

*Fundamental Principles of CT  
Performance Evaluation  
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# *Basic Operation of a CT Scanner*



- The “Generation” Race
  - 1st Generation - single beam, translate-rotate
  - 2nd Generation - multiple beam, translate-rotate
  - 3rd Generation - fan beam, rotate
  - 4th Generation - fan beam, fixed ring

# *CT Performance Factors*



- X-ray Technique
  - kVp
  - mAs
  - slice thickness
  - filtration
  - collimation

# *CT Performance Factors*



- Computerized image formation
  - Filtered back-projection
    - Convolution filter (Shepp & Logan, Std Head, H9)
      - Noise versus spatial resolution (Sharp vs smooth)
    - Matrix size
      - 80x80, 160x160, 256x256, 512x512
    - Pixel (51.2cm FOV = 1mm pixels)
    - Voxel (pixel with Z dimension, 1x1x3mm slice)

# *CT Performance Factors*



- Scan motion (3rd Generation)
  - Axial (contiguous versus spaced)
  - Helical (spiral)
    - Pitch = Table feed per rotation / slice thickness
    - Pitch =  $d / NT$  (table feed / number sections x thickness)

# *CT Performance Factors*



- Scan Object Effects
  - Size of object (e.g. large body vs pediatric)
    - cupping/capping artifacts - beam hardening
  - Composition (e.g. skull, air, metal pins)
    - edge effects, streaks

# *CT Performance Factors*



- Detectors
  - Xenon ionization
  - Solid state
- Factors - absorption, signal, stability, decay rate

# *CT Performance Tests*



- CT Number Scale

- $CT\# = K \cdot [ (u_x - u_w) / u_w ]$

- where K is a scaling factor (orig. 500 now 1000)
    - currently called “Hounsfield Units” (HU)
    - Air = -1000, Water = 0, Plexiglas = 120-130



# *CT Performance Tests*



- Slice thickness
  - Slice Sensitivity Profile (SSP)
- Method of Measurement
  - Thin ramp (FWHM)
  - Inclined plane of wires

# *CT Performance Tests*



- Low Contrast Detectability
  - phantom with low contrast objects (  $\sim 5\text{HU}$  )
- High Contrast Resolution
  - phantom with small hole patterns - AAPM
  - bar patterns with different line-pairs/cm (2- 5lp/cm)

# *CT Performance Tests*



- Field Uniformity
  - CT Number variation in a uniform phantom
  - Scan of a water phantom (16-50cm diameter)
  - ROI of center versus edges (  $\pm$  3-5 HU's)
  - Artifact evaluation

# *CT Performance Tests*



- CT Radiation Dose
  - Multiple Scan Average Dose (MSAD)
  - Computed Tomography Dose Index (CTDI)
    - $CTDI_{140}$      $CTDI_{100}$
    - $CTDI_w$

# *CT Performance Tests*



- $CTDI = f \cdot C \cdot D \cdot L / nT$ 
  - where:
    - $f =$  exposure to dose ( 0.78 rad/R acrylic, 0.94 tissue)
    - $C =$  chamber factor (R/reading)
    - $D =$  reading
    - $L =$  active length of chamber
    - $n =$  number of simultaneous sections
    - $T =$  slice thickness

# *CT Dose Measurement*

- CTDI measure

