Scientific workgroups - Mammo dosimetry, Cone Beam CT protocol, etc

MPEC/MEIbioeng 2017- EFOMP Session - 13 Sep 2017

HELSINKI UNIVERSITY DEPARTMENT OF PHYSICS HUS Medical Imaging Center

Mika Kortesniemi
Chair of the EFOMP Science Committee
European Federation of Organisations for Medical Physics

Adjunct Professor, Chief Physicist, PhD
HUS Medical Imaging Center, University of Helsinki

Purpose of the EFOMP QA protocols

- One of the aims of EFOMP is to encourage exchanges between the National Member Organisations and disseminate professional and scientific information through publications and meetings.
- The purpose of the **quality assurance protocol series** is to develop a minimum set of easily implemented quality control tests on diagnostic and therapeutic systems that can be used to assure the performance of a system within a set and acceptable range.

Regular updates for medical physicist use

- It is intended that these be implemented as part of the daily routine of medical physicists and system users throughout Europe in a harmonised way so allowing results to be compared.
- EFOMP pursues to update these protocols every few years taking into consideration the experience gained through their implementation in different settings.

Mammo QC

- **EFOMP Mammo Protocol** (2015) was the first of the series on quality control protocols.
- It proposes tests that can be applied by each country with the resources available locally, accepting the fact that there are different technological levels across the European countries.

Mammo protocol publication

5

Mammo protocol publication

EFOMP *Mammo Working Group Protocol, March 2015*

6

CBCT QC protocol

- The most recent EFOMP working group document is the **Quality control in cone beam CT** (CBCT) protocol, just published (Sep 2017), presenting procedures for quality control of CBCT systems used for **dental, radiotherapy, interventional radiology** and guided surgery applications.
- It was created as a collaborative effort with ESTRO and IAEA, hence called the EFOMP-ESTRO-IAEA protocol, as a result of the experience and knowledge of an international group of leading medical physics experts.

mika.kortesniemi@hus.fi

CBCT protocol publication


E F M P

EFOMP

European Federation of Organisations for Medical Physics

ESTRO European Society for RADIOTHERAPY & ONCOLOGY

IAEA International Atomic Energy Agency

Quality control in cone-beam computed tomography (CBCT)

EFOMP-ESTRO-IAEA protocol

EFOMP

Final version 2nd of June 2017

CBCT protocol publication

9

CBCT protocol publication

mika.kortesniemi@hus.fi

10

CBCT protocol publication – Chapter 3, IQ

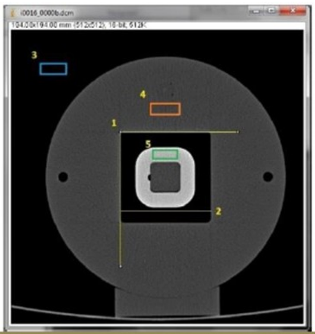


Figure 3.2.1.Illustration of geometrical measurements on the DIN phantom. The 90-degree angle (1) and the 60 mm-side of the air gap (2) can be used to check the linearity in the xy-plane.

Freeware tip: To measure angles and distances in the DICOM image, the freeware ImageJ[40] can be used. For this purpose, select the straight line or the angle tool, click on the image object that you want to measure (see Figure 3.2.1) and select "measure" on the Analyze menu. A pop-up window containing a table of results will show the values of the angle and/or the length on the right columns.

11

CBCT protocol publication – Chapter 3, IQ

3.7. Summary table

Table 3.7.1. Summary of image quality tests including suggested frequencies and action levels for the described procedures.

Parameter	Procedures	Frequency*			Action level		
		Dental	Interven-tional radiology	Radio-therapy	Dental	Interven-tional radiology	Radio-therapy
3.1 Uniformity	XYZ uniformity curves	Annual		Monthly	Manufacturer specifications, or > 10% difference air water		Deviation from baseline > 10 HU
	DIN method				Uniformity parameter U < 5		
3.2 Geometrical precision	Geometrical accuracy	Annual (or none)		Monthly	>1 mm	> 2 mm	> 2 mm for conventional treatments,> 1 mm for SRS/SBRT
	Linearity	Annual (or none)		Monthly			
	Spatial Stability	n.r.		Monthly (coincidence of isocentres daily)	n.r.	n.r.	

12

CBCT protocol publication – Chapter 4, IQ phantoms

4.4. Summary table

TABLE 4.4.1. Summary of commercial phantoms available

Phantom	Diameter (mm)	Height (mm)	Materials	Noise/ Uniform.	CNR	Spatial res.	Contrast res.	Density values	Artefacts	Geom. accuracy	Applica-tions
Quart DVT_AP	160	150	PMMA PVC Air Enhancement set[2]	Y	Y	Y	*	Y	Y	Y	Universal CBCT[1]
Quart DVT_KP CBCT 161	160	40	PMMA PVC Air	Y	Y	Y	*	Y	Y	Y	Universal CBCT[3]
Quart DVT_150	120 x 120 x 60 mm[3]			N	N	Y	N	N	N	N	Dental 3D
SedentexCT IQ	160	162	PMMA Aluminium PTFE Delrin LDPE Air	Y	Y	Y	Y	Y	Y	Y	Dental CBCT

mika.kortesniemi@hus.fi

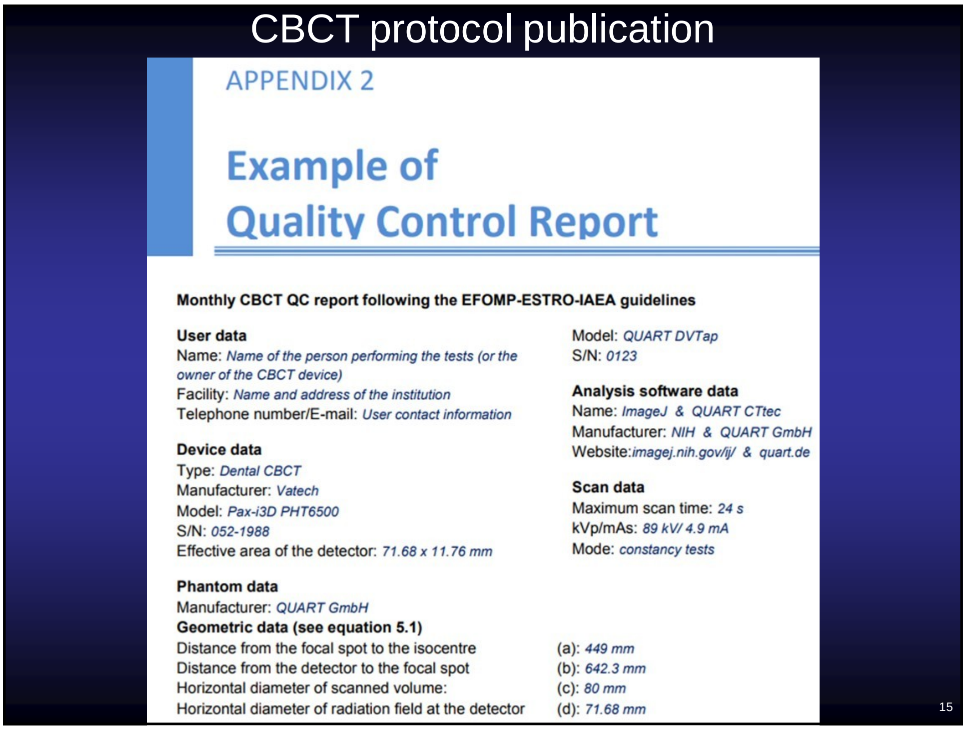
CBCT protocol publication – Chapter 5, Radiation output

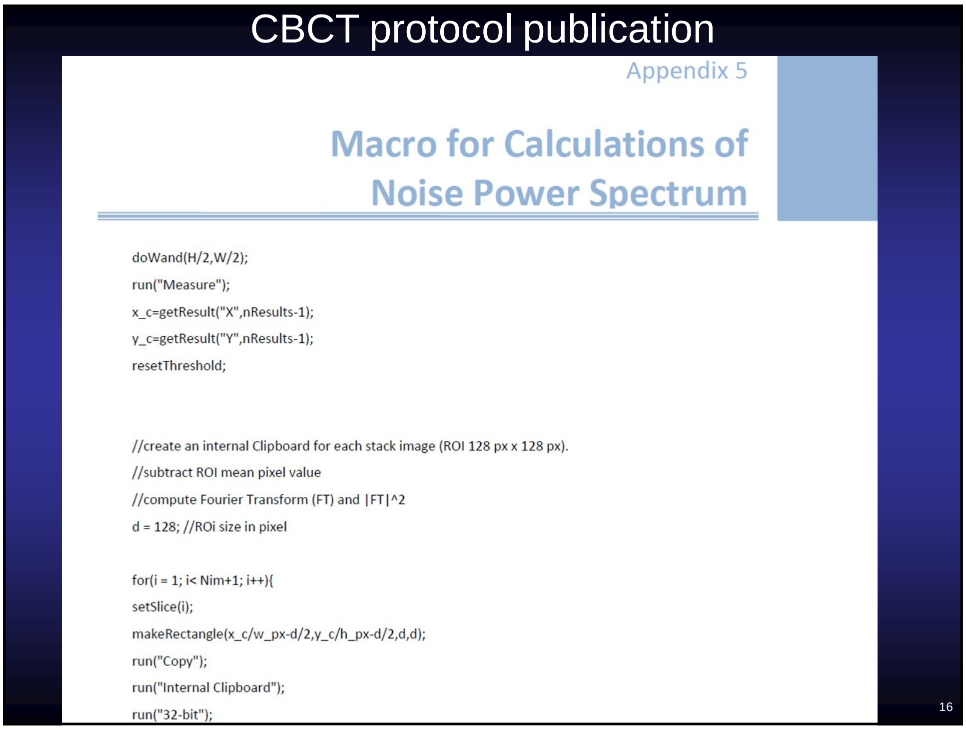
the longitudinal size of the scanned volume is user-defined. For the data acquisition, the exposure parameters for a standard patient are used following indications of the manufacturer. If the x-ray device makes use of an automatic exposure control, it is necessary to manually enter the appropriate exposure parameters.

Figure 5.2. Position of a flat solid-state probe to measure the $K_{a,i}$(FDD) in a dental CBCT (left), a C-arm for angiography CBCT (right) and a CBCT in radiotherapy. Used with permission from F. Schöfer, B. Renger and K. Mair, respectively.

The advantage of this simple measurement is that it enables the calculation of a dose quantity, D_{FOV}, which takes into account the kind of geometry, size of the field of view and rotation angle. This quantity is an estimation of the average dose calculated over the diameter of the FOV, and it can be determined from the $K_{a,i}$(FDD)using a simple geometrical relation:

$$D_{FOV} = K_{a,i}(\text{FDD}) \cdot \frac{b}{a} \cdot \frac{d}{c'} \quad [5.1]$$


CBCT protocol publication
APPENDIX 2
Example of
Quality Control Report
Monthly CBCT QC report following the EFOMP-ESTRO-IAEA guidelines
User data
Name: Name of the person performing the tests (or the owner of the CBCT device)
Facility: Name and address of the institution
Telephone number/E-mail: User contact information
Device data
Type: Dental CBCT
Manufacturer: Vatech
Model: Pax-i3D PHT6500
S/N: 052-1988
Effective area of the detector: 71.68 x 11.76 mm
Model: QUART DVTap
S/N: 0123
Analysis software data
Name: ImageJ & QUART CTtec
Manufacturer: NIH & QUART GmbH
Website:imagej.nih.gov/ij/ & quart.de
Scan data
Maximum scan time: 24 s
kVp/mAs: 89 kV/ 4.9 mA
Mode: constancy tests
Phantom data
Manufacturer: QUART GmbH
Geometric data (see equation 5.1)
Distance from the focal spot to the isocentre (a): 449 mm
Distance from the detector to the focal spot (b): 642.3 mm
Horizontal diameter of scanned volume: (c): 80 mm
Horizontal diameter of radiation field at the detector (d): 71.68 mm
15


CBCT protocol publication
Appendix 5
Macro for Calculations of
Noise Power Spectrum
doWand(H/2,W/2);
run("Measure");
x_c=getResult("X",nResults-1);
y_c=getResult("Y",nResults-1);
resetThreshold;
//create an internal Clipboard for each stack image (ROI 128 px x 128 px).
//subtract ROI mean pixel value
//compute Fourier Transform (FT) and |FT|^2
d = 128; //ROi size in pixel
for(i = 1; i< Nim+1; i++){
setSlice(i);
makeRectangle(x_c/w_px-d/2,y_c/h_px-d/2,d,d);
run("Copy");
run("Internal Clipboard");
run("32-bit");
16

The future breast dosimetry publication

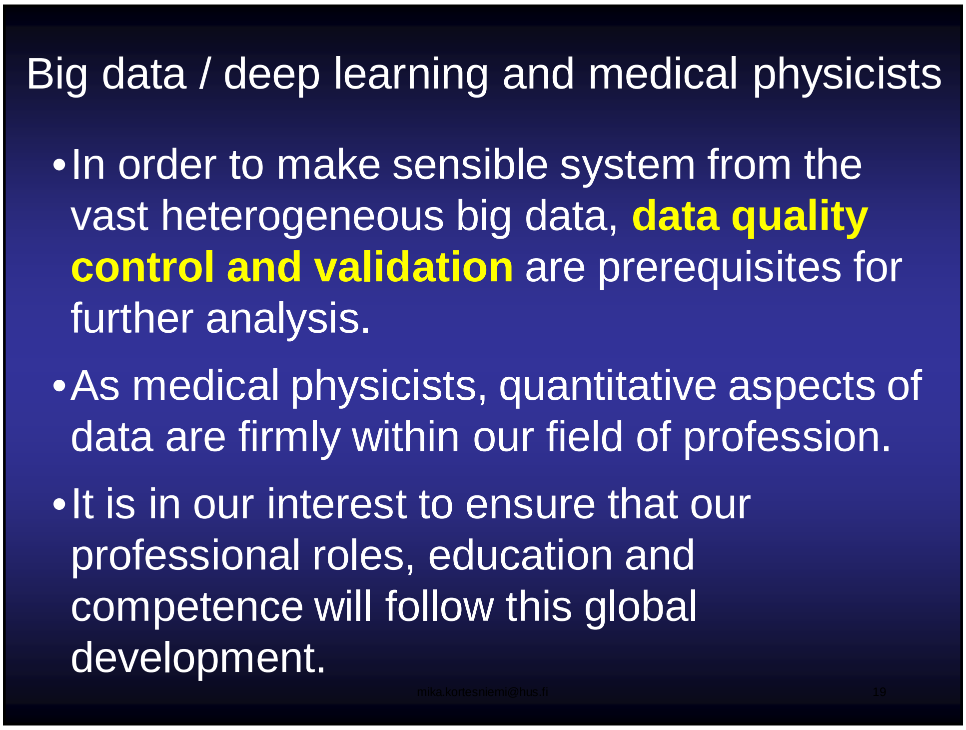
- Work in progress regarding a **universal breast dosimetry** under the **EFOMP-AAPM-ICRU** Task Group 282.
- The development aims to a new model and methodology to estimate the breast average glandular dose (AGD) from x-ray based image acquisitions (standard, contrast-enhanced, spot, magnification mammography and breast tomosynthesis.

mika.kortesniemi@hus.fi

Big data and deep learning

- Big data and deep learning will profoundly change various areas of professions and research in the future. This will also happen in medicine and medical imaging.
- Patient specific optimisation (in a clinically relevant way) requires big data analysed by AI.
- As physicists, we should pursue beyond the concept of quality, to extend our methodology towards measuring the diagnostic value **in terms of outcome**.

mika.kortesniemi@hus.fi


Big data / deep learning and medical physicists
• In order to make sensible system from the vast heterogeneous big data, **data quality control and validation** are prerequisites for further analysis.
• As medical physicists, quantitative aspects of data are firmly within our field of profession.
• It is in our interest to ensure that our professional roles, education and competence will follow this global development.