Technology Support & CFS Impact

This session will examine issues related to the tunnel and access-tunnel X-sections and input penetration layout. Is the generic tunnel layout including accessibility and safety now stable?

Radiation shielding and related issues (20 min.)

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Objective of this presentation

- Outline of radiation shielding design and related issues on KAMABOKO tunnel design

Direct radiations

Thickness of the separation wall

Design for special sections
- Personal passage way, Waveguide hole, penetrations, tune-up dumps, collimators, etc

Induced activities
Activity in air, water

Damage for devices, Operation and decommissioning

Procedure for design

(ex) Information requested to fix the wall thickness

Physics ⇔ Beam power/quality → Accelerator design → Beam loss

Construction site → Law and Regulation
BCS,PPS, Operation mode → Safety Design and failure scenario

Separation wall thickness ⇔ Tunnel structure ⇦ We are here!

Need approved document to move to the next layer, otherwise the layer becomes fantasy. What items do we have now?

Required parameters (1)

The following parameters are required to determine the wall thickness. If we don't have any approved document about the parameters, most pessimistic scenario should be taken

- Beam power

  Maximum power among 200-500GeV baseline parameters (TDR Volume3 part II, Table 2.1), since tunnel upgrade is impossible.

  → 1TeV CM, 4Hz, 1.74e20 electrons, 2450 bunches = 13.64MW
  [2.6 times more than 500 GeV CM energy baseline]
  (18MW for RDR)

  CFS can provide design guideline

Required parameters (2)

- Operation hours per year
  No information, continuous operation is assumed
  Up to 6000 hours for KEK electron accelerator, for example.

- Beam loss rate and scenario (Failure process and rate)
  Few information on beam loss are available
  (ex)TDR Volume3, part I Section 3.2 gives FLASH 9mA operation
  (ex)TESLA TDR suggests 0.1 W/m uniform loss
  → 1 W/m uniform loss is assumed (as the worst case assumption).

  Someone says, “Serious beam loss induces quench, thus beam operation must be stopped immediately”

Required parameters (3)

- Target properties (Material, thickness, installation status)
  Device potentially hit by beam
  Nb cavity, spoiler and collimators, ceramics beam profile monitors, gate valve. Most of them are not designed yet.
  → 20 X_0 long, 1 X_0 rad. Cu target.

- Beam line position (Distance from beam line to the wall)
  CFS can provide. 1.5m away from the wall

- Material composition and density of the wall
  Quality control is required if we adopt concrete with density higher than 2.1 gcc.
  Currently 2.3 gcc is used

Required parameters (4)

- Beam operation and service tunnel access mode

  Full time operation with regardless of service tunnel occupancy

  Limited access during full power operation instead of above.

- Fence out area of the service tunnel

  Area close to waveguide penetration could be fenced out

Required parameters (5)

- Law and regulation should be obeyed
  In RDR, most tight regulation was chosen among large facilities, DESY, SLAC, Fermilab and KEK.

  SLAC rule (RSS by SLAC)
    250 mSv/h, 30 mSv per event, for system failure(18MW point loss = maximum credible)
    5 mSv/h for mis-steering situation
    5 μSv/h for normal operation (1W/m line loss)

It must be replaced to Japanese rule, 20 mSv/year, if someone provide failure rate per year and total amount of beam loss for the failure. Normally, this kind of consideration is not required since normal loss is set to be percent of maximum beam power.

Required parameters (6)

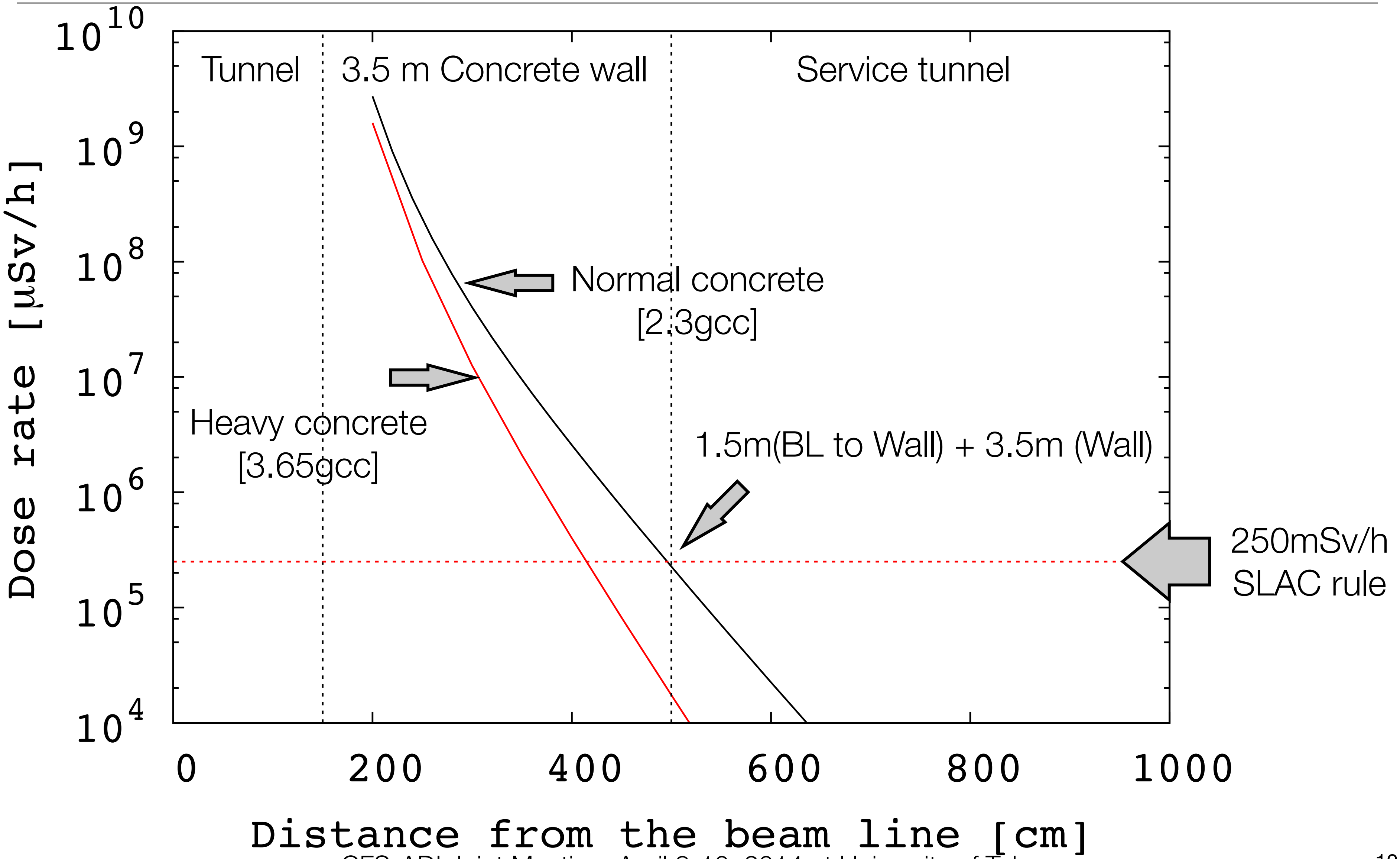
- BCS and PPS

  It must help to reduce maximum credible loss if we have robust and reliable system to prevent beam operation during failure.
  It should be passive, and, two or more active devices for keeping redundancy.

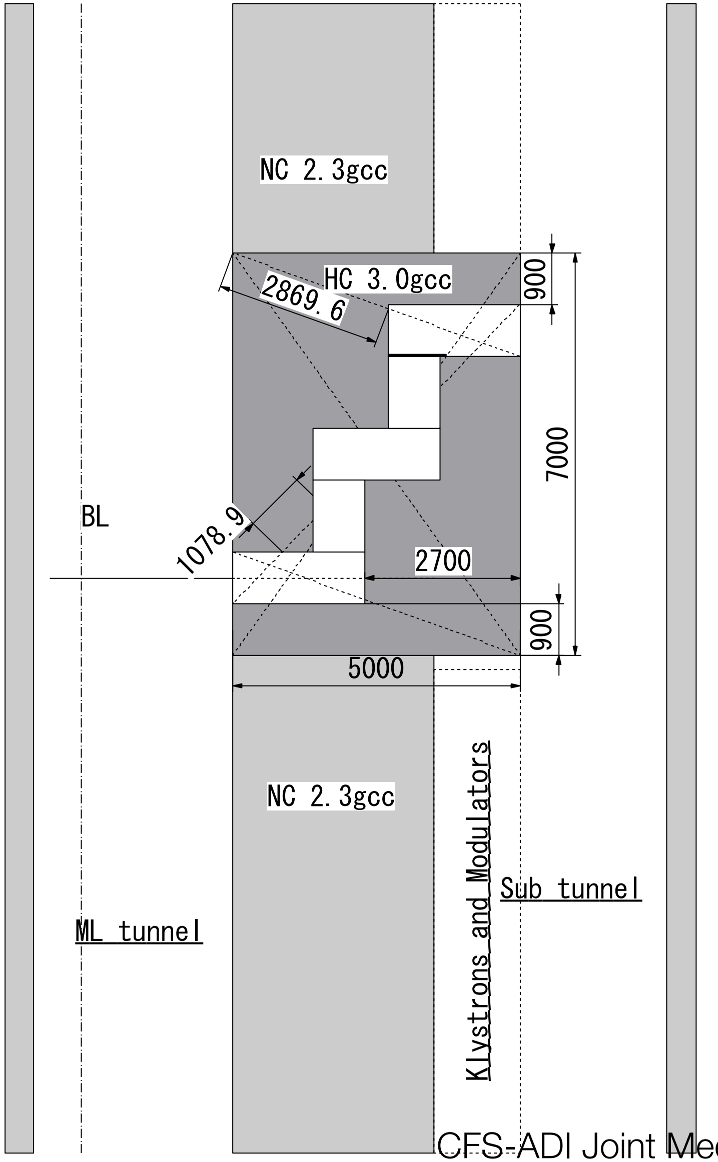
  <u>Currently, no special BCS and PPS for this purpose</u>

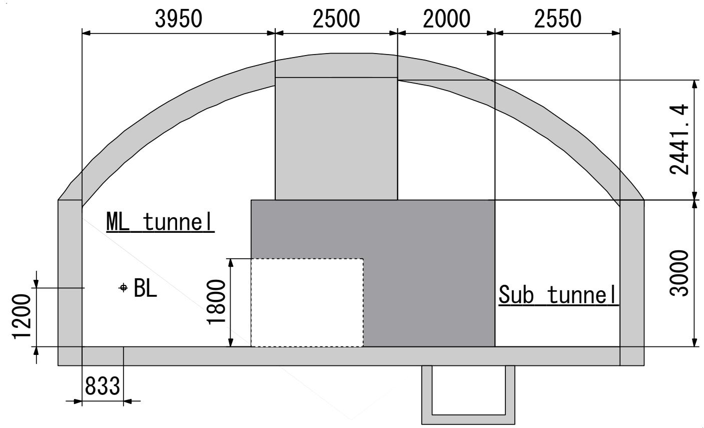
With the above <u>underlined parameters and assumptions</u>, thickness of the wall can be deduced using empirical equation.

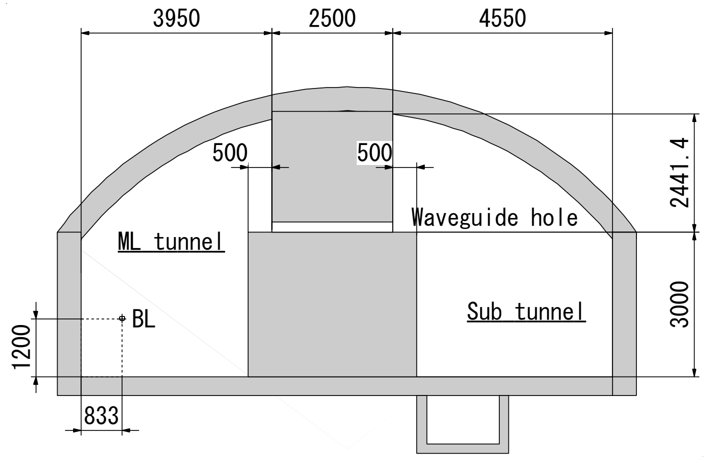
500GeV, 18 MW beam on Cu 20 X_0 target



Shielding design for 3.5 m wall with personal passage way and waveguide penetration



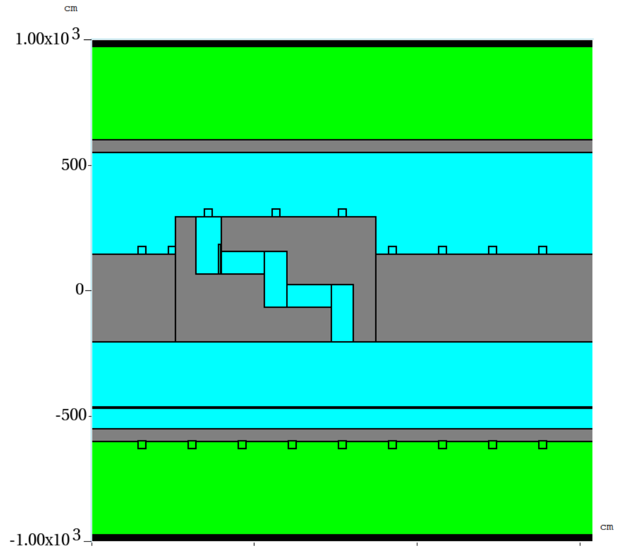


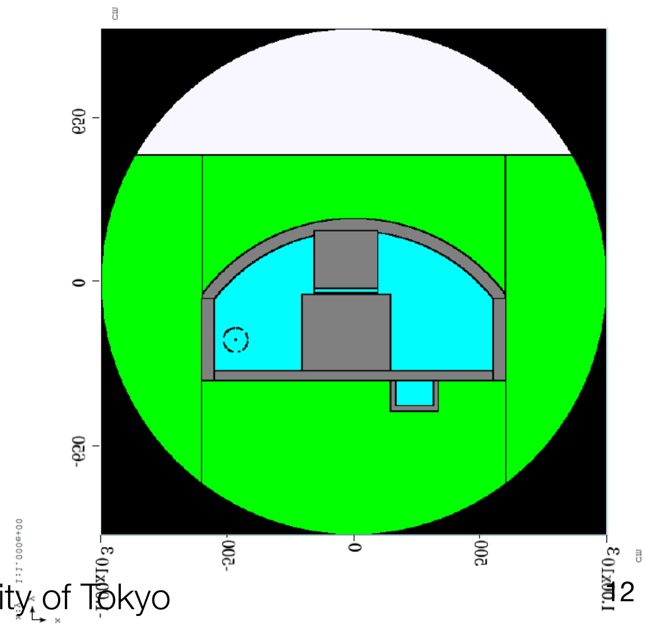


- Heavy concrete and different thickness(equal to moderators) for personal passage way
- Thinner wall above accessible area for pipes and utilities

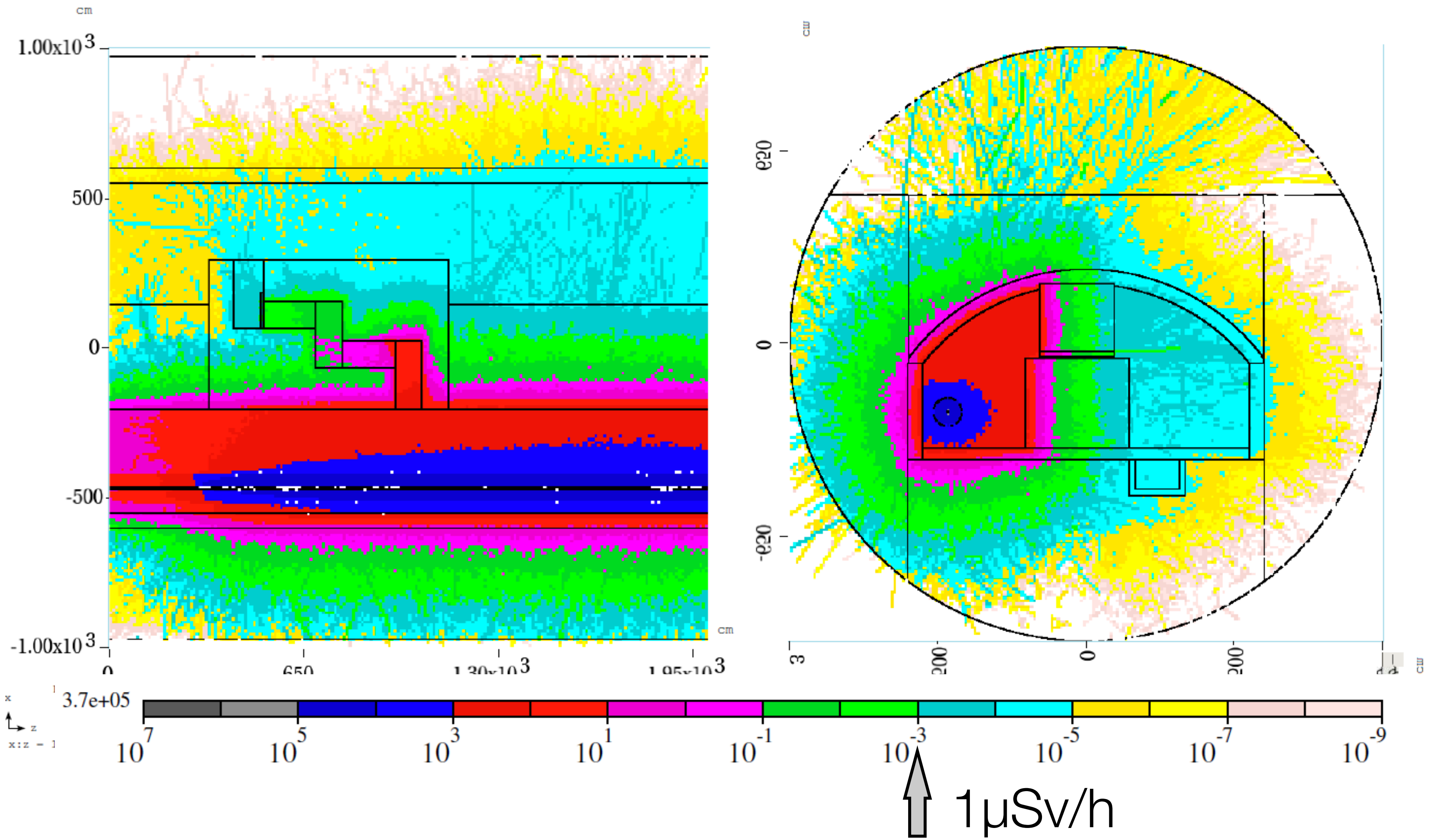
Model for Mote-Carlo simulation

- Geometry including personal passage way, waveguide hole was developed for Monte-Carlo simulation
- MARS code developed at Fermilab was used
  - 1 W/m uniform beam loss on stainless steel pipe with 1 mrad grazing angle was assumed
  - Neutron threshold was down to thermal energy with evaluated cross section data.

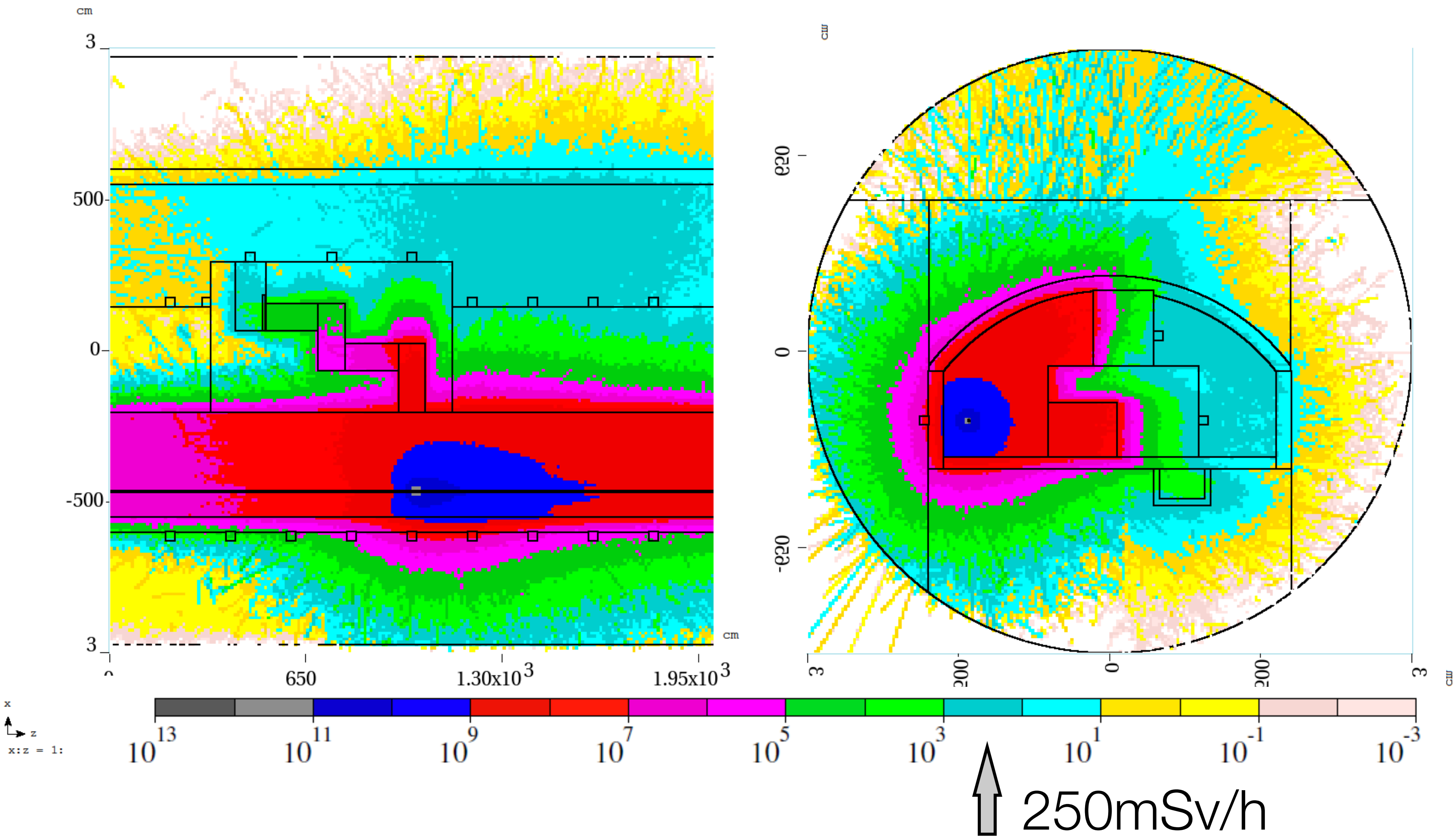




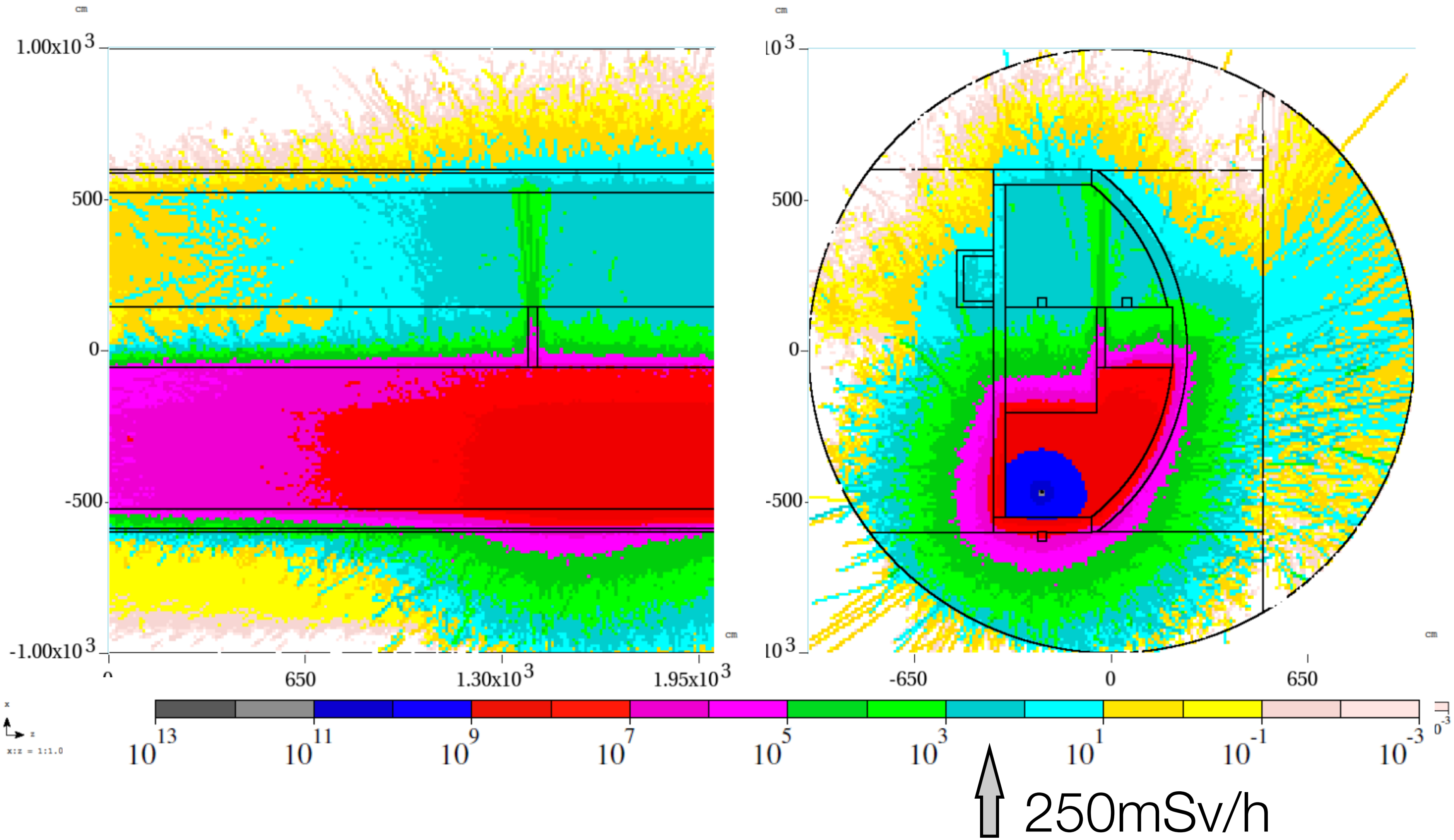
Dose rate for 1 W/m line loss



Dose rate for 18MW point loss in front of the personal passage way entrance



Dose rate for 18MW point loss in front of the waveguide penetration



Induced activity in air

- Beam loss : 1 W/m (as the worst case)
- Ventilation : 5000m long unit, replace the entire air in the unit within 3 hours
- Tunnel structure : Volume, Surface area.
- Parameters : Swanson, fraction of deposited energy (1%), average path length of photons (2m), Neutron flux, cooling time

- Production rate of radioactivity, ^{3}H, ^{7}Be, ^{11}C, ^{13}N, ^{15}O, ^{38}Cl, ^{39}Cl, ^{40}Ar, are evaluated to be less than legal limit of exhaust air, however the production should be as low as reasonably achievable

Induced activity in water

- Beam loss : 1 W/m (as the worst case)
- Amount of cooling water in ML section : two 2-inch-diameter (too small), 5000m-long, water channels
- Parameters : Swanson, fraction of deposited energy (0.2%), cooling time
- Production rate of radioactivity, ^{3}H, ^{7}Be, ^{11}C, ^{13}N, ^{15}O, are evaluated to be less than legal limit of drainage water, however circulation route should be determined with considering in case of leakage and dose rate around the pipe.

Remaining items should be addressed

List of issues from radiation safety viewpoint

- Beam loss : Primary important parameter
  - Approved value is required for further design
  - Information from existing and future accelerators, TESLA, STF, ATF, LCLS-II
  - Many consideration for designing and operation phase, dark current, beam loss scenario, quench, monitoring device, Interlock system and access mode, treatment of liquid helium

Remaining items should be addressed

- Tunnel and Buildings
  - Isolation of high radiation areas, dump, collimator, positron production target
  - Connection part to access tunnel
  - Definition of site boundary
  - Amount and treatment of spring water
  - Impact on environment
  - Effect from muon

Conclusion

- Radiation safety design is ongoing with pessimistic assumptions.
  - The assumptions should be replaced approved values based on information on existing and future machines.
  - First draft of total radiation safety design for entire facility will be required soon, for CFS basic planning, thus go through entire accelerator structure to find issues should be addressed before fixing CFS design
  - Basic planning → Basic design (Revision) →Detailed design (Modification)
  - Experience and knowledge of shielding design and radiation control operational work in other lab. is required.