

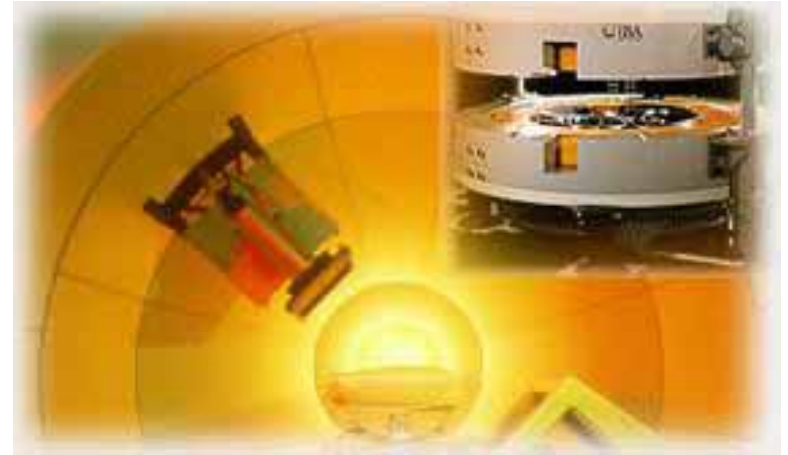
Proton Radiotherapy

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Jefferson Lab



HU Proton Therapy Institute

About Proton Therapy

- Cancer is the (2nd) largest cause of disease-related death in the USA and other developed nations.
- Cure achieved for ~45% of all cancer patients using available therapeutic strategies: chemotherapy (5%), surgery (22%), and radiation treatment (12%, 18% in combination with surgery). *Changing*
- Disease is well-localized in 2/3 of patients at time of diagnosis
- 50% of (USA) cancer patients receive radiation treatment, most with external beam.
- Proton therapy is widely recognized as the *most* effective external beam method in the selective destruction of cancer cells.

Because.....

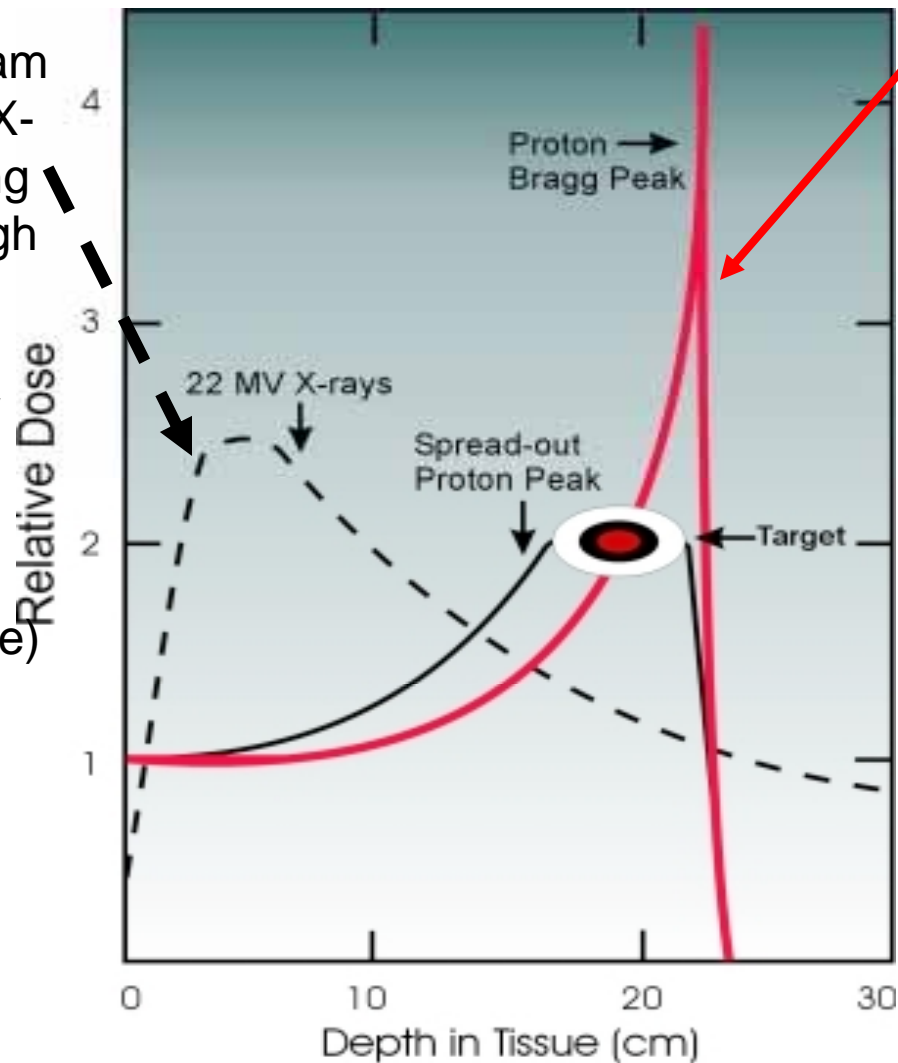
- The goal in radiation therapy is to deliver lethal doses to the tumor while **minimizing or eliminating normal tissue injury.**



About Proton Therapy: *Fundamental Physics*

Conventional beam therapy delivers X-ray radiation along entire path through patient, and maximal dose in front of the tumor

Photons interact with matter (tissue) via photoelectric effect, Compton scattering, pair production



Proton beam treatments deliver minimal dose in front of the tumor, over 4 times higher dose to the tumor region, and *no dose* behind it

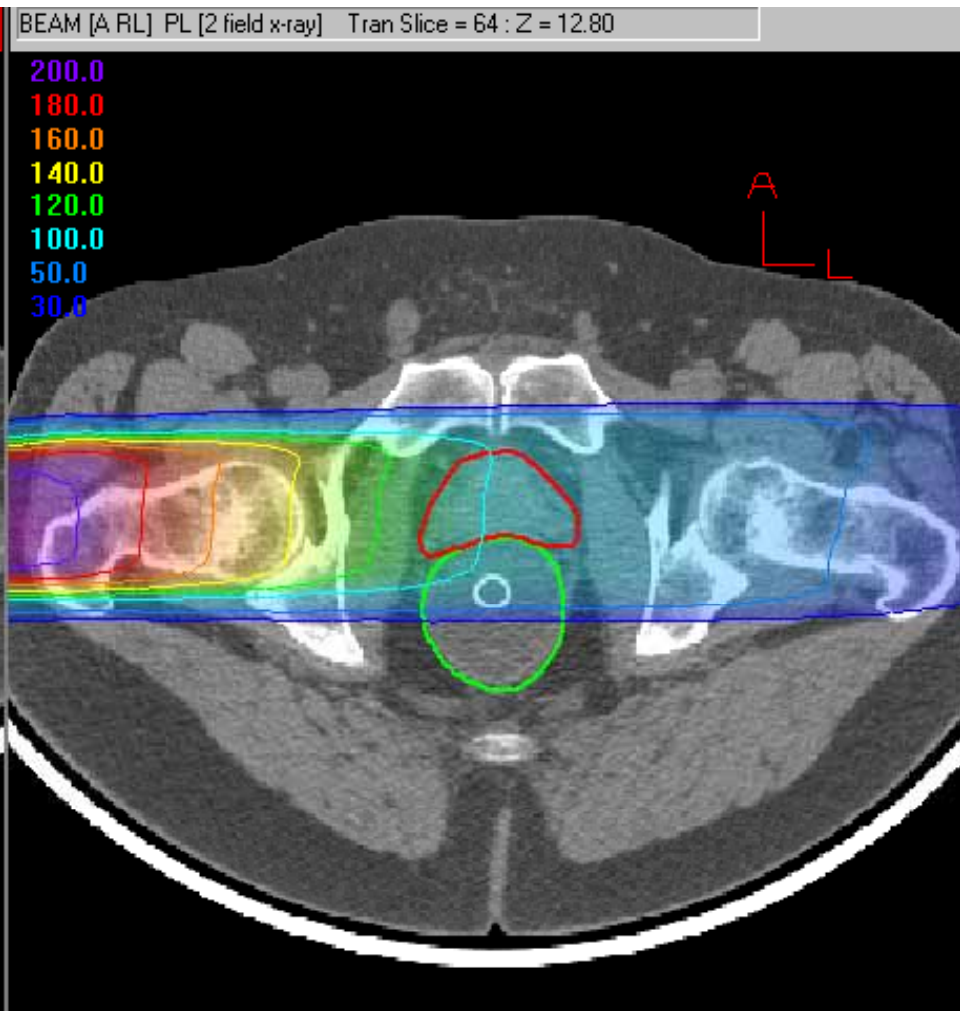
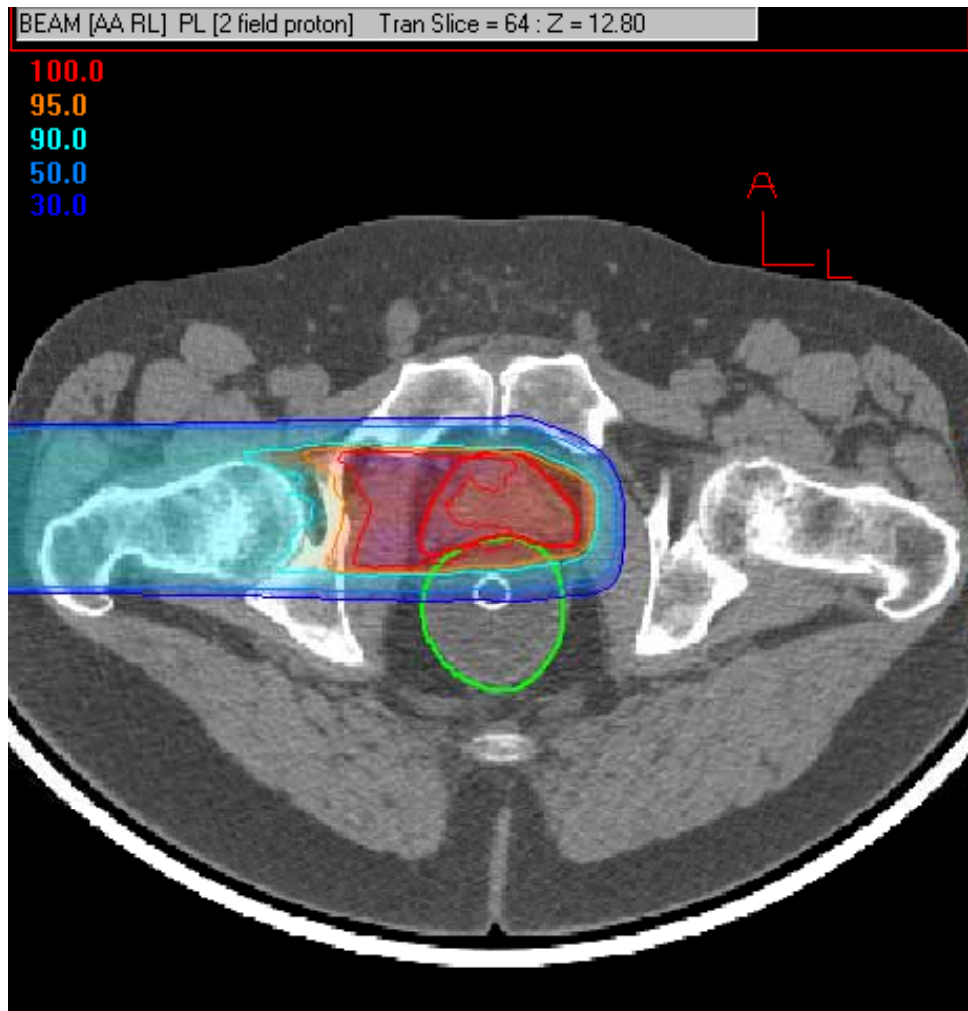
Proton ionization energy deposition

$$dE/dx \sim 1/(\beta c)^2$$

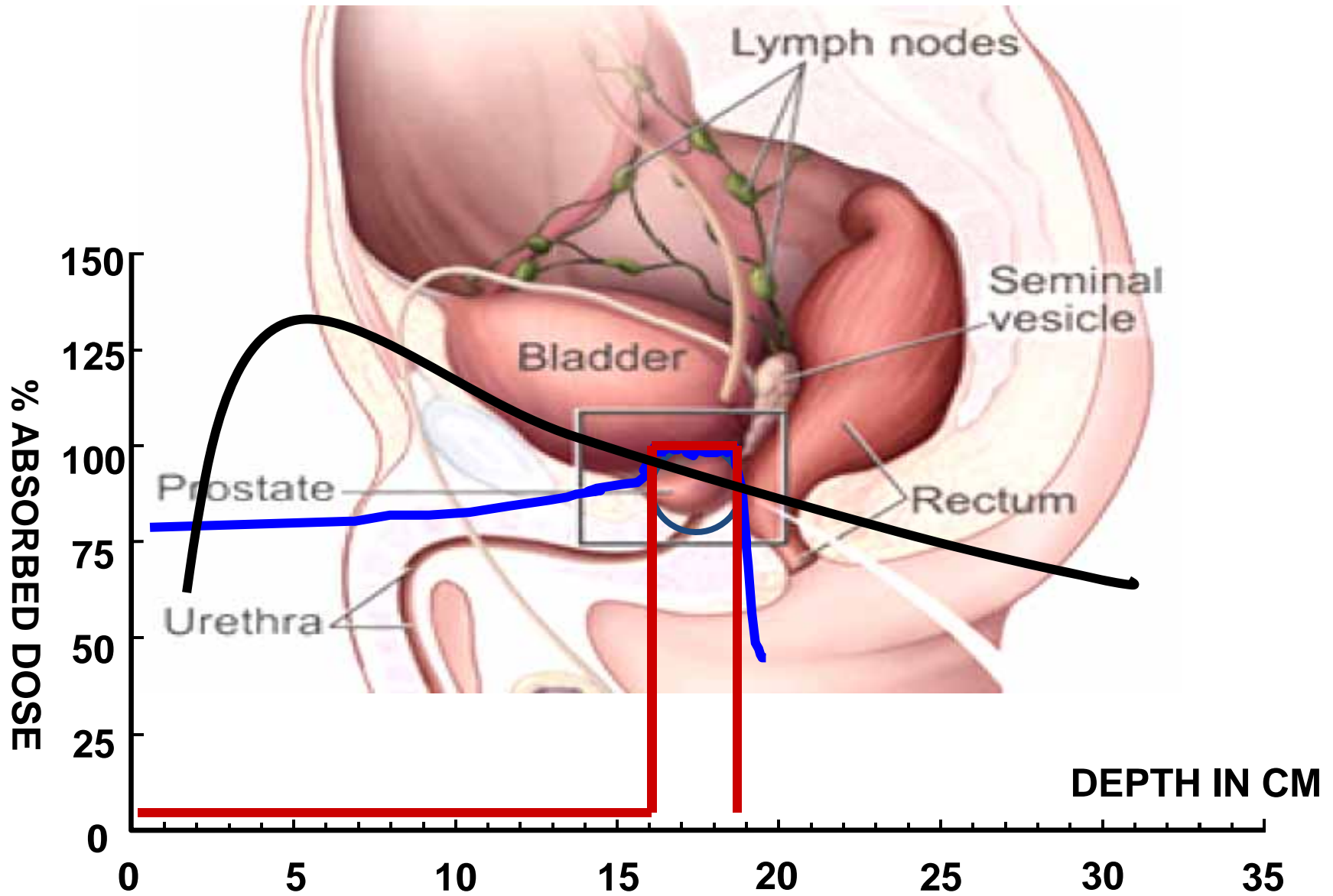
is inversely proportional to the square of the speed of the particle (Bethe-Bloch)

Proton Beam

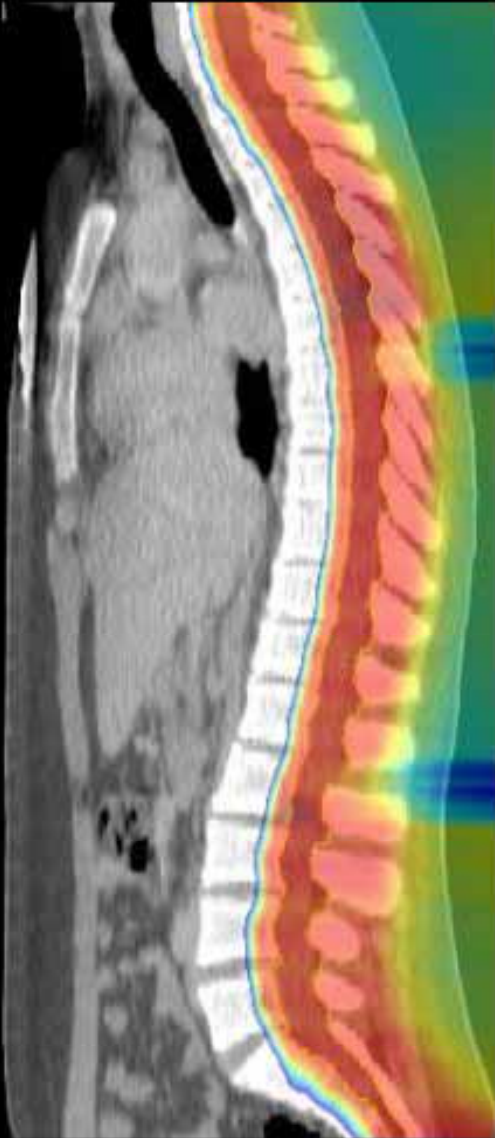
X-Ray Beam



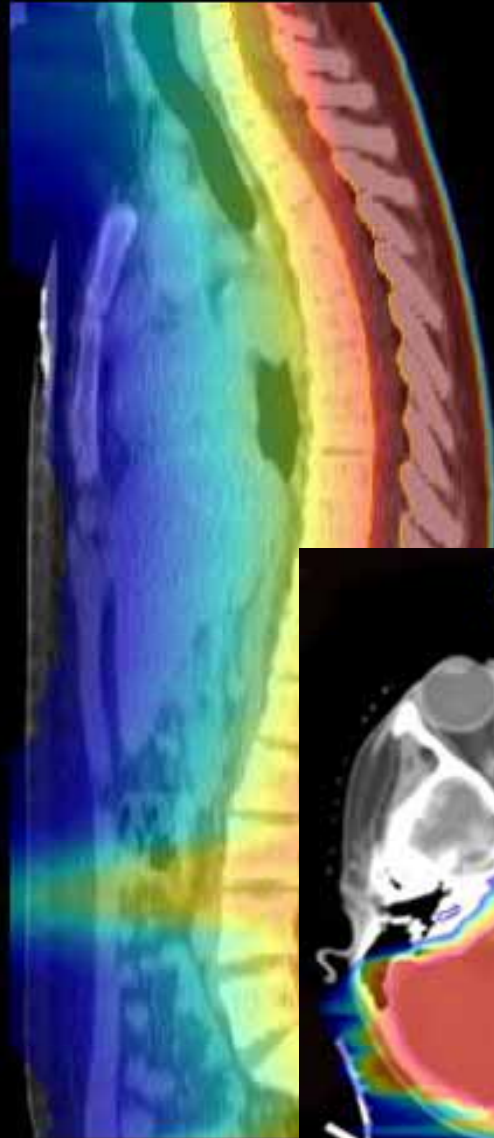
Treatment Delivery **protons vs. x-rays**



Protons



X-Rays

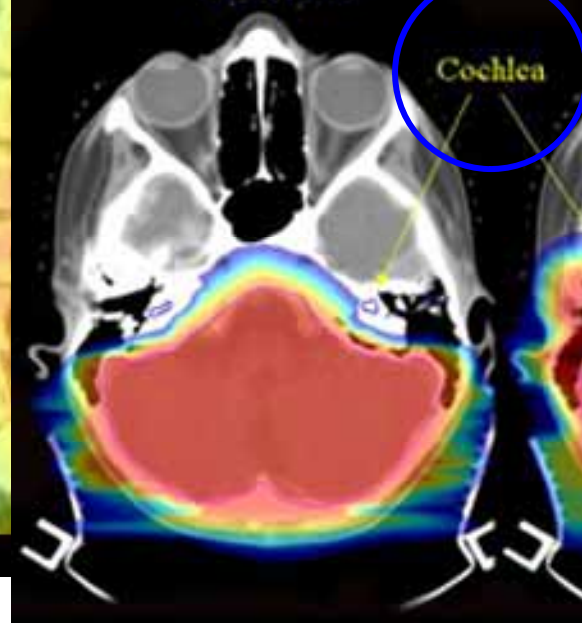


Medulloblastoma

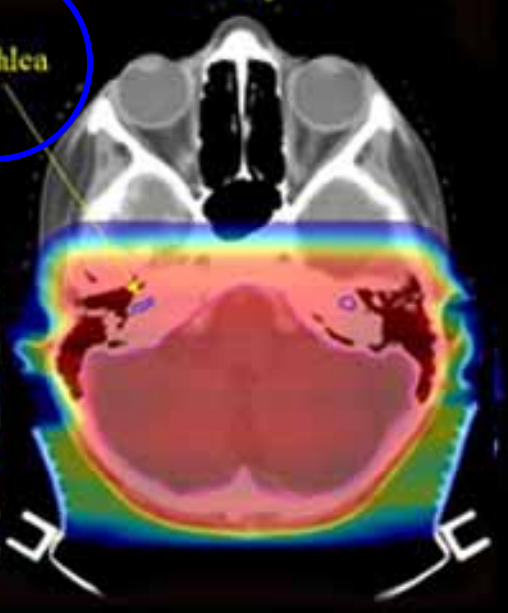
Most common malignant brain tumor in **children**

Spreads to CNS - deliver radiation to the entire neuraxis

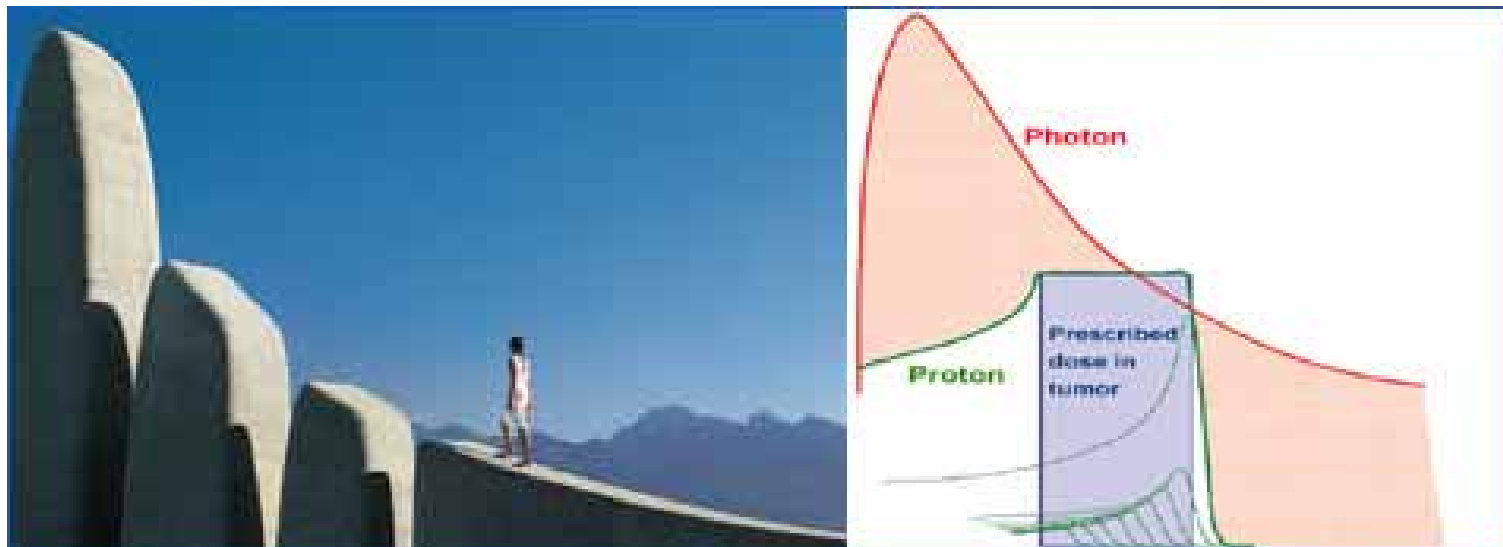
Protons



X-Rays



- The goal in radiation therapy is to **deliver lethal doses to the tumor** while minimizing or eliminating normal tissue injury.
 - *Increased dose*
 - *Higher relative biological effectiveness*



Example: Prostate Cancer

- Cancer of the prostate is the most commonly diagnosed cancer in men. In the National Cancer Institute (NCI) in 2008, approximately 186,320 US men were diagnosed with prostate cancer, and approximately 28,660 died from the disease.
- According to the NCI, *one third of all* American men over age 50 have microscopic signs of prostate cancer.
- Many treatment options are associated with undesirable side effects (impotence, incontinence, others)
- From 1992 to 1999, the average annual incidence of prostate cancer among African American men was 59% higher than among Caucasian men and the average annual death rate was more than *twice* that of Caucasian men.

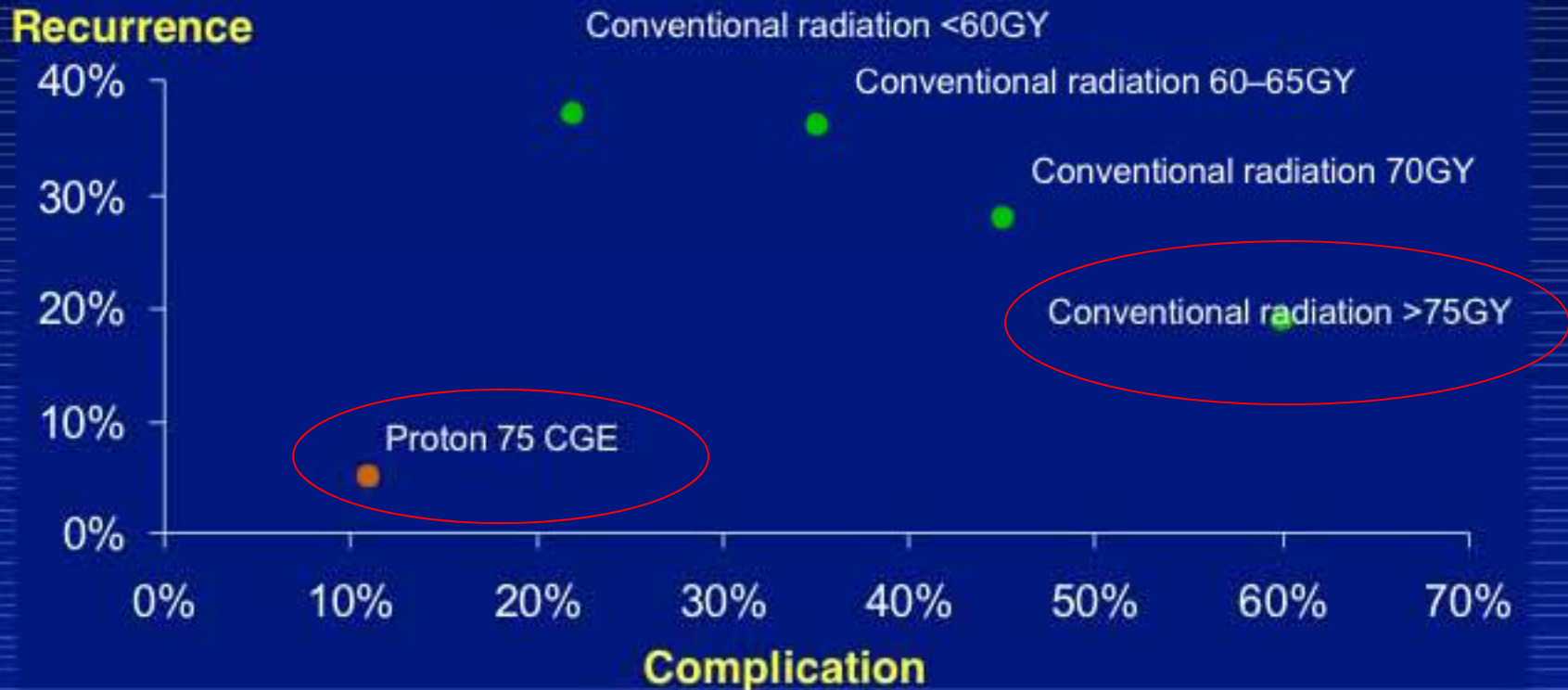


over 45,000 prostate cancer patients treated with protons

Proton results: Locally advanced prostate cancer

Loma Linda University Medical Center clinical results

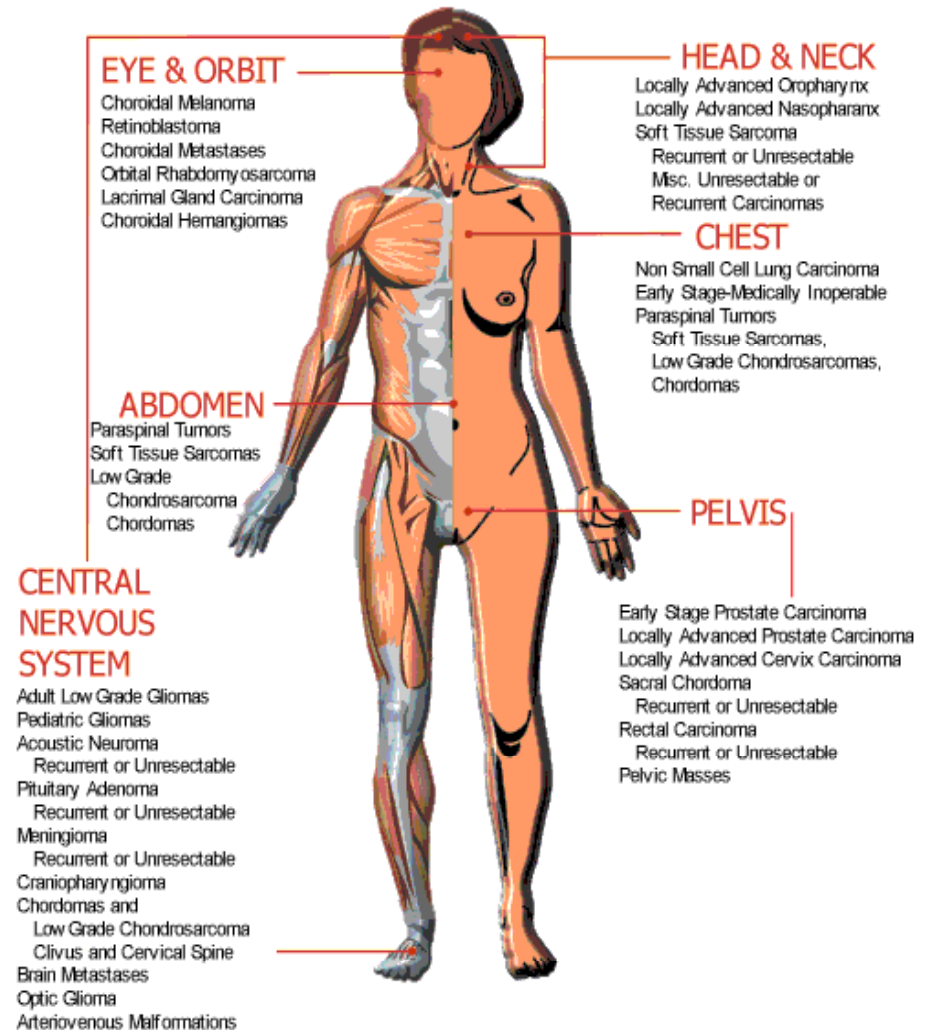
Treatment results: Conventional radiation (by dose) versus proton therapy



Many cancers treatable

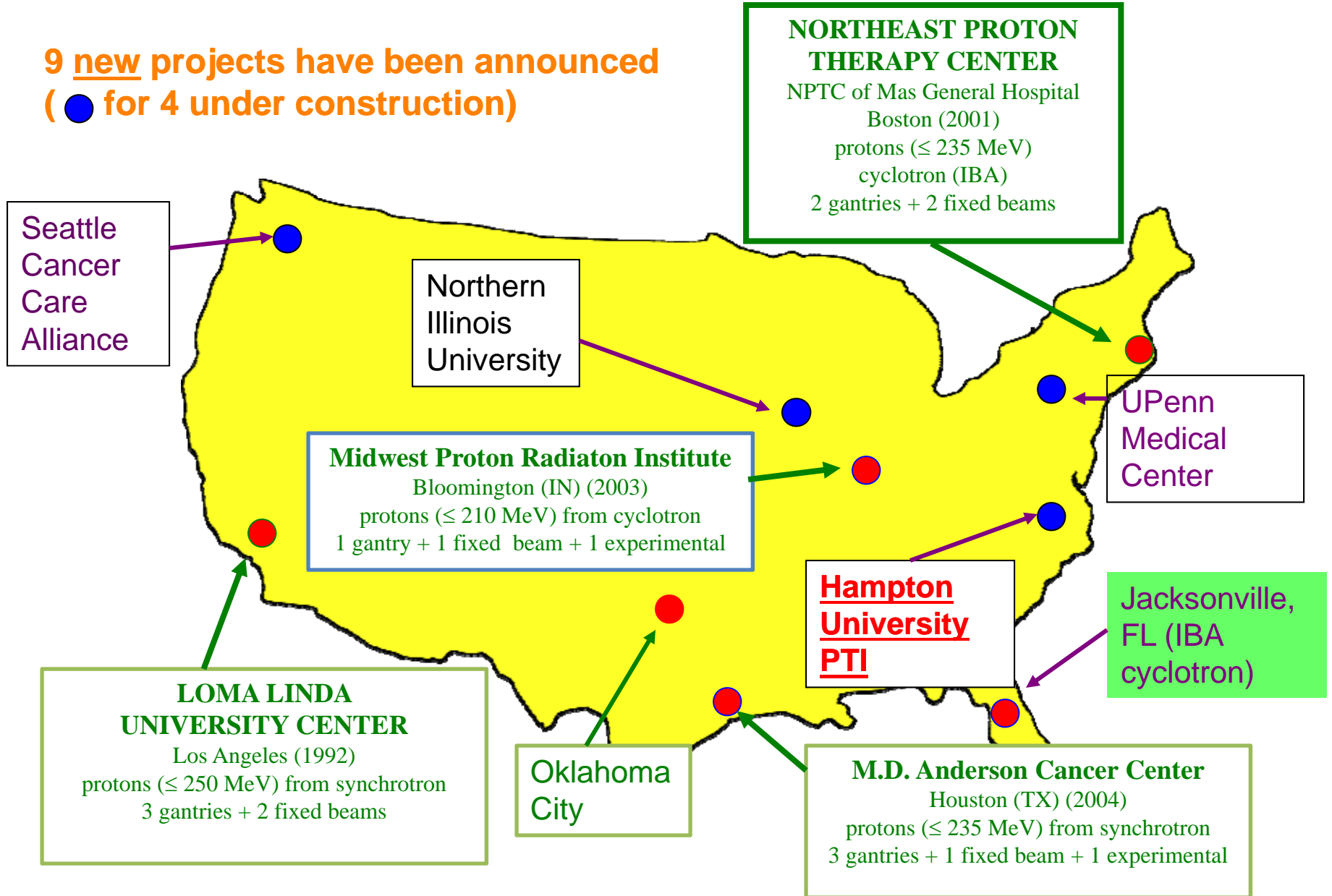
By the end of 2007, almost 62,000 patients worldwide had been treated with particle radiotherapy, according to recent data from the Particle Therapy Co-operative Group, PTCOG. Of these patients, the vast majority (53,818)

received proton therapy.



Proton Therapy in the USA (6 centers today)

9 new projects have been announced
(● for 4 under construction)

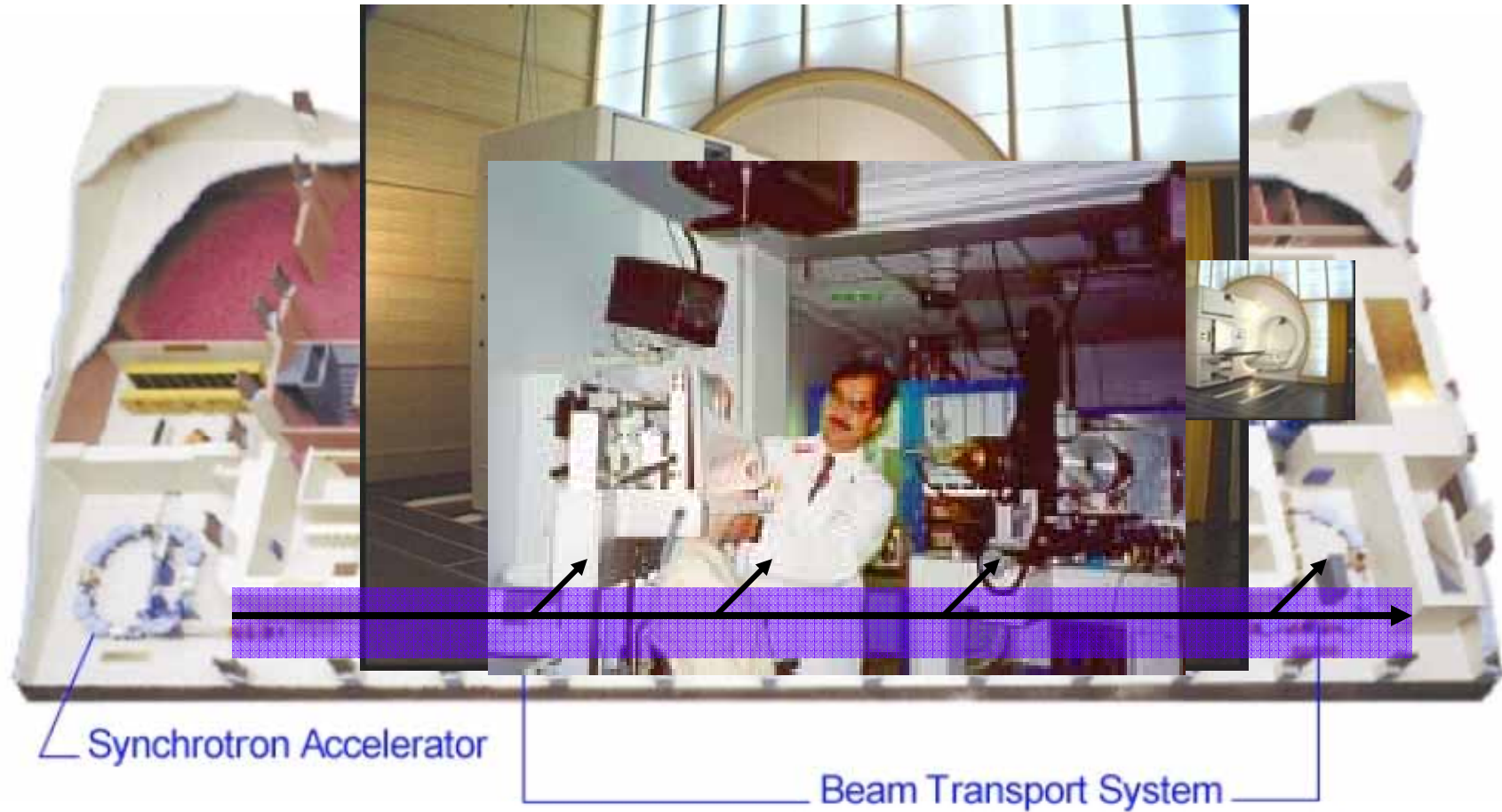


Proton Therapy in the World - 26 centers



Typical Center Design

LLUMC



Hampton University Proton Therapy Institute



~\$200M project

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

Largest and most advanced in
the nation / world

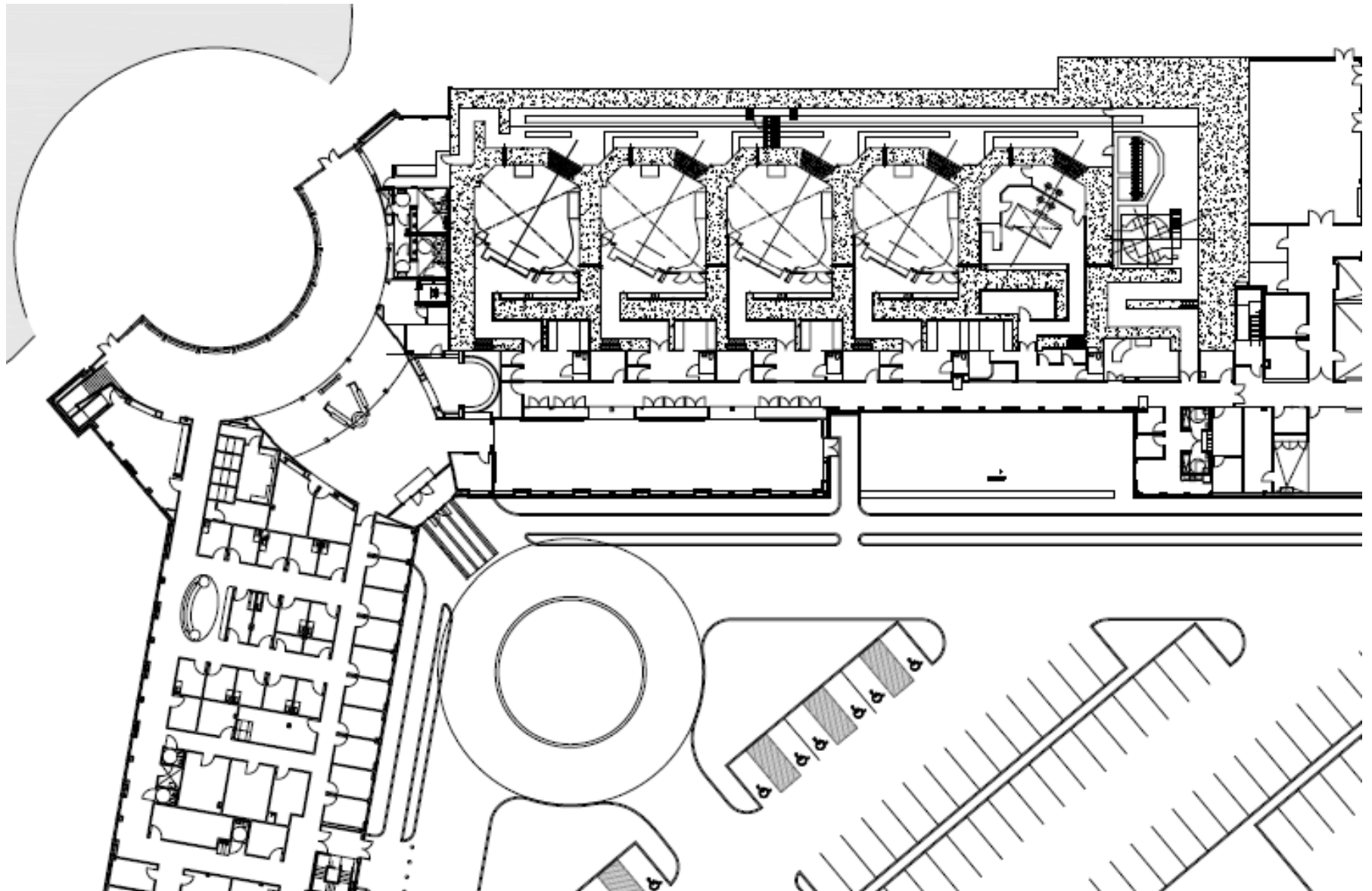
At maximum capacity, will
treat >150 patients / day

4 gantries, fixed beam room,
dedicated research line



Hampton University

Proton
Therapy Institute



The Accelerator





Rinecker Proton Therapy Centre
(Munich)

Gantries

- 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
- The gantry supports the bending and focusing magnets, vacuum system, and all equipment necessary for controlling and monitoring patient treatment.



MPRI (IUCF)

Hampton University Proton Therapy Institute

98% equipment on site for all 5 treatment rooms

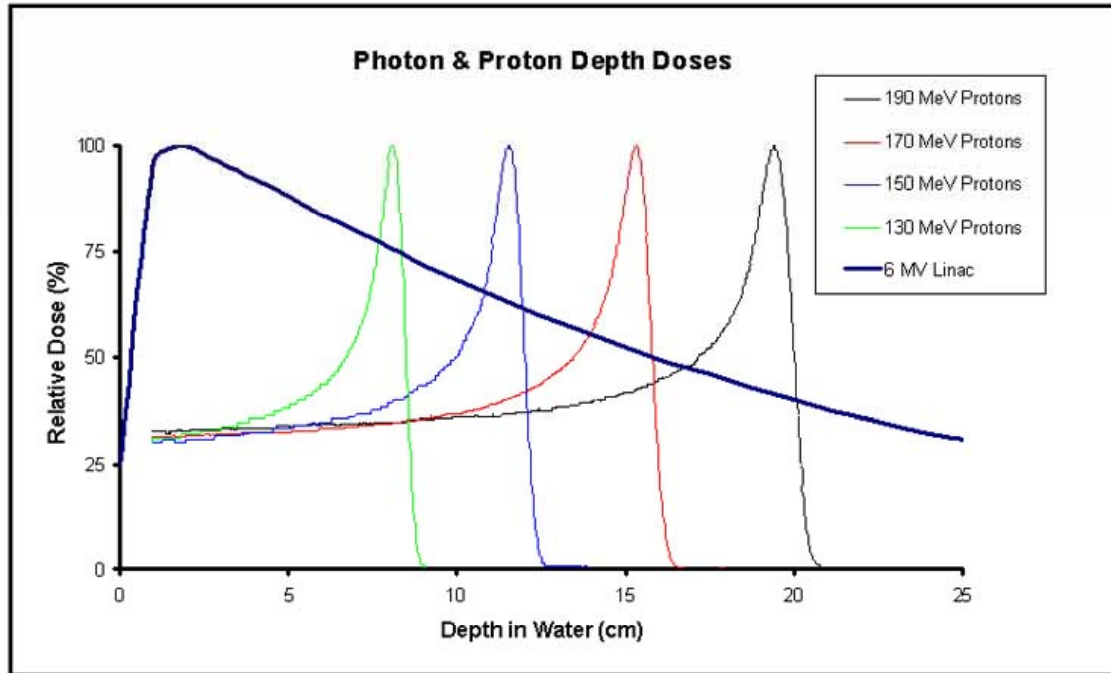
Beam line installation complete

Gantry superstructures complete

Cyclotron operational, in beam testing phase

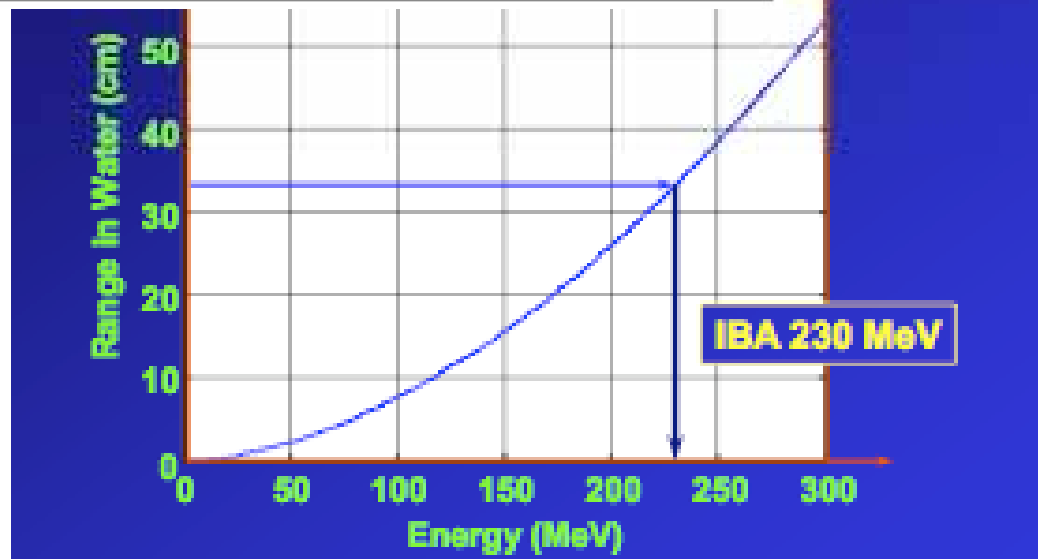


About Proton Therapy: *Fundamental Physics*



Proton treatment dose depth can be controlled by energy tuning

Higher energy = increased depth in patient



~230 MeV is highest energy needed