Photons Will Be Dosimetrically Superior
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Has Photon RT Hit the Limit?

Based on 10 years of experience with IMRT, we have learned that the opportunities in improving plan quality are limited within the constraint of practical IMRT delivery. To improve the quality of IMRT treatment plans, we must select new degrees of freedom. This may require an overhaul of existing technologies.

Future: Inject New Freedom, NOT Protons
Why not Protons?

- Technology
  - More complicated, therefore harder to advance

- Physics
  - Penumbra, Bragg Peak uncertainty
  - Sensitive to anatomical variations
  - Interplay effects with organ motion

- Biology
  - RBE uncertainty

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Proton Treatment Facility
Treatment Control

1. At a given time, only one room can have proton beam
2. All treatments in all rooms are centrally controlled
3. Techniques common with photons are difficult with protons
   - Arcs
   - MRI guidance
   - Motion tracking/gating

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Lateral Penumbra

The dose penumbra at deeper depth is less steep for Proton beam (6-10mm) than for photon beams
Effects of large penumbra

S.J. Gandhi et al: Practical Rad Oncol. 2015 1-10.

Adapted from iba-protontherapy.com

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LET
Published RBE Proximal to SOBP

Assumption: $RBE_{Proton}^{Co-60} = 1.1$

- For target cell killing – may be true
- For normal structure preservation – may not be true because the goal and biology are different
- In radiation protection, we have been using a quality factor of $Q = 20$
- If we use a RBE of 1.5 - 2 for normal tissue dose, the physics advantage of protons v.s. photons will be reversed!

Economic Considerations

“Describe a mechanism to figure out how to pay for proton therapy. Something that will get us out of this mess.”

Anthony Zietman, July 20, 2015
Social/Accessibility Considerations

Advancing Photon RT Is the Answer!

How to Improve Photon Plan Quality?

“The DVHs or subsequently derived biological scores depend on the total number of strata, which is defined as the product of the number of beams and the intensity levels within each beam. As the number of beams increases, the number of intensity levels required to obtain optimal dose distribution is reduced.”

We just need to increase the number of independent fields!
4π RT

Physics Contribution
4π Non- Coplanar Liver SBRT: A Novel Delivery Technique
Peng Dong, PhD, *Percy Lee, MD, *Dan Xuan, PhD, *Tony Long, BS, *Evelin Rosenfeld, PhD, *
Yingyi Tang, PhD, *Daniel Low, PhD, *Patrick Ruppin, HS, * and Ken Sheng, PhD *

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4π RT for Liver Cancer

Peng Dong et al Int J Rad Oncol Biol Phys. 85(5), 2013

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Compared with 4π RT

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Compared with $4\pi$ RT for Lung Cancer

Compared with $4\pi$ RT: Prostate Cancer

Conclusion

- Constrained by the delivery technology and techniques, photons appear to have hit a limit
- By injecting new degrees of freedom, photons could be dosimetrically superior to protons for most common sites
- Protons are extremely expensive, complicated, and cumbersome, thereby harder to advance
- Protons has many shortcomings, some cannot be changed by technology
- The dosimetric advantages of protons will be short lived, photons will be dosimetrically superior!