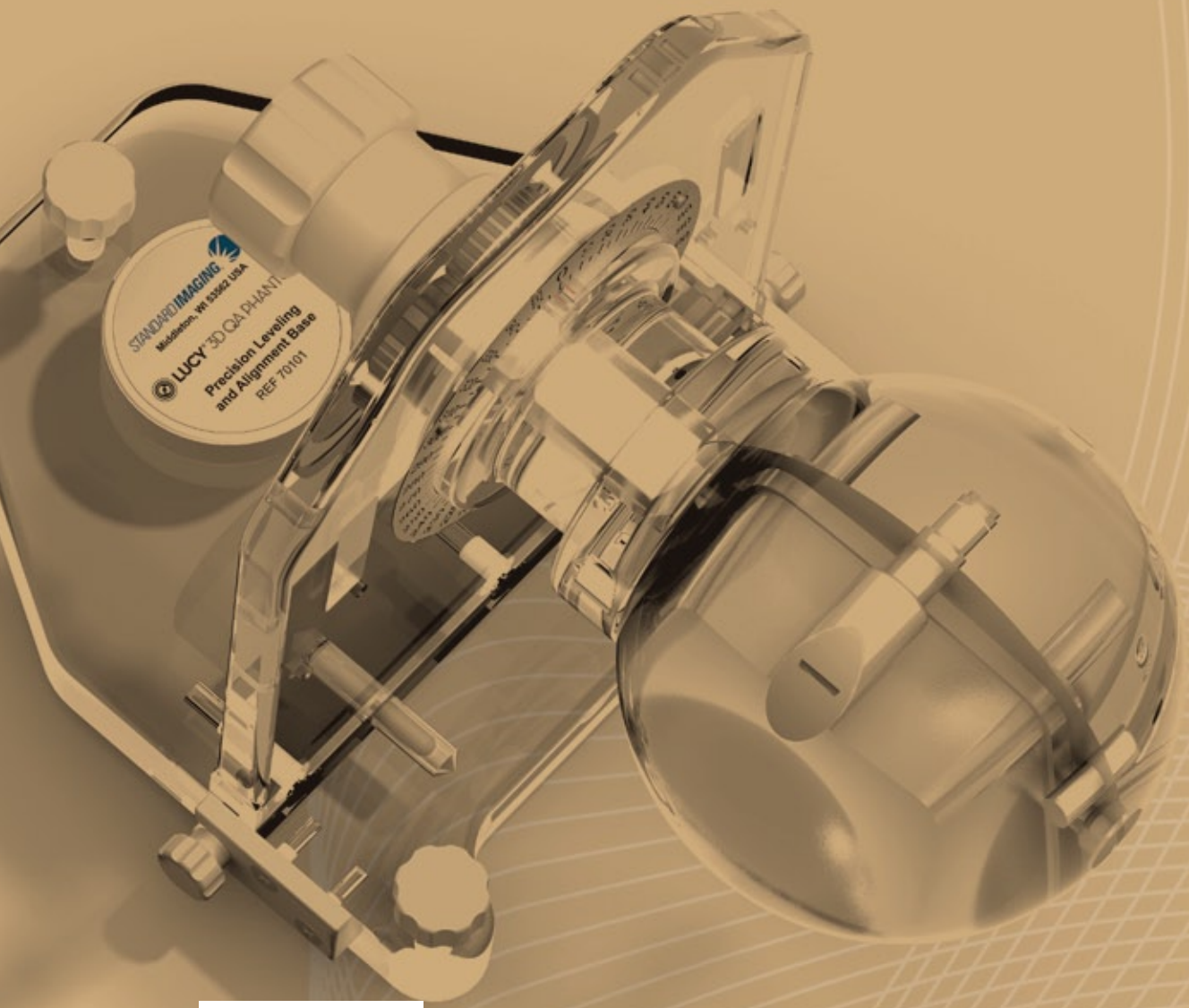
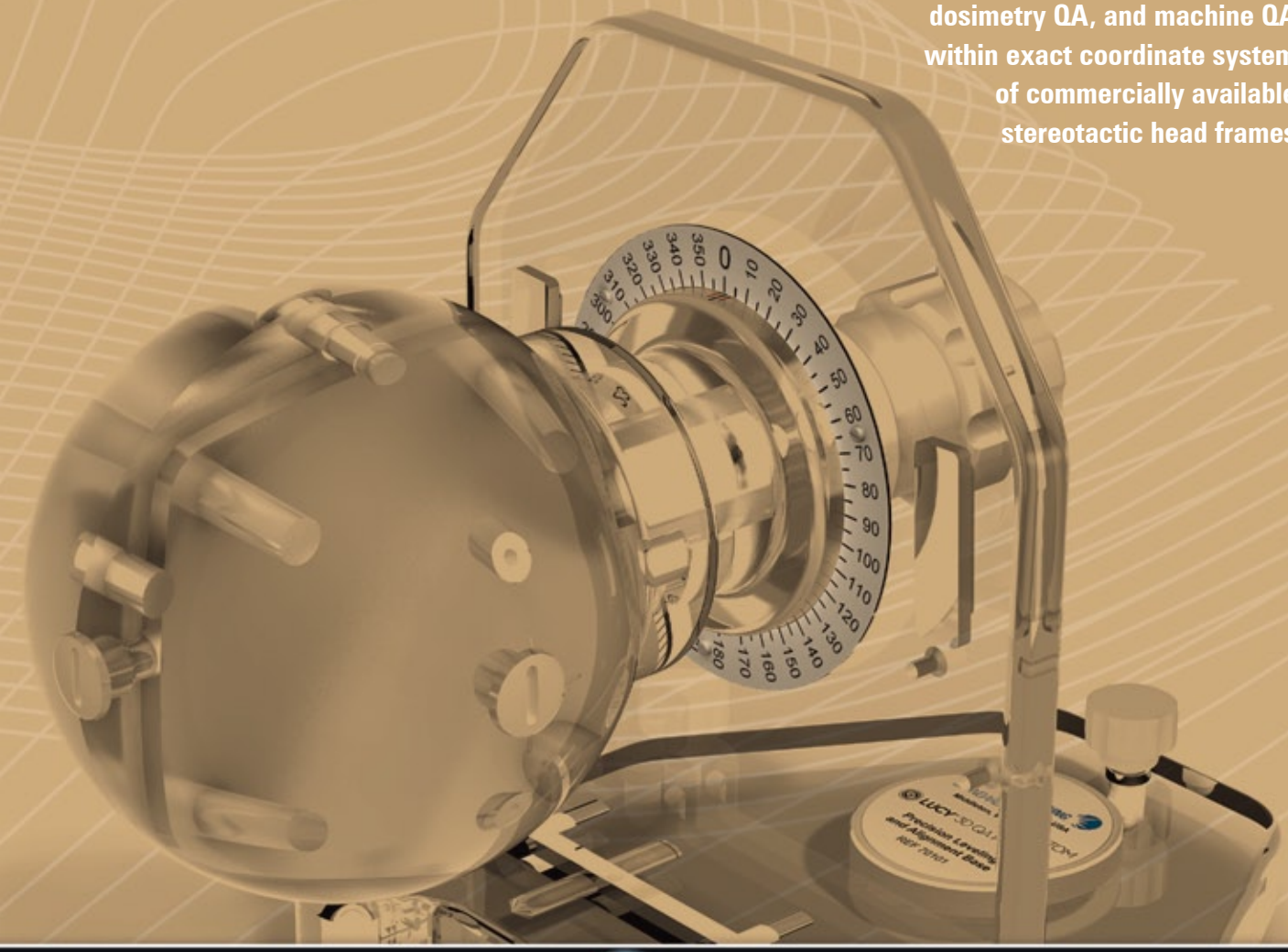


STANDARD IMAGING

COMPLETE, STEREOTACTIC RADIOSURGERY/SRT QA

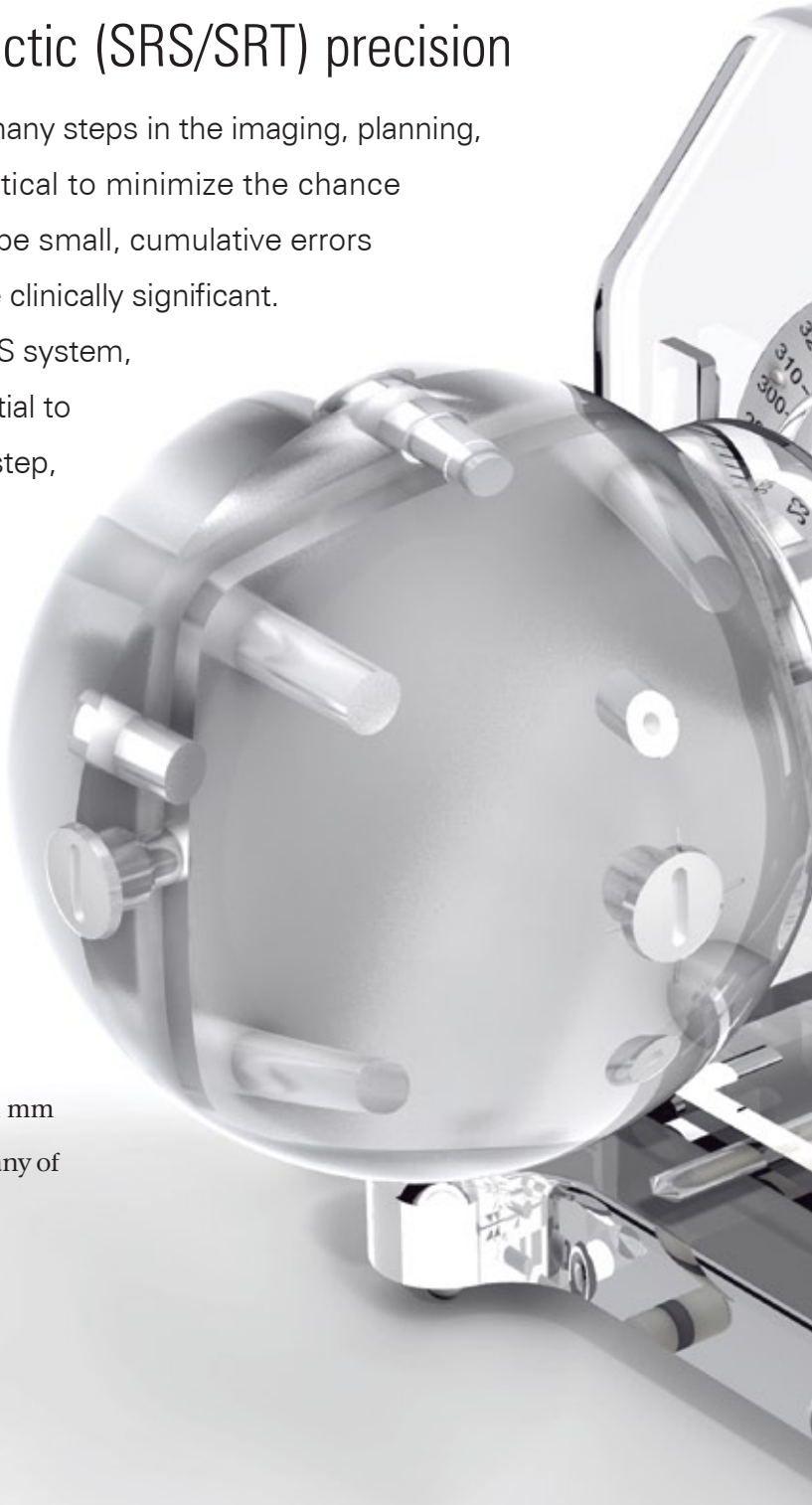
The Lucy 3D QA Phantom performs image transfer QA, dosimetry QA, and machine QA within exact coordinate system of commercially available stereotactic head frames



LUCY® 3D QA PHANTOM

The Lucy 3D QA Phantom
verifies and assures stereotactic (SRS/SRT) precision

Current advances in SRS/SRT incorporate many steps in the imaging, planning, and treatment chain. At each step, it is critical to minimize the chance of error. Although errors in each step may be small, cumulative errors over the entire SRS/SRT chain may become clinically significant. To assess the overall performance of an SRS system, the versatile Lucy 3D QA Phantom is essential to assure the precision and accuracy of each step, and of the entire treatment process.



Imaging and Dose Assessment

The Lucy 3D QA Phantom is compatible with CT and MRI imaging modalities providing assessment of TPS calculations for image fusion, distance measurements, volume measurements, and dose. These parameters are evaluated within the exact coordinate system of commercially available stereotactic head frames. Critical dimensions of the Lucy 3D QA Phantom are made with a tolerance of 0.1 mm or less[1]. The Lucy 3D QA Phantom will accomplish many of the commissioning requirements of your TPS[2].

Ideal for commissioning and stereotactic treatment verification.

1. R.W. Schulte, T.S. Lee, K.E. Schubert , "MRI Distortion Correction for Submillimeter-Precision Functional Radiosurgery," Med. Phys. 66(3), 5252 (2006).

2. AAPM Radiation Therapy Committee TG 53, "Quality assurance for clinical radiotherapy treatment planning," Med. Phys. 25(10), October 1998.

IMAGE TRANSFER QA

Minimize clinically significant errors by quantifying system variances in the imaging chain to within 0.1 mm. Increase your confidence in the capability of your system to correctly image known volumes, distances, and geometries. Confirm that CT/MRI/Angio scans and image fusion are accurately recreated within the TPS therefore assuring accurate target dose delivery.

LOCKS INTO SRS FRAMES

Quickly and precisely position the Lucy 3D QA Phantom within the manufacturer's exact coordinate system with the Stereotactic Frame Interface, available for commercial SRS systems.

SRS PATIENT DOSIMETRY QA

Obtain absolute dose, relative dose, and point dose dosimetry QA measurements at isocenter and at exact positions off isocenter, using standard ion chambers, film, diodes, gels, MOSFETs, and TLDs you currently use.

RADIATION ALIGNMENT MACHINE QA

Assess optical and geometric isocenter, laser alignment, indexed table positioning alignment, and positioning coordinates for a comprehensive evaluation of geometric accuracy.

"The Lucy phantom, with the new MRI Isocentric Volume Insert, is the only option I have found that provides for a true end-to-end test of radiosurgery accuracy, addressing both frame-based and frameless image-guided localization. It is an essential tool for any physicist responsible for quality assurance of a radiosurgery service."

Sam S. Hancock, Ph.D., DABR, DABMP
Chief Medical Physicist
Southeast Missouri Hospital

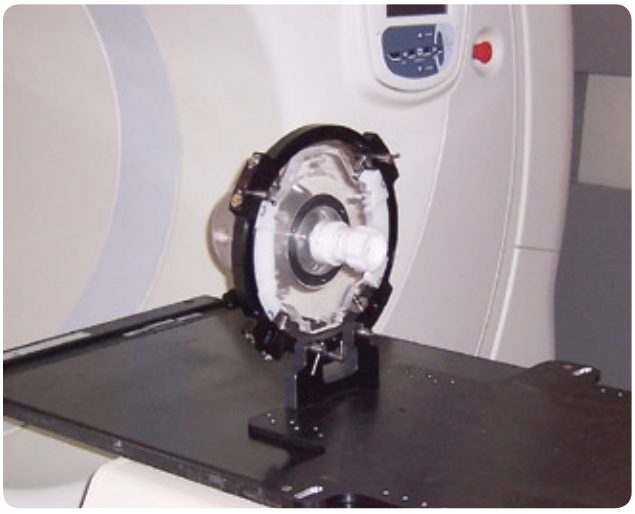
Frameless Stereotactic Radiosurgery

The Lucy 3D QA Phantom mounted on the Precision Leveling and Rotational Alignment Base simulates patient positioning for frameless cranial or body SRS. The 3D geometry of the patient set-up can be examined throughout 360° in the transverse, sagittal, and coronal planes.

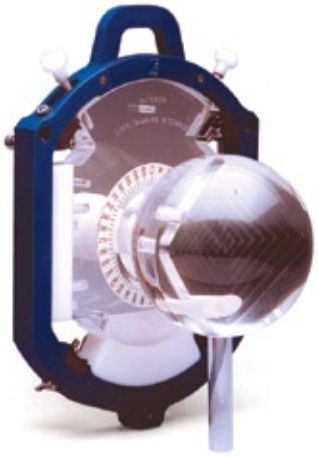
Locks into **SRS Frames**

Make QA setup easy by locking the Lucy 3D QA Phantom to an exact SRS coordinate system

The Lucy 3D QA Phantom can be mounted on commercial SRS frames and positioned for CT, MRI, and angiographic imaging. The SRS frame with Lucy 3D QA Phantom is then mounted on the treatment couch and treated to simulate a patient. Quickly and precisely position the Lucy 3D QA Phantom within the manufacturer's exact coordinate system.



The Lucy 3D QA Phantom positioned on a TomoTherapy® couch using a Varian / Radionics™ / CRW/BRW frame



BrainLAB
Stereotactic Frame Interface

The Lucy 3D QA Phantom in a Radionics™ localizer box being positioned for a CT scan

Varian / Radionics™ / CRW/BRW
Stereotactic Frame Interface

Leksell Gamma Knife®
Stereotactic Frame Interface

Lock the Lucy 3D QA Phantom into your SRS coordinate system

The QA Process

Verify and control critical elements of the SRS process

Image Fusion

If both CT and MRI scans are imported into the treatment planning software, the images can be fused using the tools within the treatment planning software. The accuracy of the fused images can be evaluated by comparing them to the known measurements described in the Lucy 3D QA Phantom specifications.

Distance Measurements

Exact manufacturing tolerances allow you to compare the Lucy 3D QA Phantom distance measurements to the distance measurements of images in treatment planning software[3]. Distance measurements should be evaluated at every step of the imaging process as errors may occur whenever images are transferred from one program to another. The steps after which distance accuracy should be evaluated include:

1. Acquisition of CT and MRI images
2. Transfer of the CT and MRI images to treatment planning software
3. All fusion and planning steps
4. Saving and recalling plans from record and verify software

Distance measurements should also be verified in all planes used for treatment planning, transverse, sagittal, and coronal.

Planned Dose to Delivered Dose

To compare the delivered radiation pattern with the planned dose distribution, the film density pattern must be registered with the planned dose distribution[4]. To compare the planned dose to the delivered dose, an isodose distribution must be produced from the film and overlaid on the treatment plan isodose distribution.

In a similar manner, the Dosimetry Insert for Ion Chamber may be used to confirm prescribed dose at the exact center of the Lucy 3D QA Phantom. The TLD Dosimetry Cassette and the MOSFET Dosimetry Cassette may also be used for dosimetry tests.

Additional Information

For a 14 step general guideline for using the Lucy 3D QA Phantom as a tool for stereotactic treatment verification, contact Standard Imaging and ask for Technical Note 4647 “Stereotactic Treatment Verification with the Lucy 3D QA Phantom” or visit our website:

www.standardimaging.com

Applications

- Make QA set up easy by locking the Lucy 3D QA Phantom to your exact SRS coordinate system
- Commission your system quickly by using the Lucy 3D QA Phantom to confirm specifications upon delivery of equipment
- Use as a QA tool as described in the performance validation references (see end of brochure) and in AAPM Task Group reports
- Evaluate CT/MRI/Angio fusion at 20 points in 3D space
- Effectively evaluate six degrees of freedom positioning systems in 3D space with convenient image markers
- Evaluate manufacturer’s automatic patient positioning systems with film, ion chambers, diodes, gels, MOSFETs, and TLDs
- Check cone beam CT performance in 3D space
- Use for QC and dosimetry measurements with framed and frameless SRS systems

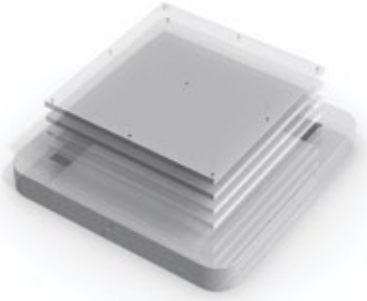
3. R. Ramani, et.al., “A QA phantom for dynamic stereotactic radiosurgery: Quantitative measurements,” Med. Phys. 22(8), August 1995.

4. R. Ramani, et.al., “The use of Radiochromic film in treatment verification of dynamic stereotactic radiosurgery,” Med. Phys. 21(3), 1994.

Comprehensive QA Packages

All of the accessories you need to perform Dosimetric, CT, and MRI QA

Dosimetry QA Accessory Package



Dosimetry Insert for Ion Chamber

Several Chamber Cavity Options Available

The ultimate goal of SRS is to be able to deliver a prescribed dose to within an accuracy of ± 2 %. A treatment can be planned to easily measure the absolute dose with the ion chamber.

The insert is made so the center of the ion chamber's active volume is positioned at the geometric center of the Lucy 3D QA Phantom. A clamp is provided to fix the chamber in position.

Each insert accommodates a specific model ion chamber, however multiple inserts for different ion chambers can be used interchangeably with one Lucy 3D QA Phantom.

Target/Treatment Verification Film Cassette REF 70078

This cassette is made of black acrylic to accommodate radiochromic or conventional therapy film. It positions one 3 inch by 3 inch film at the exact center of the Lucy 3D QA Phantom.

There are sharp markers in the Target/ Treatment Verification Film Cassette which produce four impressions forming a square on the film equidistant from the center used for isocentricity and distance measurement tests.

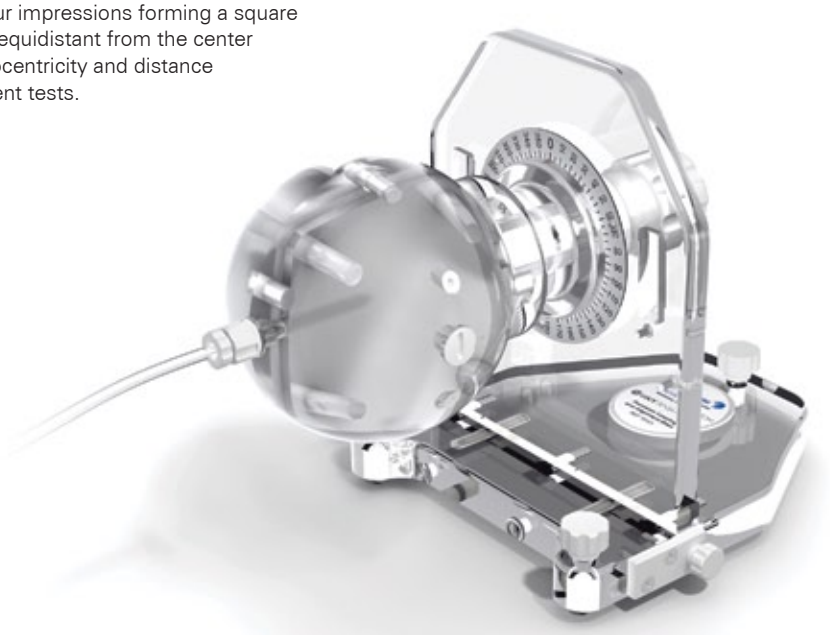
Dosimetry Film Cassette for Three 2.5 x 2.5 Inch Films REF 70084

This cassette positions three films at the exact center of the Lucy 3D QA Phantom for film dosimetry measurements. The two films on either side of the central film are separated by 2.25 mm acrylic spacers. The cassette and spacers are made of clear acrylic.

MODEL A16 EXRADIN MICROCHAMBER

— Collecting Volume: 0.007 cc

- Capable of measuring extremely small field sizes of 3.4 mm by 3.4 mm, allowing it to fit inside a 4 mm beam. *sold seperately*



The Lucy 3D QA Phantom showing the Exradin A16 Microchamber in position

Planned dose to delivered dose verification

CT Imaging QA Accessory Package

CT Marker Cylinders, set of Four REF 70072

Each marker cylinder contains five 2 mm diameter aluminum spheres which are spaced 5 mm center to center. The targets within the four marker cylinders create a rectangle 30 mm on each side. The CT Market Cylinders, REF 70072, when used in conjunction with the MRI Marker Cylinders, REF 70074, are used to evaluate the fusion function of treatment planning programs.

CT Grid Insert for Spatial Distortion REF 70075

This insert is a two dimensional metallic grid specifically designed for checking image distortion and symmetry. Grid lines are visible at conventional settings for CT scanners. The grid wires are 0.5 mm aluminum and are spaced 5 mm apart. The wires originate at the center of the insert.

CT Volume Insert with Three Known Geometries REF 70076

This insert has three irregularly shaped known air volumes of 250, 750, and 1750 mm^3. The volume insert is used to evaluate the integrity of images as they are moved from one imaging system to another, challenging the TPS to accurately recreate.

Electron Density QA Insert REF 70104

The Electron Density Insert is designed to be a quick and convenient check of the CT density tables utilized by the CT imaging and treatment planning systems. The insert is comprised of five materials of differing density: Blue Water (a water equivalent material), air, trabecular bone, cortical bone, and adipose.

MRI Imaging QA Accessory Package

MRI Marker Cylinders, set of Four REF 70074

Each marker cylinder contains five 2 mm diameter spheres filled with mineral oil. The spheres are spaced 5 mm center to center. The targets within the four marker cylinders create a rectangle 30 mm on each side. The MRI Marker Cylinders, REF 70074, when used in conjunction with the CT Marker Cylinders, REF 70072, are used to evaluate the fusion function of treatment planning programs.

MRI Volume Insert with Three Known Geometries REF 70077

This insert has three irregularly shaped volumes which are filled with mineral oil. The volume insert is used to evaluate the integrity of images as they are moved from one imaging system to another.

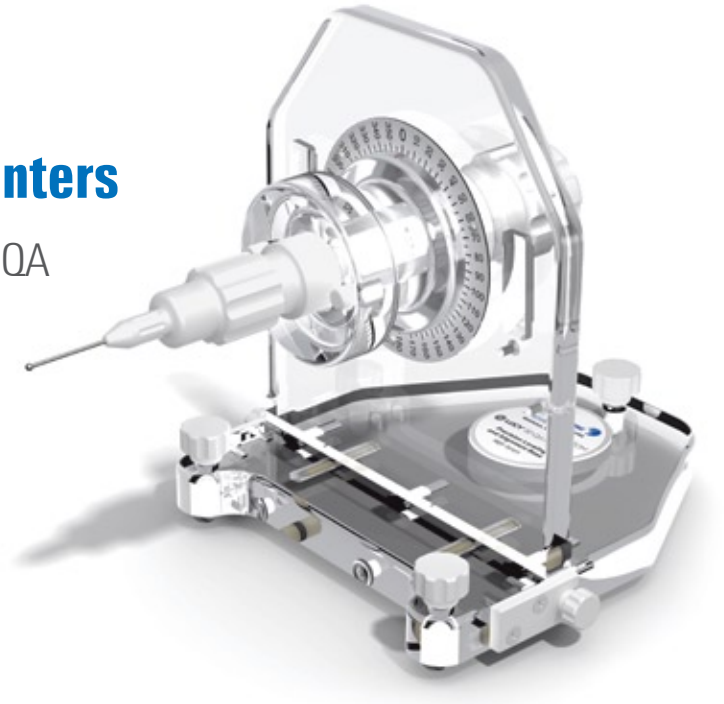
MRI Signal Generator REF 70063

The signal generator fits into the large cavity of the Lucy 3D QA Phantom and contains a manganese chloride solution. The volume of manganese is required to produce enough MRI signal strength to image the MRI Marker Cylinders.

Evaluate the accuracy of CT and MRI image fusion

Mechanical **Alignment Pointers**

Perform radiation alignment machine QA



Radiation Alignment Pointers
REF 70079

The Radiation Alignment Pointers attach to the Precision Leveling and Rotational Alignment Base for secure positioning. Two alignment pointers are provided, one with a 5 mm tungsten sphere tip and one with a 3 mm aluminum sphere tip. The spheres are used for optical alignment and also for radiation isocenter alignment when used with radiographic film.

Assess optical and geometric isocenter, laser alignment, indexed table positioning alignment, and positioning coordinates for a comprehensive evaluation of geometric accuracy.

Winston-Lutz Test for Radiation Isocenter

The tungsten or aluminum sphere tips of the Radiation Alignment Pointers can be imaged for the Winston-Lutz test. The sphere is placed at the mechanical isocenter of the treatment room as determined by the room lasers. The accelerator is then rotated to each required gantry angle, and the sphere is imaged with film or an EPID. Utilize PIPSpro Comprehensive Software to perform an automatic analysis of these images to determine the absolute size and position of the radiation isocenter. Contact your Standard Imaging representative for more information or a demonstration.

Additional **Accessories**

MRI Isocentric Volume Insert **REF 70107**

The MRI Isocentric Volume Insert features an isocentrically placed target of known volume which allows for integrated testing of CT and MR imaging, image fusion, and treatment planning. Used in combination with available dosimetric inserts for treatment delivery verification, the Lucy Phantom is a complete end-to-end QA system for your SRS program. This insert was developed in cooperation with Sam Hancock, Ph.D. of Southeast Missouri Hospital[5].

3D Volumetric Target Dosimetry Kit
REF 76013

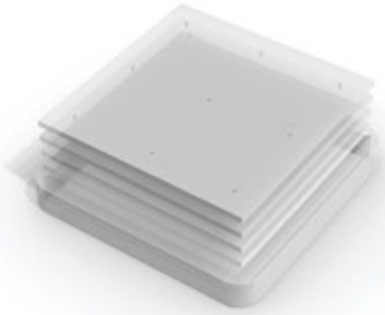
The Multiple Target Shapes Insert offers you complex geometric targets of known dimensions and volumes to challenge and assess the treatment planning system's re-construction capabilities. Evaluate the ability of your TPS to include and avoid critical structures and then utilize the included film cassette to verify dose delivery to the target.

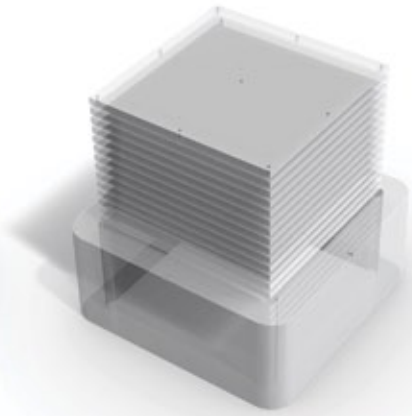
MedicalQC.com

Tools for radiation isocenter and optical alignment

5 Hancock, S., "End-to-End QC of Stereotactic Radiosurgery with the Lucy Phantom", Presentation, BrainLAB User's Meeting, Chicago, IL June 2008.

Additional **Accessories** *continued*





IGRT kV and X-Ray Angiography Marker Cylinders REF 70073

The IGRT kV and X-Ray Angiography Marker Cylinders are used with the CT Marker Cylinders and the MRI Marker Cylinders to evaluate the fusion function of treatment planning programs.

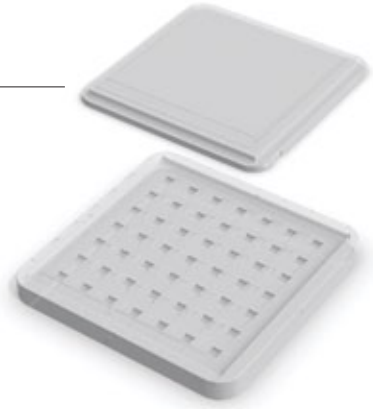
Dosimetry Film Cassette for Three 3 x 3 Inch Films REF 70091

This cassette positions three films at the exact center of the Lucy 3D QA Phantom for film dosimetry measurements. The two films on either side of the central film are separated by 2.25 mm acrylic spacers. The cassette and spacers are made of clear acrylic.

Dosimetry Cassette for Thirteen 2.5 x 2.5 Inch Films REF 70089

This cassette positions thirteen films in the large void in one hemisphere of the Lucy 3D QA Phantom for film dosimetry measurements. The cassette and spacers are made of clear acrylic.

TLD



Dosimetry Inserts for TLD Detectors

Dosimetry Insert for 3mm TLD Detectors **REF 70059**
Dosimetry Insert for 1mm TLD Detectors **REF 70106**

This dosimetry insert allows the positioning of up to [49 TLDs - 3mm] or [85 TLDs - 1mm] in the central plane of the Lucy 3D QA Phantom. One TLD is positioned at the exact center of the phantom. The size of the cavities are [3.4 x 3.4 x 1 mm] or [1.5 x 1.5 x 1 mm].

MOSFET

Dosimetry Insert for MOSFET Detectors REF 70058

This dosimetry insert positions 15 MOSFET detectors in the central plane of the Lucy 3D QA Phantom. One detector is positioned at the exact center of the phantom. The size of the cavities are 2.5 x 8 x 1 mm.

Lucy 3D QA Phantom **Components**

Lucy 3D QA Phantom

- Spherical Lucite Phantom
- Precision Leveling and Rotational Alignment Base
- Pelican™ Carrying Case

Stereotactic Frame Interfaces

- BrainLAB
- CyberKnife®
- Leksell Gamma Knife®
- Sandstrom Stereo-Adapter
- TomoTherapy Hi-Art System®
- Varian / Radionics™ / CRW/BRW
- Precision Leveling and Rotational Alignment Base for frameless systems and extracranial work

Lucy Dosimetry QA Accessory Package

- Dosimetry Insert for ion chamber of your choice
- Dosimetry Film Cassette for three 2.5 x 2.5 inch films
- Target / Treatment Verification Film Cassette

Lucy CT Imaging QA Accessory Package

- CT Marker Cylinders, set of four
- CT Volume Insert with three known geometries
- CT Grid Insert for spatial distortion
- Electron Density QA Insert

Lucy MRI Imaging QA Accessory Package

- MRI Marker Cylinders, set of four
- MRI Volume Insert with three known geometries
- MRI Signal Generator

Radiation Alignment Pointers

- Includes a 5 mm tungsten sphere tip and a 3 mm aluminum sphere tip

Additional Accessories

- IGRT kV and X-Ray Angiography Marker Cylinders, set of four
- Dosimetry Film Cassette for three 3 x 3 inch films
- Dosimetry Film Cassette for thirteen 2.5 x 2.5 inch films
- MRI Isocentric Volume Insert
- 3D Volumetric Target Dosimetry Kit
- Other accessories are available for many ion chambers, TLD dosimetry, diode detectors, MOSFET detectors and MRI compatible bases for phantom positioning

Dosimetry Instruments

- SuperMAX Electrometer
- MAX 4000 Electrometer
- Exradin A16 MicroChamber
- Exradin A14SL MicroChamber
- Exradin A1 Thimble Ion Chamber
- Exradin A18 Thimble Ion Chamber

PERFORMANCE VALIDATION

R. Ramasesham, M. Heydarian, "Comprehensive quality assurance for stereotactic radiosurgery treatments," **Phys. Med. Biol.** 48(2003) N119-N205.

R. Ramani, et.al., "A QA phantom for dynamic stereotactic radiosurgery: Quantitative measurements," **Med. Phys.** 22(8), August 1995.

R. Ramani, et.al., "The use of Radiochromic film in treatment verification of dynamic stereotactic radiosurgery," **Med. Phys.** 21(3), 1994.

AAPM Radiation Therapy Committee TG 53: "Quality assurance for clinical radiotherapy treatment planning," **Med. Phys.** 25(10), October 1998.

AAPM Radiation Therapy Committee TG 66: "Quality assurance for computed-tomography simulators and the computed-tomography-simulation process," **Med. Phys.** 30(10), October 2003

LUCY 3D QA PHANTOM (REF 91210) SPECIFICATIONS

LUCY 3D QA PHANTOM	Acrylic Sphere 140 mm (5.51 in) diameter
Blank Filler Plug (HEMI-C)	81 x 81 x 35 mm (3.19 x 3.19 x 1.38 in)
Blank Filler Plug (HEMI-A)	85 x 85 x 10 mm (3.35 x 3.35 x .39 in)
Accessory Port for Ionization Chambers	8 mm (.31 in) diameter
PRECISION LEVELING AND ROTATIONAL ALIGNMENT BASE	
Height	30 cm (11.81 in)
Depth	23 cm (9.06 in)
Width	20 cm (7.87 in)
Weight	3.4 kg (7.5 lbs)
DOSIMETRY QA ACCESSORIES	
Dosimetry Insert for Ion Chamber	85 x 85 x 10 mm (3.35 x 3.35 x .39 in)
Dosimetry Film Cassette for Three 2.5" x 2.5" films	85 x 85 x 10 mm (3.35 x 3.35 x .39 in)
Target/Treatment Verification - Film Cassette - Four Titanium Fiducial Markers - One Titanium Fiducial Marker for Orientation	85 x 85 x 10 mm (3.35 x 3.35 x .39 in) 60 mm (2.36 in) square pattern
Dosimetry Film Cassette for Three 3.0" x 3.0" films	85 x 85 x 10 mm (3.35 x 3.35 x .39 in)
Dosimetry Film Cassette for Thirteen 2.5" x 2.5" films	85 x 85 x 35 mm (3.35 x 3.35 x 1.38 in)
CT QA ACCESSORIES	
CT Marker Cylinders, set of four - Five 2.0 mm Aluminum Spheres per cylinder	10 mm (.39 in) length, 25 mm (.98 in) diameter 5 mm (.197 in) center-to-center
CT Volume Insert with 3 irregular known volumes - Geometry One - Geometry Two - Geometry Three	85 x 85 x 10 mm (3.35 x 3.35 x .39 in) Area 250 mm, Volume 2500 mm^3 Area 750 mm, Volume 7500 mm^3 Area 1750 mm, Volume 17500 mm^3
CT Grid Insert for spatial distortion	85 x 85 x 10 mm (3.35 x 3.35 x .39 in) 0.5 mm (.02 in) aluminum wire spaced 5 mm (.197 in) apart
MRI QA ACCESSORIES	
MRI Marker Cylinders, set of four - Five 2.0 mm mineral oil spheres per cylinder	10 mm (.39 in) length, 25 mm (.98 in) diameter 5 mm (.197 in) center-to-center
MRI Volume Insert with three known Geometries - Geometry One - Geometry Two - Geometry Three	85 x 85 x 10 mm (3.35 x 3.35 x .39 in) Area 250 mm, Volume 1700 mm^3 Area 750 mm, Volume 5250 mm^3 Area 1750 mm, Volume 12250 mm^3
MRI Signal Generator - Cavity Filled with Manganese Chloride	85 x 85 x 35 mm (3.35 x 3.35 x 1.38 in)
IMAGING QA ACCESSORIES	
IGRT Localization & Angiography Marker Cylinders, set of four - One 2.0 mm Lead Sphere in each cylinder	10 mm (.39 in) length, 25 mm (.98 in) diameter
RADIATION ALIGNMENT POINTER	
Includes 3 mm Optical Alignment Tip and Radiation 5 mm Alignment Tip	
MOSFET DOSIMETRY CASSETTE	
Cassette with 15 cavities 2.5 x 8 x 1 mm to accommodate MOSFET Diodes	85 x 85 x 10 mm (3.35 x 3.35 x .39 in)
TLD DOSIMETRY CASSETTE	
Cassette with 49 cavities 3.4 x 3.4 x 1 mm to accommodate TLDs	85 x 85 x 10 mm (3.35 x 3.35 x .39 in)
Cassette with 85 cavities 1.5 x 1.5 x 1 mm to accommodate TLDs	85 x 85 x 10 mm (3.35 x 3.35 x .39 in)

All critical dimensions have a tolerance of 0.1 mm or less