RSNA 2002 Refresher Course 426
Update on PACS Acquisition, Display Technology, and DICOM:

PACS Acquisition Technology

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Learning Objectives

- Explain how ordinary radiographic images can be captured in digital form
- Describe how special imaging modalities can supply images to PACS
- Preview some advanced systems for acquiring digital images

What is a digital image?

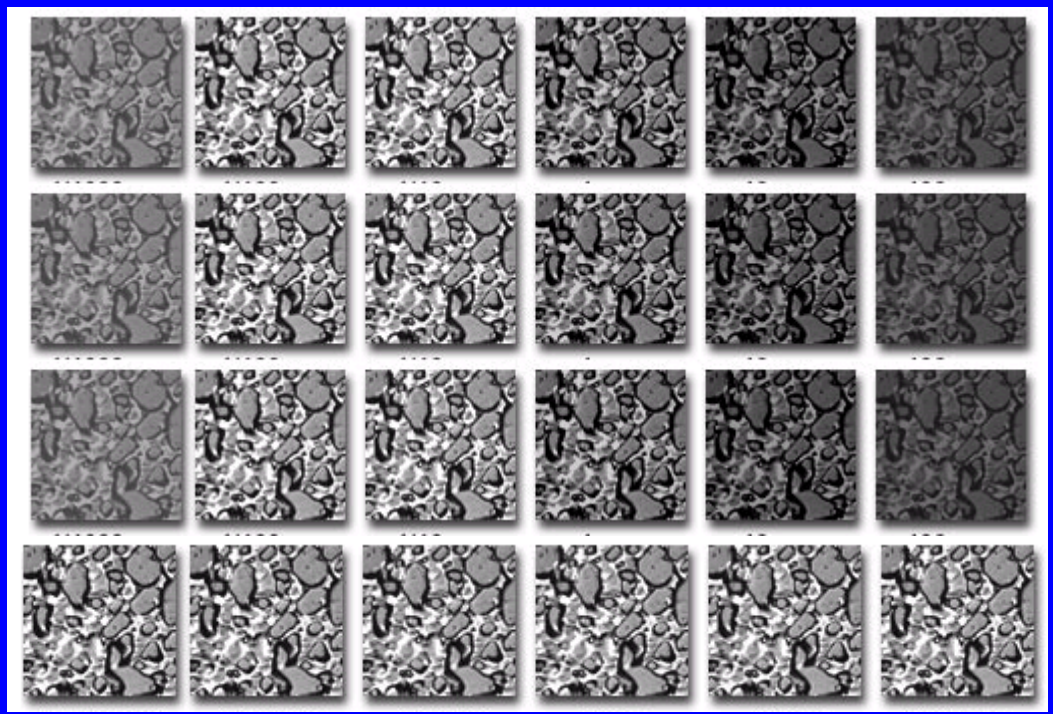
Etruscan Roman Mosaic circa 50BC

Conventional Screen-film Radiography

- Radiographic projection strikes intensification screen(s) producing *fluorescence*
- Fluorescent light exposes photographic film producing *latent image*
- Latent image is chemically developed to produce *density* in film
- Film density is viewed by *transillumination*

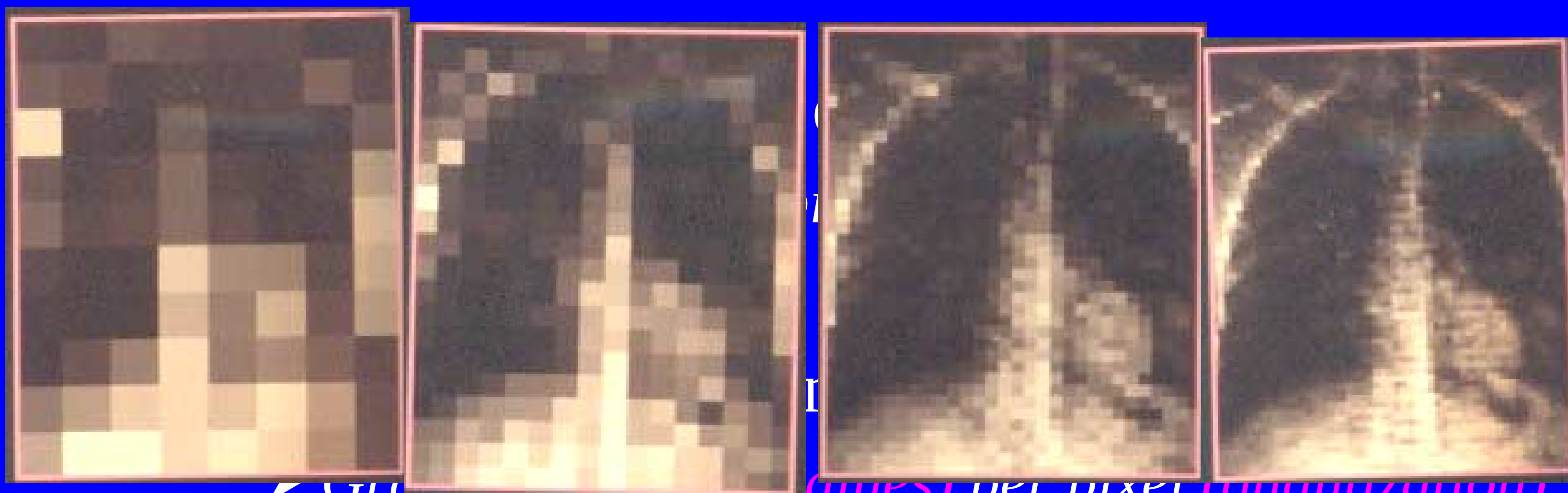
Developed Film is Effectively Analog

- Density is result of many developed silver grains
- Grains in intensification screen are quite small



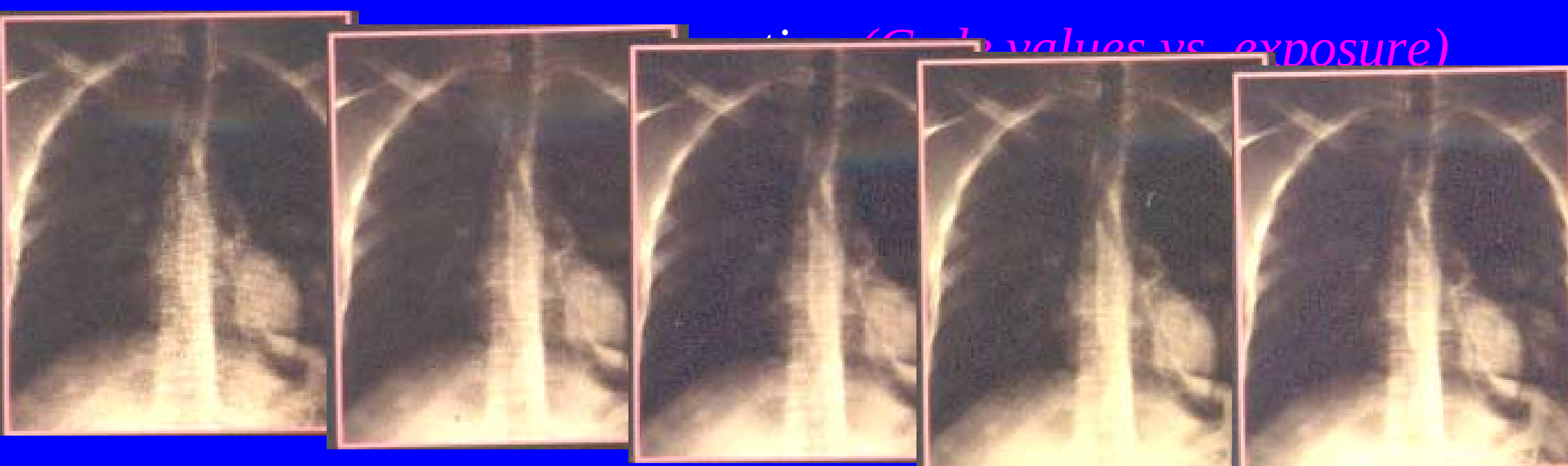
[1,0,0,2,3,4]
[1,0,0,2,3,4]
[1,0,0,2,3,4]
[0,0,0,0,0,0]

How good an approximation does the digital image make?



➤ Grayscales (Code values) per pixel (quantization)

...tion (Code values vs. exposure)



Approaches to Digital Radiography

- Translate developed film into digital form.
- Capture the radiographic projection by non-photographic method and digitize during development.
- Capture the radiographic projection *or its fluorescence* directly in digital form.

Film Digitization

- Video of transilluminated radiographs
  - *"Camera-on-a-stick"*
  - *Low cost, low quality*
- Laser film digitizers
  - *Best quality, less cost than other approaches*
  - *Highest cost of digitizers, periodic maintenance costs*
- CCD film digitizers
  - *Less cost than lasers, less maintenance, better quality than camera-on-a-stick*
  - *Old problems of drift, noise, non-uniform illumination, and veiling glare – probably rectified*

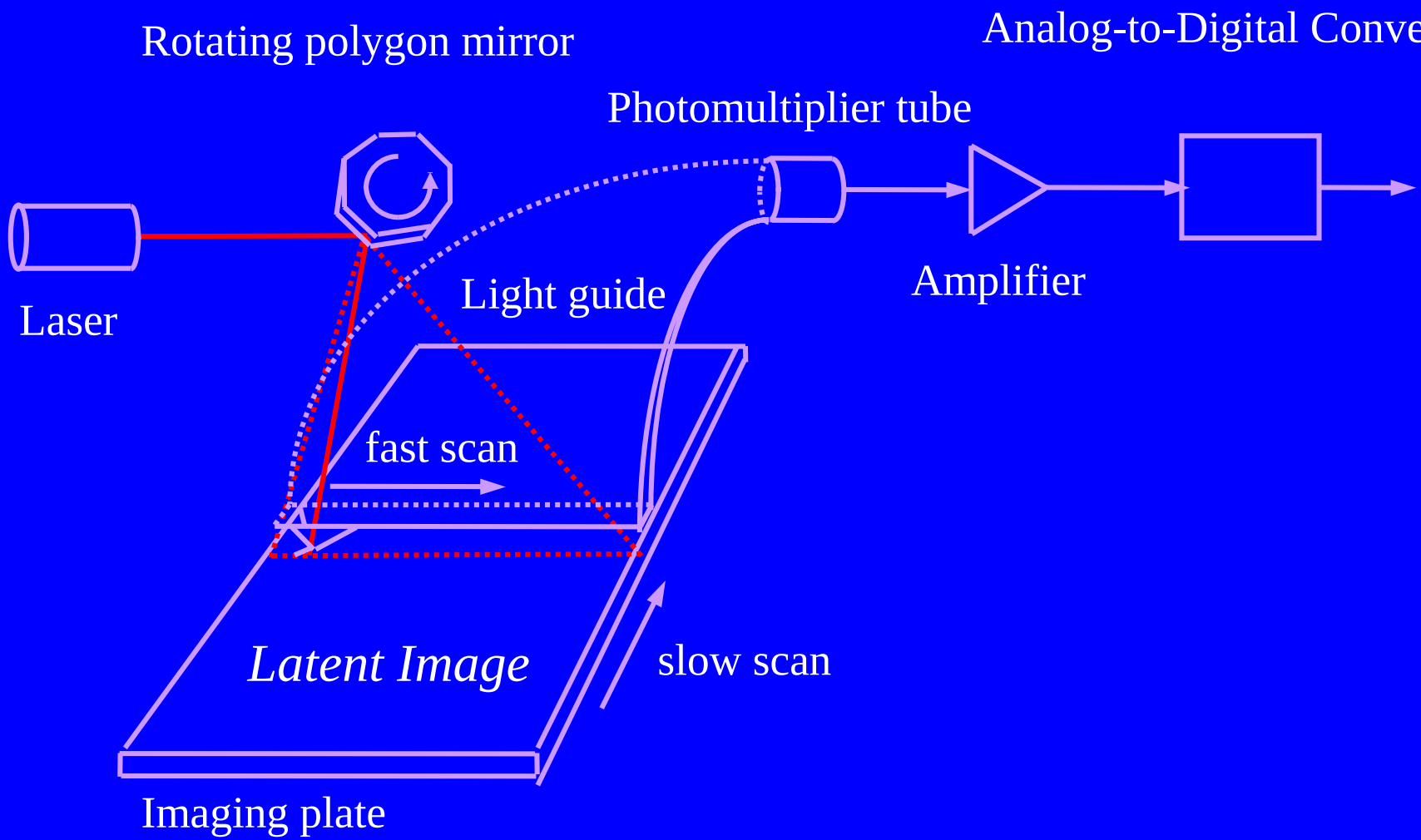
Film Digitization

- Fundamental limitations
  - *Prone to artifacts*
  - *Best quality achievable is limited by original film-screen image*

Non-photographic capture with digital development – Computed Radiography

- Computed Radiography *(CR)* or Photostimulable Phosphor *(PSP)* Radiography
- Latent image is “developed” physically instead of chemically
- As the latent image is “developed” …
  - *Stimulated light is directed to a Photomultiplier Tube (PMT)*
  - *The PMT current is digitized by an Analog-to-Digital Converter (ADC)*
- The digital image consists of an array of ADC Code Values
  - *ADC Code Values represent density information*
  - *Array locations represent spatial information*

Photostimulable Phosphor Reader



Non-photographic capture with digital development – Selenium Plate

- Xeroradiography
  - *charged Selenium pla*
  - *Electrostatic latent im*
  - *Charge distribution t*
- Selenium drum detec
  - *Selenium deposited o*
  - *Selenium uniformly charged before exposure*
  - *X-rays partly neutralize the charge*
  - *Charge distribution measured by electrometer array*

"Direct" Capture

- X-ray-to-light Converters with photodetector
  - *Fluorescent material such as $Gd_2O_2S:Tb$, $CsI:Th$, with good x-ray stopping power*
  - *Photodetector relatively transparent to x-rays*
  - *Also Scintillating Fiber Optics (SFO) as converter*
- Direct X-ray Conversion (photoconductor)
  - *PbI_2, ZnCeTe with high Z*
  - *Thick layer of a-Se*

"Direct" Capture

- Synchronous scanning mechanism
  - *Collimated x-ray beam and linear detector array scan anatomy*
- Large Area detector
  - *Entire image captured at once*

"Direct" Capture

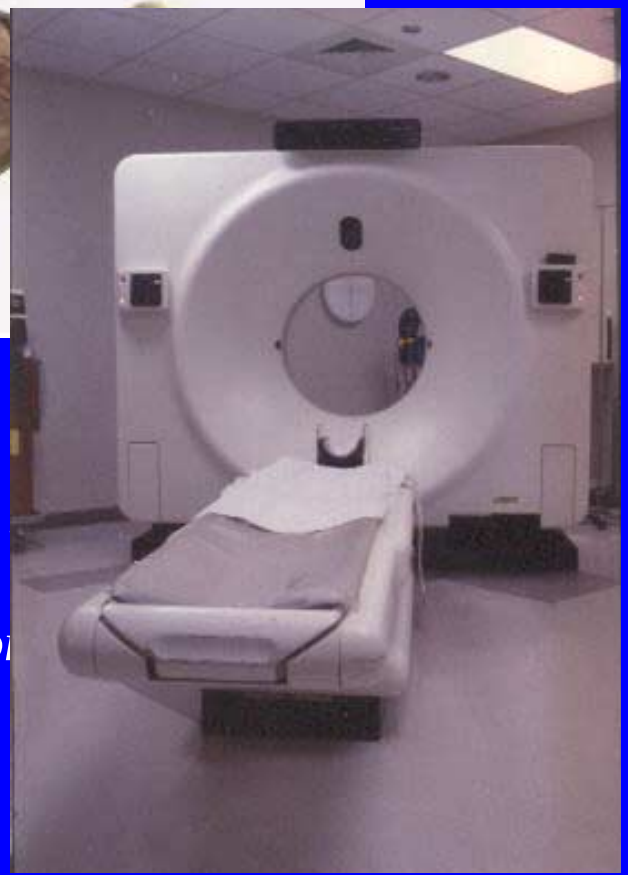
- Fluorescent screen with video camera *(video-fluoroscopy, image intensifiers)*
- Fluorescent screen with Charged-Coupled Devices *(CCD)*
  - *Optical lens coupling*
    - *Secondary quantum sink*
  - *Fiber optic coupling*
    - *Small area*
- Hydrogenated Amorphous Silicon *(a-Si:H)* with Thin Film Transistors *(TFT)*
- Alpha Selenium *(↑-Se)* electronically coupled to TFT

"Direct" Capture

- Rapid acquisition and processing
- High initial capital investment
- Challenging manufacturing processes
- No systems for bedside radiography
- Brief history of clinical operation
  - *Life cycle issues unknown (durability?)*
  - *Image rendering unknown*
  - *Exposure factor issues*

Interfacing Special Imaging Modalities (Fluoro, US, CT, MR, NM)

- Video frame capture ("fram



Interfacing Special Imaging Modalities (Fluoro, US, CT, MR, NM)

- Interfacing is Two-sided challenge
  - *Does modality provide proper information to PACS?*
  - *Does PACS properly interpret the information supplied?*
- Advances in acquisition modalities increase demands on PACS
  - *Multislice CT, Dynamic US, Functional MR have associated storage, transmission, and display overhead*

Digital Mammography => extreme technical challenge! (OpEd page)

- Mammography is exam of high consequence
- At the limits of spatial and contrast resolution for conventional screen/film
- Digital display for 4Kx4K matrix size is recent development
- Primary driver for digital mammography is Computer Assisted Diagnosis (CAD), rather than image distribution or archiving
- Catalyzing improvements in digital radiography and digital fluoroscopy

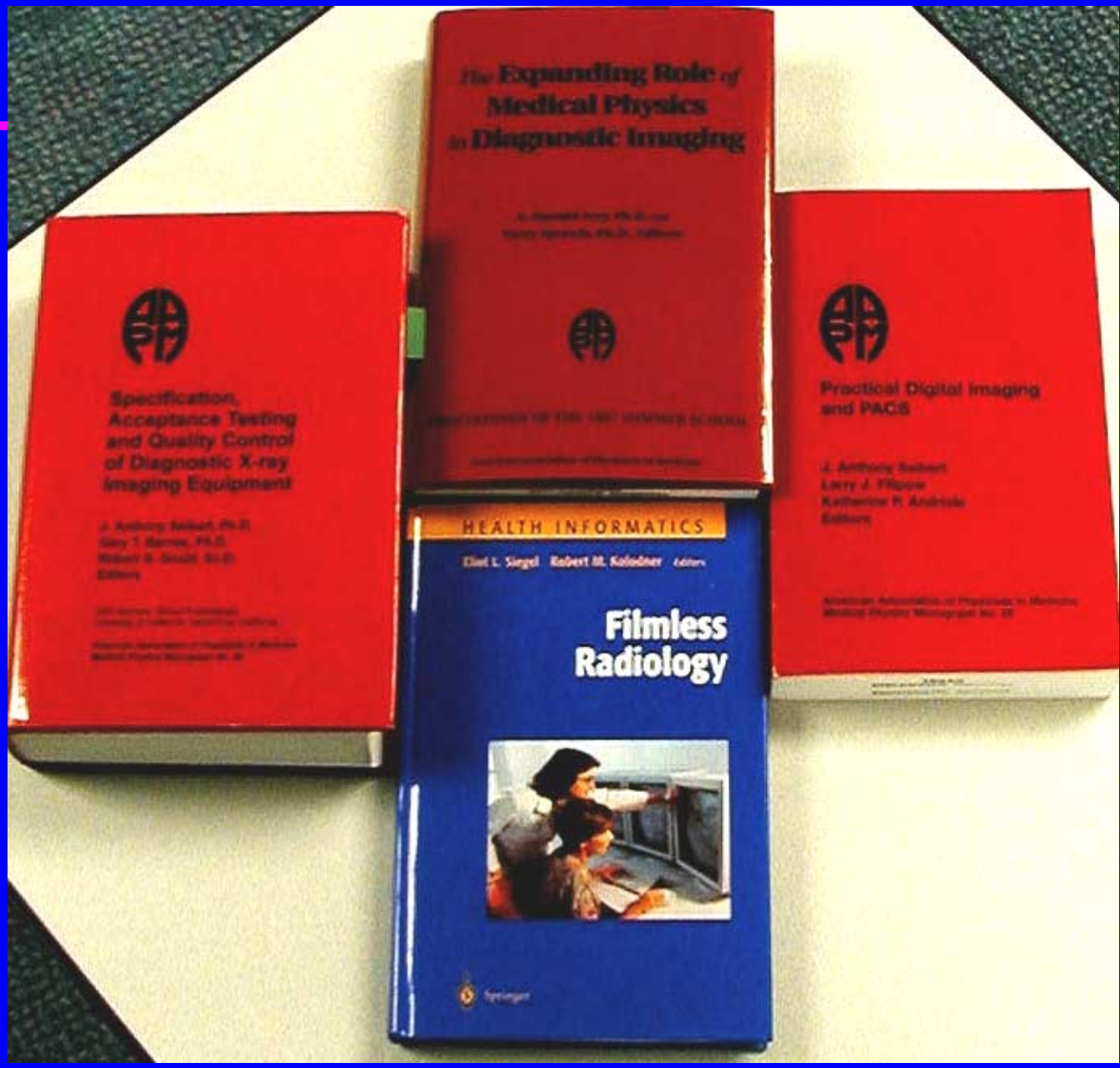
New Approaches

- All the Direct Detectors
- Two-sided CR reading
  - *Transparent imaging plate support*
  - *Stimulate from front side only*
  - *Collect luminescence from front and back*
- Needle-crystal CR with slot-scanner
  - *Linear light source (array of laser diodes)*
  - *Linear CCD array*
  - *Columnar phosphor (CsBr:A)*

Conclusions:

- A variety of methods exist for introducing ordinary radiographic projections into PACS
- Special imaging modalities can also be imported into PACS via DICOM
- New systems are being developed to acquire diagnostic quality digital images rapidly and at the lowest radiation exposure to the patient

References:


The Expanding Role of Medical Physics in Diagnostic Imaging
Specification, Acceptance Testing and Quality Control of Diagnostic X-ray Imaging Equipment
Practical Digital Imaging and PACS
HEALTH INFORMATICS
Eliot L. Siegel Robert M. Kolodner
Filmless Radiology