Simulation of LINAC and Full Energy Booster for SESAME Synchrotron

SAFETY OFFICE

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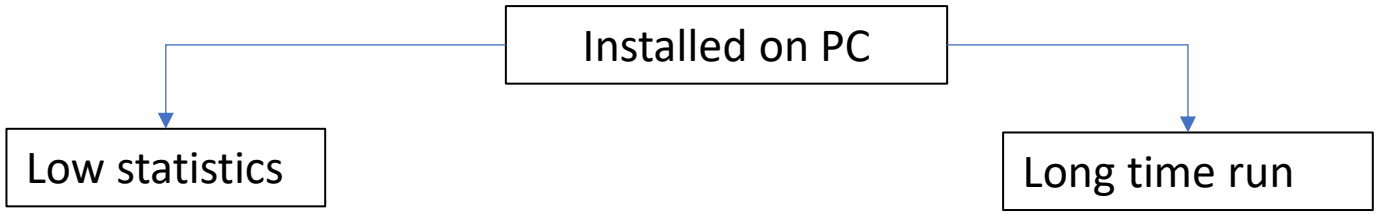
Shielding and Beam Loss Analysis using FLUKA Monte Carlo simulations

FLUKA, CERN version

"preliminary"



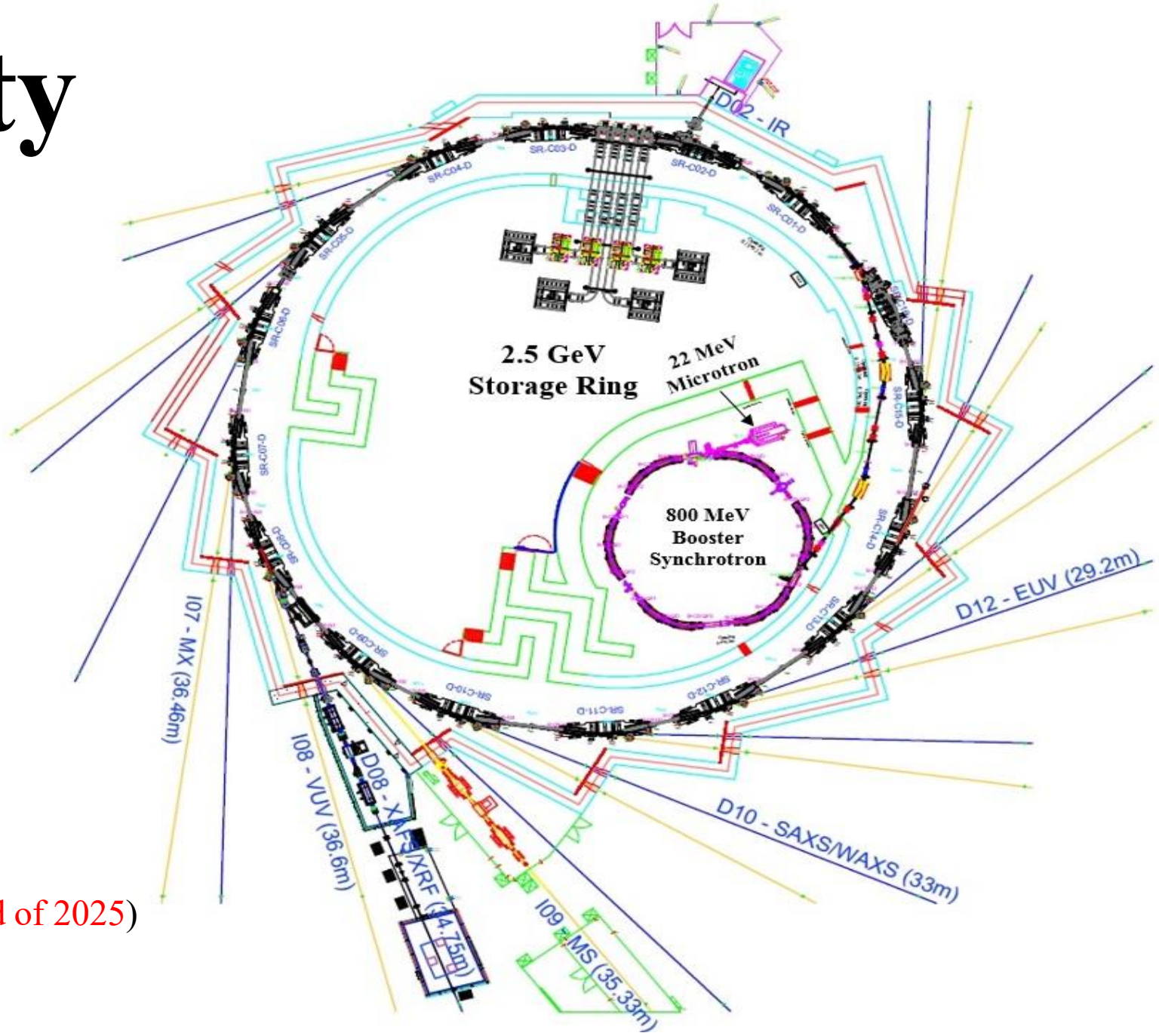
Facility

- Energy: 2.5 GeV
- Injection: Microtron and booster synchrotron
- Storage Ring: 133.2 m circumference
- operational current : 250-300mA with beam lifetime ~ 24h.

The design current is 400mA.

Beamlines :

BM02 - IR	2018
BM08 - XAFS/XRF	2018
ID09 - MS/XPD	2020
ID10 - BEATS	2024
ID11L - HESEB	2024
ID11R - TXPES	(under installation/end of 2025)



PHASE 1 : LINAC installation. (3 years project)

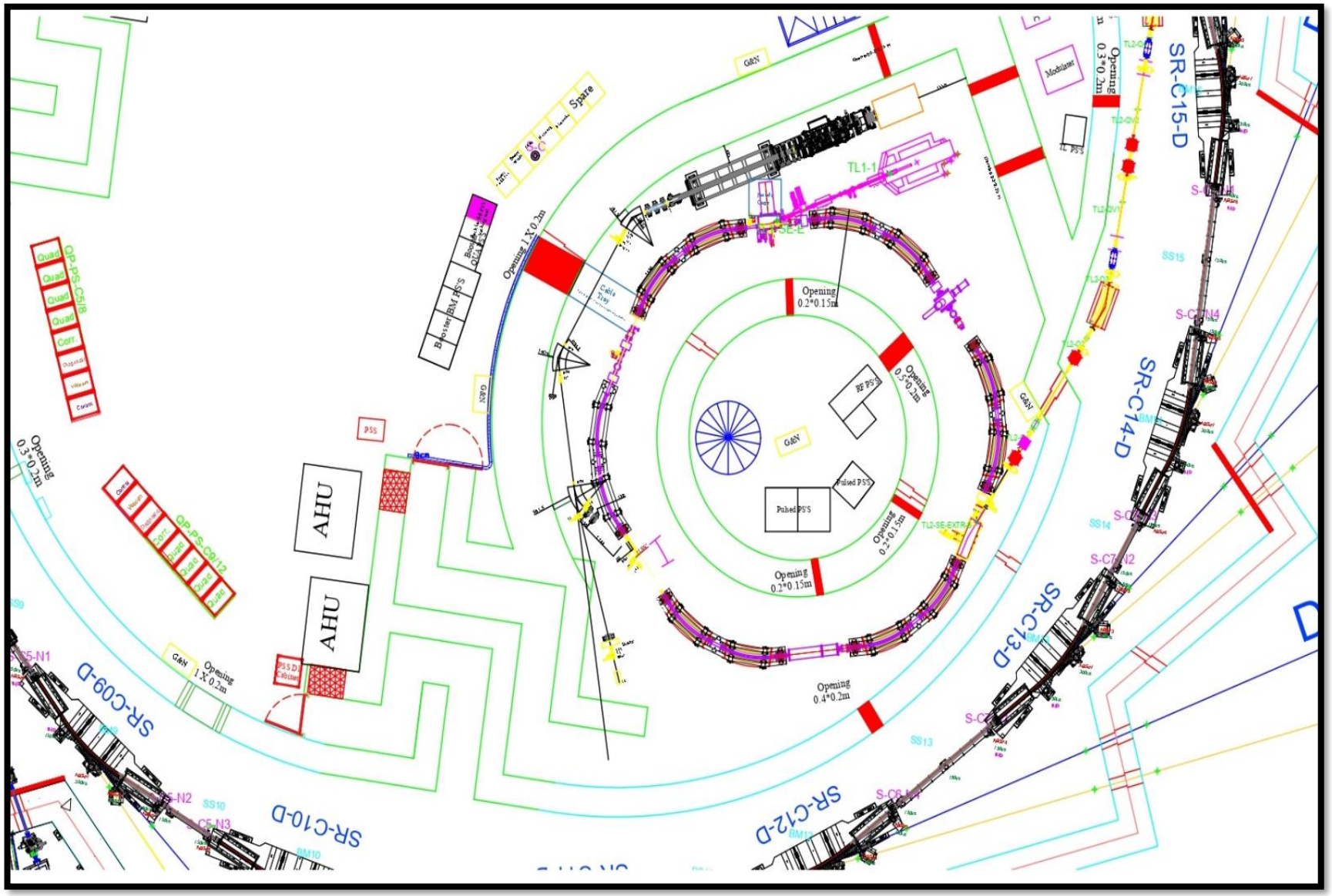
LINAC

Total length= 8.2m
Max. energy= **100MeV**

operation frequency up to **3Hz**

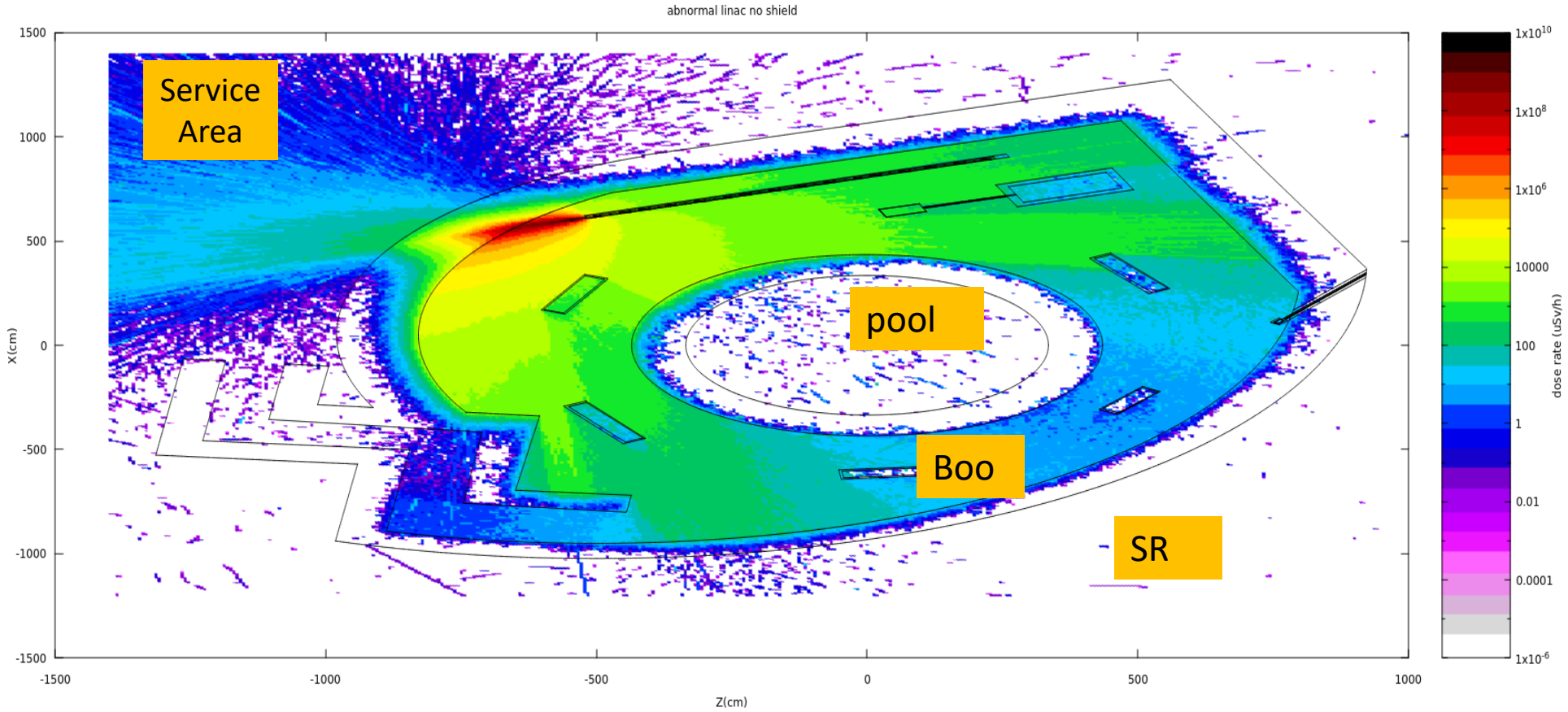
single bunch mode: length >= 1ns, charge up to 2nC

multi bunch mode: length up to 400ns, charge up to **4nC**.



Case1: Full continuous losses took place. No extra Shielding . (worst scenario)

full loss for the total current, in the case of failure of the bending magnet at the end of LINAC



Multi bunch mode ,3Hz

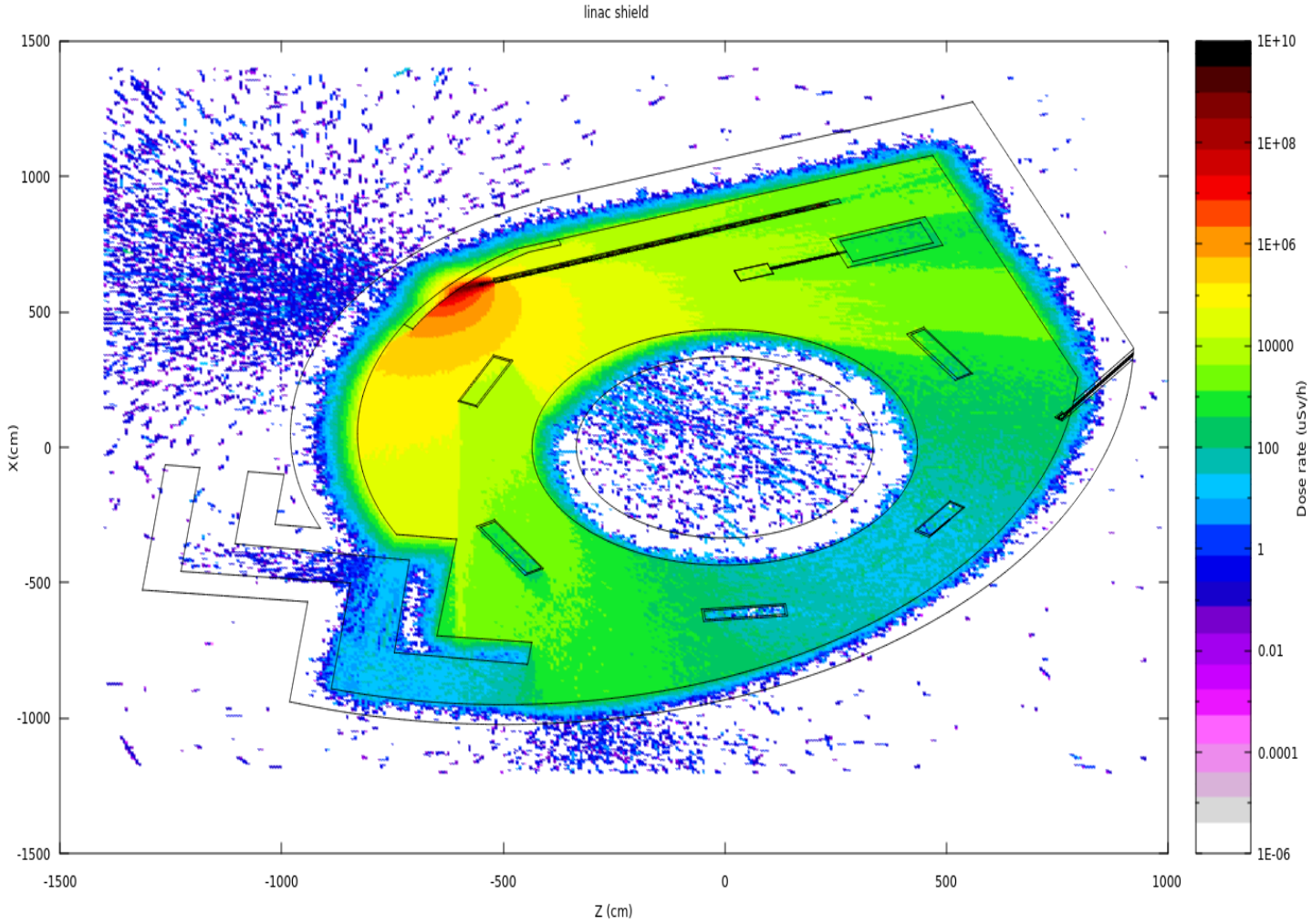
Ambient dose rates ≤**115μSv/h**

Case 2: adding 25cm of lead shielding attached to the inner booster wall and full continuous losses took place.

full loss for the total current, in the case of failure of the bending magnet at the end of LINAC

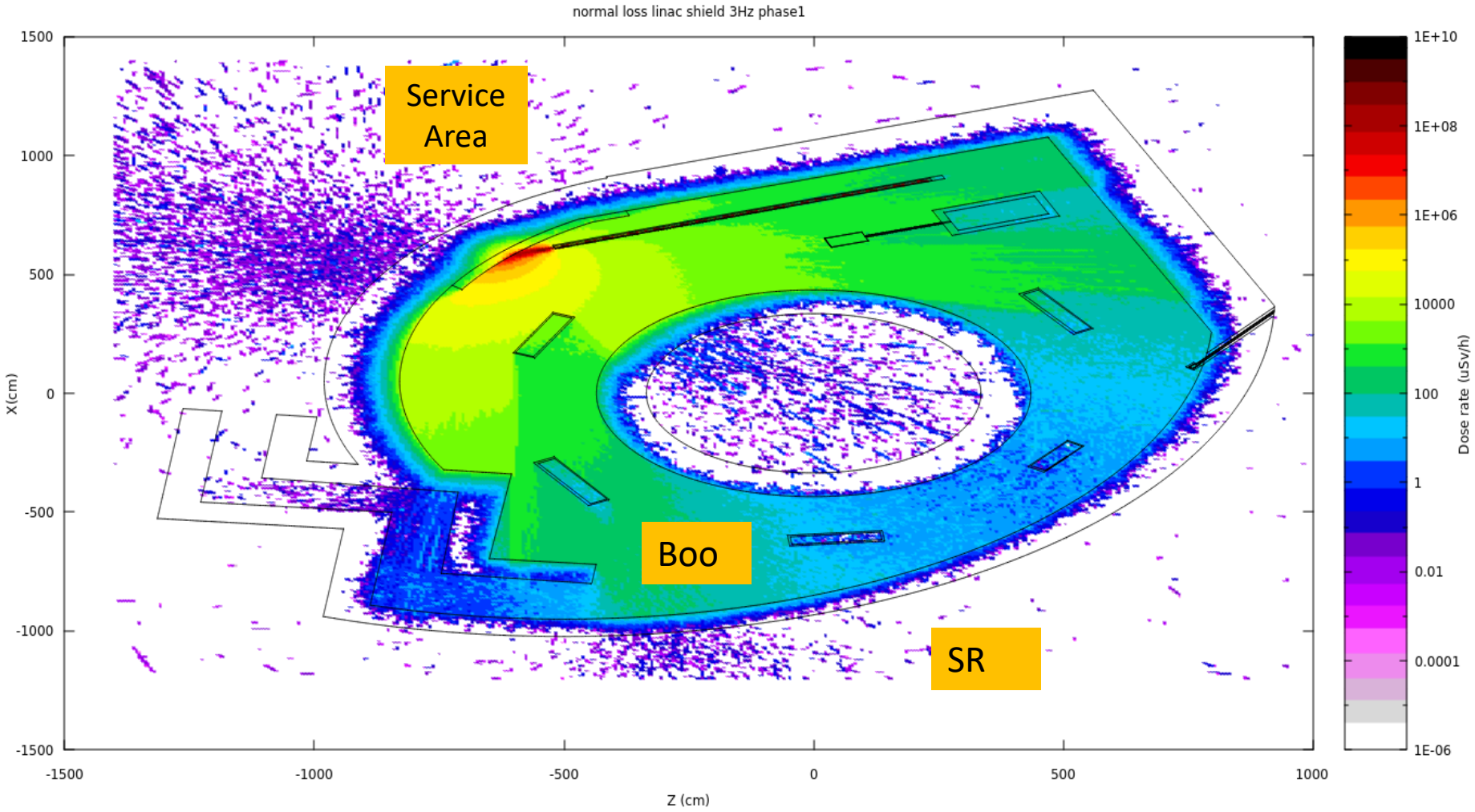
Multi bunch mode ,3Hz

ambient contact dose rates decreased to be less than **1μSv/h**



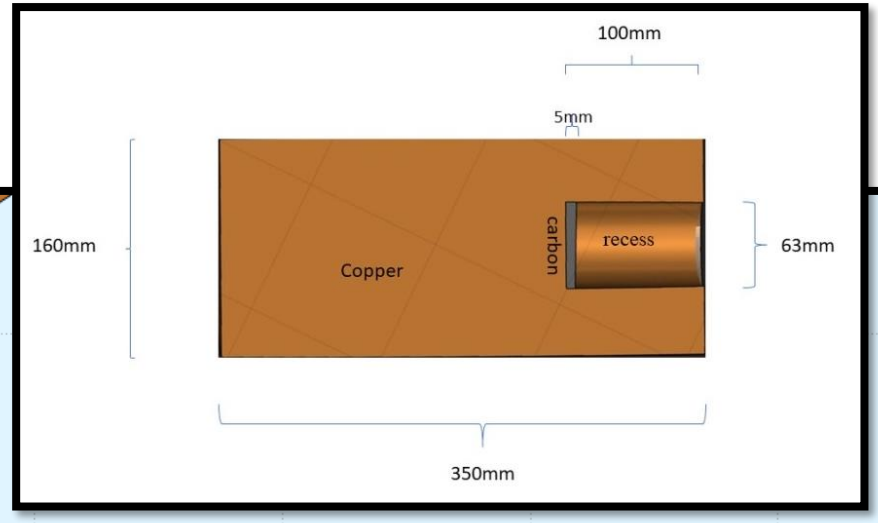
Case 3: adding 25cm of lead shielding attached to the inner booster wall and full continuous losses took place.

Normal loss of 25% of the current at the same point



ambient dose rates less than **0.25 µSv/h,**

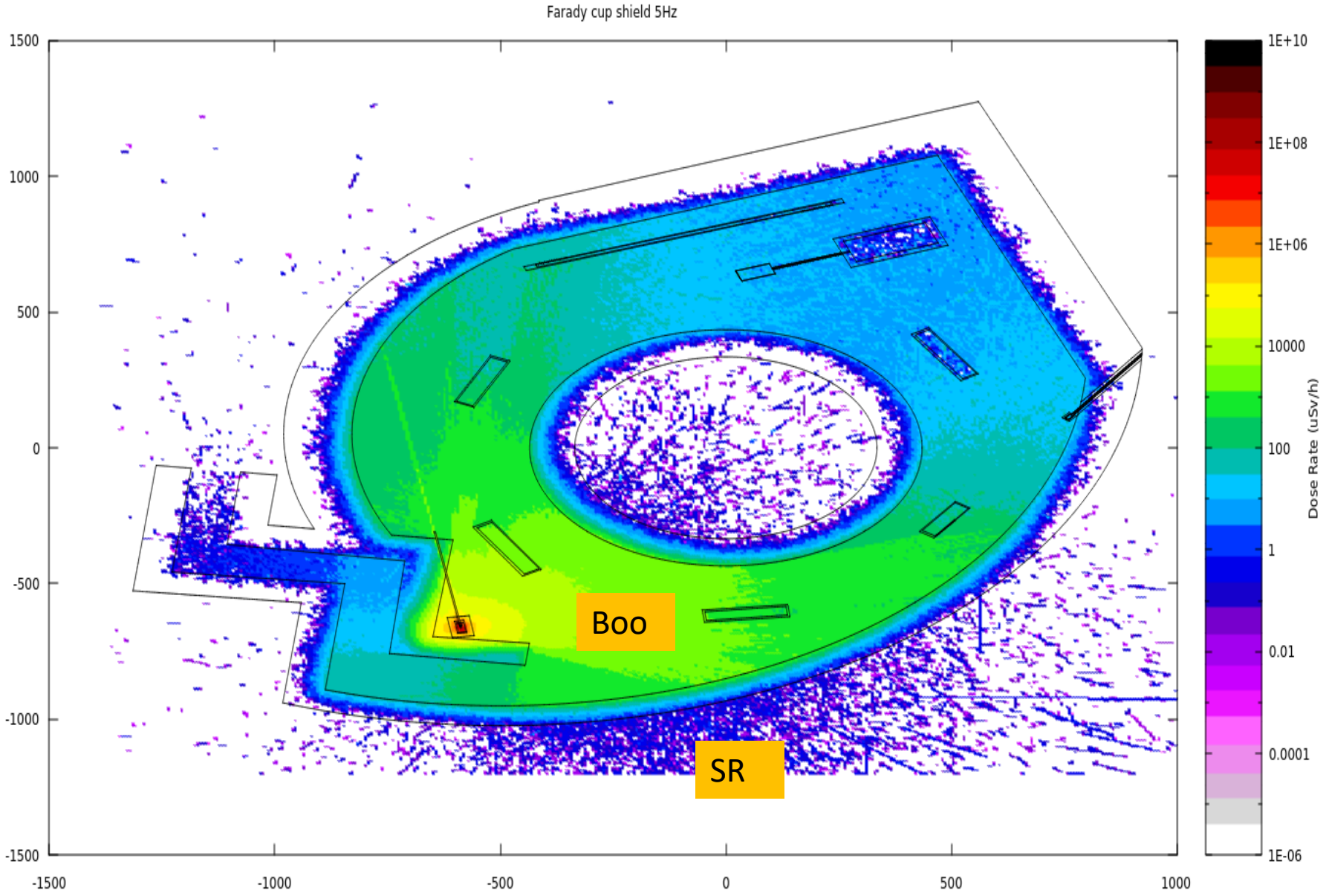
Case 4: Faraday cup



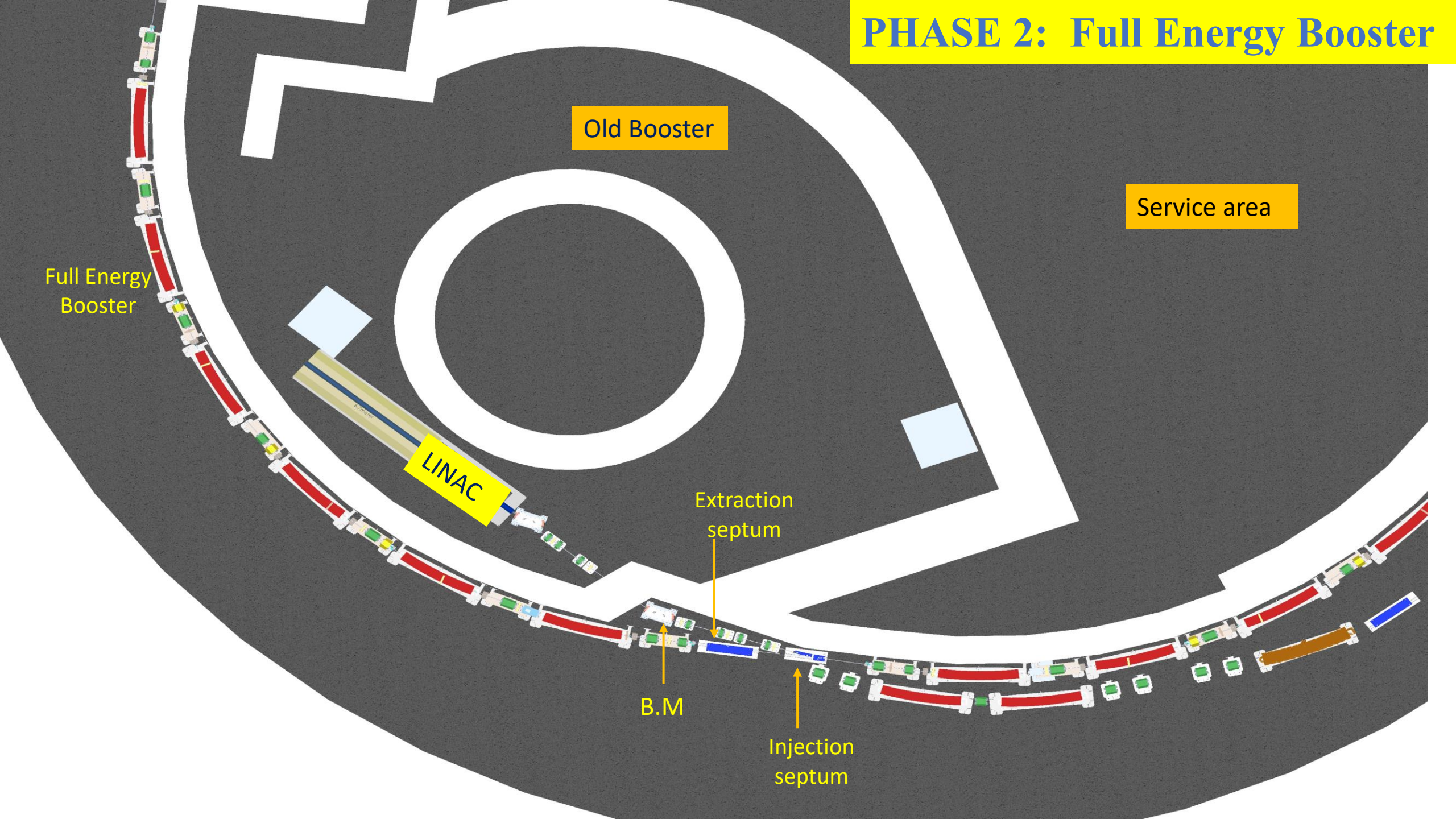
will be installed to dump the electrons coming from the Linac .

15 cm of lead was added around the faraday cup from all directions

Total ambient dose rates , **below 0.5µSv/h** in the direction of storage ring tunnel, keeping in mind the storage ring tunnel will be not accessible when the linac or if the booster in operation as well.



PHASE 2: Full Energy Booster



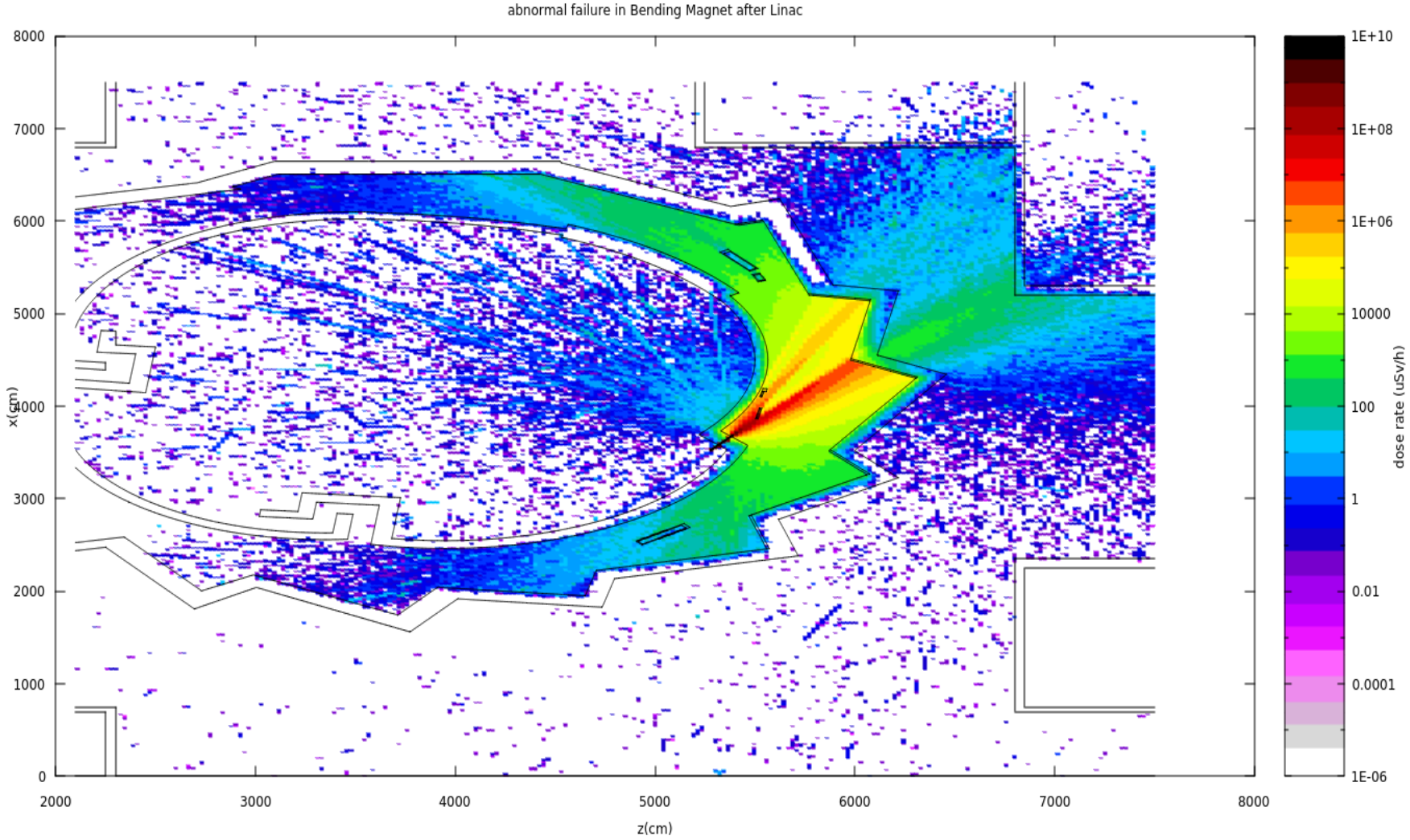
Scenario 1: Abnormal failure in Bending magnet after Linac in Storage Ring

E=100MeV
Multi bunch mode 400ns, 4nC

3Hz
Number of electrons= 75e9 /s (total loss)

assuming a full and continuous beam losses for one full hour

dose rates showed values below **350μSv/h**

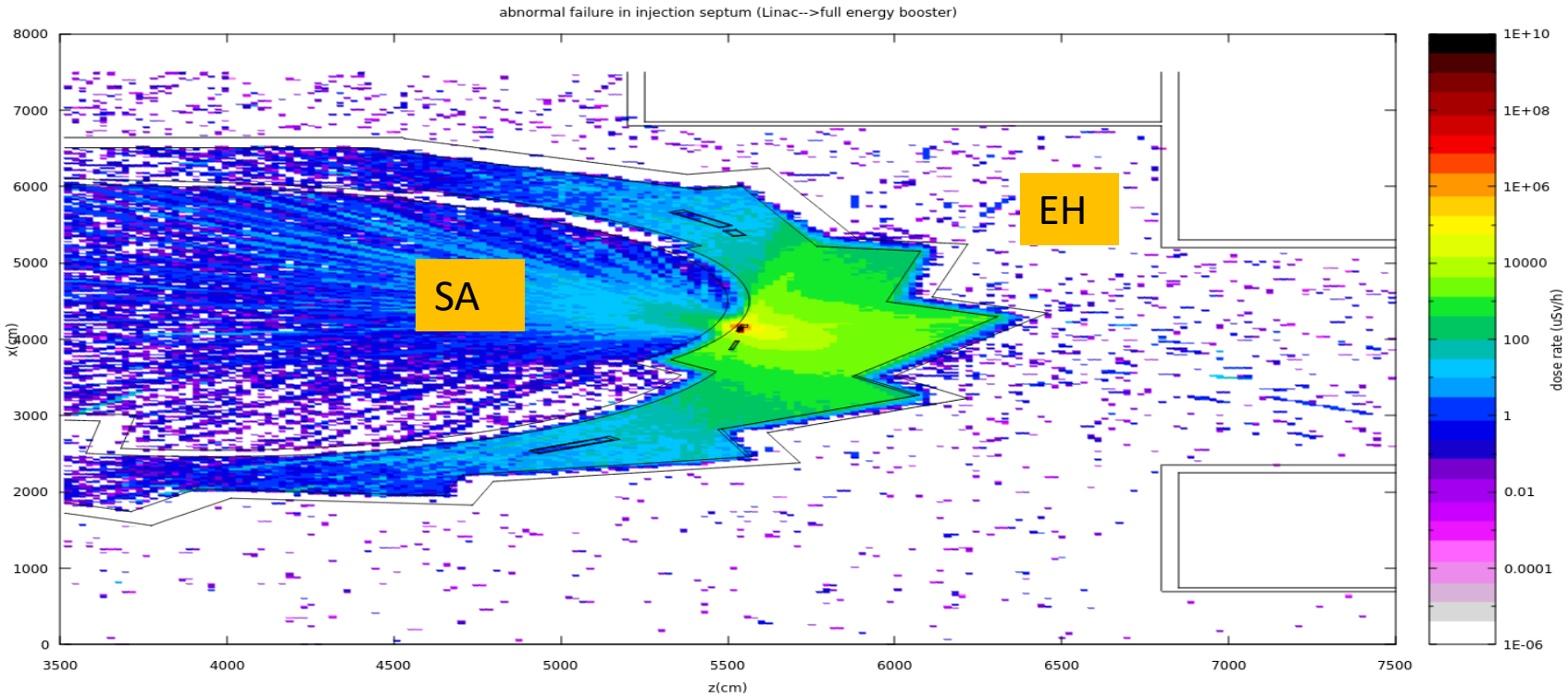


Scenario 2: Abnormal failure in injection septum (Linac to full energy booster) at the end of Linear to Booster

E=100MeV
Multi bunch mode 4nC

3Hz
Number of electrons= 75e9 /s (total loss)

assuming a full and continuous beam losses for one full hour



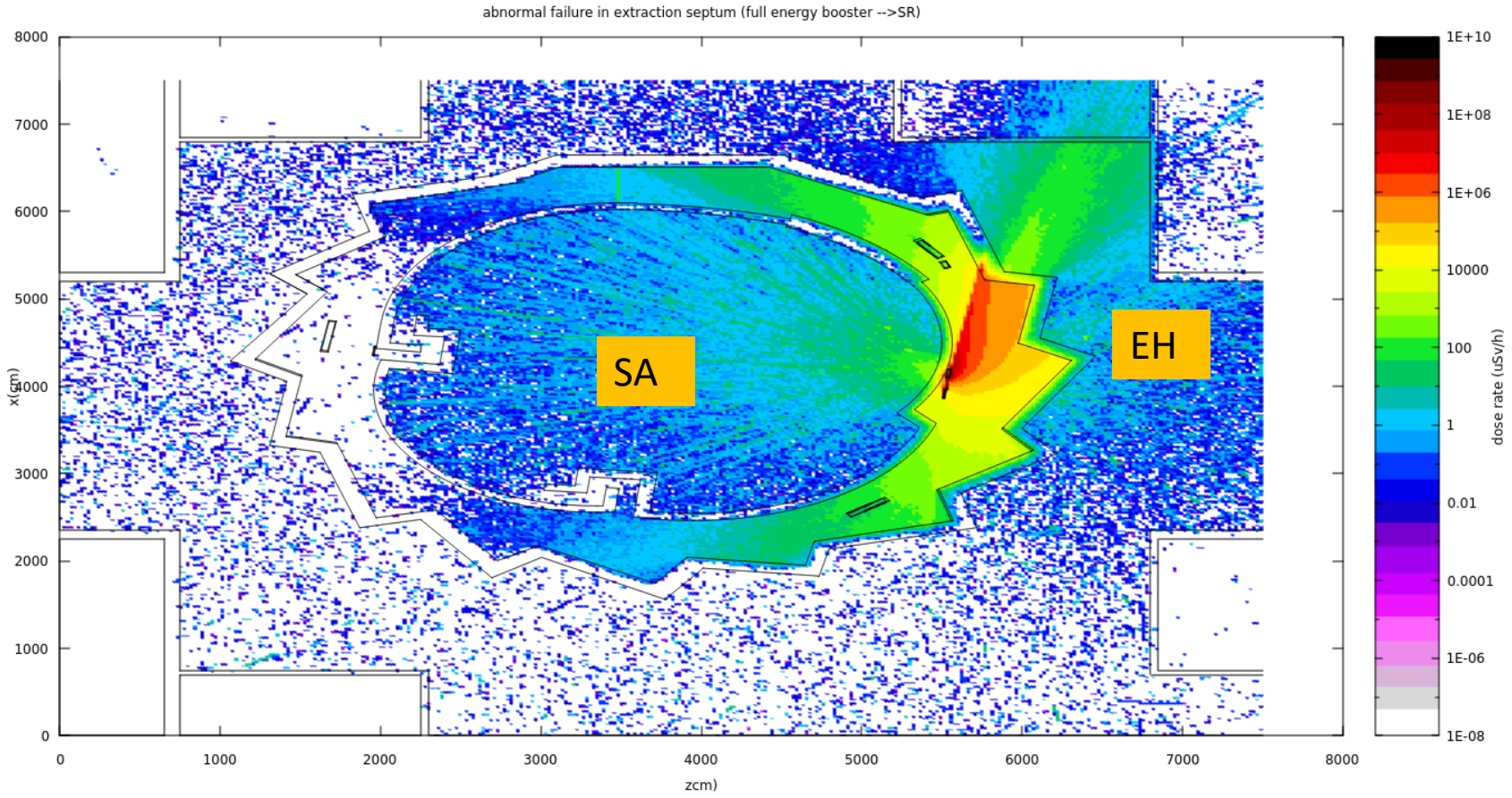
dose rates showed values below **350µSv/h**

in the direction of the service area

Scenario 3: Abnormal failure in extraction septum (full energy booster to SR)

E=2.5GeV
Max current 10mA
Loses current 10 mA

3Hz
Q=4nC
Number of electrons= 7.5e9 /s



assuming a full and continuous beam losses for one full hour

dose rates showed values below **370μSv/h**

the both directions of experimental hall and service area

the loss will take place in a short time

the cases will be controlled by the PSS.

High care will be taken to deal with these cases during the commissioning period of time.

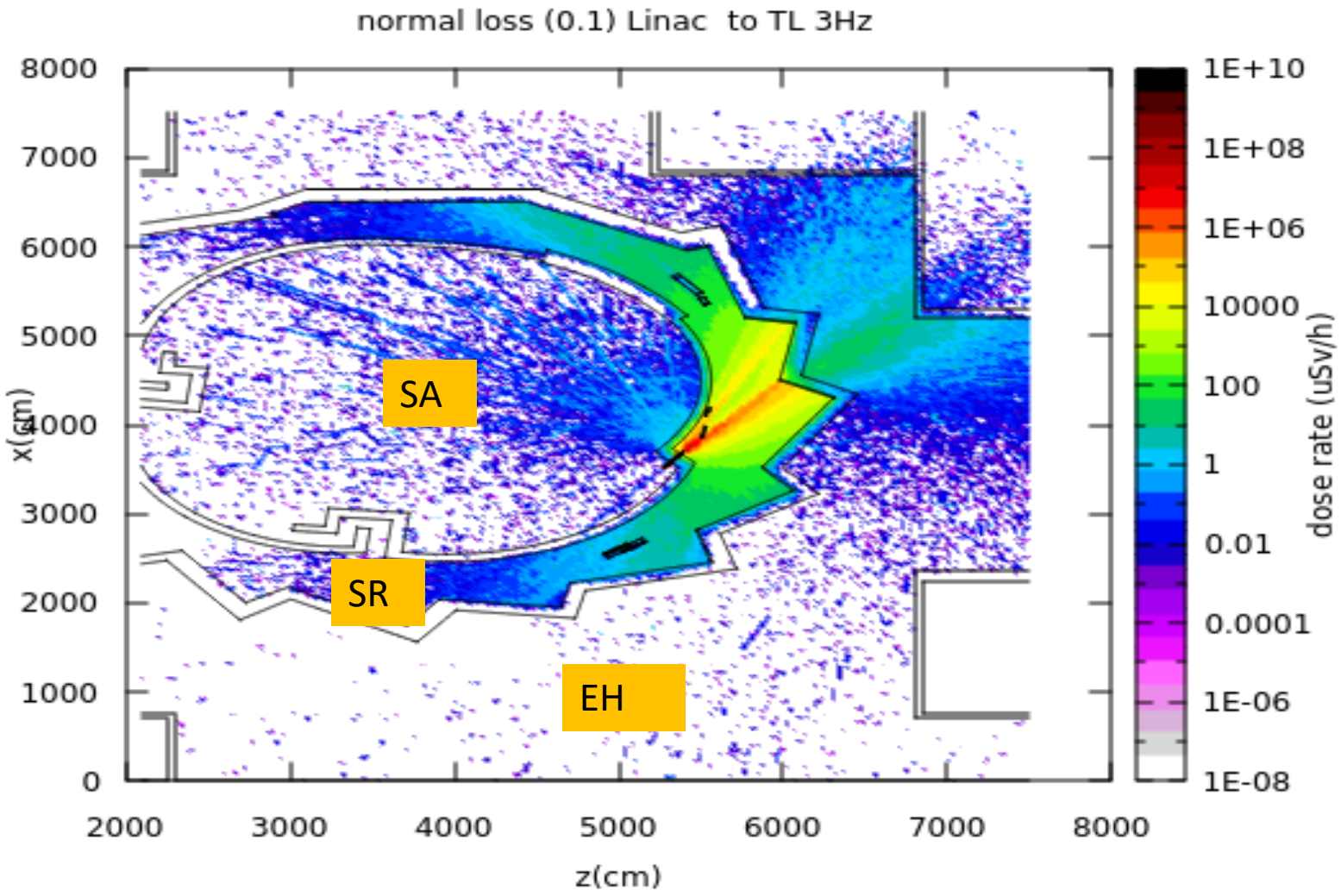
Extra localized shielding is expected and recommended even for a short time of injection.

Normal Beam Losses

Case1: linear to full energy booster loss

Expected **10%** loss fraction of electrons at 100MeV in the bending magnet directly after the Linac showed ambient dose rates below **35µSv/h** in the direction of experimental hall.

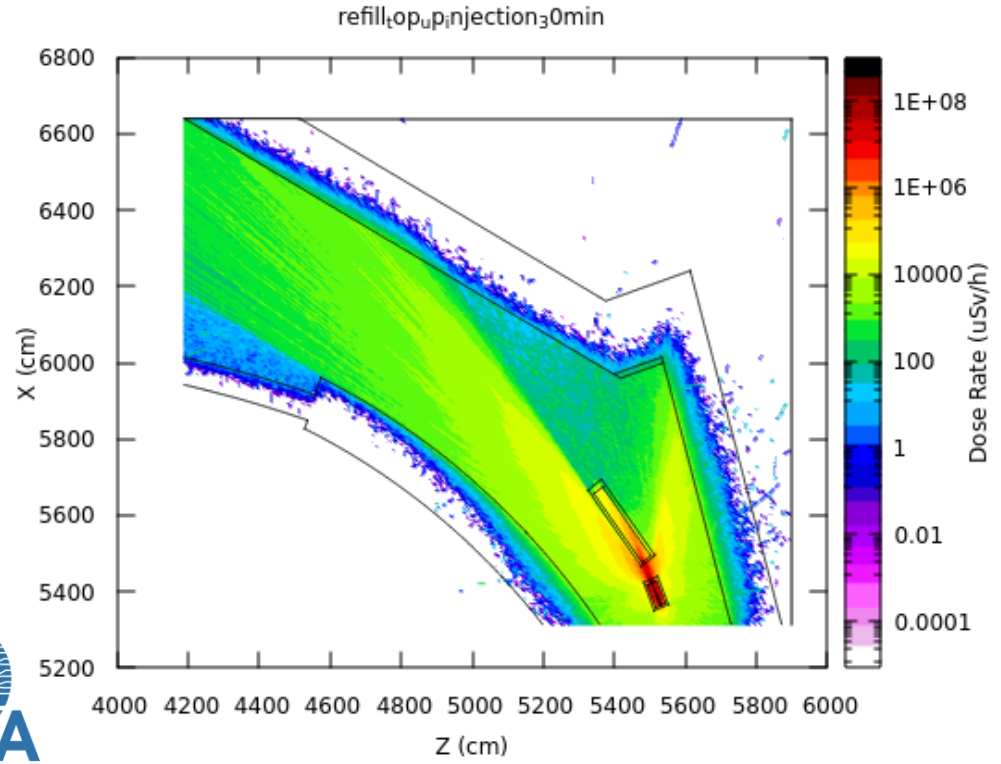
localized shielding is recommended due to this potential hotspot outside the ratchet wall to reduce the shift doses up to acceptable values.



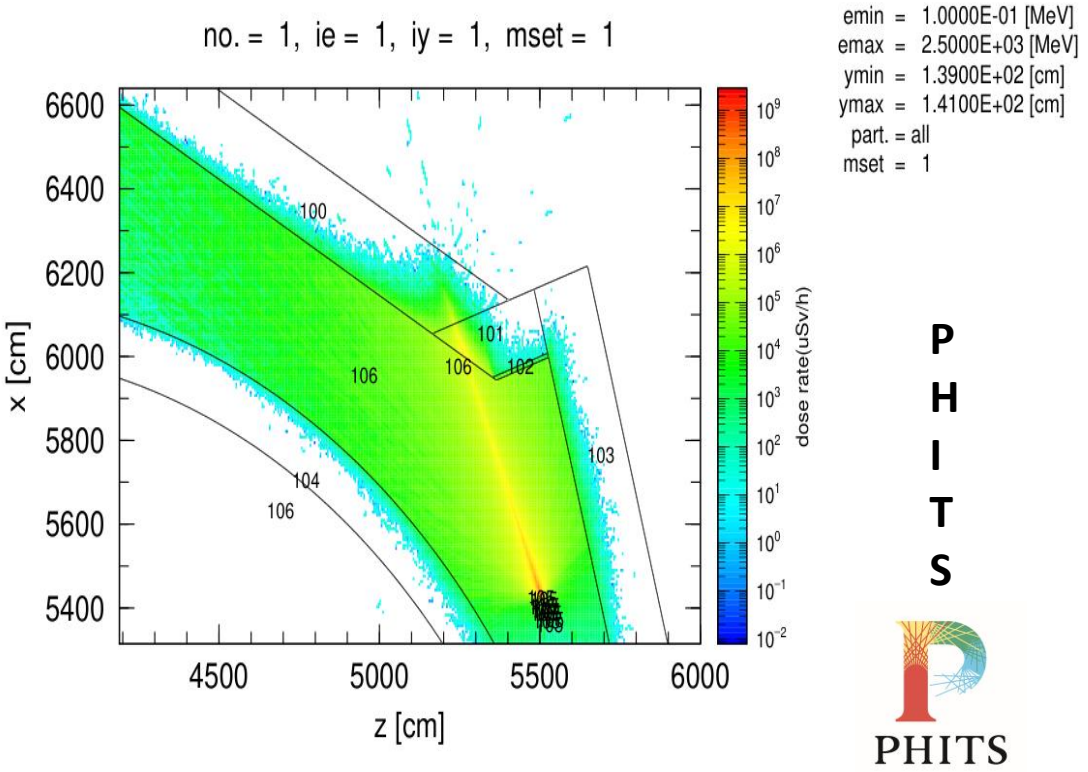
Case2: Losses at the injection septum of the Storage ring 2.5GeV during refill (top up mode).

During refill of 5mA (1.38e10 electrons)/10 seconds every 30 minutes from full energy booster into the storage ring.

FLUKA



PHITS



Less than **0.5µSv/h** outside the storage ring tunnel

Our goal to have total shift doses less than 2µSv/4h during full fill of 400mA after shutdowns, which are within our main radiation protection guideline at SESAME

A. Future work

More detailed modeling and optimization will be addressed for the following cases to finalize the safety case for upgraded SESAME operation:

- High dose rates areas outer the ratchet walls in the direction of experimental hall or for any accessible areas, however, extra local shielding is recommended due to potential hotspots.
- The dose rates on the roof, specially above the injection and extraction areas.
- More understanding of Injection and extractions efficiencies at different points across the 3 accelerators.
- Simulation of the new location of Faraday cup location for phase two.
- More concentrations on the losses at the injection septum of the Storage ring @2.5GeV

THANK YOU
FOR
YOUR ATTENTION

Notes

Advices

Questions