Head imaging with C-arm CT: Investigation on the impact of data redundancy handling and orientation of the scanning plane on image quality

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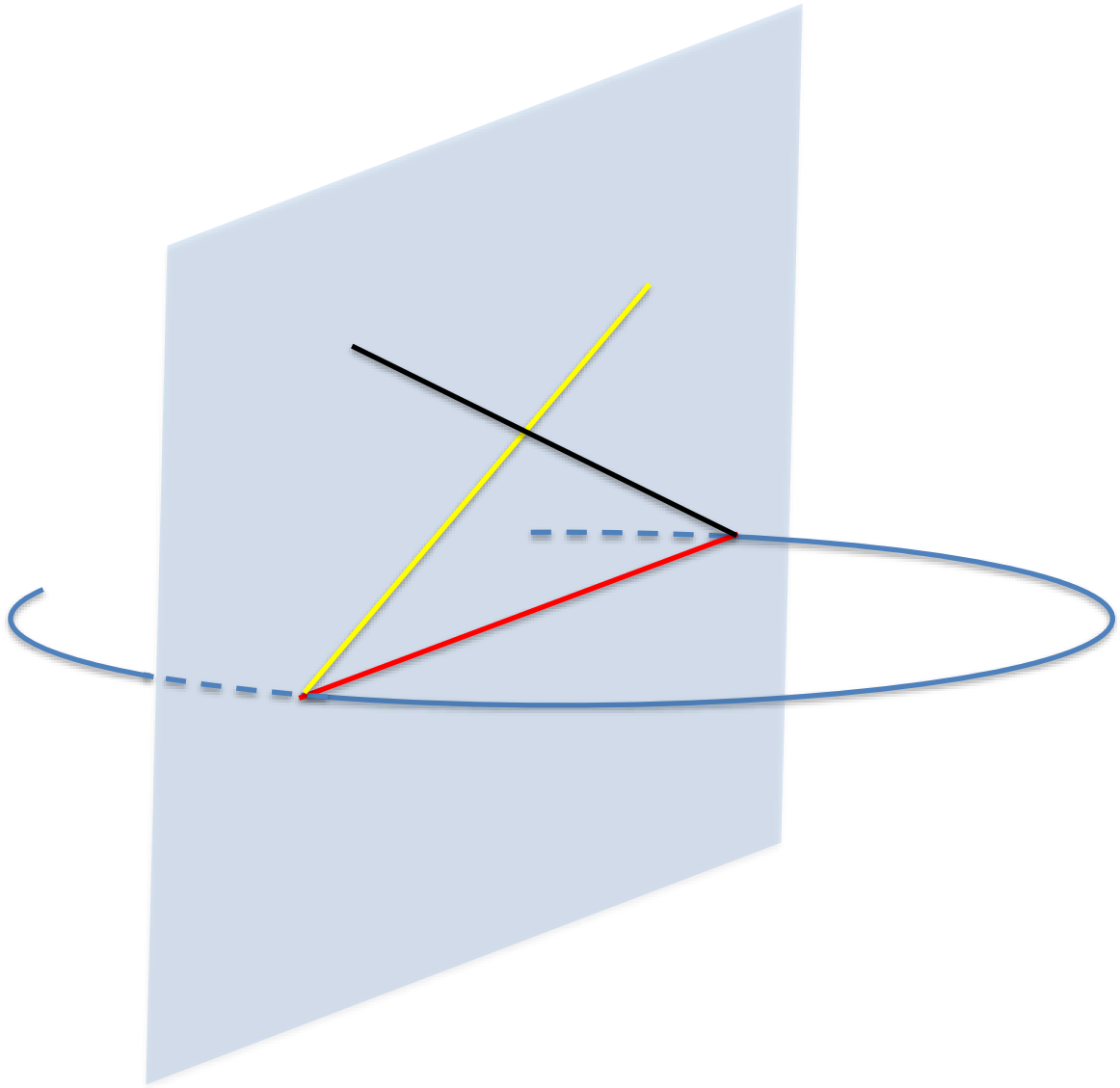
Motivation

- FDK-type algorithms like SS-FDK do not properly handle data redundancy.
- Location/shape of bones within the skull (e.g., petrous bone) relative to scanning plane can yield significant CB artifacts.
- Can image quality in C-arm CT imaging of the head be improved by:
  - employing a reconstruction algorithm that properly accounts for data redundancy, like the ACE* method
  - applying a change in the orientation of the scanning plane to emulate the gantry-tilt geometry used in diagnostic CT

*Nett B, Chen GH, Arc based cone-beam reconstruction algorithm using an equal weighting scheme, J X-ray Sci. & Tech, 2013

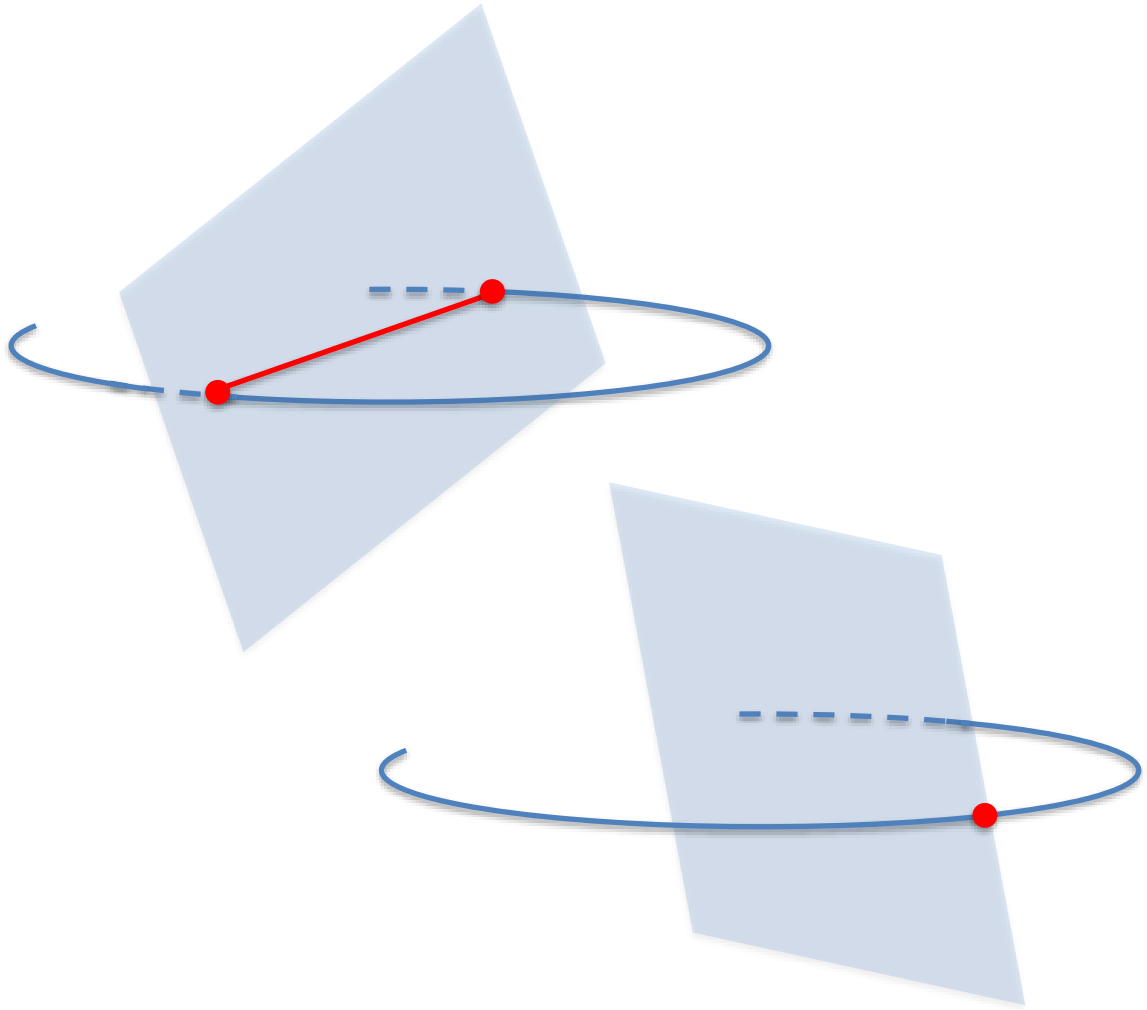
FDK and data redundancy

- FDK is based on fan-beam reconstruction
- Rays that lie in the same transaxial plane are assumed to be redundant
- The assumption only applies to the rays in the trajectory plane, or when the object is constant in z



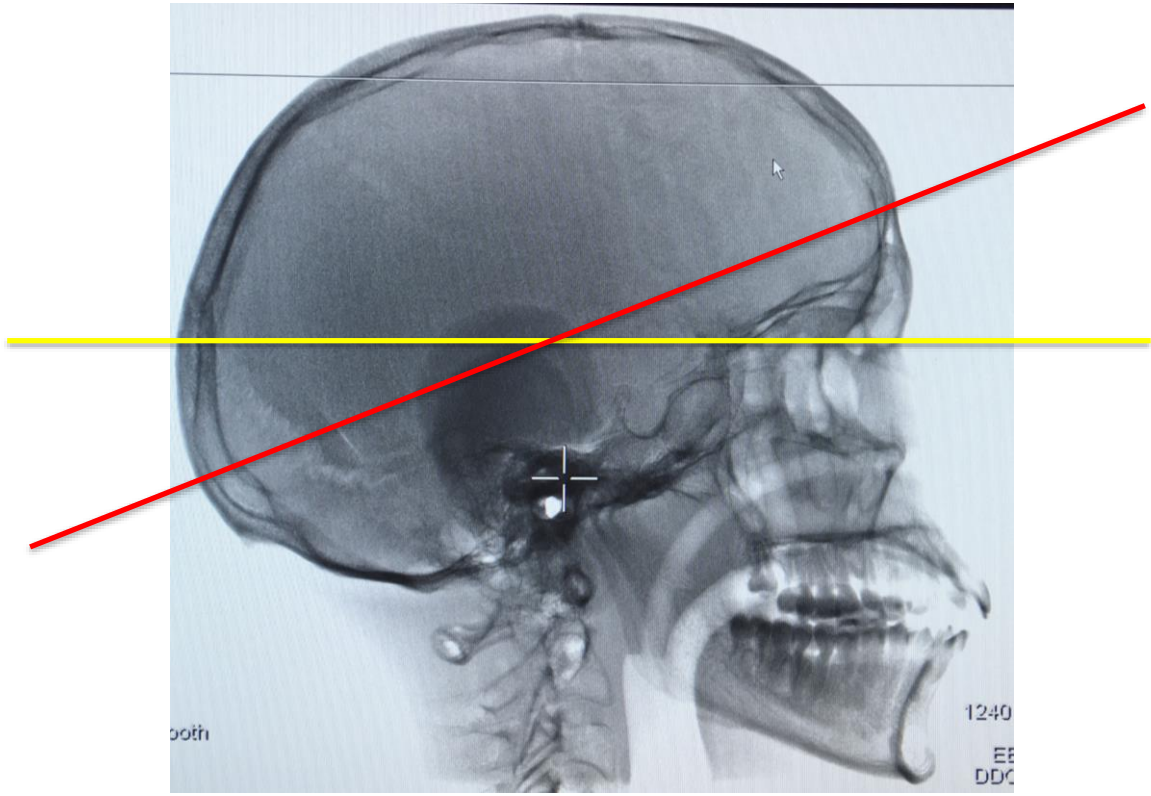
Proper handling of data redundancy

- CB projections are related to plane integrals, as expressed by Grangeat's formula
- Any plane integral intersecting the source trajectory is measured: planes that have two intersections are measured twice; others are measured once
- FBP reconstruction using equal weighting for all measured planes is possible: e.g. ACE algorithm



Tilted geometry

- Data acquisition with a tilted source trajectory changes the set of measured plane integrals, hence can change image quality



Experiment set-up (conventional head scan protocol)

Distance from source to isocenter (R)	786 mm
Distance from source to detector (D)	1198 mm
Radius of the FOV (r)	120 mm
Scanning range	198^{o}
Number of projections	496
Tube voltage	109 KVP
Detector pixel size	0.308 mm
Detector size	1240×960
Volume voxel size	0.49 mm

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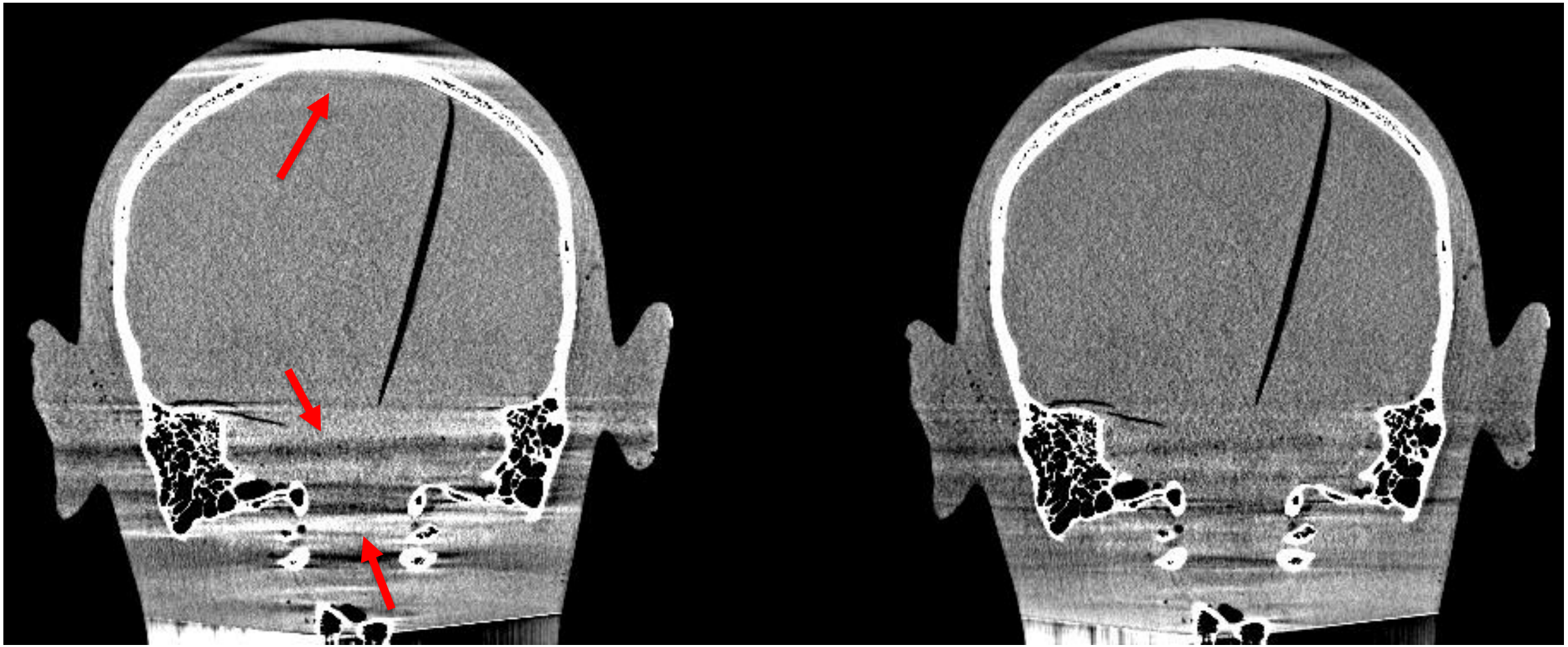
SS-FDK v.s. ACE

SS-FDK

ACE



Gray scale: [-200,200] HU

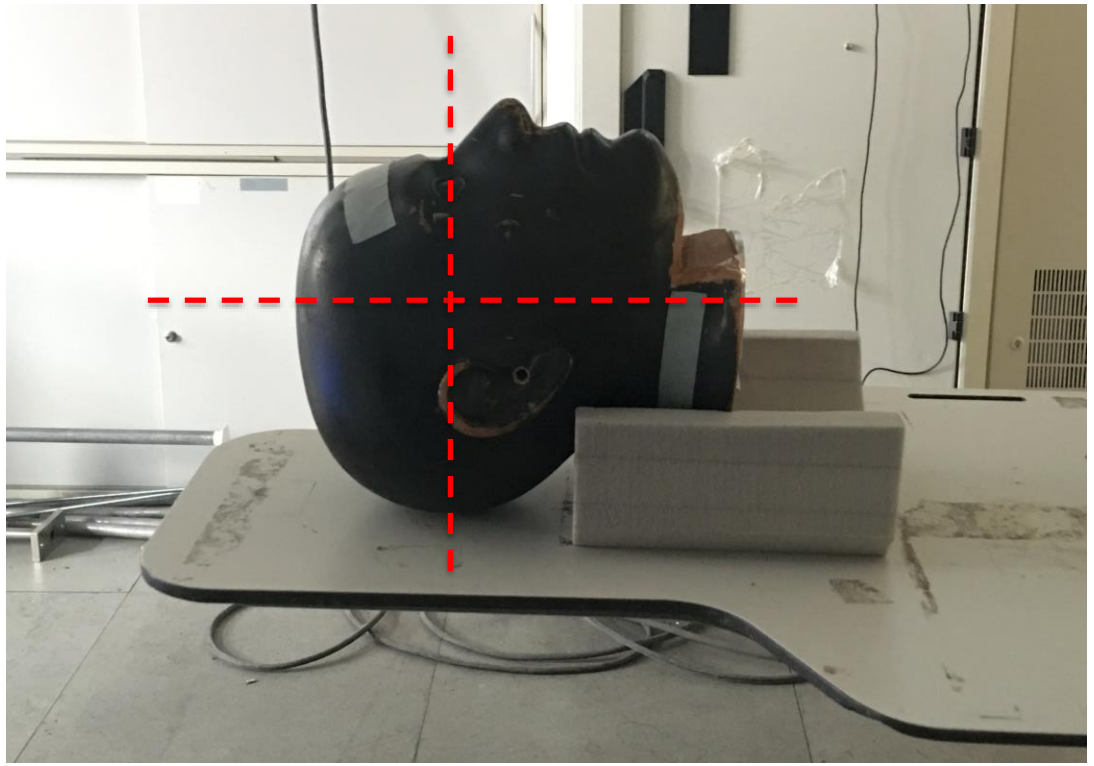
SS-FDK

ACE

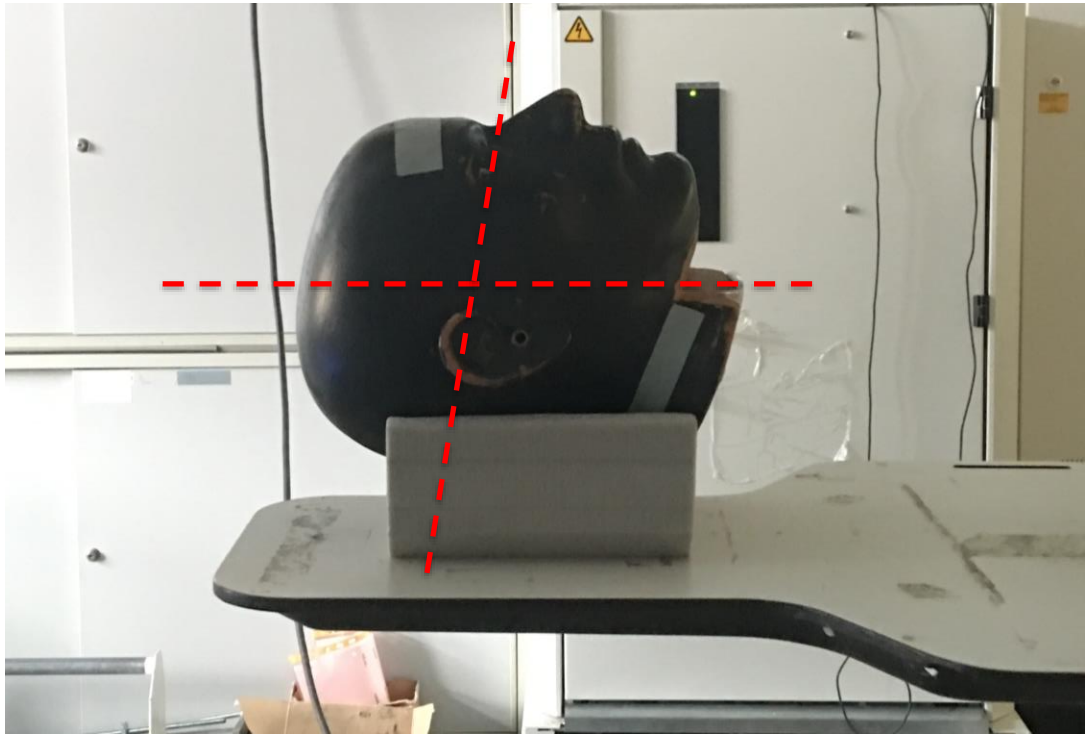
Gray scale: [-200,200] HU

Non-tilted v.s. tilted geometry

non-tilt

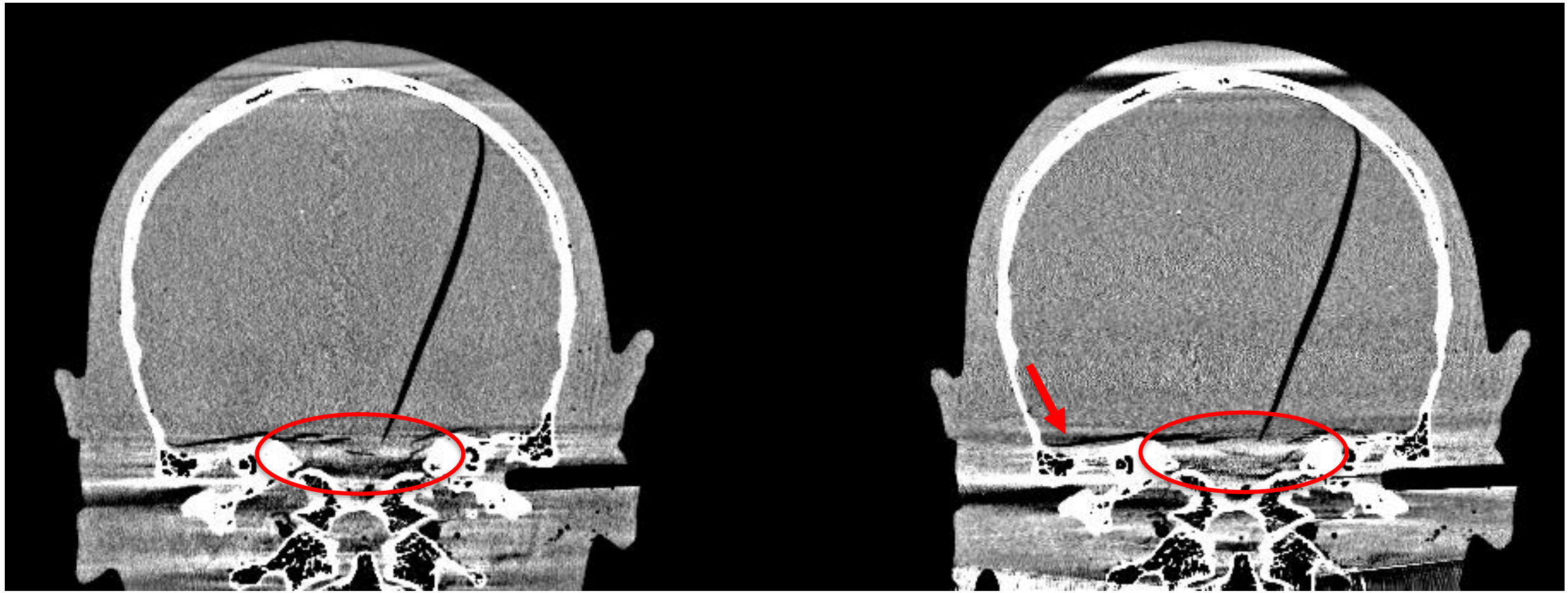


tilt



non-tilt
SS-FDK

tilt
SS-FDK



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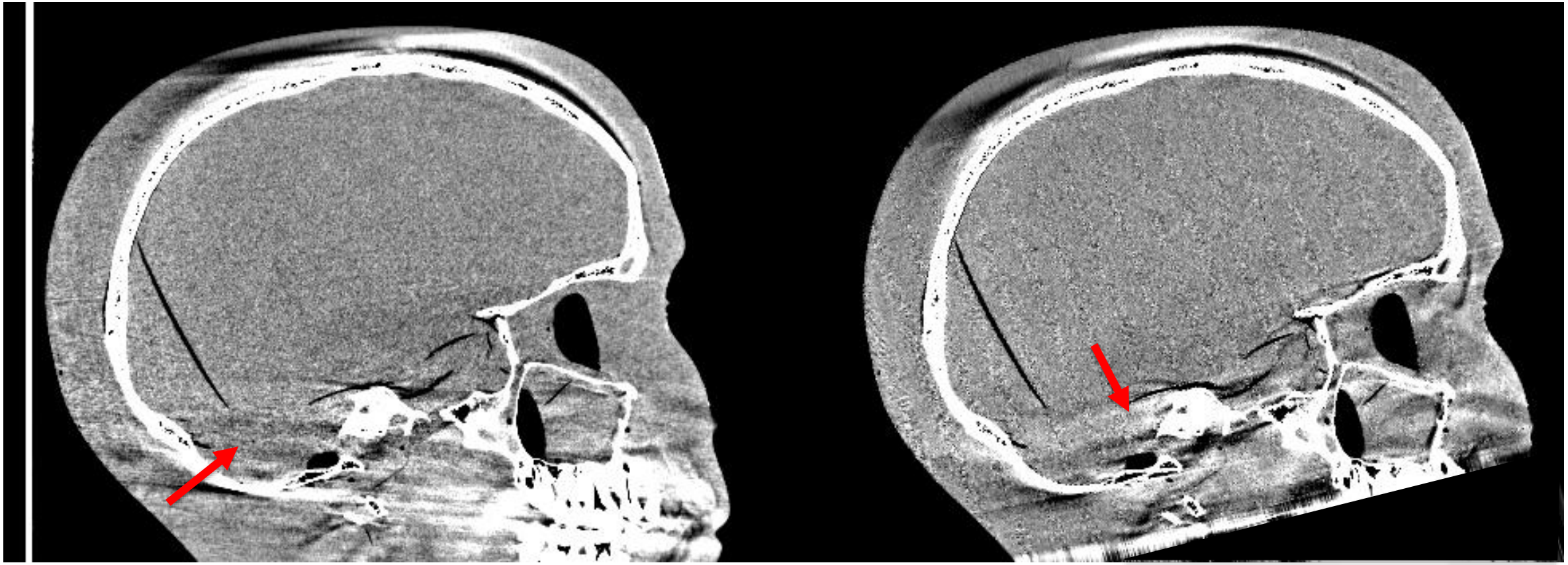
non-tilt
SS-FDK

tilt
SS-FDK



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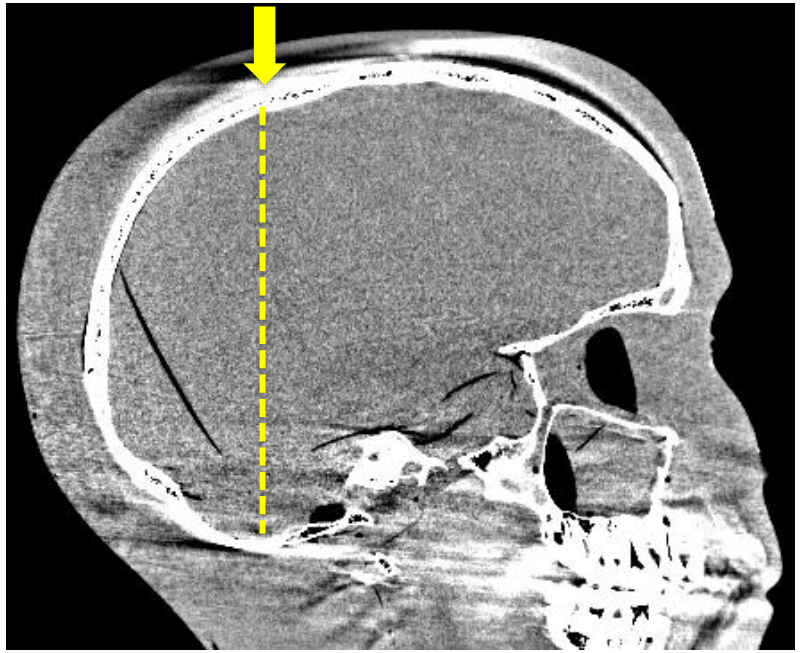
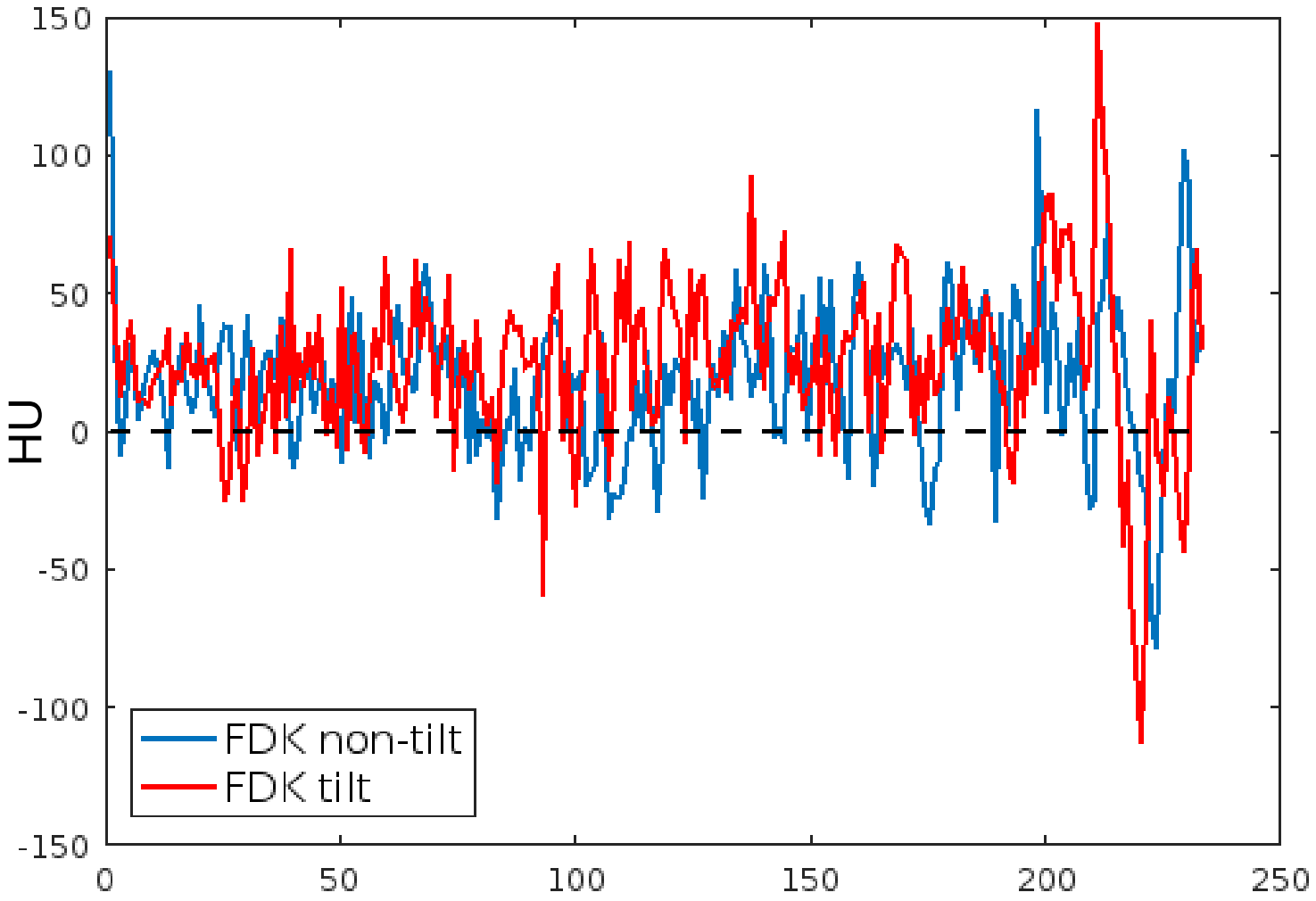
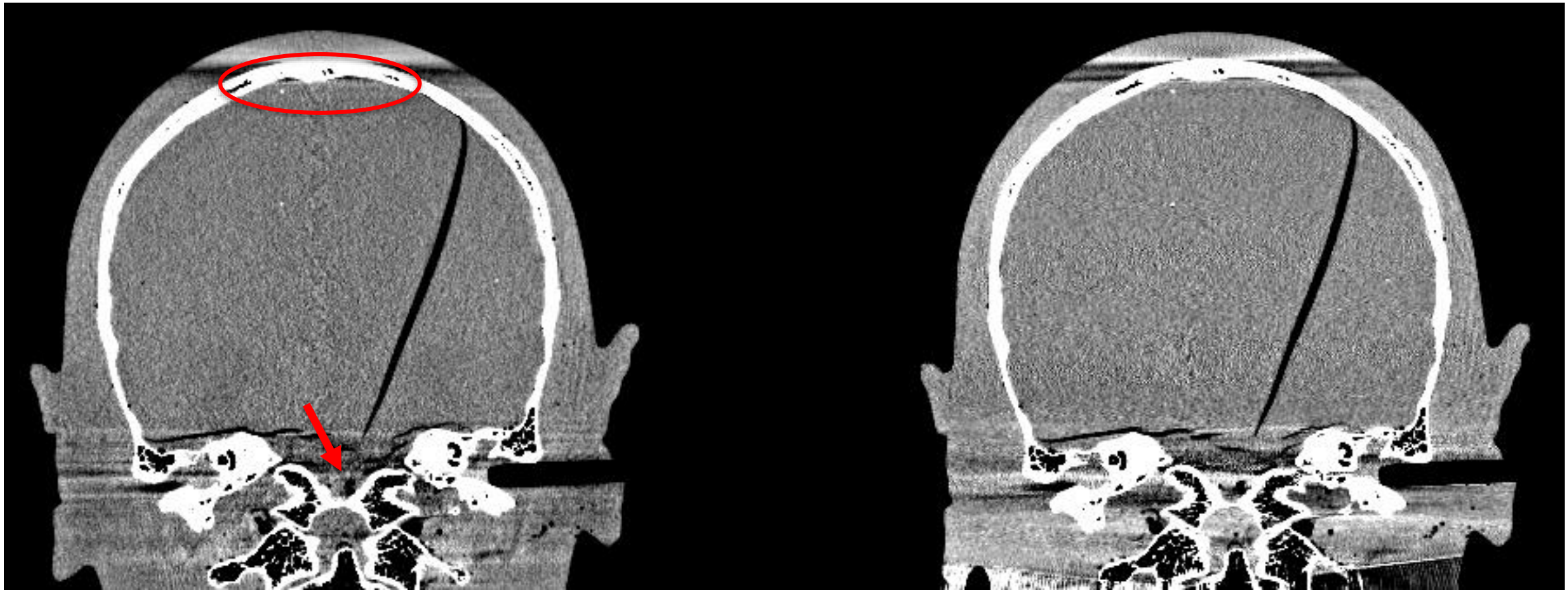


SS-FDK


150
100
50
0
-50
-100
-150
HU
0
50
100
150
200
250
FDK non-tilt
FDK tilt

non-tilt
ACE

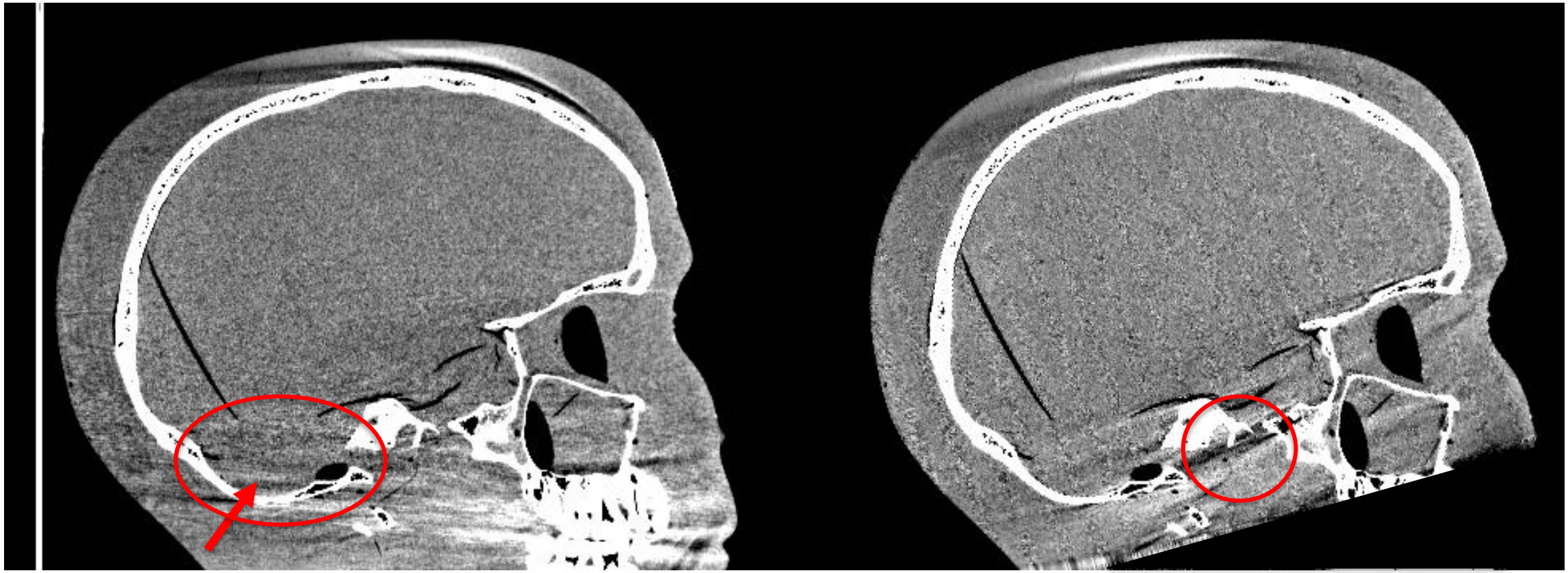
tilt
ACE



Gray scale: [-200,200] HU

non-tilt
ACE

tilt
ACE



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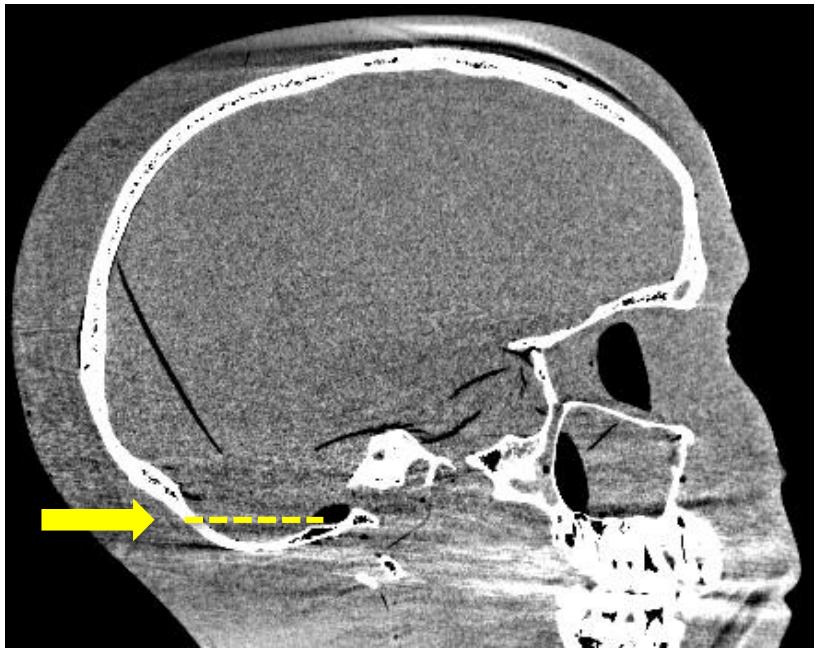
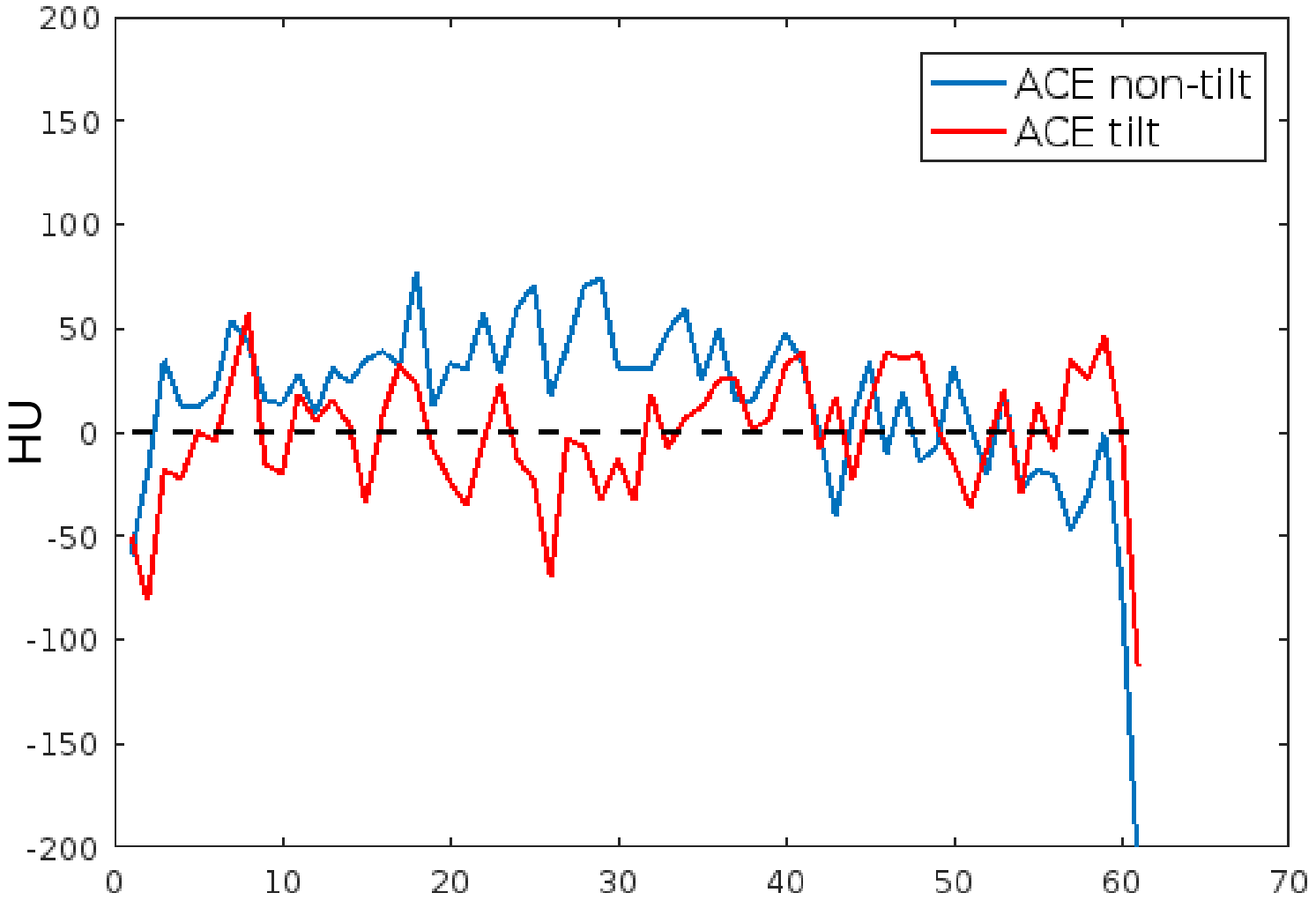
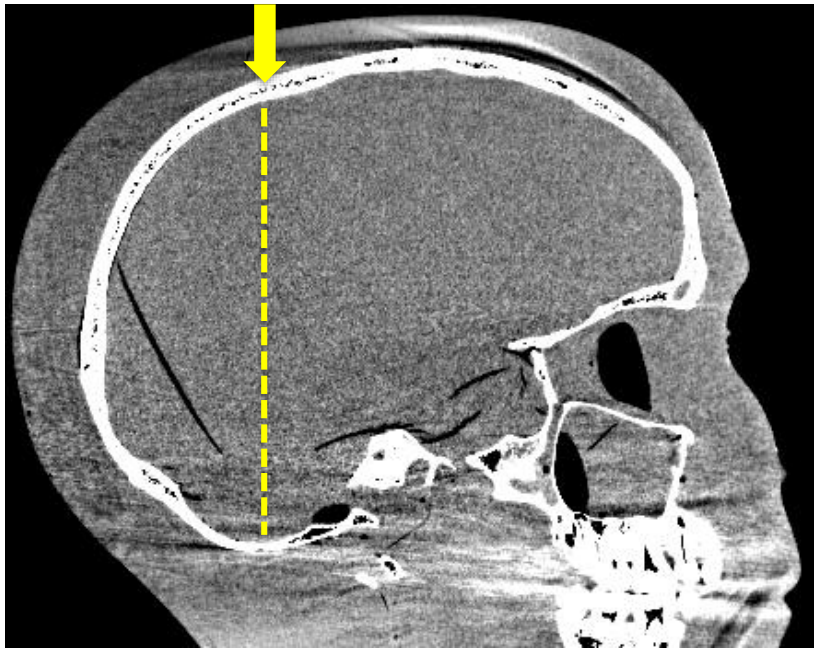
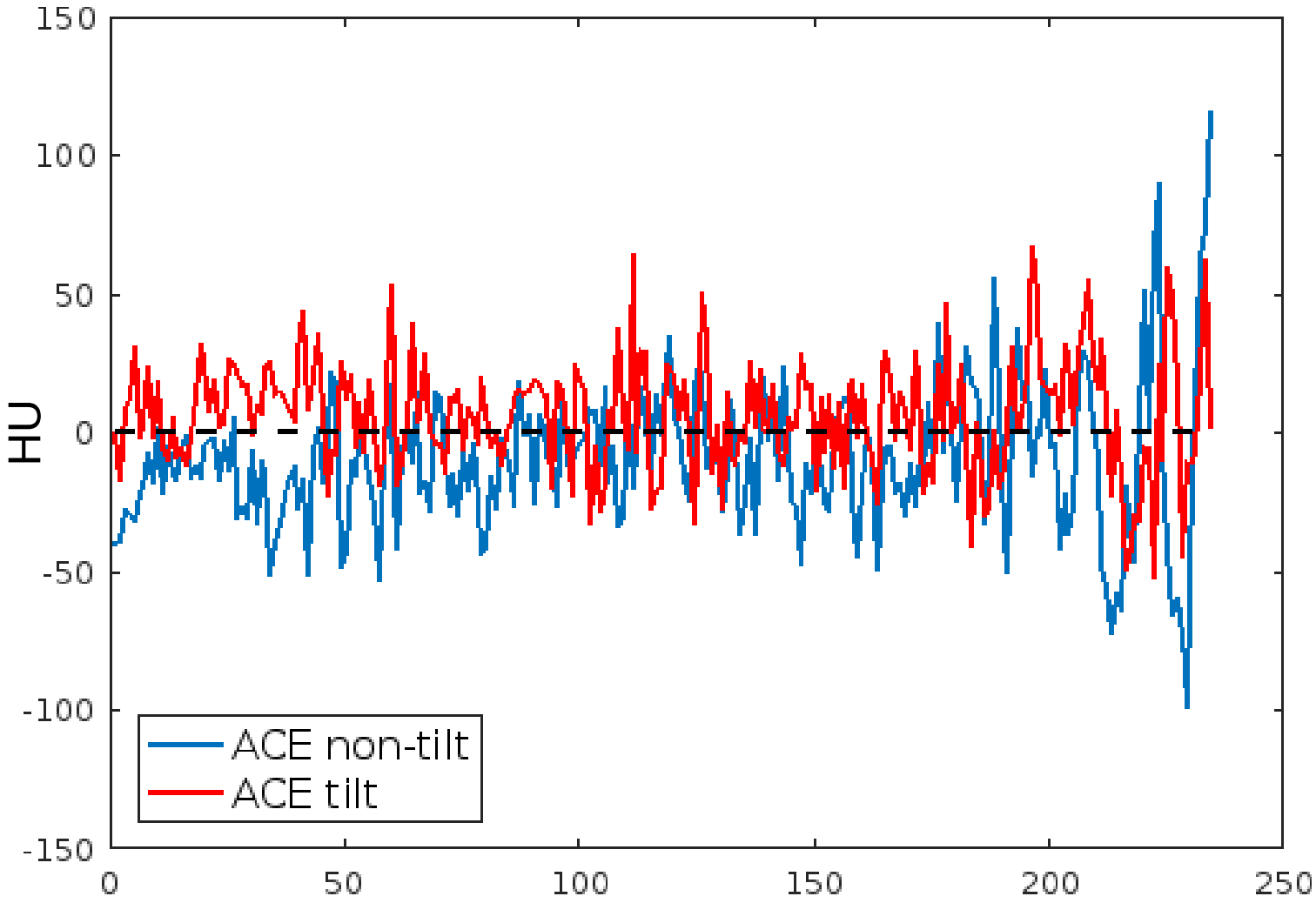


ACE


ACE non-tilt
ACE tilt
HU
200
150
100
50
0
-50
-100
-150
-200
0
10
20
30
40
50
60
70



ACE


150
100
50
0
-50
-100
-150
HU
0
50
100
150
200
250
ACE non-tilt
ACE tilt

Conclusion and discussion

- C-arm CT imaging of the head can be significantly improved using an algorithm that properly accounts for data redundancy.
- Orienting the scanning plane to emulate a gantry tilt is not beneficial for reconstruction with SS-FDK
- Impact of the tilt on reconstructions with ACE was shift-variant: the tilt provided benefits at some locations at the cost of degraded image quality at other locations
- If a region-of-interest is a-priori known, a better image quality can benefit from a tilted scanning plane with ACE
- Further experiments on tilted scanning planes are needed.

Thank you!

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