Designing and Implementing

A PACS-Aware DICOM Image Object

For

Digital X-ray, Mammography and Intraoral Applications

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Quintiles Intelligent Imaging

Clear Vision for the Healthcare Industry

Outline

- Existing experience with DICOM images
- Reasons for a new DICOM object
- Digital X-ray (DX) object family features
  - general, mammography, intra-oral
- Implementation of DX objects
  - Provider (modality)
  - User (workstation)

Existing DICOM Objects

- Projection radiography objects
  - Computed radiography (CR)
  - Secondary capture (SC) - for film/screen
  - X-ray Angio/Radioflouroscopy (XA/XRF)
- Cross-sectional objects
  - Computed Tomography (CT)
  - Magnetic Resonance (MR)
  - Ultrasound (US), Nuclear Medicine (NM) ...

Existing DICOM Objects

- CR
  - doesn't describe new detectors well
  - no useful grouping images by series
  - multiple exposures per image allowed
  - anatomy, view etc. poorly described
  - grayscale not defined
  - relation to x-ray intensity not defined
  - processed vs. unprocessed controversy

Existing DICOM Objects

- Secondary Capture
  - most of the CR object problems, plus ...
  - unconstrained grayscale,color
  - no modality specific technique attributes
  - no orientation
  - essentially no conformance mechanism

Existing DICOM & PACS

- Services adequate (store, Q/R etc)
- Application (esp. reporting) limitations:
  - routing of images (worklist or station)
  - identification of image/exam type
  - grouping of images
  - layout of images
  - grayscale appearance of images

Digital Projection Radiography

- Established technologies
  - Computed Radiography
  - Thoravision (selenium drum)
  - Optically scanned film
  - CCDs for small area (dental, mammo bx)
- New technologies
  - large flat panels (+/- scintillator)
  - slit scans, etc.

Why a new object anyway ?

- New technology & new characteristics
- Characteristics of image pixel data
  - Contrast changes & image processing
  - Relationship to X-ray intensity
- Quality control needs description of
  - Acquisition
  - Detector behavior & identification
  - Dose

Why worry about PACS ?

- Modality and PACS vendors/groups traditionally have separate goals
- Cost effective deployment of digital detector technology may well depend on efficient image management and efficient soft copy reading
- Encourage digital detector sales by improving PACS usability & productivity

Digital X-Ray WG Goals

- Support new digital detector technology
- Reuse existing DICOM facilities
- Support for PACS integration
- Enhance workflow/productivity
- Consistent image quality/presentation
- Support advanced applications
- Support regulatory requirements

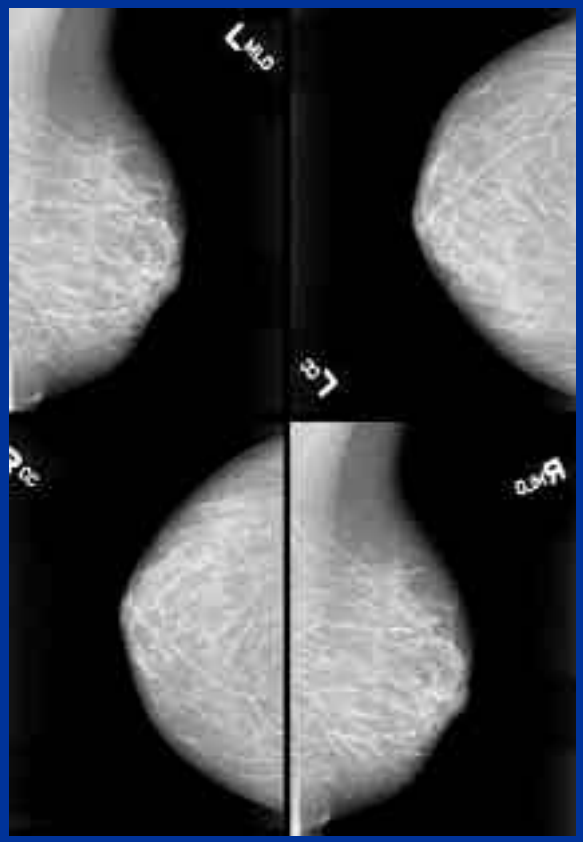
Identifying the PACS Needs

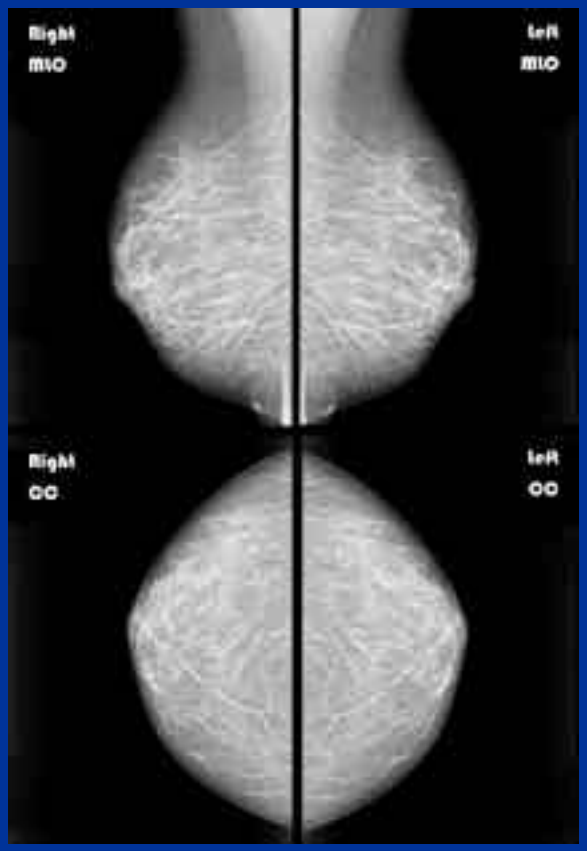
- Image management functions of PACS
  - matching images with request
  - matching images with old studies
  - routing images to reading worklist/station based on request/anatomy/physician
- Softcopy reading functions of PACS
  - images in correct order & orientation
  - images with appropriate grayscale

Failure to Meet PACS Needs

- Radiologists can’t read
  - images without request
  - request without images
  - images without old images
  - images not on reading worklist or station
- Radiologists won’t read or read slowly
  - images in wrong order or upside down
  - images with wrong contrast

Productivity - Image Hanging





Satisfying the PACS Needs

- Emulate all the functions of film
  - Visual cues
    - for file clerk/technologist/radiologist
  - Flashed identification
  - Lead markers
  - Wax pencil marks
  - Well defined, repeatable grayscale

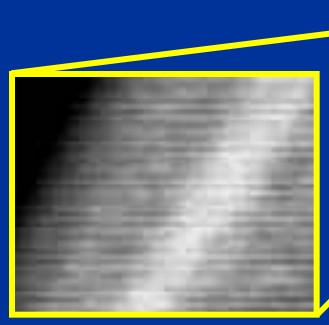
Management Features of Film

Visual Cues to Human:
Modality = X-ray
Anatomy = Skull
Projection = Lateral
Row Direction = Ant
Col Direction = Feet

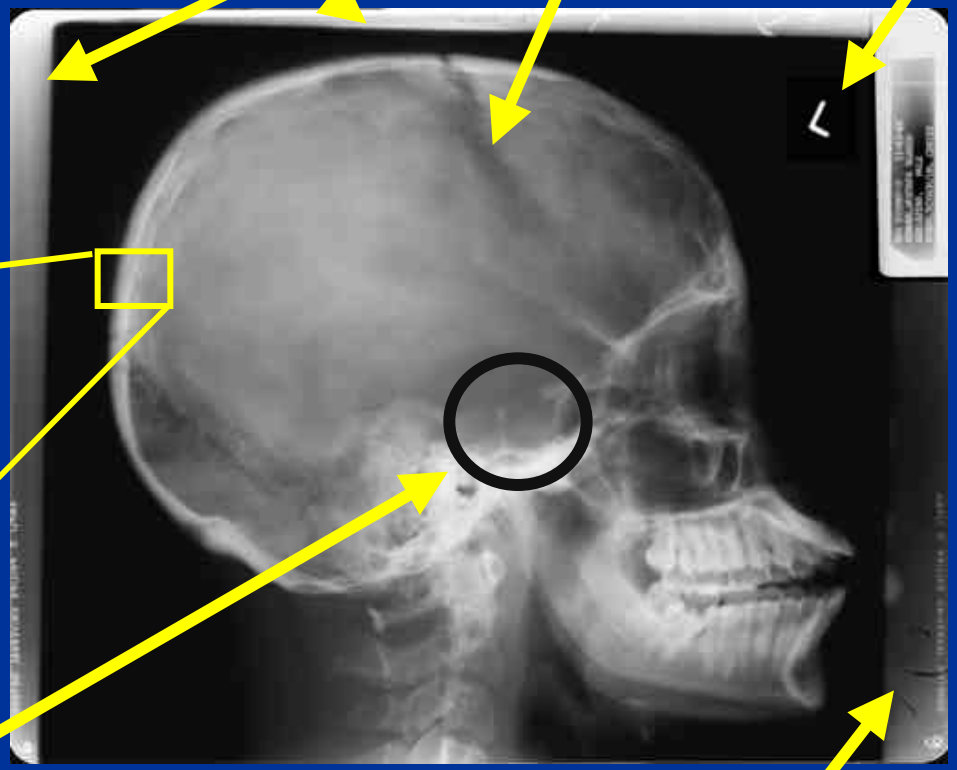
Grayscale: Film type & exposure

Collimator Edges

Lead Marker:
Laterality = L
Projection = L



Grid Used = Yes

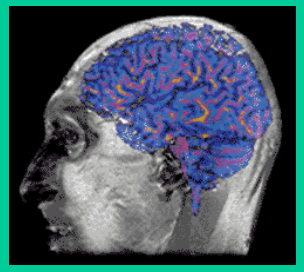


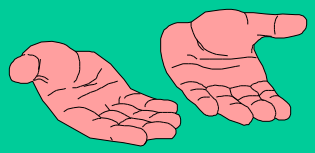
Flashed ID:
Patient Name
Patient ID
Patient DOB
Patient Sex
Physician
Institution

Wax Pencil:
Enlarged Sella

Wax Pencil: Film Number

Hanging a Film





Technology

L	L	L	L
Old Lateral	***New Lateral***	***New Frontal***	***New Townes***
F	F	F	F

Old Study

New Study

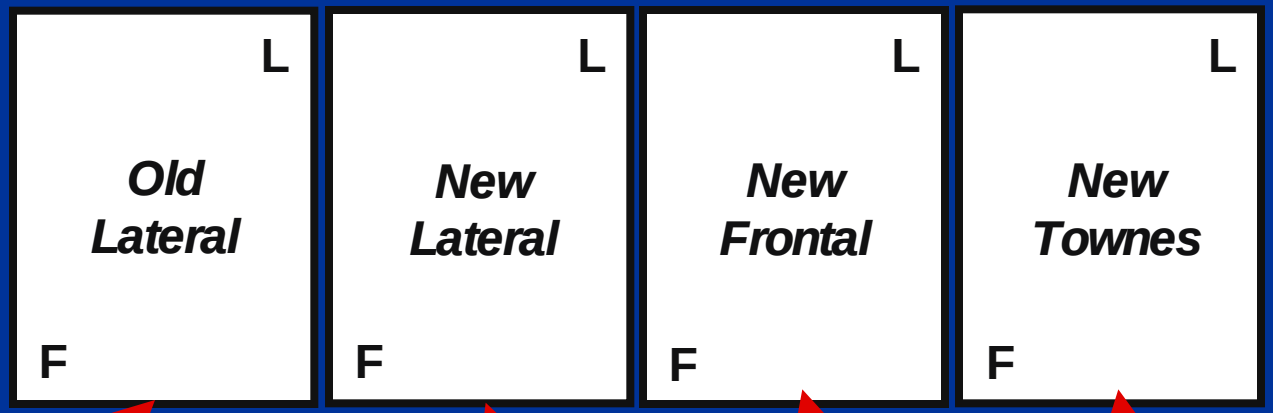
Hanging a Film

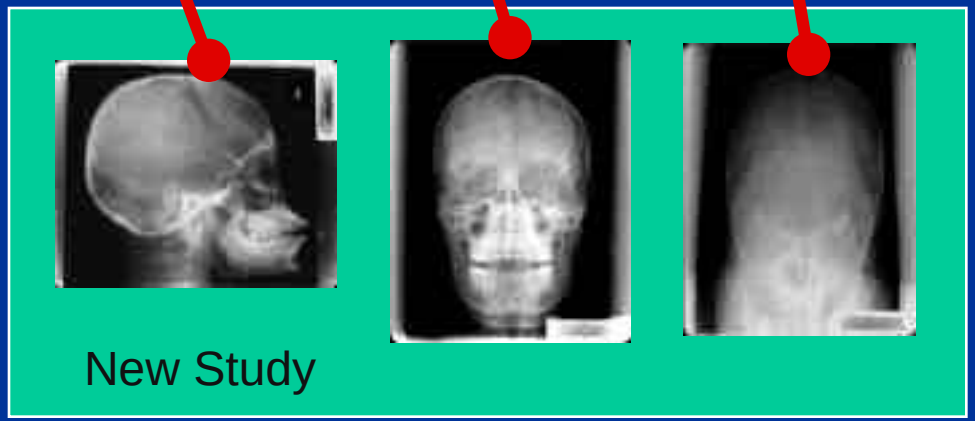
- Extract films from patient folder
- Sort into old and new films
- Verify patient name & ID on each film
- Arrange into desired hanging order
  - Match old with new for same anatomy/view
- Turn/flip to correct orientation
  - Left on right of viewbox, feet on bottom
- Turn on lightbox, +/- use bright light

Displaying an Image

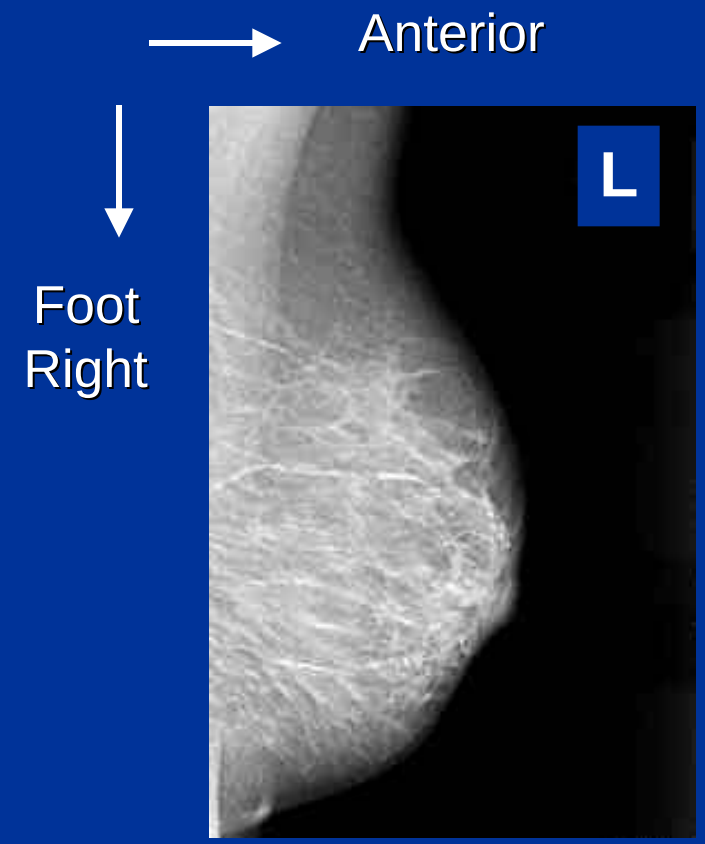
- Receive studies from worklist/prefetch
- Match modality/anatomy with protocol
- Per protocol:
  - arrange old and new images
  - arrange by anatomy/laterality view
  - rotate/flip image based on orientation
  - annotate images as desired
  - select from available contrast choices

Display Hanging Protocols





Information for Hanging



Modality: Mammography
Anatomic Region: Breast
Image Laterality: L
View Code: Medio-Lateral Oblique
Patient Orientation: A\FR

DICOM Support for Protocols

	Old Objects	DX Objects
Modality	Non-specific	More specific
Anatomy	Optional,text	(Required),coded
Laterality	Optional	Required
View	Optional,text	(Required),coded
Orientation	Optional	Required

Key distinguishing feature of DX object family:

- ***More critical attributes are required***
- ***More critical attributes are coded***

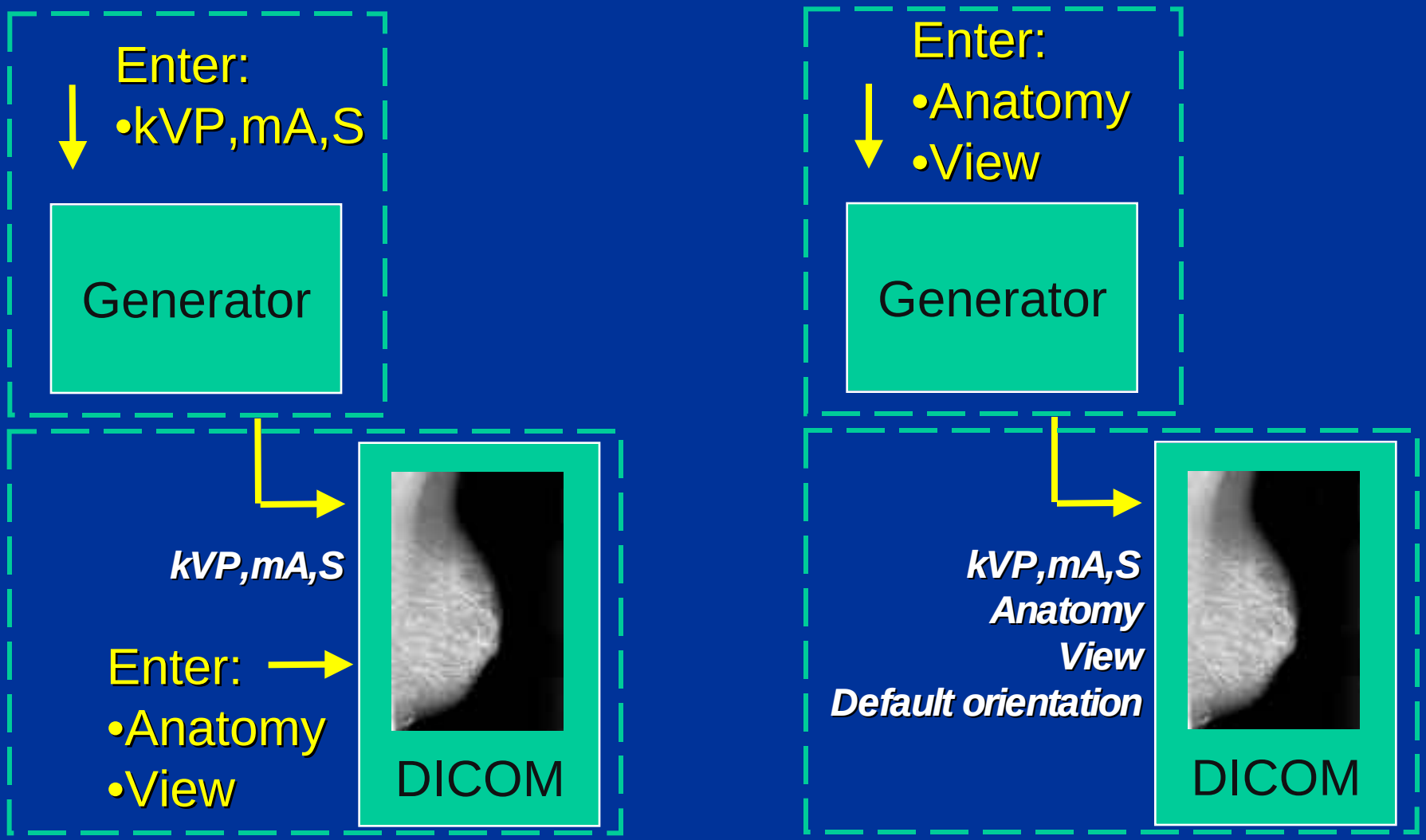
Implementing DX Objects

- SCU (the modality or x-ray system)
  - source of mandatory attributes
  - orientation of the image
  - contrast/processing choice
- SCP (the PACS or workstation)
  - take advantage of new attributes
    - routing/reading worklist improvement
    - hanging or default display protocols
  - ***standardization of existing practice***

DX SCU Design

- Distinguish
  - add-on systems
  - integrated systems
- Goal is minimize operator's burden
  - don't re-enter information
  - take advantage of known information
- Is a trade-off when necessary
  - PACS efficiency prioritized over modality

Generator Protocol Data



Generator Protocol Data

- Too coarse, e.g. Chest Lat = Oblique
  - make it more granular, including L or R
- Complete attributes in DICOM
  - Technique (kVP,mA,S) and derived dose
  - Anatomy and view
  - Default or preferred orientation
- Select frequency/contrast processing

Sources of Data

- Generator protocol selection
- Detect/select collimation
- Physical gantry (e.g. upright bucky)
- Detect/select filtration on tube
- Detect/select grid
- Detector values and statistics

Determining Orientation

- Use to describe/change orientation:
  - view e.g. PA not AP
  - geometry e.g. upright bucky
  - pixels arranged as viewed from tube side
- Therefore:
  - pixels on right towards patient's right
  - pixels at bottom towards patient's feet
  - either describe or flip to "normal" view

Determining Orientation

Operator selects …

- Image Laterality: L

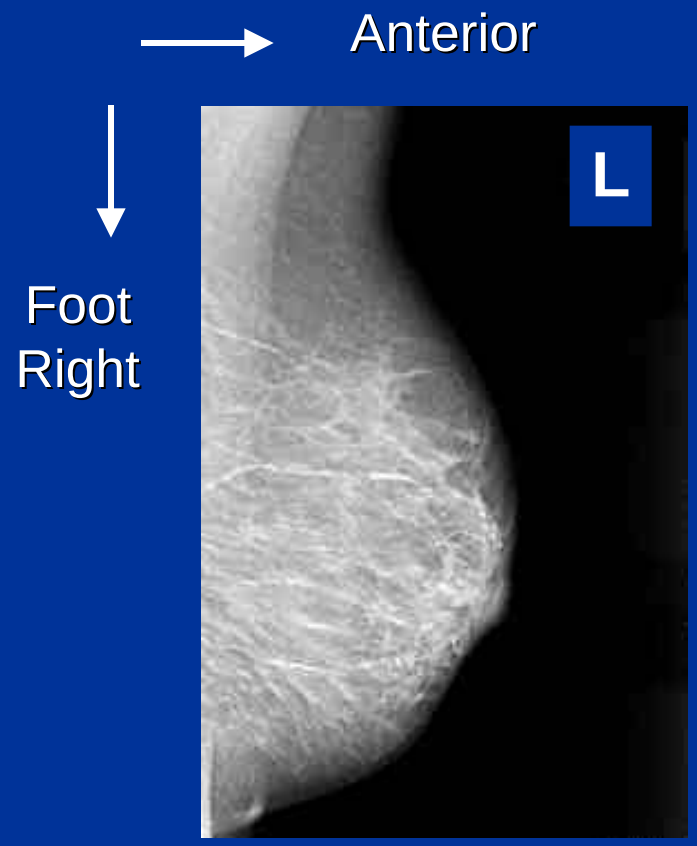
From angle and direction of gantry rotation …

- View Code: Medio-Lateral Oblique

Therefore ...

- Patient Orientation: A\FR

Already in natural view sense so don't need to flip top/bottom



DICOM Support for Routing

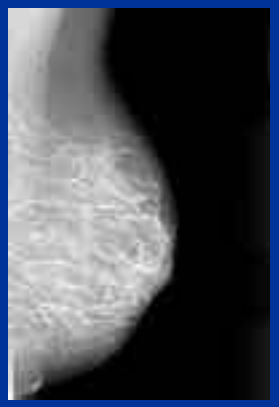
- Coded and mandatory attributes help
  - Modality+anatomy+view
- Still critical need for Modality Worklist
  - To supply identifiers that match IS/PACS
  - Patient ID/Name/Study ID
  - ***Study Instance UID***

Don't buy or build a modality or PACS without (a good) modality worklist !!!

Contrast Transformation

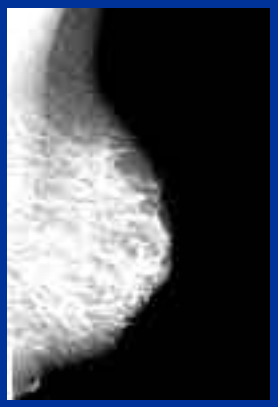
- Correct contrast transformation
  - crucial to create “film-like” appearance
- Display (& print) devices vary greatly
- Incorrect contrast is a source of
  - inefficiency
  - dissatisfaction
  - fatigue
  - errors in diagnosis

Image Presentation

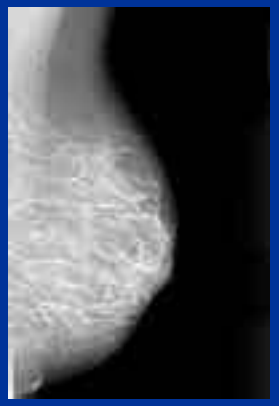


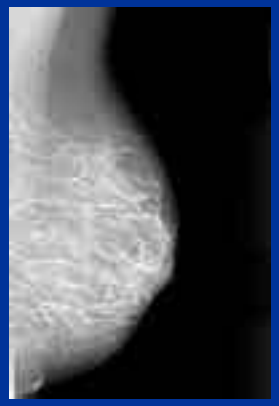
Acquire

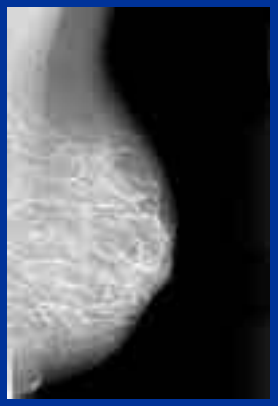
Display



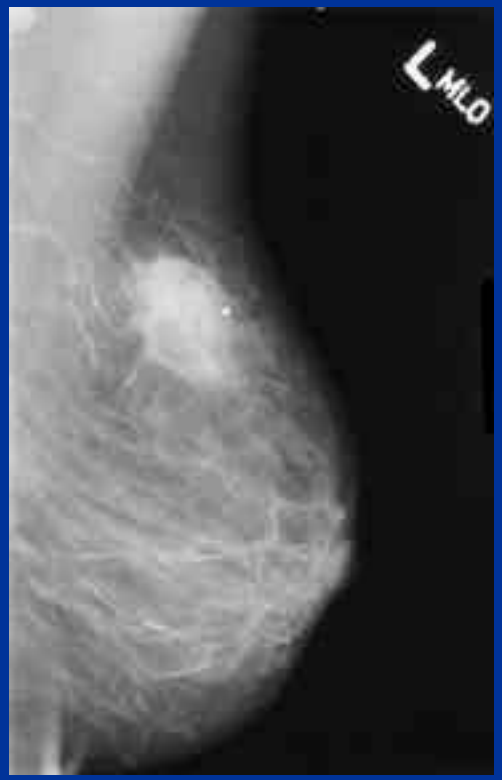
Print



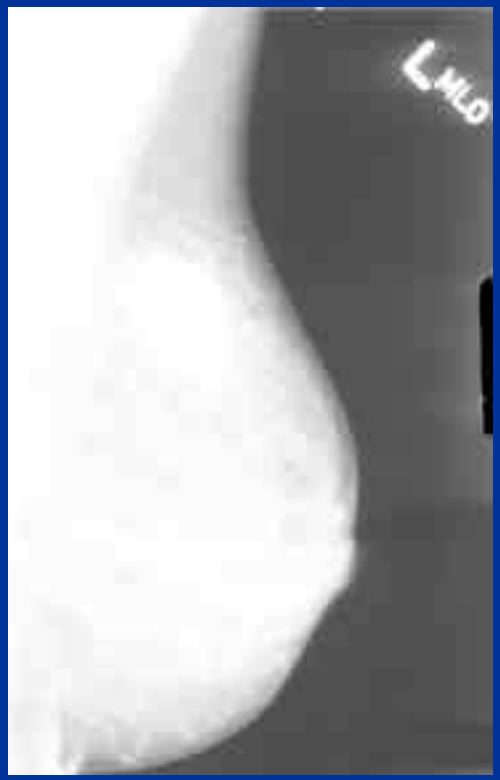




Problems of Inconsistency



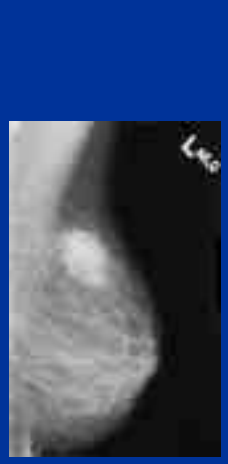
mass visible

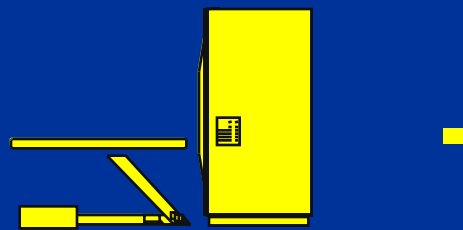


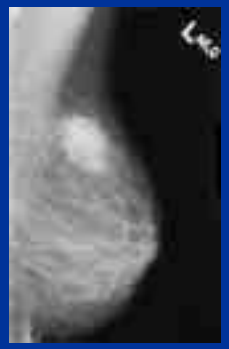
mass invisible

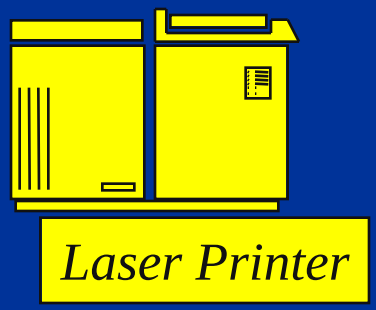
- VOI chosen with on one display device
- Rendered on another with different display
- Mass expected to be seen is no longer seen

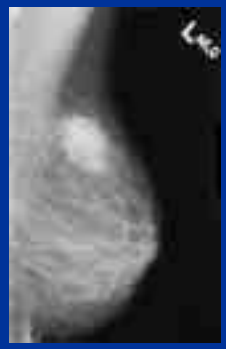
Distributed Image Consistency



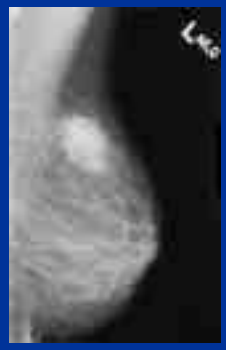








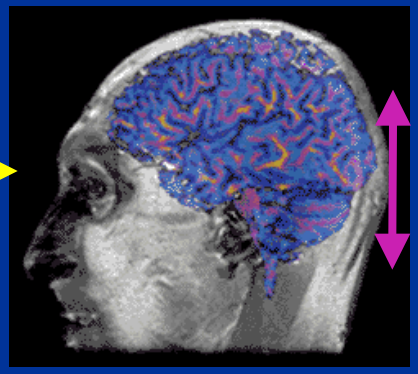
Identical perceived contrast



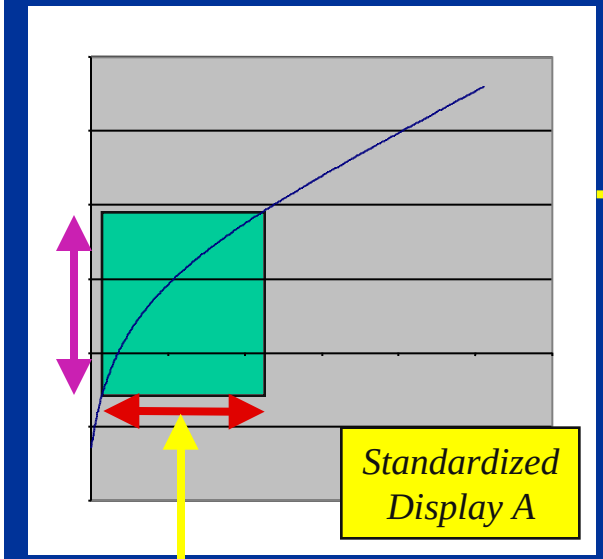
Contrast Transformation

- Existing DICOM - optional & arbitrary
- DX family - mandatory & standard
- Two key elements
  - appropriate choice of contrast function
    - linear or non-linear LUT
    - automated choice(s) based on anatomy/view
  - standard device independent output space
    - DICOM Grayscale Standard Display Function
    - perceptually linear P-Values

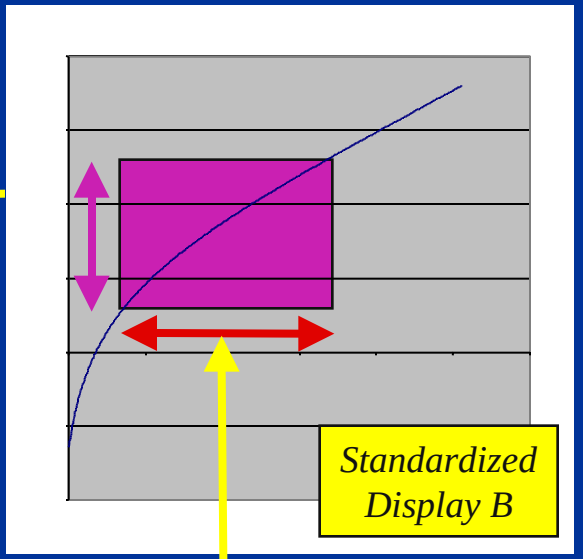
Device Independent Contrast



Standard Display Function



Standard Display Function



P-Values: 0 to 2^n-1

Implementing Contrast Consistency

- SCU Implementation (modality)
  - choose contrast (window or VOI LUT) based on standard display function rather than specific film/camera/monitor
- SCP Implementation (workstation)
  - display must be standardized
  - display must be calibrated
  - quality control process in place

Conclusions

- New technology provided opportunity
- PACS experience with existing DICOM
- New Digital X-ray (DX) object family
- PACS productivity improvement
  - display hanging protocols
  - routing and reading worklist
  - consistent grayscale appearance
- Implementation reuses available data