

My Journey from Physicist to Physician

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My Career Observations

- Definitions (Websters)
 - ◆ Job vs. Career (sometimes used interchangeably)
 - ◆ Job - Work that is done for a set fee; a project worked on; a position of employment
 - ◆ Career - The profession or occupation a person takes for life
- How to get satisfaction and success from your career search and choices (within or outside of physics)
 - ◆ Experiences shape your options and perceptions
 - ◆ No Gedanken experiments!
 - ◆ Rid yourself of preconceived notions and be open minded
 - ◆ Explore and take advantage of opportunities
 - ◆ Don't shy away from uncomfortable situations
 - ◆ Give your future career the time and effort it deserves
 - ◆ Most important, the ancient Greek aphorism, "Know Thyself"
 - ◆ Understand your motivations, satisfactions, and personality



FLATTERY

IF YOU WANT TO GET TO THE TOP, PREPARE TO KISS A LOT OF THE BOTTOM.

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The Early Years

- Loved physics as an academic subject and never thought about it as a career
 - ◆ Couldn't imagine doing anything else
 - ◆ Most family members not in science (Business, Law, etc. with one relative who was a Mechanical Engineer)
 - ◆ High school and college math/physics teacher mentors
 - ◆ Majored in physics and math at a liberal arts college
 - ◆ 'Disliked' pre-meds, fainted while giving blood, and had no interest in medicine
 - ◆ Problem: I assumed my love of the subject would naturally transition to a satisfying physics career
 - ◆ No career mentors except for teachers/professors

Graduate School

- No regrets; great memories
- Met my wife (she was an undergrad in fine arts)
 - ◆ No, I wasn't her TA.....
- I got cancer - Hodgkin's Disease (Lymphoma)
 - ◆ After surgery, I had radiation therapy (left grad school for six months) and have been cured (now over 20 yrs)
 - ◆ 'Exposed' me to the field of radiation oncology and medical physics
 - ◆ Too focused on being a patient
 - Wasn't thinking of this as a career until much later
 - Wanted to get back to my physics research projects

Graduate School

- Develop general skills which are broadly applicable to other careers (esp. medicine)
 - ◆ Focus on problem solving and completing projects successfully
 - ◆ Software and hardware skills
 - ◆ Conveying your thoughts and ideas to others - most important
 - ◆ TA, publishing, presenting at conferences, etc.
- An advanced degree in physics is respected in medicine
 - ◆ Help with MCAT's, getting into med school and residency programs
 - ◆ Is highly respected in the more technical areas of medicine like radiation oncology (RO, 'rad onc') or radiology
- Ability to apply logic - it's funny how MD's will quote dogma and processes which do not always make sense....

My Physics Career Path

■ Supply >> Demand

- ◆ Always been difficult to secure a perm physics job
 - ◆ Very difficult in 1970's ('physicist cab drivers'), in early 90's (my time), etc.
 - ◆ Exacerbated by semiconductor 'down cycles'
 - ◆ Decreasing science funding in government and corporations

■ Despite the times, and seeing the difficulties of more senior grads, 'I only knew physics'

- ◆ Scared, uncomfortable about leaving physics 'path'
- ◆ Secured prestigious post-doc @ Harvard and traveled to Brookhaven light source and Bell Labs
- ◆ While making career switch to medicine, worked as a 'temporary' staff scientist at Sandia Labs

My Motivations and Realizations

- Day-to-day life in physics wasn't for me
 - ◆ During post-doc, securing funding and continual grant writing seemed tedious and unsettling
 - Authored and co-authored a number of publications but it didn't make me happy
 - ◆ No interest in building a research 'empire'
 - ◆ Being in the lab, writing papers and grants, and thinking about the research was a 'lonely' experience
 - Needed/wanted more 'human' contact - part of my 'extrovert' personality wasn't being satisfied
 - ◆ Influenced by an older research colleague who was given early retirement from Bell Labs
 - Became embittered and angry
 - Got sense his career never lived up to his expectations (never got the big accolades or discoveries of some of his colleagues)

My Motivations and Realizations

- It's tough giving up something you love
 - ◆ 'Day-to-day' physics didn't fit aspects of my personality
 - ◆ Could I continue to do this for the next few decades?
 - The research excited me, but the process didn't
 - The 'reward' was too slow and long-term in coming
 - ◆ Is my research work ever going to benefit people or society?
 - Is this important to you!
 - Some feel ('It's cool to get paid to sit and think about fascinating topics') - but not me
 - ◆ Would I feel like my unhappy colleague at the end of my career?
 - What 'legacy' would I want for myself and my career?

Multi-task Career Search

- While you're doing your research also spend time looking into, or learning about, other careers
 - ◆ 80-90% of all physics PhD's will not be doing academic physics whether they want to or not
- Be Creative
 - ◆ Some people I knew at APS were concerned about the job situation and wanted to do something....I submitted a proposal to APS to develop an 'Alternative Career Questionnaire'
 - ◆ Small budget; reviewed data base and got back 40 questionnaires from physicists in business, finance, engineering, medicine, etc.
 - ◆ APS never put results in a useful format or published it
 - ◆ Opened my eyes to other careers
- Be open-minded
 - ◆ I thought I didn't like medicine till I learned about it
- Meet people - Network
- Put yourself in uncomfortable situations - "Test yourself"
 - ◆ Interviewed for positions in finance on wall street
 - ◆ I didn't see myself on wall street but I needed to 'prove it' to myself; read up on derivatives, Black-Scholes modeling, etc.

Multi-task Career Search

- ◆ By the end of my post-doc, I had
 - ◆ interviewed at academic physics depts. just to prove to myself that it wasn't right
 - ◆ interviewed for research and development as well as engineering positions within many tech companies
 - Couldn't get into wearing a 'bunny suit' for some of the positions
 - ◆ interviewed at finance firms
 - ◆ taken biology and chemistry courses to see if I even enjoyed 'medically-related' studies
 - Enjoyed it, could still memorize, talked to radiation oncologists....this was it!
 - ◆ interviewed for National Lab positions
 - Took SNL position b/c it was interesting research (by day) and I could also continue to take pre-med classes (at night)
 - ◆ 'researched' and considered but ultimately decided against
 - business school, management consulting firms, medical physics post-doc programs, work in 'science policy', and many other options
- ◆ My advice: Explore all potential career options and enjoy the process
 - ◆ In the end, I learned a lot about myself, I felt more in control of my 'destiny' and I didn't have any regrets



INDIVIDUALITY

ALWAYS REMEMBER THAT YOU ARE UNIQUE, JUST LIKE EVERYBODY ELSE.

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The Medical Path

- No short cuts to getting a medical degree
 - ◆ Have to complete all required pre-med course work
 - ◆ Multiple undergrad biology, chemistry and lab classes
 - Took me 2 years while working full-time
 - ◆ MCAT's - Biology, Chemistry, Physics and Math/Analytical sections (you won't have a problem with this), Essay writing, etc.
 - ◆ Medical Schools
 - ◆ Competitive; look at GPA, MCAT, background
 - Maybe 17k are accepted; 40k apply
 - ◆ You're a non-traditional student which can help or hurt
 - ◆ What got me through was enjoyment of the process and of learning new things!
 - ◆ Say you want to be a primary care doctor in a rural community!.....med schools have 'quotas' for different kinds and backgrounds of students they want

The Medical Path

■ Medical school

- ◆ 4 years, expensive (from \$15k to \$50k/yr)
 - ◆ SUNY downstate was \$20k/yr in 1996 when I went
- ◆ Take many different subjects
 - ◆ 2 years classes: Anatomy, Physiology, Microbiology, Biochemistry, etc. - large breadth of subjects
 - ◆ 2 years hands on with patients: Learn normal vs. disease states, Pediatrics, Ob/Gyn, Internal Medicine, etc.
 - ◆ You are 'rewarded' as a student the faster you can answer a question correctly
 - Thinking deeply is not rewarded
 - Lots of memorization; the older you are the harder it is to retain it all and the more difficult it is to get consistently high grades
 - ◆ What do they call the lowest ranking student in the class?

DOCTOR!

The Medical Path

- Must pass 3 separate (Step) board exams to move on to residency
- The more specialized the residency, the smaller the number of open slots, and the greater the chance you won't 'match'
 - ◆ 5-10% US medical students don't match
- Radiation Oncology (RO) Residencies
 - ◆ \$40+k/yr starting salary as a resident (at least at Wash Univ.)
 - ◆ One of the more competitive specialties to match into
 - ◆ More MD/PhD's go into RO than other specialties
- 1 year internal medicine then 4 years 'rad onc'Nine years total time commitment before starting your career!

A Life in Radiation Oncology

■ Cons

- ◆ A lot of 'electronic' paperwork (medicine in general)
- ◆ Suck up to some referring docs (they supply pts.)
 - ◆ MD's can have some very outsized egos (esp. surgeons)
- ◆ Stressful - responsible for knowing all patient details and for all patient-related decisions
 - ◆ Frequently have to make decisions on limited info
 - ◆ Hierarchy in Medicine: Must be 'controlling' since nurses, staff, patients, etc. all come to you with problems to be quickly solved
 - Less tolerant of people not doing their jobs to a high standard
 - Can translate into family life.....
- ◆ Emotional
 - ◆ Giving bad news and getting close to patients (and their families) who die
- ◆ Hospital Administrations and Insurance Companies
 - ◆ Business and local politics

A Life in Radiation Oncology

- Pros (greatly out-way the cons)
 - ◆ Well-defined career path with demand increasing for years
 - ◆ Medicine limits supply of doctors so you'll never have to worry about having a job (and be in demand somewhere)
 - ◆ At least for now, high paying (for most specialties)
 - You won't be 'rich' but very comfortable
 - ◆ Rad Onc in particular has a high quality of life
 - Work 8-5; M-F.....Cancer stops growing on the weekends!
 - 'Call' is very light compared to most of medicine
 - ◆ Never question your usefulness; very meaningful work
 - ◆ Your trying to save people's lives on a daily basis!
 - The fruits of your labor manifest itself in weeks (seeing some tumors 'melt' away) to months, typically
 - ◆ Busy everyday from when you walk in the door until you leave
 - ◆ Honest and 'real' relationships with your patients
 - ◆ In RO, get to play with constantly evolving technology and deal with physicists on a daily basis (and give them a hard time!)
- Overall, a great career choice that you will not regret!

You are a highly paid worker bee



GET TO WORK

YOU AREN'T BEING PAID TO BELIEVE IN THE POWER OF YOUR DREAMS.

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Outline

- Overview of the Field
- Who are we and what do we treat?
 - History of Radiation Oncology
- Why does radiation work?
 - Physics and Radiobiology
- How do we deliver radiation?
 - Physics and Technology
- What do we do?

Overview

- The Cancer Team: Surgical Oncologist, Medical Oncologist and Radiation Oncologist
 - For most cancers, the diagnosis is made by the surgeon (or on a biopsy prior to seeing a cancer specialist). Radiation oncologists rarely diagnose cancers.....we get referred the patient from the surgeon or medical oncologist.
 - 1.3 million cases of (non-skin) cancer diagnosed in US each year!
 - 60+% of cancer patients will at some point in their disease be treated with radiation
 - Radiation plays a major role in the 3 big cancers (Breast, Prostate, and Lung)

Tumor Board

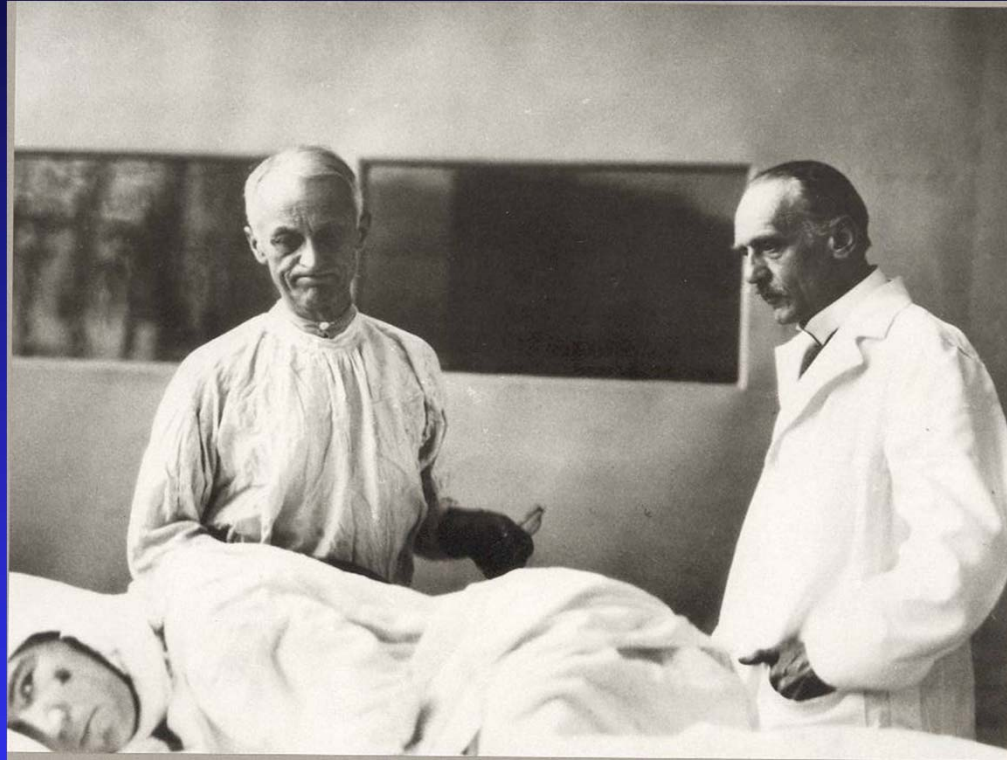


MEETINGS

NONE OF US IS AS DUMB AS ALL OF US.

www.despair.com

The Surgeon



“Of course I know the leg bone is connected to the thigh bone.....”

The Medical Oncologist

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Hard at work mixing cytotoxic therapies

The Radiation Oncologist

- Licensed by the NRC and state agencies to handle/utilize radiation in all forms (machine, sealed/unsealed sources, etc.)
 - Need to pass specialty board exams after residency (2 written and oral)
 - Every 10yrs need to re-certify with exams, etc.
- We see patients on consultation and follow-up after treatment
 - Most of my time during the day is spent dealing directly with patients and their problems during the radiation treatments
 - We do not generally manage patients in the hospital
- We manage most aspects of care during radiation treatments and on follow-up along with medical oncologists and surgeons
 - Diagnosis, imaging and lab studies, prescribing medications, etc.
- We develop treatment plans (doses of radiation, treatment volumes, etc.) and perform minor surgical procedures (i.e., radioactive implants)
- ‘We are NOT radiologists’ - though we do read CT, MRI, etc. ‘films’ for treatment planning in the context of the patient’s anatomy, specific cancers, and where the cancer metastasizes

The Radiation Oncologist

- About 60-75% of patients seen by a radiation oncologist are potentially curable; the rest are treated for palliation (i.e., reduce pain caused by the tumor metastases, etc.)
- In an academic center, in addition to treating patients, the oncologists may be performing research, involved with clinical trials, teaching, etc.
- Rough starting salary: \$250+k....can increase after a few years to quite a bit more....

Clinical Diseases Treated with RT

- Rad Onc's are the doctors who decide what diseases should get treated with radiation
- Benign Conditions (proliferative/inflammatory disorders)
 - Eye (Pterygium, Exophthalmos, Macular degeneration, Orbital Pseudotumor, Angiomas)
 - Skin/Subcutaneous tissues (Keloids, Warts, Plantar Fasciitis, Bursitis/Tendonitis, Keratoacanthoma)
 - Hemangiomas (skin, bone, liver, CNS)
 - CNS (AVM, Trigeminal Neuralgia, Meningioma, Pituitary Adenoma, Craniopharyngioma)
 - Heterotopic bone formation
 - Glandular (Gynecomastia, Ovarian Castration, Parotitis)

Clinical Diseases Treated with RT

- Malignant Disease (Definitive)
 - Skin (Basal and Squamous Cell)
 - CNS (Gliomas, Medulloblastoma, Ependymoma)
 - Head and Neck (All sites - naso/oro/hypopharynx, larynx and thyroid with treatment to neck for locally advanced)
 - Lung (NSCLC/SCLC, Thymoma) and Esophagus
 - Breast (Early, Locally advanced and recurrent)
 - GI (Stomach, Pancreas, Hepatobiliary, Rectum, Anal)
 - GU (Prostate, Bladder, Testicular, Penis/Urethra)
 - Gyn (Cervix, High-risk Endometrium, Vagina/Vulva)
 - Hodgkin's and Non-Hodgkin's Lymphoma, Cutaneous lymphomas, Plasmacytomas
 - Sarcomas
 - Pediatric Cancers (CNS, Wilm's, Neuroblastoma, Ewings, Rhabdomyosarcoma, Lymphomas)
 - Palliation: Bone/Brain/Spinal Cord metastases, melanoma, myeloma, leukemias, etc.

We decide who to treat with RT

- Patient selection is critical! What RT techniques, doses, etc.? What does the evidence-based data suggest? To use it before, after or concurrent with surgery, chemotherapy, molecularly-targeted agents, etc....

TUESDAY, NOV. 12, 2002

Man charged in sex assault on dog

South Brunswick trailer where he lived is later searched for a bomb

By KEN SERRANO
STAFF WRITER

SOUTH BRUNSWICK — Reacting to a threatening phone call to 911 operators, authorities searched for a "biological bomb" yesterday at a home in a Route 1 trailer park, where a 47-year-old man was arrested earlier in a sexual assault on a dog, police said.

Specialists from the State Police Domestic Preparedness Unit, a bomb-sniffing dog from the Middlesex County Sheriff's Office, county authorities and township police descended on a Maple Street home at the Monmouth Mobile Home Park at 2:45 p.m.

They found no explosives. But they seized journals containing passages that included "various conspiracy theories" penned by Joseph Cocho, the man arrested in the torture of a 2-year-old mixed beagle in the home, said South Brunswick police Detective Jim Ryan.

The bizarre turn of events started at 12:30 a.m. yesterday when police received a call from a woman who said she saw Cocho sexually assaulting her dog, Daisy, after the dog's barking led her to peer into Cocho's room, Ryan said.

"It doesn't get any sicker than that," the 33-year-old woman, Dorothy Gallagher, said last night. Cocho rented a room from Gallagher.

Police arrested Cocho on charges of torturing an animal, a fourth-degree offense, a crime that could bring him 18 months in prison if convicted. Ryan said police also discovered a dagger in



Joseph Cocho

Cocho's room and charged him with possession of a weapon, a third-degree crime that carries a prison term of three to five years if convicted.

While that arrest took place, Cocho "made assertions about having a dirty bomb," Ryan said. "He also made comments about the CIA, the FBI and the Mafia coming after him."

Cocho was taken to Middlesex County Adult Correction Center in North Brunswick, where he remained last night in lieu of \$1,000 bail.

Gallagher said Cocho worked in the mail room of a large corporation, but quit recently.

"He left . . . because he thought the business was owned by the Mafia and that satellites were after him," Gallagher said. "Everything was Mafia-owned."

He rented the room from her for a couple of months and ap-



Daisy

peared harmless, she said, adding that she thought his strange ramblings "were just a lot of talk."

Six hours after the arrest, while Cocho remained in jail, State Police 911 operators received a call from a man claiming to be part of a "specific group" that planted a "biological bomb" in the mobile home park, Ryan said. He would not elaborate on the group or the message, but said the caller did not specify an address.

The voice was altered, possibly by electronic means, Ryan said.

Cocho's remarks and the area mentioned in the threat led police to seek a search warrant to return to the Maple Street home where Cocho was arrested.

Ryan said investigators determined the call was not made from the correction center where Cocho was incarcerated.

No one from the Monmouth Mobile Home Park was evacuated during yesterday's search.

Based on our Hippocratic oath, we treat everyone who needs our services.....

The Radiation Oncology Team

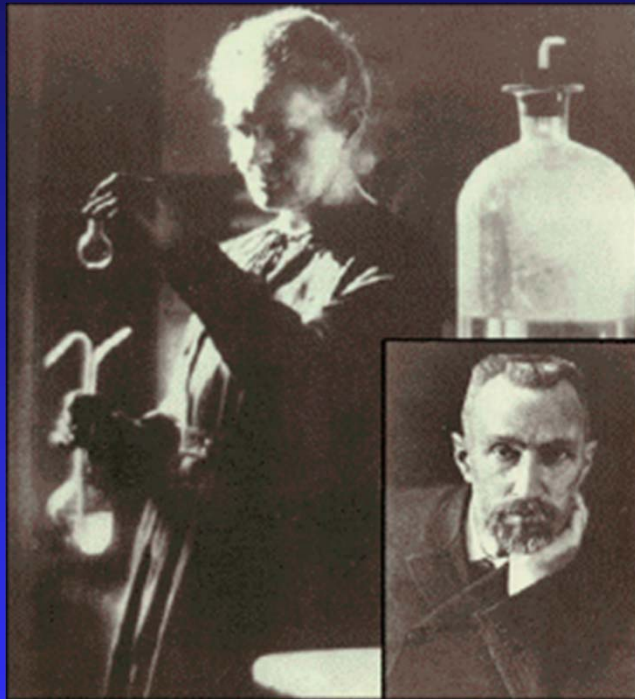
- Radiation (Medical) Physicists
 - Ensures QA of equipment, dose calculations and accuracy of delivered treatment (basically all technical aspects)
- Radiation Dosimetrists/Therapists
 - Responsible for the completion of treatment plan details & administration of the radiation treatments
- Oncology Nurses/PA's and support staff (Nutritionists, PT/OT, social work, psychiatry, etc.)

Medical Physicists

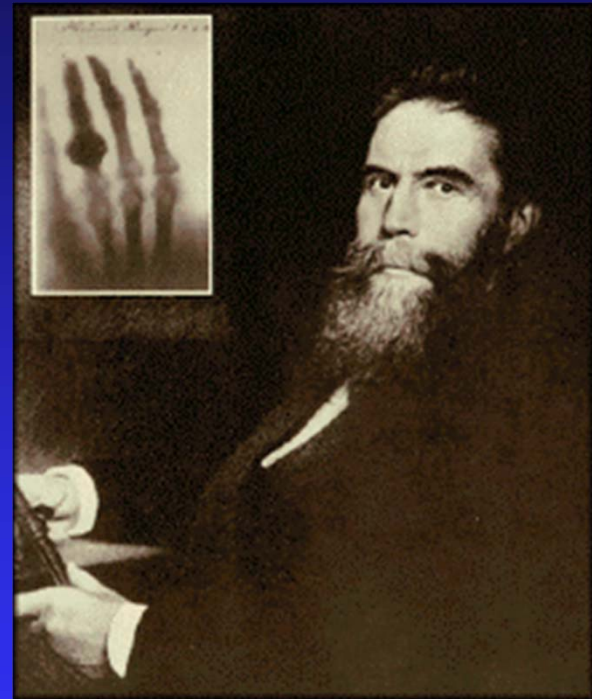
- Medical Physics is an applied branch of physics concerned with the application of the concepts and methods of physics to the diagnosis and treatment of human disease
- Involved with radiation safety in radiation oncology and in radiology
 - Develop improved delivery and imaging techniques
 - Collaborate with radiation oncologists on treatment plans
- Monitor equipment and procedures to ensure that cancer patients receive the prescribed dose of radiation to the correct location
- In an academic setting, they would be involved with research and teaching
- Can take a 3 yr. 'post-doc/residency' in medical physics or get an MS (or PhD) in a medical physics program
- Once passed board exams, work unsupervised in hospitals
 - Rough starting salaries: MS (\$150k), PhD (\$200k)

History of Radiation

Physicists in Medicine



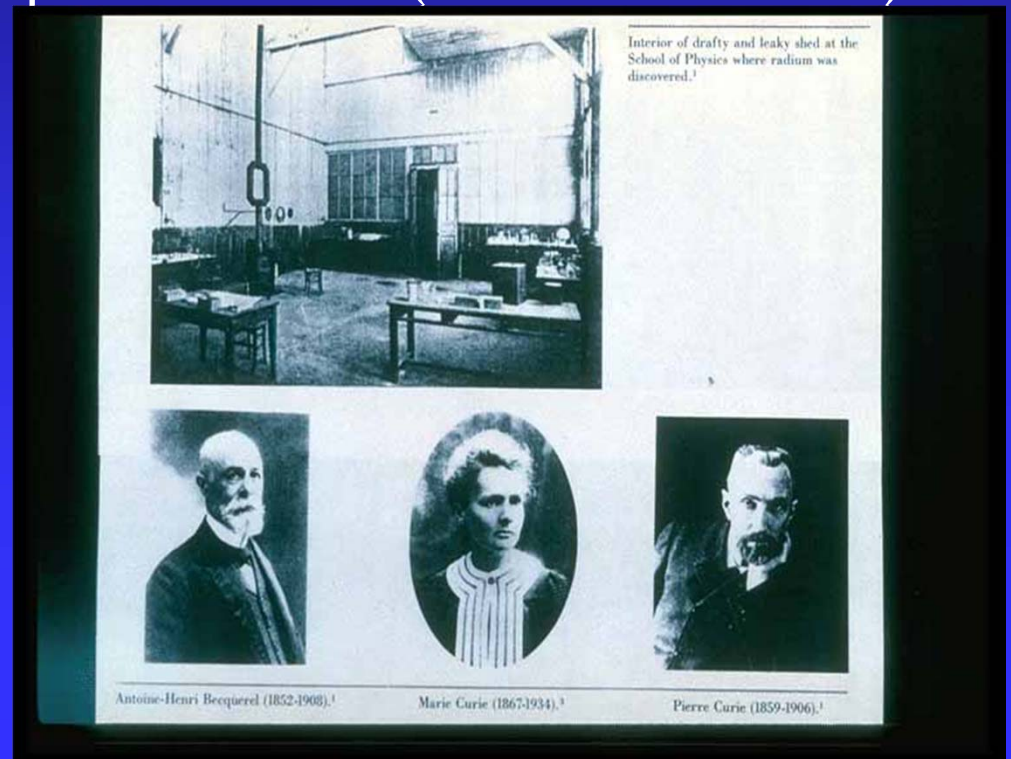
Pierre Curie (1859-1906)
Marie Curie (1867-1934)
Nobel Prize 1903 (Radium)



Wilhelm Conrad Roentgen
(1845-1923)
Nobel Prize 1901 (X-rays)

Discovery of Radioactive Materials

- 1896: Antoine Henri Becquerel, Marie and Pierre Curie announce discovery of radium and spontaneous 'radiation'
- 1903: They share a Nobel Prize in physics for this
- 1911: Marie Curie wins second Nobel prize (Chem) for studies of isolation of radium and polonium
- 1934: Marie Curie dies of aplastic anemia (radiation-induced)

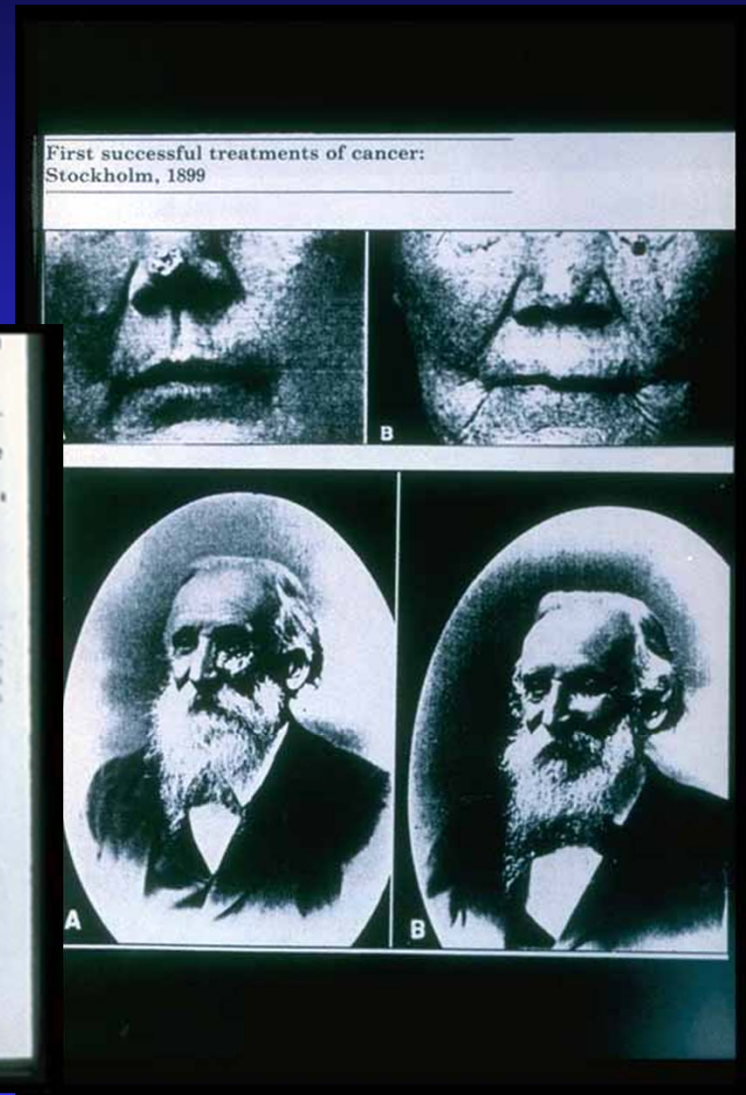
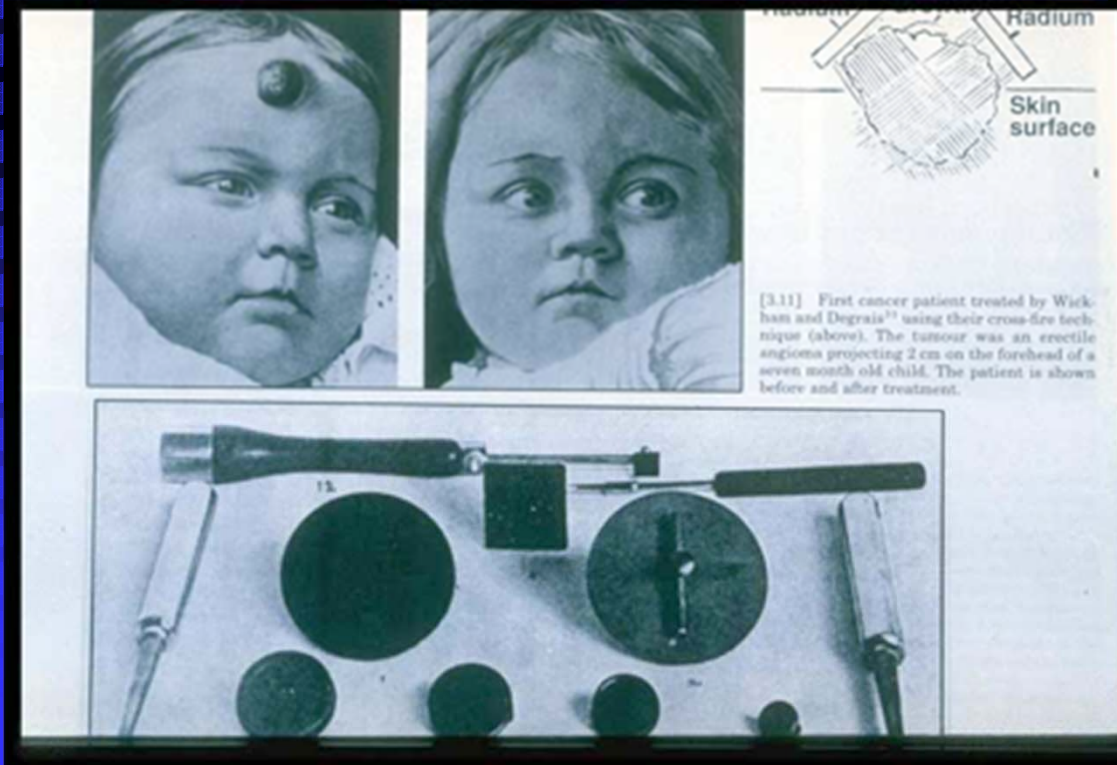


Early Uses - The miracle cure!

- Emil Grubbe, a Chicago electrician and metallurgist, first treated **recurrent breast cancer** of a 55-year-old woman in the last days of January 1896--only weeks after the announcement of Roentgen's discovery!
- William Pusey (1898) reported beneficial effects on **hypertrichosis** and **acne** and Leopold Freund (1898) pioneered the use of the rays in benign conditions (pediatric nevus and lupus vulgaris)
- Frands Williams published on the x-ray cure of a **cancer of the lower lip** (1901).
- Margaret Cleaves, a New York physician, published in 1904 her treatment of a patient with **carcinoma of the cervix** by inserting radium into the uterine cavity.

Early Cures

- Basal and Squamous cell skin cancers (1899) using a kilovolt source
- Benign erectile angioma (1907) using radium sources with early applicators



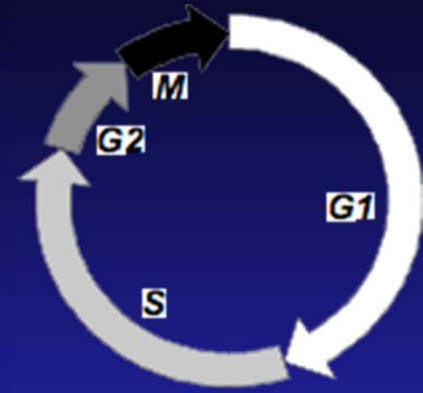


Extraordinary follow-up. In November 1896, Leopold Freund in Vienna irradiated a four-year-old girl with an extensive dorsal hairy nevus. Although the immediate result was a painful moist radioepidermatitis, permanent regression followed. The young woman led a normal life, bearing a healthy son. Photographs taken at 74 years of age, however, reveal lumbar skin scarring, kyphoses, keratoses, and osteoporosis.

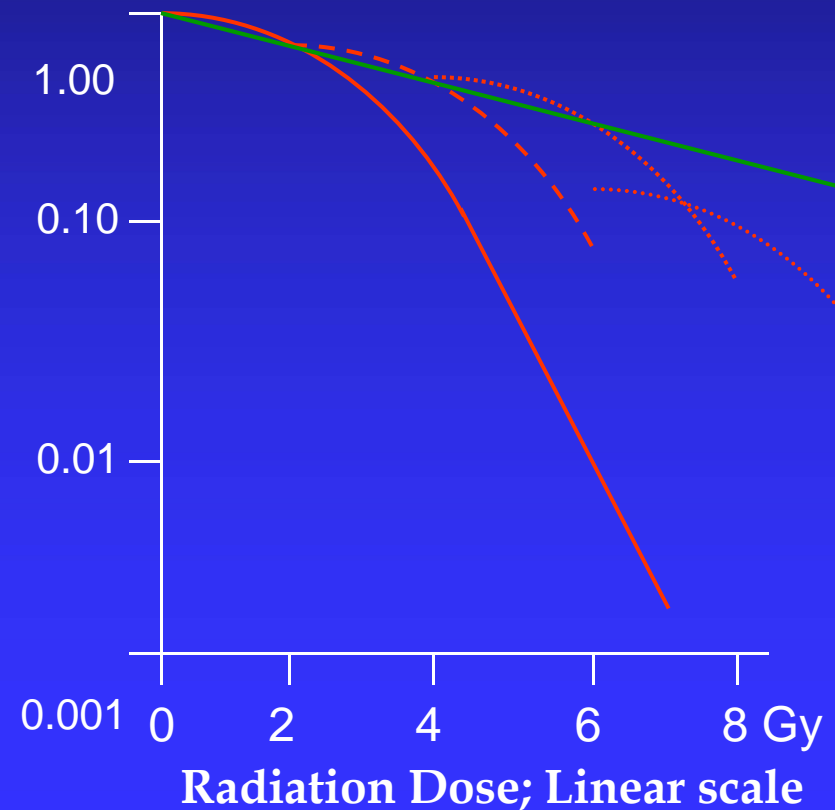
Why? - Radiation Biology Basics

- **Cancer - uncontrolled cell proliferation**
- **Radiation (and chemotherapy) preferentially kills cells (normal and cancerous) which are proliferating**
- **Normal tissue recovery from sub-lethal and potentially lethal radiation-induced damage modifies dose effectiveness**
- **Reproducible tumor cell killing as a function of radiation dose and dose rate is the basis for radiation therapy**

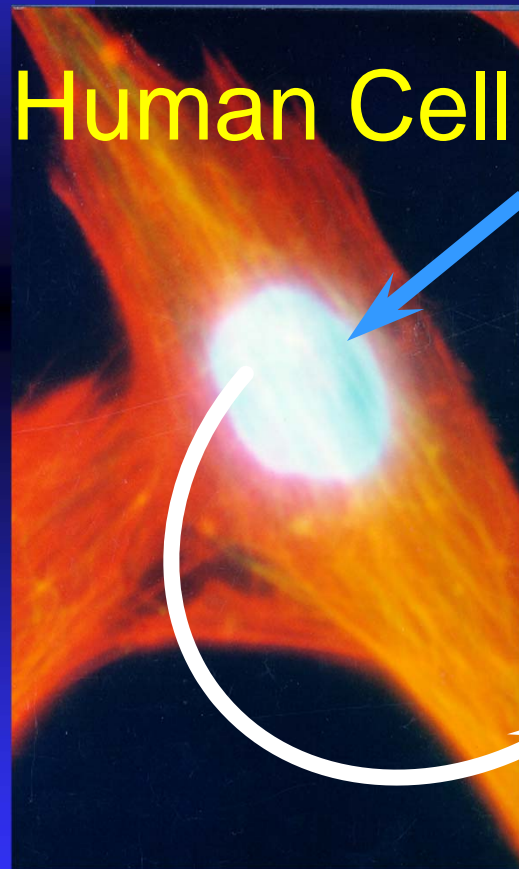
- Mitotic cell cycle - cells are most sensitive to radiation in or near mitosis - very complex with cell cycle check points/regulatory genes



- Cell survival curves - if we 'fractionate' the radiation dose, normal cells can repair the radiation damage

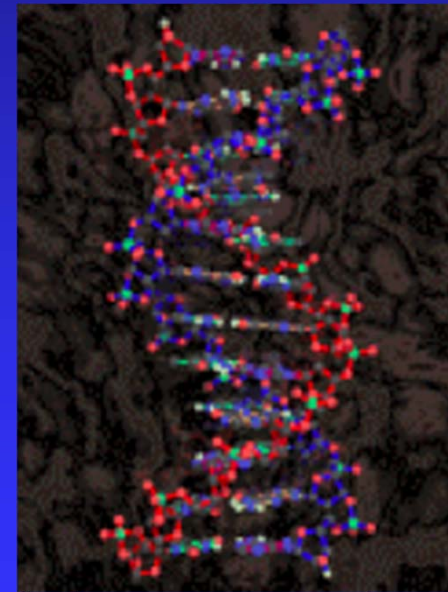


What? - Critical Radiation Target is DNA



Human Cell

Nucleus contains DNA



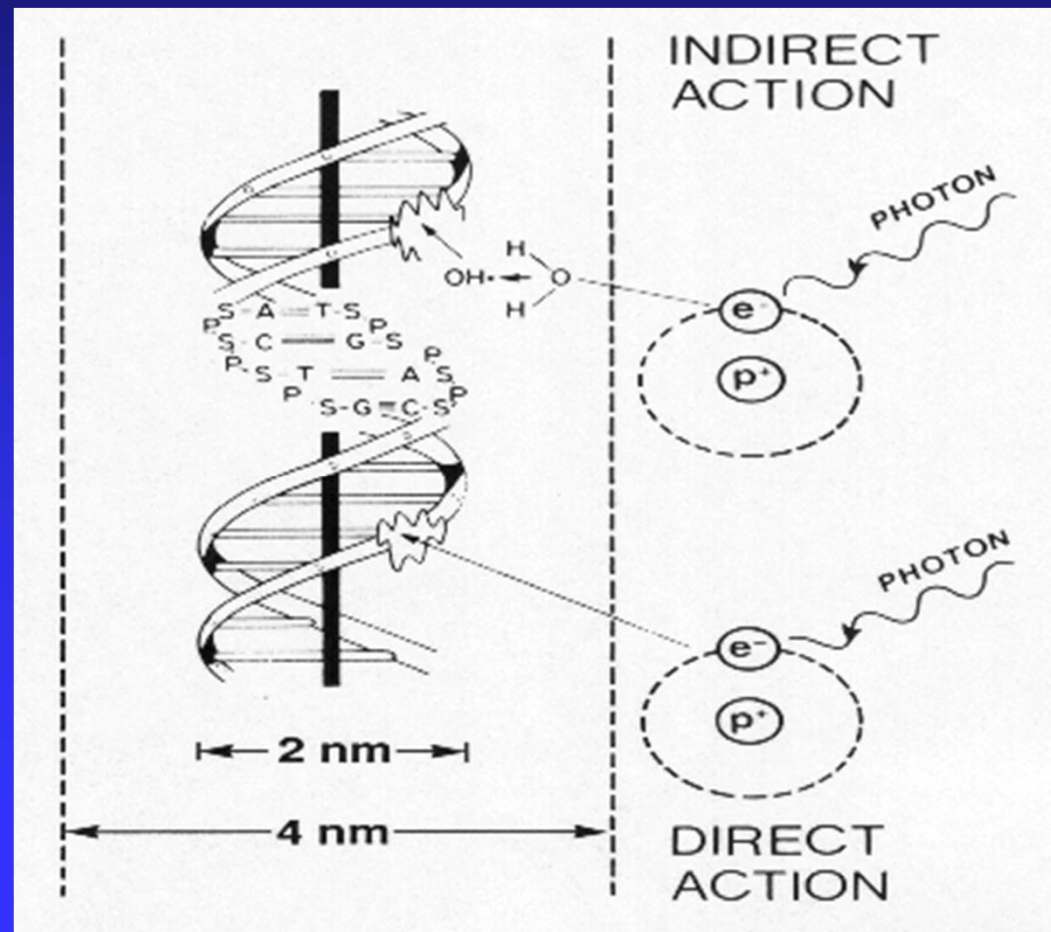
DNA double stranded helix

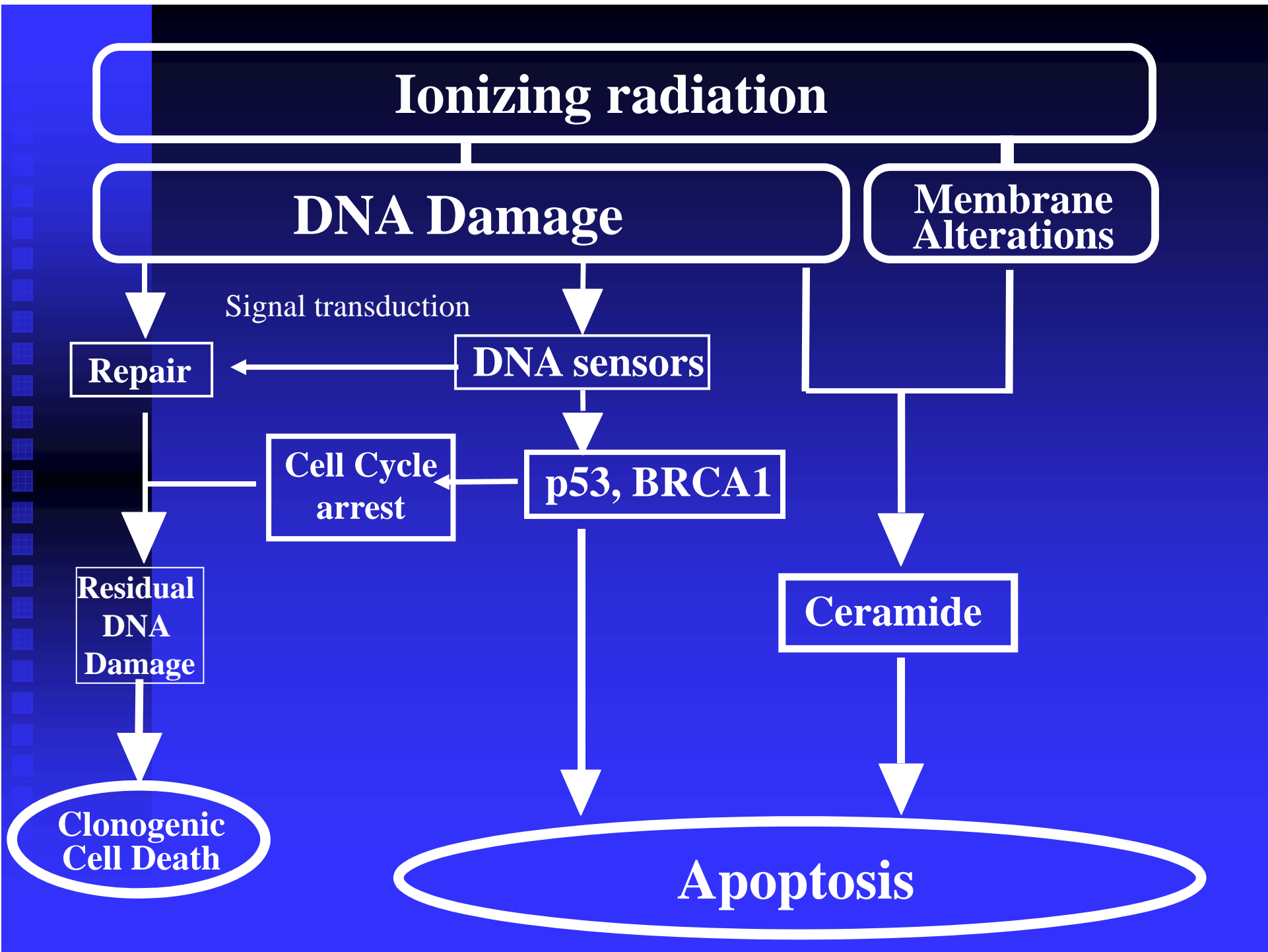
DNA is packaged on chromosomes



Direct and Indirect Actions of Ionizing Radiation

- Target of radiation is DNA
- Radiation causes damage either by direct effects or production of damaging ions





Ionizing radiation

DNA Damage

Membrane Alterations

Signal transduction

Repair

DNA sensors

Cell Cycle arrest

p53, BRCA1

Ceramide

Residual DNA Damage

Clonogenic Cell Death

Apoptosis

Other Radiobiology Effects

- Normal tissue dose and dose rate relationships
 - Spinal cord has different tolerances than lung, etc.
 - Early (Acute) effects of radiation during treatment and Late (Chronic) effects 3-6 months or longer after treatment
- Radiosensitizers and protectants
 - Synergistic effects with chemotherapeutic and molecular-targeted agents
 - Chemo: 5FU, Cisplatin, Temodar, etc.
 - Molecular/Other: Erbitux (EGFR inhibitor), LHRH Agonists, Hyperthermia
 - Radioprotector: Amifostine

How and What? - Radiation Physics

- Definitions

- Dose - amount of energy absorbed in tissue

- Gy (Gray) - energy absorption of 1 J / kg
 - 1 Gy = 100 cGy (in old terminology 1 cGy = 1 rad)
 - Definitive radiation treatments for solid tumors: 6000 - 10000+ cGy
 - In one year, normal public receives ~0.4 rem (~cGy) mainly from radon and cosmic rays
 - Chest x-ray ~ 0.01 rem (~.1 cGy)

- Terminology/Acronyms

- Energy of radiation: MV (or MeV) - Mega electron volts
 - Brachytherapy - Brachy from Greek meaning 'short'
 - HDR or LDR - High/Low Dose Rate (>12 Gy/hr or 0.4-2 Gy/hr)
 - IMRT - Intensity Modulated Radiation Therapy
 - IGRT - Image Guided Radiation Therapy
 - SRS/SRT - Stereotactic RadioSurgery (Therapy) - CNS only
 - SBRT - Stereotactic Body Radiation Therapy - Non-CNS

All Acronyms Approved by **CRAP**

Committee

for

Responsible

Acronym

Production

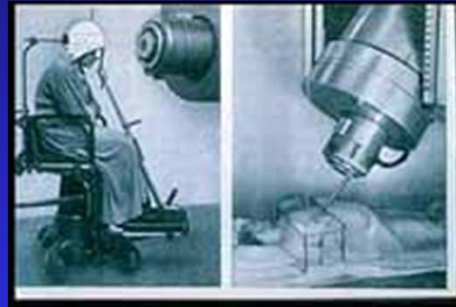
How do we deliver the dose?

- Linear Accelerators (usu. 6 - 23 MV)
 - Treat with x-rays or electrons (shallow penetration)

In 1930's



In early 1940's



In 1950's



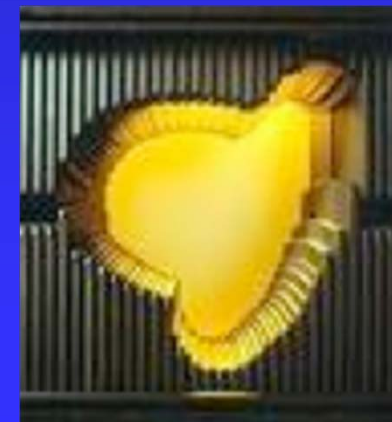
Today - Clinac 23 (work horse)



Trilogy



Multi-Leaf Collimator (MLC)



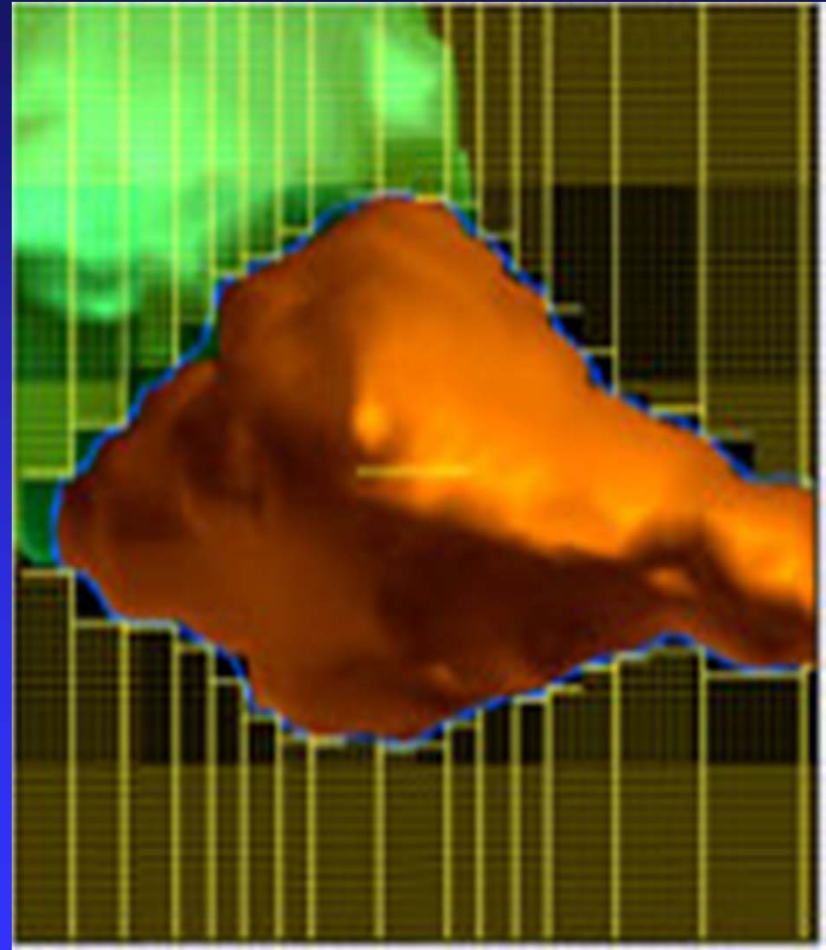
Treatment Delivery

- 10-20 minutes per day
- Monday-Friday
- 180 - 200 cGy /day, typically
- Palliative: 3000 cGy in 2 weeks
- Definitive (Prostate): 8000 cGy in 9 weeks



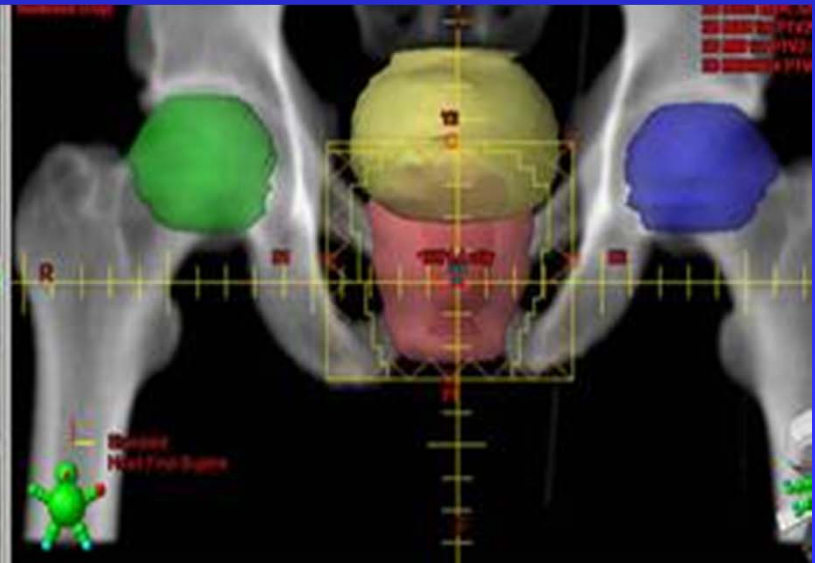
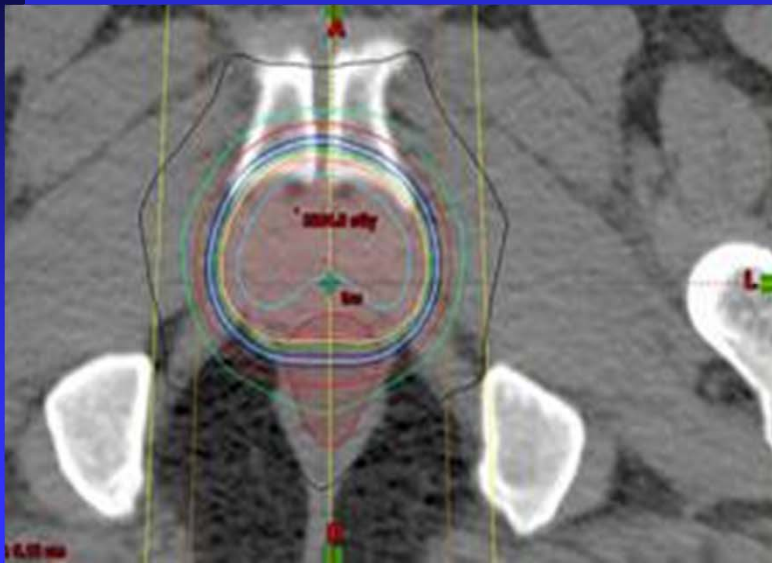
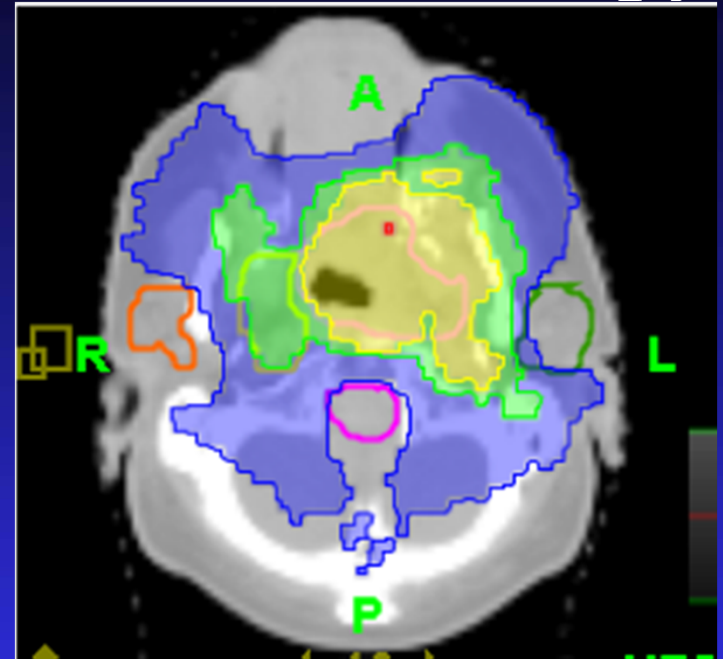
Treatment: Linear Accelerator

- High energy X-rays from linear accelerator (Linac)
- Each beam shaped using MLC's to match tumor dimensions w/ appropriate margins



IMRT (Intensity Modulated Radiation Therapy)

- The intensity of the radiation beam (in a given direction) is modulated by the MLC's moving while the beam is on



RapidArc™

Radiotherapy Technology

- Treat in under 2 minutes
- Less time for organ movement
- Reduce out of field dose
- Simple planning and treatment
- One continuous arc



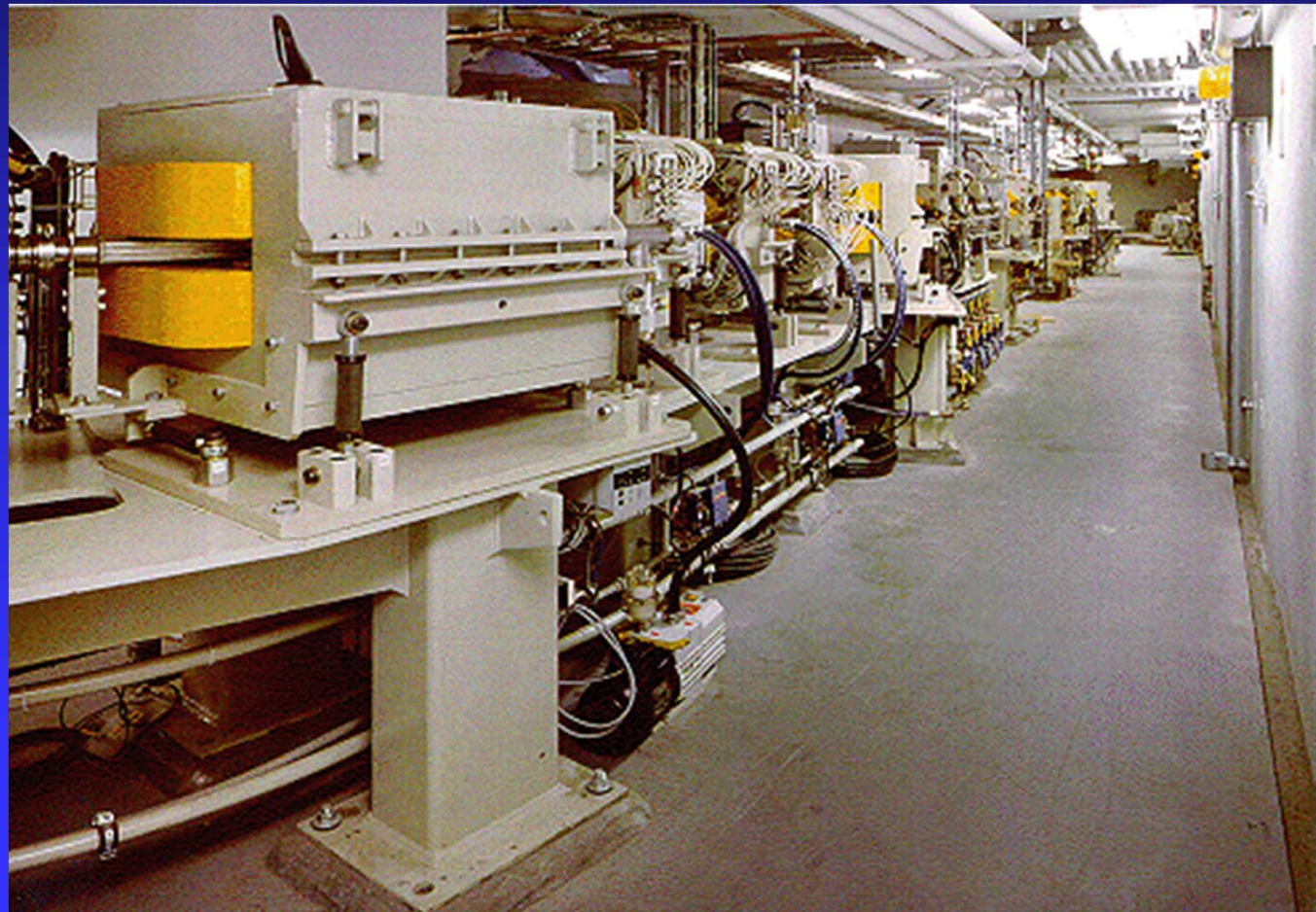
Other Multi-Million Dollar Toys

- Tomotherapy Gamma Cyber
CT + 6MV accelerator; Knife Knife
Only IMRT



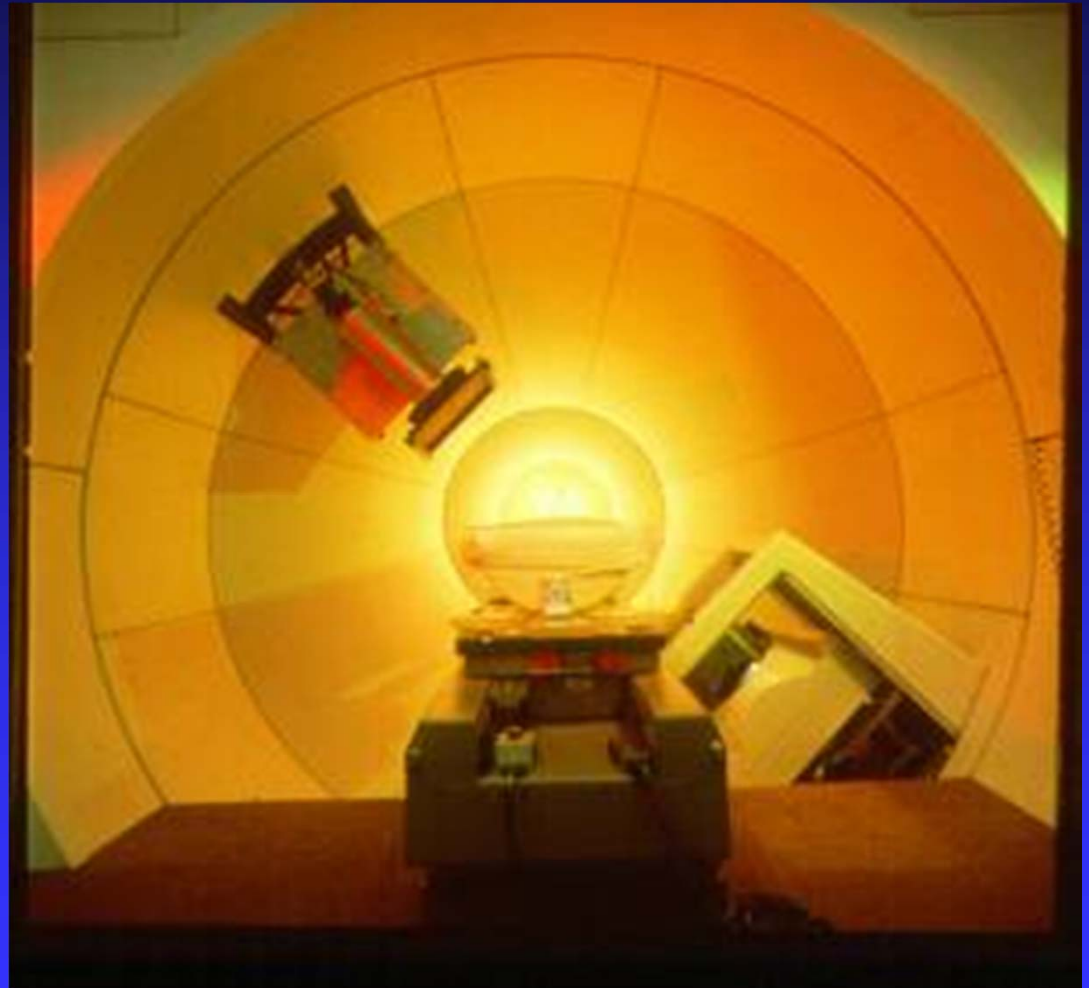
Proton Beam Therapy - The Big Toy

- Essentially a synchrotron facility
 - ◆ 10+ facilities in the country; 1-4 treatment bays
 - ◆ ‘Table top’ size in production
- Maintains proton beam energy homogeneity and focusing



Proton Gantry

- Isocentric gantry with better than 1 mm isocenter radius
- 100 ton weight
- Rotation speed up to 1 RPM
- >\$100M



Interactions/Energy Loss

- Heavy Charged particles interact with electrons in material
- Can be calculated: *The Bethe-Bloch Equation*
- Ok for energies between 6 MeV and 6 GeV
- 1st order: $-dE/dx \sim (1/\text{velocity})^2$

Maximum energy loss
in single collision

$$T_{\max} \approx 2m_e c^2 \beta^2 \gamma^2$$

Constant

$$-\frac{dE}{dx} (\text{eVcm}^2 \text{g}^{-1}) = Kq^2 \frac{Z}{A\beta^2} \left[\frac{1}{2} \ln \frac{2m_e c^2 \beta^2 \gamma^2 T_{\max}}{I^2} - \beta^2 - \frac{\delta(\beta\gamma)}{2} \right]$$

Stopping
Power

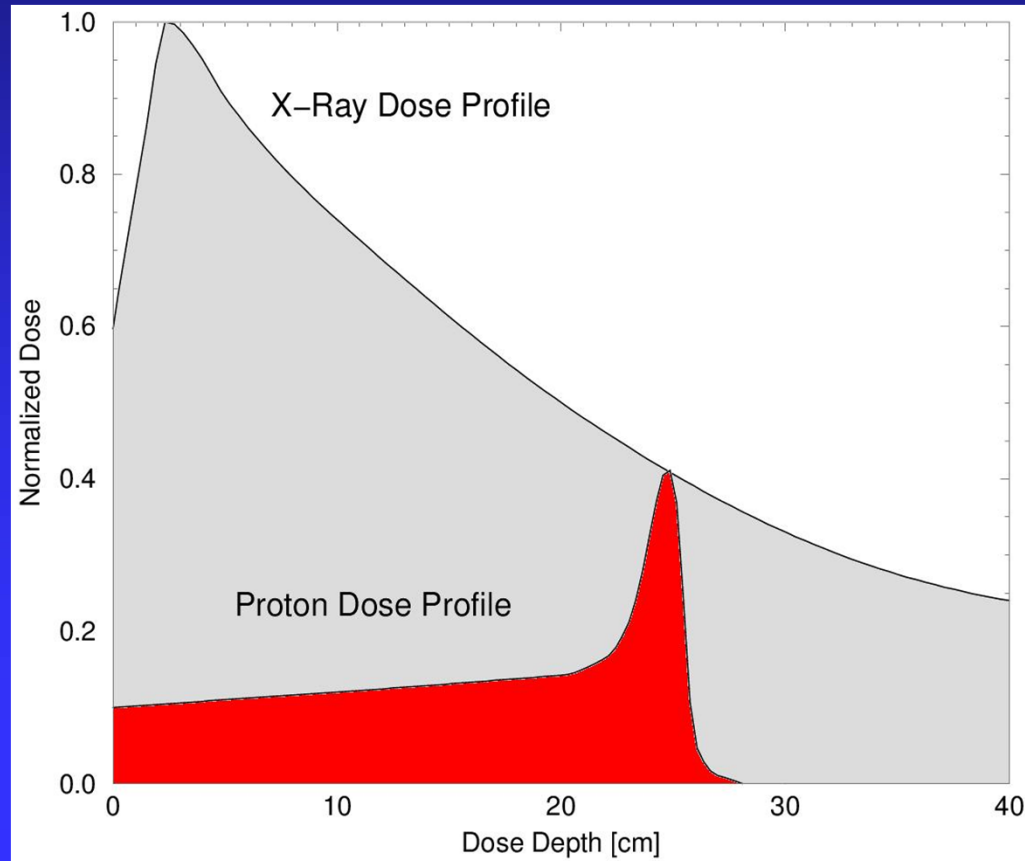
»1/2

Ionisation
Constant for
material

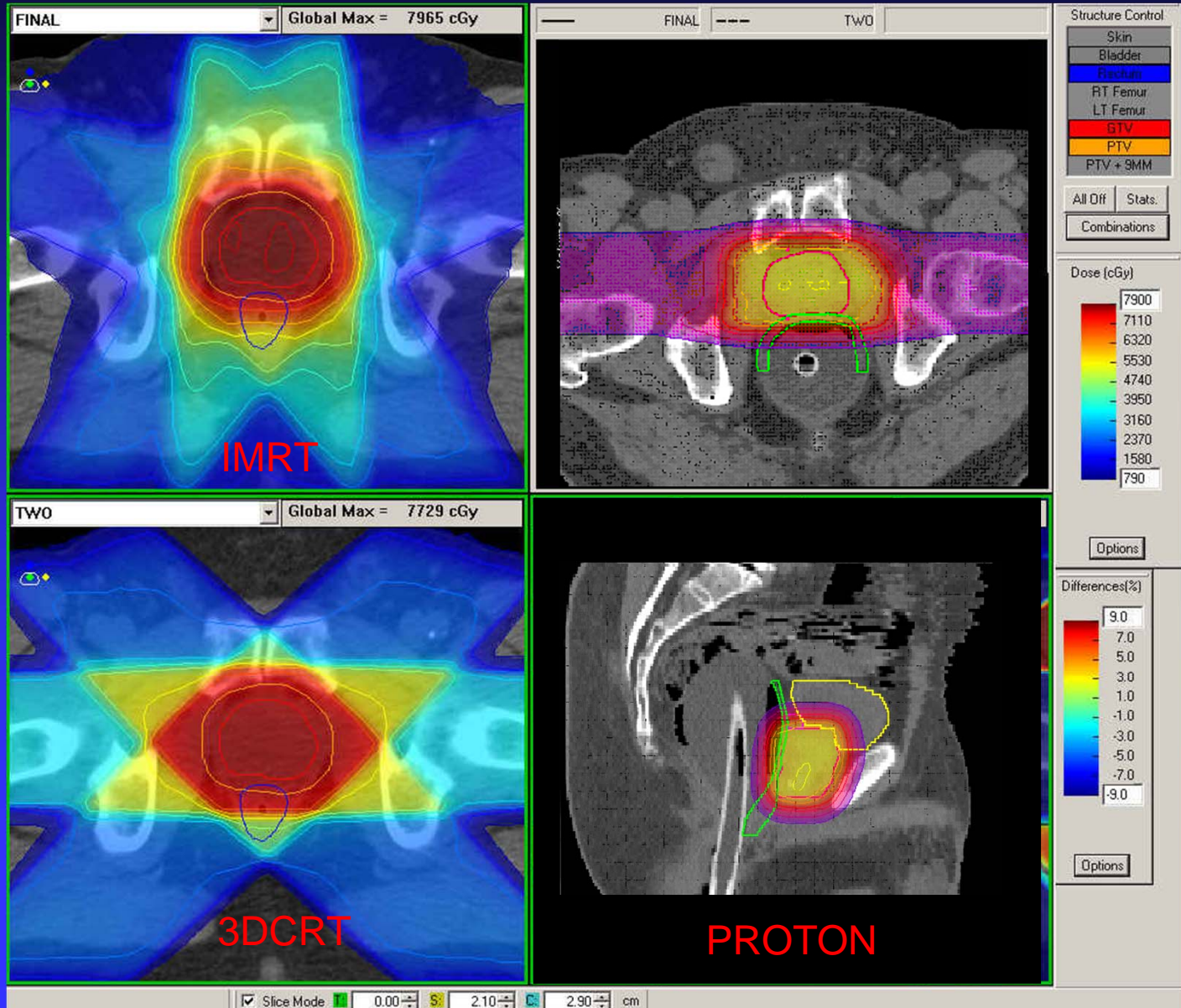
Density correction

Proton Therapy

- Depth dose curves: Photons vs. Protons
 - ◆ X-rays lose energy mainly via pair production (at >6 MeV)
 - ◆ Protons lose energy mainly via coulomb interactions with the outer-shell electrons of the target atoms



3DCRT vs IMRT vs Protons

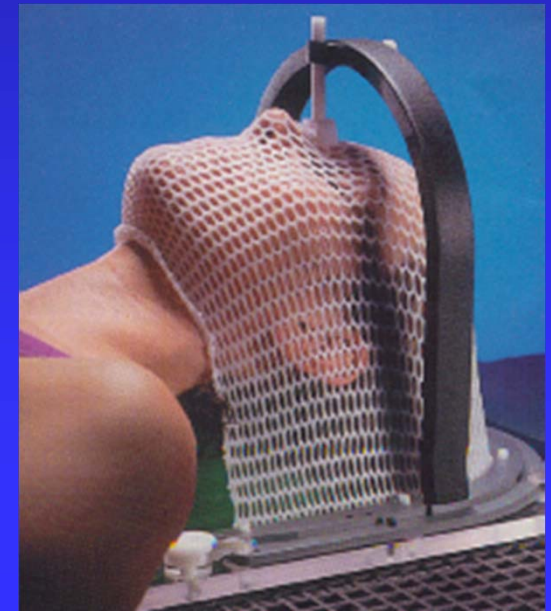
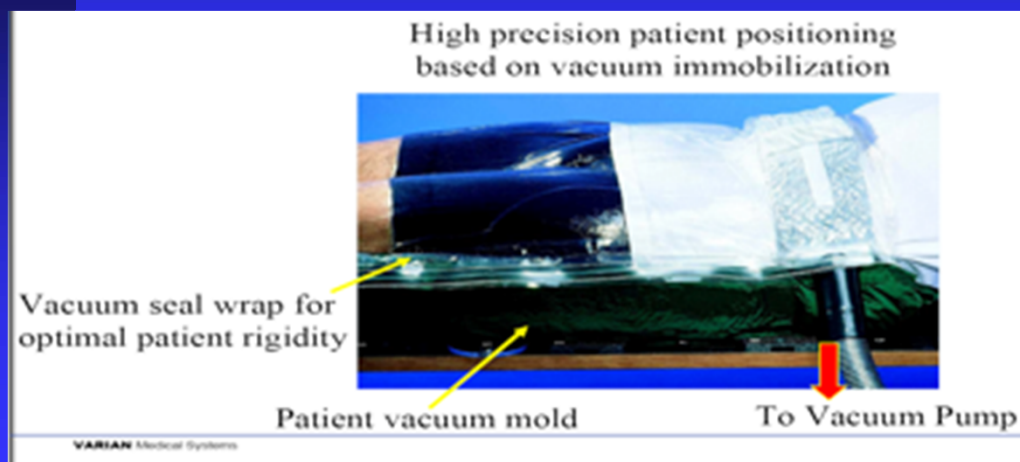


CT Planning

We have special CT scanners for radiation therapy planning

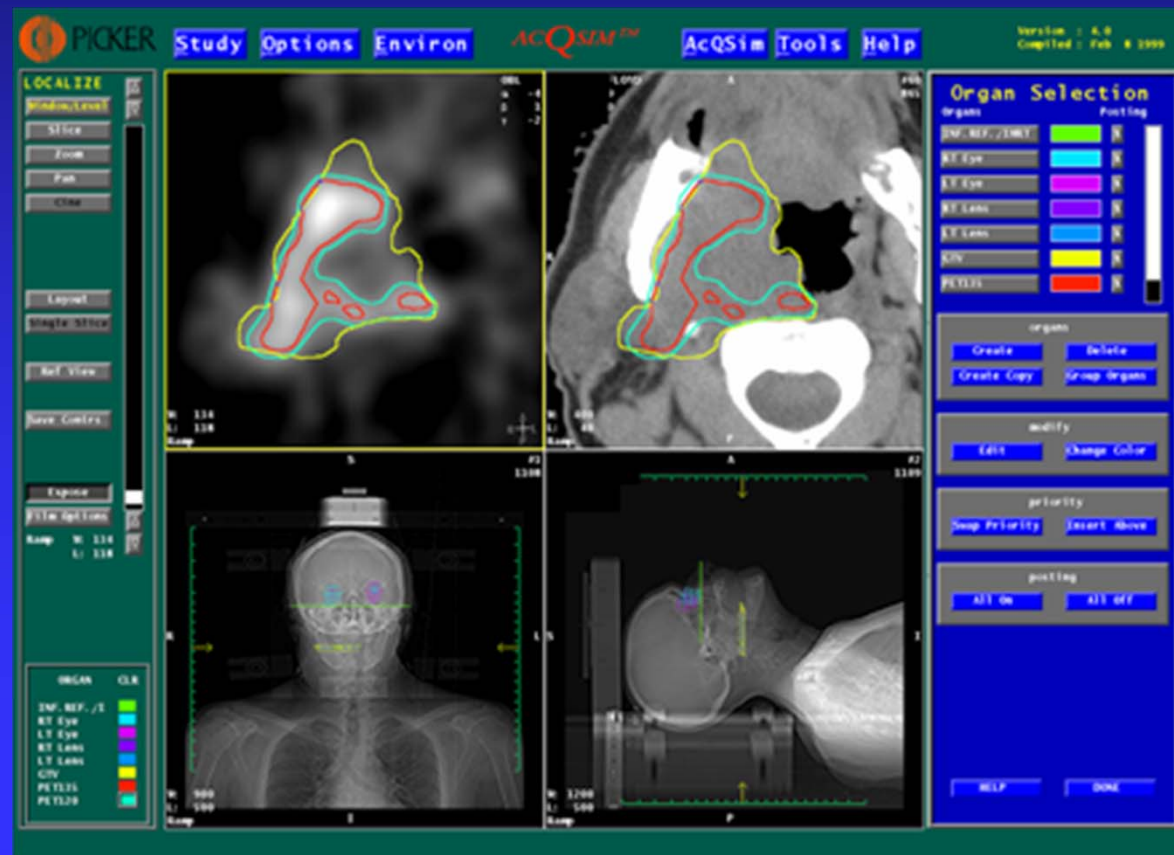


- 4D - new paradigm (acquire multiple CT series of same area (i.e., lung) over time to accurately gauge tumor motion)
- Patient Immobilization critical



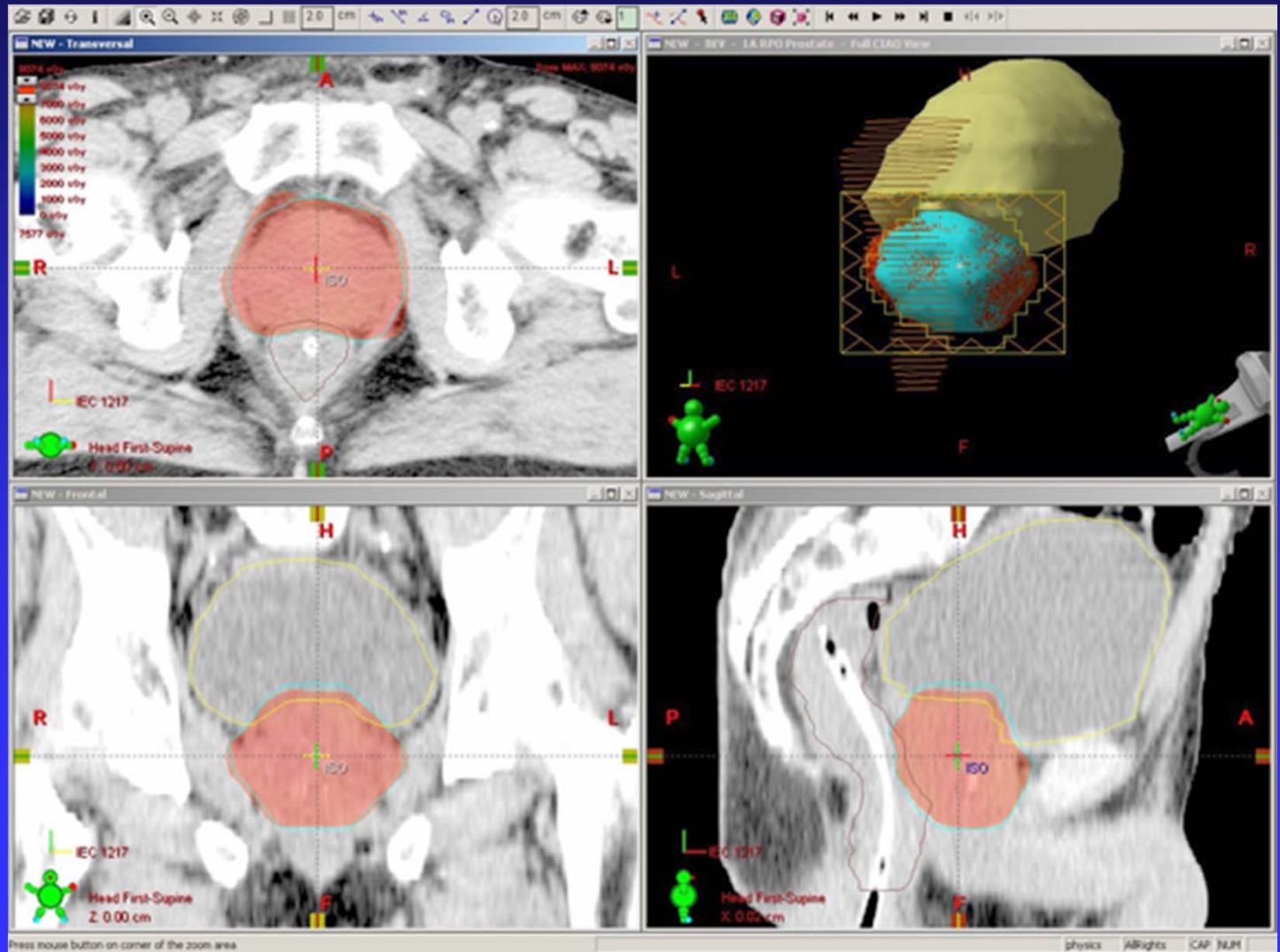
Multimodality Image Registration

- We can fuse our CT planning images with PET or MRI to additionally help determine optimal tumor dimensions



What we do - Contouring

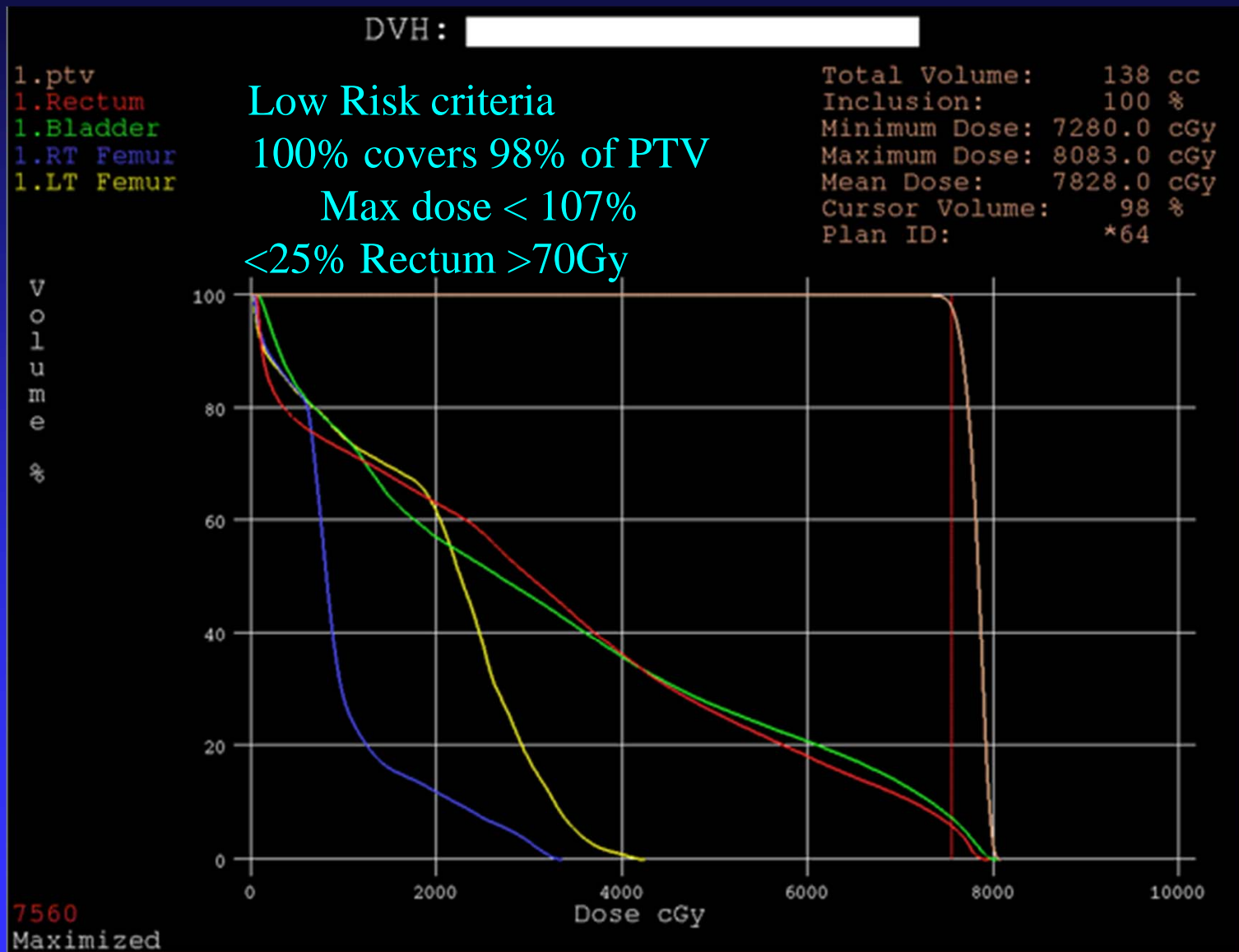
- Contour tumor, involved lymph nodes, other regional areas at risk for tumor spread, and critical normal tissue structures for which we want to limit dose



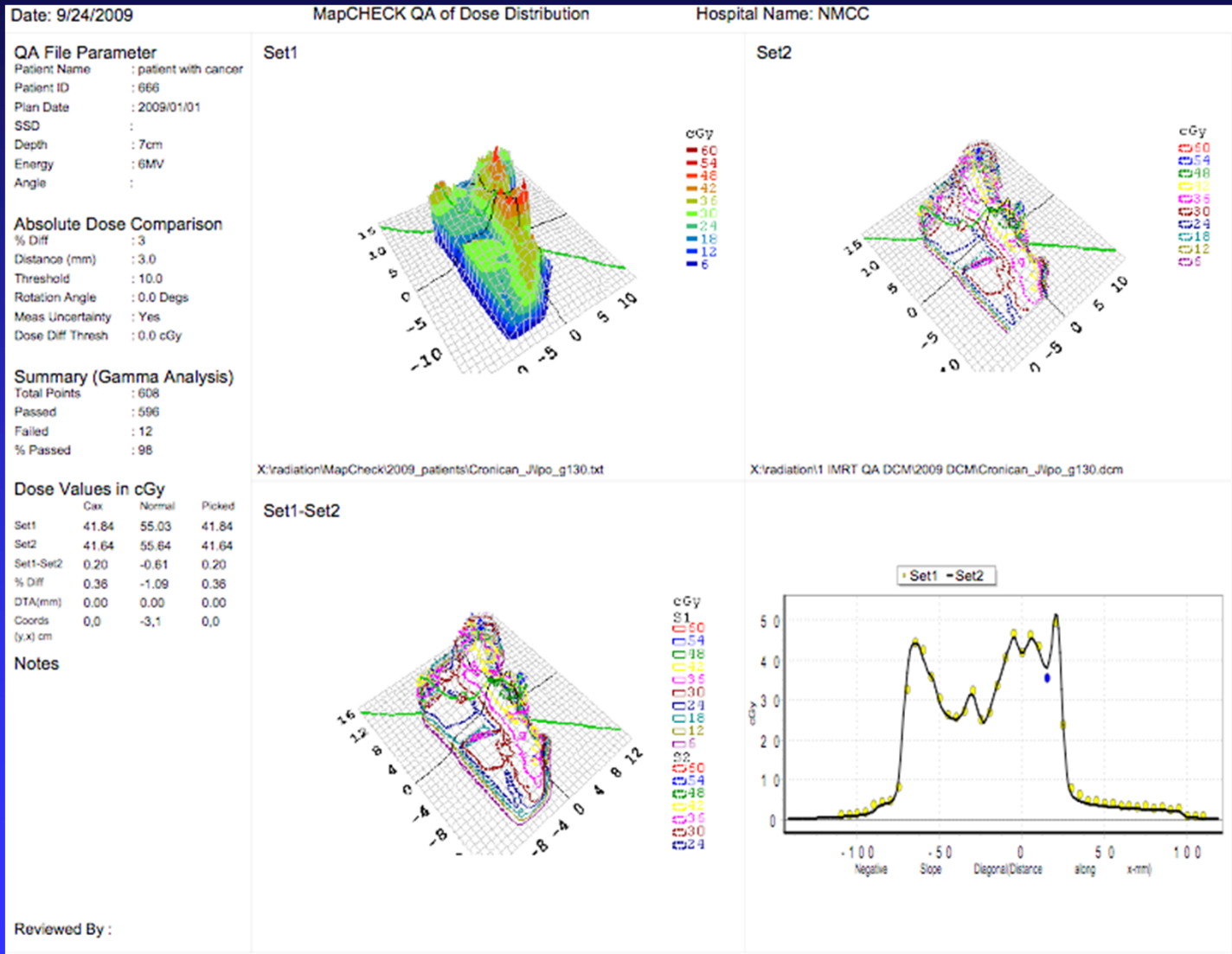
IMRT Treatment Planning



Dose-Volume Histogram (DVH)



Physics QA





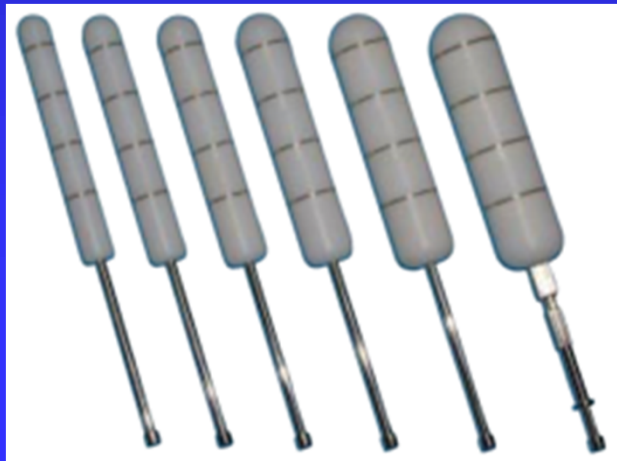
MISTAKES

IT COULD BE THAT THE PURPOSE OF YOUR LIFE IS
ONLY TO SERVE AS A WARNING TO OTHERS.

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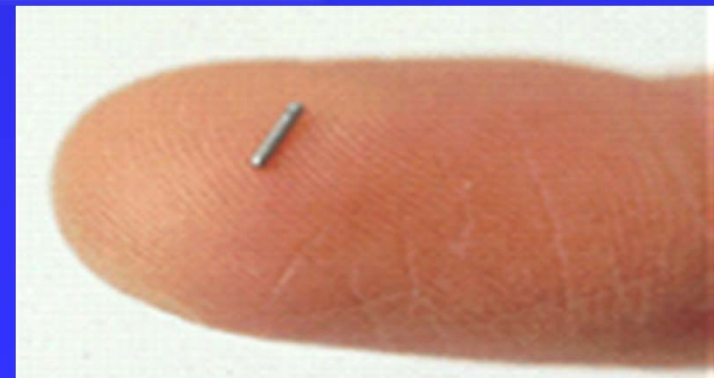
Brachytherapy

- Brachy is from Greek (brachus) meaning 'short'
- Consists of placing sealed radioactive sources very close to or in contact with the tumor
- Rapid dose falloff outside of source allows very high doses to be delivered in a very localized fashion
- Intracavitary - In a body cavity (i.e., rectum, cervix, vagina, etc.)



Brachytherapy

- Interstitial - needles or seeds placed into tissues (can leave behind plastic catheters within tissues)
 - Breast, sarcoma, prostate, vaginal/anal cancers, head and neck cancers
- HDR (High Dose Rate)
 - Place hollow catheters and devices in patient; temporarily
 - Small Iridium source (Ir-192) goes into catheters, gives off radiation
 - Sealed in machine
 - Highly radioactive (avg. 0.38 MeV)
 - Treatment completed in short time; catheters removed
- LDR (Low Dose Rate)
 - Ex: Implant ~100 radioactive 'seeds' (I-125) placed in prostate (permanently) giving off radiation over months

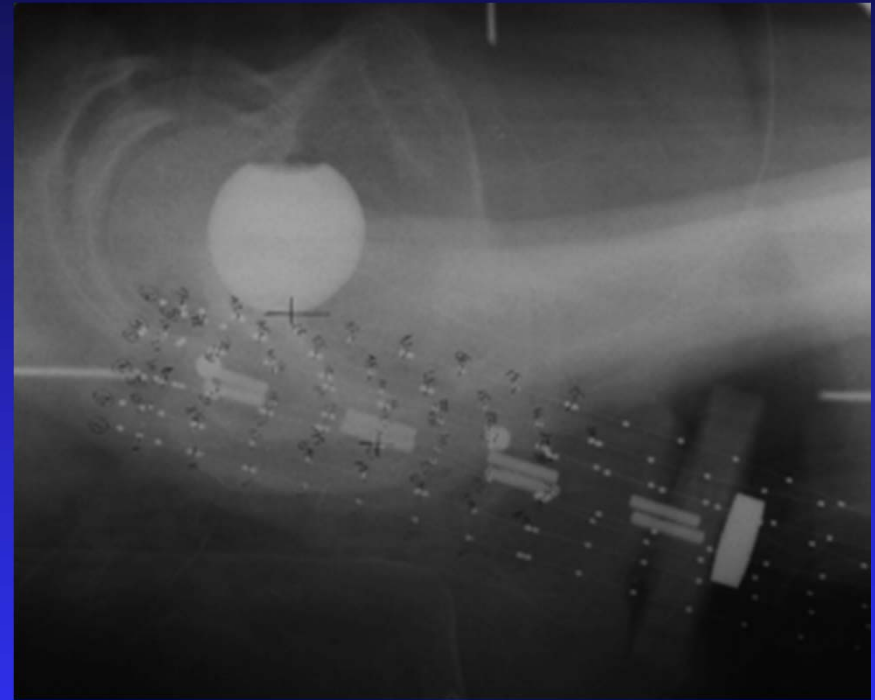
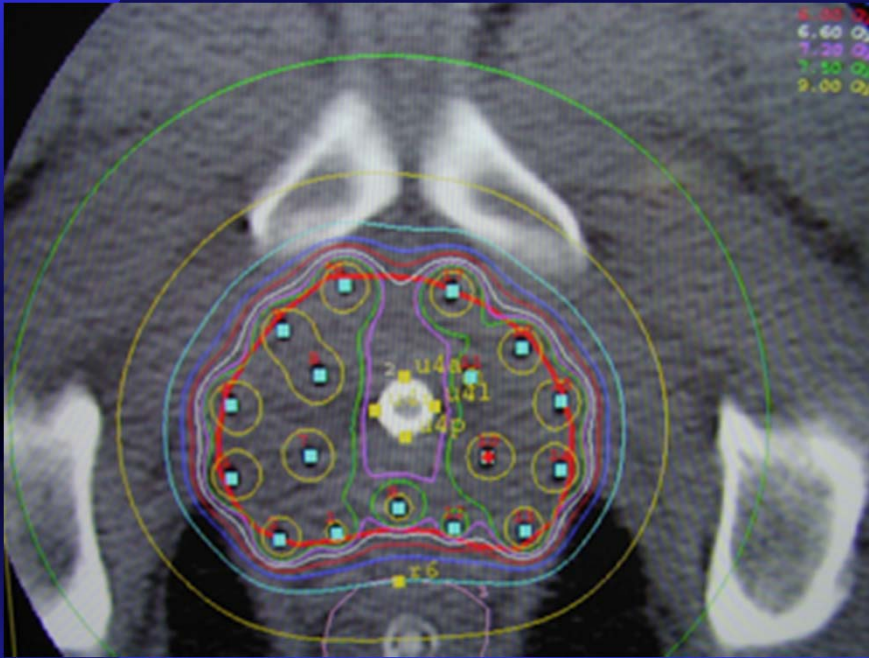


Early Breast Brachytherapy



Radium treatment of breast Cancer, Paris, circa 1930. From *Oncology: Tumors and Treatment—A Photographic History, 1845-1945*, by Stanley B. Burns.¹ Reprinted by permission.

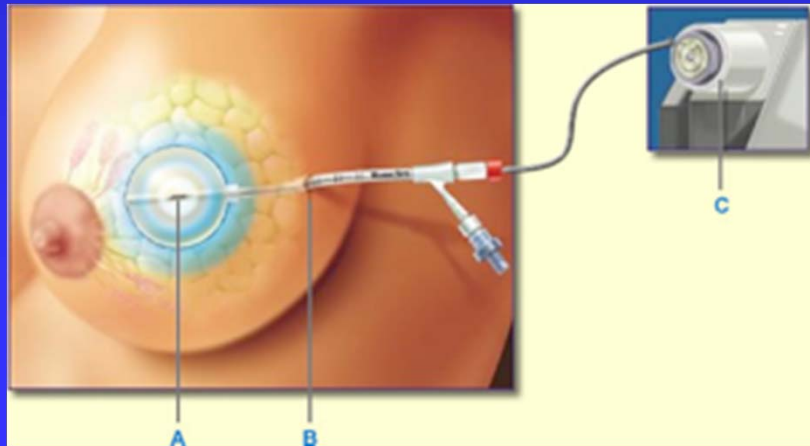
HDR Interstitial Implant Dosimetry



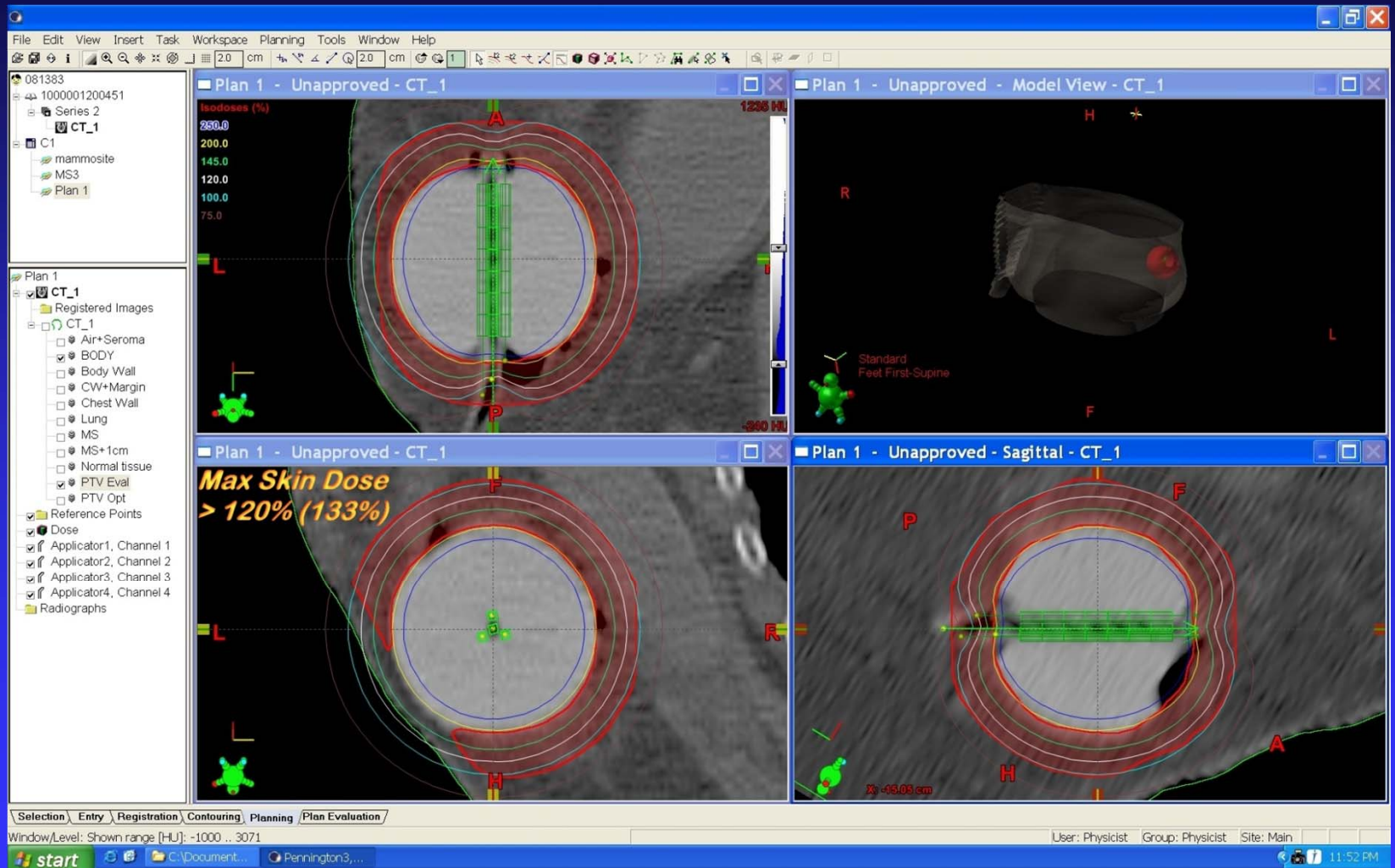
- Fluoroscopy in OR shows alignment of needles in prostate
- CT based planning - Build up dose based on position and dwell times of the Iridium source
 - Notice dose shaped around rectum (beneath) and urethra (in center)

Interstitial Brachytherapy

- Different forms of accelerated partial breast irradiation (APBI)
- Both use High Dose Rate (HDR) machine

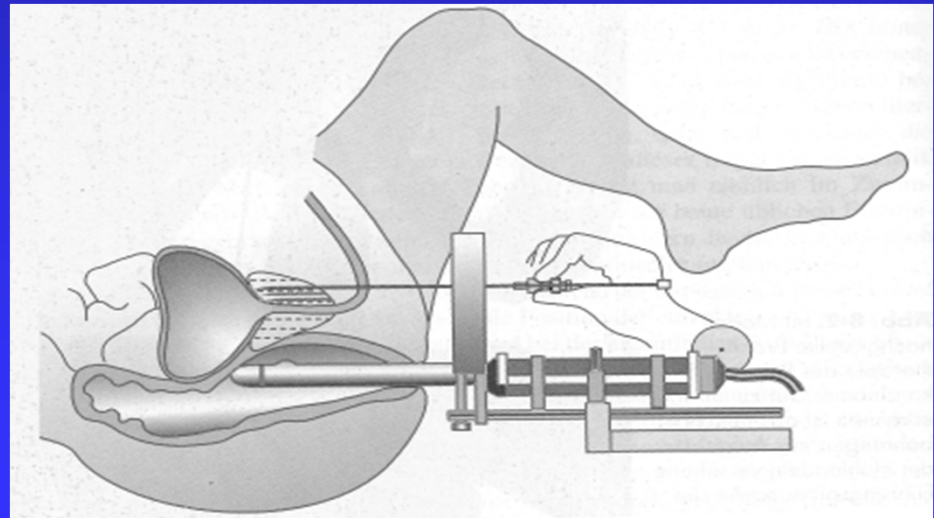
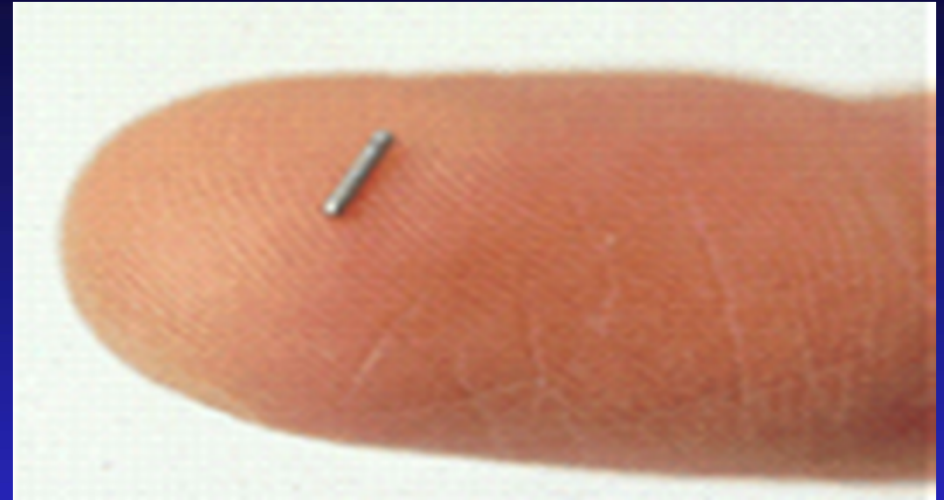


Conformal Dose Distributions



Prostate (LDR) Brachytherapy

- Delivering radioactivity by positioning sources directly into or in close proximity to the tumor
- Transperineal approach



Fluoroscopic Evaluation



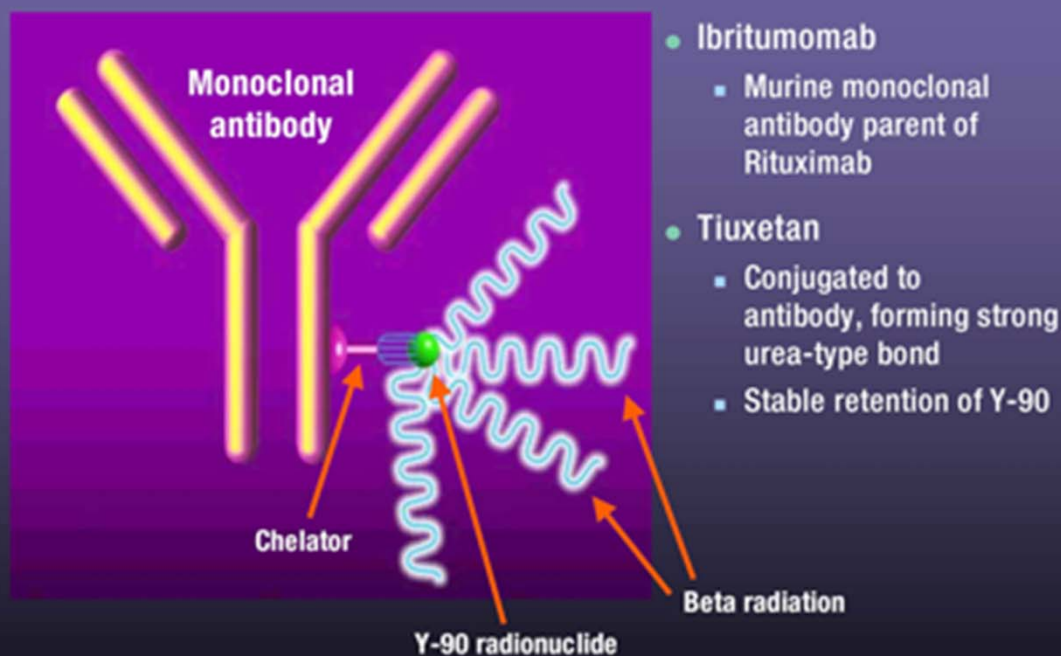
Radiation Targeted IV Therapies

- Classically, the first true ‘targeted’ therapy was radioactive-iodine (I-131) given for papillary and follicular thyroid cancer
- Radioactive Strontium (and Samarium 153 - “Quadramet” and now Radium-233) are useful for patients with cancer (i.e., prostate) which spread to bones and demonstrate uptake on bone scan

Novel Radiation Targeted Therapies

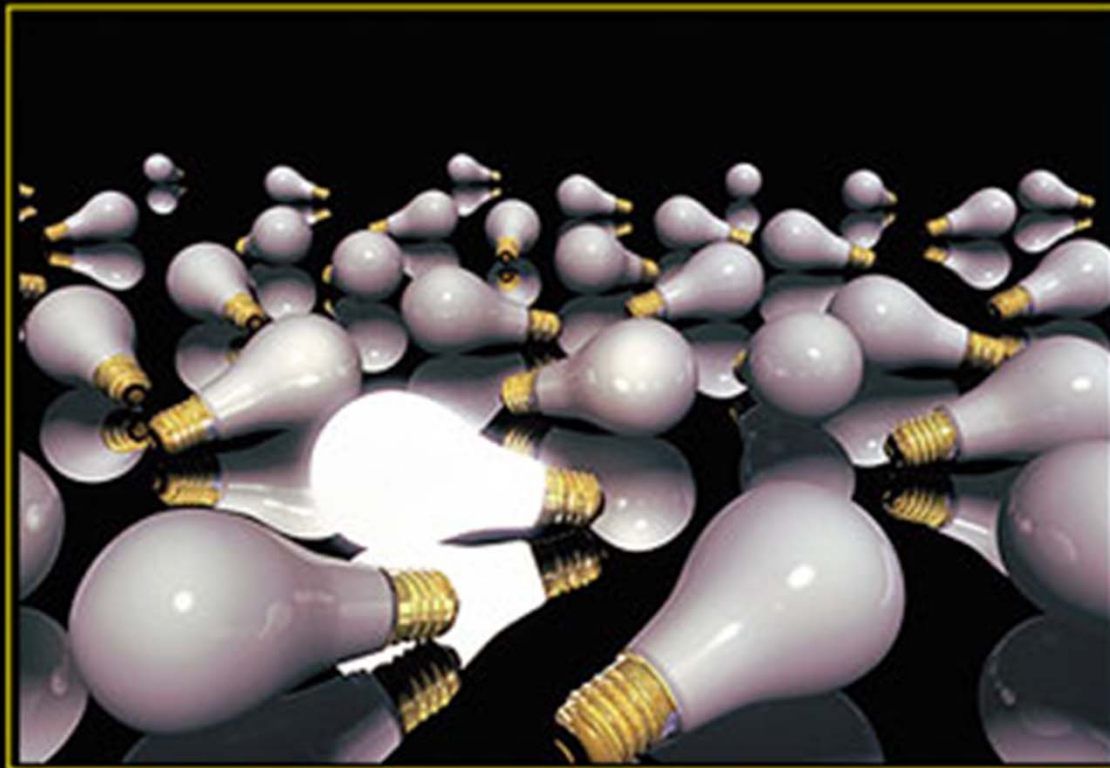
- Non-Hodgkins B-cell Lymphoma - Zevalin (Y-90) and Bexxar add RT to antibody targeting CD-20

Yttrium-90 (Y-90) Zevalin Radioimmunotherapy Delivers Increased Cytotoxicity by Antibodies



ZEVALIN™
Ibritumomab tiuxetan

Thank you!



CLUELESSNESS

THERE ARE NO STUPID QUESTIONS,
BUT THERE ARE A LOT OF INQUISITIVE IDIOTS.

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