SIMULTANEOUS RECONSTRUCTION OF THE ACTIVITY IMAGE AND REGISTRATION OF THE CT IMAGE IN TOF-PET

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Abstract

- Previously, maximum-likelihood methods have been proposed to **jointly** estimate the activity image and the attenuation image [1]-[2] (or the attenuation sinogram [3]-[5]) from TOF-PET data.
- In this contribution, we propose a method that addresses the same problem for TOF-PET/CT by combining **reconstruction** and **registration**. The method, called MLRR, iteratively reconstructs the activity image while registering the available CT-based attenuation image, so that the pair of activity and attenuation images maximize the likelihood of the TOF emission data.
- With a non-rigid motion model, **MLRR** sequentially updates:
  1. **Activity** using TOF-MLEM
  2. **Attenuation** using MLTR + Demons' Registration [6]-[7]
- The algorithm is accelerated by using Nesterov's momentum and a multi-resolution scheme, which also helps to avoid getting stuck at a local optima.

Introduction

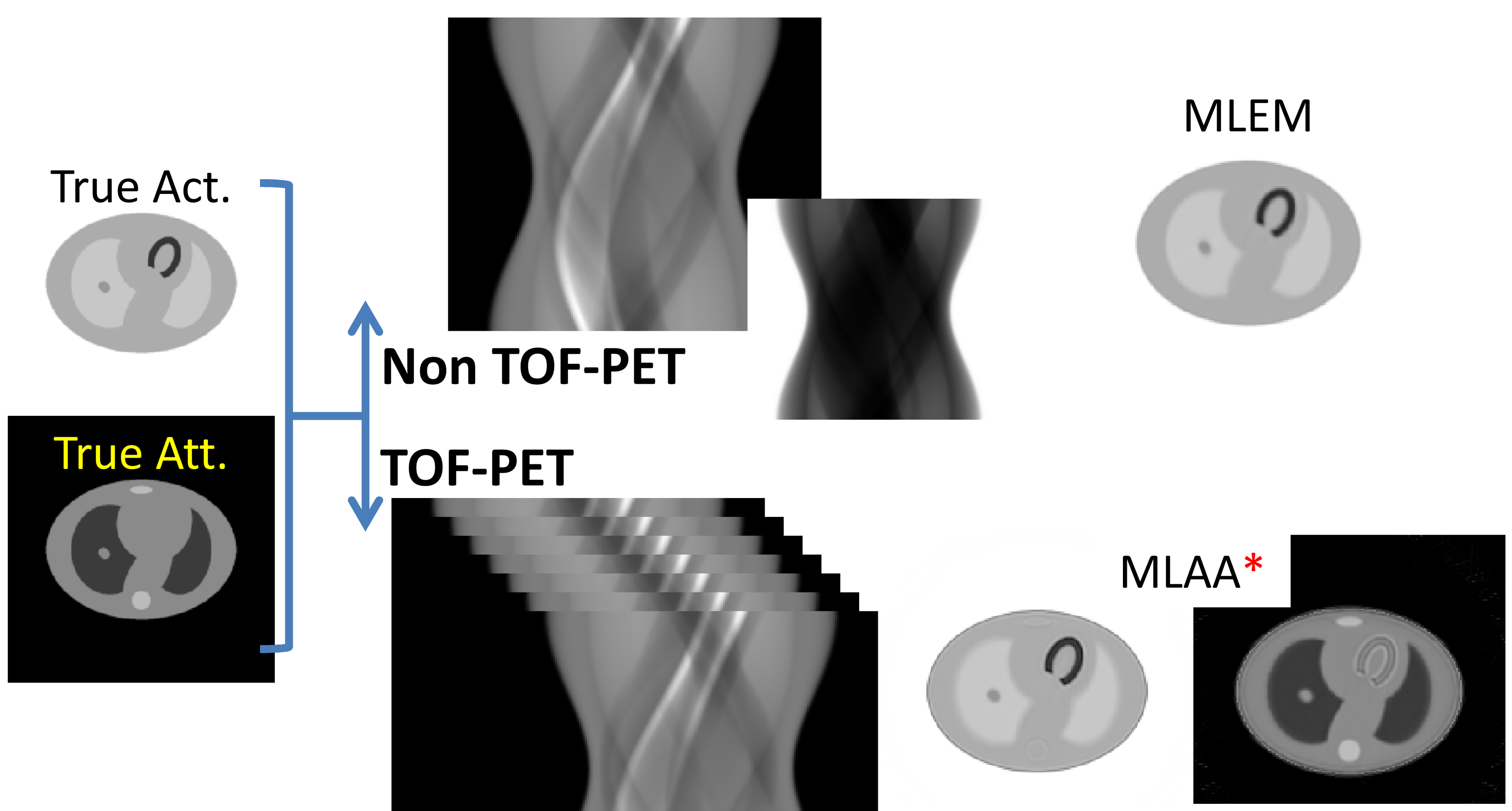
In clinical PET/CT,

- PET emission data are corrected for attenuation by the projections of the "adjusted" (511 keV photon energy) CT image.
- Problem: between-scan and in-scan motion.
  1. PET and CT scans are acquired sequentially.
  2. PET data are acquired over a relatively long time interval whereas the CT data are acquired almost instantaneously.

Transformation estimation from emission data:

- Affine transform of a known attenuation image [8]-[9].
  - Problem: stability issues, non-realistic motion model
- **TOF information allow estimation of complex motion models**

Standard non-TOF PET vs. TOF-PET emission reconstruction:

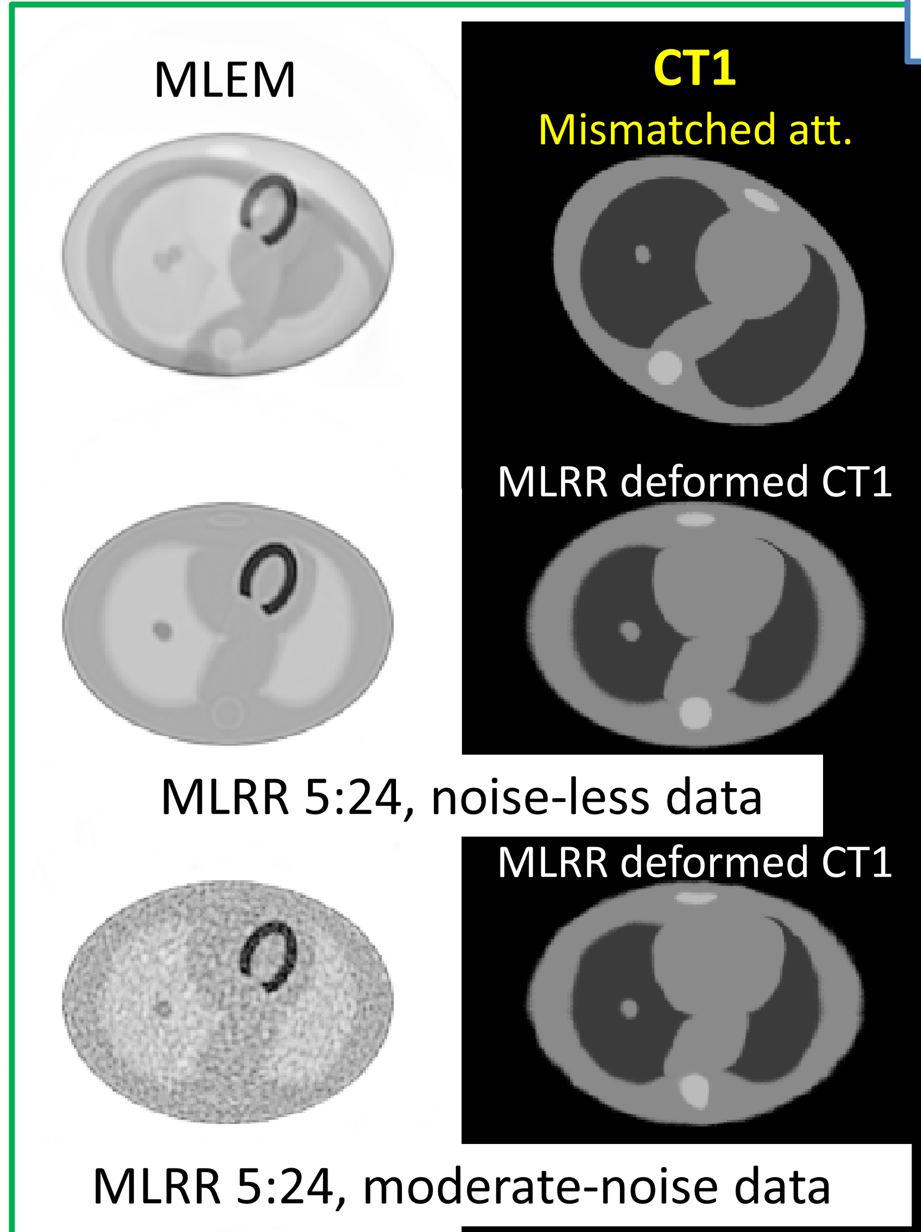


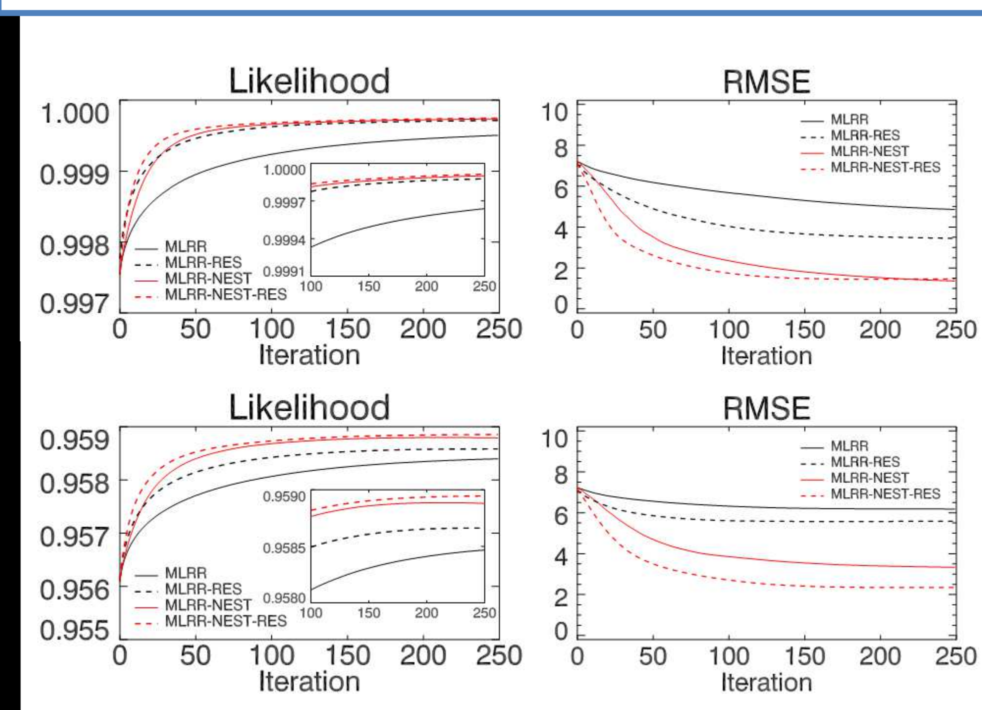
* requires correction for the scale [10]

Conclusion/Discussion

- Our simulations show that the method is able to produce aligned activity and attenuation reconstructions similar to MLAA, with two advantages: 1- the constant/scale problem is solved automatically by using CT-based attenuation coefficients, and 2- the resulting attenuation image is free of noise.
- The activity reconstructions of a 4 min ^{18}F-FDG clinical scan produced by MLRR suffer less from motion-induced artifacts (arrows in red) than the reference MLEM activity reconstructions.
- The improved alignment of CT and PET might also benefit the diagnostic value of the image pair, which remains to be investigated.

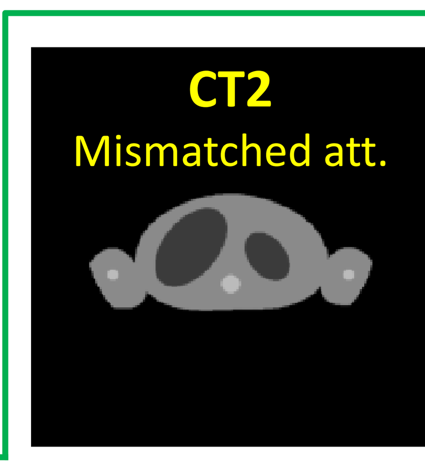
Experiment Design/Results

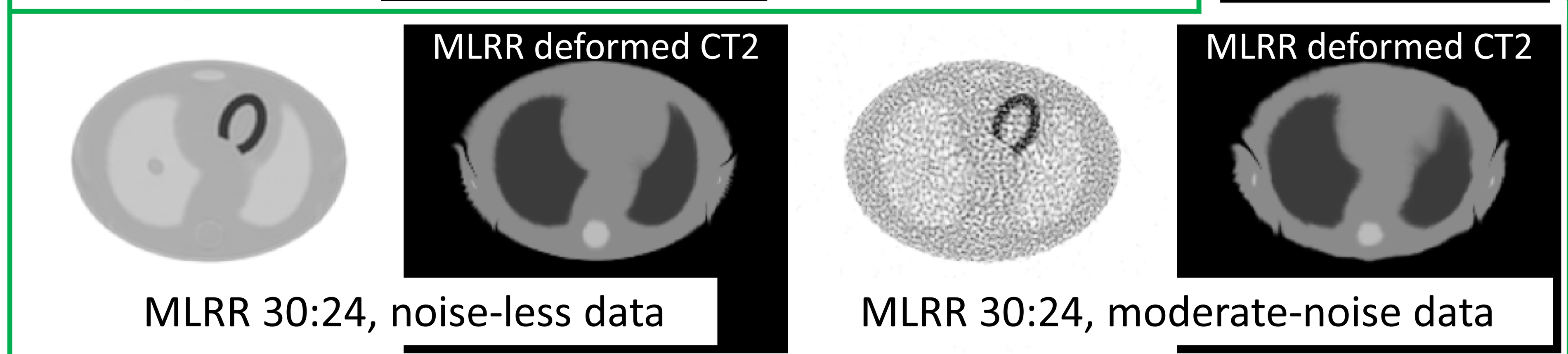


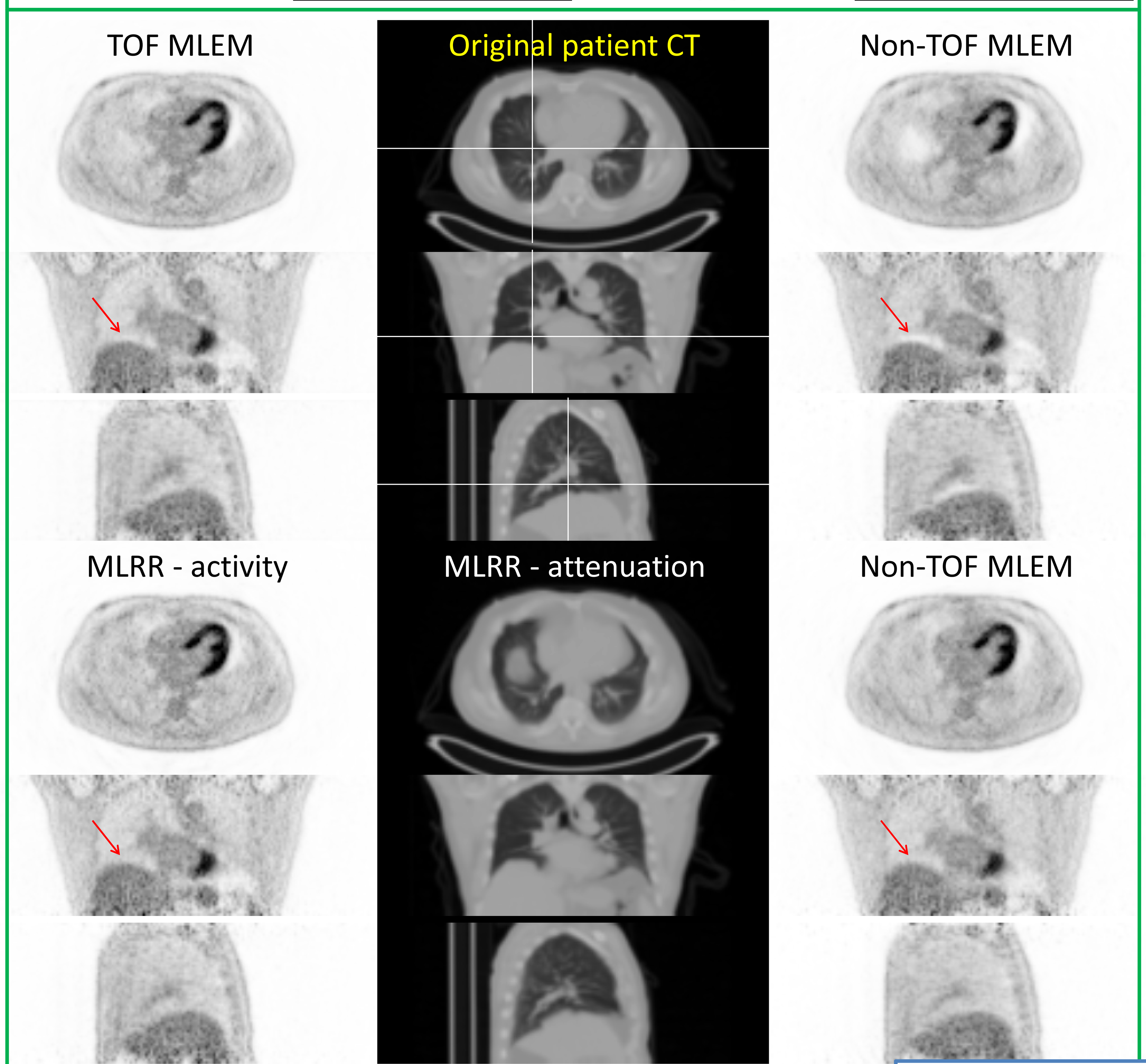


Siemens Biograph mCT:

- 580ps TOF res.
- 13 time-bins of 312ps
- 400 #detectors mashing factor: 2
- 168 #angles







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