



WHAT HAPPENS TO IMAGE QUALITY AT THE EDGE OF THE COUCH?

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INTRODUCTION



IMAGE QUALITY
ASSESSMENT IN CT



LIMITATIONS OF QA
PHANTOMS



SCANNER GEOMETRY
AND IMAGE QUALITY



ASSESSMENT OF IMAGE
QUALITY ACROSS FULL
COUCH WIDTH



RESULTS



IMPLICATIONS FOR
CLINICAL PRACTICE

Pro CT MkII



IMAGE QUALITY PHANTOMS

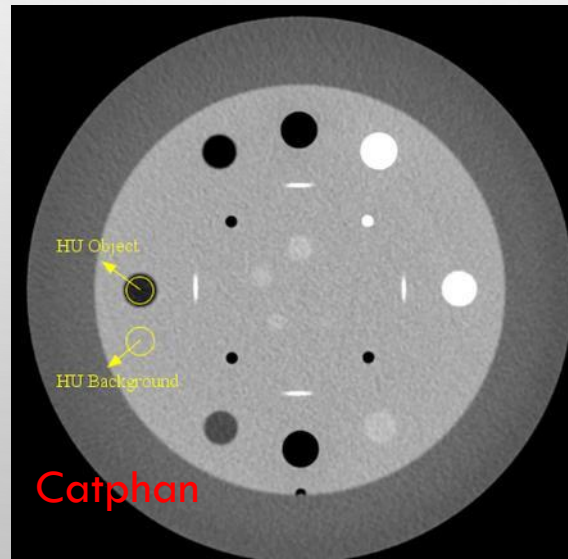


IQphan

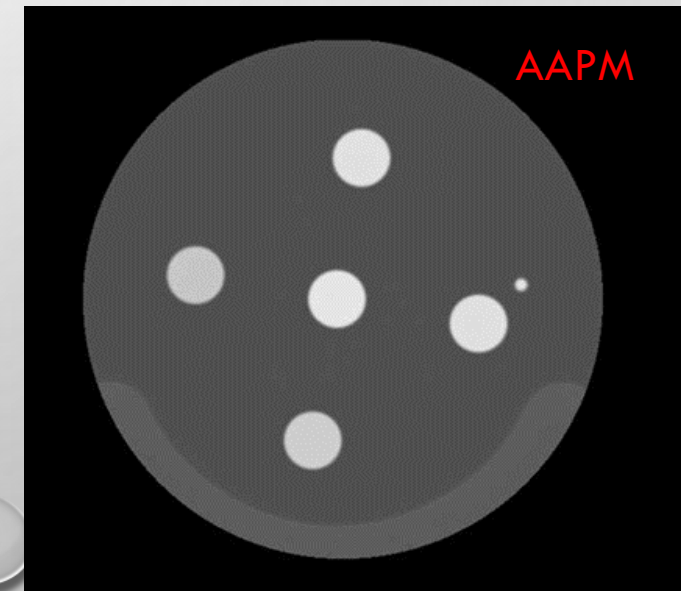
Phantom	Manufacturer	External diameter (cm)
Catphan	Phantom Laboratory	20
IQphan	Sun Nuclear	20
CTIQ	Leeds Test Objects	16
AAPM CT Performance Phantom	CIRS	20
Pro CT MkII	Pro Project	20



CTIQ

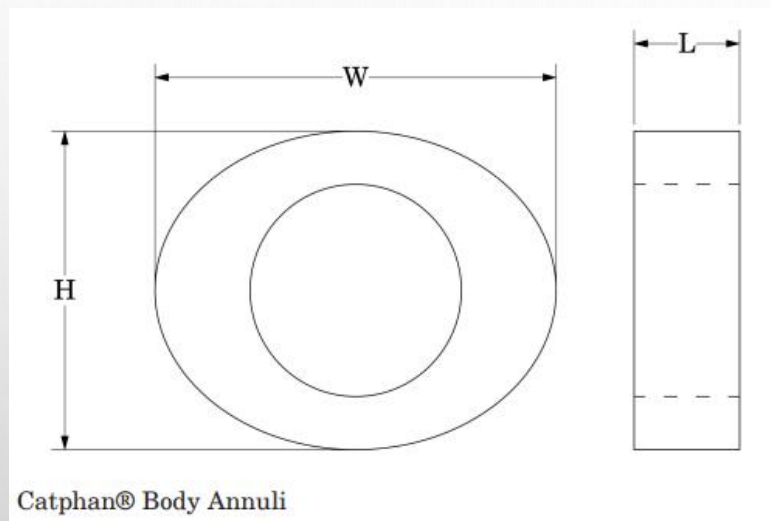


Catphan

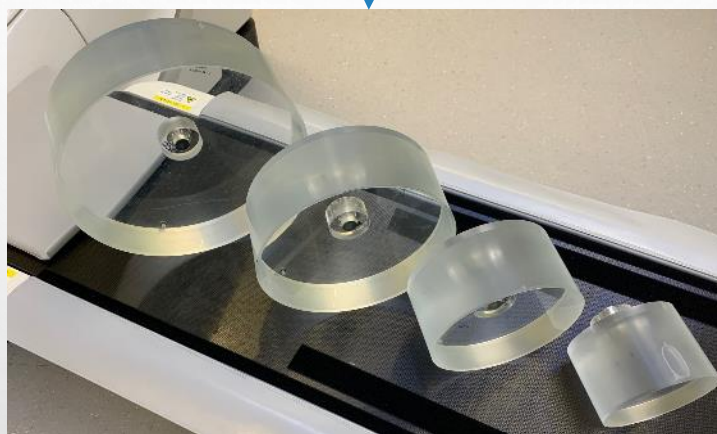


AAPM

BODY SIZED PHANTOMS?

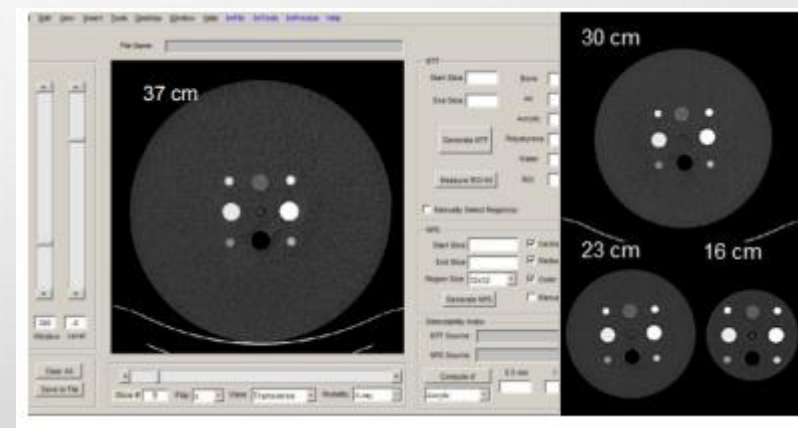


IPEM 91 says we should use these for noise assessment



Makes phantom larger but details remain in centre

FujiFilm water phantoms – 16 – 38cm diameter – no details

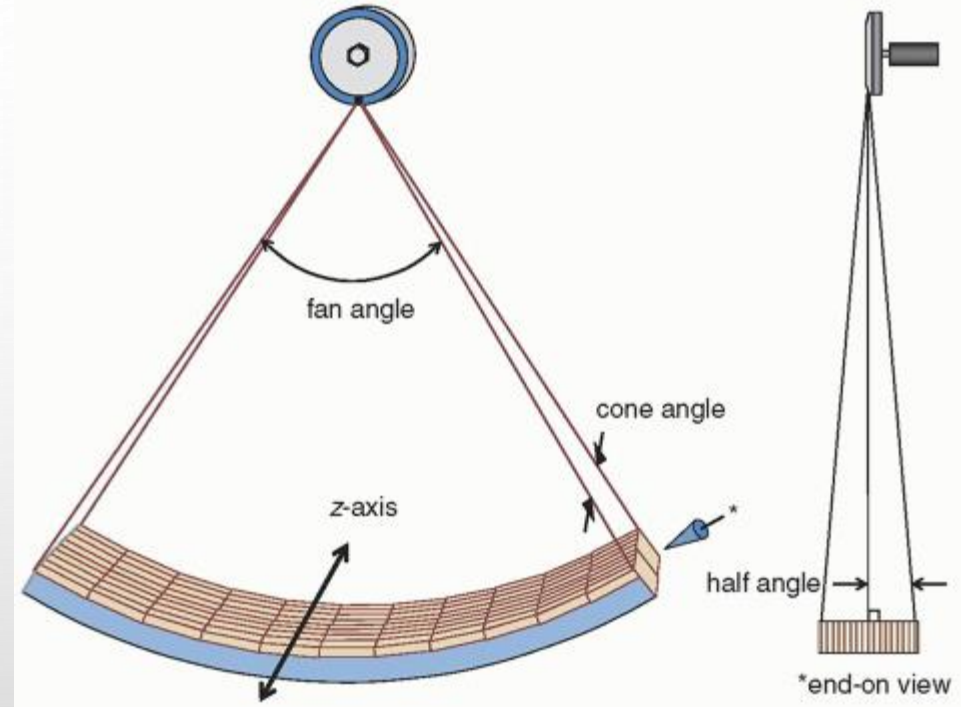


Details remain in central ~15cm

CT SCANNER GEOMETRY

Detectors arranged on radius of curvature from focal spot – all detector elements ~same distance from source

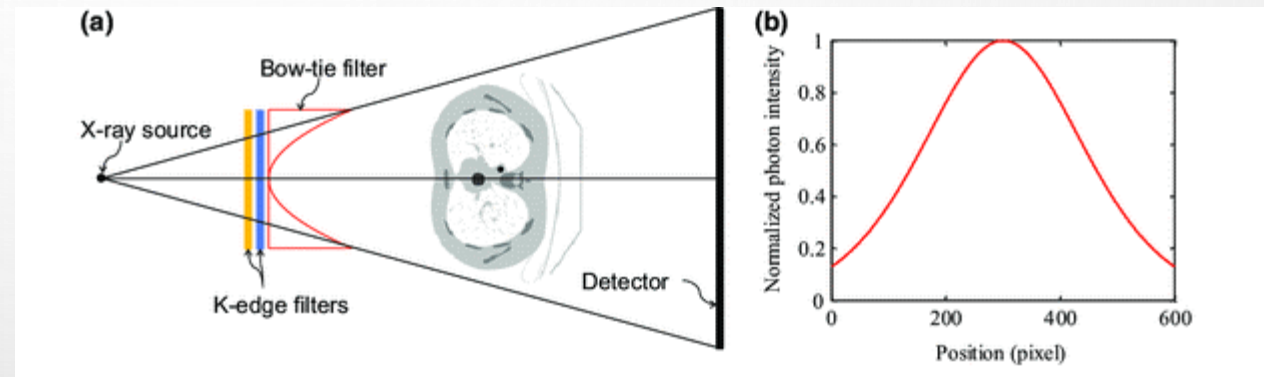
Detector element size self-consistent:
In x-y plane
In z axis



<https://radiologykey.com/computed-tomography-15/>

EFFECT OF BOWTIE FILTER

Bowtie filter reduces peripheral beam intensity
Fewer photons reaching peripheral detectors



<http://dx.doi.org/10.1002/mp.12933>

OUTCOME

Should expect:

- Equal spatial resolution across imaged field
- Some increase in noise towards periphery
- CT numbers may be variable depending on calibration conditions

ACCUMETRA CTLX1 PHANTOM

- Three modules placed at 0mm, 100mm, and 200mm from isocentre
- Each module is hollow cylinder of Delrin
- Air region inside and outside cylinder
- Teflon cylinder above and Acrylic cylinder below the Delrin
- Designed for lung cancer screening IQ assessment

Unique phantom looks at performance across imaged field

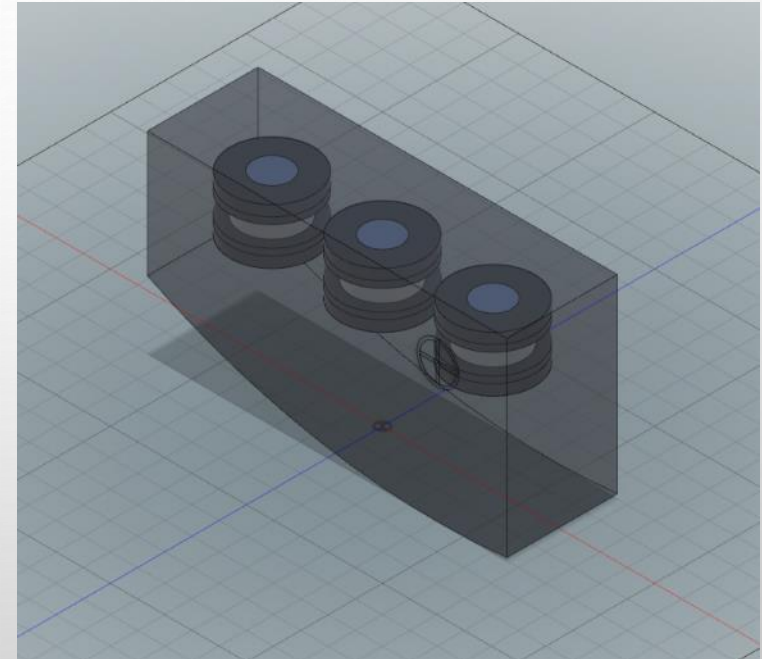


IMAGE QUALITY MARKERS

Edge enhancement –
shall not exceed 5%

Spatial warping –
3D image acquisition results in
Spatial warping of less than
0.3mm Root Mean Square
Error

HU bias –
CT HU value deviation of less
than 35 HU for Air and Acrylic
materials

3D resolution -
A 3D PSF sigma ellipsoid
volume of less than or equal to
1.5mm³

3D resolution aspect ratio -
A Z PSF sigma less than two
times larger than the in-plane
PSF sigma

Noise –
a standard deviation that is
≤ 50 HU for homogeneous
Air and Acrylic materials

SCANNING

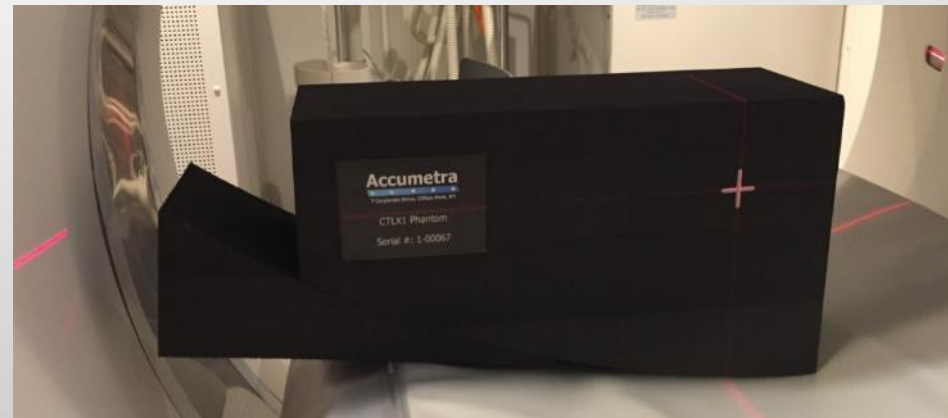
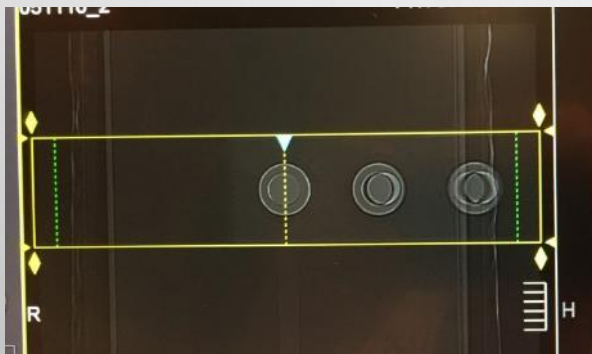
Scanned on
typical low dose
lung protocol



Reconstructed with
range of kernels



Investigate
variation of IQ
parameters across
imaged field

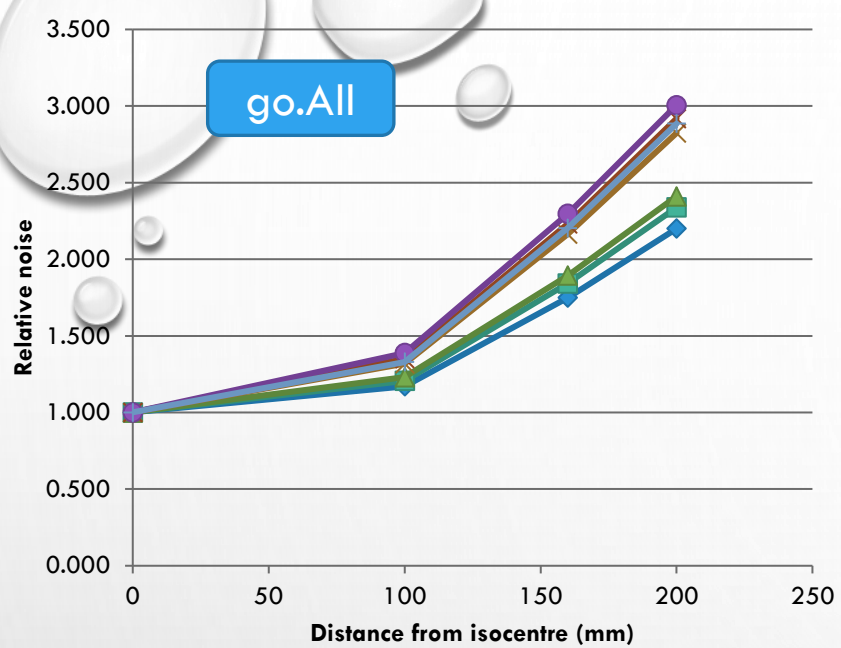


SCANNERS INCLUDED

Canon	Aquilion Prime SP
	Aquilion ONE Genesis
FujiFilm	Scenaria View
GE	BrightSpeed 16
	VCT
	Revolution Evo
	Revolution HD
Philips	Big Bore
	Incisive
	Ingenuity
	IQon
Siemens	Definition AS+
	Somatom Drive
	Definition Edge
	Emotion 16
	Somatom Force
	go.All

Results presented for only a subset of scanners to identify key points

IMAGE NOISE (RELATIVE NOISE)

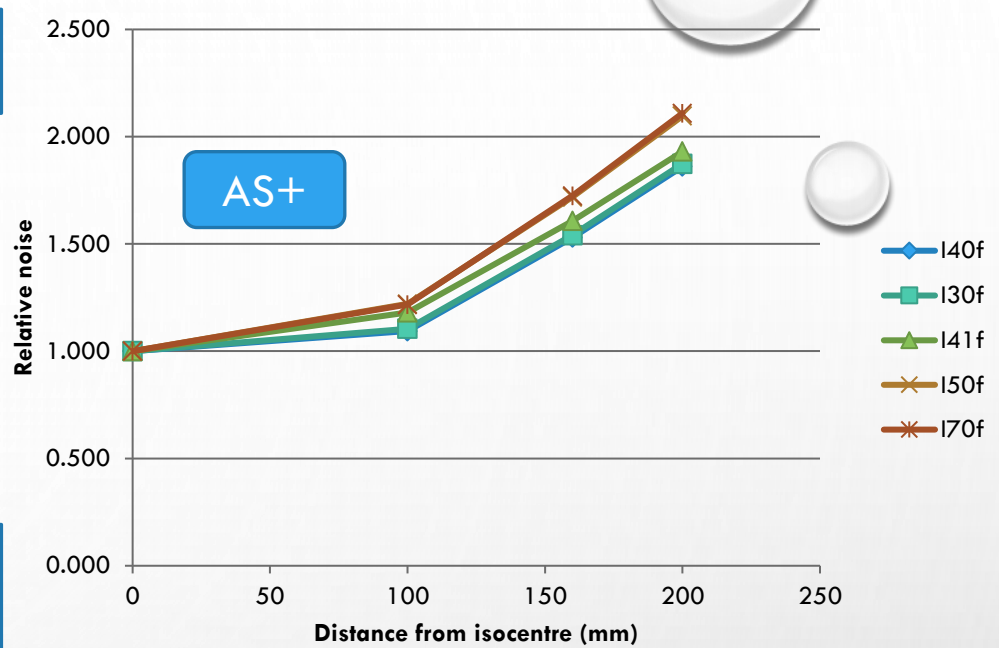


Siemens scanners

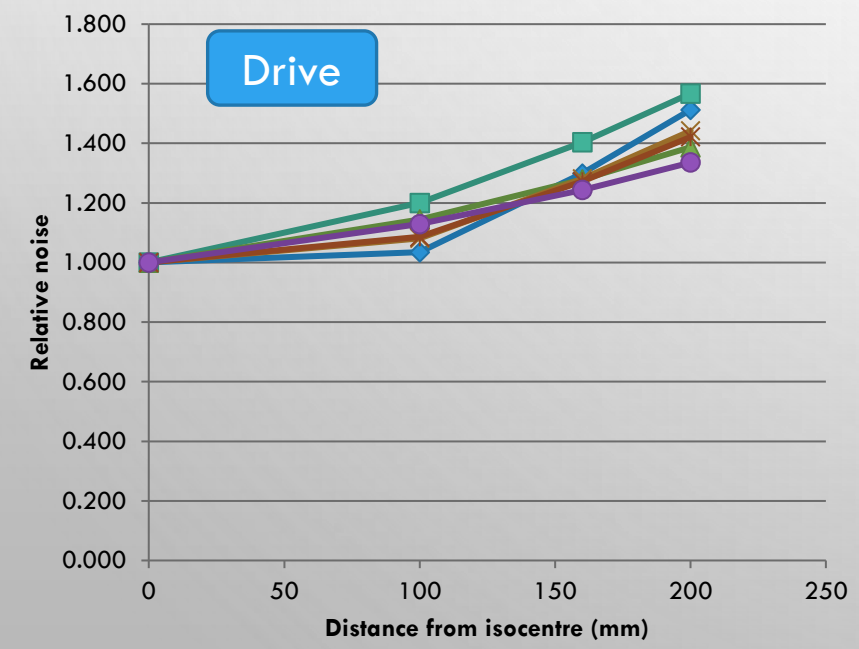
- Br36
- Br40
- Br44
- Br48
- Br56
- Br60
- Bl56

Noise variation across field affected by:

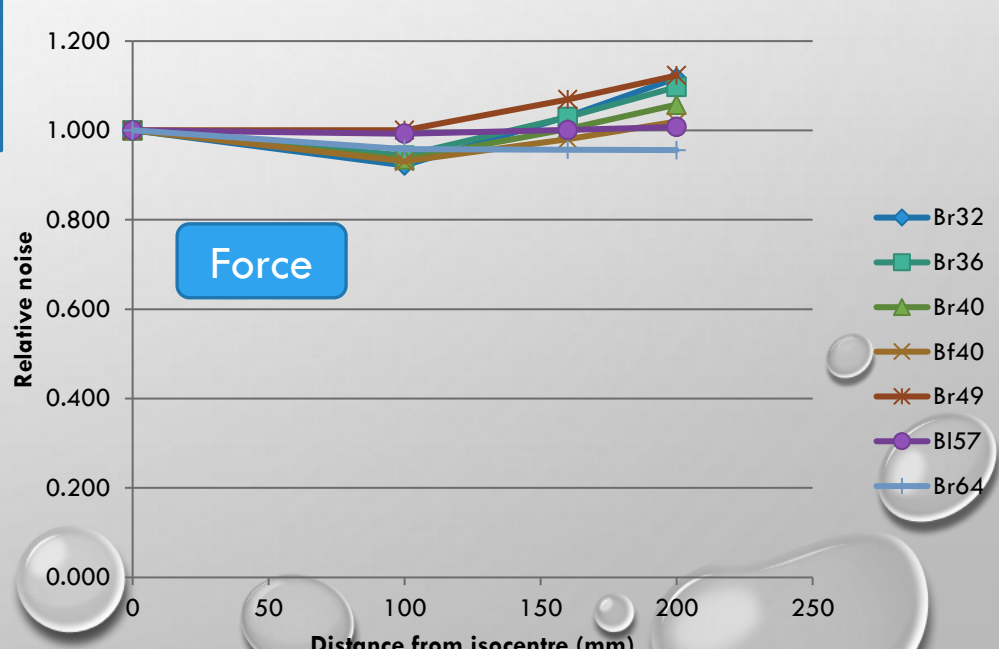
- Kernel – no clear relationship
- Spec. – variation lower in high spec scanners



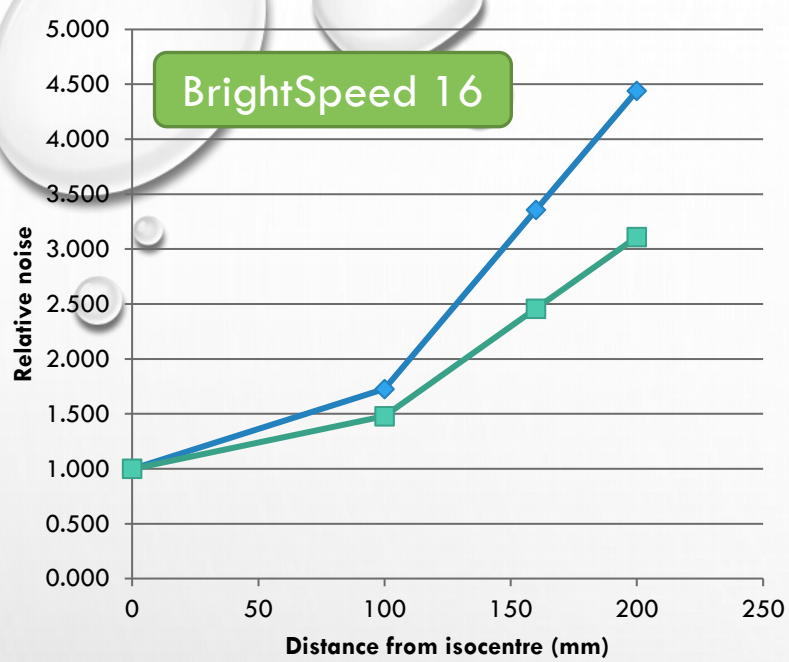
- I40f
- I30f
- I41f
- I50f
- I70f



- Br32
- Bf37
- Bf39
- Bv38
- Bv40
- Bf42



- Br32
- Br36
- Br40
- Bf40
- Br49
- Bl57
- Br64

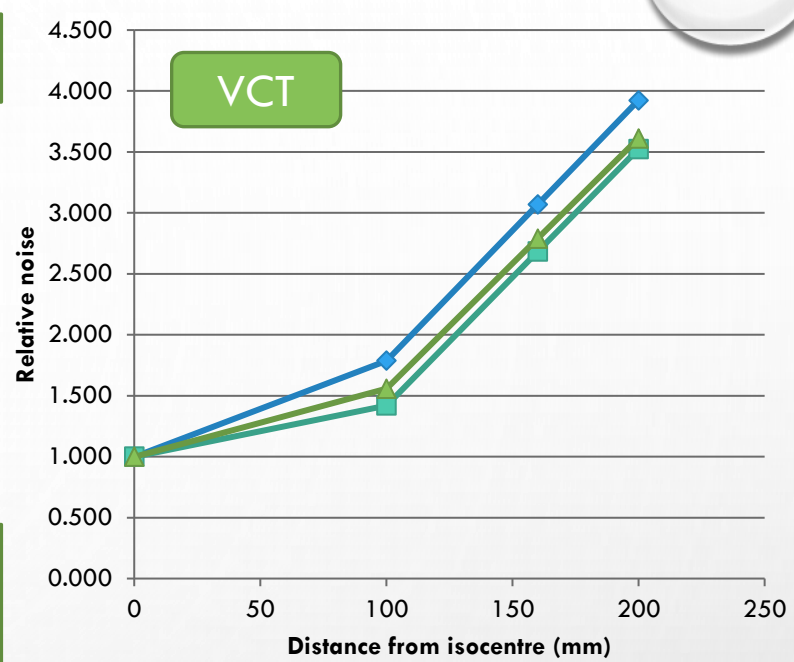


GE scanners

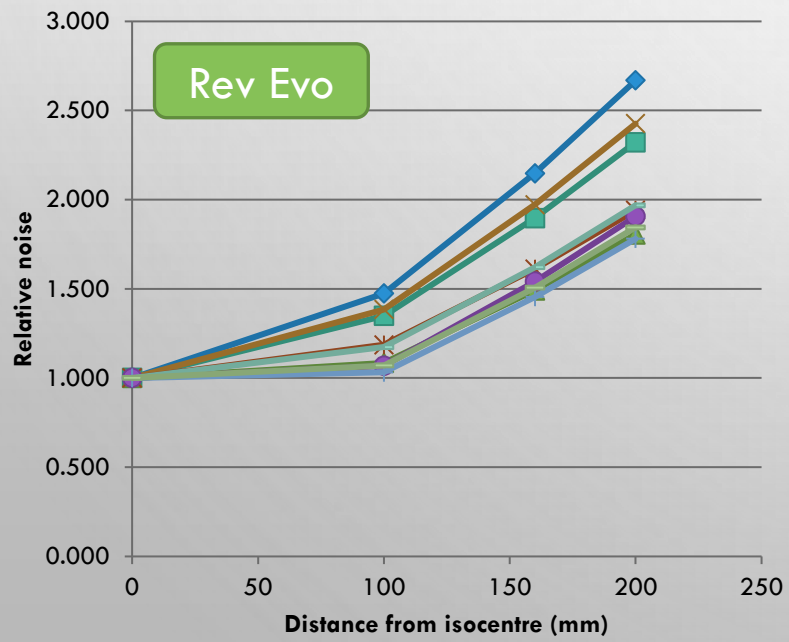
- Standard
- Bone

Noise variation across field affected by:

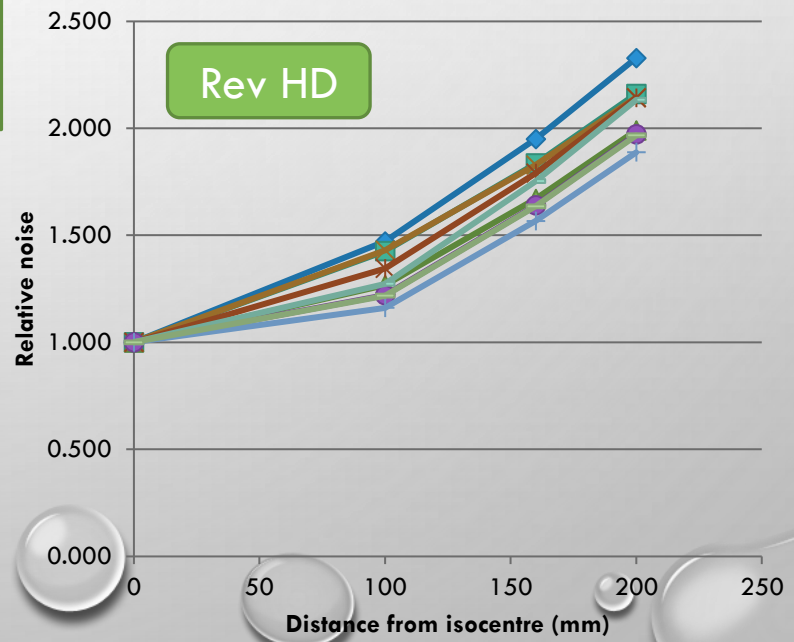
- Kernel – softer kernels give greatest variation
- Spec. – variation lower in high spec scanners



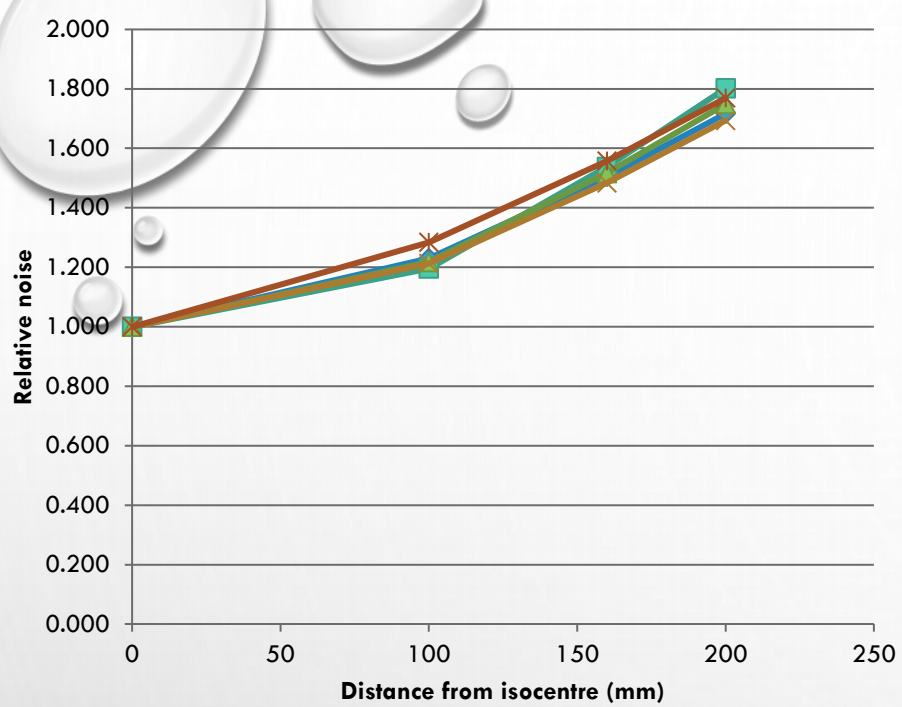
- Standard
- Lung
- Bone



- Soft
- Standard
- Lung
- Detail
- Chest
- Edge
- Edge Plus
- Bone
- Bone Plus

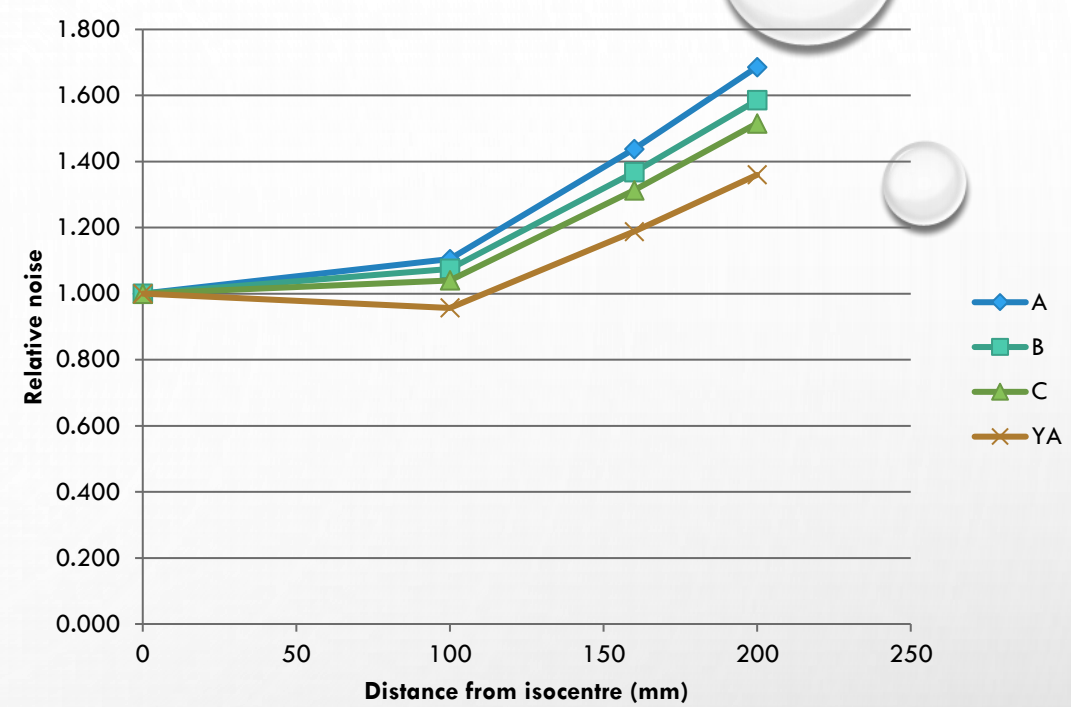


- Soft
- Standard
- Lung
- Detail
- Chest
- Edge
- Edge Plus
- Bone
- Bone Plus



Canon Aquilion Prime

Very little variation
between kernels



Philips Big Bore

Least variation for
sharpest kernels

NOISE SUMMARY

Should expect:

- Some increase in noise towards periphery

Variation

- Noise increases across FOV
- Up to 4.5x central value
- Variation lowest for Siemens Force

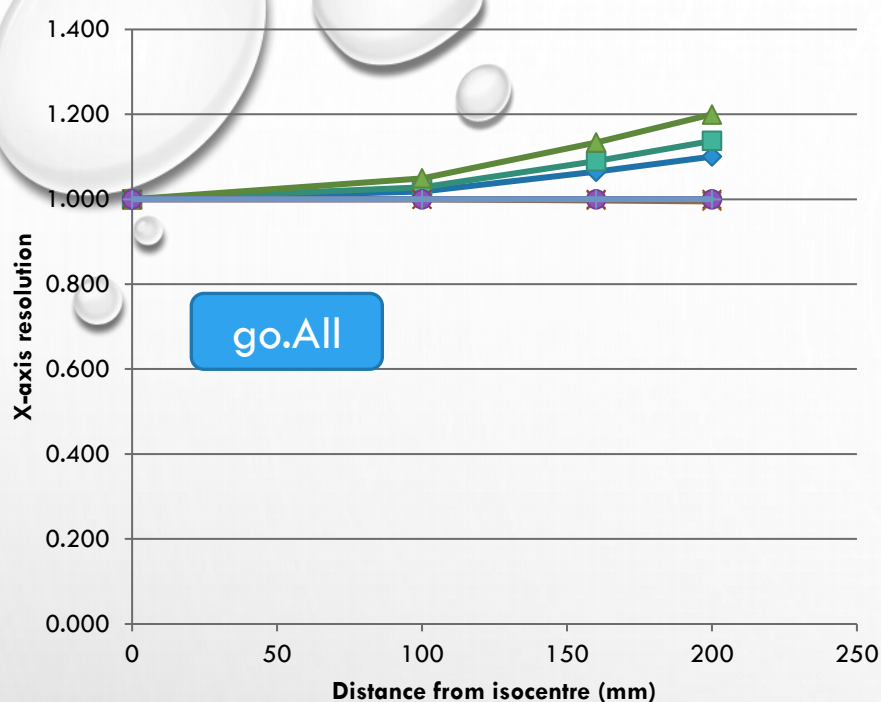
Kernel

- Siemens – no clear relationship
- GE & Philips – softest kernels show greatest variation
- Canon – variation unaffected by kernel

Scanner spec.

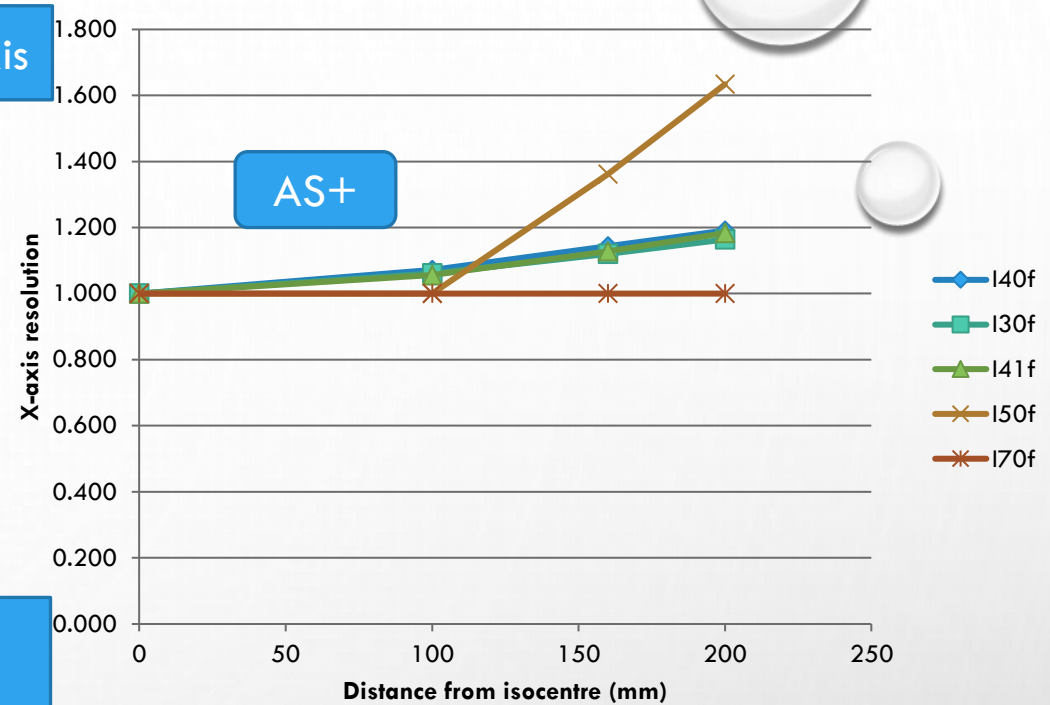
- Generally lower noise variation for higher specification systems (Siemens & GE)
- Need to check for Canon & Philips

SPATIAL RESOLUTION (RELATIVE)



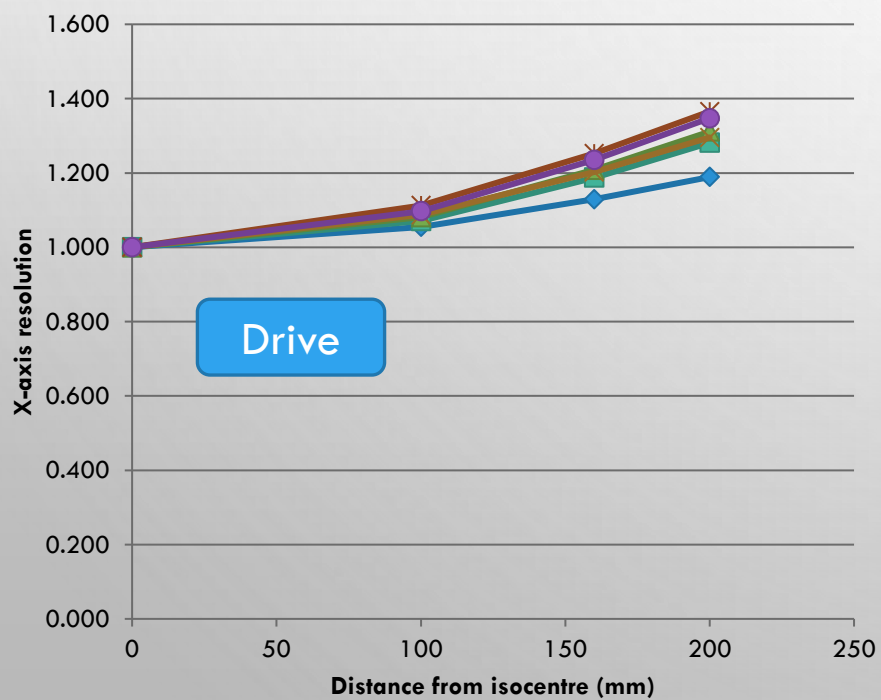
Siemens scanners – x-axis

- Br36
- Br40
- Br44
- Br48
- Br56
- Br60
- BI56

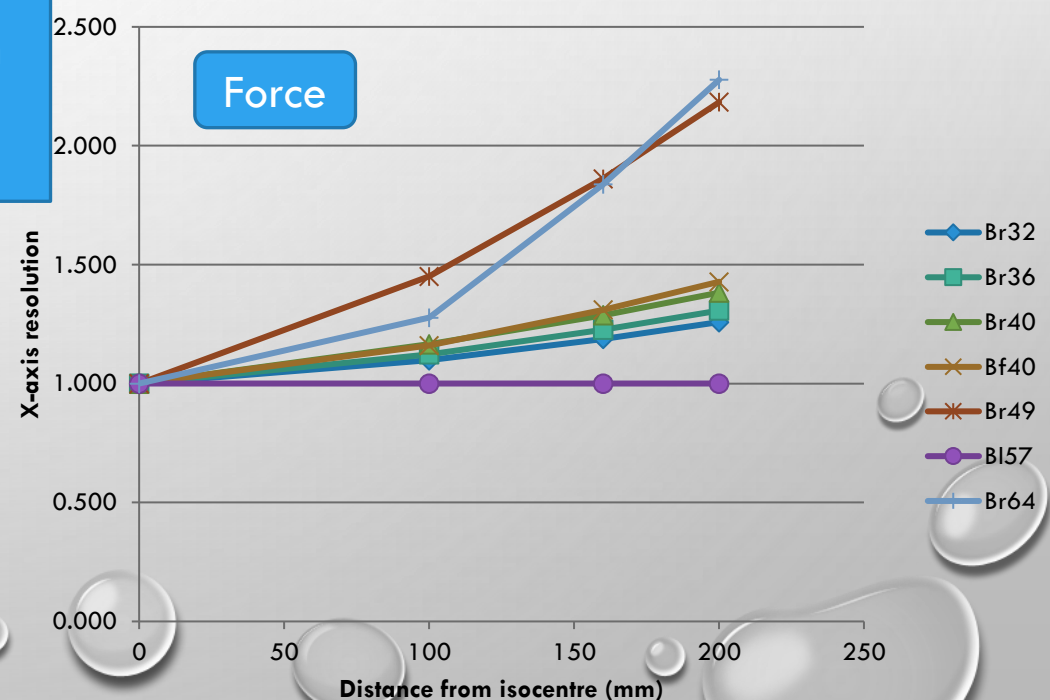


- I40f
- I30f
- I41f
- I50f
- I70f

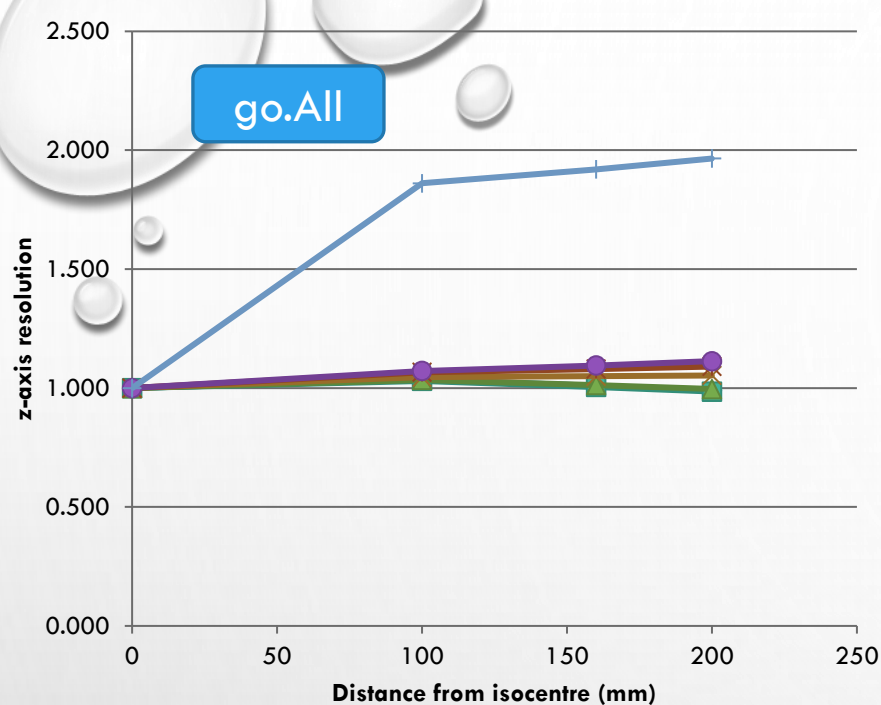
- In plane variation generally <20%
 - Much larger variation for some (but not all!!) sharper kernels



- Br32
- Bf37
- Bf39
- Bv38
- Bv40
- Bf42

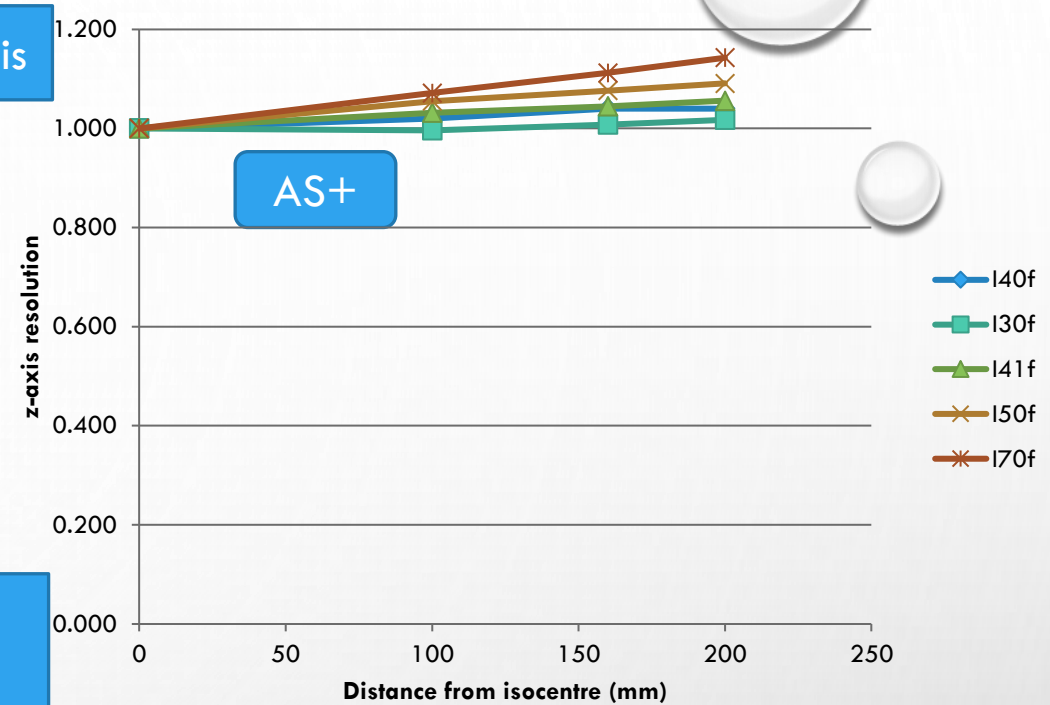


- Br32
- Br36
- Br40
- Bf40
- Br49
- BI57
- Br64



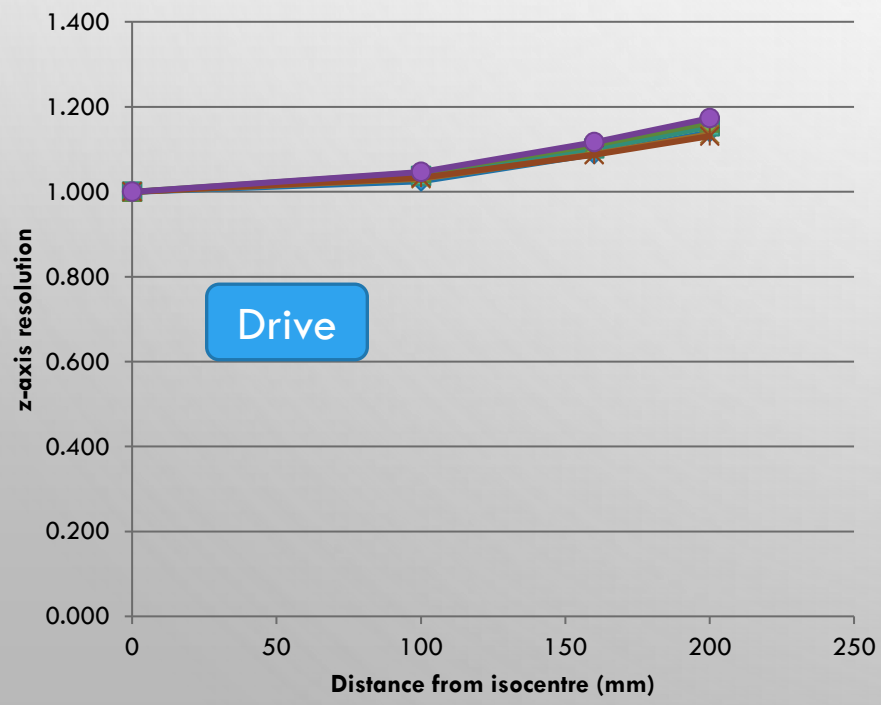
Siemens scanners – z-axis

- Br36
- Br40
- Br44
- Br48
- Br56
- Br60
- BI56

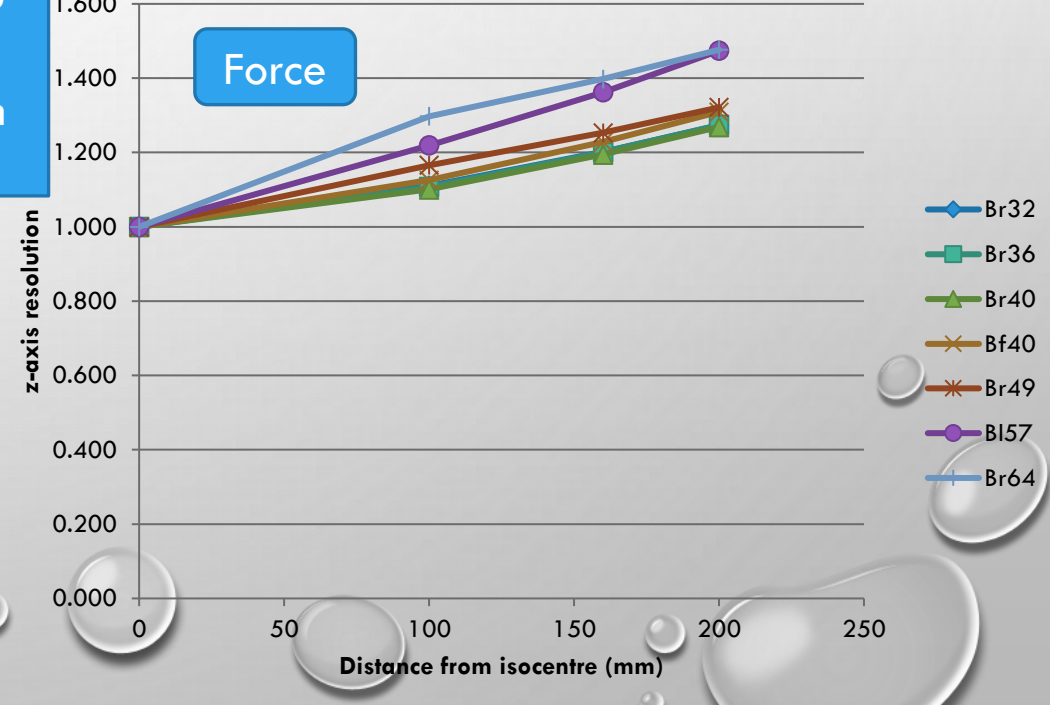


- I40f
- I30f
- I41f
- I50f
- I70f

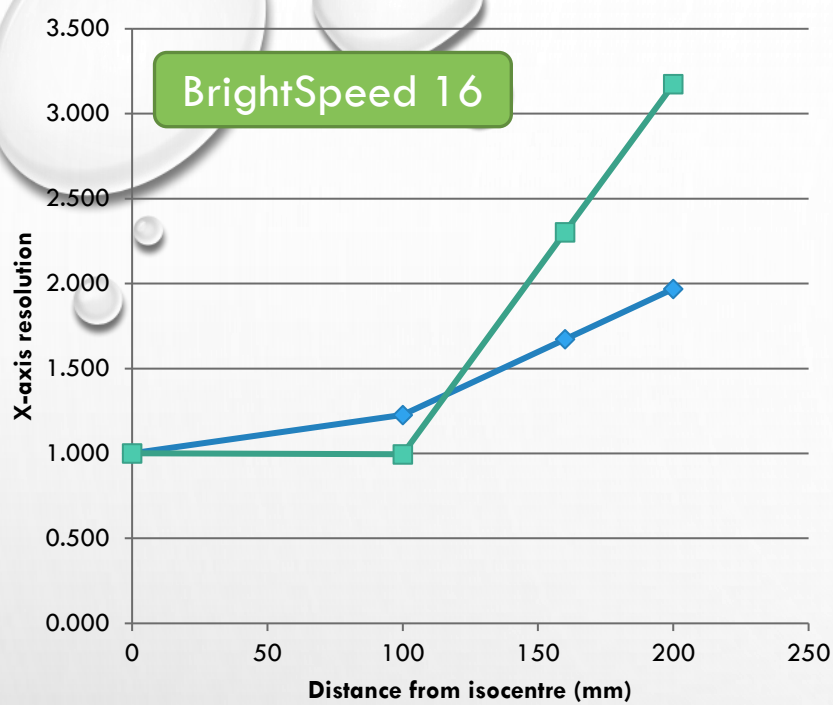
- Z-axis variation generally <15%
 - Higher for some sharp kernels
 - Greatest variations on Force



- Br32
- Bf37
- Bf39
- Bv38
- Bv40
- Bf42



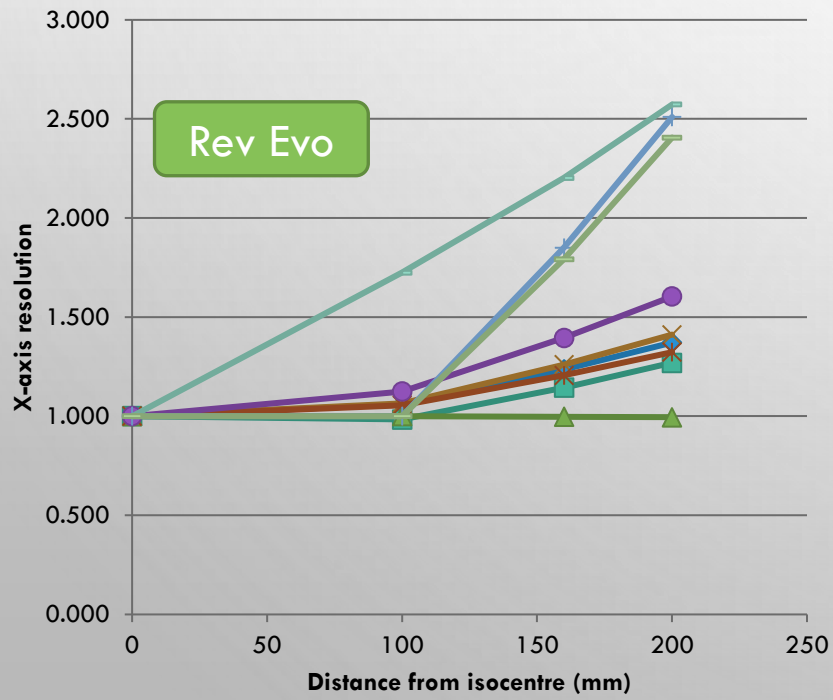
- Br32
- Br36
- Br40
- Bf40
- Br49
- BI57
- Br64



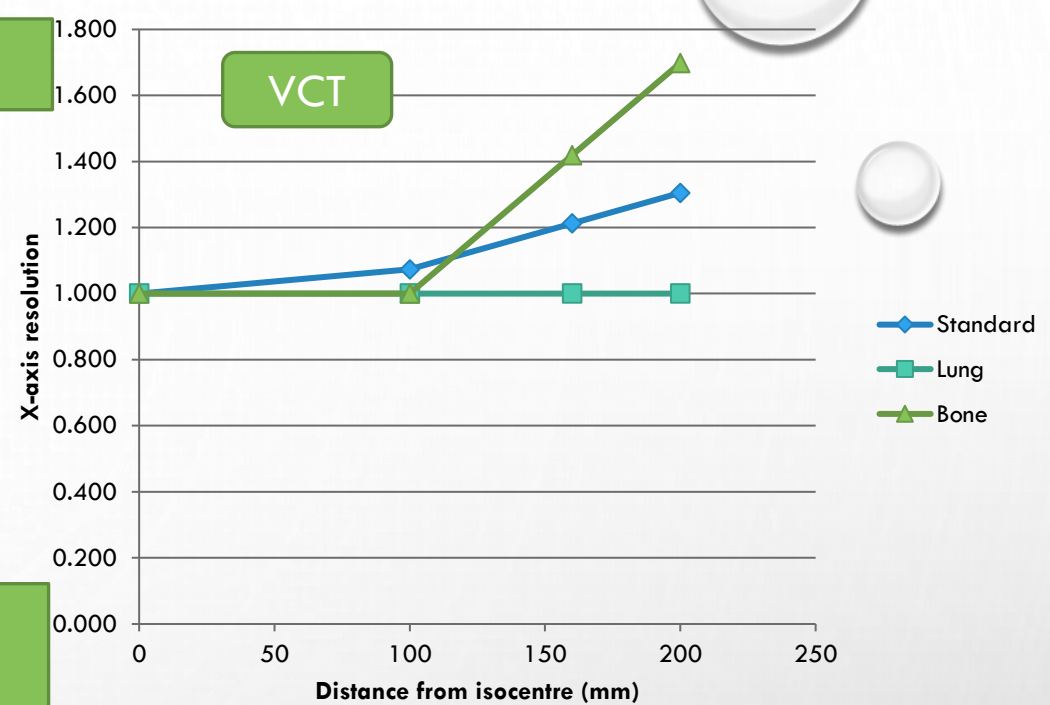
GE scanners – x-axis

- Standard
- Bone

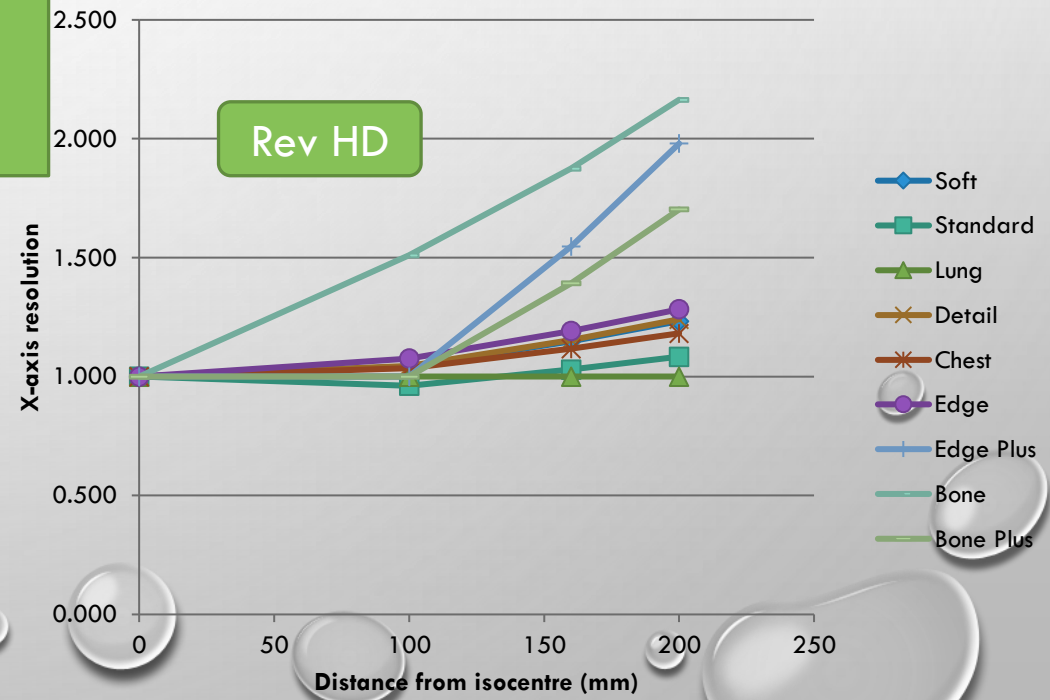
- Generally greater variation for harsher kernels
 - Smaller variations for higher spec. scanners



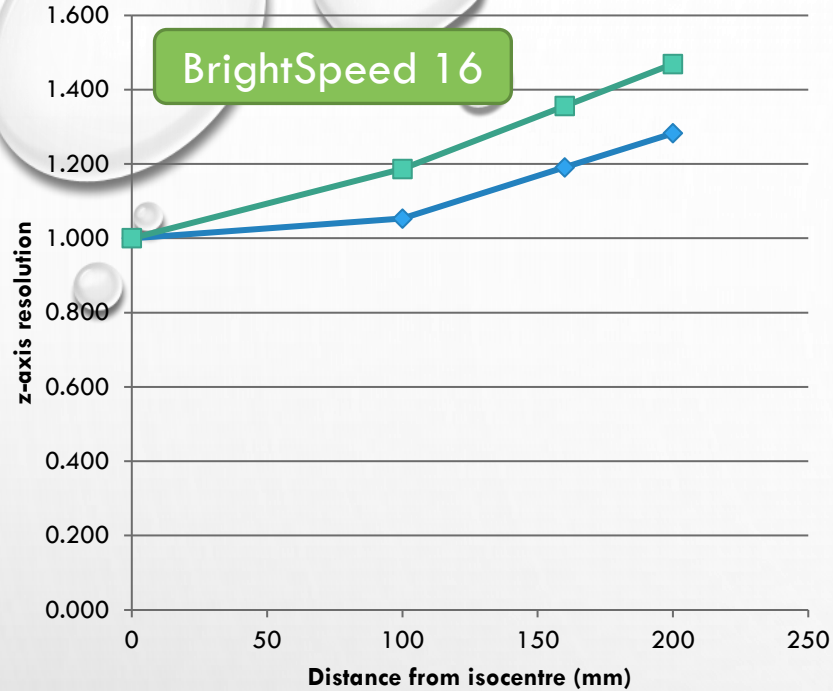
- Soft
- Standard
- Lung
- Detail
- Chest
- Edge
- Edge Plus
- Bone
- Bone Plus



- Standard
- Lung
- Bone



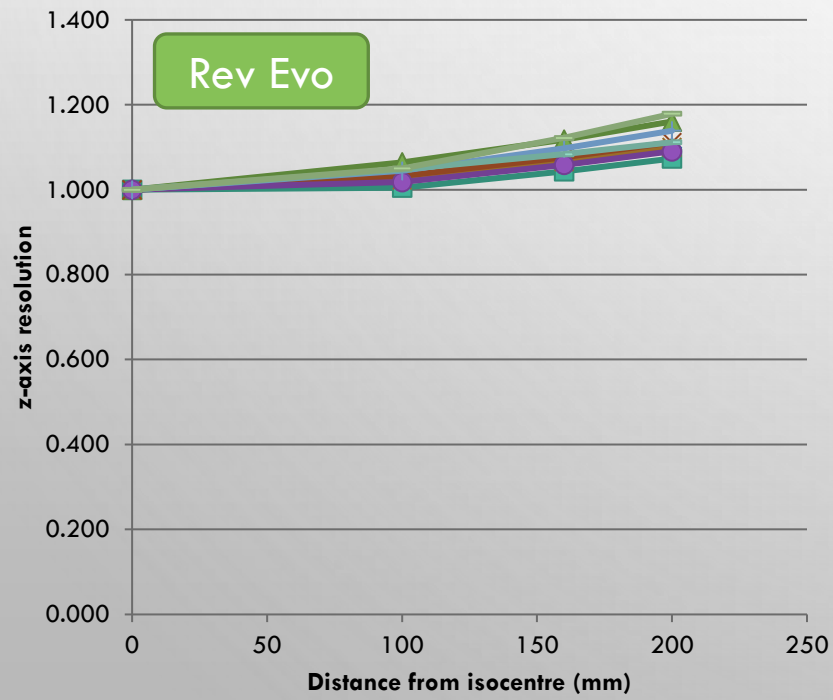
- Soft
- Standard
- Lung
- Detail
- Chest
- Edge
- Edge Plus
- Bone
- Bone Plus



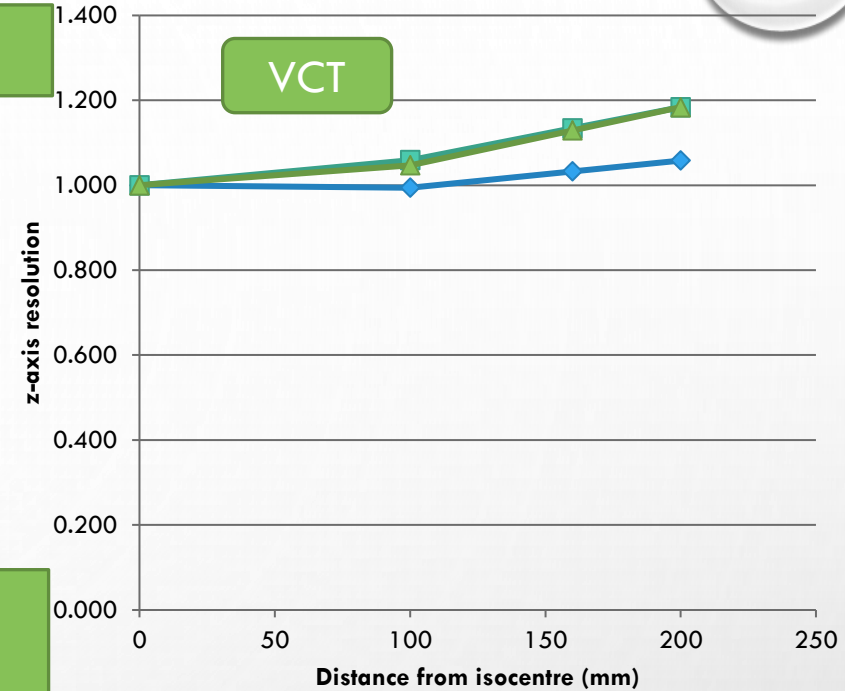
GE scanners – z-axis

- Standard
- Bone

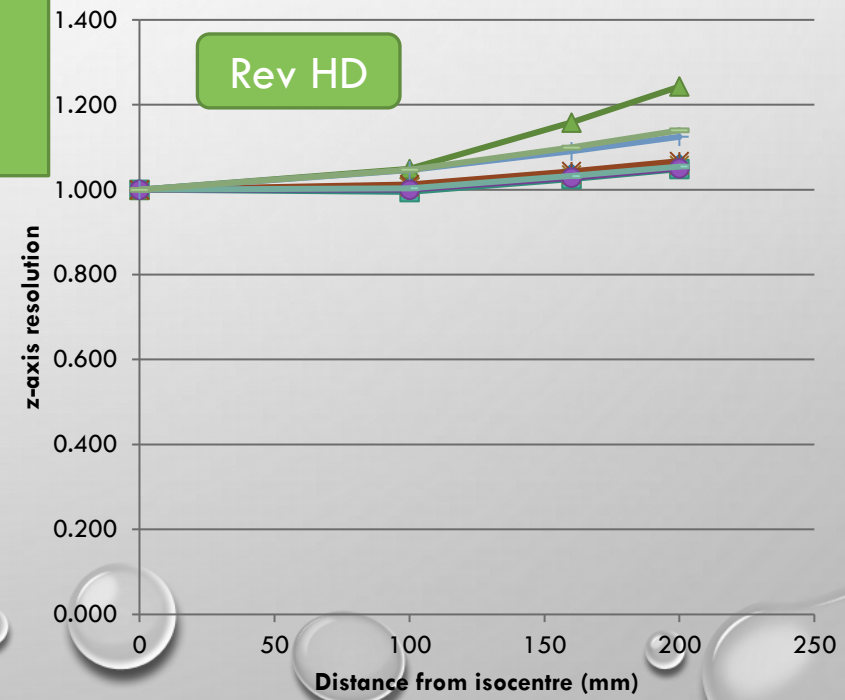
- Some increased variation for harsher kernels
- Smaller variations for higher spec. scanners



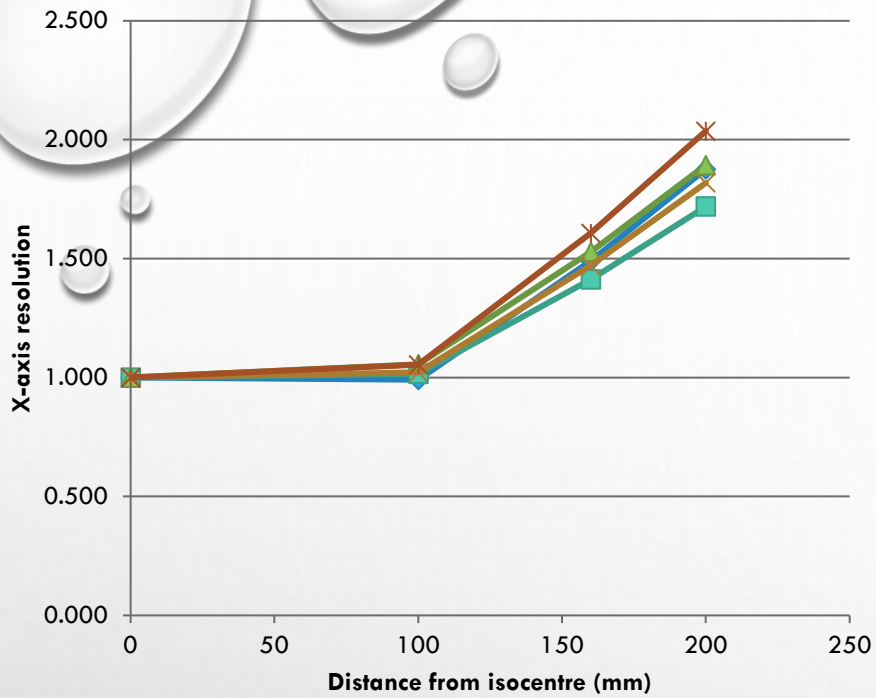
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- Standard
- Lung
- Detail
- Chest
- Edge
- Edge Plus
- Bone
- Bone Plus



- Standard
- Lung
- Bone

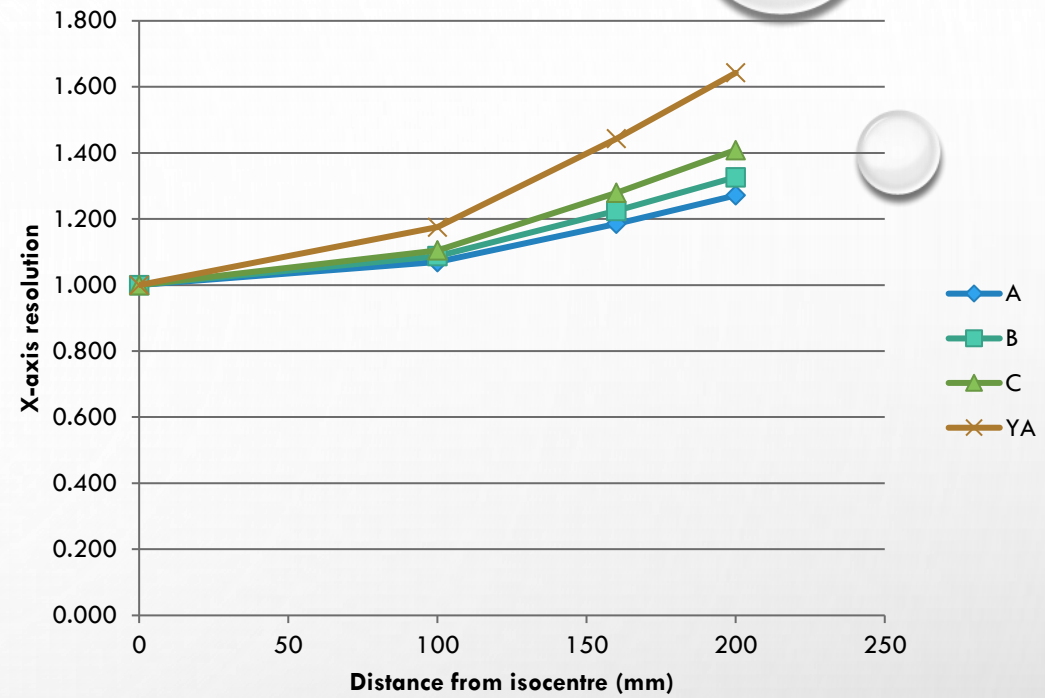


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- Standard
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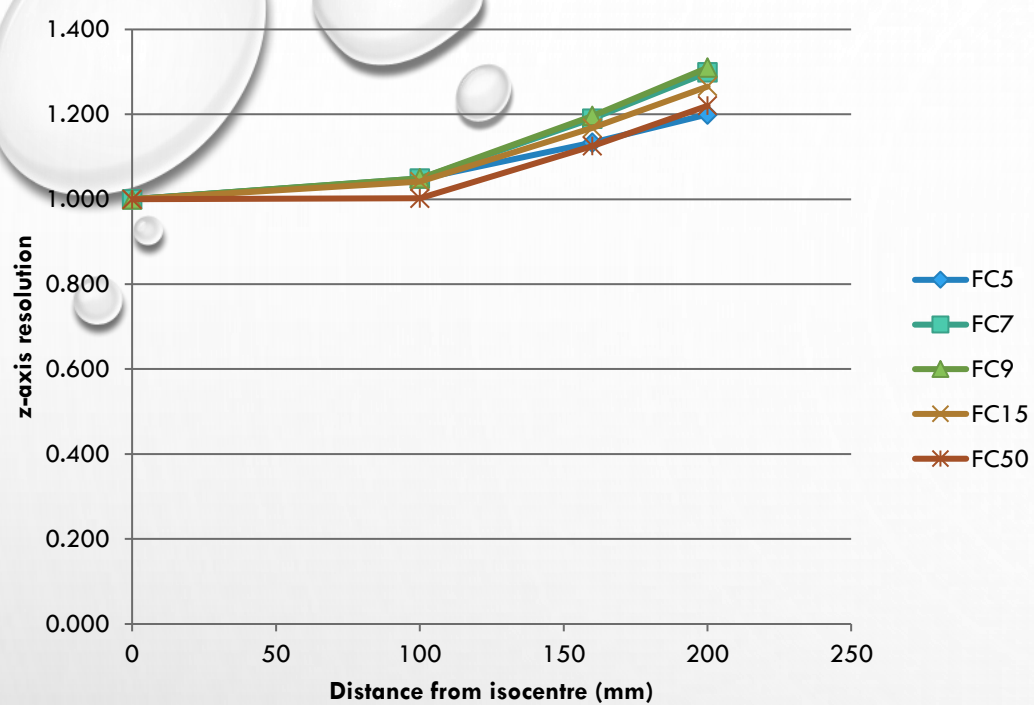
Canon Aquilion Prime

Very little variation between kernels
ALL kernels show >70% change across field



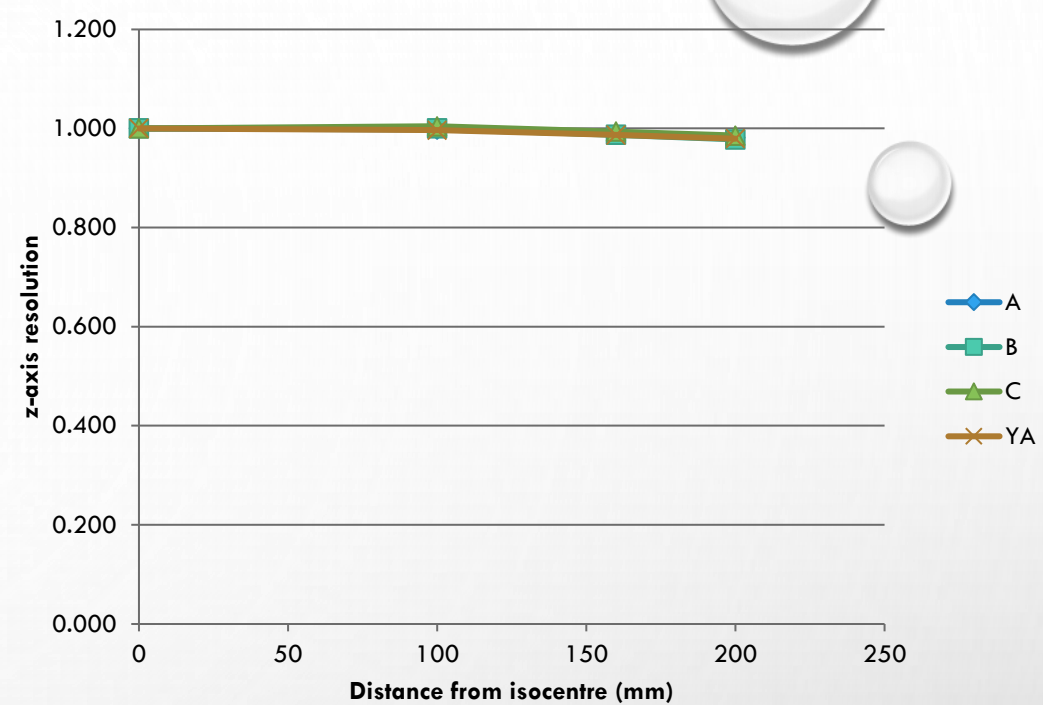
Philips Big Bore

Greatest variation for sharpest kernels
<40% variation for most kernels



Canon Aquilion Prime

Very little variation
between kernels
All kernels show 20-30%
change across field



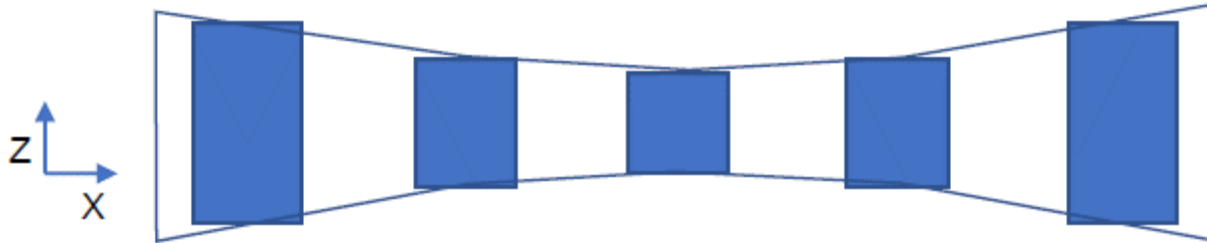
Philips Big Bore

Virtually no change
across field for any kernel
($<2.5\%$)

RESOLUTION SUMMARY



Some systems/kernels – some change in x-axis, negligible in z-axis



Some systems/kernels – notable change in x-axis, large change in z-axis

Should result in significantly worse 3D spatial resolution towards couch edge

RESOLUTION SUMMARY

Should expect:

- Equal spatial resolution across imaged field

Variation

- Resolution generally worsens across FOV and in z-axis
- x-axis: $>3x$ central value
- z-axis: up to $2x$ central value

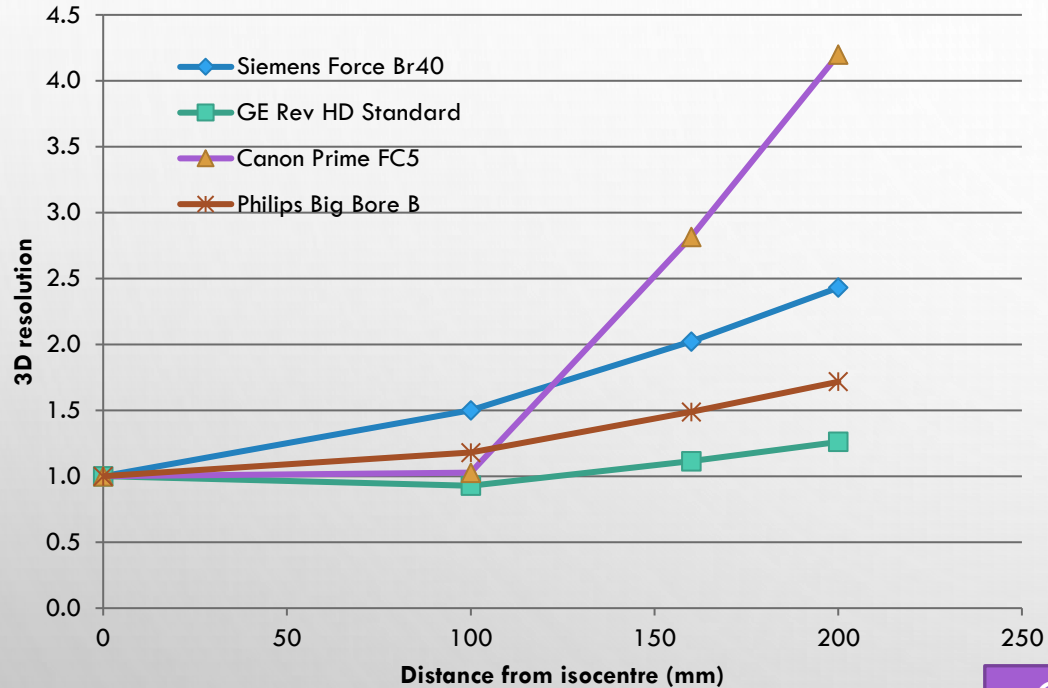
Kernel

- Siemens – no clear relationship
- GE & Philips – harshest kernels show greatest variation
- Canon – variation unaffected by kernel

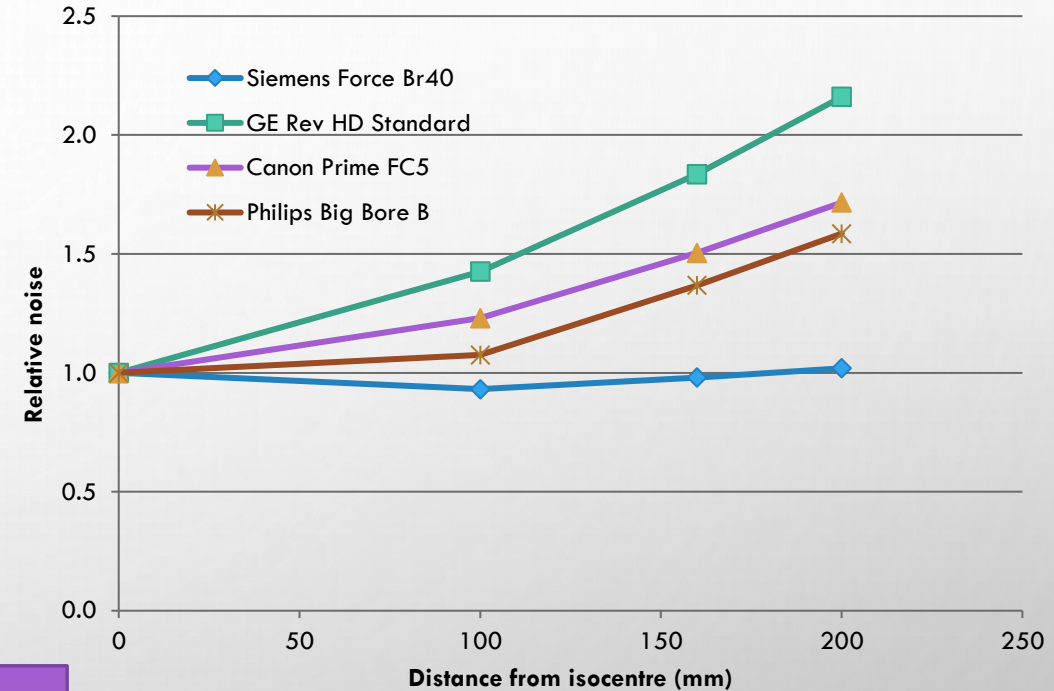
Scanner spec.

- Generally lower variation for higher specification systems (not Siemens Force)
- Need to check for Canon & Philips

RESOLUTION & NOISE COMPARISON



Medium kernel all manufacturers



- Generally high resolution variation means low noise variation & vice versa
- Canon doesn't seem to fit with this...

IMPLICATIONS FOR PRACTICE



Clinical staff

Notable variations in noise and/or resolution away from centre of bore

Potential effect on diagnostic utility of images

Users should be made aware of variations

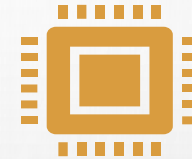


Physics

Differences not detectable with conventional image quality phantoms

Should we be checking IQ metrics away from isocentre?

Would same tolerances apply?



Manufacturers

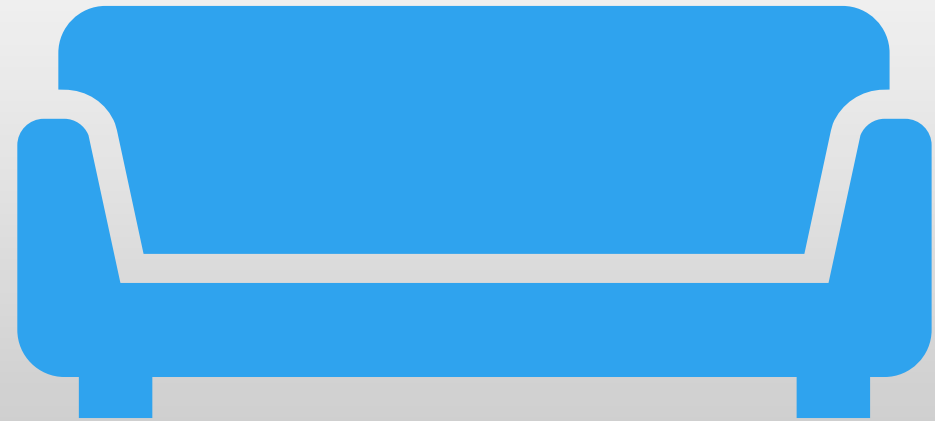
Clear differences in approach between manufacturers

Large variation between Siemens scanners

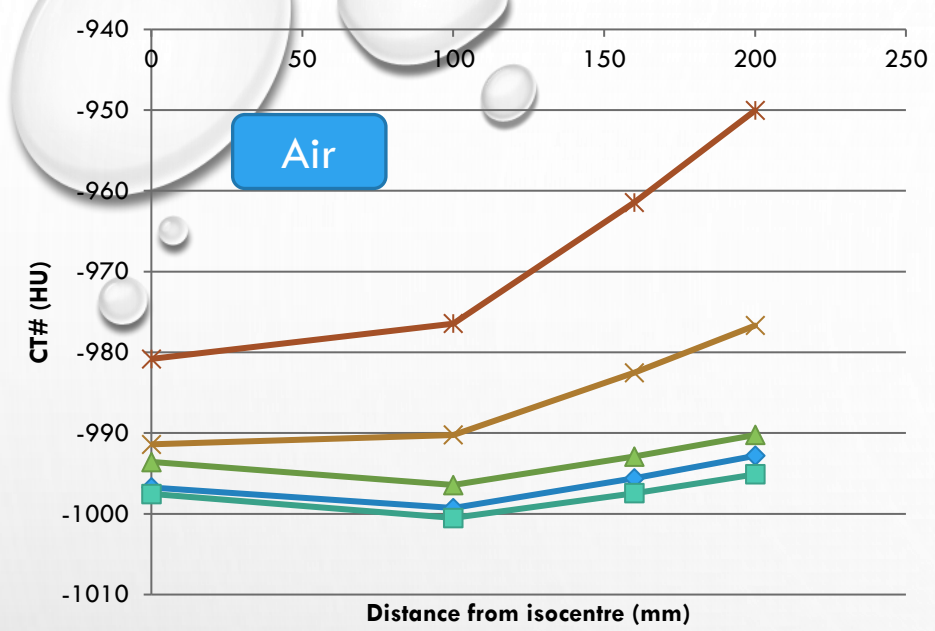
Should cross-field performance be stated in specifications?

THANK YOU!

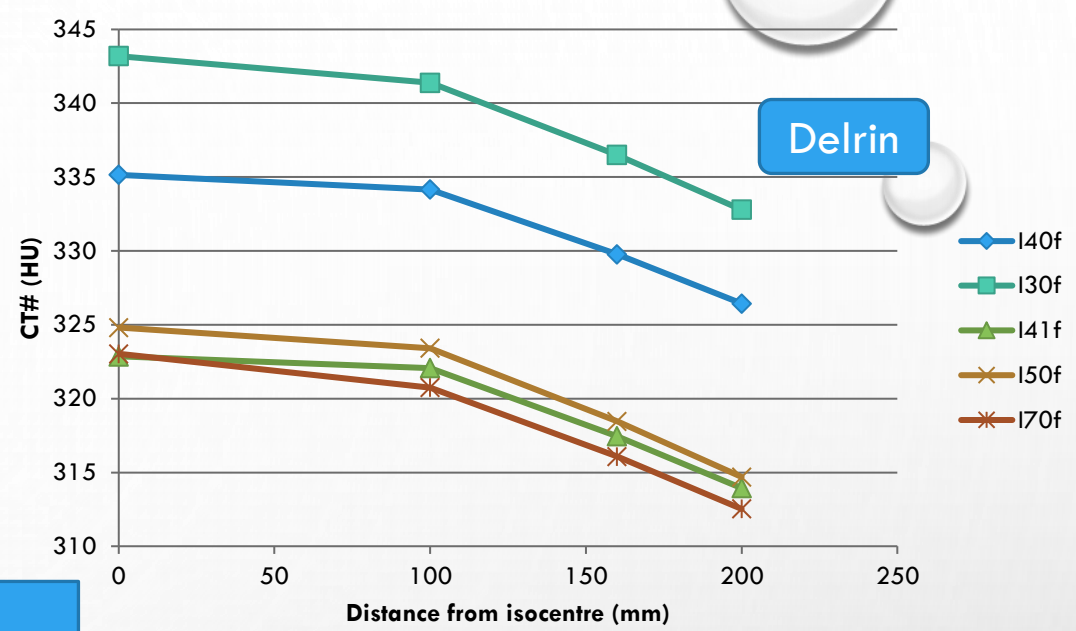
QUESTIONS?



CT NUMBERS

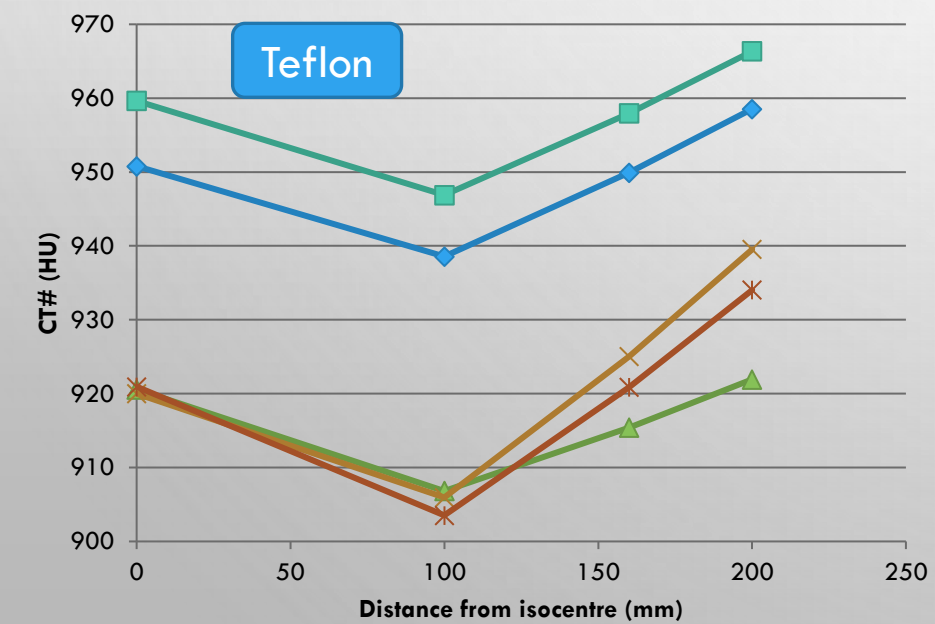


- I40f
- I30f
- I41f
- I50f
- I70f

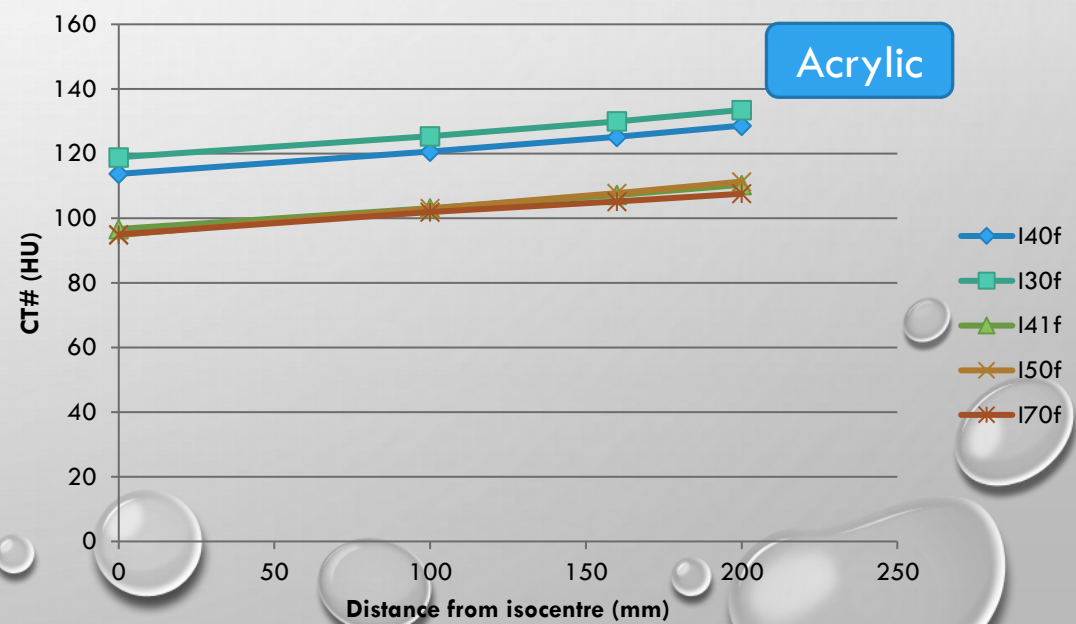


- I40f
- I30f
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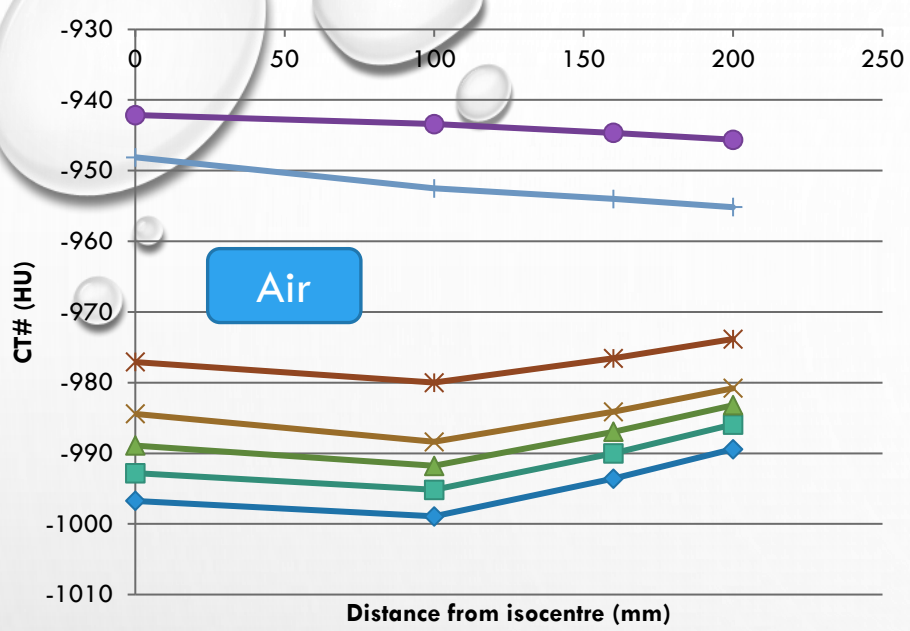
Siemens Definition AS+



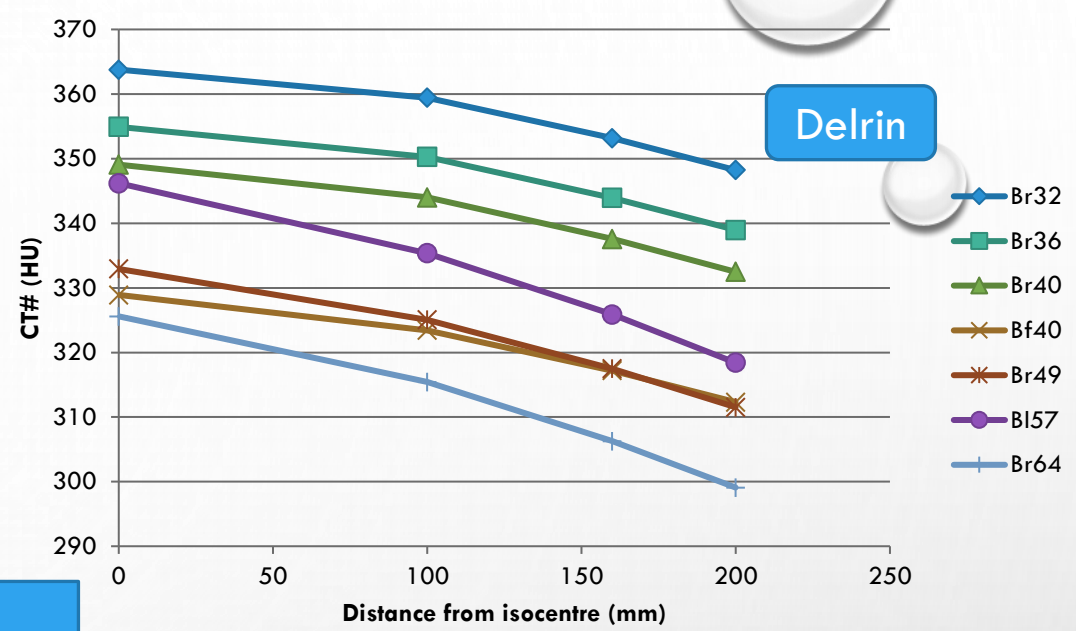
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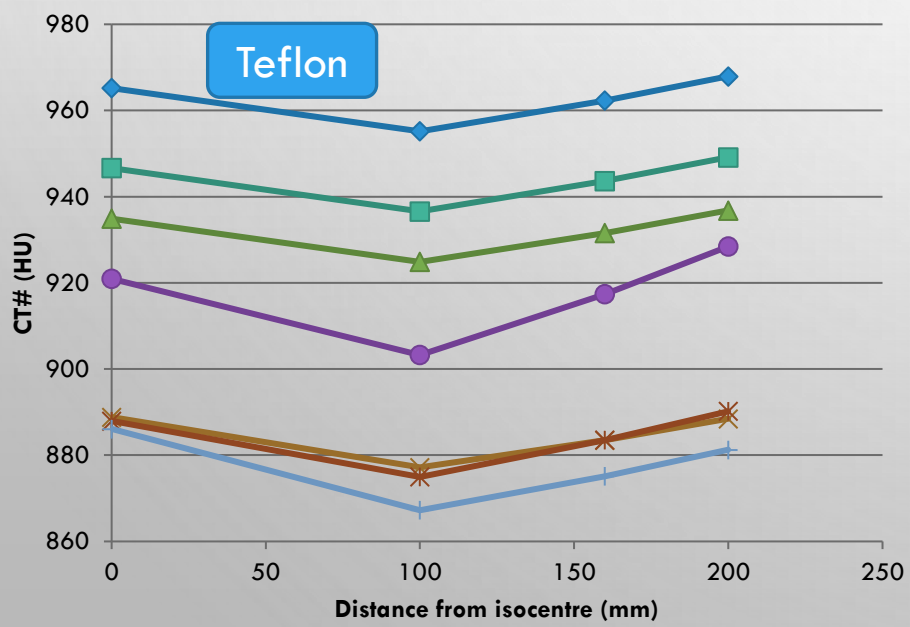


- ◆ Br32
- Br36
- ▲ Br40
- × Bf40
- * Br49
- BI57
- + Br64

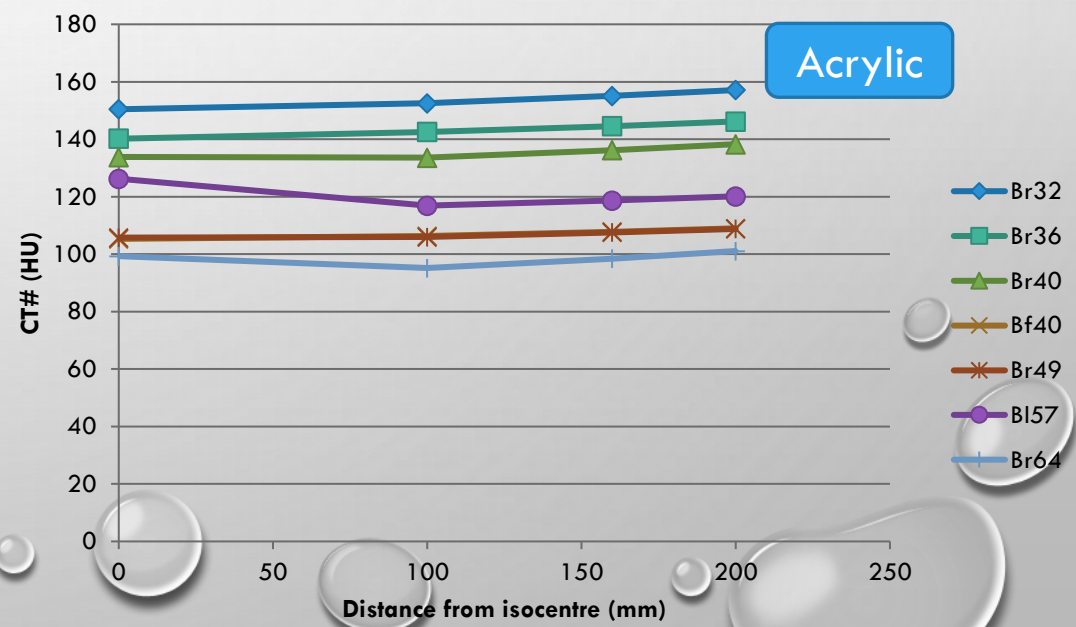


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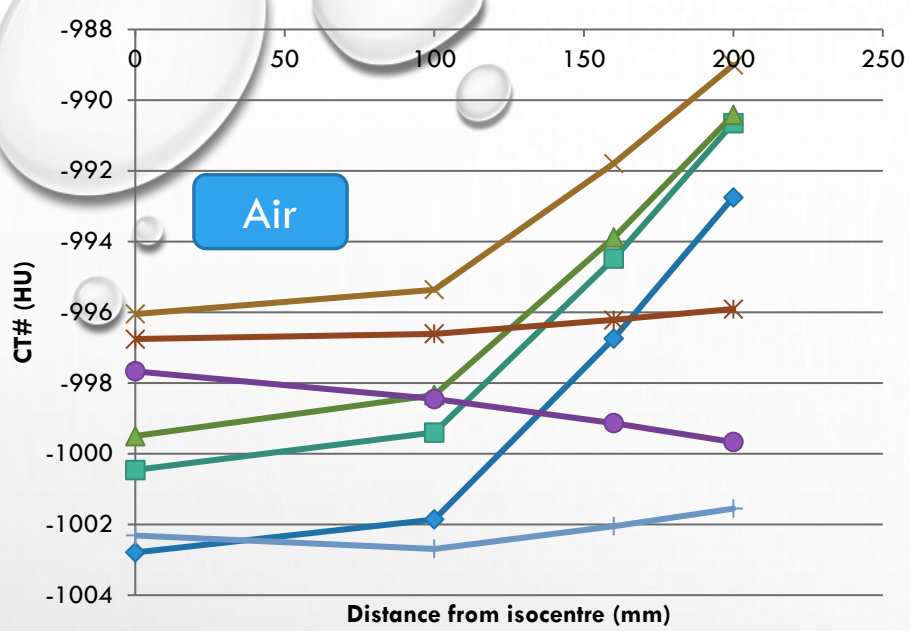
Siemens Somatom Force



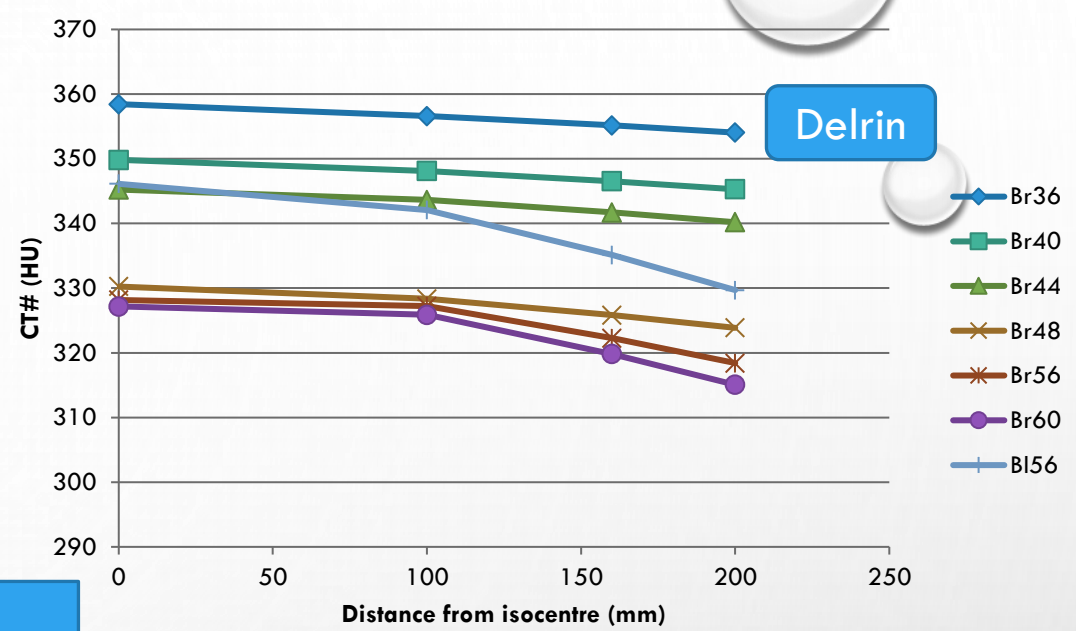
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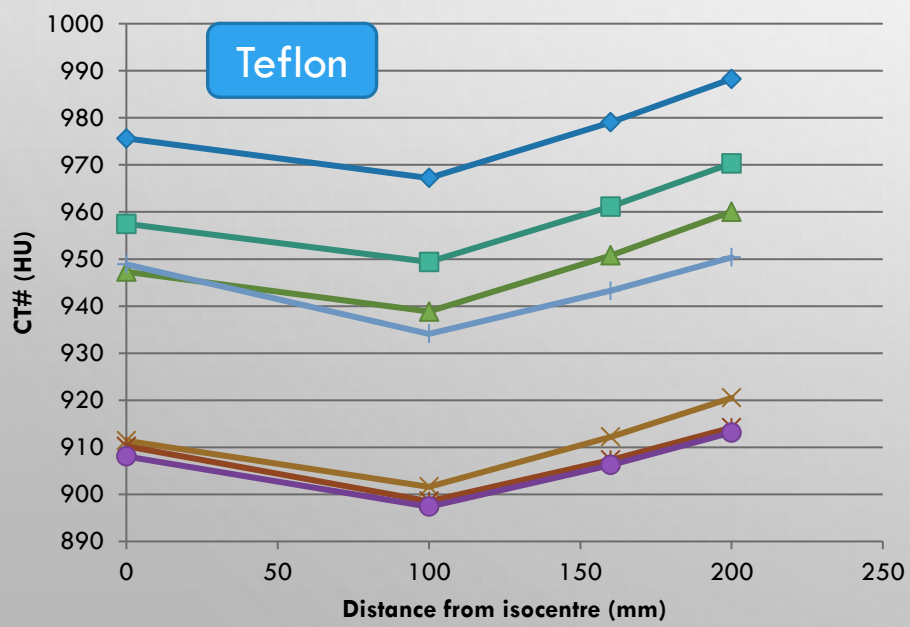


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- ▲ Br44
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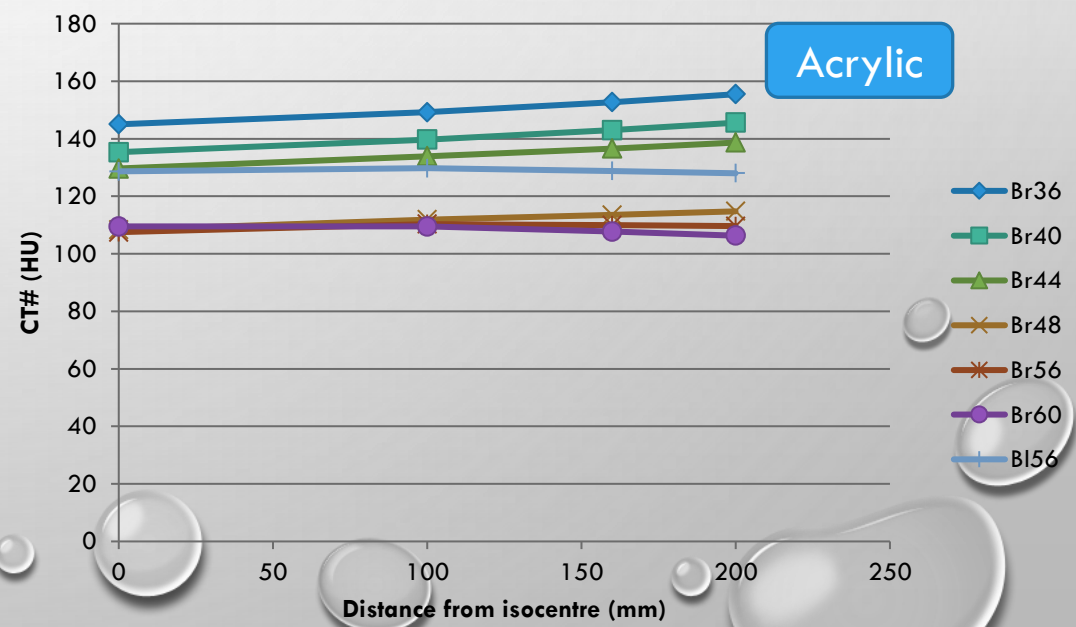
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Siemens go.All

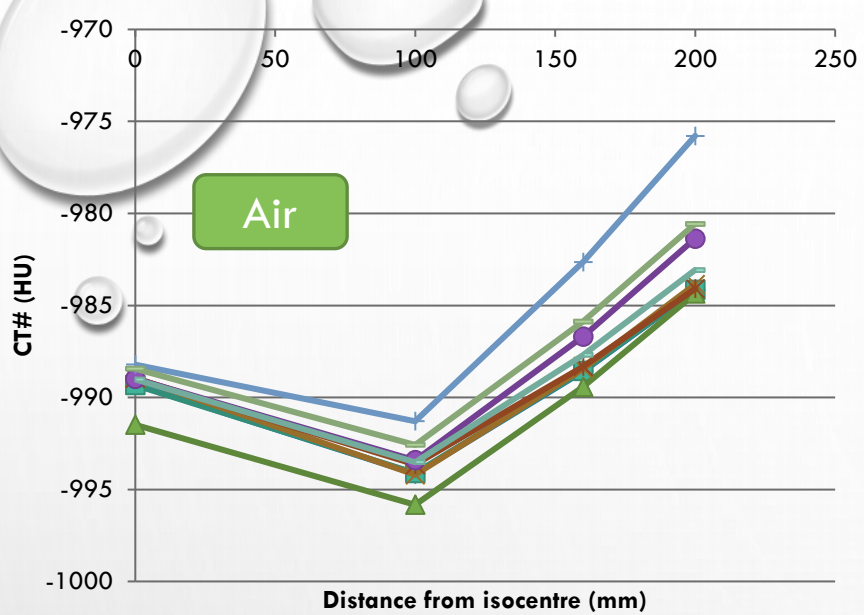


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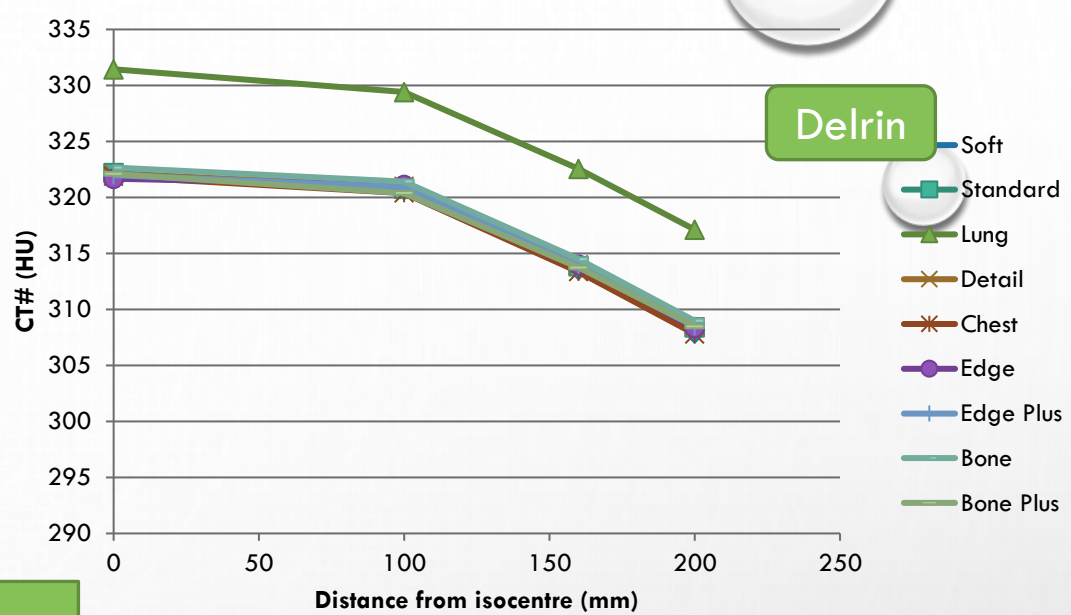
We had CT# calibration issues on this scanner...



- ◆ Br36
- Br40
- ▲ Br44
- × Br48
- * Br56
- Br60
- + BI56

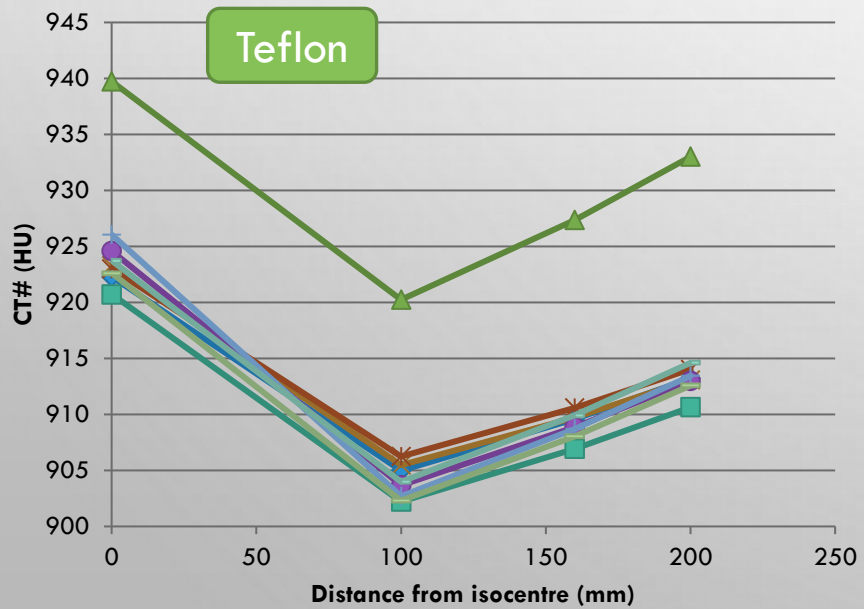


- Soft
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- Bone
- Bone Plus

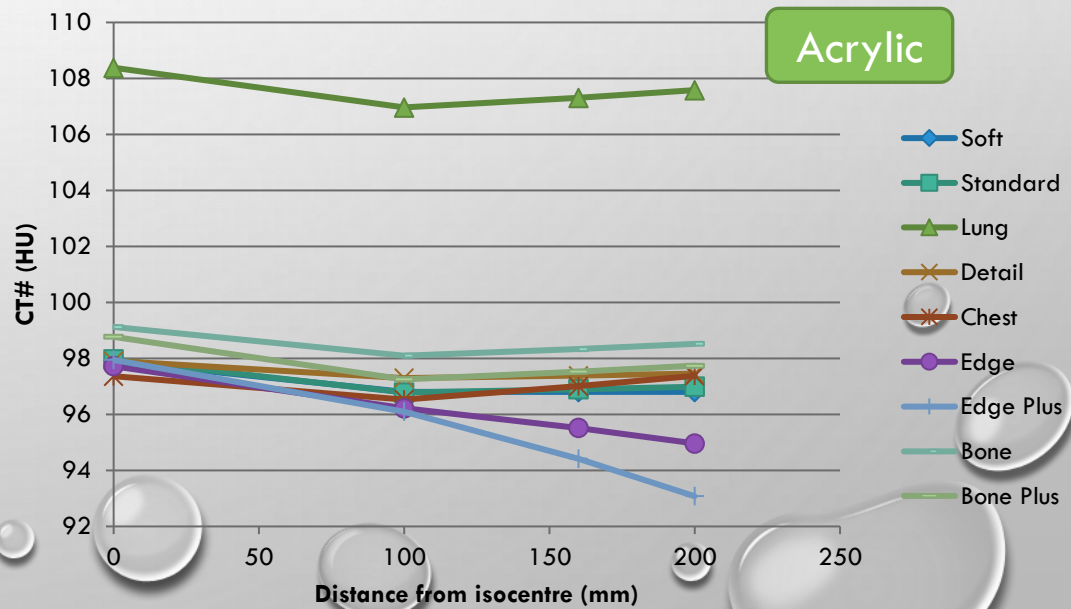


- Soft
- Standard
- Lung
- Detail
- Chest
- Edge
- Edge Plus
- Bone
- Bone Plus

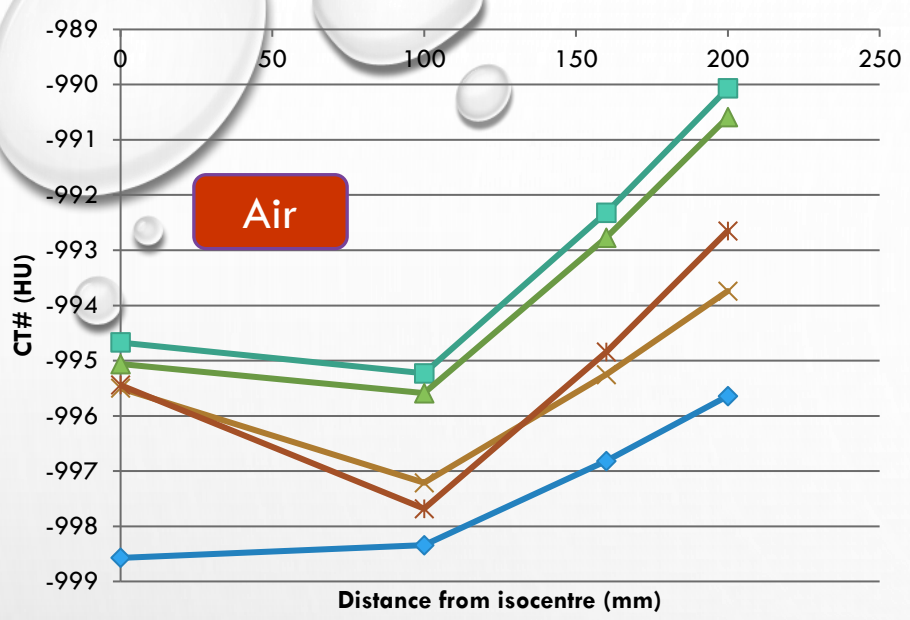
GE Revolution HD



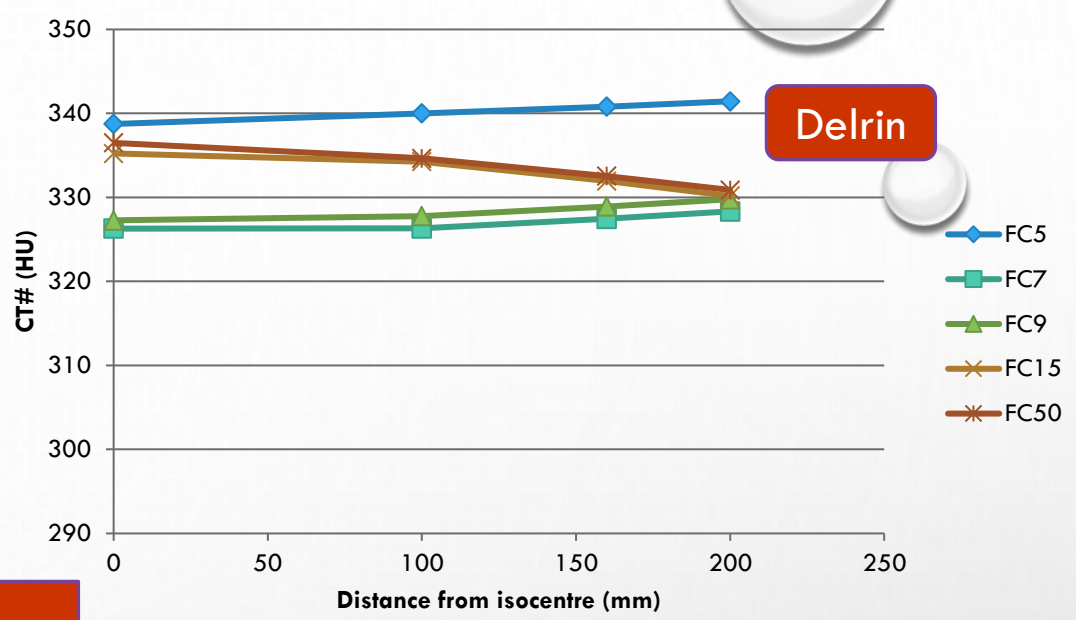
- Soft
- Standard
- Lung
- Detail
- Chest
- Edge
- Edge Plus
- Bone
- Bone Plus



- Soft
- Standard
- Lung
- Detail
- Chest
- Edge
- Edge Plus
- Bone
- Bone Plus

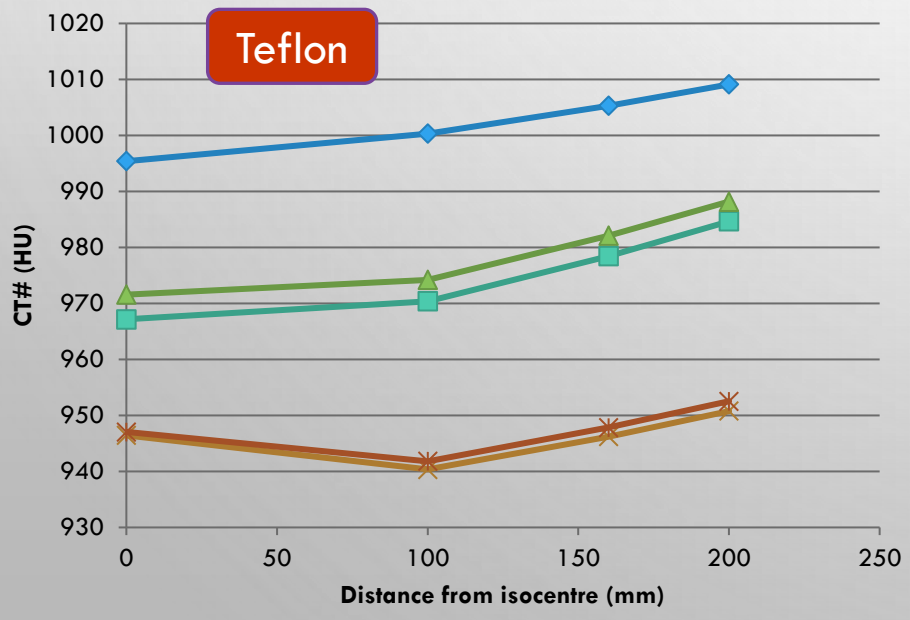


- FC5
- FC7
- FC9
- FC15
- FC50

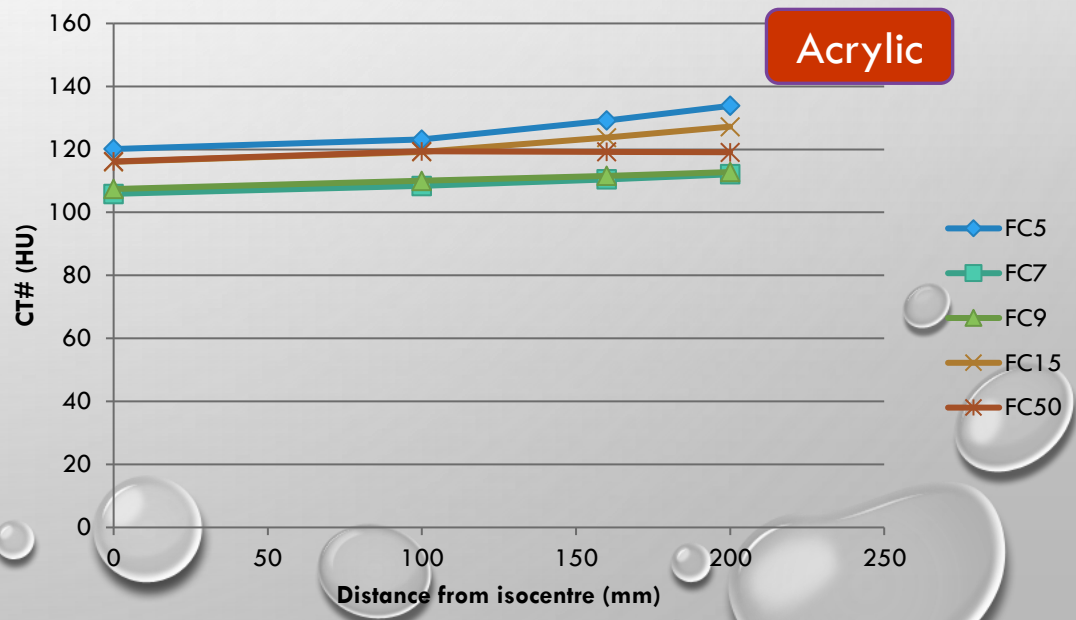


- FC5
- FC7
- FC9
- FC15
- FC50

Canon Aquilion Prime



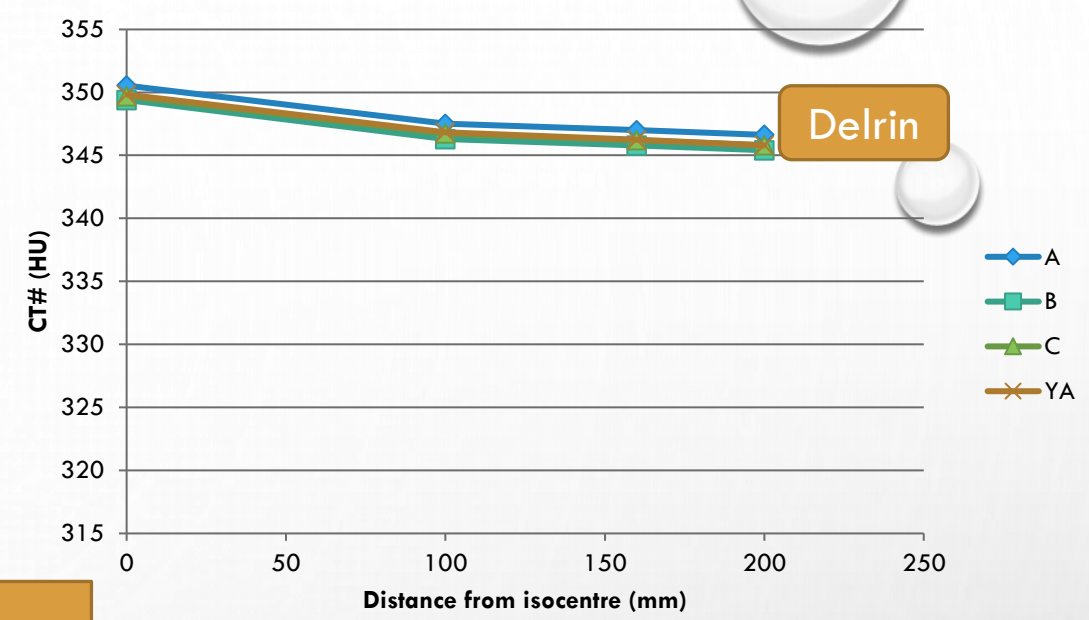
- FC5
- FC7
- FC9
- FC15
- FC50



- FC5
- FC7
- FC9
- FC15
- FC50

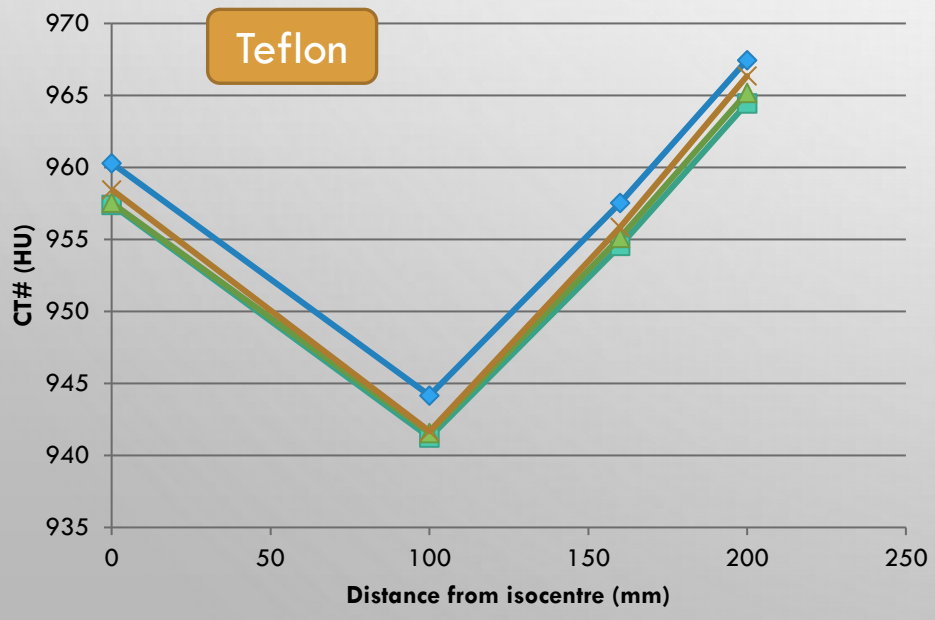


- ◆ A
- B
- ▲ C
- ✕ YA

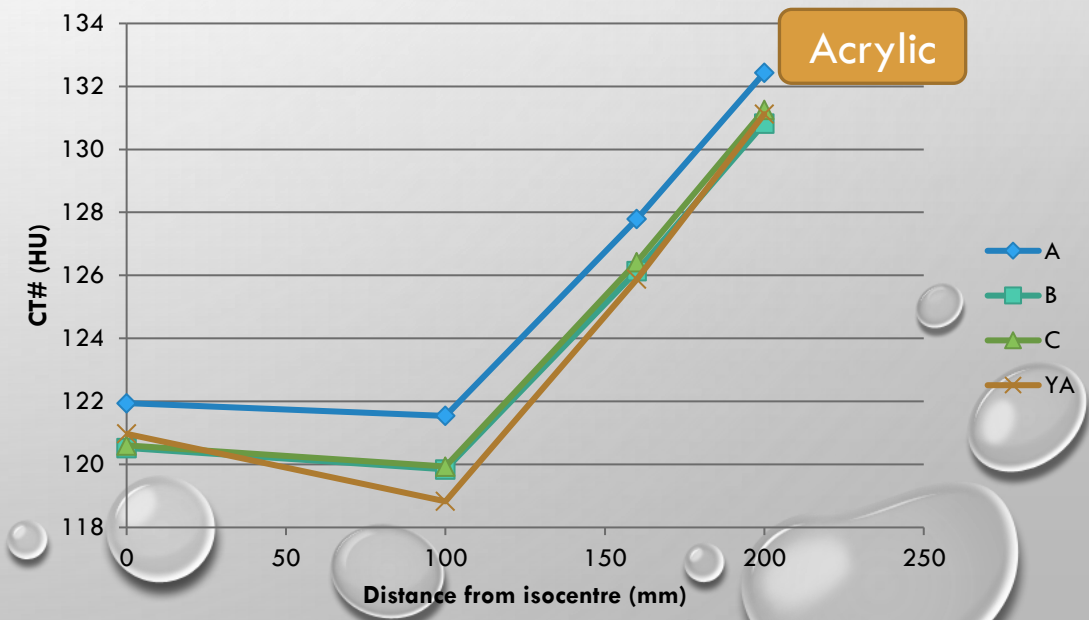


- ◆ A
- B
- ▲ C
- ✕ YA

Philips Big Bore



- ◆ A
- B
- ▲ C
- ✕ YA



- ◆ A
- B
- ▲ C
- ✕ YA