

# Image Quality of Three Generations of CT Systems for Protocols Fulfilling the German Lung Cancer Screening Requirements

Mishal Ursani<sup>1,2</sup>, Thuy Duong Do<sup>3</sup>, Hans-Ulrich Kauczor<sup>3</sup>, Heinz-Peter Schlemmer<sup>1</sup>, Tobias Lasser<sup>2</sup>, Stefan Schönberg<sup>4</sup>, Stefan Sawall<sup>1,5</sup>, and Marc Kachelrieß<sup>1,5</sup>

<sup>1</sup>German Cancer Research Center (DKFZ), Heidelberg, Germany

<sup>2</sup>Technical University of Munich, Germany

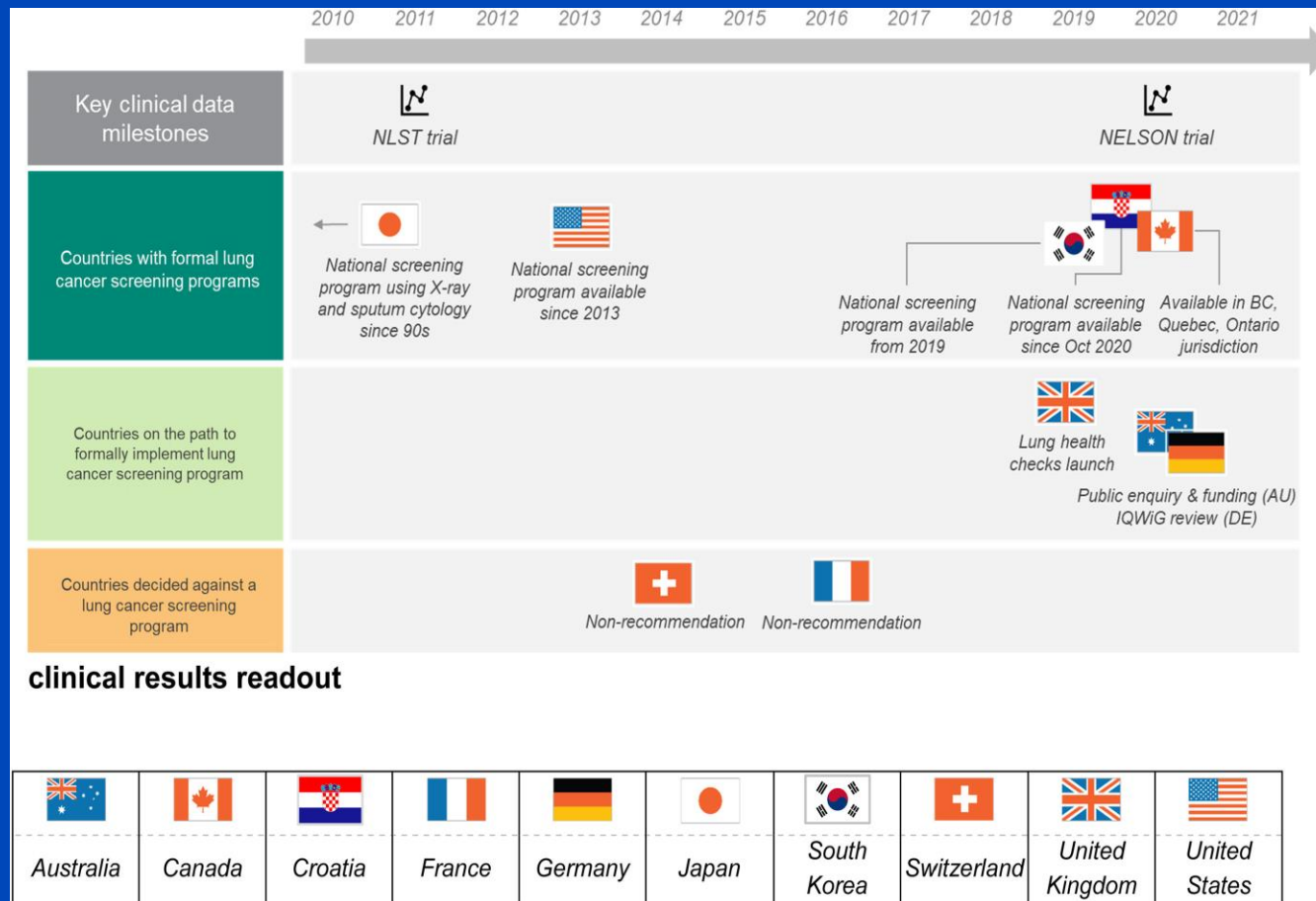
<sup>3</sup>University Hospital Heidelberg, Germany

<sup>4</sup>University Hospital Mannheim, Germany

<sup>5</sup>Heidelberg University, Germany

# Background and Aims

- Germany is about to establish a lung cancer screening program.
- To do so, requirements for the CT scanners and protocols are set forth.
- Vendors likely to provide dedicated acquisition protocols.
- **Our aims:**
  - To manually determine suitable acquisition protocols
  - To verify their compliance with the technical requirements
  - To do this for three different CT systems



# Technical Demands According to BfS<sup>1</sup>

Parameter	Requirement	Comment
Dose conversion	$k = 0.019 \text{ mSv/mGy/cm}$	$D_{\text{eff}} = k \cdot \text{DLP}$
Topogram CTDI	$\leq 20\%$ of screening CTDI	Use additional prefilter
Scan length	Adapt to lung	Not longer than lung
Scan time	$\leq 15 \text{ s}$	Breath-hold required
Rotation time	$\leq 1 \text{ s}$	
Screening CTDI	must not exceed 1.3 mGy	For BMI = 26 kg/m <sup>2</sup>
Additional prefilter <sup>1</sup>	Yes	At least for BMI $\leq 40 \text{ kg/m}^2$
TCM, auto kV-selection	Yes	TCM in $\alpha$ and $z$
Dynamic collimation	Yes, if at least 64 detector rows	To avoid overbeaming
Reconstruction	Iterative or deep learning	
Spatial resolution	between 0.8 and 1.0 mm	For low contrasts (150 HU)
Slice thickness	up to 0.7 mm	
Viewing thickness	up to 3.0 mm	

**Exposure parameters and dose levels are to be adapted to patient size!**

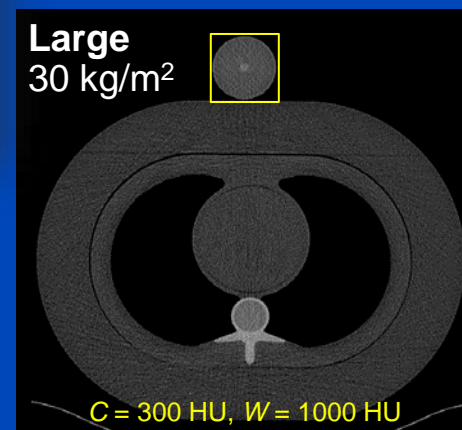
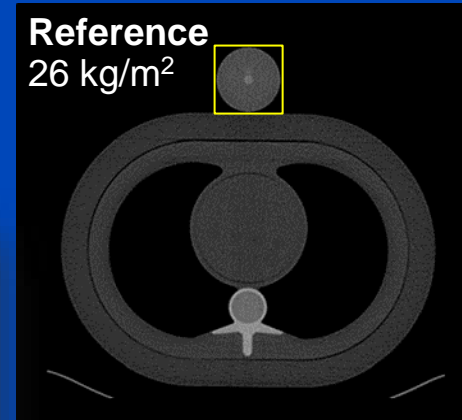
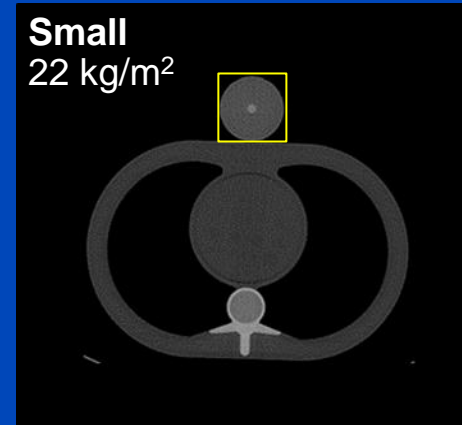
**Ground glass nodules: about 150 HU  
Other lung lesions: 500 HU or more**

<sup>1</sup>Prefilter that can be adjusted to patient size, e.g. removable for large patients.

	BfS		BMUV	
Parameter	Value	Comment	Value	Comment
Dose conversion	$k = 0.019 \text{ mSv/mGy/cm}$	$D_{\text{eff}} = k \cdot \text{DLP}$		
Topogram CTDI	$\leq 20\%$ of screening CTDI	Use additional prefilter	$\leq 20\%$ of screening CTDI	
Scan length	Adapt to lung	Not longer than lung	Adapt to lung	Not longer than lung
Scan time	$\leq 15 \text{ s}$	Breath-hold required	$\leq 15 \text{ s}$	Breath-hold required
Rotation time	$\leq 1 \text{ s}$	-	$\leq 0.5 \text{ s}$	
Pitch	According to vendor	-	0.9-1.2	
Screening CTDI	$\leq 1.3 \text{ mGy}$	For BMI = 26 kg/m <sup>2</sup>	$\leq 1.3 \text{ mGy}$	Can be exceeded based on habitus
Additional prefilter <sup>1</sup>	Yes	At least for BMI $\leq 40 \text{ kg/m}^2$		
TCM, auto kV-selection	Yes	TCM in $\alpha$ and z	Yes	
Dynamic collimation	Yes, if at least 64 detector rows	To avoid overbeaming	Yes, if at least 4 cm collimation	To avoid overbeaming
Reconstruction	Iterative or deep learning		Model based iterative or similar	
Kernel	Body kernel	Less noise than lung kernel	Lung kernel	
Spatial resolution	between 0.8 and 1.0 mm	For low contrasts (150 HU)	between 0.8 and 1.0 mm	For low contrasts (150 HU)
Slice thickness	up to 0.7 mm			
Viewing thickness	up to 3.0 mm			

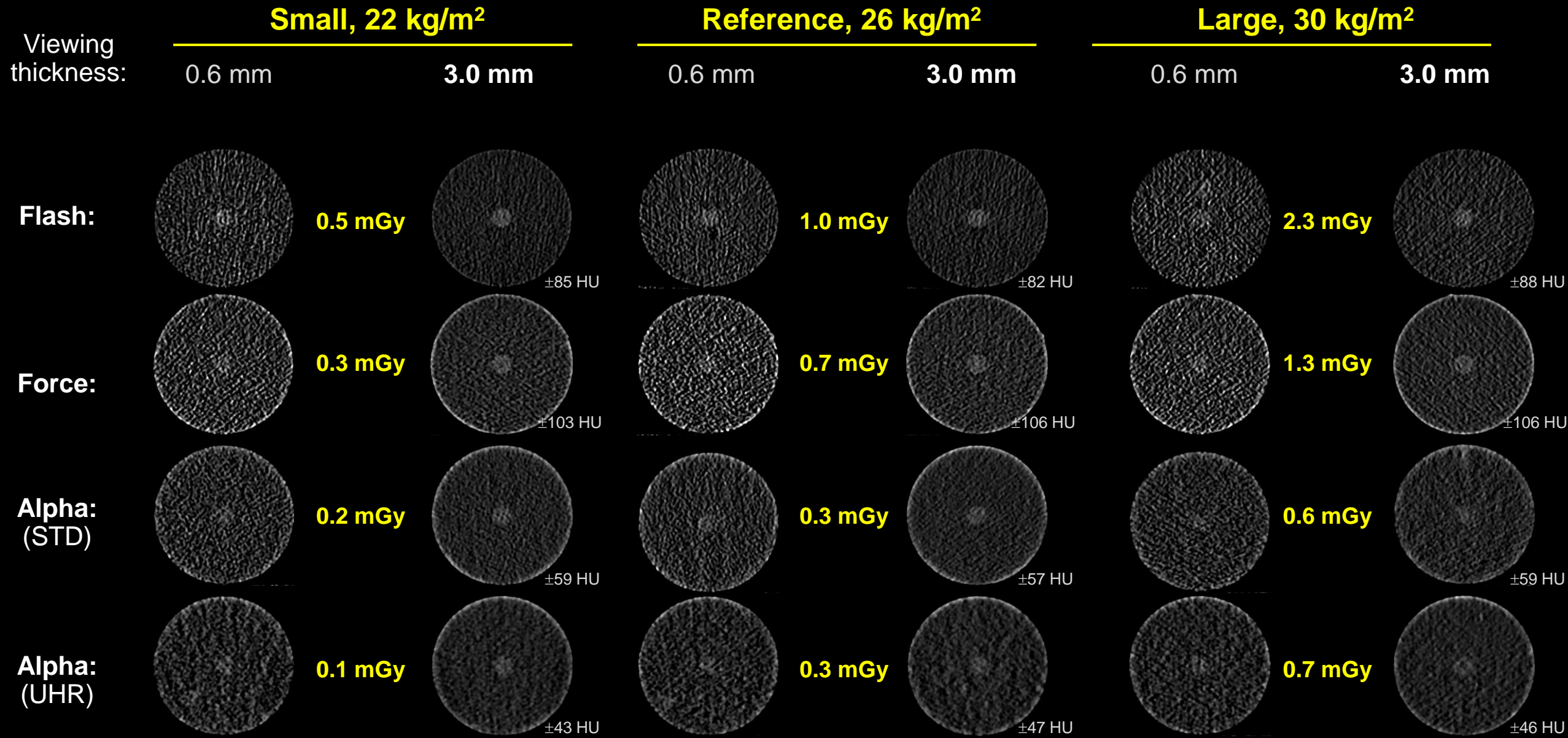
# Materials and Methods

	Somatom Flash	Somatom Force	Naeotom Alpha (Std and UHR mode)
CTDI	1.3 mGy	1.3 mGy	1.3 mGy
Tube voltage	120 kV	120 kV Sn	100 kV Sn
Tube current time product	20 mAs	120 mAs	2x153 mAs
Slice thickness	0.6 mm	0.6 mm	0.4 mm
Tin filter thickness	-	0.6 mm	0.6 mm
Reconstruction algorithm	SAFIRE	ADMIRE	QIR
Reconstruction kernel	I50	BI57	BI56



**Scan parameters if one wanted to scan at the maximum permissible CTDI of 1.3 mGy. Only permissible if 1.3 mGy at 26 kg/m<sup>2</sup> are ALARA!**

# Results (Showing the Lesion with 150 HU Contrast)



Rule of thumb for adult lung scans: 2 mGy  $\approx$  1 mSv. C = 500 HU, W = 1000 HU

# Conclusions

- CT systems of different generations are able to satisfy the BfS requirements.
- Manually finding the optimal scan protocols is cumbersome.
- Vendors should provide adequate LCS protocols.
- These must include the adaptation to patient attenuation (or size or BMI).

# Thank You!



This presentation will soon be available at [www.dkfz.de/ct](http://www.dkfz.de/ct).

Job opportunities through [marc.kachelriess@dkfz.de](mailto:marc.kachelriess@dkfz.de) or through DKFZ's international PhD or Postdoctoral Fellowship programs.

Parts of the reconstruction software were provided by RayConStruct® GmbH, Nürnberg, Germany.