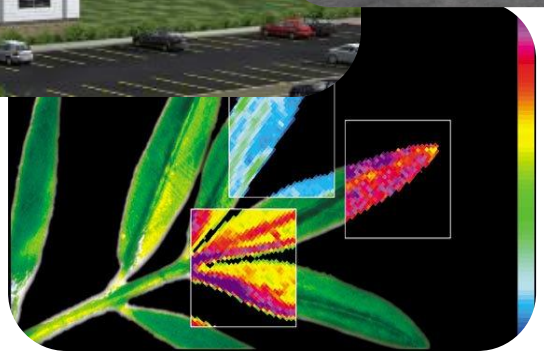
Canadian Light Source Inc.



Our National Synchrotron Science Facility

Dose rate considerations for the BMIT POE3 at the Canadian Light Source

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- Talk consists of
  1. Introduction
  2. Model and parameters used in simulations
  3. Dose rate distribution immediately behind the back wall
  4. Dose rate distribution along the side wall
  5. Dose rate distribution along the roof
  6. Conclusions

1. Introduction

- Canadian Light Source: 2.9 GeV, 500 mA Synchrotron

- BioMedical Imaging and Therapy (BMIT) ID beamline
  - One of 7 beamlines in Phase II
  - Primary Optics Enclosure 3(POE3) houses
    (1) Computed Tomography (CT) monochromator
    (2) Diffraction enhanced imaging (DEI) monochromator
    (3) K-Edge subtraction (KES) monochromator

CT and bremsstrahlung : only 1.5 cm apart vertically

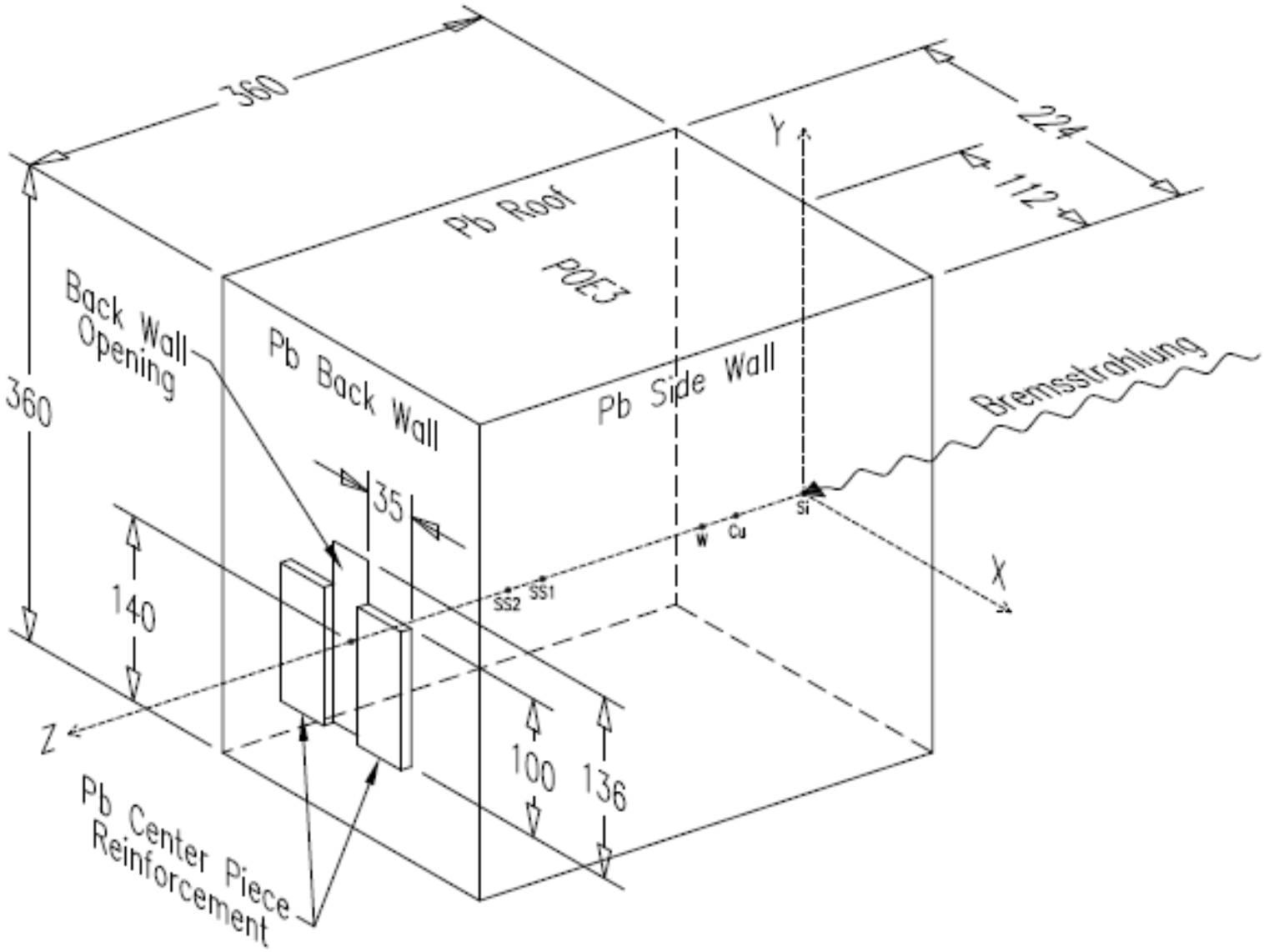
2. Model and parameters used in simulations

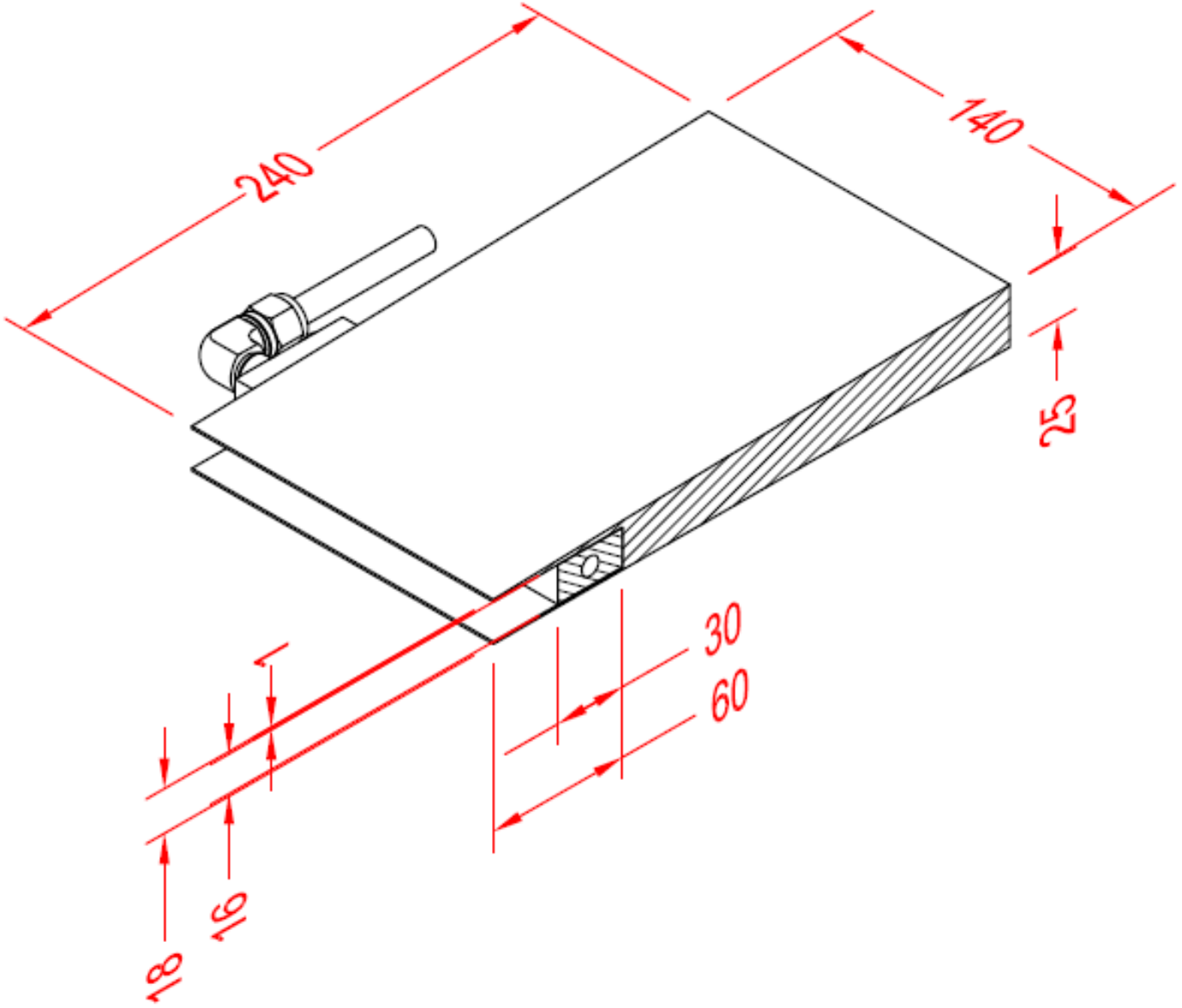
- In POE3 from upstream:

  * Silicon crystal, Si(16.0, 2.0, 1.0) at Z=0.0
  * Copper absorber, Cu(21.4, 1.60, 3.0) at Z=37.0
  * Tungsten beam stop, W(21.4, 1.8, 18.0) at Z=40.0
  * Lead safety shutter 1, SS1(21.4, 15.0, 13.0) at Z=321.0
  * Lead safety shutter 2, SS2(21.4, 15.0, 13.0) at Z=334.0
  * Lead Movable wall, Pb(40.0, 204.0, 13.0) at Z=347.0
  * Lead back wall, Pb(224.0, 360.0, 5.0) at Z=360.0
  * Lead reinforcement, Pb(100.0, 35.0, 8.0) at Z=365.0

  (all in units of cm)

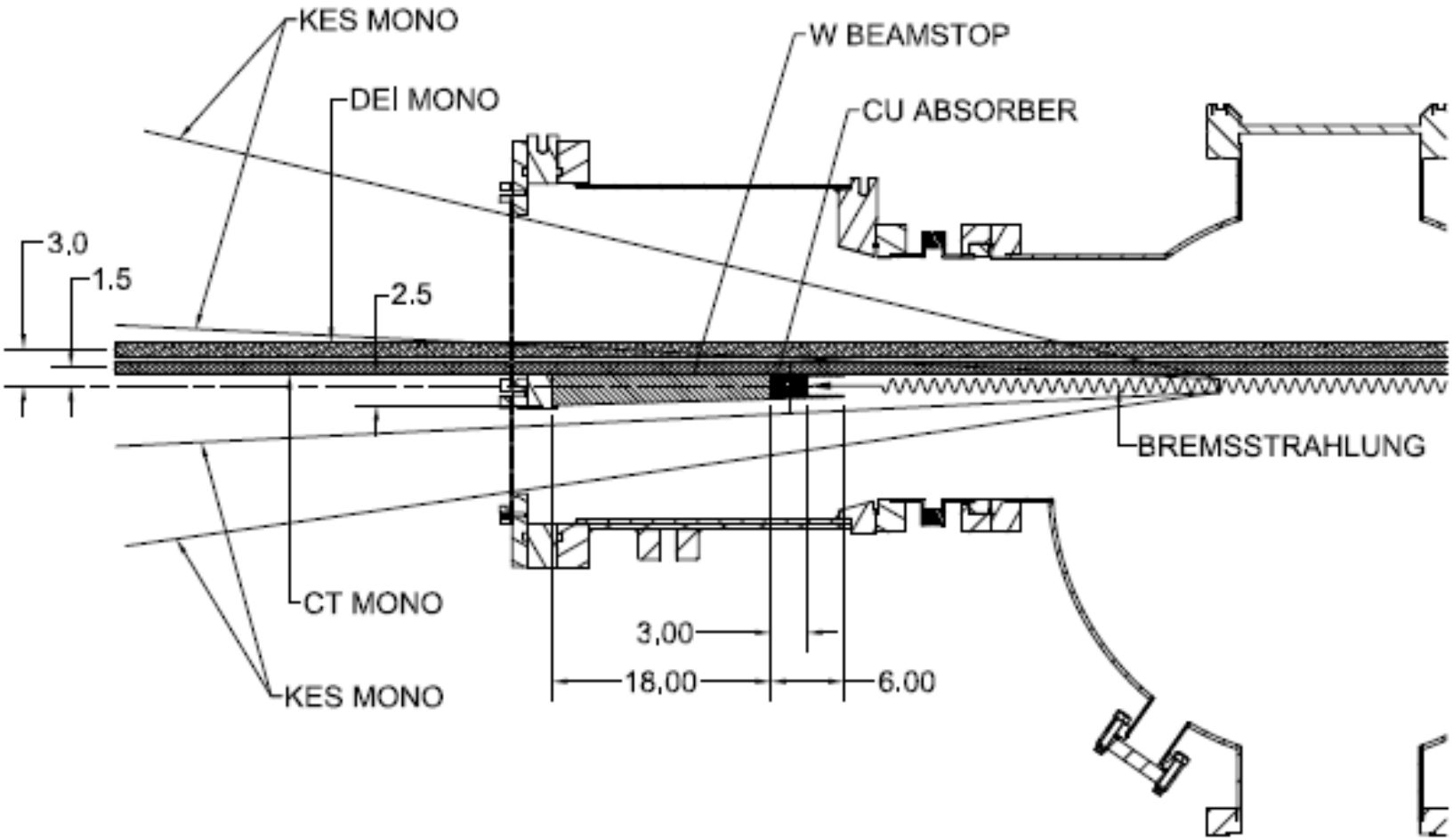
  * Side wall: 3 cm thick lead
  * Roof: 1 cm thick lead


360
224
112
Y
Pb Roof
POL3
Back Wall
Opening
Pb Back Wall
Pb Side Wall
Bremsstrahlung
360
35
140
W
Cu
Si
SS2
SS1
X
Z
100
136
Pb Center Piece
Reinforcement



CENTERLINE SECTION

Cu-W unit: stop bremsstrahlung while letting CT and DEI rays into experimental area



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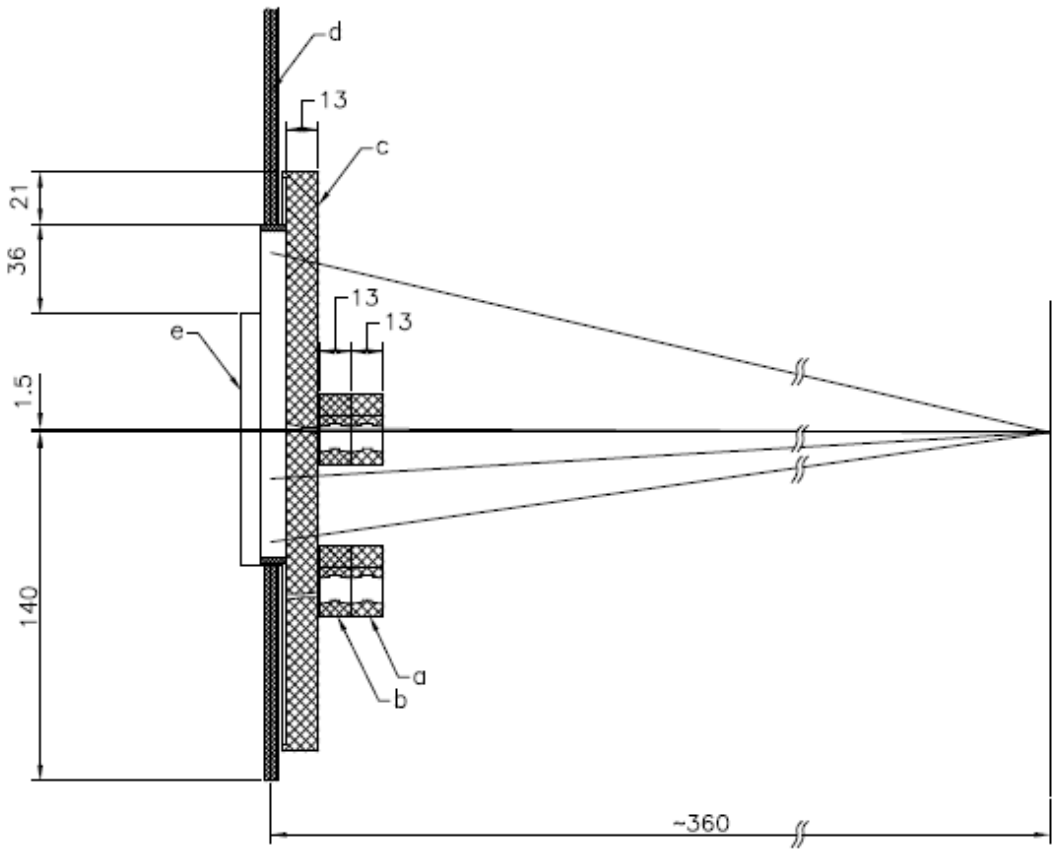
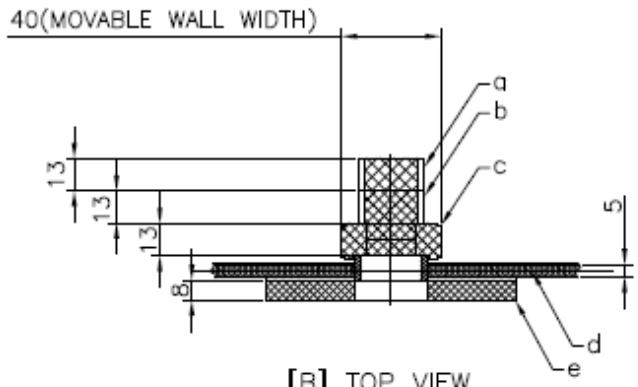


[A] SIDE VIEW



[B] TOP VIEW

- Parameters;
  - * Circulating electron energy: 2.9 GeV
  - * Stored current in the storage ring: 500 mA
  - * Gas pressure: 0.133 μPa (10^{-9} Torr)
  - * Length of ID straight section: 8 m
  - * Minimum photon energy considered: 0.01 MeV
  - * Number of photons (NOFPs): 3.71×10^{9}/h

3. Dose rate distribution immediately behind the back wall

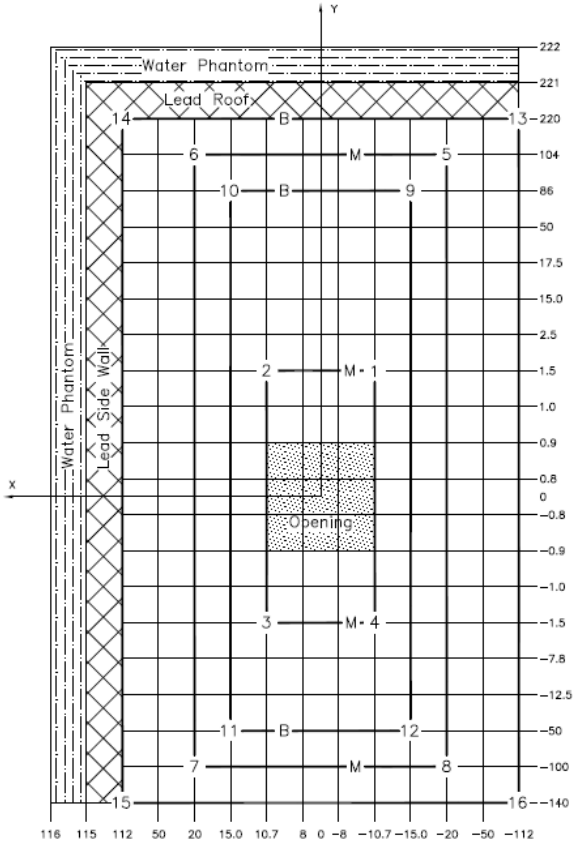
- Energy deposition/volume calculated by EGS4
  * volume=scoring area x 1 cm thick water phantom
  * 5 cm thick water phantom, divided into 1 cm interval

  <u>Safety shutters SS1 and SS2 are open</u>

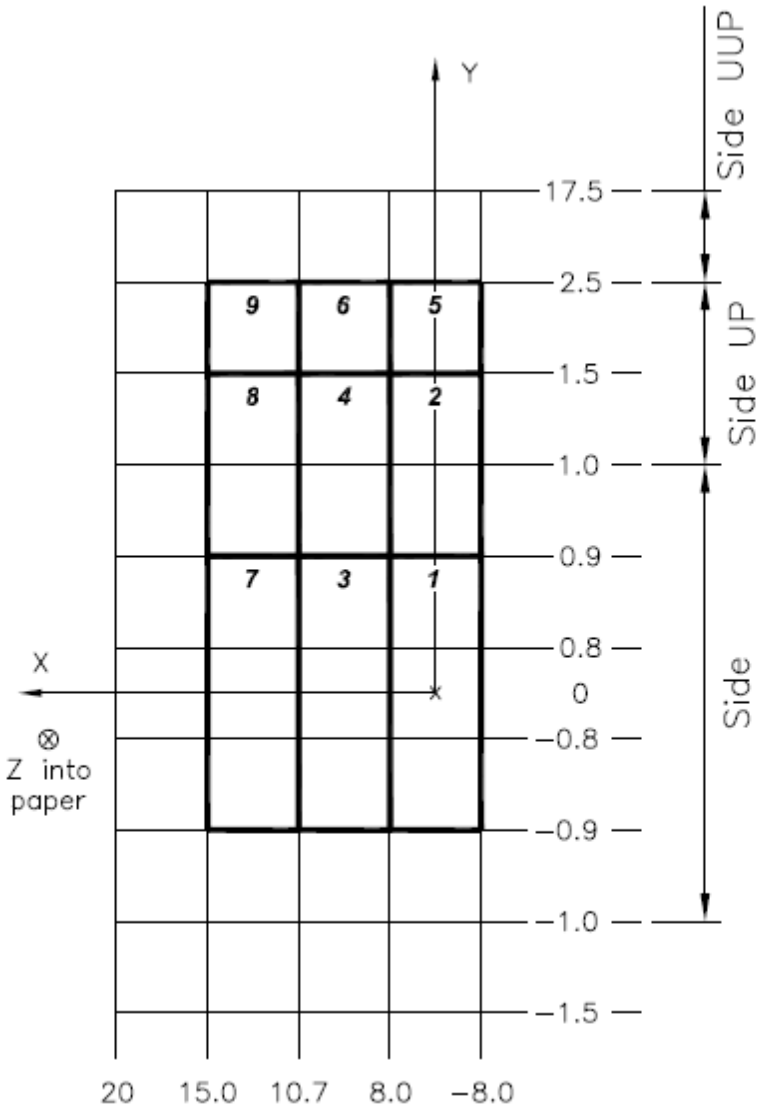
Immediately behind the back wall

* Outer edge of movable wall: *5-6-7-8*
* Hole of movable wall: *1-2-3-4*
* Outer edge of back wall: *13-14-15-16*
* Hole of back wall: *9-10-11-12*

Shaded area: *Shadow image of the tungsten stop*

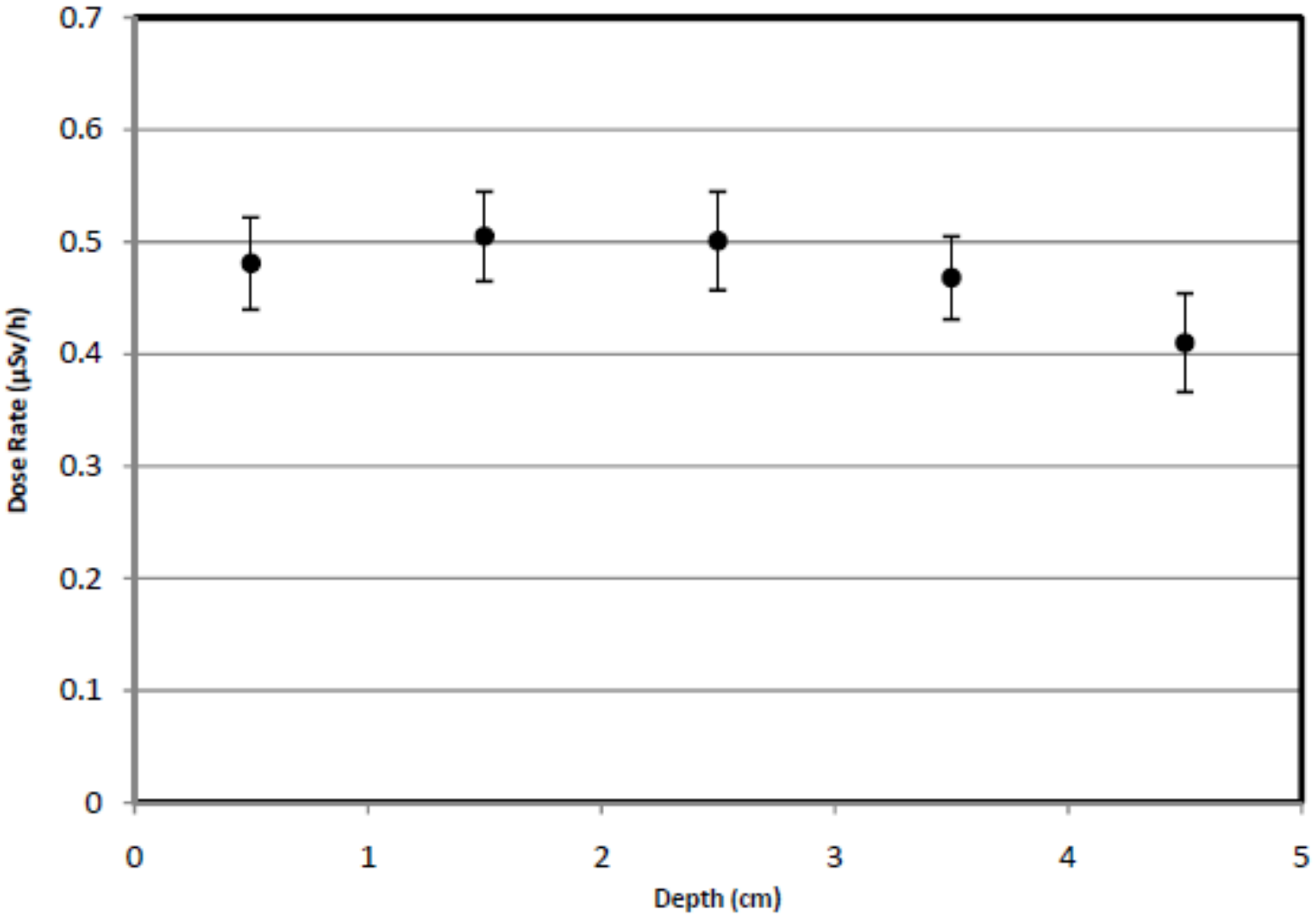


Regions *1, 3*: shadow of W stop, no shield after W stop
Regions *2, 4*: no shield to experimental area
Regions *5, 6, 7, 8, 9*: behind 13 cm thick movable wall



May 2009

- The Maximum dose rate: 0.505 0.040 μSv/h in Region *1*
  between 1 cm and 2 cm


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Dose Rate (µSv/h)
0
1
2
3
4
5
Depth (cm)

4. Dose rate distribution along the side wall

- Side wall: 3 cm thick lead

  * 360 cm long, divided by 12 equal sections

  * from beam axis to inside side wall: 112 cm

  Scoring Area: Side----------30 cm by 2 cm

  Side UP -------30 cm by 1.5 cm

  Side UUP ----- 30 cm by 15 cm

- Recall tungsten stop, W(21.4, 1.80, 18.0) in cm

  Moliere radius (R_M)= 0.92 cm

  3.5 R_M --- expected to contain 99% of radiation radially

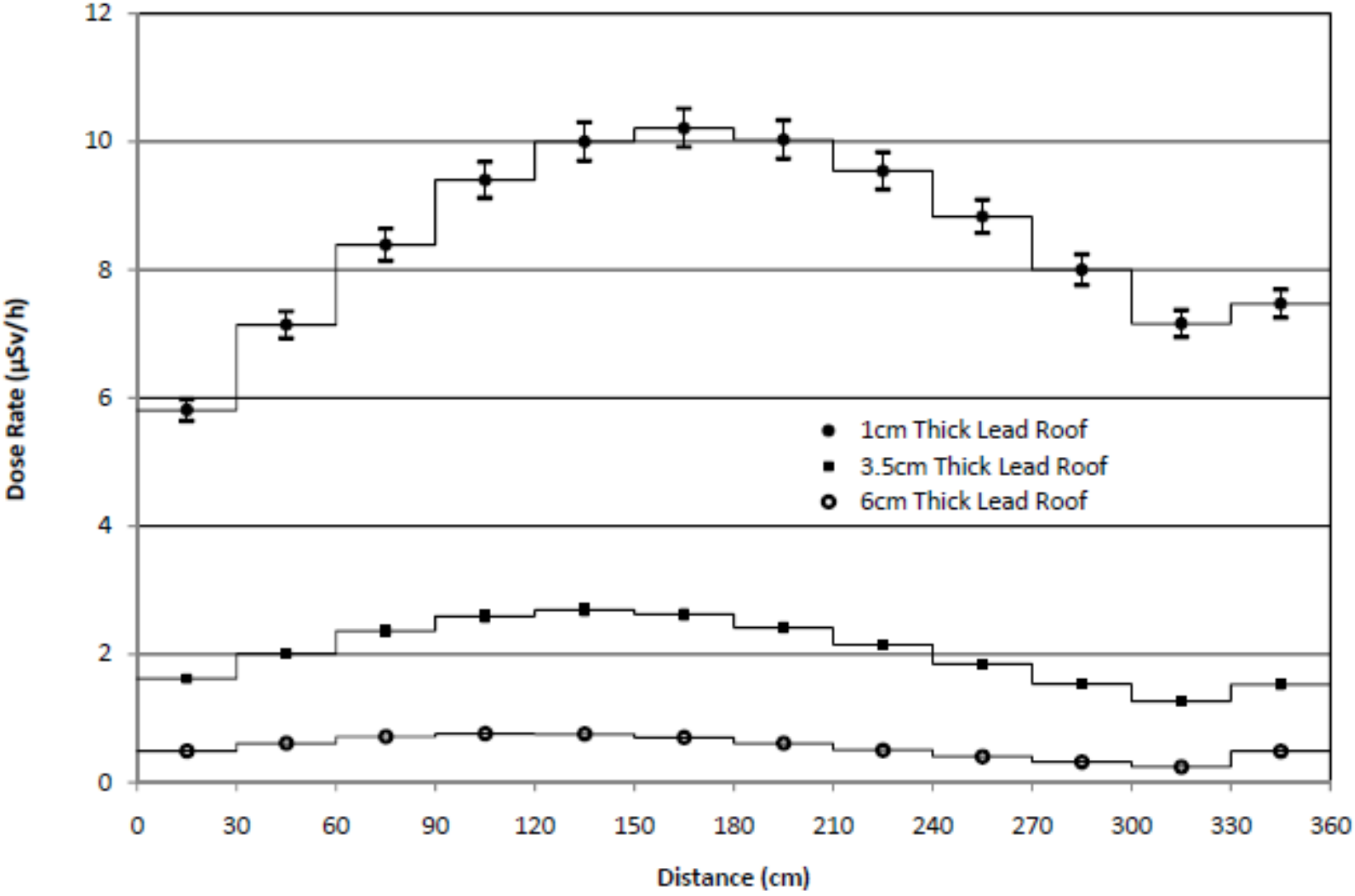
- No appreciable radiation ~ 0.25 0.02 μSv/h

5. Dose rate distribution along the roof

- Roof: 1 cm thick lead
  from beam axis to inside roof: 220 cm
- Scoring area: 30 cm by 224 cm
- Tungsten stop: 0.9 cm high from beam axis
- Dose rate: Max value 10.2 0.3 μSv/h between 150 cm and 180 cm.

- With 3.5 cm thick lead roof: 2.69 0.08 μSv/h between 120 cm and 150 cm

- With 6 cm thick lead roof: 0.76 0.02 μSv/h between 90 cm and 120 cm


12
10
8
6
4
2
0
Dose Rate (µSv/h)
0
30
60
90
120
150
180
210
240
270
300
330
360
Distance (cm)
1cm Thick Lead Roof
3.5cm Thick Lead Roof
6cm Thick Lead Roof

6. Conclusions

- Dose rates due to bremsstrahlung striking the Cu-W unit in the POE3 for the BMIT ID beamline are studied.
  (when CT in use, SS1 and SS2 are open.)

- Dose rate behind the back wall: 0.51 0.04μSv/h.
  along the side wall: 0.25 0.02 μSv/h.

W stop, W(21.4, 1.8, 18.0) is capable of containing the radiation in these two areas.

- Dose rate along the roof:

  * 1 cm thick lead roof----- 10.2 0.3 μSv/h
    (between 150 cm and 180 cm)

  * 3.5 cm thick lead roof----- 2.69 0.08 μSv/h
    (between 120 cm and 150 cm)

  * 6.0 cm thick lead roof------ 0.76 0.02 μSv/h
    (between 90 cm and 120 cm)

For the roof, a local shield of ~ 2.5 cm thick lead block is required.

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CIHR IRSC
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