

Identifying Image Artifacts, Their Causes and How to Fix Them: PET

Brad J Kemp, PhD

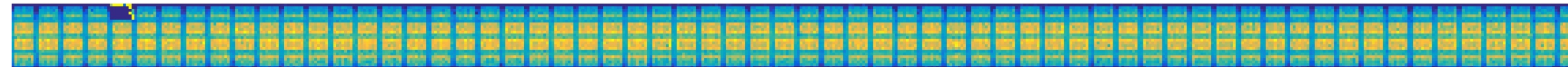
Mayo Clinic, Rochester, MN

Case 1

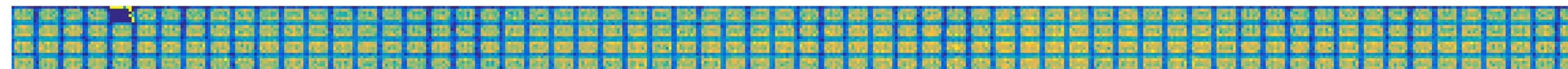
Can we scan with a defective block detector?

Daily Quality Assurance Results

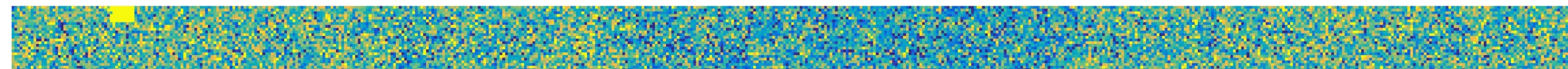
Singles



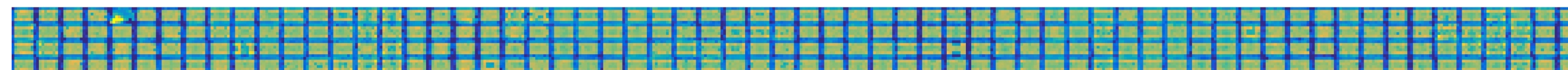
Coincidence



Timing



Energy



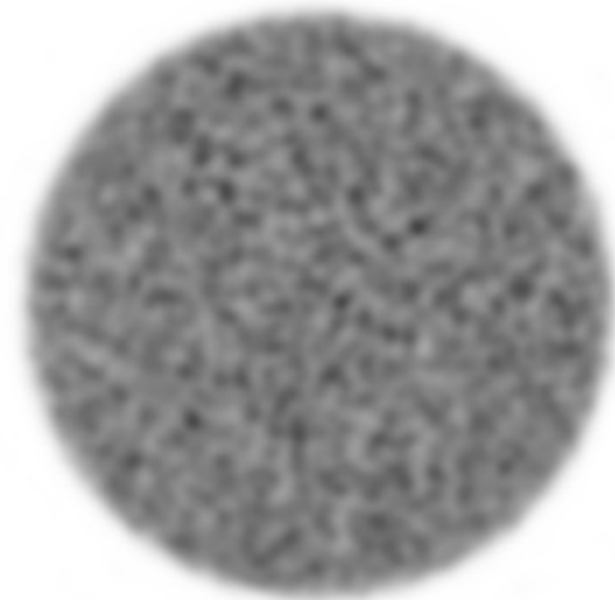
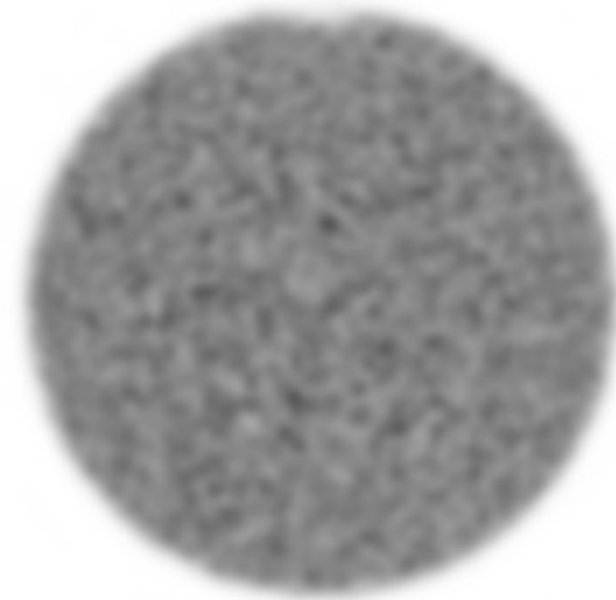
Case 1

Uniform phantom of F-18 in water

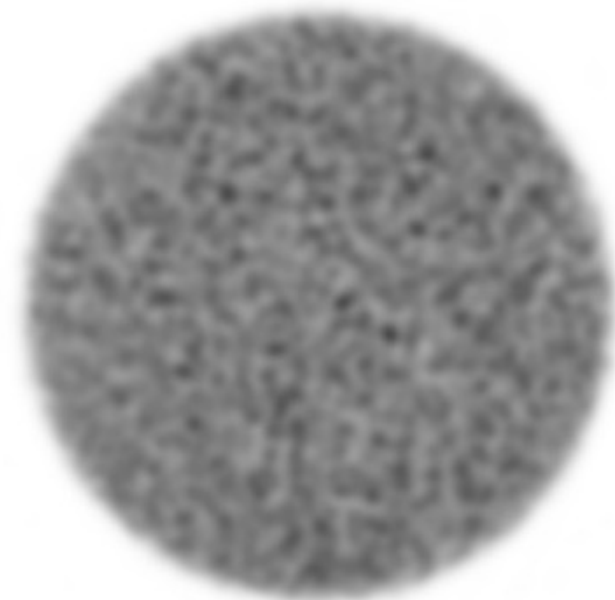
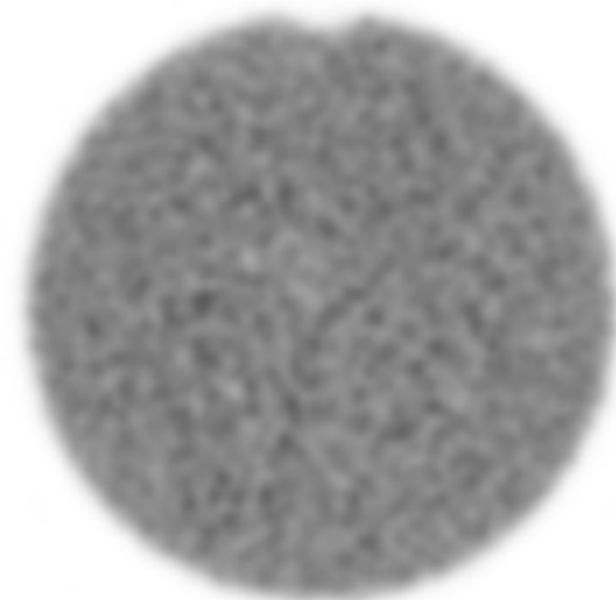
Current Day
Defective Block

Previous Day
System Okay

non-TOF

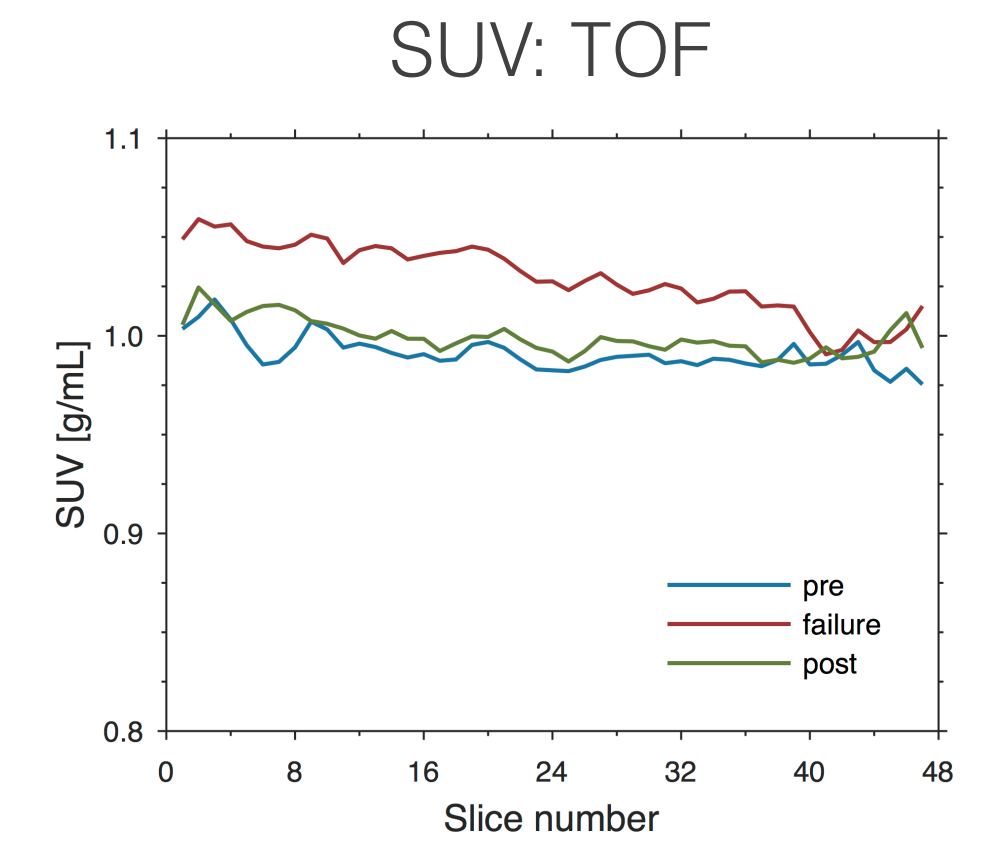
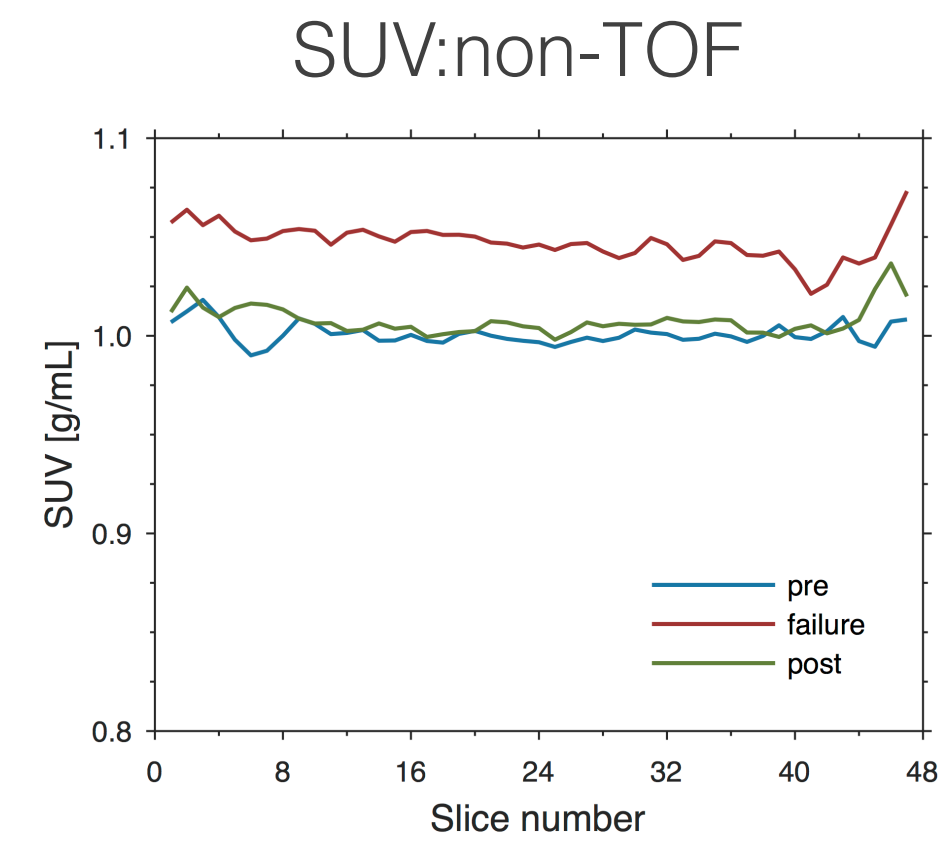
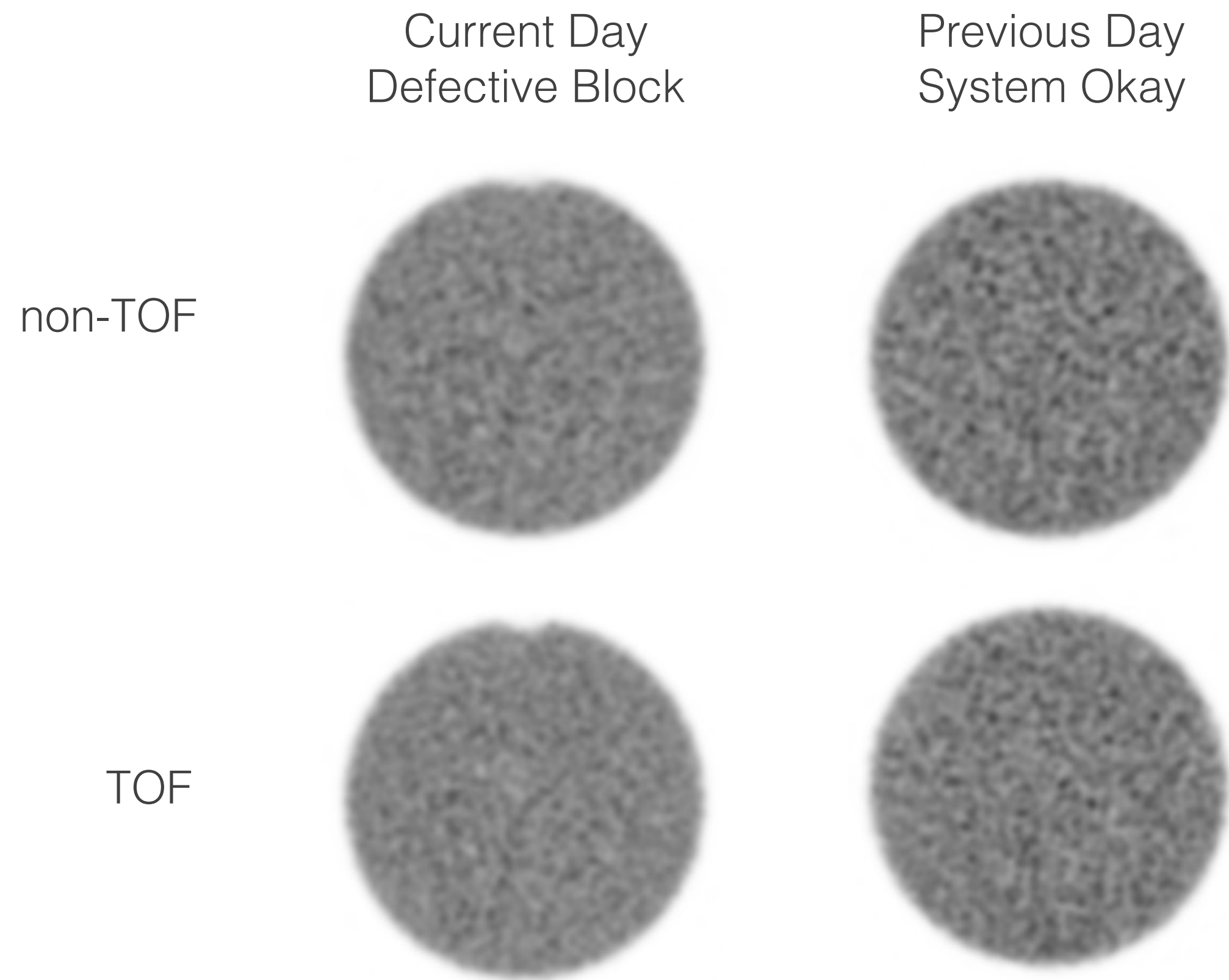


TOF



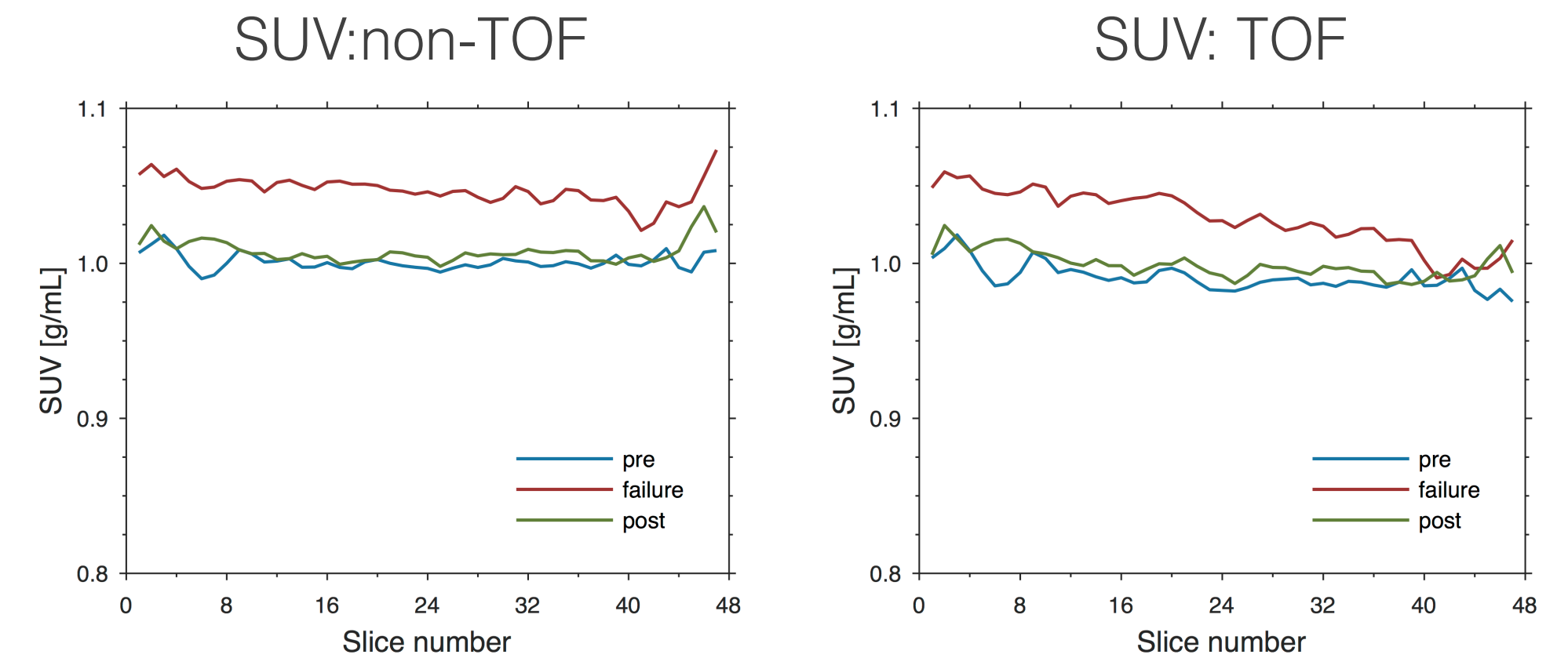
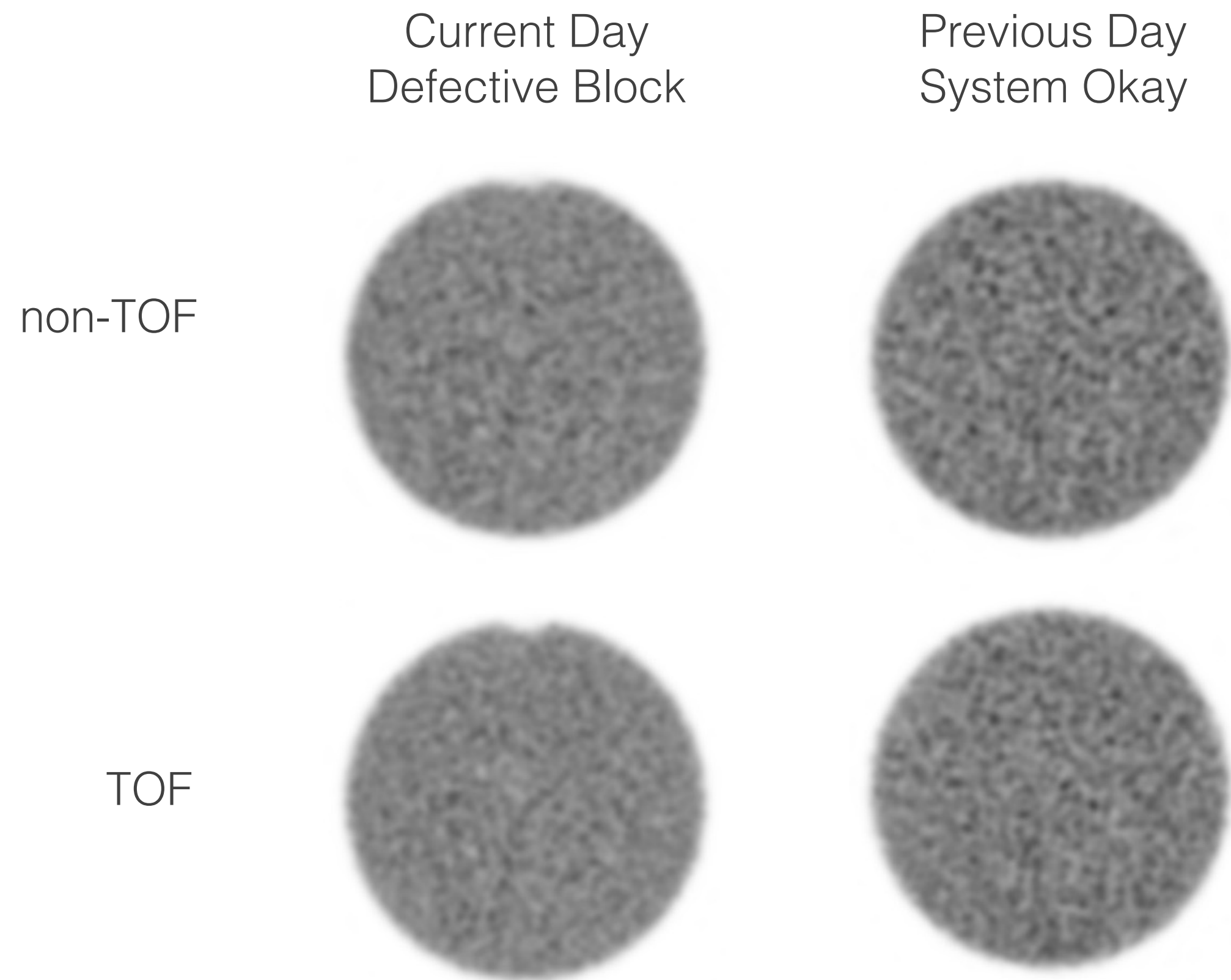
Case 1

Uniform phantom of F-18 in water



Case 1

Uniform phantom of F-18 in water



Discussion:

- Artifacts will depend on
 - whether system is PET-only or hybrid
 - number of blocks and their location within scanner
 - activity distribution within the object
- SUVs will be affected

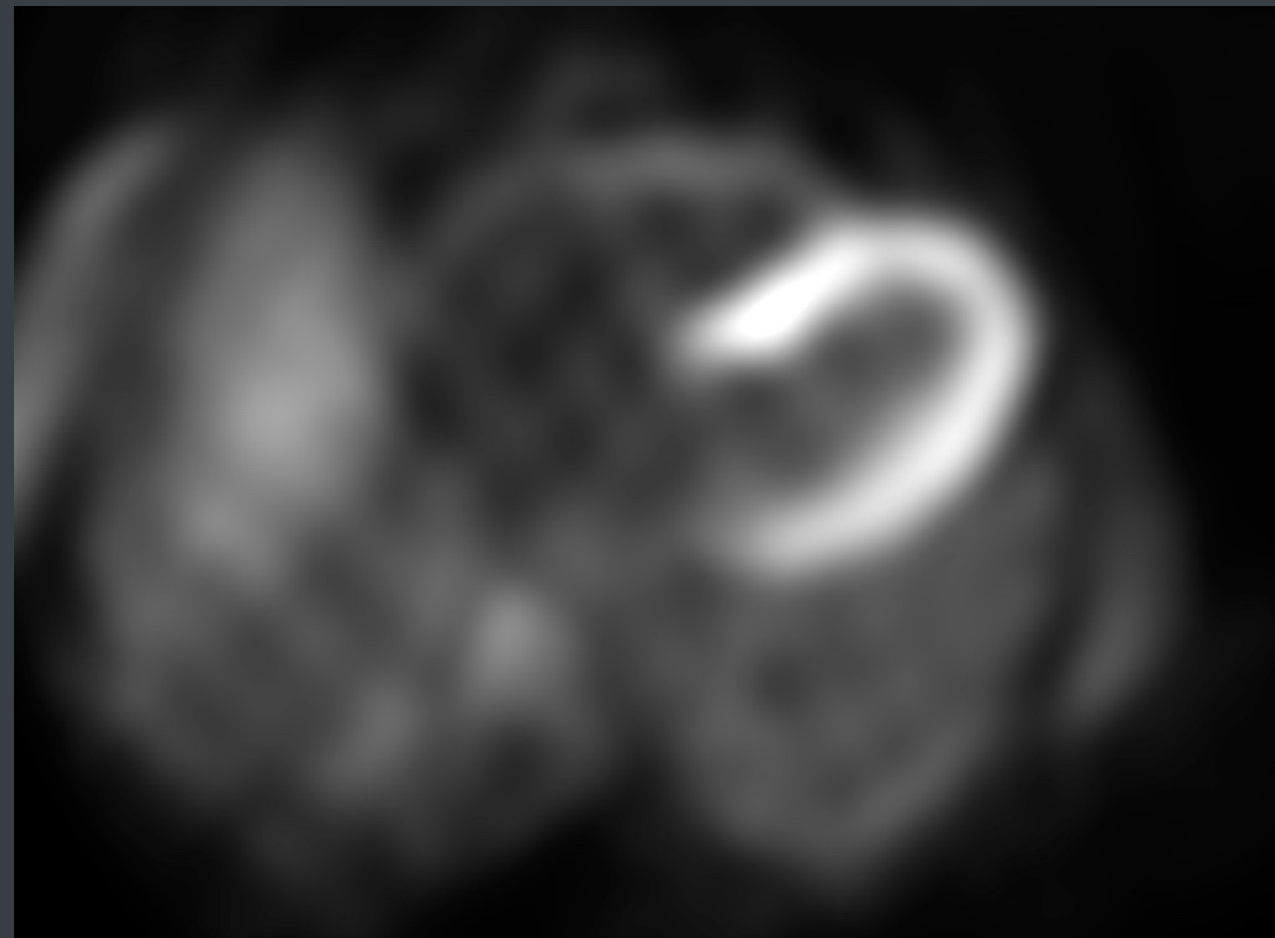
Case 2

Description:

- Streaks throughout reconstructed PET images

N-13 ammonia cardiac PET study

Transaxial image



Coronal image



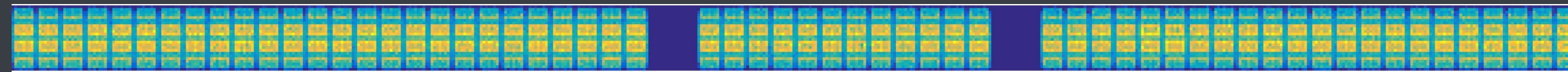
Case 2

Cause:

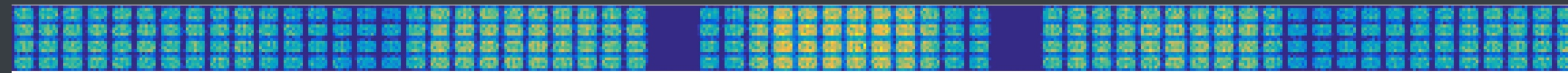
- Failure of two modules (16 block detectors) during the day

Daily Quality Assurance Results (mid-day)

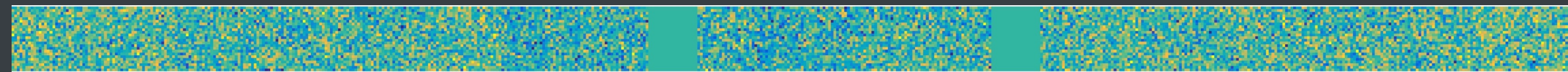
Singles



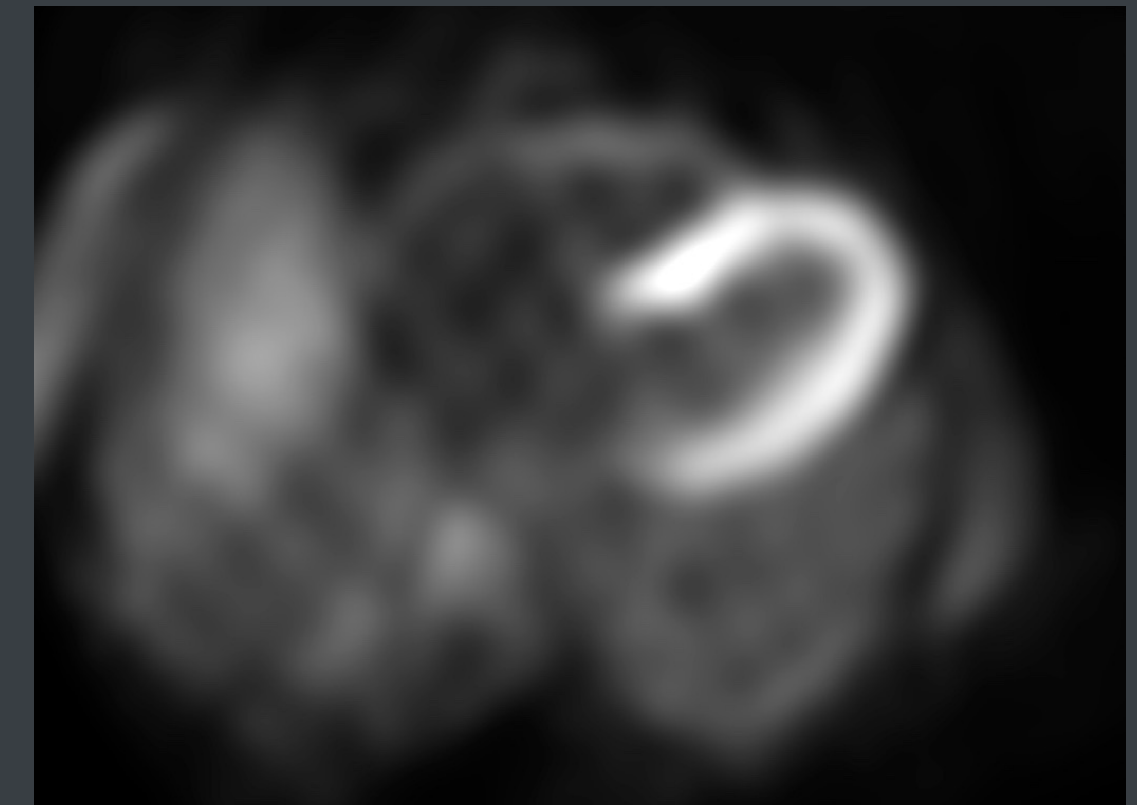
Coincidence



Timing



Transaxial image



Resolution:

- Reboot system
- Replace hardware

Case 3

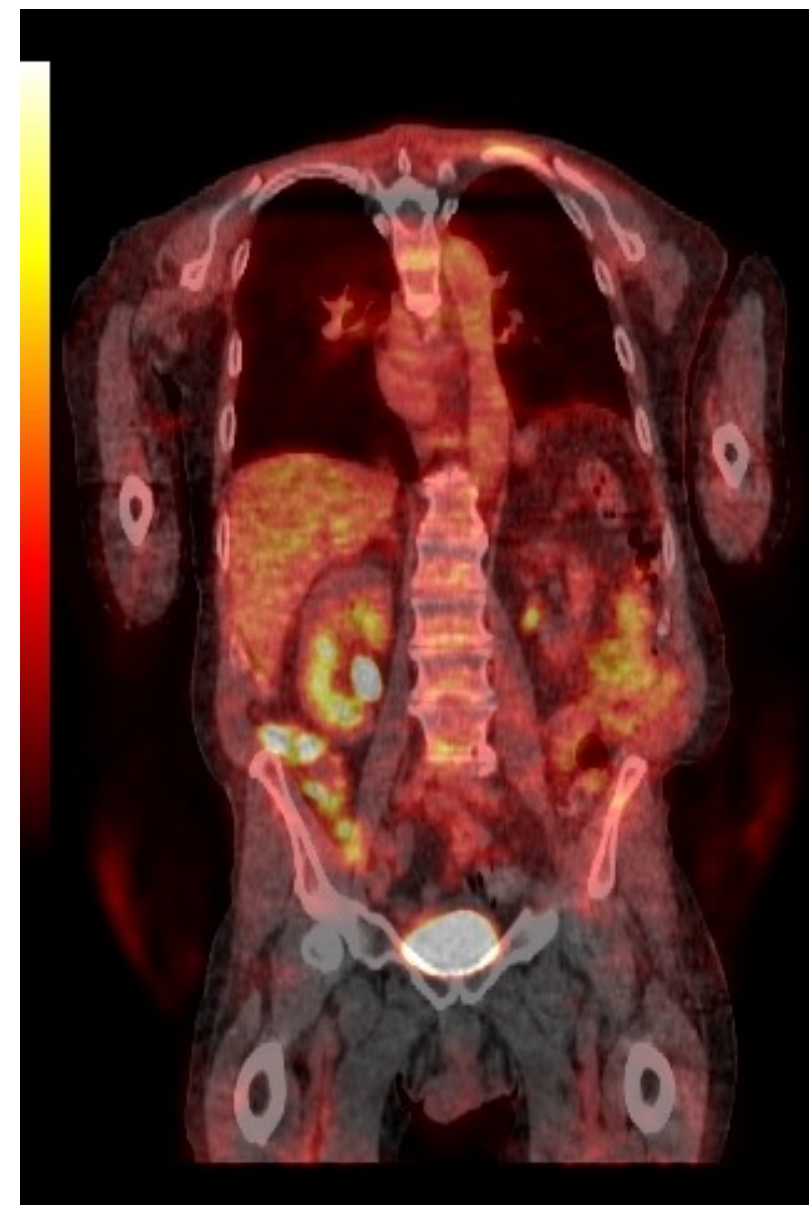
Description:

- Streaks in coronal PET images
- Large photopenic areas with no apparent uptake

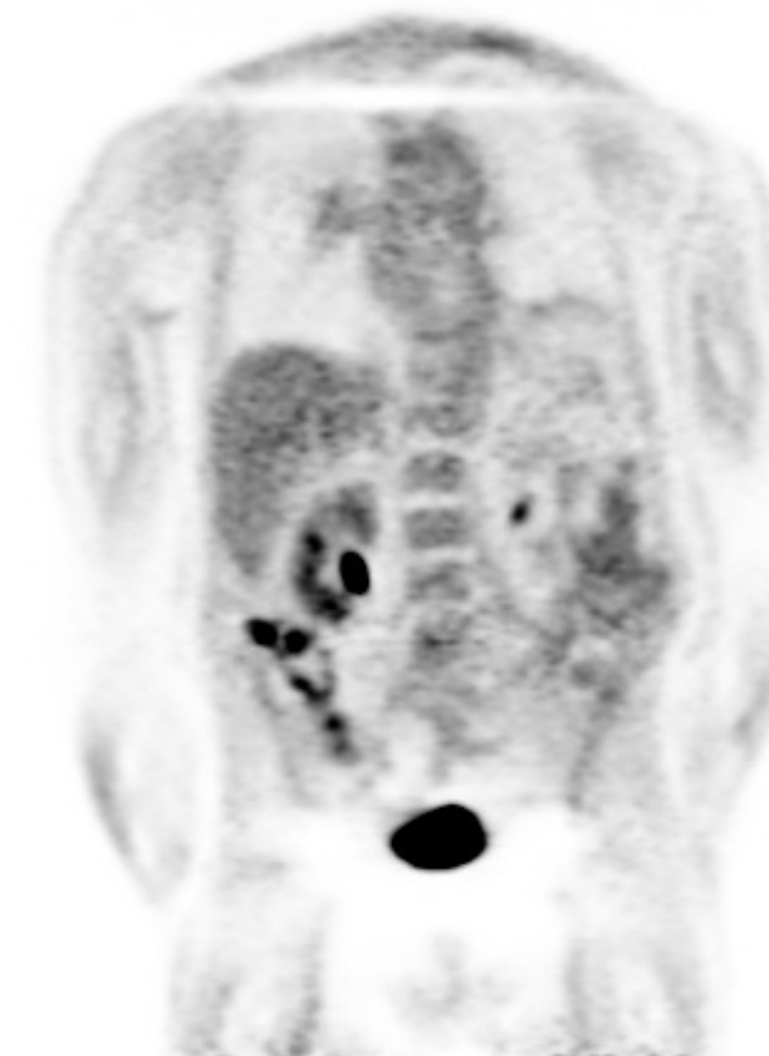
CT



PET/CT Fused

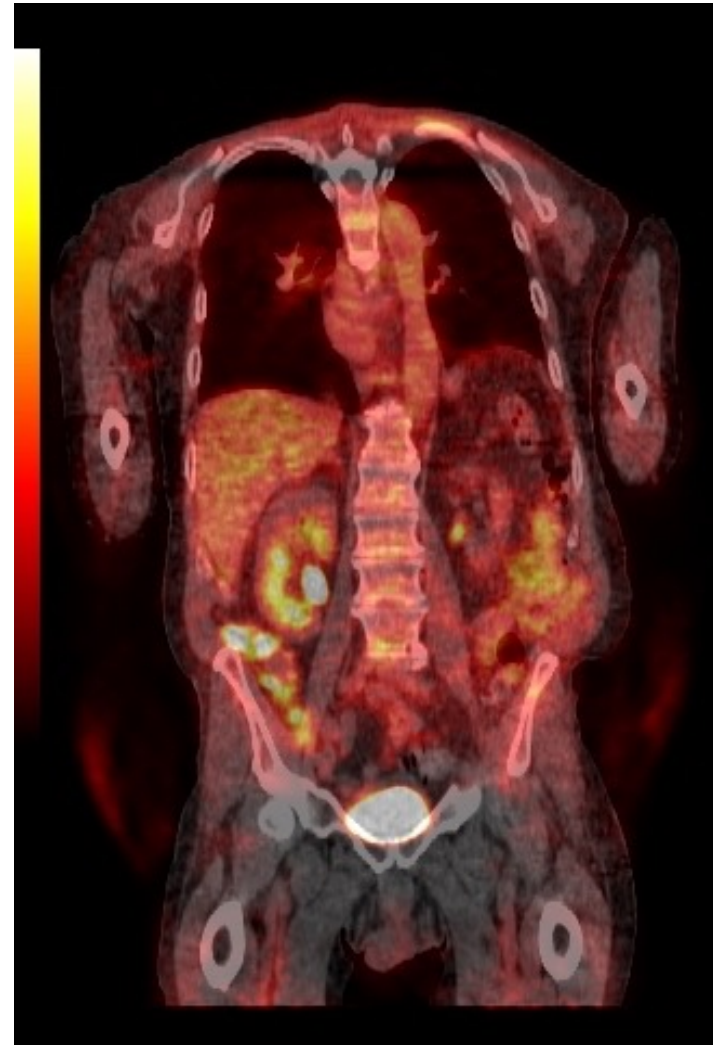


PET with CTAC

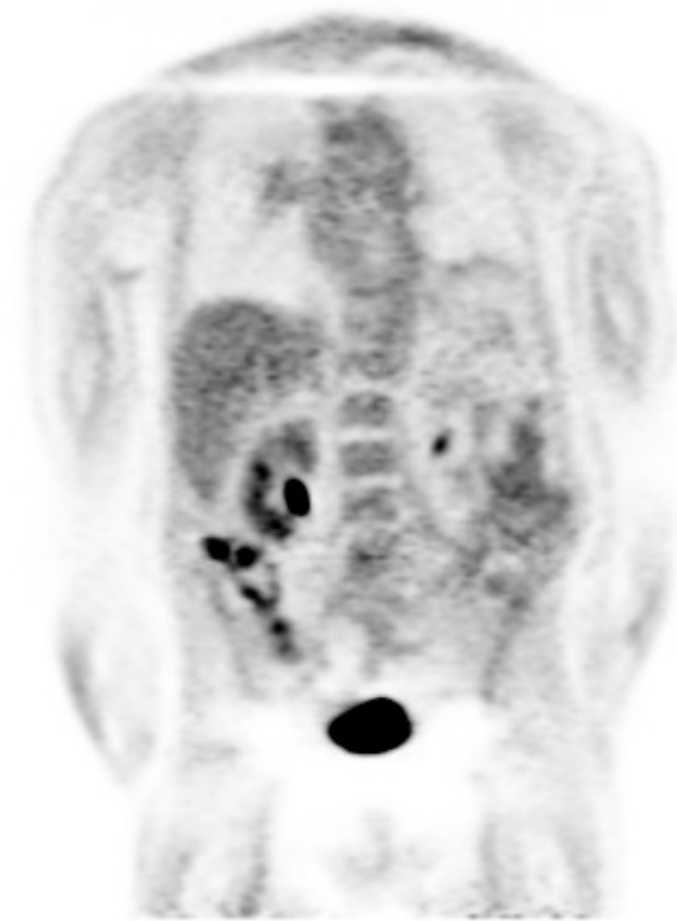


Case 3

PET/CT Fused

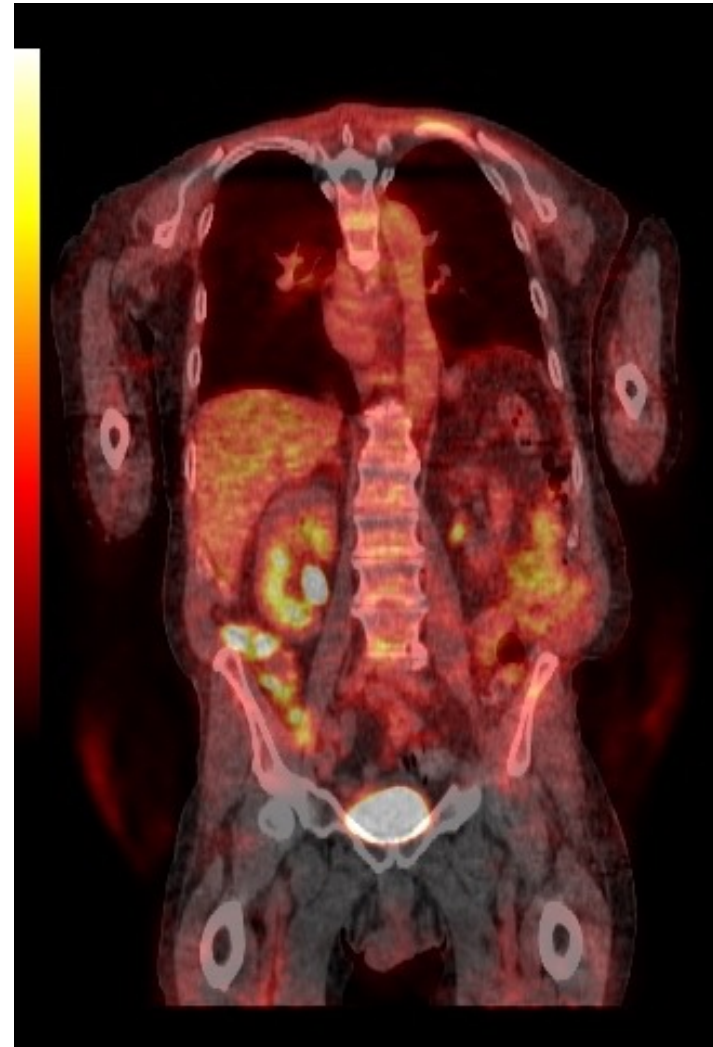


PET with CTAC

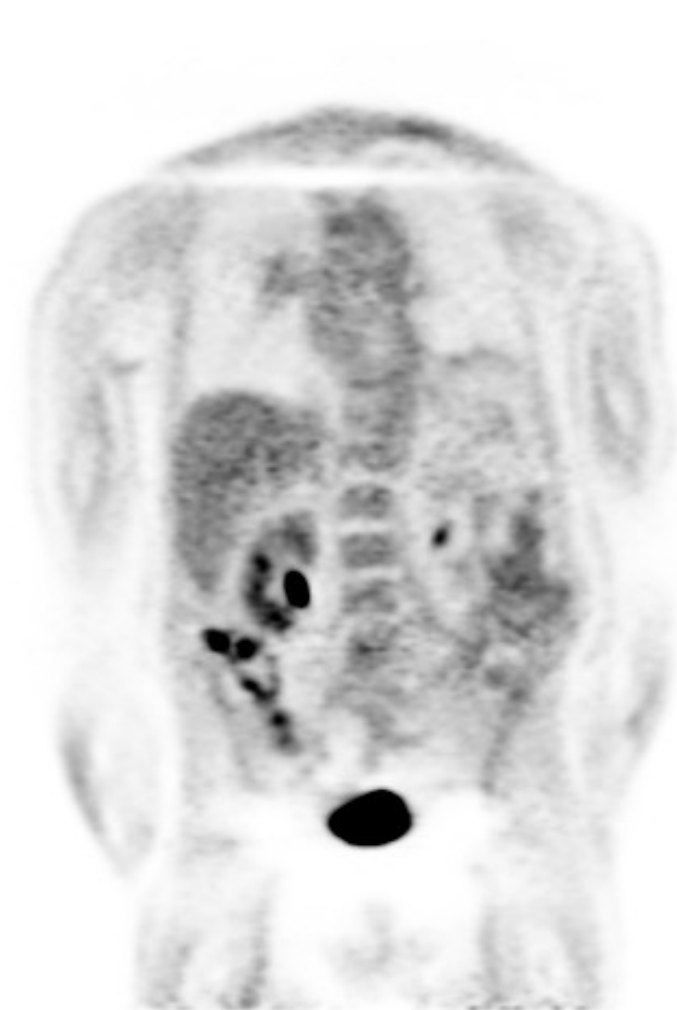


Case 3

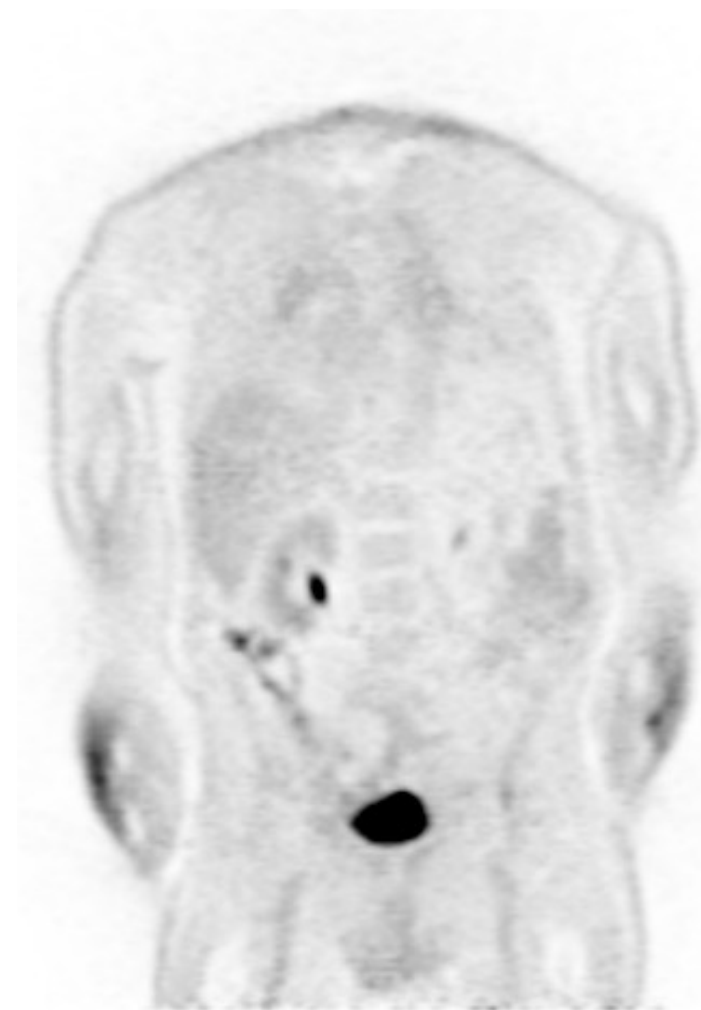
PET/CT Fused



PET with CTAC

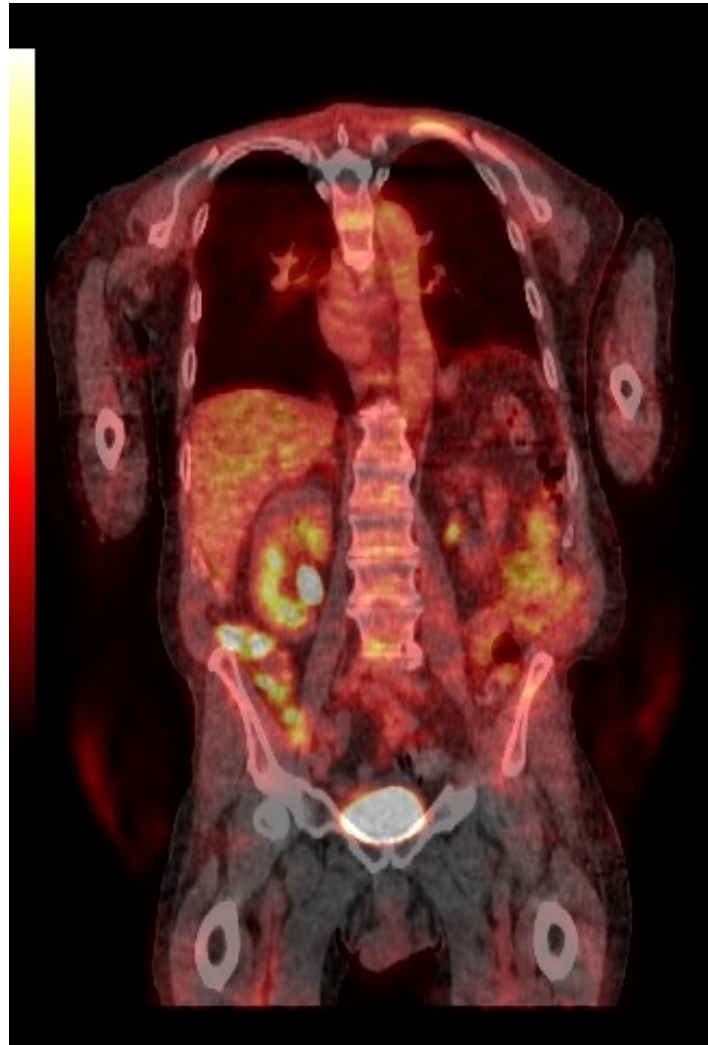


PET NAC

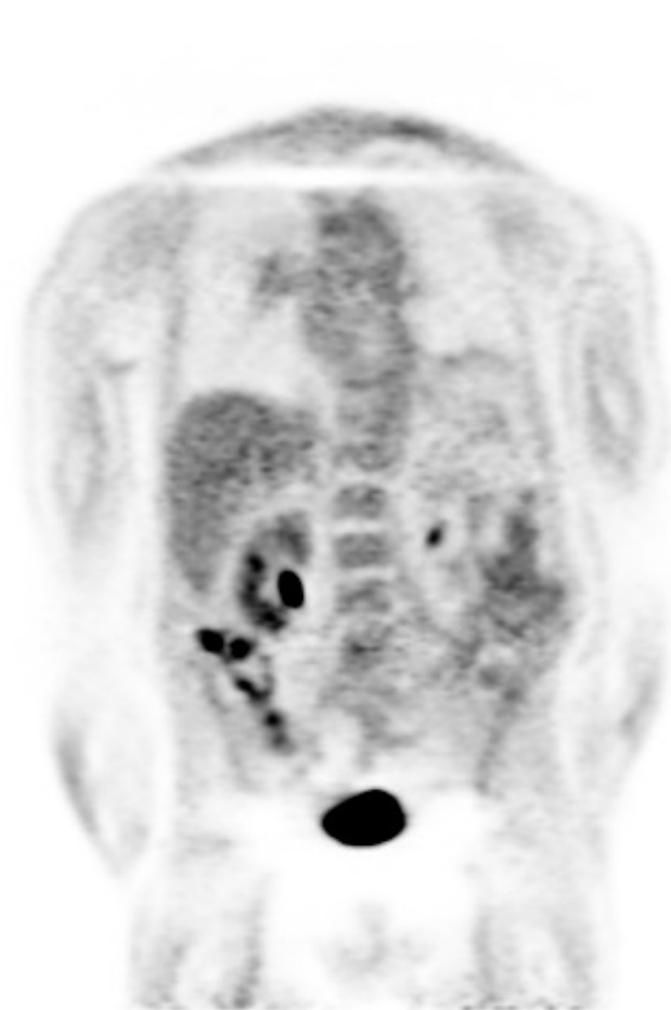


Case 3

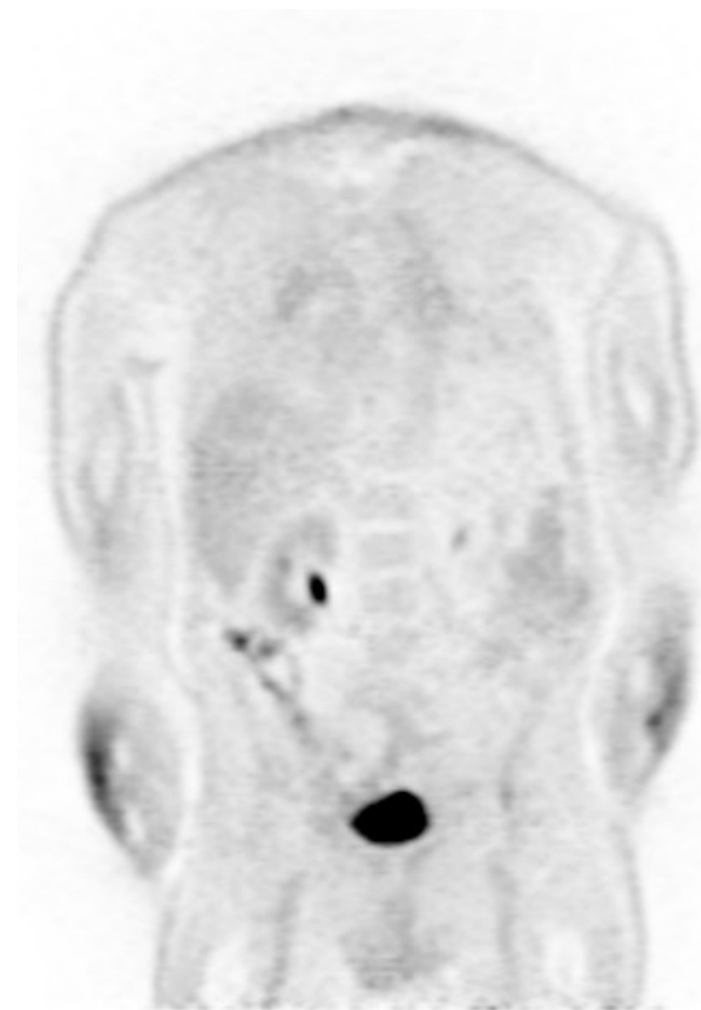
PET/CT Fused



PET with CTAC



PET NAC

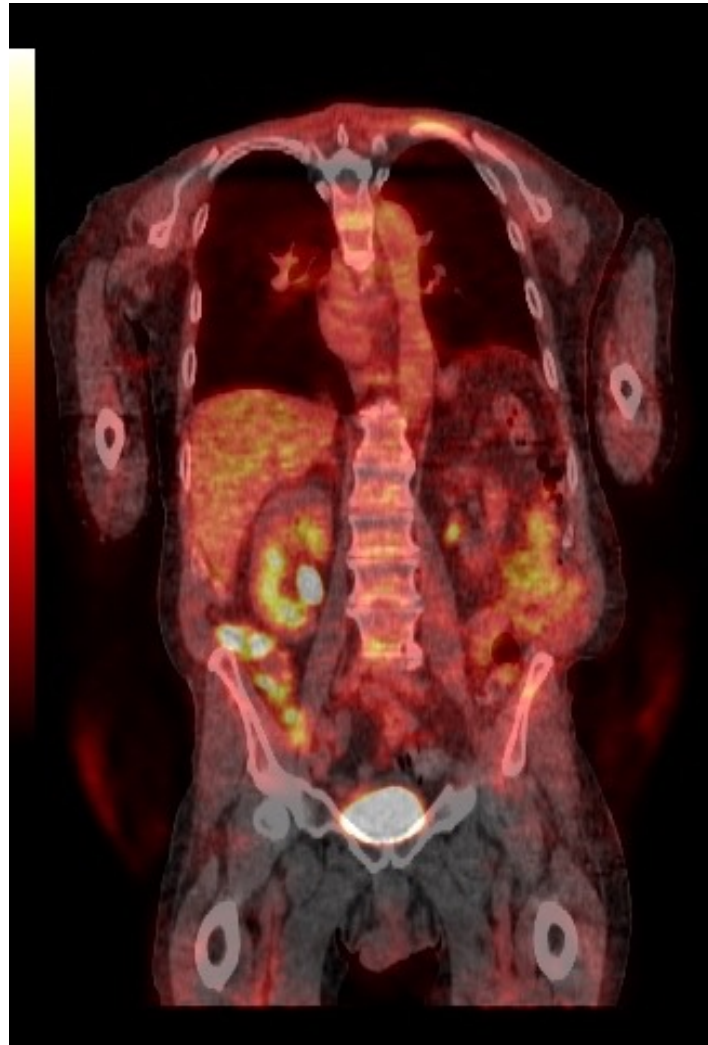


Cause:

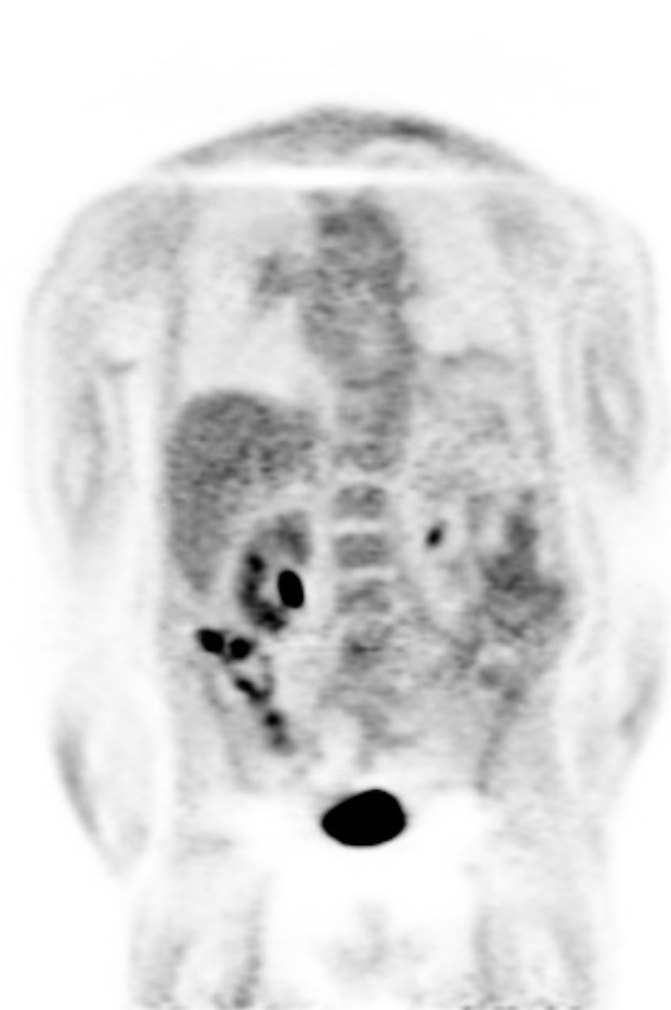
- Patient motion between CT and PET scans
- Activity appears to be outside the body
- Overcorrection of scatter
- There will be errors in attenuation correction too

Case 3

PET/CT Fused



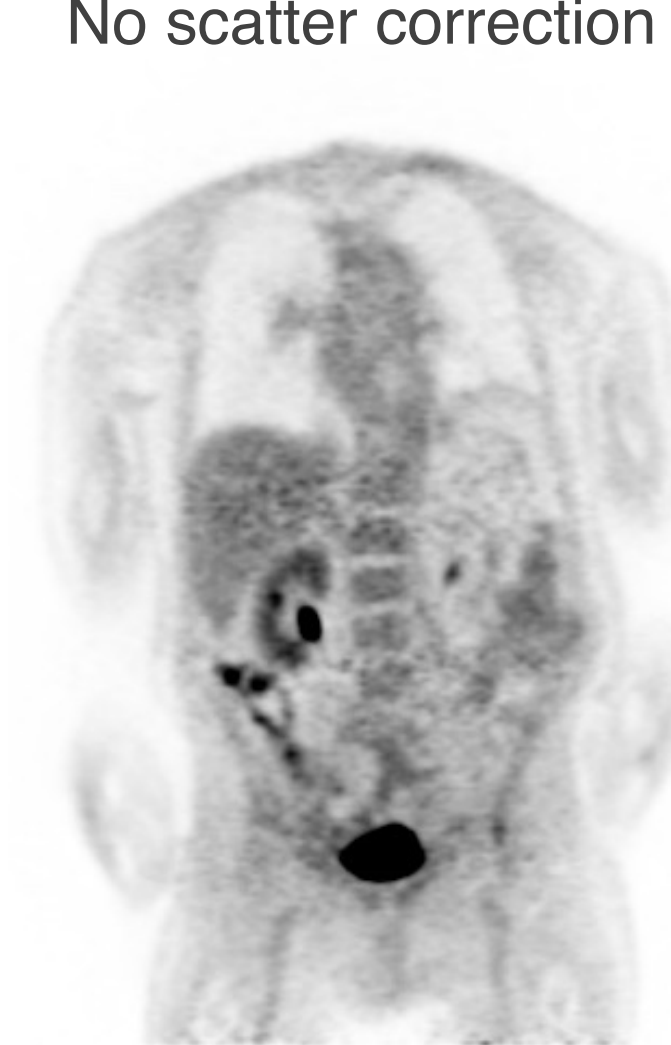
PET with CTAC



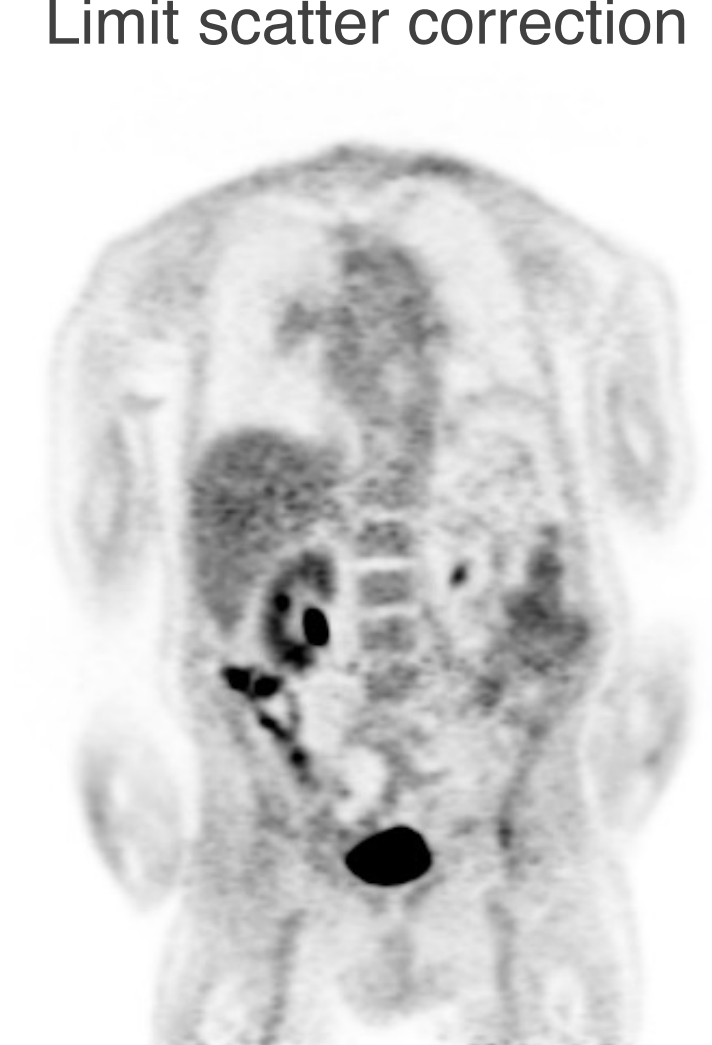
PET NAC



PET with CTAC
No scatter correction



PET with CTAC
Limit scatter correction



Cause:

- Patient motion between CT and PET scans
- Activity appears to be outside the body
- Overcorrection of scatter
- There will be errors in attenuation correction too

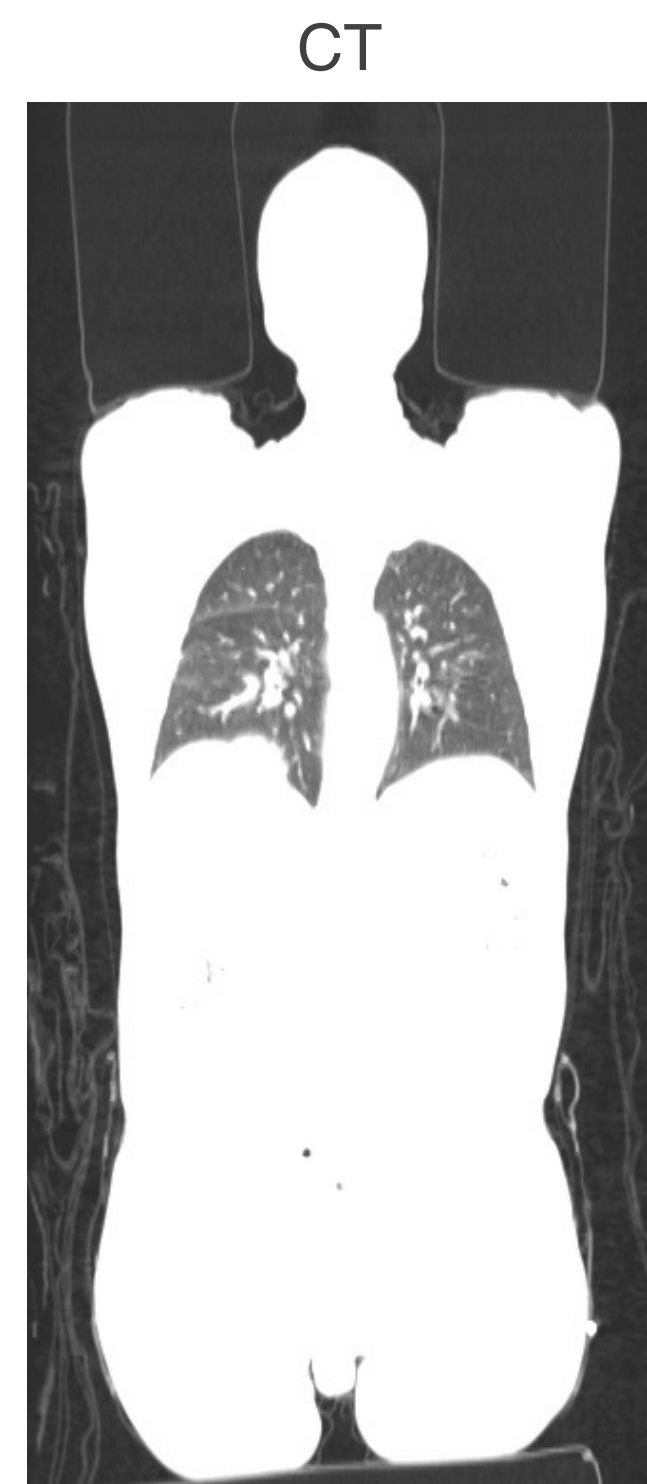
Resolution:

- Do not apply scatter correction
- Limit the scatter correction

Case 4

Description:

- Photopenic areas over diaphragm and dome of liver



Case 4

CT



PET with CTAC



Case 4

CT



PET with CTAC



PET NAC



Case 4

CT



PET with CTAC



PET NAC



PET with CTAC
TOF



Case 4

CT



PET with CTAC



PET NAC



PET with CTAC
TOF



Cause:

- Respiratory motion
- Misregistration of PET and CT at the diaphragm
- Undercorrection of attenuation

Resolution:

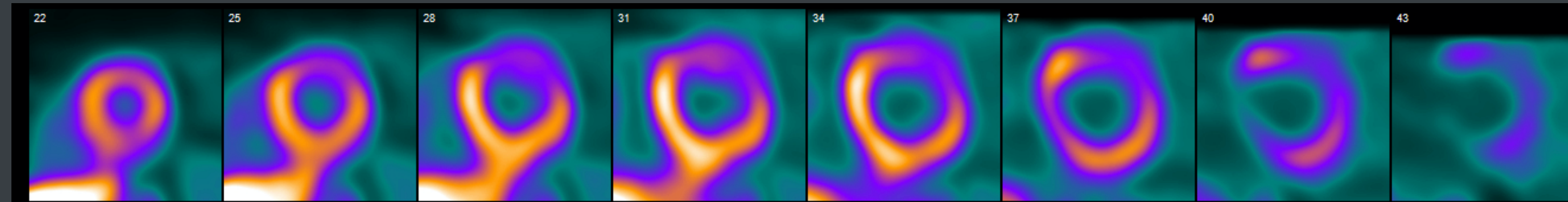
- Breathing techniques
- Respiratory gated PET and CT
- Apply TOF

Case 5

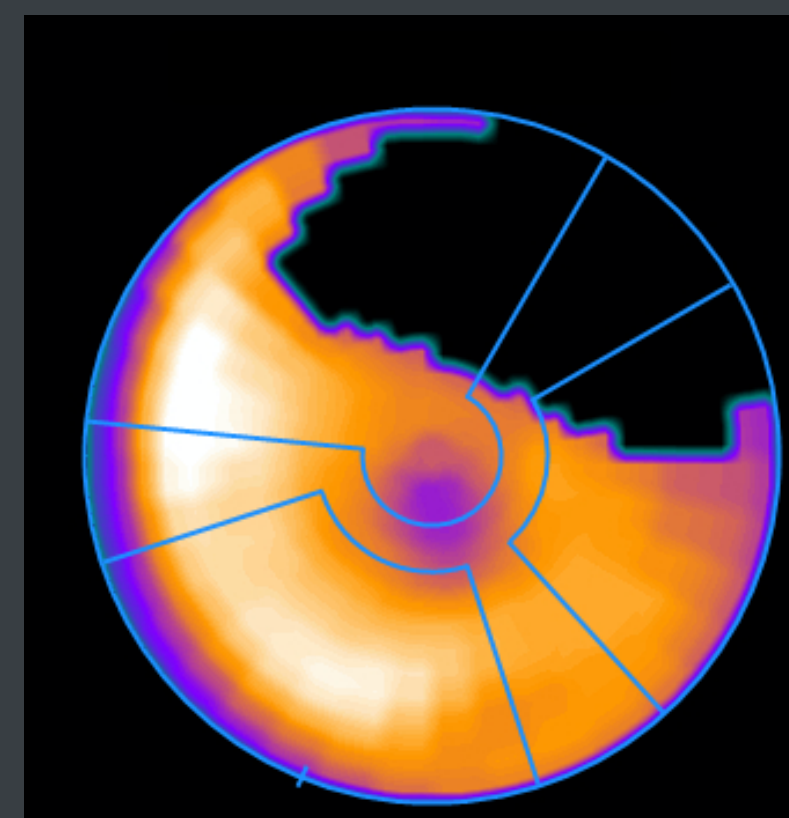
Description:

- Reduced blood flow in anterior region of an N-13 ammonia myocardial blood flow study

SA slices: Apex to base



Polar Map

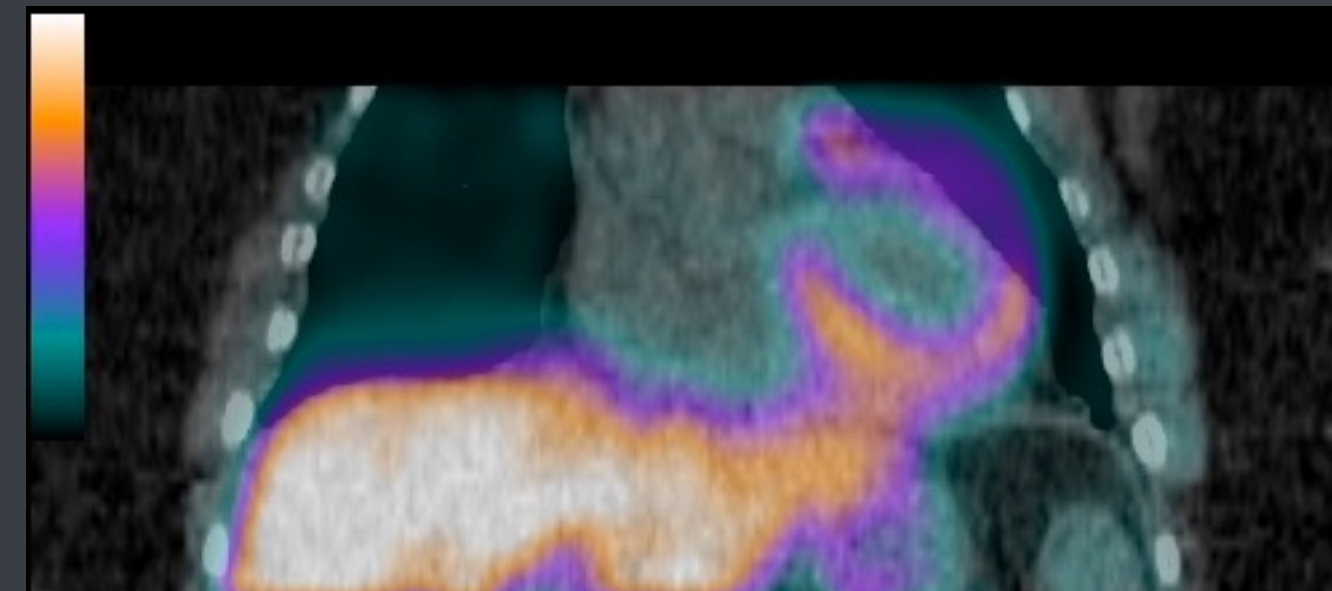


Case 5

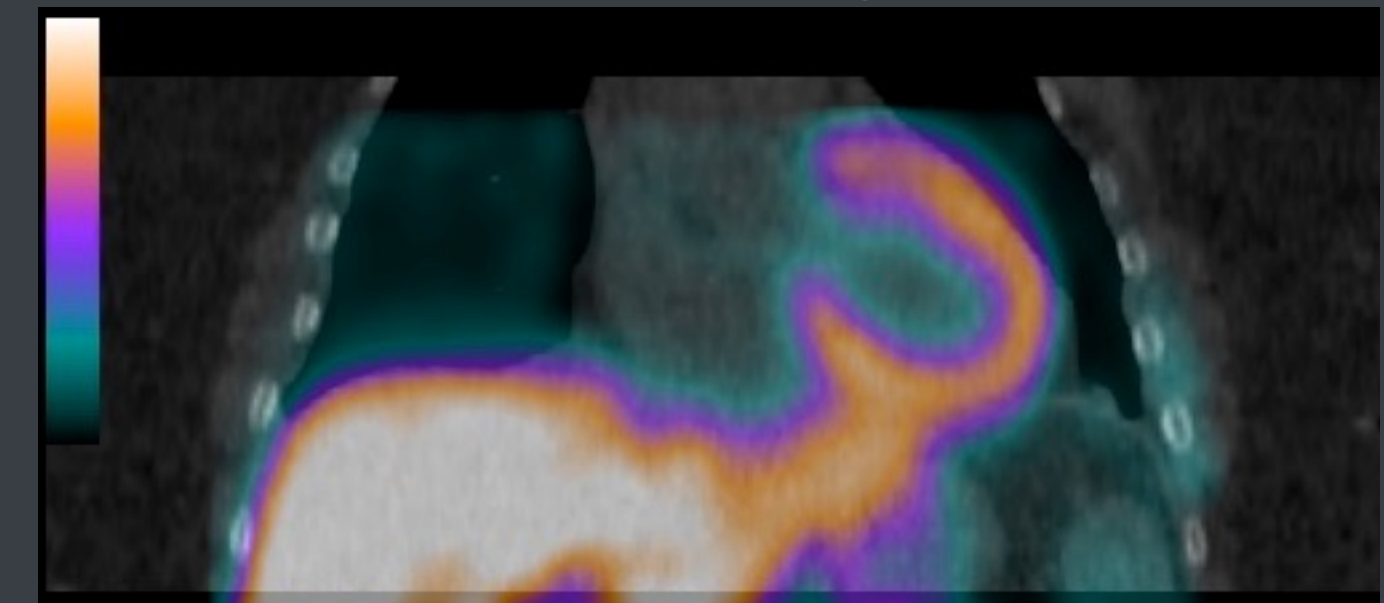
Cause:

- Respiratory motion
- Misregistration of the myocardium in PET and CT
- Undercorrection of attenuation

Original Images



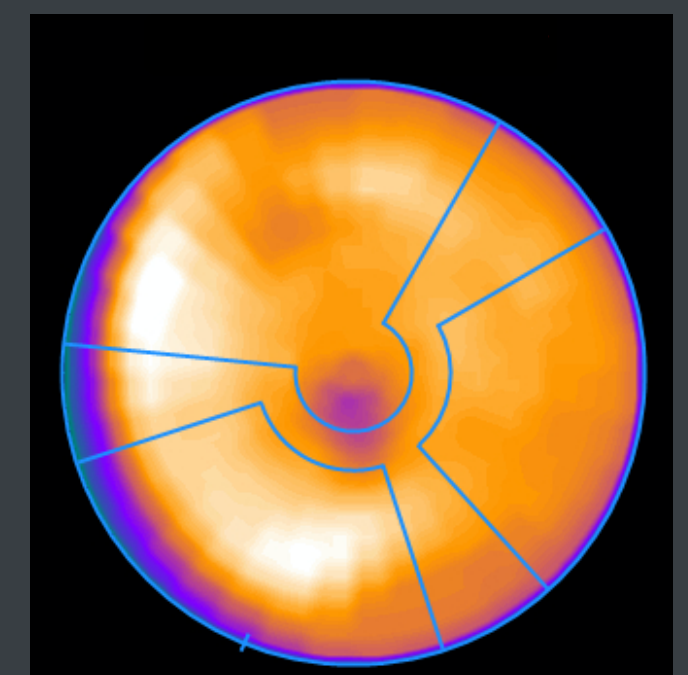
Corrected Images



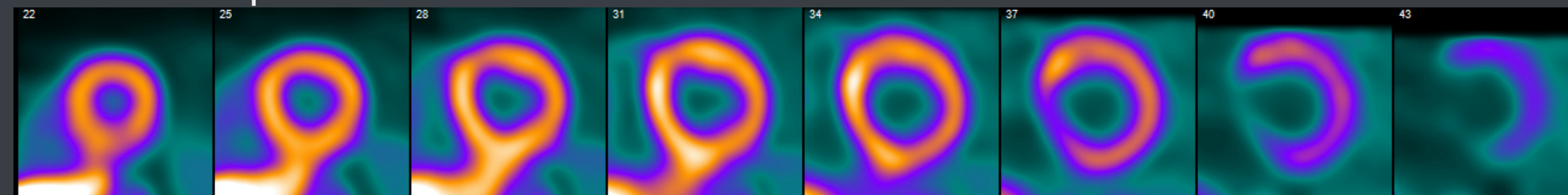
Resolution:

- Re-align CT AC images onto PET images
- Re-reconstruct PET data with re-aligned CT AC images
- Limitations: Rigid body realignment with translations only
- Apply TOF

Polar Map



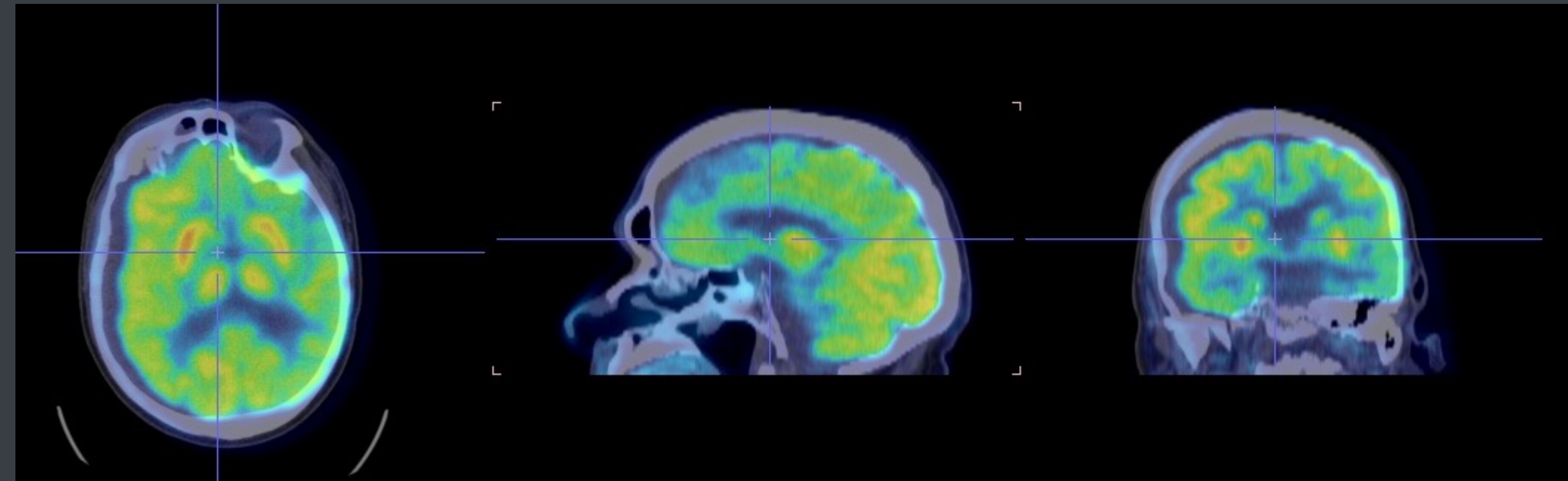
SA slices: Apex to base



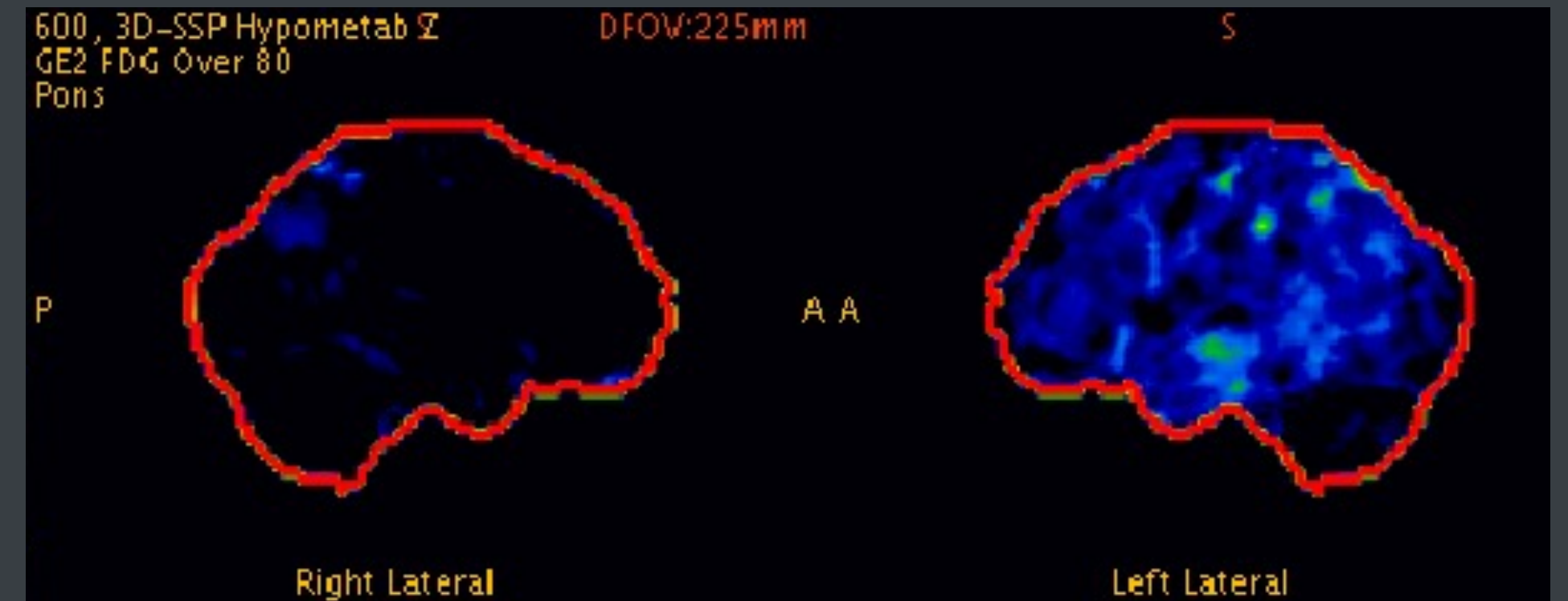
Case 5

Patient moves between CT and PET

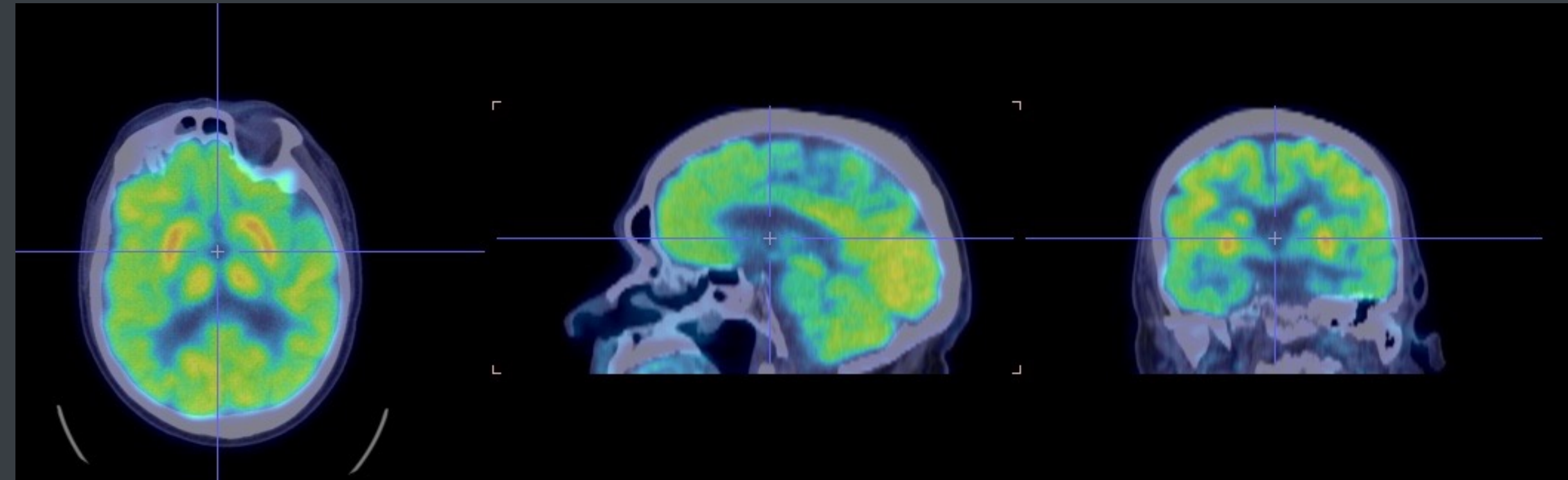
Original images



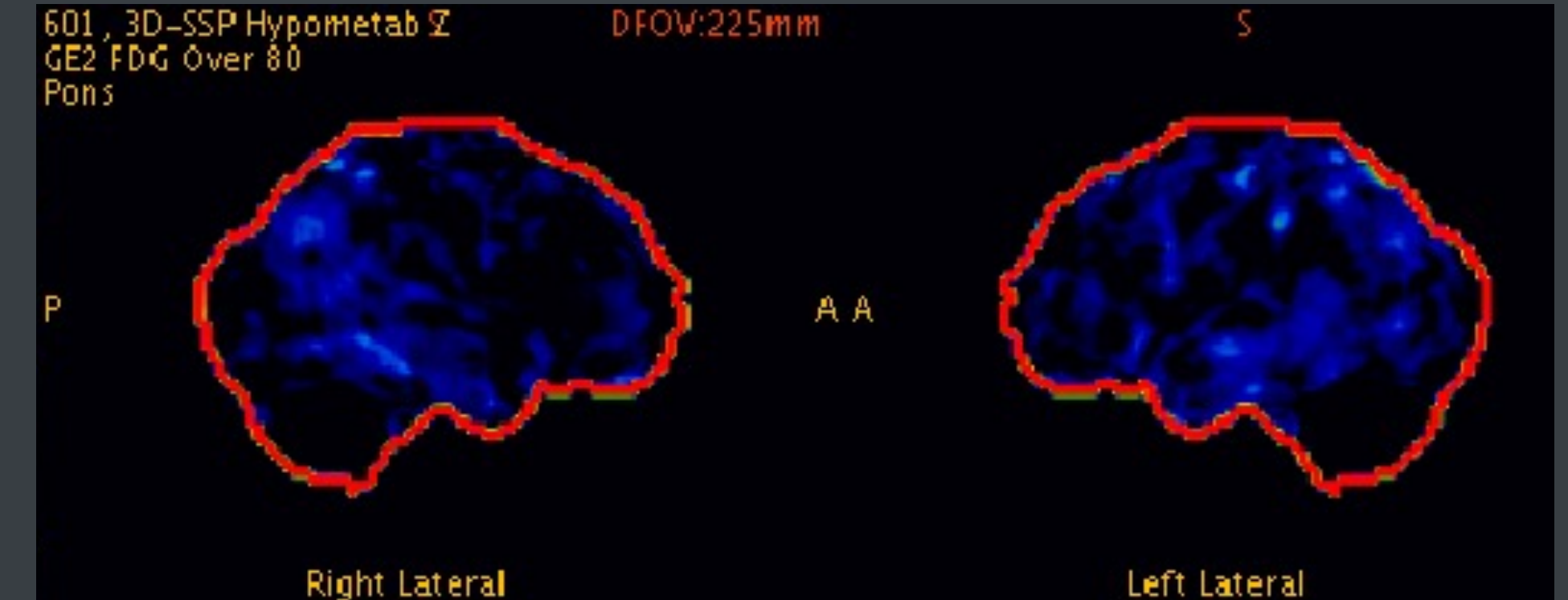
Z-scores, compared with normals database



Corrected images (re-aligned, re-reconstructed with proper attenuation correction)



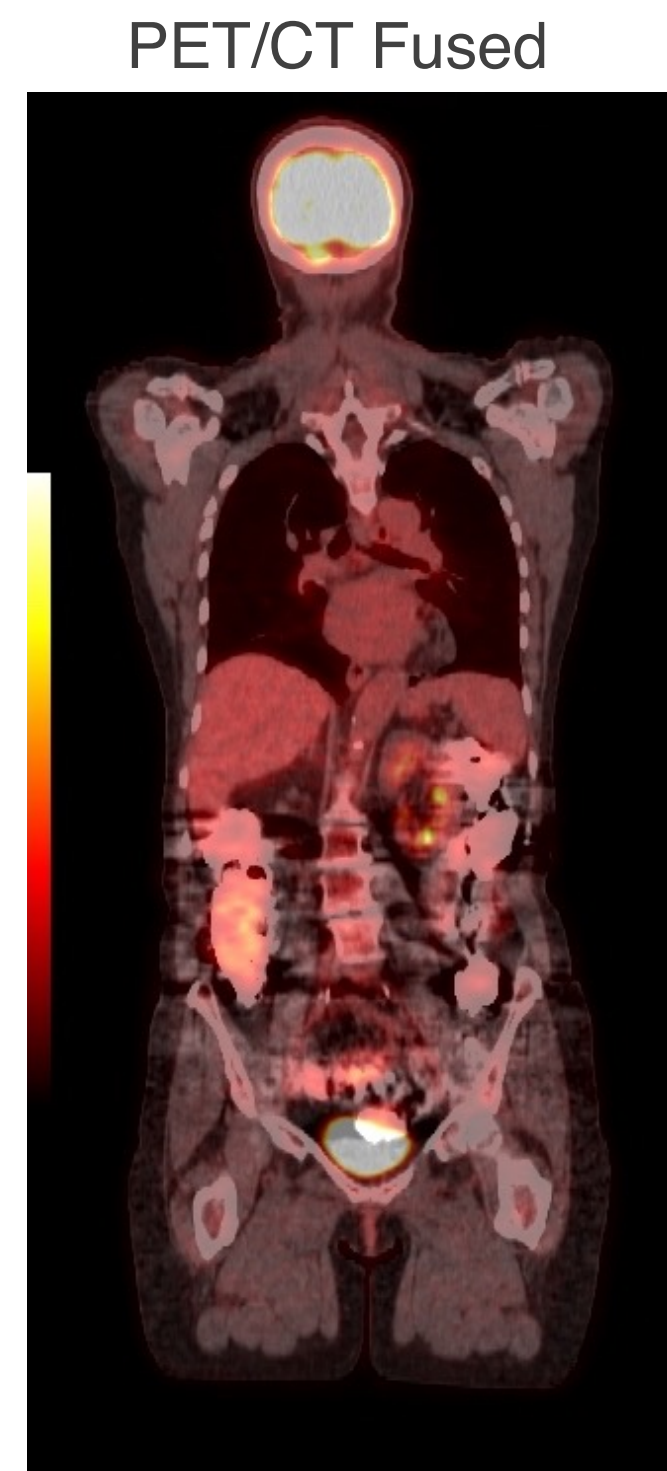
Z-scores, compared with normals database



Case 6

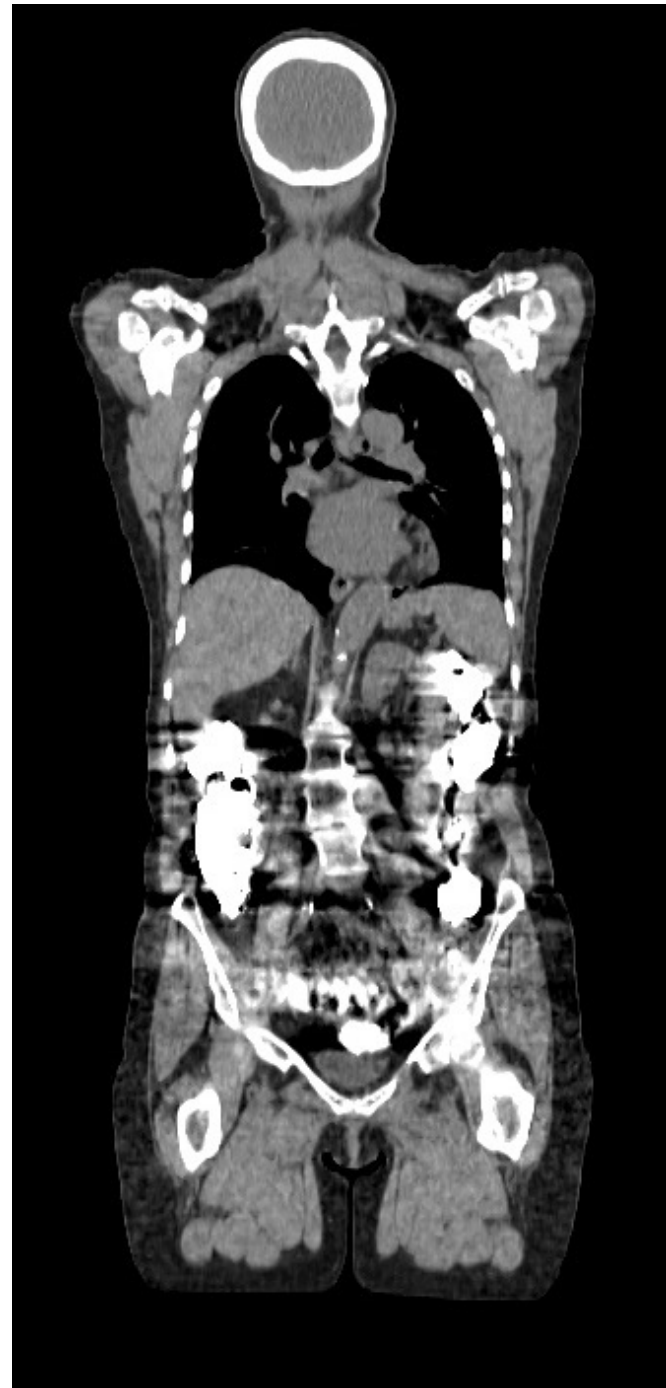
Description:

- Increased uptake in abdomen



Case 6

CT



PET with CTAC



Case 6

CT



PET with CTAC

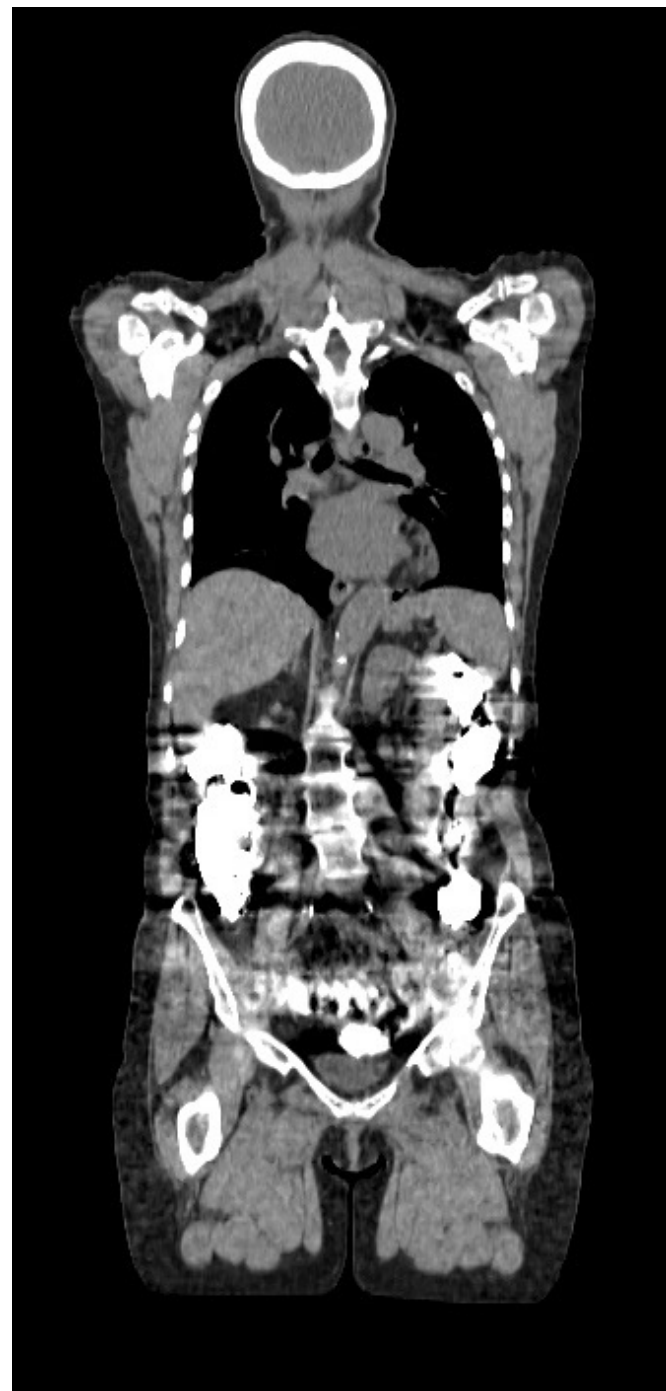


PET NAC



Case 6

CT



PET with CTAC



PET NAC



PET with CTAC
Contrast Correction

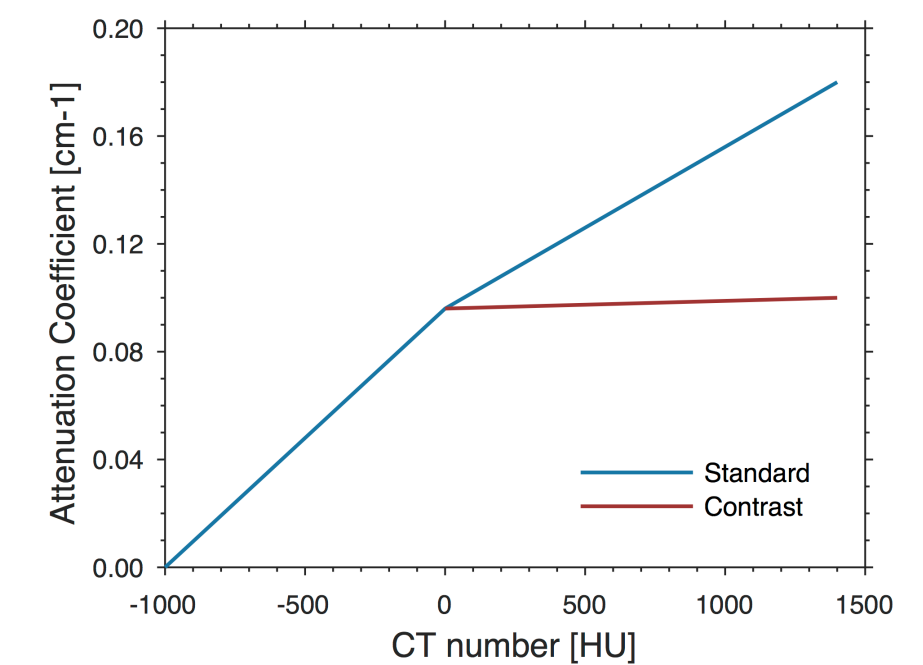


Cause:

- Overcorrection of attenuation due to presence of contrast

Resolution:

- Apply bilinear HU \rightarrow μ conversion with contrast correction



Recommendations

If artifacts are present:

- Investigate the PET data
 - Review sinograms
 - Review PET NAC
- Investigate the attenuation correction data
 - Review AC maps (especially for PET/MR studies)
 - Are PET and AC maps registered?
 - Is contrast media, metal, truncation present?

To reduce artifacts:

- better algorithms
- reduce patient motion
- use TOF whenever possible

References

- Elhami E, Samiee M, et al. On the significance of defective block detectors in clinical ^{18}F -FDG PET/CT. *Mol Imaging Biol* 2011;13:265-274.
- Gould KL, Pan T, et al. Frequent diagnostic errors in cardiac PET/CT due to misregistration of CT attenuation and emission PET images: a definitive analysis of causes, consequences and corrections. *J Nucl Med* 2007; 48:1112-1121.
- Lodge MA, Mhlanga JC, Wahl RL. Effect of patient arm motion in whole-body PET/CT. *J Nucl Med* 2011;52:464P.
- Sureshbabu W, Mawlawi O. PET/CT imaging artifacts. *J Nucl Med Tech* 2005;33:156-161.
- Surti S. Update on time-of-flight PET imaging. *J Nucl Med* 2015;56:96-105.