

PRESENT AND FUTURE OF PROTON THERAPY: Special Emphasis on Pediatrics

Joao Seco^{1,2} and Paulo Martins¹

¹ DKFZ, Division of Biomedical Physics in Radiation Oncology, Heidelberg, Germany

² Department of Physics and Astronomy, University of Heidelberg, Germany

dkfz.

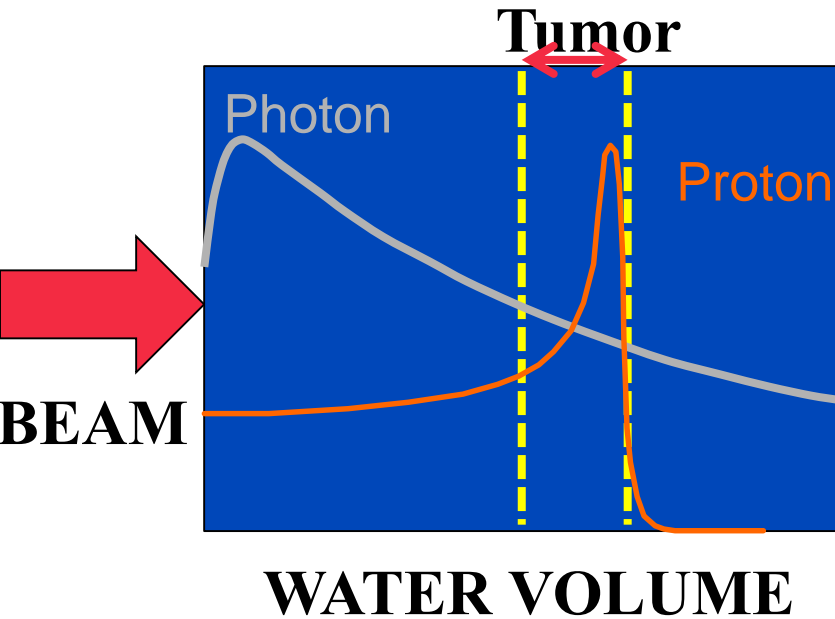
GERMAN
CANCER RESEARCH CENTER
IN THE HELMHOLTZ ASSOCIATION



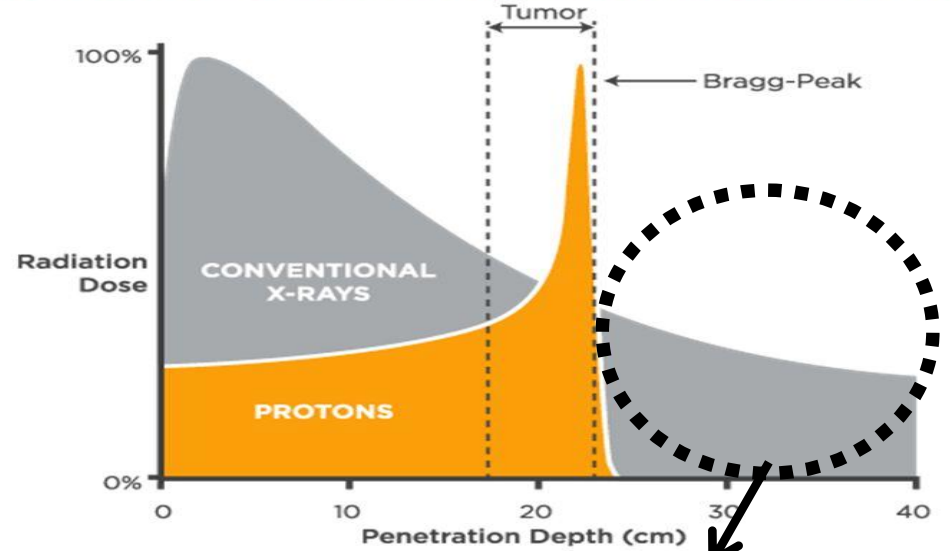
Research for a Life without Cancer

Why Particle Therapy?

“Bragg Peak”



Particle vs photon beam dose penetration



Organ Sparing Region

Wonderful graphical illustration...



VISION OF PROTON THERAPY IN PORTUGAL



**Gaspar Barreira,
LIP**



Paul Scherrer Institute (PSI), Zurich Switzerland

What is Cancer?



Simple English
WIKIPEDIA

Cancer

From Wikipedia, the free encyclopedia

Cancer is a type of **disease** where **cells** grow out of control, divide and invade other **tissues**. In a person without cancer, **cell division** is under control. In most **tissues**, healthy cells divide in a controlled way and copy themselves to create new healthy cells. With cancer, this normal process of cell division goes out of control. Cells change their nature because **mutations** have occurred in their **genes**. All the daughter cells of cancer cells are also cancerous.

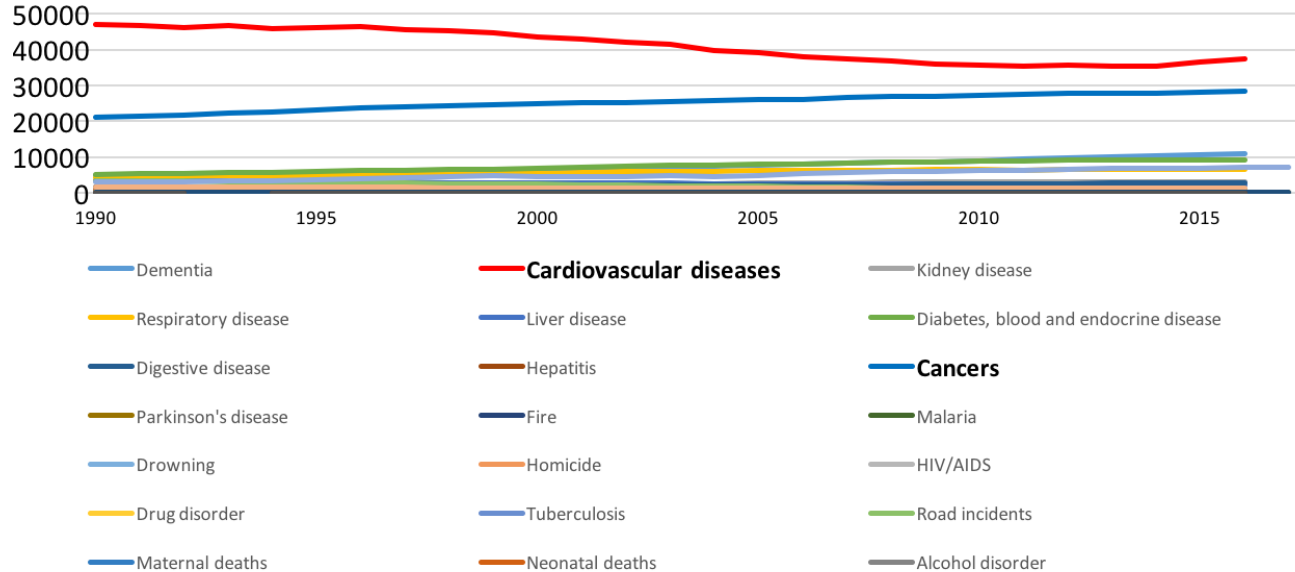
Main page
Simple start
Simple talk

**CANCER
STEM CELLS**



Cancer and cardiovascular mortality in Portugal

Deaths in Portugal (1990-2016)



Cancer:

- Ageing
- More diagnosis
- Lack of response

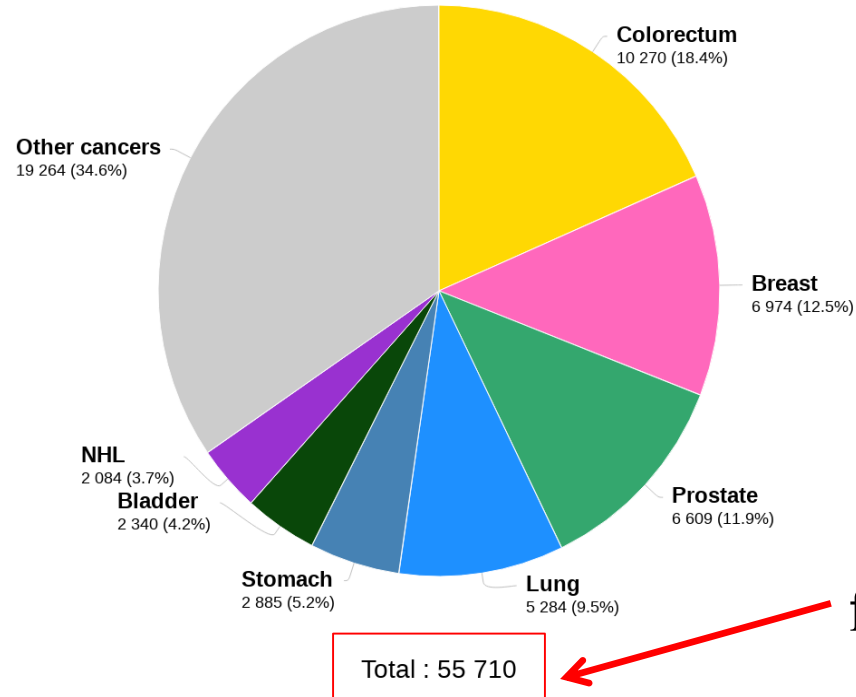
CV diseases:

- Revascularization
- Prevention

Cancer - 34 % increase vs. CardioVascular diseases – 20% decrease

Cancer in Portugal

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



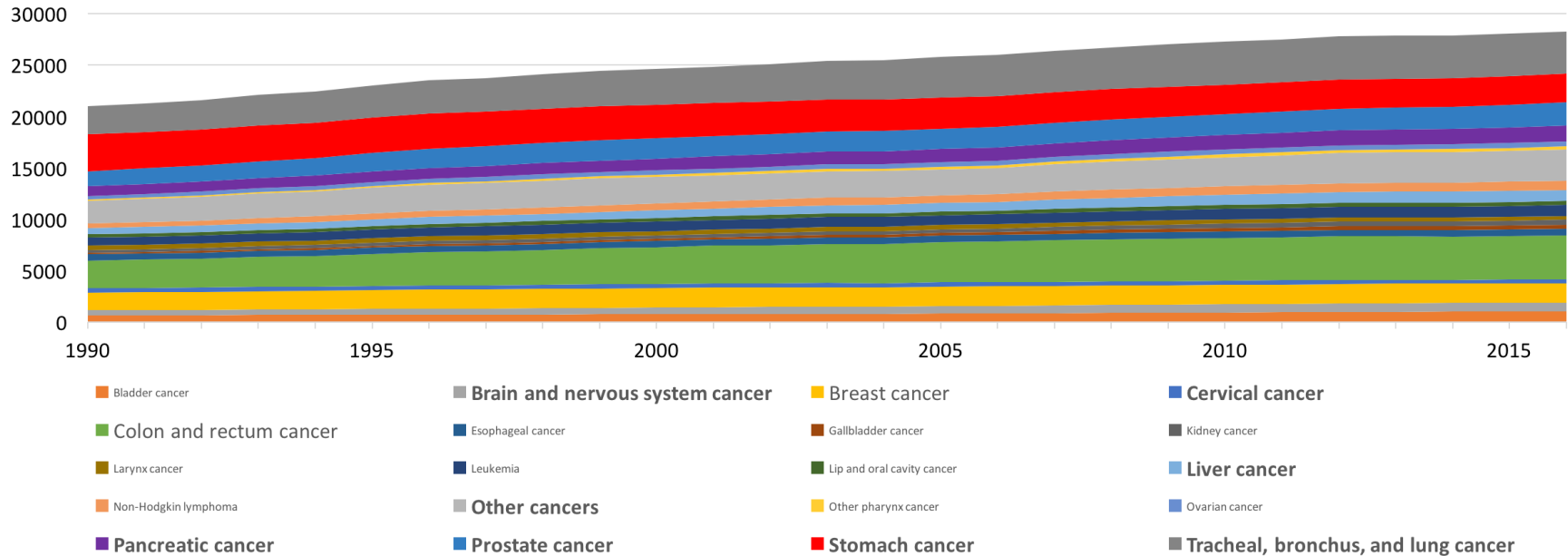
**50% benefit
from Radiotherapy**

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

International Agency for Research on Cancer
World Health
Organization

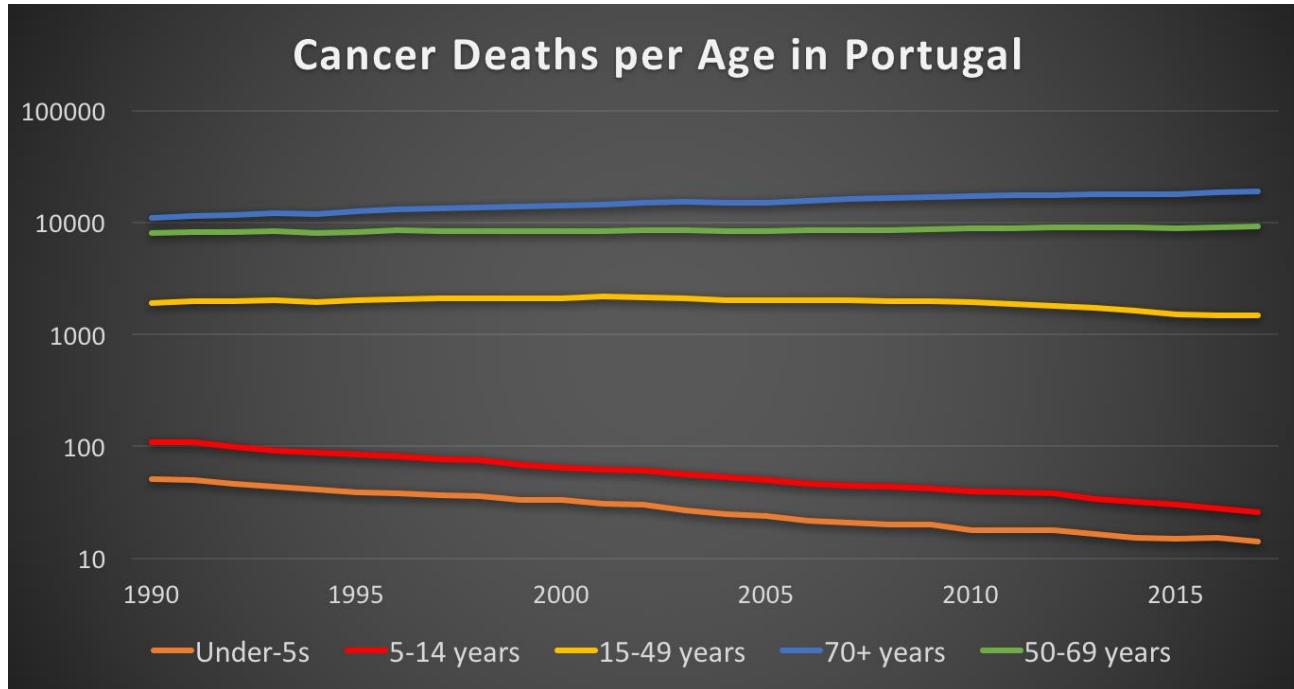
Cancer mortality trend in Portugal between 1990 and 2016

Cancer Deaths by organ



Increase: liver (80%); brain/CNS (69%); colon/rectum (60%); lung (54%)
Decrease: stomach (23%); cervical (16%)

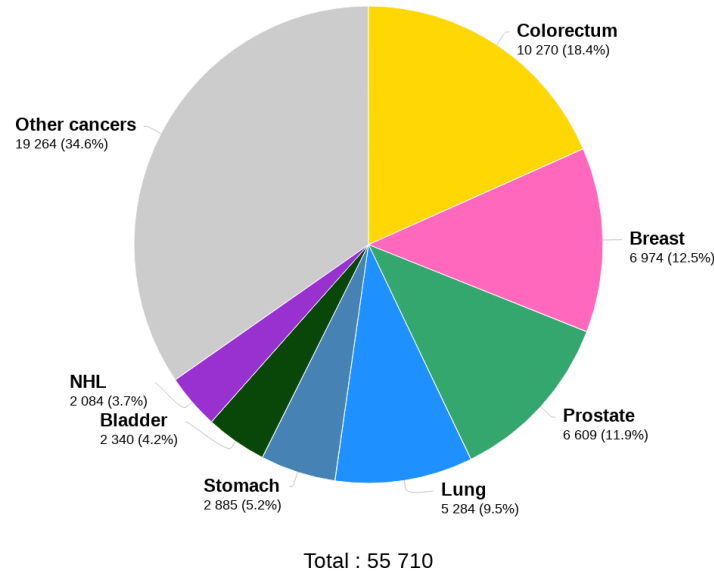
Cancer mortality per age in Portugal



Similar trends show ageing as main cause for cancer increase
However many pediatrics still need special care

Cancer in Portugal

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

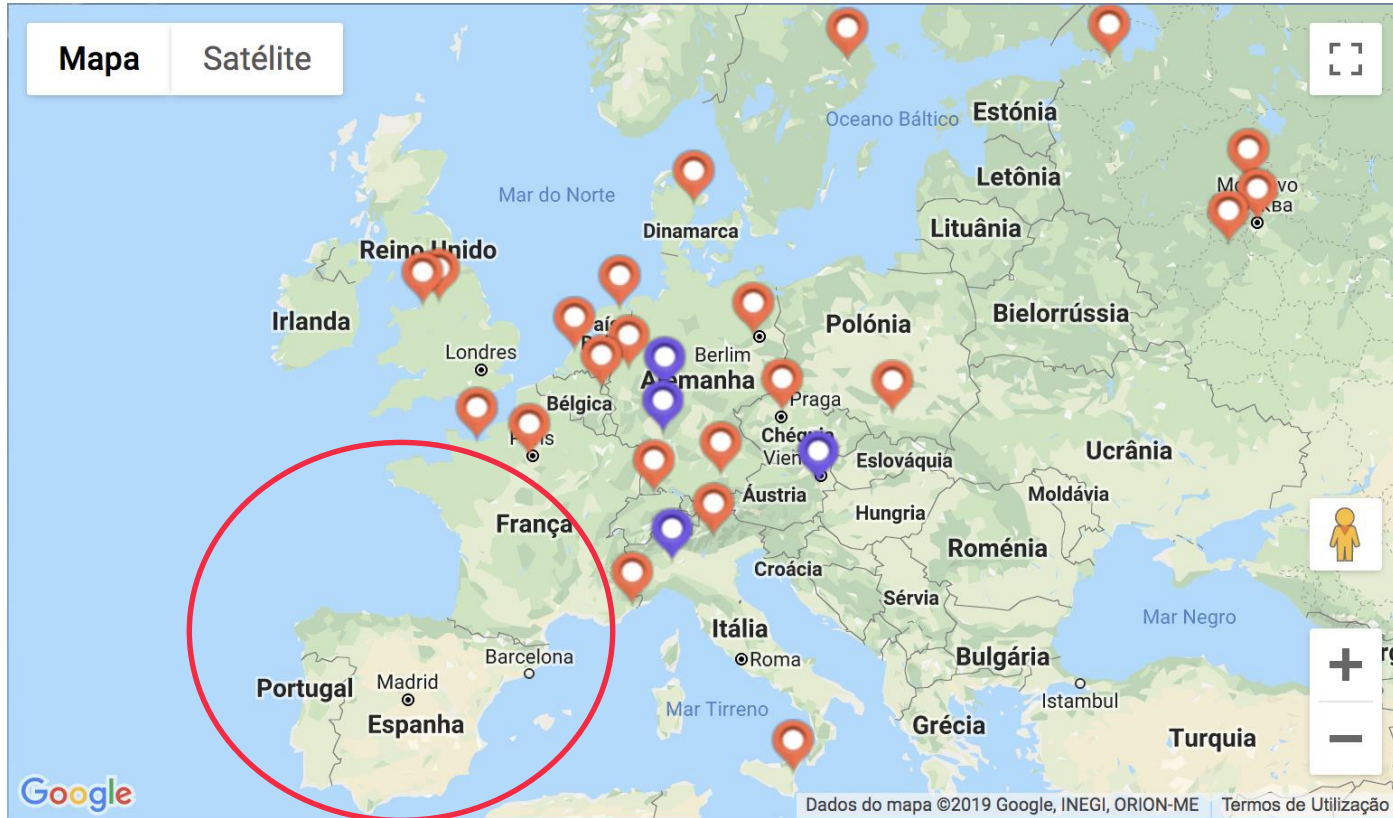


Proton Therapy Patients

15% of X-ray Patients (50% of Total): 4200 pts/Year

2017 Hirohiko Tsujii „Overview of Carbon-ion Radiotherapy“ Journal of Physics: Conf. Series 777 (2017) 012032

Particle Therapy in operation in Europe



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 around the world

89 centres in operation in 26 countries

USA (32 p)

Japan (14 p, 6 C)

England (3 p)

Germany (6 p, 2 C)

Austria (1 p, C)

Italy (3 p, 1 C)

Netherlands (3 p)

Denmark (1 p)

77 planned centres also in 11 new countries

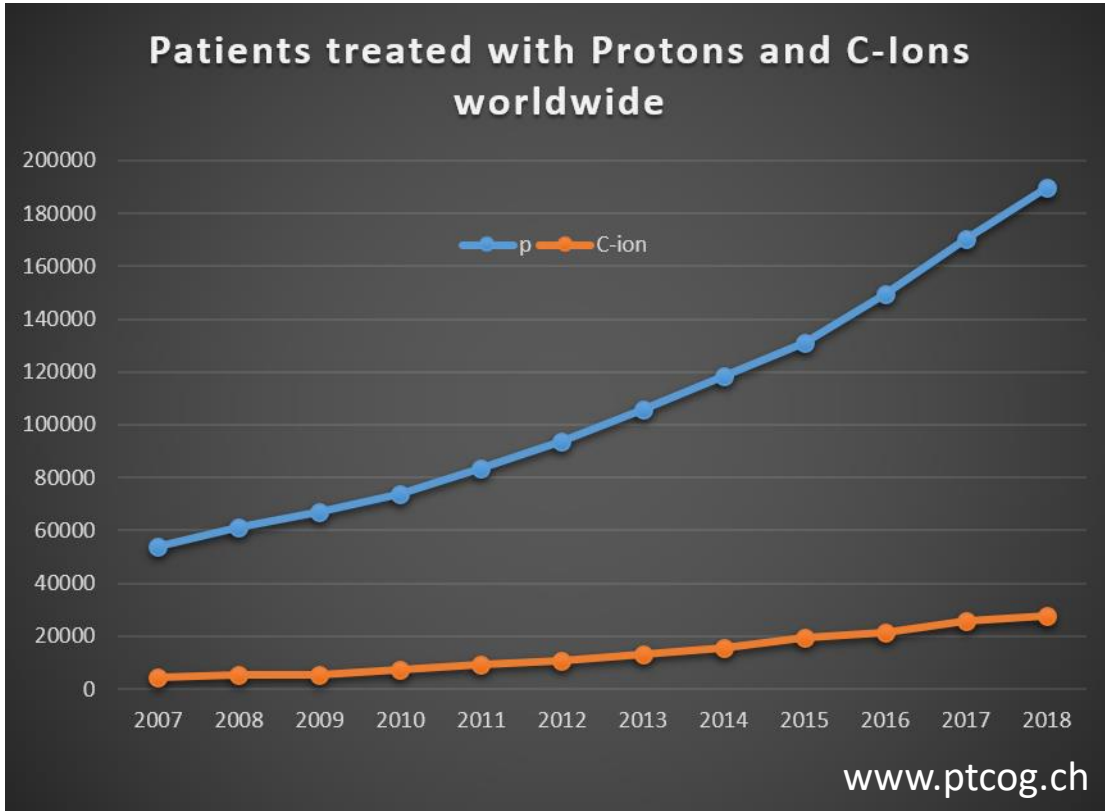
Spain (2 p)

Belgium (1 p)

Norway (2 p)

166 centres in 31 countries

Patient statistics



1990 Loma Linda – 20400 (~10%)

1994 Chiba – 12649 (C)

2001 Boston – 10374

1991 Orsay – 9476 (eye)

1980 PSI - 8824

2006 MD Anderson – 8800

2001 Hyogo – 5984 (p) + 2897 (C)

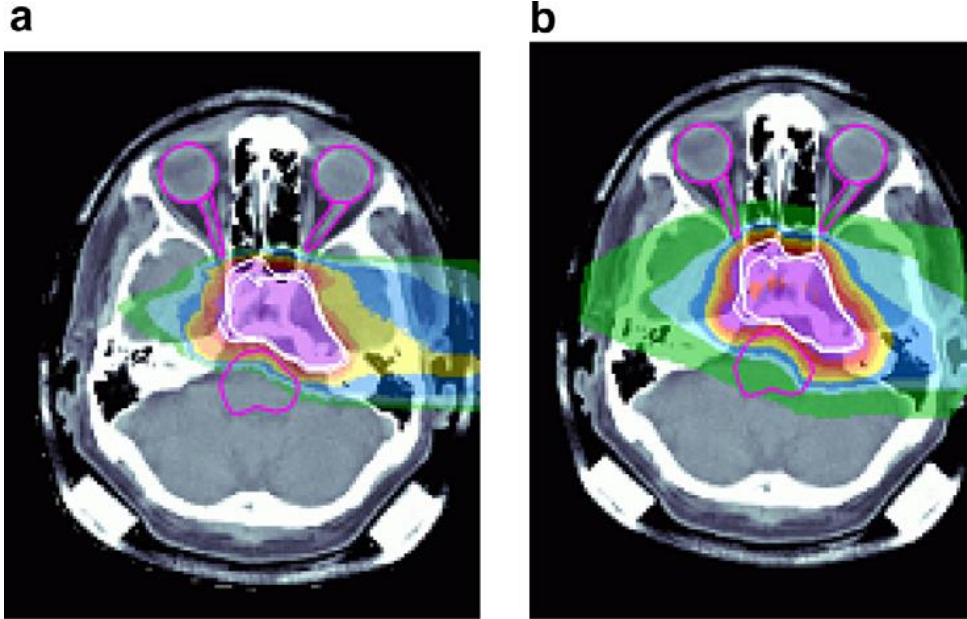
2009 HIT – 2186 (p) + 3016 (C)

2001 Tsukuba – 5490

2010 UPenn – 5800

2012 New Jersey - 4000

Radiotherapy of a tumor of the skull base



- Treatment plans for a patient with a head/neck tumor
- The volumes receiving high dose are quite similar for the two plans.
- The normal tissue volume irradiated to low doses is appreciably larger for ^1H treatment.

C-ion beams

^1H beams

O. Jäkel at DKFZ

A. Trofimov at MGH

H. Suit et al., (2010) Radiotherapy and Oncology 95 3-22

PROTON THERAPY FOR PEDIATRICS

The 2019-20 Best Children's Hospitals Honor Roll

1. Boston Children's Hospital
2. Children's Hospital of Philadelphia
3. Cincinnati Children's Hospital Medical Center (tie)
3. Texas Children's Hospital (tie)
5. Children's Hospital Los Angeles
6. Children's National Medical Center
7. Nationwide Children's Hospital
8. UPMC Children's Hospital of Pittsburgh
9. Johns Hopkins Children's Center
10. Seattle Children's Hospital

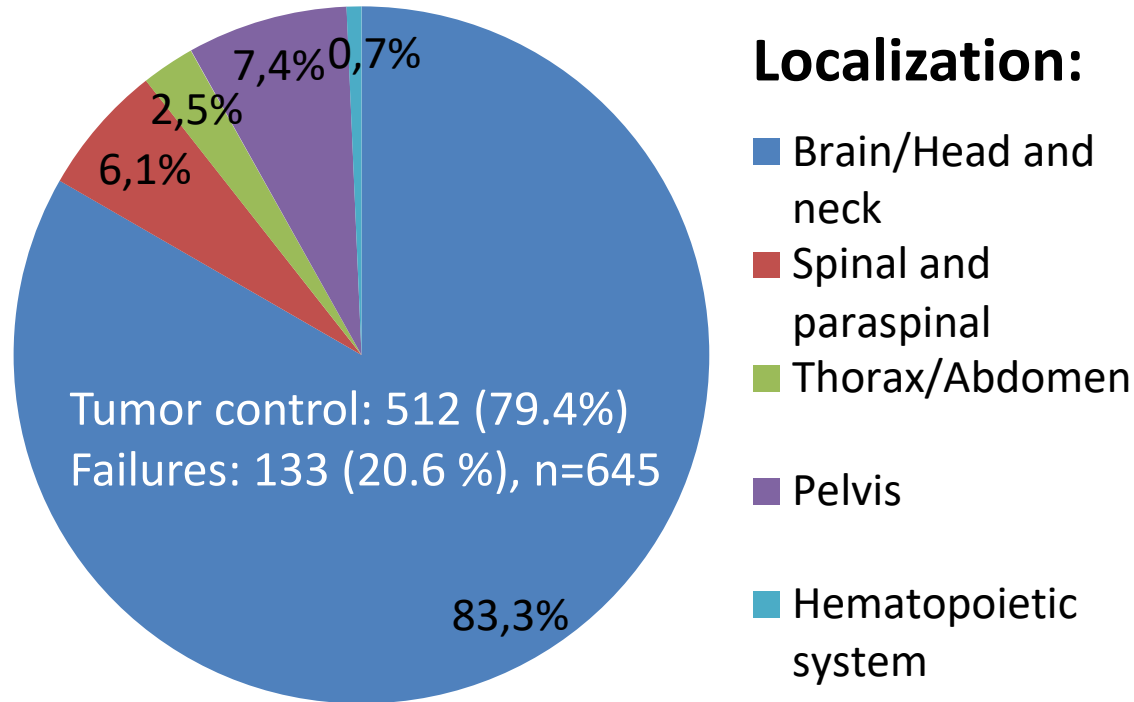


Boston Children's Hospital
Until every child is well™

Pediatric proton centers of reference



Pediatric cancer and proton therapy



WPE Essen (Statistics):

Jul 2013 – Aug 2018: data from **725** patients with a median age of 6.7 years (0.7-17.9)

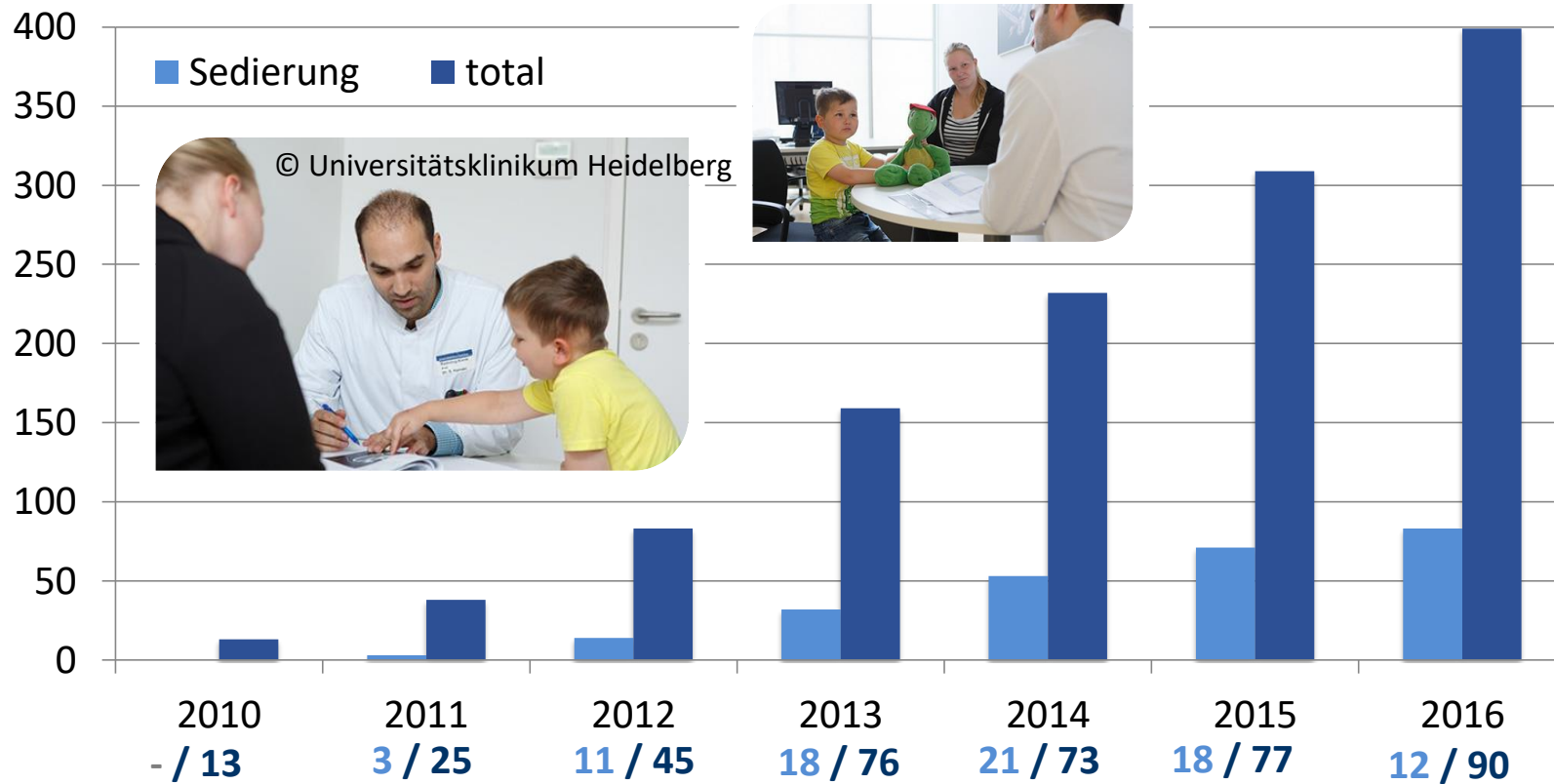
CNS tumors: 459 (**63.3%**)

- Ependydoma: 138 (30%)
- Medulloblastoma: 102 (22%)
- Glioma: 61 (13%)

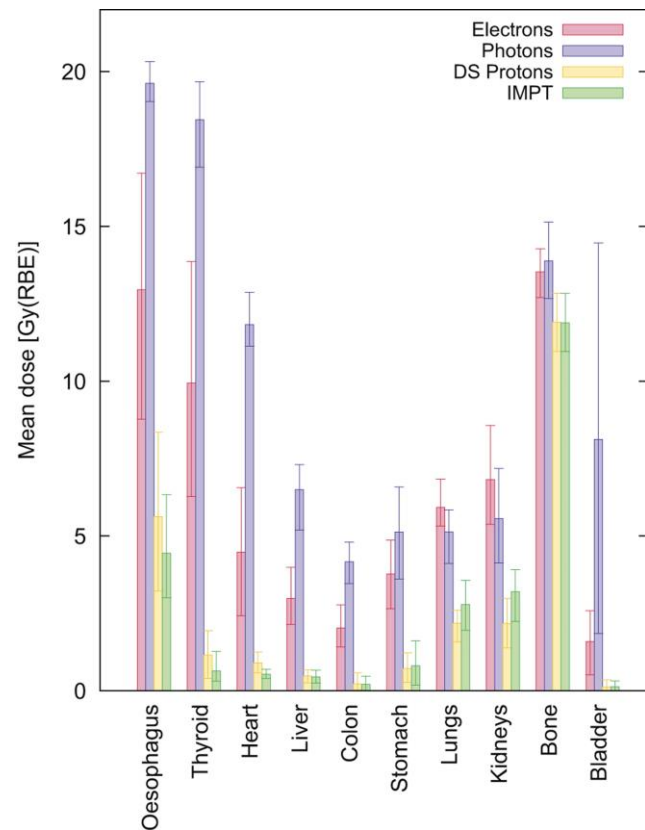
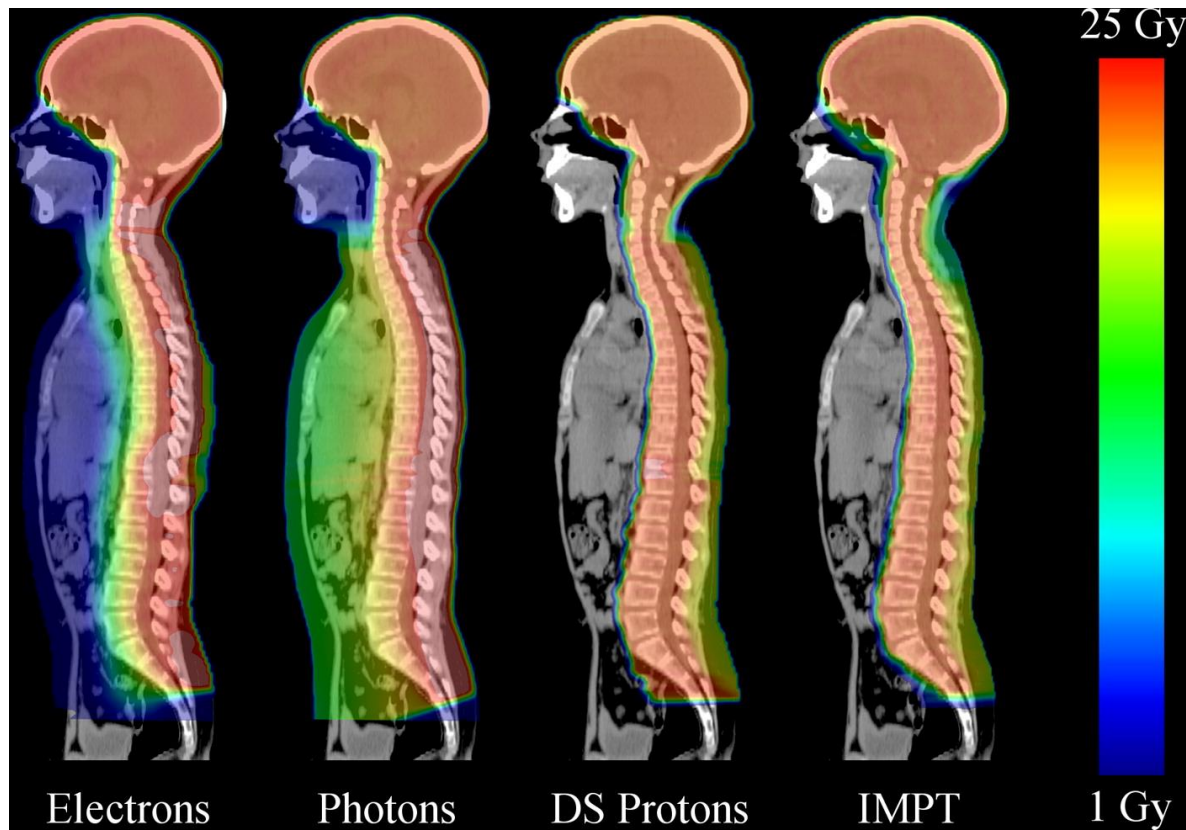
Sarcomas: 219 (30.2%)

D. Geismar & B. Timmermann, (2018) 2nd ISOP, Heidelberg

Pediatric patients at HIT



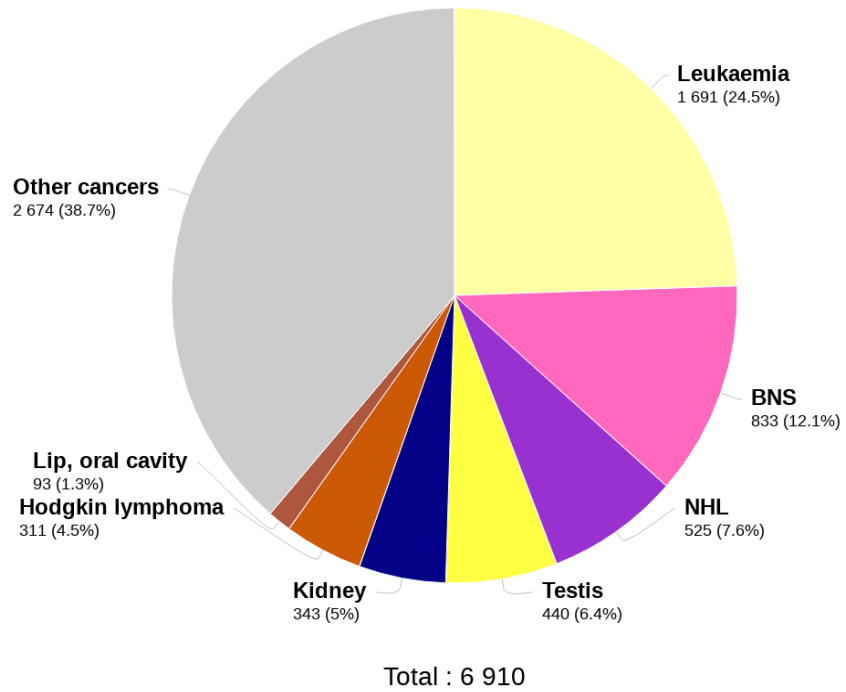
Radiotherapy of the Craniospinal Axis – Electrons, Photons & Protons



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

Cancer pediatric incidence and mortality in Portugal and CPLP Countries

Estimated number of new cases in 2018, Brazil, all cancers excl. NMSC, both sexes, ages 0-14



Portugal

- Incidence: 83
- Mortality: 21

Angola

- Incidence: 99
- Mortality: 46

Mozambique

- Incidence: > 500

Guinea-Bissau

- Incidence: 18

Brazil

- Incidence: > 1500

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



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

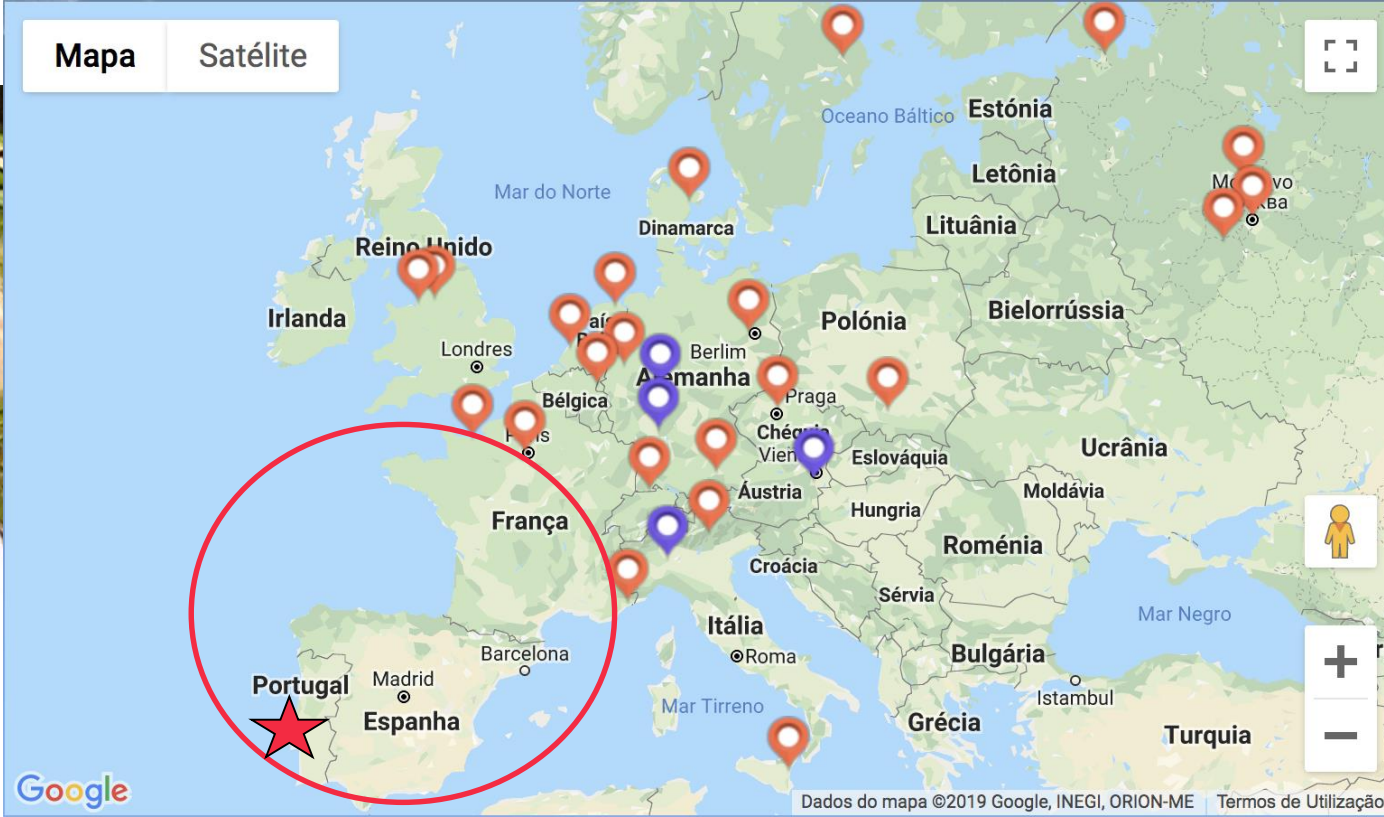
Conclusions

- Proton therapy offers the largest margin of benefit in pediatrics both in local control and prevention from later side effects.
- Brain and CNS cancer is more resistant to other therapies and benefits from particle therapy, specially in pediatric patients.
- Portugal and the CPLP countries should put common efforts in treating patients with such advanced technology since language is one of the main barriers for patients treated abroad.

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**Gaspar Barreira,
LIP**





**UNIVERSITÄT
HEIDELBERG**
ZUKUNFT
SEIT 1386



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