



Federal Office for
Radiation Protection

Type testing of CTs using the model observer approach

A suggestion for an automated analysis

CCRI Webinar: Approaches to assess image quality in x-ray diagnostics

05.11.2024, Online



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Image reconstruction algorithms

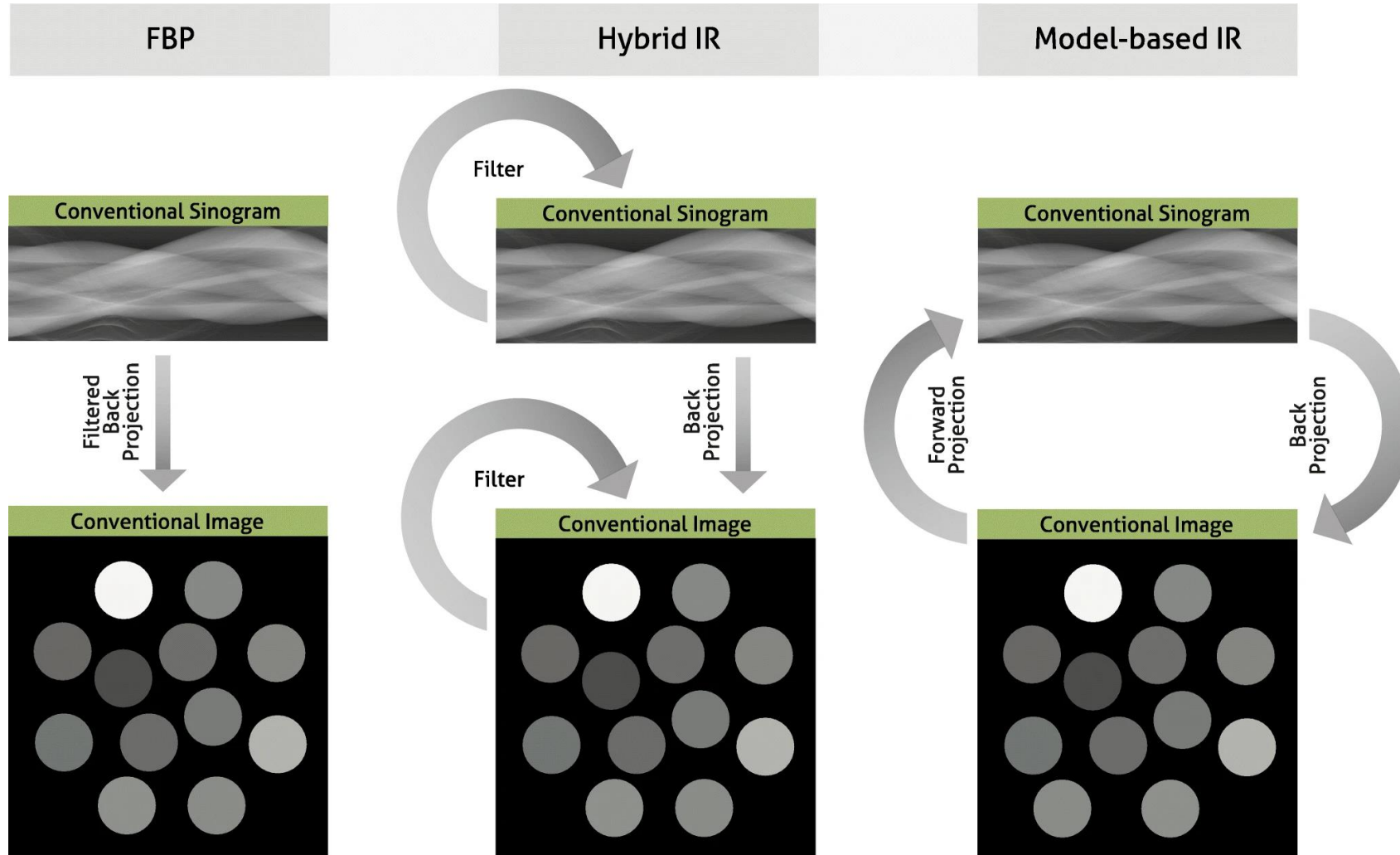
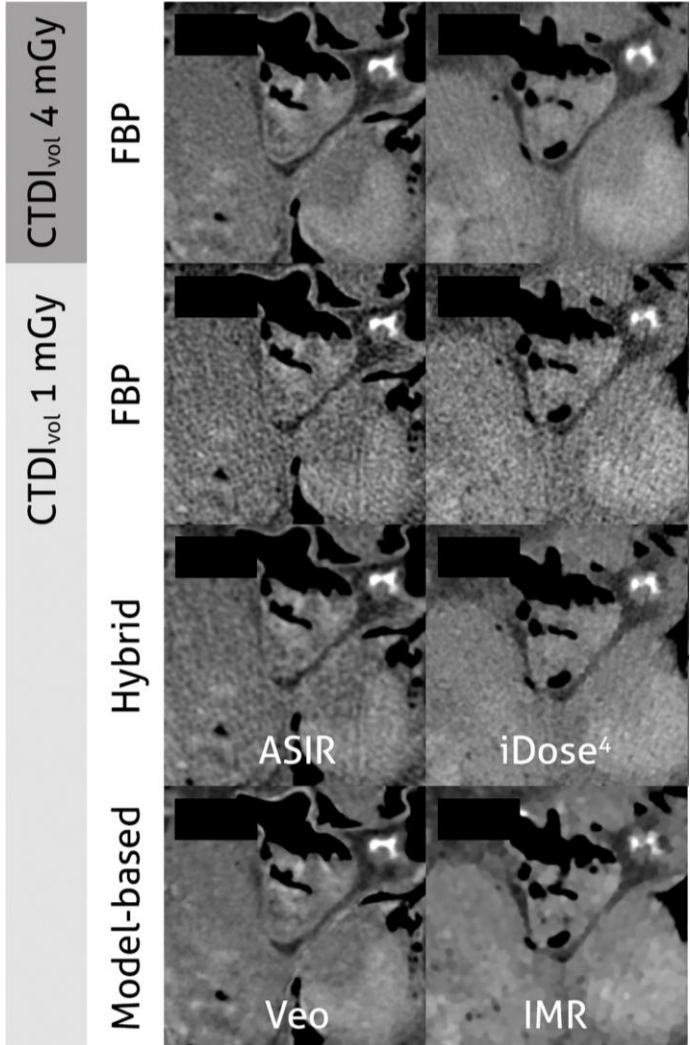


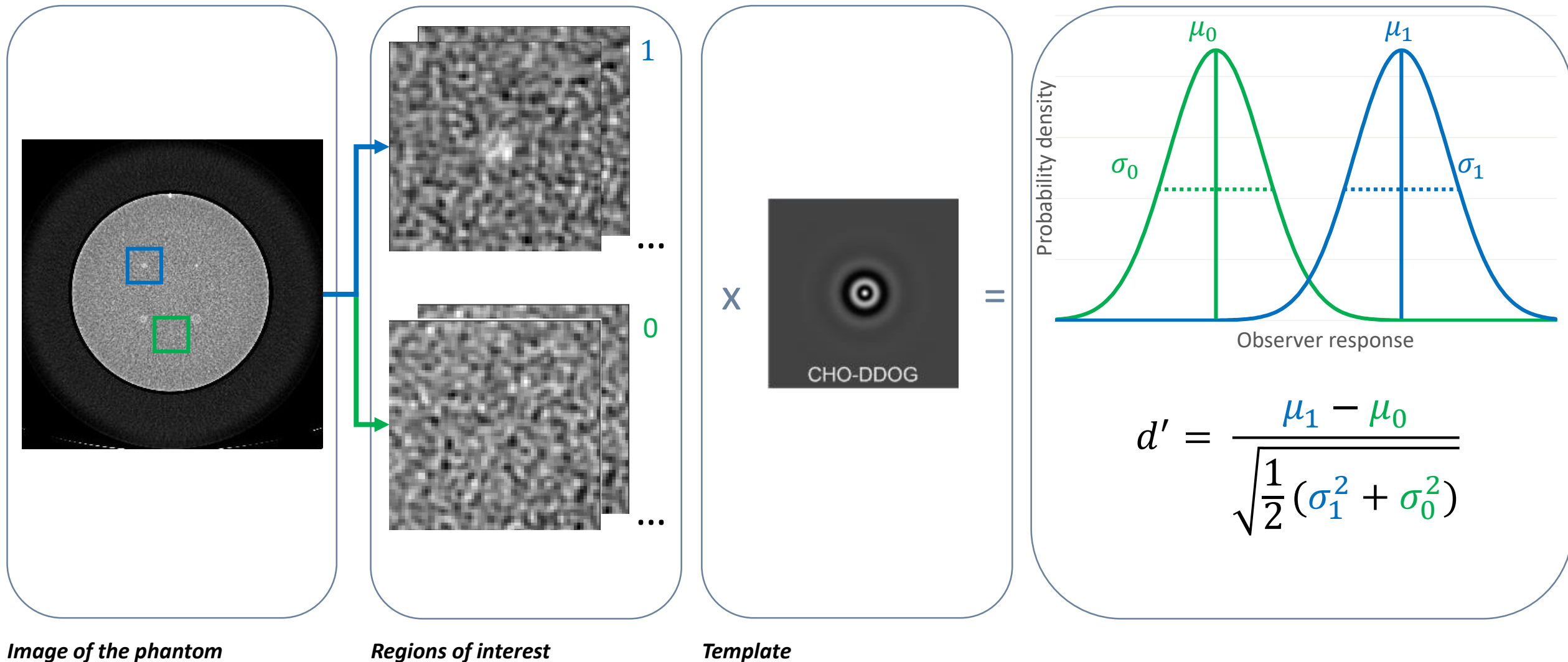
Image reconstruction algorithms

	Speed	Noise reduction	Dose reduction potential
FBP	Fast	No	Low
Hybrid IR	Rather fast	Moderate	Moderate
Model-based IR	Rather slow	Pronounced	Pronounced



Introduction to model observers

Detection of low-contrast objects using model observers

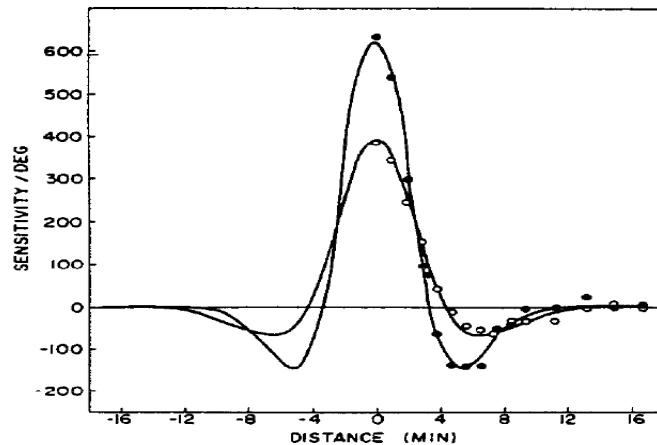


Historic development

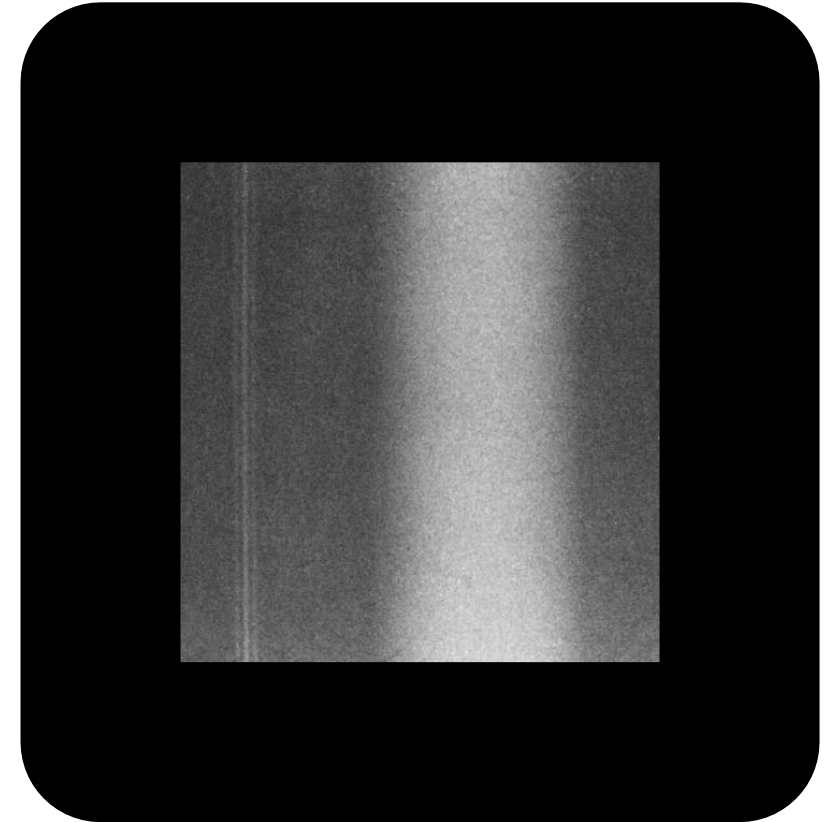
Addition of a channel mechanism to the ideal-observer model

- Kyle J. Myers and Harrison H. Barrett

“Given that these **narrow frequency channels** are present in the **human visual system**, they can be **added to an ideal observer** model to determine their effect on the detection ability of the ideal observer.”



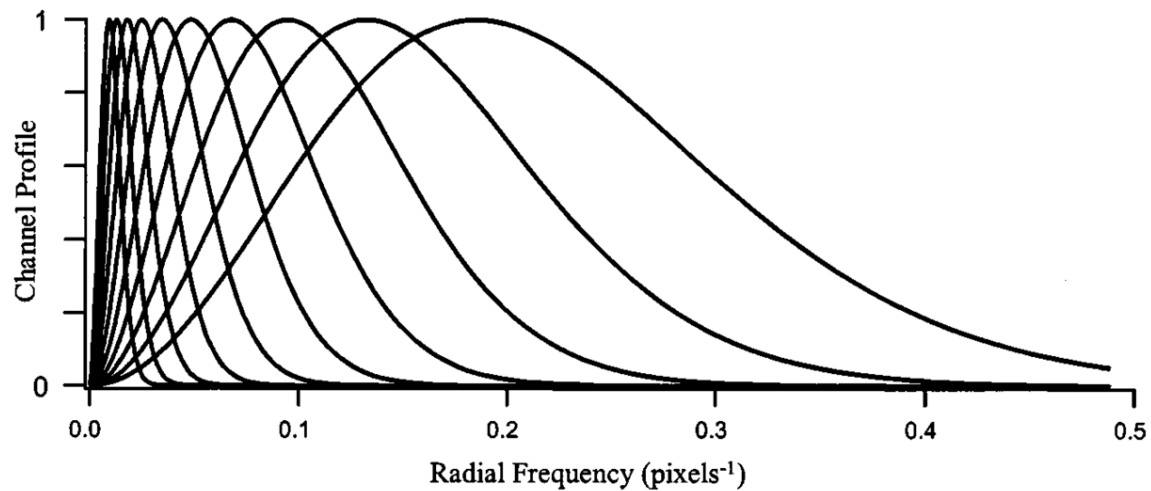
Determined line spread functions that were fitted by the difference of two Gaussians



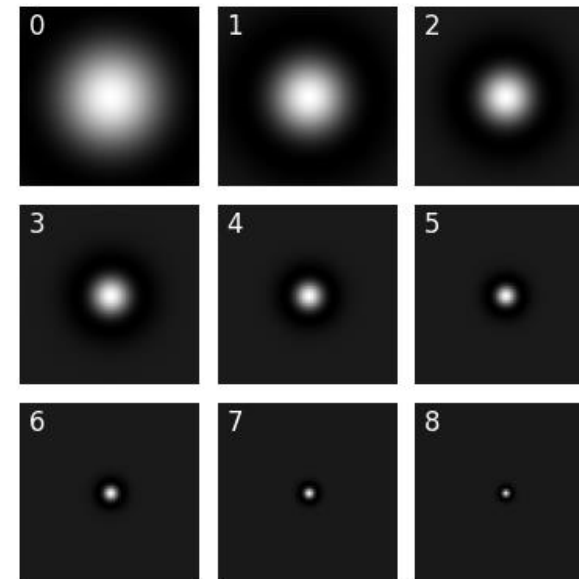
Luminance patterns used: thin line with two half contrast flanking lines, cosine bar

Difference of Gaussians

Difference of Gaussians channels model the human visual system's spatial frequency selectivity.



Profiles in frequency domain.



Representation in image domain

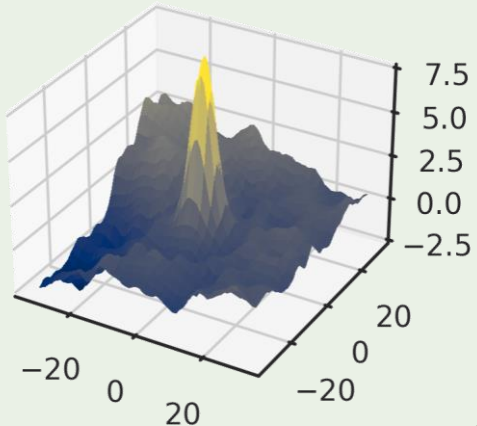
Channelization

1:

Image

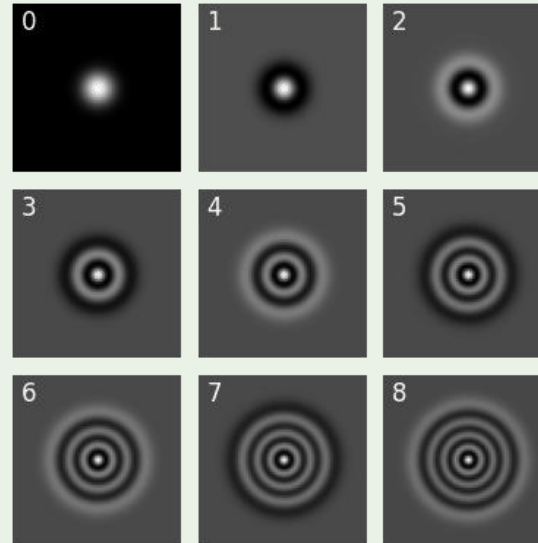
$$\mathbf{s} = \bar{\mathbf{g}}_1 - \bar{\mathbf{g}}_0 \in \mathbb{R}^{M \times 1}$$

$$\mathbf{s} = \begin{pmatrix} 0 \\ 2 \\ 1 \\ 4 \\ \dots \\ \dots \end{pmatrix}$$



2:

Channel matrix $\mathbf{U} \in \mathbb{R}^{N_c \times M}$



Laguerre-Gauß-channels

3:

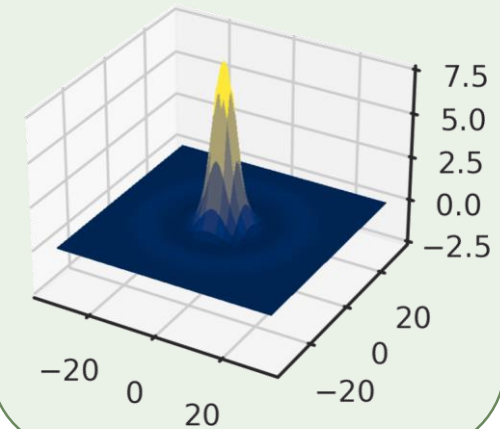
Channelized image

$$\mathbf{v} = \mathbf{U}\mathbf{s} \in \mathbb{R}^{N_c \times 1}$$

$$\mathbf{v} = \begin{pmatrix} 100 \\ 80 \\ \dots \end{pmatrix}$$

[back projection]

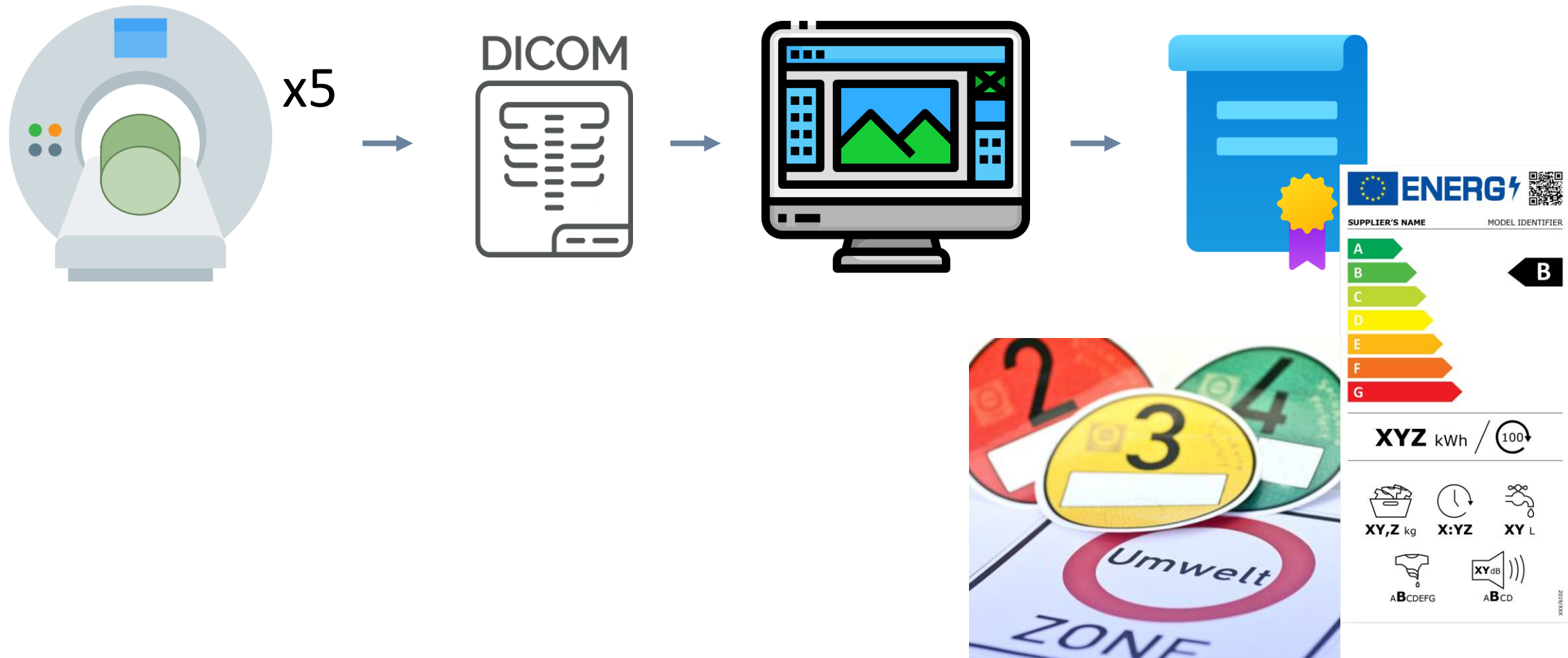
$$\mathbf{U}^T \mathbf{v}$$



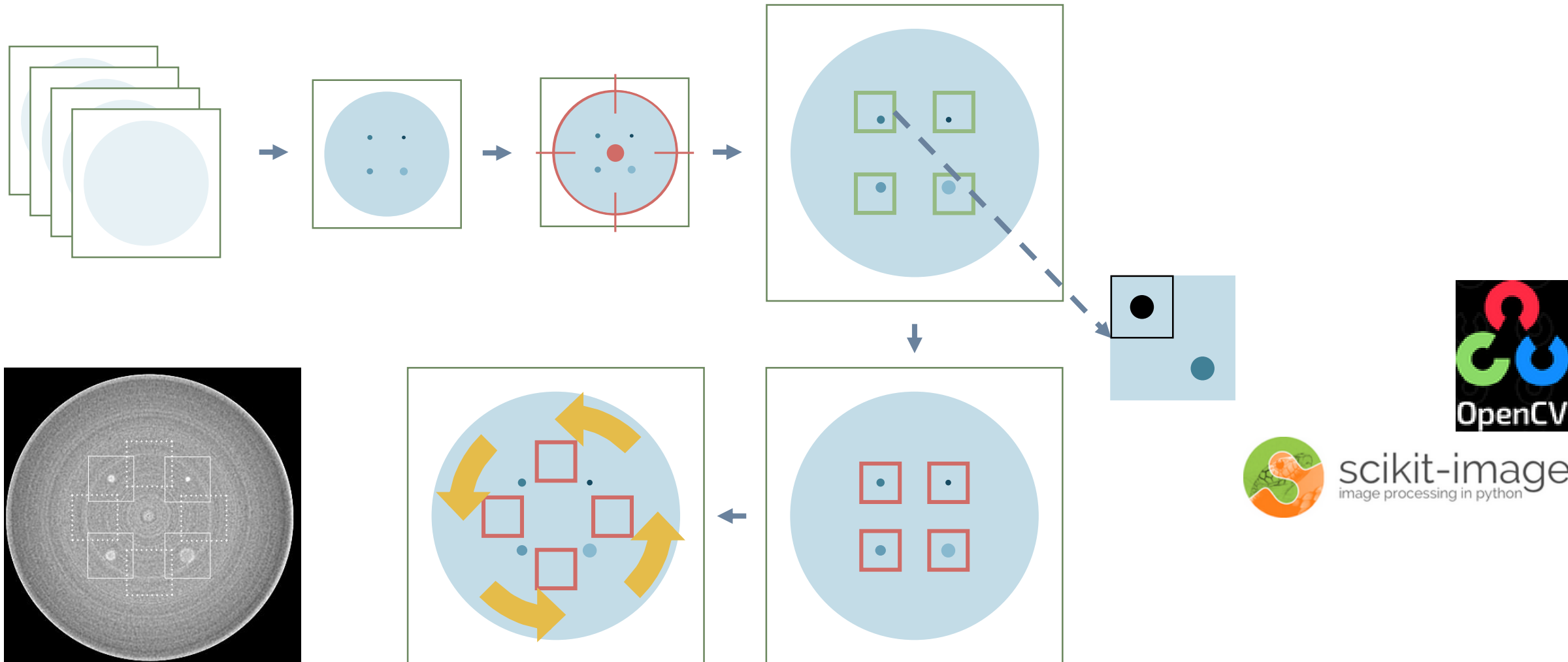
Schematic representation of the channelization mechanism

Method „dose efficiency“

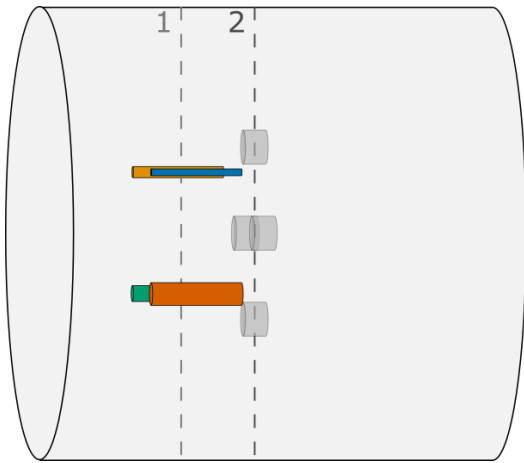
Aim: Establishment of a type testing



Automatic image processing



Phantom, protocol and calculation of the figure of merit



CCT189

Diameter [mm]	Contrast [HU]
3.0	14.0
5.0	7.0
7.0	5.0
10.0	3.0

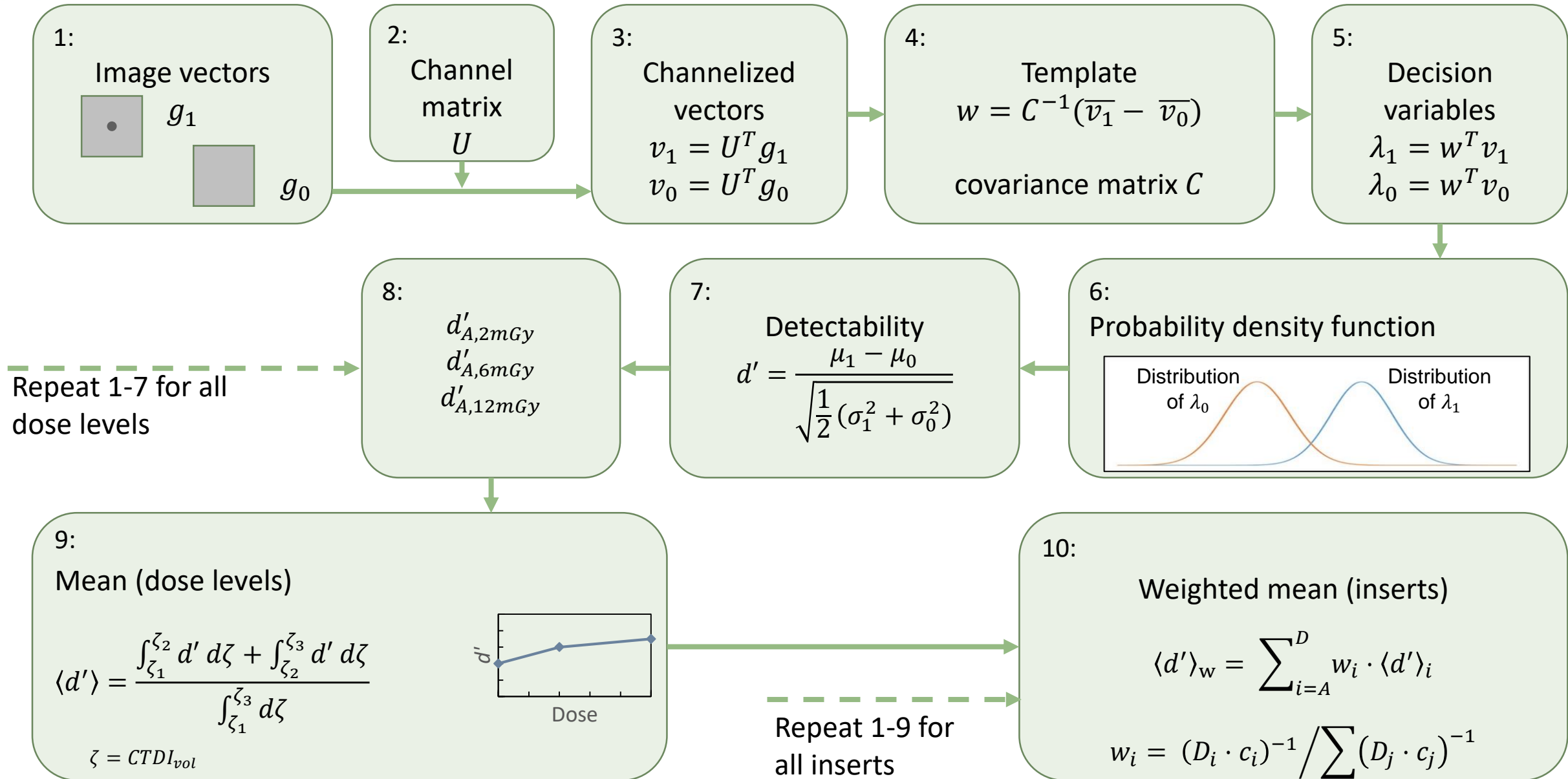
Parameter	Setting
Protocol	Abdomen (adult)
Scan mode	Axial
Tube voltage [kV]	120
$CTDI_w$ [mGy]	2, 6, 12
Slice thickness [mm]	5
Reconstructed field of view [mm]	250

- Assessment made averaging at three different dose levels and weighing over all four contrast inserts

Insert Dose [mGy]	3 mm 14 HU	5 mm 7 HU	7 mm 5 HU	10 mm 3 HU	
2	1.6	1.6	2.0	1.4	
6	1.8	2.4	3.3	2.5	
12	2.8	3.6	4.5	3.9	

dose efficiency index $\langle d' \rangle_w$

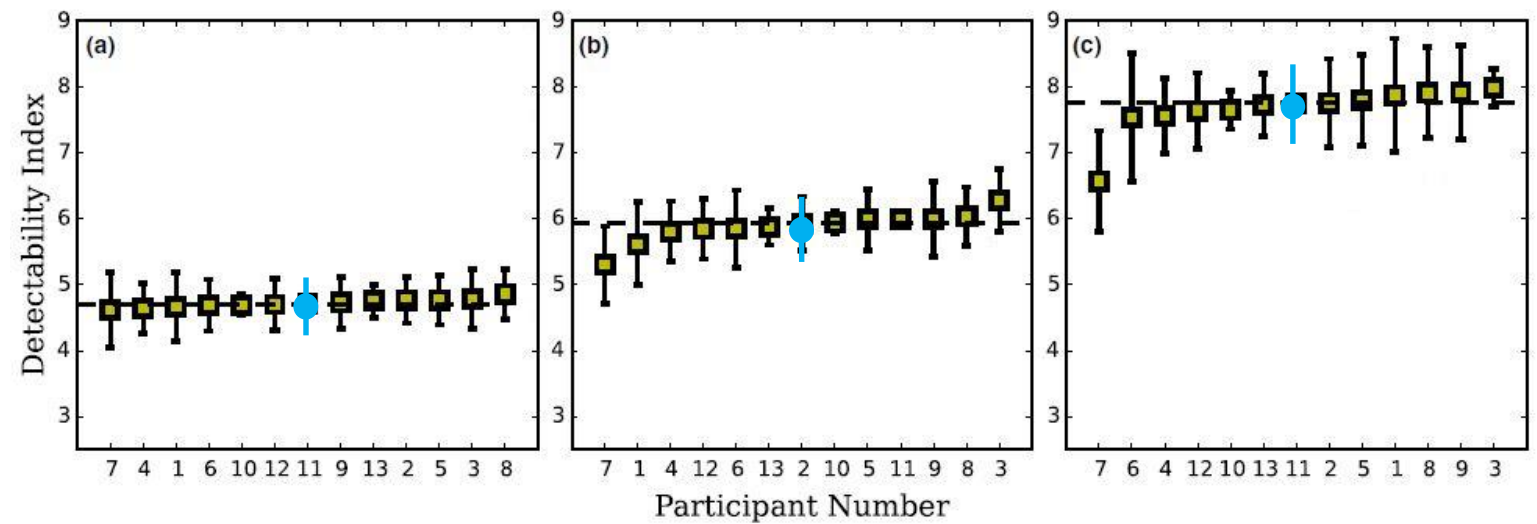
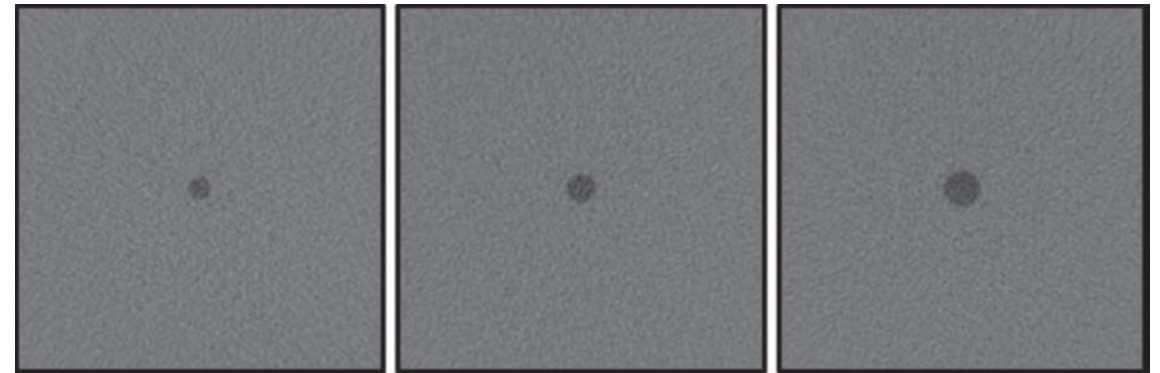
Scheme for calculation of dose efficiency index



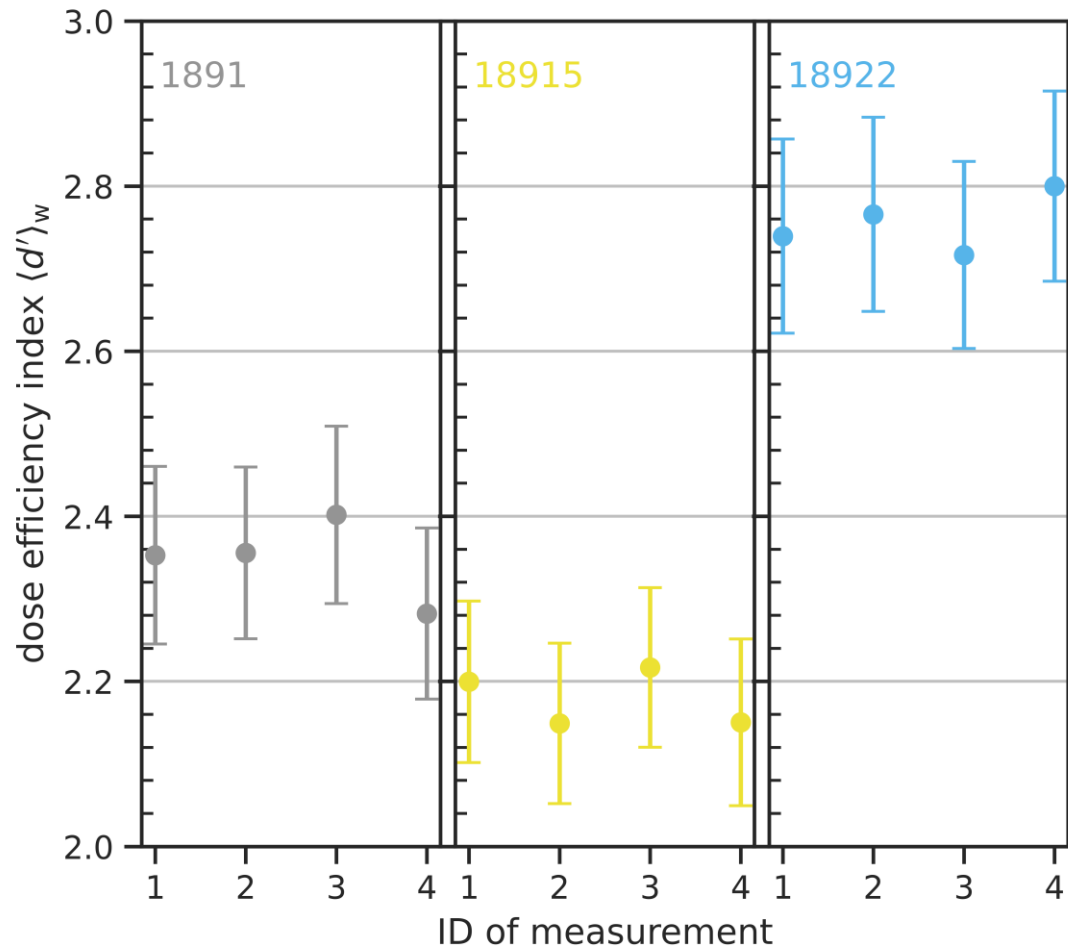


Results

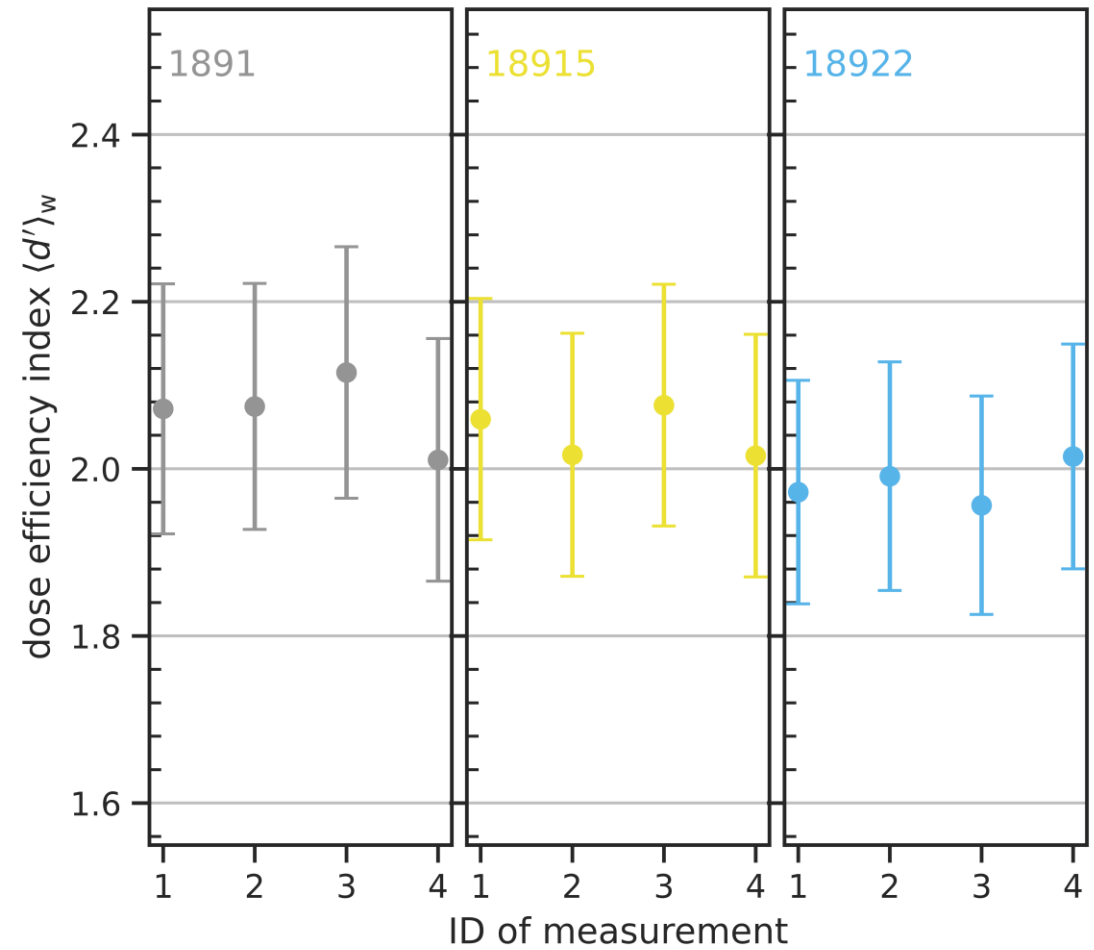
Ba et al.: Inter-laboratory comparison of CHO



Correction based on measured contrasts of one protocol with three specimen

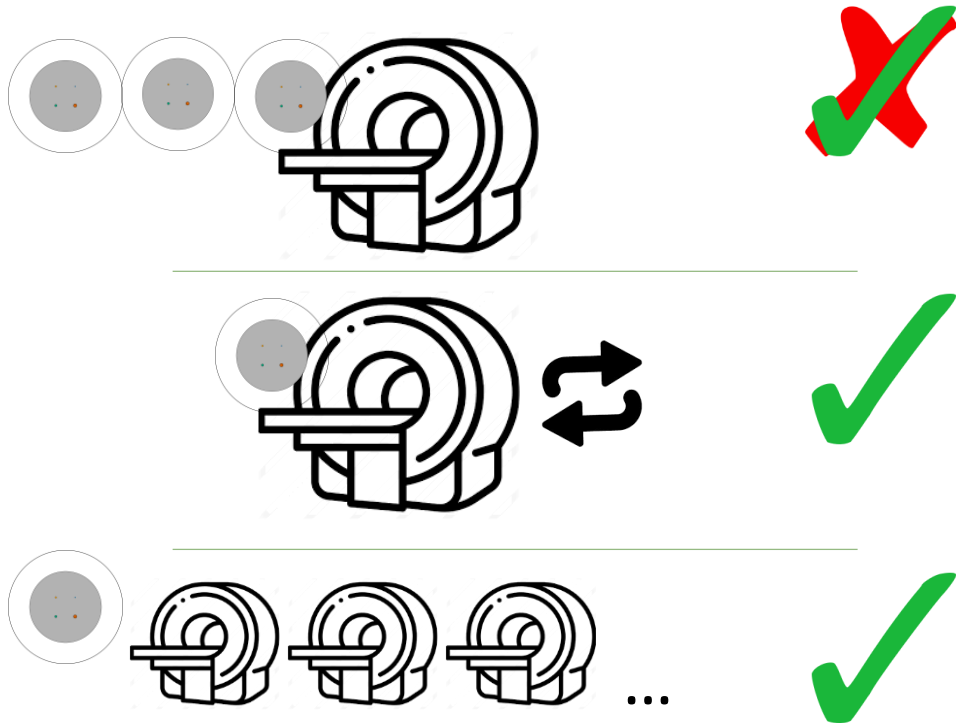


Results without correction.



Results with correction.

Conclusion



Outlook

- Further steps towards realisation
 - Build a web application
 - Include in a guideline

**The presented methodology can be used to determine
the dose efficiency of CT systems (based on low-contrast resolution).**




MEDICAL PHYSICS

The International Journal of Medical Physics Research and Practice



RESEARCH ARTICLE | [Open Access](#) |

Dose-efficiency quantification of computed tomography systems using a model-observer

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