CTLM® CT Laser Mammography System

TECHNICAL DESCRIPTION

OVERVIEW

CTLM IS A REVOLUTIONARY NEW LASER IMAGING MODALITY. IT HAS BEEN DESIGNED TO IMPROVE BREAST CANCER DETECTION METHODS AND TO BE AN ADJUNCT TO MAMMOGRAPHY TO HELP REDUCE THE NUMBER OF NEGATIVE BREAST BIOPSIES.

THE CLINICAL PROBLEM

The technology of mammography has developed to the point that extremely sharp, detailed pictures can be obtained if the breast is tightly compressed, a rather painful and undignified procedure. These pictures, in the hands of an expert radiologist, will reveal whether any abnormality is present in only approximately 70 out of 100 cases. This means that up to 30 out of 100 cancers are "missed" on the first set of mammograms; this occurs most frequently in breasts that are very dense.

Many of these missed lesions will subsequently be picked up by other imaging techniques or by follow-up mammography. However, it is very important to note that the mammogram, no matter how good its quality, does not contain all of the necessary information for many radiologists, no matter how expert, to say whether the abnormality detected is a cancer, requiring surgery, or a benign lesion, which can simply be followed by imaging.

Therefore, in order to avoid missing a cancer, the mammographer advises biopsy on many lesions which later turn out to be benign (up to 80%). Thousands of women sustain great emotional and/or physical trauma, removal of breast tissue, and considerable expense only to prove that the mammographic finding was a "false positive."

THE CTLM SOLUTION

The high percentage of false positive biopsies also presents a substantial cost to the health care system. Reducing false positive biopsies, therefore, can have a favorable effect on managing breast cancer detection and staging. **The CTLM® system may be an optimal tool to address these needs and opportunities.**

CTLM® CT Laser Mammography System

CLINICAL APPLICATION

The CT Laser Mammography (CTLM®) system is intended for use as an adjunct to mammography in patients who have indeterminate mammographic findings, particularly in dense breasts. It is not intended for use in cases with clear mammographic or non-mammographic indications for biopsy. This device provides the radiologist with additional information to decide whether a biopsy is necessary. The CTLM system has received approval in many countries although it is not yet approved for sale in the United States.

BENEFITS

- **Leading-edge CT molecular imaging study**
- **No ionizing radiation (no X-ray)**
- **Helps eliminate unnecessary biopsies**
- **Complements conventional mammography**
- **Works well with dense breasts**
- **Non-invasive/Comfortable**
- **No breast compression (no pain)**
- **Easy and inexpensive to operate**
- **High Throughput**

The Food and Drug Administration has determined that the CT Laser Mammography system is a Non-Significant Risk (NSR) device study as it does not present the potential for serious risk to the health, safety, or welfare of the patient.

UNIQUE CTLM DESIGN

The CTLM functions somewhat like a conventional CT scanner in that an energy source, a near-infrared (NIR) laser, scans the breast; a computer reconstructs cross-sectional images based on measured optical data. The measured optical values are directly related to the optical effective transport coefficient of the breast tissue. Like CT, the images may be viewed as single slices or as 3D volumes.

The patient lies face down in a comfortable position so that the breast to be examined is suspended through the circular aperture in the table top and within the ring of the gantry (Figs. 1A and B.) Nothing touches the breast; there is no compression, and, even more important, there is no X-irradiation, because the CTLM system uses a laser as the light source instead of an X-ray tube. The laser beam is not strong enough to even warm the skin; by choosing the right wavelength, the beam passes through even large and/or dense breasts.

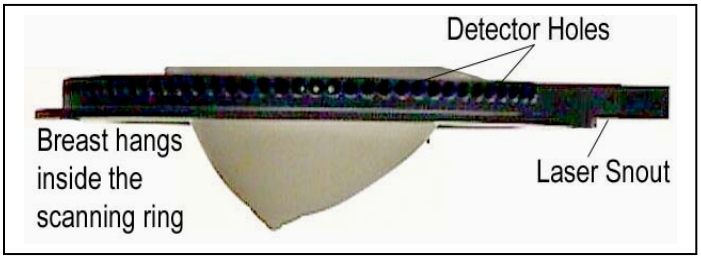

Figure 1A. Breast in scanning position.

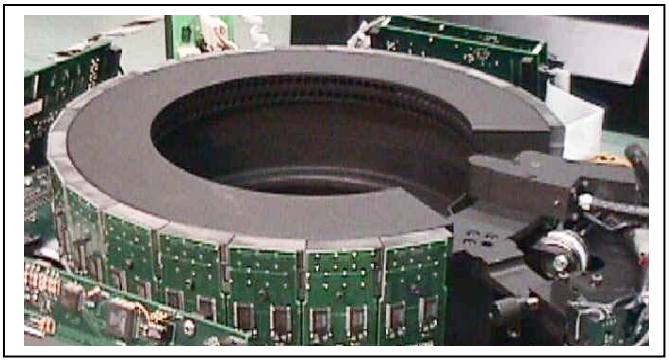

Figure 1B. Laser scanning electronics. Detectors are arrayed around the breast in a CT-like design.

THE THEORY OF CT LASER SCANNING IN CLINICAL PRACTICE

Our approach is based on the fact that all cancers must develop a blood supply of their own in order to survive. In fact, a cancer can not grow beyond 2.0 mm in size without this new blood supply, which is developed through the process of **angiogenesis**. The CTLM system images the angiogenic blood supply by detecting the presence of increased hemoglobin in the imaging field. Since the area of angiogenesis is much larger than the tumor itself, tumors which are invisible or barely visible on the mammogram can be detected. Images are not as sharp and crisp as seen on CT or mammography, but have the character of Nuclear Medicine results because the process of angiogenesis is diffuse. CTLM is, therefore, a 'functional' imaging modality with the potential to perform molecular imaging.

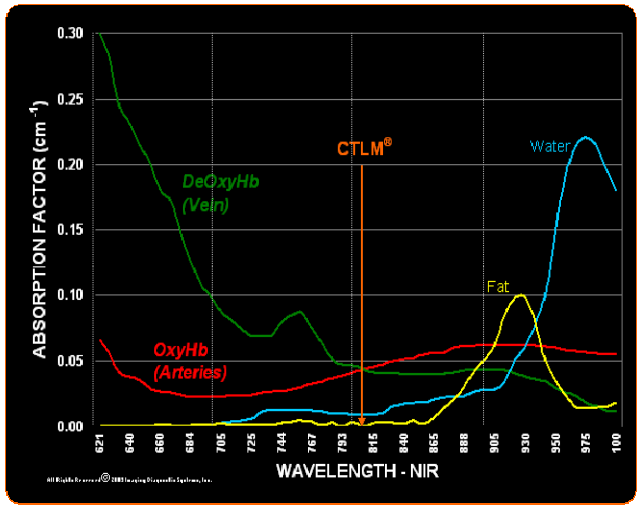

Figure 2. Absorption of light (vertical axis) in hemoglobin, water, and fat, at various wavelengths (horizontal axis). CTLM uses a wavelength of 808 nm, the point at which both oxy and deoxyhemoglobin absorb the near infrared light but water and fat absorb virtually none.

At the particular wavelength chosen (Fig. 2), blood absorbs most of the light, providing excellent 3D and tomographic images of the entire breast from the chest wall to the nipple. If there is a cancer present, an area of angiogenesis will be seen, which will be invariably much larger, and therefore easier to see, than the original lesion on the mammogram. In fact, a tumor which is only 3.0 mm in size on the mammogram will usually have an area of angiogenesis which is 4 to 6 cm in size on CTLM studies (Figs. 3A and B).

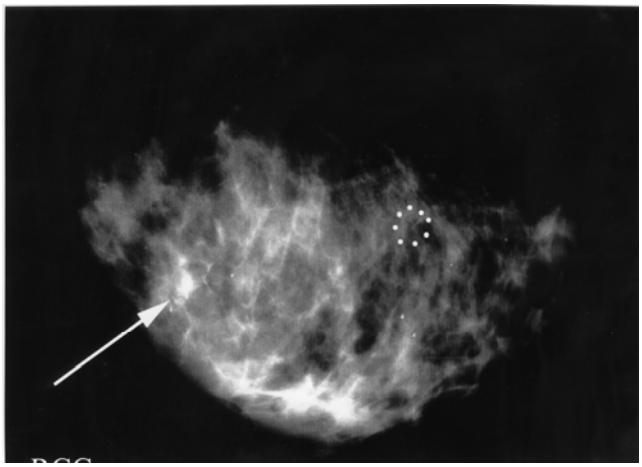

Figure 3A. Cranio-caudal mammogram showing a minute (3.0mm) lesion (white arrow). Patient stated she had a small "dimple" in the skin (dotted circle).

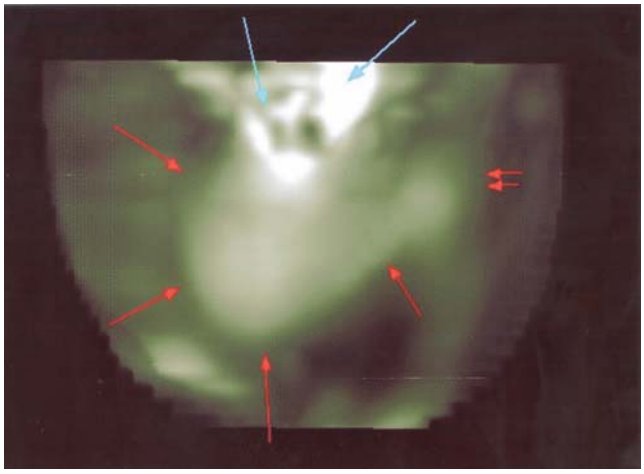

Figure 3B. Cranio-caudal CTLM shows a very large volume of angiogenesis (red arrows) and new vessels growing in from the chest wall (blue arrows). Tumor size 3.0mm, angiogenesis size 6.0cms. Angiogenesis extends across the breast where the tumor has involved the skin (double red arrows).

CTLM AND MRI FUSION

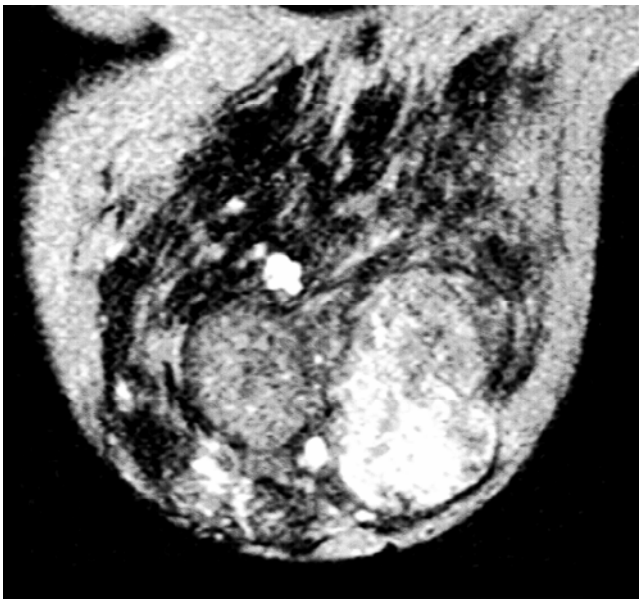

Figure 4A. MRI of the breast showing a bilobed area of angiogenesis. One of the lobes shows very little angiogenesis.

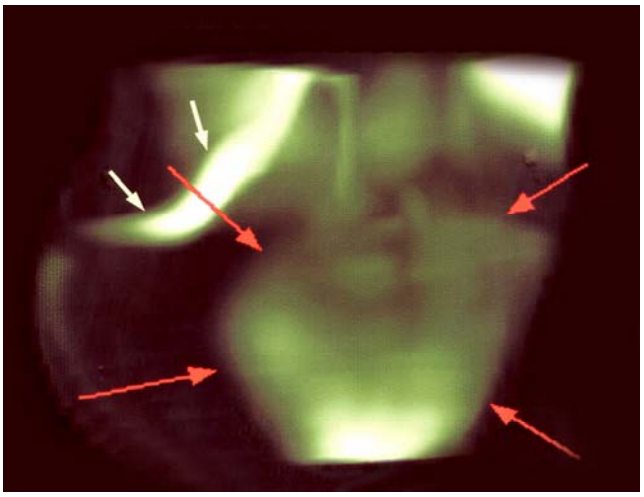

Figure 4B. CTLM of the same breast in the same projection also shows bilobed angiogenesis with one lobe showing little angiogenesis.

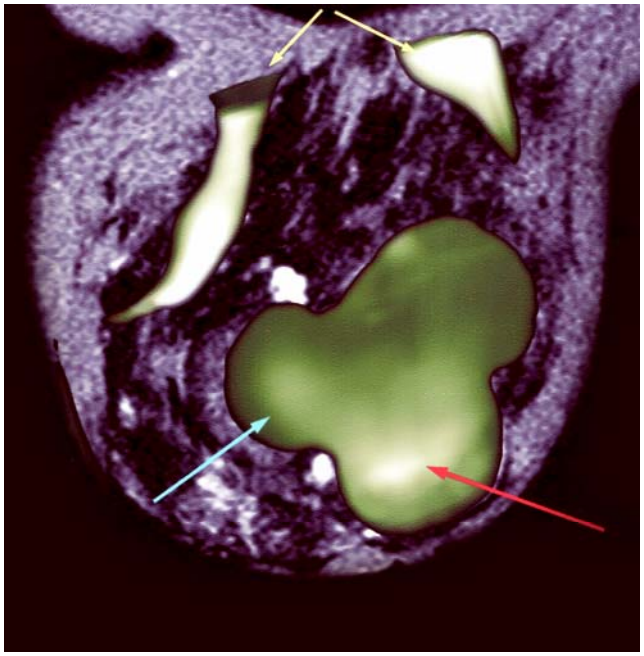

Figure 4C. Fusion of the MRI and CTLM images shows that the CTLM and MRI demonstrate the same angiogenesis. The red arrow points to a malignant phylloides tumor, while the blue arrow indicates a fibroadenoma.

CTLM is much quicker than MRI, much cheaper, and uses no contrast media injection.

CTLM 3D Imaging

CTLM images are collected in CT fashion; they can be displayed as CT sections or as true 3D images, rotatable in space (Figs. 5 and 6).

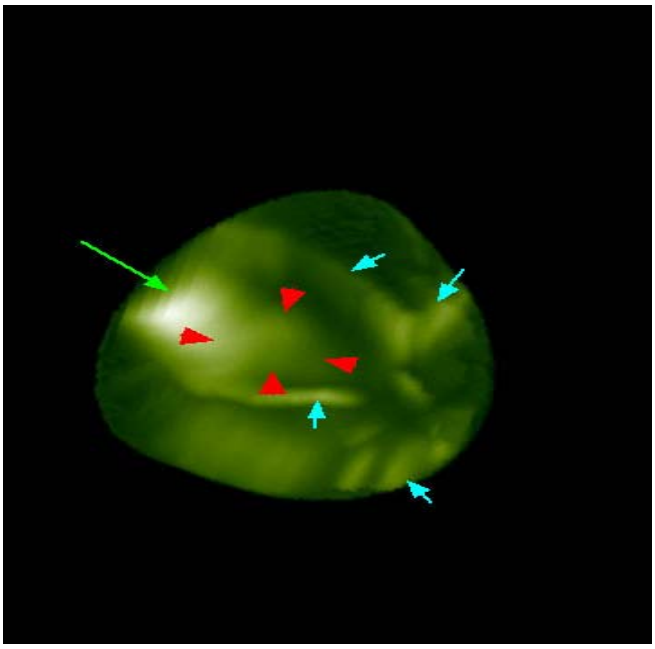

Figure 5. Maximum Intensity Projection (MIP)
The arrowheads mark a large volume of angiogenesis. The short arrows indicate normal "tubular" veins.

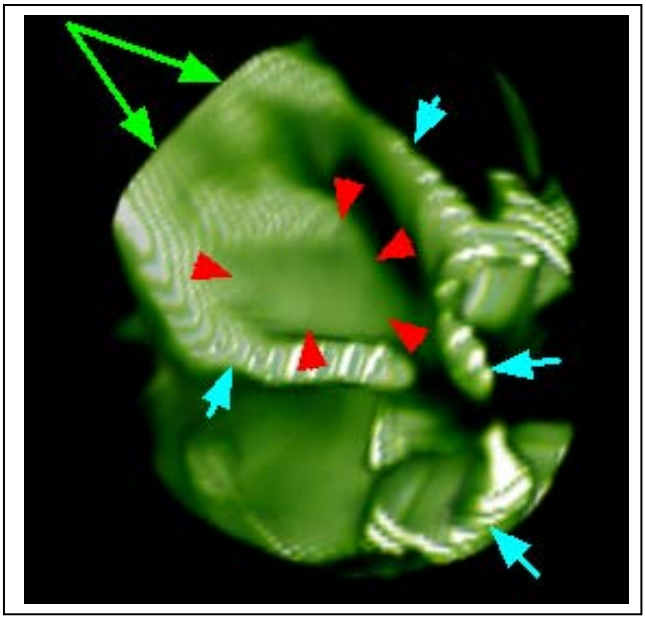

Figure 6 Surface-Rendered FTB Projection
This is the same case as Figure 5. The morphology of the angiogenesis is better demonstrated by this "one click" function.

CTLM Standard Views

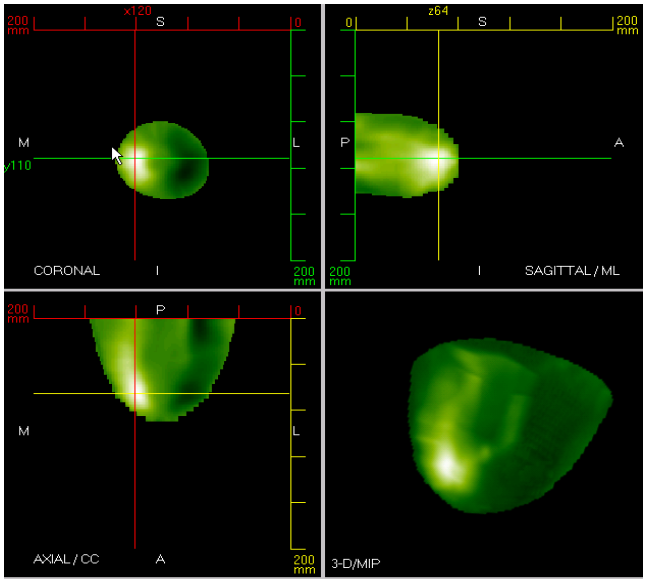

Figure 7. Sagittal, Coronal and Axial Planes
This is the standard four view image presented on the reading console: the coronal, sagittal, and axial views and the three dimensional image. The white lines indicate intense angiogenesis in an invasive ductal cancer.

CTLM Side-by-Side Mammo/CTLM Display

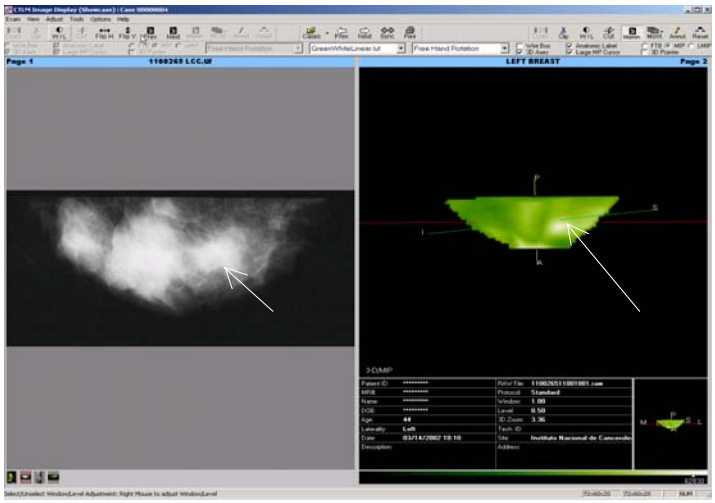

Figure 8. The cranio-caudal mammogram shows three lesions. The CTLM shows angiogenesis in only one of them, indicated by the long arrow, the other lesions, circled, are benign.

FULL CTLM DISPLAY WITH FTB

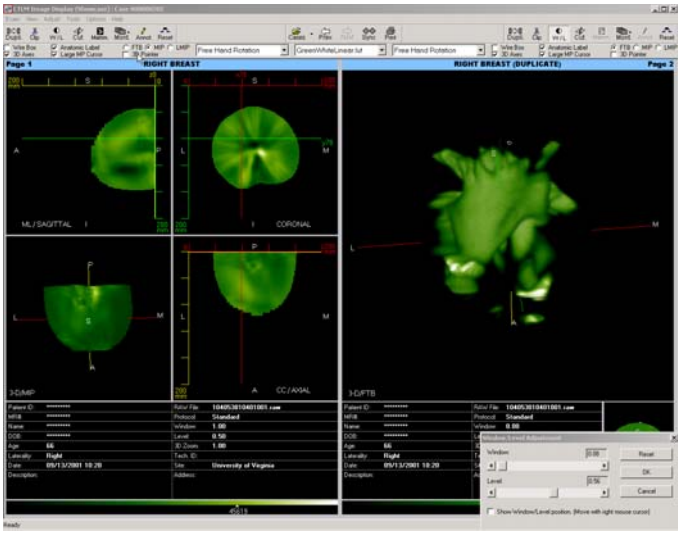

Figure 9A. Surface rendering Front-To-Back (FTB) projection of Figure 4.

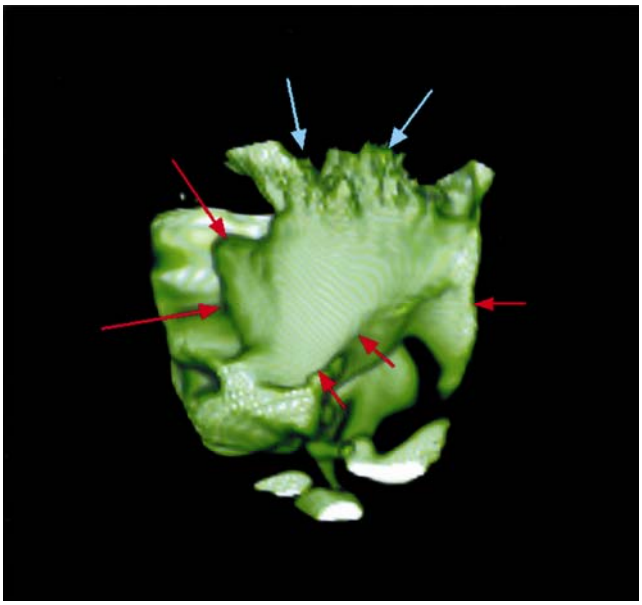

Figure 9B. This is a 3D "surface-rendered" FTB image of the case in Figure 3. This reconstruction reveals more clearly the extent and structure of the angiogenesis. FTB projection gives an excellent presentation of the numerous small vessels associated with this tumor.

FTB reconstruction provides a dramatic 3D solid representation of structures, normal and abnormal, within the breast. It can be of great diagnostic value, particularly for displaying areas which are doubtful and/or difficult to see on the standard MIP projection.

FTB AND MAMMO FUSION

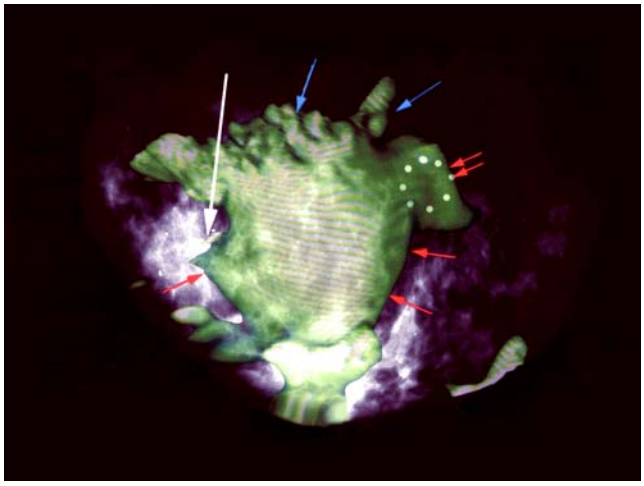

Figure 10. The FTB image has been merged with the cranio-caudal mammogram. The original 3.0 lesion is at the tip of the white arrow. The angiogenesis extends across the breast and there is involvement of the skin, denoted by the double red arrows. Blue arrows show new vessels arising from the chest wall.

IMAGE QUALITY

In-vitro studies of imaging phantoms provide objective performance quantifications:

Object Detectability - The CTLM system clearly resolves a 2.0 ±0.2 mm spherical opaque inclusion suspended in a 110mm diameter circular phantom of standard IntraLipid solution, with the inclusion 20mm (radially) from the bucket wall.

Field Uniformity - The CTLM clearly resolves a 3.0 ± 0.2mm spherical opaque inclusion suspended in a 110 x 80mm elliptical phantom of standard IntraLipid solution, with the inclusion 10mm (radially) from the bucket wall at the 12:00, 3:00, 6:00 and 9:00 positions.

SCANNER

Scan Field of View – The scanner acquires data from a 200mm diameter by 200mm tall right cylindrical field of view.

Laser Beam Characteristics – The laser source beam diameter is 3mm ±20% through the scanning well. The average power delivered to the patient does not exceed 500mW. The wavelength is nominally 808 nanometers. Polarization is random.

Nominal Ocular Hazard Distance – Per IEC 60825-1, Annex 5, the NOHD is given by:

NOHD = $(((2.5 * 4 * P_o / \pi * E_{MPE})^{1/2}) - a) / \phi = 69$ meters

Positioning accuracy– orbit position is accurate to better than ±0.1%, relative to the start flag.

Rotational speed constancy – orbit speed variations do not exceed ±3% over the orbit time range of 12 – 45 seconds.

Elevation accuracy - elevator position accuracy is better than ±0.5mm.

Laser Stability – for the duration of 1 slice (45 seconds max), the laser output power varies no more than ±0.2% peak-to-peak.

Perimeter Accuracy – the measured perimeter lies within ±0.5 millimeters of a fitted circle, measured with a centered 110mm diameter, circular IntraLipid-filled phantom.

ELECTRICAL

Earthing – All devices that receive hazardous voltage with accessible metal parts have less than 0.1 Ohms of resistance between the accessible metal part and the earth ground at the supply connection.

Residual Power – a voltage of 60V is not available at the source of the unit 1 sec after the disconnection from the mains.

Isolation – The surfaces of the unit that are intended to come in contact with the patient are isolated from the power circuits such that a potential of 1500Vdc is applied between the two points and a breakdown of the insulation does not occur.

Leakage Current - The maximum normal condition leakage current does not exceed 500 microamperes. The maximum single fault leakage current does not exceed 1 mA.

Operator Console – The Operator Console requires a 220VAC line source (198VAC - 250VAC) at 50/60 Hz with a capacity of 20 Amps.

System – The system typically draws 5 Amps at 220VAC, 60 Hz. The heat dissipation is 1100 Watts or 3760 BTUs/hour.

SCANNING BED AND GANTRY

The Scanning Bed provides a horizontal surface on which the patient lies in the prone position during the examination. It is 737mm (29") tall for easy patient access and includes a cushioned pad for patient comfort. The Scanning Bed includes 4 Centering Rings, which are selected for use according to the patient's breast size. The enclosure of the Scanning Bed is of fiberglass material supported by a metal frame. The power electronics are housed in a steel box in the middle of the Scanning Bed. The Scanning Bed is 88" x 34" (2235mm x 865mm) and weighs 465 lbs (210 kg).

Weight Rating – The Scanning Bed is rated for a uniformly distributed load of 2500 lbs (1140 kg). Maximum patient weight is 400 lbs (180 kg).

OPERATOR'S CONSOLE

The operator's Console includes the system PC, a 21" LCD video monitor for image review, a writable DVD-R drive for image archive and an optical mouse and keyboard for operator interaction. The system PC is a Pentium 4 personal computer running the Windows 2000 operating system and CTLM system software. It also includes 1GB of memory, dual 120GB mirrored disk drives for data

storage and a 256MB video card. An uninterruptible power supply for immunity to power surges and drawer space for storage are also included. An optional image printer can connect to the Operator's Console or to the Physician's Review Station. The Operator's Console is 53" x 33" (1345mm x 840mm), weighs 390 lbs (180 kg), and is made of fiberglass.

Environmental - The CTLM system operates in a temperature range of +18ºC to +27ºC, a relative humidity of 30% to 75%, and an atmospheric pressure of 700hPa to 1060hPa (altitudes of sea level to 10,000 feet), as long as the dew point does not exceed the laser operating temperature of 19´C.

Shock and Vibration - The CTLM system, in its original shipping materials, meets the vibration requirements of MIL-810F, per Annex A, section 2.2.1, Category 4a - Truck transportation over US highways.

PHYSICIAN'S REVIEW STATION

The Physician's Review Station (PRS) is an accessory to the CTLM system that allows simultaneous image review and archiving while scanning. The PRS supports the full display functionality of the CTLM system. It can be used to archive images and to reformat images into axial, sagittal, and 3D projections. The PRS can perform any image metrics supported by the CTLM display software for the scan in progress.

The PRS consists of a PC, a 21" LCD video monitor for image review and an uninterruptible power supply for immunity to power surges and dropouts. The PC is a 3.4GHz Pentium 4 personal computer running the Windows 2000 operating system and the CTLM image analysis software. It includes 1GB of memory, a 120GB disk drive, a CDRW to capture images, and a 256MB video card. The Physician's Review Station connects to the Operator's Console via a private 100Mbit Ethernet link.

PRINTERS

Codonics Horizon® Ci or Codonics Horizon® SF (Recommended)

The Horizon® Ci is an intelligent desktop dry film imager that produces superior diagnostic-quality medical films as well as color and grayscale paper images quickly, conveniently and affordably. The imager is compatible with many industry-standard protocols including DICOM and Windows network printing. High-speed image processing, networking and spooling are standard.

Specifications

Print Technology: Dye-diffusion and direct thermal
Spatial Resolution: 320 dpi (12.6 pixels/mm)
Throughput: Up to 100 films per hour
Grayscale Contrast
Resolution: 12 bits (4096)

Epson 1280

The Epson Stylus Photo 1280 ink jet printer is the ideal large format choice, with BorderFree photo-quality prints of 4" x 6," 5" x 7," 8" x 10," letter, 11" x 14" enlargements and 13" x 44" panoramas. The 6-color 2880 x 720 dpi results in continuous tone quality for prints. The 4-picoliter variable-sized ink droplets feature prints 8" x 10" prints in less than two minutes. The Epson Stylus Photo 1280 can produce water-resistant and lightfast media. Water-resistant prints can be printed on EPSON Premium Glossy Photo Paper and EPSON Photo Paper. Epson Stylus Photo 1280 is Windows and Macintosh compatible.

EPSON Stylus Photo 1290S

The EPSON Stylus Photo 1290S inkjet printer provides lightfast 6-color Photo Reproduction Quality. The Stylus Photo 1290S becomes a desktop photo lab, printing everything from portfolios & proofs to letters & web pages, delivering edge to edge output without the need for cropping. The Stylus Photo 1290S includes support for the Universal Serial Bus, fully supported by Microsoft Windows 98, Windows ME, Windows 2000 & Apple iMac, G3 & G4.

CLASSIFICATION

The CTLM® system is classified by Underwriter's Laboratories as a class I, type B device ordinary equipment in continuous operation with intermittent loading. The use of flammable anesthetics or oxidizing gases, such as nitrous oxide (N_2O) and oxygen (O_2), should be avoided.

SAFETY (ELECTRICAL/MECHANICAL/LASER)

EN 60601-1:	Medical Electrical Equipment, Part 1: General requirements for safety.
EN 60601-1-1:	Medical Electrical Equipment, Part 1: General requirements for safety, Collateral standard: Safety requirements for medical electrical systems.
EN 60601-2-22:	Medical Electrical Equipment, Part 2: Particular requirements for the safety of diagnostic and therapeutic laser equipment.
IEC 60825-1:	Safety of Laser Products, Part 1: Equipment classification, requirements and user's guide.
EN 60950:	Safety of Information Technology Equipment Including Business Equipment.

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UL 60601-1:	Standard for Safety of Medical Equipment, Part 1: General requirements for Safety.
EN 540:	Clinical investigation of medical devices for human subjects.
FDA:	21 Code of Federal Regulations, Parts 820, 900, 1010, 1020.10, 1040
Canada:	CAN/CSA-C22.2 No. 601.1-M90: Medical Electrical Equipment, Part 1: General Requirements for Safety.
Europe:	93/42/EEC: Council Directive Concerning Medical Devices

EMC

EN 60601-1-2:	Medical electrical equipment. Part 1: General requirements for safety 2. Collateral standard: Electromagnetic compatibility - requirements and tests.

PROGRAMMABLE ELECTRICAL SYSTEMS (SOFTWARE)

EN 60601-1-4:	Medical electrical equipment. Part 1: General requirements for safety 4. Collateral standard: Programmable electrical medical systems.

QUALITY ASSURANCE SYSTEMS

ISO 9001: 2000	**Quality Management Systems Requirements**
ISO 13485: 2003	**Quality Systems - Medical devices**
ISO 13485: 2003	**CMDCAS Canadian Medical Device Conformity Assessment System Quality Systems Medical devices**
CE Certificate	**Annex II, Section 3 of the Directive 93/42/EEC Medical Device**

DISPLAY AND PRINTER SET-UP AND QUALIFICATION

SMPTE RP 133-1999, Specifications for Medical Diagnostic Imaging Test Pattern for Television Monitors and Hard-Copy Recording Cameras (R1999)

RISK ASSESSMENT

ISO 14971:	Medical devices - risk management
IEC 1025:	Fault tree analysis (FTA)
IEC 812:	Analysis techniques for System reliability – Procedure for failure modes and effects analysis (FMEA); failure modes and effects criticality analysis (FMECA)

ADDITIONAL MARKINGS / SYMBOLS / TERMINOLOGY/ DOCUMENTATION

EN 980:	Terminology, symbols and information provided with medical devices. Graphical symbols for use in the labeling of medical devices.
EN 1041:	Medical devices – Information supplied by the manufacturer (FOREIGN STANDARD.)

LICENSES

FDA Certification of Exportability	4875-9-2003
Canada Medical Device License#	63242
People's Republic of China	REG. No: SFDA(I) 20043241646

Available Model(s): CTLM® System 1020 100003
(Not Yet Available in the United States)

CTLM® System	Cat. No.
Scanning Bed Model 1020	100011
Operator's Console Model 1020	100027
Physician's Review Station (110VAC)	100032
Physician's Review Station (220 VAC)	100033

Printer Options	Cat. No.
Codonics Horizon Ci, 8 x 10	160362
Codonics Horizon SF, 14 x 17	160363
Epson Photo 1280, (110VAC)	160360
Epson 1290S, (220VAC)	160361

