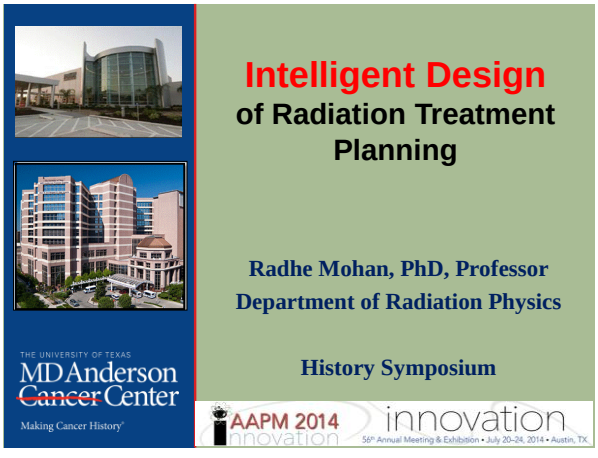


Treatment Planning is the Most Important Component of Radiotherapy

Plan quality determines the outcome

Accuracy **Optimality**

Goals of Treatment Planning

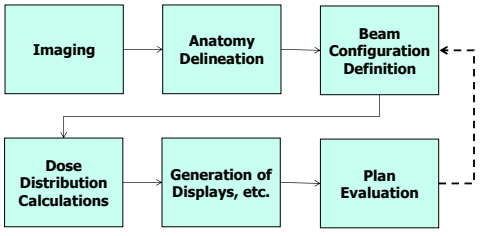
To model / simulate a treatment ("virtual treatment")

To produce a treatment plan that shows the dose distribution expected to be delivered over the course of therapy

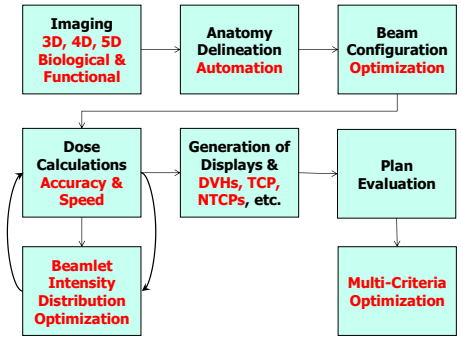
To Take uncertainties into account

To optimize dose distributions to achieve an appropriate balance between tumor coverage and normal tissue sparing

Basic Process



Evolution Over the Years

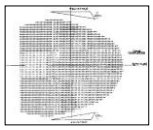


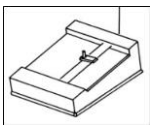
Evolution Over the Years - Management of Uncertainties

- **Reduction**
  - **More accurate dose computations**
  - **Imaging**
  - **Image guidance**
- **Incorporation**
  - **Margins**
  - **Robust optimization**

Personal Perspective – Starting in the "Flat-Earth" Era

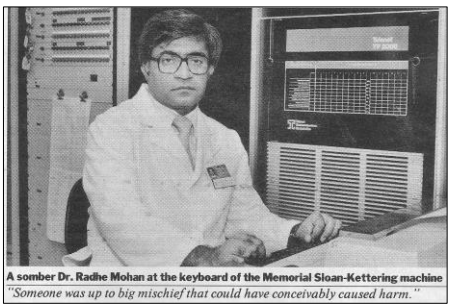
- **Junior faculty at MSKCC hired to develop 2D TPS**
  - **Time-shared computers**
  - **Character maps, hand drawn contours on films, teletypes**
  - **Pen plotters, digitizers, sophisticated terminals**
- **"Memorial Dose Distribution Computation Service"**
  - **~200 institutions served**
- **In-house PDP 11's in mid 1970's and VAX in the early 1980's**





First Ever to be Hacked (1982)

Time Magazine Photo



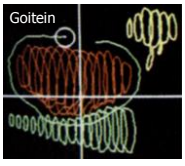
A somber Dr. Radhe Mohan at the keyboard of the Memorial Sloan-Kettering machine

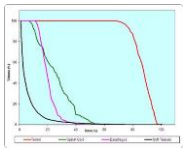
"Someone was up to big mischief that could have conceivably caused harm."

Helped FBI Find and Apprehend the 414 Gang

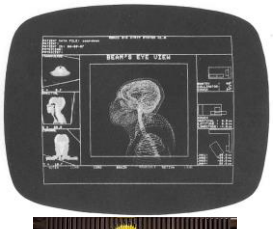
3D Treatment Planning – 1980's

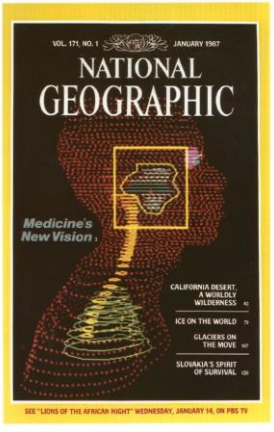
- Rhode Island
- MGH - Goitein (Particles)
- University of Michigan – Fraass, et al
- NCI Contract for the "evaluation" of 3D Treatment Planning (NCI Project Leader: Al Smith)





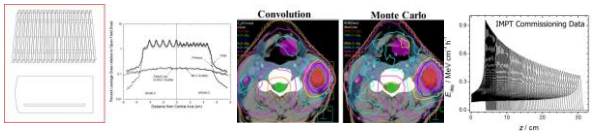
3D RTP at MSKCC – Propelled by NCI Contract



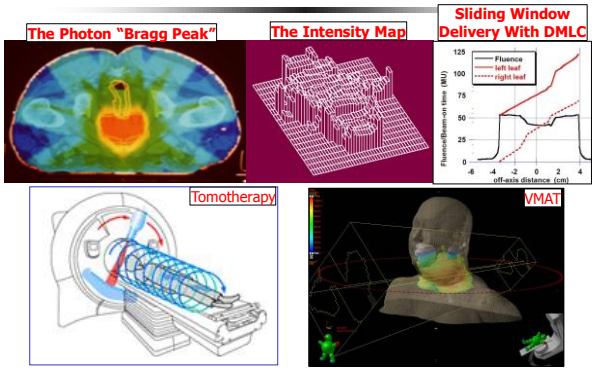


Monte Carlo Revolution (~1980 → …)

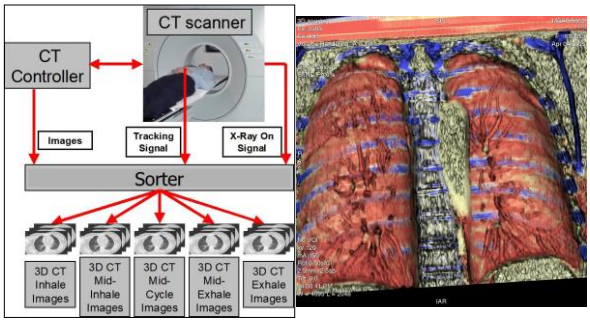
$$\frac{\partial f}{\partial t} + v\nabla_x f + a\nabla_v f = -(f - f_0)/\tau$$



IMRT, Dynamic Multi-Leaf Collimation, Tomotherapy and VMAT (1990's)



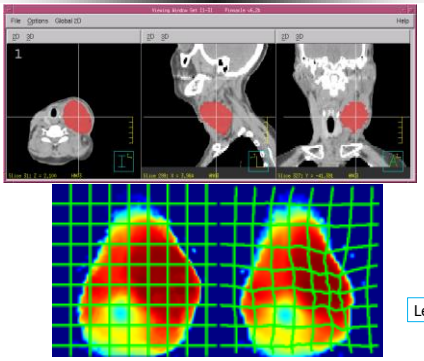
4D CT, Respiratory Motion Management and 4D Planning (Late 1990's and 2000's)



Keall

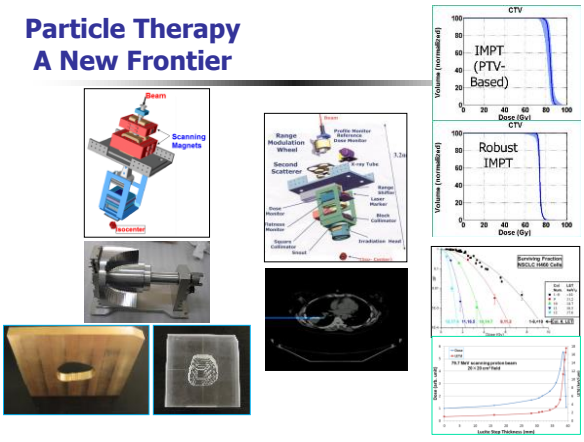
Courtesy - Balter

Deformable Registration, Auto-Segmentation, Dose Accumulation, Adaptive Planning– 2000's



Lei Dong

Particle Therapy A New Frontier



Drivers of Evolution of Treatment Planning

- **Computers**
- **Imaging**
- **Technologies (e.g., MLC, Tomo, VMAT, …)**
- **Monte Carlo Techniques**

Amazing progress made

History of RTP is still being made

Lesson – It never ends

Thanks

Jake Van Dyke

Summary

History to be Made

Challenge of Uncertainties

In day-to-day practice, the dose distribution seen on a treatment plan is accepted as the gospel truth

It is assumed that WYSIWYG

However, there are uncertainties

Understanding uncertainties and their impact and minimizing and accounting for them is critical

- Inter- and intra-fractional variations
  - Motion
  - Anatomy changes
  - Set up variations
- Approximations in dose computation methods
- Delineation of targets and normal tissues
- Tumor heterogeneity
- Dose response of tumors and normal tissues

Improving the Effectiveness of Treatment Plans

- Functional and biological imaging
- Optimization and intensity-modulation
- Improving our knowledge of dose response of therapy (including in combination with chemical and biological agents)
- Automation
  - For efficiency
  - To reduced inconsistencies
  - Overcome obstacles caused by complexities
- Planning for Particle Therapy