

Proton imaging for hadrontherapy: status and prospects

Friday, 9 September 2022 09:00 (40 minutes)

The currently established imaging modality used for treatment planning in ion therapy is x-ray computed tomography (CT). Due to the non-bijective relation between the photon attenuation coefficient, reconstructed with x-ray CT, and the relative stopping power (RSP) required for ion therapy treatment planning, RSP errors of about 3% may occur [1]. The use of ion CT promises to yield improved RSP estimation as input to particle therapy treatment planning [2], at a low imaging dose. Recently, proton CT (pCT) has been shown to yield RSP accuracy on par with state-of-the-art x-ray dual energy CT [3]. Several pCT prototype systems have been built or are currently in the design phase [4-7].

In this talk, the current status of pCT will be first reviewed. A large number of studies has been published by different groups presenting different approaches for building a pCT scanner. For many of these systems, the RSP accuracy and the spatial resolution achievable with different pCT scanners has been quantified and compared to the theoretical limits of pCT [3, 6, 7, 8]. In addition, work has been done in investigating how the performance of these systems translates to particle therapy treatment planning/dose calculation [9,10]. As pCT systems have not yet matured to commercial products, a lot of effort is still invested into optimizing their image quality. A few of the artifact reduction methods applied to pCT will be also presented [11,12]. Finally, motivated by the envisaged use of pCT beyond simply treatment planning, to its application to image guidance, the concept of fluence modulation as a means for extremely low dose clinical imaging modality will be outlined [13].

REFERENCES

- [1] H. Paganetti. *Phys Med Biol.* 2012 Jun 7;57(11):R99-117
- [2] R.W. Schulte, S.N. Penfold. *Trans Am Nucl Soc.* 2012 ; 106: 55–58
- [3] G. Dedes, J. Dickmann, K. Niepel, P. Wesp, R.P. Johnson, M. Pankuch, V. Bashkurov, S. Rit, L. Volz, R.W. Schulte, G. Landry, K. Parodi. *Phys Med Biol.* 2019 Aug 14;64(16):165002
- [4] R.P. Johnson, V. Bashkurov, L. DeWitt, V. Giacometti, R.F. Hurley, P. Piersimoni, T.E. Plautz, H.F. Sadrozinski, K. Schubert, R. Schulte, B. Schultze, A. Zatserklyaniy. *IEEE Transactions on Nuclear Science*, 63 (2016), pp. 52-60
- [5] C. Miller, B. Altoos, E.A. DeJongh, M. Pankuch, D.F. De- Jongh, V. Rykalin, C.E. Ordoñez, N.T. Karonis, J.R. Winans, G. Coutrakon, J.S. Welsh. *Journal of Radiation Oncology*, 8 (2019), pp. 97-101
- [6] M. Esposito, C. Waltham, J.T. Taylor, S. Manger, B. Phoenix, T. Price, G. Poludniowski, S. Green, P.M. Evans, P.P. Allport, S. Manolopoulos, J. Nieto-Camero, J. Symons, N.M. Allinson. *Physica Medica*, 55 (2018), pp. 149-154
- [7] C. Civinini, M. Scaringella, M. Brianzi, M. Intravaia, N. Randazzo, V. Sipala, M. Rovituro, F. Tommasino, M. Schwarz, M. Bruzzi. *Phys Med Biol.* 2020 Nov 17;65(22):225012
- [8] D.F. DeJongh, E.A. DeJongh, V. Rykalin, G. DeFillippo, M. Pankuch, A.W. Best, G. Coutrakon, K.L. Duffin, N.T. Karonis, C.E. Ordoñez, C. Sarosiek, R.W. Schulte, J.R. Winans, A.M. Block, C.L. Hentz, J.S. Welsh. *Med Phys.* 2021 Dec;48(12):7998-8009.
- [9] S. Meyer, F. Kamp, T. Tessonier, A. Mairani, C. Belka, D.J. Carlson, C. Gianoli, K. Parodi. *Phys Med Biol.* 2019 Jun 12;64(12):125008.
- [10] L. Volz, C-A Collins-Fekete, E. Bär, S. Brons, C. Graeff, R.P. Johnson, A. Runz, C. Sarosiek, R.W. Schulte, J. Seco. *Phys Med Biol.* 2021 Nov 29;66(23):10.1088/1361-6560/ac33ec.

- [11] J. Dickmann, C. Sarosiek, V. Rykalin, M. Pankuch, G. Coutrakon, R.P. Johnson, V. Bashkirov, R.W. Schulte, K. Parodi, G. Landry, G. Dedes. *Phys Med.* 2021 Jan;81:237-244.
- [12] J. Dickmann, C. Sarosiek, S. Götz, M. Pankuch, G. Coutrakon, R.P. Johnson, R.W. Schulte, K. Parodi, G. Landry, G. Dedes. *Phys Med.* 2021 Jun;86:57-65.
- [13] J. Dickmann, F. Kamp, M. Hillbrand, S. Corradini, C. Belka, R.W. Schulte, K. Parodi, G. Dedes, G. Landry. *Phys Med Biol.* 2021 Mar 2;66(6):064001.

Primary author: DEDES, George (Department of Medical Physics, Ludwig-Maximilians-Universität München, Germany)

Presenter: DEDES, George (Department of Medical Physics, Ludwig-Maximilians-Universität München, Germany)

Session Classification: Practical and clinical aspects of radiotherapy

Track Classification: Hadrontherapy and associated technologies