

Current Status of and Future Applications for Telemammography

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Telemammography Application

Allow multi-site radiology practices to monitor & interpret examinations off-site, so that those radiologists in the group with the greatest interpretive expertise will read all or mostly all examinations.

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Telemammography Requirements

- **Equivalent image quality to film**
- **User-friendly interface**
- **Rapid-throughput performance**
- **“Real time” performance**

Telemammography Requirements

Rapid-throughput and “real time” telemammography performance is practical only with soft-copy image interpretation of full-field digital mammograms.

Full-Field Digital Mammography Unit

Fischer SenoScan mammography system

- Slot-scanning system
- Dose-efficient scatter rejection
- Image field size: 24 x 30 cm
- Pixel size : 54 microns

Workstation Properties

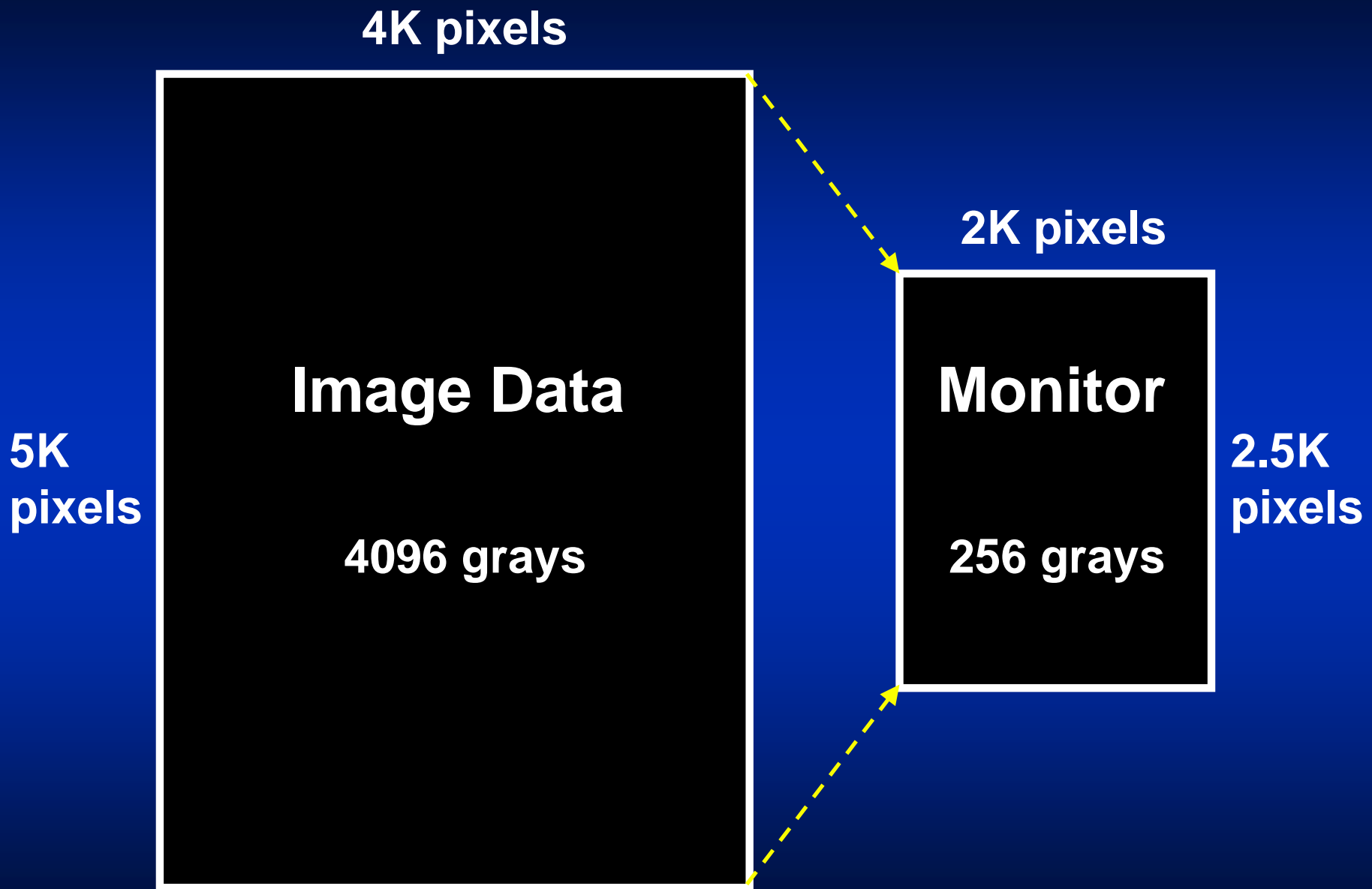
- **Rapid display of up to 8 images**
- **Automatic window - level function**
- **User-friendly window - level tool**
- **User-friendly magnification tool**
- **Archive chosen optimized images**

Full-Field Digital Mammograms

- **Image Matrix: 4096 x 5625 pixels**
- **Pixel Gray Level Range: 0 - 4095 (12-bit)**
- **Image File Size: 46 MBytes**

Image Data Compression

Full-field digital mammogram data must be compressed for image display, to match the matrix and gray level limitations of commercially available soft-copy monitors.



4K pixels

Image Data

4096 grays

2K pixels

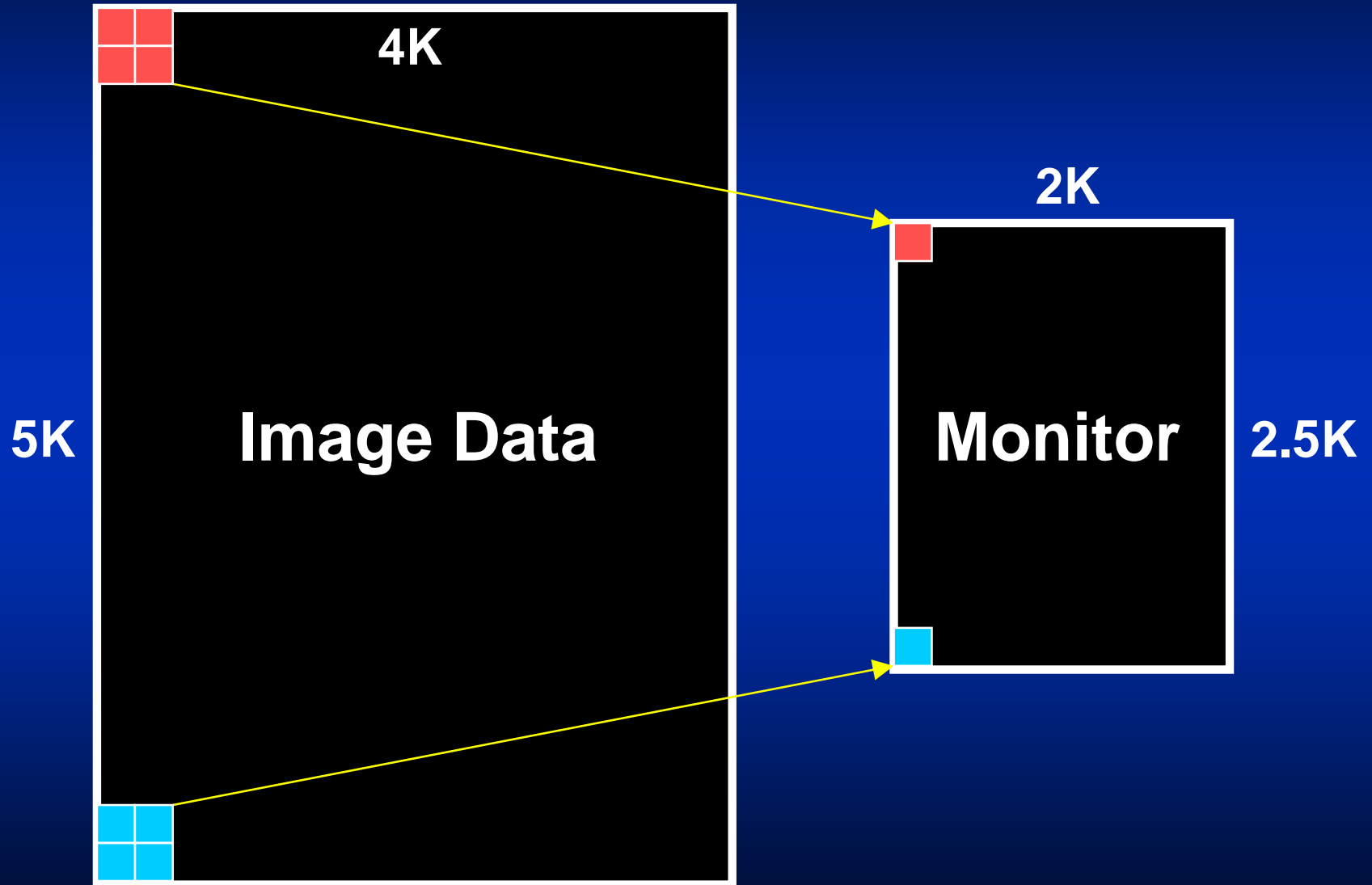
Monitor

256 grays

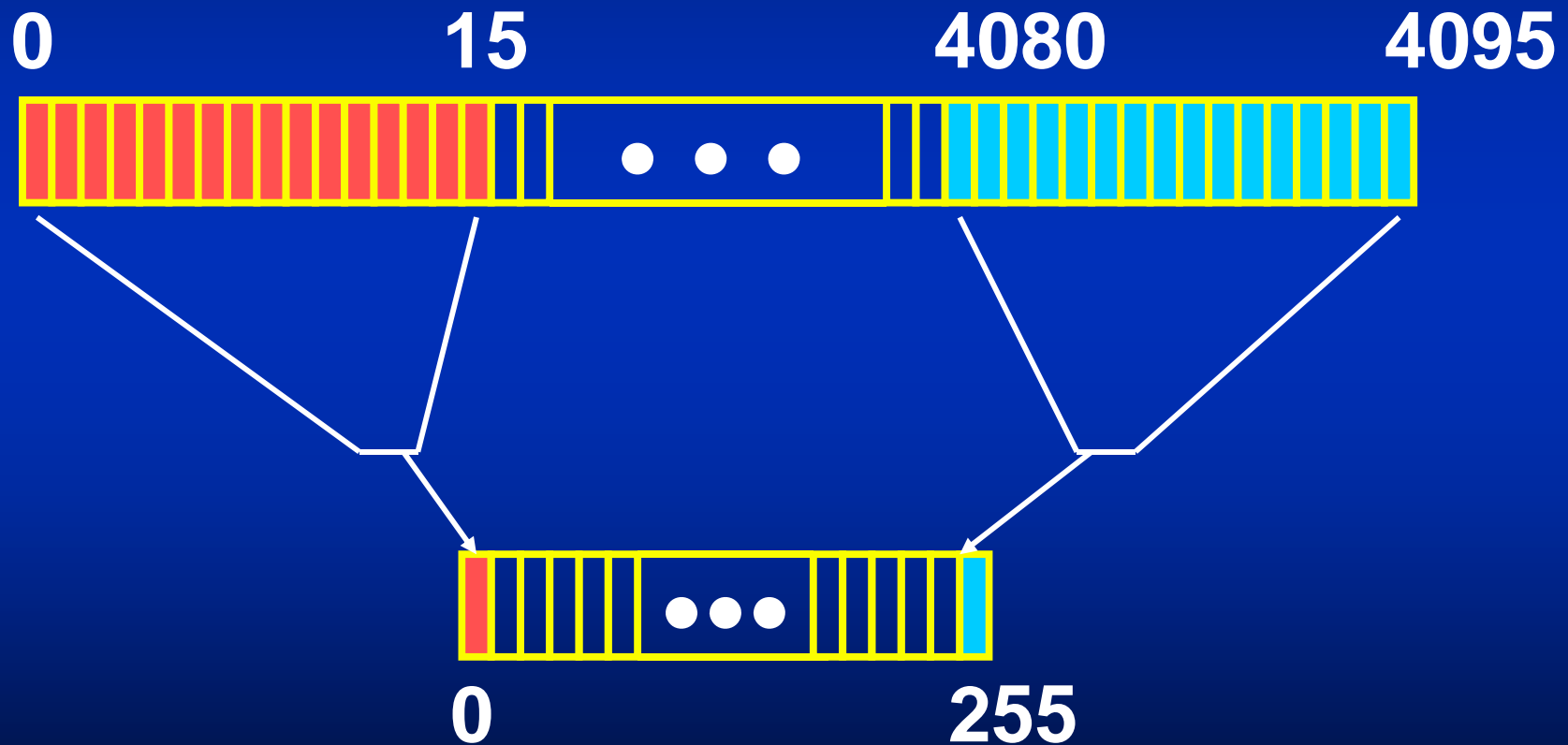
5K pixels

2.5K pixels

Pixel Mapping (4:1)



Gray Value Mapping (16:1)

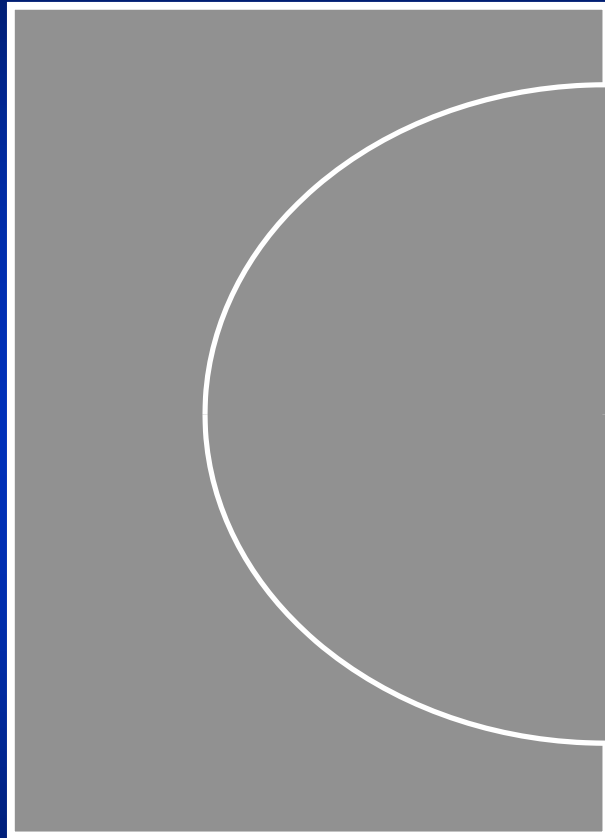


Breast Region Extraction

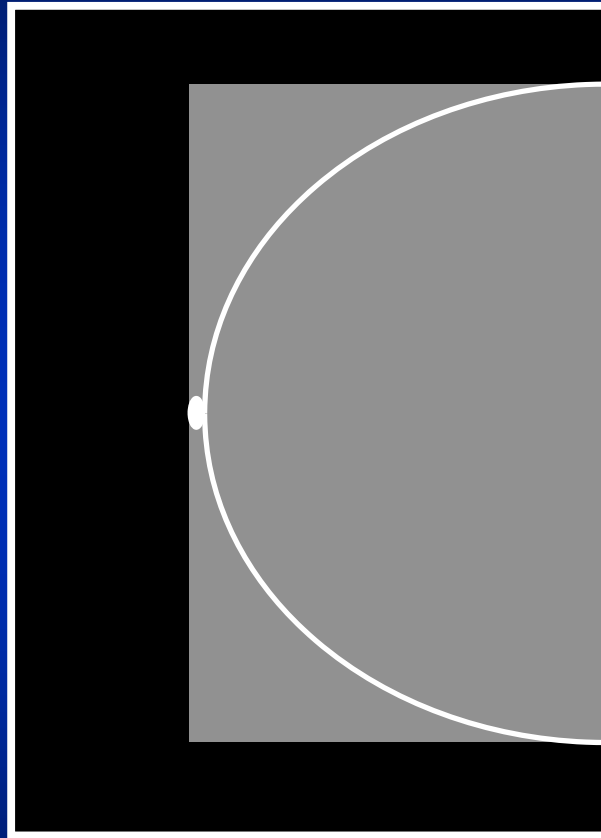
Digital mammograms are processed to extract the region where the breast actually is located:

- **to reduce image file size (speeds up display)**
- **to derive gray values (speeds up analysis)**

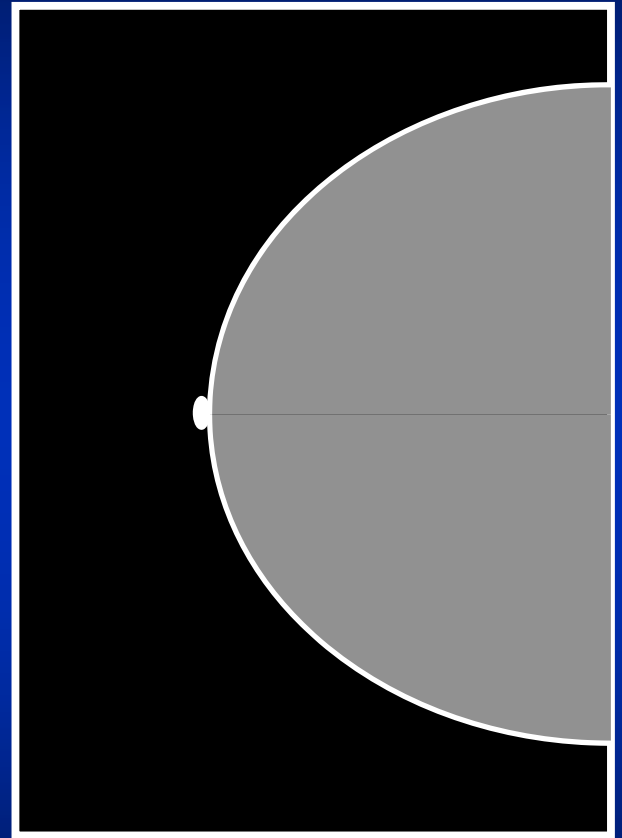
Image File Size Reduction



**No
Reduction**



**Cropped
Reduction**



**Packed
Reduction**

Image File Size Reduction

Type of Reduction \ Breast View	CC	MLO	Total
Cropped Reduction	3.69 : 1	3.08 : 1	3.40 : 1
Packed Reduction	5.68 : 1	4.53 : 1	5.12 : 1

n = 422

Image Display Speed Comparison

Time	Packed Reduction	Without Reduction	With Reduction
Time to display one mammogram from disk storage		7.75 sec	2.55 sec

n = 422

3 times faster with packed reduction

Derived Gray Values

Gray-value ranges are derived from within the breast region for the fatty, fibroglandular, and skin / subcutaneous portions of the breast. These are used to produce “smart” gray-value mapping (automatic window / level function).

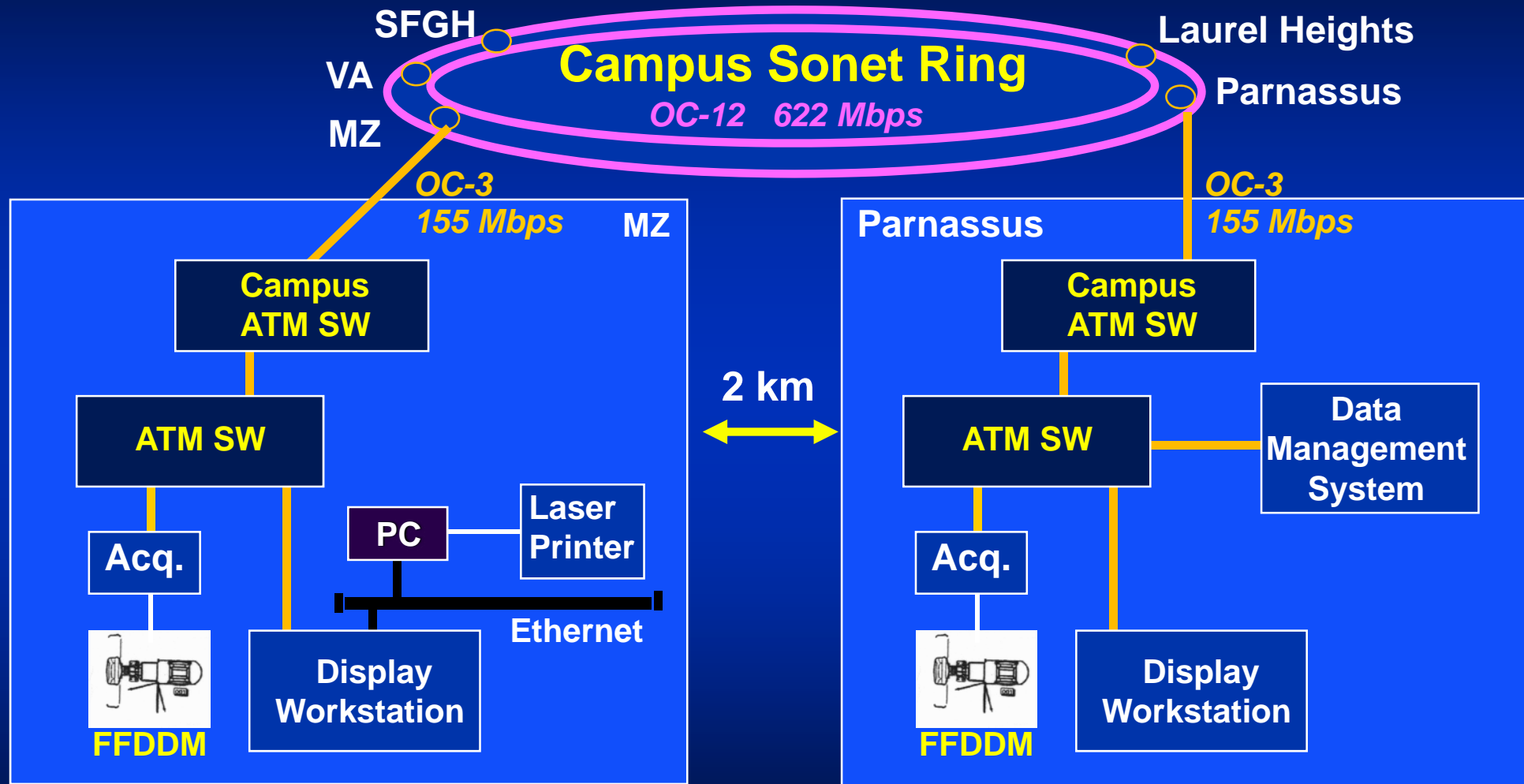
Window / Level Speed Comparison

Time / W/L Function	Without Auto W/L	With Auto W/L
Radiologist time spent per case doing windowing / leveling	49.3 sec	7.0 sec

n = 1426

7 times faster with auto window / level function

Telemammography Chain



MZ: UCSF / Mount Zion Breast Center

Parnassus: UCSF Ambulatory Care Center

Telemammography: Image Transfer

Exam Site

Interpretation Site

**FFDM
Unit**

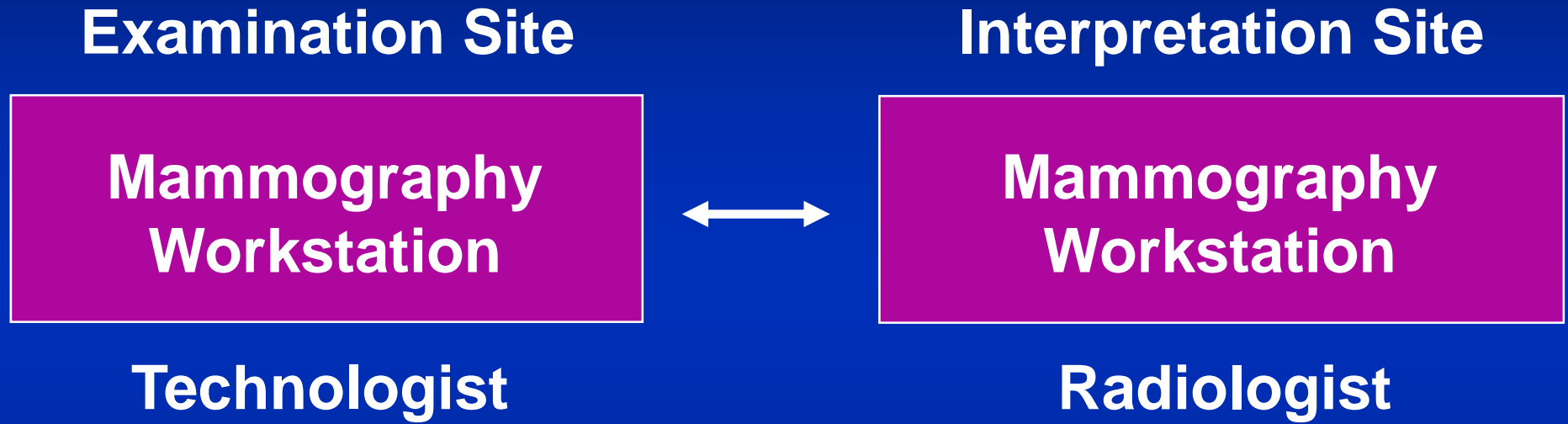


**Mammography
Workstation**

**Patient and
Technologist**

**Interpreting
Radiologist**

Telemammography: Interpretation



Real-time synchronization of image display / image manipulation / dual cursors, with verbal communication via telephone.

Experimental Design

**Film mammograms read on-site by
general diagnostic radiologists vs.
full-field digital mammograms read
off-site by breast imaging radiologists**

- **real-time performance**
- **accuracy of interpretation**
- **single-blinded interpretation**

Experimental Design

For conventional film mammography and for full-field digital mammography:

- **record the radiologist's interpretation after standard-view mammograms**
- **record whether or not additional views were obtained / requested**
- **record time from end of imaging to end of standard-view image interpretation**
- **determine accuracy of interpretation**

Results

Film Mammography Performance

From	To	Time (sec)
Completion of last exposure	Completion of image interpretation	317

n = 595

Digital Mammography Performance

From	To	Time (sec)
Completion of last exposure	Completion of image interpretation	250

n = 595

Film Mammography Performance

From	To	Time (sec)
Completion of last exposure	Exam brought to reading room	257
Exam brought to reading room	Films displayed on viewbox	14
Films displayed on viewbox	Completion of image interpretation	46

n = 595

Digital Mammography Performance

From	To	Time (sec)
Completion of last exposure	Exam available on workstation	166
Exam available on workstation	Images displayed on workstation	12
Images displayed on workstation	Completion of image interpretation	72

n = 595

Clinical Outcomes

Malignant	Biopsy done	89
Benign	Biopsy done	106
Presumed benign	No biopsy, no cancer 2 yr f/u	400
Total		595

Clinical Outcomes

Proved Malignant

Interp. + Interp. –

Film mammo.

78

11

Digital mammo.

83

6

Interpretation positive: BI-RADS 0, 4, or 5

Interpretation negative: BI-RADS 1 or 2

Clinical Outcomes

Proved Benign

	Interp. +	Interp. –
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Film mammo.	104	2
Digital mammo.	87	19

Interpretation positive: BI-RADS 0, 4, or 5

Interpretation negative: BI-RADS 1 or 2

Clinical Outcomes

	Presumed Benign	
	Interp. +	Interp. –
Film mammo.	56	344
Digital mammo.	17	383

Interpretation positive: BI-RADS 0, 4, or 5

Interpretation negative: BI-RADS 1 or 2

Clinical Outcomes

	Sensitivity	Specificity
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Film mammo.	87.6%	68.4%
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Digital mammo.	93.3%	79.4%
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Assuming all presumed benign cases prove to be benign

Conclusions

Full-field digital tele mammography, involving image interpretation at a remote site, can be performed in a time-efficient manner with currently available (but prototype) equipment.

Preliminary results, using such a prototype system, suggest improved interpretation accuracy for transmitted digital mammograms read by expert radiologists, compared to conventional film mammography practice.

**Widespread implementation of practical
telemammography must await extensive
nationwide distribution of full-field
digital mammography (FFDM)
equipment and ultra-fast image
transmission, both at reasonable cost.**

New Telemammography Research

**2 FFDM units linked to distant (110 mi)
mammography workstation**

**1314 cases sent real-time, without data
compression, using multiple VPNs,
through 2 firewalls, via cable internet**

Melton A, et al. Presented at RSNA Nov. 28, 2005

New Telemammography Research

Cases averaged 125 MB of data

Each image transmitted in < 45 seconds

Transmitted images visually identical in image quality to original images

< 0.2% byte discrepancy in file size of transmitted vs. original images (essentially no data loss)

Melton A, et al. Presented at RSNA Nov. 28, 2005

New Telemammography Research

**Agreement in image interpretation for
147 / 150 cases (original vs. transmitted)**

**Interpreter variation rather than image
quality accounted for disagreement in
the 3 cases, none of which were recalls**

Melton A, et al. Presented at RSNA Nov. 28, 2005

New Telemammography Research

Conclusion: “Remote interpretation of digital mammograms using a real-time communications link via cost-effective cable internet to a remote workstation has been established and validated.”

Melton A, et al. Presented at RSNA Nov. 28, 2005

Telemammography Applications

Allow multi-site radiology practices to monitor & interpret examinations off-site, so that those radiologists in the group with the greatest interpretive expertise will read all or mostly all examinations.

Telemammography Applications

Regional interpretation centers could be established to improve the accuracy and efficiency of screening mammography, to reduce screening backlogs, and to aid underserved areas.

Telemammography Applications

Facilitate 2nd opinion interpretation, by making remote but world-class mammography expertise accessible in real time to community-practice radiologists.

Telemammography: Consultation

Remote Site

Local Site

**Mammography
Workstation**



**Mammography
Workstation**

**Consulting
Physician**

**Expert
Physician**