Modern equipment in classical radiotherapy based on linacs

Slawomir Wronka, CAS 11.10.2006
Contents

• Epidemiological data

• Machines used for „classical” radiotherapy

• High-art. techniques
Poland

- Cancer is the second main mortal disease in Poland (20%)
- 110 000 cases / year
- ~ 50-60% requires radiotherapy treatment
  → 60 000 patients yearly

World

> 200,000 patients treated daily
> 7500 radiotherapy accelerators
Typical beams

Electrons

![Graph showing percent depth dose for different energies of electrons versus depth in cm.](image)

![Image of a radiation therapy treatment planning system.](image)
Typical beams

Photons
Typical beams

• At present, in radiotherapy, the upper energy range of 15 to 20 MeV is considered optimal. The lower limit in photon therapy is determined by clinical requirements of the treatment of head and neck tumors for which the energies of 4 to 6 MeV are optimal.*

* W. Maciszewszki, W. Scharf „PARTICLE ACCELERATORS FOR RADIOTHERAPY. PRESENT STATUS AND FUTURE. “
Linear accelerator

Electron source

Pulsed modulator

Accelerating structure

RF power source

Accelerator head
Medical linac
Electron source

- Electrons are thermionically emitted from the heated cathode and accelerated toward the anode through which they enter the accelerating structure.
Electron source

Diode Electron Gun

- FOCUSING ($V_0 - HV$)
- ACCELERATING STRUCTURE
- FILAMENT
- e-cloud
- CATHODE (-HV)

Image of diode electron gun
The electrons are accelerated in the accelerating structure by radiofrequency (RF) fields which are produced by the RF power generators.

The microwave frequency used for electrons acceleration is about 3 GHz.
Accelerating structure

Standing wave

Traveling wave
Accelerating structure
Accelerating structure
Accelerating structure
RF power generation system

- The microwave radiation, used in the accelerating structure to accelerate electrons to the desired kinetic energy, is produced by the RF power generation system which consists of two components:
  - RF power source
  - Pulsed modulator
RF power source

• The RF power source is either magnetron or klystron. Both are devices using electron acceleration and deceleration in vacuum for production of the high power RF fields. Both types use a thermionic emission of electrons from a heated cathode and accelerate the electrons toward an anode in a pulse electrostatic field.
Pulsed modulator

• The high voltage (~100kV), high current (~100A) and short duration pulses (~1μs) required by the RF power source (magnetron or klystron) and the injection system (electron gun) are produced by the pulsed modulator.
90° Magnet
270° Magnet

electrons from accelerating waveguide

tight distribution of electron energy and direction

focus of electron beam source

target
„Slalom”
Energy spectrum filter
Dose monitoring

• The dose is monitored typically by two ionization chambers.
Multileaf collimator
Electron MLC ?
Portal imaging
Portal imaging
Treatment planning
Treatment planning
# Treatment techniques

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<th>Conventional Radiation Therapy (external)</th>
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<th>Intensity Modulated Radiation</th>
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Intensity Modulated RT (IMRT)
Improvement in Radiotherapy

1950’s field
1980’s field
2006’s field
Improvement in Radiotherapy

- **1950’s** – more people were harmed than benefited

- **1980’s** – approximately 70% of the people benefited and 10% were harmed

- **2006** – approximately 90% of the people are benefiting with 1-2% side effects.
Breathing motion control
Available systems

• Patient cooperation

And/Or

• Automatic beam gating

OR
Dynamic Adaptive RT

Inhale

Intermediate

Exhale

Tumor volume
Image Guided RT (IGRT)
Tomotherapy
Robotic Arm (CyberKnife)
Conclusions

„About one person of three is confronted in his life with cancer and out of five dies from this disease. In a society with healthcare services comparable to the United States, Japan or Western Europe, the average person has a one in eight chance of being treated on a linear accelerator in his or her lifetime…”

Let’s fight together!
X-Ray Simulator Simax

Equipped with a new generation tube and imaging system with integrated CCD camera, Simax X-ray simulator, thanks to rigid design and to cooperation with the Polkam 16 therapeutic table, provides excellent positioning and perfect imaging - necessary in modern radiotherapy.

Simulator uses radiographic and fluoroscopic imaging to verify treatment fields, and to prepare final simulations with necessary setup corrections.
X-ray simulator
DIGITAL IMAGING DEVICE (OPTIONAL)

- Based on amorphous silicon matrix
- Matrix size: 41 cm x 41 cm
- Resolution: 1024 x 1024
- Pixel pitch: 400 μm
- ADC converter: 16 bits
- Integration time: from 96.45 ms
- User-friendly software for advanced image processing
- DICOM RT standard

FACILITY REQUIREMENTS

- Power supply: Input voltage 360/240 VAC, 50 or 60 Hz, line to line, 3-phase, 4-wire plus ground, 15 kW, total resistance ≤ 3Ω
- Cooling water
- One pump (domestic) for water or closed loop system (optional)
- Ventilation: At least 6 air exchanges per hour
- 1% room temperature 22-25°C and humidity ≤ 70%