In-Vivo Coronary Micro-Computed Tomography Angiography in Mice

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Disclosures

I or one of my co-authors have no financial interests or relationships to disclose with regard to the subject matter of this presentation.

Prior Art Cardiac In-Vivo Micro-CT

Dinkel, Bartling, Kuntz, Grasruck, Kopp-Schneider, Iwasaki, Dimmeler, Gupta, Semmler, Kauczor, Kiesling. **Intrinsic gating for small-animal computed tomography: a robust ECG-less paradigm for deriving cardiac phase information and functional imaging**. Circ Cardiovasc Imaging 1(3):235-243, 2008.

Bartling, Kuntz, Semmler. **Gating in small-animal cardio-thoracic CT**. Methods 50(1):42-49, 2010.

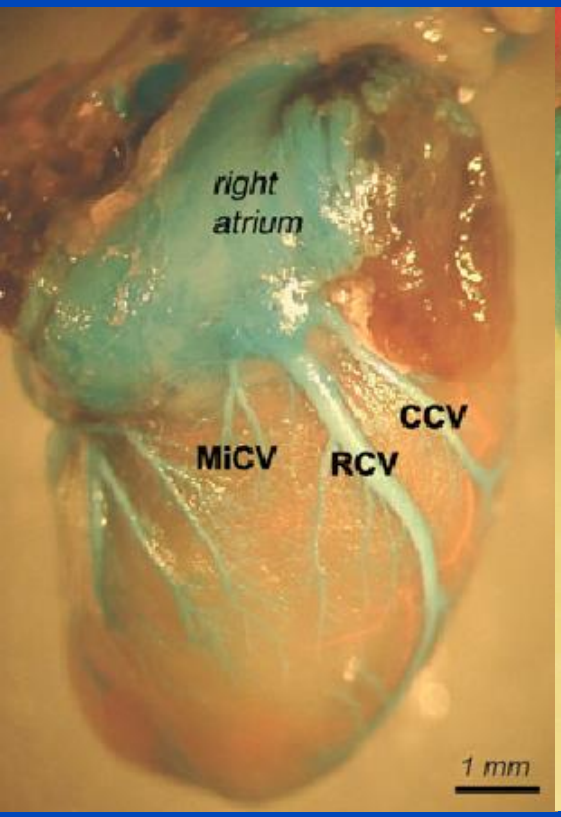
Holbrook, Clark, Badea. **Low-dose 4D cardiac imaging in small animals using dual source micro-CT**. Phys. Med. Biol. 63(2):025009, 2018.

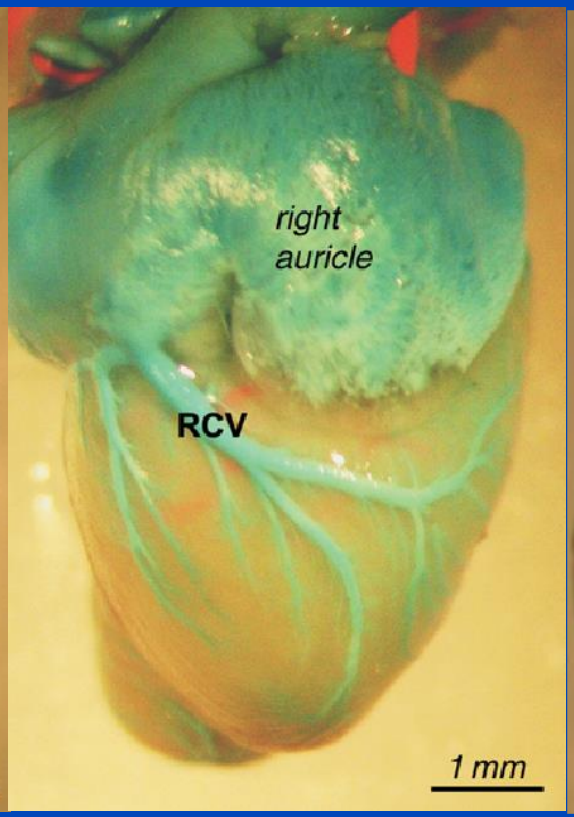
Sawall, Franke, Kirchherr, Beckendorf, Kuntz, Maier, Kraupner, Backs, Briel, Kachelrieß. ***In Vivo* Quantification of Myocardial Infarction in Mice Using Micro-CT and a Novel Blood Pool Agent**. Contrast Media Mol Imaging 2017:2617047, 2017.

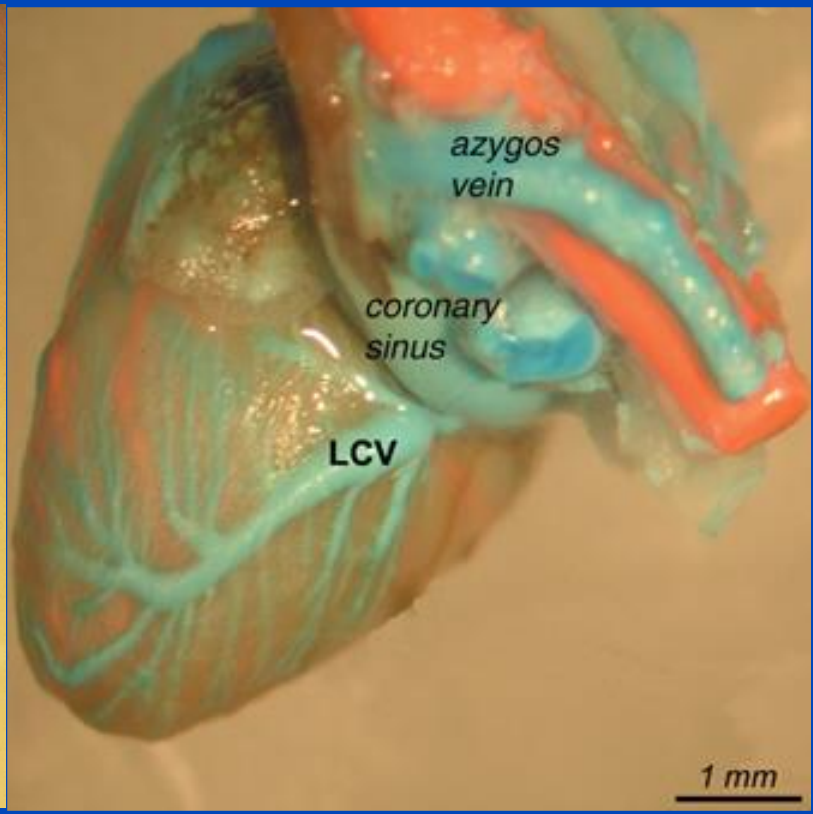
Clark, Holbrook, Lee, Badea. **Photon-counting cine-cardiac CT in the mouse**. PLoS One 14(9):e0218417, 2019.

And many more…

Cardiac Ex-Vivo Micro-CT







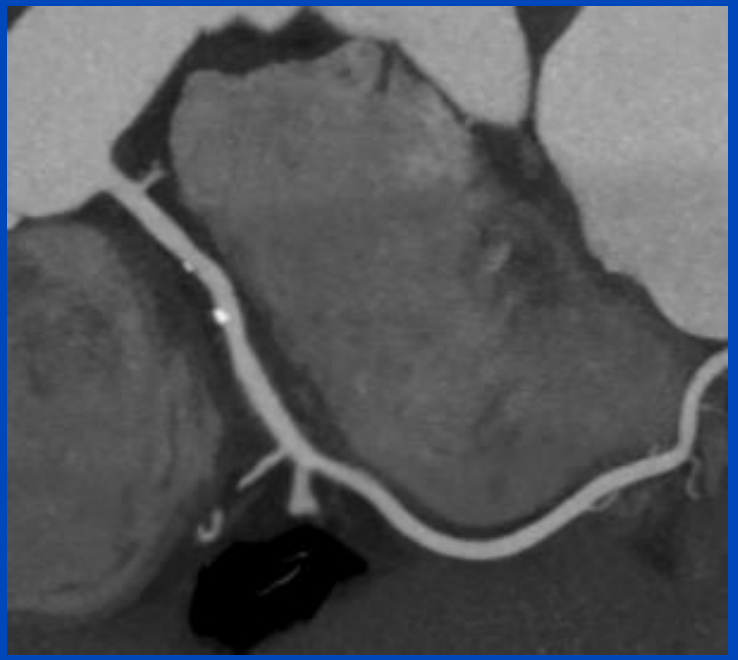
Ciszek, Skubiszewska, Ratajska. The anatomy of the cardiac veins in mice. J. Anat. 211:53-63, 2007.

Demand for Spatial Resolution

Mouse in a Standard Micro-CT

C/W=400 HU/1400 HU

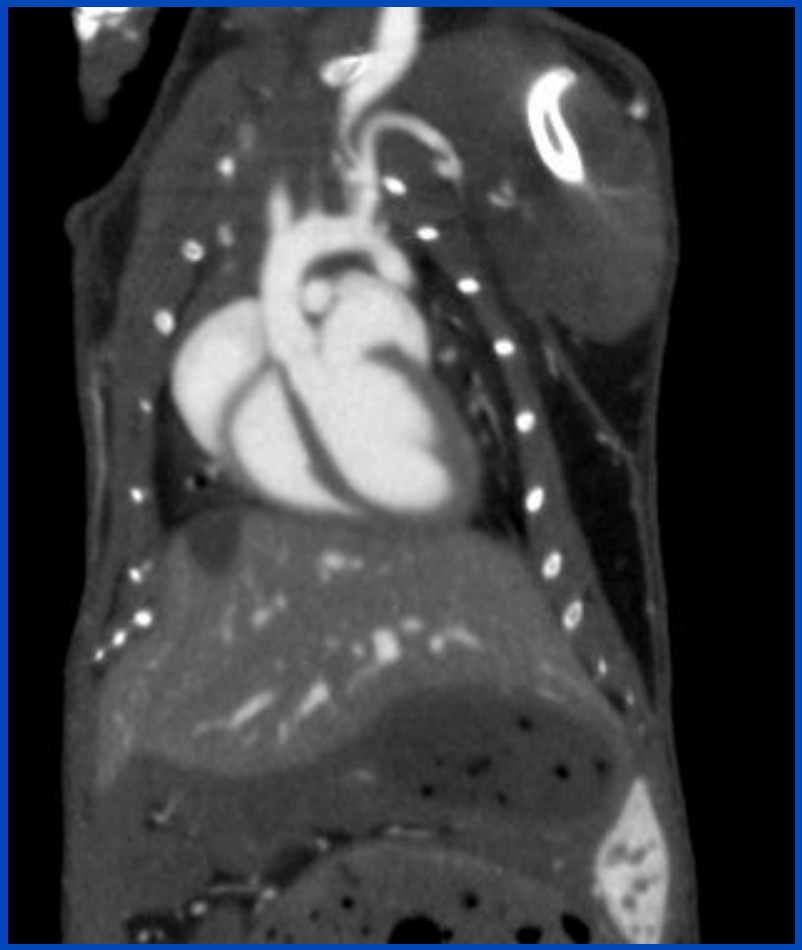
Human in Clinical CT



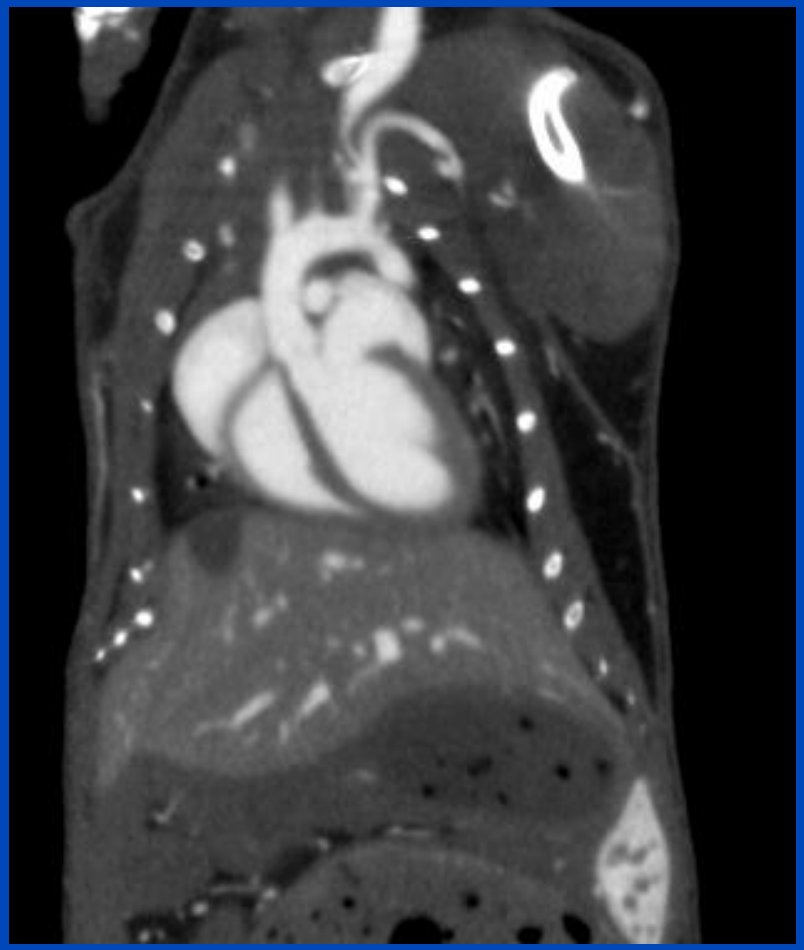
C/W=200 HU/600 HU

Clinical data courtesy of Stephan Achenbach.

Demand for Temporal Resolution



360 bpm
2 × slower (180 bmp)



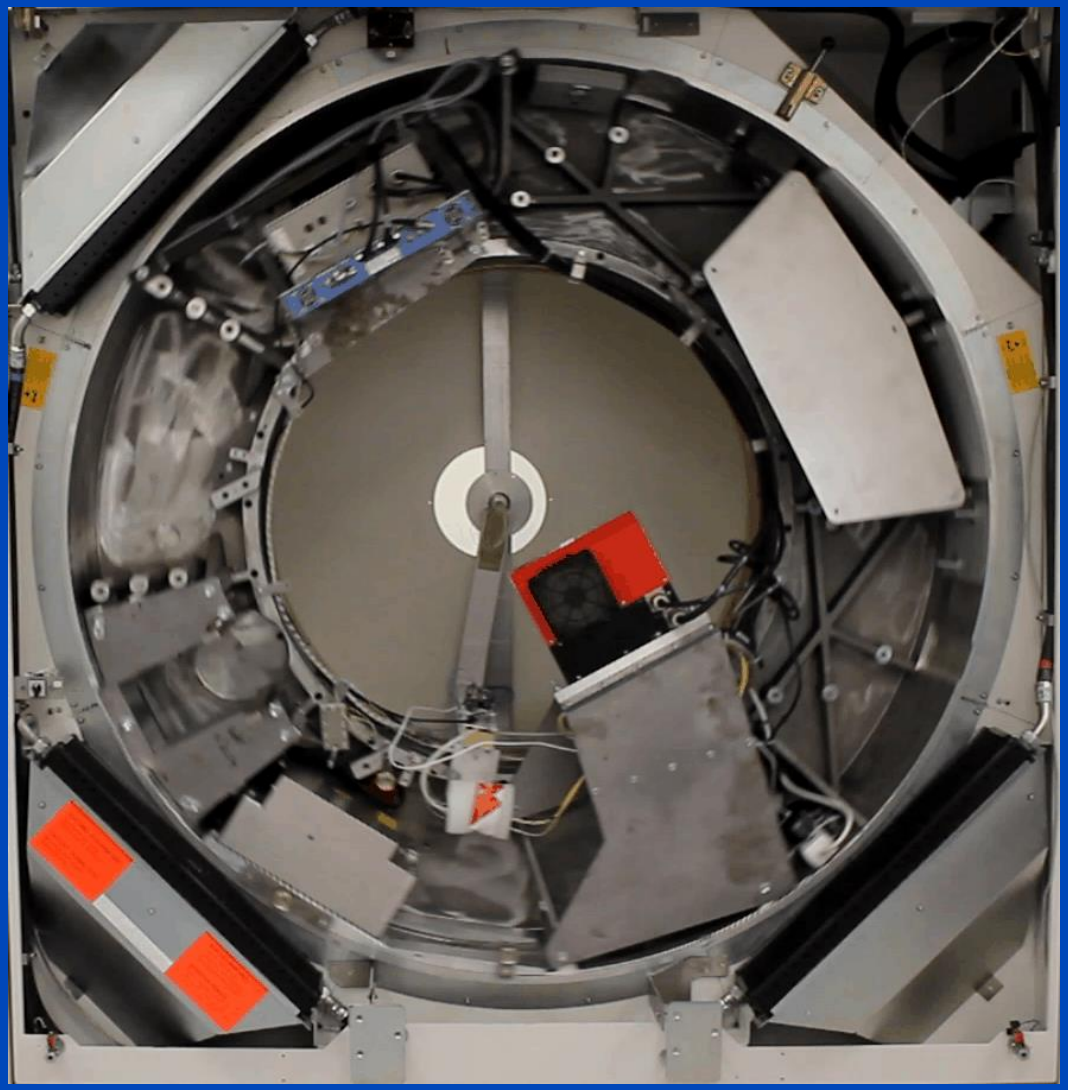
360 bpm
5 × slower (72 bpm)

Brehm, Sawall, Kachelrieß et al. Cardiorespiratory motion-compensated micro-CT image reconstruction using an artifact model-based motion estimation. Med. Phys. 42(4): 1948-1958, April 2015.

Aim

We aim at illustrating that coronary micro-CT angiography is possible in mice and in small animals.

Dedicated Cardiac Micro-CT

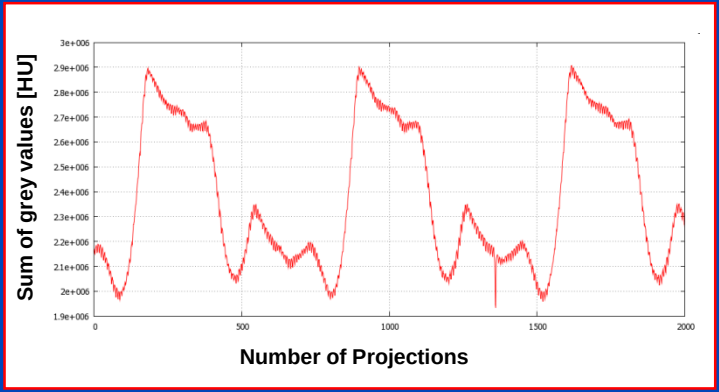


Scan Parameters

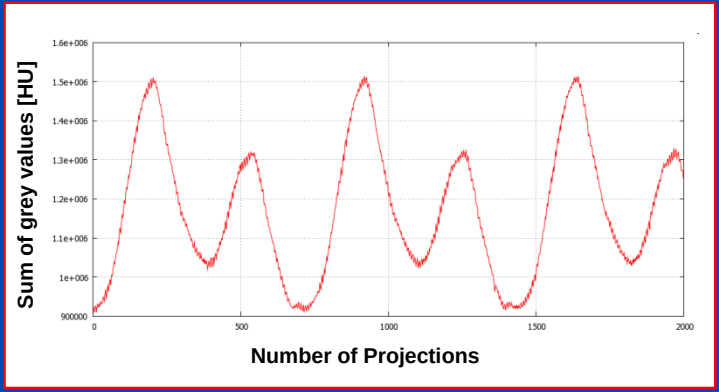
- All measurements presented in the following were obtained using a rotation time of 5 s per revolution.
- Data were acquired using a tube voltage of 60 kV and 833 µA, i.e. at 50 W.
- The focal spot size is about 80 µm.
- The x-ray detector is operated using 86 fps.
- The spatial resolution in the center of rotation is about 71 µm.
- Radiation dose for the reference acquisitions is 5 Gy. A lower dose is achieved by using only a fraction of these data.
- Ten mice were measured and administered with a blood pool contrast agent (ExiTron nano 12000) prior to scanning.

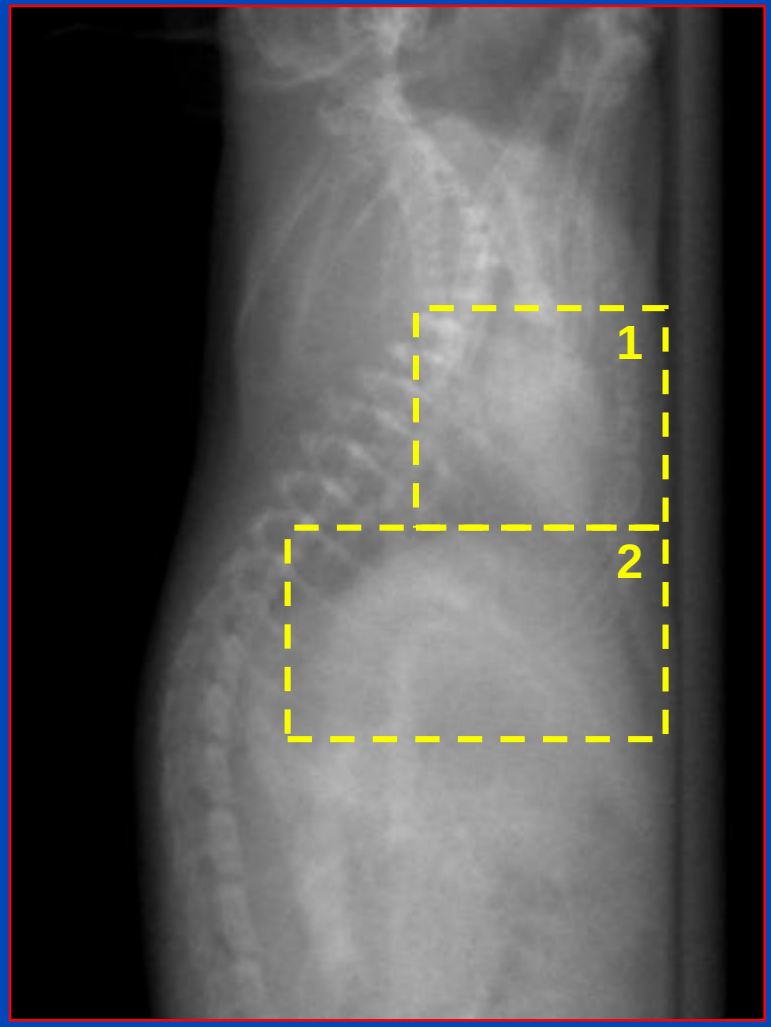
Intrinsic Gating

- **ROI 1 (Cardiac-gating):**



- **ROI 2 (Respiration-gating):**





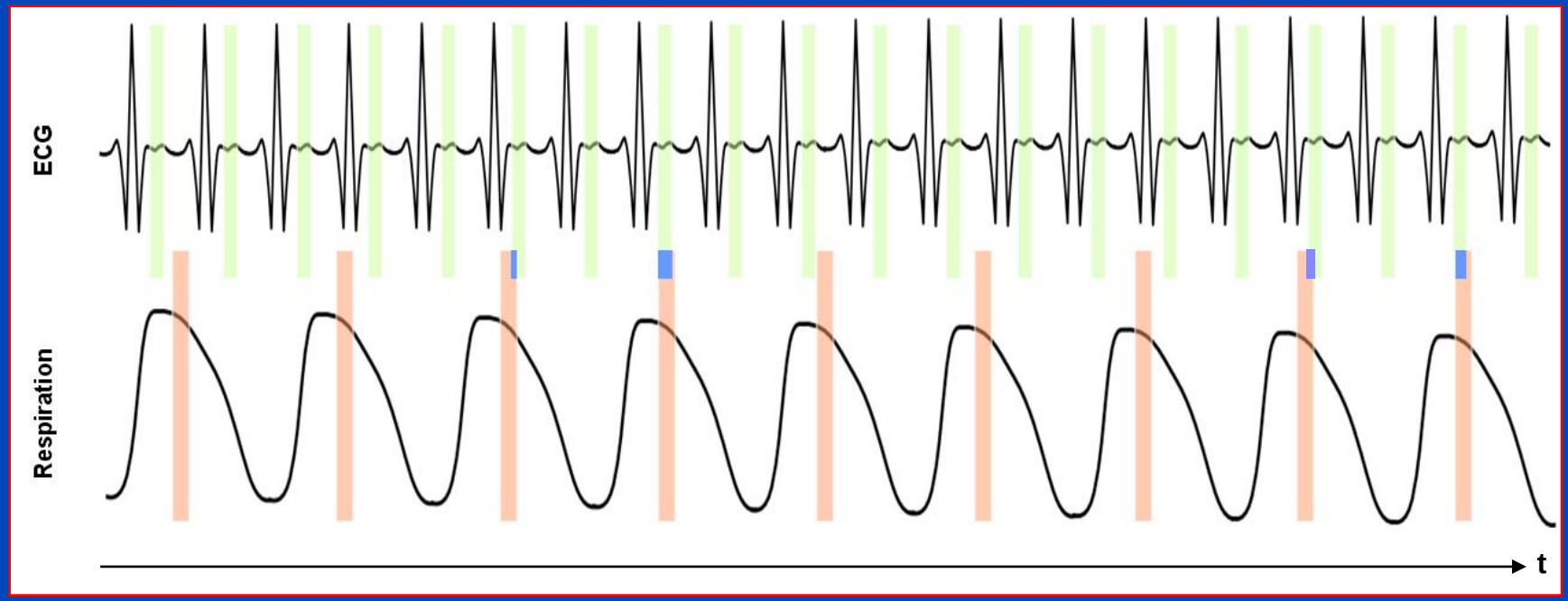
Projection image with ROIs.

Kachelrieß et al. Kymogram detection and kymogram-correlated image reconstruction from subsecond spiral computed tomography scans of the heart. Med. Phys. 29(7): 1489-1503, July 2002.

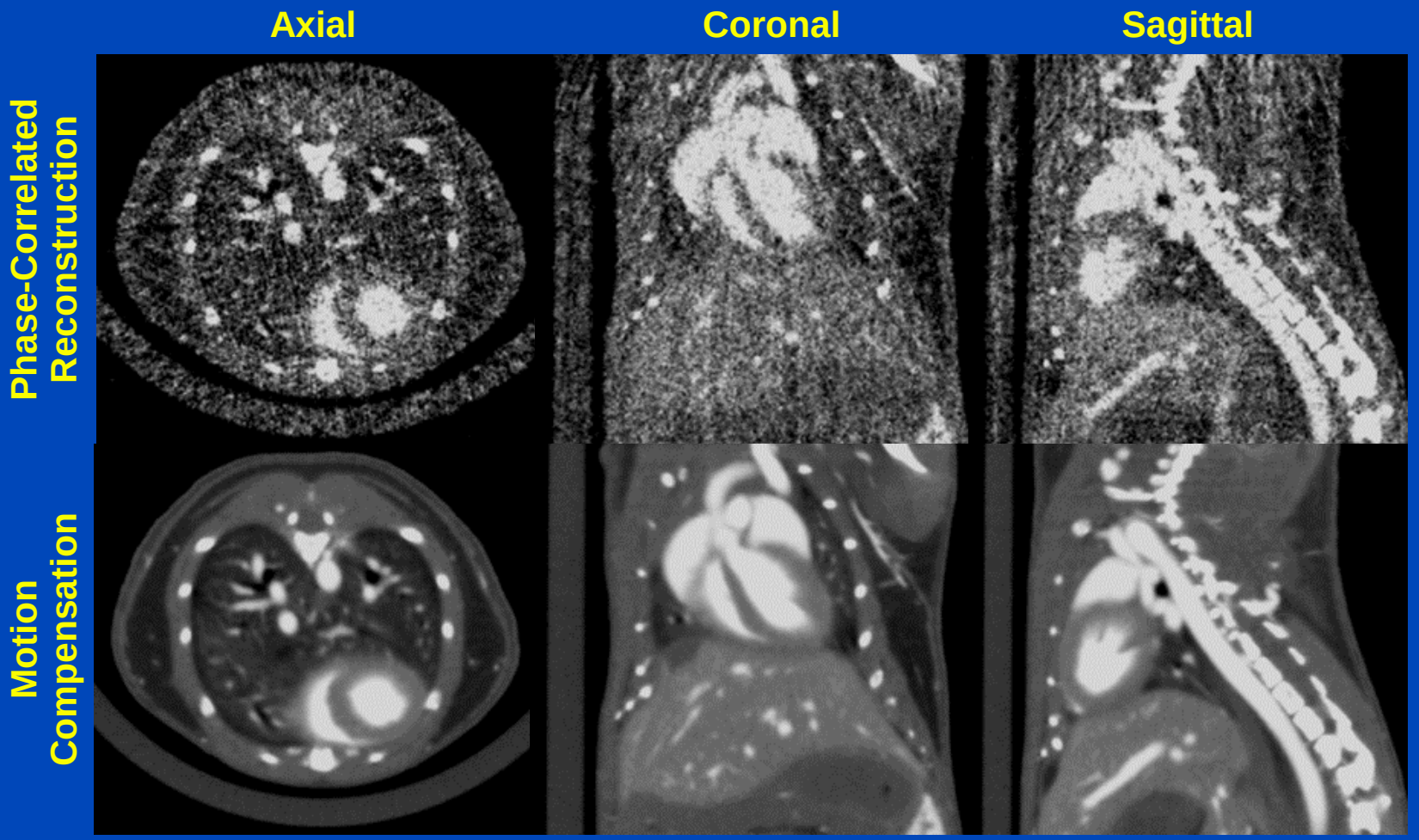
Phase-Correlated Reconstruction

Double gating:

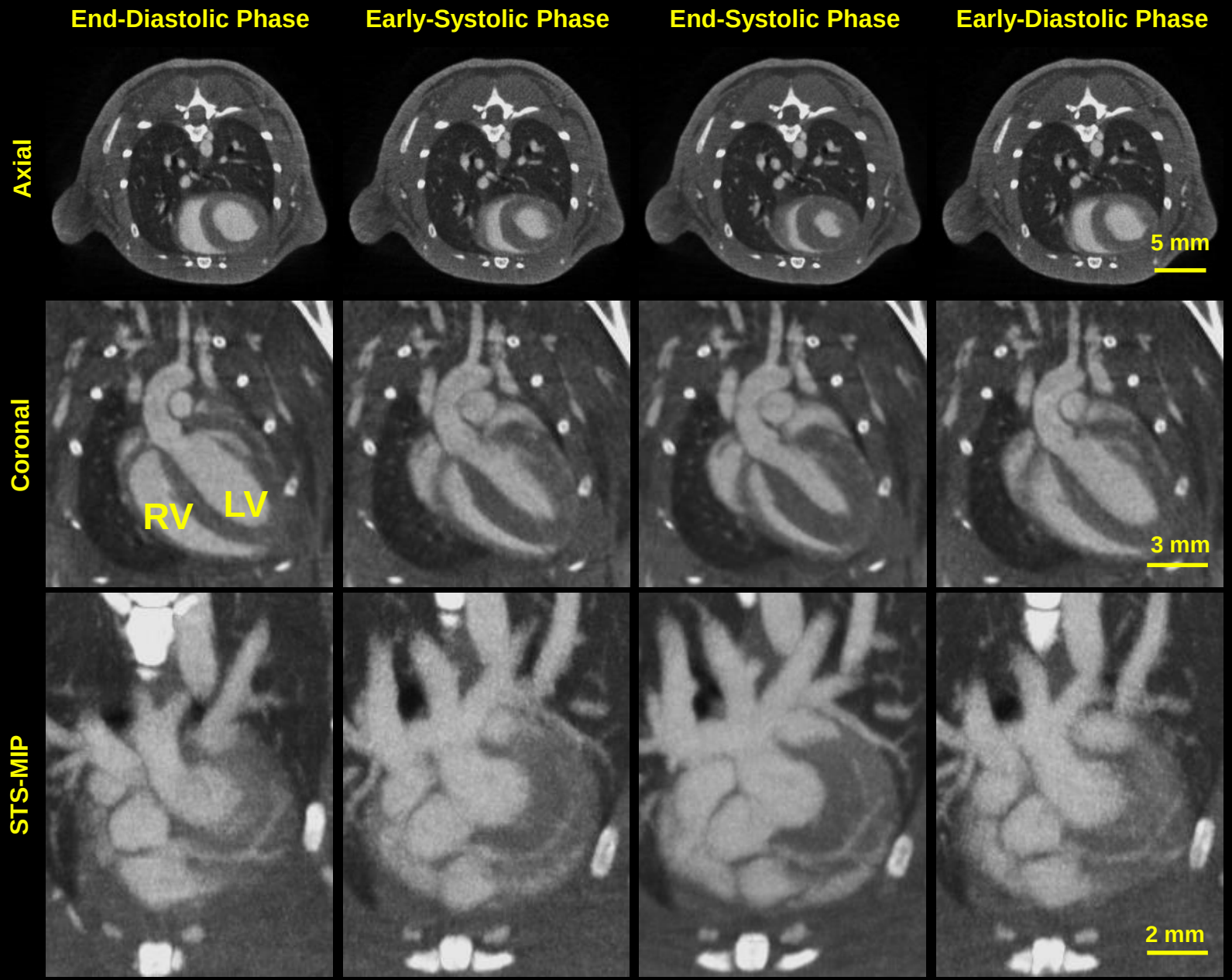
- **Cardiac window width: 20%**
- **Respiratory window width: 10%**
- **Only 2% of all projections, e.g. 200 of 10000 per volume**

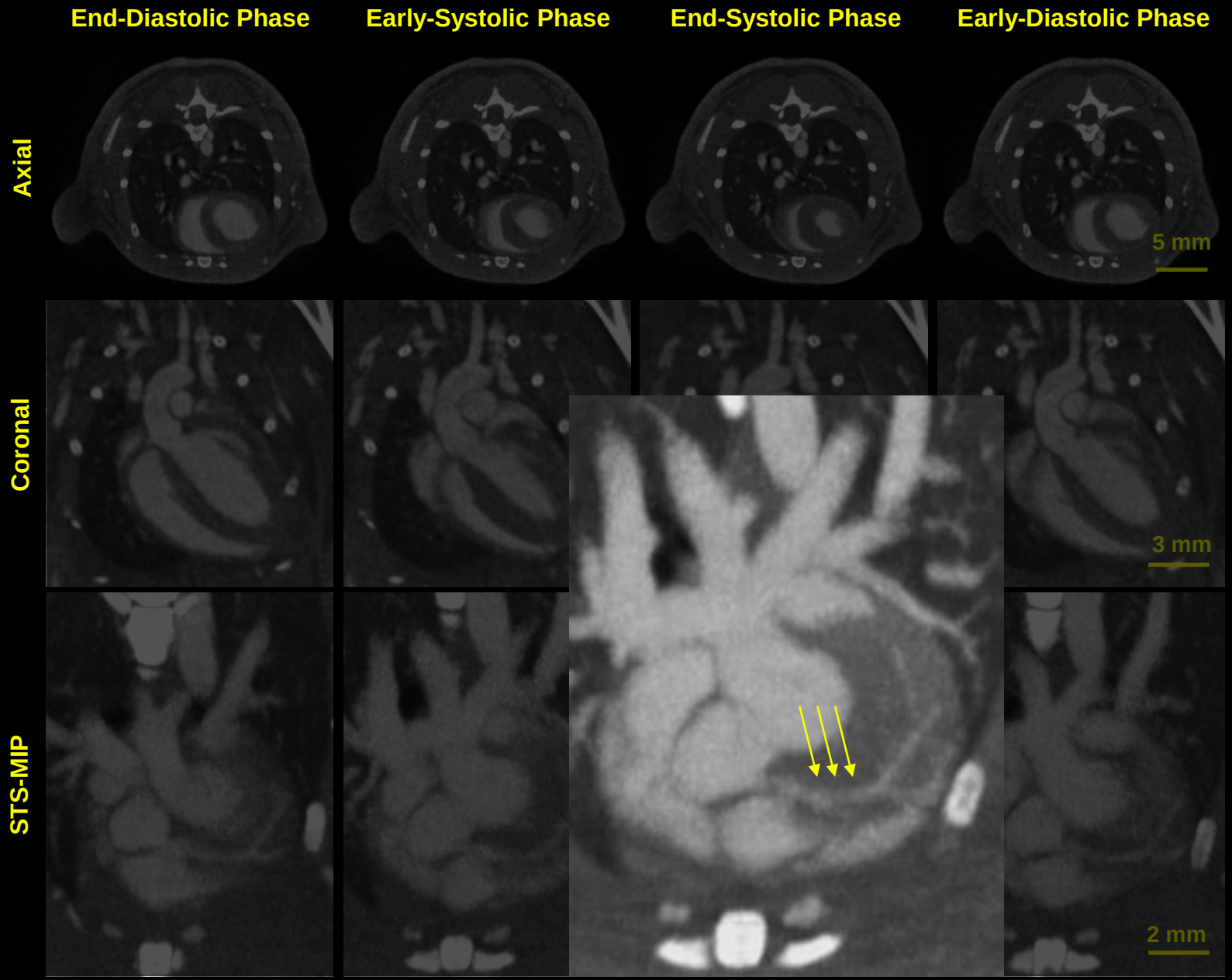


Motion Compensation



Brehm, Sawall, Kachelrieß et al. Cardiorespiratory motion-compensated micro-CT image reconstruction using an artifact model-based motion estimation. Med. Phys. 42(4): 1948-1958, April 2015.


End-Diastolic Phase
Early-Systolic Phase
End-Systolic Phase
Early-Diastolic Phase
Axial
Coronal
STS-MIP
RV
LV
5 mm
3 mm
2 mm

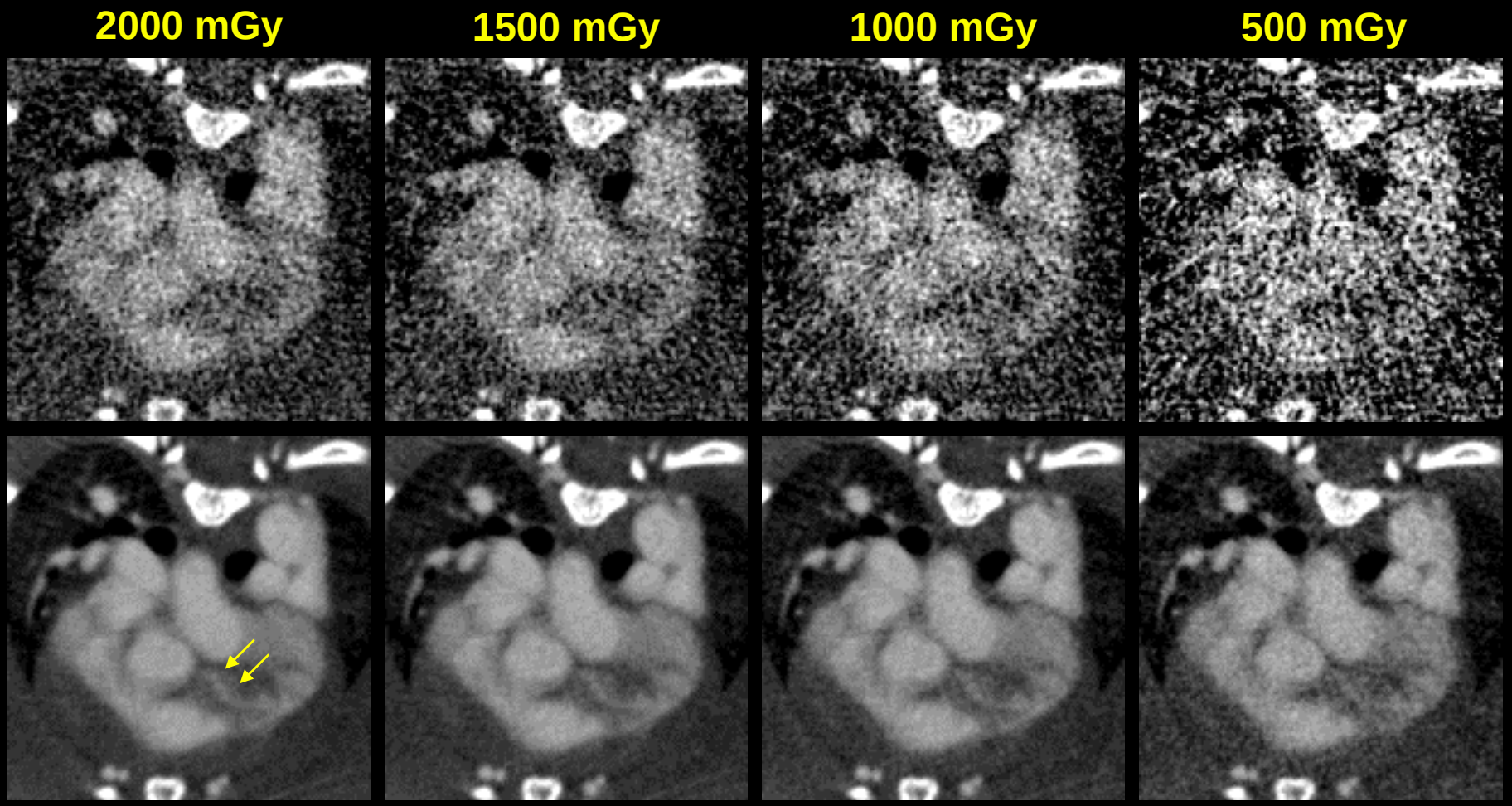

End-Diastolic Phase
Early-Systolic Phase
End-Systolic Phase
Early-Diastolic Phase
Axial
Coronal
STS-MIP
5 mm
3 mm
2 mm

Volume Rendering

Frontal

Lateral

Dose Reduction Study



Summary & Conclusion

- Coronary micro-CT angiography in mice is possible.
- The resulting image quality does not yet match state-of-the-art clinical cardiac CTA.
- We were able to visualize the LAD and RCX and all major branches thereof.
- Reducing radiation dose is challenging but can be achieved by using sophisticated reconstruction and motion estimation methods.
- In-vivo micro-CT of coronary arteries in small animals could boost studies of myocardial infarction, (re-)perfusion and other processes in preclinical models of cardiac pathologies.

Thank You!

This presentation will soon be available at www.dkfz.de/ct.

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

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