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Inveon

No Limits on Discovery

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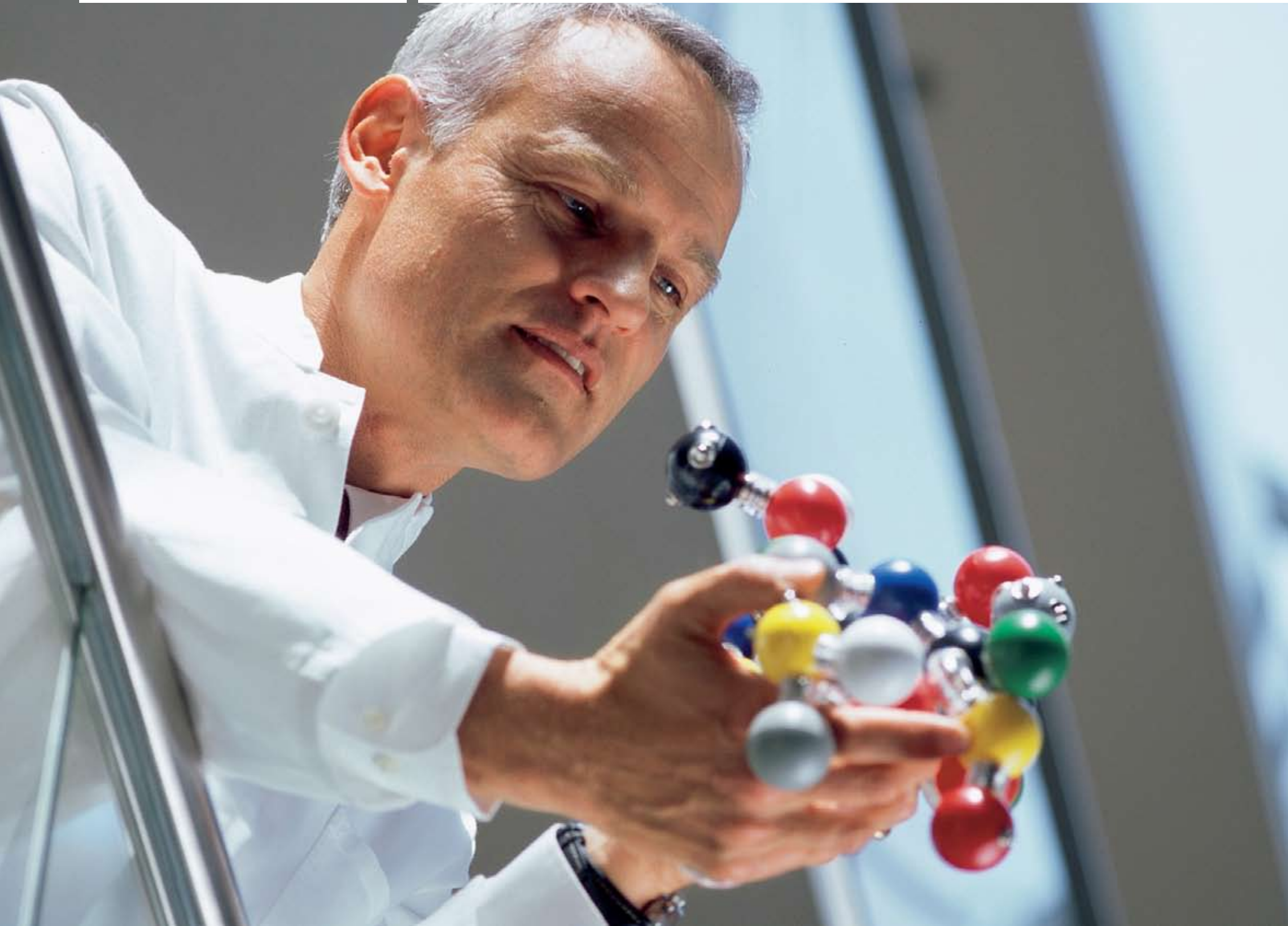
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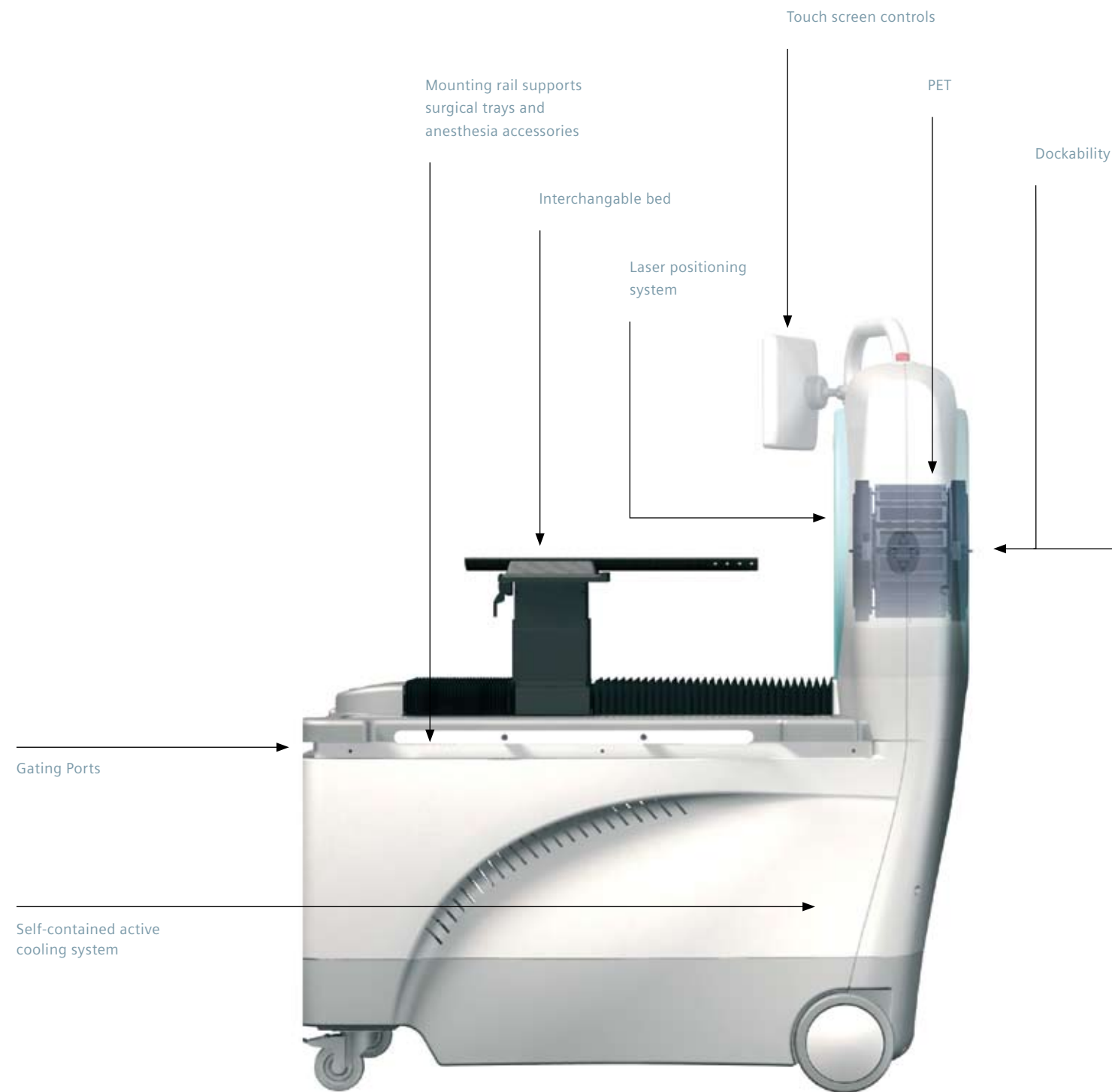
Siemens' preclinical solutions are removing the limits on driving medical research from the laboratory to the clinic. Siemens Inveon™ provides the highest performance and versatility available to address your preclinical imaging research needs. From basic science and disease progression, to drug discovery and development, Inveon offers an unrivaled solution for optimizing your research outcomes.

Continuing Siemens' legacy of innovation, Inveon represents a new class of preclinical multimodality imaging solutions, offering you a comprehensive range of imaging capabilities that are relevant today and as your needs grow.

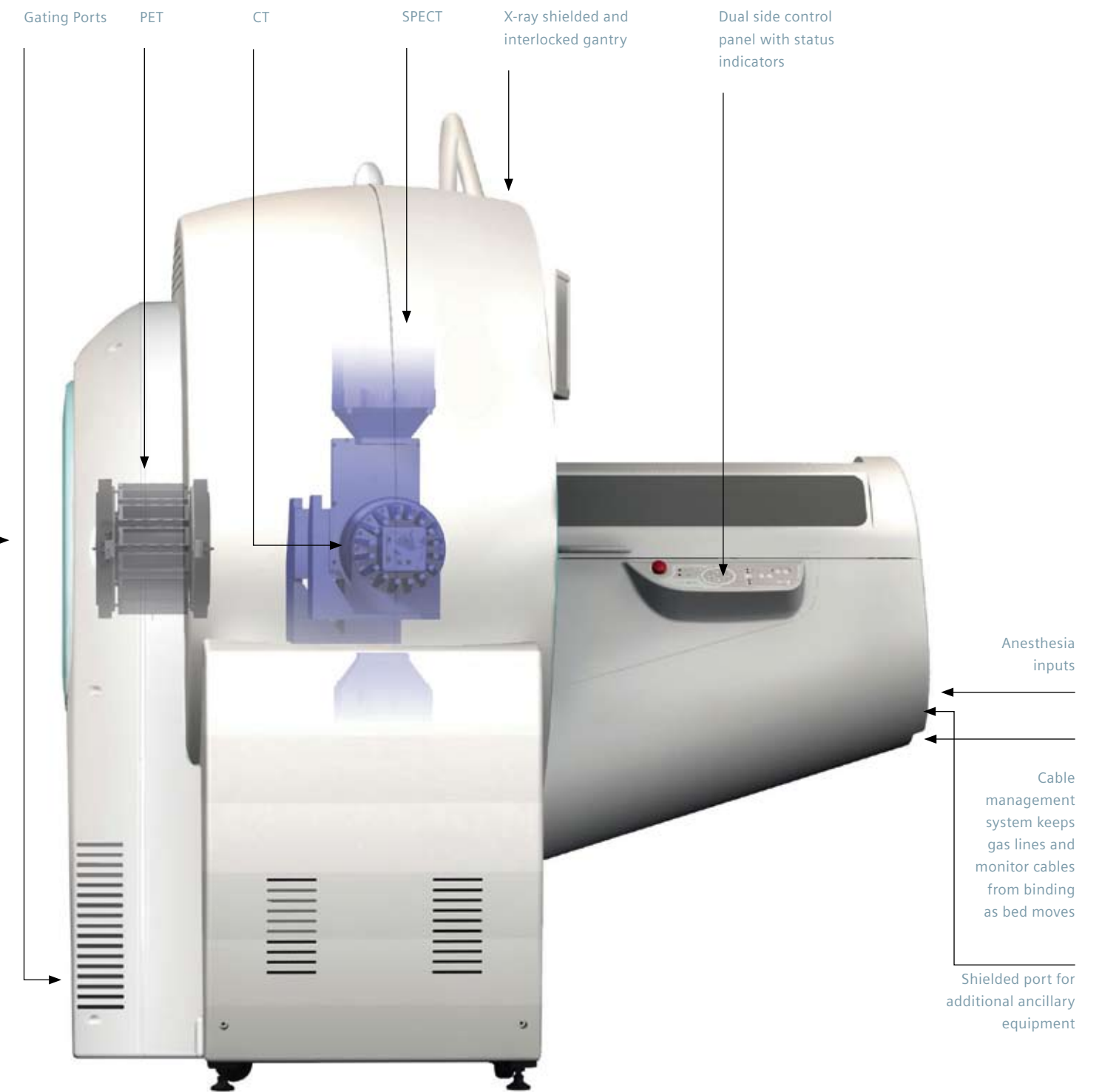


Inveon Platform

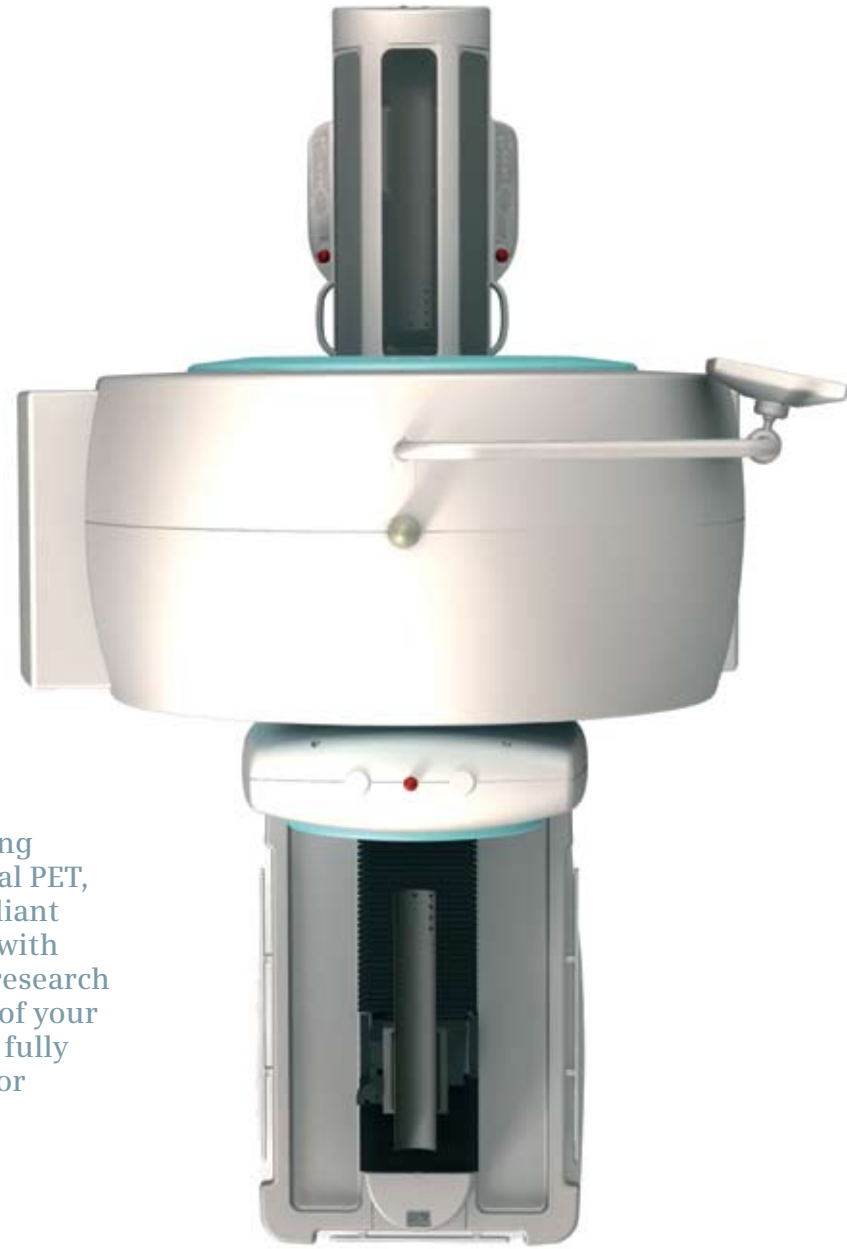
Dedicated PET System



Multimodality System



Introduction



Inveon is a revolutionary preclinical imaging platform, providing integrated small animal PET, SPECT and CT imaging and analysis. A brilliant combination of cutting-edge technologies with multiple configuration options to fit your research needs, Inveon becomes an invaluable part of your research workflow. Inveon is available as a fully integrated or dockable system with single or multimodality configurations.

No Limits on Performance

Inveon's exceptional performance is based on true system integration for fast, quantitative analysis with excellent sensitivity and resolution. Inveon is built on an innovative acquisition architecture which unifies data collection from multiple modalities (PET, CT, and SPECT). By providing true system integration and solid performance, Inveon takes molecular imaging to a new level.

- Versatile multimodality platform allowing the system to be configured to specific research applications
- Unified control of PET, SPECT, and CT data acquisition
- Unmatched PET detector technology for high resolution and sensitivity
- Groundbreaking new PET and SPECT acquisition and processing technology for excellent count rate performance

- Unique PET transmission method for fast and accurate attenuation correction
- Advanced multi-pinhole SPECT collimators for high sensitivity and spatial resolution
- Novel CT automated zoom control for optimized field of view (FOV) and resolution

No Limits on Versatility

Inveon's integrated multimodality platform delivers best-in-class PET, SPECT, and CT in a single system. Designed for adaptability, Inveon is upgradeable to grow with your research program. Start with CT or SPECT and build versatility by adding additional modules to configure multimodality systems such as PET•CT, SPECT•CT, or PET•CT•SPECT. All components are fully integrated and optimized for outstanding performance.

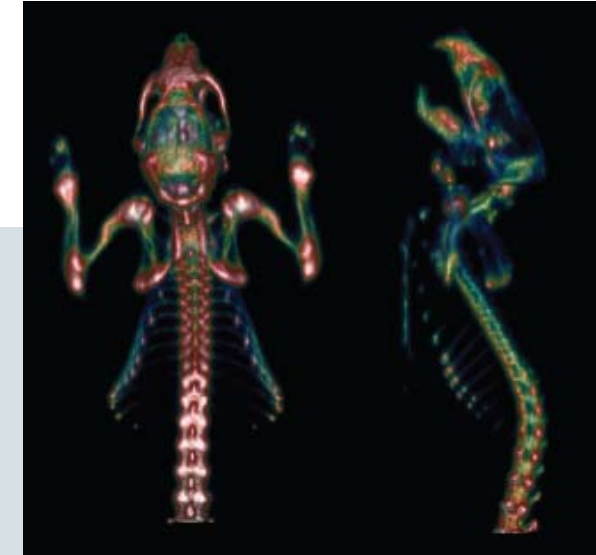
Our novel approach to dedicated PET delivers an additional dimension of versatility — it is dockable. The dedicated PET system docks with the multimodality system, providing the convenience of a single multimodality platform. You can simply connect and calibrate the gantries to turn your systems into one multimodality unit. In the docked configuration, both systems can operate independently or as a single gantry under the control of a single workstation.

No Limits on Workflow

The Inveon Acquisition and Research Workplaces put the power of three modalities at your fingertips and simplify every aspect of data acquisition, processing, fusion and analysis.

- Optimized data acquisition system for controlling all modalities from a single application — one workplace
- Comprehensive suite of reconstruction algorithms
- High end integrated visualization and analysis workplace offering a wide range of research features
- State-of-the-art image fusion technology
- Comprehensive suite of preclinical data analysis applications

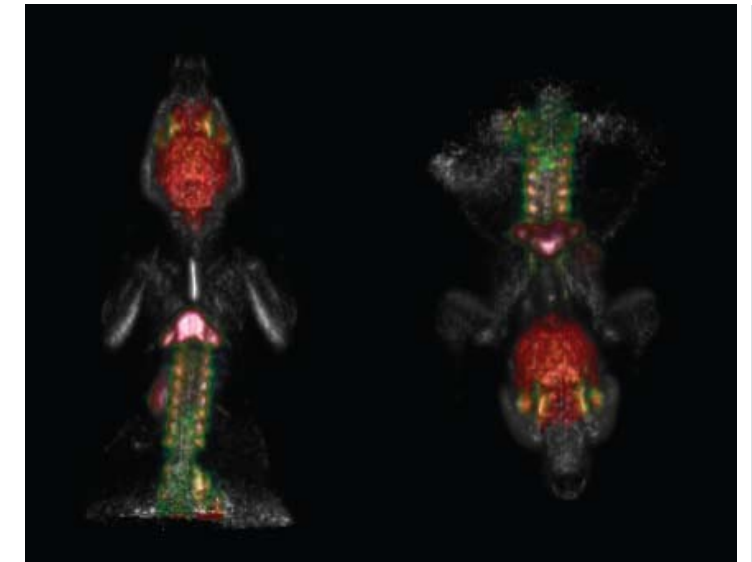
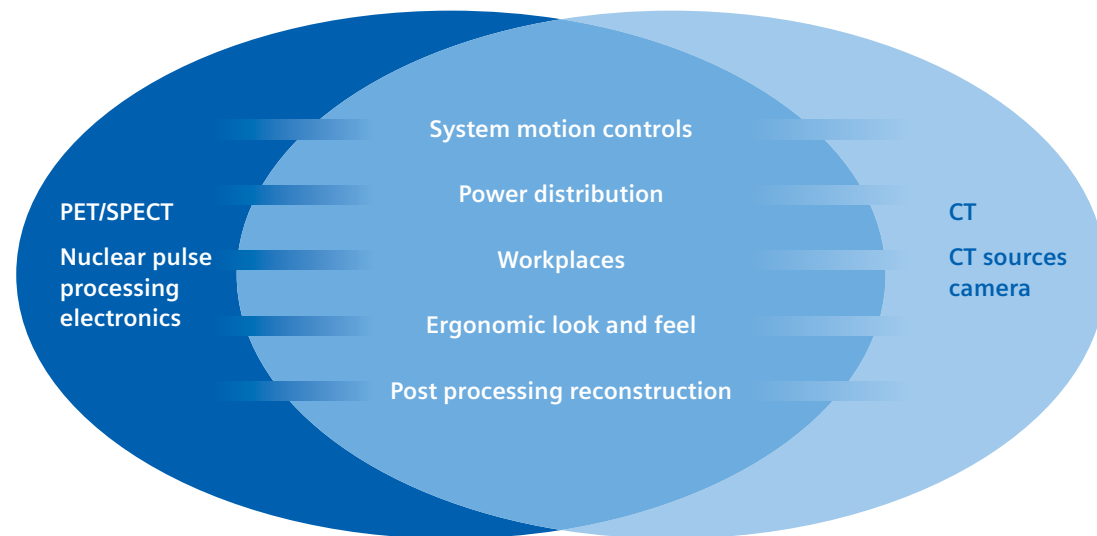
Data courtesy of University of Tuebingen, Laboratory for Preclinical Imaging and Imaging Technology, Tuebingen, Germany



No Limits on Investment Protection

With our long history at the forefront of preclinical technological innovation, you can count on Siemens to keep you ahead, every step of the way. Support begins before delivery and continues throughout the product life cycle. We offer a full range of service plans to ensure that your Inveon system continues to meet factory specifications and maintains the highest level of reliability. Ready to grow with you, it is easy to add additional modalities to your system to meet your growing requirements into the future.

Multimodality Integration



Data courtesy of Universitaetsklinikum Erlangen, Nuklearmedizinische Klinik, Erlangen, Germany

Integrated Acquisition System

Inveon's versatile data acquisition system provides optimal PET, SPECT, and CT performance on a platform designed as a true multimodality system. Networked computers embedded in the gantries coordinate PET, SPECT, and CT data acquisition, and an innovative new nuclear pulse processing system acquires high resolution PET and SPECT data.

Integrated Motion Control

Historically, preclinical multimodality solutions have consisted of two independent systems, often with separate workstations, loosely packaged in a single gantry. Inveon changes the paradigm. An integrated CAN bus network precisely controls the position of up to twelve stages, coordinating beds, SPECT detector positioning, CT source and detector positioning and transmission source mechanism, tightly integrating the command and control of each modality.

Integrated Data Processing

Inveon PET and SPECT each use the same new Siemens pulse processing technology and event handling architecture for high resolution, high count rate gamma ray processing. In PET mode, this architecture virtually eliminates electronic dead time and dramatically improves singles and coincidence count rates. In SPECT mode, this architecture provides high spatial and energy resolution while providing excellent count rate performance.



PET Technology

Based on Siemens' leading-edge technology, Inveon delivers a high performance PET system. Our leadership in LSO detector materials, advanced detector technology, state-of-the-art acquisition systems, and advanced attenuation correction provide high count rate performance as well as enhanced resolution and sensitivity for excellent image quality and quantitative accuracy.

LSO Detector Material

The performance of a PET scanner depends greatly upon the physical and scintillation properties of the crystal detector material. LSO offers the best combination of properties of any PET scintillator used today — fast scintillation decay time, high light output, and effective atomic number.

Detector Architecture

Inveon's detector design includes an innovative high efficiency light guide* that delivers more photons to the photomultiplier tube, thereby improving energy and timing resolution. The detector also features a larger 20 x 20 crystal array that increases the scanners axial FOV and improves system sensitivity. Siemens' detector assembly process minimizes the gap between crystal elements, providing at least a 92% packing fraction. The net result is a PET system with exceptional spatial resolution and sensitivity.

Acquisition System Technology

The new Inveon data processing architecture improves PET count rate performance, energy resolution, and timing resolution. Count rate performance is improved through a new store and forward coincidence processing technique that virtually eliminates the electronic dead time associated with traditional multiplexing architectures. Energy resolution is improved through the use of 10-bit high speed analog-to-digital converters that fully digitize the detector signals with 100 MHz sampling. Timing resolution is improved through the use of 312 ps time bins. The result is a PET system with exceedingly high singles and coincidence data rates as well as excellent random and scattered event rejection.

Attenuation Correction

Transmission Source Attenuation Correction:

Dedicated PET System

With rotating ⁵⁷Co transmission source – inboard and self-shielded – Inveon provides fast, accurate attenuation scans. This high speed point source mechanism takes advantage of the lower energy of ⁵⁷Co. With an emission energy of 122 keV, ⁵⁷Co transmission scans provide superior contrast and more accurate attenuation maps than scans acquired with ⁶⁸Ge (511 keV) or ¹³⁷Cs (662 keV). Moreover, ⁵⁷Co gamma rays are detected with more than 98% efficiency, reducing scan times and improving image integrity. ⁵⁷Co transmission scans can also be reconstructed for anatomic localization of the PET signal.

CT-Based Attenuation Correction:

Low dose, high speed CT offers the most accurate attenuation correction available for preclinical PET. For this reason, the Inveon family offers CT-based attenuation correction for all configurations, either directly through an integrated CT module, through the use of a docked CT module, or by registering PET images to CT images acquired separately.

Fine Resolution

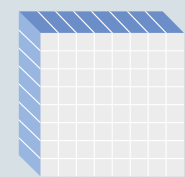
Combining the high light output of LSO with 1.6 mm x 1.6 mm detector pixel spacing, the Inveon delivers 1.4 mm FWHM (at center of field of view) spatial resolution in images reconstructed using the filtered back projection algorithm. Higher reconstructed image resolution can be achieved with Siemens' suite of iterative reconstruction algorithms.

Large FOV

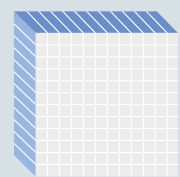
New detector design provides an axial FOV of 12.7 cm. In addition, continuous bed motion effectively extends the axial FOV to 30 cm on the Inveon dedicated PET system. This provides temporal data over the entire axial FOV and offers better image quality due to the oversampling of each projection.

Dockability

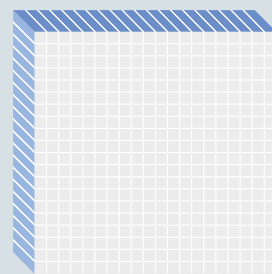
The versatility of the Inveon platform can be extended by docking the dedicated PET system to the multimodality system. In docked mode, the two scanners can operate independently or as a single multimodality system under the control of a single workstation. The design offers leading-edge performance today with room for multimodal upgrades as your needs grow.



First Generation
8 x 8 array



Second Generation
12 x 12 array



Inveon Detector Technology
A larger 20 x 20 array detection area for
increased axial FOV and sensitivity

Features

High Count Rate Performance

Inveon technology utilizes an asynchronous coincidence processing architecture which virtually eliminates electronic dead time and substantially improves count rate performance and peak NEC.

Unmatched Sensitivity

Siemens detectors provide high sensitivity through a combination of dense, 10 mm thick LSO crystals and very thin inter-pixel reflector layers as well as through careful design of the detector ring geometry. Absolute sensitivity in the center of the FOV is greater than or equal to 10%.



CT Technology

Designed to meet your throughput, resolution, and image quality needs, Inveon sets the standard for *in vivo* preclinical micro computed tomography. With a range of X-ray source and detector configurations available, the ability to adjust the scanner magnification between scans, and a suite of image reconstruction and data analysis tools, the Inveon delivers a versatile preclinical CT solution.

X-ray Source

Standard Source

The standard source is an 80 W, tungsten anode, 35-80 kVp source with less than a 50 micron focal spot. This source provides a high X-ray flux for high speed scanning and a large cone angle for high magnification studies. The maximum achievable resolution with this X-ray source and the standard detector is 40 microns. Typical scan times are less than 5 minutes.

Variable-focus Source

For ultra high resolution studies, a variable-focus X-ray source is available, which can operate in microfocus mode (less than 6 micron focal spot) providing a maximum resolution of 20 microns with both detector options. The same source can operate with a larger focal spot at up to 40 W for high speed studies.



X-ray Detector

125 mm Detector

This versatile X-ray source is recommended for high speed whole mouse or rat preclinical X-ray CT studies. The detector has 3072 x 2048 pixels and may be configured for a FOV as large as 8.4 cm x 5.5 cm. The raw data is 12 bits deep, and the detector dynamic range is 69 dB with 1 x 1 binning and 72 dB with 2 x 2 and 4 x 4 binning. The maximum achievable resolution with this detector and the standard X-ray source is 40 microns. With the variable-focus X-ray source, the maximum resolution is 20 microns.

165 mm Detector

A large area detector for scanning larger animals is available with 4064 x 4064 pixels, providing a maximum FOV of 10 cm x 10 cm. With this detector, the FOV permits the operator to crop each data set to match the geometry of the subject. This detector also has a superior signal to noise ratio with 14 bit readout and a dynamic range of 67 dB with 1 x 1 binning, 79 dB with 2 x 2 binning, and 84 dB with 4 x 4 binning. The maximum achievable resolution with this detector and the standard X-ray source is 40 microns. With the variable-focus X-ray source, the maximum resolution is 20 microns.

Features

Automated Zoom Control

The X-ray source and detector are positioned on precision, computer controlled mechanical slides, allowing the operator to adjust the scanner FOV and magnification from the command console.

High Resolution

With the optional variable focus X-ray source, the Inveon delivers *in vivo* resolution as low as 20 microns.

Large FOV

With the optional 165 mm X-ray detector, the Inveon FOV can be as large as 10 cm. The bore diameter is 12 cm.

Respiratory and Cardiac Gating

A high-speed shutter acquires image frames with exposure times as short as 10 ms for gated studies. TTL gating ports allow the input of both cardiac and respiratory trigger signals.

Data Reconstruction

Siemens uses a modified Feldkamp algorithm for fast, accurate volumetric image reconstruction. Two reconstruction configurations are supported:

- **Standard** – volumetric reconstruction algorithm running on the data acquisition workstation
- **Real Time** – reconstruction performed on a dedicated high speed platform during a scan. The real time reconstruction engine allows reconstruction to start as the projection data is being acquired. Reconstruction times depend on imaging protocol but can be complete by the end of the acquisition.

SPECT Technology

Building on Siemens' established leadership in SPECT detector, collimator, and hybrid imaging technology, the Inveon SPECT module delivers fine resolution, high sensitivity, exquisite image quality, and seamless integration with PET and CT data. Featuring large area, high sensitivity pixelated detector heads, an extensive suite of high resolution collimators, and new multi-pinhole technology, the Inveon SPECT module extends the versatility of preclinical SPECT, providing significant improvements in sensitivity and resolution.

Detector Heads

The Inveon high resolution SPECT detectors deliver sub-millimeter resolution with the largest pixelated detector heads in the industry. The SPECT module detects gamma rays from 35 keV to 300 keV, providing sensitivity to most widely used research and clinical single photon isotopes. Key features of the detector head include:

- Large active area (150 mm x 150 mm) permits greater pinhole magnification, improving sensitivity while maintaining a large FOV
- Small detector crystals (2 mm x 2 mm x 10 mm) provide high intrinsic detector resolution.

Collimators

Inveon delivers an extensive suite of collimators for every application. The following collimators are available:

- 0.5, 1.0, 2.0, and 3.0 mm single pinhole collimators
- LEAP (low-energy all-purpose) parallel hole collimator set
- Mouse Brain and Mouse Whole Body multi-pinhole collimators

Multi-pinhole Data Acquisition and Reconstruction

Multi-pinhole reconstruction and calibration software allows you to produce high resolution images in a fraction of the time required with traditional collimators. Since a single multi-pinhole collimator configuration is not optimal for all preclinical studies, Inveon includes a range of multi-pinhole collimator configurations and an innovative software calibration tool. Operators can select a different multi-pinhole collimator configuration for each study and calibrate the scanner with a simple automated process. This method increases the versatility of Inveon and provides higher quality images than traditional manual calibration methods.

Features

Automated Zoom Control

Each detector has a 15 cm x 15 cm active area and is mounted on a computer controlled stage. With pinhole collimation, the detector magnification factor is easily adjusted, enabling the operator to select the optimal FOV and resolution for each study.

High Intrinsic and Spatial Resolution

The pixelated NaI crystal has 2 mm x 2 mm pixels and 2.2 mm x 2.2 mm pixel spacing. This fine sampling supports sub-millimeter reconstructed image resolution with pinhole collimation.

Unmatched Sensitivity

The NaI crystal is 10 mm thick, providing high sensitivity even to energetic photons. The detector housing is heavily shielded with more than a centimeter of lead for minimal penetration by out of FOV photons.

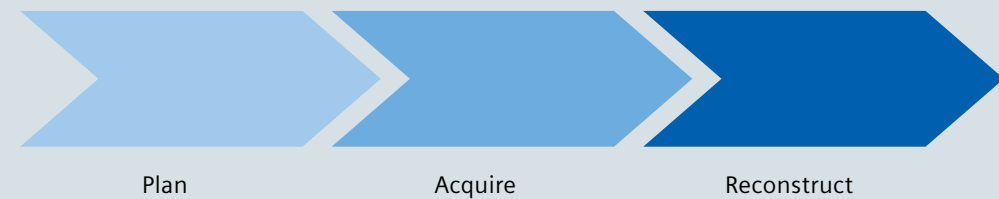
Versatile Reconstruction

Each SPECT system includes advanced image reconstruction algorithms including 3D-OSEM and 3D-MAP.

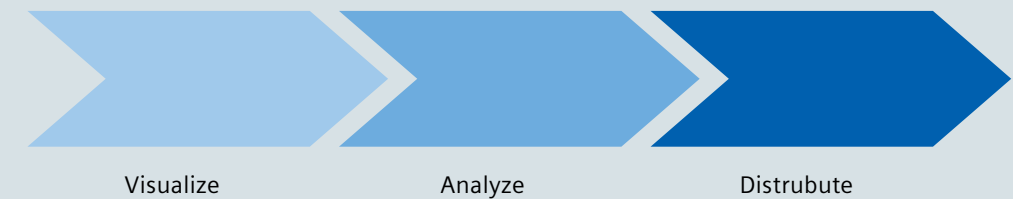


Applications Workflow

Inveon Acquisition Workplace



Inveon Research Workplace



Inveon Acquisition and Research Workplaces offer you comprehensive solutions. Designed for an intuitive and seamless workflow across PET, CT, and SPECT, the Inveon Acquisition Workplace provides a common platform with fast access, enabling acquired data to be processed smoothly and efficiently. The Inveon Research Workplace is a multimodality image review, fusion, and analysis package offering you a complete post processing workplace that delivers total preclinical integration.

With Inveon, truly integrated multimodality image analysis is available in a powerful and easy-to-use environment, giving you expanded research capabilities.

The Inveon Acquisition and Research Workplaces have many features to organize your workflow.

Plan

- Protocol Builder defines the details of acquisitions and reconstructions
- Drag and Drop Workflow Builder seamlessly integrates PET, CT, and SPECT acquisitions and reconstructions
- Navigator Window easily displays protocols and workflows

Acquire

- Workflow Builder easily prepares and runs multimodality acquisitions on the same computer
- CT Projection Viewer displays *in vivo* animal data in real time

Reconstruct

- 2D or 3D PET analytical and iterative reconstruction methods
- Feldkamp CT reconstruction method
- 3D-OSEM and 3D-MAP SPECT reconstruction methods
- CT and source-based* attenuation correction
- Scheduler Viewer for queuing and prioritizing all PET and SPECT reconstruction jobs

Visualize

- Multiple data sets viewed in a single image window
- 2D and 3D fused data review
- View dynamic and gated processes

Analyze

- Static, gated, and dynamic data
- Up to three different data sets loaded simultaneously
- Quantitative analysis including ROI statistics, time activity curves, and line profiles
- Pharmacokinetics and pharmacodynamics modeling

Distribute

- Allows data to be exported in DICOM format
- Enables graphs and snapshots to be captured to clipboard and saved as image files
- Allows numerical data to be exported as text files
- Enables dynamic images to be exported as movie files
- Allows storage on most common archiving and storage solutions

Inveon Research Workplace

The Inveon Research Workplace is a multimodality image review, fusion and analysis package designed to enable efficient research, producing repeatable and reliable analysis results. Supporting CT, PET, SPECT and MR data in DICOM, and Siemens' Inveon CT, PET and SPECT formats, as well as raw data import, the data browser makes it easy to import and manage your data. Using industry-standard DICOM communication protocols, data can be directly sent to and received from a host of other DICOM enabled devices including acquisition systems and storage solutions. Direct import features make it simple to locate data stored on local and networked devices. With optimized workflows at your fingertips, the Inveon Research Workplace offers a comprehensive set of visualization and image analysis tools so researchers can:

- Visualize multimodality data sets
- Analyze pharmacokinetic information
- Adhere to regulatory standards
- Effortlessly transition research from bench to bedside

Inveon General and Kinetic Analysis Workflows

At the core of the Inveon Research Workplace are the General and Kinetic Analysis Workflows. These analysis workflows provide a wide range of easy-to-use tools which are presented in an intuitive interface. Analysis of static, gated and dynamic data is supported with up to three different data sets being loaded simultaneously. These may be registered together using rigid and affine algorithms, as appropriate. A wide range of manual, predefined and semi-automated region of interest creation techniques allow quantitative analysis of the data, including visualization of time activity curves and line profiles. Image data can be exported in DICOM format while graphs and image snapshots can be captured to the clipboard as image files or as movie files (as appropriate) and numerical data can be exported as text files.

Inveon Pharmacokinetic Modeling Option

The functionality of the core kinetic analysis workflow can be extended by the addition of pharmacokinetic analysis tools to further analyze time activity data. This option provides a range of standard pharmacokinetic models integrated within the kinetic analysis workflow allowing easy analysis of one or more regions of interest with the same

model simultaneously. Any necessary input functions may also be defined from the loaded image data or alternatively loaded from an external file. The models available include:

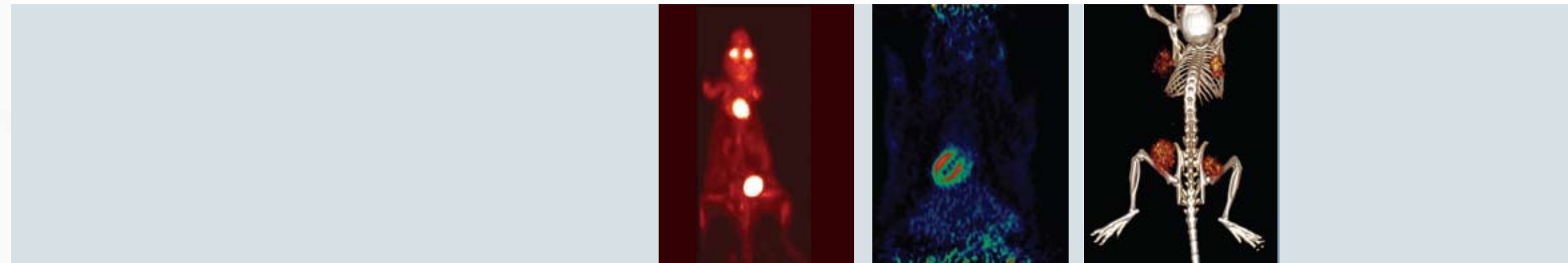
- Two compartment reversible
- Two compartment irreversible
- Patlak
- Reference Patlak
- Logan
- Reference Logan
- Multiple Exponential
- One tissue compartment model
- Simplified reference tissue model

The results of each model are displayed in both graphical and tabular forms. The quality of the model fit can be assessed from the displayed statistical values such as the Chi-squared error and the correlation coefficient between the fitted parameters.

Additionally, some of the models can be used to generate parametric images from dynamic data sets. Kinetic models available for parametric imaging are:

- Patlak
- Logan
- Reference Patlak
- Reference Logan

Once calculated, parametric images are displayed in the standard orthogonal views and can be viewed or overlaid on the original dynamic data and/or associated anatomical data.



Data courtesy of the University of Wisconsin, Madison, WI

Data courtesy of Eberhard Karls University Tuebingen, Tuebingen, Germany

Data courtesy of the University of Wisconsin, Madison, WI

Inveon 3D Visualization and Analysis Option

The Inveon 3D Visualization and Analysis option allows 3D fusion viewing of multiple static or dynamic volumes simultaneously of any modality. Additional support is included for the display of both thick orthogonal slices and oblique multiplanar reformatting. Movies of clipping and rotating 3D objects can be created and exported. Available as a native 64-bit application, the software is capable of displaying very large data sets (limited only by the amount of memory installed on the workstation). A range of tools to define regions of interest are included

within the 3D Visualization software. These tools allow the definition of ROIs both for quantification purposes and for 3D display. ROIs can also be readily interchanged with the general and kinetic analysis workflows. Included in this software is a specialty tool which enables the analysis of trabecular bone parameters. The following calculations are available:

- Bone Volume/Tissue Volume
- Bone Surface/Volume
- Trabecular Thickness
- Trabecular Number
- Trabecular Spacing
- Trabecular Pattern Factor

Inveon CT Research Workplace

The Inveon CT Research Workplace is an alternative version of the Inveon Research Workplace dedicated to the image review and analysis of CT data only. This package combines both a CT analysis workflow (similar to the Inveon General Analysis workflow) and a CT 3D Visualization workflow (a CT-only version of the 3D Visualization and Analysis option).

Inveon Acquisition Workplace

Inveon Acquisition Workplace provides versatile data acquisition and reconstruction on a totally integrated platform. Providing easy-to-use Protocol and Workflow Builders, Inveon Acquisition Workplace seamlessly integrates PET, CT, and SPECT acquisitions and reconstructions on a single software platform from one console.

PET

- Easy-to-use planning wizards
- List mode data format to allow for flexible rebinning and reframing
- Dual gated dynamic imaging
- Rebinning
 - Fourier rebinning
 - SSRB

- 2D reconstruction methods
 - 2D-FBP
 - 2D-OSEM
- 3D reconstruction methods
 - 3D-RP
 - 3D-OSEM
 - 3D-MAP
 - 3D-OSEM+MAP
 - 3D-OSEM+fastMAP™
- Corrections
 - Normalization
 - CT-based attenuation correction
 - ⁵⁷Co based attenuation correction (Dedicated PET only)
 - Scatter correction
 - Decay correction
 - Deadtime correction
 - Pileup rejection
- Continuous bed motion acquisition*, and step and shoot

CT

- Easy-to-use planning wizards
- Modified Feldkamp reconstruction
- Real-time high speed image reconstruction

SPECT

- Easy-to-use planning wizards
- List mode data acquisition
- Reconstruction methods
 - Parallel hole OSEM
 - Single and multi-pinhole 3D-OSEM
 - Single and multi-pinhole 3D-MAP

Extended Options



Additional Inveon options are available for expanded versatility and ease of use:

Physiological Monitoring and Heating System

The BioVet® (m2m Imaging) is a physiological monitoring and heating system designed for use in preclinical imaging applications. The BioVet system is designed for physiological monitoring and gating of imaging sequences by physiological events (respiration and/or ECG) within the animal study. The BioVet temperature regulation unit is used to regulate the temperature of anesthetized animals.

Isoflurane System

This portable small animal anesthesia system by Summit Anesthesia Solutions was designed specifically for use in small animal laboratory research. This modular unit includes a removable compact anesthesia system mounted on a rolling stand which holds two E-tanks of oxygen. Complete with a new Tec 3 style vaporizer, rodent induction chamber, and a Mapleson-D non-rebreathing system specifically tailored for use on the Inveon. This configuration is self-contained, easily transported, and readily stored while not in use.

With the most comprehensive capabilities in the industry, Siemens Molecular Imaging can help you stay ahead in the race to personalized medicine. We lead the market in clinical, preclinical, and biomarker solutions. Enabling diagnosis and treatment to be more targeted. More cost-effective. And more successful than ever before. Because at Siemens Molecular Imaging, innovation is in our genes.



Imaging system uses a laser device; look for following label on the system.