Novel Technologies for Cancer Therapy and Research

BIOMEDICAL TECHNOLOGY FORUM

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Introduction to proton therapy
  - Dosimetric Advantages
  - Unique Challenges
  - Delivery Techniques
HUPTI
Research
We have come a long way...
Radiation Therapy

- **The goal**
  - deliver *lethal doses of radiation to the tumor* killing cancer
  - minimize or eliminate healthy tissue injury.
Treatment Delivery
Treatment Delivery: protons vs. x-rays

Graph showing the comparison of absorbed dose for protons and x-rays at various depths in cm.
Advantages of irradiation with Protons

- Deliver *less* dose *in front* of the tumor

- *Deliver maximum dose* to the *tumor region*

- *NO DOSE behind* the tumor

- **Protons destroy tumor more effectively** than x-rays or electrons — protons are \(~2000\) *times* heavier than electrons
Beam Delivery Techniques

- Scattering
  - Double Scattering
  - Single Scattering

- Uniform Scanning
- Modulated Scanning
Spread-out Bragg Peak
Beam Delivery - Scattering

Figure 3-2 Ridge Filter

Figure 3-3 Bolus

Figure 3-4 Final collimator

Range modulator, provides spread out Bragg peak (uniform 3D dose)
Uniform Scanning

- Narrow proton beam is scanned laterally by scanning magnets for each energy layer.
  
  - Scanning area cover full field
  - Dose delivered layer by layer
  - Beam shaping by
    - Block in lateral direction
    - Compensator in range

![Diagram of proton beam scanning](image-url)
Cure vs. Complications

For x-rays

- A reduction of dose by 5% lowers the chances of cure significantly, from 65% to 15%.

- On the other hand an increase of dose by 5% may kill all the cancer but increases the risk of complications from 10% to 80%.

Due to excellent healthy tissue sparing protons allow to increase the dose without such high risks of complications.
COMPLETED PROTON PATIENTS BY DIAGNOSIS
From Inception to December 2004

Prostate 65%

Choroidal Melanoma 1.5%
Pituitary 0.8%
Acoustic Neuroma 0.7%
Meningioma 1.5%
Astrocytoma 1.4%
Other Brain 3.3%
Craniopharyngioma 0.2%
Head & Neck 6.2%
Other Pelvis 1.0%
Orbital 0.6%
Paraspinal Tumors 1.2%
Chordoma/Chondrosarcoma 4.5%
Sarcoma 1.1%
Other Chest 4.0%
AVM 1.5%
Other Abdominal 1.4%
SNVM 4.2%

(100% = 10,300)
Loma Linda University Medical Center clinical results

Treatment results: Conventional radiation (by dose) versus proton therapy

Recurrence

Conventional radiation <60GY
Conventional radiation 60–65GY
Conventional radiation 70GY
Conventional radiation >75GY
Proton 75 CGE

Complication

f. presentation Dr. N. Mendenhall, University of Florida
A brief tour of the treatment process (courtesy of Loma Linda) ...

• Treatment rooms use gantries to deliver the proton beam. The 90-ton, three-story gantries can be rotated 360 degrees to deliver the beam at the precise angle prescribed by the physician.
Simulating therapy machines

• Most of the ~40 ft. tall, 90 ton, gantry is concealed by the walls and floor of the treatment room--the patient only sees the front of the proton nozzle rotating prior to treatment
Cyclotrons

Septum

Cyclotron

Degrader

130 MeV
Proton Therapy in the USA (5 centers)

9 new projects have been announced ( )

1. **NORTHEAST PROTON THERAPY CENTER**
   - NPTC of Mas General Hospital
   - Boston (2001)
   - protons ($\leq 235$ MeV)
   - cyclotron (IBA)
   - 2 gantries + 2 fixed beams

2. **Midwest Proton Radiation Institute**
   - Bloomington (IN) (2003)
   - protons ($\leq 210$ MeV) from cyclotron
   - 1 gantry + 1 fixed beam + 1 experimental

3. **LOMA LINDA UNIVERSITY CENTER**
   - Los Angeles (1992)
   - protons ($\leq 250$ MeV) from synchrotron
   - 3 gantries + 2 fixed beams

4. **M.D. Anderson Cancer Center**
   - Houston (TX) (2004)
   - protons ($\leq 235$ MeV) from synchrotron
   - 3 gantries + 1 fixed beam + 1 experimental

5. **UPenn Medical Center**

6. **Jacksonville, FL (IBA cyclotron)**

7. **Northern Illinois University**

8. **Hampton University PTI**

9. **Seattle Cancer Care Alliance**

10. **Oklahoma City**
What will the Hampton center look like?
Inside.....

$11,000,000 in concrete.
Hampton University Proton Therapy Institute

~$200M project

Construction started 7/2007, First patient expected 8/2010

Largest and most advanced in the nation / world

At maximum capacity, will treat >150 patients / day

4 gantries, fixed beam room, dedicated research line
Hampton University Proton Therapy Institute

99% equipment on site for all 5 treatment rooms

Beam line installation complete

Gantry superstructures complete

First beam delivered from cyclotron March 2009

Currently delivering test beam to treatment rooms

• HUPTI has accepted the first treatment room in February

• On track to treat patients in August 2010
A brief tour –

Currently Commissioning First Room
A brief tour –
Imaging System

PET/CT imaging unit from Philips is being installed.
Collaboration Opportunities – Applied Research

- **Radiation Biology** *(in collaboration with EVMS, NASA)*
- **Proton Tomography**
- **Neutron Shielding Materials Research** *(in collaboration with Veritas Medical Solutions)*
  - Hybrid and Light-weight solutions
- **Radiobiologically Optimized Therapy Simulations** *(in collaboration with Varian Medical Systems)*
Collaboration Opportunities – **Instrumentation**

- Dedicated Imager for Proton Radiotherapy Guidance and Monitoring (*in collaboration with TJNAF*)

- Respiration Gating Technologies (*in collaboration with Philips Healthcare*)

- Development of QA Tools (*in collaboration with CIRS*)
The facility is a $225 million, state-of-the-art treatment and research center.

Nation's 7th proton therapy facility, the largest in the world (98,000 sq.ft) also a hotel and conference center

HUPTI will treat over 2,000 patients per year, including 65% prostate cancer treatments. The remaining 35% includes breast, lung, pediatric, and other cancers.

First patient – August 2010

Put Hampton Roads “on the map” as a high-end medical destination.
Where to get more information.....

• HUPTI website
  http://www.hamptonproton.org/

• Scientific and Technical Director
  Cynthia Keppel, keppel@jlab.org

• Vahagn.Nazaryan@hamptonproton.org

• The National Association for Proton Therapy; http://Proton-therapy.org

• Loma Linda University Medical Center
  http://www.llu.edu/proton/

• Particle Therapy Co-Operative Group; http://ptcog.web.psi.ch/
Thank You!

Questions?