# RADIATION SHIELDING DESIGN AND RADIATION LEVEL OF PARMS

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Partical Radiation Medical Science Center(PARMS) is a facility designed mainly for accomodating radio-biomedical researchers with proton- and neutron-radiation fields. The energy and the intensity of proton beams which this facility offers to the users is up to 300 MeV and about $2x10^9$ protons per pulse--16 pulses per second, respectively. These proton beams are produced as a result of energy degradation of 500 MeV primary proton beams, which are supplied from the KEK booster synchrotron accelerator, with an apparatus of alminum rod assembly and the other equipment. At the neutron irradiation room, we can use neutron beams of the average energy of about 70 MeV which are generated in a tungsten target bombarded with 500 MeV proton beams and then emerge in a forward direction.

Performance of the PARMS Shielding:

At this institute, main theme on radiation shielding is how to shield spallation neutrons which are generated in many sites bombarded by high energy protons and neutrons ( 100 MeV). These high energy neurtons have the small attenuation length and then generate many low energy neutrons including thermal neutrons.

a): an important factor for dominating the thickness of the shield wall = permissible dose rate at the boundaries of the radiation control area in KEK.

Level 1 : $\geq$2mrem/hr for the area corresponding to no admitance

Level 2 : 80 rem/hr for the boundary of the control area

We must satisfy these conditions of levels of dose rate on the performance PARMS shielding.

b) : Shielding Calculation for PARMS

Shielding calculation for PARMS was based on Moyer,s method and on the empirical formula by Braid.

Formulae for calculating the thichness of the shield wall;

1) $D=B\cdot P(dn/d\Omega)_{E>100MeV}\langle g\rangle^{-1}\cdot r^{-2}\exp(-L)$

2) $r^2\cdot D=I\cdot D_1\exp(-\lambda(t-100))$

D : dose rete corresponding to permissible dose rate

P : loss rate of proton numbers (protons per second)

$(dn/d\Omega)_{E>100MeV}$ : diferential cross section for neutrons of which energy is higher than 100 MeV.

g : $\int_{0.1MeV}^{100MeV}\phi(E)dE / \int_{100MeV}^{E_{max}}\phi(E)dE$

r : the total distance from the site bombarded by proton to the outside of the shielding wall

L : the thickness of the shielding wall expressed in terms of the attenuation length of neutrons of energy higher than 100 MeV

I : proton beam current

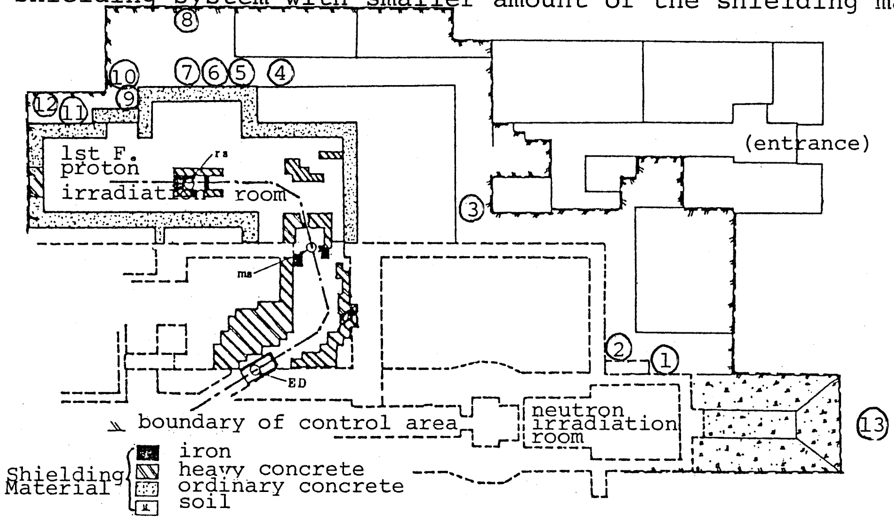
$D_1$ : the numerical value of $r^2D$ for $t=100g/cm^2$ and $I=1\mu A$

$\lambda$ : a constant

Results

Figure shows the schema of the first floor of PARMS.

The thickness of the shielding wall around the proton irradiation port is one meter. Majority part of this wall is made of the ordinary concrete, but the part of the wall to which proton beams are normally incident is compose of the iron and the heavy concrete. Along the proton beam line, several sites at which an energy degrador, a momentum slit, a ring scatterer, a block collimeter and so on are set are covered exceptionally with the assemblies of the heavy concrete blocks because of high yield of neutrons. Due to this method of the shielding composition by which shielding blocks are additionally set for attenuating neutron flux intensity around near the generating points of neutrons, we can compose the shielding system with smaller amount of the shielding material.




Dose rates at the points shown as No.①—No.⑬ in the figure illustrated above are listed in a table.

Table: Dose rate at the each point corresponding to No. in the figure; unit: $\mu$rem/hr

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ① | 20 | ② | 15 | ③ | 15 | ④ | 40 |
| ⑤ | 180 | ⑥ | 280 | ⑦ | 130 | ⑧ | 45 |
| ⑨ | 130 | ⑩ | 50 | ⑪ | 90 | ⑫ | 40 |
| ⑬ | 30 | | | | | | |

Operation mode of the beam transport:

a) to the points of ①, ② and ⑬ ; the cold neutron mode
proton beam intensity; $4.5\times10^{11}$ppp, 16pps, 500MeV
neutron beam shutter ; close to points ① and ②
open to point ⑬

b) to points of ③—⑫ ; the medical proton mode
proton beam intensity ; $4.5\times10^{11}$ppp, 16pps, 500 MeV
$1.8\times10^{9}$ppp, 16pps, 250 MeV

From these results in practice, it is achieved that dose rate at the boundaries of the control area was lower than 80$\mu$rem/hr of the permissible dose rate at KEK.

Problems : 1) content levels of induced radioactivity in air of neutron irradiation room.
2) permissible dose rate suitable to the medical facility as PARMS.