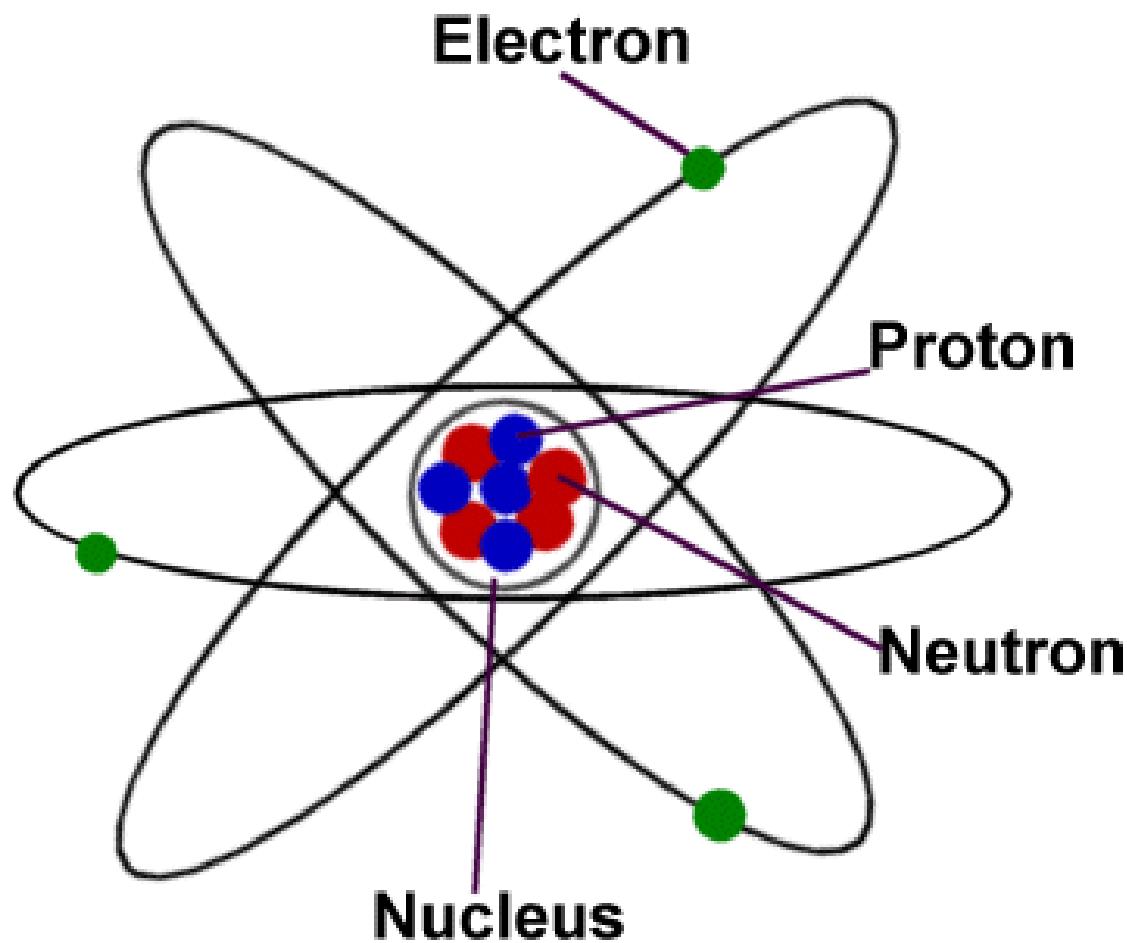


# Protonen therapie & hersentumoren

*Daniëlle Eekers*  
*Neuro-oncologie Symposium*

## Disclosure belangen spreker

(potentiële) belangenverstrengeling	Geen / Zie hieronder
Voor bijeenkomst mogelijk relevante relaties met bedrijven	Bedrijfsnamen
<ul style="list-style-type: none"><li>• Sponsoring of onderzoeksgeld</li><li>• Honorarium of andere (financiële) vergoeding</li><li>• Aandeelhouder</li><li>• Andere relatie, namelijk ...</li></ul>	<ul style="list-style-type: none"><li>•</li><li>•</li><li>•</li><li>•</li></ul>



**Nucleus**

**Proton**



"I'm positive!"

**Electron**



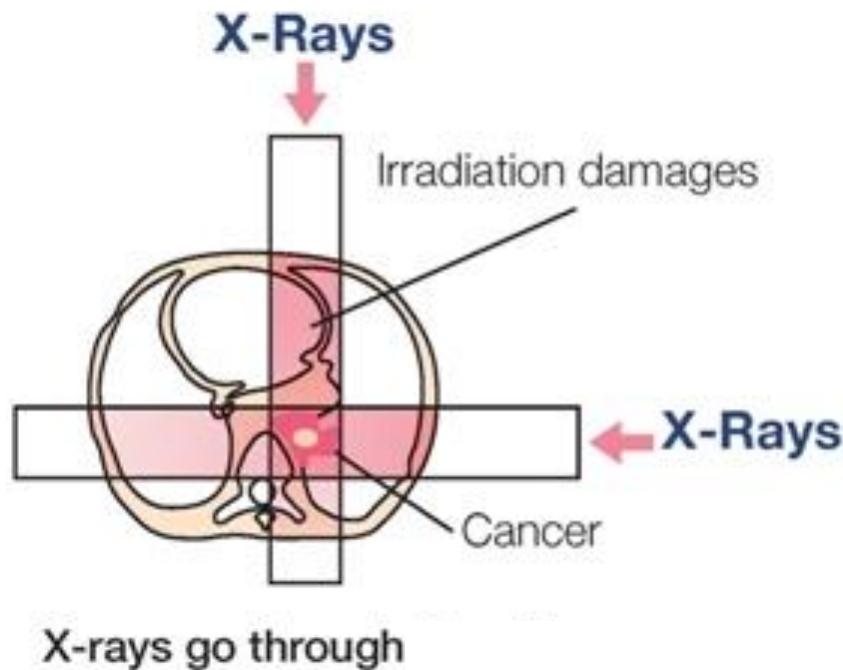
"I'm negative"

**Neutron**



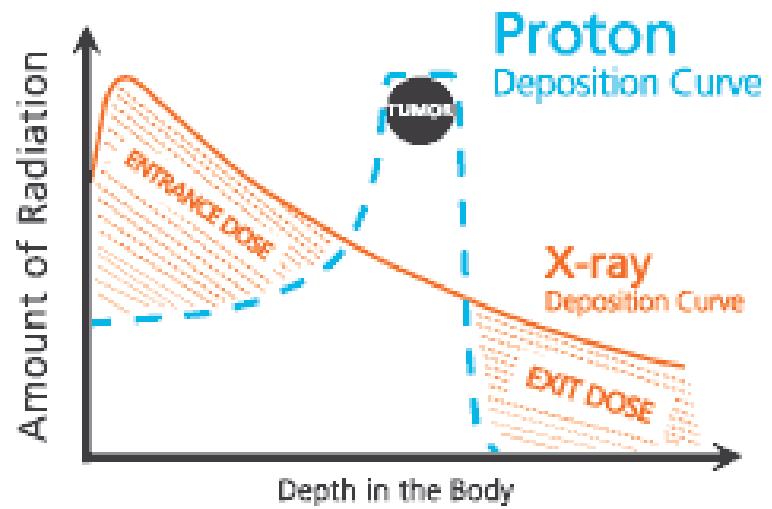
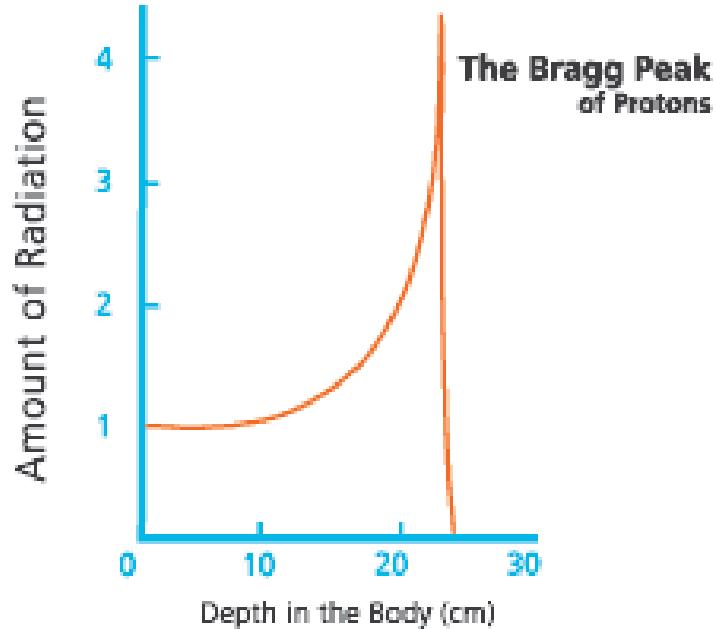
"I don't give a fuck"

# Fotonen

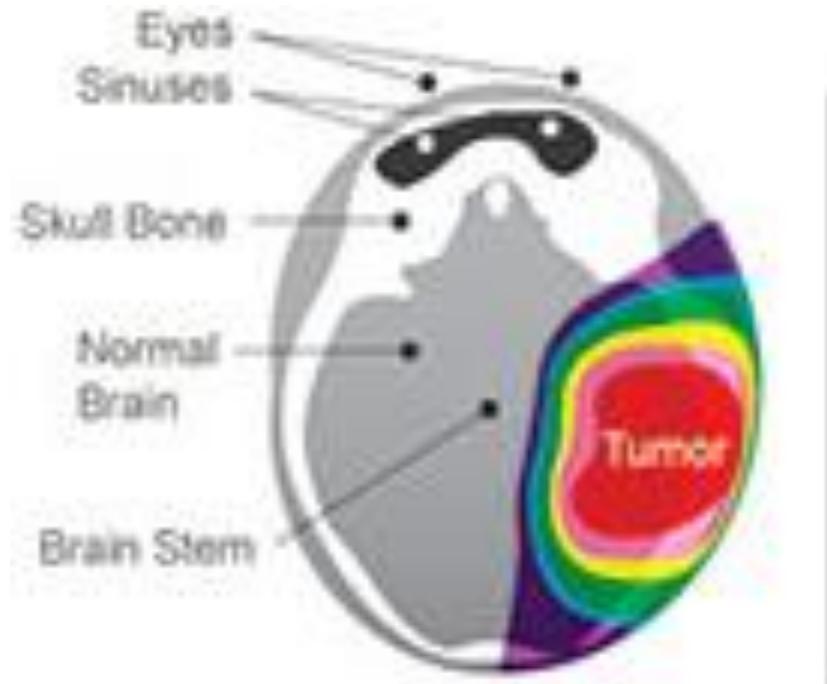


# Protonen

# Protonen



# Protonen



Less  
Radiation



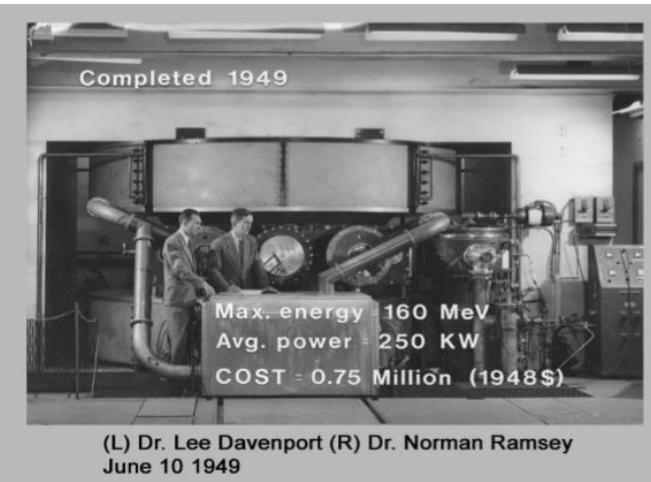
# Fotonen



More  
Radiation



THE HARVARD SYNCHROCYCLOTRON



**1903** Discovery of the Bragg peak

<b>1929</b>	Cyclotron invented by Ernest O. Lawrence as a way to accelerate nuclear particles to very high speeds.
<b>1930s</b>	60-inch cyclotron built at Berkeley Radiation Laboratory with financing from the late William H. Crocker, a University of California regent. Machine is used in creation of seven new elements.
<b>1939</b>	Lawrence wins Nobel Prize in physics for invention of cyclotron.
<b>1946</b>	Lawrence protégée Robert R. Wilson, a professor of physics at Harvard and designer of Harvard's cyclotron, first proposes using protons for the treatment of cancer.
<b>1948</b>	Berkeley Radiation Laboratory conducts extensive studies on protons and confirms predictions made by Wilson.
<b>1954</b>	First patient treated with protons at Berkeley Radiation Laboratory.
<b>1957</b>	Treatment successfully duplicated on patients in Uppsala, Sweden.
<b>1950s</b>	Lawrence offers 60-inch cyclotron to John Jungerman, who would become the founding director of the Crocker Nuclear Laboratory at UC Davis. In collaboration with Oak Ridge National Laboratory and the Naval Research Laboratory in Washington, D.C., the Berkeley machine is modified to a 76-inch cyclotron.
<b>1961</b>	Harvard treats first patient in its cyclotron.

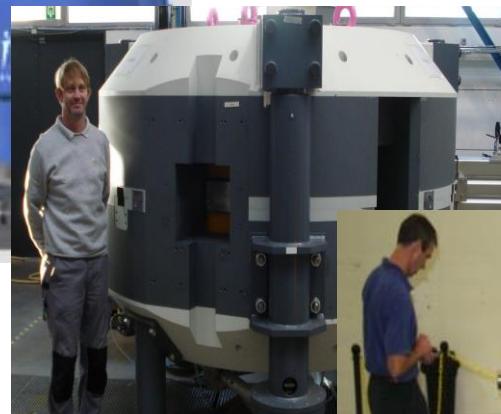
# “Miniaturization” of the proton source...



IBA – 220 Ton  
Isochronous Cyclotron



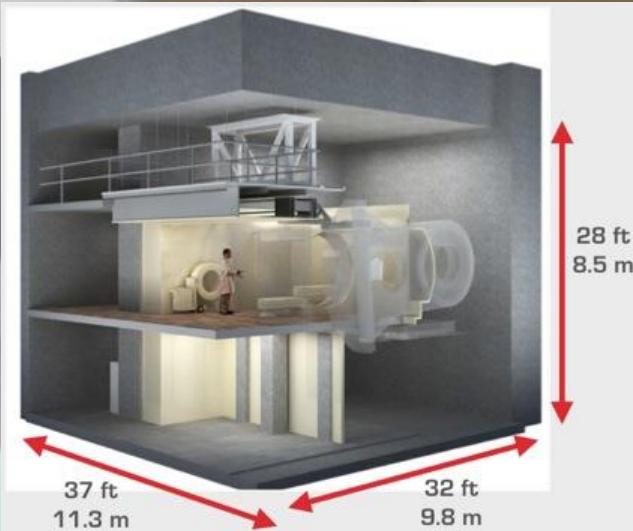
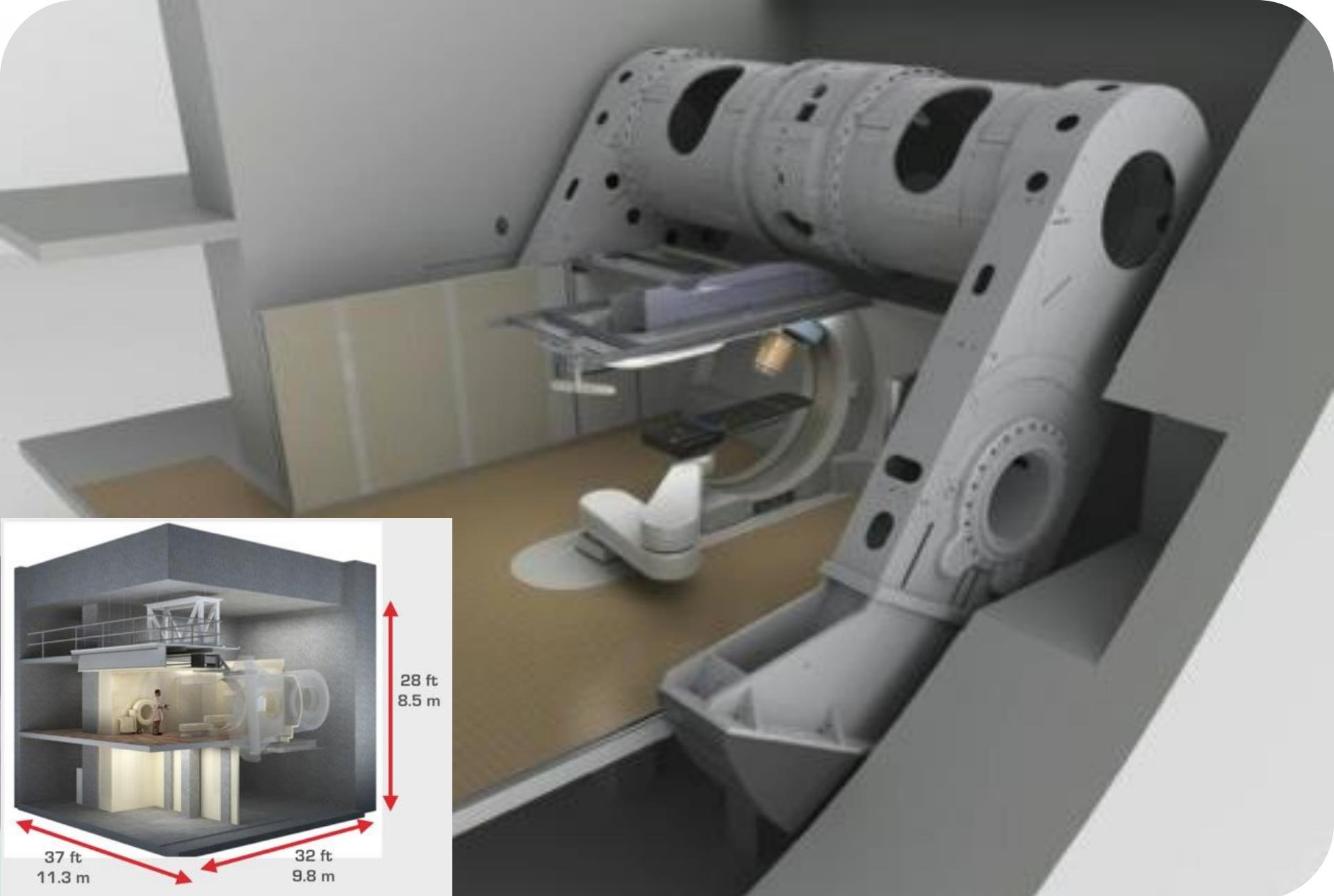
Varian – 90 Ton  
Isochronous Cyclotron



IBA – 50 Ton  
Synrocyclotron



MEVION – 15 Ton  
Synrocyclotron





# Protonen in NL UMC's

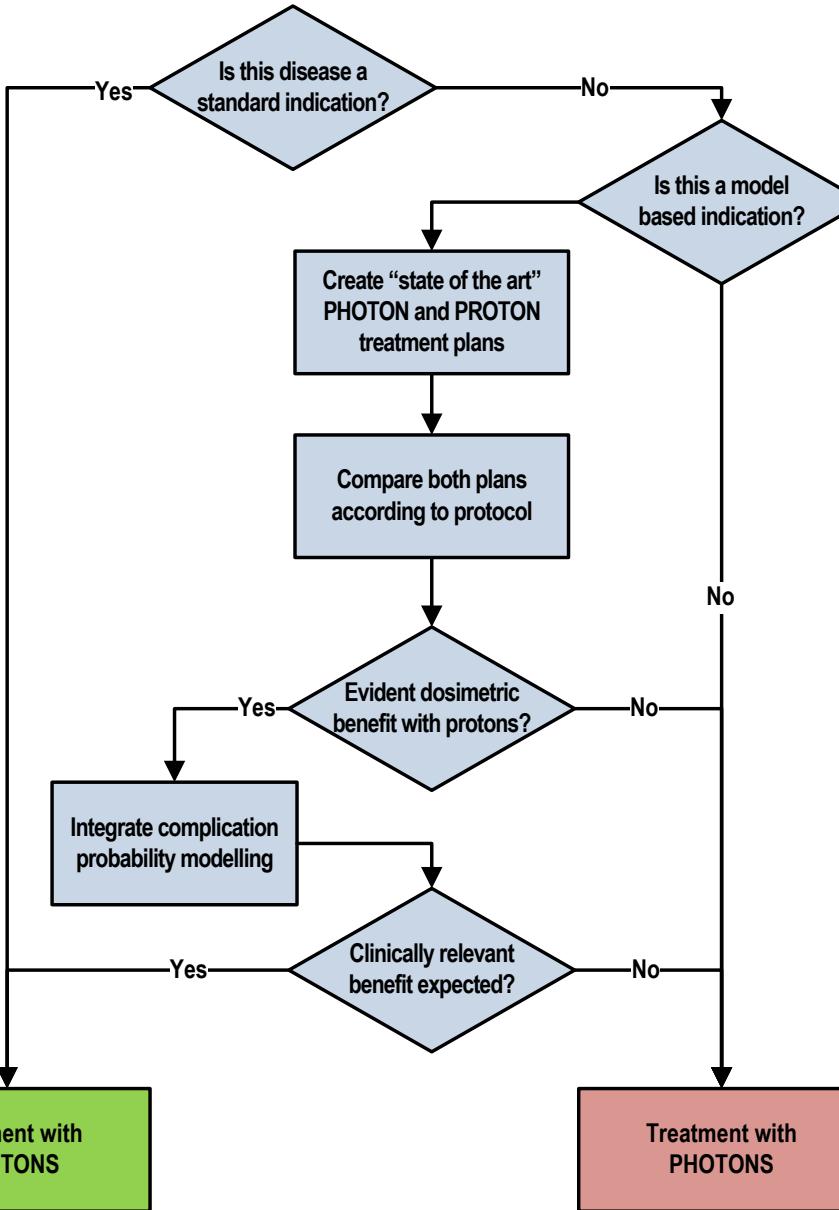
- Erasmus MC, LUMC, *TU Delft* Holland PTC
  - AMC, VUmc, Avl Amsterdam PTC
  - UMCG Groningen PTC
  - Maastro, MUMC+ ZON-PTC
- 
- RadboudUMC, samenwerking met ZON-PTC
  - UMCU -> ontwikkeling MRI-Linac



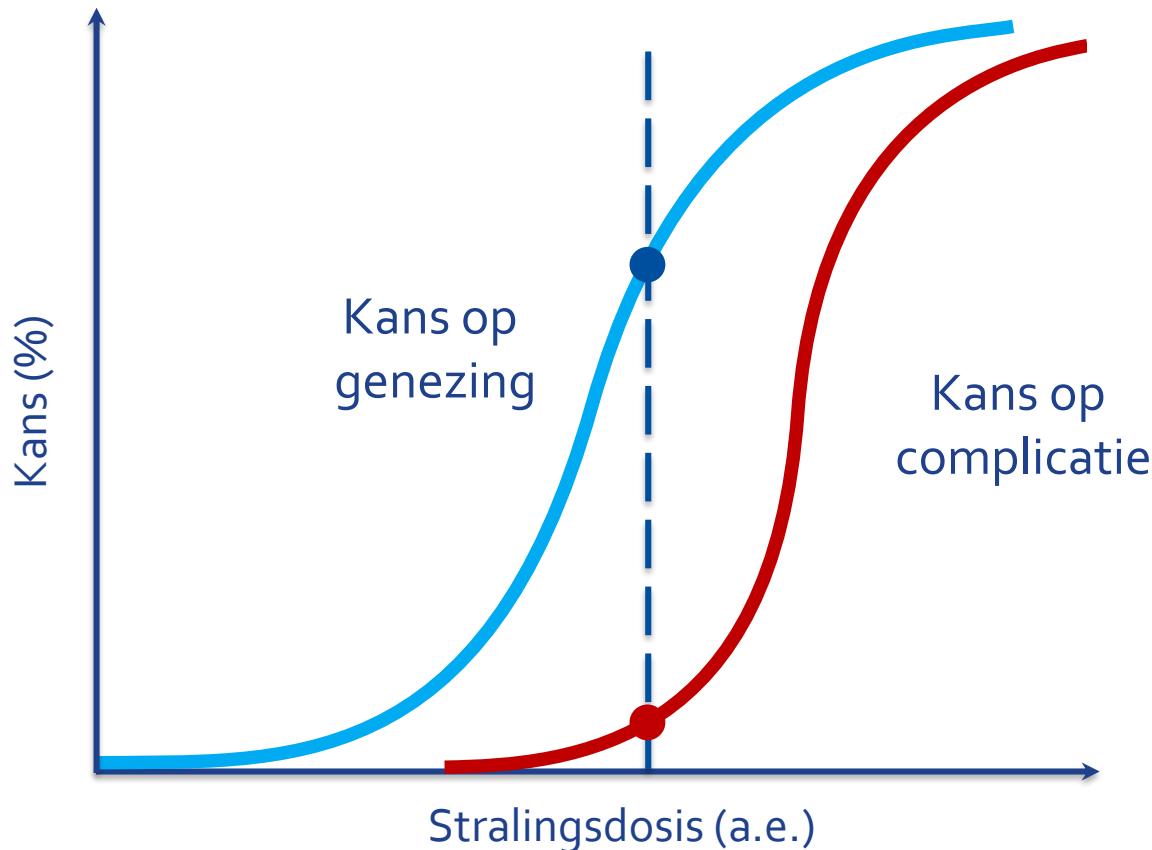
# Protonentherapie in NL

- Standard indicaties
  - Pediatricke tumoren
  - Oogmelanomen
  - Schedelbasistumoren
- Model – based indicaties
  - Hoofd-hals, Long, mamma en prostaat
  - Overige model-based indicaties (vb. herbestraling)

# Proton therapy reimbursement decision tree for the Netherlands

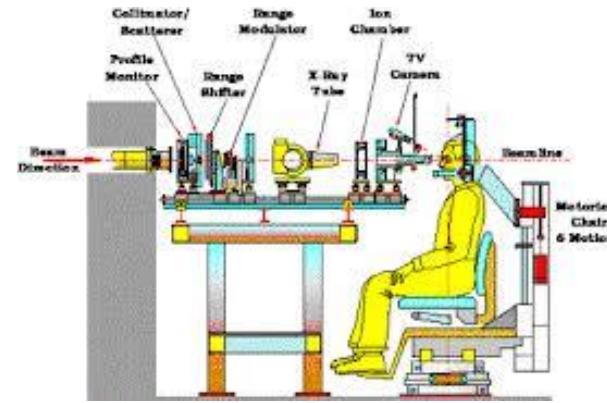


# Risico's bij behandelen

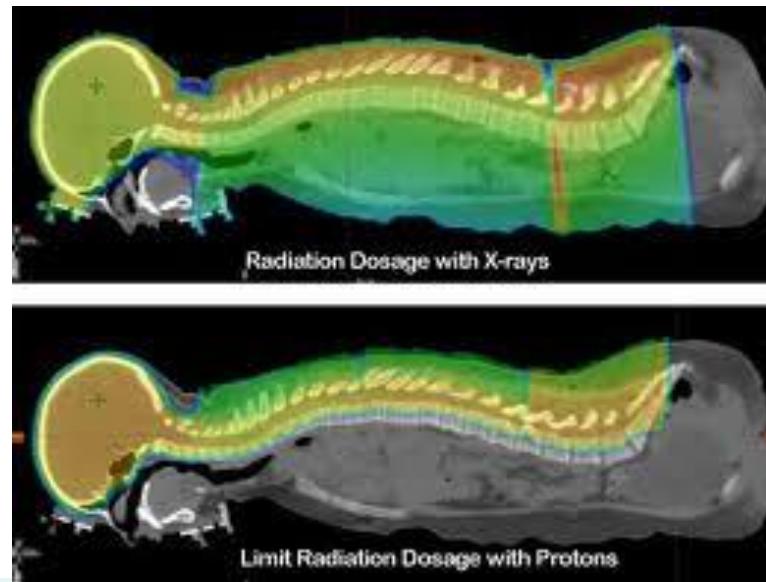


# Standard indications (250/yr)

- Intra-ocular tumors



- Chordoma / chondrosarcoma
- Pediatric tumors



# Pediatric tumors

## Mean % Volume of Non-Target Tissue Irradiated With Protons vs IMRT<sup>s</sup>

Pediatric Cancer Type	Non-Target Tissue	DVH Dose Level	Protons	IMRT
Retinoblastoma	Orbital bone	$\geq 20$ Gy	3%	22%
	IL optic nerve	$> 36$ Gy	8%	25%
Medulloblastoma	Cochlea	$\geq 20$ Gy	34%	87%
	Hypothalamus-pituitary	$\geq 10$ Gy	21%	81%
Pelvic Sarcoma	Ovaries	$\geq 2$ Gy	0%	100%
	Bowel	$\geq 30$ Gy	5%	12%
	Vertebrae	$\geq 20$ Gy	9%	29%

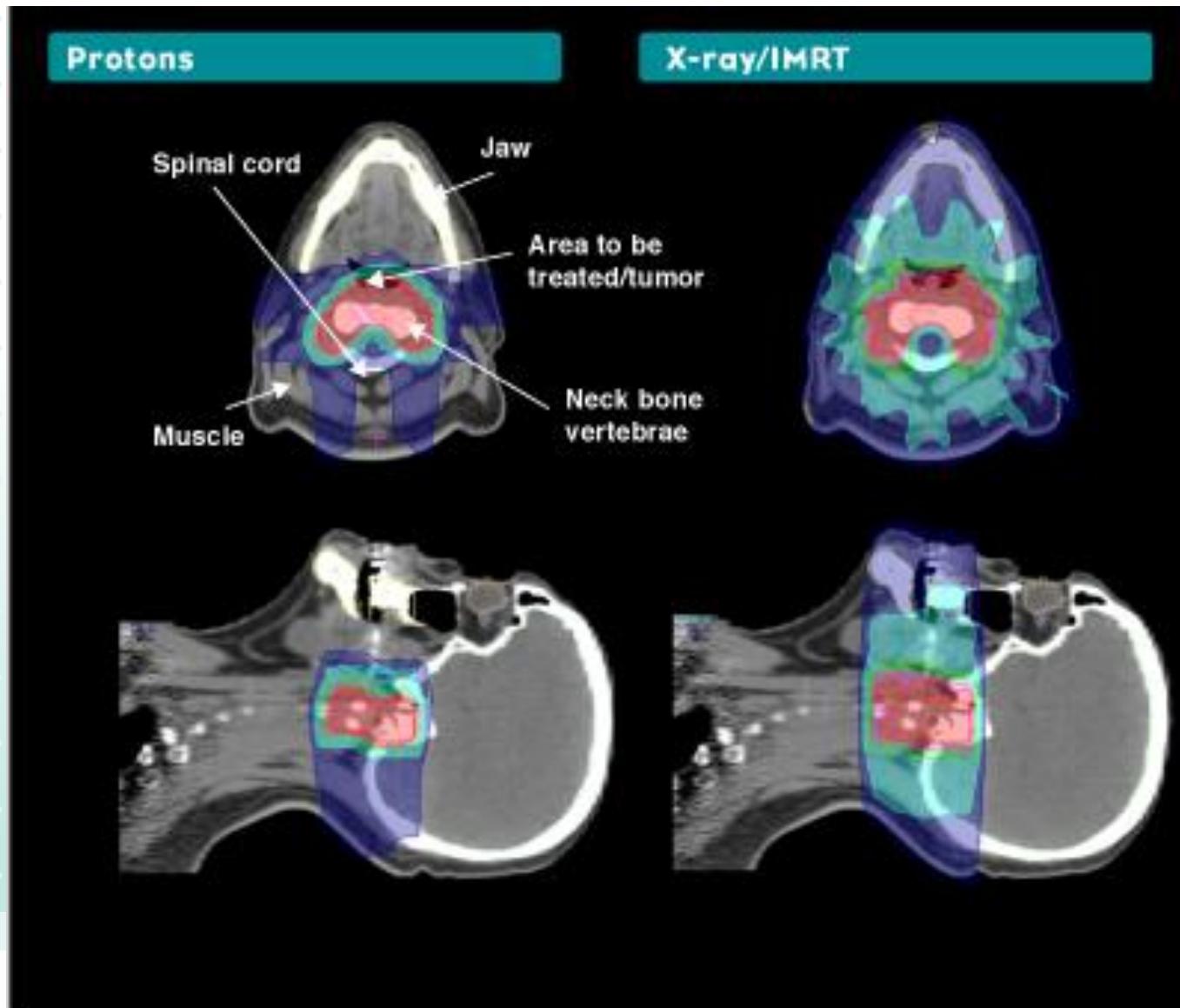
# Secondary Malignancies

A Comparison of the Risk of Secondary Malignancies After Treating Medulloblastoma<sup>3</sup>

Tumor Site	IMRT X-Rays	Proton Therapy
Stomach and esophagus	11%	0%
Colon	7%	0%
Breast	0%	0%
Lung	7%	1%
Thyroid	6%	0%
Bone and connective tissue	2%	1%
Leukemia	5%	3%
All Secondary Cancers	43%	5%

Lee Int J Radiat Oncol Biol Phys. 2005;63(2)

# Base of Skull



# Chordoma and Chondrosarcoma

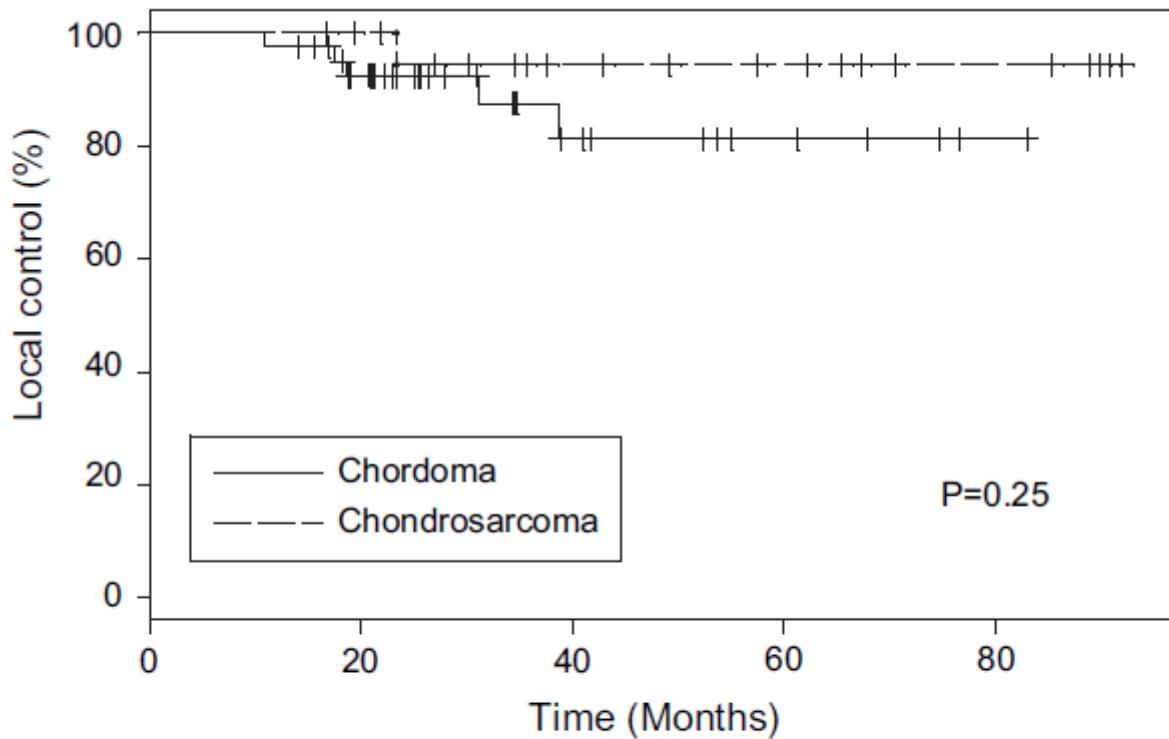


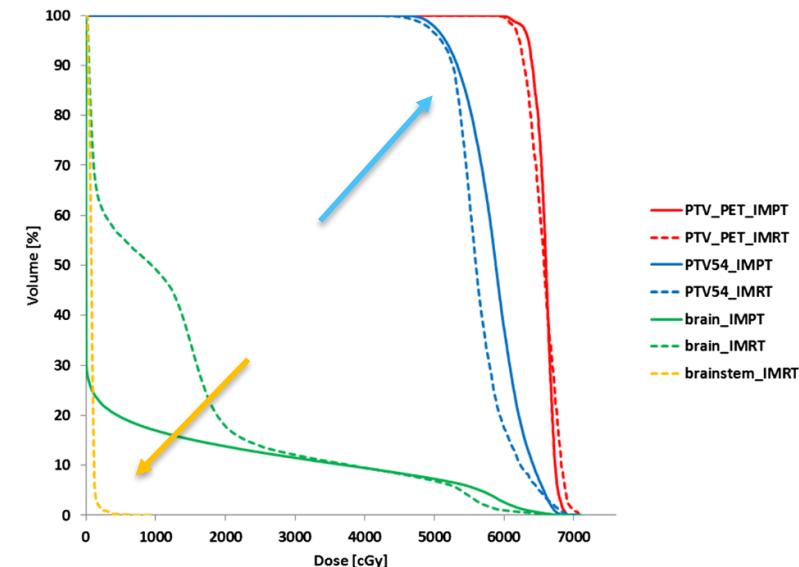
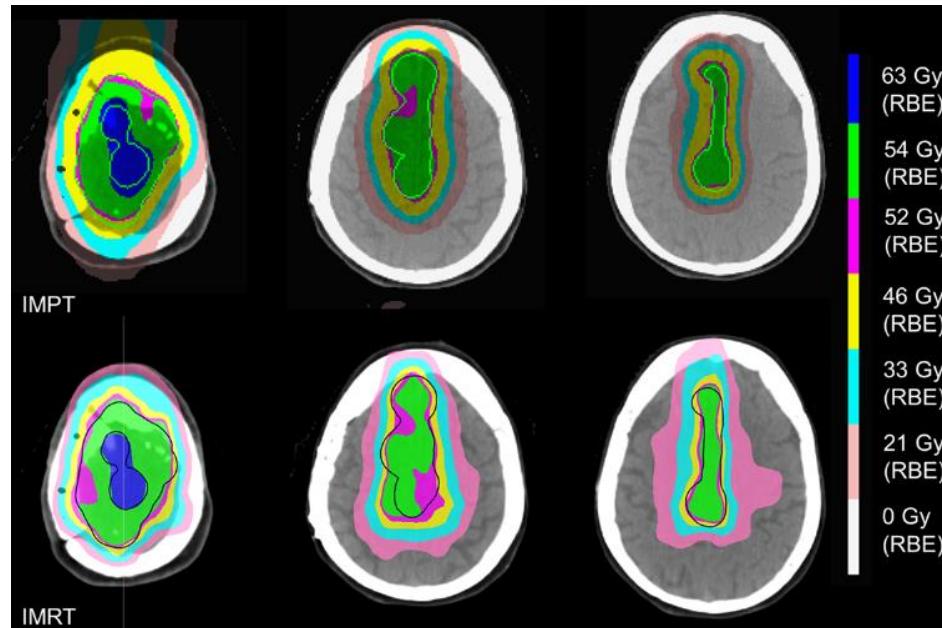
Fig. 2. Local control probability in 64 patients with skull-base chordoma and chondrosarcoma following spot-scanning-based proton radiotherapy.

RESEARCH

Open Access

# Dose-painting intensity-modulated proton therapy for intermediate- and high-risk meningioma

Indira Madani<sup>1,2\*</sup>, Antony J Lomax<sup>1</sup>, Francesca Albertini<sup>1</sup>, Petra Trnková<sup>1</sup> and Damien C Weber<sup>1,3</sup>

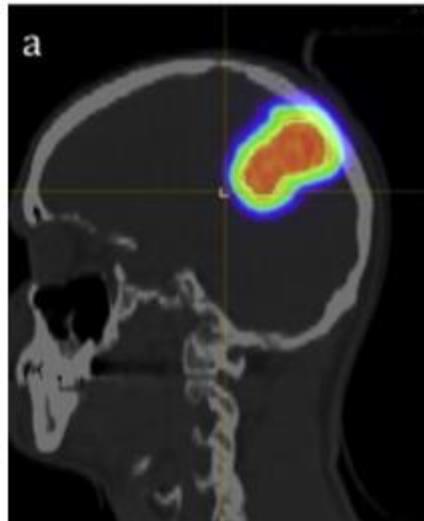


STUDY PROTOCOL

Open Access

# Randomized phase II study evaluating a carbon ion boost applied after combined radiochemotherapy with temozolomide versus a proton boost after radiochemotherapy with temozolomide in patients with primary glioblastoma: The CLEOPATRA Trial

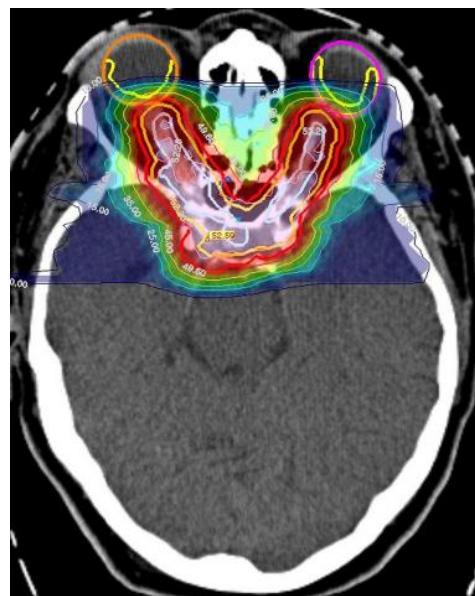
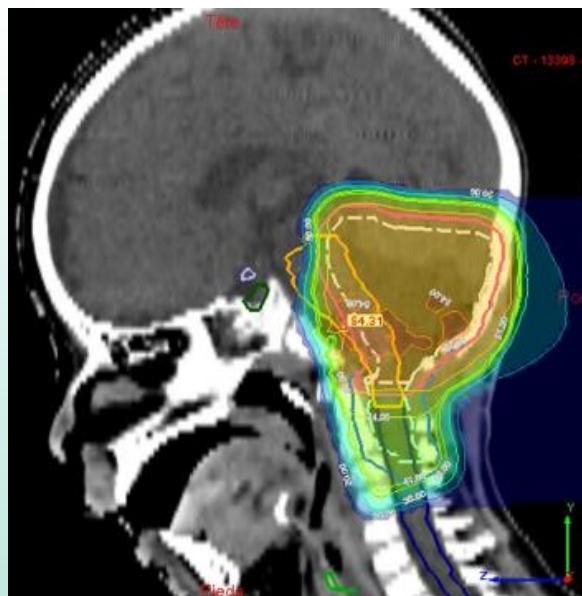
Stephanie E Combs<sup>1\*</sup>, Meinhard Kieser<sup>2</sup>, Stefan Rieken<sup>1</sup>, Daniel Habermehl<sup>1</sup>, Oliver Jäkel<sup>3</sup>, Thomas Haberer<sup>3</sup>, Anna Nikoghosyan<sup>1</sup>, Renate Haselmann<sup>1</sup>, Andreas Unterberg<sup>4</sup>, Wolfgang Wick<sup>5</sup>, Jürgen Debus<sup>1</sup>



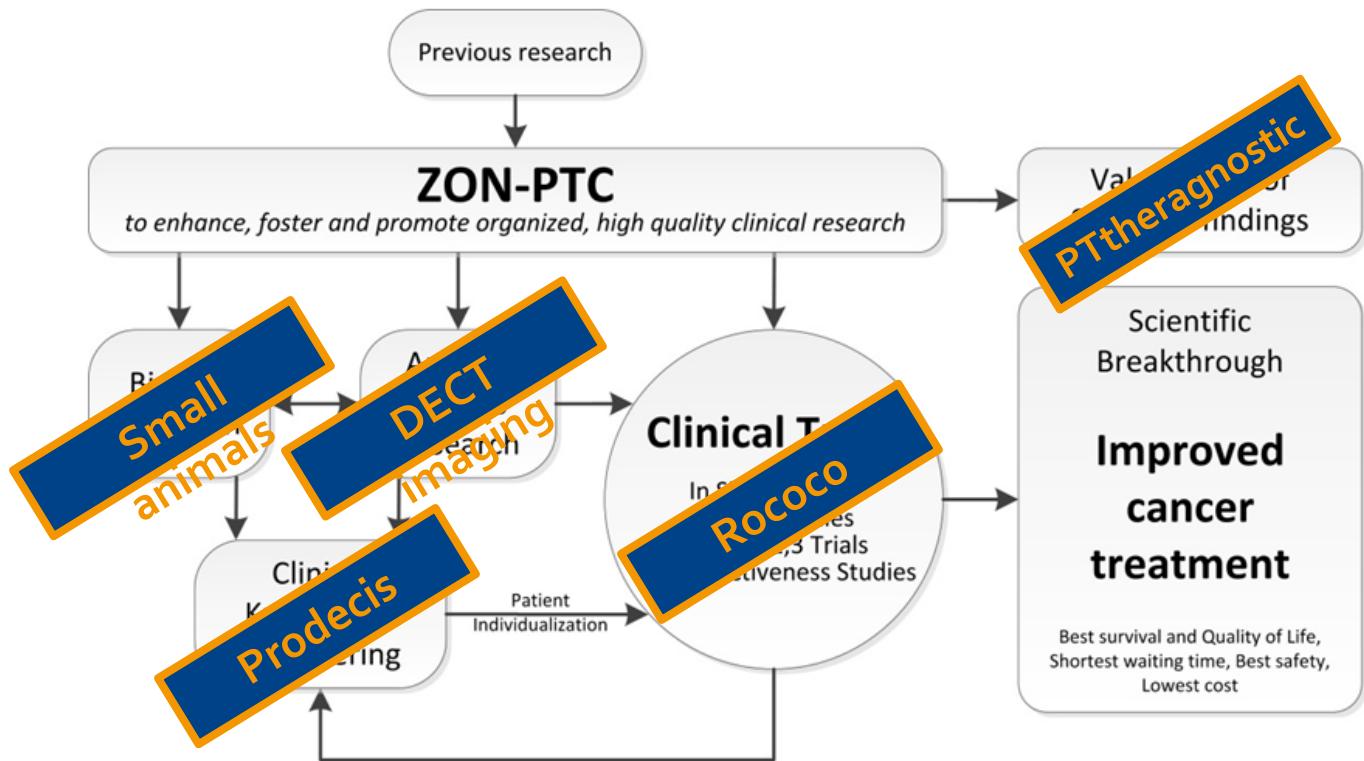
Review article

# Paediatric brain tumours: A review of radiotherapy, state of the art and challenges for the future regarding protontherapy and carbontherapy

A. Laprie<sup>a,b,\*,c</sup>, Y. Hu<sup>d</sup>, C. Alapetite<sup>e</sup>, C. Carrie<sup>d,f</sup>, J.-L. Habrand<sup>e,g,h,i,j</sup>, S. Bolle<sup>e,k</sup>, P.-Y. Bondiau<sup>l,m</sup>, A. Ducassou<sup>b,c</sup>, A. Huchet<sup>n</sup>, A.-I. Bertozzi<sup>c,o</sup>, Y. Perel<sup>o</sup>, É. Moyal<sup>a,b,c</sup>, J. Balosso<sup>d,p</sup>, on behalf of the radiotherapy committee of SFCE and France Hadron<sup>1</sup>



# Research



- 5 PhD students with subject on proton therapy
- 5 professors of Maastricht University working in the field of proton therapy (*Lambin, de Ruysscher, Verhaegen, Dekker, Vooijs*)

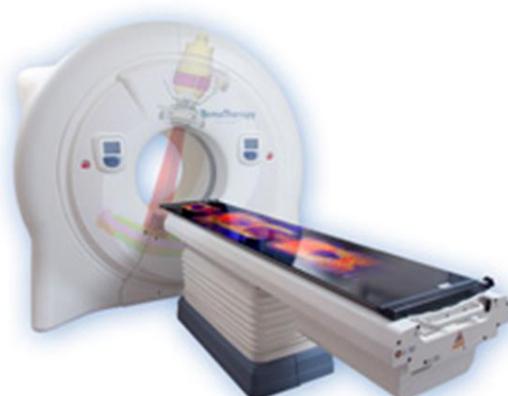


# Low Grade Glioma

VMAT



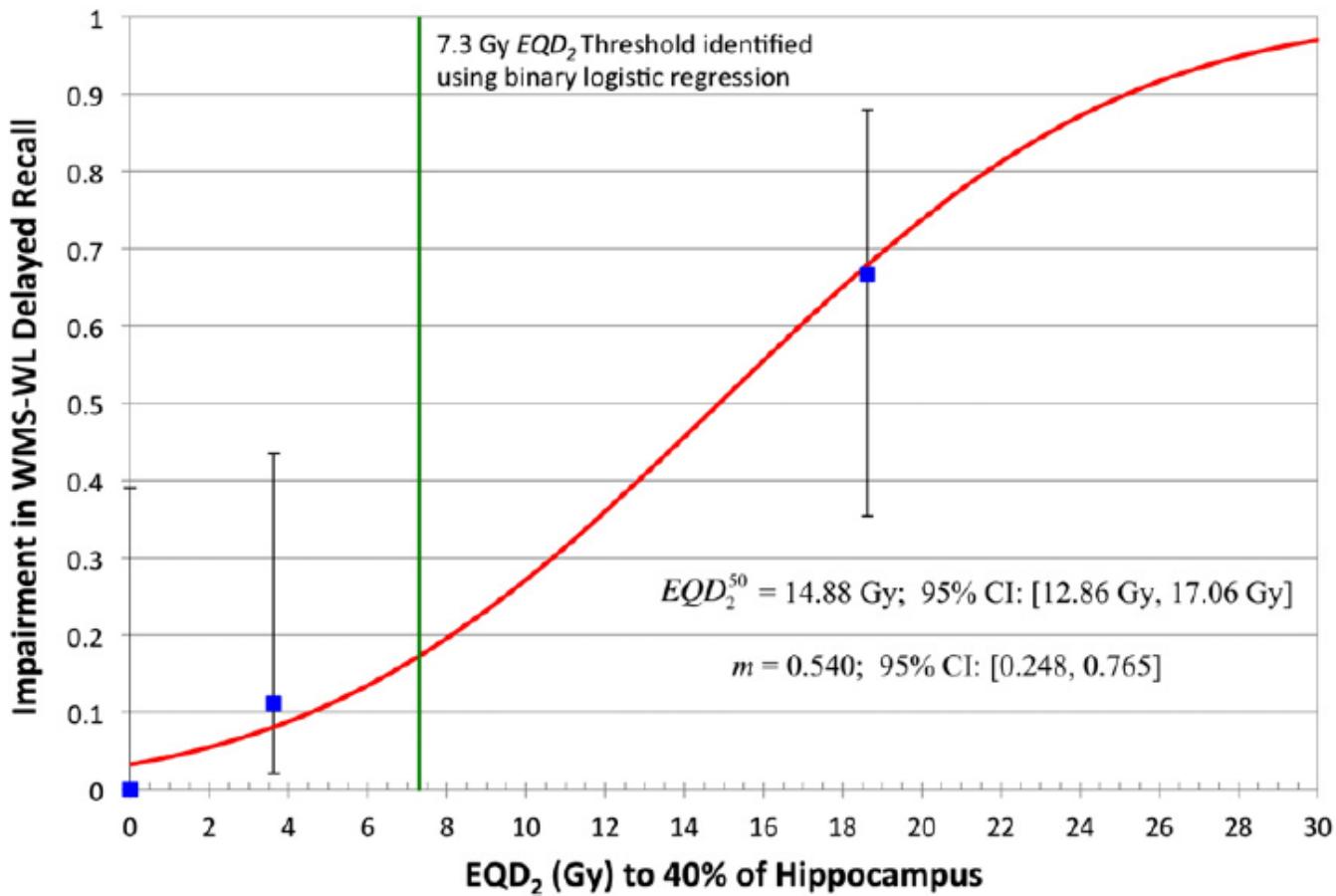
TOMO



IMPT



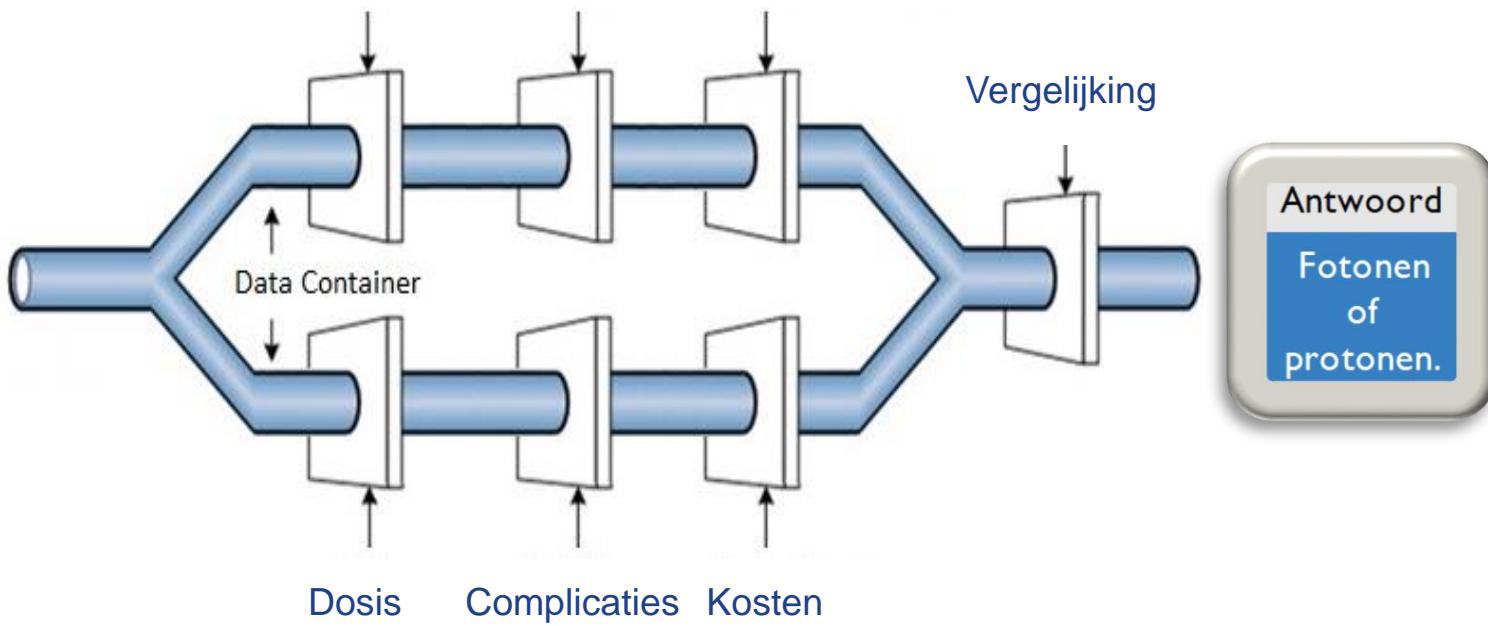
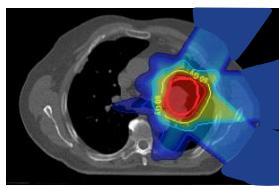
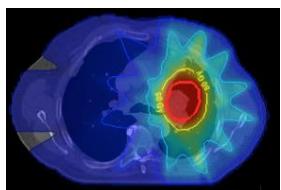
# Hippocampus D40%



# Protontherapie keuzehulp

## Proton Decision Support (PRODECIS)

Invoer data





Maastricht University



Maastricht UMC+

BraCom

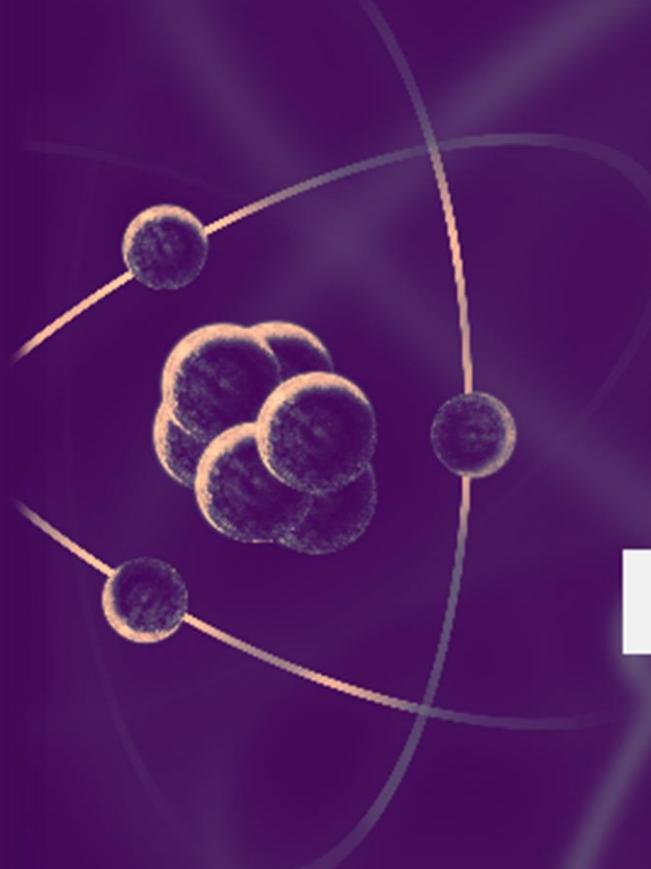


Maastricht University





# Cognitie



**THINK  
LIKE  
A  
PROTON  
AND  
STAY POSITIVE.**