Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

Irradiations for IC2017n at PTB

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Working Group 6.44
„Neutron Dosimetry“

EURADOS IC2017n Participant Meeting
at the EURADOS Annual Meeting 2019, Łódź, Poland
Tuesday, February, 12th 2019

Physikalisch-Technische Bundesanstalt

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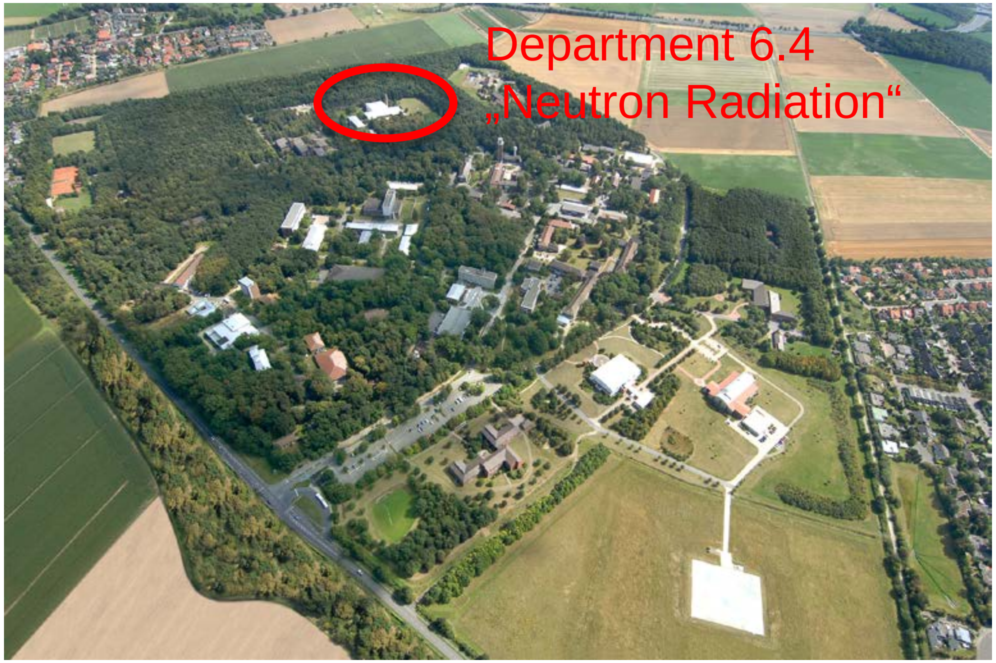
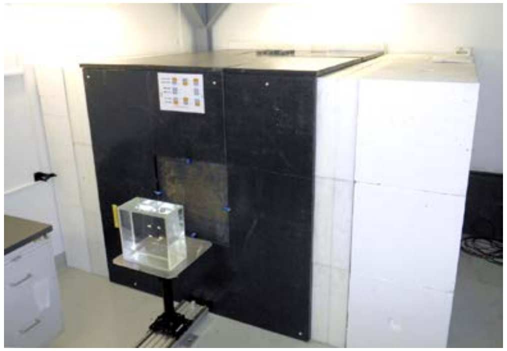


Calibration and irradiation capabilities

Reference neutron fields produced by radionuclide sources *(contact person: desiree.radeck@ptb.de)*
^{252}Cf
^{252}Cf (D_2O mod., 1 mm Cd)
^{252}Cf (D_2O mod.)
^{241}Am-Be(α,n)
Thermal (80% of $H_p(10)$ below 0.5 eV)
Workplace field: ^{252}Cf, scattered neutrons behind a shadow cone
Workplace field: ^{252}Cf (D_2O mod., 1 mm Cd), scattered neutrons behind a shadow block



Reference neutron fields produced by accelerator *(contact person: ralf.nolte@ptb.de)*
Monoenergetic field, E_n = 24 keV
Monoenergetic field, E_n = 144 keV
Monoenergetic field, E_n = 250 keV
Monoenergetic field, E_n = 565 keV
Monoenergetic field, E_n = 1.2 MeV
Monoenergetic field, E_n = 2.5 MeV
Monoenergetic field, E_n = 2.8 MeV
Monoenergetic field, E_n = 3.2 MeV
Monoenergetic field, E_n = 5.0 MeV
Monoenergetic field, E_n = 8.0 MeV
Monoenergetic field, E_n = 14.8 MeV
Monoenergetic field, E_n = 19.0 MeV

Reference fields of radionuclide sources

- Dimensions of irradiation room: 7 m x 7 m / height: 6.5 m
- Thickness of walls: 1 – 1.2 m of reinforced concrete
- Low-scatter source holders (wires with diameter of 0.4 mm)
- Neutron sources:
  - ^{241}Am-Be(α,n)
  - ^{252}Cf
  - ^{252}Cf (D_2O mod.), ^{252}Cf (D_2O mod., 1 mm Cd)
- Additional ^{137}Cs source for test of photon sensitivity
- Inscattered neutron fields behind shadow object

Determination of reference values

- Traceability of ^{252}Cf dose equivalent rates
  → neutron emission rates from NPL manganese bath
- Determination of personal dose-equivalent rate

$$\dot{H}_{\mathrm{p}}(10) = \frac{B}{4\pi D^2} F_{\mathrm{A}} \exp(-\Sigma\, D)\, h_{\mathrm{p}\Phi}(10,\alpha)_{\mathrm{dir}} + \varphi_{\mathrm{ins}}\, h_{\mathrm{p}\Phi}(10,\mathrm{isotropic})_{\mathrm{ins}}$$

B: neutron source strength
F_A: correction factor for anisotropy
D: distance between source and point of test
Σ: air attenuation factor
$h_{p\Phi}(10;\alpha)_{dir}$: fluence-to-dose-equivalent conversion factor for the direct contribution
$h_{p\Phi}(10;\mathrm{isotropic})_{ins}$: fluence-to-dose-equivalent conversion factor for the inscattered contribution (based on energy-dependent conversion factors in ICRP 74 (1997))
φ_{ins}: fluence rate of inscattered neutrons (measured with PTB Bonner sphere spectrometer)

- Fluence-to-dose conversion factors

Neutron source	$h_{p\Phi}(10;0°)_{dir}$ / (pSv·cm^2)	$h_{p\Phi}(10;\mathrm{isotropic})_{ins}$ / (pSv·cm^2)
^{252}Cf	400 ± 8	50 ± 7
^{252}Cf (D_2O mod., 1 mm Cd)	114.8 ± 7.2	13.7 ± 1.7

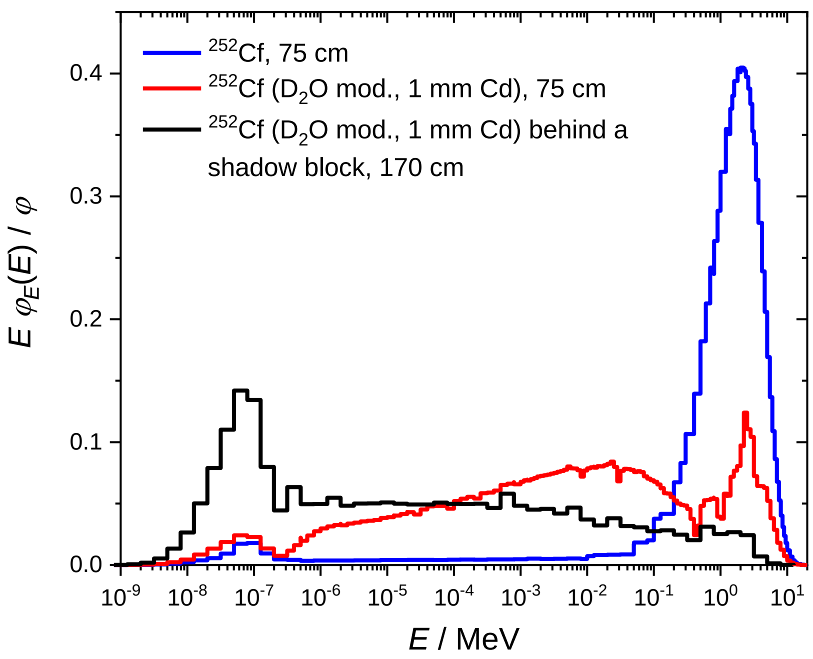
Irradiations at PTB for EURADOS IC2017n

Neutron source	Angle	Distance / cm	($H_p(10)_{ins}$ / $H_p(10)$) / %	$H_p(10)$ / mSv	Number of irradiated dosemeters
^{252}Cf + additional irradiation with photons of a ^{137}Cs source	0°	75	2.24 ± 0.32	1.50 ± 0.06 (4 %) (1.00)	4
^{252}Cf (D_2O mod., 1 mm Cd)	0°	75	2.40 ± 0.40	1.20 ± 0.11 (9 %)	4
^{252}Cf (D_2O mod., 1 mm Cd) behind a shadow block	isotropic	170	100	1.00 ± 0.15 (15 %)	2

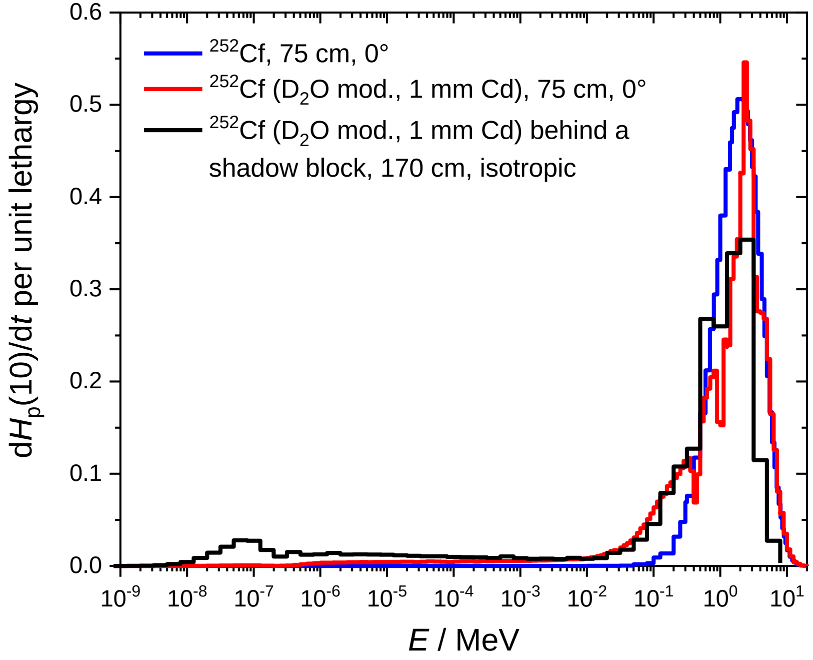
* All uncertainties are expanded measurement uncertainties (k = 2).

Characteristics of neutron reference fields

Spectral neutron fluence rate

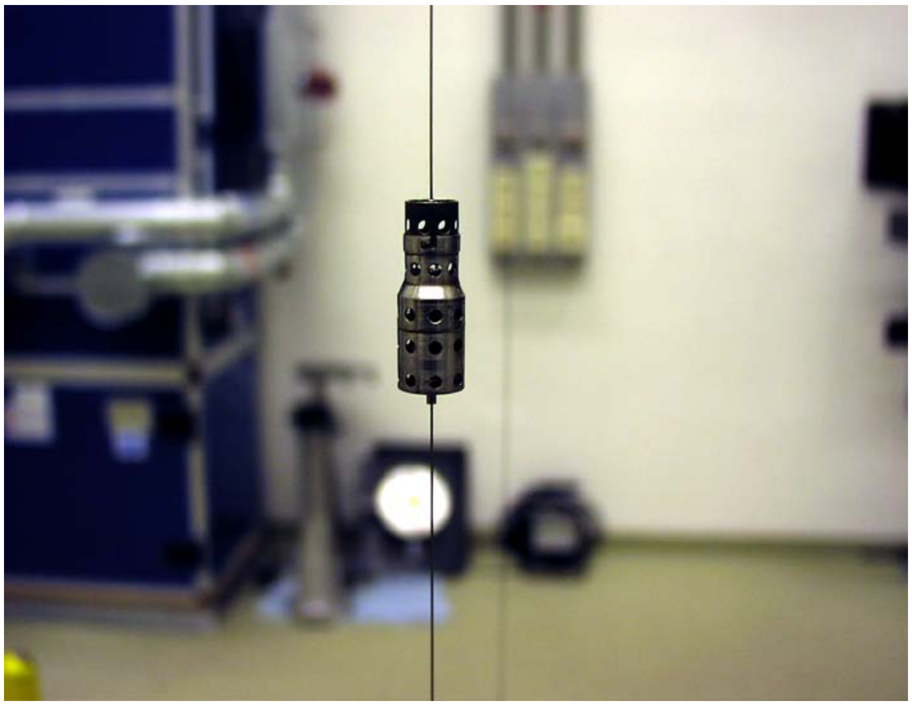


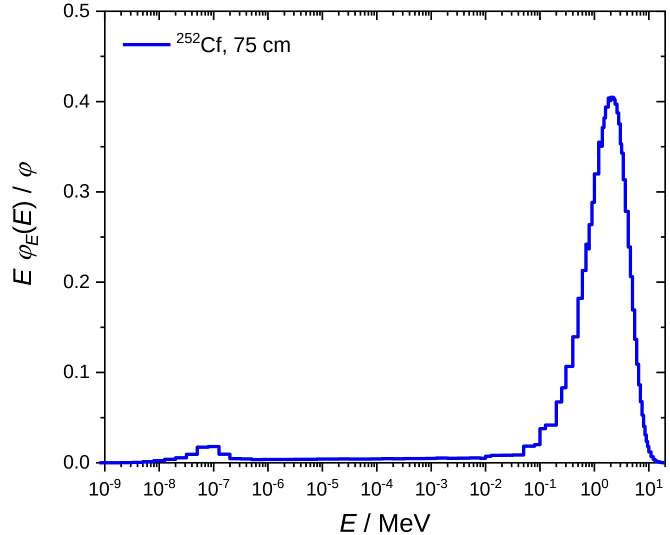
Neutron dose rate distribution

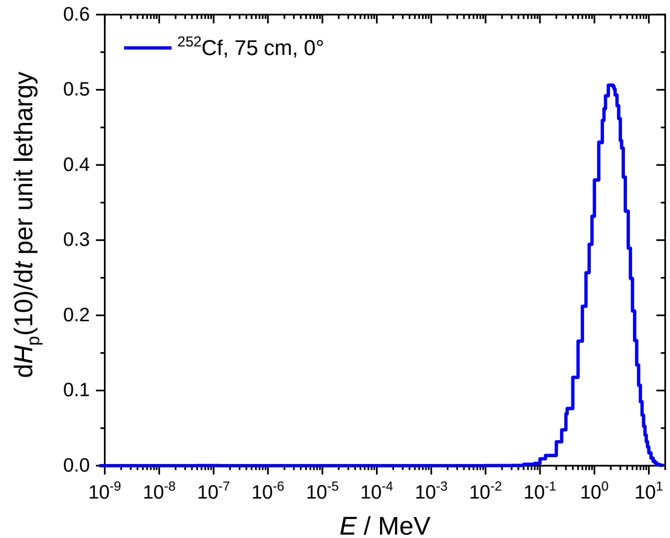


^{252}Cf

- $H_p(10)$ = 1.5 mSv
- plus additional irradiation with photons of a ^{137}Cs source with $H_p(10)_{ph}$ = 1.0 mSv
- Irradiation period ~ 2 h
- Mixed photon-neutron field

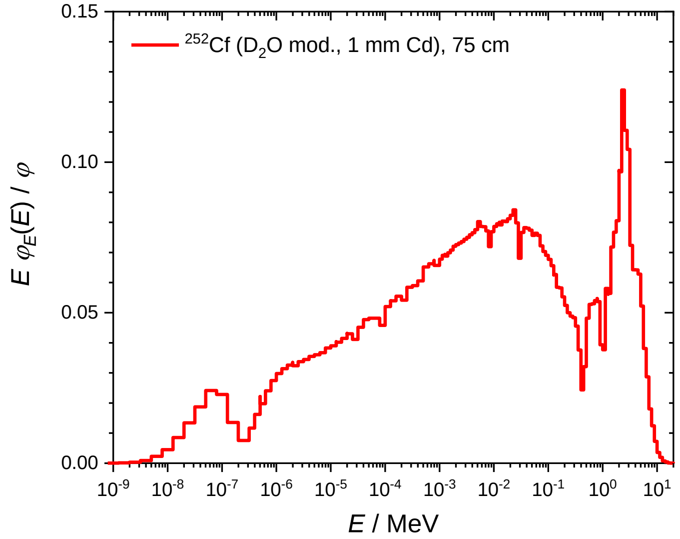


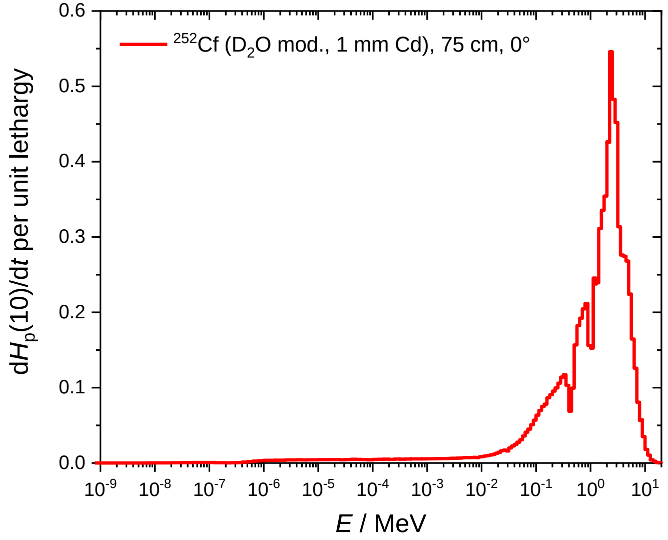




^{252}Cf (D_2O mod., 1 mm Cd)

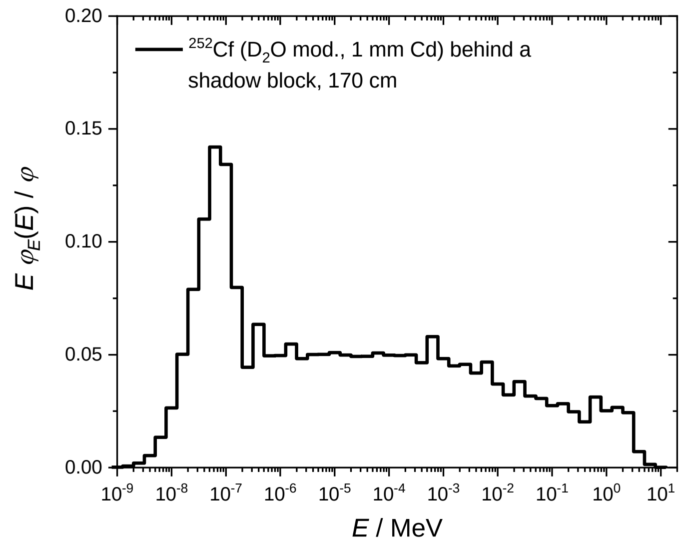
- $H_p(10)$ = 1.2 mSv
- Irradiation period ~ 1.5 h
- Simulated workplace field

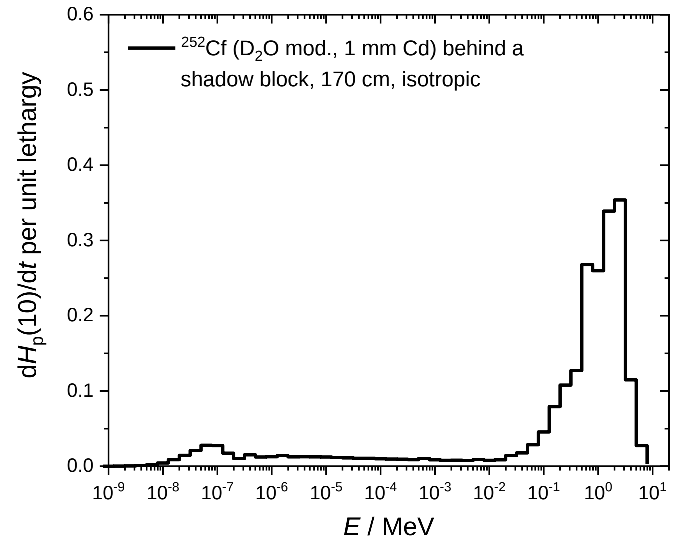




^{252}Cf (D_2O mod., 1 mm Cd), shadow block

- $H_p(10)$ = 1.0 mSv
- Irradiation period ~ 2 days
- Simulated work place field by making use of wall-scattered neutrons





Summary

- Date of irradiations at PTB:
  02-06-2017 to 10-07-2017 (38 days)
- Irradiation of 330 dosemeters (+ 5 spare dosemeters)
- Mixed neutron-photon field, simulated workplace field (irradiation behind shadow block)
- Irradiation of four dosemeters on the phantom, for the irradiation behind the shadow block irradiation of eight dosemeters
- Dosemeters of participants were mixed
- Management of irradiations by four-eyes principle and providing pictures and guidelines

Thank you for your attention!

Questions?

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