Performance of several active personal dosemeters in interventional radiology and cardiology

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Outline

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- Objective
- Materials and methods
- Main Results and Discussion
- Summary and Outlook

Background and framework

- Personnel involved in **fluoroscopy-guided procedures** can be exposed to **high doses**.

- There is a **wide range of dose rates** at the workplace depending on the procedure, thickness of the patient, position and experience of the medical staff..

- In many applications, active personal dosemeters (APDs) present some advantages :
  - ✓ have improved radiation workers safety
  - ✓ have contributed to the reduction of doses
  - ✓ have increased personnel awareness of unexpected exposures

→ **USE OF APDs IN PULSED RADIATION FIELDS**

Background and framework

However..

- The use of APDs in pulsed fields (e.g. IR) is still **very limited**.

Because ..

- There is **a lack of international standards** which address technical requirements for APDs to be used in pulsed radiation fields.

- APDs present some **limitations in pulsed fields** according to several recent works..

  - **Current problems in the field of radiation protection technique - Use of Active Personal Dosimeters (APD) in pulsed radiation fields (2009)** *C. Schmidt et al.* Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

  - **Deficiencies of active electronic radiation protection dosemeters in pulsed fields.** U. Ankerhold, O. Hupe, P.Ambrosi **.** Radiation Protection Dosimetry, 135:149–153, 2009.

  - **Active personal dosemeters in interventional radiology: tests in laboratory conditions and in hospitals.** Clairand, I., Bordy, J-M., Daures, J., Debroas, J., Denozière, M., Donadille, L., Ginjaume, M., Itié, C. et al. **.** Radiation Protection Dosimetry, 1-6, 2010.

Objectives

- The goal is to verify the performance of **four active personal dosemeters based on silicone diodes** and **one DIS-type** personal dosemeter in three typical interventional cardiology procedures.

- Two new systems have been tested

Materials and methods

Tested devices

Two newer systems have been considered

	Thermo EPD	MGP DMC 200 XB	Unfors EDD–30	Philip DoseAware	Mirion Instadose
Type of detector	3 silicon diodes	3 silicon diodes	Semiconductor	Semiconductor	Direct ion storage
Energy range	0.015 to 10 MeV (±20 %)	0.02 to 6 MeV (±30 %)	0.014 to 0.120 MeV (±10 %)	0.048 to 0.100 MeV (±30 %)	0.015 to 6 Mev (±10 %)
Dose rate range	0 µSv/h to > 4 Sv/h	0.01 mSv/h to 10 Sv/h	0.03 mSv/h to 2 Sv/h	40µSv/h to 300 mSv/h	0.03 mSv - 5 Sv

→ **Unfors EDD-30** and **Philips Dose Aware** cover a restricted energy range (up to 100 keV) out of this range could be not suitable

→ REFERENCE DOSEMETER: whole body **TLD** (LiF chips of the type GR-200A) .

Preliminary tests:

- **Energy calibration in continuous x-ray fields**

  APD were calibrated at the **INTE-UPC** Secondary Standard Dosimetry Laboratory: **N-80 , N-120** (ISO 4037) and **RQR-6, RQR-9** (IEC 62167)

RQR 6 calibration factor is used in the experience, since it is the most similar radiation quality to the tested IR radiation fields.

- **Influence of irradiating one dosemeter at a time**

  Irradiation configuration:

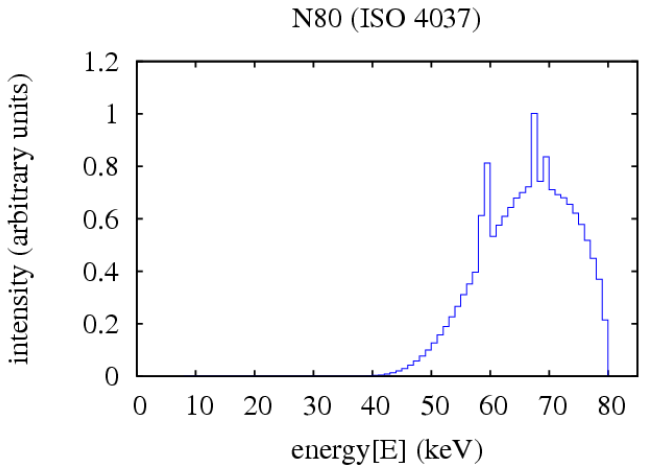
  - one by one at the centre of the ISO phantom
  - all the APD irradiated at the same time

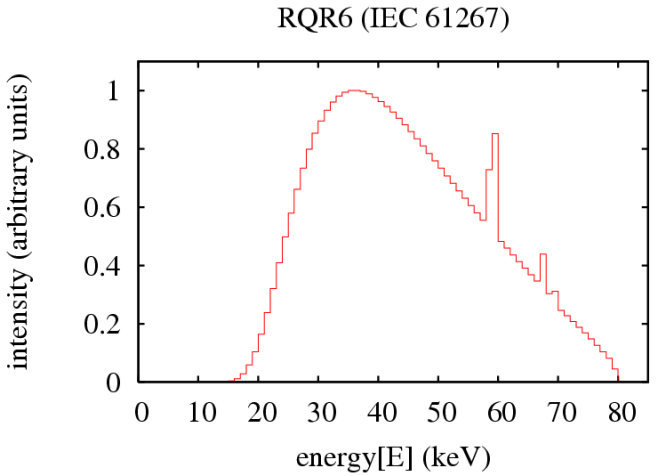
Influence of neighbours < 6 % → Validates that APD can be irradiated at the same time.

Preliminary tests

Energy calibration factor at laboratory conditions:

	N 80	RQR 6	Differences	
	$Hp(10)_{REF}$ / $Hp(10)_{APD}$		Devices	N80 / RQR 6
Thermo EPD1	0.97 (± 3.1 %)	1.03 (± 3.1%)	< 2 %	6 %
Thermo EPD 2	0.95 (± 3.1 %)	1.01 (± 3.1%)		
MGP 1	0.99 (± 3.1 %)	1.01 (± 3.2%)	< 2 %	1 %
MGP 2	1.06 (± 3.3 %)	1.02 (± 3.2%)		
Unfors EDD 1	2.08 (± 2.4 %)	1.32 (± 2.4%)	20 - 50 %	26 - 57 %
Unfors EDD 2	1.11 (± 2.4 %)	0.88 (± 2.4%)		
DoseAware 1	0.97 (± 3.7%)	1.04 (± 3.4%)	< 5 %	10 %
DoseAware 2	0.91 (± 3.5 %)	1.05 (±3.4%)		
Instadose 1	1.34 (± 1.8%)	1.27 (± 2.2%)	< 4 %	1 %
Instadose 2	1.29 (± 1.8%)	1.30 (± 2.2%)		
Instadose 3	1.26 (± 1.8%)	1.27 (± 2.2%)		



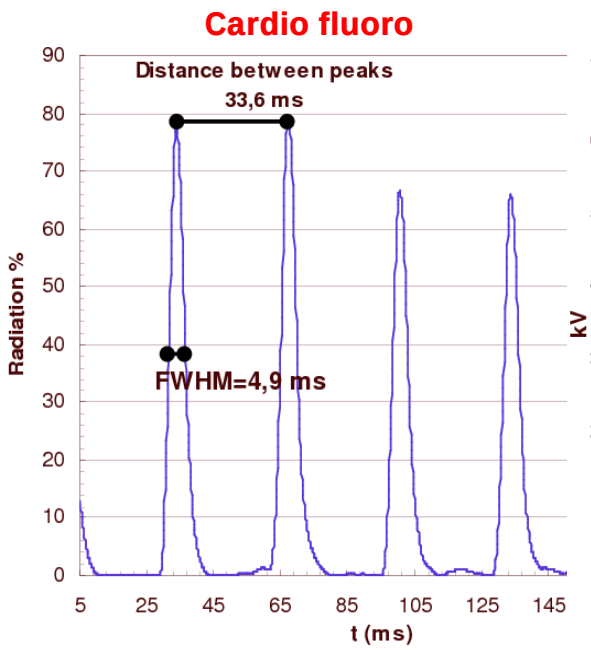


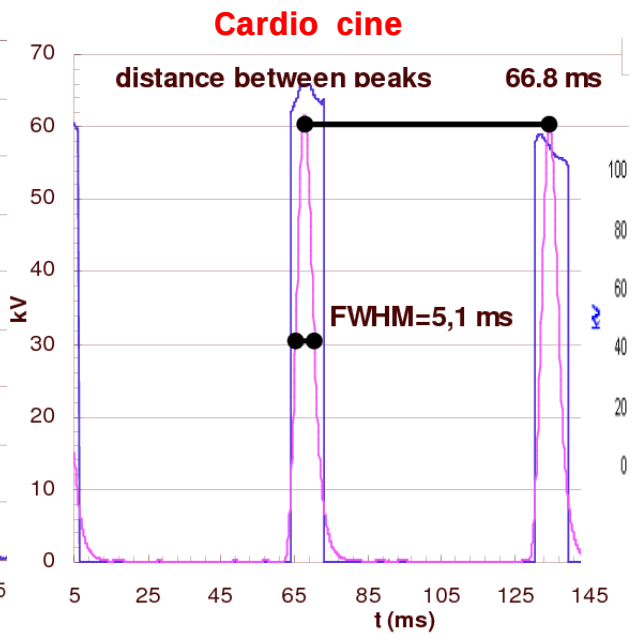
Tests in hospital

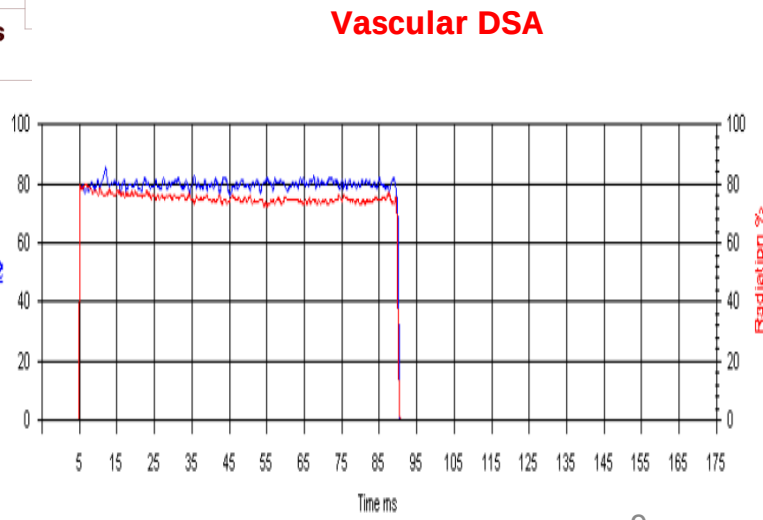
Irradiation conditions

- 3 common procedures of IR/IC were considered:

Procedure	Additional filtration (mm)	pps	FWHM (ms)	kVp (kV)	HVL (mm Al)
Cardiology fluoro	0.1 Cu + 1.0 Al	30	4.9	72	4.96
Cardiology cine	0	15	5.1	68	3.24
Vascular DSA	0	3	85	80	4.90







Tests in hospital

Procedure

- At San Carlos University Hospital

- Allura FD 10/20 **fluoroscopic** system:
  - pulsed x-ray beam was generated with an x-ray unit (Philips MRC-GS)
  - detector screen field size (FOV) of 27 cm

- 3 independent tests

- **Experimental set up** (realistic situation):

  - Two ISO water slab phantoms at a representative position of the radiologist and of the nurse

  - 30 x 30 x 20 cm^3 PMMA slab phantom on the table to simulate the radiation scattered by the patient.

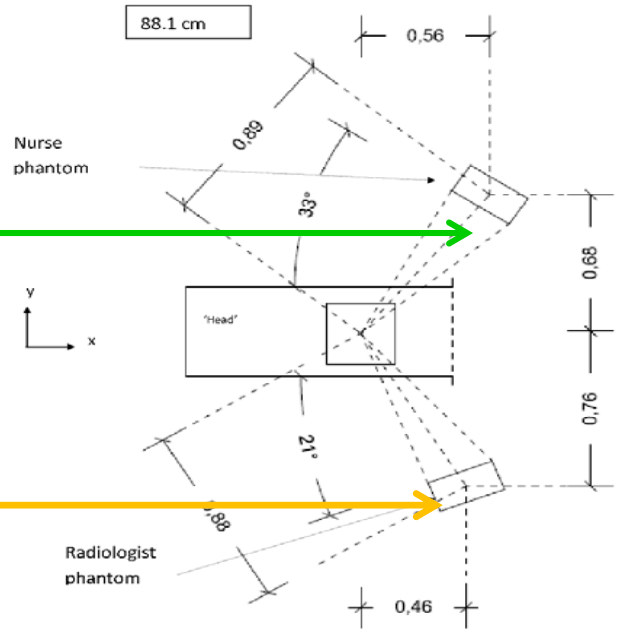
Tests in hospital

Experimental set up

Dose rate at the radiologist position:

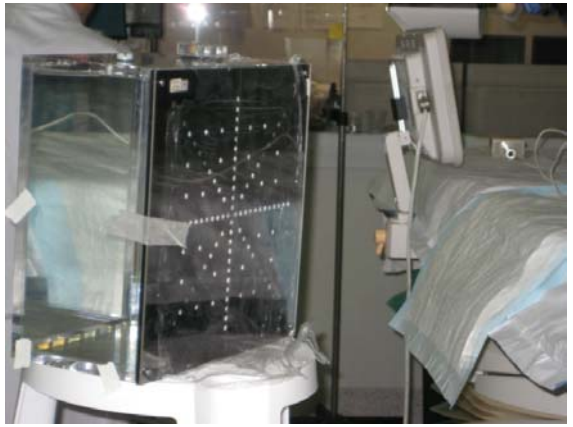
Cardiology fluoro	Cardiology cine	Vascular DSA
12 mSv/h	75 mSv/h	140 mSv/h

"radiologist" phantoms were at 80 cm from the isocentre.



Tests in hospital

Homogeneity at the phantom surface

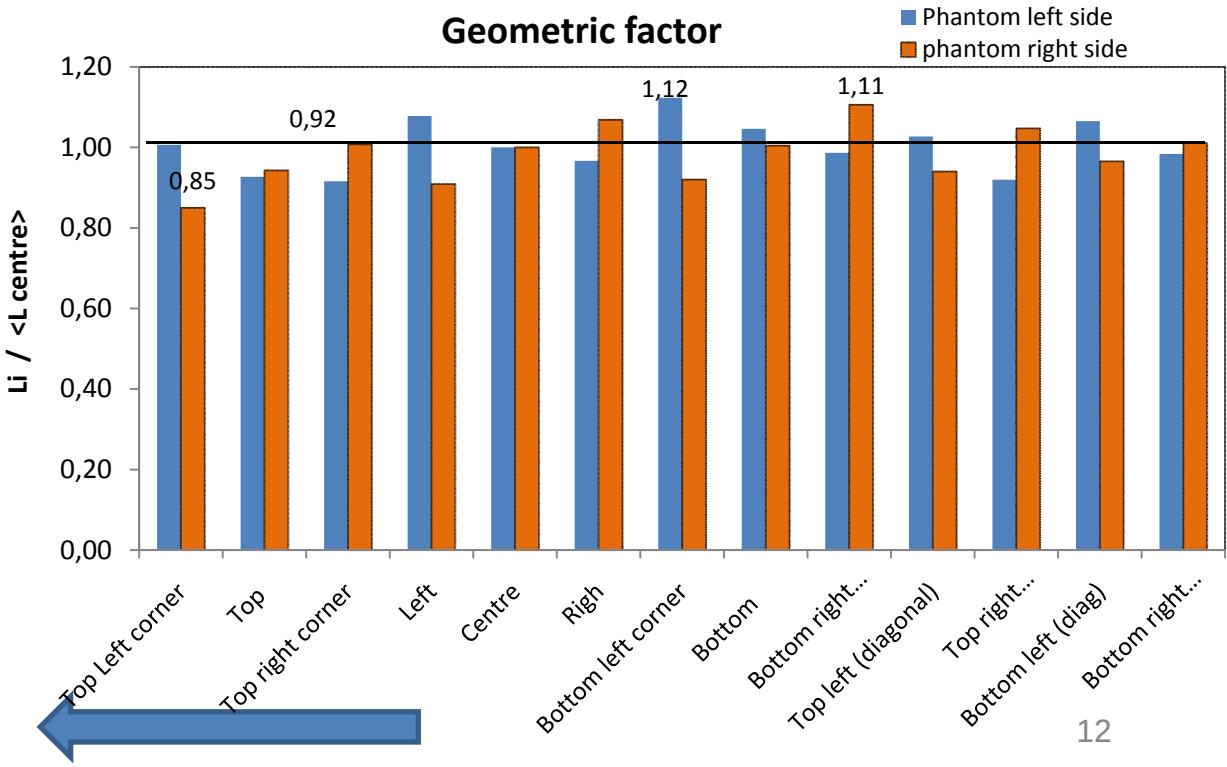


The dose distribution at the phantom radiologist was studied with a TLD array

→ **Left side: difference of 14 % left /righ**

→ **Right side: difference of 20 % left /right**

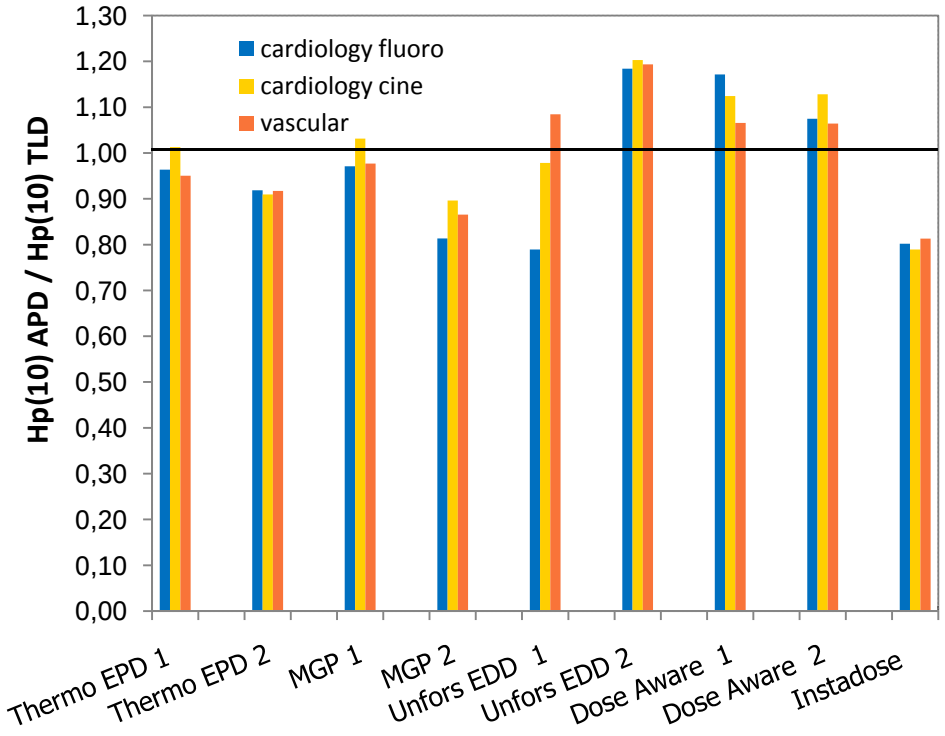
APD readings were corrected with the geometric factor



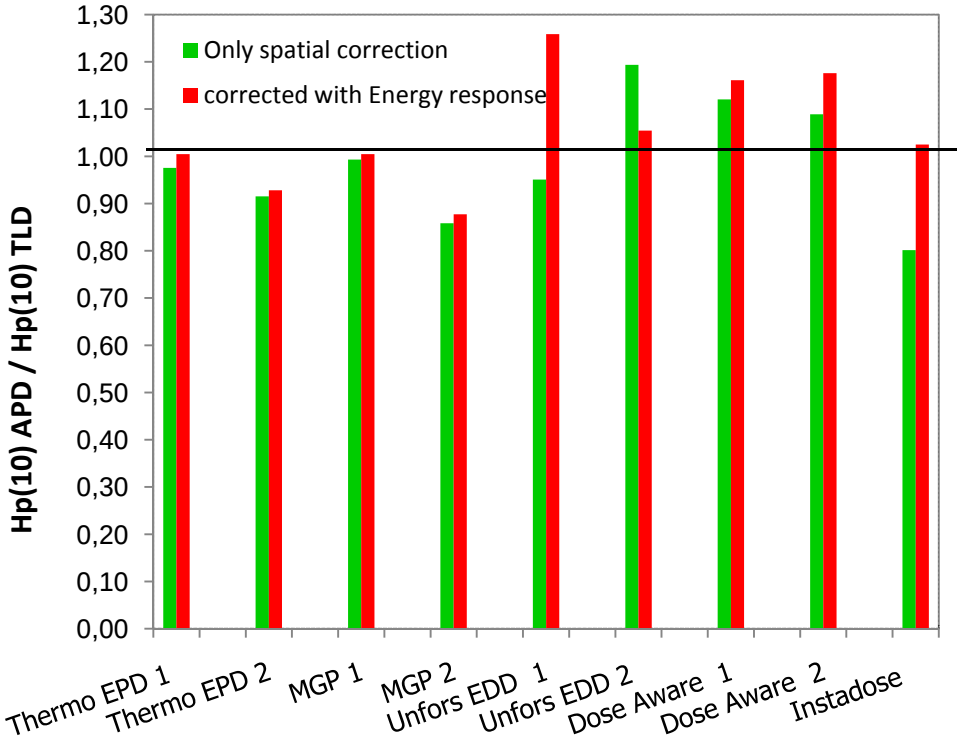
Main results

The operational dosimetric quantity used in the comparison was the personal dose equivalent at a depth of 10 mm, **Hp(10)**.

Responses for each procedure



With energy correction



Main results

Responses of APDs:

$$R = Hp(10)_{APD} / Hp(10)_{TLD}$$

Without Energy correction

	Thermo EPD	MGP	Unfors EDD *	Dose Aware	Instadose
Min	0.82	0.81	1.08	0.92	0.63
< R >	**0.95** ± 3.0 %	**0.93** ± 2.7 %	**1.19** ± 3.3 %	**1.10** ± 2.8 %	**0.80** ± 7.0 %
Max	1.15	1.09	1.29	1.28	1.00

With Energy correction

	Thermo EPD	MGP	Unfors EDD *	Dose Aware	Instadose
Min	0.83	0.83	0.96	0.96	0.81
<R > · Fen	**0.97** ± 3.5 %	**0.94** ± 3.3 %	**1.05** ± 4.1 %	**1.15** ± 4.7 %	**1.03** ± 7.3 %
Max	1.19	1.10	1.14	1.33	1.27

Tested devices present satisfactory results within 15 % of difference compared with TLDs.

*Only considering Unfors EDD-2

Summary and Outlook

- ✓ The tested APD present a **similar behaviour** independently of frequency [3-30 pps] and pulsed width [5-85 ms], compared with TLDs (range of ± 20 %).

- ✓ It is especially recommended to apply an energy correction factor for Instadose.

The tested APDs can be useful tools for dose staff monitoring during interventional radiology procedures.

- Further work:
  - Study APD response at higher dose rates, to know its behaviour if the medical staff is accidentally exposed to the direct beam.

Thank you for your attention!

Acknowledgements

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