From Physics to Daily Life

Particle Beams for Cancer Therapy

Ugo Amaldi

TERA Foundation and Technische Universität Munchen

120 years of particle accelerators are the best demonstration…

The beginnings

fundamental physics

Curie radium

Roentgen rays

1895

1898

therapy

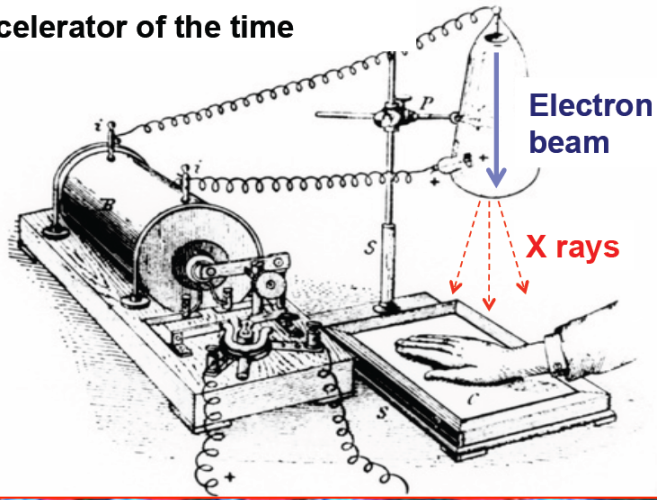
diagnostics

Roentgen rays

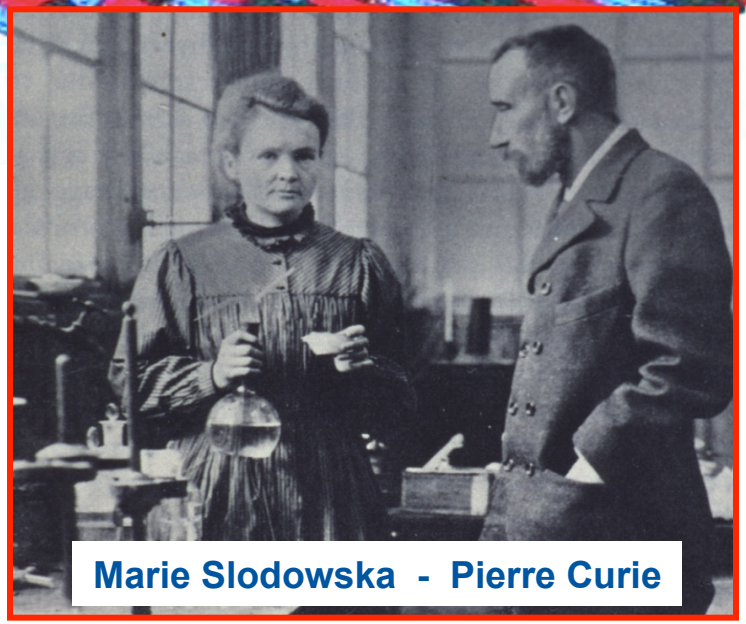
Roentgen rays

Curie radium

Crookes tube : the best accelerator of the time



2014



Marie Slodowska - Pierre Curie

About 15 years later

fundamental physics

therapy

diagnostics

1895

1898

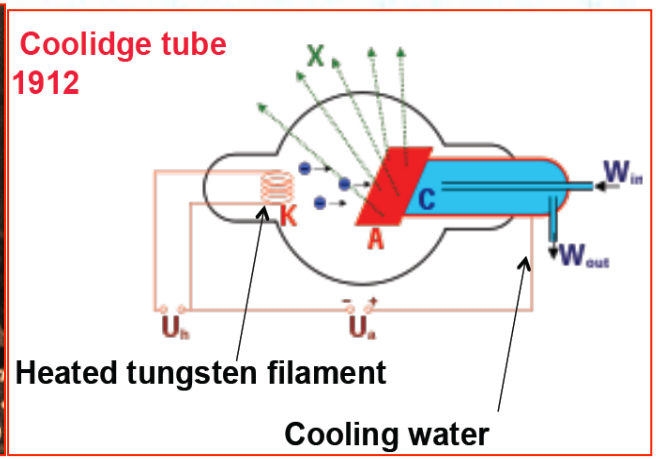
Hess cosmic rays

1912

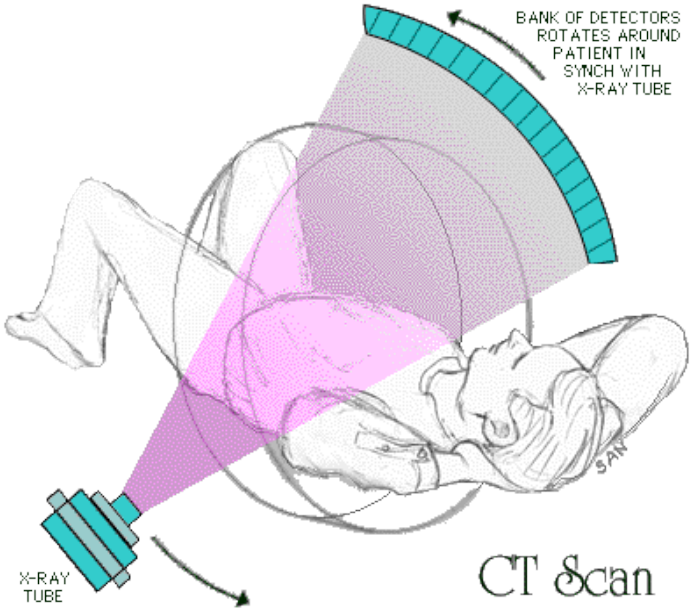
1913

Coolidge tube

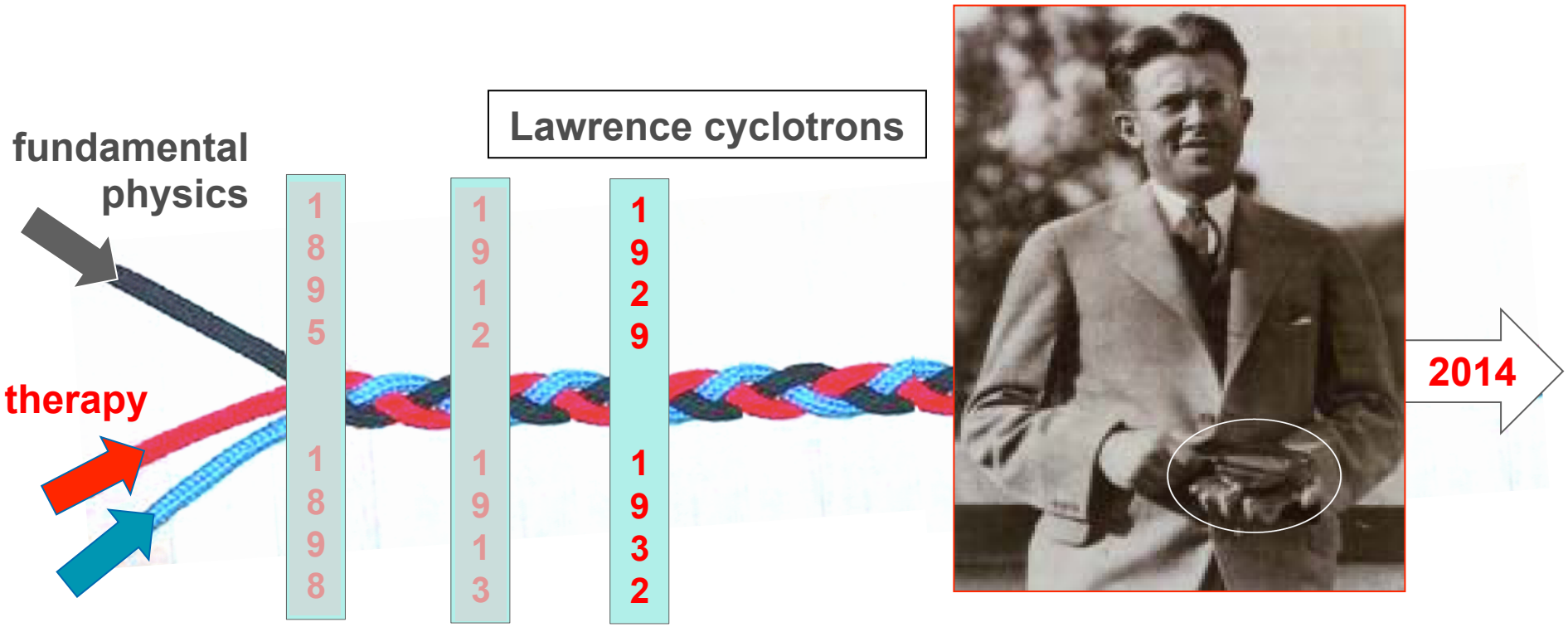
Coolidge tube



Today every CT scanner uses a Coolidge tube



About 15 years later an American giant contributed to the three yarns



Lawrence cyclotrons

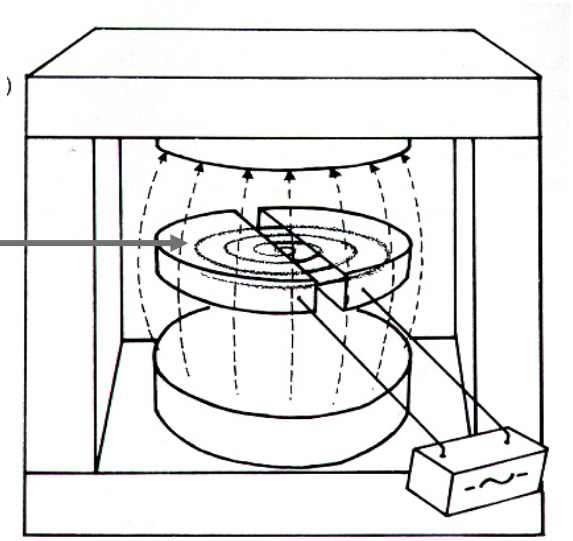
Lawrence cyclotrons

1 MeV = 1 million electronvolts

= 0.001 GeV

About 15 years later an American giant contributed to the three yarns

Spiral trajectory of an accelerated particle



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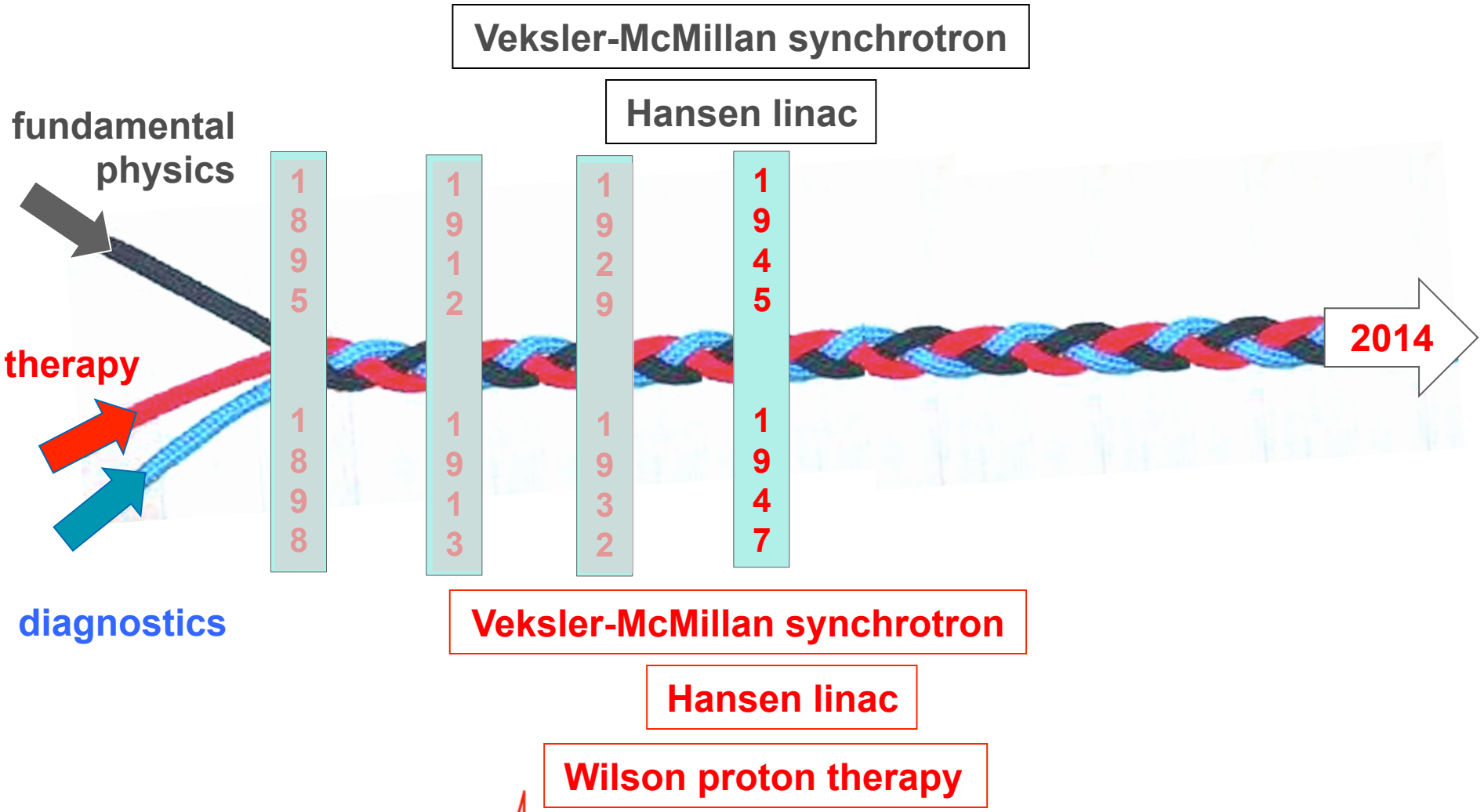
Another 15 years jump forward



Another 15 years jump forward

Veksler-McMillan synchrotron

Hansen linac

fundamental physics

therapy

diagnostics

1895 1898

1912 1913

1929 1932

1945 1947

1959: Veksler visits McMillan

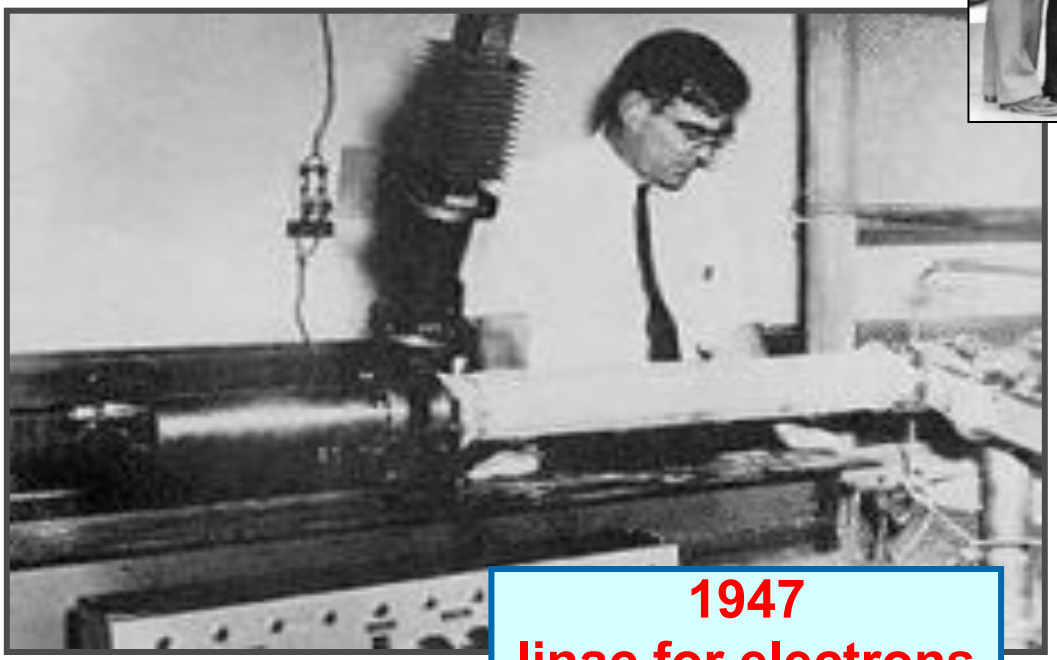
Veksler-McMillan synchrotron

Hansen linac

Wilson proton therapy

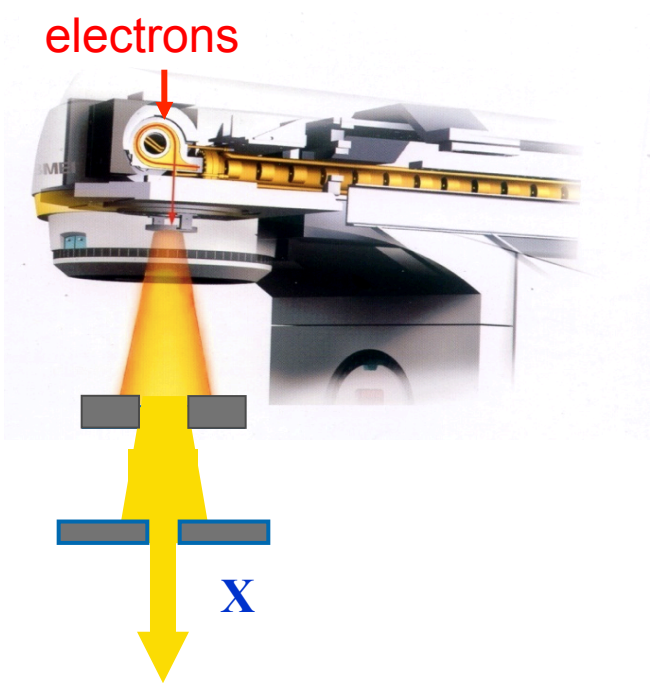
The first electron linac above 1 MeV

William W. Hansen



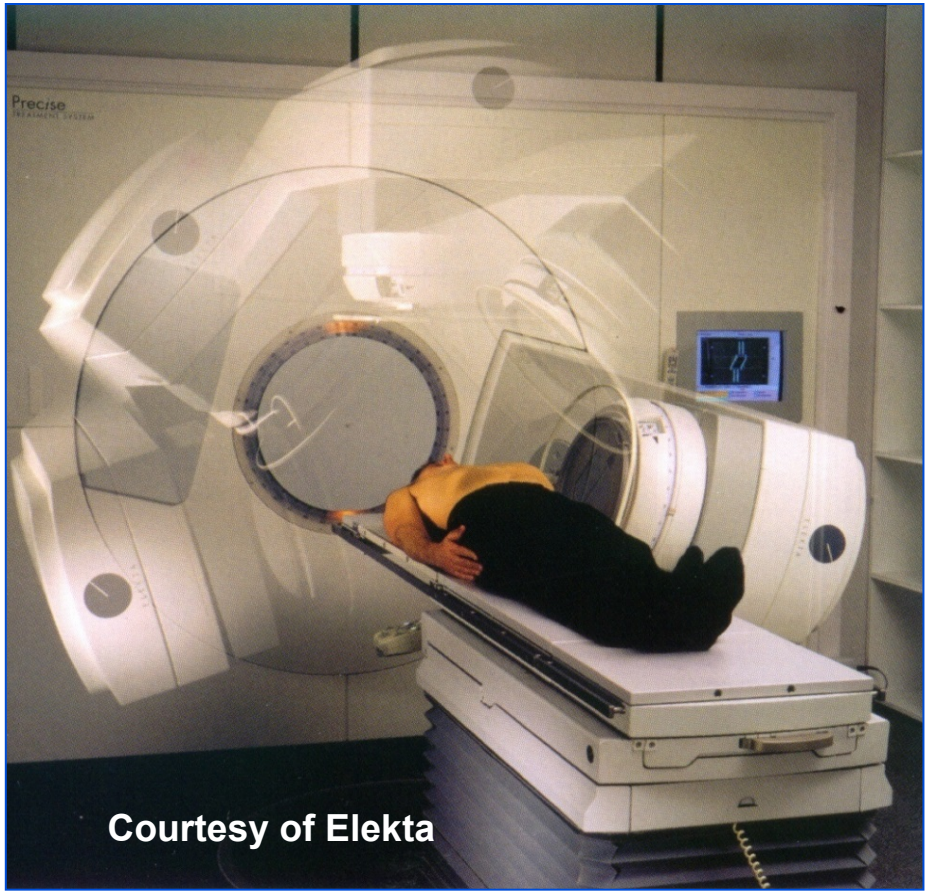
1947
linac for electrons
1.5 MeV at 3 GHz

‘Conventional’ radiotherapy: linear accelerators dominate



2000 patients/year every in 1 million inhabitants

1 treatment in 30 sessions



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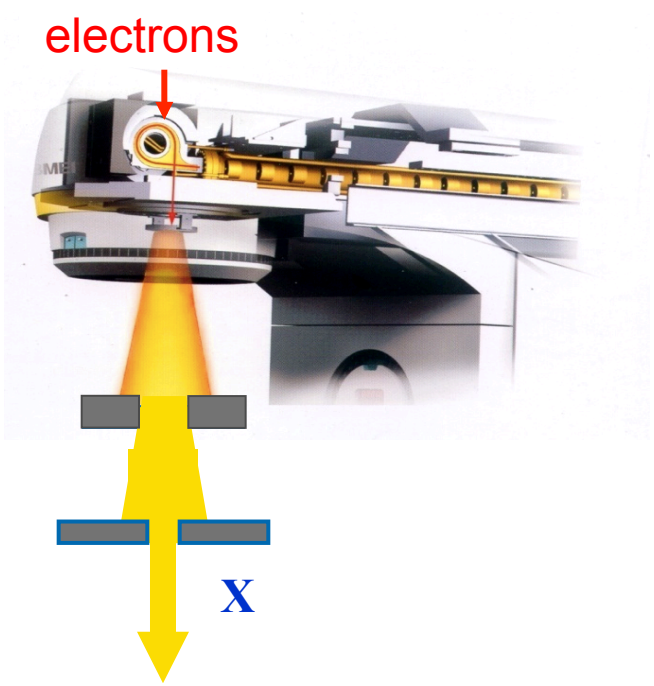

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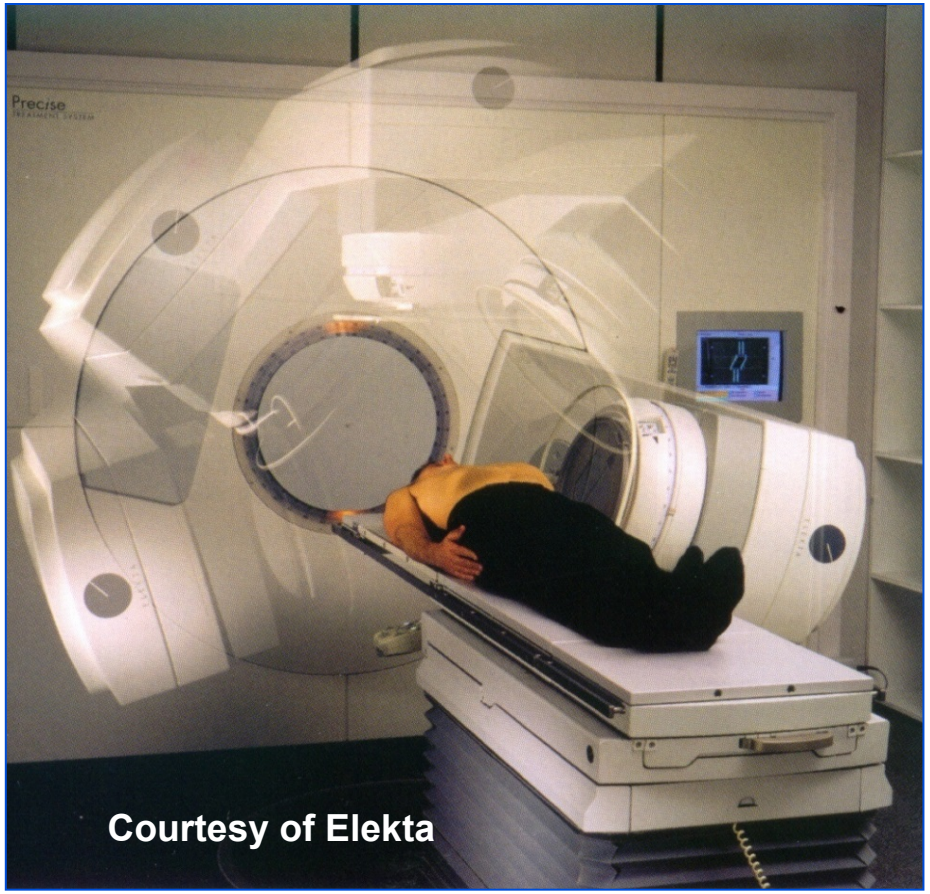


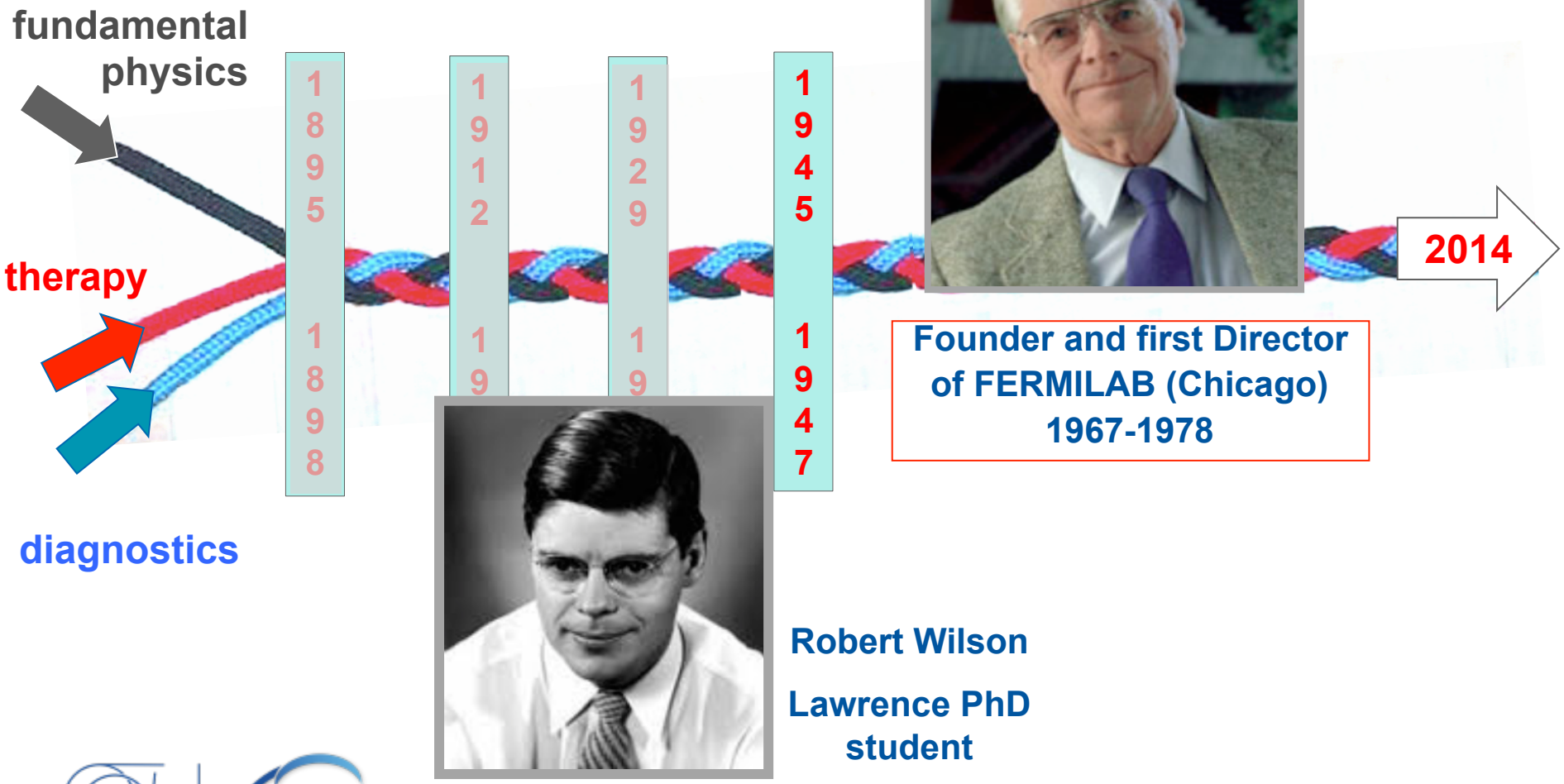
In the world radiation oncologists use 20 000 electron linacs

50% of all the existing accelerators

70 years later VARIAN is still the market leader

VARIAN was founded in 1948 by W. Hansen, Russell Varian and Sigmur Varian

1946: 'Bob' Wilson proposal



Founder and first Director of FERMILAB (Chicago) 1967-1978

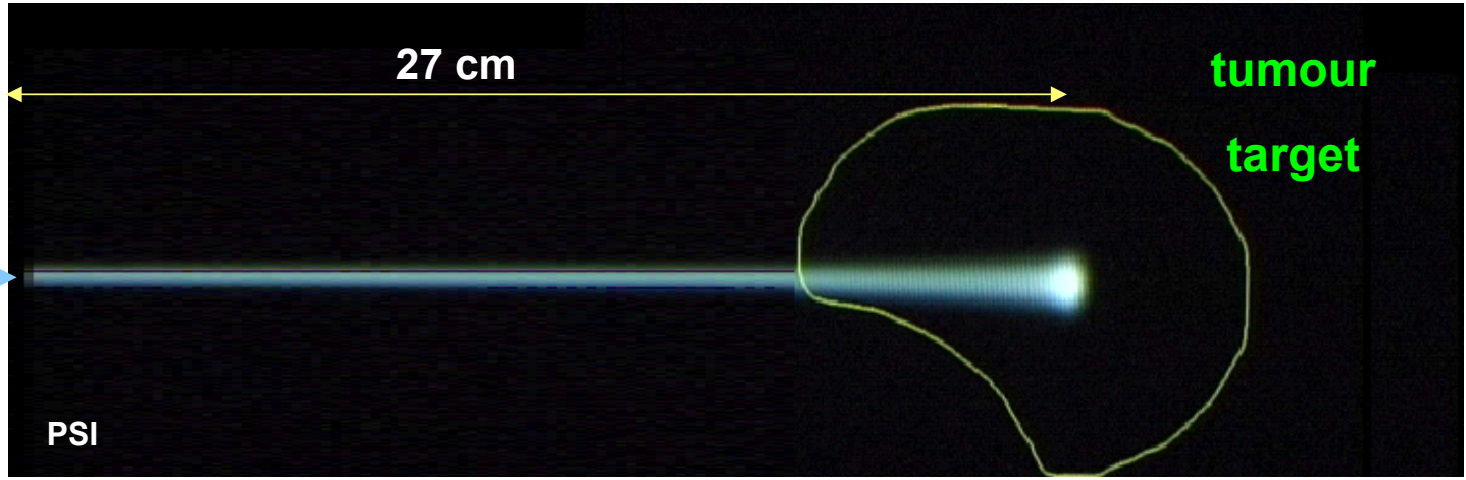
Robert Wilson

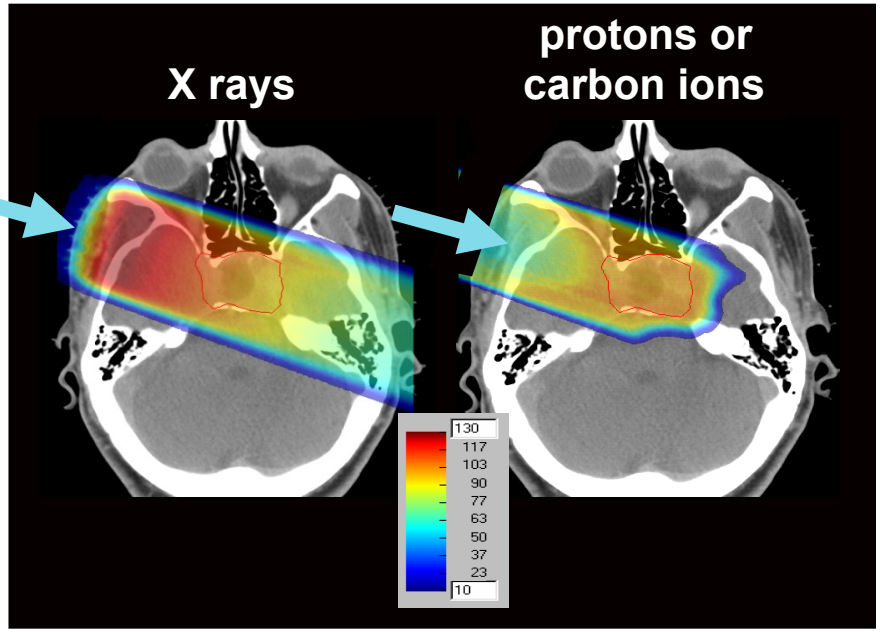
Lawrence PhD student

Protons and ions spare healthy tissue

200 MeV protons

5000 MeV carbon ions





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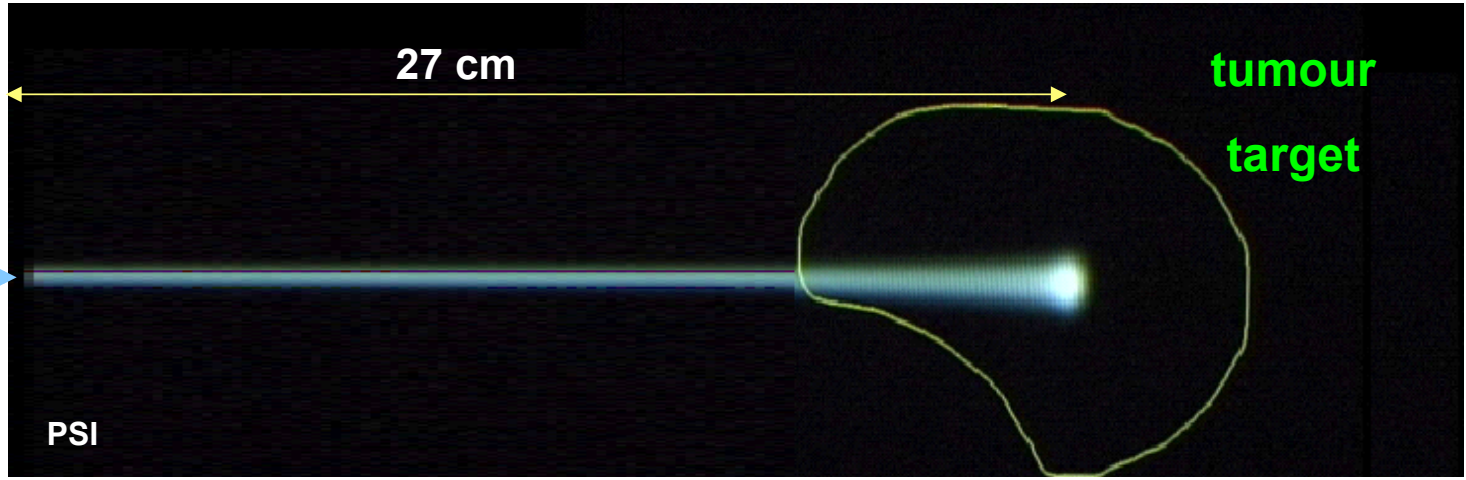
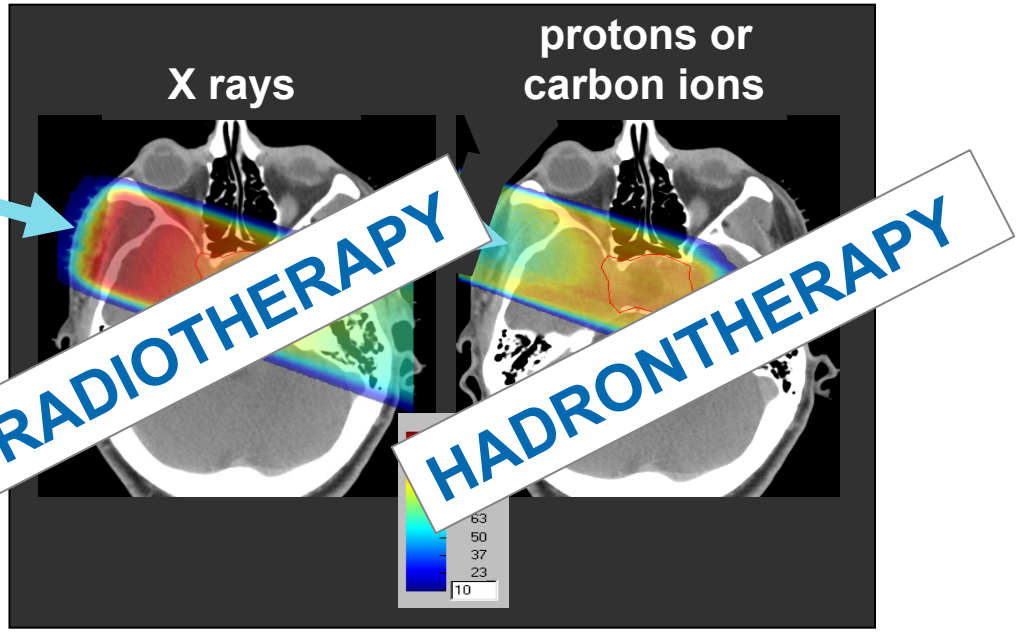
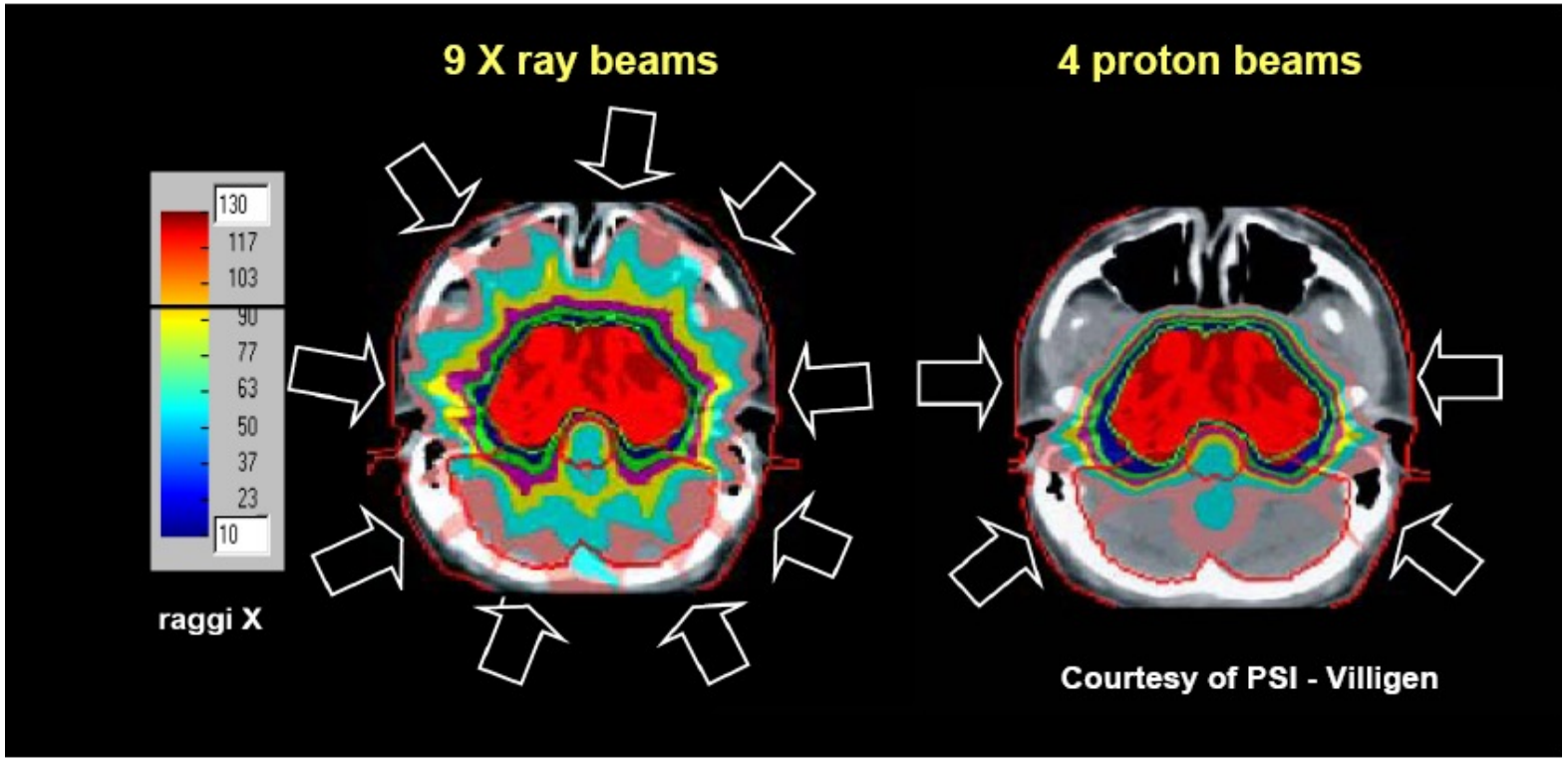
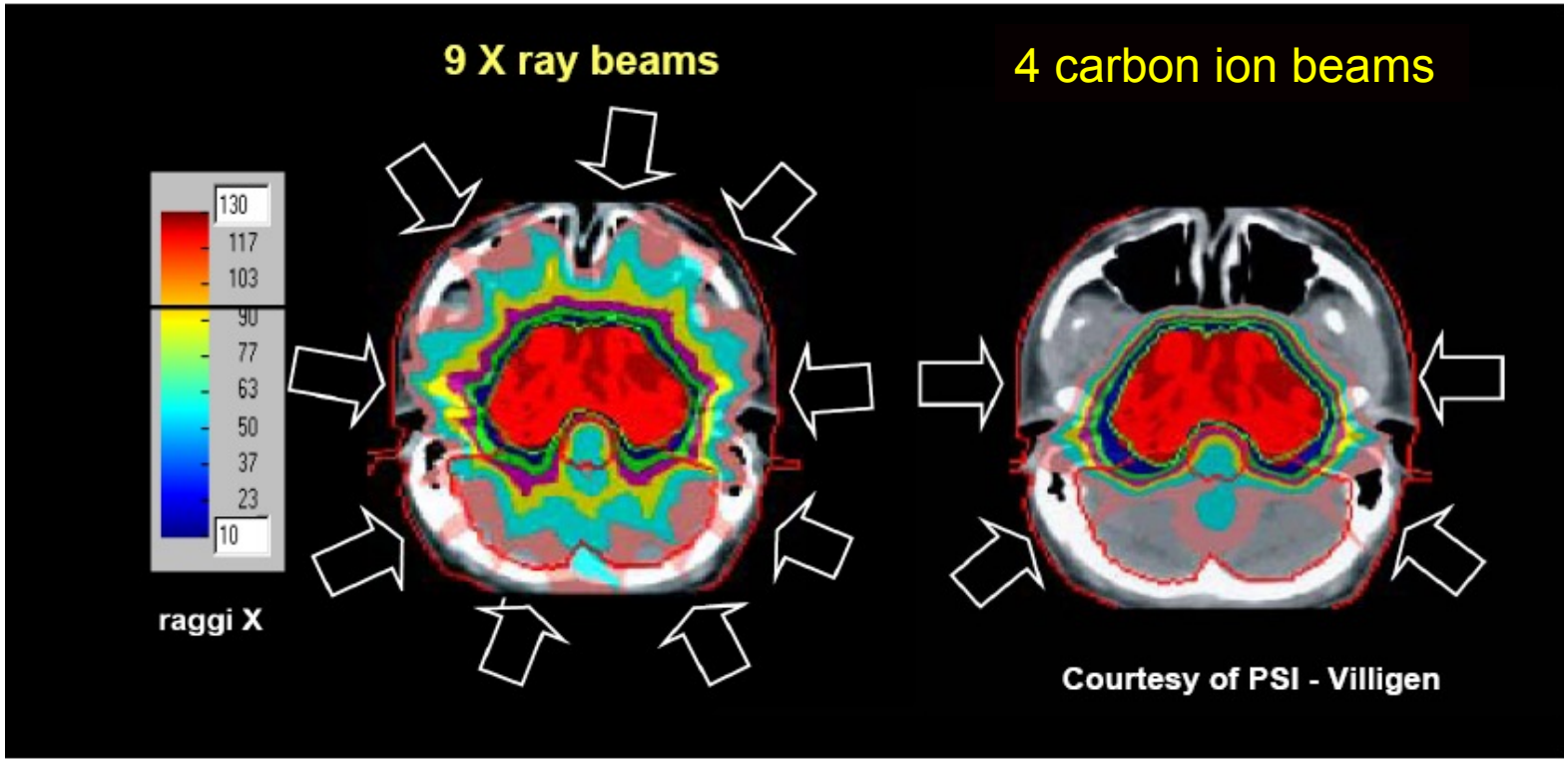




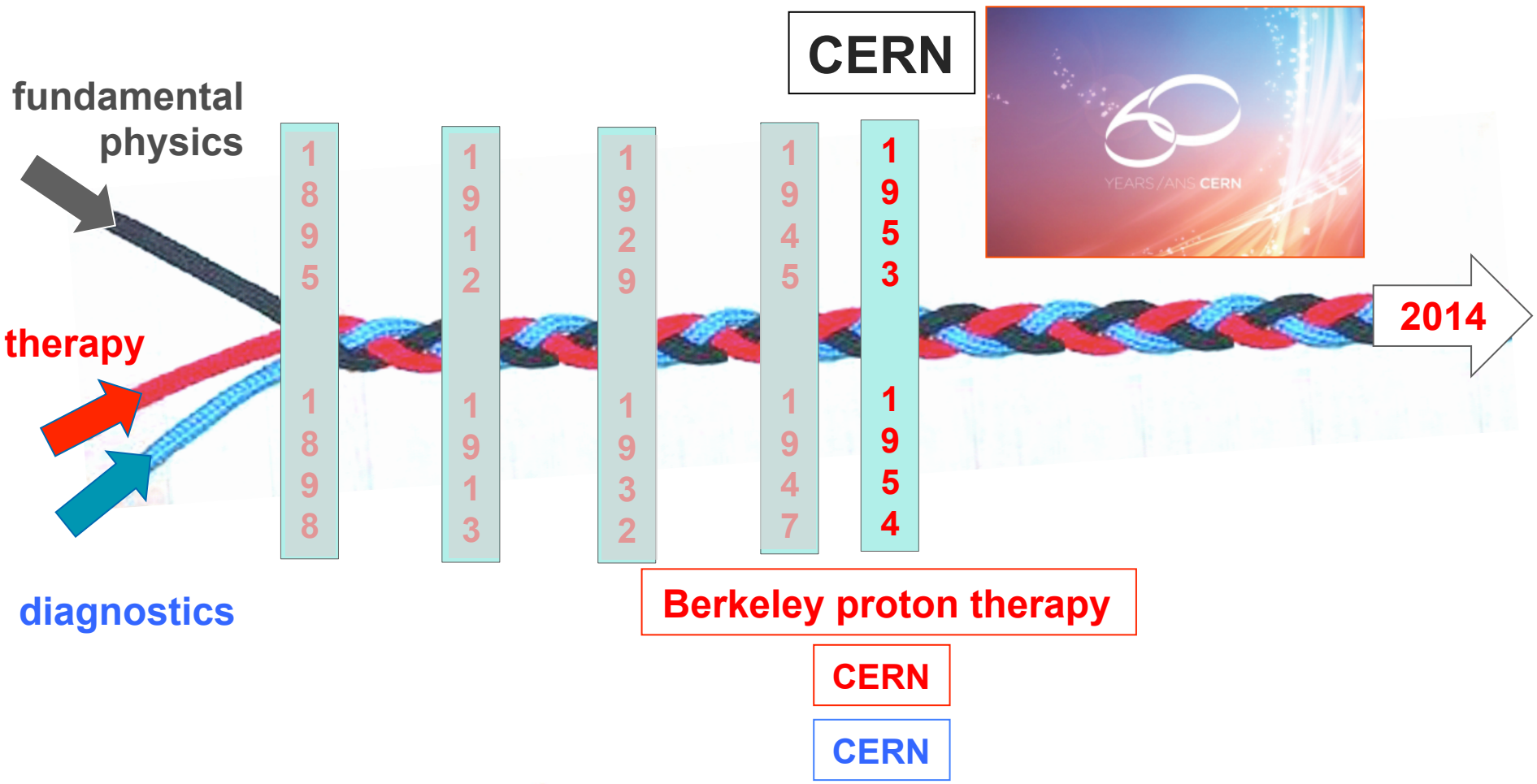
Comparison of the macroscopic dose distributions between X rays and protons



In the tumour target carbon ions produce CLUSTERED DOUBLE STRAND BREAKS and can control radioresistant tumours



60 years ago: CERN creation and first proton therapy



60 years ago: CERN creation and first proton therapy

fundamental physics

therapy

diagnostics

1895 1898 1912 1913 1932 1947 1954

CANCER RESEARCH

VOLUME 18 FEBRUARY 1958 NUMBER 2

Pituitary Irradiation with High-Energy Proton Beams
A Preliminary Report*

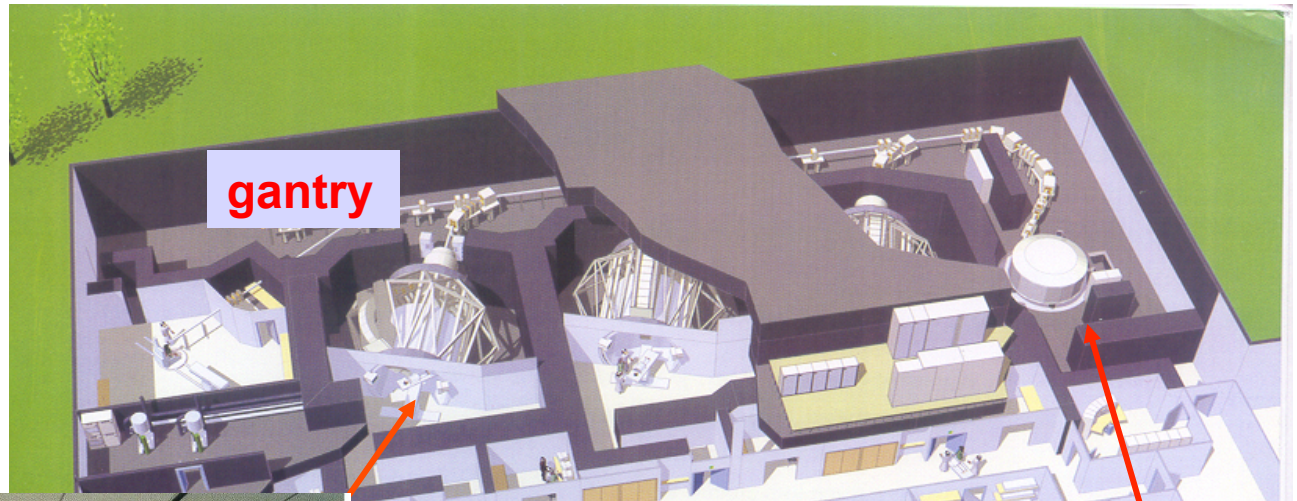
C. A. TOBIAS, J. H. LAWRENCE, J. L. BORN, R. K. MCCOMBS, J. E. ROBERTS, H. O. ANGER, B. V. A. LOW-BEER,† AND C. B. HUGGINS‡

(Donner Laboratory of Biophysics and Medical Physics, Donner Pavilion, and the Radiation Laboratory, University of California, Berkeley, Calif.)

Berkeley proton therapy

Cornelius Tobias
"Toby"

Proton therapy centers – with a cyclotron or a synchrotron and many rooms - proliferate



230 Mev cyclotron

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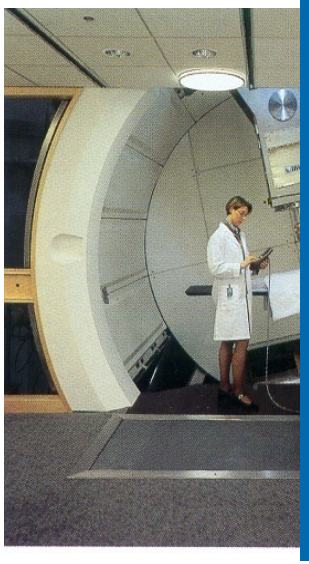
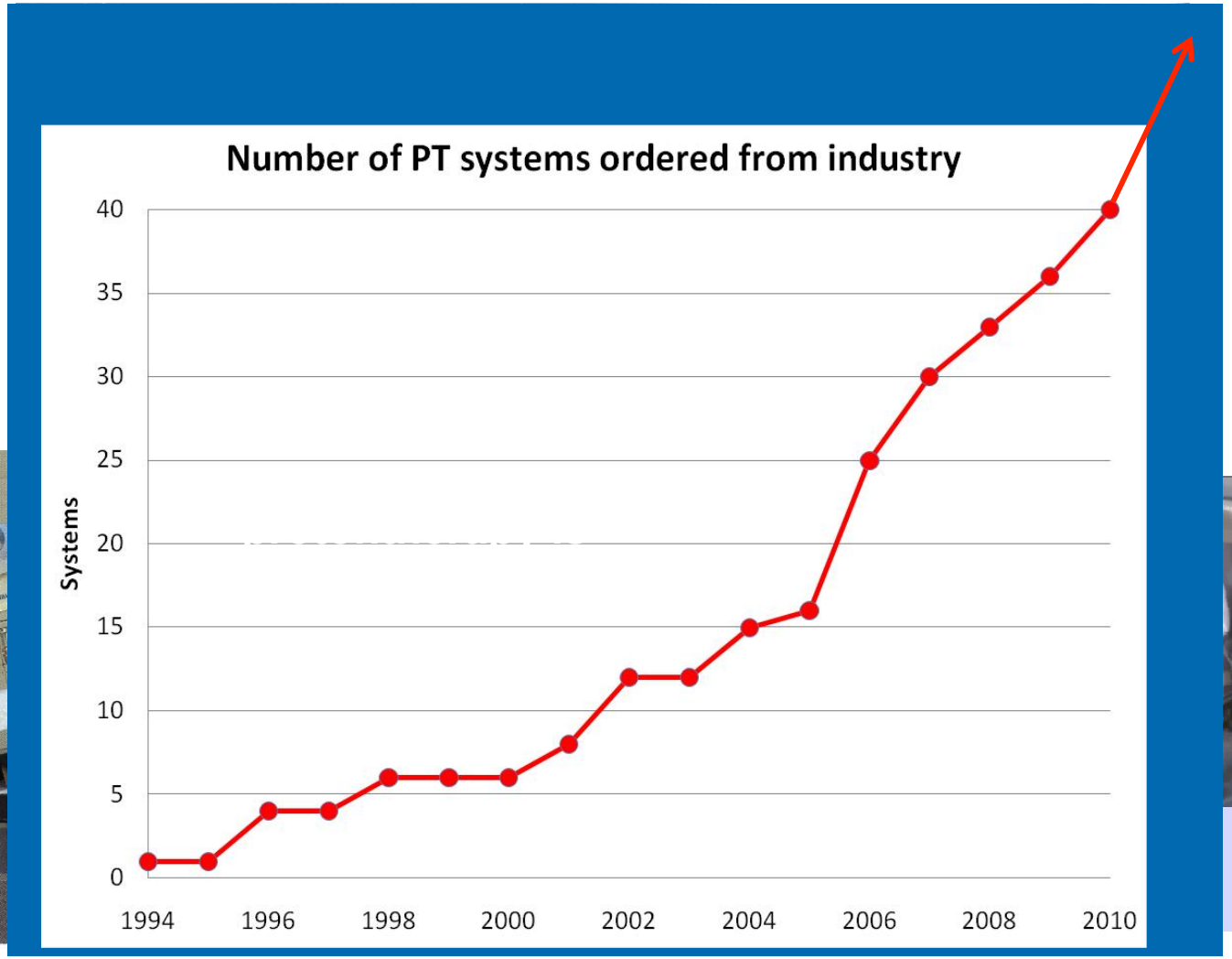
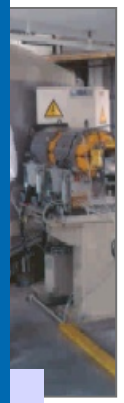






HIMAC in Chiba is the pioneer of carbon therapy

Yasuo Hirao

Hirohiko Tsujii

8500 pts 1994-2014

Contributions of CERN to the red yarn

In 1995 U.A. and M. Regler convinced CERN to start Proton Ion Medical Machine Study, PIMMS

Optimized synchrotron for therapy

Project Leader: Phil Bryant

Chair of PAC: Giorgio Brianti

1996-2000

In 1995 U.A. and M. Regler convinced CERN to start Proton Ion Medical Machine Study, PIMMS

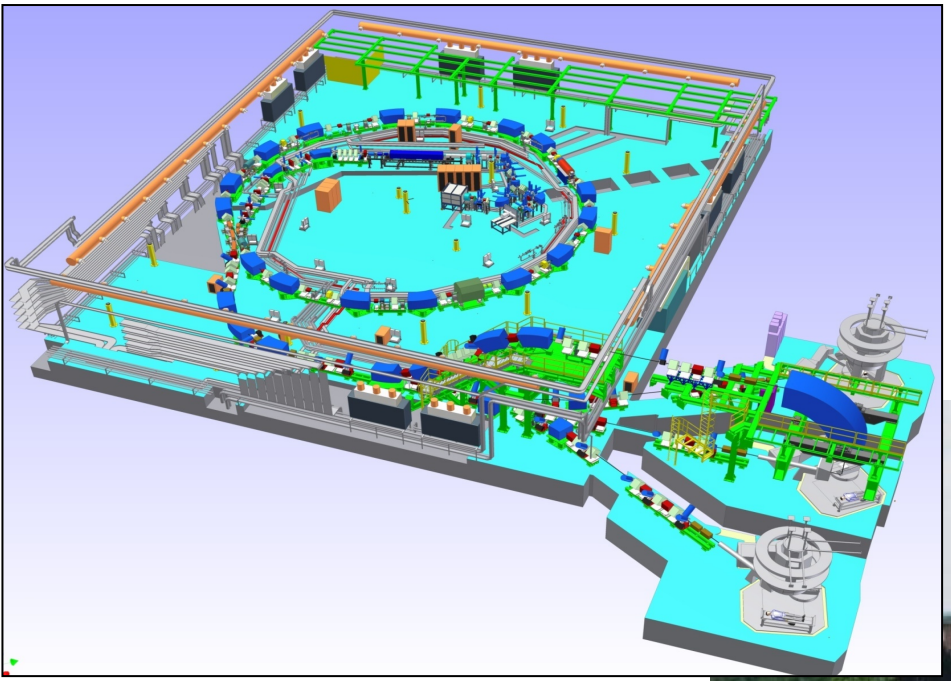
Contributors:

CERN

TERA Foundation (Italy); MedAustron Project (Austria)

M. Regler

The Italian National Centre for Hadrontherapy CNAO has been designed by TERA and built in Pavia by CNAO Foundation



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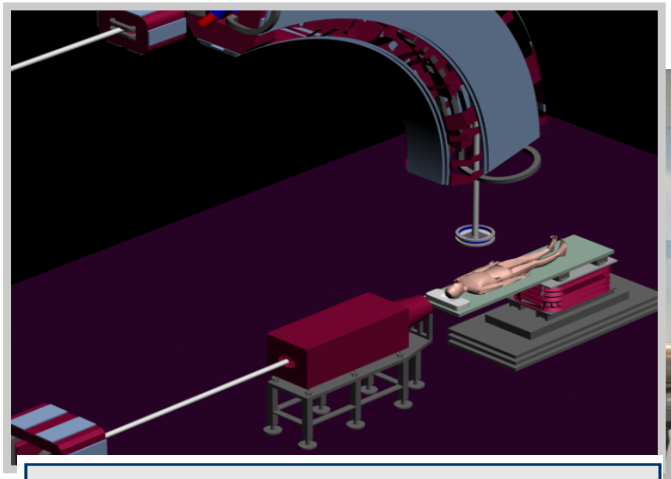
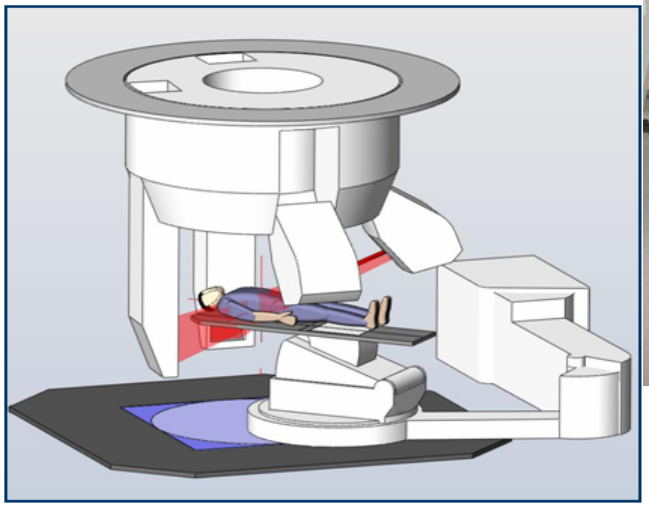
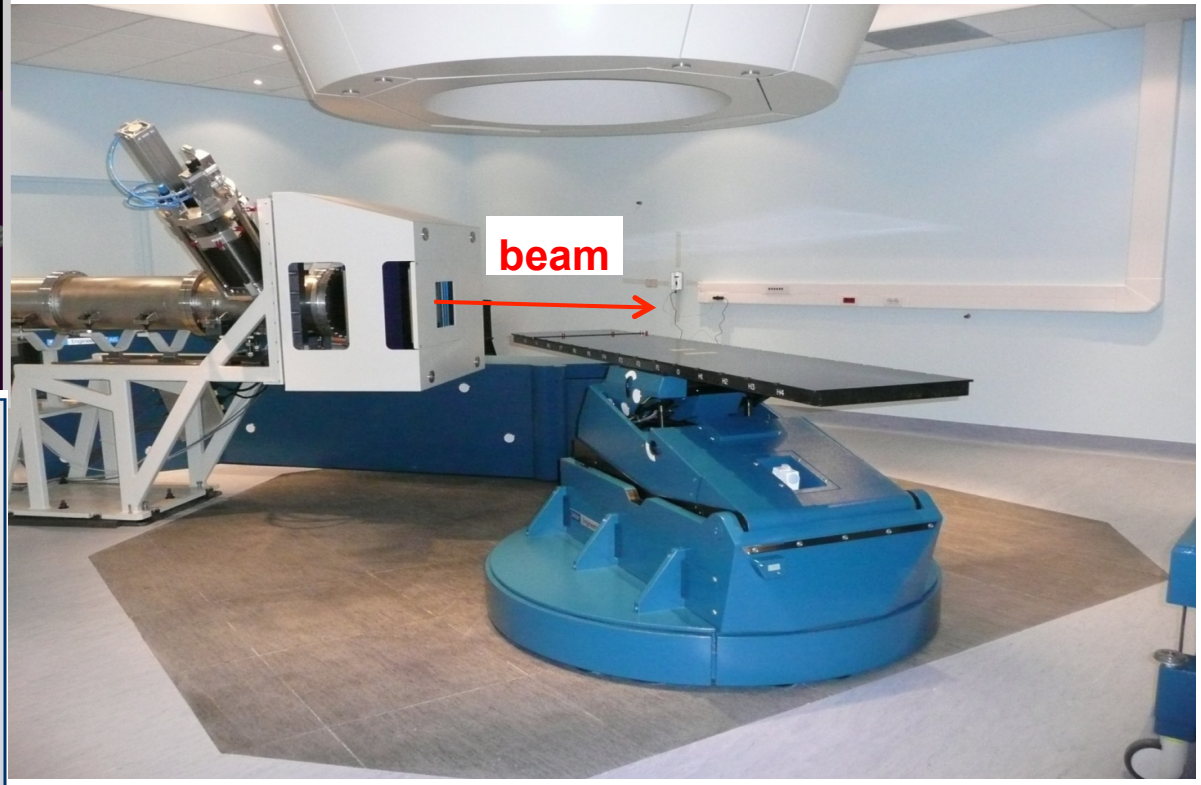




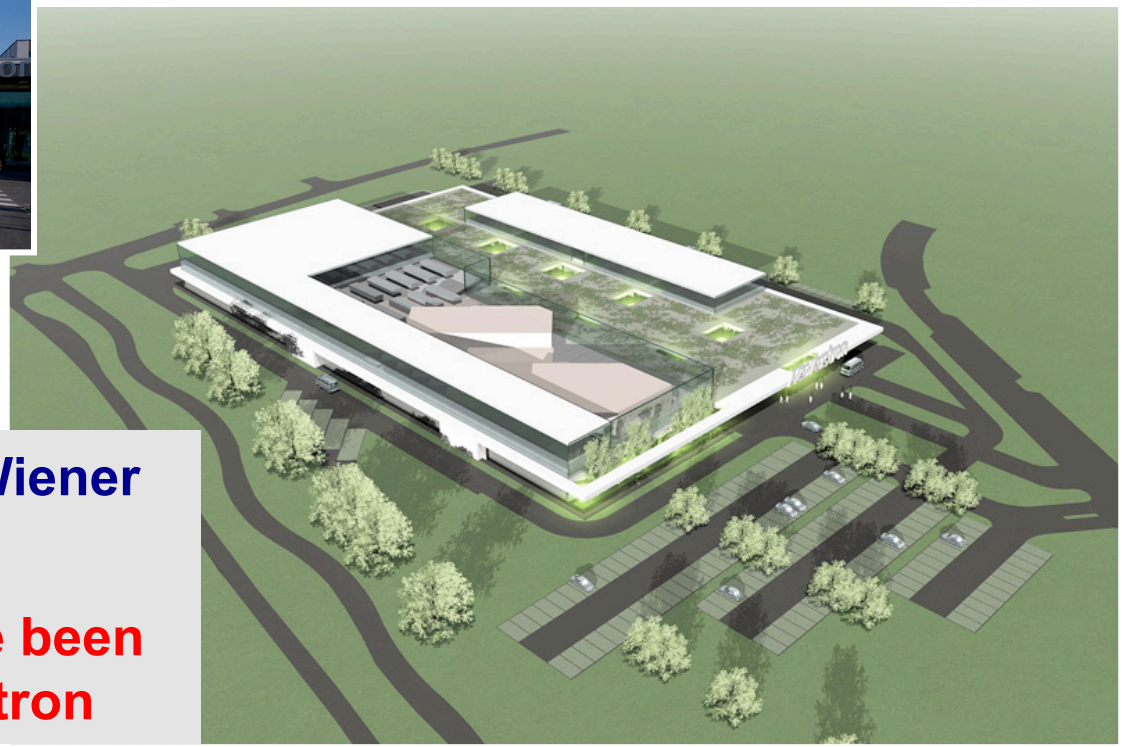


September 2014: 300 pantients treated

MedAustron promoted and participated in PIMMS

MedAustron in Wiener Neustadt

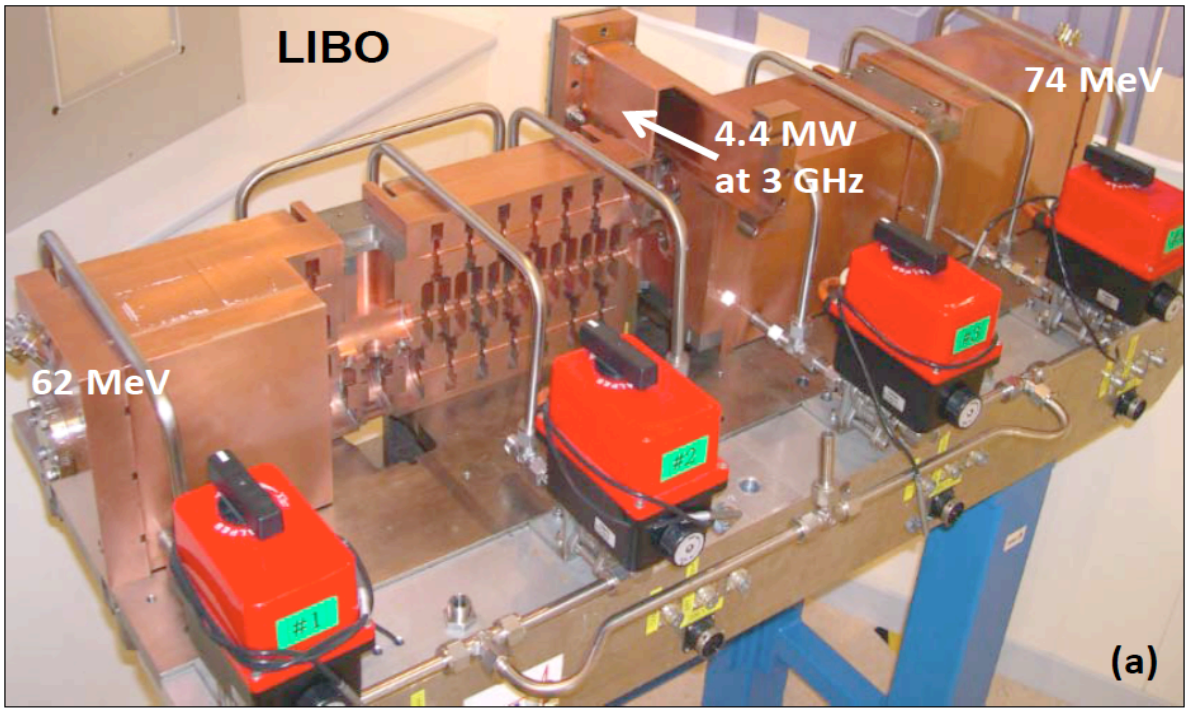
MedAustron promoted and participated in PIMMS

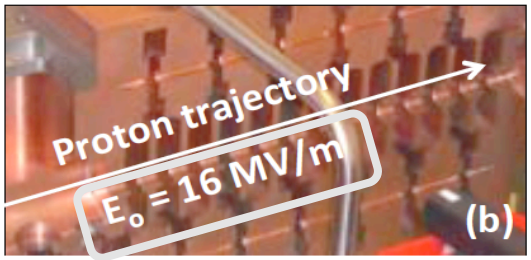


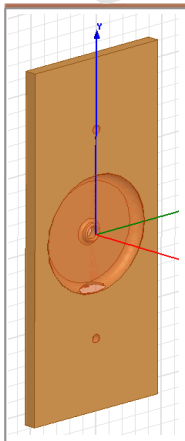
Construction completed in Wiener Neustadt:

Two weeks ago protons have been accelerated in the synchrotron

Second TERA program: linacs for protontherapy



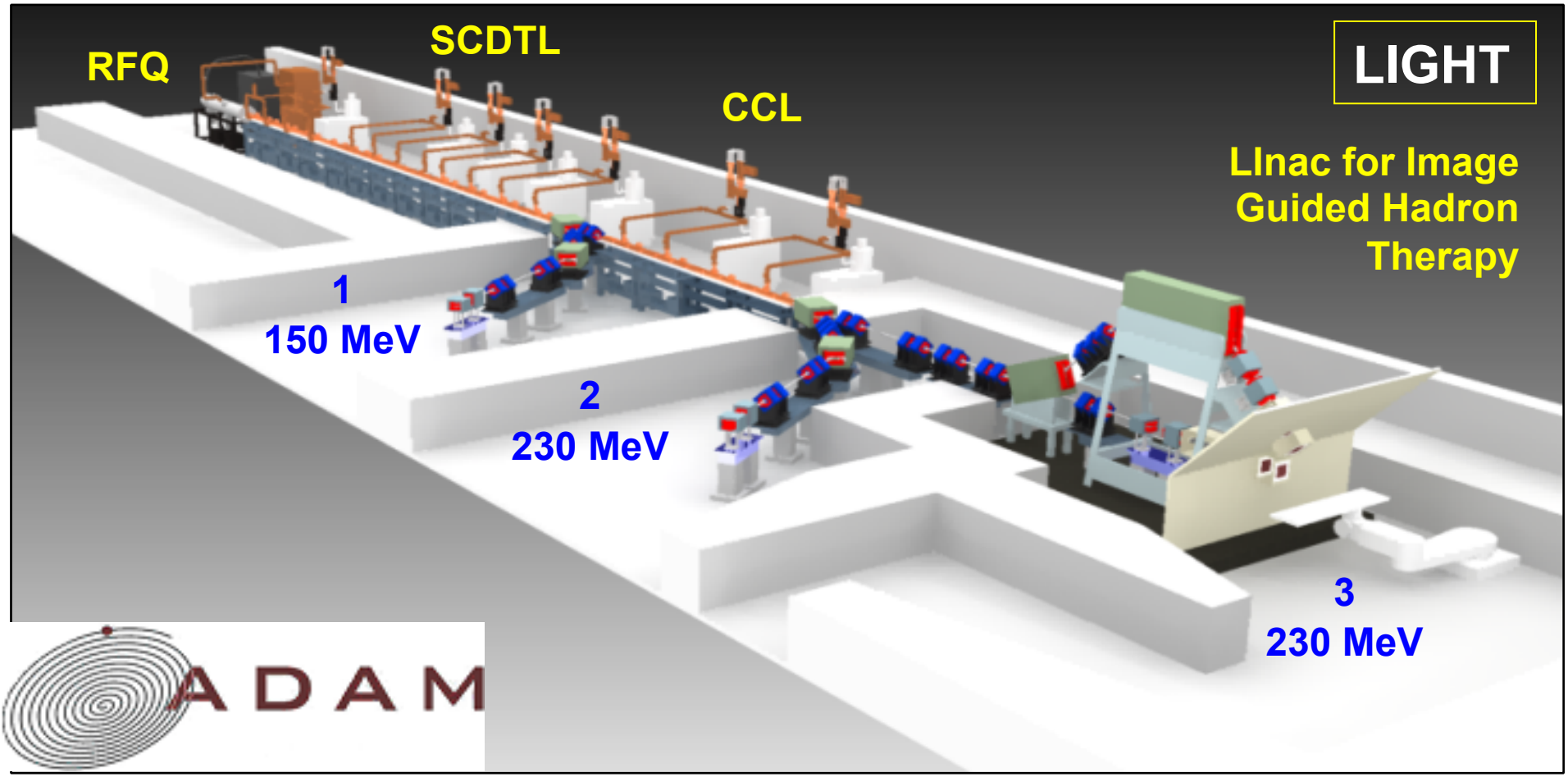




Basic unit: half-cell

LIBO = LInac BOster for protons similar to an electron linac has accelerated particles from 62 MeV to 74 MeV

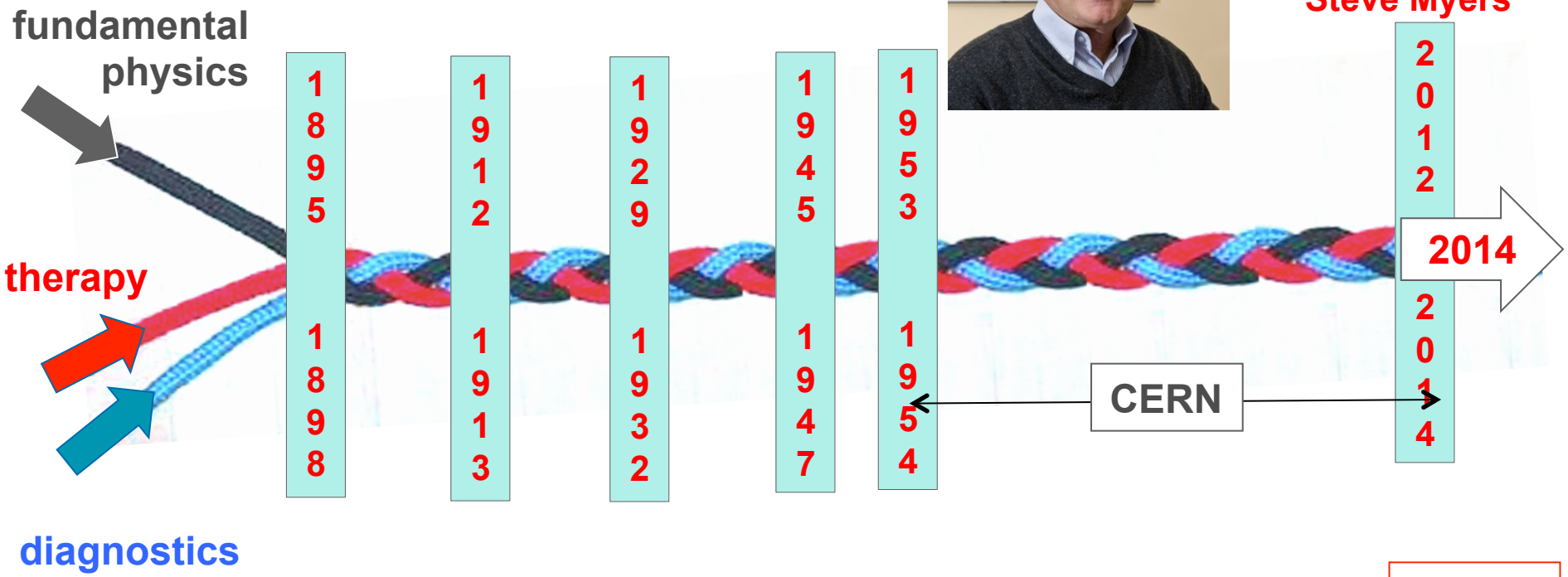
Centre offered by A.D.A.M. – a CERN spin-off Company acquired in 2013 by Advanced Oncotherapy



To conclude: in 2014 CERN has made a further step

Office for CERN Medical Applications

1st January 2014
Steve Myers



CERN
CERN