Hadron minibeam radiation therapy: feasibility study at Heidelberg Ion-Beam Therapy Center (HIT)

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Hadron minibeam radiation therapy (hadron MBRT)

Context

- Despite the advancements in RT, significant limitations remain.
- **Hadron therapy** has shown remarkable effectiveness. However, it could still benefit from a **lower impact on non-targeted tissues to allow its administration at higher doses**.
- Development of **new dose delivery radiotherapy approaches**.

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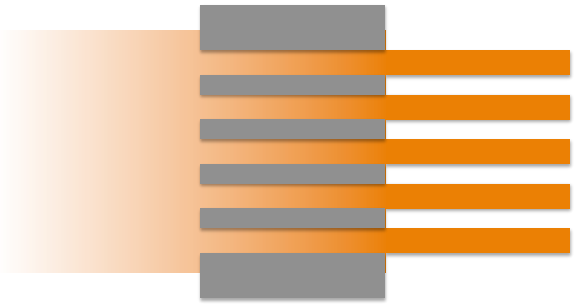
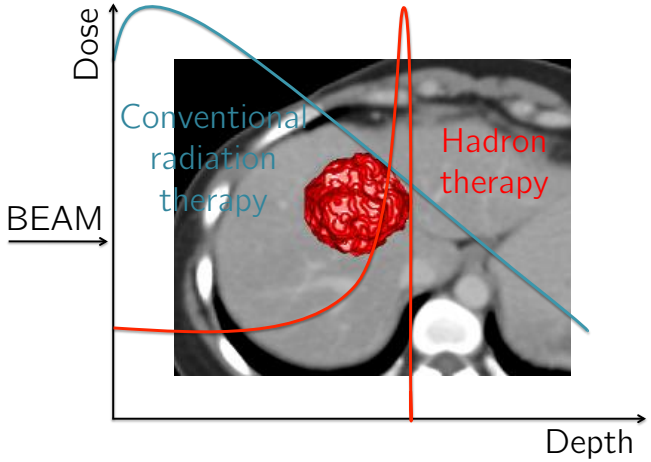
Hadron minibeam radiation therapy

Spatially fractionated radiation therapy (MBRT)



Hadron therapy



X-ray minibeam radiation therapy (MBRT)

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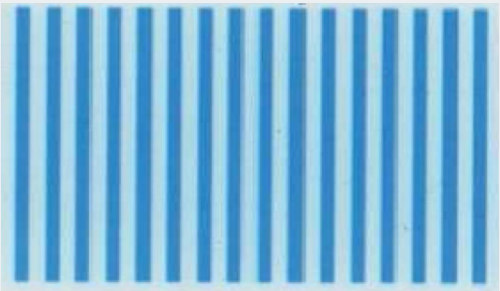
Minibeam radiation therapy

- Submillimetric field sizes (beam width: hundreds of μm).
- Spatial fractionation of the dose.



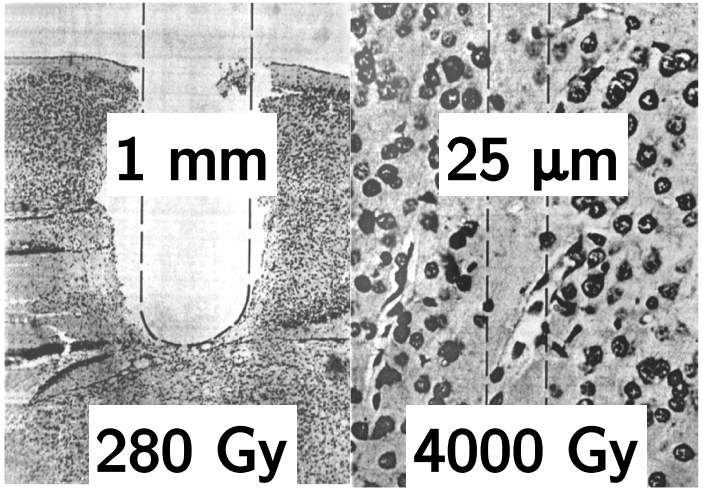
Conventional radiation therapy

- Large field sizes (larger than 1×1 cm^2).
- Homogeneous dose distributions.

X-ray minibeam radiation therapy (MBRT)

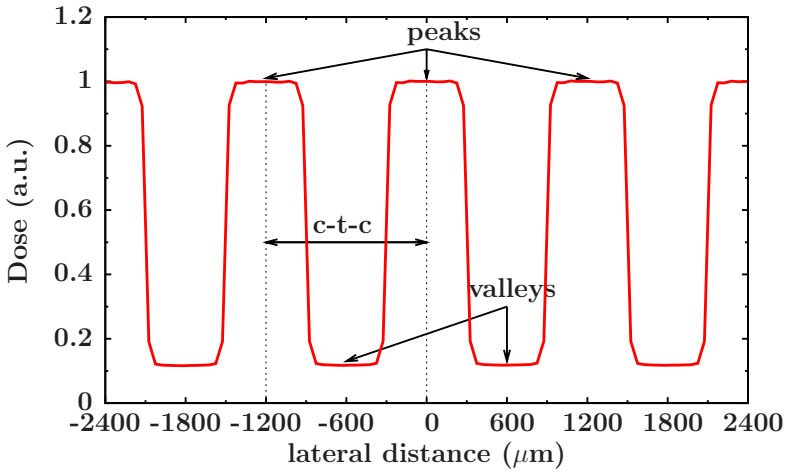
- **Submillimetric field sizes ⇒ Dose-volume effect**

[Zeman et al. *Science* (1959)]



- **Spatial fractionation of the dose**

Lateral dose profile



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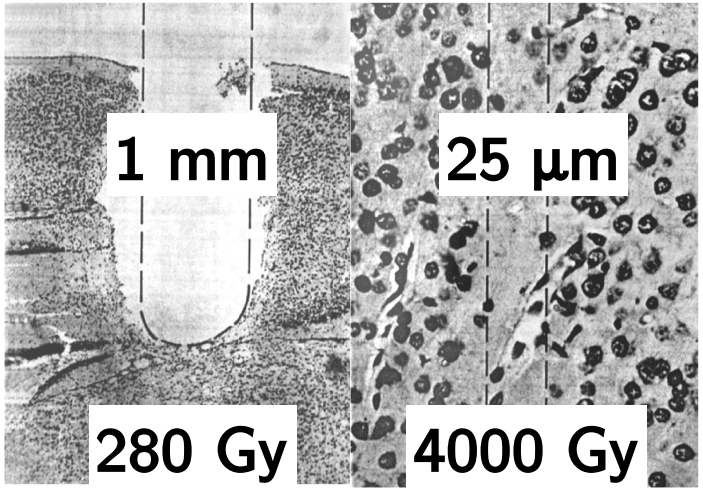

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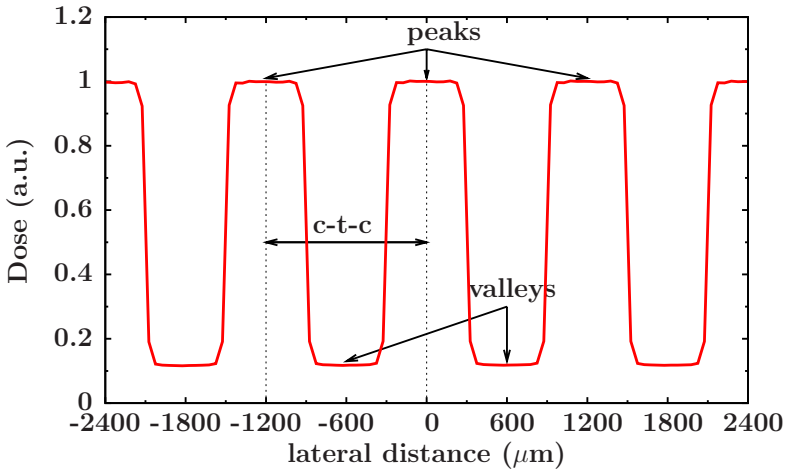


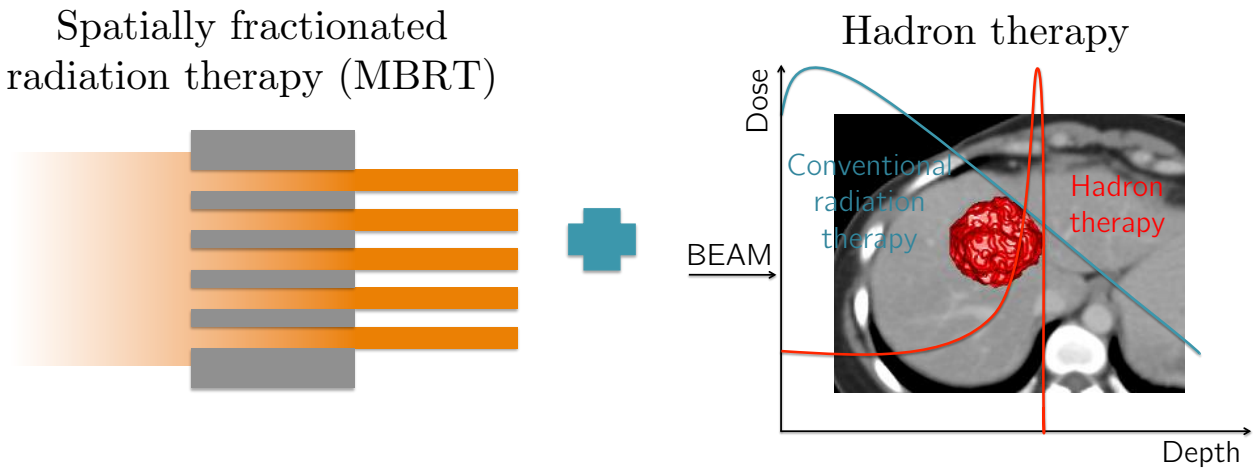
Breaking paradigms of conventional radiotherapy!

- Healthy tissue is able to withstand extremely high doses (>100 Gy).
- Highly aggressive tumors can be ablated.

[Dilmanian et al. *PNAS* (2006), Deman et al. *IJROBP* (2012), Prezado et al. *JSR* (2012)], ...

Hadron MBRT: hadron therapy + MBRT

Hadron minibeam radiation therapy



- This novel strategy might guarantee tissue recovery and reduce the side effects of radiation in healthy tissues.

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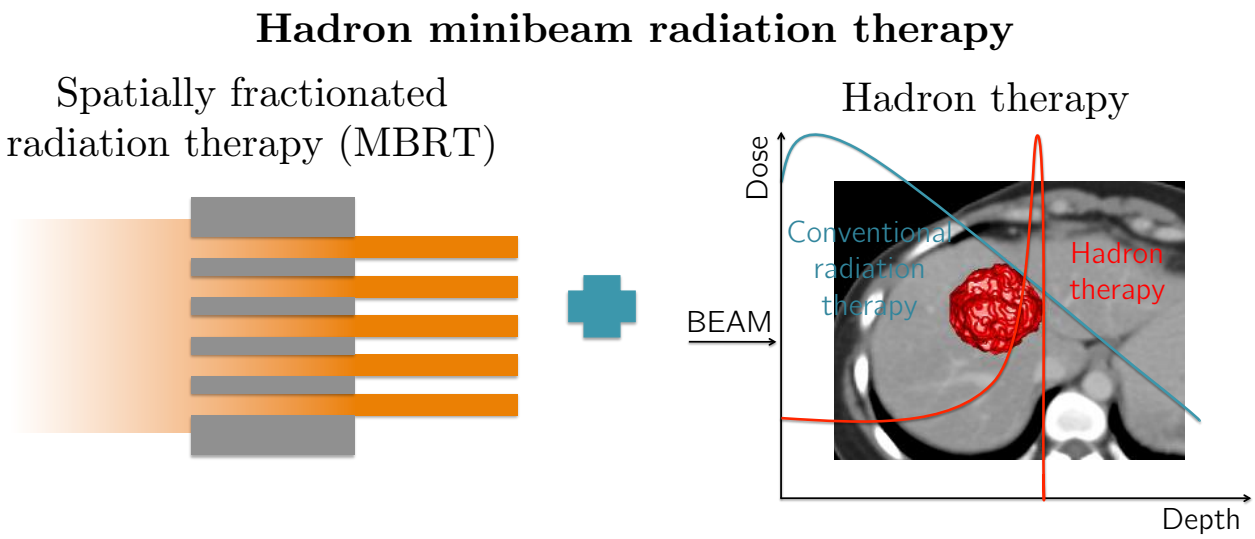


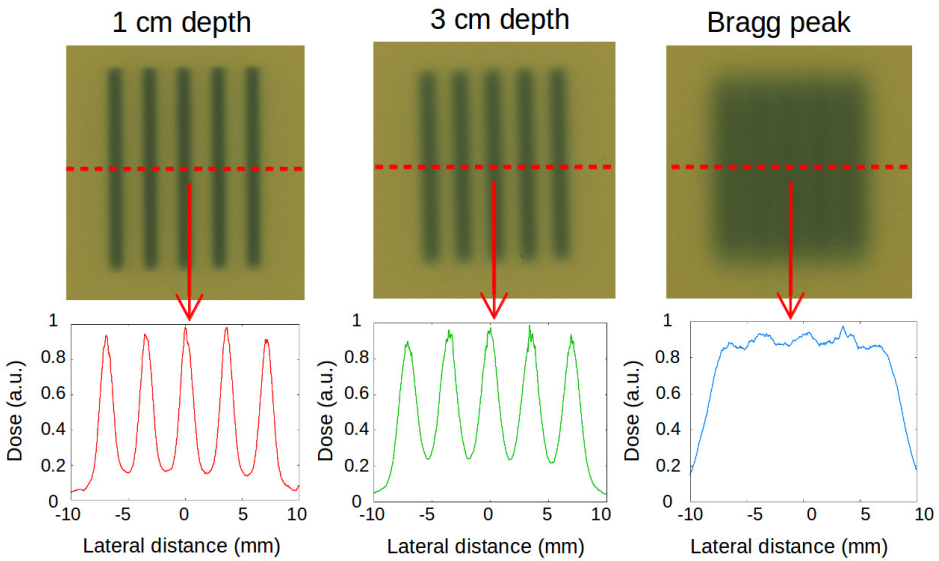
- This novel strategy might guarantee tissue recovery and reduce the side effects of radiation in healthy tissues.

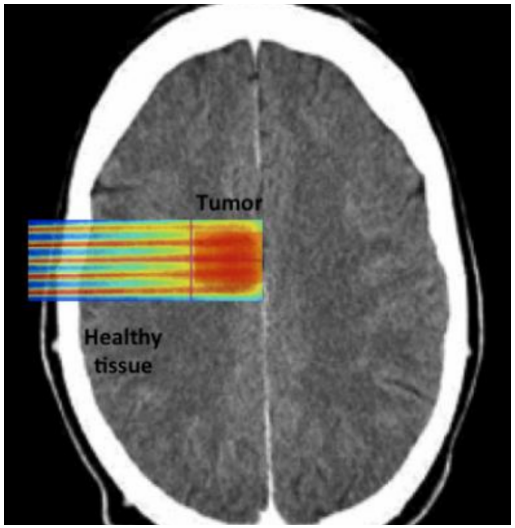
Technical implementations at clinical centers

- **Proton minibeam radiation therapy (pMBRT)**: at Institut Curie proton therapy center (CPO, France).
- **Carbon and oxygen minibeam radiation therapy**: at Heidelberg Ion-Beam Therapy Center (HIT, Germany).

Proton minibeam radiation therapy (pMBRT)

Dosimetry: Proton minibeam radiation therapy (pMBRT) at CPO





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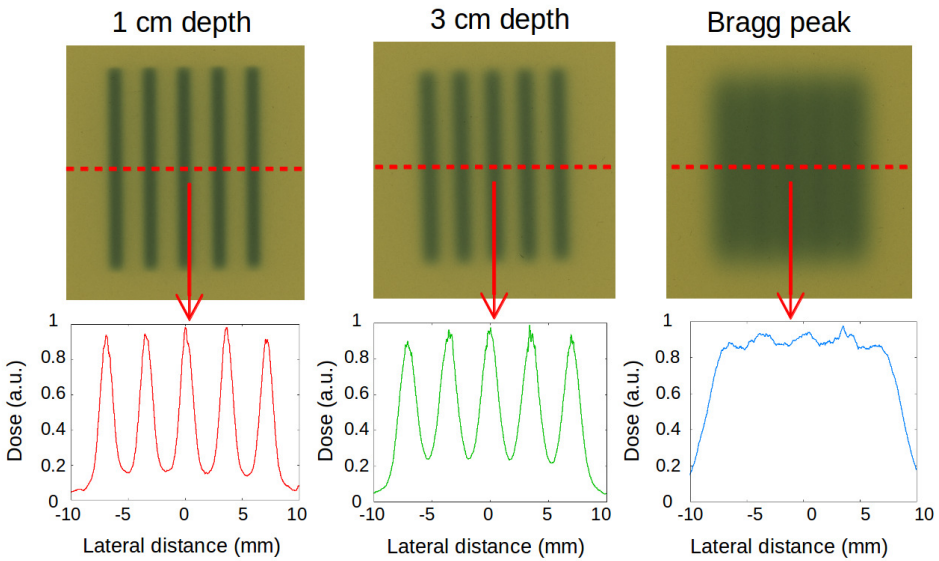

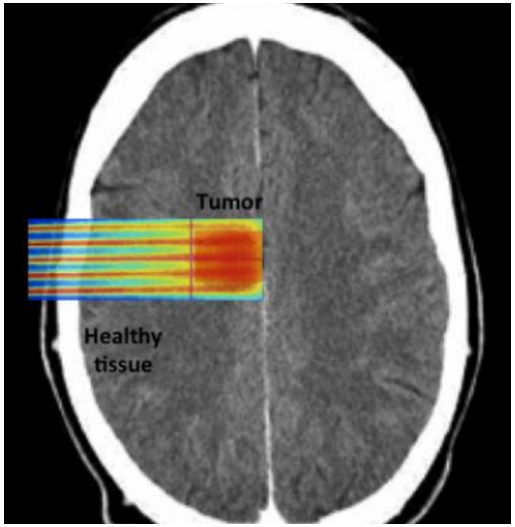

- Confirmation of the feasibility at a clinical proton therapy facility.
- Required dosimetric database for first biological experiments is now available **[Peucelle et al., Med. Phys. 42 7108-13 (2015)]**.
- More information on **oral presentation of C. Peucelle *et al.*** (tomorrow at 14h15, room 4).

Carbon and oxygen minibeam radiation therapy

Previous biological studies: [Dilmanian et al. *IJROP* (2012)]

- First biological indication of the advantages of carbon MBRT.
- Rabbit brains were irradiated at a **research facility** with 130 MeV/n carbon 300 μm-wide beams (target doses: 40 Gy; single fraction).
- **Results**: Normal behavior of rabbits (6 month-follow up). MRI showed substantial focal target damage and little damage to surrounding brain.
- **No dosimetric study has been detailed**.

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Goal of this study: Implementation of hadron MBRT at a clinical center

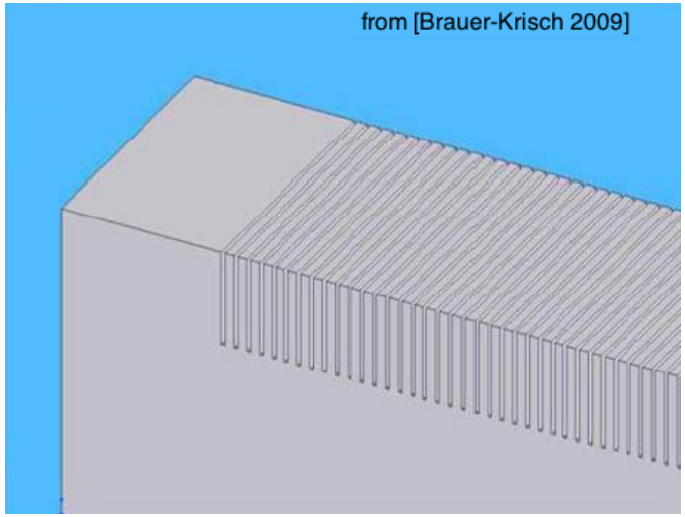
- Feasibility study of **carbon** and **oxygen** MBRT at HIT (Germany).
- **First dosimetric studies**.

Contents

Experimental setup

Irradiation conditions

- **Carbon** and **oxygen** minibeams.
- **Multislit collimator**.



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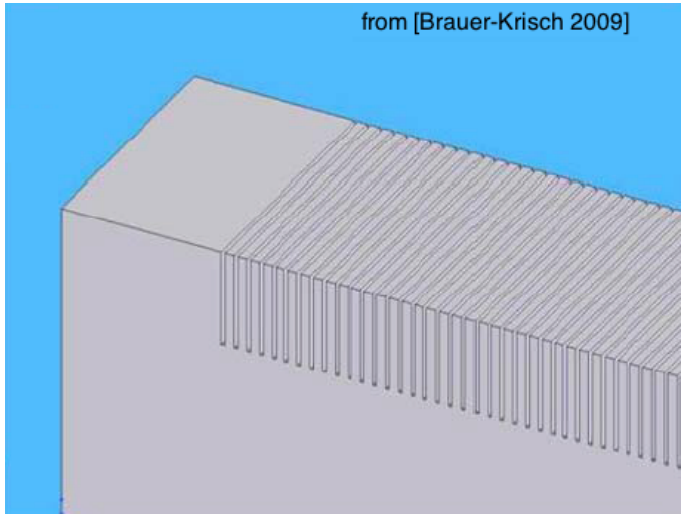

Detector systems

- Absolute dosimetry: Ionization chamber (TM30013 PTW Farmer).
- **Relative dose distributions**: Radiochromic films (EBT3) in RW3 solid-water phantoms.
  - Correction of quenching effects.

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Conclusions

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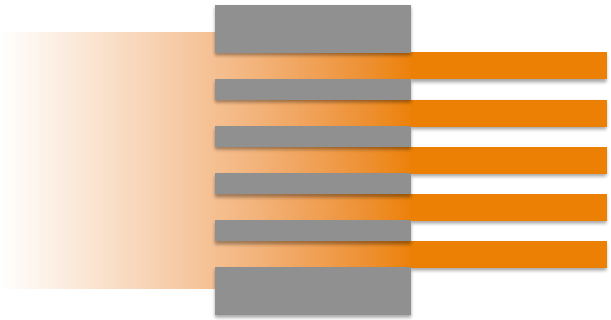
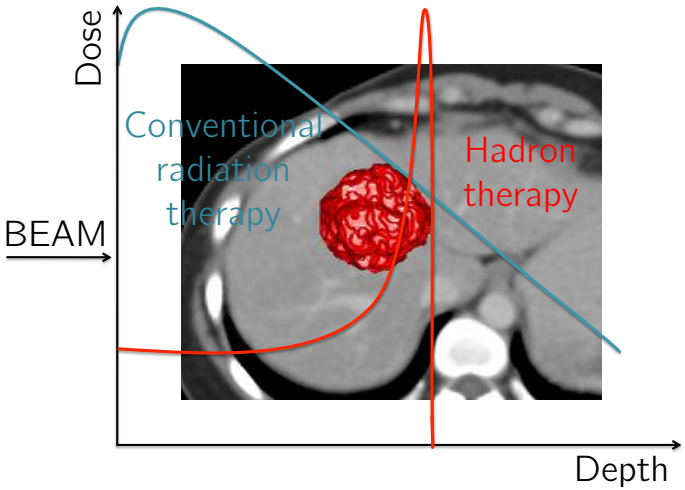


Hadron therapy



- This is the first exploratory study that experimentally proves the **technical feasibility of hadron MBRT at a clinical center**.
- Dosimetric results show that hadron MBRT might allow reducing side effects in the healthy tissues. This might also be used to apply hypo-fractionated schemes.
- Biological experiments are warranted.

Thank you very much for your attention!