

# Patient Size-Dependent Ultra Low Dose Data Completion Scan in a Whole Body Photon-Counting CT Scanner

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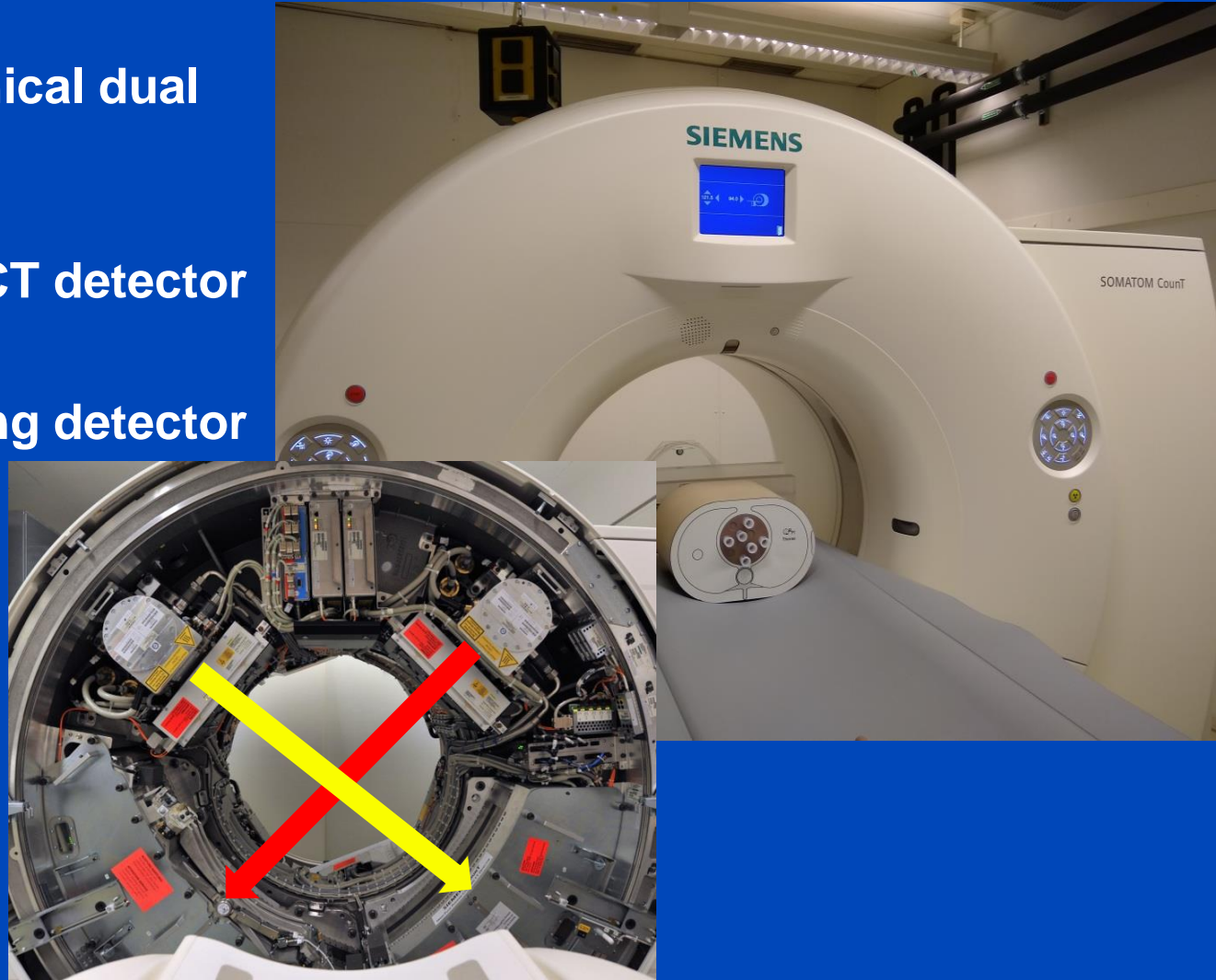
DEUTSCHES  
KREBSFORSCHUNGSZENTRUM  
IN DER HELMHOLTZ-GEMEINSCHAFT

# SOMATOM CounT CT System

Gantry from a clinical dual source scanner

**A:** Conventional CT detector  
(50 cm FOV)

**B:** Photon counting detector  
(27.5 cm FOV)



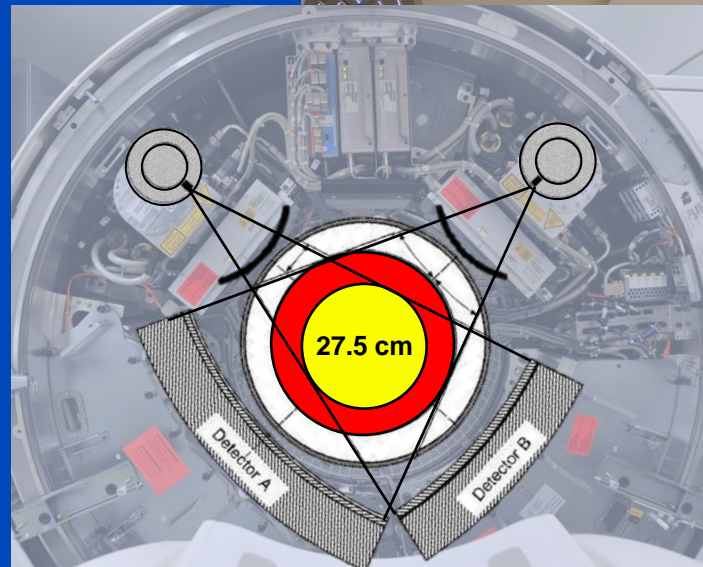
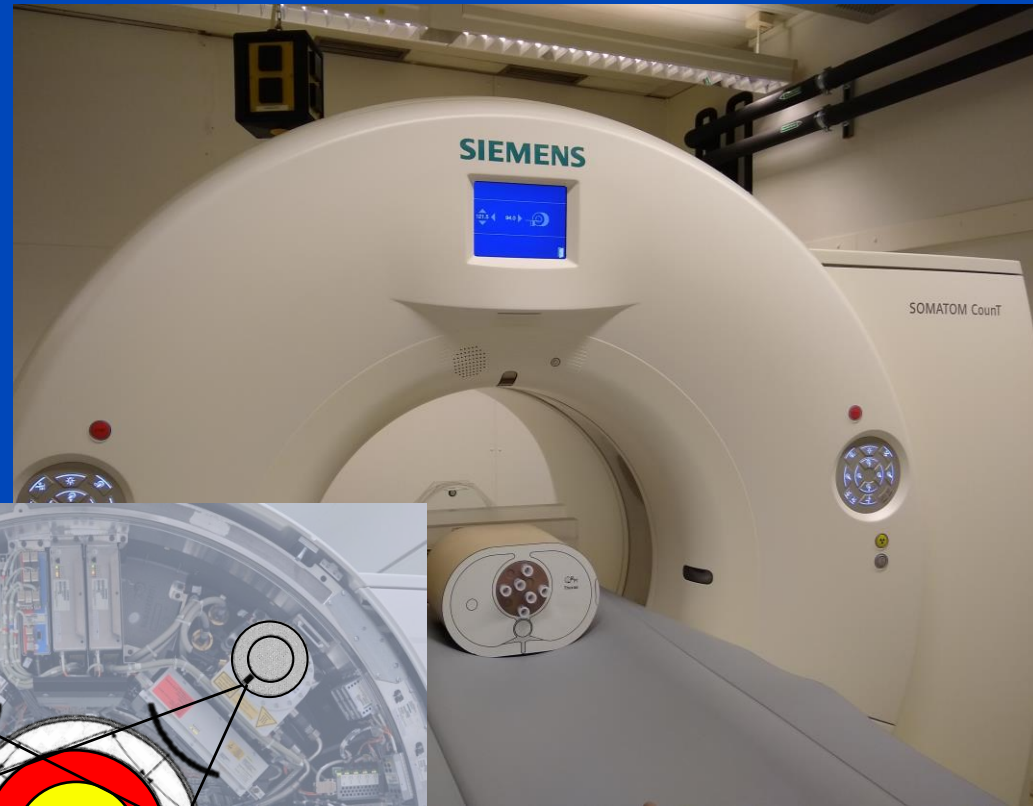
Prototype, not commercially available.

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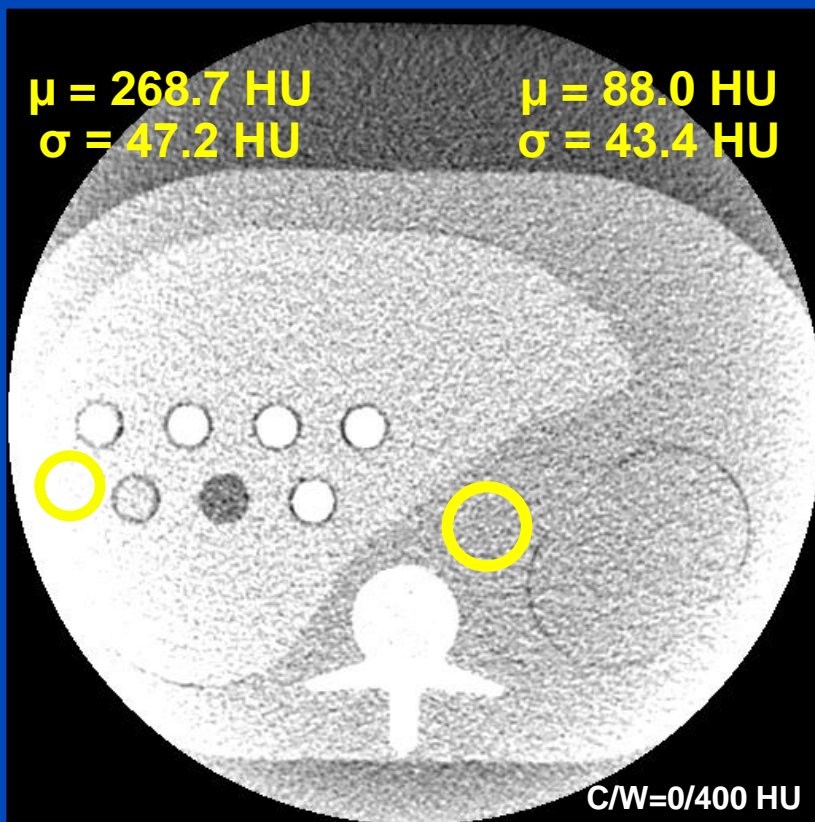


Prototype, not commercially available.

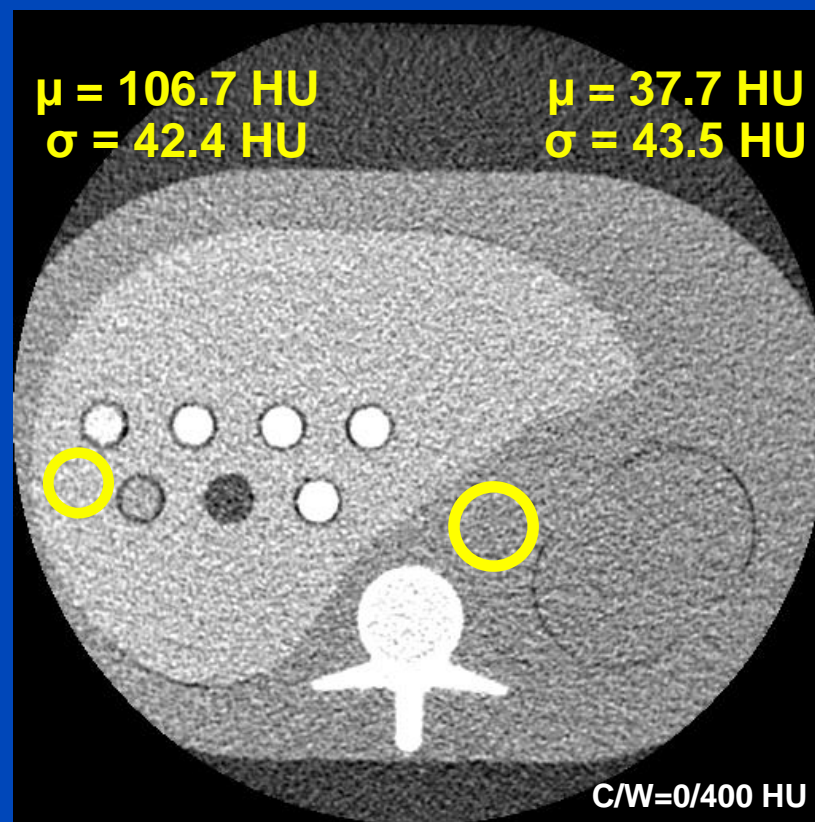


# Influence of Data Detruncation

PC scan  
with truncation



PC scan with detruncation using  
the data completion scan.



DCS dose as in previous study\*

# Aim

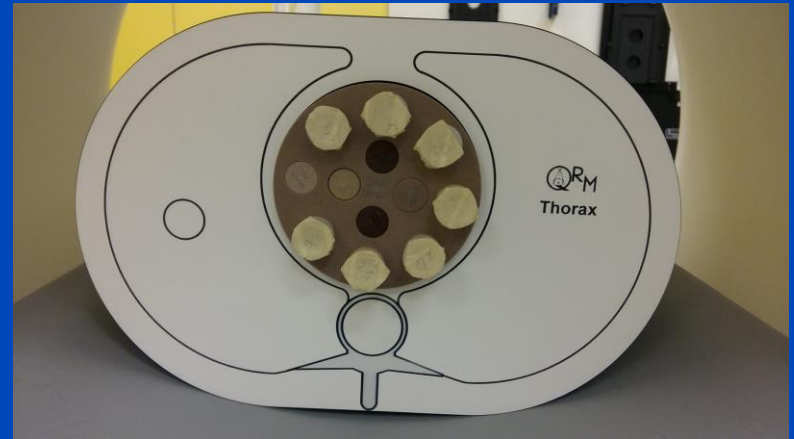
**To find the minimum possible dose of the data completion scan (DCS) on a photon-counting (PC) CT prototype**

**To provide recommendations for a corresponding dose-optimized DCS scan protocol**

# Materials & Methods

## Phantoms

- Anthropomorphic thorax and liver phantom
- Three different phantom sizes
  - Small (200 × 300 mm)
  - Medium (250 × 350 mm)
  - Large (300 × 400 mm)



# Materials & Methods

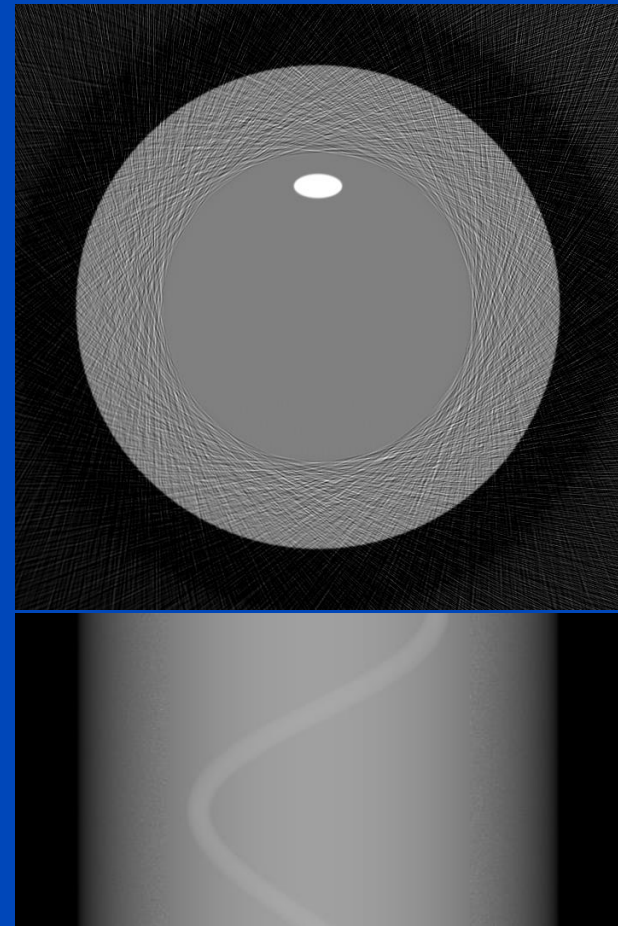
## Image Acquisition

- **PC scan (B system): Macro mode**
  - Tube voltage of 120 kV
  - 200 mAs<sub>eff</sub>
- **DCS scan (A system)**
  - Varying mAs<sub>eff</sub> and fixed tube voltage of 120 kV
    - » 100 mAs<sub>eff</sub>, 20 mAs<sub>eff</sub>, 7 mAs<sub>eff</sub>
  - Varying tube voltages and fixed mAs<sub>eff</sub> of 7 mAs
    - » 120 kV, 100 kV, 80 kV
  - High pitch of 1.5 enabling ultra low dose levels

# Materials & Methods

## DCS-based Detruncation

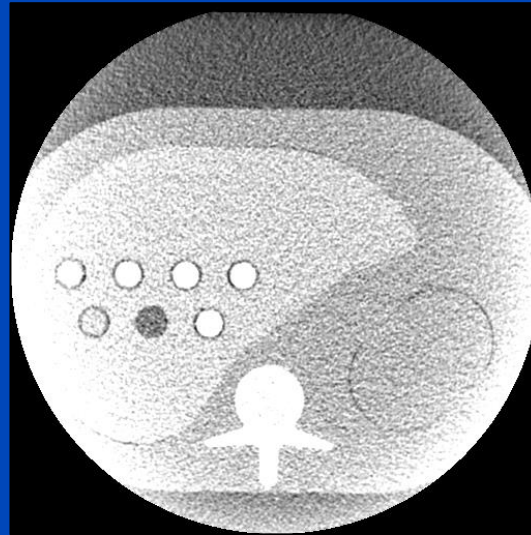
- Reconstruction of DCS scan followed by a forward projection of EI data in PC geometry
- Missing projections are estimated and scaled to ensure smooth transition between PC and EI data
- Data completion only used during filtering step in reconstruction
- Photon-counting image is limited to small FOM.
- Almost no noise propagation to the inner FOM due to the reconstruction kernel's central element being dominant.



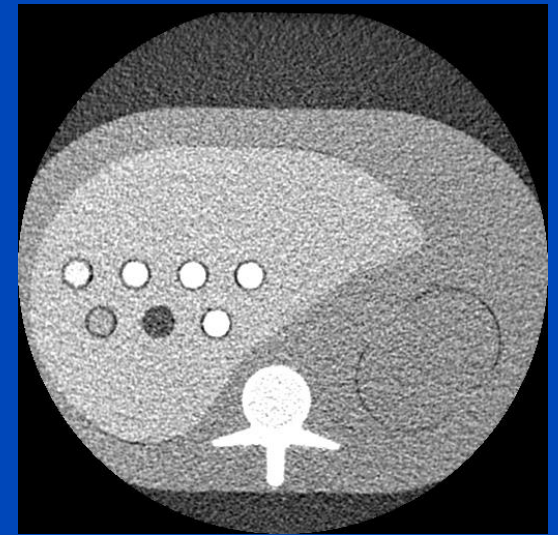
Noise added to outermost 25 % of detector channels.



PC scan  
with truncation



PC scan  
with DCS detruncation.

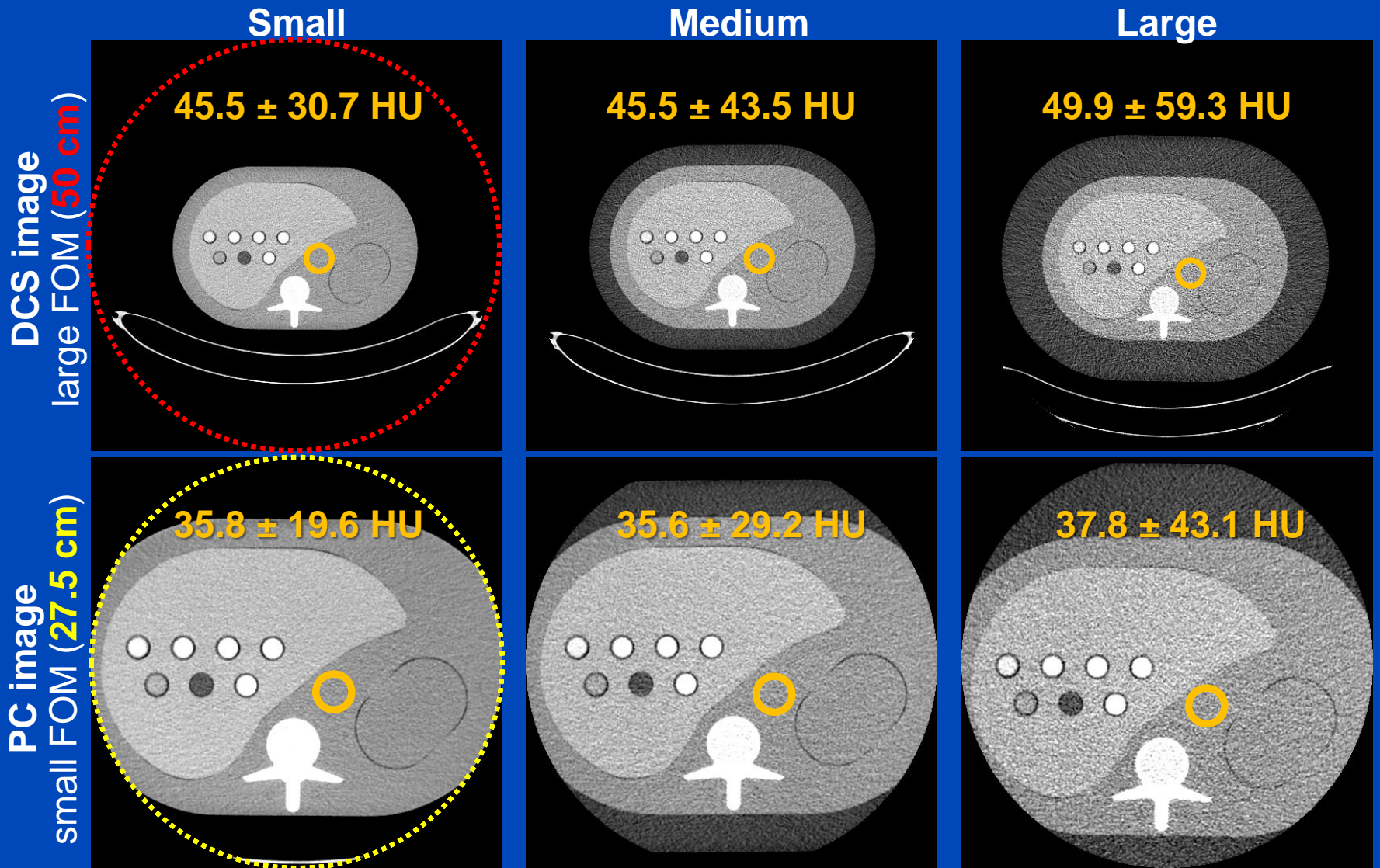


# RESULTS

## LIVER PHANTOM

# Results

Liver Phantom: 6.70 mGy DCS, 100 mAs<sub>eff</sub>, 120 kV, pitch 1.5

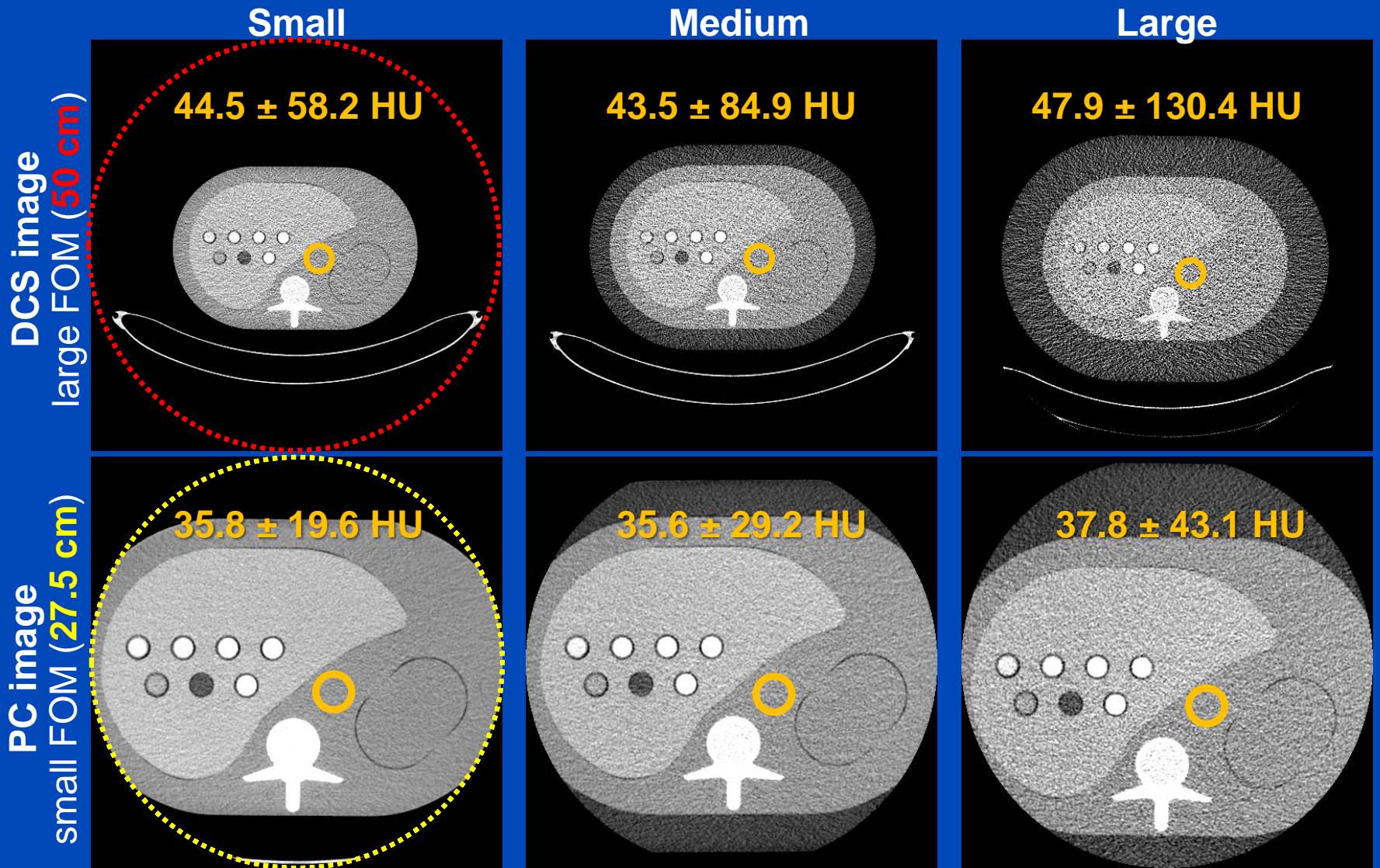


C = 0 HU, W = 400 HU



# Results

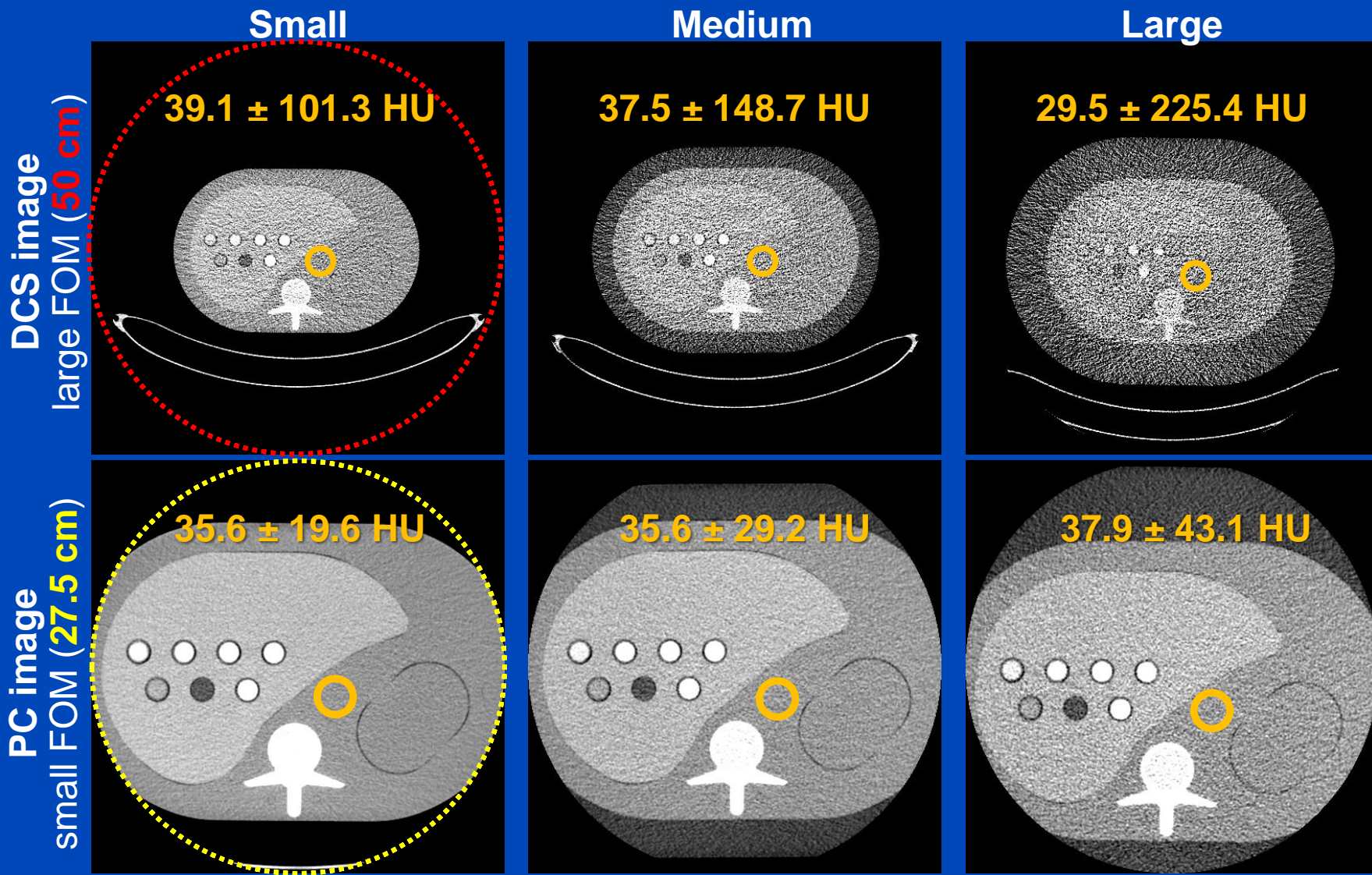
Liver Phantom: 1.35 mGy DCS, 20 mAs<sub>eff</sub>, 120 kV, pitch 1.5



C = 0 HU, W = 400 HU

# Results

Liver Phantom: 0.43 mGy DCS, 7 mAs<sub>eff</sub>, 120 kV, pitch 1.5

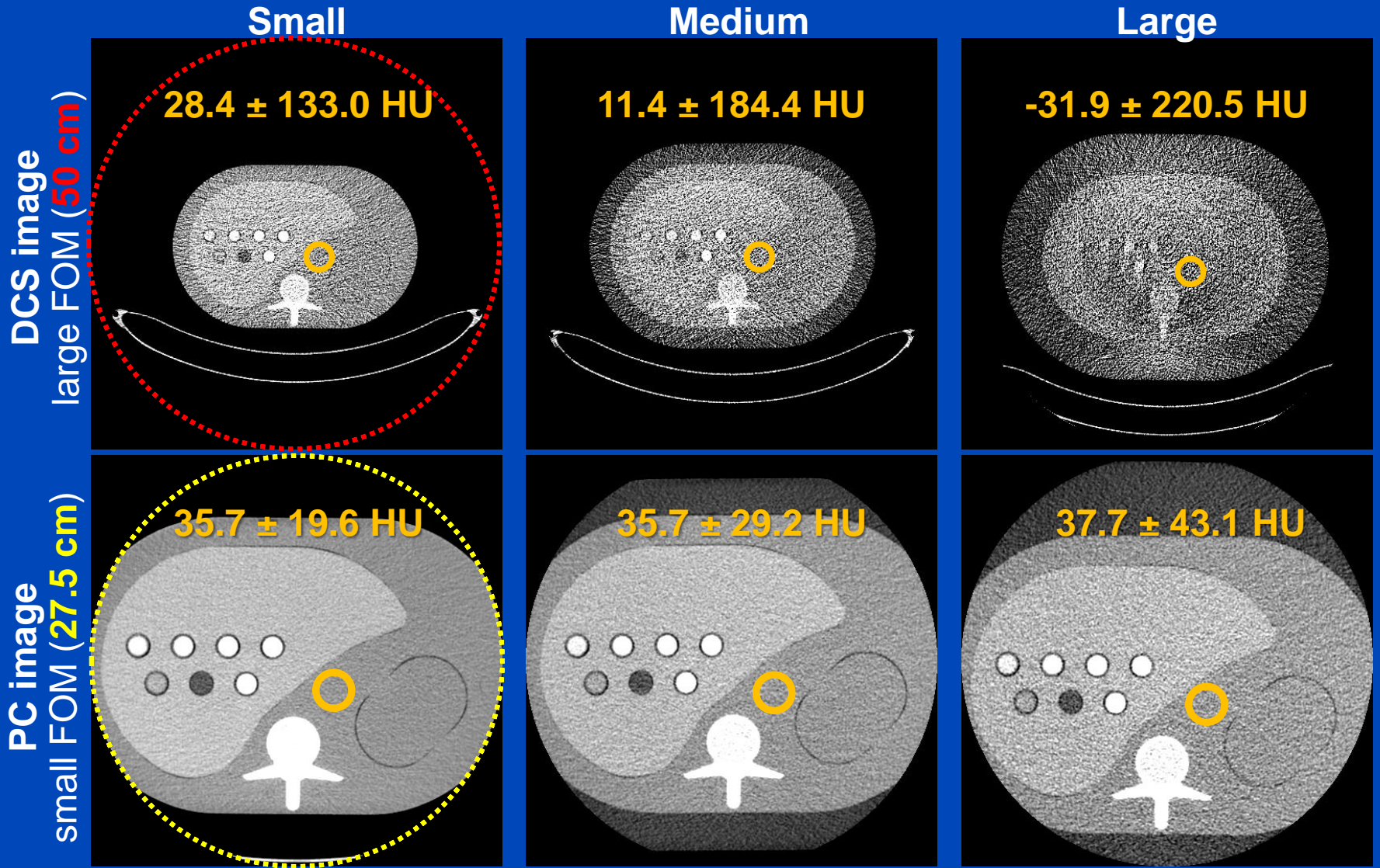


C = 0 HU, W = 400 HU



# Results

Liver Phantom: 0.27 mGy DCS, 7 mAs<sub>eff</sub>, 100 kV, pitch 1.5

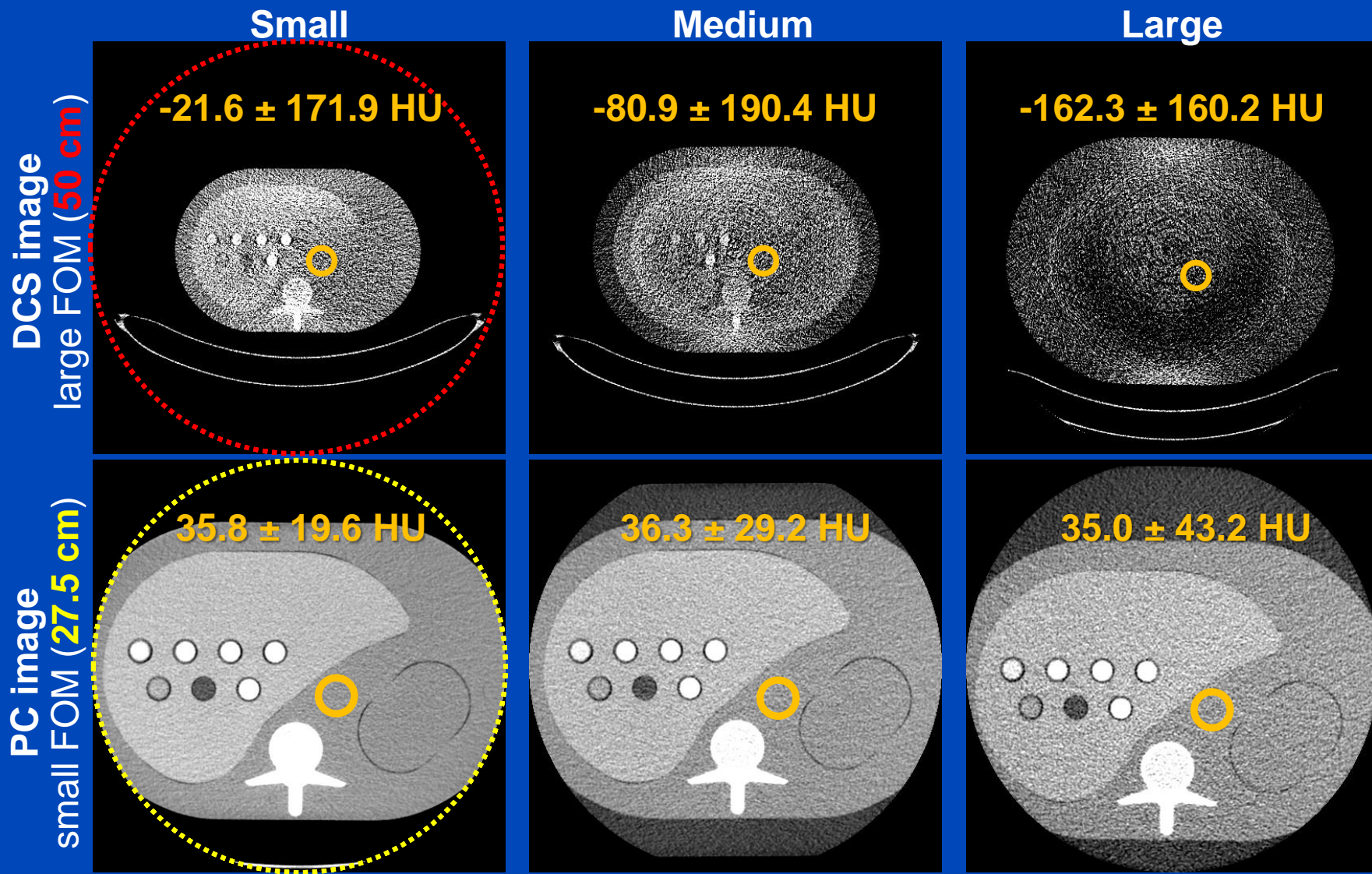


C = 0 HU, W = 400 HU



# Results

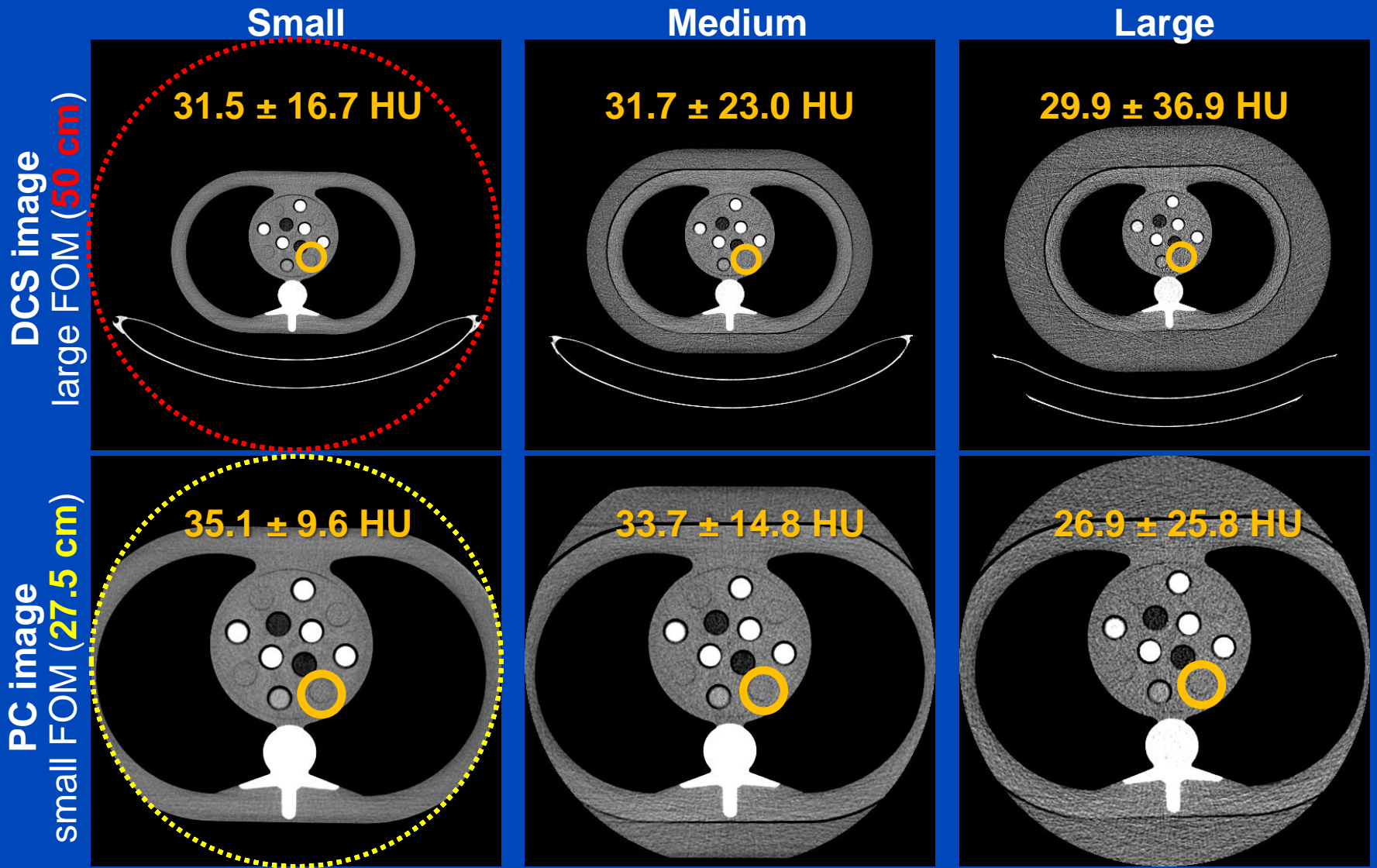
Liver Phantom: 0.13 mGy DCS, 7 mAs<sub>eff</sub>, 80 kV, pitch 1.5



C = 0 HU, W = 400 HU

# Results

Thorax Phantom: 6.70 mGy DCS, 100 mAs<sub>eff</sub>, 120 kV, pitch 1.5

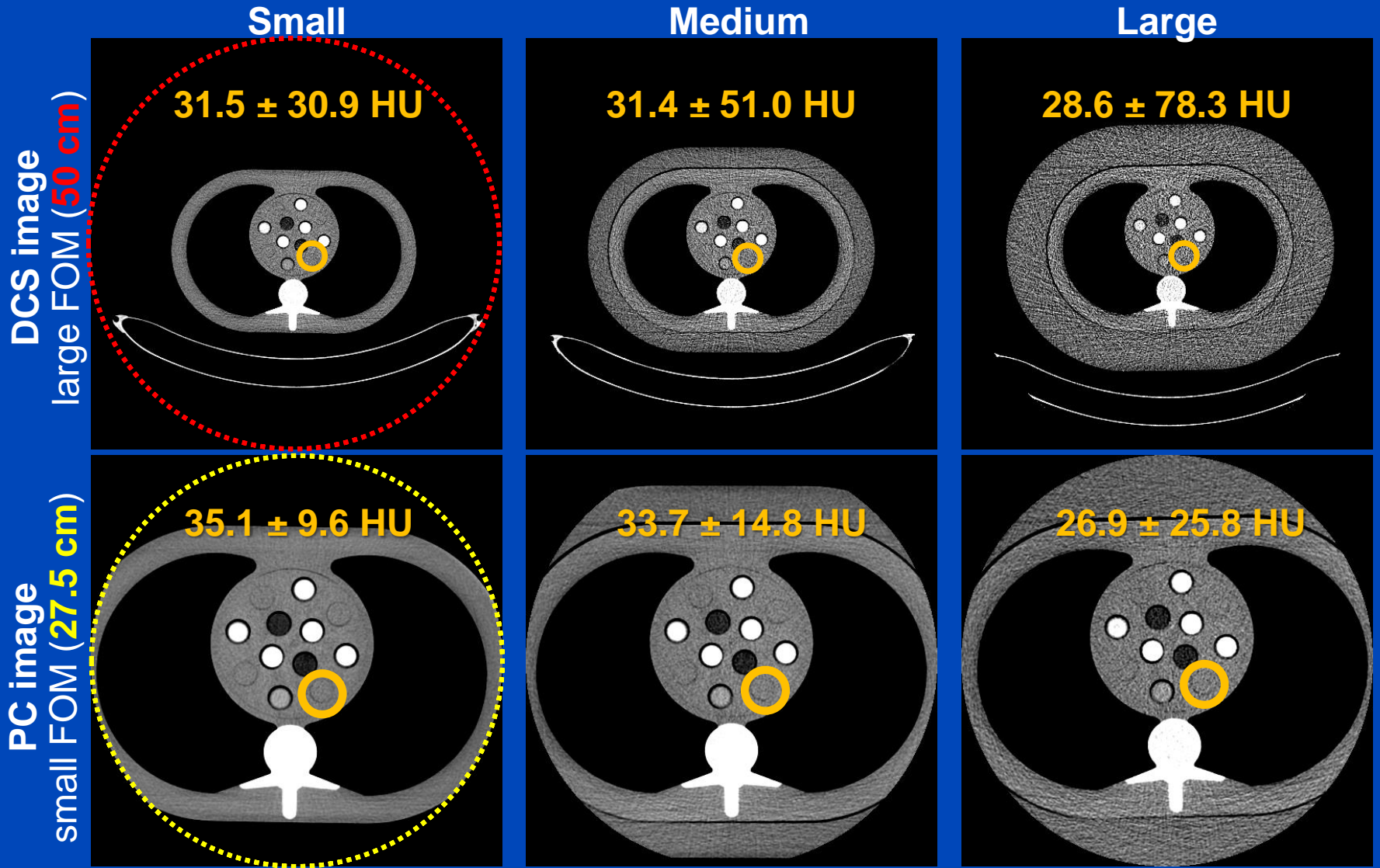


C = 40 HU, W = 300 HU



# Results

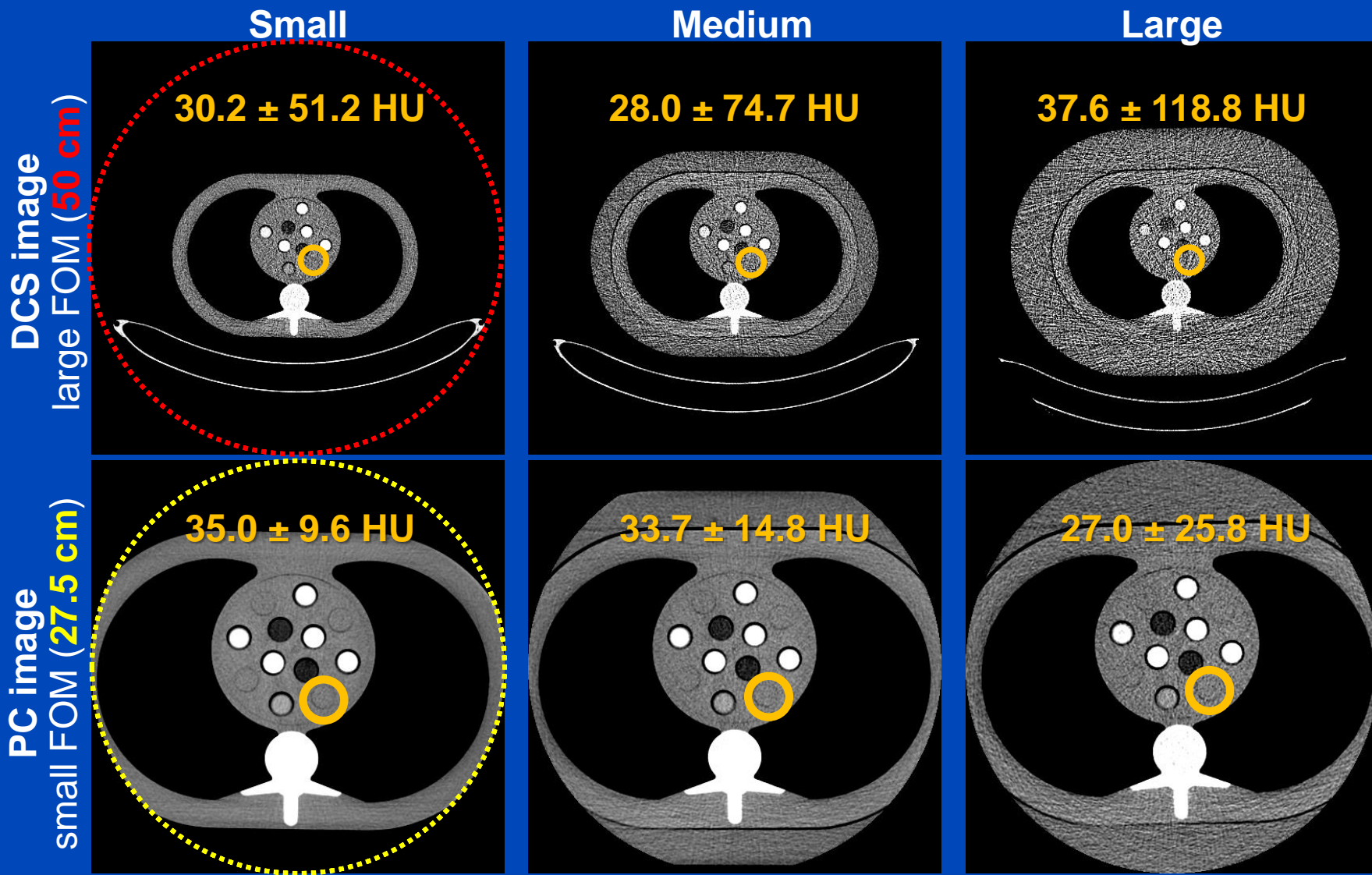
Thorax Phantom: 1.35 mGy DCS, 20 mAs<sub>eff</sub>, 120 kV, pitch 1.5



C = 40 HU, W = 300 HU

# Results

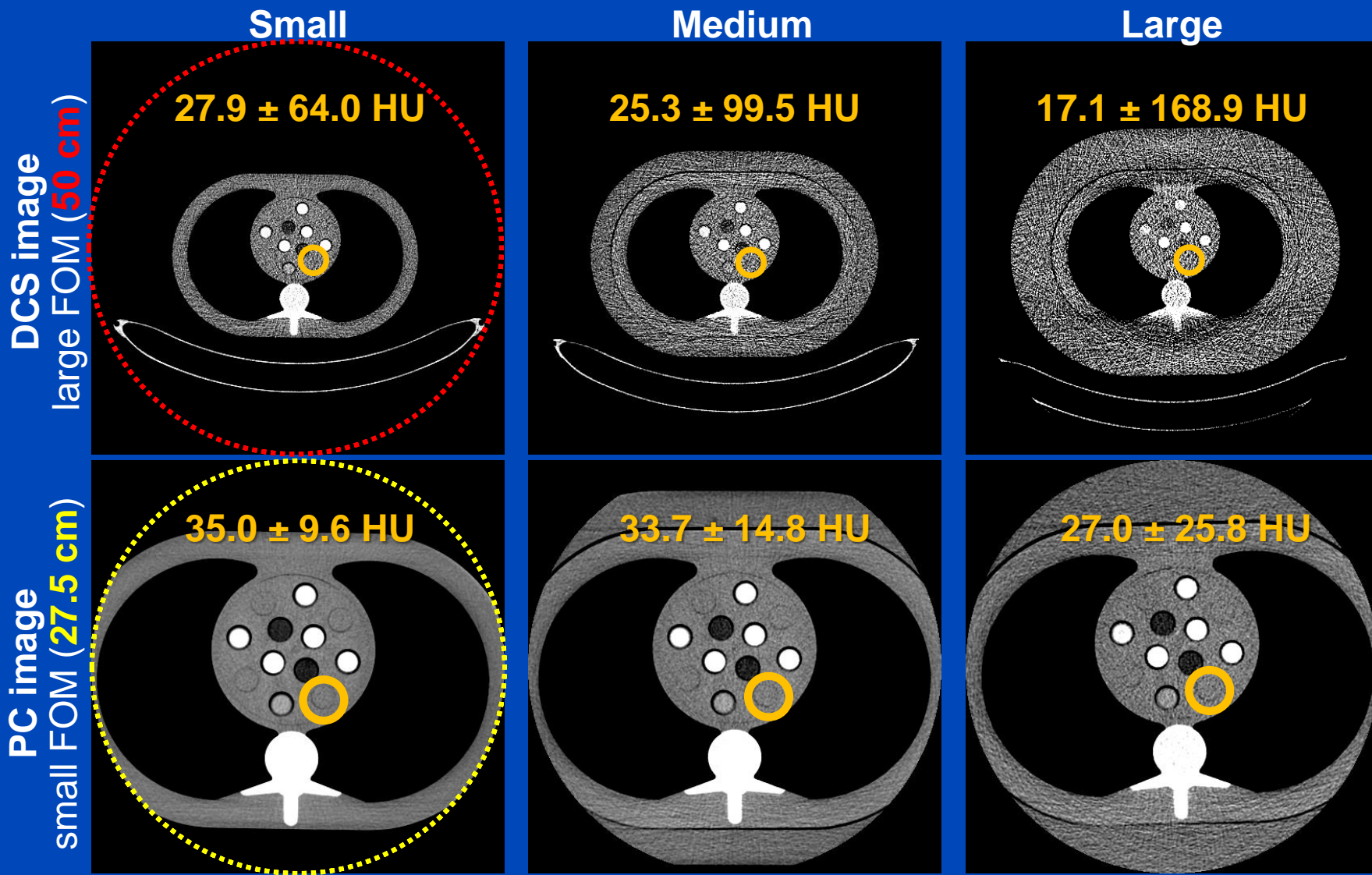
Thorax Phantom: 0.43 mGy DCS, 7 mAs<sub>eff</sub>, 120 kV, pitch 1.5



C = 40 HU, W = 300 HU

# Results

Thorax Phantom: 0.27 mGy DCS, 7 mAs<sub>eff</sub>, 100 kV, pitch 1.5

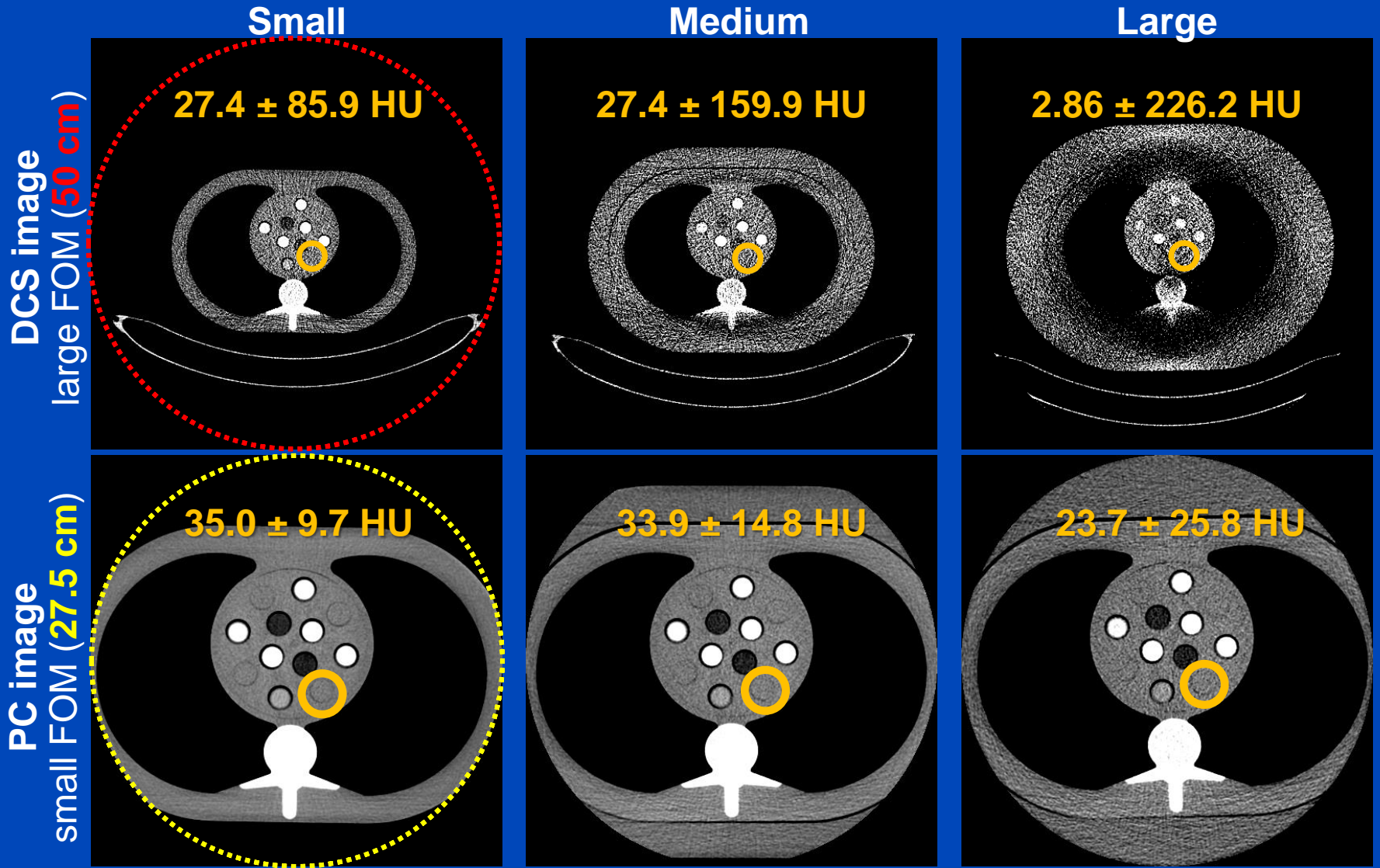


C = 40 HU, W = 300 HU



# Results

Thorax Phantom: 0.13 mGy DCS, 7 mAs<sub>eff</sub>, 80 kV, pitch 1.5

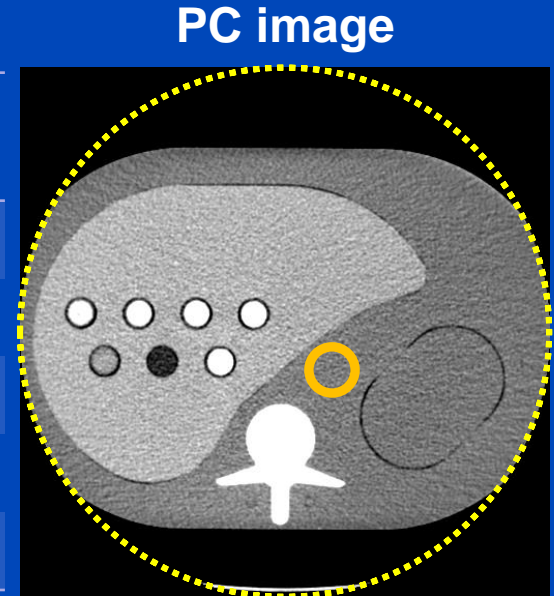


C = 40 HU, W = 300 HU

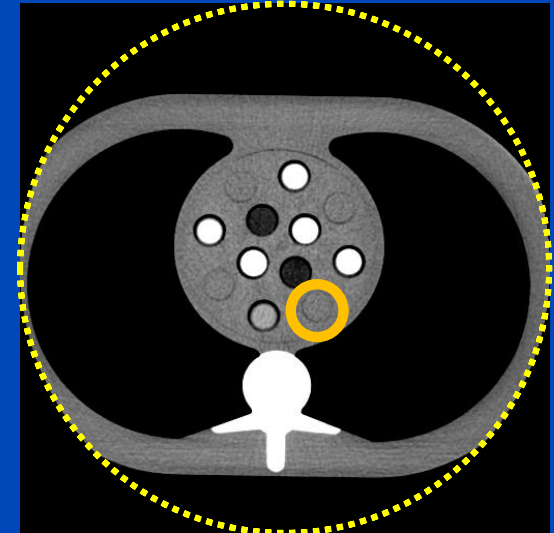
# Results

## Quantitative Evaluation

<b>LIVER ROI</b> <i>DCS protocol</i>	Mean value <b>S</b>	Mean value <b>M</b>	Mean value <b>L</b>
100 mAs <sub>eff</sub> , 120 kV	35.8 HU	35.6 HU	37.8 HU
20 mAs <sub>eff</sub> , 120 kV	35.8 HU	35.6 HU	37.8 HU
7 mAs <sub>eff</sub> , 120 kV	35.6 HU	35.6 HU	37.9 HU
7 mAs <sub>eff</sub> , 100 kV	35.7 HU	35.7 HU	37.7 HU
7 mAs <sub>eff</sub> , 80 kV	35.8 HU	36.3 HU	<b>35.0 HU</b>



<b>THORAX ROI</b> <i>DCS protocol</i>	Mean value <b>S</b>	Mean value <b>M</b>	Mean value <b>L</b>
100 mAs <sub>eff</sub> , 120 kV	35.1 HU	33.7 HU	26.9 HU
20 mAs <sub>eff</sub> , 120 kV	35.1 HU	33.7 HU	26.9 HU
7 mAs <sub>eff</sub> , 120 kV	35.0 HU	33.7 HU	27.0 HU
7 mAs <sub>eff</sub> , 100 kV	35.0 HU	33.7 HU	27.0 HU
7 mAs <sub>eff</sub> , 80 kV	35.0 HU	33.9 HU	<b>23.7 HU</b>



# DCS Protocol Recommendation for Thorax & Abdomen

Phantom size	DCS protocol	CTDI <sub>vol</sub> (32 cm)	Effective dose	Reference CTDI <sub>vol</sub> (32 cm)*	Reference Effective dose
Small (200 mm x 300 mm)	7 mAs <sub>eff</sub> 80 kV	<b>0.13 mGy</b>	<b>0.06 mSv</b>	1.13 mGy	0.51 mSv
Medium (250 mm x 350 mm)	7 mAs <sub>eff</sub> 80 kV	<b>0.13 mGy</b>	<b>0.06 mSv</b>	1.13 mGy	0.51 mSv
Large (300 mm x 400 mm)	7 mAs <sub>eff</sub> 100 kV	<b>0.27 mGy</b>	<b>0.12 mSv</b>	1.18 mGy	0.53 mSv

*To convert to effective dose we assumed a scan length of 30 cm and an abdomen k-factor of 0.0150 mSv/mGy/cm.*

- **Up to 8.7-fold dose reduction compared to findings of previous study for small and medium phantom size**
- **4.2-fold dose reduction for the large phantom size**

# Conclusion

- **The lowest possible effective dose is 0.06 mSv yielding reasonable CT values in our experiments.**
  - No significant shift in CT values observable for small and medium phantom sizes
  - 8.7-fold dose reduction compared to reference values
- **For very large phantom sizes, the tube voltage should be increased to 100 kV.**
  - Effective dose of 0.12 mSv
  - 4.2-fold dose reduction compared to reference values
- **DCS dose (0.06-0.12 mSv) is small compared to a conventional x-ray acquisition of the thorax (0.15 mSv\*).**



# Thank You!



## The 6<sup>th</sup> International Conference on Image Formation in X-Ray Computed Tomography

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Conference Chair: **Marc Kachelrieß**, German Cancer Research Center (DKFZ), Heidelberg, Germany

This presentation will soon be available at [www.dkfz.de/ct](http://www.dkfz.de/ct).  
Job opportunities through DKFZ's international Fellowship programs ([marc.kachelriess@dkfz.de](mailto:marc.kachelriess@dkfz.de)).  
Parts of the reconstruction software were provided by RayConStruct® GmbH, Nürnberg, Germany.