Deep Learning-based 4D CT and 4D CBCT Motion Compensation of Periodic and Non-Periodic Patient Motion with Single-View Temporal Resolution

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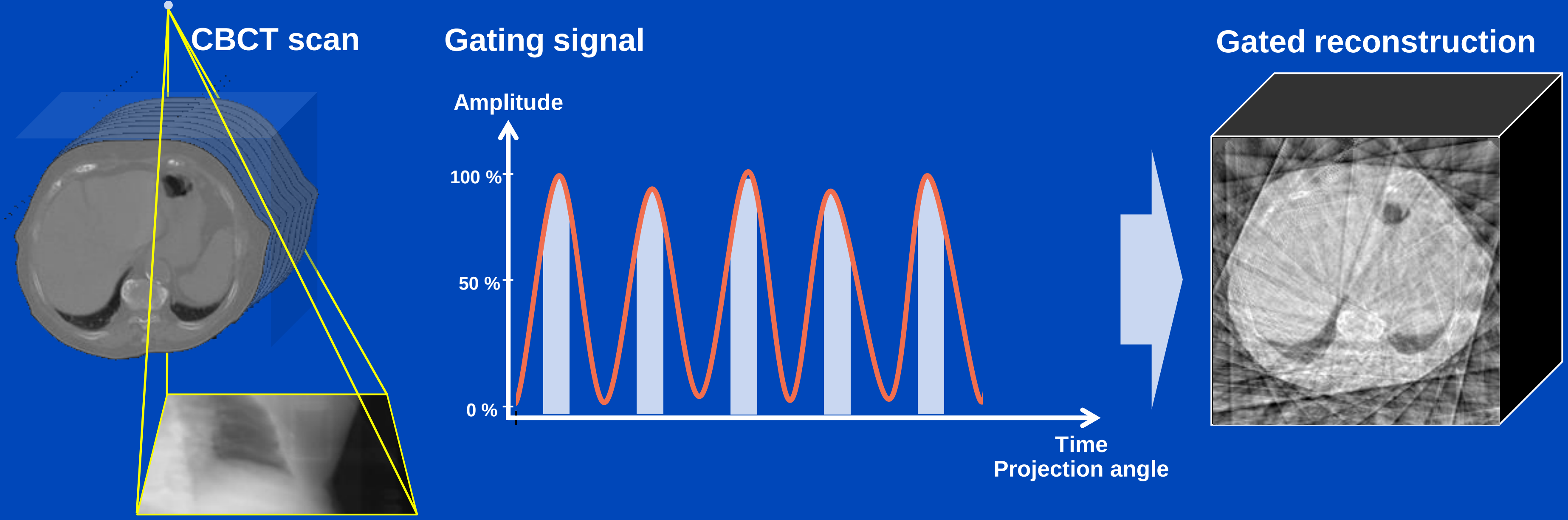
Motion in CT and CBCT

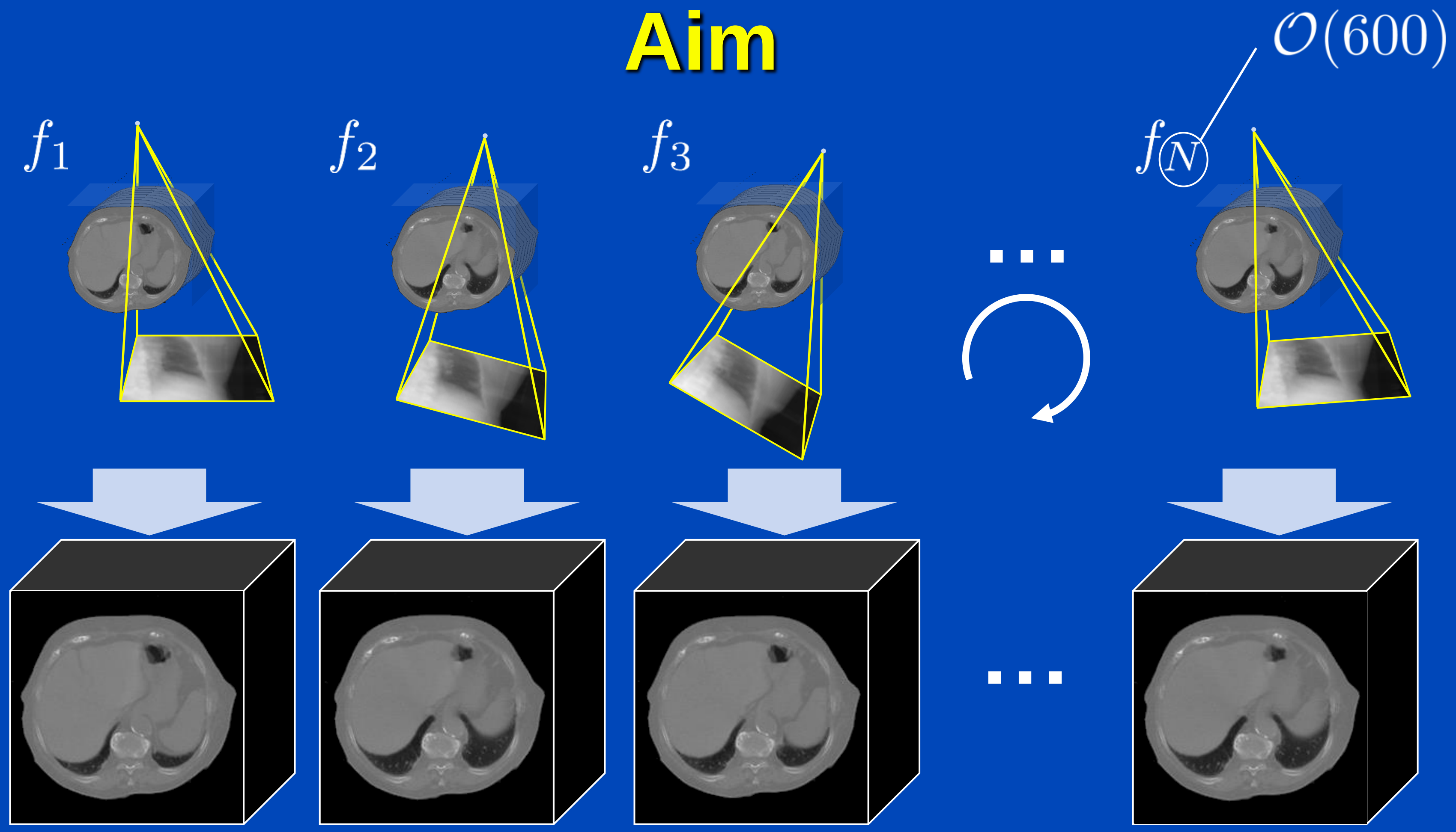
Gating-based strategies



Drawbacks:

- requires gating signal,
- assumes periodic motion,
- has low temporal resolution,
- fails on irregular breathing.

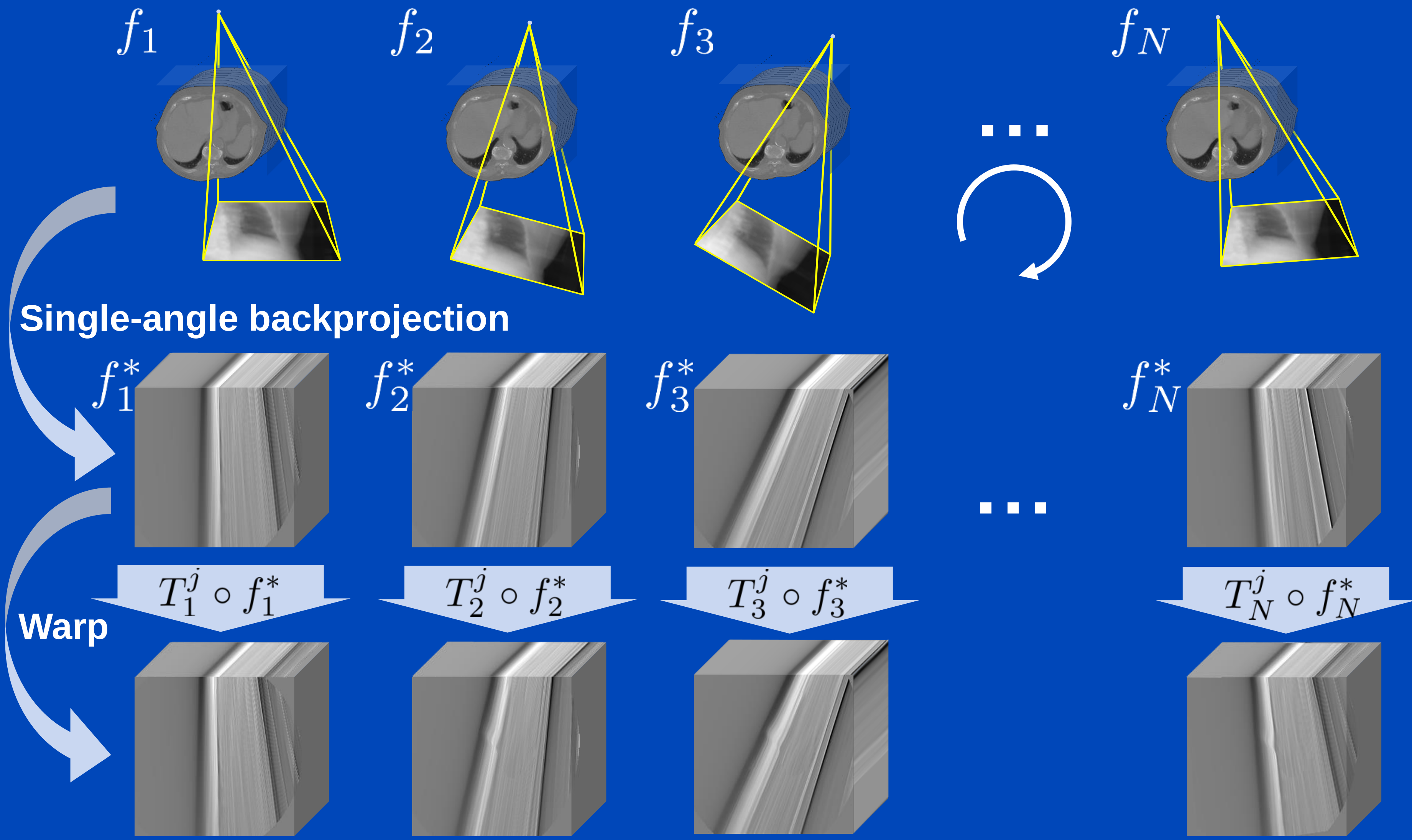
Aim



Goal: Reconstruct any motion state that occurred during the CBCT scan, i.e. reconstruct a separate volume for every projection view, without the need for a gating signal.

Single-angle Motion Compensation (SAMoCo)

Basic Principle



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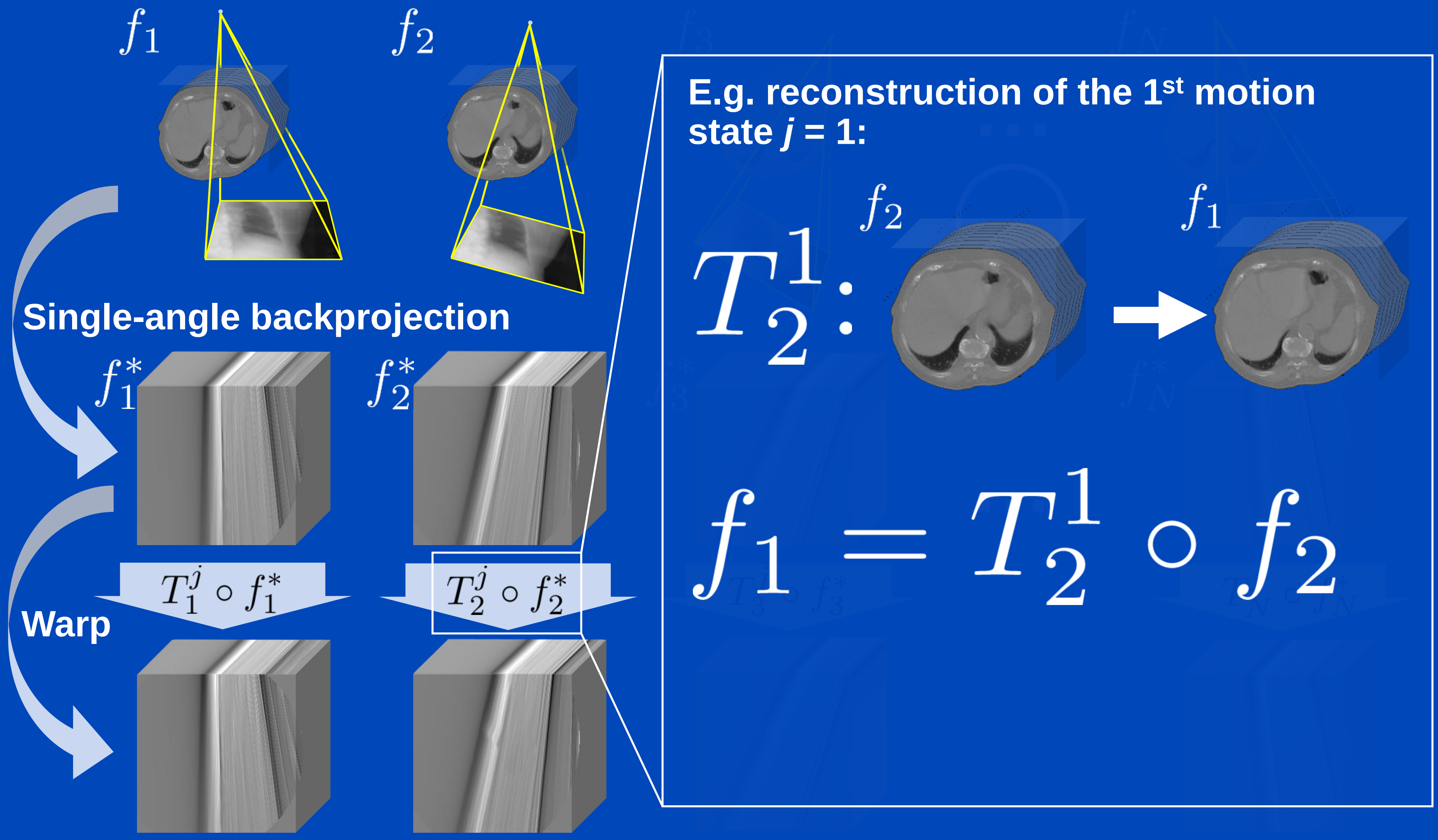

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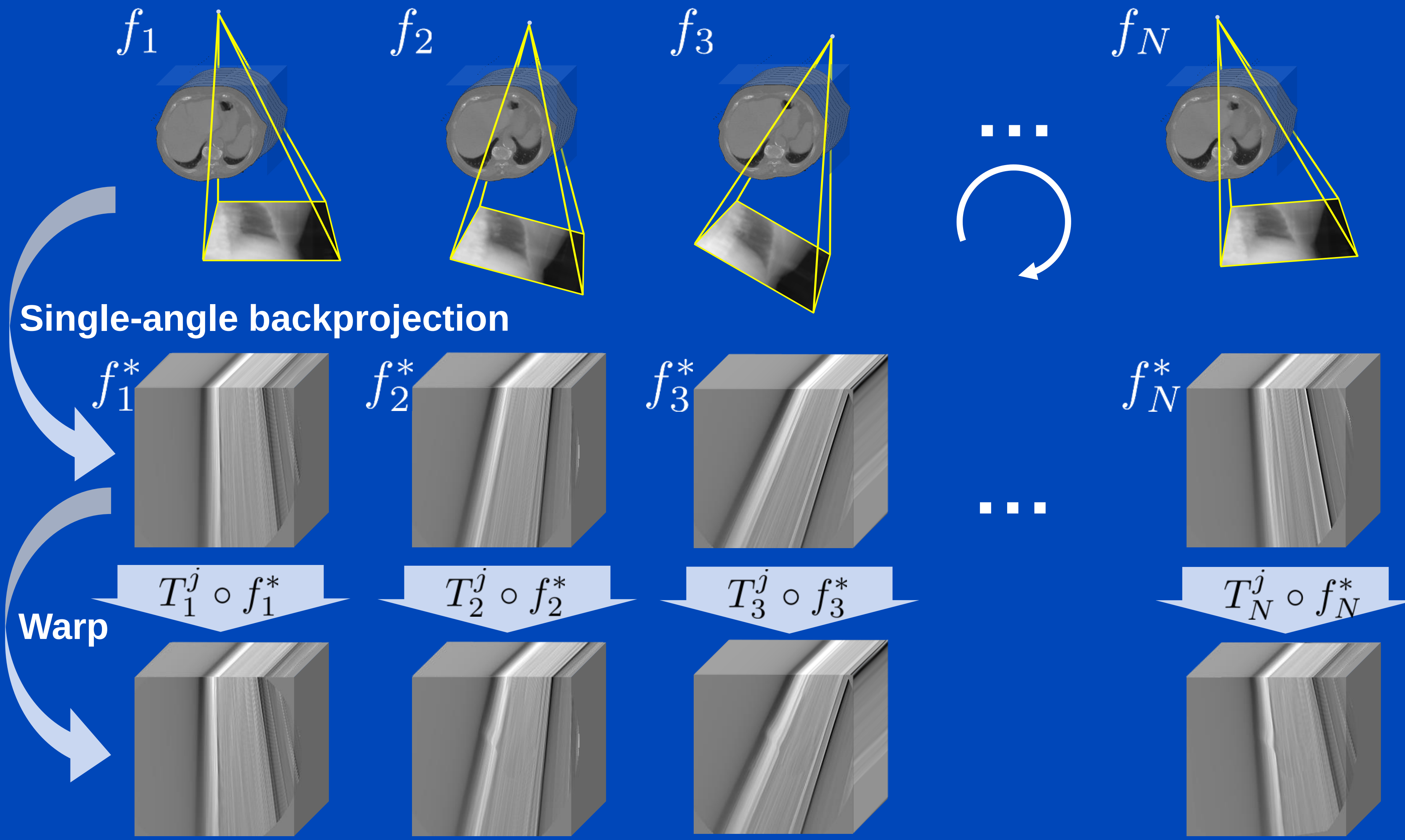
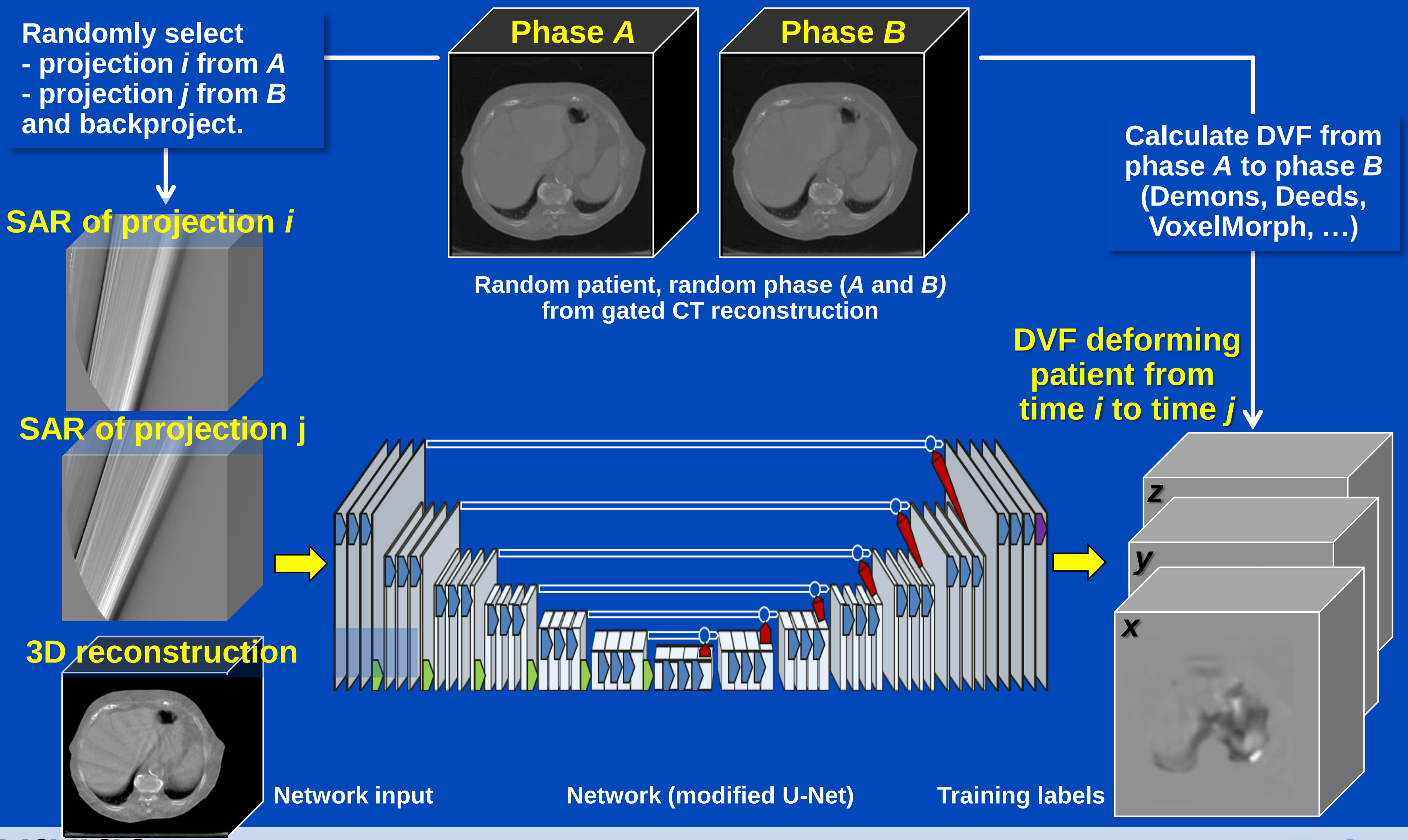


SAMoCo: $f_{j,\mathrm{MoCo}} = \sum_i T_i^j \circ f_i^*$

Learning to Predict Deformation Vector Fields



Training and Testing Details

- **Training using gated CT reconstruction (high temporal resolution, no motion artifacts)**
  - Gated CT reconstructions of 84 patients.
  - Simulation of CBCT (shifted-detector) single-angle reconstructions with random motion state and random projection angle.
  - Training of the network for 500 epochs using the MSE between prediction and ground truth DVF as loss function.
- **Testing:**
  - Simulated shifted-detector CBCT scans (rotation time: 60 s, 657 views per rotation).
  - Real-measurements of a Varian TrueBeam CBCT system.

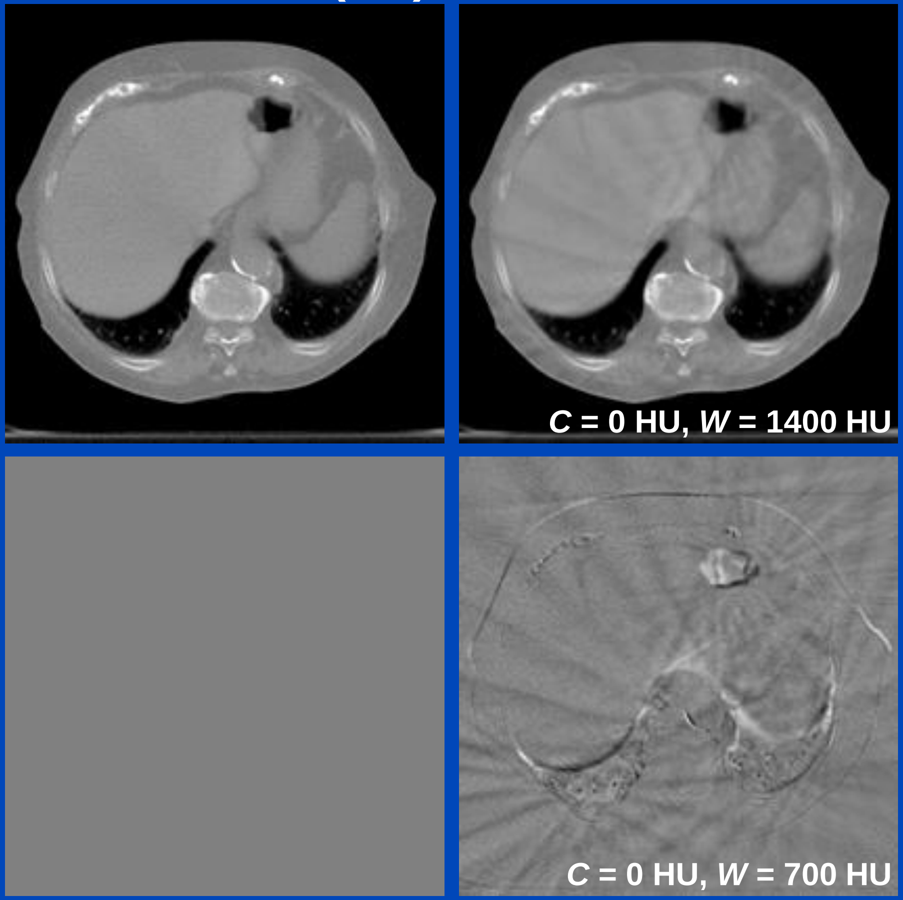
Results: Simulation Study

Axial view

Ground truth (GT) | SAMoCo

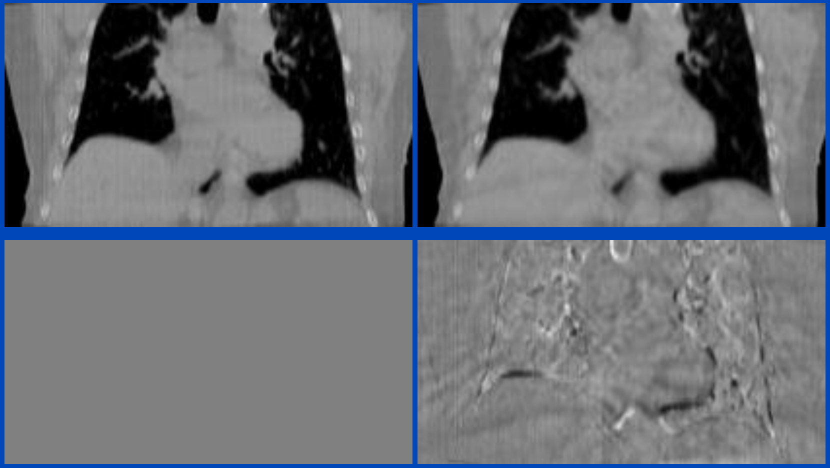
Reconstruction

Difference to GT

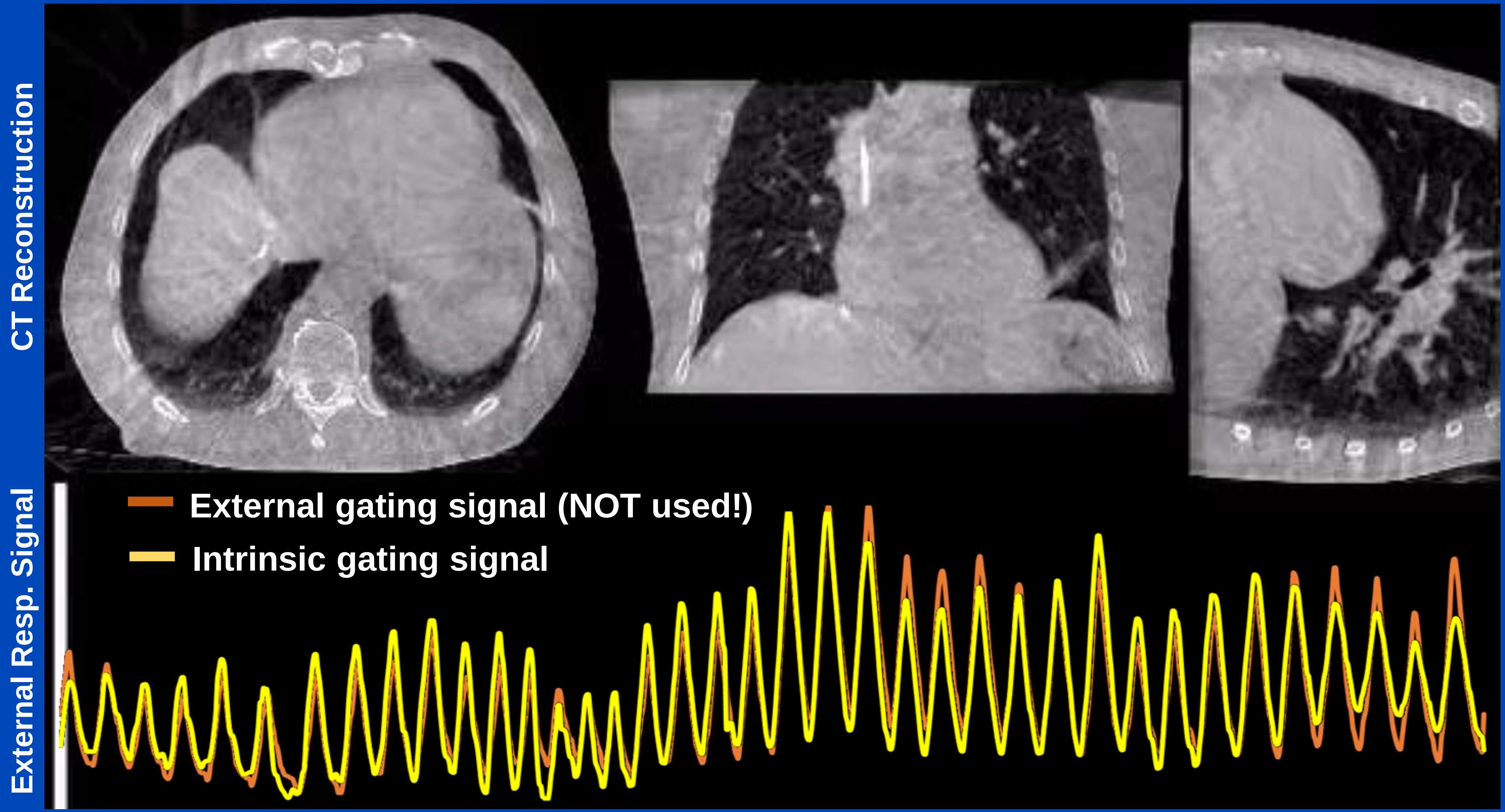


Coronal view

Ground truth (GT) | SAMoCo



Results: Varian CBCT Measurement



Conclusions

- Deep SAMoCo is able to resolve cardiac and respiratory motion with single-view temporal resolution.
- High correlation between intrinsic respiration signal and Varian RPM marker block.
- Deep SAMoCo can potentially overcome limitations of gating-based motion compensation.
- Further efforts are needed to improve the quality of the reconstructions. In particular this issue will be addressed by incorporating the SAMoCo concept into an iterative reconstruction framework.

Thank You!

This presentation will soon be available at www.dkfz.de/ct.
Job opportunities through DKFZ's international PhD programs or through marc.kachelriess@dkfz.de.
Parts of the reconstruction software were provided by RayConStruct® GmbH, Nürnberg, Germany.