Radiation in Medicine: Roles of Physicists

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Who Are Medical Physicists?

• Have an MS or Ph.D. in medical physics, physics, or a related discipline
• Have training in clinical medical physics in four subspecialties:
  - Therapeutic (cancer treatment) 70%
  - Diagnostic (imaging) 15%
  - Nuclear Medicine (imaging) 10%
  - Public Health 5%
What Do Medical Physicists Do?

- Clinical Service
- Research
- Teaching
Clinical Services

– Treatment planning design for radiation treatment of cancer patients
– Quality assurance (QA) of radiation outputs
– Quality control in imaging systems
– Monitor radiation exposure to patients and employees
Treatment Planning Design

- Using CT images as a patient model
- Design the best radiation beam directions and intensities
- Based on the tumor location and prescription dose.
An Example of Radiation Dose Distributions

77 Gy, 70 Gy, 66 Gy, 56 Gy, 50 Gy
Patient Specific QA

Point doses : RTP vs MOSFET (cGy)

<table>
<thead>
<tr>
<th>Detectors --&gt;</th>
<th>A1</th>
<th>A2</th>
<th>A3*</th>
<th>A4</th>
<th>A5</th>
<th>B1</th>
<th>B2</th>
<th>B3</th>
<th>B4</th>
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<tbody>
<tr>
<td>RTP-dose</td>
<td>81.7</td>
<td>82.0</td>
<td>99.4</td>
<td>96.8</td>
<td>82.0</td>
<td>102.6</td>
<td>101.9</td>
<td>91.5</td>
<td>90.2</td>
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<tr>
<td>MOSFET</td>
<td>81</td>
<td>82</td>
<td>97</td>
<td>99</td>
<td>82</td>
<td>102</td>
<td>102</td>
<td>94</td>
<td>93</td>
</tr>
<tr>
<td>%DIV</td>
<td>-0.9%</td>
<td>0.0%</td>
<td>-2.4%</td>
<td>-2.3%</td>
<td>0.0%</td>
<td>-0.6%</td>
<td>0.0%</td>
<td>2.7%</td>
<td>3.1%</td>
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</tbody>
</table>
How Research Improves Clinical Care
Conventional Dose Distributions

49 Gy
45 Gy
35 Gy
A Typical Modern Plan

59.0 Gy
54.0 Gy
48.6 Gy
45.0 Gy
35.0 Gy
Computer Optimization in Treatment Planning
Intensity Modulated Volumetric Arc Therapy

Increased beam directions from 7~9 to 90~180
Image Guided Radiation Delivery
On Board Imager (OBI)–KV-Cone Beam CT

Elekta KV-OBI

Varian KV-OBI
CT on Rails

Siemens
Co-Registration Between Image of the day With Initial CT Images
On the Horizon
Promise of Proton Radiotherapy

Depth-dose curve for 177 MeV protons

- Depth in water (cm)
- Dose per proton (nGy)

\[ \frac{dE}{dX} \propto \frac{1}{(\beta c)^2} \]

Peak-to-plateau ratio 3-5 (depending on width of energy spectrum)

Width of peak dependent on range straggling in medium and initial energy spectrum; typically 8 mm for 177 MeV p
Research Driven Patient Care

Current Photon Therapy

Current Proton Therapy

Future Image-Guided Proton Therapy

10 Gy  20 Gy  35 Gy  50 Gy  70 Gy
Summary
Radiation Therapy Is Effective

- Radiation therapy is a local treatment.
- Radiation is a universal treatment that can treat most solid tumors effectively.
- About 50% of all cancer patients receive some type of radiation therapy sometime during the course of their treatment.
Responsibilities Of A Medical Physicist

- Assure the safe and effective delivery of radiation
- A qualified medical physicist
  - Obtains a MS or Ph.D. degree
  - Receives clinical training and passes a specific board exam.