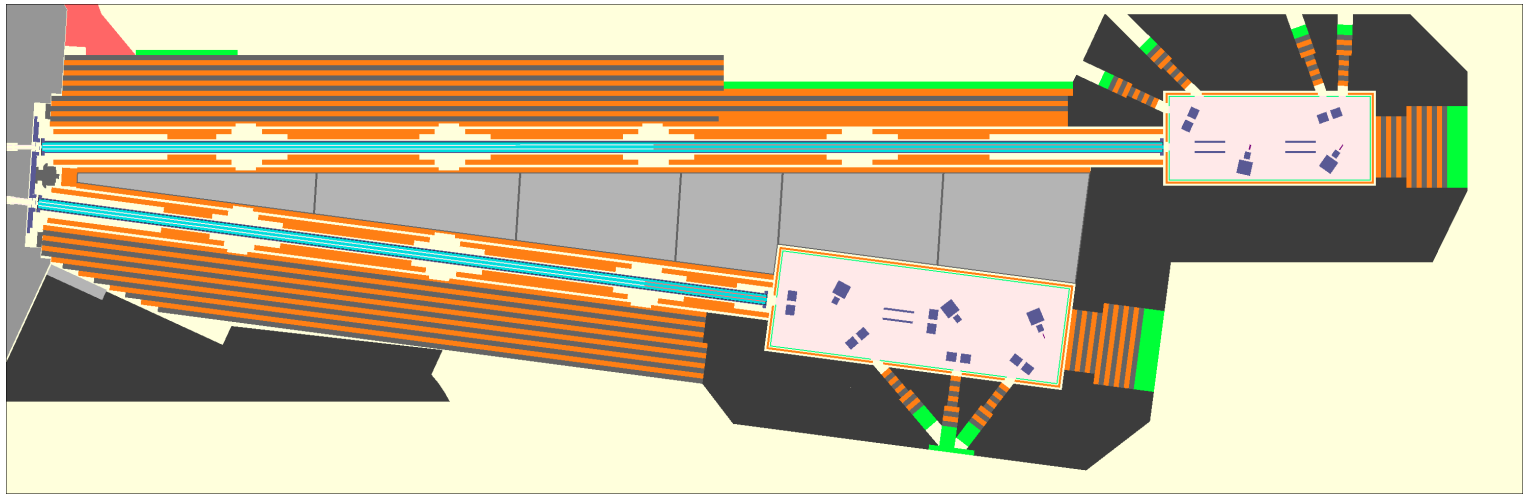


Neutron dose rate mostly determined by particles with E_i > 1 MeV

New SR8 shielding



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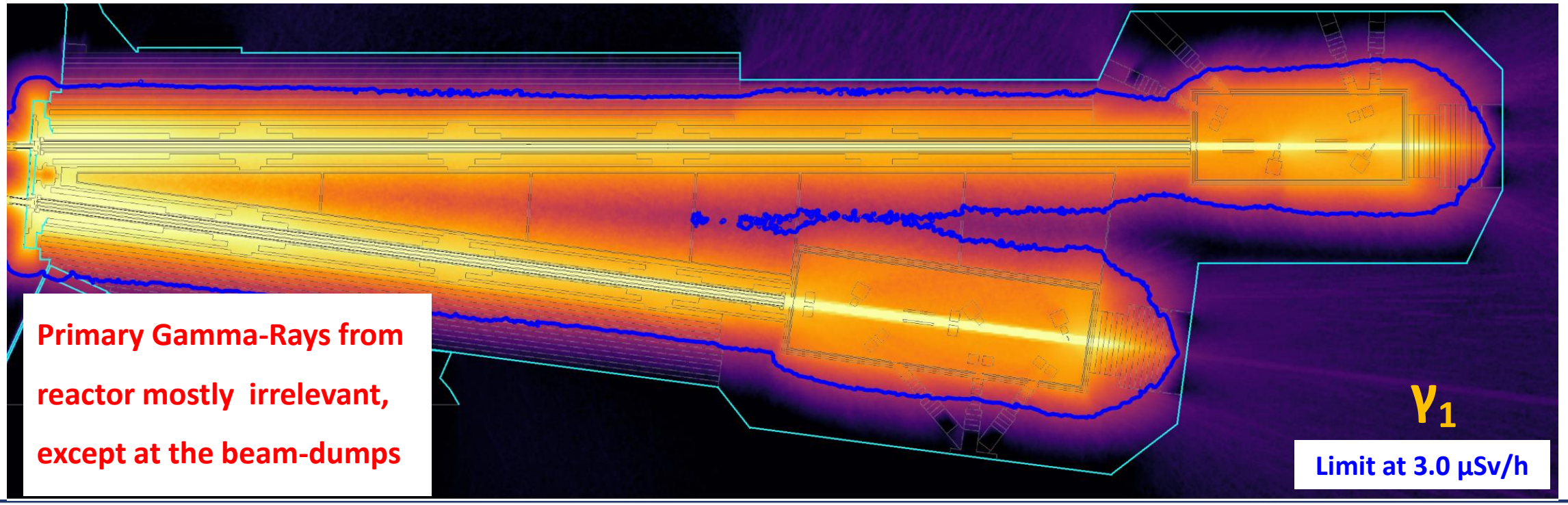
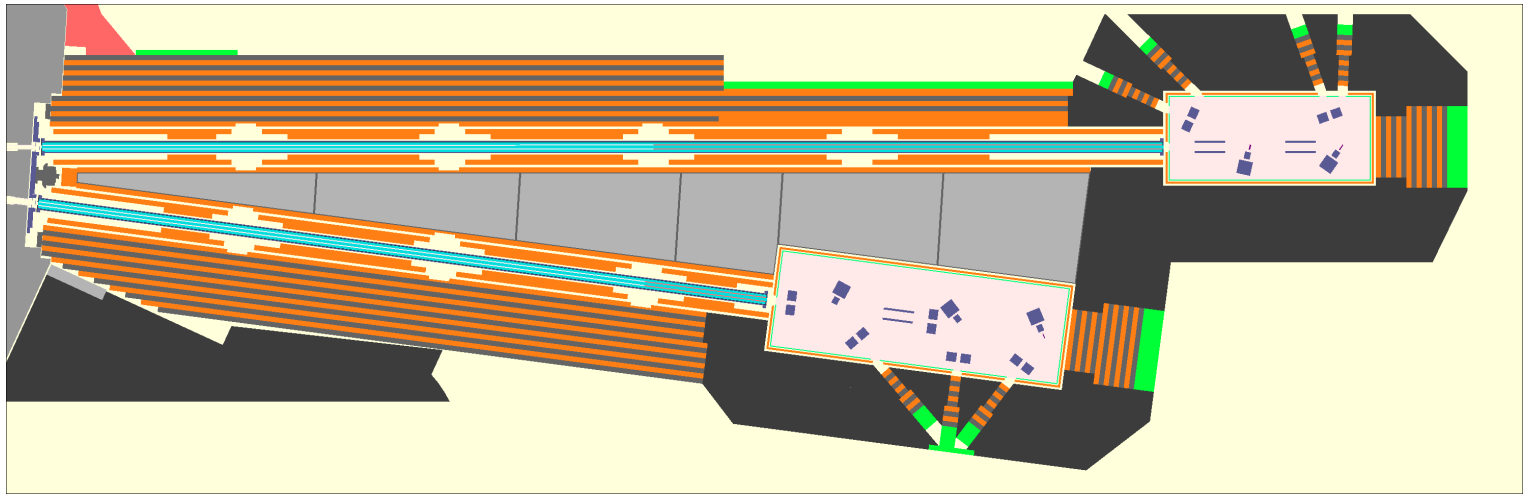


Primary Gamma-Rays from reactor mostly irrelevant, except at the beam-dumps

New SR8 shielding



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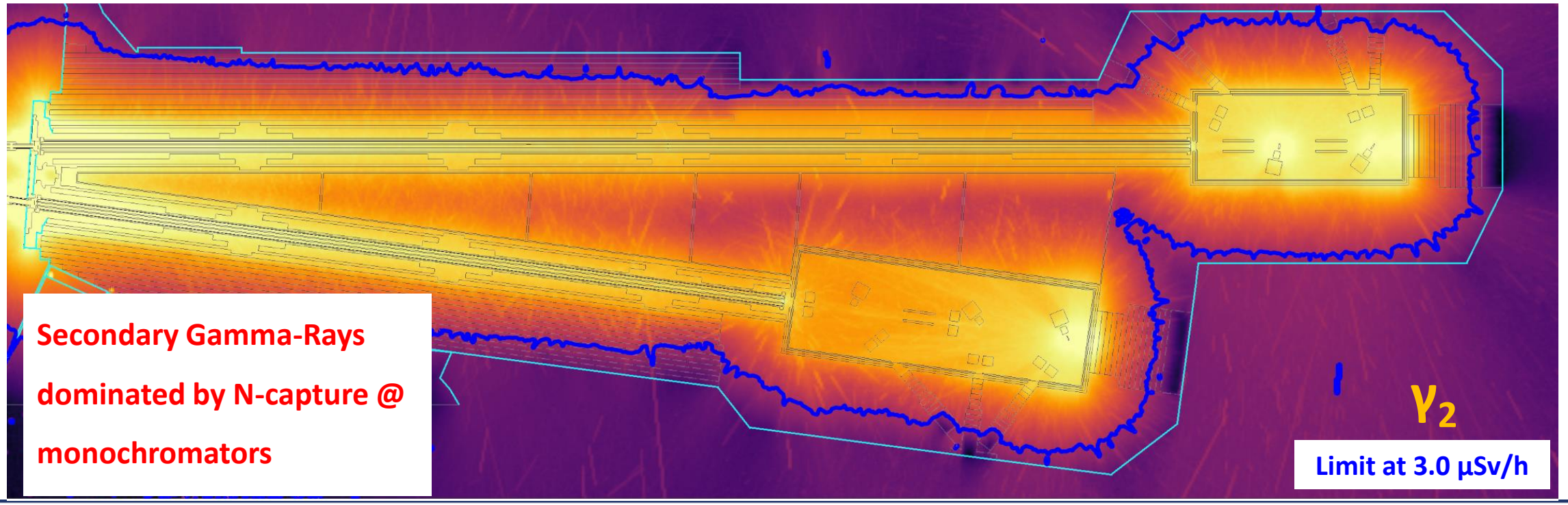
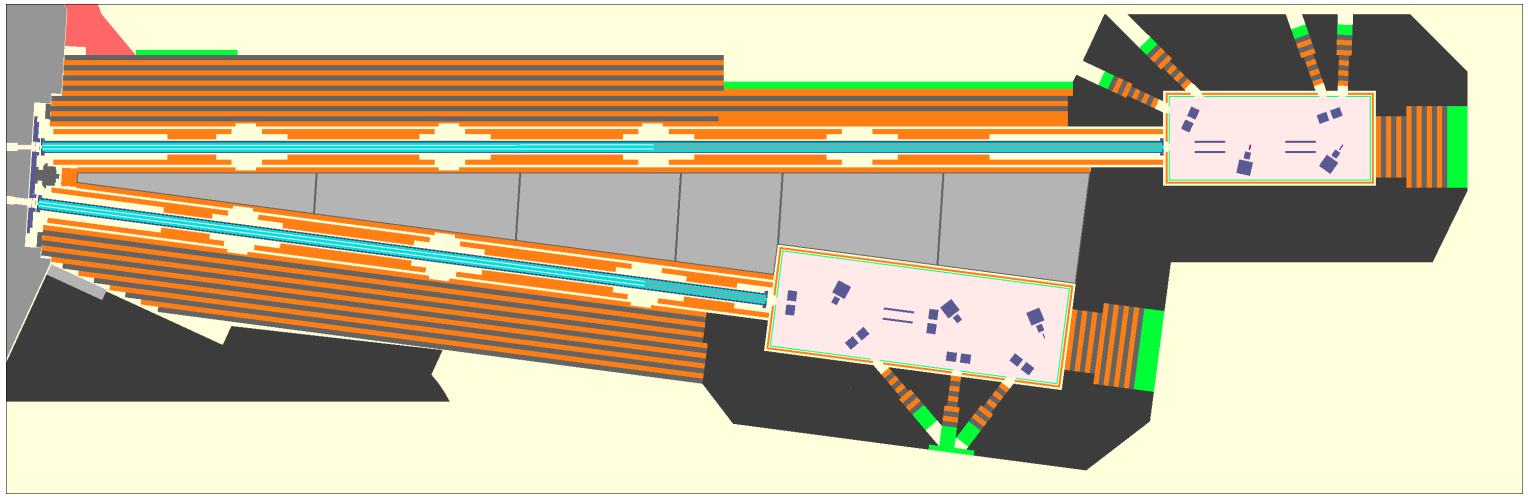


Secondary Gamma-Rays dominated by N-capture @ monochromators

New SR8 shielding



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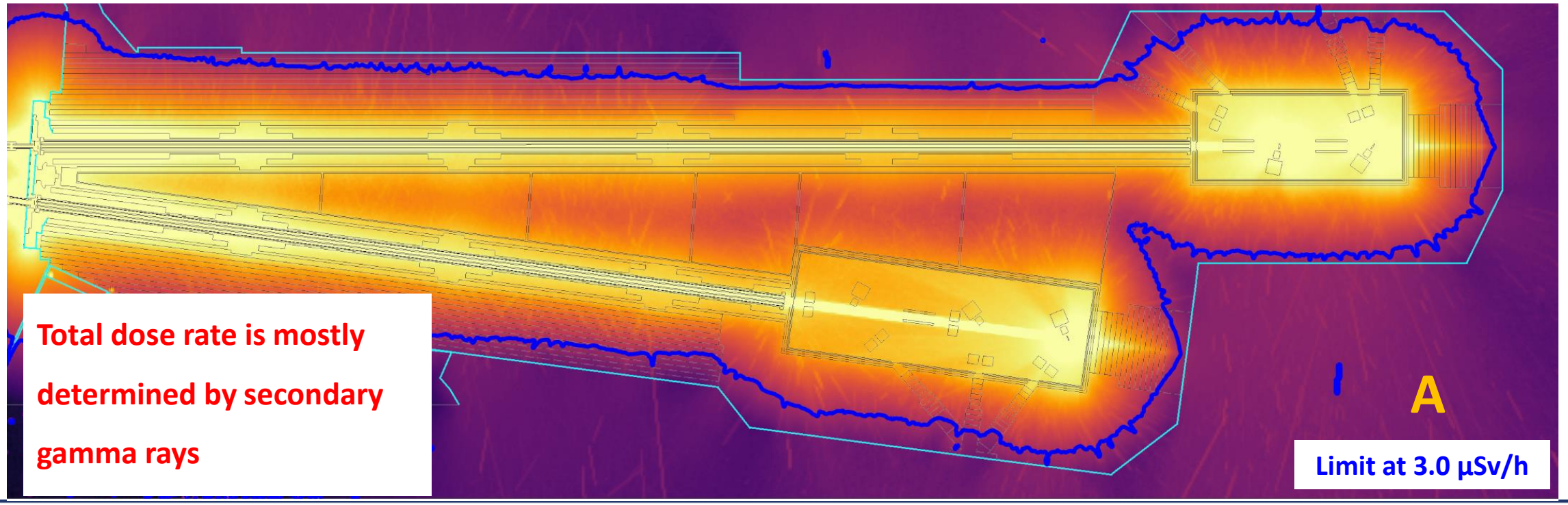
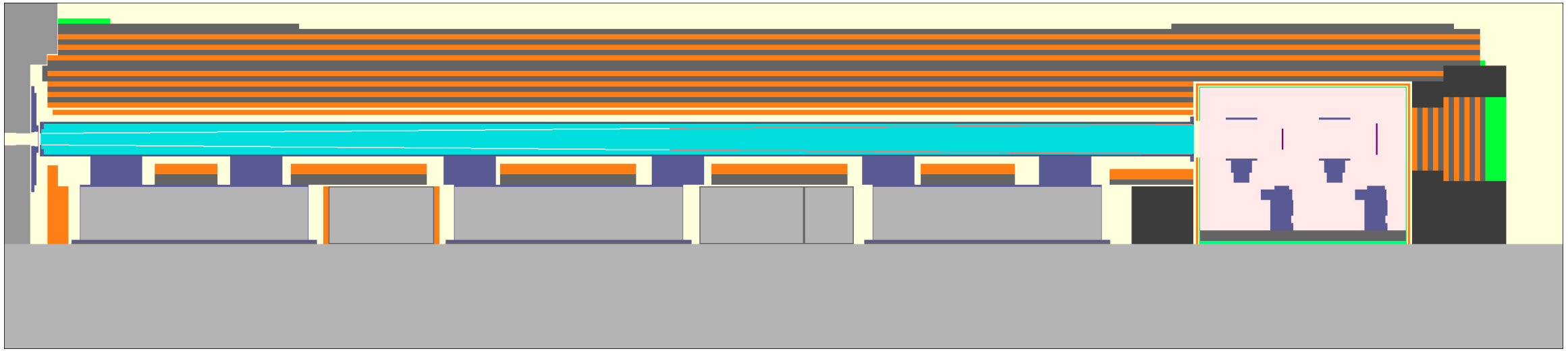
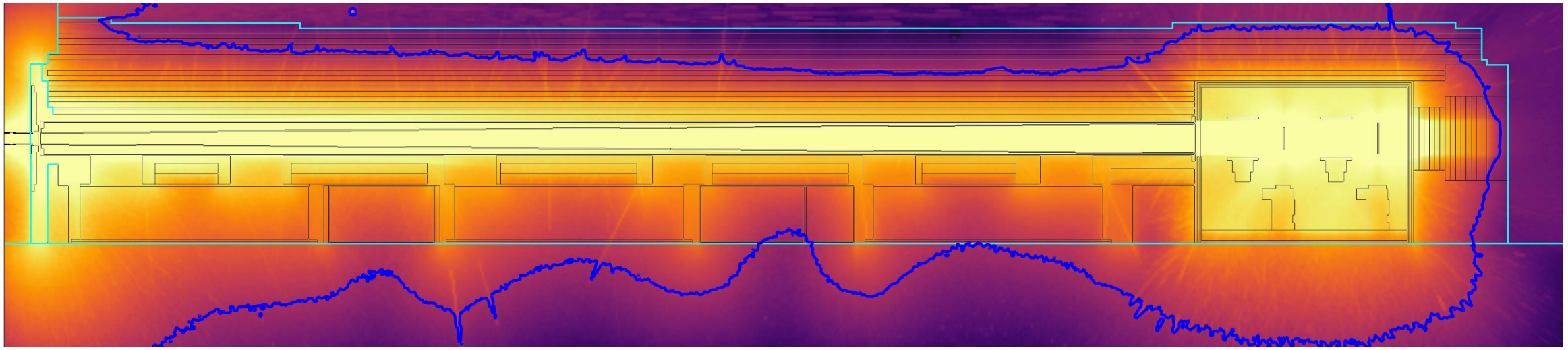
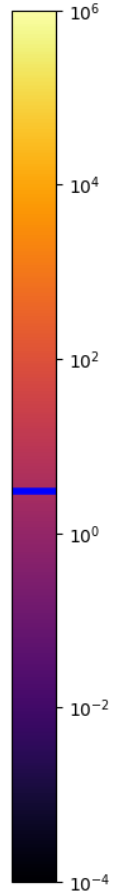


Total dose rate is mostly determined by secondary gamma rays

New SR8 shielding



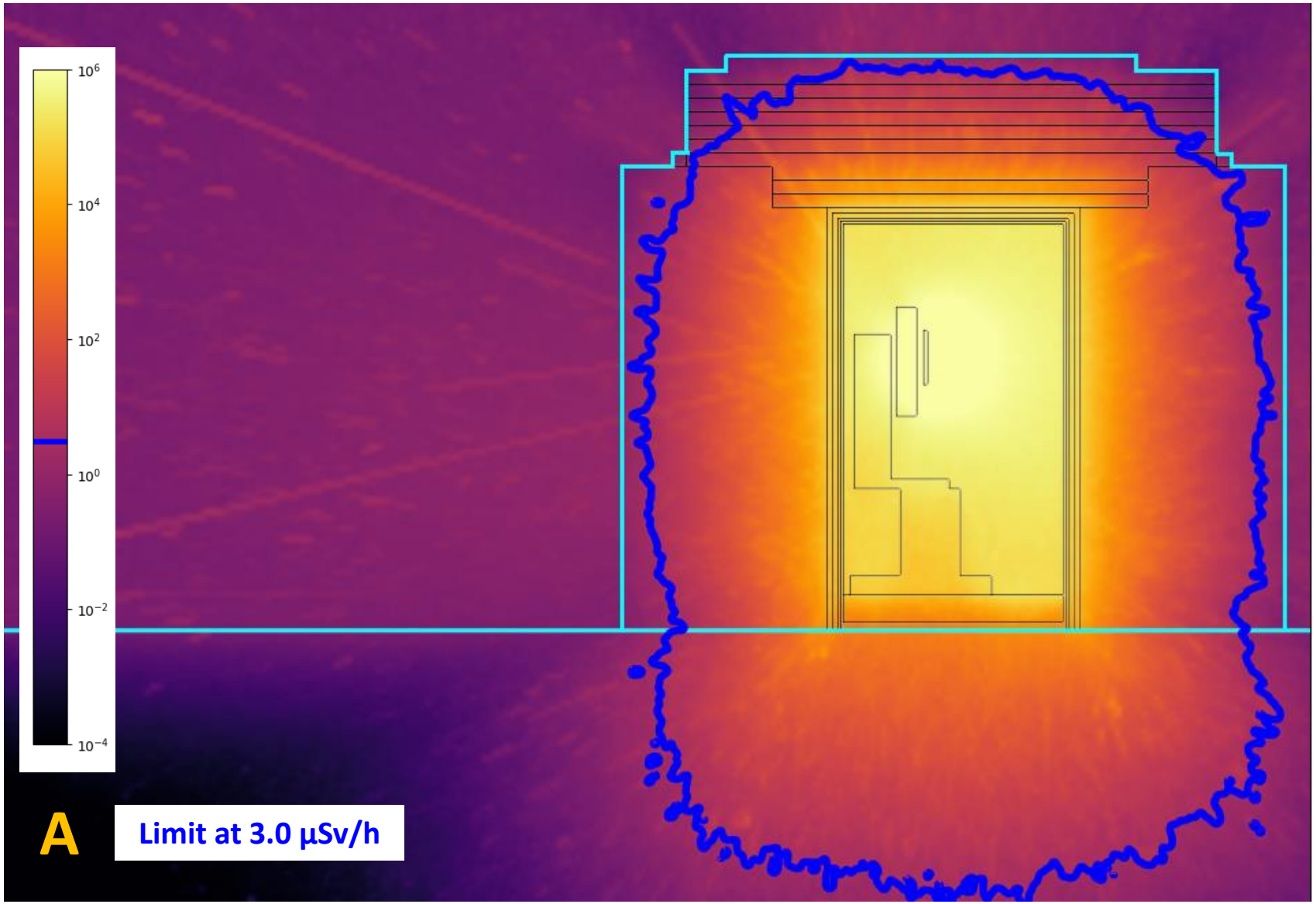


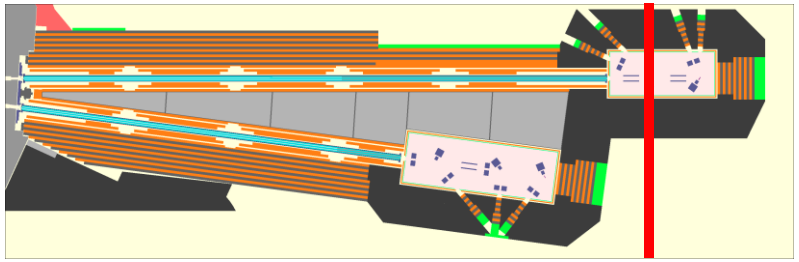


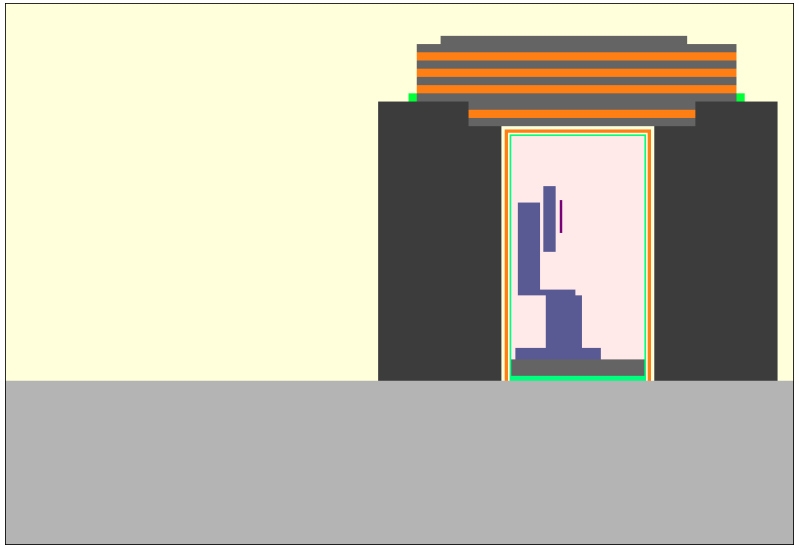
Total dose rate; limits at 3.0 µSv/h

20% B-PE; Steel; concrete; heavy concrete Al; Na-Float; Boro-Float; vacuum; ANTARES-boxes; reactor Limit at 3.0 µSv/h

New SR8 shielding







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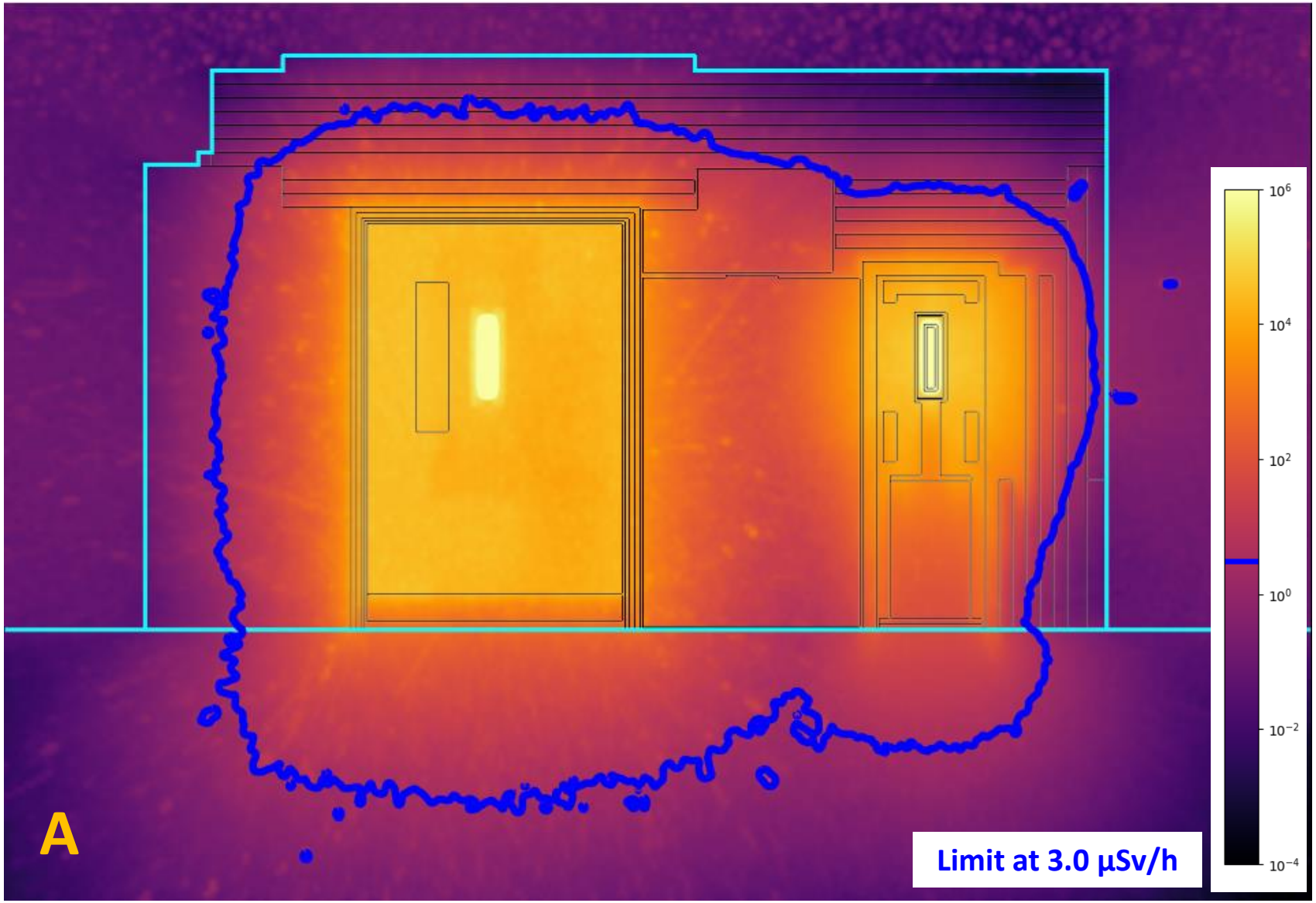

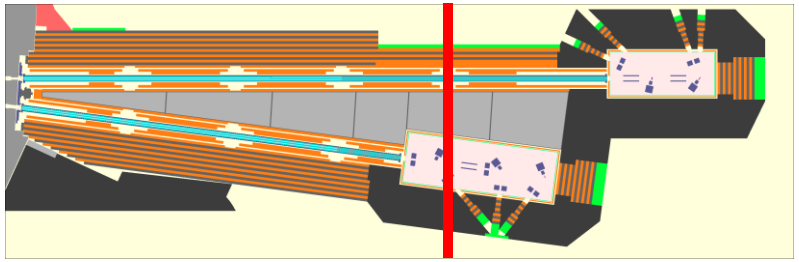

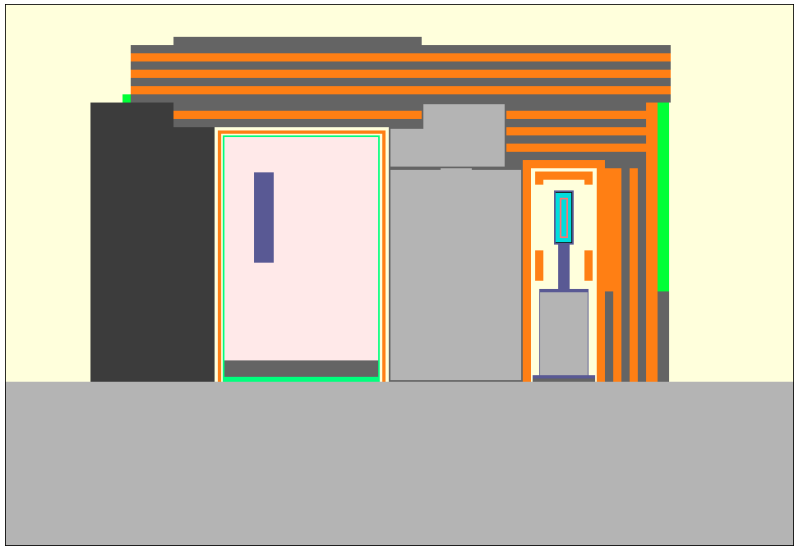

Many thanks to

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Peter Link

Anatoliy Senyshyn

Markus Hölzel

Björn Pedersen

And Thank you for your attention

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