

Advances in the shielding design of the cold neutron imaging instrument ASTOR

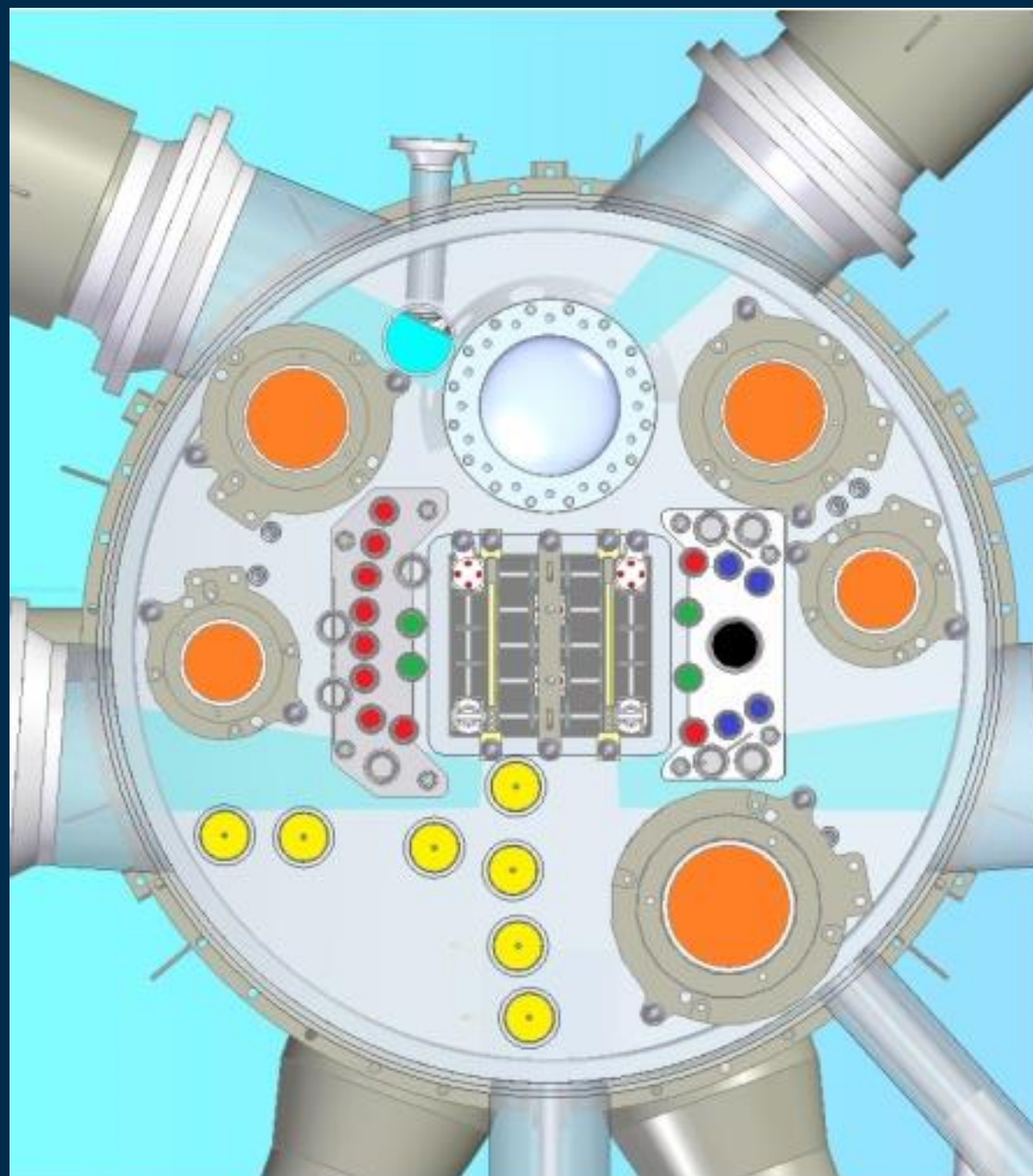
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OUTLINE

- Introduction
- Preliminary design of ASTOR
- Changing the preliminary design
 - Suggestions from experts
 - Election of beam line
 - Secondary shutter design
- Conclusions

Introduction

- The multipurpose reactor RA-10

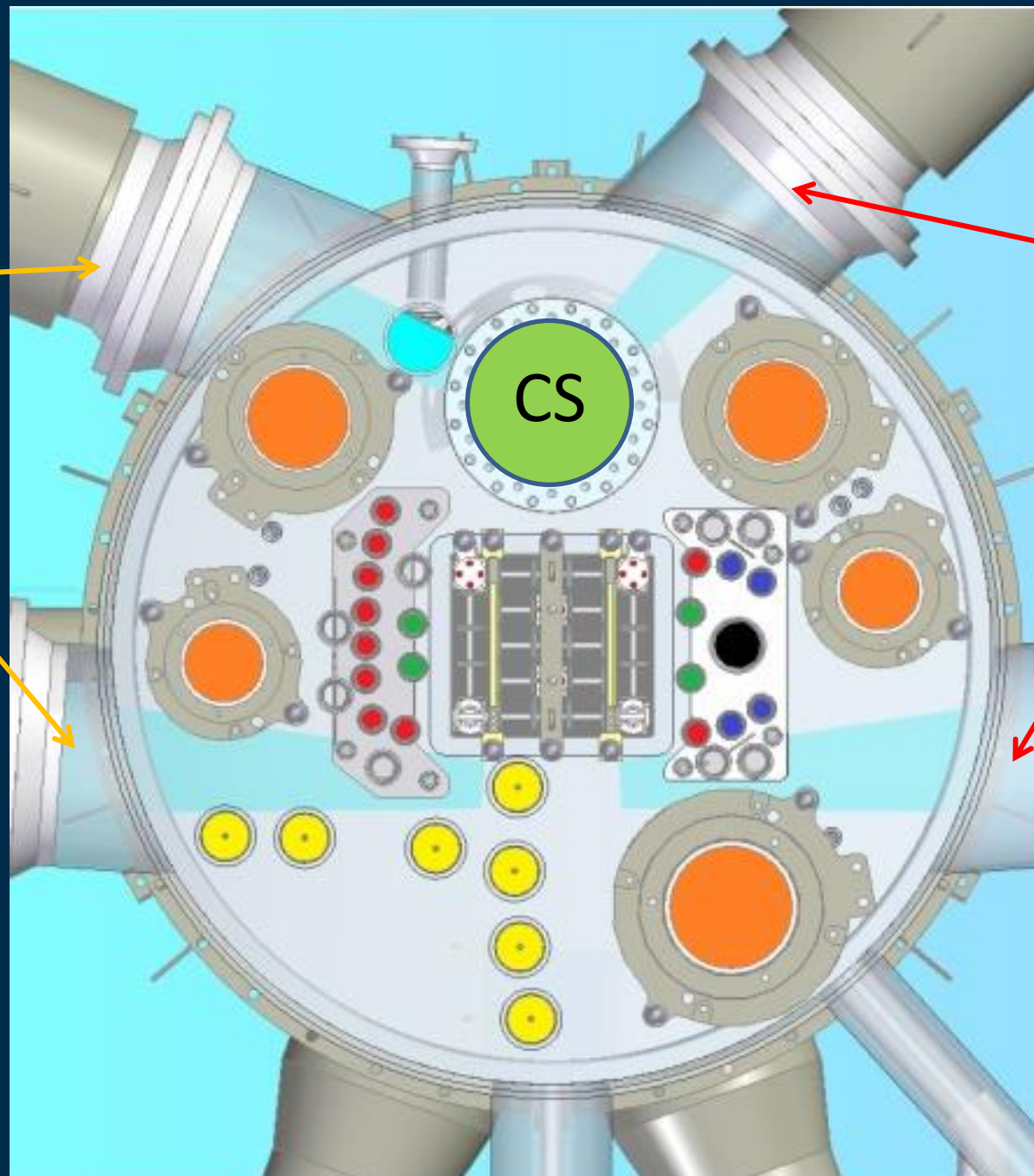


- Ir-192 MED/ Lu-177
(up to 4 positions)
- Mo-99
(10 positions)
- Ir-192 IND/ ORI
(up to 4 positions)
- LOOP
- PNEUMATIC DEVICE
(7 X 2 positions)
- NTD
(5 positions)

Introduction

- The multipurpose reactor RA-10

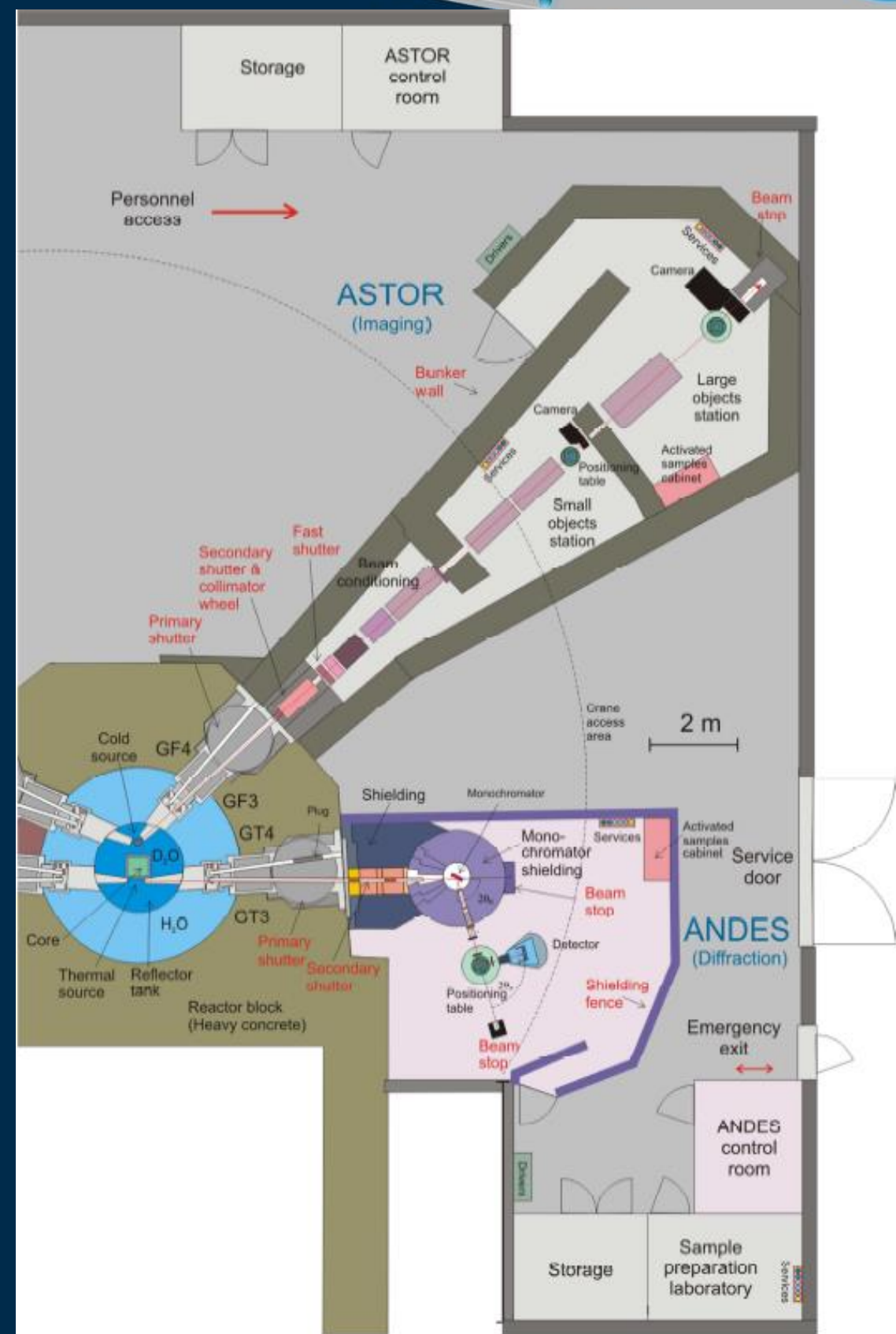
Neutron
beams to
the guide
hall



Neutron
beams to
the reactor
hall

Introduction

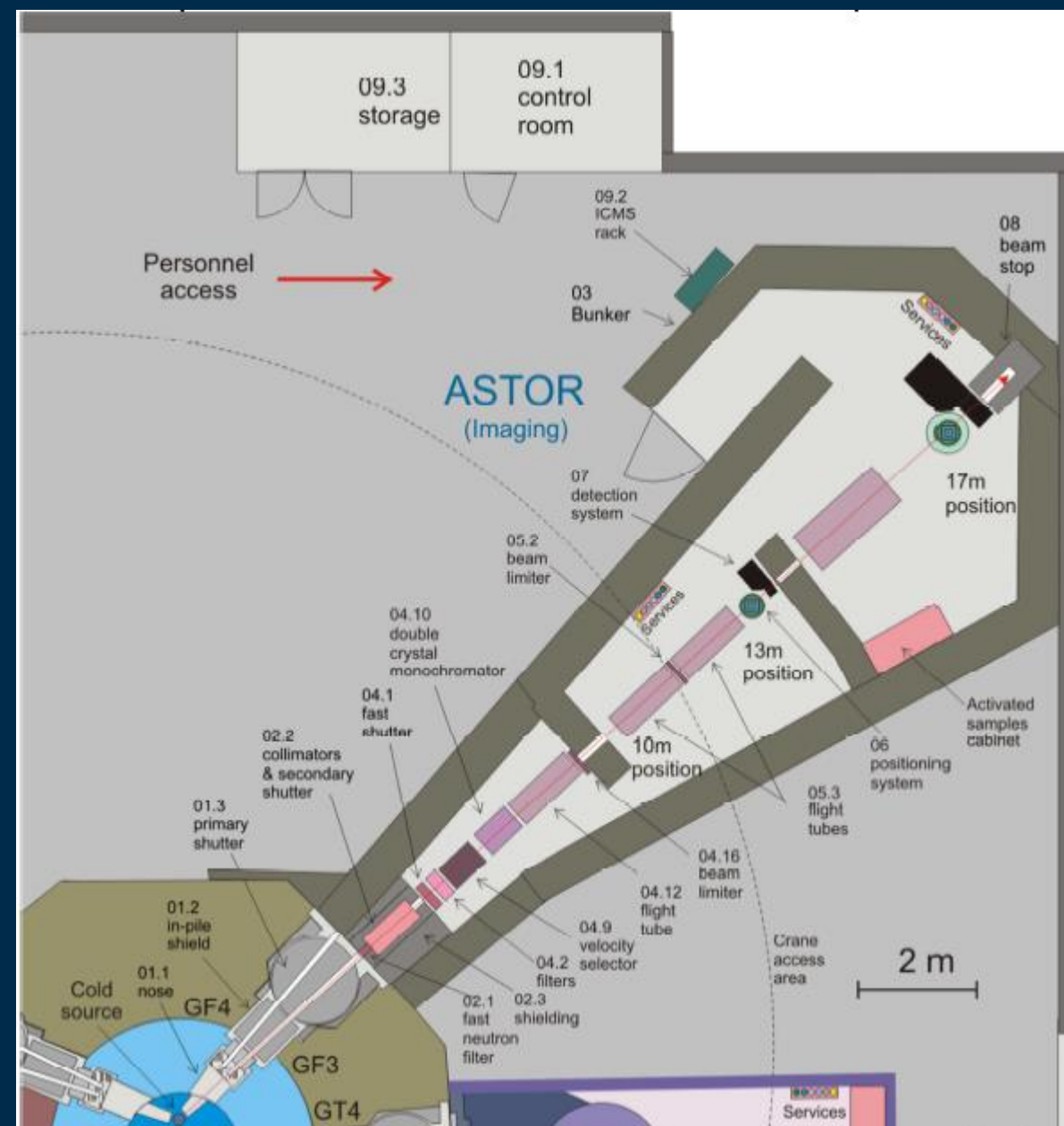
- The reactor hall
- First stage
 - 1 diffractometer (thermal beam)
 - 1 imaging instrument (cold beam)
- Future
 - 1 more facility (cold beam)
(To be defined)



Preliminary design of ASTOR

ASTOR: Advanced System for Tomography and Radiography

- Flux: up to 10^8 n/cm².s at 10 m (L/D=212)
- L/D: from 400 to 2000 at 17 m
- Labyrinth access
- 3 rooms without shielded doors
- 75cm-thick heavy concrete walls
- Inner lining of borated polyethylene



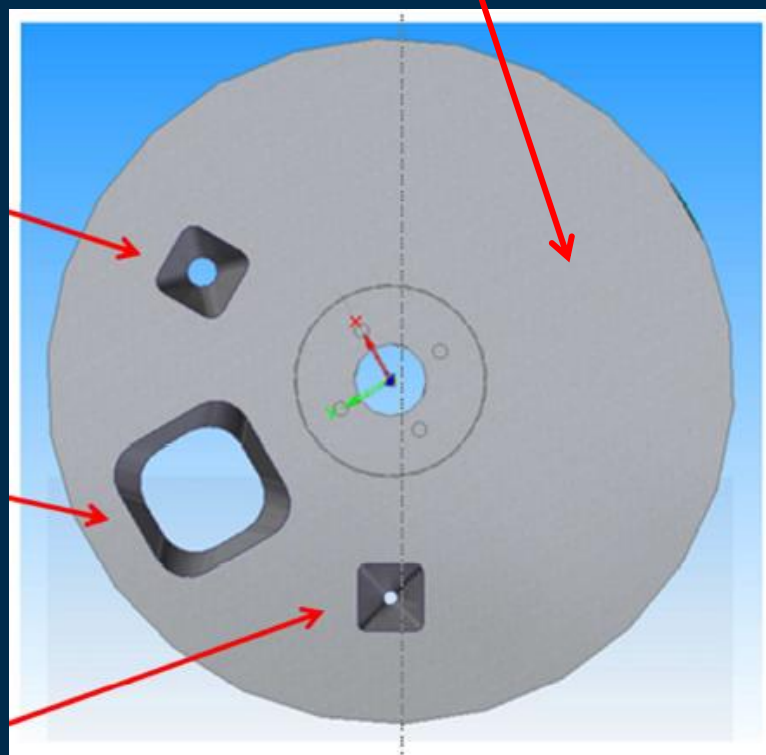
Preliminary design of ASTOR

Secondary collimator/shutter Shutter

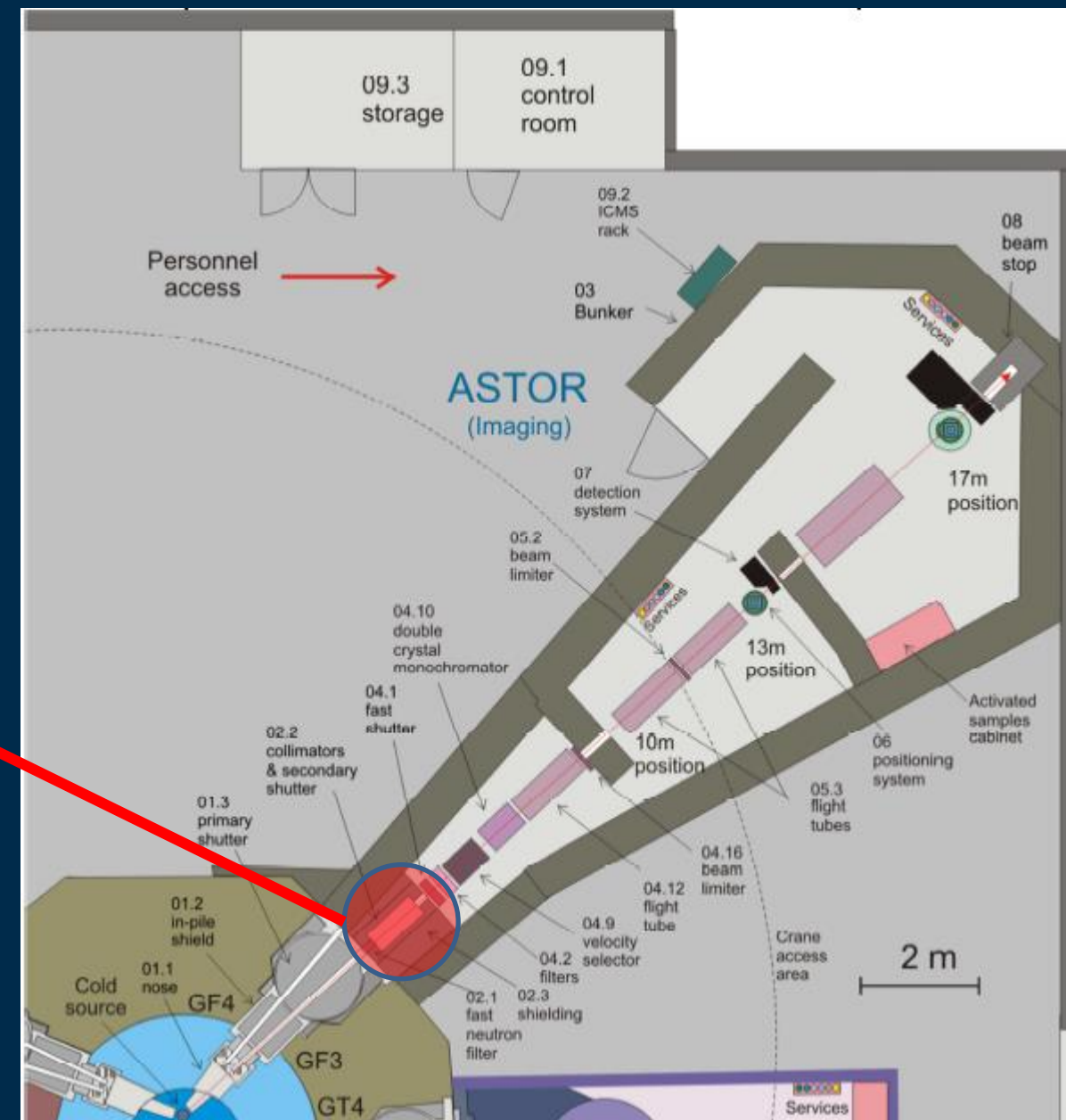
L/D: 1000
at 17 meters from cold
source

L/D: 400
at 17 meters from
cold source

L/D: 2000
at 17 meters from cold
source



Length: 1 meter



Preliminary design of ASTOR

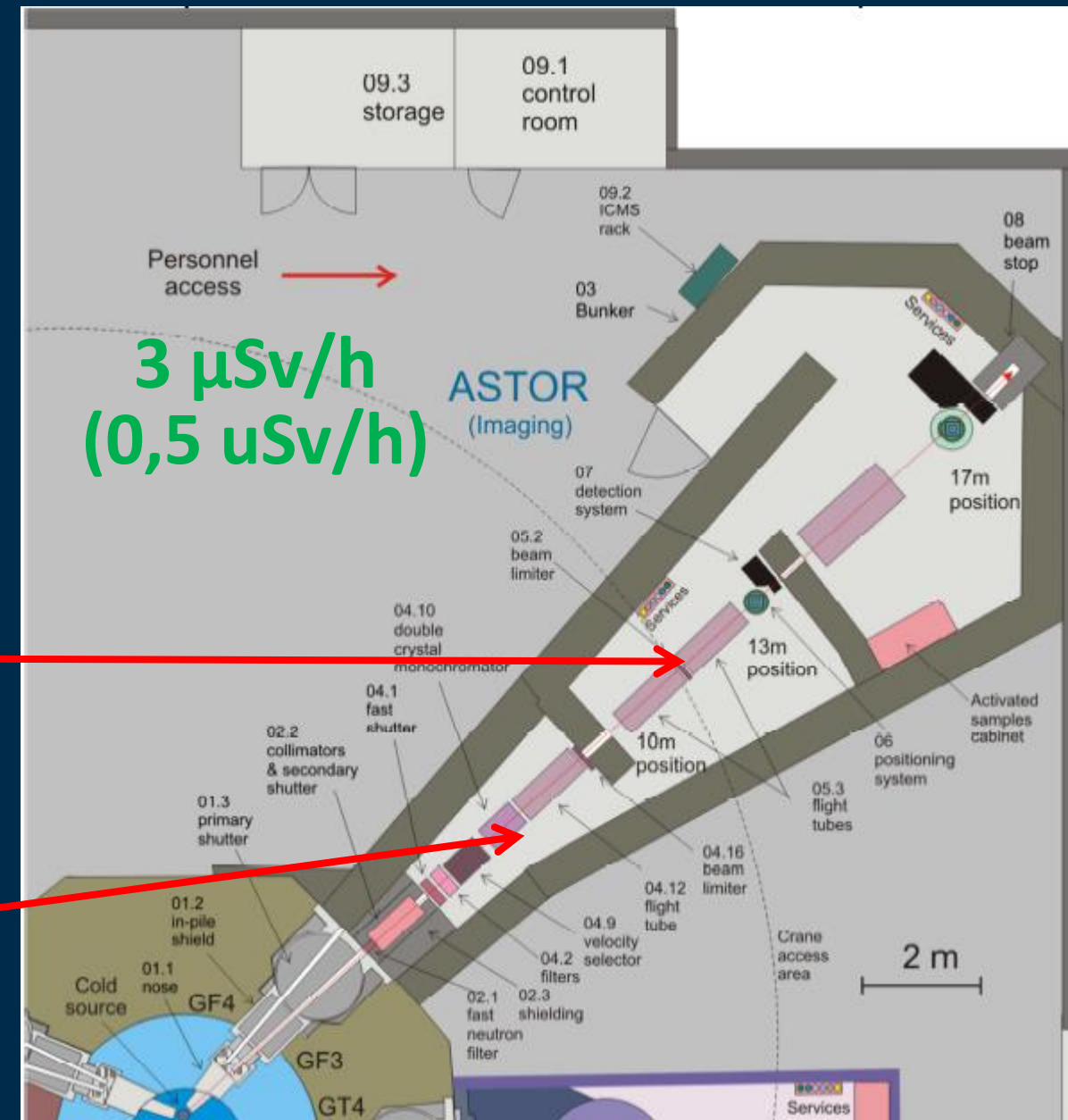
Shielding design criteria: Ambient dose equivalent

RA-10 criteria
(limit used)

Secondary shutter:
opened position
closed position

$3 \mu\text{Sv/h}$
($0,5 \mu\text{Sv/h}$)

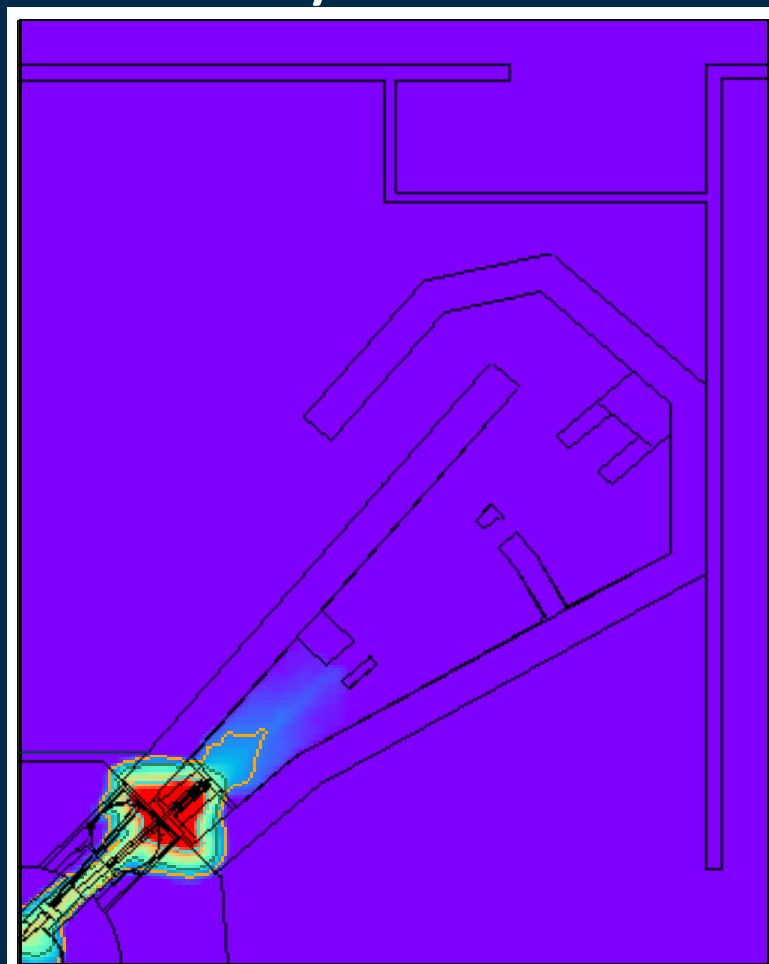
$200 \mu\text{Sv/h}$
($40 \mu\text{Sv/h}$)



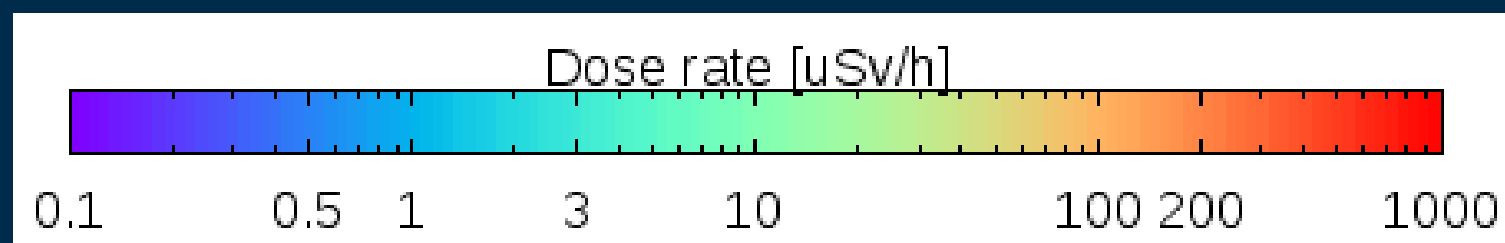
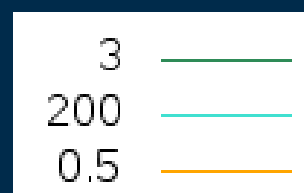
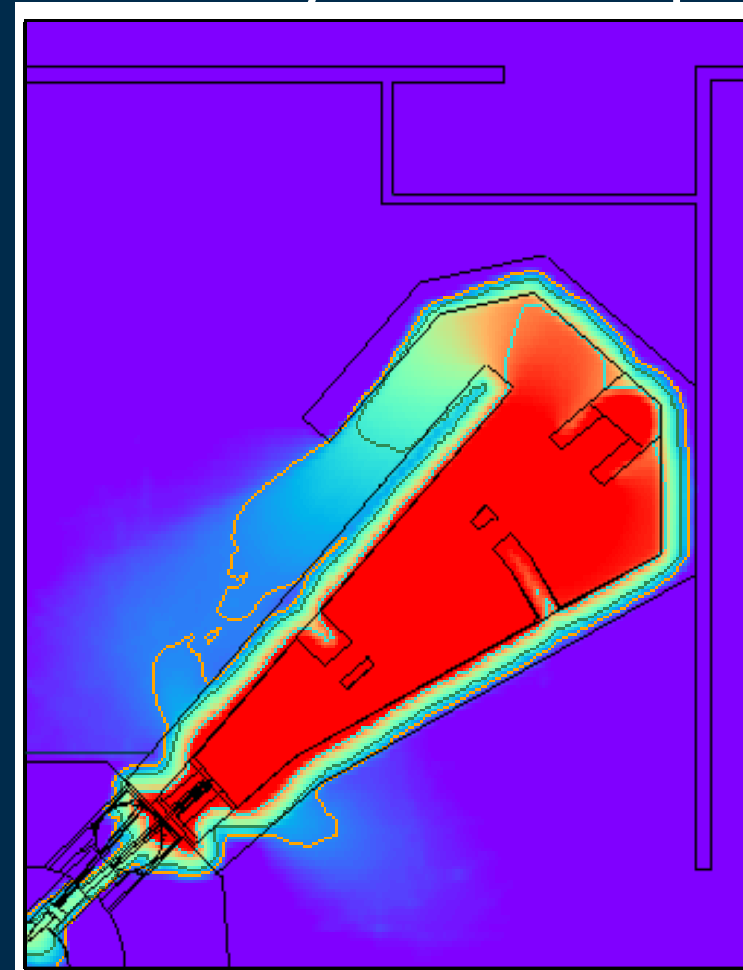
Preliminary design of ASTOR

Dose rate calculations

Secondary shutter close



Secondary shutter open



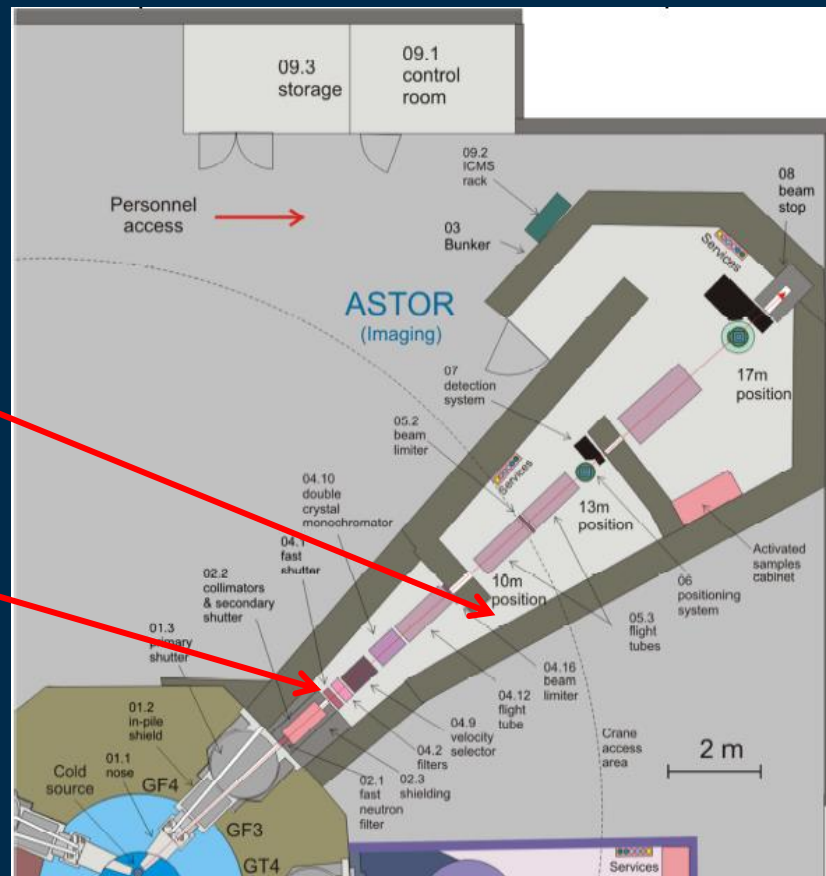
Changing the preliminary design

- March 2017: Meeting with the scientific and technical advisory group of the instrument.
Suggestions and comments:
 - Separate the secondary shutter and collimator in 2 independent systems
 - Consider the effect of the sample over the dose rate calculations
 - Add higher flux capabilities with lower L/D
 - Almost impossible to add a new instrument in GF4 without completely dismantling ASTOR

Separate secondary collimator and shutter

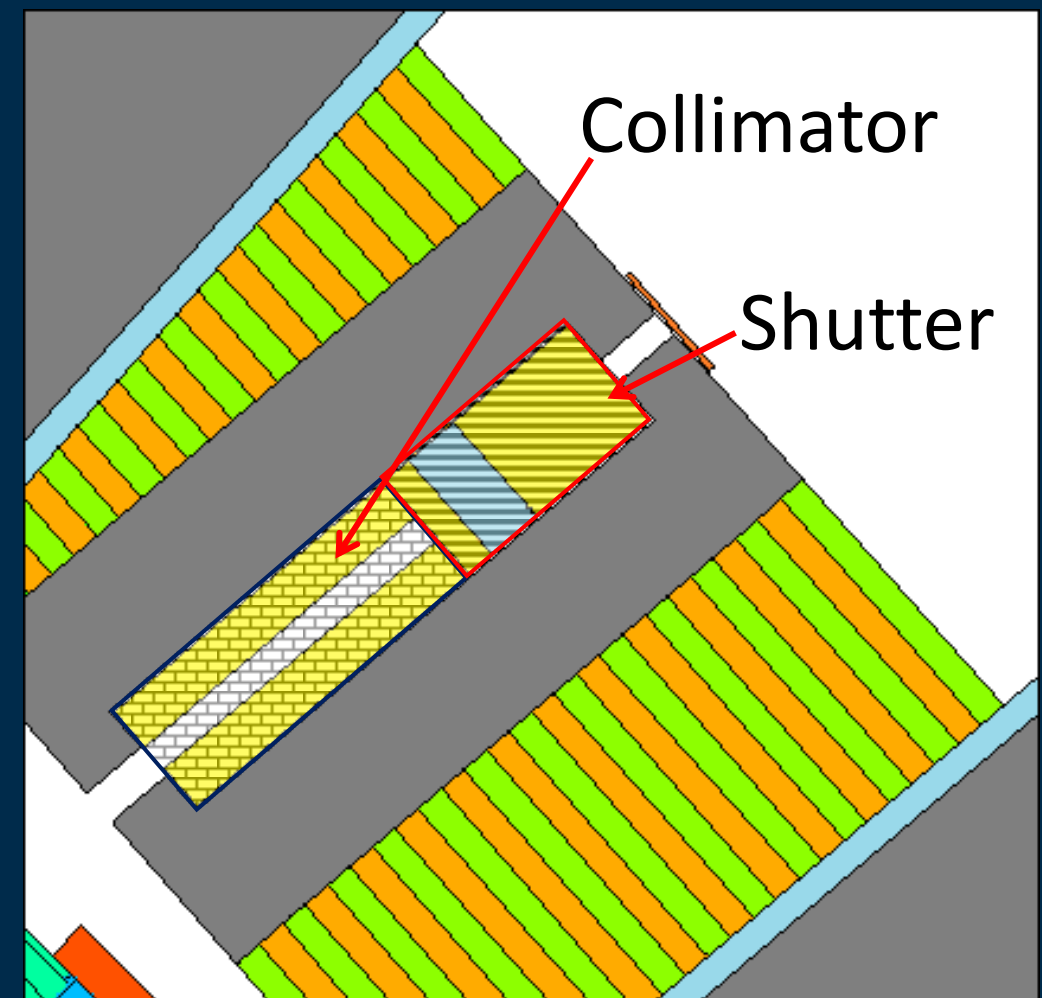
Design criteria:

- Collimator length + Shutter length = 1 meter
- Minimum collimator length: 40 cm
- Dose rate limits:



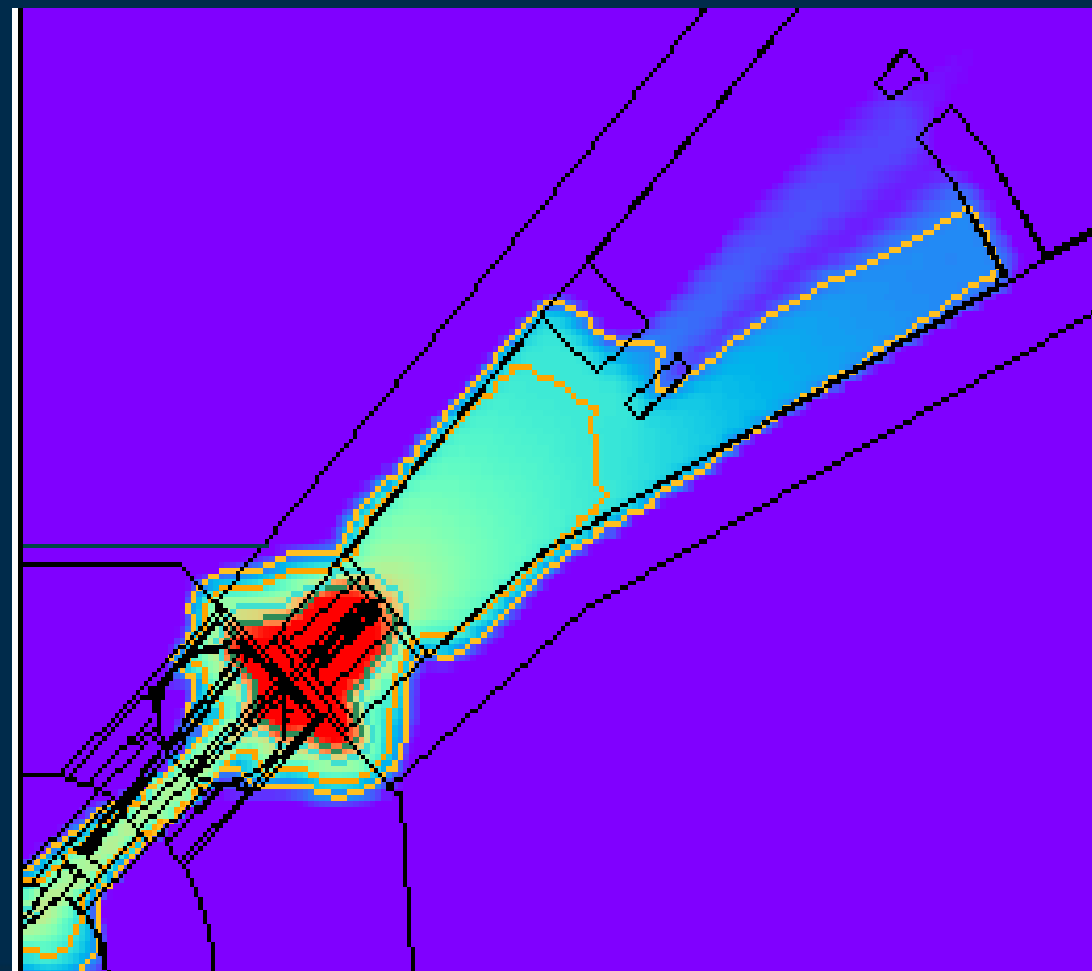
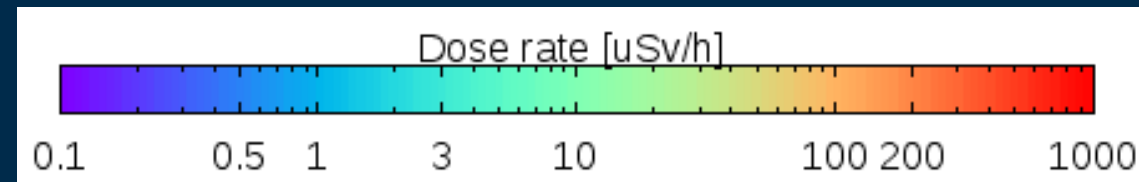
0,5 $\mu\text{Sv/h}$

40 $\mu\text{Sv/h}$



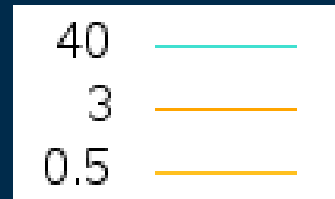
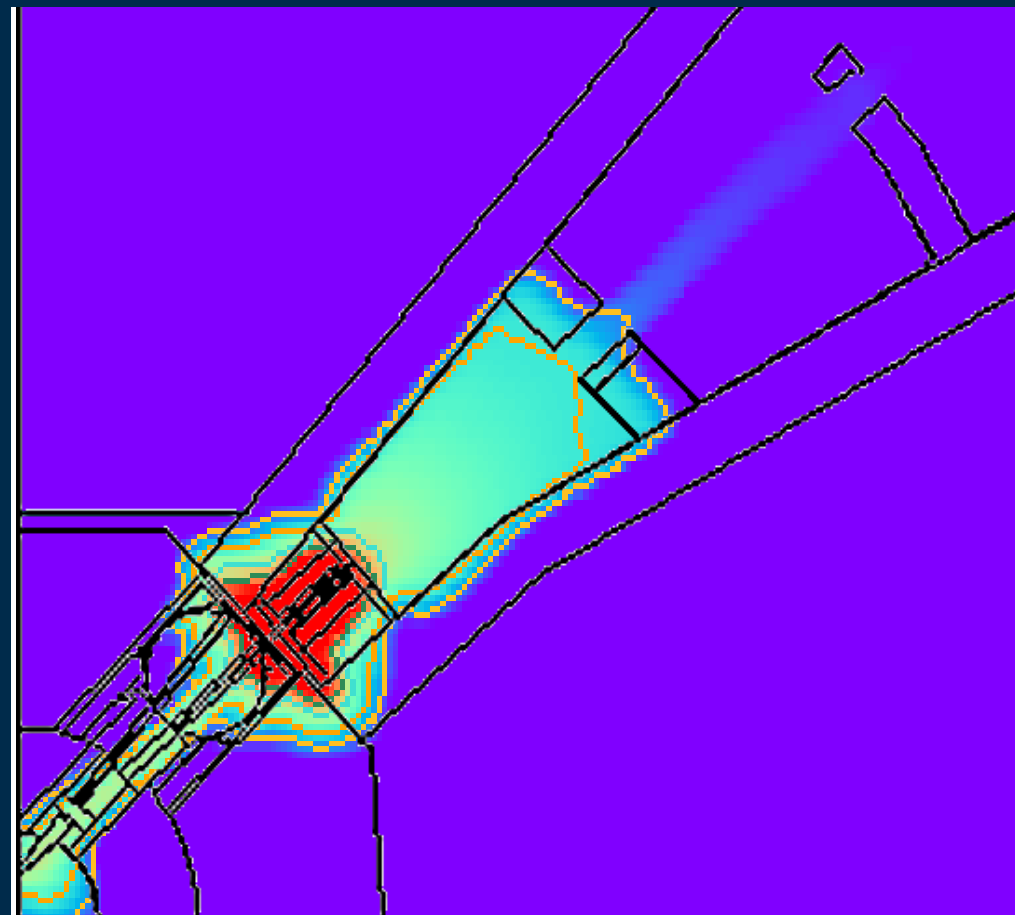
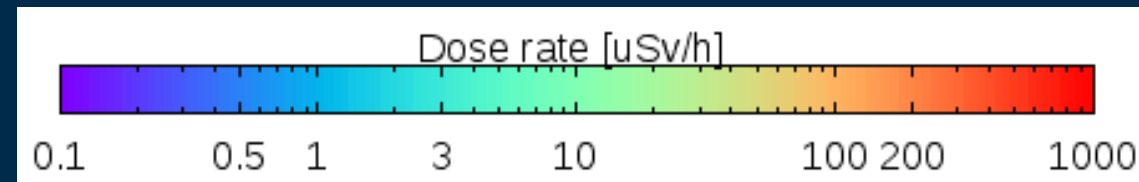
Separate secondary collimator and shutter

Optimal shutter composition: 30 cm of borated steel and 30 cm of borated polyethylene



Separate secondary collimator and shutter

In order to fulfil requirements it is necessary to separate beam set up room from experimental room.



Consider the effect of the sample over the dose rate calculations

Cilindrical samples of:

- Polyethylene
- Graphite
- Steel

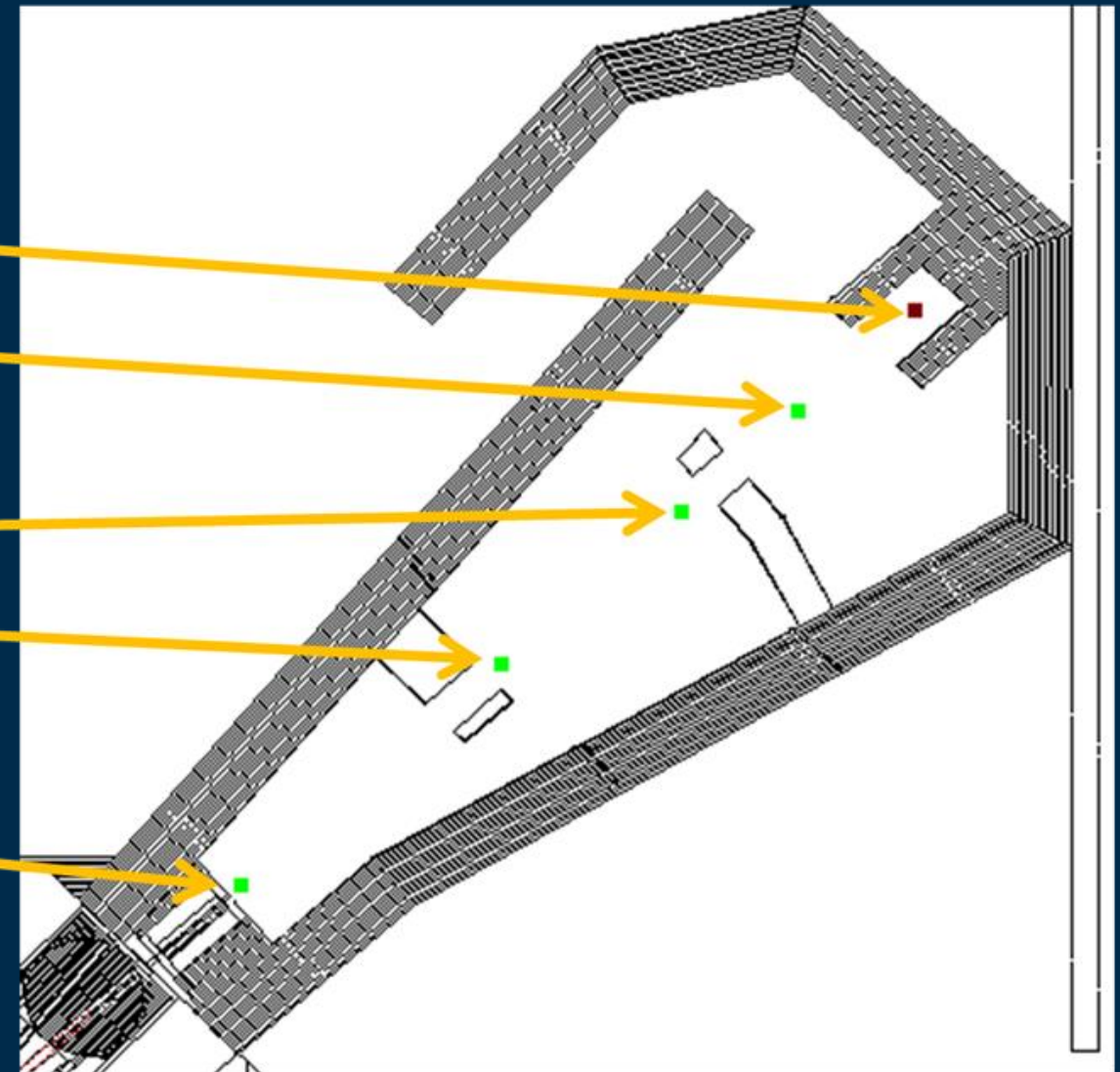
17 meters

15 meters

13 meters

10 meters

Beam
conditioning



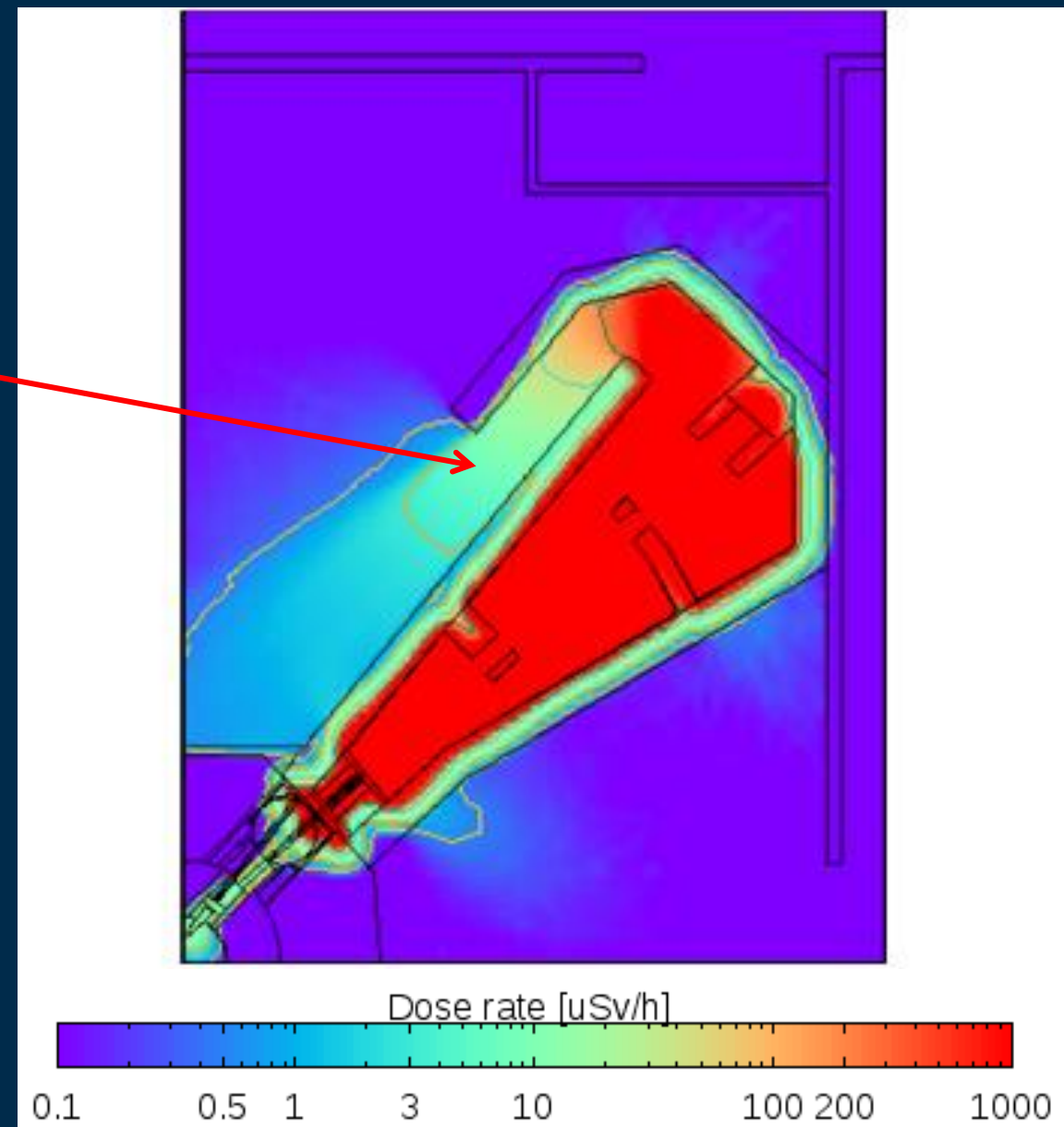
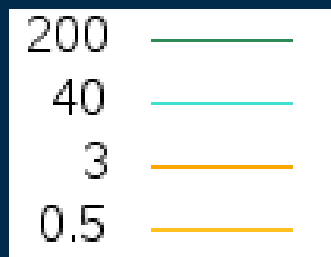
Consider the effect of the sample over the dose rate calculations

Worst scenario: Steel sample at 15 meters

Dose rate at the
entrance of the
laberinth increases
from 1.7 $\mu\text{Sv/h}$ to
7.5 $\mu\text{Sv/h}$

This value overcomes the
dose rate limits, but the
value could be lowered in
future design phases

7.5 $\mu\text{Sv/h}$



Add higher flux capabilities with lower L/D

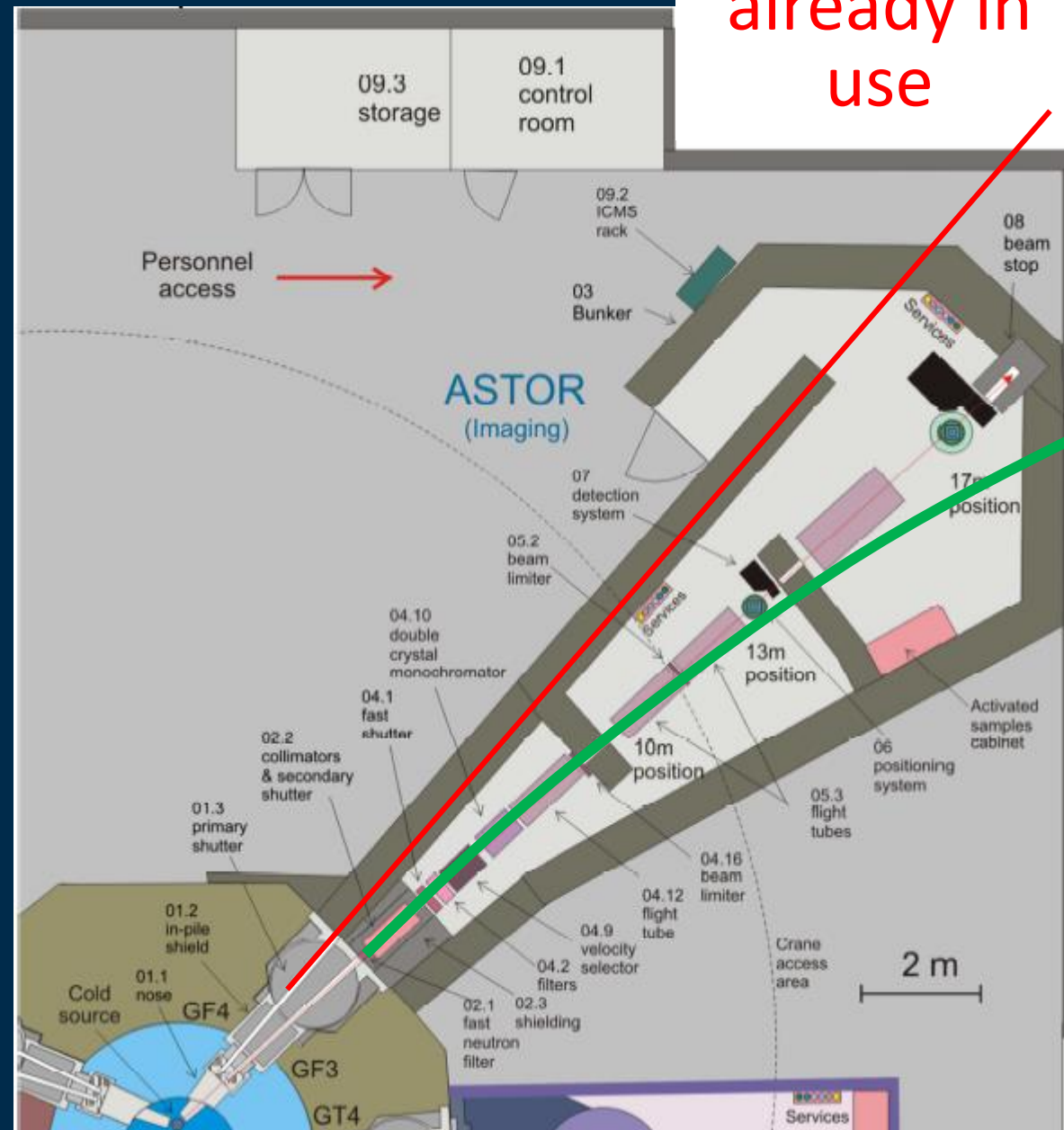
- Minimum L/D decreases from 200 to ~ 120
- Maximum neutron flux 3 times higher

Almost impossible to add a new instrument in GF4 without completely dismantle ASTOR

- ASTOR moved from GT3 to GF4

ASTOR in GF4

A neutron guide could be placed in GF3, but not in GF4

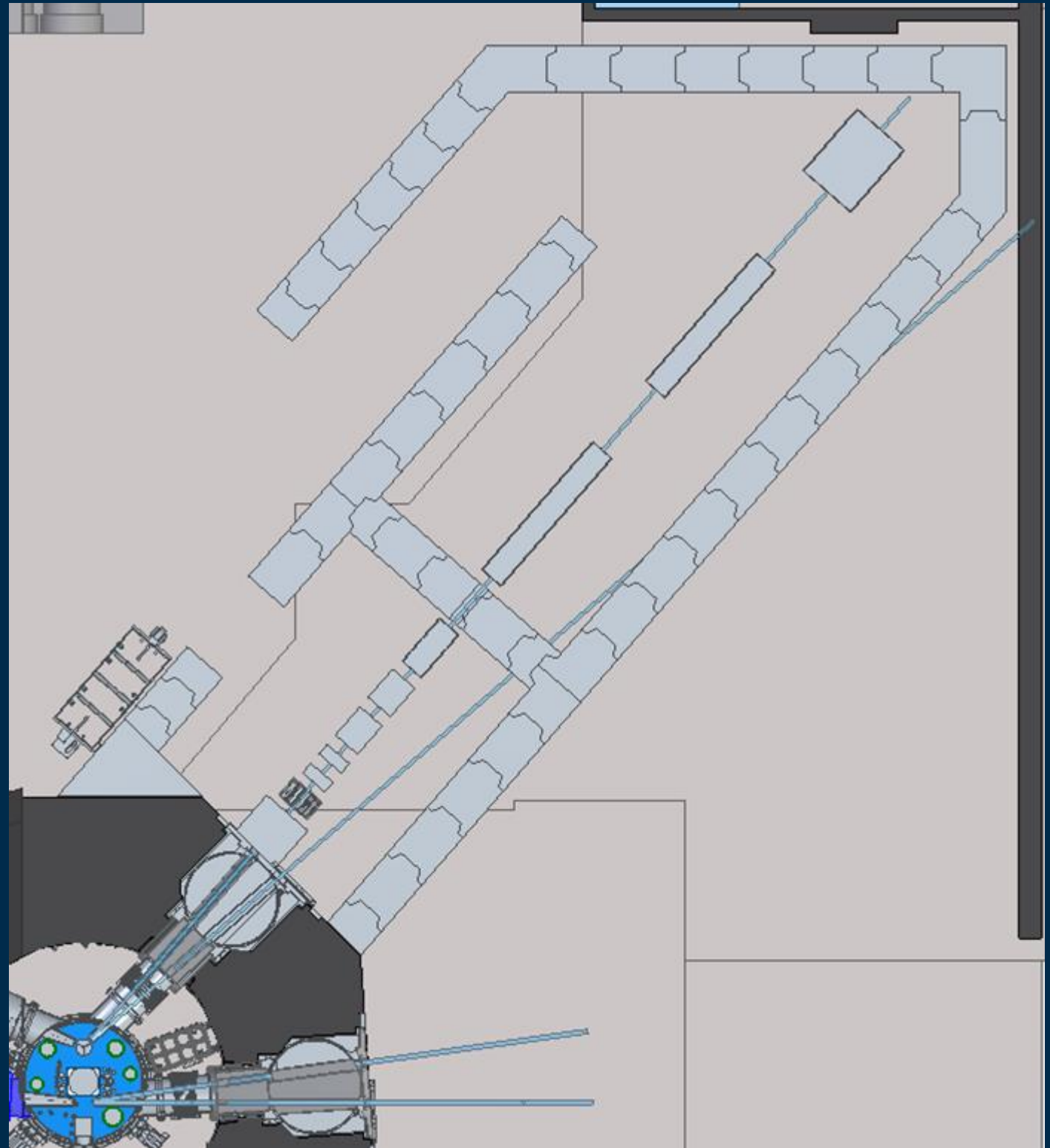


Space
already in
use

(Free space)

New design of ASTOR v.0

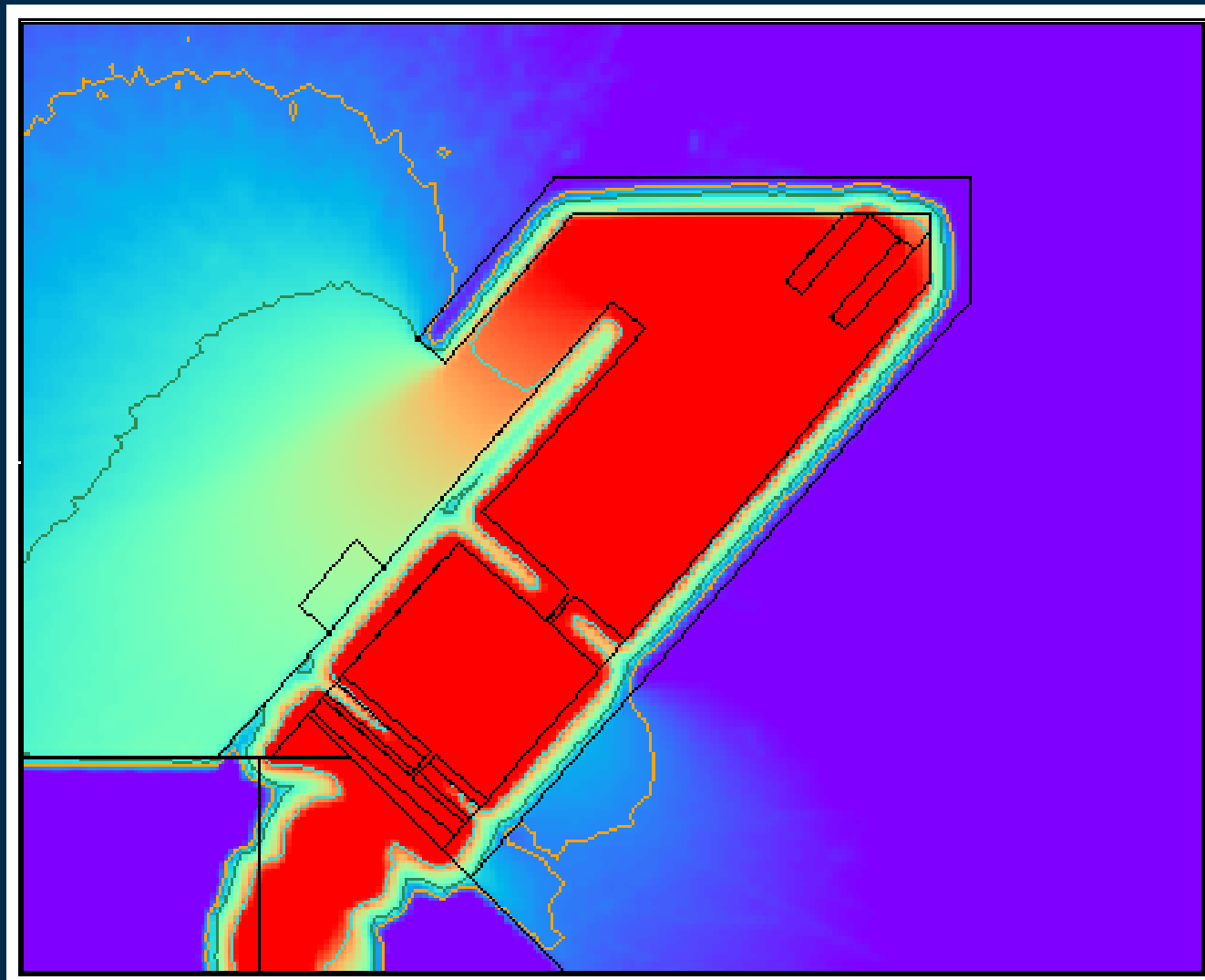
- Straight walls to simplify assembly
- Maximum neutron flux 3 times higher



New design of ASTOR v.0

ASTOR in GF4

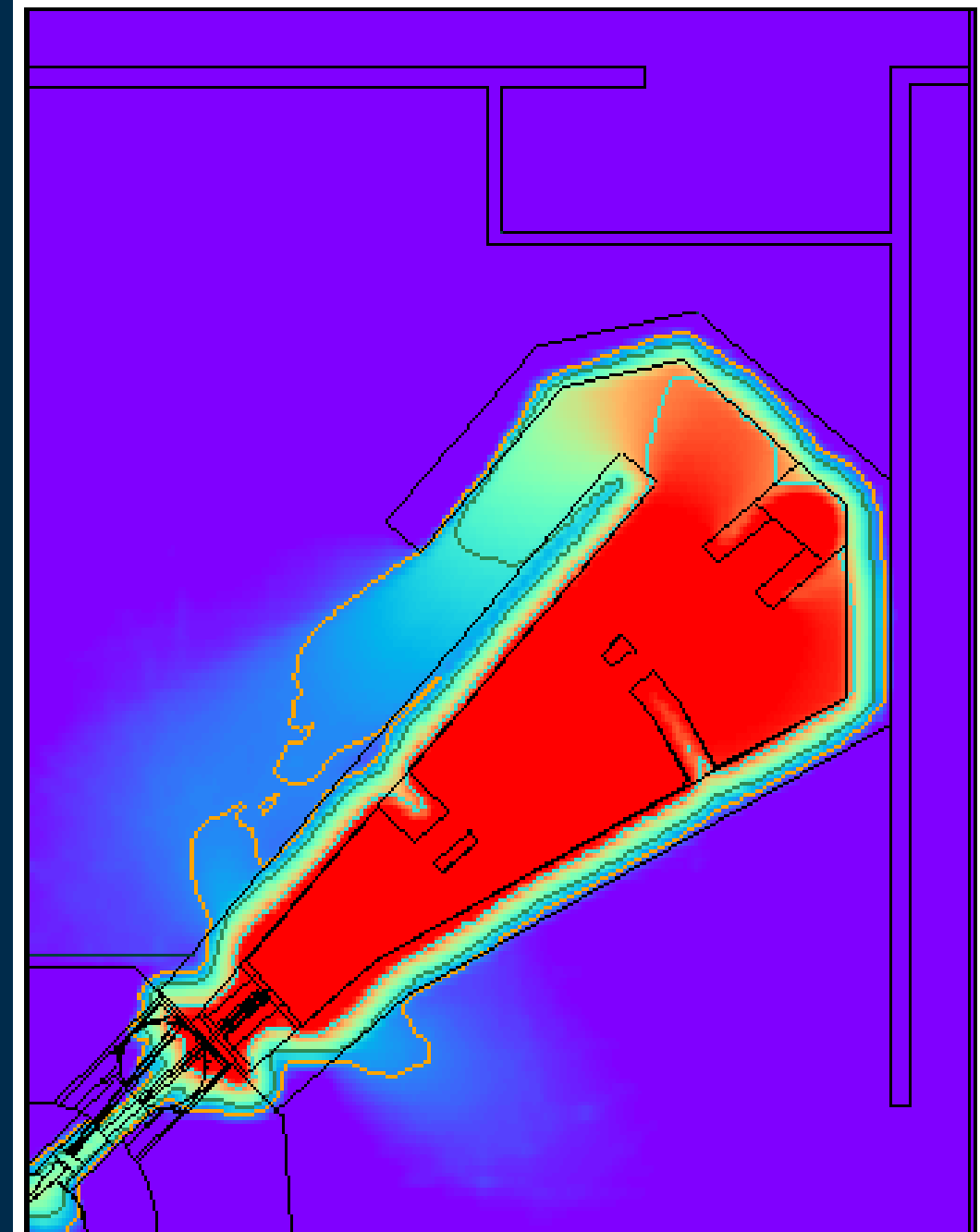
3 —
200 —
0.5 —



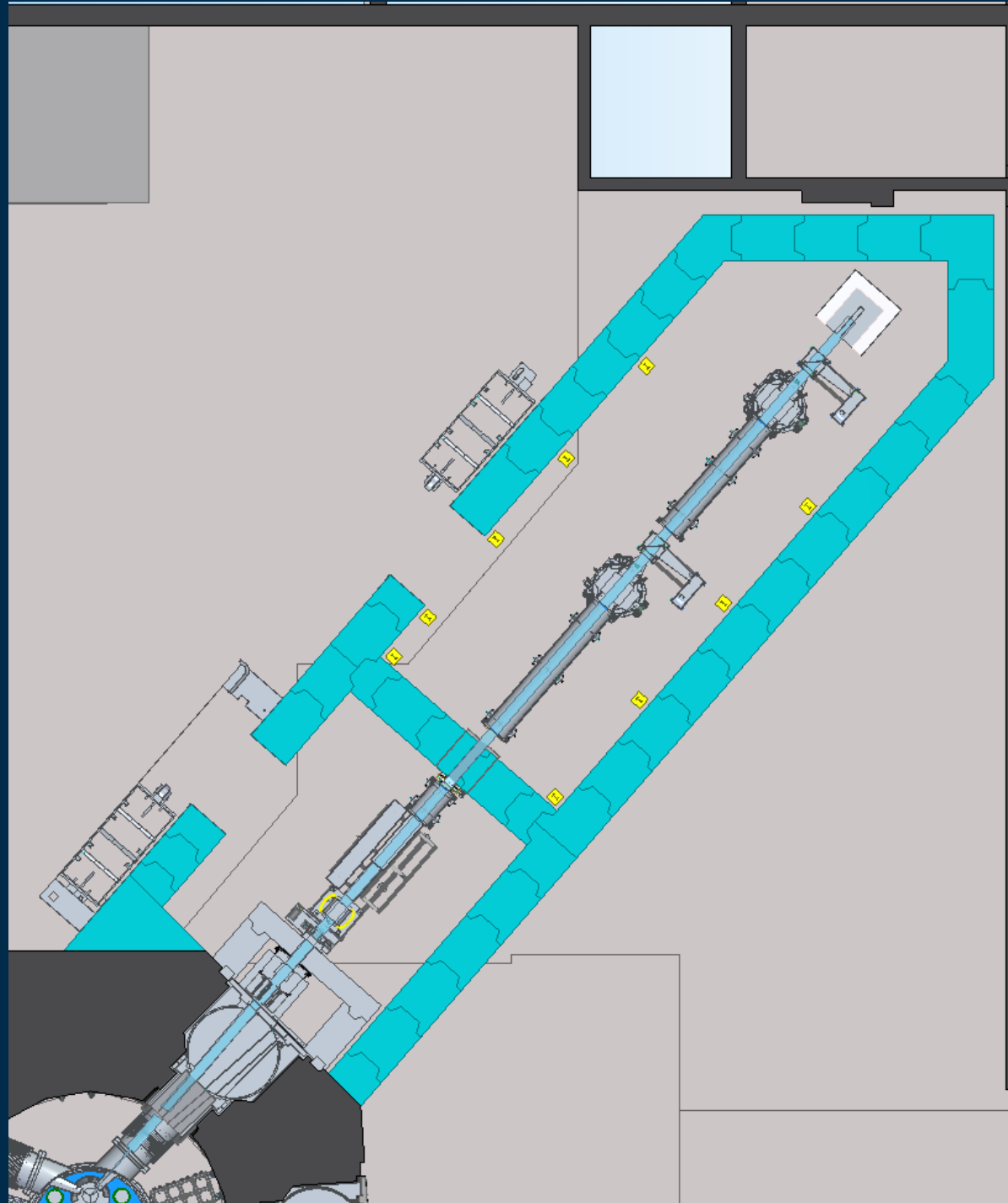
Dose rate [$\mu\text{Sv/h}$]



Preliminary design in GF3



New design of ASTOR v.1



Conclusion

- We presented the evolution of the shielding design of ASTOR from a single room with labyrinth access to 2 independent rooms with independent shielded doors.
- The dose rates limits outside the bunker in the new position could not be complied even without considering the scattering of radiation on the sample.
- 2 separate rooms allow to comply with the dose rate limits in the beam set up room, using a shorter secondary shutter.

Thank you for your attention
Questions/comments/suggestions?

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