Separation shield of ML tunnel

Radiation Shielding

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Scope of this presentation

- Radiation shielding for main linac tunnel
  - Single tunnel but separated region
  - One for main linac, the other for Klystrons and modulators

  →How much thickness for separation shield ?

The evaluation is important because

The shield would occupy considerable amount of tunnel space

The shield limits maximum allowable beam power

- Boundary condition
  - Smaller tunnel would be preferable for cost
  - Enough radiation dose reduction under any beam condition

Achievement of RDR

- ILC_RDR_Volume_3-Accelerator 2.9.4.1,2

Radiation shield is designed with considering the following three cases

(1) Normal operation

(2) Mis-steering situation

(3) System failure

Beam losses for

(1) and (2), TESLA-TDR cites 0.1W/m and 100W/m

(3) SLAC maximum credible beam loss, i.e, 18MW at one point

These number should be revised according to ILC beam loss scenario

Area classification depends on lab.

TABLE 2.9-2
Maximum allowable radiation levels and doses.
(a) Radiation Protection Instructions, DESY, June 2004.
(b) Radiation Safety Instructions, KEK, in Japanese, June 2004.
(c) Radiation Safety System, SLAC, April, 2006.
(d) Fermilab Radiological Control Manual, FNAL, July, 2004.

	DESY (a)	TESLA	KEK (b)	SLAC (c)	FNAL (d)
Standard	20 mSv/yr	1.5 mSv/yr	20 mSv/yr		50 mSv/yr
Fertile women	2 mSv/month	1.5 mSv/yr	6 mSv/yr 2 mSv/3months		
Pregnant women	1 mSv /pregnancy	1.5 mSv/yr	1 mSv /pregnancy		5 mSv /pregnancy
Operating conditions					
Normal			20 μSv/hr (1mSv/week)	5 μSv/hr (10 mSv/year)	
Mis-steering			20 mSv/event (20 mSv/year)	4 mSv/hr	
System failure			20 mSv/event (20 mSv/year)	250 mSv/hr for max. credible beam (30 mSv/event)	

Calculation of dose rate

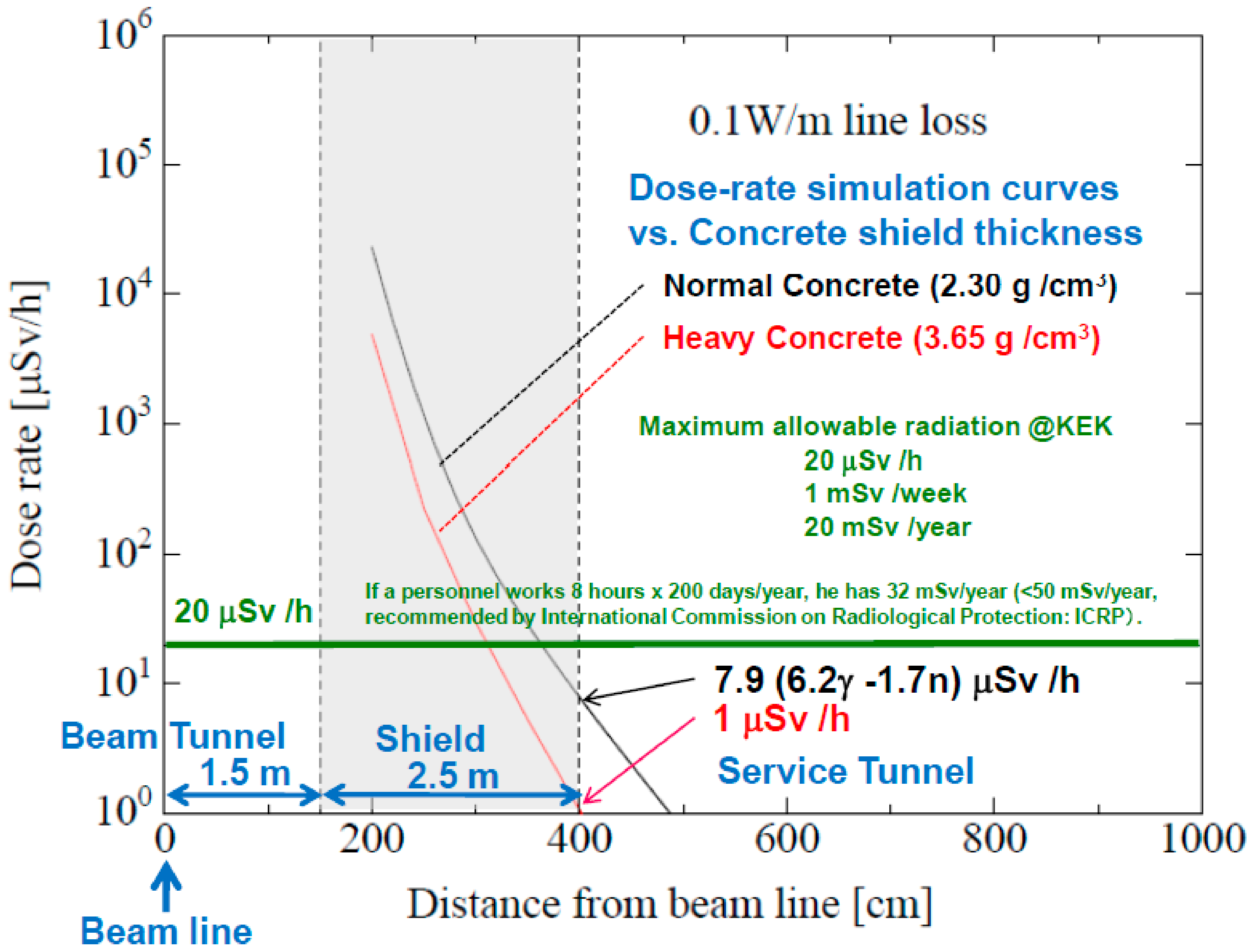
- Relationship between shield thickness and dose rate for
  - (1) Normal operation : 0.1 W/m line loss
  - (2) Mis-steering : 100 W/m line loss
  - (3) System failure : 18 MW(*) at one point

    (*) 500 GeV x 2 at Stage 2, 4Hz rep. rate

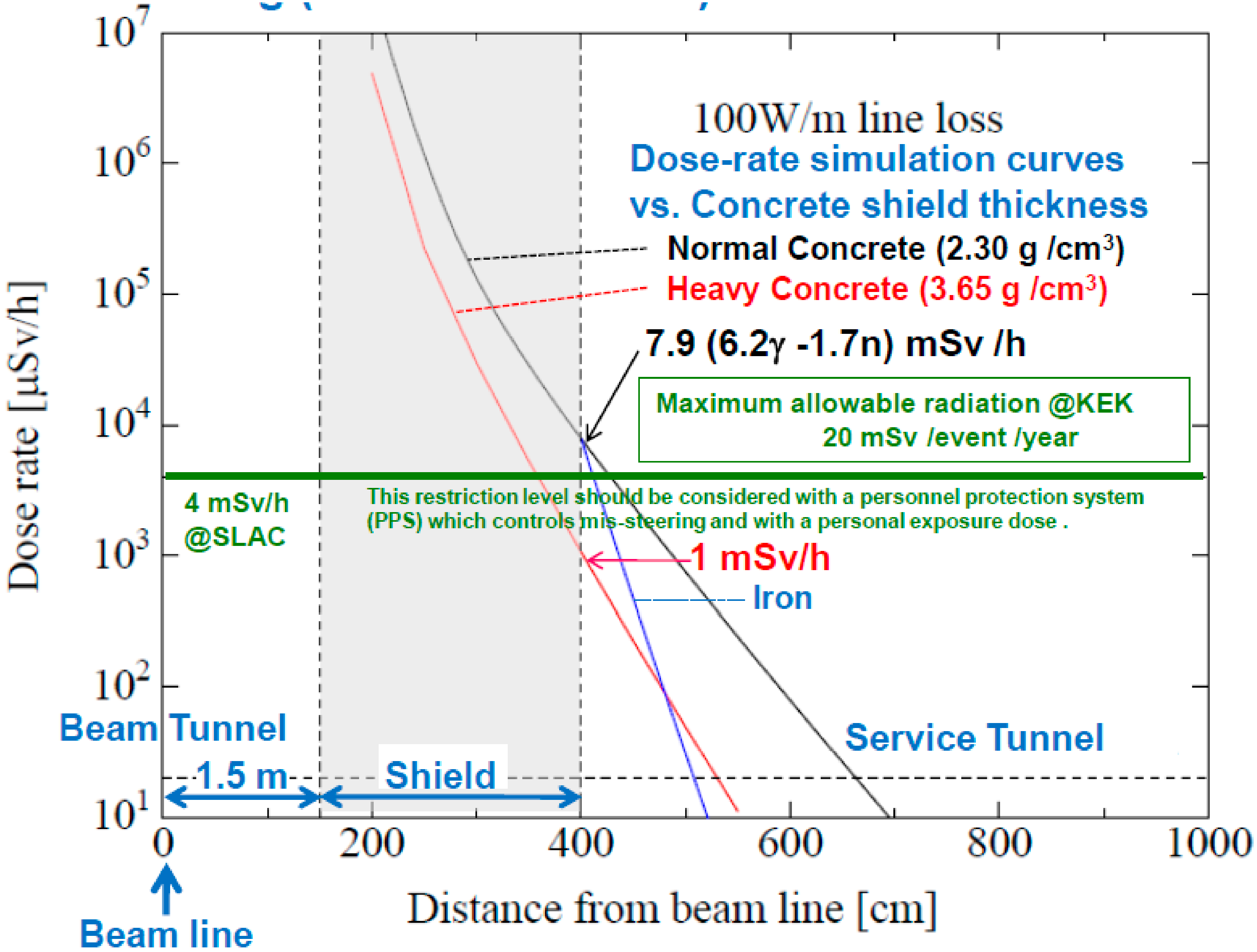
    $\rightarrow$9mA x 1ms x 500GeV x4 = 18MW

- 1.5 m distance between BL to wall
- 20 X_0 copper target (worst beam loss)
  - Jenkins empirical equation
- Ordinary concrete (2.3gcc), Heavy concrete (3.65gcc)
- No penetration, emergency passageway, etc.

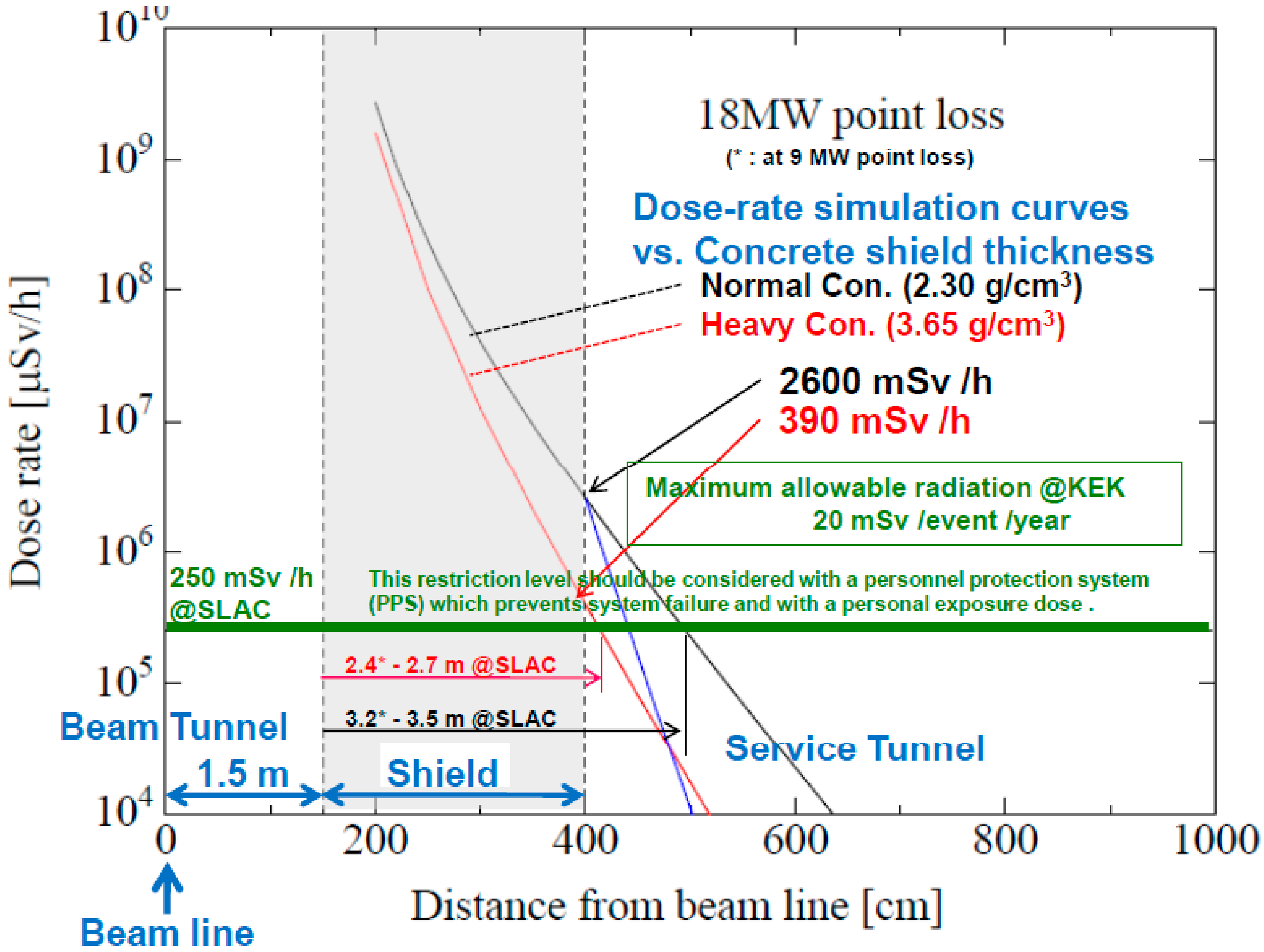
Normal operation



Mis-steering



System failure



Summary - 2.5m concrete

- 2.5m ordinary concrete scenario with KEK rule
  - Normal operation : 7.9μSv/h (<20μSv/h)
  - Mis-steering situation : 8mSv/h (1mSv/week 20mSv/year)
    - 1mSv/week → Recover within 1/8 =7.5 min
    - Beam tuning : Reduce current, Rep. rate, Pulse width
  - System failure : 2600 mSv/h (20mSv/year)
    - Beam must be stop within 20/2600=0.0077h=27sec
    - How to ensure ? (Beam monitors, rad. Monitors, etc)
    - How many times ? (Accident scenario)

Summary – 3.5 m concrete

- 3.5m ordinary concrete scenario
  - Normal operation : <1. μSv/h (< 5 μSv/h, SLAC)
  - Mis-steering situation : 1mSv/h (< 4mSv/h, SLAC)
    - 1mSv/week → Recover within 1/1 =60 min
    - Beam tuning : Reduce current, Rep. rate, Pulse width
  - System failure : 250 mSv/h (< 250mSv/h, SLAC)
    - Beam must be stop within 20/250=0.08h=288sec

3.5 m is preferable from radiation control

Summary

- Radiation dose behind the separation wall of ML tunnel
  – For normal operation, mis-steering situation, system failure
  – At least 2.5 m ordinary concrete require to satisfy KEK rule
  – 3.5 m ordinary concrete is preferable

- For more detail evaluation
  – Evaluation of beam loss scenario
  – Beam operation scenario
  – Hardware (MPS,BCS,PPS)

- Must be considered for
  – penetration, emergency passageway, etc.

Muon

SLAC ESA experiment (14GeV and 18 GeV)

Data to evaluate large angle production

SLAC RADIATION PHYSICS NOTE

RP-07-15
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Code benchmark of muon flux after a several meters of iron from 14 and 18 GeV electron induced reactions in forward direction

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W.R.Nelson and K.R.Kase, *Nucl. Instrm. Meth.* **120** (1974) 401-411

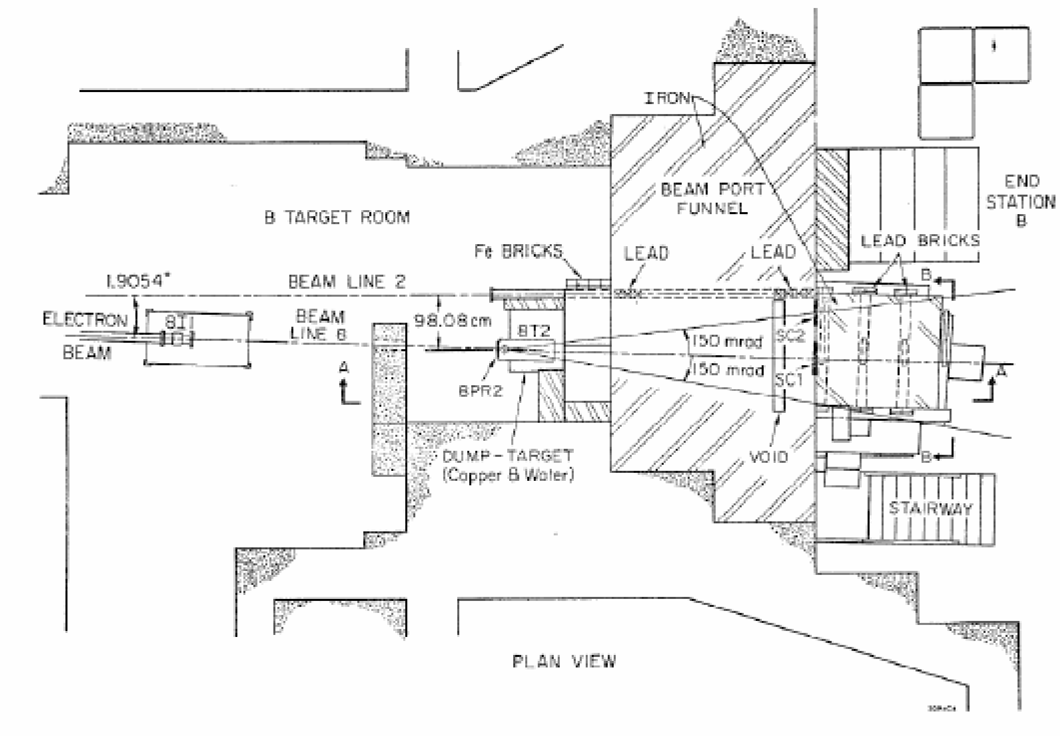
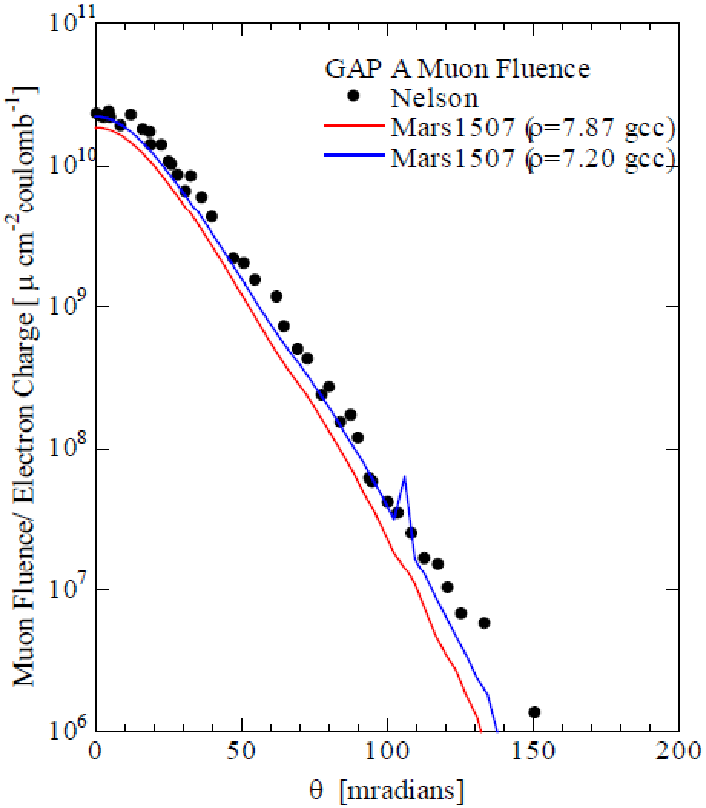


Figure 1. Plan view of experimental setup



Muon

FNAL NuMI experiment (120GeV p)

Data to evaluate large angle scattering and effects from secondary particles

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ARTICLE

Shielding Experiments at High Energy Accelerators of Fermilab(I)
- Dose Rate Around High Intensity Muon Beam -

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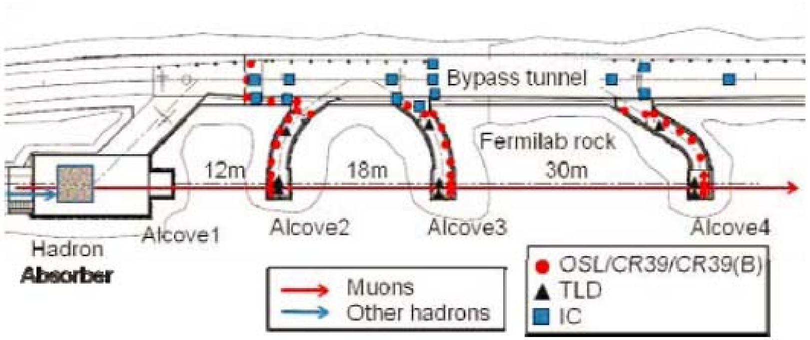

Fig. 2 Locations of dosimeters and detectors to measure muons and secondary particles. The thicknesses of rock between the alcoves are also shown in this figure.

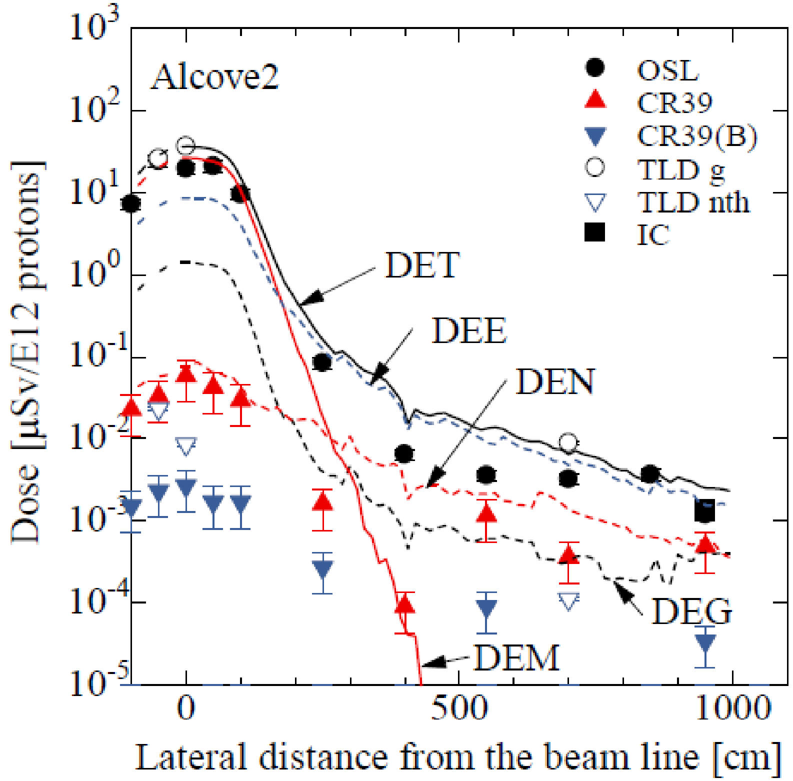

Fig. 4 Experimental and calculation results for dose along alcove 2. DET, DEG, DEM, DEN and DEE stand for dose rate total, photon, muon, neutron and electron, respectively