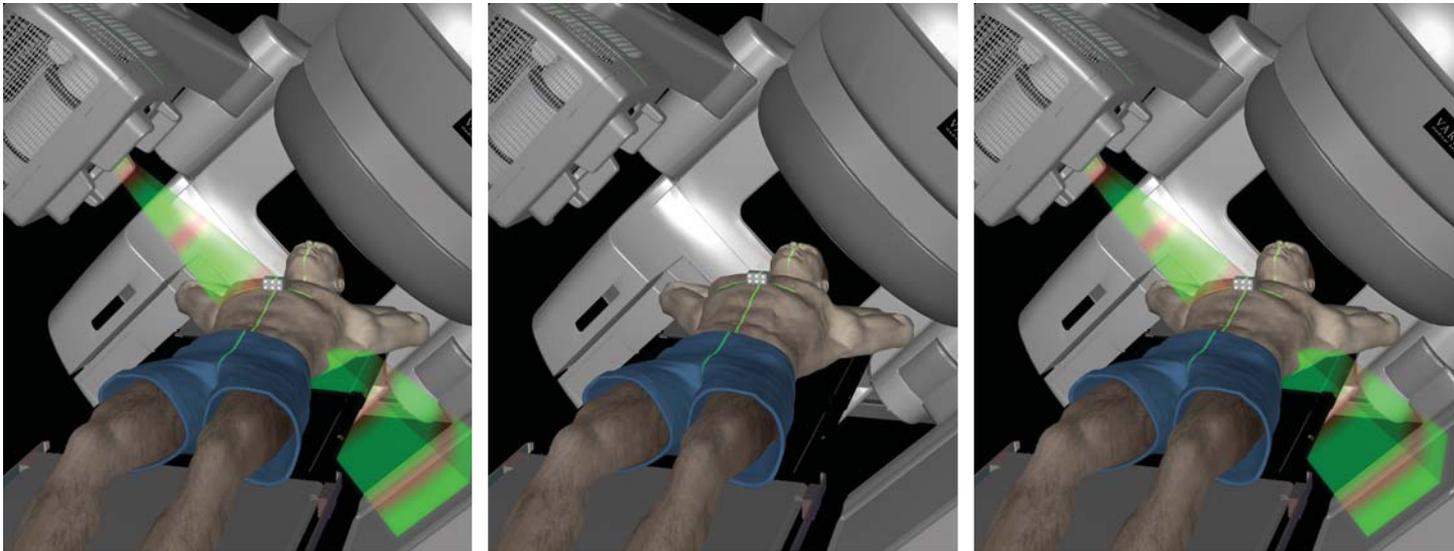


Real-time Position Management™ System

COMPREHENSIVE SYSTEM FOR TOTAL MOTION MANAGEMENT



RPM gates the imaging and treatment beams on and off at predetermined intervals based upon the patient's breathing pattern, and also detects unexpected motion in any direction.

Key features

- > Respiration-synchronized imaging and treatment
- > 3D real-time patient position monitoring detects unexpected motion
- > Patient-friendly system eliminates the need for breath holding
- > Versatile – interfaces with CT, PET/CT, PET, On-Board Imager® kV imaging system, and PortalVision™ MV imaging system
- > Pretreatment fluoroscopic verification of gating
- > Supports all standard breathing protocols, including free-breathing
- > Easy to use, easy to learn
- > Backed by Varian experience and world-class customer support

The Varian Real-time Position Management™ (RPM) system is a patient-friendly, video-based system that compensates for target motion, enabling improved imaging and treatment in areas such as lung, breast and upper abdominal sites. RPM is accurate and easy-to-use, and provides both respiratory gating for respiration-synchronized imaging and treatment, as well as 3D real-time patient position monitoring. It is comfortable for the patient and accommodates all clinical breathing protocols, including free-breathing.

How it works

RESPIRATION-SYNCHRONIZED IMAGING AND TREATMENT

RPM Respiratory Gating technology enables correlation of the tumor position with the patient's respiratory cycle. Using an infrared tracking camera and a reflective marker placed on the patient, the system measures the patient's respiratory pattern and range of motion and displays them as a waveform.

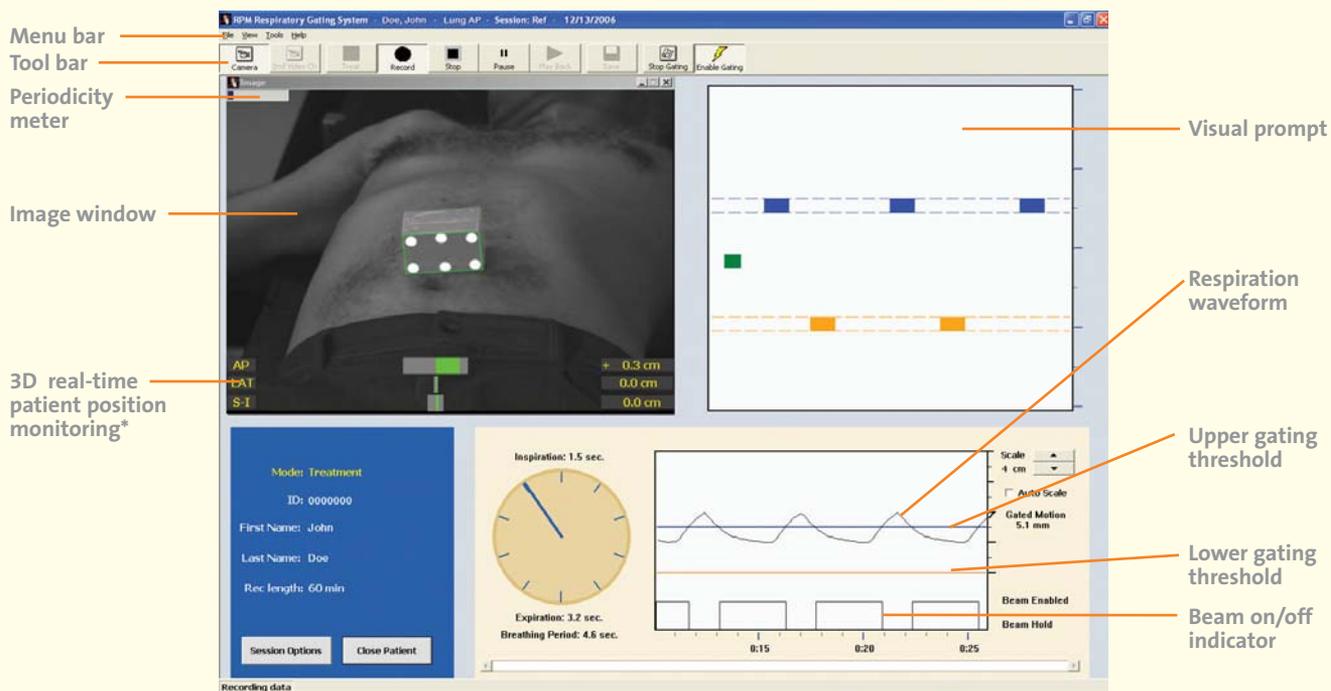
Once it is determined how the tumor moves in relation to the waveform, gating thresholds can be set along the waveform to mark when the tumor is in the desired portion of the respiratory cycle. These thresholds determine when the automatic gating system turns the treatment beam on and off. Gating the beam allows for patient-specific treatment margins, rather than population-based margins, and may permit an increased prescription dose to the tumor, while reducing dose to the surrounding tissues. In addition, patients may breathe normally throughout treatment.

3D REAL-TIME PATIENT POSITION MONITORING*

In addition to respiratory gating, **RPM Patient Position Monitoring** tracks the position of the marker block in three dimensions (vertical, longitudinal and lateral). Any unexpected movement of the marker block, in any direction, reflects unexpected movement of the patient and tumor relative to the treatment field. The ability to detect unexpected motion provides additional confidence that the target is always precisely positioned in the treatment aperture, and that the correct dose will be delivered to the tumor, as planned.

** 3D real-time patient position monitoring requires a six-dot marker block.*





RPM software runs on the PC workstation. RPM workstations are networked to a multi-user gating database.

MAJOR COMPONENTS OF THE RPM SYSTEM

Infrared tracking camera

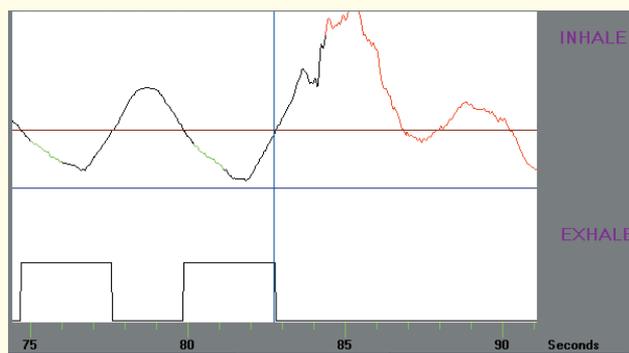
The infrared tracking camera is a video camera equipped with an array of LEDs that emit infrared light in the direction in which the camera is pointing. Dots on the marker block reflect the infrared light back to the camera, which captures the signal. The software then uses this signal to track and analyze the motion of the dots, which corresponds to motion of the chest or abdomen.

Marker block

The marker block is a lightweight plastic box available with either two or six reflective dots on one side. The marker block is placed on the patient within view of the tracking camera, usually between the umbilicus and the xiphoid. It should be placed at the same location during imaging for planning and simulation, and throughout the treatment course. The six-dot version of the marker block is required for 3D real-time patient position monitoring.

Predictive Filter

The patented Predictive Filter, a crucial part of the RPM software, monitors and predicts the patient's breathing pattern. Once the pattern has been established, the Predictive Filter continuously verifies that this pattern is being followed. If the patient coughs or otherwise interrupts the predicted breathing pattern, the Predictive Filter detects the interruption and RPM instantly gates the beam off.



The Predictive Filter automatically turns the beam off when respiratory motion deviates from the established pattern, as shown here during coughing.

* 3D real-time patient position monitoring requires a six-dot marker block.

RPM is in routine clinical use worldwide. Here is an overview of the clinical process:

PATIENT SELECTION

When RPM is used with the Acuity™ treatment planning, simulation and verification system, evaluating patients for gated treatments is a simple and straightforward process. RPM integrates with the fluoroscopic mode of Acuity to establish the extent of the patient's respiratory motion and the stability of breathing.



The Acuity system is used to select patients and adjust gating thresholds.

IMAGING FOR TREATMENT PLANNING

Before and during image acquisition, stable breathing is established with the aid of RPM.

Prospective gated imaging

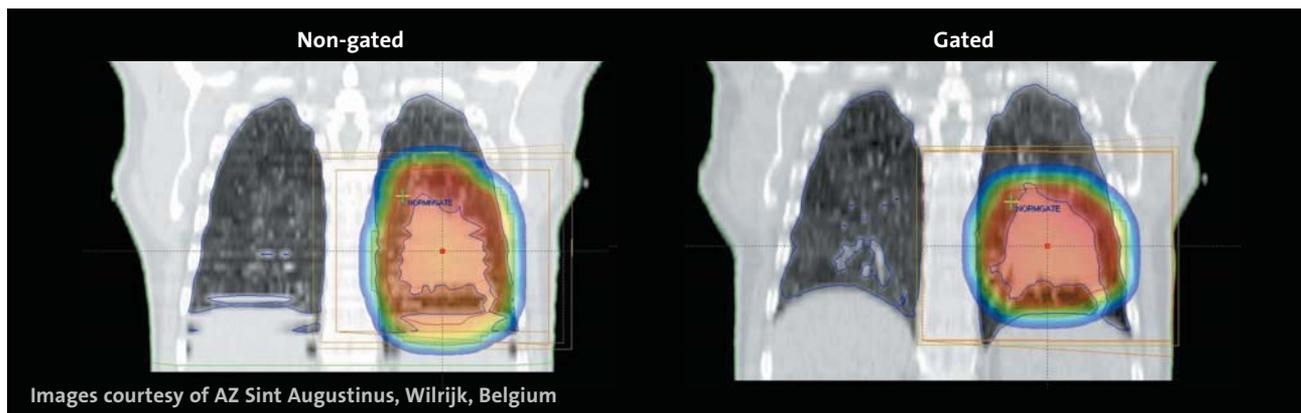
In prospectively gated imaging, the CT scanner uses the RPM trigger signal to synchronize image acquisition with respirations. The therapist determines the gating thresholds before the scan, and the scanner acquires images when the marker block (tumor) is within the defined thresholds. The result is a single gated volumetric data set.

Retrospective image acquisition

In retrospective image acquisition, the CT scanner acquires images continuously, and the scan is acquired through at least one respiratory cycle at each couch position. Following image acquisition, the CT image set is synchronized with the RPM reference motion file. The images are sorted into the corresponding phase bins of the respiration cycle, and are then evaluated to determine the optimum phase for treatment. The selected phase bin of images is sent on to treatment planning.



RPM, shown here with the GE LightSpeed™ RT CT Scanner.



In these treatment planning images from Eclipse, the non-gated image shows motion artifacts in both the normal anatomy and target volume. The gated image shows clear definition of both the normal anatomy and target volume. In the non-gated image, 50% of the prescription dose is given to 49% of the normal lung volume. In the gated image, 50% of the prescription dose is given to 23% of the normal lung volume.

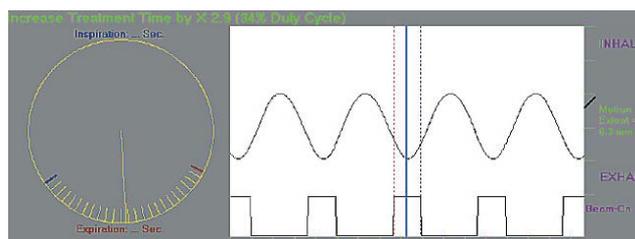
TREATMENT PLANNING

The Eclipse™ treatment planning system displays the motion of targets and critical structures using its optional 4D tools. With this visual information, the clinician can easily design 3D conformal and IMRT treatments, using images that are either retrospectively binned according to the RPM signal or prospectively acquired using RPM gated imaging. In the case of retrospective 4D images, Eclipse automatically registers phase- or amplitude-binned image series together with any corresponding derived image series such as MIP, Min-IP, Average-IP or Free Breathing images.

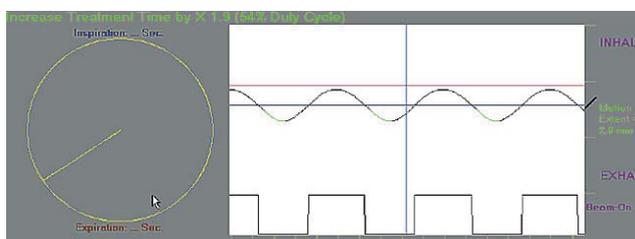
The clinician can view and assess the motion by displaying the 4D image series as movie loops and as blended or “blinking” images. Eclipse’s 4D image display accommodates CT, PET/CT, PET, and images provided from the On-Board Imager. Contouring and field setup are just as fast and efficient as in 3D planning, with the advantage of 4D visualization throughout the planning process.

PRETREATMENT VERIFICATION

The Acuity system allows efficient pretreatment verification of gating thresholds and anticipated gated delivery before setting up the patient on the accelerator for treatment. If adjustments to the gating parameters are required, they can be made in advance of treatment delivery. Acuity supports both 2D and 3D position verification, as well as fluoroscopic evaluation of gating thresholds.



Phase-based gating allows automatic gating of image acquisition and treatment delivery during identical phases of the patient’s respiratory cycle. This image illustrates gating in the exhalation phase.



Amplitude-based gating allows automatic gating based upon the absolute position of the marker block on the patient’s chest or abdomen, irrespective of the phases of the respiratory cycle. This image shows gating at maximum inhalation.

RPM clinical process and workflow: Treatment delivery

TREATMENT DELIVERY

The patient is positioned for delivery with the marker block in the same location on the chest or abdomen as during simulation.

Gated radiograph positioning

This technique is similar to radiographic image positioning with the On-Board Imager (kilovoltage) or PortalVision (megavoltage), enhanced by RPM to enable gated image acquisition. The system automatically acquires radiographs during the pre-determined phase of the respiratory cycle, when the treatment beam is gated on. The gated kV or MV radiograph is then compared to a gated radiograph (DRR) from a 4D CT or gated scan to verify that the patient is correctly positioned.



PortalVision electronic portal imaging system with amorphous silicon detector is mounted on the robotic Exact Arm.

Fluoroscopic pretreatment verification

Fluoroscopy with the On-Board imager is an effective way to verify tumor motion and to ensure that the treatment aperture encompasses the full range of residual target motion.

At the treatment console, a visual representation of the treatment aperture alternates colors between green and red to indicate when the beam will be turned on and off during treatment. Activating fluoroscopy with a footswitch, the therapist qualitatively verifies just before treatment that the marker and gating thresholds are properly set to keep the target precisely aligned within the treatment aperture.

** 3D real-time patient position monitoring requires a six-dot marker block.*



The Clinac iX[®] with On-Board Imager provides gated digital radiographs and pretreatment fluoroscopic verification of respiratory gating.

Gated treatment

The therapist enables RPM Respiratory Gating and modes up the treatment session and treatment field in the usual way. The treatment beam is turned on, and RPM automatically gates the beam on and off instantly according to the selected upper and lower gating thresholds. At the end of treatment, the record of the gating trace and image window can be stored for later review and analysis.

3D real-time patient position monitoring*

RPM Patient Position Monitoring continuously tracks the position of the marker block in all three directions. When the marker block has been positioned in close proximity to the tumor, any unexpected movement of the marker block reflects unexpected movement of the patient and tumor relative to the treatment field. The intuitive 3D position display makes it possible to easily monitor the patient's position, and turn the beam off whenever unexpected changes in position occur, throughout the treatment process.



Easily monitor the patient's position using the intuitive 3D position display.

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