Calibration of Survey Meters by using A Newly Developed Quasi-Monoenergetic of ~190 keV Photon Field:

A Preliminary Result with Back-Scatter Layout

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Dosimeters to measure ambient dose equivalent rate for photons is calibrated commonly with Am-241 (60 keV) and Cs-137 (662 keV).

due to its long half-life and mono-energy radiation.

To ensure the accuracy of photon dosimeter, it is necessary to determine the response of detector for high energy and low energy.

to know the extent of over-response (or under-response) for energy region of interest ~200 keV photon
~200 keV is missing energy for calibration

Energy (keV)

0 100 200 400 600 800 1000

LOW MIDDLE HIGH

Radio isotope
- Long Half life
  - Am-241 (60)
- Short Half life
  - Ce-139 (166)
  - Cr-51 (321)
  - Cs-137 (662)
  - Co-60 (1275)

X-Ray
- K Fluorescence
- Filtered

Synchrotron

Available option ~200 keV:
- Short $T_{1/2}$ sources
- Broad X-ray beam
- Less affordable
How to obtain 200 keV photon field

Idea:

Backscattered photon has almost constant energy mono-energetic field

“If we choose the Compton-scattered photon to have a scattering angle of 150-180°, its energy range is ~200 keV.”
Uniformity: within 10 % for 10 cm x 10 cm x 10 cm vol.

- Ambient dose rate
- Peak to total ratio
- Uniformity
- Average energy

Back-scatter Layout

Detector to lead (Pb) distance (DPD)

SFD=20 cm

Pb block (10 x 10 x 10 cm³)

Source: Cs-137 of 208 MBq

Iron block (1.4 m x 1.4 m x 0.05 m)

Tested area

Concrete floor
The layout were optimized through calculations and experiments.
\(~200\) keV photon field of B/scatter layout

Calculated photon spectra

- Concrete Floor
- Added Iron

Concrete Cylinder: 
- Radius: 1.5 m
- Thickness: 1.0 m

Iron block: 
- Square of 1.4x1.4 m
- Thickness: 5 cm

Calculated photon spectra at \(~200\) keV using a backscatter layout with a bare concrete floor and with the addition of a iron square on the floor.

Adding iron on the concrete floor decreases the low energy components of the spectra (<155 keV) by a factor of 3.
Calculated dose rate (µSv/hr) for Cs-137 and Co-60

Common upper dose rate limit for environment dosimeters
~200 keV photon field of Filtered X-ray

Merit of backscattered photon field:
✓ Stable and adequate uniform photon field
✓ Adequate ambient dose rate (Filtered X-rays is too intense)
✓ Easy to obtain
Calibration of CsI(Tl) Survey Meters Using Backscatter Field For Energy Response of:

Horiba PA-1000 & Mr.Gamma A2700.

(0.001 ~ 9.999 μSv/h)
For the backscatter field energy, the responses were normalized to the NaI(Tl) TCS–172 survey meter. NaI(Tl) used as a reference survey meter due to it has energy compensation to display more accurate dose value.
a) Mono-energetic field is newly developed using backscatter layout with affordable intensity gamma source. With the same source (Cs-137; 208 MBq), we could obtain 2 energies for dosimeters calibration by;

1. Direct measurement for 662 keV &
2. Indirect measurement for about ~200 keV (back-scatter layout).

✓ Significant dose rate (3.18 µSv/hr) could be obtained with main peak at 189 KeV; FWHM 4.6%.

b) Several recommended X-ray filters are tested to obtain mono-energetic field around 200 keV. The peak width is larger than the developed backscatter field.
Offer Monte Carlo simulations (1): Rad. Detector

Isotropic source was positioned at 10 cm to the central axis of the surface scintillator.

Wrapping materials were not considered.

Quartz window of 5 mm

2” cylinder

E-mail: suffian@unisza.edu.my
Offer Monte Carlo simulations (2) : Rad. Shielding

Air

Clay (t=2 cm)

Parallel beam

E-mail: suffian@unisza.edu.my
Calibration set-up: (with standard calibration check sources)

Source to detector distance 0.5 m.
0.66 m above the ground.

<table>
<thead>
<tr>
<th>Source</th>
<th>Environmental Scintillation survey meters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aloka NaI(Tl)</td>
</tr>
<tr>
<td></td>
<td>Mr. Gamma CsI(Tl)</td>
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<td></td>
<td>Horiba CsI(Tl)</td>
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<tr>
<td>TCS 171</td>
<td>(bg ~30 µSv/hr)</td>
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<tr>
<td>A2700</td>
<td>(0.001 - 9.999 µSv/hr)</td>
</tr>
<tr>
<td>PA-1000</td>
<td>(0.001 - 9.999 µSv/hr)</td>
</tr>
<tr>
<td>(0.05 - 3 MeV)</td>
<td>(&gt; 150 keV)</td>
</tr>
<tr>
<td>(&gt; 150 keV)</td>
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</tr>
<tr>
<td>Background</td>
<td>0.082 ± 0.007</td>
</tr>
<tr>
<td>*Cs-137 (208MBq)</td>
<td>1.930 ± 0.014</td>
</tr>
<tr>
<td>Co-60 (149kBq)</td>
<td>0.242 ± 0.011</td>
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</table>

* measured at distance 3.5m

Dose rate for check sources intensity were corrected by dose rate conversion factor to obtained theoretical dose rate.

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<tr>
<td></td>
<td>(µSv.m².MBq^-1.h^-1)</td>
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<tr>
<td>Cs-137</td>
<td>0.0927</td>
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<tr>
<td>Co-60</td>
<td>0.354</td>
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Ratio of measured-to-theory dose rate.

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