

## SPX-4

**All-Purpose Integrated Digital Gamma Camera with Large circular Field-of-View**



The APEX SPX-4 is a high performance, all-purpose, integrated digital gamma camera, optimally designed for superb SPECT and planar imaging. It incorporates a 37-PMT 400 mm circular field-of-view, with advanced optronic detector design, yielding outstanding lesion detectability.

Superior diagnostic power is provided by an array of 12 dedicated microprocessors featuring 74 MIPS, ranging from ultrafast digital signal processing to 66 MHz 32-bit data processing. Raw computer power, a 1416 x 1168 resolution display\*, and validated APEX software result in superior clinical reliability and exceptionally high throughput.

Key features and selected optional items include:

- Superb image quality combines excellent lesion detectability and uniformity throughout the entire 400 mm UFOV, real-time digital correction system and high-precision, micro-cast parallel-beam collimation\*.
- Ultra-fast acquisition and processing, utilizing state-of-the art, Intel microprocessor, enhanced by multi-processor array including an AMD 64-bit acquisition-dedicated processor.
- DIGITAL GUARD™, built-in optronic detector stabilization, guarantees optimal digital tuning at each energy level for highly accurate single and multi-isotope imaging
- Ultra-high count rate performance, featuring maximal count-rate of 500,000 CPS
- Optimal ergonomic design for cardiac and brain imaging, featuring 3.2" "brain reach" and off-center magnification for superb brain SPECT scans.
- High-performance integrated workstation featuring Intel processors, 1416 X 1168 resolution 21" color monitor\* and a true multi-tasking operating system, ensures superior clinical diagnostic power.
- Compatibility and connectivity with other APEX and XPert systems - ensure easy integration with current APEX or other vendors' systems\*. Combining the benefits of both data and clinical software compatibility with earlier APEX models results in immunity from data and clinical software obsolescence.

- Multi-task environment allowing simultaneous acquisition, processing, and networking\* for increased patient throughput.
- Outstanding PACS, featuring full archival unification throughout the network to ensure instantaneous data access to any of its systems, high performance laser multi-imagers. Extended connectivity packages provide multi-environmental ETHERNET networking\* platforms, including TCP/IP\* and ISO/OSI.
- The most comprehensive clinical software package, including the full range of applications from automatic cardiac ventriculography analysis to quantitative SPECT. CLIP\*, Elscint's unique clinical macro-programming language, and over 600 modular and linkable clinical functions ensure both clinical versatility today and immunity from future software obsolescence.

## SYSTEM DESCRIPTION

### **detector**

High-performance optronically-controlled detector features 3/8" NaI(Tl) crystal, 37 high quantum efficiency photomultipliers, and a circular 400 mm field-of-view, optimally shielded for imaging at 40-400 keV energy range.

### **gantry**

An 85 cm (33") aperture computer controlled ring-gantry supports the detector. Vacuum fluorescent flat panel display atop the gantry provides digital readout of detector head and gantry positioning. A 12-function hand-held remote command unit controls gantry motion and data acquisition.

### **patient handling system**

APEX SPX-4 features an optional patient table:

#### **ECT table**

Low attenuation carbon-fiber table-top with a motorized vertical motion.

### **integrated workstation**

An acquisition and processing station, based on 32/64-bit multi-processor array including Intel processors, an acquisition dedicated array processors, a 21" color monitor with 1416 x 1168 resolution display\*, 340 Mbyte magnetic fixed disk, 800 Mbyte optical disk\* and a 5 1/4" flexible disk drive.

### **software**

The standard APEX clinical software repertoire, including: SPECT, Gated SPECT\*, 3D display\* package, CLIP programming\* and ISO/OSI networking\* protocols.

### **CONFIGURATIONS**

Various configurations employ the same advanced electronic and software architecture, including a wide spectrum of clinical protocols, CLIP (a clinical macro-programming language), and a range of APEX functions.

ECT software package and scanning attachments may be added to the standard configuration.

### **standard**

The standard APEX SPX-4 imaging system features a high performance workstation integrated with a large circular FOV detector, mounted on a computer-controlled motor-driven ring-shaped gantry.

### **optional**

**ECT:** The standard configuration plus computer-controlled orbiting capability, scanning table, and supplementary SPECT software package.

### **WORKSTATION**

#### **computer architecture**

The SPX integrated computing system, APEX's 3<sup>rd</sup> generation, accelerates processing by a factor of 450% while maintaining software compatibility with thousands of existing APEX clinical programs. Unprecedented raw computer power is integrated on-board the camera; a 12-processor array ranges from HI-RES 50 MHz, 24-bit digital signal processing; through 64-bit AMD acquisition-dedicated array processor; to Intel's CISC micro-computing power. These capabilities yield 74 MIPS cumulative peak performance from: 500,000 CPS detector and real-time correction of nuclear events; through 0.22 second-per-slice tomographic reconstruction speed; to 17 second comprehensive cardiac multi-gated analysis. APEX SPX advanced micro-architecture incorporates more than 16 MB RAM, on-chip virtual memory management, 64-bit inter-unit transfer bus and 106 Mbyte/sec Burst Bus rates. Its dedicated control and data buses permit simultaneous multi-unit access to an 8 MB dual-ported RAM. High integration features on-chip floating-point unit and data cache memory bank. This powerful architecture is designed to support high count-rate acquisition and compute-intensive multiprocessing environment simultaneously, without compromising performance speeds.

### **operator console**

The integrated workstation includes an ergonomically-designed operator console featuring a 21" 1416 x 1168 high resolution\* color display, a 14" alpha-numeric monitor, and an extended keyboard with both standard and functional keypads.

The functional keypad includes 96 keys - 24 of which are user-programmable; a highly sensitive trackball and positional keys for interactive graphics control; two control knobs enabling fine digital tuning of the display; and a cine-rate adjustment knob.

## SYSTEM PERFORMANCE

### MECHANICAL SPECIFICATIONS

#### gantry

Computer controlled gantry movements.

#### rotational diameter (in/out)

*Range:* 0 to 63 cm (0 to 25")

*Velocity:* 80 cm/min

*C.O.R height:* 98 cm (38.6")

#### head tilt

*TILT GUARD™:* Special mechanism maintains detector alignment while adjusting rotational diameter.

*Range:* -75° to + 185°

#### gantry rotation

*Range:* ±360°

*Velocity:* fast - 1 rpm; slow - ¼ rpm

#### gantry lateral motion\*

*Range:* AEL 100 cm (39.3")

*Velocity:* Fast 150 cm/min (59"/min)  
Slow 5 cm/min (2"/min)

### patient handling system:

*Max. Load:* 130 kg (280lb)

#### vertical motion

*Range:* min. 65 cm (26")

max. 95 cm (37")

## NEMA PERFORMANCE

### SPECIFICATIONS\*\*

#### calibration

DIGITAL GUARD™, a high-speed, automatic optronic detector stabilization package

#### energy range

40 - 400 keV

#### intrinsic spatial resolution

CFOV:	FWHM	≤4.1 mm
	FWTM	≤8.1 mm
UFOV:	FWHM	≤4.2 mm
	FWTM	≤8.2 mm

#### intrinsic energy resolution

≤10.6 %

#### intrinsic linearity

CFOV:	Absolute	≤0.4 mm
	Differential	≤0.1 mm
UFOV:	Absolute	≤0.4 mm
	Differential	≤0.1 mm

#### flood field uniformity

CFOV:	Integral	≤3.8 %
	Differential	≤2.1 %

UFOV:	Integral	≤4.0 %
	Differential	≤2.4 %

<b>point source sensitivity</b>	≤2.5 %
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#### high count rate performance

All corrections apply at all count rates

#### maximum count rate\*

500,000 cps

#### performance at high count rates\*

maximum with 20% window: >	320,000 cps
(observed)	(incident)

20% loss >	180,000 cps
	225,000 cps

maximum with 30% window: >	400,000 cps
(observed)	(incident)

20% loss >	220,000 cps
	275,000 cps

#### intrinsic spatial resolution (at 75Kcps)

FWHM: 4.4 mm; FWTM: 8.4 mm

#### flood field uniformity (at 75 Kcps)

CFOV:	Integral	≤5.7 %
	Differential	≤2.4 %

UFOV:	Integral	≤5.8 %
	Differential	≤2.7 %

#### multiple window spatial registration

Max. displacement (<sup>67</sup>Ga): 1.5 mm

#### system imaging performance

##### LEHR collimator (APC-45S)    LEGP collimator (APC-35S)

##### FWHM (mm)

without scatter	7.4	8.7
with scatter	7.8	9.6

##### FWTM (mm)

without scatter	13.6	15.9
with scatter	16.7	19.5

##### system sensitivity

counts/min/µCi	160	270
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#### ACQUISITION

APEX SPX-4 can acquire images in Static, Dynamic, Multi-gated, List mode, SPECT\* and Gated SPECT\* acquisition modes.

- Simultaneous acquisition; processing and networking
- Acquisition termination by preset time, preset count or manual stop
- User-definable preset protocols for easy acquisition set-up
- Up to four isotopes/peaks enabling multi-isotope or multi-peak (summed) acquisition modes
- Persistence mode-display
- Continuous range off-center magnification
- Rotated and reflected acquisition modes (in steps of 1°)
- 512 channel PHA display

#### SPECT imaging performance

Measurements were taken using APC-45HS collimator, 120 views, 3° per view, 15 cm radius-of-scan, acquisition magnification factor x2, ramp-filtered back projection, 128<sup>2</sup> frame size:

#### reconstructed system spatial resolution (mm)

Tangential FWHM	6.8
Radial FWHM	9.6
Central FWHM	9.8

**multi-gated acquisition**

- Equi-time and equi-phase gating modes
- Dual buffer acquisition for accurate irregular beat rejection
- ECG display during acquisition
- On-line R to R histogram display
- Live cine display during acquisition

**multi-gated acquisition capacity**

<b>matrix</b>	<b>max. frames/cycle</b>
256 x 256 x 16	2
256 x 256 x 8	4
128 x 128 x 16	8
128 x 128 x 8	16
64 x 64 x 16	32
64 x 64 x 8	64

**ECT acquisition\*****angular view resolution**

1, 2, 3, 4, 5, 6 and 9 degrees

**acquisition modes**

- Continuous: 1 min to 60 min per revolution
- Step & Shoot: 1 sec to 300 sec per step

**scan orbits**

- Circular (max. diameter 63 cm)
- Elliptical\*: Patient width 0-100 cm

**matrix size**

64 x 64 or 128 x 128

**dynamic acquisition****frame mode**

Up to five frame rate intervals may be defined per dynamic study.

**frame rates**

<b>matrix</b>	<b>max. frames/cycle</b>
256 x 256 x 16	1
256 x 256 x 8	3
128 x 128 x 16	6
128 x 128 x 8	12
64 x 64 x 16	25
64 x 64 x 8	50
32 x 32 x 16	100
32 x 32 x 8	200

**list mode**

- Simultaneous acquisition of up to two energy peaks
- Time markers, resolution 1 msec
- List of R-wave time markers, acquisition of digital ECG or other physiological signals
- Resolution 256 x 256 for single isotope; 128 x 128 for up to four isotopes
- Data reframing and curve generation using list mode data

**static acquisition capacity**

<b>matrix</b>	<b>single isotope or 2 peak summing</b>	<b>dual isotope</b>	<b>quad isotope</b>
512 x 512	8 bits	-	-
256 x 256	8 or 16 bits	8 or 16 bits	8 bits
128 x 128	8 or 16 bits	8 or 16 bits	8 or 16 bits
64 x 64	8 or 16 bits	8 or 16 bits	8 or 16 bits
32 x 32	8 or 16 bits	8 or 16 bits	8 or 16 bits

**ARCHIVING**

Management of clinical data flow and storage within the system and through the ApexNet. Access to clinical data by patient name, patient I.D., date or study label. Archive data includes images, curves, ROIs, markers, reports and alphanumeric information. The following table represents archive storage capacity available on the standard 340 Mbyte disk:

**standard fixed disk capacity**

<b>matrix</b>	<b>capacity</b>
512 x 512	1000 frames
256 x 256	4000 frames
128 x 128	1600 frames
64 x 64	64000 frames
32 x 32	256000 frames

**DISPLAY****display matrix**

- Standard 708 x 584 pixels resolution (non-interlaced) 256 gray levels
- Optional High Definition Display featuring:
  - 21" high resolution color monitor (1416 x 1168 graphic pixels)
  - Simultaneous display of both acquired data and concurrent data-processing activity
  - High resolution\* (1416 x 1168 pixels) hard copy

**High Definition Display\* formats**

- 4 x 512<sup>2</sup>, 16 x 256<sup>2</sup>, 64 x 128<sup>2</sup>, 256 x 64<sup>2</sup>, 1024 x 32<sup>2</sup> or combinations thereof.
- Cine, windowing and baseline settings can be handled independently for each image in formats of 4 x 256<sup>2</sup> and 16 x 128<sup>2</sup>, 64 x 128<sup>2</sup>
- special modes:
  - 2 x 512<sup>2</sup> + 2 x 256 x 1024 for simultaneous data processing and Whole Body scan viewing; 4 x 256 x 1024 for Whole Body scan reports

**color tables**

- 256 shades
- Virtually unlimited number of color tables can be created interactively by user.

**zoom factors**

2, 4, 8

**PROCESSING****image processing**

Smoothing, normalization, interpolation, background subtraction, magnification, inter-frame arithmetic, non-linear contrast enhancement, grouping, cyclic addition, isocontour display, profile display

**regions of interest**

Simultaneous display of up to 250 ROIs of any shape, including duplication, reflection, motion, and automatic edge detection.

**curve management**

Up to 64 curves displayed side-by-side or overlaid, featuring curve scaling, smoothing, normalization, interpolation, inter-curve arithmetic, fitting, deconvolution, integration, and differentiation in various display formats.

**clinical protocols**

APEX clinical software includes dozens of clinical packages in the following categories:

- Cardiac First Pass
- Cardiac gated equilibrium
- Planar myocardial perfusion
- Tomographic myocardial perfusion
- Cedars-Sinai Quantitative SPECT\*
- Gated tomography\*
- 3D interactive display\*
- Renal analysis
- Tomographic HMPAO brain studies
- Planar cerebral perfusion
- Lung ventilation/perfusion
- Thyroid uptake
- Gastric emptying

**ECT data processing\*****normalization**

Sensitivity correction for collimator non-uniformities.

Correction of rotation speed, center of rotation, isotope decay.

**attenuation correction**

Chang method

**reconstruction**

**Modes:** Interactive or batch mode transaxial, coronal, sagittal and oblique reconstruction.

**Transaxial Reconstruction Time:**

0.22 sec/slice (60 x 64<sup>2</sup> matrix);

0.68 sec/slice (60 x 128<sup>2</sup> matrix);

Other planes reconstructed in real-time.

**Format:** 64 x 64 (up to 64 slices) or 128 x 128 (up to 128 slices).

**back projection filters**

Based on user-defined parameters: Hanning, Hamming, Butterworth, Parzen, Shepp-Logan and Ramp.

Adaptive: Metz and Wiener.

**display formats**

- Standard two dimensional multi-plane tomograms
- Interactive and dynamic 3D\* display in surface and volume rendering modes

**NETWORKING****ApexNet communication\***

- Local area network to all APEX systems (ISO/OSI Ethernet standard). TCP/IP link available through ApexView or ACM-14
- Modem networking available through ApexView
- The APEX SPX Series is software compatible, data compatible and connective through the ApexNet with existing APEX systems.

**CLINICAL PROGRAMMING\*****powerful clinical programming**

APEX software awards its users with a wide array of clinical software packages and powerful programming tools. Used in over ten million procedures, they fall into the following categories:

- CLIP Programming, a simple, friendly "Basic" type interpreter language capable of invoking any of the APEX functions (more than 600), and linking them together into a clinical program.
- PLM86 high level programming language along with comprehensive libraries of modules interfacing user-generated code to APEX software.
- A large selection of user-friendly editors enabling modifications in the dialogs, menu windows, user-generated programs and acquisition protocols available in the standard APEX software.

This powerful clinical programming toolbox guarantees both high clinical versatility today and immunity from software obsolescence in the future.

**advanced clinical software**

Strong cooperation with APEX users and CLIP's advanced programming tools make APEX clinical software extremely modular and highly efficient. The clinical programs fall into three categories:

- Built-in CLIP programs covering the widest spectrum of nuclear medicine processing protocols.
- More than 600 modular and linkable APEX functions, each optimized to handle a specific processing task. These functions are used as building blocks for the CLIP programs.
- An ever-growing number of user-generated CLIP programs which are not included in standard APEX software versions.

**operational simplicity**

APEX operator interface is designed to match both routine operation and advanced processing requirements.

- Multi-Operational Modes: APEX software may be activated by single key, by clinically driven menu windows or by command lines.
- Friendly Dialogs: Parameters may be entered via an interactive simple-format series-of-queries called dialog.
- Help Menus: APEX built-in Help Menus minimize operator dependence on documentation. They are available any time on any level of the interaction for any command.

The advanced human interface of APEX software is a built-in guarantee of operational simplicity without compromising clinical diagnostic power.

**OPTIONS****SCANNING ATTACHMENTS****ECT-X**

SPECT scanning including: ECT patient table, computerized gantry motion control including side long arm-rest, ECT reconstruction and processing package.

**AEL-S**

Elliptical orbit option for systems equipped with ECT

**ADST**

Head support attachment - optimized for brain SPECT

**AHG-1**

Hand grip for cardiac/torso SPECT (overhead arm support).

**ARM-1**

ARM support for ECT patient table

**DATA STORAGE DEVICES****MINIMAX 3000S**

0.8 Gbyte, optical disk (two cartridges included)

**ODC-3**

3 MINIMAX-3000S optical disk cartridges

**ACCESSORIES****DISPLAY-HD**

High definition display (1416 x 1168 pixels), including 21" color monitor (in lieu of the 14" monitor)

**AXM-14**

Auxiliary 14" image monitor

**AEG-1A**

ECG amplifier/synchronizer

**AFS-1**

Foot switch (remote acquisition start/stop)

**ATC-15**

Extended terminal cable to electronics cabinet

**AMX-1S**

Auxiliary camera multiplexer

**CLINICAL PACKAGES****GSPECTS**

Gated ECT acquisition and processing

**A3D-1**

Interactive 3D display of tomographic studies

**ACSP-1**

Cedars-Sinai polar mapping package for  $^{201}\text{Tl}$  tomographic studies, including comparisons to the Cedars-Sinai normal data base

**ACSP-2**

"CEQUAL" Cedars - Emory Quantitative Analysis

$^{99\text{m}}\text{Tc}$  MIBI SPECT package (including normal patients data base)

**ASFI-1**

Scatter-free imaging package

**PSPECT**

Pinhole SPECT Imaging Package

**PROGRAMMING LANGUAGES****CLIP**

Clinical macro-programming language

**APL-1-PLMS**

PLM-86 programming language

**NETWORKING and DATA TRANSFER****ACM-22S**

Single port fast Ethernet link (with thin cable connector)

**TCM-12S**

Thick cable Ethernet transceiver

**ACM-2A**

Thick cable for Ethernet network

**ACM-2B**

Thin cable for Ethernet network

**ACM-14**

Multiple port TCP/IP networking server communication link

**ADT-1**

Data transfer to/from "Non-ELSCINT" computers via 5 1/4" diskette

**AAN-1**

Analog X, Y, and Z outputs

**HARDCOPY DEVICES****Helios 810**

Polaroid Digital Laser Imager with dry development (additional networking server, ACM-14, is required)

**Agfa Drystar/N**

Networked color or black and white multi-imager with dry processing (additional networking server, ACM-14, is required)

**Codonics NP-1600**

Digital color printer with dye sublimation (additional networking server, ACM-14, is required)

**Visiplex/LR**

Video multi-imager multi-format (1, 4) with conventional film processing including one 8x10" film cassette

**Shinko CHC-S443**

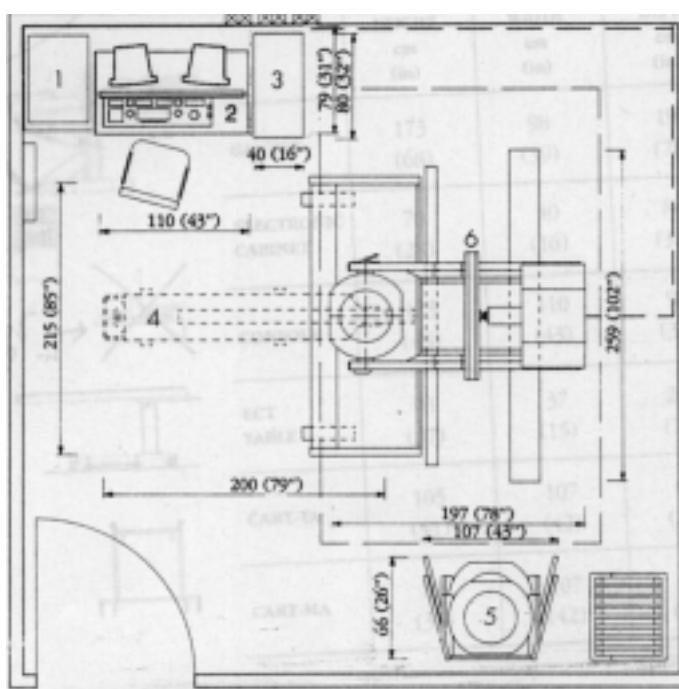
Mitsubishi Video color printer with dye sublimation

## COLLIMATORS SPECIFICATIONS

Name	Application	Energy keV	Septal Penetration %	Geometric Res. FWHM (mm) @0	Geometric Res. FWHM (mm) @100	System Res. FWHM (mm) @100 mm	Sensitivity Counts/min/μCi	Weight Kg(lbs)
<b>APC-1S</b> LEUHS	Cardiac 1st Pass	140	2.6	4.9	17.4	17.6	1520	11(24)
<b>APC-2S</b> LEHS	Gated cardiac (stress)	140	3.7	3.9	14.9	15.1	990	11(24)
<b>APC-3S</b> LEHS	Gated cardiac	140	2.3	2.9	10.2	10.4	430	11(24)
<b>APC-34S</b> LEAP	All purpose	140	2.4	2.4	9.1	9.4	360	11(24)
<b>APC-35S</b> Cast/LEGP	General purpose	140	0.8	2.1	8.4	8.7	270	16(35)
<b>APC-4S</b> LEHR	Bone scans	140	1.9	1.9	7.2	7.9	220	12(26)
<b>APC-45S</b> Cast/LEHR	Bone Scans	140	0.3	2.0	6.7	7.4	160	18(40)
<b>APC-5S-C</b> Cast/MEGP	<sup>67</sup> Ga studies	300	2.4	3.6	10.5	10.7	190	46(101)
<b>APC-6S-C</b> Cast/HEGP	<sup>131</sup> I studies	360	2.0	4.2	10.2	10.4	140	46(101)
<b>APC-64S</b> Cast/LEUHS	Cardiac 1st Pass	140	0.9	2.0	22.8	23.1	1630	11(24)
<b>APC-8S-C</b> HEGP Pin hole	Thyroid scans (3 Inserts)	360	-	-	-	4.3 7.0 12.2	34 136 374	44(97)

## TYPICAL ROOM LAYOUT

1. Multi-imager
2. Terminal
3. Cabinet
4. ECT Scanning Table
5. Collimator Carts
6. Gantry



APEX SPX-4 with ECT

**PHYSICAL CHARACTERISTICS****ELECTRICAL REQUIREMENTS****power consumption**

2300 VA, 1850 watt including options

**heat dissipation**

6300 BTU/H

**mains**

115/230V ±10%, 20/10 A

(maximum current with all motors in operation)

60/50 ±1Hz (single phase)

**GANTRY FLOOR LOAD**

350 kg (771 lbs) at each of 4 support points.

[Points are at corners of a 45 x 77 cm

(18" x 30") rectangle].

**OPERATING ENVIRONMENT****temperature**

18° C-27°C (64° F-80° F)

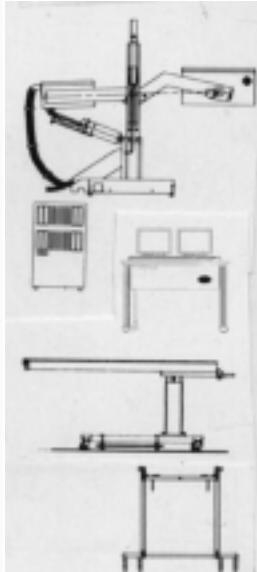
**maximum temp. gradient**

3°C (5°F) per hour

**humidity**

40%-60%, non-condensing

Meets UL544 and IEC-601.1 standards.

**DIMENSIONS & WEIGHTS**

	HEIGHT cm (in)	WIDTH cm (in)	DEPTH cm (in)	WEIGHT Kg (Lb)	HEAT DISSIPATION (BTU/H)	POWER CONSUMPTION (WATTS)
<b>GANTRY</b>	173 (68)	98 (39)	19 (78)	1100 (2426)	1530	450
<b>ELECTRONIC CABINET</b>	70 (28)	40 (16)	80 (32)	70 (155)	3740	1100
<b>CONSOLE</b>	123 (48)	110 (43)	90 (35)	132 (290)	1020	300
<b>ECT TABLE</b>	95 (37)	37 (15)	200 (79)	80 (176)	Included in "GANTRY" specification (above)	
<b>CART-TA</b>	105 (41)	107 (42)	66 (26)	15 (33)	-	-
<b>CART-MA</b>	89 (35)	107 (42)	66 (26)	14 (31)	-	-

\* *Optional*\*\* *Based on NEMA publication NUI - 86*# *"Fast" acquisition mode*

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**Elscint**  
*The Intelligent Image*

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