Hampton University Proton Therapy Institute

Brief introduction to proton therapy technology, its advances and Hampton University Proton Therapy Institute

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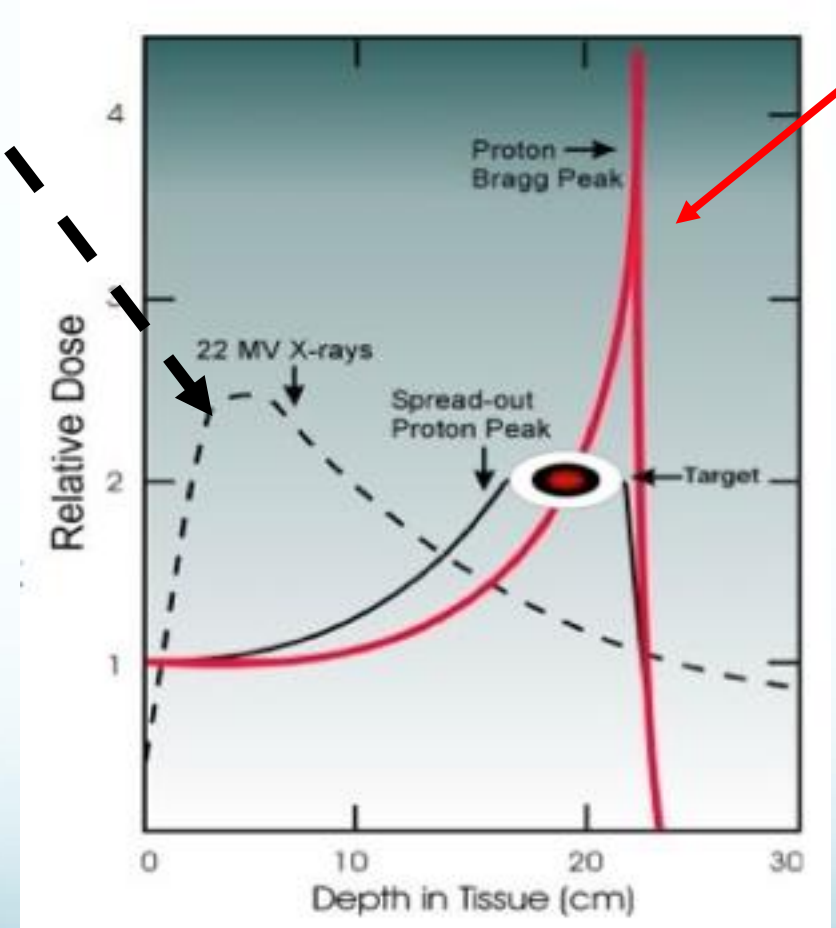
About Proton Therapy

- 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: 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 photoelecric effect, Compton scattering, pair production



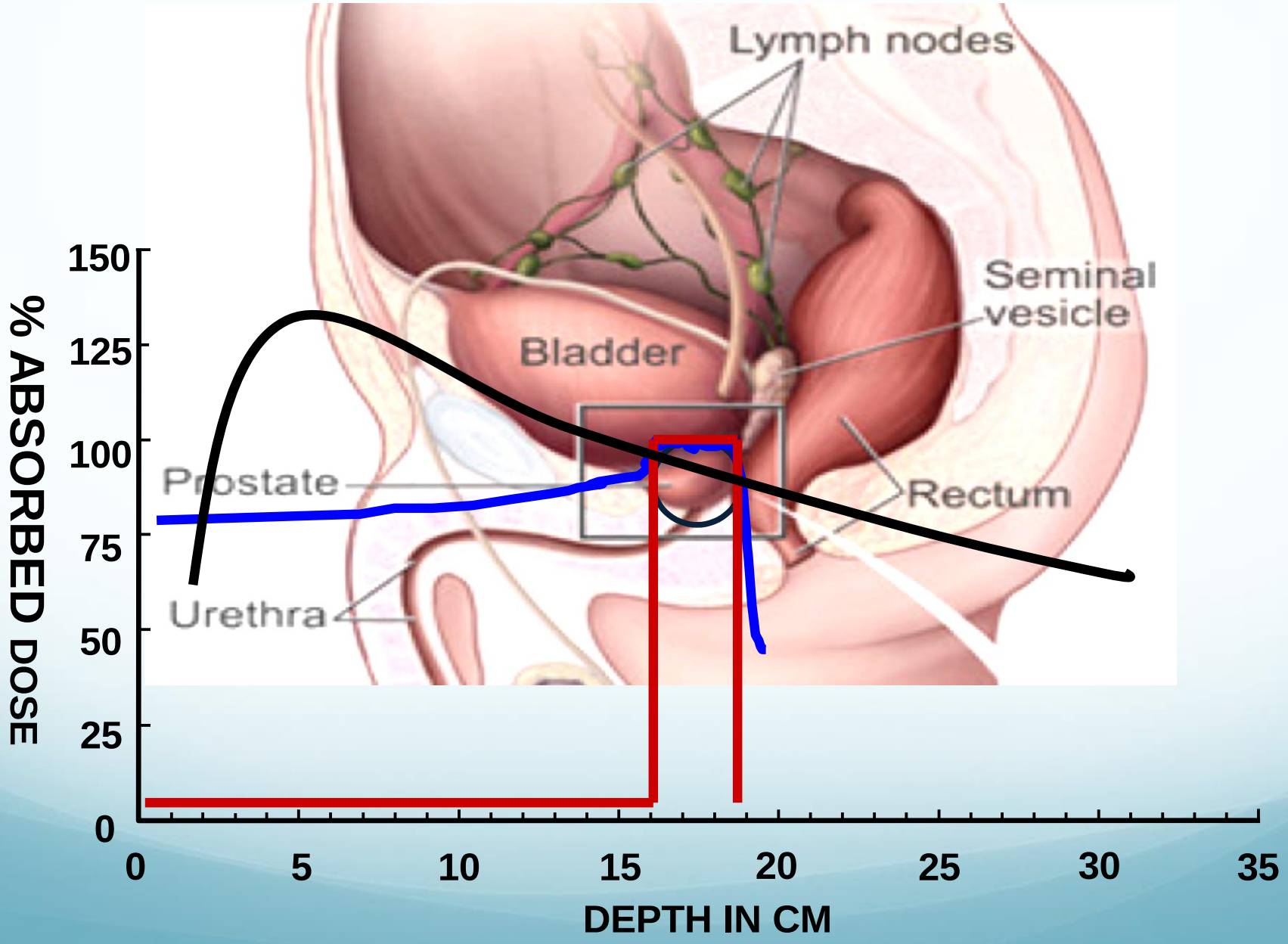
Proton beam treatments deliver minimal dose in front of of the tumor, maximum dose to the tumor region, and *no dose* behind it

Proton ionization energy deposition dE/dx is ***inversely*** proportional to the square of the speed of the particle (Bethe-Bloch)

Radiation Therapy

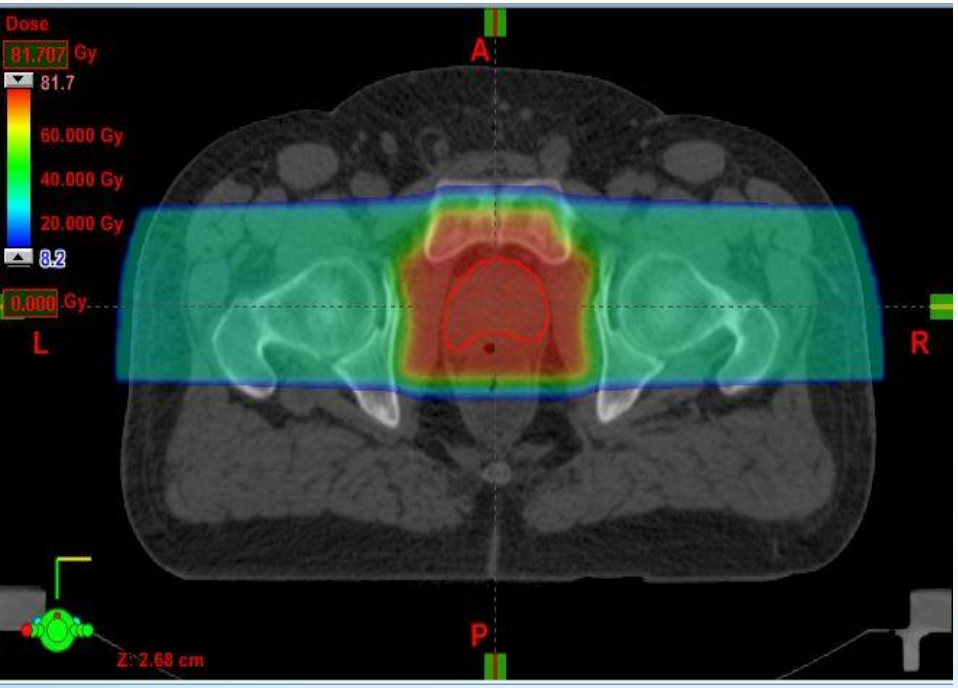
- The goal
  - deliver lethal doses of radiation to the tumor killing cancer
  - minimize or eliminate healthy tissue injury.

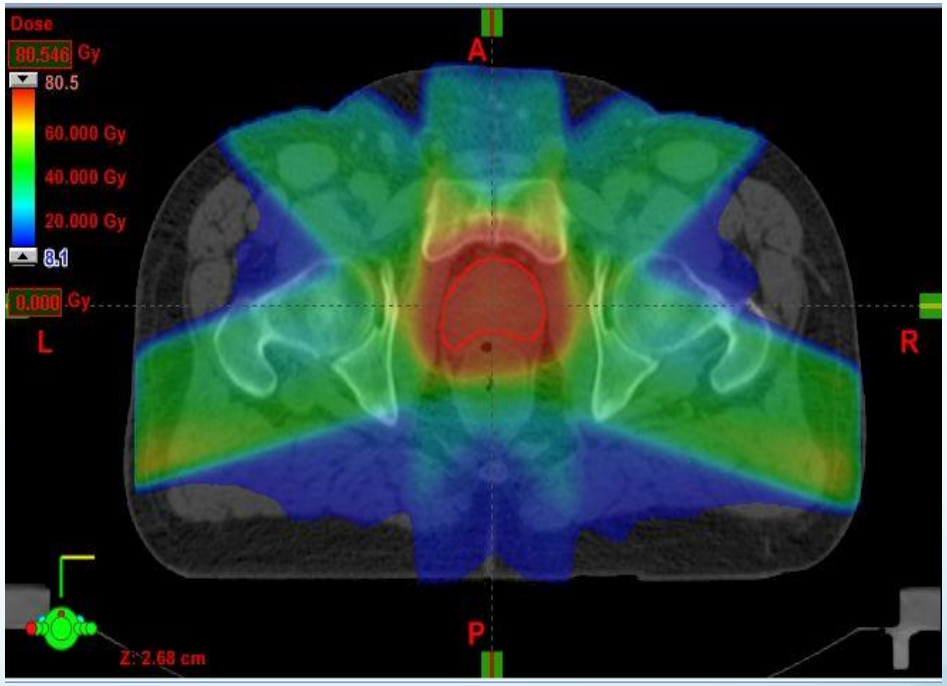
Treatment Delivery protons vs. x-rays

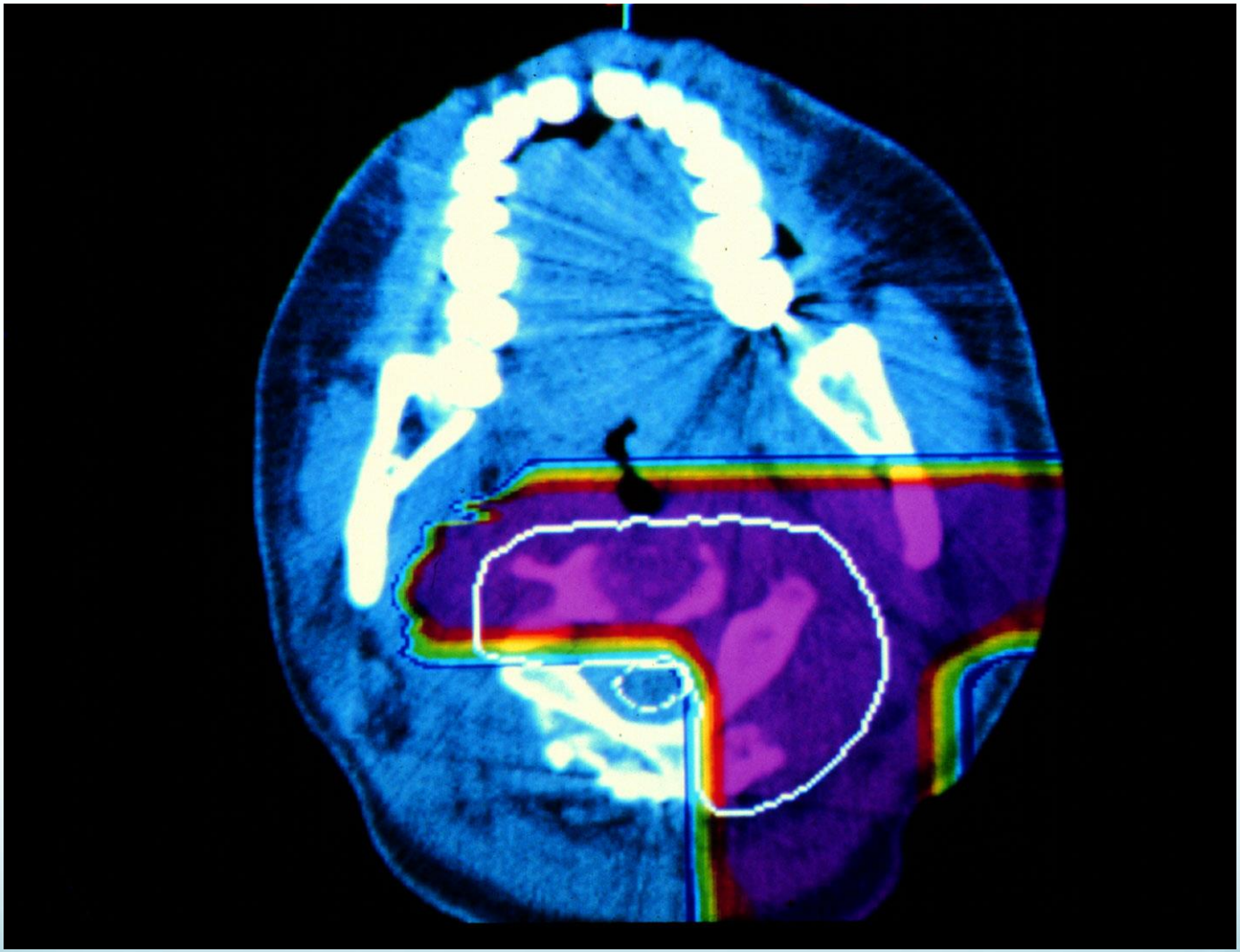


Proton Therapy vs. IMRT

Proton therapy delivers significantly less radiation to the bladder and rectum areas than conventional radiation, reducing likelihood of side effects.

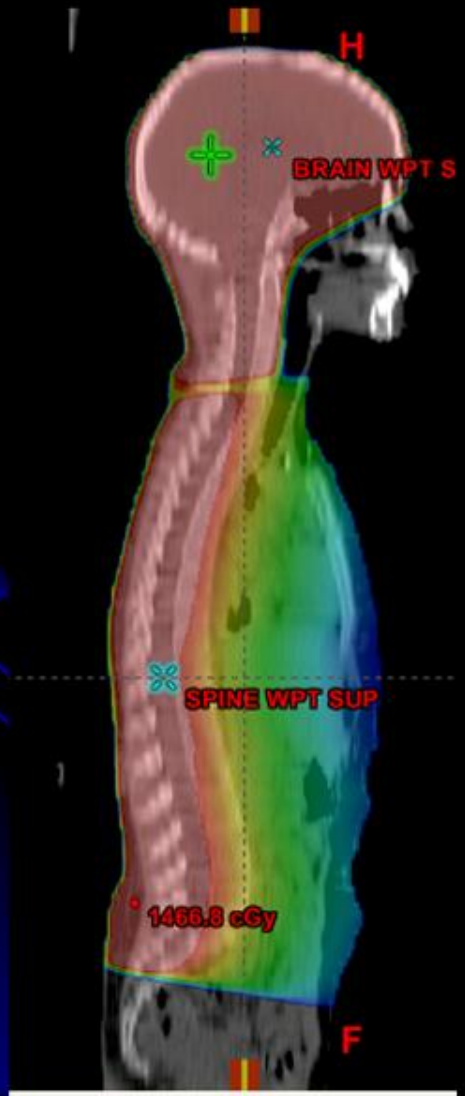






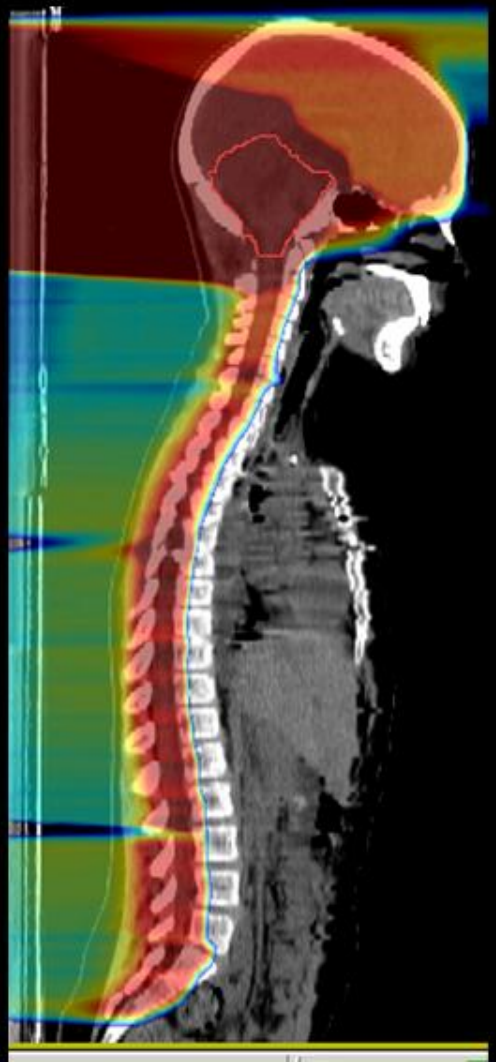
10 year old female with M0 medulloblastoma

Conventional Craniospinal

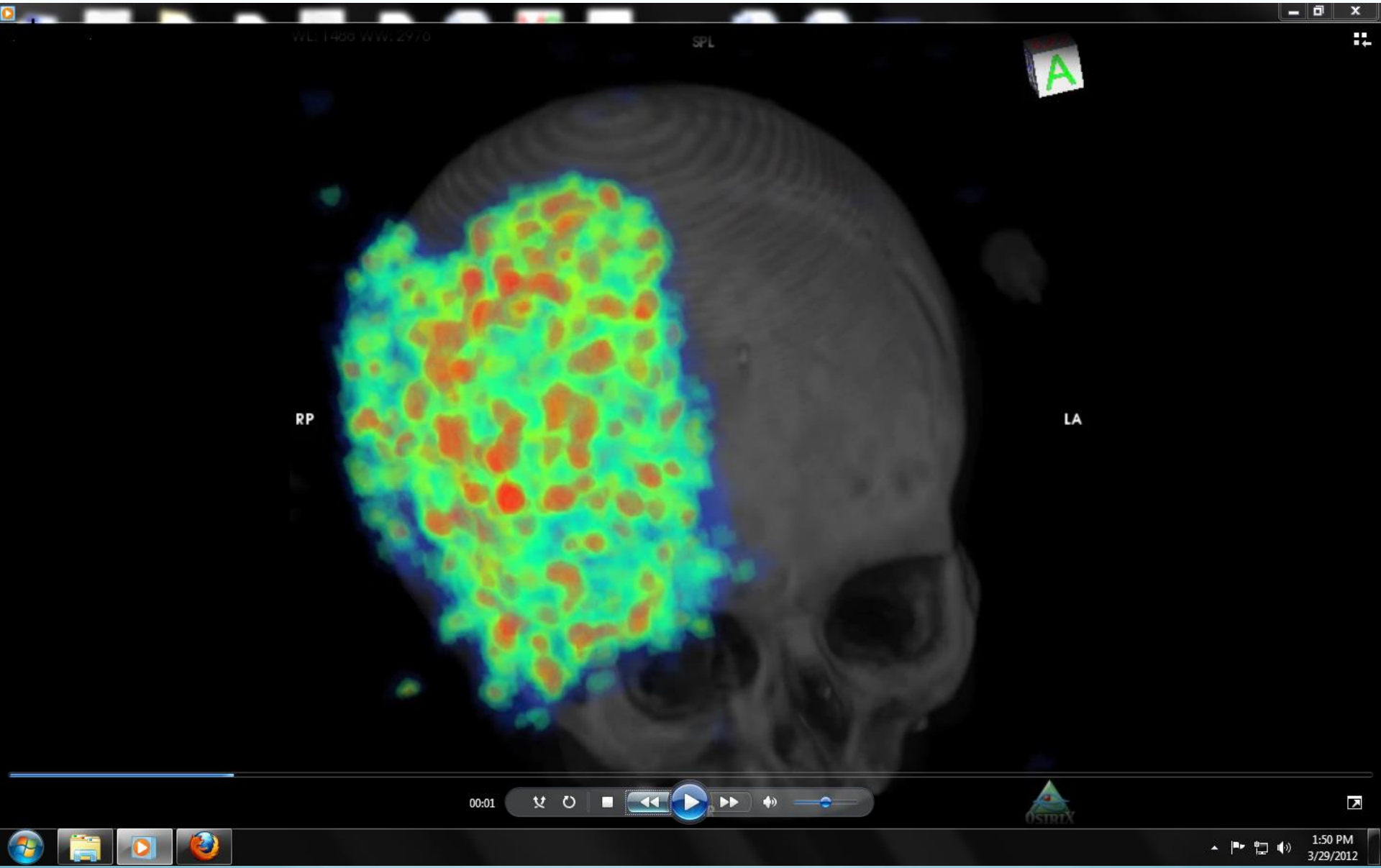


CSI to TD
23.4 Gy

Proton Craniospinal



C^{11} activation



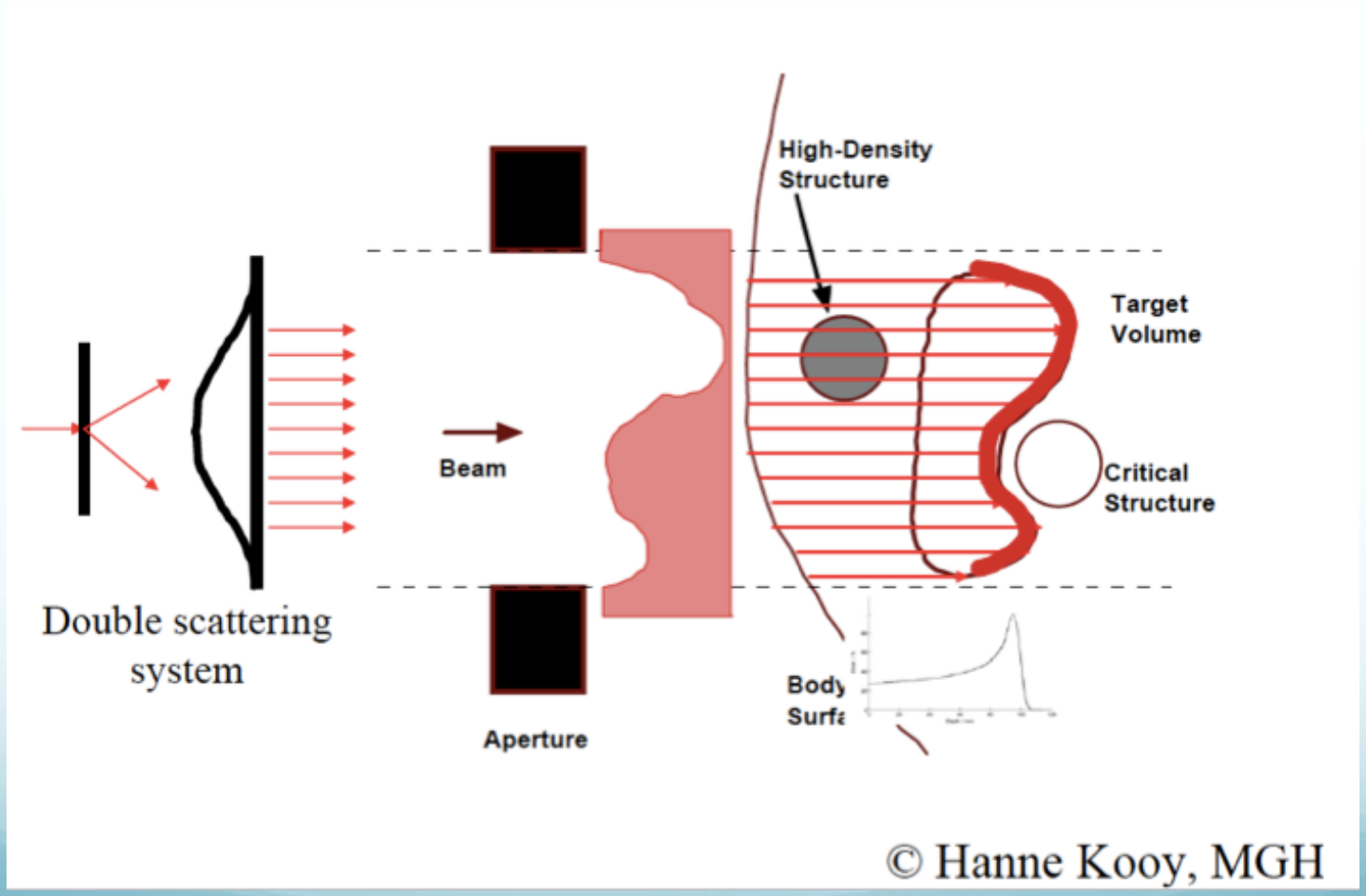
The value of planning - Cure vs. Complications

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%.*

Dose Shaping with Scattering

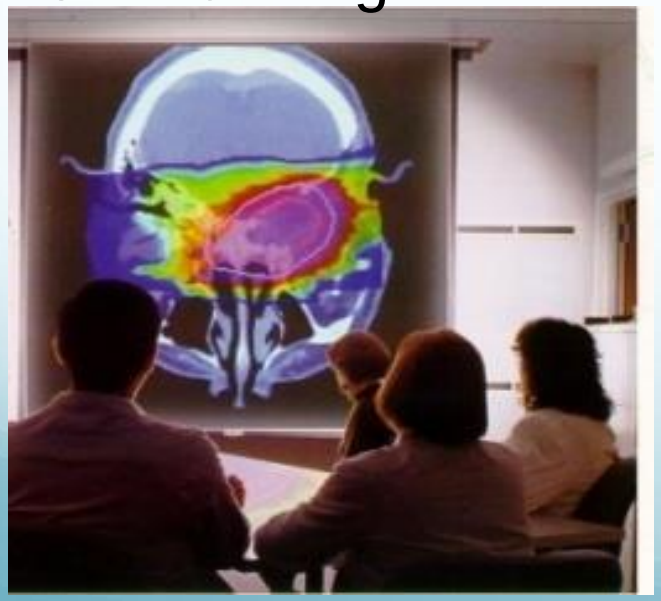


A brief tour…

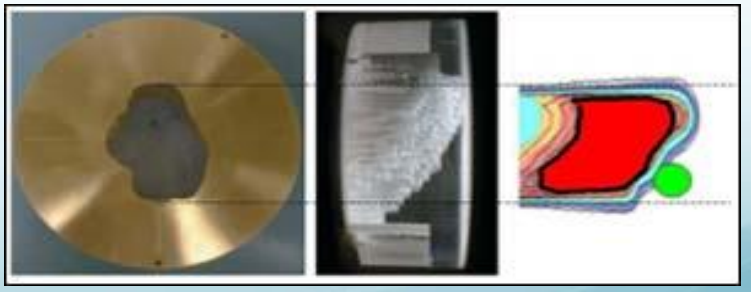
1. Patient Setup

2. Imaging

3. Planning

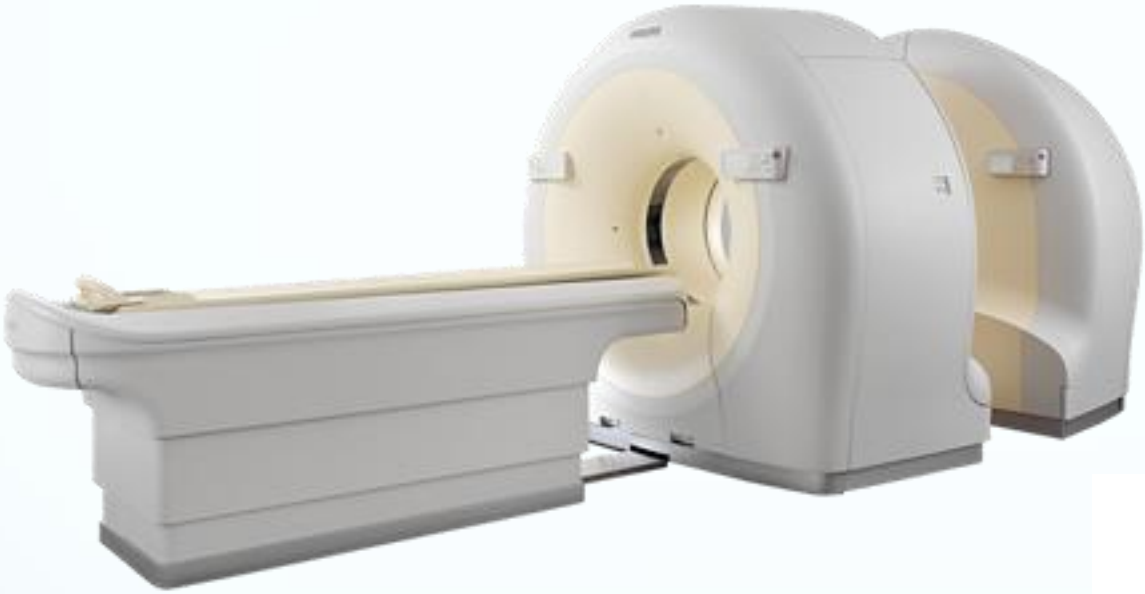


4. **4D** Customized treatment and QA



Patient Setup

Imaging



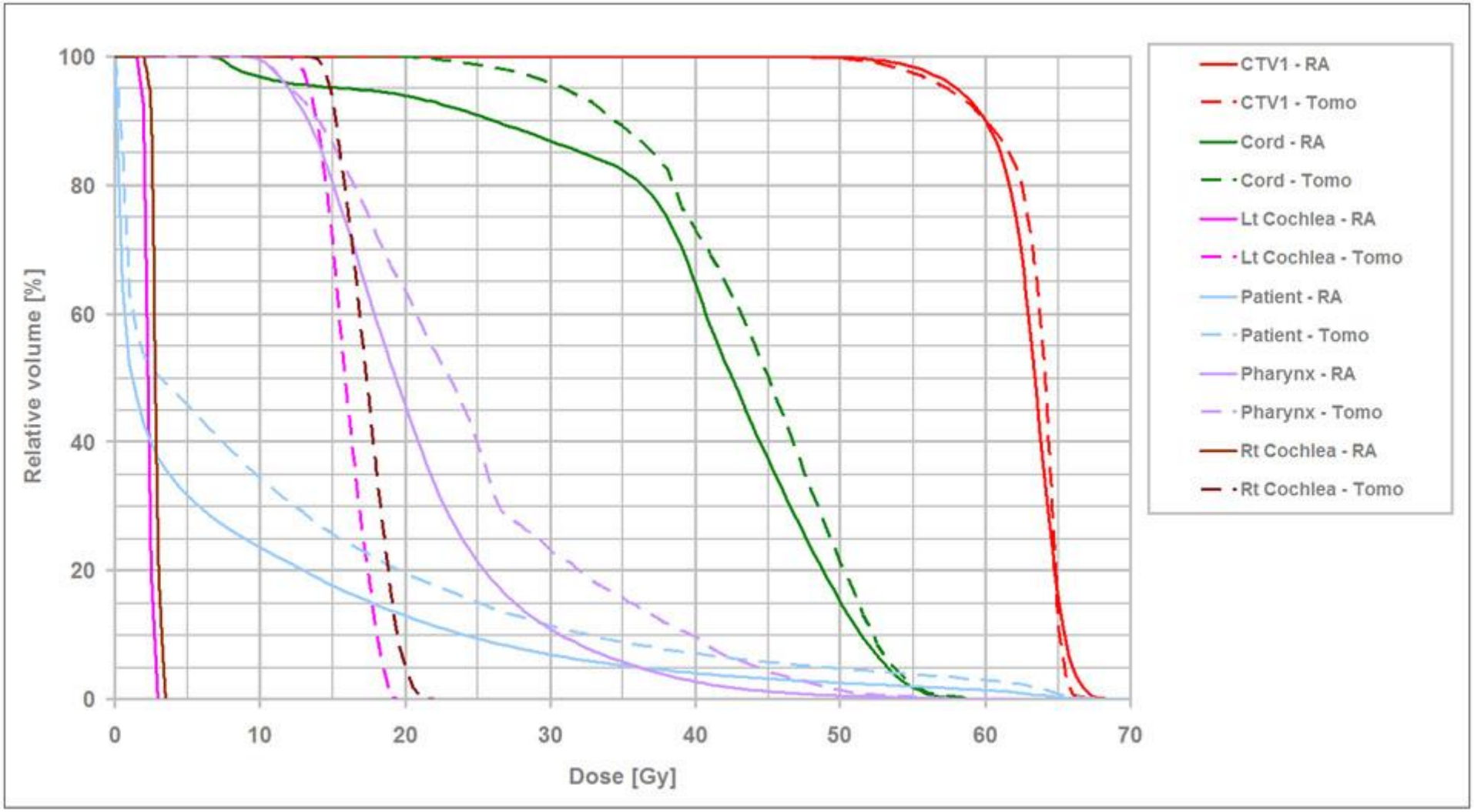
Treatment Planning

Computerized simulation of treatment delivery – dose calculation, and evaluation

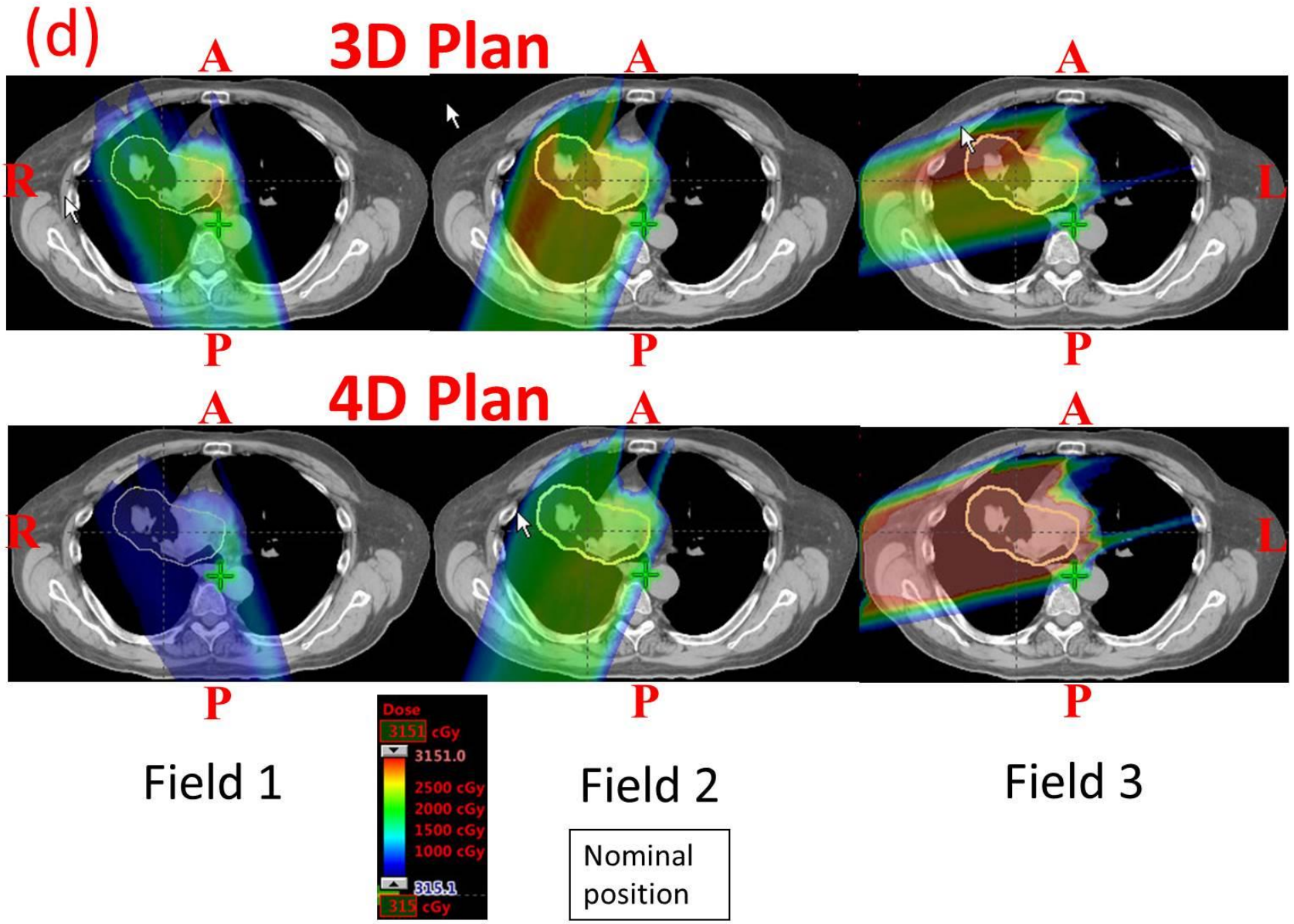
- Evaluation tools – DVH
- Robustness - against parameters that you can not control well
- Moving targets
  - selection of technique of irradiation
  - respiration gating

- Dose calculation algorithms
  - Inhomogeneities – Monte Carlo simulations to improve accuracy
  - RBE

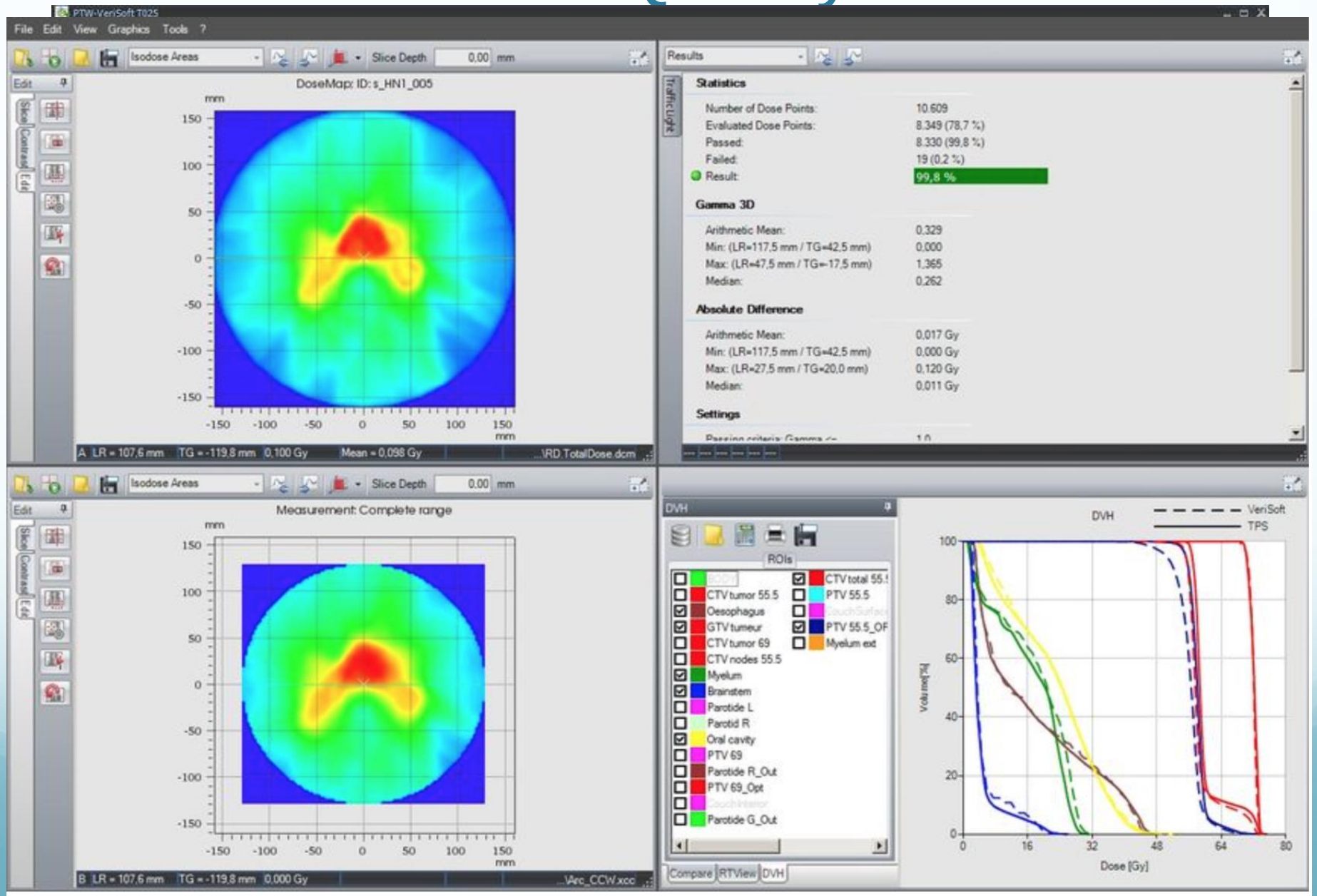
Dose-Volume Histogram



Robustness analysis



Quality Assurance



A lot of room for improvement

- A few examples
  - Development of refined MC calculations for proton therapy
  - Development Quality assurance tools
    - *Zebra, Lynx, IC array*
      - none is well designed for volumetric verification (*dosimetric gel*),
      - none is designed for verification of dose delivery in inhomogeneous media
      - tissue equivalent media exist
        - Detector/phantom development
        - **Adaptive Treatment Planning**

- Collaboration Opportunities

- HUPTI is a genuine national resource: a $225M state-of-the-art cancer treatment facility and the nation's largest stand-alone proton beam treatment facility.
  - Five treatment rooms
  - Dedicated Research line
  - PET/CT imaging suite
  - Most advanced proton therapy technology available

2005
Inspired by an HU alumnus, Dr William R. Harvey puts project planning into motion.

2006
The planning progress is well under way with vendor selection and this architectural rendering.

2007
Ground breaks on July 23 and official construction begins.

2009
State-of-the-art equipment is brought to the facility for instillation.

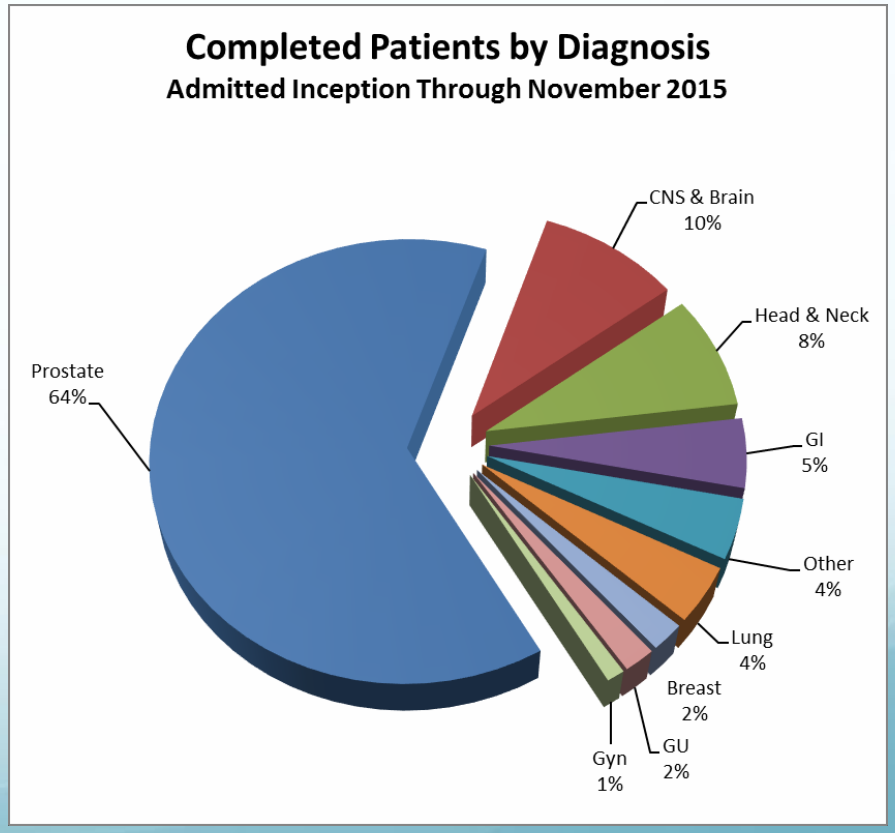
2010
HUPTI opens its doors to patients.

2011
All five treatment rooms are operational; the facility reaches completion.

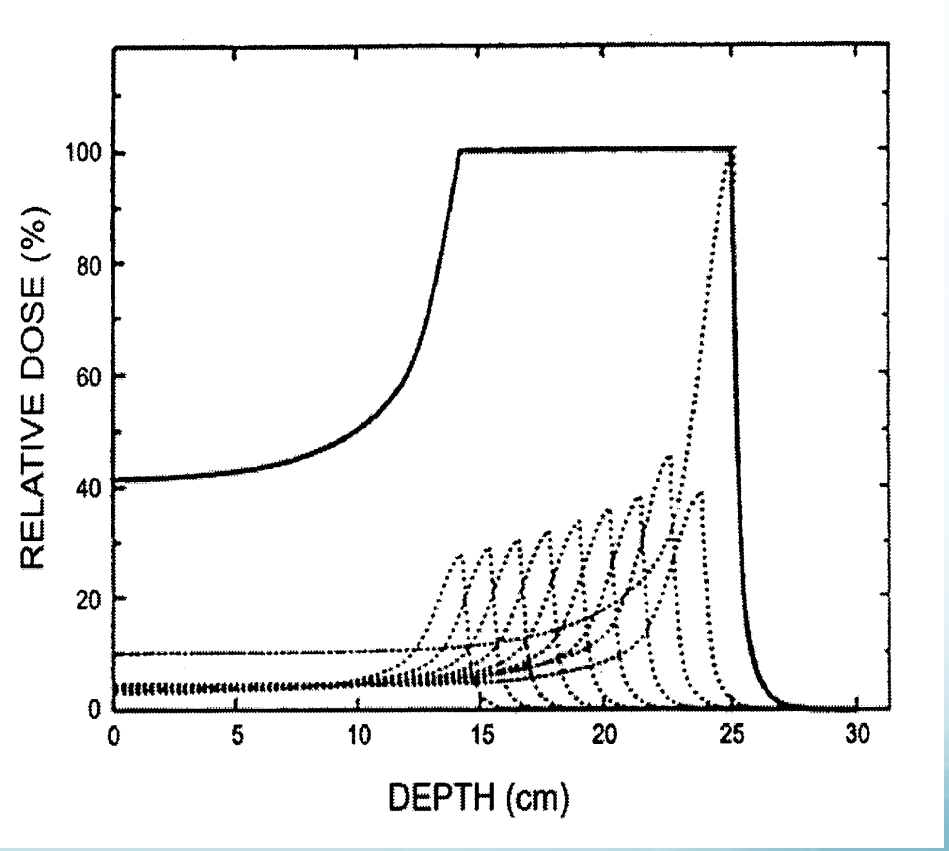
Today
With an eye toward the future, HUPTI remains focused on cancer care.

- The HUPTI treats a variety of cancer types, including prostate, lung, and breast cancers – all of which are associated with the highest incidence rates in the Commonwealth and nationally.

- There is a vast underserved need, and most patients eligible for proton radiotherapy will not be able to receive this treatment. In fact, the Massachusetts General Hospital proton center recently published an article describing the difficulty in making decisions regarding patient selection for proton therapy, given their proton therapy waiting lists.



Planning the energies

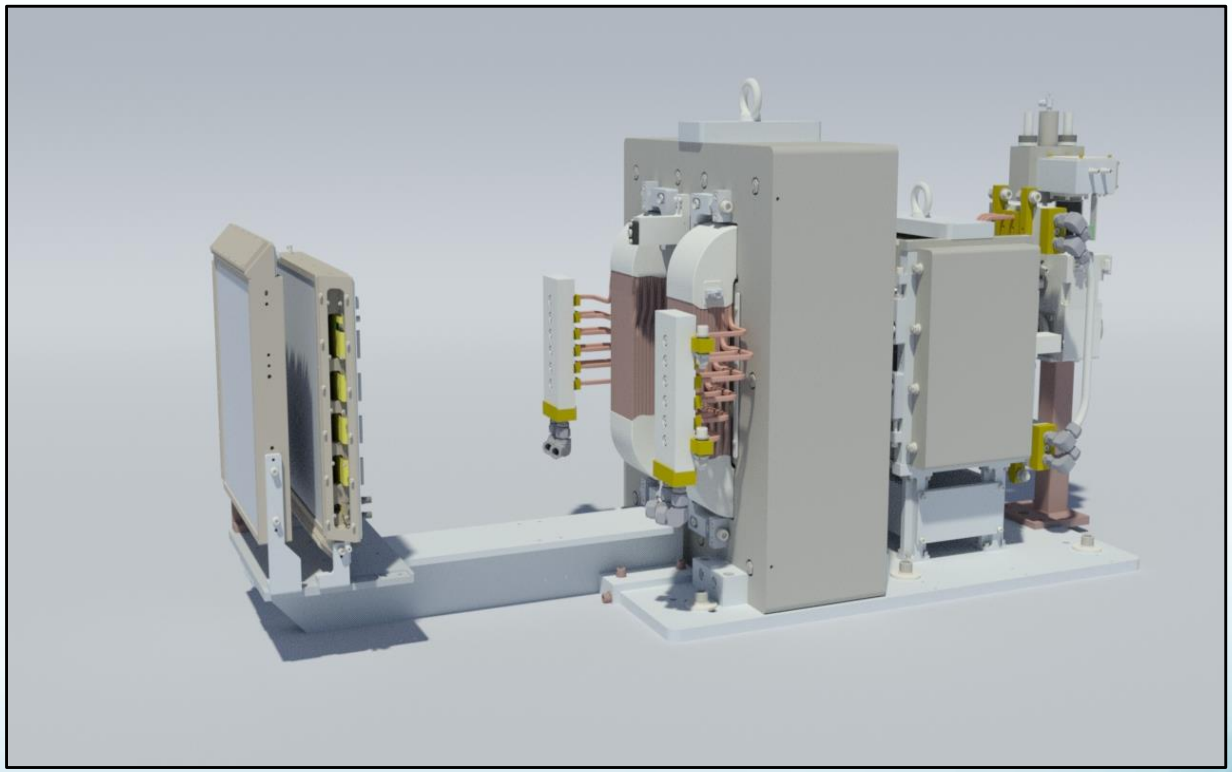


Proton beam scanning nozzle

Measure

- **Spot position**
- **Spot size**
- **Number of delivered protons**

- **Helium Chamber** to reduce spot size
- **Snout** to hold a range shifter, aperture, ridge filter, etc.



Spot Scanning