

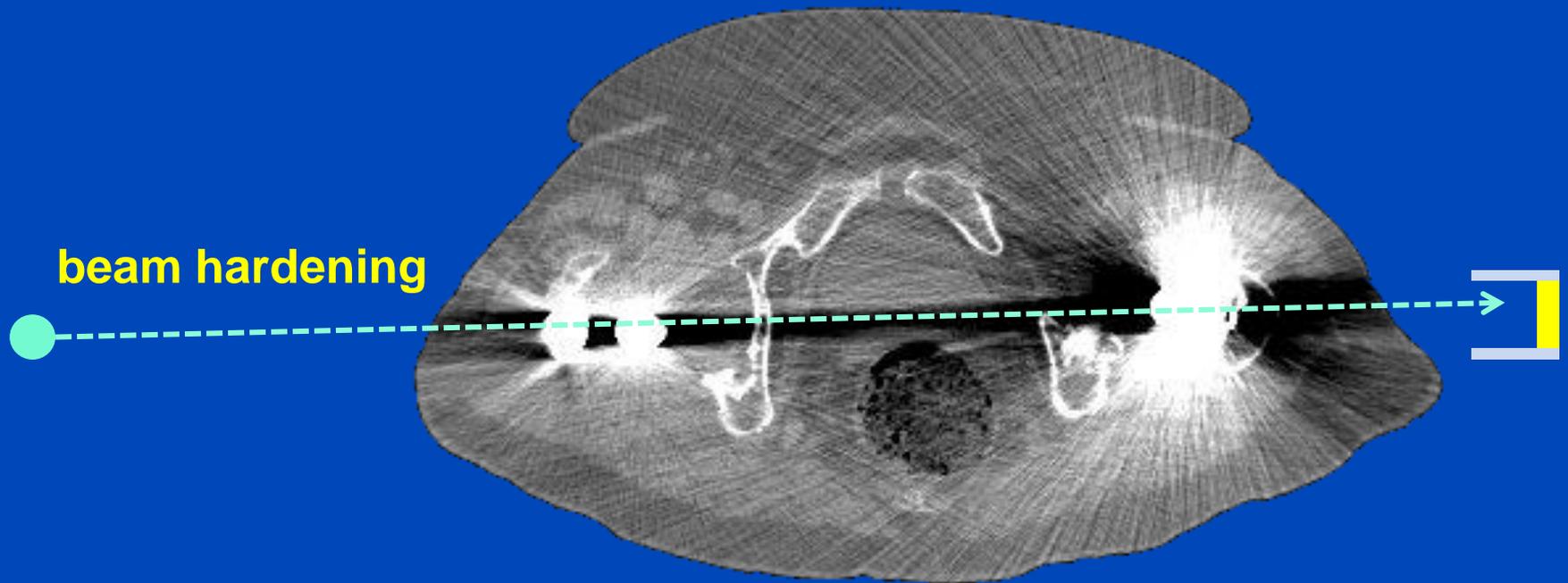
Moving Metal Artifact Reduction for Cone-Beam CT (CBCT) Scans of the Thorax Region

Andreas Hahn^{1,2}, Sebastian Sauppe^{1,2}, Michael Knaup¹,
and Marc Kachelrieß^{1,2}

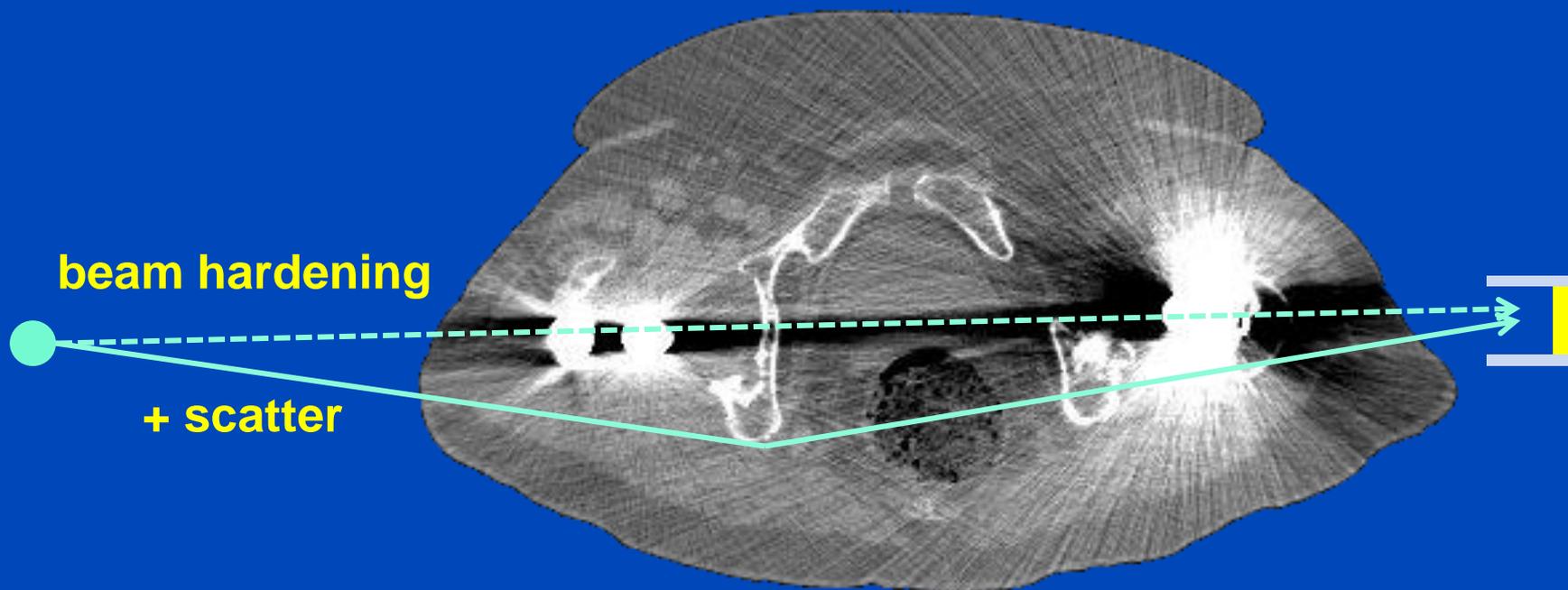
¹German Cancer Research Center (DKFZ), Heidelberg, Germany

²University of Heidelberg, Heidelberg, Germany

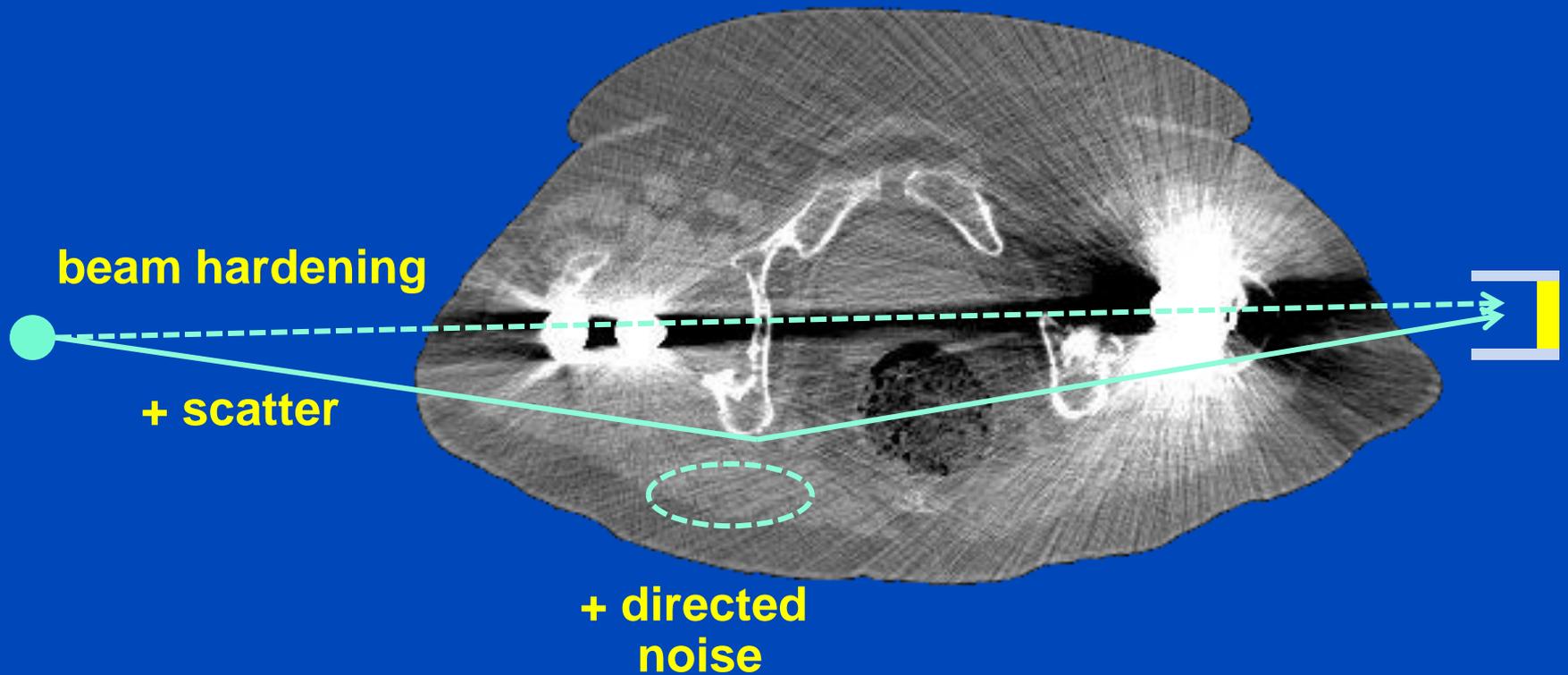
Metal Artifacts



Metal Artifacts



Metal Artifacts

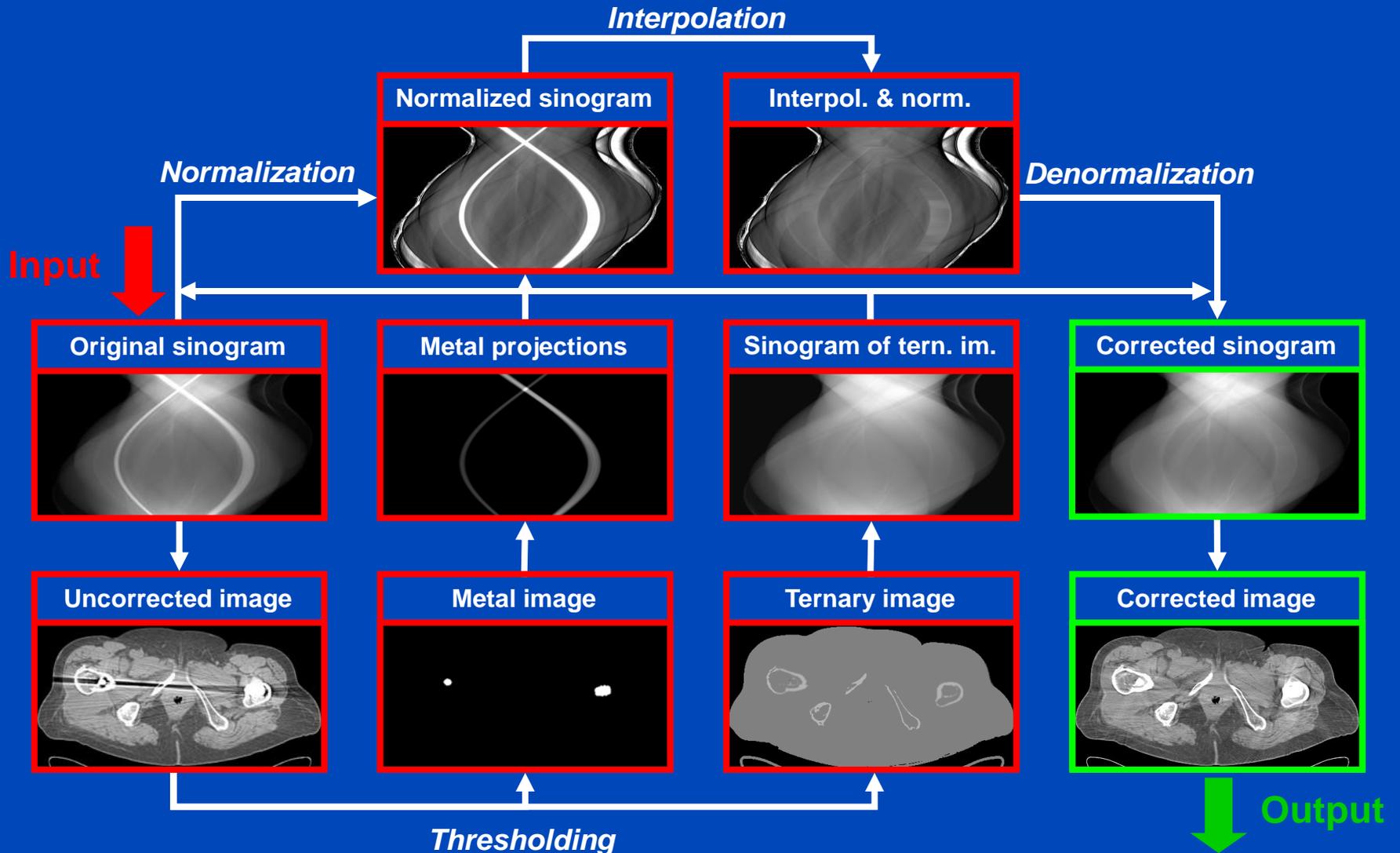


Metal Artifacts

sharp
edges
+ motion

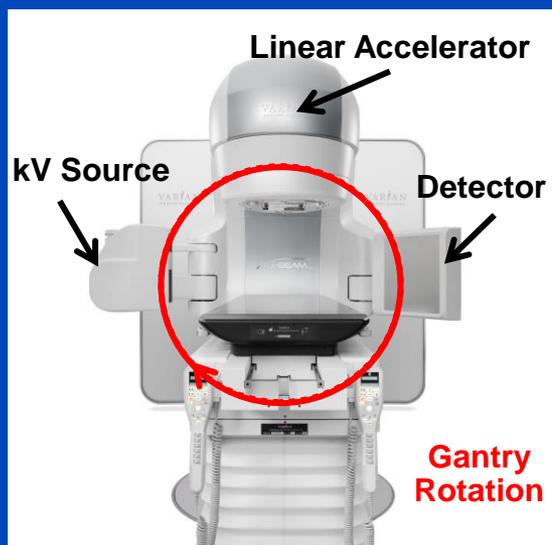


Illustration of Conventional Metal Artifact Reduction: Normalized MAR (NMAR)



Moving Metal

- Image-guided radiation therapy (IGRT)
 - CBCT imaging unit mounted on gantry of a LINAC treatment system
- Slow gantry rotation speed of 6° per second (**60 s/360°**)
 - Much slower than clinical CT devices (**0.25 s /360°**)
- Breathing about 10 to 30 rpm (respirations per minute) and thus per scan



Projections
→



Metal subject to respiratory motion

Problem of Conventional MAR

- Conventional inpainting-based methods like NMAR do not account for motion.
- Threshold-based segmentation yields a static metal insert.

Metal segmentation
in volume



Metal mask in projections



Reconstructed volume
after interpolation



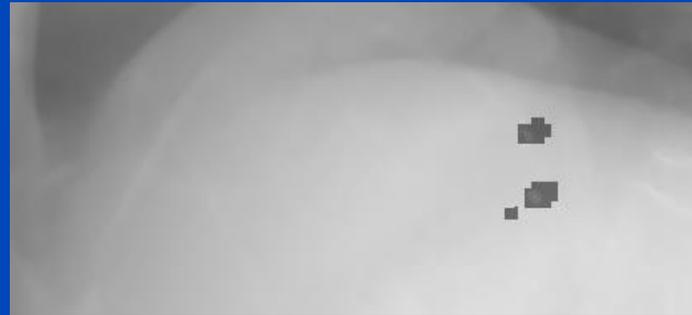
Problem of Conventional MAR

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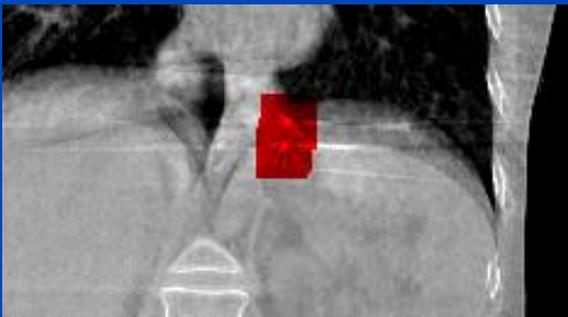
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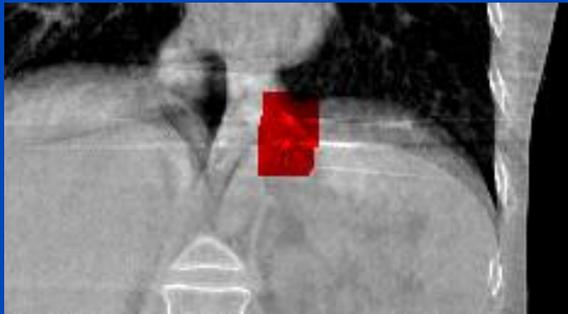
Accounting for Metal Motion

- Most MAR methods do not account for motion.
- Several publications on raw data-based segmentation:
 - Zhang et al.: Reducing metal artifacts in cone-beam CT images by preprocessing projection data, Int J Radiat Oncol Biol Phys 67(3):924–932, March 2007
→ **requires user input**
 - Veldkamp et al.: Development and validation of segmentation and interpolation techniques in sinograms for metal artifact suppression in CT, Med Phys 37(2):620–628, February 2010
→ **lacks robustness**
- New approach aims for a combination of image and raw data-based segmentation:
 - Toftegaard et al.: Moving metal artifact reduction in cone-beam CT scans with implanted cylindrical gold markers, Med Phys 41, December 2014
→ **prior knowledge needed (shape of inserts)**

Accounting for Metal Motion

- Combination of volume and raw data-based metal segmentation: Moving metal artifact reduction (**MMAR**)
 - Brehm et al.: Moving metal artifact reduction (MMAR): A metal artifact reduction algorithm for flat 280 detector cone-beam CT scans with metal subject to respiratory motion, RSNA Conference Proc., November 2011

Metal segmentation
in volume



Metal mask in projections

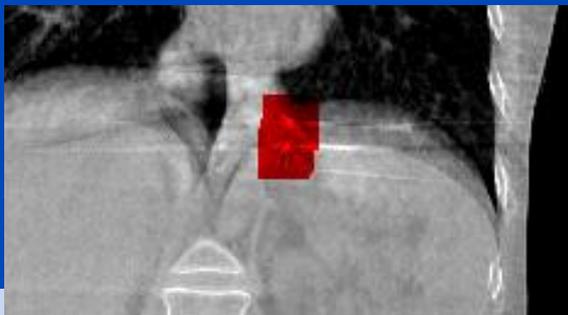


Reconstructed volume
after interpolation



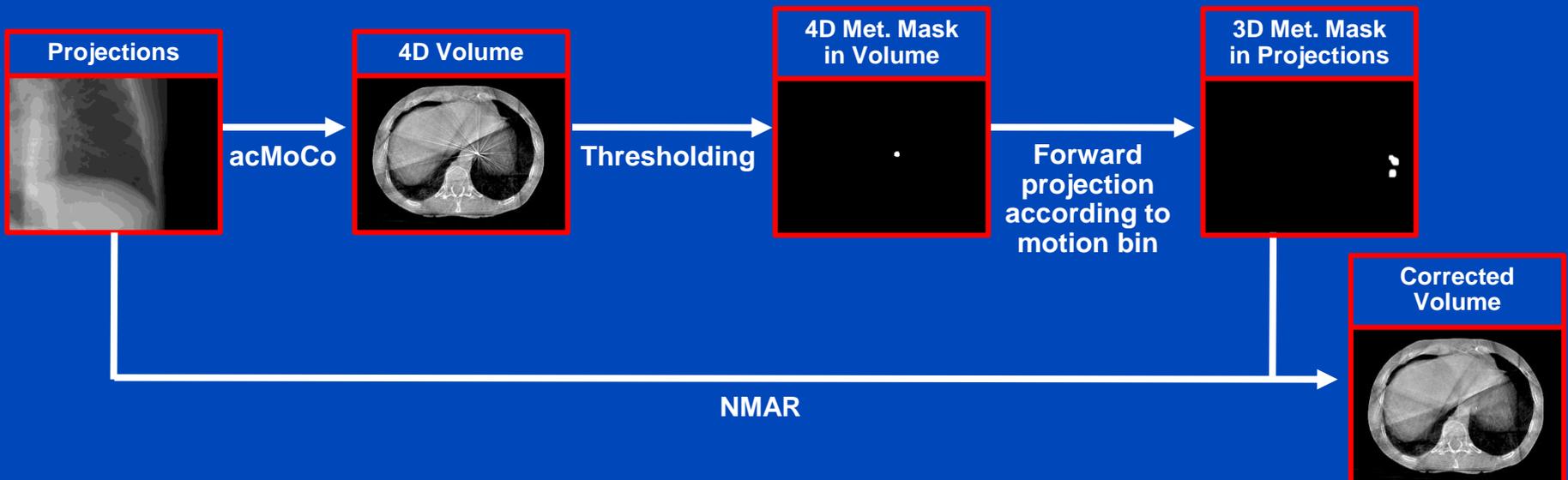
MMAR

refined segmentation



MoCoMAR

- Aim: Removal of metal artifacts in 3D CBCT volumes.
- Idea:
 - For **NMAR**¹ static metal is segmented in a **3D volume**.
 - For our new approach (**MoCoMAR**), NMAR is improved by segmenting the metal in a **4D volume**.
 - The 4D volume is reconstructed using the **acMoCo**² algorithm.



Results

Patient 1

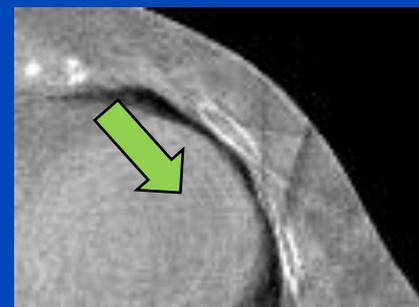
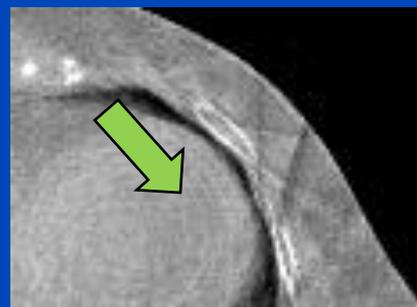
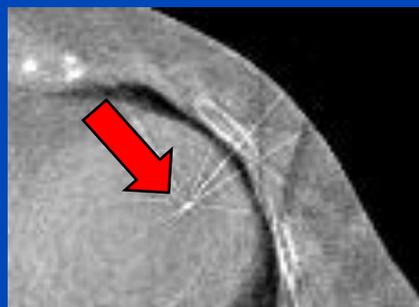
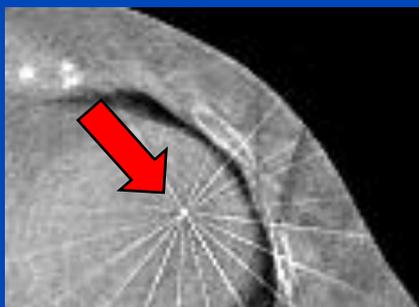
Standard

NMAR

MMAR

MoCoMAR

axial



sagittal



Results

Patient 1

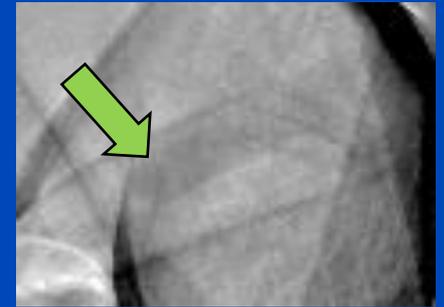
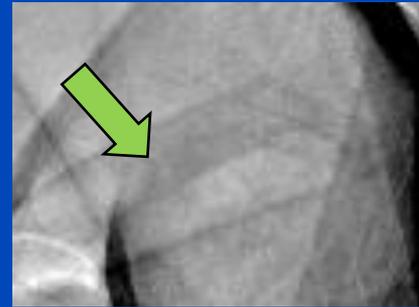
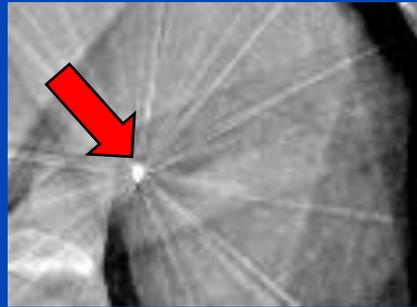
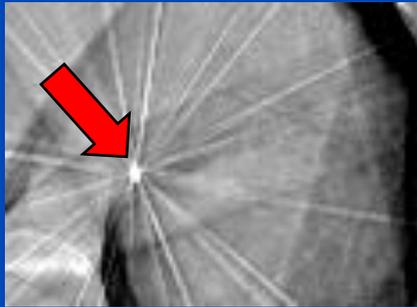
Standard

NMAR

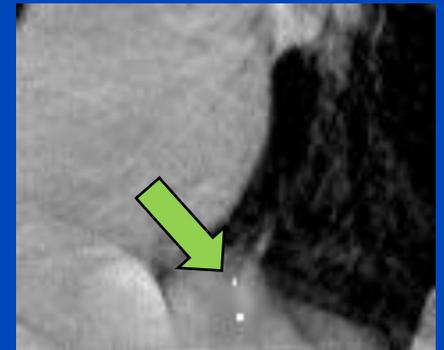
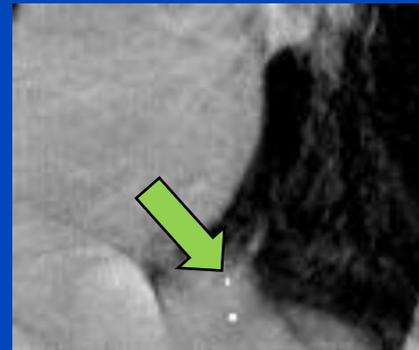
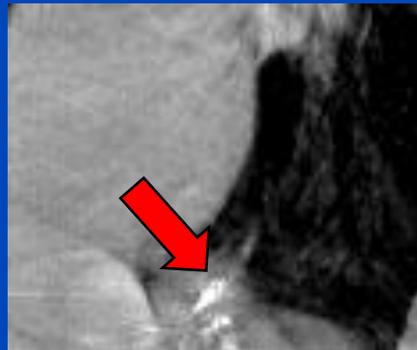
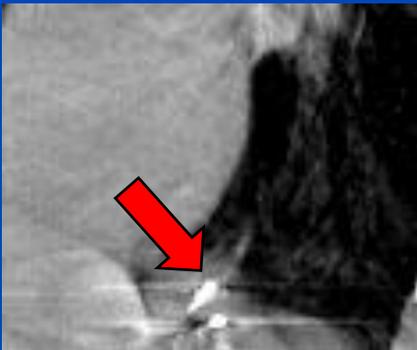
MMAR

MoCoMAR

axial



sagittal



Conclusions

- MMAR and MoCoMAR outperform NMAR when it comes to moving metal inserts.
- The proposed method (MoCoMAR) was able to achieve similar results to MMAR. It is, however, computationally more expensive.
- More patients have to be evaluated to see if there are cases where one of the methods that account for motion outperforms the other.

Thank You!

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

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

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