Neutrino target station at JPARC

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Contents

- Introduction
- Radiation (detail: talked by Oyama)
- Support system & maintenance
- Cooling system
- Schedule

Neutrino beam line and target

Target

- Carbon target: 30mm-ϕ,900mm-L
- beam size: σ_r ~6mm

0.75MW beam

1st Horn **2nd Horn** **3rd Horn**

Fast-extracted proton beam line

Target Station

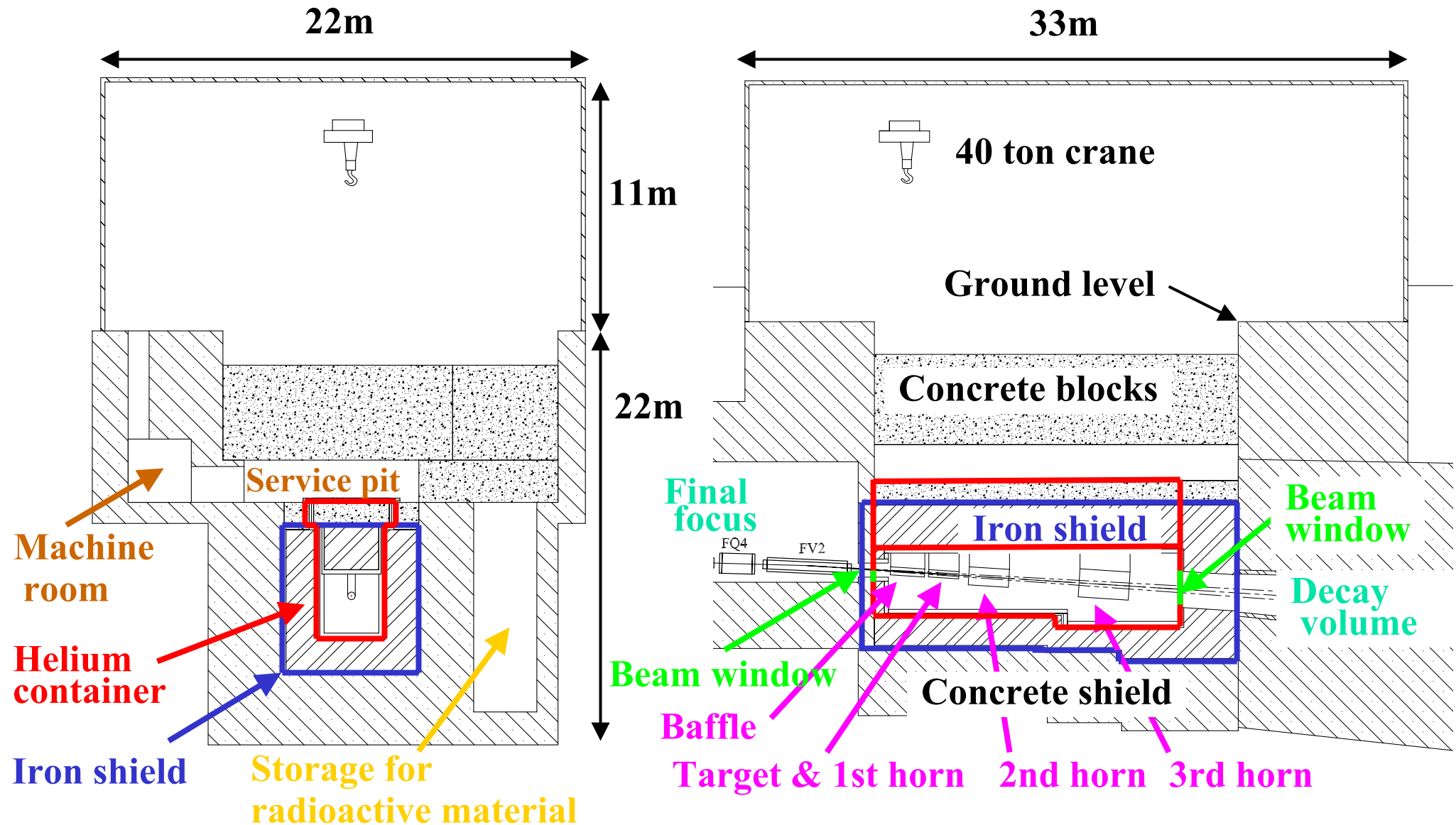
Decay volume

Beam dump

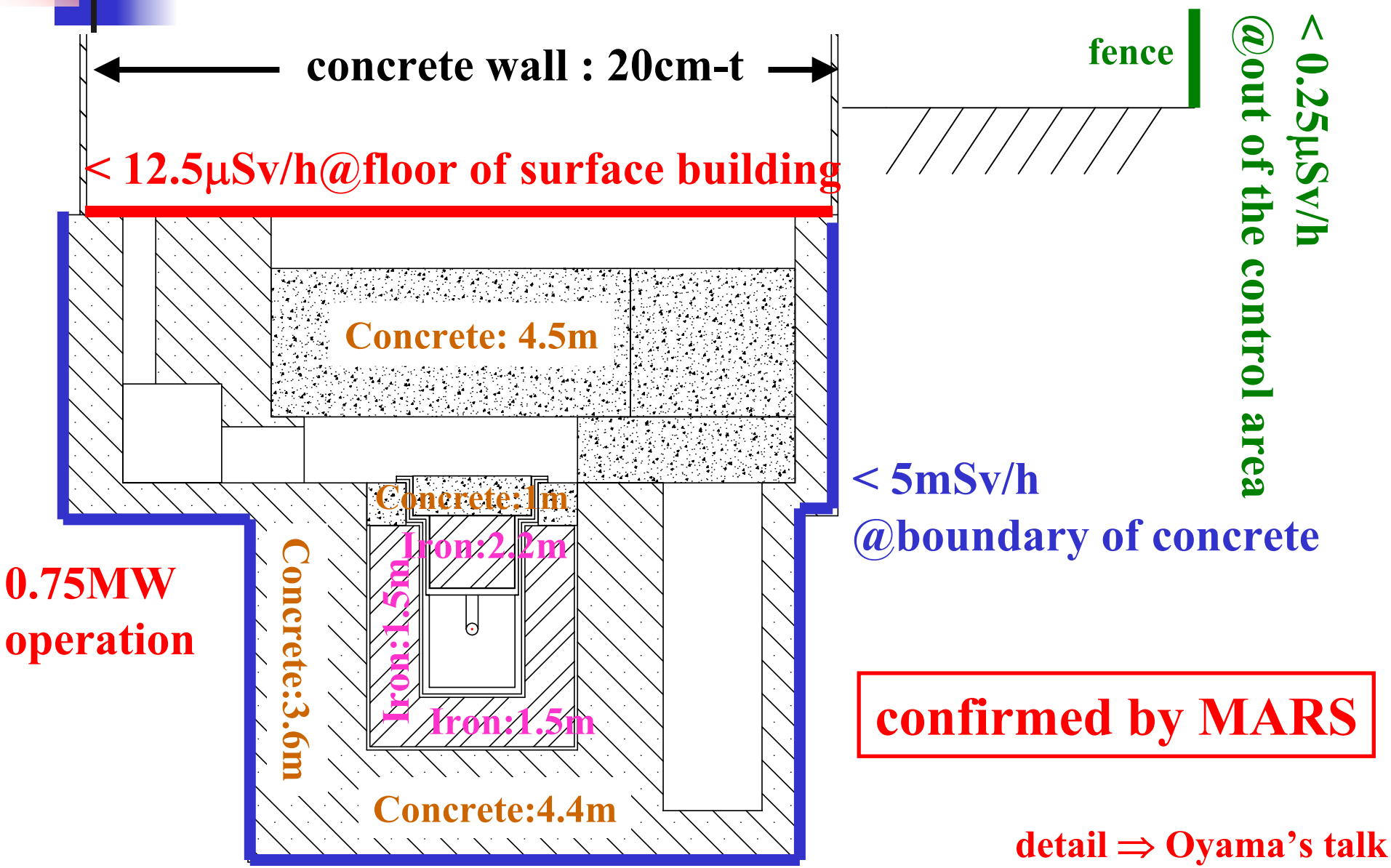
50GeV PS

ν beam to SK

Neutrino target station



Shielding and radiation level

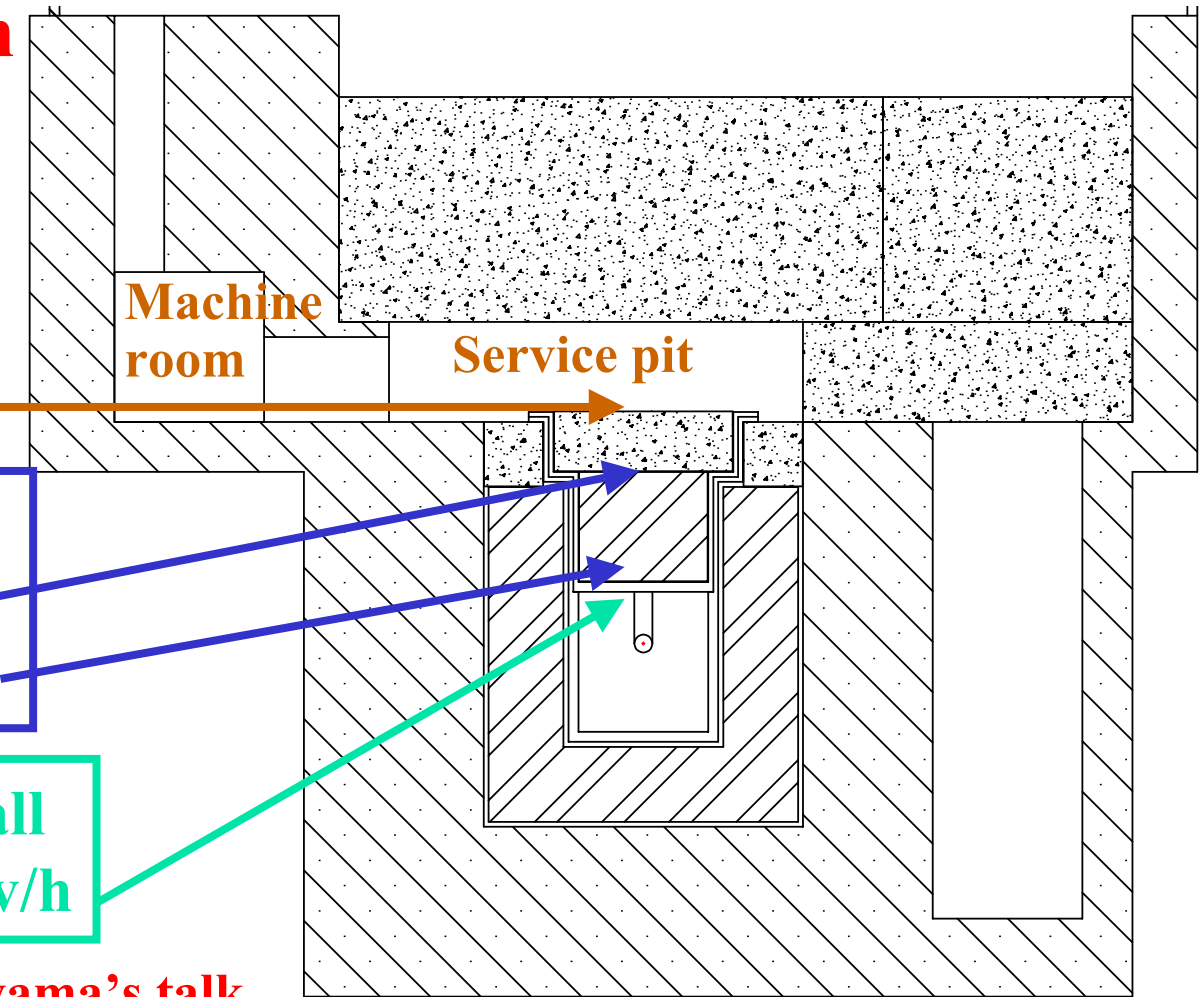


confirmed by MARS

detail ⇒ Oyama's talk

Residual dose

One (seven) day cooling after one year operation (by MARS)



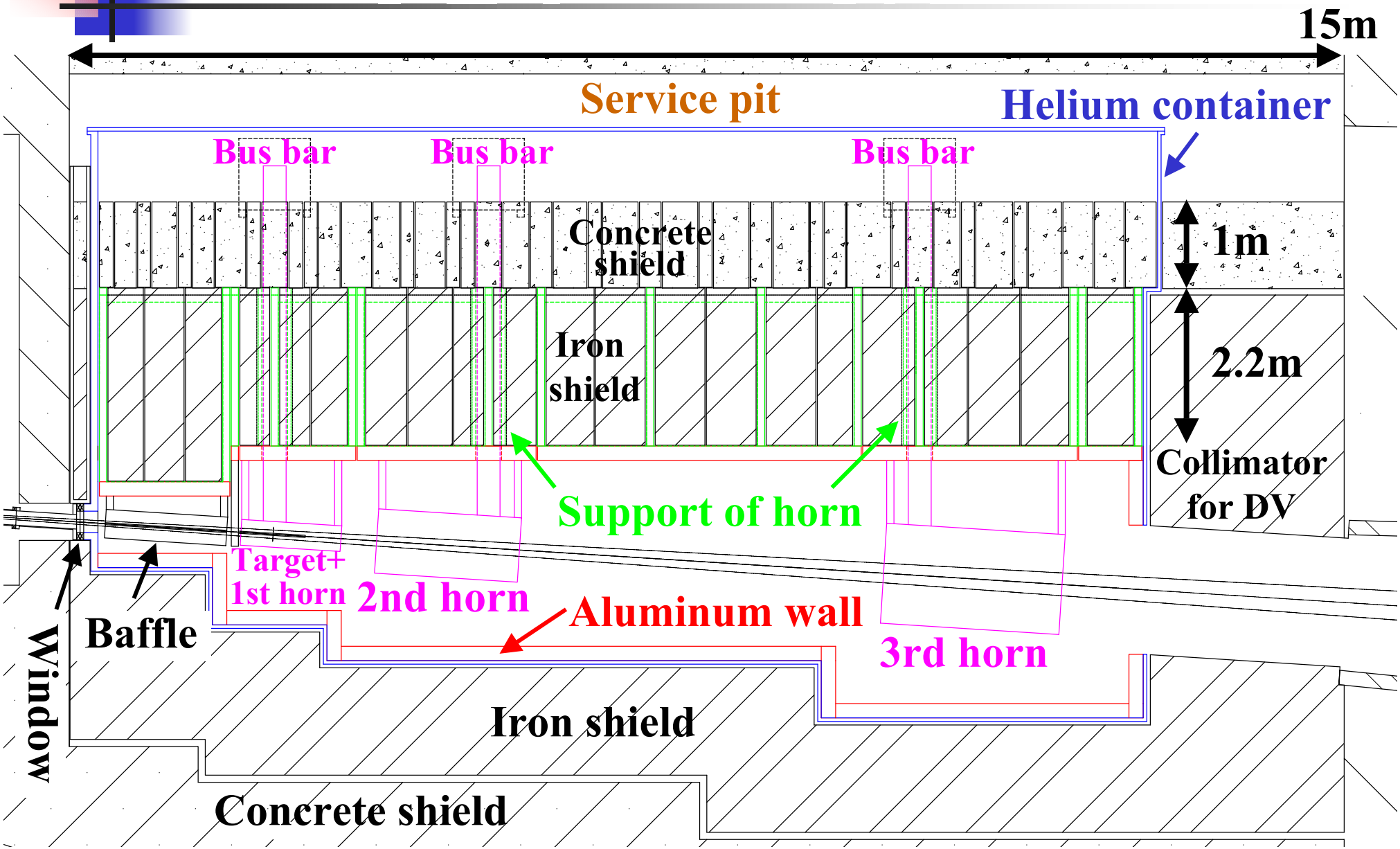
Floor of service pit
~0.1(0.07) μSv/h

Upper iron shield
Outer : 22(16) μSv/h
Inner : 0.56(0.42) Sv/h

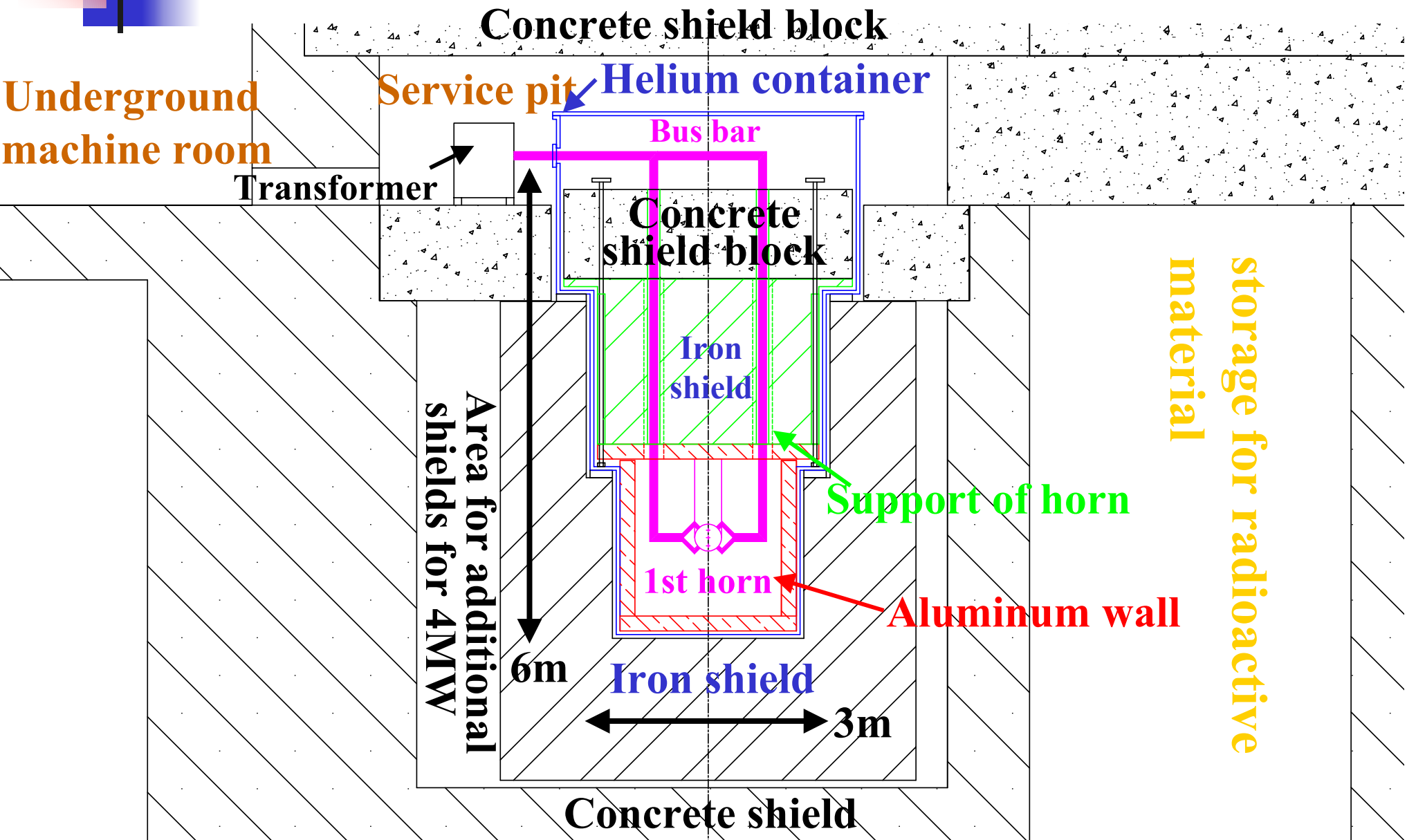
Aluminum wall
~0.65(0.17) Sv/h

detail ⇒ Oyama's talk

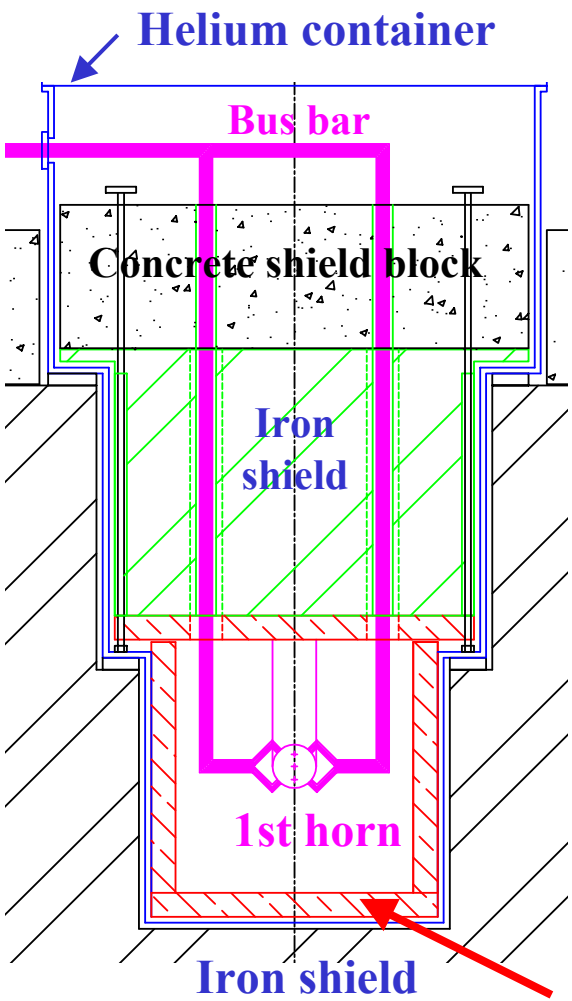
Side view of target area



Front view of target area

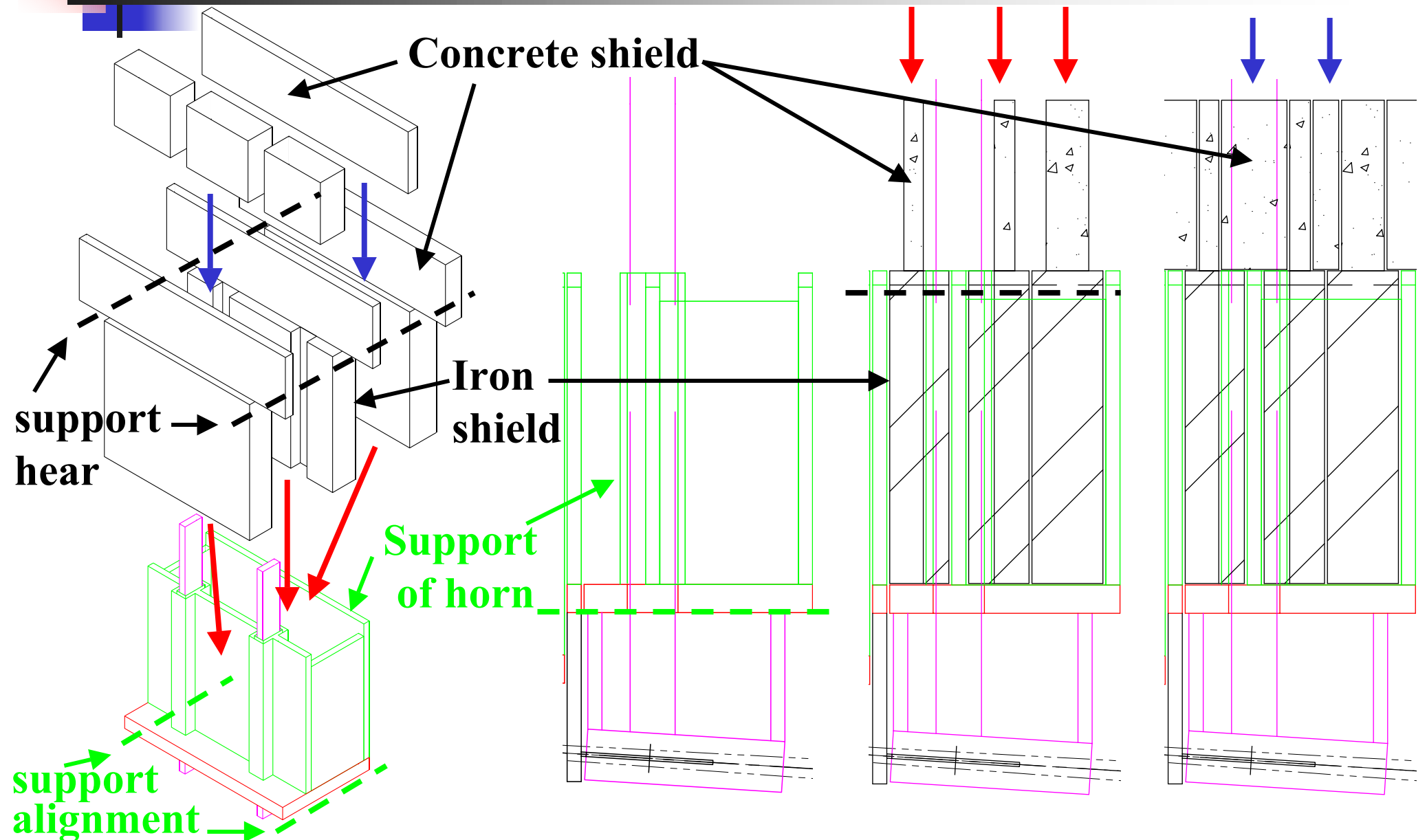


Helium container



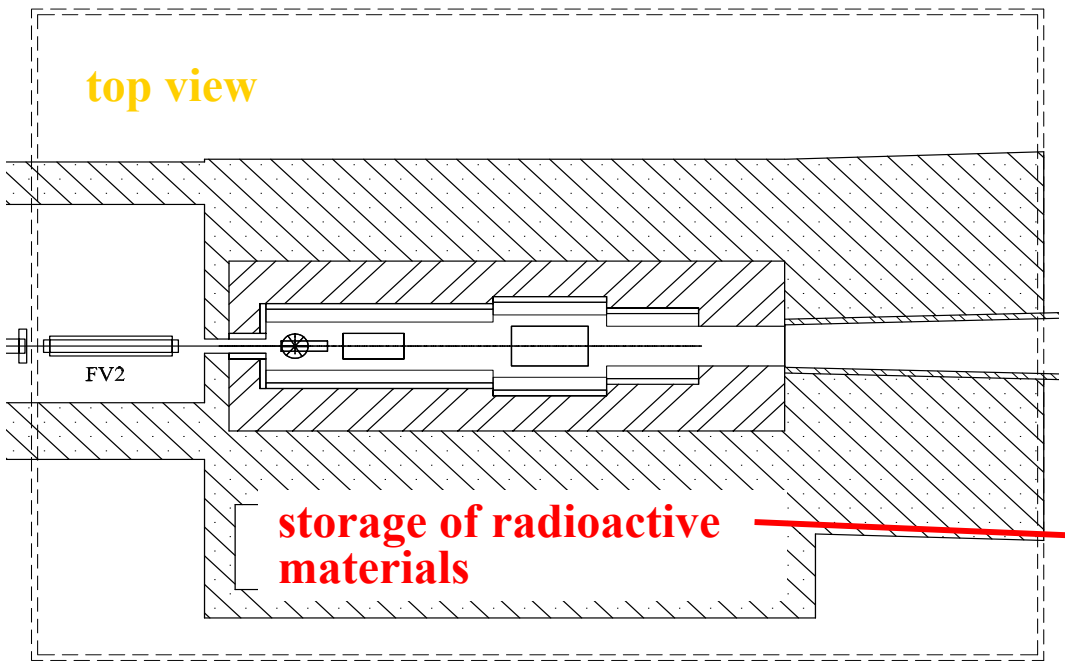
- 3m(W)×6m(H)×15m(L), 5cm-thick iron wall
- Filled by Helium gas (1-atm, 130m^3, ~99%)
- Reduce Tritium production : ~1/25?
  - σ~30mb for Air, σ~1.2mb for He
  - Tritium production after 200 days operation:
    Air:800Bq/cm^3, He:30Bq/cm^3
  - Ventilation time after 200 days operation
    Air:110days, He:5days
    (ventilation: 8000m^3/hour, regulation:5mBq/cm^3)
- Reduce corrosion by NOx : ~1/100?
- 20cm thick Aluminum wall in target area
  reduce surface dose by ~1/10 at maintenance

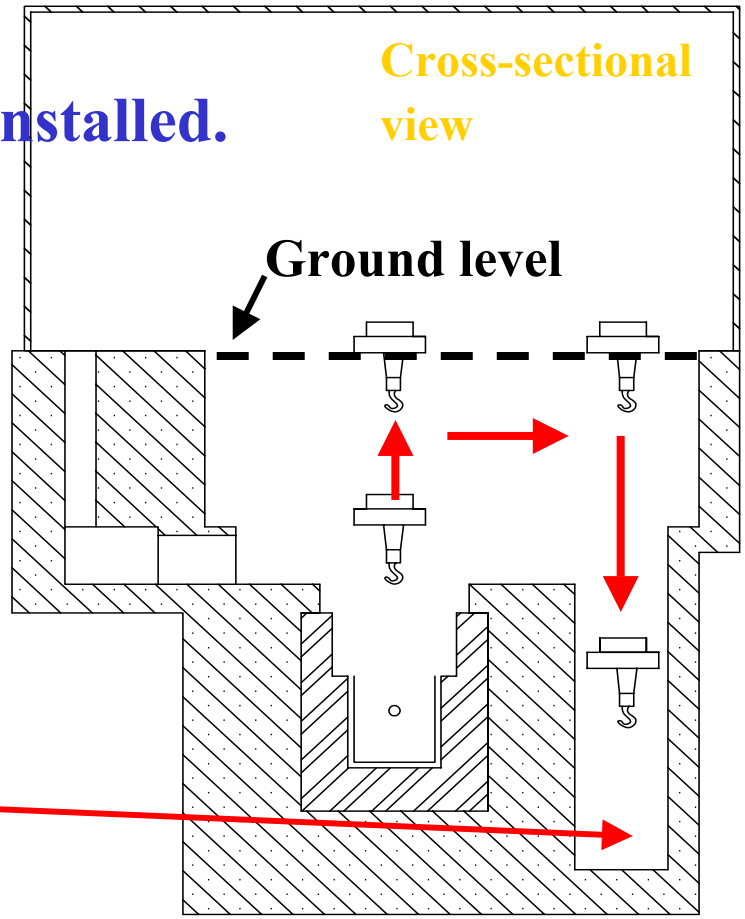
Support system of horn



Exchange of the target/ horn

- Upper Iron and concrete shields are removed.
- Highly radioactivated target/horn are moved under ground-level and kept in the storage of radioactive materials for several years.
- New target/horn are installed and shields are installed.
- All works should be done remotely.





Exchange of the target

A) If horn is broken, scrap target and horn.

B) If target is broken;

1) Scrap target and horn.

or

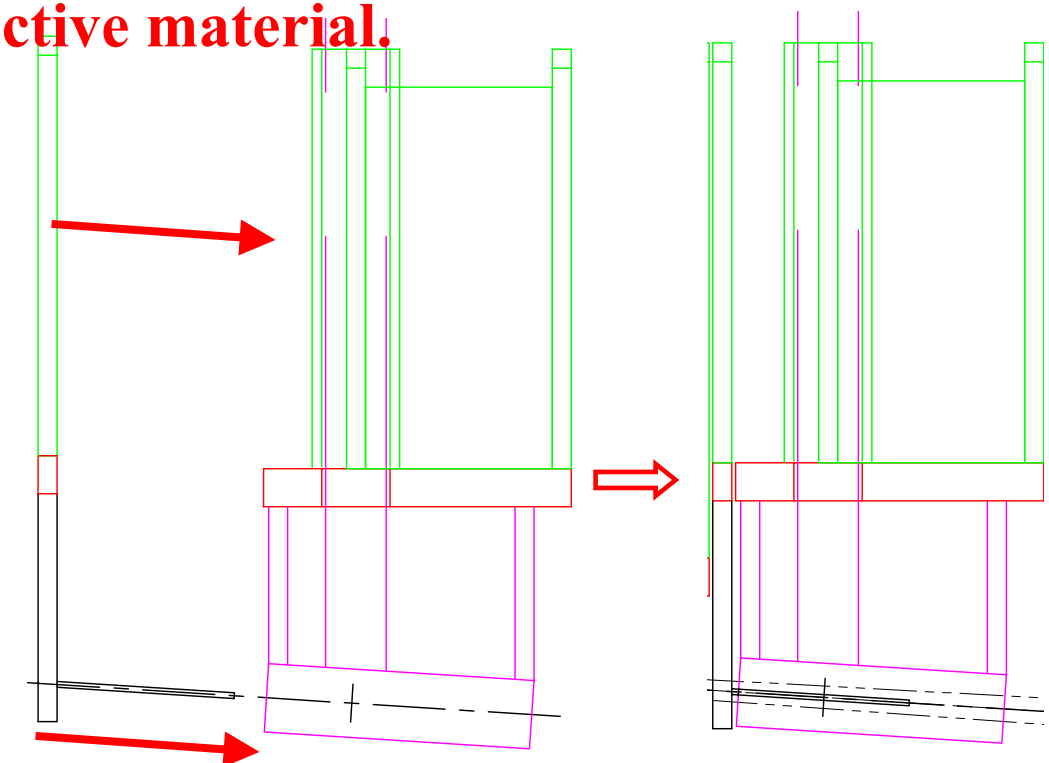
2) Replace broken target with new one in the horn

i) at the storage for radioactive material.

or

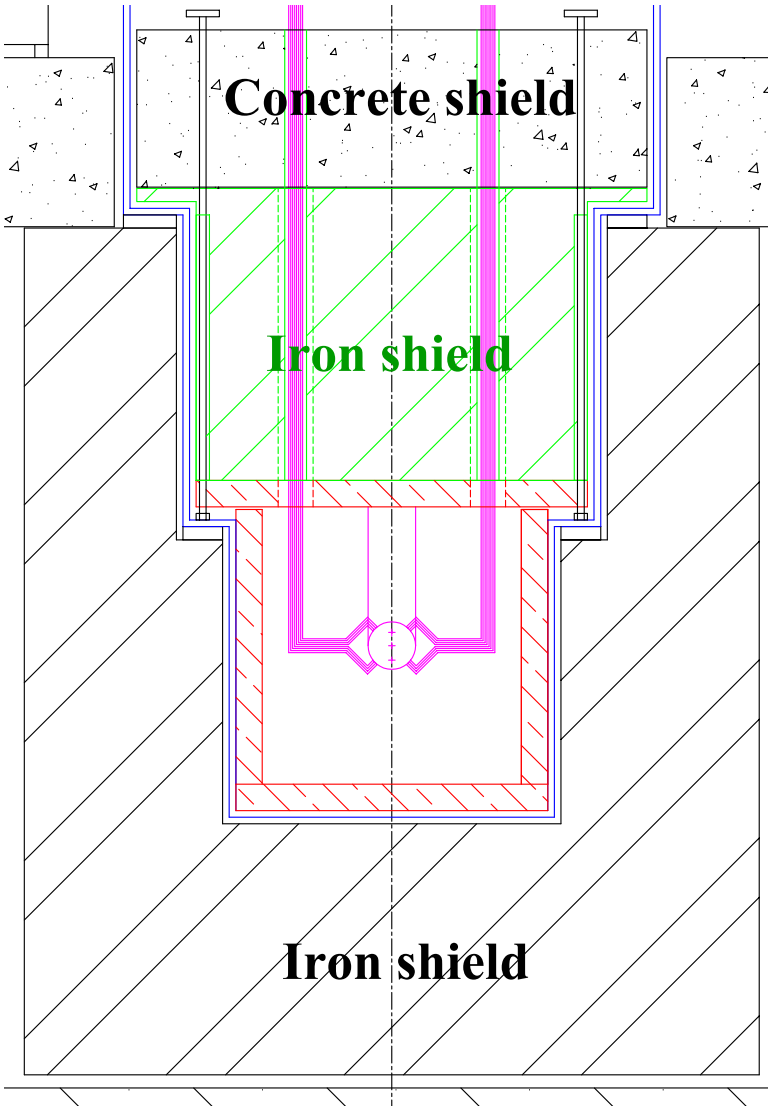
ii) at the beam line.

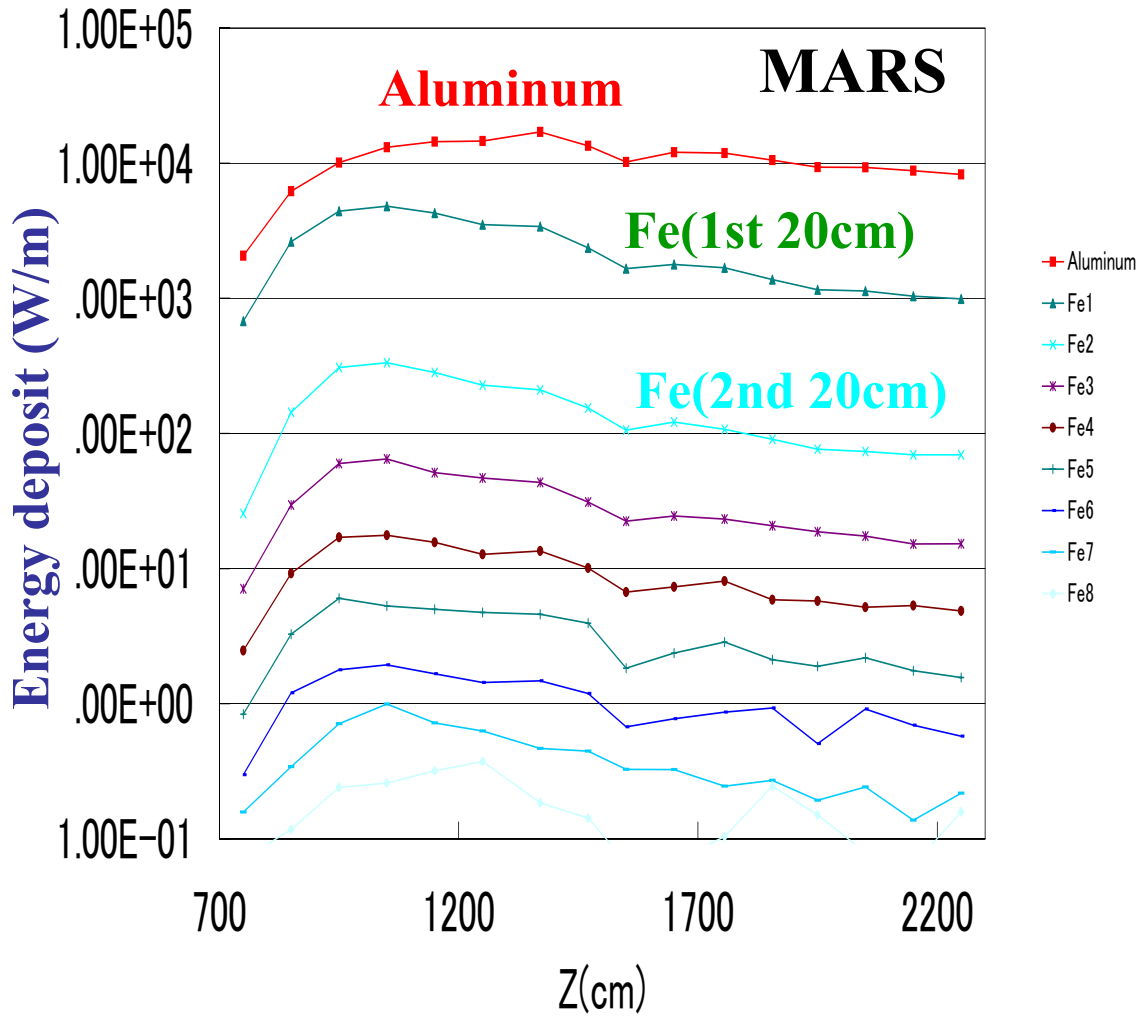
All works should be done remotely.



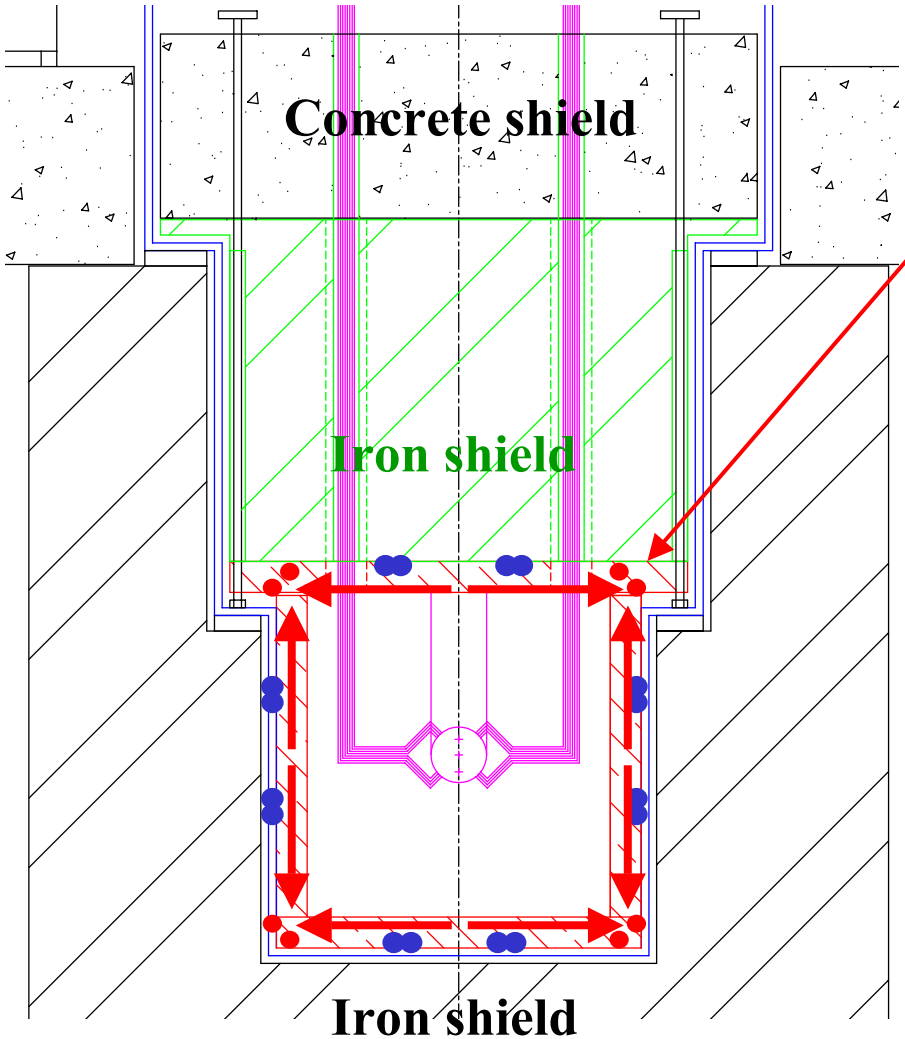
Heat load on Al-wall/Fe-shield

Heat load : ~170 kW on Aluminum, 40kW on Iron





Cooling for Aluminum wall



Water pipe for Aluminum wall

● (option for 4MW)

Temperature rise in Al wall

Q_{Al}=17/8(kW/m), L= 3/2(m),

α_{Al}=240(W/mK), A=0.2(m^2)

$$\Delta T = \frac{Q_{Al} \times L/2}{\alpha_{Al} \times A} = 33(K)$$

Water flow =170(kJ/s)/4.2(J/g/K)/10(K)/8

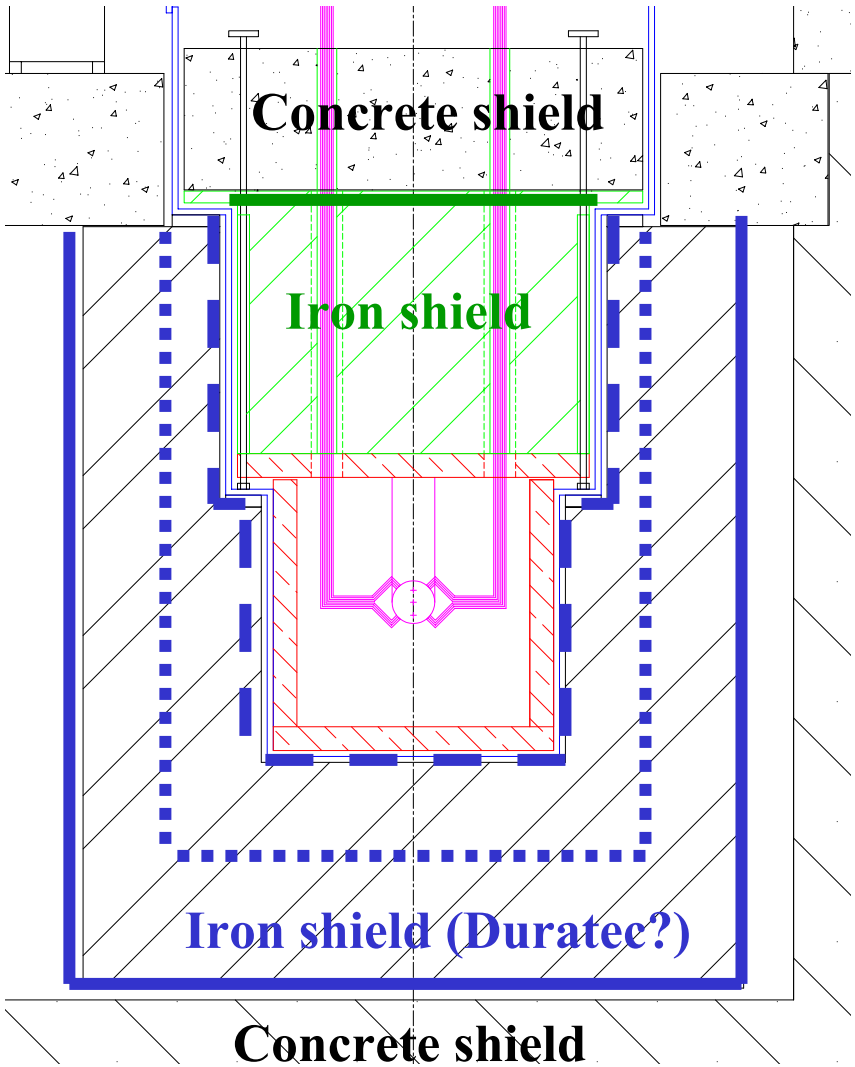
=30(Litter/min.)(×8)

1-inch tube: Re=32000, k=4860(W/m^2K),

$\Rightarrow \Delta T$=3.7(K)、ΔP=0.11(kg/cm^2)

Radio activity of water ⇒ Oyama's talk

Cooling for Iron shield



Water pipe for upper iron shield

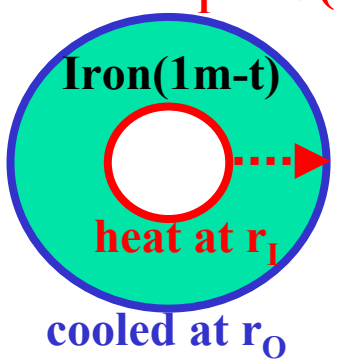
Air cooling surface for iron shield

- Outer surface (Default)
- Middle surface (Option for 4MW)
- Inner surface (Option for 4MW)

Temperature rise in iron shield

Q_{Fe}=4(kW/m), α_{Fe}=80(W/mK),

r_I=1.5(m),r_O=3.0(m), k_O=10(W/m^{2}K)



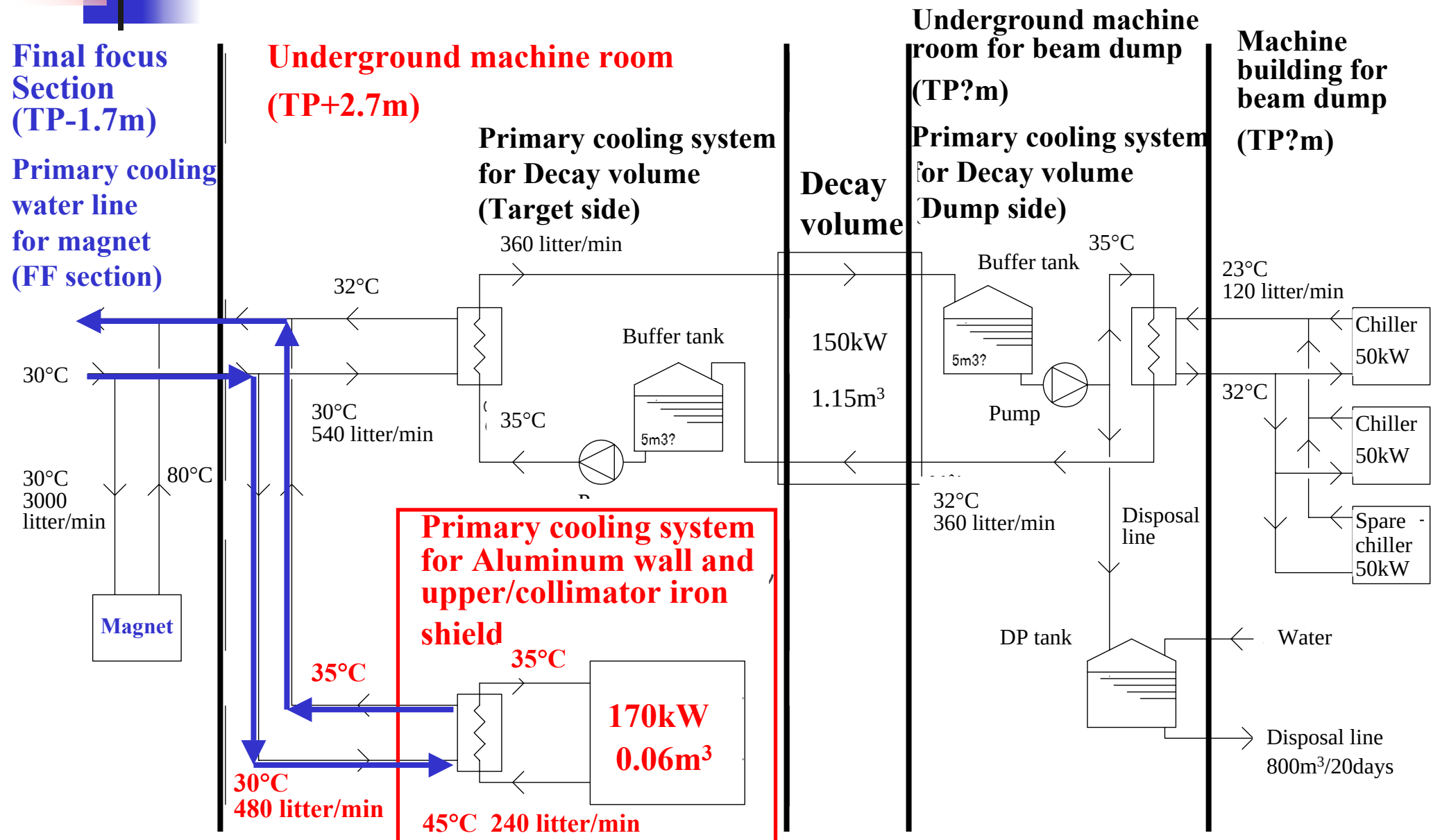
$$\Delta T_O = \frac{Q_{Fe}}{2\pi\alpha_{Fe}} \ln\frac{r_O}{r_I} + \frac{Q_{Fe}}{2\pi r_O k_O}$$

$$= 5.5(K) + 21.2(K) = 27(K)$$

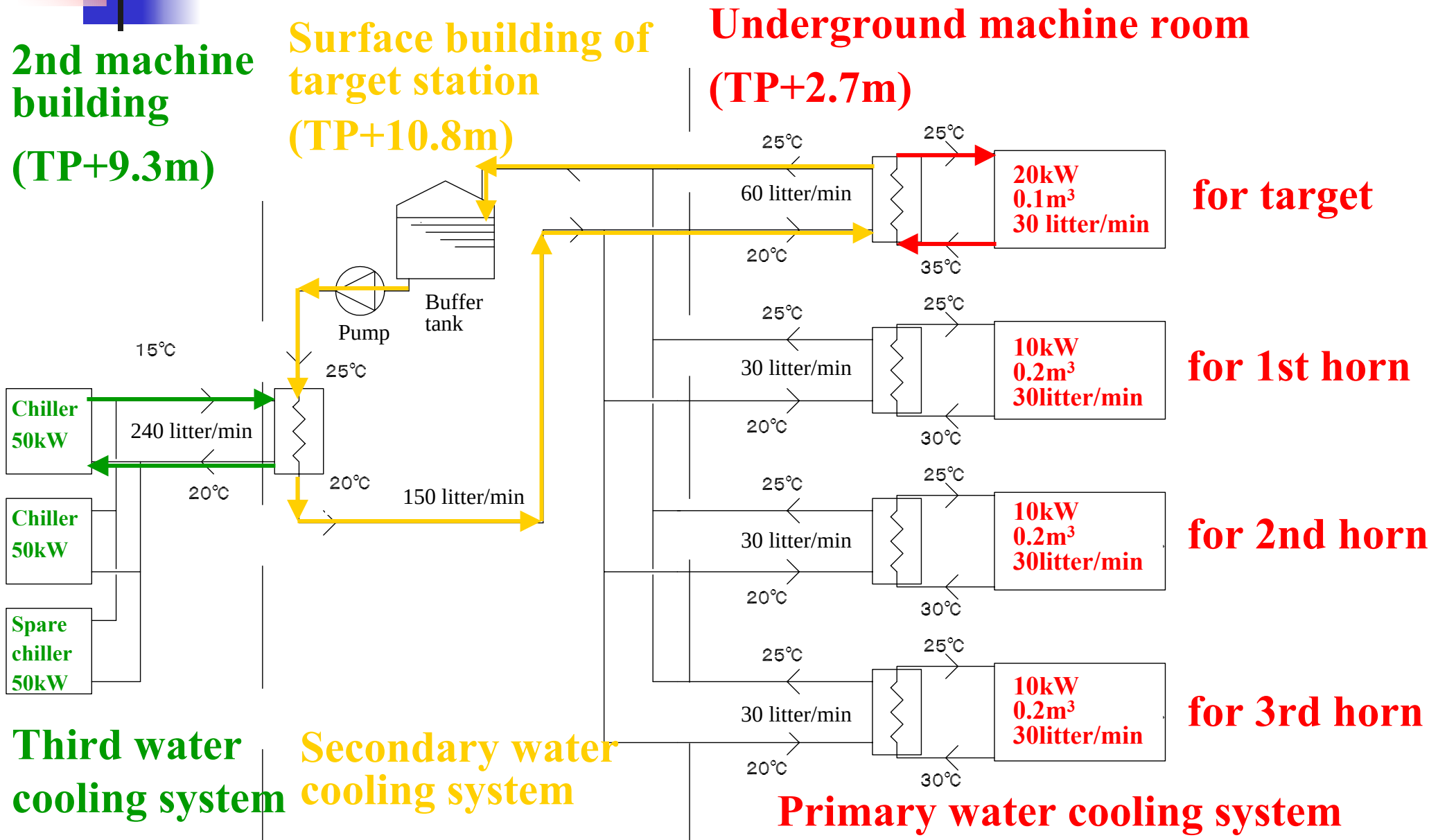
Air flow: 40000(J/s)/1.0(J/g/K)/10(K) =200(m^3/min)

Radio activity of air ⇒ Oyama's talk

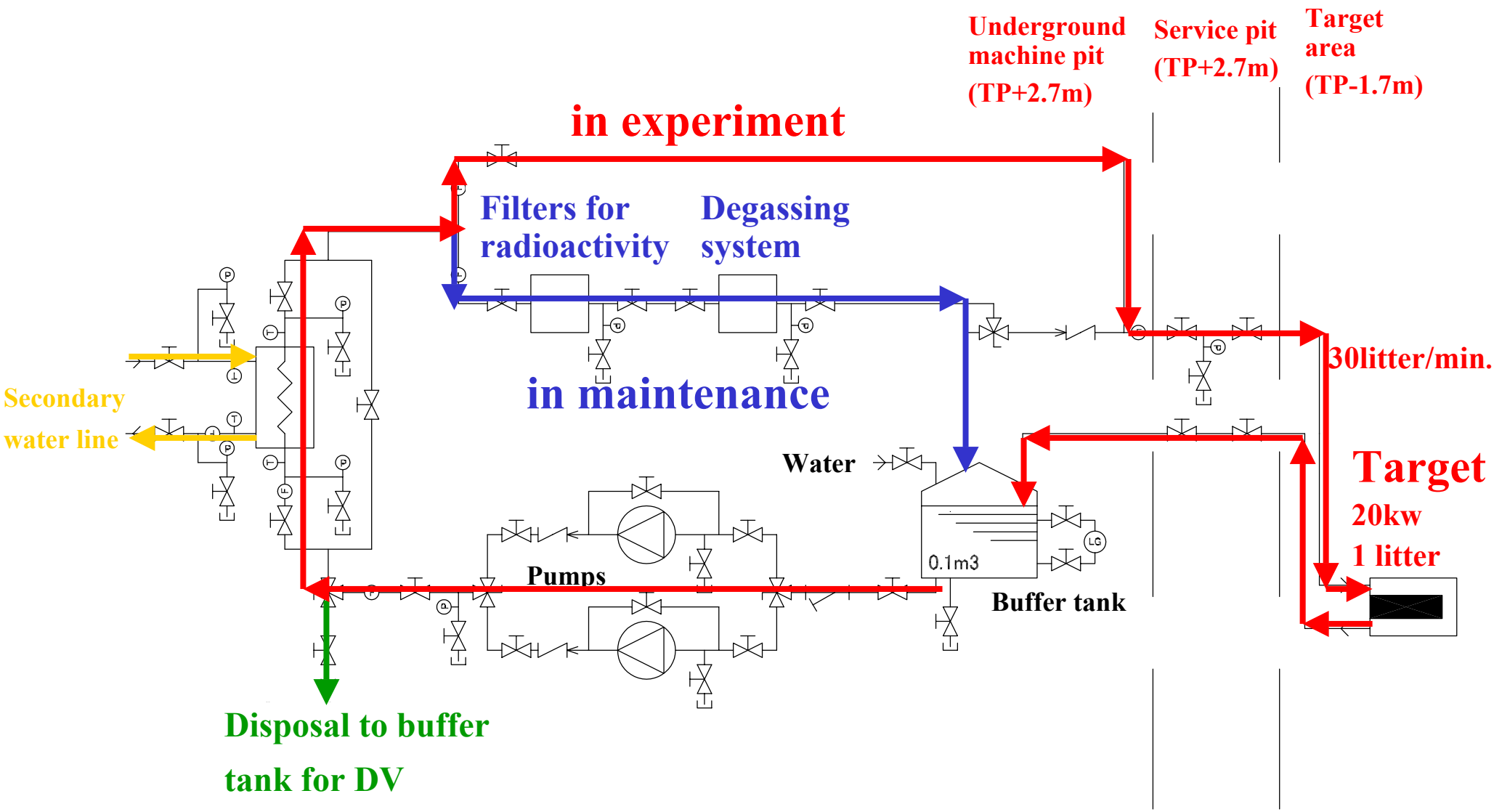
Cooling system for Al wall



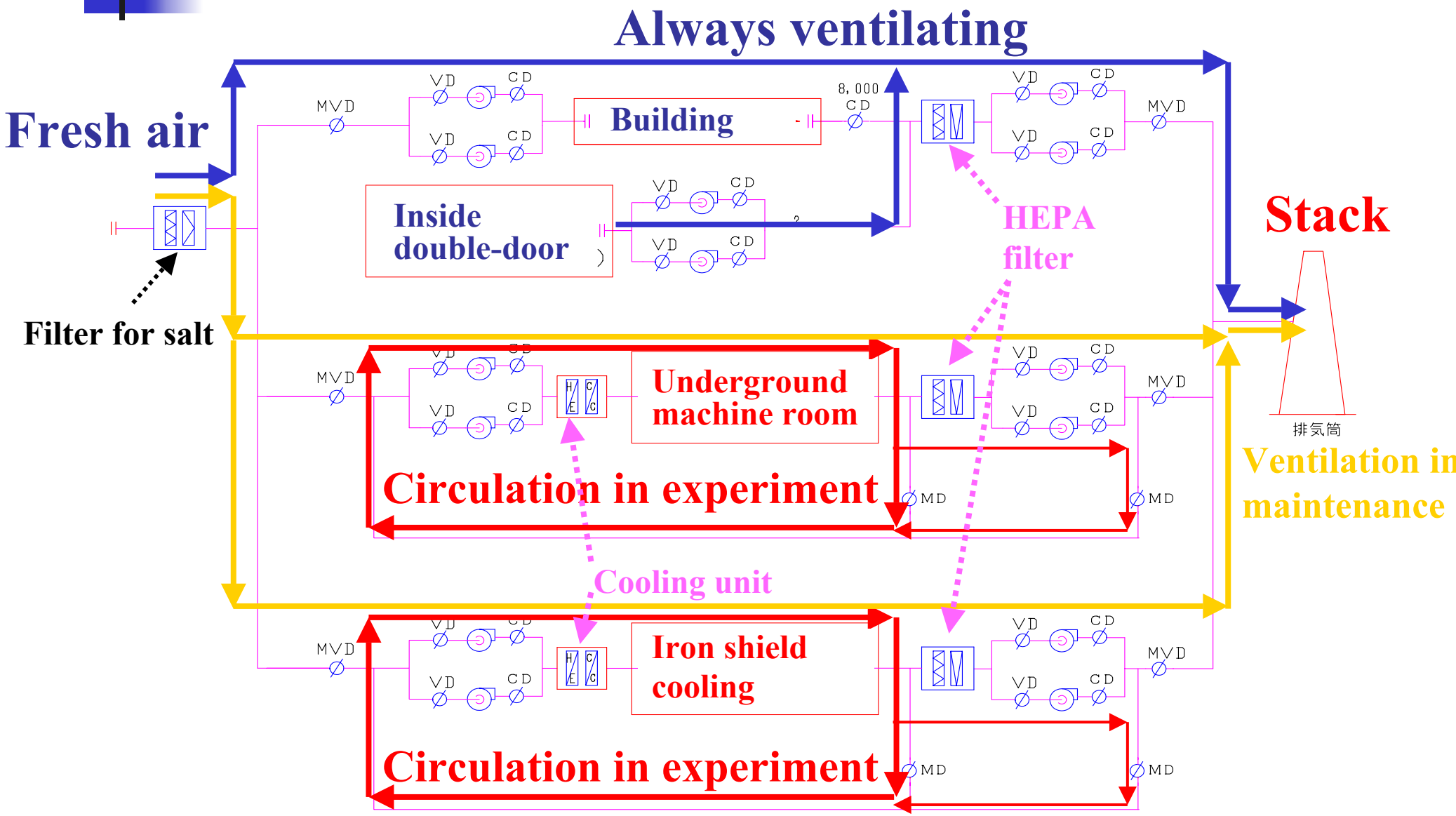
cooling system for target/horn



Primary cooling system for target

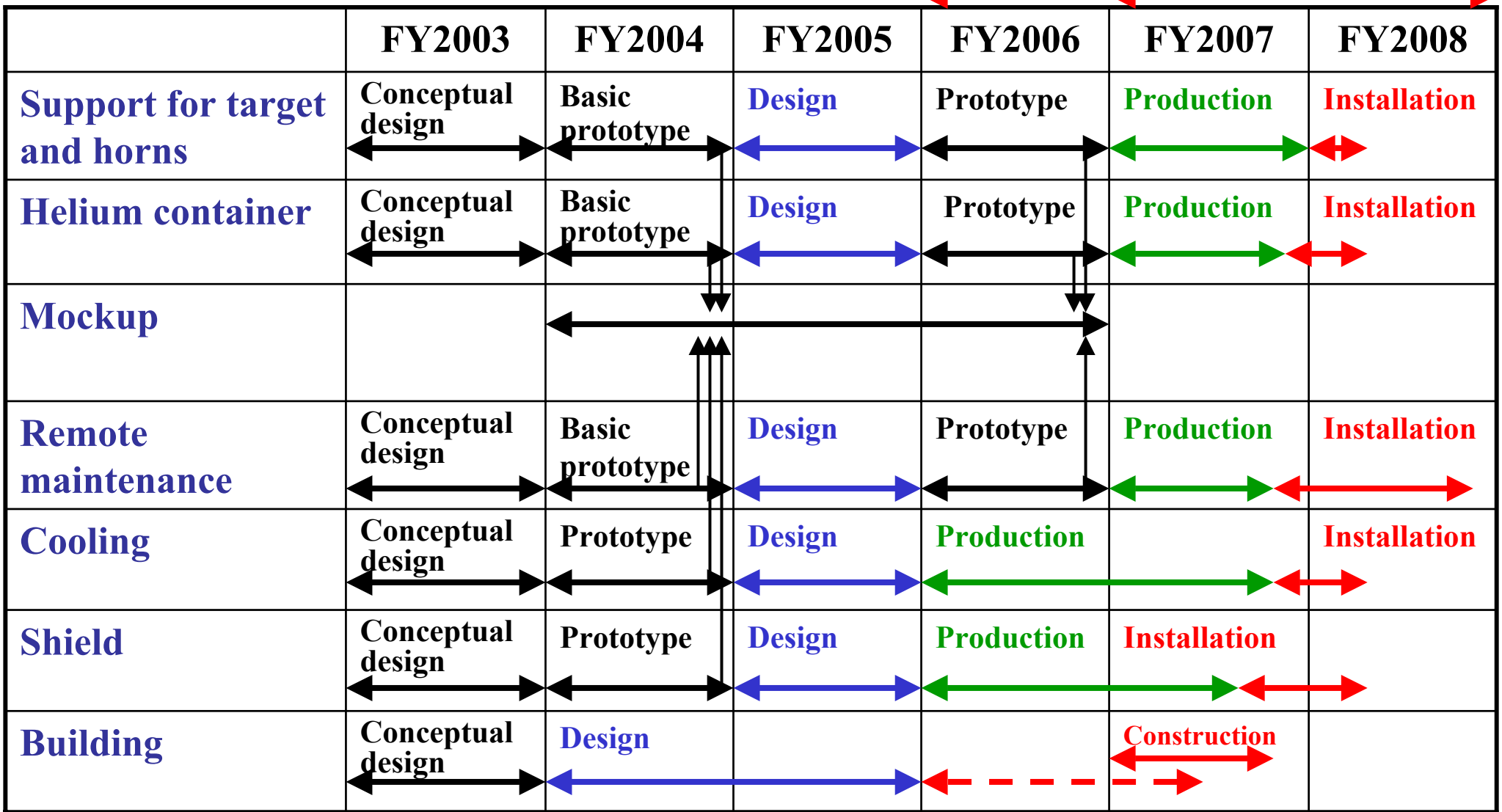


Air circulation/ventilation system



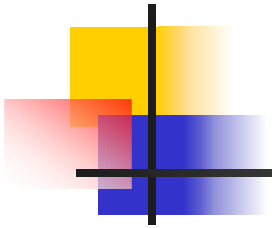
Schedule

(our hope) Budget for TS



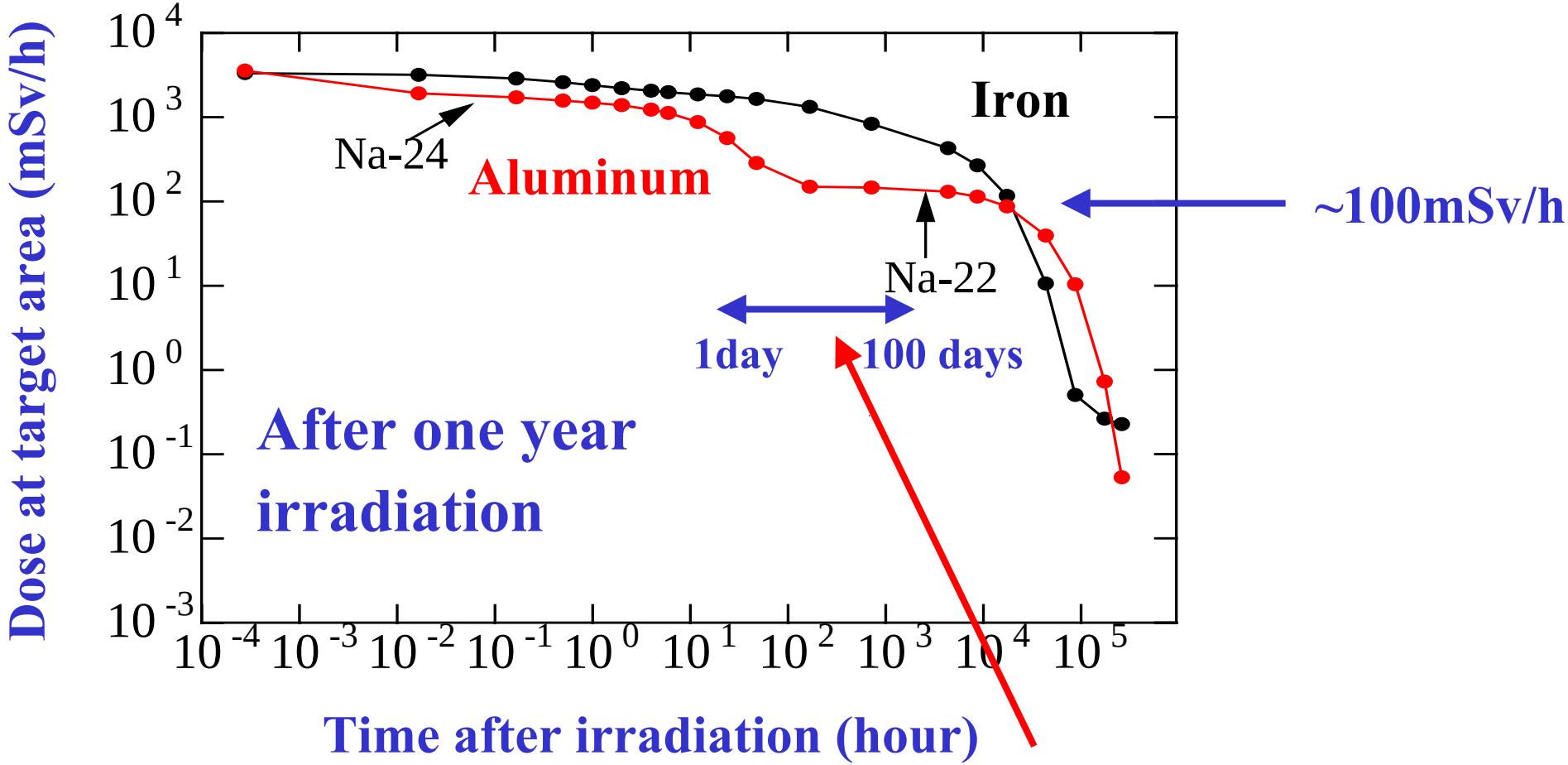
Summary

- Conceptual design of Target Station finish soon.
  - Building
  - Shielding
  - Cooling
  - Support
  - Maintenance
- Realistic design, R&D work and prototyping will start.
- Construction will start in 2006 and end in 2008 if budget is approved.



Backup

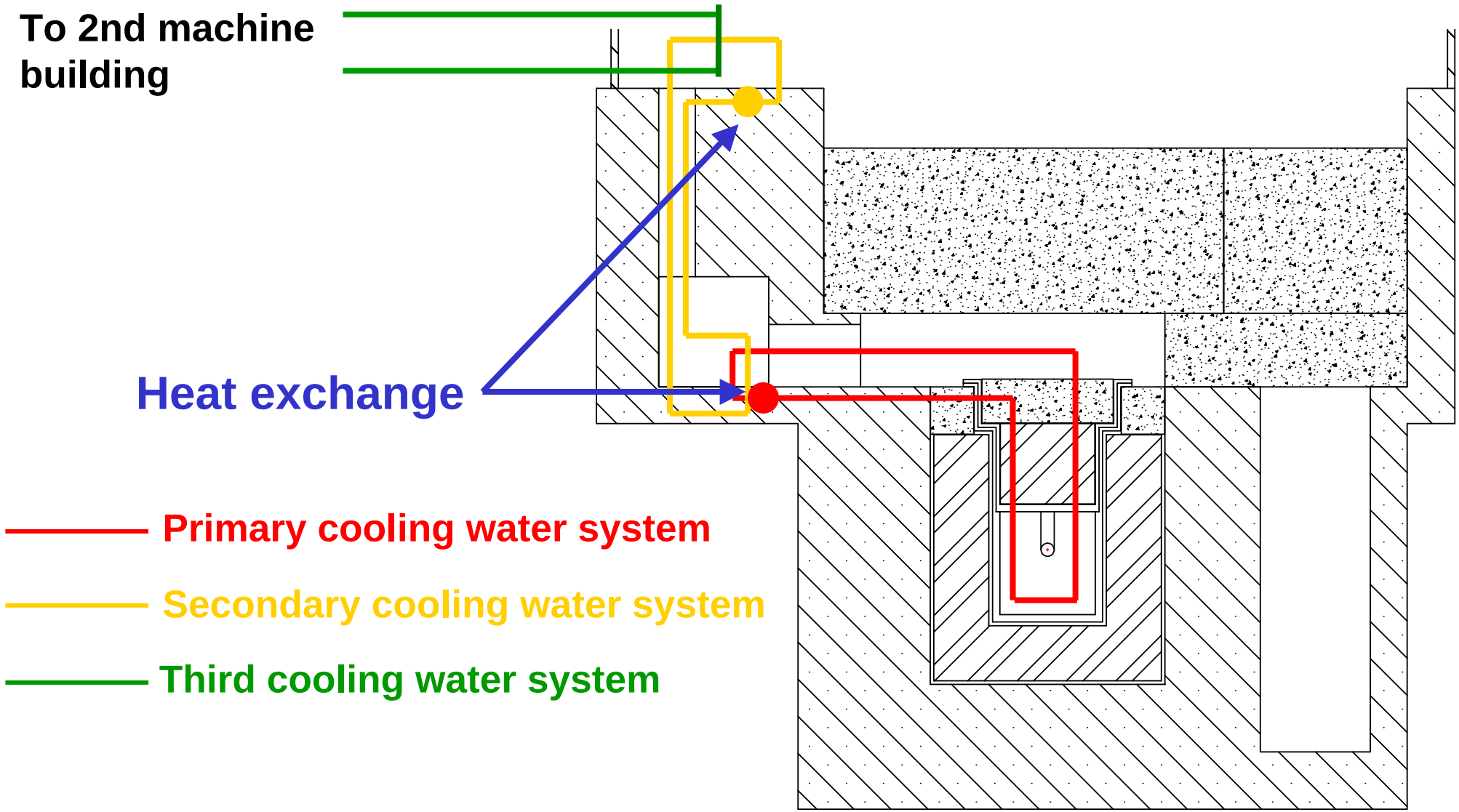
Effect of Aluminum wall



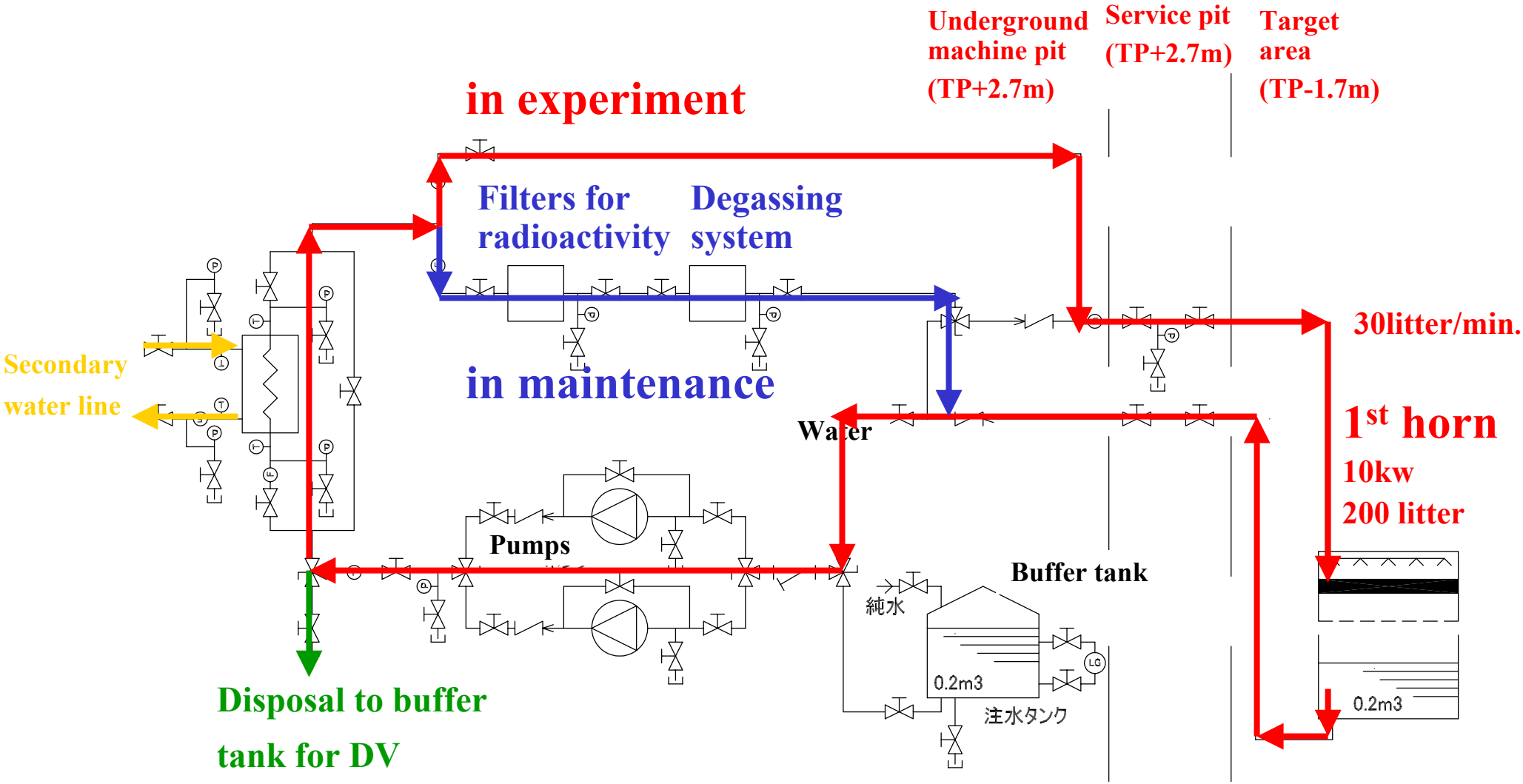
Aluminum wall reduces surface dose by ~1/10 at maintenance.

Cost vs Performance should be studied.

Cooling system for Target/Horn



Primary cooling system for horn



Very rough cost estimation

- Building: ~4.3M$(Underground) + ~0.8M$(Surface)
- Crane: ~0.5M$
- Concrete shield blocks: 1600m^3×~300$/$m^3$ = ~0.5M$
- Iron shield blocks: 4000ton×(200~300)$/ton = 0.8~1.2M$
- Helium container: 160ton×~1000$/ton×~2? = 0.3M$?
- Aluminum wall: 120ton×~3000$/ton×~2? = 0.7M$?
- Support system of horn: ~0.1M$?×4 = ~0.4M$?
- Air cooling & ventilating system: ?
- Water cooling system: ?

- 1M$ ~ 1×10^8 Yen
- Excluding horns and target

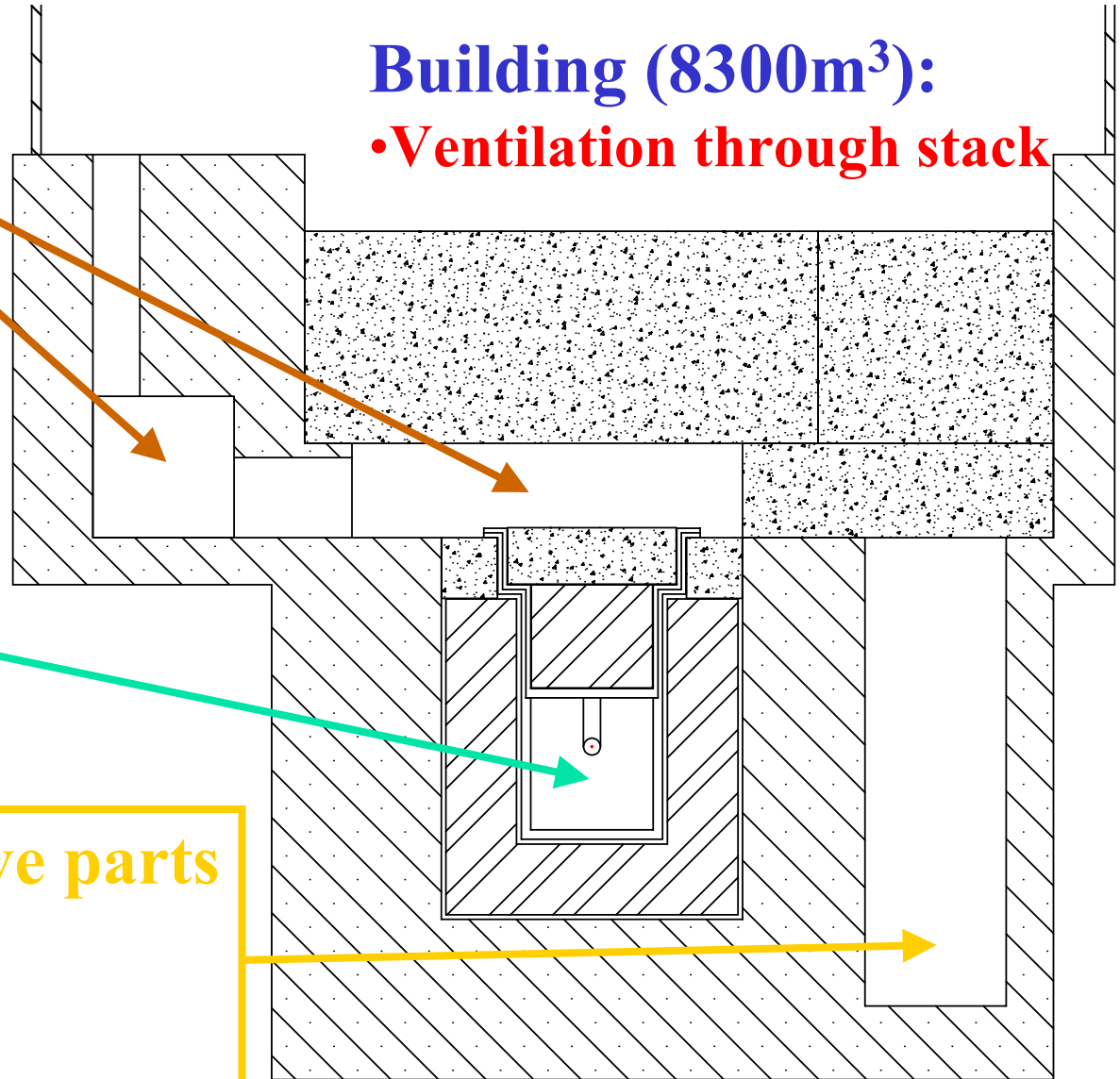
Control of air

Building (8300m^3):
- Ventilation through stack

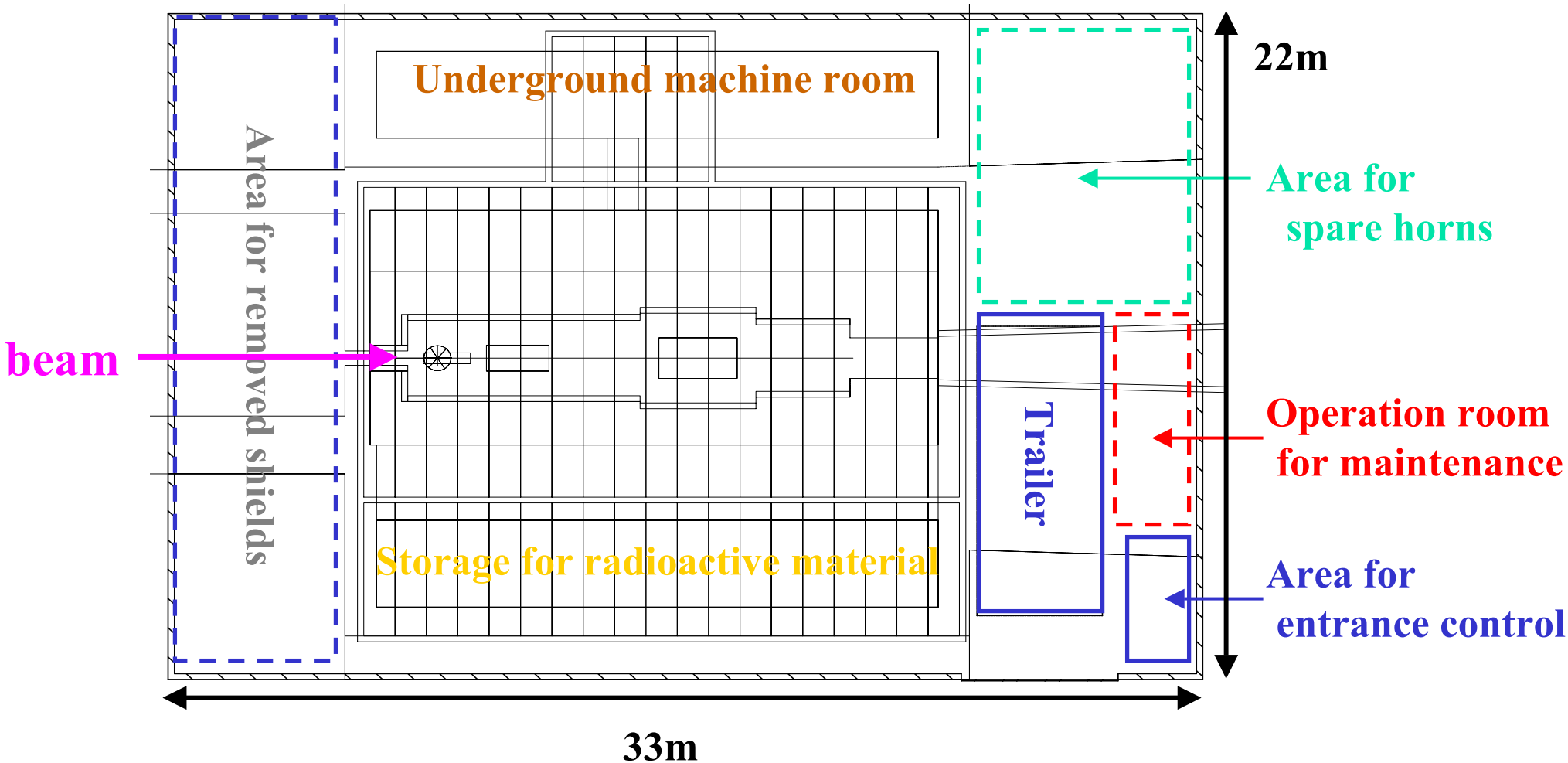
Service pit(230m^3)
Machine room(140m^3)
Keep out in experiment
- In experiment:circulation
- In maintenance:ventilation

Helium container:
Keep out forever
- Circulation of Helium

Stock room for radioactive parts
Keep out forever
- In experiment :circulation
- In maintenance:ventilation

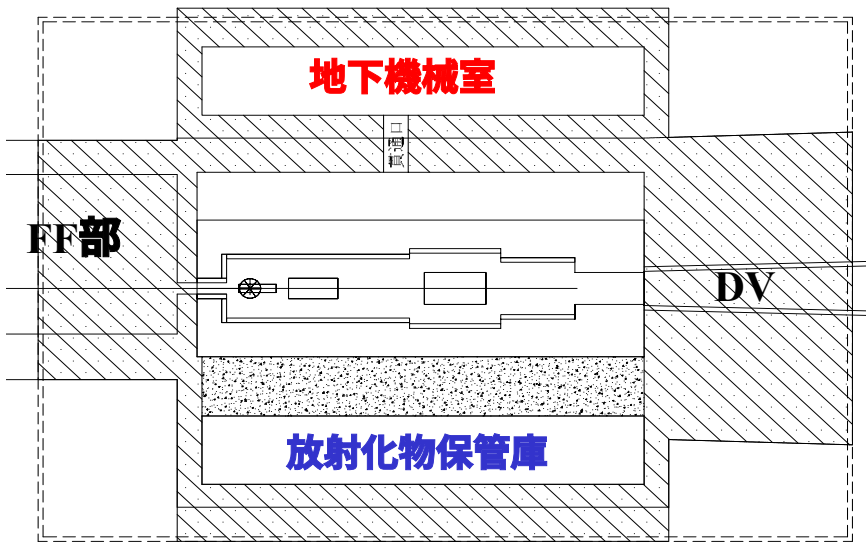


Top view of target station



Underground machine room

- ターゲット
  一次冷却水 (0.01m^3,28kBq/cc) のポンプ＋タンク、
  熱交換器(~30kW)、二次冷却水のポンプ＋タンク
- ホーン
  一次冷却水 (0.6m^3,5kBq/cc) のポンプ＋タンク、
  熱交換器(~30kW)、二次冷却水のポンプ＋タンク
- 鉄シールド＋アルミヘリウム箱
  一次冷却水 (数m^3?,数kBq/cc?)
  のポンプ＋タンク、熱交換器(~200kW)
  (二次系はFF部と共通)
- ディケイボリューム
  一次冷却水 (3m^3,数kBq/cc)
  のポンプ＋タンク、熱交換器(~200kW)
  (二次系はFF部と共通)



排水は地下機械室よりディケイボリュームを通って下流のDPタンクへ

空気・ヘリウムの放射化

0.75MW20日運転後（反応断面積σ=30mb）　排気基準：5mBq/cc以下

場所	Neutron fluence (/p/cm^2)	放射化 (Bq/cc)	容量 (m^3)	トリチウム (Bq)	排気時間 (h)
上屋	1×10^{-19}	4×10^{-14}	8000	0.3	1
サービスピット	5×10^{-12}	2×10^{-6}	230	5×10^{5}	0.03
地下機械室	5×10^{-12}	2×10^{-6}	330	7×10^{5}	0.04
放射化物保管庫	5×10^{-12}	2×10^{-6}	780	1.6×10^{6}	0.1
鉄シールド外面	1×10^{-10}	4×10^{-5}	38	1.5×10^{6}	0.005
鉄シールド中間	1×10^{-8}	4×10^{-3}	33	1.3×10^{8}	0.004
鉄シールド内面	2×10^{-5}	8	28	2.2×10^{11}	5.6
TSヘリウム	2×10^{-4}	80?	135	1.1×10^{13}?	270?
DVヘリウム	5×10^{-5}	20?	1600	3.1×10^{13}?	800?

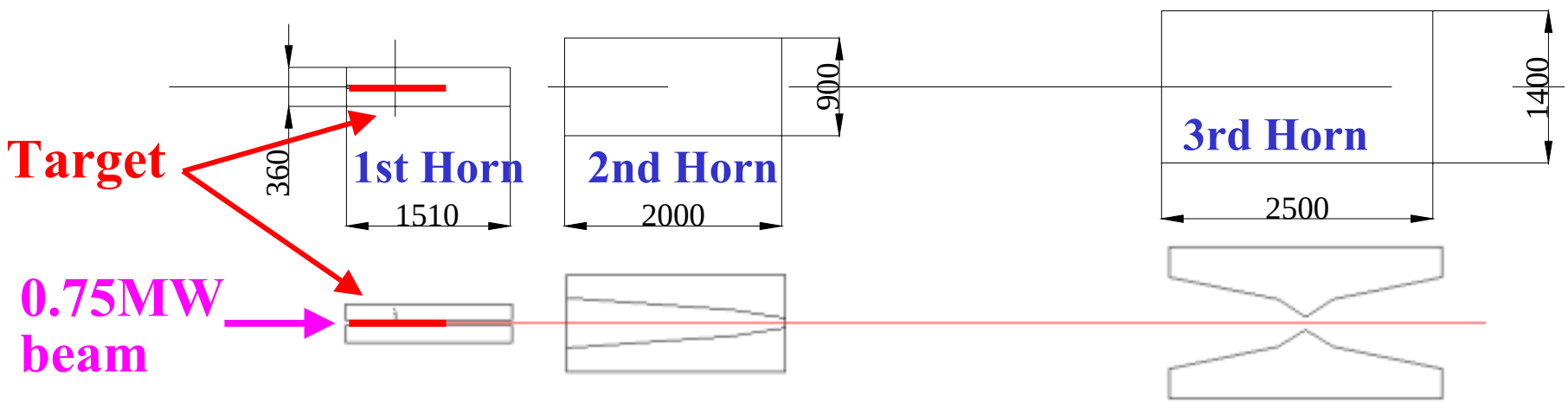
ヘリウムの断面積は1.2mb？（1/25？）

Neutrino target

Graphite rod

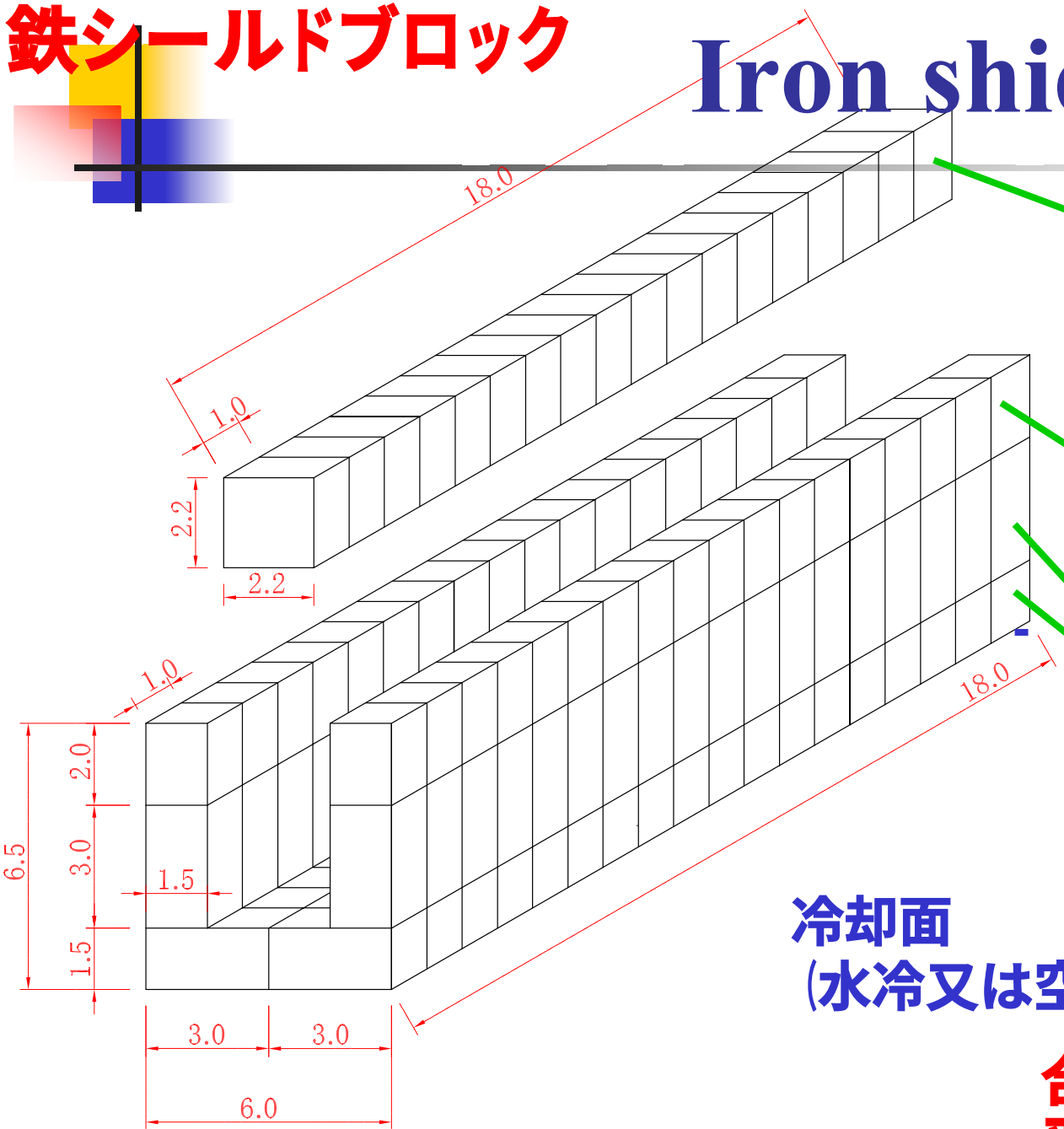
- diameter:30mm, Length:900mm (80% interaction)
- beam size: σ_r ~6mm
- fixed inside 1st horn
- 20kw heat load: cooled by water

⇒ Hayato's talk tomorrow

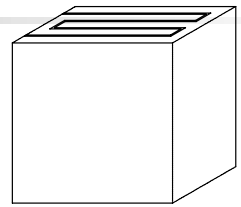


鉄シールドブロック

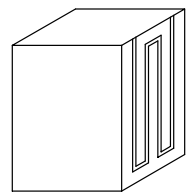
Iron shield



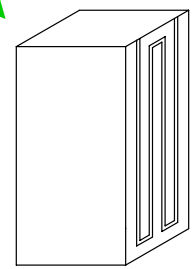
水冷の場合、
冷却管取付け



2.2mX2.2mX1m
(36トン)
18個＝650トン



2mX1.5mX1m
(23トン)
36個＝810トン



3mX1.5mX1m
(34トン)
72個＝2430トン

冷却面
(水冷又は空冷、２５０kW)

合計３９００トン
平成18年度製造、19年度据付