HISTORY OF HADRON THERAPY: 1935-2015

Ugo Amaldi

TERA Foundation (Novara), CNAO Foundation (Pavia), Tera-Care Foundation (Geneva)

About nomenclature

I prefer 'hadrontherapy' or 'hadron therapy' to 'particle therapy' because:

- The photons of X rays, used in all Radiotherapy Departments, are also 'particles'
- The electrons , used in many Radiotherapy Departments and in modern 'FLASH therapy' are also 'particles'

About nomenclature

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- **The electrons , used in many Radiotherapy Departments and in modern 'FLASH therapy' are <u>also</u> 'particles'**

I prefer '<u>light ions</u>' to '<u>heavy ions</u>' because:

- **Following the International Commission on Radiation Units - ICRU**
  "all ions with a charge number Z<10 (NEON) will be referred to as 'light ions' "

'HEAVY PARTICLE THERAPY' IS SCIENTIFICALLY CORRECT

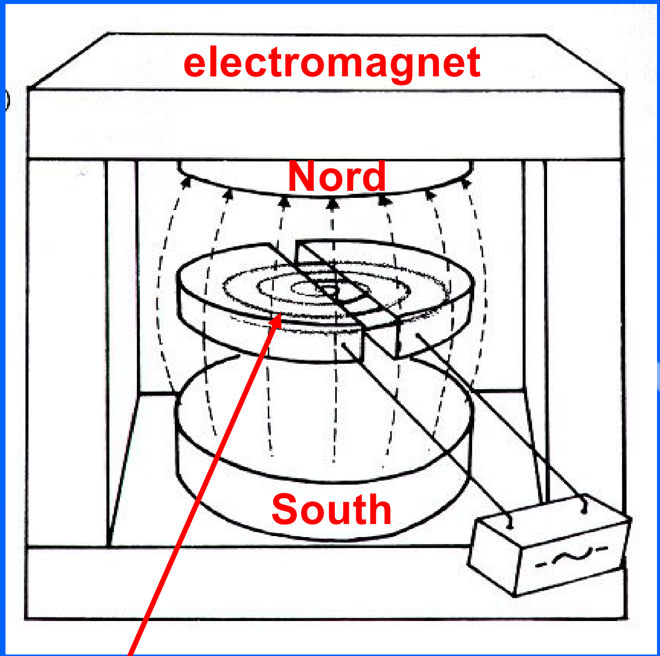
The beginnings: neutron beams

John Lawrence was a MD at Yale

1935: Ernest Lawrence persuaded his brother, John Lawrence, to come to Berkeley and use his cyclotron to treat cancer and produce medical radioisotopes

Ernest and John at the control of the 37-inch cyclotron used to produce
- radioisotopes
- neutron beams

1. 1930 – Invention of the cyclotron



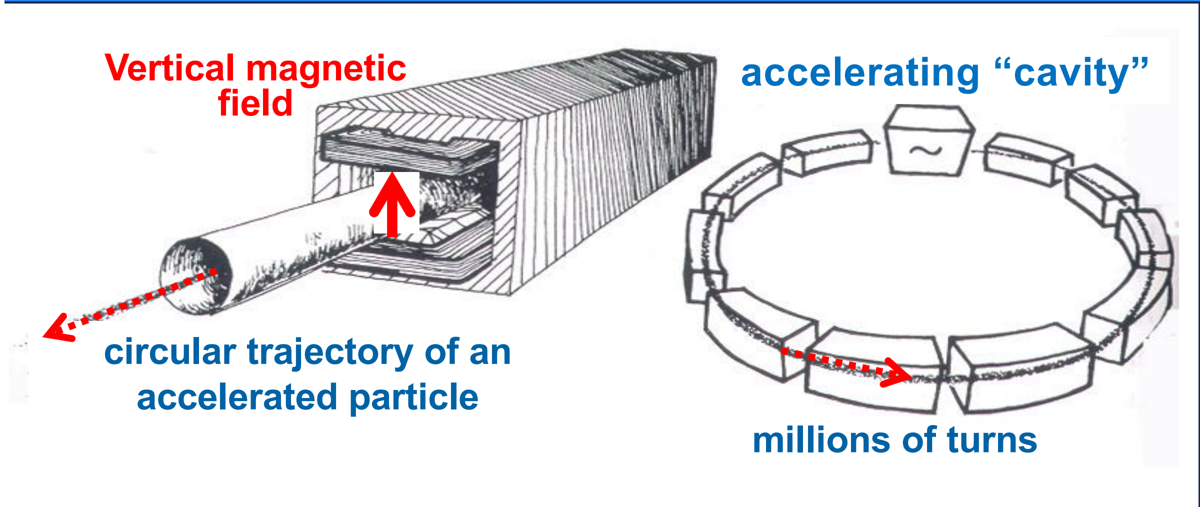
Spiral tajectory of an accelerated particle

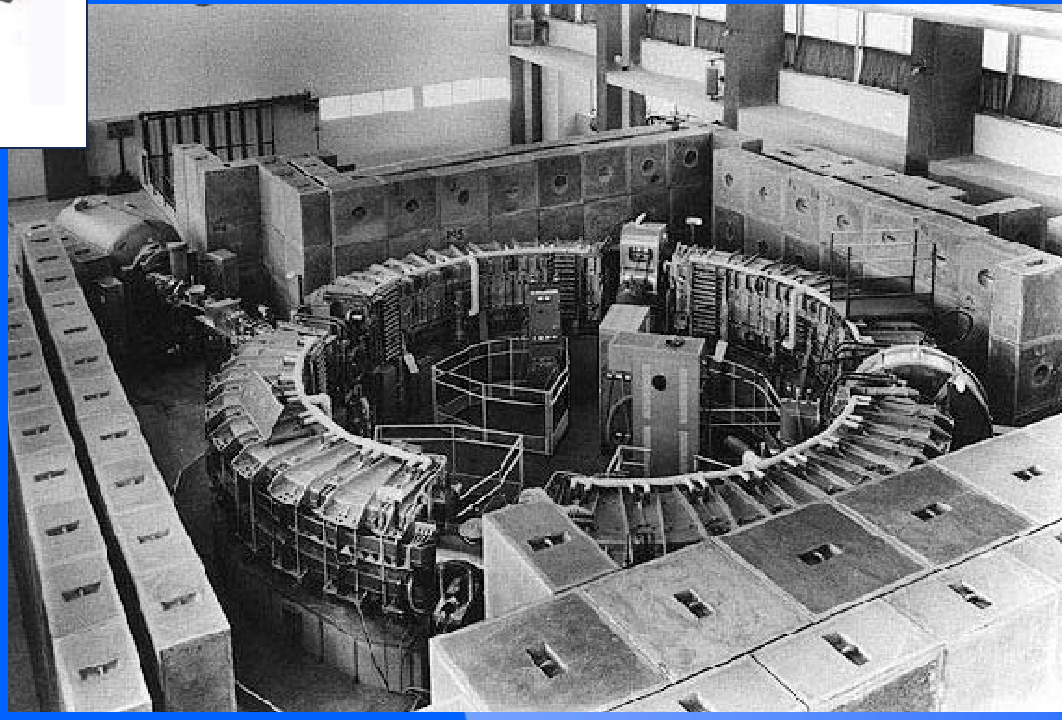
Ernest Lawrence

proton energy

= 0.001 GeV

2. 1945 – Invention of the synchrotron

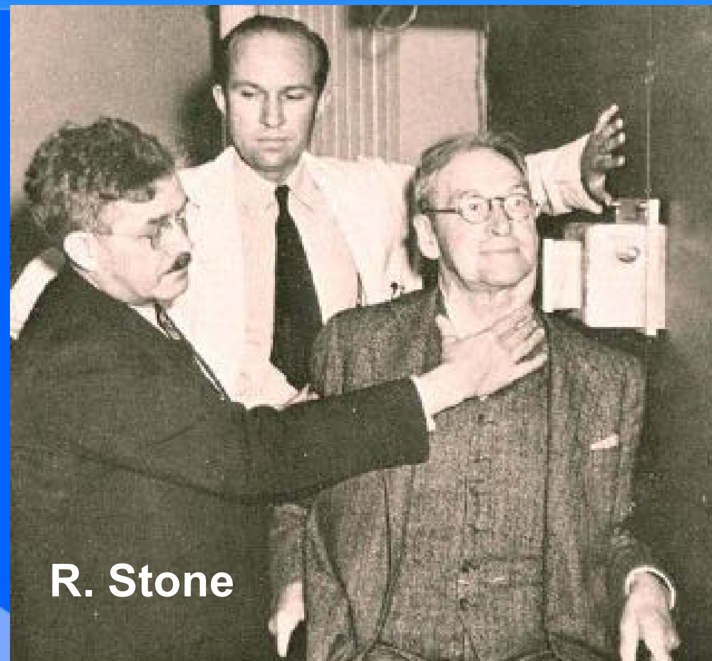




1959
Synchrotron that accelerates electrons

Frascati Laboratories - INFN

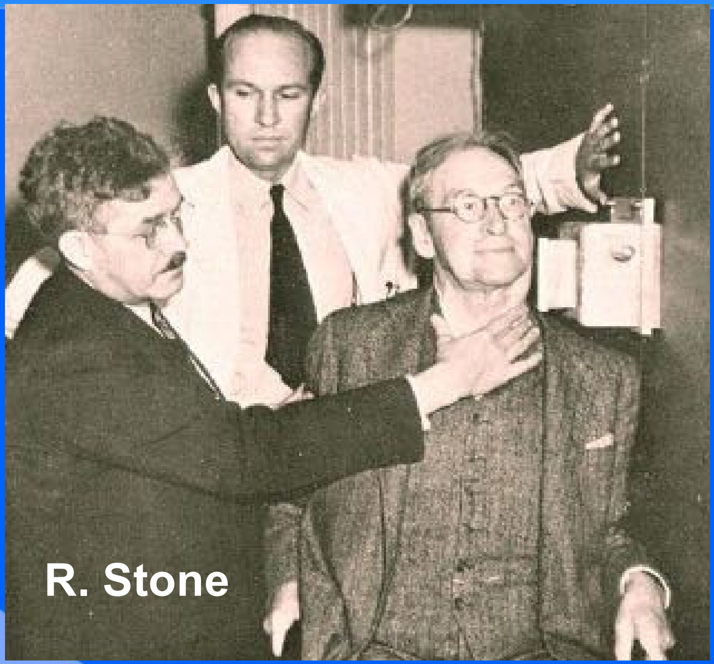
60-inch Crocker medical cyclotron



Robert Stone and John Lawrence treat a patient with neutrons from the 60- inch cyclotron:

deuterium + beryllium ⟶ fast neutrons

60-inch Crocker medical cyclotron



Robert Stone and John Lawrence treat a patient with neutrons from the 60- inch cyclotron:
deuterium + beryllium ⟶ fast neutrons

1948: R. Stone evaluated the effects on 24 pts treated at the 37-inch and 226 treated at the 60-inch cyclotrons

"Neutron therapy as administered by us has resulted in such bad late sequelae in proportion to the few good results that it should not be continued"

But neutron therapy started again

1965 - Mary Catterall at the Hammersmith Hospital:
Phase 3 trials with better beams and more fractions
and had good results for superficial adenocarcinomas

1978 - Bob Wilson and Chicago oncologists
60 MeV Fermilab linac for 'Neutron Therapy Facility'

National accelerator Centre (Faure – South Africa) 66 MeV p+Be

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(Faure – South Africa)
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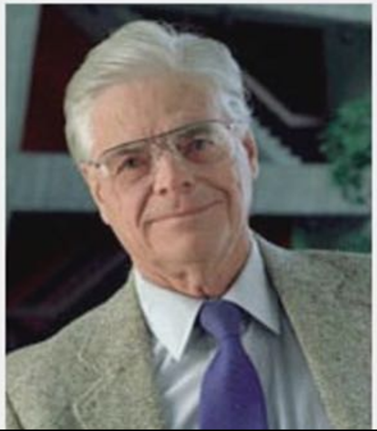
Total: about 35 000 patients treated
Only few facilities still running

Recent review paper: Although fast neutrons have a bad name due to their controversial clinical track record, their overall potential in cancer treatment seems to be underestimated. Based on radiobiological data, fast neutrons might kill tumour cells with comparable effectiveness as Carbon ions. They are interesting for radioresistant superficial tumours. Fast neutrons are guaranteed a limited, but special, place in modern radiation oncology

Review of neutron therapy – 2022:
www.ncbi.nlm.nih.gov/pmc/articles/PMC9415749/



Lawrence student
Founder and first
director of
Fermilab

The first steps at the Berkeley Laboratory

In 1946 Robert (Bob) Rathbun Wilson (*):

Protons can be used clinically

Accelerators are available

Maximum radiation dose can be placed into the tumor

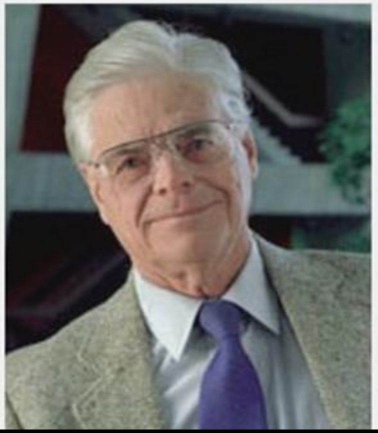
Proton therapy provides sparing of normal tissues

Modulator wheels can spread narrow Bragg peak

Carbon ions can also be effectively used

(*) Wilson, R.R. (1946), "Radiological use of fast proton". Radiology 47, 487.

The first steps at the Berkeley Laboratory



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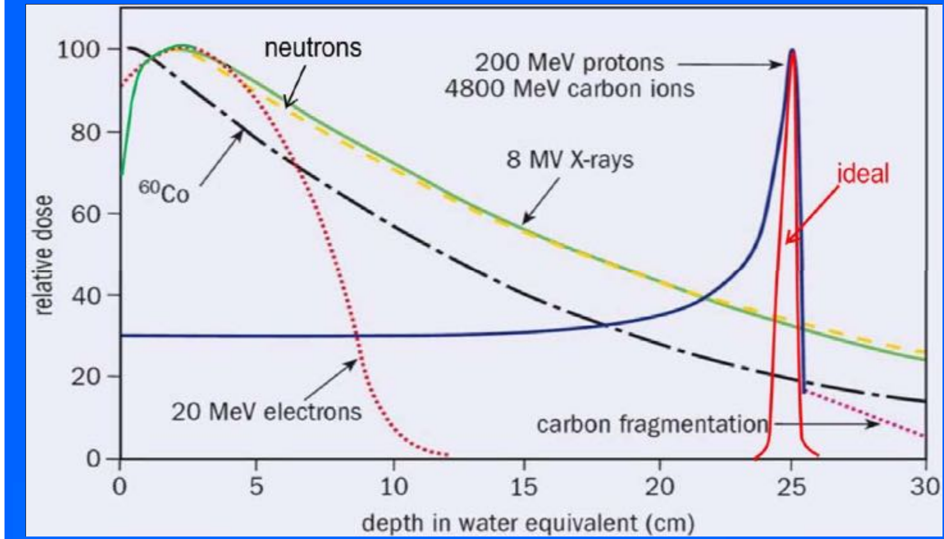
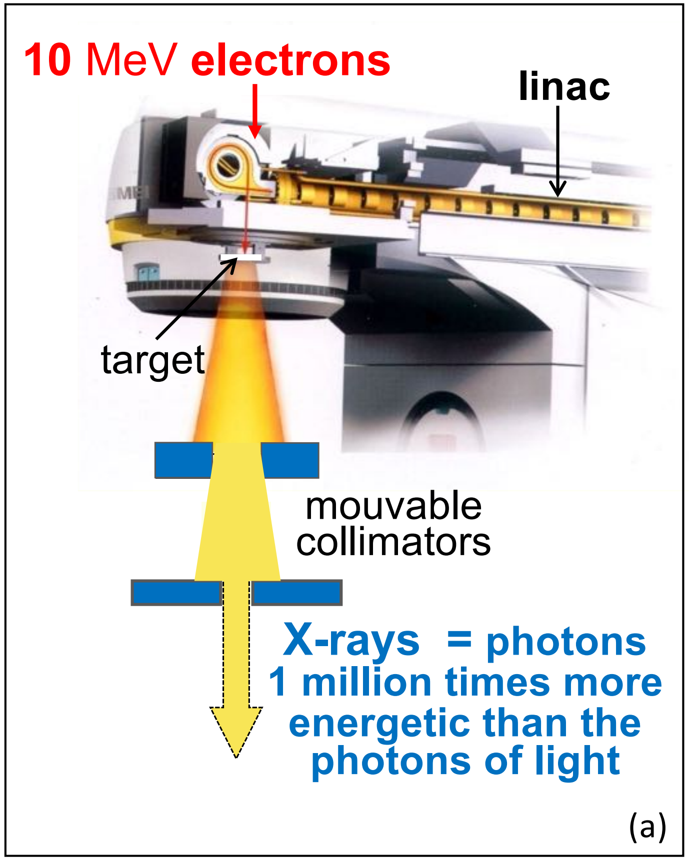


THE 'ICON OF HADRON THERAPY'

TERA

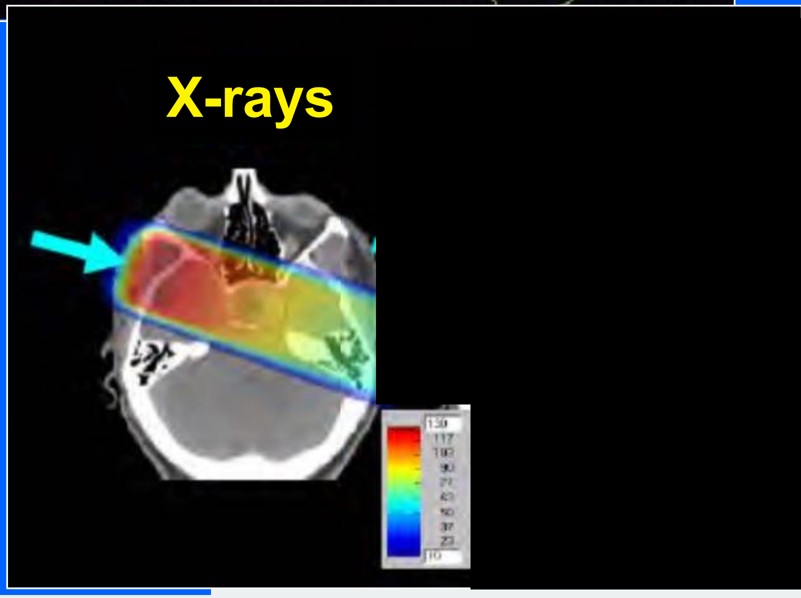
Today view of hadron therapy with protons and carbon ions



Conventional X-ray therapy : 3000 patients / 1 million people
in High-Income Countries

Energy deposition by radiation beams

X-rays by
10 MeV electrons

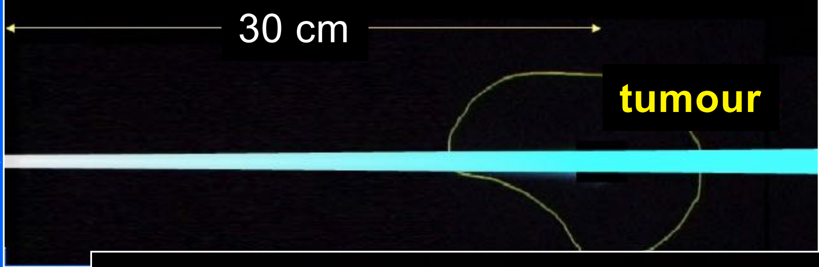


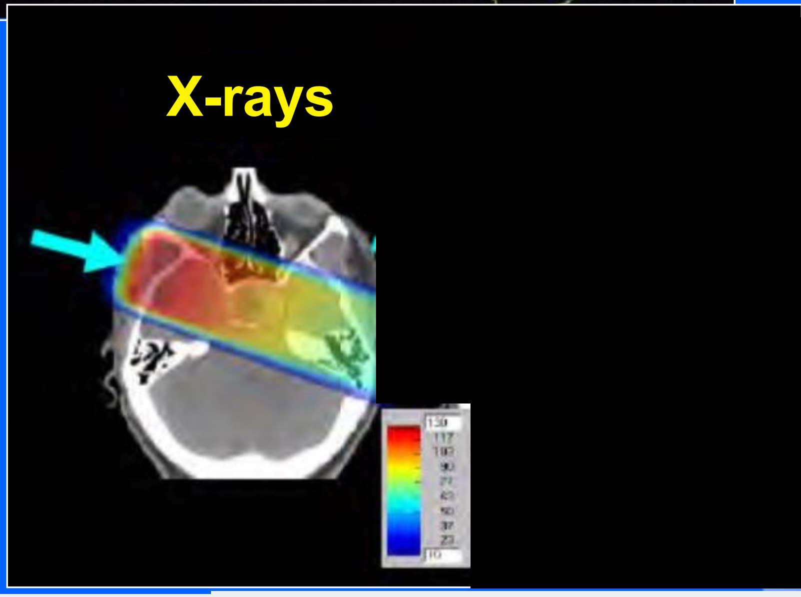
Energy deposition by radiation beams

Two problems:

1. close-by critical organs (10%) — 300 pts / 1 million
2. radioresistant tumours (1%) — 30 pts / 1 million

X-rays by
10 MeV electrons

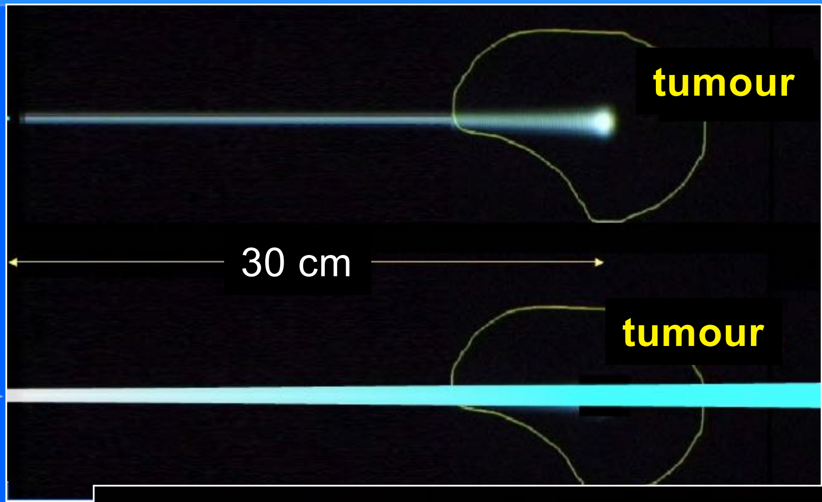




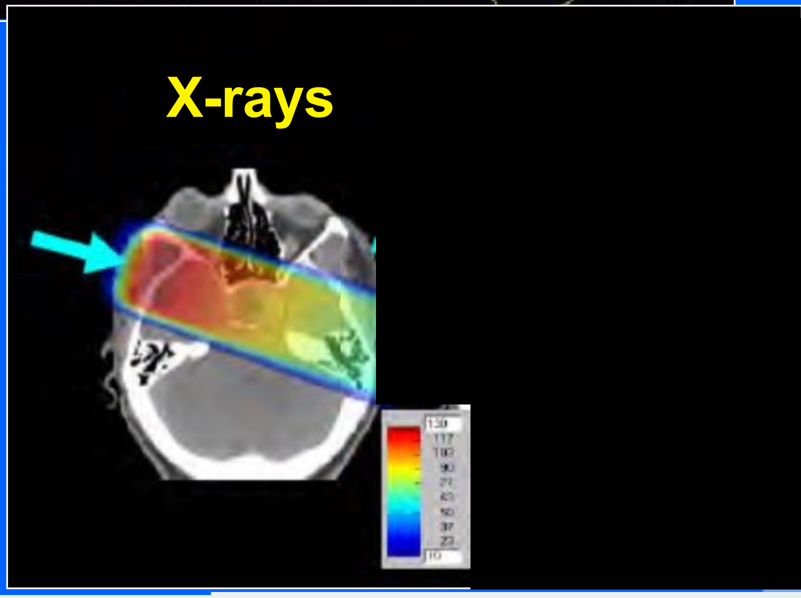
Energy deposition by radiation beams

protons 250 MeV

X-rays by
10 MeV electrons



300 pts / 1 million



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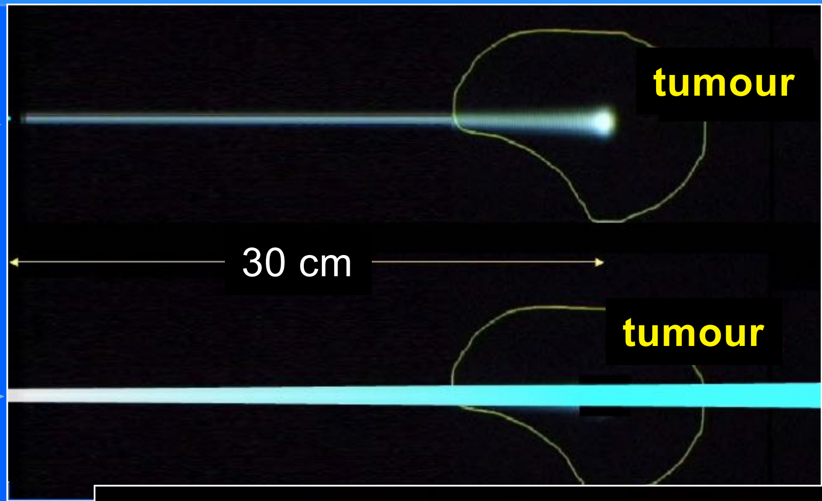

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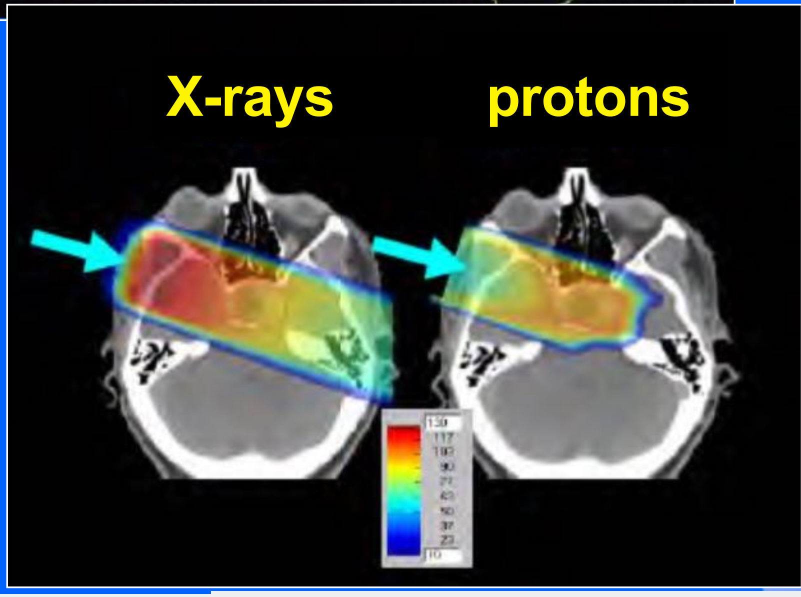

Energy deposition by radiation beams

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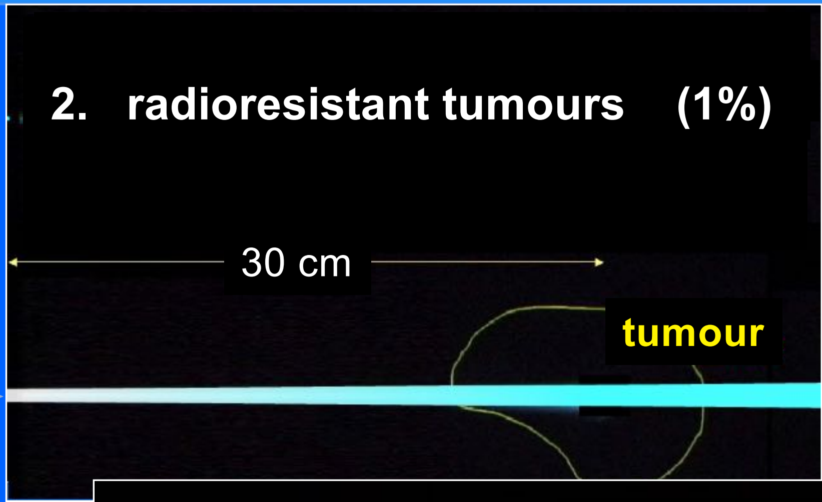
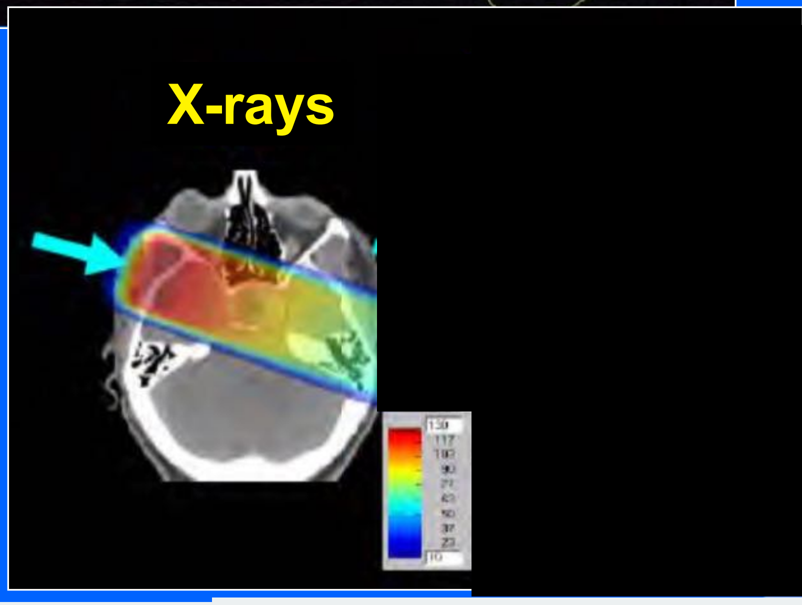


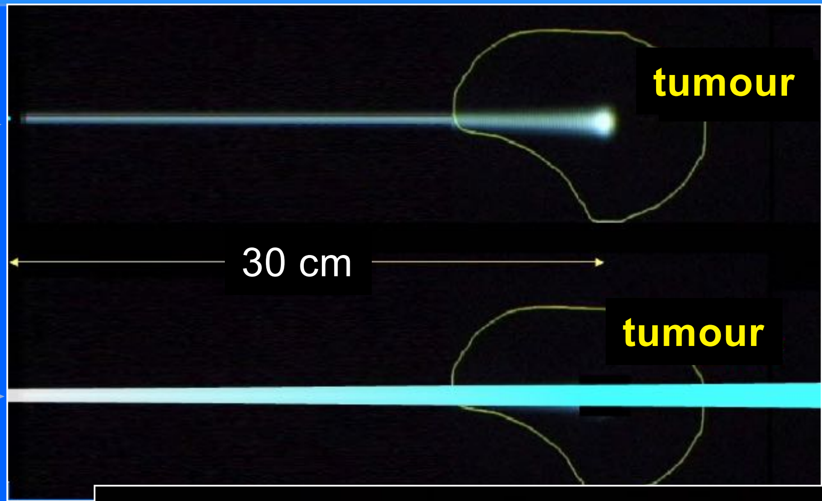
X-rays by
10 MeV electrons



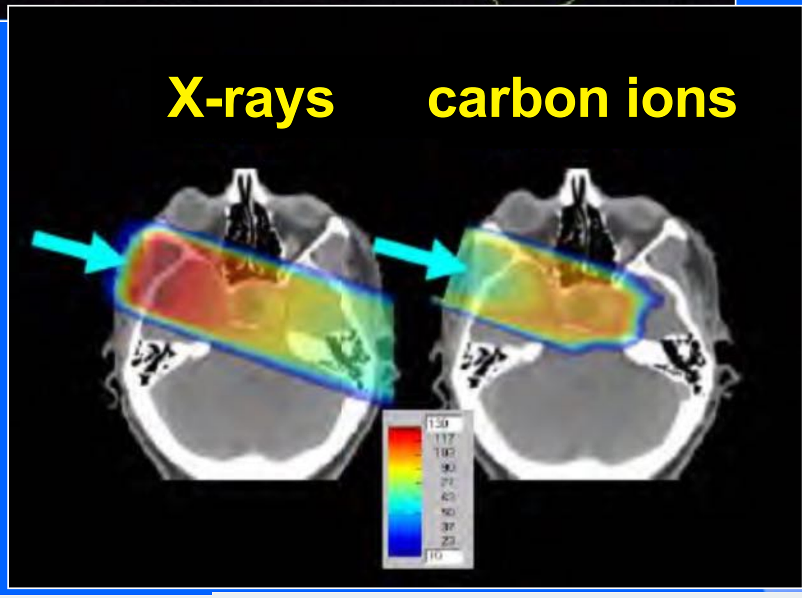
Energy deposition by radiation beams

carbon ions 5000 MeV

X-rays by
10 MeV electrons



30 pts / 1 million



Energy deposition by radiation beams

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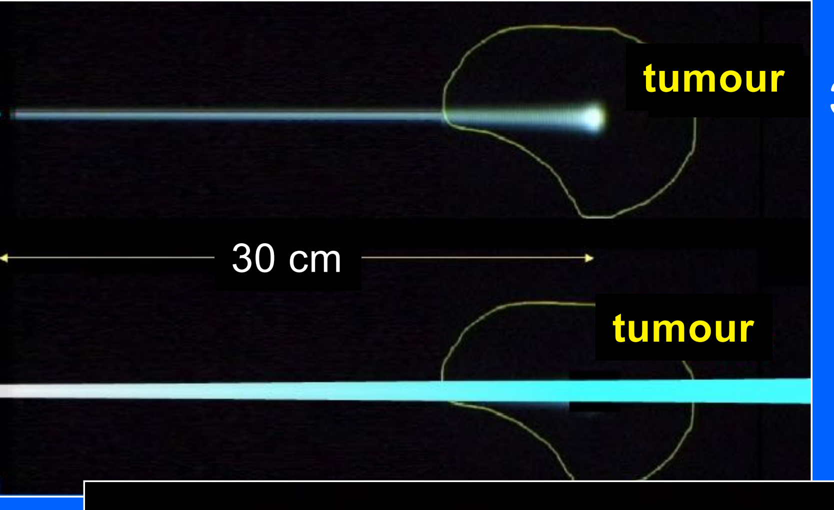

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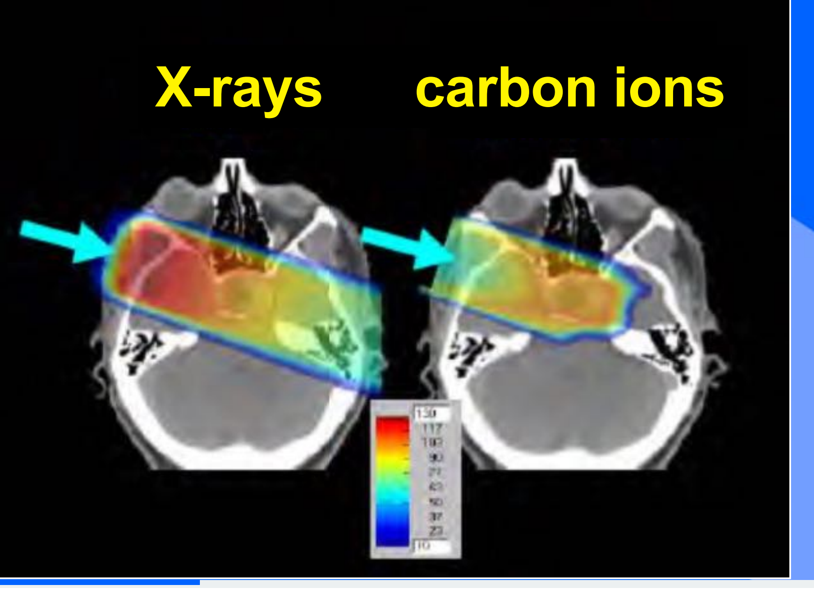

In each traversed cell a C-ion leaves 5000/250 = 25 more energy and strips 25 times more electrons from the molecules it passes through producing in the DNA **multiple double-strand-breaks that are not repaired**

Energy deposition by radiation beams

carbon ions 5000 MeV

X-rays by
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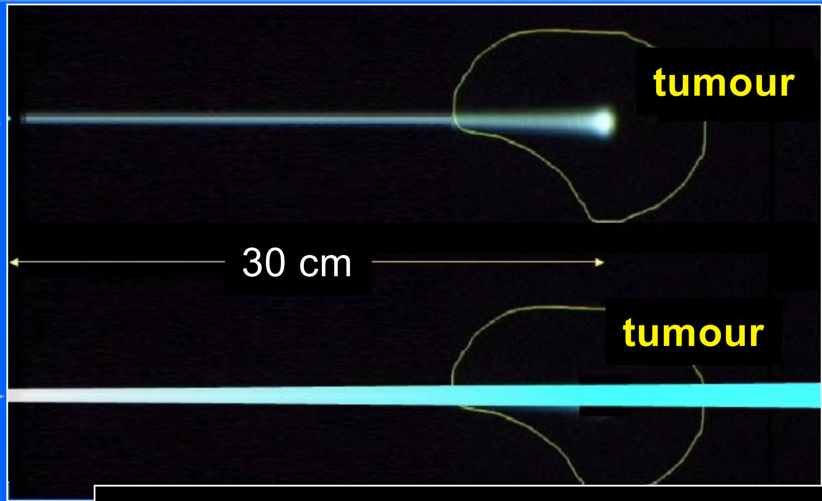

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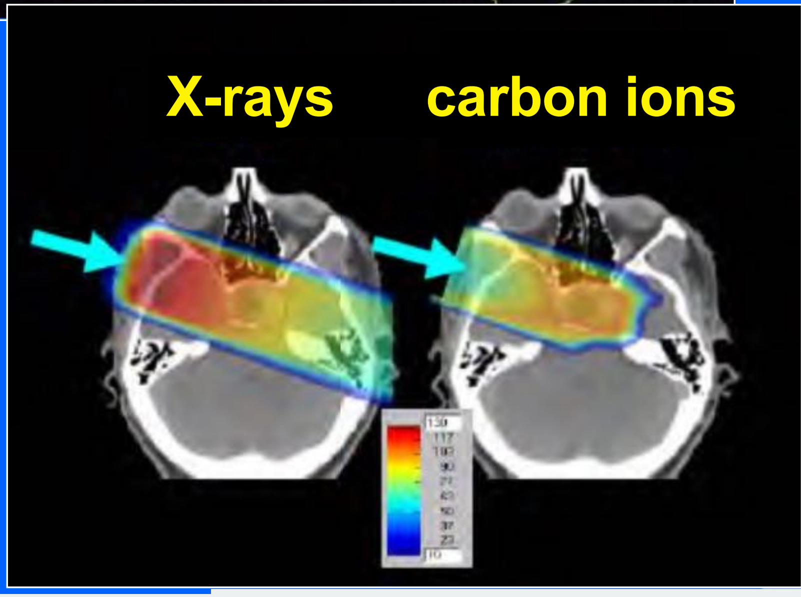

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Thus C-ions can control radioresistant tumours

Carbon ions are a DIFFERENT type of radiation with respect to X-rays and protons

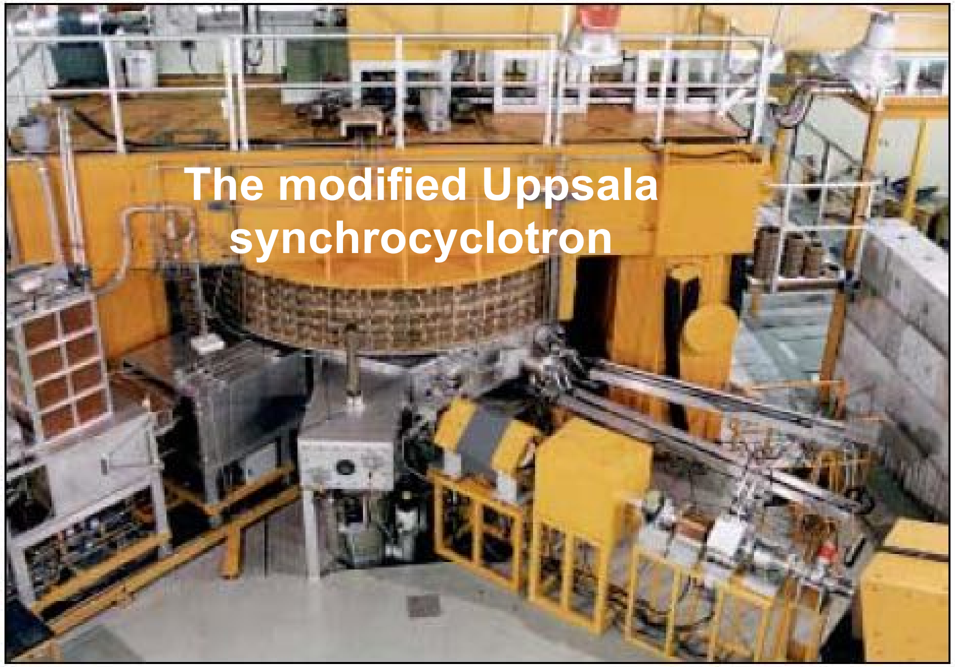
The 184-inch cyclotron - 1946

Cornelius Tobias
1918-2000

At the Berkeley Laboratory

70 years ago: First proton treatment of pituitary glands: 1954
Treatment of pituitary tumors: 1956
1000 patients by the end of the program 1974

Uppsala - 1957

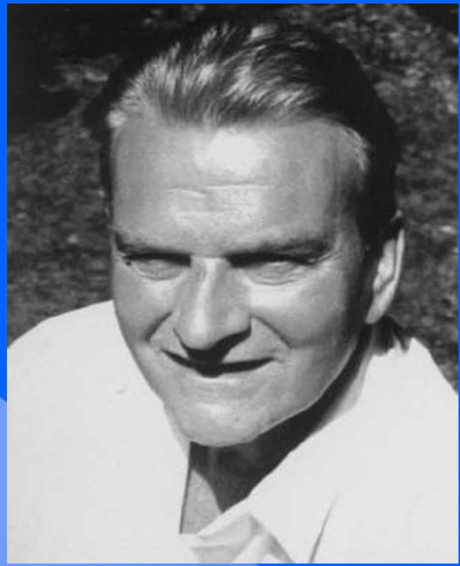


The modified Uppsala synchrocyclotron

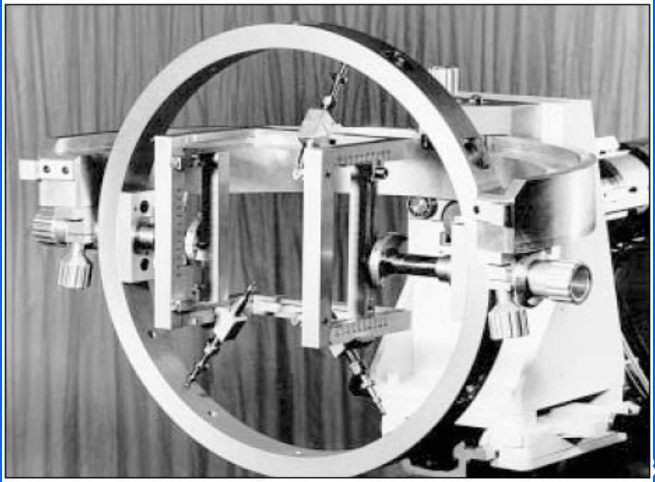
Bőrje Larsson

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

Uppsala - Doctoral dissertation - 1962



(1931-1998)



Alignment system for the treatment of head tumours with 185 MeV protons

The new Harvard cyclotron in 1949

Designed by 'Bob' Wilson who after the war became Associate professor at Harvard

(L) Dr. Lee Davenport (R) Dr. Norman Ramsey
June 10 1949

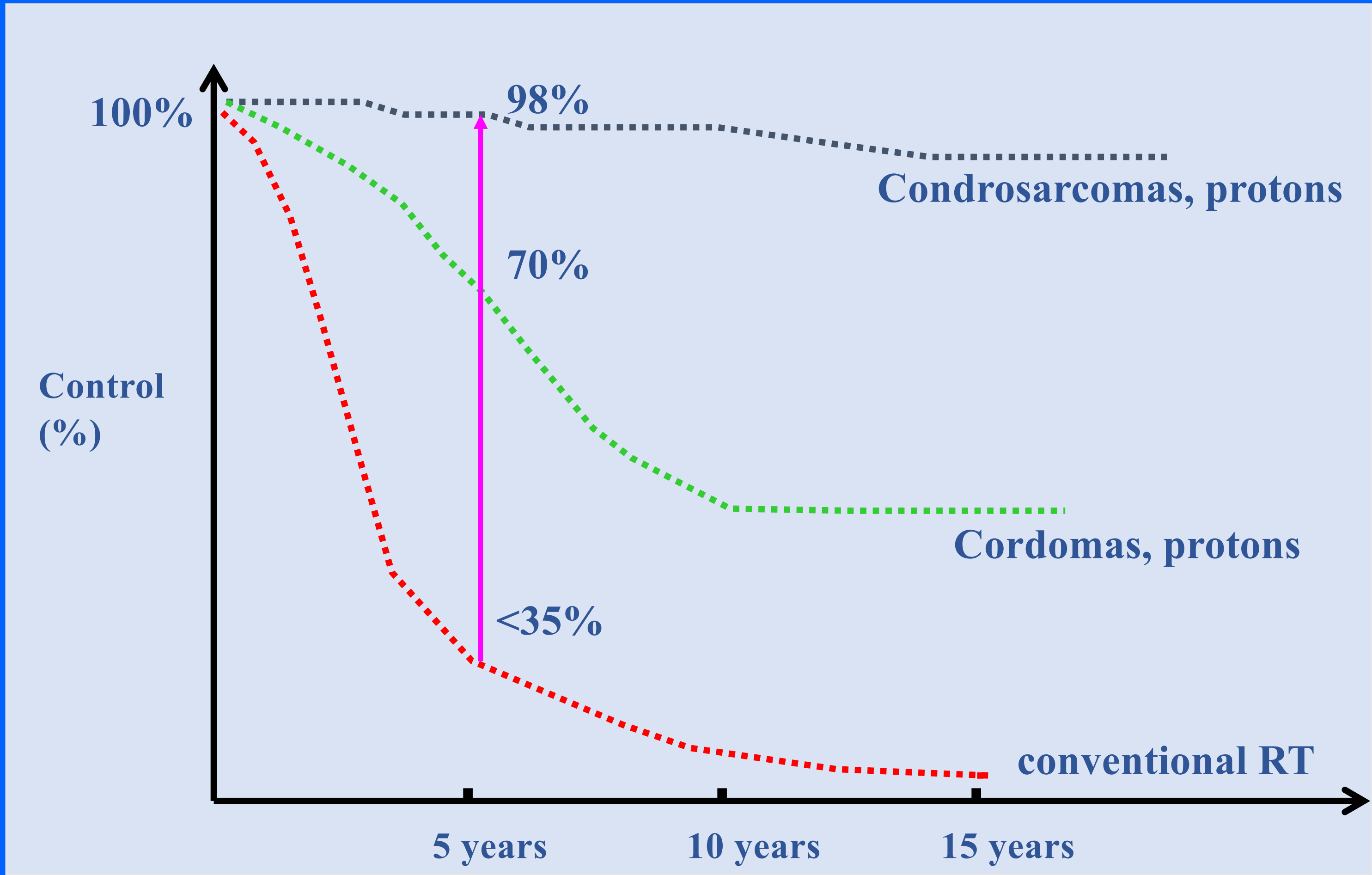
The three programs at the Harvard cyclotron

Neurosurgery for intercranial lesions (AVMs)
(3,687 patients)
Neurosurgery Dept. of MGH
Raymond N. Kjilberg, Bernard Kliman

Eye tumors
(2,979 patients)
Massachusetts Eye and Ear Hospital.
Ian Constable, Evangelos Gragoudas

Large tumors
(2,449 patients)
Radiation Medicine Dept of MGH
Herman Suit, Michael Goitein,Joel Tepper, Lynn Verhey

The important results obtained by the MGH-Harvard group



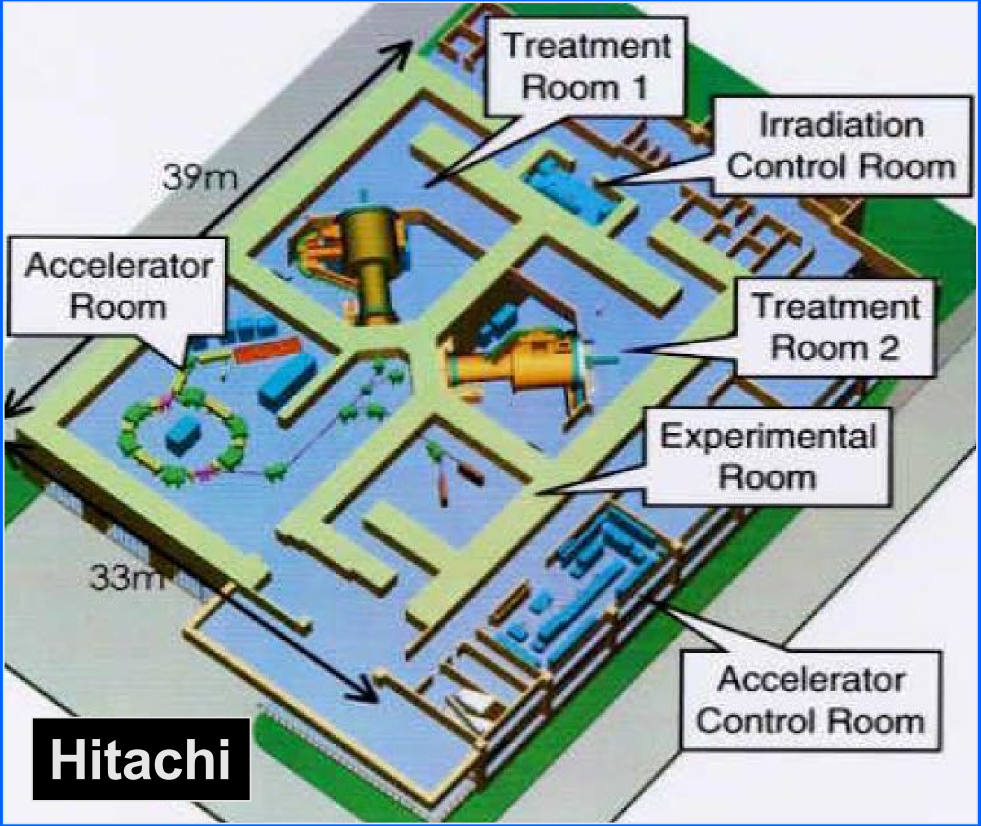
30 years of pioneering proton therapy in physics labs

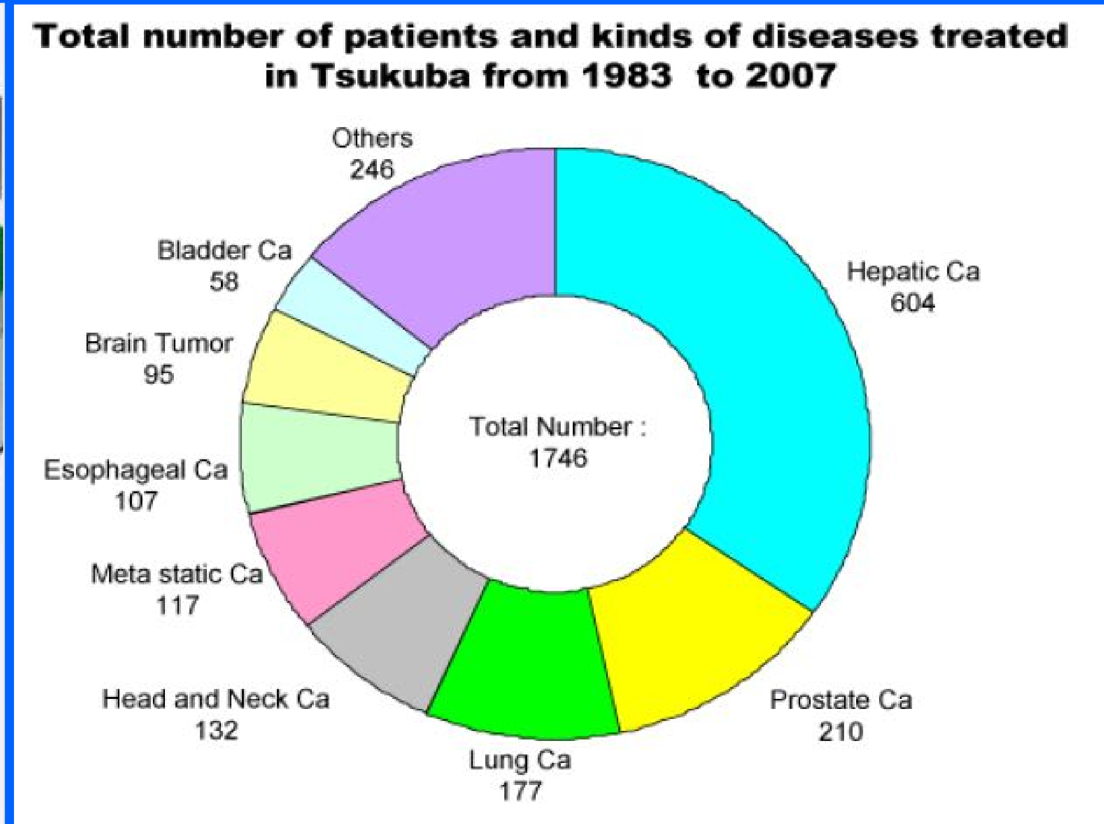
Lawrence Berkeley Laboratory	USA	1954
Uppsala	Sweden	1957
Harvard Cyclotron Laboratory (*)	USA	1961
Dubna (JINR)	Russia	1964
Moscow	Russia	1969
St. Petersburg	Russia	1975
Chiba	Japan	1979
Tsukuba (KEK)	Japan	1983
Paul Scherrer Institute	Switzerland	1984

(*) 9,115 patients were treated with protons before the laboratory closed in 2002

University of Tzukuba treatments

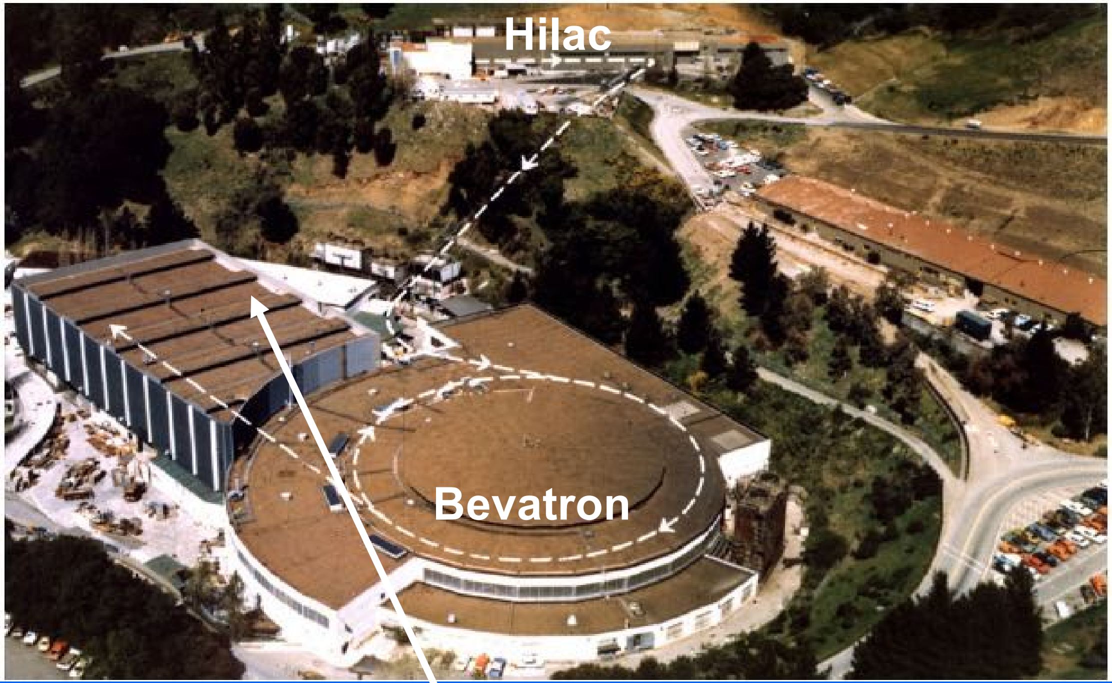
1983 - 2000 : 700 patients treated at the KEK synchrotron
2000 - 2007: 1046 patients treated at PMRC , close to University Hospital

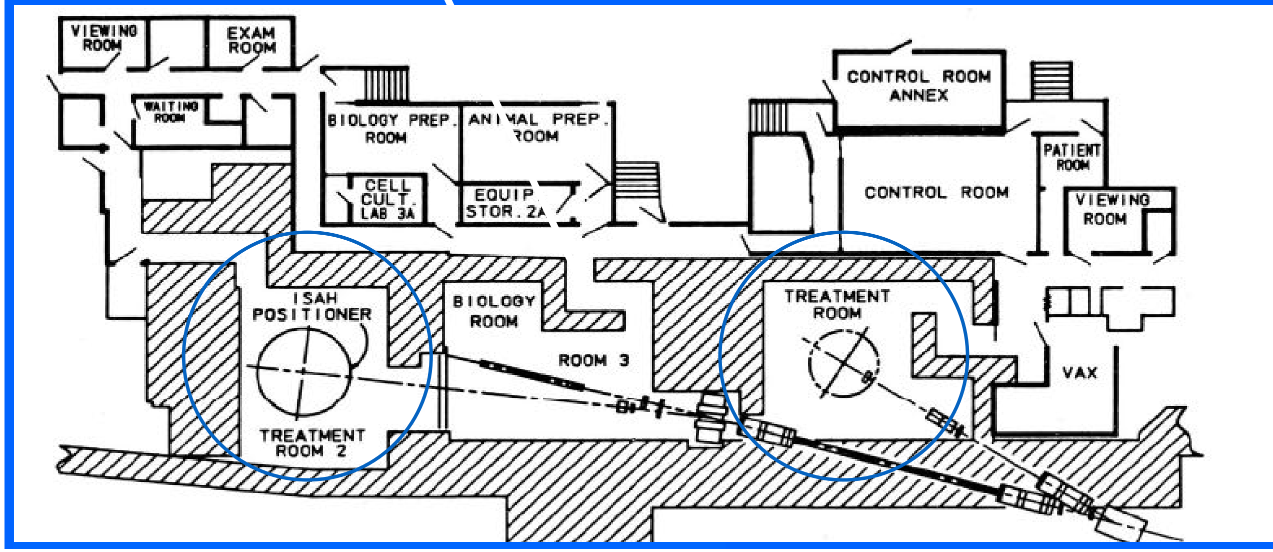




Light ion therapy at the Lawrence Radiation Laboratory

Berkeley Bevalac: 1975-92





The linac HILAC injects ions in the Bevatron, which produces high-current beams of all ions

1992
Clinical treatments end with the closure of the Bevatron

About 1,000 patients had been treated in the period 1975-1992

TERA

New techniques of light ion therapy in Berkeley

The seminal work done at Berkeley on light ions

"Cornelius Tobias, Joseph Castro (UC San Francisco) and colls.
used beams of helium ions 700 patients
neon ions 300 patients
revealing both physical and biological characteristics favourable to eradicating hypoxic, radioresistant tumour cells at deep locations in the body, while sparing radiation damage to overlying normal tissues"

Eleanor Blakeley, Lawrence Radiation Laboratory

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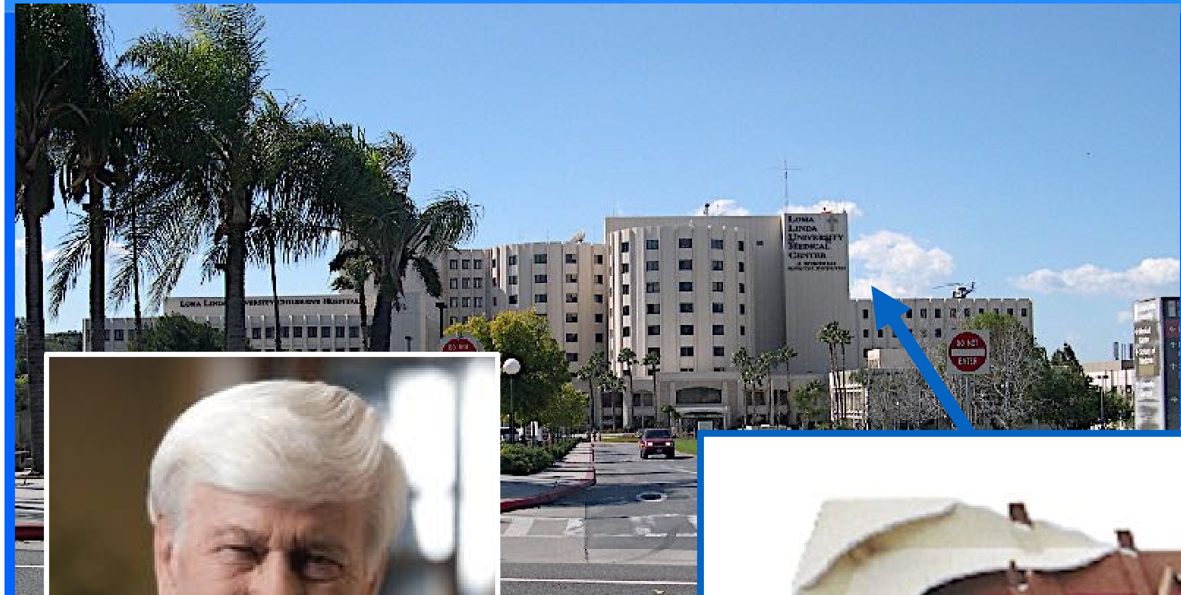
Eleanor Blakeley, Lawrence Radiation Laboratory

It was found that the neon ions have too large a charge and neon beams are far from optimal

Around 1990 - General consensus: carbon ions are the 'best' compromise

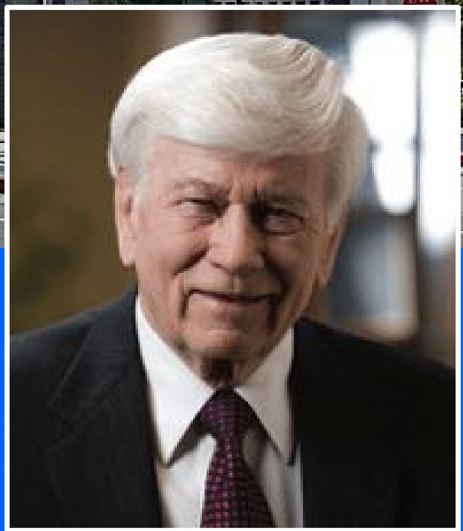
Five crucial years: 1990 – 1994
bracketing the closure of Bevalac in 1992

First hospital centre: Loma Linda University Medical Centre

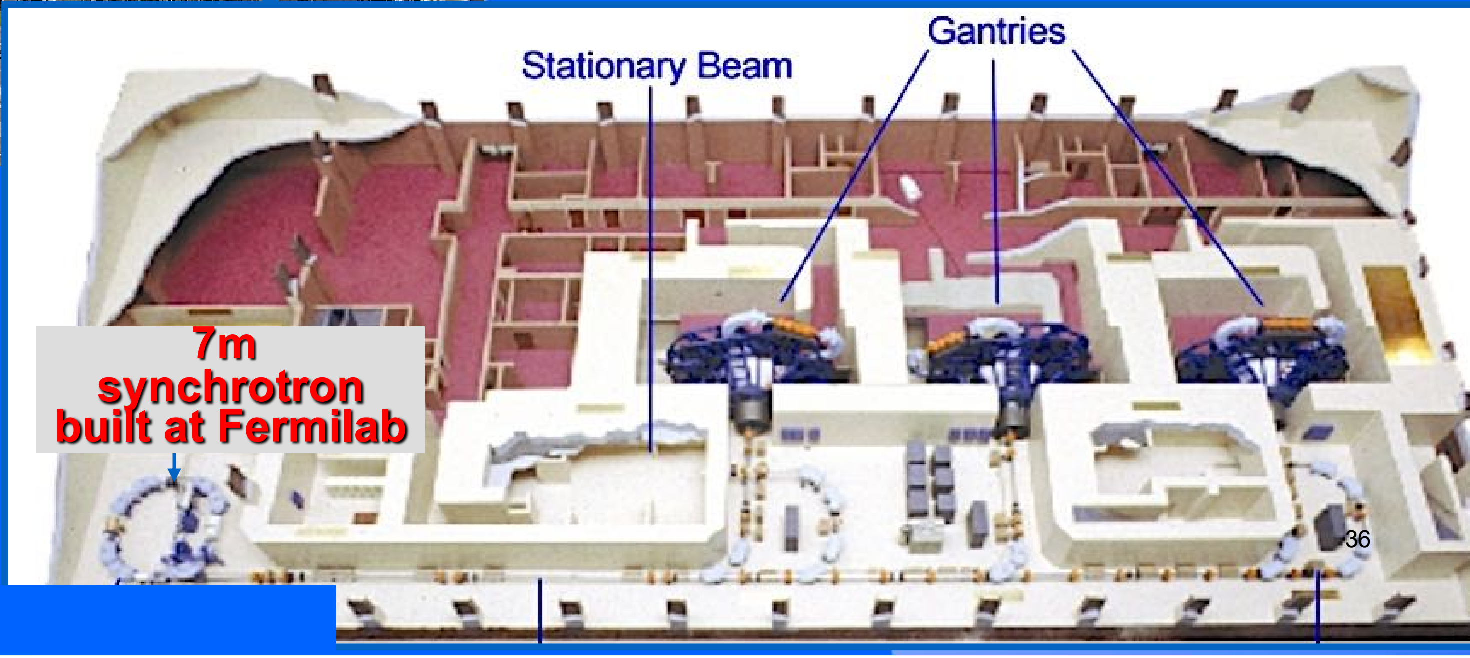


First proton patient: 1990

This date closes the exploratory period of HT



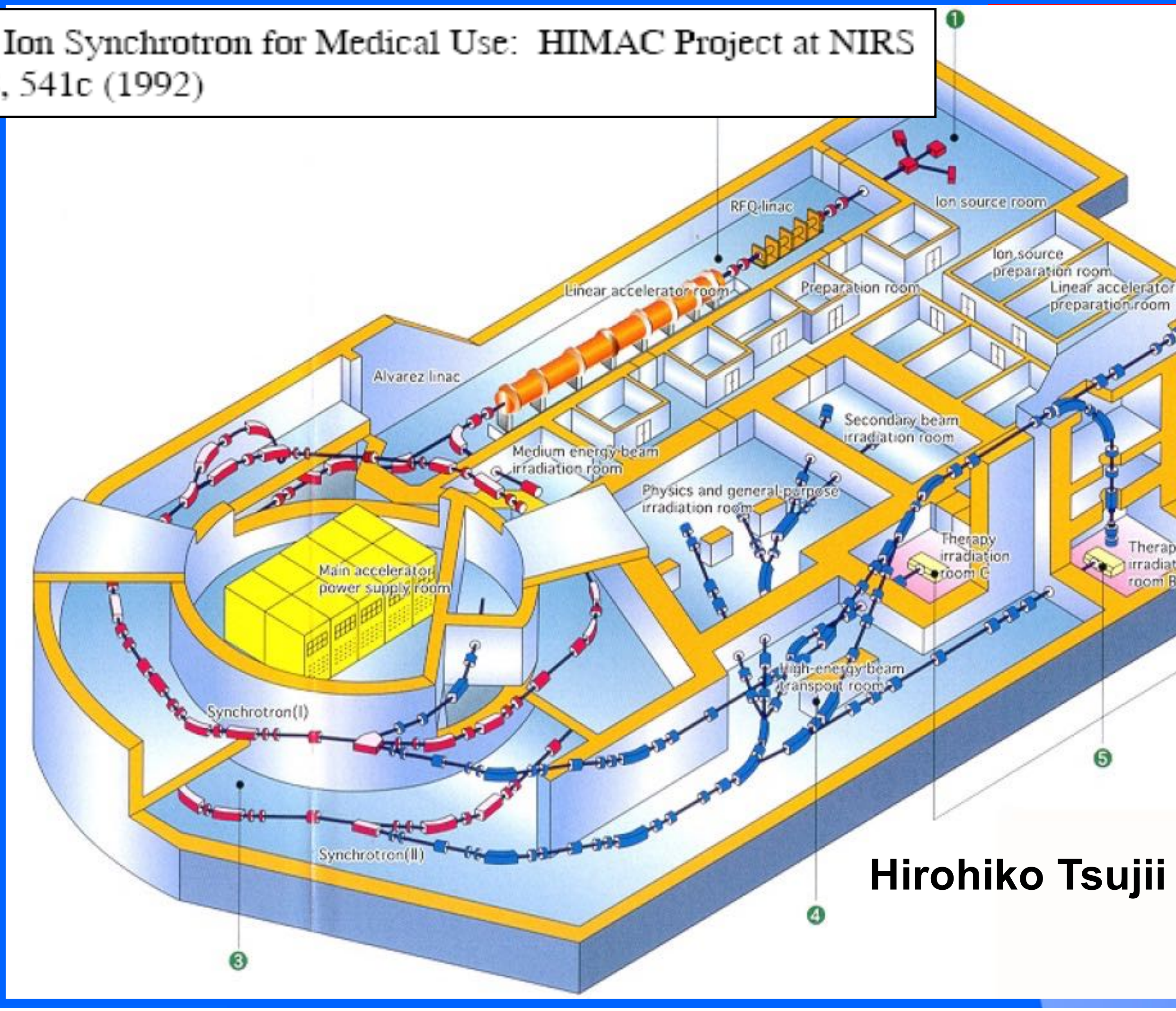
Dr. James M. Slater MD



Heavy Ion Medical Accelerator in Chiba – 1994: 1° pt

[15] Hirao, Y. et al, "Heavy Ion Synchrotron for Medical Use: HIMAC Project at NIRS Japan" Nucl. Phys. A538, 541c (1992)

Yasuo Hirao



Hirohiko Tsujii

The Como International Symposium on Hadrontherapy

1992 – creation in Novara of TERA Foundation

Elio Borgonovi
UniBocconi
Vicepresident

Giampiero Tosi
Board: 92-96

Gaudenzio Vanolo
Secretary General

MAIN PURPOSE

DESIGN AND CONSTRUCTION OF
Centro Nazionale di Adroterapia Oncologica

Roberto Orecchia

TERA 91/ 1 GEN 1
25 Maggio 1991

Per un Centro di
Teleterapia con Adroni

Ugo AMALDI [1] Giampiero TOSI [2]

1 CERN, 1211 Genève 23, Switzerland
2 Università di Milano - Servizio di Fisica Sanitaria - Ospedale Niguarda Ca Granda - Piazza Ospedale Maggiore, 3 - 20166 Milano - Italy

The First International Symposium on Hadron therapy

End of 1992 U.A. visit B. Larsson (professor at ETHZ and responsible of medical physics at PSA) in Villigen initiating a long collaboration with PSI

From fall 1992 Organization of an International conference on HT with Refereed Proceedings

A NOVELTY FOR THIS FIELD

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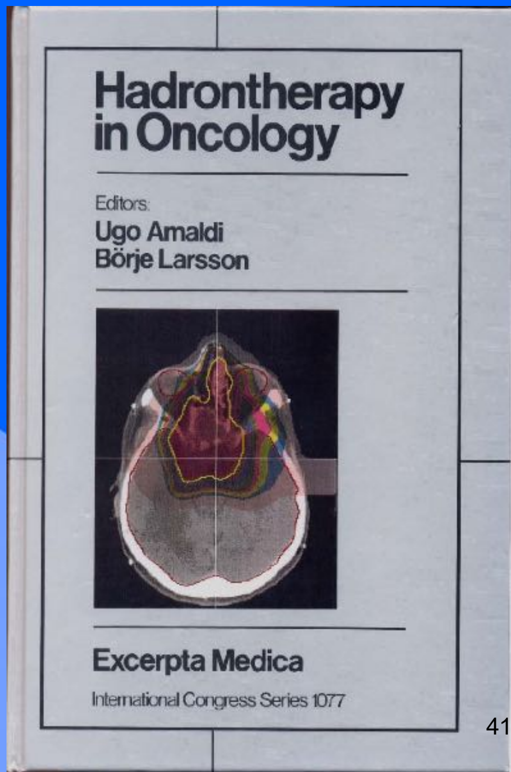
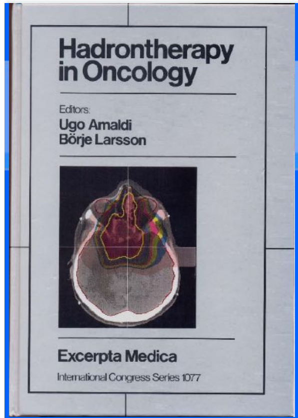
A NOVELTY FOR THIS FIELD

Proceedings of the First International Symposium on Hadrontherapy, Como, Italy, 18–21 October 1993

All the actors were present from USA, Japan and Europe

Elsevier-1994
750 pages





The IBA room temperature cyclotron

Cyclotron-based protontherapy system including a new design of large throw gantries

Y. Jongen[1], W. Beeckman[1], A. Laisné[1], J.P. Dufour[1], S. Zaremba[1], D. Vandeplassche[1], H. Marie[1], R. Verbruggen[1], T. Satoh[2], N. Tachikawa[2], M. Sano[2], K. Ishii[2] and K. Ohtomo[2]

[1]Ion Beam Applications, Chemin du Cyclotron 2, Louvain-la-Neuve, Belgium; and [2]Sumitomo Heavy Industries, Niihama-city, Japan

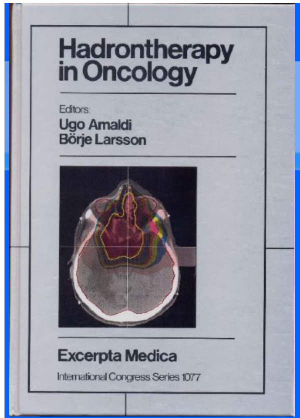
Table 1. Beam characteristics

Energy of the extracted beam	235 MeV
Energy spread (one sigma, optimal tuning)	350 keV
Energy reproducibility (one sigma)	350 keV
Maximum extracted current (continuous)	
— when intentionally hardware-limited	300 nA
— when hardware limits are removed	1500 nA

Table 2. Magnet system

Number of sectors	4
Sector angle at the center	32°
Sector angle at the extraction	62°
Maximum gap height	96 mm
Maximum hill field	2.9 T

MGH special tendering procedure



Michael Goitein:

For the Burr Proton Therapy Center (MGH)

the specifications of the proton beam

and

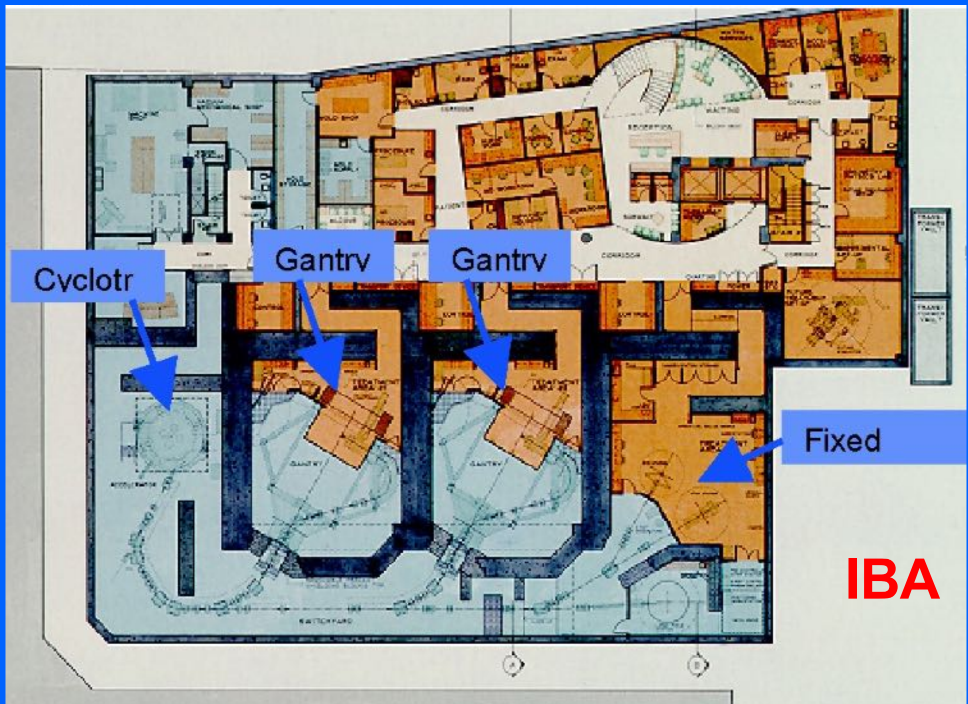
of the treatment field

were given

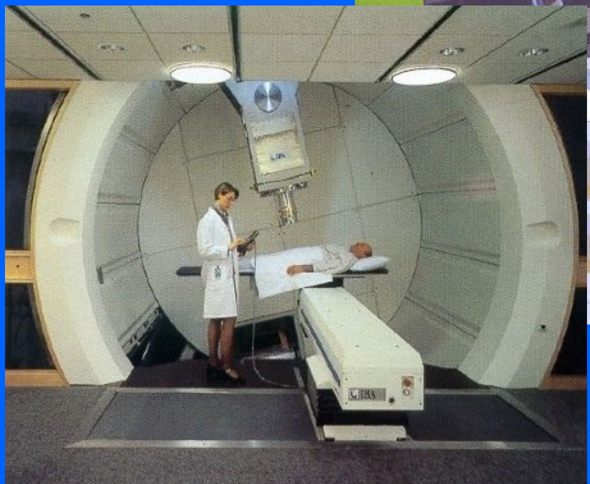
WITHOUT

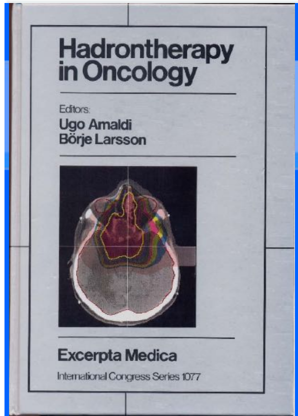
defining the type of accelerator:

Cyclotron/Synchrotron



Later developments: 3-rooms facilities



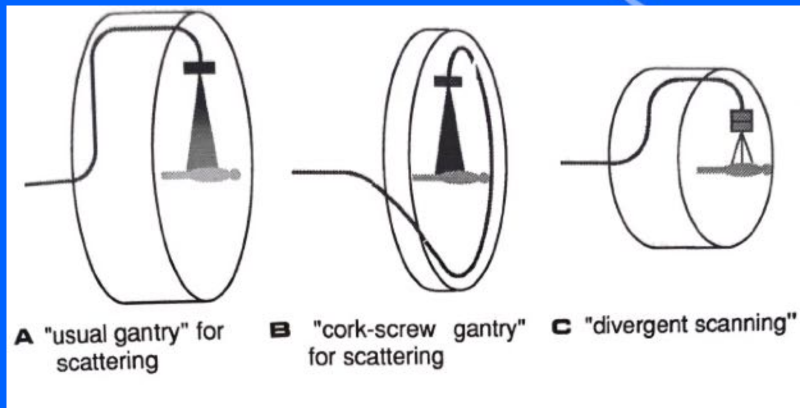


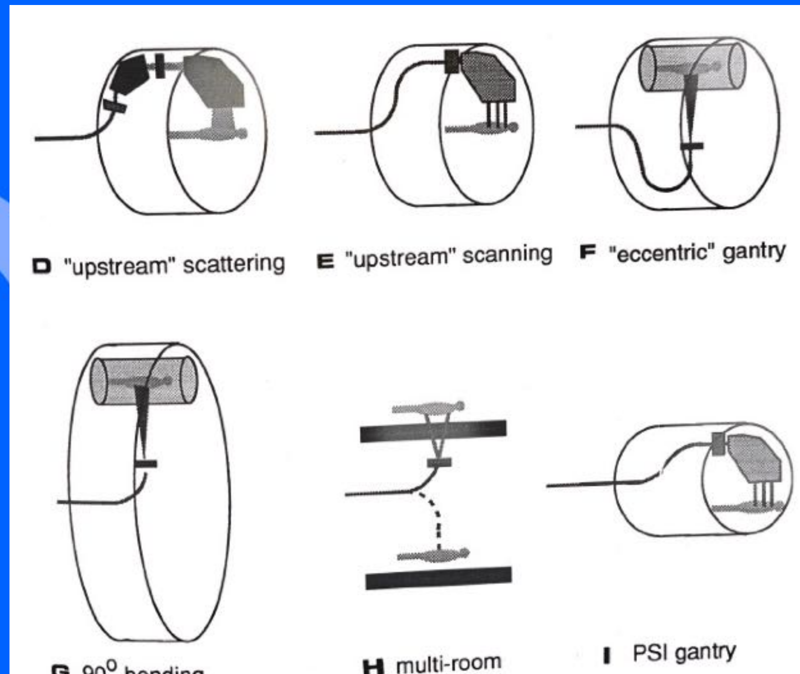
Seminal contribution by Eros Pedroni on p-gantries

Beam delivery

E. Pedroni

Department of Radiation Medicine, Paul Scherrer Institute, Villigen, Switzerland

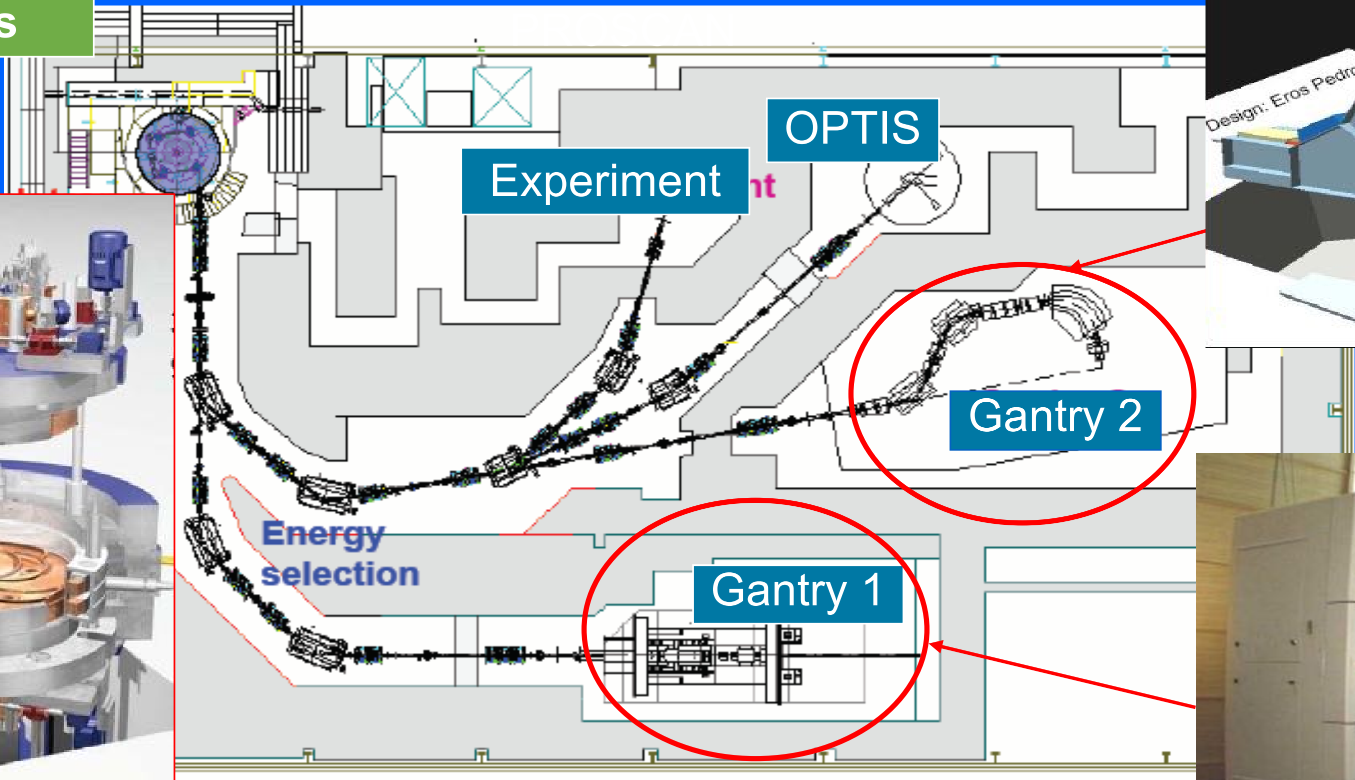


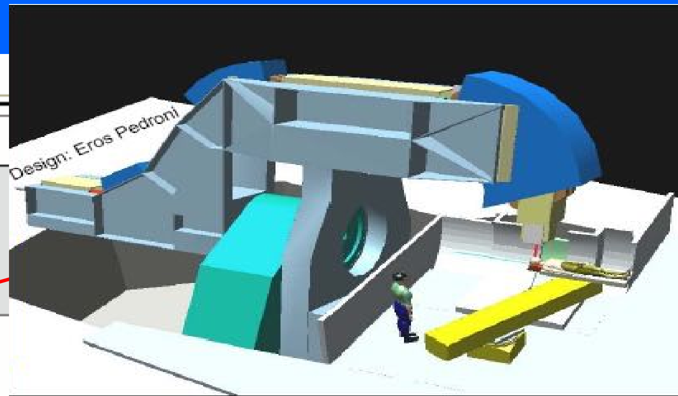


Pedroni's gantries for PSI - Villigen

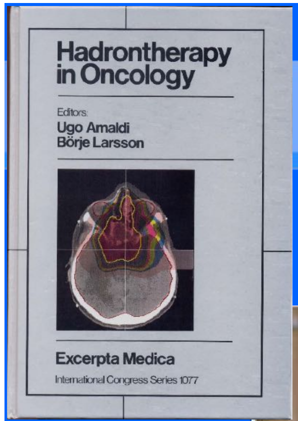
ACCEL
SC cyclotron
250 MeV
protons

→ **VARIAN**

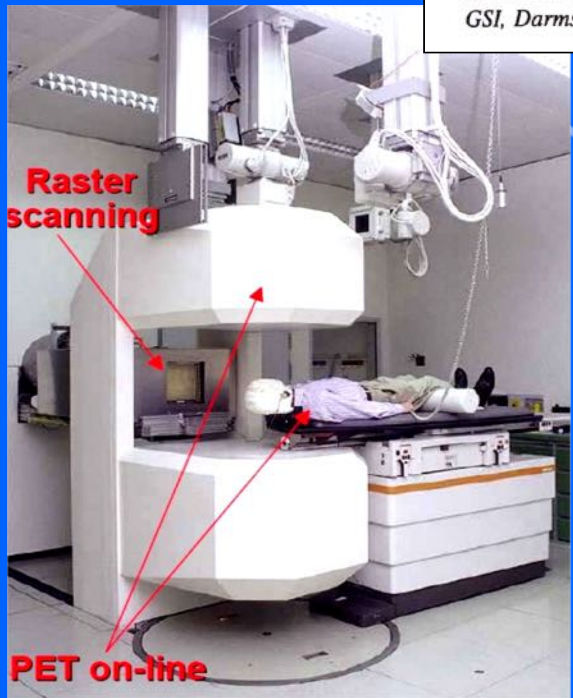




The GSI carbon ion pilot project: 1997-2008



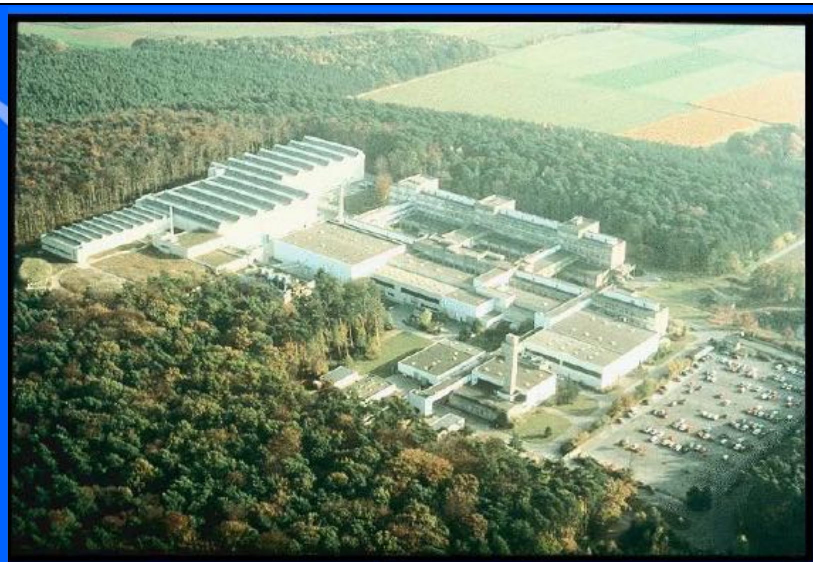
J. Debus



450 patients treated with carbon ions

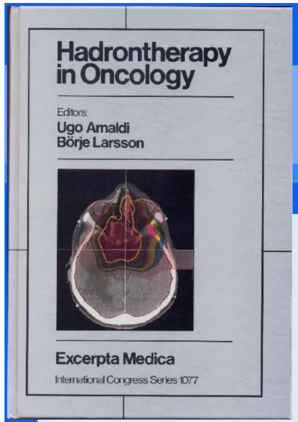
The Darmstadt Program HITAG: heavy ion therapy at GSI

G. Kraft, W. Becher, K. Blasche, D. Böhne, B. Franczak, Th. Haberer, W. Kraft-Weyrather, M. Krämer, B. Langenbeck, G. Lenz, S. Ritter, M. Scholz, D. Schardt, H. Stelzer, P. Strehl and U. Weber
GSI, Darmstadt, Germany



Availability for clinical applications
3 beam time blocks / year
20 days each

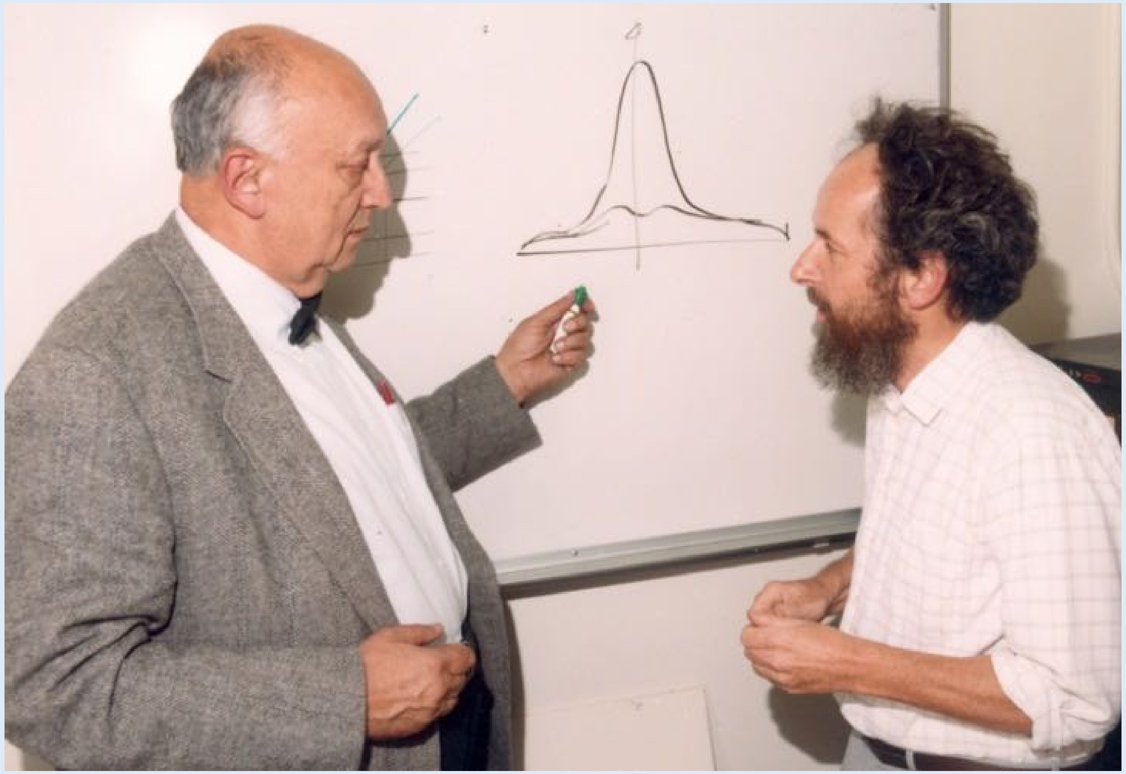
The GSI carbon ion pilot project: 1997-2008



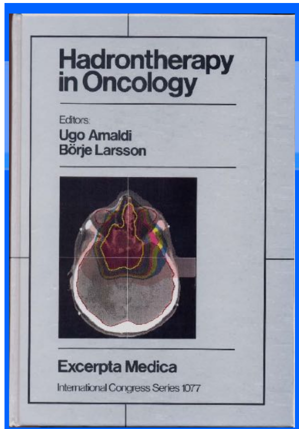
Origin of all GSI-Heidelberg developments

1984

Gerhard Kraft was fellow at the Lawrence Radiation Laboratory



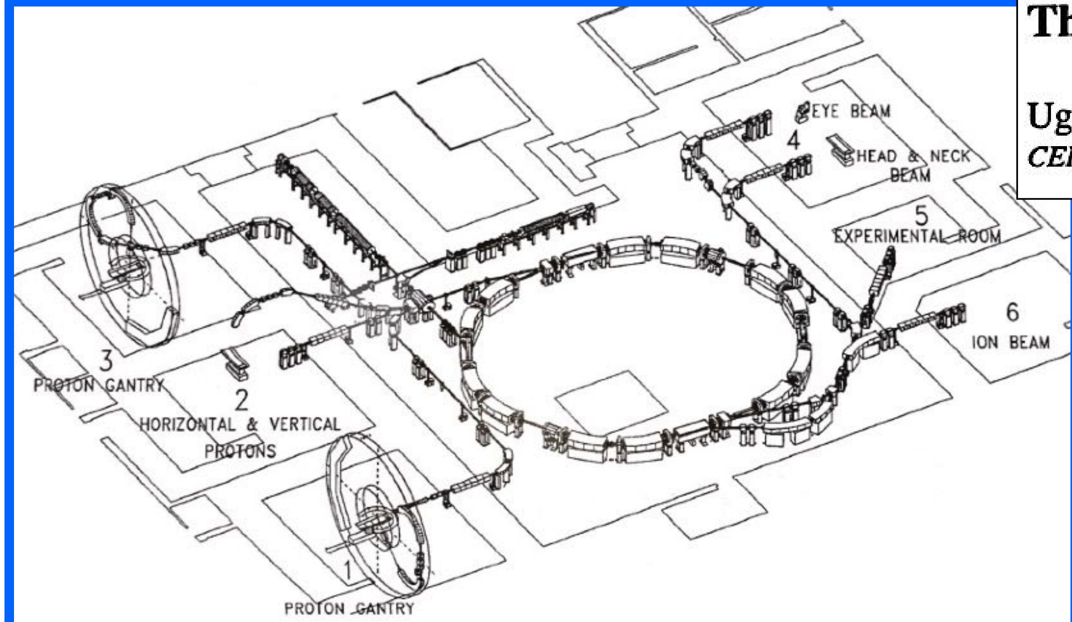
Cornelius Tobias



TERA presentations at the Como Symposium

A hospital-based hadrontherapy facility for Italy

U. Amaldi[1,2], G. Arduini[3], R. Cambria[4], D. Campi[1], C. Canzi[5], F. Gerardi[6], F. Gramatica[4], R. Leone[6], G. Manfredi[7], M. Nonis[8], G. Petrucci[1], S. Rossi[4], L. Sangaletti[6], M. Silari[7], G. Tosi[9], L. Vecchi[6] and M. Weiss[1]

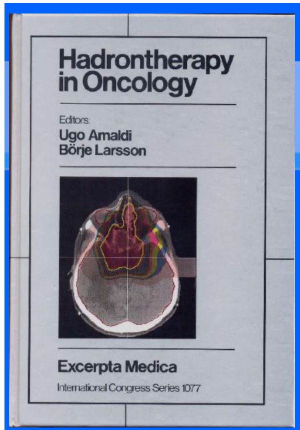


The Italian Hadrontherapy Project

Ugo Amaldi
CERN, Geneva, Switzerland; II Science Faculty, Milan University, Como Seat, Italy

The Italian hadrontherapy accelerator complex

G. Arduini[1], R. Leone[2], R.L. Martin[3], S. Rossi[4] and M. Silari[5]



MedAustron presentation at the Como Symposium

Ion cancer therapy research as part of the AUSTRON project

Ph. Bryant[1], H.D. Kogelnik[2], M. Pavlovic[3], R. Pötter[4], M. Regler[5] and H. Schönauer[6]

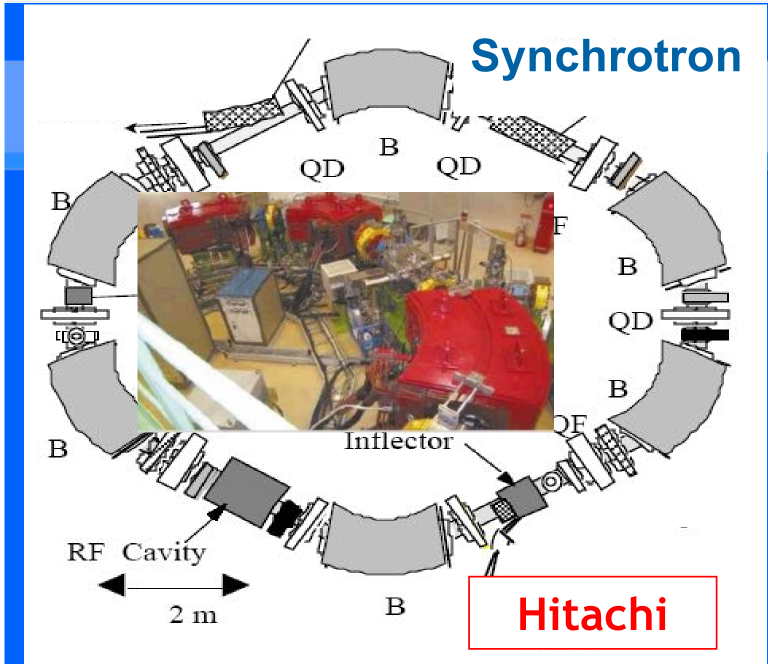
[1]CERN, Geneva, Switzerland (AUSTRON Planning group); [2]Institut für Radiotherapie und Radio-Onkologie, LKA Salzburg, Austria; [3]AUSTRON Planning group (on leave from the Slovak Technical University); [4]Universitätsklinik für Strahlentherapie und Strahlenbiologie, AKH Wien, Austria; [5]AUSTRON Planning group (partially on leave from the Austrian Academy of Sciences); [6]CERN, Geneva, Switzerland

1995-2015: Development of proton therapy

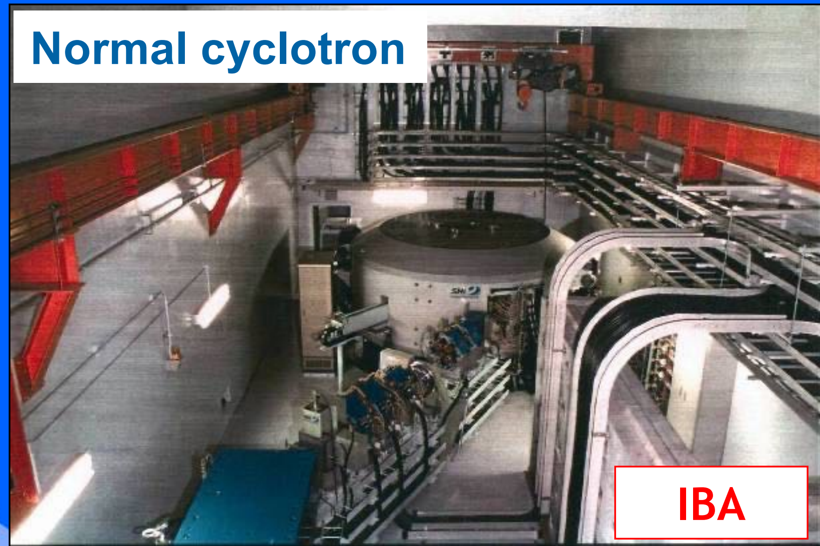
Ten years of tenders: 1994 - 2004

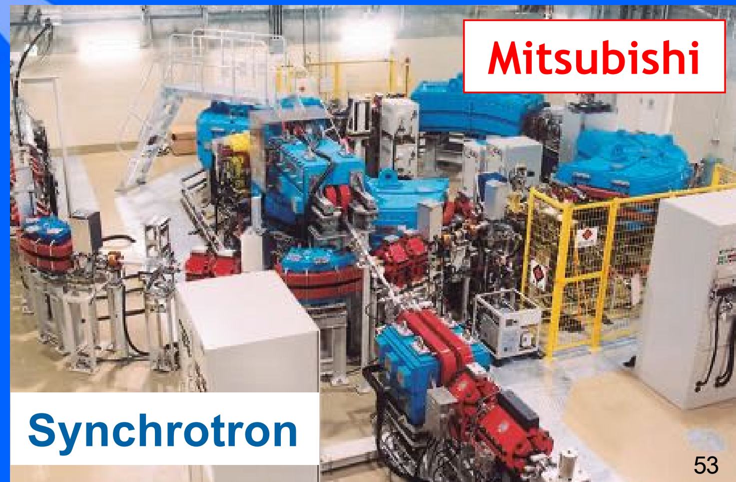
Year	Customer	Provider
1995	MGH, Boston MA, USA	**IBA**
1996	NCC, Kashiwa, Japan	SHI/**IBA**
1996-99	Tsukuba University	Hitachi
	Wakasa Wan Energy Research Center	Hitachi
	Shizuoka Prefecture	Mitsubishi
2001	PSI – Villigen, Switzerland	Accel
	Wanjie Tumor Hospital – Zibo, China	**IBA**
	Chang An PMC – Beijing, China	**IBA**
2002	Rinecker PTC – Munchen, Germany	Accel
	Korean NCC - Seoul	**IBA**
	IUCF (MPRI), Bloomington IN, USA	**IBA**
	M.D. Anderson CC, Houston TX, USA	Hitachi
2004	University of Florida, Jacksonville FL, USA	**IBA**

Ten years of tenders: 1994 - 2004

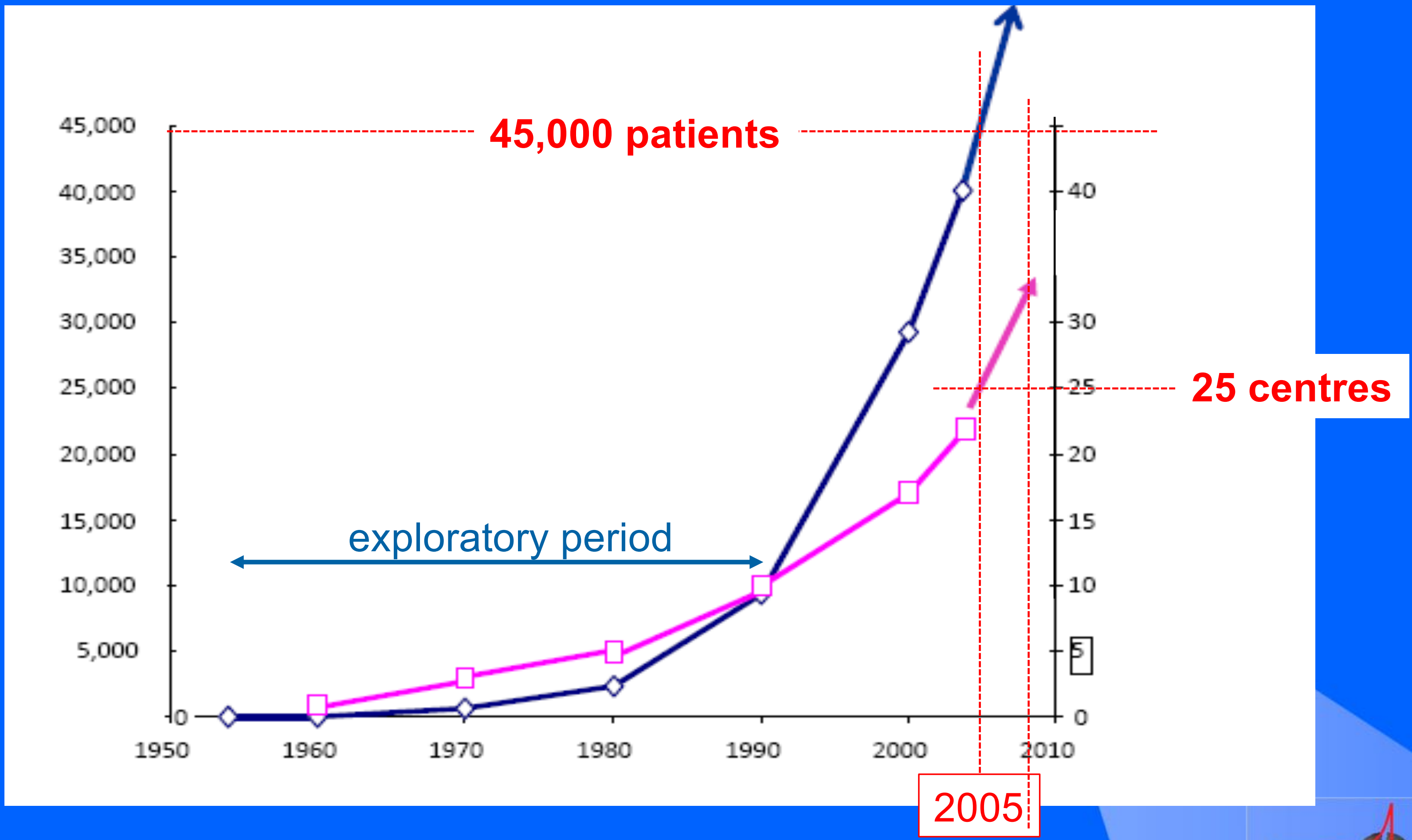


4 commercial 230-250 MeV proton accelerators

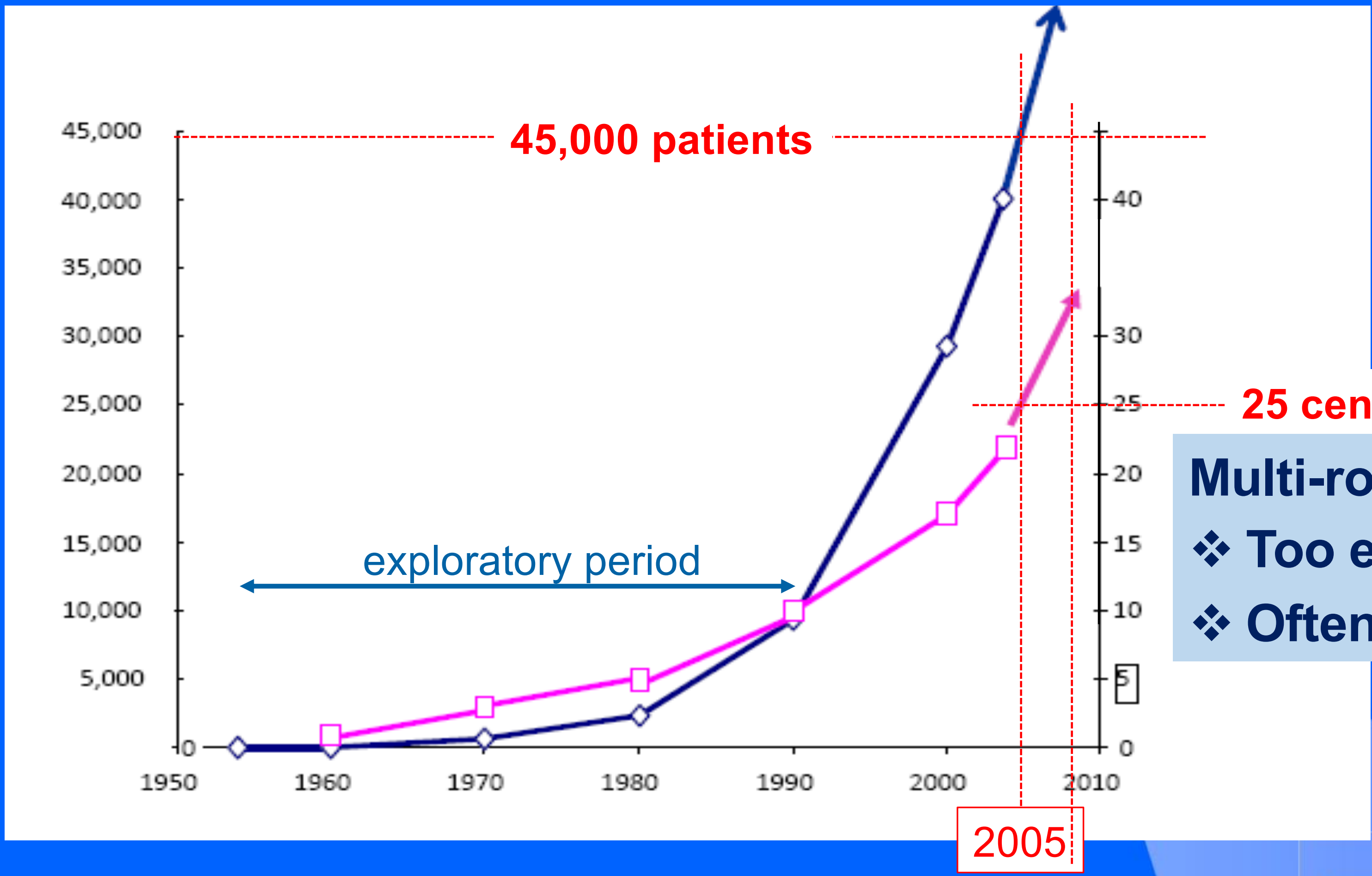




Proton therapy situation in 2005



Proton therapy situation in 2005



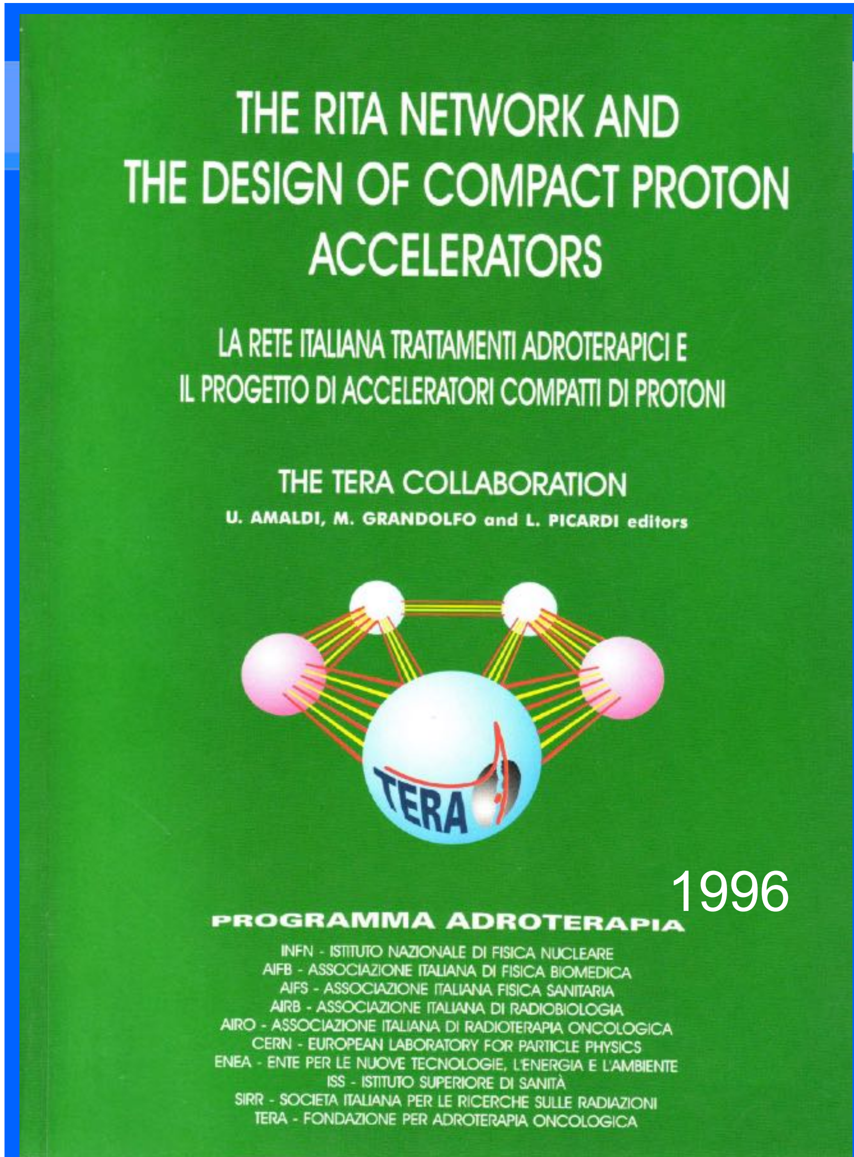
Multi-room facilities

- ❖ **Too expensive**
- ❖ **Often not needed**

TERA

Proton single-room facilities

1996: First IBA single room facility



THE RITA NETWORK AND
THE DESIGN OF COMPACT PROTON
ACCELERATORS

LA RETE ITALIANA TRATTAMENTI ADROTERAPICI E
IL PROGETTO DI ACCELERATORI COMPATTI DI PROTONI

THE TERA COLLABORATION

U. AMALDI, M. GRANDOLFO and L. PICARDI editors

TERA

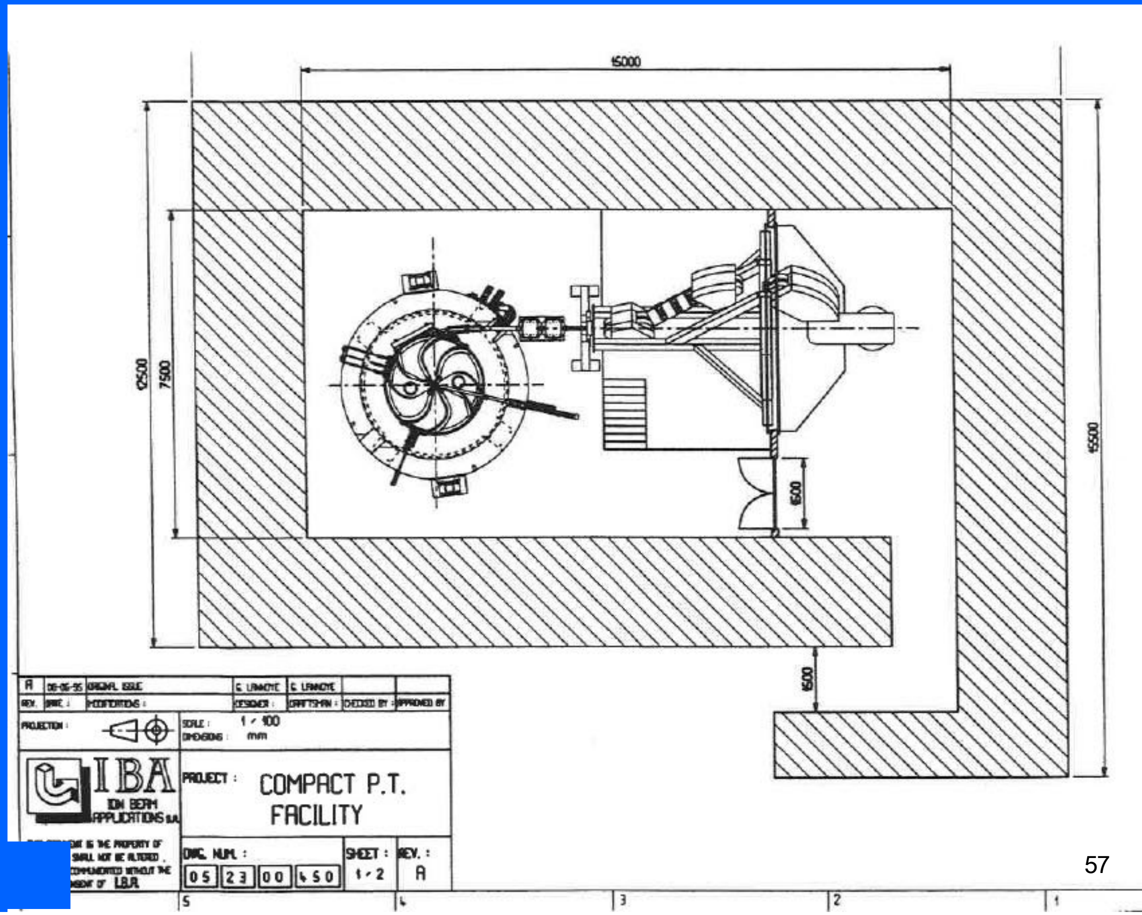
PROGRAMMA ADROTERAPIA

INFN - ISTITUTO NAZIONALE DI FISICA NUCLEARE
AIFB - ASSOCIAZIONE ITALIANA DI FISICA BIOMEDICA
AIFS - ASSOCIAZIONE ITALIANA FISICA SANITARIA
AIRB - ASSOCIAZIONE ITALIANA DI RADIOBIOLOGIA
AIRO - ASSOCIAZIONE ITALIANA DI RADIOTERAPIA ONCOLOGICA
CERN - EUROPEAN LABORATORY FOR PARTICLE PHYSICS
ENEA - ENTE PER LE NUOVE TECNOLOGIE, L'ENERGIA E L'AMBIENTE
ISS - ISTITUTO SUPERIORE DI SANITÀ
SIRR - SOCIETA ITALIANA PER LE RICERCHE SULLE RADIAZIONI
TERA - FONDAZIONE PER ADROTERAPIA ONCOLOGICA

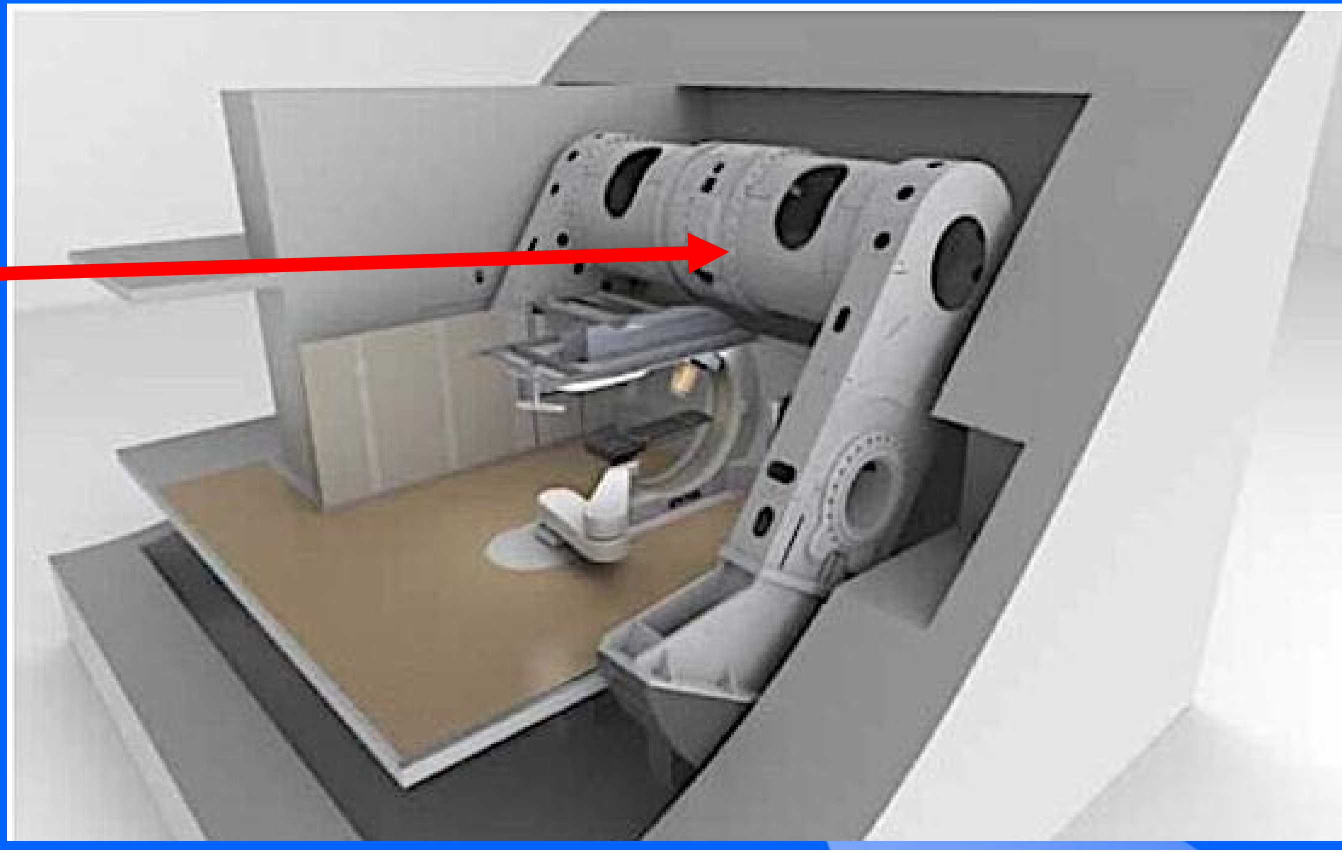
1996

THE IBA CYCLOTRON–BASED SYSTEM

P.Cohilis[1], Y. Jongen[1],



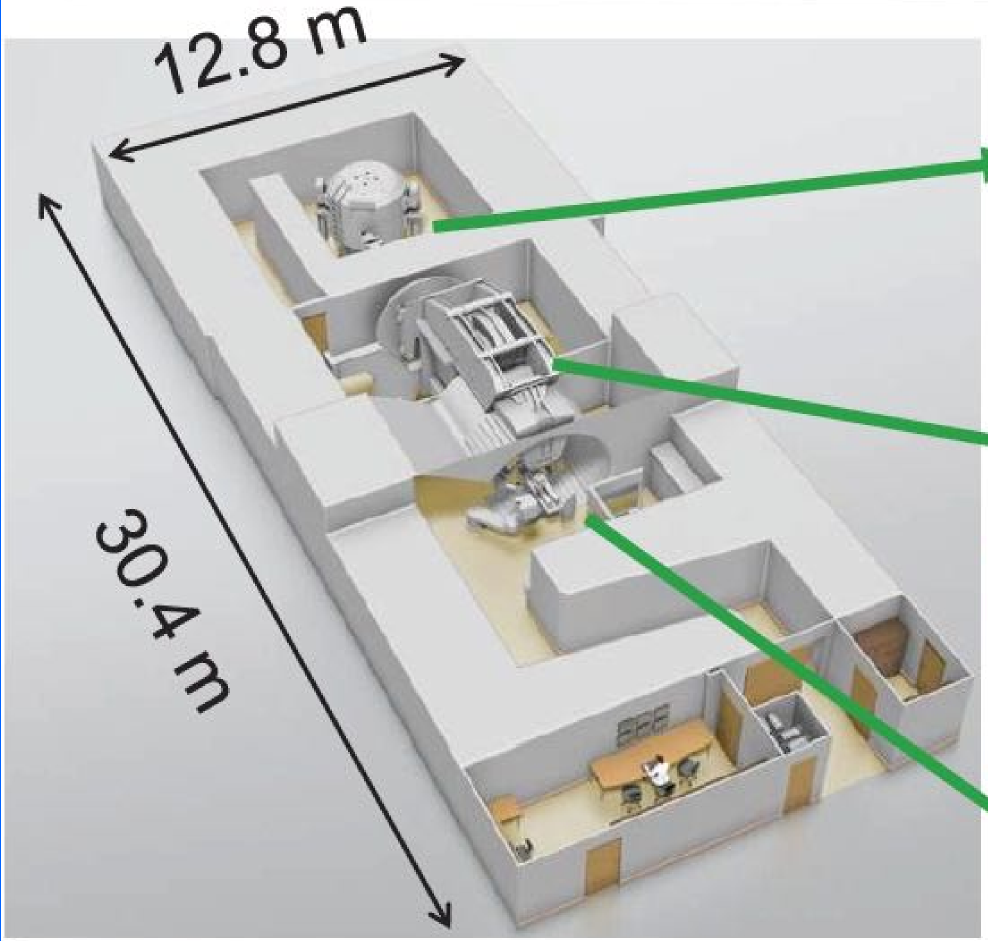
MeVion single-room facility

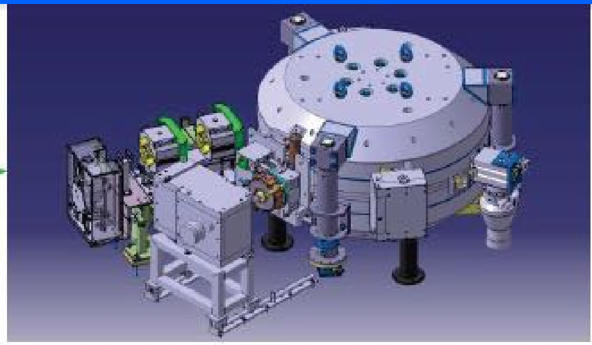


Very high field: 7 tesla

In 2013, the first compact proton therapy system, the MEVION S250, began to treat cancer patients in St. Louis, MO

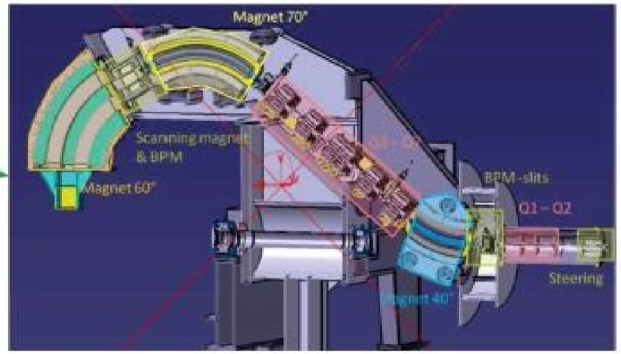
IBA single room facility: Proteus One





Synchrocyclotron with superconducting coil: S2C2

New Compact Gantry for pencil beam scanning



Patient treatment room

2015 - The components of ProteusONE tested in Nice

TUP07 Proceedings of Cyclotrons2016, Zurich, Switzerland

COMMISSIONING AND TESTING OF THE FIRST IBA S2C2

S. Henrotin*, M. Abs, E. Forton, Y. Jongen, W. Kleeven, J. Van de Walle and P. Verbruggen
Ion Beam Applications, Louvain-la-Neuve, Belgium

Abstract

The first unit of the IBA superconducting synchrocyclotron (S2C2), used in the Proteus®ONE compact proton therapy solution, has been installed and commissioned in Nice.

Centre Antoine Lacassagne

Table 1: S2C2/Proteus®ONE Main Properties and Key Figures

Nominal beam energy	230 MeV
Max. clinical charge at isocenter	4.5 pC
Energy spread at nominal energy	≈400 keV
Pulse repetition rate	1 kHz
Pulse duration	10 μs
RF frequency range	60-90 MHz

IBA and Toshiba sign a Partnership in Particle Therapy

9 Apr, 2015

Collaboration signed to enhance access to proton therapy and carbon therapy worldwide

Toshiba Medical Systems Corporation to become IBA's Proteus®ONE distributor in Japan

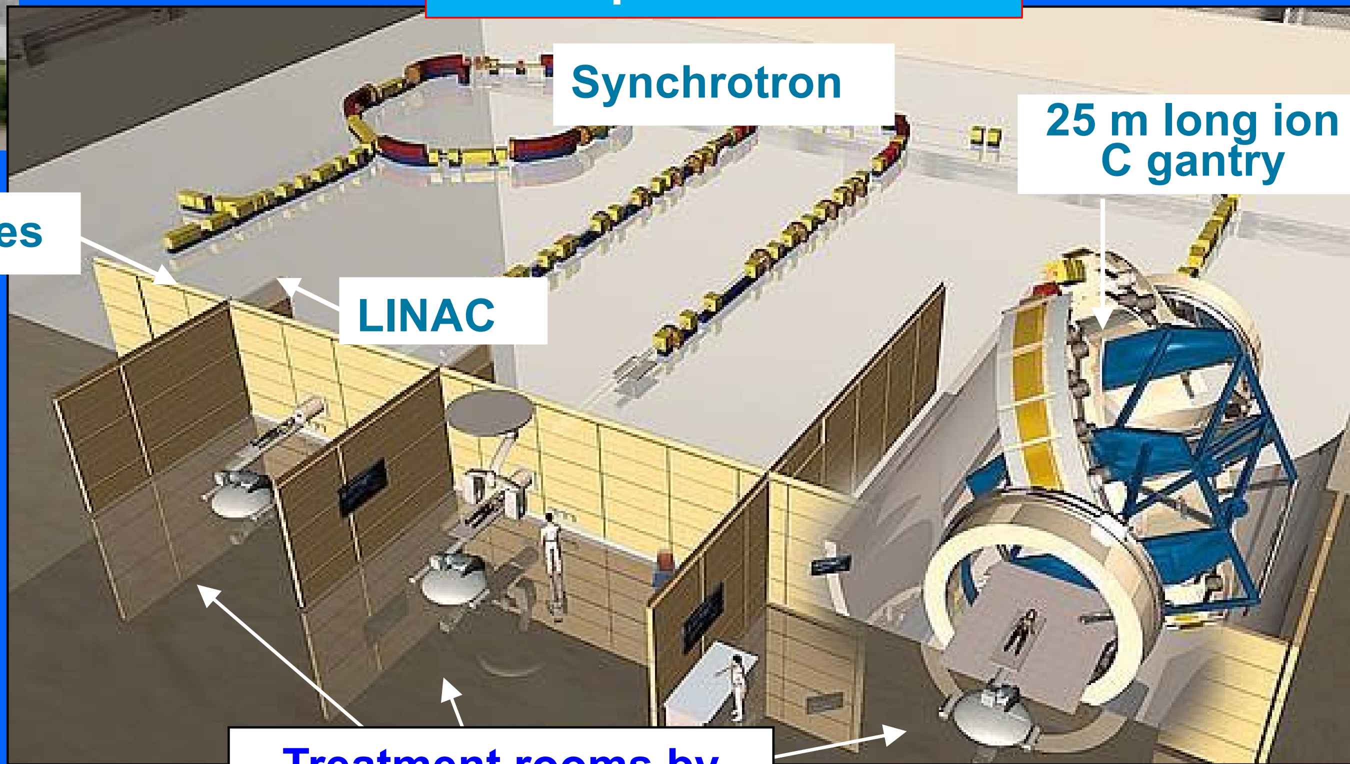
IBA to become Toshiba's carbon therapy agent outside of Japan

1995-2015: development of carbon ion therapy

Development of the pilot project: HIT

Beginning of the construction: 2004

First patient in 2009

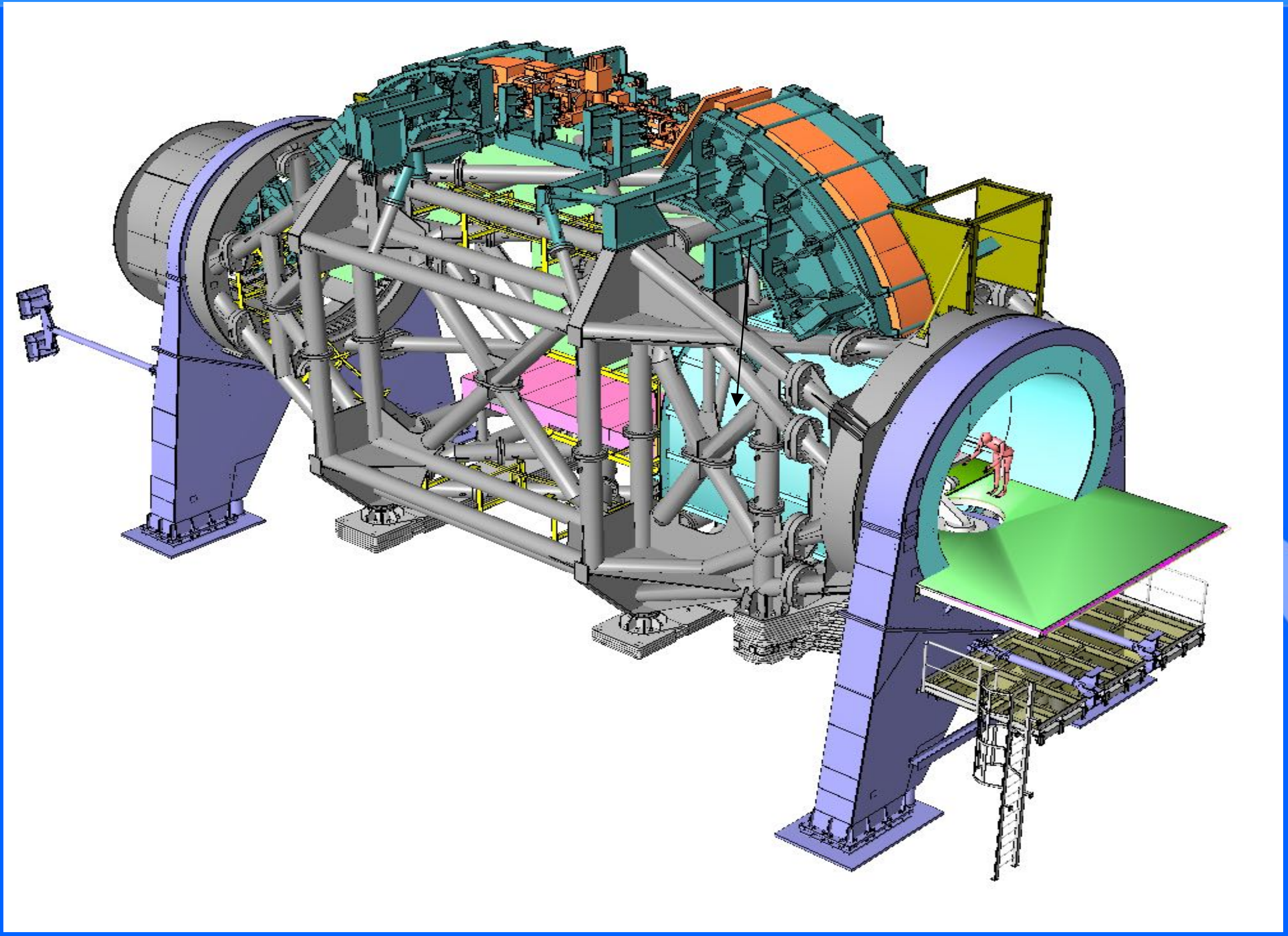


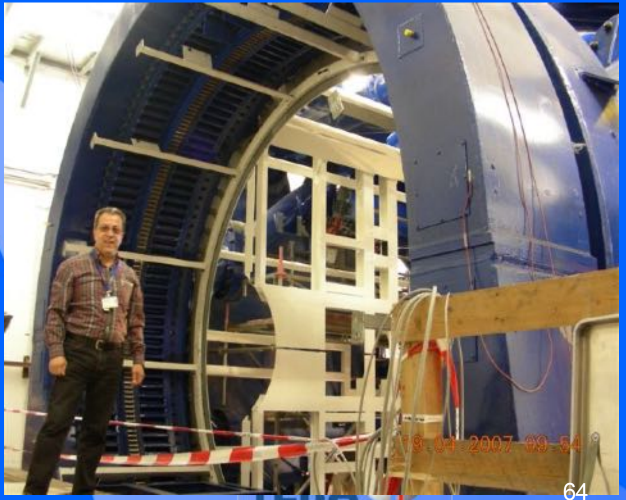
Project by GSI – Darmstadt

Technical Director
Thomas Haberer

Medical Directoir
Jurgen Debus

HIT: first carbon ion gantry: 25 m, 600 tons and 400 kW





In 1995 U.A. and M. Regler convinced CERN to start PIMMS

M. Regler

Proton Ion Medical Machine Study

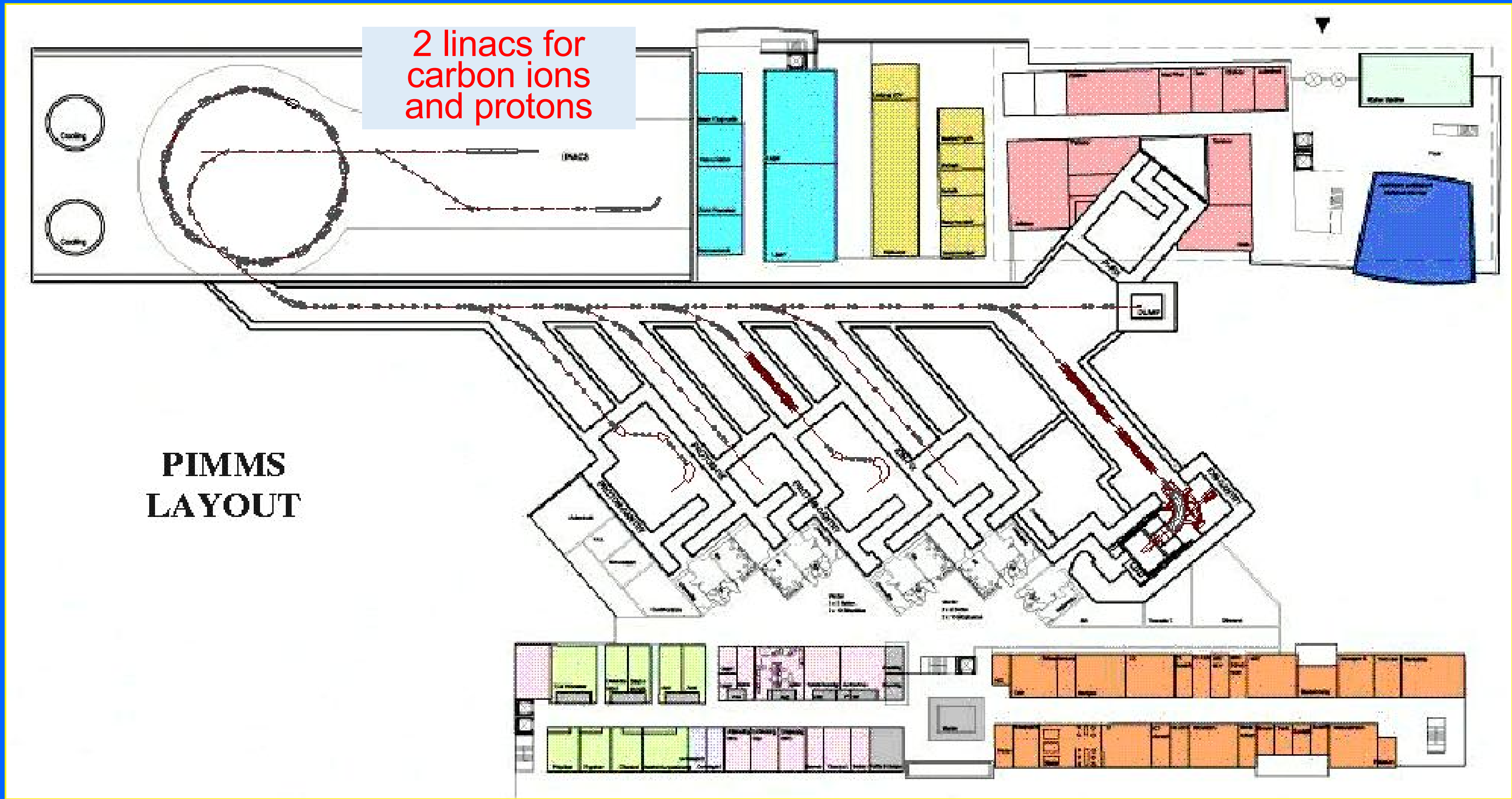
Optimized synchrotron for therapy
Project Leader: Phil Bryant
Chair of PAC: Giorgio Brianti
1996-2000

The design was conceived as a "toolkit" from which to take the parts of interest for building a particular centre

In 1995 U.A. and M. Regler convinced CERN to start PIMMS

Contributors: CERN

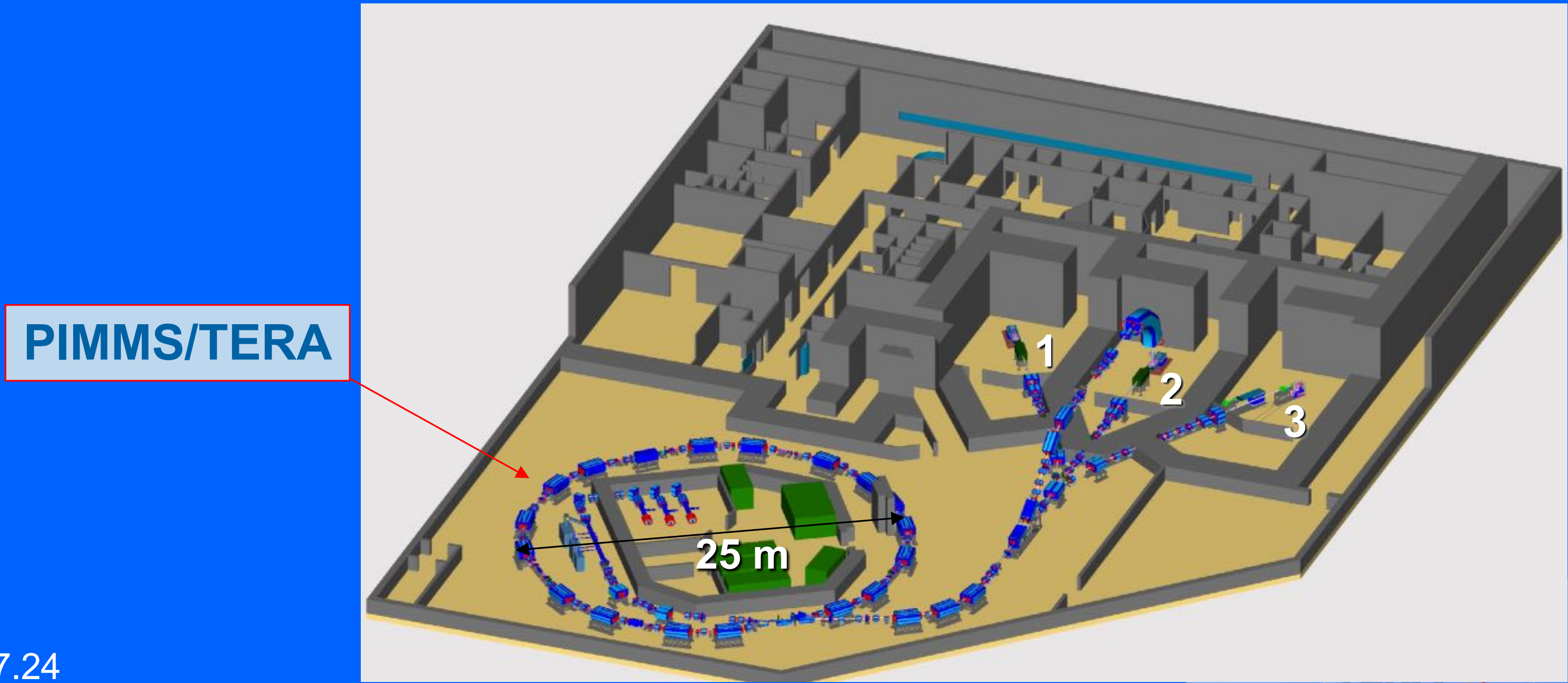
TERA Foundation (25 man years); MedAustron Project (10 man years)



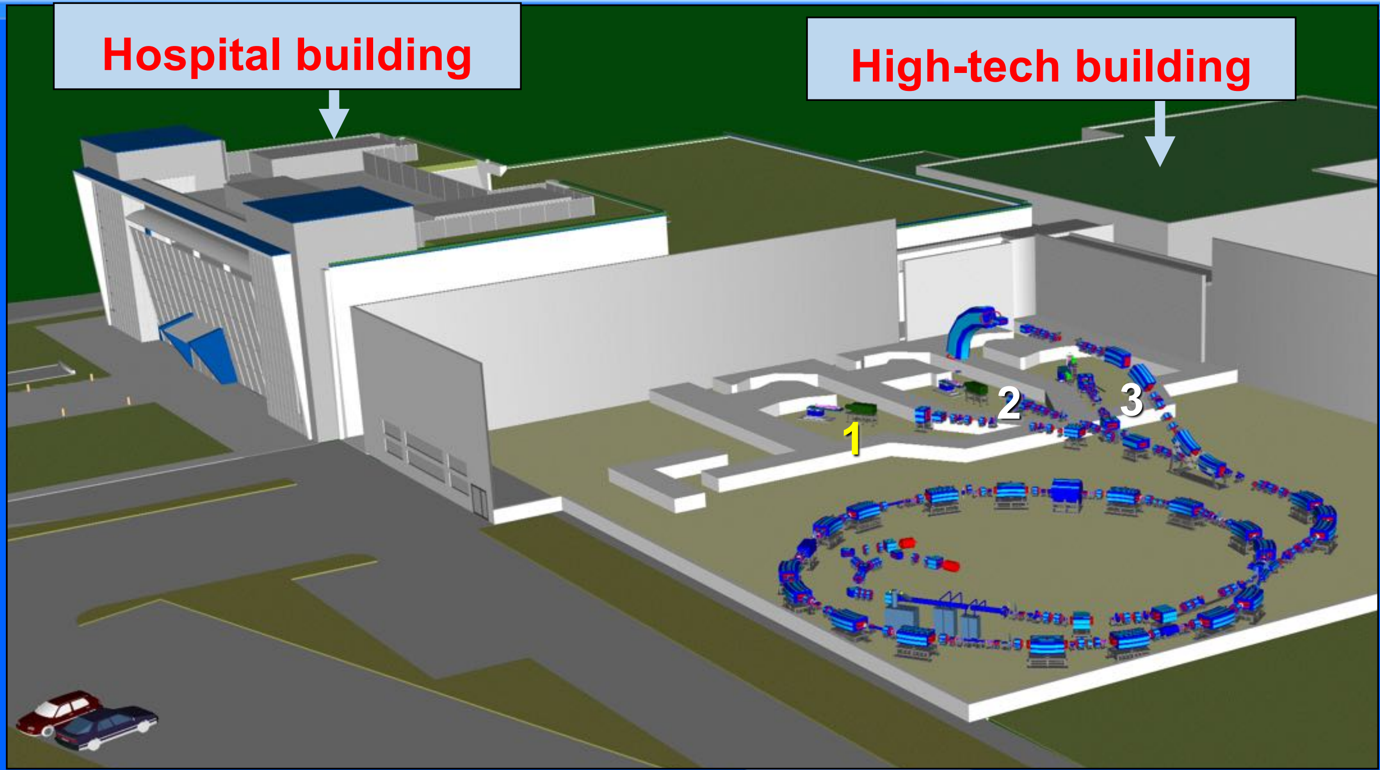
CNAO = Centro Nazionale di Adroterapia Oncologica

CNAO Foundation proposed by TERA and created in 2000 by the Italian Health Minister Umberto Veronesi : 4 Hospitals in Milan, 1 Hospital in Pavia and TERA

In October 2003 TERA passed to CNAO the design of CNAO (2000 pages) and 25 people (S. Rossi as Technical Director)



The layout of CNAO



Beginning of the construction: 2005

First patient in 2011

Technical Director: Sandro Rossi

Medical Director. Roberto Orecchia

INFN: CONTRIBUTED TO THE CONSTRUCTION

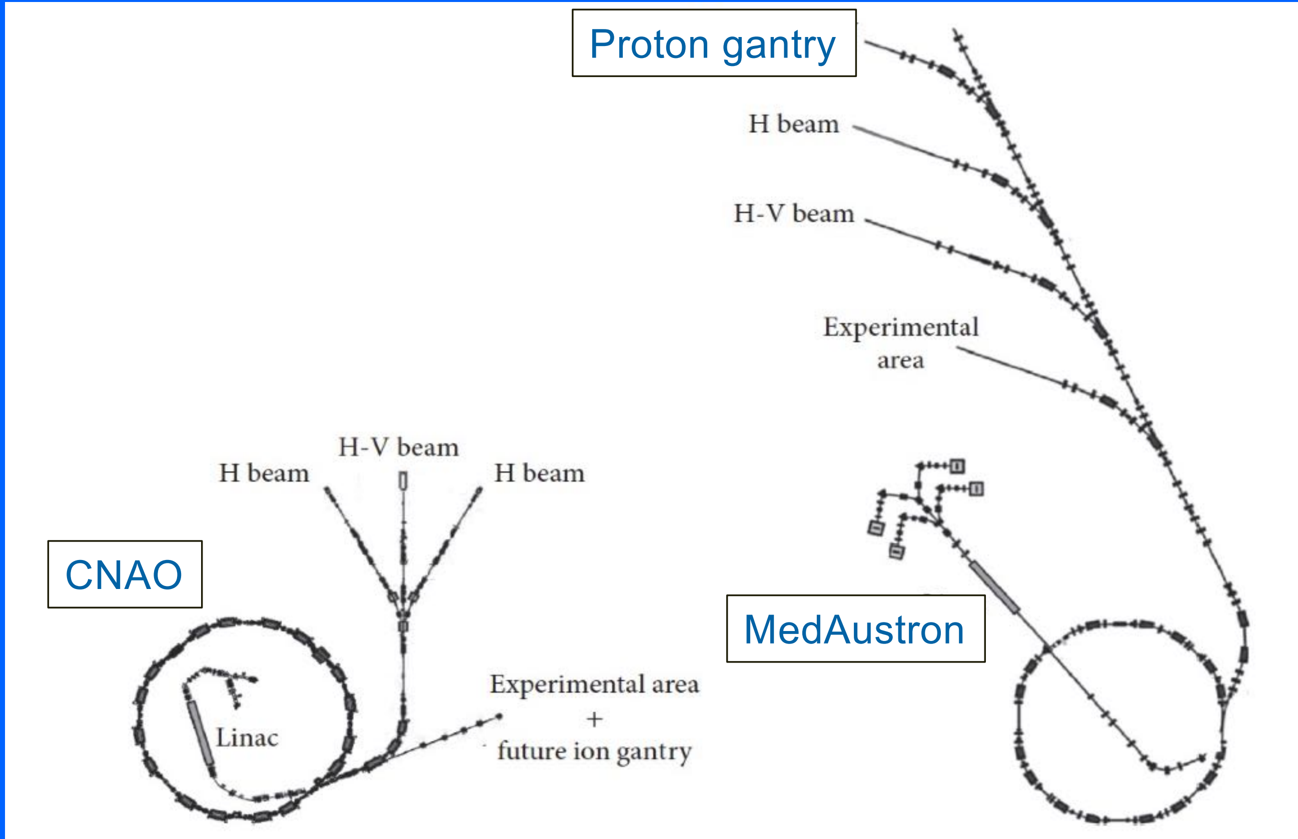
The layout of MedAustron

The layout of MedAustron

Beginning of the construction: 2009

First patient in 2016

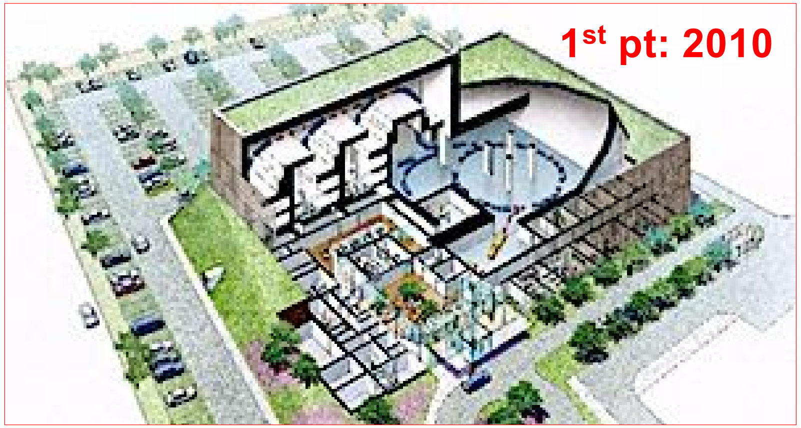
Two different choices



CNAO used PIMMS as a toolkit to reduce the footprint

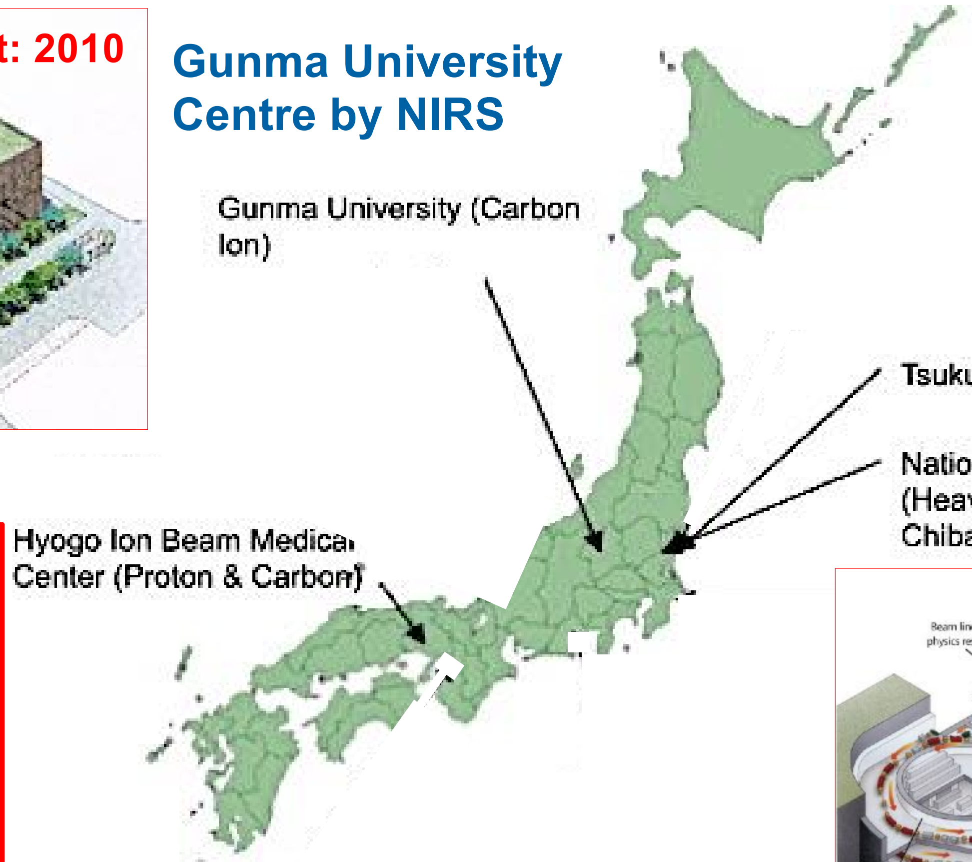
MedAustron built PIMMS

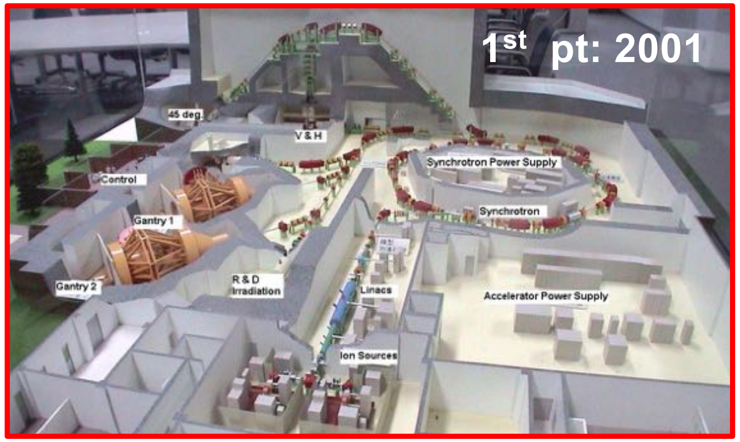
In Japan: 2010



1st pt: 2010

Gunma University Centre by NIRS



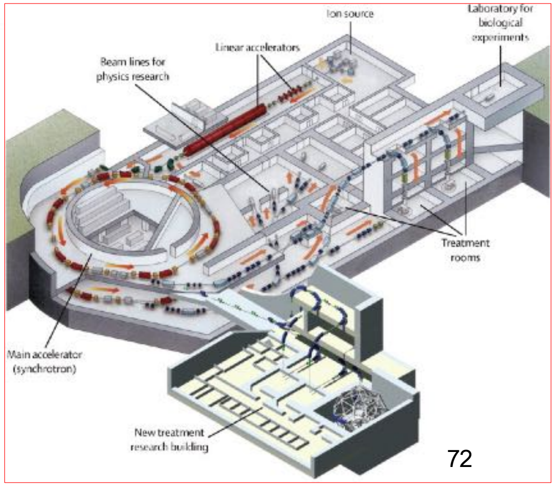


1st pt: 2001

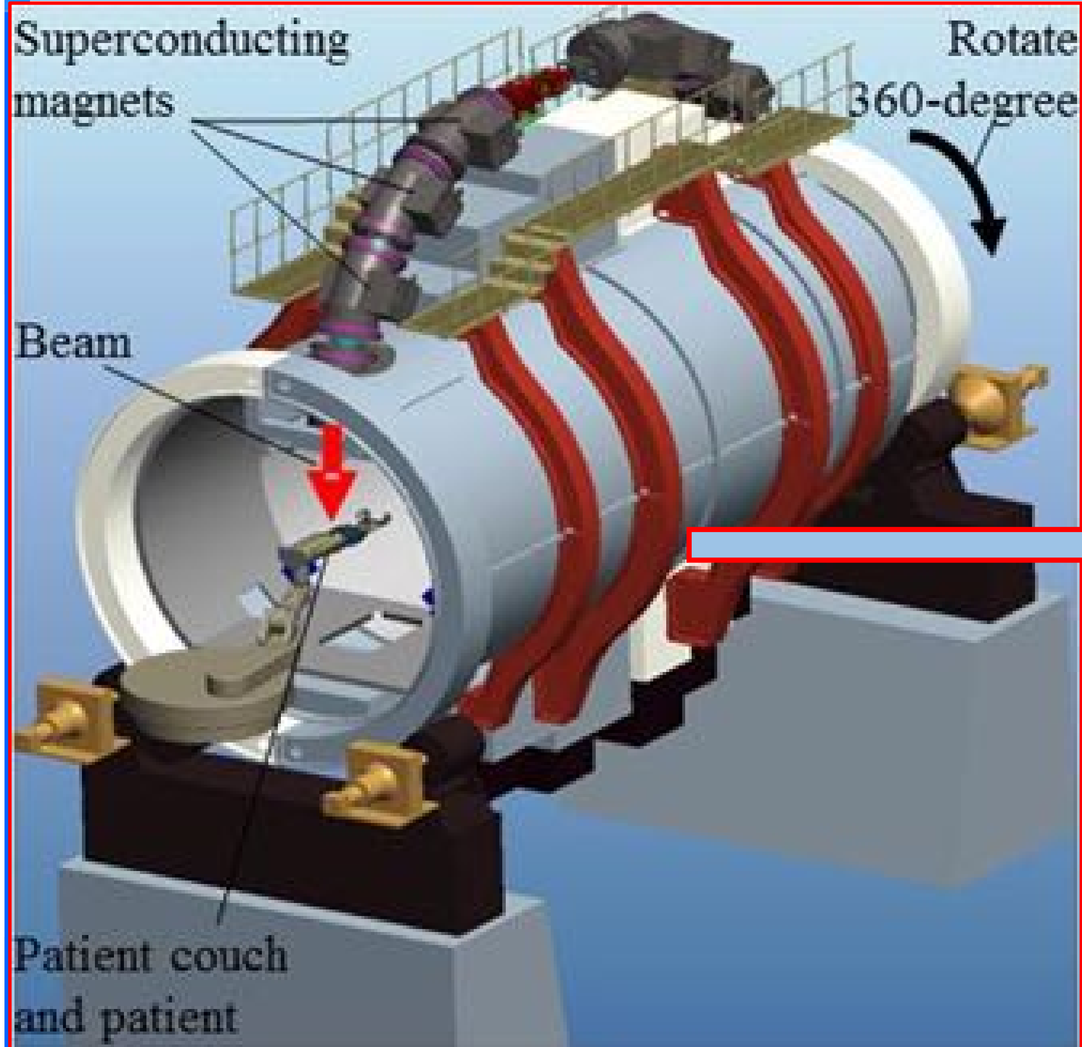
HYOGO by Mitshubishi

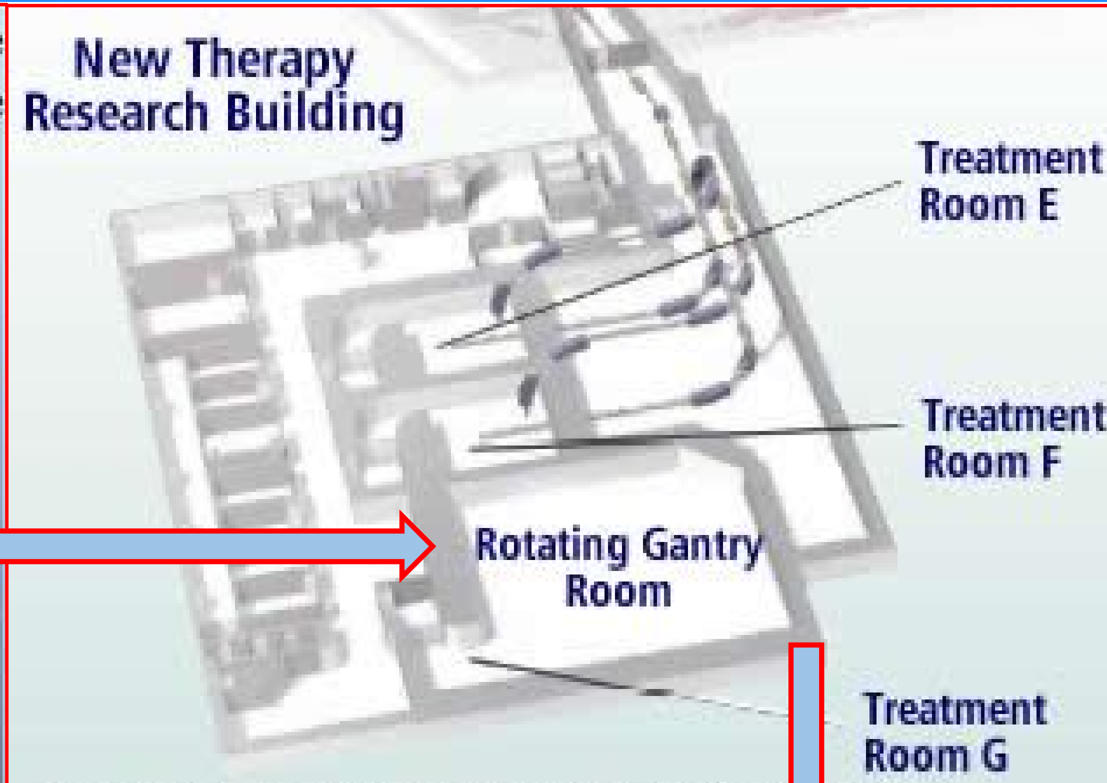
1st pt: 1994

NIRS - HIMAC



HIMAC: the most advanced carbon ion centre in the world

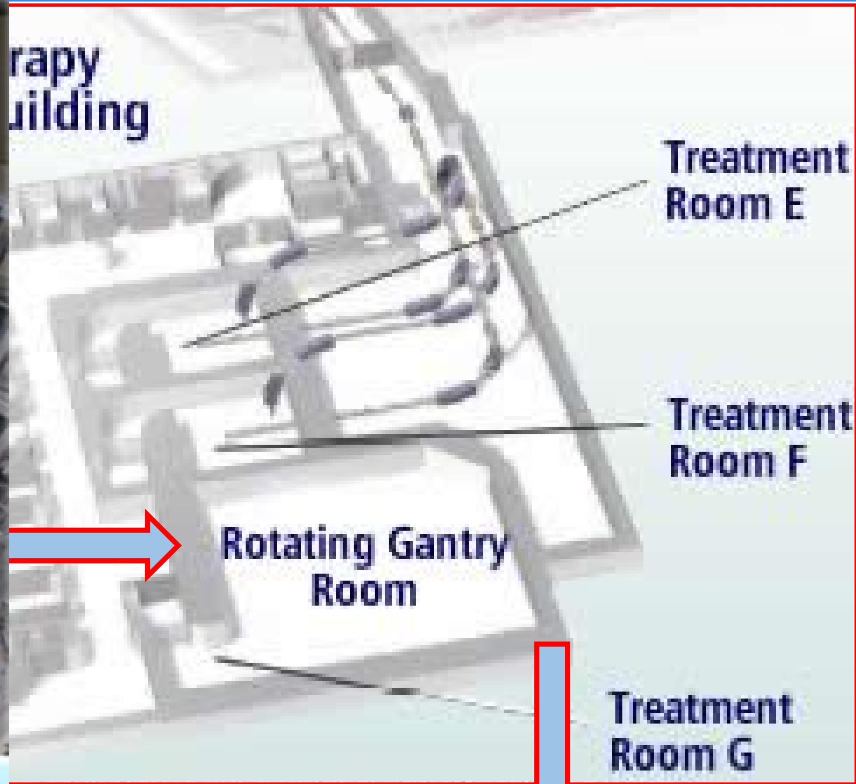




1st pt: 1994

NIRS - HIMAC

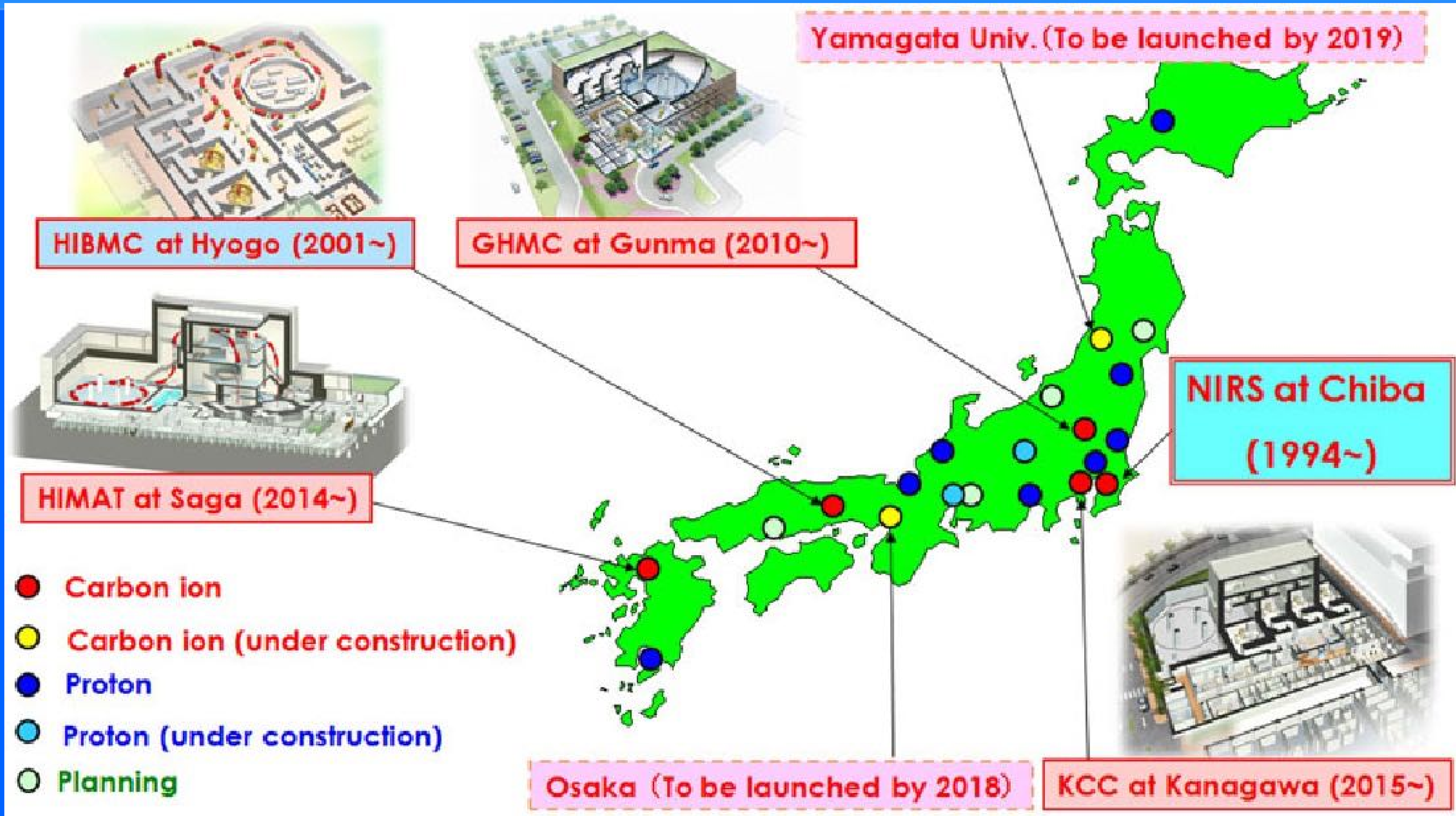
HIMAC: the most advanced carbon ion centre in the world



1st pt: 1994

NIRS - HIMAC

In 2015 the japanese network was already impressive



ON THE MAP
built or construction

8 proton centres

11 carbon centres


CNAO @ PAVIA
THE END

Appendix – 1996: Bob Wilson fifty years later

Physicist, engineer, sculptor, architect and science manager

During World War II, the Harvard cyclotron was moved to Los Alamos:

In 1943, the Manhattan project needed the Harvard cyclotron for nuclear studies. Radiologist Dr. Hymer Friedell came to Harvard with a "cover story" that it was needed to make isotopes for Army hospitals.
The photograph shows Hymer Friedell (left) discussing with the dpartment chairman Percy Bridgeman (right).Robert Wilson (middle) reported years later Percy Bridgeman's response:
"If you want it for what you say you want it for, you can't have it. If you want it for what I think you want it for, of course you can have it."

After World War II, Harvard could not get back the cyclotron but got funds to build a new one.

Bob Wilson, who had worked at the Manhattan project, designed it

Later the 160 MeV Harvard cyclotron was instrumental in proving the medical advantages of proton therapy

Hymer Friendell Bob Wilson Percy Bridgeman

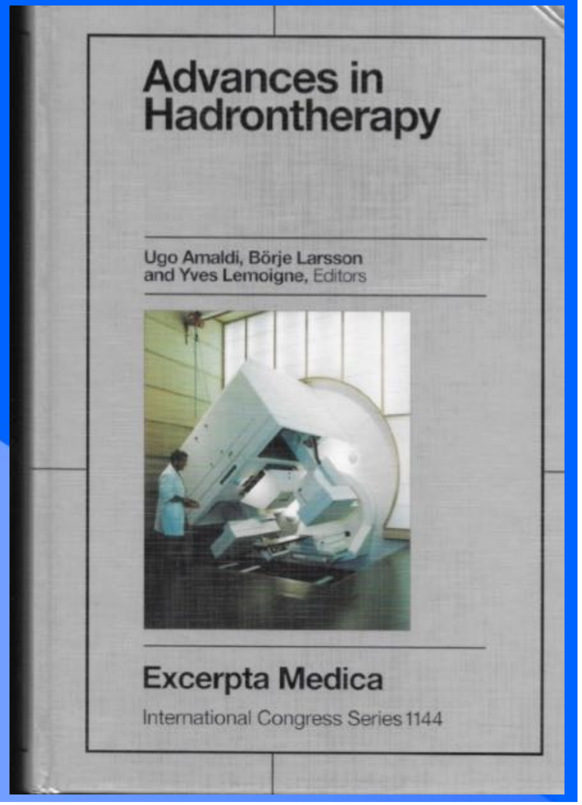
Physicist, engineer, sculptor, architect and science manager

- After the war Bob Wilson was Associate Professor in Harvard and then went to Cornell University as physics professor and Director of the new Laboratory of Nuclear Studies, where he conceived and directed the construction of four electron synchrotrons
- In 1961 I was introduced to him when he was on leave in Rome working in the morning in a sculptor atelier and in the afternoon at the INFN electron synchrotron in Frascati
- In 1965 we met when I gave at Cornel a seminar on the novel results my group had obtained at the same accelerator by studying the (e,e'p) reaction on Carbon
- In 1967 he assumed the directorship of the National Accelerator Laboratory, near Chicago, subsequently known as Fermilab, where he acted also as architect
- In 1976 he wrote me praising the proposal of using superconducting linacs firing at each other to produce electron-positron collisions at hundreds of GeV (*)
- Along the years, we had many occasions to meet and discuss at conferences and meetings both in USA and around the world

(*) U. A. 'A Possible Scheme to Obtain e- e- and e+ e- Collisions at Energies of Hundreds of GeV' Phys. Lett.B 61 (1976) 313-315

1996 - Second International Symposium on Hadrontherapy

- The Second Symposium on Hadrontherapy had to be held in 1996, three years after the first one
- With B. Larsson we decided to organize it at CERN in connection with the PTCOG meeting of fall 1996 organized by PSI in Villigen
- The PSI part (9-11September 1996) had the usual structure of all PTCOG meetings: short oral presentation and posters
- The CERN part (12-13 September) was mainly based on invited talks
- Michael Goitein was the chairman of the Organizing Committee
- The proceeding of the second part were published by Elsevier in a volume that contains also the proceedings of the 1995 International Week on Hadrontherapy organized by Y. Lemoigne in Archamps (France)



Elsevier-1994
550 pages

Bob Wilson 50 years later

Six months before the Symposium I realized that 50 years had passed since Wilson's 1946 fundamental paper and one evening I called him at his home in Ithaca. Bob came with his wife Jane and I went to pich them up at the Geneva Airport

This is the beginning of the Foreword appearing in the Proceedings

Foreword to the Second International Symposium on Hadrontherapy

Robert R. Wilson
Director Emeritus, Fermi National Accelerator Laboratory, Batavia, Illinois, USA

Recently, Ugo Amaldi phoned me and pointed out something that I did not remember: this year is the 50th anniversary since the time when I wrote the paper proposing the use of the Bragg peak for radiotherapy. He also suggested that I briefly speak to you about how it came to be that I wrote the paper, after all I was not a physician, but I had been at the University of California for some time working in nuclear physics. I immediately accepted his invitation to address you on this occasion.

Bob Wilson 50 years later

of a conscience that was somewhat out of joint. At Los Alamos, where I had been working for the past 5 years, no matter how justifiable it may have been, we had been working on one thing, and that was to kill people. When that became crystallised in my mind by the use of the atomic bomb at Hiroshima, it was a temptation to go on, to salvage what was left of my conscience, I suppose, and think about saving people instead of killing them. I think that was the main reason that did cause me to go on.

So I went on, and instead of just talking about the penetration of particles, I jumped into the almost obvious thing I could see next: because one could hurt people with protons, one could probably help them too. So I tried to work out every detail I could from the scattering to the Bragg curve, and I was surprised to see that, when all the details were taken into account, the Bragg curve came up and then came down very sharply. So from the spot where the protons entered into a person — up until the peak, there would be many centimetres and then the protons would go no further. That should have made them very interesting. Another thing I found was that the protons followed an almost straight line, with just a little wiggle at the end, so one could deposit a large fraction of the energy into a few cubic centimetres. I thought all that was great and thus I sent the paper to Radiology, strangely enough thinking that would be of interest to foreign radiologists, while the physics part of it was submitted to the Physical Review. Afterwards I felt pretty good as, even if my conscience was not completely healed, I had played my part towards my fellow men and I was a little prouder now than for what I had done previously.

Bob Wilson was photographed - outside the CERN Auditorium - in front of two posters of the exhibition

ATOMS FOR HEALTH

produced in 1995 by CERN, GSI and TERA for the 100th anniversary of the discovery of X rays