The case for Helium-ion RT

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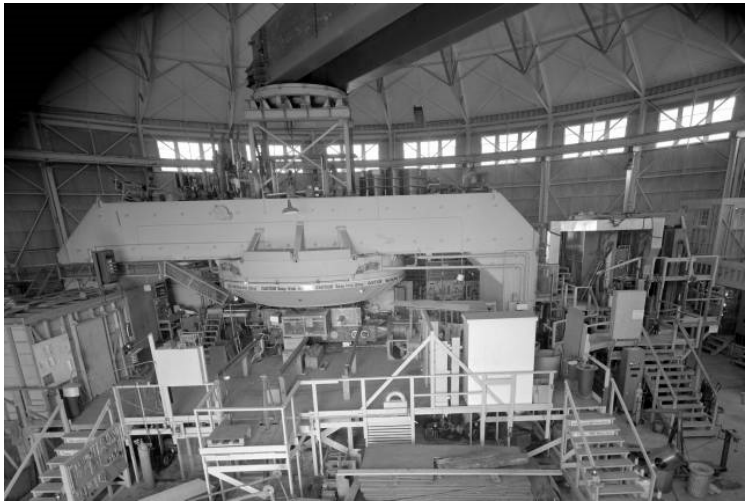
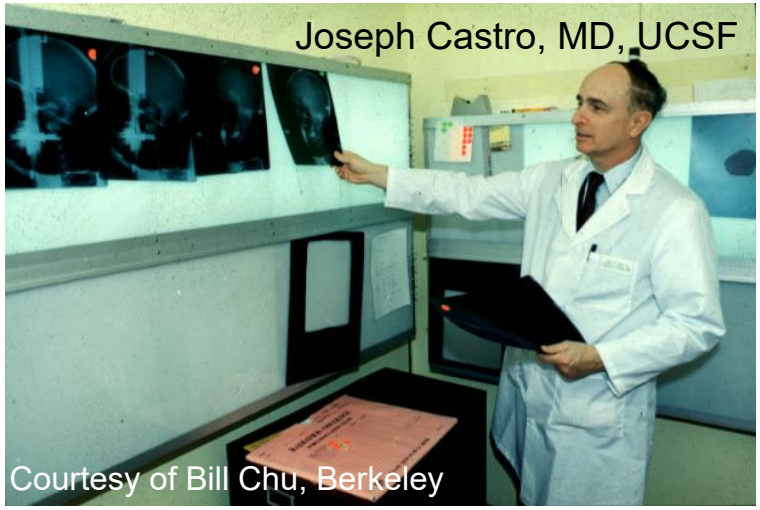
History of Helium beam RT: LBNL 1956–1992





First treatments with Helium in 1956 at 184 inch synchrocyclotron at LBNL

(Tobias and Lawrence 1957)

Since June 1975 clinical trials by UCSF

Total patient # treated with Helium at LBNL: 2054
He patients in clin. trials: 858

Int. J. Radiation Oncology Biol. Phys., Vol. 39, No. 5, pp. 989–996, 1997

0360-3016/97 $17.00 + .00

PII S0360-3016(97)00494-X

Clinical Investigation

15 YEARS EXPERIENCE WITH HELIUM ION RADIOTHERAPY FOR UVEAL MELANOMA

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INDER K. DAFTARI, PH.D.*† JEANNE M. QUIVEY, M.D.* RAJINDAR P. SINGH, PH.D.,†
ELEANOR A. BLAKELY, PH.D.† AND THEODORE L. PHILLIPS, M.D.*†

Helium treatments at LNBL

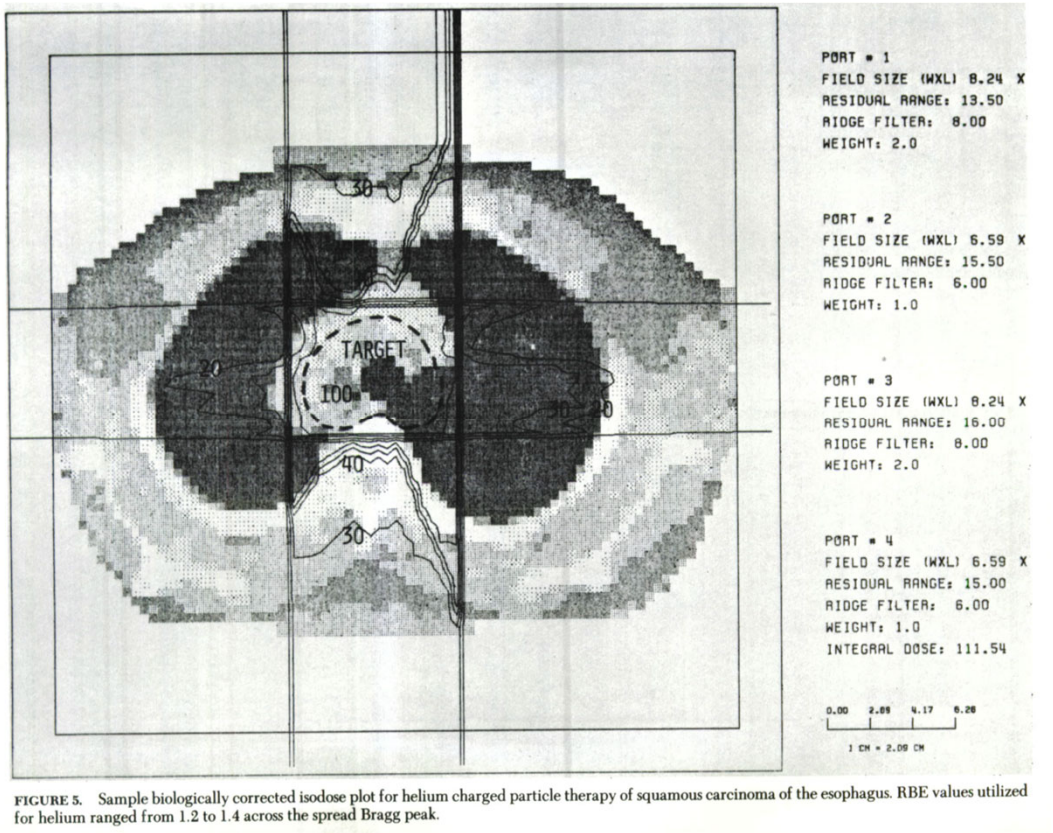


FIGURE 5. Sample biologically corrected isodose plot for helium charged particle therapy of squamous carcinoma of the esophagus. RBE values utilized for helium ranged from 1.2 to 1.4 across the spread Bragg peak.

Treatment plan for a lesion in the Esophagus using He-RT

30-35 Fx of 2Gy (RBE=1.3)

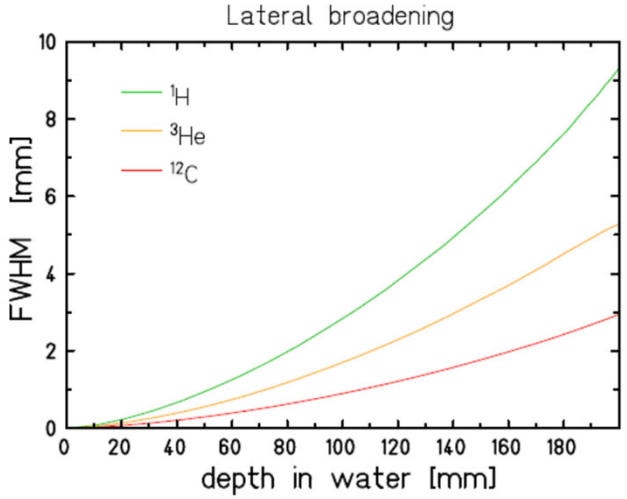
Castro et al. Am. J. Clin. Oncol. ‘83

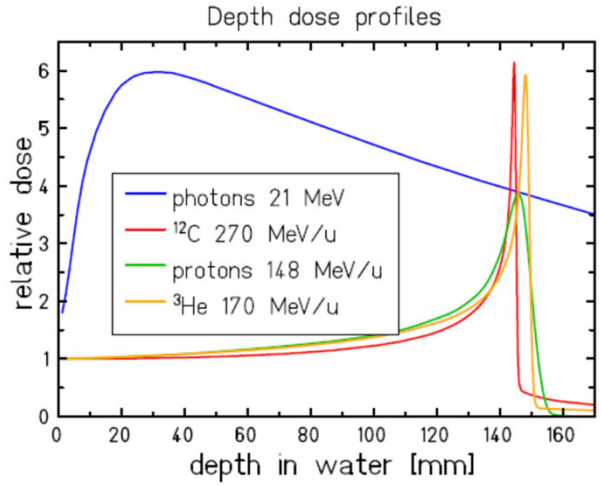
4 portals

Treatment in seated or standing position

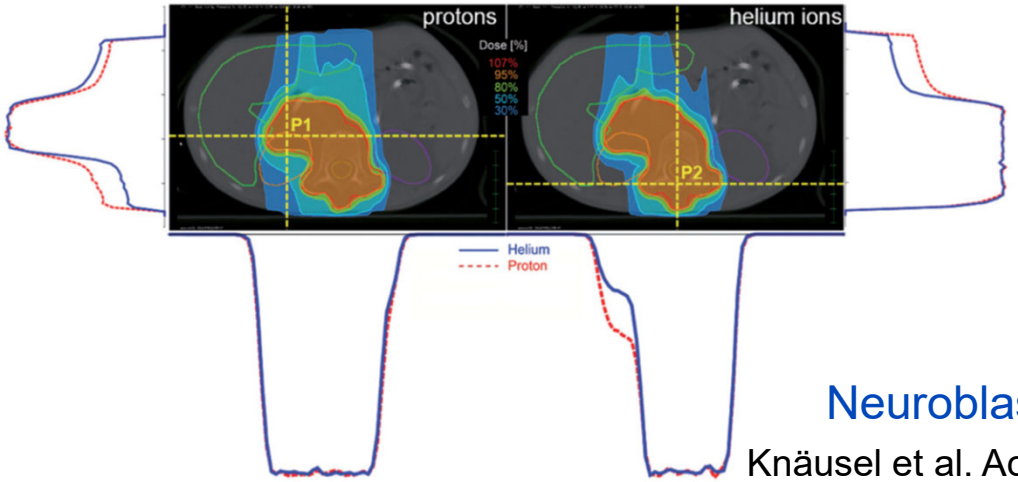
“… helium beam has not shown increased biological potential over low LET photon therapy. In this respect helium seems to be similar to proton therapy.”

Rationale for Helium: dose conformation





Krämer et al. Med. Phys. 2016



Neuroblastoma TP

Knäusel et al. Acta Oncol. 2016

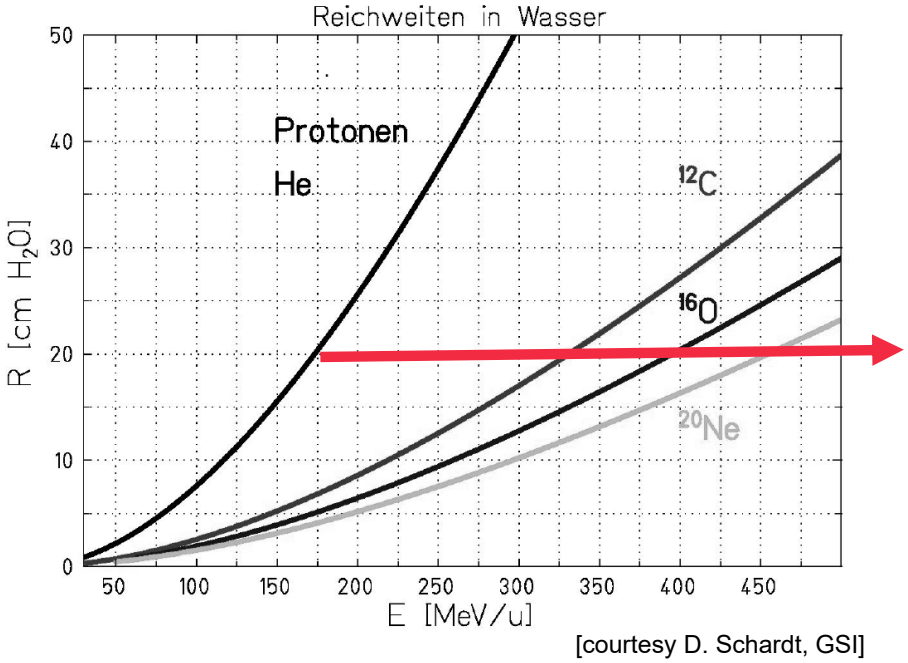
- Sharper lateral penumbra
- Steeper distal dose fall-off
- Lower entrance dose

} vs. p

- No tail dose, less neutrons (vs. C)
- Little advantage due to RBE
- **Feasible with a cyclotron**

Particle range and costs

csda Range: $R(E) \cong \int_0^{T_0} \left(\frac{dE}{dx} \right)^{-1} dE \propto E^{1.75}$



[courtesy D. Schardt, GSI]

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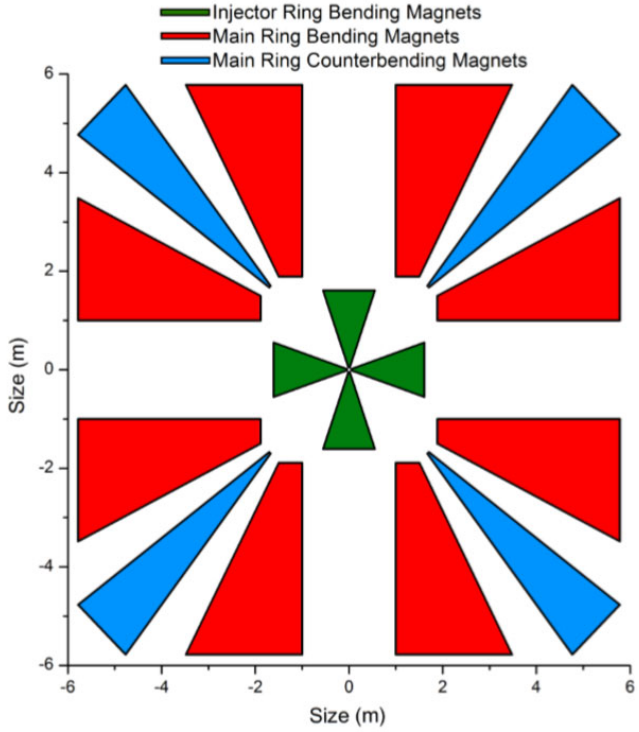
ns-FFAG design for a 900MeV He RT

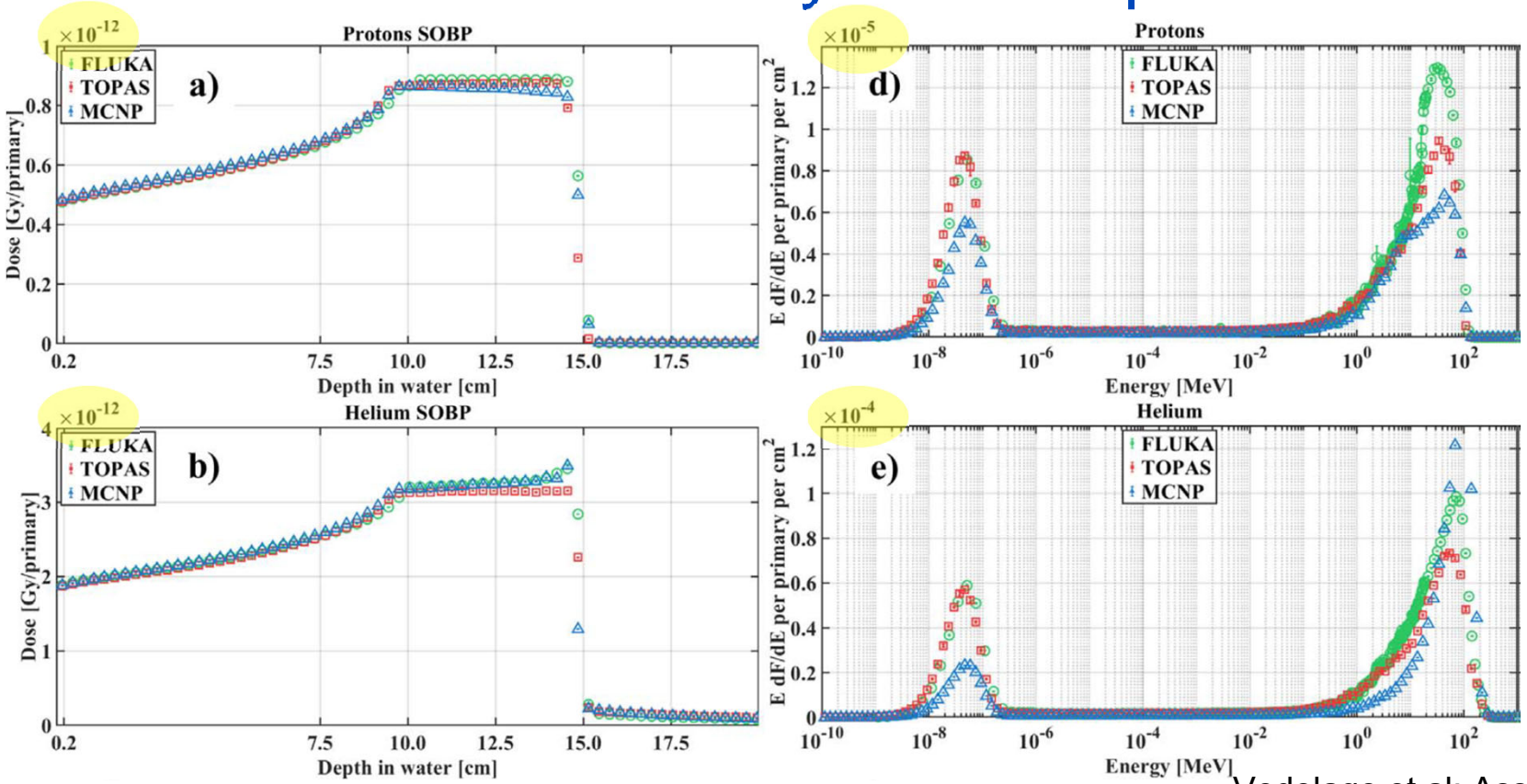
Taylor et al. IPAC 2016, Busan



Heavier ions → higher energies → larger machines

Helium-RT machines could be much smaller/cheaper than carbon machines

Secondary neutron production

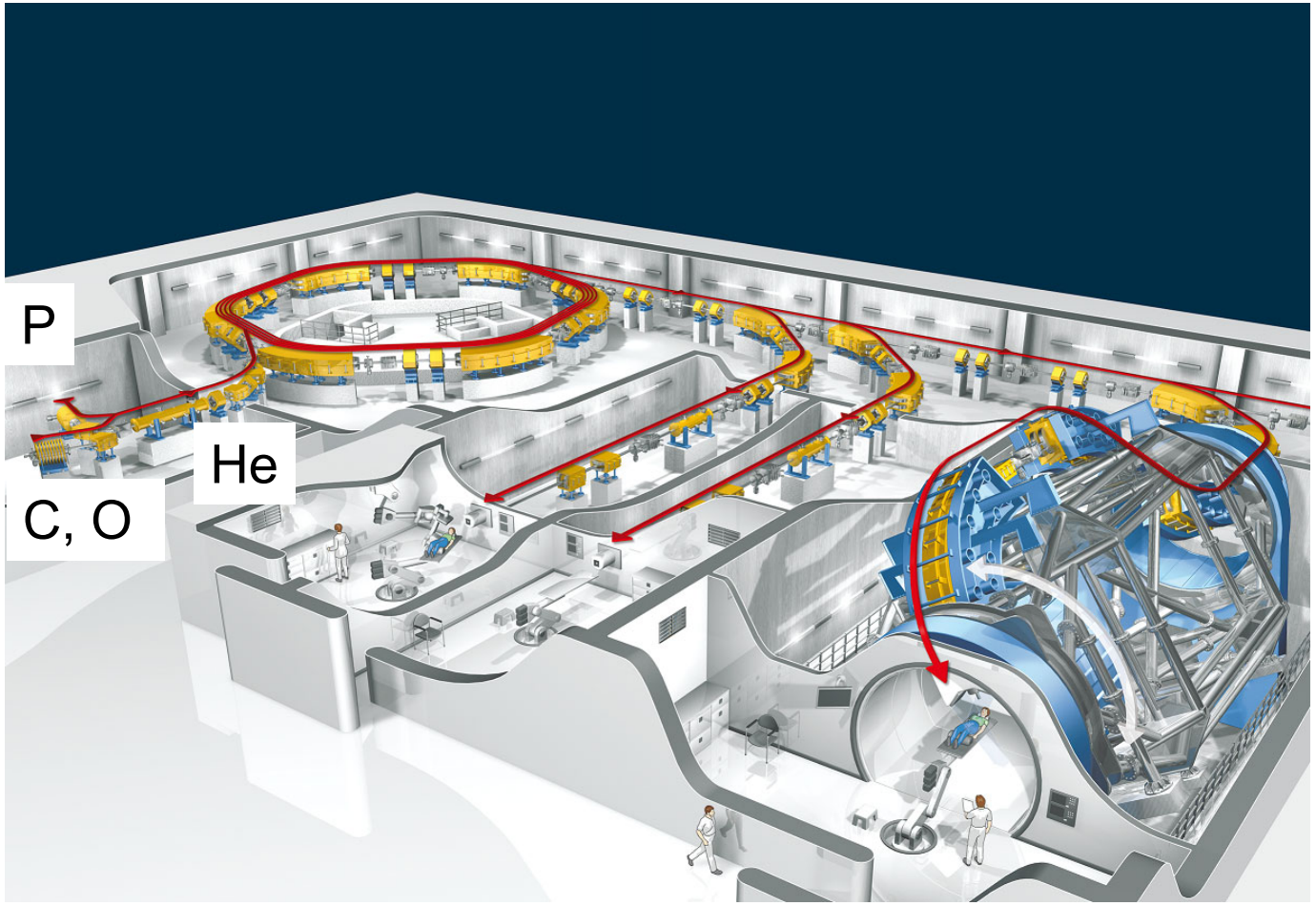


To be scaled down by ~6 for He!

Vedelago et al: Assessment of secondary neutrons in particle therapy… Phys.Med.Biol. 67 (222)

Helium is very similar to protons in no. of secondary neutrons !

Heidelberg Ion Beam Therapy Center



11/2009: 1. patient RT

10/2012: 1. Gantry pat.

Today: ~8400 patients

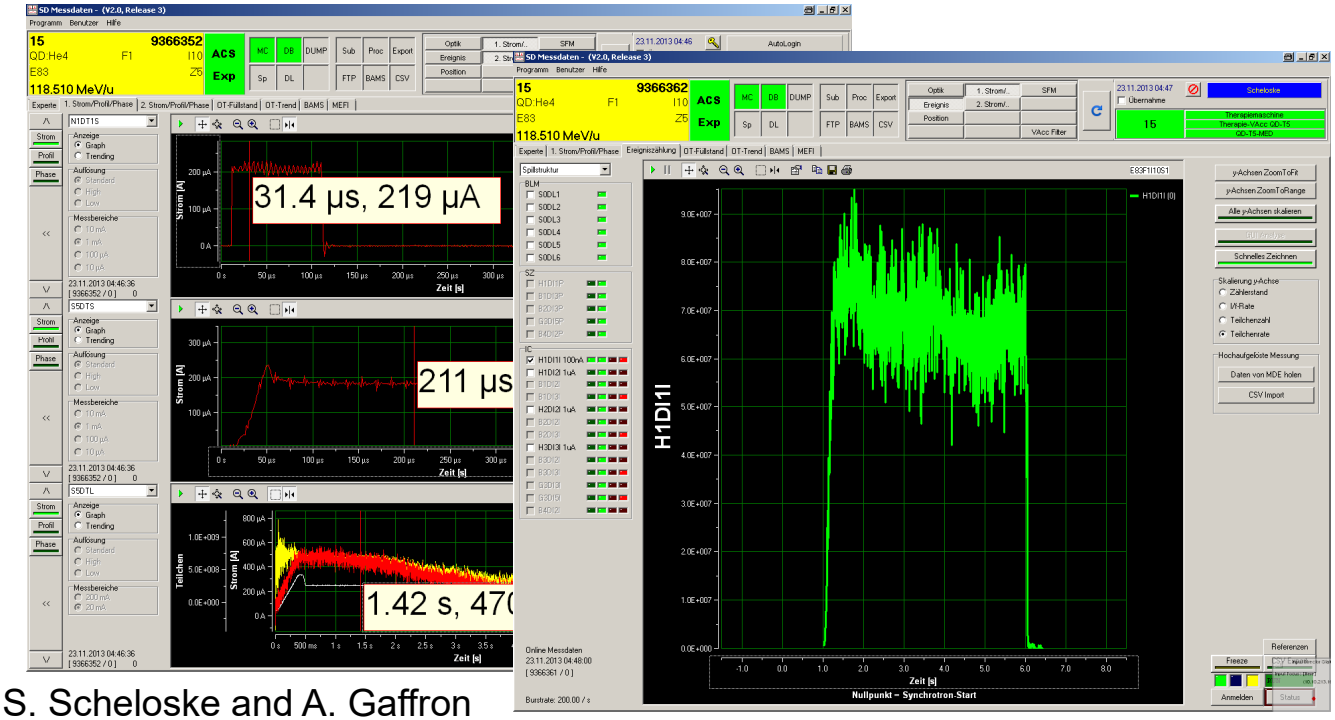
Experimental area

Research Labs

HIT is routinely operating with **p,** He, **C** and O beams for **RT** and research

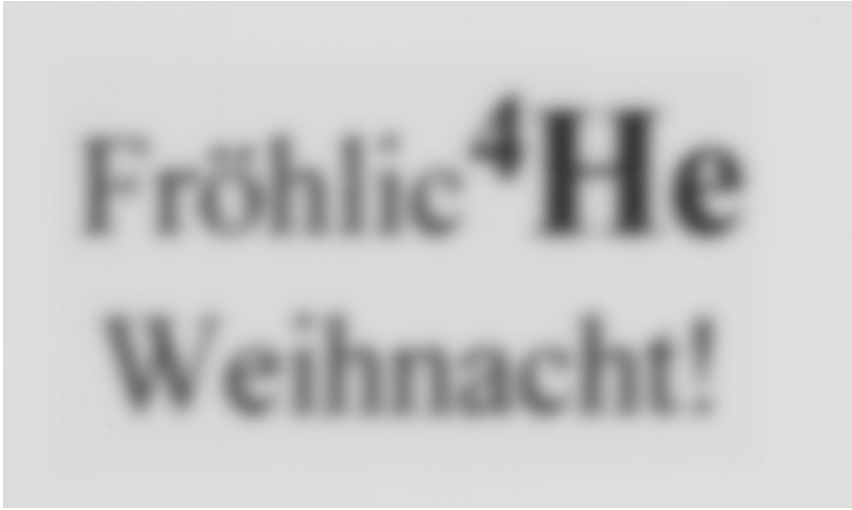
Helium beam line tuning

- He source installation in late 2012
- Tuning of LEBT, LINAC, MEBT
- 23.11.2013: 1st extraction from synchrotron
- 13.12.2013: 1st scanned beam QA room



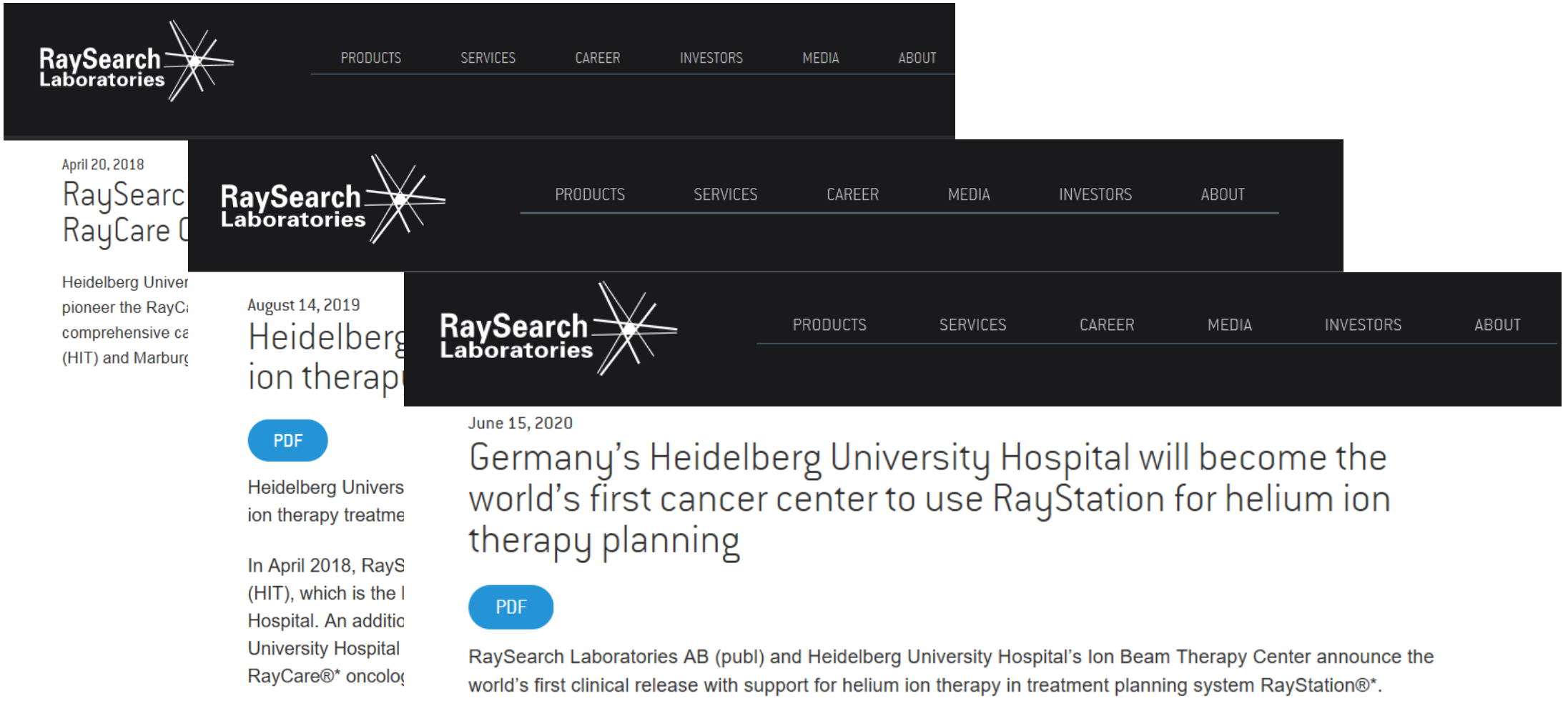
S. Scheloske and A. Gaffron

Scanning on radiographic film



Scanned He beams are being used routiney for research since 2014

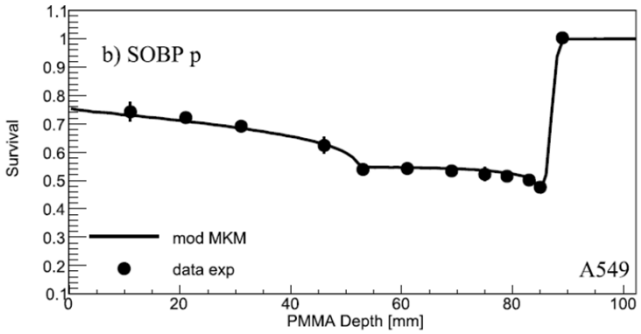
Implementation of Helium in the Raystation

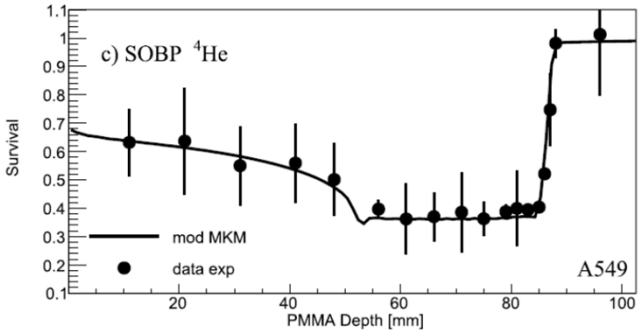


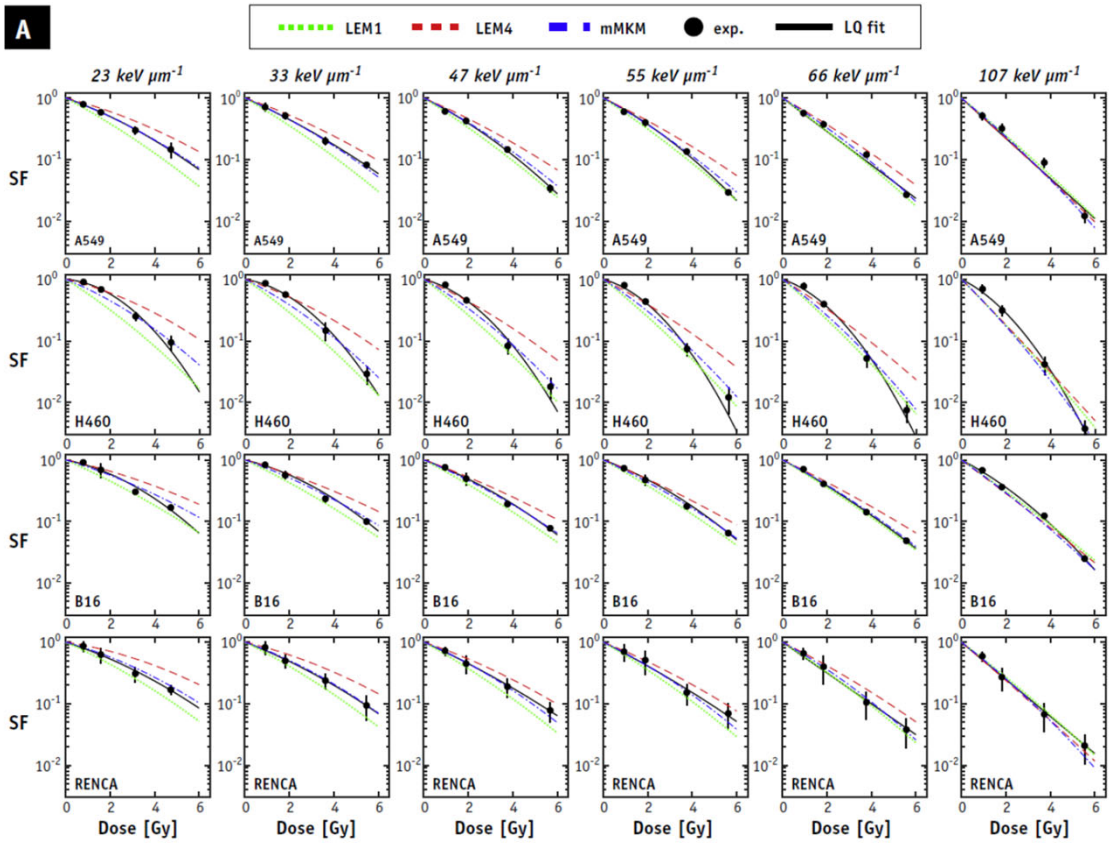
RBE modelling: optimization of mMKM

Optimizing the modified microdosimetric kinetic model input parameters for proton and ^{4}He ion beam therapy application

A Mairani[1,2], G Magro[1], T Tessonnier[3,4], T T Böhlen[5], S Molinelli[1], A Ferrari[6], K Parodi[2,3,4], J Debus[2,3] and T Haberer[2]



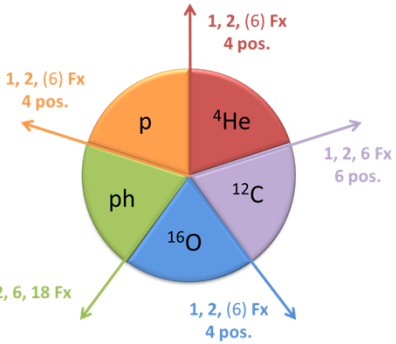




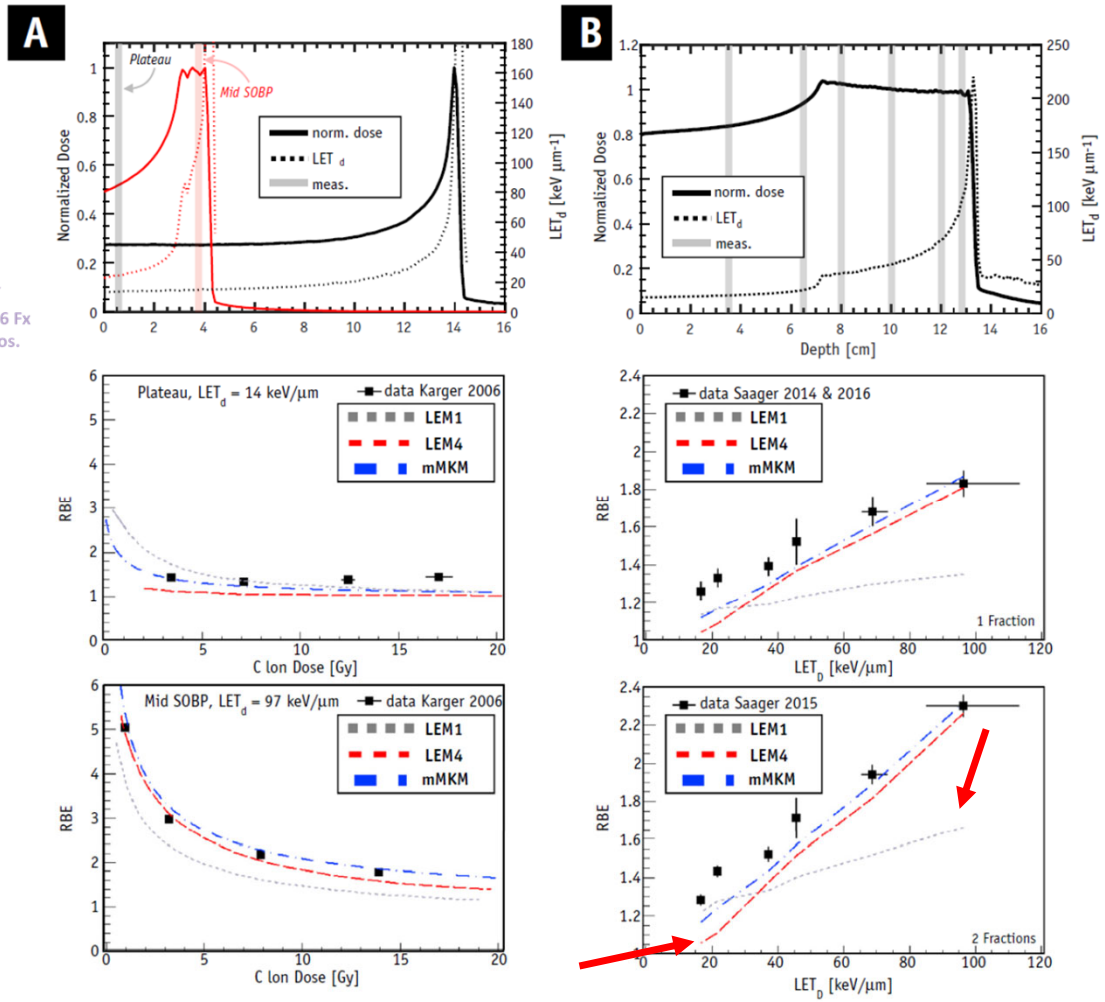
Optimizing the mMKM parameters yields a consistent description of $RBE_{p,He}$ (LET, D, cell line)

Benchmarking of mMKM against in-vivo data

RBE_{C12} of rat spinal chord for various fraction doses and LET

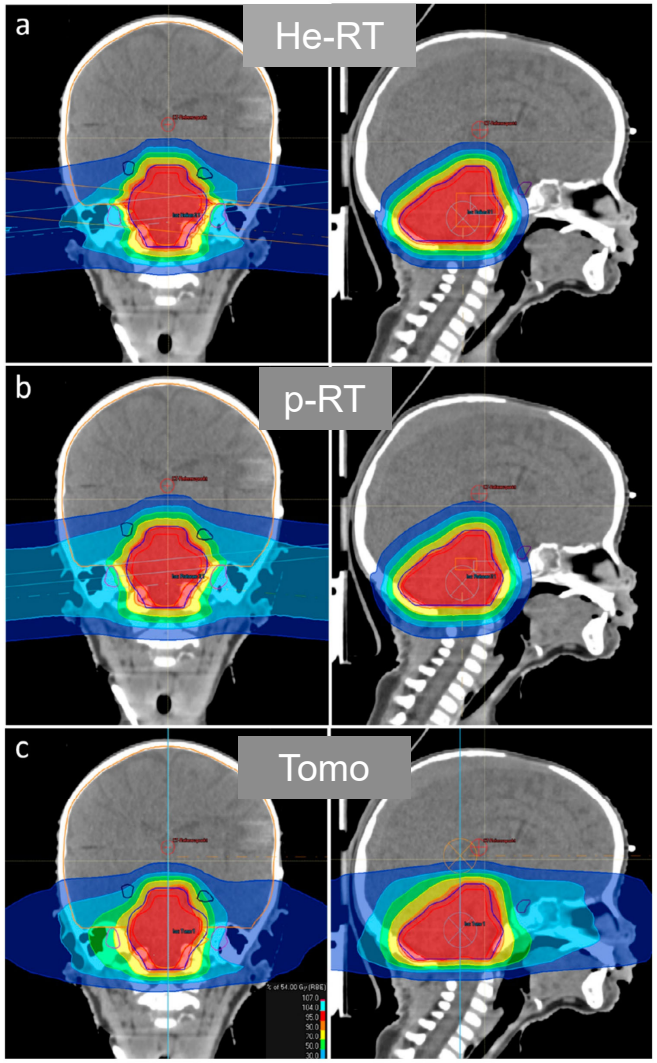


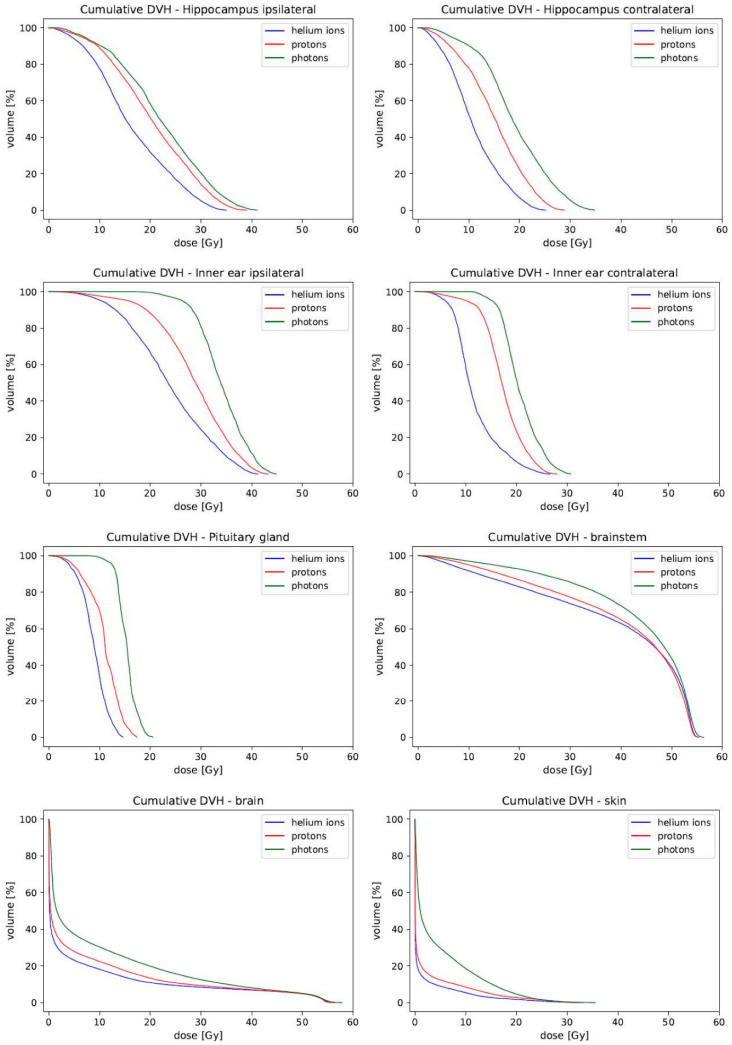
- Hintz et al Radiother. Oncol (2022):
  He 1 and 2 Fx
- Saager et al. Radioter Oncol 2015, 2018 C ions, 1, 2, 6 Fx
- Karger et al (in preparation)
  He ions 6Fx
- Mein et al. IJROBP 2020
  RBE modelling comparison



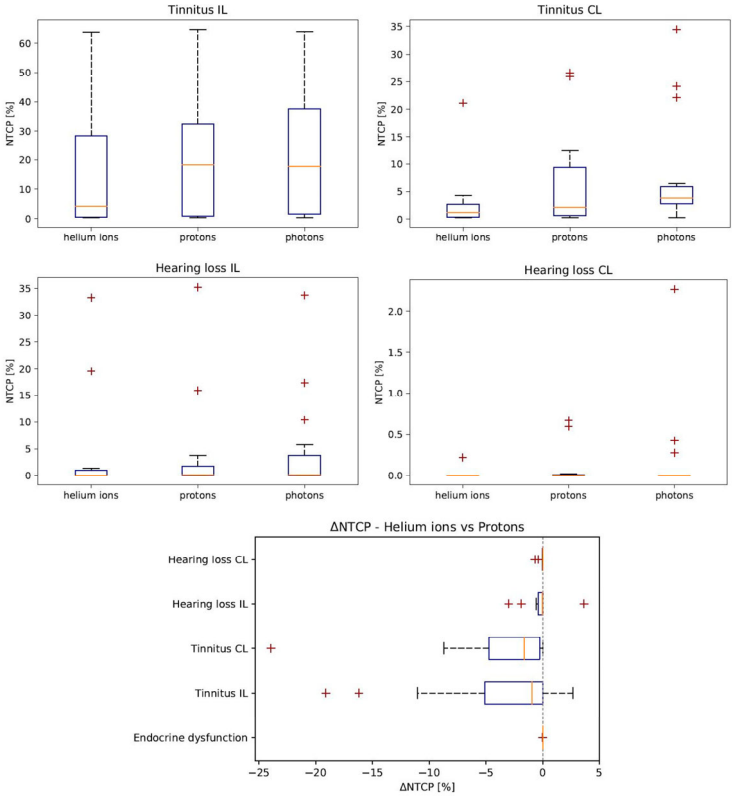
Optimised mMKM gives a more consistent description of RBE for p, C and He in vivo.

A planning study for Helium-RT in 15 ependymoma patients





endocrine & neurocognitive outcome at 54 Gy (RBE)



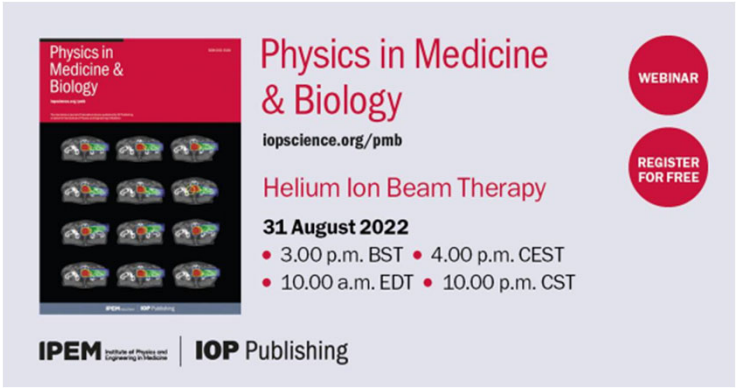
R. Wickert, Cancers 2022

1st Helium RT at HIT (July 20th 2021)

Sorry the clinical data cant be shared!

- 30y old patient
- **Recurrent** anaplastic hemangio-pericytoma III°
- 20 x 2Gy (RBE)
- RBE: 1.4-2.1
- p-RT 2015: 30 x 2Gy (RBE)
- **stable tumor remission > 2yr**

Conclusions

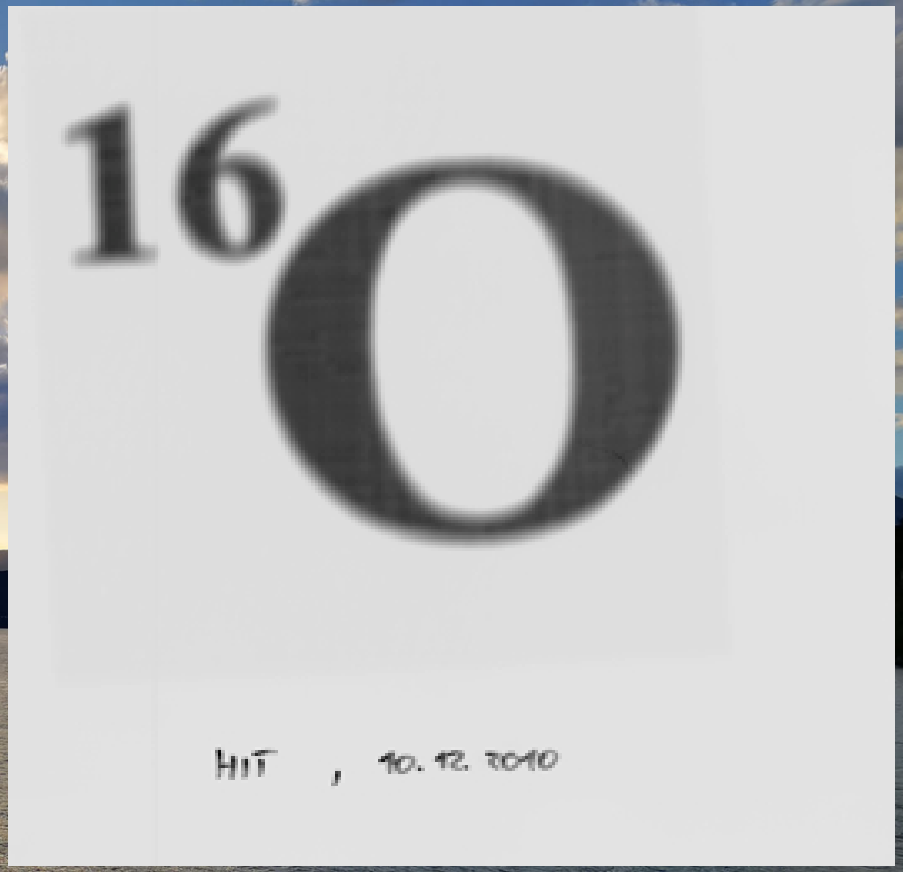


- Commissioning finalized
- Regulatory issues solved, documents submitted
  - Modification of TCS (Siemens)
  - Commissioning of He-Raystation & interface to TCS
  - Implementation of a QMS
  - Clinical assessment by regulatory body initiated
- Indications:

  Difficult p-RT indications, recurrent tumors, pediatric tumors, radiosurgery, pregnant patients (registry trial initiated)

Routine clinical treatments will start in early 2024

Far outlook



Thank you for your attention!