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MEDICAL SCHOOL

# Sparse View Computed Tomography (CT)

Massachusetts General Hospital

And Harvard Medical School

Synho Do, PhD

# Conclusions

Sparse view CT will be able to contribute to air cargo imaging.

→ By increasing scan throughput

:Super fast scan, no need to fill Radon data space fully, less artifacts compared to FBP etc

→ Freedom in CT geometry

:Multiple sources, Heterogeneous detector, Non-circular scan trajectory (no gantry scanner), Stationary Scanner etc

→ Reducing iterative image reconstruction time

:Smaller data size, smaller memory etc

# Massachusetts General Hospital and Harvard Medical School



Synho Do, PhD

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[BIO](#) [NEWS](#) [PUBLICATIONS](#) [RESEARCH](#)

Synho Do, PhD, is an Assistant in Physics at Massachusetts General Hospital, where he is a technical committee member of Webster Center for Advanced Research and Education in Radiation, and Instructor at Harvard Medical School. Dr. Do received the Ph.D. degree in Biomedical Engineering from University of Southern California. He is currently a member of IEEE Signal Processing Society, Bio-Imaging and Signal Processing (BISP). He is a MGH site PI for nVidia CUDA Research Center (CRC). Dr. Do's current research interests include statistical signal and image processing, estimation, detection, and medical signal and image processing, such as computed tomography. He has been a Co-Investigator for multiple medical imaging projects, and Co-PI/PI on medical (i.e., GE, Siemens, and Philips etc) and security (i.e., DHS, DARPA etc) image reconstruction projects.

Latest News

RSNA

DHS meeting

<http://scholar.harvard.edu/synho>

Nationality: U.S.A. (2013~present)

Ground truth

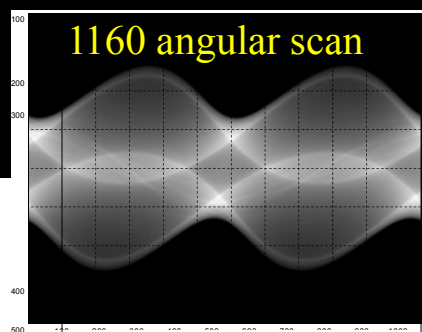
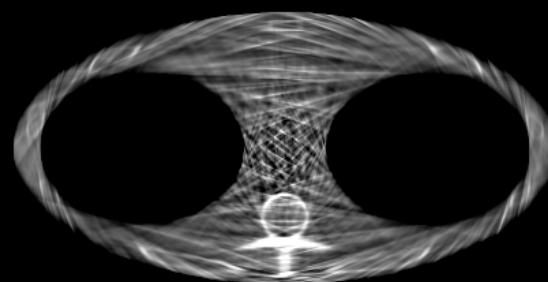
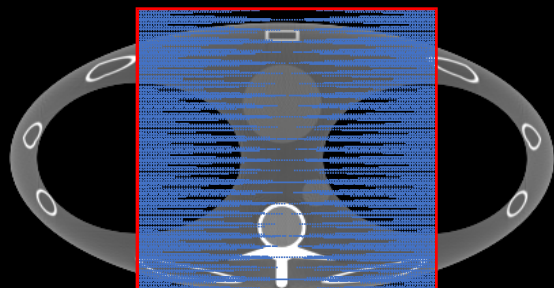
CW [-200 500]

FBP

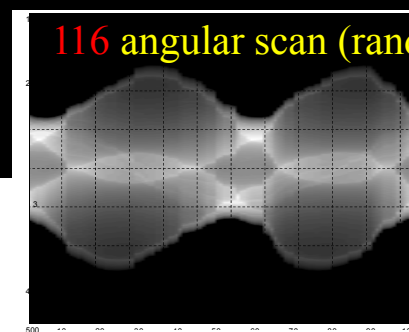
10% angular scan

MGH IRT

10% angular scan



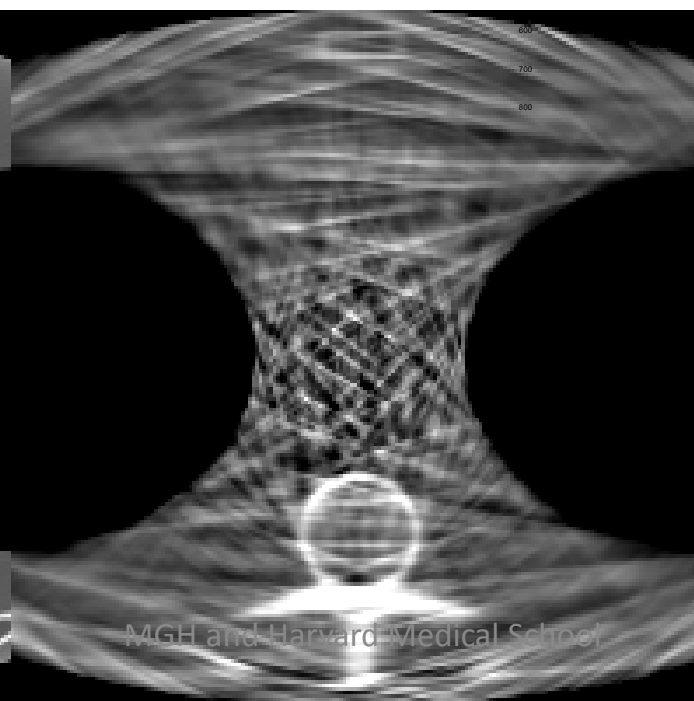
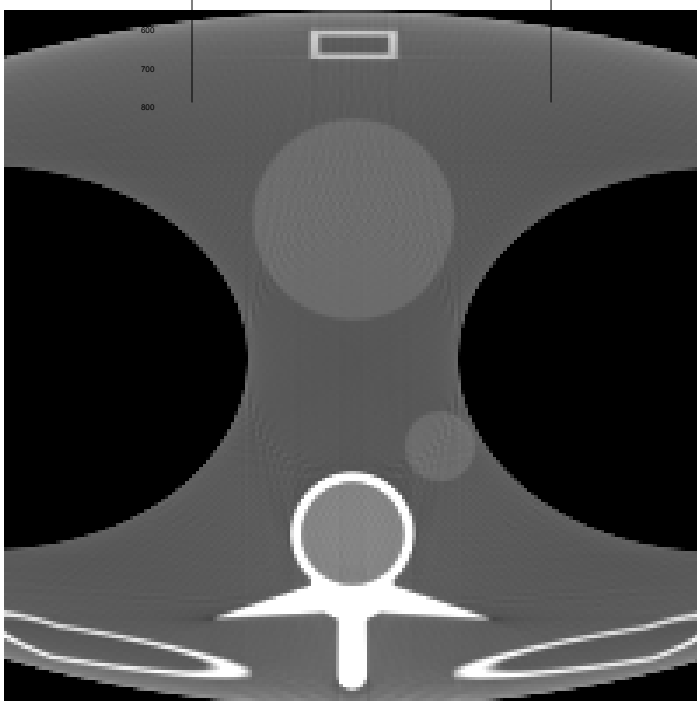
1160 angular scan



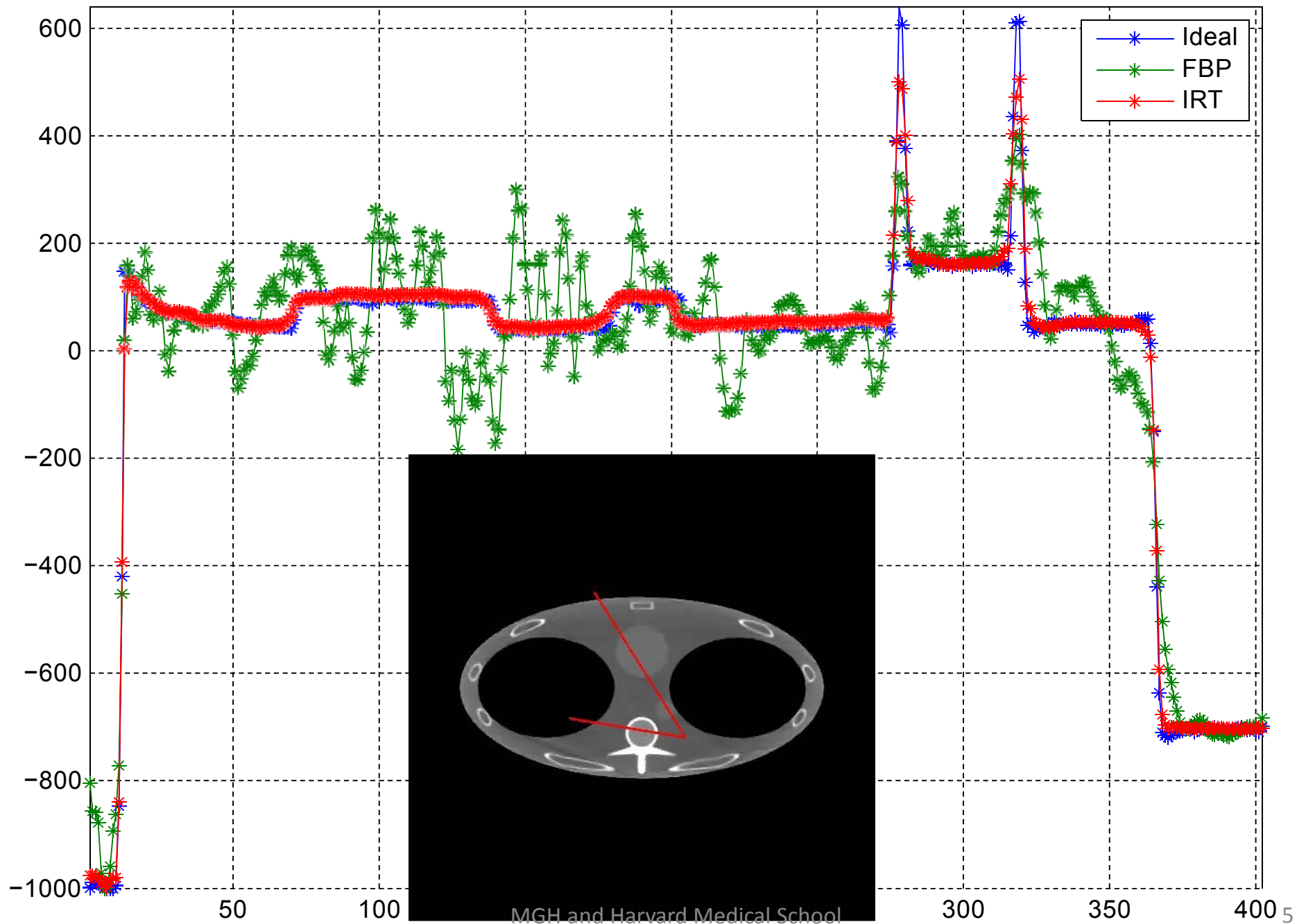
116 angular scan (random)

RMSE=66.62

RMSE=19.18



# Image profile comparison



Ground truth

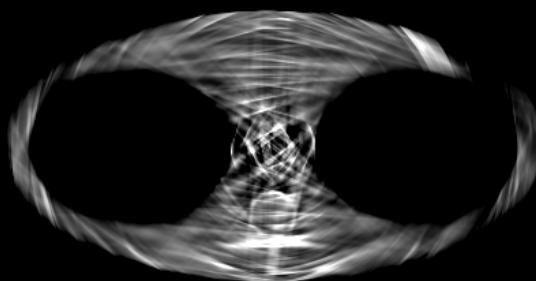
CW [-200 500]

FBP

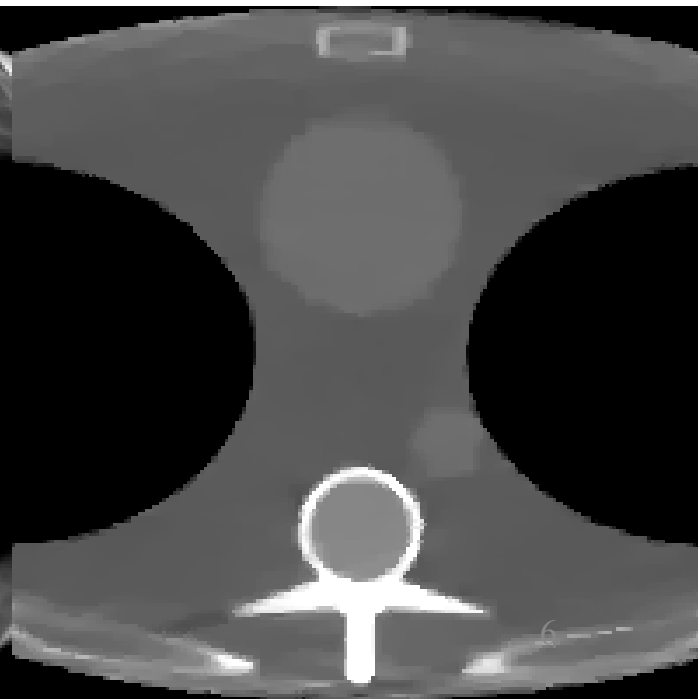
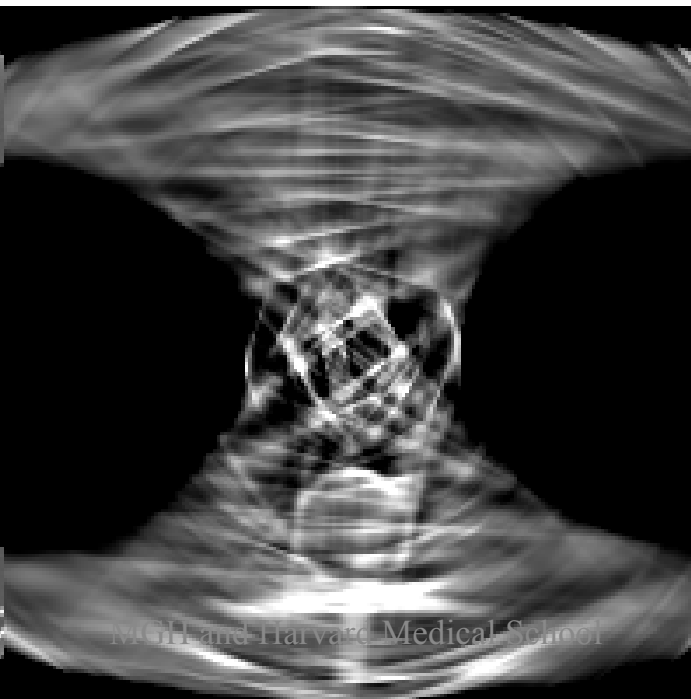
8% angular scan

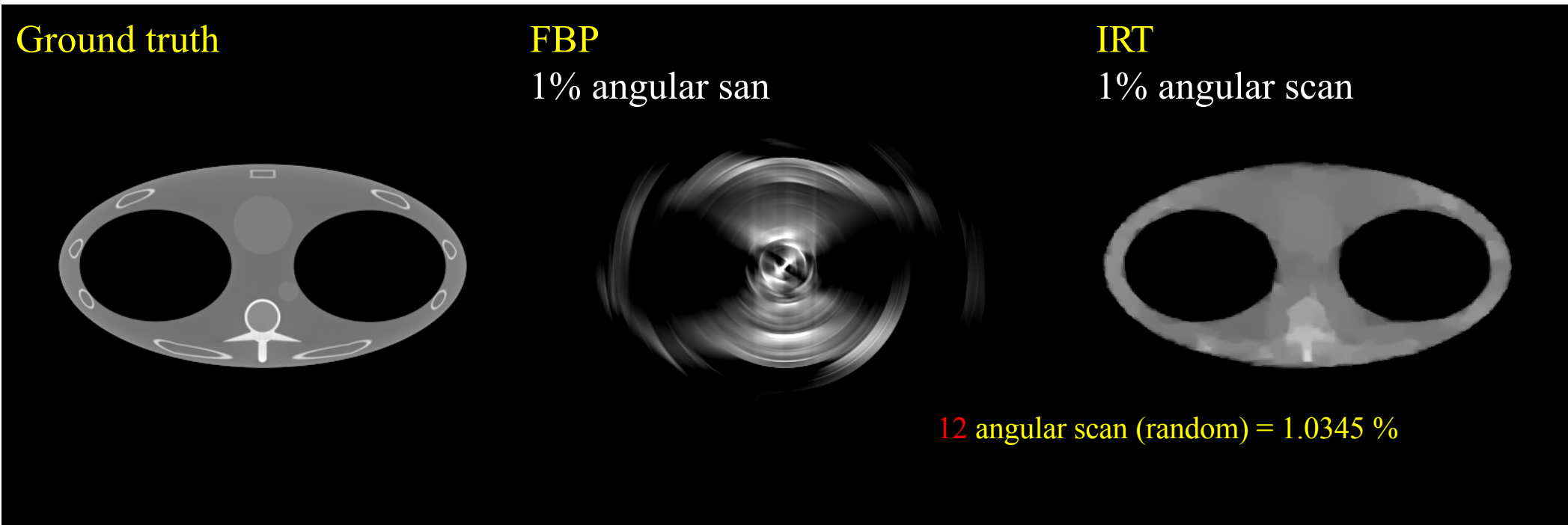
IRT

8% angular scan



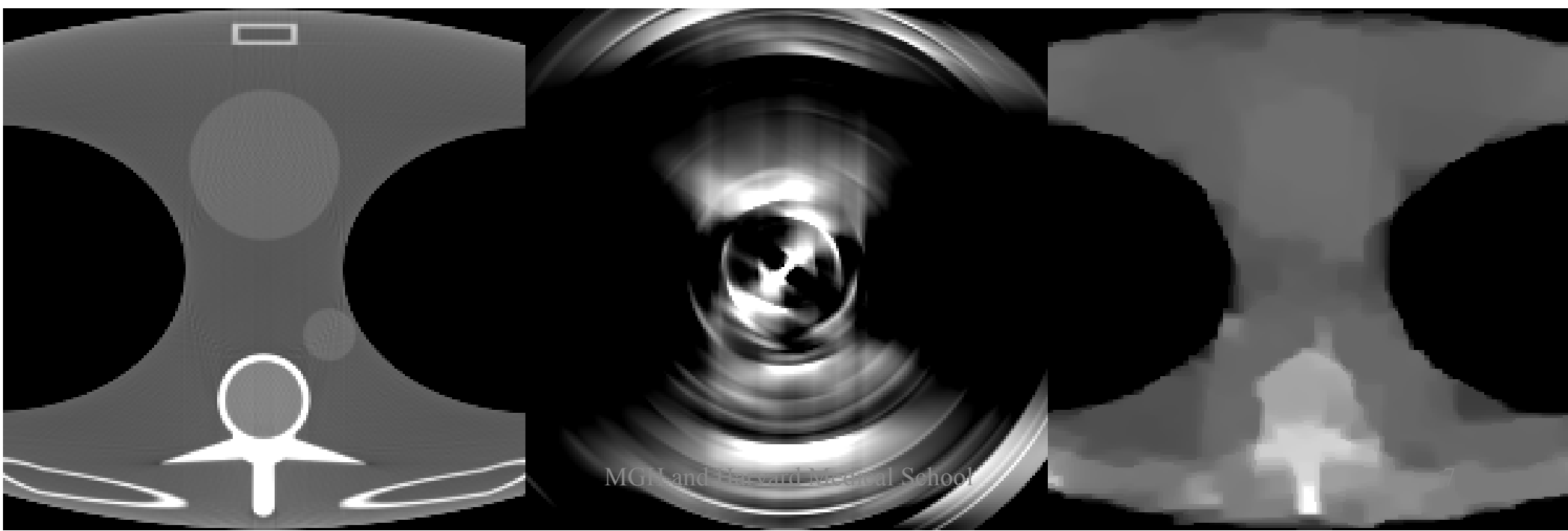
93 angular scan (random)





1 % of original angular views

Image size: 512x512

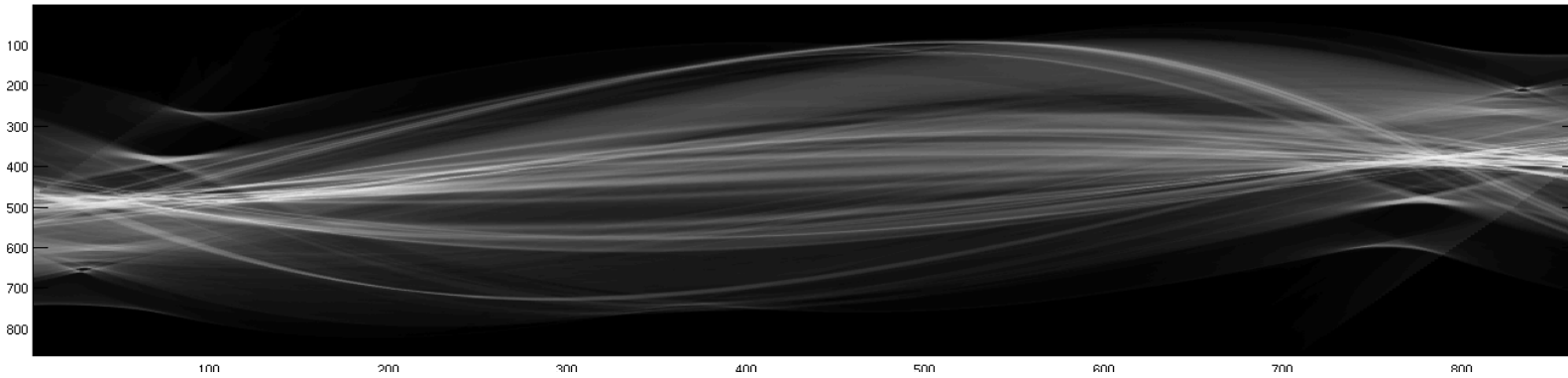


# Imatron C300 scanner

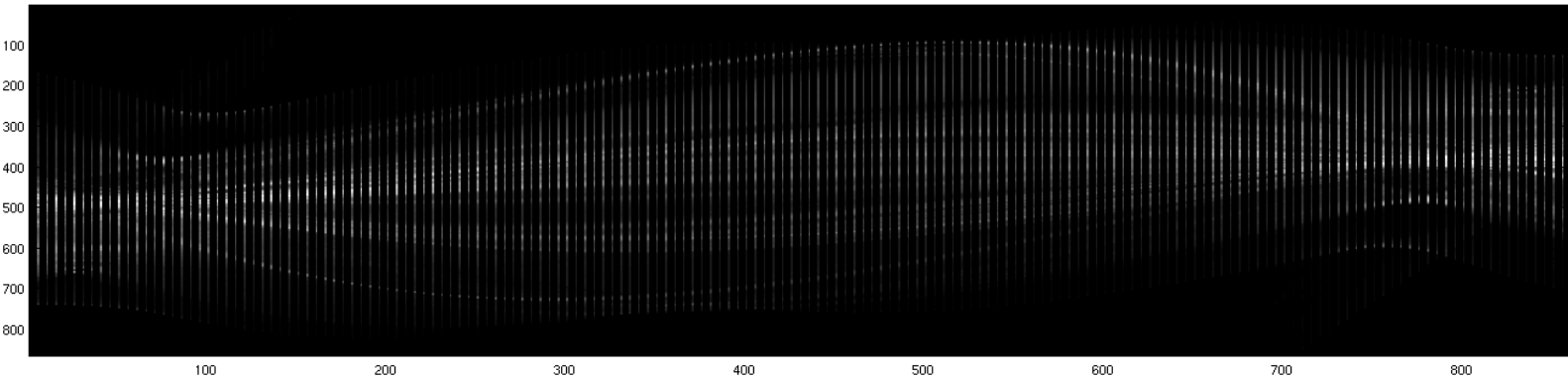
Emulation using **real raw data**  
- by throwing away angular samples



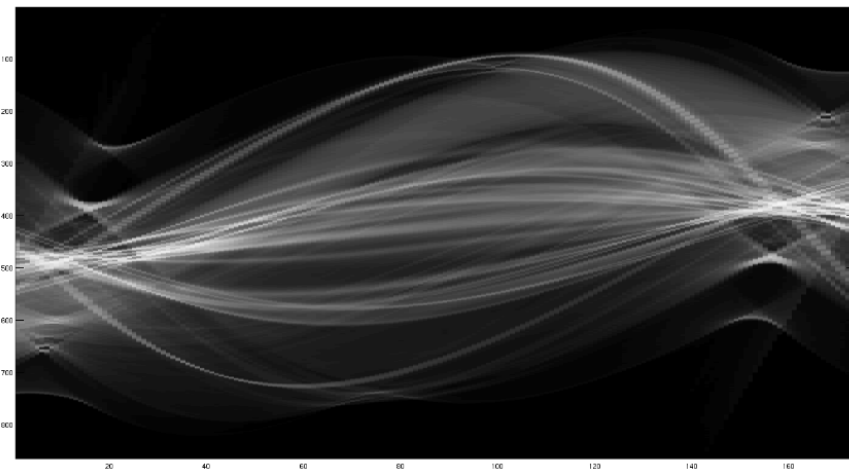
# Imatron Data (20 % of angular sample)



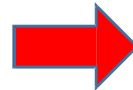
Original Sinogram  
864 x 864



Angular Down-sampled  
864 x 173  
20% of original

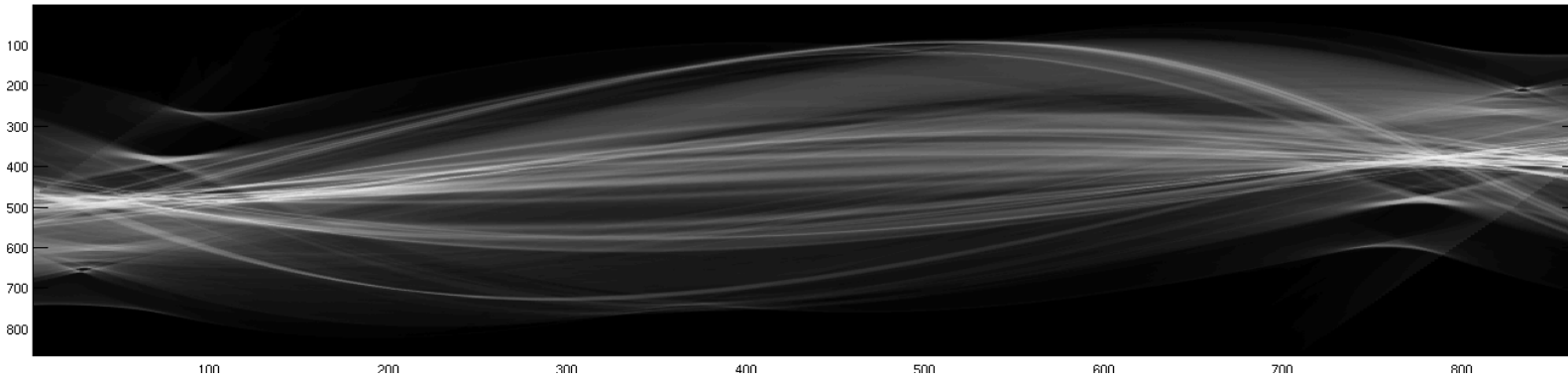


New Sinogram  
864x173

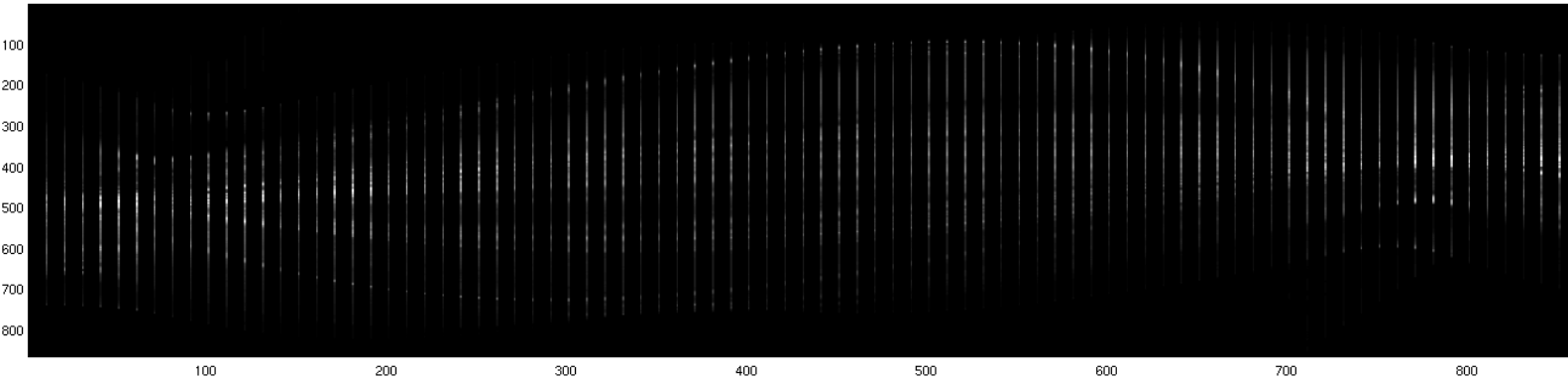


512x512  
Iter. =300

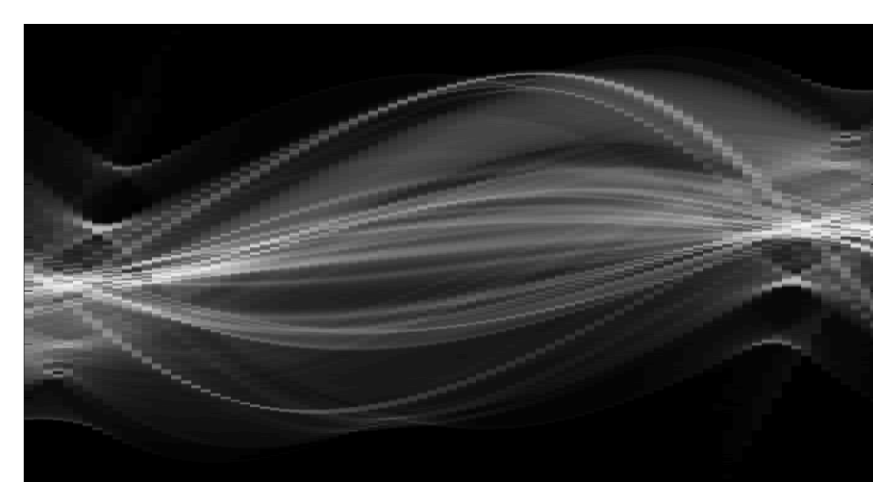
# Imatron Data (10 % of angular sample)



Original Sinogram  
864 x 864



Angular Down-sampled  
864 x 87  
10% of original



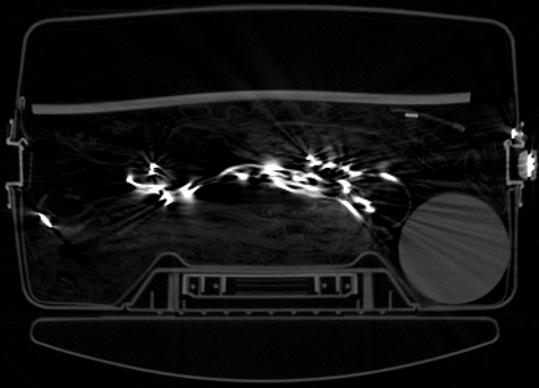
New Sinogram  
864x87



512x512  
Iter. =300

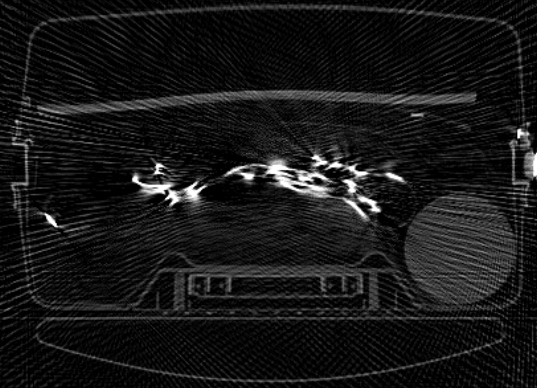
# Image comparison (1/2)

100% Data **FBP**



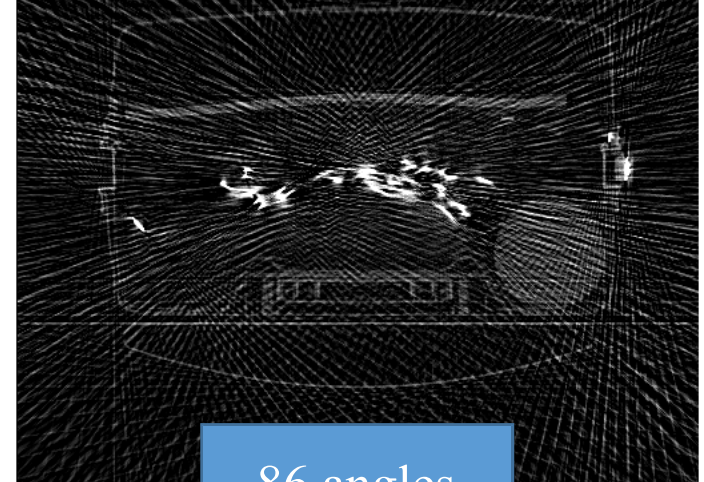
864 angles

20% Data **FBP**



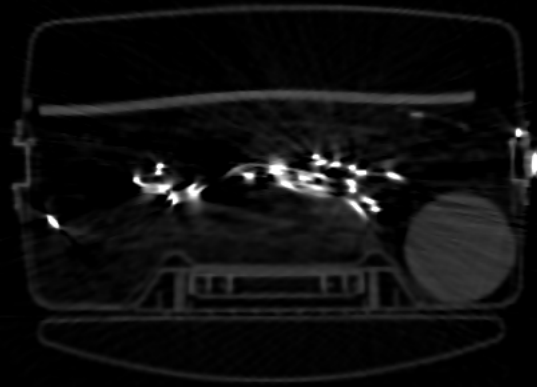
172 angles

10% Data **FBP**



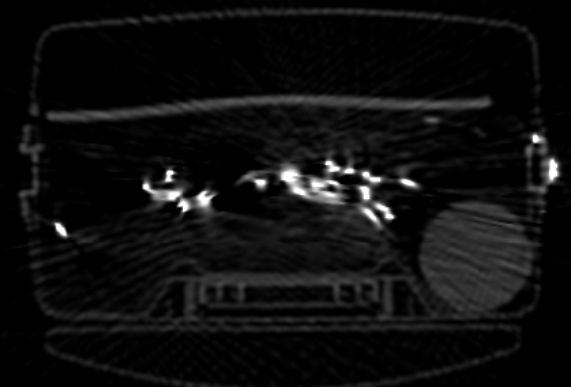
86 angles

20% Data **IRT**



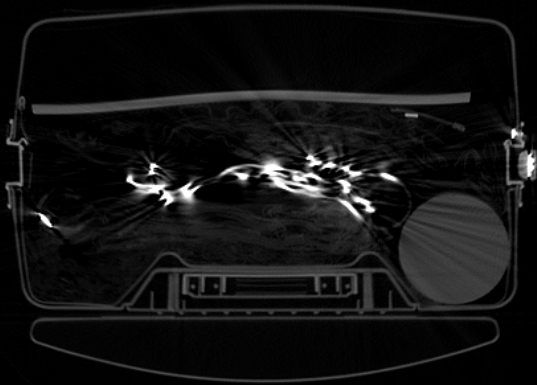
MGH and Harvard Medical School

10% Data **IRT**



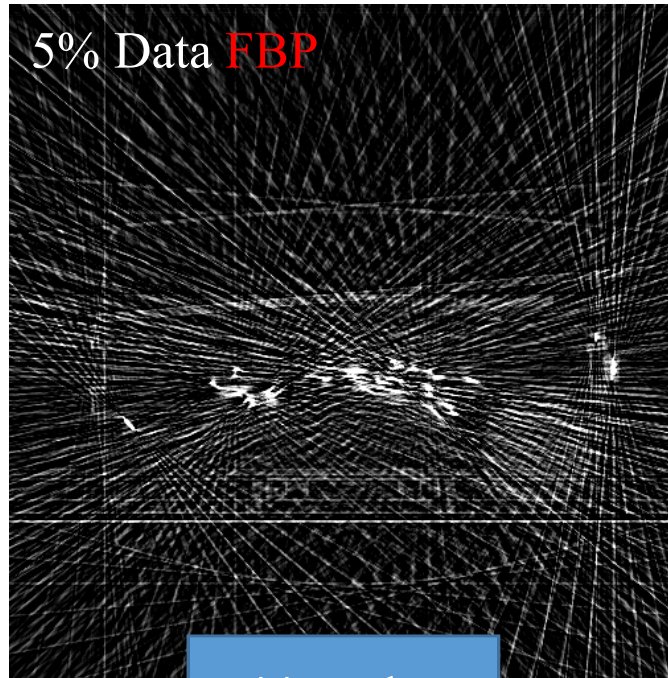
# Image comparison (2/2)

100% Data **FBP**



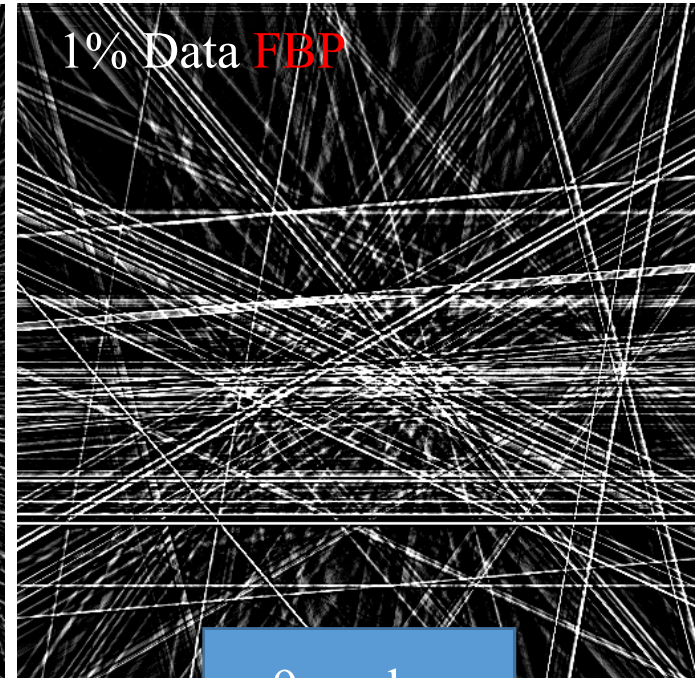
864 angles

5% Data **FBP**



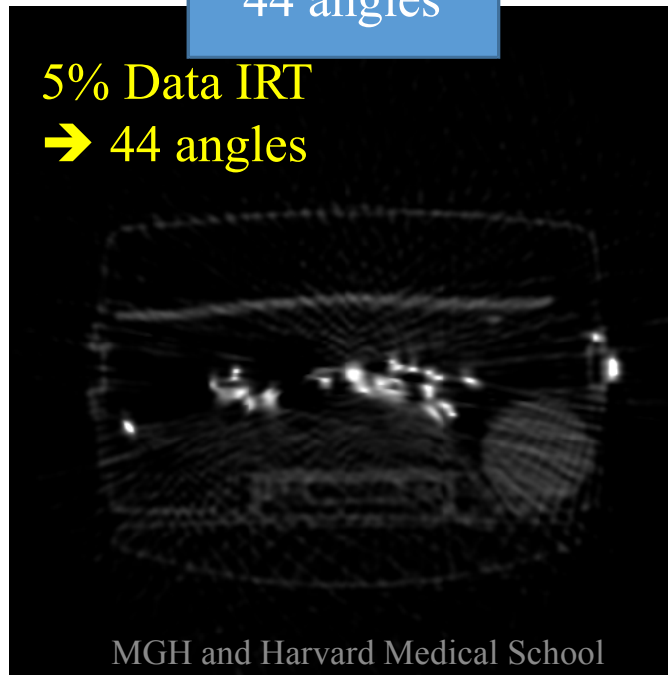
44 angles

1% Data **FBP**

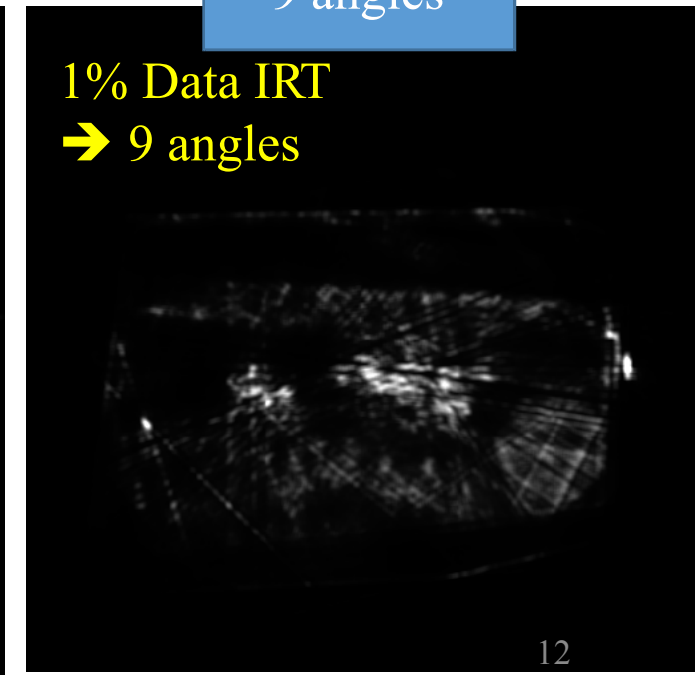


9 angles

5% Data **IRT**  
→ 44 angles



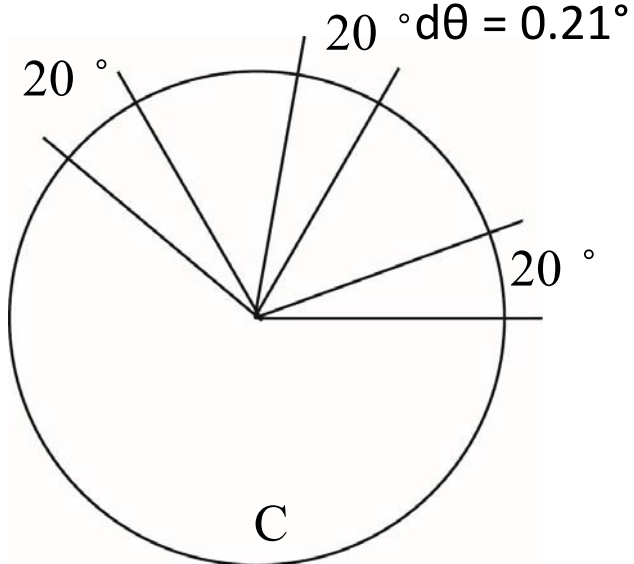
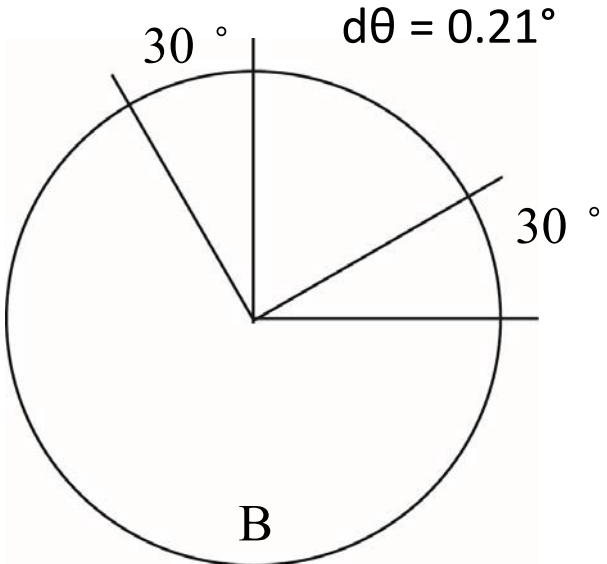
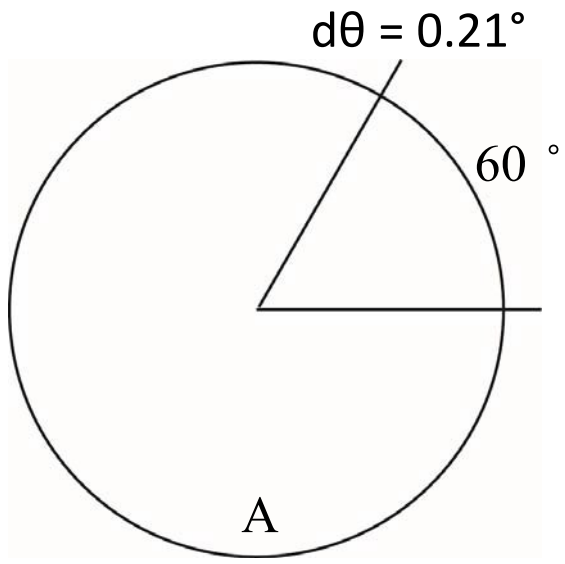
1% Data **IRT**  
→ 9 angles



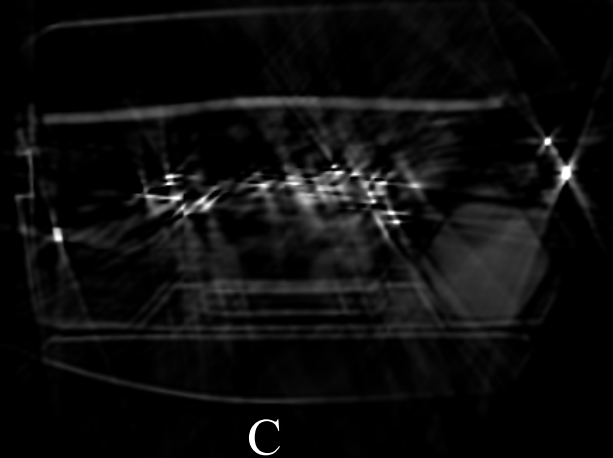
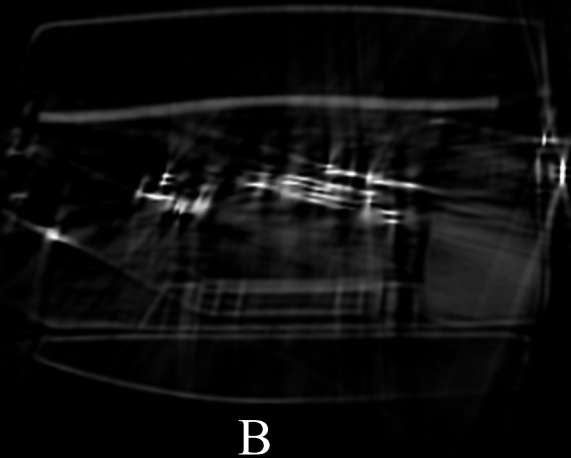
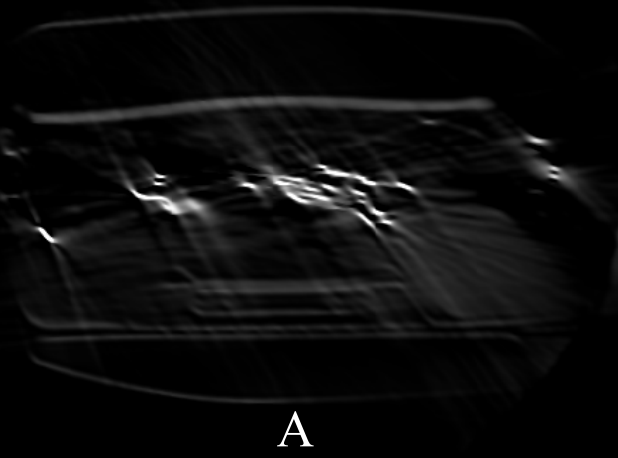
Algorithm can be improved.

# of angles:288

# Only 60 degree angular sampling



A dense and burst sampling is not a solution.



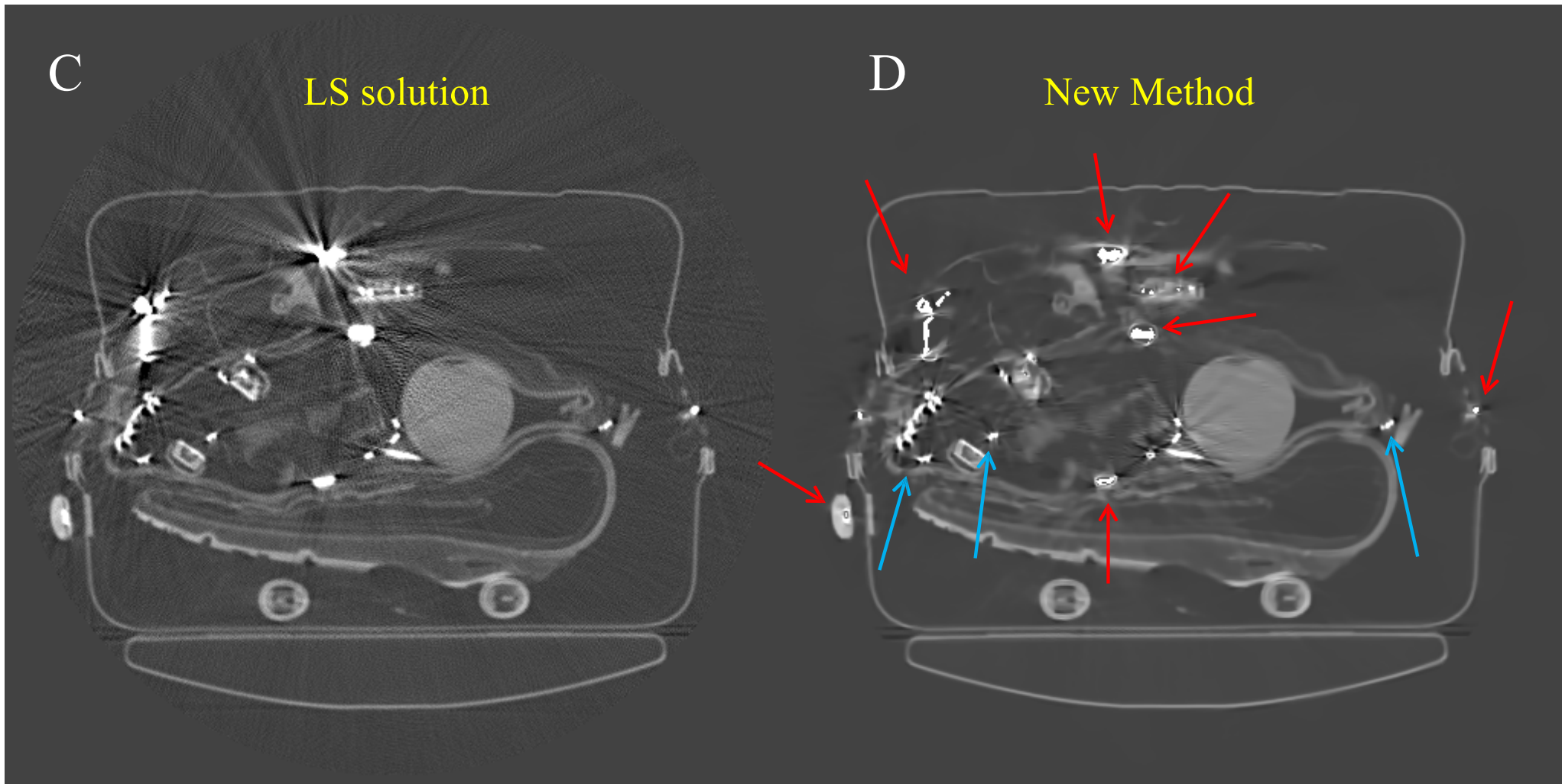
# SSMART (Sinogram **Sparcified** Metal Artifact Reduction Technology)

Practical implementation

Supported by ALERT TO3

“This material is based upon work supported by the U.S. Department of Homeland Security, Science and Technology Directorate, Office of University Programs, under Grant Award 2013-ST-061-ED0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Department of Homeland Security. [12/2013]”

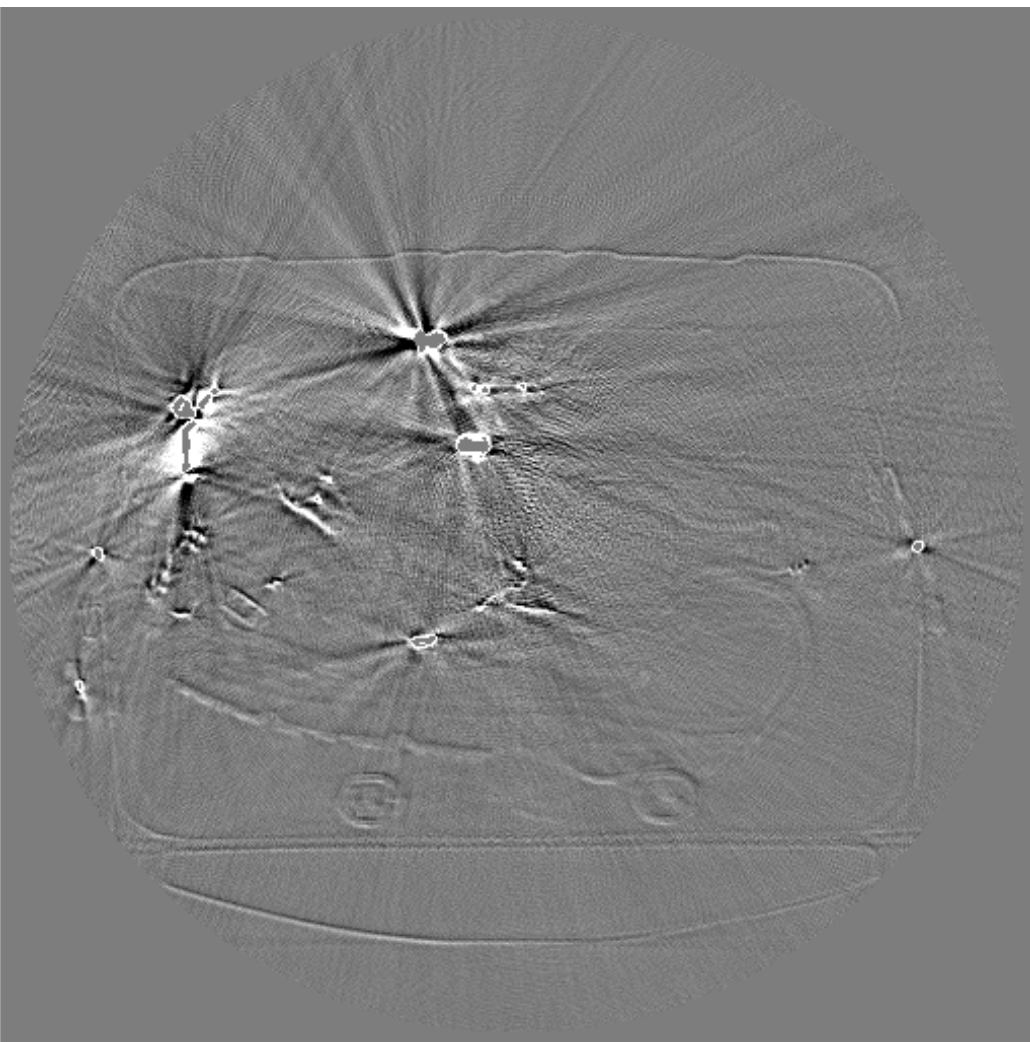
# SSMART



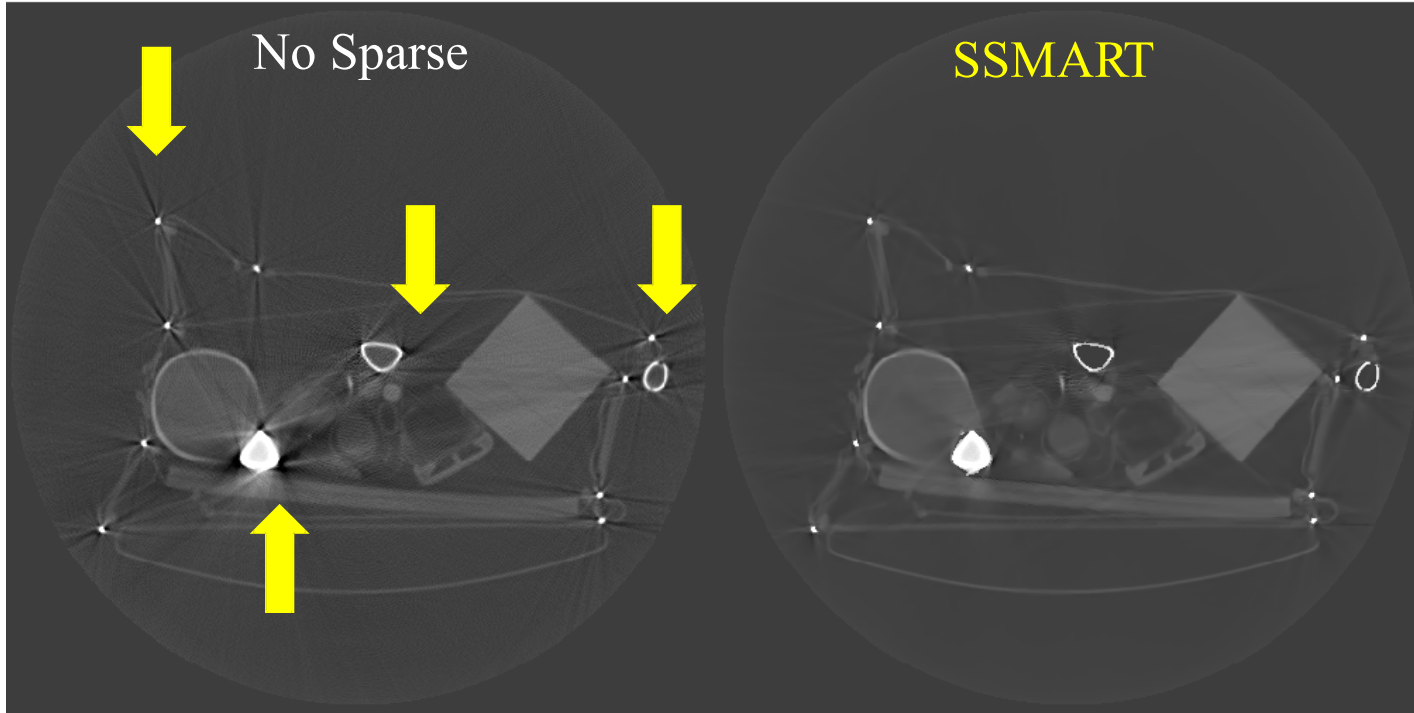
1. Metal Artifacts have gone in image D (new method).
2. Metal boundaries are not smooth so parameter tweaking will be needed.
  - **Red arrows** : Identified as metal components
  - **Blue arrows** : Not included as metal components

# Difference Map

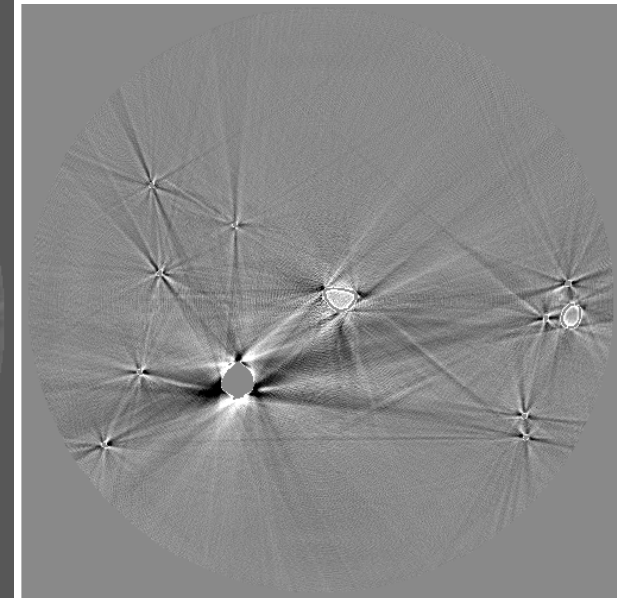
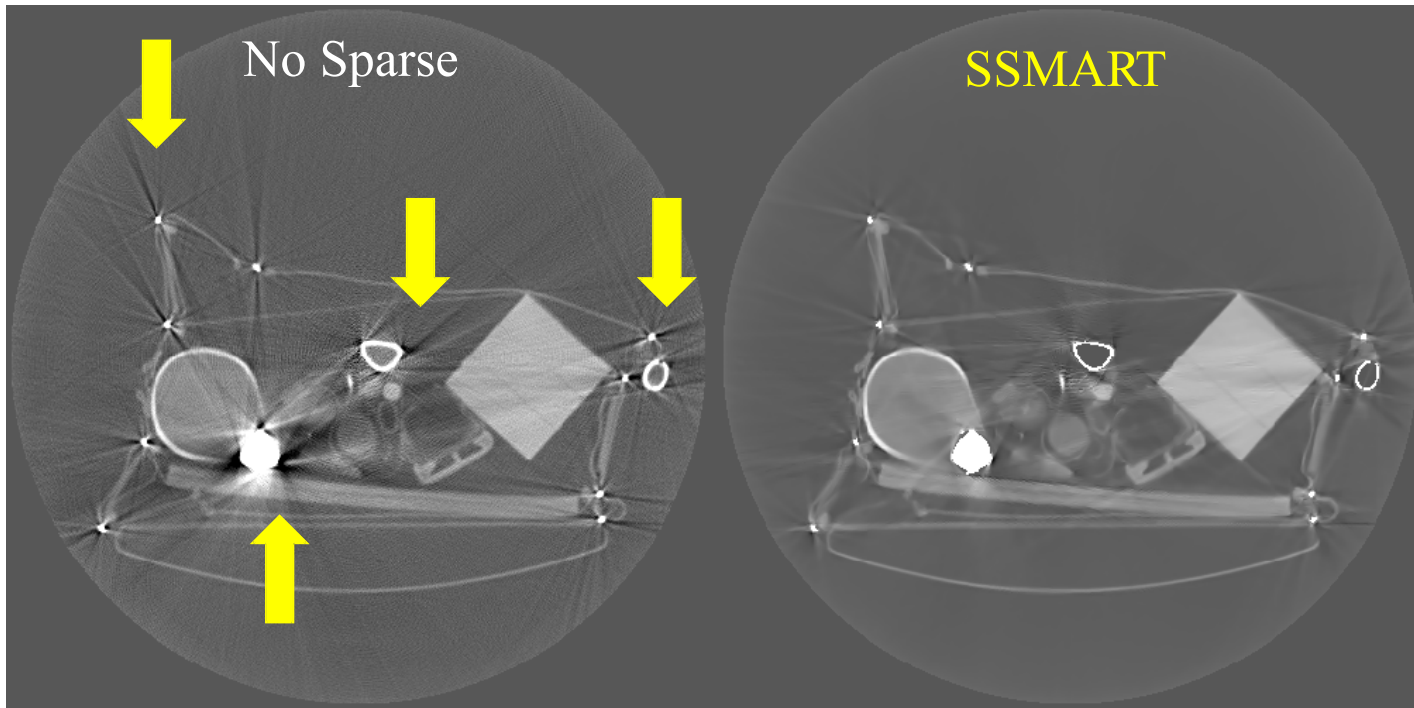
Selected Metal Components





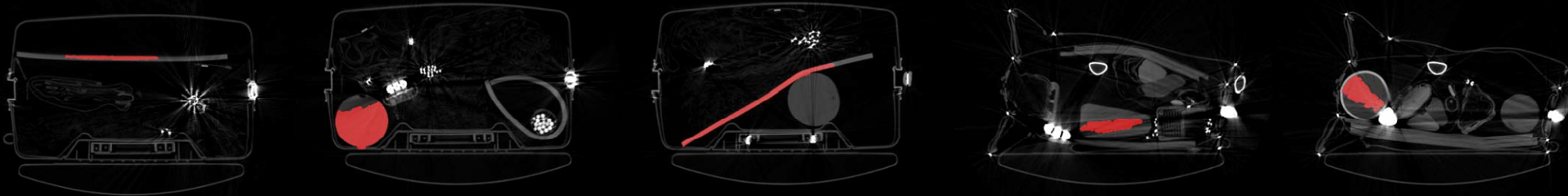


Imatron C300  
-High Clutter Case

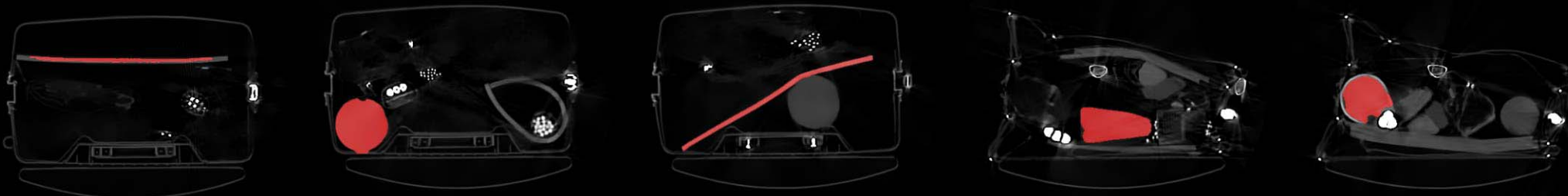


Difference Map

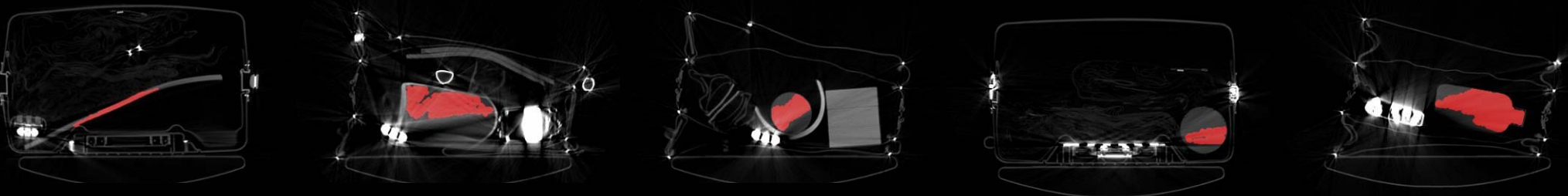
Xrec



SSMART



Xrec



# Archimedean Spiral Sparse Sensing CT

- Novel method of sensing



# Archimedean Spiral on Radon Space (ASRS):

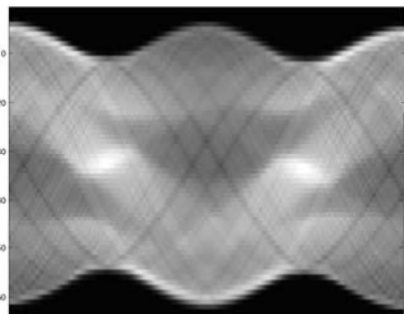
A non-uniform super-resolution compressed sampling method for tomographic imaging

Is it possible to achieve 1mm resolution with 1cm detector ?

Ideal Image



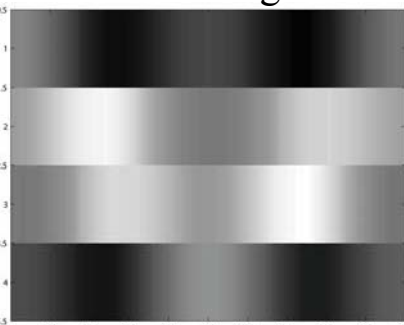
Conventional Sinogram



dx = 1 mm



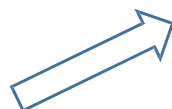
New Sinogram



dx=16 mm



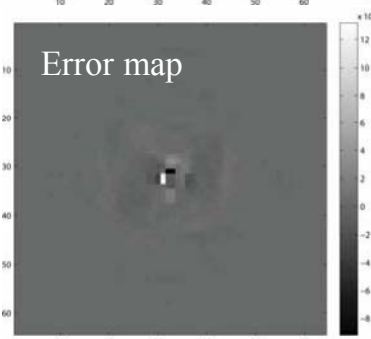
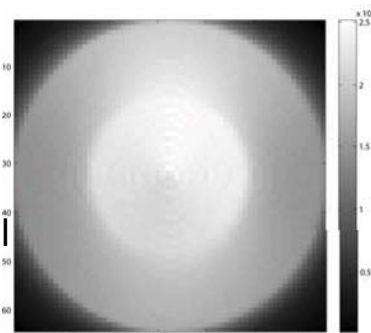
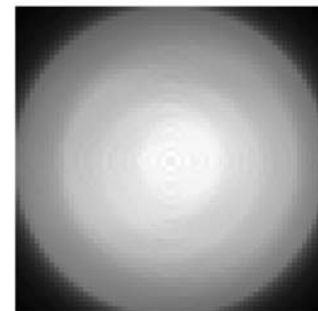
Conventional Method



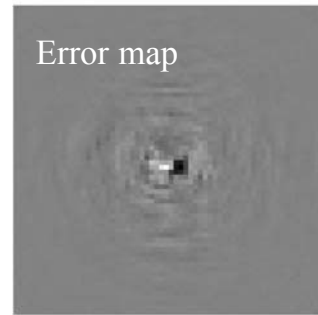
New Iterative Reconstruction method



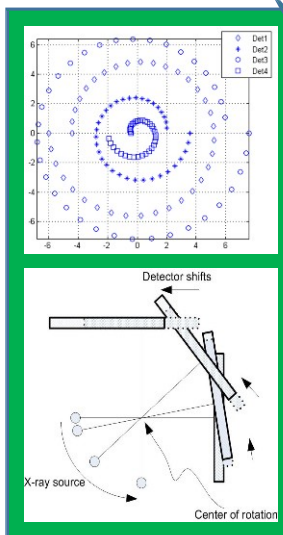
Clinical data simulation



Error map



Error map



A detector motion, generating spiral pattern on Radon space, is encoded on Sinogram.

16-fold resolution

NMSE=0.0092

Don't complain about your detector rather use a smart method.

Improvement



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- Our team at MGH has the knowledge, expertise, and skills to detect cancer tissues.
- The explosives look like terminal cancer (or cancer in the terminal) of air cargo security.

Thank you for your attention !