Evolution of Radiation Therapy
Proton and Carbon Ion Beam Radiotherapy

Jiade J. Lu, MD, MBA

Professor of Clinical Oncology

Executive Vice President

Shanghai Proton and Heavy Ion Center

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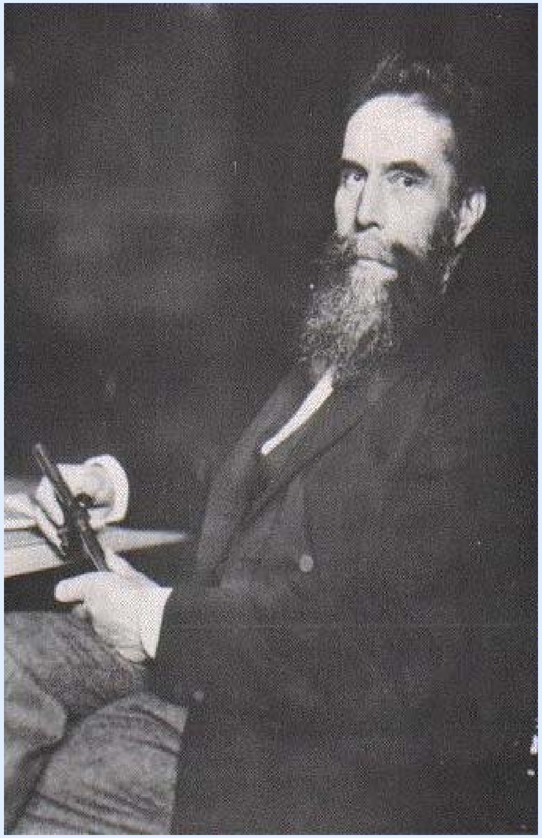
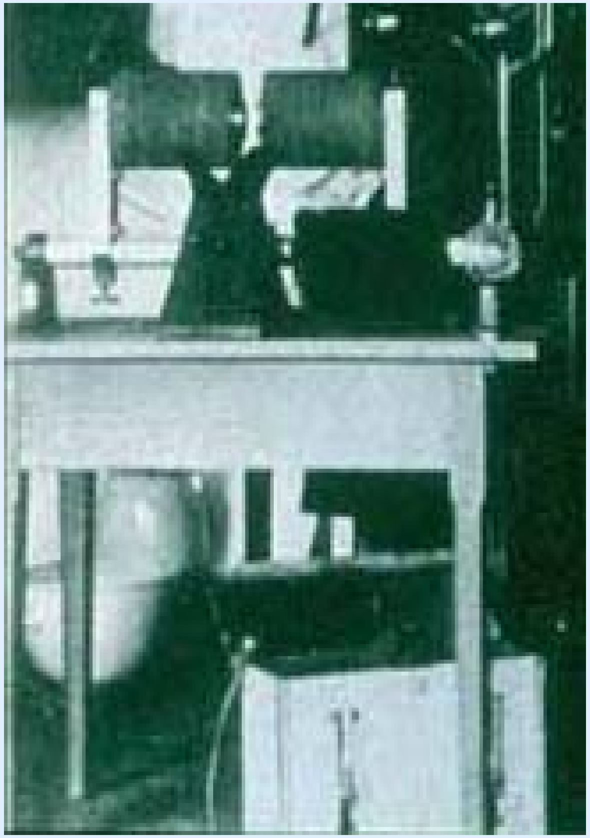
Nuclear Techniques in Human Health

Prevention, Diagnosis, Treatment

The Use of Radiation in Cancer Rx

X (Roentgen) Ray was discovered in 1895

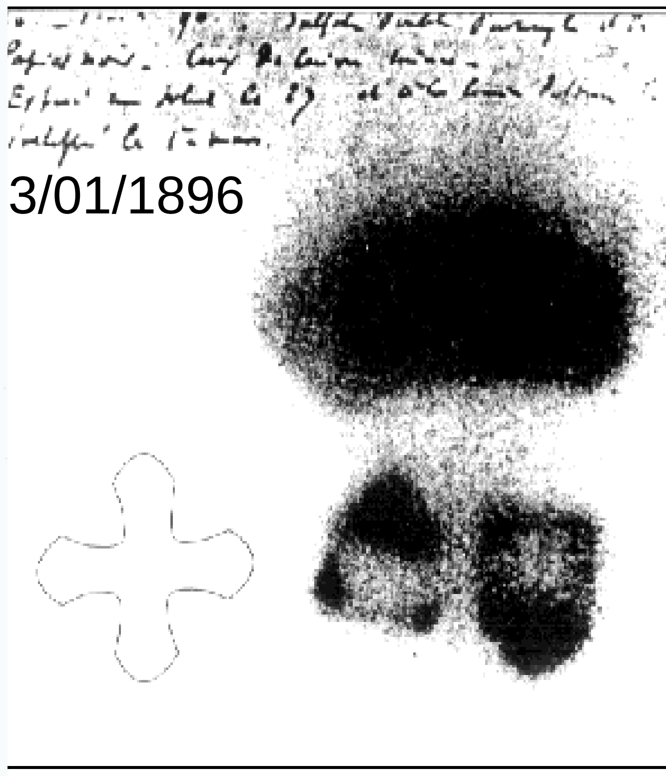


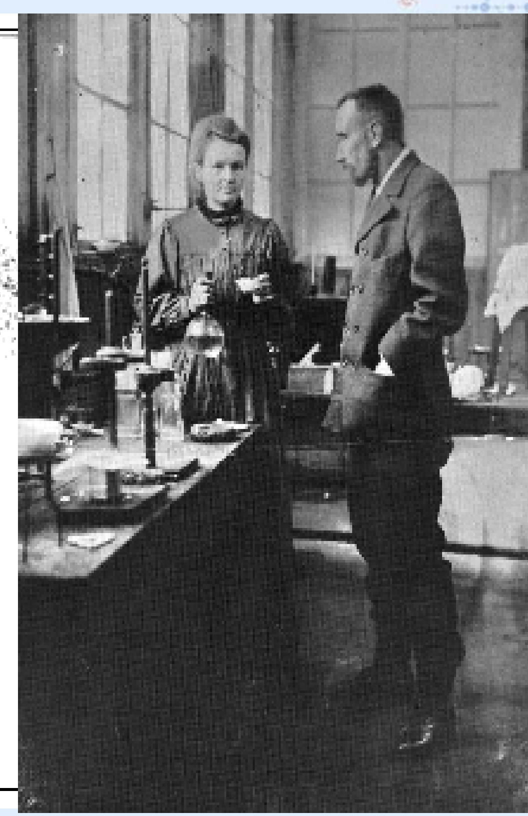


Received the 1st Nobel Prize of Physics in 1901

The Use of Radiation in Cancer Rx

The Discovery of Uranium (1896) and Radium (1898) by Becquerel and Curries





Becquere, Pierre & Marie Curie

Received the Nobel Prize of Physics in 1903

The Use of Radiation in Cancer Rx

The 1st radiotherapy case in 1896 in Vienna

Angioma case treated by Radium by Wickham in 1899

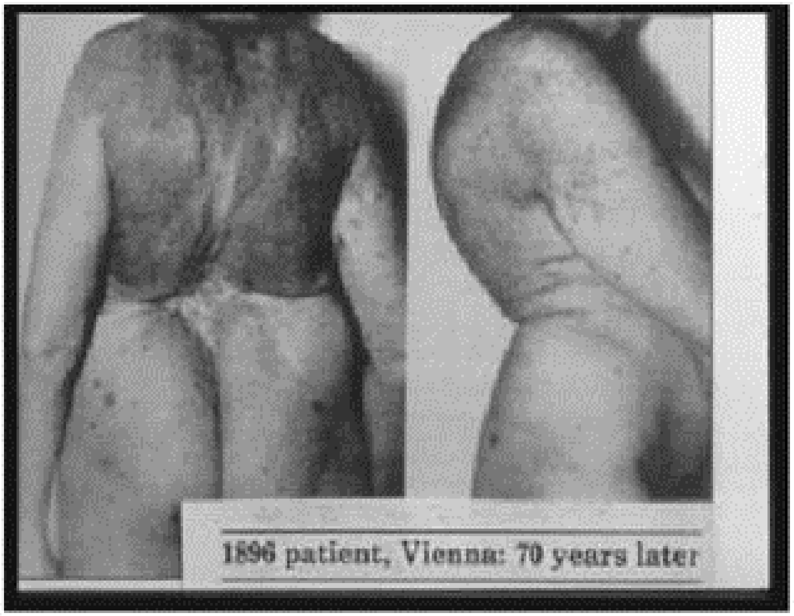


图 2-5-1-1　1896 年，维也纳第一位成功接受 x 线放射治疗病人。70 年后照片

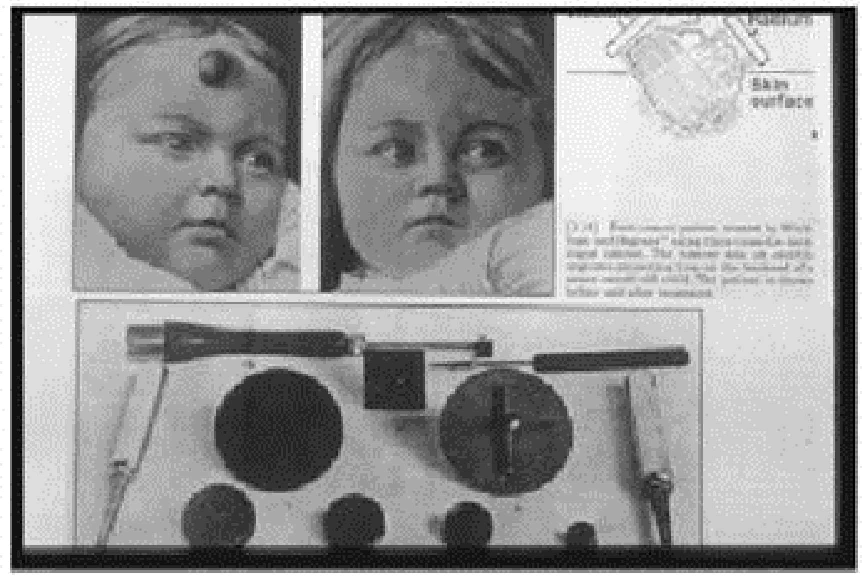


图 2-5-1-2　1899 年，Wickham 等首次利用镭疗治愈额头皮肤血管瘤病人

70 years after the treatment

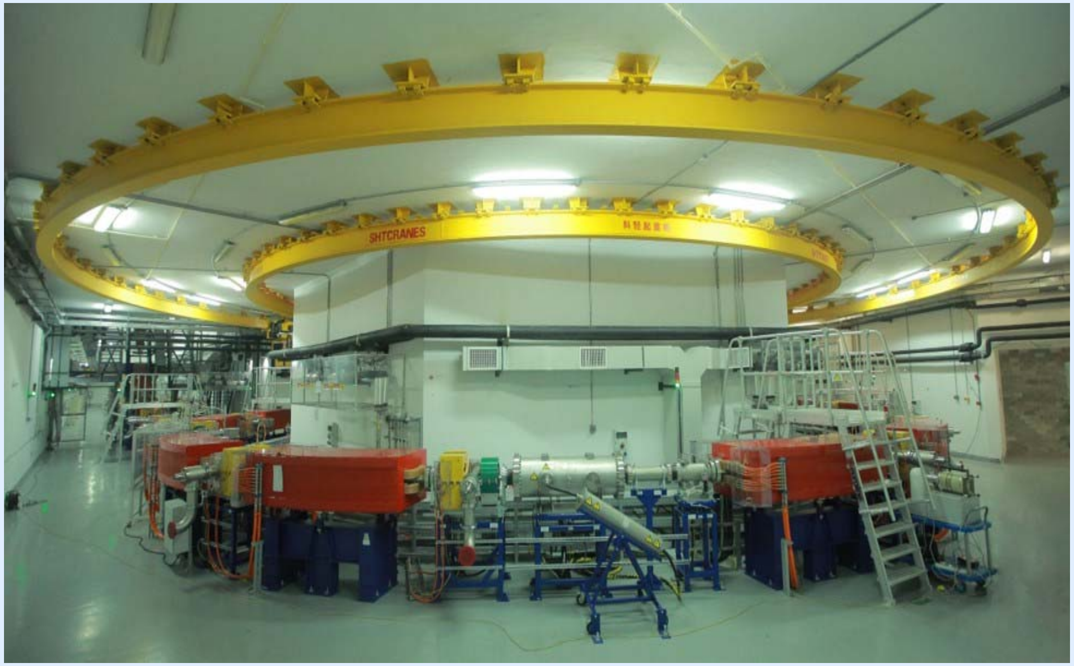
The History of Radiation in Cancer Rx

- 1896 – First case of radiotherapy
- 1920's – X-ray therapy for laryngeal cancer; radium therapy for cervical cancer
- 1930's – Fractionated radiotherapy by Courtard
- 1950's – Co-60 treatment for cancer
- 1954 – First patient treated with Proton (Berkeley)
- 1970's – Applying CT in the diagnosis and planning for radiotherapy
- 1977 – First patients treated with Carbon/Neon
- 1980's – Intensity modulated radiotherapy (IMRT)
- 2000's – Imaging guided radiotherapy (IGRT)

BEVALAC

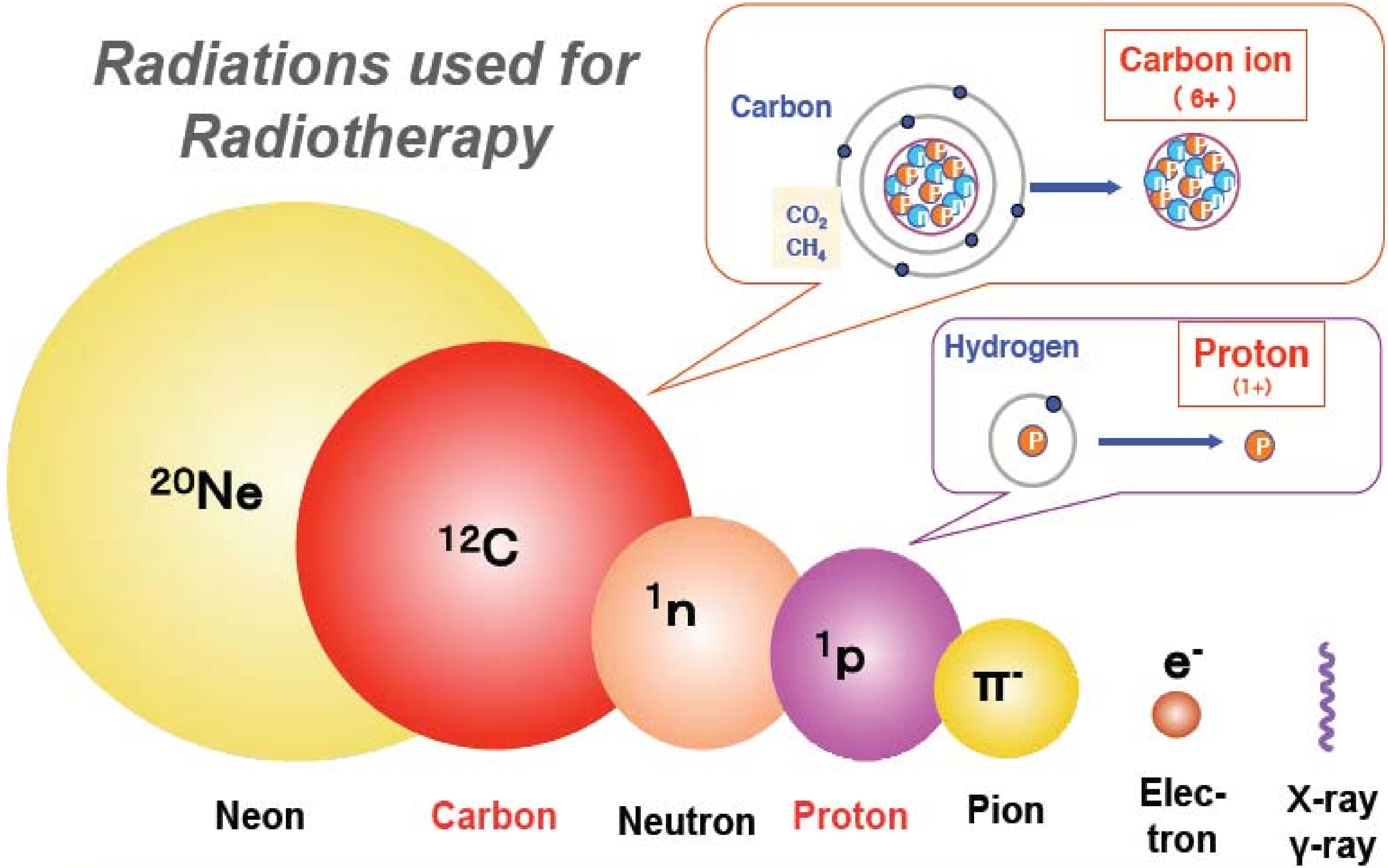
Lawrence Berkeley Laboratory, BEVatron + SuperHILAC, circa 1974

Synchrontron & Treatment Room



- Two Ion Sources
  - Proton, 50 – 250 MeV
  - Carbon, 85 – 430 MeV
  - Switch time, less than 20 sec
  - Helium and Oxygen (non-medical)

Radiations used for Radiotherapy



Mass	20 :	12 :	1 :	1 :	1/7	: 1/1800	-

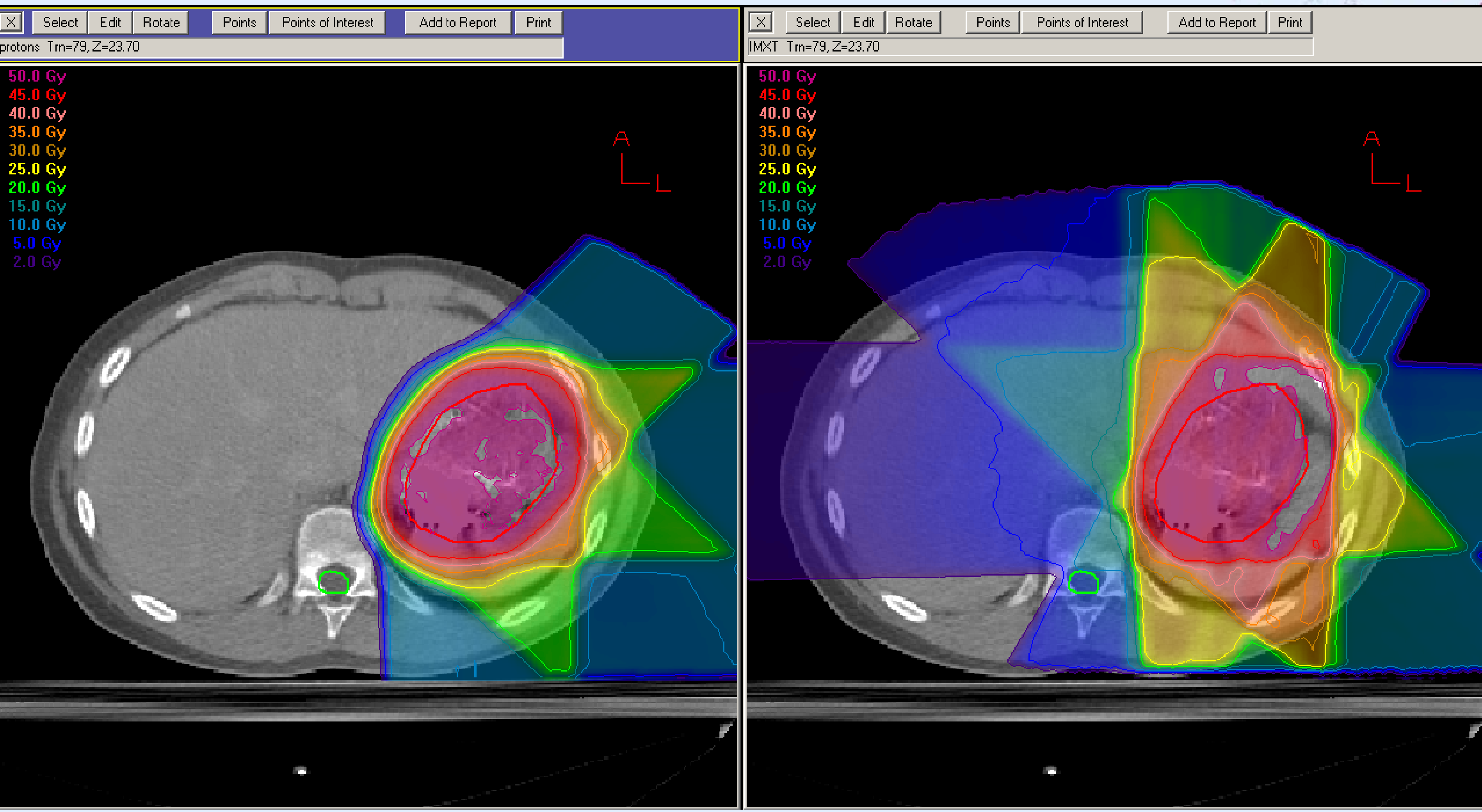
Rational for Proton and Heavy Ion Rx

1. The dose delivered to non-target tissues relative to the dose delivered to target tissues is lower than for other radiation beams due to the depth dose distribution.

2. The lateral and distal dose gradients are higher than for other radiation beams enabling better splitting of the target and normal tissues.

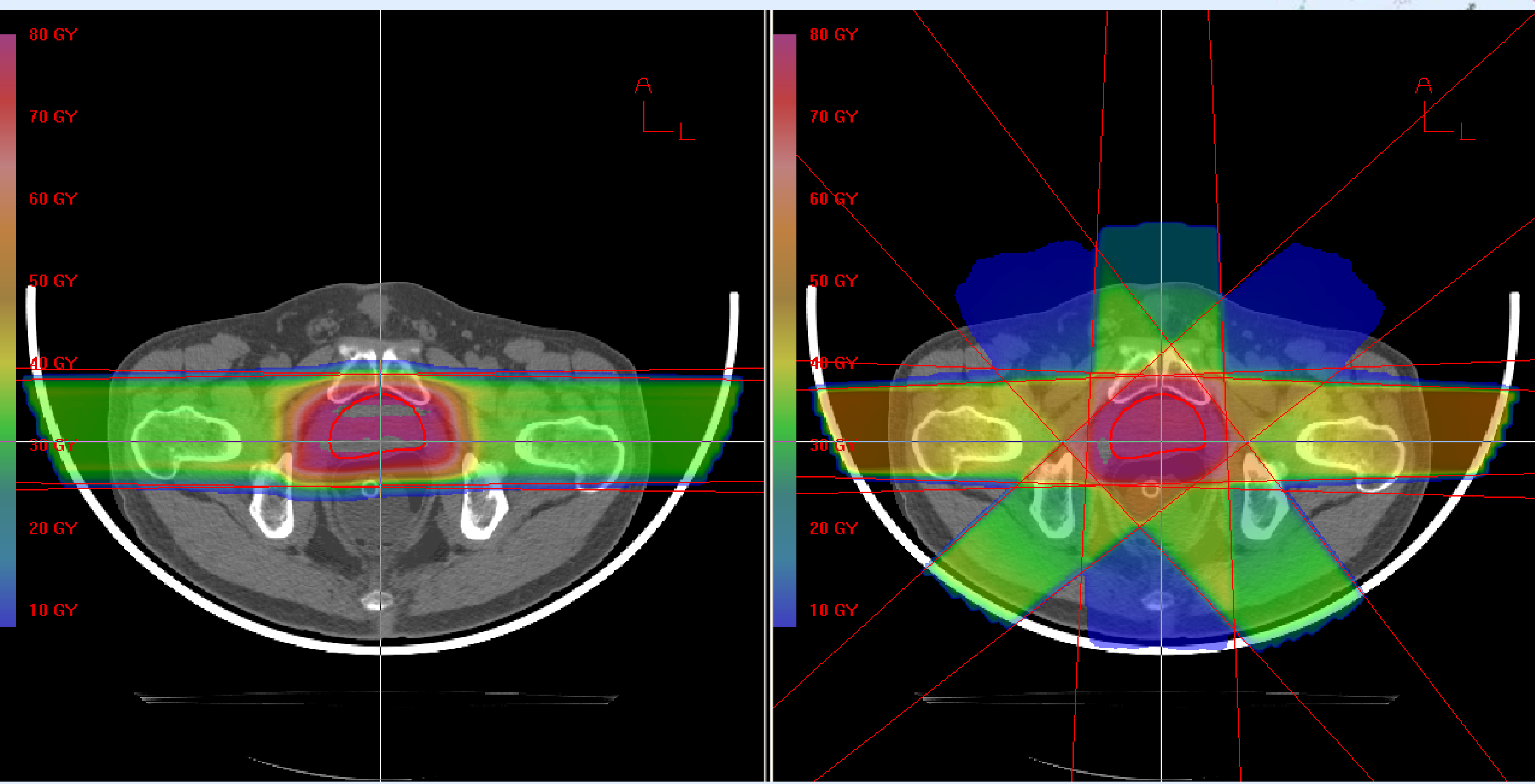
3. For ions such as **carbon**, a differential RBE with depth results in a higher biological dose in target tissues compared to surrounding normal tissues.

Proton vs. IMRT – Chest Tumor



- ratio of integral dose to body outside target = 1.76
- ratio of volume of body outside target receiving > 2 Gy = 2.47

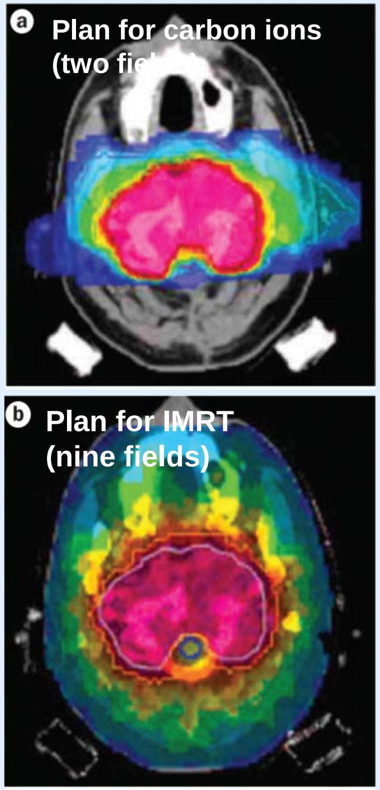
Proton vs. IMRT – Prostate Cancer

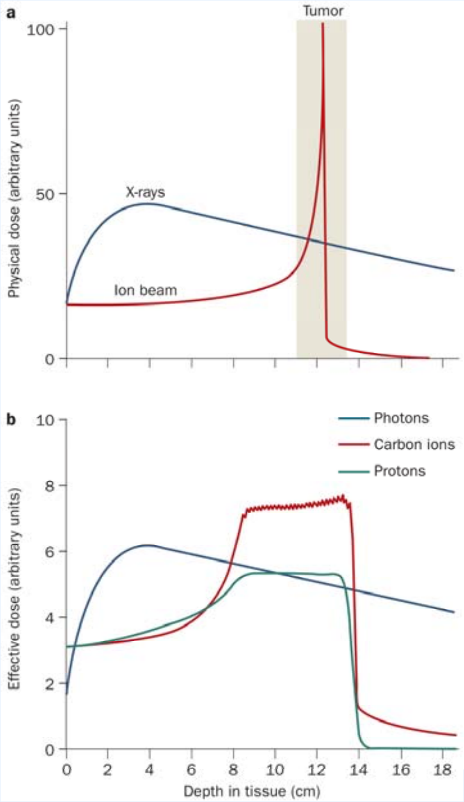


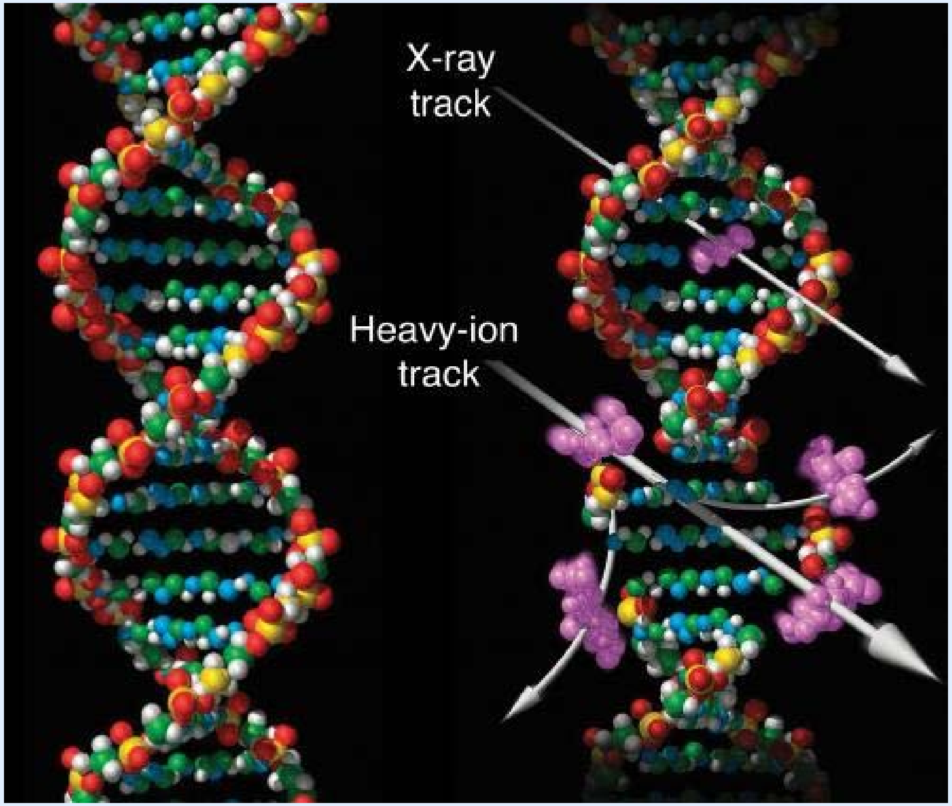
- ratio of integral dose to body outside target = 1.81
- ratio of volume of body outside target receiving > 2 Gy = 2.59

The "Ideal" Beam of Cancer Therapy

- Carbon ion Radiotherapy is featured with
  - High Precision – physical advantage
  - High Biological Effectiveness – biological advantage







Durante M, Loeffler JS. Charged particles in radiation oncology. *Nat Rev Clin Oncol*. 2010 Jan;7(1):37-43

The "Ideal" Beam of Cancer Therapy

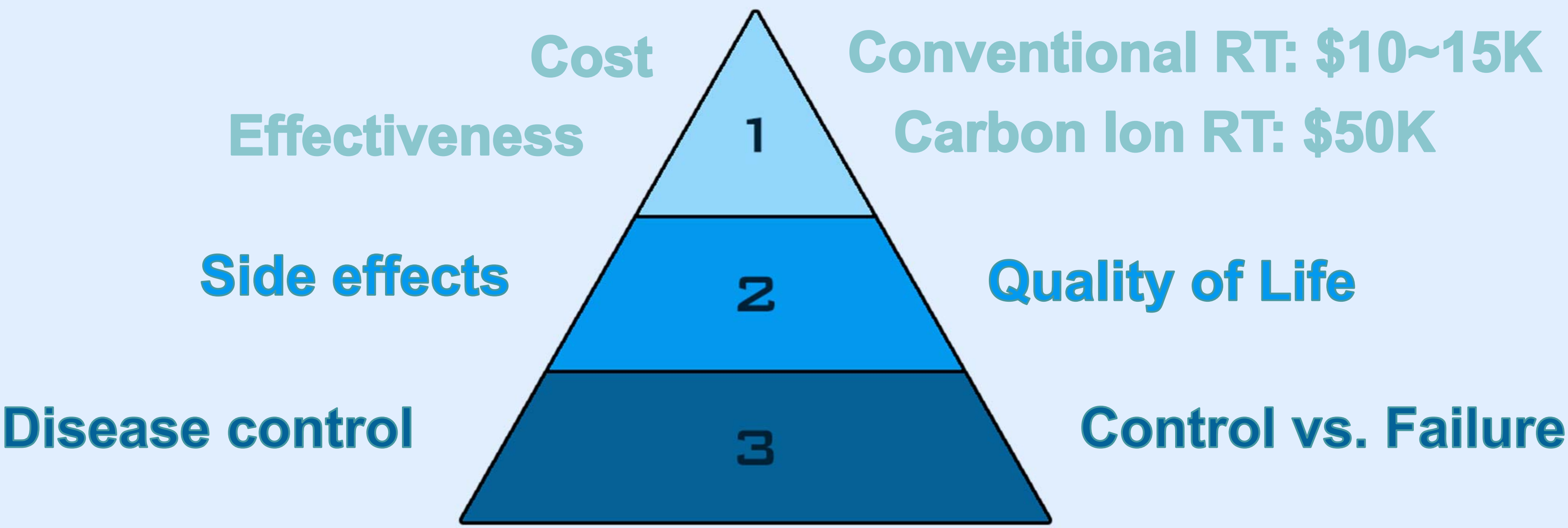
- **Carbon ion radiation therapy is highly effective for cancer treatment – with more than 20K patients treated**
- **Investment for a carbon ion radiation facility is vast – e.g., SPHIC cost *US$400 million* including a 200-bed hospital**

Questions

1. **Is it need to replace X-ray radiation by CIRT or proton radiation ?**
2. **What are the types of cancer that fit CIRT ?**

Select the Right Beam

- The selection of beams
  - Conventional X-ray radiation therapy
  - Particle radiation therapy
- The considerations



THANK YOU FOR YOUR ATTENTION

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