

Simulated PET acquisition of a moved NCAT- human torso phantom using the GATE toolkit

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Purpose of PET simulation

- Evaluation of image quality
- Scanner performance check (resolution, efficiency)
- Design study for scanner improvement
- Ground truth data for development of new acquisition and reconstruction schemes.



Moved Objects in PET

- Problem:

- Image blurring during long scan times
- Attenuation correction with static CT data produces artifacts in images

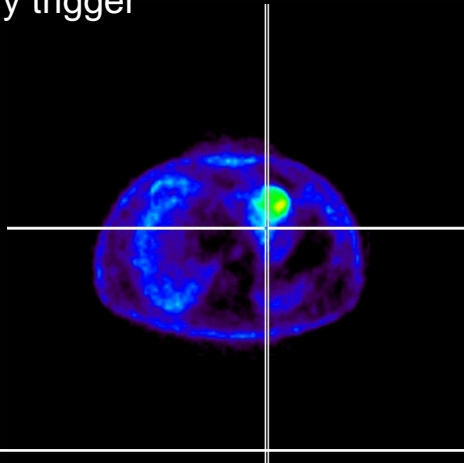
- Solution:

- Gated listmode PET freezes motion
- Use of software morphing (optical flow) to produce motion free images inheriting the full statistics

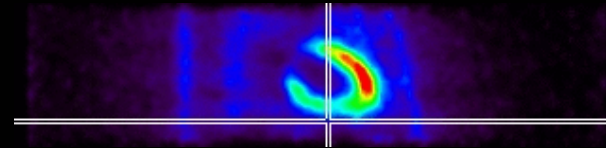


Real PET images to compare with

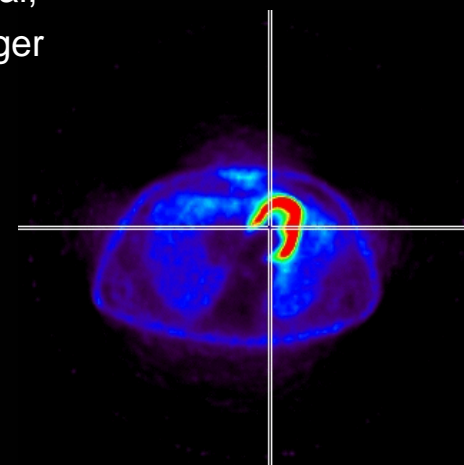
transversal,
respiratory trigger



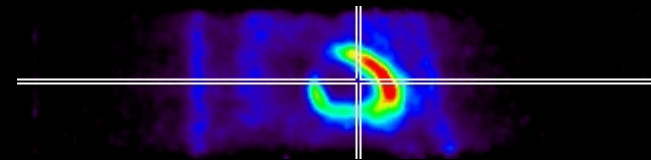
sagittal,
respiratory trigger



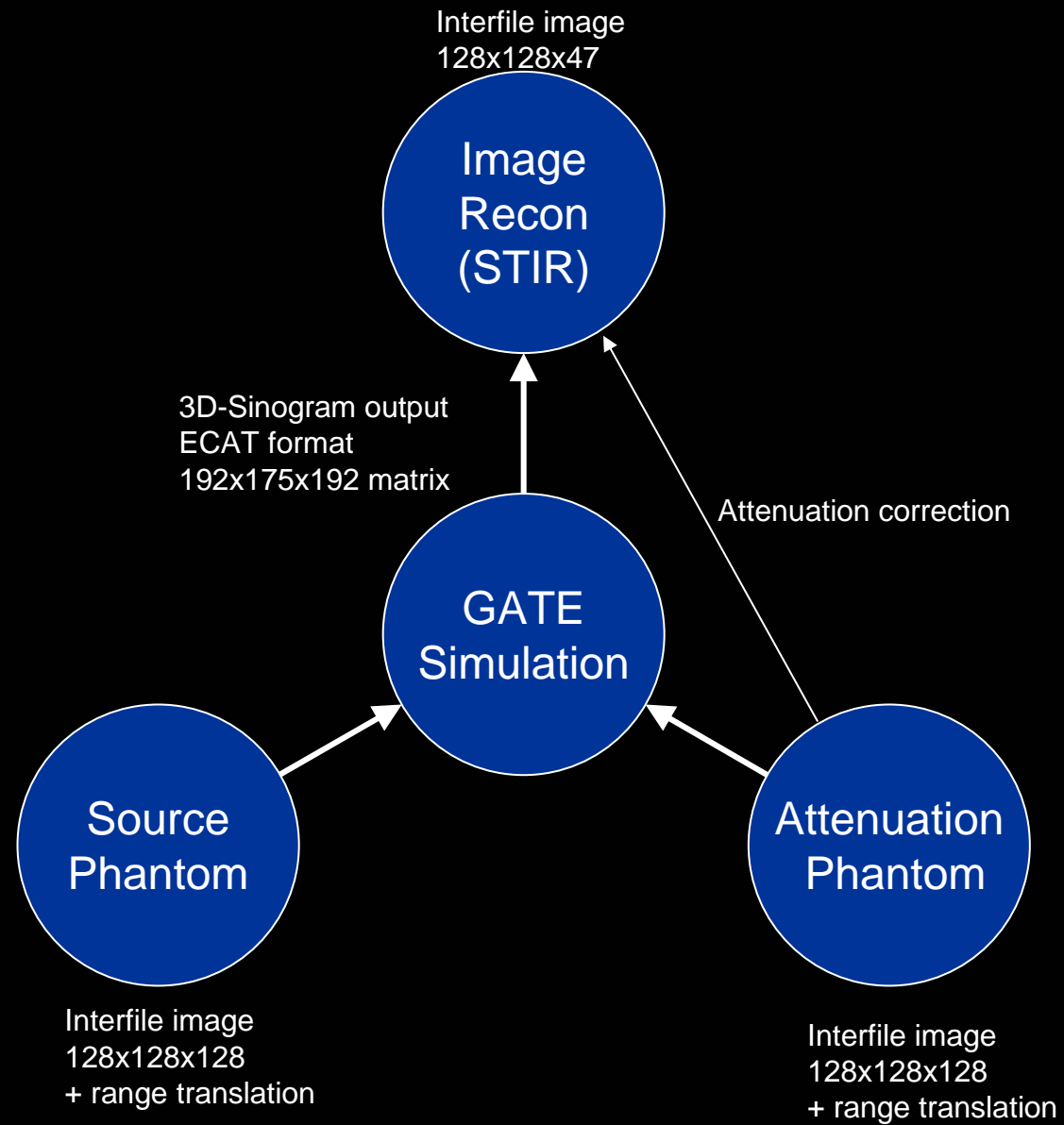
transversal,
ECG-trigger



sagittal,
ECG-trigger

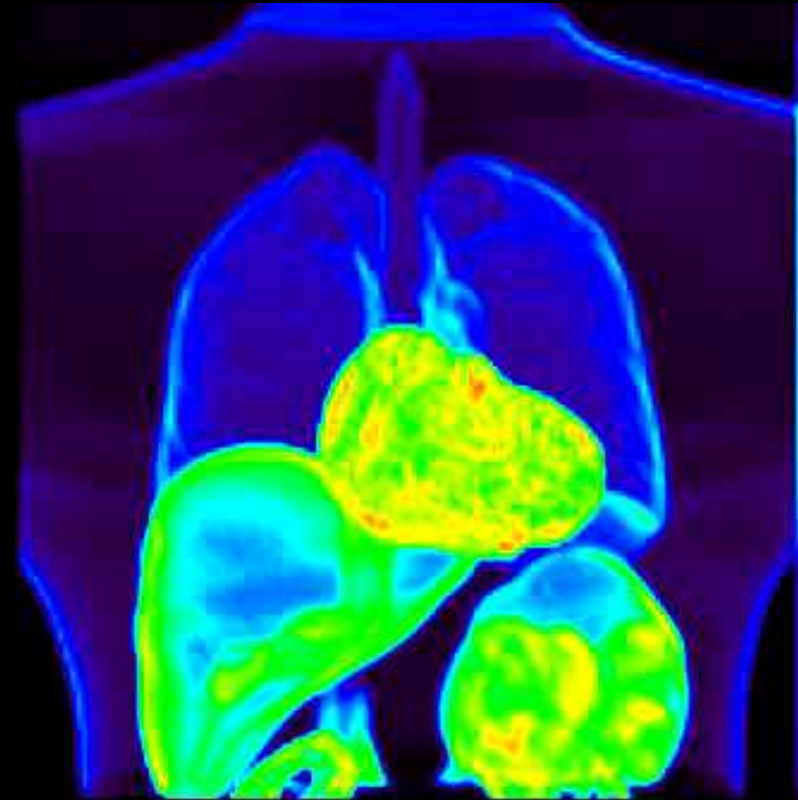


Workflow of Simulation



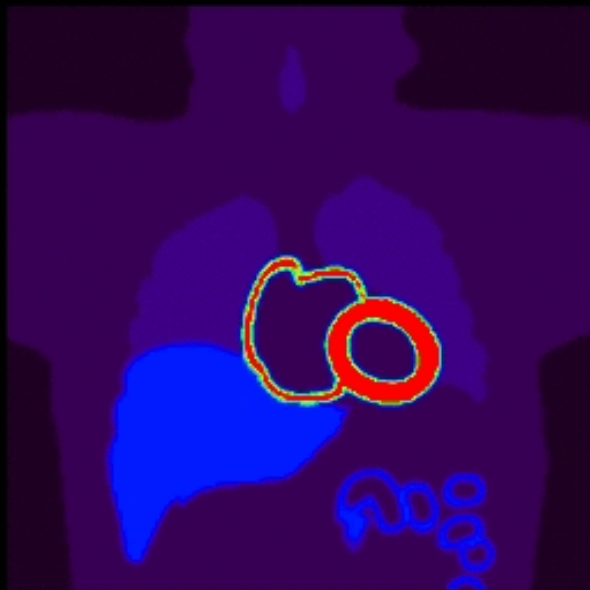
The NCAT Human Torso Phantom

- Voxelized 3D-anatomy of human body
- Respiratory and cardiac motion implemented
- Emission and attenuation configuration
- Simulation of lesion or infarction
- Ideal tool for GATE-PET simulation

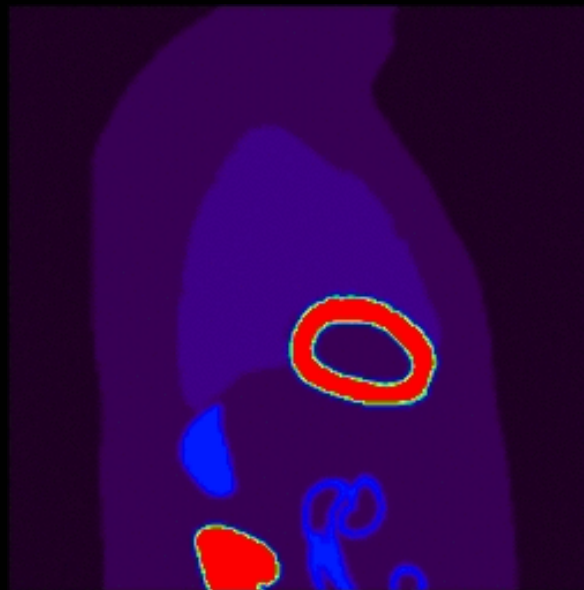


Respiratory Motion

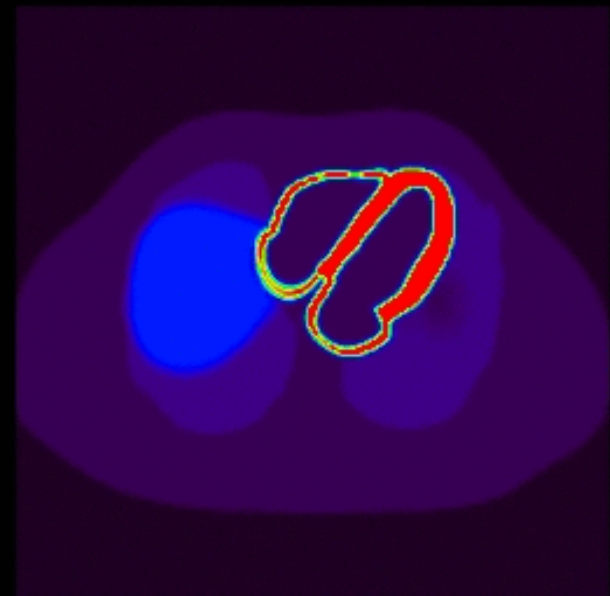
NCAT matrix of 128x128x128 voxels,
8 different phases



coronal



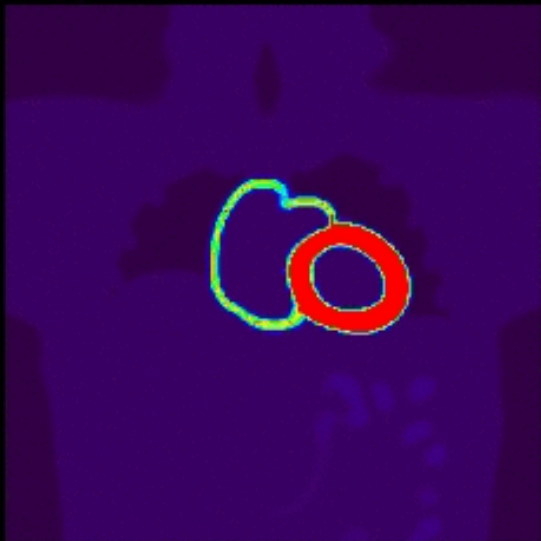
sagittal



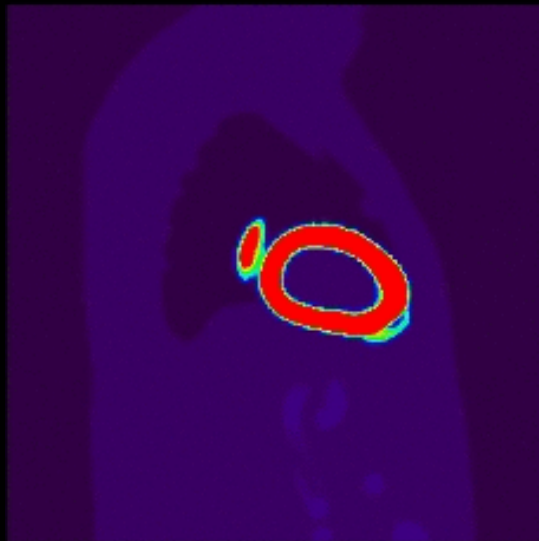
transversal



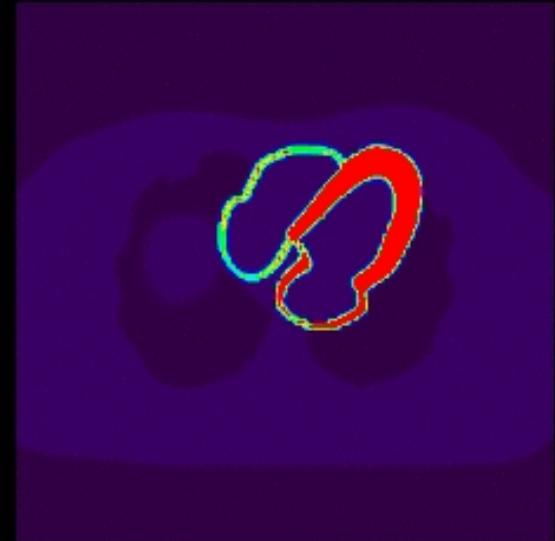
Heart Motion



coronal



sagittal

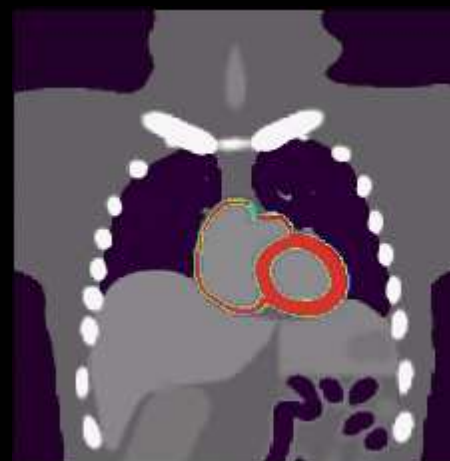
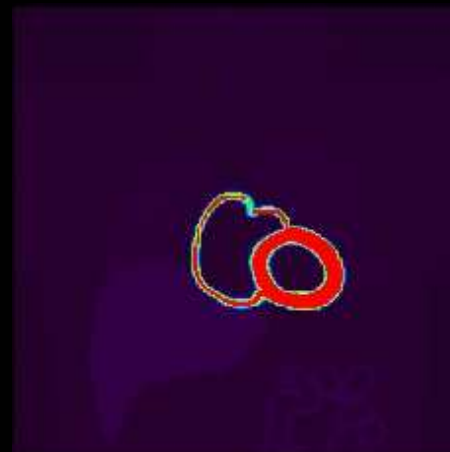


transversal



Phantoms „inside“ GATE

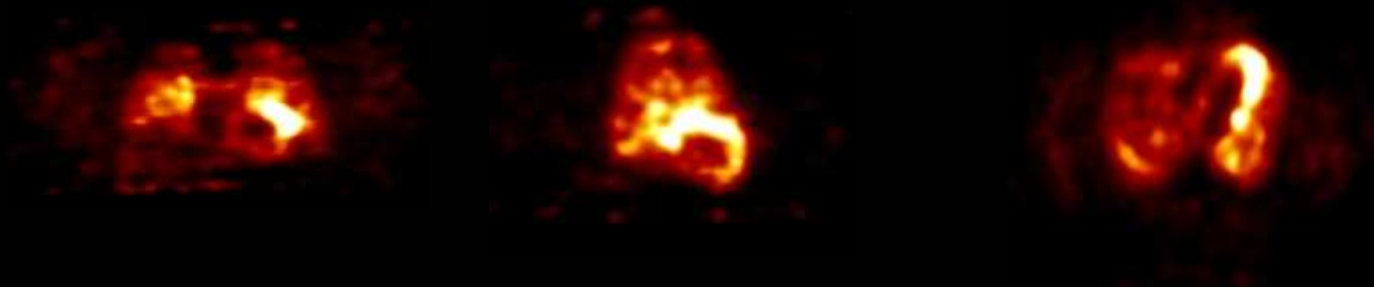
- Emission:
 ^{18}F -FDG source,
 $e^+ e^- \rightarrow \gamma\gamma @ 511\text{keV}$
- Absorption:
Back-to-back γ 's;
scatter + attenuation



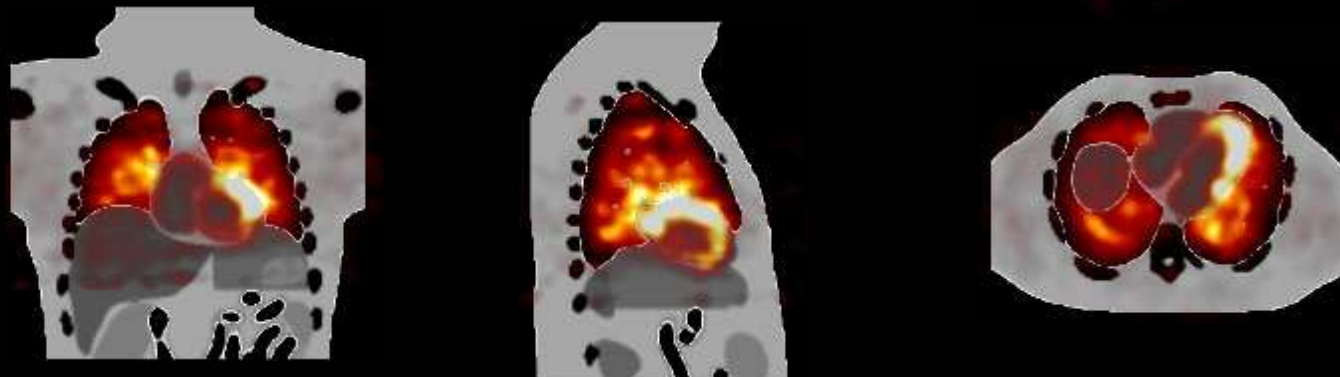
Simulated PET scan

OSEM reconstruction,
1536 events max. in 1 bin
0.6 million coincidences
12000 min. CPU time

Only PET,
Emission+
Absorption
phantom



PET fused
with
anatomy of
absorption
phantom

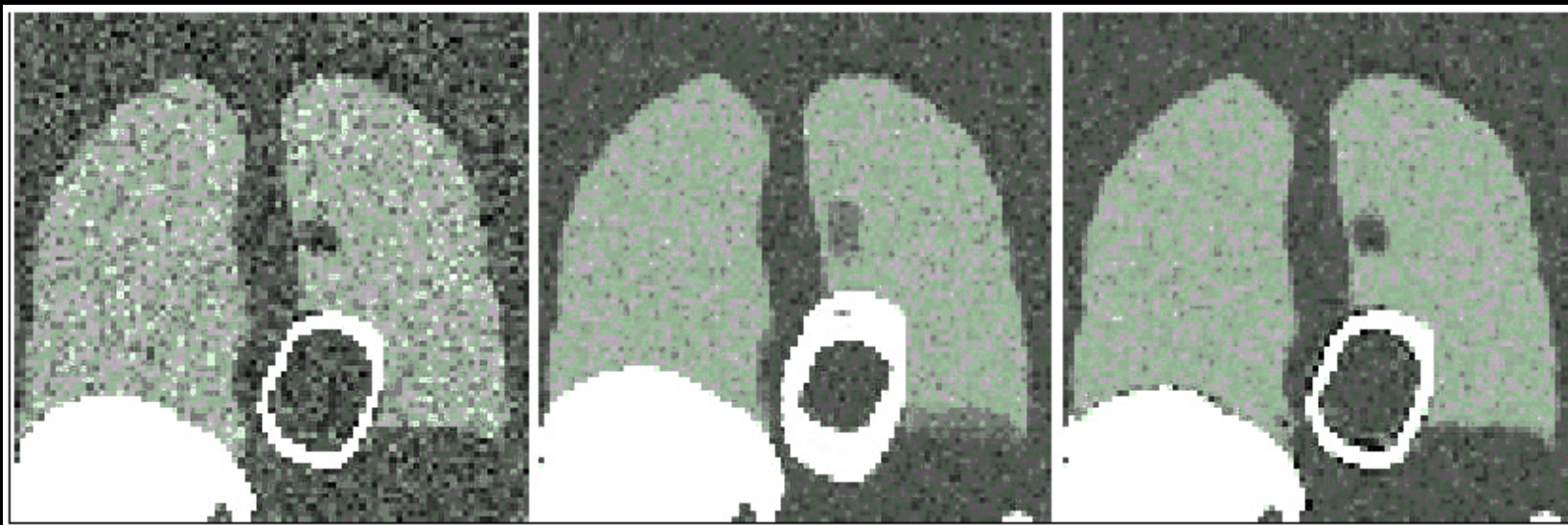


Computing Constraints

- Weeks of CPU-Time (2,4 GHz Xeon) needed for single image
- Attenuation increases CPU time by factor of 10 !
- Parallel cluster computing needed (not yet implemented in GATE)
new random seed for each event?



Motion Correction using optical flow



single gate

four moved gates

after motion correction



Outlook

possible
image
quality:



Simulated without attenuation phantom, $400 \cdot 10^6$ coincidences, 3 days CPU time

Simulation of
small animal
Scanner:
Imaging of mice
scanned in
QuadHIDAC

