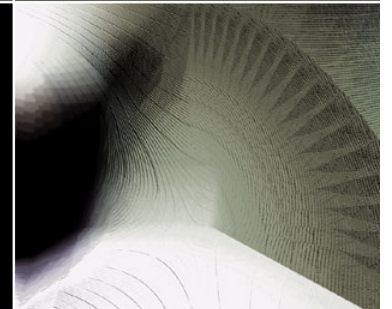
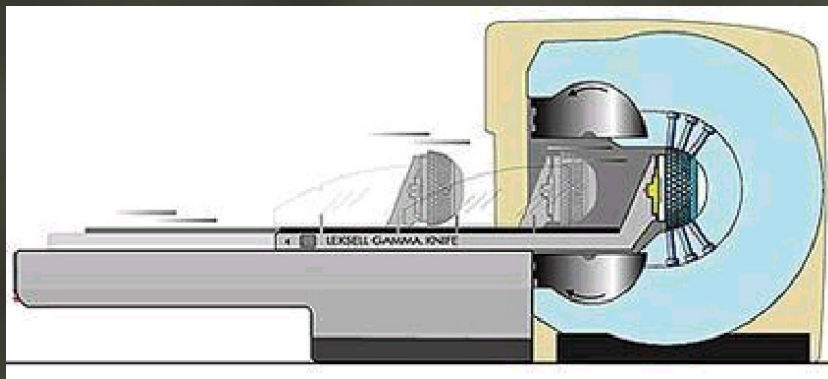
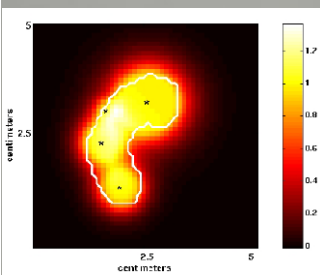


GAMMA KNIFE DOSIMETRY & CALIBRATION

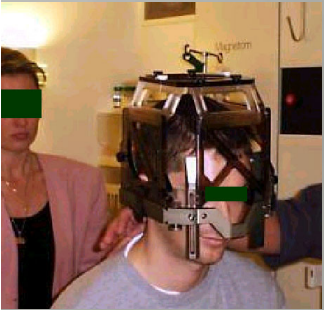


The gamma knife works by a process called stereotactic radiosurgery, which uses multiple beams of radiation converging in three dimensions to focus precisely on a small volume, such as a tumor, permitting intense doses of radiation to be delivered to that volume safely.



Patient Treatment Procedure

- A stereotactic frame is attached to the patient's head and remains in place until treatment is completed.
- An indicator plate is used to visualize the frame's coordinate system on a diagnostic image.
- Images are reviewed and target coordinates are for each radiation isocenter is determined for treatment.



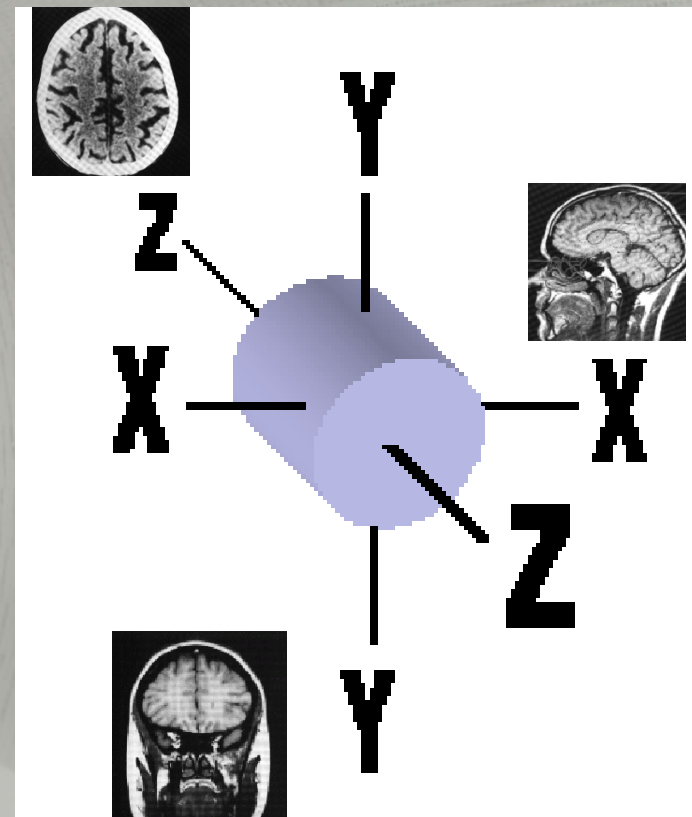
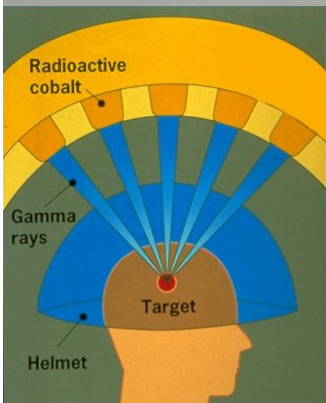
Targeting for Treatment

3 Dimensional Cartesian Coordinate system is used to locate targets in stereotactic space.

Z = Axial

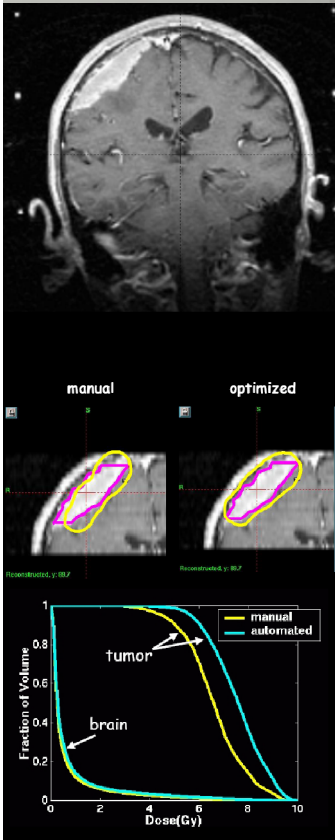
X = Sagittal

Y = Coronal

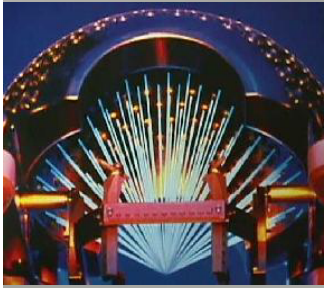


Dose Calculation & Treatment Planning Algorithm

- Plot X,Y,& Z coordinates of the target and the gamma angle
- 24 preselected points on the surface of the skull are then measured with a special plastic frame that is attached to the frame.
- These measurements are then utilized by Gamma Plan treatment software to formulate the actual treatment.



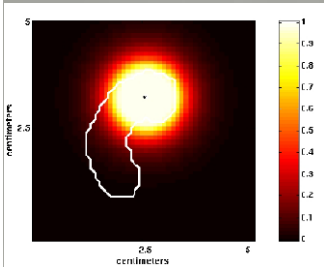
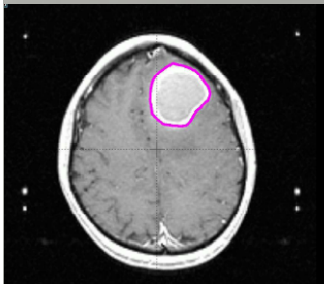
DOSE



The dose delivered by each of the 201 radiation beams is calculated in a 31 X 31 X 31 matrix of points centered on the area of interest.

DOSE SINGLE BEAM

Dose calculation for a single beam requires definition of the skull configuration, the transverse radiation profiles for a specific collimator size, and the dose reference in a water phantom.



AGGREGATE BEAM DOSE

Contributions from all 201 sources are summed for each point within the matrix, provided no beam ports are occluded. Determination of an absolute dose at a given point allows normalization and display of isodose distributions with the matrix volume.

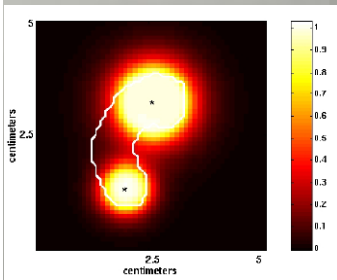


AGGREGATE BEAM DOSE

If multiple irradiation isocenters are considered, the contribution from each is weighed and summed to yield final the final dose distribution.



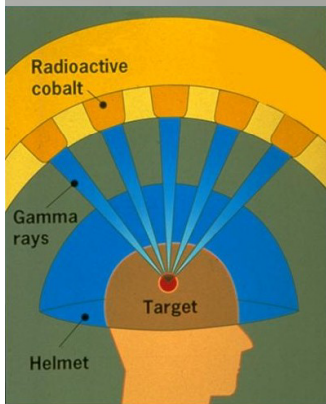
AGGREGATE BEAM DOSE



Calculation of the treatment time for each irradiation "shot" is based upon weight given each radiation, the relative output of the selected collimator helmet, and the output at the focus for the given skull configuration.

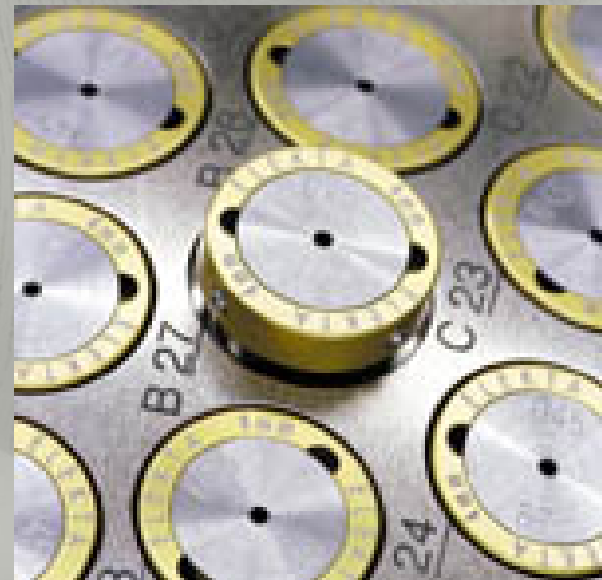
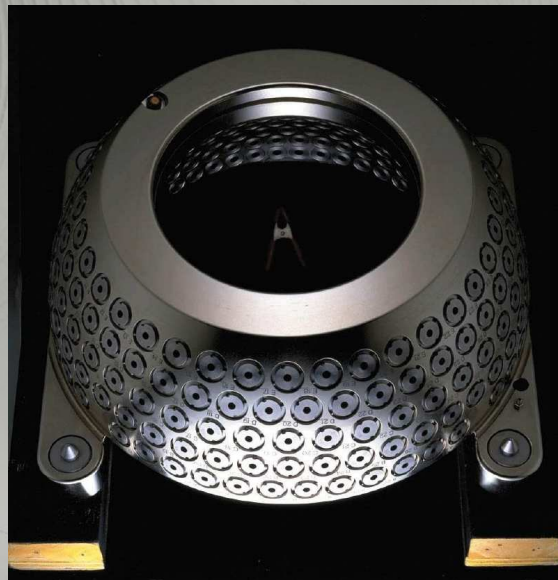
DOSE CALIBRATIONS & MEASUREMENTS

To determine the best dosimetry system for measurements of the small focal point of beams, several different detection systems have been used including ion chamber, silicone diode, thermoluminescent dosimeters, and even film.



PLUG PATTERNS

Because the gamma knife contains 201 cobalt 60 sources, with each collimated beam focusing at a central point, the dose profile of each beam is a building block of total block distribution of multiple beams of various plug patterns.

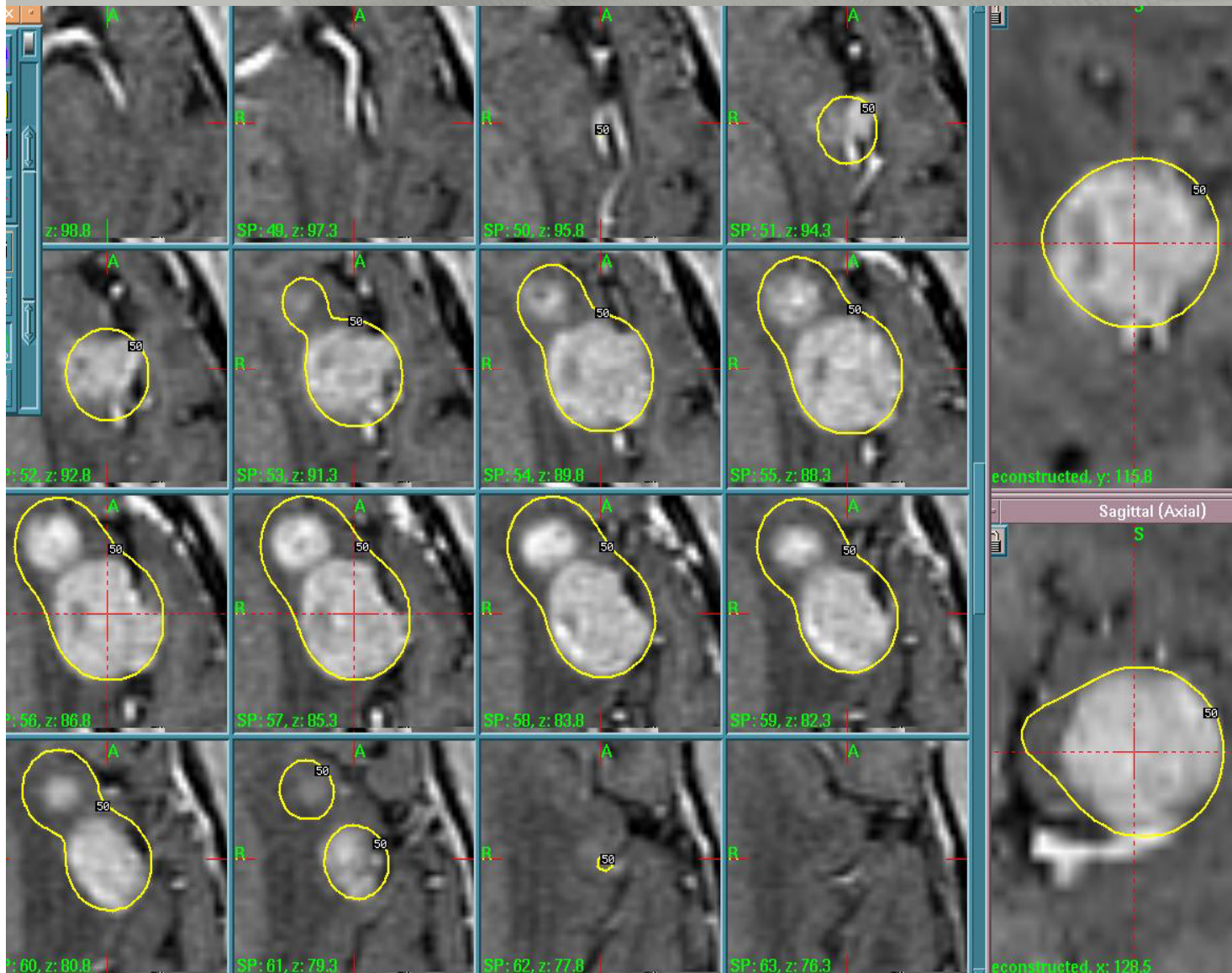


DOSE CALIBRATIONS & MEASUREMENTS

Initial dose measurements on a new Gamma Knife unit yield a dose in excess of 300 cGy/min.

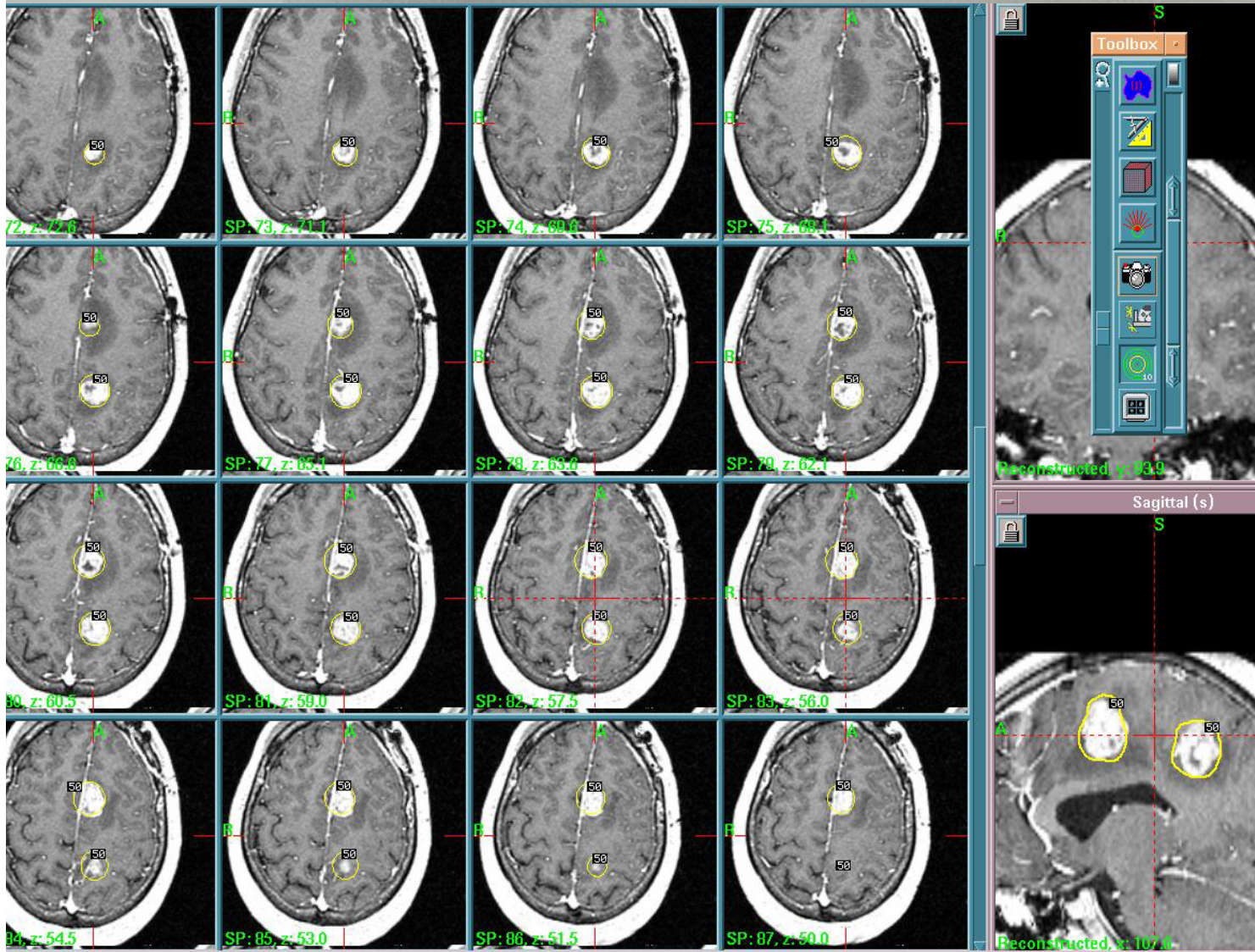


Gamma Knife Radiosurgery



Multiple tumors in treatment planning workstation with the delivered dose in yellow.

Gamma Knife Radiosurgery



Multiple tumors in treatment planning workstation with the delivered dose in yellow.

DOSE CALIBRATIONS & MEASUREMENTS

Dose location and penumbra at the treatment site is dependent upon the number of collimators open and the size of the helmet.



DOSE CALIBRATIONS & MEASUREMENTS

NRC 35.635 requires that the direct output be determined to be no more than $\pm 3\%$ for a range of sizes.

As part of full calibration of the gamma knife in meeting 10 CFR 35.635 using an indirect method, the collimator factors or relative helmet factors are determined using film, diodes, or thermoluminescent dosimeters. If the measurement results agree within $\pm 5\%$ of the manufacturer's values, then no change is made within the treatment software.



Quality Assurance & Testing

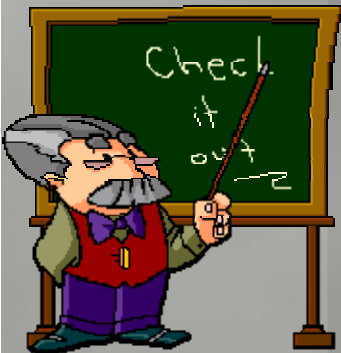
Once the gamma knife has been installed and initial testing and calibrations have been performed, a quality assurance program must be started.



Full Calibration

The first calibration must be done before the unit is used for medical treatment. Also calibrations are required :

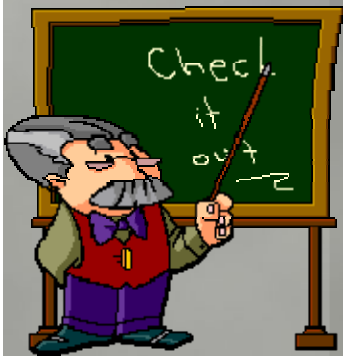
- When spot check measurements show output that differs more than 5% from output obtained from the last full calibration corrected mathematically for radioactive decay
- Following replacement of sources or following the reinstallation of the unit in a new location
- Following repair of the unit that includes removal of sources or major repair of the components associated with the source assembly
- At intervals not to exceed 1 year, with the exception of relative helmet factors which must only be determined before first medical use or damage to the helmet.



Full Calibration

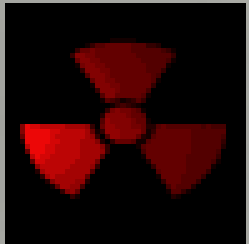
Full calibration measurements must include determination of:

- The output within +/- 3%
- Relative helmet factors
- Isocenter coincidence
- Timer accuracy and linearity over the range of use
- On-Off error
- Trunion centricity
- Treatment table retraction mechanism, using backup battery power or hydraulic backups with the unit off
- Helmet micro switches
- Emergency timing circuits
- Stereotactic frames and localizing devices (trunions)



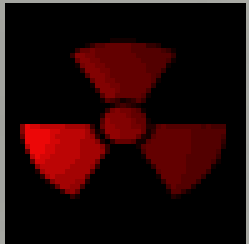
10 CFR 35.630(a)

A licensee must use the dosimetry system described in 35.630(a) to measure the output for one set of exposure conditions. The remaining radiation measurements may be made using a dosimetry system that indicates the relative dose rates.



10 CFR 35.630(a)

Part 35.630(a) requires that a licensee have a calibrated dosimetry system available for use.



10 CFR 35.630(a)

Method 1

Part 35.630(a) requires that a licensee have a calibrated dosimetry.

Use a system or source calibrated using a system traceable to the National Institute of Standards and Technology (NIST) and published protocols accepted by nationally recognized bodies; or by a calibration laboratory accredited by the AAPM. The calibration must have been performed within the previous 2 years and after any servicing that may have affected system calibration.

10 CFR 35.630(a)

Method 2

Part 35.630(a) requires that a licensee have a calibrated dosimetry.

The system must have been calibrated within the previous 4 years. 18 to 30 months after that calibration, the system must have been intercompared with another dosimetry system that has been calibrated within the last 24 months by NIST or by a calibration laboratory accredited by the AAPM. The results of the intercomparison must indicate that the calibration factor of the licensee's system has not changed by more than 2%. The licensee must not use the intercomparison result to change the calibration factor. When intercomparing dosimetry system to be used with sealed sources for therapeutic units, the licensee shall use a comparable unit with beam attenuators or collimators, as applicable, and the sources of the same radionuclide as the source used at the licensee's facility.

Additional Licensee Requirements

- **Must have a dosimetry system available for spot check and it must be calibrated or compared to a system that is calibrated.**
- **Records of each calibration, intercomparison, and comparison.**

Outputs

The licensee must mathematically correct the outputs determined by Part 35.635 at intervals not exceeding 1 month for cobalt 60 and at intervals consistent with a 1% physical decay for all other radionuclides. Physical decay corrections must be performed by the authorized medical physicist.

The slide features a central area with a complex, wavy, and textured grey background. This central area is framed by solid black horizontal bars at the top and bottom. The text 'Thank You' is centered in the middle of the slide in a large, bold, black sans-serif font.

Thank You