

# Dental Imaging in the First Clinical Photon-Counting CT (PCCT) System: Comparison to Digital Volume Tomography (DVT)

S. Sawall<sup>1,2</sup>, J. Maier<sup>1</sup>, S. Sen<sup>3</sup>, H. Gehrig<sup>4</sup>, T.-S. Kim<sup>4</sup>,  
H.-P. Schlemmer<sup>1,2</sup>, S. O. Schönberg<sup>5</sup>, M. Kachelrieß<sup>1,2</sup>, and M. Rütters<sup>4</sup>

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

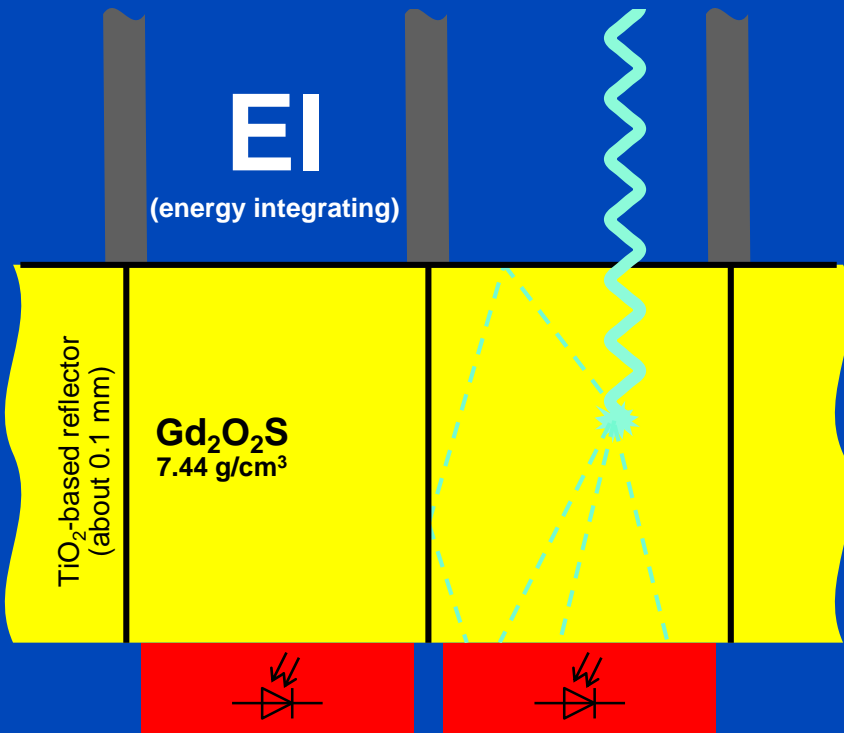
<sup>2</sup>Ruprecht-Karls-University of Heidelberg, Heidelberg, Germany

<sup>3</sup>University Hospital Schleswig Holstein, Kiel, Germany

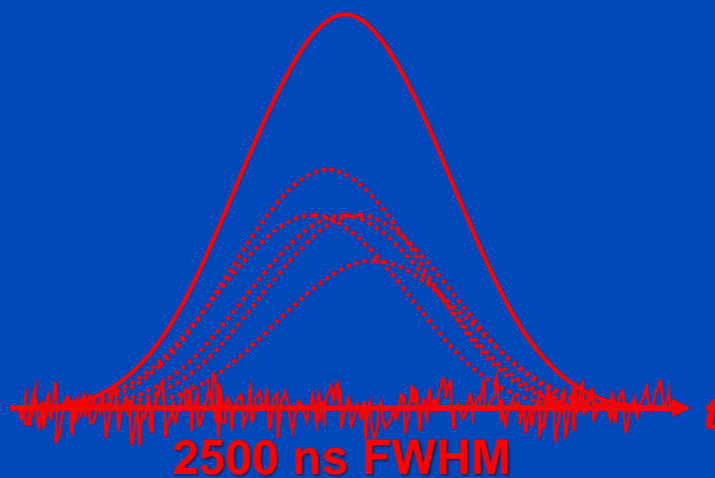
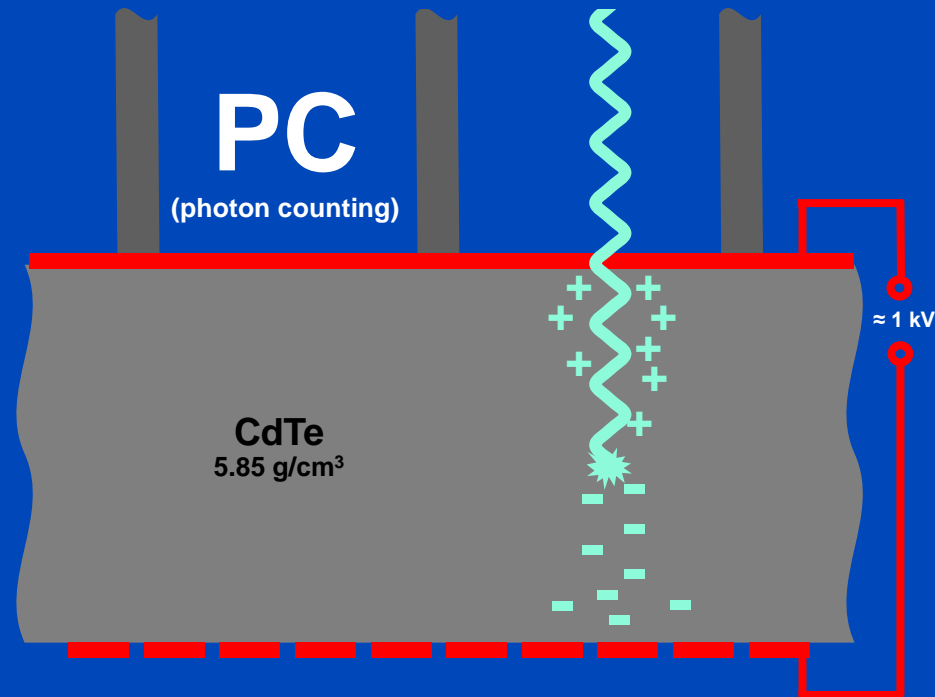
<sup>4</sup>Heidelberg University Hospital, Heidelberg, Germany

<sup>5</sup>Mannheim University Hospital, Mannheim, Germany

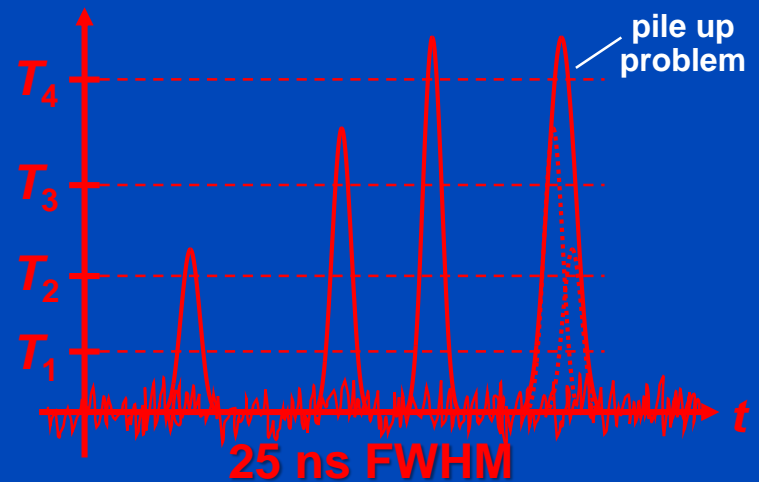
# Indirect Conversion



# Direct Conversion



i.e. max O(40·10<sup>3</sup>) cps



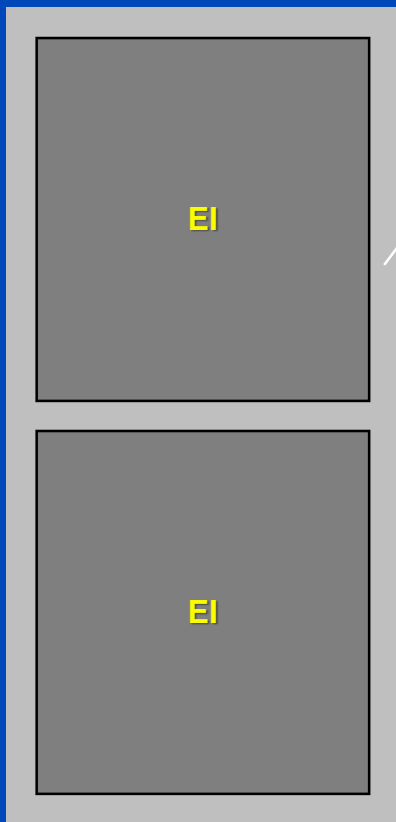
i.e. max O(40·10<sup>6</sup>) cps

Requirements for CT: up to 10<sup>9</sup> x-ray photon counts per second per mm<sup>2</sup>.  
Hence, photon counting only achievable for direct converters.

# Detector Pixel Force vs. Alpha

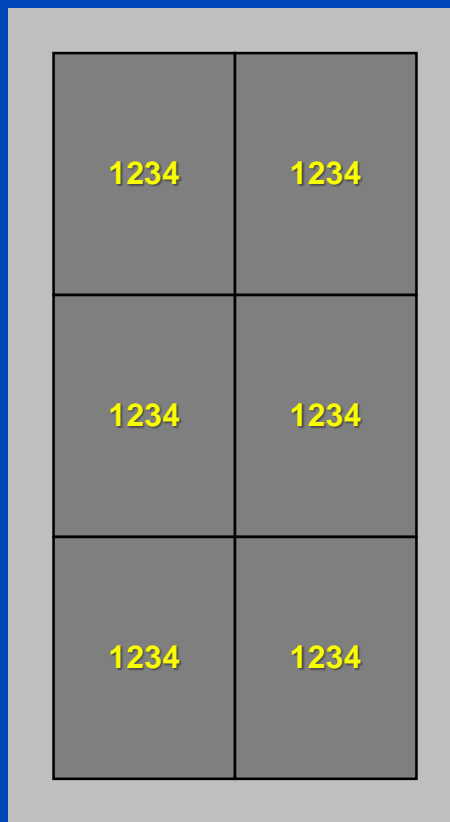
## Force

920 × 96 detector pixels  
 pixel size 0.52 × 0.56 mm at iso  
 avg. sampling 0.56 × 0.6 mm at iso  
 57.6 mm z-coverage



## Alpha (Quantum Plus)

1376 × 144 macro pixels  
 pixel size 0.3 × 0.352 mm at iso  
 avg. sampling 0.344 × 0.4 mm at iso  
 57.6 mm z-coverage



## Alpha (UHR)

2752 × 120 pixels  
 pixel size 0.15 × 0.176 mm at iso  
 avg. sampling 0.172 × 0.2 mm at iso  
 24 mm z-coverage



Focus sizes (Vectron): 0.181×0.226 mm, 0.271×0.7316 mm, 0.362×0.497 mm at iso  
 which are 0.4×0.5 mm, 0.6×0.7 mm, 0.8×1.1 mm at focal spot

# Background

- Clinical photon-counting CT (PCCT) systems offer an **increased spatial resolution**, in the order of **150  $\mu\text{m}$** , compared to previous generations of CTs.
- This spatial resolution is in the order of dental cone-beam CT/DVT systems.
- However, clinical systems provide several other **potential benefits**:
  - detectors with a **high dynamic range**
  - **powerful x-ray tubes**
  - **optimized prefilters** for dose efficient acquisitions
- We want to investigate the potential benefits of a clinical PCCT (**Naeotom Alpha**) in comparison to a DVT (**Orthophos SL 3D**).

# Imaging Systems

Dental Cone-Beam CT (DVT)

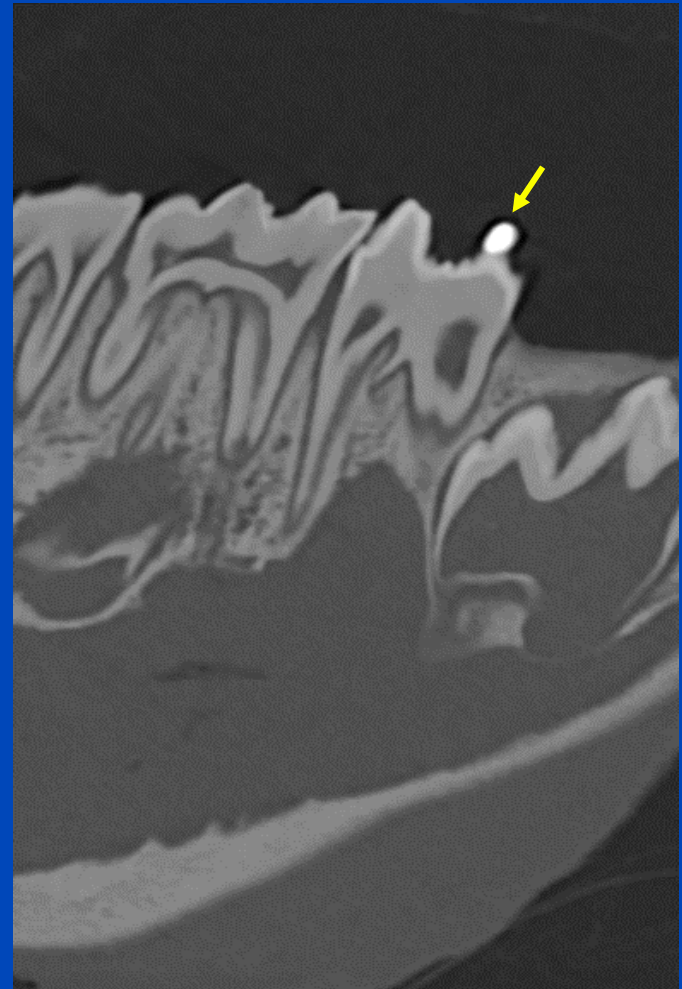


Photon-Counting CT (PCCT)



# Sample Preparation

- Since multiple measurements are required, we used 10 **porcine jaws** in this study.
- To allow for registration between DVT and PCCT, radio-opaque markers were attached to all samples.
- These markers are identified and a registration is performed by minimizing the squared Euclidean distance between them.



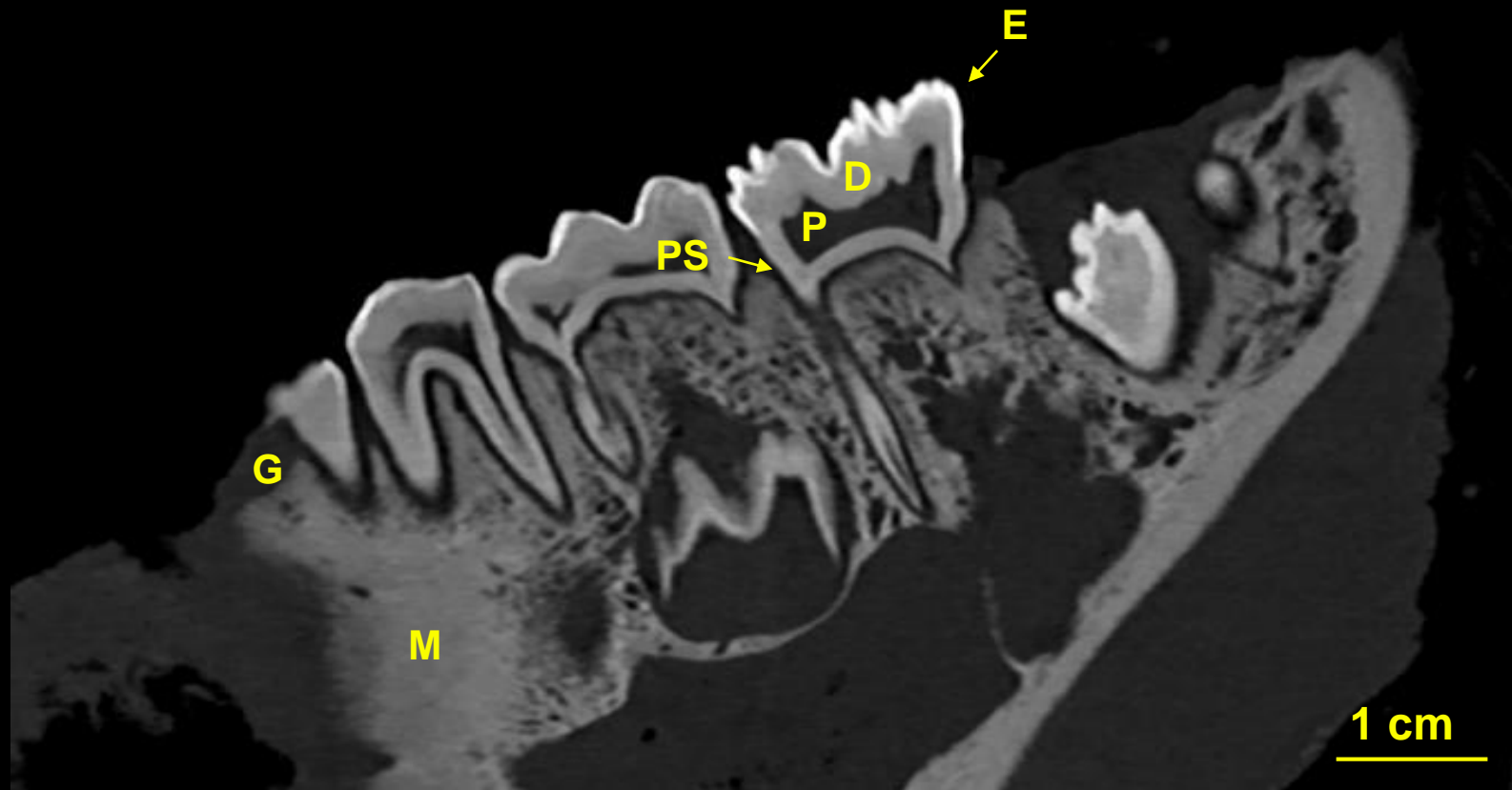
C = 2000 HU, W = 2000 HU

# Image Acquisition & Reconstruction

- We investigate a low-dose (0.34 mGy  $\text{CTDI}_{16 \text{ cm}}$ ) and a high-dose (4.75 mGy  $\text{CTDI}_{16 \text{ cm}}$ ) protocol.
- Data were acquired
  - with 85 kV at the DVT
  - with 100 kV Sn in the UHR mode of the PCCT.
- Image reconstruction was performed with the best available methods at each system:
  - Filtered backprojection (FBP) in case of the DVT and
  - Quantum Iterative Reconstruction (QIR3) in case of the PCCT.
- We use the PCCT kernel Hr84 in order to match the spatial resolution of the DVT.

# PCCT

High Dose (4.75 mGy CTDI<sub>16 cm</sub>)



M - mandibula  
P - pulp cavity

D - dentine  
E - enamel

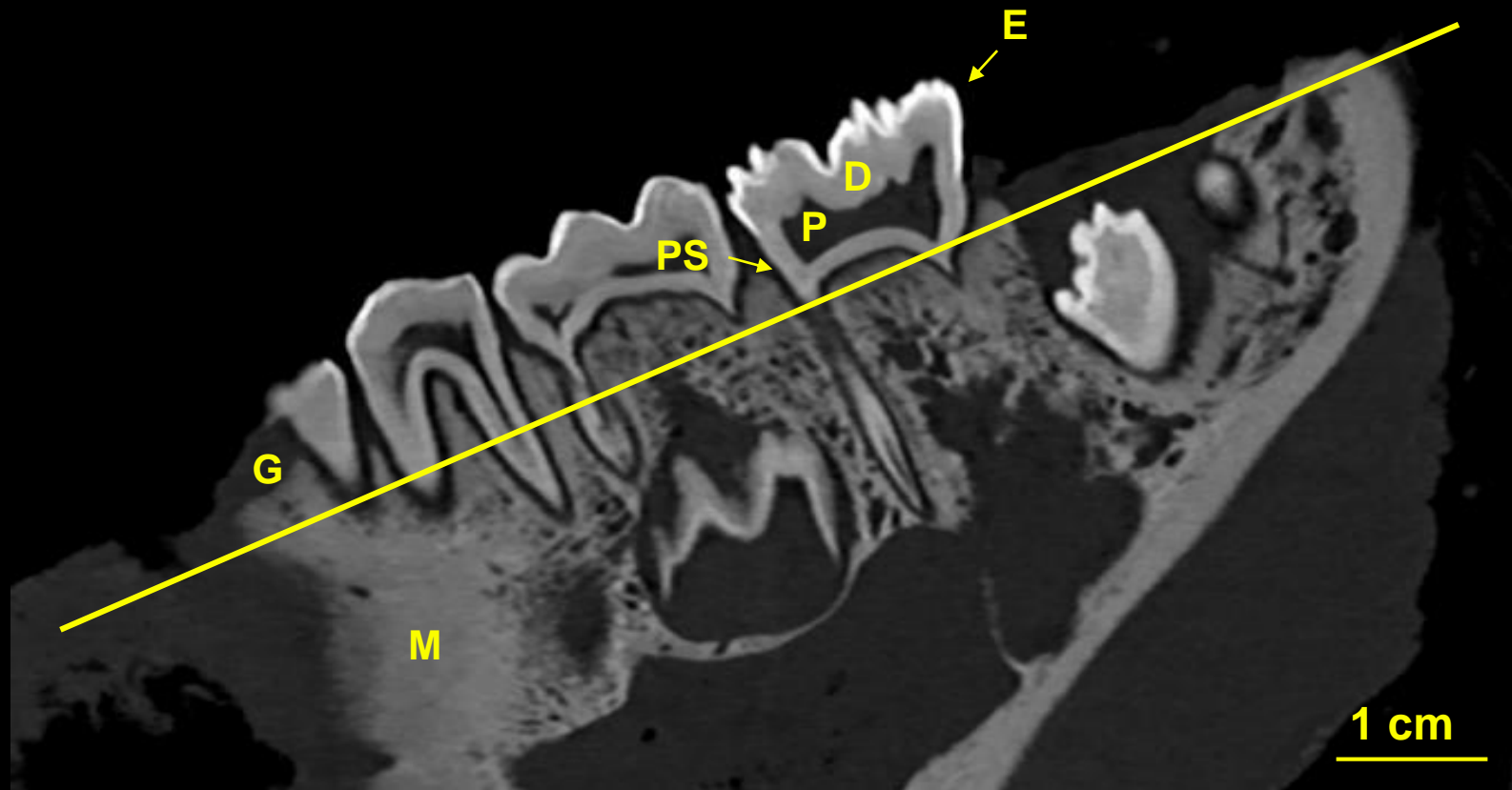
G - gingiva  
PS - peridontal space

C = 900 HU, W = 4200 HU



# PCCT

High Dose (4.75 mGy CTDI<sub>16 cm</sub>)



M - mandibula  
P - pulp cavity

D - dentine  
E - enamel

G - gingiva  
PS - peridontal space

C = 900 HU, W = 4200 HU

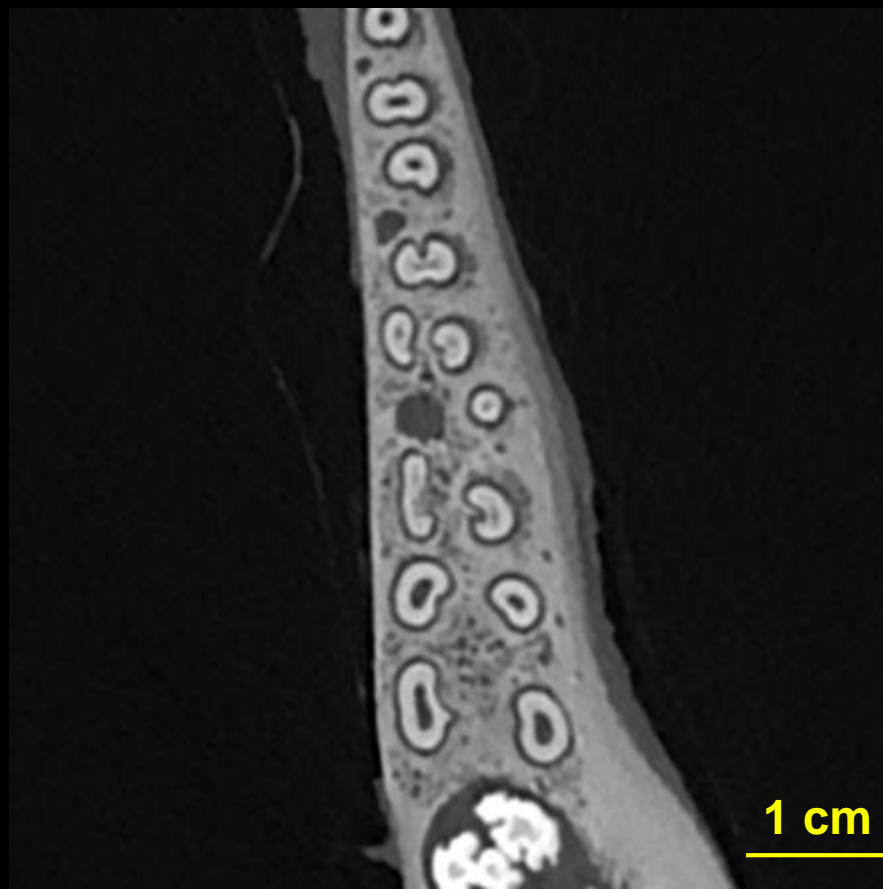
# DVT vs. PCCT

High Dose (4.75 mGy CTDI<sub>16 cm</sub>)

DVT



PCCT

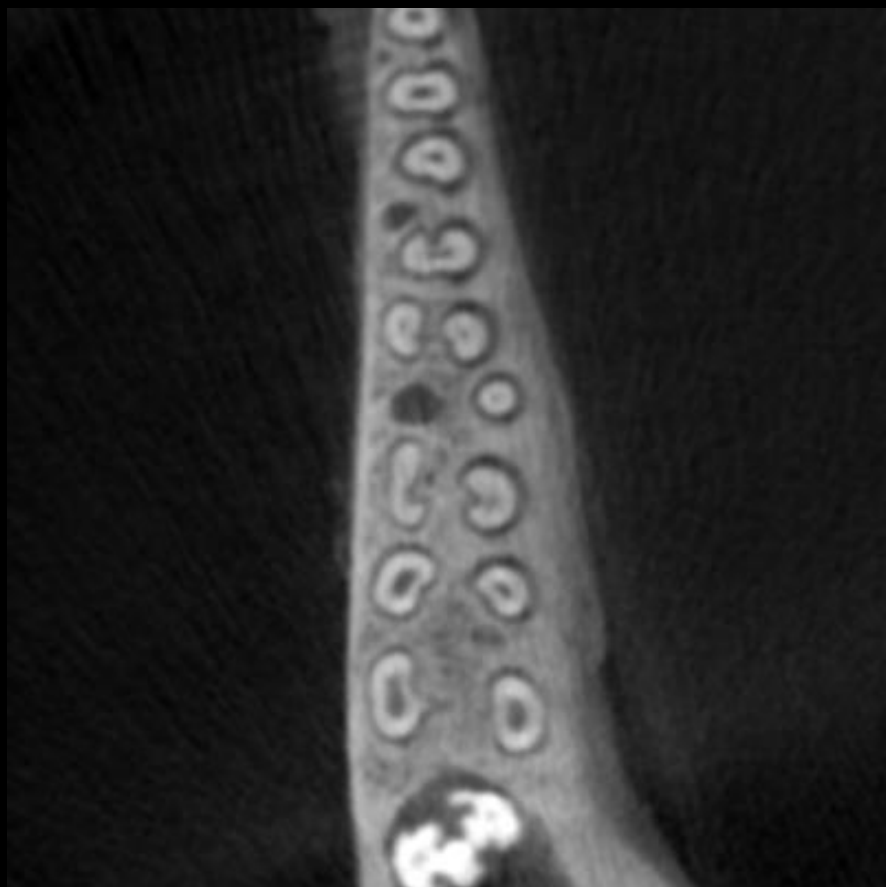


C = 900 HU, W = 4200 HU

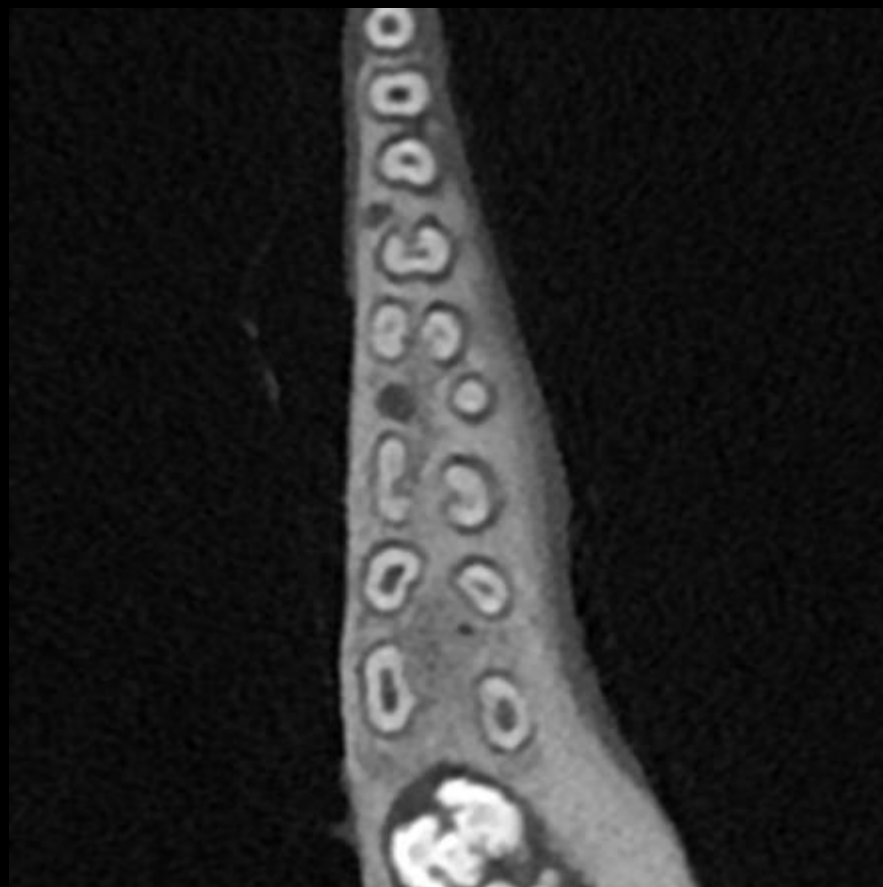
# DVT vs. PCCT

Low Dose (0.34 mGy CTDI<sub>16 cm</sub>)

DVT



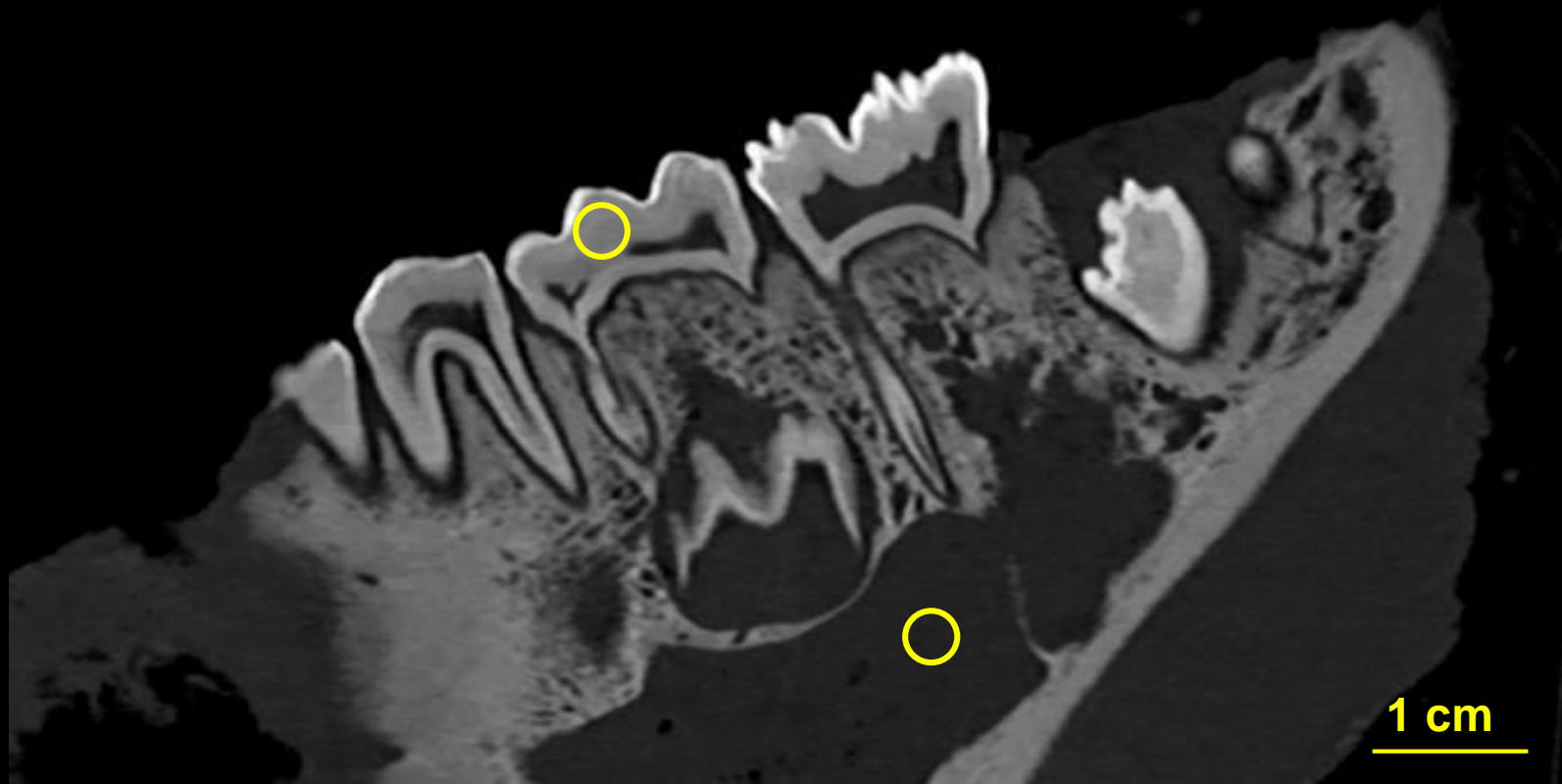
PCCT



C = 900 HU, W = 4200 HU

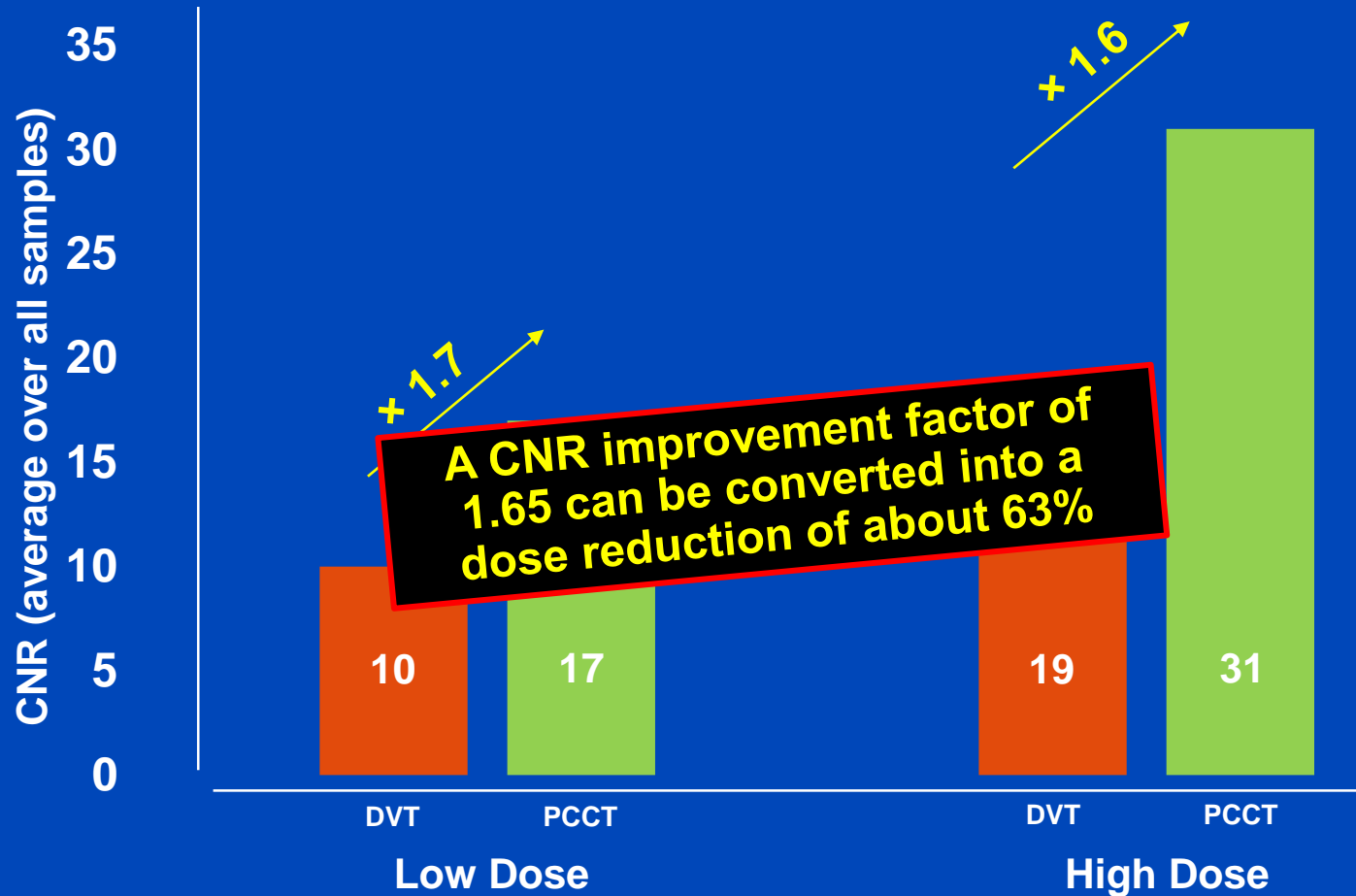
# PCCT

High Dose (4.75 mGy CTDI<sub>16 cm</sub>)



C = 900 HU, W = 4200 HU

# Results: CNR Gingiva-Dentine



# Summary & Conclusions

- **Clinical PCCT offers an advantage in terms of image quality and radiation dose efficiency compared to DVT.**
- **This is further aided by reduced motion artifacts due to faster scan speeds and a prone position of the patient in clinical systems.**
- **However, access to PCCTs for dental diagnostics is mostly limited to university hospitals.**

# Thank You!

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<sup>®</sup> GmbH, Nürnberg, Germany.