Educational Point Counter/Point: Has Photon RT Hit the Limits?

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Introduction

Has Photon RT Hit the Limits?

No!

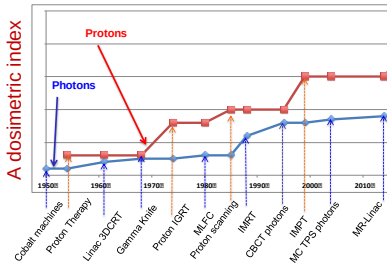
Can Photon RT catch up dosimetrically with proton therapy?

No!

Photon RT has reached its limit in terms of catching up dosimetrically* with proton therapy!

* unclear whether this matters clinically

Introduction

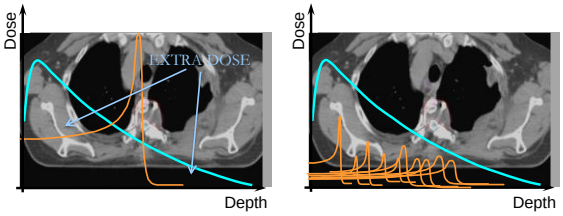


Introduction

Where are we today?

- The achievable target dose conformity is often not significantly different between photon and proton techniques
- In-room imaging technology is (still) more advanced in photon RT
- Dose to critical structures is overall lower with protons
- Although the dosimetric gap seems to close at times, photon RT can not reach proton RT

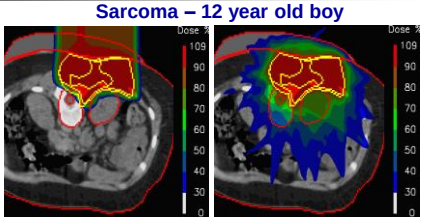
Protons are always* superior dosimetrically: Integral dose



* not necessarily at depths beyond 15 cm

Protons are always* superior dosimetrically: Integral dose

Sarcoma – 12 year old boy

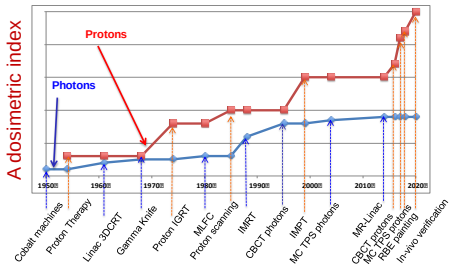


Single field IMPT 9 field IMRT

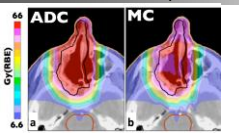
Factor 6 lower integral dose for protons

© T. Lomax (PSI)

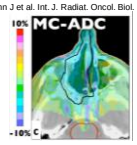
Protons are always* superior dosimetrically: Integral dose



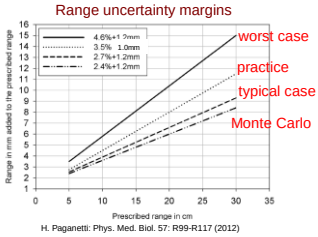
Future advances in proton RT: Monte Carlo based planning



Schuemann J et al. Int. J. Radiat. Oncol. Biol. Phys. 2015



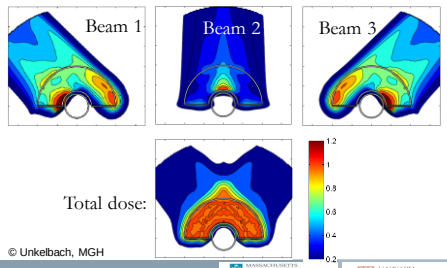
Range uncertainty margins



H. Paganetti: Phys. Med. Biol. 57: R99-R117 (2012)

Future advances in proton RT: Intensity modulated proton therapy

Mitigating range uncertainties using robust planning in IMPT



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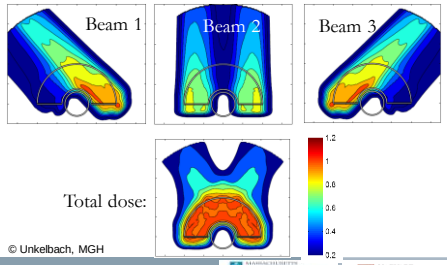
Future advances in proton RT: Intensity modulated proton therapy

Mitigating range uncertainties using robust planning in IMPT



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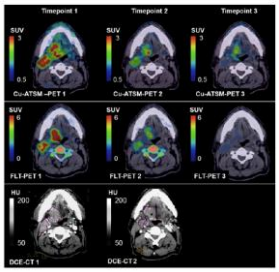
Future advances in proton RT: Dose painting



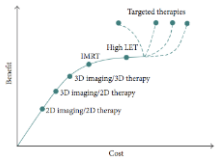
Molecular imaging to assess complex radiation treatment regimens.

- Cu-ATSM PET
- FLT PET
- DCE CT

before bevacizumab monotherapy (timepoint 1), after 3 wk of bevacizumab (time point 2), and after 1–2 wk of chemoradiation therapy (time point 3)

Nyflot MJ, Kruser TJ, Traynor AM, et al. Int J Radiat Oncol Biol Phys. 2015;91:942–951

Future advances in proton RT: Dose painting



Head and neck cancer patients over-express the epidermal growth factor receptor (EGFR) which is linked to poor prognosis. Targeted molecular therapy against EGFR could play a pivotal role as adjunct therapy.

Allen, Bezak, Marcu: Quo Vadis Radiotherapy? Technological Advances and the Rising Problems in Cancer Management. *BioMed Research International 2013*

Future advances in proton RT: Biological dose painting

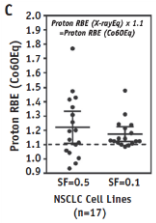
Inter-patient variability on RBE can be utilized

"Links Fanconi Anemia/BRCA pathway defects to elevated proton RBE"

Liu, Ghosh, Magpayo, Testa, Tang, Biggs, Paganetti, Efstathiou, Lu, Held, Willers: Int J Radiat Oncol Biol Phys 2015 91: 1081-1089

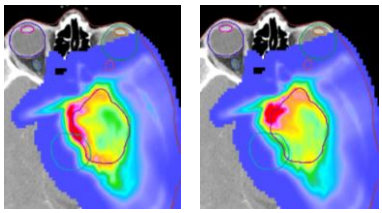
"Repair kinetics in HR-deficient cells were significantly delayed after proton irradiation, with elevated amounts of residual gH2AX foci"

Grosse, Fontana, Hug, Lomax, Coray, Paganetti, Sartori, Pruschy: Int J Radiat Oncol Biol Phys 2014 88: 175-181



Future advances in proton RT: Biological dose painting

LET times dose: Base-of-skull Chordoma



reference plan re-optimized

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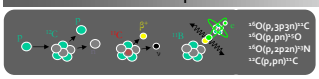
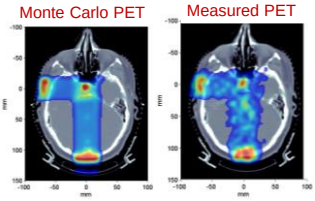
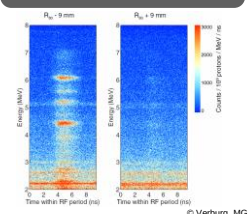
Future advances in proton RT: In vivo range verification for ART



Monte Carlo PET Measured PET





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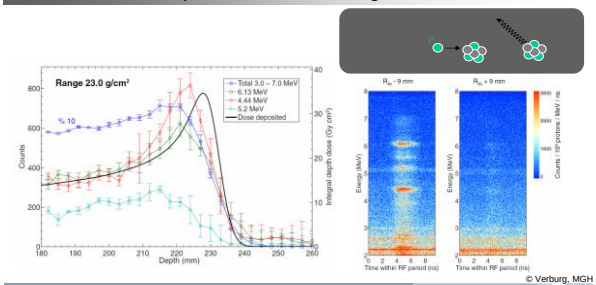
Future advances in proton RT: In vivo range verification for ART



Conclusion

- Photon RT has narrowed the gap to proton therapy (without closing it entirely due to the integral dose difference).
- Further improvements in photon therapy are either marginal or can be utilized on the proton side as well.
- As both photon as well as proton therapy technology will continue to improve, the ceiling for proton therapy is higher because several advances in RT will be proton specific.

- The dosimetric gap between photon and proton RT will increase
- It is likely that this will have an impact on treatment outcomes.