Welcome to Loma Linda…

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LLU Health Campus (Troesh Medical Campus)

Loma Linda University Medical Center

Before we begin – Important Information!

- You are in a hospital environment.
- Facilities you will tour are used to treat cancer patients.
- In health care, patient privacy and confidentiality is not only important; it is the law.
- It is part of HIPAA – Health Insurance Portability and Accountability Act (1996)

…*with that declaration, let us now begin*

Medical Physicist

- Clinical support
- QA
- R&D
- Teaching
- Regulatory issues

Physics

Medicine

A medical physicist is a bridge or interface between physics and medicine

Medical Physics Disciplines

- Therapeutic Radiological Physics
- Diagnostic Imaging Physics
- Medical Nuclear Physics

- Medical Health Physics

Career Path to Clinical Medical Physics

- MS and or PhD in Medical Physics
- 2-year Residency in Clinical Medical Physics
- Board Certification by the American Board of Radiology (ABR)
- A Qualified Medical Physicist

A medical physicist is a member of American Board of Medical Specialties

Primary professional Organization: American Association of Physicists in Medicine (AAPM) www.aapm.org

Treatment Options for Cancer (Oncology)

- Surgery
- Chemotherapy
- **Radiation Oncology**
- A combination of these

- No Action (Watchful Waiting)

Radiation Oncology - Treating Cancer with Radiation

Radiation Therapy: Basic Facts

(i) Radiation kills tumor cells

(ii) Radiation also kills normal cells

Radiation Therapy: Basic Goals

(i) Maximize dose to tumor

(ii) Minimize dose to normal structures

All progress in radiation treatment delivery is driven by these goals

Radiation Therapy

Treating cancer with high energy radiation

- Gamma rays (photons)
- X-rays (photons)
- Electrons (particles)
- **Protons** and heavy ions **(charged particles)**

Two modes of radiation delivery

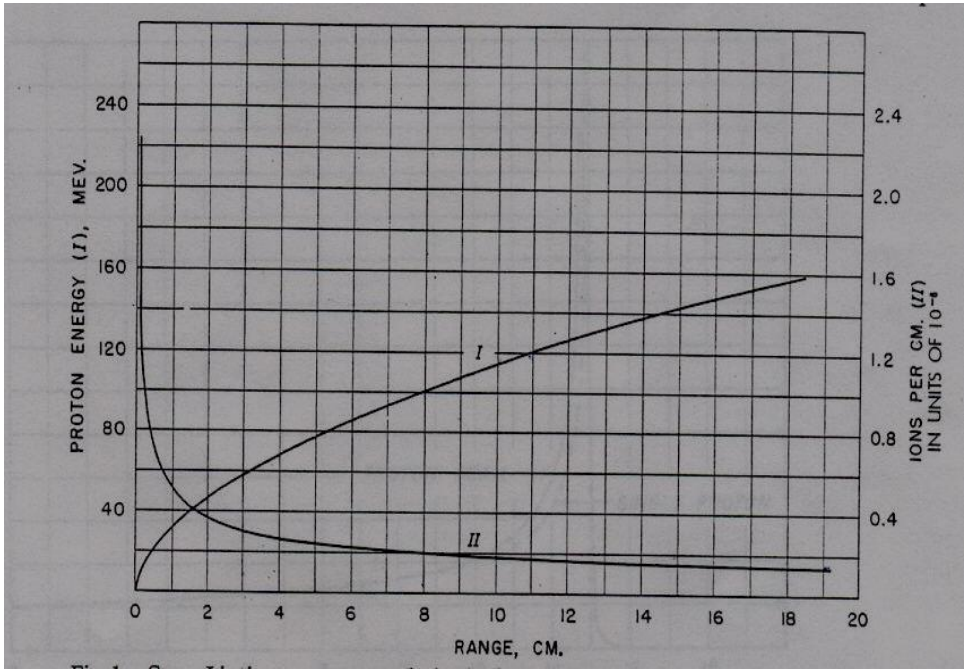
- External beam therapy
- Brachytherapy

Proton Therapy - This is where it all began...

Radiological Use of Fast Protons

ROBERT R. WILSON
Research Laboratory of Physics, Harvard University
Cambridge, Massachusetts

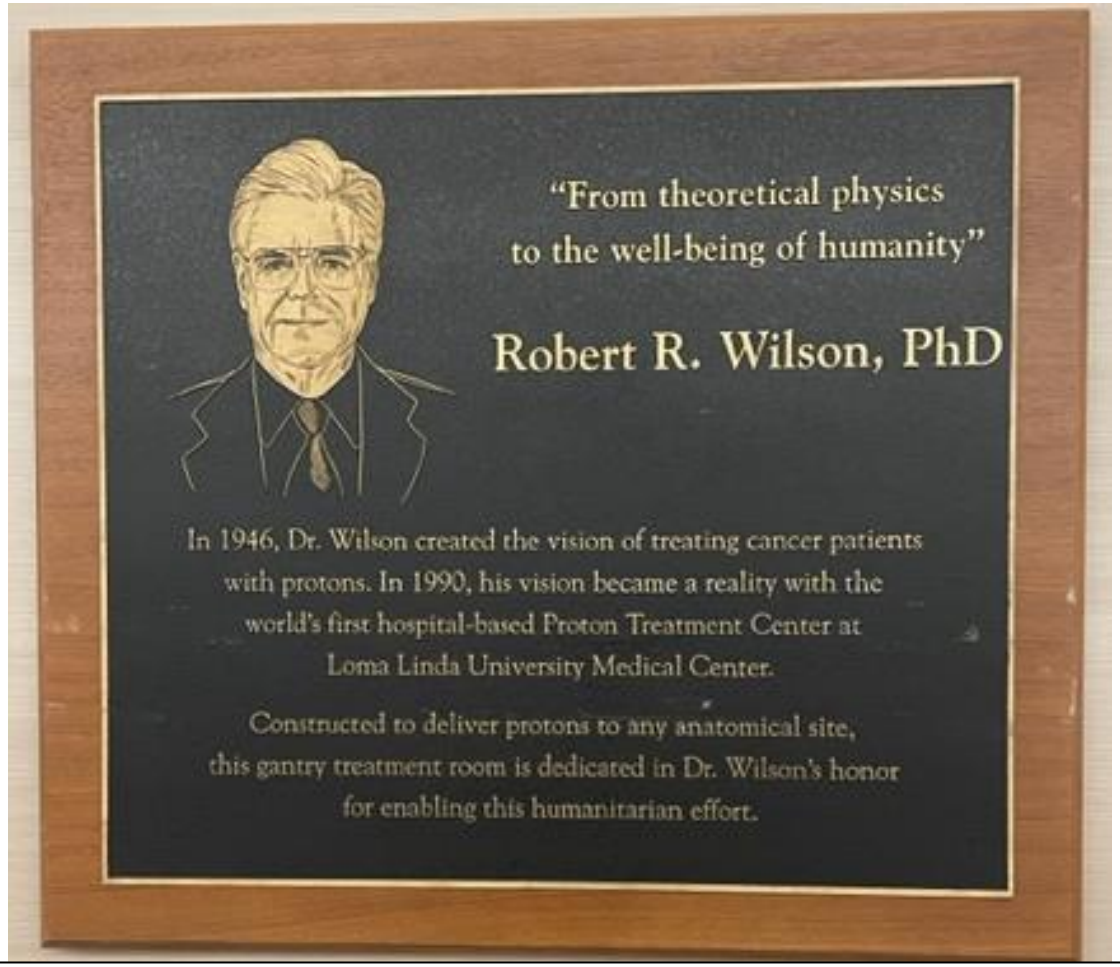
Radiology, 47: 487-491 (1946)



Above: Curve I Range, Curve II: Ions/cm

Right: Hyperbolic Obelisk by Robert R Wilson

From Theoretical Physics to the Well-being of Humanity…



Loma Linda honors Dr. Wilson for his 1946 paper which set the stage for treating cancer with protons…

A Fun Fact…

E.O. Lawrence won Nobel Prize in Physics for invention of Cyclotron in 1939.

His prototype cyclotron cost?

$25.00!

Why Protons?

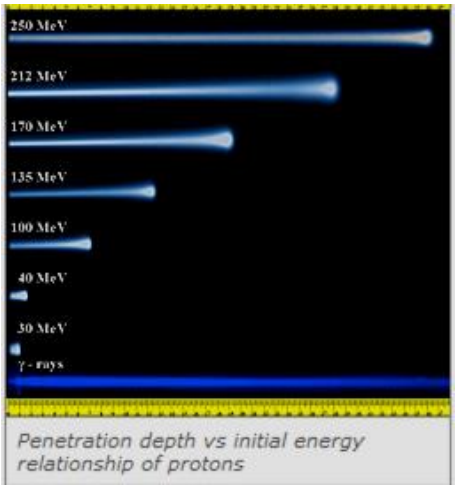
Rooted in the basic interactions of high energy protons with matter are the properties, ideally suited for radiation therapy:

- Well defined range
  ⇒ **A proton beam stops**
- Initial rate of energy loss is low
  ⇒ **Low entrance & proximal dose**

Tumor stops

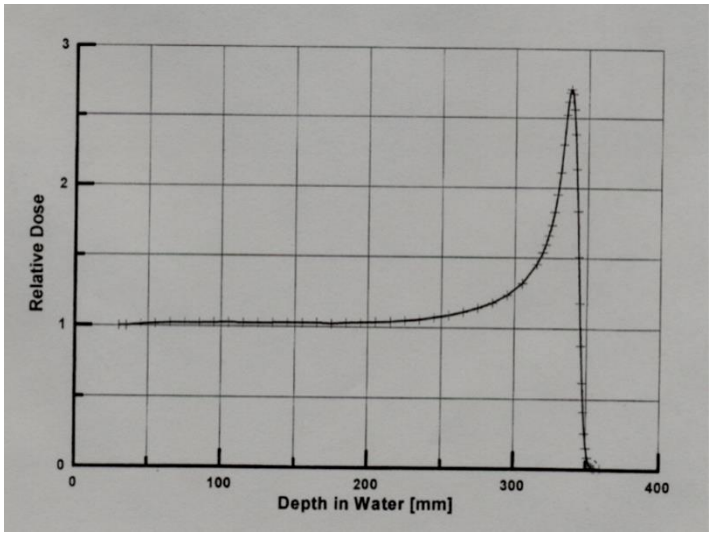
Vertex fields

Patch fields



Penetration depth vs initial energy relationship of protons

- Most of the beam energy is deposited near the end of the range over a very small volume (**Bragg Peak**)
  ⇒ **Maximal dose to tumor**
- No energy deposited beyond the Bragg Peak
  ⇒ **No dose to normal tissues distal to the tumor**

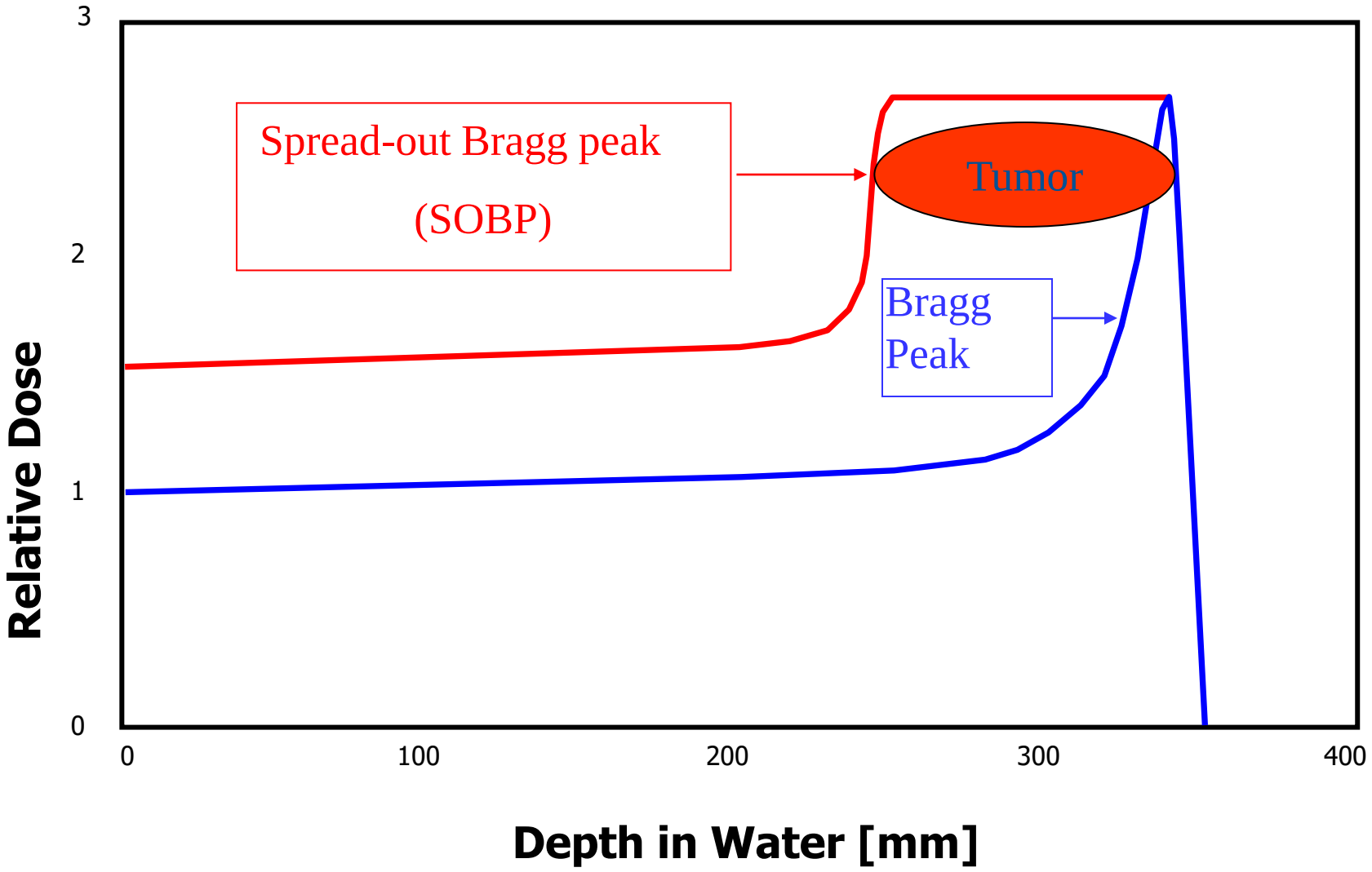


Why Protons?…

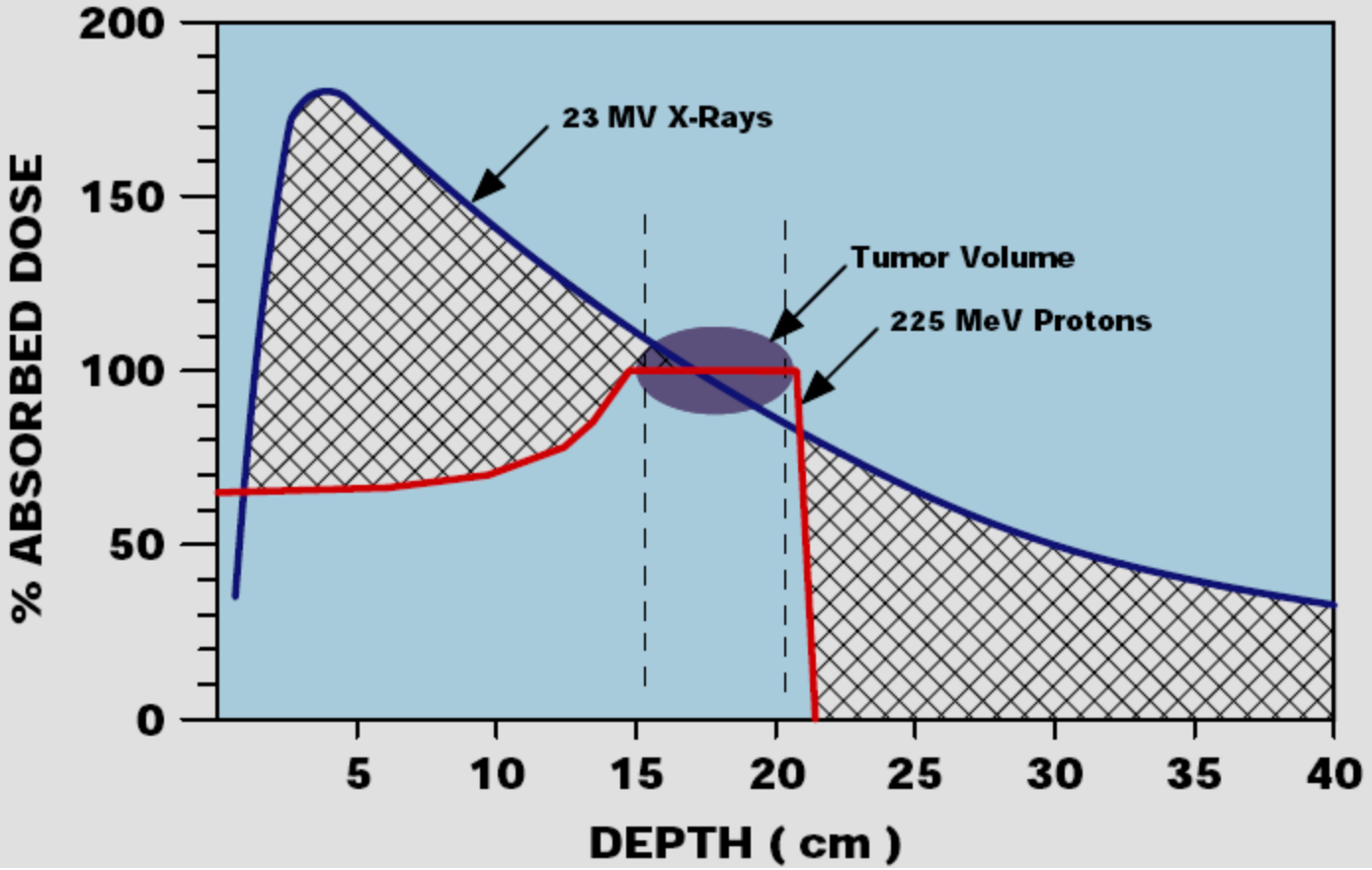
"Just using the **intrinsic properties** of high energy protons, we can, in principle, deliver **maximal dose to a tumor** in the body, at the same time **spare tissues proximal (upstream)** to the tumor, and **deliver no dose to structures distal (downstream)** to the tumor."

This, in nut-shell, is the dosimetric superiority of high energy proton beams. It is rooted in basic physics. It is not a medical opinion.

Proton Therapy: Concept



Protons Vs. X-rays: Depth Dose Profiles



James M. Slater, MD, Proton Therapy & Research Center, LLUH

World's first hospital-based proton treatment facility (1990)

Protons accelerator: a synchrotron

Treatment Machines

- three isocentric gantries
- one fixed horizontal beam line
- one fixed eye beam line
- one research room (3 fixed beams)

Clinical Energies (MeV): 250, 225, 200, 186, 155, 126, 100

140-160 patients can be treated with protons everyday

Milestones and Major Upgrades (Seamless Integration)

1988:
Ground-breaking for world's first hospital-based proton therapy system

1990:
First Patient Treated with LLUMC Eye Beam Line

1991:
First Patient Treated with LLUMC Horizontal Beam Line

1991:
First Patients Treated in LLUMC Gantry 1

1994:
First Patients Treated in LLUMC Gantry 2 and 3

1995:
Completed Calibration / Research Room

1996:
World's First Large Format Digital Imaging

1997:
NASA Research Room Upgrade

1997:
3,000th patient treated

1997:
Beam Transport Upgrade

1998:
Treated 100 Patients per Day

1999:
Accelerator Ion Source Upgrade

2000:
PBTS Control System Requirements & Design

2000:
Began Beam Scanning Studies in Research Room

2001:
Beam Energy/Intensity Performance Upgrade

2002:
Treated 150 Patients per Day

2002:
Accelerator Control System Replacement

2003:
Accelerator Control System Upgraded to Electronic Variable Energy

2004:
Demonstrated Active Beam Scanning Capability in Research Room

2005:
Beam Transport & Treatment Room Control System Upgraded for Variable Energy

2005:
10,000th patient treated

2005:
Treated 170 Patients in a Day

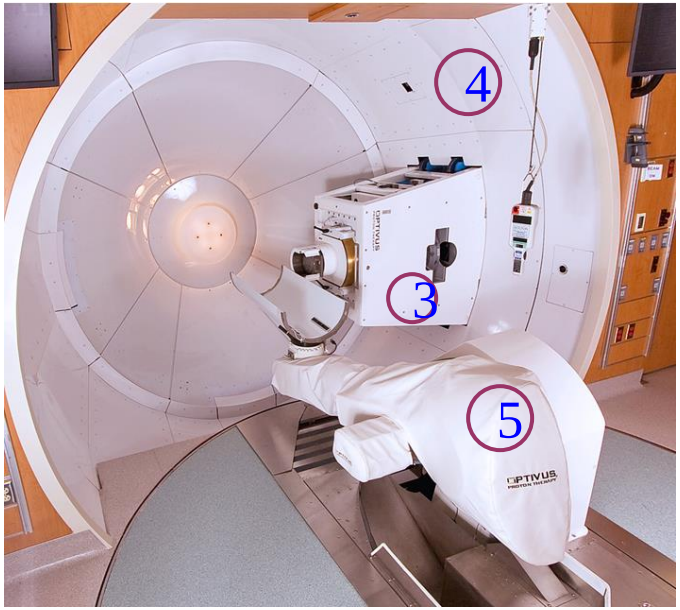
2007:
DICOM treatment planning integrated into PBTS

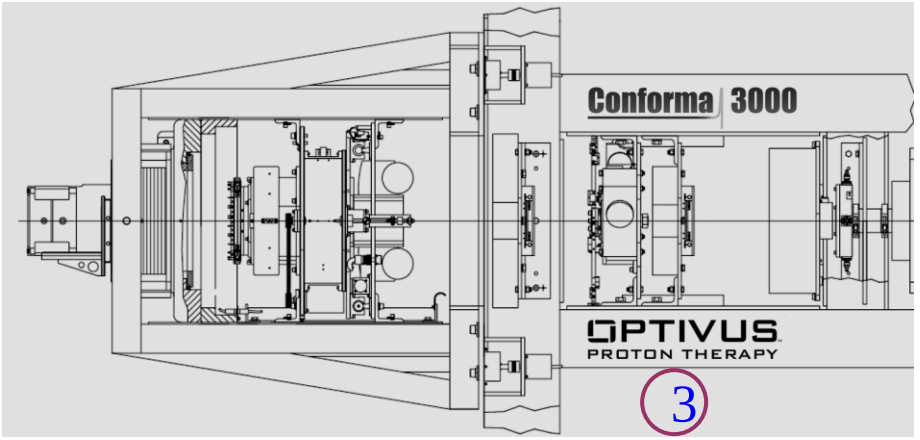
2008-2009:
Robotic Precision Patient Alignment System (PPAS) installed at LLUMC

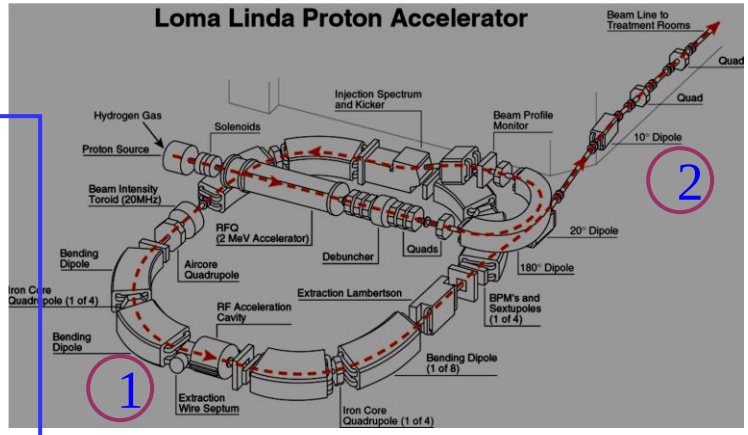
April 2010:
14,500th patient treated

All upgrades done by Optivus Proton Therapy , San Bernardino, CA

A Proton Treatment System







1 Accelerator
- Beam position monitoring
- Beam energy monitoring
- Beam current monitoring
- Beam steering

2 Beam Transport System
- Beam routing to tx rooms
- Beam profile and centering

3 Nozzle
- Beam shaping/steering
- Beam monitoring
- Dose monitoring

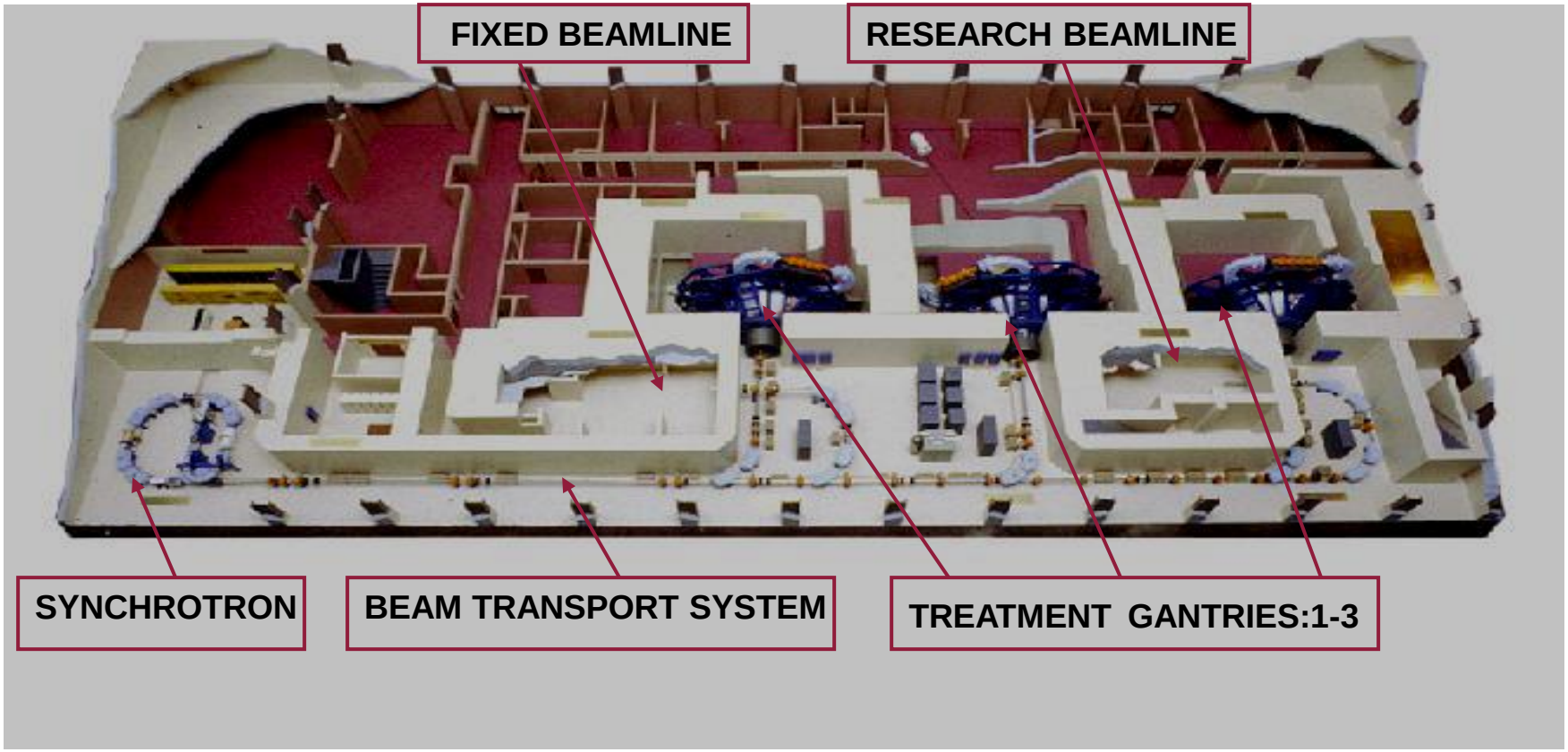
4 Gantry
- Beam rotation/aiming
- Imaging

5 Patient Positioner

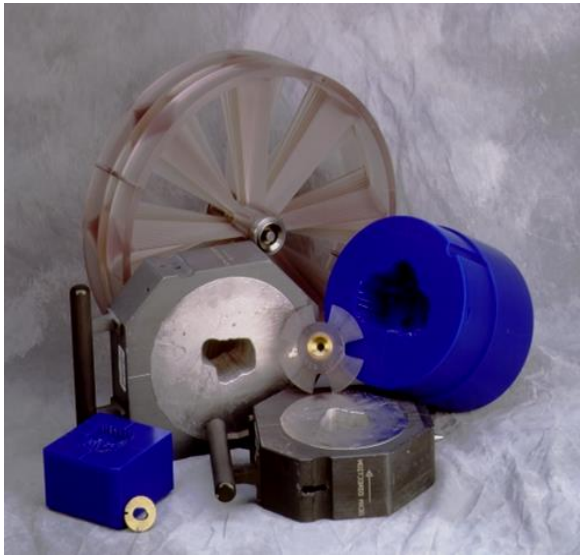
A few fun facts about Loma Linda Synchrotron!

1. 100 billion protons at 2 MeV injected into the ring in half a second
2. It takes another half a second to accelerate these protons to 250 MeV
3. During that half a second protons go around the ring 2.5 million times! (traveling about 15000 miles!)
4. Over next half a second about 34 billion protons extracted at the right energy and delivered to the tumor
5. Steps 1 to 3 repeated every 2.2 second till right dose is delivered to the patient.
6. To deliver 1.8 Gy to a typical target, it may take between 1.5 to 2.0 trillion protons, delivered in less than 2 minutes!

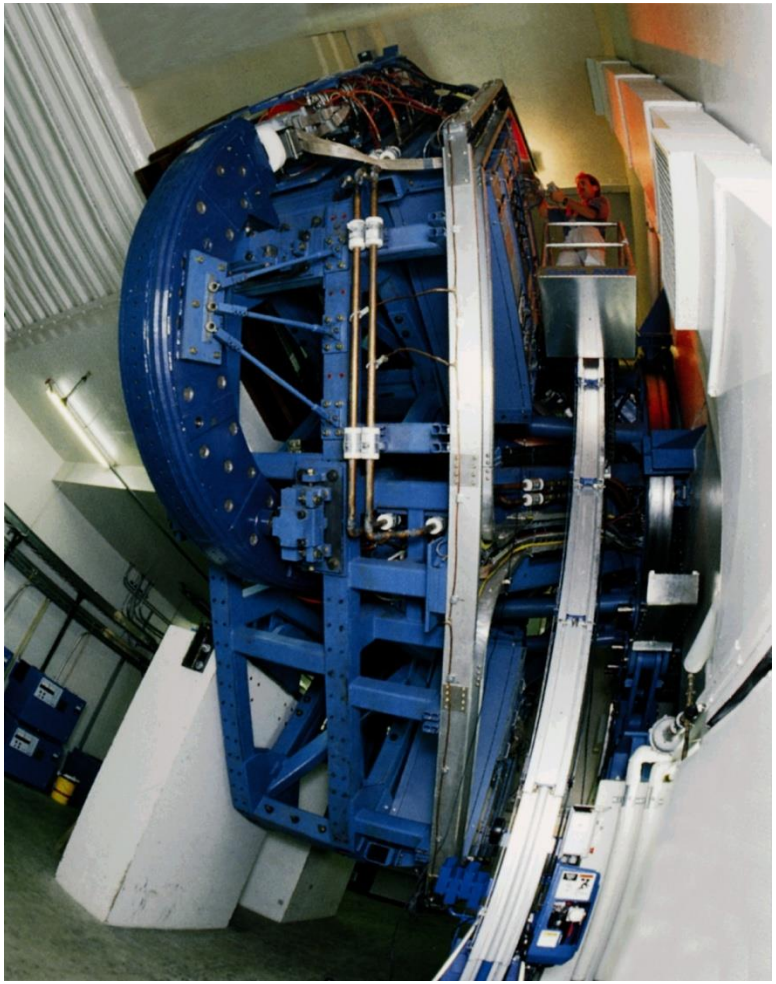
Loma Linda Proton Treatment Facility Layout



A Typical Proton Treatment



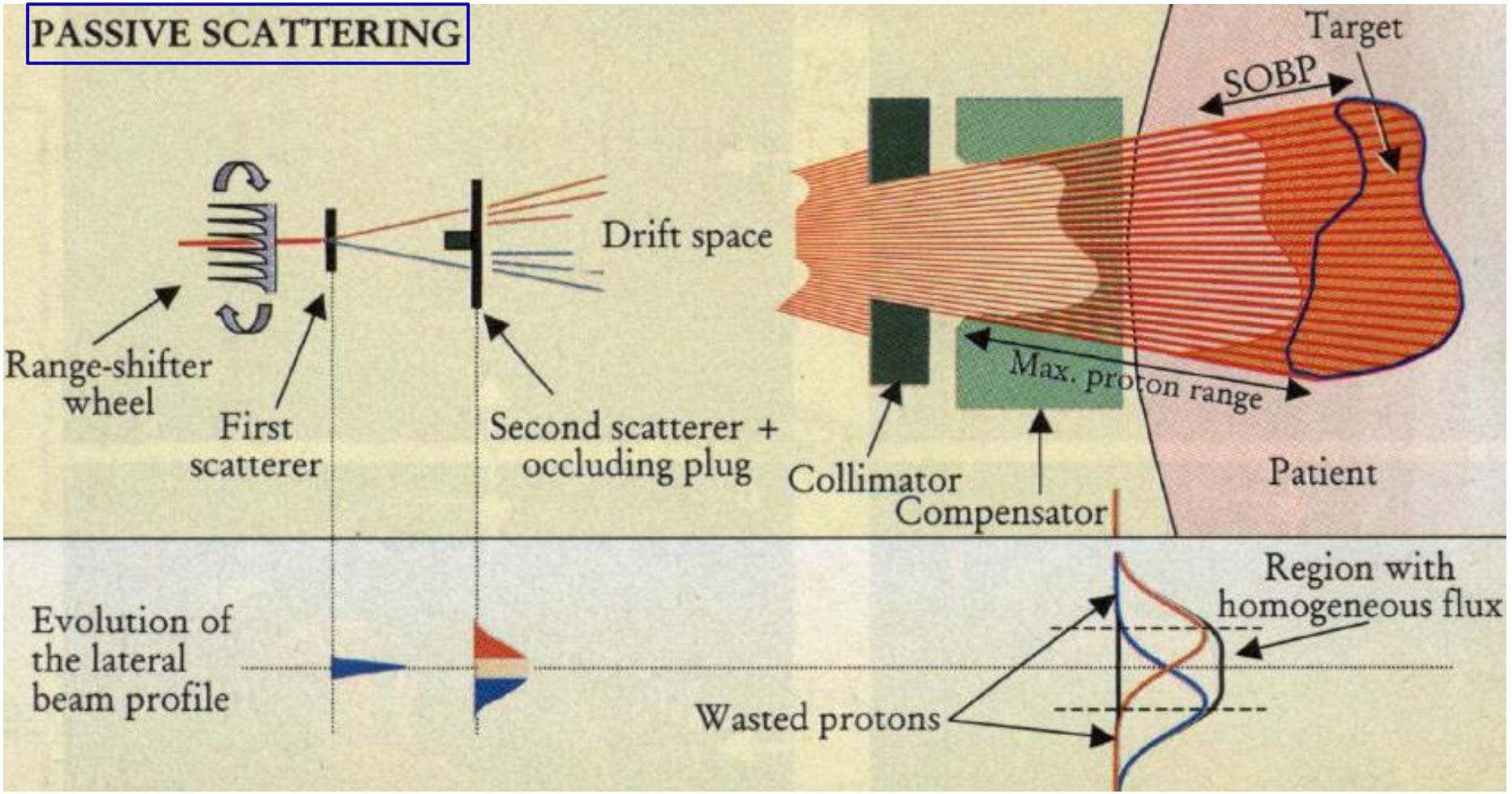
Proton Treatment Gantry Structure



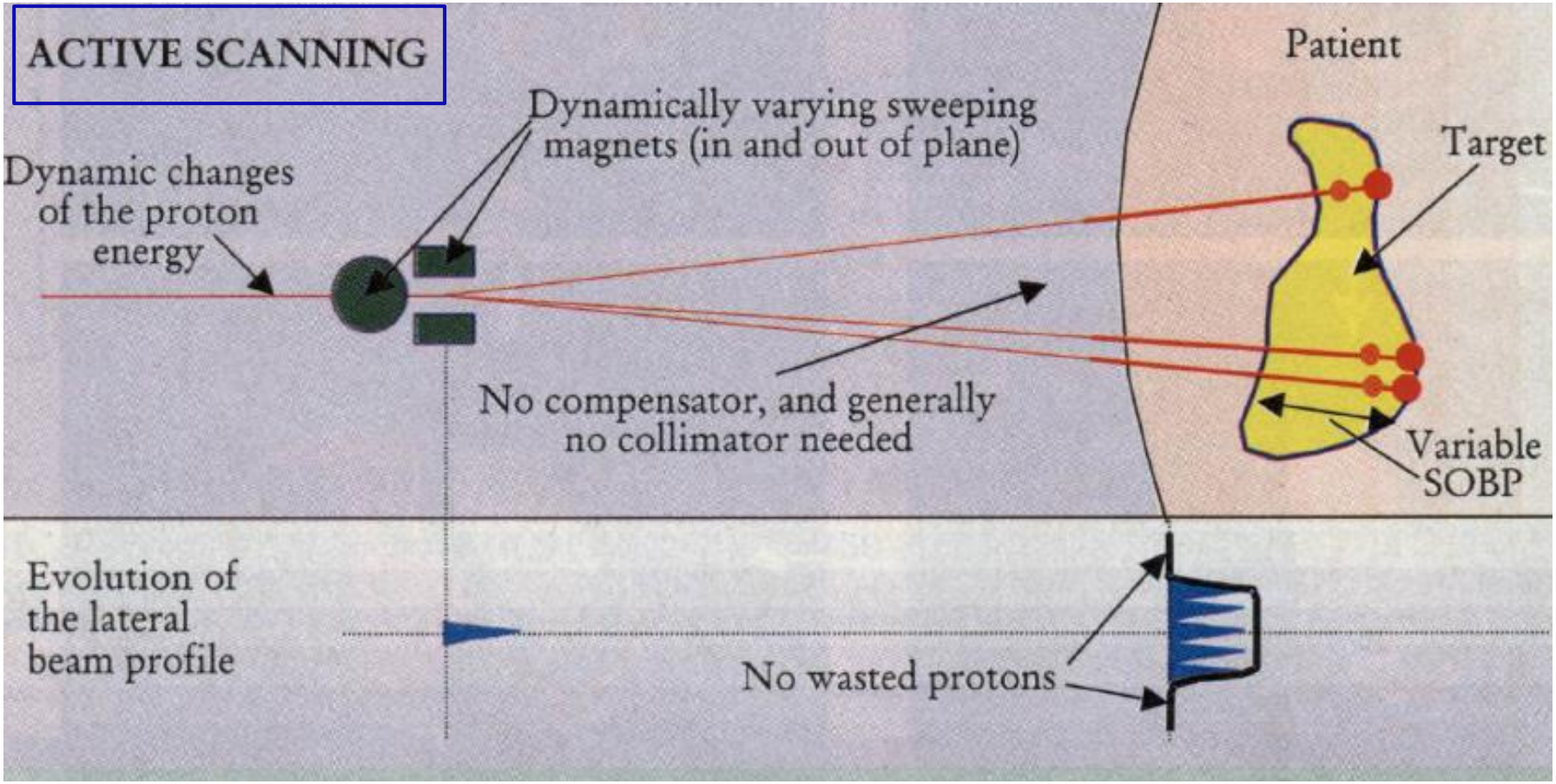
35 feet diameter
(3-story tall!)
Weighs 90 tons

Isocentric,
SAD=250-285 cm
Isocentric
Accuracy = 1 mm

Beam Delivery

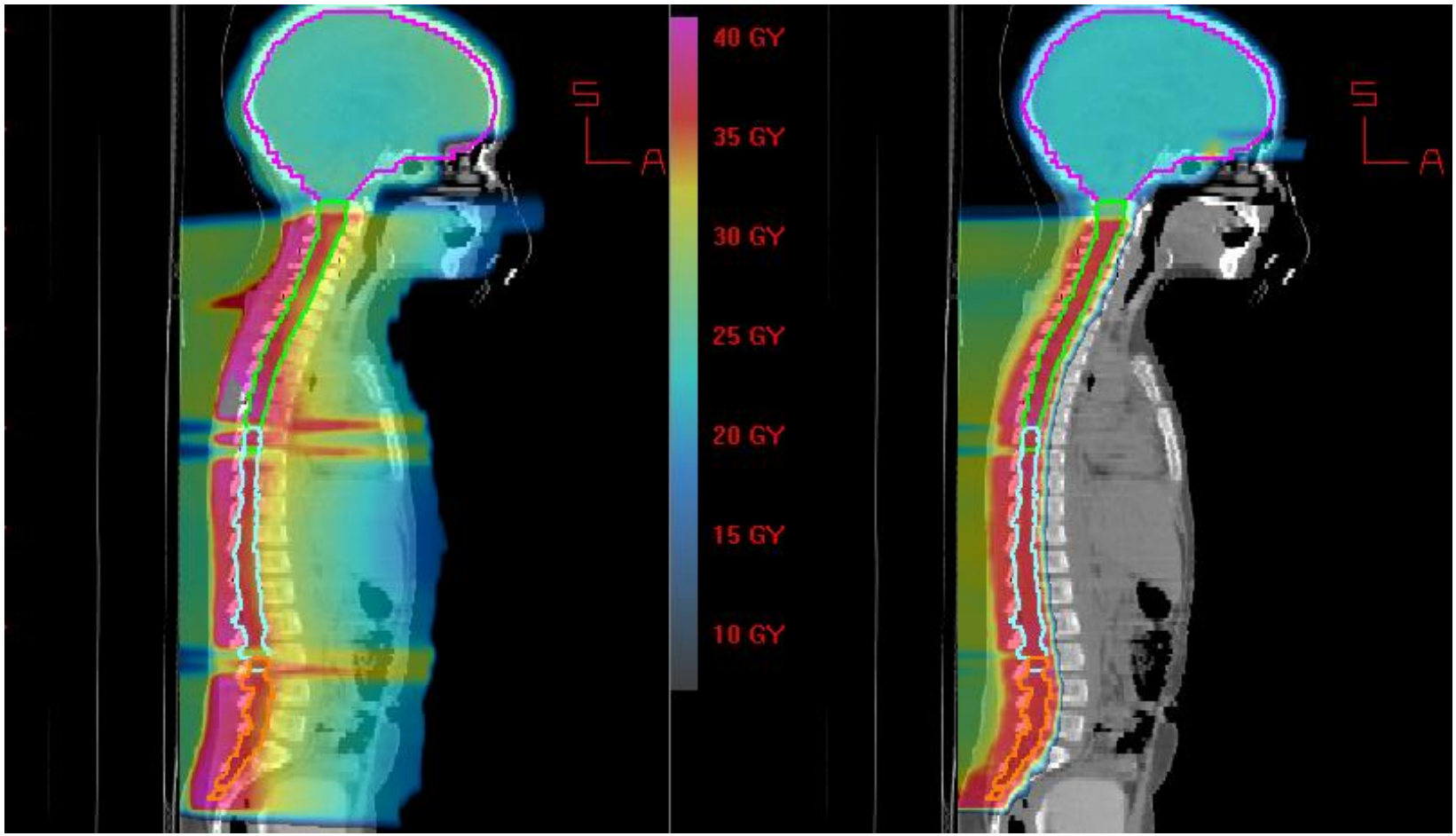


Beam Delivery…

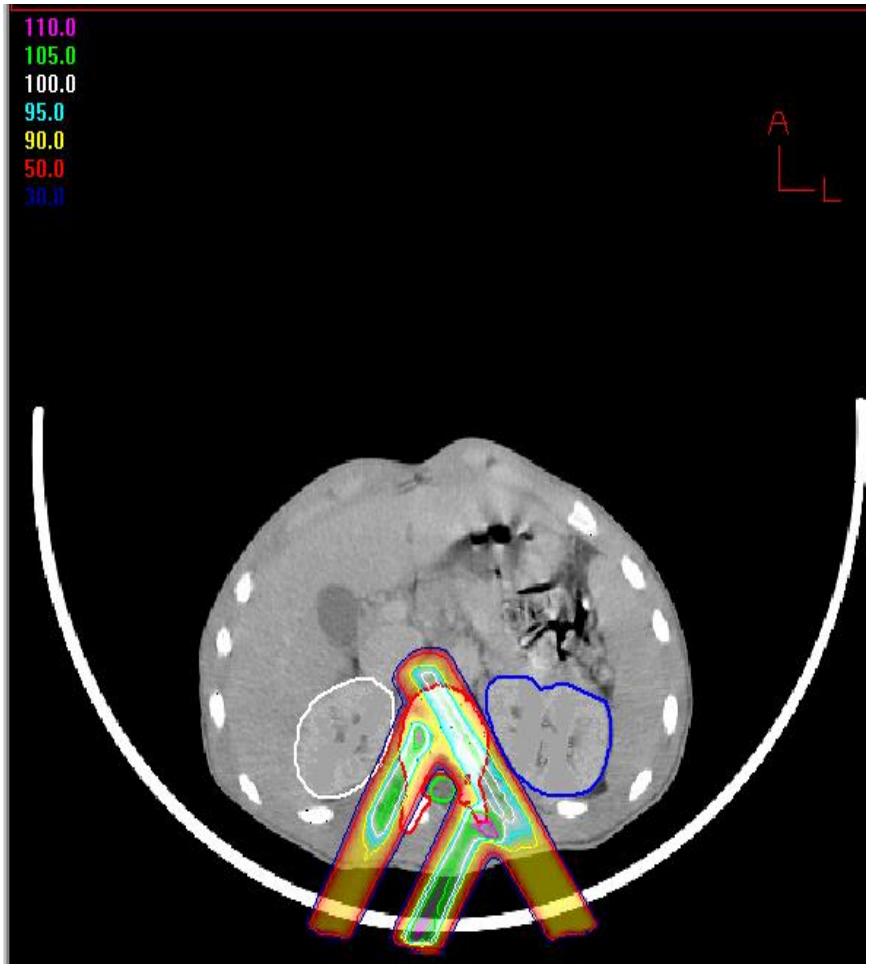


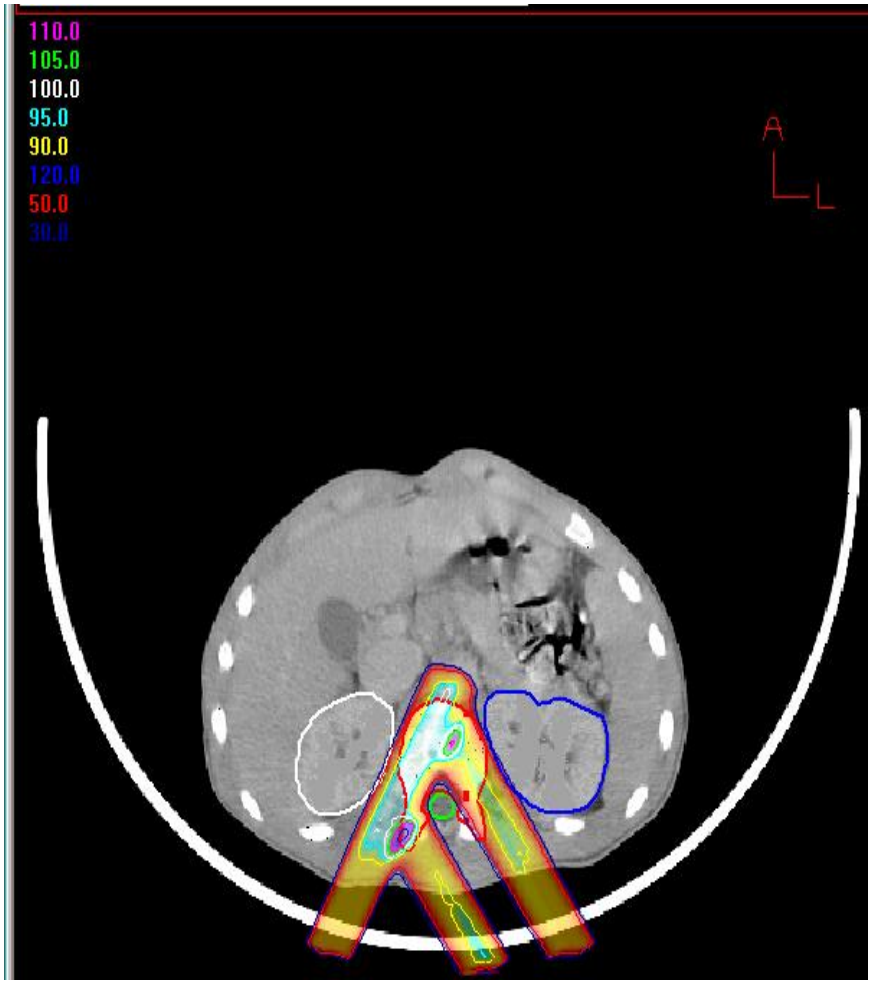
So, Why Protons? (Medulloblastoma:PNET)

Treatment with X-rays **Treatment with Protons**



Proton Patch Fields : Simple and Elegant

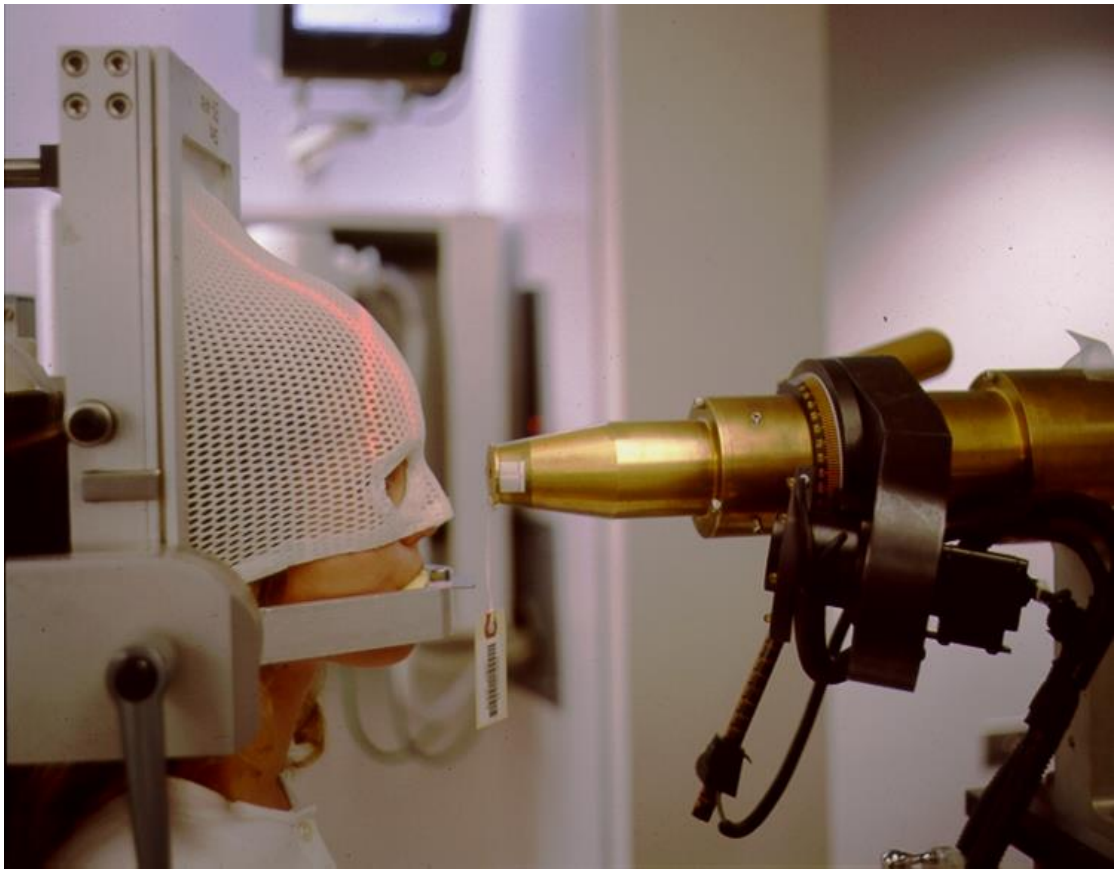




Proton Eye Treatment

What is happening?

What will it take to sit on this chair?



Trust

Quality Control

It is our job to build that trust through a culture of quality

Proton Center Outside Users Program

- Facilities available to outside researchers
- Currently our primary outside user is NASA
- About 14 other companies use our facilities

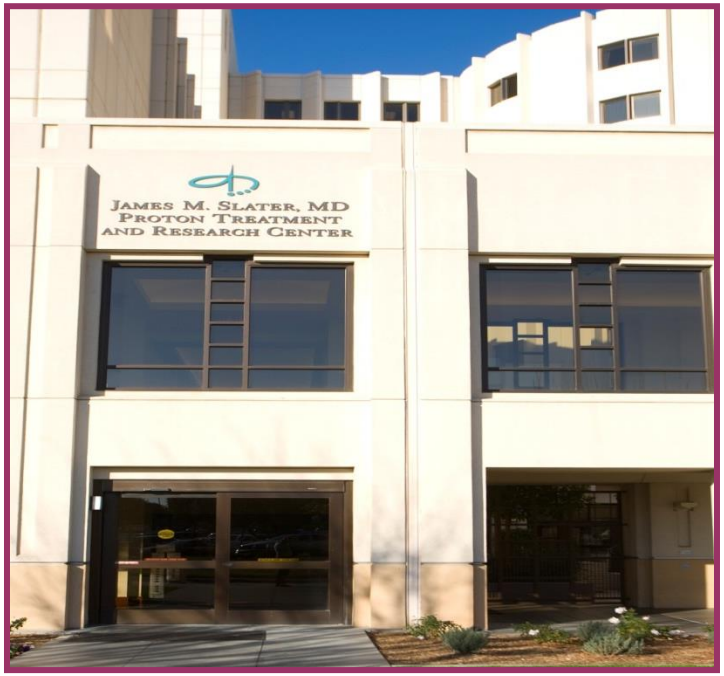
It takes a village…

Medical Physics Team 2022

A Few Fun Facts about Loma Linda…

First Infant Heart Transplant

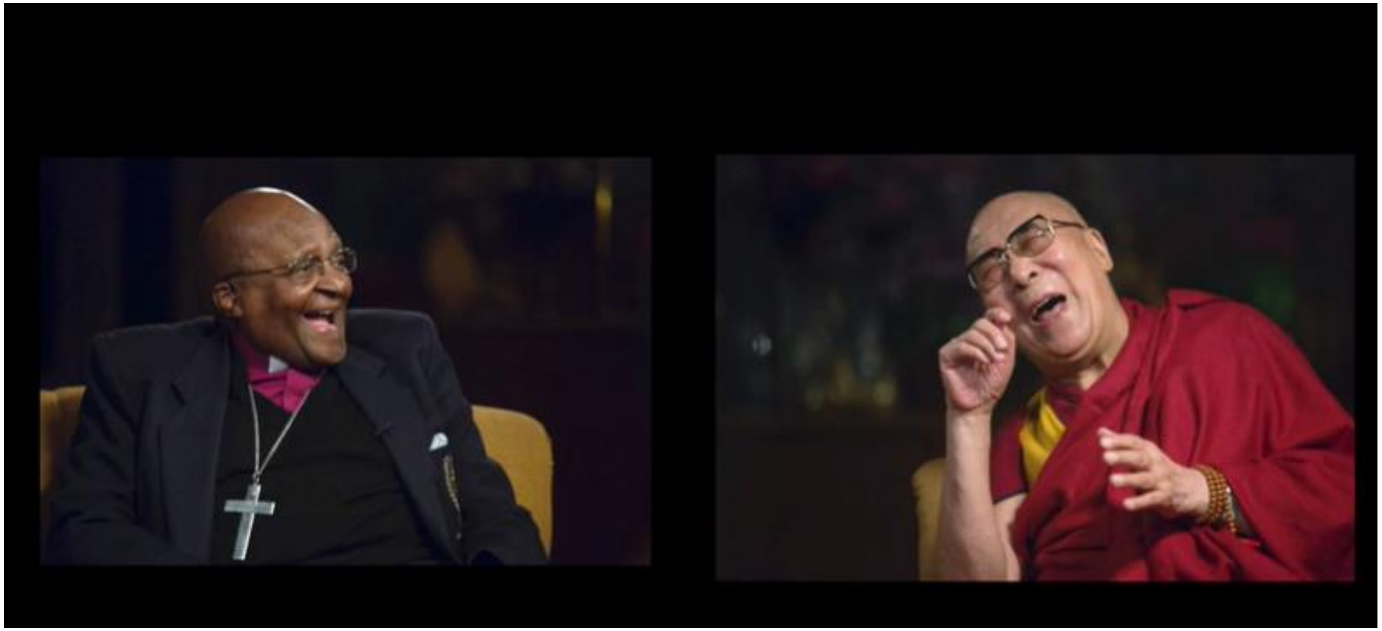
First Hospital-Based Proton Accelerator for Treatment of Cancer



Within 50 miles of Loma Linda….

And finally,
your prescription from today's hospital visit….

Have some real fun everyday…



Don't postpone joy!


Thank You!