

MRI

Magnetic Resonance Imaging



Leeds Test Objects
medical imaging phantoms



MagIQ



MRI



MagIQ includes:

- Phantom
 - Solo - single chamber
 - Duo - dual chamber
- 1.5T and 3T solutions to fill the main sections
- Carry case

MagIQ



Phantom Positioning:

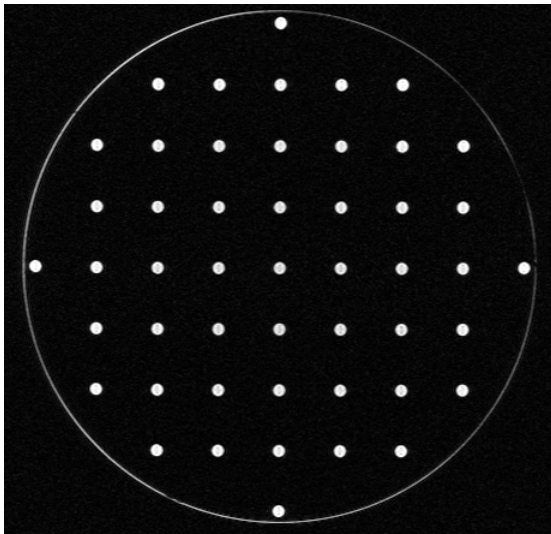
- Place phantom on couch
- Check temperature
- Use engravings & spirit level for alignment / levelling

Imaging Protocol:

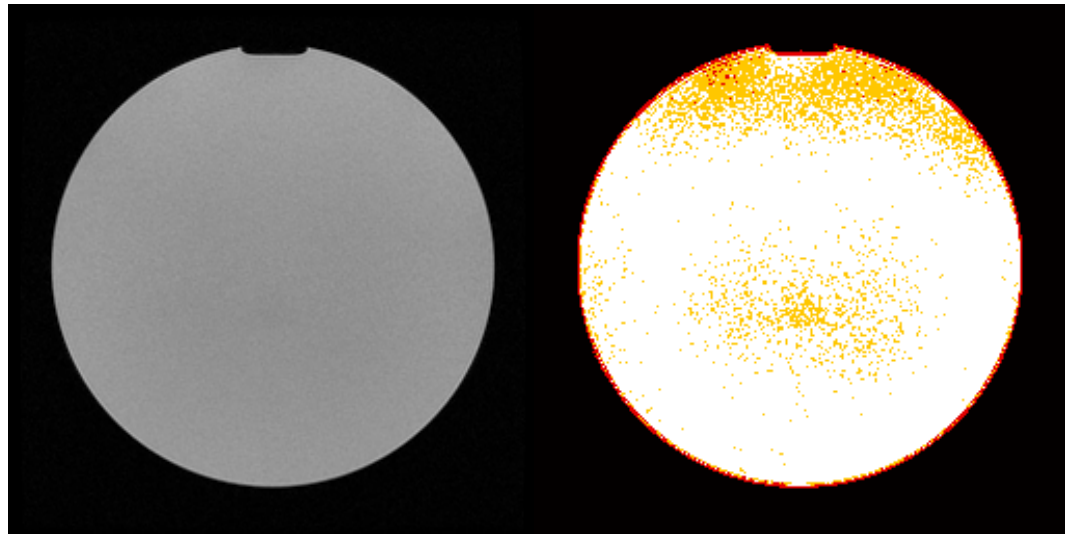
- Refer to user manual for details



Geometric distortion



Ghosting / SNR / Uniformity



25mm spaced points (wide area)

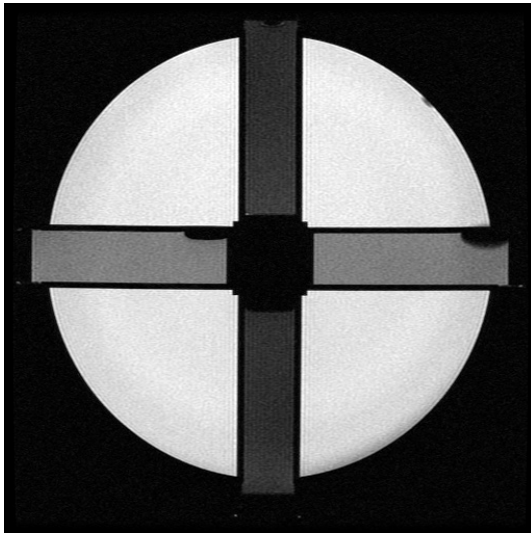
- Subjective - skewed?
- Objective - measure distances

Flood-fill section

Uniformity map
($\pm 1\%$ white, $\pm 5\%$ yellow)

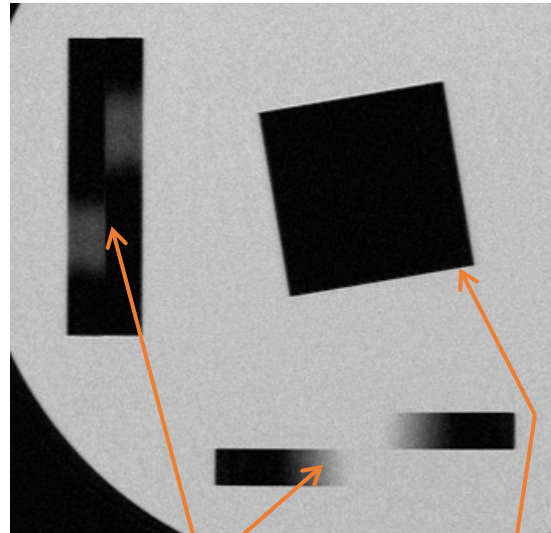


Fat Suppression



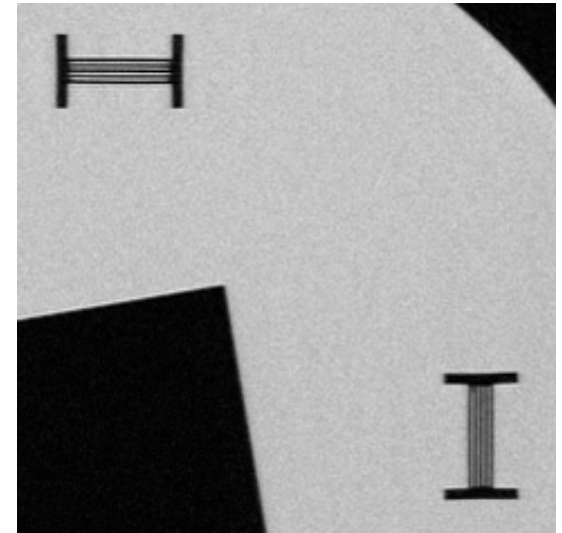
“Classic” suppression on
1.5T GE Signa

Slice Profile / MTF



Pairs of 10° wedges,
separated by 1mm;
Square oriented at 10° for
MTF measurement

Phase/Frequency Resolution



1.0 LP/mm bar patterns
arranged at 90°
- Pass/fail test



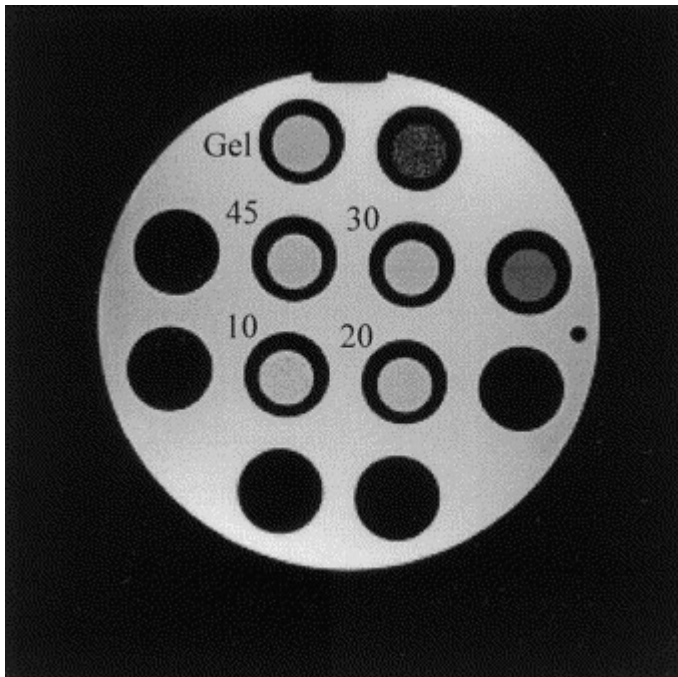
Actions:

- Repeat any test(s) that fail to verify the result
- Refer to common protocol
- e.g. AAPM 100 – 2010 : Acceptance Testing and Quality Assurance Procedures for Magnetic Resonance Imaging Facilities
- BS EN 62464-1 – 2007 : Magnetic resonance equipment for medical imaging – Part 1: Determination of essential image quality parameters

MagIQ T1 and T2 gels

An accessory to MagIQ

A set of 18 test tubes containing Gadolinium-doped agar gel with a range of T1 and T2 values for calibration of T1 and T2 values





Computed Tomography



TO.CTDI / TO.CTDI+



TO.CTDI includes:

- 'Adult body' phantom
- 'Adult head' phantom
- 9 x PMMA pegs
- 2 x PMMA adapters for different detector sizes
- Stands for all phantoms
- Hard, wheeled case with telescopic handle

TO.CTDI+ also includes:

- 'Paediatric Head' Phantom
- 4 x Extra PMMA Pegs



TO.CTDI / TO.CTDI+

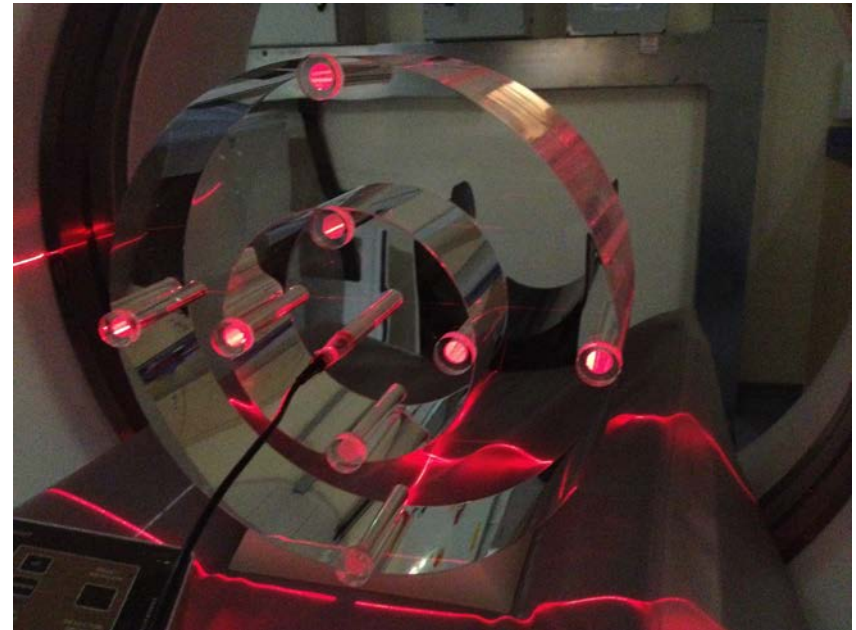


Phantom Positioning:

- Place phantom on stand on couch
- Use engraved markers for alignment

Exposure Conditions:

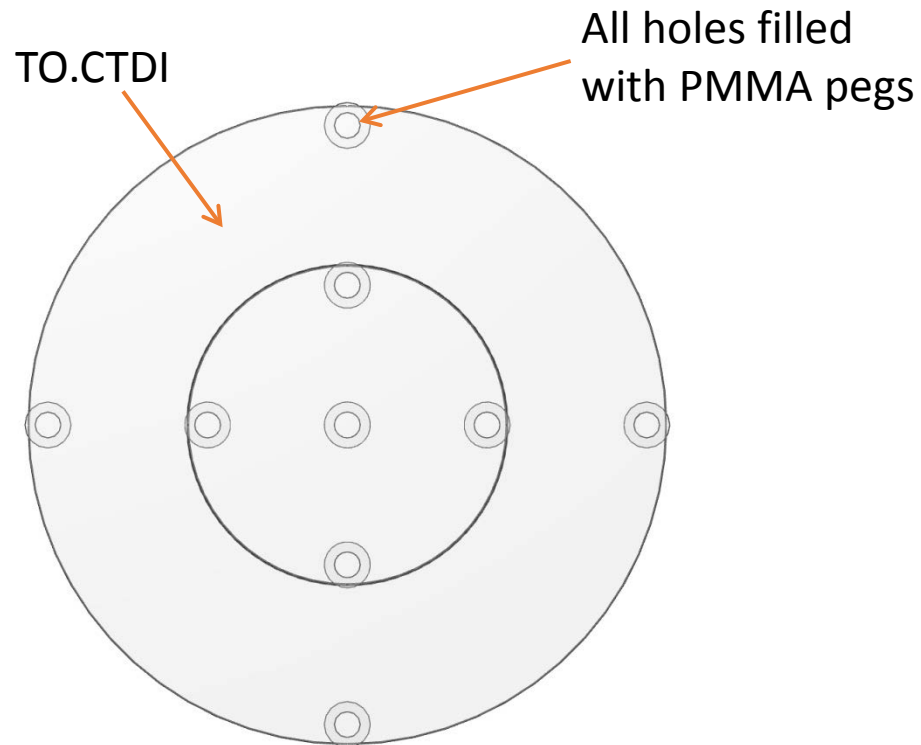
- Place detector in each position in turn
- Fill remaining holes with PMMA pegs
- Refer to User Manual for details





TO.CTDI / TO.CTDI+

Measuring Image Noise & Uniformity



Uniformity:

- Measure CT number in ROI at centre and periphery
- Subtract the values

Noise:

- Measure CT number in central ROI, 40% phantom size

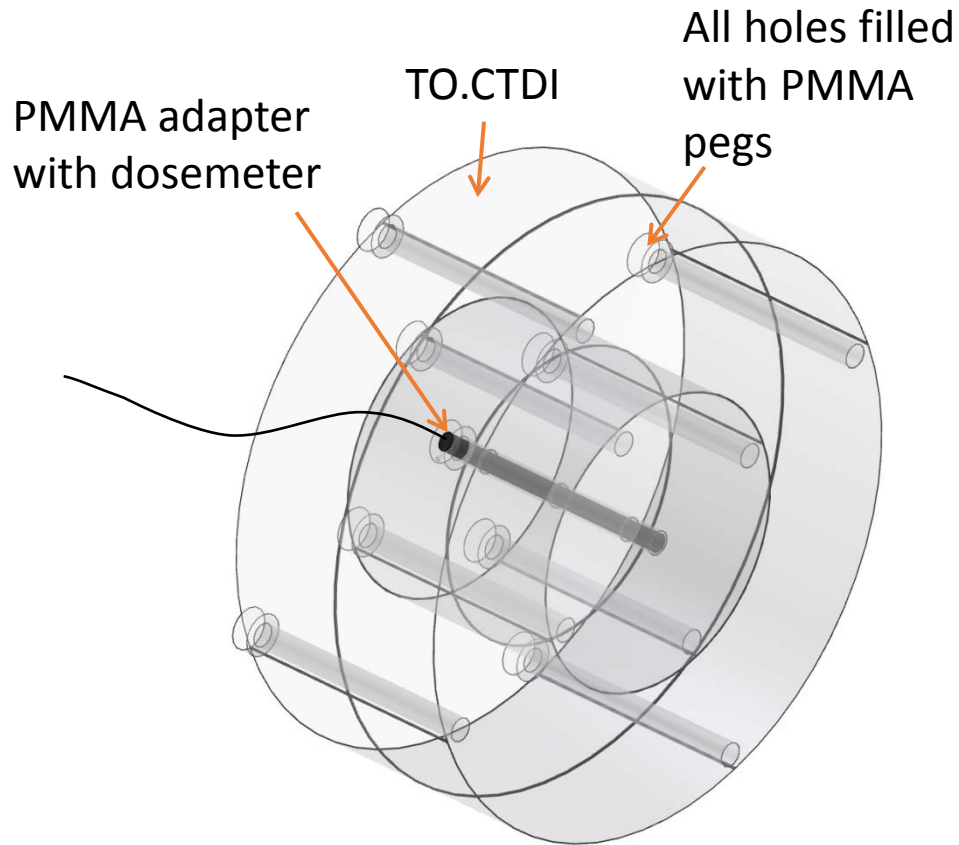
Interpretation:

- Refer to user manual for details

TO.CTDI / TO.CTDI+



Measuring $\text{CTDI}_{100,(\text{CENTRE})}$



Adapters for dosemeters have engravings for positioning



Interpretation:

- Refer to user manual for details

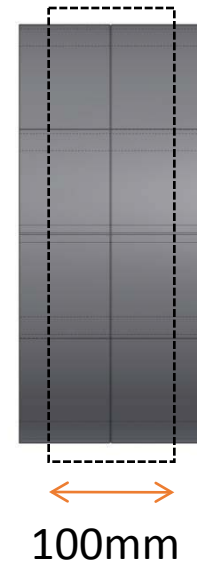
TO.CTDI / TO.CTDI+



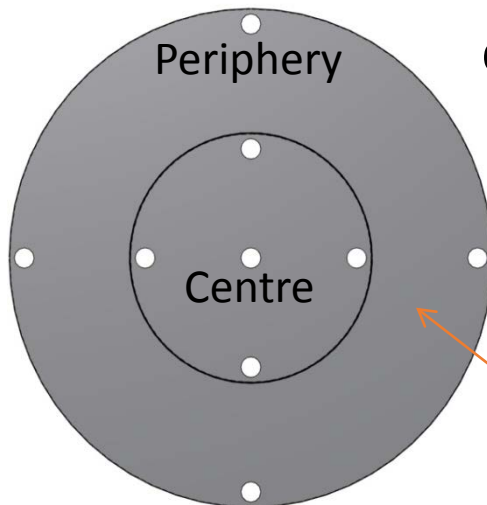
CTDI₁₀₀: linear dose index over central 100mm



CTDI_{vol}: dose index over central 100mm volume



CTDI_w: CTDI₁₀₀ weighted between centre and periphery



$$\text{CTDI}_w = \frac{1}{3} \text{CTDI}_{100,(\text{CENTRE})} + \frac{2}{3} \text{CTDI}_{100,(\text{PERIPHERY})}$$

TO.CTDI



TO.CTDI / TO.CTDI+

$CTDI_{FREE\ AIR}$: as $CTDI_{100,(CENTRE)}$ but in air (no phantom)

DLP (Dose-Length Product): $CTDI_{vol} \times$ total (axial) distance scanned

Dose Profile: graph showing dose along the 100mm line used for $CTDI_{100}$

- in air
- with phantoms

And many more...



TO.CTDI / TO.CTDI+

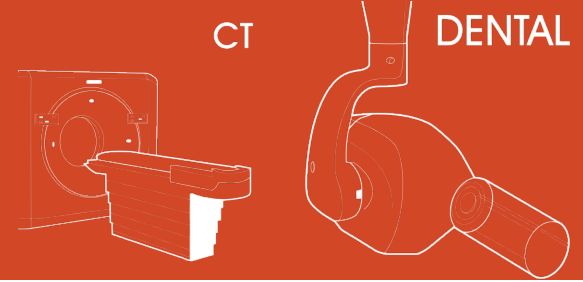
Actions:

- Repeat any test(s) that fail to verify the result
 - Refer to common protocol
- e.g.
- IEC 61223-3-5:2004 Evaluation and routine testing in medical imaging departments — Part 3-5: Acceptance tests — Imaging performance of computed tomography X-ray equipment
 - IEC 61223-2-6:2007 Evaluation and routine testing in medical imaging departments — Part 2-6: Constancy tests — Imaging performance of computed tomography X-ray equipment
 - IEC 60601-2-44:2009 Medical electrical equipment — Part 2-44: Particular requirements for basic safety and essential performance of X-ray equipment for computed tomography

CTIQ

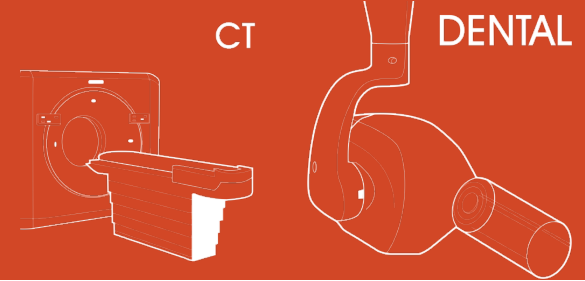
CT

DENTAL



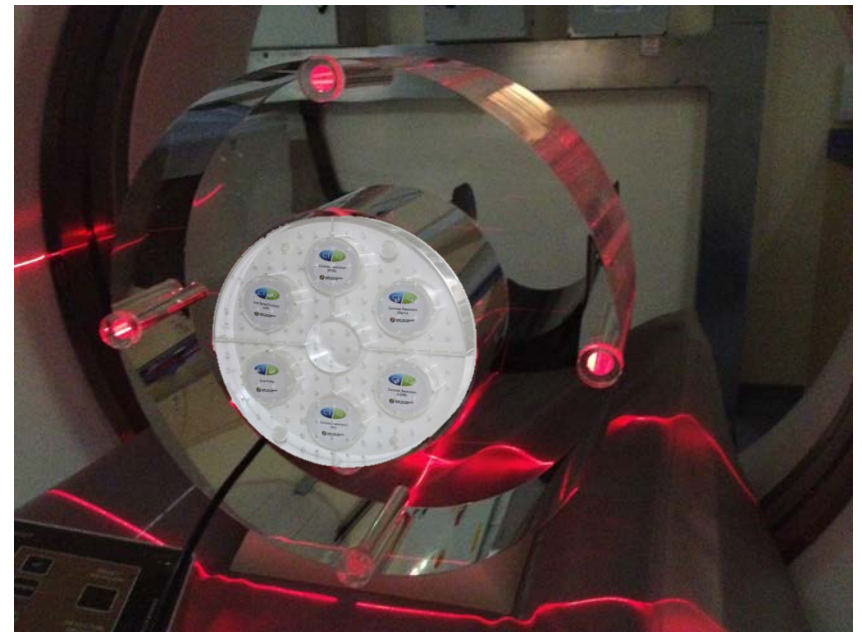
CTIQ includes:

- Phantom
- Various test inserts (constancy/routine)
- Small padded bag



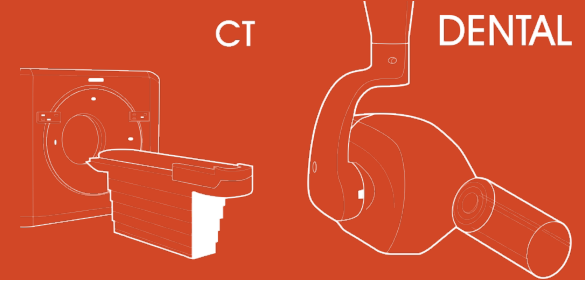
Phantom Positioning:

- Place phantom on stand on couch or inside the CTDI phantom
- Use engraved markers for alignment

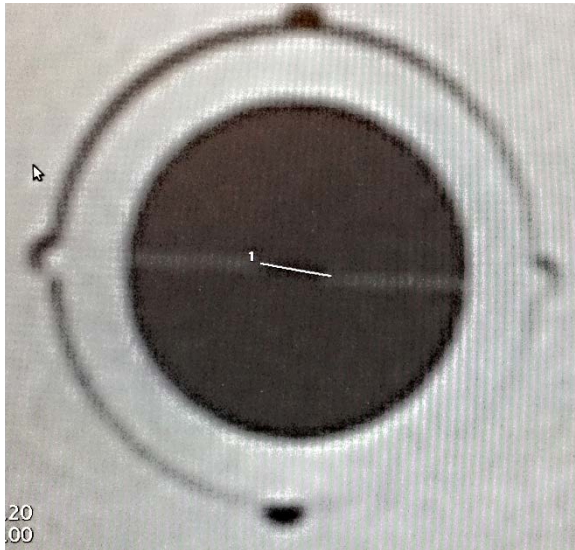


Exposure Conditions:

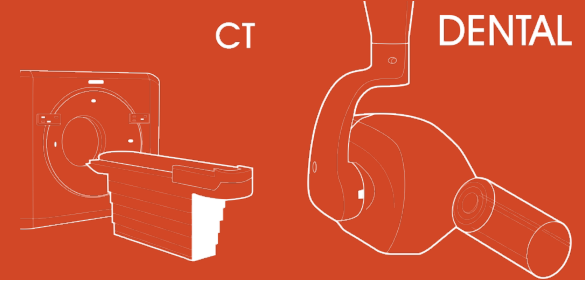
- Refer to user manual for details
- Same each time, and same as for acceptance



Slice Profile

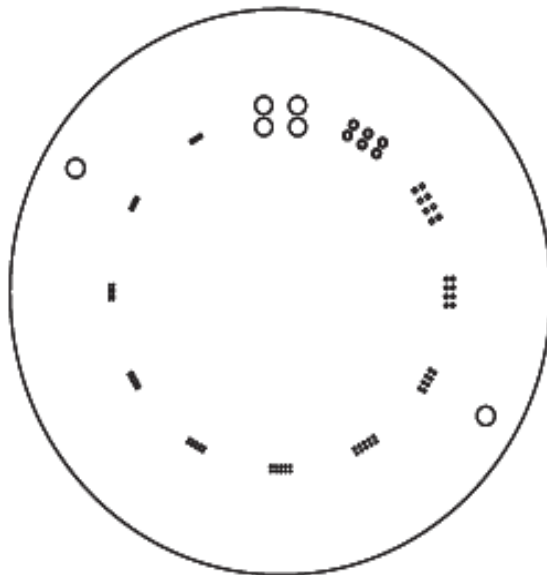


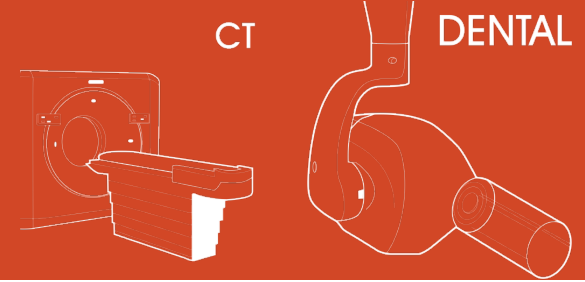
Measured using the
0.25mm stainless steel wire,
which is angled at 23° and
suspended in air



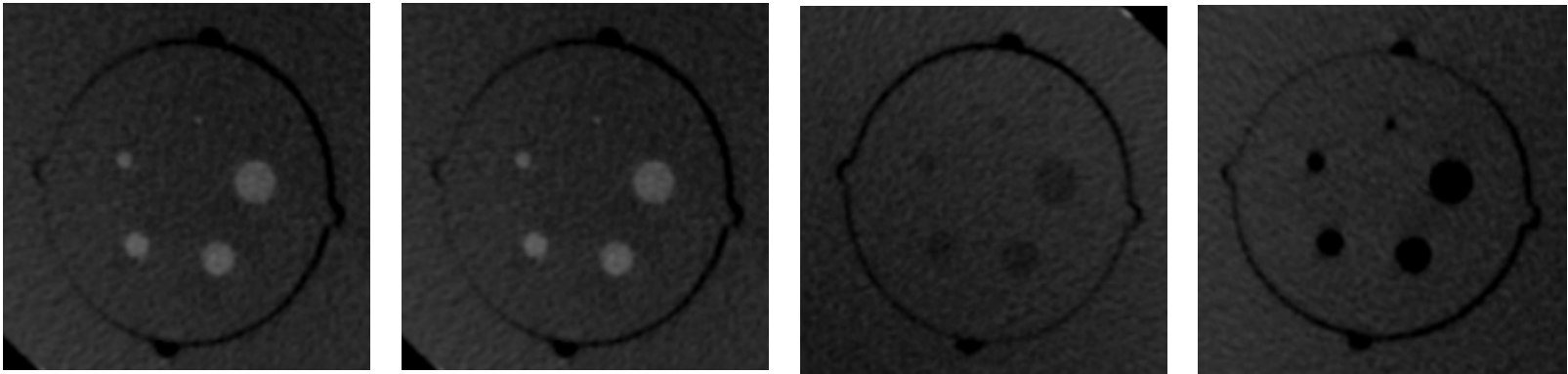
Spatial Resolution

A series of line pair groups with frequencies of;
1.0 LP/cm to 12.0 LP/cm

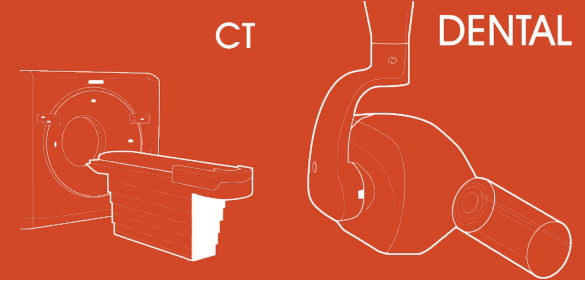




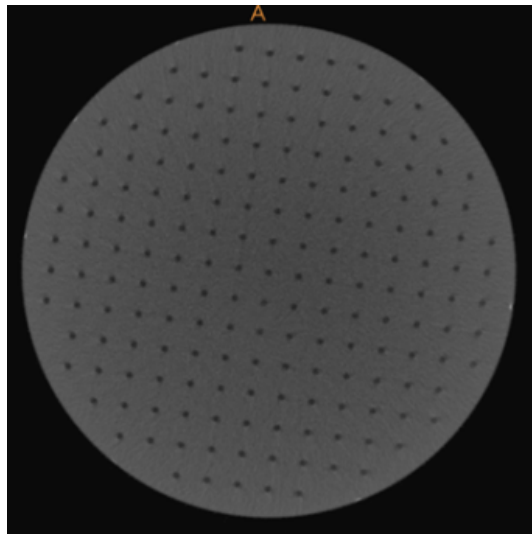
Contrast Resolution



Measured using the 1.0, 2.0, 3.0, 4.0 and 5.0mm diameter PTFE, Delrin, LDPE and Air rods

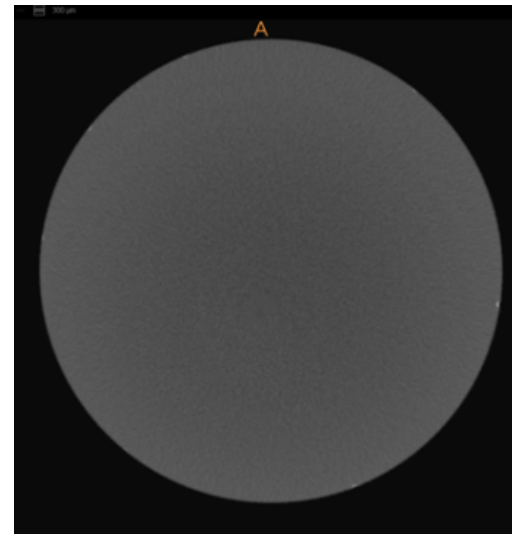


Geometric Distortion

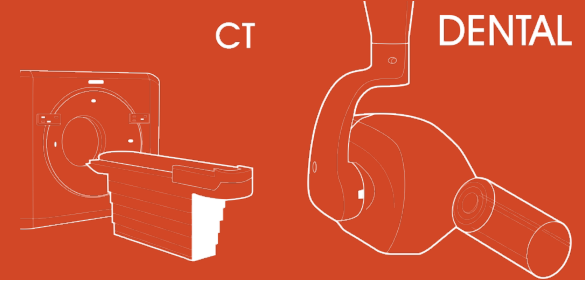


An array of regular 2.0mm diameter, 3.0mm deep air gaps uniformly pitched at 10.0mm intervals

Noise / Uniformity



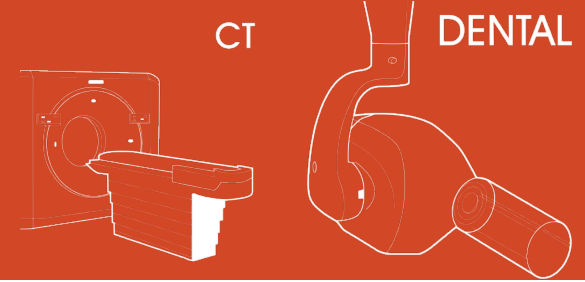
Used in conjunction with the TO CTDI phantom (uniform PMMA)



Actions:

- Repeat any test(s) that fail to verify the result
- Refer to common protocol

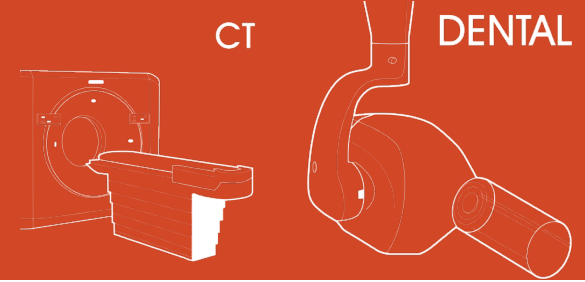
SedentexCT IQ



SEDENTEXCT IQ includes:

- PMMA housing
- Various test inserts (commissioning/acceptance)
- Lid
- Tripod

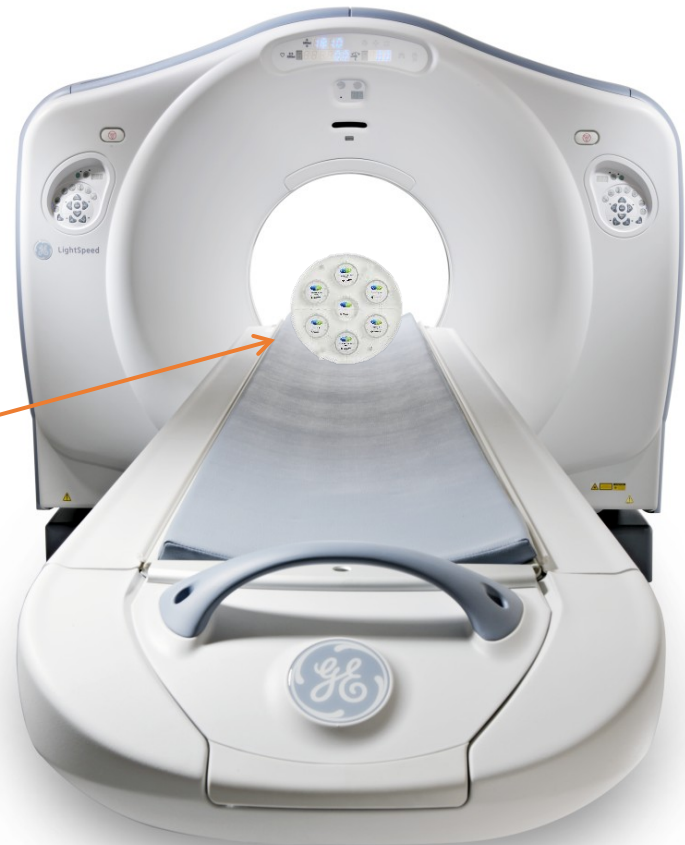
SedentexCT IQ



Phantom Positioning:

- Place on phantom support
- Use alignment markers
- Reproducible positioning

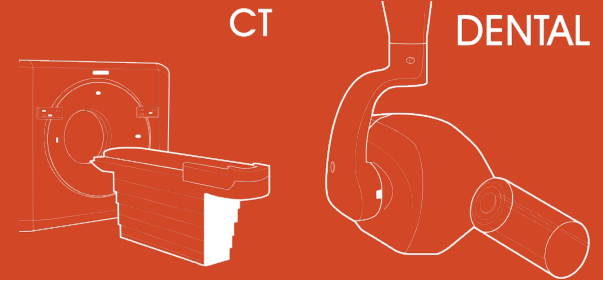
Phantom goes here



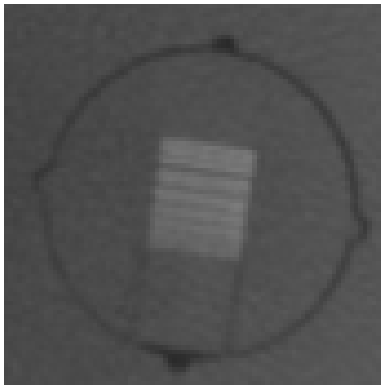
Exposure Conditions:

- Refer to user manual for details

SedentexCT IQ

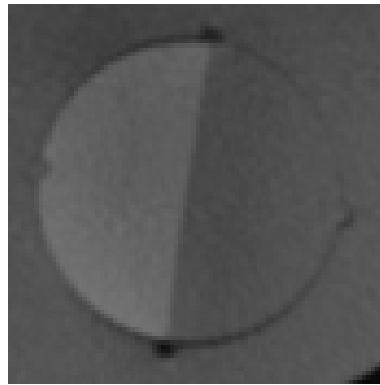


3D spatial resolution test pattern



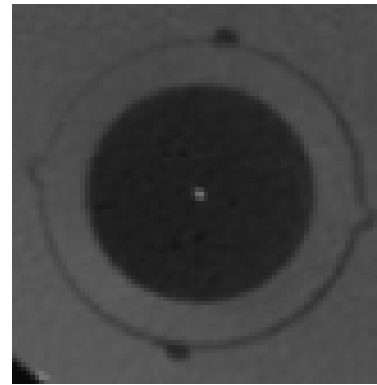
7 groups of
discs between
1.0-5.0 LP/mm
2 orientations for
3-D

Line spread function (ESF)



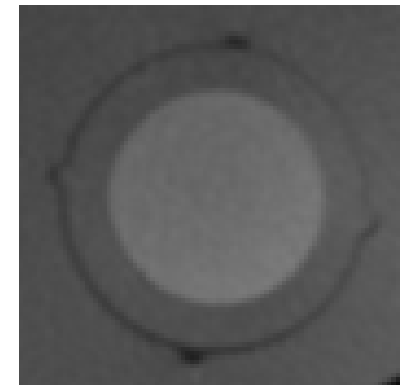
Straight edge
between two
different
contrast regions

Point spread function (PSF)



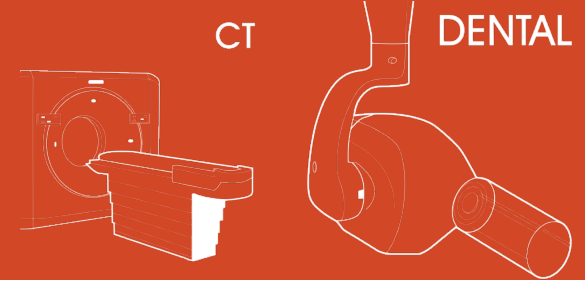
0.25mm
diameter
high contrast
wire

Pixel intensity Value (PIV)

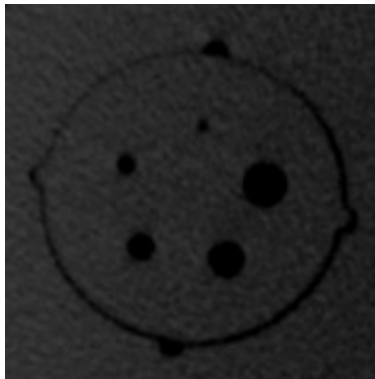
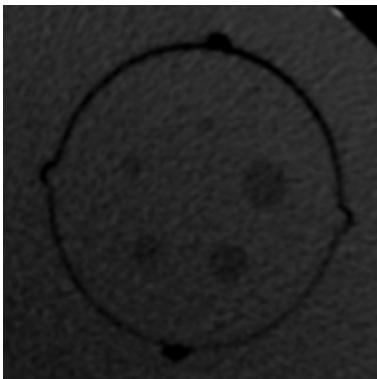
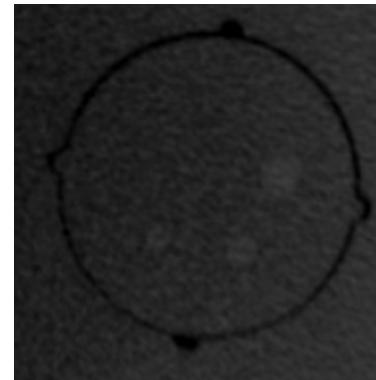
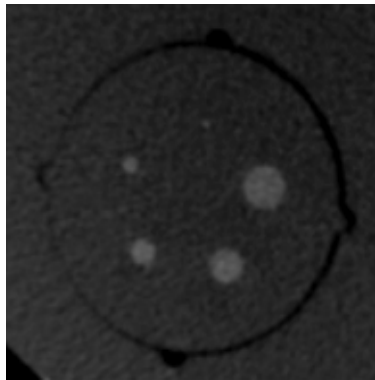
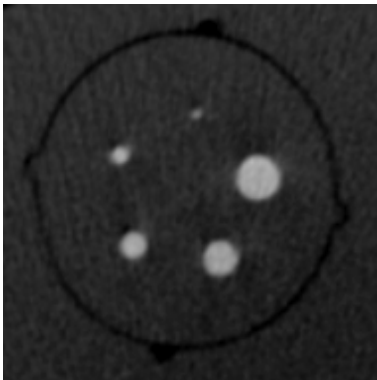


5 discs of various CT
number - checking
reproducibility
(mean and standard
deviation)

SedentexCT IQ



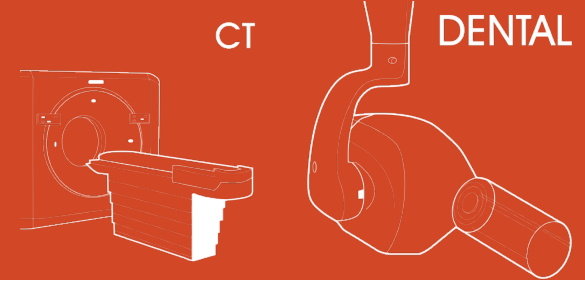
Contrast resolution



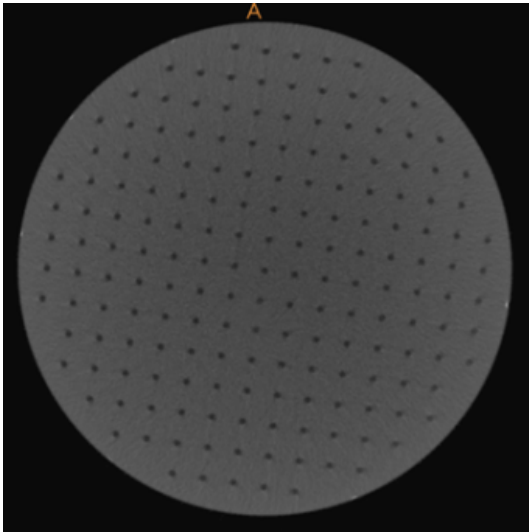
25 circular contrast details
arranged in groups of 5;
1-5mm diameter

Imaged to test the phantom;
clinical conditions would
show less resolved details

SedentexCT IQ

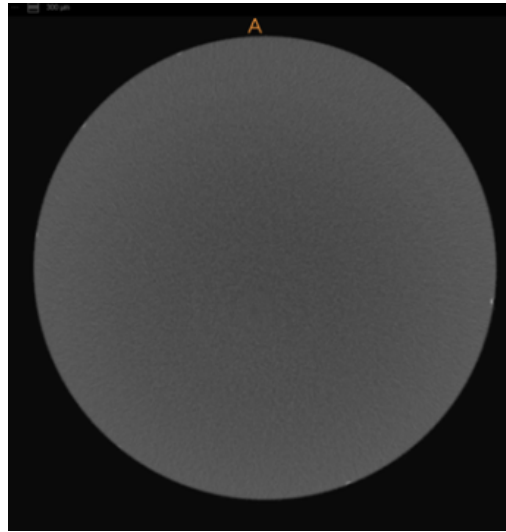


Geometric Distortion



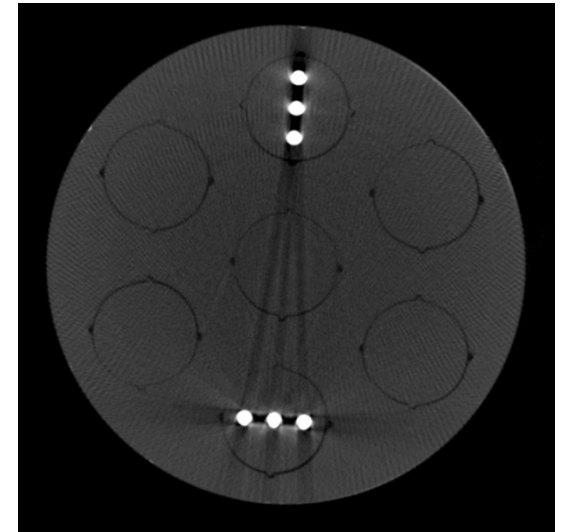
Grid of 3mm holes at fixed pitch

Homogeneity & Noise



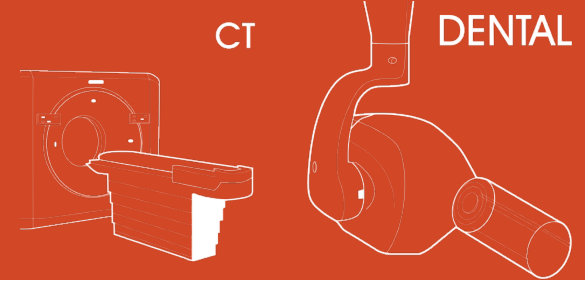
Blank volume (3-D)

Artefact Evaluation



High contrast rods

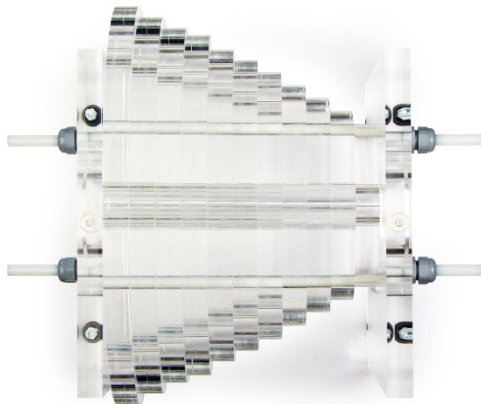
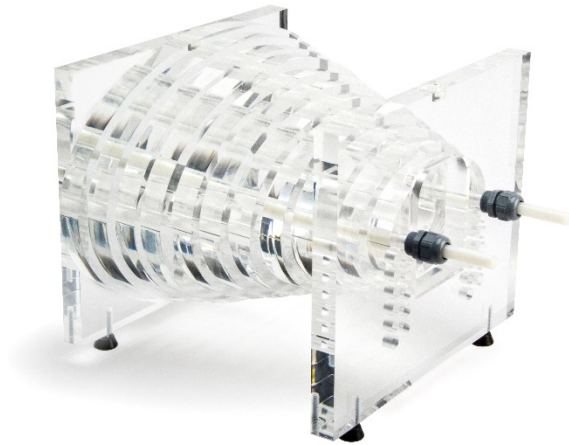
SedentexCT IQ



Actions

- Repeat any test(s) that fail to verify the result
- Refer to common protocol (SEDENTEX-CT Guidelines)
- <http://www.sedentexct.eu/>

CT AEC



CT AEC includes:

- 11 x PMMA Ellipses of varying size
- 2 x end-plates with integral spirit levels and adjustable levelling feet.
- 2 x nylon support rods and nuts
- 1 x centre rod
- 45 x blank PMMA inserts
- 11 x PMMA ion chamber inserts
- 1 x wheeled protective case

CT AEC



Phantom Positioning:

- Place on patient couch
- Use levelling system
- Use alignment markers
- Reproducible positioning



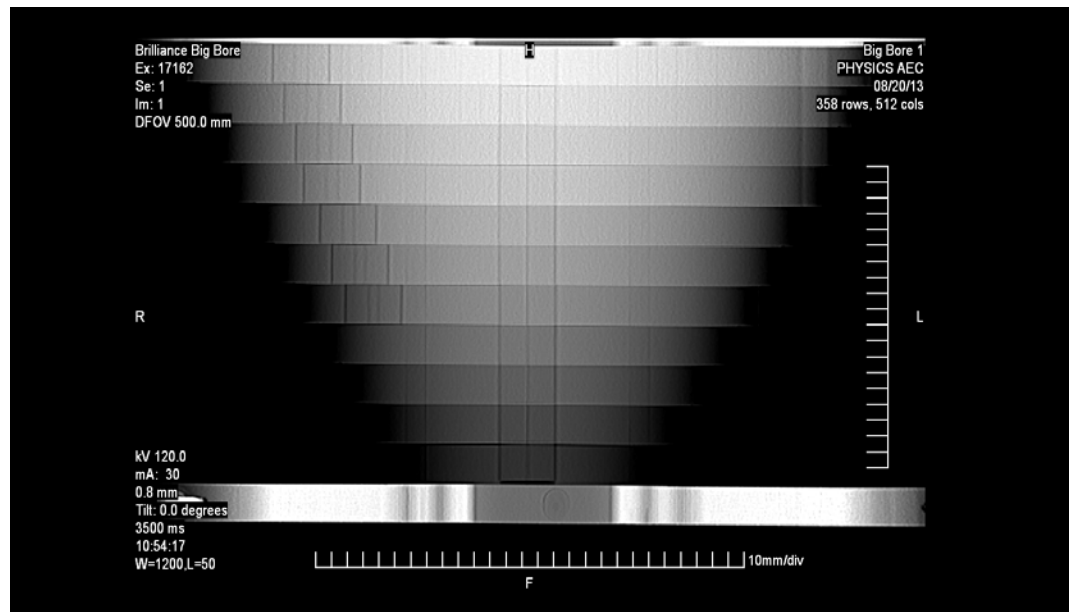
Exposure Conditions:

- Refer to user manual for details

CT AEC

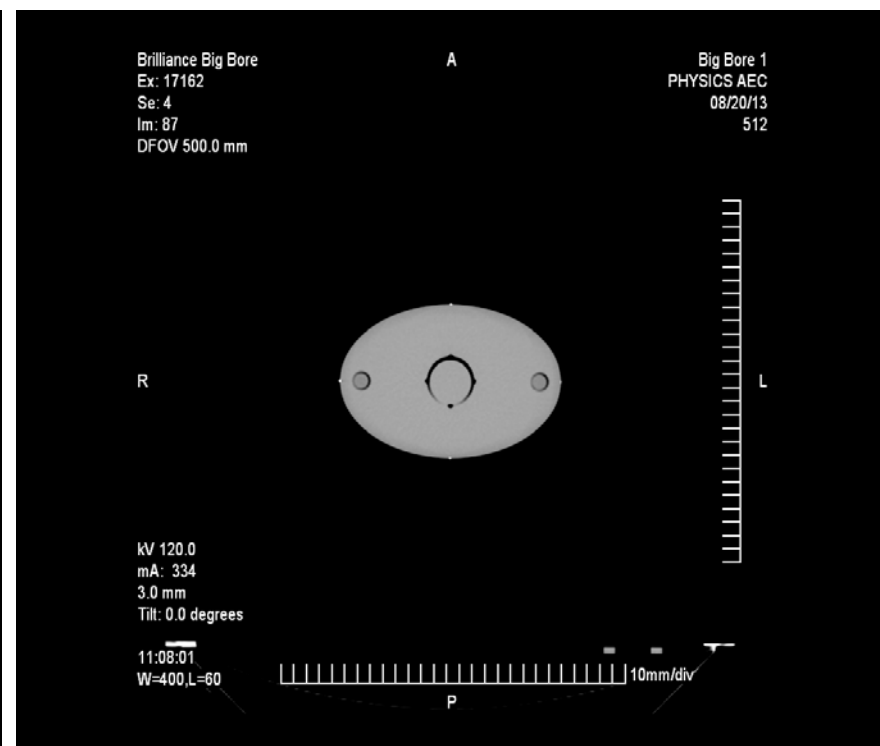
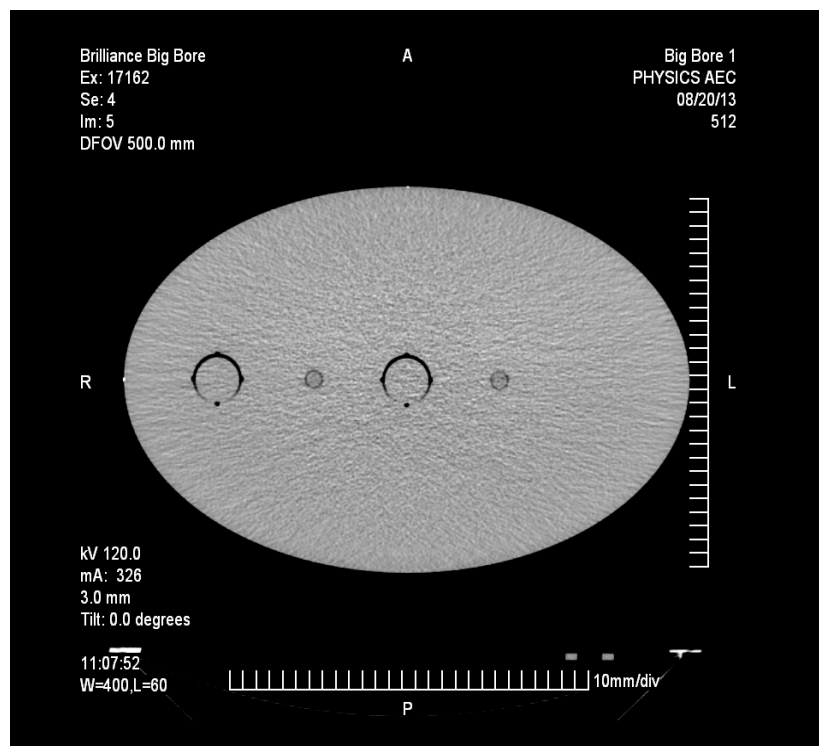


The following image library shows a scout image of the Leeds CTAEC phantom followed by slices from each of the individual ellipses that make up the phantom. The scan was performed over the entire phantom with the same kV and mAs. Note that the noise in the largest ellipse is greatest and reduces as the ellipses reduce in size.



CT AEC

CT



CT AEC



The purpose of the CT AEC system is to vary the current of the x-ray tube proportionally to the different levels of attenuation of the x-ray beam.

The advantages are:

- Consistency of image quality between slices from different regions of the same patient.
- Consistency of image quality between patients of different sizes/shapes/composition.
- Dose optimisation.
- Reduction of streaking artefacts (especially in asymmetric regions such as the shoulders).
- Reduced load on the x-ray tube.



- WT1 water equivalent nested body and head cylinders
- 16x test inserts of various tissue equivalent materials (e.g. bone, soft tissue, lung)
- 1 x Wheeled protective case

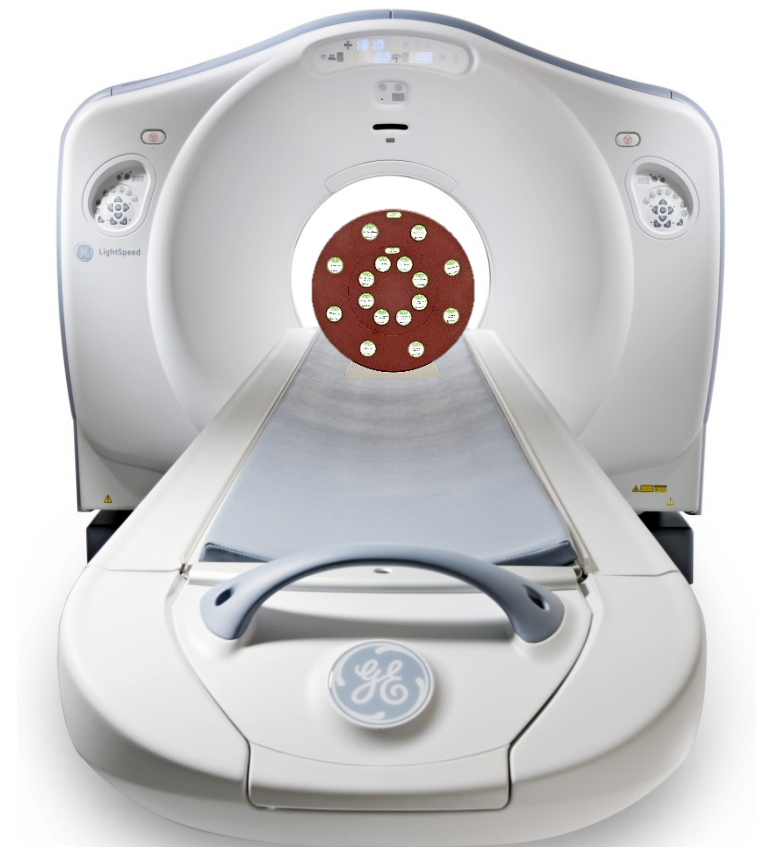
- WT1 water equivalent nested body and head cylinders
- 16x test inserts of various tissue equivalent materials (e.g. bone, soft tissue, lung)
- 1 x Wheeled protective case

CT TE



Phantom Positioning:

- Place on patient couch
- Use alignment markers
- Reproducible positioning



Exposure Conditions:

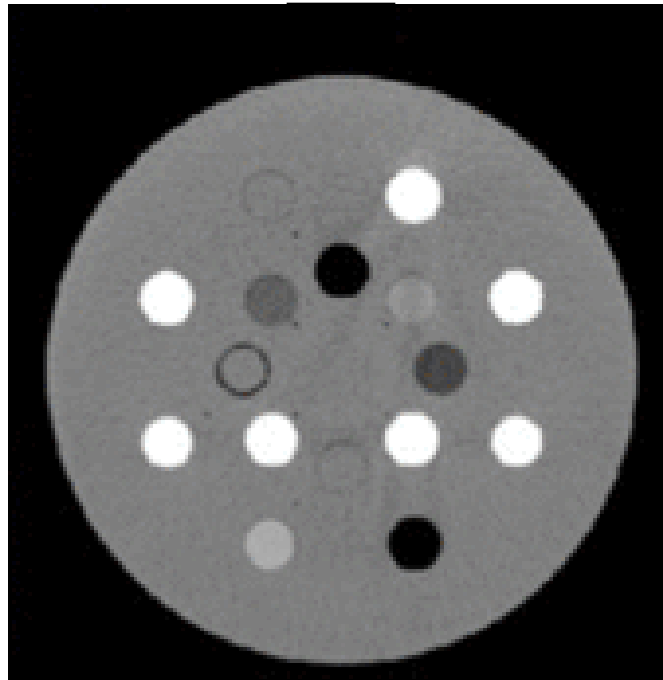
- Refer to user manual for details

CT TE

CT

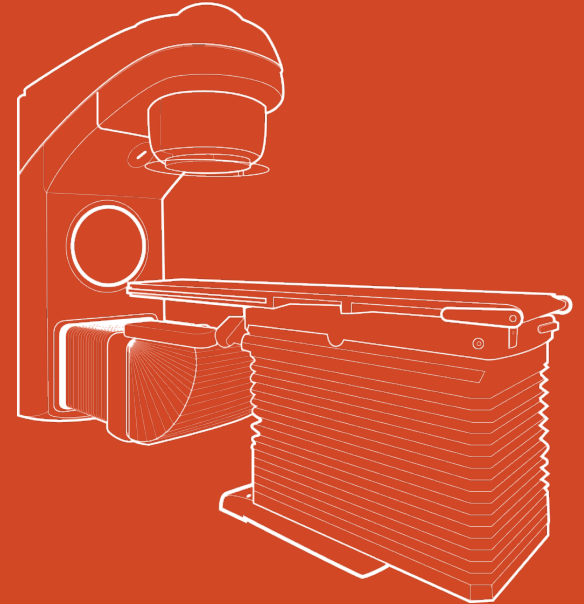


Measure the HU (CT number) of each insert and the background at commissioning to set the baseline value for each tissue type. Perform constancy tests thereafter.



THERAPY

Therapy

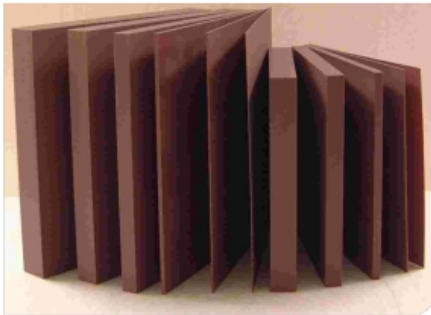


Leeds Test Objects
medical imaging phantoms





Tissue Equivalent Materials



Available in the following materials:

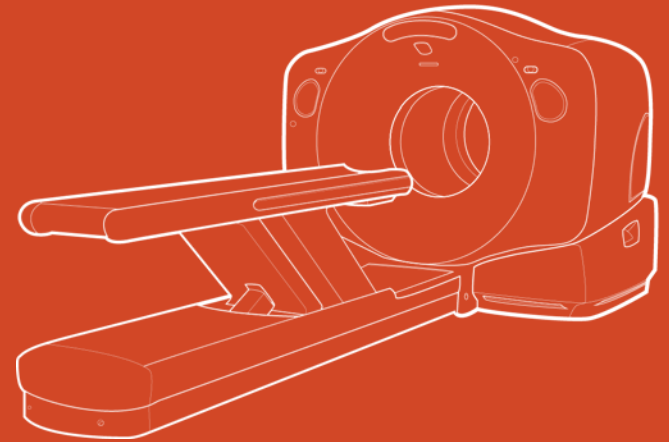
- Water (WT1)
- Adipose (AP7)
- Breast (BR12)
- Hard Cortical Bone (SB5)
- Inner Bone (IB7)
- Rib or Average bone (RB2)
- Lung (LN10)
- Soft Tissue (ST1)
- Kidney (KD1)
- Liver (LV1)

Suitable for both kV and MV energies

Made to order, in many sizes and shapes, including moulded or machined cavities to house dosimeters

PET

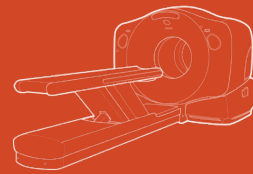
Nuclear Medicine



Leeds Test Objects
medical imaging phantoms



PET IQ

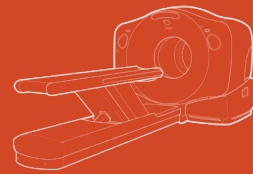


The image shown is the extended PET IQ set which was developed in collaboration with Central Manchester University Hospitals

PET IQ includes:

- Phantom
- Hard, wheeled case with telescopic handle
- Meets NEMA NU2 protocol

PET IQ



Phantom Positioning:

- Place phantom on couch
- Use engraved markers for alignment



Exposure Conditions:

- Refer to User Manual for details
- Same each time, and same as for acceptance

PET IQ

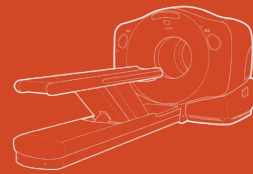
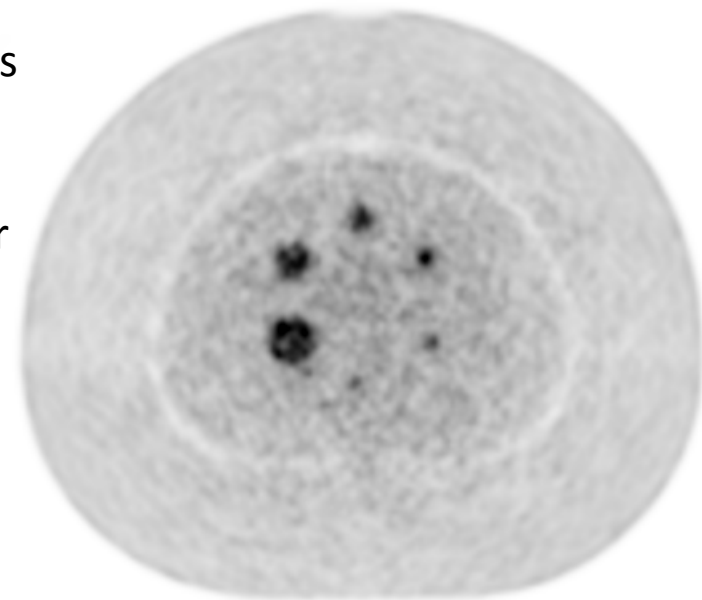


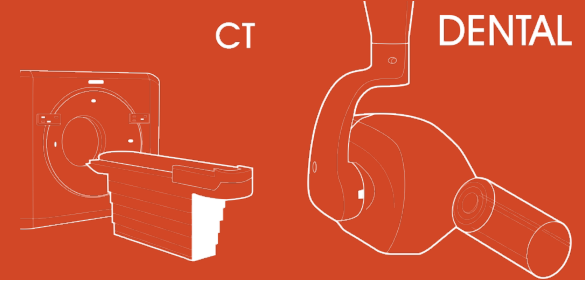
Image quality (contrast recovery, recovery coefficient)

- visualisation of spherical targets (6 hollow spheres filled with an activity concentration of ^{18}F)
- calculate the percent contrast and standard deviation for each sphere (calculations in the user manual)



Accuracy of attenuation and scatter corrections

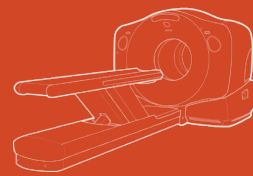
- draw 1 ROI centered on the lung insert
- draw 12 background ROIs
- calculate residual error in scatter and attenuation corrections



Actions:

- Repeat any test(s) that fail to verify the result
- Refer to common protocol
e.g.
 - IEC 61675-1 am1 Radionuclide Imaging Devices – characteristics and test conditions – Part 1: positron emission tomographs
 - NEMA NU-2

NU4 PET IQ

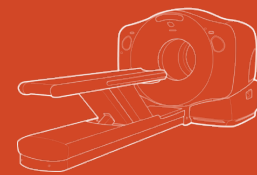


Meets NEMA NU4-2008 protocol for testing image quality, attenuation correction and scatter correction of small Field-Of-View pre-clinical PET systems.

- Phantom
- Case



NU4 PET IQ



Recovery Coefficient

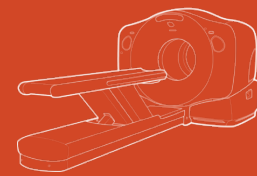
5 x fillable rods 1-5mm diameter

Draw circular ROIs around the rods, measure the maximum pixel value

Determine the mean and standard deviation of the slices covering the middle 10mm of the rods, for each rod size

$$\%STD_{rc} = 100 \left(\sqrt{\left(\frac{STD_{line\ profile}}{Mean_{line\ profile}} \right)^2 + \left(\frac{STD_{background}}{Mean_{background}} \right)^2} \right)$$

NU4 PET IQ



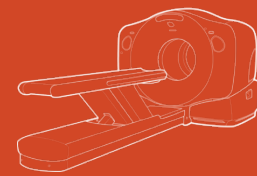
Uniformity

1x fillable section 15mm thick

Draw a 22.5mm diameter by 10mm long cylindrical VOI

Measure the minimum and maximum pixel values and the STD

NU4 PET IQ



Accuracy of Corrections

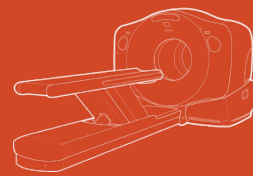
2x 8mm diameter fillable cylinders

Create a 4mm diameter and 7.5mm long VOI in the water and air filled inserts

Record the standard deviation

Calculate the Spill-over-Ratio (SOR) = $Mean_{cold\ region} : Mean_{hot\ region}$

GAMMA RESOLUTION

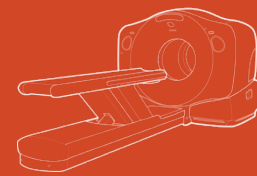


Quality control testing of the spatial resolution of a gamma camera detector array

Gamma resolution includes:

- Phantom
- Soft bag

GAMMA RESOLUTION

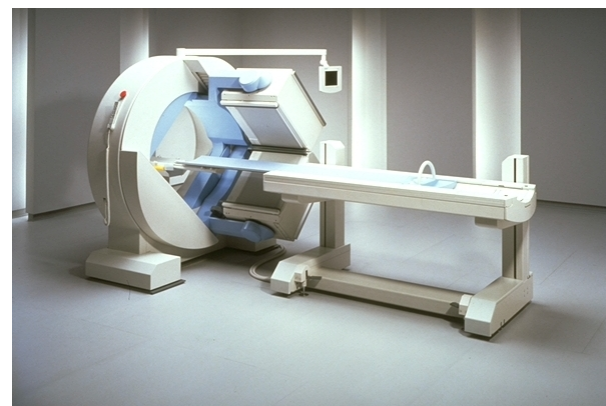


Phantom Positioning:

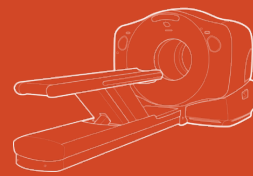
- Remove the collimator from the gamma camera
- Position the camera head so that the detector array is facing up
- Place the phantom on the detector array
- Place the camera's holding fixture over the phantom and secure the fixture to the detector head
- Use engraved cross hairs to assist with alignment

Exposure Conditions:

- Refer to user manual for details
- Same each time, and same as for acceptance

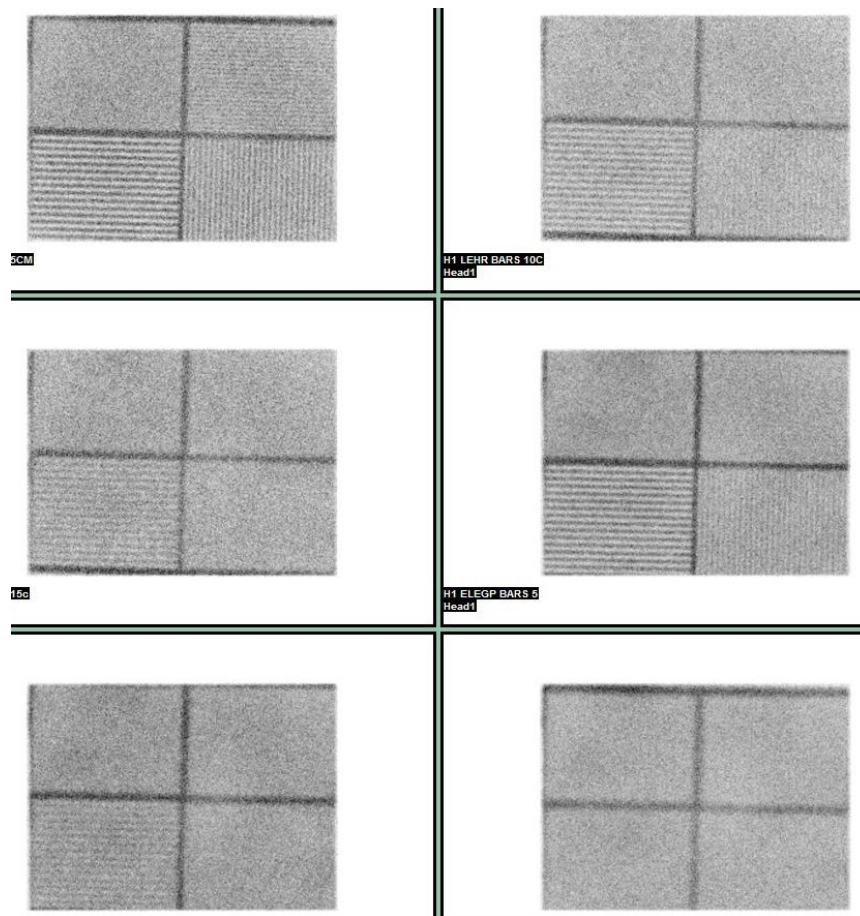


GAMMA RESOLUTION

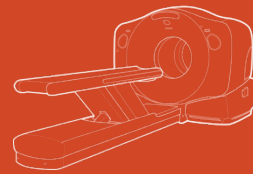


Resolution:

- Using a point source aligned to the detector array centre, accumulate 500,000 to 900,000 counts
- Record the image
- Determine the number of resolvable line pair groups



GAMMA DISTORTION

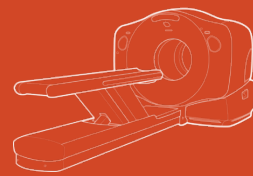


Quality control testing of the geometric distortion and PSF of a gamma camera detector array

Gamma distortion includes:

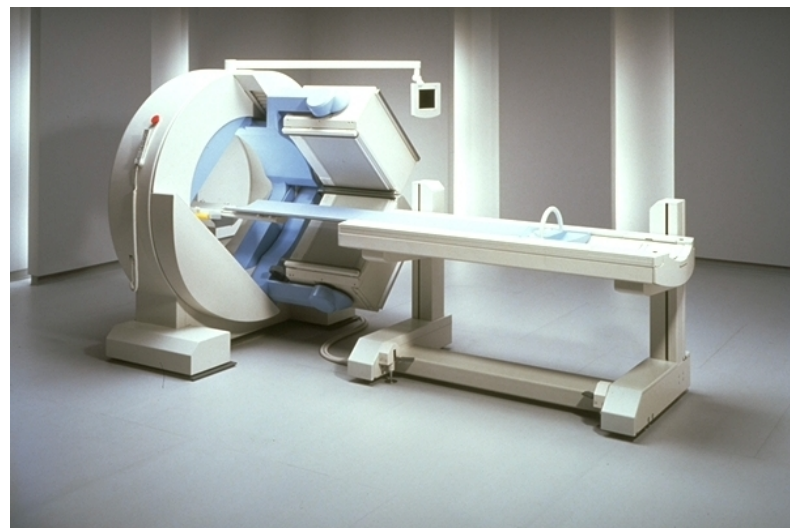
- Phantom
- Soft bag

GAMMA DISTORTION



Phantom Positioning:

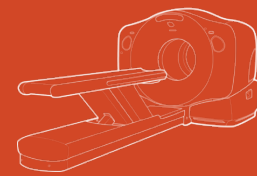
- Position the camera head so that the collimator faces up
- Place the phantom on top of the collimator



Exposure Conditions:

- Refer to user manual for details
- Same each time, and same as for acceptance

GAMMA DISTORTION



The array of holes in the phantom should contain 1 to 2mCi of Tc-99m or other appropriate radionuclide

With a 20% window, accumulate 500,000 to 900,000 counts

Record the image

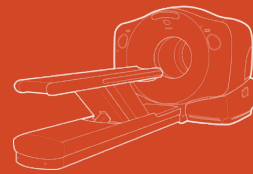
Geometric Distortion:

- Determine the distance between the point sources using digital callipers

Collimator Resolution:

- Plot the intensity against distance from a line drawn through any given point source
- Measure the FWHM to determine the PSF

GAMMA FLOOD



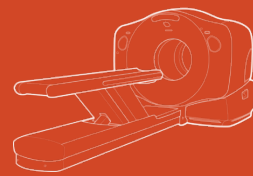
Quality control testing of the uniformity of a gamma camera detector array



Gamma flood includes:

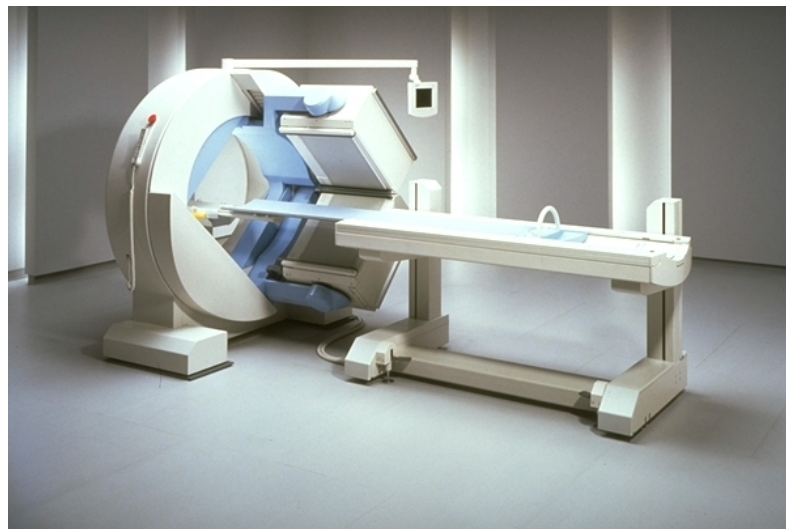
- Phantom
- Soft bag

GAMMA FLOOD



Phantom Positioning:

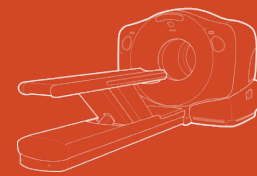
- Place the phantom on top of the inverted detector-collimator assembly



Exposure Conditions:

- Refer to user manual for details
- Same each time, and same as for acceptance

GAMMA FLOOD

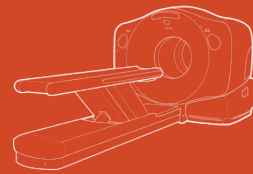


- Accumulate sufficient counts necessary to simulate clinical conditions (e.g. 300,000)
- Record the time necessary to accumulate the counts
- Observe that the image intensity is smooth
- Any variance in the time required to record the data will indicate variations in sensitivity

Actions:

- Ensure that the phantom contains the same total activity each time the test is carried out
- Report variances to the resident medical physics expert or supplier service

PET/CT/MR ALIGNMENT CUBES

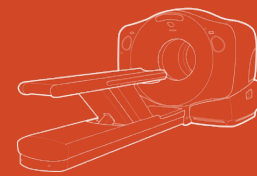


PET / CT / MRI alignment cubes:

- 7 cubes with fillable spheres
- Case



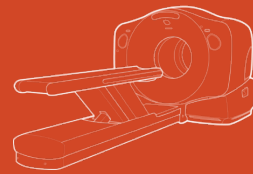
PET/CT/MR ALIGNMENT CUBES



PET/CT/MR alignment cubes can be used:

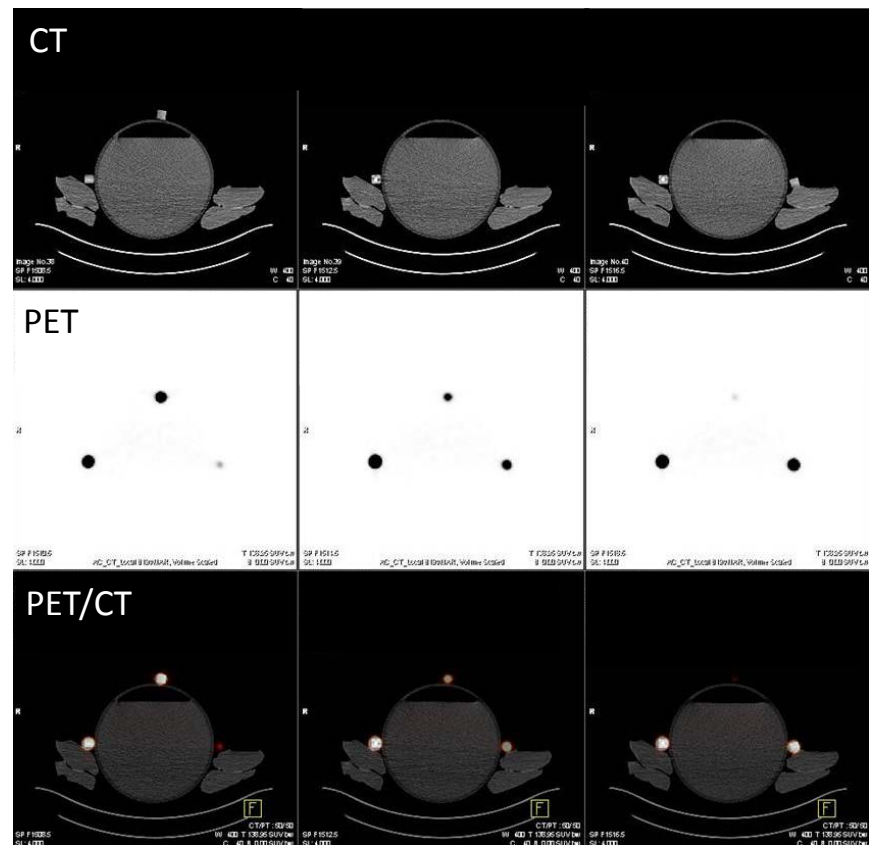
- As fillable point source markers to accurately and reproducibly measure alignment between modalities
- To aid with dataset and image registration from different scanners
- As skin marker on patients to identify anatomical landmarks to aid with spatial registration in software in cases where the patient has moved between PET and CT

PET/CT/MR ALIGNMENT CUBES



Phantom Positioning:

- Position the cubes around the phantom
- Stick with tape



Exposure Conditions:

- Standard clinical settings