Gammex RMI CT Phantom, 438

(ACR CT Accreditation phantom, 464)

S. Edyvean, Jim Weston

Imaging Performance Assessment of CT Scanners

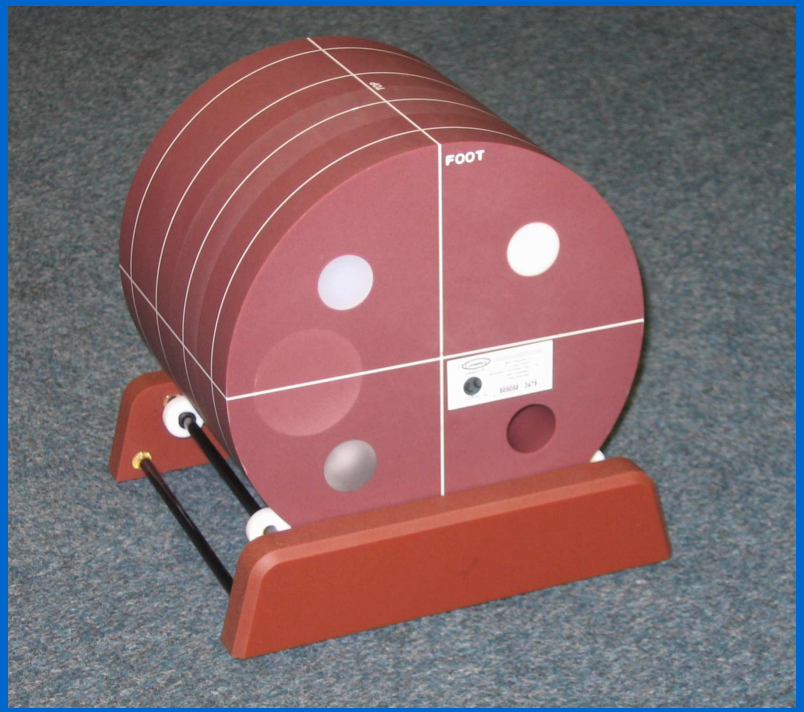
St. Georges Hospital, London

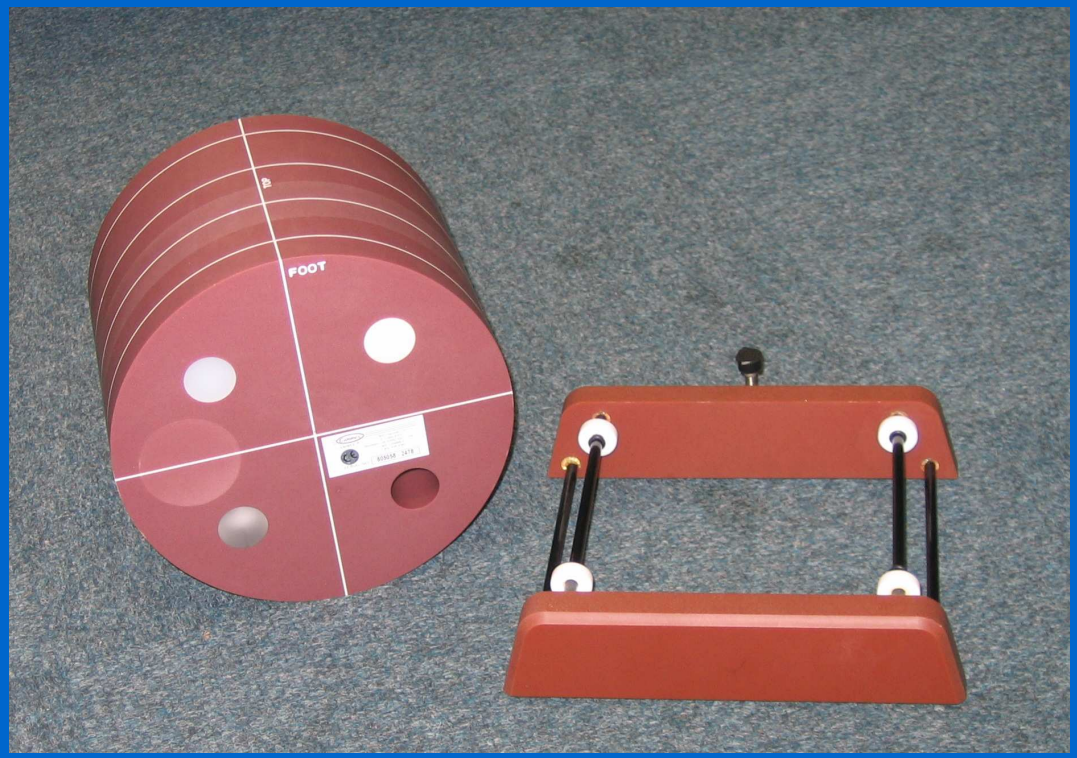
www.impactscan.org

Some images courtesy of Cynthia McCullough
Mayo Clinic, Rochester, USA

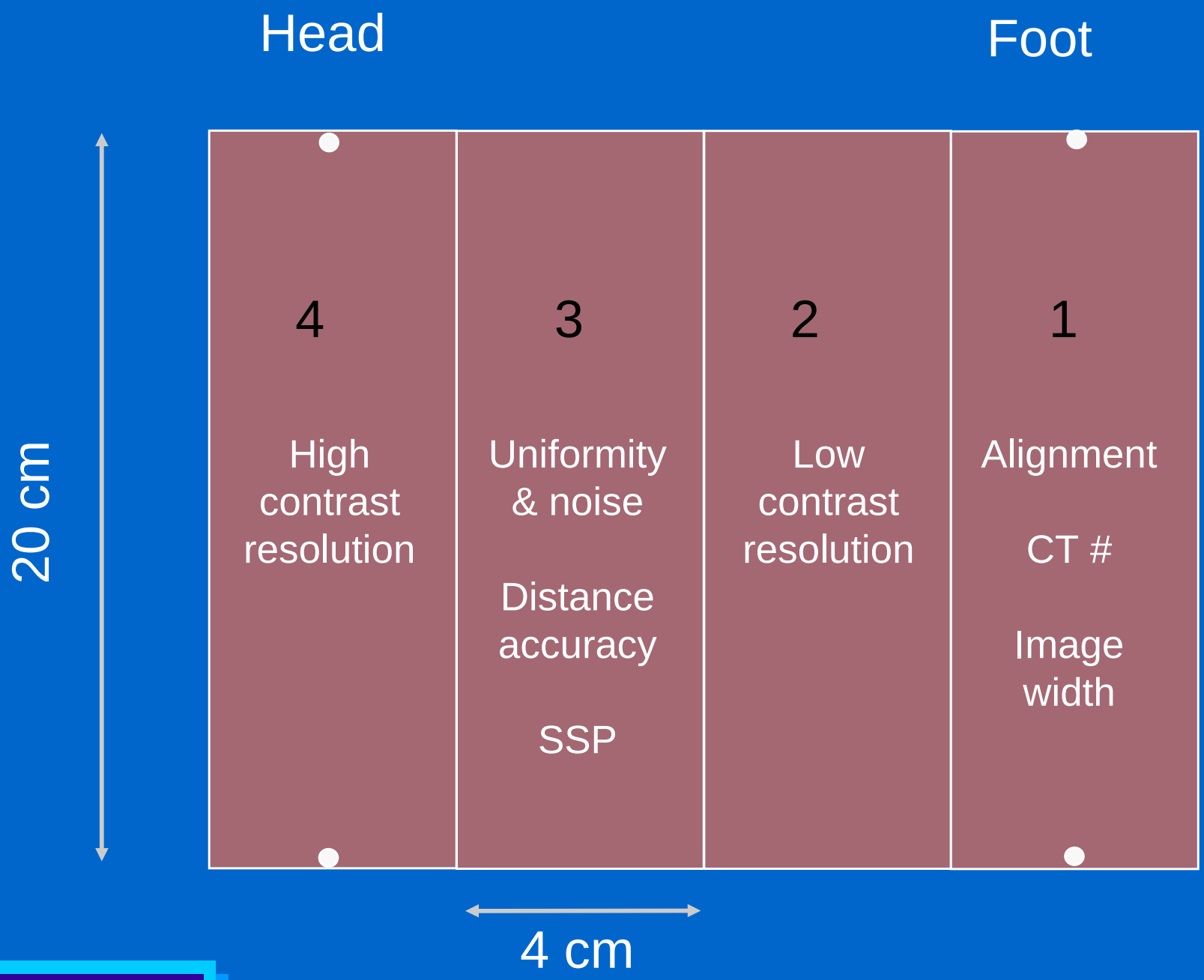
Gammex RMI CT Phantom, 438

- David Aikman
  - Gammex RMI Ltd.,Nottingham

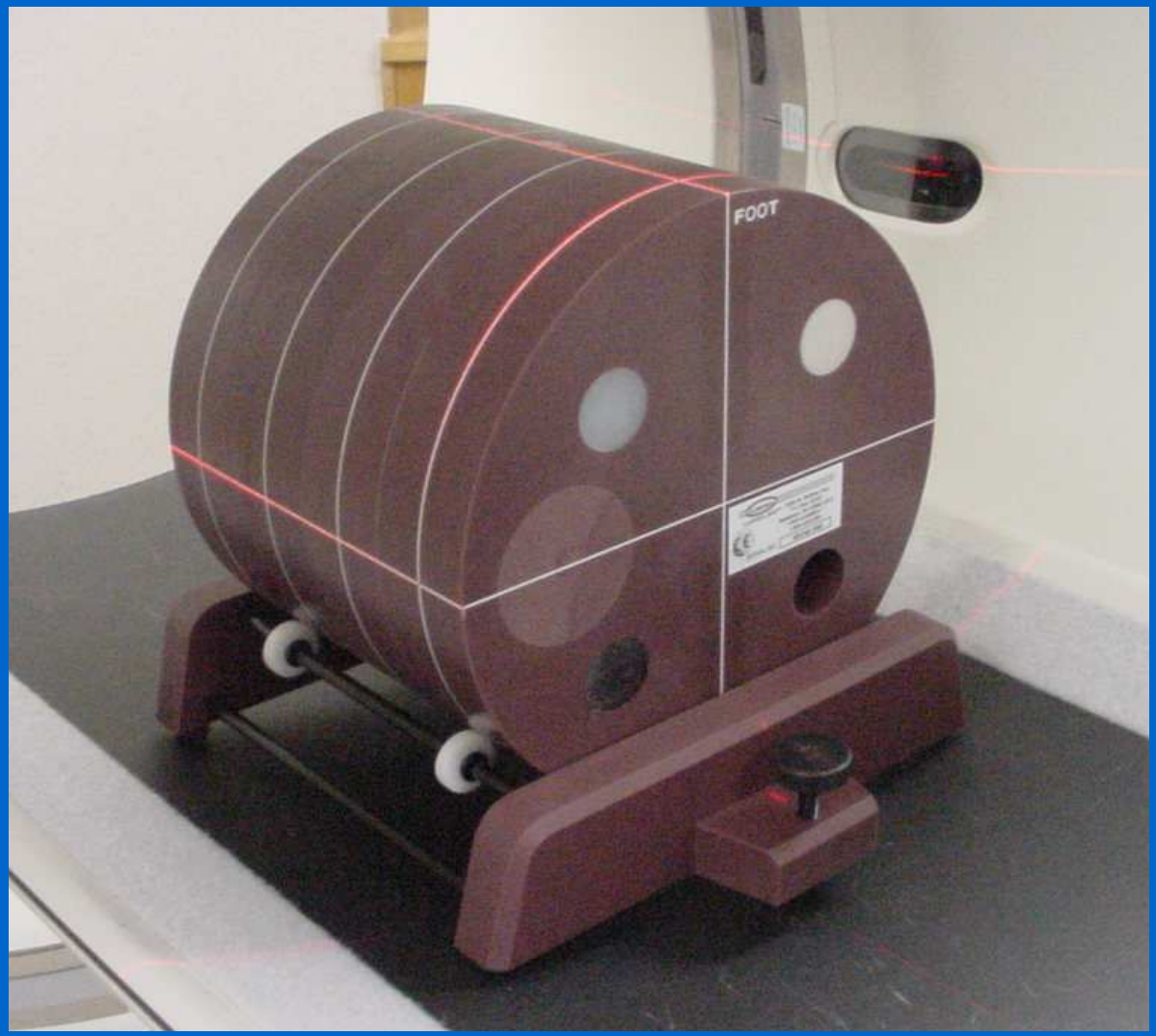




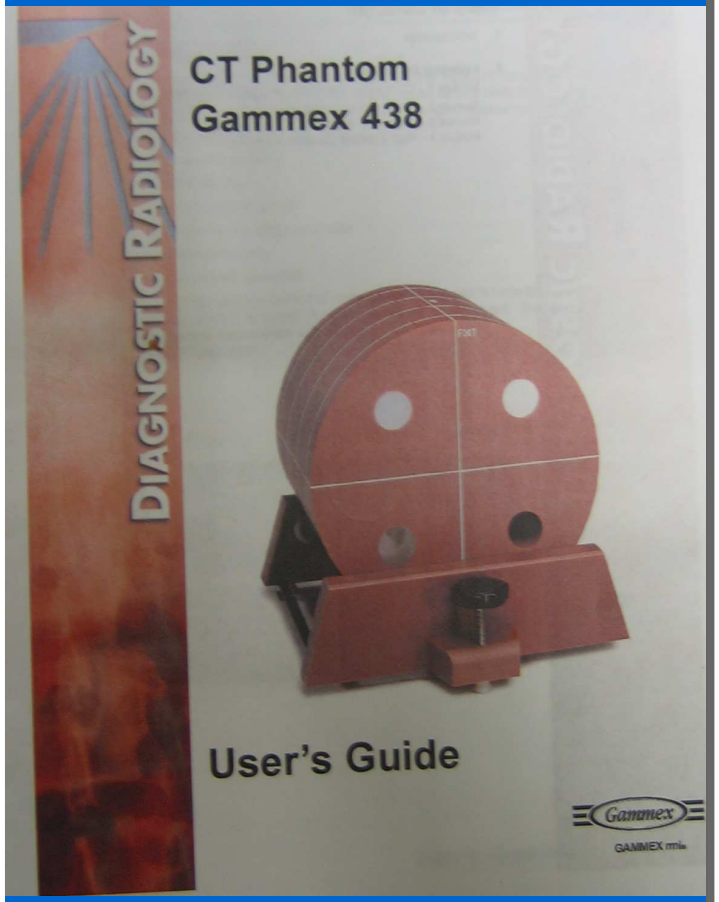
Gammex RMI CT Phantom



Gammex RMI CT Phantom



Documentation



ACR
1891 Preston White Drive, Reston VA 20191

Computed Tomography (CT) Accreditation Program
PHANTOM TESTING INSTRUCTIONS

INSTRUCTION MANUAL FOR TESTING THE ACR CT PHANTOM

Please follow these instructions carefully for submission of test materials.

INTRODUCTION

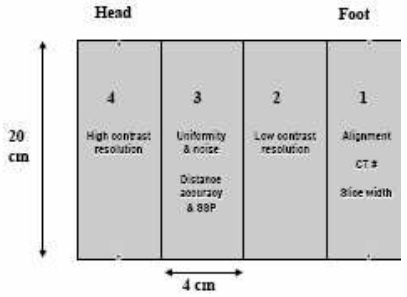
The ACR CT accreditation phantom has been designed to examine a broad range of scanner parameters. These include:

- Positioning accuracy
- CT # accuracy
- Slice width
- Low contrast resolution
- High contrast (spatial) resolution
- CT number uniformity
- Image noise

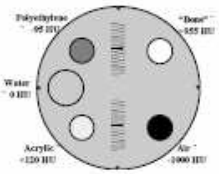
This document describes the test procedures in sufficient detail to allow a CT technologist or medi desired images and perform the necessary analysis and calculations. A medical physicist, howeve necessary dosimetric data.

THE PHANTOM

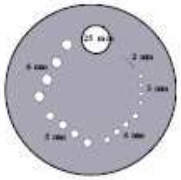
The ACR CT accreditation phantom is a solid phantom containing four modules, and is constructe equivalent material. Each module is 4 cm in depth and 20 cm in diameter. There are external align and painted white (to reflect alignment lights) on EACH module to allow centering of the phantom cranial/cauda), coronal (y-axis, anterior/posterior), and sagittal (x-axis, left/right) directions. There and "TOP" markings on the phantom to assist with alignment.



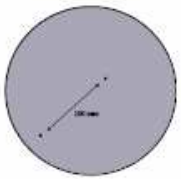
Module 1 is used to assess positioning and alignment, CT number accuracy, and slice thickness. The background material is water equivalent. For positioning, the module has 1-mm diameter steel BBs embedded at the longitudinal (z-axis) center of the module, with the outer surface of the BB at the phantom surface at 3, 6, 9, and 12 o'clock positions within the field of view (19.9cm center to center). To assess CT number accuracy, there are cylinders of different materials: bone-mimicking material ("Bone"), polyethylene, water equivalent material, acrylic, and air. Each cylinder, except the water cylinder, has a diameter of 25 mm and a depth of 4 cm. The water cylinder has a diameter of 50 mm and a depth of 4 cm. To assess slice thickness, two ramps are included which consist of a series of wires that are visible in 0.5-mm z-axis increments.



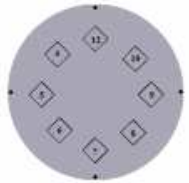
Module 2 is used to assess low contrast resolution. This module consists of a series of cylinders of different diameters, all at 0.6% (6 HU) difference from a background material having a mean CT number of approximately 90 HU. The cylinder-to-background contrast is energy-independent. There are four cylinders for each of the following diameters: 2 mm, 3 mm, 4 mm, 5 mm, and 6 mm. The space between each cylinder is equal to the diameter of the cylinder. A 25-mm cylinder is included to verify the cylinder-to-background contrast level.



Module 3 consists of a uniform, tissue-equivalent material to assess CT number uniformity. Two very small BBs (0.26 mm each) are included for optional use in assessing the accuracy of in-plane distance measurements. They may also be used to assess section sensitivity profiles.

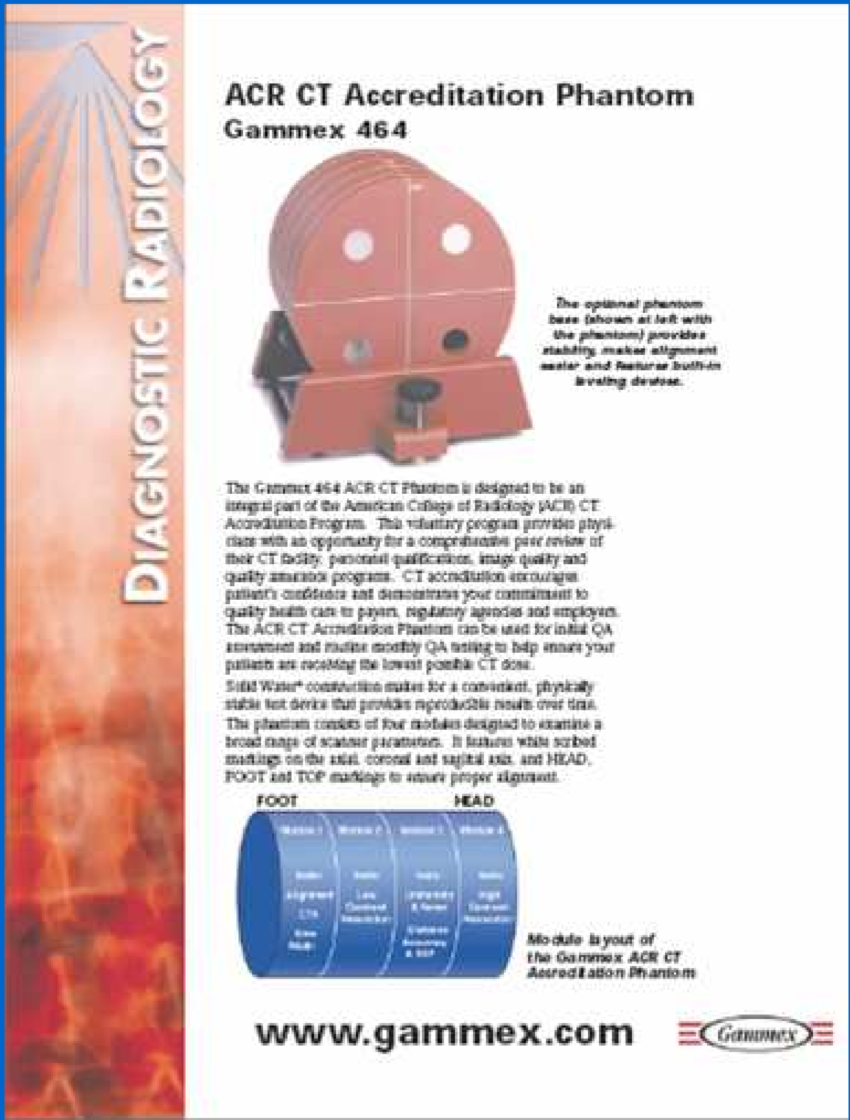


Module 4 is used to assess high contrast (spatial) resolution. It contains eight bar resolution patterns: 4, 5, 6, 7, 8, 9, 10 and 12 lp/cm, each fitting into a 15-mm x 15-mm square region. The z-axis depth of each bar pattern is 3.8 cm, beginning at the Module 3 interface. The aluminum bar patterns provide very high object contrast relative to the background material. Module 4 also has four 1mm steel beads, as described for Module 1.



Manual, also ACR (American College of Radiology) website

https://www.gammex.com



DIAGNOSTIC RADIOLOGY

ACR CT Accreditation Phantom
Gammex 464

The optional phantom base (shown at left with the phantom) provides stability, makes alignment easier and features built-in leveling devices.

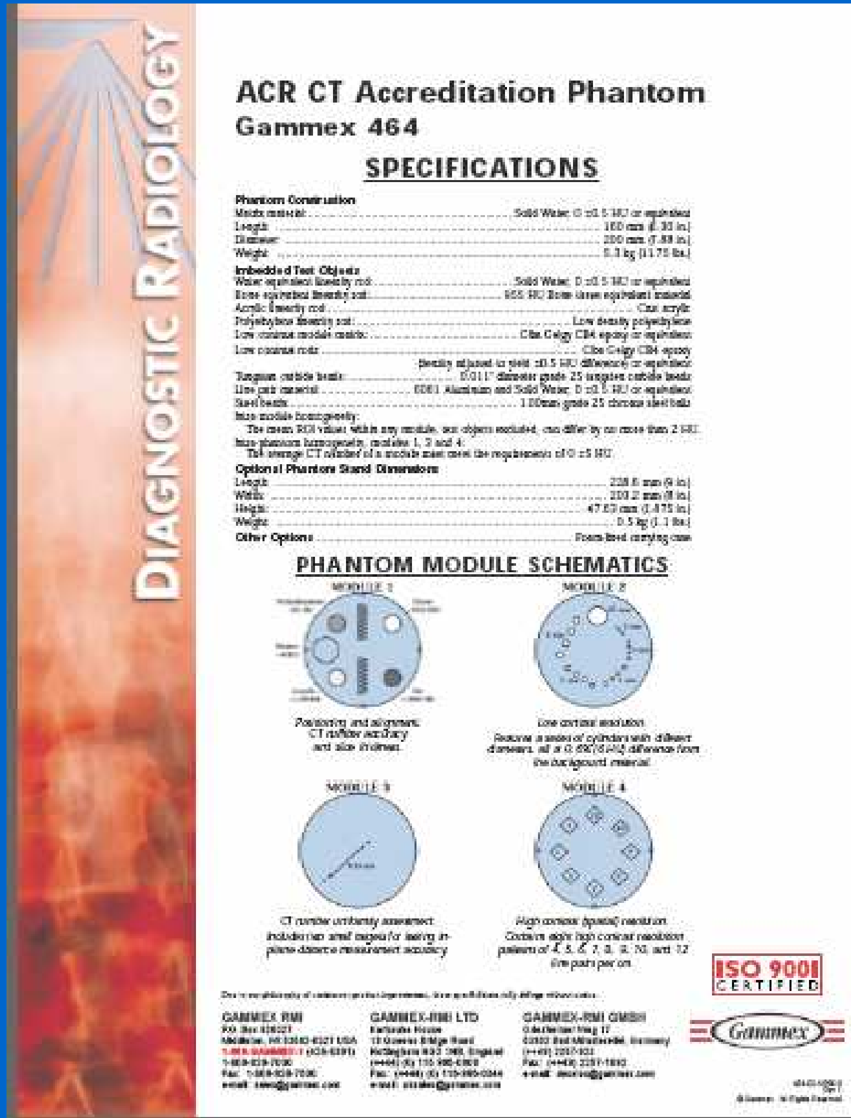
The Gammex 464 ACR CT Phantom is designed to be an integral part of the American College of Radiology (ACR) CT Accreditation Program. This voluntary program provides physicians with an opportunity for a comprehensive peer review of their CT facility, personnel qualifications, image quality and quality assurance programs. CT accreditation encourages patient's confidence and demonstrates your commitment to quality health care to payers, regulatory agencies and employers. The ACR CT Accreditation Phantom can be used for initial QA assessment and routine monthly QA testing to help ensure your patients are receiving the lowest possible CT dose.

Solid Water® construction makes for a convenient, physically stable test device that provides reproducible results over time. The phantom consists of four modules designed to examine a broad range of scanner parameters. It features white scribed markings on the axial, coronal and sagittal axis, and HEAD, FOOT and TOP markings to ensure proper alignment.

Module layout of the Gammex ACR CT Accreditation Phantom

www.gammex.com

Gammex



DIAGNOSTIC RADIOLOGY

ACR CT Accreditation Phantom
Gammex 464

SPECIFICATIONS

Phantom Construction
Matrix material: .... Solid Water, 0 ±0.5 HU or equivalent
Length: .... 160 mm (6.30 in.)
Diameter: .... 200 mm (7.88 in.)
Weight: .... 5.3 kg (11.75 lbs.)

Imbedded Test Objects
Water equivalent linearity rod: .... Solid Water, 0 ±0.5 HU or equivalent
Bone equivalent linearity rod: .... 955 HU Bone (bone equivalent material)
Acrylic linearity rod: .... Clear acrylic
Polyethylene linearity rod: .... Low density polyethylene
Low contrast module matrix: .... Ciba Geigy CB4 epoxy or equivalent
Low contrast rods: .... Ciba Geigy CB4 epoxy (density adjusted to yield ±0.5 HU difference) or equivalent
Tungsten carbide beads: .... 0.011" diameter grade 25 tungsten carbide beads
Line pair material: .... 6061 Aluminum and Solid Water, 0 ±0.5 HU or equivalent
Steel beads: .... 1.00mm grade 25 chrome steel balls
Intra-module homogeneity:
The mean ROI values within any module, test objects excluded, can differ by no more than 2 HU.
Intra-phantom homogeneity, modules 1, 3 and 4:
The average CT number of a module must meet the requirements of 0 ±5 HU.

Optional Phantom Stand Dimensions
Length: .... 228.6 mm (9 in.)
Width: .... 203.2 mm (8 in.)
Height: .... 47.63 mm (1.875 in.)
Weight: .... 0.5 kg (1.1 lbs.)
Other Options .... Foam-lined carrying case

PHANTOM MODULE SCHEMATICS

MODULE 1
Positioning and alignment, CT number accuracy and slice thickness.

MODULE 2
Low contrast resolution. Features a series of cylinders with different diameters, all at 0.6% (6 HU) difference from the background material.

MODULE 3
CT number uniformity assessment. Includes two small beads for testing in-plane distance measurement accuracy.

MODULE 4
High contrast (spatial) resolution. Contains eight high contrast resolution patterns of 4, 5, 6, 7, 8, 9, 10, and 12 line pairs per cm.

ISO 9001 CERTIFIED

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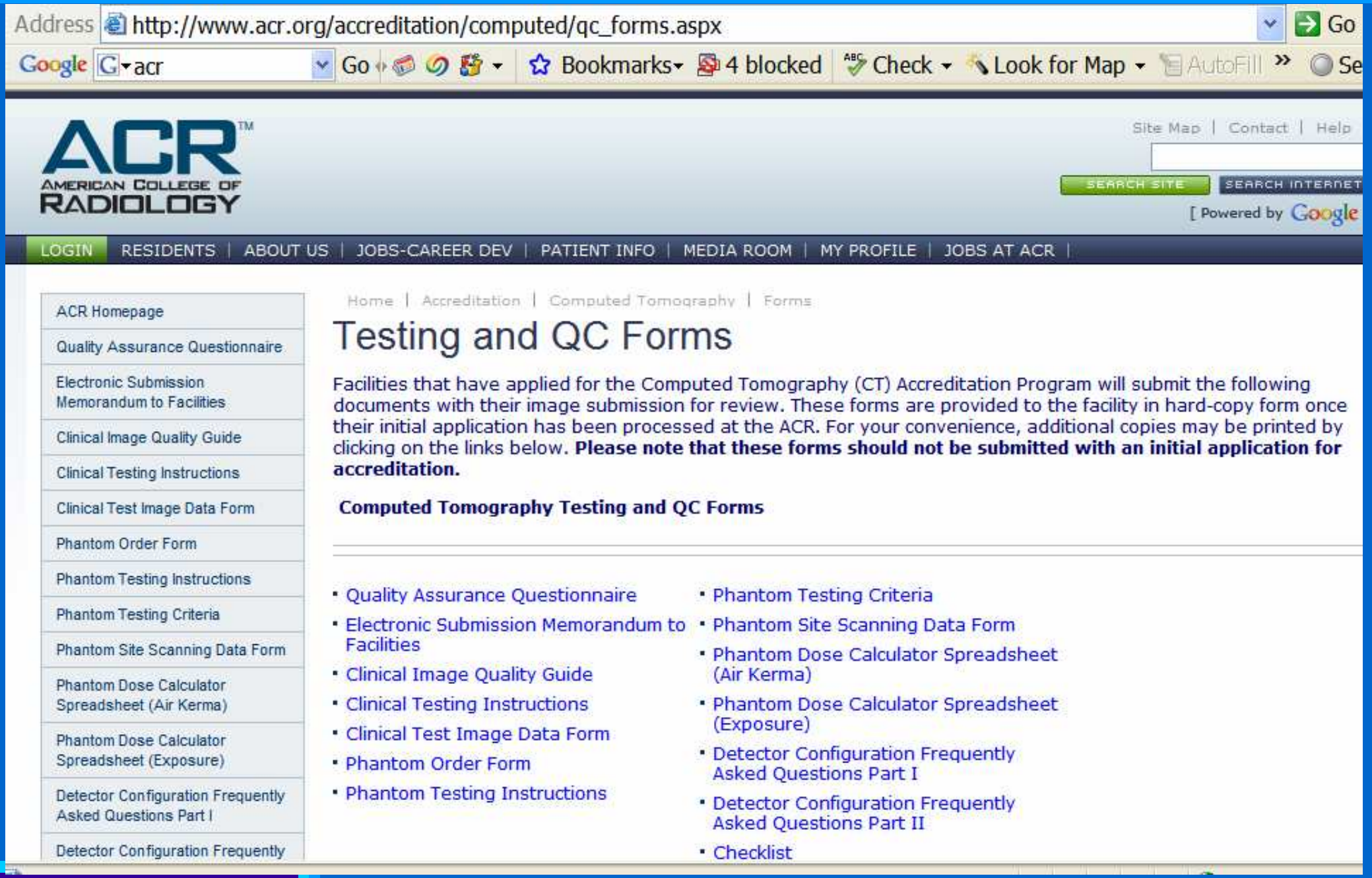
Middleton, WI USA
e-mail: sales@gammex.com

GAMMEX-RMI LTD
Nottingham, England

GAMMEX-RMI GMBH
Germany

Gammex

ACR CT Accreditation Program



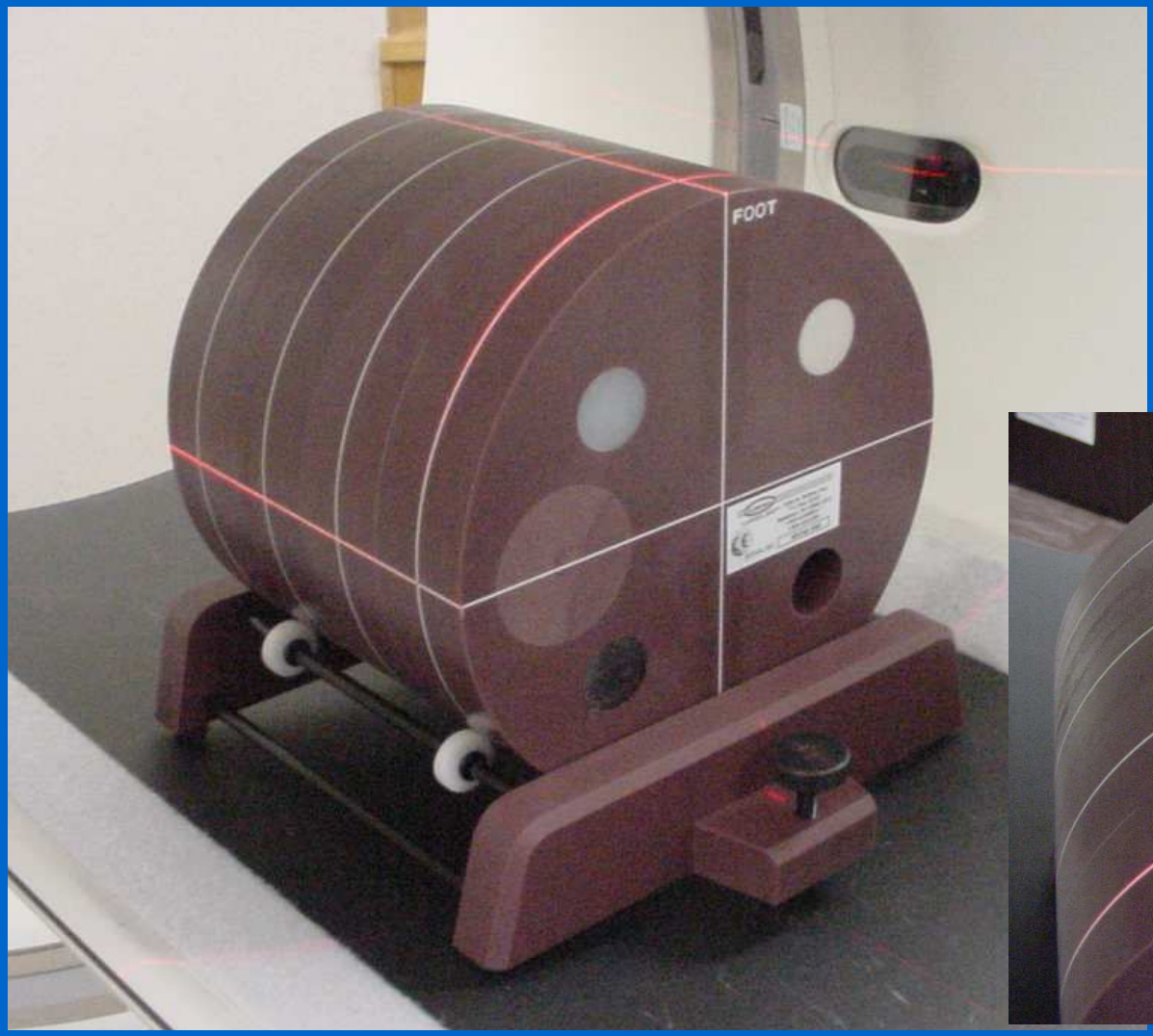
ACR documentation

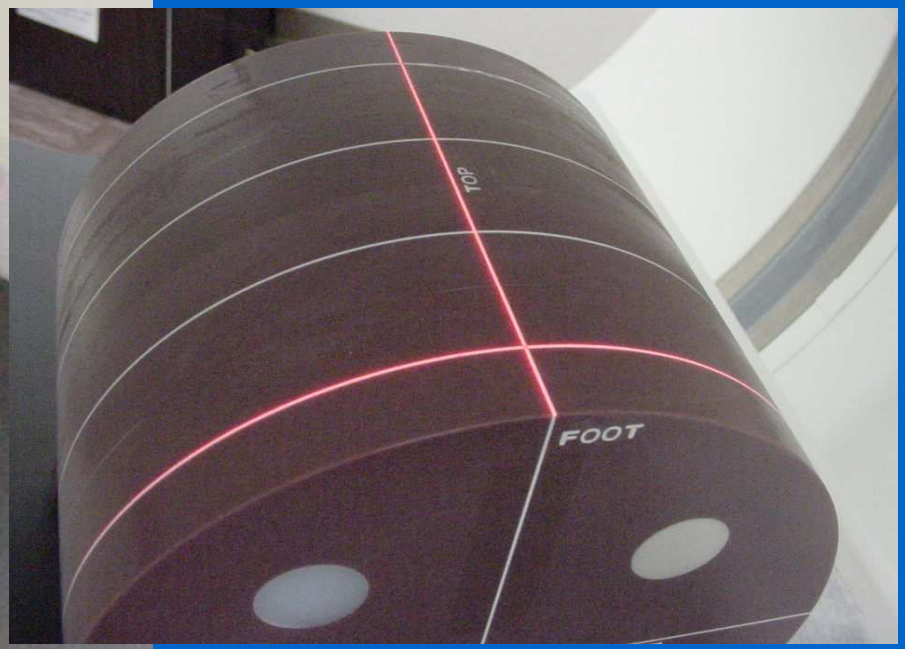
Table 1: Typical Image Acquisition Technical Parameters

	Adult Head (cerebellum portion)	High Resolution Chest	Adult Abdomen	Pediatric Abdomen (5 y.o.)
kVp				
mA				
Time per rotation (s)				
Scan FOV (cm or name)				
Display FOV (cm)				
Reconstruction Algorithm				
Axial (A) or Helical (H)				
Z-axis collimation (T, in mm) [1]				
# data channels *used* [1] (N)				
A: Table Increment (mm) or H: Table Speed (mm/rot) (I) [1]				
Pitch [2]				
Reconstructed Scan Width (mm)				
Reconstructed Scan Interval (mm)				
Dose Reduction Technique(s) [3]				

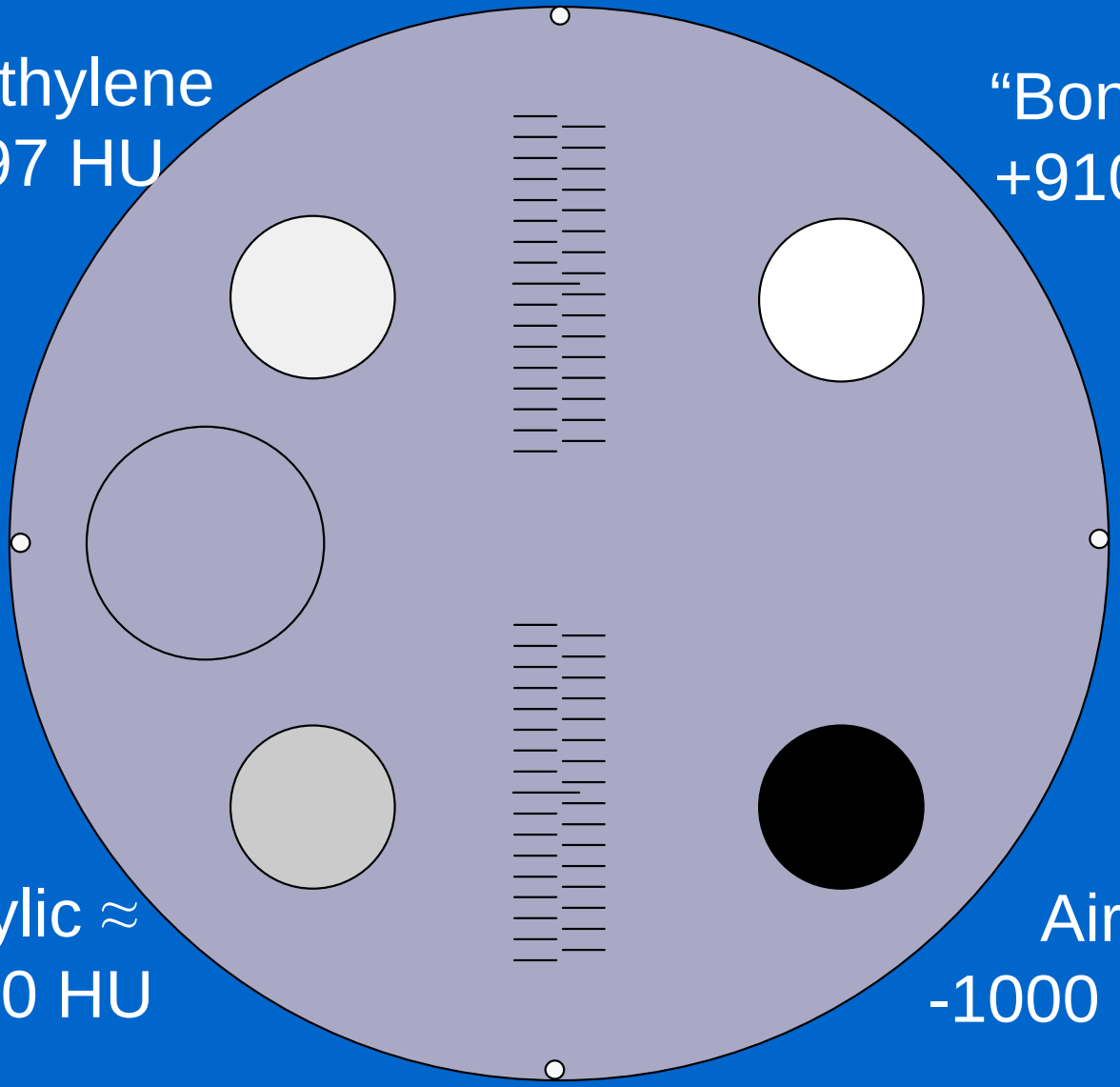
[1] See definitions on page 2 of the Physics Testing Instruction

Setting up





Module 1: alignment, image thickness, CT number



Polyethylene ≈ -97 HU

"Bone" ≈ +910 HU

Water ≈ 0 HU

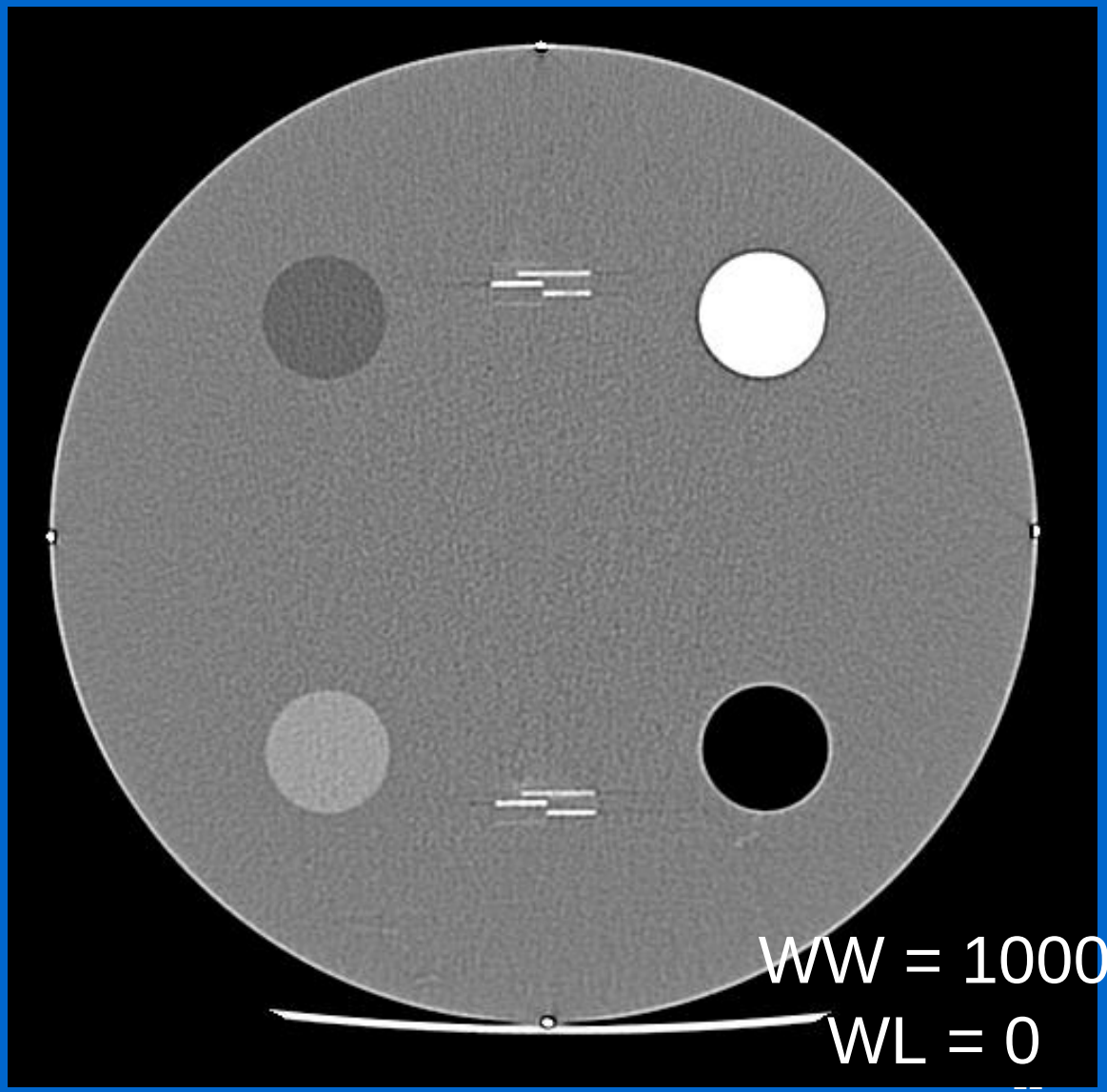
Acrylic ≈ +120 HU

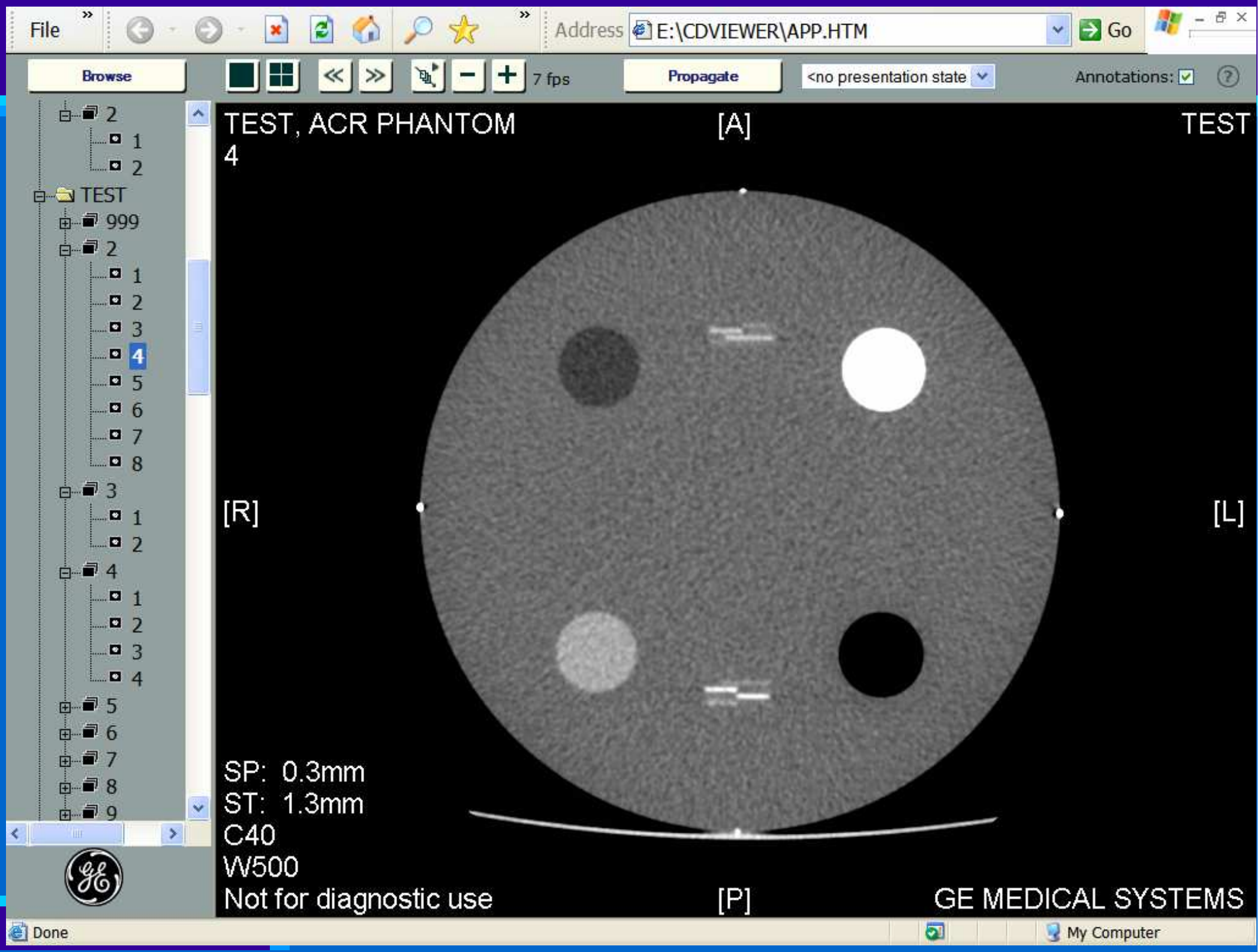
Air ≈ -1000 HU

Module 1: alignment, image thickness, CT number

Must see all four BBs (in Modules 1 & 4)

Longer wire must have same number of lines above and below (±1)

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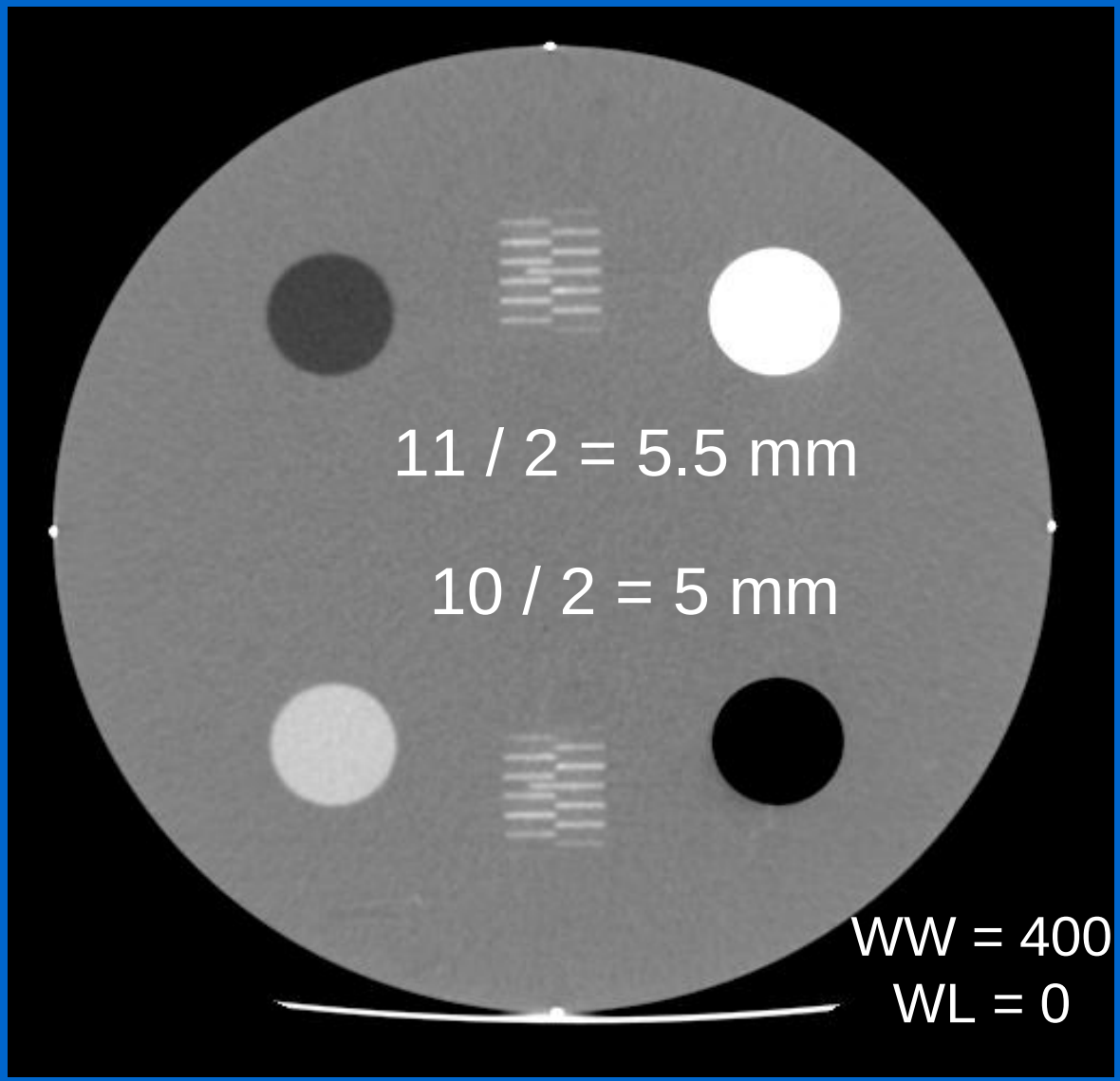
Module 1: alignment, image thickness, CT number

Wires are 0.5 mm apart in z-direction

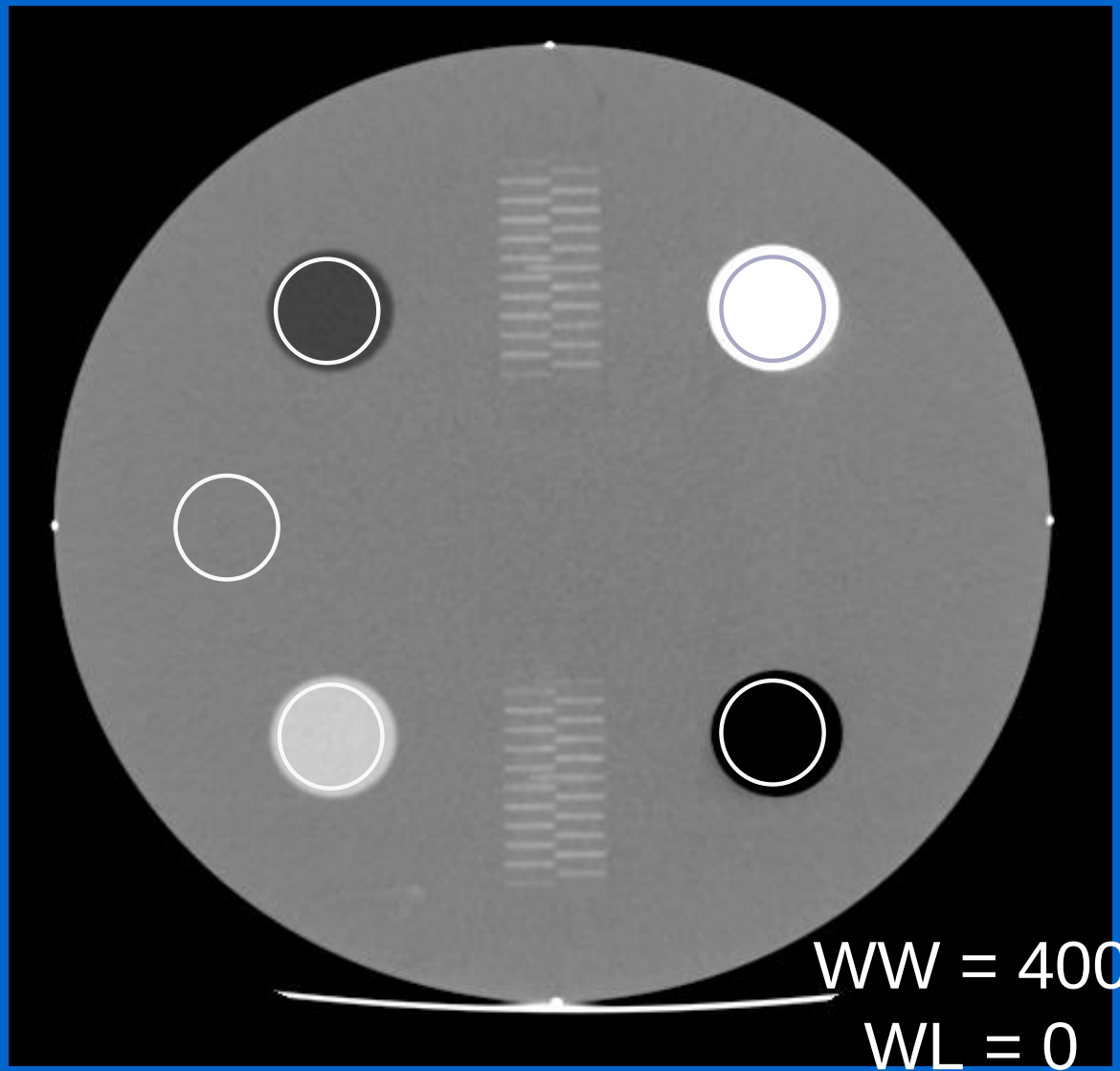


Module 1: alignment, image thickness, CT number

Polyethylene
≈ -97 HU

Water ≈
0 HU

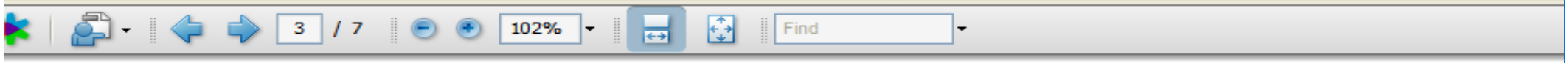
Acrylic ≈
+120 HU



“Bone” ≈
+910 HU

Air ≈
-1000 HU

ACR documentation: module 1

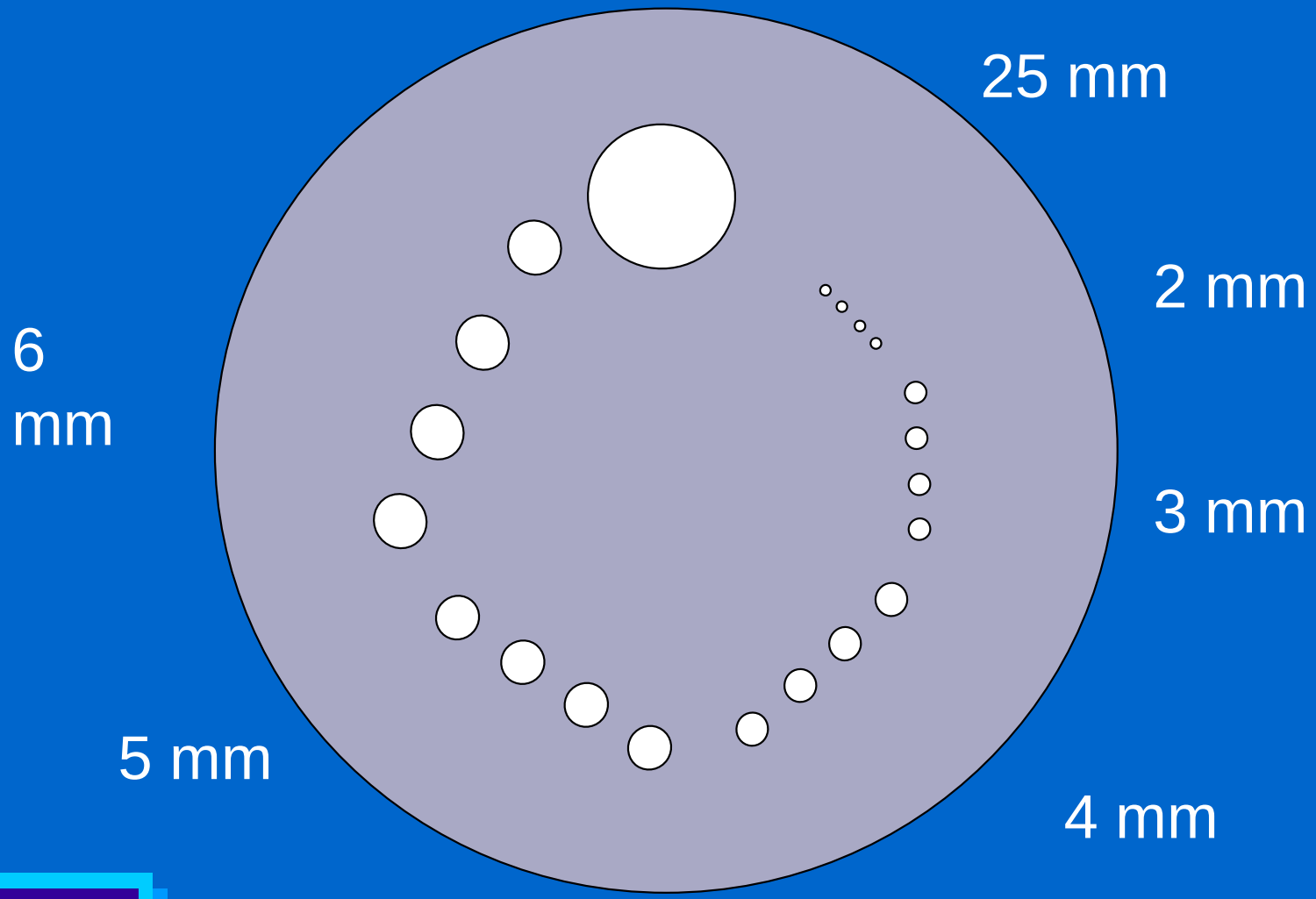


Section 5 – Module 1: CT Number Calibration and Slice Thickness **Adult Abdomen technique**

Parameter	Measured			Film Page: Box
Location of center of Module 1	_____mm			
CT number calibration and scan width accuracy for adult abdomen slice width				
Polyethylene	Mean CT # = _____HU	Top	Bottom	1:4
Water	Mean CT # = _____HU	_____mm	_____mm	
Acrylic	Mean CT # = _____HU			
Bone	Mean CT # = _____HU			
Air	Mean CT # = _____HU			
Dependency of CT Number of water on scan width and kVp, and scan width accuracy				
	CT number of water	Top	Bottom	
Hi Res Chest = _____mm	Mean CT # = _____HU	_____mm	_____mm	1:5
≈ 3 mm = _____mm	Mean CT # = _____HU	_____mm	_____mm	1:6

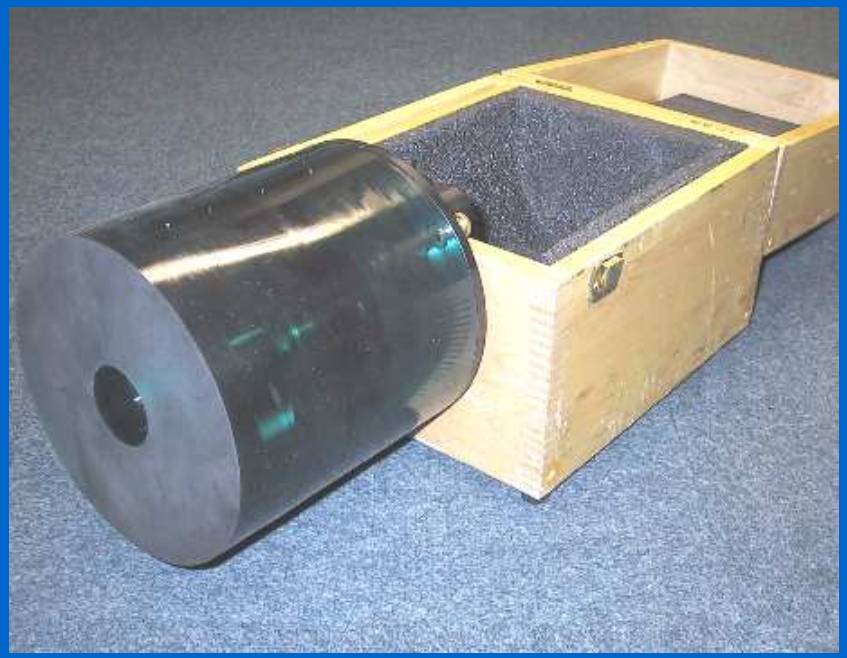
Module 2: Low contrast detectability

- Low contrast = 6 HU ± 0.5 HU
  - (cf Catphan 10, 5, 3 HU single object of each size)



Phantoms for low contrast detectability (LCD)

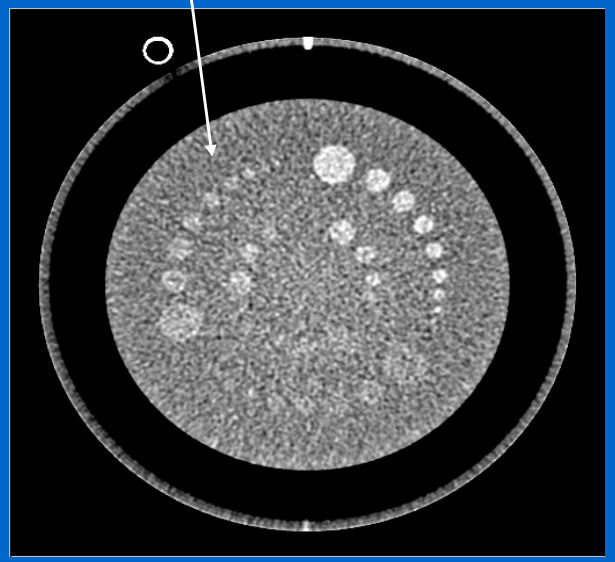
- Catphan 500



2-15 mm diameter

10 HU contrast

5 HU contrast

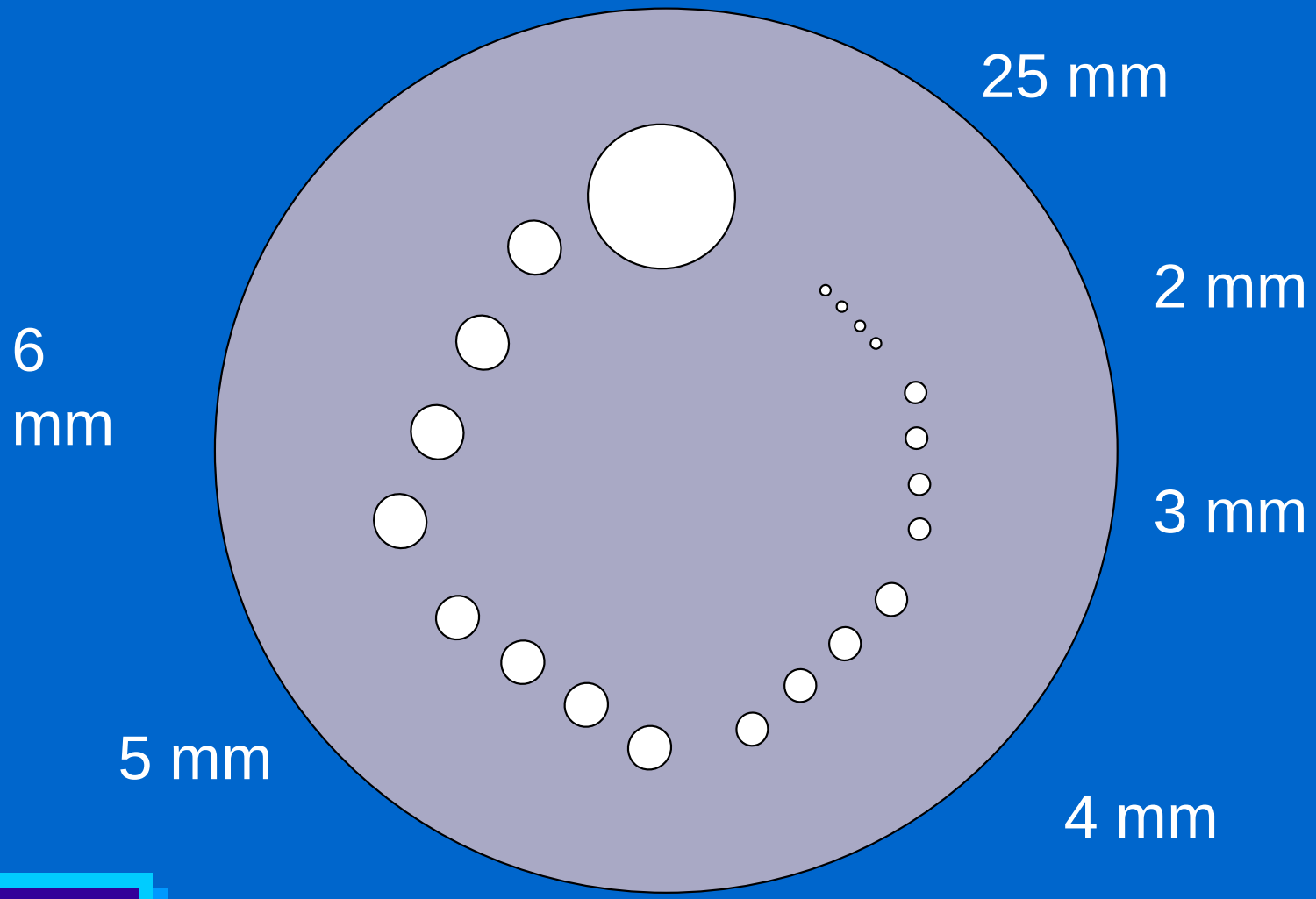


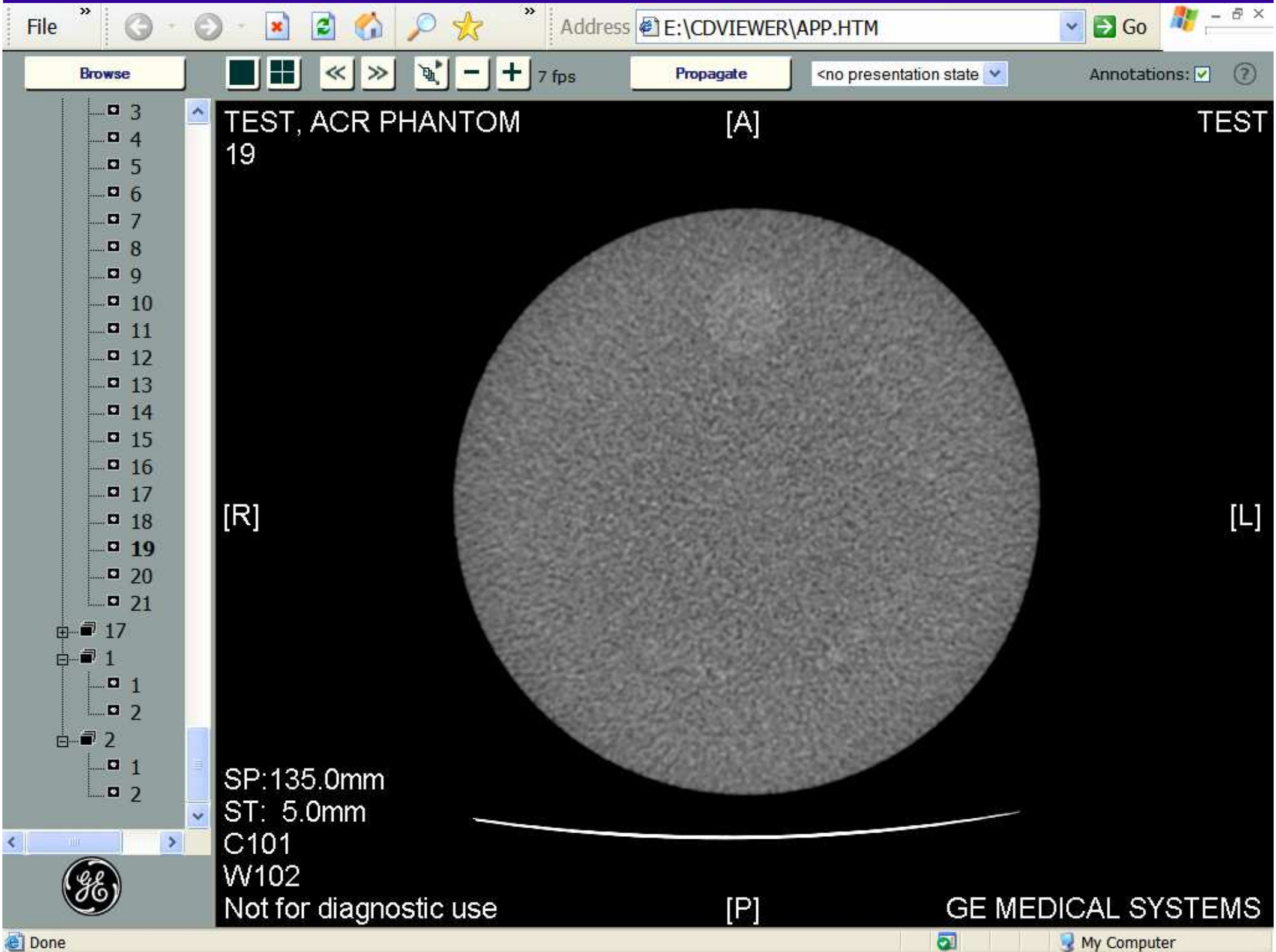
3 HU contrast

- Catphan is closest to a ‘standard’ phantom

Module 2: Low contrast detectability

- Low contrast = 6 HU ± 0.5 HU
  - (cf Catphan 10, 5, 3 HU single object of each size)

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SP:135.0mm
ST: 5.0mm
C101
W102
Not for diagnostic use
[P]
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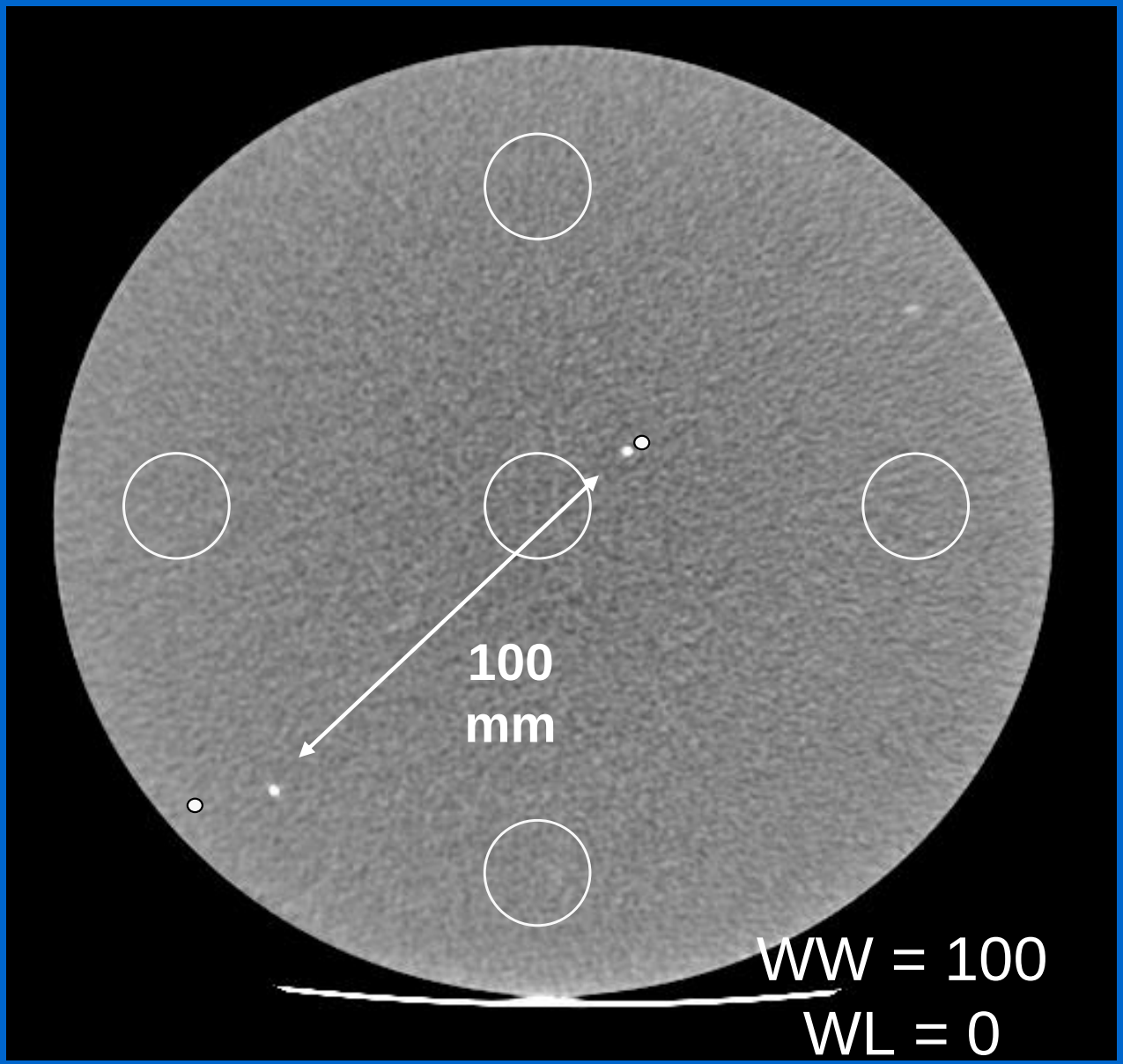
Done
My Computer

Module 3: uniformity, noise, distance, mtf & ssp

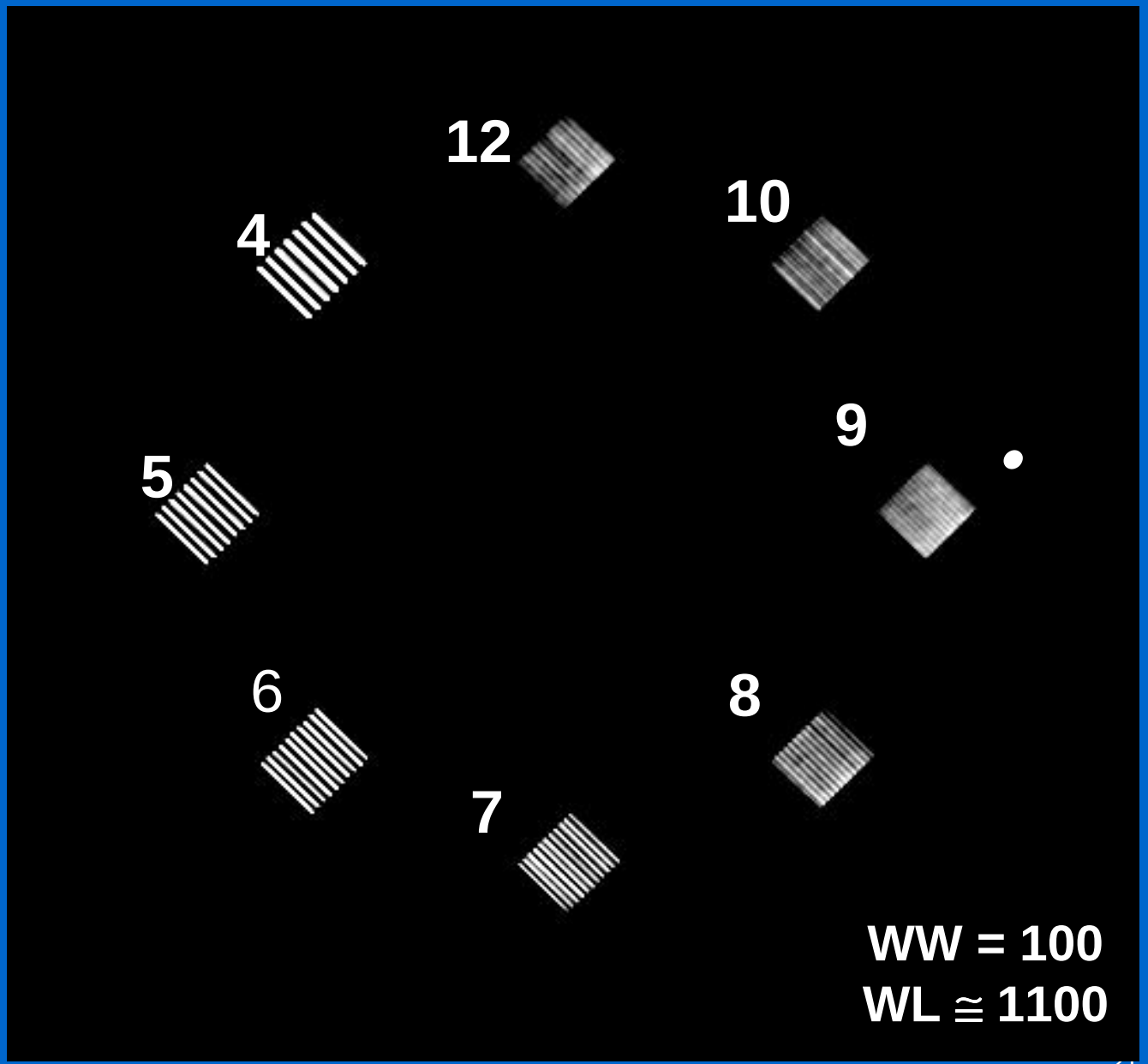
0.3 mm tungsten carbide beads



Module 4: high contrast spatial resolution

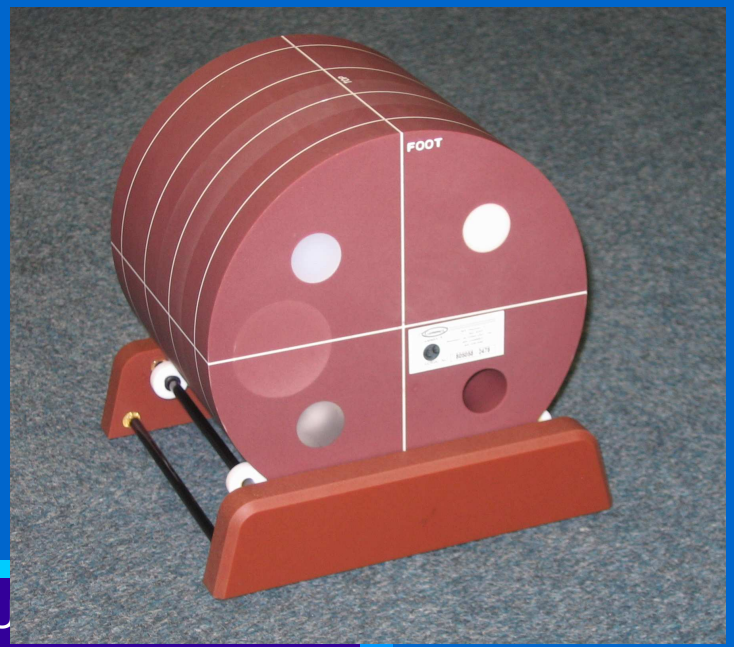
Bar patterns:
lp/cm

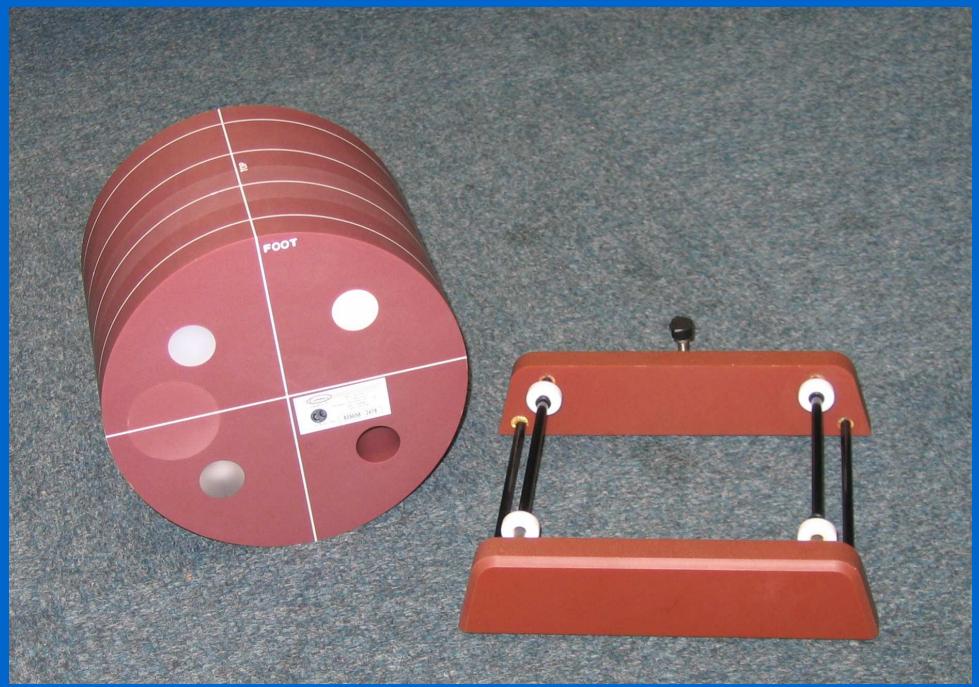
Aluminium in
solid water



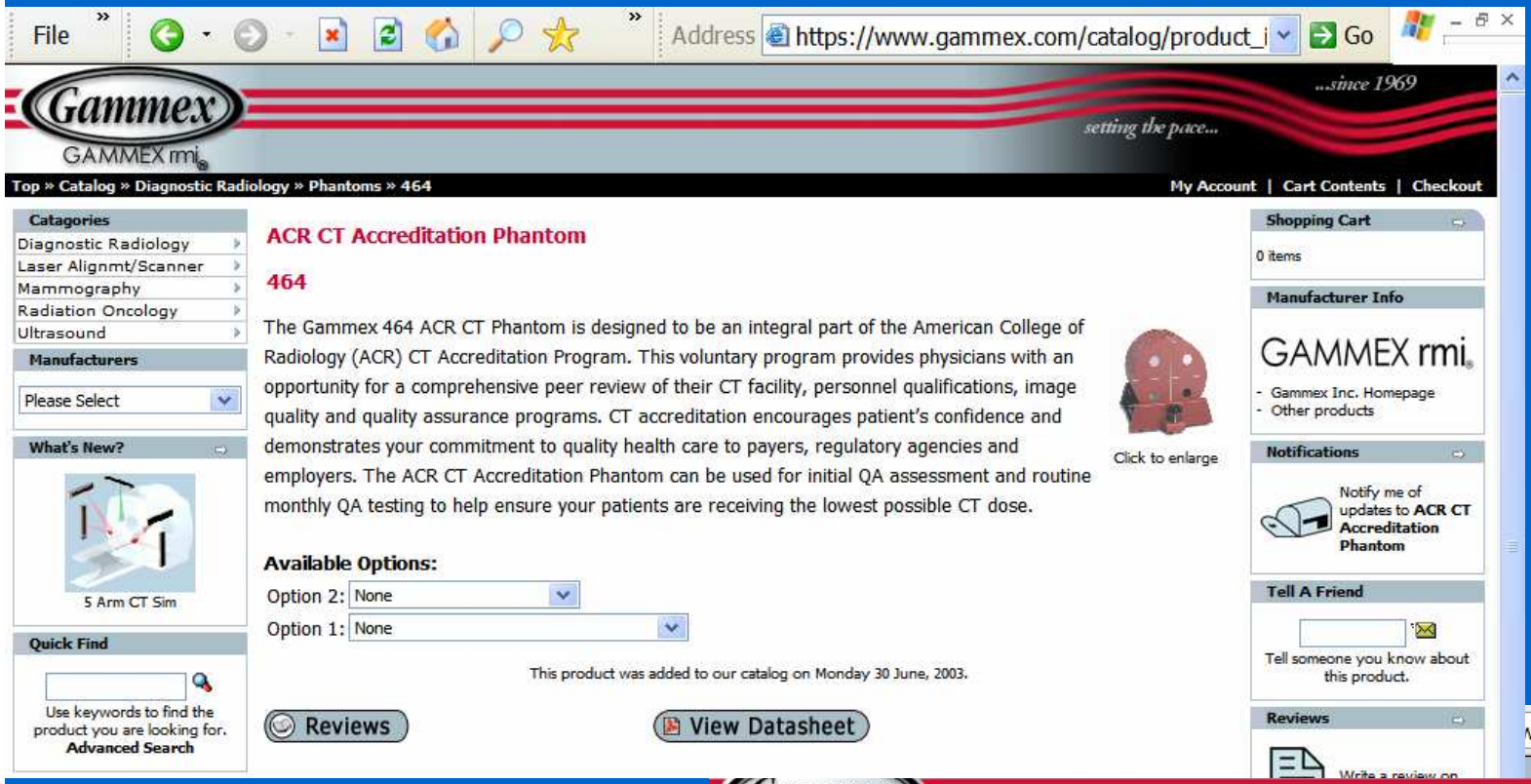
Gammex RMI CT Phantom

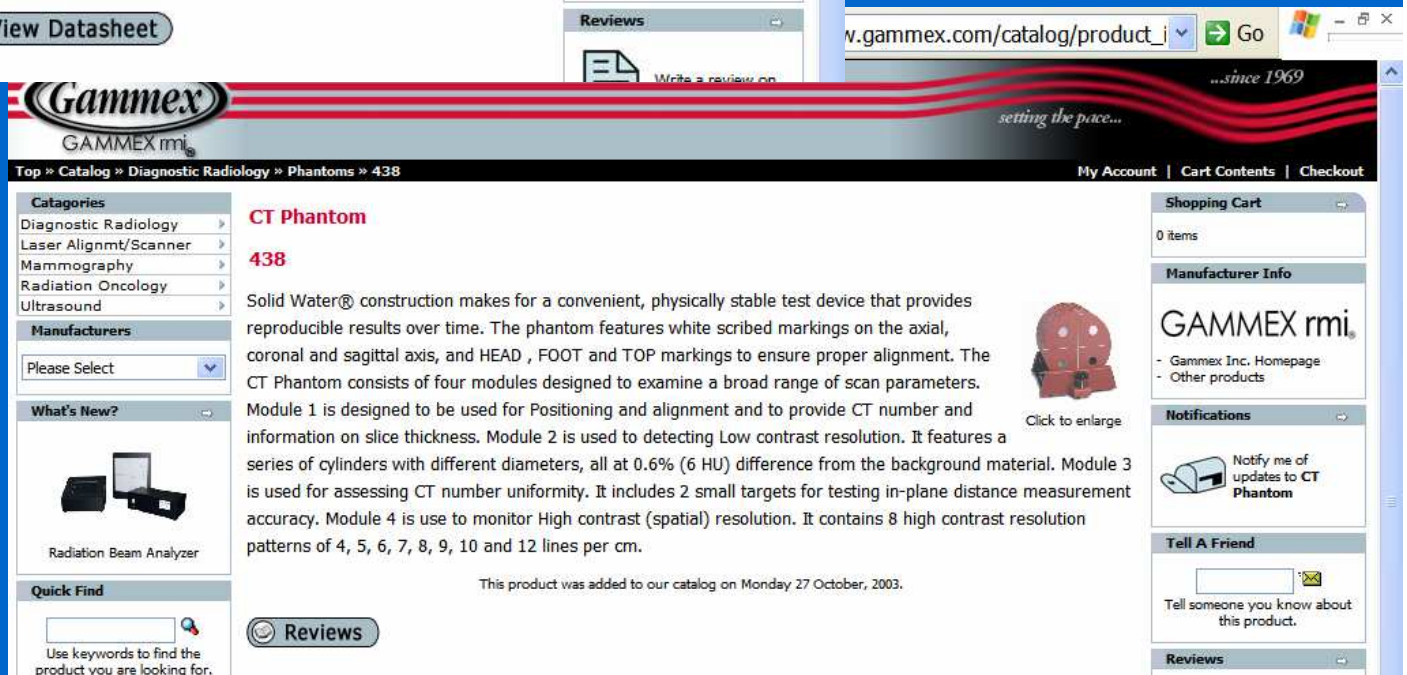
- Nicely designed phantom
- Excellent phantom stand
- Good additional documentation from ACR
- Slightly limited for axial MSCT? (40 mm modules)
- Bar pattern doesn’t go to maximum resolution
- LCD of 6HU different from manufacturers spec. (use 3HU from Catphan)





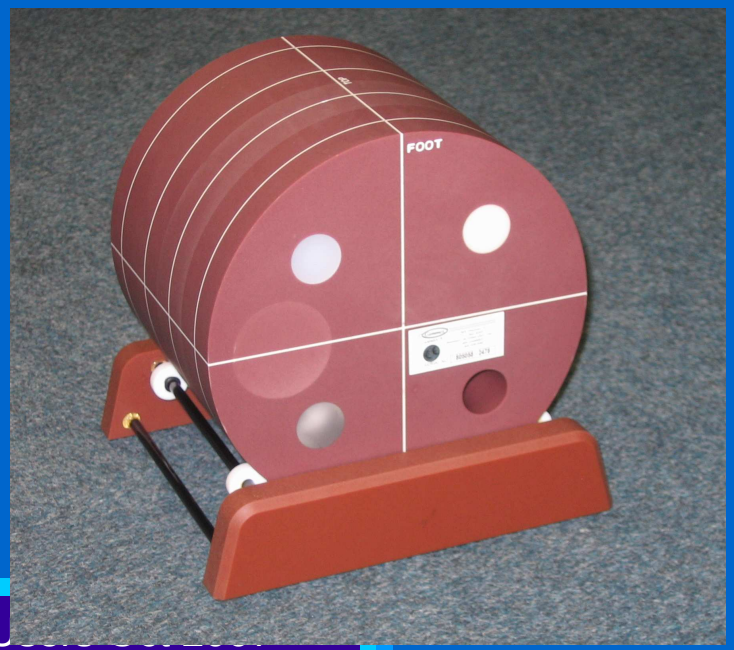
https://www.gammex.com

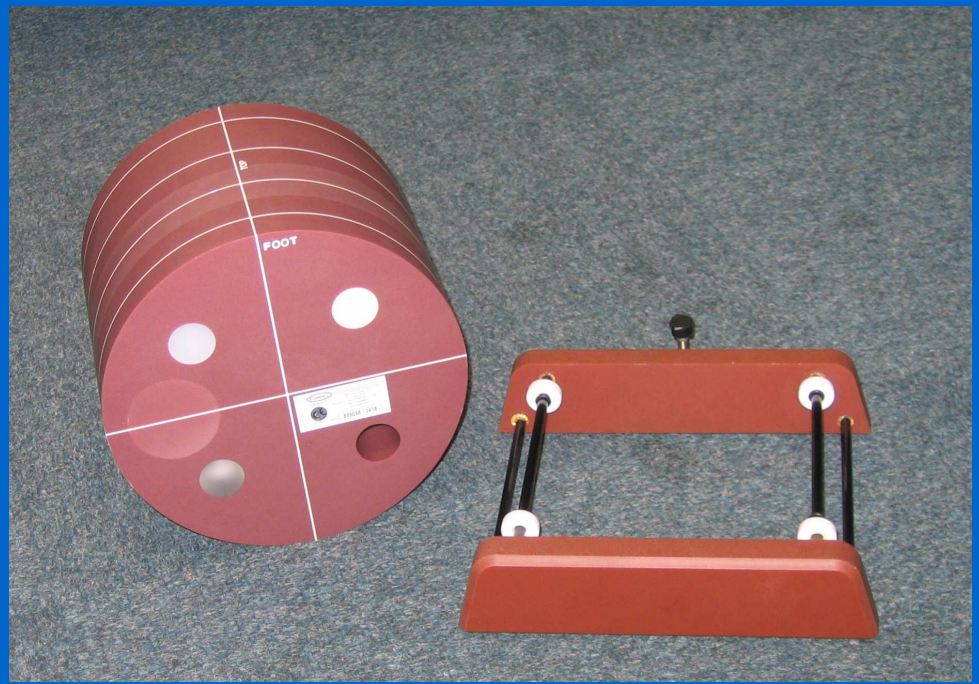




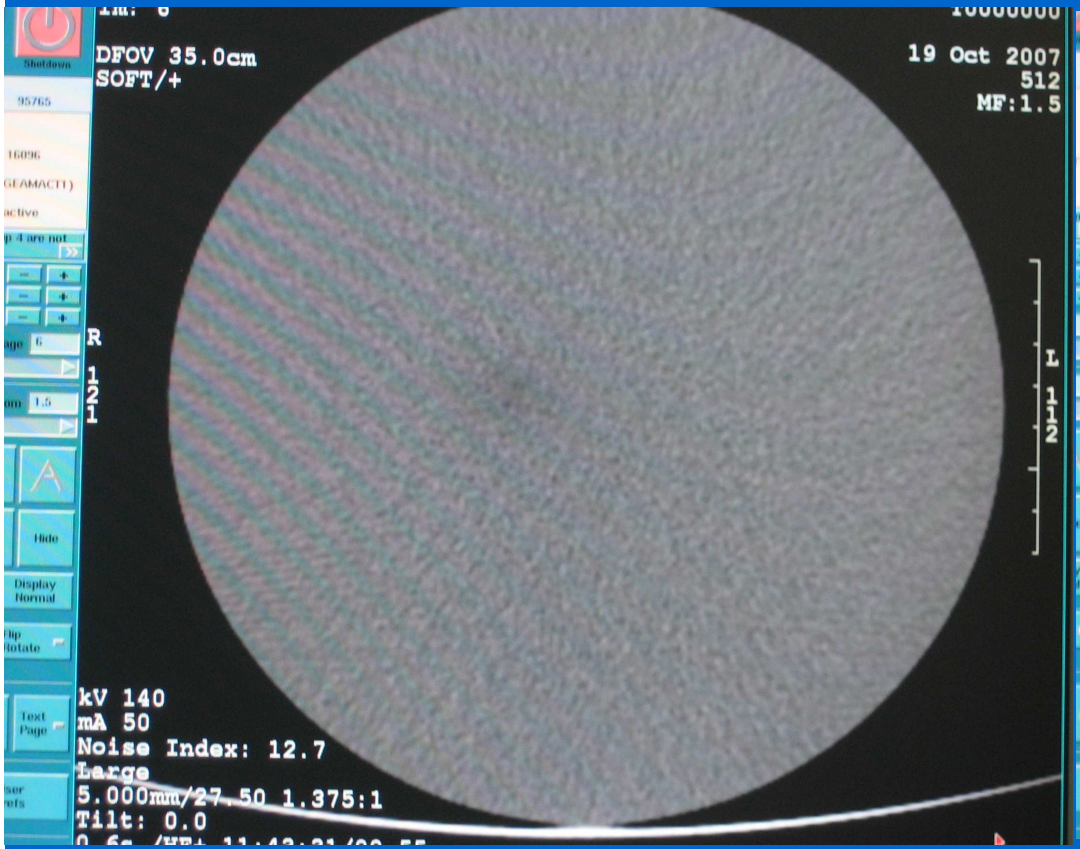
Gammex RMI CT Phantom

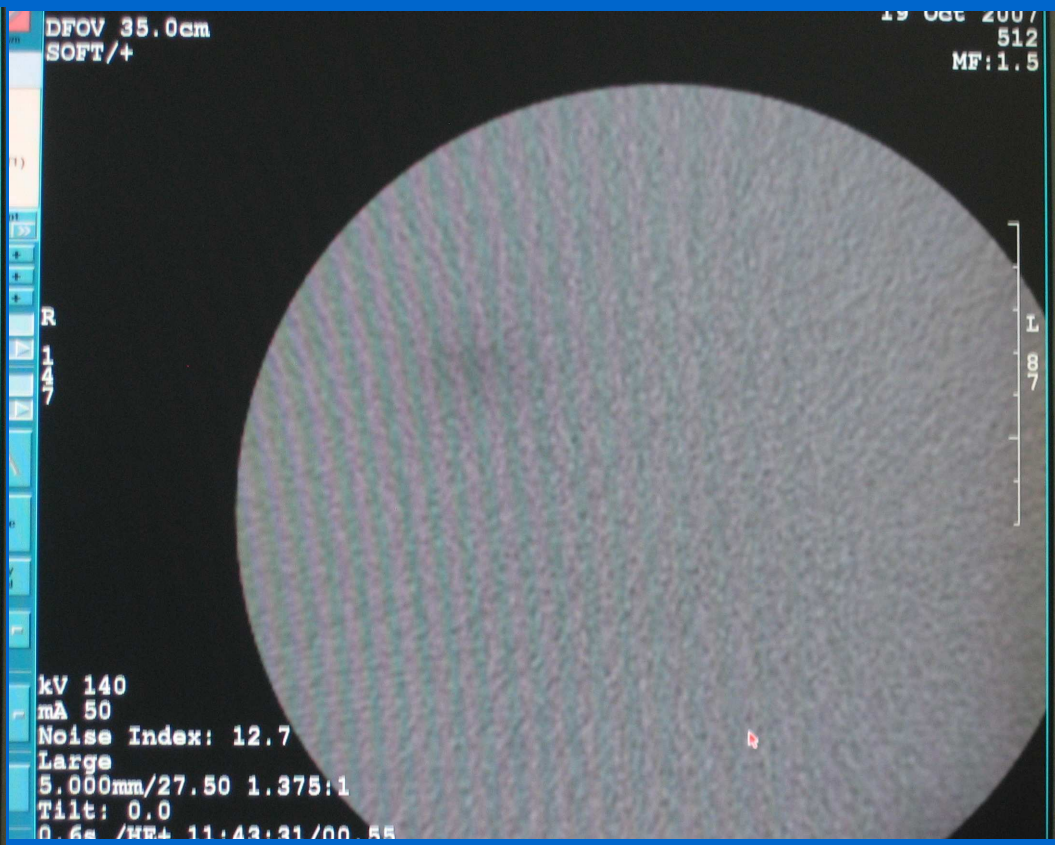
- David Aikman
  - Gammex RMI Ltd.,Nottingham
  - 01159850808, daa@gammex.com
- Cost
  - List price £5589 (not including stand),
  - Discount for early sales ~10%





Incidental Findings





Incidental Findings

Incidental Findings

Gammex RMI CT Phantom, 438

(ACR CT Accreditation phantom, 464)

S. Edyvean, Jim Weston

Imaging Performance Assessment of CT Scanners

St. Georges Hospital, London

www.impactscan.org

Some images courtesy of Cynthia McCullough
Mayo Clinic, Rochester, USA