



Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

Angular dependence of $H_p(3)$ – *radial vs. polar rotation* – RAD13-47

Rolf Behrens

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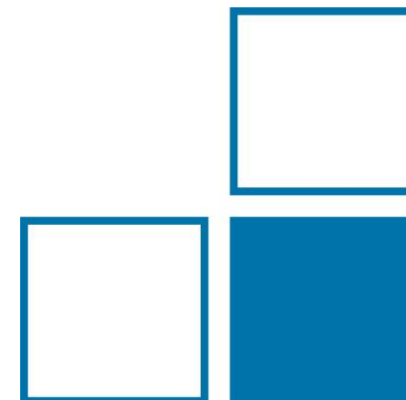
[PTB, Department "Radiation protection dosimetry" \(6.3\)](#)

[Hyperlinks underlined and in light blue](#)

RAD
CONFERENCE

THIRTEENTH INTERNATIONAL CONFERENCE ON RADIATION,
NATURAL SCIENCES, MEDICINE, ENGINEERING, TECHNOLOGY AND ECOLOGY

JUNE 16-20, 2025
HUNGUEST HOTEL SUN RESORT, HERCEG NOVI, MONTENEGRO

The banner has a dark blue background with white and orange text. The word 'RAD' is in large orange letters, and 'CONFERENCE' is in white. The conference details are in white text on the right side.

Introduction

Definition $H_p(3)$

Radiation transport simulations for $H_p(3)$ (EGSnrc, EGSpp)

Results for photons

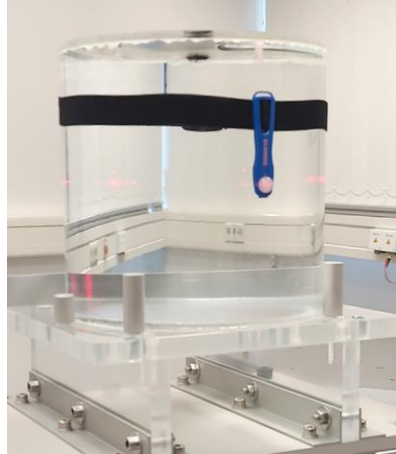
Eye lens dosemeters for $H_p(3)$

Typical eye lens dosemeter



<https://awst.mirion.com/leistungen-produkte/teilkorperdosimetrie/augenlinsendosimeter/>

usual type test geometry



Photograph: PTB, Khanbabaee

radial rotation

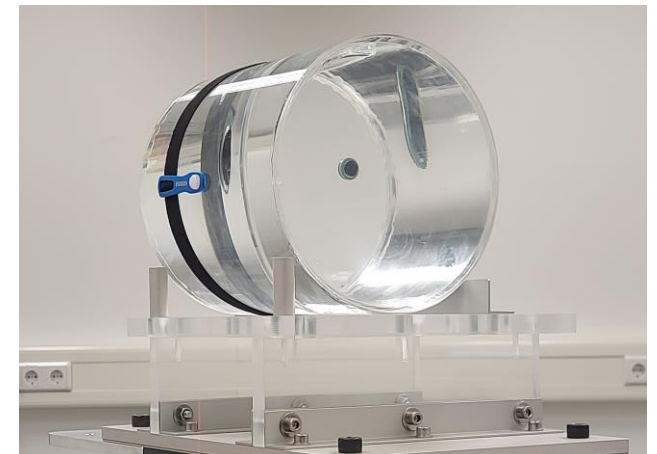
but
... typical irradiation geometry:
oblique from bottom



<https://www.klinikum-lueneburg.de/diagnostische-und-interventionelle-radiologie/interventionelle-radiologie/>

vs.

→ additional type test geometry:
oblique from bottom



Photograph: PTB, Khanbabaee

polar rotation

The same conventional quantity (true) value?

In other words: the same conversion coefficient for $H_p(3)$ for radial and polar rotation?

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Personal dose equivalent at a **depth of 3 mm in the person** at the point where the dosimeter is worn, $H_p(3)$

- Conservative: $H_p(3) \geq H_{\text{lens}}$ (homogeneous field)
- 3 mm is the approximate depth of the eye lens



Eye lens dosimeter worn at representative position

Accordingly:



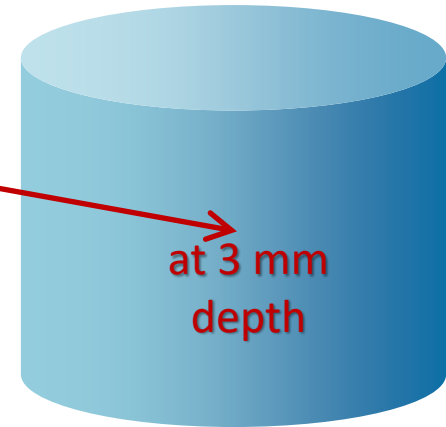
$$H_p(10) \geq E$$



$$H_p(0.07) \geq H_{\text{local skin}}$$

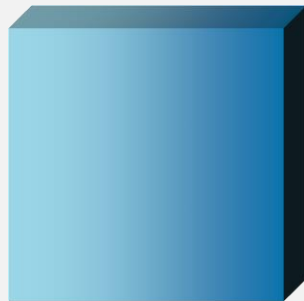
For calibration at a depth of 3 mm *in a cylinder phantom* made of ICRU 4-element tissue, $H_p(3)$

- Conservative: $H_p(3) \geq H_{lens}$ (homogeneous field)
- 3 mm is the approximate depth of the eye lens



at 3 mm depth

Accordingly:



$$H_p(10) \geq E$$



$$H_p(0.07) \geq H_{local\ skin}$$

Eye lens dose represented at 3 mm depth

Calibration *on* a waterfilled PMMA cylinder phantom to mimic the backscatter of a person:

$H_p(3)$



Eye lens dosimeter on appropriate phantom

Accordingly:



$H_p(10)$



$H_p(0.07)$

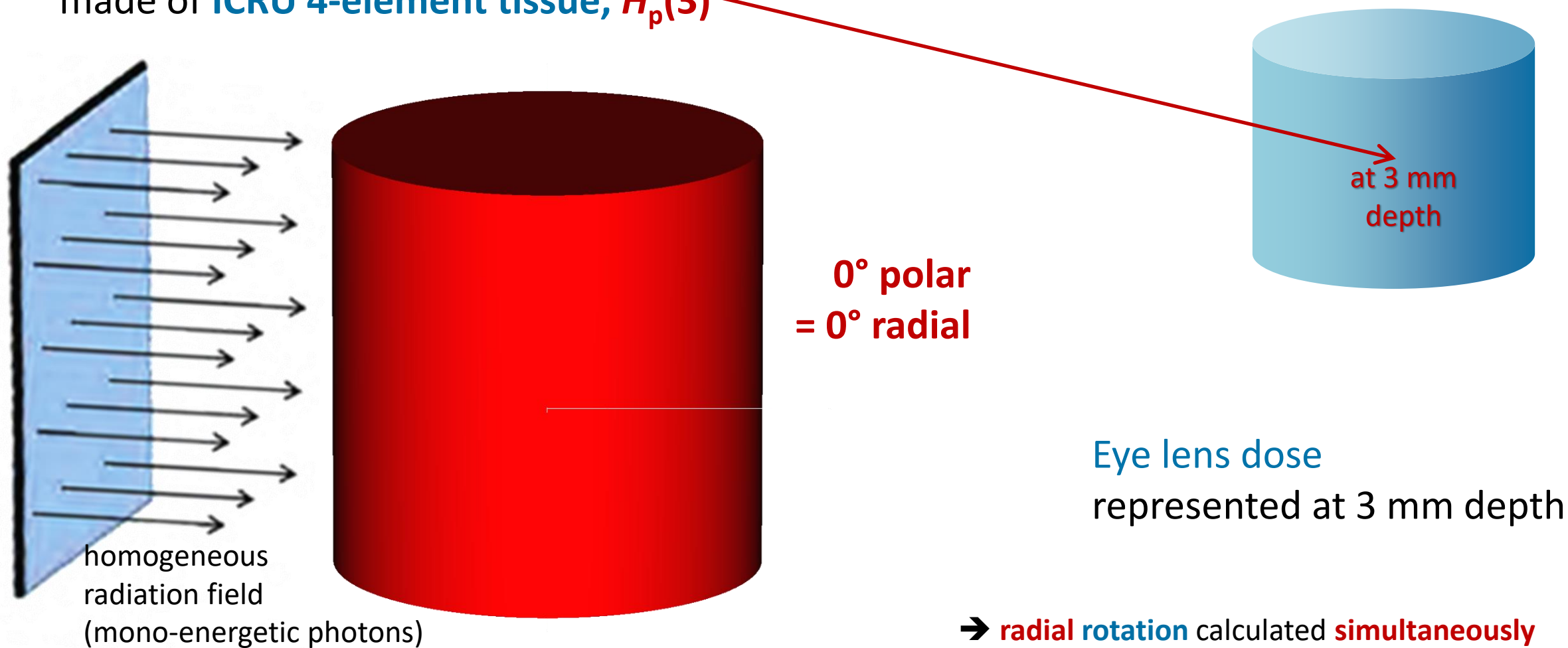
Introduction

Definition of $H_p(3)$

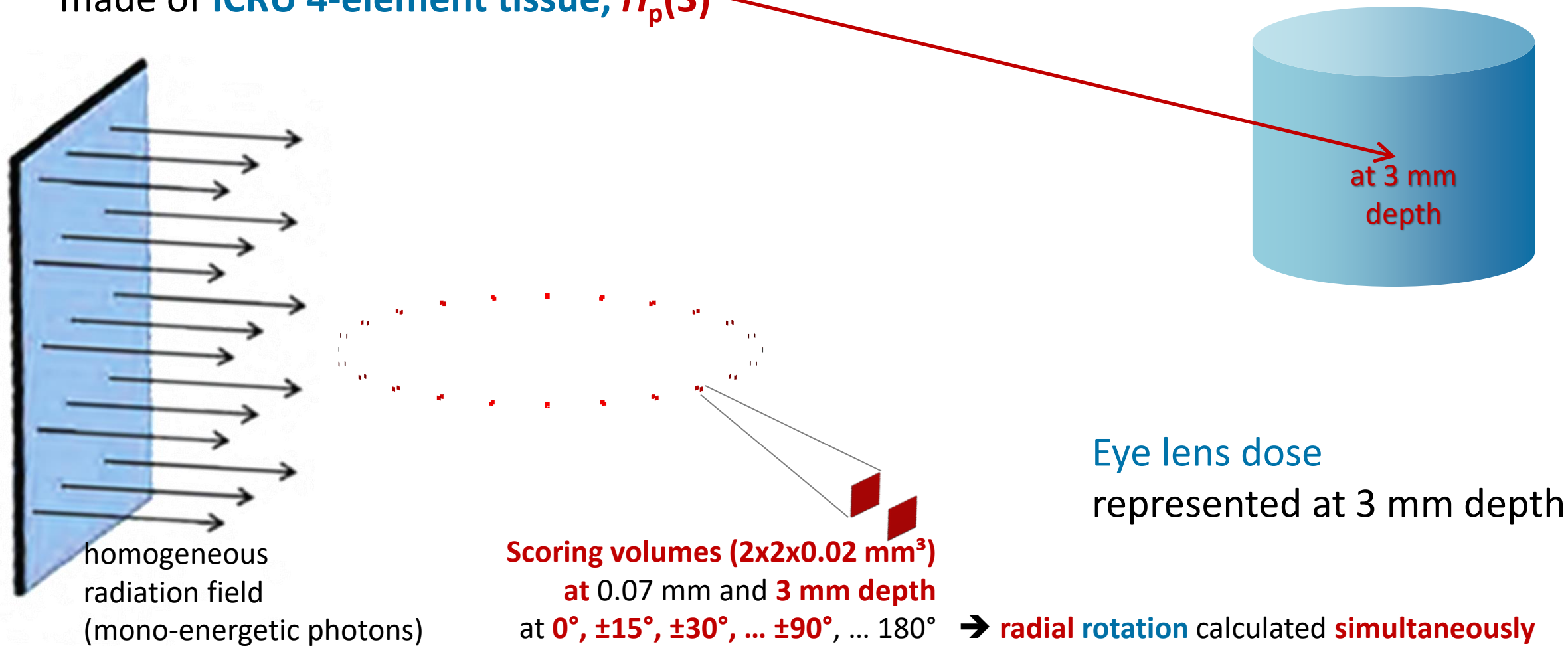
Radiation transport simulations for $H_p(3)$ (EGSnrc, EGSpp)

Results for photons

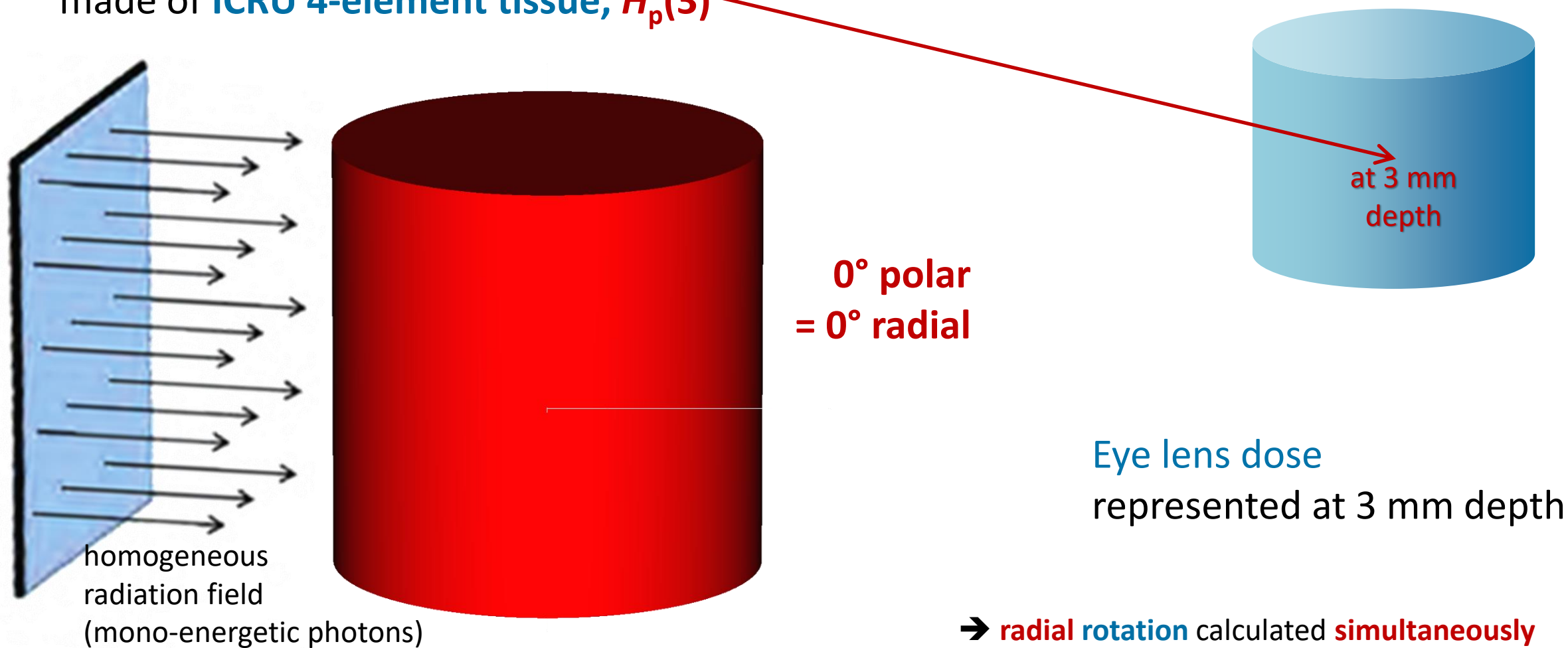
Calculation at a depth of 3 mm *in a cylinder phantom* made of ICRU 4-element tissue, $H_p(3)$



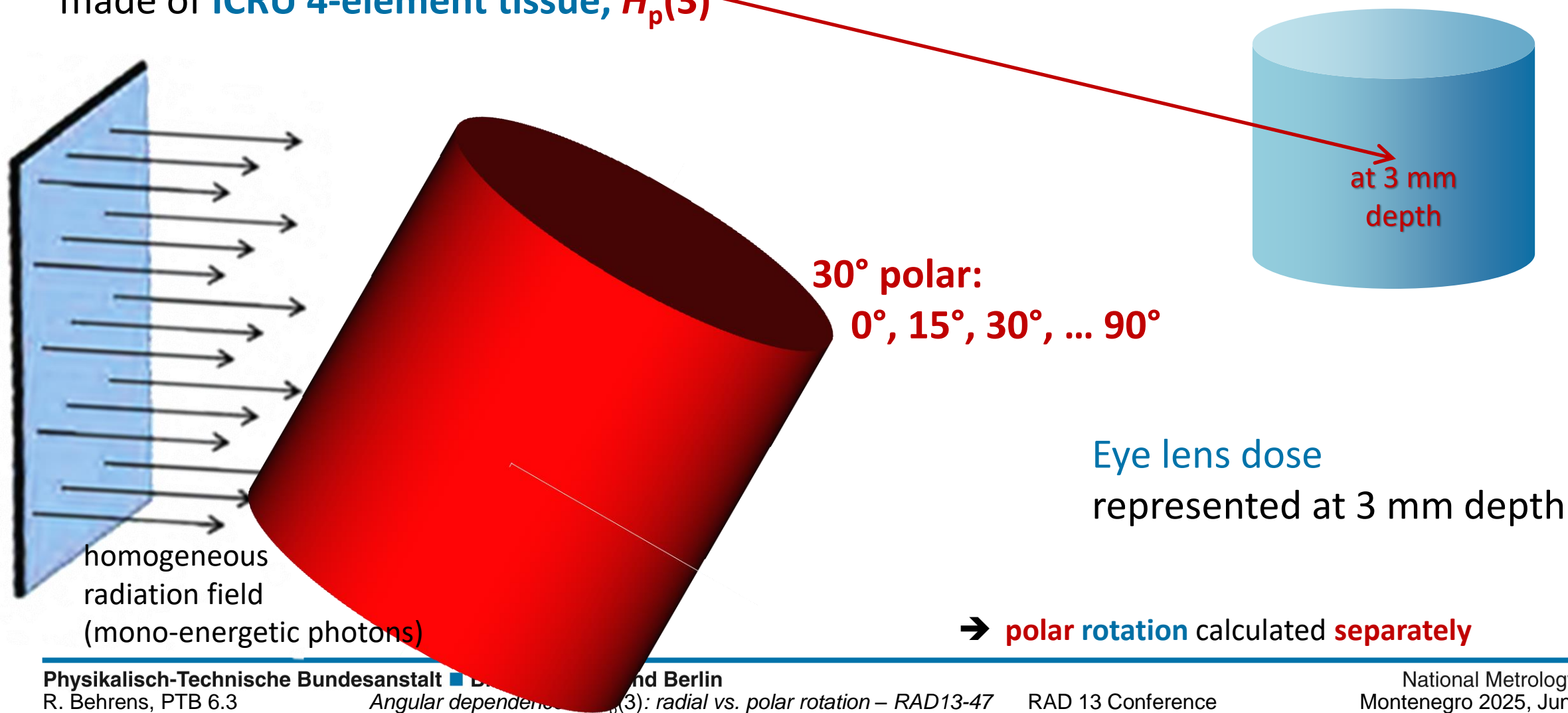
Calculation at a depth of 3 mm in a cylinder phantom made of ICRU 4-element tissue, $H_p(3)$



Calculation at a depth of 3 mm in a cylinder phantom made of ICRU 4-element tissue, $H_p(3)$



Calculation at a depth of 3 mm *in a cylinder phantom* made of ICRU 4-element tissue, $H_p(3)$



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EURADOS
European Radiation Dosimetry Group e.V.

EURADOS Report 2012-02
Braunschweig, April 2012

ORAMED: Optimization of Radiation Protection of Medical Staff

Vanhaver F., Carinou E., Gualdrini G., Clairand I., Sans Merce M., Ginjaume M., Nikodemova D., Jankowski J., Borden J-M., Rimpler A., Wach S., Martin P., Struelens L., Krim S., Koukorava C., Ferrari P., Mariotti F., Fantuzzi E., Donadille L., Itié C., Ruiz N., Carnicer A., Fulop M., Domienik J., Brodecki M., D.

Vanhaver et al.

cylinder of 4 elements ICRU tissue (10.1% H, 11.1% C, 2.6% N and 76.2% O) with a mass density of 1.0 g cm^{-3} .

2.3.1 Air kerma to $H_p(3)$ conversion coefficients

$H_p(3)$ was calculated at the depth of 3 mm below the phantom surface in a set of forty scoring circular sector volumes (Figure 2.1). The values were evaluated with MCNP5 and PENELOPE (both used by CEI). A study on the influence of the usage of different photon interaction libraries was performed at ENEA with MCNPX comparing mcplib04 (White, M. C. 2003) and the older mcplib02 (Hughes, H. G. 1996).

Mono-energetic photons were transported with source energies from 10 keV to 10 MeV, in an aligned and expanded field. In Figure 2.1 the irradiation model is shown.

A series of 23 monochromatic photon beams and 22 different incident angles were analyzed (Table 2.1).

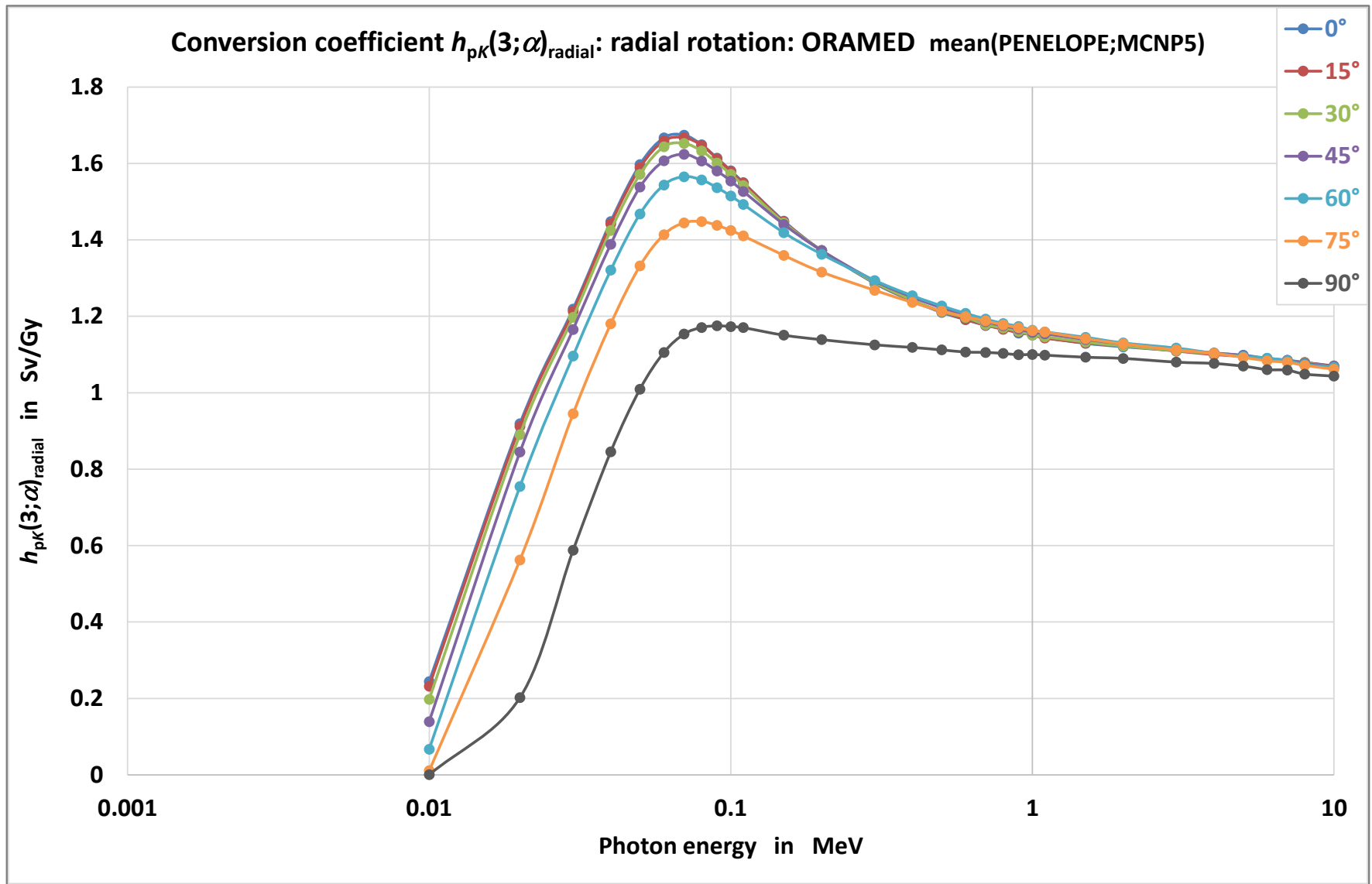
Particular attention was devoted to the evaluation of photon-electron non equilibrium at 3 mm depth occurring for energies above 1 MeV source photons with MCNP5 and PENELOPE. Even if this energy domain is rather unusual for direct irradiation of the eye, it is anyway necessary to point out this effect shown in Figure 2.2.

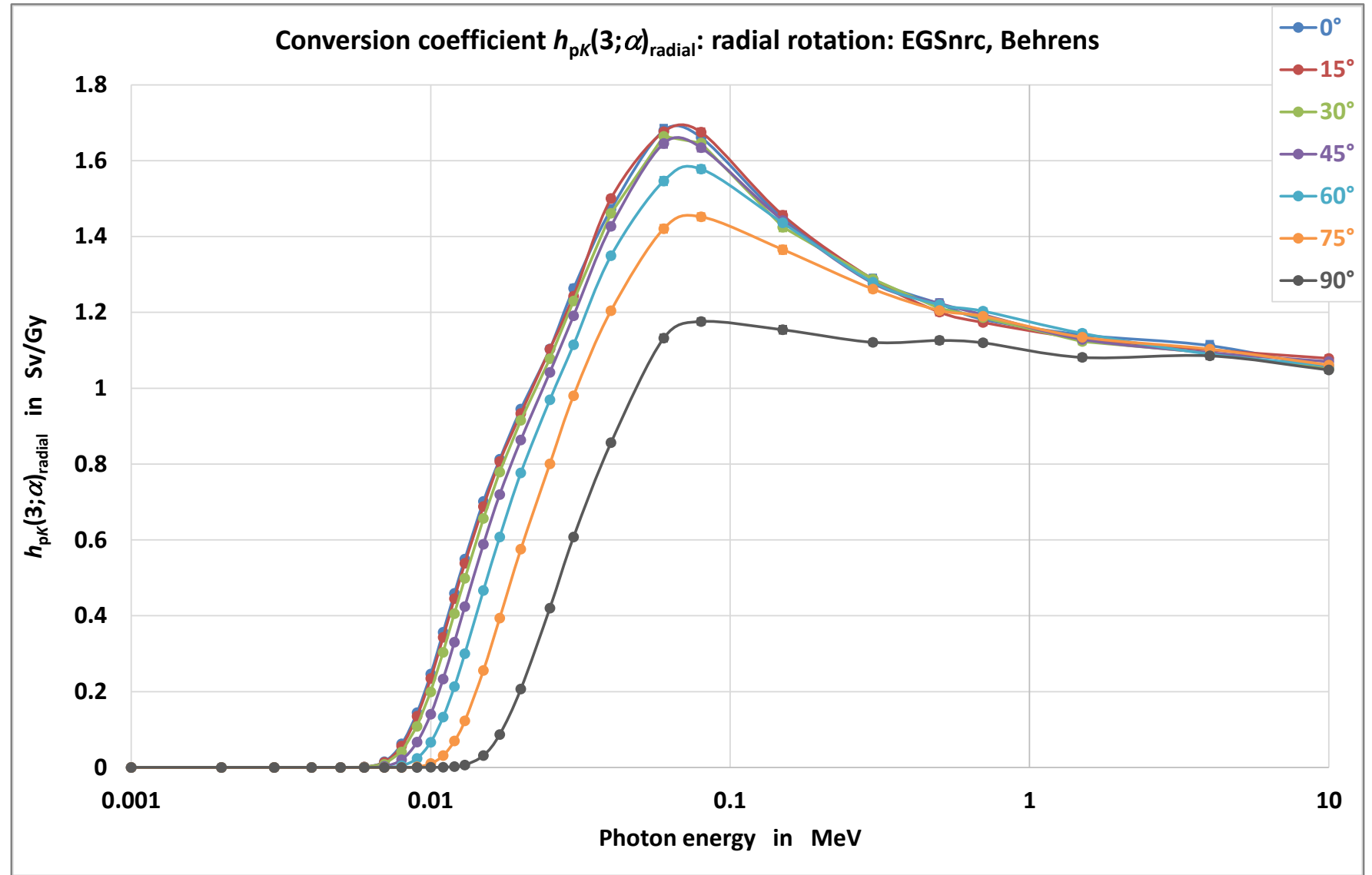
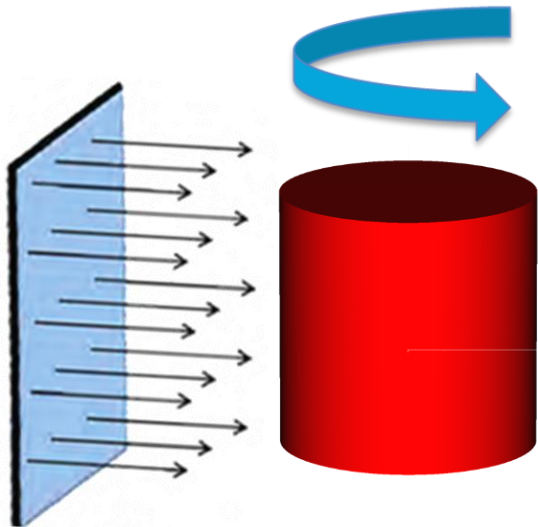
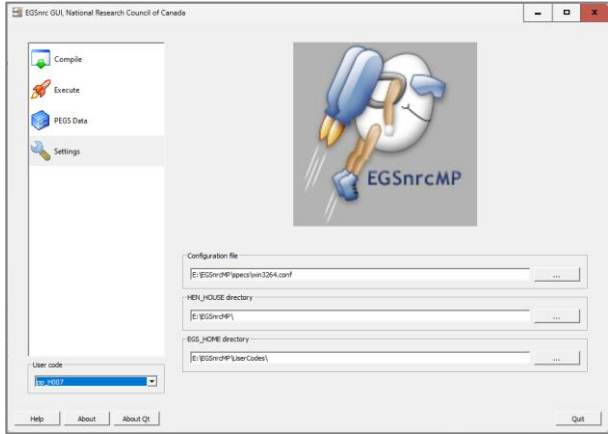
Figure 2.1: Schematic view of the set of forty scoring circular sector volumes used to provide $H_p(3)$.

Table 2.1: Photon beams energy and directions with respect to the normal to the incident surface of the phantom.

Energy	Angles
10, 15, 20, 30, 40, 50, 60 keV,	0°, 10°, 20°, 30°,
70, 80, 90, 100, 200 keV,	40°, 45°, 50°, 60°, 70°, 75°,
300, 400, 500, 600, 800 keV,	80°, 90°, 100°, 110°, 120°,
1, 2, 3, 6, 8, 10 MeV,	130°, 140°, 145°, 150°, 160°, 170°, 180°.

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$$\frac{\text{Ratio: EGSnrc}}{\text{mean}(PENELOPE;MNCN5)}$$

EURADOS
European Radiation Dosimetry Group e. V.

EURADOS Report 2012-02
Braunschweig, April 2012

Cross section variability

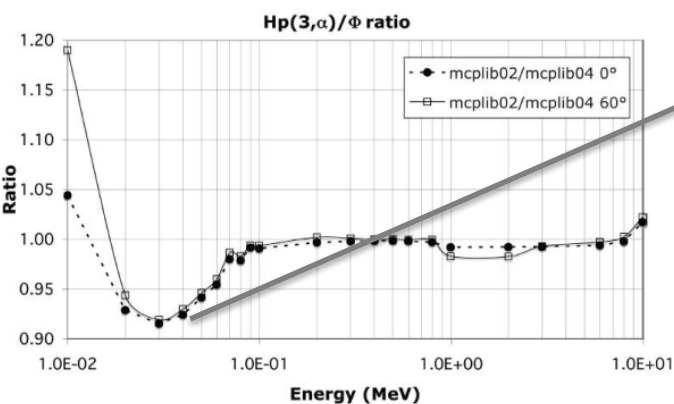
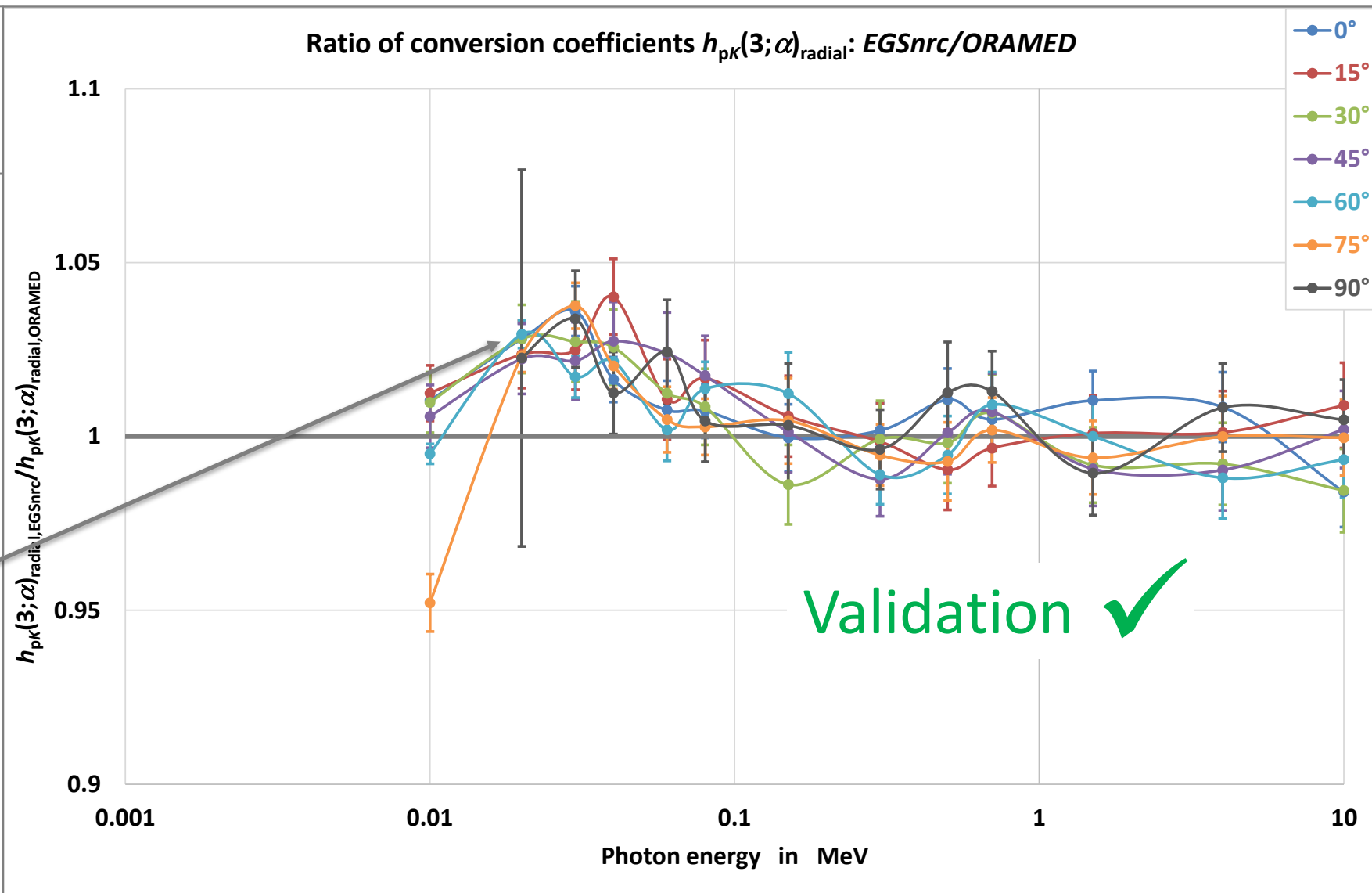
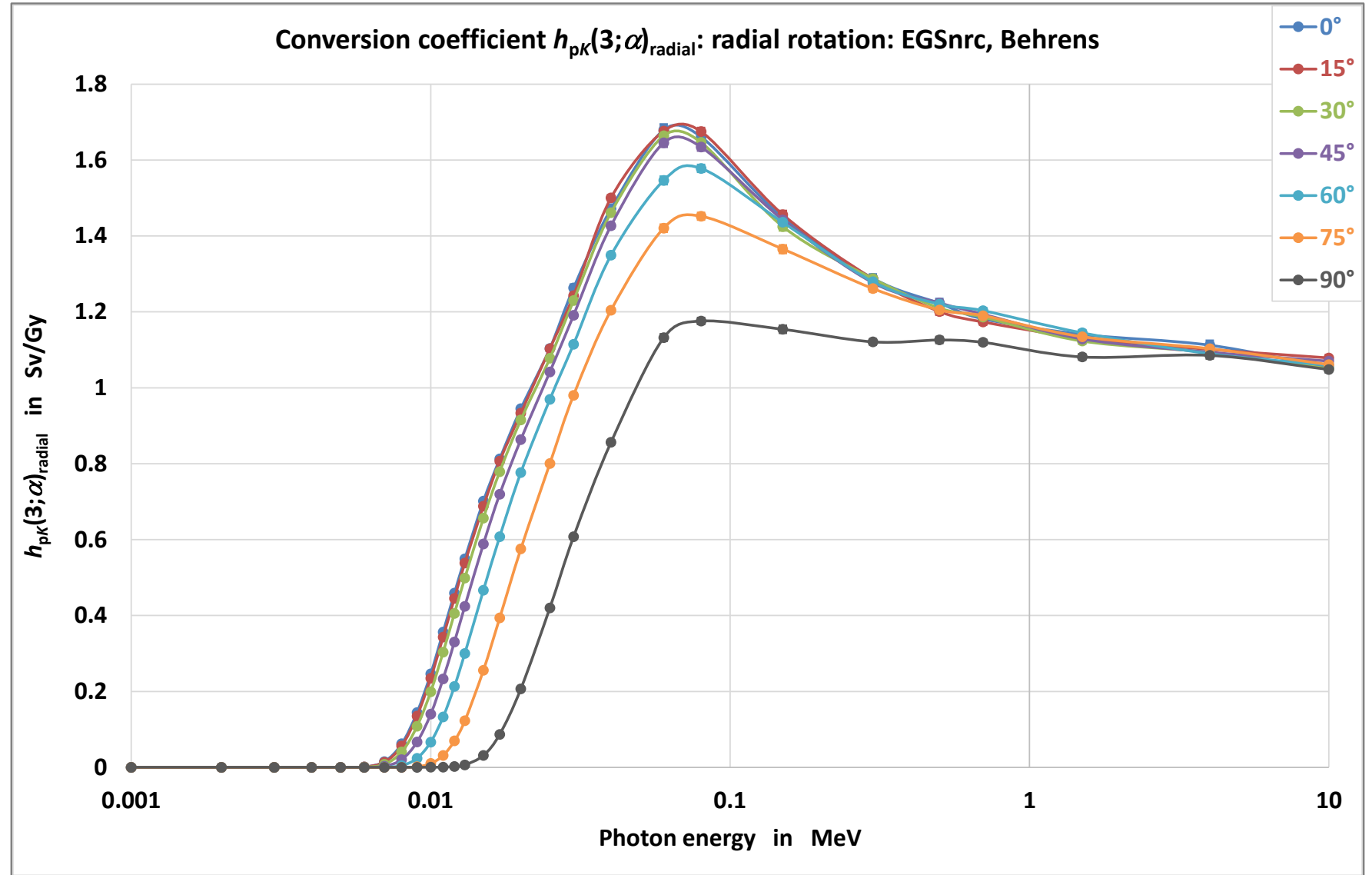
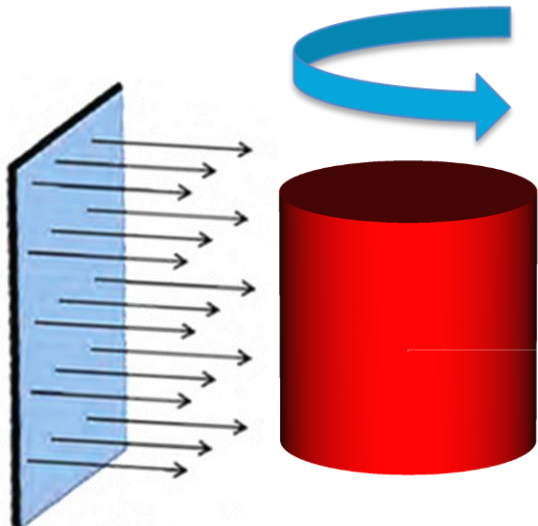
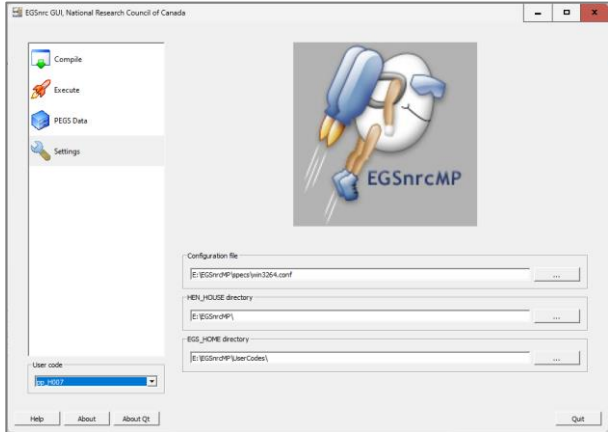
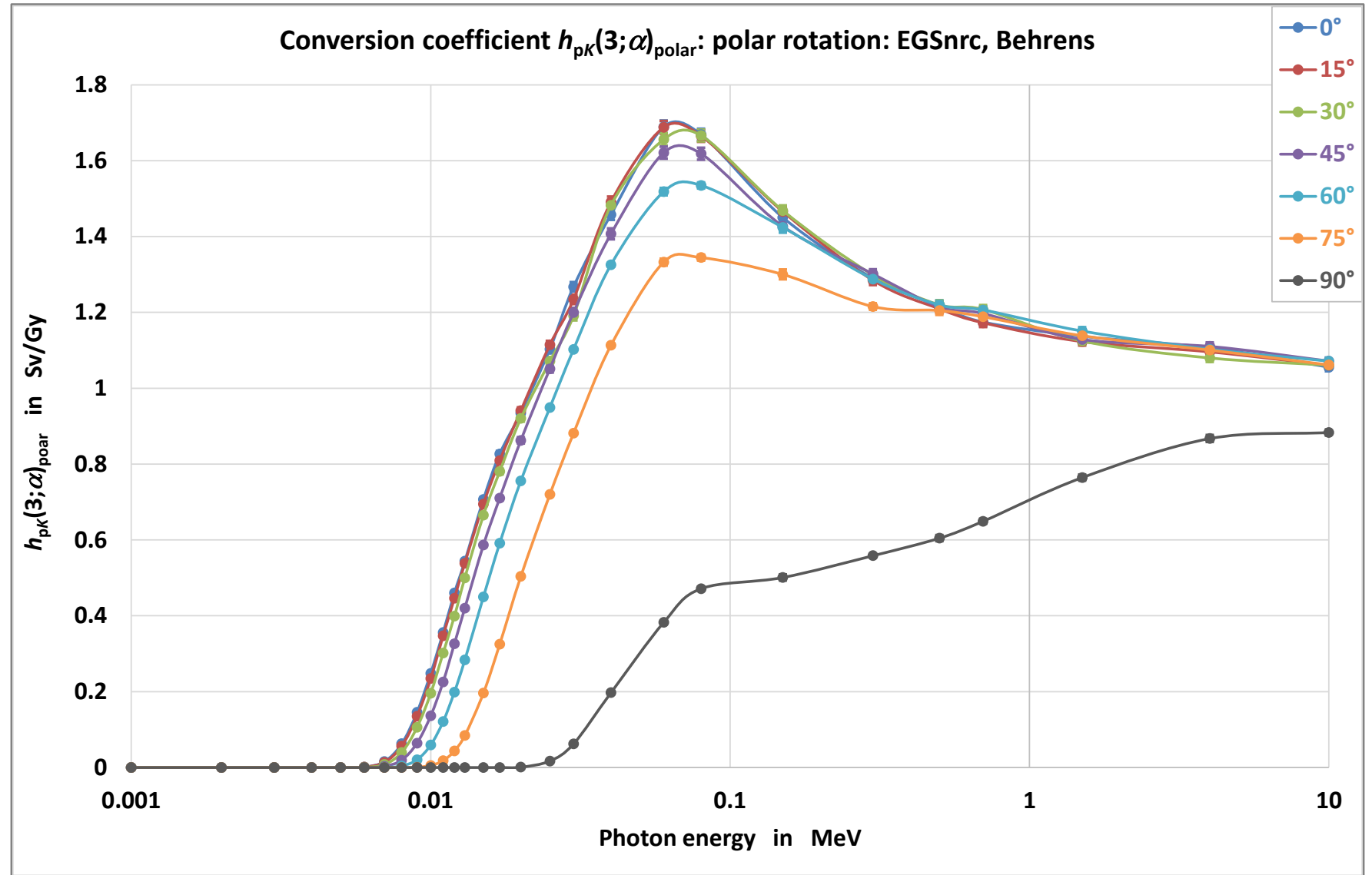
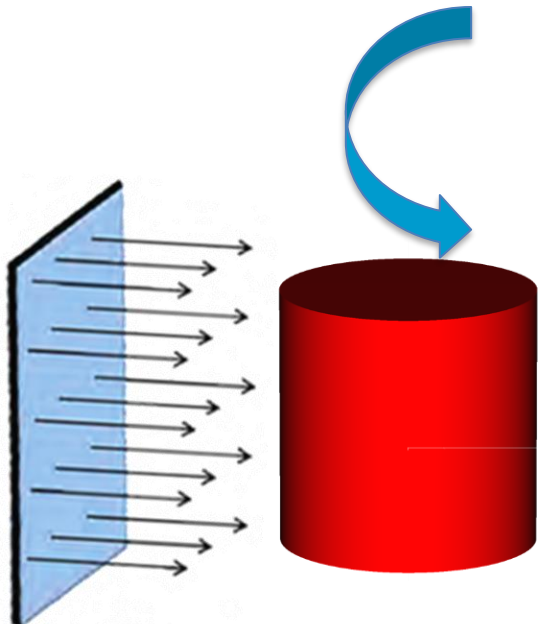
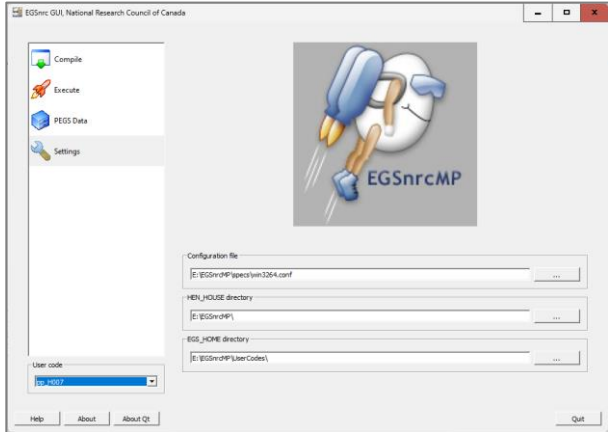
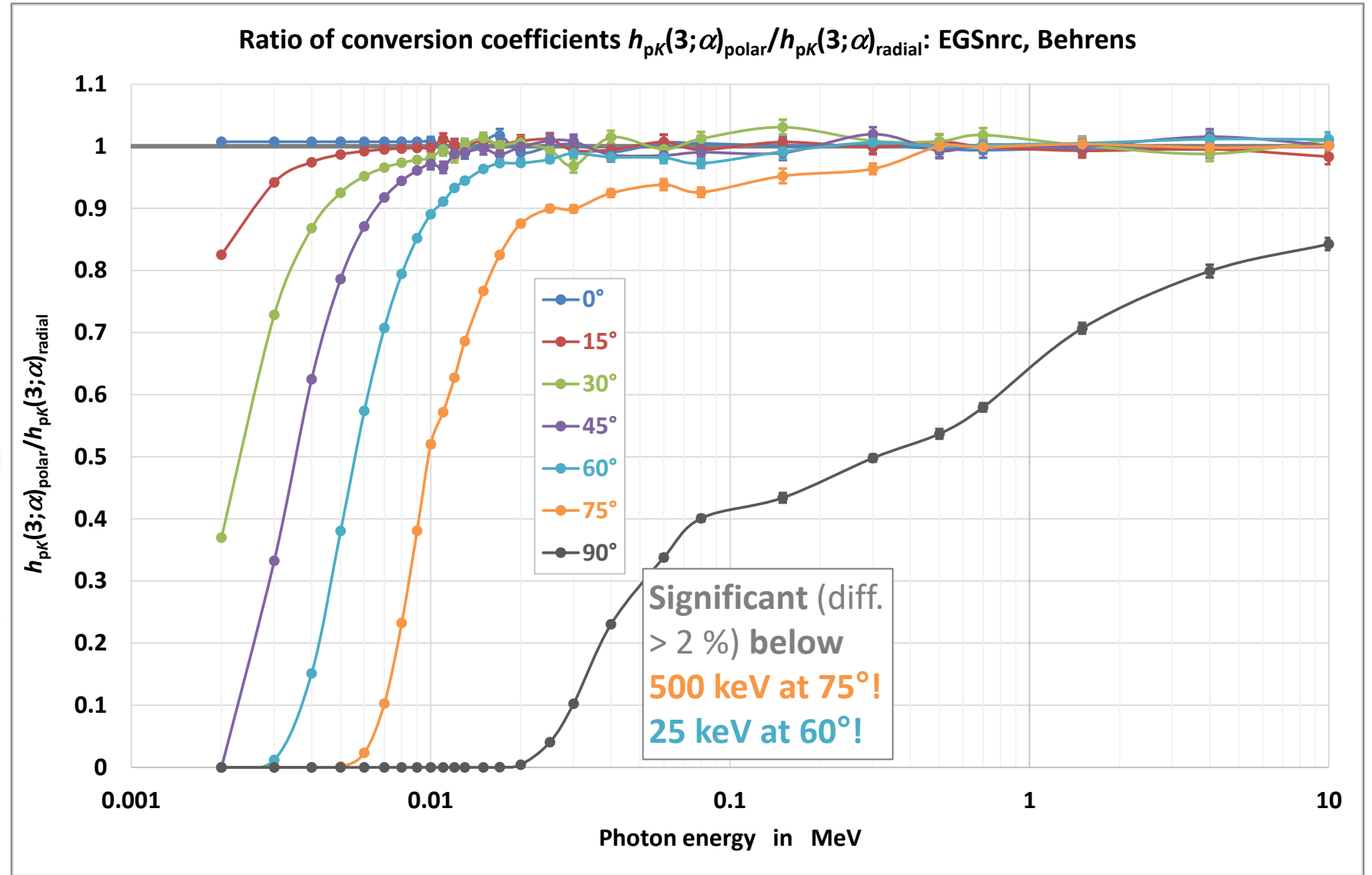
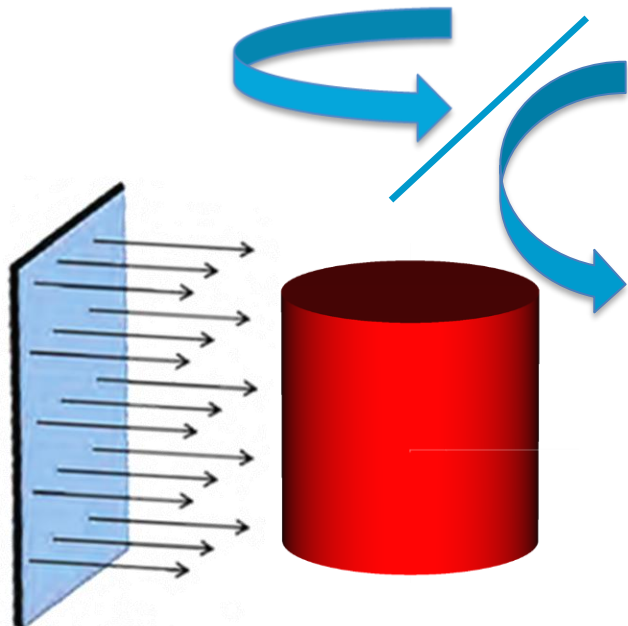
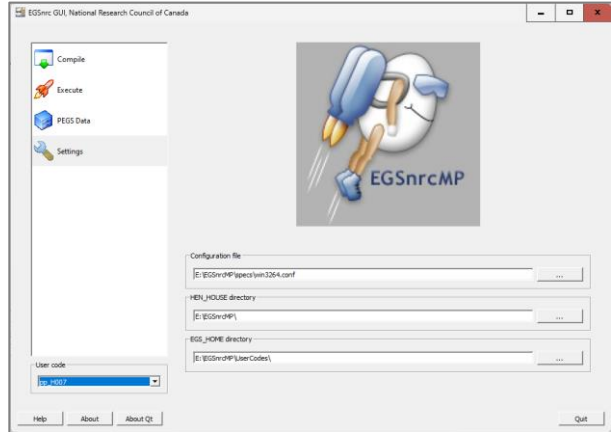


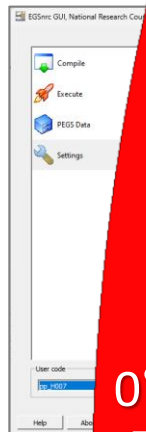
Figure 2.10: $H_p(3)/\phi$ ratio between values based on mcplib02 and mcplib04











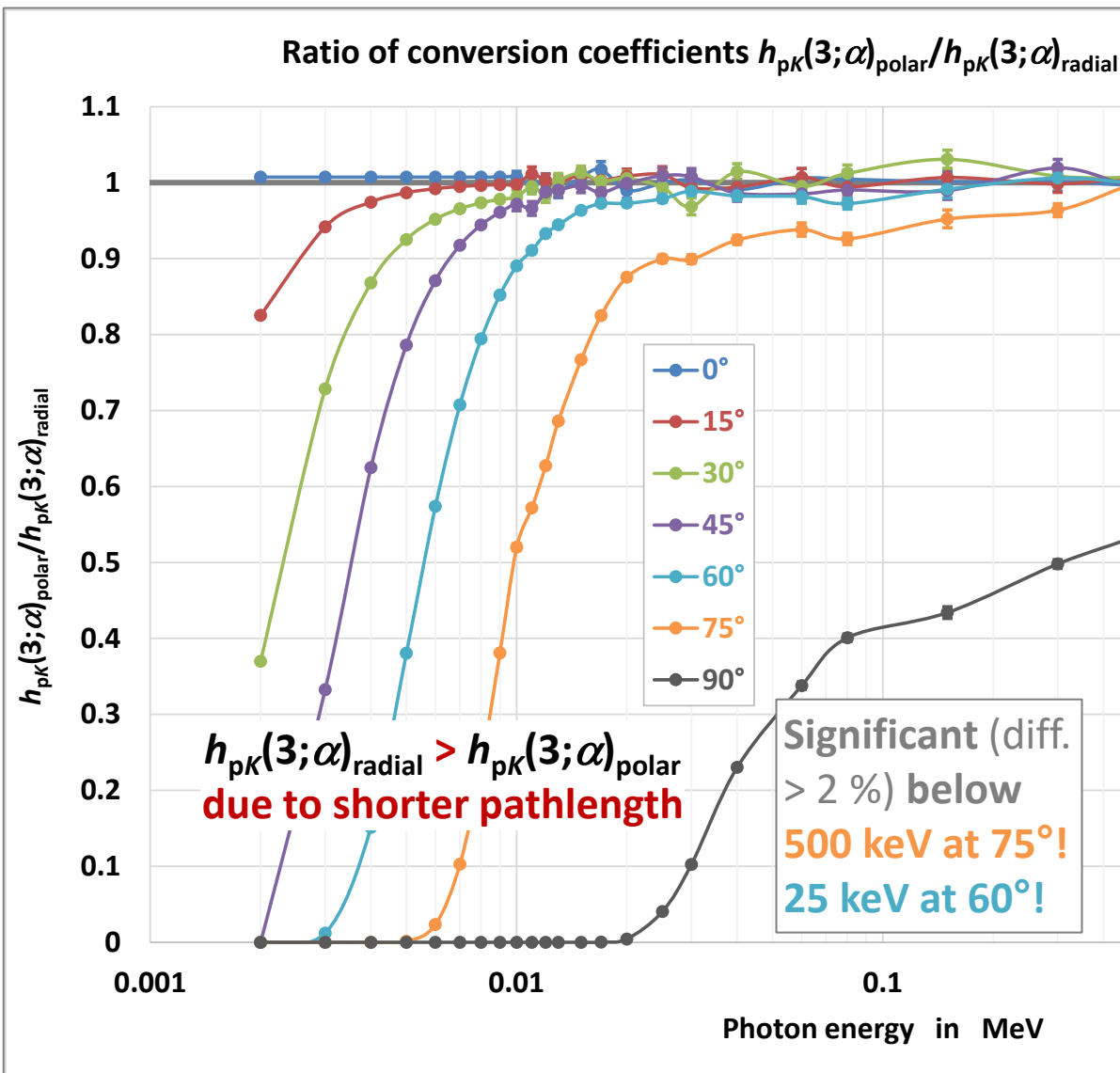
Cylinder:
view from top

0° radial
→ 3.00 mm

60° radial
→ 5.75 mm

75° radial
→ 9.8 mm

90° radial
→ 24.3 mm



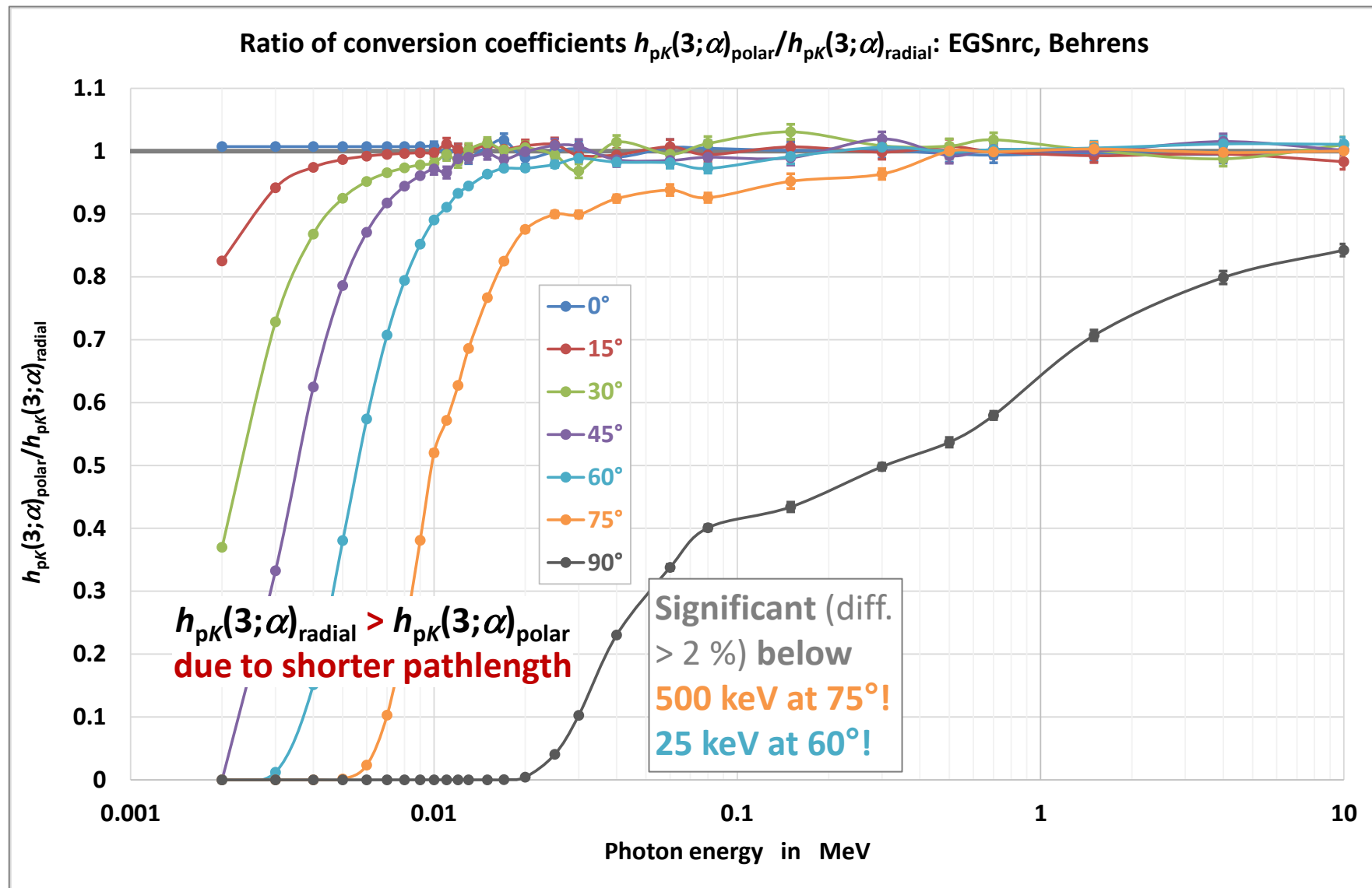
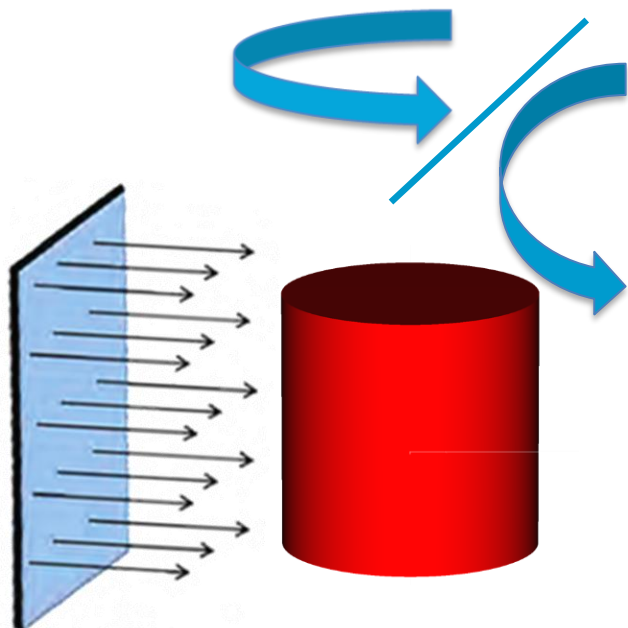
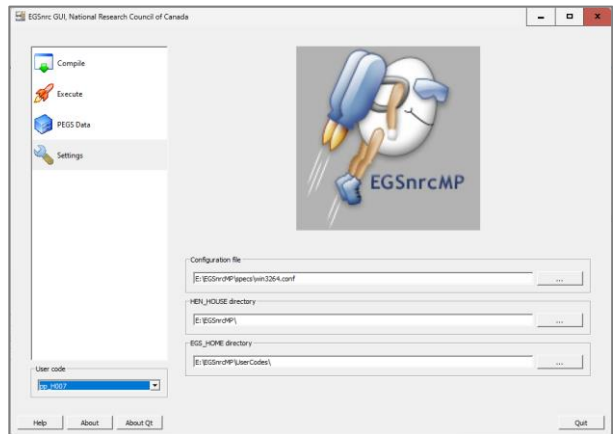
Cylinder:
view from side

0° polar
→ 3.00 mm

60° radial
→ 6.00 mm

75° polar
→ 11.6 mm

90° polar
→ 100 mm



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06/2025

