Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

Novel radiation qualities XMM-results and spectrometry methods

Elisabeth Salomon, Stefan Pojtinger

Elisabeth Salomon: funded by the Austrian Science Fund (FWF) J4719-B

Stefan Pojtinger: funded as part of the European Patnership for Metrology project 22NRM01 TraMeXi, co-funded by the European Union's Horizon Europe Research and Innovation Program and the participating States.

Background

- Quality control measurements for breast imaging using X-rays
- Quantity of interest is mean glandular dose MGD or average glandular dose AGD
- Air kerma and half-value layer (HVL) needed for its calculation
- X-ray multimeters measure multiple quantities such as air kerma and half-value layer (HVL) after only one exposure
- They are optimized for their intended use on mammography systems
- Wide range of radiation qualities used
- When tested under standatized laboratory conditions XMM might exceed the measurement uncertainty stated by the manufacturer

Aim:
To assess the range of radiation qualities used in breast imaging
To investigate the performance of XMM during field calibration

Radiation Qualities

- IEC 61267 RQR-M (Medical diagnostic X-ray equipment- Radiation conditions for use in the determination of characteristics)

Anode	Mo
Filter	Mo 30 µm

Radiation Qualities

- IEC 61267 RQR-M (Medical diagnostic X-ray equipment- Radiation conditions for use in the determination of characteristics)
- TraMeXi Survey | Measurements

Anode	**Mo** or Mo-V	**W** or W-Re[2] or W-Re-Mo[3]	**Rh**
Filter	Mo 30 µm	Rh 50 µm 60 µm	Rh 25 µm
	Rh 25 µm	Ag 50 µm 75 µm	Ag 30 µm
		Al 0,7 mm 1,0 mm	

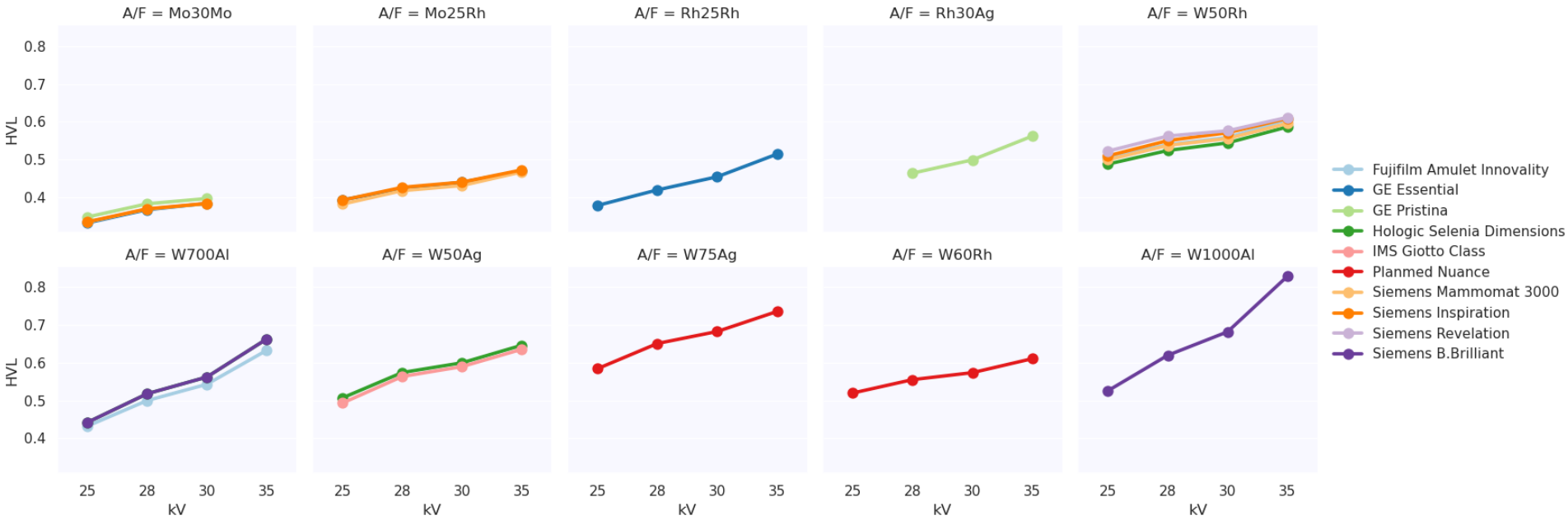
[1] GE,
[2] Hologic
[3] Siemens, Fuji, Metaltronica

Mammography systems

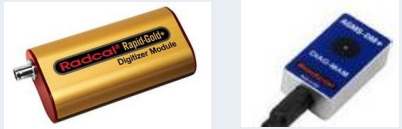
Manufacturer	Fujifilm	GE	Hologic	IMS Giotto	Planmed	Siemens
Model	Amulet	Essential, Pristina	Selenia	Class	Nuance	Mammomat 3000, Inspiration, Revelation, B.Brilliant
Max hight CP cm	148 | 185	125 | 280	238 | 268	283	160	200 | 250 | 252

Mo 30µm Mo	Mo 25µm Rh	W 50µm Rh	W 0,7mm Al	W 50µm Ag	Rh 25µm Rh	Rh 30µm Ag
Siemens Mammomat 3000	Siemens Mammomat 3000	Hologic Selenia	Hologic Selenia	Hologic Selenia	GE Essential	GE Pristina
Siemens Inspriation	Siemens Inspriation	Fujifilm Amulet	Fujifilm Amulet	IMS Giotto Class		
GE Essential	GE Essential	Siemens Mammomat 3000	Siemens B.Brilliant			
GE Pristina		Siemens Inspriation				
	W 60µm Rh		W 1,0mm Al	W 75µm Ag		
	Planmed Nuance	Siemens Revelation	Siemens B.Brilliant	Planmed Nuance		

Range of half-value-layers



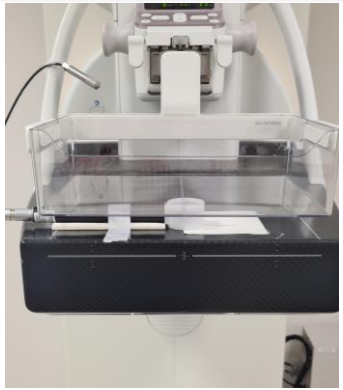
X-ray multimeters

X-ray multimeters	Max deviation stated in the manual	
	Air kerma	HVL
IBA MagicMax, XM Multi Detector 	±5%	±10% or 0,05 mm Al
Radcal Rapid Gold+ Digitizer, AGMS-DM+ Detector 	±5%	±10% or 0,05 mm Al
RaySafe X2, MAM Detector 	±5%	±5%
RTI Piranha Multi 	±5%	±10%
PTW NOMEX Dosemeter, Mulimeter 	±2,5%	± 0,1 mm Al

Measurement protocol

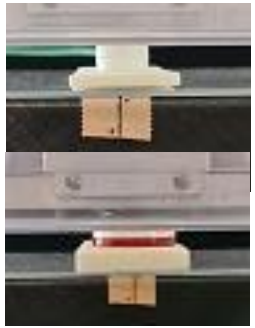
Air kerma:
Radcal RC6M ioization chamber
Calibrated against the primary standard
Compression paddle in contact
Influence of the backscatter < 5 ‰

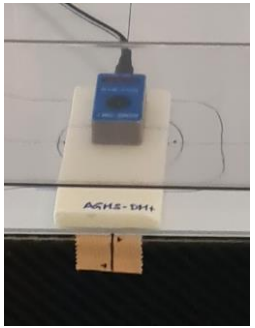
Half-value layer:
narrow beam geometry (TRS-457)
Compression paddle
High purity Al sheets



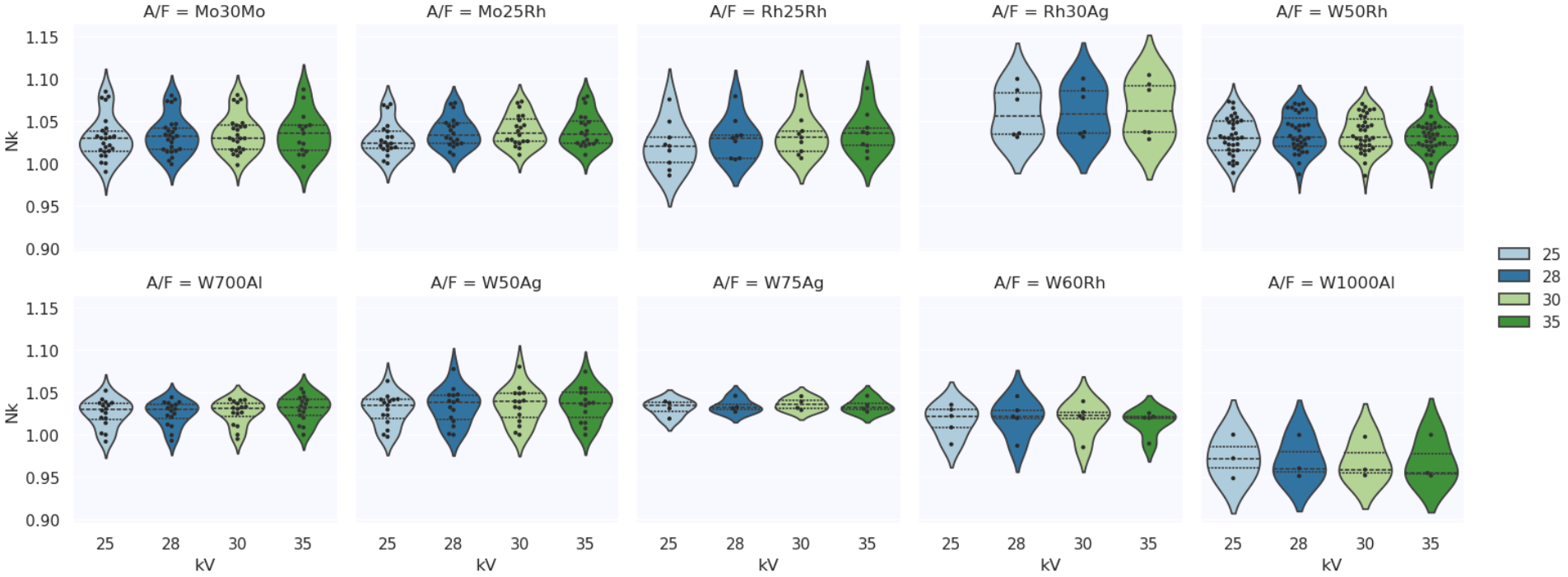
X-ray Multimeter:
In contact with the compression paddle
Same height of the individual reference points
RTI Piranha: scatter factor of 1,06

Selection in the XMM software:
anode/filter combination - X2 only for tube voltage
filter thickness – Nomex, Piranha
use of compression paddle – X2, Piranha, Nomex

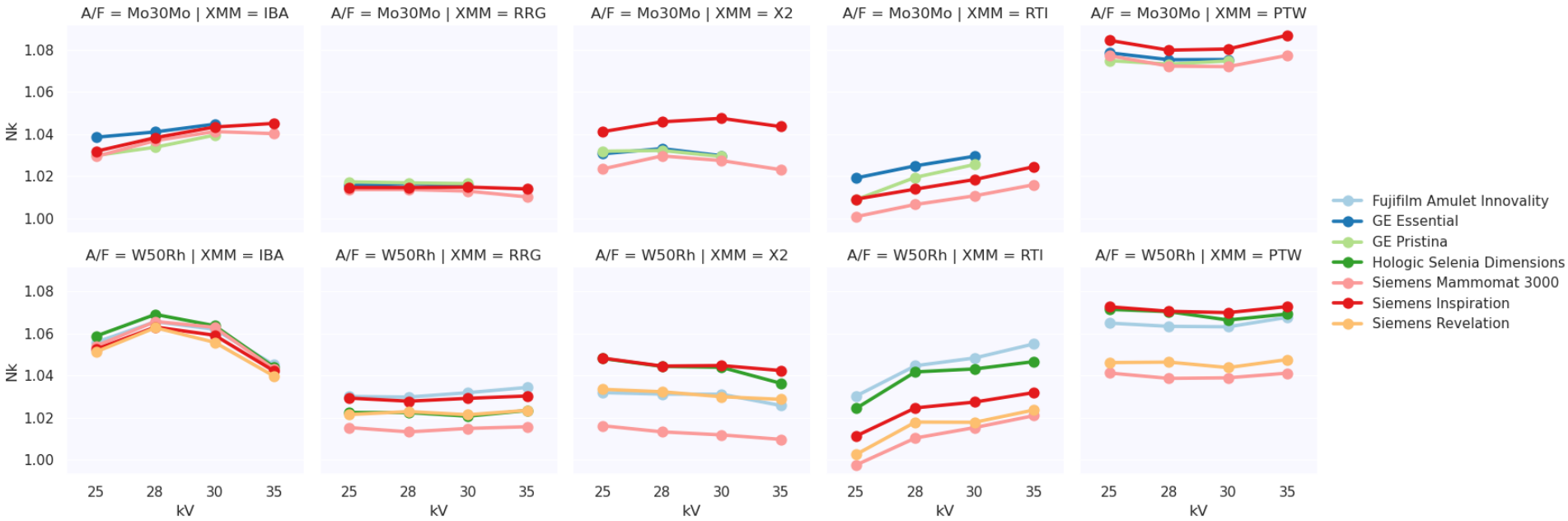




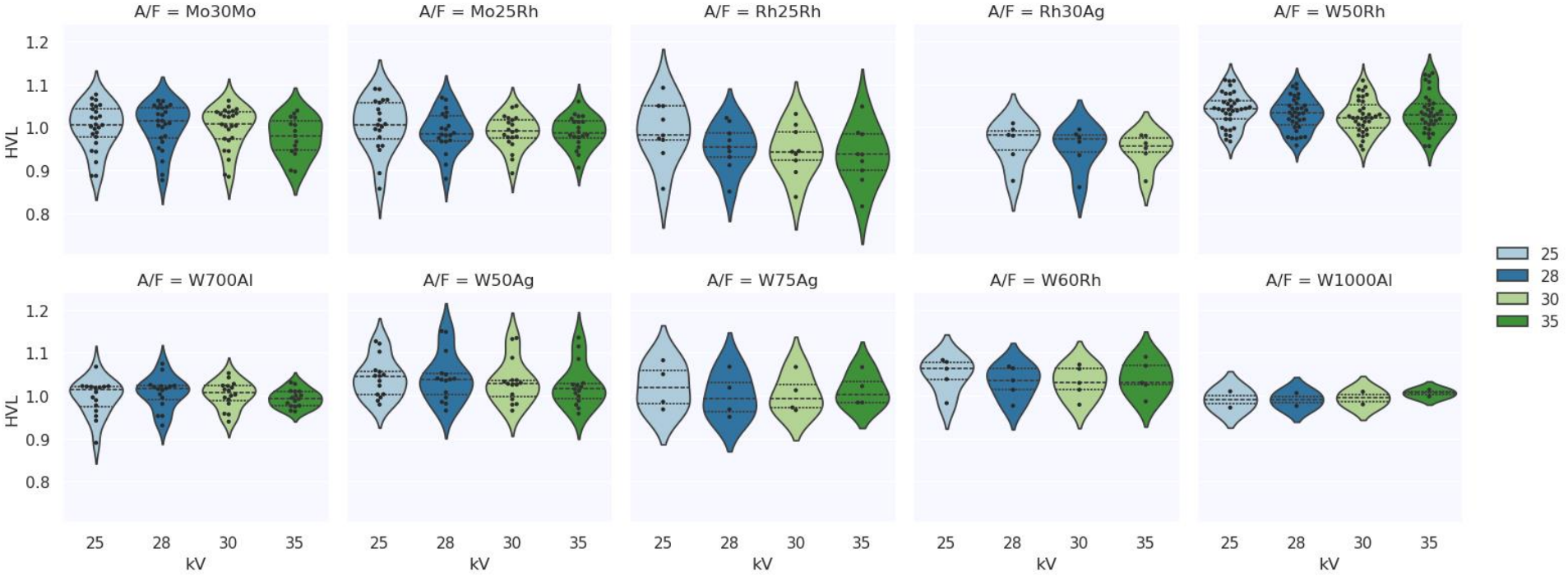
Results – air kerma



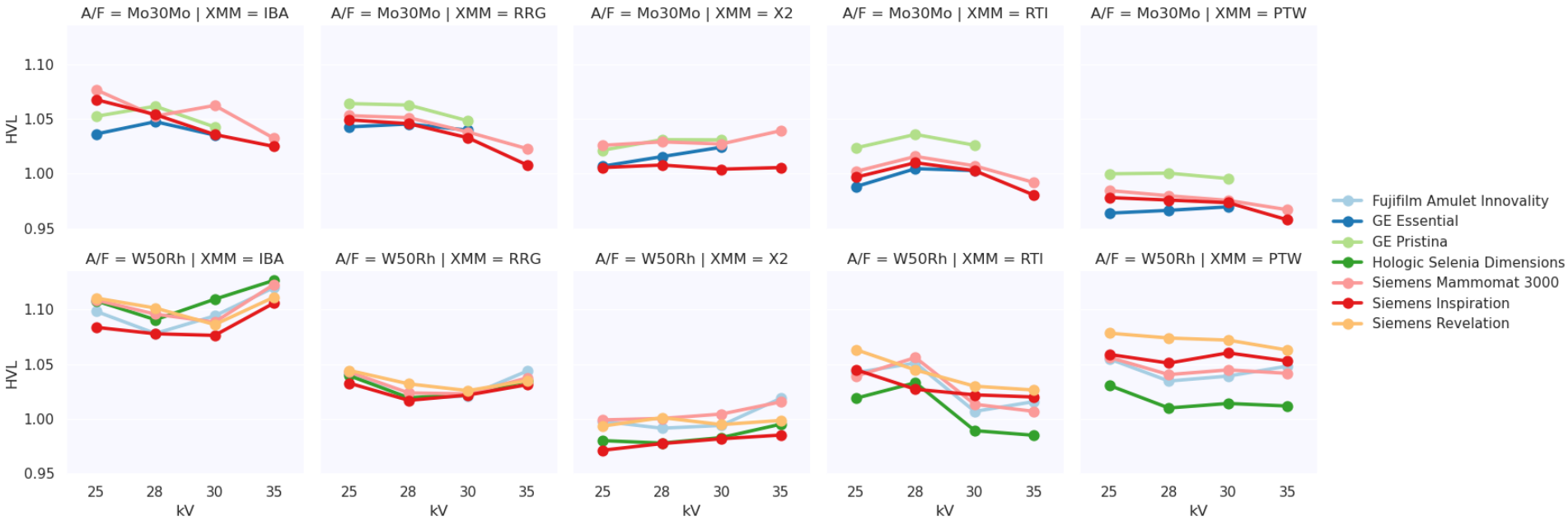
Results – air kerma



Results – half-value layer



Results – half-value layer



Uncertainty estimation

air kerma measurement:

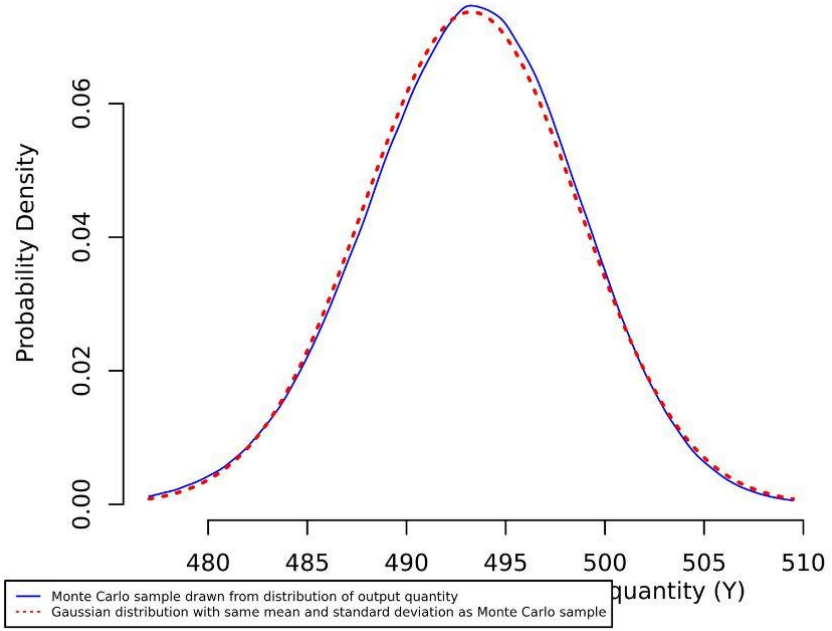
Calibration against the primary standard (0,5%)
Electrometer calibration (0,1%)
Resolution electrometer (0,06%)
Air density (0,4%)
Reading and resolution (0,18%)

Relative combined uncertainty 1,4% (k=2)

HVL measurement:

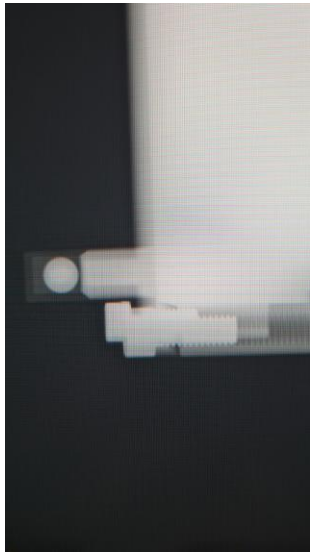
Current measurement (0,5%)
Filter thicknesses (< 6 µm)

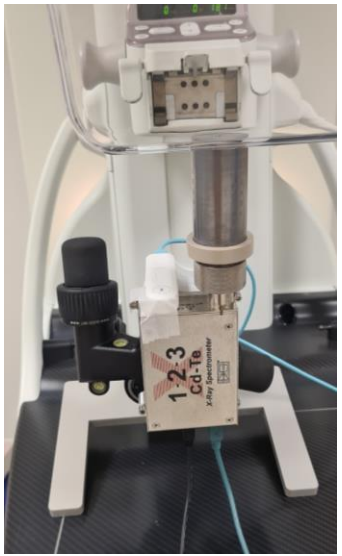
Relative combined uncertainty 1,1% (k=2)
from linear interpolation



Spectrometry methods

Amptek X-123CdTe Complete X-Ray & Gamma Ray Spectrometer
Positioning by aligning two aluminium spheres in the spectrometer axis
Substitution of the positioning device with the spectrometer





Conclusions

- Most XMMs remain in the limits stated by the manufacturers
- Different performance for different anode/filter combinations
- Protocol for field measurements on clinical mammography systems
- Uncertainties for air kerma and HVL measurements could be improved by cross-calibration on clinical systems