The first complete, integrated solution for IMRT verification
Modern IMRT treatment techniques have found widespread acceptance and implementation in radiotherapy. The dosimetric complexity of such treatments require an accurate verification of the IMRT process.

I’mRT – A unique concept

I’mRT is the brand-new, innovative concept solution for IMRT verification from Scanditronix Welhöfer. I’mRT meets the physicists’ need for a complete, fast and accurate dosimetric verification of the IMRT planning and delivery process, whilst maintaining an efficient patient throughput in clinical routine.

I’mRT – Complete IMRT verification

Whether during implementation of IMRT or for verifications in clinical routine, I’mRT enables an efficient and accurate analysis with a minimum amount of dedicated IMRT devices needed:

- **I’mRT Phantom** is a RW3 water equivalent IMRT phantom for multiple film measurements and verification of the absolute dose. The innovative modular construction allows for Universal Body, Head and Neck and Stereotactic applications.

- **I’mRT QA** is an advanced 2D measurement device for acquisition of both individual as well as integrated IMRT fields. The I’mRT QA system can be attached to the gantry or positioned on the treatment couch. Both for step and shoot and sliding window techniques, the unique spatial and temporal resolution of the I’mRT QA allows for a precise, real-time reconstruction of complexly shaped MLC fields and IMRT distribution patterns.

- **OmniPro™ I’mRT** is a user friendly, intuitive application software for complete IMRT verification. It compares TPS planned data with dose distributions from films that were exposed in the I’mRT Phantom, or with 2D data acquired with the I’mRT QA. Furthermore OmniPro™ I’mRT incorporates application routines for MLC and Linac QA.

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**The I’mRT concept:**

- Complete verification of the IMRT planning and delivery process
- Modular equipment solution:
  - Film dosimetry and verification of the absolute dose with the I’mRT Phantom
  - Real-time acquisition of 2D IMRT fields, MLC and Linac QA data with the advanced I’mRT QA system
  - User friendly, intuitive OmniPro™ I’mRT application software
- High integration into clinical IMRT workflow allowing efficient patient throughput
- Compatible with all Linac/MLC and TPS that support DICOM RT or RTOG formats

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The first complete, integrated solution for IMRT verification!
I’mRT – Modular equipment solution

Data Import: TPS dose maps

OmniPro™ I’mRT
I’mRT Phantom

- Film verification of delivered vs planned dose
- Verification of the absolute dose
- Basic MLC QA
- Linac QA

OmniPro™ I’mRT
I’mRT QA

- Real-time verification of the IMRT delivered vs calculated planar dose
- Verification of individual and integrated IMRT fields
- Advanced MLC QA
- Light vs radiation field congruence
- Linac start-up
- Real-time Linac QA
- Simultaneous inplane and crossplane beam profile adjustment

I’mRT Phantom

I’mRT QA

1) Requires a Vidar, Kodak (Lumisys) or Twain compatible film digitizer.
2) Requires a therapy dosimeter and ionization chamber.
A smart modular phantom solution for IMRT verification

During implementation of IMRT treatments in clinical routines, film dosimetry is used to verify the planned TPS dose versus the measured dose distribution.

The new I’mRT Phantom is a water equivalent phantom for multiple film measurements and verification of the absolute dose. The innovative modular design can be used for Universal Body, Head and Neck and Stereotactic applications.

Universal Body verification
The I’mRT Phantom consists of a universal body shaped section in which up to 15 films can be exposed simultaneously to larger IMRT fields. Subsequent comparison of the film dose distribution with the planned TPS data in the OmniPro™ I’mRT software provides an accurate verification of the IMRT delivery cycle.

- Exposure of multiple films for high accuracy in IMRT verification
- Water equivalent RW3 material
- Modular design for film verification of Universal Body, Head and Neck and Stereotactic IMRT treatment plans
- Easy adjustment under the Linac and in CT scanners
- Absolute dose verification with different ionization chamber types
- Optionally available TLD insert plates
Head and Neck / Stereotactic verification

The modular I’mRT Phantom design also includes a removable cubic phantom that has been developed in cooperation with the University Hospital Hamburg-Eppendorf and Euromechanics. It is specifically designed for Head and Neck and Stereotactic applications.

With film distance plates of 1 cm thickness up to 15 films with a maximum size of 16 x 16 cm can be positioned in a transversal, coronal or sagittal orientation. The cubic phantom docks into the torso, thus restoring the original anthropomorphic shape.

Markers are engraved on the surface of the cube in different colors for easy adjustment of the phantom under the accelerator and in a CT scanner. Optionally, a set of 6 localizer plates is available for the use of the cubic phantom in a CT scanner.

For absolute dose verification different types of ionization chambers can be inserted in the cubic phantom module. Several auxiliary inserts with different depths and for different chamber types are available. In combination with the film distance plates the ionization chambers can be placed at any position in the phantom.

Optionally, one or more TLD plates can be inserted in the cubic phantom, either as stand-alone application or in conjunction with film. Each TLD plate can be loaded with up to 196 TLD detector rods on each side with an individual spacing of 1 cm.
Modern IMRT and conformal therapy techniques have exhausted the limits of conventional quality assurance instrumentation and techniques. The need for patient throughput combined with the complexity of IMRT treatments require advanced technology that allows fast acquisition and verification of a complete IMRT cycle.

The new I’mRT QA is the most advanced system for the real-time 2D verification of IMRT delivery. It combines fast acquisition of complex 2D data with highest temporal and spatial resolution. This makes the I’mRT QA also an ideal tool for fast, advanced MLC and Linac QA. Moreover, the light-radiation field congruence can be measured using a special scintillator.

Data acquisition with the I’mRT QA as well as the subsequent real-time visualization and analysis are fully integrated in the OmniPro™ I’mRT software platform.

A unique 2D acquisition device:

- Easy set-up: ready for measurement in less than 3 minutes
- Gantry mount or patient couch positioning
- Real-time 2D availability of 12 bit data
- Individual as well as complete integrated IMRT fields
- Accurate reconstruction of MLC shaped field through highest spatial resolution available: 0.4 x 0.4 mm²
- Field sizes up to 40 x 40 cm²
- Full integration in OmniPro™ I’mRT application software
I’mRT QA – Concept and operation

The I’mRT QA is an optically sealed system consisting of a copper plate coated with a Gd₂O₂S scintillator screen. The X-rays interacting in the copper plate are converted into light through the high quantum efficiency of the scintillator screen and then mirrored to a high-end lens system and digital CCD camera.

The CCD camera offers a 12 bit data output with a resolution of 820 x 820 pixels. Each pixel element covers an area of 0.4 x 0.4 mm². The shortest sampling time per 2D image is 120 msec and is user selectable in 1 msec intervals. The deadtime between single images is negligible thus enabling the complete recording of a whole IMRT treatment.

By means of an adapter the I’mRT QA can be inserted in the accessory holder of the linear accelerator. In this configuration field sizes of up to 40 x 40 cm² can be acquired at any gantry angle in a continuous or fractionated rotational mode. Alternatively it can be positioned on the treatment couch with a maximum beam monitoring size of 30 x 30 cm² at 100 cm SSD.
OmniPro™ I’mRT is the new, advanced application software for complete dosimetric verification and QA of IMRT treatment cycles.

OmniPro™ I’mRT incorporates the latest software technology to seamlessly import and compare TPS planned data with dose distributions from films that were exposed in the I’mRT Phantom, or with 2D data acquired with the I’mRT QA.

A modern intuitive graphical environment offers 1D, 2D and 3D display modes with different color palettes and convenient cursor analysis functions, thus assuring optimal visualization of the complex IMRT data.

OmniPro™ I’mRT enables fast, real-time verification of measured versus planned IMRT treatment cycles. It includes 1D profiles, 2D isodose profiles as well as fully automated comparisons using state-of-the-art analysis tools such as the Gamma method.

Applications

- Film verification of delivered vs planned dose
- Real-time verification of the IMRT delivered vs calculated planar dose
- Verification of step and shoot and sliding window techniques
- MLC QA
- Light vs radiation field congruence
- Linac start-up
- Simultaneous inplane and crossplane beam adjustment of the linear accelerator

Manual comparison
- 1D profiles
- 2D isodoses

Automated analysis
- Sum
- Difference
- Absolute difference
- Correlation
- Multiplication
- Gamma method
OmniPro™ I’mRT Features

- Intuitive, user friendly graphical interface
- Easy parameter set-up
- Import of planned 2D and 3D data from all TPS supporting DICOM RT and RTOG formats
- Flexible ASCII export and printing functions

I’mRT Phantom data
- Film data from Vidar, Kodak (Lumisys) and Twain compatible film digitizers
- Film and scanner calibration routines
- Absolute dose verification

I’mRT QA data
- Step and shoot or sliding window fields
- Individual and integrated IMRT fields
- MLC QA
- Light vs radiation field
- Linac QA fields
- Linac start-up
- Real-time 2D intensity of the delivery system
- Real-time, simultaneous display and parametrization of 1D inplane and crossplane profiles

Data display
- 1D, 2D and 3D data visualization: profiles, isodose contours, 2D/3D dose distributions
- Different color palette representations
- Extensive cursor analysis functions such as zoom, distance, position etc.
- Region of interest analysis

Verification and analysis
- 1D measured vs planned profiles
- 2D measured vs planned isodose maps
- Automated verification of measured vs planned IMRT data incl. sum, (absolute) difference, correlation, multiplication and Gamma method
- Light vs radiation field congruence
- MLC QA:
  - leaf position verification and reproducibility
  - leaf acceleration and deceleration
  - leaf transmission
  - leaf gravity effects at different gantry angles

Planned 2D/3D dose distribution files and position information can be conveniently imported in OmniPro™ I’mRT from all TPS supporting DICOM RT or RTOG file formats.

OmniPro™ I’mRT incorporates scanning and calibration routines of films that were exposed to an IMRT cycle. Scanners supported in the software include Vidar, Kodak (Lumisys) and Twain compatible scanners.

Excellent display functionality of 1D, 2D and 3D data for increased accuracy and convenient analysis.
Film verification of planned versus measured dose

During the implementation of IMRT treatments in clinical routines, film dosimetry is used to verify the planned TPS dose versus the measured dose. Planned TPS data can be conveniently imported and verified against 2D digitized data from films\(^1\), that were exposed in the I’mRT Phantom. State-of-the-art analysis tools in OmniPro™ I’mRT enable a fast and accurate verification of 1D profiles, 2D isodoses as well as automated comparison routines of measured versus planned data.

Auto analysis tools inclusive Gamma method

Next to the calculation of the sum, (absolute) difference, correlation and multiplication of measured vs planned IMRT data sets, OmniPro™ I’mRT includes the advanced Gamma method\(^2\).

This analysis tool is considered to be the most advanced dosimetric verification in IMRT as it combines the correlation of both the difference between measured and planned dose distribution, as well as their isodose distance. The pass/fail criteria can easily be defined by the user. The Gamma method analysis result is displayed in different gradients of blue (pass) or red (fail) for convenient analysis and localization of dose/distance discrepancies.

\[ \Gamma(x, x') = \sqrt{\frac{(D_m - D_{calc})^2}{\Delta D_{max}^2} + \frac{(x - x')^2}{\Delta x_{max}^2}} \]

\[ \gamma(x) = \min \Gamma(x, x') \forall x' \]

\(^1\) Requires a Vidar, Kodak (Lumisys) or Twain compatible film digitizer

\(^2\) Low, Harms, Mutic and Purdy: A technique for the quantitative evaluation of dose distribution

The integration over an IMRT treatment cycle with the I'mRT QA results in the display of the integral 2D IMRT field. From this distribution any measured 1D profile or 2D isodose contour can be extracted and compared to the calculated TPS planar dose data.

Next to the integral IMRT field delivery, the I’mRT QA can also measure the individual step and shoot or dynamic IMRT fields. In case of an inconsistency between the measured and planned integral field delivery distribution, the individual IMRT field measurements provide efficient information to localize and correct the IMRT delivery parameters.

Because of its unique spatial resolution, complex MLC shaped fields can be accurately measured with the I’mRT QA for subsequent reconstruction and analysis in OmniPro™ I’mRT. Garden fence technique shown in example.

Using a special scintillator the I’mRT QA can measure the light vs radiation field with just two fast images. OmniPro™ I’mRT provides the analysis functions to verify the coincidence between the light and radiation field and to determine the actual field size.
Technical specifications

I’mRT Phantom

Size of complete phantom: 33 (L) x 36 (W) x 18 (H) cm
Carriage and levelling plate: 33 (L) x 44 (W) x 1 (H) cm
Material: RW3
Density: 1.045 g/cm³
Weight: 22 kg

Universal Body section

Number of slabs: 15
Thickness: 1 cm
Film type: ready-packed films
Number of films: up to 15
Film spacing: min. 1 cm
Geometry: transversal
Marking of films: universal Body film marker. 3 marking holes define intersection of film plane with coronal and sagittal planes as well as film orientation.

Head and Neck/Stereotactic cubic section

Dimensions (outer): 18 x 18 x 18 cm
Film size: 16 x 16 cm
Film spacing: min. 1 cm
Number of films: up to 15
Geometry: transversal, coronal or sagittal orientation
Compensation of film thickness: distance plates included: 16 plates with 10 mm, 1 plate with 1 mm, 2 plates with 2 mm and 1 plate with 5 mm thickness
Film preparation: films cut and charged in darkroom
Film marking: manually in darkroom
Ionization chamber inserts: Farmer type (FC65G/P)
Chamber positioning: at all points in the cube within a 1 cm grid (2 cm steps in depth)
Lateral stray bodies: two lateral stray bodies that can be mounted on all sides of the cube Width with stray bodies: 36 cm

Options

Ionization chamber inserts: Compact type (CC13) and inserts for detectors of other manufacturers optionally available
CT localizer plates: set of 6 localizer plates for the use of the cubic phantom in a CT scanner
TLD plate inserts: up to 196 TLD detector rods (Ø 1 * 6 mm) on each side, 1 cm spacing

Minimum Computer Requirements

Operating system: Microsoft Windows
Processor: Pentium at 1300 MHz
Memory: 256 MB RAM (minimum), 1 GB RAM (recommended for real-time intensity mode)
Hard disk: with at least 160 MB available, recommended 40 GB for data archiving
Monitor and graphics: supporting a resolution of 1024 x 768 pixel at True Colour (32-bit)
Ports: 1 free PCI slot for the frame grabber board (when using I’mRT QA), interface to film scanner
Film scanners supported: Vidar VXR 12, VXR 16, VXR 16 DosimetryPRO, Kodak (Lumisys), Twain compatible scanners
Import of planned data: all TPS that support DICOM RT or RTOG formats
### I’mRT QA

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy range:</strong></td>
<td>high energy photons, $^{60}$Co-50 MV X-rays high energy electrons, 4-25 MeV</td>
</tr>
<tr>
<td><strong>Sensitive detector area:</strong></td>
<td>300 x 300 mm$^2$</td>
</tr>
<tr>
<td><strong>Spatial resolution:</strong></td>
<td>0.4 x 0.4 mm$^2$</td>
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<tr>
<td><strong>Distortion:</strong></td>
<td>&lt; 1 mm</td>
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<tr>
<td><strong>Temporal resolution:</strong></td>
<td>1 msec</td>
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<tr>
<td><strong>Minimum sampling time:</strong></td>
<td>120 msec</td>
</tr>
<tr>
<td><strong>Dimensions:</strong></td>
<td>780 x 310 x 397 mm$^3$ (LxHxW)</td>
</tr>
<tr>
<td><strong>Weight:</strong></td>
<td>13.8 kg</td>
</tr>
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</table>

### Scintillators

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation scintillator</td>
<td>1 mm copper</td>
</tr>
<tr>
<td>Light/radiation field scintillator</td>
<td>2 mm PMMA</td>
</tr>
<tr>
<td>Scintillator material</td>
<td>0.4 mm Gd$_2$O$_2$S 0.2 mm Gd$_2$O$_2$S</td>
</tr>
</tbody>
</table>

### Lens

- High end customized lens.
- Corrected distortion: < 5 µm
- Transmission uniformity: < 5% between center and edges
- Relative aperture: 1 : 1.4
- Focal length: 11.7 mm
- Wavelength range: 490 – 650 nm

### Camera

- Interline progressive scan CCD matrix.
- Pixel matrix: 1286 x 1024
- Active pixel matrix: 820 x 820
- Chip size: 2/3" x 2/3"
- Pixel size: 6.7 x 6.7 µm$^2$
- Signal standard: RS644 (LVDS)
- Dynamic range: 0 – 4.095, used 0 – 2.500
- ADC Signal/noise ratio: 63 dB
- Power supply: 90 – 265 VAC (desktop power supply unit)
- Non-linearity: ± 0.5 %

### Adaption frame

Adaption frames for attaching the I’mRT QA to the accessory holder are available for various linear accelerator types.

### Frame grabber board

- PC Interface: PCI
- On board memory: 8 MB
- Interface: RS644 (LVDS)
- Input: 12 Bit digital data

### Connection Cables

- Mains cable: 3 x 0.75 mm$^2$; for USA standard DIN 494; for European standard DIN 49457
- Data cable: max. 30 meters, LVDS cable CSA LL 112842

### Calibration

Each I’mRT QA device is calibrated in $^{60}$Co and 15 MV X-rays.

Technical data is subject to change without prior notice.
Product range

Dosimetry in Radiotherapy
- Relative Dosimetry
- IMRT
- Absolute Dosimetry
- In Vivo Dosimetry
- Software Applications
- Film Dosimetry
- Quality Assurance
- Patient Positioning Lasers

Dosimetry in Radiology
- Patient Dose Monitoring
- QA of Film Processing Units
- QA of X-Ray Units
- QA of Computed Tomography
- QA of Ultrasound Units

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