VIRTUAL SIMULATION QA

S. Guru Prasad, Ph.D., DABR

Director of Medical Physics
IAEA Consultant
NorthShore University Health System and University of Chicago, Pritzker School of Medicine

PURPOSE

- Current TPS utilize more information from CT simulators and Virtual simulators than in the past
- These new requirements mandate a QA program to ensure CT data accuracy
- With new treatment options; dose escalation, SBRT, and SRS this procedure is of increasing importance

CT GANTRY

GANTRY CONTROL

AREAS OF INTEREST

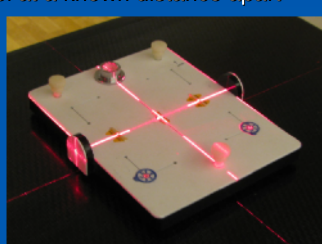
- Geometric accuracy and reproducibility
- Laser alignment
- High contrast resolution and low contrast sensitivity
- Field uniformity and noise
- CT number linearity
- Scan technique mAs versus SNR

GEOMETRIC ACCURACY

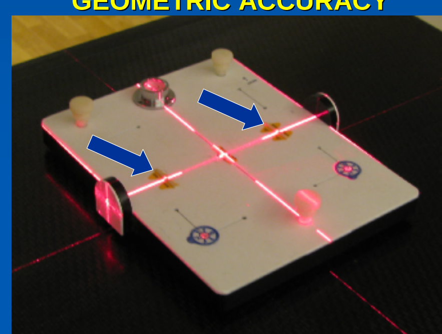
- Three dimensions (x,y,z)
- Scanning of a device of known dimensions
- Utilization of the scanners measurement tools
  - X and Y dimensions
- Incrementing the table a known distance
  - Z dimension

PROCEDURE

- **X dimension**
  - CT Marker wires are placed on a laser QA tool at a known distance apart



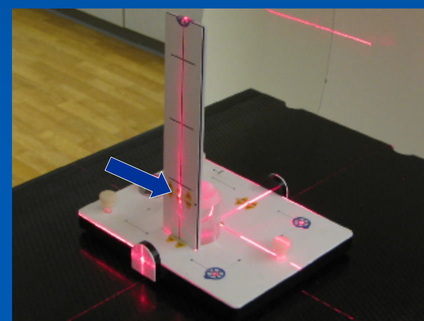
GEOMETRIC ACCURACY



PROCEDURE

- **X dimension**
  - CT Marker wires are placed on a laser QA tool at a known distance apart
- **Y dimension**
  - CT Marker wire is placed on a device in the vertical direction at a known distance

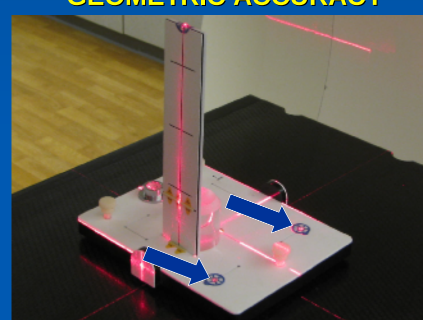
GEOMETRIC ACCURACY



PROCEDURE

- **X dimension**
  - CT Marker wires are placed on a laser QA tool at a known distance apart
- **Y dimension**
  - CT Marker wire is placed on a device in the vertical direction at a known distance
- **Z dimension**
  - CT Marker BB's are placed a known distance from the central axis

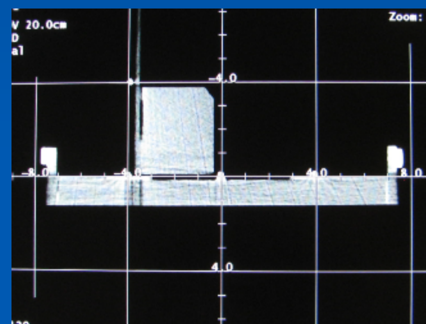
GEOMETRIC ACCURACY



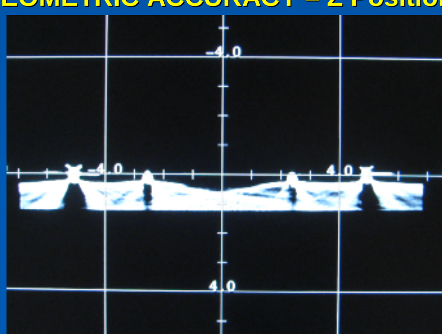
PROCEDURE

- Scanning of laser QA tool
  - Suggested technique: 120 kV 80 mA 1-2mm slice
- Three scans are performed, one each at superior, central axis and the inferior BB locations.
- Geometric accuracy in three dimensions can be measured

GEOMETRIC ACCURACY – X and Y



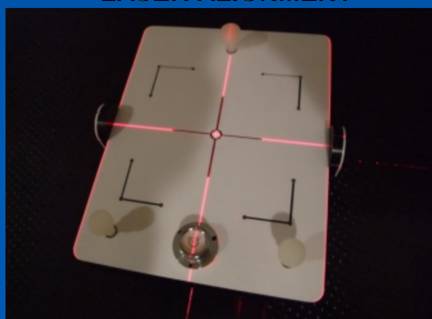
GEOMETRIC ACCURACY – Z Position



LASER ALIGNMENT

- Scanning of laser QA device can also be used to check accuracy of laser alignment to imaging isocenter

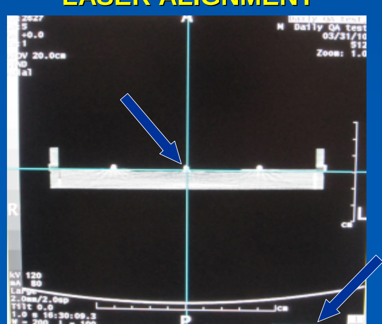
LASER ALIGNMENT



PROCEDURE

- Align laser QA tool to internal CT lasers
- Scan a single axial slice of 1-2 mm
- A CT marker BB placed on the device is used to mark the isocenter
- The crosshair tool is used to measure the coordinates of the laser isocenter

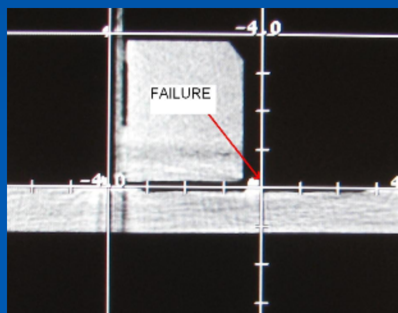
LASER ALIGNMENT



LASER ALIGNMENT

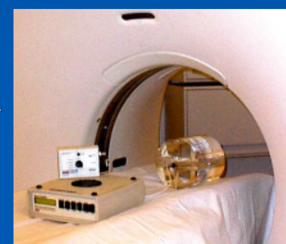
- An intentional offset of 2 mm to the Sagittal laser demonstrates the sensitivity of the test

SAGITTAL LASER FAILURE



FIELD UNIFORMITY and NOISE

- Position the C.T. head phantom centered in the gantry. Using 1 cm slice thickness, obtain one scan using typical head technique. Select a circular region of interest of approximately 400 sq. mm. And record the mean C.T. number and standard deviation for each of the positions 1 through 5



FIELD UNIFORMITY

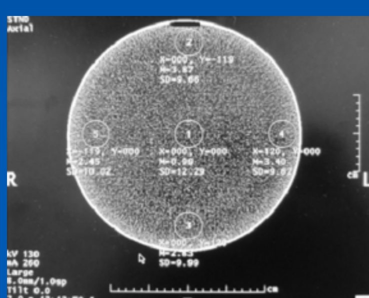


Fig 6. CT daily QA uniformity test

FIELD UNIFORMITY

kVp	mA	seconds	
Position	**Mean C.T. #**	**S.D.**	**C.V.**
1			
2			
3			
4			
5			

FIELD UNIFORMITY and NOISE

- CT# of water should be within +/- 5 HU of zero across field
  - Range of kVp should be tested if applicable
- The standard deviation of each ROI is a measure of noise
  - Determine the SNR as a ratio of mean to SDV
  - This value should be constant over a period of time

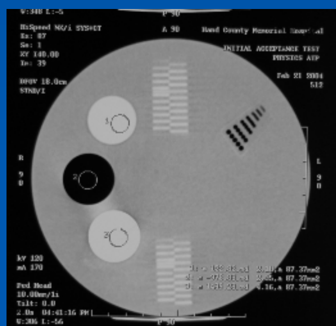
HIGH and LOW CONTRAST

- Use of a phantom such as the ACR or an acceptable CT performance phantom
- Set up the mini C.T. performance phantom
- Select the section containing the high resolution test objects
- Select the head technique
- Perform a single transverse scan
- Select the area containing the high resolution test objects and zoom as necessary
- Select appropriate window and level for the best visualization of the test objects
- Record the smallest test object visualized on the monitor

HIGH and LOW CONTRAST

CT # SET UP

HIGH CONTRAST RESOLUTION

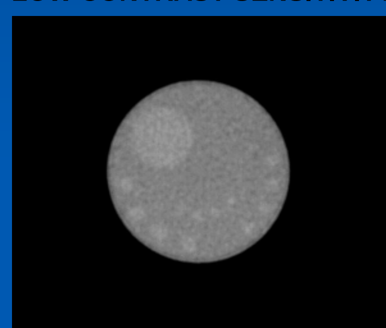


HIGH CONTRAST RESOLUTION

LOW CONTRAST RESOLUTION

- Select the section containing the low resolution test objects in the mini phantom.
- Perform a single transverse scan utilizing the same technique as high resolution

LOW CONTRAST SENSITIVITY



CT NUMBER LINEARITY

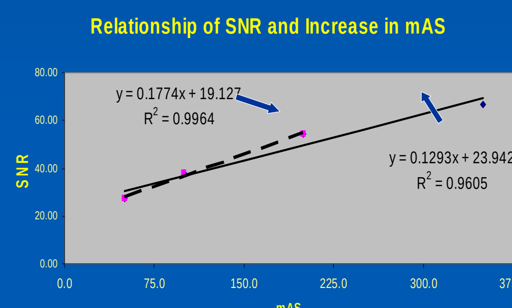
- Plot of expected versus measured CT#
- Procedure
  - Determination of energy
    - » Measurement of HVL of Al -> linear attenuation coefficient
    - » Determination of energy from lookup table of energy dependant linear attenuation coefficients
  - Calculation of expected CT#
    - » CT# = K(µ(E) - µ(E)water) / µ(E)water
    - » K: Scaling factor, typically value of 1000
  - Measurement
    - » Scan of device with many different materials of known electron density

CT NUMBER LINEARITY

SCAN TECHNIQUE

- Ensure that the scan technique used is appropriate
- Plot of mAs versus SNR

SCAN TECHNIQUE



MSAD / CTDI

- Set up the dose phantom as shown in the figure
- Connect pencil chamber
- Select head technique, 120 kvp, 170 mA and 2 seconds, 10mm slice thickness
- Perform four scans in this position. record the exposure in mR

SET UP / DOSE PHANTOM

MSAD

Skull Technique	Run Number	Exposure in mR
kVp	1	
mA	2	
Scan Time Sec	3	
Slice Thickness 10 mm	4	
Slice Increment = 0		
		Mean Exp./SD/ COV

- MSAD = (E x f x K x L)/T
- E = Average exposure reading
- F = Factor to convert exposure in air to absorbed dose
- Mean Exposure
- F = 0.00078 rad / mR
- K = Calibration factor of radiation measuring system K=1
- L = Effective length (mm) of radiation measuring system
- T = Tomographic slice thickness in mm

- Calculated MSAD = rad

CTDI

- **CTDI = E*f*L*C/N*T**
  - N = number of slices