Scan Acquisition Settings - Trade Offs Between Speed, Resolution and Dose

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Overview

- Clinical Considerations
- Technical Considerations
  - Rotation time and mA
  - Pitch
  - Image thickness
  - Collimation settings
  - kiloVoltage
  - Reconstruction algorithm

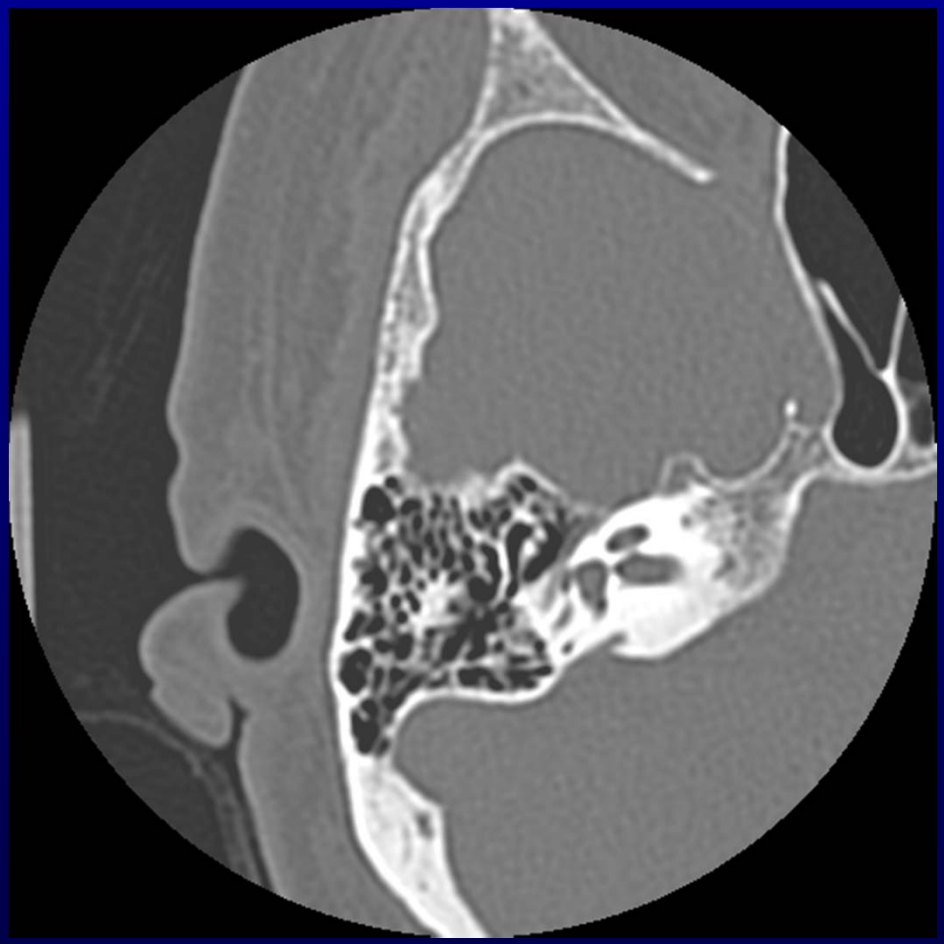
Clinical Considerations

- Scan time
  - Single breath-hold
    - <15 seconds
  - Less patient motion
    - Especially peds
    - Emergency room

Breathing motion in upper image

Clinical Considerations

- High-contrast spatial resolution
  - Fine detail
  - Thin images

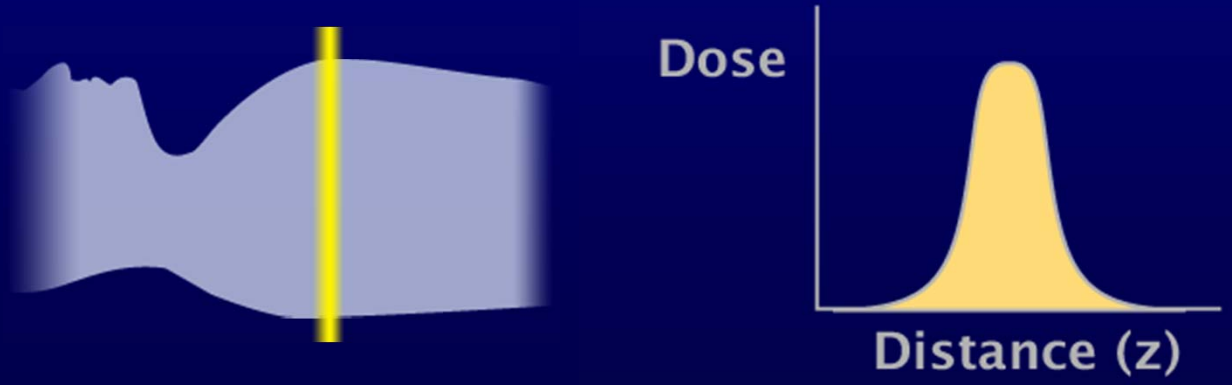


Clinical Considerations

- Low-contrast resolution
  - Low noise
  - Organ boundaries & structures

Clinical Considerations

- Dose
  - Not too high
  - Not too low
  - Matched to clinical task & patient size



Rotation Time

- Affects
  - Total scan time (proportional)
  - Noise / Low contrast resolution
  - Dose (proportional)

  Generally want to minimize rotation time

- Note:
  - IV contrast timing may need adjustment
  - mA needed may exceed tube/generator limits

mA

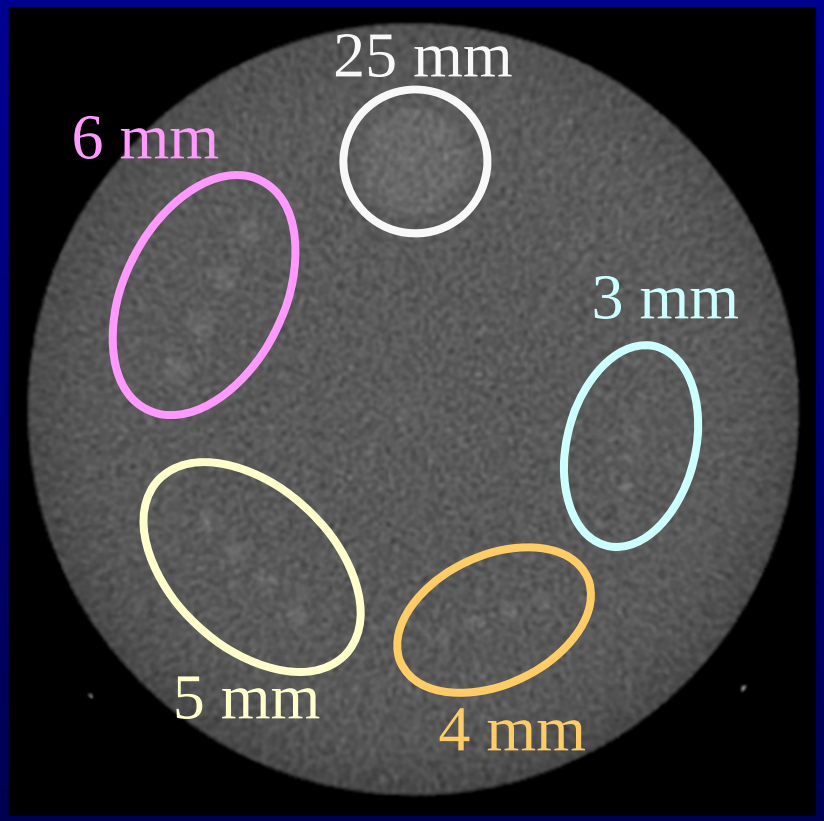
- Affects
  - Noise / Low contrast resolution
  - Dose (proportional)
- Note:
  - mA near tube/generator limits can be problematic (especially when dose modulation is used)

Pitch

- Affects
  - Total scan time
  - Noise / Low contrast resolution
  - Dose
- Note:
  - Pitches >1 may increase image thickness (vendor-specific)
  - Pitches >1 may require mA to be increased near limits

Pitch

Pitch	$CTDI_{vol}$
0.562	162

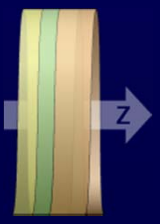


Variable pitch.

All other parameters constant.

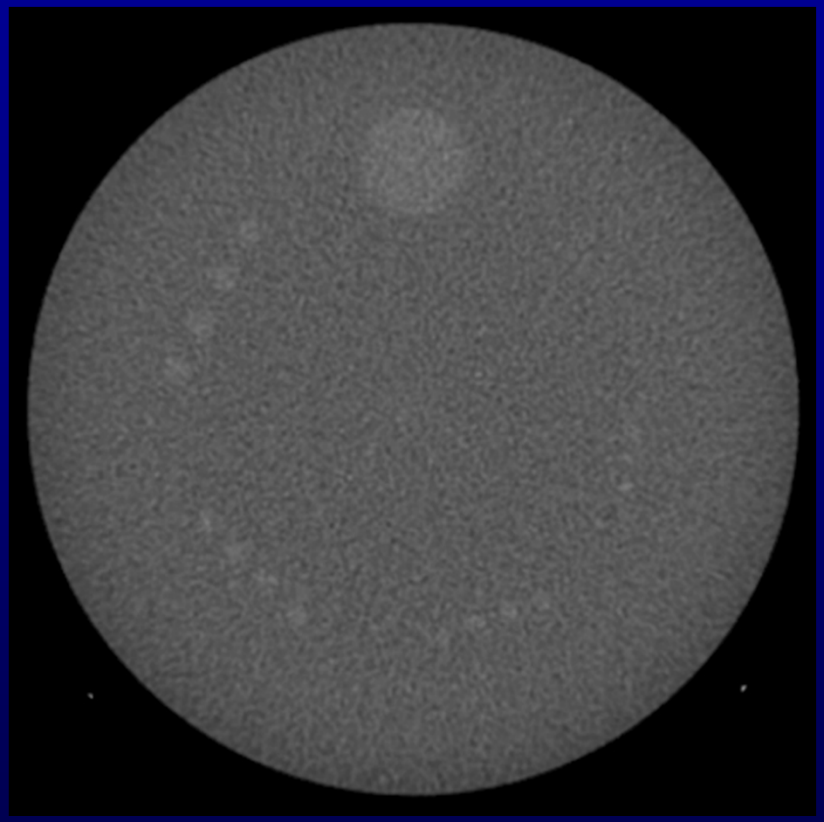
Pitch: 0.562

$CTDI_{vol}$: 162 mGy



Pitch

Pitch	$CTDI_{vol}$
0.562	162

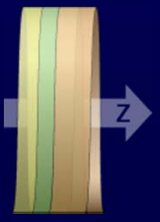


Variable pitch.

All other parameters constant.

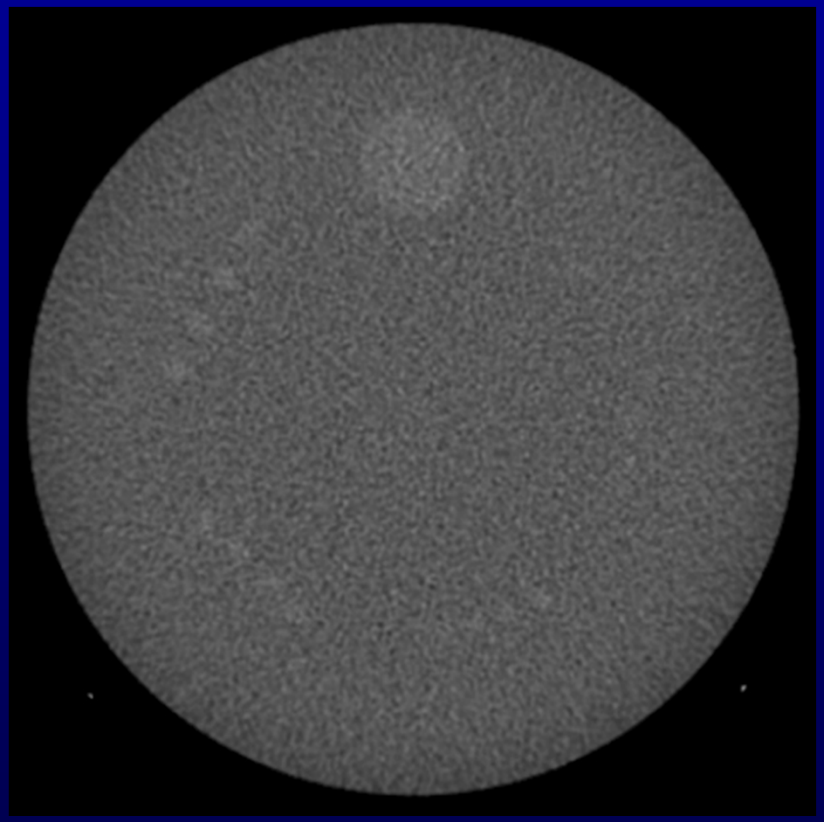
Pitch: 0.562

$CTDI_{vol}$: 162 mGy



Pitch

Pitch	$CTDI_{vol}$
0.562	162
0.938	97

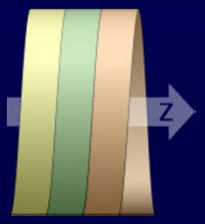


Variable pitch.

All other parameters constant.

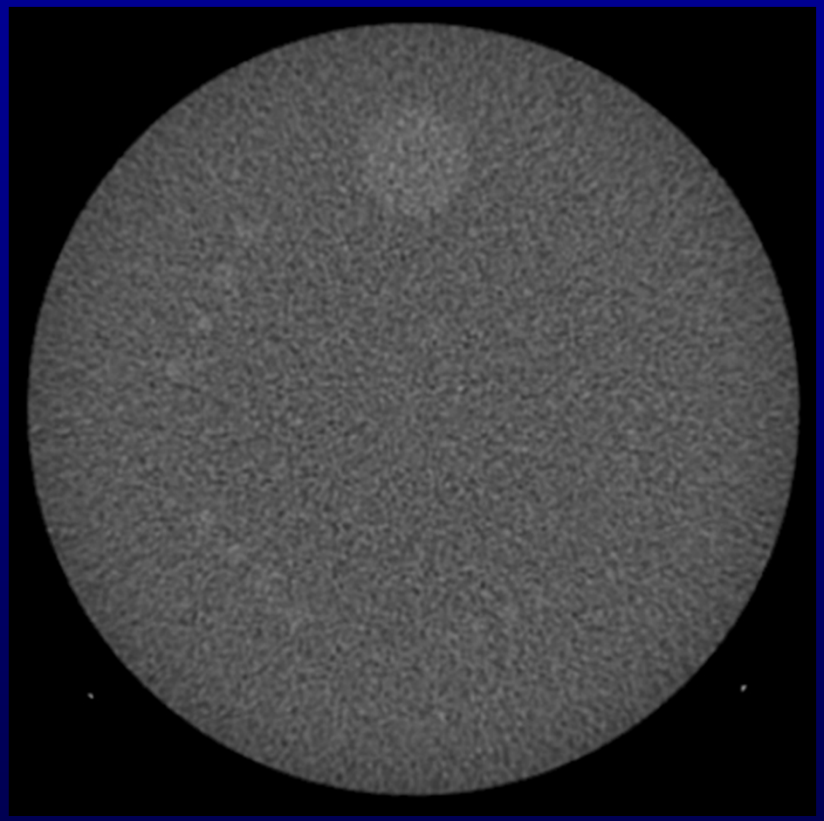
Pitch: 0.938

$CTDI_{vol}$: 97 mGy



Pitch

Pitch	$CTDI_{vol}$
0.562	162
0.938	97
1.375	66

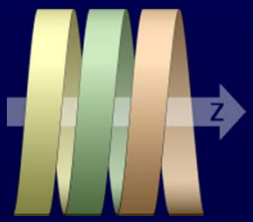


Variable pitch.

All other parameters constant.

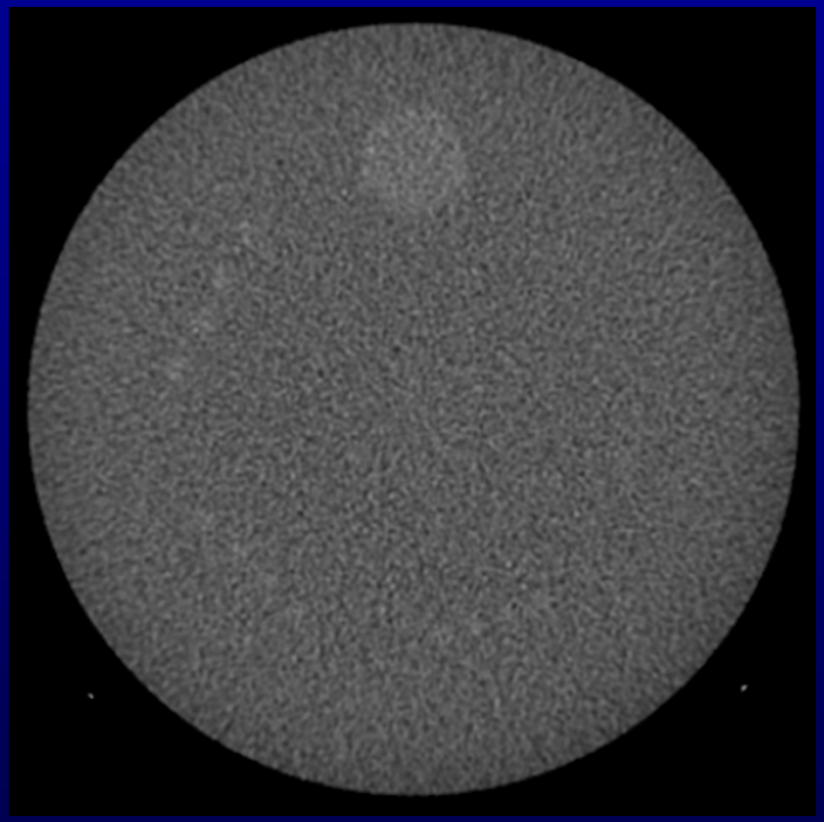
Pitch: 1.375

$CTDI_{vol}$: 66 mGy



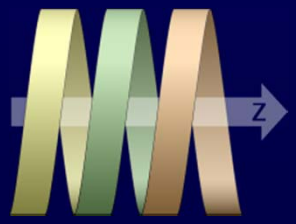
Pitch

Pitch	$CTDI_{vol}$
0.562	162
0.938	97
1.375	66
1.75	52



Pitch: 1.75

$CTDI_{vol}$: 52 mGy



Variable pitch.

All other parameters constant.

Pitch, Rotation Time, mAs

Eff mAs = 280
Rotn time: 0.5s, Pitch: 0.8
Total scan time: 20s

Want scan time to be 15s

Change pitch to 1.1 (scan time=14.5s)

But max eff. mAs=264 (need 280)

Maybe use p=1.0 (scan time=16s)?

How about rotn time=0.33, p=0.6?

Gives scan time=17.6s

	kV	120
	max mA:	580
Time	Pitch	Max Eff mAs
0.33	0.5	383
	0.6	319
	0.7	273
	0.8	239
	0.9	213
	1.0	191
	1.1	174
	1.2	160
	1.3	147
	1.4	137
	1.5	128
0.5	0.5	580
	0.6	483
	0.7	414
	0.8	363
	0.9	322
	1.0	290
	1.1	264
	1.2	242
	1.3	223
	1.4	207
	1.5	193
1.0	0.5	1160
	0.6	967
	0.7	829
	0.8	725
	0.9	644
	1.0	580
	1.1	527
	1.2	483
	1.3	446
	1.4	414
	1.5	387

Image Width

- Affects
  - Noise / Low contrast resolution
  - Dose (?)
- Note:
  - Potential to dramatically increase mA (and dose) to compensate for increased noise with thinner images

Image Thickness

$$\text{Noise} \propto \frac{1}{\sqrt{\#\ \text{Photons}}}$$

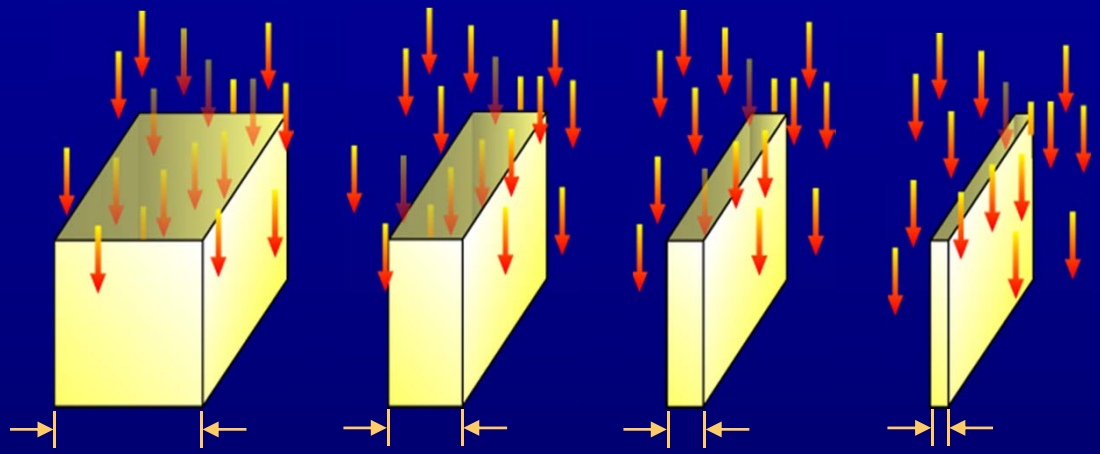
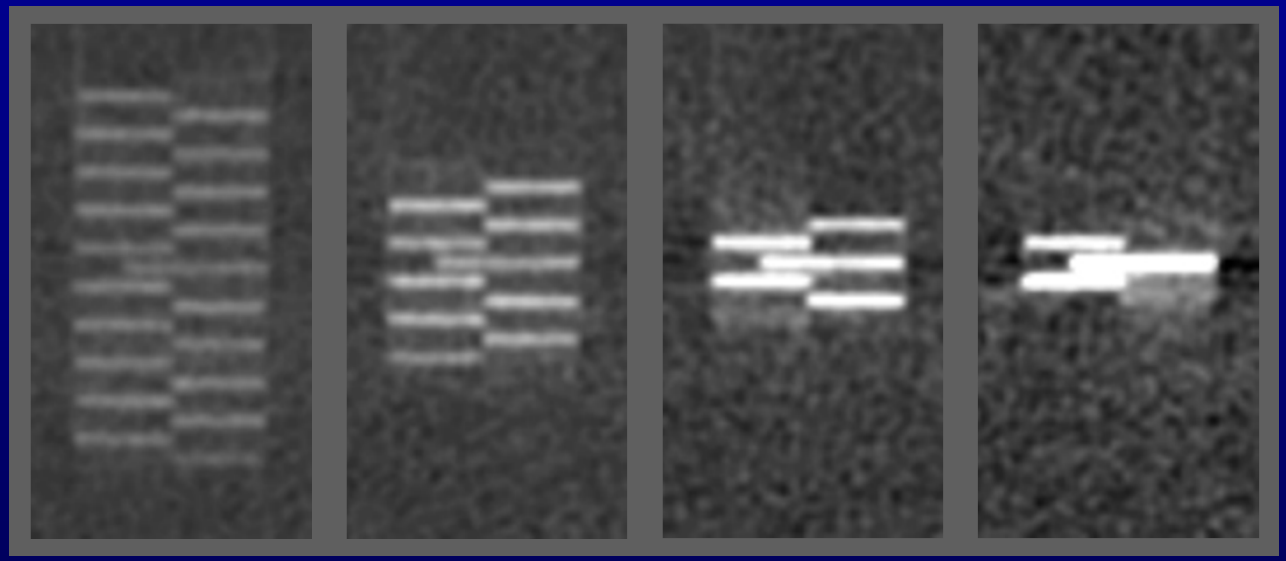


Image (mm):	5	2.5	1.25	0.625
Rel. Noise:	100%	141%	200%	283%
Req. mAs (for = noise):	100%	200%	400%	800%

- **Better z-resolution (less partial vol. averaging)**
- **Increased image noise**
- ***Potential* for increased radiation dose**

Image Thickness

Image (mm):	10	5	2.5	1.25

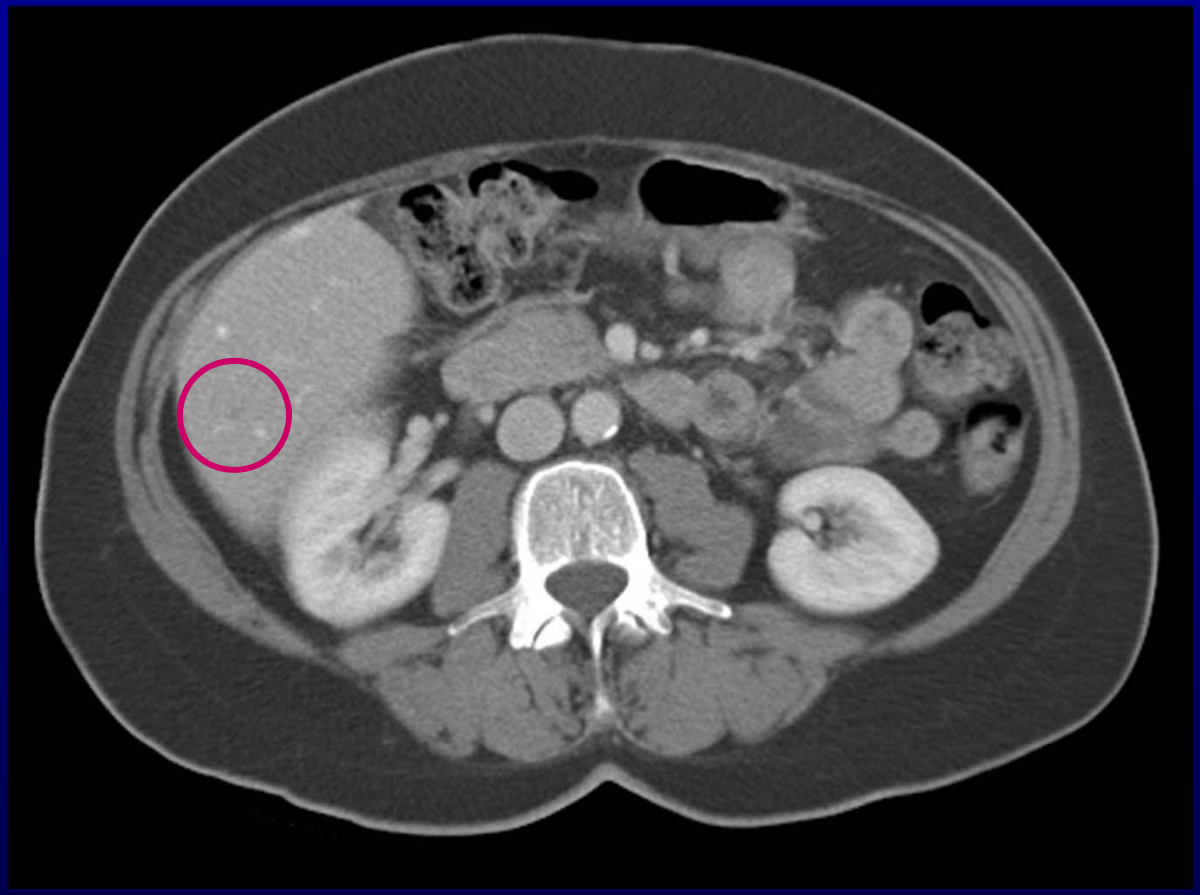


Noise (HU):	2.93	3.84	5.89	7.82

Thinner images => less partial volume effect

Only image thickness varied, all other parameters are identical

Image Thickness



10mm image thickness

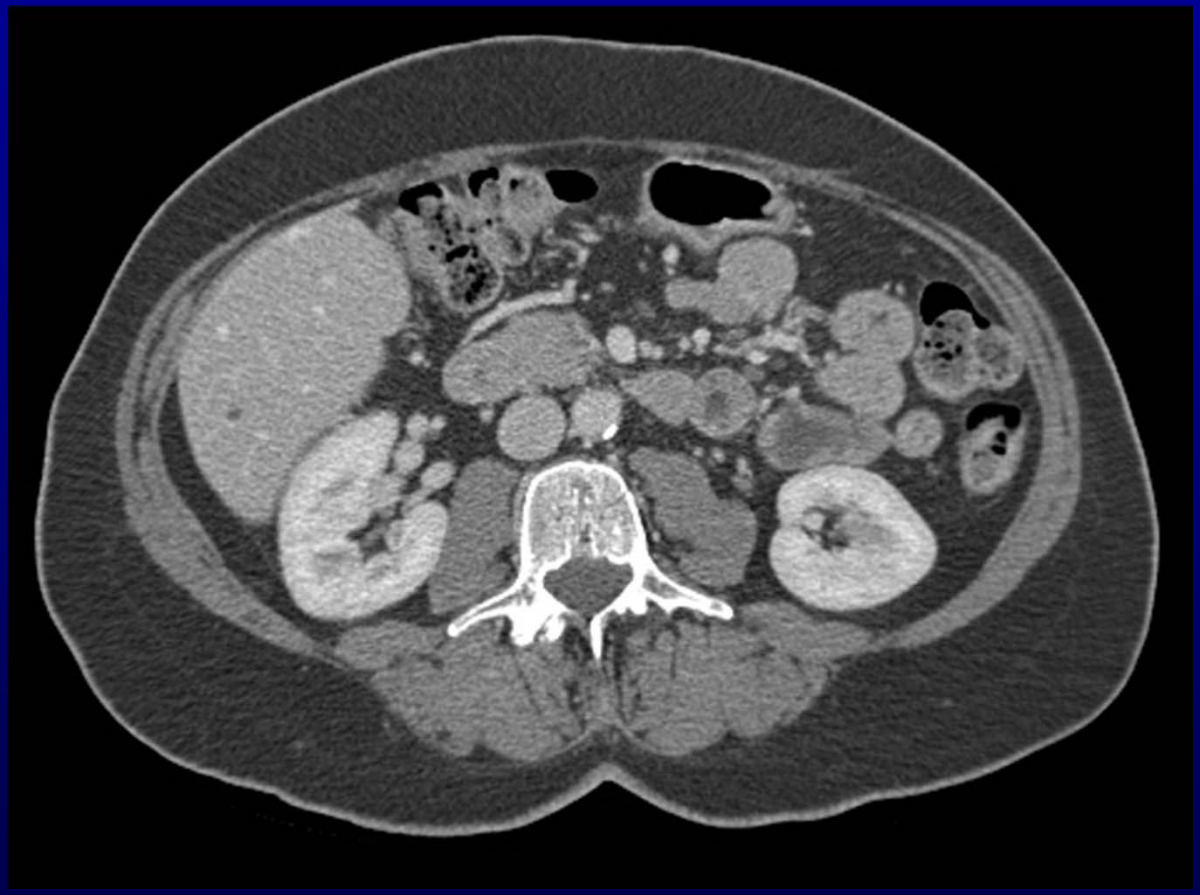
All other parameters are identical

Image Thickness

5mm image thickness

All other parameters are identical

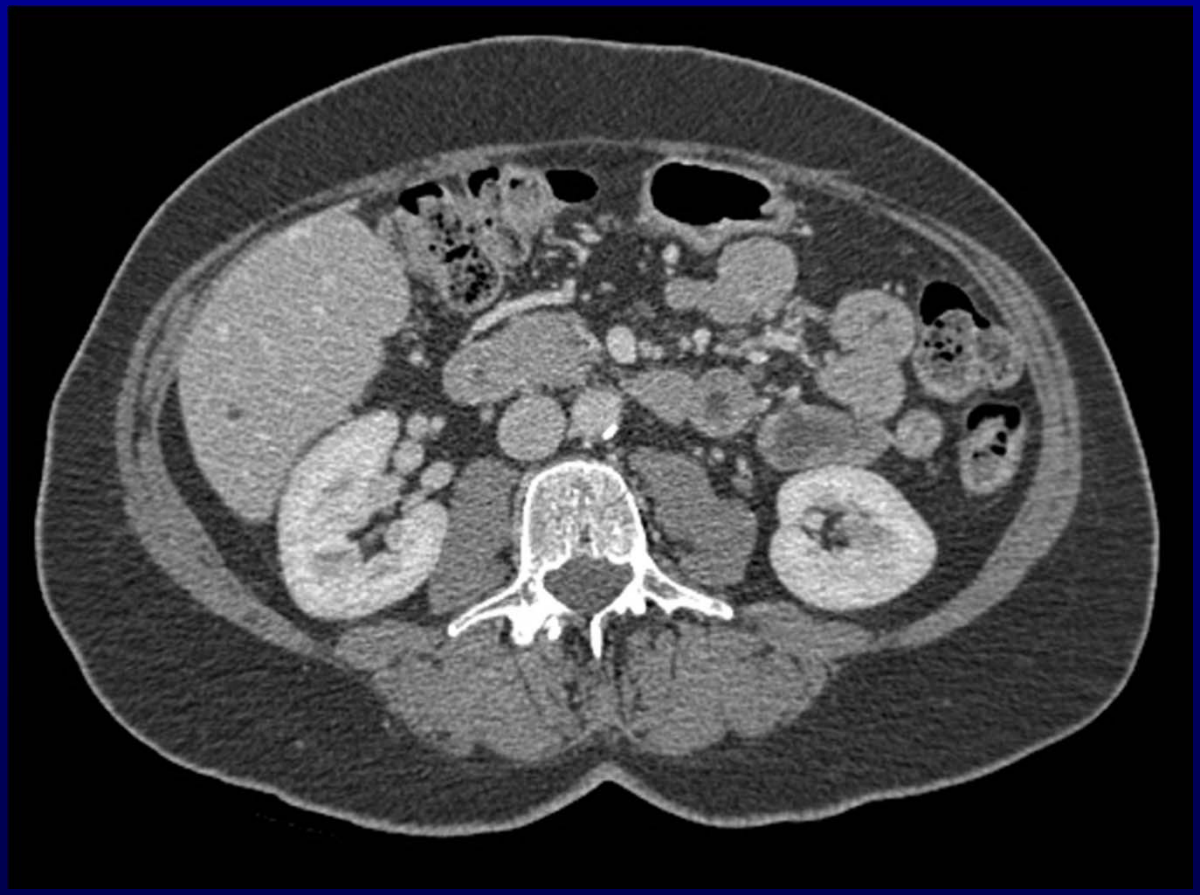
Image Thickness



2mm image thickness

All other parameters are identical

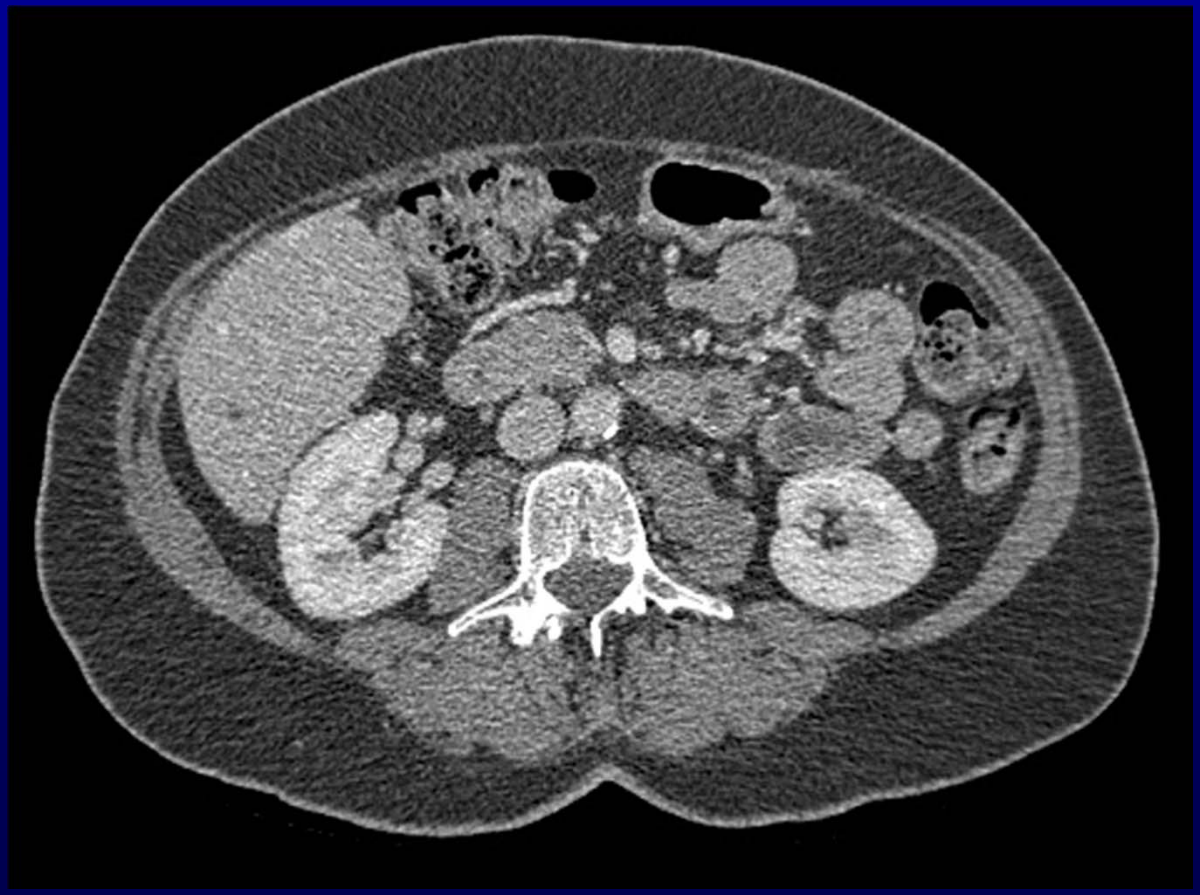
Image Thickness



1mm image thickness

All other parameters are identical

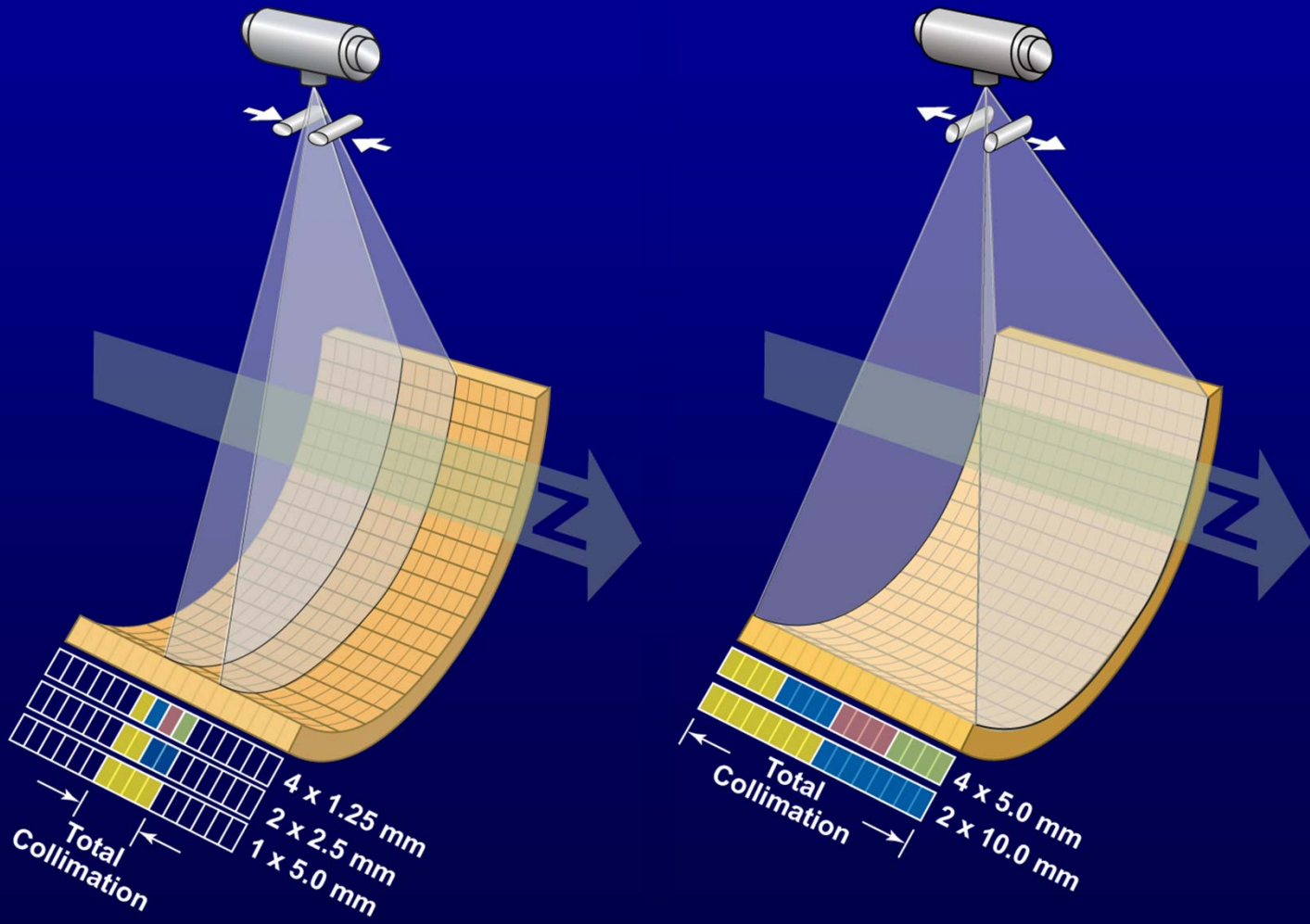
Image Thickness



0.6mm image thickness

All other parameters are identical

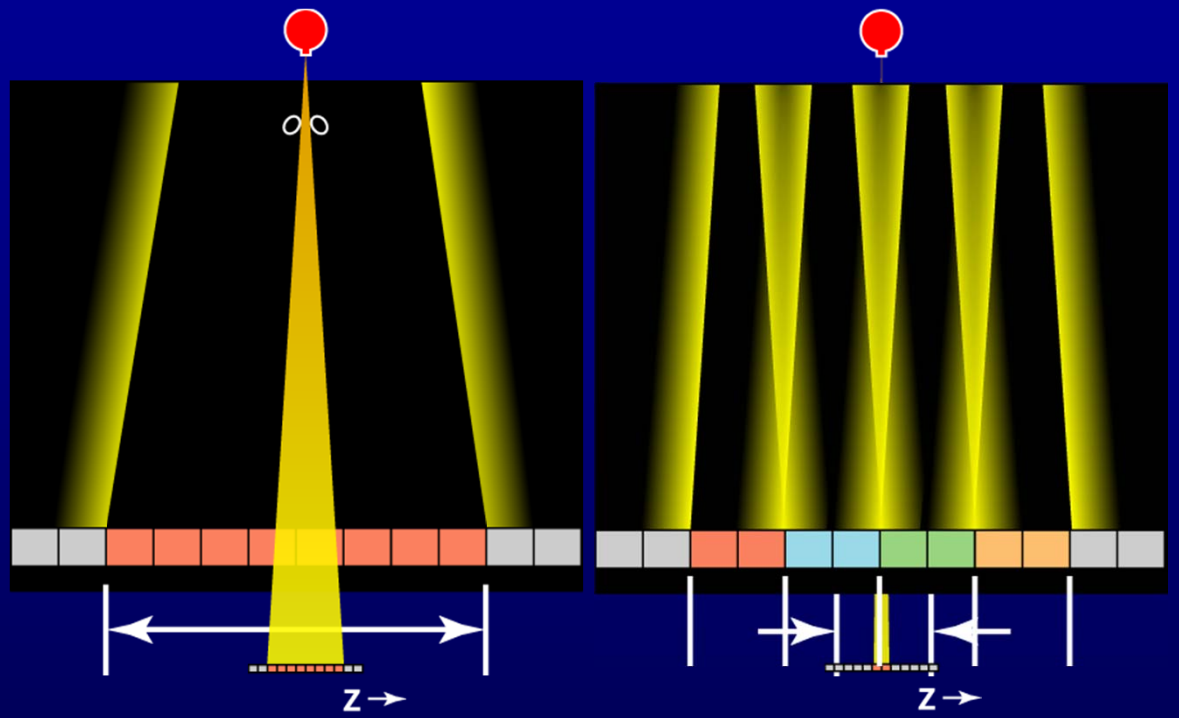
Detector Configuration



Detector Configuration

- Potentially many possible configurations
  - Not all available under all circumstances
- Narrow Collimation
  - Less scatter
  - Less coverage
  - Less dose efficiency (potentially)

Detector Configuration



"Wasted" radiation—contributes to dose only

Larger percentage of small beam is wasted!

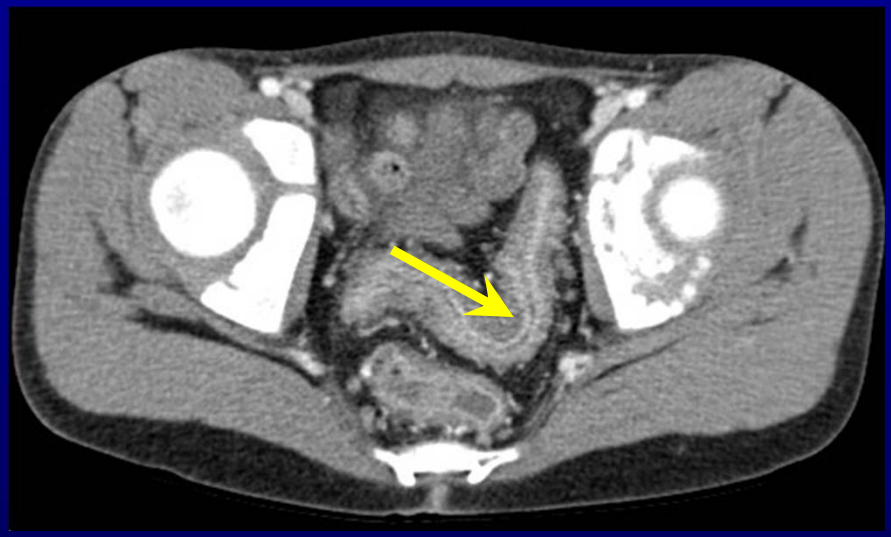
Detector Configuration

- Affects
  - Total scan time
  - Noise / Low contrast resolution
  - Thinnest available recons
- Note:
  - Recommend using thinnest channel widths for best IQ
  - Some configurations (esp. narrow collimations) are less dose efficient (vendor-specific)
  - Compare relative dose using CTDI-vol on console

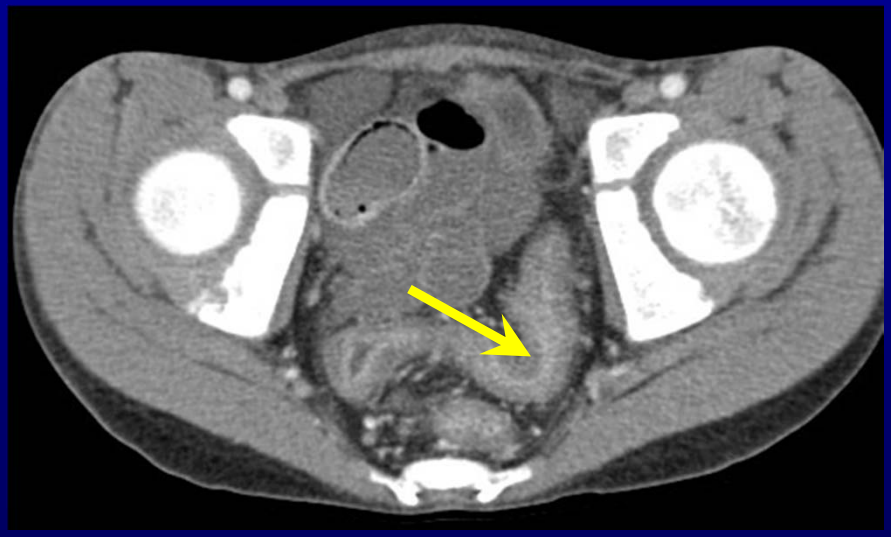
kiloVoltage

- Affects
  - Contrast resolution
  - Dose
- Note:
  - Optimum mA varies with kV
  - Bolus tracking thresholds are different at different kVs
  - Make sure scanner is calibrated for all clinical kVs

kiloVoltage



100 kV
($CTDI_{vol}$=3.98 mGy)

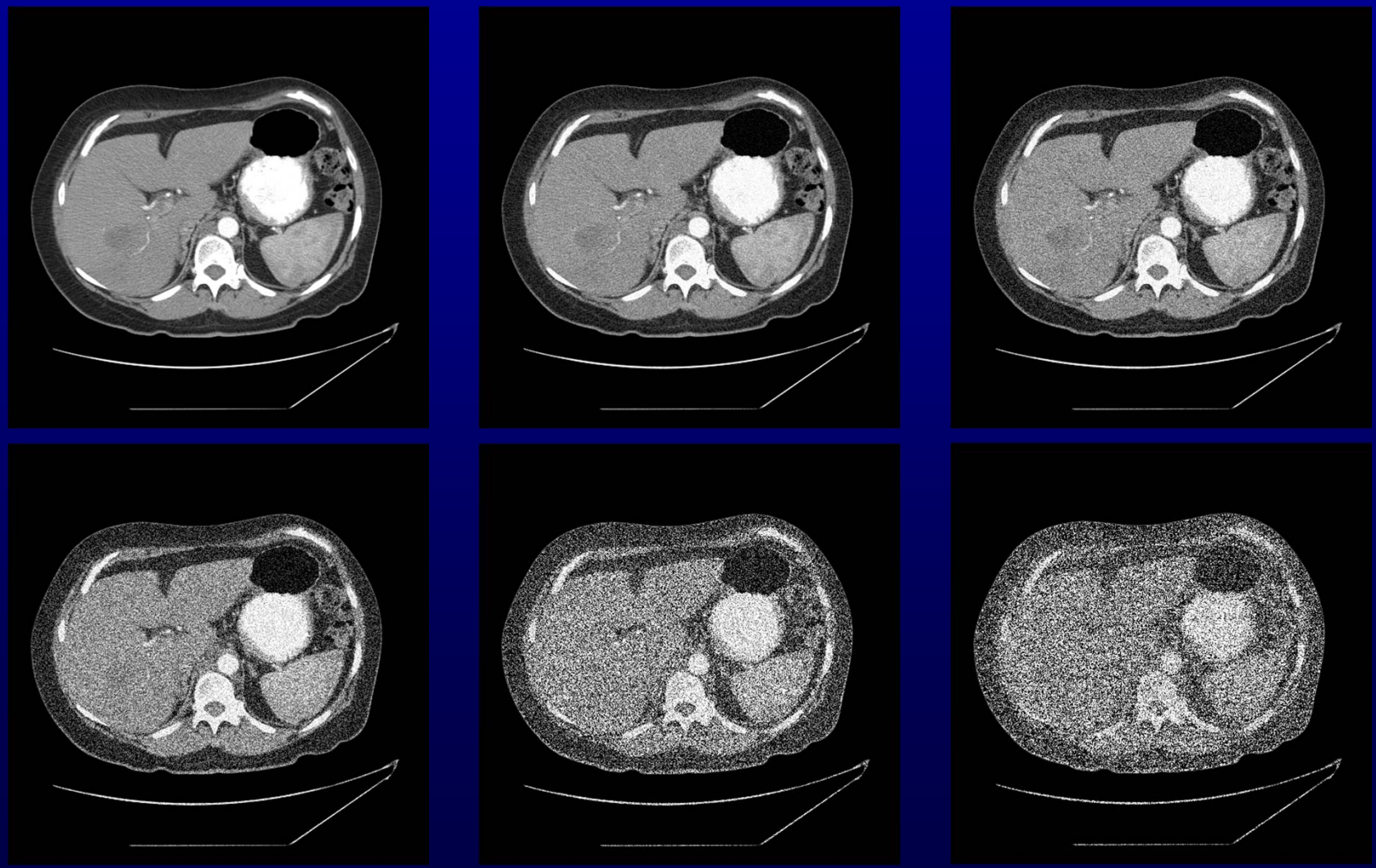


120 kV
($CTDI_{vol}$=5.18 mGy)

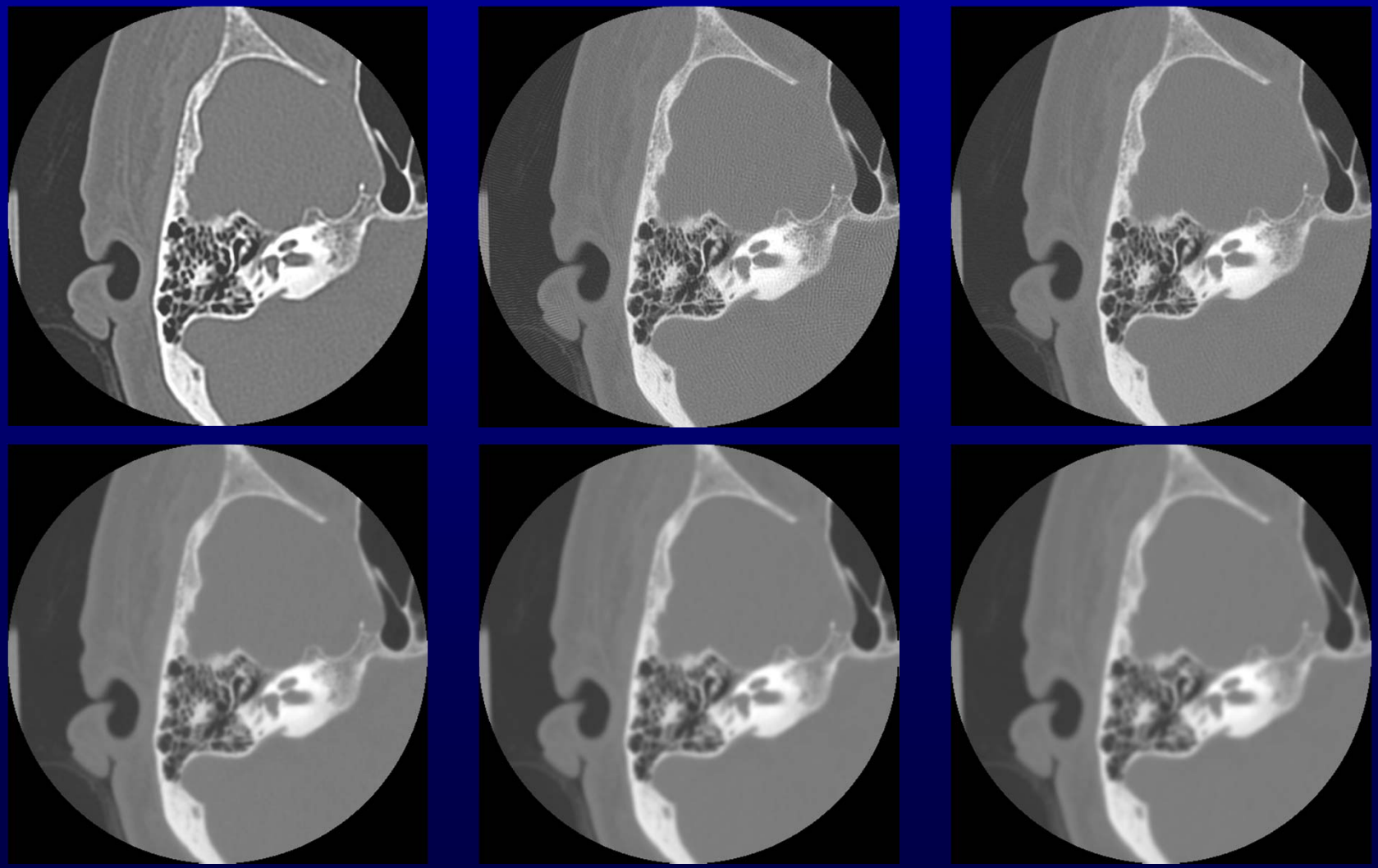
Reconstruction Algorithm

- Affects
  - Noise / Low contrast resolution
  - Spatial resolution
- Note
  - Kernels/algorithms can have obvious-to-subtle differences—get consensus from radiologists.
  - Reprocessing using different kernel is FREE (no dose cost)

Reconstruction Algorithm ~ Noise



Reconstruction Algorithm ~ Frequency



Conclusions

- Not always a “perfect” answer
- “Best” parameters for standard conditions
  - Strategies presented in other sessions
  - AAPM website, manufacturers
- Guidelines for atypical conditions
  - Large patients, metal implants, etc.
- On the fly decisions
  - Know your scanner!
  - Techs, physicists, radiologists