SPX-6

Integrated Digital Gamma Camera with Extra-Large Rectangular Field-of-View

The APEX SPX-6 is a high performance, all-purpose, integrated digital gamma camera, optimally designed for superb WB, planar and SPECT imaging. It incorporates a 59-PMT extra-large 540x400 mm rectangular 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 high-speed digital signal processing to 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 and excellent lesion detectability throughout the entire 540 x 400 mm UFOV, real-time digital correction system and high-precision, micro cast parallel and fan-beam collimation*
- Ultra-fast acquisition and processing, utilizing state-of-the-art Intel microprocessors, enhanced by multi-processor array including an AMD 64-bit dedicated acquisition 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 yields immunity from data and clinical software obsolescence.

* optional
• 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 or digital printers. Extended connectivity packages provide multi-standard ETHERNET networking* platforms, including TCP/IP* and ISO/OSI.

• A 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, with over 600 modular and linkable clinical functions, ensure both clinical versatility today and immunity from future software obsolescence.

**SYSTEM DESCRIPTION**

**detector**
High-performance detector features 3/8” NaI(Tl) crystal, 59 high quantum efficiency, optronically controlled photomultiplier tubes, and a rectangular 540x400 mm field-of-view, optimally shielded for imaging at 40-400 keV energy range.

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

**patient handling system**
APEX SPX-6 features two optional patient tables:

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

**WB table**
Low attenuation flat-profile table with ultra-thin fiberzine table-top for single/dual-pass whole-body scanning.

**integrated workstation**
An acquisition and processing station, based on 32/64-bit multi-processor array including Intel processors, an acquisition dedicated array processor, a 21" color monitor with 1416 x 1168 resolution display*, 340 Mbyte magnetic fixed disk, 800 Mbyte optical disk* and a 5¼ " , 1.2 Mbyte flexible (floppy) disk.

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

**CONFIGURATIONS**
The 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 and Whole Body (AWB) software packages and scanning attachments may be added to the standard configuration.

**standard**
The standard APEX SPX-6 imaging system features a high performance workstation integrated with an extra large rectangular 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.

**AWB**
The standard configuration plus scanning table, horizontal single-pass scanning capabilities, and supplementary whole body scanning software package.

**ECT+AWB**
The standard configuration plus scanning tables, computer-controlled orbiting capability, horizontal single/dual-pass scanning capabilities, and supplementary SPECT and whole body scanning software packages.

**WORKSTATION**

**computer architecture**
The SPX integrated computing system, APEX’s 3rd 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 50MHz, 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 detection 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 a dual-ported RAM. High integration features on-chip floating-point processing unit and data cache memory bank. This powerful architecture is designed to support high count-rate acquisition and compute-intensive multiprocess- ing 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 image color display*, a 14" alpha-numeric control 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: 1/4 rpm or 1 rpm
C.O.R height: 98 cm (38.6")

**head tilt**

TILT GUARD™:
Special mechanism maintains detector alignment while adjusting scan diameter.
Range: -75 to +185°

**gantry rotation**

Range: ±360°
Velocity: fast - 1 rpm; slow - 1/4 rpm

**gantry lateral motion**

Range:
AWB 200 cm (78.7")
AEL 100 cm (39.3") - elliptical ECT orbit

Velocity:
Fast 150 cm/min (59"/min)
Slow 5 cm/min (19.7"/min)

**patient handling system:**

227 kg (500 lb) max. load

**vertical motion**

Range:
in. 65 cm (26")
max. 95 cm (37")

**NEMA PERFORMANCE SPECIFICATIONS**

**calibration**

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

**energy range**

40 - 400 keV

**intrinsic spatial resolution**

CFOV: FWHM ≤4.3 mm

FTWM ≤8.1 mm

UFOV: FWHM ≤4.3 mm

FTWM ≤8.2 mm

**intrinsic energy resolution**

**intrinsic linearity**

CFOV: Absolute ≤0.5 mm

Differential ≤0.1 mm

UFOV: Absolute ≤0.7 mm

Differential ≤0.1 mm

**flood field uniformity**

CFOV: Integral ≤4.0%

Differential ≤2.1%

UFOV: Integral ≤4.5%

Differential ≤2.4%

**point source sensitivity**

≤2.5%

**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

with 20% window: (observed) (incident)

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

maximum with 30% window > 400,000 cps

with 30% window: (observed) (incident)

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

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

FWHM: 4.6 mm; FWTM: 8.8 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 (111Ga): 1.5 mm

**system imaging performance**

**LEHR**

FWHM (mm)

Central FWHM 6.8

Radial FWHM 9.6

Central FWHM 9.8

**ACQUISITION**

APEX SPX-6 can acquire images in Static, Dynamic, Multi-gated, List mode, SPECT*, Gated SPECT*, and Whole Body* acquisition modes.

- Simultaneous acquisition processing and networking
- Acquisition termination by preset time, preset count, overflow 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 an APC-45RS collimator, 120 views, 3° per view, 15 cm radius-of-scan, acquisition magnification factor x2, Ramp-filtered back projection, 128° 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-buffer design enabling accumulation of both accepted and rejected beats
multi-gated acquisition capacity

<table>
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<tr>
<td>256 x 256 x 16</td>
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<tr>
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<tr>
<td>64 x 64 x 16</td>
<td>32</td>
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<tr>
<td>64 x 64 x 8</td>
<td>64</td>
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ECT acquisition

angular view resolution
1, 2, 3, 4, 5, 6 and 9 degrees

acquisition modes
- Continuous: 1 min or 4 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

AWB acquisition

scanning modes
Single pass, left to right / right to left scanning with the detector head over or under the table. Continuous sequential multi-spot advanced scanning modes* enable automatic transition from posterior to anterior scans and interactive body contouring (dual-pass)

matrix size
256 x 1024

dynamic acquisition

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

frame rates

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<td>25</td>
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<tr>
<td>64 x 64 x 8</td>
<td>50</td>
</tr>
<tr>
<td>32 x 32 x 8</td>
<td>100</td>
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</table>

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

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<th>single isotope</th>
<th>dual isotope</th>
<th>quad isotope</th>
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<tr>
<td>256 x 256</td>
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<td>8 or 16 bits</td>
<td>8 or 16 bits</td>
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<tr>
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<td>64 x 64</td>
<td>8 or 16 bits</td>
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<td>32 x 32</td>
<td>8 or 16 bits</td>
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</table>

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

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<tr>
<td>256 x 256</td>
<td>4000 frames</td>
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<tr>
<td>128 x 128</td>
<td>16000 frames</td>
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<tr>
<td>64 x 64</td>
<td>64000 frames</td>
</tr>
<tr>
<td>32 x 32</td>
<td>256000 frames</td>
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</table>

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
- Real-time interpolated zoom during cine
PROCESSING
image processing
Smoothing, normalization, interpolation, background subtraction, magnification, interframe 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 and dynamic uptake brain studies
- Planar cerebral perfusion
- Lung ventilation/perfusion
- Thyroid uptake
- Gastric emptying

ECT data processing*

normalization
Sensitivity correction for collimator non-uniformities. Corrections of rotation speed, center of rotation (on line possibility), 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 64^2 matrix)
0.68 sec/slice (60 x 128^2 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^3 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
- Modern networking available through ApexView
- The APEX SPX Series is software compatible, data compatible and connective through the ApexNet with all 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.
- PLM-86 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, are 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

**AWB-S**
- Whole Body scanning option (enables elliptical orbit on systems with ECT option), including Whole Body patient table and software package

**ASCN-1**
- Advanced Whole Body scanning modes

**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)

### CLINICAL PACKAGES

**GSPECTS**
- Gated ECT acquisition and processing

**A3D-1**
- Interactive 3D display of tomographic studies

**ACSP-1**
- Cedars-Sinai polar mapping package for Tl201 tomographic studies, including comparisons to the Cedars-Sinai normal data base

**ACSP-2**
- "CEQUAL" - Cedars-Emory Quantitative Analysis, Tc99m MIBI SPECT package (including normal patients data base)

**ASFI-1**
- Scatter-free imaging package

### PROGRAMMING LANGUAGES

**CLIP**
- Clinical macro programming language

**APL-1-PLMS**
- PLM-86 programming language

### NETWORKING

**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 5¼" diskette

**AAN-1**
- Analog X, Y, and Z outputs

### HARDCOPY DEVICES

**Helios 810**
- Polaroid Digital Laser Imager with dry development

**Agfa Drystar/N**
- Networked color or black and white multi-imager with dry processing

**Codonics NP-1600**
- Digital color printer with dye sublimation

**Shinko CHC-S443**
- Mitsubishi Video color printer with dye sublimation

### 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 ± 2°C (64°F ± 40°F)
- maximum temp. gradient
- 3°C (5°F) per hour

**humidity**
- 40%-60%, non-condensing

### Design

- Designed to meet UL544
- IEC-601.1 certified
**COLLIMATORS SPECIFICATIONS**

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<tr>
<th>Name</th>
<th>Application</th>
<th>Energy keV</th>
<th>Septal Penetration %</th>
<th>Geometric Res. FWHM (mm) @0</th>
<th>Geometric Res. FWHM (mm) @100</th>
<th>System Res. FWHM (mm) @100 mm</th>
<th>Sensitivity Counts/min/1cm²</th>
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**TYPICAL ROOM LAYOUT**

1. Multi-imager
2. Operator Console
3. Cabinet
4. ECT Scanning Table
5. Collimator Carts
6. Gantry
7. Scanning Table
8. AWB Track
## Dimensions & Weights

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<tr>
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<th>Height (cm)</th>
<th>Width (cm)</th>
<th>Depth (cm)</th>
<th>Weight (Kg)</th>
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<th>Power Consumption (Watts)</th>
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<tbody>
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<td><strong>Gantry</strong></td>
<td>173 (68)</td>
<td>98 (38.6)</td>
<td>197 (77.6)</td>
<td>1100 (2426)</td>
<td>1530</td>
<td>450</td>
</tr>
<tr>
<td><strong>Electronic Cabinet</strong></td>
<td>70 (27.6)</td>
<td>40 (15.7)</td>
<td>80 (31.5)</td>
<td>70 (155)</td>
<td>3740</td>
<td>1100</td>
</tr>
<tr>
<td><strong>Console</strong></td>
<td>140 (55)</td>
<td>110 (43)</td>
<td>79 (31)</td>
<td>132 (290)</td>
<td>1020</td>
<td>300</td>
</tr>
<tr>
<td><strong>ECT Table</strong></td>
<td>95 (37.4)</td>
<td>37 (14.6)</td>
<td>200 (78.7)</td>
<td>80 (176)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AWB Table</strong></td>
<td>83 (32.7)</td>
<td>215 (84.7)</td>
<td>87 (34.3)</td>
<td>110 (243)</td>
<td>Included in “Gantry” specifications (above)</td>
<td></td>
</tr>
<tr>
<td><strong>AWB Track</strong></td>
<td>8 (3.1)</td>
<td>259 (102)</td>
<td>23 (9)</td>
<td>35 (77)</td>
<td></td>
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<tr>
<td><strong>Cart-TR</strong></td>
<td>105 (41.3)</td>
<td>107 (42.1)</td>
<td>66 (26)</td>
<td>15 (33)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cart-MR</strong></td>
<td>89 (35)</td>
<td>107 (42.1)</td>
<td>66 (26)</td>
<td>14 (31)</td>
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<tr>
<td><strong>Cart-SR</strong></td>
<td>78 (30)</td>
<td>107 (42.1)</td>
<td>66 (26)</td>
<td>13 (29)</td>
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</tr>
</tbody>
</table>

* Optional

** Based on NEMA publication NU 1-1994

*** Nema class standard

# "Fast acquisition" mode

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