A Physicist's Perspective of Proton Therapy

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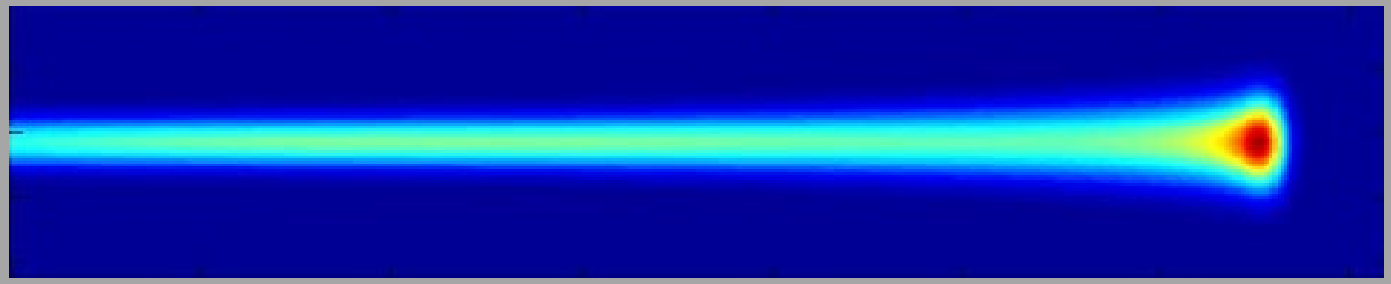


First idea by Robert Wilson in 1946

Radiological Use of Fast Protons

ROBERT R WILSON
Research Laboratory of Physics, Harvard University Cambridge, Massachusetts
Accepted for publication in July 1946.

Except for electrons, the particles which have been accelerated to high energies by machines such as cyclotrons or Van de Graaff generators have not been directly used therapeutically. Rather, the neutrons, gamma rays, or artificial radioactivities produced in various reactions of the primary particles have been applied to medical problems. This has, in large part, been due to the very short penetration in tissue of protons, deuterons, and alpha particles from present accelerators.

Higher-energy machines are now under construction, however, and the ions from them will in general be energetic enough to have a range in tissue comparable to body dimensions. It must have occurred to many people that the particles themselves now become of considerable therapeutic interest. The object of this paper is to acquaint medical and biological workers with some of the physical properties and possibilities of such rays.

To be as simple as possible, let us consider only high-energy protons: later we can generalize to other particles. The accelerators now being constructed or planned will yield protons of energies above 125 MeV (million electron volts) and perhaps as high as 400 MeV. The range of a 125 MeV proton in tissue is 12 cm., while that of a 200 MeV proton is 27 cm. It is clear that such protons can penetrate to any part of the body.

- 1950s/60s; 1st patient treatments at LBNL, Uppsala University, HCL
- Berkeley; heavy ions. Harvard; protons

Particle Therapy around the world

89 centres in **operation** in **20 countries**

USA (32 p)

Japan (14 p, 6 C)

Germany(6 p, 2 C)

England (3 p)

Austria (1 p, C)

Italy (3 p, 1 C)

Netherlands (3 p)

Denmark (1 p)

77 planned centres also in **11 new countries**

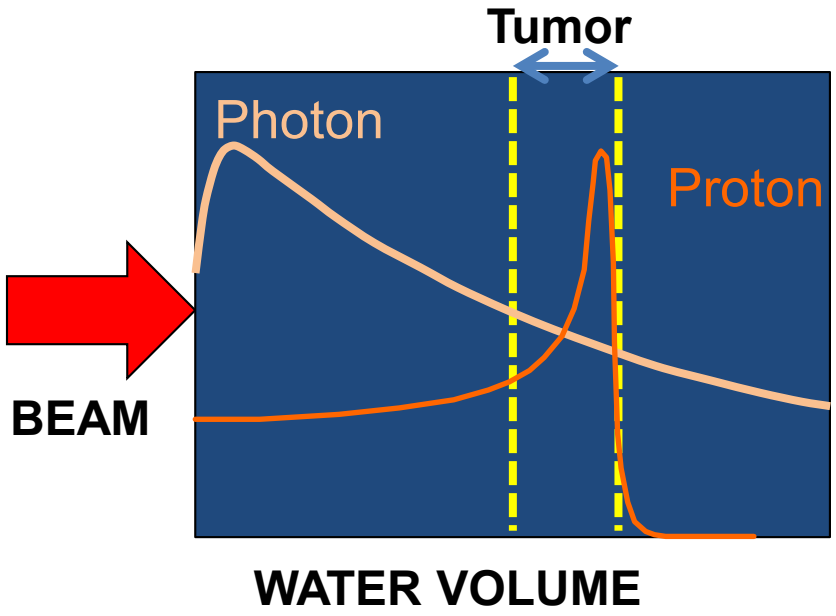
Spain (2 p)

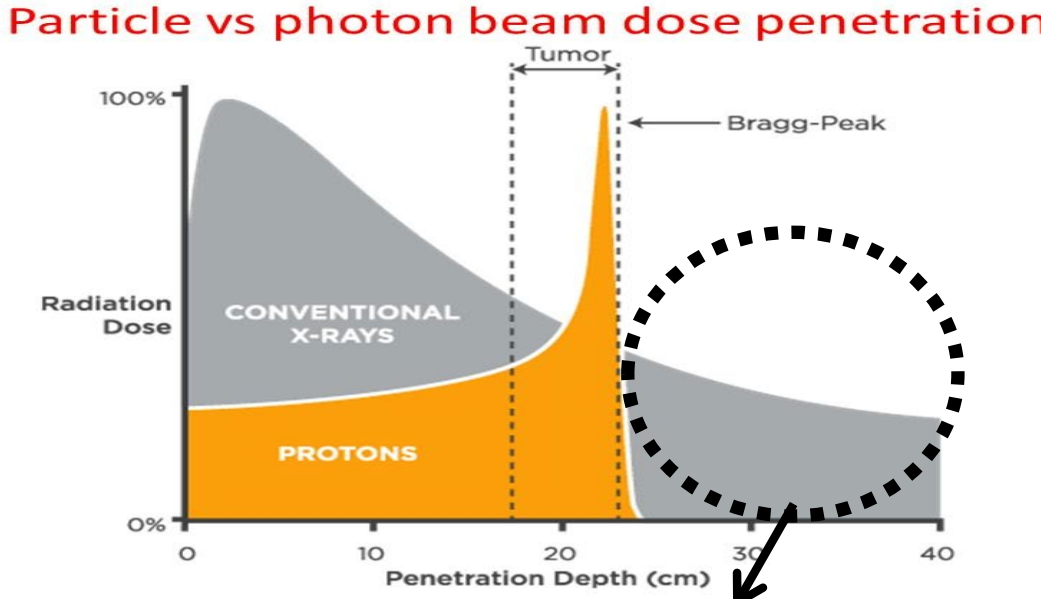
Belgium (1 p)

Norway (2 p)

Particle Therapy in operation in Europe

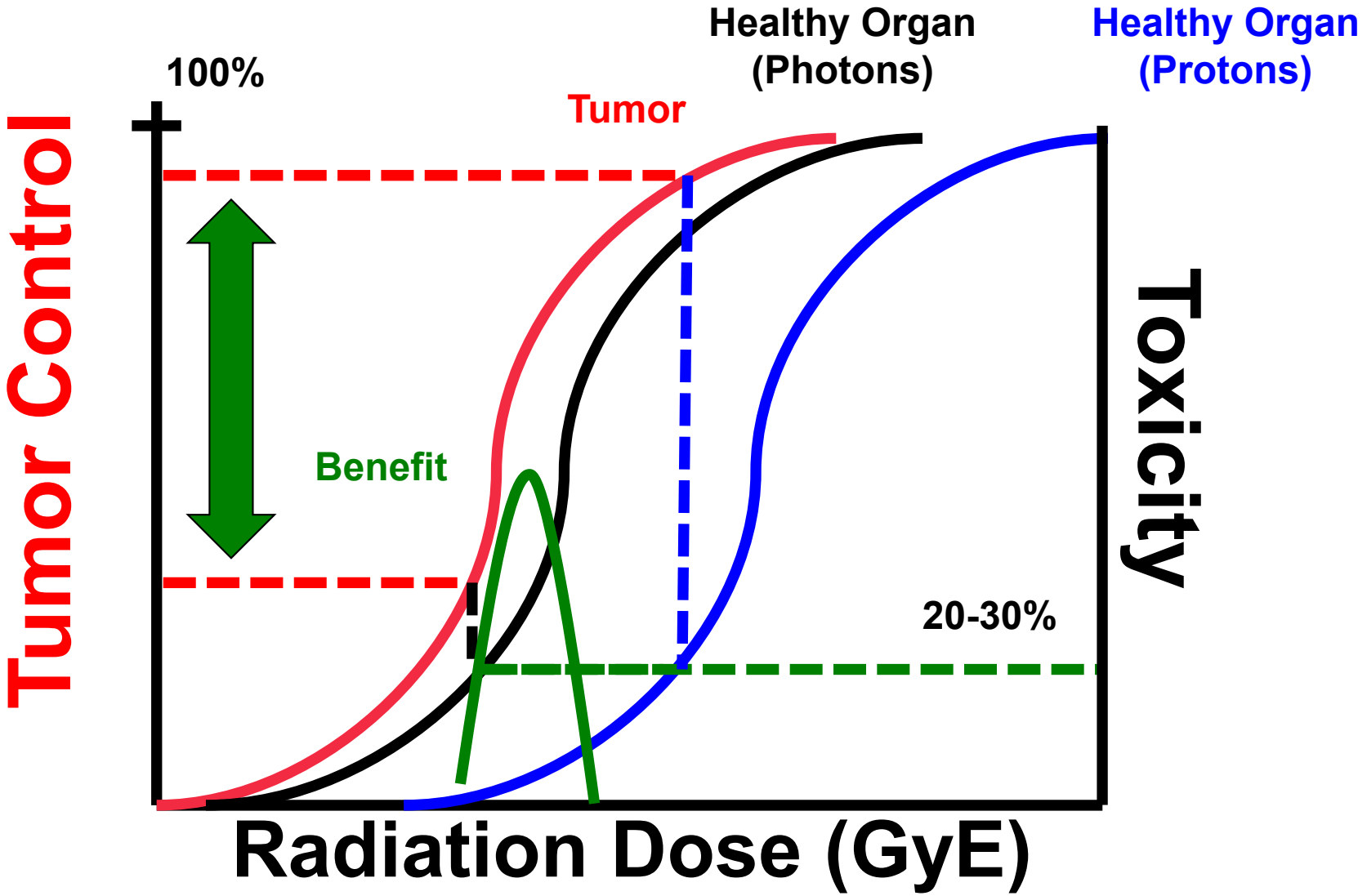
Why Proton Therapy?
"Bragg Peak"



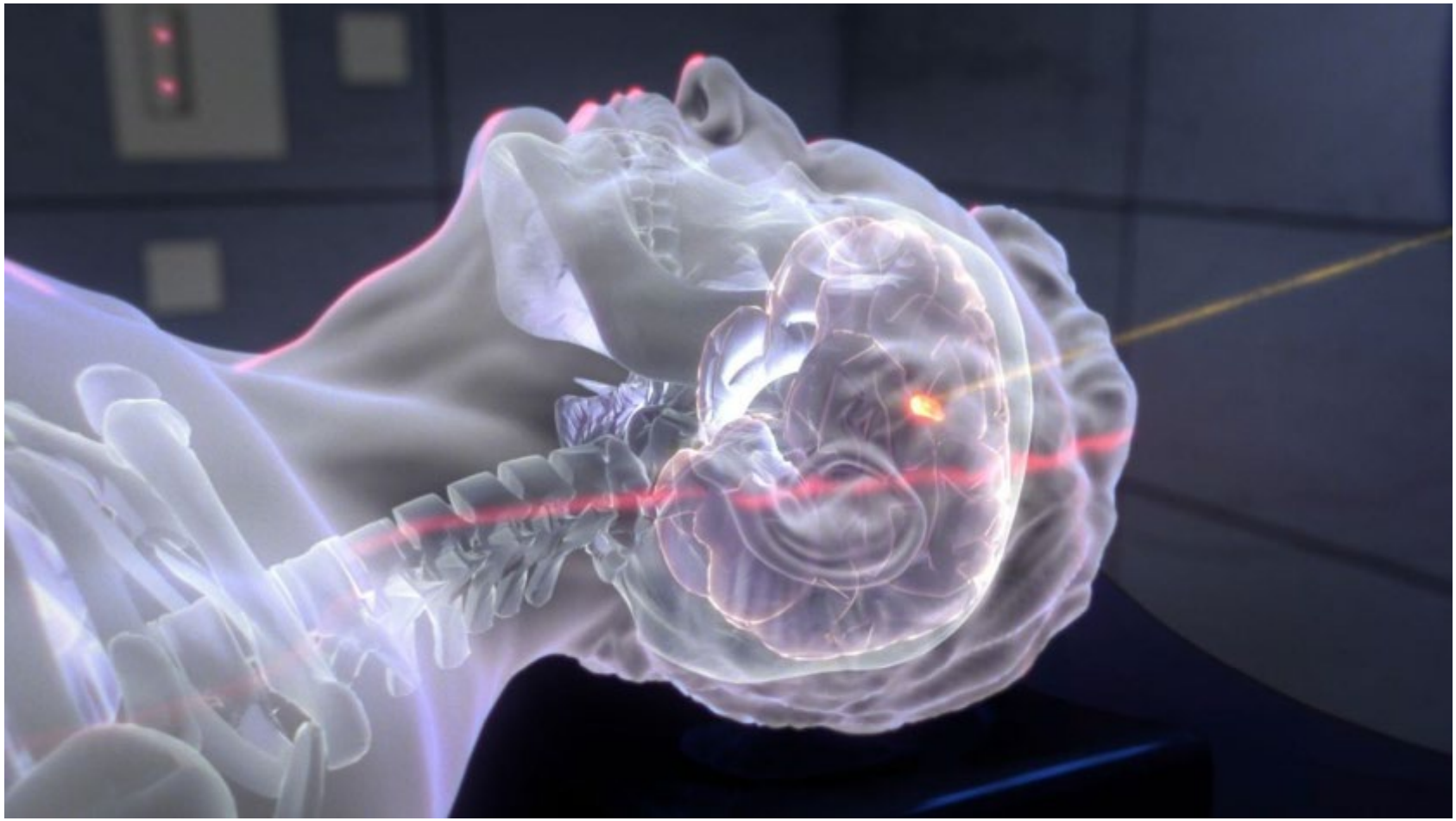


Organ Sparing Region

Advantage of Proton Therapy



Wonderful graphical illustration…



… but this is not (yet) the clinical reality in particle therapy

“There is no advantage whatsoever to irradiating uninvolved healthy tissue”

Dr. Herman Suit

Harvard / MGH Proton Center [1]

(1) Herman Suit, “The Grey Lecture 2001: Coming Technological Advances in Radiation Oncology,” International Journal of Radiation Oncology Biology Physics 53 No. 4 (2002): 798-809.

The next step: Hospital based facilities

- Success at HCL suggested that the technology belonged in hospitals vs. labs
- In 1983, Proton Therapy Cooperative Group (PTCoG) was formed to develop hospital based PT facilities (35 members)
- PTCoG has evolved to >700 people meeting annually

Loma Linda

- Pr. James (Jim) Slater at Loma Linda University Medical Center (LLUMC) was the first to raise the funds needed to build a hospital based PT facility

Massachusetts General Hospital (MGH)

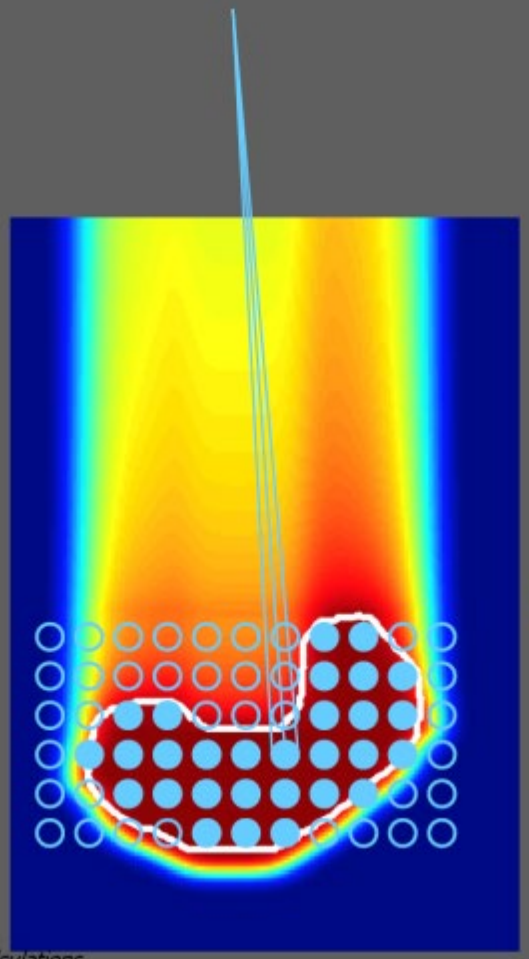
- 1992, MGH obtained the budget needed to build an in hospital PT facility from NCI and private donors. An international tender was launched

1995-2000: Japan active

- 1995 to 2000, the public authorities of Japan, financed the construction of 4 PT facilities and one carbon/proton facility by 3 Japanese companies; Hitachi, MELCO and SHI

Passive Scattering and Pencil Beam Scanning (PBS)

pencil beam scanning



- conforming pdd

fluence optimized per energy layer

→ beam only turned on inside target

- better proximal conformity
- no compensator scatter

compensator

Theoretical calculations.

What Cancers Can Protons Treat?

Classic indications:

Base of skull tumors

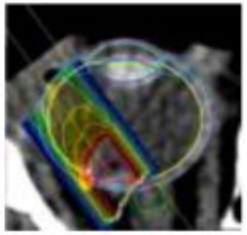
Eye (uveal) melanomas

Brain tumors

Pediatric tumors

Spinal / Paraspinal tumors

Prostate cancers



Lung

Liver

Breast

Esophagus

Pelvic tumors

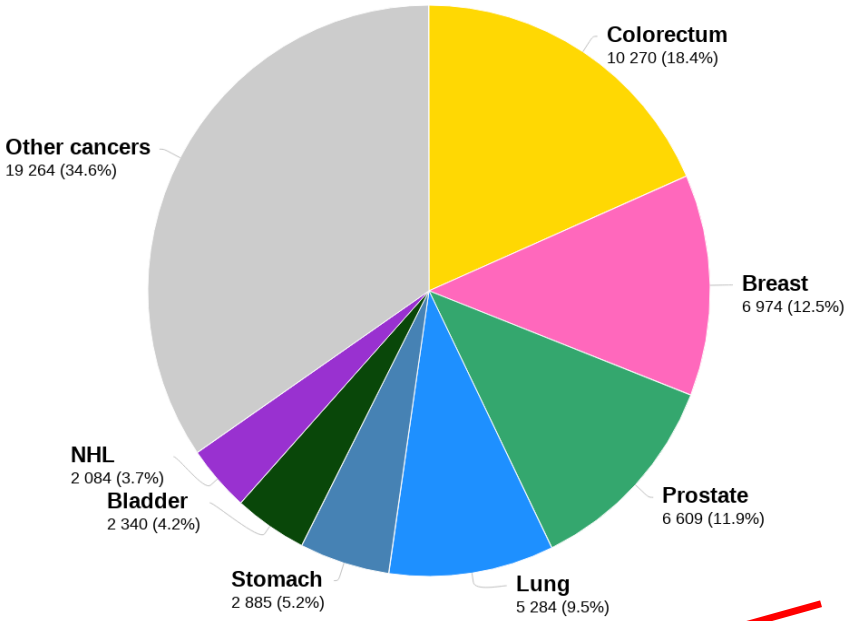
Large sarcomas

Mediastinal tumors

Reirradiation of recurrent tumors

Cancer in Portugal

Estimated number of new cases in 2018, Portugal, all cancers excl. NMSC, both sexes, all ages



Total : 55 710

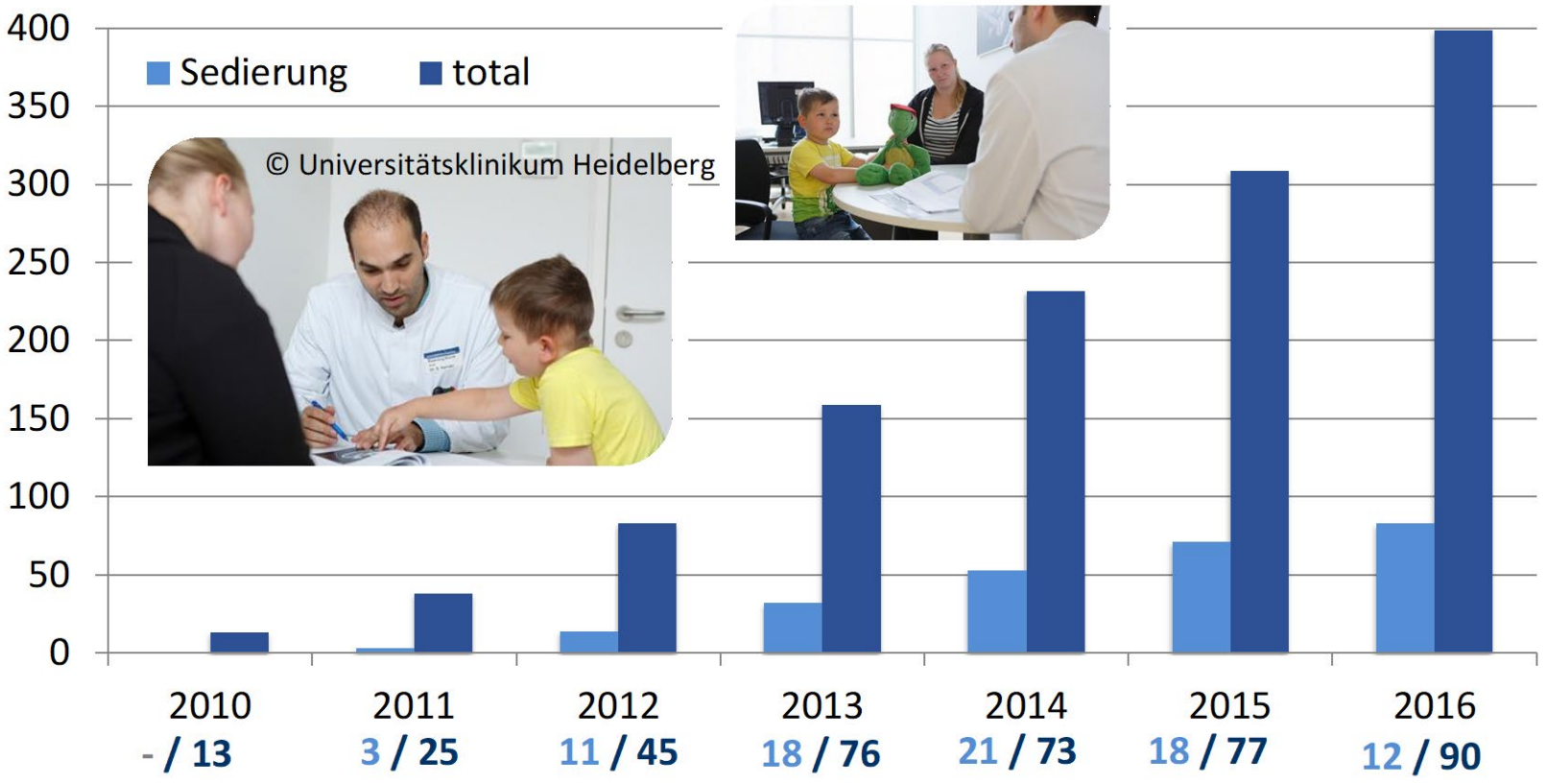
50% benefit from Radiotherapy

Data source: Globocan 2018
Graph production: Global Cancer Observatory (http://gco.iarc.fr)

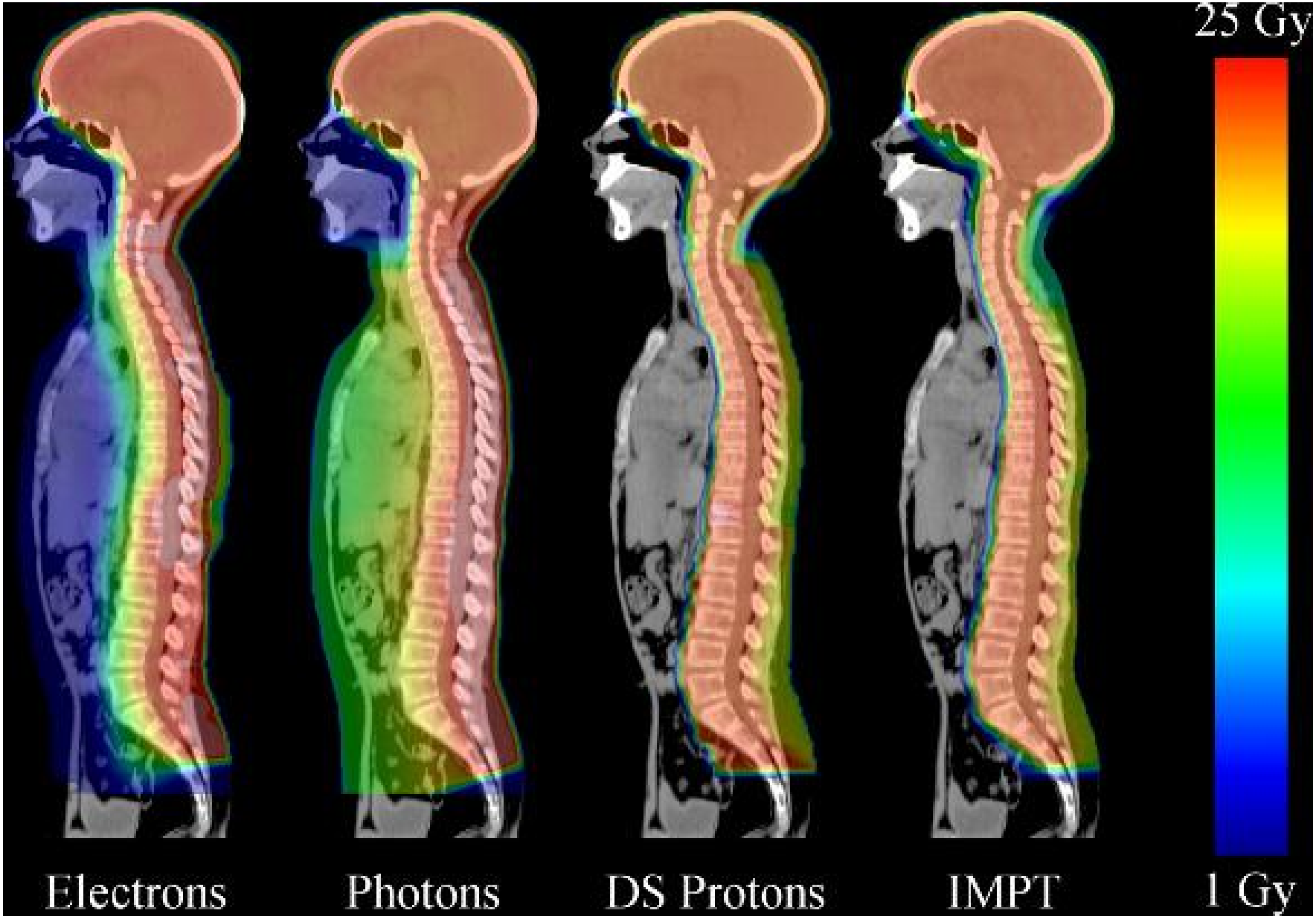
International Agency for Research on Cancer
World Health Organization

Pediatric proton centers of reference

Pediatric patients at HIT



Radiotherapy of the Craniospinal Axis – Electrons, Photons & Protons

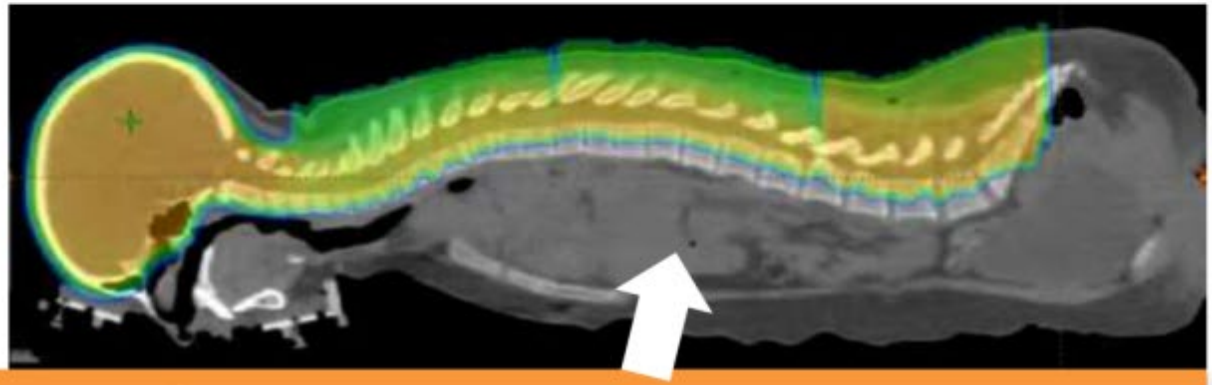


Stokkevåg et al., (2014) Acta Oncol. 53:8 1051-2

The Value of Protons

Protons are **physically superior** to X-rays:

Protons

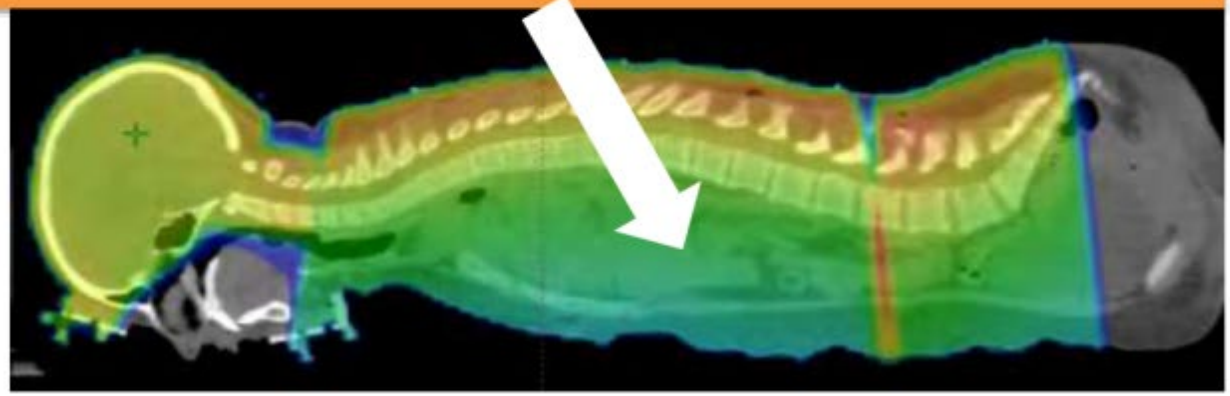


Protons avoid unnecessary radiation

to heart, lungs, intestines delivered by X-rays

X-Rays do not stop

Continue to travel
into normal tissues
beyond the target



Christie Proton Therapy Centre in Manchester

- Opened December 2018
- Procurement 1.5 y/Construction 3 y
- Owned by the NHS
- 3 Gantries and 1 Exp. Room
- 750 patients/year
- **35% pediatrics**
- Treatment time: 20-45 minute
- Proton centre full cost: €140m
- £41,000 - £43,000 each patient

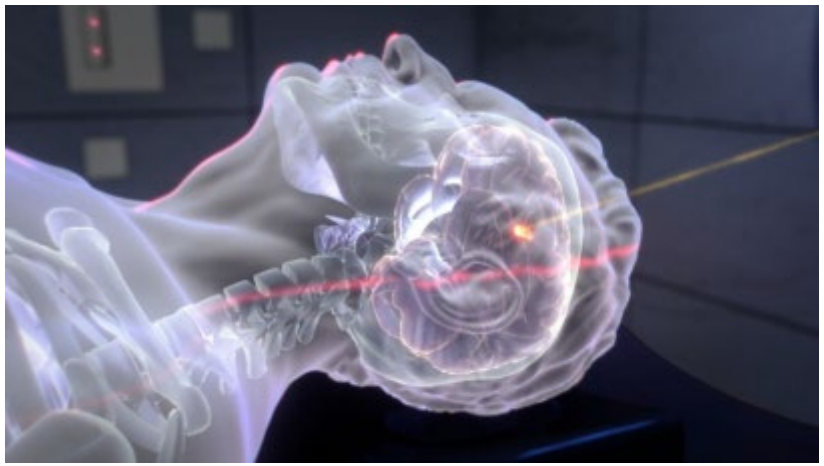
VISION OF PROTON THERAPY IN PORTUGAL

Gaspar Barreira,
LIP

Conclusions

Protons therapy can significantly reduce side effects in the treatment of cancer and potentially allow dose escalation

Thank You for Your Attention ☺



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Relaxing!