CT NUMBER ACCURACY ANALYSIS FOR RADIOTHERAPY TREATMENT PLANNING IMAGING

Julian Liu[a], Keisha Robinson[a], DhanaJayan Kothandan[a] and Joshua Luis[b]
(a) Cancer Centre London
(b) University College London

FACTORS AFFECT CT NUMBERS

In diagnostic Imaging

- KV
- mAs
- X-ray beam uniformity

Measured by scanning a designed phantom, e.g. Catphan or RMI 467
Consistent in Z-direction in image acquired region

Focusing on balancing patient dose and image quality (optimisation)

FACTORS AFFECT CT NUMBERS

The density of the clinical CT scanning objects are Z-direction variable

For RT treatment planning imaging, the accuracy of CT number is crucial

- Sequential or helical
- Sequential: central slice or non-central slices
- Helical: pitch and tube starting position

Scanning phantoms

- Modified RMI 467
- Rambo head

METHODS AND EXPERIMENTS

A Siemens Somatom Definition AS64 CT scanner

Phantom RMI467 with setting up as

- (a) Swap positions of LN300 Lung and CB2-50% with cortical bone and B200 Bone, respectively
- (b) Set the depth of the inserts cortical bone and CB2-50% as 24.25mm and 25.75mm, respectively

Rambo Head phantom

METHODS AND EXPERIMENTS

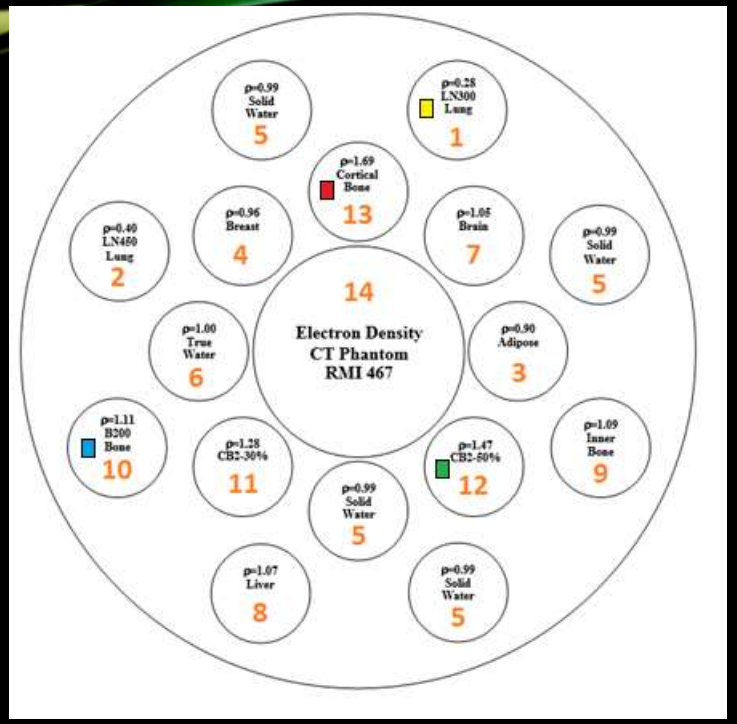
Protocols

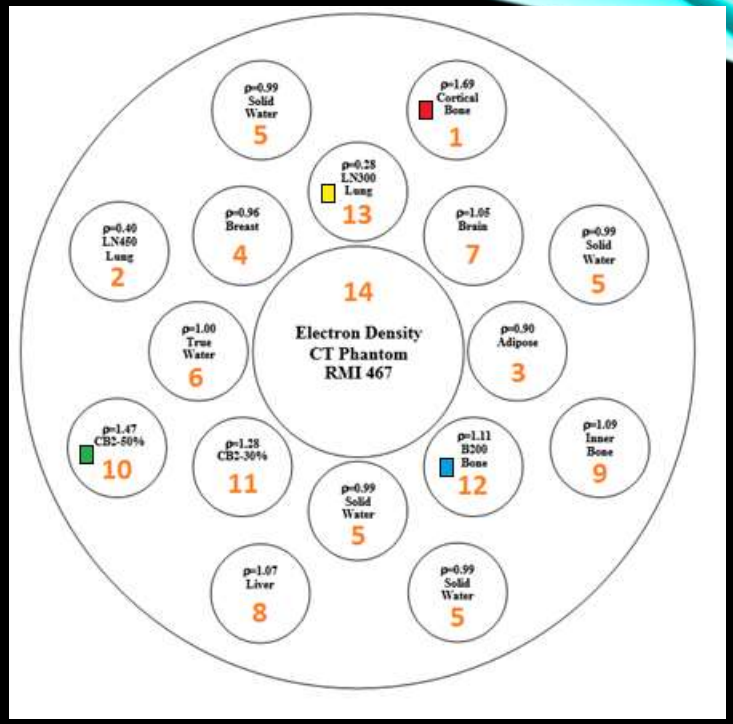
1. Abdomen Routine, Caredose/CarekV off, 120 kV, 450 mAs, 0.6 mm, 1 second rotation, 32 x 0.6 (19.2mm), pitch: 0.55, 0.80, 1.00, 1.25 and 1.45 (5 protocols)
2. Abdomen Routine Sequential, Caredose/CarekV off, 120 kV, 450 mAs, 0.6 mm, 1 second rotation, 32 x 0.6 (19.2mm) (1 protocol)

METHODS AND EXPERIMENTS

Scans

- All protocols and RMI 467 (a) (6 scans)
- Protocol 2) and RMI 467 (b) with and without ±3mm and ±6mm central slice location shift (5 scans)
- Protocol 1) and RMI 467 (b) with 5 times repeat (5 x 5 =25 scans)
- All protocols and Rambo with 5 times repeat (6 x 5 = 30 scans)





Scans: 66

Images: 66 x 28

ROIs: 14

- 16 inserts where the four of solid water as one (1st - 13th)
- the rest of the whole area of RMI 467 (14th)

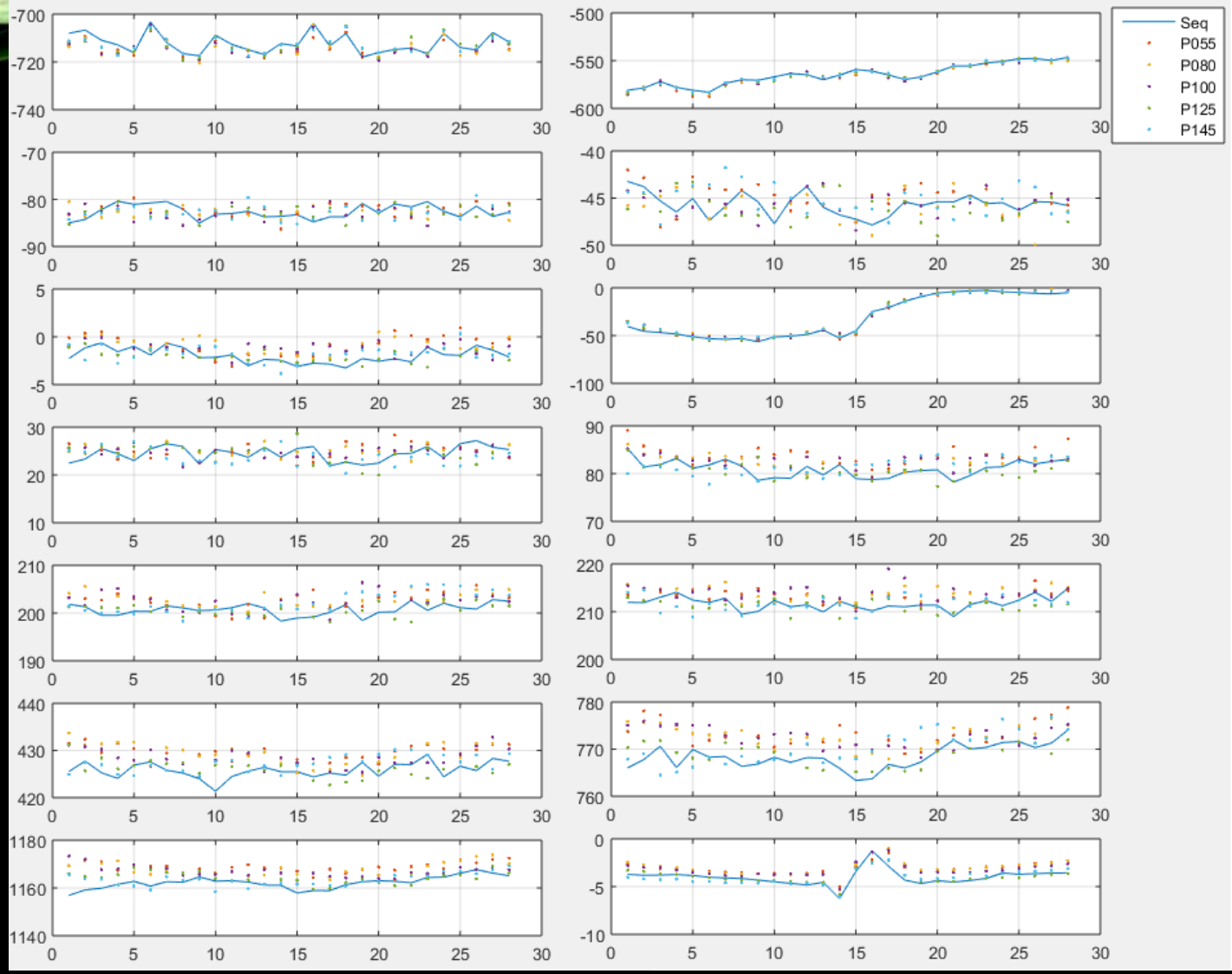
Fully inserted RMI

Protocol:

- Sequential
- Helical: 0.55, 0.80, 1.00, 1.25 and 1.45

Measurements

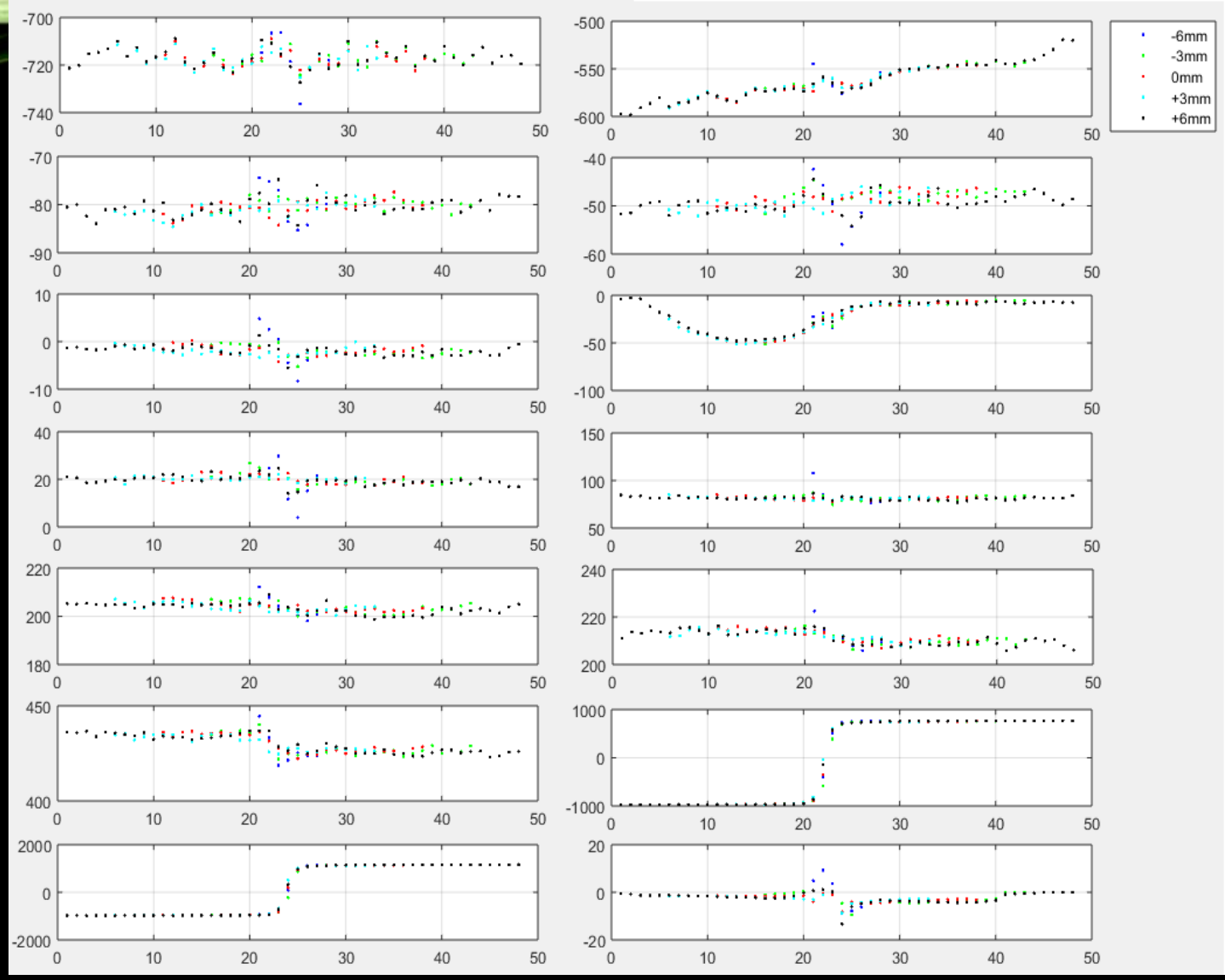
- 12 of 14 ROIs within ±10
- True water with a bubble
- LN450 Lung ±25,due to poor density consistency in z-direction of the insert



Partial inserted RMI

Protocol:

- Sequential
- Central slice position shift 0, ±3, ±6 (mm)



Measurements

- 3 of 14 ROIs within ±10
- 7 of 14 ROIs within ±20
- 2 of 14 ROIs within ±25
- The ROIs of partial inserts were dynamic, and the ±3mm shift causing worst error up to ± 420 & ± 140

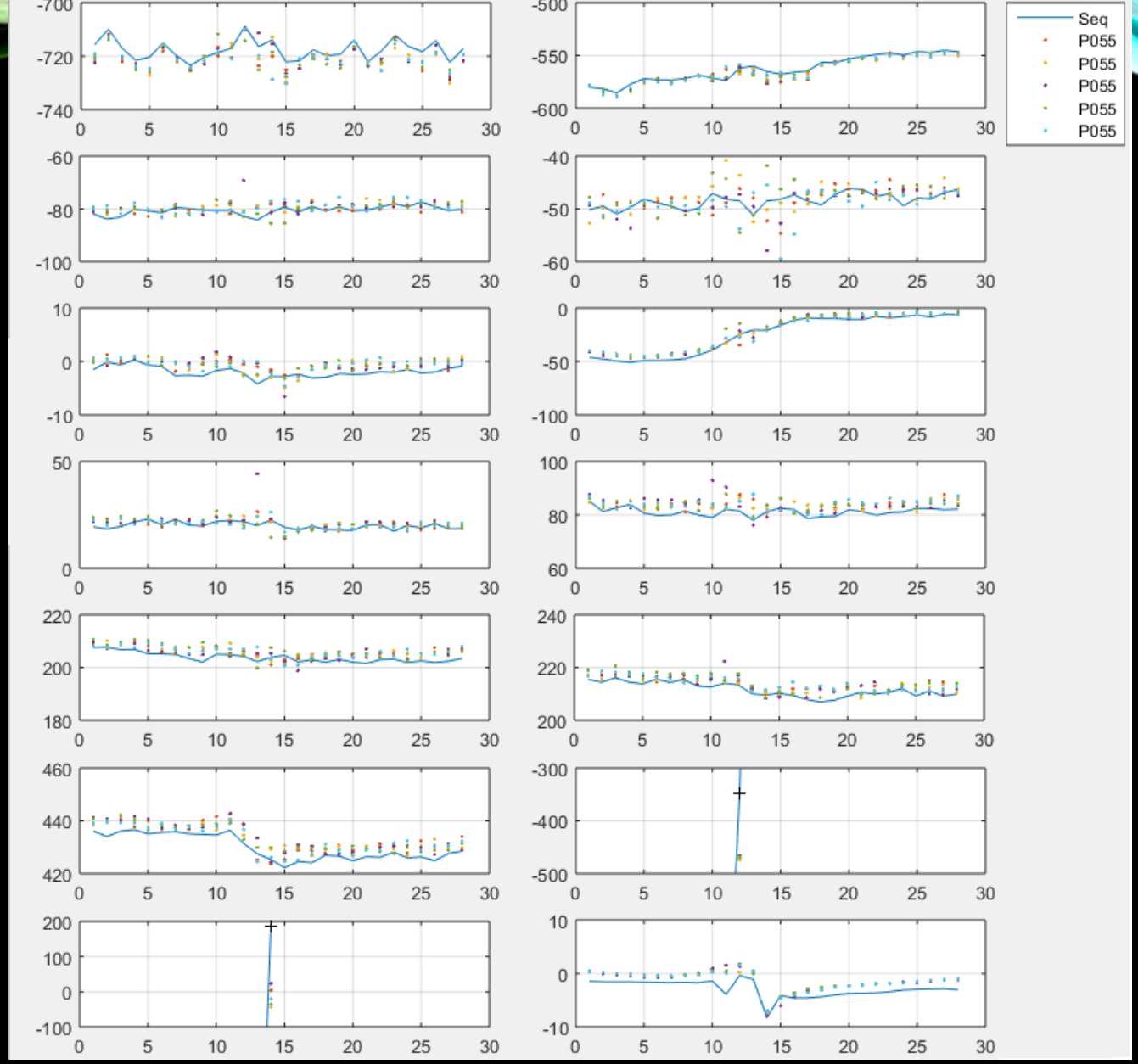
Partial inserted RMI

Protocol:

- Helical, starting tube location sensitivity
- Pitch 0.55

Measurements

- 3 of 14 ROIs within ±10
- 8 of 14 ROIs within ±20
- 1 of 14 ROIs within ±25
- The ROIs of partial inserts were within ±30 and ±50, and significant different from the results of Sequential protocol, about 130 and 170



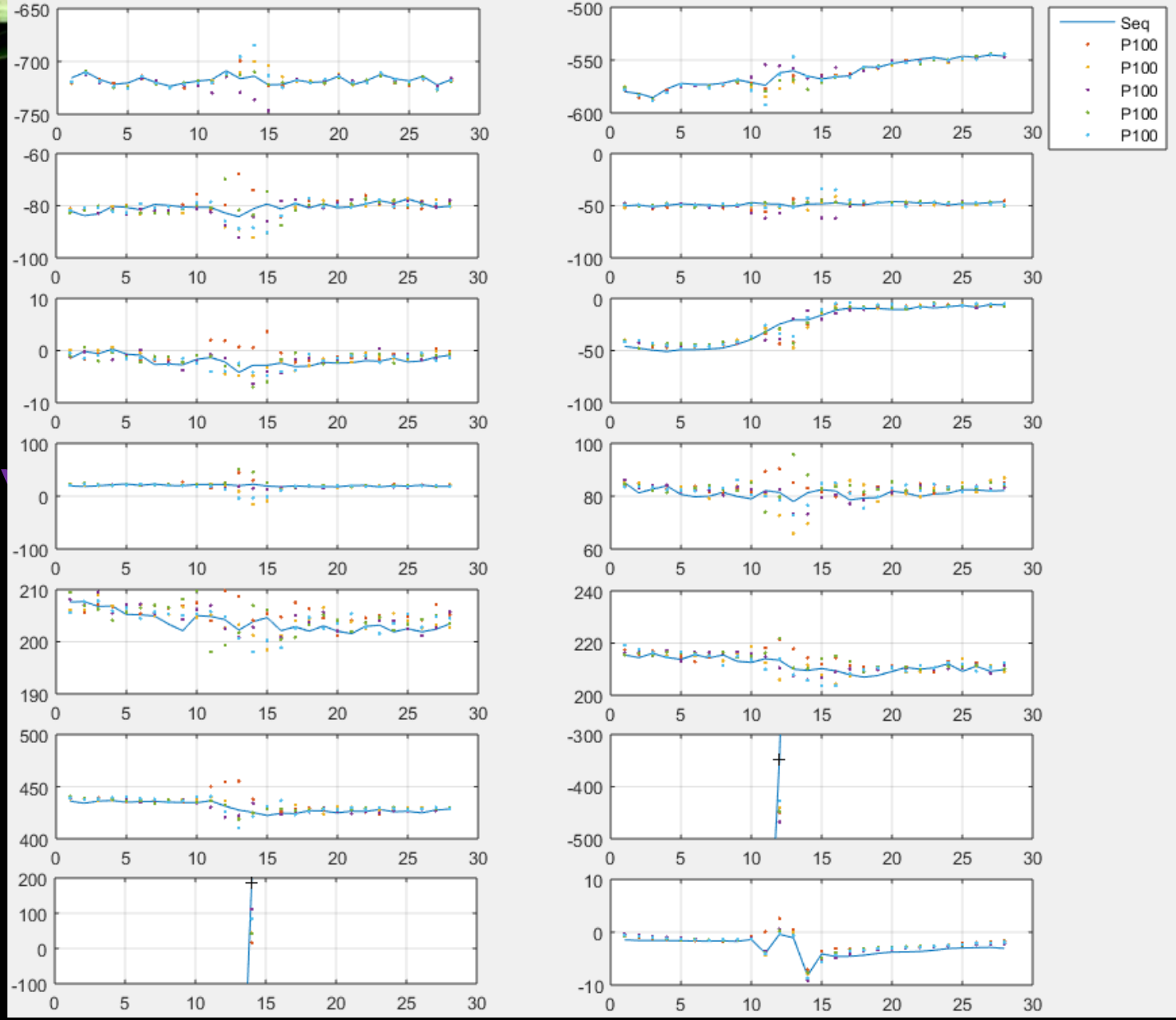
Partial inserted RMI

Protocol:

- Helical, starting tube location sensiti
- Pitch 1.00

Measurements

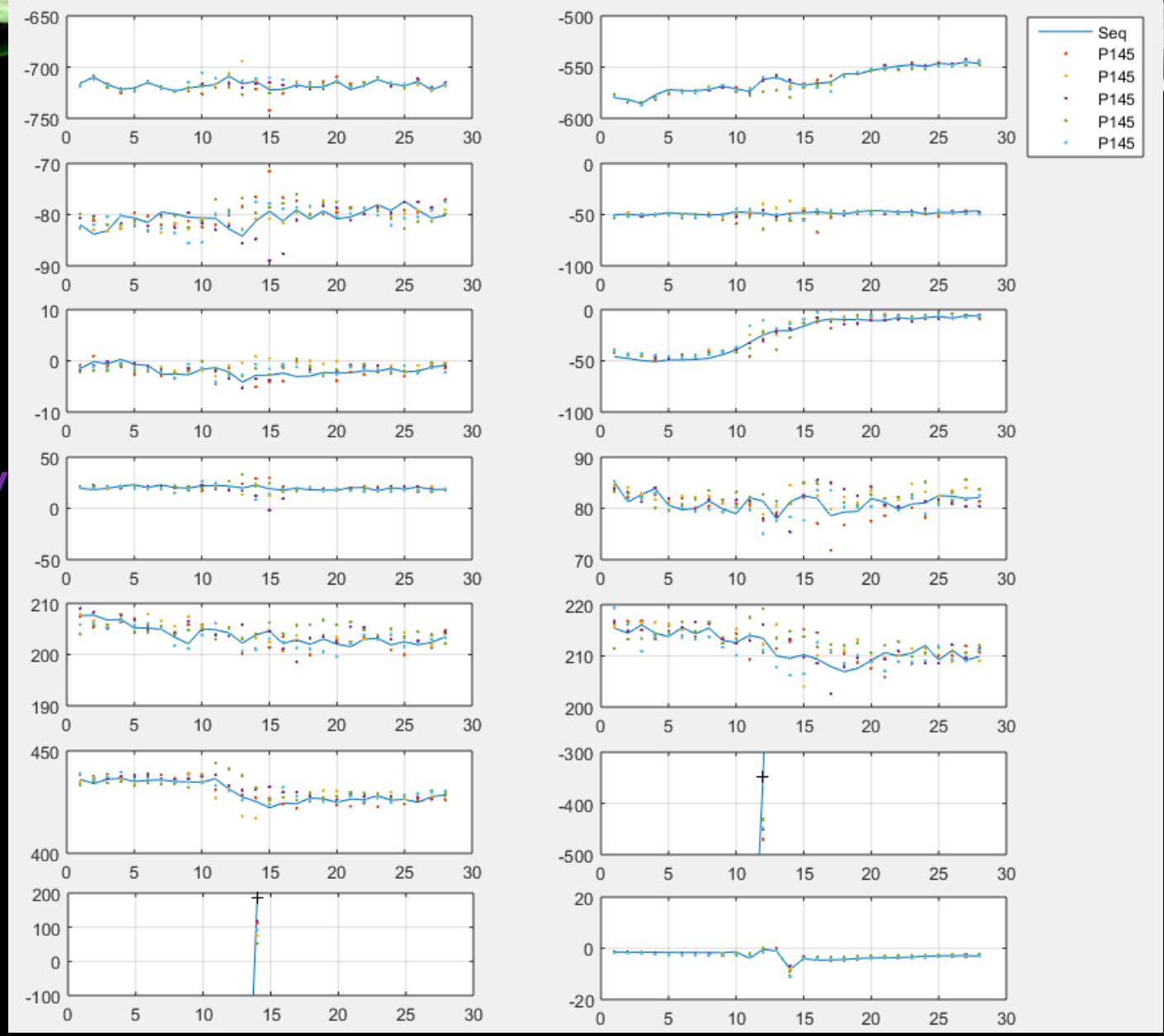
- 3 of 14 ROIs within ±10
- 3 of 14 ROIs within ±20
- 5 of 14 ROIs within ±25
- 1 of 14 ROIs within ±50
- The ROIs of partial inserts were within ±35 and ±70, and significant different from the results of Sequential protocol, about 110 and 150



Partial inserted RMI

Protocol:

- Helical, starting tube location sensitiv
- Pitch 1.45



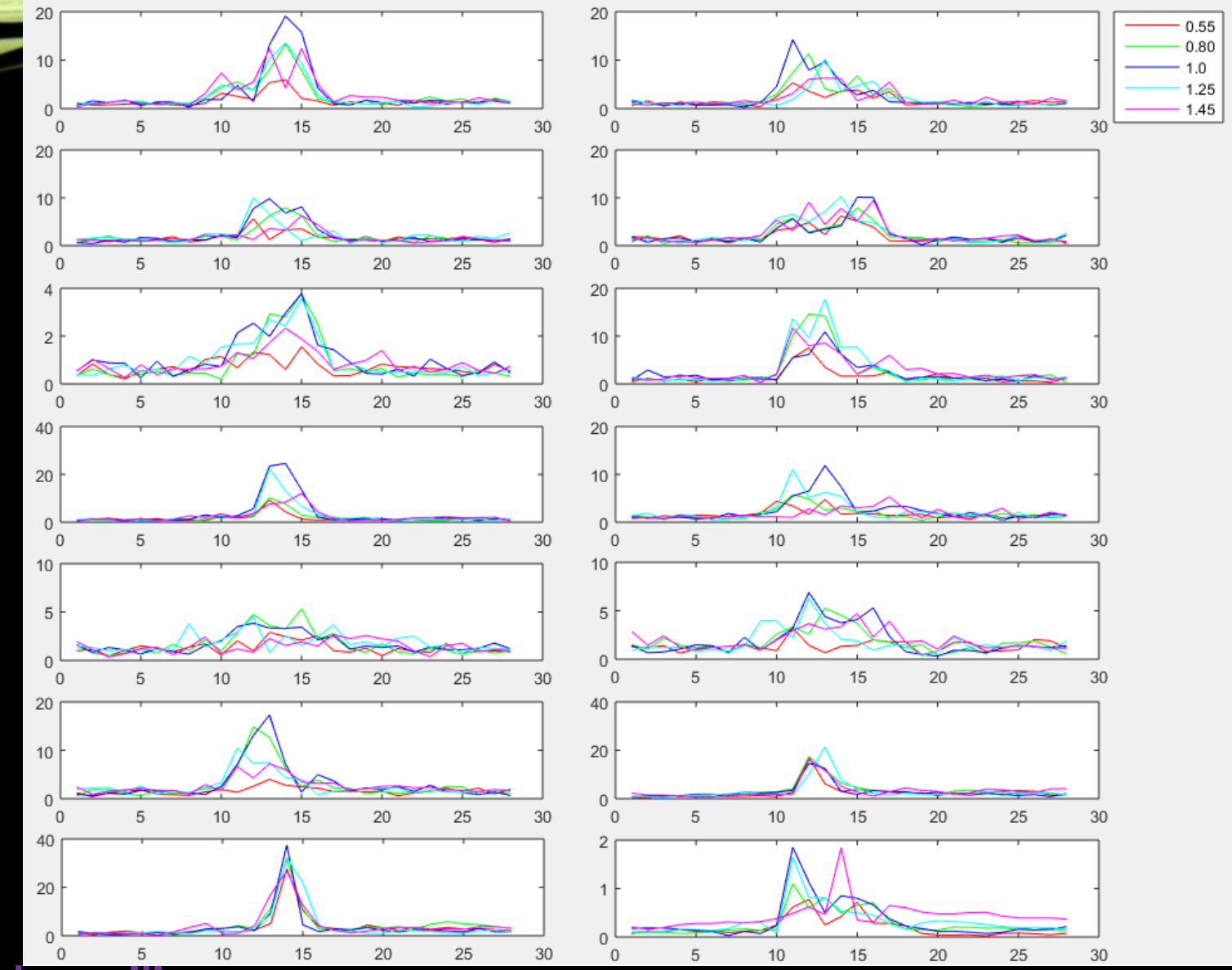
Measurements

- 6 of 14 ROIs within ±10
- 5 of 14 ROIs within ±25
- 1 of 14 ROIs within ±30
- The ROIs of partial inserts were within ±30 and ±35, and significant different from the results of Sequential protocol, about 120 and 110

Partial inserted RMI

Protocol:

- Helical, starting tube location sensitivity
- Standard deviation cross the pitches



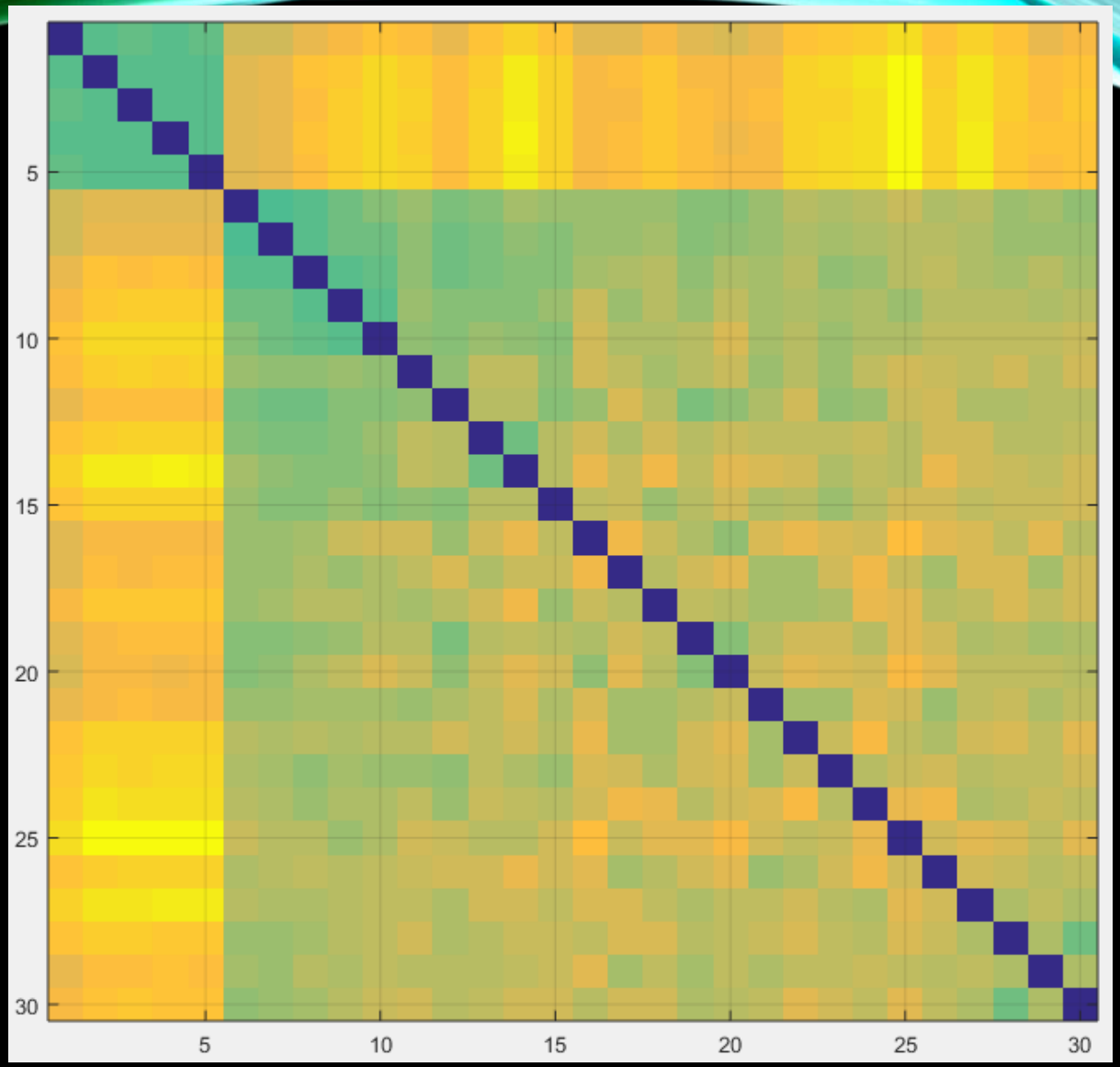
Measurements

- Pitch = 0.55 is the most robust
- In general, pitch = 1.00 is the most sensitive
- Pitch = 1.45 is not the most sensitive may because the method for sinogram generation developed by the manufacturer

Rambo head phantom

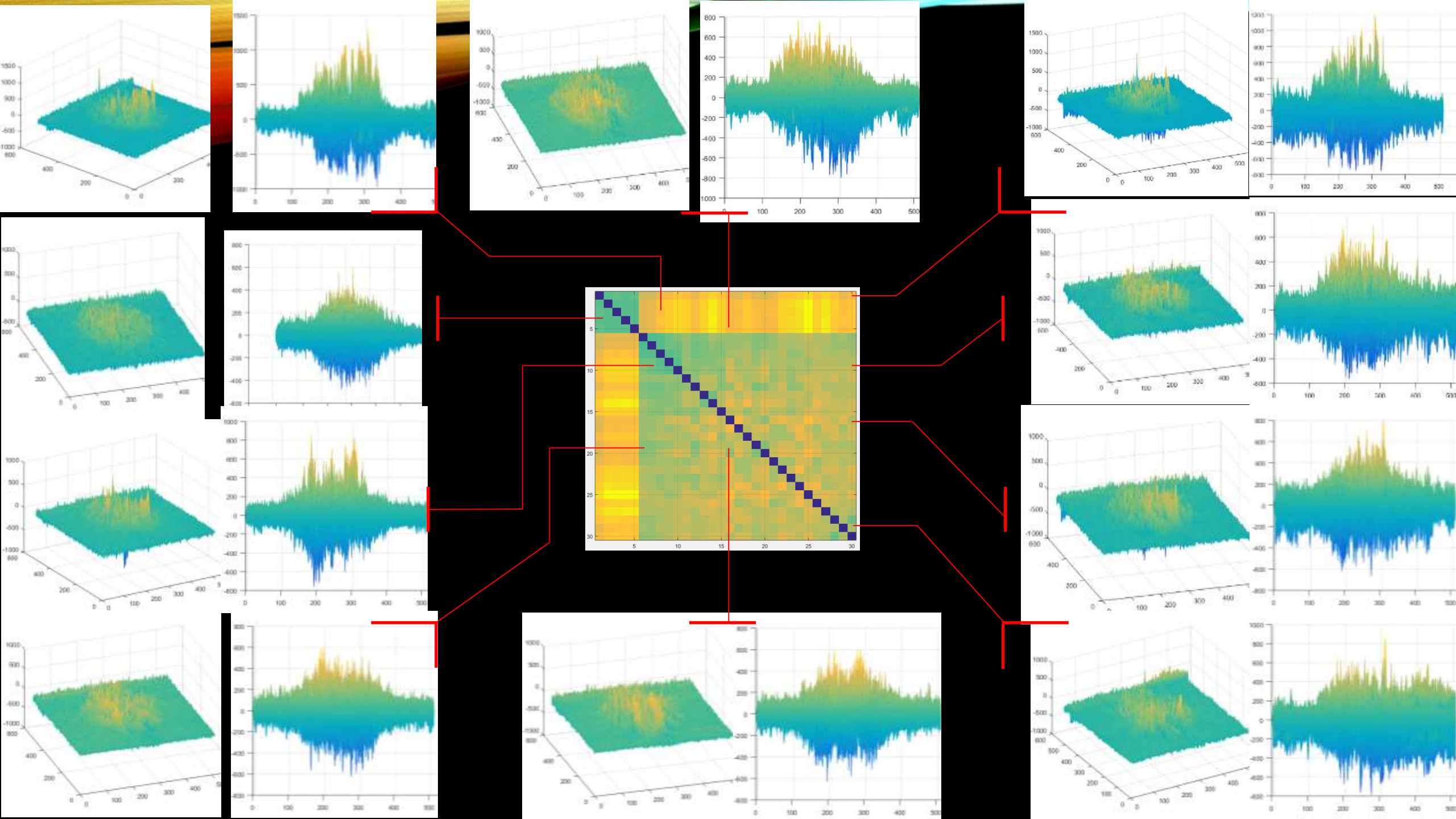
Protocol and scan:

- Sequential (1-5)
- Helical: 0.55, 0.80, 1.00, 1.25 and 1.45 (6-30)
- All repeated 5 times, 30 scans



Measurements

Difference analysis via subtract between images



DISCUSSIONS

- Confirmed the robustness of the relevant factors with z-direction constant while all of the inserts were with full depth.
- The errors in cortical bone CT number caused by central slice location ±3mm and ±6 mm up to ±420 HU and ±140 HU, respectively
- The statistical analysis showed that the 0.55 pitch had significant better consistency to the tube starting position and the robustness to the z-direction density variation.
- The ±3mm shift and 1.0 pitch were the worst may due to no correction

CONCLUSIONS

- The accuracy of CT numbers in axial scans is robust to the variation of x-ray tube starting position, in the central slice it is robust to z-direction variation but not other slices of which could be worse than some of the helical scans.
- The accuracy of CT numbers in helical scans is affected by z-direction variation, x-ray tube starting position and the pitch. As a result, we recommended pitch=0.55 to obtain better constant accuracy of CT numbers for radiotherapy treatment planning imaging using a Siemens Somatom AS scanner.
- The accuracy of Radiotherapy treatment planning imaging should be considered as one of the key factors of uncertainty.

FURTHER INVESTIGATION

- Extending this investigation to more protocols of CT scan for radiotherapy treatment planning imaging, and all of the models and makes.
- Quantitatively investigate the consequence of imaging error in treatment planning
- recommending a suitable method of CT reconstruction for Radiotherapy treatment planning imaging
- Considering a better method of generating the projection with high computational efficiency

Thank you!