The Panorama 1.0T open MR system

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Figure 1. The Panorama 1.0T with the FastTrak dockable patient support. The system combines high performance with a truly open design and attractive modern styling.

▶ **Open-magnet MRI systems are less claustrophobic and allow unrestricted access.**

Open-magnet MRI systems are less claustrophobic than cylindrical systems, and allow unrestricted access to the patient. Some patients may refuse to enter a cylindrical magnet, or require sedation. Consequently, patient friendliness is an important consideration, particularly where imaging centers and hospitals have to compete for patient referrals.

On the other hand, field strength plays a major role in determining the quality of the MR images and the speed of the examinations. Until recently, open-magnet systems have suffered from relatively low field strength, resulting in reduced image quality and lower patient throughput than higher-field cylindrical systems, as well as a more limited range of applications. They have also been relatively heavy, with a large fringe field, requiring special - usually expensive - siting arrangements.

▶ **The Panorama 1.0T combines the comfort of an open system with the power of high-field MR.**

Philips Medical Systems has more than a decade of experience in open MR with the Panorama 0.23T and Panorama 0.6T low- and mid-field systems, and has channeled the company's extensive research and development facilities into the development of a commercially available product combining the patient comfort of an open system with the applications power of high-field cylindrical MR.

After extensive testing at the Philips Medical System's site in Best, the Netherlands, the first commercial version of the new system has now been installed at the Nevada Imaging Centers in Las Vegas. In this article we describe the philosophy behind the new system, its features, and the results obtained to date.

The Panorama 1.0T

The Panorama 1.0T (Figure 1) is a high-performance, truly open system, with an image quality equivalent to that of a 1.5 T cylindrical system. Through active shielding, the system is relatively light in weight, with a small fringe field, allowing it to be installed in an existing department without additional high siting costs.

The compact dimensions of the system are accentuated by attractive modern styling.

FreeWave data acquisition
Like the Philips Achieva high-field cylindrical systems, the Panorama 1.0T works with FreeWave data acquisition, and advanced SENSE™ ultrafast parallel acquisition. The powerful multichannel scalable FreeWave architecture is prepared for new and future applications, including next-generation SENSE™ functionality, new multi-channel SENSE™ coils, and IView functional imaging.

Enhanced workflow
Panorama 1.0T shares the same back end and easy-to-use ExamCards as the Achieva high-field cylindrical systems, so that operators can easily transfer from one system to the other. The ExamCards speed up workflow by delivering an

integrated sequence of protocols for a complete examination, at the touch of a button. They carry a large amount of clinical information, and can be edited and customized. Setting up an examination needs far fewer operator actions, there are fewer mistakes (e.g. wrong or overlooked scans) and training is much easier. ExamCards can also be exchanged via the internet.

The ExamCards are grouped in anatomical areas, such as Head CNS, giving a clear overview of scans in a particular brain study, e.g. "Standard Brain". Operation is truly intuitive.

The Panorama 1.0T is supported by Philips User Networks and Philips NetForum. On-line connection to NetForum enables users to keep abreast of new developments and advanced applications, and to electronically exchange ExamCards with other users and with Philips Medical Systems.

Panorama 1.0T is part of Philips' vision for the future, where many routine examinations can now be done quickly and efficiently with the open, patient-friendly Panorama 1.0T.

Open design
The Panorama 1.0T has been designed to provide maximum patient comfort and access. The patient gap is 160 cm wide and 45 cm high, with virtually 360° access. The panoramic viewing angle means that patients can always see outside the magnet during MR examinations, eliminating claustrophobic effects. The state-of-the-art design also gives the operator easy patient access and optimal patient visibility.

FastTrak patient support
The mobile, dockable FastTrak patient support facilitates fast, easy patient preparation and transport. Patients can be fully prepared away from the magnet, reducing patient anxiety, and in busy departments a second (optional) FastTrak can be used, allowing one patient to be prepared while another is being examined. The table has a width of 80 cm, with an extensive longitudinal movement of 285 cm, and a transverse movement of 62 cm. The wide tabletop comfortably accommodates all patients, while its ergonomic design with extensive horizontal and vertical movement capabilities ensures fast, easy patient preparation and transport.

Isocentric imaging
The longitudinal movement allows whole-body coverage from head to toe, while the transverse movement allows the region of interest to be positioned at the isocenter for optimum image quality.


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Figure 2. The longitudinal movement of the FastTrak allows whole-body coverage (T2-weighted imaging with Integrated Dual Quadrature Body Coil).
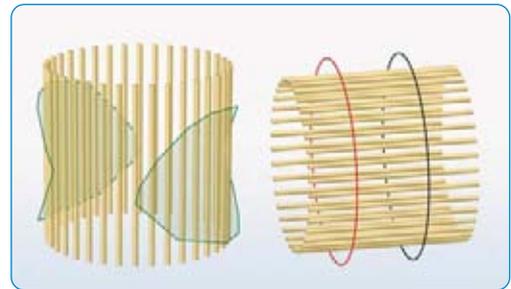
▶ **The Panorama 1.0 T has been designed to provide maximum patient comfort and access.**

▶ **The Fast Trak patient support allows whole body coverage.**

Figure 3. Phantom and coil layout for vertical field (left) and horizontal field (right). Arrows indicate direction of B₀.
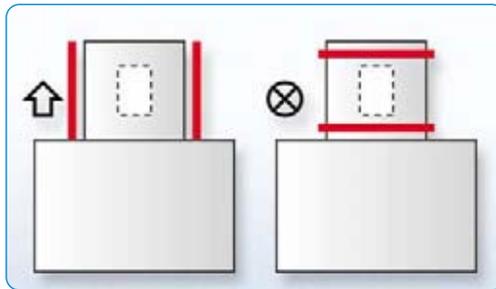
Figure 4. Coil layout: vertical (left) and horizontal (right).

Table 1. Signal-to-Noise ratio with different coil configurations.

Phantom study	1.0T cylindrical	1.5T cylindrical	Panorama 1.0T
SNR in center	47.0	63.3	60.1

While docked at the magnet, FastTrak can be controlled from both the operator's console or from the System Control Units (right or left) at the magnet. Physiology monitoring, receive coil connectors, controls for vertical height adjustment, foot brake and tabletop release button are all integrated in the FastTrak.

A complete set of positioning accessories are provided, including mattress, headrest, knee support, sandbags and positioning wedges.

Advanced magnet system
The Panorama 1.0T's unique magnet system has been designed to meet three major requirements: 1.0T field strength for optimum soft tissue contrast, high-field clinical performance, and maximum patient comfort. The open design, in combination with the extensive transverse table movement, enables high-quality imaging of off-center anatomical structures.

Active shielding
The magnet contains two concentric super-conducting coil sets. The inner set produces the main magnetic field, while the outer set reduces the fringe field outside the magnet to the minimum.

High homogeneity
Passive shimming ensures high magnetic field homogeneity with excellent gradient linearity, providing excellent image quality over large volumes with a 45 cm FOV.

Image quality comparable to 1.5T conventional system
Experimental comparison [1] of the Signal-to-Noise ratio (SNR) of the receive coils of the 1.0T open MR system (vertical field) with those of cylindrical systems (horizontal field) have shown that the image quality is comparable to that of a 1.5T horizontal-field system. The reason for this is that most of the coil elements of a vertical-field MR system enclose the object, while in a cylindrical system the coil elements form loops at the surface of the object (Figure 4).

Since the enclosing coil elements of the open system have a higher filling factor, their SNR is generally better [1,2]. This has been both measured and simulated [3]. The imaging results and the simulation show the same trend: the receive coils for a vertical field system are more efficient than the ones for horizontal field systems. Table 1 shows that the SNR of a 1.0T vertical field system (Figure 3a) is fully comparable to that of a 1.5T horizontal field system (Figure 3b).

Coils
Integrated body coil
An integrated body coil produces very high-quality images, often without the use of surface coils. As a result, set up is extremely fast, and multistation whole-body imaging can be performed without the need to change coils.

Standard RF coils
Panorama 1.0T RF coils have built-in preamplifiers in all receiver coils, while the Panorama 1.0T Synergy and SENSE™ coils have built-in pre-amplifiers in all coil elements. The advantages include:

• Optimum SNR
• No RF coil matching required prior to scan
• Fixed tuning for all rigid coils
• Fast, fully automatic tuning for all flexible coils.
• Built-in decoupling circuitry enabling several coils to be connected at the same time.
• Dedicated preset procedures are included in the software.

RF receive coil connectors are integrated in the FastTrak patient support.

A 4-channel SENSE Head coil is delivered with the system, and a full range of optional SENSE™-compatible coils is available.

▶ **The unique magnet system combines high-field performance with open design.**

▶ **The 1.0T vertical field provides image quality comparable to that of a 1.5T horizontal field.**

4-channel SENSE Head coil

The 4-channel SENSE Head coil provides high-resolution (1024^2) brain imaging, including vascular imaging. The coil can be split into two sections, anterior ans posterior, for easy positioning. The coil design combines good homogeneity with maximum openness, avoiding claustrophobic effects.

FreeWave data acquisition system

At the heart of the Panorama 1.0T is FreeWave, a fully digital broadband data acquisition system. FreeWave is designed to scale up to 16 independent RF channels. The system is initially available with 8 channels. Its revolutionary new fully digital broadband RF receivers enable FreeWave to handle any combination of independent quadrature RF coil elements, allowing full use of SENSE™ parallel imaging technology. FreeWave's powerful architecture supports new imaging techniques, real-time feedback mechanisms and a new generation of multi-channel SENSE™ coils.

FreeWave is the first commercially available data acquisition system to provide:

• Direct Digital sampling
• True Live MR imaging
• 3 MHz channel bandwidth
• Scalable architecture

Direct Digital sampling

FreeWave monitors the MR signal in real-time. This allows it to directly sample the signal, thereby avoiding the analogue processing steps necessary in conventional MR systems. The digital signal resulting from this Direct Digital sampling is extremely pure with an excellent Signal-to-Noise ratio.

True Live MR imaging

Another benefit of FreeWave's speed is that it enables true live MR imaging. It uses real-time navigators to monitor patient motion and it instantaneously (i.e. within a single TR) fine-tunes the acquisition to ensure optimal image quality.

3 MHz bandwidth

FreeWave's 3 MHz channel bandwidth virtually eliminates bandwidth limitation. A single FreeWave channel can process the same quantity of information as three conventional 1 MHz channels or even six quadrature channels. As a result, FreeWave's 16-channel configuration is equivalent to 48 1 MHz quadrature channels. This not only meets the requirements for the most advanced modern techniques, but also anticipates the techniques of the foreseeable future.

Short TE and TR values

FreeWave's 3 MHz channel bandwidth allows it to exploit Philips' gradients to their full potential, resulting in extremely short TE and TR values. This offers the potential for significant improvements in such applications as perfusion, lung imaging and MRA.

Scalable architecture

The Panorama 1.0T's FreeWave architecture features a scalable number of transmitters, receivers and reconstructors, making it fully prepared for future developments in multi-channel technology.

Currently, the spectrometer supports the simultaneous use of up to eight receiver channels. The Panorama 1.0T's Synergy and SENSE™ RF coils utilize FreeWave for increased coverage and better SNR than conventional surface coils, while the SENSE™-optimized coils enable revolutionary faster image acquisition.

Computer control

The Panorama 1.0T's computer uses an innovative parallel multiprocessor design to achieve the speed and capacity needed for advanced research and clinical operation. Separate processors control scanning, reconstruction and the Operators' Console to allow simultaneous operation for improved efficiency, flexibility and streamlined data management.

In addition to the RapidView reconstruction speed of more than 1200 images per second, the system supports true parallel scanning and reconstruction.

QuickPlanning in 3D displays three simultaneous images for rapid scan planning while QuickStart saves time in patient tuning. Hard copies can be created with a click on the mouse.

The Panorama 1.0T's computer supports a whole range of DICOM networking features, ensuring easy integration into any department or large institute.

Operator's console

The operator's console consists of a high-resolution liquid crystal display (LCD) color monitor with large viewing area for all image display and operator dialogue. A two-way intercom provides easy communication with the patient. The desk provides ample space for both the user interface devices and all paperwork.

Fast and efficient workflow

The Panorama 1.0T incorporates a range of features for a fast and efficient workflow.

▶ **FreeWave meets the requirements for the most advanced techniques now, and in the future.**
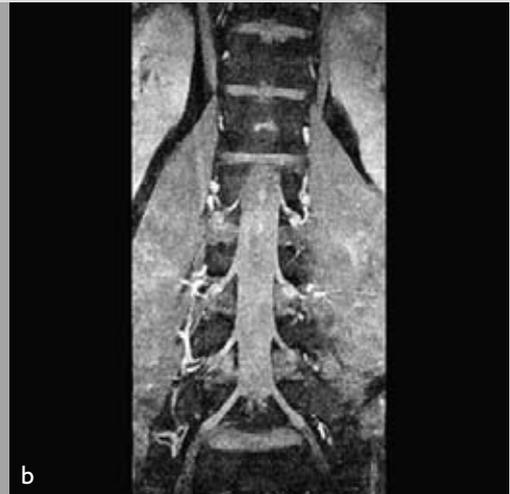
▶ **Multiprocessor design achieves true parallel scanning and reconstruction.**

▶ **The Panorama 1.0T's computer supports a whole range of DICOM networking features.**

Figure 5. T2-weighted TSE, 3 mm slice thickness.

Figure 6a. Spine imaging using the Integrated Dual Quadrature Body Coil. Lumbar spine: sagittal view.

Figure 6b. Spinal cord: coronal view made with the Body/Spine coil.

a

b

Figure 7a. T2-weighted TSE Cervical spine: sagittal view.

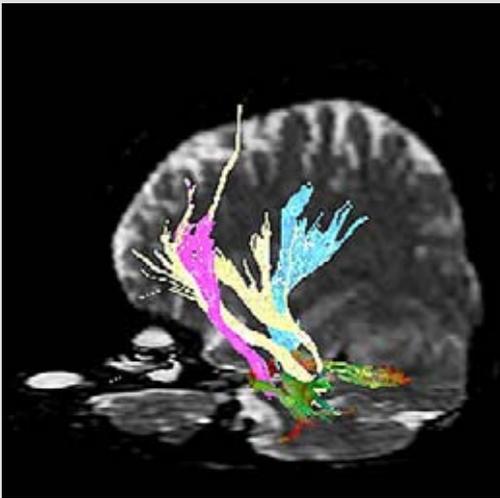Figure 7b. Brain: axial view.

a

b

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Figure 8. Brain fiber tracking with
diffusion-tensor MRI
(Not available in the U.S.A.)

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Figure 9. High-resolution inflow
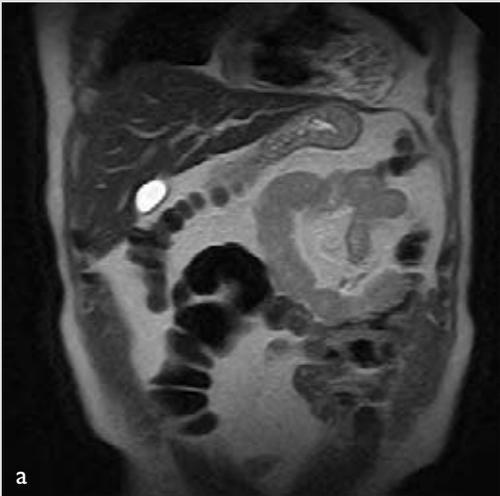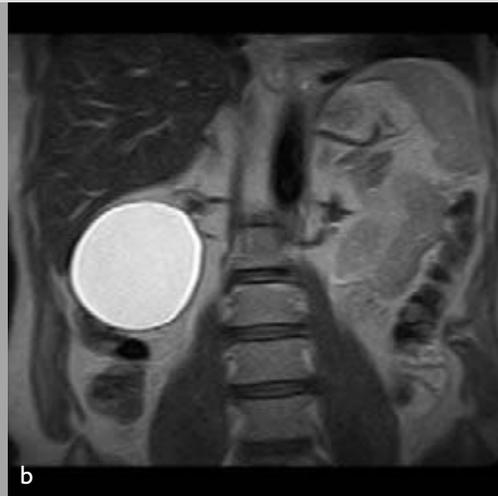using SENSE™; scan time 5:10 min.

a

b

Figure 10. Abdominal imaging.

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Figure 10a. Single-shot TSE;
scan time 8 s.

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Single-shot TSE.

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Figure 11. High-resolution T1
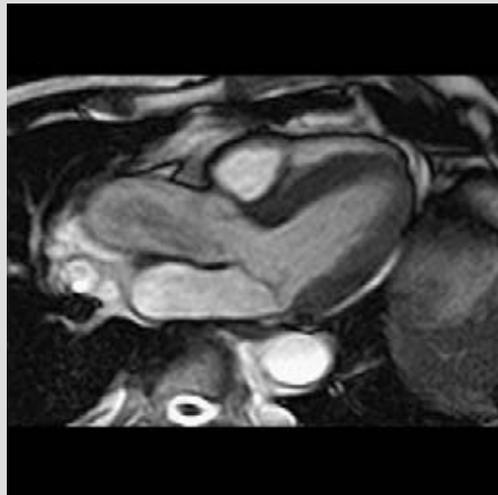weighted TSE; 100 mm field of view.

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Figure 12. Cardiac imaging.
Left ventricle outflow tract;
12 s breath hold.

ScanTools

ScanTools, the Panorama 1.0T's clinical applications software, consists of a comprehensive suite of imaging, viewing, processing, patient administration, data storage and connectivity features, optimized to deliver uncompromised clinical imaging performance, workflow and ease of use. Some of ScanTools' extensive capabilities are described below.

ScanForum

ScanForum is the Panorama 1.0T's new, intuitive user interface providing comprehensive scanning, viewing, archiving, and printing functionality. Designed to enable quick and easy operation of all scanner functions by simple mouse clicks, its multi-tasking capabilities allow a single operator to achieve high patient throughput.

Moreover, it is fully compatible with the Philips Vequion harmonized user interface, ensuring consistency with other Philips diagnostic imaging modalities, facilitating staff training and ease of use across the department.

ScanForum employs ExamCards to make complete examinations selectable at a single mouse click. An ExamCard contains a list of the procedures required for a particular exam, saving operator time and ensuring consistency. The system is supplied with a comprehensive set of ExamCards. These ExamCards can be further modified and/or extended according to the user's wishes. Once an ExamCard is selected and started, the system will automatically perform all the defined procedures, pausing only for operator input where necessary (for example, to confirm patient table movement).

While the complete examination is defined by its ExamCard, the operator still has the flexibility to modify settings, whether they are individual procedures within the ExamCard or parameters of the procedures themselves. The MR parameter sets of the protocols have been carefully established and clinically tested to achieve the optimum image quality in the shortest possible scan time.

NetForum

Philips is known for its tradition of MR User Network meetings that ,bring together our MR users worldwide, strengthening our clinical partnerships and building a community that is focussed on best practice MR. Now Philips takes these user networks online with the new NetForum Community to give our MR users access to best-practice clinical knowledge and expertise, anywhere, anytime. And that includes contributions from expert users around the world.

With NetForum, you can download ExamCards directly into your MR scanner- a great way to learn from the experience of others. You can use ExamCards in their original form, or you can customize them to suit your own preferences and specific clinical needs.

Remote View and Remote Assistance enable remote support from applications or service specialists. For security reasons, the user must explicitly grant the remote support specialist permission to view the screen.
Mouse control by the remote support requires a second permission.

ViewForum

ViewForum is Philips' multi-modality environment for integrated viewing and processing. The optional ViewForum workstation integrates seamlessly with the Panorama 1.0T console, enhancing scanner workflow and productivity. ViewForum provides an interactive viewing environment that allows users to customize their virtual working environment using worklists, personalized display protocols (role-based access that maintains security and presents only the information that the user requires. ViewForum is the launch pad for a variety of optional clinical applications.

ScanTools clinical packages

ScanTools includes seven clinical application packages, each with pre-defined ExamCards that provide protocols for complete exams for all application areas at the touch of a button:

• NeuroPlus Package
• CardiacPlus Package
• OrthoPlus Package
• BodyPlus Package
• AngioPlus Package
• OncoPlus Package
• PediatricPlus Package.

Imaging techniques

ScanTools provides a wide array of imaging techniques for all common MR studies such as total-body imaging, spine, brain, angiography, gastointestinal, orthopedic and even cardiac examinations (Figures 5-12).

SENSE™

SENSE™, Philips' revolutionary parallel imaging technology, increases imaging speed in all applications. ScanTools provides SENSE™ with a speed increase of a factor of two for all sequences. With the optional SENSE™ Performance package, imaging speed can be increased up to a factor of eight. SENSE™ offers the CLEAR coil uniformity correction technique, optimizing

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▶ **ScanTools software provides optimized imaging, workflow and ease of use.**

▶ **ExamCards make complete examinations accessible at a single mouse click.**

▶ **NetForum provides easy and secure information sharing with Philips and with other users.**

image quality when imaging with multi-channel SENSE™ coils.

SENSE™ parallel imaging achieves much faster scanning, revolutionizing motion and time sensitive studies, enabling higher resolution and/or more slices.

Connectivity

The Panorama 1.0T fits seamlessly into any network environment with standard DICOM functions for storage, retrieval and printing. Features such as Autopush maximize efficiency, transferring images as soon as they are reconstructed.

The Panorama 1.0T optionally supports functions required by IHE (the RSNA / HIMSS initiative for Integrating the Healthcare Enterprise) through query of Modality Worklists, reporting of the Modality Performed Procedure Steps and recognition of archived images with storage commitment.

Conclusion

The Panorama 1.0T is a high-performance, truly open system, combining easy access and a non-claustrophobic patient environment with a performance equivalent to that of 1.5 T cylindrical system. It shares the robust Philips Achieva platform, combining the advanced features of the top-class Achieva systems with an open environment that is appealing to both patients and physicians. Active shielding combines a small fringe field with lightweight construction, allowing the Panorama 1.0T to be installed in an existing department without additional high siting costs ■

▶ **SENSE™ parallel imaging technology increases imaging speed in all applications.**

▶ **The Panorama 1.0T combines open access with the performance of a 1.5T cylindrical system.**

References

[1] Xu S, Gade TPF, Matec C, Zakian K, Alfieri AA, Hu X. *In Vivo Multiple Mouse Imaging at 1.5 T.* Mag Res Med 2003; 49: 551-557.
[2] Ballon et al. Mag Res Imag 1989; 7: 155-162.
[3] Ham K, Warntjes M, Gulpers S. *Comparison of Image Quality between Open and Cylindrical Systems.* ISMRM 2004.