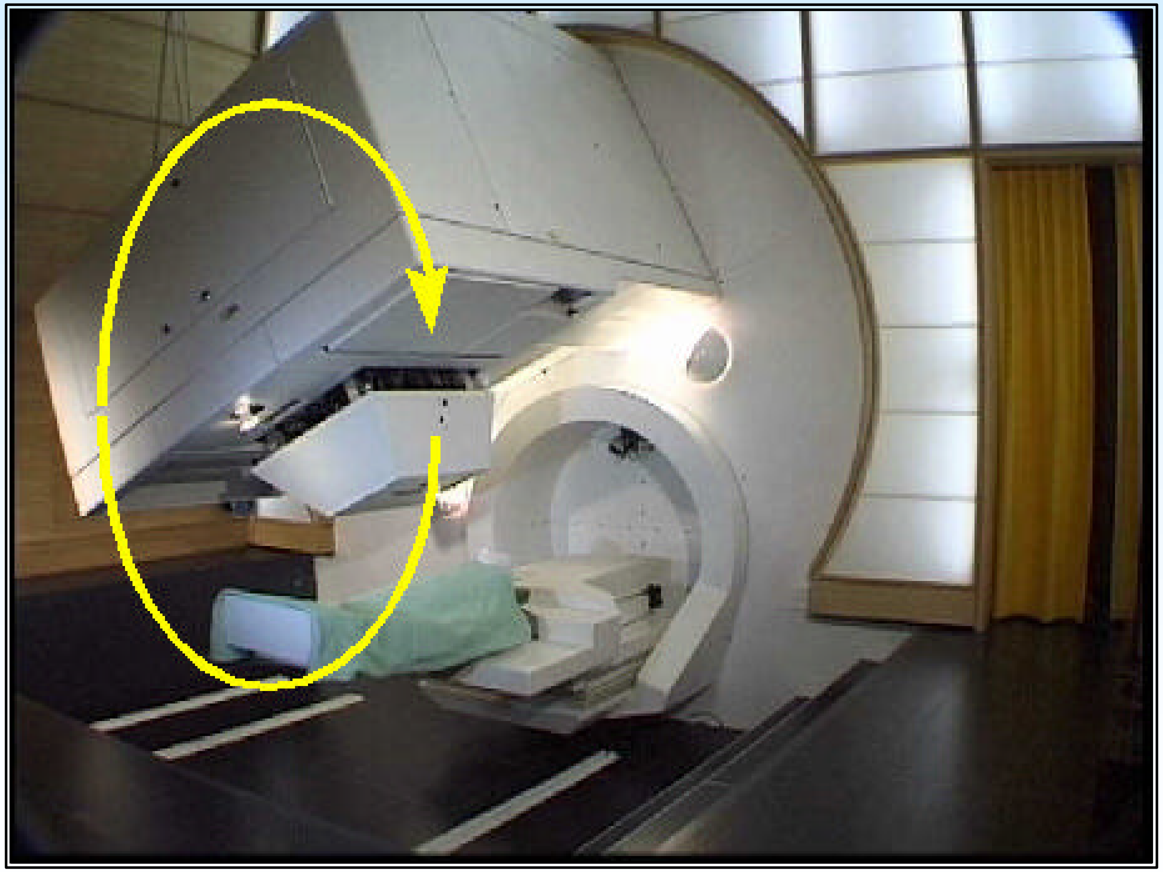
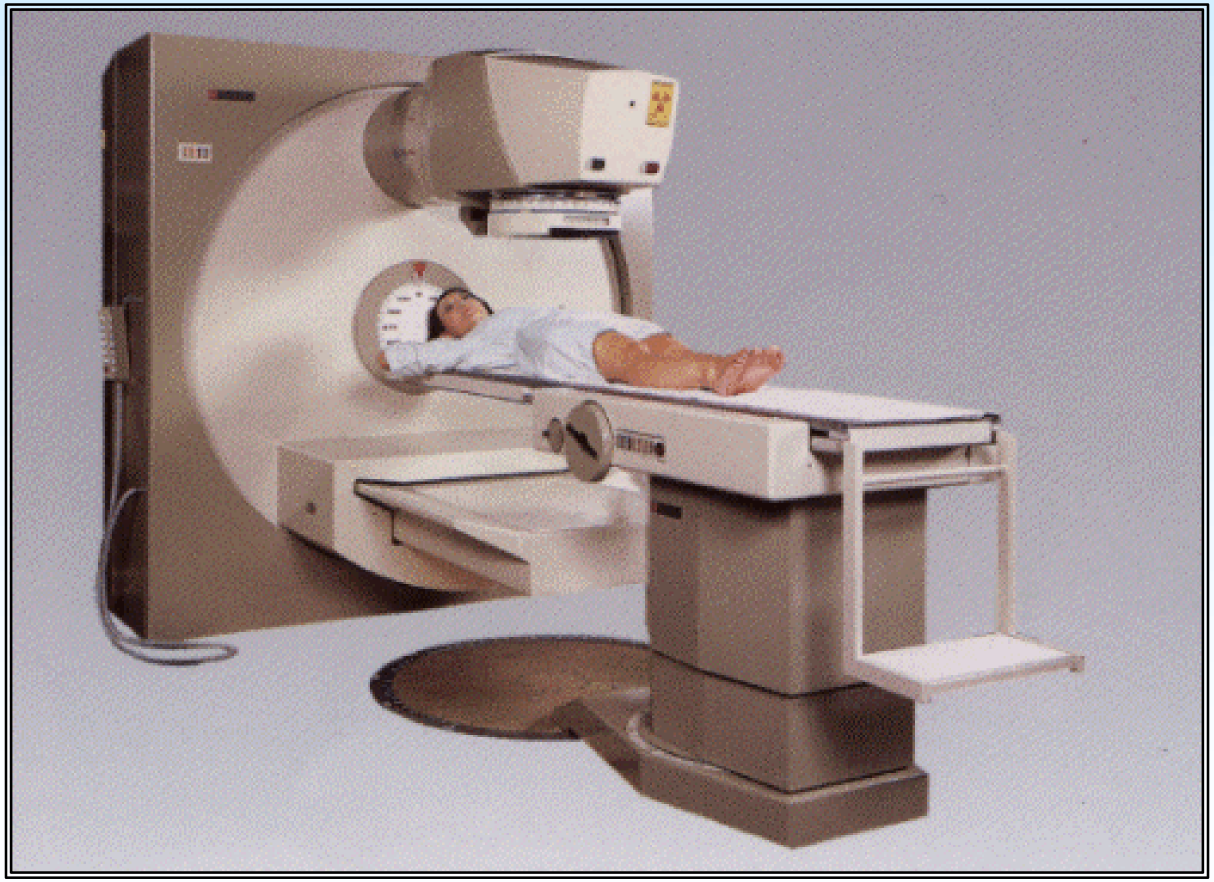
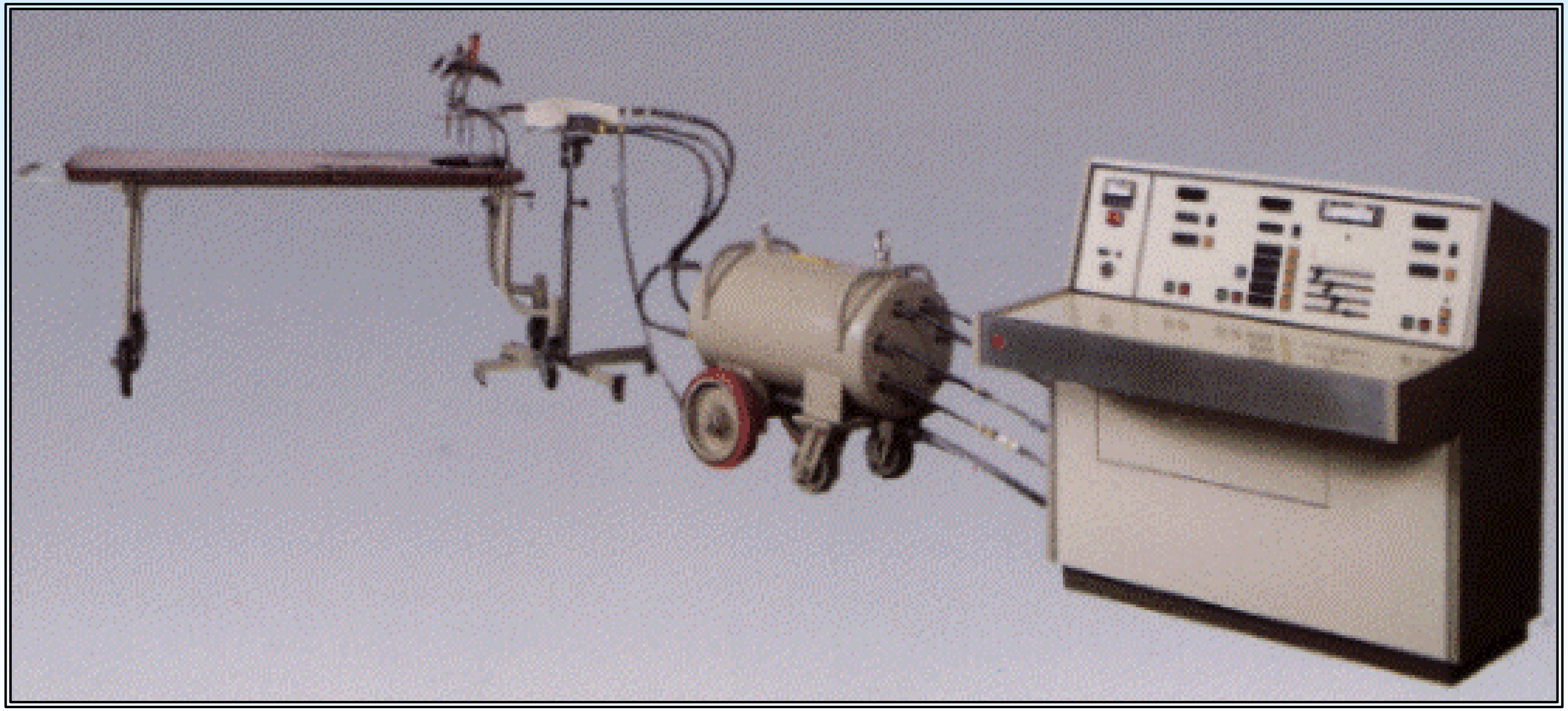
Radiotherapy Technology



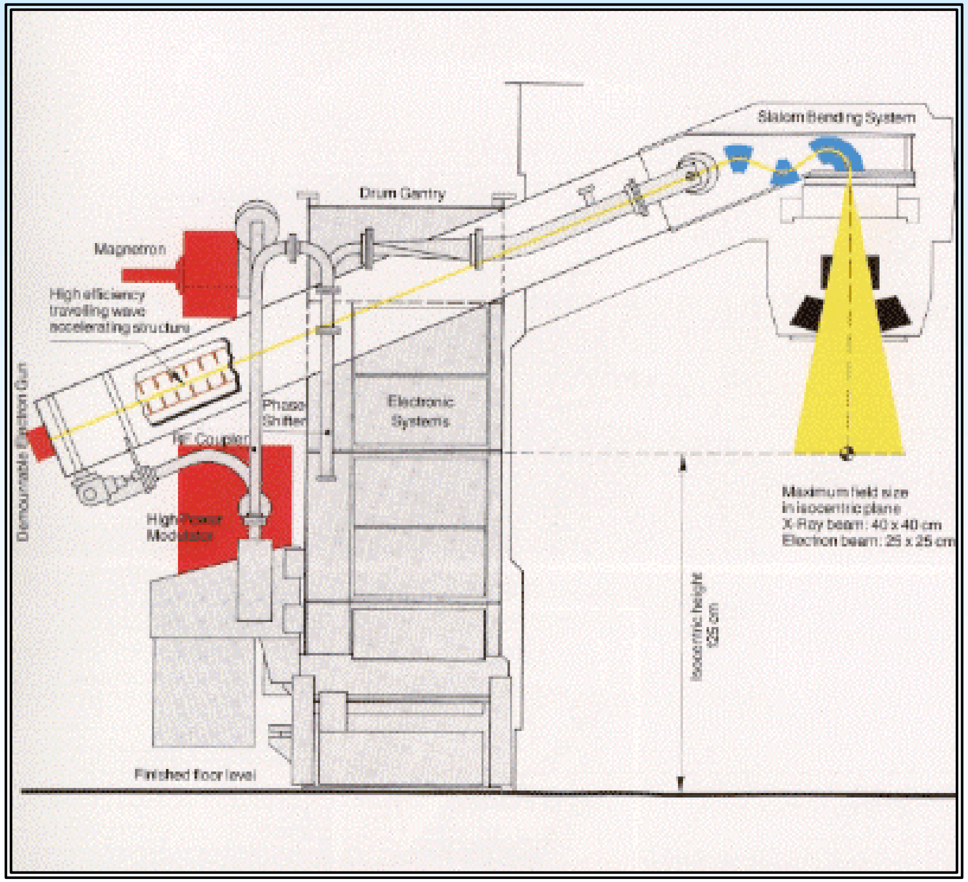
^{60}Co Teletherapy



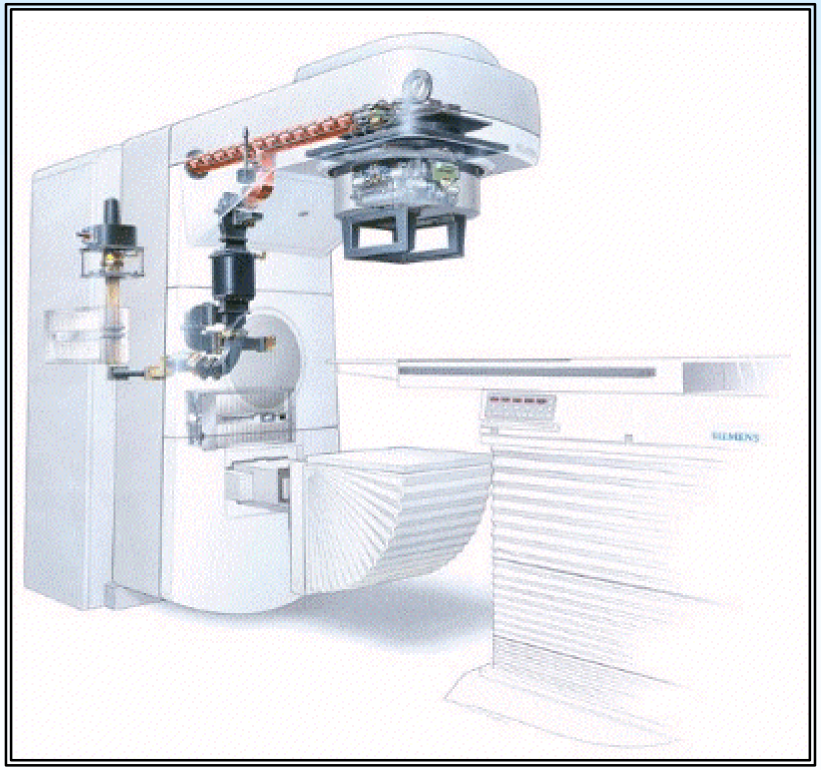
^{60}Co, ^{137}Cs & ^{92}Ir Brachytherapy

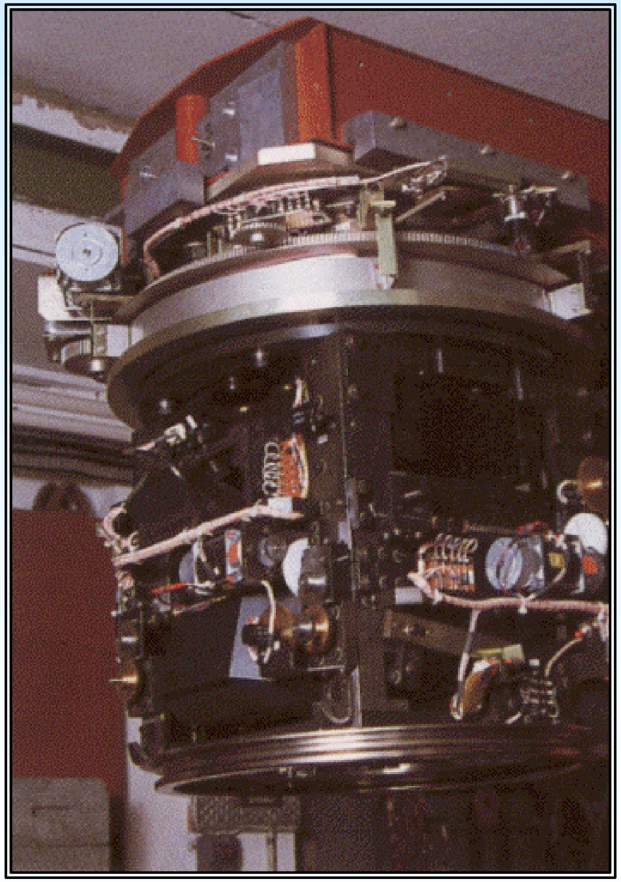


Linear Accelerator: Block Diagram

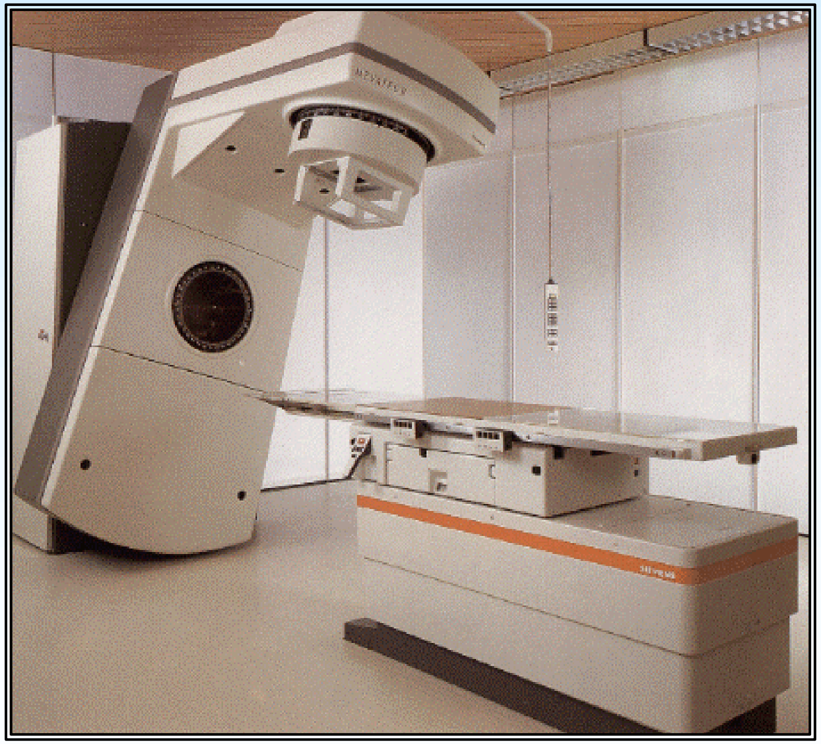


Linear Accelerator: Components and Irradiation Head Details

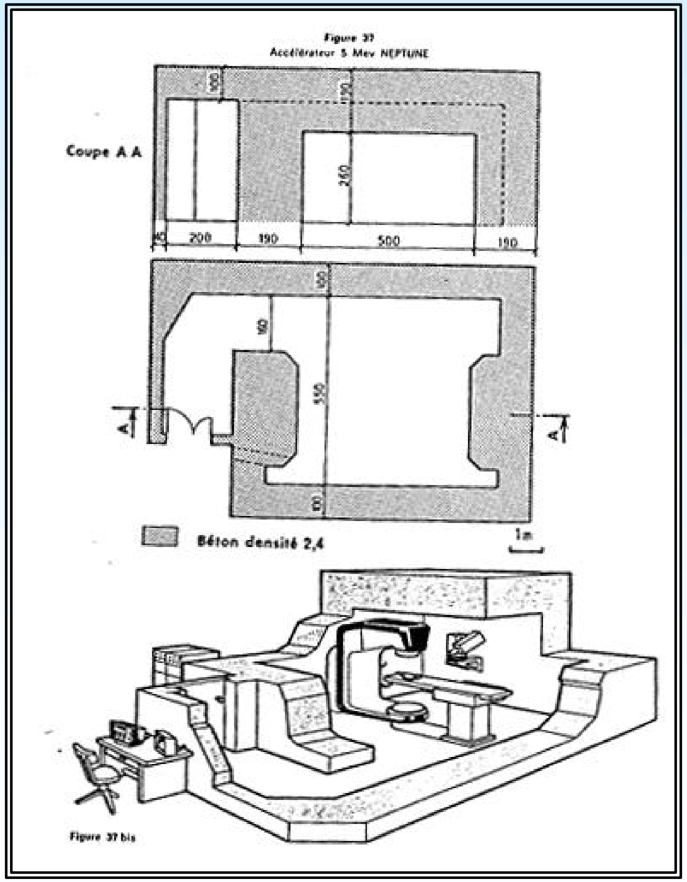




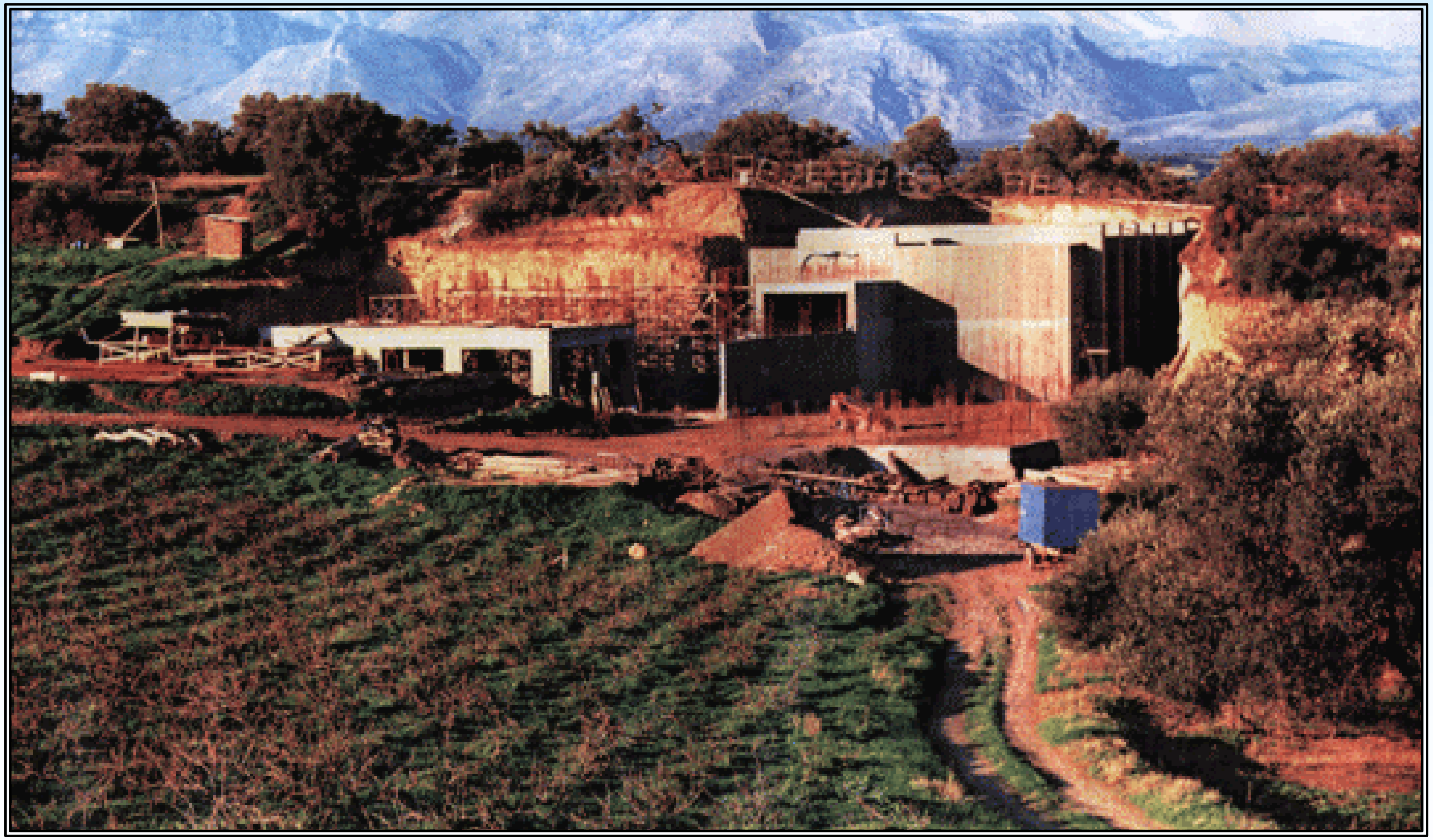
Typical Linear Accelerators



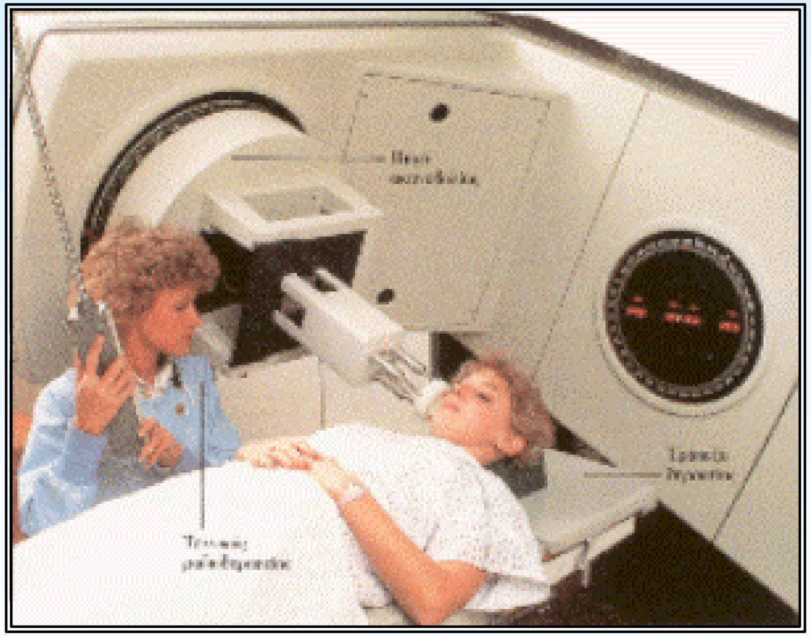
Linear Accelerator Room typical Layout and Elevation



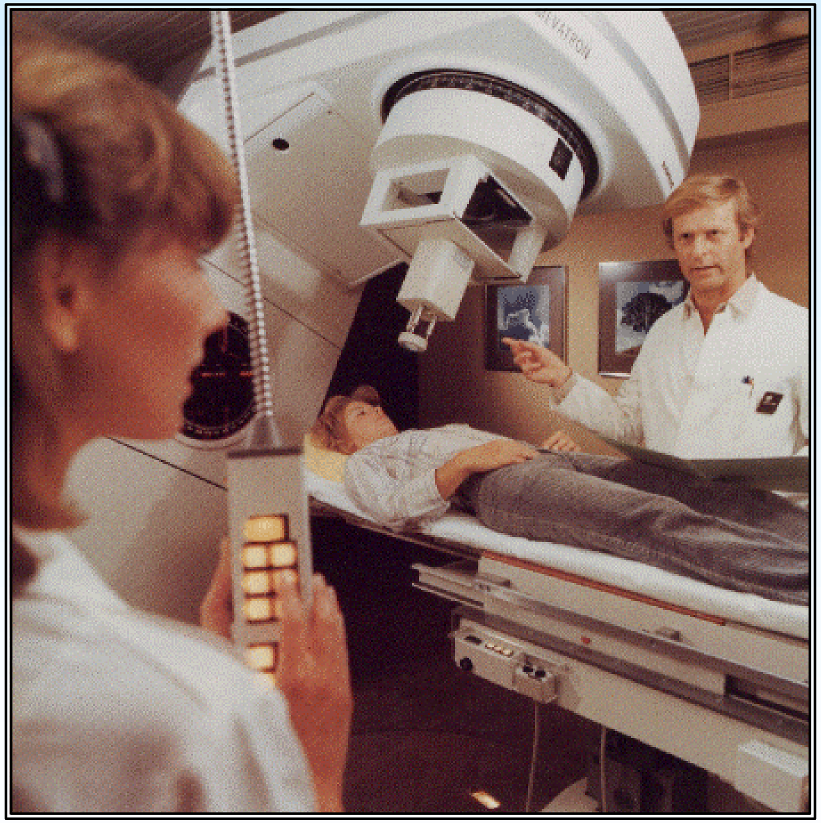
Shielding Construction for a Linear Accelerator Vault



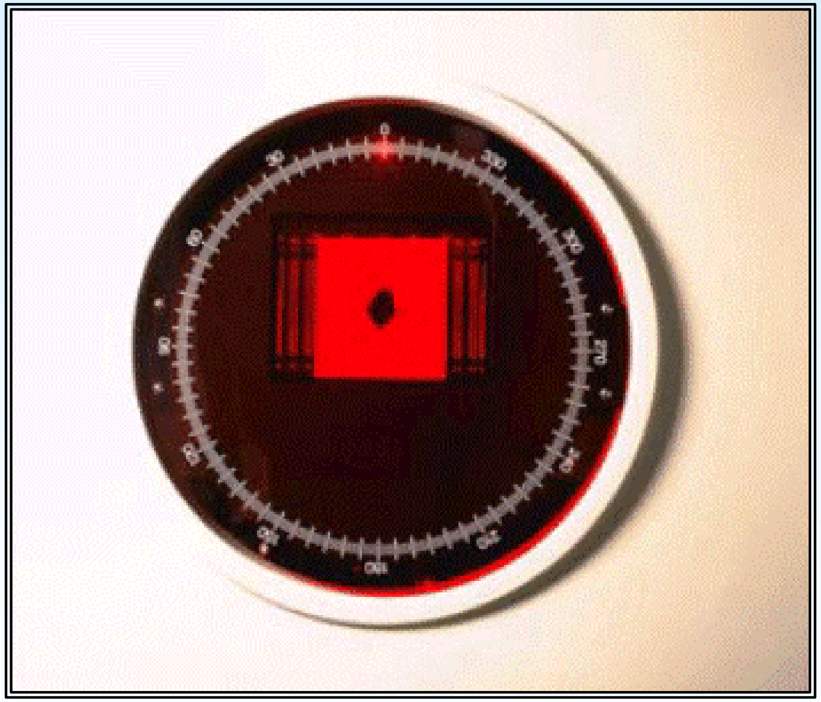
Linear Accelerator: Movement Possibilities



Linear Accelerator: Patient Positioning

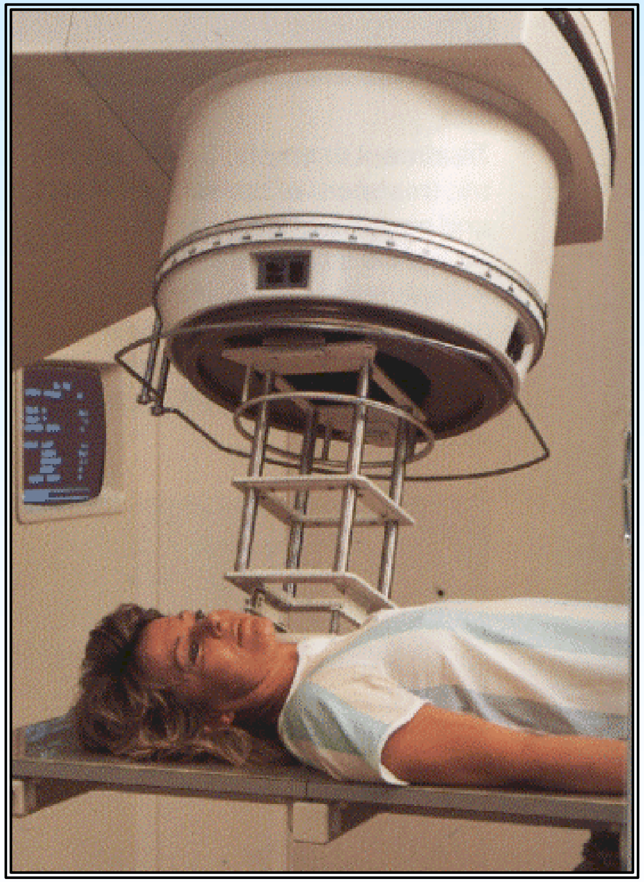


Patient Positioning Aids

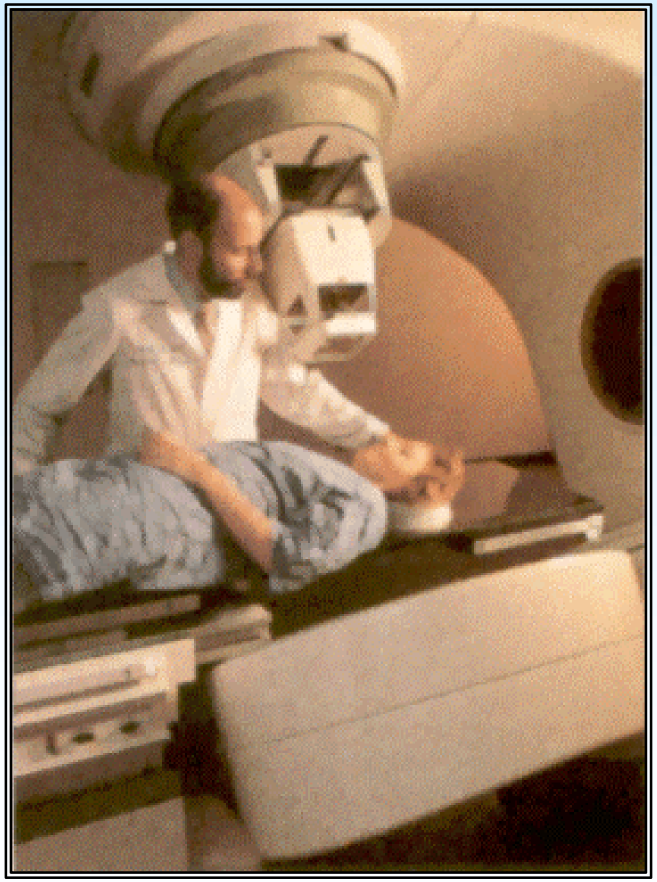


Patient Positioning for Photon Therapy

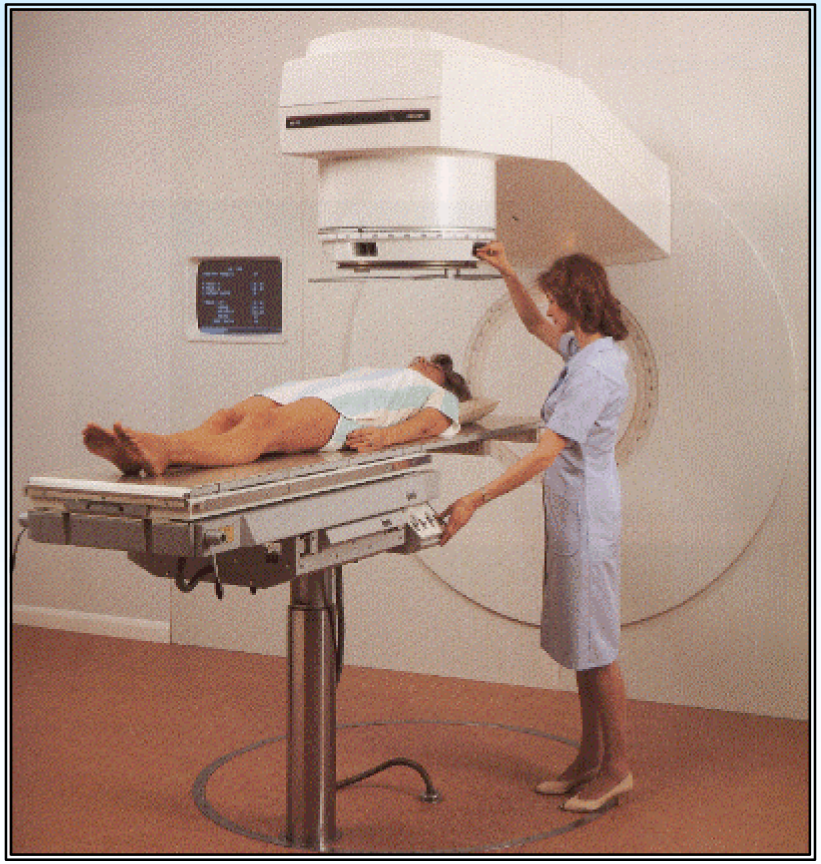
Patient Positioning for Electron Therapy

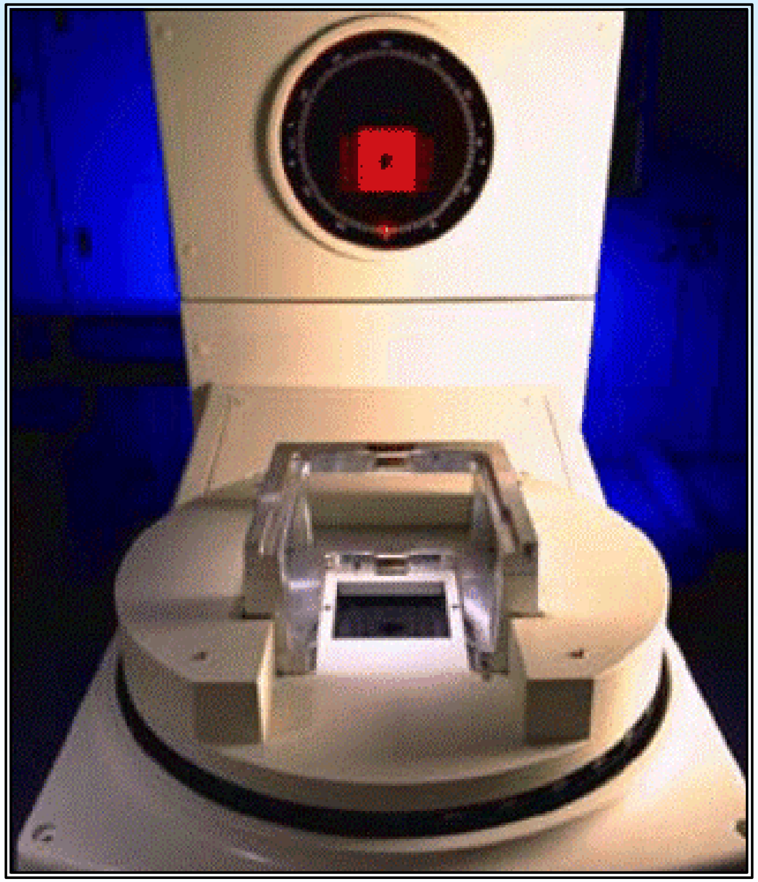


Patient Positioning for Radiotherapy combined to Hyperthermia



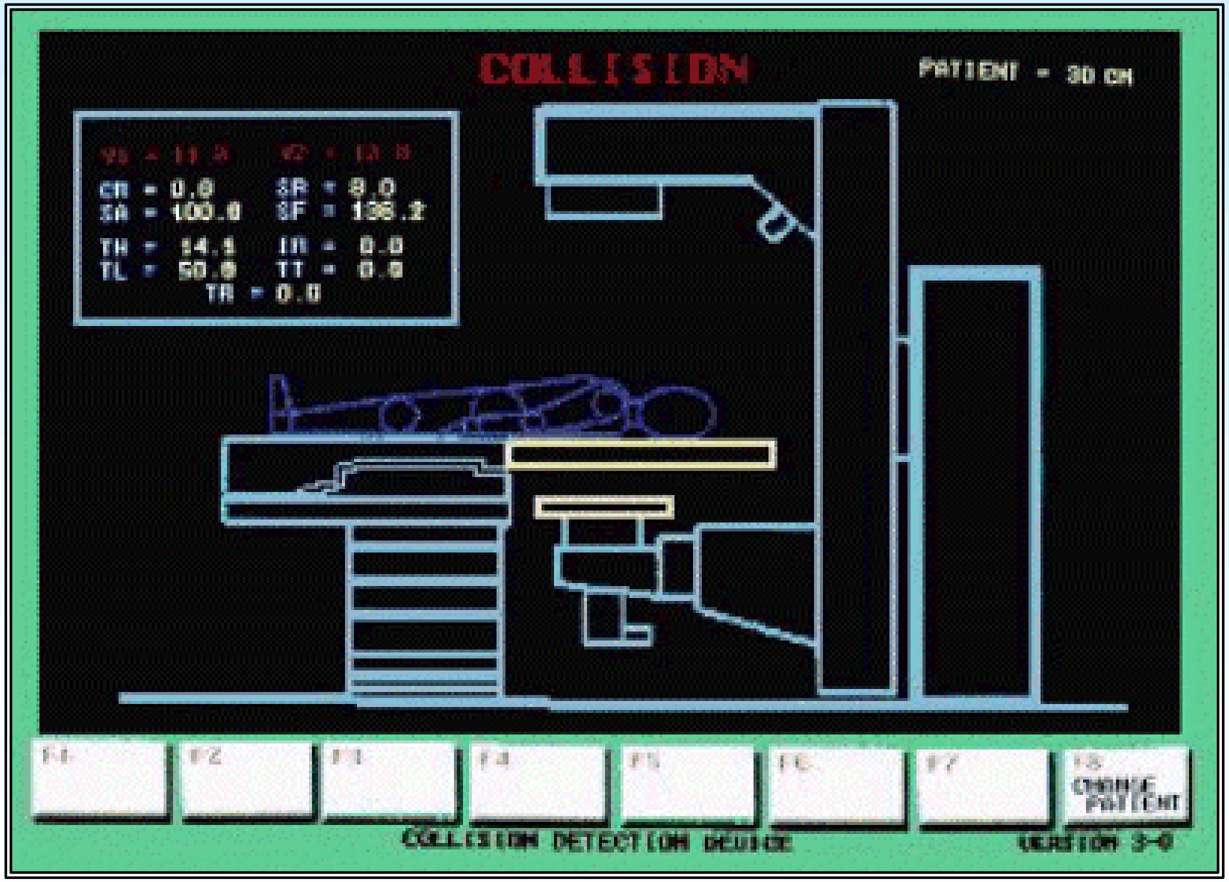
Patient Positioning for rotational Therapy



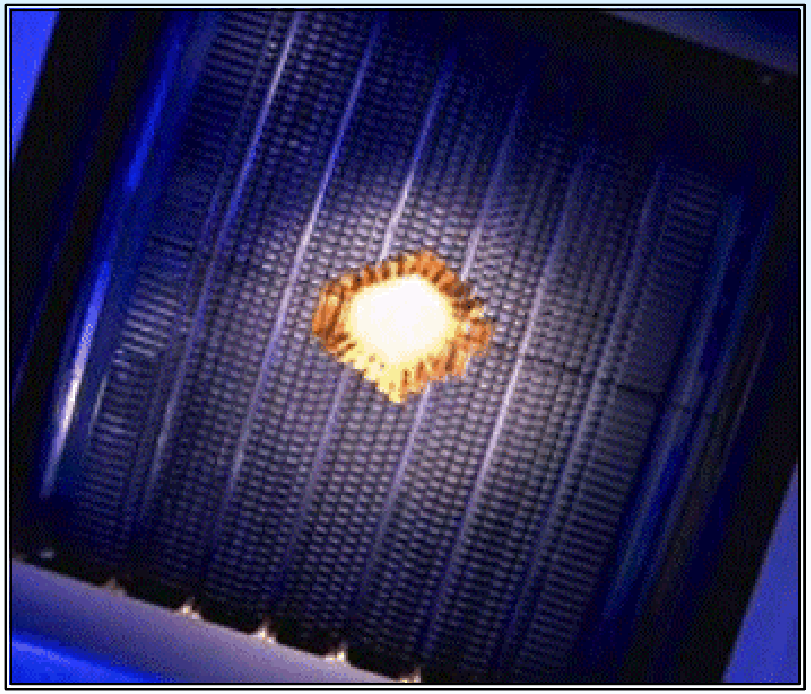


Radiotherapy Console

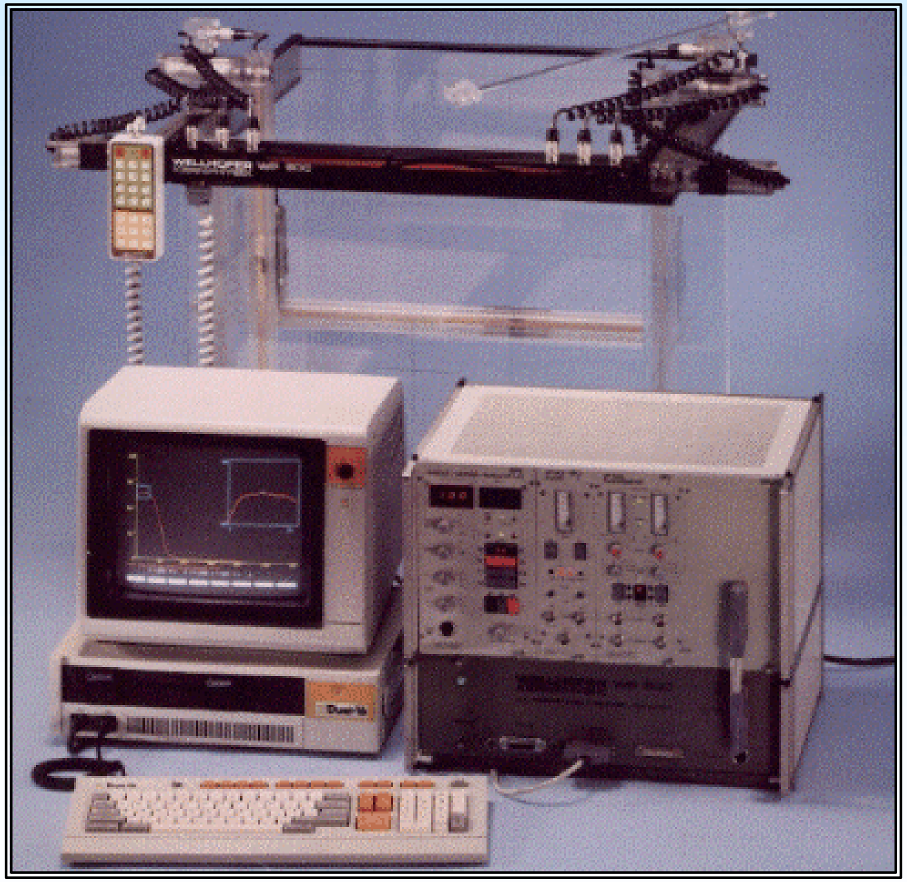
Collision Monitoring Screen



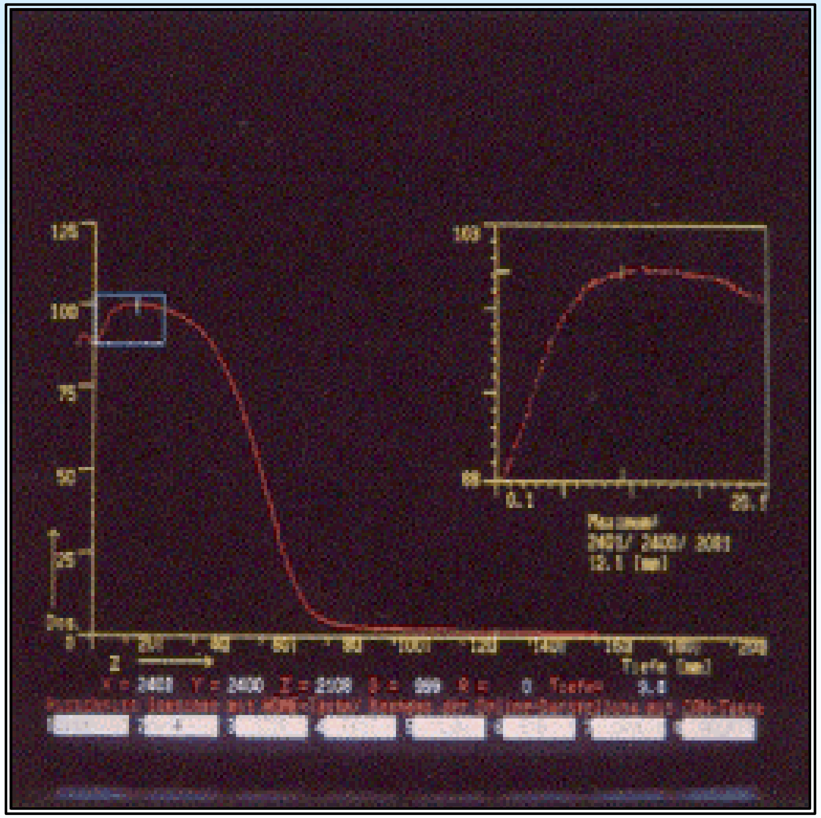
Administered Dose Monitoring Screen

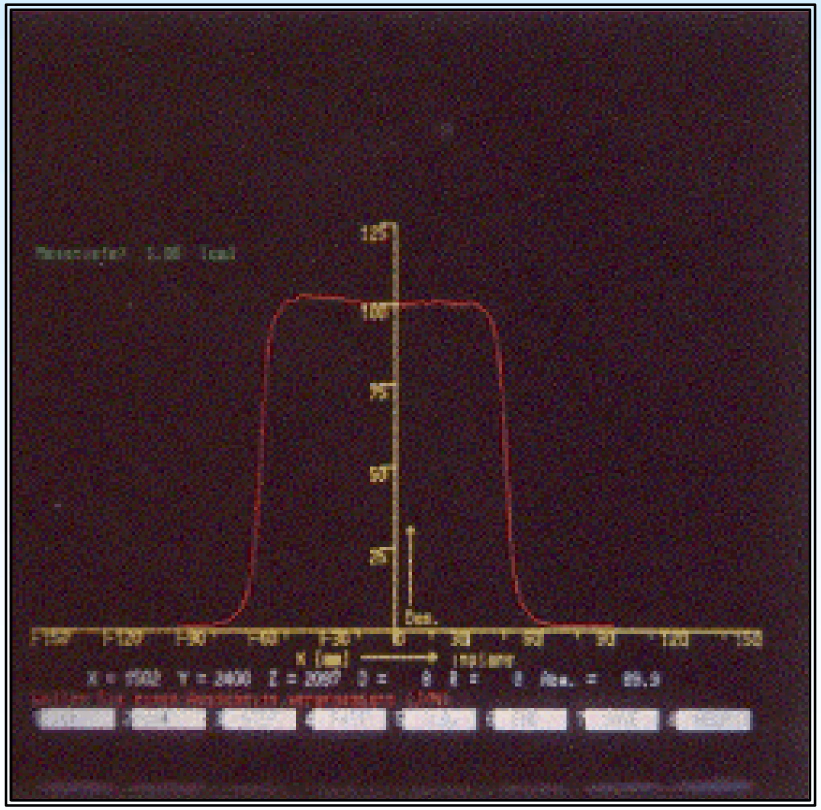


Water Phantom Dosimetry System

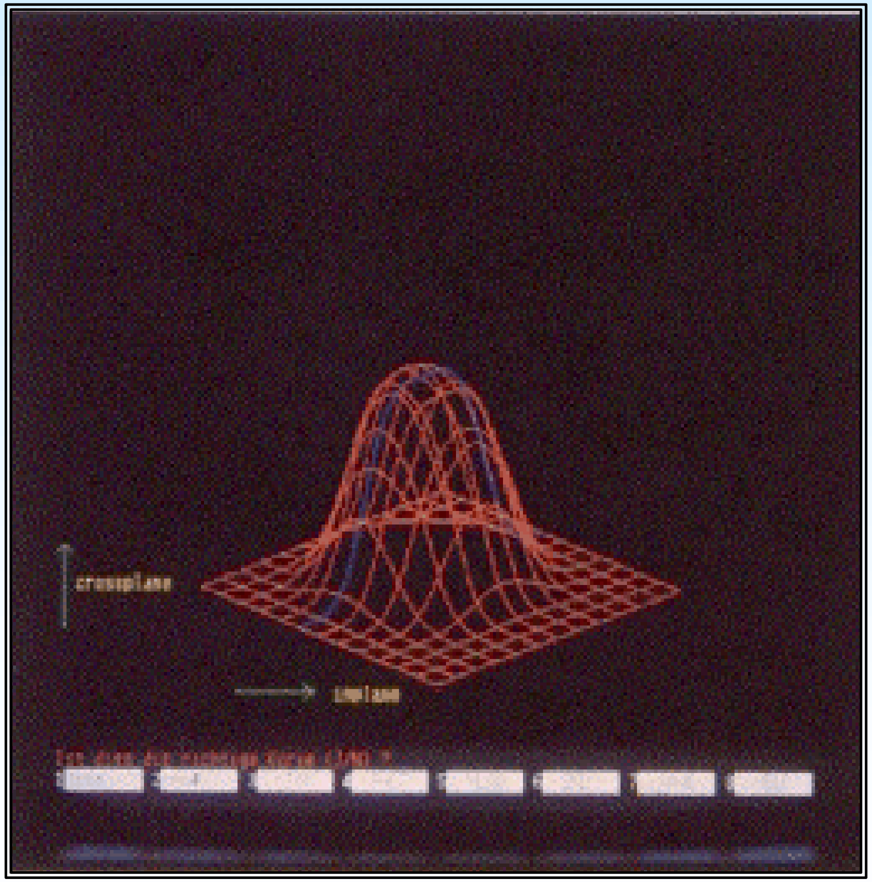


Photon Therapy Dose Profiles

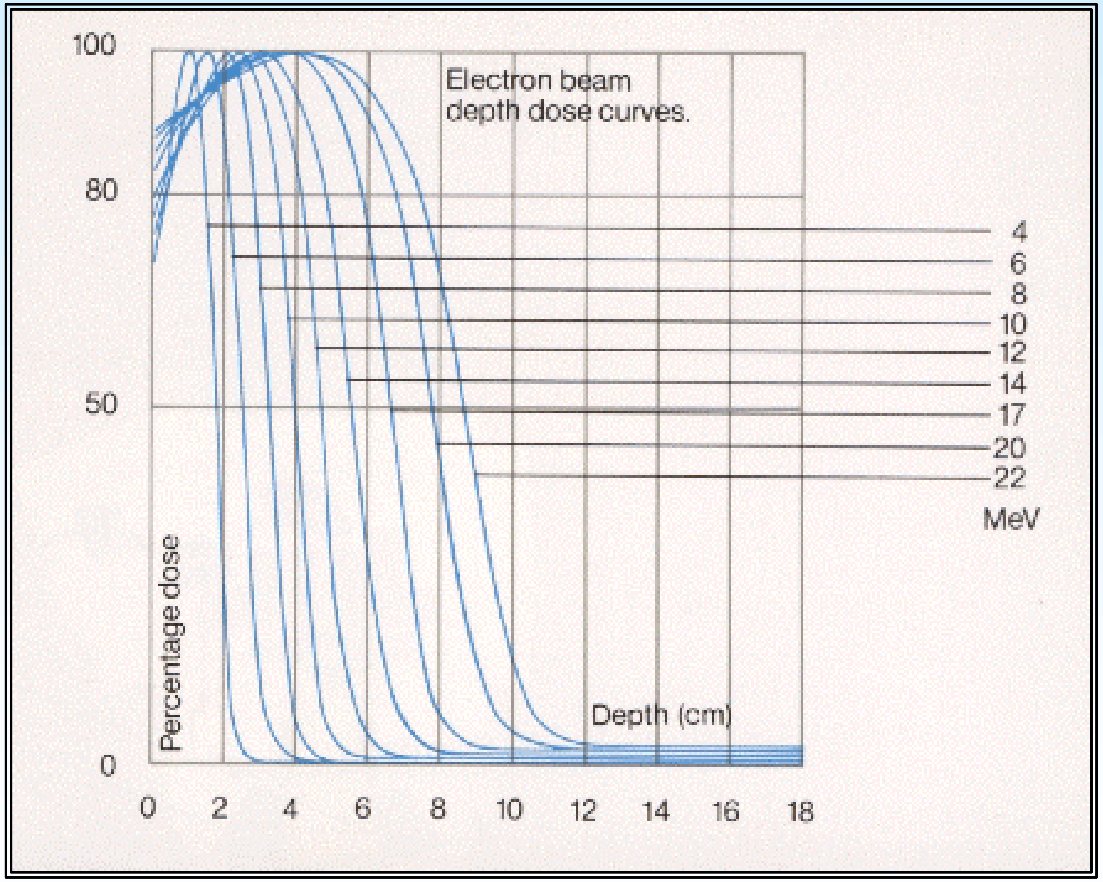




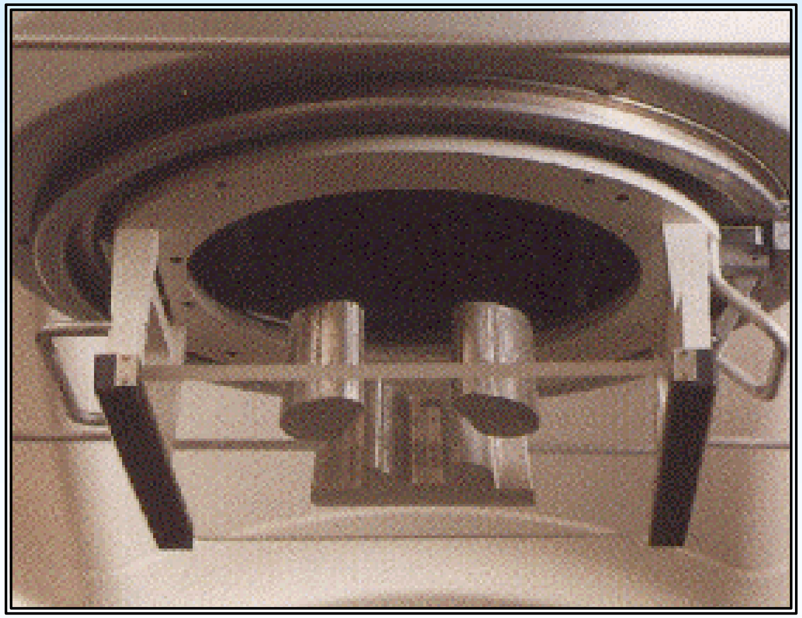
3-D Photon Therapy Dose Profiles



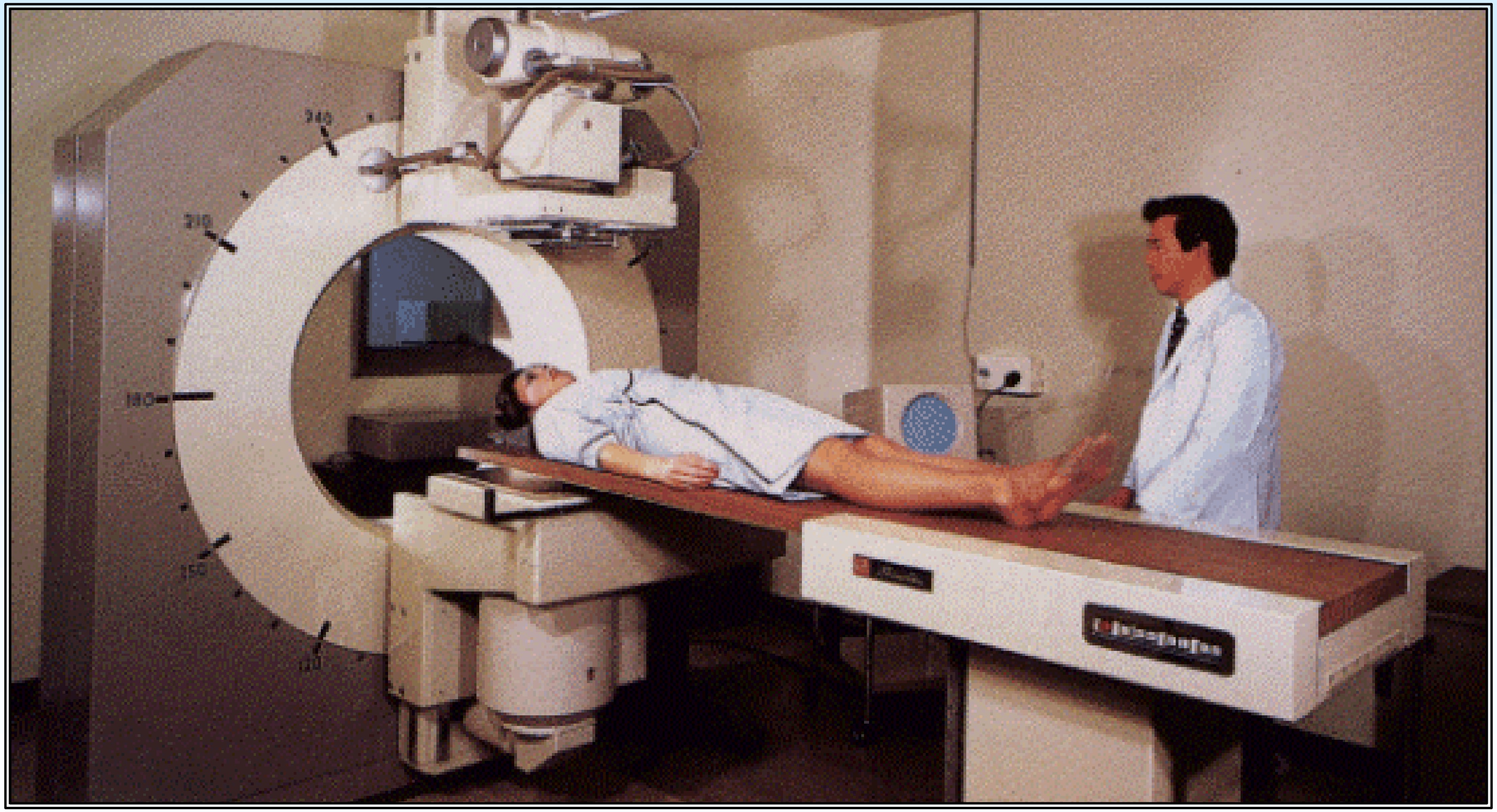
Electron Therapy Depth Dose Profiles



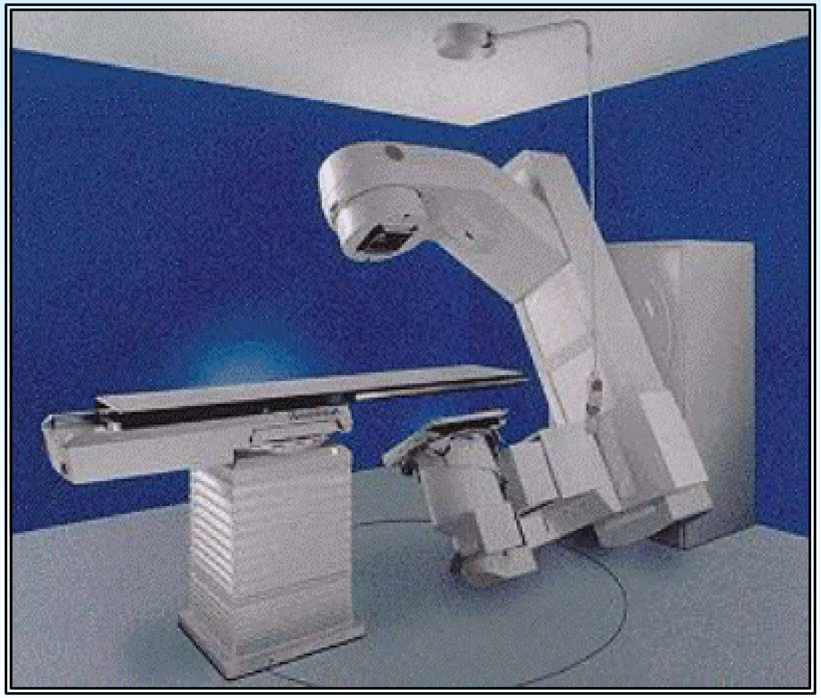
Irregular Field Photon Therapy

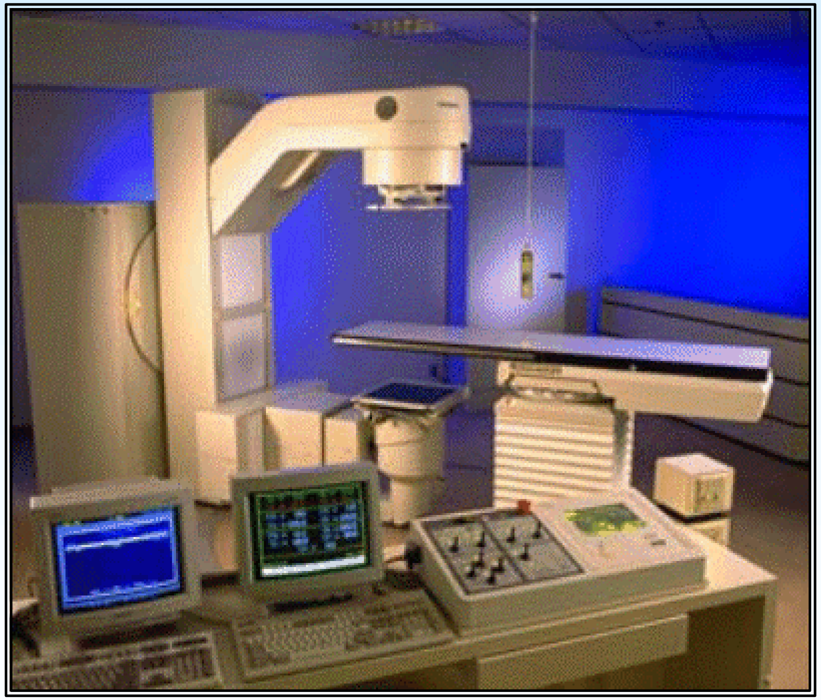


Radiotherapy Localizer - Simulator

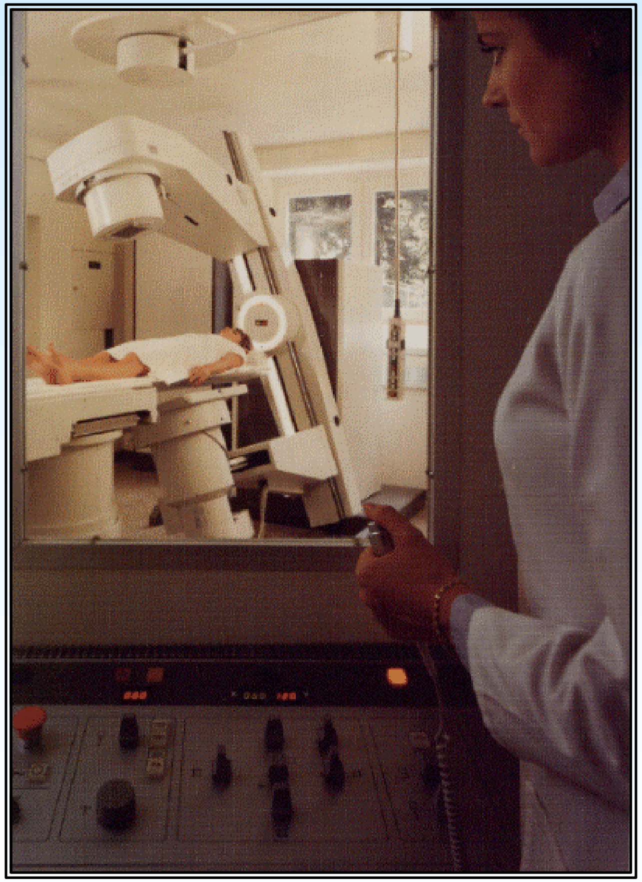


Radiotherapy Localizer - Simulator Rooms

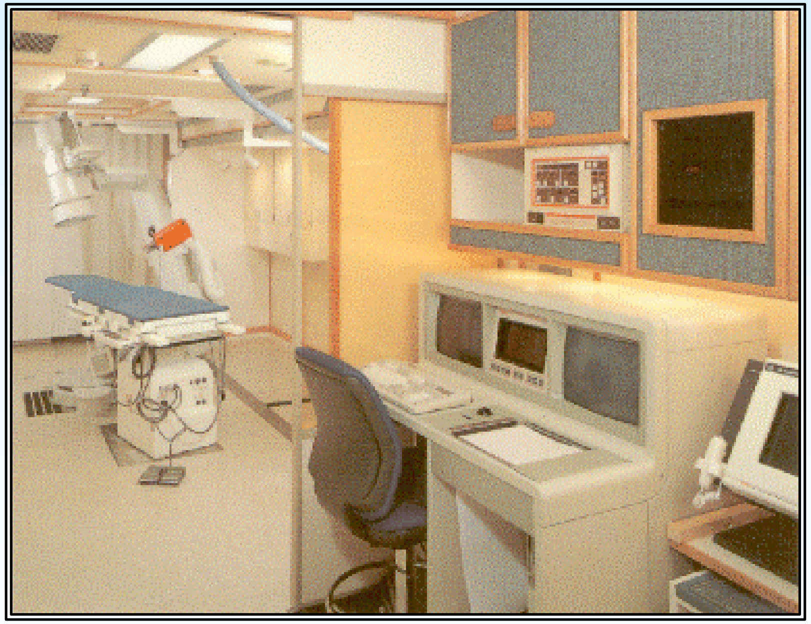


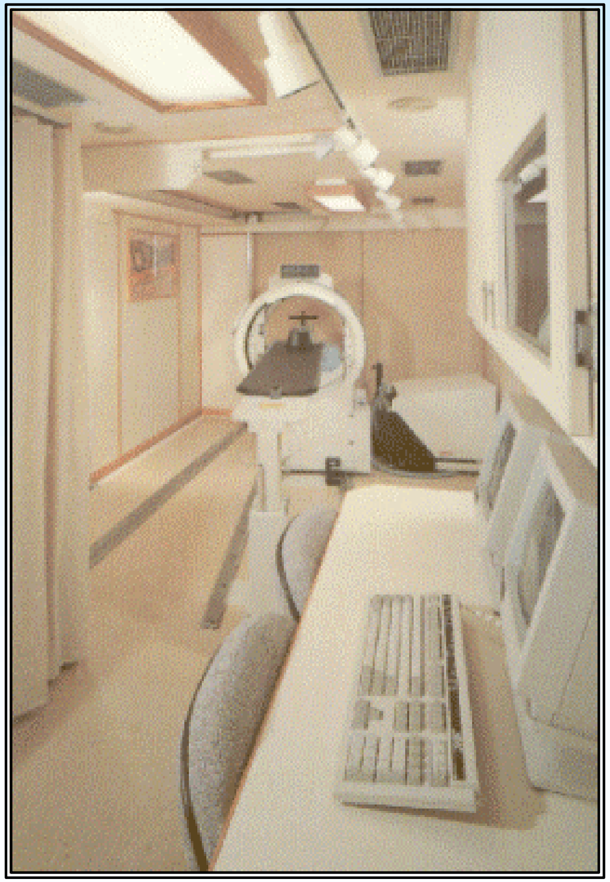


Radiotherapy Localizer - Simulator Application



Radiotherapy Localizer - Simulator combination to CT

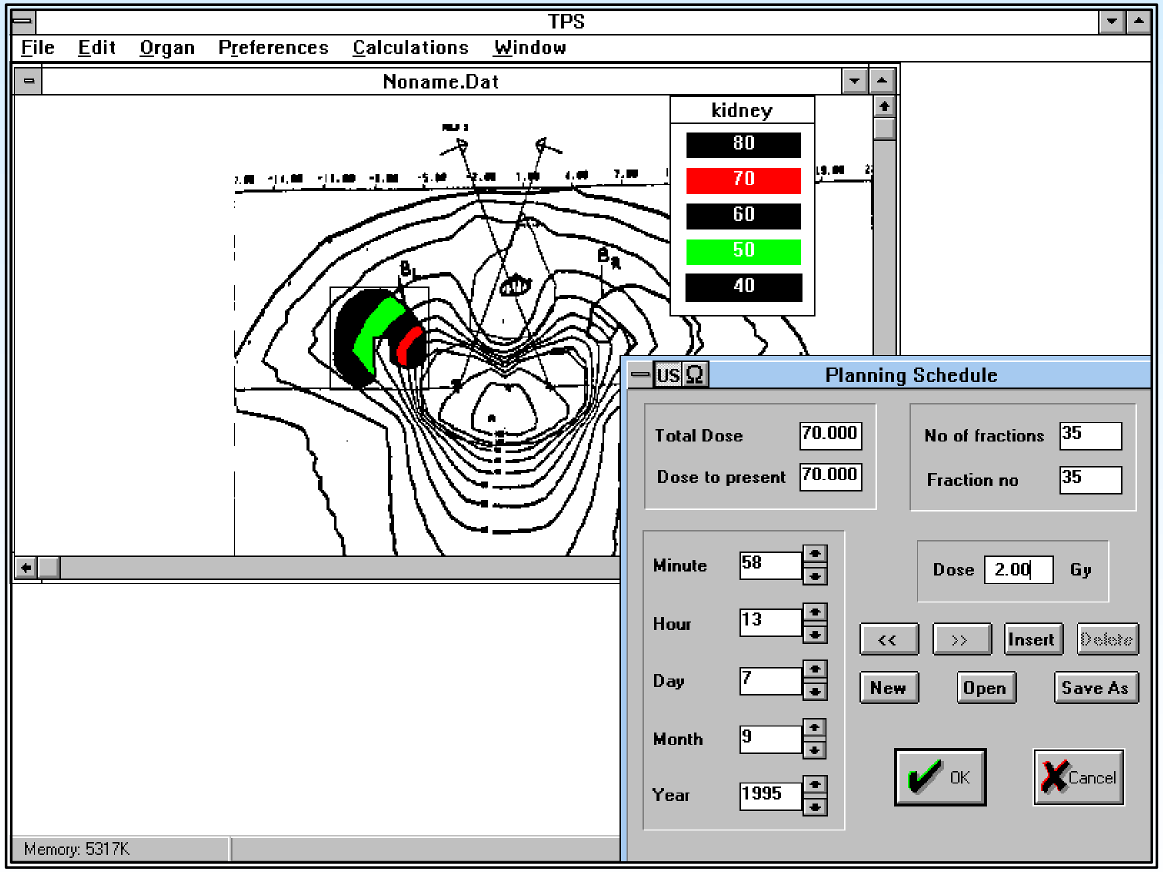




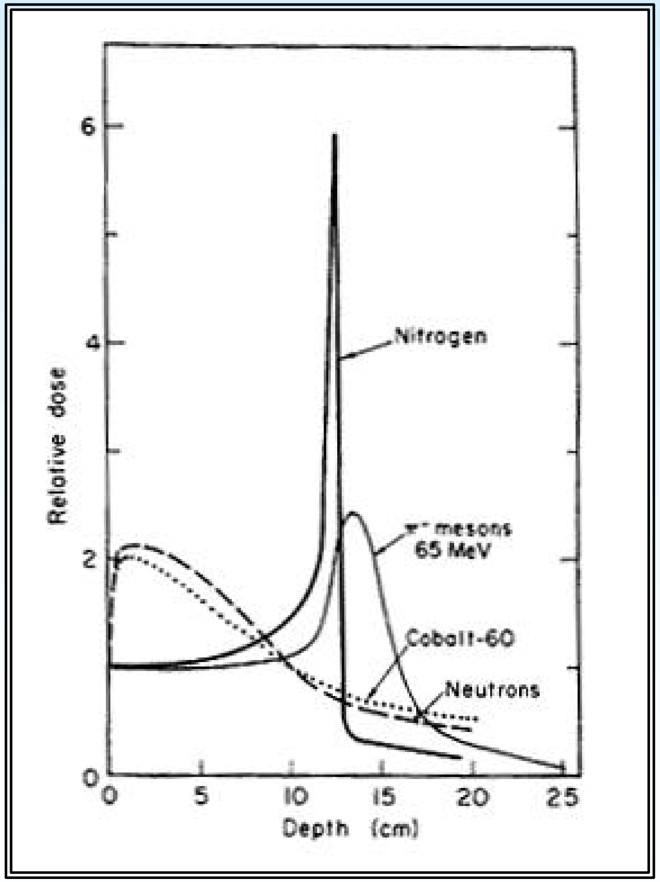
Treatment Planning

Treatment Planning Workstation

Treatment Planning: Combination of physical and biological parameters



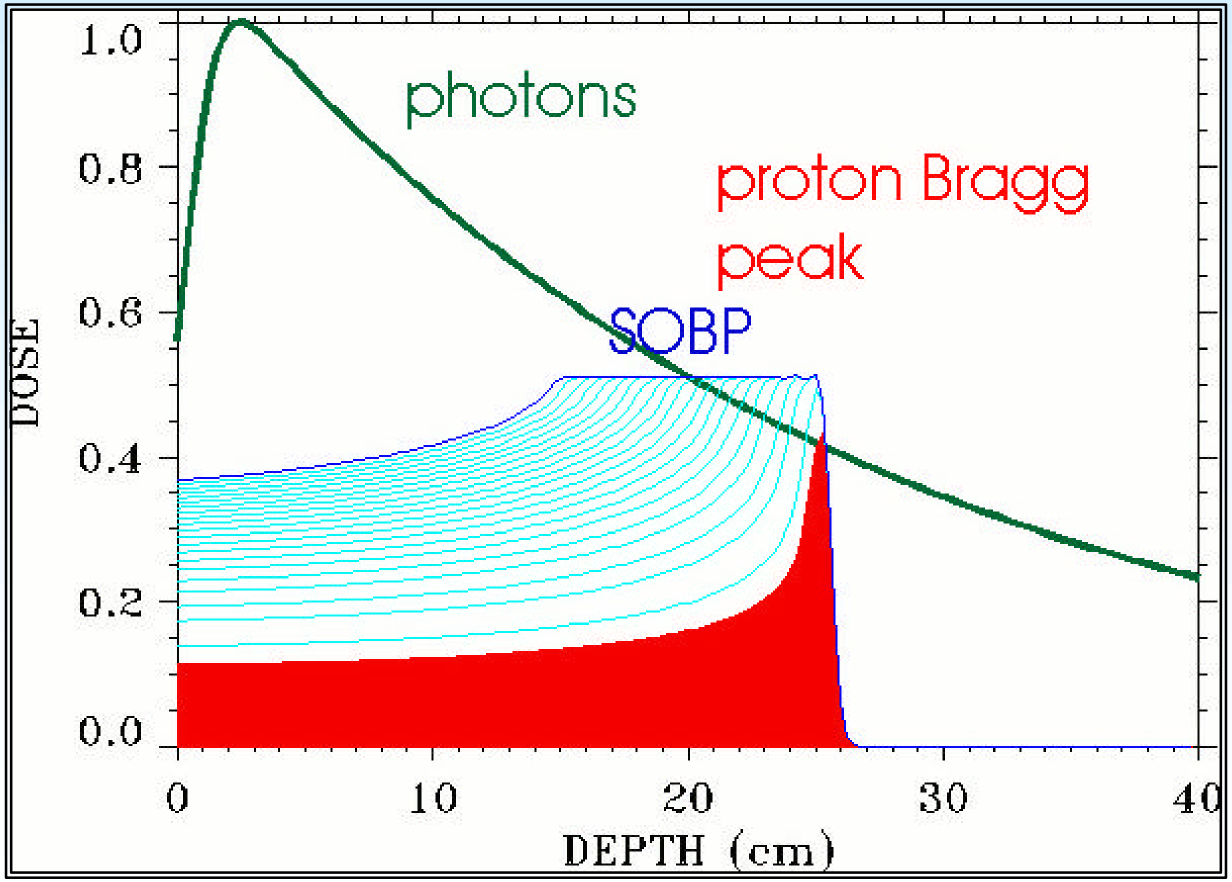
Heavy charged particles in Radiation Therapy



Heavy charged particles are gaining importance in external radiotherapy of deep located tumors, because of:

- *The limited angular and lateral scattering.*
- *The growth of energy deposition with increasing penetration depth.*

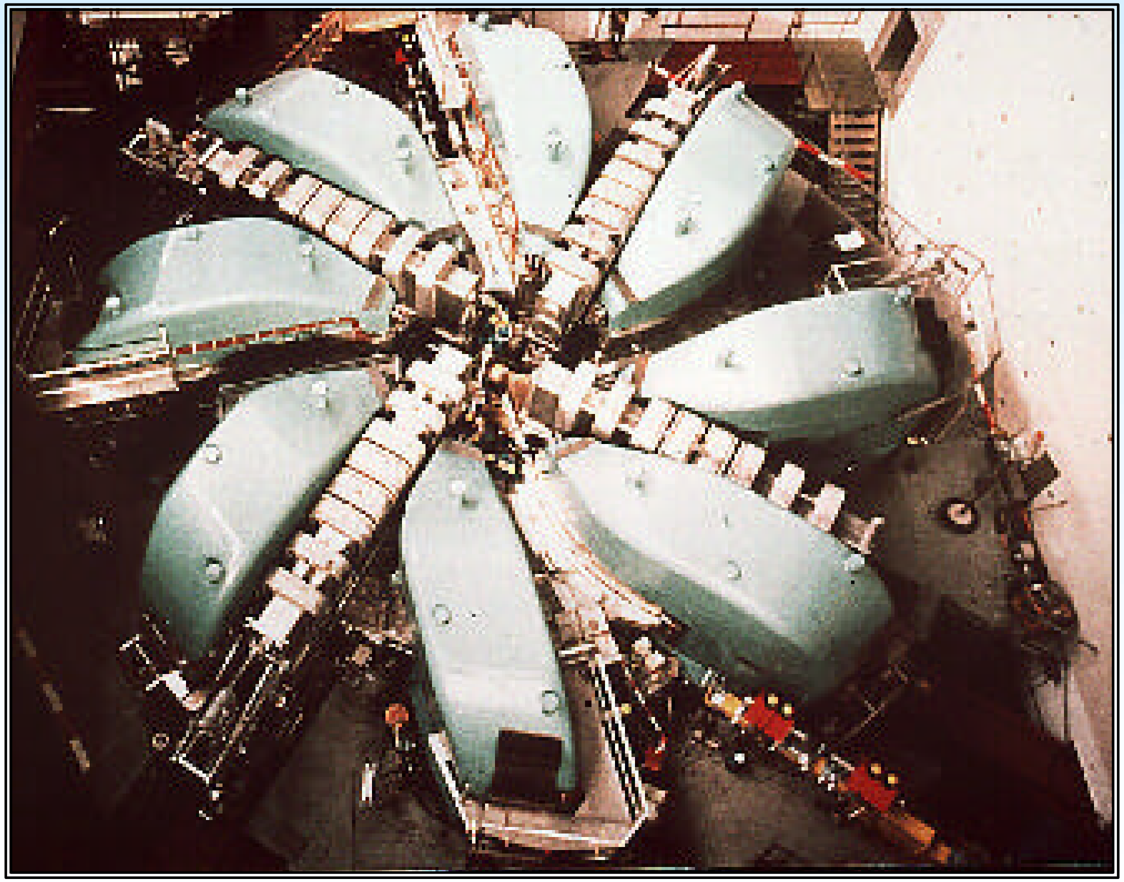
Proton Bragg peak vs. Photon Depth Dose



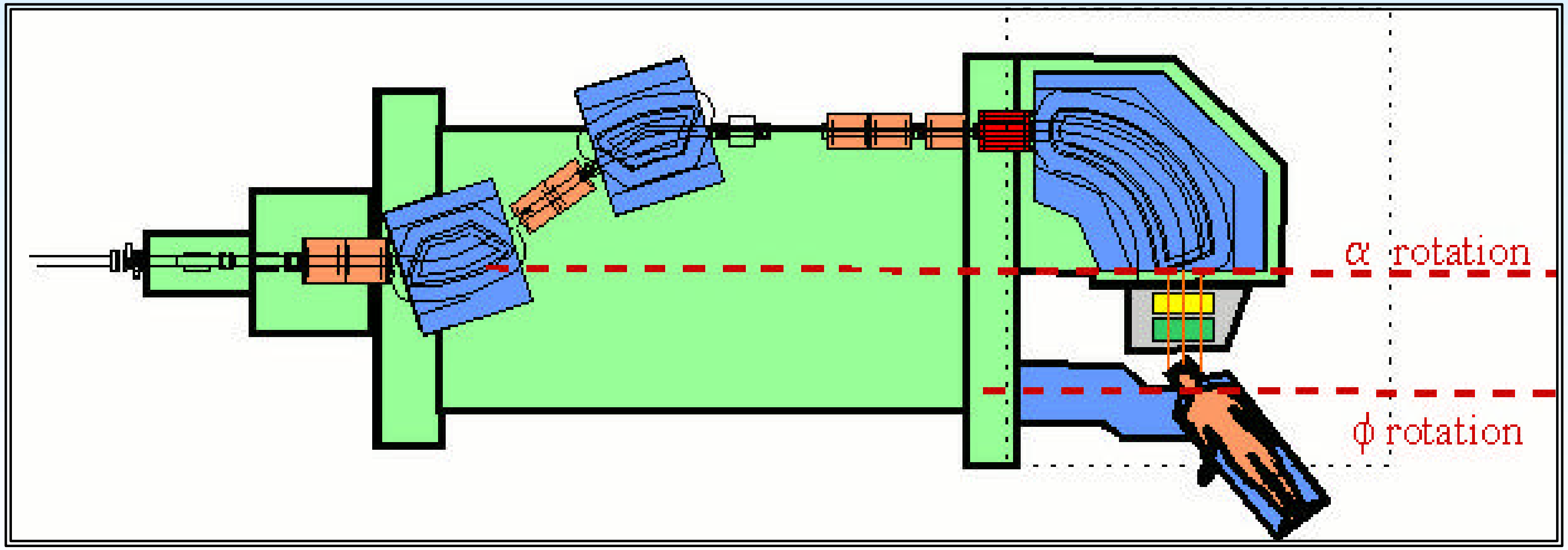
Proton radiotherapy of the Eye

- Proton radiotherapy allows for a precise irradiation of the target volume and optimal sparing of the healthy tissue surrounding the tumor. The maximum range is precisely defined by the energy of the particle. The scattering is limited due to the mass of the protons. In the OPTIS beam line, the dose delivered to the tissue decreases from 100 % to zero within 2 mm as well at the distal part as at the borders of the target volume.
- In order to benefit from this property the location of the target volume has to be known precisely. Tantalum clips are sutured on the sclera by the ophthalmologist to delimit the tumor border. These clips are used as marks for the computerized eye model, for tumor reconstruction in the treatment planning program as well as for the positioning of the patient.

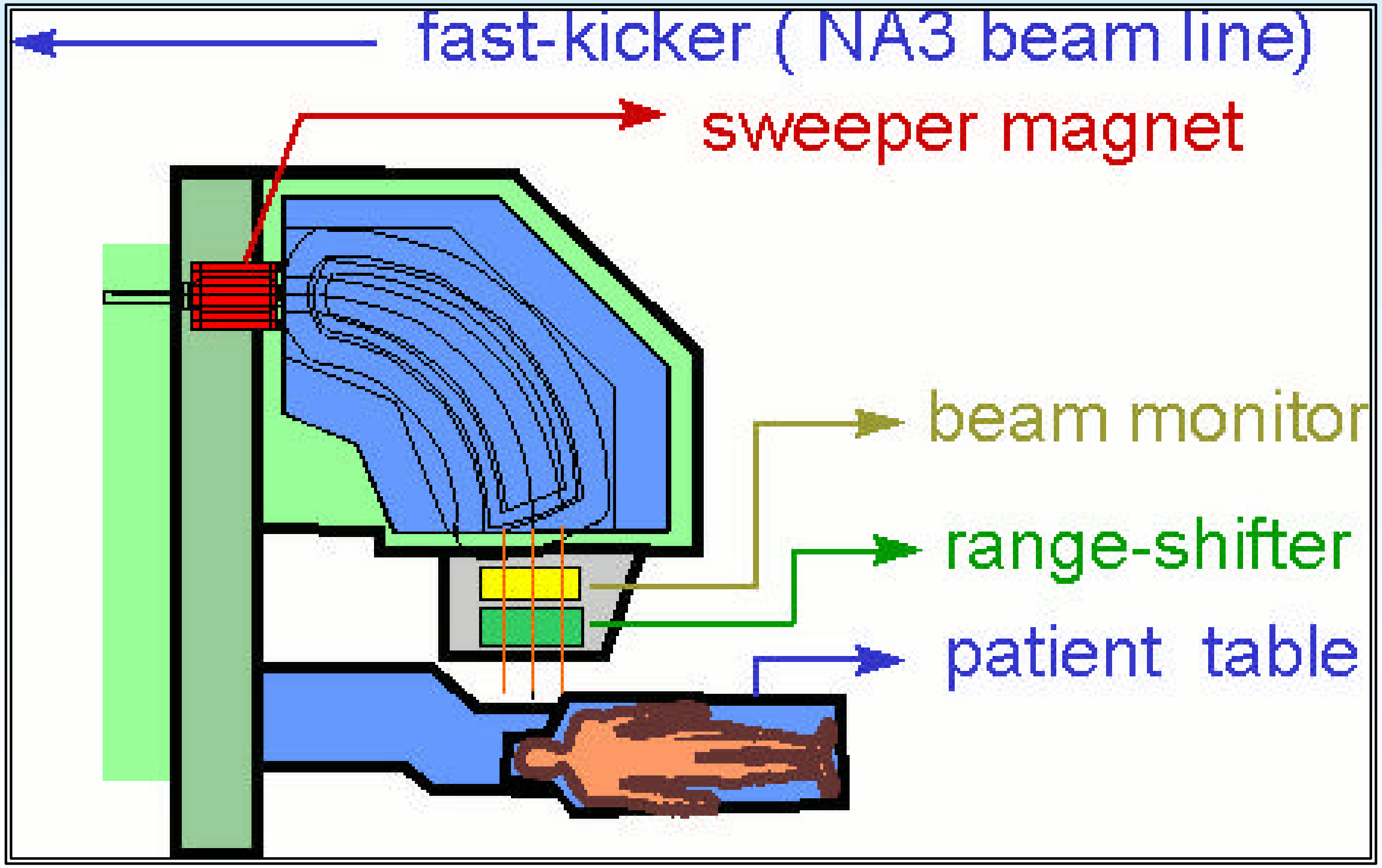
The Cyclotron



Cross section of the gantry



Gantry details

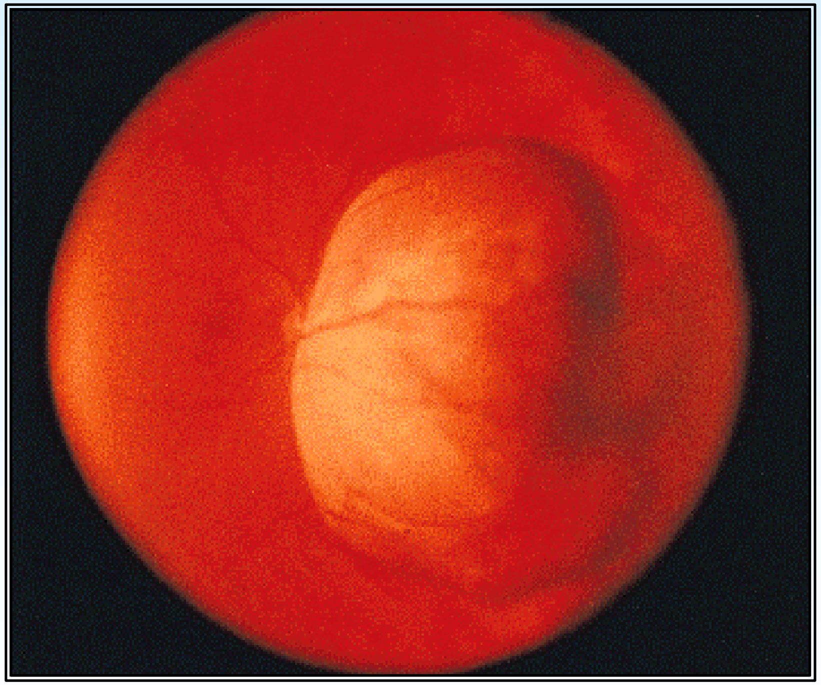


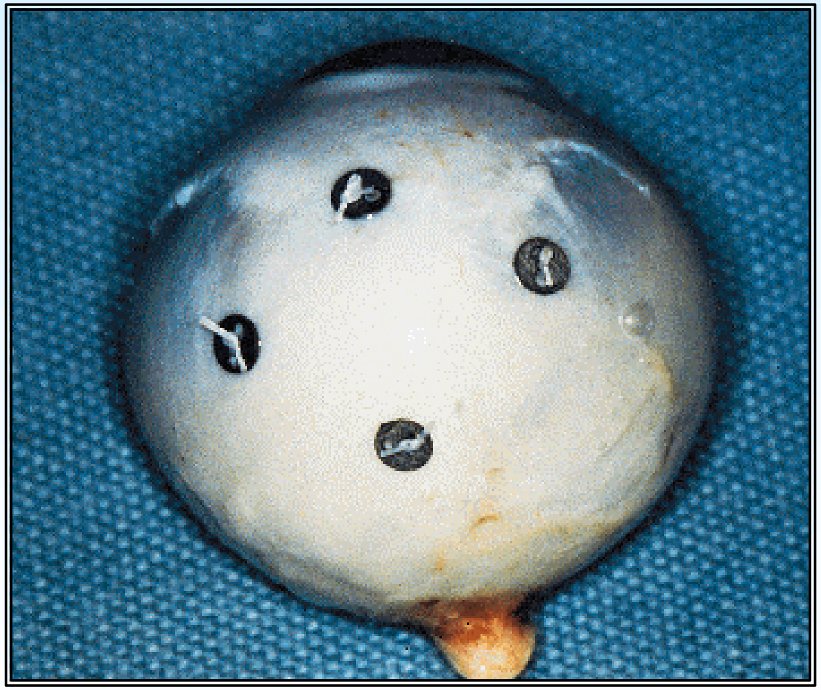
Preparation to treatment and Positioning

Tumor reconstruction

- After a simulation where X-ray pictures from the eye showing the tantalum clips are taken, the coordinates of the tantalum clips are introduced into the treatment planning program together with the eyelength measured by the ophthalmologist. This allows to build a computerized model of the eye.
- According to eye fundus pictures, ultrasound images of the tumor, the measurement of the distance between the tantalum clips and the tumor, the tumor is reconstructed in the computerized ocular model. Then, the treatment position is searched for, i.e. a position allowing the irradiation of the tumor while sparing the optic disc and nerve, the macula or the lens if possible. This depends on tumor size and location within the eye.

Tantalum clips sutured on the sclera

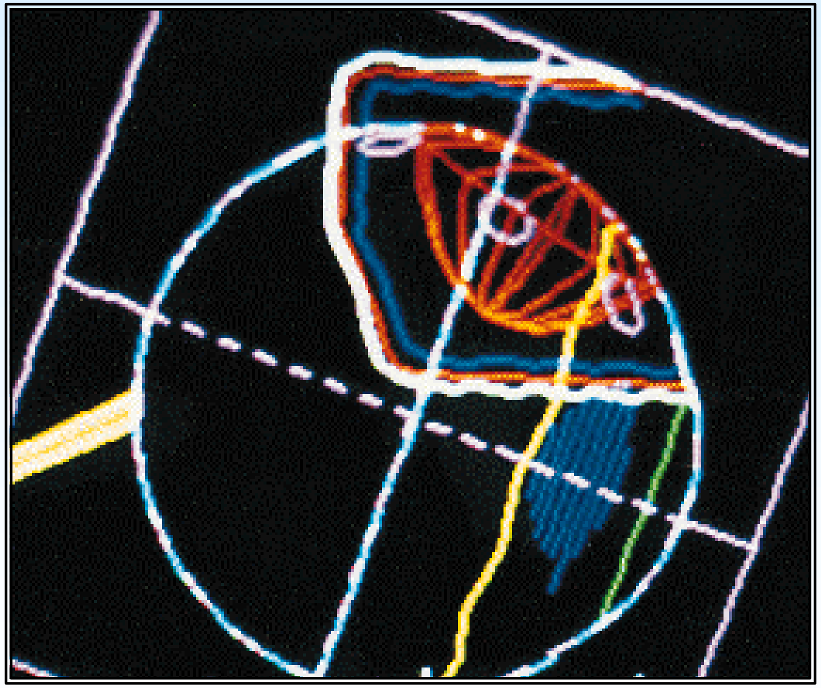




Correction of the positioning

- The treatment planning program provides a reference X-ray picture which will be used for patient positioning. A simulation in the treatment position shows the actual location of the tantalum clips. The comparison of this X-ray picture with the reference picture provided by the treatment planning program allows the detection of positioning errors of 1/10 of millimeter. Only after correction of the position, when no positionning error is detectable anymore will the irradiation be done.
- The results are accordingly excellent: the local tumor control probability is larger than 98 %.

Dose distribution achieved with proton radiotherapy



Proton radiography

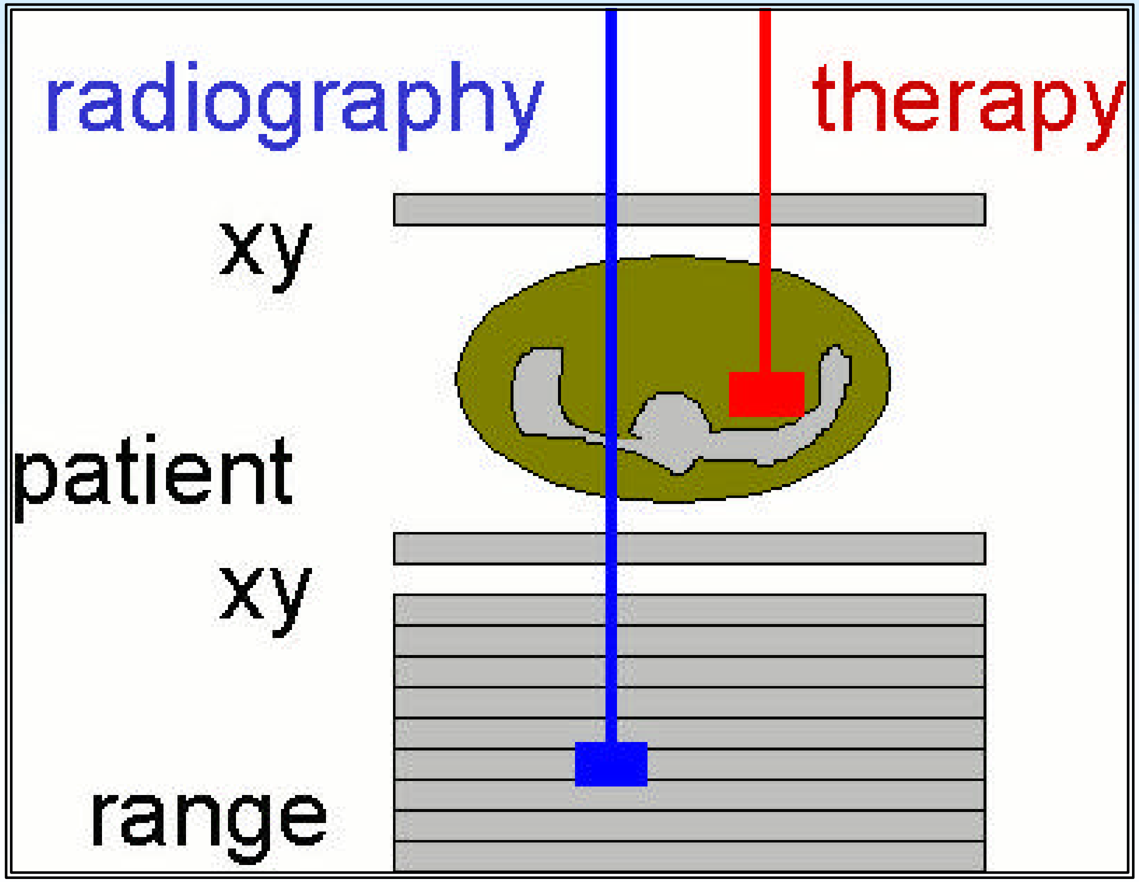
- Two large boxes containing the instrumentation for proton radiography are mounted on the same sliding supports used to transport the X-ray tube and the film cassette.
- In the "working" position at the isocenter, the boxes can be rotated by 90 degrees into the beam, one box in front of and the other behind the patient. In this way we can bring, under remote control, the instrumentation for proton radiography directly in and out of the proton beam on the gantry.

Proton radiography on the PSI gantry

Proton radiographies as a quality assurance tool for therapy

- Proton radiographic images will be produced on the gantry by measuring in coincidence with position sensitive detectors (scintillating fibers) the coordinates of the entrance and exit points of the protons transmitted through the patient.
- With a stack of scintillators the residual range of the proton leaving the patient is measured in coincidence with the spatial coordinates.
- The proton transmission radiographic images are obtained as two dimensional maps of the mean residual range of the protons emerging from the patient.

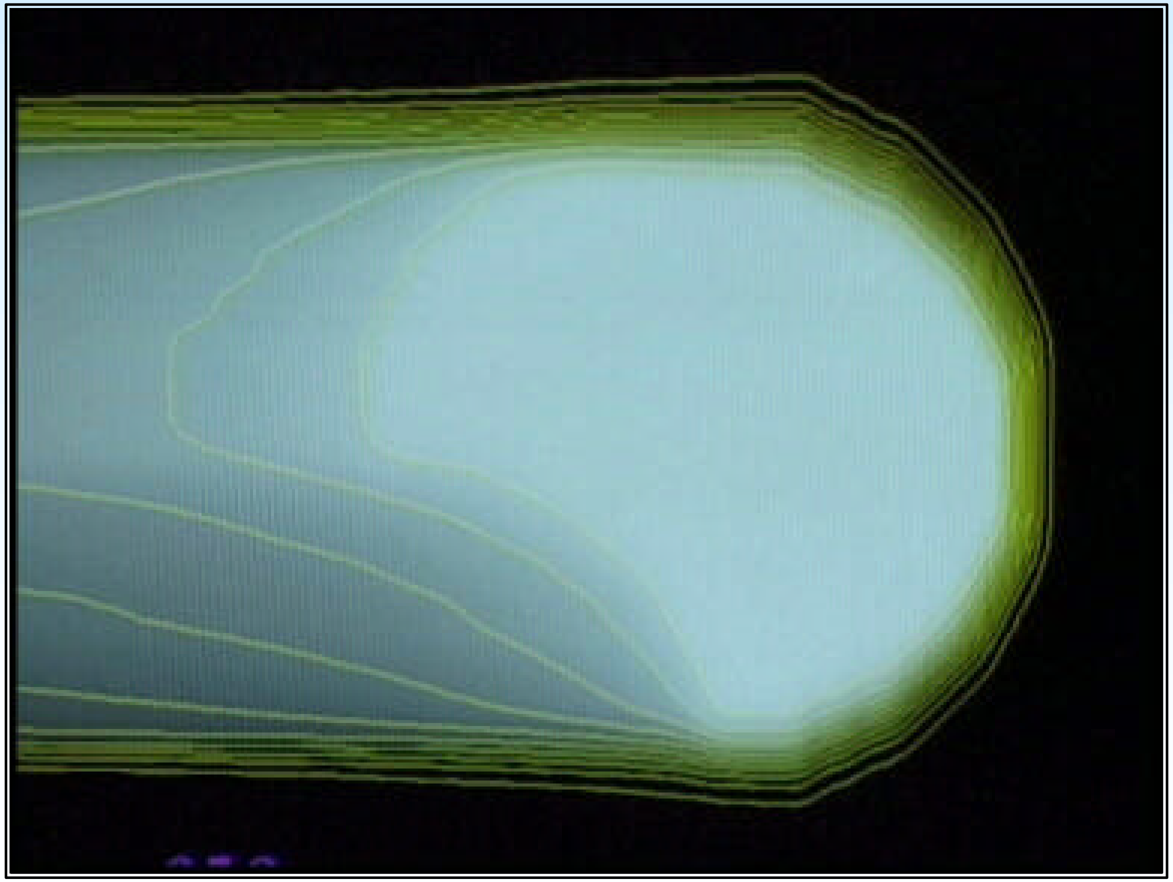
The principle of Proton radiography



Range information contained in the images

- Proton radiography will provide an interesting alternative to conventional radiography for checking the position of the patient on the gantry.
- Compared to X-ray images, the proton images are expected to have poorer spatial resolution but better density resolution at a much lower dose.
- The most interesting information is however given by the range information contained in the images, which can be used for checking indirectly the precision of the calculation of the proton range in the patient.

Ranges predicted by the algorithms of treatment planning.

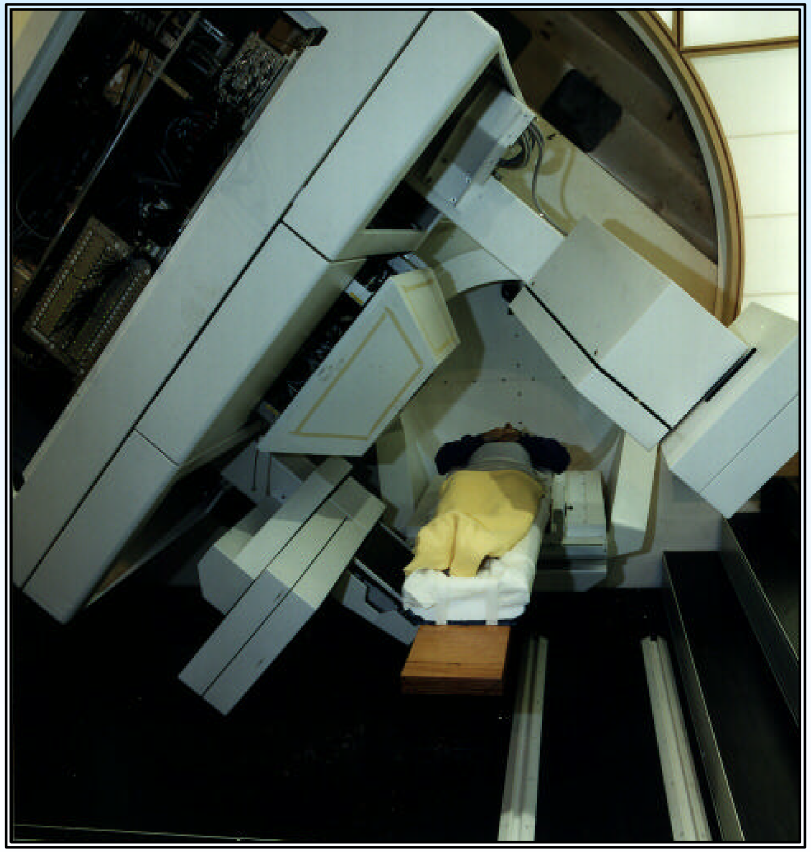


Proton radiographs vs. range prediction algorithms

- Since proton radiographs are range calibrated images of the residual range of protons in the patient, they can be compared with the results of the range prediction algorithms of treatment planning.
- If the agreement is good one can then expect that the predictions of treatment planning will be equally precise for the therapeutic beam, when the beam must be stopped in front of sensitive healthy structures.

Proton radiographs

Treatment execution

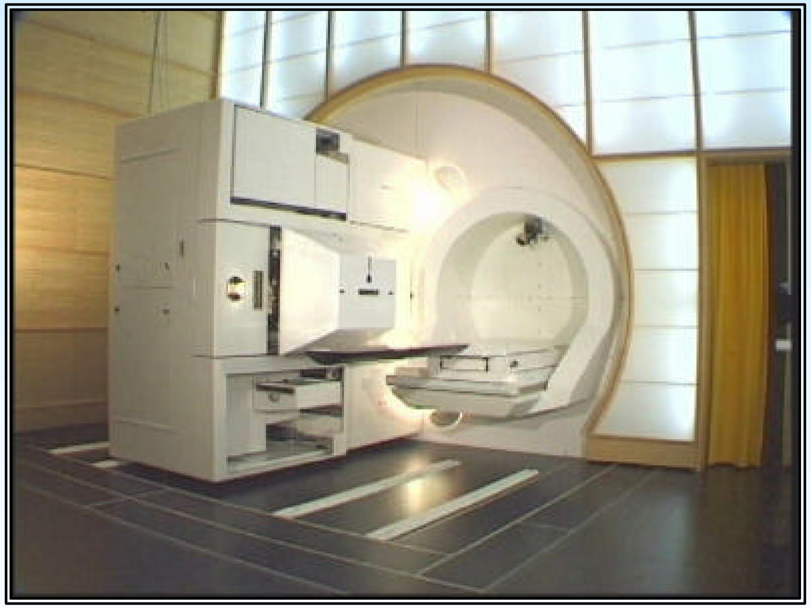


Radiotherapy and Industrial Sterilization Facility Radiation Protection

Radiation Protection in Radiotherapy and Industrial Sterilization Facilities includes several aspects concerning:

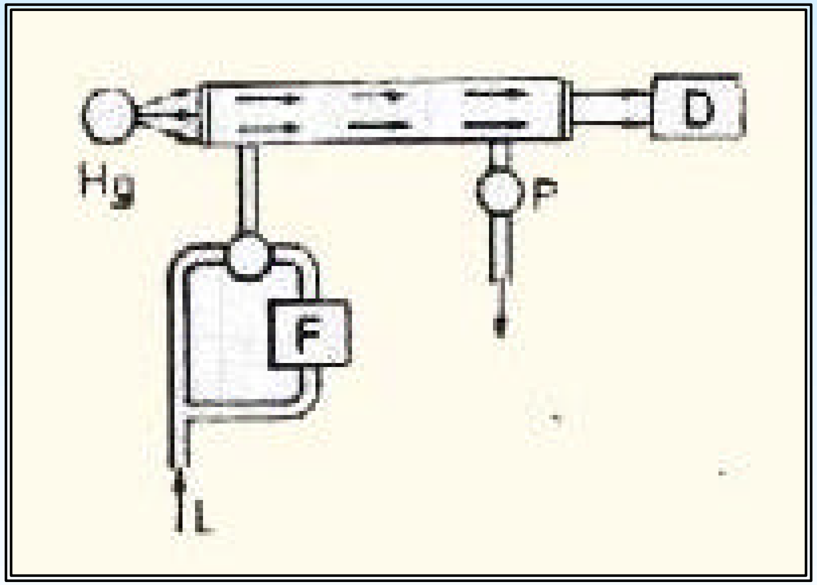
- *Their planning.*
- *The hazard-sources.*
- *The environmental protection.*
- *The general safety.*

Radiological Policy and Facility Planning



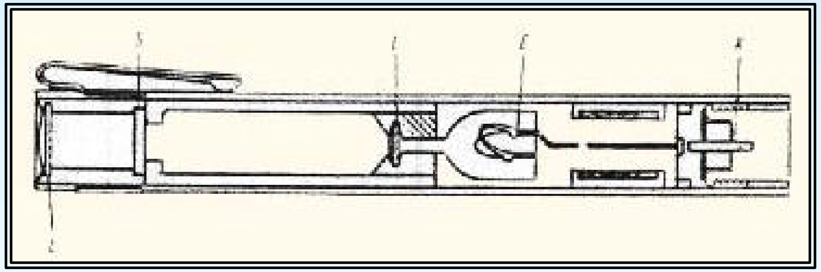
- Site Planning.
- Main Aspects to be encountered.
- Potential Hazards.
- Electromagnetic Cascade.
- Shielding Calculations.

Activation and Noxious Gases



- Component Activation.
- Air Activation.
- Activity induced in Water.
- Production of Noxious Gases.

Radiation Protection Instrumentation



- "Real - time" Monitoring.
- Personnel Dosimetry.
- Site Dosimetry.
- Activation Monitoring.
- Beam Diagnostics related to Radiation Protection.

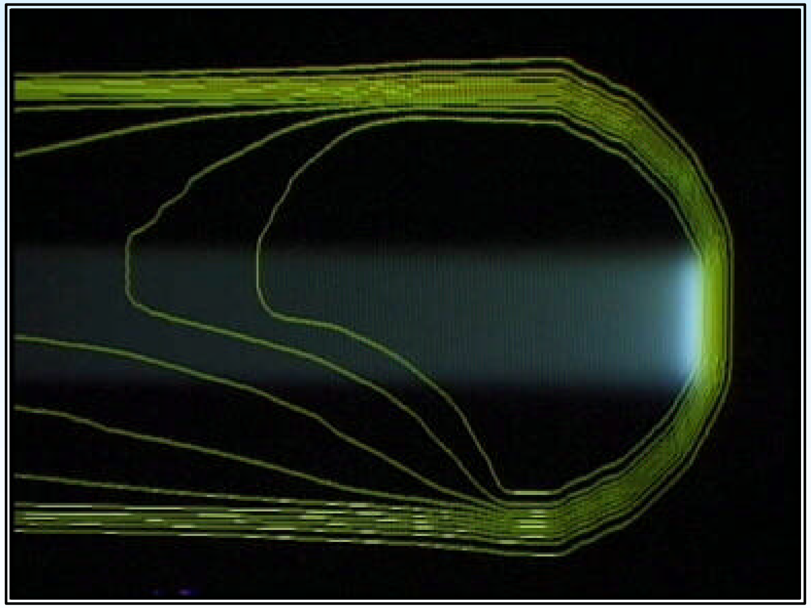
Environmental Monitoring Program

- Ambient radiation dose - rate measurements.
- Aerosols (air, vapor and dust) measurements.
- Water measurements.
- Soil, grass and vegetation samples measurements.
- Measurements of Noxious gases in the accelerator vault.

General Safety Requirements

- Mechanical Hazards.
- Electrical hazards.
- Vacuum.
- Electromagnetic Compatibility.
- Fire Protection.
- General Policy for Accident Limitation.

Radiation Treatment Planning and Administration



- Simulation & Localization in Radiotherapy.
- Treatment Planning in Radiotherapy (Physical).
- Treatment Planning in Radiotherapy (Biological).
- Intra Operative Radiation Treatment.
- Patient and/or materials Irradiation Management.