Hadron Therapy

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APS2010

The Problem: Cancer Incidence

Cancer Incidence

Every year about 2 million new cases in Europe

The rate of patients treated with RT will likely increase in the years to come

The main cause of death between the ages of 45 and 65.

Second most common cause of death

The Problem: Cancer Incidence

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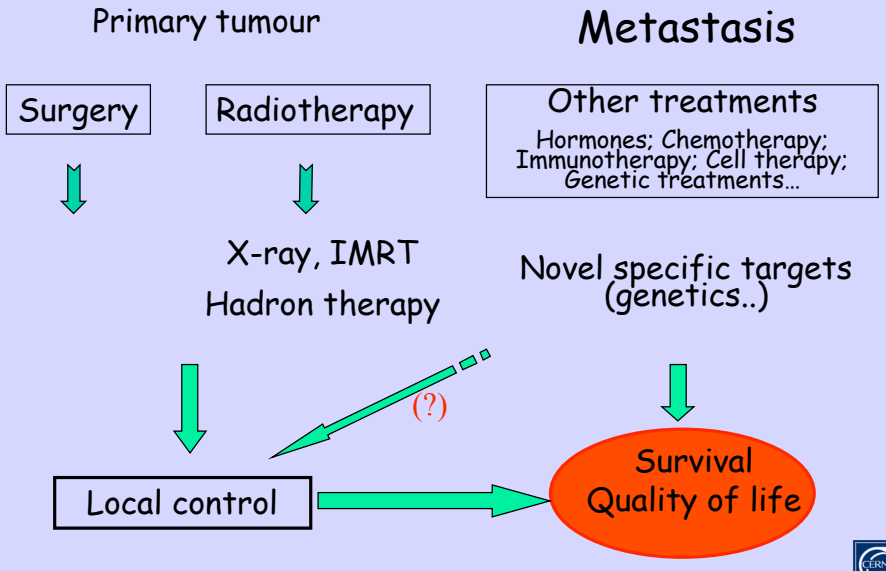
Treatment Options…



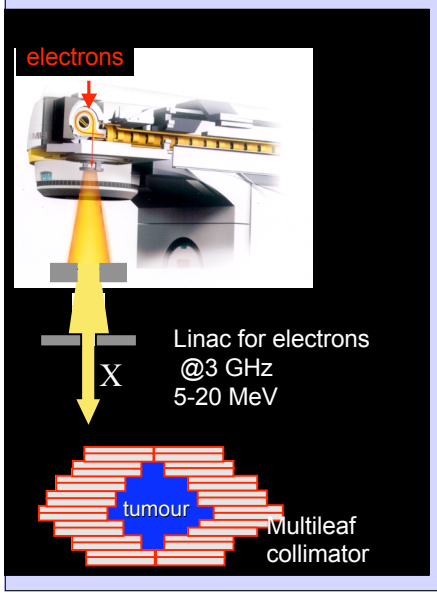
Cancer

Ideal cancer treatment would be to eliminate all tumour cells without affecting any normal cells

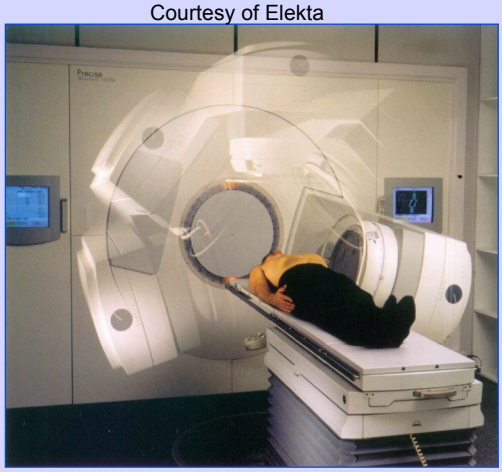
Physics : 100% of the dose on target
0% of the dose in surrounding healthy tissues or critical organs

Biology : differential effect
kill 100% of cancer cells "protect" normal cells

'Conventional' radiotherapy: linear accelerators dominate



Courtesy of Elekta



20 000 patients per year every
10 million inhabitants

1 linac every <250,000 inhabitants

Cancer and Radiotherapy in 21st Century

- RT is, nowadays, the least expensive cancer treatment method (around 5% of cost)
- Good cure rate (30-40%)
- Conservative (non-invasive, fewer side effects)
- There is no substitute for RT in the near future

Present Limitation of RT: 30% of patients still fail locally after curative RT

(Acta Oncol, Suppl:6-7, 1996)

How to overcome failures?

- Physics & treatment technology: dose escalation
- Imaging: MRI, PET, image registration
- Biology: altered fractionation, radiosensitization

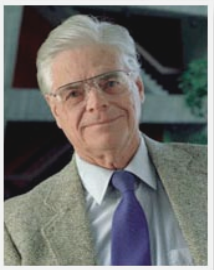
Raymond Miralbell, HUG

Protons and ions

Why start using hadrons in radiation therapy?

What makes them important?

What are the differences with X-ray ?

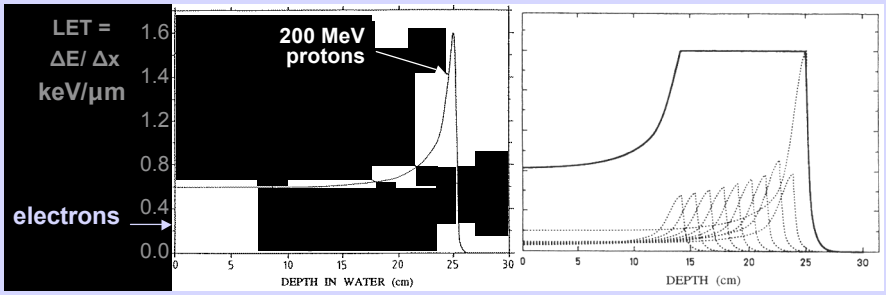


Founder and first director of Fermilab

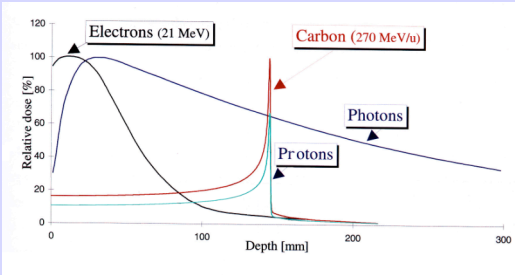
All started in 1946 by Wilson….

In 1946 Robert Rathbun Wilson :

- **Protons can be used clinically**
- **Accelerators are available**
- **Maximum radiation dose can be placed into the tumour**
- **Proton therapy provides sparing of normal tissues** (*) Wilson, R.R. (1946), "Radiological use of fast protons," Radiology 47, 487.



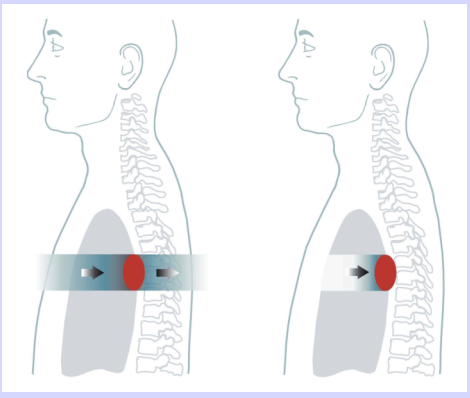
Hadrontherapy vs. radiotherapy



- Tumours close to critical organs
- Tumours in children
- Radio-resistant tumours

Photons and Electrons	vs.	Hadrons
• Physical dose high near surface		• Dose highest at Bragg Peak
• DNA damage easily repaired		• DNA damage not repaired
• Biological effect lower		• Biological effect high
• Need presence of oxygen		• Do not need oxygen
• Effect not localised		• Effect is localised

Slide from Med-Austron

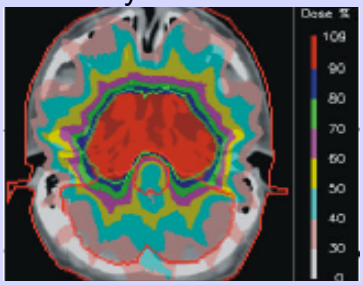


Conventional: X-Rays

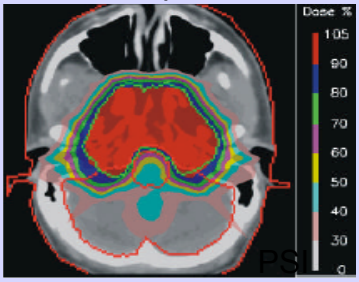
MedAustron: Ion Radiation

Protons are quantitatively better than X-rays

9 X-ray fields



4 proton fields

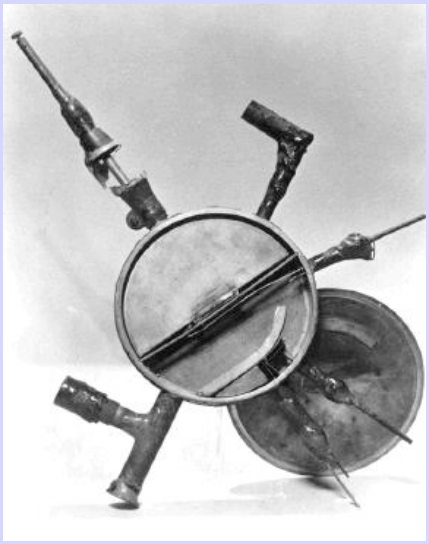


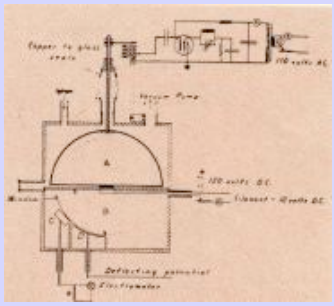
A better dose distribution allows an increase in the tumour dose: typically if the dose increases from 60 Gy to 72 Gy the tumour "control rate" at 5 years passes from 50% to 65%

Ernest Orlando Lawrence

Ernest Lawrence came to Berkeley from Yale as associate professor of physics in 1928.

The First Successful Cyclotron……..





The first successful cyclotron constructed by Lawrence and M. S. Livingston (1930).

12 cm in diameter.

184-Inch Cyclotron

1945

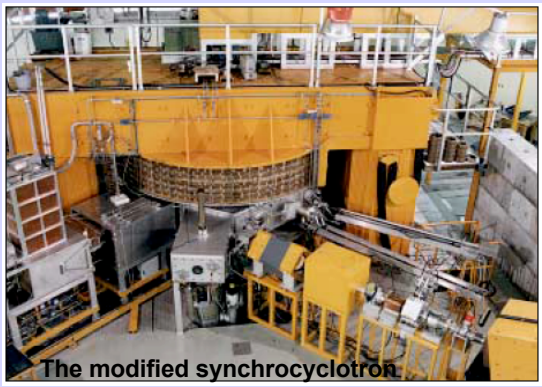
The first beam, November 1, 1947.

Protontherapy in Europe

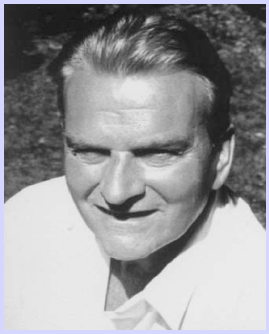
Börje Larsson at Uppsala

"On the Application of a 185 MeV Proton Beam to Experimental Cancer Therapy and Neurosurgery"

Doctoral dissertation - 1962



The modified synchrocyclotron



(1931-1998)

1943 - Harvard

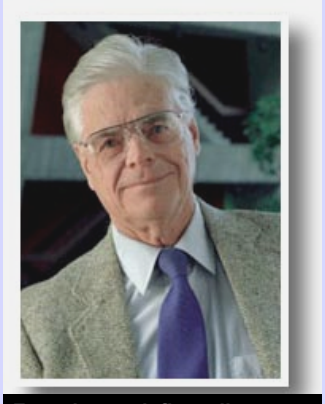
Hymer Friendell Bob Wilson Percy Bridgeman

Protontherapy

1946 R.R. Wilson proposes the use of Bragg Peak

1954 First irradiations in Berkeley

1961 New Harvard cyclotron irradiates patients



Founder and first director of Fermilab - 1990

184-Inch Cyclotron and Hadron Therapy

1956 - 1986

Hadron Therapy

Clinical Trials

1500 patients treated

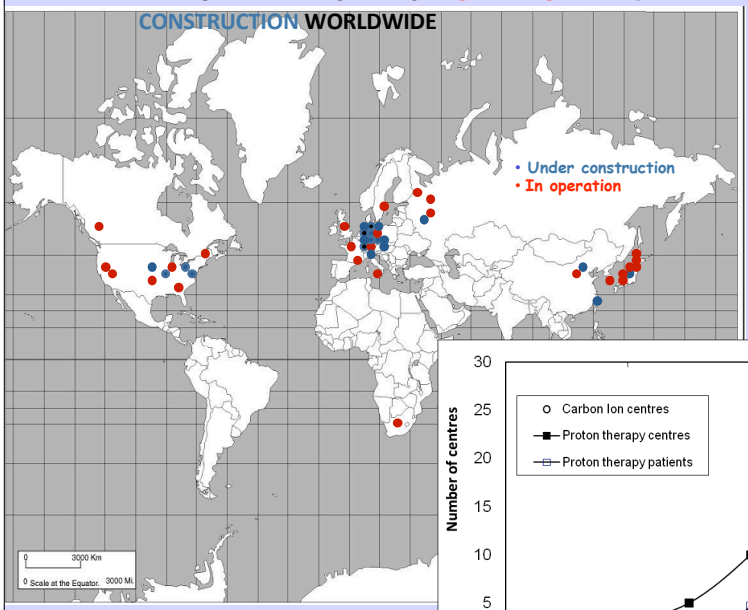
Closure of the 184-Inch, 1986.

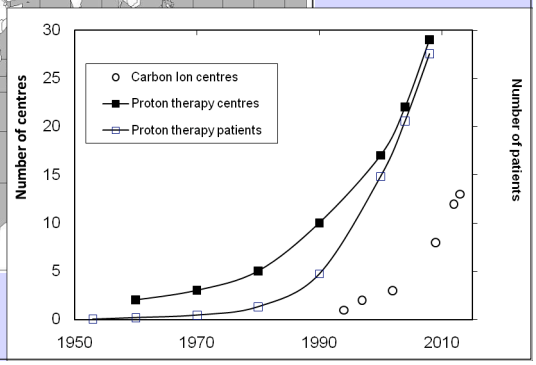
Milestones of Hadron therapy

1991 — First hospital based *Proton* facility
Loma Linda University Medical Center, CA, USA

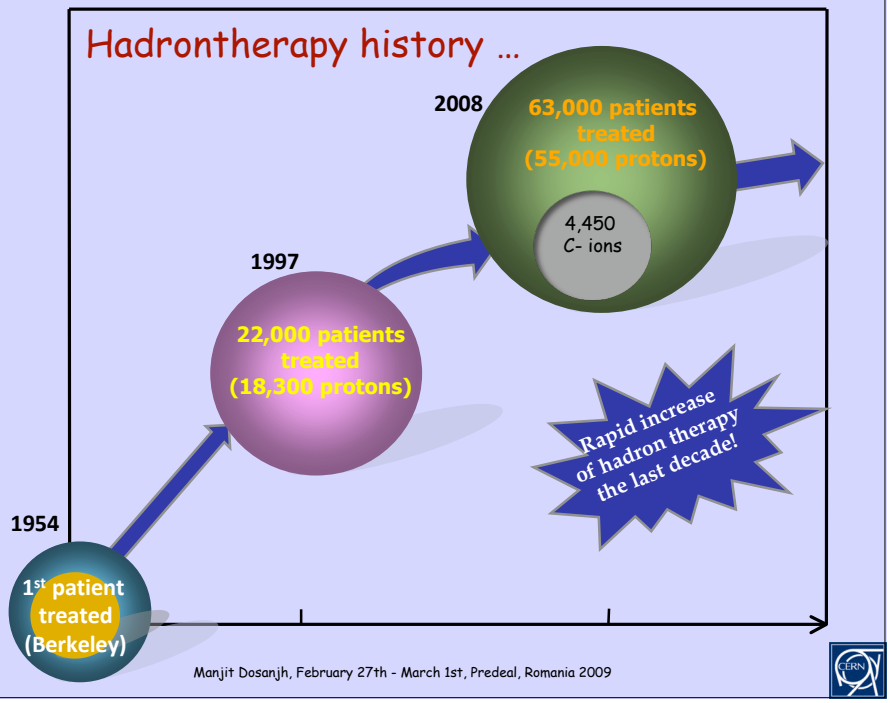
360^0 Gantry

HADRON THERAPY CENTRES IN OPERATION AND UNDER CONSTRUCTION WORLDWIDE





Hadrontherapy history …



Hadrontherapy goals (HIT-Heidelberg facility

- Provide the irradiation technologies and the detection systems to optimally use the advantages of charged particles
- Optimize the dose to the tumour by beam scanning and adaptation of the delivery e.g. organ motion, respiration
- Treat 1000 patients per year and perform clinical trials using low-LET (p, He) and high-LET (C, O) beams
- Conduct technical, physical and clinical R+D