

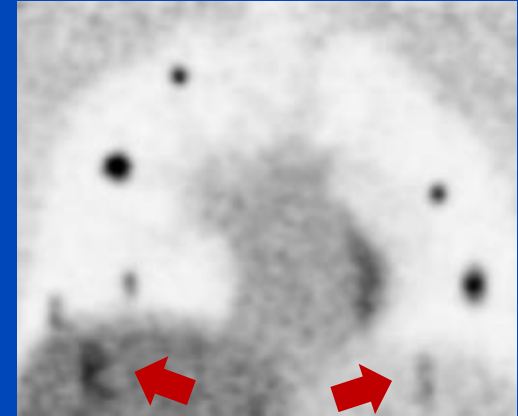
Respiratory Motion Compensation for Simultaneous PET/MR Based on Measurements of Strongly Undersampled Radial MR Data

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Introduction

- One major challenge in PET image reconstruction is patient motion (respiratory, cardiac, involuntary motion)
- Motion causes image blurring and an underestimation of the reconstructed activity up to 25%¹
- Gating
 - divide (cyclic) motion into certain gates and reconstruct images from the data of each individual gate separately
 - trade-off between temporal resolution and an appropriate SNR and CNR of the reconstructed images
- **Recent approach: PET/MR motion compensation (MoCo)^{2,3}**
 - use MR information to estimate 4D motion vector fields (MVFs)
 - 4D MoCo PET reconstruction from 100% of rawdata



[1] Kinahan, Fletscher. PET/CT Standardized Uptake Values (SUVs) in Clinical Practice and Assessing Response to Therapy. Semin Ultrasound CT MR 2010.

[2] Grimm et al. Self-gated MRI motion modeling for respiratory motion compensation in integrated PET/MRI. Med. Image Anal. 2015.

[3] Fürst et al. Motion Correction Strategies for Integrated PET/MR. J. Nucl. Med. 2015.

Aim of Work

- Develop a framework for respiratory motion compensation of PET images
- Use information from a strongly undersampled radial MR sequence with an acquisition time of 1 minute
- Difficulty: obtain high-fidelity MVFs from strongly undersampled MR data

Data Acquisition and Processing

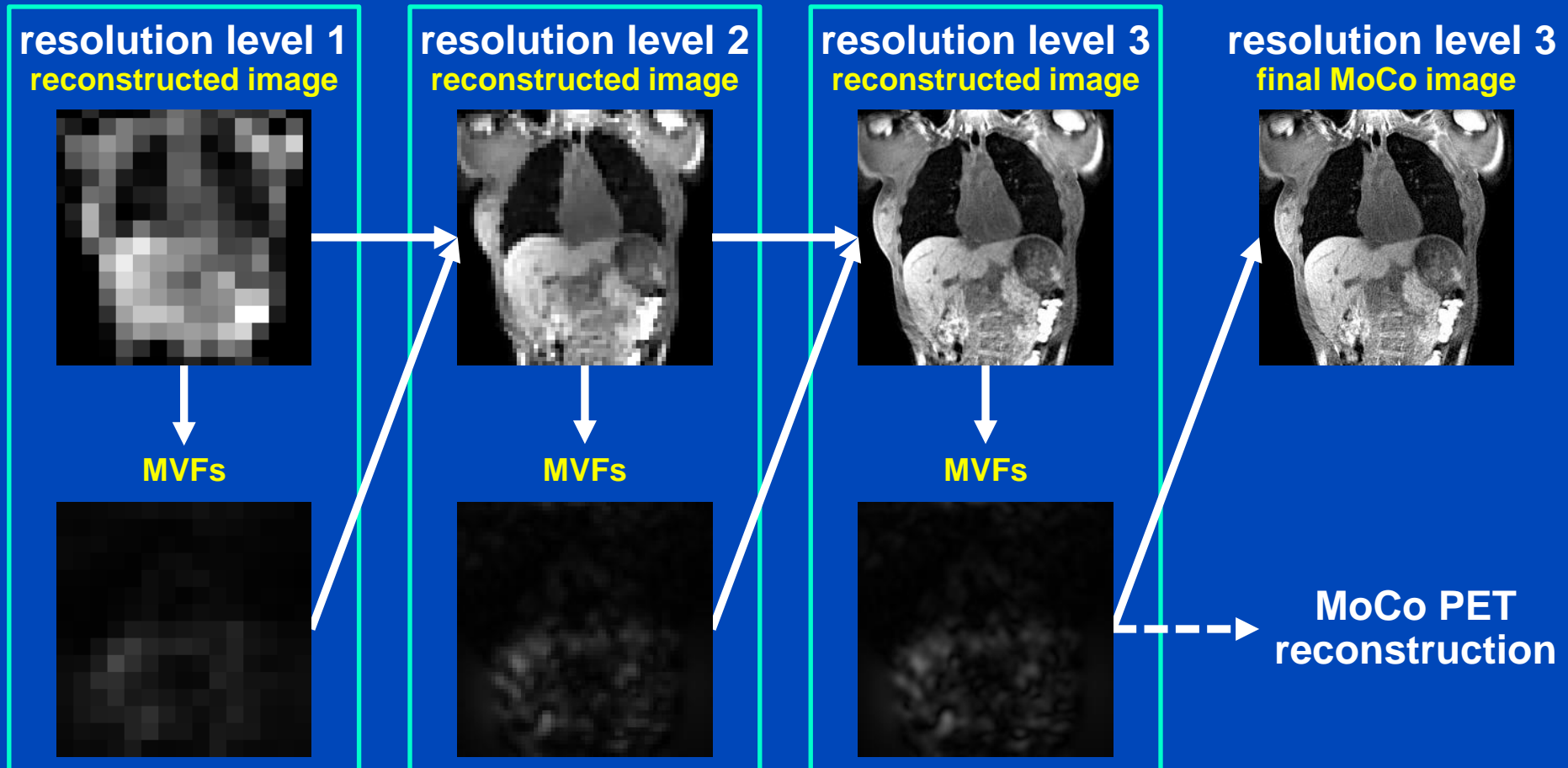
- Simultaneous PET/MR acquisition at Biograph mMR
 - tracer: fluorodeoxyglucose (^{18}F -FDG)
 - MR sequence: 3D-encoded gradient echo sequence with radial stack-of-stars sampling scheme and golden angle radial spacing
- Retrospective generation of undersampled MR raw data



- MR and PET data were sorted retrospectively into 20 overlapping motion phase bins (10% width)

Estimation of MVFs

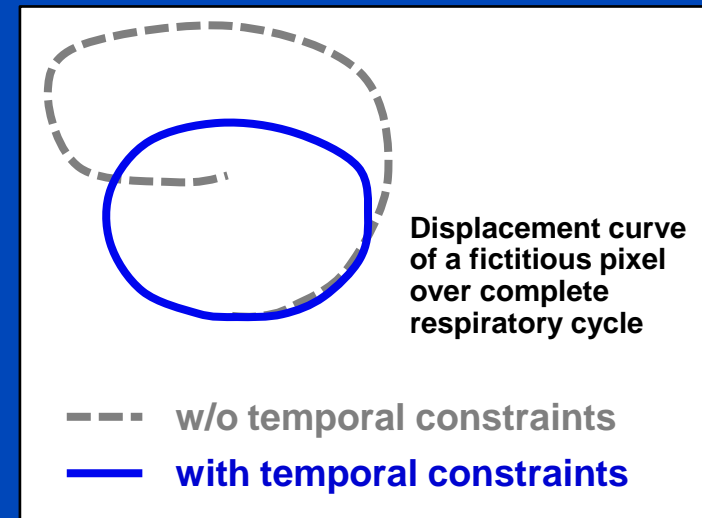
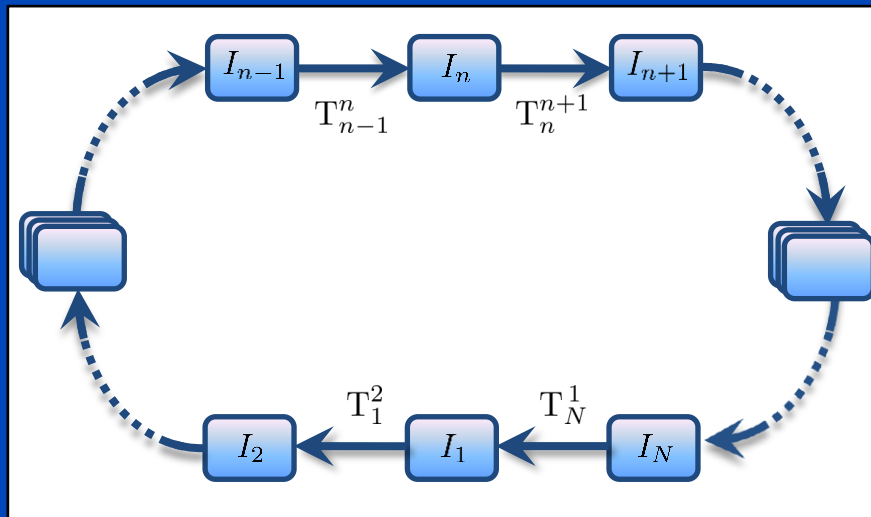
Schematic Overview



Estimation of MVFs

Cyclic Deformable Registration¹

- Motion estimation only between adjacent phases
 - all other MVFs given by concatenation



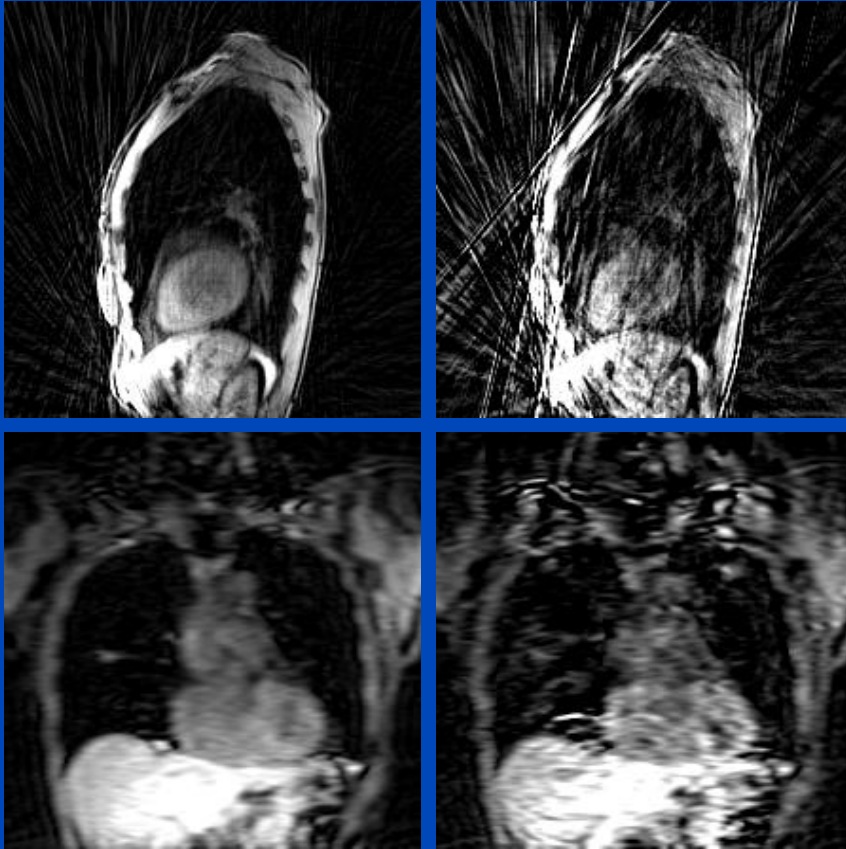
- Incorporate additional knowledge
 - a priori knowledge of quasi periodic breathing pattern
 - non-cyclic motion is penalized
 - error propagation due to concatenation is reduced

Initial Results of MR Reconstruction

4D gated gridding

5 min / bed

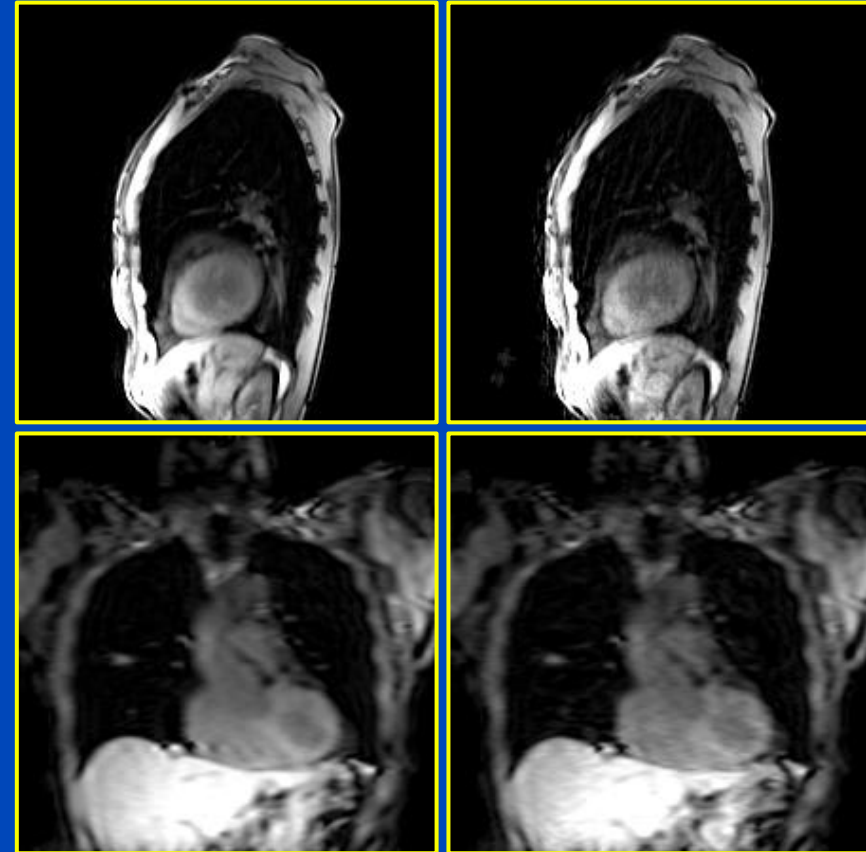
1 min / bed



4D MoCo

5 min / bed

1 min / bed



MVFs

MVFs

Initial Results of PET Reconstruction

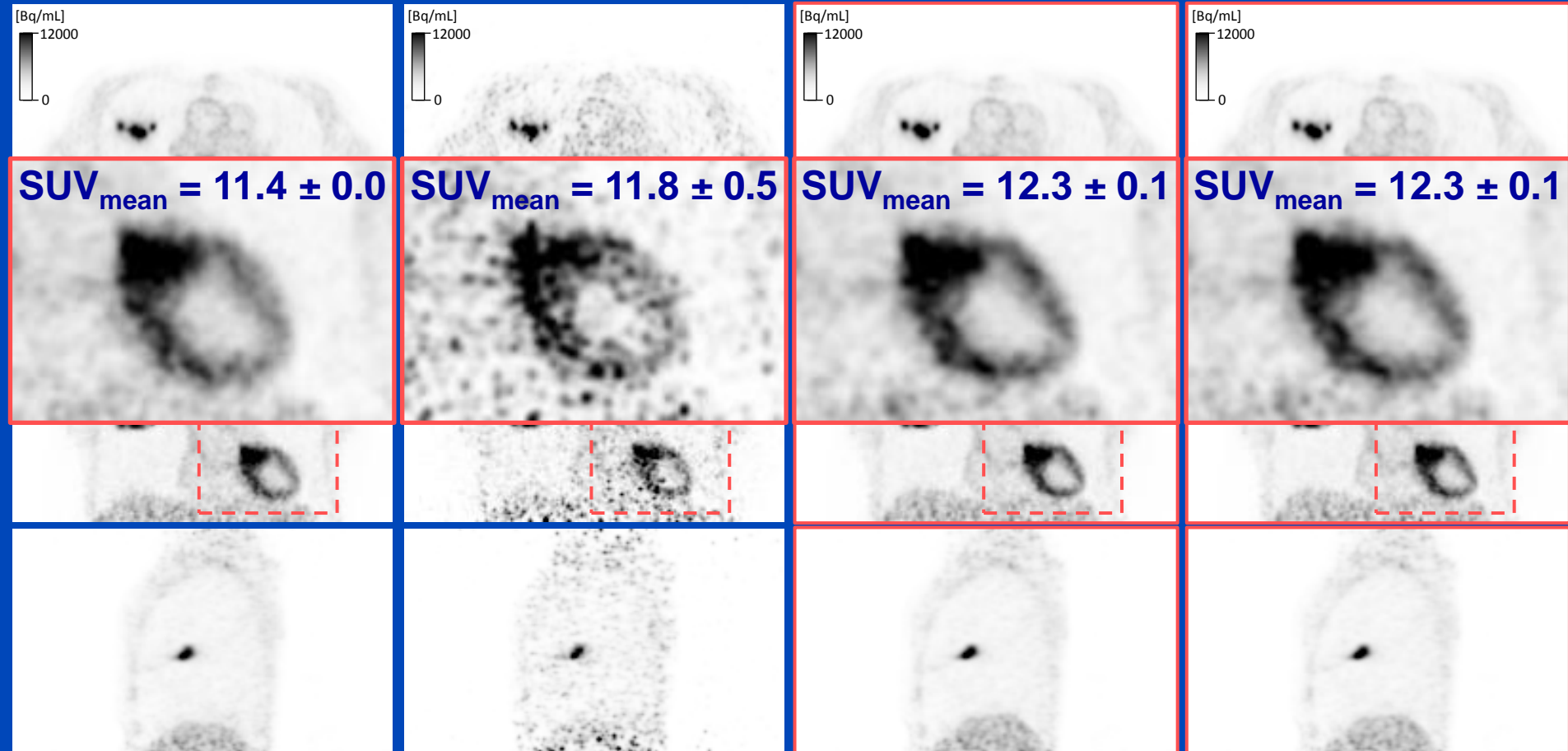
4D MoCo

3D

4D gated

MR: 5 min / bed

MR: 1 min / bed



Summary and Outlook

- High quality PET respiratory MoCo is possible based on 1 minute MR acquisition
- The strong MR undersampling requires to reconstruct MVFs and MR images in an alternating manner
- MoCo for PET considerably improves PET quantification, image quality, temporal resolution and noise level
- Next steps:
 - Verification of results with larger number of patients
 - Optimization of MR sequences for dedicated MoCo scans
- More on MoCo:
 - Hahn, Kachelrieß. MoCo from Short-Scan Data in Cardiac CT.
Tue, Dec 1, 10:40 AM, Room S403B
 - Sauppe, Kachelrieß. Respiratory and Cardiac 5D MoCo for CBCT.
Wed, Dec 2, 11:10 AM, Room S403B

Thank You!



The 4th 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

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

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