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SEIBERSDORF LABORATORIES

2240 IRRADIATED PERSONAL DOSEMETERS FOR THE EURADOS IC2014 INTERCOMPARISON AT SEIBERSDORF

IM2015 Conference, Bruges/Belgium, April 20-24 2015

Seibersdorf
30 km to the south of Vienna

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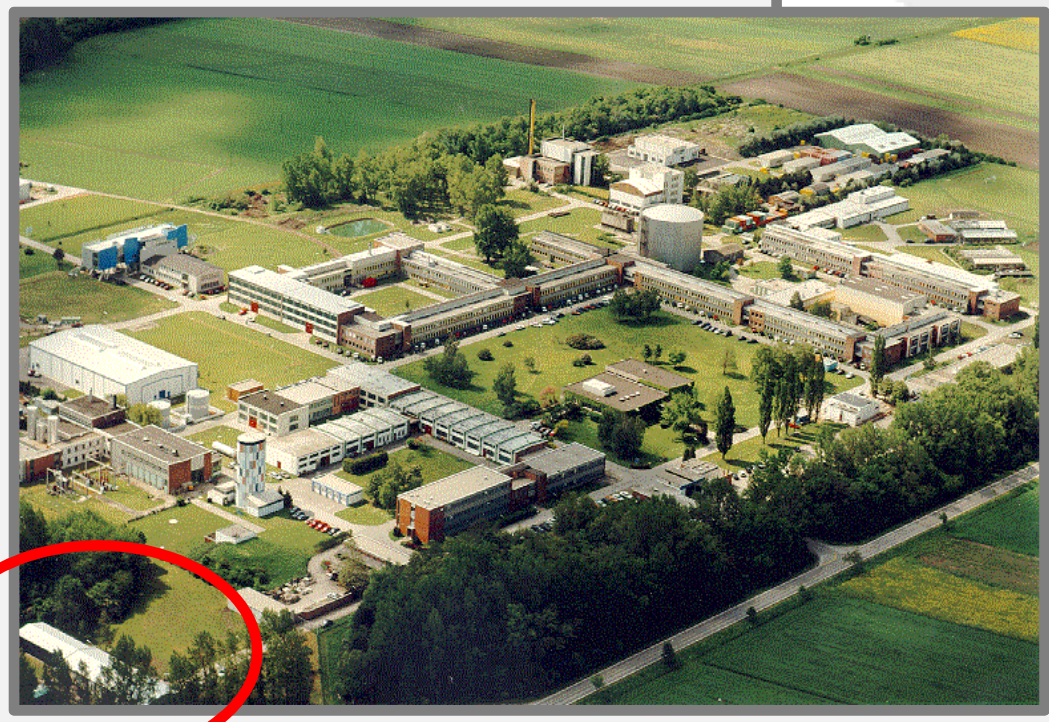

Dosimetry Laboratory Seibersdorf (DEL)

Testing and Calibration Laboratory
Confirmation of Accreditation

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Measurement hall
(320 kV X ray unit, $^{137}Cs/^{60}Co$ reference facility)


AKKREDITIERUNG AUSTRIA

Prüfstelle / Testing Laboratory

Seibersdorf Labor GmbH

EN ISO/IEC 17025:2005

Testing and Calibration Laboratory
Confirmation of Accreditation

SEIBERSDORF LABORATORIES

AKKREDITIERUNG AUSTRIA

Prüfstelle / Testing Laboratory

Seibersdorf Labor GmbH

EN ISO/IEC 17025:2005

Measurement bunker
(^{60}Co Picker teletherapy unit)

ISO standards
Irradiation conditions

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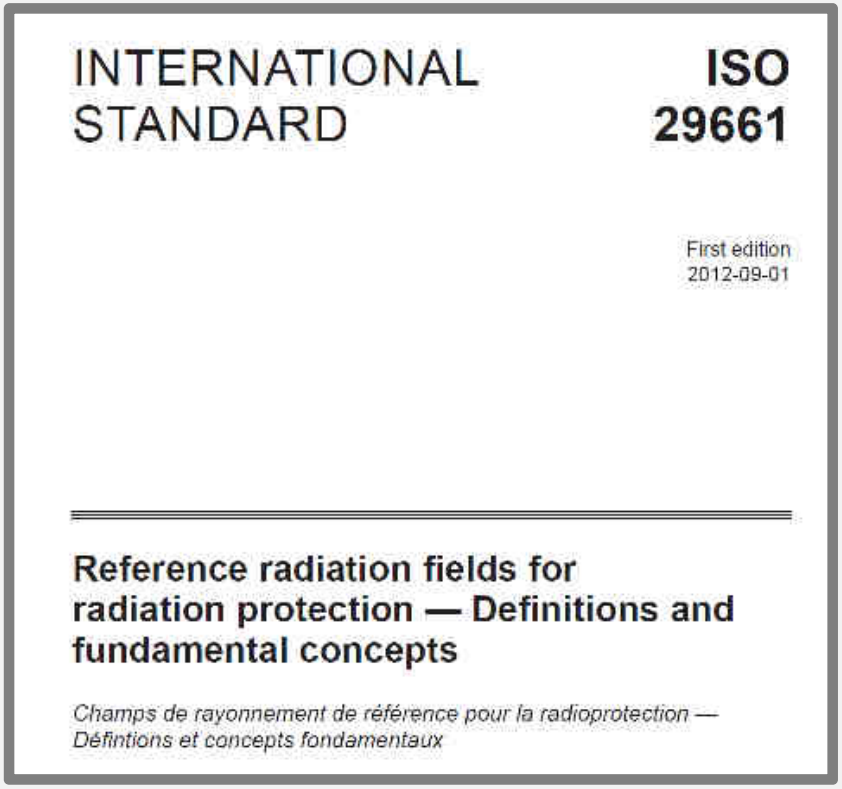


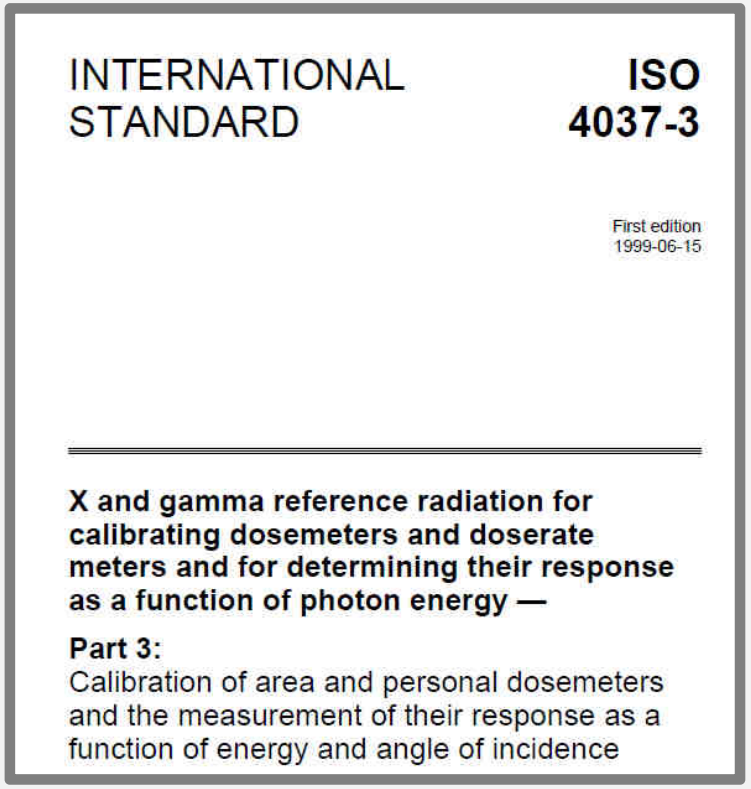
INTERNATIONAL STANDARD

ISO 29661

First edition
2012-09-01

Reference radiation fields for radiation protection — Definitions and fundamental concepts

Champs de rayonnement de référence pour la radioprotection — Définitions et concepts fondamentaux



INTERNATIONAL STANDARD

ISO 4037-3

First edition
1999-06-15

X and gamma reference radiation for calibrating dosemeters and doserate meters and for determining their response as a function of photon energy —

Part 3:
Calibration of area and personal dosemeters and the measurement of their response as a function of energy and angle of incidence

ISO 29661
Reference point on phantom

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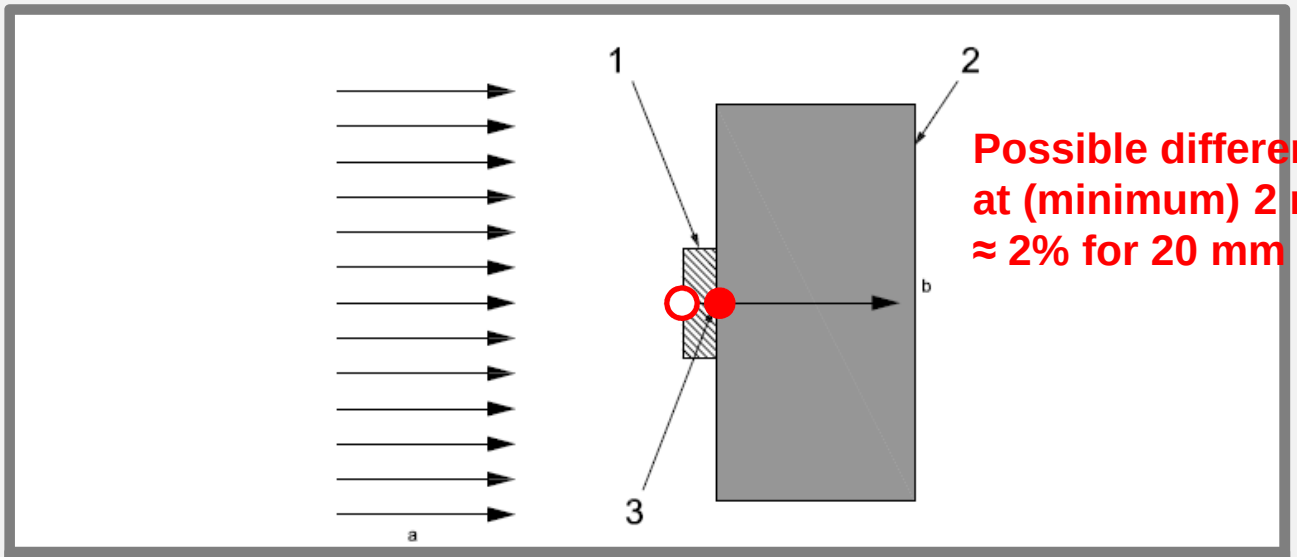

Key

1 personal dosemeter
2 water slab phantom
3 reference point

a Direction of radiation incidence.
b Reference direction.
c Radiation incidence.

Figure 1 — Reference direction and direction of radiation incidence of personal dosemeter mounted on water slab phantom [see 6.6.2 a)]

Possible difference to calibration at (minimum) 2 m distance: ≈ 2% for 20 mm

ISO 29661
Phantom rotation

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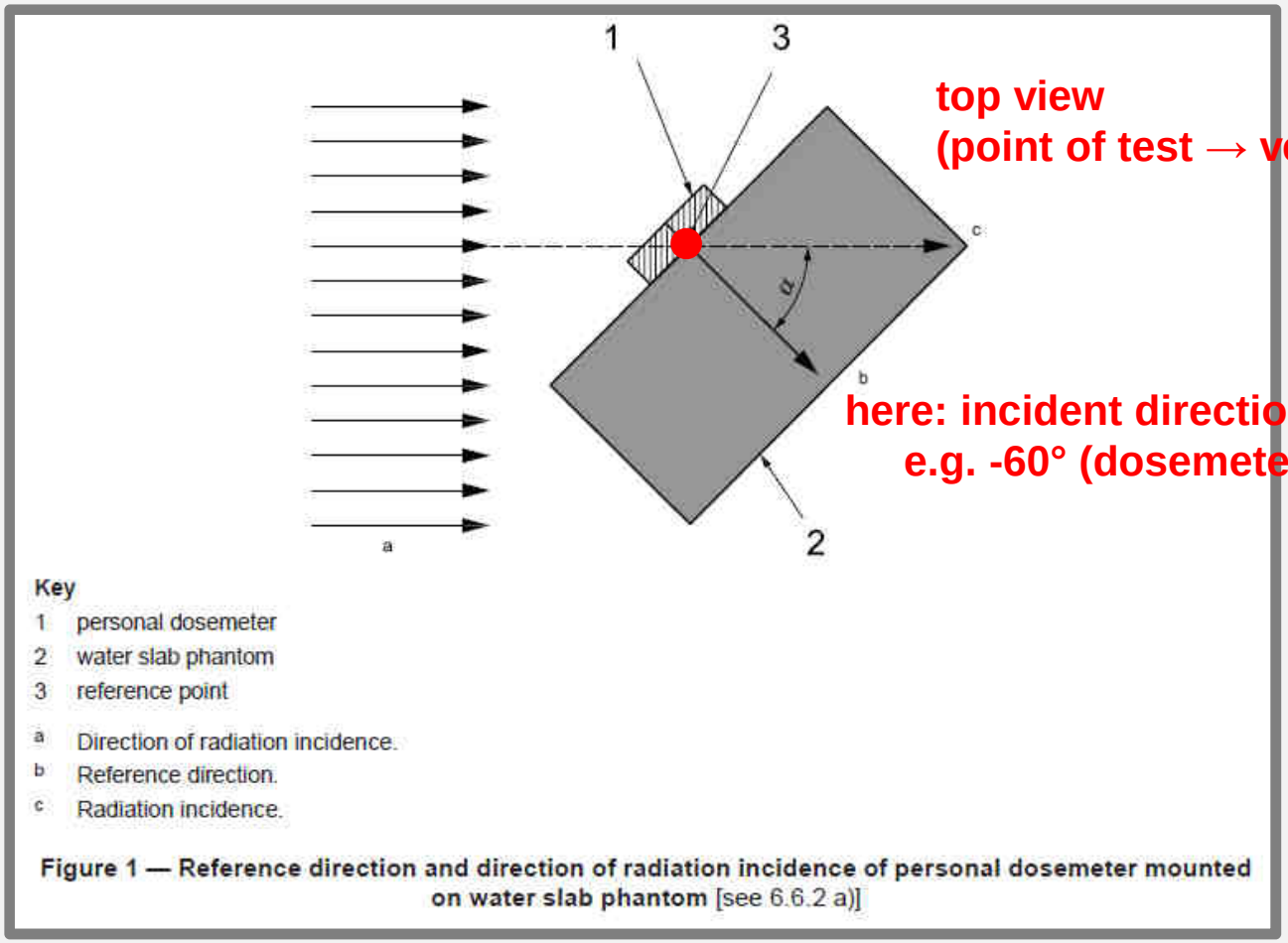

Key

1 personal dosemeter
2 water slab phantom
3 reference point

a Direction of radiation incidence.
b Reference direction.
c Radiation incidence.

Figure 1 — Reference direction and direction of radiation incidence of personal dosemeter mounted on water slab phantom [see 6.6.2 a)]

top view
(point of test → vertical axis of rotation)

here: incident direction from the left side
e.g. -60° (dosemeter wearer‘s view)

Reference orientation
Reference point

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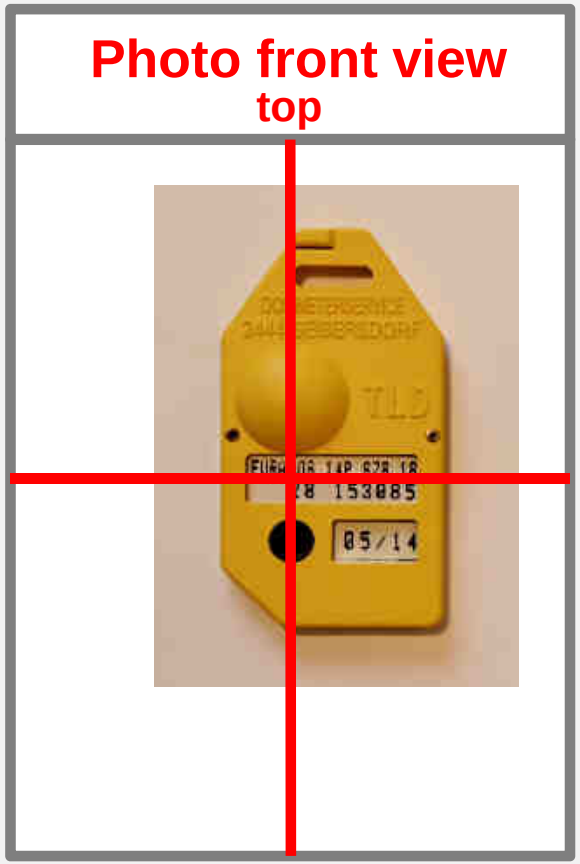
- Photos were taken according to stated reference orientation

  front side

  upright (wearing) position

- Reference points were identified



60° irradiation setup

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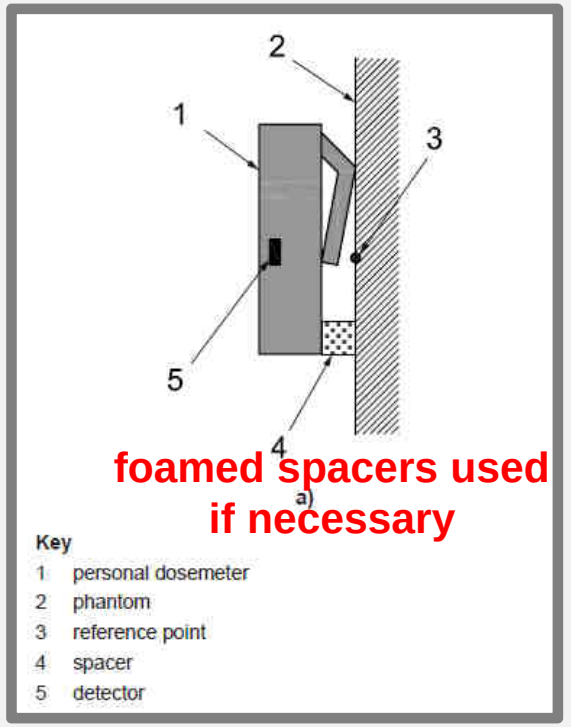

Philips MG320 x-ray facility, 20° tungsten-anode, 2.5 mm Be inherent filtration
Pneumatic shutter
Filter wheel with additional filters
Monitor chamber at 325 mm, BEV calibrated for 2500 mm distance

9 irradiation setups

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Overview setup 1 to 5
2 gamma radiation qualities (^{137}Cs and ^{60}Co nuclide sources ISO 4037-1)

testing calibration

Setup number	1	2	3	4	5
Radiation quality	S-Cs	S-Cs	S-Co	S-Co	S-Co
Average photon energy	0.66 MeV	0.66 MeV	1.25 MeV	1.25 MeV	1.25 MeV
Angle of radiation incidence	0°	0°	0°	0°	0°
Source detector distance	2 m	2 m	4.5 m	2 m	2 m
Field size	52 cm diam.	52 cm diam.	90 x 90 cm^2	40 x 40 cm^2	40 x 40 cm^2
Max. detector size on phantom	15 x 15 cm^2	15 x 15 cm^2	15 x 15 cm^2	15 x 15 cm^2	15 x 15 cm^2
Applied dose equivalent range	0.9 - 1.1 mSv	7.1 - 9.2 mSv	7.9 - 10 mSv	71 - 92 mSv	413 - 499 mSv
Uncertainty (k=2)	5 %	5 %	5 %	6 %	6 %

testing high dose linearity

9 irradiation setups

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Overview setup 6 to 9
3 X-ray radiation qualities (ISO 4037-1 and IEC 61267)

testing low energy response

Setup number	6	7	8	9
Radiation quality	RQR 7	W-80	W-80	W-150
Average photon energy	47 keV	57 keV	57 keV	104 keV
Angle of radiation incidence	0°	0°	60°	0°
Source detector distance	2.5 m	2.5 m	2.5 m	2.5 m
Field size	43 cm diam.	43 cm diam.	43 cm diam.	43 cm diam.
Max. detector size on phantom	15 x 15 cm^2	15 x 15 cm^2	5 x 15 cm^2	15 x 15 cm^2
Applied dose equivalent range	7.8 - 9.9 mSv	7.6 - 9.7 mSv	7.3 - 9.4 mSv	7.4 - 9.5 mSv
Uncertainty (k=2)	6 %	6 %	6 %	6 %

testing angular response at low energies

Irradiation setup 6 details

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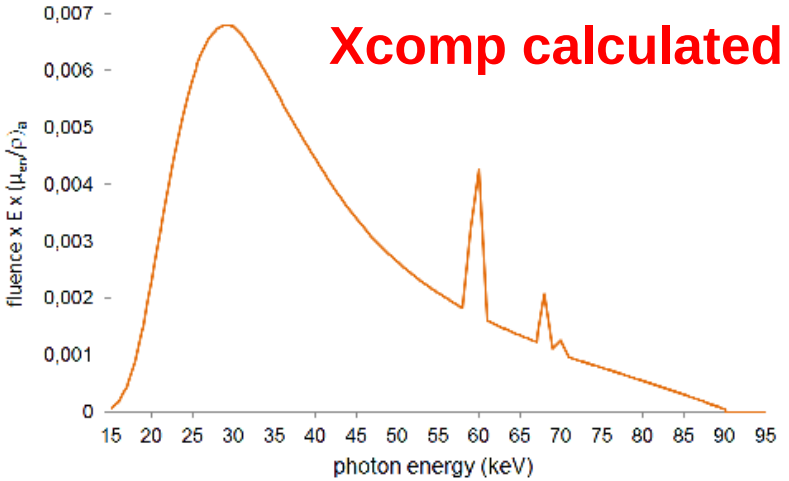
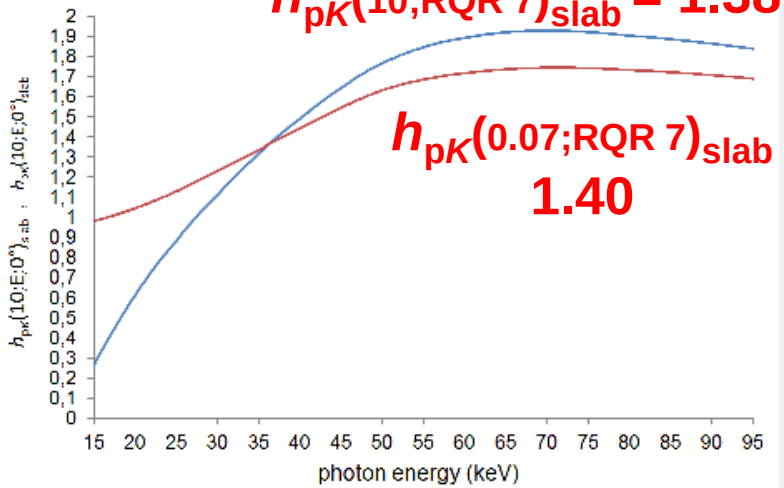
radiation quality DV-90 (IEC RQR 7)
3 mm Al additional filtration
1. HVL 3.4 mm Al

Setup number	6
Radiation quality	RQR 7
Average photon energy	47 keV
Angle of radiation incidence	0°
Source detector distance	2.5 m
Field size	43 cm diam.
Max. detector size on phantom	15 x 15 cm^2
Applied dose equivalent range	7.8 - 9.9 mSv
Uncertainty (k=2)	6 %



$h_{pK}(10;RQR\ 7)_{slab} = 1.38$



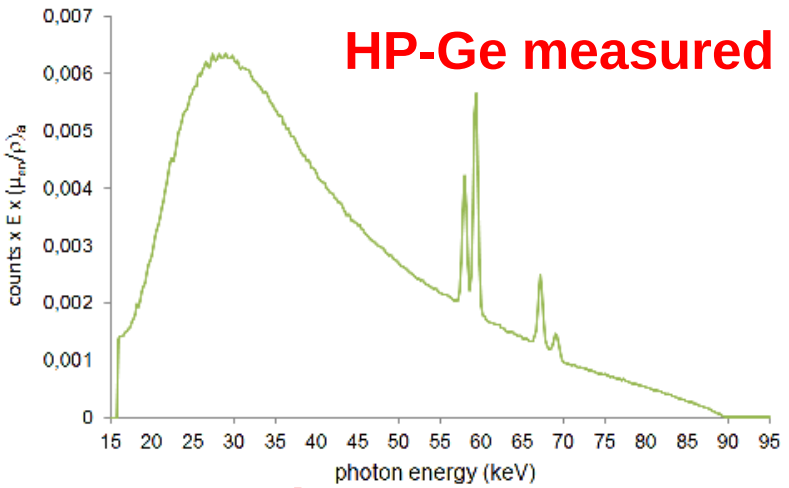
$h_{pK}(0.07;RQR\ 7)_{slab}$ 1.40

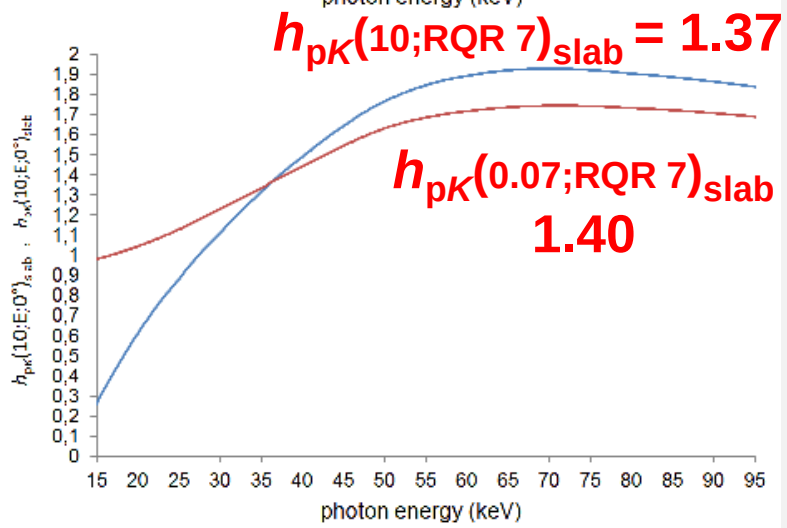
Irradiation setup 6 details

SEIBERSDORF LABORATORIES

radiation quality DV-90 (IEC RQR 7)
3 mm Al additional filtration
1. HVL 3.4 mm Al

Setup number	6
Radiation quality	RQR 7
Average photon energy	47 keV
Angle of radiation incidence	0°
Source detector distance	2.5 m
Field size	43 cm diam.
Max. detector size on phantom	15 x 15 cm^2
Applied dose equivalent range	7.8 - 9.9 mSv
Uncertainty (k=2)	6 %





Irradiation setup 6 details

SEIBERSDORF LABORATORIES

radiation quality DV-90 (IEC RQR 7)

Setup number	6
Radiation quality	RQR 7
Average photon energy	47 keV
Angle of radiation incidence	0°
Source detector distance	2.5 m
Field size	43 cm diam.
Max. detector size on phantom	15 x 15 cm^2
Applied dose equivalent range	7.8 - 9.9 mSv
Uncertainty (k=2)	6 %

2D-aSi flat panel image

Irradiation setup 6 details

SEIBERSDORF LABORATORIES

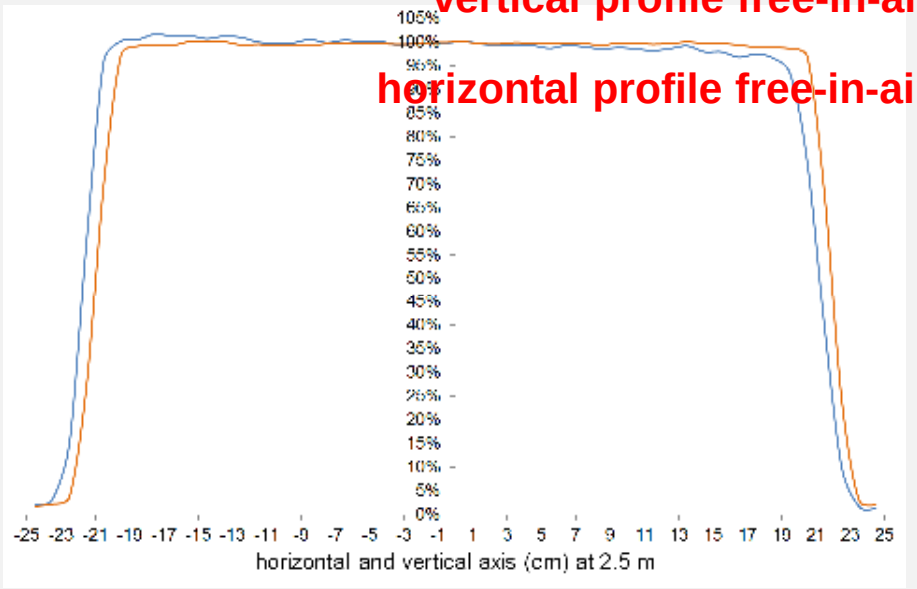
radiation quality DV-90 (IEC RQR 7)

Setup number	6
Radiation quality	RQR 7
Average photon energy	47 keV
Angle of radiation incidence	0°
Source detector distance	2.5 m
Field size	43 cm diam.
Max. detector size on phantom	15 x 15 cm^2
Applied dose equivalent range	7.8 - 9.9 mSv
Uncertainty (k=2)	6 %

2D-aSi flat panel image measured field profiles

vertical profile free-in-air

horizontal profile free-in-air



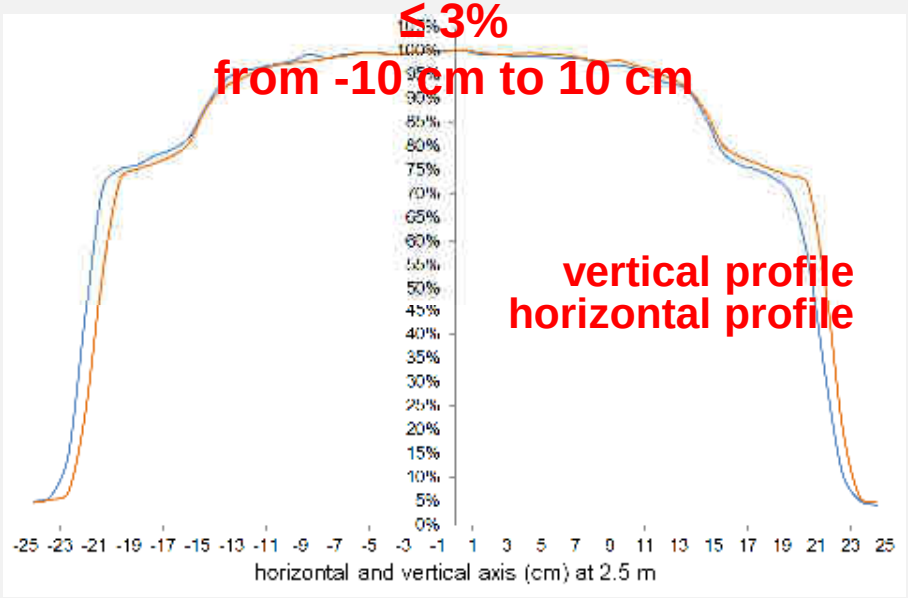
Irradiation setup 6 details

SEIBERSDORF LABORATORIES

radiation quality DV-90 (IEC RQR 7)

Setup number	6
Radiation quality	RQR 7
Average photon energy	47 keV
Angle of radiation incidence	0°
Source detector distance	2.5 m
Field size	43 cm diam.
Max. detector size on phantom	15 x 15 cm^2
Applied dose equivalent range	7.8 - 9.9 mSv
Uncertainty (k=2)	6 %

MC simulated field in front of ISO slab phantom



Irradiation setup 6 details

SEIBERSDORF LABORATORIES

radiation quality DV-90 (IEC RQR 7)

Setup number	6
Radiation quality	RQR 7
Average photon energy	47 keV
Angle of radiation incidence	0°
Source detector distance	2.5 m
Field size	43 cm diam.
Max. detector size on phantom	15 x 15 cm^2
Applied dose equivalent range	7.8 - 9.9 mSv
Uncertainty (k=2)	6 %

Irradiation planning
4 groups of dose values

Setup 6 RQR 7 (DV-90), 0°	Group1	Group2	Group3	Group4
planned date	22.05.	22.05.	23.05.	23.05.
planned persons	MK, CH	MK, CH	MK, CH	MK, CH
MG320 mode	000	000	000	000
kV	90,0	90,0	90,0	90,0
mA	5,80	5,80	5,80	5,80
filter	F4-10	F4-10	F4-10	F4-10
expected Monitor (100nF) K_a-rate (mGy/h)	264	264	264	264
K_a (mGy)	5,69	6,20	6,72	7,23
$H_p(10)$rate (mSv/h)	362	362	362	362
proposed $H_p(10)$ (mSv)	7,80	8,50	9,20	9,90
$H_p(0,07)$rate (mSv/h)	370	370	370	370
$H_p(0,07)$ (mSv)	7,97	8,69	9,40	10,1
Distance (mm)	325/2500	325/2500	325/2500	325/2500
time (s)	77,6	84,6	91,6	98,5

Radiation qualities
12 conversion coefficients

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$$H_p(d;Q,\alpha) = K_a(Q) \cdot h_{pK}(d;Q,\alpha)_{slab}$$

tabulated
ISO 4037-3[a]
IEC 62387[b]

$$h_{pK} = \frac{H_p}{K_a} = \int \frac{1}{K_a} \left(\frac{d\Phi}{dE} E \frac{\mu_{en}}{\rho}\right)_a \cdot h_{pK}(E)\, dE$$

tabulated
ICRU-57/ICRP-74[c]

radiation quality	average energy	1st HVL	angle of radiation incidence	$h_{pK}(10)$ (Sv/Gy)	$h_{pK}(0.07)$ (Sv/Gy)
S-Cs	662 keV	-	0°	1.21 a)	1.21 b)
S-Co	1250 keV	-	0°	1.15 a)	1.17 b)
RQR 7	47 keV	3.3 mm Al	0°	1.37 c)	1.40 c)
W-80	57 keV	0.35 mm Cu	0°	1.77 a)	1.64 a)
W-80	57 keV	0.35 mm Cu	60°	1.39 a)	1.50 a)
W-150	104 keV	1.9 mm Cu	0°	1.77 a)	1.64 a)

Irradiation procedure for an irradiation setup

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- ✓ Choose 2 to 4 dosemeters of a system (dosemeter numbers by chance)
- ✓ Sort systems according to planned sequence (4 groups)
- ✓ Check protocol (irradiation date, responsible, irradiation parameters)
- ✓ Check facility parameters, Monitor chamber and phantom positioning
- ✓ Check software parameters (Monitor reading)
- ✓ Verify setup by APD test irradiation

- ❖ Fill in Excel protocol (irradiation number, dosemeter numbers, time)
- ❖ Positioning according photo-documentation
- ❖ Take photo directly before irradiation (time-stamp of photo)
- ❖ Observe stable positioning of dosemeters by camera
- ❖ Mark dosemeter directly after irradiation (red dot ●)
- ❖ Separate irradiated dosemeters
- ❖ Finish Excel protocol (Monitor reading)

112 dosimetry systems
Photo documentation

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Photos of about half of the participating dosimetry systems
(similar types and APDs were not shown due to limited space)

112 dosimetry systems
2240 dosemeters irradiated

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20 dosemeters per participating system

	kerma rate (mGy/h)	$H_p(10)$ range (mSv)	number of irradiated dosemeters
Setup number 1	25	0.9 – 1.1	2
Setup number 2	39	7.1 – 9.2	4
Setup number 3	304	7.9 – 10	2
Setup number 4	1640	71 – 92	2
Setup number 5	1640	413 – 499	2
Setup number 6	264	7.8 – 9.9	2
Setup number 7	115	7.6 – 9.7	2
Setup number 8	115	7.3 – 9.4	2
Setup number 9	115	7.4 – 9.5	2

27 wrong irradiated dosemeters

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Spare dosemeters were used for:

☹ front side/rear side wrong
18 dosemeters

☹ dosemeter moved or dropped down
5 dosemeters

☹ dosemeter maybe not irradiated
4 dosemeters

Dosemeter identification	Status
S004-17	wrong irradiated
S004-30	wrong irradiated
S004-15	wrong irradiated
S004-24	wrong irradiated
S004-21	wrong irradiated
S004-29	wrong irradiated
S019-18	wrong irradiated
S024-05	wrong irradiated
S024-29	wrong irradiated
S024-09	wrong irradiated
S024-14	wrong irradiated
S035-06	wrong irradiated
S035-17	wrong irradiated
S035-19	wrong irradiated
S035-27	wrong irradiated
S039-06	wrong irradiated
S039-07	wrong irradiated
S039-14	wrong irradiated
S039-22	wrong irradiated
S045-03	wrong irradiated
S045-28	wrong irradiated
S054-02	wrong irradiated
S054-25	wrong irradiated
S098-11	wrong irradiated
S098-23	wrong irradiated
S099-17	wrong irradiated
S099-23	wrong irradiated

4-pages test reports issued

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